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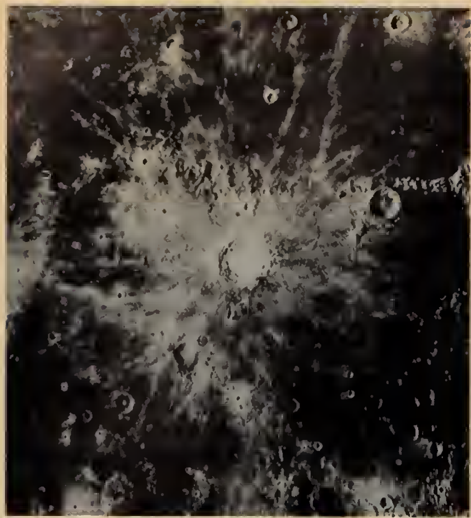
Were the moon's craters formed by a storm of giant meteorites?

see pages 2 and 3

7 SECRETS OF THE MOON



The "ray" crater Corpernicus

ABOUT THE COVER

How Were the Moon's Craters Formed?

As our cover shows, the moon's craters may be giant scars left by meteorites that crashed into the moon's surface millions of years ago. But this is only a theory. Exactly how the craters were formed remains a mystery.

What if the craters were formed by meteorite storms? On striking the moon's surface each giant meteorite would have shattered with an explosive force. At the same time, a tremendous amount of heat and light would be given off.

Among the most striking craters on the moon are some called "ray" craters. If you look at one through a pair of binoculars you will see powder-like rays, stretching out like the spokes of a wheel. The crater named Copernicus is one of the most dazzling ray craters. A photograph of it is shown here.

Why do some craters have rays? We do not know. Years ago some astronomers thought that the powder-like rays might be volcanic ash that had created splash patterns when the craters were formed. This leads to still another question about the moon: does it have active volcanoes now? We do not know.

Our cover painting by Helmut K. Wimmer, staff artist at the American Museum-Hayden Planetarium, shows a smoke cloud rising from a great crack in the moon's surface. Called "clefts," many such cracks can be seen on the moon's surface today, but all seem to be inactive. Perhaps they were great hotbeds of volcanic activity millions of years ago when the craters were formed.

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Contents

Cover by Helmut K. Wimmer

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A SCIENCE MYSTERY by Franklyn M. Branley

7 Secrets of the Moon

To escape the intense heat and cold on the moon's surface, men who set up the first lunar station will probably live underground. A few feet below the surface the temperature may stay around 20°F. below zero both day and night.

The moon is a satellite of secrets. The more we learn about it, the more questions we find to ask.

■Men have been asking questions about the moon for many thousands of years. What is it made of? How did it get there? Is there life on it?

Today we are still asking questions about the moon, more questions than ever before. We are also getting more answers. Over the past 100 years telescopes, and cameras that take pictures through telescopes, have shown us many details of the moon's landscape. Photographs show that the side of the moon facing us has more than 30,000 craters. Some astronomers think that the craters were formed millions of years ago when huge meteorites crashed into the moon (see cover). Photographs also show many mountains with sharp peaks. Some of the peaks reach nearly 30,000 feet into the sky, about as high as Mount Everest.

Even though we have photographed the moon and made detailed maps of it, we have much more to learn. Today, scientists are firing rockets toward the moon for a close-up look. Soon many kinds of instruments will be sent to the moon in rockets. Once there, the instruments will gather many different kinds of information about the moon and send the information back to us by radio.

Next, perhaps within eight years, the first astronauts will land on the moon, and the age of moon colonies will start (see picture at left). Then we will quickly solve the seven riddles that follow:

Secret 1: What Is the Moon Made of?

Is the moon made of the same kinds of rocks that are found on the earth? We can measure the speed of the moon and its path around the earth. When we do this we can figure out that the moon weighs 3.3 times more than it would if it were all water. This figure is the moon's density. The density of rocks such as granite is also around 3. Could this mean that the moon is made of granite? It may, but we cannot say for certain. We will have to wait until we can test samples of moon rocks.

The first explorers of the moon will be able to make these tests. Perhaps they will find that the density of some parts of the moon is more than for granite, other parts less.

Dr. Franklyn M. Branley, Associate Astronomer of The American Museum-Hayden Planetarium and supervisor of the Planetarium's educational services, is the author of many science books for young people.

SECRET 2: What Covers the Moon?

Is the moon covered by a layer of dust that comes from outer space? Many astronomers think so. Every minute of the day and night millions of *meteoroids* rain down on the moon. These are solid bodies of rock or metal no larger than grains of sand. They rain down on the earth too. (You can sometimes see larger grains at night as shooting stars.) But these meteorites do not collect noticeably on the earth. They are blown by the winds and settle on the ocean bottom.

On the moon there is probably no wind because there is hardly any air. The meteorites settle where they land and form a layer of dust. Probably much of this dust settles in the hollows and valleys of the moon. More dust is formed as the rocks on the surface of the moon crumble. This crumbling is caused because the rocks expand and shrink. The high daytime heat makes them expand, and the bitter nighttime cold makes them shrink.

Some astronomers think that the layer of dust is a mile deep on some parts of the moon. Others think that the layer is only a few inches or a few feet deep. If the dust is loose and deep a man or a spacecraft would sink into it. But the dust layer may be packed hard—hard and strong enough to support men and spacecraft.

SECRET 3: What Is the Temperature on the Moon?

How hot and cold does it get on the moon? If you were standing on the moon with the sun right overhead, you would be heated to about 215°F. This is hot enough to boil water. Astronauts will have to wear special protective suits if they leave their spacecraft. But not all the lighted half of the moon is that hot. At the "edge" of the moon, which is partly in light and partly in shadow, the temperature drops to 58°F. below zero. During the long lunar (moon) night, which lasts for two weeks, it is even colder. It seems to be around 250°F. or more below zero.

But these huge ups and downs of temperature are for the moon's surface only. A foot or two below the surface the temperature may be warmer and steady. It may remain at 20°F. or so below zero—both day and night. It is possible that moon explorers will live in man-made underground caves, just as Antarctic explorers live in heated rooms beneath the snow. But we are not sure about these underground moon temperatures. And we will not be sure about them until the first moon explorers set up a station and make measurements.

SECRET 4: Is There Life on the Moon?

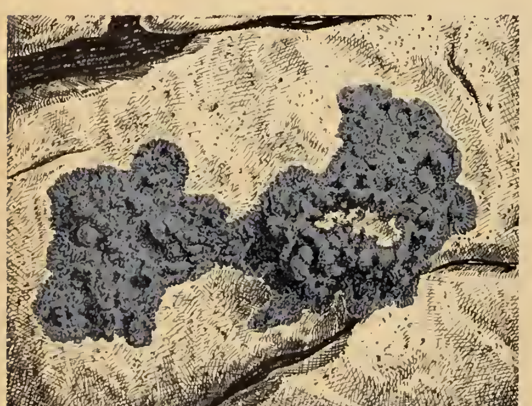
Astronomers are quite certain there is little or no water or air on the moon. There may be some, but so little that only the simplest plants could live there. Perhaps the astronauts will discover some very hardy form of plant life, like *lichens (lie-*kens). These are rugged, crust-like plants that you sometimes see growing on rocks and brick walls.

The first astronauts to land on the moon will also be on the lookout for fossils and other signs of simple forms of life that might have existed on the moon millions of years ago. The chances are slim that they will find anything, but imagine how exciting it would be to discover that life once existed on a world other than our own.

SECRET 5: What Is on the Far Side of the Moon?

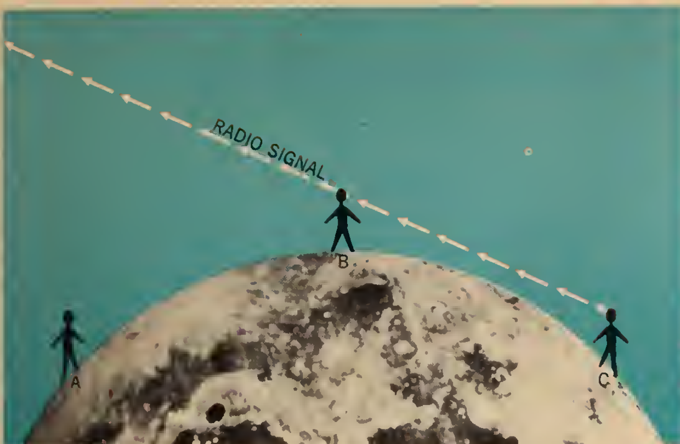
The same half of the moon is always turned toward the earth. We can see a little bit around the edges of the moon, but most of the far side has never been seen, even through telescopes. Lunik III, a Russian satellite that circled the moon in 1959, took pictures of the moon's hidden side. But the pictures were fuzzy and did not show much detail.

Are there craters on the far side of the moon? Are there flat regions (called *maria*), deep crevices, mountains, and



Hardy plants called lichens may be able to live on the moon. They can grow in climates that are very cold (or hot) and very dry.

More than a hundred years ago, many people, including some scientists, believed that the moon might be inhabited. These bat-like people and dancing bears are make-believe. Animal life cannot exist on the moon.



Radio contact between distant points on the moon will be possible if the moon has an ionosphere. Without an ionosphere (above) a radio signal would reach the man at B but not at A, because the signal would escape into space. If the moon has an ionosphere, radio signals will be reflected off it. The man at A would then be able to receive signals.

plains, as there are on the side that faces the earth? Most astronomers think all these features will be found there, but we cannot be sure. The moon's far side is a secret.

Secret 6: Does the Moon Have an Ionosphere?

High above the earth are several layers of gases called the *ionosphere*. The ionosphere helps us in many ways. For one thing these gas layers serve as a kind of mirror. Some radio waves bounce off them (see diagram). This bouncing, or *reflection*, makes radio signals travel very far.

The earth's ionosphere also protects us from harmful *cosmic radiation*. Cosmic radiation includes atoms, or pieces of atoms, that bombard us from outer space at very high speeds. The ionosphere protects us by breaking up some of this radiation. We cannot see the ionosphere, but we can see one of its effects. From time to time the sun shoots great numbers of atomic particles into space. When some of these enter the ionosphere, the sky seem to shine.

Many astronomers think there may be a very thin ionosphere around the moon. If there is, radio waves can be sent far and wide over the moon. If there is no lunar ionosphere, radio signals sent from a lunar station on one side of the moon would not reach a station on the other side. Without an ionosphere, one radio receiver would have to be on a line-of-sight with the other (see diagrams). Also, an ionosphere above the moon would help protect lunar explorers from some of the dangerous high-speed cosmic particles. Without such protection, we would have to find other ways of warding them off. We now think that the moon might have an ionosphere, but we do not know for sure.

Secret 7: Does the Moon Act as a Magnet?

The earth acts as if a giant bar magnet ran from the North Pole to the South Pole. If you scatter iron filings around a bar magnet they form a pattern called a *magnetic field*. It is the earth's magnetic field that makes compass needles point north. We now think that the moon does not have a magnetic field. What does this tell us? If the moon is without a magnetic field this might mean that the moon has a solid center. Some scientists believe that the earth's magnetism is caused by a liquid-like material at the earth's center.

We do not know for sure if a compass would work on the moon. The nature of the moon's core, and whether or not it acts as a magnet, is another of the moon's secrets.

When astronomers, geologists, and other scientists reach the moon, they hope to find answers to these seven questions. They will also try to answer many other questions: Just how much of an atmosphere does the moon have? How were the moon's great flat areas of dark rock (called *seas*), formed?

As we solve these lunar puzzles, each answer will lead to new and even more exciting questions. Astronomy, like the other sciences, is a never-ending search. Each answer that is found leads to new and exciting questions ■

PROJECT

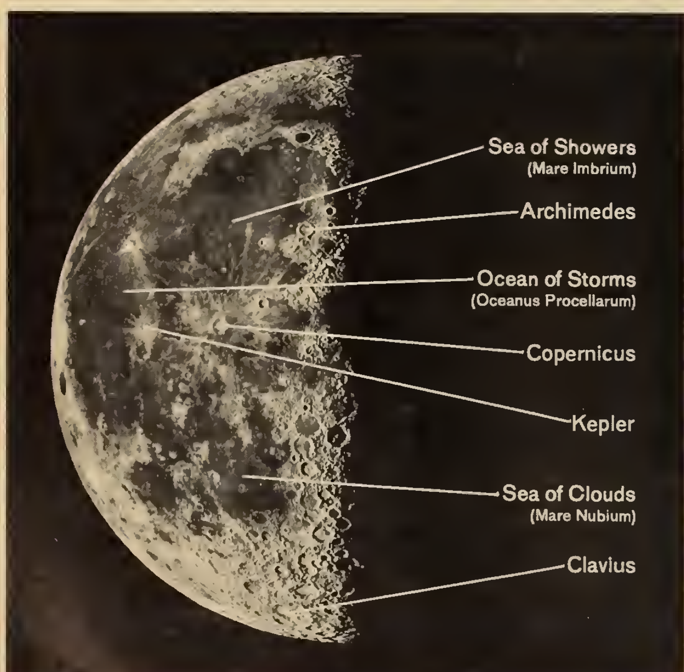
HOW AN ECLIPSE WORKS

Have you ever seen an eclipse, or a photograph of one? Do you know how the moon eclipses the sun? To find out what an eclipse is, make your own "eclipse" of a lamp, or a clock, with your thumbnail. Here is what you do.

Close one eye and move your thumbnail in front of the open one in such a way that you block out the lamp. Now how does the moon eclipse the sun? Can you eclipse the moon by using a 50-cent piece? A quarter? A dime?

MAPPING THE MOON

With the aid of binoculars you can draw a map of the moon. This article tells you how.



Hundreds of craters, some with rays, are visible in these photographs of the moon at third (top) and first quarters. "Maria," great dark plains hundreds of miles across, are also visible.

■ Astronomers used to make maps of the moon by looking at it through a telescope and then drawing what they saw. Today maps of the moon are made from clear, sharp photographs like those you see on this page. The older method is sometimes still useful, for example in making a map of Mars. This is because many details of Mars can be seen only in fleeting glimpses and are too blurry for good photographs.

You might think that the best time to observe the moon is when it is full. Actually, this a poor time to see details. When the moon is full, the sun falls on it in such a way that we cannot see any shadows.

The best time to see details of the mountains, the craters, and the "seas" of the moon is when the moon is a crescent, at the quarters (as in the photos), or *gibbous.* (A gibbous moon is one that is almost full but not quite.) At these times sunlight strikes the moon at an angle. This causes the mountains and craters to cast long shadows, which can be easily seen against the bright background. The shadows show up best of all at the *terminator,* the line that separates the lighted part of the moon from the dark part.

During the third quarter you should be able to see the craters Copernicus and Kepler. Both of these craters appear in the top photograph on this page.

Check a calendar or almanac to find out when the moon will next be gibbous. For your first attempt, observe the moon with your eyes alone. As you observe, work with a flashlight and drawing pad. Draw carefully just what you see. The larger you make your drawing, the easier it will be to make an accurate map. Write the date on your drawing.

Compare Your Map with a Friend's Map

Ask a friend to make a drawing at the same time that you make yours, then compare the two. Some people see features sharply, but others do not see the same features clearly.

When you have finished your drawing, make another one. But this time use a pair of binoculars. Night glasses, which are 7 x 50 binoculars, will give you the best results. When you use the binoculars, rest them against a firm object so that your view of the moon will be steady. You will be surprised by the amount of detail you can see. The lunar "seas," which are not really seas but waterless plains, and certain large craters stand out quite sharply. When you have finished this drawing, compare it with the one made by your friend. Also compare it with the photographs on this page to find out how accurate you have been. Many people who are amateur and professional astronomers first became interested in astronomy by studying the moon ■

PROJECT

Using a pair of binoculars, how many of the features shown in these two photos can you see?

HOW LONG DO ANIMALS LIVE?

HOUSEFLY
2 WEEKS TO 3 MONTHS

— AN INVESTIGATION —

In spring small fruit flies gather around decaying bananas and grapes. How long do fruit flies live? How would you find out? Plan an investigation of your own and carry it out. If you send us a report of your project we may print it in Nature and Science.

■Can you put these animals in a list so that the one you think lives the longest is on top, the next longest second, and so on —elephants, horses, spiders, bats, dogs, cats, and hamsters? When you have made your list check it with the information in the next paragraph.

Horses are considered old at age 20, but some live into their 40s, and one is reported to have reached age 62. Elephants have a life span of about 50 years. Spiders live from eight months to four years; one is reported to have lived 20 years. Bats may reach the age of 20. Cats and dogs are considered old when they reach age 10 or 11. Hamsters live for about two years.

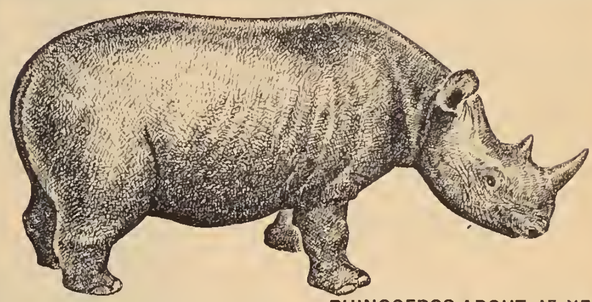
Exactly what do these figures mean? Do they tell us how long these animals *could* live if they were protected and cared for? Or do they tell us how long the animals can expect to live in the wild? Most of the figures we have for the life span of animals are based on studies of animals living in zoos, on farms, or in homes. Here they are protected from their enemies and kept in good health. Very little is known about how long animals live in the wild.

To measure the life spans of animals in the wild accurately we would have to observe many elephants, many spiders, or many of whatever animal interested us. And we would have to do this from the time an individual animal was born until it died. In most cases this is impossible to do. Then how do scientists learn anything about the life span of animals living in the wild?

One way is to band them. Young animals, including fish, are trapped and marked with a tag or band, then they are released. If they are caught again months or years later, the date on the band tells how long the animal has been alive.

Some animals have built-in "bands" that reveal their ages. The teeth of horses show their ages quite accurately. The ages of bighorn rams can be read by counting the seams on their horns. But few animals reveal their ages so easily. Many people think that you can tell the age of a rattlesnake by counting the number of separate rattles on its tail—one rattle for each year. But this is *not* a reliable age calendar. Many snakes lose some of their end rattles. Others may add two in a year instead of one, and so upset the calendar.

BEAVER ABOUT 19 YEARS



RHINOCEROS ABOUT 45 YEARS

We know surprisingly little about how long animals live in the wild. Ages of the animals shown here are based on records kept in zoos and laboratories, where the animals can be protected.

Scientists who study animals say that large animals tend to live longer than small ones. This may be because large animals have fewer natural enemies than small ones. Very few wild animals, large or small, die of old age. If they do not die of disease or starvation, other animals kill them.

One thing we know for a fact is that aging takes place as the body cells die. But just what does this mean when we compare the life span of large animals with the life span of small ones? Large animals have more cells than smaller ones, so perhaps they have more cells to spare than smaller animals.

But this theory about aging has yet to be proved. One thing we do know for certain is that bigness alone does not mean that a large animal will live longer than a smaller one. For example, the mammal with the longest known life span is not the elephant or the rhinoceros, but man ■

—VIRGINIA COIGNEY

by Roy A. Gallant

Are We Running Out of Fresh Water?

Many people of the world are on the brink of fresh-water starvation. Why? And what can be done about it?

The shortage of fresh water in Calcutta, India, is so severe that many people are forced to drink impure river water. The result is widespread disease. The Shasta Reservoir in California stands out in contrast with its rich supply of fresh water.

▪ Try to imagine a world without water. What would happen in your town or city if your water reservoirs and the streams feeding them dried up?

Power plants would grind to a stop. Without water behind the dams we could not generate enough electricity to light our homes or run factories. Even those power plants that burn oil or coal need water, because their generators are driven by steam. Without water farm crops would die, and so would the animals we depend upon for food.

Man's body is about 70 per cent water. Without water a human being

Roy A. Gallant has written many science books for children. The Thomas Alva Edison Foundation has selected one of his books for their top award.

would die within a week or two. All of your body tissues are bathed in water. They need water to carry out the hundreds of chemical reactions that take place every minute of the day and night. For example, when you chew food and swallow it, the food is broken down by a watery liquid called *saliva* (sa-*lie*-va). We need water just as much as we need air.

There is no danger of the world's water supply suddenly drying up tomorrow. But there is danger of another kind. As the world population climbs steadily higher, our needs for *usable* water become greater. By 1980 people in the United States will be using twice as much water as they did in 1954. And by the year 2000 the need will be three times as great as in 1954.

How We Use Water

Have you ever stopped to think of just how much water your family uses every day, and the many different ways you use it? The water you drink is only a small part of the total. During the day when you brush your teeth, take a bath, wash your hands, and flush the toilet, you use at least 40 gallons. Add to this many more gallons used when the dishes are washed, the lawn watered, or the car washed. One complete cycle of some automatic washing machines takes about 45 gallons.

Our use of water does not stop here. Factories use water in hundreds of ways. Your electric toaster, the books you read, the clothes you wear all needed water when they were made. Producing one gallon of gasoline takes 10 gallons of water.

But what does this mean to you? If we divide the total amount of water used by industry and by people in our country in one day by the number of people in the United States, we come up with a surprisingly large figure. About 1500 gallons of water are needed for every man, woman, and child each day. By 1980 this amount is expected to climb to 2170 gallons for each person each day.

Will there be enough water to go around by 1980? And by the year 2000? Yes, there will be enough. But *usable* water is quite another question. The oceans, lakes, and rivers contain more water than man will ever need. But the salts in ocean water make it unfit to drink and unfit to use in most machines. Also, the wastes and sewage emptied into most rivers and streams from our homes and factories make that water unfit for drinking.

According to the Public Health Service, sea water made pure for drinking must meet certain standards. For example, think of drops of water and "drops" of salts, such as table salt. Sea water made fit for drinking should not have more than 1000 drops of salts in a million drops of water.

Water used on farms for irrigation should not have more than 1200 drops of salts in a million drops of water. Water used in high-pressure boilers should not have more than two or three drops of salt to a million! Certain machines seem to be "more particular" about the water they use than man is. The way water is to be used, then, helps decide the "freshness" of water. Freshness also depends on how much money a community is willing to pay to purify its water.

People in many parts of the world today are on the brink of fresh-water starvation. This happens naturally in times of drought or in regions of very dry climates.

Stretching the Supply

Man himself often creates a water shortage by unwise use of water stored naturally in the ground. This water is called *ground water*. Around Los Angeles, Calif., so much

Water that many communities use comes from natural underground reservoirs. Each time it rains, water "percolates" down into the soil and forms a film around each soil particle (see the small diagram at right). The more it rains, the deeper the water percolates into the ground. It keeps seeping down until it reaches a layer of watertight clay or rock. Here the water becomes trapped and forms a reservoir. It can then be pumped to the surface to supply a community's needs. The top level of this stored water is called the "water table." During times of heavy rainfall the water table is high. During times of drought it is low.

ground water has been pumped out that it has been necessary to dig deeper and deeper wells. Many wells now reach below sea level. Because so much ground water has been removed in the Los Angeles area, salt water from the Pacific Ocean is slowly replacing it by seeping inland at the rate of 500 feet a year.

What can a community do to prevent a water shortage? It can store water when it is plentiful and use it during times of drought. It can borrow or buy water from areas that have more than enough. (Your own community may have a lot of water and serve as a "rescue" area.) Or it can develop ways to purify its own used water in such a way that the same water can be used over and over again.

How Water Becomes Polluted

Why is it that most river and lake water is unfit for drinking? How does it become unclean, or *polluted* (po-*lute*-ed)? Many materials that pollute the water enter our natural and man-made reservoirs in three ways:

1. **Topsoil** is washed off the land by rain and flood waters. It is then carried into streams and rivers where we get our drinking water. Carried along with the topsoil are millions of harmful bacteria that come from septic tanks, barnyards, and other places.

2. **Waste materials from our factories and homes** are constantly dumped into streams and rivers as sewage. Among the industrial wastes are acids, salts, oils, gases, and animal and vegetable matter. These are discharged by factories, canneries, oil fields, and mines. Certain detergents pose a widespread problem. They form a foam that is very hard to destroy and that clogs drains. Also, many of them cannot be removed from water when it is purified.

3. **Agricultural wastes** also pollute our reservoirs. Insecticides, such as DDT, are washed off the land by rain and carried into the rivers. Not all of these wastes can be removed when the water is purified for drinking, so they tend to collect in our bodies. They may be harmful not only to people who drink the water, but also to fish and wildlife.

The used water from your home may flow through sewer pipes into a river nearby. Part of the river water seeps into the ground and is used by trees and other plants. Part of it rises into the air as water gas, called *water vapor*. The process that changes liquid water to water vapor is *evaporation* (e-vap-o-*ray*-shun). As the river winds its way toward the sea the water picks up many salts and other minerals from the land. Eventually these impurities are carried to the sea, where they have been collecting for millions of years, ever since the oceans were formed.

It is in the enormous natural reservoirs of the oceans that the water cycle begins. It is called the *hydrologic* (hi-dro-*loj*-ic) *cycle*. Just as part of the river and lake waters

1. Water is made pure in different ways in different cities. The five stages here show what may happen to your city's water from the time it leaves the reservoir until it flows out of the tap. In SETTLING BASINS mud and other solids settle to the bottom and carry germs with them.

2. In COAGULATION BASINS chemicals that form a jelly-like mass are added to the water. As the mass sinks to the bottom, it removes still more mud and disease-carrying germs.

3. During FILTRATION the water is passed through sand or gravel, which removes still more solid particles.

PROJECT

Shake up a quart of water with some soil. Can you make a small model of a water purifying system to "purify" your quart of water? A milk carton with an inch of sand on the bottom, and with tiny holes made in it, acts as a filtering bed.

4. During AERATION the water picks up oxygen, which helps remove bad odors and tastes. It also kills bacteria.

5. CHLORINATION, the final stage, kills most remaining disease germs.

The oceans are the great natural reservoirs of the world. It is here that the water cycle begins. Heat from the sun causes the surface waters to evaporate, forming water vapor. The water vapor rises and turns into droplets which form clouds. The clouds drift over the land and release rain or snow. As this water finds its way back to the sea again in rivers, it carries minerals with it. When the water evaporates anew, the minerals are left behind in the seas.

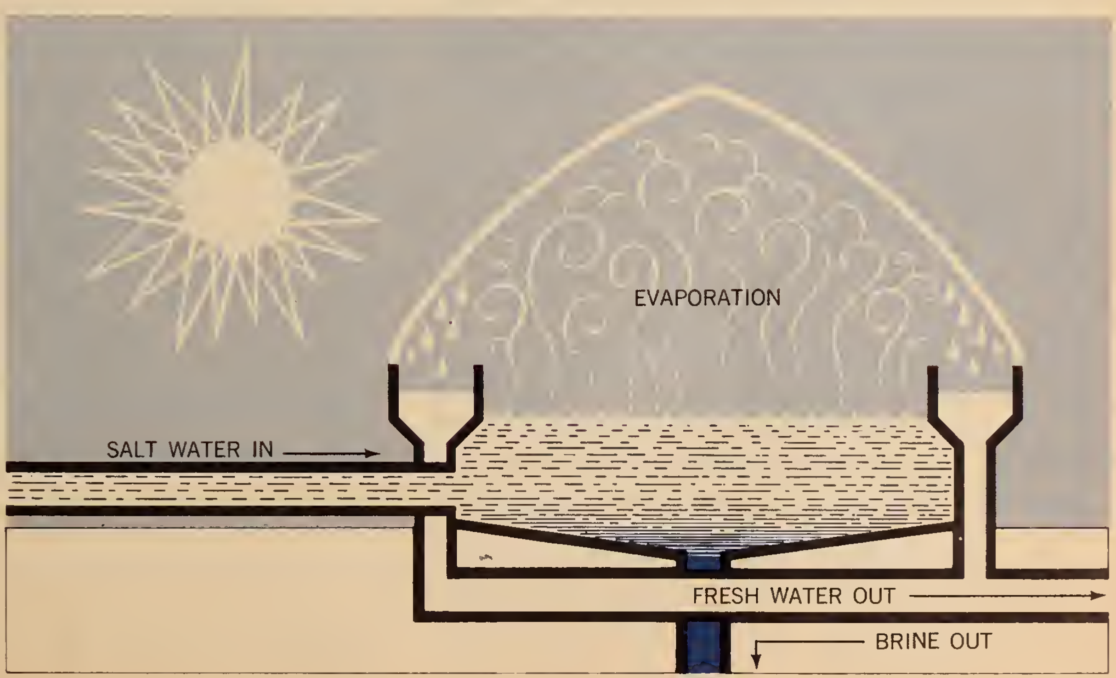
evaporate over the land, the surface waters of the oceans also enter the air as water vapor. During this process the salts and other minerals are left behind in the sea. As the water vapor rises into the air it cools and changes into small droplets that form clouds. The clouds are blown over the land and release their moisture in the form of rain or snow, called *precipitation* (pre-sip-i-*tay*-shun).

Can We Drink Ocean Water?

In the mountains, rain and melting snow soak into the ground. During a heavy rainstorm some of the water runs off the surface and flows into streams, rivers, and lakes. An area of lakes, like those in New York's Catskill Mountains, forms a natural collecting ground for water. Each of these areas, called a *watershed,* supplies many cities with water.

In general, the search for usable water is not a search for *more* water. It is a search for better ways of controlling and purifying the water already around us. This may be polluted river or lake water, or the salt water of the oceans. Scientists and engineers of more than 30 countries are now studying ways of taking the salts out of sea water so that the water can be used in homes and factories. One way is to imitate nature by evaporating sea water in a giant greenhouse covering several acres (see diagram).

If a solar fresh-water factory of this type is to work well, it must be built in a region with a sunny climate. The largest solar fresh-water plant now in operation is on the Persian Gulf in the Middle East. It produces six million gallons of fresh water a day. Other such plants are now planned in parts of California, Texas, Florida, and other regions ■

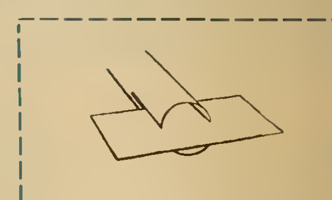


Solar stills make fresh water out of sea water. Salt water is piped into the collecting tank. Heat trapped inside the greenhouse evaporates salt water. Water vapor rises, collects as fresh water on the glass, and trickles down into a trough. As the surface water evaporates, a salty soup (brine) is left and drains out of the tank. Many areas are now planning to use solar stills to help them meet their fresh water needs.

HOW MUCH WATER DO YOU EAT?

by David Webster

You'll be surprised by how much water some foods have in them. Here is how you can find out by building your own scale.



■Everyone needs water to stay alive. If you had to go many days without water, you would become very sick. Once several men were locked inside a railroad car and lived for almost a week without anything to drink or eat. No one has ever stayed alive much longer than this without having food or water.

Because you *eat* water every day, you could go many weeks without drinking any water. Milk, orange juice, and ginger ale are mostly water. If all the water were taken out of a glass of milk, only a little bit of solid stuff would be left at the bottom. There is also water in many of the solid foods you eat, such as apples and hot dogs. How can you find out which solid foods contain water? Do the juiciest foods have the most water?

Think about other things you have seen with water in them. You know that a wet towel is heavy, but the towel gets lighter as it dries. How could you measure how much water is in a wet towel? You could squeeze some of the water out, but not all of it. If you had a scale you could weigh the towel. How many weighings would you have to make to see how much water the towel held?

By weighing food—an apple, say—before it has been dried, then after it has been dried, you can figure how much water it contains.

David Webster is teaching and writing for The Elementary School Science Project of Educational Services Incorporated, Watertown, Massachusetts. He formerly taught science in Lebanon, New Hampshire and was elementary science supervisor at Lincoln, Massachusetts.

Making a Scale for Weighing Things

It is easy to make a scale for weighing small pieces of food. All you need is: (1) a long paper straw; (2) a needle; (3) some thin cardboard; (4) two books the same thickness; (5) a pair of scissors; (6) a paper punch; (7) a piece of stiff paper to form the cradle for your scale.

After looking at the illustration and the details in the diagrams, make a slit in both ends of the straw with the scissors. Next, push two small squares of thin cardboard, each about the same size, into the slits. These are your weighing shelves. Now loop a strip of the stiff paper under the straw. Put the needle through the strip so that it just touches the top of the straw. This will help keep the straw in place. Rest each end of the needle on a book, and the scale is ready to use.

For weights, you need a lot of little things all the same size. Circles of thin cardboard cut out by a paper punch work well. Staples or small paper clips can be used instead.

How to Use Your Straw Scale

Slide the needle back and forth on the straw until the scale becomes balanced with both ends off the table. Now put what you want to weigh on one shelf and add the little weights (cardboard punchings) to the other shelf until there are enough to make the scale balance. The number of cardboard punchings needed to do this is the weight. So with your straw scale something might weigh eight cardboard punchings rather than eight pounds or eight tons.

Weighing Foods on Your Scale

Practice using your scale by weighing several small things around the house—a dead fly, or a safety pin. What do you think would happen if you balanced a small piece of wet paper towel on the scale and watched it as it dried out? Try it. After that you will be ready to carry out the experiment on the water in foods. What food do you want to test first? Cut off a little piece and weigh it on the scale. The piece you use should be very small, probably weighing no more than 15 or 20 cardboard punchings. Write down the weight so you can remember it.

Now leave the piece of food for a few days so it will begin to dry out. There are things you can do to the food to make it dry faster. Can you think of one? If so, you might want to try it.

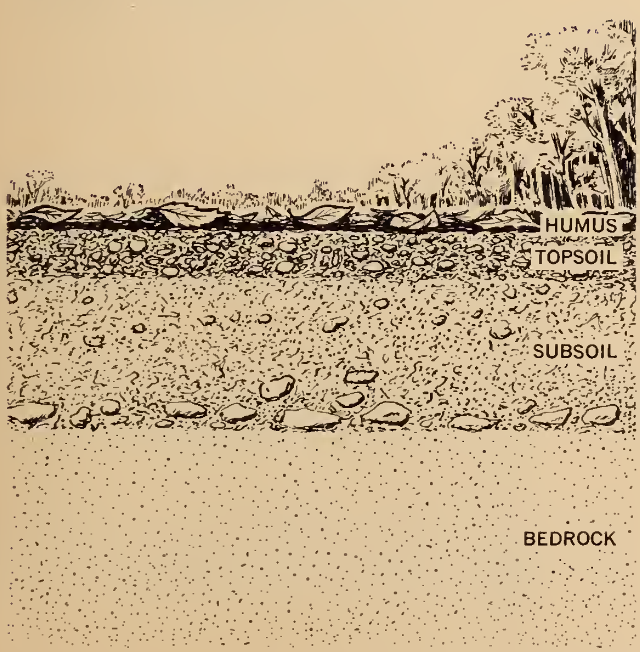
When you weigh your food after it has dried out some, you can guess that it will be lighter than before. Of course, the more water that goes away, the lighter the food becomes. Maybe you can let the piece of food dry out even more, then weigh it again. How will you know when there is no water left?

You probably will want to test many foods to see how much water is in them. You might try some of these: jelly, peas, tomatoes, fried eggs, lettuce, and bacon. Or you could use a little piece of each thing you eat in a day.

Which foods are almost all water? Which are just about half water? Do any have no water in them? Do you eat more water than you thought?■

AN INVESTIGATION

HOW MUCH WATER CAN SOIL HOLD?



Soil can have water in it too. The ground soaks up rain water like a sponge. Then the soil gradually dries out again until the next rain. Plants use the water which is stored in the soil.

How much water can soil hold? Do different kinds of soil soak up different amounts of water? You can find out by doing another experiment with your soda straw scale.

First collect some soil. You can see in the diagram that humus (rotten leaves) and topsoil are near the top of the ground in the woods so these two may be easy to get. You might have to dig to find subsoil. If you are lucky you may find subsoil piled up by a bulldozer where a new house or road is being built. Maybe you live near a swamp, a lake, or a clay pit where you can get other types of soil. See if you can collect four or five kinds.

Take one kind of soil and make a little wet mud ball about as small as a pea. Weigh it on your scale. A tiny piece of aluminum foil on the paper shelf will keep the shelf from getting wet. Now dry the mud ball out until all the water is gone, and weigh it again. Should you use the piece of aluminum foil this time too? Make pea-sized mud balls with the other soils and figure out how much water each one holds.

Which soil held the most water? In which soil would you expect to find plants which need only a little water to grow? Why do you think some soils hold more water than others?

Venus's flytrap is a plant that traps insects and digests them. This photograph shows a fly resting on the lobes of the leaf.

When the fly touches the small "trigger" hairs on the lobes, the leaf quickly closes, traps the insect, then digests it.

How to Bring Nature Indoors

by Paul Showers

Did you know that some plants "eat" bugs? And that you can see plants growing? Why not build a terrarium and watch nature at work?

▪Did you ever see a plant catch an insect and "eat" it? Or did you ever see a plant whose leaves close up when you touch them? You may have noticed that flowers bend toward the sun, but did you ever try to find out what makes them bend? Have you ever *watched* a plant grow? Do you know how a frog catches a fly? Or how a spider spins a web?

It is not always easy to watch plants and animals in their natural surroundings. It is much easier to bring them indoors and keep them in *terrariums* where you can watch them whenever you like. A terrarium is an indoor garden that is enclosed in plastic or glass like a tiny greenhouse.

You'll have many pleasant and interesting hours by bringing the world of nature indoors. Future issues of *Nature and Science* will show you how to set up many different kinds of terrariums and how to keep them thriving.

You can make a terrarium inside a large bottle, in an old fish tank, or even in a plastic bag. Future issues will also bring you ideas for experiments and investigations with the living things in your terrarium. *(Nature and Science* will also have many articles on aquariums and fishes.)

Paul Showers is the author of several children's biology books and is on the staff of the New York Times Magazine. *This article was prepared with the help of staff members of the New York Botanical Garden.*

Experimenting with Plants

One of the most unusual plants you can grow in a terrarium is a Venus's flytrap. This is a plant that traps and digests small animals. It lives on insects or bits of raw beef, and can even give your finger a gentle "nip" (without hurting you in the least). The plant grows its traps on long, blade-like leaves (see illustration). The upper part of each leaf is divided into two lobes that close together like clamshells. Three small hairs growing on the inner surface of each lobe act as triggers. When anything touches them, the trap quickly closes and long spines along the edge of the lobes prevent the insect from escaping. The soft parts of the insect are slowly digested by a fluid that oozes from the leaf.

Or perhaps you would like to grow a plant called the sensitive plant, and watch some of its odd actions. Just as scientists do not understand exactly how the flytrap works, they are also puzzled by the sensitive plant. This plant has feathery leaves, each leaf being a group of small, slender leaves called *leaflets*. The leaflets grow along a central stalk, like two pocket combs held back to back. If you touch one of the leaves, each leaflet will fold together like the wings of a butterfly. If you hold something hot near the tip of a leaf, its leaflets will fold up one after another right down the central stalk. Then, as the effect of the heat moves on along the plant stem, the next leaf will fold up its leaflets.

Both of these plants are fairly easy to raise in a terrarium. The flytrap grows from a bulb, the sensitive plant from seed. You can order them from nurseries and seed dealers.

You can perform many unusual experiments with the seedlings of beans, corn, peas, radishes, and other vegetables grown in terrariums. If you do the right things, the plants begin to develop within two or three days. What you do is place the seeds in peat moss in plastic bags, close the bags tight to shut in the moisture, then expose the bags to white fluorescent light for about 15 hours out of every 24. The seeds develop and the young plants grow rapidly this way. At certain stages you may even be able to watch the unfolding of a leaf from hour to hour.

Watching a Plant Grow

One good way to keep track of the growth of a *seedling* (a young plant) is to make small ladder-like marks along its stem with indelible ink. As the stem grows longer, the marks spread farther and farther apart. If you measure the distance between them every day, you can keep an exact record of how fast your seedlings are growing.

Scientists are puzzled by many things about plant growth. We still do not know exactly why leaves expand when light shines on them. It is not clear why growing plants do better when they are kept in darkness for several hours every day, instead of being exposed to light all the time. You can watch these and many other puzzling things about plants by experimenting with seedlings in a terrarium.

For instance, suppose you arrange several terrariums in a row beside a fluorescent lamp. The first terrarium is set directly under the lamp, the second a foot away, the third two feet away, and so on. With an ordinary photographic light meter you can measure just how much light each terrarium gets. Then you can watch to see how your seedlings grow with these different amounts of light.

Another thing you can do is test your seedlings with colored lights. What you do is raise three seedlings in three terrariums. Next you cover each terrarium with a hood of differently colored plastic. Then you watch how one seedling grows under red light, another under blue light, and the other under green light. You can also build a dark chamber with a window in it and find out which color of light causes plants to bend.

Raising Animals

You can also keep several kinds of insects and small animals in your terrarium. There you can watch their habits at close range, observing them through a magnifying glass. In the natural state frogs spend the winter hibernating in the mud at the bottom of ice-covered ponds and streams. In a sunny terrarium, with a dish of water for them to jump into from time to time, they will stay awake all winter. Frogs eat mealworms and can be taught to snap up pieces of raw hamburger from the end of a string dangled in front of their noses.

Salamanders, chameleons, and horned toads are other interesting animals for your terrarium. So are snails, spiders, crickets, and mantises. One thing that you must remember is that most small animals must be kept by themselves because some of them eat one another.

When you raise things like frogs, salamanders, or chameleons, it is a good idea to put growing plants in with them. This gives them something to hide under. But be prepared to replace your plants from time to time.

When plants are grown in a terrarium along with animals, the plants usually get trampled, uprooted, or eaten. If you want to raise seedlings and plants, your life will be simpler if you leave the animals out. But probably the most interesting terrarium of all is one where plants and animals live together as a community—as they do in nature in a swampy place or in a quiet corner of a garden ■

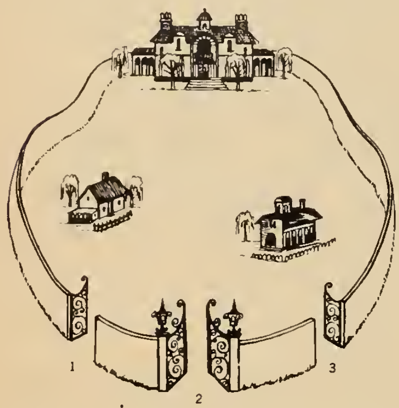


You can keep several kinds of insects and other small animals in your terrarium. Chameleons, mantises, and horned toads are only a few that you might want to try. Snails, spiders, crickets, frogs, and salamanders also make interesting terrarium animals.

brain-boosters

■ **Paths of Friendship**

The great American puzzle wizard Sam Loyd invented this puzzle when he was nine years old: Three neighbors who



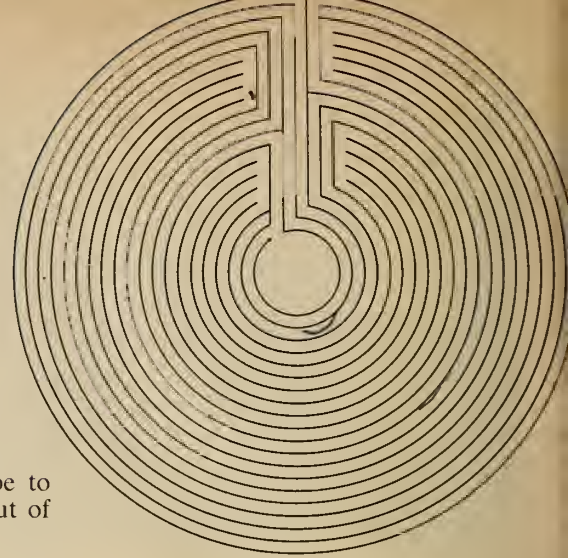
were forever fighting with one another lived in a small park enclosed by a wall. The neighbors decided that the only way to keep peace would be to build private pathways leading out of the park.

The family living in the large house made a private path leading to gate number 2. The family living in the house on the left made a private path leading to gate number 3. And the family living in the house at the right built a private path leading to gate 1.

The paths did not cross each other. How were they made?

■ **Southern Exposure**

A man went to an architect and said that he wanted to build a square house with a window in each wall. Each window, the man said, must face south, and the house could not be built on a rotating platform. At first the architect was puzzled, but after a moment's thought he said that he could build the house. Where did he build it?



■ **The Philadelphia Maze**

A Philadelphia businessman is said to have shot himself because he could not solve this maze problem. All you have to do is enter the opening at the top, then work your way to the center. You do this simply by following whichever path (not line) you think will lead you to the center. If you can find five paths without tearing your hair out you will be doing well. Actually there are 640.

Answers to the brain teasers on this page will be given in Pilot Issue No. 2 of *Nature and Science.*

WHAT COLORS DO YOU SEE?

■ These two discs can give you spectacular glimpses of red, green, and other colors.

Here is what you do. Cut out each disc. Paste each disc on a thin piece of cardboard and with sharp scissors cut out each circle carefully. Now punch a very small hole in the dot in the center of each disc. Unbend a paper clip and put one end through the hole.

Now, start spinning the disc by tapping it with your finger. For a few seconds you may not see any color, but soon the colors will appear. Try spinning the disc faster, then slower. Do the colors change? Spin the disc in the opposite direction. What happens?

Try your discs in daylight, then under a lamp or a fluorescent light. Try them under a red light. Do the different kinds of light give you different colors?

nature and science

PILOT ISSUE NO 1 / MARCH 1963

TEACHER EDITION

Your introduction to NATURE AND SCIENCE a new science magazine for the elementary grades

THE AMERICAN MUSEUM OF NATURAL HISTORY
Central Park West at 79th Street, New York 24, New York

Dear Colleague:

With this pilot issue of <u>Nature and Science</u>, a new 16-page science magazine for the elementary grades, The American Museum of Natural History extends its educational goals on a nationwide basis.

In our role as educators, we have long felt that such a publication has been needed both in the classroom and in the home. To bring <u>Nature and Science</u> to teachers of the middle and upper elementary grades, the Museum has combined its scientific and educational resources with the publishing resources of Doubleday & Company, Inc., in an effort to publish a children's magazine that ranges over the entire spectrum of science—including plants and animals, physics, astronomy, chemistry, and mathematics.

What, exactly, are the educational goals that we have set for <u>Nature and Science</u>? We believe that the wide range of facts assembled by science—whether in the field of animal behavior, astrophysics, or plant physiology—can be made interesting and significant to children, and that children want to know about them. But we also know that, in the past, well-intended attempts at popularization sometimes have had an undesirable result: <u>the facts of science too often have been presented as science itself</u>. We intend to show the <u>ways</u> of science so that every child, no matter what his or her future career, will appreciate the excitement and wonder that is available to every growing mind as it discovers the natural world.

Thus in <u>Nature and Science</u> we hope to show the child that science is not only an exotic jungle of fascinating facts, but much more a <u>way</u> of looking at and understanding the ever-changing world around us, a way of seeing the variety in nature and the laws of nature. We feel, then, that science should be portrayed as an endless search in which the individual, whether professional or amateur, is always discovering something new for himself—and occasionally discovering something new for mankind.

To help the child participate in this search, the feature articles and "Science Workshop" departments in <u>Nature and Science</u> will be presented in such a way that the child is asked challenging questions; at the same time he will be encouraged to set up his own investigations in order to find his own answers.

In a few weeks Pilot Issue No. 2 of <u>Nature and Science</u> will be sent to you free of charge. In September the first regular issue of the magazine will appear. By that time we hope that you will be among our subscribers and will be suggesting ideas that will help us make <u>Nature and Science</u> one of your most effective teaching aids.

James A. Oliver

Dr. James A. Oliver
DIRECTOR

What NATURE AND SCIENCE will bring to you and your students

NATURE AND SCIENCE: STUDENT EDITION Every two weeks from September to June, *Nature and Science* will come to your classroom with 16 pages of illustrated articles, including student projects, to help you introduce modern science to children of the middle and upper elementary grades.

FEATURE ARTICLES: Science Mysteries Many of our main articles will show science as an open-ended, never-completed quest for knowledge and understanding of the world. Thus, "Seven Secrets of the Moon" in this Pilot Issue shows how exploration of the moon will not only answer ageless questions about the nature of the moon but will pose entirely new questions for succeeding generations.

FEATURE ARTICLES: Science in Everyday Life These articles will strive to develop an understanding of the applications of science and technology. For example, in the article "Are We Running Out of Fresh Water?" we encourage children to think about water from a conservation point of view.

FEATURE ARTICLES: Science Adventures Many articles will accentuate the drama and personal satisfactions of scientific discovery. Some will be stories of the great zoological and anthropological expeditions of The American Museum of Natural History. Some will review the lifework of a scientist, showing how he designs his experiments, the difficulties he meets, and the excitement of making new discoveries. Others will be the stories of youngsters, often subscribers to *Nature and Science,* and their discoveries.

CONTINUING PROJECTS: The issues of *Nature and Science* appearing at the beginning of each school year will have articles explaining how you and your students can set up *workable* "laboratories" for a continuing study of plant and animal life. Later issues will suggest ways of keeping these communities thriving, and a variety of inquiries that your students can undertake with them.

Projects will include "plant labs" ranging in size from window pots to sizable terrariums. A preview of this continuing project is offered in this issue in an article prepared under the guidance of scientists at the famous New York Botanical Garden. Future issues of *Nature and Science* will show how to set up a practical, low-cost aquarium for the classroom. The child will also be shown how to set up a simple home aquarium.

SCIENCE WORKSHOPS: Each issue will have two or more articles designed to encourage children to conduct investigations on their own. In this issue, for example, note the "Mapping the Moon" article. Ingredients: a clear night, a pair of binoculars, and an inquisitive child. In Pilot Issue No. 2 the child will be told how to build an ant maze, how to stock it, and how to test the ability of ants to solve problems by learning to overcome obstacles. Also in this issue, we ask "How Much Water Do You EAT?" and help the child answer this question by showing him how to build a simple yet accurate scale out of a soda straw.

TEACHER EDITION OF NATURE AND SCIENCE With every issue of *Nature and Science* you will receive a comprehensive teacher edition of four or more pages to serve as an aid in your teaching of science throughout the year. Written under the supervision of teachers with wide experience in introducing science in the elementary grades, this edition will give you:

1. Practical and imaginative suggestions on how to use *Nature and Science* in your class and for field work.
2. Advance information of future editions.
3. News about the several education research groups supported by foundations and institutions currently devising new ways of presenting science in the elementary grades. *Nature and Science* will encourage contributions from the staffs of these experimental groups.
4. Suggestions for related science activities—seasonal field trips; visits to local museums, zoos, botanical gardens.
5. Critical reviews of new books for young people; advance information on network TV programs of interest to your students; reports on new teaching materials.

SPECIAL TOPIC ISSUES: Twice each semester *Nature and Science* will devote most of its pages to a special topic and suggest student investigations related to the topic. A typical schedule of special issues: Early fall: **Smog and the Pollution of Our Atmosphere.** Early winter: **Early Man in North America.** Early spring: **Our Senses: How Well Do We Use Them?** Late spring: **Understanding Insects.**

NATIONAL ADVISORY BOARD: Each issue of *Nature and Science* will be prepared under the guidance of a National Advisory Board made up of elementary school teachers, science supervisors, and scientists particularly concerned with new methods of teaching science to children. The members of this board will be announced soon.

Coming in NATURE AND SCIENCE

Codes and Messages • "Seeing" by Reflected Sound Waves • How Living Matter Decays • Life in a Rotting Log • Telling Time by the Stars • How to Weigh the Earth • How Animals Migrate • How Fish Swim • The Indestructible Sponge • Echoes • Superstitions and How to Test Them • What Is Color • How Things Fall • Animal Venoms • Why Get Vaccinated? • How Animals Navigate •

Using This Issue of NATURE AND SCIENCE In Your Classroom

Page 3: Seven Secrets of the Moon

There is still much that we do not know about the moon. In this article Dr. Branley presents seven unsolved problems of interest to us today.

Many of the seven secrets are related to the moon's period of rotation, so you may wish to review the rotation of the moon on its axis. Because the moon's period of rotation and time required for it to complete one orbit coincide, we can observe only one face of the moon.

Have one child represent the moon by walking around the class and keeping his face toward the class. This will demonstrate that the moon does not appear to rotate when viewed from the earth. But if viewed from the sun (represented by your desk at the front of the room, so that the "moon child" passes between the class and your desk), the moon would be seen to rotate once each time it circled the earth (the class).

Secret 1: The concept of density will be new to most of your pupils. The density of a substance is its *mass per unit of volume.* A cubic centimeter of water at 0° C. weighs one gram. Thus the density of water is one gram per cc.

Ask one of your pupils to obtain some balsa wood. Have some blocks cut from the balsa wood and other woods (both hard and soft) so that all blocks are the same dimensions. Weigh the blocks. Ask the pupils to account for the differences in weight. Someone may volunteer that there is more wood (or material) in the heavier blocks.

Secret 2: The words *meteoroid, meteorite,* and *meteor* express quite different ideas. *Meteoroids* are small stony or metallic objects in space. When a meteoroid enters the earth's atmosphere, it may be heated by friction to visible white heat and vaporize. The meteoroid has then become a *meteor,* a "shooting star." The object that strikes the earth (or the moon) is a *meteorite.*

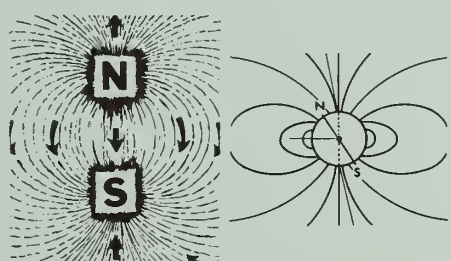
Secret 3: When you discuss this secret, you might call attention to the temperature change from day to night on the earth. Perhaps one of your children has vacationed in the desert regions. If so, have him tell about it. Earth temperatures are tempered by the atmosphere, which insulates us against both heat gain and heat loss. Because the moon is without an appreciable atmosphere, lunar explorers will have to wear insulated clothing to protect them from the intense heat and cold.

Secret 4: The material covered here is highly conjectural. The point to stress is that we cannot observe any signs of life on the moon's surface. Our direct observations also lead us to believe that water, air, and, therefore, atmospheric pressure (requisites for life) are absent, or nearly so. However, primitive plant forms, such as lichens, may exist on the moon.

Lichens are not difficult to find. Try keeping them in environments of various types (say, with varying degrees of humidity) to observe changes.

Secret 5: The Lunik III photographs indicate the moon's hidden side has the same *general* type of features as those found on the side facing the earth. Until recently this has been a matter for speculation. Sharper photographs are needed before conclusions can be reached.

Secret 6: The concept of a gas bearing a charge is an extremely difficult one. Such devices as fluorescent lights (mercury vapor) and neon tubes may be used to help children understand that gas can carry electric charges.



Magnetic fields of a magnet and the earth.

Secret 7: Most children have had some experience with magnets and compasses. This article brings up a concept that may be new—a *magnetic field.* The well-tried demonstrations with bar magnets and iron filings are appropriate to demonstrate the idea of a field.

After experimenting with magnets, iron filings, and compasses, relate the field of a magnet to the magnetic field of the earth. Compasses work because the earth's field is all around us. If the moon does not have a magnetic field, compasses will not work there. How, then, will moon explorers find their way around? A good discussion can be built around this question. Some possible means are radio and radar.

Page 6: Mapping the Moon

The more thoroughly children understand the problems and the difficulties involved in this activity, the more satisfactory their experiences will be. For one thing, unless you brace the binoculars against a support of some kind they will tend to wiggle and make observation difficult.

On some night when the moon is full and rises early, the class can observe that the moon comes up in the east and moves westward in the sky. This *apparent* westward motion of the moon is caused by the earth's eastward rotation.

If the children can sight across the moon to a star and observe it for one hour, they will see that the moon moves eastward with reference to that star. The amount of shift in one hour will equal just about one full diameter of the moon. This is explained by the moon's orbital motion, a *real* motion from west to east, rather than apparent motion.

Observations for mapping purposes are best between the first quarter and full moon because of the shadow effect. This may be demonstrated by comparing the short shadows in the schoolyard at noon with the long shadows made early in the school day or late afternoon.

Page 7: How Long Do Animals Live?

In this article we have a fine demonstration of one of the fundamental processes of science—making controlled observations. When we ask how long animals live, we bring up the question of what we mean by life span. You can explain that *potential longevity* (the length of time an animal can live under ideal—protected—conditions) is usually quite different from the *life expectancy* of an animal living in the wild.

The article also touches on the concept of aging, related to cell deterioration. For most children in the intermediate grades, the concept of cells may be new. If you have a microscope or, even better, a microprojector, demonstrate epithelial cells taken from the linings of the pupils' mouths.

Insects are ideally suited for life cycle observations. They are relatively easy to culture and require a minimum of space. The fruit fly *(Drosophila)* undergoes complete metamorphosis in from 10 to 12 days. The rate of metamorphosis is controlled to some degree by temperature. This opens another line of investigation.

The suggestions for using this issue of Nature and Science *in your classroom were prepared by William L. Deering, Managing Editor, Education Division, Doubleday & Company, Inc.*

Instructions for culturing fruit flies may be obtained from any of the biological supply companies and from such manuals as Brandwein, Morholt, and Joseph, *Teaching High School Science: A Sourcebook for the Biological Sciences* (Harcourt, Brace, 1958) or Miller and Blaydes, *Methods and Material for Teaching Biological Sciences* (McGraw-Hill, 1961).

Page 8: Are We Running Out of Fresh Water?

In this article children are exposed to the interdisciplinary approach to a pressing environmental problem.

Mr. Gallant makes it abundantly clear that a solution to this important problem requires a sound basis in biology, chemistry, physics, geology, and mathematics. It may be worth while to point out to your pupils that many problems in science require the attention of many kinds of scientists. Mr. Gallant's article should excite the interest of children.

Several concepts in the article may need clarification.

A distinction is made between the *total water supply* and the supply of *usable water*. Then the author points out that the standards determining whether water is usable vary. In terms of dissolved salts, drinking water needs to be less pure than the water required for some machines. The point is that human bodies can tolerate and excrete a small amount of salt, while machines cannot.

Drinking water standards are also based on the presence or absence of bacteria and upon flavors. The amount of salts is usually given as parts per million (ppm.) parts of water. You may wish to expand the text notation "drops per million drops" into parts per million.

The author suggests that we can stretch the current water supply by careful use and re-use. He also details some of the sources of pollutants. Finally, there is a brief description of one method (solar distillation) of desalting sea water. (For another method—by freezing—see the December 1962 issue of *Scientific American*.)

Mr. Gallant's article may be used for short- or long-term experiences. A few are given below:

1. Take your class on a field trip to a water works. Possibly you can arrange a longer trip to a reservoir or pumping station. If you can do neither, then invite a representative from the public water works to address the class and explain where your community gets its water.

2. Most incorporated cities and villages have some kind of a sewage treatment works. A visit to such a plant would make an ideal trip to follow a trip to the water works.

3. Most state and local health departments make routine bacteriological examinations of water. See if you can arrange to have bacterial analyses made of samples brought to school by children.

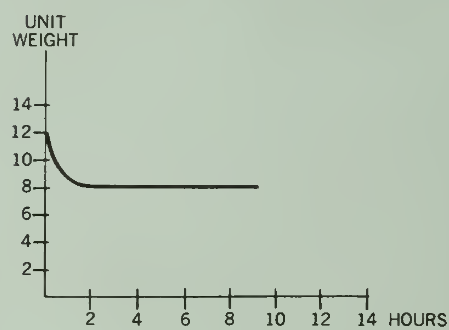
4. The water in living tissue can be demonstrated by cutting an apple, potato, or any fruit or vegetable into pieces and weighing the pieces. Place the piece on a window sill, in an oven, or over a radiator to dry. Then weigh again. This exercise can be used to calculate both the actual amount and the percent of water in various tissues.

Page 12: How Much Water Do You EAT?

Suppose that your pupils construct a soda-straw balance and find that a section of an apple, say, weighs 20 "weights" before drying, and 5 "weights" after drying.

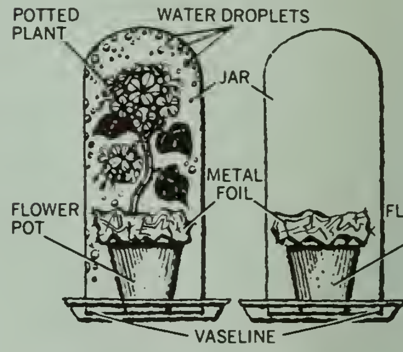
Is one weighing enough? How can they be sure that the apple is dry? This simple problem gives you an excellent opportunity to introduce a graph and the manner in which it can be used to organize data and make predictions. For example, the sample is dry if it remains the same weight for several measurements.

Set up a graph and divide the Y (vertical) axis into as many equal units as the total (unit) weight of the wet specimen. Divide the X (horizontal) axis into weighing intervals—hours or days. When the graph levels off after several weighings we can be reasonably sure that the specimen is dry. This exercise represents a very real approach to one kind of mathematical analysis practiced by scientists.



While water is a necessary substance to sustain life, the amount of daily water intake varies considerably in various plants and animals.

Most plants give off water through their leaves and stems. This process, called transpiration, will enable your pupils to compare the different amounts of water given off by a geranium, say, and a begonia with that given off by a cactus. The cactus stores large amounts of water in its fleshy stems. Leafy plants lose water through their leaves.



A demonstration of transpiration.

The diagram shows a method for demonstrating transpiration through a leaf. Cover the moist soil with metal foil to prevent evaporation through the soil. Enclose the plant within a suitable jar with the lip covered with vaseline. As a control, set up a similar demonstration without a plant in the soil. Transpiration will cause water droplets to form on the inside surface of the jar. Ask your students where the water came from.

Page 14: How to Bring Nature Indoors

One of the most exciting features of *Nature and Science* is the "continuing project" (see page 2T). In this article are several teaser-projects that can be carried out with terrariums—some on the classroom level, others by the individual student.

In future issues of the magazine, we will present many of these teaser-projects in detail, in each article describing the kind of terrarium (old fish tank, plastic bag, or bottle) that can be set up. Each project will be designed to encourage the student to solve a problem by *doing* something, and each answer he finds will pose new problems.

As we develop our terrarium (and aquarium) continuing projects, hints for many activities will be given—but there will rarely be an answer to the problem posed, and never an exact description of what the young eye and mind "should" perceive before it happens. So it is in the scientist's laboratory. The scientist does not follow predetermined steps that lead him to a "right" answer.

Here, if you will, is science as it really is. Our features will pose a problem, provide some of the mechanical means of solving it, but little else.

We believe that our continuing project articles are a good example of how far we have come from the cookbook science of a few years ago.

nature and science

PILOT ISSUE NO 2 / APRIL 1963

A SCIENCE MYSTERY

70,000,000 years ago the last of the dinosaurs died. Exactly why, no one knows.

see pages 4 – 7

WHY DID THE DINOSAURS DIE OUT?

ABOUT THE COVER

Lives of the "Terrible Lizards"

The huge flesh-eating dinosaur above is *Tyrannosaurus rex*, one of the most fearsome of the "terrible lizards" that once ruled the earth. Armed with sharp teeth and talons, and weighing nearly 10 tons, this reptile was well suited to prey on other dinosaurs. But this mighty monster disappeared with all the dinosaurs long before men appeared on our planet.

The story that begins on page 4 tells how scientists have discovered part of the dinosaur life story, and the mysteries that remain. Although we have learned many facts about the Age of Dinosaurs, much of the story of these reptiles is still a puzzle.

Why do scientists want to learn about the lives of dinosaurs? One reason is that these animals ruled the earth for such a long time—over 100 million years. During that time they lived on nearly every continent. So far, mankind's time on earth has been only a tiny fraction of the length of the Age of Dinosaurs.

Will other groups of animals disappear, like the dinosaurs, in the future? By learning about dinosaurs, we may be able to understand why groups of animals die out, or, as we say, become extinct.

Our cover and the painting on page 4 show sections of the 90-foot-long dinosaur mural at the Peabody Museum of Natural History, Yale University. Artist Rudolph F. Zallinger painted this famous view of the "terrible lizards" as they probably appeared many millions of years ago.

nature and science

PILOT ISSUE NO 2 / APRIL 1963

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Contents

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A FISH THAT BECAME A FOSSIL

Portheus, a famous fossil fish, with its last meal inside.

■About 90 million years ago a huge 14-foot-long fish named *Portheus* swallowed its last meal and died. After the fish sank to the bottom of the sea it was covered with ooze, sand, and other things. After a long time its bones were turned to stone and the fish became a fossil.

The remarkable fossil of *Portheus* was found in western Kansas chalk beds in 1952 by scientists from The American Museum of Natural History. The diagrams on this page show how *Portheus,* with its last meal inside, became a fossil and was eventually uncovered.

Fossils are the remains of living things that have been preserved in rock through the ages. They give scientists important clues to solve the mysteries of past life on the earth, and to imagine what life of old looked like.

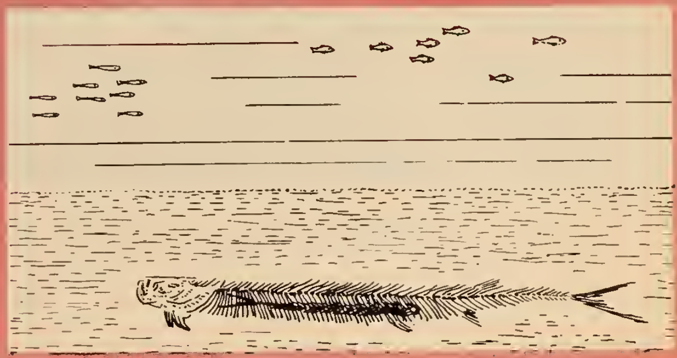
Fossils come in many forms. One kind is the pattern of a leaf pressed in ancient swamp ooze that later hardened into rock. Another kind was formed when insects that lived millions of years ago were trapped in the sticky pitch oozing from pine trees and became coated with it. Eventually the pitch hardened into amber.

Most fossils we find are only parts of the original animal or plant. Usually they are the hard parts such as shell, bone, or teeth. The flesh and skin are eaten by other animals, or they decay.

Fossils are usually found in sedimentary (sed-e-*men*-tary) rocks. These rocks, such as sandstone and limestone, are formed as layer upon layer of clays, mud, sand, and other materials are laid down layer upon layer. Over millions of years the layers of sediment harden into rock. At the bottom are the older layers, and near the top are the newer layers.

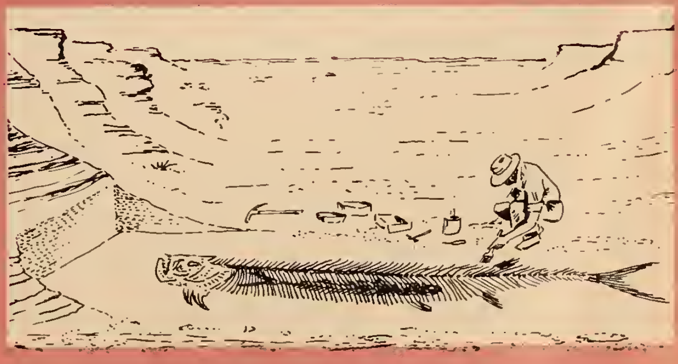
On the next pages, you will read about dinosaurs, which we know about almost entirely through the study of fossils found in sedimentary rocks■

1 Ninety million years ago, Portheus caught a 6-foot-long fish (Gillicus) and then ate it head first.



2 Portheus died and sank to the bottom of the sea. After many years, its bones were buried by clay and sand.

3 Over millions of years, the bones were buried still deeper. Then wind and water wore away the clay and sand.



4 Eventually, part of the Portheus skeleton was uncovered, and in 1952 scientists found the remarkable fossil.

Some dinosaurs, like Brontosaurus (left) ate only plants, as did the armored Stegosaurus (left center). Like the giant Allosaurus (center), others ate only meat. Some dinosaurs (Podokesaurus, right) were as small as a dog.

WHY DID THE DINOSAURS DIE OUT?

These remarkable animals ruled the earth for millions of years, then they mysteriously disappeared, and no one knows why.

■ Dinosaur means "terrible lizard." Although they weren't really lizards—but relatives of present-day reptiles such as snakes, turtles, and crocodiles—some dinosaurs were surely terrible.

The mightiest and most terrible of all was *Tyrannosaurus rex* (tye-ran-o-*saw*-rus), whose name means "king of the tyrant lizards." *Tyrannosaurus,* the largest meat-eating animal that ever lived, was 50 feet long and about 20 feet high. It could have poked its great head armed with teeth that looked like sharp six-inch-long knives into a second-story window.

But, in spite of "monster movies," there is no danger that you will look up from your reading some night and find a *Tyrannosaurus* staring hungrily into your window. The last dinosaur disappeared from the earth nearly 70 million years ago—long before the first human beings appeared on the earth.

This article and the article on page 3 were prepared with the advice of Dr. Edwin H. Colbert, Chairman and Curator of the Department of Vertebrate Paleontology, The American Museum of Natural History, and Miss Marlyn Mangus, Scientific Assistant in the department.

The "king of tyrants" was only one of many kinds of dinosaurs. *Brontosaurus* (bront-o-*saw*-rus) or "thunder lizard," measured 70 feet long and weighed 35 tons or more. It must have really jarred the earth as it stamped along. In spite of its size, this giant reptile lived on plants. Probably, because of its great size, *Brontosaurus* spent most of its time in shallow water, half walking and half floating through the swamps.

The smallest known dinosaur was only two and a half feet from its three-inch head to the tip of its tail. And there were many shapes and sizes in between.

Where did these creatures of the past come from? What did they look like? Where and how did they live? And why did they die out? We can answer all of these questions but the last one. After more than 100 years of study scientists still don't know why the dinosaurs died out.

If no human being has ever seen a dinosaur, how do scientists know so much about them?

Dinosaurs Preserved in Rock

The story of the dinosaurs has been preserved in rocks that contain the remains of plants and animals (see page

3). By studying these remains, or *fossils* as they are called, scientists can tell what an animal or plant looked like. Fossils also give us a very good idea of how the world looked at different times in the past, even though no human being was there to observe it.

Scientists have found fossil remains of dinosaurs in the United States, Canada, South America, England, Europe, Africa, Asia, and the Australian region. In the United States, Utah, Wyoming, Colorado, New Mexico, and Montana have been the richest grounds for dinosaur fossils. Perhaps such fossils can be found in your area.

You can see that dinosaur fossils are not rare at all. In fact, you can buy rocks with dinosaur footprints in them. And, not so long ago, three New Jersey school boys discovered some fossils of the oldest known flying reptiles in a quarry near New York City.

Ancestors of the Dinosaurs

Where did the dinosaurs come from? By studying fossils scientists can tell that there was a time—more than 200 million years ago—when there were no dinosaurs (see chart on pages 8 and 9). Then, the ruling land animals were giant amphibians. These creatures were distant ancestors of our present-day frogs, toads, and salamanders, but were much larger.

Amphibians can live in or out of the water, but most of them must lay their eggs in the water just as frogs do today. Gradually, over millions of years, the descendants of some of the amphibians changed so that they could live on land all the time. These "changed" amphibians were the first reptiles, and they were the ancestors of the dinosaurs, the largest land animals in history.

Just how these changes took place, or why, is a mystery of science that no one has solved. But scientists know that certain important changes had to happen before animals could exist on land. One important change was in the eggs laid by the amphibians.

If you have ever seen the eggs of frogs or salamanders, you know that they are laid in the water in jelly-like masses and don't have any shells. You may also know that when frogs' eggs hatch, the young don't look like frogs at all. Instead they look more like fish and are called tadpoles or polliwogs. Tadpoles are suited for living in water but not on land.

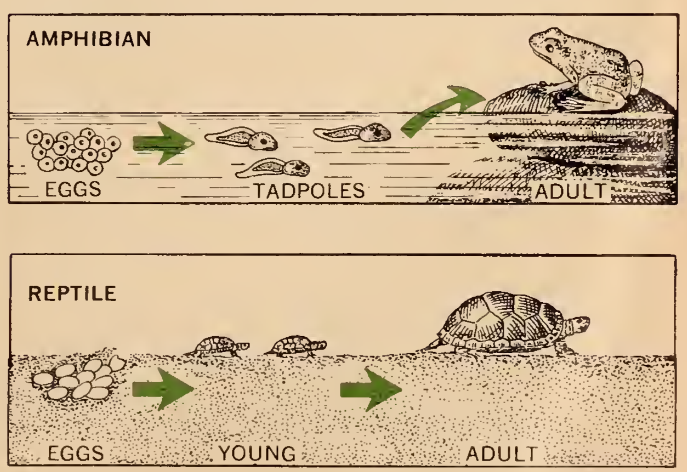
If a frog laid its eggs on land, the eggs would dry up because they have no shells. The eggs would not hatch because the growing tadpole needs water in order to live. Animals could not live on land until they were able to lay eggs with shells. The shells kept the liquid inside of the egg from evaporating. Scientists have found quite a few nests of fossil dinosaur eggs, and the fossils show that the eggs had shells (see diagram and photograph).

When reptile eggs hatch, the young are small models of their parents. Unlike the tadpole stage of frogs which must live in water, young snakes and turtles are "all ready" for land living. So it must have been with baby dinosaurs. The amphibian eggs changed so that they hatched into babies that could live on the land. When this happened, the amphibians had gradually become reptiles, able to produce young on land.

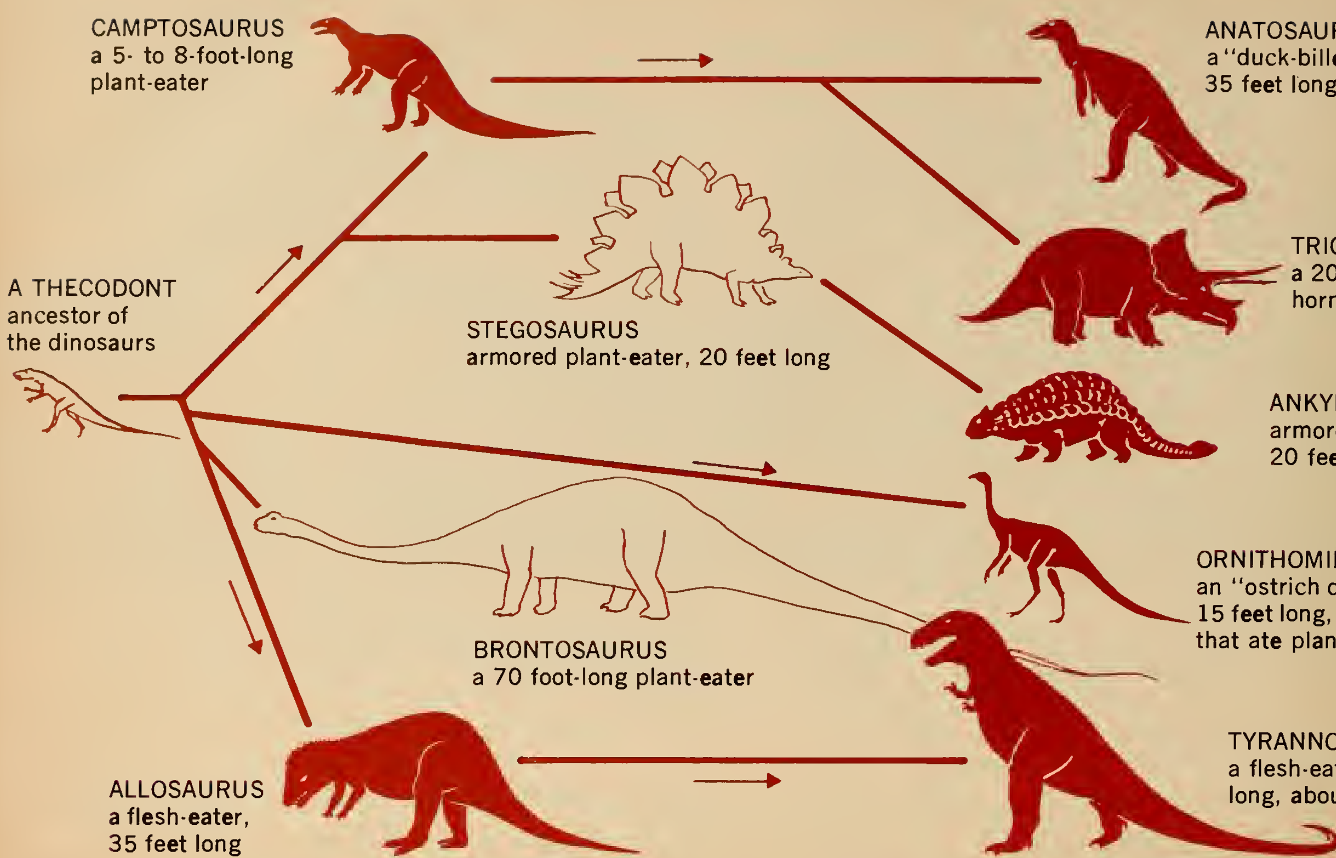
Once they were fitted for life on the land, reptiles added many new branches to their family tree. Turtles, which have come down through the ages almost unchanged, were early reptiles. So were snakes and lizards.

Another early reptile walked on its hind legs and used arm-like forelimbs to grasp and hold its prey. This animal, called *thecodont* (*theek*-o-dont), was about four to six feet long. Thecodonts were the ancestors not only of

Study of fossils has helped scientists make accurate models of dinosaurs. This one shows baby horned dinosaurs hatching. Many dinosaur egg fossils have been found.



Most amphibians lay their eggs in water. The eggs, which do not have shells, would dry up if laid on land. Reptile eggs have shells, so they do not dry up on land.



The dinosaurs, which came in many shapes and sizes, developed from early reptiles. The dinosaurs were the biggest land animals that ever lived. Can you think of an animal living today that is larger than any dinosaur?

modern birds and crocodiles, but of the largest and most powerful land animals the world has ever known—the dinosaurs, which ruled the land for millions of years.

Lives of the "Terrible Lizards"

Some dinosaurs such as the mighty *Brontosaurus* ate only plants. Others were flesh-eating beasts. Some walked almost erect on their hind legs. Others moved on all fours like lizards of today.

Before we take a closer look at the dinosaurs, we should remember that they were the kings of the land animals for more than 100 million years. During that very long time there were many kinds of dinosaurs, but not all of them lived at once.

Scientists call the time of the dinosaurs the Age of Reptiles and divide it into three periods of millions of years each. *Brontosaurus* lived in the second period and had disappeared from the earth long before *Tyrannosaurus rex* became ruler.

Although *Brontosaurus* held the record for being the heaviest during the second period, some others took the prize for odd shapes.

One was called *Stegosaurus* (steg-o-*saw*-rus), which means "covered lizard." It was a strange, armored, hump-backed beast weighing some 10 tons. *Stegosaurus* carried its pin-shaped head close to the ground, and along its backbone was a double row of huge triangular bony plates. What they were used for remains a mystery. It also had four great spikes along the top of its tail. These were probably used as a weapon in combat.

Later, in the third period of the Age of Reptiles, there were dinosaurs that looked like giant armadillos. Some had armor plating of spiked and studded skins, while others had horns like those of the rhinoceros.

In this last period of dinosaur life, the two-legged dinosaurs were equally odd. Some—called *trachodons* (*trak*-o-dons), meaning "rough teeth"—had flattened skulls and duck-like bills. *Tyrannosaurus rex,* the truly terrible lizard, came into his own near the very end of the Age of Reptiles, about 70 million years ago.

It would be difficult to imagine a creature better equipped for both attack and defense. Yet when the Age of Reptiles came to an end, *Tyrannosaurus rex* disappeared, as did the smallest of the dinosaurs. But the turtles survived. So did the crocodiles, the snakes, and the lizards. Why not the dinosaurs? Why did they vanish after so many years of ruling the land?

Attempts to Solve the Mystery

Over the years many scientists have tried to unravel the mystery. Following are four interesting attempts to explain why the dinosaurs died out about 70 million years ago, leaving only fossils as clues to their past.

1. Climate Changes: During the Age of Reptiles the earth went through many changes. Climate and plant life changed very much, but the changes were not sudden. They took place ever so slowly. Some places that had been tropical lowlands with palm trees slowly became cooler hardwood forests. Could this climate change have affected the dinosaurs?

It may be that the plant-eating dinosaurs no longer had the tropical food plants they needed, and began to die out. This in turn meant that the flesh-eating dinosaurs also began to lose part of their food supply, and many of them died.

But if this is so, why is it that the close relatives of dinosaurs, the crocodiles and other reptiles, did not die out also? Lower temperatures and changes in plant life over millions of years cannot be the only reason why the dinosaurs died out. There must be other reasons as well.

2. The Coming of Mammals: The Age of Mammals followed the Age of Reptiles (see pages 8 and 9). But, once again, the change was slow. Some of the mammals appeared on the scene millions of years before the last of the dinosaurs died out.

The early mammals may have been better hunters than the dinosaurs and competed with them for food. Some of the mammals probably robbed the dinosaur nests of eggs, and so helped the dinosaurs along the road to death. But it is not likely that egg-robbing alone led to the end of dinosaur life.

3. As a Group, Did the Dinosaurs Die of "Old Age"? We know that each individual animal, such as a cat or a dog, has a certain number of years to live. Some scientists suggest that an entire *group* of animals—such as all elephants—also has only a certain length of time to live. The scientists who think this is so say that all elephants and all horses on earth will die out because of "group old age" some time in the distant future. They think this is what may have happened to the dinosaurs.

4. Did the Dinosaurs' Eggs Fail? Over the years many fossils of unhatched dinosaur eggs have been uncovered

Drawing by Ned Hilton

"Take a telegram to the Museum of Natural History."

in southern France. The eggs were laid by dinosaurs living near the end of the Age of Reptiles. Some scientists believe that the unhatched eggs tell a story of their own.

For some reason their eggs would no longer hatch, so the animals died out. But other scientists think that too few unhatched eggs have been found to make this a very good explanation. They have found only a few hundred compared with the vast numbers of eggs that must have been laid during the millions of years these last dinosaurs inhabited the earth.

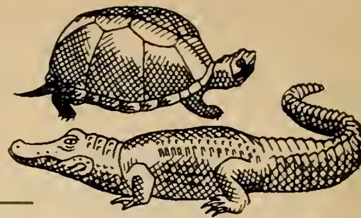
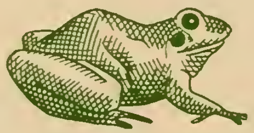
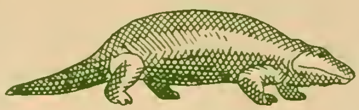
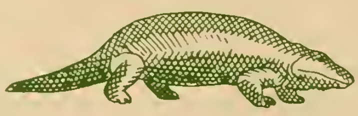
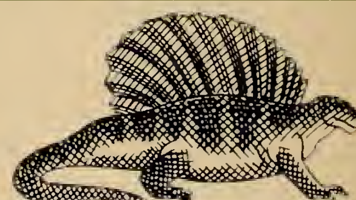
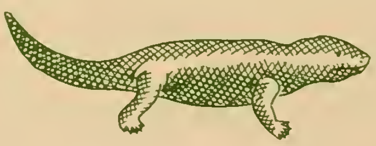
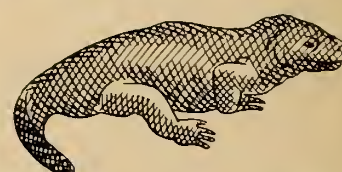
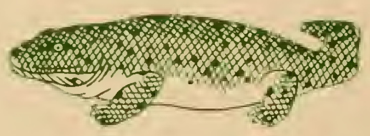
What Is the Answer?

Many other attempts have been made to solve the mystery of the dinosaurs' disappearance, but no single one by itself seems to answer the question once and for all. If the answer is ever found, it may be a combination of two, three, or more of the theories.

For whatever reasons the dinosaurs disappeared from the face of the earth, one thing about them is certain. They were a splendid success. The dinosaurs ruled the earth for more than 100 million years. This is hundreds of times longer than man has been master of the earth ■

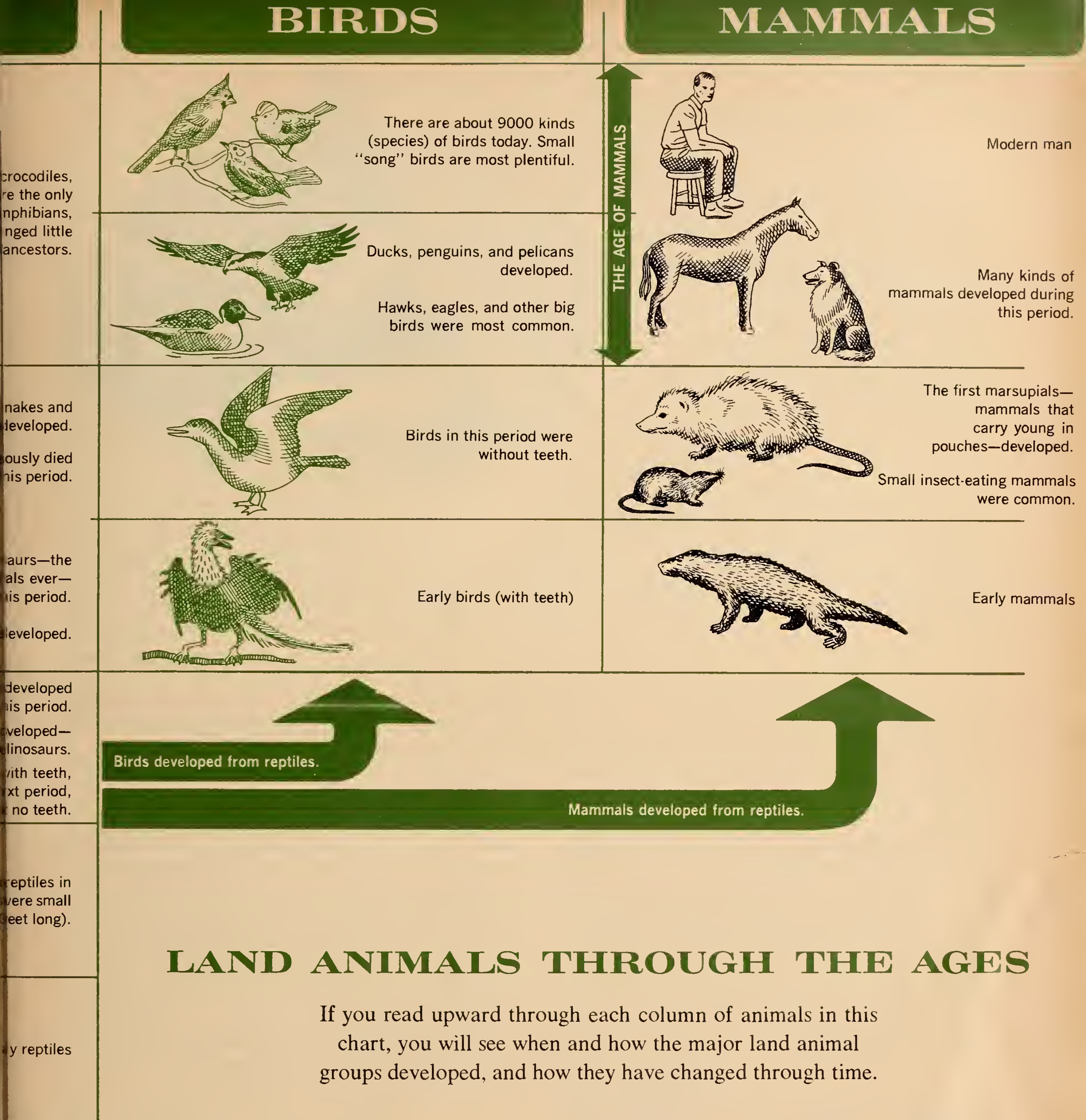
PROJECT

The next time someone in your house cooks a chicken or turkey, save all of the bones. When you have collected them all, boil them to get off as many of the bits of meat as you can. When the bones have cooled and dried, you can pick off the remaining bits with tweezers. When all the bones are clean, see if you can put the animal back together again. If you use copper wire as a frame, and glue the bones together, you can mount the skeleton.

Groups of Animals ▶ When the Animals Lived ▼		AMPHIBIANS	REPTILE
From present to 3 million years ago	QUATERNARY	 Frogs, toads, and salamanders are the most common amphibians today. They are very much like their early ancestors that developed millions of years ago.	 Lizards, sn and tu reptiles today. they ha fron
3 million to 63 million years ago	TERTIARY	 Salamanders developed.	
63 million to 135 million years ago	CRETACEOUS	 As far as we know, frogs and toads were the only amphibians during this period.	 croc Dinosaurs out at the e
135 million to 181 million years ago	JURASSIC	 Early frogs and toads developed.	The bigge largest lar lived d Early l
181 million to 230 million years ago	TRIASSIC	 The last of the big amphibians died out.	The first din l  Thecod ancestors Early t developed. I tur
230 million to 280 million years ago	PERMIAN	 Some amphibians were as big as early reptiles. The two groups of animals competed for food.	 There were this period (less th
280 million to 345 million years ago	CARBONIFEROUS	 Amphibians were the only land animals with backbones for a time during this period. Then another group began to develop—the reptiles.	
345 million to 405 million years ago	DEVONIAN	 Early amphibians	
405 million to 425 million years ago	SILURIAN	Amphibians developed from fishes.	

THE AGE OF REPTILES

Reptiles developed from amphibians.



LAND ANIMALS THROUGH THE AGES

If you read upward through each column of animals in this chart, you will see when and how the major land animal groups developed, and how they have changed through time.

A time scale for life on earth has been worked out by scientists who study rocks and fossils. (See the dates in the left column.) Some of the names given to time periods in the scale are named for places. The Jurassic Period, for example, is named for the Jura Mountains of Europe, because rocks of that age form these mountains. Other periods are named for a special type of rock—Cretaceous means "chalk-bearing."

Scientists are not sure of the *exact* number of years in each period of the time scale. But, as they keep gaining new information about the rocks and fossils, they are able to make the scale more accurate.

Drops of liquids do strange things. To find out about them all you need is a medicine dropper, some cooking oil, and a piece of aluminum foil.

WHAT'S IN A DROP?

by David Webster

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

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

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

David Webster is teaching and writing for The Elementary School Science Project of Educational Services Incorporated, Watertown, Massachusetts. He formerly taught science in Lebanon, New Hampshire, and was elementary science supervisor at Lincoln, Massachusetts.

Drops Have Elastic Skins

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

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

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

Watching Falling Drops

You can watch a water drop as it falls and see what happens to it. When they fall through oil, the water drops fall more slowly, so you can watch them all the way down. Get some cooking oil—like Wesson Oil or Mazola Corn Oil—and fill a small jar with the oil. Now put a drop of water on the oil with a medicine dropper or paper straw. The drop will probably float on top. Do you think this means that water is lighter than oil? Push the drop down into the oil with your fingers. Now what do you think? What held the water drop up on top of the oil? Has oil an elastic skin too? If it does, is its skin tougher than the skin of water?

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

Now, for a change, make some drops "fall" up instead of down. Fill a medicine dropper with cooking oil. Put the end of the medicine dropper at the bottom of a glass of water and force out a little oil. Why does the oil drop go up? See if you can find other things to make drops with and experiment with them.

Drops of Air and Solid Drops

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

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

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

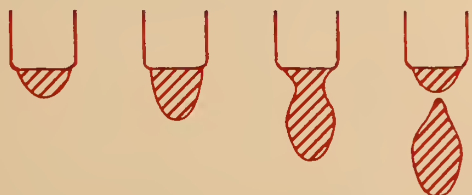
AN INVESTIGATION

MEASURING THE SIZE OF DROPS

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

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

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



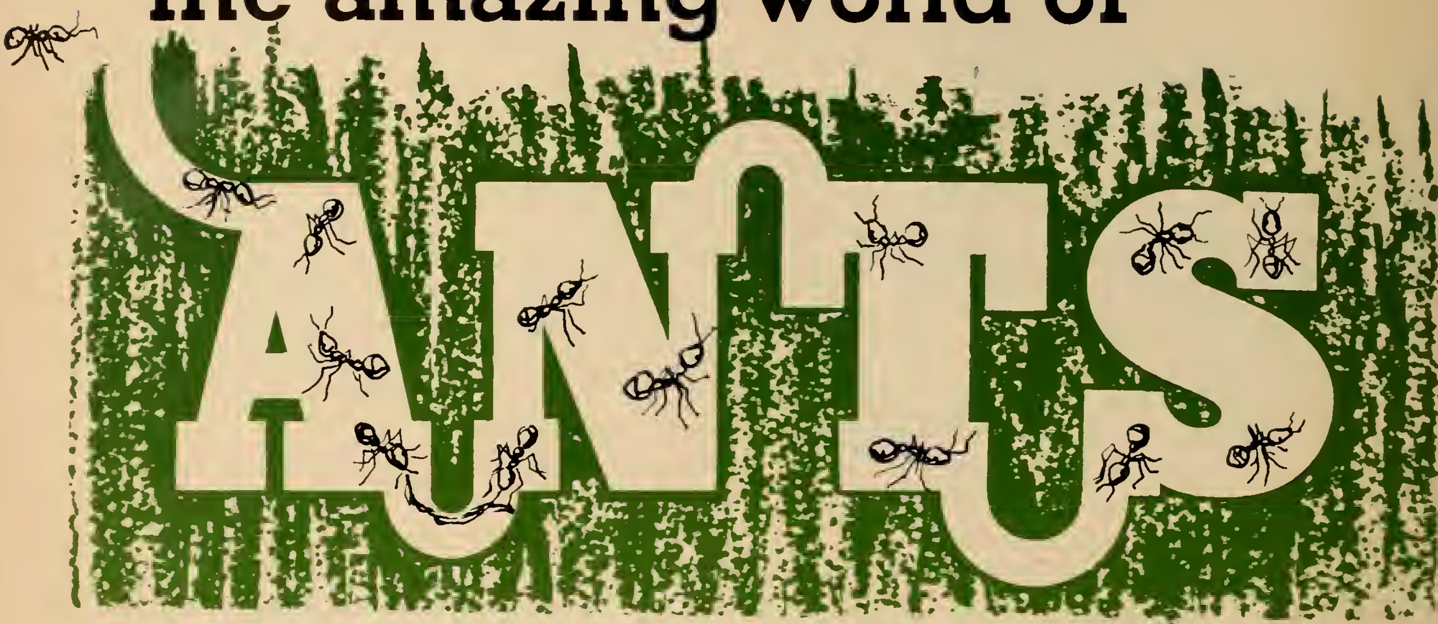
One drop is so small that it is hard to measure alone. But by putting many drops together, you should have enough liquid to measure. Squeeze out several hundred drops of one liquid into a small, narrow bottle like a pill bottle. Before emptying it, mark how high the liquid is. You can stick a piece of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

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

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

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

the amazing world of ANTS



by Paul Showers

Some ants are skilled gardeners and raise food. Others keep "slaves" and store food in them. Many ants can solve problems that you set for them.

▪ Did you ever watch a group of ants swarming over a piece of bread, tearing at it with their powerful jaws? For its size an ant has great strength and will often seize a piece of food several times larger than itself and carry it off to its nest.

Did you ever watch an ant war, with the ants from two different nests locked in deadly combat? Many kinds of ants are savage fighters, biting or sawing off their foes' legs and heads with their jaws, or using their stingers to paralyze or kill the enemy.

How Ants Build Their Nests

There are more than 6000 different kinds (or *species, spee*-shees), of ants in the world, and they have many different ways of building nests and gathering food. Weaver ants in the tropics build their nests of leaves. They bind the leaves together with silk that is spun by the young ants, called *larvae* (*lar*-vee). Some forest-dwelling ants make nests of crude paper. They make the paper themselves by chewing wood.

Most ants nest in the ground. In hot, dry regions the desert ants may tunnel down more than 10 feet until they reach the moisture they need to keep alive.

Some kinds of ants have no fixed home but travel from place to place in large armies. These army ants of Central and South America march overland and carry out great raids. They invade the nests of other insects and carry off the young and the adults as food.

Ants feed on many different things. The harvester ants of the southern and southwestern United States gather grain and grass seeds and take them into their nests. There they strip off the husks and store the kernels for future use.

The parasol ants of Central America grow their own food supply underground. These ants cut up the leaves of nearby trees and bushes. Carrying the leaf fragments over their heads like umbrellas, they march down into the nest. There they chew the leaves into a soft mass and carry it into storage tunnels. In these dark gardens a

Paul Showers is the author of several young people's biology books, and is a staff member of the New York Times Magazine. *This article was prepared with the advice of Dr. T. C. Schneirla, Curator of the Department of Animal Behavior, The American Museum of Natural History.*



Weaver ants, as shown above (left), pull leaf edges together and bind them into nests with silk spun by young ants. Some honeypot worker ants (center) are used as food tanks. Other workers pump food into them. Parasol ants (right) carry cut-up leaves to their nest, where the leaves are used to grow a fungus that the ants eat.

certain kind of plant, called *fungus,* begins to grow on the moist leaf pulp. The fungus, not the leaves, is the food that the parasol ants live on.

Ant Colonies and the "Honeypots"

Ants are called *social insects* because they live together in groups or colonies, never alone. Each ant performs certain duties. Every colony has a queen ant surrounded by soldier ants and various other kinds of workers. The queen lays the eggs, which means that she is the mother of the entire colony. While the soldiers—the largest workers—defend the nest, the medium-size workers gather food. The smallest workers spend most of their time taking care of the queen and her brood of young ants.

One unusual kind of ant—the honeypot—uses some of the workers of the colony as food storage tanks. The food gatherers bring honey to the nest. There they pump it into the crops, or pouch-like storage stomachs, of other workers. These storage crops, which are called "social stomachs," swell up to such a size that the ants cannot move. All they can do is cling to the ceiling of the nest. There they remain, ready to supply the other workers with food when it is needed.

Scientists interested in the behavior of animals have carried out many experiments to find out how ants see, smell, feel, and how quickly or slowly they learn to solve problems. We know, for example, that ants have a keen sense of smell, located mainly in their feelers. By smell, each ant knows whether the other is a friend from the same nest or an enemy from a strange nest.

If their feelers are coated with varnish, their sense of smell is blocked and strange things can happen. Or, using a fine brush, you can coat an ant's body with vanilla to give it a new and stronger odor. Then two ants from the same nest may fight each other. On the other hand, two coated ants from different nests may get along peaceably, even though they usually are enemies.

How Ants Find Their Way

Trailmaking ants leave behind them invisible pathways of scent as they go to and fro. These trails of chemical scent can lead to a food supply and the trails are followed by other ants of the colony. You might be able to see this happen around your own house. If you find a train of ants, draw your finger firmly across their path and see if this breaks the scent trail.

Other kinds of ants do not rely on scent trails but depend on their eyes, being guided by lights and shadows. If you shine a light on the path they follow to and from the nest, and then change the position of the light, you can confuse them.

A good way to study the ability of ants to learn is to build a maze. It is a kind of puzzle they have to solve. An ant maze has narrow passages leading from one into another. The passages come to a dead end here and there. When there is a branching of the path, the ants must learn to take the open turn, avoiding the one that leads to a dead end. At one end of the maze is the ant nest; at the other end is a box of food. In order to reach the food, an ant must leave the nest. Then it must find its way through the maze and into the food chamber.

At first the ant makes many mistakes. It takes wrong turns, comes to dead ends, and has to turn back. But, little by little, the ant learns to make correct turns. Finally it learns to make the trip from the nest to the food box without making a mistake.

You can make your own ant maze and set up a number of problems for the ants to solve. Then you can observe them as they learn to master the maze. In a future issue we will show you how to build an ant maze.■

AN INVESTIGATION

How do ants communicate? Swat a fly and drop its body a few inches from the entrance to an ant nest. How long does it take for the first ant to find this food material? What does the first ant do after finding the fly? How soon do other ants come? How many come? What do they do with the fly?

A Man Who Likes Wolves

A great American naturalist, Adolph Murie made the Alaskan wilderness his home.

▪Adolph Murie probably knows as much about wolves as any man alive. The howl that inspires a shiver in the hearts of most men is, to Murie, the music of the North. He has devoted his life to the study of animals in the wild. A paperback edition of the book describing Murie's life work, *A Naturalist in Alaska,* was recently published by The Natural History Library.

In Alaska, his second home, Murie has tracked grizzly bears, lynx, and wolves. He has tried to imagine what goes on in the minds of these creatures.

Murie and his older brother Olaus grew up in Minnesota on the Red River. As boys they swam, skated, and explored in prairie and woodland untouched by machines. Their love of the out-of-doors was so strong that they decided to give their lives to the study of wildlife.

Adolph Murie first went to Alaska in the summer of 1922 as assistant to his brother. By this time Olaus had already spent two summers and a winter in the Hudson Bay region studying caribou.

In 1939, the National Park Service, which supervises and protects park and wildlife areas, asked Murie to study the wolves in Alaska's Mount McKinley National Park. What do wolves eat? How do they hunt? How do they behave toward each other? To answer such questions, Murie spent three springs and summers, two autumns and a winter in the 3000-square-mile park.

Murie knew that any student of nature working in the wild has to be a good detective. To learn how wolves live, his first task was to find a family of them. Next he would have to observe the animals to discover exactly how they lived. But how was he to find a wolf den?

Face to Face with a Black Wolf

One day in May, Murie saw wolf tracks leading up and down a stream. He knew there was no game upstream to attract the wolves. What else could interest them? Murie followed the tracks upstream for more than a mile, then he reached a point where the tracks led up and over a high bank bordering the river. Suddenly he found himself face to face with a black wolf.

As surprised as Murie, the wolf ran for a quarter of a mile before stopping to howl and bark a warning. Murie continued to follow the tracks. Soon he found what he had hoped for—a wolf den. When he was within a few feet of it, a frightened female wolf rushed out past him to join her mate. Murie walked up to the entrance and listened. From deep inside came the soft whimpering of

This article is based on the book A Naturalist in Alaska, *by Adolph Murie, published in 1961 by Devin-Adair.*

pups. He wriggled into the burrow, which was only 16 inches high and a scant 25 inches wide. Inside were six pups.

From that time until July 7 he observed the family every day. Almost immediately he discovered that a wolf family does not always consist of only two adults and their pups. Three other adult wolves seemed to be a part of this family group. Possibly they had been hunting when Murie first found the den. One of them was a female who helped the mother wolf care for her young. The other two were gray males. One moved slowly and carefully as though he were old and stiff. Murie called him "Grandpa." Sometimes the wolves hunted singly, other times in twos and threes, and still other times as a pack.

Preparing for a Hunt

Before the wolves left for their nightly hunt they joined in what appeared to be a hunting ceremony. There was much tail wagging, frisking, and jumping about. This kind of play would end suddenly as the wolves pointed their muzzles skyward, howled, then trotted off. Several times Murie followed the hunt. Except in June and July, when there is little snow in the park area, the wolf tracks served as a clear record of the hunt. Signs of stalking, the chase, the kill, all were clearly "written" in the snow.

Wolves, Murie observed, are not always successful hunters. Time and again Murie watched hunts in which the wolves failed to catch their prey. This can happen for several reasons. If they are after mountain sheep, the rams, which are skillful fighters, often drive the wolves off. The lambs, after a few days, can run as fast as their parents. Unless a wolf can surprise the herd, the sheep usually escape among high rocky ledges where the wolf cannot keep up.

The Web of Nature

Murie does not agree with the popular view of the wolf as one of nature's "villains." Along with the other animals, wolves are simply part of the web of nature. The number of wolves, of sheep, of all living things in an area is everchanging. For example, suppose that an epidemic kills most of the wolves in an area. This could cause an increase of animals that the wolves feed upon —among them sheep and caribou. Over a period of time there would be too little food for the increased number of sheep and caribou. The result would be starvation for many of these animals.

In the meantime the wolves would have recovered from the epidemic, so the number of sheep, caribou, and wolves would again be about the same as it was before the epidemic. Nature tends to keep a balance of this kind.

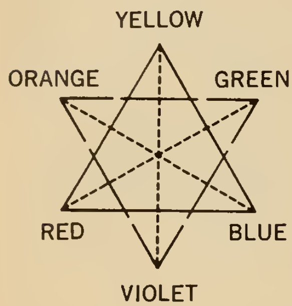
In nature's vast web each strand is important to every other strand. Change the number of strands, remove any one, and the entire web is affected. Man, too, is a part of this web, as are the forests, rivers, and oceans. This is what Murie means when he says that wolves should not be judged as either good or bad. They are simply a part of the wilderness scene. Foxes, grizzly bears, sheep, lynx, and man all have their place in the balance of nature ■

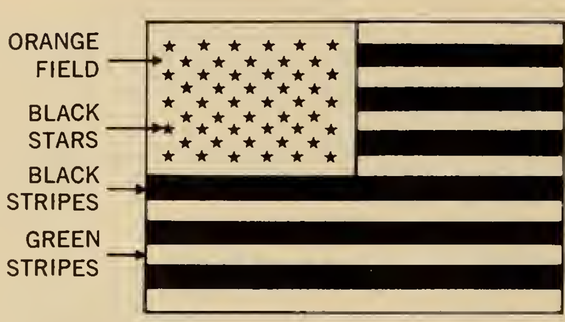
—Virginia Coigney

Murie's family lived with him in Alaska while he studied the lives of wolves. They made a pet of one wolf pup (center) named Wags, and kept him until he grew up (right). Wolves are not "villians," as some people believe. Like sheep, caribou, and foxes, wolves play an important part in the "web of nature" (see story above).

brain-boosters

Do you think that it is possible to take a photograph of a mirage? If so, why do you think so? If not, why do you think that it is not possible?





■ **Changing Colors**

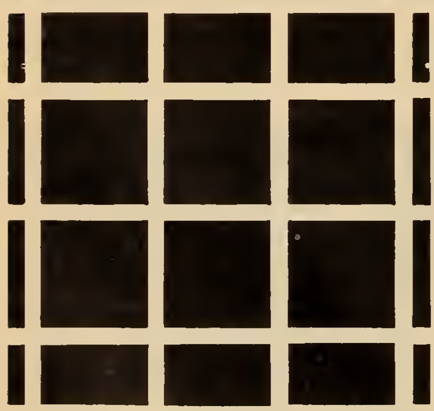
Have you ever seen a red spot turn green? Or a blue spot turn orange?

If you look at a big spot of color on a sheet of white paper long enough, the eye seems to get tired of seeing the color. Then if you look immediately at a piece of blank paper the eye sees a different color.

To prove this, take a red crayon and make a solid red spot about two inches across in the center of a piece of white paper. Now place the paper under a bright light and stare at it steadily for half a minute. Without moving your eyes, replace the piece of paper with the red spot with a blank sheet of paper. If you keep staring at the blank paper for a few seconds without blinking, you will see a green spot appear.

This is what happens: white light is made up of all colors. After the eye has looked at the red spot, say, for a long time, it grows tired of seeing red. When you next stare at a white sheet of paper, the eye sees the white, but subtracts the red. What happens is that you see the *complement* of red, which is green. (By looking at the star diagram marked with colors, you will see that the complement of yellow is violet, the complement of orange is blue, and so on.) Experiment with these colors as you did with red.

You can see a striking optical illusion in color if you draw an American flag the following way. Color six of the stripes black and color the other seven green. Next, color the star field orange and fill it in with black stars. Make your figure about the size of a sheet of typewriter paper and hang it on a white wall when the room is brightly lighted. Stare at it steadily for about half a minute and then look away from it at a blank section of wall. What colors do you see? Does the star diagram showing the complements of colors give you an idea?

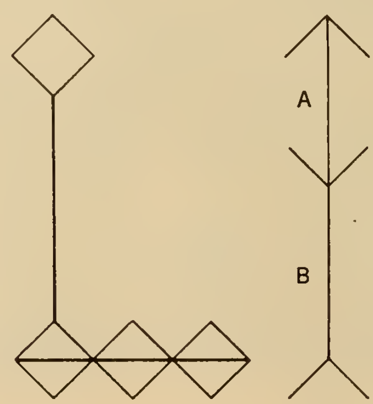


■ **The Disappearing Dots**

Do you see spots in front of your eyes? You should when you look at this figure made up of solid squares and white paths. Every time you try to look directly at a dot, it disappears. New dots appear and then disappear as you move your eyes over the figure. Does this happen because of the way you look at the figure? Or do you think that very faint dots are printed at the crossroads? How could you find out?

■ **Which Line Is Longer?**

Actually, each of the heavy lines in the L-shaped figure is the same length. Why do you think that the

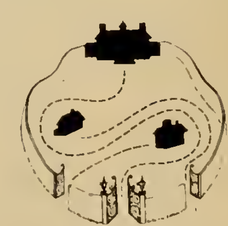


up-and-down line appears longer than the one going across? Study this figure, then look at the other line with the arrows. Part B of the line with the arrows appears to be longer than Part A. This happens for the same reason that the up-and-down line appears longer than the line going across.

Can you think of a reason for this being so? Cover up the diamonds and the arrows, then look at the lines. Now measure them.

■ **Solutions to Brain-boosters appearing in the last issue**

Paths of Friendship: The three neighbors built private paths to the exits of the park this way.



A Southern Exposure: The house which has four windows, each on a different wall, but each having a southern exposure, is built at the North Pole. At the North Pole there is only *one* direction—south.

nature and science

PILOT ISSUE NO 2 / APRIL 1963

TEACHER EDITION

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Your introduction to NATURE AND SCIENCE a new science magazine for the elementary grades

AMERICAN MUSEUM OF NATURAL HISTORY
Central Park West at 79th Street, New York 24, New York

Dear Colleague:

Here is Pilot Issue No. 2 of Nature and Science. Last month we announced this new science magazine for young people by making a nation-wide mailing of more than 300,000 copies of Pilot Issue No. 1 to teachers in elementary schools, grade supervisors, administrators, science supervisors, and others concerned with the teaching of science. With Pilot Issue No. 2 we ask you to "have another look at us."

In our role as educators, we at The American Museum of Natural History have long felt that such a publication has been needed both in the classroom and in the home. To bring Nature and Science to teachers of the middle and upper elementary grades, the Museum has combined its scientific and educational resources with the publishing resources of Doubleday & Company, Inc., in an effort to publish a children's magazine that ranges over the entire spectrum of science—including botany and zoology, physics, astronomy, chemistry, and mathematics.

What, exactly, are the educational goals that we have set for Nature and Science? We believe that the wide range of facts assembled by science—whether in the field of animal behavior, astrophysics, or plant physiology—can be made interesting and significant to children, and that children want to know about them. But we also know that, in the past, well-intended attempts at popularization sometimes have had an undesirable result: the facts of science too often have been presented as science itself. We intend to show what science actually is, so that every child will appreciate the excitement and wonder that is available to every growing mind as it discovers the natural world.

Thus in Nature and Science we hope to show the child that science is not an exotic jungle of fascinating facts, but much more a way of looking at and understanding the ever-changing world around us, a way of seeing the variety in nature and the laws of nature. We feel that science should be portrayed as an endless search in which the individual, whether professional or amateur, is always discovering something new for himself—and occasionally discovering something new for mankind.

James A. Oliver

Dr. James A. Oliver
DIRECTOR

…School Year • Individual Student Activities • Teacher
…Teaching Aids and Materials • Book Reviews • Science
Projects • Science Workshop Features • Special Topic
…Edition with Each Issue • Brain-Boosters • Science Mysteries

In this issue of *Nature and Science* are three features describing past life on earth. The pictorial article on page 3 is about fossils and shows how a 90-million-year-old fish was discovered in a Kansas chalk bed. This article and the main article about the extinction of dinosaurs are both put in the perspective of vast spaces of time on the chart on pages 8 and 9.

The purpose of the chart is twofold: First, it shows at what points in geologic time the amphibians, reptiles, birds, and mammals populated the earth. Second, it shows a few of the changes that took place among these groups of animals since they developed.

Page 3: A Fish That Became a Fossil

This article describes one of the most remarkable fossils ever found—that of *Portheus molossus,* a Cretaceous fish that lived about 90 million years ago.

Many local or state museums and universities have excellent collections of fossils. You might arrange a class trip to such a museum to study the rock types in your area and to find out what kinds of fossils—if any—may be found locally. Usually a member of the museum staff will be happy to talk to your class about the rocks and fossils of the area, if the museum is notified in advance of the trip.

You could also write to the Office of the State Geologist, or to a geologist at the state university, and ask for information and sources of maps of possible nearby fossil-collecting areas. Good collecting sites are areas of exposed sedimentary rocks, such as rock quarries, coal mines, road and railroad cuts, and stream beds.

You could encourage a group of your pupils to start a labeled fossil collection that could be kept as a permanent classroom collection.

Page 4: Why Did the Dinosaurs Die Out?

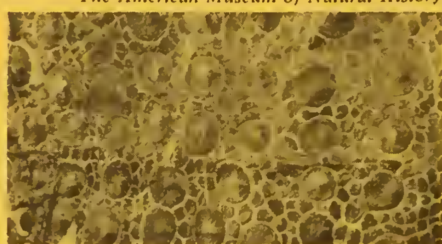
This article will help you bring out several major concepts in life science. One is that animal life has constantly changed through the ages, as shown on pages 8 and 9, but these changes have been much too slow to observe directly.

Another concept is that to survive, living organisms must adapt, or change, to fit into their changing environment. But again, these changes are usually too slow for us to observe directly. In the case of the dinosaurs, the animals survived for more than 100 million years. Then, for some reason unknown to us, or for a combination of reasons, the animals failed to adjust to changing conditions and died out.

Raising and caring for living reptiles native to your region should give your pupils some appreciation of the climate conditions in which some of the dinosaurs lived.

The special care required for present-day captive reptiles, such as turtles, points out the needs of this group of animals. Many turtles kept as pets developed a softening of the shell and bones that usually leads to death. This softening is due to a lack of enough sunlight, warmth, and an insufficient diet of foods containing calcium. (You will find several suggestions for keeping classroom reptile pets in *Teaching Elementary Science: A Sourcebook for Elementary Science,* Hone, Joseph, etc., Harcourt, Brace & World, Inc., 1962, $7.50.)

The American Museum of Natural History



This fossil fragment shows in detail the bony plates on the back of a 12-foot-long armored dinosaur found in North America.

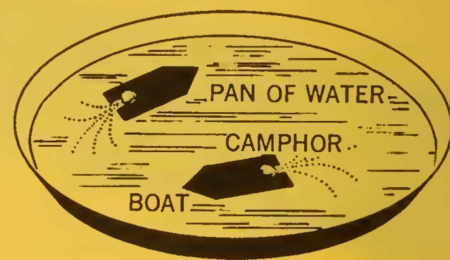
Imprints that the dinosaurs left in rock provide important clues about these animals. You can demonstrate how this particular type of fossil is formed by using a flattened piece of modeling clay and an object such as a shell, leaf, or twig. Press the shell or other object into the surface of the clay. When the object is removed, the imprint is plainly visible in the clay. You can explain to your pupils that imprints of this type reveal, among other things, the skin texture of animals that lived millions of years ago.

The suggestions for using this issue of Nature and Science *in your classroom were prepared by Kenneth Bobrowsky, Bank Street College of Education, and the Bronx High School of Science, New York, New York.*

Page 10: What's in a Drop?

This article by David Webster will introduce your pupils to some of the physical concepts of surface tension in fluids. Surface tension is the resistance of the surface film of a liquid to rupture. This phenomenon appears at the surface of a liquid or at the meeting surfaces of liquids of different densities.

Moving a "Boat" by Surface Tension: You can use camphor to reduce surface tension and so produce motion. Cut a few "boats" from soft wood or stiff paper (see diagram), each about two inches long. Next cut a notch in the rear large enough to hold a piece of camphor about the size of a pea. The camphor should be about one third submerged. Float the boats in a pan of water. The reduction of surface tension by the camphor at the rear of the boat will cause the boat to move forward.



A demonstration of surface tension.

One Effect of Soap on Surface Tension: Dust a film of talcum powder on the water in a pan. With a wet piece of soap touch the water near the edge of the pan. You will see that the powder begins to move to the opposite side of the pan. By weakening the attraction between molecules forming the surface of the water, the soap reduces the surface tension at the point of contact. The tension on the opposite side of the pan remains the same, with the result that the powder is "pulled" to that side.

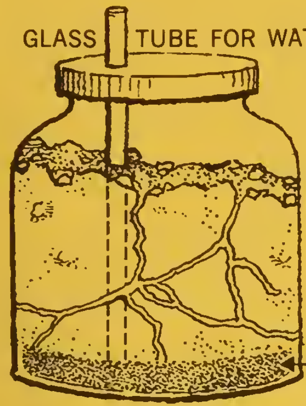
One of the most delightful and informative books about surface tension is *Soap Bubbles,* by C. V. Boys, a Doubleday Anchor Book in the Science Study Series, Garden City, N.Y., 1959, 95¢. You will find this classic volume a rich source of demonstrations. Another paperback edition of this title is available from Dover Publications, Inc., New York, N.Y., 1958, 95¢.

Page 12: The Amazing World of Ants

In this article Mr. Showers describes some fascinating types of ant behavior which should delight your pupils.

After reading the article, some of your pupils may wish to carry out investigations in ant behavior and the ways ants form colonies.

A simple ant colony can be set up for observation in a large glass jar. After you or your pupils have collected the ants and placed them in a glass



You and your pupils can keep an ant colony in a two-quart jar for several weeks and observe the behavior of these insects.

jar-nest, you should leave the ants alone in the dark for two days or so. If you do, as they build a new nest they will make some tunnels against the inside of the jar and you will be able to observe them in the nest.

If you want to keep a colony thriving for more than two weeks or so, it is important to find the queen and larvae when you dig the original nest out of the ground.

There are many investigations that your pupils will be able to make with an ant colony. One is the study of ant social castes. Your pupils will see that ant life is highly organized. The castes include soldiers, nurses, builders, and ants that appear to be garbage collectors. Have your pupils try to identify the different divisions of labor of the ants in their colony.

You might have your pupils put an ant from a different nest into the colony. Ask them what they think will happen. Soldier ants that guard the nest may rear on their hind legs and squirt formic acid at the intruder, or attack it with their jaws. Ask your pupils what they think will happen if one member of the colony is isolated outside the nest for two days or so. When the ant is returned to the nest the soldiers may give it a very thorough inspection with their antennae before admitting it back into the colony.

Page 14: A Man Who Likes Wolves

This short account of some of Adolph Murie's research on wolves gives some of the flavor of the life of a scientist whose laboratory is the out-of-doors and whose equipment consists of sharp eyes and disciplined curiosity.

Murie's work presents an important aspect of science to your pupils. His samples were limited, so many of his conclusions must be qualified.

Does this lead us to question Murie's reliability as a scientist and observer? Not at all. But before scientists can predict a behavior pattern of such a complex animal as a wolf, many observations are necessary. This point should be made clear.

The article relates Murie's observations to the study of ecology. The ecologist is concerned with the relationships between a species and its environment, which includes the physical phenomena of terrain and climate, and other living things, including man. The wolf, as predator, plays an important role in nature's web.

We are inclined to use the word "balance" to describe this relationship. It should be made clear that balance in nature is dynamic. New balances appear continually as the environment changes.

We often hear the term "balanced" aquarium. Is an aquarium ever really balanced? Here is a truly challenging problem to present to pupils.

The webs of nature may be studied in many ways. If you start cultures of insects, aquariums, or vivariums, pupils can work out the webs in these simplified environments. Terrariums containing plants make splendid controlled "microenvironments" for class study.

Ants, Turtles, and Verbal Scruples

An article like "The Amazing World of Ants" (pages 12-13) raises some fascinating questions about how one should talk or write about animal behavior. The temptation to read some purpose into the activities (teleology) of *army* ants or *harvester* ants is often strong on the writer and the teacher. Should this temptation be resisted? Here is what Consulting Editor Paul Brandwein has to say:

☆ ☆ ☆

The two sentences that follow seem quite clear and should not produce controversy among scientists or teachers of science. But they do. **Turtles swim to the shore to lay their eggs. Ants lay eggs to reproduce their young.** The bone of contention is the word **to.** To some, it implies a purpose, an end; that is to say, the turtle's behavior is end-directed. The fact is that the turtle cannot be concerned with the survival or extinction of its species. The animal isn't capable of constructing such a problem. To those for whom the statements imply end-directedness, or teleology, the statements would have to be restated:

Turtles swim to the shore **and** lay their eggs.
Ants lay eggs **and** the eggs hatch into young.

To still other scientists and teachers, this problem is one of verbal scruples only. Perhaps we might state the situation somewhat as follows.

Organisms—all organisms—are the product of long evolutionary development. In their development, these organisms acquired a genetic code, or the hereditary message compounded of chromosomes and genes that produced each organism's characteristics *in a given environment.*

An organism (note the word) is organized. To say that living things are organized is to say that they are adapted. Further, to say that an organism is organized is to say that it is organized for certain functions. This means that the turtle doesn't "think" about what it is doing when it goes ashore *to* lay its eggs. It means that its organization is such that it has to go ashore *to* lay its eggs.

This statement doesn't necessarily imply cause, or meaning, or purpose. It is simply another way of describing the turtle's action. Most statements, after all, are largely a matter of style. It is only when style leads to inaccuracy that it becomes objectionable.

If we use the word "abandon" or "desert" to describe the action of a female of a species leaving her young, we imply that the animal is capable of making a judgment akin to man's. Here is a clear case of style leading to inaccuracy by attributing to the animal a faculty which it does not have.

In short, the solution to the problem of teleology becomes difficult only if one seeks in every simple act an answer to the riddle of the universe.

The editors of *Nature and Science* have this goal: to make the teaching and learning of science in the elementary grades *effective, enjoyable,* and *memorable.* By serving you in this way, we hope to make the introduction of science a major source of stimulation and creativity in the lives of young people.

Here are seven ways in which we hope to achieve our goal:

1. CONTENT: We will select the subjects of our articles in order to broaden the scientific curiosity in all young minds. (A sample of the variety of articles we plan is shown below.) In choosing our topics we will be guided by the scientific staff of The American Museum of Natural History, by our consulting editors, and by our National Advisory Board of educators, active teachers, and scientists with a special interest in elementary education.

2. WRITERS: Our articles will be written by men and women who have proven themselves expert in the art of writing science for young people. Many of our authors are now, or were until recently, active teachers of science in the elementary grades.

3. TREATMENT: The variety of articles and activities appearing in *Nature and Science* will be presented in such a way that slower pupils, as well as advanced pupils, will find projects that will interest them. In this issue, for example, David Webster's article "What's in a Drop?" should capture the interest of slow learners, yet there are activities here that will fascinate advanced students as well. "The Amazing World of Ants" on pages 12 and 13 should awaken new interests in slow and rapid learners alike.

4. INNOVATION: We will often experiment with new ways of presenting science. At times the pupil will be enticed into new concepts by means of a series of carefully conceived clues and questions (see pages 10 and 11) that lead the pupil into his *own* investigations.

We will not only present concepts and projects new to the curriculum of elementary science, but we will also devise new ways of enlivening the traditional topics. To carry out this plan we are working with various experimental science teaching groups now developing new methods in different parts of the country.

5. ACTIVITIES: We feel that the "operational" aspects of science must be stressed—science *reading* should be reinforced by science *doing* (and vice versa). Each issue will be rich with suggestions for observations, experiments, projects, and investigations—all simple and safe, yet carefully constructed to be both manageable and stimulating to your pupils.

6. BEYOND THE CLASSROOM: While *Nature and Science* will be edited for the elementary classroom—reinforcing concepts in the curriculum and giving new richness to textbooks—we hope that the ideas and activities in the magazine will spread far beyond the classroom: into the back yards and the woods near the child's home, and beyond school hours into evenings, weekends, and long vacations.

7. TEACHER EDITION: About half of each Teacher Edition of *Nature and Science* will consist of suggestions of ways in which you can use the Student Edition in your classroom. (See pages 2T and 3T of this issue.) Background information, related reading, additional projects and demonstrations, ideas for field trips, and so on will supplement the material appearing in the Student Edition. Furthermore, we will keep you up-to-date about new science books for children and the latest books of professional interest to you.

We will also call your attention to valuable TV science shows, to new films, and to new offerings of science kits for children. We will try to serve as a clearinghouse for new ideas being developed by elementary school teachers as a result of research in science education.

Coming in NATURE AND SCIENCE

A variety preview of the kinds of articles that will appear in NATURE AND SCIENCE beginning with the September 1963 issue.

FEATURE ARTICLES:
SCIENCE MYSTERIES
- Animal Migrations
- What Is a Star?
- Things in the Night Sky
- Echo-Navigation of Bats and Porpoises
- How Animals Become Extinct
- Meteors and Other "Visitors" from Space

FEATURE ARTICLES:
SCIENCE IN EVERYDAY LIFE
- Big Magnets and Little Magnets
- How Things Work: Cameras and Telescopes
- Myths and Superstitions
- Wonderful Ways of Measuring
- The Art of Making Quick Estimates
- Antiseptics and How They Work

FEATURE ARTICLES:
SCIENCE ADVENTURES
- Collecting Fishes in the Jungle
- A Man Who Studies Skunks
- Arrowhead Archaeologists
- Watchmen of America's Wildlife

SPECIAL-TOPIC ISSUES
- The Air around Us
- Early Man in North America
- Understanding Insects
- How Animals and Plants Prepare for Winter

BRAIN-BOOSTERS
- Math Games
- Puzzles with a Purpose
- Cartoons
- Optical Illusions

SCIENCE WORKSHOPS
- How to Weigh the Earth
- Life in a Rotting Log
- The Strength of Different Glues
- Crystal Growing
- Proving the World is Round
- Science and Soap Bubbles

nature and science

VOL.1 NO.1 / SEPTEMBER 20, 1963

What mood is hidden behind the "smile" of this chimpanzee?
see page 3

NEVER SMILE AT A CHIMP

ABOUT THE COVER

Do you think that the young chimpanzee on our cover is showing its teeth as a sign of anger, or as a sign of pleasure?

Like their facial expressions, the grunts, whimpers, and other sounds made by chimps form part of the animals' language. To other chimpanzees, and to scientists who study these remarkable animals, each sound and facial expression has a definite meaning.

Chimpanzees, which live in equatorial Africa, are probably the most intelligent animals among the group known as the great apes. In captivity the animals can be taught to do many things—from roller skating and riding a bicycle to painting pictures *(see page 5)*.

Chimpanzees have four close relatives, and it is these animals that make up the rest of the great apes group—gorillas, orangutans, long-armed gibbons, and the siamang, which is the largest of the gibbons. All of the great apes are so manlike in appearance that they are called *anthropoid* (manlike) apes.

Chimpanzees are strong animals with rather heavy bodies and long legs. Unlike humans, chimpanzees' hands are longer than their feet. The animals sometimes stand on their hind legs and walk upright. But more often they travel on all fours with their hands folded so that they lean on their knuckles. Chimpanzees live in trees 25 or 30 feet above ground.

nature and science

Vol. 1 No. 1 / September 20, 1963

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Contents

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A SCIENCE ADVENTURE

NEVER SMILE AT A CHIMP

by Roy A. Gallant

To understand why animals do what they do, scientists must try to see the world from the animal's point of view. A "smile" usually means pleasant things to us; to a chimp it can be an invitation to trouble.

Dr. Morris and Congo take a few minutes to relax. Congo, a young chimp, was Dr. Morris's special study for three years. The scientist learned that Congo, like other chimps, had a language of facial expressions, grunts, whimpers, and screams.

■ You have probably seen a trained chimpanzee doing tricks on television or at the movies—riding a bicycle, or wearing baggy clothes and carrying on like a clown. In some ways chimpanzees seem to be rather stupid, but funny, human beings. Of course, nothing could be further from the truth. If we think of chimpanzees as backward human beings we can get into all kinds of trouble.

The "smile" we think we see on the face of a chimp isn't a smile at all. And the high-pitched squeals of "laughter" we hear as a chimp bangs the ground in what seems to be high fun isn't laughter at all. What is the chimp really doing when it curves its mouth into what seems to be a smile? Or when it jumps about thumping the ground?

This article about Dr. Desmond Morris and Congo is adapted from a report Dr. Morris wrote for the British magazine Biology and Human Affairs. *Roy A. Gallant, author of science books for children, is Editorial Director of* Nature and Science.

The Language of Chimpanzees

Dr. Desmond Morris, Curator of Mammals at the London Zoo, England, has studied chimpanzees for several years. For three years he lived at the zoo with a young chimp named Congo, so he was able to watch the animal closely. Dr. Morris has learned the chimpanzee's language—of grunts, squeals, screeches, and other sounds. He has also learned that certain faces a chimp makes, and special ways the animal moves its body, mean certain things.

When a chimp "talks," it makes several different sounds. If one chimp greets another one it makes an *ough-ough-OUGH* sound. At the Bronx Zoo in New York City, Jimmy, one of the oldest chimpanzees in captivity, sometimes delights a visitor by grunting back when the visitor grunts a greeting in typical chimp style.

When a chimp is feeding, it may make an *aack-aack* sound. In all there are six or more different chimp sounds that we know of. Each sound has a special meaning.

At times a chimp may mix two different sounds. When the animal is given food, he may "greet" the food by making a sound between *ough* and *aack*. If a chimp is upset by something it may whimper by making an *ooo-ooo* sound. If it is afraid it makes an *OOGH-OOOOGH* sound. If it is very excited it screams. Dr. Morris says that people who know the different sounds soon understand quite well what feelings the chimp is expressing.

Smiles and War Dances

The different faces a chimp makes also mean different things. A person visiting a zoo can make a big mistake by smiling or laughing at a chimp. Humans smile at each other as a sign of friendly greeting, or to show that they are amused, and the more teeth we show, the better. But not so with a chimp.

When a chimp is playful and happy it does not smile as we do. Usually it holds its mouth open, keeping its teeth covered. Sometimes, however, its lower teeth may be showing, but never the upper ones. The only time a chimp bares all of its teeth is when it is angry or frightened. Knowing this about the animal, what would you expect to happen in a zoo if you gave a friendly, toothy smile to a chimp?

You may expect the chimp to smile back, but something else can happen, says Dr. Morris. The chimp sees two rows of bared teeth and becomes frightened or angry, so the animal bares its teeth in return. You think that the chimp is "smiling" back at you, so you become more amused and laugh out loud.

The chimp now sees more teeth and hears what it thinks is a threat, or anger. The chimp may make its own threat-noise in return. Both the visitor and the chimp become more and more excited by each other—the visitor with pleasure, the chimp with anger or fear.

Once in a while a chimp becomes angry enough to try to attack people watching it in a zoo. First it may begin a "war dance" by beating its chest. Then it may sway about and clap its hands, then beat its chest again. It claps its hands faster and faster and faster. Then at one stage of anger it begins beating the walls of its cage. Finally, the chimp may stamp its feet excitedly, kick the wall, and leap at the bars of its cage toward the crowd.

Chimps in the Wild

People who expect to meet a chimpanzee in the wild should know certain things about the animal. If its hair is

When an adult chimp attacks an enemy, as here, its body hairs stand on end. This is a sure sign of anger.

standing on end, it would be a good idea to leave the area quickly. This means that the chimp is angry and that it may attack. Or the animal may begin beating its chest or banging the ground. This could mean that there is not quite so much danger.

When a chimp in the wild first sees an intruder, the chimp may be frightened. At the same time it may want to attack, but it doesn't dare to. Since it is afraid to attack, although it wants to, it attacks the ground instead or anything else around.

Scientists who work closely with chimpanzees soon come to know one of the signs of a friendly greeting. The animal approaches and tries to push the back of its limp hand against or into its keeper's mouth. In addition to the *ough-ough-OUGH* grunts, this hand gesture is also a greeting.

If a chimpanzee is left alone it may become unhappy and begin rocking back and forth. Dr. Morris says that he has seen gorillas and orangutans do the same thing. He thinks that "it may not be so silly to compare this with certain types of human dancing." The rocking back and forth may comfort the ape in a way. "Whatever it is," Dr. Morris says, "I do not think we understand it fully yet."

Rubber Snakes and Mushrooms

Chimpanzees, which are found in the tropical forests of West and Central Africa and live on a diet of fruit, have several fears. In addition to being afraid of large, flesh-eating animals, chimpanzees seem afraid of snakes. When Dr. Morris once showed a chimp a piece of rubber tubing painted like a snake, the chimp tried to run away.

Dr. Morris was surprised to find the chimp rejecting mushrooms. When he offered one to the animal, the chimp broke it up into tiny pieces and then swept all the crumbs away until every last bit was gone.

Like monkeys and certain other animals, chimpanzees groom each other. Grooming is not a simple act of keeping clean, as it may appear to most of us. Although grooming is a way of keeping clean, it does other things for chimpanzees. When Dr. Morris was working with Congo, his three-year-old male chimpanzee, he found that the only way to calm the animal when it became excited was by grooming him. When the grooming was done with care, the animal relaxed completely.

Another activity of chimpanzees is bed-making. At night, each animal living in the forest makes its own bed by collecting branches, leaves, and twigs and forming a nest of them. Sometimes this is done on the ground, but usually they choose a safer place in the treetops. In a zoo chimps also make beds, even though they have not had the chance to do so in the wild.

Congo Learns to Paint

One day Dr. Morris gave Congo a drawing pad and some paints. Success came quickly, and in a very interesting way. Until this time Congo had often been restless and made up for it by going on rampages of breaking Dr. Morris's belongings at the London Zoo. Dr. Morris wondered if some of this energy could be put to use in a different way. He found that it could.

With a drawing pad and some paints in front of him, Congo began making pictures. At first they were only scribbles. Then gradually the animal began making fan patterns and other figures.

Congo even used certain rules in his picture-making. He drew small pictures on small sheets of paper and large pictures on large sheets. Dr. Morris says that certain twists of the wrist that Congo used made patterns that belonged to Congo alone. They could not be mistaken for drawings made by other apes. Congo had his own artistic "style."

Congo Moves to the Monkey House

As Congo grew older he gave up drawing pictures and began "drawing blood," as Dr. Morris put it. At this stage the animal was moved to the monkey house.

This was necessary because Congo was getting too good at defending his human "family." He looked on all visitors as intruders and felt that he must drive them away from Dr. Morris. Congo was growing up and becoming dangerous. When he was moved to the monkey house, he was given two young female chimpanzees as companions. This was to make up for the loss of his human family.

He quickly settled down to the new way of life, but

Congo learns to paint. His first attempts with a pencil and drawing pad resulted in scribbles. Later he used colored paints and brushes. He drew small pictures on small sheets of paper and large pictures on large sheets of paper.

Congo looks at one of his paintings. Certain wrist actions he used gave his paintings a style all of his own.

Dr. Morris did not visit him for some months. He did this on purpose so as to not confuse Congo by reminding him of his earlier home.

Congo is now growing up and will soon be a large, mature ape. Chimpanzees become mature when they are about ten years old. One day, perhaps, Congo will produce a "Son of Congo," and Dr. Morris will be able to start another special investigation.

Studying the behavior of animals is very difficult. To understand why an animal does certain things, the scientist must try to see the world from the animal's point of view. But this leads to many difficulties. For example, when we say that an animal is "afraid" or "angry," or that it "hates" something, we are using words that describe human feelings. We do not know if animals have the same feelings. So when we describe their actions in human terms we must be very careful.

Aware of these difficulties, Dr. Morris nevertheless tried to see as much of Congo's world from the animal's point of view as he could, as any scientist would. "By learning how to be a chimp," Dr. Morris says, "I had been able to enter into the chimp's world to some extent. Had I been treating the animal as a small, black, stupid, hairy human being, I would have failed." ■

■ If you want to find out more about chimpanzees and their relatives, look for these books: **All About Monkeys,** by Robert S. Lemmon, Random House, New York, 1958, $1.95. This book gives a lot of information about monkeys and apes. An easy-to-read book on these animals is **Monkeys,** by Herbert S. Zim, William Morrow & Co., Inc., New York, 1955, $2.50. Exciting experiences with apes are described in **My Best Friends Are Apes,** by Heinrick Oberjohann, E. P. Dutton & Co., Inc., New York, 1957, $2.95.

A CHIMP IN THE HOUSE

Meshie was a chimpanzee from the African jungle. When a baby, she was captured by a native and sold to H. C. Raven, a scientist from The American Museum of Natural History. Mr. Raven raised the animal in his home as a member of his family.

Meshie's ability to learn shows the intelligence of chimpanzees. In less than two minutes she learned to drink through a straw. Only once did she have to be shown how to fit a key into a padlock. She liked to turn the pages of a book and examine the pictures. She also enjoyed riding in the family car and would sit contentedly between Mr. Raven's children in the back seat. Meshie was very much a part of the family. She ate her meals at the table, using a spoon and fork.

Eventually Meshie grew too big and strong to be kept at home and was given to the Chicago Zoo where she stayed until she died. After her death Meshie was mounted (see photo) and is now part of the Museum's animal collection.

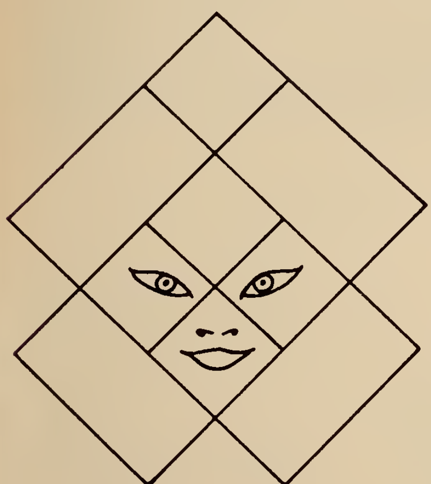
brain-boosters

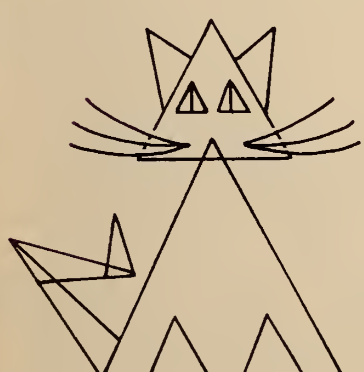
■ The Hindu and the Cat

How many different squares can you count in the picture of the Hindu boy wearing a turban?

How many different triangles can you count in the picture of the cat?

Look carefully. The problems are not as easy as you might think!





■ The Delivery Boy's Salary

"I quit," said the delivery boy to the store owner. "I like this job but you are not paying enough money."

"Sorry," said the store owner, "I can't afford to pay you more."

"I like this job so much," said the boy, "that I'll make a deal with you. Starting Monday I'll work three weeks for you, including Saturdays. The first day you pay me only a penny. The second day two pennies. The third day four pennies. Each additional day I work, just double the number of pennies you paid me the day before."

Anxious to keep the boy, the store owner shrugged and said, "Okay."

What was the boy's salary when he left at the end of three weeks?

■ How To Play NIM

Put nine pennies (or other counters) in three rows as shown in the diagram. Two players take turns removing one or more pennies. Whichever penny or pennies you take away must come from the same row. For example, a player could take one penny from the top row, or *all* the

pennies from the bottom row. The person who is forced to take the last penny is the loser.

If you are the first player and make the correct first move, and if you continue to play the game well, you can win every time. If you fail to make this correct move, and if the person you are playing against plays well, he can always win.

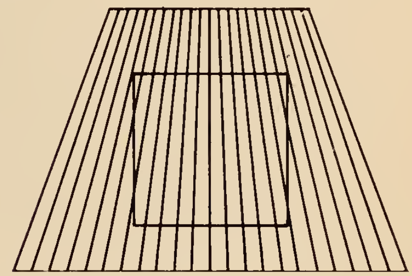
Try to figure out the correct first move. Can you discover the patterns which always leave you the winner? Try a 3-4-5 arrangement of the pennies. Here the winning rules are tougher to discover.

■ A Druggist and His Pills

A druggist working late one night was startled by a flash of lightning during a storm. He knocked over two pill bottles—one with white pills, the other with pink pills. All of his lights had gone out. In the dark he began picking up the pills. Mathematics was his hobby, and he began wondering how many pills he would have to pick up to be *certain* that he had two white pills *or* two pink ones.

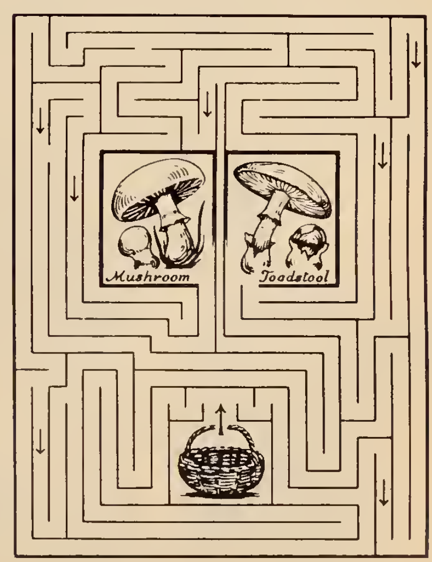
■ Case of the Crooked Square

Things are not what they seem to be. The figure within the lines is a perfect square.



■ Fun with Fungi

Start at the basket and see if you can get to the mushroom, but beware of picking the toadstool by mistake! The rule of the road is that you may not go against the small arrows or travel the same road twice.



Answers to the brain-boosters on this page will be given in the next issue of *Nature and Science* which you receive.

Keeping Track of Our Wildlife

■ Some scientists weigh bears. Others trap antelope, shock fish, or catch wild geese in nets. These are only a few of the unusual jobs done by wildlife biologists—men who are trying to learn more about our wild animals.

Here are some typical questions: How many wild geese are killed by hunters? If a bear is trapped and moved 50 miles from its home grounds, will it stay there? How big must a trout be before it produces young?

Finding answers to these questions is not easy. To find out how many geese are killed a year, scientists trap many geese and put metal identification bands on their legs. A band shows when and where the bird was banded.

When the bands from dead geese are sent to the scientists, they can get an idea of where the birds have traveled and estimate how many geese were killed. Scientists can then help to set the hunting laws for the next year.

Some areas have so many of one kind of animal—bears, for example—that the animals become a nuisance. When there are too many bears in one area they may ruin young trees by chewing on them, or disrupt summer camps while looking for food. By trapping and tagging them, scientists can learn more about how these animals live and perhaps find ways to stop them from being pests.

In most areas, fishing laws prevent us from taking fish that are under a certain length. These laws are useful because they allow fish to grow big enough to breed before they are caught. When scientists find out how big certain fish must be to produce young in a particular stream or lake, they may change the size limit on fish in that area.

The pictures on these pages show some of the modern ways scientists are using to learn about wild animals in order to manage our wildlife wisely ■

SHOCKING FISH: Electricity goes from a generator on the shore through a cord that men push through the stream with poles. Fish are attracted to the electricity, then stunned by it. The fish are netted and taken to shore where they are weighed and measured. Then they are tagged and released. Electro-shocking is dangerous and the electro-fishermen must wear rubber boots or waders to protect themselves from being stunned by the electricity.

A CANNON NET traps wild geese. The net is rolled up and hidden in an area where flocks of wild geese feed. Heavy weights are attached to one edge of the net, and each weight is put into a small cannon that points into the air. Bait of corn lures the geese in front of the net. Then men hidden nearby flick an electric switch that fires the cannons. The weights shoot into the air, carrying the net over the birds to trap hundreds of them. In this picture (upper right) a goose was accidentally killed by one of the weights shot from cannons. Usually the geese are not hurt. Scientists put a numbered band on the leg of each goose before letting it go. Each bird has a different number. When a banded goose is trapped again, or killed by hunters, scientists can identify the bird by its band and find out how long it lived and where it was banded.

A HELICOPTER HERDS these pronghorn antelope into a huge trap made of cotton mesh. Then teams of men from the Colorado Fish and Game Department catch the antelope and load them into trucks. The antelope are taken from an area where food is scarce to areas where food is plentiful. So far, about 1,000 wild antelope have been moved to better ranges in this way.

A SLEEPY BEAR is weighed after being trapped. The bear trap is made of a huge pipe that is closed on one end. On the other end is a heavy door that slides up and down. When a bear goes into the pipe and tugs on some bait, the sliding door falls shut behind him. Then scientists spray ether into the trap to knock the bear out. The bear is pulled from the trap, weighed, measured, tagged, and released before waking.

CASTAWAY ON A TROPICAL ISLAND

■ Imagine that you have been shipwrecked on a tropical island in the middle of the ocean. There are enough coconut trees and other kinds of food around so that you don't have to worry about starving. After you have rested you want to explore your island to learn as much about it as you can. Chances are that another ship will not be along for several months, so you will be on your own.

There are many things you want to know about your island—its size, its shape, and the kinds of animals that live on it.

As you wander about, you observe many different kinds of trees and small plants. Although you are exploring your island in order to survive, you are exploring it also because you are just plain curious. Your curiosity makes you wonder about many things. For example, you notice three other islands far out in the ocean, and you want to know how far away they are from your island.

How Big is Your Island?

First you want to know how big your own island is. You decide that this is not hard to find out. You can walk around the shore and get an idea of its size by counting the number of paces you take. You can also stand on a high hill to find the shape of the island. You could then draw a fairly accurate picture of your island in the sand. It would show where the coves are, how large or small they are, and locations of the hills. But how can you find out how far away the other islands are? You cannot measure their distance directly by pacing them off.

What you will have to do is *estimate* or in some way work out, roughly, how far away they are. You want to show in your sand map the approximate position and size of each island. To do this you will have to use some clues that will help you decide whether one island is nearer or farther away than another.

Your own experience tells you that size is one clue. One of the islands seems to be closer than the other two because it appears to be the biggest one and because the trees on the island can be seen in fairly clear detail. Trees on the other two islands appear hazy. You cannot make out their individual shapes.

Color can be another clue. You notice that the vegetation on two of the islands seems a pale green compared with the brighter colors of the third island. Because you can see the third island's trees the most clearly and because this island has the brightest colors, you decide that it must be nearer than the other two.

After you have supper, you watch the sun set below

This is the first in a series of articles adapted by permission of the Elementary-School Science Project from the revised edition of its booklet, Astronomy: Charting the Universe, *© 1962 by the Board of Trustees of the University of Illinois.*

the western horizon. This tells you where west is, so you can estimate the positions of north, south, and east, and mark them on your map in the sand.

How Far Away Are the Sun and Stars?

As you watch the sun, it appears to sink out of sight just behind the most distant island. If you trusted only your eyes, how could you be sure that the sun is not at the same distance as the island?

Soon after sunset, stars appear in the sky and a crescent moon moves across them. Depending on your eyes alone, how could you tell if the moon, the sun, or the stars were nearer? The sun appears bigger, brighter, and gives off heat you can feel. With only these clues you would probably decide that the sun was the nearest. You fall asleep wondering about the distances and real sizes of the millions of heavenly bodies shining overhead.

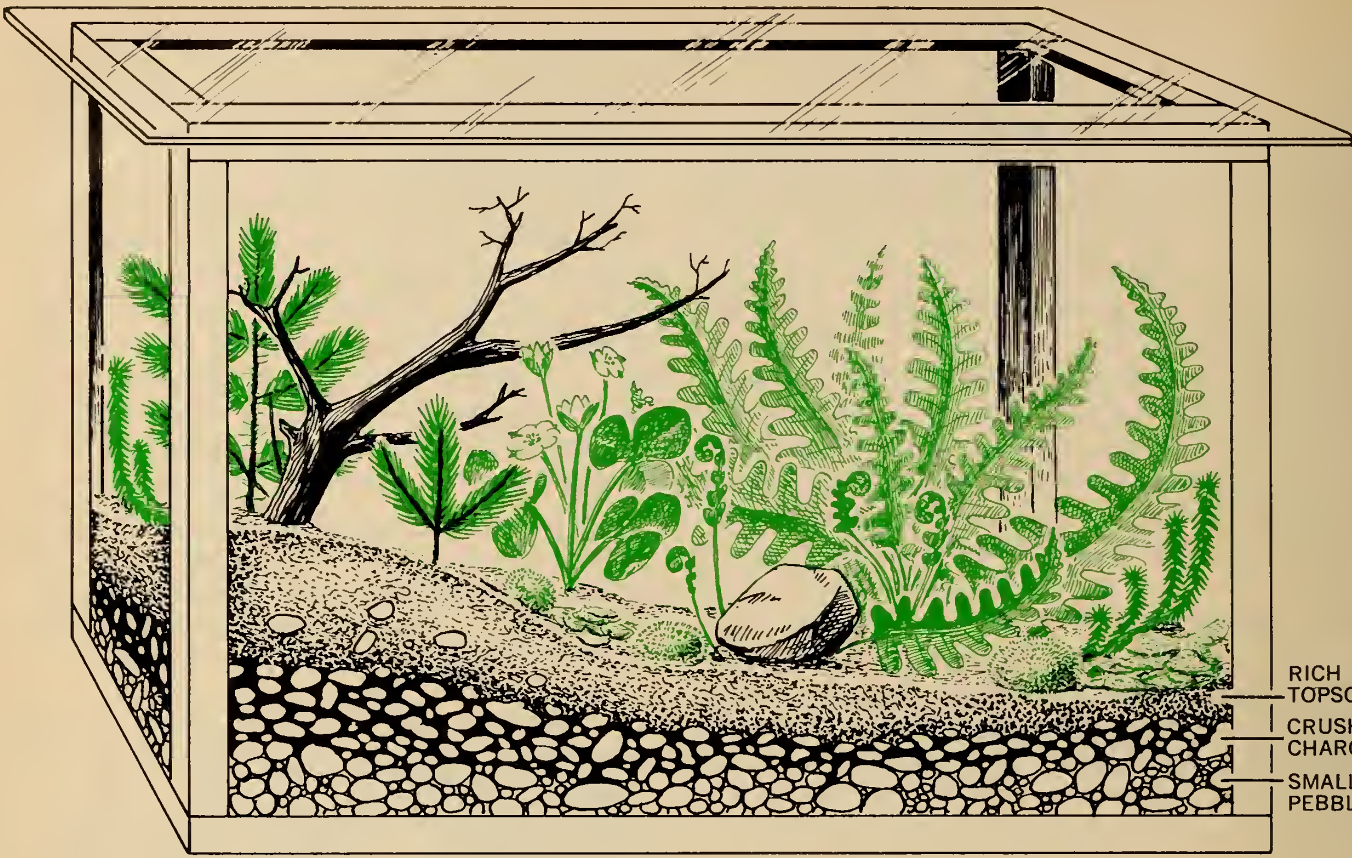
Other Worlds in Space

Men living in ancient times also wondered about these things. Because they were curious they wanted to learn about their world just as you want to learn about your island world. They wanted to know if there were other worlds, like the earth, in the heavens. Could there be living things on the sun? Were the stars tiny flames burning in the sky?

The astronomer has problems similar to those that you have on your make-believe island when you try to work out the distances of things you can see but cannot measure directly. Every scientist searches for ways to use all the clues he has. Clues that astronomers use to chart the positions of the stars, sun, and moon are gained from observations made over great distances.

In this series of articles you will learn many things: how men discovered that the earth is a sphere, how to measure lines and angles, how to build a range finder that will show you the distances to trees and other objects in your back yard. Some of the techniques you will learn about were developed by ancient scholars long, long ago. They are the same techniques used today by surveyors, engineers, navigators, and astronomers who are measuring the shape and size of the universe ■

Watch for the next issue of Nature and Science. *The second article in this series will ask the question "How did ancient peoples discover that the earth is a sphere?" In this article you will be shown a way to prove to yourself that the earth is a sphere.*



Building a Woodland Terrarium

Here is how you can plant a miniature forest and watch the wonders of nature in your own living room.

by Paul Villiard

■ By bringing woodland plants indoors as the summer ends and watching them grow during the winter, you can discover some remarkable things about the world of plants. For example, did you know that the leaves of plants move in order to follow the light?

You can watch this motion and many more things happening by building your own terrarium. A terrarium is really a small greenhouse set up in a large bottle or in an old fish tank. When you have built one, you will be able to watch your woodland plants grow over a period of several weeks or months.

A used aquarium makes an ideal terrarium. A local pet shop may have an old aquarium with cracked glass that would sell for very little. Or if you want a smaller terrarium, you can make one out of a widemouthed gallon-size pickle or mayonnaise jar.

Paul Villiard, who lives in New Rochelle, New York, is a naturalist of many talents. He has lived in Brazil, the Hawaiian Islands, California, Texas, and other parts of the United States. Wherever he has traveled or lived, he has studied and written about the local plants and animals.

Setting Up Your Terrarium

The first thing to do when you set up your terrarium is to cover the bottom with an inch-deep layer of small pebbles or gravel. This provides a space for extra water to go. A little crushed charcoal should be mixed with the gravel to prevent the soil from turning too sour. Even though woods soil is naturally "sour" (meaning acid), you do not want the bottom of your terrarium to have a strong odor. Charcoal stops this.

Above the gravel, firmly pack two or three inches of rich topsoil. Take the topsoil from the place in the woods where you dig up the plants. As you add the topsoil, avoid making just a flat bed. You could make a hill in the back of the container and a small valley running across a corner.

Your terrarium will be more interesting if the surface is uneven.

Finding Plants for Your Terrarium

There are dozens of different plants that you can find in cool, moist places in the woods. Here are a few: violets, if you can find them at this time of year, pipsissewa (an evergreen herb), partridgeberry (a trailing plant with evergreen leaves and red berries), wintergreen (which first has white bell-shaped flowers, then red berries in the fall), liverworts (shiny plants that grow by ponds or streams), and hepatica (a plant that grows in dry soil and has leathery, hairy leaves).

Small tree seedlings of hemlock, maple, pine, and spruce will survive for a long time in a terrarium. Many kinds of mosses and ferns will do very well. Mosses are excellent as ground cover and for holding in moisture.

If you plan to dig up plants from another person's land, be sure to ask the owner's permission first. Also, some wild flowers are protected by state law, so be sure that you know which ones not to uproot. (You can find out by writing to your State Department of Conservation. Also check your local library for guides to wild flowers and ferns in your area.)

In your search for terrarium plants, watch where you walk so that you do not crush young plants. Take only one of each kind for your collection and leave the rest.

When you have found the woodland plants you want for your terrarium, take a lump of soil with the roots when you dig them up. Keep the soil from falling away from the plant by wrapping the roots and soil tightly in a plastic bag or in a wet newspaper. Or you can slip the entire plant into a plastic bag and tie the top tightly. Mosses should be taken up in small pieces with some soil sticking to them.

By slipping all of your plants into plastic bags and carrying them home this way, they may not wilt after you transplant them. If you dig up tiny seedling evergreens, dig carefully to avoid breaking off too many of their roots. It is very important not to let the roots dry out between the time you dig and the time you transplant them.

Arranging Your Plants

When you transplant, pack the soil firmly around the roots of each plant as you position it. Press the mosses firmly into place so there are no air spaces left under them. You might want to put in a small piece of wood, or bark, from a log. Place it on its side at the top of the hill in your terrarium.

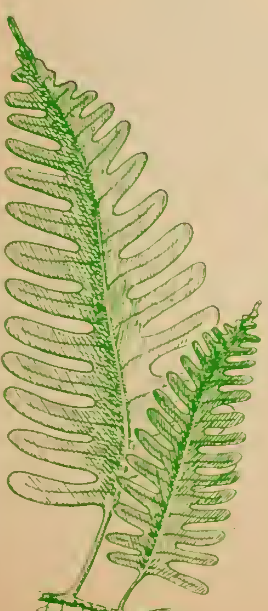
You can transplant a few tree seedlings at the back of the terrarium and you will have a shady glen in which to set up two small ferns. Since liverworts need a wet place, transplant them in the lowest part of the terrarium.

A stone or two, especially ones covered with tiny scaly plants called *lichens*, will add interest to your terrarium. But these can cause mold. If you put them in your terrarium, place them in the driest part. If a plant gets moldy, remove it quickly.

Don't clutter up your terrarium with small plastic or metal statues. They are out of place in a woodland setting.

Caring for Your Plants

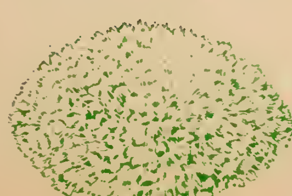
After all the plants are in place and the soil and moss are firmly packed down, water the moss and soil thoroughly with a bulb sprayer or with a watering can. Get the soil good and wet, but not so wet that puddles form.


POLYPODY


HEPATICA


CLUB MOSS


COMMON VIOLET


PINCUSHION MOSS


PARTRIDGEBERRY

Now cover the terrarium with a pane of glass. If you are using a jar, cover the opening with plastic held on by a rubber band. Next, place the terrarium on a window sill or a table near a window where it will receive enough light—but very little direct sunlight.

If your plants get enough light and are kept at a fairly even temperature they should live all winter. A woodland terrarium should not be kept too warm. Never keep one on or near a radiator. The plants need cool, moist air with lots of shade and broken sunlight.

If droplets of water form on the inside of the glass, this means that the terrarium is either too warm or too moist. Slip the cover off part way for a day or two. This will allow the air to dry out a bit. Then replace the cover and see if the glass stays dry most of the time. Once you have the right amount of moisture, and you have found the right temperature for your plants, the terrarium will need very little attention. You may have to water it a little once every ten days or two weeks. If the tap water in your area is extremely hard, you should use rain water ■

TERRARIUM INVESTIGATIONS

1. When your terrarium is set up and thriving turn it part way around for a few days. Does the new direction of light do anything to the plants?

2. Try leaving the terrarium three feet beneath a 60 or 100 watt light all night for a week or two. What happens? If you have a fluorescent lamp at home, try putting the terrarium a foot beneath it for 10 or 12 hours each day. Do the plants seem healthier growing under artificial light?

3. When collecting plants for your terrarium, also gather a handful of dried leaves, seeds, and other chaff that has collected on the forest floor. Put these in your terrarium and see what develops over the next few weeks.

4. Next February and March compare the wild flowers and the ferns in your terrarium with their former neighbors outdoors. Are the captive plants building and blossoming earlier? Has the artificial light speeded up a plant's life? The daily amount of light a plant receives often determines when it will blossom. Scientists do not know all the answers about this.

5. If you have extra pickle jars you may want to try a terrarium which is much drier than the woodland terrarium—a miniature desert—taking plants from dry spots in your neighborhood or buying a few tiny cacti. Also you can make a miniature swamp or bog in a pickle jar by taking plants and muck from the shoreline of a pond or marshy pool.

A Laboratory on Your Lawn

by Phyllis Busch

Here is a way to find out how dandelions win over other plants in the struggle for survival.

Dandelions (left) and grass plants (right) often grow side by side on lawns. By studying some of these plants outdoors, you can discover why dandelions are such common weeds. (The two plants shown here are not drawn to scale.)

Phyllis Busch, a former college biology teacher, is now a consultant on outdoor activities for The Elementary School Science Project of Educational Services Incorporated, in Watertown, Massachusetts.

■ Plants compete with each other for the things they need in order to live—sunlight, water, minerals, gases, and a space to live.

Sometimes man has to protect certain plants to keep weeds from winning the struggle for survival. Weeds often win when they compete with other plants. You can find out how they do this by comparing a weed with other plants around it as they compete for survival.

A good weed to observe is the sturdy dandelion, which grows almost everywhere, even on most well-kept lawns. You will need some simple equipment for your investigation: a pencil and paper, some sheets of newspaper, a trowel, ruler, and a piece of string six feet long. Once you have your equipment, go to a yard or field where dandelions grow.

Setting Up Your Laboratory

At first just look at the dandelion plants. You will probably see some with bright yellow flowers, others with seeds, and some that haven't bloomed yet. (Dandelions bloom and produce seeds from early spring to fall.)

Using your string, measure off an area six feet square that includes several dandelions. Mark the corners of your square with twigs pushed into the ground. Using your ruler, next draw a map six inches square.

Wherever you find a dandelion on your plot, locate it with a "D" on your map. Then print an "X" to locate shrubs, grasses, and other plants that grow in the plot. Do you notice any dandelions that are growing where no grass or other plants grow? If so, draw a circle around its "D." Can you think of what conditions make it possible for the dandelion to grow but keep grass or other plants from growing?

Now look at a part of your plot where there is a dandelion growing right in the midst of many grass plants. Can you figure out why grass grows better in this spot than in the other spot? Could it have anything to do with the amount of sunlight the grass receives?

Now spread two sheets of newspaper on the ground. Carefully dig up some dandelion plants from both sunny and shaded areas with the trowel. Try to get as many of the roots as you can; this is important. Shake the soil off the roots, place the plants on the newspaper and spread out their leaves and roots. Do the same with grass plants from the same area.

Observing the Plants

Compare the two groups of plants and see if you can figure out which one is better fitted to get the things that it needs in order to live—water and minerals from the ground, sunlight and gases from the air. Remember that energy from sunlight and gases enters a plant through its leaves. As you compare the plants, record the information in the table shown here (or make one of your own).

The table allows space for four plants of each type, but this is a small sample. Remember that scientists do hundreds of experiments before they draw any conclusions from their data.

First count the number of leaves on each plant, and measure the leaves to find their length and width. Next compare their roots. Using a ruler, measure the width and length of the largest root on the dandelion and grass plants.

When you have the table filled in, study the measurements that you have taken. Which plants have bigger leaves? Do big leaves help a plant in any way? Do you think that dandelions would grow better or worse if the grass of a lawn were allowed to grow, instead of being cut? Look at the root measurements. Which root system would be better suited to get water if there was a shortage of water in the soil?

With the information you have collected about dandelions, you can probably figure out several reasons why dandelions win so many struggles for survival with other plants.

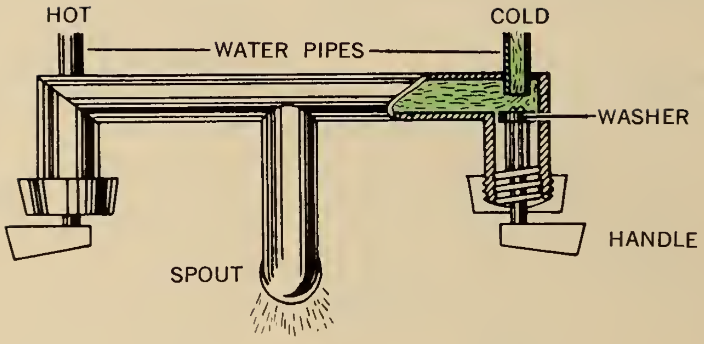
What is a weed? Some people say a weed is a plant that grows where we don't want it. Can a rose be a weed? Is a weed a plant that has no uses? Can you name some ways that dandelions can be used? ■

THINGS TO MEASURE	DANDELIONS					GRASS PLANTS			
	1	2	3	4		1	2	3	4
Number of leaves on the plant									
Average width of leaves									
Average length of leaves									
Width of largest root									
Length of largest root									

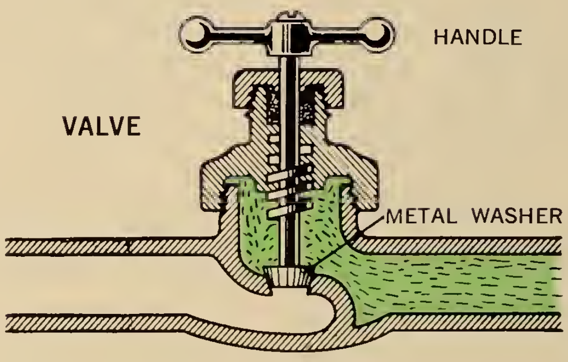
HOW IT WORKS

Faucets

FAUCETS
(AS SEEN FROM ABOVE)



VALVE



Have you ever wondered how a faucet works, or why a faucet sometimes drips even though it is turned off?

The parts of a faucet we usually see are the handle and the spout where the water comes out. As the diagram shows, the faucet handle is at the end of a metal rod. On the other end of the rod is a washer. It is a ring of rubber, fiber, or plastic with a hole in the middle. A screw fits through this hole and holds the washer to the rod.

When you turn the faucet handle to the left, the metal rod moves and the washer is moved away from the opening of the water pipe. Water then flows out of the spout. When you turn the faucet handle to the right, the washer plugs the opening of the water pipe and the water flow is stopped.

One cause of a dripping faucet is a worn-out washer. To fix a leaky faucet, first turn off the water supply by turning the valve handle on the pipe below the sink. Then replace the old faucet washer with a new one. The valves on water pipes rarely leak, because they have a metal washer that fits tightly into the opening that water flows through *(see valve diagram)*. Even though this type of washer does not leak, it is not used in faucets. The reason is that it takes too much effort to close the valve tightly and to open it.

nature and science VOL.1 NO.1 / SEPTEMBER 20, 1963 TEACHER'S EDITION

Dear Colleague:

Here is our first issue of Nature and Science.

In our role as educators, we at The American Museum of Natural History have long felt that a children's magazine that ranges over the entire spectrum of science has been needed both in the classroom and in the home.

What are the educational goals that we have set for Nature and Science? For one thing, we hope to show the child that science is not an exotic jungle of fascinating, unrelated facts, but more a way of looking at and understanding the ever-changing world around us.

Guiding Nature and Science is a National Board of Editors made up of classroom teachers, educators, and scientists. On page 5T of this issue you will find a brief report on the first meeting of our Board of Editors and a description of the scope and purposes of the magazine.

Our hopes are that you will find Nature and Science just the kind of classroom magazine that you have been looking for. We also hope that you will be suggesting ideas that will help us make the magazine one of your most effective teaching aids.

James A. Oliver
DIRECTOR
The American Museum of Natural History

One of the purposes of science teaching is to help children gain an understanding of the world about them. A rational view of the world is basic to a rational life.

Now a scientist doesn't go about investigating everything about him—without rhyme or reason. This is obvious. It is just as obvious that science teaching should not be formless. It should seek relevance, but relevance to what?

George Gaylord Simpson remarks that there are "families of ideas"; James Bryant Conant suggests there are conceptual schemes which furnish frames of reference for understanding the world. The conceptual schemes are, in a way, springboards into further investigation, into further learning. They are, if you will, patterns of ideas which in turn pattern our observation.

Thus to recognize that matter is particulate means that one seeks an understanding of matter in terms of molecular structure and behavior. To understand the conceptual scheme that *all life developed over the ages from pre-existing life* is to begin to understand the origin of fossils and their relation to existing life.

Furthermore, an understanding of the conceptual structure of scientific knowledge helps the teacher organize lessons for more effective learning. The lessons have structure because the concept gives them pattern and meaning.

Nature and Science will publish many articles based on and developing understanding of the major conceptual schemes in science.

The Teacher's Edition of *Nature and Science* will indicate the basic concepts underlying the various articles appearing in the student's edition. This should make it easier for teachers to fit the learning activities suggested in these articles into the teaching programs they have planned.

Page 3: Never Smile at a Chimp

Basic concept: All organisms respond to their environment. (Inherited and learned responses are part of an organism's adaptation to the environment.)

This article can be used to help youngsters gain insight into the quality of responsiveness as part of an animal's armament of adaptation to the environment. Which of the chimp's behaviors are inborn, that is, inherited? Which are learned?

To help your pupils learn to distinguish between *inborn* and *learned* acts, you might introduce two investigations.

1) Can you keep your eyes from blinking? (Have a pupil hold a clear plastic sheet in front of his eyes as another throws crumpled paper at the sheet. Will he be able to keep from blinking? No.) The act is inborn, or reflex in nature.

Discuss with the class which of the chimp's acts are inborn. His way of smiling? His way of displaying anger (baring of teeth)?

2) Now ask your students to investigate a learned behavior. (Recite a poem to them. Ask them to copy it as you recite it. But they are not to dot their i's or cross t's. How many of them can do it?)

Discuss the difference between an inborn and learned behavior. Which of the chimp's behaviors are learned? Drawing pictures? Is the fear of snakes learned or inborn?

From this discussion and careful reference to the article, boys and girls should be able to augment their insight into their own behavior. A fruitful discussion might enlarge on their understanding of their own inherited and learned behavior.

The basic concept stated above (on adaptation of organisms) is part and parcel of the vast conceptual scheme: *All organisms are interdependent with their environment.*

The suggestions for using this issue of Nature and Science *in your classroom were prepared by Paul F. Brandwein, chairman of our National Board of Editors (see page 5).*

Morris Warman

Learning by observing at The American Museum of Natural History. Nature and Science will draw on the Museum's exhibits and staff for many articles.

Page 8: Keeping Track of Wildlife
Page 14: A Laboratory on Your Lawn

Basic concept: Organisms interchange energy with their environment.

Wildlife biologists study living things in order to understand the way organisms live in dynamic equilibrium with their environment. To study one living thing as it lives in harmony with its environment is to begin to understand one's own relationship to a given environment.

Your pupils may begin a long-term investigation of their own. Object: to observe the relationship of a living thing to its environment. It would be difficult and perhaps undesirable to undertake banding, or to trap wild animals. Your pupils can, nevertheless, study wildlife—that is, plants in the "wild."

Ask your pupils to select one plant in their environment. Let them begin their observations this fall. A record of accurate dates is important. If it is a tree or shrub, when does it lose its leaves? When do its leaves reappear? When does it flower? When does it fruit?

On the basis of one year's observations, will these events take place on the same date next year? If not, what is the explanation for the difference?

Similar observations can be made on herbaceous plants growing in the woods, in a lot, in the yard—almost anywhere. In addition to the questions above, these may be added: Does the plant reappear in the same place? Has the plant reproduced itself? Other questions will occur.

Nevertheless, the significant aspect of the study is to understand how it is that the living things are able to grow and develop in that environment. If plants do *grow* successfully in a given environment, it must mean that they get *minerals, water, sunlight* from their environment; that is, the plants are able to obtain energy from their environment.

Page 10: Measuring the Universe 1
Castaway on a Tropical Island

This article is Part 1 of a series that will continue well into the second sem-

setting guidelines for NATURE AND SCIENCE

"Confront the child with something that leads into some creative act on his own—maybe reading, maybe experiment." So advised our Board of Editors. David Webster, left, Raymond Barrett, Elizabeth Hone, Richard Winslow, Franklyn Branley.

National Board of Editors

PAUL F. BRANDWEIN, Chairman of the National Board of Editors of *Nature and Science,* is the Senior Editor and Assistant to the President of Harcourt, Brace & World, Inc., and Director of the Pinchot Institute in Conservation Studies. Dr. Brandwein was formerly the General Editor and Editorial Consultant to Harcourt, Brace & Co., and Consulting Science Editor to Science Research Associates. He also was a member of the Steering Committee of the Physical Science Study Committee and Biological Sciences Curriculum Study. He is the author of several textbooks and of books on science education.

J. MYRON ATKIN is Co-Director of the University of Illinois Elementary-School Science Project, a course-content improvement project sponsored by The National Science Foundation. He is a Professor of Science Education at the University of Illinois College of Education. During the summers, he has been an instructor at Lehigh and N.Y.U. At one time Dr. Atkin was a high school science teacher in New York City, and an elementary school science consultant in Great Neck, N. Y.

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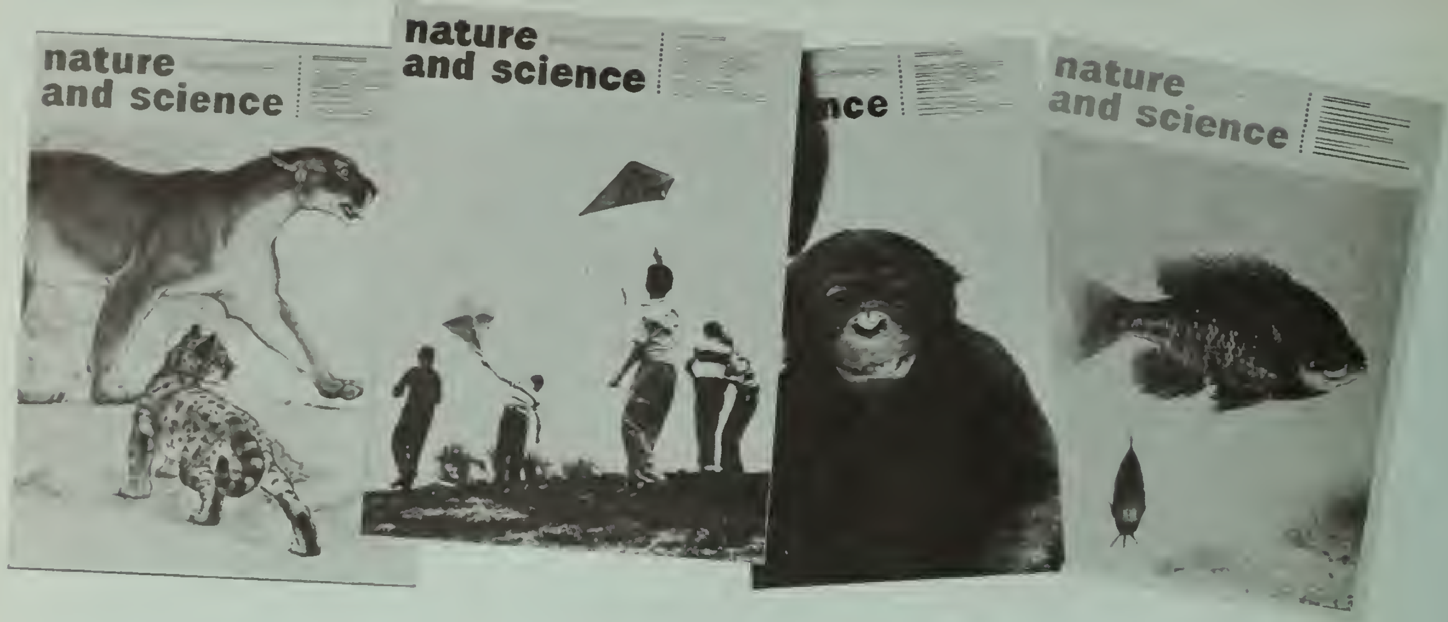
RAYMOND E. BARRETT is the Director of Education of the Oregon Museum of Science and Industry in Portland. He is Director of the Oregon Science Summer Camps, the Northwest Teachers of Science, the Northwest Science Fair for grades K to 12, and the Special Interest Class Program for grades K to 10. He also directs in-service classes for elementary teachers in the Portland area. He is the author of *Build-It-Yourself Science Laboratory.*

MARY M. BLATT is Science Specialist for the Pennsylvania Department of Public Instruction. At present she is formulating a new elementary science program for the state of Pennsylvania, stressing information about trends in the teaching of science and the participation of local people and industry. She has an extensive background in the teaching of elementary science. Her most recent publication is the article *Are We Teaching Elementary Science?*

KENNETH BOBROWSKY is Chairman of the Science Department of the Bank Street College of Education and Science Curriculum Coordinator for the Bronx High School of Science, in New York City. He is an elementary science teacher and consultant for the Bi-Cultural School in Stamford, Conn. Now Vice-President of the New York Biology Teachers Association, he is also a member of the American Society of Ichthyologists and Herpetologists.

FRANKLYN M. BRANLEY is an Associate Astronomer of The American Museum-Hayden Planetarium. Before joining the Planetarium staff, Dr. Branley was Assistant Professor in the Department of Science at the New Jersey State College where he specialized in preparing students in the teaching of science in the elementary school. Earlier, he taught in schools in Alabama and Louisiana. He is the author of nearly four dozen books and numerous articles in the field of science, on science education, and for young people.

WILLIAM L. DEERING is Managing Editor of the Education Division of Doubleday & Company, Inc. Prior to this, he was Associate Professor of Education and Science Supervisor of the



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Why Did the Dinosaurs Die Out?

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ester. The articles are adapted from the revised edition of *Astronomy: Charting the Universe,* a 71-page booklet based on experimental studies by the Elementary-School Science Project at the University of Illinois, Urbana, under the co-direction of J. Myron Atkin and Stanley P. Wyatt. A 36-page *Teacher's Guide* was prepared for use with this booklet.

If some of your pupils follow these articles, they will learn about many of the problems confronting astronomers today and some of the techniques astronomers employ as they attempt to measure and chart the universe. Your pupils will learn that it is not enough to know only the correct answers to questions. Equally important is their understanding of how astronomers formulate their questions and arrive at their answers, many of which are constantly changing.

In discussing Part 1 of this series with children, it will be helpful to show them how past experiences affect their interpretation of clues to the size and distance of objects. It is also important for them to realize what it is they take for granted about the size, color, and brightness of objects.

For example, is the child assuming that palm trees growing on the nearby islands are the same size as the trees on his island? This is probably safe to assume, but it should be recognized as an assumption.

Do colors appear as bright when seen from a long distance as when seen from a shorter distance? (Compare a view of nearby hills and distant ones—either actual or in color photo slides.) Distant hills look more gray-blue than the ones not so far away.

Do lights of equal brightness appear equally bright when one is farther away than the other? (Use flashlights of equal brightness in a darkened room.)

Can you see details in a picture as well from a distance as when you are up close? (Ask children at different distances from a detailed picture or newspaper page what each can see or read.)

Is the apparent size of similar objects a trustworthy indication of their distance from the viewer? This question can be investigated by placing two toy automobiles (or other objects) that are similar in shape and color but different in size on a table as shown on this page. Adjust the objects so they appear to be the same size when sighted with one eye from a marked spot at the end of the table.

Keep several children out of the room until the others are ready to observe. Then bring them in, blindfolded, one at a time. Guide each to the sighting position, uncover one eye, and ask him which object seems farther away and how much farther it is. Would a familiar book placed beside each object make it easier to estimate its distance?

These are a few ways you can help children learn to evaluate clues to the distance and size of objects they see.

Page 12: A Woodland Terrarium

Basic concept: Organisms affect and are affected by their environment.

Here again is an article which will permit your youngsters to be on their own. Your classroom can be the center for a number of woodland, tropical, or desert terrariums, in addition to the individual ones students may keep. A few investigations suggest themselves in the line of seeking understanding of the basic concept.

Let your boys and girls investigate the effect of changes of the environment on living things. Again, plants lend themselves to these investigations.

Have them soak a dozen bean seeds overnight. Plant each in a glass jar lined with wet blotting paper by inserting the seed between the blotter and the glass. With this technique they may design investigations to deal with questions such as these:

1) What is the effect of temperature on growth? (The refrigerator may be used, and its effect compared with the effect of room temperature.)

2) What is the effect of excessive watering? (In one jar, add enough water to "drown" the seed. Compare it with one growing under conditions of a soaked blotter.)

3) What is the effect of excessive drying?

4) What is the effect of different kinds of light? (Cover the jars with cellophane of different colors. Red cellophane will give the most interesting effect.)

5) What is the effect of darkness?

Also, in designing these investigations the boys and girls may begin to learn the meaning of the *control* in an experiment. In a control the postulated cause is eliminated. Thus if we wish to investigate the effect of light, the control experiment would eliminate light. If we wish to investigate the effect of moisture on the growth of bread mold, the control would eliminate moisture. Thus the investigation would include at least two investigations:

1) The investigation proper—dry bread, the spores of the bread molds, *plus moisture.*

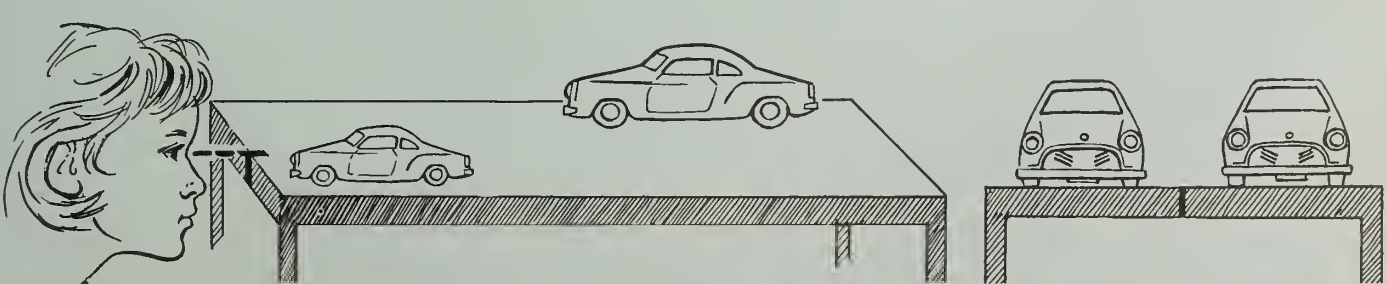
2) The control—dry bread, the spores of the bread mold, *without moisture.*

New Magazine for Science Teachers

Science and Children, a new 32-page magazine, will be published eight times a school year beginning in September by the National Science Teachers Association. This periodical replaces *Elementary School Science Bulletin* as the NSTA journal for elementary science teaching. Contents of *S&C* will include:

- Reports of pertinent curriculum research programs.
- Articles by recognized leaders in elementary and science education.
- Reports from schools and school systems carrying on forward-looking work.
- Background science information articles.
- Instructional suggestions.
- Questions and answers for teachers, administrators, and students.
- Special articles for elementary school principals.
- Reviews of materials for science teaching — texts, supplementary books, films, filmstrips, apparatus, equipment.
- Announcements of pertinent national and regional meetings.

Subscriptions to *S&C* at $4 a year may be ordered through your periodical agent or sent directly to NSTA at 1201 Sixteenth St., N.W., Washington 6, D.C.



If you position small and large model autos as shown above, they will appear from the sighting point to be the same size.

■ The National Board of Editors for *Nature and Science* held its first meeting May 17 and 18 at The American Museum of Natural History. The Board brings together a wide diversity of talent and background—teachers, scientists, editors, and educators. Despite this diversity, the Board members have a common bond: an extraordinary desire to contribute to the science education of elementary school children. Many of them express this concern by working regularly with elementary school pupils throughout the year.

At its first meeting the Board was voluble, frank, keenly critical, yet always enthusiastic and constructive. Each member agreed to contribute to the pages of the magazine as an editor and writer. There was no consensus for a rigid "educational policy" for the magazine; nevertheless, the Board did achieve general consensus on several major guidelines for the magazine's development:

1) *Scope.* We will let the subject matter of our issues range far and wide, sometimes treating the traditional topics of elementary school science with a fresh approach, at other times introducing topics that in the past have been considered beyond the purview of elementary school classrooms, e.g., animal behavior, astronautics, and anthropology. We will not only be concerned with the stuff of science but also with scientists themselves—how they make their inquiries; their frustrations and their satisfactions.

2) *Concepts.* Each article will develop a key conceptual scheme in an appealing way (see Dr. Brandwein's comments on pages 2 and 3). Some articles will be of interest to the advanced student; others to the slow learner. Some articles will appeal most to the boy or girl who is a good reader; others will be for the child who likes to work with his hands.

3) *Setting. Nature and Science* usually will be read first by young people in the elementary classroom, but we hope that the ideas and activities of the magazine will spread far beyond the class, into the back yards and woods near home, and beyond school hours into afternoons, weekends, and vacations.

4) *Serving Teachers.* Each issue of *Nature and Science* will be accompanied by a Teacher's Edition. About half of each Teacher's Edition will contain suggestions for using the student's edition to best advantage. The Teacher's Edition will also present special articles on new methods of science teaching now being developed in various parts of the country. It will suggest ideas for field trips; review science books both for children and of professional interest to you; advise on new science materials, and give advance notice of TV shows of particular value to you and your class.

Just as we expect our Board of Editors to be ever watchful of and helpful to our efforts, we hope the teachers who are using *Nature and Science* in their classrooms will comment on the magazine, suggest articles that we might undertake, and make their own contributions in the form of articles for *Nature and Science* or its Teacher's Edition ■

campus laboratory school at State University of New York, at Oneonta.

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nature and science

VOL. 1 NO. 2 / OCTOBER 4, 1963

You can train a sunfish to come to dinner by building...

A POND IN YOUR LIVING ROOM

see page 13

ABOUT THE COVER

These two common members of the sunfish family—a bluegill (top) and a pumpkinseed—were photographed in a large aquarium. Thirty different kinds of sunfish live in the freshwater streams, lakes, and ponds of North America. These small fish make interesting aquarium pets *(see pages 13-15),* although they may attack another fish, especially during the spring breeding season.

Before sunfish mate, the males clear away debris and dig a nest in the sand or dirt. You can see these light-colored circular patches, about a foot across, near the edges of lakes and ponds. After the fish breed, or *spawn,* the male guards the eggs against all intruders.

Sunfish are so plentiful in some areas that there is not enough food—insects, worms, and smaller fish—to go around. Most conservation departments let fishermen catch all the sunfish they want. The sunfish that remain may then get enough food to grow to full size. Full grown sunfish of different kinds range from one inch to one foot in length.

Sunfish are called "bream" in most of the southern states. Some of the species have interesting names: warmouth, goggle-eye, shellcracker, long-eared sunfish, and stumpknocker.

nature and science

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Contents

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A SCIENCE ADVENTURE

"I've Never Met a Skunk I Didn't Like"

DR. RICHARD G. VAN GELDER FINDS THAT SKUNKS ARE FUN TO STUDY — IF YOU CAN GET CLOSE ENOUGH.

by Laurence Pringle

■ Have you ever smelled a skunk? If you have, you probably remember it well. The odor of a skunk is one of the strongest animal odors in the world.

Although most of us avoid skunks, a scientist at The American Museum of Natural History has spent 13 years going out of his way to track down and study these animals. His name is Dr. Richard G. Van Gelder, and he has collected and observed skunks in most of the United States and 19 countries in South and Central America. After handling thousands of skunks, dead and alive, Dr. Van Gelder still has not been "stunk-up" by one.

During most of his skunk study he has tried to find out how many different kinds there are, and how one kind differs from another. We know of four kinds, or *species,* of skunk that live in the United States. Two species—the hooded and the hog-nosed skunk—live only in the Southwestern states. The other two species are the striped and the spotted skunk. These two species can be found in most areas of the United States.

Striped Skunks and Spotted Skunks

Striped skunks are the type that you have probably seen —and smelled—most often. Sometimes they visit lawns and gardens at night searching for insects and grubs to eat. In the morning, you may find little pits that they dug in the earth in their search for food.

Dr. Van Gelder has handled thousands of wild and tame skunks. At the right he holds "Meph," a pet striped skunk. Dr. Van Gelder began to study skunks while he was a student at the University of Illinois, 13 years ago. He now lives in Manhattan with his wife and infant son. He is Chairman of the Department of Mammalogy, The American Museum of Natural History. The author, Laurence Pringle, is an editor of Nature and Science.

If you ever see a striped skunk, you can recognize it by its size and color. A striped skunk is about the size of a house cat, but its legs are shorter than a cat's. Its body is black, except for a white stripe on its forehead and two white stripes that run from the top of its head and sometimes to the tip of its tail.

Dr. Van Gelder has found that the white stripes along the backs of these skunks vary in length and width from skunk to skunk. A few striped skunks have such narrow stripes that their backs are nearly all black. Striped skunks live in most parts of the United States and far into Canada. In the lower two-thirds of the United States the spotted skunks can be found living near striped skunks. Spotted skunks — smaller than striped skunks — seldom weigh more than three pounds. They have white spots and short stripes on their rumps and six zigzag white stripes that run along their sides as well as their backs.

Mystery of the Dead Skunks

When he was studying striped and spotted skunks in Arizona, Dr. Van Gelder noticed something odd about them. As he drove around he saw many dead striped skunks on the highways, struck down by automobiles. But he saw only a few dead spotted skunks, although they were just as common as striped skunks in that area. Why were more striped skunks than spotted skunks killed by automobiles?

The spotted skunk (top) has its tail raised and spread—a warning to keep away. The striped skunk (bottom) is digging for insects, which it finds with its keen sense of smell. All types of skunks find food in this way.

Spotted skunks sometimes do a "hand-stand." This strange position is a final warning before the skunk shoots its smelly spray. The spotted skunk shown above is part of an exhibit at The American Museum of Natural History.

To find the answer, Dr. Van Gelder began to study both kinds of skunk—in cages and in the wild. Soon he noticed some striking differences. The large striped skunks move slowly and seem to expect everyone to get out of their way. This is fine if the striped skunks meet people or other animals. But a car or truck is a different matter.

Dr. Van Gelder noticed that the spotted skunks are quicker and more careful than striped skunks. When a spotted skunk crosses an open space, it does not expect everyone to get out of its way, as the striped skunk does. Because they make sure the way is clear before they cross, few spotted skunks are killed on the highways.

So the mystery of the dead skunks was solved. But, as often happens in science, the solution to this puzzle led to a new question: why are striped and spotted skunks so different? Dr. Van Gelder thinks that the answer to that question is hidden in the millions of years during which they gradually changed into the animals they are today.

Long ago, skunks probably were like weasels in the way they looked and lived. Spotted skunks are still like weasels in their shape and actions. For some reason they have changed less over the years than striped skunks. Striped skunks have changed much more. Their stocky bodies and slow movements set them apart from their ancient weasel ancestors. The only defense that striped skunks seem to have against an enemy is their famous odor, although they are able to scratch and bite.

If a Skunk Does a "Hand-stand" Watch Out!

Once an animal has tangled with a skunk, the animal will probably remember the experience for the rest of its life. There are animals—in Africa and Asia—that produce strong odors, but the skunks of North and South America have the best "odor-defense" system. The strong odor comes from a yellow liquid in two large glands beneath the skunk's tail. Skunks can squirt a jet of this liquid about 15 feet. They have enough spray for several squirts from each gland.

A skunk never shoots any of its smelly yellow fluid unless something or someone seems to threaten it. If you ever meet a wild skunk outdoors, it will usually give some clear warning signals before squirting a jet of its awfulsmelling liquid. First the skunk will turn toward you and stamp its front feet. If you keep going closer, it will raise its tail straight over its back, with the hairs spread. This is the final warning. If you go any closer, the skunk will swing its hind end toward you and squirt a stream of its smelly fluid in your direction.

Spotted skunks have still another way of warning their enemies. Like striped skunks, these animals first stamp their front feet and then raise and spread their tails. If these warnings fail to scare the enemy, the skunk may do a "hand-stand" and attack by walking forward on its front feet. Whether or not spotted skunks can squirt their smelly fluid from this position is still not known.

If you are unlucky enough to meet a skunk suddenly at close quarters, it will probably squirt its fluid at you immediately without warning. At short range a skunk is quite accurate, so you would have the job of "de-skunking" your clothes. Dr. Van Gelder says that a cupful of household ammonia mixed with a pail of water is one of the best ways of cleaning stunk-up clothes.

Dr. Van Gelder has trapped and handled dozens of live skunks without ever being sprayed. He has trapped them so that he could attach tags to their ears. Then, if one of the same skunks was caught again in another trap, Dr. Van Gelder could recognize it by its tag and learn something about the skunk's movements.

To release a skunk from a trap, he approaches the animal slowly and covers the trap with a sack or large piece of cloth. He lets the skunk out and stands perfectly still. The skunk escapes and does not spray. Dr. Van Gelder suggests that if you are ever faced with a skunk that has given a warning signal, stand still and do not make any sudden movements or noises. If the skunk senses that you mean it no harm, it will usually go on its way.

Skunks as Pets

Many people have tried to make pets of skunks, but few have tried to keep skunks still "armed" with their scent glands. Usually the glands are removed in a simple operation. Dr. Van Gelder has kept several "de-scented" skunks as pets, but he feels that most skunks are poor house animals. People usually expect a pet to obey commands and show affection. He found that few skunks can be trained and most of them do not show affection. Many states have laws against keeping skunks—and other wild animals—as pets. Like other animals, skunks are more useful when they live in the wild.

In summer, skunks eat grasshoppers and other insects that destroy crops. In all seasons they help rid farms of mice and other grain-eating rodents. Many farmers have found that skunks are better "ratters" than cats.

In New York State several years ago, people thought skunks were eating the eggs of wild ducks nesting in a nearby marsh. They trapped and killed many skunks, but found even fewer ducks than before. Why? Scientists investigated and found that snapping turtles were eating the ducks' eggs. And there were more turtles around because the skunks had been eating the turtles' eggs.

This story shows how skunks and other animals are important to each other. If one kind of animal increases or decreases, it usually means a change in the numbers of some other animal.

There are still some gaps in our information about skunks. For example, why do striped and spotted skunks living in the northern areas have smaller stripes than skunks living in warmer climates? Dr. Van Gelder hopes to find an answer to this and many other questions as he continues to study skunks in the coming years ■

■ For more information about skunks, look in your library or book store for these books: **The Mammal Guide**, by Ralph S. Palmer, Doubleday & Company, Inc., New York, 1954, $4.95. This book describes the habits, markings, and range of skunks and other North American mammals. **Familiar Animals of North America**, by Will Barker, Harper & Brothers, New York, 1956, $4.95, gives more details of the lives of many mammals, and has good illustrations.

PROJECT

Hognosed skunks have white backs and long, pig-like snouts.

Hooded skunks have tails as long as their bodies. Their backs may be black or white.

Striped skunks have two back stripes that may be narrow or wide.

Spotted skunks are marked with white wavy stripes and spots.

The four kinds of skunks that live in the United States are shown here. What kinds live in your area? To find out, you might visit a nearby zoo and see what kinds of skunks are there. Ask a zookeeper where the skunks came from, to be sure that they are found in your area. Also watch for dead skunks along highways and try to identify them.

LIQUID LAYER CAKES

by Eleanor Duckworth

Some liquids, like water and milk, mix together. Others form layers instead. Mix some household liquids and see how many floating layers you can make.

■ You've probably seen liquid layers floating on top of one another: gasoline on water in a lake, or cream on top of a bottle of milk. Have you seen layers in a bottle of salad dressing? How many? What do you think they are?

Try mixing some liquids for yourself. You may have some small bottles around the house, or you could use test tubes if you have a chemistry set. Otherwise get some plastic pill bottles from a drugstore.

You can use your imagination to think of different sorts of liquids that might float on each other. Try ones you have at home—water, vinegar, mineral oil, Karo syrup, rubbing alcohol, liquid detergent. (There are lots of kinds of alcohol. One good kind to try is called *isopropyl,* 91 per cent.)

When you pour any two of these liquids into a bottle, does one always sink and the other float? Or do they mix together? What happens if you let them stand in the same bottle for a long time? What happens if you shake them together? Does it depend on what liquids you have used?

Forming Stripes with Liquids

Perhaps you have found two liquids that always seem to stay separated. Does it make any difference which one is put in the bottle first? If you first pour some of one, then some of the other, then some of the first again, then some of the second, and so on, can you fill the bottle up with "stripes" of these two liquids?

Now try three or four different liquids. How many different layers can you make?

Why does one liquid float on top of another? You will probably say, because one is lighter than the other. Then what happens when neither one floats on top? Is that because neither one is lighter? Are they both the same weight?

Weighing Your Liquids

You can compare the weights of your liquids with a soda-straw balance. The diagram in this article shows you how to make one. After you have set up your balance, hang an empty pill bottle on each end of the balance arm with some thread. Be sure the balance arm is level when the empty bottles are hanging on it. If it is not, move the straw a little bit in the cardboard cradle toward the end that is high. You might have to slip the straws back and forth a few times before you have them exactly balanced.

Next, take the bottles off the balance and put a little of one liquid into one bottle so that it comes up to a certain level. In the other bottle pour a different liquid so that it comes up to *exactly* the same level. If you keep your bottles

Eleanor Duckworth is a member of the teaching staff of The Elementary School Science Project of Educational Services Incorporated, Watertown, Massachusetts.

side by side when you fill them, you will be able to see when their liquids reach the same height. Now hang a bottle on each end of the balance arm. Is the arm still level, or does it dip down on one end? Can you tell whether one liquid is heavier than the other?

Do you think that weight is important in deciding whether two liquids will mix? Do you think there might be something else that is important in deciding whether they will mix?

If two liquids mix together, we say that they are *miscible*. You will find that water and milk mix together. Are there any other liquids that mix with water? Make a list of the liquids that seem to be the *water miscible* kind.

Now start with another liquid that does not mix with water—salad oil, for instance. Do any other liquids mix with this? Make a list of these liquids. You might call them the *salad oil miscible* kind.

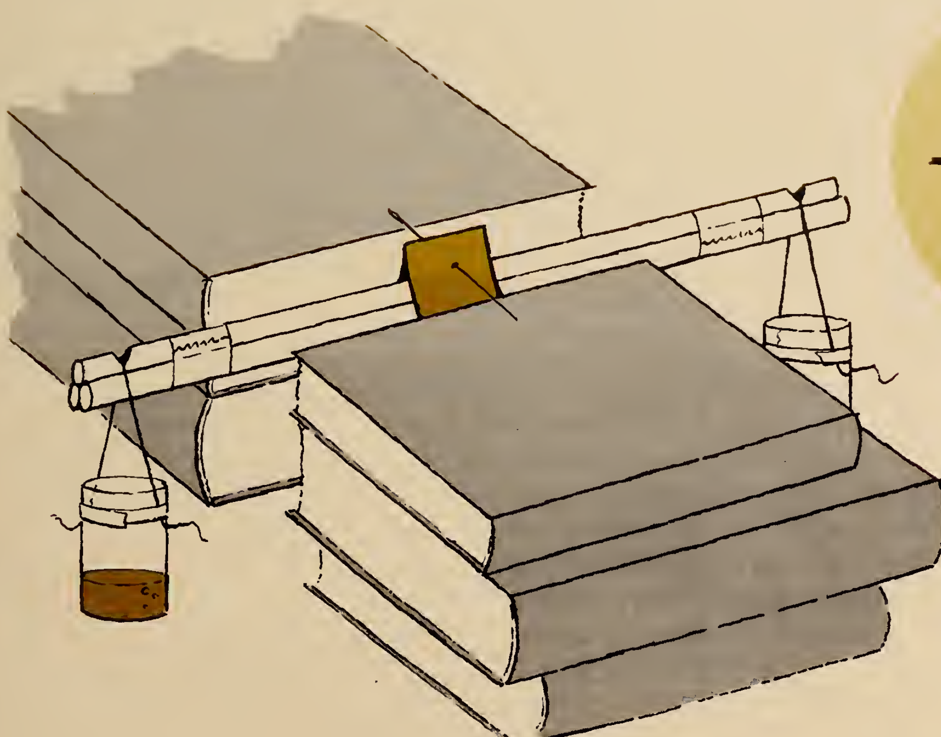
AN INVESTIGATION

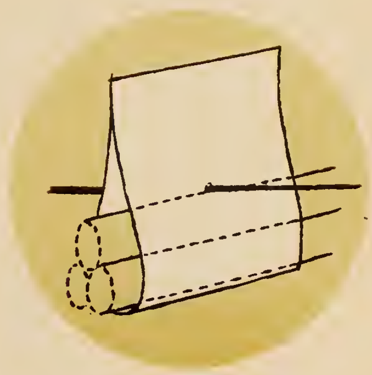
Here is a way to add still more floating layers. Try to float some bits of solids on your liquid layers. You know that wood chips float on water. Do they float on every liquid? Do they float on vinegar? On alcohol? Do different kinds of wood float on different layers? Try bits of plastics, candle wax, seeds, and other things. See if you can float bits of solids *between* the liquid layers.

See if you can find any other miscible kinds.

By this time, you might be finding that it is hard to tell some of the liquids apart when they are in the same bottle. Can you think of a way to help tell them apart? You might try to add colors to some of them. It is fun to see what happens to the colors in bottles of different floating layers. With an eye dropper you could color one of your liquids with drops of ink. You could color another liquid with drops of iodine, and another with cake coloring ■

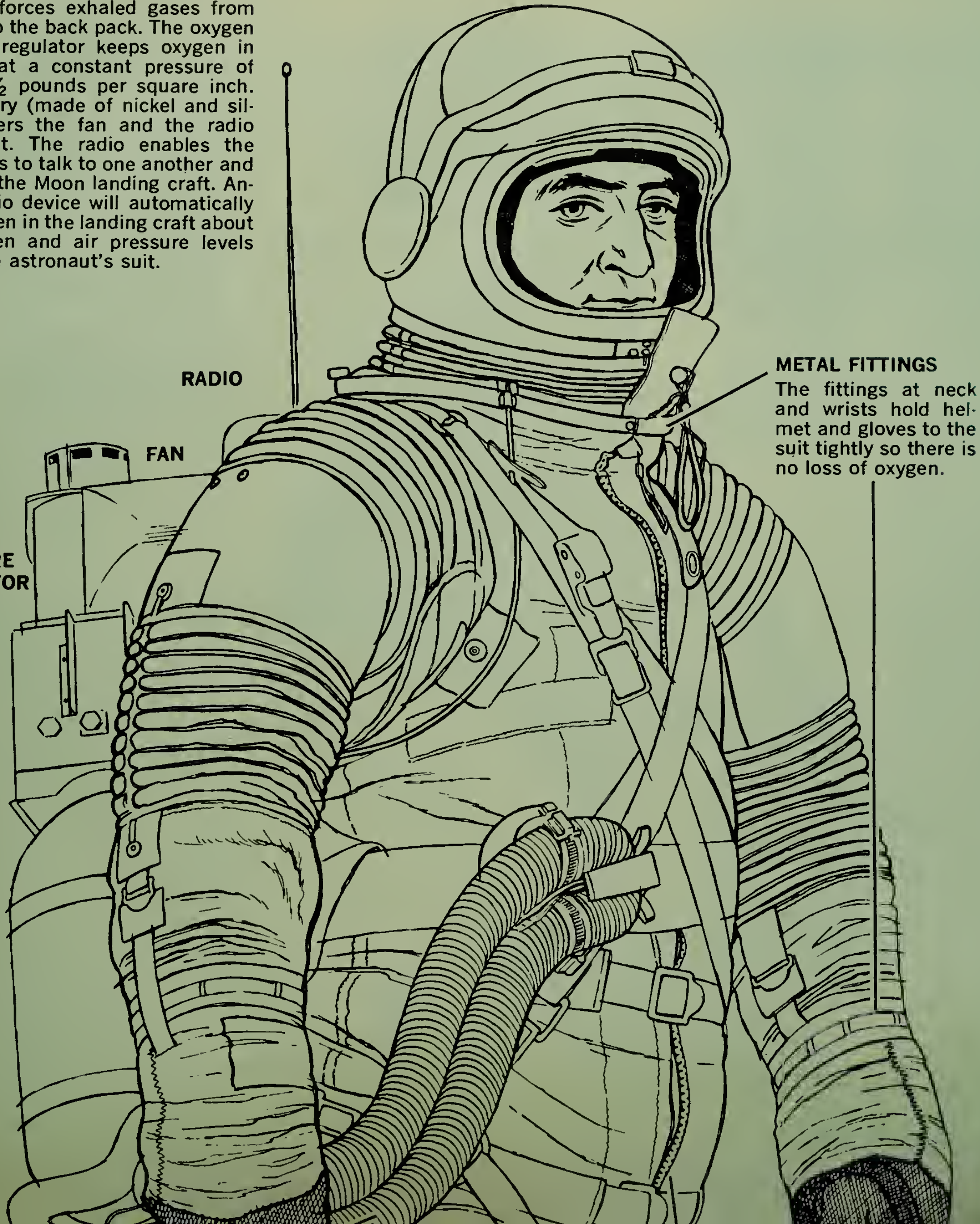
HOW TO MAKE A SODA-STRAW BALANCE





It is easy to make a soda-straw balance for weighing your bottles of liquids. All you need is three long paper straws, a needle, and a piece of stiff paper. First, bind the three straws together with sticky tape, as shown in the diagram. Next, cut out a small strip of stiff paper and form a "cradle" for the straw. Push a needle through the strip so that the needle just touches the top of the top straw. This will help keep the straw from slipping back and forth in the cradle.

If you make a little notch on the top of the top straw near each end, the threads fixed to your pill bottles will not slide off the straw. Use a narrow band of adhesive tape to hold the ends of the thread to the bottle. When you have rested each end of the needle on a pile of books, your soda straw balance will be ready to use.



DRESSING FOR SPACE

■ If a man were flung into the emptiness of outer space, he wouldn't last very long. The side of him facing the sun would quickly broil, and the side in shadow would freeze in a few seconds.

In the vacuum of space he would have no air to breathe, and the lack of air pressure would cause the liquid in his body tissues to seep out through his skin and evaporate. He would soon become totally dried out —a sort of space mummy.

To protect men in space, scientists are designing suits that will enclose the body within an Earth-like atmosphere. Such suits provide a man with oxygen to breathe, keep him from becoming too hot or too cold, and give him the atmospheric pressure he needs in order to stay alive.

The space suit shown here is an experimental one being used as a step toward the final suit to be used in Project Apollo—the United States program to land men on the Moon.

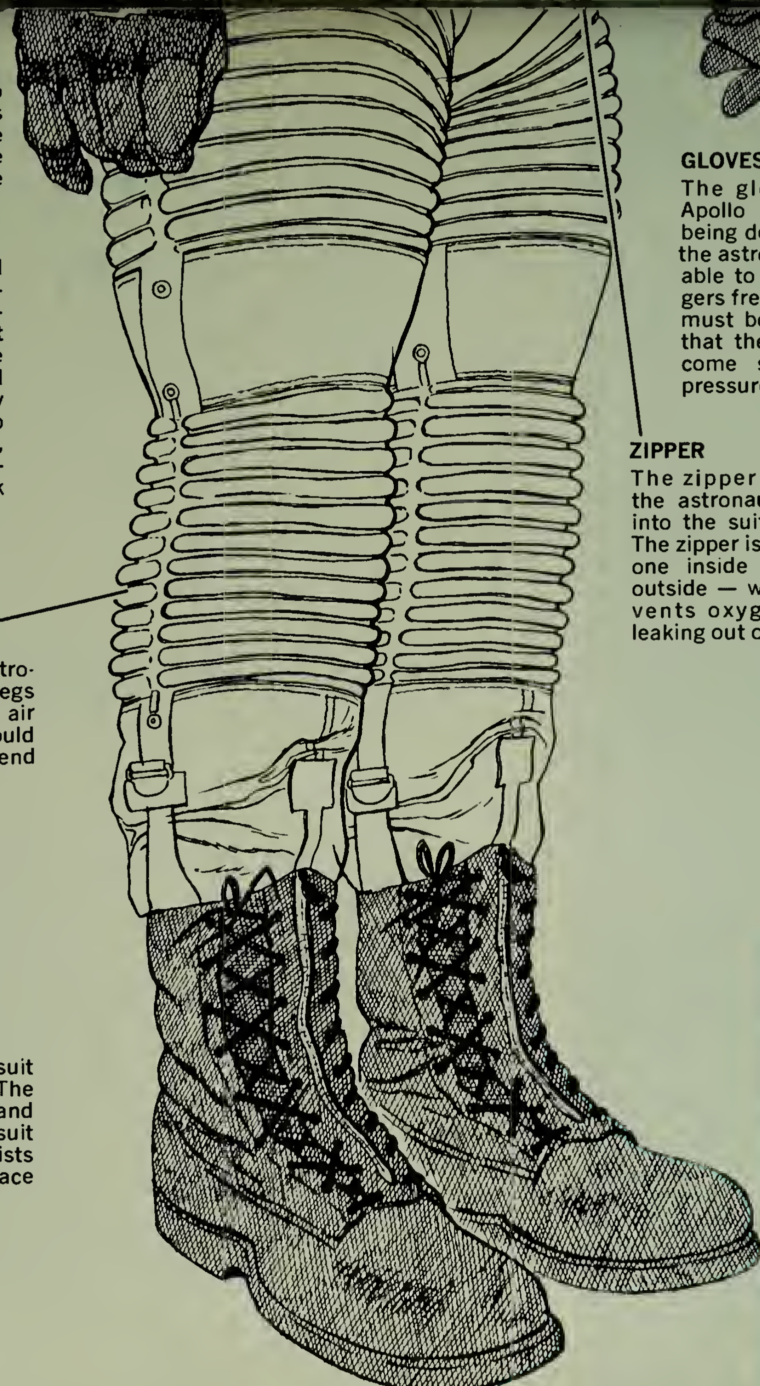
The space suits you have seen on the Project Mercury astronauts were designed to be used inside a space capsule. The Project Apollo suit is designed to be worn outside the spacecraft. This will be possible because the suit will have a special back pack.

are not used by our bodies.

Another job of the suit is to maintain air pressure all over the body of the astronaut. At sea level, there are 14.7 pounds of air pressing on every square inch of our bodies. The oxygen pressure in the space suit will be about one quarter of that amount, which is enough to keep the astronaut comfortable.

The suit will keep the astronaut from getting cold by using some of the heat given off by his body. To keep from getting too hot, he will have a silver-colored outer garment *(see lower left)*. This garment reflects the intense heat coming from the Sun and from the Moon's surface. During the Moon's long day, which lasts two Earth weeks, the lighted portion of its surface heats up to more than 200°F.

When the Apollo spaceship comes near the Moon, the astronauts will put on their suits (which takes about five minutes) and ride to the Moon's surface in a small landing craft. The space suit and back pack will weigh about 80 pounds on the Earth. Since the Moon's gravitation is only one-sixth that of the Earth's, the suit and pack will weigh about 13 pounds on the Moon ■



When men land on the Moon (left), they will be protected from intense heat by silver-colored outer garments. The Apollo suit is being designed (right) by Hamilton Standard for the National Aeronautics and Space Administration.

HOW WE KNOW THE EARTH IS ROUND

This photograph was taken by astronaut L. Gordon Cooper as his Faith 7 Mercury capsule orbited more than 100 miles above the Atlas Mountains in Africa. Lay a ruler along the horizon and you will see the Earth's curvature.

■ Imagine yourself as a geographer living several thousands of years ago. You want to figure out the size and shape of the Earth. How would you go about it?

Today most of us know the answers to these questions. If we don't, all we have to do is look them up in a book. While knowing the answers to such questions is important, it is usually more important to know how to go about finding answers to such questions.

Proving That the Earth Is a Sphere

If someone asked you how you know the Earth is a sphere you would probably answer by saying that we can travel all the way around it and return to the place we left. But if you think about this a moment, it is not a very good answer. If the Earth were shaped like a great hot dog we could travel around it in the same way.

Are there ways of finding out for certain the shape of the Earth? During a lunar eclipse the Earth's shadow falls on the Moon. When these eclipses take place we can see the Earth's shadow on the surface of the Moon, and the edge of the shadow is always part of a circle. There is only one object, no matter which way it is turned, that always produces a circular shadow—a sphere. More than 2,000 years ago, ancient Greeks observed lunar eclipses and concluded that the Earth must be a sphere. Yet long after

This is the second in a series of articles adapted by permission of the Elementary-School Science Project from the revised edition of its booklet, Astronomy: Charting the Universe, *© 1962 by the Board of Trustees of the University of Illinois.*

PROJECT

Find four or five objects of different shape, among them a baseball or a pingpong ball. Stand near a wall and hold the objects a foot or so away from the wall so that the Sun casts sharp shadows of the objects. One by one, turn each object this way and that to see if the shape of the shadow changes.

their time there were men who firmly believed that the Earth was flat.

Even though we know that the Earth's surface is curved, we are not aware of it when we take long trips. We cannot see the roundness of the Earth because we can see only small parts of its surface at any one time. Astronauts, on the other hand, look down on the Earth from a height of about 150 miles. From this altitude they can see a large part of the surface at one glance and can see the Earth's curvature clearly *(see photo)*.

The Ocean's Surface Is Also Curved

When you go to the ocean you can see a much larger part of the Earth's surface than you can when you are on the land. The next time you go to the shore watch for a ship far out at sea. If it is going away from you, you will see that the ship does not only get smaller and smaller, it gradually "sinks" out of view. If the ship has high masts, the masts will still be visible after the hull has disappeared below the horizon.

You can see the same effect of the curvature of the Earth the next time you go to a large lake. Lie down flat on the beach and look through a pair of binoculars held just a few inches above the water. If the lake is about two miles across you will be able to see only the upper part of people standing on the opposite shore. The curvature of the Earth will prevent you from seeing their feet.

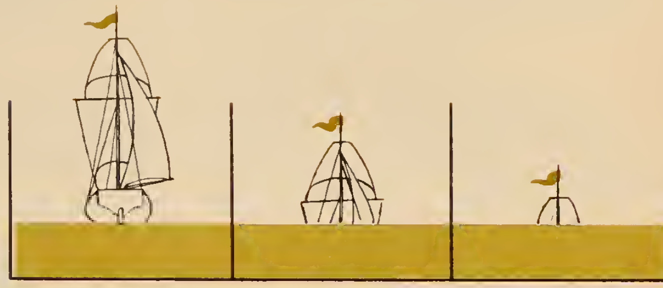
The clues in this article (the Earth's shadow during a lunar eclipse, and a ship sailing over the horizon) have shown you how to prove two things: 1) that the Earth's surface is curved, and 2) that the general shape of the Earth is that of a sphere. Now suppose that you wanted to find out how large the Earth is. How would you go about it without looking up the answers? (Ask several of your friends if they know how many miles it is around the Earth's equator.)

In the last issue of *Nature and Science* we left you stranded on a tropical island. There were many things you wanted to learn about your island and the other islands nearby. It was easy for you to find out the *shape* of your island. All you had to do was look down on it from a hill. But to find its *size* you would need to make some measurements—for example, by pacing off the distance around the shoreline. But you could not pace off the distance to the other islands any more than you could stretch a tape measure across the oceans to find the distance around the Earth. Your problem now is to learn how to make such measurements *indirectly*.

In the next issue of *Nature and Science* you will find that men have used many different units for measuring things—the length of a thumb, an arm, a dog's tail.

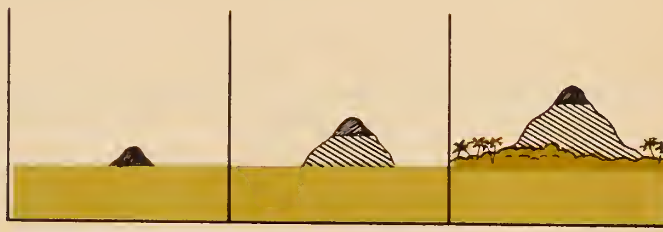
PROVING THAT THE EARTH IS CURVED

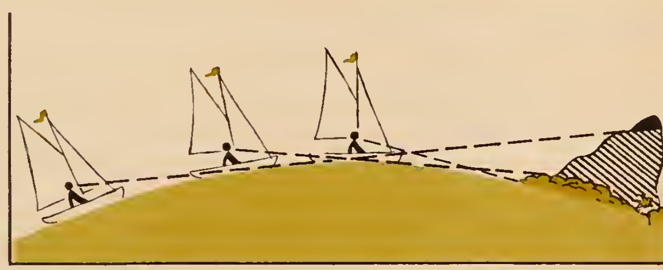
How a ship looks as it sails away from you:



A ship sailing away from you is clearly visible at the horizon. Then it sinks out of sight like a truck going over the top of a hill. If the Earth were flat, the ship would disappear by shrinking away in the distance.

How an island looks as you sail toward it:



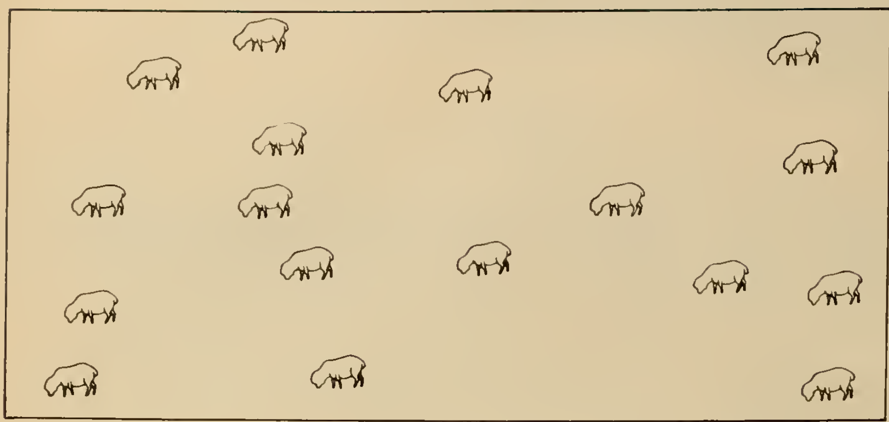


Sailing toward an island, you first see only the highest part of it. Like a broad hilltop, the curved surface of the sea blocks your view of the rest of the island. As you move nearer and nearer, the shoreline rises into your line of sight and you can see the whole island.

PROJECT

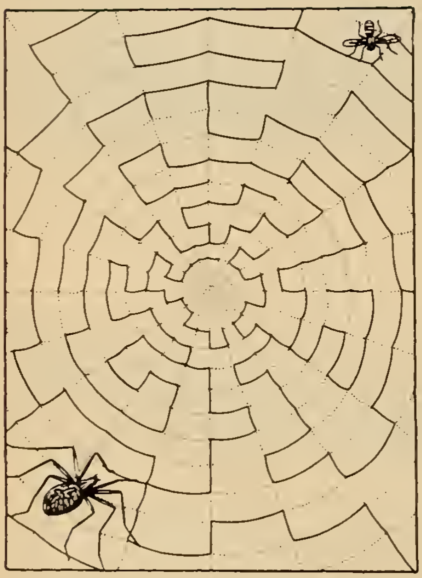
Sight over the top of a large beach ball as you move a small paper ship around it. This will help you to understand what happens when a ship disappears from view over the horizon. Compare a sighting over the beach ball with a sighting made along the floor as you move the paper ship farther away from you toward the other end of the room.

brain-boosters



■ Fence Them In

There are 17 sheep in the pasture shown here. Can you put each sheep in a separate pen by drawing six straight lines? (The lines may cross.)



■ The Spider and the Fly

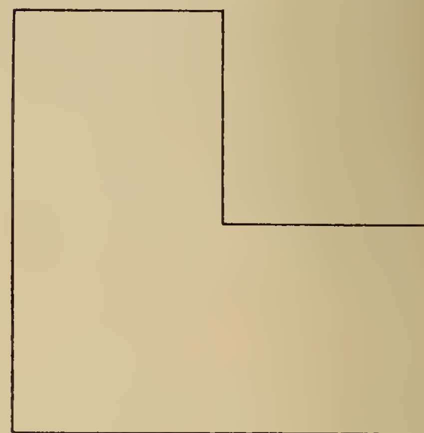
"Won't you walk into my parlor?"
Said the spider to the fly.
"No, thank you!" said the other, "Not
Unless you tell me why."
"The fact is, all my feet are stuck,
And I've a sort of hunch
That I must struggle free again
Or figure in your lunch!"
"How right you are!" the spider said,
"But sure as I'm a sinner,
I've got five minutes' tight-rope walk
Before I catch my dinner!"
"Why, that's O.K.!" the fly declared,
"I'll only be a minute!
By all means try to catch your lunch
But you will never win it!"

Starting at the spider's forelegs, see if you can catch the fly in less than one minute, traveling over the solid lines only.

■ How To Play "50"

Here is a tricky game for two people to play. The first player picks a number between one and six. Then the second player adds a number (between one and six) to the first number. The first player adds a number to that, and so on. The player who reaches 50 or higher first is the winner.

There is a way to win all the time if you are the first player. Can you figure it out?



■ A Surveying Problem

A surveyor wanted to divide this plot of ground into four smaller plots, each the same shape as the large plot. Can you figure out how he did it?

Solutions to Brain-Boosters appearing in the previous issue

How to Play Nim: The only way the first player can be sure of winning is by taking three pennies from the bottom row on his first move.

Any play that leaves one of the following patterns is sure to win:

1. One coin in each of three rows
2. Two coins in each of two rows
3. Three coins in each of two rows
4. One coin in one row, two in another, three in a third

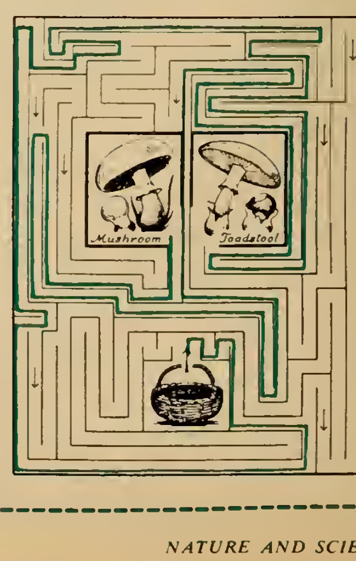
The Delivery Boy's Salary: At the end of three weeks, the boy's total salary is $2,621.43.

A Druggist and His Pills: If the first two pills don't match, then the third is sure to match one of the first two. So the answer is three pills.

The Hindu and the Cat: When you work problems of this sort always count the figures in some systematic way. Count the squares in the Hindu boy in order of size. There are five small squares, five medium-sized squares, and one large square. Total number of squares—11.

Count the triangles in each part of the cat's body. There are 10 in its head, three in its body and feet, and seven in its tail. Total number of triangles—20.

Fun with Fungi: Follow this route to pick the mushrooms.



SCIENCE WORKSHOP

A POND IN YOUR LIVING ROOM

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

If you keep a bullhead in your pond aquarium, watch to see how it uses its eight sensitive feelers to find food on the bottom. Since these feelers look like cat whiskers, bullheads are often known as catfish.

■ 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 uses 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 at least 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 and dangerous to move. Put the tank in a place that doesn't receive much 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)*

This article was prepared with the advice of Barbara Neill, Senior Instructor at the Natural Science Center, The American Museum of Natural History. The investigations were suggested by Dr. Evelyn Shaw, Research Associate of the Department of Animal Behavior.

Some water plants—like *Cabomba* and *Sagittaria*—have roots that must be well covered with the gravel or sand of your aquarium. Other plants—like Anacharis pondweed *(Elodea)* 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 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 most 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).

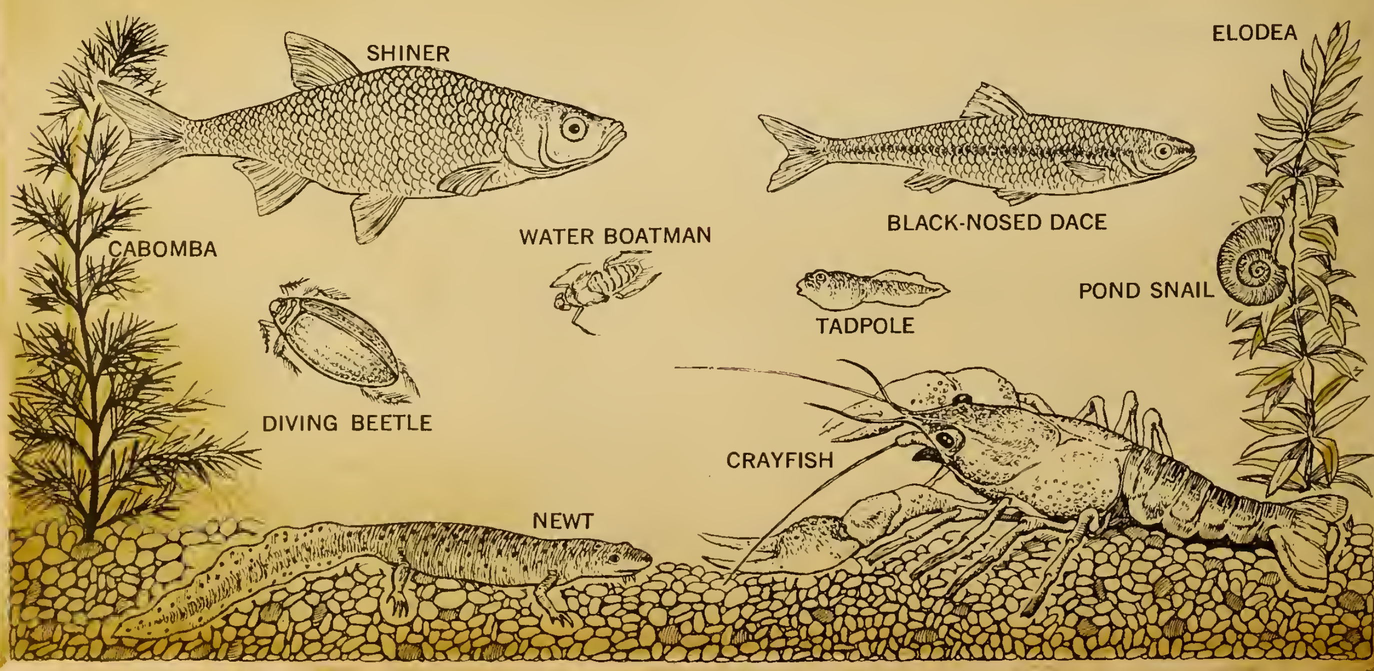
Water insects — like beetles, water boatmen, and dragonfly nymphs — are easy to catch with a small net or a kitchen strainer. Many of these water insects prey on other animals, and on each other. But some people find water insects so fascinating that they keep them in aquariums so they can watch these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

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 fresh-water 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 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 both lettuce and meaty foods.

The animals should be fed lightly and only once 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 which collect on the bottom should be taken out of the tank once a week or more often. Aquarium shops sell gadgets that help remove food wastes easily.

How Many Animals?

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. However, you will be able to keep more animals in an aquarium that has plants growing in it.

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 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 in 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.

—Laurence Pringle

■ For more information about fresh water, tropical, and salt water aquariums, look for these books: *The Care of Water Pets*, by Gertrude Pels, Thomas Y. Crowell Company, New York, 1955, $3.50. *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¢.

INVESTIGATIONS

A. 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?

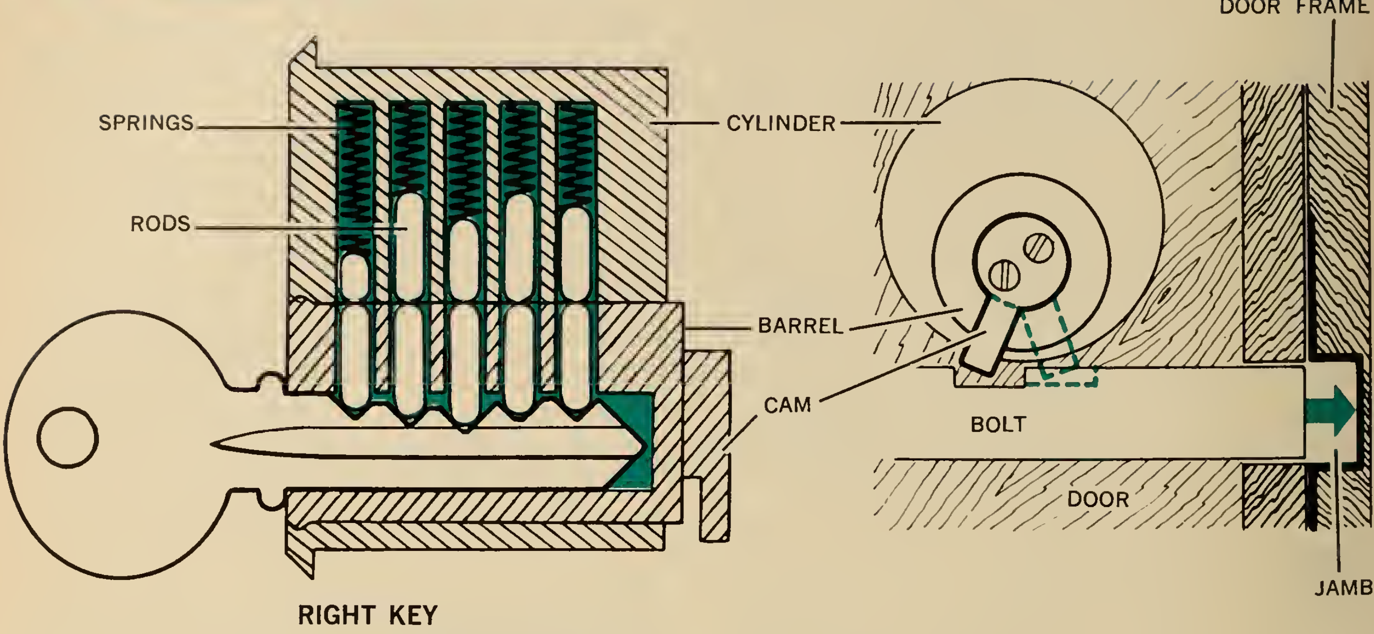
B. Minnows have been trained to jump out of the water and grab a bit of food when a red light flashes. You can try to train, or "condition," some of your animals to come to a certain corner of the tank when you blow a whistle. Here is how to do it:

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 experiments and see how long it takes to train your animals. Do some learn faster than others?

Door Locks



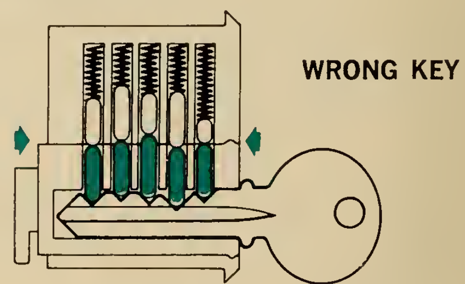
You door key probably is a flat piece of metal with grooves and ridges along the sides, and peaks and valleys along the top. The grooves and ridges match and slide along grooves and ridges in the keyhole. If they didn't match, the key would not fit into the lock.

The peaks and valleys along the top make your key different from the key to any other lock. They are designed to match a row of little rods—each different in length from the others. The rods are held in channels that run between the lock *cylinder* and the lock *barrel*. There are two small rods in each channel. A spring pushes down from the top of the channel and holds the ends of the two rods together *(see diagram)*.

As you push the key into the lock, the rods ride up and down along the peaks and valleys until the key is all the way in. At this point the tops of the lower rods are lined up with the top of the barrel. The barrel is the part of the lock that you turn to open the door. Since the rod ends all line up, the barrel can be turned.

Attached to the end of the barrel is a lever, or *cam*. The cam extends down into a slot cut in the *bolt*. It is the bolt, which slides back and forth, that prevents you from opening the door.

When you turn the barrel one way with your key, the cam turns and pushes the bolt into the *jamb*, or hole in the door frame. When you turn the key in the other direction, this pulls the bolt out of the jamb and unlocks the door so it can be opened.



What happens when the wrong key is used? It may slide into the keyhole all right, because the grooves and ridges along the side of two keys may be the same. But as the key slides in, the tops of the lower rods will not line up. If only one rod is out of line with the edge of the barrel, then the barrel cannot be turned.

Locksmiths carry a whole stock of different size rods. They can change your lock in a few minutes by changing the rods or by rearranging them in a different order in the barrel. A new key is then required.

nature and science VOL. 1 NO. 2 / OCTOBER 4, 1963 TEACHER'S EDITION

How Science Study Increases Reading Power

by Roma Gans

The relationship between growth in science scholarship and increase in reading power is so obvious that it comes as a surprise to find that these two parts of a school problem are often considered separately.

A brief account of the change in the quality of one school in New York State will highlight this point. A teacher of science in a junior high school was made principal of an elementary school in a rural area.

Over the years the school had grown in pupil population, but the program had remained static, except for the adoption of a new basal reading system. No study of science had been added. A teacher who was the spokesman for the staff explained that some fields, such as science, had not been included because the program was already crowded and they did not wish to jeopardize their high achievement in the three R's, especially reading.

Planting the Seeds of Interest

The new principal had a fine background in teaching science and an assuring manner with children and adults. When he visited classrooms he told each group a little about his background in teaching science. He also displayed science books and science equipment in his office. Youngsters shared in the development of a terrarium. Accounts of interesting events in science were clipped from newspapers and magazines and posted on a bulletin board outside his office door. Children and teachers stopped to read "what's new." Soon they began to add interesting items of their own.

In about three months, requests from teachers and children for help on science problems increased at such a rate that a science program was actually under way. The next step was a plan for a regular program from kindergarten through the elementary school.

No sooner had the regular study of science begun when youngsters in the fifth and sixth grades had a genuine need for dictionaries and encyclopedias. Their teachers sent a committee of children to the principal with the request. Previously, such reference books had seldom been used, and the fact that they were very out-of-date went unnoticed.

Many times pupils, even second graders, examined maps and globes to find where science events reported in newspapers and magazines were taking place. Other children studied graphs and diagrams carefully for instructions.

As they read about such topics as erosion, mineral deposits, prehistoric animals, marine life, and conservation, the children's interest in these fields widened and the need for more reference books grew. Classroom libraries also started to grow, and by the end of the year the entire staff sent a request to the board of education for a school library.

(Continued on page 4T)

Dr. Roma Gans, now Professor Emeritus of Childhood Education at Teachers College, Columbia University, has written books on children and reading which include Reading Is Fun *($.75) and* Guiding Children's Reading Through Experiences *($1.25), available from Columbia Teachers College Bureau of Publications; and* Common Sense in Teaching Reading, *The Bobbs-Merrill Company, Inc., New York, $4.*

What To Do With a Dead Hummingbird

If you should find a dead hummingbird on your desk one morning, this is what could happen to you. The following sequence of events was reported to us by Miss Frances Henshaw of the Bayville Intermediate School, Bayville, New York:

A dead hummingbird was deposited on my desk in the fourth grade. The children decide to stuff it. The local taxidermist will do it, but needs a permit. A class committee is formed to get the permit from the State. The State says that since the bird is migratory, the permit must come from Washington.

Washington wants to know how the bird died. They discourage us from pursuing the matter any further, and offer to dispose of the bird in accordance with department policy. Then Washington sends our request to the district office in Boston. This delays the decision about the dead hummingbird even more.

Meanwhile, the dead bird is in the cafeteria freezer marked "staples," and a big shipment of ice cream is expected. Washington finally sends the permit.

We collect milk containers from the school cafeteria to make flower pots; we grow plants from seeds, cuttings, and tubers for a plant sale to raise $15 to pay the taxidermist. (A sneaky way of teaching some botany.) He mounts the bird, but says the charge will be $19.

On the big day, the mounted bird comes back. The children crowd around and look at it. "It's awful skinny!"

Page 3: I've Never Met a Skunk...

Central concept: Organisms interact with their environment; their behavior (responses) depends on the changes in the environment.

So many people think of the skunk only in terms of an offensive odor that the animal's name is often used as an expression of contempt. Dr. Van Gelder's experiences with skunks show that this popular image of the animal is both misleading and undeserved. The odor-spraying ability which has brought the skunk such ill fame is used for self-defense.

But the article does more than describe the skunk's characteristics and explain its behavior. In tracing the development of these characteristics, it provides an example of the concept: *Animals are adapted for survival in their environment.*

In the long period of evolution from a weasel-like form, some types of skunk have changed more than others. The hognosed and striped skunk, for example, became bulkier and slower in movement. These skunks dig in the soil for most of their food and never climb trees. Spotted skunks, however, are agile climbers and have a weasel-like body shape. Some of the other members of the weasel family show similar adaptations (*see illustration*).

Your pupils can probably name some animals—such as fawns—that are colored so they are usually difficult to see. Some scientists think that the skunk's bold coloration has a protective effect. The theory is that the skunk's enemies see the skunk's black-and-white coat pattern, recognize it as an odorous skunk, and stay away. The white of a skunk's coat is more easily seen than any other colors at night. Also, most of the animals that might hunt skunks are color-blind, so the skunk's black-and-white pattern is more visible than patterns of other colors.

Another important concept is exemplified in this article: *Any change in the environment (or in the natural population of animals) may change the "balance of nature."*

The example is that of people killing skunks because they mistakenly thought that the skunks were eating duck eggs (*see page 5*).

Your pupils should understand that the "balance" of nature is not stable (a better term would be dynamic equilibrium in nature); in short, the balance of nature is always changing. Populations of animals like the ducks, turtles, and skunks change gradually through the years as their environment changes. In this case, a sudden shift in numbers was brought about by the action of man.

For further information you may wish to read Charles Darwin's classic *The Voyage of the Beagle,* and *Horses,* by George Gaylord Simpson, both paperbacks in The Natural History Library, Doubleday Anchor Books, $1.45 each. *The Balance of Nature,* by Lorus and Margery Milne, Alfred A. Knopf, Inc., New York, 1961, $5, is a clearly written book on a complex subject.

Some members of the weasel family (see above) have evolved into forms that are slender and agile, while others are bulky and slow-moving. The spotted skunk and long-tailed weasel are adapted to catch their food by quick maneuvers, running, and climbing. The badger and the hognosed skunk are adapted—with long claws and snouts—to root in the soil for most of their food.

Page 6: Liquid Layer Cakes

Basic concept: Matter undergoes changes in state: Its physical changes depend on the properties of its constituent particles.

This article encourages investigation of the relative buoyancy of liquids of different densities.

The smallest piece of any substance that still retains all the properties of that substance is a molecule. The molecules of each substance are different in structure, weight, size, and arrangement from the molecules of other substances. For this reason, equal volumes of different substances have different weights.

This is the concept of *density,* which means weight per unit of volume (expressed in grams per cubic centimeter). For convenience in comparing the densities of different materials, water is used as the standard. The number of times a material is denser than water is called the *specific weight* (or *specific gravity*) of that material, and is expressed as a pure number. A material with a specific weight of 2.5 weighs two and one-half times as much as an equal volume of water.

When your pupils have weighed equal volumes of three or four of the liquids described in the article, ask them to predict which ones will form the top, bot-

The suggestions for using this issue of Nature and Science *in your classroom were prepared by Kenneth Bobrowsky, Bank Street College of Education, and the Bronx High School of Science, New York, New York.*

tom, and in-between layers when they are poured together in a jar. Then have them test their predictions.

Can your pupils explain why ice floats on water? Is ice as dense as water, or do the particles of water occupy more space when they are frozen into tiny crystals? Here is a way to find out:

Set a small jar in a bowl or pan and fill the jar with water to the brim, taking care not to spill any water into the bowl. Very gently lower an ice cube into the water until it floats. With the tip of your finger push the cube down until the top is even with the surface of the water. The cube will displace its own volume of water into the bowl. Now lift your finger so the cube floats freely.

As soon as everyone has seen the cube floating, lift the jar out of the bowl without spilling any more water into the bowl. Then remove the ice cube and set it in a cup to melt. Pour the water from the bowl into a small, transparent pill container and label it "displaced water." When the ice has completely melted to water, pour it into another container the same size. Comparison shows that the water in the cube must have occupied more space when it was frozen. The molecules occupy more space when water is frozen than when it is in liquid form, so ice is less dense than water—which explains why it floats on water.

Another interesting investigation can be launched by setting an uncooked egg on the bottom of a tall jar and pouring in water until it is about half full. The egg stays at the bottom because it weighs more than an equal volume of water; its specific weight is more than 1.

Now stir about one-half pound of salt slowly into the water. Can your pupils explain why the egg floated to the surface? To test their conclusions, have them weigh equal quantities of plain water and the water to which salt has been added. Salt water is more dense than plain water—and, in this case, more dense than the uncooked egg. This explains why the egg floats, and also why it is easier for a person to float in the ocean, which contains salt, than in fresh water.

Page 8: Dressing for Space

Central concept: Animals must adapt to their environments for survival; however, man's intelligence enables him to modify the environment.

Man as a form of animal life is well adapted for life on most areas of the Earth's surface. And by the use of clothing and shelter, man has learned to adapt himself for survival in the warmest as well as the coldest regions on the Earth's surface.

But the environment encountered by an astronaut in space presents problems that are not encountered on the Earth. Removed from the life-sustaining properties of the Earth's atmosphere—oxygen, air pressure, moderate temperature—a man in space would be as helpless as a fish out of water.

An aquarium is to a catfish what a space suit is to an astronaut. Man must manufacture his own environment if he is to survive during his space explorations.

Your pupils may find it interesting to compare the different types of clothing devised by people in different parts of the world to protect themselves against the climatic conditions found in their areas.

Page 10: Measuring the Universe 2

How We Know the Earth Is Round

When we tell a child that the Earth is round, he accepts this information as truth. Before a scientist accepts something as "true" he must be satisfied that the statement can be verified.

The projects proposed in the article will help the child understand how man first reached the conclusion that the Earth is round. The photograph on page 10, taken by astronaut L. Gordon Cooper as he orbited the Earth, shows the curvature of a section of the Earth's surface. The curvature can be emphasized by placing a straightedge along the horizon in the photograph.

A child with a critical mind may well wonder why the curvature of the horizon line is not more evident inasmuch as the picture was taken from a hundred miles or so above the Earth's surface.

The reason can be demonstrated with a 16-inch globe. If this represents the Earth, then the radius of eight inches represents the Earth's radius (4,000 miles). An astronaut circling the Earth about 100 miles above its surface would be only one-fifth of an inch above the globe on this scale.

Ask the child to place his eye one-fifth of an inch from the globe. (This is about an eyelash length above the globe.) Ask him to describe what he sees. He will probably be able to observe no more than a small portion of the curve of the horizon in any direction.

Would the curvature of the Earth's surface be more evident to the astronaut if he were higher? Here is a way your pupils can visualize how an astronaut's view of the Earth would change as he traveled away from its surface.

Cut a small hole in an index card with a pencil. Make the hole about 1/8th inch in diameter. Observe the edge of the globe by placing the index card over the eye. The hole represents the astronaut's view from the capsule.

Start the observations as close to the globe as the child can get and still see the horizon. As he moves farther and farther from the globe, more and more of the horizon will come into view and the curvature will be more and more evident. The closest distance from which the globe's full diameter will be visible is about 16 inches. On our scale this means that the astronaut would be at an altitude of about 8,000 miles. This is equal to the diameter of the Earth.

"Investigation" vs. "Experiment"

Possibly you will wonder about our use of the term *investigation* rather than *experiment* in both the Teacher's Edition and the student's edition of *Nature and Science.* Most of the "experiments" done by children are not "experiments" in the true sense of the word. Most are demonstrations the results of which are almost forced on the child.

Children will not learn the ways of the scientist if they try their hands only at "experiments" that will not fail. An experimenter does not experiment when he *knows the result.*

Hence, the term "investigation." One investigates by reading, as well. The child can learn to investigate and—if he is so minded—can at last become an experimenter, if not a scientist.

Page 13: Pond in Your Living Room

Basic concept: Organisms capture energy from their environment; they are interdependent.

An artificial pond in the classroom or home can provide many enjoyable hours in watching and maintaining aquatic plants and animals. Equally as important, the aquarium can be an invaluable teaching aid in many areas of science study.

Here is a miniature indoor laboratory in which the observer can see and study many interrelationships among organisms.

The popular myth of a "balance" between aquarium plants and animals is exploded on page 15 of this article. The chief reason for keeping plants in an aquarium is to provide shelter for the animals. Although the plants also provide some food and oxygen, nearly all of the oxygen required by aquarium animals enters the water through its surface.

For detailed information about stocking and maintaining aquariums, in addition to references listed at the end of the article, see: *Exotic Aquarium Fishes,* by William T. Innes, Aquarium Publishing Co., Norristown, Pa., 1956, $9.75.

Science and Reading Power

(Continued from page 1T)

A new excitement over learning had developed. Not only were youngsters using a wider variety of materials and making more intelligent use of them, but the children showed some totally new and mature developments in comprehension evaluations.

For example, in reading two references on fossils of mammals found in the United States, two boys noticed that Montana was mentioned as a rich source in one reference, but not included in the other. One account of erosion gave a short description of erosion by glaciers, the other omitted this point. Alert readers noted references and dates of publication. They discussed points of difference. Children eight to twelve years old demonstrated comprehension of concepts that teachers had assumed they were not yet ready for.

Critical Thinking Developed

One markedly new facet to their intellectual growth was that of sensing when to pause, to reconsider, perhaps to read more, and at times to defer acceptance of information. This new-found power, to challenge accuracy and authenticity, carried over into all other work. Many of the children had their first experiences in critical thinking.

Such thinking was reflected not only in their reading comprehension, it also was noticeable in their study of science. They frequently asked how and why. A questioning attitude pervaded their work in such experiences as testing out seeds from three different companies, following demonstrations suggested in their science texts to prove expansion of air, and examining evidences of glacial deposits in a gravel bank.

The principal cited instance after instance of children reading more extensively and more critically as a result of the newly planned program in science.

Although the teachers felt the need of a basic text as a prop for their adventure into this new field of teaching, the program did not become textbook centered. Instead, teachers encouraged their children to keep on the lookout for science news, and sought to enlarge their concept of science. The teachers covered both natural and physical science topics and tried to develop some understanding of the many different areas included in the omnibus term *science.*

Questions and topics which arose, even when not included in the text, were studied according to the children's interest and readiness. For example, the term "redskin" appeared in a story read to a second grade class and a girl asked, "Are Indians' skins really red?" The teacher admitted that she had never seen an Indian. Then she added, "Those interested in this question, as I am, can look into this and report to us."

It was only natural that skin coloration and racial characteristics should come into this brief follow-up. The teacher told the seven-year-olds that the topic was in the subject of anthropology. She wrote "anthropology" on the board and told her youngsters about some of the things anthropologists do. In similar manner, other teachers extended the program beyond their basic texts, thereby stimulating children's alertness and extending their learning.

Is such stimulating, intellectual reading an inevitable effect of all science programs? It could be, but it must be fed by a stimulating science program. A science program based only on how-to-do experiments and predigested information for youngsters to remember and recite may clutter children's reading and intellectual ability rather than develop it.

In the school I have described, the principal guided the teachers in encouraging children to explore, to test, to challenge, and to create. With day-to-day help and encouragement, these youngsters were becoming better thinkers and more intelligent readers.

From youngsters so taught will come scientists of the future—those who can conceive ideas and design instruments and systems to test them—as well as informed citizens who are able to understand and support scientific endeavor.

The quality of scholarly reading and creative thinking which a science program generates is an important criterion for judging the soundness of that program.

THE NEXT ISSUE of *Nature and Science* will be the first of two special-topic issues for this semester.

It is devoted mostly to the air around us—the gases it is composed of, what other substances are in it, and how it is polluted by man.

A chart, ideal for the classroom bulletin board, shows how the temperature and density of the air vary with altitude; locates the aurora and meteoric displays, and shows how high birds, kites, and man himself have penetrated into the atmosphere.

Science Workshop articles investigate the water in the air and how much air we breathe. An article on kites and their uses illustrates principles of aerodynamics.

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nature and science

VOL. 1 NO. 3 / OCTOBER 18, 1963

SPECIAL-TOPIC ISSUE

ALL ABOUT THE AIR

WHY SCIENTISTS FLY KITES

See Page 13

ABOUT THE COVER

The first craft that man launched into the air was probably a kite something like those shown on our cover. There is some evidence that kites were flown by the Egyptians and Chinese more than 2,000 years ago.

Ever since, people have been flying kites—sometimes to scare away evil spirits, sometimes for more practical purposes, but mostly just for fun.

In Japan and some other countries, kite flying is a national sport; contest winners are considered heroes. In our country, water skiiers hang from kites to be lifted into the air as they are towed behind motorboats.

In warfare, kites have been used to lift scouts over both land and sea to spy on enemy movements. They have also been used to deliver and drop bombs and as practice targets for gunners.

An English schoolmaster sailed two huge kites to pull a lightweight carriage up to 25 miles per hour in 1827. Less than 100 years later, the Wright brothers added a wind-making machine to a box kite to make the first successful airplane.

Scientists have been using kites to study the air for several centuries. Now a new kind of kite may replace the parachute to bring space capsules safely back to Earth *(see page 13).*

nature and science

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The things in the air may be quite different around high mountains (above) and in a smoggy city (below).

What's In the Air?

Besides the oxygen we need to keep alive, we breathe an amazing variety of things into our lungs. The air is a jungle of particles – soot, ash from volcanoes, dust from outer space.

by Laurence Pringle

■ How many times have you heard someone from the city say, "Ah, smell that wonderful fresh country air," or someone from the country say, "This city air is awful. How can they breathe it day after day and stay alive?"

Few of us think any more about the air we breathe than we think about breathing itself *(see page 7)*. Yet we breathe in and out about 18 times every minute.

The air that surrounds us is made up of gases, germs, countless billions of tiny particles of smoke and soot, salt from the sea, ash from volcanoes, dust from outer space, pollen from plants....The list could go on and on.

Sometimes there is more dust and other such particles in the air than at other times. Changes in the amounts of dust and other matter in the air cause different color displays at sunrise and sunset. In 1883 the volcanic island of Krakatoa, near Java, exploded out of the sea. For months afterwards dust and ash hung in the air around the globe. In some areas people reported purple snowfalls and green sunsets.

We live at the bottom of a deep "ocean" of air that extends upward at least 500 miles. At ground level the air is the densest, but the higher into the atmosphere we climb,

(continued on the next page)

the less air there is. On a mountain top 18,000 feet high, for example, the air is only half as dense as it is at sea level *(see page 8)*. At sea level 14.7 pounds of air press against every square inch of your body. Right now about a ton of air is pressing in on you from all sides, but like a fish that lives at great depths in the sea you are not aware of the pressure. At an altitude of 50 miles, 99.997 per cent of the air is left behind. So far as atmospheric pressure is concerned, at that height you could consider yourself in outer space.

Gases in the Air

The air we breathe contains about a dozen gases. You already know the names of some of them.

Nitrogen is the most common gas in the air. It makes up about three-quarters (78 per cent) of the air that we breathe. Although we take nitrogen into our lungs every time we breathe, our bodies do not use this gas. We just breathe it out again when we exhale. Even though we don't use nitrogen, the gas is important to us in another way. It is needed by plants, which we use for food.

Oxygen is the second most common gas in the air. It makes up about 21 per cent of the air that we breathe. When we take air into our lungs, some of the oxygen enters our blood and is used to change our food to energy.

Carbon dioxide makes up only a small fraction (three hundredths of one per cent) of the total volume of the air. It is a waste gas given off by our lungs when we breathe out. It is also released into the air by erupting volcanoes, by burning fuels, and by decaying soil. The oceans absorb most of the carbon dioxide from the air. However, green plants also take this gas from the air. They combine carbon dioxide with water and make sugar (glucose). In the process, they release oxygen into the air.

Water vapor is water that has changed from a liquid to an invisible gas *(see page 12)*. When the percentage of water vapor in the air is high, we say the air is muggy, or sticky, and that the relative humidity is high.

The water vapor in the air comes from many sources —from animals when they exhale and perspire, from the oceans, lakes, and rivers, from the ground, and from plants. Plants give off an amazing amount of water vapor. For example, an acre of corn gives off 1,200 tons of water into the air during a single growing season of about 100 days. Water vapor rises into the air, cools, and changes back into water droplets which form clouds, rain, and snow.

There are several other gases in the air that we breathe. Argon, for example, makes up just a little less than one per cent of all the air. But as with nitrogen, your body does not use argon. Nor does it use neon, krypton, hydrogen, xenon, ozone, and radon, gases which are also found in the air in very small amounts.

Scientists have found that the mixture of the gases in the air stays just about the same up to a height of 15 or 20 miles. Above this height the chemistry of the air changes. Between 15 and 35 miles, for example, a different kind of oxygen is found. It is called *ozone* and forms a layer that protects us against ultraviolet rays from the sun.

The Dusty Air

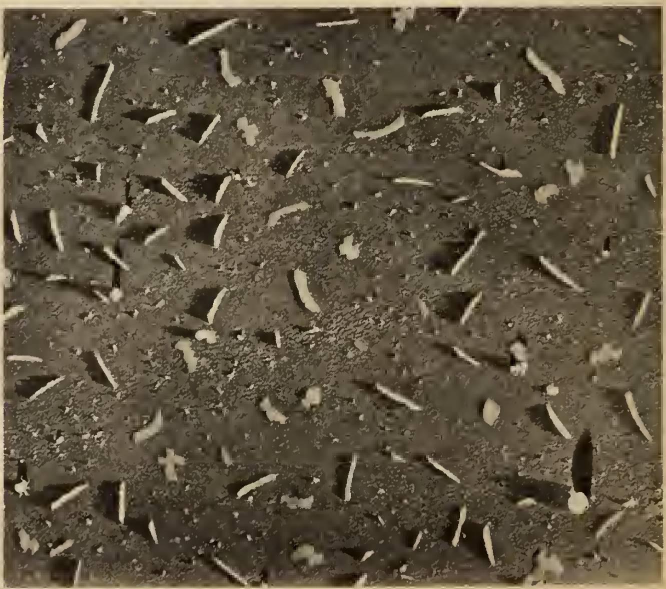
There are other things in the air besides gases. If you take a close look at a beam of light in a darkened room, you will see fine particles of dust floating in the air. This dust comes from many sources. Most of it comes from the soil. Some of it is tiny bits of ash from volcanoes. There is even some dust that comes from outer space.

Some other types of dust in the air come from plants. One type is pollen, a fine powder that comes from flowers. When pollen grains land on flowers of the same type that they came from, part of the flowers develop into seeds. Another kind of plant dust is spores, which come from plants like mosses and molds. When spores land on a favorable spot they may grow into new plants.

Most of us do not notice this plant dust in the air. However, when pollen is plentiful, some people get hay fever.

Life in the Air

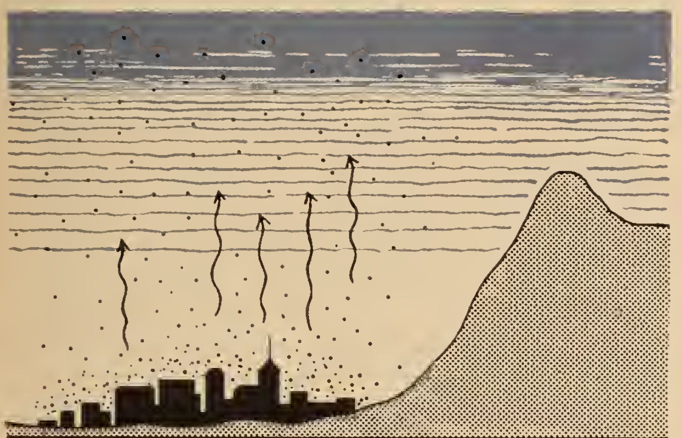
Besides gases and bits of dust, the air also has many "germs" in it. These tiny things are so small that they can be seen only with special microscopes. Some germs—like



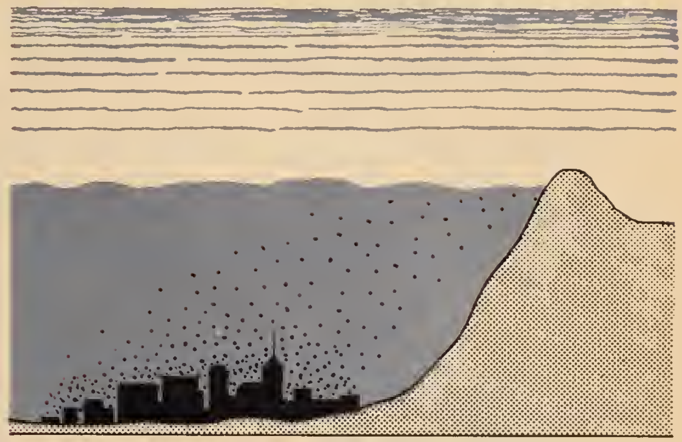
Particles of dust, pollen, and other things in the air are usually too tiny to see. This picture shows some smog particles enlarged 18,000 times by a special microscope.

bacteria—are alive, but scientists are not sure if another kind—*viruses*—are alive or not. When we breathe in air, some of these germs get into our lungs. Some are harmful, and some are not.

The number of germs that you breathe into your lungs depends a lot on where you are. When a person breathes the clean air on a high mountain, he may inhale only one germ every 20 minutes. A person in a crowded room, however, may inhale as many as 60,000 germs with each breath.



Air near the ground is usually warmer than the air above it. Since warm air rises, it carries the dust, wasted fuel, and other pollutants higher into the atmosphere.



Sometimes a layer of cool air moves in under warm air. The cool air does not rise and pollutants are trapped in it. This is how smog is formed in Los Angeles and other cities.

Our Polluted Air

The air we breathe is never completely free of dust and other materials. Most of these wastes get into the air from automobile engines and when fuel and trash are burned in our factories and homes.

Sometimes you can see air pollution if you look at the horizon. Can you see the horizon clearly, or is it partly or completely hidden by a layer of haze? This haze is sometimes called *smog,* a word that means "smoke mixed with fog." Actually, not all polluted air has smoke or fog in it, but the word "smog" is used to describe any thick haze of polluted air.

Smog forms when the wastes that get into the air are not carried away by air motion. Usually the air that is near the ground rises, because it is warmer—and therefore lighter—than the air above it. When it rises, it carries pollutants with it.

Sometimes, however, a layer of cool air moves in under the warm air. This cool air becomes trapped near the ground and cannot rise. The pollutants in it are also trapped, and a hazy smog forms. Los Angeles has smog more than half of the days of the year. Cool air flows in from the Pacific Ocean and becomes trapped under a layer of warm air in the Los Angeles basin *(see diagram).*

When polluted air is trapped in an area for several days, the result may be a disaster. This happened in Donora, Pennsylvania, in 1948. After six days of thick smog, nearly 6,000 people were sick and 20 people died from breathing the polluted air.

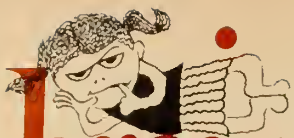
Such disasters are rare, but they remind us of the dangers of unclean air. Polluted air causes billions of dollars of damage to crops, buildings, and animals each year. Scientists are trying to answer the important question of whether or not breathing small amounts of pollutants for long periods of time is just as dangerous as breathing thick smog for only a few days. If this is so, then the problem of air pollution is even more serious than we realize.

Can We Stop Air Pollution?

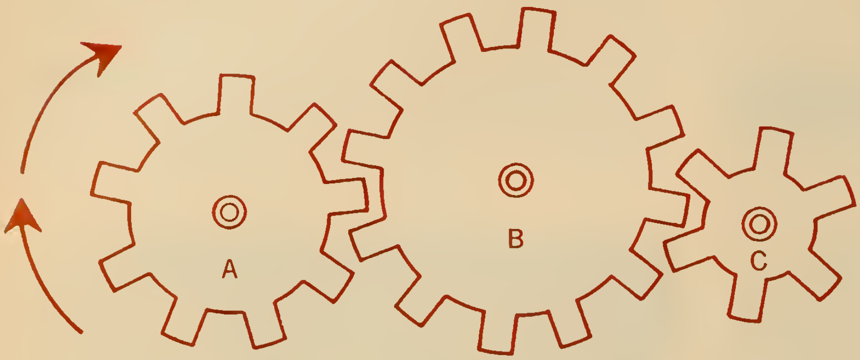
There will always be some pollutants in the air. However, many kinds of pollutants can be kept from the air, and others can be reduced.

One way to lessen air pollution is to stop the burning of rubbish when there is danger of smog forming from the wastes. Factories can use devices on their smokestacks to keep wastes from the air.

All 1963 model automobiles in the United States have engine devices that stop some of their unburned fuel from going into the air. Engineers are studying ways to reduce the amount of wasted fuel that comes from automobile exhausts. This is one of the most serious sources of polluted air. For example, the three million autos in and near Los Angeles give off 10,000 tons of pollutants every day. If the exhaust wastes from the 73 million automobiles in the United States could be kept from the air, the air that we need for life would be much cleaner ■



brain-boosters



■ Shift These Gears

If Gear A turns to the right in the direction of the arrow, can you tell what happens to the other gears? Circle the number before each correct statement in the list below:

1. Gear B will turn to the right.
2. Gear B will turn to the left.
3. Gear C will turn to the right.
4. Gear C will turn to the left.
5. Gear B will turn faster than A.
6. Gear B will turn slower than A.
7. Gear C will turn faster than A.
8. Gear C will turn slower than A.
9. Gear C will turn faster than B.
10. Gear C will turn slower than B.

■ Who Won the Race?

Four girls—Alice, Brenda, Cissie, and Doreen—had a race to find out who could run the fastest. Afterwards they couldn't agree on the order of finish.

Alice said, "Cissie was first and Brenda was second."

But Brenda said, "No, Cissie was second and Doreen was third."

Finally, Cissie said, "Doreen was fourth and Alice was second."

Doreen kept quiet.

Each of the three girls made one true and one false statement about the race. Can you name the girl who finished first, second, third, fourth?

■ Travels of a Bookworm

A bookworm was eating paper from the inside of the front cover of Volume I of a set of four books. He was a clever worm and realized that there would be some delicious pages in Volume IV under the subjects "steak, squash, and salad," so the worm decided to make a non-stop trip to the fourth volume.

It takes the bookworm two days to eat through a book cover, and seven days to chew through the pages of one book. How long will it take the worm to reach the last page of Volume IV?

■ Not a Drop More Than 4

Old Mr. Todd had a 1928 car that acted in a very strange way. Whenever it ran out of gasoline, it would start only if exactly 4 pints were poured into the empty tank.

Now Mr. Todd ran out of gasoline one day and had to walk a mile to the nearest farm. When he got there the farmer pointed to the barn and said, "Help yourself. Over yonder you'll find a drum full of gasoline. And on top of the drum you'll find a 3-pint jar and a 5-pint jar."

Until he thought about it for a while, Mr. Todd was upset. His problem was to bring back exactly 4 pints of gasoline.

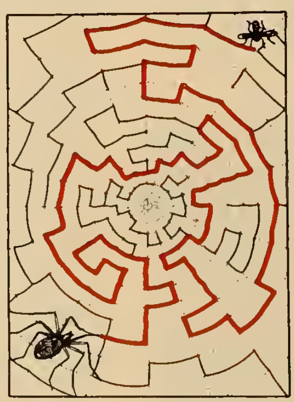
How did he do it without marking either of the jars?

■ The Ant's Journey

An ant fell into a hole 30 feet deep. The ant climbed up 3 feet each day, but slipped back 2 feet each night. How many days did it take the ant to reach the top?

Solutions to Brain-Boosters appearing in the previous issue

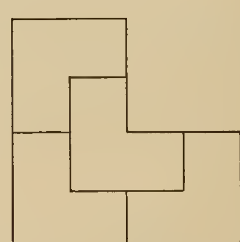
The Spider and the Fly: Follow this route to catch the fly.



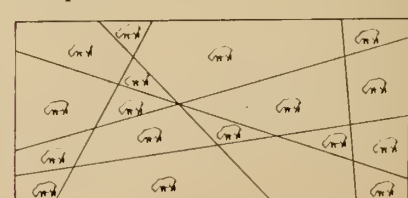
How to Play "50": To reach "50" first, the first player must keep certain key numbers in mind. For example, if the first player calls 43 after several plays, the most the second player can add is 6 for a total of 49. The first player can then add one, call 50, and win. In the same way, if the first player calls 36, the second player cannot prevent the first from calling 43 on his next turn.

The key numbers are 1, 8, 15, 22, 29, 36, 43. If the first player always chooses these numbers, he will always win.

A Surveying Problem: Here is how to divide the large plot into four plots the same shape.



Fence Them In: By drawing these six straight lines, you give each sheep a separate pen.



HOW MUCH AIR DO YOU BREATHE?

■ Take a deep breath of air, as if you were going to dive into the water. Now blow the air out as you would if you were blowing up a balloon. How much air are you able to take into your lungs *(inhale)* and then blow out *(exhale)*?

If you could measure the space that this amount of air fills, you would know what scientists call the *vital capacity* of your lungs. This is not the total capacity of your lungs. A certain amount of air is always left in them because your ribs prevent your chest muscles from collapsing your lungs all the way, which would force all the air out.

Here is how you can measure the vital capacity of your lungs. It's a good idea to do this experiment at the kitchen sink.

First, fill a glass jar—the kind with a screw-on cap—to the very top with water and measure how much water it holds. You can do this by pouring all of the water into a kitchen measuring cup, which is marked to show how many fluid ounces of liquid are in it. A cup like this usually holds 8 or 16 fluid ounces, so you will probably have to fill and empty it several times to measure how much water the jar holds. Write down this number of ounces.

Now set the jar on its side inside a deep pan and pour water into the pan until the water is about one inch above the jar. For the next step you will need a piece of rubber tubing. Put one end of the tubing into the jar and hold the other end out of the water. Now turn the jar so it is upside down in the water and hold it there with one hand *(see diagram).*

Take one deep breath and blow every bit of the air through the hose and into the jar. This will force water out of the jar. Make sure that all of your breath goes into the jar and that none of it escapes by bubbling up into the pan of water.

When you have exhaled completely through the hose, lift the jar a little bit without tilting it and slide out the hose. Holding the jar very carefully, reach into the water with your other hand and cover the opening of the jar completely. To get a tight fit you could cover the jar opening with a square of cardboard. Be sure not to let any extra water get in. Turn the jar right side up and lift it out of the pan.

If you blew all of the water out of the jar, repeat the experiment by using a larger jar. If there is some water left in the jar, measure how much is left and write it down. Now subtract the number of ounces of water left in the jar from the total number of ounces that the jar holds. This tells you how many ounces of water you blew out of the jar.

Try the experiment several times. Do you blow just about the same amount of air into the jar each time? If not, can you explain why? Ask a friend to try the experiment with you. Ask an adult member of your family to try it ■

An Investigation

Do you usually inhale as much air as you did for this experiment? Can you find out how much air you usually inhale and exhale in, say, one hour?

Try doing this experiment again, but this time just breathe normally. Time yourself by the second hand of a watch. For one minute exhale each breath into the hose —no faster or stronger than you do most of the time. After measuring how much air you breathe out in one minute, can you figure out how much air you breathe in one hour? One day? One year?

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.

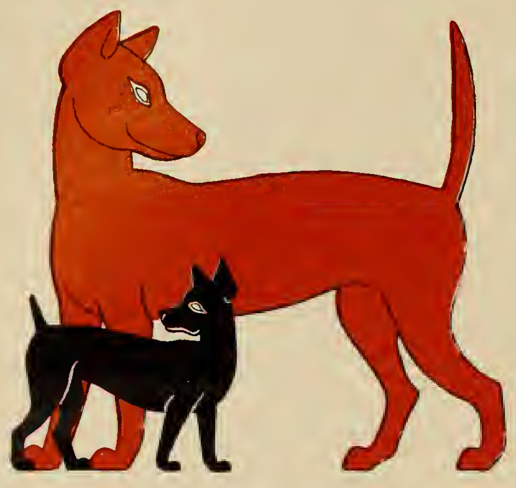
Ninety-nine per cent of the air is made up of a mixture of nitrogen and oxygen. In addition there are several other gases in the air. Mixed with all the gases are dust, pollen, bacteria, soot, salt grains from the sea, and dust from space (see page 3).

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 birds are geese that migrate over the Himalaya Mountains.
- The highest kite was used to learn more about high altitude winds.
- The highest manned balloon was used to find out the effects of high altitude and low air density on humans.
- The X-15 is an experimental rocket plane, used to find out the effects of high altitude flight on humans.
- Cumulus clouds, which are made of water droplets, are the lowest types of clouds.
- Cirrus clouds are high clouds made of ice crystals.
- Nacreous clouds are probably made of ice crystals, and may be seen after sunset.
- Noctilucent clouds are the highest of all clouds, and can be seen only after sunset. They are probably made of bits of volcanic or meteoric dust, coated with ice.
- Meteors by the millions enter our atmosphere every day. They burn up because of the heat of friction which builds up when they zoom into the dense air close to the Earth.
- Northern lights are caused by electrically charged particles that come from the Sun and collide with particles in our atmosphere.
- Cosmic particles are tiny high-speed particles from outer space.
- Jet stream winds move at speeds of 150 to 300 miles per hour.
- The glowing green band may be caused by charged oxygen atoms. It was first photographed in color by astronaut L. Gordon Cooper.

HOW LONG IS A LINE?



■ What if a friend asked you how long an inch is? A foot? A yard? If you didn't have a ruler would you be able to show him? Sometimes we must be able to measure things very accurately. Yet there are other times when we cannot measure as accurately as we would like. Then we have to estimate.

One way you could show your friend how long an inch is would be to hold up your thumb, and bend it at the knuckle. The distance from the tip of your thumb to the knuckle is *about* an inch. But if your friend is smaller than you are, he will probably have a shorter thumb. If he is larger than you are his thumb will probably be longer than yours.

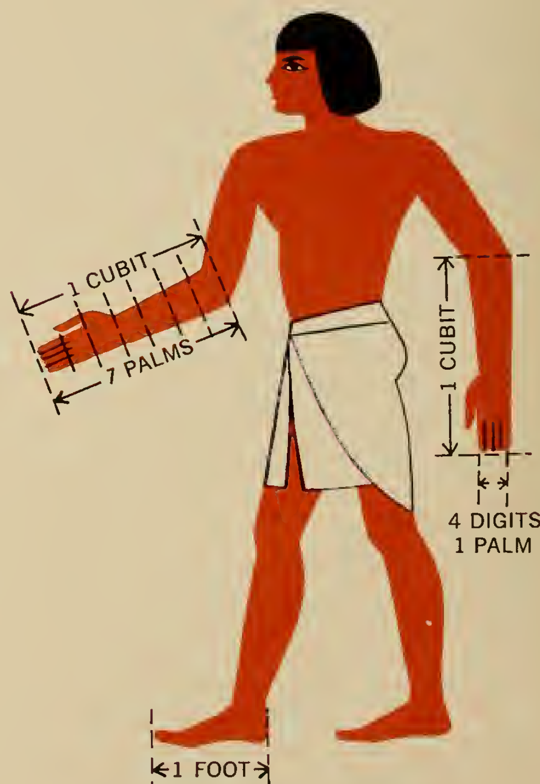
In ancient times, when men had to measure the length or width of things, they used their thumbs, arms, feet, or even a dog's tail as *units* of measure. A man could say that a house is 20 dog-tails high. This was fine if the man doing the measuring used the same dog each time. But imagine the difficulty if a man with a St. Bernard came along. If he measured the height of the house with a St. Bernard's tail, it might be only 12 tails high.

From Dogs' Tails to Rulers

There came a time when men living in the same community needed to put units of measure on sticks so that they would all be using the same units. People living in the United States and Great Britain use inches and feet as units to measure length. But people in other countries use different units, called the *metric* system. One *meter*, for example, is equal to 39.37 inches. In a special vault at the Bureau of Standards in Washington, D. C., there is a bar of platinum one meter long that serves as a standard for measuring distance. In addition, each state has a bronze copy of the platinum bar, which itself is a copy of the master bar kept in Paris.

Have you ever been to a country that uses the same name for a unit of measure that you do, but uses a different standard? In Canada a gallon of gasoline (called an *imperial* gallon) is bigger than a United States gallon. An imperial gallon is 1.2 U. S. gallons. A sailor who travels a *nautical* mile goes farther than you do when you go an ordinary, or *statute*, mile. A nautical mile in the U. S. is 6080.2 feet.

In this series of articles inches, feet, and miles will be our standard units of measure. But the inches we use will not be divided in the usual way into halves, fourths, and so on.



Some of the early systems for measuring were based on the proportions of a man's fingers, hand, arm, and foot.

This is the third in a series of articles adapted by permission of The Elementary-School Science Project from the revised edition of its booklet, Astronomy: Charting the Universe *© 1962 by the Board of Trustees of the University of Illinois.*

PROJECT

Invent your own private system for measuring distances. Once you decide on a unit of length, give it a name. For example, the length of one paper clip could equal one sehcni; and seven sehcnis could equal one toof. Now you could make a ruler with these units of measure marked on it.

When you have practiced with your new system of measure, explain it to a friend. Then work out a way to convert, or change, sehcnis to a regular foot. (We tried it and came out with about nine sehcnis to a foot.) Compare other systems of measure—for example, an object one dog-tail long may be seven pocket combs long, or one-half baseball bat long.

Instead, our inch units will be divided into 10 equal parts, so each division will be one-tenth of an inch. You can make a ruler of your own by using a strip of stiff cardboard and carefully marking tenths units on it. Make your ruler 10 inches long, using the ruler shown here as a guide.

Using Your Ruler

Suppose that you measure a line and find that it is one and two-tenths inches long. You can write this figure three ways—1 2/10, 12 tenths, or 1.2 inches. Try your new ruler and measure the length of the line shown here.

Right away you can see that it is not exactly 2.2 inches long. It is somewhere between 2.2 and 2.3 inches. Try measuring several different things around the house. You will find that few of your measurements will be *exactly* on a tenth mark. What you have to do is pick the nearest tenth mark. But suppose that you want to be more accurate.

Can We Measure Exactly?

You could measure more accurately if you put more marks between the tenths marks, but this would make your ruler too crowded. You will have to imagine more marks. Try imagining 10 small lines between each pair of tenths lines *(see ruler diagram)*. Because these imaginary marks divide the inch unit into 100 parts, we call them *hundredths* marks. When you use them you will be *estimating*. Here is how it works.

There are six arrows (*a* through *f*) on the ruler shown here. The one marked *a* we would write this way: 2.45. The 5 is the hundredths figure and represents the estimate made between the fourth and fifth tenths marks. The arrow marked *b* points right at the first tenth mark after 3. This means that there is no hundredths figure to estimate, so we would write the figure this way: 3.10.

Write down your estimate of where the other arrows point. Ask a friend to make estimates also, then compare your estimates with his. The two of you probably will agree on the inch numbers and the tenths numbers. But you may not agree on the hundredths numbers. Differences in the way you estimate are bound to creep in. If you don't agree, how can you know whose answer is "correct?" Is there an absolutely correct answer?

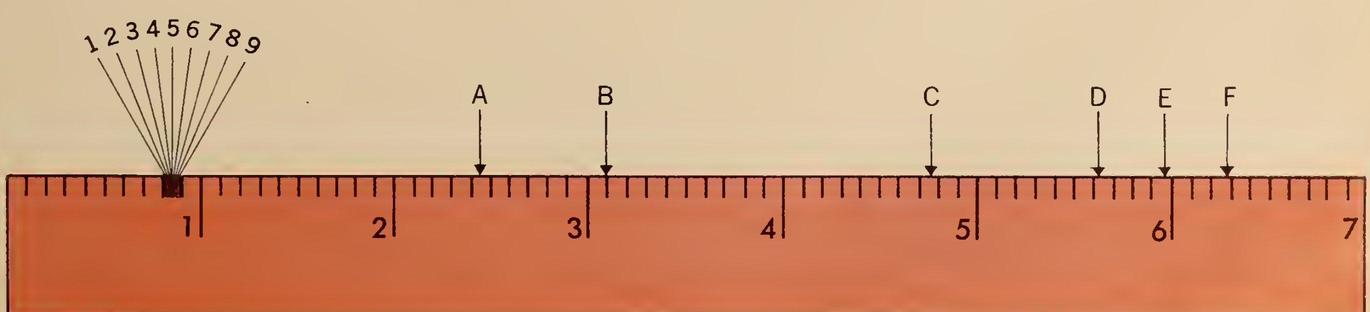
Averaging Your Estimates

When several people measure the same object they are likely to get different answers. Or if you yourself measure the same line three times you may get three different answers.

Say that a line you are measuring is a little more than 3.2 inches long. The first time you estimate the hundredths figure you get 2, the next time 3, and the next time 4. Which is the "correct" estimate to use? You could do what the scientist does—take an average. Add the three answers together and divide by the number of answers. In this case, since the inches and tenths numbers are the same, we need an average of the hundredths figures only. We add 2 + 3 + 4, which equal 9. Then we divide 9 by 3 and get 3 for the hundredths figure answer. We can then write the length of our line as 3.23.

If you make several estimates of things you measure and then take an average of your answers, your answer will be "right." If a measurement you make does not agree with one made by someone else, you are not necessarily wrong. Neither is the other person wrong. You have only estimated differently.

Now that you have had some experience in measuring things and estimating small units of length, in the next issue of *Nature and Science* we will ask you to try your skill at measuring angles. After that you will be in for a surprise ■



IS THERE WATER IN THE AIR?

■ We all know there is water in the air when it rains. Is there water in the air when it isn't raining? Here is an easy way to find out.

Fill a glass with ice water. Make sure the outside of the glass is very dry. Let it stand for a few minutes. You will see that water droplets have formed on the outside. Where did the droplets come from? Is the glass leaking? When droplets form on the outside of a glass of iced tea, are they water droplets or tea droplets?

Some morning after a clear, cool night, touch things outside your house. Railings, doorknobs, and bushes will be wet. Where does this dew come from?

The droplets and the dew come from water in the air. This water is usually invisible and is in the form of a gas called water vapor. Water vapor will stay in the air until the temperature drops quite sharply. Then the air can no longer hold the vapor and it *condenses* into the droplets that you can see—on the glass, on the grass, or high in the air as rain clouds.

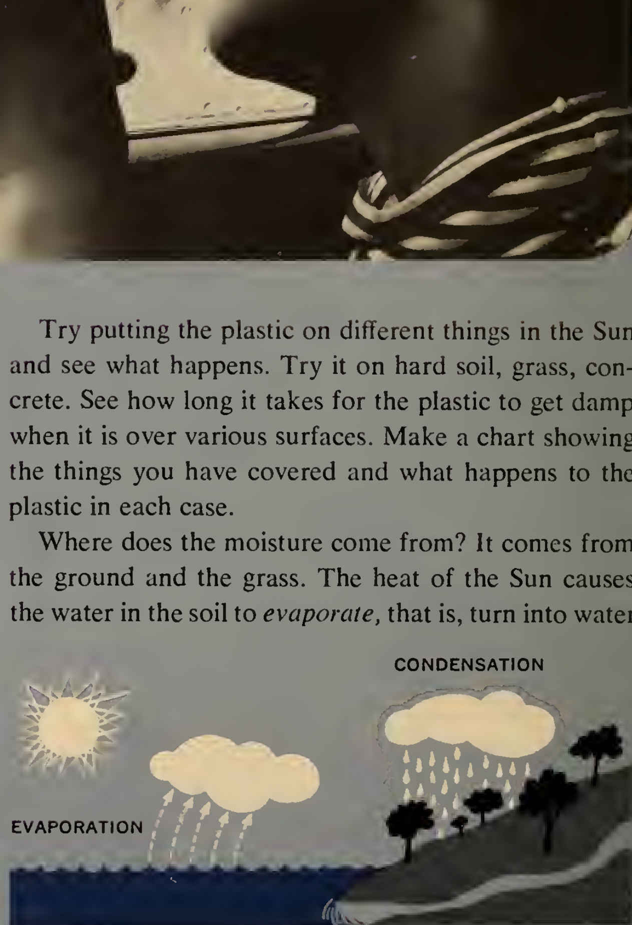
Where Does the Water Vapor Come From?

Put a piece of thin, clear plastic over some moist soil. Let the Sun shine through the plastic for about 10 minutes. Has water formed on the plastic? On which side?

Adapted in part from "What Makes the Weather," a teaching unit by Raymond E. Barrett, Oregon Museum of Science & Industry, Portland, Oregon.

Try putting the plastic on different things in the Sun and see what happens. Try it on hard soil, grass, concrete. See how long it takes for the plastic to get damp when it is over various surfaces. Make a chart showing the things you have covered and what happens to the plastic in each case.

Where does the moisture come from? It comes from the ground and the grass. The heat of the Sun causes the water in the soil to *evaporate,* that is, turn into water



vapor *(see diagram).* This is the opposite process from condensation. Evaporation—of rain water that has seeped into the ground, or from the surface of ponds, lakes, and oceans—is what puts water vapor into the air.

You can repeat the water cycle in the atmosphere in your kitchen. Fill a pan with hot water. Put a grating or grill on top of it. Put a tumbler of ice water on the grating. Evaporation of the hot water forms water vapor which rises, then condenses on the cold tumbler. When enough droplets form on the tumbler they will drip down, like a few raindrops ■

Kite-Flying Scientists

by William L. Deering

Some people fly kites for fun. Others fly them to learn more about the ways flying objects behave in the air.

The time: A stormy June day in 1752.
The place: A shed on the outskirts of Philadelphia.

■ Thunder rolled and lightning flashed while a scientist was getting ready to make an experiment that would make him famous. That scientist was Benjamin Franklin.

Franklin was curious about lightning, one of the most spectacular events that take place in the ocean of air. He believed that lightning was a huge spark of electricity, and now he was going to test his idea.

The equipment for this famous and important experiment was simple. Franklin had a silk-covered kite with a small metal rod mounted on top of it. He attached an ordinary metal door key to the end of the kite string. Between the key and his hand there was a piece of silk ribbon. Dry silk doesn't carry electricity very well. Franklin, sure that he was right, used the silk as an insulator to protect himself against a serious shock.

Standing under the shed to keep himself and the ribbon dry, he flew the kite close to the tall, dark clouds known as thunderheads. No flash of lightning came down the string, but Franklin saw the frayed ends of the string bristling away from each other. Your hair does the same thing when it is charged with electricity. Then cautiously —very cautiously—he put his knuckle near the key. A spark jumped from the key to his knuckle. Probably Franklin jumped a little, too.

Ben Franklin had proved that thunderheads are charged with electricity and that lightning is a huge spark. He was lucky that his experiment had a happy ending. We know now that he might have been killed.

Kites Helped Explore the Ocean of Air

Ben Franklin wasn't the first person to use kites to fish for information in the ocean of air. Three years before, two Scotsmen, Alexander Wilson and Thomas Melvill, flew a train of six kites attached at intervals to a single kite string. From the tail of each kite, a thermometer hung on a string to which a fuse was attached. The fuses were lighted as each kite left the ground.

When the highest kite was up about 3,000 feet, the fuses burned to their ends and the thermometers dropped. Paper tassels tied to the thermometers slowed their fall enough to get them down safely. Wilson recovered the thermometers before they could warm up, and thus got a good idea of the temperature of air at various heights.

The experiments conducted by Wilson were the first case of the most important scientific use of kites. To make accurate weather forecasts, we have to know what's going on in the upper air. The only way we can find out is to take samples and make measurements. From the middle

On Kite-Flying Day in China, men and women, boys and girls all over the country used to compete to see who could make kites of the most novel shapes, who could send kites the highest, and who could maneuver their kites in the air to capture other flying kites.

Kites have been flown in China for at least 2,000 years, and Kite-Flying Day was long observed each year on the ninth day of the ninth moon (October 25th by our calendar).

Kites shaped like real and imaginary birds are shown in this old engraving of Kite-Flying Day in Hae-Kwan, China.

Kites come in many shapes and sizes. A dragon kite may be 20 feet long, a "bird" kite only 18 inches. Plain- or fancy-shaped flat kites range from a few inches to a few yards in size. A large box kite can lift a man.

of the last century until 1930, kites were the main way to get weather instruments up into the air for this purpose.

The U.S. Weather Bureau employed professional kite-flyers to send instruments aloft. They used trains of three or more cloth-covered box kites to lift an instrument called a meteorograph. This instrument measured and recorded air pressure, wind velocity, temperature, and humidity.

How High Can Kites Go?

The world's altitude record for kites was set at the German Aerological Observatory in Lindenberg, where scientists sent a kite to the height of 9,700 meters, or about 32,000 feet. The U.S. record was set in 1910 on a weather flight at Mount Weather, Virginia. A train of 10 kites took out nine miles of wire and rose to 23,835 feet. Such an operation takes hours and a large crew of men.

The string, which helps to get a kite aloft and control it, also limits the height that the kite can reach. It has to be strong and light, otherwise it will break under the pull of the kites or under its own weight. The Weather Bureau used piano wire so light that a mile of it weighed only 16 pounds, but it was strong enough to lift 280 pounds. (The danger from lightning is much greater when wire is used.)

At altitudes of several thousand feet the winds blow in different directions at different levels. If several kites are spaced in a train with a few thousand feet between them, the kites pull against each other and no one portion of the line bears their combined pull. But if the wind dies while your train is aloft, the kites come down in a tangled mess.

You can see that weather kites were troublesome. When scientists learned how to collect and report weather data from the sky with light, inexpensive radios, the kites were doomed. It's much easier to attach a radio to a balloon and let it float away, sending information about the atmosphere as it goes.

Although scientists of the U.S. Weather Bureau have put their kites away, the scientific use of kites goes on. At present the most important kite research is going on at the giant wind tunnel at Hampton, Virginia, operated by NASA, the National Aeronautics and Space Administration. Dr. Francis M. Rogallo is using kites to investigate theories of aerodynamics (how objects behave in air).

Dr. Rogallo and his wife invented a flexible-wing kite made of plastic that has excellent lifting ability. One version of the Rogallos' kite, known as a paraglider, is being considered for use in the Gemini Program, which will place two men in orbit for periods lasting up to two weeks. The paraglider would replace the large sail parachute used previously to lower space capsules through the atmosphere. It would give the astronauts better control over their

Towed behind a car, this paraglider kite is controlled in flight by its pilot. Astronauts in a space capsule suspended from such a kite could land horizontally on the ground.

descent and enable them to make a horizontal landing on the ground instead of dropping straight into the sea.

A Kite Is Like an Airplane Wing

How do kites fly? What keeps them up? For many years people thought that air pushing on the under side kept a kite in the air. Scientists today know that this effect, called the *kite effect,* is only part of the story.

A kite may be considered as an airplane anchored to the ground. This is not quite an exact comparison, but it is helpful. Both kite and plane stay up because of the movement of air around the wing surfaces. To make the air rush over and under its wings, an airplane is pulled or pushed through the air by its propellors or jet engines. A kite, of course, is all wing. It is held in place by the string while the air rushes around the kite itself.

PROJECT

Hold the edge of a sheet of paper horizontally before your face, letting the far end droop down away from you. Hold the near edge just above your lips and blow. The end of the paper is blown upward, just as you probably expected it to be. Now place the edge of the paper just below your lips. Can you guess what will happen if you blow across the top of the curved surface? Try it and see.

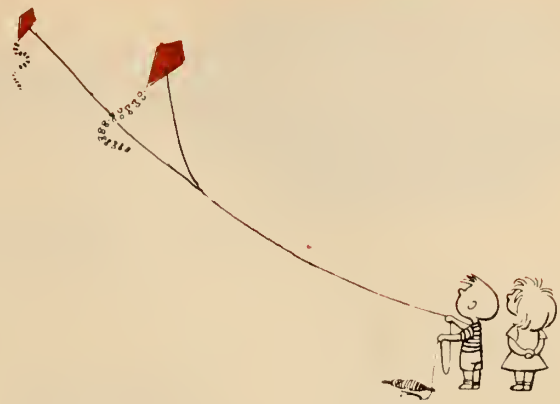
Air that rushes along the under surface of an airplane wing (or a kite) tends to push the wing or kite upward. But the air that flows over the upper surface of the wing or kite provides even more lifting power. How can this be?

About 200 years ago a Swiss scientist named Daniel Bernoulli discovered that water flowing rapidly through a pipe presses against the inside of the pipe with less force than water flowing slowly. The *Bernoulli effect,* as this is called, also applies to air. It explains in part why airplanes —and kites—can fly.

Air that flows over the curved upper surface of an airplane wing travels a longer path than air that flows under the wing. The air flowing over the wing therefore has to move faster than the surrounding air in order to keep up with it. But the slower flowing air pushes up the lower surface of the wing with greater force than the faster moving air pushing down on the upper surface. This provides the extra force needed to lift the airplane off the ground and keep it flying.

If you hold a kite so that the wind is blowing against one side, you will see that the paper surface bulges somewhat like the top of an airplane wing. When the kite is flying, the weight of the string holds the front surface downward so that air flows over the curved upper surface, as it does over an airplane wing. This provides the lift that keeps your kite in the air ■

GO FLY A KITE



To fly a kite properly and safely, you need a windy day and an open field, away from highways, electric power lines, or transmission towers. Always use a dry string—never wire or metal string that would conduct lightning. Kites should not be flown in wet or stormy weather.

You can launch a tailless kite by just holding it up and letting the wind take it away. But if the wind is not strong enough, or if your kite has a tail, you may need help. Have a friend hold the kite up as you back away about 25 steps into the wind. If he lets go of the kite as you start running into the wind, it should go up.

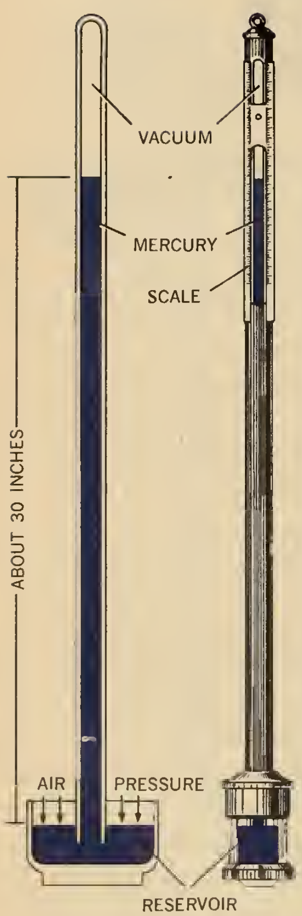
When a kite is flying right, the cord should sag. If it is too straight and taut, the wind is too strong and the string may break. If the string sags so much that the lower part is parallel to the ground, you need more lift. You can either reel in some of the string, bringing the kite down lower, or you can try this: Launch a second kite and tie the first kiteline to the second (see diagram). The first kite will then go higher.

A flat kite needs a tail to keep it from bobbing and spinning in the air—if you can get it up at all without a tail. Tie narrow strips of cloth or paper like bow ties at intervals along a length of string so it presents plenty of surface to the wind. For a small kite, start with a tail about 10 feet long. If the kite can't lift this tail, shorten it. If the kite still spins around in the air, lengthen the tail.

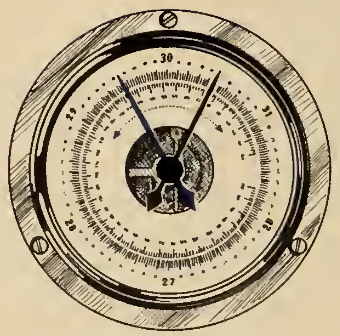
(These tips on kite flying are adapted from "Kite Flight," by Gove Hambidge, published by the American Public Power Association. Instructions for making Malay, flat, and box kites are included in the 16-page pamphlet which can be obtained by sending 15 cents to "Kite Flight," 919 18th St., N.W., Washington, D. C.)

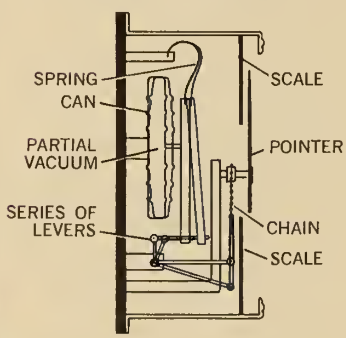
HOW IT WORKS

Barometers



MERCURY BAROMETER


ANEROID BAROMETER



■ To forecast the weather, weather men must know how much the air above a particular place weighs, how warm or cold the air is, and how much water vapor it contains.

These men measure the weight of the air, or air pressure, with a *barometer*. The pressure of the atmosphere over your city, or any other place, changes from hour to hour or from day to day as the air around you becomes warmer or cooler. Because cool air is heavier than warm air, cool air presses harder against a barometer than warm air.

There are two kinds of barometers. One of them, the *mercury barometer,* was invented by an Italian scientist, Evangelista Torricelli, in 1643. Scientists still use the mercury barometer because it is the most accurate instrument for measuring air pressure. Here is how it works.

The mercury barometer is a narrow glass tube a little more than 30 inches long, closed at one end. It is filled with mercury and then placed open end down in an open basin, or *reservoir,* of mercury. The mercury in the tube drops down a few inches, leaving a *vacuum,* or space with almost no air in it, at the closed end.

What keeps the mercury standing in the tube? The air presses down on the surface of the mercury in the reservoir and holds up the mercury in the tube. When the air gets heavier, it pushes the mercury higher in the tube. When the air gets lighter, it presses less on the mercury in the reservoir, so the mercury in the tube drops lower.

A scale near the top of the tube shows exactly how many inches the top of the column of mercury is above the surface of the mercury in the reservoir. Weather reports usually give the barometer readings in inches and tell whether the air pressure is rising or falling.

Air pressure can also be measured with an *aneroid barometer,* which looks something like a dial thermometer or a clock. You may have seen an aneroid barometer hanging on a wall or sitting on a desk.

Inside the aneroid barometer is a small, disk-shaped metal can from which most of the air has been removed. As the air pressure outside of the can increases, it pushes the surface of the metal can inward. As the air pressure outside the can decreases, the air in the can pushes the surface of the can outward.

The motion of the can surface is too small to see. However, the movement is made larger when it is carried by a series of levers and a chain to a pointer on the barometer scale. The pointer moves with the changes of air pressure and the scale is arranged so that it shows the same readings (in inches) as a mercury barometer.

Air pressure also decreases as you get higher above the level of the sea. Barometers in different places have to be adjusted so that the difference in pressure due to difference in altitude is not measured along with the changes in air pressure.

The mercury barometer can be adjusted by simply moving the scale up or down. An aneroid barometer is adjusted by turning a knob that tightens or loosens a spring attached to the can surface ■

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TEACHER'S EDITION

Outdoors in the City's Shadow

by Hannah Williams

■ Riverdale is an area three miles long and half a mile wide on the northwest edge of the Bronx, the northernmost borough of New York City. Even 15 years ago there were fields in the area where the knowing could find wild strawberries. There were fine oaks, ponds with frogs in them, and little streams that flowed into the Hudson River. In 16 years Riverdale's population rose from 25,000 to 60,000. Problems of protecting open land have increased in direct ratio.

In 1959 three women in Riverdale met. One was a high school chemistry teacher on leave to study education in natural resources. One was a teacher who had been experimenting with local woodlands as a learning experience for young children. The third was a housewife with an interest in city planning. They agreed that most teachers, whether their field was science, social studies, or the humanities, would like to use the world of nature as a teaching tool.

The community was fortunate in having two city parks with generous portions of woodland. In addition, it had three smaller pieces of Park Department-owned woodland near its schools, and several open lots and parcels of woodland in the hands of interested private owners. Eighteen public, private, and parochial schools (10 elementary schools, six high schools, and two colleges) plus several nursery schools were within the community limits.

The three women talked with members of the Riverdale Community Planning Association and came to the conclusion that by pooling the resources of the community three things might be gained:

1) If teachers were given help tailored to their available time and to the outdoor possibilities that were within walking distance, they could be encouraged to use outdoor laboratories.

2) If the program was designed to fit their own curriculums, it would not be looked on as an "extra," but instead would be a new aid in developing scientific curiosity.

3) It was hoped that a school program would bring new users to the natural park areas, and that presence of students would focus attention on protection and maintenance.

So the three women approached the Planning Association with their idea—the introduction of a short course for teachers in the use of open lots and parks near their schools. The Association made a contribution, and the program was launched.

Under the leadership of Charles Roth, a naturalist with a gift for teaching, a slightly enlarged group of teachers from various schools pooled their ideas for a 10-day course. The only paid member of that first staff was a leader for field sessions — a trained teacher of biology. Another field-worker was Kenneth Bobrowsky, the coordinator of science projects for the Bronx High School of Science. Mrs. Martin Hunzer, a chemistry teacher who was on leave from a local private school to do research for The Conservation Foundation, completed the staff.

Help came from many organizations. The National Audubon Society had a wealth of project suggestions and simple instructions on how to carry them out. The Conservation Foundation, although devoted mainly to specific research programs, made available films, visual aids, and publications. Many other sources contributed valuable advice.

An interested housewife who could contribute fifteen hours a week was supplied with a telephone and secretarial services. Her duty was to coordinate the roles played by the city's Departments of Parks and Sanitation, the Board of Education, private and public schools, community organizations, and educational consultants. She was also in charge of publicity for what was now to be known formally as the Riverdale Outdoor Laboratories.

(Continued on page 4T)

Hannah Williams was instrumental in establishing the Riverdale Outdoor Laboratories.

Arline Strong

In a cutover area of Riverdale, N.Y., elementary school children study interrelationships of living things at first hand. Both teachers and pupils favor "Let's find out" over "I'll tell you" as an approach to learning about nature and science.

Page 3: What's in the Air?
Page 8: Our Ocean of Air

Your pupils probably don't think about the air very often because they cannot see it. The article "What's in the Air?" and the chart on pages 8 and 9 present an opportunity to remind them that plants and animals could not live if the Earth had no atmosphere.

Your pupils may understand the pressure of our atmosphere better if they compare it with water pressure. If they have swum underwater, they will recall the strong pressure on their bodies. You might point out that if they lived underwater all the time, when they came to the surface the lighter pressure of the air might prove disastrous. When fish that live thousands of feet beneath the ocean's surface are brought to the surface, their bodies burst apart because they are adapted to the much greater pressure of deep water.

In the same way, our bodies are adapted to the air pressure at the bottom of our ocean of air. All gases, including the oxygen we need for life, are scarcer at high altitudes, and the less dense air presses against our bodies with less pressure. Hence "mountain sickness," or *hypoxia,* a condition in which the body tissues do not get as much oxygen as they need.

You can also point out to your pupils that as we move upward in the lower atmosphere, the temperature falls about 1°F. for every 300 feet of altitude. This is because we are getting farther from the Earth, which reflects the Sun's heat, and because warm air expands as it rises, becoming cooler.

When your pupils examine the temperature scale on the chart on pages 8 and 9 some of them may wonder why there is a sudden warming at an altitude around 30 miles. This is caused by the ozone layer. Oxygen molecules composed of two atoms (O_2) are being changed to molecules composed of three atoms (O_3), called ozone, by radiation from the Sun. In the conversion process, heat is produced.

Above an altitude of about 50 miles, the word "heat" as most of us use it loses its meaning. The high temperatures shown on the chart at extremely high altitudes refer to the speed at which the molecules are moving. But at these high altitudes there are so few molecules that heat would not be transferred to our bodies as these molecules struck us. At ground level, where the air is much denser, heat is transferred to our bodies as we are constantly bombarded by molecules.

As you explain to your pupils that the temperature in the lower atmosphere decreases as altitude increases, you should also explain that the density of the air decreases as altitude increases, and it falls off more rapidly than many of us think *(see pages 8 and 9).* These figures will be helpful: At sea level the atmospheric pressure is 14.7 psi (pounds per square inch); at 18,000 feet the pressure is reduced by one half, to 7.34 psi; at 34,000 feet it is cut in half again, to 3.62 psi. At 100,000 feet (about 20 miles) the pressure is only one-sixth of a pound per square inch.

After a discussion about the decrease in air density and temperature with increasing altitude, you might ask your pupils if they can explain why men who climb Mt. Everest need oxygen masks and special clothing

The section of "What's in the Air?" that deals with air pollution tells how man is fouling his own atmospheric environment. The study of air pollution can become an interesting class project. If you live near a city, your pupils will be able to find many examples of air pollution to report in class.

Local public health officials have pamphlets and other information about air pollution, and they will know about efforts to reduce pollution in your area. If there is an air pollution control program in your area, perhaps you can arrange a tour with your class to see how pollution is being combated.

For further information about air pollution, see these pamphlets: *Our Threatened Air Supply,* an Audubon Nature Bulletin, available from the National Audubon Society, 1130 Fifth Avenue, New York 28, N.Y., $.15; *"What's in the Air?,"* Public Affairs Pamphlet No. 275, available from Public Affairs Pamphlets, 22 East 38 Street, New York 16, N.Y., $.25; *The Air We Live In—The Health Effects of Air Pollution,* Public Health Service Publication No. 640, available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., $.10.

The suggestions for using this issue of Nature and Science *in your classroom were prepared by Kenneth Bobrowsky, Bank Street College of Education, and the Bronx High School of Science, New York, New York.*

THIS ISSUE of *Nature and Science* is a special-topic issue on the air. All of the articles except one deal with various aspects of the atmosphere and can be used to promote a well-rounded understanding of the air around us and the dependency of living things upon it.

Three major concepts occur again and again throughout this issue:

1. Matter is composed of particles which we call molecules (matter is particulate).

2. There is an interchange of matter and energy between living things and their environment.

3. Man modifies his physical and biological environment.

Good examples of the first concept are the section on the gaseous composition of the atmosphere in the article beginning on page 3; the water vapor article on page 12; and the article on barometers on page 16.

The space suit article on pages 8 and 9 is a good example of the second and third concepts, as is the section on air pollution in the article beginning on page 3.

Keep these three concepts in mind as you read this issue. You might find it helpful to mark various sections of the articles in such a way that you have the three concepts cross-referenced throughout the issue.

Page 7: How Much Air Do You Breathe?

The investigations suggested in this article can be extended in several ways:

1. Have your pupils measure and record the *vital* capacity *(see article)* of their lungs. You could have several groups working on this project. When they have their data, help them compare their findings. The larger the child, the greater the lung capacity. Boys usually have greater capacity than girls, and athletes usually have a greater capacity than non-athletes

2. How much of our vital lung capacity do we use in *normal* breathing? The article suggests a way to find out how much air you breathe normally in one minute. During such an investigation, count the number of breaths taken (usually about 18-20 per minute). Divide the ounces of air exhaled into the container by the number of breaths taken. This gives the volume of a single normal breath of air.

The vital capacity of our lungs may be as much as seven times their normal breathing capacity. We use this extra capacity only in emergencies.

3. How much air do you and your class require for one hour of normal breathing? Have six or so boys and girls

of varying sizes measure how much air each breathes normally in one minute. Find the average number of ounces per person and multiply by 60 for the average ounces per hour. Multiply this figure by the number of children in the class plus 2 (for the teacher). (One fluid ounce equals about one-thousandth of a cubic foot, so dividing the ounces of air by 1,000 gives the volume in cubic feet.)

Is your classroom large enough to contain that much air at one time? Have your pupils measure the length, width, and height of the room in feet, and multiply these three figures together to find the capacity of the room in cubic feet.

Even if the room holds as much air as its occupants breathe normally in one hour, there must be some way of bringing fresh air, containing about 21 per cent oxygen, into the room and removing the stale air, which has been collecting carbon dioxide. Your pupils may recall how drowsy they have felt in rooms that were inadequately ventilated. Breathing air that contains too much carbon dioxide and too little oxygen, or that is too warm and humid, creates this drowsy feeling.

How is fresh air brought into your classroom and stale air removed? Through windows, through air ducts, or both? This is an excellent opportunity to have the children investigate the school ventilation system—where and how air is brought into the building, whether it is cleaned, heated, cooled, dried, moistened, or otherwise modified; how it is distributed through the school; and how used air is removed.

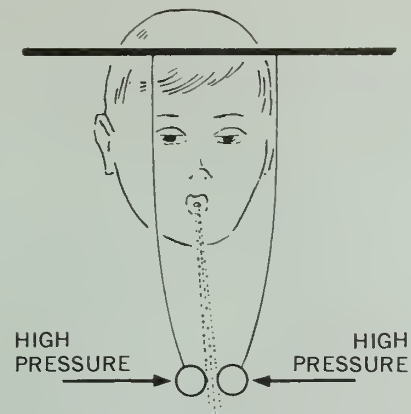
Page 13: Kite-Flying Scientists

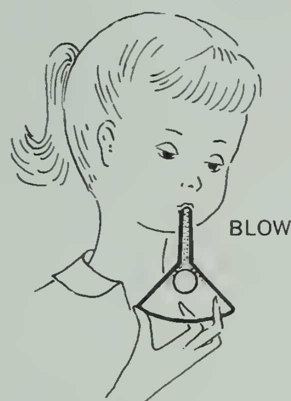
Making and flying kites is a sport most children engage in at one time or another, but few are aware of the scientific aspect of kites—that is, what keeps them up. This article describes how scientists have sent kites aloft to investigate the temperature of the air at different altitudes and to investigate the nature of lightning. It also explains the aerodynamic principle of "lift" that enables airplanes, as well as kites, to fly.

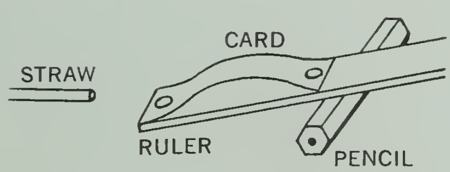
Two hundred years ago the Swiss physicist and mathematician, Daniel Bernoulli, found that the faster a fluid flows through a pipe, the less pressure it exerts on the walls of the pipe. Since air may be considered a fluid, it acts in the same way.

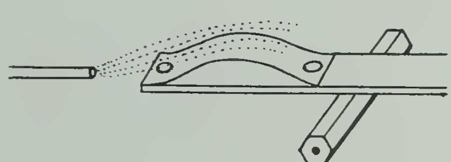
Your pupils may be interested in investigating applications of the Bernoulli principle. Here are several ways to observe it in action.

1. Attach pieces of thread to two ping-pong balls with glue or tape. Hang the balls about an inch apart. Will blowing between the two balls push them farther apart or bring them together? Air blown between the balls moves faster than the surrounding air, and therefore presses









outward (at right angles to its direction of flow) less than the surrounding air is pressing inward. The balls are thus pushed toward each other.

2. A child can use the Bernoulli effect to counteract gravity by placing a ping-pong ball in a funnel held wide end downward, then letting go of the ball as he blows through the narrow end of the funnel. Air rushing around the top and sides of the ball exerts less pressure than the air below it, and this holds the ball in the funnel.

3. The curved shape of an airplane wing (similar to the shape of a kite with wind blowing against it) can be tested for "lift." Tape or tack both ends of a card to the flat end of a ruler *(see diagram)* so that the card curves up like the top of an airplane wing. Lay the ruler across a six-sided pencil so that it tips down lightly at the end with the card. Blow through a straw or rubber hose so that the air stream flows from the end of the card up over its curved surface, the pressure of this air is reduced, and the air below the ruler end pushes it upward.

While the air that pushes against the front (downward surface) of a kite or the bottom of an airplane wing supplies some lift (this is the "kite effect" referred to in the article), about two-thirds of the lift that keeps a kite or airplane up is the result of the Bernoulli effect.

Page 10: Measuring the Universe 3
How Long Is a Line?

Part 3 of this series of articles is the first one that comes to grips directly with systems and techniques of measurement. The underlying concept in this article is that *all units of measure are arbitrary, and that before any unit of measure can be adopted it must be agreed upon by the group using it.*

Another way of making this point to your pupils, and of getting them involved quite directly, is to have three children of quite different size use their thumbs (from the center of the knuckle to the tip) as a unit of measure. Have each child measure the length of your desk, or the distance across the window sill. Their answers should be quite different.

Have them repeat the measurement, as exactly as they can, this time using a conventional 12-inch ruler. (Be sure to have each child use the same ruler.) If they come out with different answers, as they probably will, you can tell them that it is due to *personal error.* Astronomers call this error *personal equation.*

There are also errors in the instruments we use. It may come as a surprise to your pupils to learn that the length of different measuring instruments often differs. Have the children compare the lengths of several different rulers — a wooden one, a cloth tape, a plastic ruler, a machinist's rule. Are all the rulers *exactly* the same?

The article encourages children to make up their own units of measure. You could break the class into three or more groups and instruct each group to make up a measurement system of its own and become a private "bureau of standards." For example,

1 inch = standard unit
5 inches = 1 diffy
2 inches = 1 daffy

Point out to your pupils that the sizes of standard units should bear *convenient* relationships to each other. If the inch were the standard unit and it took ten thousand inches to make a diffy, the number of inch units we would have to write down when we measured things less than a diffy long would become unwieldly. For this reason astronomers do not use miles when recording distances to the stars.

Here is a good opportunity to explain the expression *light-year,* which most

Using this issue . . .

(Continued from page 3T)

children have heard. A light-year is the distance that light travels in one year, at a velocity of about 186,300 miles a second. One light-year equals about 6,000,000,000,000 (or 5.8783×10^{12}) miles.

Some of your pupils might find it interesting to look up the origins and work out the relative values of some of the following: a rod, an inch, a pace, foot, cubit, palm, span, hand, mile, astronomical unit, parsec. One of your students might be encouraged to report on which countries use the metric system, and which ones use inches and feet.

To show that we all are "guilty" of personal error, you could do this: Draw a short line on the blackboard (less than the length of the ruler in the magazine), and one by one ask each child to measure it with the ruler he is instructed to make in the article. Each pupil should write his measurement (to be carried out to the hundredths unit) on a slip of paper. When you have collected all of the slips you could then chart the answers on the board and show the distribution of the measurements.

The answers will probably differ considerably. This is good, for it will show that in this kind of measurement there is no "right" or "wrong" answer. Each child simply estimates differently. An answer can be wrong only if it varies markedly from the measurements taken.

THE NEXT ISSUE of *Nature and Science* takes you into "The Secret World of *Felis catus*," the common house cat. The article is based on many years of research carried out at The American Museum of Natural History, and explains to children how to get along with a cat from the time it is a young kitten until it becomes adult.

Another feature will be a chart, ideal for the classroom bulletin board, that explains what sound is and shows the frequencies of sound audible to a variety of animals, including man.

Part 4 of "Measuring the Universe" introduces the concept of *pi* and involves the child in the measurement of angles with protractors — in preparation for a forthcoming article (Nov. 15) about building a range finder.

Outdoors in the City's Shadows

(Continued from page 1T)

The planning for the balance of the school year was done by a steering committee of teachers in cooperation with paid and volunteer staff members. During the last week in March and the first week of April in the second year, 514 children from seven schools made class visits to the park on the Hudson River. Instructors geared the walks to the curriculum of the public and private schools from which the groups came. As a result, some of the children studied Indian foods; some concentrated on soil erosion; some examined plant growth that appears on a cutover area.

These two programs—the teachers' course and the field trips for school groups—remained the backbone of the Laboratories' service to schools for the following two years. However, other services were offered. A one-day session to demonstrate nature activities that were possible within the confines of a city park was organized for counselors from 11 day camps run by neighborhood houses and settlements. Forty counselors attended, and the cost was shared by the Community Council of Greater New York and Fieldston School, one of the private schools of Riverdale. The local garden club contributed money for a survey of the Hudson River park as a step in developing it as a laboratory and sanctuary. Walks in the park, with a naturalist in charge, were made available to the general public. Laboratories had begun to spread in many directions—but with caution.

In the spring of that year, group conferences were held in 11 participating public and private schools to plan field trips that would help coordinate school curriculums and interests with projects in which enthusiasm could be sustained throughout the spring. For instance, for a whole term one teacher kept a class interested in water by means of projects that dramatized watersheds and how their use was controlled politically as well as physically. These students had a field trip planned specially for them. They measured the rate of flow in a stream; they recorded observations of silting; they built check dams; they tested water for degrees of pollution and kept field sheets to record data on which to base conclusions.

In the meantime, the program was beginning to pay dividends in several different directions. For instance, three nursery school teachers had for a number of years used a small patch of woodland near their school for occasional excursions. It was not until two of the teachers had taken the training courses that they began to realize that small children can absorb very advanced ecological concepts.

Two private elementary schools and one public school felt the influence of the course in almost all their grades. One added a naturalist with conservation training to the permanent science faculty, and the two other schools developed projects and pamphlet guides to be shared with the rest of the participating schools. One was a study of water; another, a year-long record of temperature and growth changes on a single plot of land.

Most important have been the development of a concept of the interrelationship of all living things, and a strong endorsement—by both teachers and students—of the "let's-find-out" approach, which is in sharp contrast to the "I'll-tell-you" attitude. Also encouraging was the general acceptance the teachers' course was gaining, and the solid relationship that had been built with the participating schools, which had contributed space for shelter, a lecture, a teachers' course, a meeting, or an exhibit. The Board of Education was willing to consider the teachers' course for in-service credit, and the program, revised to fulfill requirements, was accredited in February 1963.

The most ambitious program of all was a summer day camp to accommodate 10 gifted biology students about 14 years old. It had a triple objective: 1) to allow the children to pursue a subject of interest to themselves and thereby to learn something about scientific method; 2) to help them experiment in ways to make outdoor learning of interest to younger children; 3) to make the Hudson River park more useful as a biology teaching station. Students were selected for their aptitude and interest, not because they needed a place to spend the summer.

One boy made a study of soil chemistry; a group of girls concentrated on plants of economic importance; many became interested in insects; one group banded and recorded animal populations. They labeled trees, pressed and mounted plants, made maps, and improved trails. One of their most rewarding activities was in making project sheets. The sheets were twice-folded pieces of 8-by-10-inch paper. The high school students drew pictures on the outside, and inside posed a series of questions they felt would stimulate observation and interest.

Perhaps the clue to the effectiveness of the Riverdale Outdoor Laboratories lies in individuals. It may be one teacher who finds a new approach to field work and puts it in a form other classes can use. It may be another teacher who will not relinquish the search for a way to encourage even the youngest child in the delight of discovery. It might be a single child whose enthusiasm communicates itself to dozens of his classmates. An alert school student with expert guidance can begin to see that one tiny spot of ground can be translated into a world of beauty, excitement, speculation, and study.

nature and science

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Why are some cats unfriendly? It depends on how they are raised.

see page 3

THE SECRET WORLD OF FELIS CATUS

Mountain Lions in the United States

Our cover shows an adult and a young mountain lion, a type of wild cat that lives in mountains, hilly woodland, and swamps. These big cats can be found in about 15 states *(see map of their range above)*, but they are seldom seen. Mountain lions are also called pumas, cougars, or panthers. They are related—distant cousins you might say—to the housecats we keep as pets.

Scientists are not sure when the first cats developed on Earth. However, by studying fossils, they have found that cats, dogs, and bears all developed from the same kinds of animals that lived about 50 million years ago.

Scientists have also found fossil bones and teeth of about 35 kinds of cats that have died out, or become extinct, through the years. One of the most famous extinct cats is a saber-tooth "tiger"—called *Smilodon*—which had fangs six inches long.

Cats have been kept as pets for at least 5,000 years, but humans still do not completely understand the ways of cats. For example, why are some cats good pets, and other cats poor ones?

To find the answer to this and other questions about cats, Dr. T. C. Schneirla of The American Museum of Natural History has studied hundreds of these fascinating animals (*see next page*).

nature and science

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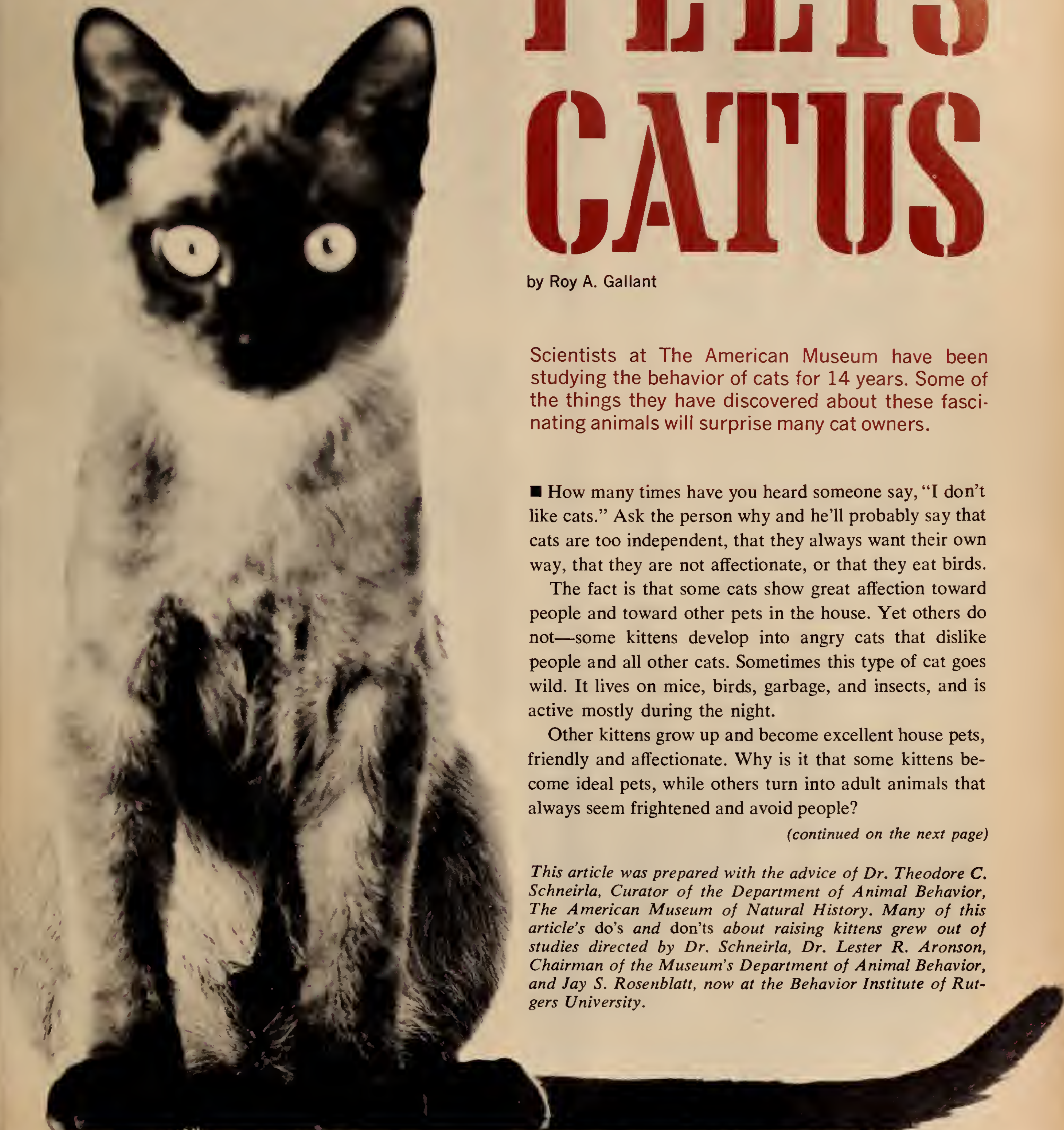
A SCIENCE ADVENTURE

the secret world of FELIS CATUS

by Roy A. Gallant



Scientists at The American Museum have been studying the behavior of cats for 14 years. Some of the things they have discovered about these fascinating animals will surprise many cat owners.

■ How many times have you heard someone say, "I don't like cats." Ask the person why and he'll probably say that cats are too independent, that they always want their own way, that they are not affectionate, or that they eat birds.

The fact is that some cats show great affection toward people and toward other pets in the house. Yet others do not—some kittens develop into angry cats that dislike people and all other cats. Sometimes this type of cat goes wild. It lives on mice, birds, garbage, and insects, and is active mostly during the night.

Other kittens grow up and become excellent house pets, friendly and affectionate. Why is it that some kittens become ideal pets, while others turn into adult animals that always seem frightened and avoid people?

(continued on the next page)

This article was prepared with the advice of Dr. Theodore C. Schneirla, Curator of the Department of Animal Behavior, The American Museum of Natural History. Many of this article's do's *and* don'ts *about raising kittens grew out of studies directed by Dr. Schneirla, Dr. Lester R. Aronson, Chairman of the Museum's Department of Animal Behavior, and Jay S. Rosenblatt, now at the Behavior Institute of Rutgers University.*

Learning How Cats Behave

To find answers to these and other questions about cats, scientists at The American Museum of Natural History have been raising and observing cats for 14 years. Why do scientists want to study the behavior of animals? Dr. T. C. Schneirla, an expert in the family life of insects and mammals, explains that, in general, it is both to understand the animal for its own sake and to cast light on the problems of the behavior of human beings.

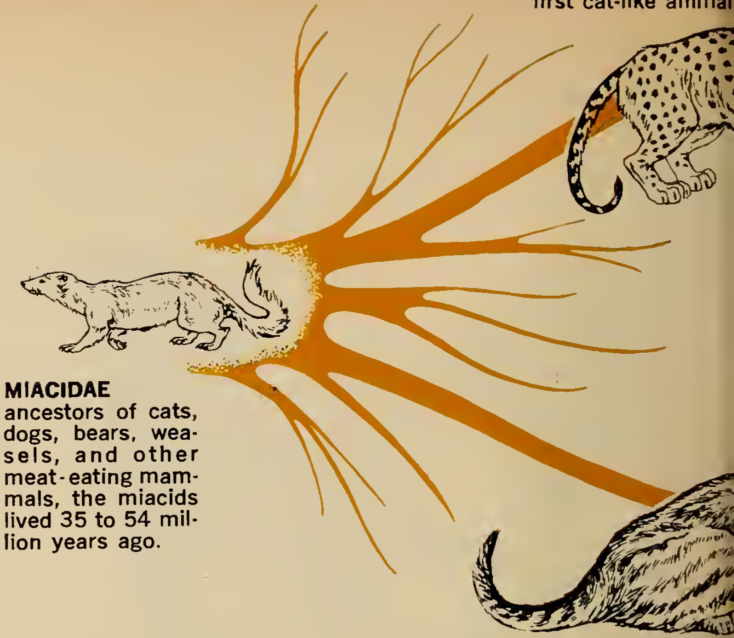
You might wonder why it's necessary to watch cats in the laboratory to learn how they behave. Why not raise a kitten at home as a pet and watch it as it grows up?

One reason is that when a scientist studies the behavior of one kind of animal, he must study many individuals to be certain he understands even their simplest actions. Like people, each cat has a personality of its own. If one cat can be taught to do a certain trick, or to solve a certain problem, it doesn't necessarily mean that *all* cats can be taught to do the same thing. If 10 cats can, then it is more likely that most cats can; if 100 cats can, it is even more likely.

Another reason is that, unlike most dogs, for example, cats usually keep to themselves. Also, they are night creatures and are more likely to rest by day and be active by night. So if a scientist is going to be able to watch them when he wants to, the cats must be in a place where they can be observed at any time.

Household, or domestic, cats (known as *Felis catus*) that have not been tamed spend most of their lives in secret. They tend to live alone, or at most in pairs. (Perhaps this is a reason why some people don't like cats!)

This mother cat is carrying its kitten to a safe nest in a cellar. If a mother cat and her kittens are not bothered by humans, she will take good care of her kittens.



believed to be the first cat-like animal

MIACIDAE
ancestors of cats, dogs, bears, weasels, and other meat-eating mammals, the miacids lived 35 to 54 million years ago.

HOPLOPHONEUS
a saber-tooth that lived 25 to 35 million years ago.

The three living groups of cats today are the small cats (Felis), **big cats** (Panthera), **and the Cheetah** (Acinonyx). **The**

"Rules" for Raising Kittens

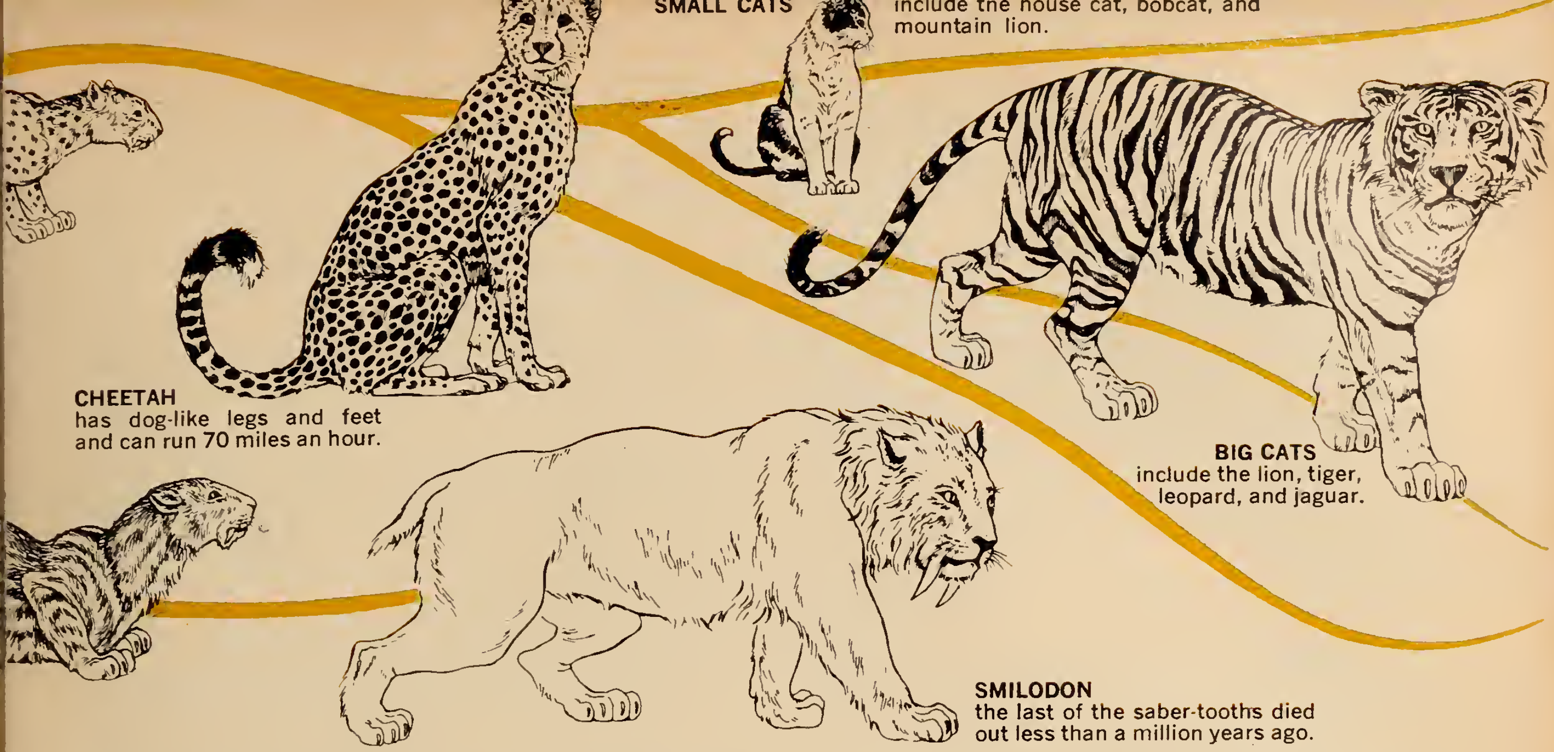
People who have kept many cats usually are quite willing to tell you the "best way" to raise a kitten. But sometimes what seems to be the "best way" for the cat owner turns out to be the worst way for the kittens and mother cat.

Over the years Museum scientists have learned that there are many *do's* and *don'ts* in rearing kittens successfully. Some of these "rules" begin with the mother cat before she has her kittens.

About a week or so before she is ready to give birth, the mother cat begins searching for a place where she can have her kittens. Cats that feel completely at ease in a household may have their kittens out in the open on a bed or in an armchair. Cats that tend to be nervous may choose a secret place like a bedroom closet or a corner in the cellar. At this stage it is best not to bother the mother cat. Don't try to find a "more comfortable" place for her. The best place is usually the place she finds by herself.

The kind of a cat a kitten will grow up to be can depend upon what happens to the kitten during the 45 or so days after it is born. This time is known as the *litter* period. The key words at this stage are "Don't bother the mother cat or the kittens." Let the mother cat take care of her kittens in her own way.

As each kitten is born it is covered with a body fluid of the mother. This fluid, according to Dr. Schneirla, plays



saber-tooths, which died out, had long fangs that were used for stabbing their prey. Saber-tooths fed on slow-moving animals, such as ground sloths, and when these animals died out, the saber-tooths also became extinct.

an important part in the future life of the mother and each kitten. Some scientists think that the mother cat finds the odor and taste of the fluid on the kitten's body pleasant. She begins licking not because she is a "good mother" but because she likes the fluid.

This first contact between mother and kitten usually leads to a bond of affection between the mother and her young. If you wash the kitten for the mother, as some cat owners do, you may do more harm than you realize. The licking action also pushes the kitten close against the mother's body and so helps guide the kitten to the nipples and the mother's milk. At this stage the kitten needs affection from *its mother,* not from a human being.

Dangers of Too Much "Help"

The first kittens born are usually the first to feed. The mother's licking actions seem to guide them to the front nipples. Those born later are likely to feed on the rear nipples. And those born last sometimes have to rely on any nipple that happens to be free.

Let the kittens feed the way they want and the way they are used to feeding. Don't try to "help" one kitten that *seems* to be having trouble. Most likely you will do more harm than good.

The best way you can help a cat become a "good" mother is to let her work out her problems by herself. Don't visit the litter too often. Give food to the mother cat at the same time and place every evening.

Don't handle the kittens too often or too long, and try not to handle any one kitten more than the others. You should never jerk a kitten out of the nest. Remove them gently. And try not to change the nest itself, even if it seems cluttered.

If you disturb the mother and handle her kittens too much, the mother may give up, go away, and lose all interest in the kittens. Or she may become so nervous that she will kill her kittens.

For the first 10 days to four weeks or so the mother cat is heavy with milk and finds it comforting to nurse her kittens. But after four weeks she produces less and less milk and can feed the kittens only at certain times of the day. The kittens soon learn when the mother is able to feed them and they learn when and how to catch her. At this stage also, the mother begins to lose interest in her kittens. Day by day the actions of the mother cat and the kittens are changing.

If a kitten is kept away from its mother for too long during the litter period, it can develop into a mean cat. In the Museum laboratory, one kitten named Fritzie was kept away from its mother all during the litter period. It grew up into a strange cat that could not get on with other cats or with people who tried to be kind to it.

When kittens are about four weeks old their *weaning* period begins. This means that they soon begin to eat solid food.

Usually they learn to do this by accident. They see the mother eating out of her dish and investigate it. Usually

(continued on the next page)

they walk into the dish, getting food on their paws. They are attracted by the food odor on their paws, lick them and get their first taste of solid food. Gradually they learn to eat out of the mother's dish.

After 30 days or so the mother cat pays less and less attention to her kittens. She leaves them more often and stays away for longer periods of time. By 45 days or so, the kittens show less interest in one another. They do not play together as often as before and spend more and more time alone. They are becoming adult cats.

How to Get Along With Your Cat

One day one of the scientists in the Museum's animal behavior department was asked by a friend if she could have one of his laboratory cats as a pet for her young son. The scientist thought about it for a while, then decided that this could be a kind of experiment. The six-month-old cat had known only the laboratory and not the outside world. The scientist realized that he would have to prepare both the boy and the cat for the event.

First he made sure the boy would be gentle and friendly with the cat. The parents also helped their son prepare for the arrival of his new pet. They made a special box-bed for the cat and carefully planned for its care. Meanwhile the scientist prepared the young cat for the change.

Twice a day for three days he took the cat from its cage to a different room in the laboratory. Each time it could explore the room, sniffing things and getting acquainted with the people working in the room. In this way it learned to get used to new places and to people doing new things. The first time the cat jumped up onto a laboratory table, the scientist slapped a folded newspaper against the table top. The noise gently frightened the cat. Very quickly the cat learned that the noise made by a newspaper meant "don't."

At the end of three days the cat was calm and friendly. It was ready to be taken to its new home. The boy gave the animal the same kind attention that the laboratory people had given it.

The boy and his family soon made friends with the cat by petting and soothing it when the cat purred and seemed to want attention. They did not rush the cat at first. They let it explore the house during the first few days. The boy often played with the cat near its box-bed and soon was petting it when it was in the box. Nobody bothered the cat when it was sleeping or when it showed that it did not want company.

Within just a few days the cat had learned the ways of the household and had come to like its new family.

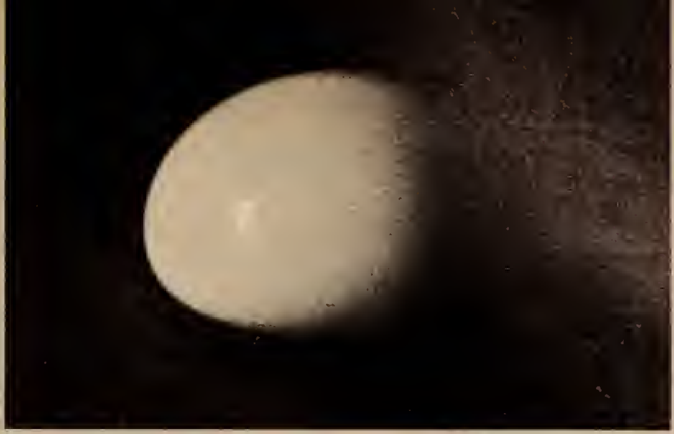
This success story really has two parts. The cat became affectionate and well mannered partly because the boy and his family treated the animal well and were friendly toward it. But the other part of the story began much earlier. In the Museum laboratory the cat as a kitten had been brought up by a healthy mother who was allowed to rear her offspring in peace. So the young cat was well on the way to becoming an "ideal" adult cat ■

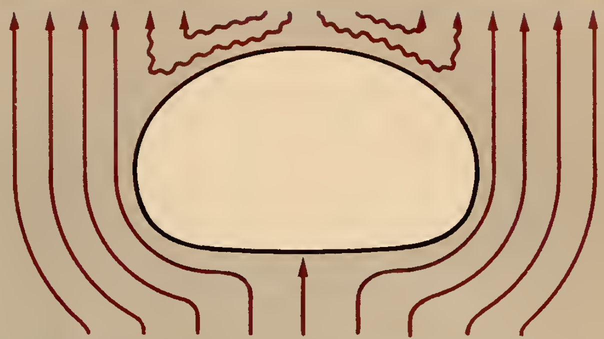
■ For more information about cats, look in your library or book store for these books: *Cats, Cats, Cats,* by J. R. Gilbert, P. Hamlyn, London, 1962, $2.98. *Her Majesty the Cat,* by Fernand Mery, Criterion Books, New York, 1957, is out of print but your library may have it. Joy Adamson describes experiences of keeping tame lions in *Born Free,* Pantheon Books, Inc., New York, 1960, $4.95; *Living Free,* 1961, and *Forever Free,* 1963, Harcourt, Brace and World, Inc., New York, both $5.95.

How an adult cat acts depends on what happens to it during its early life. If kept from its mother for a long time, a kitten may grow up to be an unfriendly cat.

How Big Are Raindrops?

by Phyllis Busch





The photograph above shows a drop of milk in mid-air, and the drawing shows how the molecules in air flow around the falling drop. The pressure of the molecules in air pushes falling drops of rain and other liquids into a shape like a hamburger bun.

■ Most of us think that a raindrop has a rounded bottom and a pointed top. At least, this is the way we usually see raindrops in cartoons and books.

Actually, raindrops are shaped like hamburger buns. Scientists have used high-speed photography to stop the motion of falling drops and have discovered that the drops have a flat shape. The size of raindrops also interests scientists (*see illustrations*).

With some items found around the house, you can set up your own raindrop workshop and find some answers to the question: How big are raindrops? For instance, do you think that all raindrops are the same size? Are the drops at the beginning of a storm bigger than those that fall at the end of a storm?

Catching Raindrops

To find out, you will need some simple equipment—a pie pan (or a paper plate that has sides), a cover for the plate, a flour sifter, some flour, ruler, paper and pencil. Put flour in the plate until it is about a half-inch deep.

The next time it rains, cover the plate and take it outdoors. Hold it in the rain, then uncover it and let the rain fall into the flour for about three seconds. You can judge about when three seconds are up by saying, "one thousand one, one thousand two, one thousand three." Cover the plate as soon as the time is up. Otherwise, several drops might land in one spot and make the drops seem bigger than they are.

After you go indoors, uncover the plate and look at the flour. You will see many wet round lumps where the raindrops fell. The drops soak up the flour particles as they hit. After the lumps of flour dry, they will harden into balls a bit larger than the raindrops themselves.

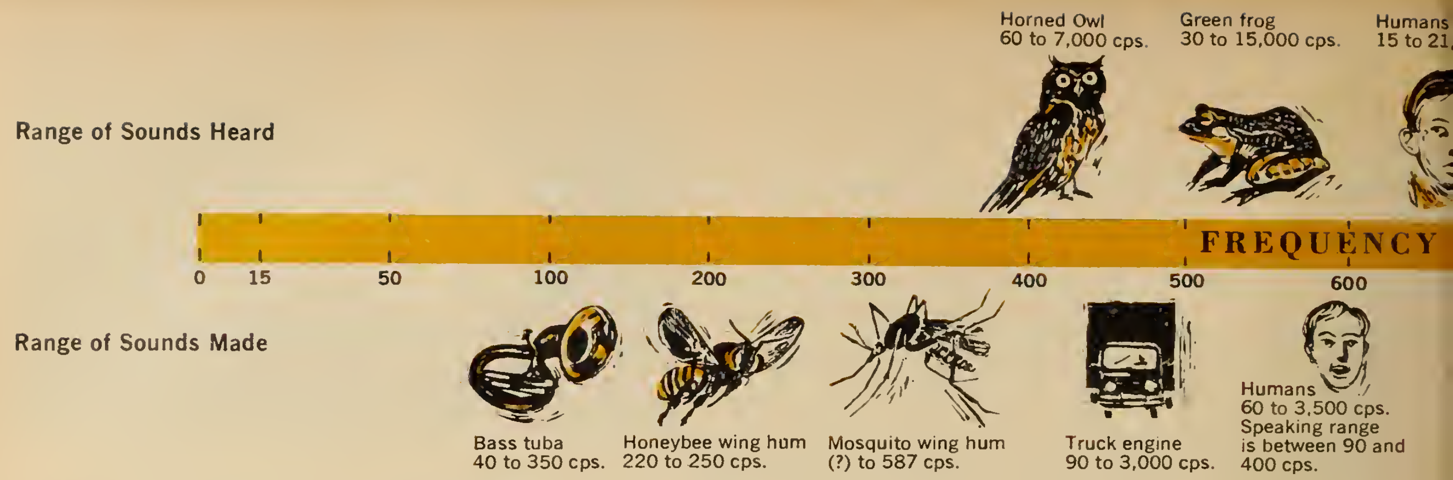
Don't try to pick up the balls of wet flour. Let them dry for two or three hours. Then use the flour sifter to separate the dried raindrops from the flour. Even though these flour balls are not exactly the same size as raindrops, you can learn something about the relative size of raindrops from them.

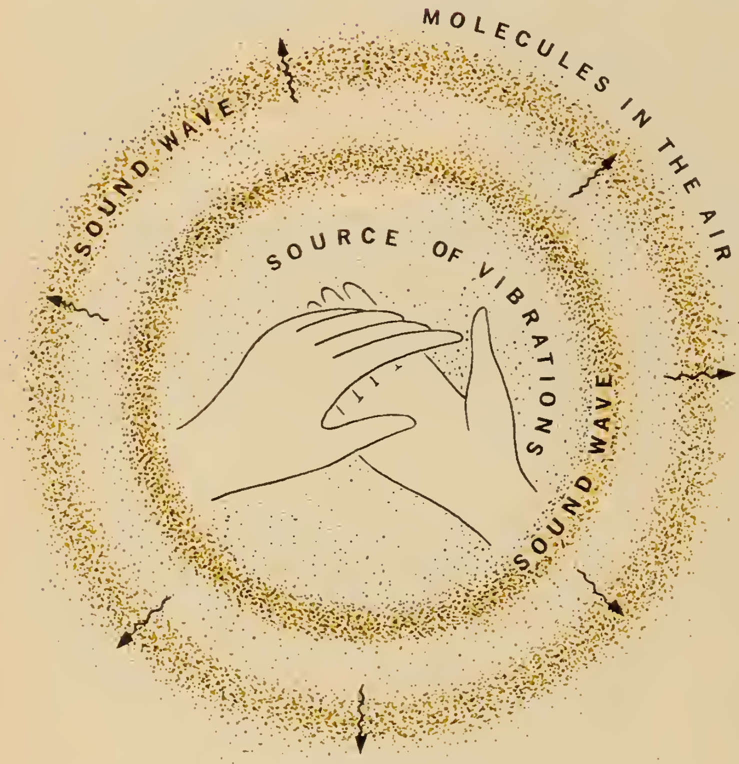
One way is to measure the flour balls with a ruler. Are they all the same size? If not, how big are the smallest and largest raindrops that fell? Measure all of the flour balls that formed and put their measurements on a chart like the one shown on this page. What is the most common size of the raindrops? Instead of measuring each of the drops, you could separate them into three groups—big drops, medium drops, and small drops.

Try catching some raindrops near the beginning, sometime near the middle, and near the end of a rainstorm to see if they differ in size. If you keep a record of your measurements, you can also compare the raindrops of one storm with those of another. Do some storms produce bigger raindrops than others? ■

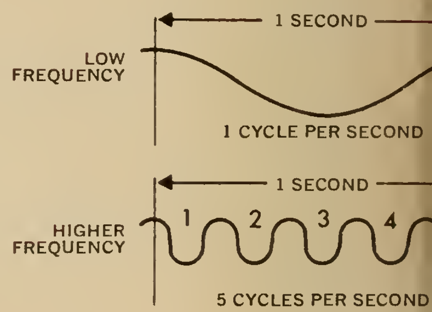
SIZE OF RAINDROPS	BIG DROPS	MEDIUM DROPS	SMALL DROPS
Number of drops at beginning of storm			
Number of drops in "middle" of storm			
Number of drops near end of storm			

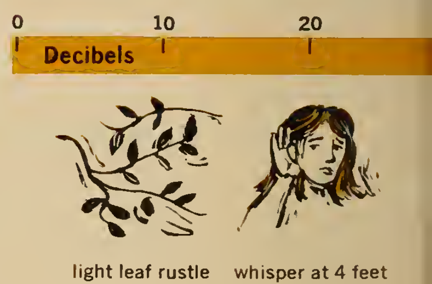
You can keep a chart like this one to compare the size of raindrops during different parts of a storm and make other charts to compare raindrops of different storms.





When an object vibrates, molecules in the air around it are pushed together and form a sound wave in the shape of a sphere. This sphere of bunched molecules pushes outward and another wave is formed. In this way, vibrations travel through the air in all directions. This diagram shows a series of sound waves that began with a hand clap.





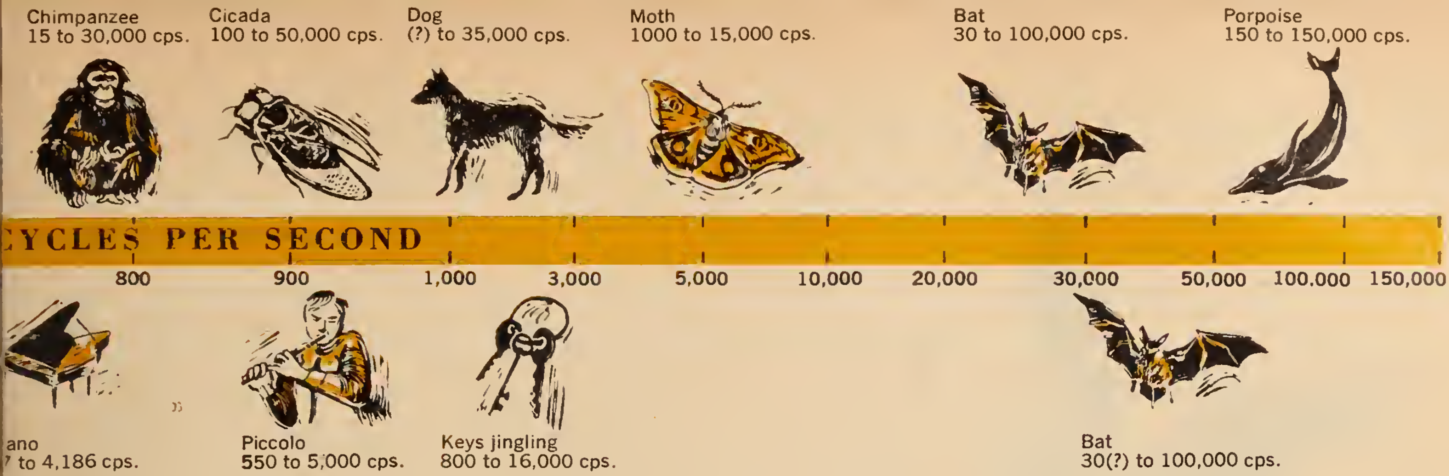
Sounds We Can Hea

■ If a tree falls in a forest and there is no one around to hear it crash to the ground, is there any sound? It depends on what you mean by "sound."

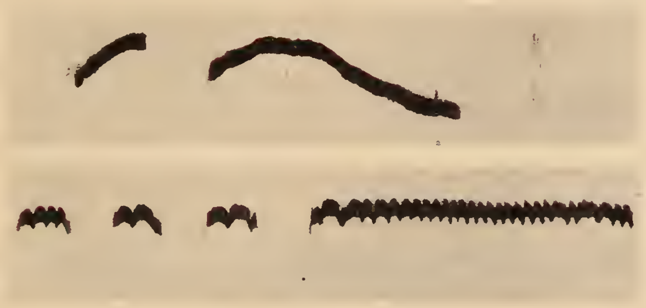
When the tree falls to the ground it pushes against tiny particles—called molecules—that make up the air. The same thing happens when your vocal cords or a violin string wiggles rapidly back and forth, or *vibrates*. Molecules of the gases making up the surrounding air are pushed outward in waves that we call *sound waves*. But the waves themselves are not sound. We do not hear sound until our ears catch the waves and a signal is sent to the brain.

Whether we hear a high-pitched sound or a low-pitched sound depends on how fast the molecules in the sound wave are vibrating. The faster they vibrate, the higher the sound. Scientists measure the frequency of these vibrations as so many *cycles per second* (cps). A kettledrum, for instance, sends out 85 to 170 vibrations per second. A bat squeaks at much higher frequencies—up to 100,000 cps. Most human speech is between 90 and 400 cps.

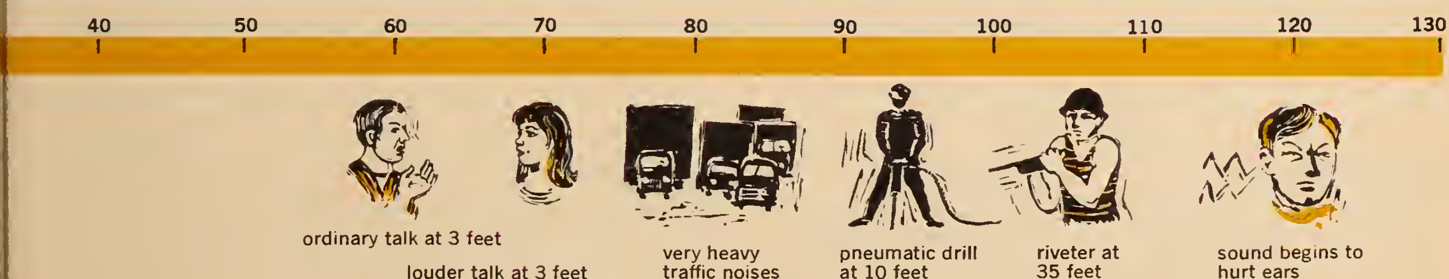
Considering all of the sound wave frequencies around us, we hear only a small range of them. Our ears are not sensitive enough to pick up very high frequency sounds,



Scientists use graphs like the ones shown here to study the frequency of sound waves. The top one shows just one vibration, or cycle, in one second. The bottom one shows a higher frequency of five cycles per second. Both of these frequencies are below the range of human hearing.



Scientists have recorded many sounds on "spectograms," which show changes in frequency of a sound. When the mark of a sound on a spectrogram rises, it indicates a rise in frequency, or a sound of higher pitch. The spectrograms here are those of a "wolf whistle" and a police whistle.



and Some We Can't

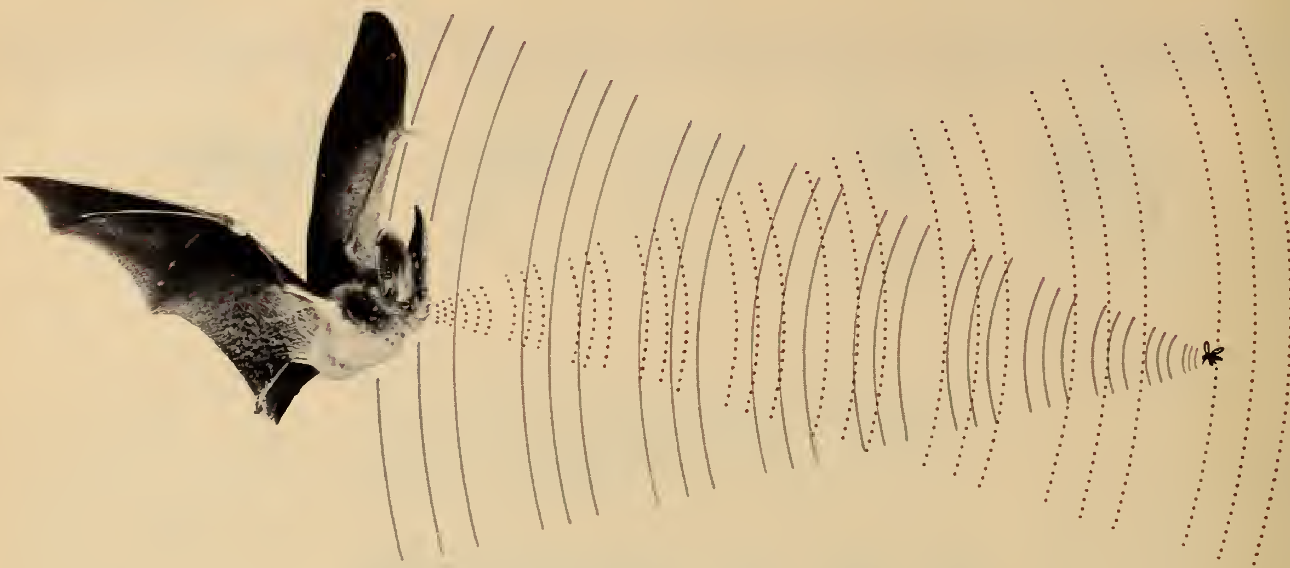
such as the upper ones made by bats. Neither are they sensitive enough to pick up very low frequency sounds, below 15 cps. Though some boys and girls can hear as many as 21,000 cycles per second, most adults hear several thousand less. Some older people may not hear beyond 8,000 cycles per second.

Scientists have studied the extremely high frequencies that we can't hear and from them have developed the science of *ultrasonics,* or sounds of very high pitch. They have invented simple ultrasonic whistles that give out sounds which dogs, but not human beings, can hear.

On one side of the chart on these pages are several commonplace things and the frequencies they produce. The other side of the chart shows the hearing (frequency) range of a variety of animals. We are not yet sure of the hearing range of many animals, including dogs and cats.

The intensity, or loudness, of sound is measured in units called *decibels.* When you hear someone whisper, the loudness is about 20 decibels, while a loud conversation produces 70 decibels of sound. Noise of about 120 decibels may hurt your ears. The decibel scale *(above)* shows the loudness of some familiar sounds ■

When sound waves sent out by a bat strike a mosquito, they bounce back and guide the bat to its prey.



Finding Your Way by Echoes

Some animals use their ears more than their eyes to guide them around obstacles and to food. Scientists are putting this system to work to help us navigate on the ground, at sea, in the air.

"HELLOOOOO" . . . . . . "h e l l o o o o o" . . . . .

■ There's something exciting about hearing an echo of your voice bounce back to you from a hill. But for many creatures, listening to echoes is not a matter of fun. Their very lives may depend on their ability to hear echoes.

Porpoises need echoes to guide them through dark or muddy waters, around obstacles, and toward fish they eat.

Echoes enable bats to dart about at night or in lightless caves without bumping into trees or rocks. Bats also use echoes to catch hundreds of insects on the wing.

Echoes of sound waves tell modern sea captains how deep the water is and where underwater rocks and icebergs are located. This system is called *sonar.* Airplane pilots use echoes of radio waves *(radar)* to avoid thunderstorms and other airplanes. Echoes even help blind people to get around remarkably well without bumping into walls, doors, and other objects. The tap-tap-tap of a blind person's cane can be an effective "sonar" system.

This article has been adapted in part from Echoes of Bats and Men, *by Donald R. Griffin, Anchor Books, Doubleday & Company, Inc., Garden City, N.Y., 1959.*

What Is an Echo?

An echo is simply a wave that has struck an object and bounced off it. Many different kinds of waves produce echoes—water waves *(see photograph)*, sound waves *(see drawing)*, radio waves, and light waves. In fact, it is the light waves that bounce off an object then travel to your eyes that enable you to see the object.

When you shout "HELLOOO" into a valley, the sound waves move away from you in all directions. If some of them bounce off an object that is large enough and not too far away, the echo that comes back to you will be loud enough for you to hear it.

An echo sounds loudest when your ears are turned toward the direction the echo comes from. This means that, by listening carefully, we can tell the direction of the object that bounced back the echo, even if we can't see it.

At sea level, sound travels about 1,130 feet per second through the air, so you can estimate the distance from you to the object that bounced your shout back. With a stop watch, measure the time it takes for your shout to travel to the object and back to you. Divide this number of seconds by 2 and multiply by 1,130 to find the distance in feet between you and the object.

Spallanzani's "Bat Problem"

How do we know that bats navigate by using echoes? In 1795, an Italian scientist, Lazzaro Spallanzani, wondered how bats fly in complete darkness without bumping into anything. First, he found that blind bats get around just as easily as bats that can see, and they catch just as many flying insects. Next, the scientist put tiny plugs into the ears of some bats, and found that when bats can't hear they can neither navigate nor catch insects for food.

But so far as anyone knew at that time, bats did not make any sounds at all. At least, human ears could not hear them. How, then, could bats' ears guide the animals around obstacles and toward insects?

Scientific Instruments Detected Bats' Sounds

In 1938, Donald R. Griffin, then a senior at Harvard, "listened" to bats in a cage. He used one of the first instruments for detecting sound waves that are too high in frequency to be heard by the human ear *(see pages 8-9)*. He discovered that bats *do* make sounds—brief bursts of very high-pitched squeaks.

Only a few of the bat's sounds are pitched low enough for us to hear them. They come through as a ticking sound so faint that scientists once thought the sounds came from the bat's fluttering wings.

Griffin tried covering a bat's mouth. This would prevent the bat from sending out any sounds at all. It meant that the bat would not be able to bounce sound waves against obstacles or insects. Dr. Griffin's experiment worked. When he covered the animal's mouth so that it could not send out its series of squeaks, the animal bumped into objects and was unable to catch prey on the wing.

Further studies showed that different kinds of bats make echoes that are different in length and in pitch. Some make sounds lasting only a few thousandths of a second; others make sounds up to one-tenth of a second long.

A bat zeroes in on its target rapidly and with deadly accuracy. When the echoes of its squeaks tell the bat that a mosquito is nearby, the bat immediately sends out shorter sounds at a faster rate. This means that more echoes are received in a shorter time and makes the bat's system of *echolocation* more accurate.

Dr. Griffin (who is now Professor of Zoology at Harvard) reports that one bat that darted around a laboratory room with lots of mosquitoes in it caught at least 175 insects in 15 minutes—more than one every 6 seconds.

Some Animals Navigate Under Water by Echoes

Fishermen and whalers have known for years that whales, porpoises, and some fishes make noises. And scientists have long known that sound travels faster through water than through air. But only in recent years have they been able to prove that fishes and other marine animals can hear and use these underwater sounds.

No one knows how many fishes navigate and track down their food by echolocation, as bats do. However, porpoises have shown this ability. More recently, sperm whales (and two species of cave-dwelling birds) have been admitted to the echo club.

Porpoises have been placed in a large pool where scientists could study their behavior. When obstacles are placed in such a pool on the darkest nights, the porpoises are able to dodge around them even when swimming at high speed. At the same time, the porpoises make noises—usually a faint clicking sound.

At the Woods Hole Oceanographic Institution in Massachusetts, scientists tested a porpoise's ability to find food by echolocation. In an extremely muddy pool, on the darkest nights, they held a small dead fish under water beside a net that extended several yards into the pool. If the hungry porpoise was making a creaking sound as he swam by, he nearly always turned in to pick up the fish, dodging the net on his way. But whenever the porpoise was not making the echolocation sound, he would swim right past.

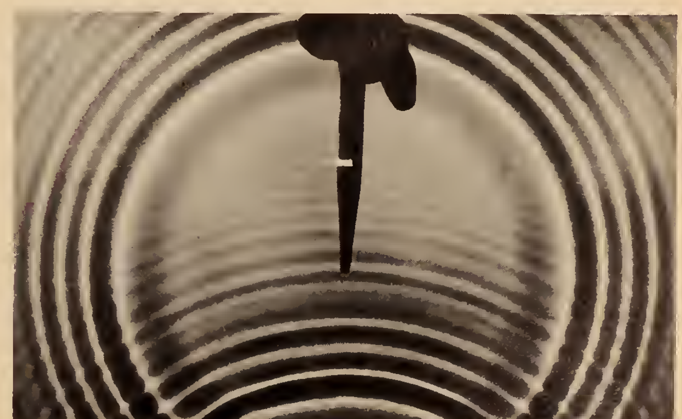
Two Mysteries Are Still Unsolved

Both bats and porpoises show a keen ability to tell one kind of echo from another. The sounds they make also echo off the ground, sea bottom, rocks, and trees that are not in their way and will not provide food. But somehow these animals can tell which echoes come from obstacles they must dodge and which come from insects or fish.

Another mystery is the speed with which bats and porpoises react to the signals that echoes bring them. To catch a tiny mosquito on the wing, or a small, darting fish, a bat or porpoise must change its course in a fraction of a second

(continued on the next page)

Water waves echo much like sound waves. When you dip a stick into water, waves move outward in circles. Bounced off a solid surface, some waves return to the stick.



as each echo reaches it from the target. The animal must even be able to predict, from the echoes it has received, where the target is going to be a second or so later, so that the animal can head it off.

Compared to these animals, man is not very adept at navigating by ear. Nevertheless, many blind people are fairly good at echolocation, even though they may not realize it. Some people who are blind tap the ground in front of them with a wooden or metal cane. Others, without canes, manage to travel around busy streets and buildings, dodging obstacles so skillfully and naturally that it is hard to believe they can't see.

Instruments Help Us Navigate by Echoes

To find out how such persons navigate, scientists conducted experiments something like the ones Spallanzani performed with bats. They found that when blind people are prevented from hearing the noises made by their own canes, footsteps, or voices, they can no longer detect obstacles in their path.

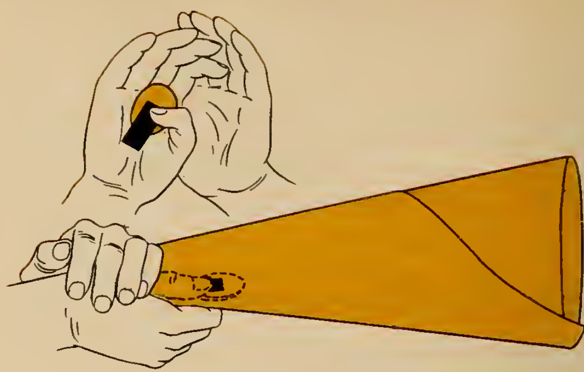
The importance of echolocation to blind persons has been proven. Now scientists are trying to find a source of sound that will bring more meaningful echoes to the blind.

Only by developing complicated electronic instruments have we been able to equal, or sometimes top, the bats and porpoises in echolocation. Our ships carry fathometers to measure the depth of the water, and sonar instruments to locate underwater obstacles or enemy submarines. Both use sound waves and echoes as the porpoise does.

Sound waves can't catch up with our speedy airplanes, and there is no air to carry sound through outer space. However, radio waves travel at the speed of light through both air and space. Our radar instruments bounce radio waves off airplanes or spacecraft and locate them almost as efficiently as a bat tracks its prey by sound echoes ■

With their claws, some bats catch small fish at the surface of the water after detecting the fish with sound waves.

INVESTIGATION



You can test your ability to hear echoes and to locate objects such as a building or a tree by means of echoes. Use a small toy frog or cricket—the kind with a thin strip of spring steel that makes a loud but short clicking sound when you bend the end of the strip with your finger. You may be able to buy one for 10 cents or so at a variety store.

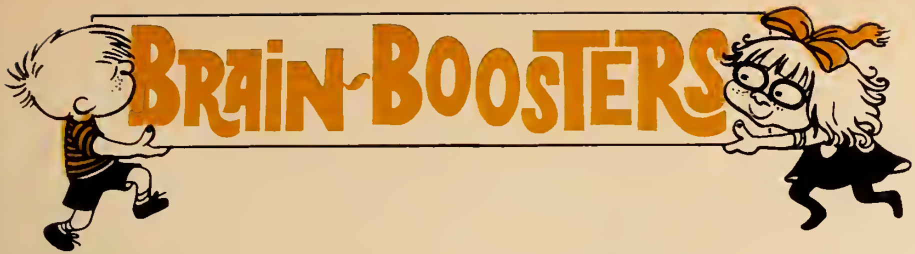
Hold the clicker with both hands cupped around it to form a horn that faces forward from you (see *diagram*). When you press the clicker with one finger, your cupped hands will block some of the original sound from reaching your ears and make it easier for you to hear an echo.

Your hands may get tired holding the clicker this way. If so, try bending a piece of thin cardboard into a cone with a small opening at one end —like the megaphones used by a cheerleader at a football game (see *diagram*). Adhesive tape will hold it in shape. Put the clicker in the small end of the horn so you can operate it with one finger, and hold your other hand around the opening to block most of the original sound from your ears.

The best place to make this investigation is outdoors in a place where buildings and trees are not too close to each other. Point your horn and clicker at a building about 50 feet away and press the clicker. Can you hear its echo? Now turn slowly from side to side, making one or two clicks per second. Does the presence or absence of echoes give you an idea of how wide the building is?

Can you hear an echo from a large tree or telephone pole that is separated from other trees or poles? If there are several trees close by, can you detect the echoes from a single tree by careful turning and listening? Do echoes from trees sound the same as echoes from buildings?

From 50 feet or so away (but not across a street!), walk slowly toward a building and listen to the echoes as you go. What happens to the echoes when you get fairly close to the building? Can you explain why?



■ **Seventeen**

How many times can you subtract 17 from 170?

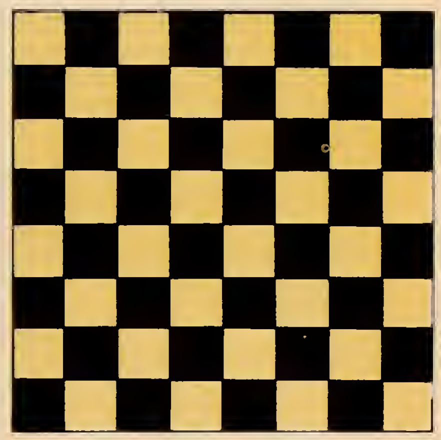
■ **Help the Mouse**

See how quickly you can help the mouse find its way through the maze of tunnels below. You do not have to stop if one tunnel runs behind another, but beware of the traps.

■ **Cats and Rats**

Mr. Trapp has a pest exterminating business. He trains cats to catch rats and other harmful rodents.

Recently three of his cats caught 3 rats in 3 minutes. How many of his cats will be needed to catch 500 rats in 500 minutes?



■ **The Checkerboard**

Put eight "checkers" on this checkerboard, making sure that no checker is in a straight line with another, or on a diagonal line with another.

■ **Weighing Dinosaur Eggs**

A scientist had nine dinosaur eggs and he suspected that one of the eggs weighed slightly less than any of the other eight. If he used a balance scale and could weigh the eggs only two different times, how could he find the one egg that weighs less?

Solutions to Brain-Boosters appearing in the previous issue

Shifting Gears: The correct statements are numbers 2, 3, 6, 7, and 9.

Not a Drop More Than 4: To get exactly 4 pints of gasoline, Mr. Todd filled the 3-pint jar and emptied it into the 5-pint jar. Then he filled the 3-pint jar again and emptied as much as he could into the 5-pint jar. That left one pint in the 3-pint jar.

Next he emptied the 5-pint jar back into the gasoline drum and poured the one pint from the 3-pint jar into the 5-pint jar. To get exactly 4 pints in the 5-pint jar, he simply filled the 3-pint jar again and added it to the one pint already in the 5-pint jar. (There is at least one more way to solve this problem. Can you figure it out?)

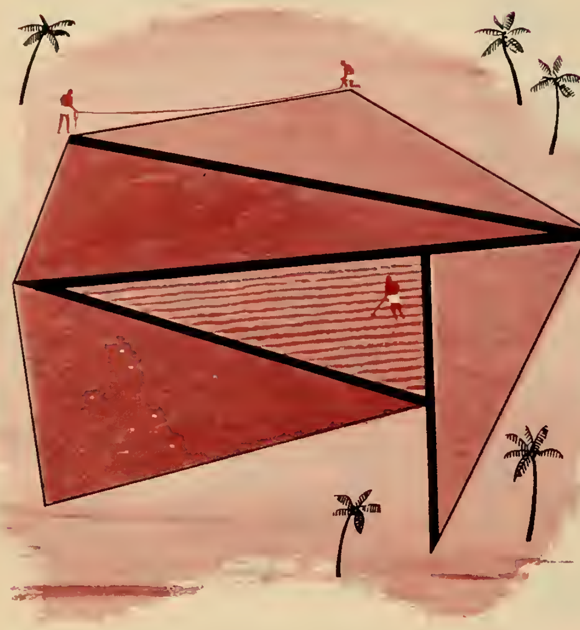
The Ant's Journey: Since the ant slipped back 2 feet each night after 3 feet of progress during the day, it would have climbed 27 feet after 27 days and nights. It can climb the remaining 3 feet on the 28th day.

Who Won the Race?: This difficult puzzle can be solved by the trial and error method. If you assume that the statement "Cissie was first." is correct, then you know that Brenda was not second.

Checking Brenda's two statements, you know that Cissie was not second, so Doreen must have been third. Finally, since Doreen was third, she cannot be fourth, so Cissie's statement that Alice was second must be true. The order of finish: 1—Cissie, 2—Alice, 3—Doreen, and 4—Brenda.

Travels of a Bookworm: The trick to this puzzle is to remember that the first page of a book is on the *right-hand* side of a book when you view the book from the back. Starting inside the front cover of the first volume, the bookworm must travel through 6 book covers and the pages of two volumes to reach the *last* page of volume IV. The trip takes 26 days.

HOW BIG IS AN ANGLE?



■ The priests of ancient Egypt were not only men of religion, they were also astronomers and tax collectors. It was their job to measure the size of the fields and tell each farmer how much he had to pay in taxes.

This job fell to the priests because of their knowledge of mathematics and geometry, and they guarded this knowledge jealously.

To find out exactly how large a farmer's field was the priests divided it into triangles and then measured the size of each triangle. When the size of all the triangles had been worked out and added together, the priests then knew the size of the field.

Measuring angles was a skill that few men had in ancient times. Today it is common. Nearly every one of us measures angles many times a day without being aware of it. The angle made by the hands of a clock, for example, is one of the clues that help us read the time on a clock face.

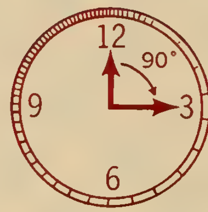
This is the fourth in a series of articles adapted by permission of the Elementary-School Science Project from the revised edition of its booklet, Astronomy: Charting the Universe. *© 1962 by the Board of Trustees of the University of Illinois.*

Making and Measuring Angles

You can make an angle by drawing two lines that meet at a point. The point where the lines meet is called the *vertex,* and the lines are called the *sides* of the angle.

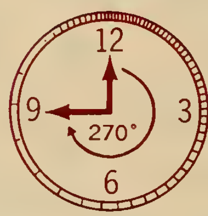
The hands of a clock will help you understand something about angles. Watch a clock at noon when both hands are on 12. As the minute hand moves down to 1 and then to 2 and 3, it sweeps out an angle that becomes larger and larger. If you were to attach a small pen to the end of the minute hand you would see it trace out a circle as it moved around. When it reached 3 it would have traced out one quarter of a circle; at 6, one-half a circle; at 9, three-fourths of a circle; and at 12 a complete circle.

Circles are divided into 360 equal parts. A circle *could*



A RIGHT ANGLE
(¼ CIRCLE)

A STRAIGHT LINE
(½ CIRCLE)

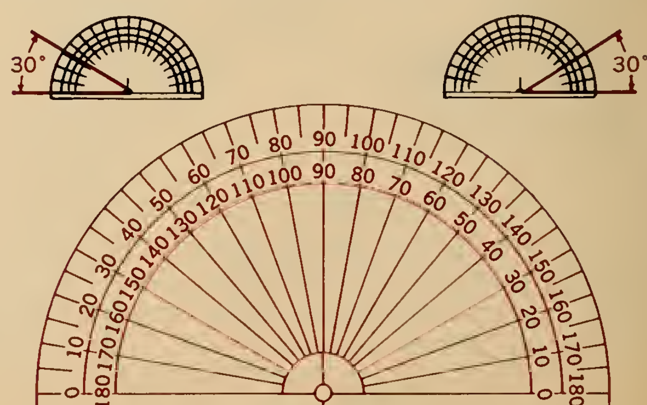


(¾ CIRCLE)

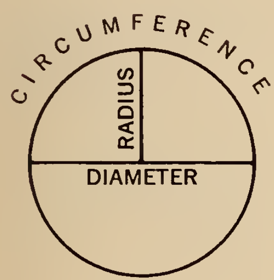
(A CIRCLE)

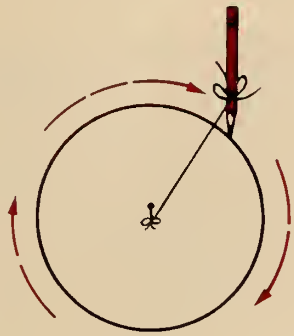
be divided into 60 equal parts, as the clock face is divided into 60 minutes. But long ago, men agreed to divide the circle into 360 parts and to call each part a *degree.* We write degrees by using a small circle after a number. The angle formed by the hands of a clock at 3 o'clock is written 90°. At 6 o'clock the hands form a straight line, and a straight line is an angle of 180°.

We measure angles with an instrument called a *protractor.* If you do not have a protractor of your own you



can make one by cutting out the one on page 14 and mounting it on a piece of cardboard cut to the same shape. To use your protractor, always place the little hole over the vertex of the angle and line up the bottom side of the angle with 0° mark on the protractor *(see diagrams)*. If the

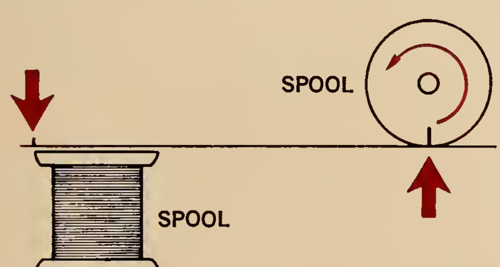




sides of your angle don't reach the rim of the protractor, just make them longer. Follow the protractor scale from 0° at the bottom side of your angle to the point where the other side crosses it, and read the size of the angle in degrees on that scale.

Like surveyors, astronomers who measure the distances of faraway objects work with angles. They also work with circles. One way to make a circle is by tying a small stick on the end of a string as shown in the diagram.

The length of the string from the center of the circle to its rim is called the *radius* of the circle. The distance through the center from one rim to the other is called the *diameter*. The distance all the way around the circle is called the *circumference*. If you make the radius of a circle longer, you make the circle bigger and increases its circumference. More than 4,000 years ago, men living in the Middle East found something interesting about the relationship between the diameter of a circle and its circumference. Exactly how they went about their discovery we cannot say. But you can make the same sort of discovery yourself.



How to Find "Pi"

On a piece of paper draw a straight line about five inches long. Next make a pencil mark on the edge of a spool of thread *(see diagram)*. Now carefully roll the spool along the pencil line so that it makes exactly one turn. (Begin with the pencil mark at the bottom and keep rolling the spool until the mark swings up and then down to the bottom again.) Be sure to mark the line in two places—the start and the finish positions of the rolling spool. The distance between the pencil marks is the same as the circumference of the circle formed by the rim of the spool.

Next stand the spool up on end and find out how many of its diameters fit between the two pencil marks.

Now try the same thing with several other objects—a paper cup, a waste basket, a bicycle wheel. Find out how many diameters of each object fit along the circumference line. You should get the same answers each time; and the number is so often used in mathematics that it has been given a special name—*pi*—a letter of the Greek alphabet written π.

If you multiply the diameter of *any* circle by *pi*, you will get its circumference.

Making and Measuring Triangles

Draw a large triangle, any shape you wish, on a large sheet of paper. Cut it out with scissors and mark each angle with a large dot. Next tear the triangle in three parts so that each part has one of the angles on it. Now put the three pieces of paper together so that the sides of the three angles touch and the three dots are side by side *(see diagram)*. What you are doing is "adding" the three angles with your eye. Try the same thing with two or three other triangles that you cut out. What happens each time? What does this angle puzzle tell you about the total number of degrees in a triangle?

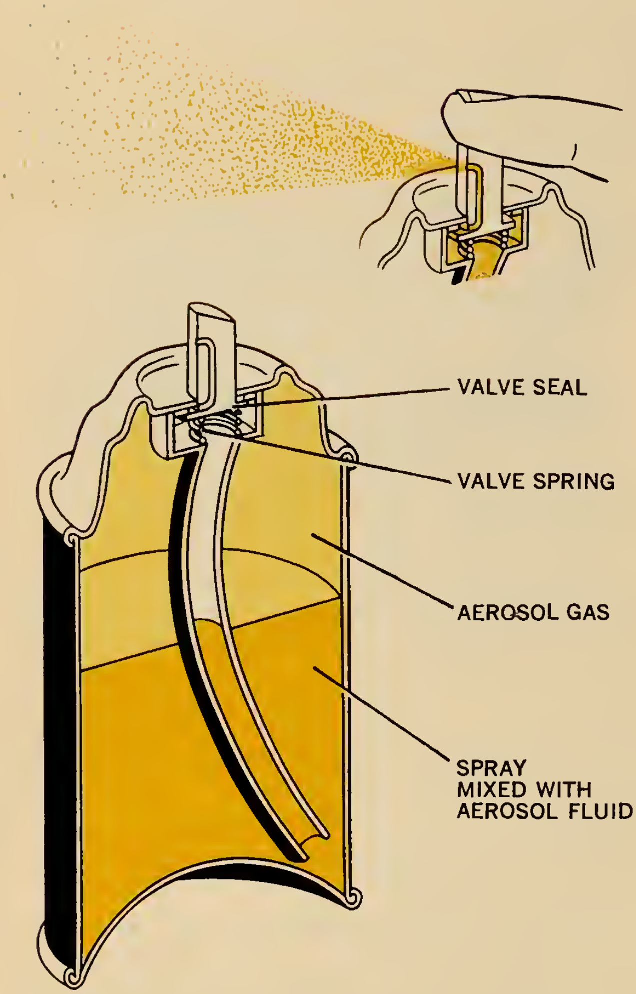
Draw another large triangle. This time measure each of its three angles with your protractor. Now add the three angles together. What total do you get? Do the same thing with two or three other triangles with different shapes. You should always get exactly the same total, in just the same way that the angle puzzle came out the same way each time.

No matter how large or small a triangle is, or what shape it is, the sum of its angles is always exactly the same.

In the next issue of *Nature and Science* we will show you how to build a range finder. With this instrument you will be able to measure the distance to trees and other objects in your yard without using a ruler or tape measure. If you had had a range finder on your tropical island *(see Sept. 20 issue of* Nature and Science) you would have been able to calculate the distance to the islands nearby ■

HOW IT WORKS

Spray Cans



■ Spray cans are filled with many different things—paint, whipped cream, insect repellent, and shaving cream, to name a few. Have you ever wondered how a spray can works?

If you ever dropped a bottle of soda pop, then took off the cap as soon as you picked up the bottle, you saw the principle of the spray can at work. To make the pop sparkling and bubbly, carbon dioxide gas is blown into the bottle before it is sealed. The gas is packed so tightly in the bottle that some of it pushes out into the air as soon as you remove the cap. When you drop or shake an unopened bottle, the gas that fills the space at the top of the bottle gets mixed up with the liquid. Then, if you take off the cap, the gas rushes out and takes some of the liquid along with it.

Spray cans work on the same principle. Along with paint or some other liquid, a gas is forced into the can at a greater pressure than the air outside and the can is then sealed. When you push down on the valve, a passage opens, and some of the compressed air escapes through a tiny hole in the valve head. This escaping air forces some liquid out with it as a spray. A spray of tiny liquid droplets is called an *aerosol*, and spray cans are often called aerosol cans.

When spray cans were first invented, compressed air was used inside the can. These spray cans did not work too well because the compressed air lost its pressure quickly and would be all used up while there was still liquid in the can. Engineers tried to solve this problem by sealing the air in the can under very high pressure. Then, however, extra strong cans were needed to keep the pressure from exploding the cans.

Eventually, engineers solved this problem by using chemicals like *Freon*, a substance that changes easily from a gas to a liquid. Freon is a gas when it is kept at normal temperature and air pressure, but it becomes a liquid when it is compressed to about six times normal air pressure.

Fluids like compressed Freon are now mixed with the paints and other liquids that are put in spray cans. When the valve on top of the can is pushed down, the pressure inside forces out some paint and some Freon. As soon as the liquid Freon meets the lower pressure of the outside air at the opening of the spray can, it becomes a gas and pushes the paint out in a fine spray.

The diagram on this page shows a cutaway view of a spray can. The spring at the base of the valve keeps the valve closed and helps seal the high pressure liquids inside the can. The bottom of the spray can is curved inward so that it can withstand the outward force of the compressed liquids inside. Such high pressure might push out the bottom of an ordinary flat-bottom can.

Spray cans should always be kept away from fire and other heat sources. When it is heated Freon changes from a liquid to a gas. If that happens, the pressure inside the can increases and there is danger of an explosion ■

nature and science

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TEACHER'S EDITION

Don Rice, New York Herald Tribune

Open-ended investigations encourage children to seek new facts and explanations, as scientists continually do. Sounds made by this cat are being recorded for study at The American Museum. We know surprisingly little about the behavior of many animals.

Why "Open-Ended" Science Teaching?

"One of the purposes of science teaching is to help children gain an understanding of the world around them." This statement contains the basis of both a philosophy and method of science teaching for elementary school teachers.

The current student's edition features an article about the behavior of cats, written by Roy Gallant with the advice of Dr. Theodore C. Schneirla, Curator of the Department of Animal Behavior, The American Museum of Natural History.

It would be easy to make this article into a "be kind to animals" lesson. Good science teaching and proper use of the article should make it clear that the piece does not categorically state that we *should* handle cats gently. All science can tell us is that if we treat kittens one way—based on Dr. Schneirla's work—we can predict one form of behavior. Treat them another way, and something else happens.

The accumulation of facts about science is secondary in importance to understanding what the facts mean. Since we don't begin our teaching with abstractions, and since we can't teach without reference to things and experience, facts are essential. But the goal is to show how the facts illustrate a concept that, in turn, can serve as a basis for understanding facts gleaned from future experiences.

Finally, we cannot provide understanding; all we can do is help children to understand. Parents, teachers, writers of articles, editors, or scientists cannot transfer their understanding to children. At first this seems to be a lamentable, inefficient, and almost wickedly stubborn attribute of the human mind. A moment's reflection reveals that it is not.

The steady progress of man's intellectual adventure is surely based on the inability or unwillingness of scientists to accept explanations. And this is the meaning of the much-mouthed, overused, and little-appreciated phrase, "open-ended investigation."

Open-endedness does not imply that we leave children free to mess about. It does not mean that the so-called cookbook laboratory exercise and the pat, well-practiced demonstration have no further use in science teaching. They do. It is impossible and really inefficient under present day demands of the curriculum on teachers to teach without these. Open-endedness merely means that we leave room for children to question more, to doubt more, to demand better explanations than we have. Thus will we help children to gain understanding of the world around them. —W. L. DEERING

A Paperback Science Library for the Elementary Teacher

As the teaching of science spreads in the elementary grades, many a teacher will no doubt feel ill-prepared for this turn of events. How many sixth-grade teachers, after all, have ever studied nuclear physics? How many fifth-grade teachers have taken a course in biology beyond a "once-over-lightly" in high school?

To be realistic, only a tiny fraction of these teachers will ever be able to catch up with the world of science by means of a summer course or some other formal instruction. But this is no cause for despair. The same trends that result in more science in the schools are also bringing about a revolution in publishing—particularly (and fortunately for your pocketbook) in paperback publishing.

A few years ago, paperbacks tended to be either sensational fiction or college-level books largely confined to the humanities. In the past few years, however, science paperbacks—both popular science and science books of use in undergraduate courses—have come into their own. Today there are over 1,000 such books, some reprints of established works, others "originals," i.e., making their first appearance in paperback format.

They range in price from 35 cents to $2. The less expensive books can often be found in drugstores or variety stores. The more expensive paperbacks are usually on sale at bookstores or at the paperback bookshops springing forth in many cities. If you live near a college, you will probably be lucky in having an enormous paperback display in the college store. (If you have trouble in finding a paperback outlet, write the publishers listed at the end of this article.)

Paperback science books will not suddenly make you an expert, nor will these books often give you an idea that you can use in the classroom the next day. But they will give you the beginnings of real scientific literacy, a familiarity with science and its ways. And with this familiarity will come a new measure of ease and confidence when introducing science to your pupils. *(Continued on page 3T)*

Page 3: Secret World of Felis catus

Basic concept: All organisms respond to their environment: In this case, the behavior of cats is comprised of inherited responses or capabilities which can be modified or adapted by environmental situations. These modified behaviors can be called learned responses.

This article is both informative and fun to read. After your pupils have read the article, it would be worthwhile to try to distinguish between the inherited behavior of cats and learned behavior.

This can be a lively discussion, for any child who has had experience with a litter of kittens, pups, or rabbits knows that individual differences of behavior are immediately apparent.

The children will probably offer incidents that contradict the "rules" for kitten raising put forth in the article. Call their attention to that part of the article dealing with Dr. Schneirla's research procedures. Try to have them distinguish between (1) variations in the behavior of individual cats which may be the result of environmental influences (e.g., the attitudes of different cats toward humans), and (2) behavior patterns that seem characteristic of all cats (e.g., the cat is a nocturnal animal).

Some ways to help your pupils learn how to distinguish between *inborn* and *learned* behavior are presented in the Teacher's Edition for September 20, page 2T, under "Never Smile at a Chimp."

Page 7: How Big Are Raindrops?

This workshop article gives children an opportunity to make an indirect investigation of common but transitory phenomena—raindrops. The writer, Phyllis S. Busch, is a teacher and consultant on outdoor education activities for the Riverdale (N.Y.) Outdoor Laboratories, described in our October 4 Teacher's Edition.

The activity described here can be done in class or at home. If you plan it in class it might best be a committee project assigned to one or two groups who have made preparations, have rain gear ready, and can be gotten out quickly. (Unless principals have changed since my day, you had better drop around to the office and explain that the next time it starts to rain several of your pupils are going to go shooting out the door with floured pie plates in hand.)

The important point to stress is that scientists have to make preparations ahead of time and be ready to record phenomena when they occur.

Try to make it clear that your investigators are measuring only *relative* size. The boys and girls will not be able to say anything about their dried raindrops other than that some are larger (or smaller) than others.

Unless the pie plates are held at exactly the same angle during all samplings the results will be invalid. Resting the plates on a flat surface (the sidewalk) might keep the angle of impact constant for all samples.

The chart on page 7 presents an interesting aspect of the whole problem of measurement. If measurements are to have any use as data, they must be standardized in some way. The chart calls for scoring three sizes of raindrops: big, medium, small.

To assign drops to the proper categories, all must be lined up first. You can point out to the children that some are obviously "big," some "small," and some "medium." But there are some at each end of the scale that will have to be arbitrarily assigned. Here is a case where it might be best to define the categories by some real number. Thus, big drops might be all those exceeding 1/16 inch in diameter. Quite possibly the definition for big in one storm will not hold true for another.

There is little scientific or practical value in knowing the size of raindrops. And, without reference to some broader field of knowledge, there is little value in knowing whether there are more big drops at the beginning of a storm than at the end. However, this investigation is fun. Your pupils will find it fascinating. And if it is used to present the problems of measuring inherent in any investigation, the activity is valuable in terms of understanding the scientific enterprise.

Page 8: Sounds We Can Hear...

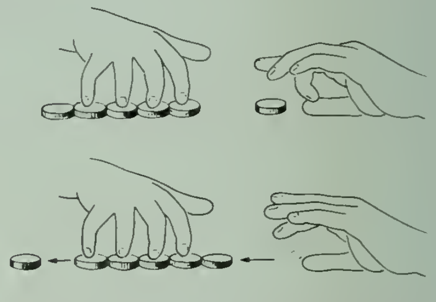
Basic concept: Matter is made of tiny particles called molecules (matter is particulate).

The concept that matter is made of molecules is difficult for children to understand, since they cannot see the molecules. A study of sound is one way to help them understand the molecular nature of matter—especially of air, which is composed of gas molecules.

First, to show that vibrating objects make sound waves, have your pupils each put a thumb and forefinger around his larynx, or voice box. When a child makes a humming sound, he will feel the vibrations that produce sound waves. He can also hear and see vibrations if he plucks a tightly stretched rubber band.

Your pupils should understand that a sound wave is a moving wave of pressure, and it is this pressure that moves through the air, *not* a group of molecules. The molecules themselves vibrate back and forth for a very short distance. You can show how a wave of pressure passes through molecules in this way:

Put six coins or checkers on a table so that five of them are in a line and touching each other *(see diagram)*. Hold four of the coins against the table with four fingers, leaving the fifth coin free but still touching the end coin in the row. Then flick a sixth coin with your forefinger so that it strikes the end of the row opposite the coin that is free to move. A wave of pressure travels through the coins in much the same way as sound vibrations travel through the molecules in air, and the free coin will move away.



A line of checkers can be used to demonstrate how sound waves are transmitted by molecules in the air (see text).

Because sound waves are often drawn as wavy lines, we tend to forget that they radiate out in the form of a sphere from a vibrating object. You can illustrate this point by having a child speak from the center of a classroom. Pupils in all directions will be able to hear, and would still be able to hear if they were above or below the speaker.

Since sound waves travel by the action of molecules alternately pushing together and moving apart, it is logical that sounds travel faster in matter where the molecules are close together and can bump into each other readily. Thus, sound travels about four times faster in water than in air, and moves even faster through solids.

For example, if we could make a loud enough sound to be heard in a town 375 miles away, it would take the sound 30 minutes to travel that distance through air. However, if we tapped out a message on a railroad track, the sound would travel 375 miles in about two minutes through the solid metal track.

The suggestions for using this issue of Nature and Science *in your classroom were prepared by William L. Deering, Managing Editor, Education Division, Doubleday & Company, Inc. He was formerly Associate Professor of Education and Science Supervisor of the campus laboratory school at State University of New York, at Oneonta.*

Sound waves travel slowly in cold air, even though the gas molecules are closer together than the molecules in warm air. This is because the molecules move less freely as temperature decreases. At high altitudes sound waves travel slowly because there are fewer molecules in the air. Outer space is deadly quiet because there are so few gas molecules there that sound waves cannot travel.

The science of controlling the sounds we hear, or acoustical engineering, is important in the construction of many buildings, especially schools. A committee of students could contact the architectural firm or contractor for your school and ask for information about the acoustical planning that went into the construction of classrooms, hallways, and the auditorium.

Page 10: Finding Your Way by Echoes

Basic concept: Organisms are adapted (by structure and function) to their environment.

This article tells how some creatures have adapted to environments in which they cannot see well enough to avoid obstacles in their path or to get food.

Some of your pupils can investigate echo-navigation. Studies show that blind people can detect obstacles by unconsciously listening to the echoes of their footsteps, breathing, and the rustling of their clothes. This can be investigated by blindfolding a pupil and discovering at what distance he can detect an obstacle (such as a portable chalkboard) in his path.

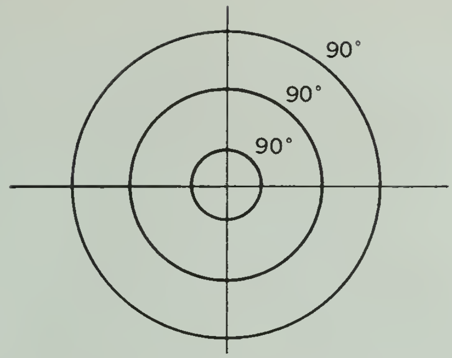
Make several trials, moving the obstacle each time while the pupil cannot hear it being put into position. Also be sure that the background sounds where you are experimenting stay at about the same level during each trial.

After several trials, you will probably find that a pupil can detect the obstacle at about the same distance each time. Let other pupils try it, to see at what distance they detect the obstacle. Then repeat the experiment while the pupils have their ears plugged with cotton and covered with ear muffs.

Page 14: Measuring the Universe 4
How Big Is an Angle?

Measurement is the essential tool of science. The projects and activities in the article introduce children to a most important concept, the angle, and to a most useful unit, the degree.

Since angular measurement is not usually introduced until the seventh grade, and then only with careful teaching over many days or weeks, most children will find this article difficult. But, in keeping with our general editorial philosophy, we try to include a variety of articles to reach a wide range of intellects and interests.



Measuring concentric circles shows that one-quarter of any circle contains 90°.

One of the most difficult intellectual hurdles children have to cross in learning to use degrees is that angular size is independent of linear size. After your pupils have practiced with the protractor and can make fairly accurate measurements, have them draw (with a compass) three concentric circles *(see diagram).*

Then have them draw two lines through the circles, dividing the circles into quarters. Measurement with a protractor will show that one-fourth of a circle contains 90° whether the circle is small or large.

You may also demonstrate this on the blackboard with straight angles. Draw an angle of 45° with sides a foot long. Then extend the sides as far as you can. Ask the children what—if anything—has happened to the size of the angle. Then have them make appropriate measurements to support these answers.

Since the measurement of angles depends partially on dexterity and sharpness of the eye and pencil, this article offers a good chance to demonstrate experimental error. The distance between lines of notebook or exercise paper is usually standard. Have the children put a dot at the far left side of the sixth line. Then have them draw an angle whose sides extend to the opposite corners of the page. Have them measure their angles and report. The measurements will vary somewhat because the angles are not drawn exactly alike and because of individual differences in measuring.

There should be a cluster of fairly similar answers as well as some extremes. Show what happens when you average all the figures and when you average those that cluster.

The project to generate the value of *pi* also depends a great deal on digital skill, ability to follow instructions, and the ability to plan. A value of 3 would be a very good value for most pupils. However, you might try having them estimate the small portion that is left over. Be sure that the children try to obtain a value for *pi* with at least two different sized circles. The more the circles differ in size, the better. The value of *Pi,* by the way, is 3.14159265358979.

A Paperback Science Library...
(Continued from page 1T)

The list that follows are suggestions of the editors of *Nature and Science* as to generally available, lower-cost paperback titles that will serve your needs.

A complete listing can be found in *A Guide to Science Reading,* a paperback itself, published by Signet Science Library of The New American Library (Signet P2283, 1963, 220 pp. 60¢). This compilation is an outgrowth of *An Inexpensive Science Library,* published for several years by The American Association for the Advancement of Science under the direction of Hilary J. Deason. In its latest form, this excellent bibliographical guide lists more than 900 titles, each succinctly described and each group according to Dewey Decimal System categories.

In addition to individual books, there are several science paperback series which should prove helpful. The elementary teacher should find one series close to indispensible—the Golden Nature Guides, with individual titles on *Birds, Flowers, Trees, Insects, Stars, Reptiles, and Amphibians, Mammals, Seashores, Fishes, Weather,* and *Rocks and Minerals.* Under the editorship of Dr. Herbert S. Zim, a former high school science teacher, these $1 books are consistently authoritative, remarkably full of information, clearly written and beautifully illustrated. They are also easy to find.

A somewhat more advanced series is the Anchor Science Study Series ($1.25-$1.45) of some 35 paperbacks devoted largely, though not entirely, to topics in physics. This series was originated by the Physical Science Study Committee as collateral reading for high school science courses.

Also of great value, though presupposing at least a year of biology, is the Prentice-Hall Foundations of Modern Biology series (typical titles: *Heredity, Adaptation, Animal Growth and Development, Animal Behavior, The Plant Kingdom).*

For a continuing view of the unfolding frontier of modern research, there is nothing better than Scientific American Books ($1.45), published by Simon and Schuster, Inc. Each is a collection of articles from *Scientific American* magazine.

In the following list, titles preceded by an asterisk are especially recommended for starting your science library.

OVERVIEWS OF SCIENCE

*CALDER, RITCHIE. *Science in Our Lives.* Signet Science P2124, 1962, 192 pp. 60¢. A wonderfully readable survey of how science and technology permeate the affairs of modern man, from his food and health to his politics and intellectual life, by the dean of mod-

(Continued on the next page)

A Paperback Science Library...
(Continued from page 3T)

ern science journalists. "This book started out by trying to show that science belongs to the humanities. The concern of all of us should be to see that science belongs to Humanity."

NEWMAN, JAMES R. (ed.) *What Is Science?* Washington Square W1076, 1961, 533 pp. illus. 90¢. Twelve famous and articulate scientists explain the strengths and weaknesses of 12 major domains of science (including astronomy, anthropology, psychiatry, physics). Not always easy reading, these contributions are consistently stimulating.

GAMOW, GEORGE. *One, Two, Three . . . Infinity.* Mentor MD97, 1953, 318 pp. illus. 50¢. Ranging far and wide over the terrain of science and mathematics, this engaging book is one of the best of several fine paperbacks by Dr. Gamow that are generally available.

*WEISSKOPF, VICTOR F. *Knowledge and Wonder.* Anchor S31, 1963, 282 pp. illus. $1.45. A remarkably clear and comprehensive view of modern science, in which astrophysics, nuclear physics, molecular biology, the new genetics, and evolution theory are shown to be interconnected both in nature and in any rational understanding thereof. This first-rate primer for the scientific neophyte, written by an eminent MIT physics professor, won the 1962 Thomas Alva Edison Foundation Award for Best Science Book for Youth.

*YOUDEN, W. J. *Experimentation and Measurement.* NSTA VOS2, 1962, 127 pp. illus. 50¢. A lucid and useful introduction to the basic aspects of measurement which underlie all of science and technology.

LIFE SCIENCES

*BATES, MARSTON. *The Forest and the Sea.* Mentor MD316, 1960, 216 pp. 50¢. How animals are adapted to their surroundings, with examples drawn from forest, grassland, fresh-water, marine, and desert environments.

CARSON, RACHEL L. *The Sea Around Us.* Mentor MD272, 1954, 169 pp. illus. 50¢. If you have read this classic already, it is not too soon to read it again.

GOLDSTEIN, PHILIP. *Genetics is Easy.* Explorer X22, 1961, 238 pp. illus. $1.45. Genetics is not really easy and never will be, but Goldstein's nicely conceived sequences of words and diagrams comes as close to making genetics easy as is humanly possible.

*BURNETT, R. WILL; HARVEY I. FISHER and HERBERT S. ZIM. *Zoology: An Introduction to the Animal Kingdom.* Golden Press 408, 1958, 160 pp. illus. $1. A wonderfully illustrated little book that contains an amazing wealth of information about biology and its central concepts.

THE NEXT ISSUE *of Nature and Science* will feature three related articles that were first published in one of our pilot issues last spring, and which we are reprinting on popular request.

The first of these articles explains how fossils are formed. The second delves into a fascinating mystery that scientists are still trying to solve: "Why Did the Dinosaurs Die Out?" The third is a two-page chart, ideal for the classroom bulletin board, that shows the development of land animals through the ages.

Measuring the Universe (Part 5) will show readers how to use what they have learned from these articles about measuring lines and angles to make a range finder that really works.

"Exploring Dreamland" reveals what scientists have found out about how we sleep and dream.

KRUTCH, JOSEPH WOOD. *Grand Canyon.* Anchor N20, 1962. 252 pp. illus. $1.25. A gifted writer brings alive the marvelously diverse geology and biology of this natural wonder.

SIMPSON, GEORGE GAYLORD. *Horses.* Anchor N1, 1961, 323 pp. illus. $1.45. In this case history of the 60-million-year development of the horse a distinguished scientist engagingly illuminates evolution theory and much of modern biology.

SIMPSON, GEORGE GAYLORD. *The Meaning of Evolution.* Yale Y23, 1960, 364 pp. illus. $1.45. A stimulating classic of modern science.

PHYSICAL SCIENCES

BATTAN, LOUIS J. *The Nature of Violent Storms.* Anchor S19, 1961, 158 pp. illus. $1.25. About thunderstorms, tornadoes, hurricanes, this book also explains the workings of clouds and the action of heat, air, and water in making the weather.

BEISER, GERMAINE, and ARTHUR BEISER. *Physics for Everybody.* Everyman D63, 1960, 191 pp. illus. $1.15. A simple introduction to the main ideas of physics.

BRANLEY, FRANKLYN M. *Exploration of the Moon.* Natural History Press B1, 1963, 146 pp. illus. 95¢. A brief, clear explanation of the steps now planned to put man on the Moon, with an outline of what we already know about the Moon and what we soon hope to learn.

CARRINGTON, RICHARD. *A Guide to Earth History.* Mentor MT335, 1961, 284 pp. illus. 75¢. A broad and readable survey of the Earth's history from its birth, its geological evolution, and the development of life on its surface.

CLARKE, ARTHUR C. *The Exploration of Space.* Premier D102, 1960, 192 pp. illus. 50¢. A literate and balanced introduction to astronautics and space travel.

COHEN, I. BERNARD. *The Birth of a New Physics.* Anchor S10, 1960, 200 pp. illus. $1.25. An engaging introduction to the laws of motion and celestial mechanics told through the great contributions of Copernicus, Galileo, Kepler, and Newton.

HECHT, SELIG. *Explaining the Atom.* Explorer X12, 1960, 237 pp. illus. $1.25. One of the first and still probably the best layman's introduction to nuclear physics, radioactivity, and all.

*HOYLE, FRED. *Frontiers of Astronomy.* Mentor MP420, 1957, 317 pp. illus. 60¢. A fine short course in astronomy by an articulate expert—covers everything from the Earth and its sister planets to the outermost galaxies of the universe.

JOHNSON, GAYLORD and IRVING ADLER. *Discover the Stars.* Sentinel 17, 1962, 152 pp. illus. $1. A beginner's guide to astronomy with helpful illustrations. Instructions for making simple instruments including the sun dial, sextant, Earth satellite model.

LESSING, LAWRENCE P. *Understanding Chemistry.* Signet Science P2260, 1959, 192 pp. illus. 60¢. This book indeed lives up to its title, giving an able account for the layman of the main ideas of modern chemistry.

ADDRESSES OF PUBLISHERS

Anchor — Doubleday & Company, Inc., Garden City, N.Y.

Boxwood—The Boxwood Press, P.O. 7171, Pittsburgh 13, Pa.

Everyman—E. P. Dutton & Co., Inc., 201 Park Ave. South, New York 3, N.Y.

Explorer—The Viking Press, 625 Madison Ave., New York 22, N.Y.

Golden Press—Affiliated Publishers, Inc., 630 Fifth Ave., New York 20, N.Y.

Mentor—New American Library of World Literature, Inc., 501 Madison Ave., New York 22, N.Y.

NSTA—National Science Teachers Association, 1201 16th St., N.W., Washington 6, D.C.

Natural History Press (Doubleday), Garden City, N.Y.

Premier — Fawcett Publications, Inc., 67 West 44th St., New York 36, N.Y.

Prentice-Hall — Prentice-Hall, Inc., Englewood Cliffs, N.J.

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nature and science

VOL. 1 NO. 5 / NOVEMBER 15, 1963

70,000,000 years ago the last of the dinosaurs died. Exactly why, no one knows.
see pages 4 — 7

WHY DID THE DINOSAURS DIE OUT?

ABOUT THE COVER

The huge flesh-eating dinosaur above is *Tyrannosaurus rex*, one of the most fearsome of the "terrible lizards" that once ruled the Earth. Armed with sharp teeth and talons, and weighing nearly 10 tons, this reptile was well suited to prey on other dinosaurs. But this mighty monster disappeared with all the dinosaurs long before men appeared on our planet.

The story that begins on page 4 tells how scientists have discovered part of the dinosaur life story, and the mysteries that remain. Although we have learned many facts about the Age of Reptiles, much of the story of these reptiles is still a puzzle.

Why do scientists want to learn about the lives of dinosaurs? One reason is that these animals roamed the Earth for such a long time—over 100 million years. So far, mankind's time on Earth has been only a tiny fraction of the length of the Age of Reptiles.

Will other groups of animals disappear, like the dinosaurs, in the future? By learning about dinosaurs, we may be able to understand why groups of animals die out, or, as we say, become extinct.

The pictures on our cover and page 4 show sections of the 90-foot-long dinosaur mural at the Peabody Museum of Natural History, Yale University.

nature and science

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Contents

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A FISH THAT BECAME A FOSSIL

Portheus, a famous fossil fish, with its last meal inside.

■ About 90 million years ago an inland sea covered most of what is now the United States. Living in the sea were some huge fish called *Portheus*. One day a 14-foot-long *Portheus* swallowed its last meal and for some reason unknown to us, died. The fish sank to the bottom of the sea and was covered with ooze, sand, and other sediments. After a long time its bones turned to stone—the fish became a fossil.

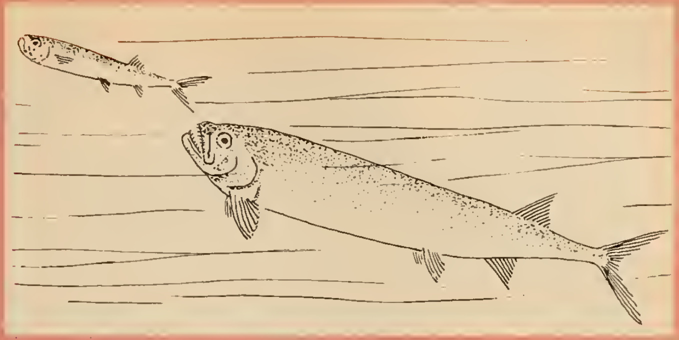
As millions of years went by, the sea dried up and then wind and water wore away the layers of sediments. Finally, in 1952, this remarkable fossil of *Portheus* was found in western Kansas chalk beds by scientists from The American Museum of Natural History. The diagrams on this page show how *Portheus*, with its last meal inside, became a fossil and was eventually uncovered.

Fossils are the remains of living things that have been preserved in rock through the ages. They give scientists important clues to solve the mysteries of past life and to determine what animals of old looked like.

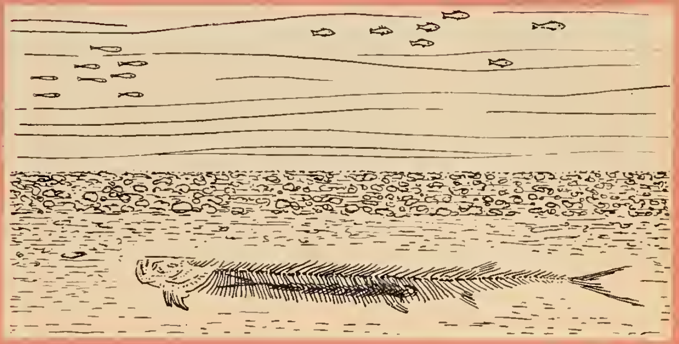
A complete fossil skeleton like that of *Portheus* is a rare discovery. Most fossils we find are only parts of the animal or plant. Usually they are the hard parts, such as shell, bone, or teeth. The flesh and skin are eaten by other animals or they decay.

Fossils are usually found in sedimentary rocks. These rocks, such as sandstone and limestone, are made of clays, mud, sand, and other materials that are laid down in many layers and harden over millions of years. At the bottom are the older layers and near the top are the newest layers. When scientists know the age of the rock layers, they can also tell the age of the fossil.

On the next pages, you will read about dinosaurs. Almost everything we know about these prehistoric creatures we have learned by studying fossils ■



1 Ninety million years ago, Portheus caught a 6-foot-long fish (Gillicus) and then ate it head first.



2 Portheus died and sank to the bottom of the sea. After many years, its bones were covered by clay and sand.

3 Over millions of years, the sea dried up, and then wind, rain, and streams wore away the clay and sand.

4 Eventually, part of the Portheus skeleton was uncovered, and in 1952 scientists found the remarkable fossil.

Some dinosaurs, like Brontosaurus (left) ate only plants, as did the armored Stegosaurus (left center). Like the giant Allosaurus (center), others ate only meat. Some dinosaurs (Podokesaurus, right) were as small as a dog.

WHY DID THE DINOSAURS DIE OUT?

These remarkable animals ruled the earth for millions of years, then they mysteriously disappeared, and no one knows why.

Dinosaur means "terrible lizard." Although they weren't really lizards—but relatives of present-day reptiles such as snakes, turtles, and crocodiles—some dinosaurs were surely terrible.

The mightiest and most terrible of all was *Tyrannosaurus rex* (tye-ran-o-*saw*-rus), whose name means "king of the tyrant lizards." *Tyrannosaurus,* the largest meat-eating animal that ever lived, was 50 feet long and about 20 feet high. It could have poked its great head armed with teeth that looked like sharp six-inch-long knives into a second-story window.

But, in spite of "monster movies," there is no danger that you will look up from your reading some night and find a *Tyrannosaurus* staring hungrily into your window. The last dinosaur disappeared from the earth nearly 70 million years ago—long before the first human beings appeared on the earth.

This article and the article on page 3 were prepared with the advice of Dr. Edwin H. Colbert, Chairman and Curator of the Department of Vertebrate Paleontology, The American Museum of Natural History, and Miss Marlyn Mangus, Scientific Assistant in the department.

The "king of tyrants" was only one of many kinds of dinosaurs. *Brontosaurus* (bront-o-*saw*-rus) or "thunder lizard," measured 70 feet long and weighed 35 tons or more. It must have really jarred the earth as it stamped along. In spite of its size, this giant reptile lived on plants. Probably, because of its great size, *Brontosaurus* spent most of its time in shallow water, half walking and half floating through the swamps.

The smallest known dinosaur was only two and a half feet from its three-inch head to the tip of its tail. And there were many shapes and sizes in between.

Where did these creatures of the past come from? What did they look like? Where and how did they live? And why did they die out? We can answer all of these questions but the last one. After more than 100 years of study scientists still don't know why the dinosaurs died out.

If no human being has ever seen a dinosaur, how do scientists know so much about them?

Dinosaurs Preserved in Rock

The story of the dinosaurs has been preserved in rocks that contain the remains of plants and animals (see page

3). By studying these remains, or *fossils* as they are called, scientists can tell what an animal or plant looked like. Fossils also give us a very good idea of how the world looked at different times in the past, even though no human being was there to observe it.

Scientists have found fossil remains of dinosaurs in the United States, Canada, South America, England, Europe, Africa, Asia, and the Australian region. In the United States, Utah, Wyoming, Colorado, New Mexico, and Montana have been the richest grounds for dinosaur fossils. Perhaps such fossils can be found in your area.

You can see that dinosaur fossils are not rare at all. In fact, you can buy rocks with dinosaur footprints in them. And, not so long ago, three New Jersey school boys discovered some fossils of the oldest known flying reptiles in a quarry near New York City.

Ancestors of the Dinosaurs

Where did the dinosaurs come from? By studying fossils scientists can tell that there was a time—more than 200 million years ago—when there were no dinosaurs (see chart on pages 8 and 9). Then, the ruling land animals were giant amphibians. These creatures were distant ancestors of our present-day frogs, toads, and salamanders, but were much larger.

Amphibians can live in or out of the water, but most of them must lay their eggs in the water just as frogs do today. Gradually, over millions of years, the descendants of some of the amphibians changed so that they could live on land all the time. These "changed" amphibians were the first reptiles, and they were the ancestors of the dinosaurs, the largest land animals in history.

Just how these changes took place, or why, is a mystery of science that no one has solved. But scientists know that certain important changes had to happen before animals could exist on land. One important change was in the eggs laid by the amphibians.

If you have ever seen the eggs of frogs or salamanders, you know that they are laid in the water in jelly-like masses and don't have any shells. You may also know that when frogs' eggs hatch, the young don't look like frogs at all. Instead they look more like fish and are called tadpoles or polliwogs. Tadpoles are suited for living in water but not on land.

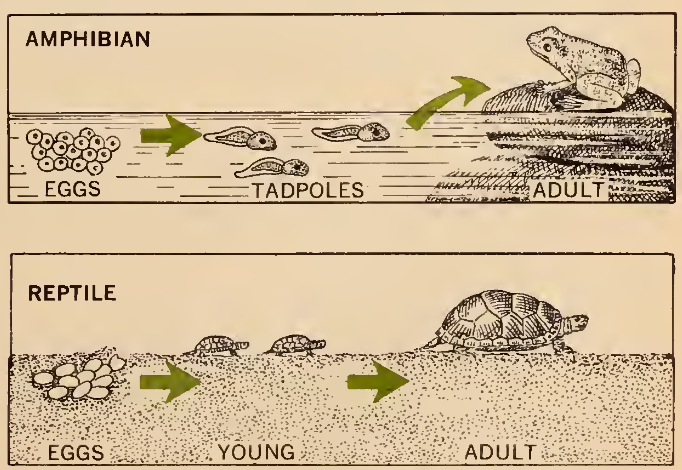
If a frog laid its eggs on land, the eggs would dry up because they have no shells. The eggs would not hatch because the growing tadpole needs water in order to live. Animals could not live on land until they were able to lay eggs with shells. The shells kept the liquid inside of the egg from evaporating. Scientists have found quite a few nests of fossil dinosaur eggs, and the fossils show that the eggs had shells (see diagram and photograph).

When reptile eggs hatch, the young are small models of their parents. Unlike the tadpole stage of frogs which must live in water, young snakes and turtles are "all ready" for land living. So it must have been with baby dinosaurs. The amphibian eggs changed so that they hatched into babies that could live on the land. When this happened, the amphibians had gradually become reptiles, able to produce young on land.

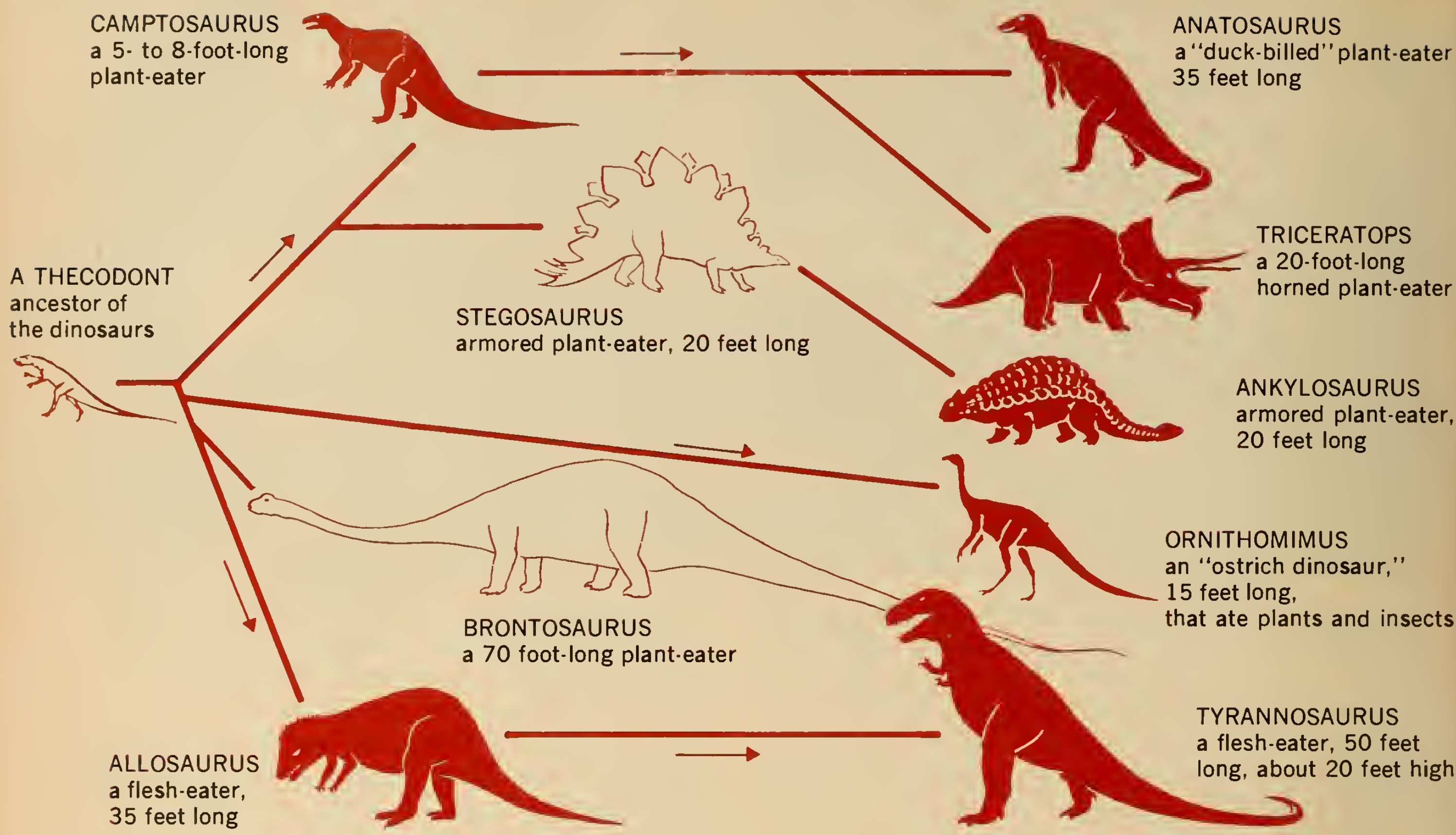
Once they were fitted for life on the land, reptiles added many new branches to their family tree. Turtles, which have come down through the ages almost unchanged, were early reptiles. So were snakes and lizards.

Another early reptile walked on its hind legs and used arm-like forelimbs to grasp and hold its prey. This animal, called *thecodont* (*theek*-o-dont), was about four to six feet long. Thecodonts were the ancestors not only of

Study of fossils has helped scientists make accurate models of dinosaurs. This one shows baby horned dinosaurs hatching. Many dinosaur egg fossils have been found.



Most amphibians lay their eggs in water. The eggs, which do not have shells, would dry up if laid on land. Reptile eggs have shells, so they do not dry up on land.



The dinosaurs, which came in many shapes and sizes, developed from early reptiles. The dinosaurs were the biggest land animals that ever lived. Can you think of an animal living today that is larger than any dinosaur?

modern birds and crocodiles, but of the largest and most powerful land animals the world has ever known—the dinosaurs, which ruled the land for millions of years.

Lives of the "Terrible Lizards"

Some dinosaurs such as the mighty *Brontosaurus* ate only plants. Others were flesh-eating beasts. Some walked almost erect on their hind legs. Others moved on all fours like lizards of today.

Before we take a closer look at the dinosaurs, we should remember that they were the kings of the land animals for more than 100 million years. During that very long time there were many kinds of dinosaurs, but not all of them lived at once.

Scientists call the time of the dinosaurs the Age of Reptiles and divide it into three periods of millions of years each. *Brontosaurus* lived in the second period and had disappeared from the earth long before *Tyrannosaurus rex* became ruler.

Although *Brontosaurus* held the record for being the heaviest during the second period, some others took the prize for odd shapes.

One was called *Stegosaurus* (steg-o-*saw*-rus), which means "covered lizard." It was a strange, armored, humpbacked beast weighing some 10 tons. *Stegosaurus* carried its pin-shaped head close to the ground, and along its backbone was a double row of huge triangular bony plates. What they were used for remains a mystery. It also had four great spikes along the top of its tail. These were probably used as a weapon in combat.

Later, in the third period of the Age of Reptiles, there were dinosaurs that looked like giant armadillos. Some had armor plating of spiked and studded skins, while others had horns like those of the rhinoceros.

In this last period of dinosaur life, the two-legged dinosaurs were equally odd. Some—called *trachodons* (*trak*-o-dons), meaning "rough teeth"—had flattened skulls and duck-like bills. *Tyrannosaurus rex,* the truly terrible lizard, came into his own near the very end of the Age of Reptiles, about 70 million years ago.

It would be difficult to imagine a creature better equipped for both attack and defense. Yet when the Age of Reptiles came to an end, *Tyrannosaurus rex* disappeared, as did the smallest of the dinosaurs. But the turtles survived. So did the crocodiles, the snakes, and the lizards. Why not the dinosaurs? Why did they vanish after so many years of ruling the land?

Attempts to Solve the Mystery

Over the years many scientists have tried to unravel the mystery. Following are four interesting attempts to explain why the dinosaurs died out about 70 million years ago, leaving only fossils as clues to their past.

1. Climate Changes: During the Age of Reptiles the earth went through many changes. Climate and plant life changed very much, but the changes were not sudden. They took place ever so slowly. Some places that had been tropical lowlands with palm trees slowly became cooler hardwood forests. Could this climate change have affected the dinosaurs?

It may be that the plant-eating dinosaurs no longer had the tropical food plants they needed, and began to die out. This in turn meant that the flesh-eating dinosaurs also began to lose part of their food supply, and many of them died.

But if this is so, why is it that the close relatives of dinosaurs, the crocodiles and other reptiles, did not die out also? Lower temperatures and changes in plant life over millions of years cannot be the only reason why the dinosaurs died out. There must be other reasons as well.

2. The Coming of Mammals: The Age of Mammals followed the Age of Reptiles (see pages 8 and 9). But, once again, the change was slow. Some of the mammals appeared on the scene millions of years before the last of the dinosaurs died out.

The early mammals may have been better hunters than the dinosaurs and competed with them for food. Some of the mammals probably robbed the dinosaur nests of eggs, and so helped the dinosaurs along the road to death. But it is not likely that egg-robbing alone led to the end of dinosaur life.

3. As a Group, Did the Dinosaurs Die of "Old Age"? We know that each individual animal, such as a cat or a dog, has a certain number of years to live. Some scientists suggest that an entire *group* of animals—such as all elephants—also has only a certain length of time to live. The scientists who think this is so say that all elephants and all horses on earth will die out because of "group old age" some time in the distant future. They think this is what may have happened to the dinosaurs.

4. Did the Dinosaurs' Eggs Fail? Over the years many fossils of unhatched dinosaur eggs have been uncovered in southern France. The eggs were laid by dinosaurs living near the end of the Age of Reptiles. Some scientists believe that the unhatched eggs tell a story of their own.

For some reason their eggs would no longer hatch, so the animals died out. But other scientists think that too few unhatched eggs have been found to make this a very good explanation. They have found only a few hundred compared with the vast numbers of eggs that must have been laid during the millions of years these last dinosaurs inhabited the earth.

Drawing by W. Miller

"I know what I am, but I can't pronounce it."

What Is the Answer?

Many other attempts have been made to solve the mystery of the dinosaurs' disappearance, but no single one by itself seems to answer the question once and for all. If the answer is ever found, it may be a combination of two, three, or more of the theories.

For whatever reasons the dinosaurs disappeared from the face of the earth, one thing about them is certain. They were a splendid success. The dinosaurs ruled the earth for more than 100 million years. This is hundreds of times longer than man has been master of the earth ■

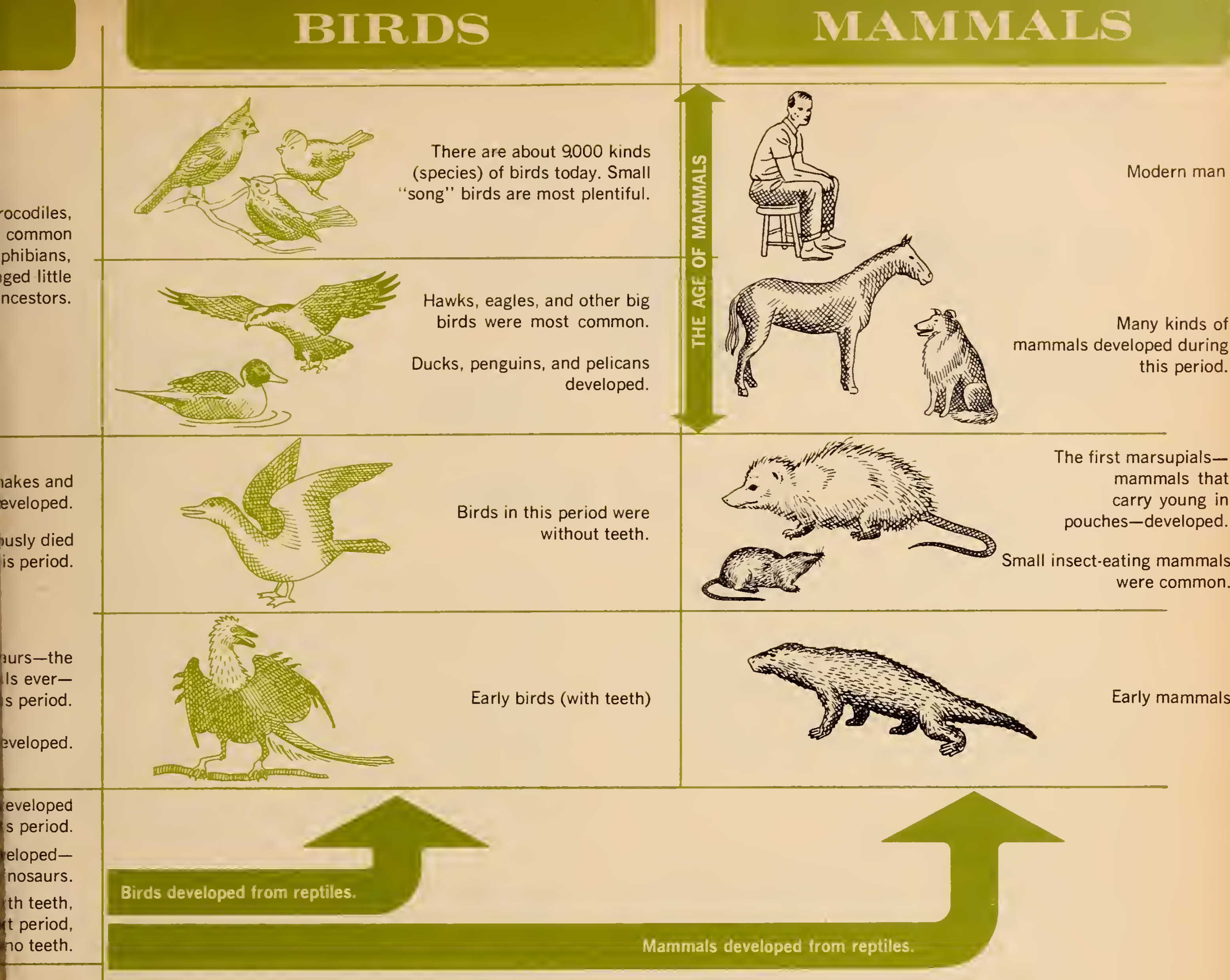
PROJECT

The next time someone in your house cooks a chicken or turkey, save all of the bones. When you have collected them all, boil them to get off as many of the bits of meat as you can. When the bones have cooled and dried, you can pick off the remaining bits with tweezers. When all the bones are clean, see if you can put the animal back together again. If you use copper wire as a frame, and glue the bones together, you can mount the skeleton.

Groups of Animals ▶

When the Animals Lived ▼

When the Animals Lived	Period	AMPHIBIANS	REPTILES
From present to 3 million years ago	QUATERNARY	Frogs, toads, and salamanders are the most common amphibians today. They are very much like their early ancestors that developed millions of years ago.	Lizards, sna and turtles a reptiles today. L they hav from
3 million to 63 million years ago	TERTIARY	Salamanders developed.	
63 million to 135 million years ago	CRETACEOUS	As far as we know, frogs and toads were the only amphibians during this period.	croco Dinosaurs m out at the en
135 million to 181 million years ago	JURASSIC	Early frogs and toads developed.	The bigges largest land lived du Early liz
181 million to 230 million years ago	TRIASSIC	The last of the big amphibians died out.	The first dino la Thecodo ancestors o Early tu developed. In turtl
230 million to 280 million years ago	PERMIAN	Some amphibians were as big as early reptiles. The two groups of animals competed for food.	There were this period. (less tha
280 million to 345 million years ago	CARBONIFEROUS	Amphibians were the only land animals with backbones for a time during this period. Then another group began to develop—the reptiles.	
345 million to 405 million years ago	DEVONIAN	Early amphibians	
405 million to 425 million years ago	SILURIAN	Amphibians developed from fishes.	Reptiles developed from amphibians.



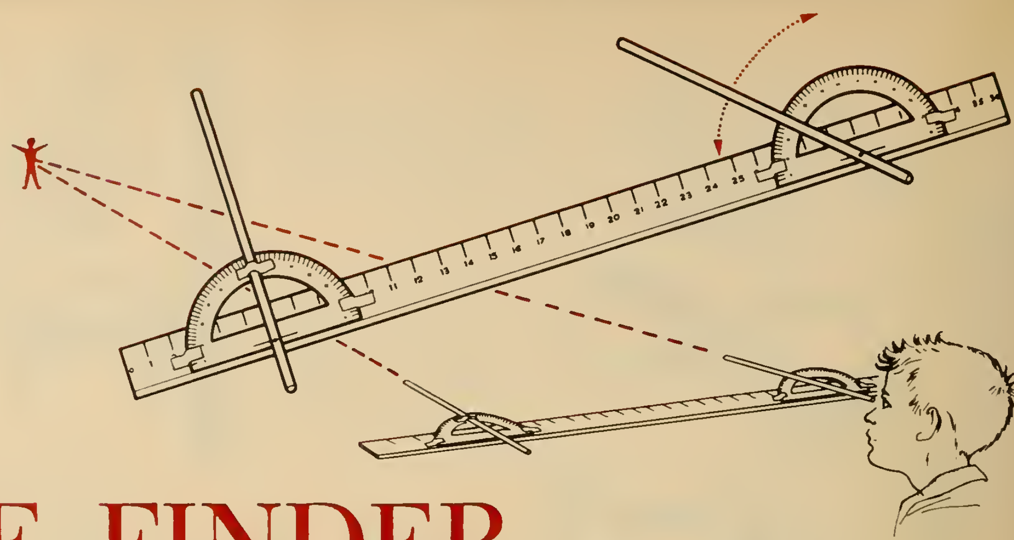
LAND ANIMALS THROUGH THE AGES

If you read upward through each column of animals in this chart, you will see when and how the major land animal groups developed, and how they have changed through time.

A time scale for life on earth has been worked out by scientists who study rocks and fossils. (See the dates in the left column.) Some of the names given to time periods in the scale are named for places. The Jurassic Period, for example, is named for the Jura Mountains of Europe, because rocks of that age form these mountains. Other periods are named for a special type of rock—Cretaceous means "chalk-bearing." Tertiary means "third." It is part of an early time scale in which periods were numbered.

Scientists are not sure of the *exact* number of years in each period of the time scale. But, as they keep gaining new information about the rocks and fossils, they are able to make the scale more accurate.

BUILD YOUR OWN RANGE FINDER



■ In the first article of this series, you were stranded on an island in the middle of the ocean. One of the things you wanted to do was measure the distance to nearby islands.

In this article you will learn how to build a range finder. With one like it, you would be able to find the distance to the islands. At home, you will be able to use your range finder to measure distances to objects in your yard as you sight them from a window or the porch.

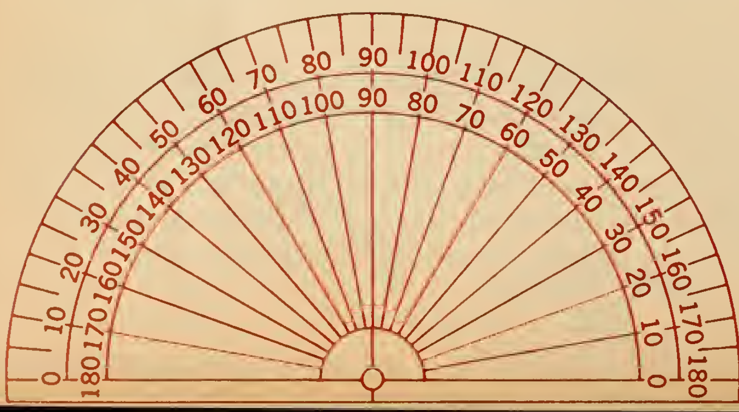
How To Build a Range Finder

To build a range finder, you will need two protractors, two large soda straws, two long thumbtacks, some plastic tape, and a yardstick or other piece of wood that is at least two feet long.

If you do not have a protractor, you can make one by cutting out the one shown here and gluing it on a piece of cardboard cut to the same shape. You can make your second protractor by tracing the markings from the first one on a piece of paper and then gluing the paper on cardboard.

Once you have two protractors, stick a thumbtack up through the small circle near the bottom of each protractor.

This is the fifth in a series of articles adapted by permission of the Elementary-School Science Project from the revised edition of its booklet, Astronomy: Charting the Universe, *© 1962 by the Board of Trustees of the University of Illinois.*



Then tape one protractor on the yardstick so that the protractor's center (90°) line is at the 6-inch mark of the yardstick (*see diagram*). Tape the second protractor at the 30-inch mark of the yardstick. Now the centers of the two protractors are exactly two feet apart and each one has a tack sticking up to hold a straw.

On one end, stick a straw on the tack so that the straw is lined up along the 90° line of the protractor. Fix it in this position with tape. Push the other straw on the other tack, but do not tape it. This is the movable straw.

Finding Distances with Your Range Finder

When your range finder is complete, try it out on some object, like a lamp, that is across the room. Set the range finder on a table, then sight through the fixed straw and move the yardstick until you can see the lamp. Without moving the yardstick, next look through the movable straw and turn it until you can see the lamp. Finally, read the angle where the movable straw lies on the protractor.

You can find the distance from the lamp to you by using the table shown here. For example, if the movable straw lies on the 80° line of the protractor, find the 80° angle in the table and the distance listed under that—11.3 feet—is your distance from the lamp.

Angle (deg.)	45	50	55	60	65	70	75	80	85	90
Distance (ft.)	2	2.4	2.9	3.5	4.3	5.5	7.5	11.3	23	—

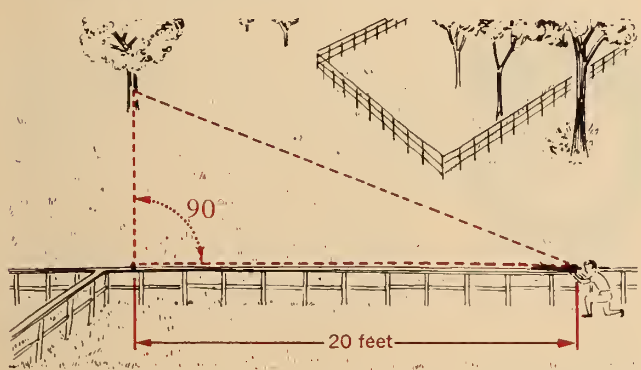
The width of the straw may cover a range of two or three degrees on the protractor, so you may not be able to tell if an angle is 80°, 81°, or 82°. That is why, if you measure the distance between an object and your range finder, you may find that the measurement differs a little from the one given in the table. However, your range finder should be accurate within a few inches of the actual distance.

The table shows that your range finder can be used to measure distances up to only 23 feet. This would not be much help on your tropical island but, luckily, there is a way you can use your range finder to measure the distance to those islands and other far away objects.

How a Surveyor Measures Distances

When a surveyor wants to find the distance to some object, he uses a device that is similar to your range finder, except that it has a more accurate protractor and a telescope instead of two straws. The surveyor takes a sighting through the telescope and then moves the telescope to take a new sighting of the object. The distance between his two sightings is called the *base line.*

On your range finder, the base line is the distance between the two straws. Your base line of two feet permits you to measure distances up to 23 feet. To measure far-away objects, you need a longer base line.



Extending Your Base Line

One way to extend your base line would be to use a piece of wood longer than a yardstick, but that would be awkward. Instead, you might try to extend your base line as a surveyor does. You can do this with your range finder, but you will also need a measuring tape and two stones or sticks to use as markers.

With this equipment, go into your yard or a field and pick out some distant object, such as a tree. Sight it through the fixed straw of your range finder. Mark the spot directly below the protractor with a stone, or by pushing a stick into the ground. Then tape off a base line of 20 feet from that mark, at an angle of 90° from the fixed straw of your range finder. You can set your range finder on the ground to serve as a guide so that your base line goes in the right direction.

Mark the other end of the 20-foot base line and hold your range finder so that the *movable* straw is directly over the marker. Then turn the straw until you sight the tree through it. When you read the angle that the straw makes on the protractor, you can find the distance of the tree by checking the table below.

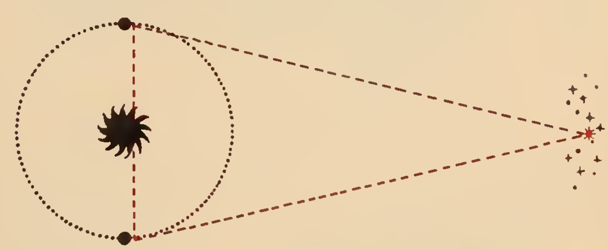
Angle (deg.)	45	50	55	60	65	70	75	80	85	90
Distance (ft.)	20	24	29	35	43	55	75	113	230	—

Remember that with a two-foot base line you could measure distances up to 23 feet. Now with a base line of 20 feet you can find the distance of objects that are 230 feet away.

Astronomers can work out the distance to the Moon by using a range finder in a similar way. But they need a very long base line because the Moon is so far away. If an astronomer in Miami, Florida, and an astronomer in Cleveland, Ohio (which are on the same line north and south) were to observe the Moon at the same moment and compare their angle measurements they could find the distance to the Moon. In this case their base line would be several hundred miles long.

As long as this base line may seem, it is not long enough to measure distance to the stars. An even longer base line is needed for this because the stars are millions upon millions of miles away. The Moon is only 240,000 miles away.

Astronomers have a ready base line 186 million miles long — twice the distance to the Sun. Here is how they use it. They first measure the angle of a star in June, say. Six months later the Earth has traveled halfway around in its orbit and is on the opposite side of the Sun—186 million miles away from its June position.



You might think that a base line this long is long enough to measure the distance of all stars, but it isn't. Only the nearer stars can be measured this way.

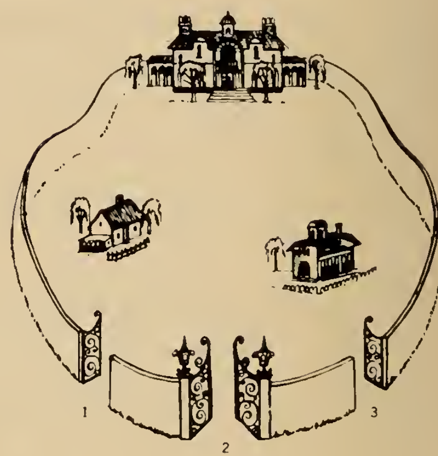
Astronomers of old had a double problem. They wanted to know the size, as well as the distance, of the Moon, Sun, and stars ■

In the next issue of *Nature and Science* we will show you how to build an instrument for measuring the size of distant objects.

brain-boosters

■ Paths of Friendship

The great American puzzle wizard Sam Loyd invented this puzzle when he was nine years old: Three neighbors who



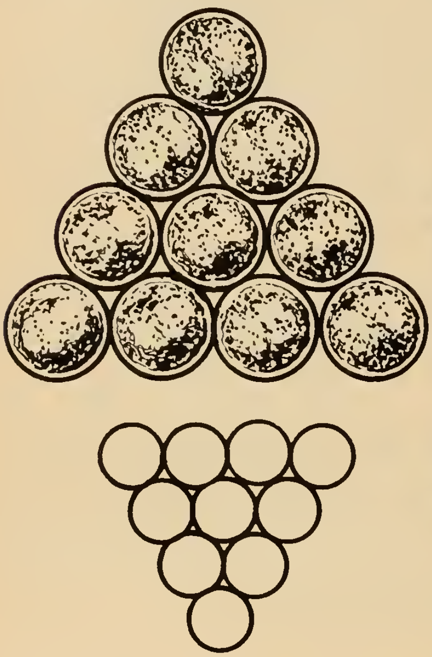
were forever fighting with one another lived in a small park enclosed by a wall. The neighbors decided that the only way to keep peace would be to build private pathways leading out of the park.

The family living in the large house made a private path leading to gate number 2. The family living in the house on the left made a private path leading to gate number 3. And the family living in the house at the right built a private path leading to gate 1.

The paths did not cross each other. How were they made?

■ Move Three Coins

By moving just 3 coins, rearrange these 10 coins in reverse order to look like the bottom figure.



■ The Four Hobbies

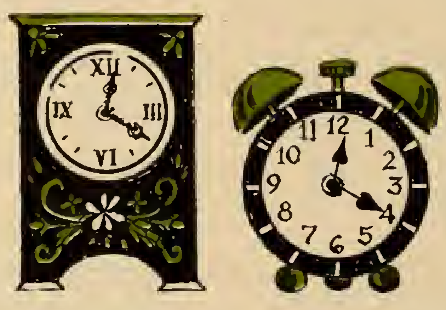
Each of four pupils—John, Jim, Joan, and Jane—has a hobby of either stamp collecting, photography, dress-making, or insect collecting.

The insect collector's brother collects stamps.

John doesn't like to collect things.

Joan hates bugs.

Can you figure out which of these four pupils pursue each of the four hobbies?

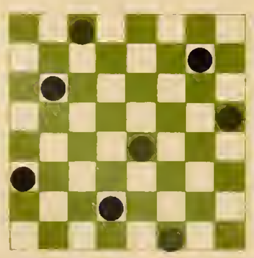


■ The Two Clocks

Mr. Brown has two clocks, but one clock loses four minutes a day and the other does not run at all. Which of his clocks is correct most often, and why?

Solutions to Brain-Boosters appearing in the last issue of *Nature and Science*:

The Checkerboard: Here is the way to put 8 checkers on a board so that no checker is in a straight line or on a diagonal with another.



Seventeen: You can subtract 17 from 170 only once. Later subtractions would not be from 170, but from some smaller number.

Weighing Dinosaur Eggs: To find the one light dinosaur egg, the scientist first divided the nine eggs into groups of three. Then he placed two of the three groups on opposite ends of the scale. If the groups did not balance, he could tell which one included the light egg, and if they did balance, the light egg had to be in the group of three that was not weighed.

Knowing which group of eggs included the light one, the scientist then placed two of the three eggs on opposite ends of the scale. If the scale balanced, the egg not weighed was the light one; if the scale did not balance, the light egg was on the end of the scale that rose upward.

Cats and Rats: Since the three cats can catch 3 rats in 3 minutes, or a rat a minute, the same three cats can catch 500 rats in 500 minutes.

Help the Mouse: The mouse traveled through the tunnels this way.

■ You are yawning and cannot pay attention to what is going on around you. Your eyelids are drooping, and you can no longer see things around you clearly. Now you seem to be floating; you find it very hard to move your muscles. No, you are not being hypnotized.

Your heartbeat is slowing down, and your breathing is shallow. Your blood pressure and body temperature are dropping. Sounds are becoming duller . . . fading away. Dancing colors pass before your closed eyes. Then . . . nothing. No, you are not dying, either. You are doing something very normal, something you do every day. You are falling asleep.

Sleep Study Is Still in the Crib Stage

Have you ever wondered what your body and mind are doing during those eight to 10 hours a day you spend sleeping?

Until about 25 years ago, we had to be content with folklore and superstitions about sleep and dreams. People read poetry in praise of sleep and dreams, but very few facts. One big problem in studying sleep is getting reliable information. In their investigations, scientists want facts. What people think happens to them during sleep is not always trustworthy.

Only recently has sleep been studied scientifically, due largely to the help of the *electroencephalograph,* called EEG for short. This instrument measures and records the strength of electric currents, or brain waves, generated by our billions of brain cells. Tiny wires from the machine are pasted to a person's scalp, where they pick up the currents and carry faint signals to the machine. There the signals cause wavy marks to be made on graph paper. This graph shows how active the brain is during sleep. This machine has also been used to record tiny movements of eye muscles in sleep.

Science Kicks Off the Covers

Nearly 3,000 years ago, the Greek poet Homer called sleep "the twin of death." The fact is that certain changes take place in the healthy body during sleep that also occur in dying persons.

Your pulse rate, your breathing, your digestion, and your *metabolism* (the rate at which food is turned into tissue and energy) all slow down when you sleep. You breathe only half as much air, for example. Your temperature and blood pressure also drop. More blood flows to your skin, and perspiration is greater. Daytime reflexes,

(continued on next page)

This article is adapted in part from The Science of Dreams, copyright © 1962 by Edwin Diamond, published by Doubleday & Company, Inc.

EXPLORING DREAMLAND

by Patricia Ralph

Scientists have begun to look into the world of sleep and dreams. What they are finding upsets many an old wives' tale.

Exploring Dreamland (continued)

such as the knee jerk, don't work. (However, scientists have noticed a special sleep reflex—the big toe wiggles if the sole of the foot is stroked.)

Can you form some sensible sleep rules about ventilation and bedclothes from this information? Can you see some ways to test whether a person is really asleep or just pretending?

When you slip off to sleep, you lose consciousness. But you do not become wholly unconscious as you would from a blow on the head or from breathing ether. In complete unconsciousness, a person cannot be wakened. Sleep is a halfway condition in which the body can still respond to certain things.

Watchdogs of the Night

When you are awake, your senses are usually sharp and can help protect you from harm. In sleep, some of your senses are still on guard, though much dulled. The sense of touch and your reaction to heat are the most active, warning that you are getting too near the edge of the bed or are becoming uncovered. Next comes the sense of hearing, and then reaction to light.

Sounds that mean something to the sleeping person are sometimes more likely to get through than strange sounds. A mother wakens to her baby's cry, for example, but not to a noise in the garage. Her husband might sleep right through the baby's crying, then be awakened by a quieter sound such as a burglar might make.

Smells will not wake a person up unless, like ammonia, they are irritating. Scientists know little about the sense of taste during sleep. Can you guess why?

With this information you should be able to form several more rules for sound sleep. Which would you expect to be more disturbing: tangled sheets on a hot summer night, or voices coming from a brightly lighted room next to yours? What might wake you up if your house caught fire?

Another sense, the *kinesthetic,* or muscle sense, keeps you comfortable when you are asleep by letting the brain know what is happening to your body. If your arm gets caught under you, for example, "pain" signals are sent to the brain. Return signals cause you to move your arm.

PROJECT

Have you ever tried to see if you wake up in the same position in which you went to sleep? Try it tonight. How would you know you hadn't turned over completely in the night, maybe many times?

Scientists say that most of us twist or turn our bodies 20 to 40 times a night. Such movements are caused by sounds that disturb our sleep without waking up, or by staying in one position too long. The most restful position is said to be on your side with your knees and elbows bent in front of you.

While we are dreaming, we seldom move our bodies, perhaps because we are concentrating on the dream as if we were awake and watching a movie. But we do move our muscles slightly while dreaming, as if we were acting out a role in the dream. Scientists discovered this by attaching wires to the arms and legs of sleepers. An instrument like the EEG machine recorded changes in the strength of the faint electrical signals that tighten or loosen our muscles.

Some Surprising Discoveries about Dreams

Some of the most interesting recent discoveries concern patterns of sleeping and dreaming. At first, scientists tested the depth of a person's sleep by the amount of noise needed to wake him up. Later they used the EEG

machine. They found that brain waves slow down when you are in deep sleep and speed up when you are sleeping more lightly or awake.

Tests all night long on many people show that sleep changes from deep to light many times a night. The first two hours of sleep are the deepest, no matter what time you go to bed. From then until you awake, your periods of deep sleep grow less and less deep.

By using the EEG, scientists discovered that in the periods of light sleep a person's eyes make a series of faint, rapid movements from time to time. When sleepers were awakened at these times, they were able to recall dreams. If they were awakened after the eye movements stopped, most people could not remember dreaming. This investigation led to the discovery that everybody, from childhood on, dreams—whether or not he remembers in the morning.

A person dreams four or five times a night, or about once every 90 minutes. Contrary to what many people think, dreams do not happen in a flash. A dream takes about as much time to unfold as the same event would in real life. Each dream of the night gets longer, lasting from 10 to 30 minutes.

Some Mysteries about Dreaming

Do we need to dream? In experiments over five nights, scientists awakened each of five sleeping men whenever his eye movements indicated that he was beginning to dream. These men soon showed signs of being tired and irritable. After several nights of undisturbed sleep, they felt rested and in good shape. Then, in a five-night control experiment, each of the sleepers was awakened the same number of times nightly as in the first experiment—but only when he was *not* dreaming. Even though their sleep had been broken just as often as before, the men showed no signs of fatigue. The scientists believe these experiments show that we do need to dream, though they do not yet know why.

What do you suppose makes some people remember their dreams and others not? Which dream of the night are you most likely to remember? Scientists are trying to answer these questions. They still have much more to learn about sleep. No one knows for sure yet what makes us fall asleep or how much sleep we really need.

Maybe someday soon scientists will unlock the door... to the rest of... this amazing... world.... ho hum..... someday.... ZZZ z z z z z

LITTLE BIRDS-BIG NEST

■ Bird nests come in many shapes and sizes. The huge nest shown here is one of the most unusual in the world. It is a giant "apartment house," that may have as many as one hundred pairs of birds nesting in it.

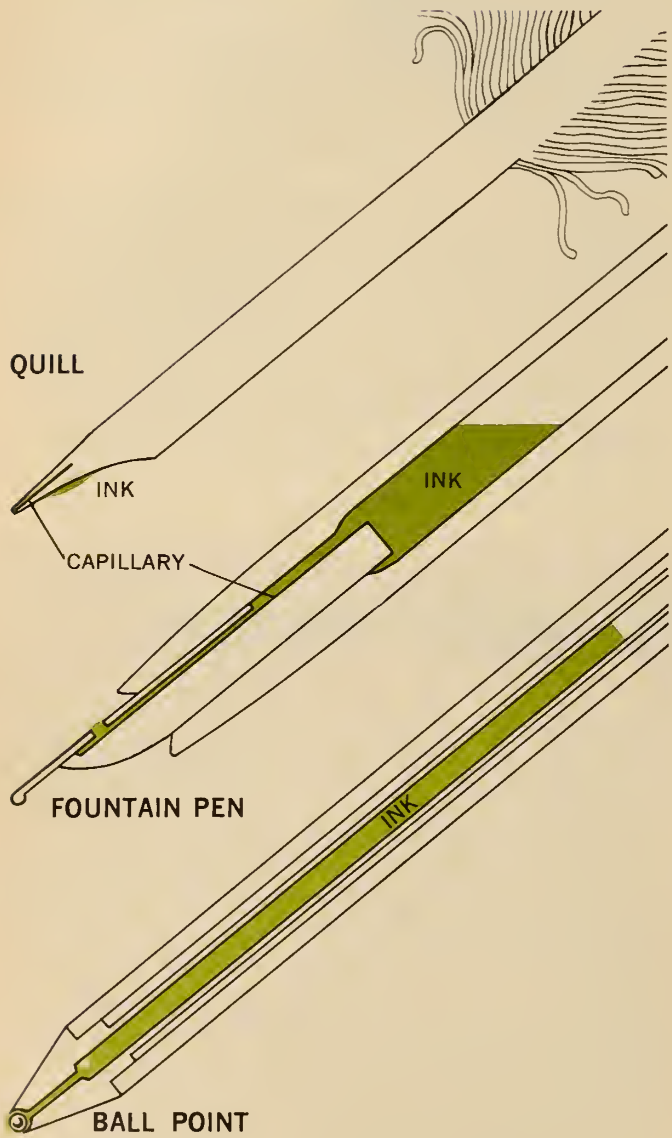
These nests are usually found in large, thorny trees that grow on the dry plains of South Africa. Birds called "social weavers" build them, and any number from twenty to two hundred birds may work on a nest. First they weave thousands of grass stems together and form a high roof, which makes up the bulk of the nest. Then each pair of birds makes a separate nest under the roof of grass. Each female lays two to four eggs in her "apartment."

The social weavers of Africa are close relatives of a common bird in the United States—the one we call a house sparrow, or English sparrow. Actually these birds, which we have misnamed, are weavers. They look, act, and sound almost the same as the weavers of Africa. One big difference between the two birds is that the small domed nests the American weavers build are simple compared with the giant nests of their African relatives ■

Weaver birds weave thousands of grass stems together to make a nest for as many as 100 pairs of birds.

HOW IT WORKS

Fountain Pens



■ For hundreds of years, men used either a piece of stiff grass, called a reed, or a long feather, called a quill, to write with ink.

The tip of the reed or quill was sharpened to a fine point to produce thin lines, or to a broader point to produce thicker lines. In both cases, the point was split up the center a short distance from the tip. Metal pen points that fit into a wooden handle came into use only about a hundred years ago. They are shaped like the reed and quill pen points.

When you dip any of these pens into ink, a little ink clings to the hollowed-out undersurface of the point. Then, as you write, ink flows from the storage space, or *reservoir*, through the narrow slit, to the tip and onto the paper.

The ink does not flow to the tip under its own weight. If it did, most of the ink would flow from the tip as soon as you lifted the pen from the bottle. The ink is fed from the reservoir to the tip of the pen by *capillary action.*

You can see an example of capillary action by looking at a glass of water. You will see that the water that touches the glass sides climbs a little way up the glass.

You can see another example of capillary action by dipping the end of a piece of cloth or blotting paper into water. The water climbs up the tiny fibers of cloth or paper. A candle wick and the wicks of old-fashioned oil lamps also work by capillary action.

The old-fashioned straight pens that we have described don't hold much ink, so they have to be dipped frequently. Fountain pens, however, have a larger reservoir for storing ink. The reservoir may be a rubber bulb, or it may be simply a "tank" inside the pen handle.

To fill the pen, depending on what type you have, you pull a little lever, or turn or pull out the top end of the pen. This pushes the air and any remaining ink out of the reservoir.

When you move the lever or top back to its original position, the reservoir is left almost empty—but not for long. The weight of the atmosphere pressing down on the surface of the ink in the bottle pushes ink into the pen and fills the reservoir within a few seconds *(see also* N&S *Oct. 18, 1963, page 16)*. Some fountain pens have removable ink tanks, or cartridges, that can be replaced.

Ball point pens work in a different way. The ink is contained in a thin metal or plastic tube that is sealed at the top and holds a tiny round ball at the point. The ink has to be just the right thickness so that it will flow down onto the ball, but will not run out. Because the surface of the ball is not perfectly smooth, the ball picks up ink inside the tube and transfers it to the paper as you make the ball roll along when you write ■

nature and science VOL. 1 NO. 5 / NOVEMBER 15, 1963 TEACHER'S EDITION

Elements in a Strategy for Teaching Science in the Elementary School

1. The Scientist's Way

by Paul F. Brandwein

■ We know this: Children learn; they learn in different ways; they learn at astonishingly different rates. On this base, generally stated, we can develop a strategy for teaching children, and for teaching them science—even though we do not know how learning really occurs.

The elements of the strategy we would propose affect *what* is to be taught, *how* it is to be taught, and *when*. History has told us, in most ample terms, *why*. And even to the most casual observer, science has become part and parcel of the early life of the child.

Scientists are learners, too

As we study the life styles of the child, of the scientist, and of the teacher of science, we detect a certain unity in what at first may seem to be a disparity. This unity within diversity becomes ever clearer as we press a realignment of the concepts of science to develop the outlines of a curriculum.

We illuminate in this way another facet of our purpose: We find that a curriculum which reflects the fabric of science reflects also a considerable segment of the child's world as well as that of the scientist. These worlds do not clash; indeed, they become congruent.

If we regard the scientist as a perpetual learner, as indeed he is, then we see a teacher of science to be similarly engaged; and in turn expect of the child no more than is to be found in a child free to seek, free to be curious, free to enquire; that is, we expect persistent learning—with the zest of creativity.

But while we emphasize psychological safety and psychological freedom in mode of enquiry, and while we recognize the tentative nature of scientific knowledge, let us not allow ourselves the luxury of disparaging acquisition of knowledge, indeed, of facts, and perhaps of "mere facts." Who was it that said: "What is so mere about a fact?"

We need rather to be concerned about the teacher's and learner's attitudes toward facts and the hazardous and tentative nature of the observations which underlie them. I, for one, would not be alarmed if children were to seek information (or, crassly, facts), if the teacher were to create a learning environment in which facts were not sought as ends in themselves, but were acquired in a search for meaning, perhaps for wisdom, and indeed for growth.

A central objective for science teaching

Consider first certain elements of the scientist's way as they have significance for our dialogue. At least *one* significant result of the scientist's work is the construction of a world which yields meaning and exacts relevance.

Relevance to what? We would say relevance to conceptual schemes, or concepts, or constructs which give us some comprehension of our world. These conceptual schemes relate what we call the body of scientific knowledge. Conceptual schemes remain recognizable at least within the span of formal education of the young and adolescent child; hence they can serve as moorings for a somewhat stable science curriculum.

Without an ordering in conceptual schemes the science curriculum becomes a potpourri; revisions are at the mercy of an ever-changing technology even as the conceptual schemes remain fairly stable.

For our purposes, it is sufficient to consider a concept as the simplest pattern which helps us to order events around us.

The possession of concepts helps us to combine, associate, or synthesize—in a word, to classify. Thus, the goose, the

(Continued on page 4T)

This is the first of three articles adapted from The Teaching of Science, *by Joseph J. Schwab and Paul F. Brandwein, published by Harvard University Press, Cambridge, Mass.* *Dr. Brandwein is Chairman of the National Board of Editors of* Nature and Science. *Parts II and III will be published in future issues.*

Arline Strong

Like the scientist, the child is a perpetual learner. One of the tasks of the science teacher is to help the child to be free to seek, free to be curious, free to enquire, and to instill in him a zest for creativity.

You may recognize the cover and first three articles in this issue. They first appeared in one of the advance pilot issues we sent to teachers last spring, and we are publishing them again, with a few changes, because of the great interest they originally aroused.

The first of these articles shows how scientists learn about creatures that no longer live on the Earth by studying their fossil remains. The second reveals what scientists know—and don't know—about some of the most notorious of these extinct creatures, the dinosaurs. And the third, a chart that pictures the development of land animals through the ages, helps the reader locate dinosaurs in time and in the evolution of animal life.

These articles illustrate the following basic concept: *Living things have changed over the years.* In developing this concept with your pupils, two subconcepts are also important:

1. Survival involves a struggle against other living things, disease, and lack of food.
2. Survival depends on the ability of the organism to adapt to environmental changes.

Page 3: A Fish That Became a Fossil

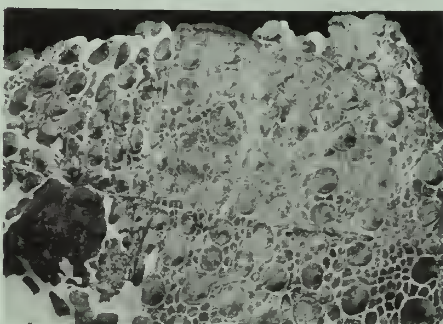
Our knowledge of past life on Earth is built on the study of fossils. This article serves as an introduction to the main feature on dinosaurs and, though short, contains important concepts.

What is a fossil? Fossils are defined as any signs of the former presence of living things. They take a variety of forms, from actual remains, dried, frozen, or chemically altered, to imprints and tracks in stone. Thus, petrified wood and bones, imprints and molds of shells and leaves, frozen mammoths, and coal are all fossils.

A fossil is something to be seen and touched, not merely talked about. Fortunately they are fairly easy to come by. Perhaps one of your pupils will have a specimen or small collection to bring in. Don't worry if you don't know the exact name of the fossil. It is enough for the class to speculate on the nature of the organism, the conditions under which it might have lived, and how it might have been buried.

Where to see fossil collections. Many museums, universities, and science departments of high schools maintain fossil collections. Check into those resources nearest you. A staff member may give an informative talk to your class if you give him advance notice. Or you might try to arrange for such a person to visit your classroom. Discreet snooping is sure to uncover at least one fossil lover in your community who would be glad to cooperate.

The state geologist should also be able to tell you of possible collection sites in your area and the types of rocks to look for in seeking fossils. Likely places are rock outcroppings, road cuts, quarries, and stream beds. Breaking coal apart to uncover possible imprints of ferns or leaves inside might make a delightful—though dirty — after-school activity for some children.



The American Museum of Natural History

This fossil fragment shows in detail the bony plates on the back of a 12-foot-long armored dinosaur found in North America.

Activities. 1. Let children make simple "fossils" by pressing leaves or shells into a slab of clay and then removing them. More elaborate and permanent ones can be made by pouring plaster of Paris on a vaseline-coated object and removing the object when the plaster has hardened. To make a cast-type "fossil," fill an imprint in clay with plaster, then pull away the clay.

2. Why not start a classroom fossil collection? Encourage your pupils to set up a simple system of labeling and organization. (For some children, seeing how many ways they could organize a football and baseball card collection might have some value.)

3. Have a few children find out what the fossils found in your state indicate about changes of climate and geography in your area. (This is rather advanced work.)

An excellent reference (on the adult level) is *The Fossil Book,* by Carroll L. and Mildred A. Fenton, Doubleday & Company, Inc., Garden City, N. Y., 1958, $12.50.

Page 4: Why Did the Dinosaurs Die Out?

Here is a real mind stretcher. The information and vocabulary in this article are quite challenging. Children will enjoy and profit from reading it out loud — especially the poorer readers.

Incidentally, the confused creature in the cartoon on page 7 has the body, wings, and tail of a *Pteranodon* and the head of its evolutionary successor, a *Rhamphorhynchus* (*ram*-pho-*ring*-kus). Both were flying reptiles, but they were not the ancestors of birds.

The concepts of change and survival through adaptation are implicit throughout the article. To check comprehension, you might ask pupils such questions as: Did the cave men have to fight off dinosaurs? (The fact is that the last dinosaur disappeared long before the first human beings appeared on the Earth.) Could a fight between a *Tyrannosaurus rex* and a *Brontosaurus* have taken place? *(Brontosaurus* disappeared from the Earth long before *Tyrannosaurus rex* became ruler.)

The possibility that dinosaurs might have stalked the land your town now occupies is an exciting one for many children who think "long ago" also means "far away."

To help the children conquer the fear of big words, you might have them repeat some in jingles, such as:

If a *Camptosaurus* saw an *Allosaurus,*
Would he stop to talk?
If an *Ankylosaurus* saw a *Tyrannosaurus,*
Would he run or walk?

Your pupils' grasp of the tremendous size of some of the dinosaurs will be aided by measuring the length and height of the room, the hall, the school building, and then estimating whether a *Brontosaurus* or *Tyrannosaurus* could fit inside, go through doors, or see over the roof, for example.

For further reading, *The Wonderful World of Prehistoric Animals,* by William Elgin Swinton, Garden City Books, Garden City, N.Y., 1961, $2.95, is especially good for children. Children and adults can both learn much from two books by Edwin H. Colbert: *The Dinosaur Book,* published for The American Museum of Natural History by McGraw-Hill Book Company, Inc., New York, N.Y., 1951, $5.95, and *Dinosaurs, Their Discovery and Their World,* E. P. Dutton & Co., Inc., New York, N.Y., 1961, $7.95.

Page 8: Land Animals Through the Ages

The main concept—living things have changed through the years—is illustrated again, this time with stress on the slow-

The suggestions for using this issue of Nature and Science *in your classroom were prepared by Patricia Ralph, elementary school teacher in the public schools of Huntington, N.Y., and member of our National Board of Editors.*

ness of that change and the differentiation that develops.

The chart gives some idea of (1) the enormity of time, (2) the categories of land animal life, and (3) how one group developed from another.

Recent studies indicate the Earth to be about 5 billion years old. Life in some form is believed to have existed for about half that time, or 2.5 billion years. You will notice that this chart goes back only 425 million years. Hang the chart on your bulletin board so that children can make a time scale on paper tacked below it. Man is a late-comer on the scene. If Earth-time were thought of as one year, man would arrive late on the night of December 31!

Categories of Animal Life. This is a good time to review the characteristics of the different forms of land-animal life. Here is a list from which to frame a variety of questions:

AMPHIBIANS:—Cold-blooded, lay eggs in wet places, have moist skin without scales, take oxygen from water through gills when young, most have lungs to breathe air when full grown.

REPTILES:—Cold-blooded, lay eggs on land (some lizards and snakes produce live young), have dry, scaly skin, breathe air with lungs.

BIRDS:—Warm-blooded (2 to 14 degrees higher than man), lay eggs, have feathers, breathe air with lungs.

MAMMALS: — Warm-blooded, bear young alive (exceptions are the duck-billed platypus and the echidna, which lay eggs), feed young with milk from their breasts, have hair, breathe air with lungs.

Make sure pupils understand that "warm-blooded" means having a *constant* body temperature and "cold-blooded" means having a temperature that *varies* with that of the surroundings.

Development of the Groups. Children will want to know how amphibians developed from fish, reptiles from amphibians, and so on. What changes in the body of an amphibian would be necessary for it to live on land? (Lungs to breathe air, legs or some locomotive apparatus.) This should lead to some lively speculation on the relationship of lungs to gills and of legs to fins.

The most surprising development to your pupils is apt to be that of birds. You might suggest that someone look for information about *Archaeopteryx*, the first-known bird. Children who still express disbelief that birds developed from reptiles can be led to consider the modern bird's leg covering — reptilian scales. Have them compare the skin of a bird's foot with snake skin.

For further reference, a book for children as well as adults is *The First Mammals*, by William Scheele, World Publishing Co., New York, N.Y., 1955, $4.95. A classic work on evolution is Charles Darwin's *The Voyage of the Beagle*, the Natural History Library, Anchor N16, Doubleday & Company, Inc., New York, N.Y., 1962, $1.45.

"Were you working here when we had the earthquake?"

Page 10: Measuring the Universe 5

Build Your Own Range Finder

This installment of "Measuring the Universe" is the Science Workshop article for this issue.

Measuring distances in this way will seem strange to most children, who naturally think in terms of rulers and yardsticks. Those who have seen a 50-foot tape measure may wonder why they are not used to measure land. Point out that obstacles such as rock formations, trees, and raised roadbeds would get in the way. Have them think about the difficulty of measuring across water this way. Accuracy is another problem. A tape measure would have to follow the contours of the ground, making a piece of land appear bigger than it really is. Also, the tape measure would shrink or stretch.

Have children check their ability to estimate distances, by first guessing the distance to an object and then using the range finder.

Page 13: Exploring Dreamland

Basic concept: Organisms are adapted to their environment.

This article brings science close to home—right into the bedroom. It is intended to acquaint children with a phenomenon within their own experience, about which there is little available information written for young readers.

You might stress that this information *describes* sleep and dreaming. The *why* still remains largely unknown, although a number of theories have been put forth.

Do all Animals Sleep? Sleep as we know it is observed only in those animals with highly developed nervous systems. Sleep habits are governed by a complex mixture of physical and environmental factors. For example, length of sleep depends on how often the animal needs to eat. Thus, some animals, like rabbits, take many short naps around the clock, while humans sleep through the night. An animal will sleep when and where it feels safe from attack.

Most animals sleep at night because of the difficulty of finding food in the dark. A few, however, like the owl and raccoon, hunt by night and sleep by day. Sleeping posture depends on bone and muscle structure. (An elephant sleeps standing up; a bat, hanging upside-down.)

Activities. 1. Ask your pupils to make a list of things that influence the sleep habits of humans (time of year, weather, TV-watching, and so forth). They might discuss what the life of a night-watchman would be like.

2. Have children observe and record the sleep patterns of a dog or a cat.

The Scientist's Way...
(Continued from page 1T)

frog, and the rabbit find an intellectual home in the concept "vertebrate"; but we expect a goose, not a frog or a rabbit, to have feathers and a warm body, and to lay hard-shelled eggs; these are associated in the concept "bird." Concepts, therefore, help us discriminate as well.

In terms of developing science as an experience in search of meaning, *concept seeking and concept forming become the legitimate, indeed, the central, objective of the science teacher,* even as they are products of the scientist's processes.

We should not in any way assume that an organization of a science curriculum around conceptual schemes becomes so inflexible that somehow children's needs and interests are ignored. A science program knit by conceptual schemes, far from being rigid, permits a more consistent organizing principle than incidental learning, or the newspaper, or the special environment, if only because the program reflects the way of the scientist as well as the way of the growing child as he progresses into and retreats from the vastness of his universe. Second, it permits the teacher to interpret the child's questions in a manner that has relevance for the kind of enquiry that results in individual activity.

And this "way of the scientist," what is its image? In it is a challenge: Clearly the universe can and should be investigated. P. W. Bridgman [the late Harvard University physicist] would add, "With no holds barred."

In it is a faith: Clearly the universe is in a state of change, yet it may have its uniformities, its continuities, its probabilities.

In the scientist's way of life is a process: enquiry. It embodies an aim: the construction and dissemination of a meaningful world (as Gerald Holton [physicist and editor of *Daedalus*] puts it).

In it is a posture: individual liberty, or idiosyncracy, in mode and method of investigation.

In this way of life is a kind of humility: There is a mistrust of one's brain to reach grand conclusions; hence a self-correcting attempt to defeat one's own conclusions; there is also the knowledge that the only certainty is uncertainty.

The nature of scientific enquiry

The way of the scientist, we repeat, is not to be interpreted as a calisthenics of discovery but as an art of investigation. In the long run the scientist knows a kind of success, but daily it comes from intelligent failure.

Consider then that the scientist, like the teacher—even like the child—never faces a situation *de novo,* but brings an area of comprehension, however limited, to his work.

Into this wide field of *comprehension* falls the history of his own experience, the history of the period in which he lives, the history of periods past, all the knowledge he has gleaned from information, all the wisdom gleaned from his knowledge — in short, all information conceptualized and some that is raw.

The shock of recognition of a problem is perhaps the result of an emerging awareness, which in itself is perhaps part and parcel of a complex and presently not understood process of conceptualizing—a period of incubation. And incubation precedes a kind of illumination. This illumination, this shock of recognition, is part of the *confrontation* of the problem and includes perhaps an identification of the problem as well as its probable solution in a flash of insight.

However it comes about, the confrontation is a creative act — and the work which follows seeks out "hidden likenesses" ([British mathematician J.] Bronowski's phrase), sees the unforeseeable, relates what hitherto has remained unrelated; it is fresh, it is individual, it has no duplicate, it is idiosyncratic.

It is the nature of the scientist's mode of *criticism* acting in the melee of *comprehension, confrontation,* and *creation* which often gives the scientific enterprise its private language. The critique does not come out of authority *per se* but develops through rigorous *confirmation* with *built-in self-correction.*

Creativity is oversimplified

Too often we have found it convenient and provident to ignore the nature of the *comprehension* preceding *confrontation.* And of the essence of scientific inquiry, *creativity* with its insight into hidden likenesses, little is known. It has been simpler to focus on the nature of scientific criticism and on the produce, the contribution, as a successful outcome of a problem-solving technique monstrously oversimplified.

It is expensive of time and space to describe a process which must be tortuous, and singular, because idiosyncratic; the pages of a curriculum bind us to silence; we oversimplify so that we have those unconscionable "steps in problem-solving" when actually they are steps in problem-doing—since the solution is already known. We confuse the scientist's concise report of his work (his paper) with the manner of his work.

We study his *contribution,* of necessity stated in a tight logical assertion, or in a systematic demonstration of proof, and proceed to describe the process of attaining the contribution as occurring in a tight logical progression as well.

In this progression, the problem is identified, and is obediently followed by a hypothesis: Neatly an experiment is designed, and replication is only a matter of successful repetition before a conclusion issues forth. In the school classroom and laboratory this inevitably successful method takes precisely 45 or 50 minutes.

The "sacred loophole"

I have tried to indicate that comprehension, confrontation, creation, and the contribution refined by a special kind of criticism are of the nature of the melee, not of the procession.

It follows that in attempting to define the artist's, the musician's, the poet's, or the scientist's way, one experiences a sense of failure. Rightly so. Creativeness is both its own cause and its own result. Creativeness, the most essential attribute of a scientist's approach, will at present not yield to definition except in the most general terms; creativity is an art of an individual. One can see the fire of creativeness but one doesn't know the technology of its incandescence.

Creativity accepts mastery as prelude to mystery, certainly as prelude to uncertainty. The very fact that we cannot contain, delimit, or define science means that it has in it a sacred loophole — through which imagination may leap, look back upon the body of science, and find it inadequate to explain the universe it has just fabricated.

And, too, if we are wise in the educational devices we build, the child will learn that not all scientists are open-minded, not all work is noble, not all the world appreciative; sometimes the world won't let the scientist work, much less create. It is possible for a longshoreman to speak his mind, but a prominent scientist, especially a Nobel Prize winner, must guard his language. The child will learn, too, that science has its limitations —and that the scientist will be the first to admit it ■

THE NEXT ISSUE of *Nature and Science* takes the reader on an expedition in Australia to discover why large euro kangaroos are flourishing on huge ranches that no longer support many sheep.

A chart ideal for the classroom bulletin board tells how to identify and find the age of common evergreen trees, especially those used for Christmas trees. Another seasonal article gives the astronomer's story of the Star in the East.

Science Workshop articles show children how to measure the size of the Moon, study convection currents in the air, and measure homemade earthquakes.

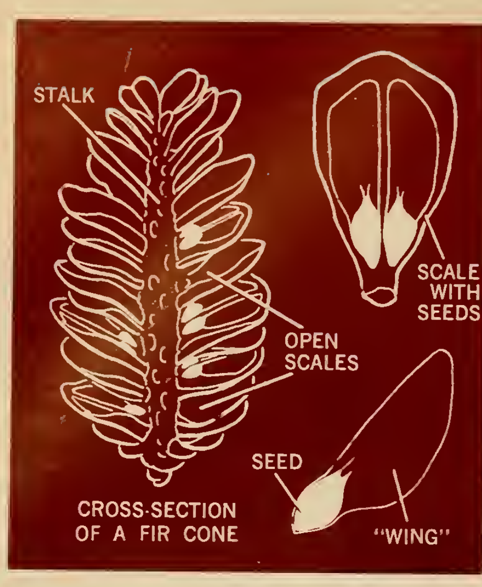
nature and science

VOL. 1 NO. 6 / DECEMBER 6, 1963

"In Australia we have a problem–

WHAT TO DO WITH OUR KANGAROOS?"

see page 4



ABOUT THE EVERGREENS

Evergreen trees, or *conifers,* first developed about 270 million years ago, long before dinosaurs roamed the Earth. Today, there are about 540 different kinds, or species, of conifers in the world, and about 65 species in the United States. The chart on pages 8 and 9 will help you identify some of the more common species of conifers in the United States.

The seeds of conifers usually grow in cones made of overlapping scales that grow from a central stalk *(see diagram).* At the base of each scale, hidden from view, are one or more seeds.

The cone's scales stay tightly closed until the seeds are fully developed. Then the scales open and the seeds fall out. Most conifer seeds have a thin "wing" that enables the wind to carry the seed away from the parent tree.

ABOUT THE COVER

The leaping red kangaroo on our cover was snapped by George Leavens, a photographer who returned to his native Australia for a visit in 1957. To get this photo, he crouched beside a fence while men in jeeps and trucks herded some kangaroos in his direction. When a kangaroo jumped the fence, he was ready with his camera.

nature and science

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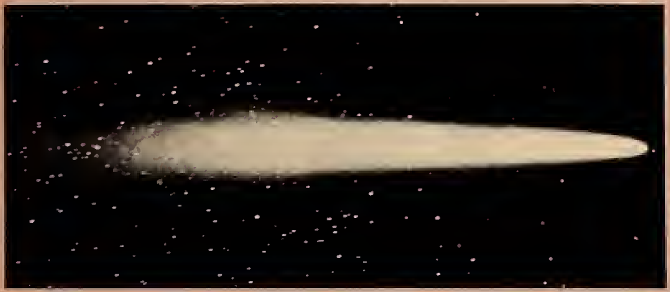
What Was The Christmas Star?

■ Stars are among the most common symbols of Christmas. Usually there is a large one at the top of most Christmas trees, and we see them on Christmas cards and in other decorations.

The Christmas Star comes to us from the story of the Wise Men. The story tells how they were guided by a bright object in the sky to the birthplace of Jesus. What was the bright object? Was it actually a star?

Astronomers believe that the star seen by the Wise Men could not have been an ordinary star. The Wise Men probably knew the stars well. They would not have been attracted by anything that they could observe on any night. Whatever they saw had to be out of the ordinary, possibly one of the unusual objects that appears in the sky every now and then, often without warning.

For example, the Star of Christmas may have been a comet. Every few years a brilliant comet appears in the sky, sometimes displaying a long, graceful tail. It may remain bright for weeks or months. But in ancient times comets were omens of evil to many people. It does not seem likely that a comet would have been taken as the sign of a wonderful event such as the birth of a king. Besides, bright comets are seen by many people, and, for the time around Christ's birth, none has been recorded.



Was the "Star" a comet? Usually a comet is seen for weeks, but none was recorded for the time around Christ's birth.

A bright fireball, or *bolide,* may have flashed across the sky toward the west, pointing direction for the Wise Men. But such bright "shooting stars" last for only a few moments. Since the Wise Men followed their Star, it must have been longer-lasting.

Some years at Christmas time the planet Venus shines brightly in the evening sky. But why should one particular time when this planet shone brightly attract the Wise Men more than other times?

There are other possibilities, too. An exploding star—a *nova*—could appear as a bright object in the night sky for a period of many nights. The famous astronomer Johannes Kepler saw such a nova in the year 1604 and wondered if one had been recorded at the time of the Wise Men's journey. None was.

When Was Christ Born?

One reason it is hard for us to say *exactly* what the Christmas Star was is that we do not know for certain the date of Christ's birth. We are fairly sure it took place before the year A.D. 1 in our present calendar—perhaps in 6 B.C. or 7 B.C.

The Bible story of the Nativity tells us that King Herod was then the ruler of Judaea. From other historians we learn that Herod died sometime after an eclipse of the Moon that took place on March 13, 4 B.C. Christ, then, must have been born before 4 B.C. Still other clues from history and from the Bible point to the spring of the year 6 B.C. as the most likely date of Christ's birth.

When we trace back the positions of the stars and planets in the sky at that time, we can search for peculiar patterns among them. At times, two or even three planets come together in the sky and form an unusual pattern. Such arrangements are called *configurations.* Often they were considered events of great importance in ancient times. When we trace back star patterns in the sky in the year 6 B.C., we find that there was a configuration of the planets Mars, Jupiter, and Saturn. Because the Wise Men knew a lot about the stars and planets, they must have known about this configuration—even though they couldn't see it. They were unable to see it because the three planets were too close to the Sun at the time. This would make the sky so bright that these planets could not be seen.

The point is that we do not have proof of what the Wise Men actually saw. Some say that it was a vision that appeared to the Wise Men alone, and that no other persons saw it. It is likely that the Christmas Star mystery will forever remain unsolved.—JOSEPH M. CHAMBERLAIN (Chairman and Astronomer, The American Museum-Hayden Planetarium)

In Australia we have a problem—

WHAT TO DO WITH OUR KANGAROOS?

by E. H. M. Ealey

E. H. M. Ealey, whose friends call him "Tim," began studying kangaroos in 1953 when he and his bride moved to northwestern Australia. The Ealeys had two children during Tim's five year study of the euro kangaroo. His problem was to find out why there were so many of these kangaroos in areas where sheep, once plentiful, were dying out. Since 1960, Dr. Ealey has taught at Monash University in Melbourne. He is now studying the spiny anteater.

■ In Australia we have many different sorts, or *species,* of kangaroos. Some, the size of rabbits and smaller, are called hare-wallabies. Others are up to seven feet tall. There are three types of big kangaroos. The red, or marloo, roams the hot, dry inland plains. The grey, or scrub, kangaroo lives in the forests closer to the coast. It also lives in plains country. When wounded or cornered, both these types of kangaroos have been known to kill men or dogs with their powerful hind feet and sharp claws.

The other large kangaroo—the kind I worked with—is the kangaroo known as the *euro.* These big ones live in many areas of Australia where there are hills. I studied the euro in the Pilbara district of Western Australia.

Western Australia is about one-third the size of the United States, and the Pilbara district is about half the size of Texas. My research station, Woodstock, was 1,000 miles north of Perth, the closest city. The names of two nearby ranches describe the land well. One was Mundabullangana, which means "the edge of the stony country." The other was Warrawagine, "the edge of the desert."

This area is in one of the hottest places on Earth. Temperatures are sometimes as high as 120°F in the shade. Only about 10 inches of rain fall each year, and this is usually brought by cyclones which often do a lot of damage. When the big rains come the creeks and rivers swell suddenly, but they run for only a few days. Most of the water drains down to the sea or sinks into the sand. After the rains the land becomes dry as bone again, and the euro has to dig for water. Other mammals and birds use the water found by the euros.

What Happened to Pilbara's Sheep?

Despite the harsh climate, sheep once did very well in the Pilbara area. Ranches as big as a million acres were leased to the sheep ranchers. These ranches are bigger than some of the smaller American states but nowadays there are few sheep; instead there are lots of kangaroos. Over the past 25 years more than half of Pilbara's sheep have died out. What happened? This was one of the puzzles our group was trying to solve.

A scientist who was studying the plants that grew in the area came up with a valuable clue. He found that several years ago there were many valuable food plants for sheep to eat. Now there are very few. Over the years their place had been taken by spiky grass called spinifex. This was because the sheep had eaten and killed most of the good plants, allowing spinifex to spread. Because spinifex is such poor food, the sheep that could find nothing else to eat could not produce enough milk for their lambs, so the lambs died.

In the meantime, euros ate the spinifex, grew fat, and increased in number. I was asked to take a team of scientists into the area and learn all I could about the euro. In 1955 we set up our headquarters in an old deserted homestead on the banks of a dry creek bed.

How We Painted Kangaroos

A good way to find out about animals is to mark them. It is best if each animal can be marked so that you can see the mark from a distance. We marked kangaroos in two different ways. First we invented gadgets that would spray euros with a little colored dye every time they drank. We built a fence around each of two drinking places, and every time a euro went through a gate in the fence it got sprayed with color. It also got counted by an automatic counting machine.

The drinking places were two to three miles apart and we arranged to have a different color for each one. Kangaroos that drank at both places got two colors on their backs. Actually very few drank at more than one place, but the surprising thing was that many never drank at all—even when it was very hot.

Our second way of marking was to put a plastic collar around a kangaroo's neck. This helped us find out what each individual animal did. But before we could mark them, we had to catch them.

We built a high fence around a drinking place and made special gates that let the kangaroos come in, but not go out. At first we were quite frightened to go into the small pen with a dozen angry, hissing euros bounding about trying to break out. These animals can bite savagely, and the animals are surprisingly strong. I have seen a big buck hurl himself at the wire so hard that he simply burst through! Some tried to bite and kick and scratch us. Others fought among themselves. We found that if we grabbed even the biggest kangaroo by the tail, it could not turn on us. It merely jumped up and down on the same spot.

Once held like this, it was easy to tangle each animal in a net and fix a bright yellow plastic collar around its neck. We always made sure to keep our fingers away from the snapping jaws. On each collar was a different set of numbers or letters made from brightly colored tape such as some people stick on car bumpers.

With our spotlights at night we could identify each euro hundreds of yards away. By watching at water holes night after night we knew how often these marked euros drank. And by driving around the countryside, also at night, we could pick up some of them with our spotlights and discover their feeding ground and home range.

As I have mentioned, some of the animals hardly ever drank. We found that they were able to go without water because they stayed out of the heat during the day by sleeping in cool places among heaps of granite rocks. The animals that didn't live near rocky outcrops drank a lot of water to keep cool. We humans use water in the form of sweat, which evaporates and thus cools us on a hot day. Kangaroos lick their arms and legs. The water that they spread on themselves evaporates and helps cool them. They also pant, as a dog does, when it is hot. They don't sweat much at all.

Learning a Lesson from Euros

During the time we studied our marked animals in the field, we were surprised to find that they had very small home ranges. They did all their feeding in areas only a few hundred yards across. Occasionally, however, some left their home ranges for a drink. The heavy summer rain

(Continued on the next page)

Scientists kept track of where the kangaroos went by putting plastic collars around their necks, then releasing them.

Each collar was marked to identify the animal, and the markings could be seen from a distance in daytime or at night.

A scientist holds a euro kangaroo by the tail after putting a plastic identity collar around its neck. One way to keep this strong animal under control is to hold it by the tail. Then the kangaroo just jumps up and down in one spot.

caused some of the animals to scatter. For some reason they did not return to their home ranges for months.

The fewer animals around after the rain, the better for the pastures. By the time the wanderers came back, the food plants in the pastures were fully grown and the seed had fallen. Grazing could do no harm at this stage.

We told the sheep ranchers that they could learn a lesson from the euro. If the ranchers fenced off part of their pasture land for a time to let the food plants recover, the sheep would have a better chance to increase in number.

We learned a lot of other things from our marked animals. By measuring and weighing them each time we recaptured them, we could tell how fast they grew. By cautiously looking at their teeth we could tell how old they were. We found that the last molar tooth doesn't come through until the animal is seven years old. All the molars and premolars slowly move forward and drop out one by one when the animal is very old. Only a few reach 20 years of age. Most die before they are 10.

Many females had pouch young (called *joeys*). We also measured these babies. If we were lucky enough to catch the same mother more than once we would measure her joey again to find out how much it had grown. Sometimes we found that the joey was missing. In some cases this was because in drought conditions the mother couldn't supply enough milk and the baby died.

In other cases it was because a wild dog, called a *dingo*, or an eagle had chased the mother until she threw out the baby, or until it fell out. The attacking animal would then eat the baby while the mother escaped. I once climbed into an eagle's nest and found the remains of six small pouch joeys. They could have been tossed out by the mother. They were too small to have left the pouch by themselves.

The euro and some other *marsupials* (animals that carry their young in a pouch) have an efficient way of replacing a joey that is lost. If a young one dies, another fertilized egg carried by the mother develops into a new baby in about five weeks.

How Joey Grows

The newborn is less than an inch long—about the size and shape of a cashew nut. It has no eyes, there are only tiny bumps where the ears will be, and it has no hair. It is hard to imagine that the tiny undeveloped back legs will one day carry a heavy animal in powerful bounds across the countryside. At this stage the front legs are much better

Euro kangaroos are increasing in many areas of Australia where there are sheep ranches (see map). The ranchers are worried because euros are increasing as the sheep die out. The map shows Australia compared with the United States.

developed. They have claws which the baby uses to climb unaided for nearly a foot through the mother's fur before it reaches the pouch. Once in the pouch it finds a nipple, or *teat,* with its mouth. The tip of the teat swells so that it is difficult to remove the tiny joey without damaging its lips. The old gold miners winked at each other when we told them about this. They still think the joey grows on the end of the teat like an apple on a branch!

The joey stays in the pouch for eight months. In that time it changes completely. It grows hair, its ears grow, and its eyes open. Sometimes it pokes out its head to chew a little grass while its mother feeds. Soon it hops along behind its mother, but still pushes its head into the pouch to drink milk for a further five months. By now, of course, there is another tiny joey in the pouch.

Sheep Ranches or Kangaroo Ranches?

Now we knew something about how these kangaroos produced their young, and how long it took for a baby to grow up. At this stage we decided to study how many were born and how many died each year. Also we wanted to know something about their breeding habits. We carefully examined about 2,000 euros over a period of nearly three years. We weighed, we measured, we examined teeth. We dissected dead euros and obtained a tremendous amount of information.

We found that euros of all ages died at quite a fast rate, especially in hard country. However, they also reproduced joeys at a fast rate. In good seasons they bred all the year round. In drought years some, especially old females, stopped reproducing but started again at the time of the year when rain might be expected. Their breeding pattern was wonderfully efficient.

No wonder euros did better than sheep. They grew fat on poor quality food. They could do well with no water at all if they had good shade. They could quickly replace any young that were lost. Some people say that we Australians should run kangaroo ranches instead of raising sheep. Perhaps this is a good idea.

The Need To Poison Euros

We were satisfied that we had done a good piece of scientific work. But you may ask, "How did this help the sheep ranchers?" They were not at all pleased with what we told them. Our evidence showed that their pastures had been ruined by their own unwise management and overstocking. Euros had played only a small part. However, we admitted that a ranch carrying say 50,000 kangaroos and only 4,000 sheep could not have its pastures restored unless some of the euros were removed.

After a lot of careful thinking, we told them that on some ranches euros must be poisoned—if the sheep were to survive. Some sheep ranchers had tried to kill euros by poisoning water troughs for a week at a time. We said that the water in troughs would have to be poisoned for a very much longer period.

Along with other lovers of wildlife, we were concerned about the effect this would have on other animals. It is quite illegal to poison any *natural* watering place, so euros and other animals around natural water holes would not be harmed. There are vast areas of country between ranches which can never be used for sheep, so animals living there would always be safe.

The sheep ranchers were sure that if they poisoned euros in one area more would come from somewhere else. Knowing that our marked animals did not move many miles from their home feeding grounds, we were able to assure the ranchers that this would not happen. "How often must we go to the trouble and expense of a poisoning campaign?" they asked. Because of our knowledge of birth rates and death rates, we were able to say that poisoning need not take place more often than once every five years.

Here was a marsupial that had done well because of the changes to its surroundings that sheep ranching had produced. Euros thrived on food that the sheep could not thrive on. And many of them could get along with hardly any water. In short, euros have become so successful that their numbers have to be controlled. Now that an adequate study of the euro has been made, the animal is not likely to face extinction as do so many other animals in Australia and elsewhere ■

Sometimes a young kangaroo, or "joey," leans out of the pouch to feed on grass. This 9-month-old gray kangaroo joey is nearly old enough to leave the pouch for good.

A GUIDE

This Christmas about 45 million homes, offices, and schools in the United States will be decorated with a tree of some sort. Some will be made of aluminum, some of paper or plastic, but most of them will be real evergreen trees.

We especially notice evergreens in wintertime, because most other trees have lost their leaves. If you look underneath an evergreen tree, however, you will find many dead leaves there too. The leaves of evergreens, called *needles,* are shed like those of other trees, but only a few types of evergreens lose all of their needles at one time. The larch, or tamarack, of the northern United States and the cypress of the south are not true evergreens because they lose all of their needles each winter.

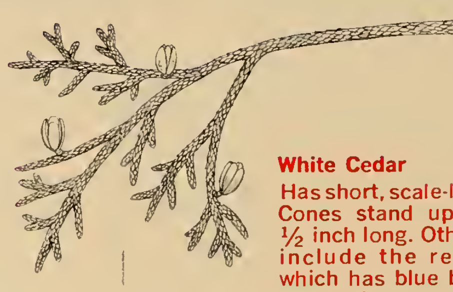
Evergreen trees are called coniferous, or cone-bearing trees, because their seeds grow in cones *(see page 2)*. You can identify the conifers by looking at their needles, cones, and bark. The illustrations on these pages will help you identify some of the common conifers, including the most popular Christmas trees.

The custom of decorating evergreens at Christmas began in Germany about 500 years ago. When German people settled in America, they were happy to find wild evergreens growing. Today, four out of five families in the United States have a tree for Christmas.

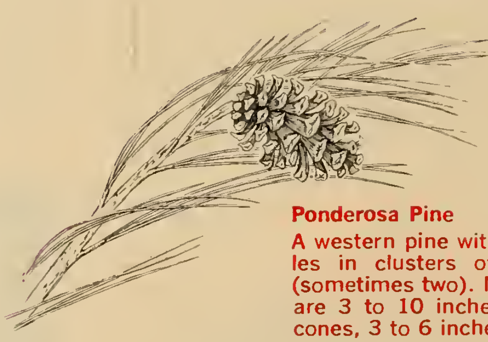
Most of the Christmas trees used today come from forests in the northern United States and in Canada. However, each year a greater number of trees come from tree farms, which grow thousands of young evergreen seedlings each year. It takes about six to 12 years, depending on the type of evergreen, for the seedling to grow to Christmas tree size. To insure a good crop of well-formed trees, the grower must prune the trees and guard them against harmful insects and other animals.

Christmas trees are usually firs or pines. The five most popular kinds of trees in the United States are the Douglas fir, Scotch pine, balsam fir, red pine, and the eastern red cedar. Spruces make poor Christmas trees. They dry out quickly and drop their needles ■

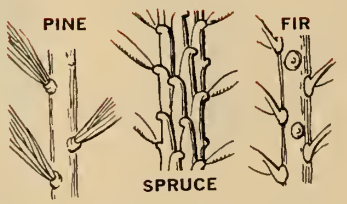
White Pine
Needles in clusters of five. Needles are 2 to 4 inches long. Hanging cones are 3 to 10 inches long.



White Cedar
Has short, scale-like leaves. Cones stand up and are ½ inch long. Other cedars include the red cedar, which has blue berries instead of cones.



Ponderosa Pine
A western pine with needles in clusters of three (sometimes two). Needles are 3 to 10 inches long; cones, 3 to 6 inches long.



These sketches show the twigs of the three main groups of evergreen trees. Pine needles grow in clusters. Spruce needles grow on tiny pegs that are rough to the touch. Fir needles leave a smooth, round mark when they are removed. Pines have long needles; spruce and fir, short ones.

You can find the age of your Christmas tree by counting the number of dark annual rings on its base. There is one ring for each year the tree has grown.

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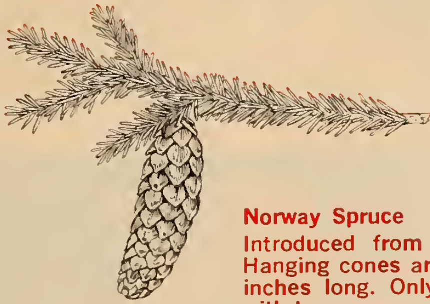
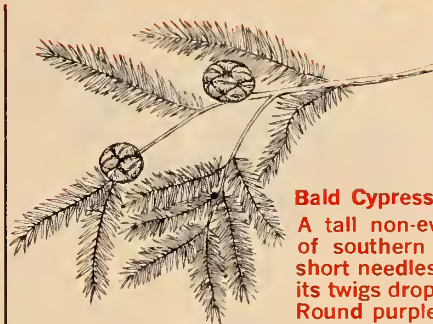
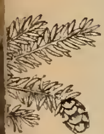


Norway Spruce
Introduced from Europe. Hanging cones are 4 to 7 inches long. Only spruce with large cones.



Bald Cypress
A tall non-evergreen tree of southern swamps. Its short needles and most of its twigs drop off in winter. Round purple cones are 1 inch in diameter.



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Red Pine
Needles in clusters of two. Needles are 4 to 6 inches long; cones, $1\frac{1}{2}$ to 3 inches long. Reddish-brown bark.

Balsam Fir
Two white stripes beneath needles. Cones stand up and are 1 to 4 inches long.

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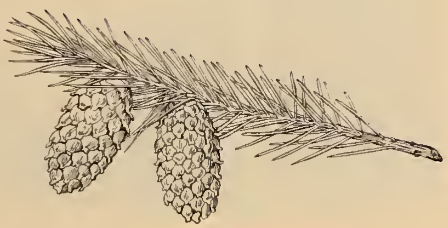

Blue Spruce
Needles are bluish-green. Hanging cones are 2 to 4 inches long.

Loblolly Pine
A southern pine with needles in clusters of three. Needles are 6 to 9 inches long. Cones are 2 to 6 inches long. Other southern pines include the longleaf (8- to 18-inch-long needles) and shortleaf (3- to 5-inch long needles).

INVESTIGATION

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Here are two ways to find the age of a Christmas tree. One is to look at a cross-section of the base of the tree and count the *annual* rings. These are a series of light and dark rings in the wood. (You may have to make a fresh cut with a saw to see the rings clearly.) Each dark ring on the base of your tree represents part of one year's growth. The total number of dark rings is the tree's age (see *diagram*).

Another way to find the age of your tree is to count the groups, or whorls, of branches that come off its trunk (see *diagram*). A new group of branches grows out from the evergreen's top each year. The distance between each whorl is a year's growth. To find your tree's age, start at the top of the tree and count the spaces between the whorls of branches, down to the base of the tree. Add three for the first years when the seedling does not grow whorls of branches.

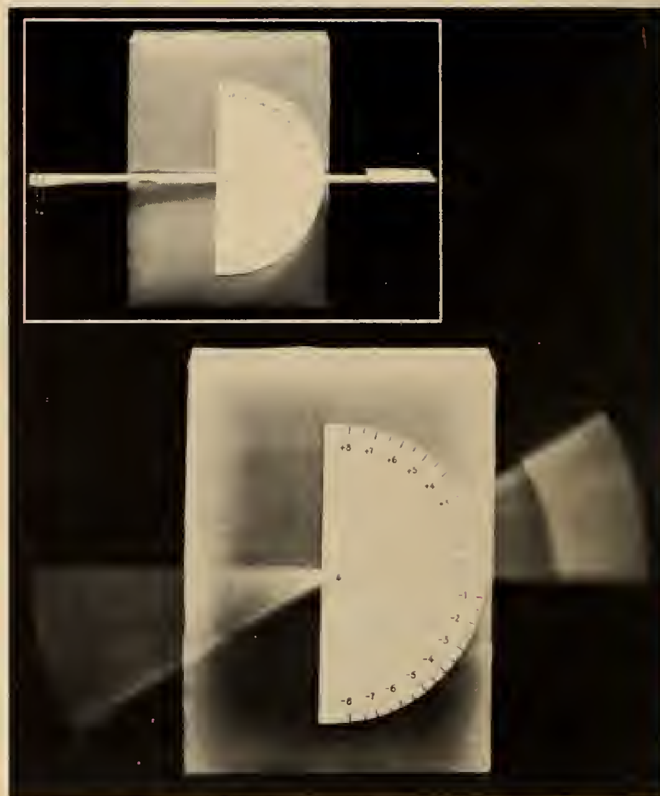
Compare the tree's age you find in this way with the age you found by counting annual rings. Is it the same? It may be different because the lower whorls of branches may be lost when the tree is cut down.

If you measure the distance from the top of the tree to the highest whorl of branches, you will find how much your tree grew during the past year. By looking at the distance between the other whorls, you can see how high the tree was during each of the years of its life. Did your tree grow at the same rate each year?

If you find that the tree grew particularly fast or slow during one year, look at the annual rings on the base of your tree. Are they farther apart or closer together for that year?

MOLECULES ON THE MOVE

■ Have you ever wondered what causes air currents to move about a room, or through the house? Here is a way to find out something about them. Air is a mixture of gases, and gases are made up of small bits of matter called molecules. Although molecules are far too tiny to see, we can feel them when they move in large numbers. When you blow on your hand, many molecules are pushed against it and you feel them as a small wind. By building an *air current detector* you can find out something about how molecules move around.



Build an air current detector like the one shown here. Then use it to measure the strength of the air currents that are always moving through your house.

Building Your Air Current Detector

First, take a sturdy soda straw, pinch one end together, and fasten a paper clip to it *(see picture)*. On the other end of the straw, tape a piece of light, stiff paper (about 2 by 3 inches) in a flat, or horizontal, position.

You can use a small breakfast cereal box for the base of your detector. Stick a pin through the middle of the straw. Then pin the straw to the box as shown. A small disk of cork, or similar material, can be glued to the face of the box to provide a good support for the pin. You might have to work the straw around the pin a few times so that the straw will swing freely.

Before you begin to measure the strength of air currents you will have to do two things: 1) Make sure that the straw is level. If it isn't, move the paper clip slightly until its weight balances the weight of the piece of paper on the other end. 2) Make a scale on the box like the one in the photograph, so you can measure the relative strength of air currents.

Your current detector is now ready to use. Notice that the detector arm moves up and down slowly, so it measures air that is rising or falling. Can it also measure air that is moving horizontally, or from side to side?

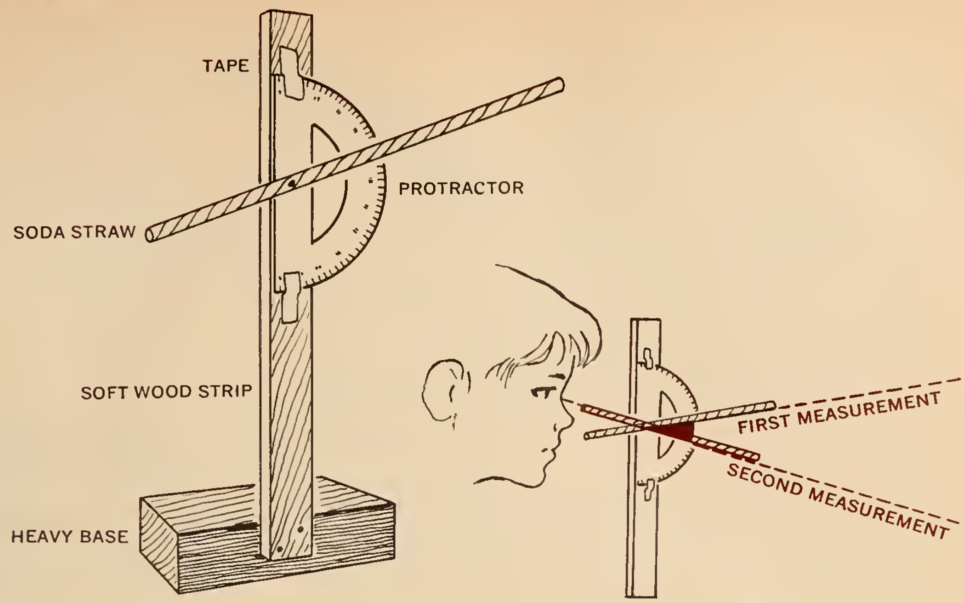
Hold the detector over an electric light bulb so that the flat piece of paper is a few inches above the bulb. Heat from the bulb heats the air around it. Does the heat make molecules move more rapidly? What happens to the arm?

Now test your detector near a cold object. Set the detector on a table. Take an ice cube tray from the refrigerator and set it under the detector arm. What happens? Now hold the tray of ice cubes above the detector arm. What happens to the arm? What effect does cold seem to have on the molecules?

You can use your air current detector near other hot and cold objects. You can also learn something about the air currents in a room. Even when windows and doors are closed, the molecules move about, causing rising and falling currents. Use your detector to find out where air currents are rising, and where they are falling. Try to find out how these currents are set in motion ■

Adapted from "Convection Currents," by Raymond E. Barrett, Oregon Museum of Science & Industry, Portland, Oregon.

How Big Is the Moon?



With this soda straw "astrolabe" that you can make at home, you can measure the size of objects that are many feet away from you.

■ From your tropical island you were wondering not only about the distance of things from you—other islands, the Sun, Moon, and stars—but also about their size. Astronomers of old also wondered about the size and distance of the Sun and Moon.

To the eye, the setting Sun and rising full Moon often appear the same size. Whenever we try to measure the size of distant objects, we must keep two things in mind: 1) We never "see" the *real* size of an object. 2) We see only its *apparent* size. For example, a 50-cent piece is 1.2 inches across. This is its *real* size. But seen from a distance of 20 feet or more the coin appears to be only a fraction of an inch across.

Try this and see how it works. Hold your thumb in front of you, close one eye, and with the open eye sight on a person at the other end of the room. Move your thumb nearer and farther away from your eye until you find the distance at which your thumb exactly hides the person's head. The *apparent* sizes of your thumb and the person's head are now just the same.

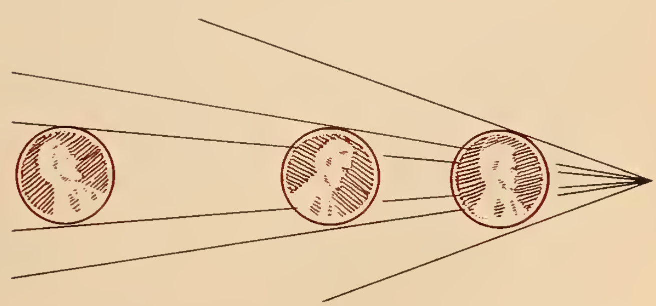
Exactly the same thing happens during a total eclipse of the Sun. The Moon (your thumb) passes in front of the Sun (the person's head). Because their *apparent* sizes are the same, the Moon exactly hides the Sun's disk.

A Penny as Large as a Clock

Try holding up a penny or some other coin so that it exactly hides the clock in your classroom. What happens if you move the coin closer to you? Now move it farther away.

If you wanted to tell someone the apparent size of an object—the Moon, for instance—how would you do it? Would it mean anything to a person if you told him that the Moon is two inches across? Remember what happened to the coin you moved nearer and farther away. Its apparent size changed. Do you think that an inch would appear first shorter and then longer as you moved a ruler farther away from you, then nearer? Try it.

There is a way that you can measure the apparent size of an object fairly accurately. It is, in fact, the way astronomers worked out the actual size of the Moon. Place a coin on a piece of paper so that the edge of the coin is near one edge of the paper. With a pencil make a dot next to the opposite edge of the paper. Now with a ruler draw straight lines from the dot to each side of the coin. Do the same thing again, but this time move the coin to the



middle of the paper before you draw the lines. Do the same thing a third time, but this time move the coin about two inches closer to the dot.

(Continued on the next page)

This is the sixth in a series of articles adapted by permission of the Elementary-School Science Project from the revised edition of its booklet, Astronomy: Charting the Universe, *© 1962 by the Board of Trustees of the University of Illinois.*

With a protractor you can measure the size of the angles you have made. Each of the three angles is the apparent size of the coin as seen from a certain distance. We call this apparent size the *angular diameter*.

How To Make and Use an Astrolabe

Here is how to make an instrument to measure the angular diameter of objects. Astronomers measure angular diameters in quite a different way, and the instrument they use is much more accurate. Nevertheless you can make fairly accurate measurements with your homemade instrument.

First, tape a protractor to a strip of soft wood, as shown in the diagram. Next, tape or nail the strip to a firm, fairly heavy base, such as a block of wood. Now with a long pin fix a soda straw to the protractor by forcing the pin into the wood strip. When you have finished, you will have an *astrolabe* of sorts. Ancient astronomers and navigators used astrolabes to measure the altitude, or height, of the Sun, Moon, or a star above the horizon.

Sight on some object, such as a basketball or a tall lamp, at the other end of the room. As you look through the soda straw, sight on the very top of the object. When you have done this, hold the straw so that it doesn't slip up or down, then read the figure on the protractor exactly at the bottom edge of the straw, and write the figure down. (Say that it is 79°.)

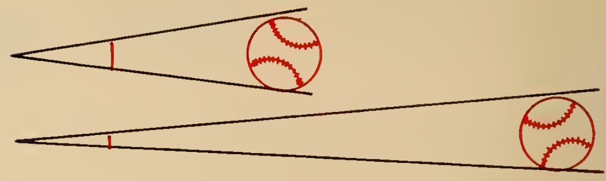
Now sight on the very bottom edge of the object and write the new figure down, reading along the bottom edge of the straw as before. (Say that the new figure is 106°.) The difference between 79° and 106° is 27°. So 27° is the angular diameter of the object. Practice measuring the angular diameter of several different objects in the room. You are doing with your astrolabe the same thing that you did when you measured the angle formed by lines drawn from the dot on a piece of paper to the sides of a coin.

Select one object in the room and measure its angular diameter from two or three different distances. What is the angular diameter when you are five feet away? When you are 15 feet away?

The things you have done so far have shown you three important things about angular diameters:

1) Objects with the same angular diameter are not always the same size; the Sun and Moon, for example.

2) An angular diameter becomes smaller as the distance to the object becomes greater.



3) Angular diameter depends both on the distance and the true size of an object.

Working Out True Size

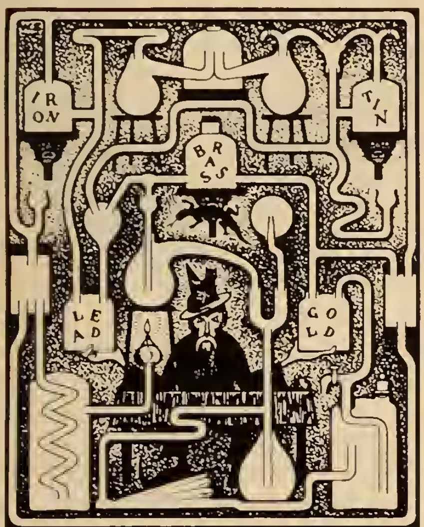
After you have measured the angular diameter (apparent size) of an object, all you have to do to figure out its real size is make a triangle to scale. For example, say that a picture hanging on the wall of your room is 10 feet away from where you stand when you measure its angular diameter. On a piece of paper draw a line 10 inches long (letting one inch represent one foot).

You measure the angular diameter of the picture and find that it is about 11°. Now draw another side of your triangle, also 10 inches long, making an angle of 11° with the first line. To complete the triangle draw a line connecting the two 10-inch sides. Now all you have to do is measure the short side. You will find it is two inches long. Since one inch equals one foot, the true height of the picture is two feet.

Using a protractor that is scaled to measure angles of 1°, try drawing as accurately as you can an angle of ½° (which is the angular diameter of the Moon). Then extend the sides of the angle to represent a distance of 240,000 miles—the distance to the Moon. If you let one inch equal 12,000 miles your angle will have sides 20 inches long. Now complete the triangle by connecting the two sides. If you were working with very accurate instruments you would find this short line to be a little less than one-fifth of an inch long, giving the Moon a diameter close to its real value—2,160 miles.

About 2,000 years ago, the Greek astronomer Hipparchus had worked out the size and distance of the Moon quite accurately. But the Sun posed a problem. Measuring instruments of the time were not good enough. Before the true size and distance of the Sun could be worked out, the telescope had to be invented. And this did not happen until 1,700 years after the time of Hipparchus. Once it did happen astronomers could then draw a scale model of the Solar System ■

In the next issue of *Nature and Science* we will show you how to make a scale model of the Solar System.



■ **Archie the Alchemist**

An alchemist named Archie set up this maze of tubing in order to make gold from lead, iron, brass, and tin. If he starts with lead, in what order must he take the other three ingredients so as to finish with gold? (Include all of the ingredients in the process; do not travel the same tubes twice; and do not cross a line.)

■ **The Christmas Gifts**

Tom and Roy each paid $11 to buy 20 Christmas gifts apiece. Then Tom bought 5 more gifts for $1.50 and Roy bought one more for 10¢. Which boy paid the highest average price for his gifts?

■ **Cutting the Cake**

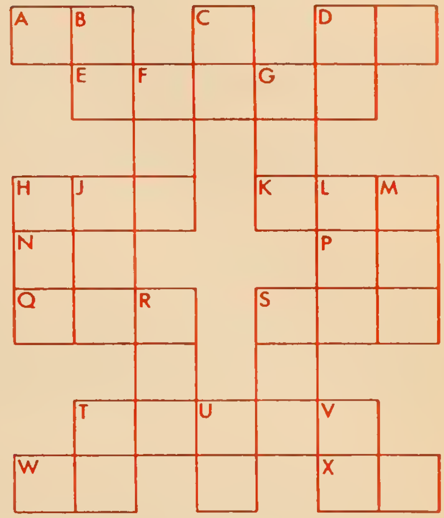
When the Jones boys—Mike and Bob—bought a cake, they measured it and found that it was 20 inches in circumference. Mike (hoping to get more than his share) suggested that they each cut their slices in turn, and he would cut first.

Bob agreed, but said that each slice of cake would have to be either two inches or one inch of the cake's circumference. The boys agreed that the one who took the last slice would wash the dishes.

How should Mike cut the first slice so he can avoid doing the dishes?

■ **Brothers and Sisters**

In the Claus family, each brother has as many sisters as he has brothers. However, each of the Claus sisters has twice as many brothers as she has sisters. How many brothers and sisters are there in the Claus family?



■ **Cross-Number Puzzle**

To solve this puzzle, fill in the correct answers as numbers in the rows of squares. See how many answers you can fill in without help. Then test your skill at looking for information —in an encyclopedia, dictionary, or mathematics book—and fill in the rest of the squares.

Numbers Down:

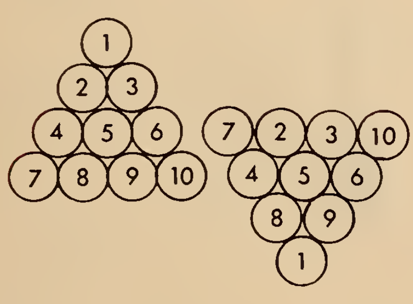
B. XXXIII in Arabic numerals.
C. 8 times 8.
D. How many feet in 6 fathoms?
F. How many centimeters in a meter?
G. How many square inches in a square foot?
H. 13593 ÷ 23.
J. 9/1000 written as a decimal.
L. 4 grams less than a kilogram.
M. 6 times 6 times 6.
R. Water boils at this temperature Fahrenheit.
S. How many degrees in a circle?
T. How many days in 8 weeks?
U. Four score and seven.
V. Another way to write 5¢.

Numbers Across:

A. 1 day less than a fortnight.
D. Water freezes at this temperature above zero Fahrenheit.
E. Mathematicians call this Pi.
H. Half a millenium.
K. How many months in 41 years?
N. How many degrees in a right triangle?
P. 9 less than a century.
Q. How many ounces in 12 pounds?
S. How many days in Leap Year?
T. How many feet in 10 miles?
W. How many legs on 2 spiders?
X. First class postage on 10 letters.

Solutions to Brain-Boosters appearing in the last issue

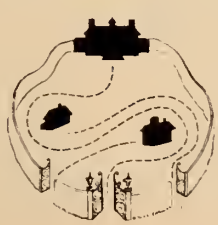
Move Three Coins: Here is how to reverse the pyramid-shaped group of coins by moving just 3 coins.

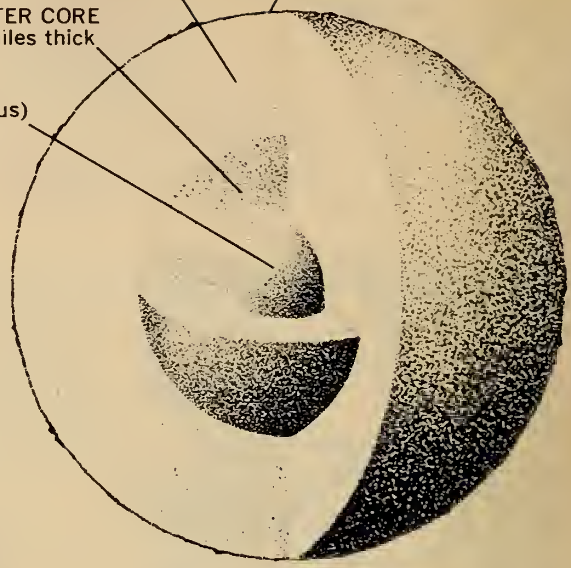


The Two Clocks: Mr. Brown found that the clock that doesn't run at all is correct twice a day. His other clock, which loses 4 minutes a day, is correct once every 180 days, or twice a year.

The Four Hobbies: John doesn't like to collect things, so his hobby must be photography (dressmaking is a girl's hobby). The clues say that a brother collects stamps, and, since Jim is the only boy left, he must be the stamp collector. Joan hates bugs, so she cannot be the insect collector and must be the dressmaker. Jane is the insect collector.

Paths of Friendship: The three neighbors built private paths to the exits of the park this way.





The Earth's crust is granite-like rock on the land, and basalt-like rock under the sea. The best guess about the mantle is that it is made of silicate rock, probably rich in iron and magnesium. The outer core may be made of silicate rock or iron-nickel, pressed together so tightly that it "flows" like liquid. The inner core may be like the outer core, but it seems to be solid rather than "liquid."

Measuring Homemade Earthquakes

by Harry Milgrom

What the inside of the Earth is made of still poses many mysteries. To find out more about our planet's interior, scientists study earthquake waves.

■ In ancient times the Greek philosopher Aristotle thought that earthquakes were caused by winds blowing into great caverns within the Earth. Another Greek scholar of old, named Democritus, also thought that there were caverns deep within the Earth, and that they were filled with water. When the water sloshed back and forth, he said, we had earthquakes.

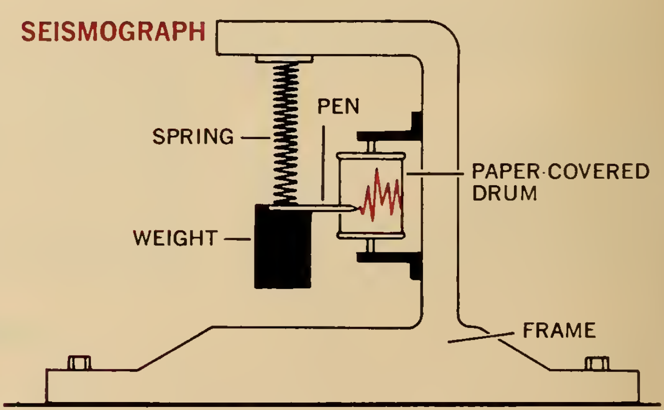
We no longer believe that the inside of the Earth has great caverns as Aristotle and Democritus imagined. Instead, we think that it is made up of different kinds of rock tightly packed together. But exactly *what kinds* of rock we do not know for sure.

The deepest rock we have seen so far is that which boils up out of active volcanoes. And this is not very deep rock. It wells up from a depth of only 50 to 70 miles. The distance to the center of the Earth is about 4,000 miles.

The scientists who try to discover how our planet was formed, what it is made of, and how it is changing, are called *geophysicists.* Some of these scientists are now working on Project Mohole. The purpose of Mohole is to drill into the Earth to obtain samples of the rocks that lie beneath the *crust* on which we live *(see diagram).* This project is not as simple as it might seem at first.

The depth of the Earth's crust ranges from about six miles (measured from the ocean's surface) to about 37 miles (measured from the surface of the continents). Scientists who drill the Mohole will do their drilling from the sea. This means that they will have to go through from about two to three miles of water and about three miles of crust. If they did their drilling from the land they would have to drill through 20 miles or more of crust. They are planning to drill this hole down to the *mantle (see diagram)* out in the ocean, but the exact drilling site has not been decided on yet.

Even when they have rock samples from beneath the crust, scientists will continue to study earthquakes to



When an earthquake shakes the ground, a seismograph jiggles up and down. The pen, which does not jiggle because it is attached to a spring, makes a zigzag line on the paper around the drum as the drum jiggles up and down.

learn more about the rocks deep within the Earth.

When we have an earthquake, the vibrations, or tremors, it makes travel out in all directions from the center of the earthquake. They pass right through the planet. By studying the vibrations on an instrument called a *seismograph,* scientists have been able to learn something about the different kinds of rock inside the Earth.

In principle, a seismograph is simply a heavy weight hanging from a spring. The spring is attached to a solid frame that is bolted to the ground. A pen attached to the weight draws an endless line on a drum of paper that is kept turning by a clock drive. So long as the ground supporting the seismograph's frame is not wiggling, the pen makes a straight line as the drum turns beneath it. You can see how this works by holding a pencil on a piece of paper and pulling the paper toward you while you hold the pencil steady. The line left on the paper should be straight.

When an earthquake takes place, the frame and paper drum of the seismograph are made to wiggle by the vibrations. Because the pen and weight are hanging from the spring, they do not wiggle. As a result, the pen makes a zigzag line on the paper drum. You can see how this works by holding a pencil on a sheet of paper as before. But this time, as you pull the paper toward you, move it also from side to side. The mark left will be a wavy line.

Clues to the Rocks Deep Down

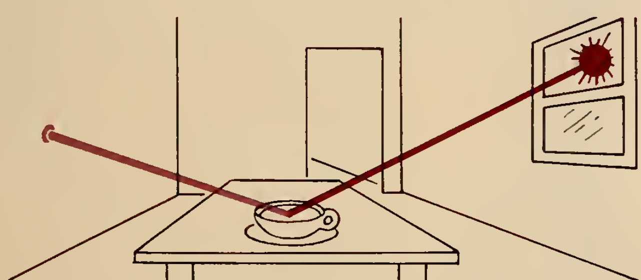
Every earthquake, large or small, leaves a record of its vibrations at seismograph stations around the world. By studying and comparing these vibration records scientists can learn something about the rocks deep within the Earth.

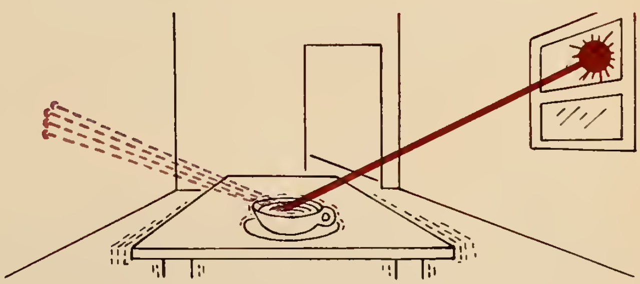
They can do this because they know how long it takes certain kinds of vibrations to pass through different kinds of rock. In general, the denser the rock the faster the vibrations travel. For example, the vibrations travel more slowly through granite than they do through harder and denser rock such as basalt. (Basalt makes up the rock floor beneath the carpet of clay, sand, and other sediments resting on the ocean bottom.)

After studying thousands of vibration records, geophysicists now think that the Earth is made up of four layers: 1) an outer crust, 2) a mantle, 3) a liquid outer core, and 4) a solid inner core. The crust is made of many different kinds of rocks. Beneath the crust the rock is thought to be very different. Deep inside the Earth the rock is squeezed so tightly by the weight of surrounding rock that it can flow much as a very thick liquid does. When Project Mohole is completed, scientists will be able to study their first sample of mantle rock. They will then know if at least part of their theory about the Earth's inside is sound ■

INVESTIGATION

Making Your Own Seismograph





Some day you may see a real seismograph in action. You can experiment with little quakes you make yourself and watch their vibrations with a homemade seismograph. Here is how to do it.

Place a pan or cup of water on a table or the floor. Arrange the cup in such a way that a beam of sunlight or a flashlight beam falls on the surface of the water. Let the reflected light strike the ceiling or a wall. (If you use a flashlight, you will have to arrange a clamp of some kind to hold the light steady.)

Now clap your hands together hard beside the cup. Rap the table or floor with your fist. Stamp one foot on the floor. Jump up and down on the floor with both feet. What happens each time?

Vibrations travel through the air, the floor, the table, and the cup to the water every time you make a little quake. When the vibrations reach the liquid, they set up ripples on the surface of the water. As soon as these tiny waves form on the water, the spot of reflected light begins to wiggle. If your homemade quake is weak, the ripples are small. If the quake is strong, the ripples are large.

Find out how sensitive your seismograph is. Does it detect the hum of the motor in your refrigerator, or some other household appliance? First place the cup on top of the appliance, then near it. Does it pick up the vibrations of a truck rumbling by? See how many other vibrations you can pick up.

Printed Photographs

■ Photographs that are not printed in color are actually many different shades of gray. But a printing press can't print gray with black ink—it either prints black or it doesn't print at all.

Look at a newspaper photograph with a magnifying glass. You will see that the photograph is made up of thousands of tiny black dots *(see illustration)*. When you see the picture without a magnifying glass, the mixtures of dots and white spaces appear to be different shades of gray.

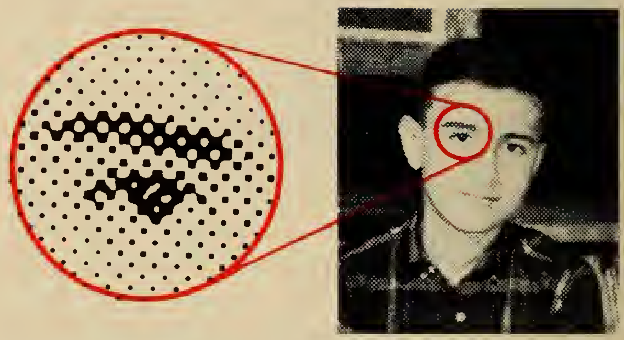
A picture that is to be printed must first be broken up into a pattern of dots. To do this, a photograph of the picture is taken through a piece of glass with thousands of criss-crossed lines on it *(see illustration)*. This is called a *halftone screen*. (You can see how it works by looking through a window screen with your eyes about two inches from the screen.)

When the film is developed, the image you see is made up of tiny dots because light from the picture passed through the halftone screen on its way to the film.

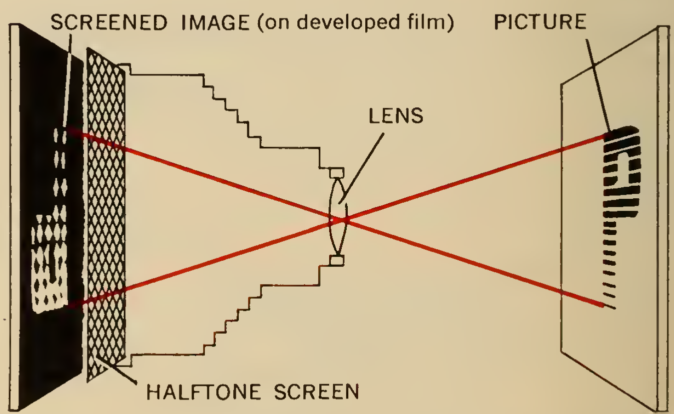
The film is laid on a sheet of metal (usually copper, zinc or magnesium) that has a special coating on it, and then exposed to a strong light. The light shines through the light spots of the film and hardens the coating on the metal sheet, or *plate*, where the light is not blocked by dark areas on the film.

Washing the plate removes the soft parts of the coating that were not exposed to light. This leaves the metal bare at those points. The plate is then put in a tank with acid that eats away, or *etches*, some of the bare metal and leaves tiny, flat-topped mountains of coated metal *(see illustration)*. The process of making a halftone plate is called *photoengraving*.

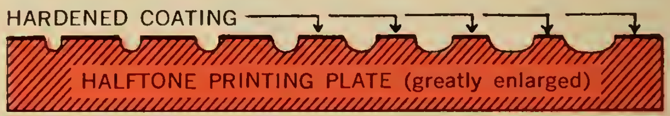
When the plate is put on the printing press, a roller spreads ink over the flat tops of the mountains. No ink goes into the valleys between them. A sheet of white paper is pressed against the plate, and picks up the ink in the form of tiny black dots. The patterns of black dots against the white paper produce areas that range from light gray to black in the printed photograph. Printed color photographs are mixtures of red, yellow, blue, and black dots printed from four separate halftone plates ■



This enlarged section of a newspaper photograph shows that the light areas are made of tiny black dots surrounded by white space. Dark areas are made of larger dots that leave almost no white space. There are 4,225 dots per square inch in this photograph. Compare it with other photographs in this magazine, which have 14,400 dots per square inch.



The picture to be printed is first photographed through a glass screen that is criss-crossed by many lines. Light from the picture goes through the tiny "holes" in the screen and forms an image of the picture in dots on the film.



Next the film is laid on a coated metal plate and exposed to light. Where light goes through dot "holes" in the film, it hardens dots of coating on the plate. The unhardened coating is washed off, leaving bare metal around the dots. Then acid eats out the metal between the dots to leave flat-topped "mountains" that print black dots of ink.

nature and science

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TEACHER'S EDITION

What Is the Average CQ of Your Pupils?

by Alma S. Wittlin

■ The CQ, or Curiosity Quotient, of your pupils is likely to be high, and potentially very high. How high it may become depends largely on you — the teacher.

It depends on your awareness of your pupils' curiosity; of sources of their curiosity; of goals toward which it may lead them; of topics that are likely to stimulate their urge to know; and of classroom procedures that nurture the exploratory drive, instead of stunting it.

Curiosity characterizes the human young in his cradle, but around the age of six to seven it begins to grow less desultory and more persistent. Now the child not merely keeps asking "why?", but is inclined to listen to answers.

The pre-schooler's magic world, in which the Moon runs after him and the Sun goes to bed, as he does, changes to a new environment. In it, he gains a separate identity, and his security becomes enhanced by knowledge of more and more facts which he can explore directly with all his senses. The 8 to-12-year-old has been described as "physicist, zoologist, chemist, astronomer, engineer, all rolled into one."

He is now wonderfully ready for an introduction to the study of science that offers better opportunities for immediate, bodily inquiry rather than the social sciences. Vikings and Eskimos too appeal to the child's imagination, but what verbal account, what book illustration or even movie can compete with rocks one can handle . . . with chemicals changing colors and emitting odors while one experiments with them . . . with liquids turned into gases by the heat of one's hands . . . with magnets in one's fingers, lifting chains of nails . . . with barely visible things suddenly growing big under a hand lens or a microscope?

Live animals occupy a special place in this growing universe: an active, voracious insect larva sinking into the stupor of a pupa from which soon a butterfly will emerge, perhaps under the eyes of a faithful and lucky observer . . . a frog, a crayfish, or a chameleon, considered first with a little aversion or fear because of their dissimilarity with warm-blooded, furry, demonstratively affectionate domestic pets, and eventually becoming friends to be taken care of.

A multitude of such experiences may become decisive for a person's attitude toward science. Not necessarily for the choice of a scientific profession, but for the acquisition of a basic *scientific literacy* so badly needed by all citizens.

The scientific interests of the younger child are encyclopedic. It is, indeed, desirable to make him aware of the interdependence between earth sciences and chemistry, between biology and physics; to cultivate in him a sense of the unity of life on Earth. He is not yet ready to deal with any problem in depth; he wants experiences of great breadth.

Add to a variety of interrelated experiences a realization of science's contribution to human welfare and an appreciation of the bold intellectual adventure implied in scientific discovery, and you have equipped your grade school pupil with the "psychological set" that should lead him toward scientific literacy during his adulthood.

Why Children Are Curious

Curiosity is not an exclusive characteristic of the human being; it appears to be a birthright of creatures on the higher levels of the evolutionary scale.

Experiments show that rats placed in a new locale run about, sniff, look, and touch objects before eating, drinking, or engaging in sexual activities. They cross electrified grids to satisfy their wish to explore. Monkeys learn to solve puzzles, in the form of locks and bolts, in return for the privilege of looking out through a window into another room.

Deprivation of sensory experiences, on the other hand, acts as a brake on the functioning of the mind and of the higher nervous system, not only in lower animals but in man too.

People confined to dark, soundproof quarters show a deterioration of memory. They fail to solve problems, be-

(Continued on page 4T)

Alma S. Wittlin, Ph.D., was a member of The Radcliffe Institute for Independent study from its inception in 1961 until 1963. During her residence in Cambridge, she served as a research associate of the Harvard Graduate School of Education and as a consultant to Educational Services Incorporated (Elementary Science Study).

Educational Services Incorporated

The 8-to-12-year-old wants to explore his world with all his senses. He is "physicist, zoologist, chemist, astronomer, engineer, all rolled into one." Given a bag of bones, these boys gleefully accept the challenge of re-assembling them.

Page 4: What To Do with Kangaroos?

Basic concept: Organisms interact with their environment. Animals are adapted for survival in their environments.

This article should make your pupils aware that conservation is "the wise use of natural resources," and not just "preservation." It describes the efforts of one team of scientists to find a solution to the serious problems threatening sheep farming in Australia.

To put their great grazing lands to use, the Australians chose to raise sheep. However, general mismanagement on the part of sheep farmers over the years has resulted in widespread ruin of grazing land and consequent decimation of flocks. Meanwhile a population explosion among the vegetarian kangaroos has further reduced the availability of grasses for sheep to feed on.

Class discussion. You could begin by explaining the peculiarities of *marsupials*—animals with pouches. Marsupials are distinguished by the fact that the female has no placenta to carry food and oxygen to the fetus from her own bloodstream.

The young are born in near-embryo form after a very short gestation period. They complete their development *outside* the mother's body, protected only by a fold of skin called the *marsupium*. This pouch acts as a kind of incubator for these "premature" babies until the proper time for their emergence arrives. The tiny babies are so delicate and helpless that they would perish if left outside the pouch for very long.

Point out that all other mammals, including humans, carry their embryos *inside*, in the placenta, during a longer gestation period.

Reproduction in kangaroos is unusual in another way. Shortly after a joey is born and crawls to the pouch, its mother can breed again. However, the newly fertilized egg does not develop past the two-day stage until the first joey leaves the pouch. This phenomenon is called *delayed implantation*, and variations of it occur in some other marsupials and in some members of the weasel family in North America.

The deliberate killing of kangaroos by poisoning may disturb some children. Point out that this form of population control serves a purpose in preserving a balance of nature that assures the survival of more useful animals. Remind the children that, since the beginning of man, animals have been killed for food, for furs or hides, and for self-protection. If poisoning seems a shocking method, you might ask your pupils whether any of them have ever used a bug bomb on mosquitoes or flies. Offer the consolation that kangaroos have been hunted for their hides, and that the hides of the poisoned animals are still valuable.

Reading. An excellent book on marsupials for 8-to-12 – year-olds is Louis Darling's *Kangaroos and Other Animals with Pockets*, published in library edition only by William Morrow & Co., New York, 1958, $2.78.

The suggestions for using this issue of Nature and Science *in your classroom were prepared by Patricia Ralph, elementary school teacher in the public schools of Huntington, N.Y., and member of our National Board of Editors.*

This issue of Nature and Science appears three weeks after the previous issue, instead of two weeks, because of the Thanksgiving holiday. Because of the Christmas holiday, this will be the only issue published in December.

The next issue will be dated January 10, 1964. Thereafter, Nature and Science will reach you every two weeks.

Page 8: A Guide to Evergreens

This chart, designed for posting on the bulletin board, and the article on page 3 are offered for their seasonal interest. "About the Evergreens" *(see page 2)* gives additional information about how conifers reproduce.

Some children will ask why the "leaves," or needles, stay on conifers "all the time" while the leaves of most other trees drop off at the end of each growing season. Point out that a conifer does drop some of its needles each year, but that most needles stay on the twigs from two to four years—or even longer—before dropping, so there are always many needles on a live tree.

Leaves and needles fall off because a layer of thin-walled cells, called the *abscission layer*, forms at the base of their stems then begins to disintegrate. When this layer is weak enough, it is broken by the action of wind and frost, and the leaf drops off. In many species of trees, the abscission layer begins to form as the days shorten each autumn. A diminishing supply of moisture from the soil may contribute to the process of abscission.

Conifer needles lose moisture less rapidly than broader leaves, because they are so narrow and relatively thick. Scientists suspect this may explain why abscission layers form less frequently on conifer needles than on the stems of broader leaves.

Page 10: Molecules On the Move

Basic concept: Matter is particulate; it consists of fundamental particles constantly in motion.

Motivation for this interesting workshop activity can be supplied by calling attention to our seasonal concern with colds, drafts, heating bills, and home insulation. Have children think of some ways we use our knowledge of air motion to keep temperatures as uniform as possible during cold weather. (Warm air

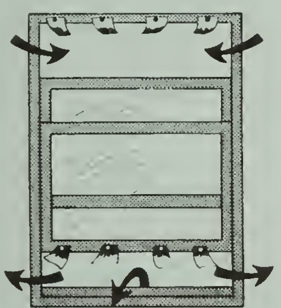
E. H. M. Ealey

At birth, the kangaroo fetus is less than an inch long. It crawls into the mother's pouch to stay for eight months. The baby kangaroo, or joey, shown above is six weeks old.

rises, so we place heating units in the basement and radiators or hot-air vents near the floor. Cold air settles, so we wear shoes or slippers on our feet and raise babies' pens off the floor.)

In studying the air current detector, make sure the class understands that the numbers on the scale have no absolute value, but are simply to help observe the relative strength of air currents.

More investigations. 1. You might supplement the detector by using a smoke torch to make air patterns visible. Smoke will float in the air and follow air currents. To make the torch, roll a piece of cloth tightly, set fire to the end, then quickly blow out the flame. Hold the smoking cloth still, then hold it over a warm electric light bulb. The rising warm air will carry the smoke upward. Check drafts by taking the smoke torch to various parts of the room—close to a door jamb and to an open window, for example. See if there is a draft between the door and a window when both are opened.



Tissue strips show the motion of air at top and bottom of an open window.

2. If the windows in your classroom open from bottom and top, tape strips of tissue paper to the lower edge of the bottom sash and to the very top of the sash frame, as shown. Have the class observe which ways the strips move. Check findings with smoke torch.

Activities. 1. Have someone use the detector to check air currents around an open refrigerator door at home and report back.

2. Visit your school heating plant. Have the custodian explain its operation and, if it is a hot-air system, point out where the cold air enters, where it is heated, and where the hot air comes out.

"Convection Currents," from which this article was adapted, is part of the *Invitation To Experiment* science teaching program developed by Raymond Barrett at the Oregon Museum of Science and Industry, in Portland.

This program provides sets of units of science study that permit each child to carry on investigations involving problem-solving approaches. Subject matter is organized under three major divisions —Energy & Matter, Living Things, and Earth and the Universe.

Page 11: Measuring the Universe 6

How Big Is the Moon?

Building on the methods and devices for measuring described in previous parts of this series, this article shows how we can determine the size of distant objects. You might take up this article in three sessions, as follows:

1st Day—Read the first section of the article. Discuss and experiment with apparent size.

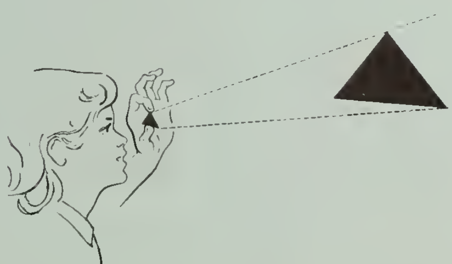
2nd Day—Read the middle section of article, make the astrolabe, and try it out.

3rd Day—Finish the article and work with additional examples involving objects in the room.

Before beginning. Review measuring angles with a protractor and drawing lines to scale. You may want to devote several arithmetic lessons to this.

Have on hand all the necessary materials. Each child should have a ruler, a protractor, and a coin, as well as pencil and paper. For the astrolabes, you will need enough balsa wood or other soft wood strips to go around, wood blocks for the base, straws, pins, and tape.

1st part of article. Reinforce the concept that the apparent size of an object varies with distance. Children should have an opportunity to work with a variety of objects to determine apparent size. Triangles that are identical in shape but different in size could be cut out of cardboard. Have your pupils hold small triangles at varying distances to block out larger, similar triangles held farther away.



A small triangle near the eye seems as big as a larger one farther away.

Working with the astrolabe. Have children who sit near each other compare their readings. To bring out the difference increasing distance makes, draw a large circle on the blackboard. Then have each child in a single row measure the circle and keep his answer to himself. Start at the back of the row and ask each child to report the angular diameter he finds.

The angles should increase, with the largest reading obtained by the pupil nearest the blackboard. After all the answers are in, most children will understand that angular diameter is larger when the sighting point is closer, and smaller when it is farther away.

Working out true size. It may be well to stress the terms "apparent size," and "true size" and establish their equivalence with "angular diameter" and "true diameter." Angular diameter, true diameter, and distance are interrelated. There is only *one* distance that an object can be to have a certain observed angular diameter from a given position.

Page 13: Brain-Boosters

The "Cross-Number Puzzle" includes many words that your pupils may not know. Here is a good opportunity to motivate them in the use of reference books. You might point out that finding information in books is a kind of puzzle, too. By looking up the unfamiliar words in a dictionary, children should be able to solve the puzzle.

Page 14: Measuring Earthquakes

Basic concept: The universe and its component bodies are in constant change, both physical and chemical.

Most children think of earthquakes in terms of death and destruction. Indeed, they are among the most terrible forces of nature man must contend with. However, as this article points out, they provide valuable information for scientists' investigations into the structure and composition of the interior of our planet.

This article will raise many questions about earthquakes. You may explain briefly that an earthquake is the cracking, shaking, and settling of the Earth's crust in some particular spot due to pressures underneath and within the crust itself. Most earthquakes occur in two belts—one around the rim of the Pacific Ocean and the other running across the Mediterranean area to the coast of China. Those occurring under water create enormous and destructive ocean waves incorrectly called "tidal waves." Their proper designation is *tsunami.* Hundreds of earthquakes are recorded each year, but usually only the disastrous ones are reported to the public.

An excellent book on the subject is *All About Volcanoes and Earthquakes,* by Frederick Pough, Random House, New York 1953, $1.95. Another is *Exploring Under the Earth,* by Roy A. Gallant, Garden City Books, Garden City, N.Y., 1960, $2.95.

Harry Milgrom, author of the book from which this article was adapted *(see page 14),* is Assistant Director of Science for the New York City Schools and Director of Science 1, a Saturday program for children at the School of Engineering, Columbia University.

What Is the Average CQ...

(Continued from page 1T)

come gullible and hallucinate when their visual, auditory, and tactile input is severely limited.

The evidence of deprivation symptoms, both in ways of behavior and in actual deterioration of brain cells, endows curiosity with a new significance. It appears as a fundamental drive, comparable to hunger—a direct need of the neuronic system, which is required for its maintenance and development.

In order to survive, a living being has to be sensitive to its environment and to react to it, to interact with it. In this sense curiosity may be regarded as a special and highly developed kind of irritability, and as a motivation to learning.

What Can Teachers Do About It?

The elementary school child needs an environment in which he can test reality with all his senses, in which he can manipulate things and effect changes to experience his increasing competence in the business of living. In our efforts to provide this environment, we face three major problems:

1. We need Centers of Learning Aids in every school system. No single school can, or need, afford the purchase and maintenance of all materials—things to look at, to touch, to handle, to listen to, to smell, and to taste. If we really want to preserve human resources, we have to prevent children from living in a world of sensory deprivation or of sensory chaos. Nature areas and wildlife refuges should be within the reach of every child.

2. We must not attempt to squeeze too much science into a school curriculum. Since it is impossible to "cover" everything from pebbles to stars, we may help children to uncover meaning in fewer topics.

3. Lastly, there is the matter of presentation. My personal experience in teaching children and in observing lessons suggests that every child ought to have access to manipulative materials in his science study.

Sometimes a couple of children may add to each other's progress and articulate thoughts in conversation. Yet every individual proceeds at his own pace. If three pupils are supposed to form a team, one of them gets easily excluded or chooses the role of a passive, casual observer.

There is no doubt a place for demonstration by the teacher, but I would not recommend that a topic be introduced by way of demonstration. It may lead to a pseudo-understanding of what goes on. Children have to come up against difficulties in their own exploration in order to appreciate a demonstration, to be better aware of significant points, to improve on their own techniques. In short, to learn more.

And finally, the actions (experiments and demonstrations) that become part of their experience must become internalized as thought; and thought improves when externalized in language ■

THE NEXT ISSUE of *Nature and Science* will be the second special-topic issue this semester.

The issue is devoted mostly to early man in North America—the peoples who lived on this continent for thousands of years before it was discovered by Europeans.

One article explores theories about how these people came to North America, how they lived, and what tools and weapons they used. Another shows how archeologists learn about prehistoric cultures by examining artifacts.

A *Nature and Science* wall chart shows children how to "talk" in Indian sign language.

nature and science

VOL. 1 NO. 7 / JANUARY 10, 1964

SPECIAL-TOPIC ISSUE

WHO WERE THE EARLIEST AMERICANS?

Where they came from, how they got here, and when they arrived are still science mysteries.

ABOUT THE COVER

The dancing Indians on our cover were painted in 1880 by Chief Turning Bear of the Brule-Sioux—one of many Plains Indian tribes.

These Indians roamed the great plains of North America, following the buffalo herds that they needed for food and clothing. They traveled on foot until, about 300 years ago, certain tribes began to ride horses that had been brought to America by Spanish settlers.

Once they had horses, the Plains Indians became expert riders, fighters, and buffalo hunters. They are the type of Indian we see most often in movies and on television. However, Plains Indians were only one of many groups of people who had been living in America a long time before people from Europe came here and settled.

But there were people living here long before the Plains Indians. The earliest ones of all hunted with crude spears and clubs. Bows and arrows—used by Plains Indians—were not introduced to America until about 2,000 years ago.

The stories that begin on pages 3 and 10 tell how scientists have used such clues as bones, spear points, and bits of pottery to trace the history of the first people to live in North and South America.

nature and science

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They came to this continent thousands of years before Columbus "discovered" it. We know a little about how they lived, but we don't know who they were, where they came from, or how they got here.

by Alfred Sundel

Who Were the Earliest Americans?

■ If someone were to ask you who discovered America, you would probably say, "Columbus." But when Columbus landed on islands near America in 1492, he found people already living there. We now know that there were many millions of people living in what was called the "New World."

Who were these people Columbus mistakenly called Indians? How long had they lived here? Where did they come from? Up to about 1927, *archeologists,* who trace the history of ancient people by studying the things they left behind, had traced the Indians back 4,000 years. Then something turned up that convinced archeologists that there were men in North America thousands of years earlier than that.

This article was prepared with the advice of Dr. Gordon F. Ekholm, Curator of Mexican Archeology, The American Museum of Natural History.

In 1927 a group of scientists from The Denver Museum of Natural History were digging near Folsom, New Mexico. They were investigating some deeply buried bones that turned out to be those of an ancient kind of bison, or buffalo, that roamed the area thousands of years ago. In the clay between two rib bones of one of these animals, they found an unusual type of stone spearhead known today as a *Folsom point.* Since then, scientists have learned that the kind of bison killed by this spear point had disappeared from the Earth about 10,000 years ago. The makers of this type of spear point, now called Folsom

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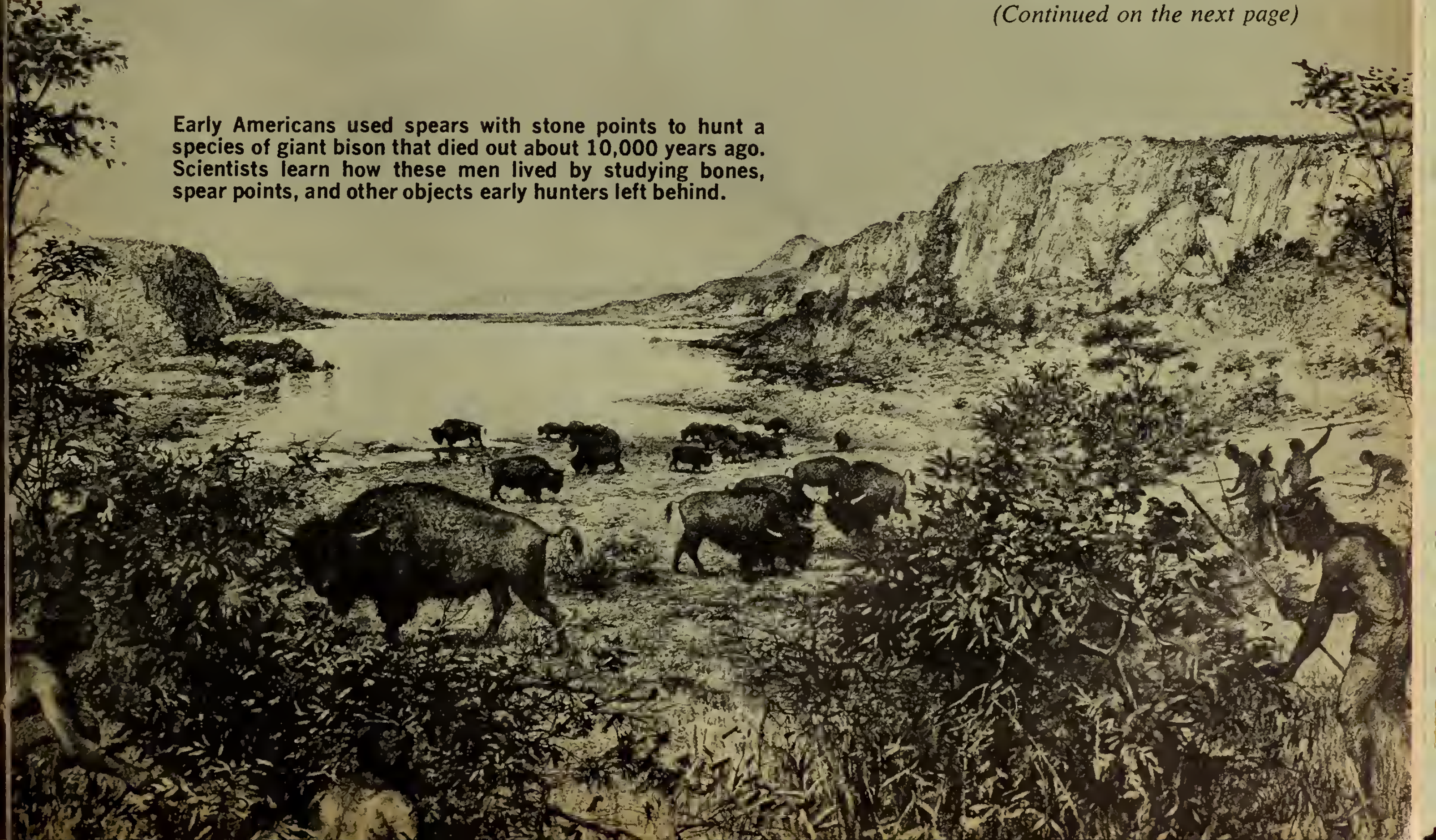
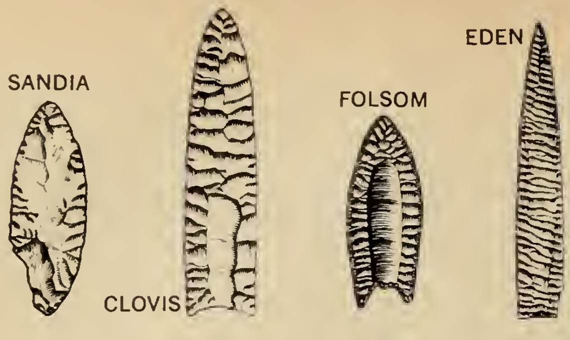


Early Americans used spears with stone points to hunt a species of giant bison that died out about 10,000 years ago. Scientists learn how these men lived by studying bones, spear points, and other objects early hunters left behind.



Early hunters chipped stone to form spear points. Sandia points, the oldest found in America, have a crude shoulder for attaching to the spear shaft. Clovis points have rough slots for this purpose. Folsom points, about 10,000 years old, are more finely shaped and slotted. Eden points made over 7,000 years ago are narrow and unslotted.

Man, must have lived before these bison died out *(see "Dating the Past," page 10).*

In 1936, another important find pushed back the time of early man in America even further. Archeologists from the University of New Mexico explored a cave in the Sandia Mountains of New Mexico. The cave had been discovered by Boy Scouts. As the scientists dug down through different layers of dust and soil, they found objects left by men who lived in the cave at different times. In one layer there were Folsom spear points among broken animal bones.

The men dug still deeper. They went through several layers of soil that had been laid down over many thousands of years. As they dug, they found more bones and teeth of animals like those that were hunted by Folsom men. With these bones, they found remains of an ancient campfire and some flint spear points.

Sandia points, as these are called, are not as finely shaped as Folsom points. They were probably made by men who lived much earlier than Folsom men—perhaps as long as 20,000 or more years ago. Sandia-type spear points have also been found in Tule Springs, Nevada. The teeth and scraps of bone found with those points have been identified as those of a camel that lived more than 25,000 years ago, then died out.

What little we know about these early men we have learned by studying their remains—spear points and other tools, parts of skeletons, grinding stones, and other things that do not easily decay. Scientists have found many of these remains and are still putting together the bits and pieces of information. It is like a jigsaw puzzle with many pieces missing; the picture they have put together so far only hints at the whole story.

What Skeleton Remains Tell Us

From skulls that have been found, we know just a little about what some early men in North America looked like. Many of the skulls are shaped something like those of the primitive peoples of Australia and Melanesia (as New Guinea, and the nearby islands are sometimes called). But the earliest known skull of a North American, found in Minnesota, is more like those of present-day North American Indians. It is believed to be about 11,000 years old.

We do not know of a single skull from the hunters who left the finely shaped spearheads behind—Folsom men. Possibly these men put their dead on open-air platforms, which protected the bodies from some animals, but not from the weather.

The oldest skull found in Middle America was unearthed near the town of Tepexpan, Mexico. Tepexpan men lived at the same time as Folsom men but were less expert at making spearheads.

No human bones found in South America are as old as Folsom men or Tepexpan men. The charred remains of human bones found in a cave near the southern tip of

Scientists have found very few skeletons of early hunters who roamed America. One reason is that these people probably did not bury their dead. Instead, they may have put them on open-air platforms like this one built by Plains Indians who lived much later.

South America date back about 8,500 years ago.

No one knows exactly where the first Americans came from. Most likely, they came from Asia by crossing Bering Strait. Today the northeastern tip of Asia is only 56 miles across Bering Strait from Alaska. In the middle of the strait are some small islands. The longest stretch of open water is about 23 miles, so even now men can cross the ice when the strait is frozen over.

The men who came to America from Asia thousands of years ago could have made the crossing on foot over the ice. But they might have crossed by land. During the last Ice Age, a lot of water from the oceans was frozen in glaciers that covered much of the northern part of the Earth. The water level of the oceans was so low that a "bridge" of land must have linked Alaska and Asia. The first men to reach America might have wandered across this land bridge in search of large animals which they killed for food.

No one is certain, though, whether the crossing was made over ice, water, or land. By about 10,000 years ago, the glaciers had begun to melt and much of the water flowed back into the oceans. The Pacific Ocean covered the land bridge except for high parts that now form the three Diomede Islands. Anyone crossing Bering Strait as late as then must have crossed either on ice or by boat.

Besides those early men who used the pathway at Bering Strait, some people may have reached America by crossing the oceans. Men from the Pacific Islands, or from southern parts of the Asian continent itself, may have crossed the Pacific at different times on rafts or in boats. But such crossings took place thousands of years after men reached America by crossing Bering Strait.

Scientists believe that the first men in America came across Bering Strait from Asia many thousands of years ago. Later, other peoples may have sailed across the Pacific Ocean to America. The Eskimos probably crossed from Siberia to Alaska about 2,000 years ago. One group of explorers—the Vikings—landed in Newfoundland 500 years before Columbus's voyage.

It is also possible that a ship from Europe might have reached America's shores. Only recently archeologists working in Newfoundland discovered an old settlement. They think that the settlement marks the home of men—Vikings—who crossed the Atlantic from northern Europe about A.D. 1000. This was 500 years before Columbus came to America.

The Trek Southward

The men who first came to America were accustomed to living in the Arctic. They increased in numbers and gradually spread outward as they wandered in search of game.

In that dim past, the way southward from Alaska was blocked in part by the great Canadian ice sheets. Through gaps in the ice, some early men must have traveled southward. Others probably traveled southward right over the ice by following game animals they needed for food.

Over the years, archeologists have found weapons and other remains of early men alongside the bones of animals. These finds tell them that early men in America hunted huge mammals, most of which have long since disappeared from the Earth. They tracked and killed the cold-climate mastodon, the bison, and the mammoth.

Hunters left different types of spearheads and other weapons scattered from Alaska to Ecuador. The weapons tell us that, by 8000 B.C., people in different places in America lived in different ways. In some places, men were expert big-game hunters; in others they lived on small game and fish.

But not all early men were hunters. Some were *food*

(Continued on the next page)

Huge mastodons were hunted by early Americans. Scientists believe the last of these elephant-like animals died out about 6,000 years ago. Their remains have been found in South America, Alaska, and near the Great Lakes.

gatherers. They ground seeds, nuts, acorns, roots, and berries into pulp on flat or hollowed stones, called *mortars.* We know about these people because they left many mortars behind. One early group of food-gathering people lived in the Channel Islands, off the coast of southern California.

How Early Men Became Farmers

Over thousands of years, some men gradually developed a new way of life. This was farming. It brought great changes to the early Americans. These people did not learn overnight how to grow their own food. Their first efforts may have been simply to clear weeds away from food plants. While tending such simple gardens, early man must have learned how to plant seeds himself. It was a long, slow process. Long enough, in the end, for Indians to grow 700 varieties of corn on thousands of square miles of land by 1492!

The first signs of farming in the New World have been found in Mexico and date back to about 7000 B.C. By 2000 B.C., farming life was well established from Mexico to Peru. Gradually it spread north to North America and east to the lowlands of South America.

Farmers turned to the aid of their gods when their crops failed for lack of rain. They built mounds and temple pyramids to the gods. The religious farmers came to be ruled by priest-kings, who studied the skies for signs from the gods.

The Rise of Temple Cities

In Middle America and Peru, huge ceremonial "cities" were built by the people, directed by their priest-king rulers. One great Middle American city was Teotihuacan. Its name means "Place Where the Gods Dwell," and its ruins are near modern Mexico City. It became a religious center 500 years before the people known as the Maya built their great temple cities farther south. But when the early Maya cities mysteriously fell, just before A.D. 900, Teotihuacan also fell. Exactly why, we do not know for sure.

While the Indians of South and Middle America were building temple cities, most of the Indians in North America were still living by hunting, fishing, and food gathering. The Southwest and the lower Mississippi Valley

Many Eskimos still wear clothing made of animal skins and build homes of snow and skins, as their forebears did.

were exceptions. The Southwest was to become the third most thoroughly farmed area in the Americas. The first two were Middle America and Peru. In the Eastern Woodlands, some Indians raised crops, but they usually got at least half their food by hunting or fishing.

The Eskimos Came from Asia Much Later

Most scientists believe that another group of people began crossing over from Siberia about 100 B.C.—the Eskimos. They came in great numbers and may have been the first people to bring the bow and arrow to America. The Eskimos are a Siberian people who came from a different area than the earlier Americans. They settled in Alaska, then some of them moved eastward along the northern fringe of North America.

Eskimos continued to come from Siberia until there were more than 100,000 of them in America. Today there are only about 35,000 Eskimos. Some may have wandered south after reaching Hudson Bay, in the middle of the continent. These Eskimos appear to have become members of Great Lakes Indian Tribes, and they may have brought with them the idea of picture-writing. Other Eskimos circled north of Hudson Bay and reached Greenland about A.D. 1300—a remarkable journey of some 6,000 miles.

The Indians Lived Many Different Ways

While the Eskimos were moving eastward, the differences between Indians of different regions continued to grow. In Peru, Indians became skilled potters and weavers. In Middle America, the Maya perfected a calendar that was more accurate than the one used in Europe at that time.

In California, several tribes wove remarkably fine baskets of plant fibers. In the Eastern Woodlands, Indians built thousands of mounds of earth for ceremonial platforms, or to bury their dead. Some of the mounds were very large and shaped like birds or snakes. In the Southwest, Indian farmers used irrigation and adapted many food plants to grow in the semi-desert. About 1,200 different versions, or *dialects,* of 160 major languages were spoken by Indians in different parts of the Americas.

By 1492, when Columbus came to America, there may have been 15 million or more people here. Only about 900,000 lived in North America. About 500,000 fished and farmed in the West Indies. Probably 6 to 7 million lived in the most heavily farmed area, Peru.

Over the past 50 years we have learned much about early men in the Americas. But the picture is still far from complete. It will take much more careful digging, development of new methods for studying and dating remains, and perhaps some lucky finds before we get a clear-cut answer to the question, "Who were the earliest Americans?" ■

■ If you want to find out more about early Americans, look for these books in your library or bookstore: **Home of the Red Man,** by Robert Silverberg, New York Graphic Society Publishers, Ltd., Greenwich, Conn., 1963, $3.95; **The Earliest Americans,** by William Scheele, The World Publishing Co., Cleveland, 1963, $2.75; **The North American Indians,** by Ernest Berke, Doubleday & Company, Inc., New York, 1963, $3.75; **Stones, Bones and Arrowheads,** by Terry Shannon, Albert Whitman & Company, Chicago, 1963, $3.

Indians of Middle America worshipped their gods from huge temples. An artist drew this temple "city" called Tenochtitlan from descriptions written by early Spanish explorers.

talking hands

■ One of the most colorful and exciting groups of American Indians were the tribes that roamed the Plains—Sioux, Crow, Cheyenne, Apache, Mandan, Blackfoot, and many others. Each tribe spoke a different language, but the Indians had a way of "talking" with their hands, and this sign language was understood by every Plains Indian tribe.

Sign language was so successful that even tribes that lived near each other never bothered to learn each other's spoken language. They depended on sign language instead. The Indians could "talk" for hours without speaking.

Sign language differs from English and other spoken languages in several ways. Words like *a, the, an, it,* are not used, and adjectives follow nouns (*chief great* instead of *great chief*). If an Indian wanted to ask "What is your name?", he would make the signs for *question-you-called.* The sign for "question" (*see chart*) can mean *what, where, why,* or *when.*

To "talk" about time, the Plains Indians made signs for nights or sleeps (days), moons (months), and winters (years). A person's age was so many winters.

You can probably guess the signs that were used for many words. How would you say *bird* in sign language? The Indians did it by holding their hands out flat near their shoulders and flapping them like wings (*see chart*). A slow motion of the hands means *large bird,* and fast motion means *small bird.* For *rabbit,* the Indians showed the height of the animal and then gave the sign for *jump.* For *run,* they gave the signs for *walk* and *fast.*

Not all of the signs are as easy as these to figure out. If you wanted to make a sign for *think,* you would probably point to your forehead. However, when sign language began long ago, the Indians believed that thinking and understanding were done with the heart and they made a sign meaning *drawn from the heart,* as shown in the chart.

The diagrams on these pages show 56 of the signs used by the Plains Indians. By learning them, and perhaps inventing some of your own, you and your friends can "speak" your own secret language. You can test your skill by trying to read the sign language story on page 16 ■

Two books on Indian sign language: **Universal American Indian Sign Language**, by William Tomkins (available for $1.60 from William Tomkins, 3044 Lawrence Street, San Diego, California) and **How—Sign Talk in Pictures**, by Iron Eyes Cody (available for $.75 plus postage from Homer H. Boelter Lithography, 828 N. La Brea Avenue, Hollywood 38, California).

BRAVE

BROTHER
Tips of fingers ogoinst lips, ond move them straight out. Then moke sign for MAN.

BUFFALO
Horns of buffalo.

CANNOT
Bounce right index finger off left palm.

CARRY
Heovy bag held over shoulder.

CRY

DAY

DRINK or WATER
Cup right hond like this.

EAT

FAST
Poss right hand quickly by left.

GREAT or BIG

HAT
Hold right hond over heod, then lower it over forehead.

HUNT
Make this sign ofter sign for WOLF.

I or ME

JUMP

LIE
Speaking with two tongues, or o forked tongue.

LISTEN

LITTLE

MAKE or WORK
With honds slightly apart make chopping motion.

MAN
(SON – same sign, then lower hond to show child's height.)

NIGHT
Hold honds flot, move right hand over left.

ONE

100
Hold honds like this by right shoulder; swing them to left ond down.

QUESTION
(Can meon WHAT, WHERE, WHY, or WHEN.)
Turn right hand from side to side 2 or 3 times.

RIVER
Moke this sign ofter sign for WATER or DRINK.

SUNRISE
(GOOD MORNING – moke signs for SUNRISE, DAY, and GOOD.)

TALK or SPEAK

THANK YOU
Sweep honds out ond down toward person.

THINK

TRADE or EXCHANGE

WITH

WOLF

WOMAN
Motion of combing hoir. (WIFE – signs for WOMAN ond MARRY.)

YESTERDAY
Moke sign for NIGHT, then turn right hond owoy from left and turn right polm up.

YOU
Point ot person.

Scientists who study early man must dig carefully. The position of a buried object may be a clue to its age.

DATING THE PAST

by Laurence Pringle

■ For the past 70 years scientists of The American Museum of Natural History have been searching for "buried treasure." The "treasure" is not one of gems or gold. Instead, it is the remains of long-lost camp sites, tools, weapons, and bones of men who lived in America thousands of years ago.

To learn about early man in America, scientists from the Museum have been searching in Mexico, Brazil, Peru, and many parts of the United States, including Alaska. Right now, Dr. James Ford of the Museum is on a one-year expedition in Mexico looking for more clues about early man in America. Only recently Dr. Ford returned from Arkansas and Louisiana, where his group found thousands of spear points to study and to add to the Museum's collection.

What do scientists hope to learn by studying tools, weapons, and other remains of men who lived many thousands of years ago? For one thing, they can find out which parts of America men lived in first, and when they lived there. The kinds of tools and weapons found also tell scientists whether the early Americans were hunters, farmers, or both *(see article beginning on page 3).*

When scientists study the objects they unearth, one of the many questions to be answered is "How old is it?" Finding the age of a piece of human bone, a bit of charcoal from an ancient fire, or an arrowhead can give us many clues about past life.

If a scientist can date a spear point found at a camp site and say that it is 5,000 years old, he then knows that men were living in the area at least 5,000 years ago.

This article was prepared with the advice of Dr. James A. Ford, Curator of North American Archeology, The American Museum of Natural History.

Sometimes, scientists can say fairly accurately that an object is, say, 10,000 years old. At other times, however, they can say only that one object is older or more recent than another one; they may not know the actual age of either object. Here are some of the different methods used to find the age of bones, pots, and other objects.

Botanists (who study plants) and *zoologists* (who study animals) sometimes are asked to help identify a bit of wood, or a bone from an animal. The animal bone may have been found alongside a man's skeleton or a tool or other man-made object. Scientists can find out when the man lived if they know when that type of animal lived.

For example, not long ago people thought that Indians had lived in America for about four thousand years before Columbus's voyage in 1492. But in 1926, a scientist from The Denver Museum of Natural History made an important discovery near Folsom, New Mexico. He found a spear point next to the bones of a long-extinct giant bison. Zoologists believe that the giant bisons died out about 10,000 years ago. Here was evidence that men had roamed America at least 10,000 years ago.

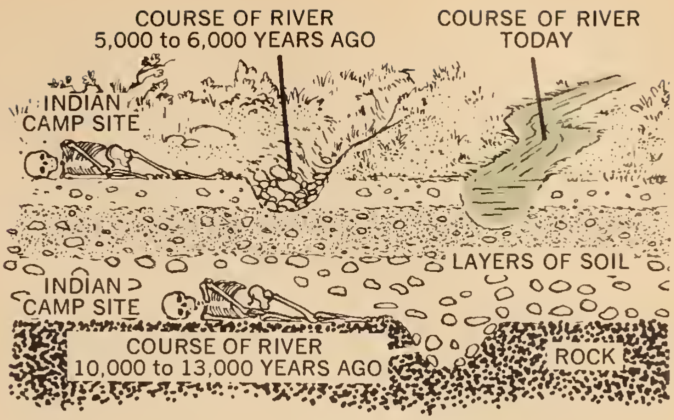
When the Denver Museum scientist announced his discovery, other scientists thought that the spear point and bones had come together by accident. They thought that the spear point might have fallen down an animal's burrow and landed beside the buried bones of the bison. However, in 1927 another spear point was found—this time between the ribs of another giant bison. And still later, scientists found a spear point sticking into a bison bone. These discoveries settled the question.

Glaciers and Ancient River Beds

Geologists, who study changes in the Earth's crust, also help find the age of early man's remains. First of all, they know that about 13,000 years ago great ice sheets, or glaciers, covered parts of North America. Geologists can also figure out what the glaciers did to plant and animal life, how they formed lakes and changed river beds. All of these changes affected the lives of people living then.

Scientists now believe that so much water was locked up in glacial ice 13,000 years ago that the sea level all over the world dropped about 450 feet. This meant that where rivers emptied into the sea they ran down slopes much steeper than we have today. This caused the rivers to run swiftly, and the force of their waters cut deep channels into the soil and rocks.

As time went by, however, the glaciers melted and the sea gradually rose again. It reached its present level about 5,000 years ago. As the sea level rose, the rivers flowed more slowly. The valleys they had cut began filling up—first with gravel, then with sands, silts, and clays that were carried by the river water and dropped to the bottom.



This cross-section of a river valley shows how a river changed its course through thousands of years. Scientists have traced these changes to find the age of the Indian objects found beside the old river courses.

During this time, the Mississippi, Ohio, and other rivers changed their courses many times. The dried-up channels of rivers and streams that have changed their courses are good hunting grounds for scientists, because men camped along the banks when the streams were flowing.

Last summer, Dr. Ford searched for ancient Indian villages in the Mississippi River Valley, as he has for many years since 1927. Most of the camp sites discovered by Dr. Ford last summer were used between 5,000 and 6,000 years ago. When he discovers one of these old camp sites he knows the age of the objects he finds because he knows when the stream was flowing *(see diagram).*

Dr. Ford also learns something about the age of his discoveries by digging into huge mounds of earth built by certain Indians. Some of these mounds were burial grounds, others were the sites of temples for worship. On still others, the Indians built their homes. Many of these mounds were built up gradually by different groups over hundreds of years. They are made of several layers of earth, each layer containing the remains of a certain group of Indians.

By carefully digging a trench through a mound, scientists can tell something about the age of the objects they find. The objects found near the bottom of the mound are older than the objects found in the upper layers.

How Long Is a Half-Life?

About 15 years ago, scientists at the University of Chicago discovered a new way of dating certain objects that are many thousands of years old. A rare type of carbon, called *carbon-14,* is in all plants and animals.

When an animal or plant dies, it stops collecting carbon-14. The carbon then begins to break down and

(Continued on the next page)

Dating the Past (continued)

gradually disappear. No matter how much carbon-14 a dead plant or animal may have, it takes about 5,600 years for half of its carbon-14 to disappear. (This period of time is called the *half-life* of carbon-14.) It then takes another 5,600 years for half of the remaining amount to disappear, and so on. By measuring how much carbon-14 is left in a piece of dead wood, for instance, scientists can figure out how long ago the wood was a living plant.

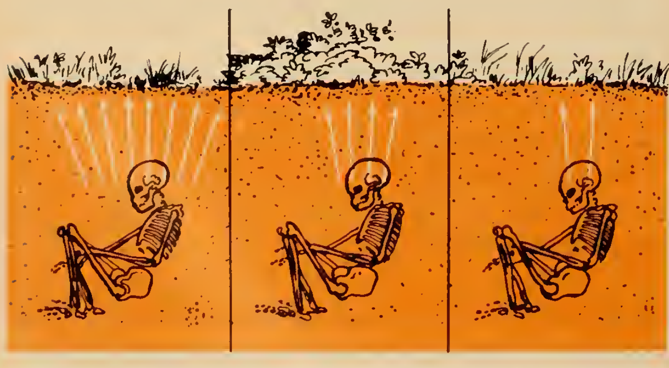
In his studies of the Indians of the lower Mississippi River Valley, Dr. Ford has found spear points, pottery, woven baskets, and charcoal from fires. He has also found skeletons and clay balls that were heated and used to cook food. Dr. Ford has been able to date his discoveries and trace the development of Mississippi River Valley Indians by using several dating methods—carbon-14, studying old river courses, and the different layers of Indian mounds.

The Indians Who Disappeared

He has found that some men living in the area—from about 10,000 to 2,500 years ago—were hunters, fishermen, and food gatherers who settled in one place only if there was enough food nearby. The men who lived in the lower Mississippi River Valley from about 2,500 to 1,100 years ago set up farming communities and were more settled than those of the people who lived there earlier. These farmers were some of the early mound builders.

About 1,000 years ago, Indians of the Mississippi River area had larger settlements and farms. They had bows and arrows, and they worshipped the Sun from wooden temples built on mounds. Most of these Indians died about 400 years ago from diseases brought to America by the earliest European explorers.

Each new clue found by scientists—whether a spear tip or a cooking pot—tells us something about the way early men lived. It is the scientist's job to piece all of these clues together into a picture of the past ■



When a plant or animal dies, it begins to lose a substance called carbon-14. It loses half of its remaining carbon-14 each 5,600 years. Scientists measure the amount of carbon-14 left in the remains of the plant or animal to find out how long ago it lived.

BUILDING YOUR OWN SOLAR SYSTEM

■ The problem now (you think to yourself on your tropical island) is to figure out the distances to the planets. From night to night you watch them moving among the stars and you wonder about them—how far away are they? How large are they?

A German astronomer named Johannes Kepler made an accurate scale model of the Solar System in the 1600s. Even though he did not know the actual distance to a single planet, he was able to draw a map of part of the Solar System. His map showed very accurately how far away from the Sun the planets are.

To find out how Kepler made his map, let's begin with the planet Venus. Say that we first observe Venus when it is crossing the Sun's disk, as shown in the diagram. As Venus continues in its orbit, it moves away from the Sun through positions 2, 3, 4, and 5. Next it appears to stop moving, then reverses its direction. This is because it is beginning to circle around behind the Sun.

When Kepler studied the many records left by his teacher, Tycho Brahe, he found that Venus never moved very far away from either side of the Sun. It never made an angle with the Sun wider than 48° (*see diagram*). This was important information for Kepler. With it he was able to begin working out his scale model.

If you made the same observation from your tropical island, here is how you could begin your model. You

This is the seventh in a series of articles adapted by permission of the Elementary-School Science Project from the revised edition of its booklet, Astronomy: Charting the Universe, *© 1962 by the Board of Trustees of the University of Illinois.*

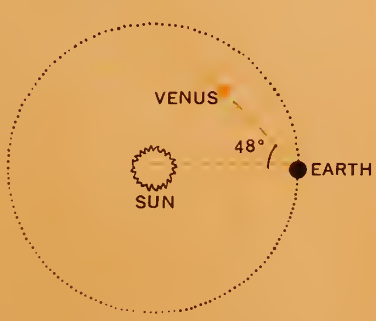
Seen from the Earth, Venus appears to move back and forth across the Sun, but no farther than 48° to either side.

could make a circle four inches, or four feet, in diameter and put the Sun in the center. The rim of the circle is the Earth's orbit, and you could put the Earth any place on its orbit-circle. Now let's say that the distance from the Sun to the Earth is *one*. Not one inch or one mile, just plain *one*. But if you want to call it *one* something, then call it one *astronomical unit*, as astronomers do.

Your problem now is to give Venus an orbit. If you can, you will know how much closer Venus is to the Sun than the Earth is. (It is like saying that you are about twice as tall as the kitchen chair even though you don't know how many inches high the chair is.)

Draw a line from the Sun to the Earth. With the Sun-Earth line as one side of an angle, draw the other side so that you make an angle of 48°; this was Tycho's figure, remember. Now all you have to do is make another circle, whose rim falls exactly on the Venus-Earth line, as shown in the diagram. This circle is the orbit of Venus.

At this stage, you know that the distance from the Sun to the Earth is *one*. And by measuring you can find out

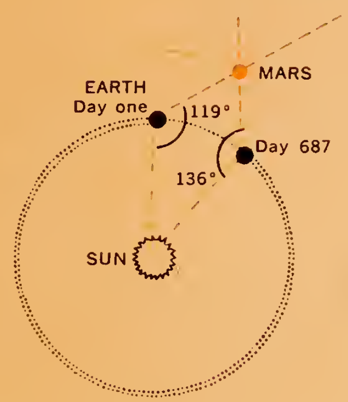


Kepler's plan for working out the orbit of Venus.

that the distance from the Sun to Venus is less than one (0.7, as Kepler found).

Kepler next wanted to fit Mercury into his model. Like Venus, Mercury also lies between the Earth and the Sun. This meant that Kepler could plot Mercury's position in the same way he plotted that of Venus. Knowing that Mercury's greatest angular distance from the Sun is 24°, all Kepler had to do was make a second angle for Mercury's orbit, then measure Mercury's distance from the Sun. It came out to 0.4.

If you have drawn a circle and plotted Venus's and Mercury's positions, you now have a scale model of the orbits of the inner three planets of the Solar System. But what about the planets that lie beyond our own?



Kepler's plan for working out the orbit of Mars.

Finding the Distance to Mars

Plotting the distance to the outer planets was a bit trickier. Because they lie beyond the Earth, we see them move in a way quite different from the way we see Venus and Mercury move.

Tycho's records showed Kepler that Mars takes 687 Earth days to circle the Sun once. With this information as his starting point, here is how Kepler worked Mars into his scale model.

Again, draw a circle four inches, or four feet, in diameter and put the Sun in the center. Now put the Earth any place along the orbit-rim of the circle. Once again, the distance from the Sun to the Earth is *one*. What Kepler had to do next was figure out how far the Earth moved in its orbit during one Martian year of 687 days. He knew where Mars would be at the end of that time (back in its original position), but where would the Earth be?

Say that we observe Mars on "Day one" shown in the diagram. We know that 365 days later the Earth will be

(continued on the next page)

back in exactly the same position. But it has 322 more days to travel before Mars will be back in *its* original position. As the diagram shows, during these 322 extra days the Earth nearly completes a second trip. When the Earth is in its "Day 687" position, then Mars will be back in its original position.

When he had worked this out, Kepler easily solved the rest of the problem. From Tycho's records Kepler knew that when the Earth was at the "Day one" position, Mars made an angle of 119° with the Sun. And at the "Day 687" position of the Earth, Mars made an angle of 136° (*see diagram*). Now all Kepler had to do was draw these angles. Where their sides crossed was the orbit of Mars.

Kepler's final step was to measure the distance from the orbit of Mars to the Sun. It came out to 1.5, which meant that Mars was half again as far from the Sun as the Earth is. To find the distances of Jupiter and Saturn, Kepler did exactly the same thing he did for Mars and was able to plot the orbits of those two planets. Kepler's model of the Solar System had to end here. The last three planets—Uranus, Neptune, and Pluto—had not been discovered during Kepler's time.

Finding the Scale of Your Model

What you want to do now is give your Solar System model a scale in miles. All you know now is the *relative* distances of the planets (*see box*). If you knew the actual distance of any one of them it would be easy to work out the actual distances for all of them.

Today we know that the Earth is about 93 million miles away from the Sun. Now that you know this distance, you can easily work out the actual distances to the other planets. For example, to find Mercury's distance from the Sun, all you do is multiply 0.4 × 93 million miles.

When you have worked out the actual distances in miles to the rest of the planets, will your scale model be complete? No. To complete it you will have to know the size of the planets and of the Sun. As we saw in "Measuring the Universe 6" (N & S, *December 6, 1963, page 11*), astronomers can measure the angular diameter of distant objects. Since he knows the actual distances to the planets, all the astronomer has to do is measure their angular diameter. He can then work out their sizes (*see box*).

Using the diameters and distances of the planets given here, see if you can make a scale model of the whole Solar System. You may be in for a surprise. If you let five inches represent 100 million miles, the Earth would be a little less than five inches from the Sun. Pluto would be about 17 feet away.

Suppose that you want to show the sizes of the planets as well. Since five inches represents 100 million miles, one inch is 20 million miles, and one-hundredth of an inch is 200,000 miles. What we have to do is work our way down to the diameter of the Earth (8,000 miles). Using our present scale, the Earth would be about two-thousandths of an inch across! And the Sun would be about a twentieth of an inch across! Jupiter, the largest planet, would be only two-hundredths of an inch across.

A Football-Field Solar System

Let's try a different scale for the model, but this time give ourselves more space—a football field. If we let one inch represent 160,000 miles, the Earth would be a tiny ball one-twentieth of an inch across at about 50 feet from the Sun. As you continued with the other planets, you would find that the most distant ones would not fit on the football field. Saturn would be a small sphere less than a half inch across and nearly 500 feet away from the Sun. Pluto would be the size of a period(.), about a fiftieth of an inch across, and would be almost half a mile from the Sun! This is nearly nine football fields end to end!

Think about your scale model. Can you make one even larger? If you live in a large city, you might position the Sun at city hall and let the Sun be 10 feet in diameter. On this scale Mercury would be about a half-inch across and its orbit would lie 400 feet down the street. How far away would Pluto be on this scale? Do you think its orbit would lie within your city limits? ■

DISTANCE OF THE PLANETS FROM THE SUN IN ASTRONOMICAL UNITS

	Kepler's Figures	Modern Figures		Kepler's Figures	Modern Figures
Mercury	0.4	0.38	Saturn	9.5	9.53
Venus	0.7	0.72	Uranus	—	19.18
Earth	1.0	1.00	Neptune	—	30.06
Mars	1.5	1.52	Pluto	—	39.44
Jupiter	5.2	5.20			

DIAMETER IN MILES OF THE SUN AND PLANETS
(at their equators)

Sun	864,000	Jupiter	88,700
Mercury	3,100	Saturn	75,100
Venus	7,700	Uranus	29,200
Earth	7,920	Neptune	27,700
Mars	4,200	Pluto	3,600 to 8,700 (?)

In the next issue of *Nature and Science* we will take you on a trip through the universe, to stars and galaxies billions upon billions of miles away. From these vast distances the Solar System itself will shrink to the size of a grain of sand.

CLIMBING WATER

by Robert Gardner

■ How does a paper towel "soak up" water? How does a blotter "pull up" ink? If you do the experiments shown here, you may be able to answer these questions. And perhaps you will come up with some new questions of your own that you will want to explore.

Cut a strip about three inches wide and two feet long from a roll of paper towels. Hang the strip so that one end dips into some colored water. You can color the water with a few drops of ink or food coloring. You can hang the strip up by taping it to a cabinet over the kitchen counter. Or you could stick it to a chair if you put the water container on the floor. You might even like to build a "water soaker-upper" machine like the one shown on this page.

Watch what happens to the strip for five minutes after you dip it in the colored water. Leave the strip in the water for 24 hours. Then look at it again. What has happened? Next, try the same thing with different types of cloth, paper, blotters, and other things you think might work. What differences do you see?

Now try something different. This time wrap a piece of waxed paper around a strip of paper towel. The paper towel should stick out of the bottom of the waxed paper covering so that it dips into the water (*see diagram*).

What happens to this strip that did not happen to the uncovered one?

What causes the water to rise up a paper towel, a piece of cloth, a blotter? If you have a microscope you might like to look more closely at a piece of paper towel, blotter, or piece of cloth. Tear it and look at the edge. You will see many tiny threads, called *fibers,* which are packed so closely together that usually we do not notice them.

Here is a clue that should help you understand why these closely packed fibers cause water to rise up a towel. Take two straight-sided drinking glasses and place them in a tray of colored water. You can make a tray by cutting a half-gallon milk carton the long way (*see diagram*). Bring the *sides* of the two glasses *very* close together. As you do so, notice what happens to the water level between the glasses.

If you can get two pieces of flat glass you can do this experiment another way. Put a thin strip of wood between the plates of glass at one end and tape the glass at both ends to form a thin wedge-like structure (*see diagram*). Place this in a tray of colored water. What do you see?

Do you now see how water moves up paper towels and other such materials?

Take two wet paper towels. Hang one in the air. Place the other in a closed glass jar. Which one dries faster? Why?

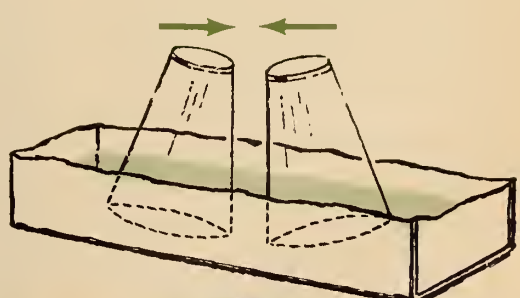
Can you now see why water rises to different heights in the covered and uncovered paper towels? ■

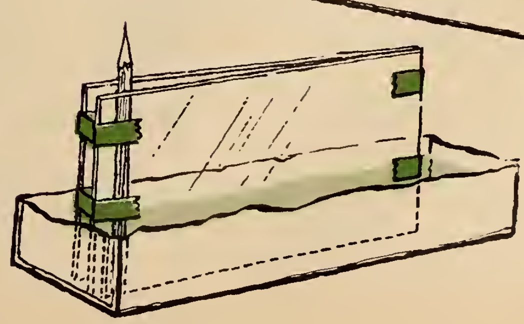
INVESTIGATIONS

1. Dip strips of paper towel in different liquids—soapy water, cooking oil, salt water, and alcohol. What happens?

2. Dip strips of different widths in colored water. How does the width of the cloth change the height to which a liquid rises?

3. Can you think of a way to move water from one dish to another or to the sink without pouring? Try it.





brain-boosters

■ Talking Hands

Two Indians from different tribes met one morning and had the following conversation in sign language. Using the chart of sign language *(pages 8 and 9),* see if you can figure out what the Indians said to each other. (Read from left to right. Blank space is the end of a sentence.)

Solutions to brain-boosters appearing in the last issue of Nature and Science

Cross-Number Puzzle solution:

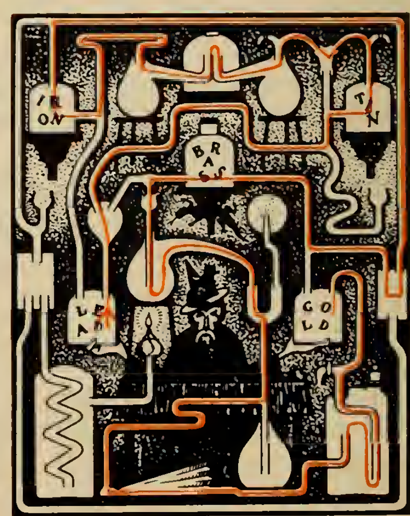
A 1	B 3		C 6		D 3	2
	E 3	F 1	4	G 1	6	
		0		4		
H 5	J 0	0		K 4	L 9	M 2
N 9	0				P 9	1
Q 1	9	R 2		S 3	6	6
		1		6		
	T 5	2	U 8	0	V 0	
W 1	6		7		X 5	0

Brothers and Sisters: There are four brothers and three sisters in the Claus family.

Cutting the Cake: To avoid having the last piece of cake and doing the dishes, Mike should cut only one inch of the cake's circumference for his first slice. After Bob cuts his slice, Mike should cut his second slice so that his two slices and Bob's slice add up to 4 inches. From then on Mike must be sure that he cuts his slices so that the total taken is 7, 10, 13, 16, and 19. Then Bob will have to take the last one-inch slice and will have to do the dishes. (But he will also have more cake than Mike.)

The Christmas Gifts: Tom paid an average of $.50 for each gift, while Roy paid about $.53 per gift.

Archie the Alchemist: Archie followed this route to make gold from lead, iron, brass, and tin.



nature and science VOL. 1 NO. 7 / JANUARY 10, 1964 TEACHER'S EDITION

N&S VIEWS

New Science Books for Children

ADVENTURING IN ARCHAEOLOGY, by C. A. Burland. Frederick Warne & Co., Inc., 1963, $2.95; 62 pp., illus.

This will be an interesting book for those who would like to learn something about what archaeologists do. It gives this information by telling the story of a number of excavations in many parts of the world that have been important in learning about the history of man.

The excavations described include some made in sites that were occupied by the hunters of the early Stone Age, some in villages of the early farmers, and others in the remains of the more highly developed early civilizations. The reader will get some idea of the various problems faced by the archaeologist, as well as a general view of the history of man's culture.

Many good illustrations of excavations and of the objects found in them are included. In the main the book is a good, accurate account of how archaeologists work and of what they find.

Several projects suggest how one can make some of the things that archaeologists study. One explains how to make a Peruvian loom, but I doubt that the instructions are clear enough to insure any success.—GORDON F. EKHOLM, *Curator of Mexican Archaeology, The American Museum of Natural History*

HOW ANIMALS LIVE TOGETHER, by Millicent E. Selsam. William Morrow & Co., 1963, $2.75; 95 pp., illus.

The subject of social relationships among animals is a highly complicated one, and it has a very extensive literature. Only a brave author would attempt a condensation of this mass of material. But the excuse is a valid one in this case. Children should be introduced to the fact of the existence of myriad social actualities in their unfolding world.

This experienced writer has provided an excellent digest and explanation of these superficially puzzling social relationships. Unfortunately, instead of the illustrations graphically extending the textural explanations, they simply take up needed space.

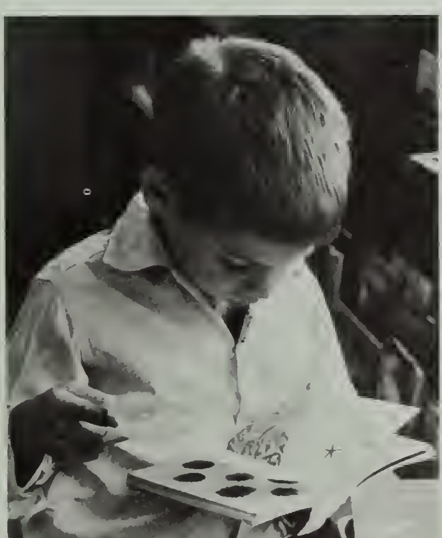
The book presents a wealth of ideas on the many faceted subject of "togetherness" in vertebrate and invertebrate animals. The child learns how patient observation and research teach us the facts of how animals live together.

There is also a bibliography and an index.—HOBART M. VAN DEUSEN, *Assistant Curator of Mammalogy, The American Museum of Natural History*

THE RACCOON'S YOUNG ONES, by Irmengarde Eberle. Abelard-Schuman Limited, 1963, $2.95; 61 pp., illus.

This charming book on raccoons, one of our most interesting North American mammals, typifies the serious attempt of our better authors to give children factual information and an understanding of animals. The book is a successful marriage of text, illustrations, and good photographs.

Beginning in early spring we follow the female raccoon in her search for a nesting hollow. The birth and training of the young carry us through the summer and autumn. Adventure and misadventure come in rapid succession. The seasons of abundance pass, and the problems of survival in winter are described. There is no attempt to sentimentalize the life of the raccoon. Children who read this book should come away with heightened sensibility for their mammal neighbors.—H. M. VAN D.



DICK LEBOWITZ EDUCATIONAL SERVICES INCORPORATED

"The Ultimate Teaching Machine," says *Punch*, the British humor magazine, is a device known as "Built-in Orderly Organized Knowledge" and called "BOOK."

THE FIRST BOOK OF WEEDS, by Barbara L. Beck. Franklin Watts, Inc., 1963, $2.50; 66 pp., illus.

When children ask, "What are weeds?", we have difficulty giving a clear-cut answer. The author of this book has the same problem. She answers the question by describing some of the most common temperate zone plants that fall into the weed category.

The book is divided into two parts, the first being a very general description of weeds, how they evolved, something about the organs of the plants, and where they may be found. In the second part are descriptions of weeds, categorized by habitats or by some quality—lawn; field, pasture, and roadside; garden; edible; poisonous; medicinal; and the last category of "strange and unusual weeds."

For each plant discussed, a common name, the scientific name, and a short description are given. There are attractive line drawings of each species described, with an indication of the height of the plant.

Obviously, the categories used are somewhat arbitrary because weeds are not sufficiently well behaved to remain in the category in which they are included in this book. Poisonous weeds are discussed, but the generalizations concerning them are too sweeping. Some poisonous weeds are medicinal plants if certain quantities are used, but with a slight change in dosage they may become poisonous.—DAVID J. ROGERS, *Curator, New York Botanical Garden*

GROWING WINGS, by Sarita Van Vleck. Doubleday & Company, Inc., 1963, $3.95; 128 pp., illus.

The birds' year, including those exhausting and little understood migrations and the problems of reproduction and survival, has been likened to a play of many scenes. Not all the actors play the scenes in the same way, and there is comedy, tragedy, and even a bit of mystery.

Here is a lively, entertaining account of this annual drama which also contains

(Continued on page 4T)

Page 3: The Earliest Americans

Basic concept: Living things have changed over the years. Like people elsewhere on the Earth, the people who have inhabited the Americas over the past 25,000 years or so have gradually changed their environment. As a result, their ways of living have also been changed.

The main article of our special-topic issue on Early Man in America is devoted to the attempts of scientists to discover the origins and patterns of human life in the Western Hemisphere. Although the concepts may be familiar, the information contained here goes beyond the usual social studies goals of the intermediate grades in amount of detail. With the following major ideas as a base, you may emphasize as much detail as class level and interest indicates.

Ideas Presented in the Article

1. Because we have no written records, the story of early life in America can be told only by archeology. Our knowledge is as yet incomplete.
2. We now know that the people whom the early explorers met here were not the first Americans.
3. The first and main route of migration is believed to have been from Asia, across Bering Strait. It is thought to have begun 15,000 to 25,000 years ago.
4. One of the chief motives for migration was the search for food.
5. Developing techniques in agriculture was an important step in the control of nature, which is part of the process of civilization.

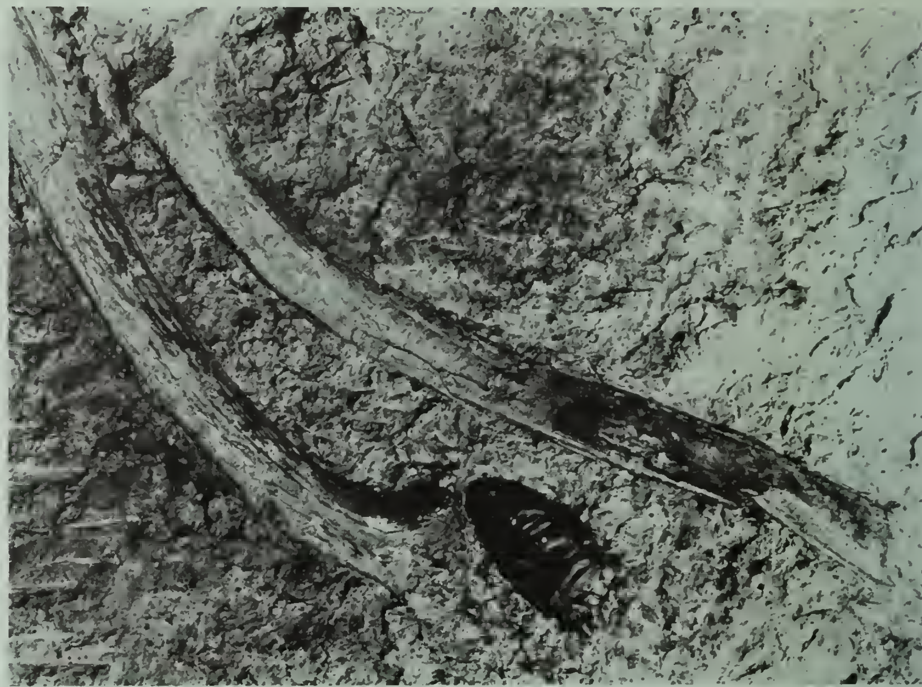
Making the Facts Come Alive

1. Try to get your class to think of archeology as a human activity, full of mystery and adventure. If anyone in the class has ever found the skeleton of an animal, encourage him to describe his feelings to the class. Inform them that many discoveries have been made by amateurs, some by accident.

Point out the danger that valuable evidence of the past may be lost because amateur archeologists are not always careful enough about preserving and recording their finds.

2. Introduce children to the phrase *kitchen midden*. This is the name given to mounds which were once rubbish piles of prehistoric peoples. They contain tools, broken pottery, and shells and bones of animals eaten for food. The words mean *kitchen leavings* in Danish, Denmark being the place where the first such mounds were studied. There are many kitchen middens along both coasts of North America.

The suggestions for using this issue of Nature and Science *in your classroom were prepared by Patricia Ralph, elementary school teacher in the public schools of Huntington, N.Y., and member of our National Board of Editors.*



THE AMERICAN MUSEUM OF NATURAL HISTORY

In 1927 archeologists from The Denver Museum of Natural History found this Folsom-type spear point imbedded in clay between the ribs of a long-extinct species of bison. Experts established that the point was used to kill the animal. This bison probably died out about 10,000 years ago. If so, the point must be at least that old.

Activities

1. To emphasize the tentativeness of conclusions about which we have no sure knowledge, bury some mementoes of a recent Sunday in a pail of sand. Include such things as a piece of newspaper, some food wrappers, utensils or hobby equipment you might have used, a thimble and some thread, shampoo and curlers. Have the children dig them up and piece together a reasonable story of how you spent your day. After several accounts have been suggested, you may recount the actual events. The children may then wish to try this themselves.
2. Discuss the practice of businesses and schools burying time capsules at the dedication of a new building. Have the class think of what they would put in such a capsule to be dug up at a later date that would give information about what school was like on this date.

Page 10: Dating the Past

To learn about the past from the remains they find, archeologists must first figure out how old the remains are. This article tells how scientists go about "dating" the remains they find. The methods most frequently used are these:

1. Association — An object may be found together with the remains of plants or animals that lived in a period of time known to scientists.
2. Location—An object may be found in a layer of rock or soil that was laid down in a period known to scientists.
3. Radioactivity—Living things contain certain amounts of the radioactive element carbon-14, which begins to disappear at a known rate when the plant or animal dies. By measuring how much carbon-14 is left in the remains, scientists can tell about how old they are.

Activities

1. Ask the class whether anyone has ever found a long-lost toy or ball in the area around his home. What changes had it undergone? Would rusting, fading, or the approximate date when a fad toy was the rage be clues to its age?
2. Take your class to a nearby woods where dead leaves have collected on the ground for many years. Carefully take away the dead leaves from a spot—a few at a time—until you reach the soil. You will probably find several layers of leaves, including some that are nearly all decayed and some that haven't decayed at

(Continued on page 3T)

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

all. Ask the children whether the oldest leaves are those in the top or bottom layers, and whether the amount of decay in the leaves also gives a clue to their age.

Page 8: Talking Hands

Much fun is to be had with this wall chart. It is the key to this issue's Brain Boosters and an unusual activity in itself.

This feature may stimulate a discussion of language and signaling, but don't belabor the point if children seem restless to get on with the activity.

Why Sign Language?
Long before man learned to speak or write, he used sign language to communicate. For the Plains Indians, sign language was necessary to overcome the spoken-language barriers of different tribes, much as we use international flag signals and radio codes.

Sign language is also used where sound cannot be heard or where secrecy is desired. Thus, in a noisy football stadium the referee uses sign language to indicate touchdowns and offside penalties. In a baseball game the catcher and pitcher exchange secret signs to help them outwit the batter. Radio and TV directors signal performers to begin, end, or slow up.

Activities

1. Encourage children to think about common signs they have been using all their lives (waving goodby, blowing kisses, nodding with eyes closed or using hands as a pillow, rubbing the stomach).
2. Have the children, after some practice, tell short sign language stories to the class.

Page 12: Measuring the Universe 7

Building Your Own Solar System

This article shows your pupils that it is possible to construct a scale model of the Solar System without knowing any distances in miles within the system. They can do this by using observations made of Venus, Mercury, and Mars.

They will see how difficult it is to make a scale model of the Solar System if the same scale is used for distance and size of planets. And this is the whole point of the article. Because of the vast distances involved, nearly all text and popular books use two different scales—one for distance, another for size of planets—in portraying the Solar System.

Suggested Approach
Treating this work as a group activity will relieve your slower pupils of some demanding arithmetic. Supplement your work at the blackboard with activities in which the children can participate.

IN THE NEXT ISSUE of *Nature and Science*, a scientist tells how he spent three years studying the struggle for survival between moose and timber wolves on an island.

In another article, four scientists explore lakes in Canada to find out whether their beds are craters dug by giant meteorites, as craters on the Moon are believed to be.

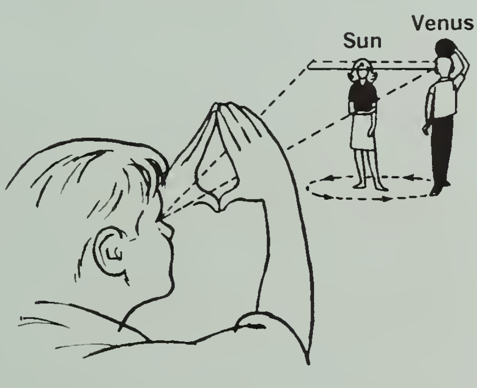
The N&S Wall Chart for this issue shows photographs of comets, meteorites, and other objects among the planets.

You could have the class read the article, and then take up the work one step at a time as follows:

1. Plot the orbits of Mercury and Venus, the two planets between the Earth and the Sun.
2. Plot the orbit of Mars, which lies beyond the Earth. (A different method is involved here.) Orbits of the remaining five planets can be plotted by using the distance data given in the article.
3. Work out one scale that will apply to both distance and size (the article mentions three).

Teaching Tips

1. To dramatize Kepler's observations of Venus, have a child stand in front of the class and represent the Sun. Have another child hold a ball on his head ("Venus") and walk around the "Sun." As the rest of the class form frames with their hands and watch "Venus" through the frames, they will see it apparently moving back and forth in front of the "Sun" and behind it.



2. To demonstrate Kepler's observations of Mars, use the blackboard. First draw the Sun, Earth, and Mars as seen on Earth Day One. Then draw a line from the Sun to the Earth to Mars forming a 119° angle. Slowly draw orbits for Earth and Mars with Earth making 1⅞ orbits while Mars makes a single orbit *(see diagram in students' edition)*. On Day 687, lines from Sun and Mars to Earth form a 136° angle.
3. To reinforce the concept of scale, have the children look at a scale model of an automobile. Then have them measure the model and also a full-size car of the same type. By comparing the measurements of the car and the model, they should be able to determine the scale to which the model was built. Or, you might draw a line on the blackboard representing one side of your classroom (perhaps drawn to a scale of ½-inch = 1 foot). Tell the children which side of the room this represents, and have them complete the scale drawing of the floor plan.
4. Nothing will drive home the object of this article more than actually working out the football-field scale on the school playground. Use a 5-inch ball (or softball) for the Sun, a tiny bead for the Earth, and peas and marbles for the larger planets. To save time, work out the distances in advance and use premeasured string or a 50-foot tape.
5. If interest warrants it, a model of the Solar System using one scale for distances and another scale for sizes of planets can be made on a mural or hung from the classroom ceiling. Make sure the difference between the distance and size scales is clearly understood.

Page 15: Climbing Water

This Science Workshop article demonstrates a principle in physics called *capillarity*. Capillarity, or *capillary action*, is the tendency of liquids to rise in small tubes or between the fibers of cloth and paper materials. This can be explained by understanding two forces, *adhesion* and *cohesion*. Cohesion is the attraction of like molecules for each other, as water molecules in a raindrop. Adhesion is the attraction of unlike molecules for each other, such as water molecules for glass or cloth, and glue molecules for wood. Blotters absorb ink and water because of capillarity. Wax paper will not absorb water because the cohesive force of water is greater than the adhesive attraction of water for wax.

What the Investigations Show

1. The more porous the material, the more liquid it will soak up.
2. Exposure to air retards capillary action in fibrous materials because air dries up the exposed water.
3. Water rises higher in narrow tubes or openings than in wide ones.

You can show your pupils how water rises from the soil into plants by capillary action. Stand a stalk of celery in a jar containing water mixed with a little ink. Slowly, the liquid will move up through the stalk and into the leaves.

Robert Gardner, the author of this article, is a staff member of the Elementary Science Study Project of Educational Services Incorporated.

N & S Views . . . Books
(Continued from page 1T)

a little of the author's personal philosophy and the considerable warmth of her own field experiences.

Miss Van Fleck has skillfully woven a story based on extensive bibliographic research performed, in part, while she was employed by The American Museum of Natural History to assist in the preparation of exhibits for the Biology of Birds Hall.

There are over 30 line drawings from the author's sketchbook which add to the charm of *Growing Wings*. Here is pleasant reading for those who have more than a casual interest in the ways of birds.—WESLEY E. LANYON, *Associate Curator of Ornithology, The American Museum of Natural History*

THE KINGDOM OF THE SUN, by Isaac Asimov, Abelard-Schuman Limited, 1963 (revised), $3.50; 160 pp., illus.

In a style distinctively his own, Mr. Asimov here turns his talents to a discussion of the exciting story of the development of knowledge of the Solar System from its beginnings in Babylon to the discovery of Pluto. The author is skilled in presenting a wealth of factual material in highly readable form.

This book is recommended without reservation for the highly motivated elementary school youngster who wants to learn about the problems men faced in understanding the relationships between the Sun and planets, and the procedures they followed to find suitable explanations of their observations.—FRANKLIN M. BRANLEY, *Astronomer, The American Museum-Hayden Planetarium*

And for teachers . . .

SCIENCE SHAPES TOMORROW, by Gerald Leach. The John Day Company, 1962-1963, $5.95; 140 pp., illus.

1. What sort of world do we want to live in?

2. What sort of science do we want to live with? These two questions that conclude Mr. Leach's book are not answered, and they shouldn't be, but Mr. Leach does give considerable information that should be weighed by those who are to provide the answers—namely, you.

The book treats backgrounds, content, and forecasts with three chapters on atomics and one each on power, radio astronomy, computers, secrets of life, and feeding the world's population.

The writing is concise, informative, and authoritative. However, the publishers should have used larger type and also a double-column format. The illustrations help develop understanding.

This book is for the serious reader who has some science background, or for the reader who is willing to study out passages here and there.—F.M.B.

nature and science

VOL. 1 NO. 8 / JANUARY 24, 1964

When wolves invade an island inhabited by moose, which animal survives? A scientist finds out in . . .

MY THREE YEARS AMONG TIMBER WOLVES

see page 3

ABOUT THE COVER

The two timber wolves on our cover once lived in northern Minnesota. They were trapped, and their skins were mounted in a life-like running pose by a taxidermist at The American Museum of Natural History. The cover photograph was taken just before the mounted wolves became part of a Museum exhibit *(above)* that shows them hunting along the shore of a Canadian lake.

Wolves once roamed all over North America, hunting deer, moose, buffalo, and caribou. The early American settlers had to protect their livestock from attacking wolves and killed thousands of them with rifles, traps, and poisons. Today there are only a few thousand wolves left in the United States, nearly all of them in Alaska.

Wolves can be valuable animals, especially in national parks and forests. Deer and other large plant-eating animals sometimes become so plentiful in these areas that they reduce their food supply to a dangerously low level and then starve. When the wolves lived in such areas, they kept large plant-eating animals from becoming too plentiful by killing off the old and weak animals.

The story that begins on page 3 describes the adventures of one scientist who studied the wolves and moose on Isle Royale National Park.

nature and science

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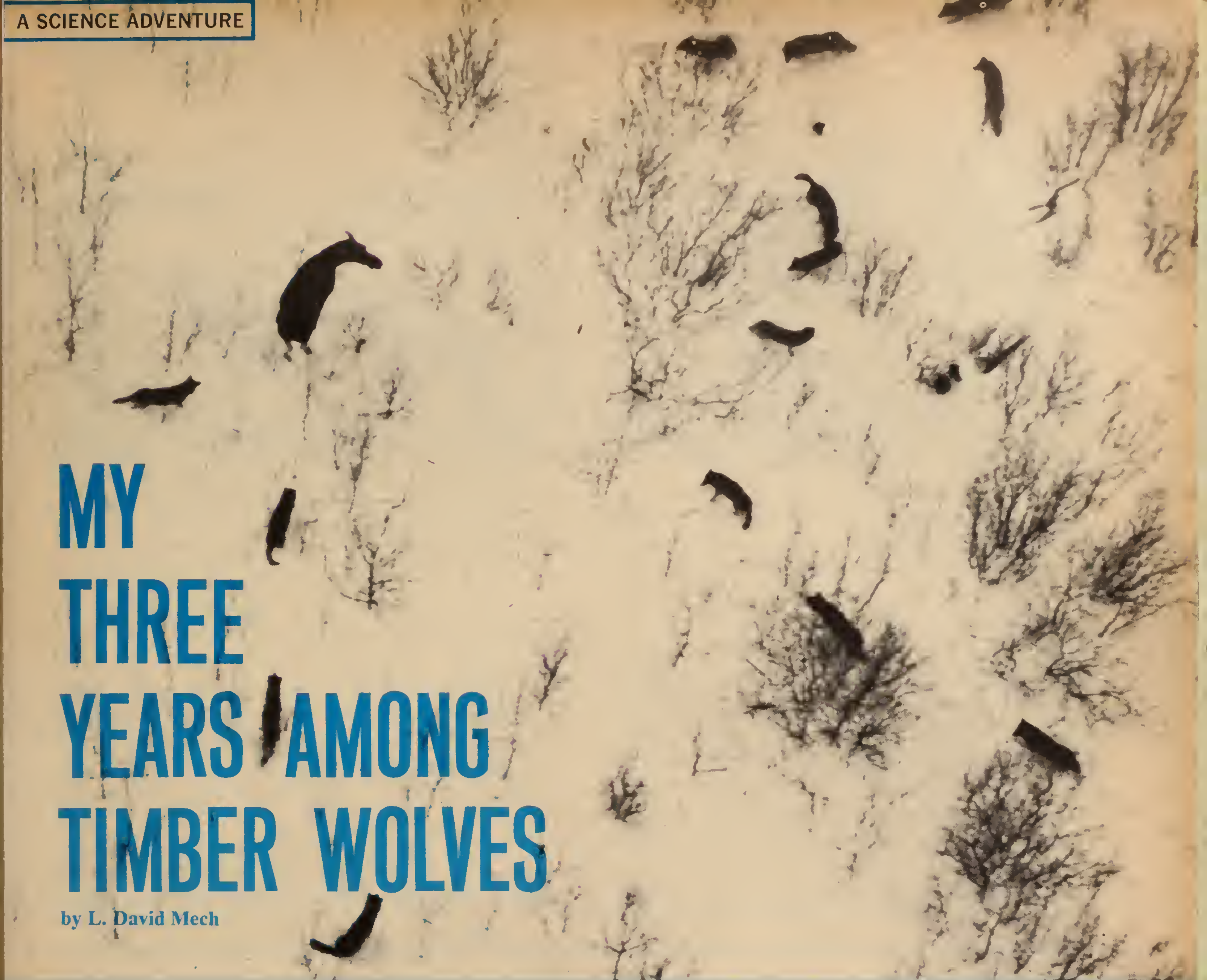
MY THREE YEARS AMONG TIMBER WOLVES

by L. David Mech



As the author watched from an airplane, this moose fought off the attack of 16 timber wolves.

My job was to study the struggle for life between wolves and moose on a wilderness island. Some of the things I learned may surprise you.

■ As I peered out the airplane window at the drama below, I saw 16 wolves just finishing off a struggling moose. One of the wolves had its fangs hooked into the moose's rubbery nose. The rest of the pack tugged away at its rump and flanks. Within a few minutes the moose was dead.

This was the first time a scientist had watched wolves hunt and kill a moose. In the next couple of months, I was to see such a sight three more times. My job was to learn all I could about wolves and moose on the rocky island called Isle Royale in Lake Superior. It was 1960, and this second winter of my three-year study promised to be most interesting.

At dusk, bush pilot Don Murray landed our light ski-plane on the frozen harbor near camp. While we snowshoed toward our cabin and talked over the day's events, I felt very lucky to have this job. I have long been interested in *predators*—animals that kill and eat other animals. I also have had a great liking for the northern wilderness. Purdue University's "Wolf Project" gave

(Continued on the next page)

My Three Years Among Timber Wolves (continued)

me a chance to study the predator that is king of the North Country.

The wilderness island where "my" wolves reign is 45 miles long and nine miles wide at its widest point. The wolves have their run of all of its 210 square miles. Since Isle Royale is a national park, the animals are not bothered by man. There are no roads, so all travel has to be done by foot, boat, or air.

This island makes an ideal laboratory for studying wolves. Here there is only one main type of wolf food—moose. And the only real enemies the moose have are the wolves. This gave me a good chance to find the answer to two important questions: Would the wolves eat all the moose? Or would the moose multiply faster than the wolves could kill them off?

To answer these questions, I had to find out several things: How many wolves live on the island? Does their number get larger, smaller, or stay the same each year? How many moose are there? How many moose are born each year? How many do the wolves kill?

Getting this information was not easy. But it was easier than studying most other predators to find out how they affect the lives of the animals they feed on. For example, take the problem of learning how foxes affect the numbers of rabbits in an area. We'd have to count not only rabbits, but also everything else foxes eat—mice, squirrels, woodchucks, birds, and so on. And we'd need to study owls, weasels, hawks, mink, and all other animals that eat rabbits. This would be too hard a job.

That is the main reason we chose to study Isle Royale's wolves and moose. There are fewer things to complicate the picture. With such an ideal setup I could not help but learn a great deal.

Besides that, the wolves soon got so used to our airplane that they paid no attention to it. Not only could we count them, but we were able to track and follow them day after day in good flying weather. We learned where their trails were and how far the animals traveled each day. We watched them fight, play, rest, mate, hunt, and eat.

A moose eats about 25 pounds of leaves and twigs every day. If moose become too plentiful, there is not enough food to go around and many of them starve to death.

Isle Royale National Park is a 45-mile-long island in Lake Superior where moose and wolves are not disturbed by man.

How "Bad" Are Wolves?

One time we flew just a few feet over a lone wolf on a frozen bay. He raised his tail, barked at us, and rolled over on his back as though wanting to play. At such times it was hard for me to think of the wolf as "mean" or "cruel."

In fact, wolves seem to be friendly, playful, and good natured. Never has one growled, snarled, or bared his teeth at me when I was near him. Instead, all the ones I have approached looked puzzled and curious, if not amused, over me. Then they turned and ran away.

Some people think that wolves are "bad." How much the story of Little Red Riding Hood and other such stories have to do with this feeling, I don't know. Anyway, I don't agree that wolves are "bad." They must kill other animals to eat. They cannot live on grass and other plants. In the case of the Isle Royale wolves, their killings had certain patterns. I found that the only moose the wolves killed were the sick, old, and weak. Had these animals not been killed, many of them would have suffered a long time, and would have eaten food that healthier animals could have had. It took me a long time to learn this.

Trailing Wolves from an Airplane

I began by watching the wolves hunt. During three winters I spent 68 hours observing 16 wolves hunt, chase, and kill moose. In one day they chased 15 animals without catching a single one. Altogether, I saw this pack try to kill 77 moose, but all they got was six.

Whenever I watched the wolves make a kill, the pilot landed on the nearest lake, and I snowshoed to the scene. The first thing I did was chase the wolves from their meal so I could examine the moose carcass. I found that most of the moose that had been killed were infected with tapeworms or with thousands of blood-sucking ticks. Some had both.

If the wolves killed a moose during the night, or at a time when we couldn't watch, I examined the well-chewed bones they left behind. By studying the bones, we could get some idea of the age and state of health of the moose. Most of the 48 adult kills we found were 10 or more years old. This is pretty old for a moose.

Wolves single out old or weak moose for a kill for a simple reason: The strong, healthy ones are dangerous. Many stand and fight when the wolves close in. I remember one moose that stood its ground and fought off 16 wolves which surrounded him for five minutes *(see photo on page 3)*. The moose was successful. The wolves gave up, trotted away and killed a different moose half an hour later.

Instead of standing and fighting, some strong moose run when they are attacked. If the moose is healthy, it can usually outlast the wolves. I saw one moose run for two-and-a-half miles. Most of the pack fell way behind, but five wolves kept right up. Suddenly the moose stopped. The wolves were so tired that they just curled up in the snow nearby and rested. A minute later, the moose ran another half-mile. The wolves continued to rest.

We spent most of our time watching the one large wolf pack on the island. But there were other wolves around—a pair and a pack of three. The total number of wolves (21 or 22) stayed the same for the three winters I was there. No one knows why they didn't increase. Probably it was because there was just enough room and food for the number of wolves already living on the island.

The author and another scientist examine a jaw bone to find the age of a moose that was killed by wolves. They discovered that wolves usually kill old and weak moose.

David Mech (pronounced like peach), the author, took many photographs of moose, wolves, and other wildlife during his stay on Isle Royale. Dave first became interested in wildlife conservation as a boy in Syracuse, New York. He is now doing research at the University of Minnesota, putting tiny radios on skunks, woodchucks, foxes, and other animals to trace their movements.

Although members of a pack are friendly toward each other, they fight wolves from other packs. Whenever animals in the big pack met a wolf from one of the other two groups, they chased it. This may be the reason why the small packs lived on a part of the island where the large pack didn't often go.

All the wolves spent most of the winter along the frozen shoreline of the island. There the snow was firmly packed, so they didn't sink into it. Thus they could travel as much as 45 miles in a day. They often moved 25 miles daily, especially when they were hungry. They *had* to travel long distances in order to find weak and sick moose.

Sometimes the wolves went five days without food. When they did, they worked up a good appetite. A hungry wolf can eat 20 pounds of meat at one feeding. The big pack could gobble up a whole 300-pound moose calf in one day. Adult moose, which weigh 800 to 1,000 pounds, took two or three days for the pack to finish. During each of the three winters of the study, the 16 wolves killed an average of one moose every three days.

Would the Wolves Kill All of the Moose?

To see how this rate of kill would affect the moose herd, I had to count the moose and to find out how many are born each year. This was the hardest part of the job. We flew back and forth over the island searching for moose. Each time I spotted a moose, the pilot dived the plane at it to make it run. Then any other unseen moose nearby also ran, and I could count them. This might sound like fun, but just thinking of it makes me airsick. We spent a

(Continued on the next page)

total of 45 hours doing this, and found there were about 600 moose on the island.

I preferred the kind of moose study that had to be done on the ground in summer. During three summers I hiked a total of 1,400 miles, searching around the island's many lakes, ponds, and swamps for moose. Then I kept track of how many calves there were compared to adults. Since I already knew the total number of moose on the island, my summer count gave me a good idea of the number of calves born to the whole herd. It turned out that there were about 227 new calves each year. This is more than the wolves kill, so the moose herd should be able to survive despite the wolves.

Looking for moose on the island can be hard work, and often I spent entire days without seeing one. Sometimes when I returned to the cabin on these unsuccessful days, my wife Betty Ann would tell me I should have stayed home—three moose strolled through the yard! Once she glanced out the bedroom window and spied a cow (a mother moose) and two calves peering in at her.

Another time, when I was out trying to take pictures of moose, a cow and a calf swam across a bay in front of our cabin. Betty Ann chased them with a boat and took their pictures. I came home without a picture.

Besides trying to spot moose, I also spent part of the summers looking over their food supply. Moose eat the leaves and twigs of trees like birch, willow, and aspen. Each animal eats about 25 pounds of these each day. When there are too many moose in an area, they eat so much food that they kill the trees and shrubs. Then the moose starve to death.

This happened on Isle Royale about 1935 before wolves had crossed the ice from the Canadian mainland to the island. Since there were no wolves to control the moose, the herd grew larger and larger. Soon there was not enough food left for them. Most of the small trees were dead—which meant that most of the moose died, too.

But today the wolves are killing only enough of the animals to keep the herd from getting too large. Now there is enough food, and the moose are healthy. All in all, the wolf-moose relationship on Isle Royale seems to be ideal.

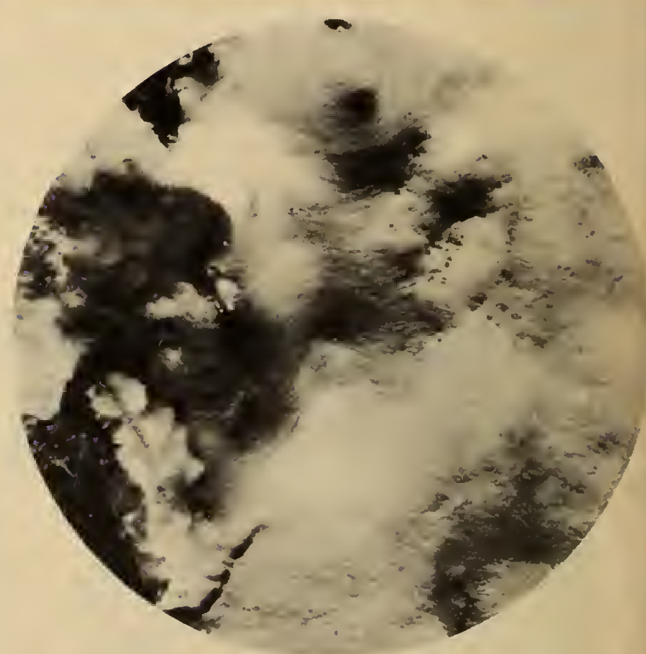
Our hunch had paid off; by choosing a simple situation to study, we were able to learn a great deal about one of the small ways in which nature works. And in doing so, we made an interesting discovery: The "big, bad, wolf"—so described in fairy tales, at least—isn't so bad after all ■

■ For more information about timber wolves, look in your library or bookstore for these books: **A Naturalist in Alaska,** byAdolph Murie, The Natural History Library, Doubleday & Company, Inc., New York, 1963, $1.45; and **Arctic Wild,** by Lois Crisler, Harper and Brothers, New York, 1958, $5.50.

SCIENCE WORKSHOP

MAKING A MOLD GARDEN

by David Webster



A fuzzy grey mold of the Ascomycete group, growing on a peach and meat sauce, is shown above as it appears to the unaided eye. The "fuzz" is the body of the mold. Its thread-like branches, called "hyphae," are enlarged about 100 times in the top photo, taken through a microscope.

■ Have you ever thought of having a mold race? Or a no-mold race? You can if you make a mold garden. You can grow your garden in a soup bowl, a plastic box, a glass jar, or a tin can. Mold, by the way, is that furry-looking stuff that grows on stale bread and other food.

First you'll need some things for the mold to grow on —bread, vegetables, meat scraps, wood, metal, leather, string, paper, plastic, or cloth. All you have to do is mix some of these things up, put them on top of some soil in a jar or can, and cover it over with a plastic bag. The mold might grow better if you add a teaspoon or so of water.

Look at your garden every day so you can see when the molds start to grow. How long was it before you first saw any? When you have some molds, examine them closely. What shapes and colors are they? How many different kinds do you have? Why do you think all the molds are not the same color?

If you have never touched molds, try it. Do they feel fuzzy or smooth? Does anything happen to the mold after you touch it? Look at some mold with a magnifying glass or microscope. Did you see any moving?

Do your molds seem to change from one day to the next? Do they ever change color or get bigger? A map of your mold garden, drawn each day, should help you notice changes. Do any molds grow so big that they kill other molds? Does everything that you put in have mold growing on it? See if you can take a piece of mold from where it is growing and get it to live on something else. When you have finished looking at your garden, don't throw it out. Put it away and keep it for about six months, then look at it again. You'll be surprised at what you see—and smell.

Have a Mold Race

Challenge a friend to a mold race. Since you already know so much about molds, you should be able to win. The idea is to see who can make the most mold grow in a week. Each person in the race should start with the same thing, a slice of bread or a slice of orange.

What could you do to your bread to make mold grow faster? Heat it? Shine a light on it? Put it outside in the fresh air? Wet it? Cut it up into little pieces? What else can you think of to try? When the race is over, try to figure out what made bread get moldy faster. What things do you think mold must have to grow?

Have a No-Mold Race

When you become a champion mold racer, you might want to try another kind of race. This is a no-mold race. Instead of trying to get a lot of mold, try to get no mold at all. Can you keep mold from growing on a piece of orange or a slice of bread for more than a week? (You may do anything to the orange or bread except scrape the mold off.) Vegetables and meat will keep for a very long time if they are kept cold in a freezer.

Have you ever eaten dried fruits like raisins, prunes, or dried peaches? Why doesn't mold grow on dry fruits? Sometimes substances are added to foods to help stop mold growth. Look on a bread wrapper and see if you can find what is put in bread to retard molds. Experiment to see if you can find something that will slow down or kill molds.

Food in cans will keep for years. But when the can is opened, the food gets moldy after a few days. Why do you think molds don't grow in canned food until the cans are opened? Is it air that makes the food in the can get moldy?

Molds are a kind of plant. They have tiny seed-like parts called *spores*. The spores are so light that they float around in the air. You can hardly ever see them because they are so small. When mold spores get into food they grow and make the food moldy ■

INVESTIGATION

A boy once did an interesting experiment with canned foods. He wanted to find out if air is what made food get moldy. He opened cans of tomato juice in different places and left them there. He thought all the cans of tomato juice would get moldy at the same time, but they didn't. The chart shows what happened.

Where cans were opened and left	Number of tomato juice cans opened	Number of cans moldy after 3 days	Number of cans moldy after 5 days	Number of cans moldy after 1 week
In the kitchen	10	7	10	10
On top of a hill	10	2	3	7
In school room	10	6	9	10
Outside near street	10	4	5	7
On a rock in a lake	10	1	1	4

Look again at the experiment chart. Do you think there are a lot of mold spores in the air? In what places do you think the air has less spores? Do you think there is any place where the air has no spores at all? Where? What do you think some tomato juice would be like after two weeks? Maybe you could get a small can of tomato juice, pour some of it into several different containers, and watch it get moldy.

Whatever kinds of molds you grow, try growing them in different places to see what happens. You could grow them outdoors, in the house, in the dark, in a hot place, in a damp place, in a dry place, and so on. You could even make a chart like the one shown here.

Space Dust, Meteors, and Comets

■ Every day, several tons of material fall onto our planet from outer space—dust and pieces of rock and metal. Some are no larger than sand grains. Others are the size of eggs, houses, or mountains. The largest known "invader" from space that has stayed in one piece is a 34-ton chunk of metal known as the Ahnighito Meteorite. Now on display at The American Museum-Hayden Planetarium, the meteorite was brought to the Museum from Greenland by the American explorer, Admiral Peary, in 1897.

The fine, dust-like material that falls onto the Earth settles to the ground or into the oceans without even being seen. Larger pieces of material—called *meteoroids*—sometimes streak through the atmosphere at speeds up to 160,000 miles an hour and burn up. We see them burning as a bright trail of light. This light streak is called a *meteor*. When a meteoroid survives the journey to the ground without burning up completely, we call it a *meteorite*.

Meteoroids travel in swarms or singly. Most of them are probably pieces of matter that make up the head, or *nucleus,* of a *comet*. When we see a comet, then, we are looking at a loose swarm of material that one day may produce a meteor shower in the atmosphere.

The pieces of rock and stony material of a comet form a cluster that is usually not much more than a mile or two across, although the heads of some comets are much larger—100 to 50,000 miles in diameter. The individual pieces of rock and metal that make up a comet are ice-coated with frozen gases. Comets move in long orbits among the planets (*see diagram*). When one approaches the Sun, heat from the Sun melts the ice coatings, changing them back to gases. This gas forms the comet's tail.

Light from the Sun pushes a comet's gas tail so that the tail always points away from the Sun. After several trips around the Sun, a comet may lose its tail. This happens as light from the Sun again and again scatters the gas.

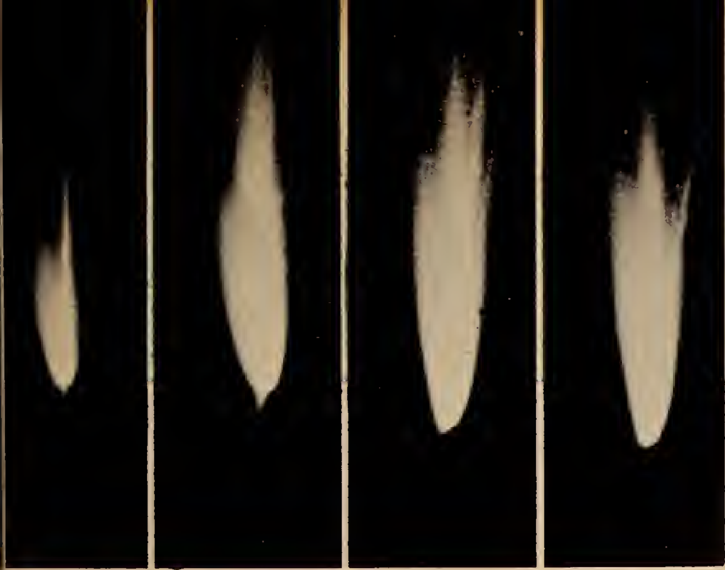
The *asteroids* are another source of meteorites. Asteroids are thousands of pieces of rock and metal that travel in orbits between the planets Mars and Jupiter. Astronomers have figured out the orbits of about 1,600 asteroids, but there must be thousands or millions more that are too small to be seen through telescopes. Scientists think that the asteroids may be the remains of a former planet.

Of all the things reaching the Earth from outer space, *tektites* remain a real puzzle. Geologists and astronomers are not sure where these small dark objects come from. Tektites, which are glass, are totally unlike meteorites, which are made of stone or metal. Tektites may have been formed in times past when asteroids crashed into the Earth or the Moon (*see page 10*). The explosions that resulted may have splashed and scattered the glassy fragments far and wide. Some of the tektites we find today may have been splashed off the Moon. Others may have been formed here on the Earth ■

HALLEY'S COMET can be seen from the Earth every 76 years. It is du to return again in 1985 or 1986. Within the gaseous head is a swarr of thousands of pieces of stone or metal. Each year five or six comet sweep into view. Most of them are new comets.

betwee THE pla

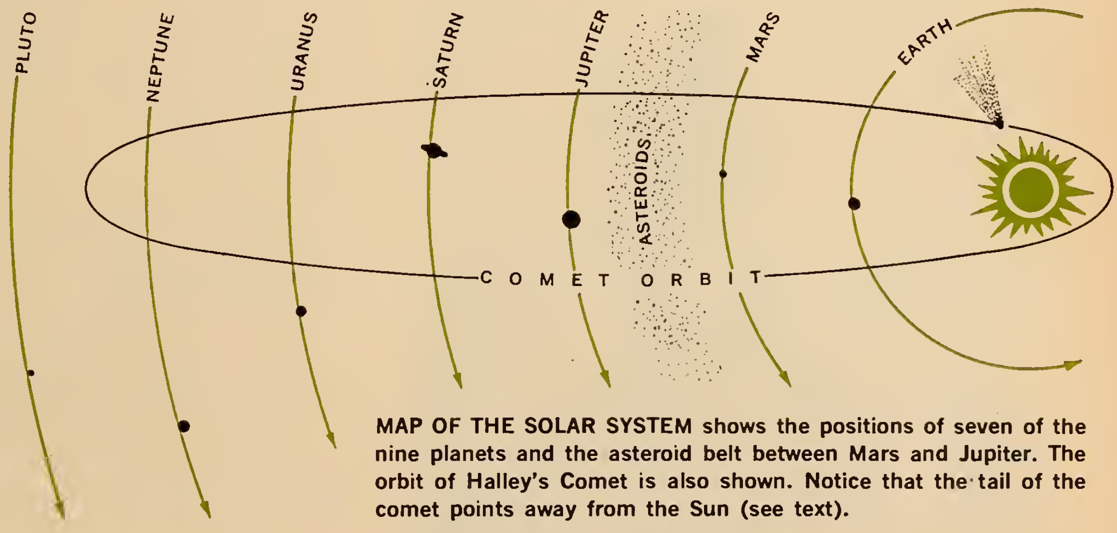
THIS IRON METEORITE on display at The American Museum-Hayde Planetarium weighs 15½ tons. The fourth largest known meteorit it was found in Oregon. Meteorites this large may come from th asteroid belt, which is located between Mars and Jupiter.



ɪE COMET AREND-ROLAND was photographed in 1957 on several ghts. These photographs show how light and heat from the Sun ıange the shape of the gaseous tail of a comet when it moves close the Sun (see diagram below).

METEOR TRAILS are caused by stony or metal objects plunging into the atmosphere and burning up. On a few nights it is possible to see a "shooting star" once every minute. Meteor "showers" should be visible April 20-22, May 1-11, July 24-August 17.

ets



MAP OF THE SOLAR SYSTEM shows the positions of seven of the nine planets and the asteroid belt between Mars and Jupiter. The orbit of Halley's Comet is also shown. Notice that the tail of the comet points away from the Sun (see text).

ɪE ASTEROID HERMES is shown here in a model which compares ɛrmes' size with New York City. Astronomers think that in times ɛst, asteroids have crashed into the Earth and Moon, leaving craters ɪ0 miles and more in diameter.

TEKTITES, which are black or green glassy objects, are a science puzzler. No one knows where they come from. They may rain down on the Earth from space, or they may be formed when large meteorites crash into the Earth or Moon.

EXPLORING CRATERS IN THE EARTH

by Esther Kitzes

Were the strange circular lakes in the Canadian wilds formed by meteorite "bombs" from space? A team of scientists set out to find the answer.

Michael Dence was the first scientist to find rocks that suggested that Lac Couture crater was formed by a meteorite.

■ The first astronaut to step on the Moon probably will step into a *crater,* one of the hundreds of pit-like marks you see in photographs of the Moon. Many scientists believe that these craters were caused by meteorites that crashed into the Moon millions of years ago.

Last summer, four scientists from the United States and Canada set out to find out more about these craters, but they didn't have to go to the Moon. Instead, they went into the wilderness of Canada. They had a hunch that some of the big craters in Canada were formed by meteorites smashing into the Earth.

So far about 50 craters have been found in North America. Some of them measure many miles across. They do not all look like bowl-shaped cavities, because their outer edges have been worn away by wind and water—two things that are missing on the Moon. Many of the craters have been "ruined" for scientific study by this wearing away, or *erosion,* and by human activities such as mining and farming. Some craters have entire villages inside them.

How the Search Began

The search for unexplored craters by the four scientists began four years ago. Dr. C. S. Beals, an astronomer who is director of the Dominion Observatory in Canada, spotted a circular lake—seven miles across—on photographs taken during an aerial mapping flight over northern New Quebec. He suspected that the basin of the lake might be a crater formed by the impact of a large meteorite.

Earth craters that we know about range in age from about 20,000 to 450 million years. Scientists believe that the meteorites which caused these craters may have been *asteroids* that came too close to the Earth and were captured by it. Asteroids are pieces of rock that circle the Sun in an orbit between the planets Mars and Jupiter. There are probably millions upon millions of asteroids. Some are the size of mountains and larger *(see pages 8 and 9)*. Others are thought to be very small. Some scientists think that in past ages many asteroids crashed into the Moon and Earth.

Dr. Beals felt that the circular lake in New Quebec, if explored, would help man understand more about the craters on the Moon. The lake, named Lac Couture, is in a vast part of Canada where no one lives, and which looks something like the Moon's surface. But there is a major difference. Unlike the Moon, this part of Canada has water, air, moss-like plants, mosquitos, and flies.

It took Dr. Beals two years to find time for the expedition which would set him and three other scientists on the rim of that mysterious lake, Lac Couture. Would it prove to be a crater formed by meteorite? To answer this question, they would have to find pieces of the meteorite or material, known as explosive *breccia,* produced by its impact. Breccia is made up of angular pieces of rock—some broken and some powdered by the shock when the meteorite struck the ground.

The Expedition Gets Under Way

In August 1963, Dr. Beals and three other men met in Ottawa, Canada, to begin the search. The men were an American, Dr. Alvin J. Cohen, a professor at the University of Pittsburgh in Pennsylvania; a young Australian, Michael Dence, who works at the Dominion Observatory; and Dr. Geoffrey H. Charlewood, the vice-president of a drilling firm in Canada.

Scientists use aerial photographs to discover meteorite craters in the Earth. This crater in Ontario, Canada, has been partly filled in since it was formed by a meteorite—perhaps an asteroid—more than 450 million years ago.

In Ottawa, they hired Paul D. Saunders, who was a Royal Canadian Air Force pilot in World War II. He became a "have plane, will travel" bush pilot after the war. He flies a 1938 twin-engine Grumman Goose seaplane which has wheels in its belly so it can land on water or on the ground.

At Ottawa, the men and supplies weighed in at 3,600 pounds. This was three times as much as the seaplane could carry, so they had to leave many of their supplies behind.

Food was the main supply item. They had some fresh oranges and apples, but most of the supplies were freeze-dried canned foods. They had sleeping bags, cots, two tents, and cooking and fishing gear. Their scientific equipment was simple: cameras, rock hammers, chisels, and cloth sample bags.

The plane landed at Povungnituk, an Eskimo village at the edge of nowhere. Povungnituk, which means "place of the horrible odor," has a Hudson Bay store that sells many of the soaps, foods, and other things you can buy at your supermarket. In a few days the men were ready to explore Lac Couture. It is 150 miles from the nearest settlement. There is no evidence that any human being had ever reached its bleak shores.

Exploring Lac Couture

Pilot Saunders landed the seaplane on a neighboring lake. As he paddled the seaplane toward shore, a two-foot-long trout struck at the paddle. The lake was jumping with hungry fish.

The scientists hiked to Lac Couture over *tundra,* a carpet of low-lying plants that covers the Arctic. Dr. Cohen said it "felt like walking over a foam rubber mattress." The men wore nets, sample bags, or tight-fitting hats to protect them against the blood-sucking mosquitos and biting black flies that swarmed over their heads.

After climbing and searching the rocky shores of Lac Couture for about eight hours, the men were exhausted and disappointed. They had found no breccia or other clues that the lake basin had been formed by the impact of a meteorite. They tried to cheer up with the thought that scientific expeditions don't always succeed.

"I guess we might as well move on," said one of the men.

Just then Michael Dence picked up a piece of fragmented rock. "Wait a minute!" he shouted, "I think I've found something." It was breccia!

And like an echo from farther along the shore came a shout from Dr. Cohen: "Look! I've found breccia!"

The men were jumping with delight, their sample-bag headgear flapping like beagle dogs' ears. The longer they searched, the more breccia they found. "It was beyond

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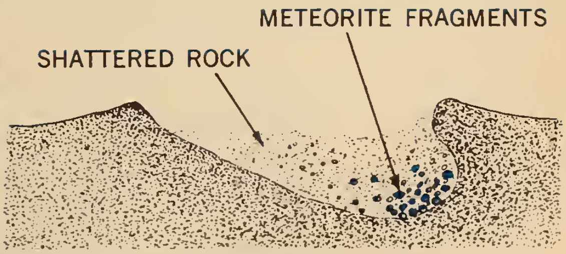


The Barrington Crater (left) was formed when a meteorite smashed into the Arizona desert about 50,000 years ago. It is 600 feet deep and three-quarters of a mile wide. By drilling deep into the soil, scientists have found fragments of the meteorite and chunks of rock that shattered when the meteorite struck (above).

Exploring Craters in the Earth (continued)

our wildest dreams," Dr. Cohen said later. It was evidence that could prove they were standing in a meteorite crater. They were as close to being in a Moon crater as anyone could be on Earth.

Dr. Cohen points out that the side of the Moon we can see has 24 craters that are at least 75 miles from rim to rim. The biggest of these Moon craters—called Bailly—measures 183.5 miles across. The second biggest Moon crater is Clavius, which is 144 miles in diameter.

Some scientists suspect that Hudson Bay itself is a giant meteorite crater. If so, it would easily rank as Earth's largest crater, a whopping 275 miles across.

The Search for Other Craters

The scientists' excitement wasn't limited to their discoveries. Once they were caught in a fog, and Saunders had to fly the seaplane through a canyon rimmed by steep cliffs on either side.

They visited Clearwater Lakes, explored earlier and thought to have been formed by twin meteorites that formed two adjoining lake basins. One is 18 miles across, the other 13 miles. They camped here, and in a sleet storm one night, Pilot Saunders baked them a delicious raisin cake in an old oil drum. He wanted to make an icing, too, but they were too hungry to wait.

All together, they flew about 5,000 miles, hiked, climbed, chipped rocks, and collected breccia and other rocks and glassy fragments that form when a meteorite smashes into the Earth at great speed.

Dr. Beals and other scientists at Ottawa's Dominion Observatory have plans for investigating other Canadian craters. They will search aerial photographs to locate the craters, in the same way that Lac Couture was discovered. Scientists will explore the crater areas, collecting rock samples and drilling deep into the soil for evidence that a meteorite struck the Earth. Their discoveries will teach us something about the craters on the Moon, and at the same time, reveal some of the past history of the Earth ■

The team of scientists flew over 5,000 miles of Canadian wilderness in their search for meteorite craters.

INTO THE DEPTHS OF SPACE

■ Four months have passed since you were stranded on your tropical island *(see* N&S, *Sept. 20, 1963).* During that time you discovered many things about the stars and planets. One thing you found is that the Solar System is a huge place.

But what about the billions of stars that can be seen through the telescope and lie far, far beyond the Solar System? How far away are they? Their distances are so great that the Solar System is tiny by comparison. The distance from the Sun to Pluto—which is the most distant planet—is only 3,670,000,000 miles. The nearest neighboring star, Proxima Centauri, is about *7,000 times farther away from the Sun than Pluto is.* And Proxima Centauri is practically in our back yard.

When astronomers talk about distances to the stars they do not use miles. If they did, the figures would be much too big to work with. Instead, they use a "yardstick" called the *light-year.*

A light year is the distance that light travels in one year. If you worked it out, knowing that light travels about 186,300 miles *a second,* you would come up with this answer: one light-year equals about 6,000,000,000,000 miles. Knowing this, can you find the distance in miles to the star Sirius? Sirius is about 9 light-years away.

Earlier in this series (N&S, *Nov. 15, 1963*) you found how astronomers can measure the distance of the nearby

This is the last article of a series adapted by permission of the Elementary-School Science Project from the revised edition of its booklet, Astronomy: Charting the Universe, *© 1962 by the Board of Trustees of the University of Illinois.*

This galaxy has a shape and spiral arms like those of the Milky Way (see diagram on next page). The vast cloud of dust, gas, and stars can be seen with the unaided eye as a fuzzy patch of light in the constellation Andromeda.

stars in the same way a surveyor measures the distance across a river. To measure how far away the really distant stars are, astronomers use the stars' *brightness* and *luminosity*. Brightness means the amount of light that reaches the eye or a light meter. Luminosity means the amount of light given off by a light source—a candle, a light bulb, or a star, for example.

The next time you walk down a street at night, notice the street lights. Those closer to you appear brighter than those farther down the street. Yet each bulb is just as *luminous* as every other bulb. In other words each bulb gives off the same amount of light.

Scientists know the exact amount by which a light appears to dim as the light bulb is moved farther away. Say that we measure the light falling on a piece of paper. From one inch or one foot or one yard away, the amount of light reaching the paper is 1. When you double the distance from the bulb to the paper, only one-fourth as much light reaches the paper; when you triple the distance, one-ninth as much light and so on *(see below)*.

Distance from light to paper	1	2	3	4	5	6	7	8	9	10
Amount of light reaching paper	1	1/4	1/9	1/16	1/25	1/36	1/49	1/64	1/81	1/100

The same thing is true of moonlight, candlelight, and starlight. So if we can measure the amount of light reaching a light meter, and if we know how much light reaches the light meter when it is held one inch or one foot from the light, we can work out the distance of the light. For example, say a light meter shows 1 when we hold it one foot from a flashlight. We next back away until the meter shows a reading of 1/64. We then know that we are eight feet from the light. Astronomers use a special kind of light meter called a *photometer*.

By using this method, astronomers have worked out the distance to many of the millions upon millions of stars that we can see through telescopes.

Finding Distances to the Stars

To work out the distance of a star by measuring its brightness, they must know what kind of a star they are looking at. As there are different kinds of light bulbs—some give out more light than others—there are also different kinds of stars. Some are more luminous than others. The star Sirius, for example, is much more luminous than the Sun, although the Sun appears brighter because it is closer to us. It would take 23 Suns to make one star as luminous as Sirius. And it would take 10,000 Suns to make one star as luminous as the star Betelgeuse!

Say we know that a very distant star has the same luminosity as the Sun, but because the star is so far away it appears quite dim. When we measure its brightness we find that the star is only 1/100 as bright as the Sun. We then know that the star is 10 times farther away.

This system works not only for stars but for *galaxies* as well. Galaxies are vast collections of stars. At one time astronomers thought that galaxies were fairly rare, but in recent years thousands of them have been discovered.

(Continued on the next page)

There are different classes of galaxies, as there are different classes of stars.

Our own galaxy is called the Milky Way. It is made up of about 100 billion stars and is many, many times larger than the Solar System. The distance from one end of the Solar System to the other is much less than one light-year. The distance from one edge of the Milky Way to the other is about 100,000 light-years!

Suppose that we tried to build a scale model of the Milky Way, and began with the nearest neighboring star, Proxima Centauri, which is 4.28 light-years away. If you traveled at 1,000 miles an hour, it would take about 3 million years to reach the star.

If we included Proxima Centauri in our scale model, here is one way we could plot it. If we let a ping-pong ball (which is about an inch across) represent the Sun, then one inch would represent about one million miles. Proxima Centauri would be about 26 million inches (about 400 miles) away on our scale. In a scale model of the stars, then, the nearest stars, or ping-pong balls, would be 400 miles apart. Others would be thousands of miles apart in a model made to this scale.

How Far to Other Galaxies?

Over the years astronomers have built telescopes that can "see" farther and farther into space. The deeper into space we look, the more galaxies we see. One of the most spectacular galaxies is one named Andromeda. It is very much like our own in shape *(see photo on page 13)*. Andromeda is about two million light-years away, and it is not a particularly distant galaxy. Our closest galaxy neighbors are two galaxies known as the Clouds of Magellan. They are about 170,000 light-years away from us.

In the seventh article of this series, we talked of building a model of the Solar System. What if we tried to build a model of the galaxies in the universe? How could we go about it? Say that we shrunk our galaxy to the size of a pancake six inches across. By doing this we could not show a single individual star, since within this pancake would be 100 billion stars with plenty of space between each one. If we want to represent other galaxies, we would start adding more pancakes, scattering them around so that neighboring pancake-galaxies are 10 feet or so apart. On this scale the most distant galaxies astronomers have been able to measure would be more than four miles away from our central Milky Way pancake—or about five billion light-years. Yet there are probably many more galaxies beyond the limit of those we can see. This means that we would not know where to end our model.

Looking Back into Time

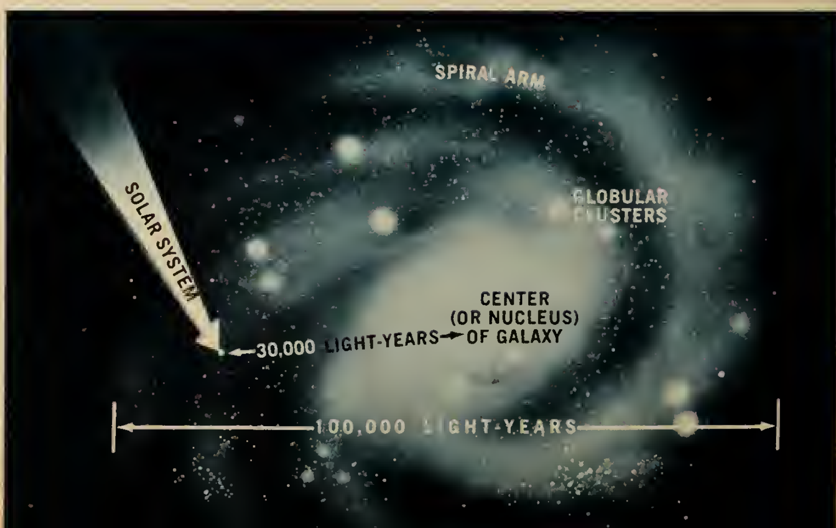
Returning to the Solar System for a moment, let's try to get some idea of these vast distances by thinking about the speed of light in a slightly different way. If the Sun were a giant light bulb and someone turned it on, it would take the light just over eight minutes to travel 93 million miles and reach us here on the Earth. So we can say that the Sun is 8.3 light-minutes away.

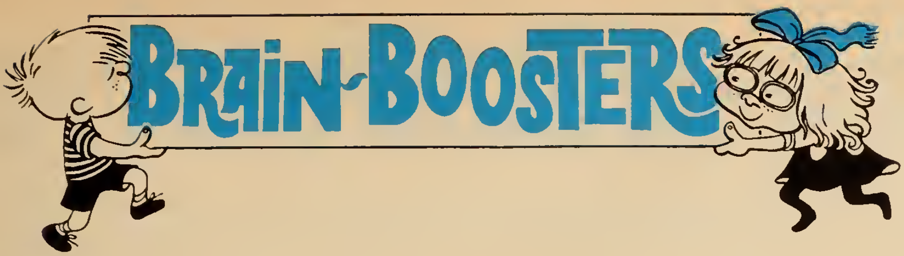
The light from Proxima Centauri takes 4.28 years to reach us. The light from the nearest galaxies takes 170,000 years to reach us. And the light from the most distant galaxies we now know of takes five billion years to reach us.

What does this mean? The light that you see tonight from Proxima Centauri started on its journey 4¼ years ago. When you see that light tonight you are looking back into time. You are seeing what Proxima Centauri looked like in the fall of 1959, not now. If the star should explode tonight, we would not see the flash of the explosion until the spring of 1968. The light reaching us tonight from the most distant galaxies we know of started out before our planet was being formed (about 4.5 billion years ago).

The next time you stand beneath the stars, pick out a bright one and look at it. Possibly you will know its name, possibly not. Chances are it will be one that was born millions upon millions of years before you were born. And if it is a typical star it will go on shining for millions upon millions of years to come. No wonder men of old looked upon the stars as being something very special ■

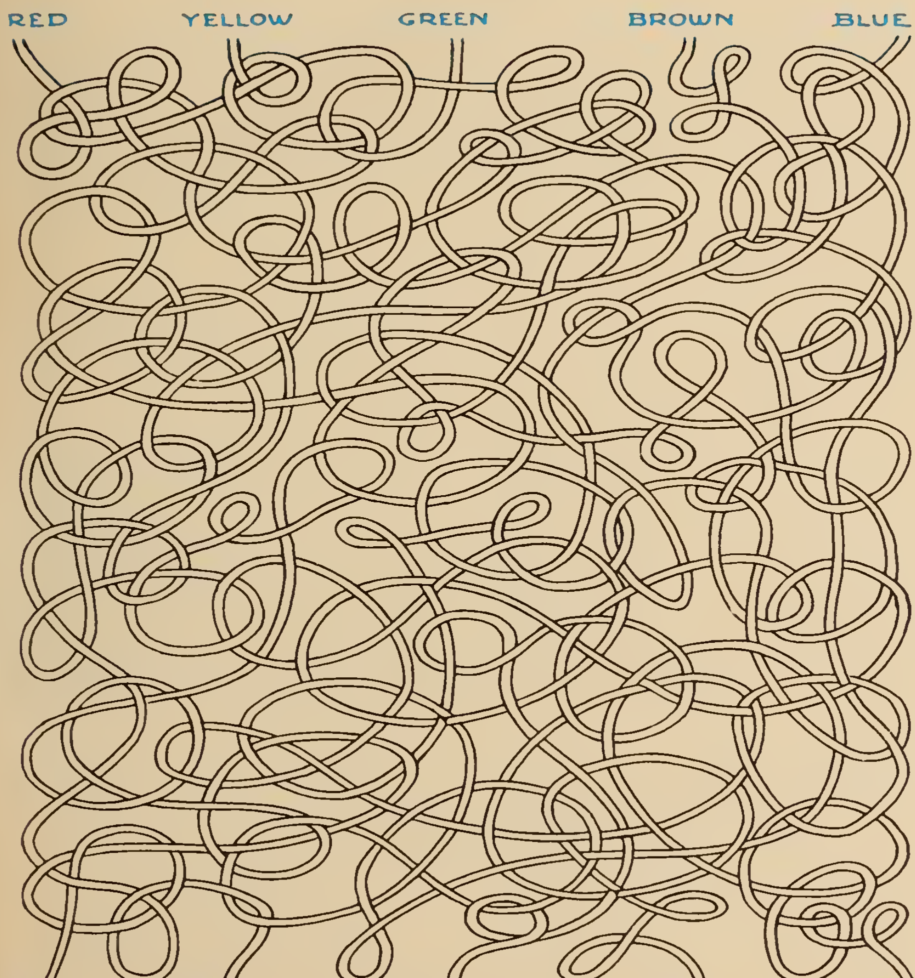
This diagram shows the star-studded arms of the Milky Way and the position of the Solar System within the galaxy. In a scale model, if the Earth's orbit were represented by a pin head, the whole galaxy would be represented by the size of the continent of Asia. Bright spots in the diagram are globular clusters of stars that surround the galaxy.





■ Kitten's Knitting

A kitten tangled five strands of yarn into this maze. See if you can trace each strand from the top to the bottom.



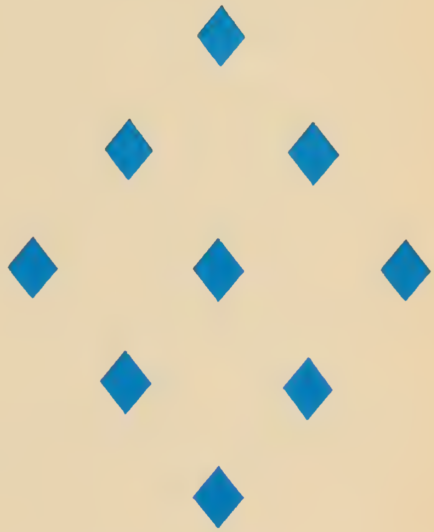
■ Boys Will Be Boys

Mr. Clark and his two sons are walking home, carrying the refreshments for a birthday party. They can shorten their hike if they use a small rowboat to cross a river.

However, the boys cannot row and the boat will carry only Mr. Clark and one boy, or Mr. Clark and the refreshments.

Mr. Clark is afraid that the boys will begin the party early if he leaves either one of them alone with the refreshments.

How can he get the boys and the refreshments across the river without leaving either boy alone with the refreshments?



■ Little Diamonds

These nine small diamonds are grouped to form one big diamond. See if you can connect all of the small diamonds by drawing just four straight lines.

Do not lift your pencil from the paper, and do not retrace any lines. (Hint: your lines may go beyond the borders of the big diamond.)

■ Loose Change

Mrs. Bush had 21 coins in her purse. She added them together and found that they totaled one dollar. Can you figure out how many pennies, nickels, dimes, quarters, or half-dollars she had?

■ Magic Math

Fred was amazed at his answer when he divided 987654321 by 8.

You will be too.

Solution to Brain-Booster appearing in the last issue

Talking Hands: Here is what the two Indians said in their sign language conversation. (There were no signs for the words printed here in *italic* type. They are added for easier reading.)

"Good morning, great chief."

"Good morning, brother. Where *did* you go yesterday, brother?"

"I went *to a* big fight. I saw *a* beaver kill *a* buffalo."

"You lie, brother. *A* beaver cannot kill *a* buffalo."

"I speak *the* truth. Beaver *is the name of* my wife. Beaver killed *the* buffalo with *a* kettle. *The* buffalo ate *my* wife's hat."

The chief laughed.

"Beaver *is* angry. My son thinks *that* beaver *is* brave."

"Why *are* you carry*ing a* kettle, brother?"

"I *am going to* kill *a* buffalo *to* make my son think I *am* brave. Where *is a* sick buffalo, great chief?"

"One *was* sleep*ing* near *the* river yesterday."

"Thank you, great chief."

"Good hunt*ing*, brother."

Vacuum Cleaners

■ Have you ever wondered how a vacuum cleaner picks up dust and dirt? Some vacuum cleaners are tanks with a hose attached to one end. The other end of the hose is a metal pipe with an opening where the dirt is picked up.

Another type, called an upright cleaner, has an opening under the front of the motor case, and a large cloth bag attached to the handle. Whatever the shape, all vacuum cleaners work just about the same way.

Here is a way you can see how a vacuum cleaner works. Lay a piece of paper about the size of a postage stamp in the palm of your hand. Then hold one end of a soda straw about a quarter of an inch above the paper and draw air from the other end of the straw with your mouth.

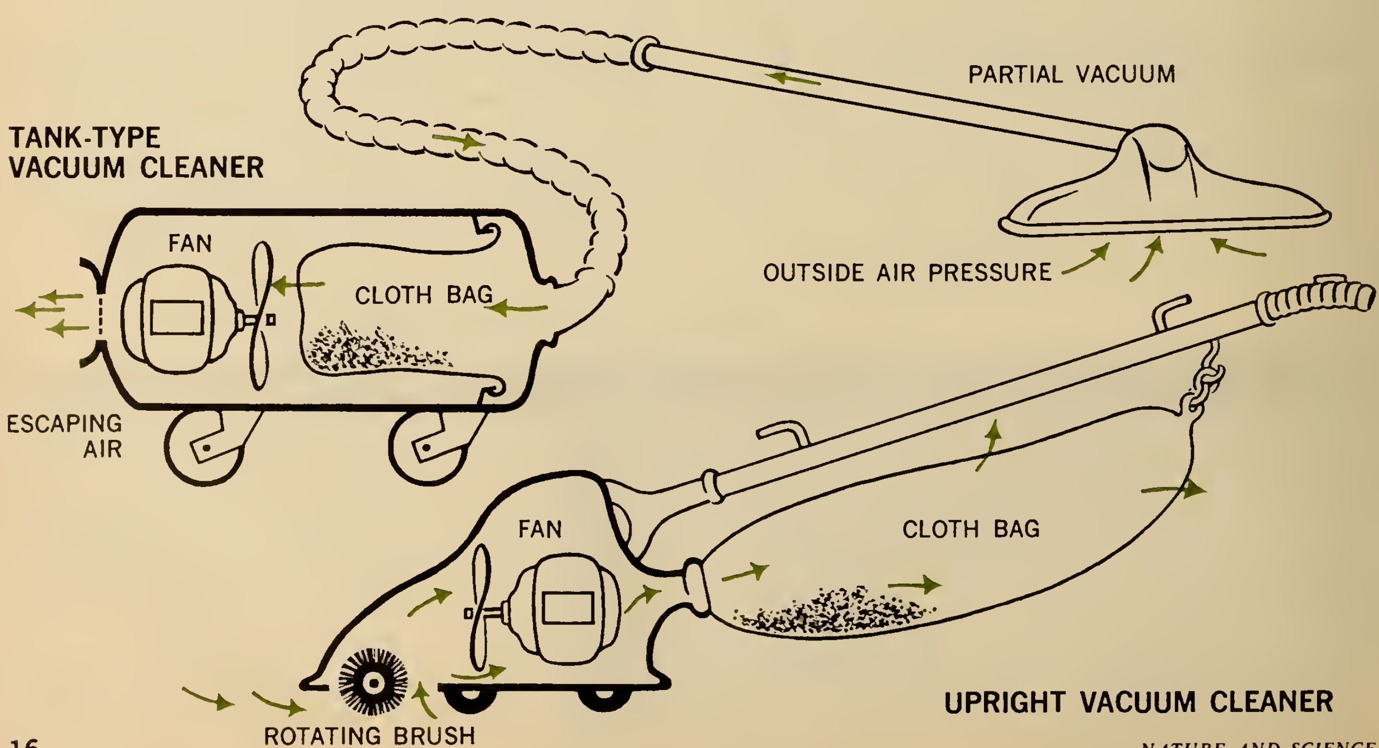
Drawing air out of the straw leaves a "shortage" of air, or *partial vacuum,* inside the straw. This means that the air pressure in the straw is lower than that of the air around the bottom of the straw. Air outside rushes into the straw to equalize the pressure, carrying the piece of paper with it.

Dust from a carpet is pushed into a vacuum cleaner in the same way. Inside the tank or motor case there is an electric fan. When the motor is switched on, the whirling fan blades push air out the back end of the cleaner, leaving a partial vacuum in the hose. Air around the pick-up vent is at normal pressure. It rushes in, carrying dust from the floor or carpet with it.

In a tank-type cleaner, this air passes into a removable cloth bag on its way to the fan. Dust particles can't get through the openings between threads that make up the bag, so they are trapped inside the bag. But the air goes right through the bag and out the back end of the sweeper.

In an upright cleaner, the fan is close to the pick-up vent. It pushes air and dust into a large cloth bag which traps the dust particles but lets the air escape through the cloth.

Cloth bags for both cleaners can be emptied and used over and over again. Paper bags through which air—but not dirt—will pass are often used inside the cloth bag. The paper bags can be thrown away after they have been used ■



nature and science
VOL. 1 NO. 8 / JANUARY 24, 1964
TEACHER'S EDITION

Elements in a Strategy for Teaching Science in the Elementary School

2. Encouraging Children To Inquire.......

by Paul F. Brandwein

■ Teaching is not synonymous with telling. The teacher is not primarily a guardian of the archives; he is first a guide to children, assuring them of their right to full development of their gifts. It is the teacher's privilege to question, and question, and question.

For example, a youngster in the fourth grade "knew" that plants grew from seeds; but, he asked, "Could I grow a seedless orange?" The teacher appropriately, to my mind, asked him how he would prefer to go about finding this out. He chose to stand up in class and ask his question, and after some discussion received a "satisfactory answer." He had inquired. The teacher *did not* use this opportunity to "cover" the field of reproduction in plants.

The teacher did bring the atmosphere of science into view by asking the youngster who supplied the "correct" information, "How do you know what you know?" He answered, "I read it." She asked, "Where?" He promised to bring in the correct reference. Till then the class accepted the answer, but it was assumed to be tentative. The teacher had made it tentative by the implicit question (it need not always be implicit): "How well do you know what you know?"

Questions That Breed Inquiry

The two following questions, pervading the elementary science class and permeating the thought of teacher and children alike, would illuminate and simplify the glad burden of maintaining inquiry as central to learning:

1. How do you know what you know? (inquiry as to the "validity" of the observation);

2. How well do you know it? (inquiry as to the "validity" of the assertion).

Again by way of example: A youngster rambled through the following; he had seen a candle burn and produce heat, he had seen a light bulb and had "burned" himself when he grasped it. He asked, "Could I get a bottle of heat?"

The teacher chose this opportunity to confront the entire class with the question, to ask them to design an investigation to answer the question—and over four days I saw the entire melee of inquiry brought into play.

The Process of Inquiry

The present *comprehension* of heat was brought to the situation: the *confrontation* produced excited comment and released the *creativity* of different children; they decided to collect "heat" and find out how much it weighed.

Many different *creative* experimental designs were offered and a few selected; *criticisms* were offered (control experiments were suggested, and rejoinders were made); and finally a *contribution* (a tight logical assertion, a conclusion) was reached. "As far as we can find out, heat has no weight." But one youngster adamantly insisted that maybe it had so "tiny" a weight and "our scales were not good enough."

The matter was left open for a better experimental design. When I left, *one* youngster had promised to continue to design apparatus on his own time. The class need not be lock-step in learning nor in doing any one investigation at any given period of class time.

The teacher had chosen this situation, this area of comprehension, for the confrontation in class. Why? The solution was not in the textbook; hence a "real" confrontation.

Often children will investigate alone. The stubborn investigator, among children and adults alike, needs to be encouraged. The incentive to do individual work relates not only to the freedom to inquire but to the psychological safety which lies in reward for failure and success alike—if the failure be the result of honest exploration or inquiry we can afford to let children fail—without threat.

In examining a concept (for instance: chemical energy can be converted into electrical energy), it is valuable to set up a learning situation even though the investigation might not be "original" to the teacher. (In this case the class analyzed a dry cell that one child had bought and found it didn't work.)

As students bring their *comprehension* (a set of concepts, however fuzzy) to the situation, there may be a *confrontation*. In proceeding to *create* an inquiry in which a more or less systematic method of developing proof is attempted, . . . a new insight into the relevance of the concept might be obtained.

It remains for the teacher to confront the class with the "new" view. For instance, after re-examination (and perhaps heightened comprehension) of the dry cell as a source of electrical energy, the teacher produced a lemon, a penny, a dime, a sensitive meter, and wondered whether electrical energy might be produced from this improbable source. And once the "cell" had been found to work, asked, "But I think you said you needed a dry cell to get electrical energy?"

Inquiry Should Be Orderly

To encourage inquiry does not mean that there can be no structure to the curriculum, that all is helter-skelter. In actuality, in observation in the classroom, children do not run about madly investigating anything and everything. The vast majority of their questions in science can at once be assigned as relevant to one or another conceptual scheme. And often their questions are the recurring ones of children, hence expected.

Furthermore, a child's question, or a general observation, may lead to a confrontation of general interest to the entire class—and the result may be a class activity in which individual or group investigation plays a natural role.

In one sixth grade, for example, a class was at work studying the geology of the region; they had been bringing in differ-

(Continued on page 4T)

This is the second of three articles adapted from The Teaching of Science *by Joseph J. Schwab and Paul F. Brandwein, published by Harvard University Press, Cambridge, Mass. © Copyright 1962 by the President and Fellows of Harvard College. Dr. Brandwein is Chairman of the National Board of Editors of* Nature and Science.

Page 3: My Three Years Among Wolves

Basic concept: Organisms affect and are affected by their environment.

This Science Adventure takes your class to a rugged island in Lake Superior where wolves and moose have apparently struck a "balance" in their struggle for existence. The article will help children to see the beauty of the complex "web of nature" and to think again about "villains" in the animal world. Also, this story and "Exploring Craters" *(see page 10)* show that some scientists can and do lead exciting lives.

Following are three thoughts, implicit in the article, that reinforce the basic concept:

1. If animals have sufficient food, shelter, and living space, they usually can maintain their numbers, even where other animals are preying on them.

2. Predatory animals are necessary to keep a community of living things in dynamic balance. Otherwise the plant-eating animals would so drastically reduce their own food supply that it could no longer permit them to maintain their numbers.

3. In the struggle for food, air, water, and light, usually the strongest organisms live and the weakest die.

Topics for Class Discussion

Scientists are still probing into the complexities of the "balance of nature." The idea of this "balance" has taken on a mythical simplicity that often leads to misunderstandings.

Class discussion of the following questions may help to clarify the idea for your pupils. The discussion may leave the children a bit awed with the many checks and balances in nature, but this is better than a mis-"understanding."

1. Why has the number of wolves on Isle Royale stayed about the same for three years? The idea here is that a given area has just enough food and space to support a certain number of certain kinds of animals.

2. What would happen if all of the wolves were suddenly removed from the island? Since the wolves are the only control of moose numbers, the moose population would "explode," reduce the available food, and many moose would die of starvation.

3. What would happen if all of the foxes suddenly disappeared from your area? Some pupils may say that there would be a "population explosion" of mice or rabbits, which foxes feed on. Probably this would not happen.

If one predatory group (foxes) is removed, others (owls, weasels) increase, and the number of prey animals (mice, rabbits) stays about the same. As David Mech points out early in his article, Isle Royale is an unusual "laboratory" because of the simple relationship between wolves and moose.

Man and the "balance." Drastic shifts in animal numbers, such as "population explosions," are rare because of the many checks and balances on animal numbers within natural communities. When they do occur, human beings are often the cause. However, in recent years man has sometimes used his knowledge of the "balance" to bring about good results. Here are some ways—good and bad—that man has affected the "balance."

- An animal or plant may be taken to a country where it has few natural enemies. A classic example is the rabbits that were imported by an Australian farmer to provide himself and friends with good hunting. The rabbits multiplied faster than they could be shot, overrunning the countryside and creating a national problem by ruining crops and grasslands. Eventually, scientists introduced a rabbit virus and the rabbits were reduced in number.
- Since man has killed most of the wolves, mountain lions, and other large predators that prey on deer, many states have so many deer that the animals damage crops, and die of starvation. To remedy this, some state conservation departments have made their laws more liberal so surplus deer can be harvested.

Ask your pupils if they can name an animal that is "no good at all." Then encourage other children to challenge the namer of the "useless" animal.

Ask them also whether they think that "conservation" means no hunting or fishing, no cutting of trees. It means the *wise* use of natural resources. Game and timber are crops that should be harvested.

Activities

Have the class obtain copies of the state fishing and hunting laws from the town clerk's office or a sporting goods store. Find out what wild animals are protected by law in your state. Why are hunting seasons set up? Why are they different for different animals?

Game laws change through the years as animal populations and hunting pressures increase or decrease, and as scientists learn more about game management. Your pupils can study these changes if they compare the fishing and hunting laws of 10 years ago, for example, with present laws.

Page 6: Making a Mold Garden

Basic concept: Organisms affect and are affected by their environment.

Molds belong to a group of plants known as *fungi,* which are relatively simple plants without chlorophyll, so they cannot synthesize carbohydrates from inorganic carbon dioxide and water. They must, therefore, depend upon preformed organic molecules—such as those found in living or dead material—as a source of food. Where the proper environment exists, fungi will thrive. A change in the environment will alter the growth of the fungus.

Under suitable conditions, various types of spores are produced. If the spores land on a suitable medium, they develop into vegetative bodies, which in turn develop new spore-bearing organs *(see photo).*

As the fungi grow, their powerful extra-cellular digestive enzymes break down the molecules in the material on which the mold lives, causing decay. Other changes which are familiar are the conversion of sugars to carbon dioxide and alcohol in the process of fermentation and the ripening of cheese by molds.

"Rules" for mold racing. Any race is

(Continued on page 3T)

THE AMERICAN MUSEUM OF NATURAL HISTORY

This photomicrograph shows a mold grown on peaches and meat sauce (see page 6). It is a member of a large group of molds called Ascomycete, to which penicillin also belongs. The clusters shown here are asexual spores and can be seen through a microscope of 400 power.

The suggestions for using this issue of Nature and Science *in your classroom were prepared by Patricia Ralph, elementary school teacher in the public schools of Huntington, N.Y., and a member of our National Board of Editors.*

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

fair only if all contestants start at the same time from the same source material. In other words, make sure the bread used is from the same loaf, or the orange peel from the same orange. Bread from different loaves may vary in freshness and amount of mold-inhibitor in it.

Practical Applications

1. Have the class recall experiences with mold and mildew around the house. Are they more of a problem in winter or summer? Upstairs or in the basement? Have the children think of ways to prevent molds from forming, such as keeping low-wattage lights on in clothes closets during the summer and making sure storage areas are well ventilated.

2. To most people (except possibly cheese lovers) molds appear to be a nuisance. Have someone investigate and report to the class the medical use of molds (in producing penicillin and other antibiotics).

Page 8: Between the Planets
Page 10: Exploring Craters on Earth

Basic concept: The universe, and its component bodies, are constantly changing.

It may surprise some of your pupils to learn that the Solar System contains many things in addition to the Sun, planets, and their satellites. The Wall Chart on pages 8 and 9 describes some of these things, locates them in the Solar System, and shows some as they appear in the sky and some that have struck the Earth.

The article on page 10 tells how scientists studied craters in Canada to learn whether they had been made by the impact of huge pieces of "space junk" striking the Earth. By studying these craters, they hope to learn something about similar-shaped scars on the surface of the Moon, and something about the early history of the Earth.

Introducing the Subject

"Danger" is a natural motivator. Your pupils may wonder whether there is any danger that they might someday be struck by a meteorite. They will probably be relieved to learn that while meteorites have landed close enough to people to be picked up still warm, only one direct hit has been reported. A woman in Sylacauga, Alabama, was bruised on the thigh by a 10-pound meteorite that crashed through her roof and bedroom ceiling in 1954.

Nor do they seem to be a great hazard to space flight. Point out that space is so vast that possibilities of a rocket ship colliding with a meteoroid large enough to puncture the hull are extremely small. Even so, scientists must guard against such possibilities and are doing so as they plan space ships of the future.

Activities

1. Encourage your pupils to watch for meteors and to describe to the class what they saw. (Meteors make a bright streak in the sky during the brief moment of their incandescence.)

2. If any child has seen a comet, ask him to describe its appearance. (Usually comets can be seen only with binoculars or a small telescope by someone who knows where to look. A comet bright enough to be seen with the unaided eye appears only about once in three years.)

3. Try to borrow a meteorite from a museum or college collection so the children can feel its weight and texture. Iron meteorites are much heavier than rocks of equal size and usually are pitted or have shallow depressions that resemble thumbprints.

4. To help your pupils understand why a meteor burns when it enters the Earth's atmosphere at a high speed, have them rub their hands together rapidly then feel with their lips the warmth generated by this friction. You might also ask one of your space enthusiasts to explain to the class the purpose of the heat shield on the Project Mercury capsules.

THE NEXT ISSUE of *Nature and Science* introduces children to a remarkable air-breathing fish that makes its nest of bubbles—the Siamese fighting fish. The article tells how to set up an aquarium for this fish *(Betta splendens)* and care for it.

For more than 2,000 years, scientists have been trying to unravel the mystery of the structure and composition of matter. The story of how their views have changed through the ages makes a fascinating introduction to the atom as we understand it today.

The number and kinds of man-made satellites now orbiting the Earth are presented in the *Nature and Science* Wall Chart.

METEOR SHOWERS

At certain times of the year "showers" of meteors occur, during which you may see dozens of meteors in an hour. These swarms are sometimes the remains of comets and appear to rain down, or "radiate," from a particular constellation. Those that come from Leo are called Leonids; those from Orion, Orionids.

Name of Showers	When They Appear	Rate Per Hour
Quadrantids*	Jan. 3	40
Lyrids	Apr. 20-22	8
Delta Aquarids	May 1-11	12
June Draconids	June 28	12
Eta Aquarids	July 24-Aug. 6	20
Perseids	July 27-Aug. 17	50
Orionids	Oct. 15-25	12
Taurids	Oct. 26-Nov. 16	6
Leonids	Nov. 15-20	6
Geminids	Dec. 9-13	60
Ursids	Dec. 21-22	12

*Quadrant was formerly the name of a constellation between Ursa Major and Draco.

Page 12: Measuring the Universe 8
Into the Depths of Space

It would be hard to give a better picture of the depths of space than what appears in this final installment.

Units of measure form one topic. Emphasize that we measure distances in the most appropriate unit—a pencil in inches, a room in feet, a road in miles, the Solar System in millions of miles. Outside the Solar System, distances are so great that measuring in miles would be something like measuring the distance to New York or San Francisco in inches.

Measuring distance by time. This idea may seem strange to children, but it should not be so new as they may think. Have them recall that when Indians said a certain place was two moons away, they meant it took two months to get there by the usual method of travel. We still speak of distances in terms of time—a certain city is three hours away, Paris about six hours by plane, and so forth.

Scientists measure deep space in terms of time, using the speed of light *(see article)* as the standard unit because it is the fastest thing known. Children may calculate some Solar System distances this new way. (The Moon is 1⅓ light-seconds away, Pluto 5⅓ light-hours.)

Activities

1. Have your pupils measure the time it takes to walk to school or to some place near their homes. Using that unit, have them measure the distance to the park, the library, or another landmark farther away. Thus, the library may be 3½ school-walks away.

2. Children will enjoy reading the many ancient legends about the Sun, stars, and creation of the Universe. Some, such as those of primitive tribes of Australia, New Guinea, and South Africa, are still believed today. Such inspiration to wonder and explain natural events in nonscientific ways may lead boys and girls to do some reading in mythology and anthropology.

Encouraging Children To Inquire
(Continued from page 1T)

ent rocks. One boy brought in a rock with a fossil in it; his explanation was a fairly good assertion concerning the existence of ancient life and evolution, as accounting for the diversity.

For a good number of the children this seemed to be their first *confrontation* with evolution, per se. But the questions took a different turn, understandably based on the children's comprehension based on prior conceptualization. One child put it this way: "But I thought that a living thing gave birth to others like it. This isn't true now, is it?"

To make a long story of confrontation short, a period of work began in the field we know as "genetics"; the dominant organizing question was: does like always give birth to like?

One boy set about finding out why he had different puppies in a litter. Two girls began to breed the class guppies to note similarities and differences. Four children began modeling plants and animals after visits to a museum.

Three children began to grow cultures of protozoa; they were fascinated by the bold suggestion of one girl, that if they could study things that reproduced very fast they wouldn't have to wait a lifetime to see a "change."

Four children were preparing cages for the hooded male and nonhooded female white mice the teacher had thoughtfully announced were on their way.

Two children began to look into the origin of their red hair.

Meanwhile, the teacher and class had planned class, library, laboratory, and field experiences to determine how, in their words, "living things gave birth to like living things and unlike ones."

Inquiry Involves Everyone

There was a "mix" of teaching-learning activities, from classroom activities involving the entire class to those involving individual investigations and projects.

There was a "mix" of teaching-administrative activities, from activities involving the teacher (collecting materials of instruction) and committees of students (also collecting materials for instruction) to those involving different consultants, librarians, teachers in the local university, and members of the community (a coal dealer brought in chunks of coal with fossil ferns). All children (with their considerable variety in levels of ability) were involved.

There was a "mix" of skills, from manipulation, to "experimentation," to reading. And through it all one child kept wondering (and nagging others) whether scientists would ever make "tiny" living things "like amoebas" in the laboratory.

There was also, you see, a "mix" of realistic thinking and imaginative searching for hidden likenesses. And fantasy, that free organization which is so characteristic of what we sometimes call creativity, was abundantly in evidence.

Often children working in a group would stop to discuss things, or go to each other. They had the freedom to learn, to investigate in whatever form inner-need states and external demands influenced them. But the teacher held them always to a kind of tangibility: they shared the product of their learning (contributions) with each other and were subject to the *criticism* of their own island of science illuminated by whatever help their ingenuity commanded.

There was also a mix of investigations originating out of highly personal needs or interests, and out of apparently more dispassionate objectives as well.

Children could *do*, could *dream*, could *discuss*, could *drop off into fantasy*—and could come back to the classroom in safety. They could discover; they could invent; they could systematize; they could disseminate.

In any field of scholarship there are leaders, followers, inventors, systematizers, and disseminators. In classroom, as in life, a "mix" of activity is natural, practicable, desirable—and inevitable ■

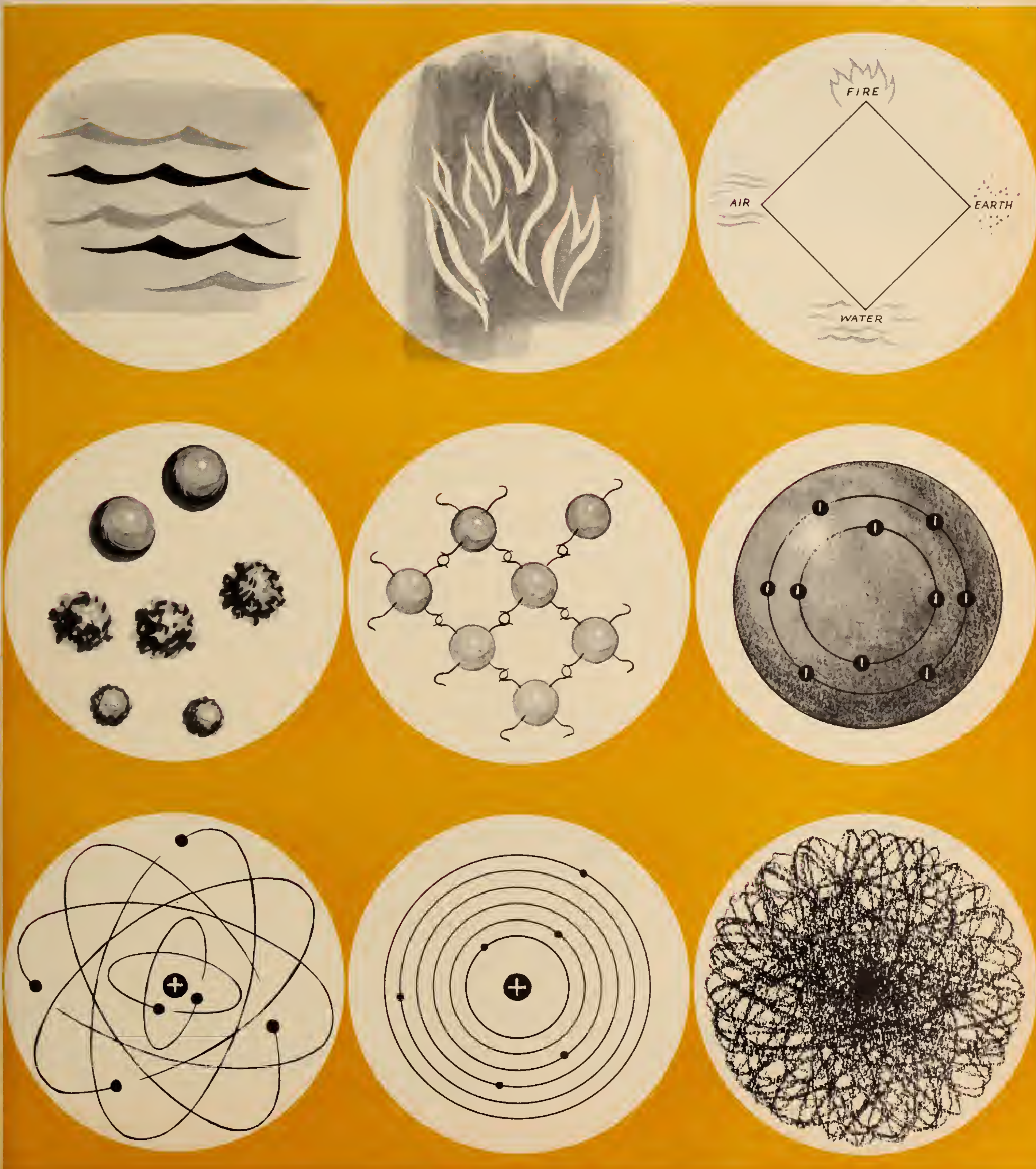
nature and science

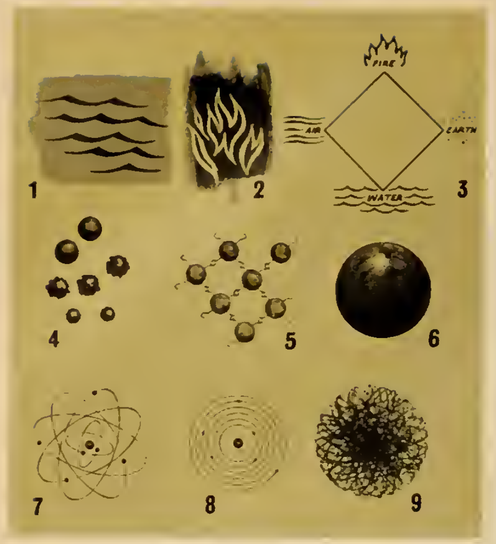
VOL. 1 NO. 9 / FEBRUARY 7, 1964

What is matter? The new tools of science are bringing us ever closer to an answer to this age-old riddle.

see page 4

WHAT ARE THINGS MADE OF?





ABOUT THE COVER

What is matter? This question has puzzled scientists for centuries. Our cover shows nine ways that men have pictured tiny units of matter called *atoms*, beginning about 2,500 years ago.

The Greek teacher Empedocles taught that all matter is made of water, fire, air, and earth (1, 2, 3). He called these "elements." Another Greek teacher, Democritus, said that matter is made of tiny particles, some rough and others smooth (4). He called them "atoms."

Over the past 200 years, as scientists have learned more about matter, their ideas of the atom have become more and more complicated. Gassendi (1630) said that solid things are made of atoms that are probably hooked tightly together (5). In 1897, J. J. Thomson discovered that atoms have tiny particles called electrons (6). Twenty-two years later Ernest Rutherford proved that Thomson's electrons circle about a heavy core, a *nucleus* (7).

Niels Bohr (1913) believed that each electron of an atom had its own orbit (8), but that electrons could jump from one orbit to another. Scientists now think that electrons move in shells or "clouds" that enclose the nucleus (9). The article that begins on page 4 tells more about the atoms and the men who have studied them through the years.

nature and science

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HOW DID EGRETS CROSS THE ATLANTIC?

■ One summer day in 1951 several people saw two strange African birds in a marsh at Cape May, New Jersey. What were these birds doing here? And how and when did they manage to get here–some 6,000 miles from home?

The next year more of the birds, called Cattle Egrets, appeared–two more in New Jersey, one in Massachusetts.

Were these five the first to arrive in the United States? No one knew. A park naturalist, Willard E. Dilley, had seen two egrets in the summer of 1941 or 1942 in a marshy pasture in Clewiston, Florida. He thought they had escaped from a zoo, so he didn't report his find.

Cattle Egrets appeared in British Guiana about 1930. If the birds flew the 1,800-mile trip from Africa, their broods could then have invaded the United States.

Tracking down bits and pieces of information about these birds, Samuel A. Grimes of Jacksonville, Florida, found a man at Belle Glade who had seen Cattle Egrets feeding "regularly with cattle for two or three years up to the time of the flood (hurricane) of 1949."

Could the birds have been in this country for 10 years without being recognized? Because they were scattered among white herons, they could have gone unnoticed.

For bird watchers the year 1952 came to a spectacular close when an exhausted Cattle Egret tried to land on a fishing boat off the Grand Banks of Newfoundland. Its appearance made a "first" for Canada.

Like the advance troops of an invading army, in 1953 the egrets began to erupt over the eastern United States and Canada, and along the 40-mile Lake Okeechobee in Florida (which is still their stronghold). By 1954 there were around 2,000 egrets in this country.

Cattle Egrets have spread over the Southwest and Plains Areas, and are a fairly common sight in many parts of the United States. They are often seen alongside grazing cattle, their white feathers gleaming, their short steps keeping pace with their huge companions. In their native Africa, they team up with buffalo, zebras, elephants, and other large animals.

Why do they choose such huge companions? Do the birds warn them of enemies? Some people think so. One thing we know for a fact is that the hooves of their companions stir up insects that the birds eat.

But this doesn't answer the most interesting question—how did the birds travel over 6,000 miles to America? Did they fly (with a good tail wind), or did they hitch a ride on ships?—Elizabeth French

Twenty or more years ago African Cattle Egrets crossed the Atlantic and took up life in South America and in North America. How they managed the journey puzzles scientists. These birds eat insects stirred up by the cattle.

WHAT ARE THINGS MADE OF?

Atoms are the smallest building blocks of the universe. We can join them together and pull them apart; we can even make atoms that are not found in nature. Yet no one has ever seen an atom, and no one ever will. The more we learn about these bits of matter, the more baffling they seem.

by Earl M. Grotke

■ For centuries men have been trying to solve the puzzle: What are things made of? Our skin, a piece of wood, specks of dust, a star, water—all things are made up of tiny particles of matter which we call *atoms.*

Atoms are tiny bits of matter so small that we cannot see them. They are far smaller than anything you can see with a microscope. It would take 1,000,000,000,000,000,000,000,000 atoms to fill a little box one inch on each side. After you finish reading this article, ask your friends and your parents if they can describe an atom. You may be surprised by some of the answers you get.

An Ancient Greek Named the Atom

Since atomic submarines and atomic power plants are so new, you may think that the idea of atoms is also new. More than 2,400 years ago, in 450 B.C., a Greek teacher named Democritus asked his students what would happen if they smashed a rock to bits, then took the smallest bit and kept breaking it into smaller and smaller pieces.

Democritus told his students they would have the smallest particle imaginable. He called such a particle an *atom.* The *a* and the *tom* are from two Greek words meaning "not" and "dividable." For Democritus and his students, atom meant something that could not be divided; and in his day rock dust could not be divided. Today we know that there are many different kinds of atoms in the dust, and some of them can be "split."

Democritus taught that everything is made of atoms—trees, hills, clouds, animals, people. He also taught that there are different kinds of atoms with different sizes, weights, and surfaces. Light, smooth ones made up the air, he said. Their smooth surfaces let them flow over one another when the wind blew. Medium-weight, smooth atoms made up water and other liquids. Large, heavier atoms with rough surfaces made up soil, rocks, and metals. Their rough surfaces made them stick together. Today scientists are studying the "surfaces" of the atom and how atoms stick together. But our ideas of atoms today are very different from the ideas of Democritus.

Another Greek teacher, named Empedocles, made a different guess about the nature of matter. He taught that all matter was made up of four things he called "elements": water, fire, air, and earth. He said that these could change themselves into all other substances—clouds, soil, rocks. Because people could see and feel these "elements" (but they could not see or feel "atoms"), Empedocles' ideas were popular for more than a thousand years. Centuries later, scientists came back to Democritus' idea.

Men called "alchemists," in the 1400's and later, tried to "grow" gold by mixing things such as blood, hearts of salamanders, and wine with mercury, silver, and other metals. Shown here is a typical alchemist's laboratory, as painted by David Teniers, who lived from 1582 to 1649.

In 1630 a French mathematician named Pierre Gassendi taught Democritus' idea of atoms. Like some other scientists of his time, he saw more truth in the ideas of Democritus than in those of Empedocles.

Gassendi was interested in how atoms fasten themselves to each other. He drew pictures of atoms as little round balls with hooks sticking out of them. He reasoned that tough substances must have many hooks, while substances easy to break had few hooks.

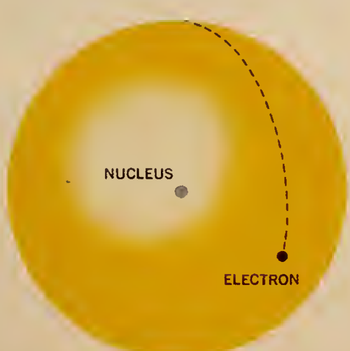
From 1650 to 1850, more and more men studied matter in their laboratories. Through his experiments, an Englishman named Robert Boyle discovered that the four "elements" of Empedocles could not even begin to account for the many changes we see in nature. Some substances, he said, could never be made from other substances. He called these *elements*. Boyle's list of true elements included gold, silver, lead, iron, mercury, copper, and others.

Scientists were learning that there are many different kinds of atoms and that each different kind is an atom of a different element. While there could be atoms of oxygen, there could not be atoms of air, because air is a mixture of many different elements—oxygen, nitrogen, and several more.

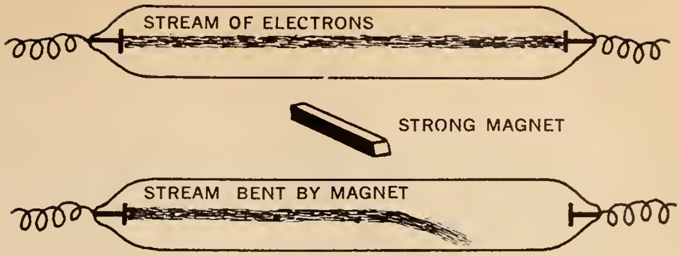
Different Atoms Make Different Elements

Another experimenter was an Englishman named John Dalton. In school he must have been very bright because at the age of 12 he began teaching, and at 19 he was an assistant principal. Dalton was fascinated by the idea of atoms and read everything he could about them. Around 1802 he reasoned that all the atoms of any one element must be exactly alike. And he meant Boyle's *elements*—gold, silver, lead, and so on—not the earth, air, fire, and water elements of Empedocles.

Atoms of different elements must be different in size, shape, and weight, Dalton said. To picture his atoms, he drew circles with special markings. For example, Dalton knew that water is made up of hydrogen and oxygen. He let a plain circle stand for oxygen and a circle with a dot in the middle stand for hydrogen. He then pictured water like this: ⊙○ . Today, using Dalton's picture writing, we would represent water this way ⊙○⊙, because we know that water consists of two atoms of hydrogen and one atom of oxygen.



Atoms are so small that we do not know what they actually look like. Atoms may be mostly empty space. For example, if the nucleus of a hydrogen atom were the size of a golf ball, the electron circling the nucleus would be about a mile away.



When J. J. Thomson held a strong magnet near a glass tube from which all the air had been removed, a stream of electrons flowing through the tube was made to curve (lower diagram). Without the magnet the electron stream traveled in a straight line through the tube (top diagram).

Dalton knew of 23 different elements. In addition to picturing them all, he also worked out the atomic weights of 16 of them. Before Dalton died in 1844, he became famous for his discoveries about atoms.

Inside the Atom

At this stage in our story, scientists knew that there were tiny bits of matter they called atoms. But were atoms solid lumps of matter, or were they made of tiny parts?

As this question was being asked, physicists were experimenting with electricity. In one experiment, J. J. Thomson, an English scientist, ran electricity through a tube from which the air was removed. The tube he used was something like the tube in a television set. In the dark, he could see a stream of bright stuff racing through the tube. When he held a strong magnet near the tube, the bright stream curved.

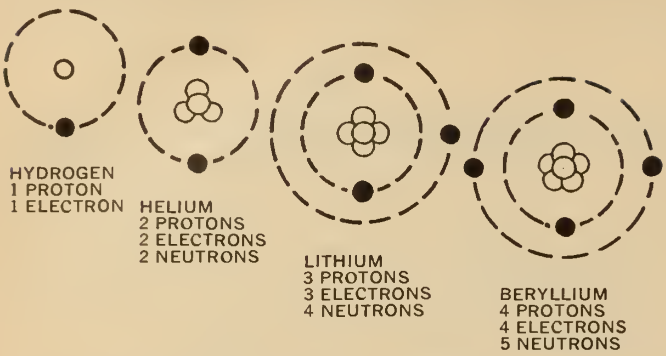
Ordinary light could not be bent in this way. What, then, was the bright stream? In 1897 Thomson said that the stream was made up of tiny particles which he called "corpuscles," and which we now call *electrons*. These electrons seemed to come from *within* atoms.

After 2,000 years, men had broken into the atom. The question they asked next was this: How many more parts might an atom have?

Twenty-two years after Thompson discovered electrons, one of his brightest students, Ernest Rutherford, showed that at the heart of every atom is something called a *nucleus*. The atom, he said, is like the Solar System. A heavy "Sun," or nucleus, is at the center, and much lighter "planet" electrons speed around it.

An atom of hydrogen, the simplest element known, has one particle, called a *proton*, as the nucleus and one electron whirling around it.

(Continued on the next page)



Each element has a different kind of atom. The four simplest atoms are: 1. hydrogen; 2. helium; 3. lithium; 4. beryllium.

Another English scientist, Sir James Chadwick, showed in 1932 that the nucleus of an atom has still other parts—which came to be called *neutrons.*

Atoms that Break Down

Before Chadwick made his discovery, other scientists had been working with the element *radium.* Radium is called a *radioactive* element because each of its atoms gradually breaks down by itself by giving up two neutrons and two protons.

This discovery of radioactivity fascinated scientists. If an atom of radium loses parts of itself, what is left? They found that such atoms change into other kinds of atoms. Rutherford found that as radium breaks down all by itself, it gradually changes into lead. Imagine that we could in some way hit a helium atom *(see diagram)* in just the right way so that we knock one of its protons, its two neutrons, and one of its electrons out of the atom. What is left is one proton and one electron—a hydrogen atom.

Here then was another major discovery. Rutherford's studies again changed man's idea of atoms. Boyle and Dalton had said that elements and atoms could not be changed. Democritus had said that atoms could not be divided. All three ideas were changed by Rutherford.

It was Rutherford's understanding of the atom's nucleus that led to the development of the atomic bomb, "atom smashers," and atomic power. In these mighty developments of the "Atomic Age," it is energy from the nucleus that is put to work.

The Atom Today

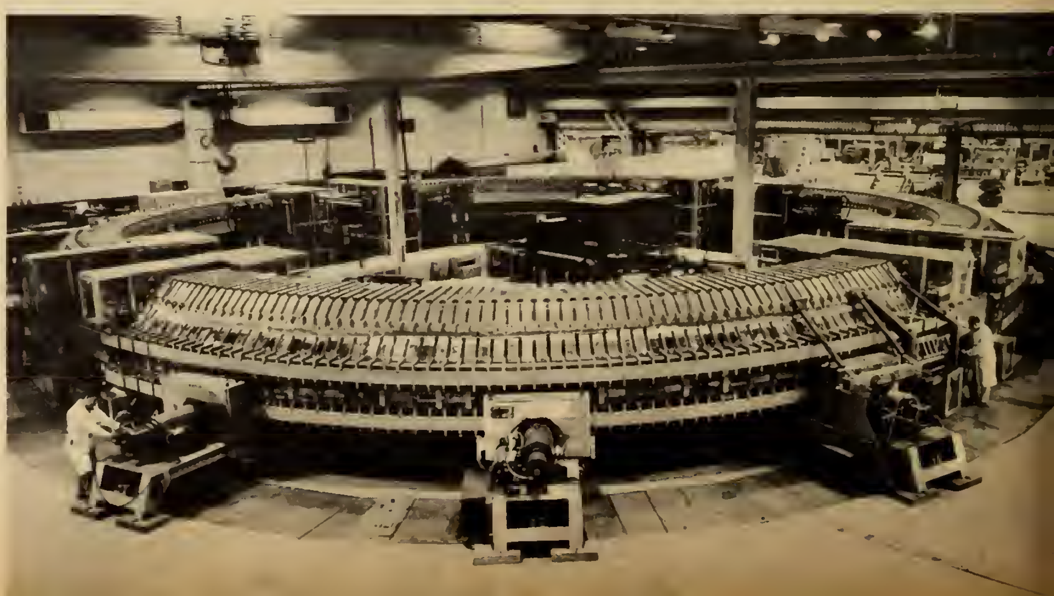
Even though it is possible to take some atoms apart, no one has ever seen an atom. The pictures we draw of atoms are only diagrams. They do not show us what an atom really looks like. The picture of Rutherford's atom *(see cover)* was quite neat; today's picture is quite blurry.

The atoms imagined by Democritus and Dalton are totally different from our idea of the atom now. Today thousands of scientists the world over are working with huge machines, called *particle accelerators,* that shoot protons or neutrons into various materials. When one of these particles smashes an atom or its nucleus, other kinds of *sub-atomic* particles appear for brief moments. Every now and then a new kind of particle is discovered. Today we know of at least 32, and scientists continue to look for more. How many will be found eventually, no one knows.

The atom is still one of science's most interesting and baffling puzzles. The atom we know today is a jungle of minute particles. The more scientists learn about them, the more complex the atom seems to become. Today it is impossible to say "This is exactly what an atom is." Each time we learn something new, our ideas about the atom are bound to change ■

■ For further information about atoms, look in your library or bookstore for these books: **The Story of the Atom,** by Mae and Ira Freeman, Random House, Inc., New York 1960, $1.95; **Exploring Chemistry,** by Roy A. Gallant, Garden City Books, Garden City, N.Y., 1958, $2.95; and **Experiments with Atomics,** by Nelson F. Beeler and Franklyn M. Branley, Thomas Y. Crowell Co., New York, 1954, $2.95.

With huge machines like this one, called a cosmotron, scientists are learning what happens to atoms when they are broken apart. Inside the machine, strong magnets pull protons around and around to speed them up, then they are released to smash into a target—a piece of the element carbon, for example. The resulting bits and pieces provide clues about many of the tiny particles that make up atoms.



How Fast Do Your Fingernails Grow?

Find out how fast your nail grows by measuring each week the distance from a scratch to the edge of the white tip.

■ Do you have any idea of how fast your fingernails grow? Here is a way you can find out. Start your investigation on one particular day of the week, say Monday.

With the edge of a fingernail file (do *not* use anything sharper than that), file a short straight line across your thumbnail right up against the *cuticle* at the base of the nail (*see photo*). Next measure the distance from the scratch to the edge of the white band around the tip of your nail. Make a chart like the one shown here on a sheet of lined paper, and write down this measurement and the date you made it.

THUMBNAIL GROWTH CHART

Date	Distance—Scratch to White Band	Growth per Week

______ Weeks for scratch to reach white band

One week later, on the same day, measure the distance from the scratch to the edge of the white band. Has the scratch moved any closer to it?

Subtracting your second measurement from the first one will show how much your nail has grown in one week. This will not be very much the first few weeks, but keep measuring it on the same day each week, and write down the date and measurement on your chart. (Every once in a while, you may have to deepen the scratch a little so that it doesn't wear away.)

After four weeks, you will be able to tell from the measurements you have taken how many sixteenths of an inch your thumbnail has grown in one month. This will be the *rate of growth*. We say that our *rate of travel* during a trip was 50 miles an hour. At the end of a month you will be able to say that the rate of growth of your nail is 4/16 (or whatever) of an inch a month. When the scratch reaches the edge of the white band, your chart will show how long it took for the nail to grow one full length.

Do you think that your thumbnail grows at the same rate all the time? Probably not, according to Dr. William E. Bean, who is a physician at University Hospitals in Iowa City, Iowa. Dr. Bean started measuring the growth of his thumbnail 20 years ago, when he was 32 years old, and has been taking measurements regularly ever since.

Sometimes his thumbnail would grow more rapidly than usual, sometimes more slowly. Dr. Bean compared his record of measurements with such things as changes of seasons and changes of location (when he made long trips to Europe). But he didn't find any connection between these changes and the "spurts" and "lags" in his thumbnail's growth. The doctor did find, though, that as he grew older, it took longer and longer for his thumbnail to grow out to its full length ■

INVESTIGATION

Do your classmates' thumbnails grow out as fast as yours? Do the boys' nails grow as fast as girls'—or faster? Try to find answers to these questions. You might ask some teen-agers and some grown-ups of both sexes to help, too.

On a chart like the one shown here, write the name, age, and sex of each person, and the date on which he or she marked a thumbnail. After about two months, keep reminding each person to watch his nail and report to you the date on which the scratch reaches the white band at the end of the nail. From these dates, you can figure out the "grow-out" period, in days, for each person.

Whose thumbnail grew out fastest? Slowest? Add all of the grow-out periods together and divide the sum by the number of people involved. This gives you the average grow-out period for the entire group. Can you figure the average grow-out period for all the boys and girls who are about the same age? The average for teen-agers? For adults? Which group's nails seem to grow fastest?

Is the average grow-out period for the boys in your age group longer or shorter than for the girls? Can you think of any other questions your figures might answer? Do you think your findings would be the same if you had been able to compare the grow-out periods for, say, 100 people?

CHART OF THUMBNAIL GROW-OUT PERIODS

Name	Age	Sex	Date Started	Date Ended	Grow-out Period

SATELLITES & SPACE JUNK

■ Until 1957, when people thought of the word "satellite," they thought of the Moon. Then the first artificial satellite —Sputnik I—was launched by the Russians. The following year the United States launched its first artificial satellite, Explorer I. Thereafter, launchings came fast.

Today there are more than 70 man-made satellites in space. Some of their names—*Echo, Telstar, Mariner*—are almost as familiar as *Moon*.

Sputnik I is no longer circling the Earth. After three months in space, it fell out of orbit. This happened as the satellite cut into the fringe of the atmosphere and gradually lost speed. With each orbit, Sputnik I had to push its way through more and more atmosphere as it circled in closer and closer to the Earth. Finally it cut deeply into the atmosphere and burned up in the same way that pieces of rock and metal do when they burn up as meteors.

The Jobs Satellites Do

Every year more satellites fall out of orbit. Yet new ones are launched, so the number in space is always changing. Each satellite has a special job. Echo I—a 100-foot shiny plastic balloon–did its job simply by staying in orbit, so that radio signals could be bounced off its surface and returned to the Earth.

The job of Ariel *(see chart)* is to gather information about the *ionosphere*. The ionosphere is a layer of air particles that begins 40 miles or so above the Earth's surface and reaches about 400 miles into space. The ionosphere is a radio "mirror" that reflects signals from one point on the Earth to another. Sometimes, however, it is disturbed by "storms" on the Sun. At such times radio signals are not reflected by the ionosphere. Hours or days may pass before long-distance radio signals can be sent. Scientists launched Ariel to find out more about these mysterious changes in the ionosphere.

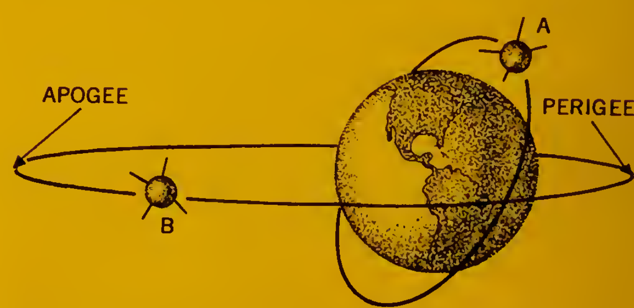
Ariel measures the numbers, temperatures, and location of the particles that make up the ionosphere. It also records x-rays and other radiation from the Sun. The information is coded on a tape recorder inside the satellite. When scientists send a signal to Ariel, the tape recorder is turned on automatically and the coded information is sent to the Earth by radio.

The instruments, tape recorders, and radios in artificial satellites are powered by batteries that last from a few months to two years or more. Some satellites, such as Mariner *(see chart)*, are powered by solar batteries, which get their energy from the Sun and have longer lives.

Eventually, the batteries of every satellite fail. When this happens the satellite speeds silently through space. It has no further use and becomes a piece of "space junk," along with 50 or more rocket bodies now coasting around our planet. After these rockets did their job of placing their satellites properly in orbit, they separated from the satellite and stayed in orbit. Scientists believe that some space junk will stay in orbit for hundreds or thousands of years.

About a half-dozen satellites have become "planets" circling the Sun, but most of the satellites in space are in Earth-circling orbits. These satellites travel in flattened paths, called *ellipses*. For some satellites, the closest distance to the Earth *(perigee)* may be only a hundred miles or so, while the greatest distance from the Earth *(apogee)* is several thousand miles *(see diagram)*. Other satellites have nearly circular orbits. The exact orbit of a satellite is usually not an accident, but is planned by scientists who control the direction and speed of the launching rockets.

The chart on these pages shows 20 kinds of satellites that are now in space. Some have become junk, but others are still gathering information about the mysteries of space and beeping it by radio to scientists on the Earth ■



Scientists can put a satellite into any kind of orbit. They can do this by controlling the speed and direction of the launching rockets. Like the planets, all satellites travel along paths called ellipses. A satellite's orbit may be nearly circular, or it may be a flattened ellipse. In orbit A, the satellite's apogee (farthest distance from Earth) is almost the same as its perigee (closest distance to Earth). In orbit B, the apogee is thousands of miles greater than the perigee.

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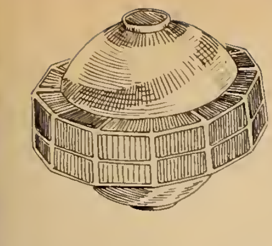

NNA One in Earth orbit, launched ct. 1962. Mission: to measure the ıape and size of the Earth.

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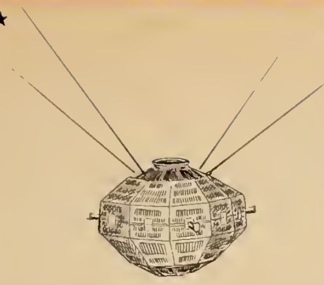

ALOUETTE (Canada) One in Earth orbit, launched Sept. 1962. Mission: to find out more about the ionosphere (see text).

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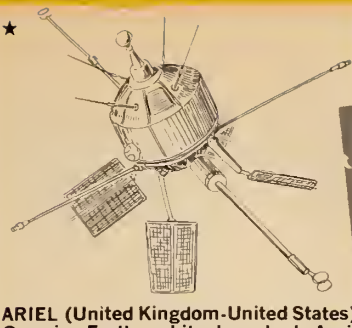

ARIEL (United Kingdom-United States) One in Earth orbit, launched April 1962. Mission: to find out more about the ionosphere (see text).

COSMOS (U.S.S.R.) Many in Earth orbits. (Twelve were launched between May 1962 and Nov. 1963.) Mission: probably like that of the United States' Discoverer satellites.

ISCOVERER Many in Earth orbits; ·st one launched Feb. 1959. (Before unches became secret in March 962, twenty-six had gone into orbit.) ission: to test instruments and techques for future space probes.

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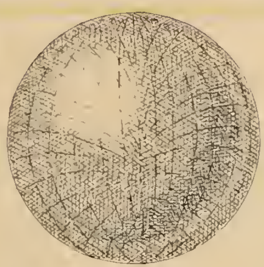

ECHO One in Earth orbit, launched Aug. 1960. Mission: to improve long-distance radio communications. Radio signals sent from California were bounced off this 100-foot-wide sphere and received in New York.

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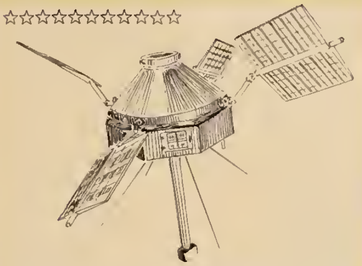

EXPLORER Eleven in Earth orbits; first one launched Jan. 1958. Mission: to measure radiation from the Sun, temperatures, and the amount of tiny meteorites in the upper atmosphere and in space.

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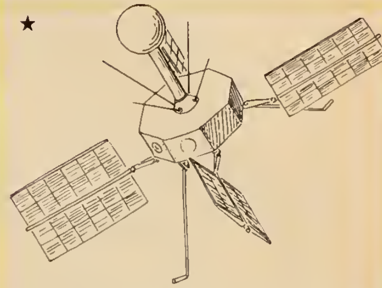

IMP (Interplanetary Monitoring Platform) One in Earth orbit, launched Nov. 1963. Mission: to measure "storms" and other radiation outbursts from the Sun.

UNIK (U.S.S.R.) One in Sun orbit, unched Jan. 1959. Mission: Flew ıst the Moon, gathering information bout the magnetic fields of the Earth ıd Moon. (Another Lunik took photo-aphs of the Moon's far side.)

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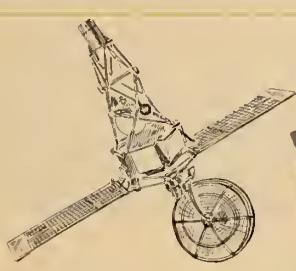

MARINER One in Sun orbit, launched Aug. 1962. Mission: to gather information about the planet Venus. Mariner II did this, sending radio signals until it was 54 million miles from Earth. It now orbits the Sun.

MIDAS and SAMOS Several in Earth-orbits; first one (Midas) launched May 1960. (Launching are now secret.) Mission: Two jobs of these "spy in the sky" satellites are to take aerial photographs and detect missiles.

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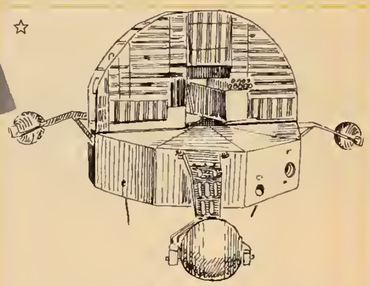

OSO (Orbiting Solar Observatory) One in Sun orbit, launched March 1962. Mission: to gather information about tiny particles, x-rays, and other radiation from the Sun.

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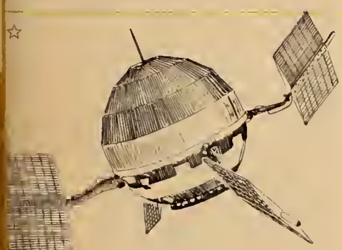

ONEER Two in Sun orbits; first one unched March 1959. Mission: to easure radiation from the Sun and e number of particles in space. Pioeer 5 sent radio signals to Earth from 2,500,000 miles in space.

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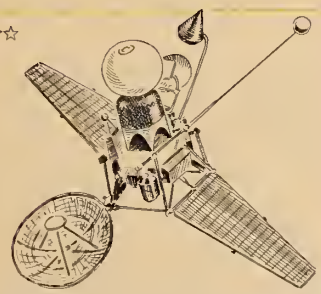

RANGER Two in Sun orbits; first one launched Jan. 1962. Mission: to test equipment required for manned flights to the Moon, and to gather information about the Moon's surface.

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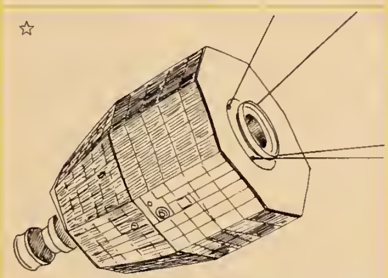

RELAY One in Earth orbit, launched Dec. 1962. Mission: to receive radio and television signals from Earth, make them stronger, then send them to other parts of Earth.

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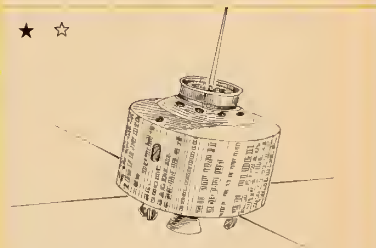

SYNCOM Two in Earth orbits; first one launched July 1963. Mission: to improve long-distance radio communications. Syncom hovers over one point on the Earth's surface because it completes an orbit in the same time the Earth completes one rotation.

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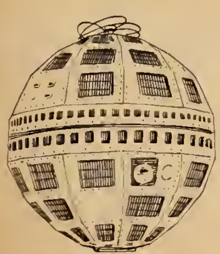

ELSTAR Two in Earth orbits; first one unched July 1962. Mission: to relay levision pictures over long distances.

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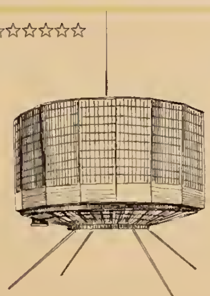


TIROS Eight in Earth orbits; first one launched April 1960. Mission: to send television pictures of cloud formations to Earth to aid weather forecasting.

★ ☆☆☆☆☆


TRANSIT Six in orbits; first one launched April 1960. Mission: to help submarines, ships, and aircraft navigate in all kinds of weather.

★ ☆☆


VANGUARD Three in Earth orbits; first one launched March 1958. Mission: to measure the shape of the Earth, gather information about the Earth's magnetic field, and count tiny meteorites in space.

★ Satellite operating ☆ Satellite not operating

■ **The Grandfather's Age**
Joan asked her grandfather when he was born and he said, "Figure it out. I was born in the last century and if you write my birth-year on a sheet of paper and turn the paper upside down, the date will be the same."

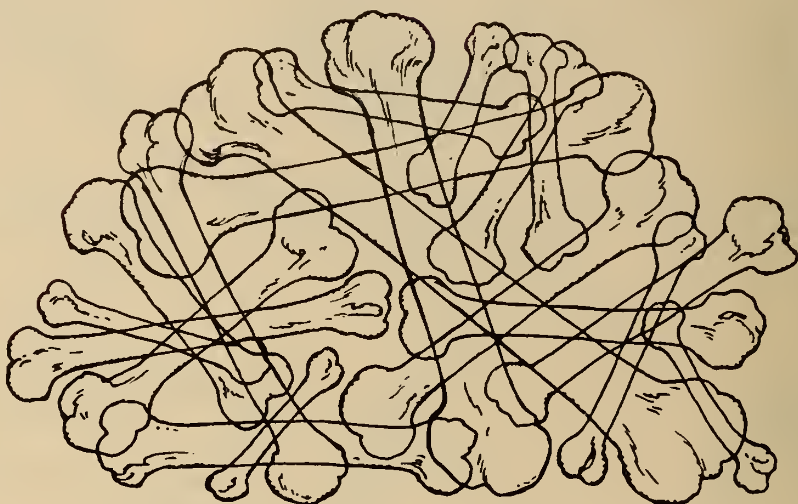
■ **Fish Story**
Mr. H. Mackerel caught 50 fish in five days. Each day he caught three more fish than the day before.

Can you tell how many he caught on each of the five days?

■ **In the Dark**
Dr. Myotis stepped into the dark cave and turned on his flashlight. He was studying bats and he smiled with delight when he saw 29 bats hanging from the ceiling of the cave. He noticed that there were 15 brown bats, 8 black bats, and 6 red bats. He wanted to collect 3 of any one color.

Just as he reached for his collecting bag, his flashlight dropped and broke. What is the least number of bats Dr. Myotis must collect to be sure he has three of the same color?

■ **A Puzzle in the Park**
The sidewalks in a city park are arranged in this figure. Begin at the arrow and see if you can walk along every path. Travel the paths just once and do not cross a path that you walked on before, except at corners.



■ **The Archeologist's Discovery**
While digging for remains of early man, an archeologist discovered this collection of bones. He drew this figure to show the bones exactly as he found them.

Can you figure out how many bones the archeologist found?

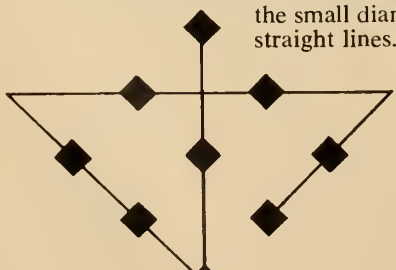
Solutions to Brain-Boosters appearing in the last issue of *Nature and Science:*

Loose Change: Mrs. Bush had one half dollar, two dimes, three nickels, and 15 pennies; or she had two quarters, three dimes, one nickel, and 15 pennies: In each case 21 coins add up to $1.

Magic Math: When Fred divided 987654321 by 8, his answer was 123456790.125.

Boys Will Be Boys: To get his two sons and the refreshments safely across the river, Mr. Clark first rowed across with the refreshments and left them on the far side. He then rowed back, picked up one boy and took him across, returning with the refreshments. He left them on the near side, took the second boy across, then returned for the refreshments.

Little Diamonds: To connect all of the small diamonds, draw these four straight lines.



Kitten's Knitting: Here is how to untangle the maze of yarn.

The Bubble Nests of Betta splendens

This Siamese fighting fish is a fascinating aquarium animal. Its delicate nest of bubbles is only one of many things about the fish that will surprise you.

by
George W. Barlow

Unlike most fishes, Siamese fighting fish get air by gulping mouthfuls at the water's surface.

■ Have you ever heard of a fish that makes its nest of bubbles? Or a male fish that chases the females away after she lays her eggs, and brings up the young fish himself? This remarkable fish is known as Betta, or the Siamese fighting fish called *Betta splendens*. It is the tamest kind of fish I know of and is easy to take care of in a home aquarium. Also, unlike many other animals, Bettas do not seem shy in captivity. They breed and carry out their daily lives even though you are watching them.

Bettas have been bred for fighting in Siam for hundreds of years. They have long flowing fins and come in a number of strikingly lovely colors. Unlike most fishes, they breathe air, gulping mouthfuls at the surface of the water. Because of this habit they can be kept in unusually small bowls. Some people raise the young fish in pint jars. One of the most popular aquarium fishes, Bettas can be bought at many pet stores.

Building a Bubble Nest

Your Betta will soon get to know you, especially if you feed him at about the same time each day. If you are gentle, he will let you stroke him with your finger, or even allow you to pick him up out of the water briefly in your cupped hand. But be careful. With a quick flick of the tail he may jump out of your hand.

If your male Betta is in good health and is kept warm (80° F.), he will probably build a bubble nest. Using inhaled air, the male forms a slimy bubble in his mouth. Just how he does this is not known. He places bubble after bubble at the water surface in a chosen place. In an aquarium this will often be in one corner or wherever a shadow falls. In nature, the male may use floating plants to anchor the nest.

When it is finished, the nest is about the size and shape of a small scoop of ice cream that has melted until it is about one-half inch high in the center. Because the bubbles keep breaking, the male is kept busy adding new ones.

It is easy to raise Bettas, and it is a fascinating performance to watch. When the female is full of eggs, as shown by her enlarged belly, she should be placed in the same bowl as the male. At first you should keep the two fish apart. If you don't, the male might attack the female and injure her. A piece of glass separating the two fish will protect the female and allow her to adjust to her new surroundings.

(Continued on the next page)

When you first bring the two together, the female will flee from the male. This is typical. But you will see that she does not flee too fast. In fact, if you watch closely, you will observe that while swimming away from the male she swims with wider than normal motions, as though she were "swaggering" away from him. Also she may tip down so that her head is lower than her tail. Dark bands may appear on her body.

The male does not attack her. Instead, he responds by swimming around her. His fins are fully spread, making him look larger than he actually is. His colors, too, become darker than before, bringing out their shiny highlights and making him more easily seen. Unlike the female, the male tends to tilt upward, his head slightly higher than his tail.

Finally the female moves toward the male. In response, he swims toward the nest and the female may follow him. Once there, he adds a few bubbles to the nest. All during this time the male seems about to attack the female. Indeed, sometimes he does. But the female presses closer to the male, nudging him in the side with her snout. When this happens, the male folds into a U and wraps himself around the female. He holds her in this position, called the spawning embrace, *fertilizing* the fresh eggs that she lays by adding sperm cells to them. Without the sperm cells, the eggs would not hatch into young fish.

Within a few seconds the male lets her go and dives after the sinking eggs, catching them in his mouth. He makes a bubble around each egg and spits them one by one into the bubble nest. Then he returns to the female.

Spawning may go on for an hour or two. In the end the female flees. If she is not removed from the aquarium, the male may kill her.

Guarding the Eggs

The male stays with the eggs and guards them. If other male Bettas are around, he chases them away. If an egg drops out of the bubble nest, the father Betta catches it in his mouth, forms a new bubble around it, and puts it back into the nest.

In about two days, the eggs hatch into tiny new fish,

called *larval* fish. These have little "glue spots," or cement glands, on their heads and elsewhere. With the help of the cement glands, the larval fish stick to the leaves of plants.

The father Betta protects his young ones and catches any that come loose and begin to drift away. After two or three more days, the baby fish lose their cement glands and hover in the water at the nest. As they grow, the little fish start to drift away from the nest. When that happens, the male "stirs" the water by quickly beating the large fins just behind the gill openings (*pectoral* fins). This action causes the young fish to swim to him. He takes them into his mouth and spits them out under the nest. Within two days or so, however, the baby fish, often called *fry* at this stage, swim off on their own.

The Mouth-Breeders

A close relative of Betta breeds in a remarkably different way. This fish, *Betta anabatoides,* is sometimes called the "mouth-breeding" Betta. They are hard to find in aquarium shops.

During the spawning embrace, the male manages to end up so that his bottom long fin (*anal* fin) forms a shallow cup under the female. The eggs are dropped into this cup. The female next picks them up in her mouth after each embrace. Then the two fish face each other. She spits the eggs at the male one by one. He catches them in his mouth and keeps them there. After many embraces, the male swims off with all the eggs in his mouth. For about a week and a half, he keeps them in his mouth where they develop and hatch. He then releases the fry into the water and they swim away. No bubble nest is built.

This method of breeding makes sense if you think about it for a moment. The mouth breeder lives in streams. A delicate bubble nest built in a flowing stream probably would be broken up by the current and all the bubbles containing the eggs broken or scattered. The Bettas have no such problems because they live in quiet waters.

In the next issue of *Nature and Science*, a Science Workshop article will suggest some investigations you can make to find out what these fish do when enemies approach. ■

Mating Bettas

This series of photographs shows the strange mating behavior of Siamese fighting fish. When the female presses close to the male, he folds himself into a U around her (far-left) and fertilizes the eggs that she lays. The eggs begin to sink to the bottom. The male dives after the eggs (middle), catching them in his mouth. Then he makes a bubble around each egg and spits them into the bubble nest at the surface (left).

You can discover a lot about a twig from a few simple clues.

HOW TO BE A TWIG DETECTIVE

■ Sometimes being a scientist is like being a detective. In both jobs, you may have only a few clues to help you solve a problem.

Imagine that you are a plant "detective," or *botanist*. You are given a single clue: a twig from a tree. What can you discover about the twig?

To find out, you will need a twig. Cut one from a tree that has lost its leaves. Clip the twig off cleanly about six inches from its tip.

You will see all sorts of markings and bumps on your twig *(see diagram)*. Depending on the type of tree, the twig may feel sticky, or hairy, or have thorns. Botanists can identify many trees just by looking at twigs. Later you might cut twigs from several kinds of trees and see how they differ.

All of the strange-looking bumps and markings on a twig are important to the life of a tree. Most of a tree's growth takes place in the twigs. Leaves grow from twigs, and twigs also produce flowers from which seeds, fruits, or nuts develop. Eventually, twigs grow into branches.

The odd-shaped bumps on twigs are called *buds*. Some buds produce leaves, while new twigs and flowers grow from other buds. Nearly all twigs have a large bud or group of buds at their tip—called a *terminal* bud—which is the source of the next year's twig growth. The smaller buds that stick out along the side of a twig usually grow into leaves or flowers. Some other buds along the twig usually do not develop at all. They grow only if the terminal bud or some leaf or flower buds are injured.

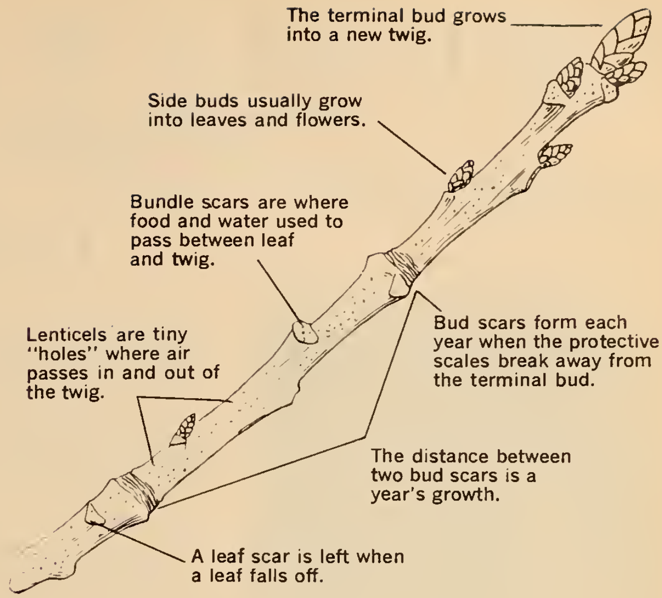
Buds are usually covered by overlapping scales that protect them from cold temperatures, injury, and insects. If you carefully peel away these scales, you will see some tightly-packed green tissue inside the bud. If left alone, this tissue will grow into next spring's leaves or flowers.

Reading the Past

Buds are important to the future of a tree, but you can also learn something about the past of a tree from its twigs. Look at the base of the buds on your twig. Below some buds you will see a scar which is the place where a leaf grew during the past summer.

When a leaf dies, a corky layer grows between the stem of the leaf and its twig. This corky layer—called a *leaf scar*—is left when the leaf falls off. How many leaf scars can you find on your twig?

If you look closely at a leaf scar (a magnifying glass will help), you will see some dots on its surface. These dots—called *bundle scars*—are the remains of tiny "pipelines" where food and water used to flow between the twig and the leaf. Count the number of bundle scars on several leaf scars of your twig. Did each leaf have the same number of "pipeline" holes?



Many trees can be identified by their twigs. These drawings show how the twigs of five different kinds of trees differ in size, shape, and markings.

Twigs have another type of scar, called a *bud* scar. These scars are rings of small, narrow marks left by bud scales when they fall away from the base of an opening bud. The most noticeable bud scars are left by the terminal buds. Each bud scar marks the place where a terminal bud began growing into a new section of twig. A twig gets one of these ring-like scars each year. How many of these scars can you find on your twig?

The distance between bud scars is the length that the twig grew in a particular year *(see diagram)*. You can find out how much your twig grew in the past year by measuring the distance from the twig's tip to the nearest bud scar. (This new growth is often easy to see because its color is different from the older parts of a twig.)

Measure the distance between the other bud scars on your twig. Are they the same for each year? The growth of a twig varies from year to year, depending on the amount of sunlight, water, minerals, and gases it gets. Compare twigs from several places on the same tree. Did they all grow the same distance during the past year?

Besides buds and scars, you may see some small speckles scattered along your twig. These speckles are called *lenticels,* and air goes into and out of the twig through them. Lenticels are easy to see on some twigs—such as cherry and peach—because their light color stands out against the dark twig.—HAROLD HUNGERFORD

INVESTIGATION

You can bring certain kinds of twigs indoors and "force" them to leaf out or to flower. First cut some twigs from several kinds of trees or shrubs. (To keep from injuring a plant, do not cut more than a couple of twigs from it.) Then put them in a vase or jar that is partly filled with water. Set the jar near a window, and then examine the twigs each day for a week or two.

Notice which buds open first. Are there any buds that do not open at all?

Cut two twigs from the same tree, remove the terminal bud from one, and then set them both in water. Notice the buds which open on each twig. Does the removal of the terminal bud have any effect on the rest of the buds?

Take another twig and cut a slit halfway around it, just above one of the side buds. This will stop the flow of some minerals and water from going up the twig beyond the bud. Then notice if this bud grows faster or slower than others.

your MUSEUM *at home*

Gorillas

■ Like many people, you may think of gorillas as huge, mean, ferocious animals. Huge they are. A full-grown male may weigh more than 400 pounds and stand seven feet high. But mean and ferocious? Not necessarily so. Recent studies of these remarkable animals have cast new light on how they live in the wild.

Gorillas live in the wild only in Africa. There are two kinds: lowland gorillas in the Cameroon area, and mountain gorillas along the eastern border of the Republic of the Congo. Lowland gorillas were first reported by European explorers around 1847. Over the years, several of the animals were shot, captured alive, or photographed by expeditions; these experiences with gorillas were brief and sometimes violent.

The huge, manlike apes looked ferocious. They had tremendous strength, and they lived in unexplored and difficult-to-reach places. This discouraged anyone from closely observing the animals, so the mystery surrounding their daily lives remained unsolved for many years.

In February 1959, an expedition headed by Dr. George Schaller (called the African Primate Expedition) left New York for the Albert National Park in the Republic of the Congo. It had one purpose—to find out as much as possible about the mountain gorilla. Dr. Schaller gathered a wealth of information by observing gorillas from close range over a period of two years.

He learned that gorillas live in groups of from two to 30 animals. Each group has one leader—a male, 10 or more years old. Younger males stay near the outer edges of the group, where they may protect it from attack. An adult male is a powerful animal and can be dangerous if surprised or threatened. Otherwise, the animals are peaceful and quite shy. Usually they flee as soon as they sense the presence of man. If a group is trailed, the leader usually will stay behind and stage a demonstration of rage that can be pure bluff. However, the wise pursuer does not call the bluff, for an angry gorilla can be deadly.

Gorillas are amazingly manlike in their postures at times. They sit, walk upright, squat, and sleep as humans do. Dr. Schaller found that, unlike most other animals, gorillas are born throughout the year, as are humans. Female gorillas reach full size soon after the age of six. Males take three or four years longer.

Gorillas spend most of their waking hours on the ground. Yet their great size and weight does not keep them from climbing trees, which they do with ease, though cautiously. They climb to feed, to rest and just look around, and to sleep if the trees provide comfortable crotches.

When danger threatens, the animals climb down to the ground to flee. Because of their great size, they can move more freely on the ground than in the trees.

The mounted gorilla shown in the photograph was captured in the mountains surrounding Lake Tanganyika, and can be seen in one of the famous habitat groups in the African Hall of The American Museum of Natural History.

—Marion B. Carr

In 1959 scientists made a detailed study of the daily lives of mountain gorillas. Some of the things they learned came as a surprise to many people.

nature and science

TEACHER'S EDITION / VOL. 1 NO. 9 / FEBRUARY 7, 1964

Elements in a Strategy for Teaching Science in the Elementary School

3. Conceptual Schemes-a Frame of Reference ...

by Paul F. Brandwein

■ The task of providing for idiosyncratic learning — individual inquiry — could be simplified if teachers had a frame of reference in which the inquiries planned had some mooring. There is a need to develop curricular frameworks around the major conceptual schemes presently acknowledged in science so that children's questions can lead to sustained inquiry—and not be fragments in the year's work.

For example, a major conceptual scheme of our time is: All living things are dependent on each other and on their environment. Or put into still more sophisticated terms: There is an interchange of energy and materials between the environment and living things.

Now the child begins experiencing this *in utero*—but without knowledge. Soon the dependence on his mother and father becomes clear. His pets depend on him. If he has ever fished, he comprehends the cycle of predator and hunted, the feeder and the things fed upon. Soon he can verbalize this interrelationship between things and their environment.

But he may know nothing yet of photosynthesis, or comprehend it very vaguely; or chemosynthesis; or host-parasite relationship; or the CO_2-O_2 cycle generally; or the entire cycle of the flow of materials and energy from the environment into living things, and their return to the environment.

Over eight grades (at least) the facts of this interrelation can be patterned into concepts (these are used in daily living); the concepts, in turn, pyramid into the conceptual scheme — and the conceptual scheme in turn into a comprehension useful in daily life.

DICK LEBOWITZ, EDUCATIONAL SERVICES INCORPORATED

What will these blocks do when the table spins? Investigations like this introduce first graders to the concept of change, which they must understand before they can discover that in our world there is also continuity through change.

Conceptual Schemes—Ideas Basic to an Elementary Science Curriculum

There are different ways of stating conceptual schemes. Various choices of conceptual schemes and their statement will be made by teachers working together. I offer the following schemes by way of suggestion and not yet in sequential order, or in order of importance.

1. Under ordinary conditions, matter can be changed but not annihilated or created.

The world of matter consists first of the world of things—from planets to rocks, solids, liquids, and gases. There is a constant physical and chemical change of states—from solid to gas and the reverse.

Clearly, the best present explanation to permit predictability of change of state and matter is to posit a particle theory of matter. This permits us to deal with symbolic states of matter—atoms and subatomic particles—and to predict their interaction and their transformation.

2. Under ordinary conditions, energy can be changed or exchanged but not annihilated.

Energy interchange is a common phenomenon. The change of chemical energy into other forms of energy is a daily experience; so is the relation of heat to light or of sound to mechanical movement. The totality of energy within a system remains the same whether we are concerned with oil in the house, gasoline in the automobile, glucose in the body, or the conversion of the energy of moving water or magnets into electrical energy. And will energy be changed into matter?

3. There is an interchange of materials and energy between living things and their environment.

Around us there are the materials of the environment; plants and animals cannot be considered apart from their environment. Plants depend on their environment for their growth and development; in addition chemosynthetic plants capture energy from the Sun and transform it; animals, in their turn, transform the chemical energy of plants. All plants and animals yield up their energy finally as they die and decay.

The demands of living in a given environment result in relations of plants and animals in communities with definite characteristics. These communities afford relations which result in survival of the species; the elements of a relation which have survival value include mating, protection, and food getting.

Understanding of these interrelations results in our ability to predict, within limits, the behavior and development of plants and animals.

4. The organism is a product of its heredity and environment.

The organism is never the result

(Continued on page 4T)

This is the last of three articles adapted from The Teaching of Science *by Joseph J. Schwab and Paul F. Brandwein, published by Harvard University Press, Cambridge, Mass. © Copyright 1962 by the President and Fellows of Harvard College. Dr. Brandwein is Chairman of the National Board of Editors of* Nature and Science.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

PAGE 3 Egrets

This provocative little article may send your pupils off on flights of their own, tracking down more information on the amazing travels of birds. Also presented is the idea of animal partnerships, or mutualism—two different organisms living together to their mutual advantage. With egrets and cattle the relationship is somewhat casual and not yet fully understood, an interesting example nonetheless.

This article illustrates the concept that *organisms are interdependent with each other and with their environment.*

Suggestions for Classroom Use

After the children read the article, have them tell what they know of bird travels. Point out that migration differs from aimless wandering in being a trip made at regular times between two places. Since these egrets haven't returned to a starting place, their journeys are not migration, but emigration.

Questions such as "Do all birds fly south at the same time?", "Do birds 'know' where they are going?", or "How do birds find their way when they fly south?" will send at least one child searching for answers.

References

A good book on this subject for children is J. D. Carthy's *Animal Navigation,* Charles Scribner's Sons, New York, $3.50. A book that should interest teachers: *Biology of Birds,* by Wesley E. Lanyon, The Natural History Press, Garden City, N.Y., 1963, $1.25.

The suggestions for using this issue of Nature and Science *in your classroom were prepared by Patricia Ralph, elementary school teacher in the public schools of Huntington, N.Y., and member of our National Board of Editors.*

PAGE 4 Matter and Atoms

The historical approach is used in this article for two reasons:

First, it provides a staircase of ideas about the atom—from a small lump of matter that Democritus called an "atom" to the complex packet of interacting particles and electrical forces revealed by modern scientists.

Moving up this staircase step by step, a child may reach understandings that he could not attain in one leap. The understandings are these: all matter is made of atoms; atoms are made of different kinds of particles which are constantly in motion; atoms of different kinds of matter are made of different numbers of the same kinds of particles. The broad concept here is that *matter is particulate.*

Second, here is an excellent example of how knowledge can be developed through scientific methods of investigation.

It is worth pointing out to your class that Democritus' description of the atom came closer to our present idea of it than did Empedocles' "four elements"; yet Empedocles' idea persisted for centuries—until men began to investigate matter.

Dalton and Boyle, for example, observed various forms of matter, tried to describe and explain the chemical reactions between different kinds of matter, and then devised experiments to test their ideas. When their findings disagreed with their ideas, these men changed their ideas to fit the new facts and developed new ways to test them.

They also began to exchange ideas, and information gained from their experiments, with other scientists, testing each other's theories and sharing those that had already been proved to their satisfaction.

We have learned more about the atom in the last half century than in all the preceding years. And as we continue to discover new things about the atom, we change our ideas about it to fit our findings.

Incidentally, Democritus is said to have developed his atomic theory from teachings of Leucippus.

Suggestions for Classroom Use

We suggest that you have your pupils take turns reading the article aloud so that questions can be discussed as they arise. Some questions of fact might best be handled by assigning the

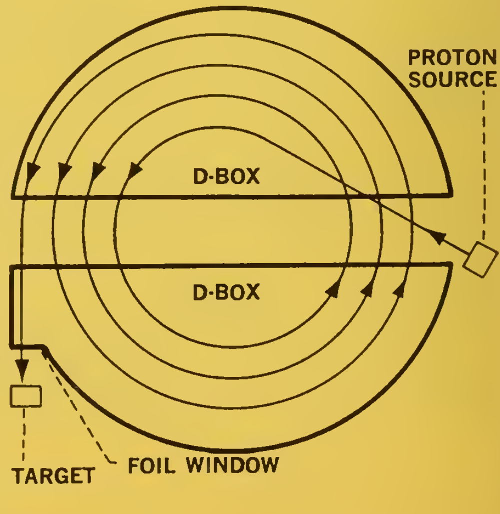
(Continued on page 3T)

HOW A PARTICLE ACCELERATOR WORKS

One way scientists are learning about the "zoo" of particles that make up the atom is by using particle accelerators like the cyclotron operated by the Brookhaven National Laboratory in New York. The nuclei of atoms are broken down by bombarding the atoms with protons (positive ions). When a proton smashes the nucleus of an atom, subatomic particles are given off and provide physicists with clues to the structure of the atom. Here is how the cyclotron works.

The machine shown here consists of a large metal container from which air has been removed. Inside it are two D-shaped, hollow "boxes" which act as electrodes—one positive, one negative. The charge in each box can be reversed rapidly. When protons are shot into the D-boxes *(see diagram),* they are accelerated by the rapidly alternating charges of the boxes. Each proton's speed is boosted twice on each trip around, and it quickly approaches the speed of light. The protons make 350,000 circuits per second.

The proton spirals outward as it goes around, and finally leaves the apparatus through a foil window, aimed at the target.



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

questioner to look up the answer in an encyclopedia or in one of the many young people's books on the atom (*see page 6*) and report later to the class. Here are some questions that might be worth discussing when they arise:

1. Why was the "four elements" idea of Empedocles favored for so many centuries? It was supported by Aristotle, whose teachings about nature and science were passed along for so many generations. Because Aristotle had introduced to the study of nature the ideas of observing and reasoning from facts, most of his ideas were accepted without question.
2. Since our present ideas of the atom are so different from those of Dalton and some of the scientists who followed him, why were their ideas useful? The ideas worked as far as they went and provided solid bases for further investigation as scientists developed new methods and equipment for probing deeper into the atom (for example, the cathode ray tube, which J. J. Thompson used, and later the particle accelerators).
3. If we can't see an atom, how can we know what it is in reality? Perhaps we never will know what an atom "looks like." Scientists can only imagine how it must be constructed in order for it to act as it does. Our ideas of the atom are bound to change as we learn more and more about it. The "best" description will always be the one that best explains the known behavior of atoms and enables scientists to predict what the atom and its particles will do under different conditions.
4. Why is an understanding of the atom more important to each of us today than it was in other times? The uses now made of the atom—to produce electric power, make bombs, and in medicine–affect each of our lives. If we expect to make intelligent decisions about the use of nuclear weapons and other radioactive materials, we must know something about radioactivity.

Activity

Henri Becquerel discovered natural radioactivity by accident in 1896. He left some chemical powder containing a tiny bit of uranium laying on a package containing photographic film. When he developed the film, he found it had been darkened by radiation that he traced to the uranium.

You can demonstrate this discovery in the classroom by placing a radium dial watch (stopped, with crystal removed) face down on a dental x-ray film (obtainable from a dentist). At the end of a week, have your dentist develop the film. The resulting picture will show that gamma rays from radium on the watch face have exposed the film.

If no one can turn up an old radium dial watch, cut a small piece from a gasoline lantern mantle and expose the x-ray film to it. Mantles, sold at sporting goods stores, are coated with minute particles of thorium oxide, another radioactive material.

References

For teachers: *Knowledge and Wonder,* by Victor F. Weisskopf ($1.45); *The Restless Atom,* by Alfred Romer ($1.25); and *The Neutron Story,* by Donald J. Hughes ($1.25)–all paperbacks in the Doubleday Science Study Series, Doubleday & Company, Inc., Garden City, N.Y.

PAGE 7 Fingernails

This Science Workshop article offers an excellent opportunity for your pupils to learn how to draw conclusions from statistical records of an investigation. Everyone knows that fingernails grow; the question is, whose grow fastest?

Suggestions for Classroom Use

This should be a volunteer operation—a few volunteers to keep the records and more volunteers to report the growth of their thumbnails.

After about two months, all should be reminded weekly to watch their scratches and report their grow-out dates. When all reports are in, have the record-keepers analyze their figures as suggested in the investigation box on page 7, then report their findings to the class.

If their findings should vary widely, have the record-keepers check each other's arithmetic.

You might even have the record-keepers combine their records on one large chart and have each of them—or perhaps the whole class—figure the average grow-out times for several different age or sex groups.

PAGE 11 Betta splendens

The colorful story of Siamese fighting fish deals primarily with a problem of survival—reproduction and care of offspring. The author, Dr. George W. Barlow, is an Associate Professor of Zoology at the University of Illinois.

Background. Reproduction is commonly thought of in terms of the courtship and pairing of male and female individuals, physical union of the two sexes, and some sort of parental care.

In fishes, however, such pairing is exceptional. Fishes of most species congregate in large groups to spawn, discharging eggs and sperm into the water, where fertilization takes place by chance.

A female may release thousands of eggs at a time, which are then left to the mercy of the sea. So great is the destruction of eggs and fry that it is estimated that for every million eggs produced, only one codfish reaches adulthood.

The Betta has a reproduction cycle that should fascinate young people. The female produces a scant 150 to 200 eggs. The male immediately fertilizes the eggs, then makes a bubble around each egg and puts it in the nest.

Another unusual aspect: the male Betta—not the female—protects the eggs from other fish. The female Betta's job is done when her eggs have been laid.

The Bettas' reproduction habits are another example of the many ways in which *organisms are adapted to their environments.*

PAGE 14 Twigs

This Science Workshop investigation into the growth of twigs can be used to encourage children to find out for themselves how trees are adapted to survive the winter—another example of how *organisms are adapted to their environment.*

Reference

This investigation might well spark an interest in learning how to identify trees by their twigs. A good source of information is the *Audubon Nature Bulletin: Trees and Their Twigs,* available for 15¢ from the National Audubon Society, 1130 Fifth Avenue, New York 28, N.Y.

Conceptual Schemes . . .
(Continued from page 1T)

purely of its heredity but of the environment interacting with it. This is true for the realization of potentialities (a red barberry is greenish unless exposed to strong sunlight; a child needs "education"), for the realization of full physical development (beets in acid soil are stunted; a child without vitamin B develops beriberi), for the realization of vigorous health (a potato seedling in the dark is attenuated; a child poorly fed and poorly housed more easily succumbs to certain diseases).

The full range of the development of organisms — reproduction, genetics, growth, nutrition, behavior, adjustment, and adaptation to the environment in which they develop — lies within the framework of this conceptual scheme.

5. The universe, and its component bodies, are constantly changing.

The preceding conceptual scheme placed the organism in a kind of dynamic equilibrium; now we develop a conceptual scheme of a universe in a kind of dynamic equilibrium.

Pre-Copernican notions recognized the dynamics of an Earth-centered system; now every child seems to know that the Solar System is changing. Man is even beginning to intrude into the Solar System. Certainly the Earth is in "constant" motion; our star is in constant eruption.

Stellar and galactic movements, the appearance of novae and supernovae, the evidence gained from cepheid variables, and the red shift indicate constant change. The universe is changing and is ever expanding.

And yet the changes in a star are understood partly in terms of hydrogen-helium conversion, and the expansion of the universe partly in terms of "explosion" of a cosmic egg.

6. Living things have changed over the years.

The dynamics of the equilibrium in species and species groups belongs within the range of this concept.

The organism changes and species change as well over the years. The concepts of adaptation over the ages, divergence in form, convergence in geographic isolation and in time are within the purview of this conceptual scheme, in short, evolution.

Subconcepts of One Conceptual Scheme

Take, as example, the first of these conceptual schemes to note a more or less sequential development of subsidiary concepts (these are by no means all of the subconcepts).

Under ordinary conditions, matter can be changed, but not annihilated or created:

—Matter changes;
—Matter can be changed physically;
—Matter can be changed chemically;
—Chemical action is the result of an interaction of atoms;
—Matter is particulate;
—Chemical action can be modified by the environment;
—In ordinary reactions, matter is not created or annihilated (the outer atom is involved);
—When the destruction of the nucleus is involved (under extraordinary conditions), matter may be annihilated;
—The atom is a source of nuclear energy;
—New atoms can be created.

Each of the six conceptual schemes can be structured in some such way.

The child comes to the first grade generally with a comprehension of the world as stable, with a continuity unbroken, with a tomorrow and a yesterday. Home is permanent, day follows night—he can count on it. In the first two grades, it is possible to introduce the child to a concept of change—so that at the end of the two years he has a different comprehension of the world, a world of change.

So in the first years, candles burn and change to other forms of matter and energy, solids change to liquids and gases, eggs hatch astonishingly into chicks—all is change. In the next years, candles are analyzed as having carbon, and carbon burns and heat energy is produced. Then carbon is found to combine with oxygen, and oxidation occurs. The oxidation results in the production of energy. Chemical energy is found to be connected with heat energy. This is what Lawrence Frank calls a calculated redundancy; it is a good term and describes the need for repetition in a new context.

And thus the stage is set for an understanding of oxidation as a process of energy release; the digital process begins to feed a fresh analogical approach; generalization begins to feed conceptualization, and conceptualization a new comprehension.

To oversimplify: Comprehension of a world of stability has preceded comprehension of a world of change. Then comprehension of a world of change has preceded comprehension of a world in which there is continuity through change.

At the end of the elementary school, perhaps the six conceptual schemes we have prepared have fortified this conception; new confrontations are possible. But what, to my mind, is exceedingly important is that the fundamental structure of science we have predicated as existing in its conceptual schemes lays the groundwork for the "educated" or fertile guess.

We all know that in this life we do not often have opportunity for sustained inquiry; the shrewd, perceptive, guess springs more easily from a matrix of conceptual schemes. Yet we should encourage children to "guess" (the term "hypothesize" is more respectable), but require them to validate their guesses in the ways we have indicated.

Those who have studied the content of science as presently organized know that what has been proposed permits the content of science as ordinarily developed in junior high school to form a selected content of elementary science. This leaves a fresh orientation (based on a comprehension of a world in which there is continuity through change) for junior and senior high school science ■

The Life Blood of Science

Discovering new laws and principles is only a part, and not necessarily the most significant part, of basic science. There is no guarantee that an investigator will ever solve the problem that concerns him most or, for that matter, that anyone else will ever solve it. The important thing is that he be involved intensively in work worthy of his talents. Solutions are found, to be sure, and the advance of technology depends on them. But the life blood of science is the new problems that arise and seem to multiply as quickly as the old ones are solved. Indeed, science may be regarded as a highly organized way of discovering problems and thereby continually replenishing surprise.—JOHN PFEIFFER

THE NEXT ISSUE of Nature and Science is a special-topic issue on SURVIVAL IN THE COLD. The lead article tells how humans adapt to extreme cold, both biologically and by creating artificial climates with clothing, shelter, and heating devices. Another article explores the strange process of hibernation by which many animals survive the cold.

The N&S Wall Chart illustrates how snowflakes, sleet, hail, and frost are formed.

Also, a fascinating Science Workshop project suggests ways to test the responses of Siamese fighting fish (*Betta splendens*), whose unique mating behavior is described in this current issue.

nature and science

VOL. 1 NO. 10 / FEBRUARY 21, 1964

SPECIAL-TOPIC ISSUE

MAN AGAINST THE COLD

What scientists are finding out about how well men can live in the cold.

ABOUT THE COVER

The cold man on our cover is one of hundreds of men who are today exploring and living in the Arctic and Antarctic.

Some are servicemen who work in radar stations scattered across the Arctic. Others are scientists, searching for minerals, or studying cold-climate animals to find out how they survive the cold. The cover photograph was taken during the International Geophysical Year (1957-1958), when scientists of every nation worked together by studying the physics of the Earth from the North and South Poles.

To stay alive, these men must keep their body temperature near 98.6°F., even when the air temperature is 180 or more degrees below that. Scientists have learned a lot about survival in the cold from the Eskimos, who have lived in the Arctic for many centuries. Many ideas for designing cold weather clothing and shelters have been borrowed from the Eskimos.

For example, at Camp Century, a military base in Greenland, all of the living quarters are beneath the ice. The ice protects the men against the cold, just as a snow house, or *igloo*, protects Eskimos.

To find out more about man and his struggle against the cold, see the article that begins on page 4.

nature and science

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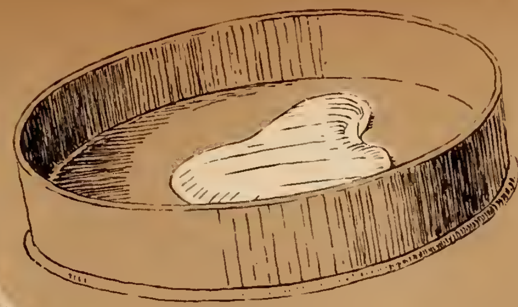
How Fast Can You Melt Ice?



by Robert Gardner

■ Have you ever wondered why some restaurants serve ice cubes with holes in them? If you do some of the experiments in this article, you may be able to answer this and other questions about ice.

Freeze some water in a plastic mold used for making a single ice cube. At the same time, freeze the same amount of water in a shallow dish or bowl made of the same kind of plastic as the ice cube mold. Make sure that you freeze them both the same length of time.

After you freeze the water in the two containers, you will have the same amount of ice in each, but the two pieces will be different in shape. Now find out which one melts faster. You can do this by leaving both pieces of ice out in the air on the same plate or pan, or by placing them in water. Which piece of ice do you think will melt faster?

Did you find that the one that is spread out most melted faster? This "spread-outness" is a measure of *surface area* —the part of the ice exposed to air or water. Heat from the air or water warms this exposed area and melts the ice. Does the amount of surface area affect the speed of melting?

By using properly shaped paper drinking cups, ice cream cups, round plastic covers from ice cream containers, and so forth, you can find a way to make tall and short cylinders of ice using the same amount of water in each. Can you predict which cylinder will melt fastest? How can you find out?

Try making cone-shaped pieces of ice and pieces shaped as spheres. Suppose you make a cone, cube, cylinder, and sphere of ice, all from the same amount of water. Which do you think will be the slowest to melt? The fastest? What does this tell you about the surface area of these shapes?

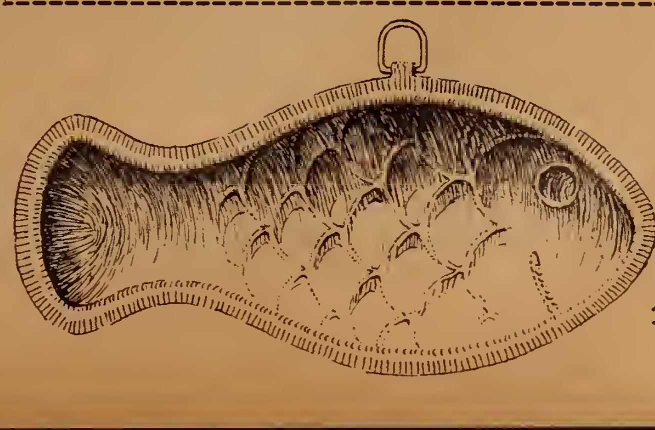
Does what you have learned about melting and surface area work in reverse? Does water freeze faster when it is spread out and has more surface area than when it is in the shape of a cube, for example? Try it and see. This may give you a clue to why restaurants, which use a great many ice cubes, often serve "cubes" with holes in them ■

INVESTIGATION

1. How many different ways can you think of to make an ice cube melt faster? Try them and see which is best.

2. Pour some water into a glass. Into a second glass pour the same amount of rubbing alcohol. Into the third glass pour the same amount of cooking oil. Let all three sit for a while until they are the same temperature. Place an ice cube in each of these liquids. In which does the ice melt fastest? What else do you notice?

3. As the ice cube in oil melts, water collects at the bottom of the glass below the oil. Why? (See N & S, *Oct. 4, 1963, "Liquid Layer Cakes."*) Carefully push the ice cube down until it touches the water layer. Notice that it seems to stick to the water. Using a straw, so that you do not disturb the oil or the ice cube, add some liquid detergent to the water below the oil. What happens to the ice cube now?



MAN AGAINST THE COLD

How well can men survive in the cold? To find out, scientists are studying Eskimos and South American Indians who have lived in cold climates for thousands of years.

■ When your bedroom is warm, you probably throw off the covers and sleep with your arms and legs spread far out. When it is cold, you probably huddle into a snug ball, as a sleeping dog or cat does. Can you figure out why the temperature of your bedroom makes you sleep in one position or the other?

This is the kind of question scientists ask as they try to find out how the human body reacts to the cold. During the past few years, as more and more men have taken part in the scientific exploration of the Antarctic, scientists have had an ideal cold weather laboratory. Here the temperature plunges to –80° F. or lower. Among the many questions scientists have been asking are these: How well can humans survive the cold? What kinds of clothing and shelter provide the best protection?

The frigid climate of the polar regions is a constant threat to men who explore these lands of ice and snow. Yet animals such as Polar Bears *(see page 16)* and penguins have no trouble living there. Why should this be so? All three—men, Polar Bears, and penguins—are warm-blooded animals. This means that their body temperature must stay nearly constant, whether the outside temperature is cold or hot. A few kinds of warm-blooded animals, called *hibernators* *(see page 10)*, can survive winter with a low body temperature, but humans die if their body temperature drops too low.

Man Is a Tropical Animal

Over millions of years, Polar Bears and penguins have adapted to extremely cold climates. Their bodies have a thick layer of fat. In addition, Polar Bears have a heavy fur coat that protects them from the cold; penguins have an especially dense coat of feathers for a bird. But man, sometimes called a "tropical" animal, does not have such efficient protection. When man enters a cold region he must take part of his warm climate with him—special clothing and shelter that will permit his body to function normally.

All warm-blooded animals produce heat by "burning" food. In humans this keeps the inside body temperature near 98.6° F. Yet the temperature at the surface of your body is several degrees lower, depending on the temperature of the air around you. Heat is always escaping from your body through your skin. This is why, when it is cold in your bedroom, you huddle into the shape of a ball. Less of your body's surface is then exposed to the cold air, which means that less heat is lost. People who have frozen to death are usually found in a huddled position. When it is hot, you sleep with your arms and legs spread out. This position lets more heat escape from your skin and helps cool you.

One of the main reasons for death by freezing is that, in most people, not enough blood gets to the hands, feet, ears, and the skin when they become very cold. This means that so little heat reaches these parts of the body that they become frostbitten. Yet some people don't have this trouble.

To learn more about how men can keep alive in cold climates, scientists are studying peoples who have lived in cold climates for thousands of years.

In 1959, a team of United States scientists went on an expedition to Tierra del Fuego, which is at the tip of South America, to study the last of the Alakaluf Indians. These Indians, now nearly wiped out by diseases, have lived in the sub-Antarctic cold for many generations. They do not use as much protective clothing as Eskimos and they sleep with little covering, even when the room temperature is 32° F.

Most of them, including women and children, walk barefoot in the snow and swim in 40° F. water. In such conditions, the Alakaluf not only maintain their body temperature at 98.6° F., but they also give off a lot of heat through their fingers and toes.

At first, the scientists who went to live among these people to study them did not give off much heat through these parts of their bodies in 32° F. cold. And their inside body temperature stayed at 98.6° F. But after several weeks, their bodies began to adjust to the cold by making certain small changes. The scientists found that their hands and feet were warmer than before. But then they discovered something interesting about themselves. Their deep body temperatures began to fall off. Why?

If the heart pumps a lot of blood to cold parts of the body—hands, feet, ears—the blood briefly warms the tissues there. As it does, a lot of heat is lost to the cold air. To make up for this heat loss, *and* to keep their inside body temperature at 98.6° F., people living in cold climates must produce more heat than people living in warm climates do if their fingers, toes, ears, arms, and legs are to be kept warm. (Doctors have lowered the inside body temperature of men to about 52° F. during operations, but only for about eight minutes.)

The scientists found that the Alakaluf Indians of Tierra del Fuego could afford to lose more heat than the scientists could in warming fingers and toes. The reason was simply that the Indians produced much more heat than the scientists did. Another group of cold climate people—the Eskimos—also do this.

Eskimos live in a world of snow, ice, and deep cold for about nine months of every year. They depend on animals like caribou, Polar Bears, and seals for most of their food, fuel, clothing, and tools. Snow and ice are their only building materials for much of the year.

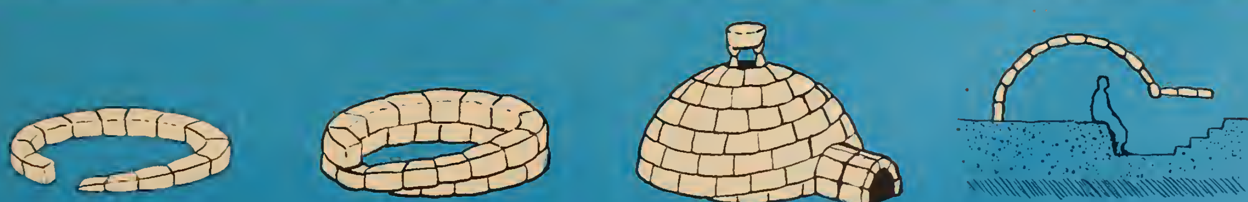
The bodies of Alakaluf Indians are adapted to survive the cold. They have shorter arms, legs, toes, and fingers (left photo) than most people living in warm climates, so they lose less body heat to the surrounding air. The hair of Alakaluf childrer grows so low on their foreheads (right photo) that it almost meets their eyebrows.

How Do the Eskimos Survive?

An Eskimo may set out on a two-week hunting trip with only two quarts of whale oil as heating fuel. Each night he builds a small house, or *igloo,* from blocks of snow. Since a house of snow does well at keeping the heat in and the cold out, an igloo can be heated by burning a little whale oil, and by heat from the Eskimo's body. The coldest air in the igloo sinks and settles into a circular pit that is dug in the igloo floor. The Eskimo eats and sleeps on a ledge above the pit *(see diagrams).*

Eskimos wear light-weight, baggy clothing made from animal skins. Although they look heavy, their clothes weigh only about one-third as much as the clothes worn by soldiers stationed in Alaska. The Eskimos have discovered that several layers of light clothing are much

(Continued on the next page)



Igloos are made of blocks of well-packed snow. Eskimos eat and sleep on a ledge above a pit that leads outside. **Igloos can be kept comfortable because the warm air rises while the cold air sinks into the pit.**

warmer than one or two thick garments. Each layer of clothes traps some "dead air" that is warmed by body heat and protects the body from the cold. The animal skins that Eskimos wear usually have the furry part facing inside, and the animal hairs also trap "dead air." (Women with fur coats would be better protected from the cold if they wore their coats inside out.)

Survival in the Cold

Ideal cold weather clothing allows some air to circulate between the layers of cloth when a person is active. And there must be a way for water vapor *(see page 8)* and body moisture to be given off to the air. Otherwise, too much heat, water vapor, and moisture stay within the clothing as the person begins to perspire. When he stops moving, the perspiration cools and chills him. Cold weather clothing should be something like Eskimo clothes, which trap lots of dead air when you rest, but allow air to circulate within the clothing when you are active.

How Cold Shapes Our Bodies

Scientists believe that the body shape of Eskimos, and other people who have lived in cold climates for thousands of years, has changed so that these people can survive the the cold better. Eskimos and the few remaining Alakaluf Indians, for example, have shorter arms, legs, fingers, and toes than people living in warmer climates. Because of this they have less skin *surface area (see page 3)* to give off body heat. Like Polar Bears and other cold climate animals, the Alakaluf Indians and the Eskimos also have an extra heavy layer of body fat. Some scientists think that the shape of the Eskimo and Alakaluf face—flattened, with fat padding and a small nose—also has developed through the years to withstand the cold better.

Snug inside their igloo, this Eskimo woman and her grandson are protected from the Arctic cold. The igloo's snow walls form an excellent trap that keeps the heat in.

Certain kinds of animals living in the Arctic may have changed in similar ways. Arctic Hares have much smaller ears than jack rabbits, which live in hot deserts. The shorter ears of the Arctic Hare are a better heat-saving device than the larger ears of the jack rabbit.

Such changes in body shape take thousands or millions of years to develop. However, there are other, less noticeable ways of adjusting to the cold that take much less time. Men and certain other animals can adjust in a small way, or *acclimatize,* to a cold climate in a few weeks or months.

How Well Can Humans Adjust to the Cold?

Experiments in special laboratory cold rooms and in the outdoors have shown that men exposed to freezing temperatures for a few weeks can stand the cold better than men who were kept out of the cold. In one test, both groups of men were asked to use their hands in a delicate job outdoors in an icy wind. The acclimatized group could do the work, but the men who were not used to the cold could not.

Scientists on an expedition to Antarctica in 1940 noticed that, at first, the men wore all the clothes they could. Gradually they wore fewer and fewer clothes, even though it was colder than when they first arrived. On the same trip, when the temperature sometimes rose from about -20° F. to zero, some men felt uncomfortable in the "heat wave." In England, where there are very cool summers, newspaper headlines report a "heat wave" when the summer temperature climbs to 70° F. or higher and stays there for several days.

A team of United States Army scientists found that warm-blooded animals other than man can adjust to the cold. For seven weeks, they kept some rabbits in a laboratory where the temperature was -20° F. Then these acclimatized rabbits and another group of rabbits that had not been acclimatized were exposed to -50° F. temperature for eight hours. The acclimatized rabbits were not harmed by the cold. The others had frostbitten ears and toes.

Scientists still have much more to learn about man's ability to adjust to the cold. But information from studies of Eskimos and soldiers based in the Arctic and Antarctic have helped scientists design effective clothing and shelters for life in the cold ■

HOW IT WORKS

Thermometers

■ You can get some idea of how warm or cold the air is from the way it feels on your skin. But to measure just how warm or cold anything is, or find its *temperature,* you must use a thermometer. Although there are many different kinds of thermometers, those most commonly used all work the same way.

The household thermometer is simply a sealed glass tube with a small glass bulb at one end. The bulb is filled with alcohol (usually colored red so you can see it easily) or mercury, a silvery-colored liquid metal. Mercury gives the more exact reading, and is used in most laboratory and medical thermometers. But alcohol freezes at a much lower temperature than mercury, and is therefore used in most outdoor thermometers.

When the air warms up, it heats the alcohol or mercury and makes it *expand,* or swell. The only space the liquid can expand into is the channel in the tube, so it rises in the tube as it gets warmer. When the air grows cooler, the liquid loses its heat to the air and *contracts,* or shrinks, dropping down toward the bulb.

Two Ways To Measure Temperature

The rise and fall of the liquid tell you only that the air is getting warmer or cooler. To measure how much the temperature is changing, or just how warm or cold the air is, you need a scale of measurement. This scale is usually printed on the board to which the thermometer is attached, or it may be marked on the glass tube.

The household thermometer scale measures temperature in *degrees Fahrenheit.* This scale was devised early in the 1700's by German physicist Gabriel Fahrenheit. There are different stories of how he decided on this scale. One is that he set a thermometer in a mixture of ice and salt and marked the lowest point to which the mercury dropped, 0° (zero degrees). He marked 100° at the level of mercury when it was as warm as the human body (we know now that normal human temperature is 98.6° F.). Then he divided the space between these points into 100 equal degrees. Water freezes at 32° F. and boils at 212° F.

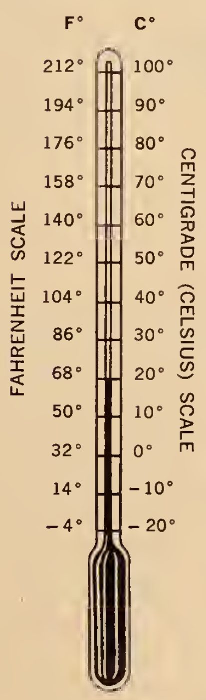
Temperature is usually measured by the Fahrenheit scale in English-speaking countries, Germany, and the Scandinavian countries. But people in all other countries and scientists everywhere use a simpler scale, called the *Centigrade* or *Celsius* scale (for Swedish astronomer Anders Celsius, who first suggested it in 1742). On this scale, water freezes at 0° C. and boils at 100° C.

You can easily change a temperature reading from Centigrade to Fahrenheit. Multiply the Centigrade reading by 9, divide by 5, and add 32°. To change a Fahrenheit temperature reading to Centigrade, subtract 32° from the Fahrenheit reading, multiply by 5, then divide by 9.

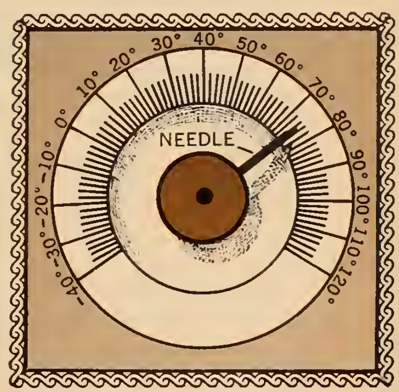
Since everything expands when it is heated, several other kinds of thermometers are based on this rule. For example, scientists sometimes use a thermometer that has a sealed container filled with gas. As the gas gets warmer, it can't expand, so it presses harder on the container. Measuring this increase in pressure gives the change in temperature.

Metal thermometers are also fairly common. They look something like a small clock. Inside is a coiled metal spring, something like a watch spring, with one end attached to a needle on the face of the thermometer. As heat expands the coiled spring, it unwinds slightly, turning the needle on the dial so it points to the correct temperature ■

LIQUID THERMOMETER



METAL THERMOMETER



FACE

BACK

February 21, 1964

nature and science / WALL CHART

THE WONDERFUL WORLD OF WINTER

SNOW FROST ICE SLEET

**Some hailstones are bigger than golf balls (left) and ma
This 2-inch-wide hailstone (right) was cut and photograph
show the bands of small and large ice crystals that form t**

**Frost forms when water vapor in the air touches a cold su
face, such as this window pane. The water vapor chang
into ice crystals, forming patterns like these.**

■ The next time you are in a snowstorm, let some flakes fall onto your coat sleeve and look closely at them. Scientists have photographed and studied thousands of snowflakes, and they have never found two exactly alike.

Snowflakes form when the temperature in a cloud is about 5°F. to −15°F. Within this temperature range, the water vapor (water in the form of a gas) and the tiny water droplets in a cloud turn into ice crystals. As more and more of these ice crystals cling together, they form a larger and heavier crystal, or snowflake, which begins to fall to the Earth.

By looking at a snowflake you can tell something about the layers of air through which it fell on its way down. When small flakes pass through a layer of moist air, they stick together and reach the ground as large, soggy flakes. The small, dry flakes you see have fallen through drie
colder air.

Snow forms as tiny particles of water vapor and tir
droplets of water change directly into ice crystals. *Sle*
is formed in another way. First, thousands of tiny wat
droplets in a cloud join and form a raindrop, which begi
to fall to the ground. When a raindrop—or a partly melte
snowflake—passes through a layer of cold air, it is froz
into a hard ice pellet that bounces when it hits the groun

Another form of sleet is *graupel,* or snow pellets. The
pellets are softer than sleet and break apart when th
hit the ground.

Hailstones are born in violent summer storm cloud
Like sleet, they are frozen raindrops, but they are forme
in a different way. Strong updrafts of wind within a clou

1.5 pounds.
›ecial light to
one.

A snowflake is made of thousands of ice crystals that form when cloud temperatures are about 0° F.

hen snowflakes fall to the ground they may change any ways. Here, the snow's surface has been melted the sun, then refrozen, leaving icicles.

Glaze ice forms when raindrops hit the freezing surfaces of trees, roofs, and sidewalks. Glaze is glass-like and heavy. It snaps off tree limbs and power lines with its weight.

't the raindrops into the cold, upper part of a cloud. The ops freeze into ice pellets and begin to fall, but the wind itches them and carries them to the upper region of the oud again and again.

Eventually they become so heavy that the winds cannot old them in the cloud any longer, and they fall to the ound.

Whether it rains, snows, or sleets depends on the temerature of the last layer of air that precipitation falls rough before hitting the ground. If the layer of air nearst the ground is warm, snow crystals and ice pellets may elt into raindrops.

When the air is cold, rain may become *glaze*. The rainops burst as they hit cold objects—roads, powerlines, ees—and the water freezes into clear, glass-like ice. Glaze ice is harder and heavier than white *rime* ice, which you can see inside the freezer compartment of a refrigerator. Rime ice forms when tiny water droplets like those that make up fog freeze.

Unlike snow and sleet, *frost* does not fall from clouds. It forms from water vapor that is in the layer of air nearest the ground. In summer when this vapor touches a cool surface—a blade of grass or the side of a house, for example—it *condenses*, or changes to water, called dew.

In winter when water vapor touches a surface that is at or below freezing—the ground or a brick wall, for example—it freezes into ice crystals, or frost. Frost crystals make complex designs which you can see on window panes.

The illustrations on these pages show closeup views of snowflakes, frost and hailstones■

The Case of the Sleeping Animals

Some animals survive the winter by sleeping through most of it. Scientists are trying to find out what keeps them alive during their long periods of hibernation. by Laurence Pringle

Chipmunks spend most of the winter in their nests, curled up in a deep, death-like sleep called hibernation.

■ As winter grips the northern United States, some animals are hidden in snug underground dens. If you could dig into one of these dens, you would be in for a surprise.

The animal wouldn't scurry away. Instead, it would lie still and cold in a death-like sleep. However, if you took the animal indoors, it would slowly waken.

This strange sleep is called *hibernation*. In some unknown way, certain animals sleep through the winter and do not leave their dens until spring. Scientists are puzzled by hibernation, and are trying to discover how animals stay alive during their long sleep.

An amazing discovery about hibernation was made by a California scientist in December 1946. Dr. Edmund Jaeger was exploring in the Chuckwalla Mountains of southeastern California when he found a small, gray-colored bird tucked in a crevice of a canyon wall. He could see that it was a poor-will, a night-flying bird that feeds on insects. So far as anyone knew, poor-wills usually migrated south in the autumn and returned in the spring.

Dr. Jaeger picked the bird up to see if it were dead. The bird's body was stiff, its eyelids were closed, and its feet were cold. However, just as Dr. Jaeger started to put the bird back in the crevice, it opened and shut one eye.

The scientist returned many times to look at the bird. He put a band on one of its legs to identify it, and found that the bird returned to the same rocky crevice for three more winters. He took the bird's temperature and discovered that it was only 67 degrees—about 40 degrees below normal for a bird. As hard as he tried, Dr. Jaeger could find no sign that the bird was breathing or that its heart was beating, yet he knew that the animal was alive.

This was an important discovery—it told scientists that one kind of bird hibernates. However, whether or not *all* poor-wills hibernate is still not known. Scientists now think that at least two other kinds of birds—hummingbirds and swifts—may hibernate during especially cold summer nights.

In the United States, woodchucks, western ground squirrels, chipmunks, and some bats and mice all hibernate. Although bears, skunks, raccoons, and certain other mammals may spend most of the winter sleeping, they do not hibernate. They are called *dormant*. Unlike hibernators, dormant mammals can be awakened quickly, and their

Prepared with the advice of Dr. Charles P. Lyman, Assistant Professor, Harvard University Medical School.

body temperatures drop only a few degrees below normal.

Ever since people discovered that some animals hibernate, they have wondered what causes the animals to go into such a deep sleep. To solve this mystery, scientists study hibernating animals in the wild and in laboratories.

Mysteries of Hibernation

Dr. Charles P. Lyman of the Harvard University Medical School in Boston, Mass., has been studying hibernating animals for 17 years. He keeps animals such as woodchucks, ground squirrels, and hamsters in individual cages—some in a special "cold" room (where the temperature is near freezing), and some in a warmer room.

Dr. Lyman keeps records of the animals' temperature, the amount of food and water they eat and drink, and if and when the animals begin to hibernate. By controlling the temperature of the rooms and amount of food the animals eat, he has investigated the cause of hibernation.

Cold temperature seems to send some animals into hibernation. One fall, when Dr. Lyman moved two ground squirrels from a warm room to a cold room, they hibernated within 24 hours. Dr. Lyman also found that some hamsters from Syria would begin hibernating in any season if he exposed them to cold temperatures for a few weeks. Some other kinds of animals, however, begin hibernating only in the fall, even when they are kept in special rooms where they can not see the changing amounts of daylight as the seasons change.

Most of the mammals that hibernate seem to need a certain amount of body fat before they begin their long sleep. Fat is the main source of energy for hibernators. As fall approaches, the animals get fatter and fatter. They may double their weight in a month's time.

When scientists first discovered the thick, brown fat on the backs of hibernating animals, they called it a "hibernating gland." Now it is known that this is not a gland. However, the fat has an important effect on some hibernators, and scientists have found that fat animals tend to start hibernating before thin ones.

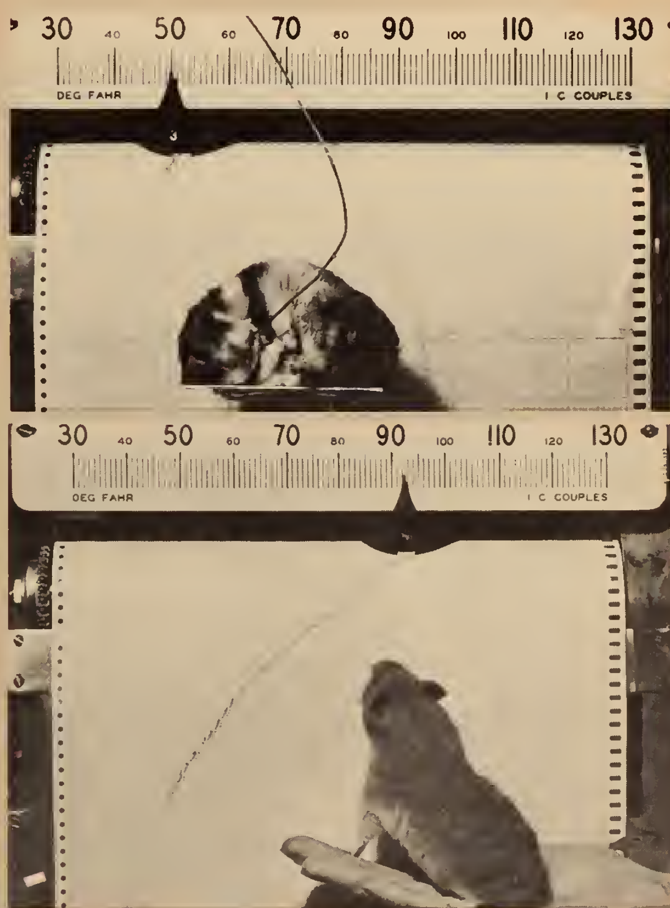
Some kinds of hibernators do not put on fat in the fall. For these animals, the key to hibernation seems to be the amount of food that they have stored in their dens. Animals like chipmunks wake up for mid-winter snacks, and in one experiment, Dr. Lyman found that golden hamsters delay their winter sleep if they are kept from storing food.

Mammals that hibernate find a snug den or other sheltered place in the fall, and then the strange sleep of hibernation begins. First, the heart beat of the animal slows. Then all of the other body processes gradually slow down too. In a few hours, the body temperature drops to near freezing and the animal may take only one breath in five minutes. It seems almost dead.

When the temperature in a hibernator's den drops to freezing, some inner part of the animal's body automatically causes it to burn more energy and keep its temperature above freezing. If the temperature of the den stays near or below freezing for very long, the animal wakes up. Hibernators need about three or four hours to wake up and to bring their body temperature back to normal.

Dr. Lyman and other scientists have discovered that hibernating mammals do not sleep all winter. Some wake up from time to time, then go back to sleep. So far, the longest known hibernation without waking is that of a European dormouse, which slept for 114 days.

There are still many unanswered questions about hibernation. For example, why do some kinds of animals hibernate, while others that are related to them do not? How does the animal control its body temperature? What makes the animal wake up when it is in danger of freezing? Scientists are still searching for the answers to these and other questions about the strange sleep of hibernation ■



Dr. Lyman moved this hibernating hamster from its winter nest to a warm room. A thermometer which he put in the animal's mouth showed its temperature was 50° F. After 1¼ hours (bottom photo) the hamster's body temperature was up to 92° F. Hibernators often take up to four hours to awaken, but the hamster was in a warm room.

brain-boosters

■ The Naturalist's Notes

When Dr. Cipher returned to the Museum from an expedition, he brought a copy of his field notes *(below)* to the *Nature and Science* office, saying, "I have a suggestion for a future issue of the magazine. It is hidden in these notes."

Here is a hint to help you find the message: Only one letter of each word is used in the secret message. The key letters have the same position in each word.

See if you can find the hidden message in Dr. Cipher's notes:

"Six pollywogs resident in northern, grassy swamp. Photographed each. Color is absolutely lovely. Trapped other pollywogs in cave. Investigated sight. Saw unusual eyeballs. One night I netted seventeen eels, catfish, toads, snakes."

	10	

■ The Magic Squares

Fill in the empty squares with numbers so that the product of each row or diagonal is 1,000. You can do it if no number in a square is higher than 100.

■ How Many Pigs?

Two farmers were discussing the pigs that they owned, and one said, "If you sell one pig to me, then I'll have as many as you have."

The other farmer replied, "Yes, but if you sell one of your pigs to me, I'll have twice as many as you have."

How many pigs does each farmer have?

■ Stop the Fish Fights

There are 14 male Siamese fighting fish, or Bettas, in this square aquarium. They must be separated to keep them from fighting.

See if you can separate each fish from the others by drawing four circles within the square. The circles may overlap, and they do not have to be the same size.

Solutions to Brain-Boosters appearing in the last issue

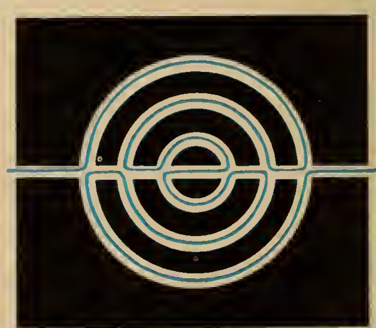
Fish Story: Mr. Mackerel caught 4 fish on the first day, then 7, 10, 13, and 16 on the next four days for a total catch of 50 fish in five days.

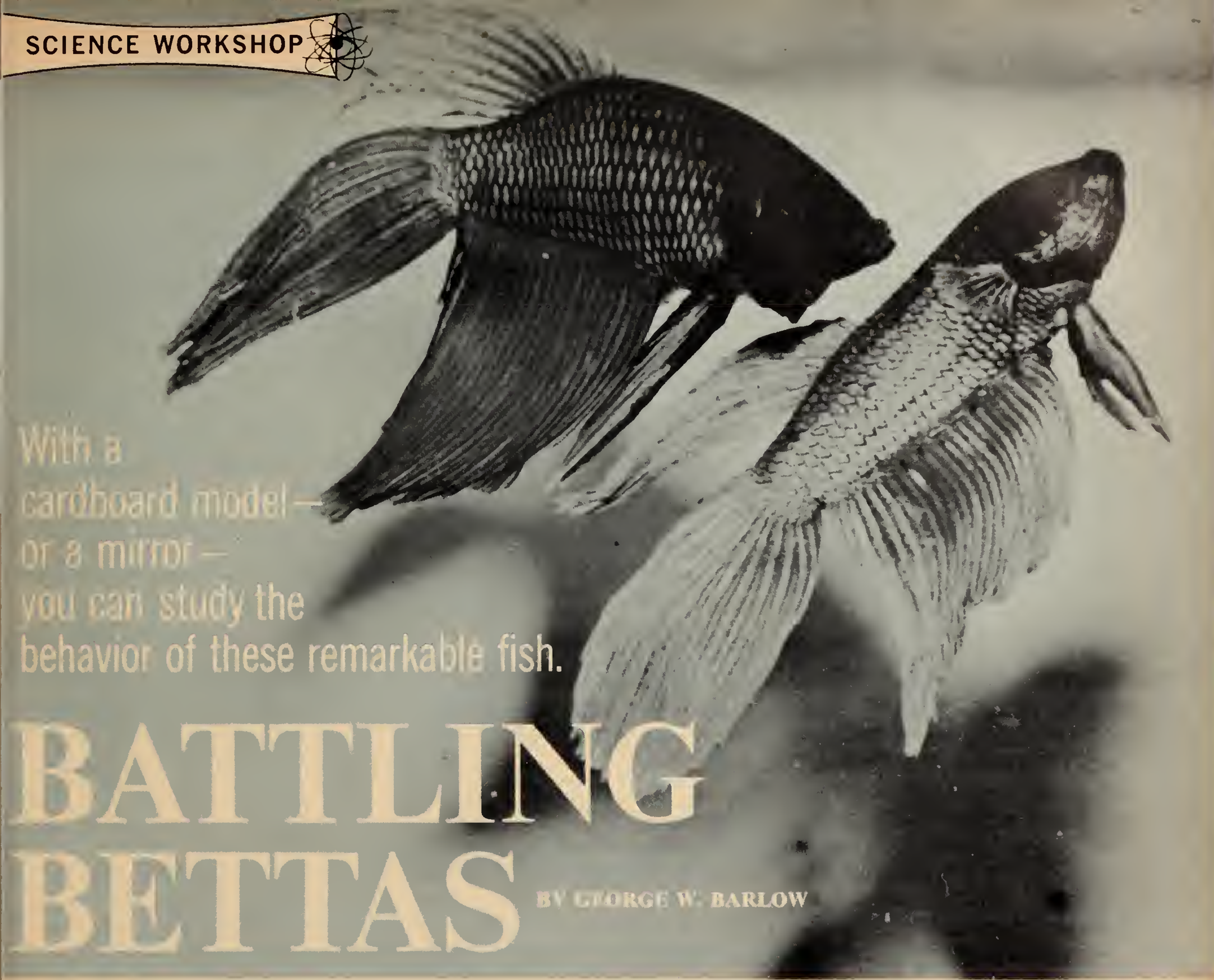
The Archeologist's Discovery: He found exactly 19 bones.

In the Dark: Dr. Myotis assumed that he might have two bats of each color among the first six bats he collected. By collecting seven bats he would be sure of having three of one color.

The Grandfather's Age: He was born in 1881.

A Puzzle in the Park: Travel these paths to solve the puzzle.





With a cardboard model— or a mirror— you can study the behavior of these remarkable fish.

BATTLING BETTAS

BY GEORGE W. BARLOW

Two male Bettas in a tank challenge each other to fight by swimming side by side, their fins spread like sails.

■ We can never know if an animal sees the world around it in the same way that we do. For instance, we know that a dummy in a store window is not a real person. Yet little girls treat dolls as "babies," even though they know that dolls are not alive.

The Siamese fighting fish you read about in the last issue of *Nature and Science* will "fight" with a model that you would easily recognize as being a fake fish. Sometimes they fight things that do not even resemble other fish. One male that I kept fought the silvery bulb of the thermometer when I took the water temperature. Yet, in an aquarium, a Betta seldom attempts to fight with any kind of fish except another Betta.

You might ask, then, how does a Betta know which is a Betta, and which is not? One way to answer this is to make models that look something like Bettas and present them to a Betta. The Betta responds to some models more than to others. So you can find out how much the model must look like a real Betta before your fish reacts to it.

One of the important lessons to learn from this is that a Betta may respond to several quite different models in quite different ways. For example, a male might attack a red model without eyes as much as a blue model with eyes. A model combining eyes and red color might cause even more attacking.

Betta Fights Follow a Pattern

Before you make the models you should know how one live Betta responds to another live Betta. If two male Bettas are put into the same tank, they may start to fight and continue until one is clearly the winner; then they

(Continued on the next page)

should be separated. Bettas bred especially for fighting may fight for several hours. A Betta not bred for fighting seldom battles more than 15 minutes.

No two Betta fights are ever alike. Yet all of them have some things in common. For one, the fish will nearly always show the same displays—meaning certain acts that occur again and again and are easy to see. Second, the fight takes place in stages.

In most fights there is first a stage when the two males approach one another. As they get near, their colors become vivid, they spread their fins, and their gill covers swing out, revealing bright red borders.

The next stage is often the longest. It could be called the *display period*. The two males spend much of their time swimming in the same direction, side by side, with fins spread like enormous sails. Now they come to the surface for air more often. At this stage it is possible to see that the pelvic fin closest to the other male is held stiffly down. The other pelvic fin is held against the belly, or opened and closed like scissors.

As the two fish swim along, one turns his head, with raised gill covers, and looks at the other, who in turn looks slightly away. Suddenly the one doing the looking straightens his head. The one looking slightly away sees this, and in a moment he turns his head and stares at his opponent. On they swim, trading stares. From time to time one swings his tail in a wide beat, sending water currents to the other, who may also reply with a tail beat. Sometimes they tilt up as they tail beat, even standing straight up on their tails.

The display period is the most important and interesting part of the fight. Each male is testing his opponent. In this way the males make clear who is the stronger. In nature, the fight usually ends here because one male swims away, leaving the stronger male the best place for spawning. That is what the fight is all about.

When challenged by a dummy fish—or by its own reflection in a mirror—a Betta may spread its fins like this one.

WHERE TO GET YOUR BETTA

One of the most popular of aquarium fishes, the Siamese fighting fish called *Betta splendens* can be bought at many pet stores. Because they breathe air by gulping mouthfuls at the surface of the water, Bettas can be raised in unusually small bowls. They should be kept in warm water (about 80° F.). How you can breed Bettas is described in "The Bubble Nests of *Betta splendens*" (N&S, *Feb. 7, 1964*).

In an aquarium, neither fish can leave. For this reason a fight between two Bettas should be stopped at this stage. If it is not, real combat will take place. They begin ramming and biting one another. The lovely fins are ripped to shreds in short order.

Finally one male hesitates before ramming the other. Suddenly he stops fighting. He folds his fins, his colors fade, and a dark stripe may appear, running the length of his body. This means "I give up" and is the last stage of the fight. As long as the loser does not move, he will not be attacked. But the moment he stirs, the winner rushes to bite him. Now the loser must have air but the winner stands over him to keep him from swimming to the surface. If the loser is not removed from the tank at this time, he may die.

When Do Bettas Fight?

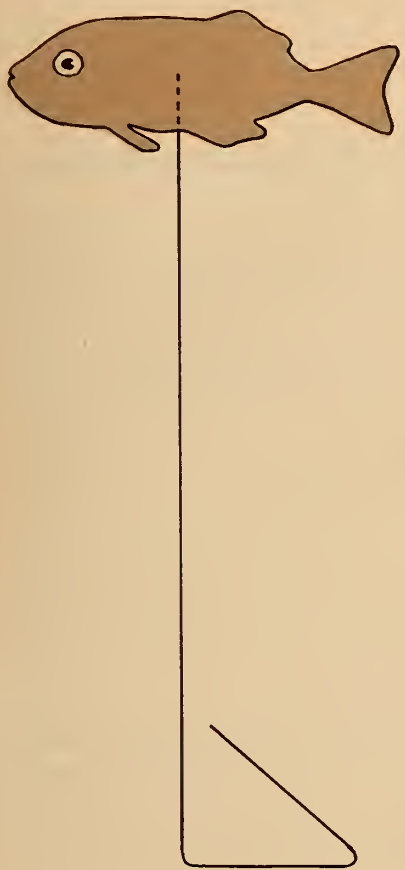
It is a mistake to think that a male Betta will always fight another Betta or a model with the same vigor. These fish are not like machines. Bettas learn to know and, for a while, remember each other. If one has recently been defeated by another, the loser will not fight back much if he meets the winner again. If a male has not fought for a long time, he will display to almost anything.

On the other hand, a male who is challenged to fight often is less and less ready to fight. Remember this when you are tempted to hold a mirror up to your Betta. If you do it too often, the Betta will stop reacting to his reflection. Fighting also depends on water temperature, hunger, and health. A male with eggs in a bubble nest is more ready to fight than one without a nest. And just as with people, there are individual differences. Some Bettas are more apt to fight than others ■

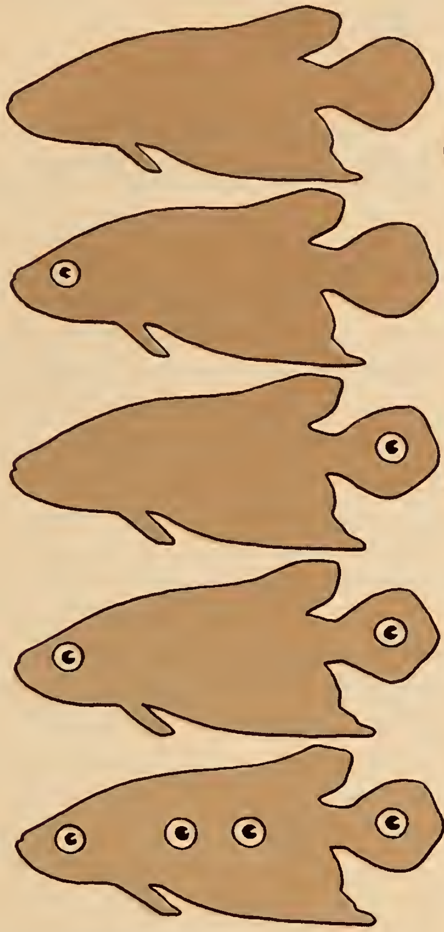
■ If you would like to read further about Bettas, the pamphlet, **Siamese Fighting Fish,** by Dr. Myron Gordon may be obtained at your petshop or from T.F.H. Publications, Inc., T.F.H. Building, 57 Academy Street, Jersey City 2, N.J., for 35 cents. Or look in your library or bookstore for **Tropical Fish in the Home Aquarium,** by Horace Vondys, The McBride Co., New York, $3.

INVESTIGATION

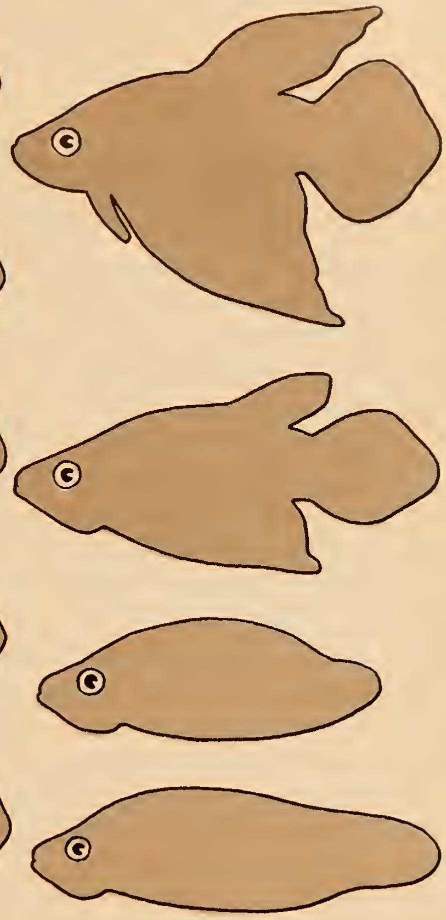
How to Test a Betta's Fight Response



Run a piece of stiff wire into the model fish's belly so you can move it from below the aquarium.



Try painting eyes on the model in different places, as shown, and see how your Betta reacts to each.



Another way to test your Betta is to change the size and number of fins on the model, as shown here.

Models of Bettas are easy to make. Because they will not be put into the water, you can make them of thin cardboard or stiff paper.

Draw an outline of the fish with the fins spread, the same size as your Betta, then cut it out with scissors. A piece of styrofoam, or clay, can also be worked into the shape of a Betta. Try paper of various colors, or paint your cut-out. Details such as eyes and mouth can be put in with a fine brush, using black and white paint.

Now take a piece of stiff wire about one foot long. Bend it sharply at one end to make a handle (see *diagram*). Run the other end into the belly of your model, or tape it in that position.

Trying Out Your Model

To test your Betta, hold the end of the wire so that your hand is hidden behind, say, the edge of a table. Hold the model against the glass wall of your Betta's bowl or aquarium. Watch how your fish responds. After one-half minute, quickly remove the model. That is the *stationary test*. In the *moving test*, make the model slowly "swim" the length of the glass, turn, and swim back. Do this for one half minute.

To decide how well your Betta responds, you must score his behavior. Give a number to each of his actions and write it down each time that action occurs. Here is a simple system: approach = 1, spread fins = 2, raised gill covers = 3, tail beat = 4, ram = 5. Your record might be 1, 2, 3, 4, 3, 4, 3, 5—which adds up to 25 for a total response.

There are several things about Bettas that you can inquire into. Color for one. The original Bettas are thought to have been red. Does a red model cause more responses than a blue, green, or yellow model? And what about markings? Try adding to your model, and removing from it the eyes, mouth, red border on the gill covers, and the long body stripe. Or add and remove fins. Turn the model upside down or move it backward. Give it two heads instead of a head and a tail.

You can also do much with a mirror by covering most of it with tape. How small a piece of his own image will your Betta respond to?

A final word of caution. Bettas learn that the models can be ignored, so do not test your male too often, or too many times in a row.

your MUSEUM *at home*

Polar Bears

■ Polar Bears live only in the Arctic, and they are as much at home in the icy water as on the snow-encrusted land. Even the scientific name of these bears, *Thalarctos,* which means "sea bear," identifies them with the sea.

Polar Bears are the second largest of the *carnivorous,* or meat-eating, animals. (*Watch for the next issue of* N&S *to find out which is the largest.*) They feed mainly on seals, ducks, and walrus cubs. They leave the adult walruses alone because they have sturdy tusks which are good weapons for defense. Polar Bears also eat caribou, foxes, birds, shellfish, and any other form of animal they can catch, as well as seaweed.

The Polar Bear male may reach a length of nine feet, stand five feet high at the shoulder, and weigh some 1,600 pounds. Most, however, are smaller. Males average 900 pounds in weight, females 700 pounds. Polar Bears in the wild live as long as 25 years. Scientists think that there are 25,000 of these animals, but that their number is becoming smaller.

How Polar Bears Survive the Cold

Polar Bears are well adapted to life in the cold. Thick, long, white fur, tinged with yellow from the stain of the ocean's brine, covers their bodies. For protection against the intense glare from the ice and snow, a third eyelid shades the animal's eyes.

Polar Bears can swim and float for a long time with ease. Air pockets within their fur buoy them up, while oily skin and a thick layer of fat protect them from the cold of icy water and the biting winds on land, where the temperature often plunges to —50° F. and colder.

Although Polar Bears live in one of the coldest regions in the world, they do not use a den as other bears do. Only the pregnant female has the typical bear habit of sleeping through the coldest months of the year. Even then, she does not hibernate in the true sense of the word (*see page 10*), for her blood temperature remains nearly normal.

In late fall or early winter, the female bear finds a sheltered bank of snow, digs down into it, and curls up to sleep. In no time she is covered over with blowing snow. In January, nine months after mating time, the baby cubs are born in this snug hollow.

At birth the cubs are nearly hairless. They weigh only two pounds or so and are a scant 10 inches long. At the age of six weeks they develop a coat of soft fur and can see. In March the cubs take their first look at the glittering, icy world around them. The mother now teaches them to hunt. Two years after birth, and some 200 pounds heavier, the young bears go off to start a solitary life of their own. These animals do not live in groups.

Polar Bears are skilled hunters. They know that seals are to be found where there are fish. So the bears find "guides" which lead them to the fish. The guides are *krill* —tiny sea animals that lure the fish near to the melting edges of the ice. Here the krill are eaten by the fish, which in turn are eaten by the seals.

When the Sun lures a seal out of the water to bask on the ice, the seal is constantly on guard for signs of trouble. Even so, the seal may not see the slowly moving, stalking bear. The animal and the snow blend together so well that the bear is nearly invisible.—MARION B. CARR

Polar Bears have toes that are webbed to help them swim, and hair on the bottom of their feet helps them walk on ice. These bears are at the Zoological Park in New York City.

nature and science

EACHER'S EDITION / VOL. 1 NO. 10 / FEBRUARY 21, 1964

&S
EWS

Some Books That Will Help You Teach Science

by Elizabeth Hone and Mabel Crittenden

■ Contrary to popular notion, the scientist's chief tool is the library, not the laboratory. Long before a scientist designs an experiment to test a hunch or resolve a problem, he reviews the literature to see if other scientists have discovered anything about the same or related questions.

By the same token, books are teachers' chief tools in leading children into science. The books that follow are not children's science books, but books for *your* shelf. They are books that will help you to answer the many questions children ask. More important, many of these books are written by people with years of experience in science teaching. They will help you to contrive situations which propel children into books and investigations to find their own answers to questions about the world around them. And they will help you to suggest and direct such activities toward worthwhile educational ends.

Here are a number of such books (or book series) that have earned a front row on the bookshelves of elementary school teachers of science.

HANDBOOK OF NATURE STUDY, by Anna Botsford Comstock. Comstock Publishing Associates, 24th ed. 1939, 942 pp., ill., trade ed. $6.75, text ed. $5.

This much beloved volume was originally compiled from "Home Nature-Study Course" leaflets written in the early 1900's to help beginning teachers in isolated rural schools. Revised and republished many times since, it is still an invaluable source of information and teaching ideas about most of the natural history objects children are apt to lug into your classroom.

For example, the section on snails begins with three pages of background material for you ("The Teacher's Story"). The page devoted to the lesson has three subheads: 1) Leading Thought; 2) Methods (in this case, how to make a "snailery" for classroom observation); 3) Observations (ten or a dozen leading questions which the children can answer by observing snails). Many other topics are similarly developed.

MAKING AND USING CLASSROOM SCIENCE MATERIALS IN THE ELEMENTARY SCHOOL, by Glenn Blough and Marjorie Campbell. Holt, Rinehart & Winston, Inc., 1954, 325 pp., $3.95.

This useful book illustrates one of the many ways we find time for science by integrating it with other school activities. Careful diagrams and classroom photographs extend the text. The areas treated are animals and plants; Earth and sky; air, weather, and aviation; magnetism and electricity; sound, light, and heat; and machines. Sources of further information and sources of materials are included for each topic.

This is the kind of book from which children can work directly in constructing equipment for investigations.

(Continued on page 4T)

Dr. Elizabeth Hone is Professor of Education and Director of the Conservation Foundation's Curriculum Center at San Fernando Valley State College, California. She has taught elementary school children and teachers for many years, and is a member of our National Board of Editors.

Mrs. Mabel Crittenden, of Menlo Park, Calif., is a school librarian working with more than 30 elementary school teachers.

WHAT IT MEANS TO BE A SCIENTIST

It is a pity that most people think a scientist is a specialized person in a special situation, like a lawyer or a diplomat. To practice law, you must be admitted to the bar. To practice diplomacy, you must be admitted to the Department of State. To practice science, you need only curiosity, patience, thoughtfulness, and time.

The scientist's effort to understand the workings of the world has two sides. On the one hand, he performs experiments on bits of the world, to find out how those bits behave. He makes the assumption that another bit of the world, similar to the one he examines, ought to behave in the same way.

For this reason he demands that a valid experiment shall be "repeatable": Anyone else, told how to perform the same experiment, must be able to repeat it in any other part of the world and get the same result. This demand distinguishes his experiments from those of people who claim to tip tables without touching them, to see the future before it occurs, or to transfer thoughts into other persons' minds without using the usual means of communication. So far, those people have not described their experiments in such a way that others can repeat them.

On the other hand, the scientist's activities also include a great deal of thinking, and of visualizing things in his mind's eye. While he is engaging in this side of his work, he is not looking at the real world as directly as he does in his experiments. He is trying to bring the experiments, done either by himself or by others, into some kind of orderly relationship—to derive from them a way of thinking that includes them all.

Out of these efforts come "pictures of the facts" and "laws of nature": ways of organizing physical experiences in the mind so that they can all be thought about together, as if they were related experiences. It is only when he has succeeded in finding such organizing principles that the scientist feels satisfied, happy, and ready to move on to another problem.—*From* Crystals and Crystal Growing, *by Alan Holden and Phylis Singer. Copyright © 1960 by Educational Services Incorporated. (Science Study Series) Reprinted by permission of Doubleday & Company, Inc.*

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

At this time of the year, people in many parts of the United States are struggling with the problems of winter weather, and children will find the variety of information and activities in this special-topic issue highly interesting and appropriate.

In class discussions, we suggest you make use of your pupils' own experiences with cold weather, snow, and ice to emphasize the very real problems these conditions pose for animal and human life.

PAGE 3 Melting Ice

Through the investigations in this SCIENCE WORKSHOP article, children can discover for themselves some of the principles of thermodynamics involved in situations described in the other special-topic articles in this issue. They will find, for example, that:

1. Heat can be transferred from one medium to another, provided one medium is warmer than the other.
2. Heat will be transferred faster from one medium to another (from ice to air in this case) as the surface area of the ice increases.
3. The speed with which heat is transferred from one medium to another varies directly with the speed at which they conduct heat.

The basic concept is that *under ordinary conditions, energy* (in this case heat) *can be changed or exchanged but not annihilated.*

Suggestions for Classroom Use

This investigation may be performed at home or (if a refrigerator is available) in the classroom. In either case, class discussion of the results will help bring out the points listed above.

These characteristics of heat should also be related to specific situations described in the articles in the student's edition. For example, ask why men need special clothing and shelter to survive in the cold, while cold-climate animals do not. (Clothing keeps body heat from escaping into the air; in shelters, air can be warmed.) Note how animals are adapted for survival in the cold: heavy fur, extra fat, hibernation, and so forth.

Point out that water vapor in the air in a refrigerator changes from a gas to a solid without passing through the liquid state (it appears as rime ice on the freezing compartment) in the same way that water vapor in a cloud changes into ice crystals.

Have the children apply their findings to some everyday problems. For example, would a frozen cut-up chicken thaw faster in one lump or broken apart? If broken apart, more surface area would be exposed.

The suggestions for using this issue of Nature and Science *in your classroom were prepared by Patricia Ralph, elementary school teacher in the public schools of Huntington, N.Y., and member of our National Board of Editors.*

PAGE 4 Man Against Cold

This article discusses the physiological response of organisms to cold temperatures and the ability of men and certain other animals to become "acclimatized." Man's ability to survive in cold climates depends much more on protective clothing and shelter than on bodily adaptation.

The article also brings out the following concepts:

1. Certain animals have become adapted over thousands or millions of years to life in cold climates. Man, on the other hand, survives the cold by modifying the local environment to suit his needs.
2. Bodily comfort and health depend on generating enough heat to balance heat loss.
3. Ideas borrowed from Eskimo clothing and igloos have been used to help explorers survive the cold.
4. One way cold-climate animals have become adapted to their environment is by reduction of the surface area of certain parts of their body, thus reducing heat loss.

These points are summed up in this basic concept: *Organisms are adapted to their environment.*

Suggestions for Classroom Use

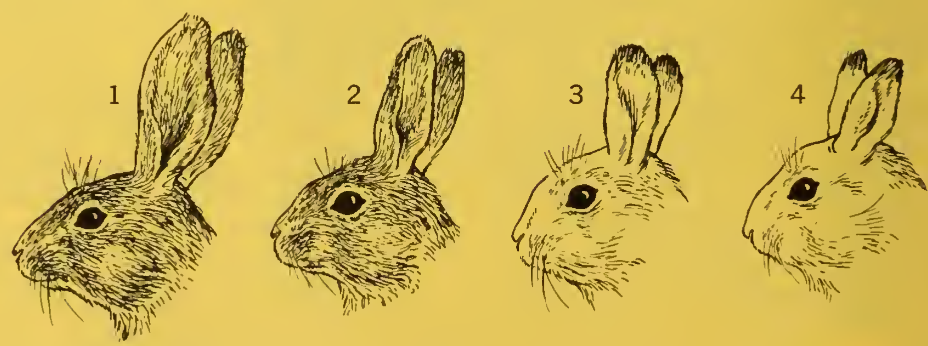
In addition to discussing the points made in the article, it will be useful to extend their implications by asking these questions:

1. What are the requirements of cold-weather clothing? It must provide insulation, keep the body dry, and shield against wind.
2. What happens if you wear too many clothes on a cold day? Overdressing causes the body to perspire, and the resulting moisture cools the body by evaporation. During strenuous play or work, some clothing should be removed or opened temporarily to allow excess heat to escape.
3. Why are mittens warmer than gloves of the same material? Less area is exposed to heat loss.
4. What is the best way to treat frozen feet or hands? Cover the frozen areas with warm clothing or blankets. Soak frozen area in warm (test with your elbow) water. Drink warm beverages. When the affected parts are warmed, exercise them.

Activities

1. Find out the following facts about the climate in your area: average tem-

(Continued on page 3T)



Cold-climate animals tend to have smaller ears than those in warm climates, thus exposing less surface area to the surrounding air. The rabbits shown here are (1) the Arizona Jack Rabbit, (2) a jack rabbit from Oregon, (3) the Varying, or Snowshoe, Hare of the northern United States and Canada, and (4) the Arctic Hare.

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

perature in summer and winter, warmest and coldest days on record, average rainfall and snowfall. You can get the facts from your local airport. Obtain similar data for two other cities—one at the same latitude as yours but about 1,000 miles away, the other at the same longitude but about 500 miles away. Compare temperature and precipitation data for the three cities.

2. Test the insulating quality of snow by comparing the temperature at the surface of snow with the temperature beneath a snowdrift.

PAGE 10 Sleeping Animals

This article explores the way some forms of animal life respond to cold temperatures by hibernation. While the article speaks of mammals and birds, children should know that certain reptiles, amphibians, fishes, insects, and worms become dormant in the winter.

The article brings out the following concepts:

1. True hibernation takes the form of a deep sleep during which the body temperature of a warm-blooded animal drops far below normal.

2. Some mammals, such as bears, pass the winter in a dormant state with their body temperature near normal.

Here again, the basic concept is that *organisms are adapted to their environment.*

Implications for Medicine. A woodchuck can live with its body temperature at 37° F., yet to date the temperature of a human cannot be lowered much below 98.6° F., except for brief periods during surgery. When scientists solve the mysteries of hibernation, they may be able to improve the technique of "deep-freezing" human beings for operations on the heart.

Suggestions for Classroom Use

The class might discuss the ways winter-active animals meet the problems of winter, such as local and long-distance migration, putting on extra fat, acquiring denser fur, or growing a more protective coloring of fur for the purposes of camouflage.

Have children consider the advantages and disadvantages of hibernation. Some disadvantages: A hibernating animal is helpless if found by an "enemy," since hibernators awaken so slowly. The active life of hibernators is compressed into the months when they are awake, and hibernators usually have time to raise only one litter per year.

Activities

Have children check available books and articles on the subject and see which animals are listed as "hibernators." Much published material does not distinguish between animals that are merely dormant and those that are true hibernators. Finding such discrepancies will demonstrate the need for checking more than one source to verify a "fact."

PAGE 8 World of Winter

This *Nature and Science* WALL CHART describes the various kinds of winter precipitation and ice cover and how they are formed. Hail is included because of its resemblance to sleet, but hail is the product of thunderstorms and, as some child may observe, falls mainly in summer.

The text explains how water in the atmosphere changes its form (water vapor, ice crystals, water droplets, snowflakes, sleet, hailstones) as the temperature of the atmosphere changes. The basic concept: *Under ordinary conditions, matter can be changed but not annihilated or created.*

Suggestions for Classroom Use

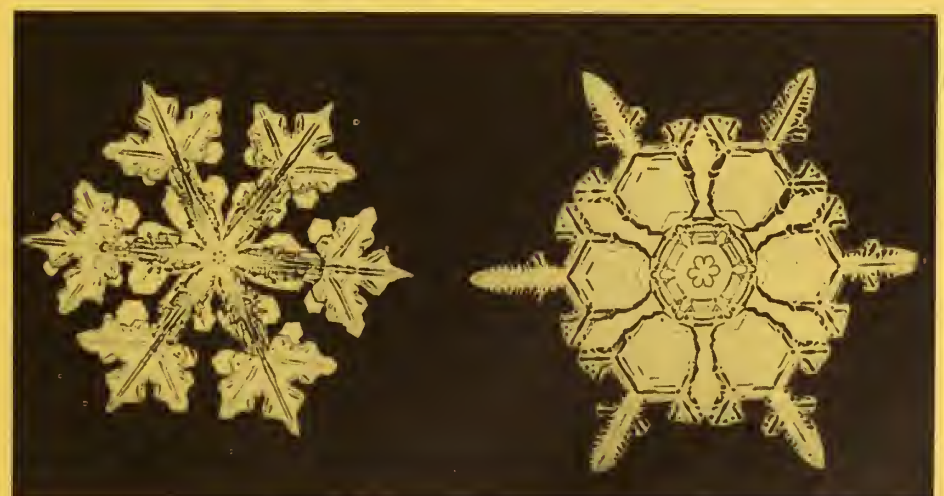
1. The exquisite beauty and infinite variety of snow crystals may motivate children to learn more about them. During the next snowfall, have your pupils catch and observe snowflakes with chilled black paper or cloth and a magnifying glass. Note that the crystals are six-sided, sometimes in the form of a hexagonal plate, sometimes in star shapes, and in various combinations of the two.

2. Snow is a good insulator against sound and heat transfer because of the air particles trapped within and between crystals *(see Activity No. 2, "Man Against Cold," above).* Its fibrous structure is thus similar to fiberglass or rock wool. Have children think of how this feature protects plants and animals underneath from below-freezing air temperatures. What happens to normal street sounds when snow is on the ground?

Activities

1. What is the water equivalent of snow? Have your class plan an investigation to see how much water is in a given snowfall. At the onset of the next storm, set out a straight-sided container to catch snow, measure the depth before and after melting. Normally 10 inches of snow contains one inch of water, but it varies according to whether it is a wet snow or a fine, powdery one. Have the class repeat this investigation with the remaining snowfalls of the season and record their findings.

2. Find where the biggest snowfalls in the U.S. occur (Sierra Nevadas)
(Continued on page 4T)



All snow crystals are six-sided. The nearly infinite variety of forms they can take include columns, needles, flat plates, capped columns, and stars. Snowflakes begin to form when water vapor molecules change from a gas directly into ice without passing through the liquid state.

Using This Issue...
(Continued from page 3T)
and why? What is the record snowfall there for one day? One year?

References

Rain, Hail, Sleet and Snow, by Nancy Larrick. Garrard Press, 1961. 63 pp. ill. $1.69.

Our Changing Weather, by Carroll Lane and Mildred A. Fenton. Doubleday & Company, Inc., 1954. 110 pp. ill. $2.95.

Exploring the Weather, by Roy A. Gallant. Garden City, 1957. 64 pp. ill. $2.50.

Everyday Weather and How It Works, by Herman Schneider. Whittlesey, rev. ed. 1961. 194 pp. ill. $3.01 (paperback 95 cents).

The Way of the Weather, by Jerome Spar. Creative Educational Society, Inc., 1962. 224 pp. ill. $4.95.

All About the Weather, by Ivan Ray Tannehill. Random House, 1953. 148 pp. ill. $1.95.

Some Books That Will Help...
(Continued from page 1T)

THE WORLD OF SCIENCE, by Jane W. Watson. Golden Press, Inc., 1961, 216 pp., ill., $5.

Among a number of books from this publisher which have contributed much to popular understanding and appreciation of science: Designed for junior high school use, the clear, easy text and wealth of illustrations make this a favorite among adults and children alike.

The series is particularly helpful to adults who feel inadequate about various fields of modern science. Even for children who cannot follow the text, the illustrations teach a great deal. The editors have also employed the end papers to show the electromagnetic spectrum and orders of magnitude from submicroscopic particles to distant galaxies.

The subtitle, "Scientists at Work Today in Many Challenging Fields," suggests the interesting treatment of modern scientific discoveries in the fields of geology, astronomy, mathematics, physics, chemistry, biology, and engineering.

UNESCO SOURCEBOOK FOR SCIENCE TEACHING. International Document Service-Columbia University Press, 1963, $4 (paperback $3). Rev. and enl. ed. under title 700 SCIENCE EXPERIMENTS FOR EVERYONE available at bookstores. Doubleday & Company, Inc., 1964, $4.

A compilation of ideas of experienced teachers from many countries: The point of view of the book is described thus:

"Science is most effectively taught and learned when both teacher and pupils practice the skills of problem-solving by engaging in group and individual study. ...[The book] proposes a wide array of science experiments from which a teacher may select those most suitable for providing the observations upon which effective learning may be based."

With simple line drawings and concise text, the book suggests materials and methods for illuminating such topics as plants, animals, the human body, rocks, soils, minerals, fossils, astronomy, air, weather, water, machines, forces, inertia, sound, heat, magnetism, electricity, and light.

The appendices include useful conversion tables for weights, measures, and temperatures; astronomical data; information on classes of rocks and identification of minerals; tables of elements, of densities, of relative humidity.

The lists of science references, periodicals, and suppliers of scientific instruments are international in character and interest.

TEACHING HIGH SCHOOL SCIENCE; A SOURCEBOOK FOR THE BIOLOGICAL SCIENCES, by Evelyn Morholt, Paul F. Brandwein, and Alexander Joseph. Harcourt, Brace & World, Inc., 1958, 506 pp., $7.50.

TEACHING HIGH SCHOOL SCIENCE; A SOURCEBOOK FOR THE PHYSICAL SCIENCES, by Alexander Joseph, Paul F. Brandwein, Evelyn Morholt, Harvey Pollach, and Joseph Castka. Harcourt, Brace & World, Inc., 1961, 674 pp., ill., $7.95.

TEACHING ELEMENTARY SCIENCE; A SOURCEBOOK FOR ELEMENTARY SCIENCE, by Elizabeth B. Hone, Alexander Joseph, and Edward Victor. Harcourt, Brace & World, Inc., 1962, 552 pp., $7.50.

These sourcebooks were designed to offer more scope and detail (depth) than was afforded by the excellent Unesco Sourcebook (*see above*). Written in each case by a team of authorities, the series might be regarded as one text, one handbook for teachers who regard science from kindergarten through 12th grade as a sequential development of basic conceptual schemes. In these three books you will find information and teaching suggestions on most of the problems and questions raised by children.

Since the spirit of science is "caught," not taught, the wise teacher knows that if one investigation or demonstration fails to spark a child's comprehension and interest, another slightly varied one may provide the key. Each of these volumes attempts to arm a teacher with ideas and information necessary to mount such a multifaceted approach.

Each sourcebook includes appendices that provide a variety of useful scientific information.

THE GENERAL SCIENCE HANDBOOK, New York State Education Department, Publication Distribution Unit, Albany, N.Y. Part 1, 1961, $1; Part 2, 1962, $1.50; Part 3, 1956, $1.25. Available through schools only.

Across the country, educators are beginning to revise upwards their ideas of what young children can comprehend in science. What was taught in junior high school in 1951, for example, is beginning to appear in materials for younger children. And topics developed in a 1959 third grade science text are found in a second grade text in 1962.

From the broad spectrum of investigations suggested by the New York State series, teachers and children can select ideas for investigations to resolve questions and to illustrate principles. In each volume, the graphic drawings are keyed to concise, simple instructions.

The three handbooks cover a wide range of science problems, each one with a slightly different emphasis and coverage. For example, Part 1 (designed for seventh grade classes) includes sections on living things, health, flowers and seeds, electric circuits, gravity, friction, light, air, seasons, and rocks.

The appendices list useful references and sources of equipment and supplies.

SCIENCE GUIDE FOR THE ELEMENTARY SCHOOLS OF RIVERSIDE COUNTY (Riverside, California), 1961. VOLUME I, grades 1-3, 139 pp., $2. VOLUME II, grades 4-6, 186 pp., $3.50.

Here are two relatively recent courses of study oriented toward the major conceptual schemes of science (*see* N&S Teacher's Editions, *Nov. 15, 1963, Jan. 24 and Feb. 7, 1964*).

The classroom illustrations, the teacher-developed teaching suggestions, the functional organization—all combine to make these books useful adjuncts to your professional library ■

THE NEXT ISSUE of *Nature and Science* tells how a young scientist's curiosity about how nocturnal animals see in the dark resulted in a zoo exhibit where such animals can be observed in an active state instead of in their usual daytime state of dormancy.

Another article gives a timely explanation of what causes winds to blow. Two stimulating SCIENCE WORKSHOP articles show how to grow crystals and how to explore the wonders of a drop of water.

The N&S WALL CHART illustrates diminishing magnitudes of things from the way humans see them down to the atomic level.

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nature and science

VOL. 1 NO. 11 / MARCH 6, 1964

A scientist discovers how
to show the secret world of night
animals to zoo visitors by . . .

TURNING DAY INTO NIGHT

see page 4

ABOUT THE COVER

The Burrowing Owls on our cover were photographed in Arizona by nature photographer Lewis Walker. Unlike most owls, Burrowing Owls do not nest in trees. They live in burrows that have been abandoned by other animals, such as prairie dogs, or dug by the owls.

These robin-sized owls live in open, treeless areas in western North America, southern Florida, and most of South America.

A dozen or more pairs of Burrowing Owls may live in one colony. In daytime, the birds rest inside or near their burrows. At night they hunt for insects, mice, and other small animals.

Scientists long wondered how owls catch their prey in the dark. For one thing, they discovered that the birds have especially large and sensitive eyes. (Owls see much better in dim light than we do.) However, owls can still see more clearly in the daytime than at night. At night they depend mostly on a sharp sense of hearing to locate their prey.

The article on page 4 describes how one scientist investigated the eyesight of night-living animals, and used his findings to develop an exciting zoo exhibit that shows night-prowling animals from all over the world.

nature and science

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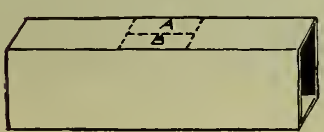
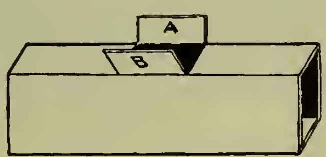
HOW FAST DOES THE WIND BLOW?

■ When the wind blows so hard that you can barely make headway walking into it, how fast is the air moving? You can measure the speed of the wind on breezy days as well as gusty ones by making a simple *anemometer,* or wind gauge. The month of March is a good time to measure winds.

To make an anemometer, you will need a milk carton with both ends removed, a long darning needle, two shorter needles, a cork, and a piece of cardboard. The carton should be thumbtacked to a block of wood. Cut the middle section of one side of the carton as shown here, and fold up flaps A and B to make supports for the axle.



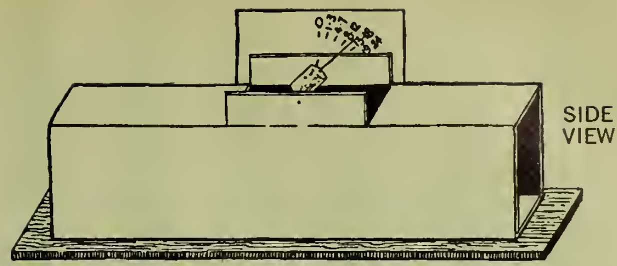


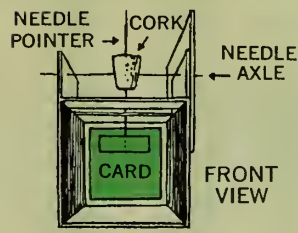
Push the long needle through the flaps, placing a cork at the center *(see diagram).* Mount one needle vertically in the cork to serve as a pointer. Cut a square of cardboard to fit inside the carton, attach the third needle to it with tape, and stick the needle into the cork as shown. When the apparatus is set up, the card should move quite easily and smoothly within the box. (You may have to adjust the cork and axle.)

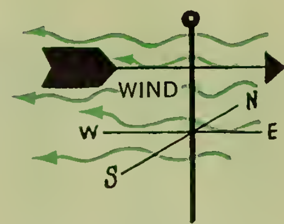
When the wind is blowing, point the apparatus into the wind so that the wind blows through the box. As the wind pushes against the cardboard square, it turns the axle and *deflects* or tilts, the needle pointer.

The distance the needle is tilted indicates how fast the wind is flowing through the carton. To measure this distance, you need a gauge. Fasten a piece of cardboard to the side of the carton and draw a line on it parallel to the indicator needle when it is standing straight up.

You can *calibrate* the gauge, or mark the tilt of the needle at different wind speeds, by using the Beaufort scale on this page.—FRANKLYN M. BRANLEY







BEAUFORT SCALE

WHEN—	WIND SPEED IS—
Smoke rises straight up	0 mph
Smoke drifts in one direction	1-3 mph
Leaves rustle; flags stir	4-7 mph
Leaves and twigs move constantly	8-12 mph
Paper, small branches move; flags flap	13-18 mph
Small trees sway; flags ripple	19-24 mph
Large branches move; flags beat	25-31 mph
Whole trees move; flags are extended	32-38 mph
Twigs break off trees; walking is difficult	39-46 mph

INVESTIGATION

Do the speed and direction of the wind give any clues about changes of weather where you live? You can find out by keeping a record on a chart like the one shown here. Each day at the same time, say about 8 o'clock in the morning, measure the wind speed and direction from which it is coming. About six hours later, note the weather (sunny, cloudy, rainy, snowy, or whatever) and enter it on the chart.

DATE	TIME	WIND SPEED	WIND DIRECTION	TIME	WEATHER

When you have kept the chart for several weeks, study it to see if there is any connection between the speed and direction of the wind and the weather that follows. Keep in mind that your findings would be more reliable if your anemometer were more exact, and if you measured the wind hourly for months, instead of once a day for several weeks. Also, that wind is only one of the things that helps make the weather what it is.

A scientist discovers how to show the secret world of night animals to zoo visitors by...

TURNING DAY INTO NIGHT

by Laurence Pringle

This Ringtail sleeps when white lights are turned on, but is active under red light, which it cannot see.

■ One day not long ago I visited the Zoological Park in New York City, better known as the Bronx Zoo. I had been told about a special exhibit that showed small night-prowling animals in an unusual way.

As I entered the Small Mammal House, I found myself in an eerie world of red light. In a few moments my eyes got used to the strange light and then I began to see something that people rarely see out-of-doors. It was daytime, yet the night animals — skunks, mice, flying squirrels, porcupines—were awake and active in their cages. By using knowledge of how animals see, scientists at the Zoo give visitors a look at animals that are active usually only at night.

The night-prowling, or *nocturnal,* animals have always posed a problem to zoo scientists who try to show captive animals as they live, feed, and move about in the wild. When zoos are open during the day, the nocturnal animals are usually asleep, curled up in a corner of a cage or hidden from view in a den. They usually begin moving about when darkness falls, after the zoo is closed for the night.

To find out more about the Zoo's exhibit of nocturnal animals, I looked up the Curator of Mammals, Joseph A. Davis, Jr. He was just leaving his office to examine a sick monkey at the far end of the Zoo, and I tagged along, asking questions about his studies of nocturnal animals.

When Mr. Davis became Assistant Curator of Mammals at the Zoological Park in 1958, he was already interested in how nocturnal animals see. His interest began in 1955, when he was a graduate student in zoology at Cornell University.

"One day, I read a magazine article that described how an English scientist studied owls at night by shining strong red light on them," he began. "The scientist was able to learn a lot about the movements and foods of the owls, and of other nocturnal animals such as mice, badgers, and foxes. He could see them in the red light, but it appeared

This article was prepared with the advice of Joseph A. Davis, Jr., Curator of Mammals, New York Zoological Park.

that the eyes of these animals were made in such a way that they were not aware of the red light at all."

Later on, Mr. Davis studied the habits of the packrat, a kind of rodent that is active mostly at night. He began by searching through books and scientific magazines to find out what other scientists has discovered about animal eyesight.

By now we had reached the Zoo's animal hospital. As Mr. Davis examined the sick monkey, he told me some of the things he had learned about animal eyesight.

Inside an Eye

Scientists 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* which receives light rays from outside the eye and focuses them on the back of the eye, called the *retina (see diagram).*

The retina is made up of millions of tiny cells. Some of them—called *rods*—are sensitive to dim light and do not detect color. Each of your eyes has about 115 million rod cells. Another kind of cell in the retina is sensitive only to bright light—both colored and white. These cells are called *cones.* Each of your eyes has about 6.5 million cone cells.

When light falls on the rods and cones, signals, or impulses, are sent to the brain. In the brain, the impulses become the picture, or *image,* which you see.

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 as important as their size and position in the retina. Human eyes have about 20 rods for every cone, but the rods are much smaller than the cones. How clearly an animal sees also depends on which kind of cell is more plentiful in the central part of the retina. In the human eye, only cones are present in the center, so you see well—and in color—when there is a lot of light.

"We can only guess at what the world looks like to other animals," Mr. Davis said. "Nevertheless, we've been able to find the numbers, sizes, and positions of rod and cone cells in the eyes of some animals, and with this information, we can imagine at least something about how other animals see."

The Eyes of Nocturnal Animals

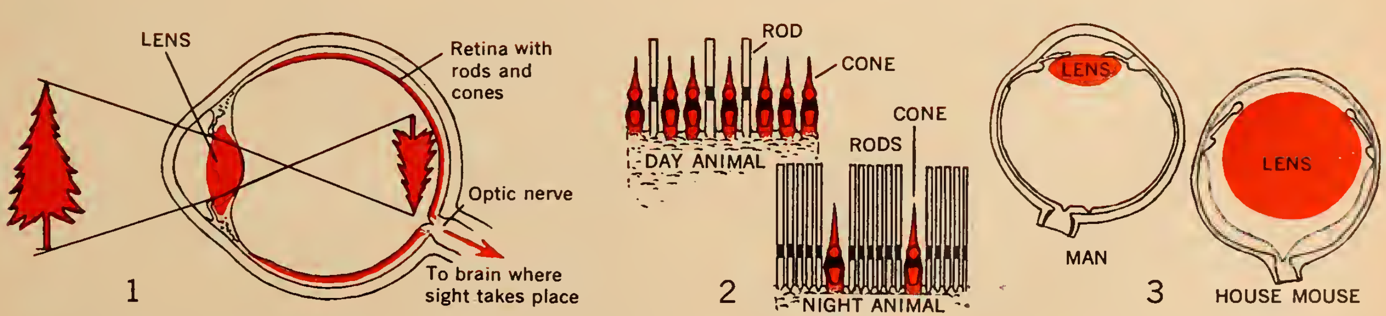
In order to see in the dim night world, nocturnal animals must have many more, and longer, rods than cones. These night animals also have larger eyes, with larger lenses and eye openings, or *pupils,* than day animals of the same size. The eyes of nocturnal animals are sensitive to light too dim for our eyes to see. However, their rod cells do not give sharp images. To find food and to identify other animals, most nocturnal animals also have an exceptionally keen sense of smell, a sharp sense of hearing, or both.

The eyes of most nocturnal animals are so sensitive to light that they must be protected from bright sunlight. Many of them have pupils which narrow down to a tiny slit, letting in very little light. The pupils open wide in the dark. Animals with slit pupils include crocodiles, many members of the cat family, and many snakes.

During the time Mr. Davis was learning about what other scientists knew about animal eyesight, he became especially interested in one thing that had been discovered about nocturnal animals. The small number of cones in their retinas means that most of these animals cannot see red light. Apparently, even a strong red light is the same as darkness to them.

Mr. Davis began to experiment with nocturnal animals and red lights at the Zoo. I asked him how he set up the experiment.

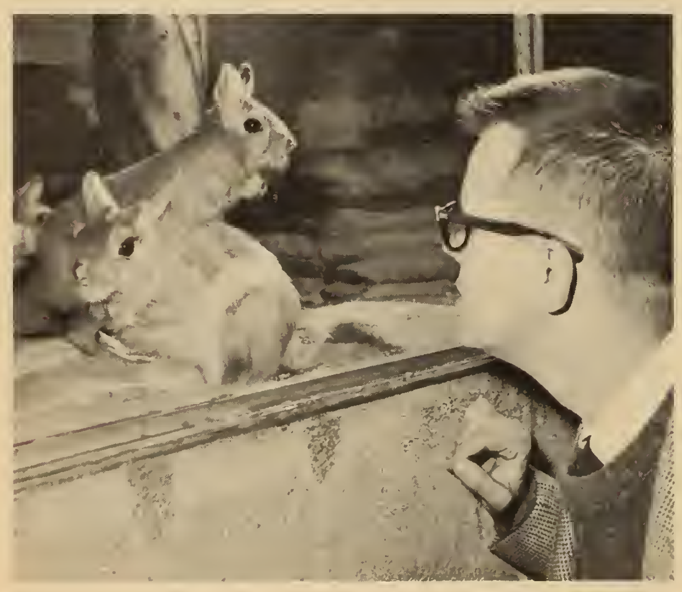
(Continued on the next page)



How the eye works: Light from an outside object is focused (upside down) on the retina (1). Impulses then travel to the brain, where sight takes place. Night animals have many special cells called "rods" in their retinas (2) and large eye lenses and lens openings (3). This enables them to see in the dark better than day animals can.

"First we put some nocturnal animals in cages that were in a darkened room. We arranged two sets of lights in the cages—one white and one red. At night we turned the white lights on instead of turning them off as usual. Then in the morning we turned the red lights on.

"All of the nocturnal animals adjusted to their new schedule within two weeks. Soon they were sleeping when it was night outside, because the bright white lights shining in their cages seemed like daytime to them. During real day, the white lights were turned off, and the animals woke up. It was time for their night. The rest was simple. With the red lights turned on, people could watch the animals move around, but the animals themselves were not aware of the red light at all."



Mr. Davis watches some Spring-haas, rabbit-like animals from South Africa. So far, about 50 kinds of night animals have adjusted to a nighttime of red light at the zoo.

Mr. Davis had finished examining the sick monkey and left a note for the Zoo's veterinarian. Then he told me more about his studies of nocturnal animals as we walked toward the Small Mammal House.

"In 1961, part of the Small Mammal House at the Zoo was set aside for more experiments, and as an exhibit of nocturnal animals. Since then we have tested about two dozen different groups of animals in the red light. They include animals from the United States—skunks, shrews, flying squirrels, wild rats, and mice. There were also animals from other countries—anteaters, and tenrecs, which are small insect-eating animals from Madagascar."

The red light exhibit led to a few surprises. For example, cockroaches—insects that raid food supplies in homes, restaurants, and zoos—are most active in the animals' cages when the red lights are on.

"After you reversed their day-night schedule, how did the animals get on?" I asked.

"Very well," said Mr. Davis. "They sleep undisturbed when the Zoo is closed for the night, and they are active during the day when people look at them. Some of the animals are breeding and producing young, even though they had not bred for three or four years before the red light experiments. The animals that are breeding successfully include the Kinkajou (a raccoon-like animal from South and Middle America), and the Malayan Mouse Deer, the smallest hoofed animal in the world. (Actually it is not a deer, but a distant relative of the camel.)"

Planning the New Exhibit

We had entered the Small Mammal House and were watching the animals moving around in the red light. "Do any other zoos have exhibits like this?" I asked.

"Yes, several European zoos also have special exhibits of nocturnal animals. In some of them, they use blue light instead of red. However, the eyes of nocturnal animals are more sensitive to blue light than to red, so very dim blue light must be used. This makes it more difficult for people to see the animals. Exhibits using the brighter red lights are now being developed in zoos in Australia, India, and in the United States—in Cincinnati, Indianapolis, Colorado Springs, and Washington, D.C.

"Here at the New York Zoological Park, we are planning a special windowless building that will be called 'The World of Darkness.' It will be built during 1964 and 1965, and will use red lights and especially designed exhibits to show nocturnal birds, mammals, snakes, and lizards as they live in the wild. When a visitor peers into one of the large cages, he may see a leopard prowling in a tropical jungle, flying squirrels gliding from tree to tree in a woodland, or fishing bats scooping their prey from a pond—all unaware of the humans nearby." ■

INVESTIGATION

1. Some night, look directly at a star or other dim object. Then look slightly away from it so that the star's light falls on another part of your retina. Which way can you see the star better? What does this tell you about the position of rod and cone cells in your eye?

2. Notice how the size of your eye opening, or pupil, changes with dim and bright light. Stand in front of a mirror in a dark room for a minute or two, letting your eyes get used to the dim light. Then shine a flashlight into the mirror and watch the size of your pupils change. Do they become larger or smaller?

In dim light, shine a flashlight into the eyes of a cat. Do the cat's pupils get larger or smaller? Cover the flashlight with some red cellophane and shine it into the cat's eyes. What happens to the cat's pupils? Try green.

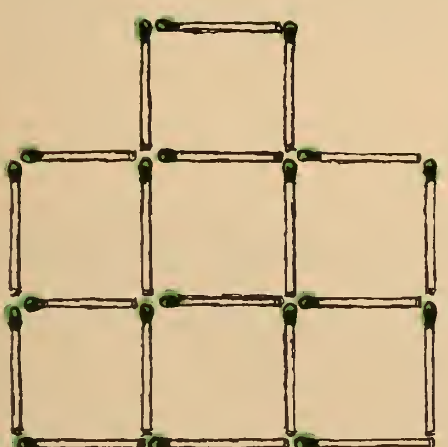
brain boosters

■ **The Impossible Puzzle**

Recently a *Nature and Science* reader told us about a puzzle which her mathematics teacher said was impossible to solve.

It seems that the families living in three adjoining houses did not get along very well. To avoid meeting each other, they decided to make separate paths to each of the three wells where they got their water. Of course, these grumpy people did not even want their paths to cross.

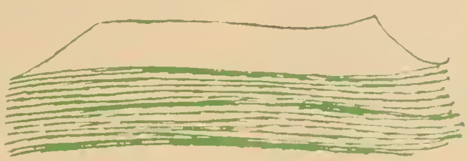
See if you can draw a separate line from each house to each of the three wells. Do you think the puzzle is impossible?



■ **Move the Matches**

Lay out 20 matchsticks or toothpicks to form seven squares like this. Then see if you can form five squares of the same size by moving just four of the sticks.

The five squares must be made up of all 20 sticks, and each square must touch another at some point.



■ **How High a Pile?**

Jim works in a paper mill, stacking sheets of paper in neat piles. One day he began a stack of paper with just one sheet. Then he doubled that, making the pile two sheets high. He doubled that, making the pile four sheets high. Another doubling made it eight sheets high.

Jim knew that each sheet of paper was one-hundredth (.01) of an inch thick, so the stack of eight sheets was eight-hundredths (.08) of an inch high.

Jim wondered how high the stack of paper would be if he doubled the number of sheets thirty times in all.

Can you figure it out? Would it be more than 10 inches, 1,000 inches, 100,000 inches, or more?

■ **Sally's Birthday**

"How old are you?" Sally was asked.

Sally said, "The day before yesterday I was 12, and on my birthday next year I will be 15."

Strangely enough, Sally was telling the truth. On what day of the year could Sally give this answer? What was the date of her birthday?

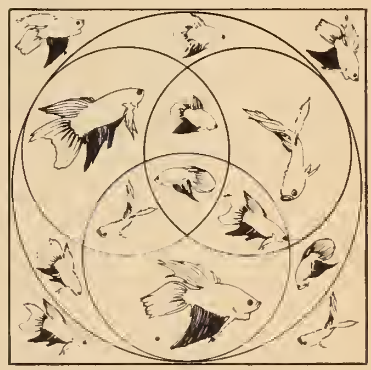
■ **Travels of an Explorer**

One day the great explorer Dr. I. M. Lost left his wilderness camp and hiked eight miles due south. Then he traveled eight miles due west. After stopping for a late lunch, he walked due north for eight more miles and found himself back at camp.

Can you figure out where Dr. Lost's camp is located?

Solutions to Brain-Boosters appearing in the last issue

Stop the Fish Fights: By drawing these four circles, you can separate each of the 14 fish from the others.



The Magic Squares: Here are the numbers that make the product of each row and diagonal 1,000.

50	1	20
4	10	25
5	100	2

The Naturalist's Notes: "Spring special topic issue on insects," was the message about *Nature and Science* hidden in Dr. Cipher's notes.

How Many Pigs?: One farmer had five pigs; the other had seven.

7 Steps t

Imagine that you could shrink until you were so sma
that an atom appeared to be about the size of a small pea
What would you see on the way "down" as first you be
came smaller than a mosquito, then smaller than a grai
of salt, and finally smaller than the smallest germ? In th

3

the Atom

even pictures here, we take you on just such a journey.
Before we start on our shrinking journey to the atom, ook at the picture of the girl working with shells (1). Notice the tiny black spot on her little finger. This is a nosquito. The picture shows the girl 1 /6 th life size.

7

2 This picture enlarges the mosquito to about life size. The girl's hand is also about the same size as your hand. From now on in our imaginary journey you will be seeing things that are impossible to see without a hand lens or microscope. Scale = 1:1 = life size.

3 In this picture everything has been enlarged 10 times. If you were to shrink to 1/10th your actual size, this is the way you would see things. Notice that the mosquito is beginning to look more like a monster than a small insect. Below the mosquito's head you can see a white speck—a grain of table salt that fell on the girl's skin. To the left of it you can barely see a water flea. Scale = 10:1 = enlarged 10 times.

4 Now you are so small that the mosquito seems to be the size of a dog, and the water flea the size of a shrimp. Normally we can see bacteria (one-celled plants) only under a microscope. But from your germ's-eye view you can see some rod-shaped bacteria as tiny specks to the left of the salt grain, which has now become large. If you had brought a tape measure along and it had shrunk with you, from this view the girl would appear nearly 500 feet tall. Scale = 100:1 = enlarged 100 times.

5 Enlarging the world still more by shrinking smaller, you can now see that the bacteria, which appeared as specks in picture number four, have different shapes. They are bacteria that cause 1) upset stomach, 2) tuberculosis, 3) diphtheria, 4) pneumonia, and 5) typhoid. Notice on the typhoid germ two thread-like hairs (called flagella) which the germ uses to move. Scale = 1,000:1 = enlarged 1,000 times.

6 In this picture you have become not 10 times smaller again, but have taken a double jump and become 100 times smaller. The view you now have is like that seen through the most powerful microscopes. What looks like a piece of rope (A) is one flagellum of the typhoid germ you saw in the last picture. In this picture you see a smallpox virus (B), and a virus called a bacteriophage (C), which attacks bacteria. These viruses are not much larger than molecules (see page 10). Scale = 100,000:1 = enlarged 100,000 times.

7 You have now taken another double jump. The salt grain that you could see in picture three now seems like a skyscraper. You are now so small that you can see things within the salt grain. These are atoms of sodium and chlorine that make up salt. They are arranged in an orderly fashion, as are the atoms forming other crystals. Floating out to the left are two molecules of nitrogen, one of the gases in air. Each molecule is made up of two nitrogen atoms. On this scale you would be so small that the girl in the first picture would be more than 8,000 miles tall. Scale = 10,000,000:1 = enlarged 10 million times.

HOW TO GROW A CRYSTAL

by James R. Gregg

All you need is some water and alum to discover some of the wonders of the world of crystals.

■ Although crystals are not made of living matter, they have a way of "growing." It even takes a "seed" to start one. If you do just the right things, you can grow a beautiful crystal in a few days. Its color and shape will depend on what kind of substances you use.

Crystals grow as the *atoms* or *molecules* that make up the substance arrange themselves into regular patterns. All matter is made of atoms—tiny, invisible particles in constant motion. Many substances are made of tiny clusters of atoms, called molecules. In solid things, the molecules are bound tightly together and don't move much. In liquids, they are looser and can move more easily. In a gas, the molecules are quite far apart and bounce around.

The patterns of molecules in some solids—sugar, for example—can be broken up by putting the substance in a liquid such as water. When the sugar molecules are mixed freely with the molecules of water, they are said to be *dissolved,* or *in solution.* It works in reverse, too. The molecules can be regrouped to form a solid again.

You can grow a crystal by first packing a liquid with all the molecules of a solid substance that the liquid will hold. Heating the liquid helps. Cooling brings molecules of the substance out of solution to form a solid again.

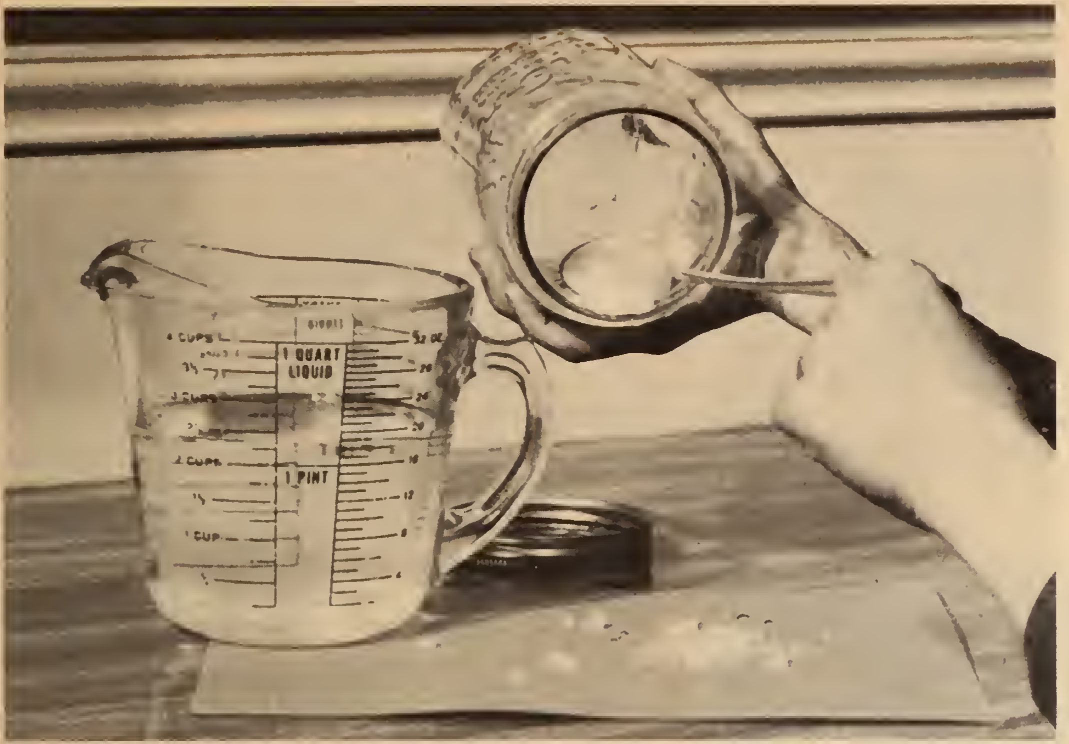
The molecules of many solid substances fit together in regular patterns. Some form cubes, others rectangular blocks or many other regular shapes. Over a period of a few days, you can watch this happen by controlling the amount of the substance you dissolve in a liquid and by controlling the temperature of the solution.

Making Alum Crystals

Potassium aluminum sulfate is one of the best compounds for making crystals. This is ordinary alum. You can get a pound at the drugstore for about 65 cents. Lump alum is purer and often makes better crystals than powdered alum.

The first step (*see below*) is to prepare a "seed" crystal. When you have made one and placed it in the solution, the molecules in alum will be attracted to it, and the crystal will begin to grow. If the conditions are right, all sides of the seed will grow at the same rate, and a smooth crystal will form. Tiny pieces of chemical may fall to the bottom of the solution and start growing too. This is called a *precipitate.* It is really nothing but other crystals, usually small and irregular in shape because their sides are not equally exposed to the fluid.

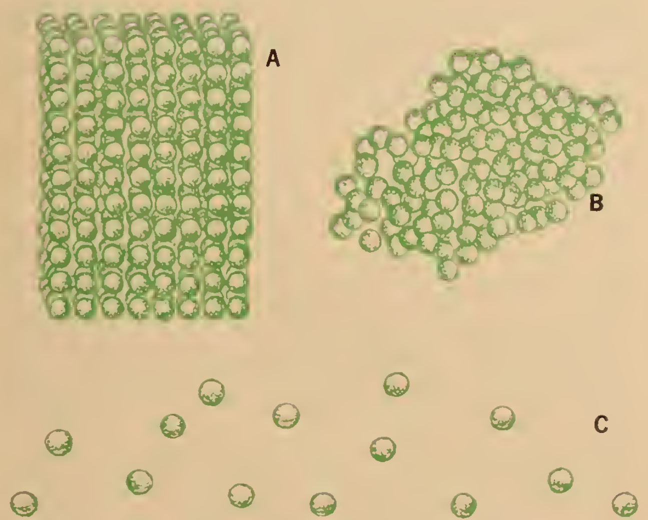
This diagram shows how the "seed" crystal should be suspended in the solution (see Step 5). A thread fixed to a cardboard disk supports the "seed" crystal.



At this stage in growing alum crystals, you will find many irregular crystals left in the bottom of the jar when you pour off the stock culture (see Step 3). Among these crystals you may find some good enough to use as "seeds."

The whole process of crystal growing requires a delicate balance of dissolved chemical, water, and temperature. If grown too fast, the crystal will look milky, or be irregular. Once you start the seed crystal in the solution you prepare, keep the temperature as even as possible (a kitchen closet is a good place) and don't disturb the solution any more than you have to.

Step 1. Weigh 4 ounces of alum and put into a quart jar with exactly 19 fluid ounces of water. Heat the jar in a pan of water but do not boil. Stir the liquid until all the alum is dissolved.



In solids (A), such as rock, the molecules are bound tightly together and are hard to break apart. In liquids (B) they are looser and can slip and slide over each other. In a gas (C) the molecules are far apart and bounce off each other as they move around.

Step 2. Pour into a small glass enough of the liquid to cover the bottom about one-quarter inch deep and put this aside without a cover. Seed crystals will form in this glass. You'll need a single crystal, regularly shaped and about one-eighth to one-quarter inch long, though you can use larger ones as well. If too much material forms, the tiny seeds will touch and blend together. If this happens, remove most of them and keep the rest separated from each other. Select the best seeds as they develop, dry them on paper tissue, and save them for later use.

Step 3. Seal the quart jar and put it where the temperature will remain even. If no precipitate forms in the bottom of the sealed jar overnight, add several grains of dry alum to it. Shake it twice a day. After a precipitate has formed and you decide that it is no longer increasing (after at least two days) the solution is ready for the next step. The solution, by the way, is called the *stock culture.* It is also called a *saturated* solution because it contains as much of the alum as it can hold at, say, room temperature.

Pour off the fluid into a clean container. Scrape out the precipitate, let it dry, and put it back with the supply of dry alum. Some of the precipitates may be good enough for seeds if the crystals have a regular shape.

Step 4. After the quart jar is cleaned and dried, pour the stock culture back in it. Measure just a little less than

(continued on the next page)

one ounce of dry alum from your original supply and put it into the stock culture. Reheat the stock culture as before to dissolve all the solid chemical. This produces a solution containing more alum that it could usually hold at a given temperature—*supersaturated* just the right amount for crystal growing.

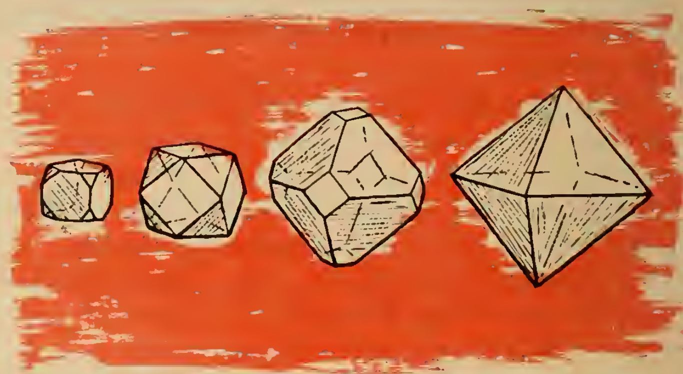
Step 5. Tie a strong thread around the seed crystal you have chosen. Cut a piece of cardboard so that it fits the top of the jar without falling into it, yet small enough for the lid to fit over. Punch a small hole in the cardboard disk and pass the thread up through the cardboard. By pulling the thread to the right height, you can adjust the position of the seed crystal so that when the cardboard is resting on the top of the jar, the seed will hang in the middle of the solution. Now tape the thread firmly to the top of the cardboard.

Step 6. Hang the seed crystal in the stock culture after the culture has cooled slightly, put the cardboard and metal lids on, and put the jar where it will be undisturbed and the temperature will remain more or less even. After five or ten minutes, check to be sure that the seed is still in place. Since the solution is still warm when you lower the seed into it, a little of the seed will dissolve, and it might fall off the thread.

This photograph shows the "seed" crystal growing in the stock culture. Notice that smaller crystals are forming along the thread. After you have selected a "seed" crystal, suspend it in the solution to about the depth shown.

Watching Your Crystal Grow

Now, over the next few days, you can watch the crystal grow. How fast it grows, and how big, depend on the conditions of the stock culture and the temperature of the room. You can take the crystal out (and be sure to dry it carefully with a cloth) when it has stopped growing for several days.



If you had a "seed" crystal shaped like a cube, it might grow in stages as shown here. The larger the cube became, the less cube-shaped it would be. Its final shape would be one called an "octahedron."

If the alum crystal you have grown is milky and not really clear, you may not have added quite enough alum. Try again. You can use the same stock culture to grow additional crystals. When you do, weigh the finished crystal and any other solids you removed with it so that you can replace them with the same amount of alum from the container. Heat to dissolve as before and grow a new crystal.

If you want to grow crystals of other shapes and colors, get a book about crystals from your library. A good one, which gives much of the science of crystals and recipes for making 12 crystal types, is the paperback *Crystals and Crystal Growing,* by Alan Holden and Phylis Singer, Anchor Science Study Series, $1.45, Doubleday and Company, Inc., Garden City, N.Y. ■

The Search for "Superior" Trees

■ Have you ever seen a superior tree? You probably have without knowing it. Foresters in the United States are searching for these special trees, which will be used to produce better forests.

All trees differ from one another in some ways, just as people do. Foresters say that a tree is *superior* if it has just the qualities that they are looking for. For example, when they search for Black Walnut trees to be used for lumber, they look for straight trees that grow fast and can resist damage by insects and diseases. Trees with these qualities produce good lumber.

Breeding Better Trees

Once a superior tree is found, it is not cut down, but is put to use as a parent of future forests. Foresters hope that the good qualities of superior trees will be passed on to the trees that grow from their seeds. In time, this should mean faster growing, more useful trees, just as men have produced superior animals by breeding parents that have special qualities, such as cattle that give more milk and pigs with bigger pork chops.

Discovering a superior tree is not as easy as it may seem. Foresters pick superior trees by their appearance. But they cannot be sure that a tree is superior just because it looks taller or wider than nearby trees of the same kind and age. Did the tree grow faster and straighter because it had more sunlight than its neighbors? Or did it inherit a tendency to grow straight and fast? To find out, foresters must test the trees.

First, they collect seeds from the trees that seem to be superior and plant them in tree nurseries. Then they study the growth of young trees, or *seedlings,* and compare them with seedlings from "average" trees. If the good qualities of the superior trees were inherited, the seedlings will show these qualities.

This method of testing gives foresters only an idea about the quality of these seedlings, but it is valuable because it is quick. This is important, because tree crops are not ready for harvest in one or two years. Most trees must be from 40 to 100 years old before they are harvested.

Foresters also test trees to see whether they are really superior by taking branches from them and attaching them to other trees *(see diagram)*. This is called *grafting*. Eventually, the foresters replace all of a "test" tree's branches with branches from superior trees. Then they know that the branches came from a superior tree if the test tree shows the good qualities of the superior tree.

Once foresters know for certain that a superior tree passes on its good points through its seeds, it is used to produce seedlings. But such breeding takes great patience. The foresters who are now experimenting with seedlings of superior trees may not be alive when the seedlings finally become a crop of full-grown superior trees themselves, many years from now.—James E. Coufal

Foresters use rifles to shoot cone-bearing branches from the tops of certain trees. Then the branches are tested (see diagram) to find out whether or not the trees have superior qualities.

Foresters test superior trees by grafting their branches onto other trees and studying their growth. This diagram shows one way of grafting one branch onto another. After the ends of the two branches are cut so that they fit together, they are wound with tape and protected with special wax.

WHAT'S IN A DROP?

Drops of liquid do strange things. To find out about them all you need is a medicine dropper, some cooking oil, and a piece of aluminum foil.

by David Webster

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

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

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

Drops Have Elastic Skins

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

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

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

You can watch a water drop as it falls and see what happens to it. When they fall through oil, the water drops fall more slowly, so you can watch them all the way down. Get some cooking oil—like Wesson Oil or Mazola Corn Oil—and fill a small jar with the oil. Now put a drop of water on the oil with a medicine dropper or paper straw. The drop will probably float on top. Do you think this means that water is lighter than oil? Push the drop down into the oil with your fingers. Now what do you think? What held the water drop up on top of the oil? Has oil an elastic skin too? If it does, is its skin tougher than the skin of water?

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

Now, for a change, make some drops "fall" up instead of down. Fill a medicine dropper with cooking oil. Put the end of the medicine dropper at the bottom of a glass of water and force out a little oil. Why does the oil drop go up? See if you can find other things to make drops with and experiment with them.

Drops of Air and Solid Drops

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

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

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

AN INVESTIGATION

MEASURING THE SIZE OF DROPS

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

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

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

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

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

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

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

Alaskan Brown Bears

■ The huge Alaskan Brown Bear is the largest meat-eating animal left on the Earth today. This bear holds the heavyweight record (in the wild) of 1,656 pounds, outranking the Polar Bear both in weight and length.

The Alaskan Brown Bear lives on Kodiak and Afognak Islands, Admiralty Island, many islands of the Aleutian chain, and on the steep, snowy mountain slopes of the barren Alaska Peninsula. Scientists do not know how many Alaskan Brown Bears there are. Surveys of the national park areas of the southeastern part of Alaska show a figure of 6,200, but this includes Grizzly Bears as well.

Brown bears eat many different kinds of food. In June, when thousands of salmon begin to fight their way up the icy rivers to spawn, the brown bears are on hand to catch their share of the yearly feast. There are so many bears by the water's edge during this season that bear trails along many streams are worn smooth and deep.

How the Brown Bear Fishes

Some popular accounts of how these bears catch salmon are more colorful than truthful. For instance, the bears are said to take a quick swipe with one of their huge clawed paws and send a fish flying toward the bank. Then, so the story goes, they catch the fish before it lands on the ground and eat it. The truth is that the bears walk upstream along the bank searching the water for salmon. When a fish comes close, the bear wades in, snares it in his claws, and eats it on the spot.

In spring, before the salmon crowd the streams, the bears graze in the green meadows bordering the mountain slopes. They eat roots, clover, grass, berries, ants, bees, honey, mice,and marmots. (Marmots are related to woodchucks or ground hogs.) In their search for food the bears seldom wander very far away from the sea.

The Alaskan Brown Bear is not so likely to attack a human as is its relative, the Grizzly Bear, although all bears are unpredictable. Only family groups of mother and cubs stay together. The adult males wander alone.

In November the mother bear finds a den high on a mountain slope. Here she has her cubs, usually every other year, and keeps them safely inside the den until April or May. The cubs stay with the mother bear throughout the first summer, and return with her to the den where they stay the following winter. When they leave the den the next spring, they are nearly as large as their mother.

The mother and cubs continue to wander around as a small group until early fall. Then the urge to seek a mate is so strong that the young bears go off and begin life on their own. This happens when the bears are between one-and-a-half and two years old. The Alaskan Brown Bear reaches maturity about its seventh year and lives about 25 years.—MARION B. CARR

The photograph on this page shows a section of the Alaskan Brown Bear exhibit in The American Museum of Natural History. The setting is the Aghileen Peninsula in Alaska. The bear shown here stands 10 feet high.

nature and science

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A New Astronomy Course for Elementary Schools

by Karlis Kaufmanis

■ Since the summer of 1961 the University of Illinois, supported by a grant from National Science Foundation, has been engaged in developing a new astronomy course for elementary schools.

Driving force for this project has come from Dr. J. Myron Atkin, Professor of Education, and Dr. Stanley P. Wyatt, Jr., Professor of Astronomy, at the University of Illinois. Being genuinely interested in improving science teaching in elementary and high schools, they believe that drastic change is imperative in both content and approach used in astronomy texts.

Why New Texts Are Needed

First, most present texts confine themselves to the Solar System. While many do mention names of some of the brightest constellations, they give scant attention to the physical and chemical properties of stars, their lives, and distribution in galaxies. By neglecting the great discoveries and current problems of modern astronomy, our present public school texts are teaching hardly more than what was known to stargazers a century or two ago.

Secondly, almost all information in present texts is purely descriptive. Pupils are taught that the Sun is accompanied by nine principal planets, 31 satellites, and other members of the Solar System. They also learn distances, sizes, and other physical properties of the nearby luminaries, but are given practically no understanding of *how* scientists arrived at this information.

The University of Illinois Elementary School Science Project is working to eliminate these shortcomings. Instead of merely listing astronomical information, the emphasis in the new approach is placed on the basic principles and problems of astronomy. Memorizing facts such as the distance to the Moon, the temperature of the Sun, or the chemical composition of stars will now be taught in terms of *how* astronomers arrived at their conclusions.

"The initial guideline for curriculum construction is the discipline itself," states Dr. Atkin. "It is *not* the apparent interests of childen. It is *not* the social utility of science. Children's interests are important. So are the uses of science in daily life. The project staff does not minimize these goals. But we feel a deep interest in science can stem from a curriculum built on the discipline itself.

"And a significant understanding of the usefulness of science can result from a basic understanding of the subject. It is hoped that a curriculum in science structured along the guidelines outlined here will lessen the confusion in the minds of most people between science and fruits of science, between science and technology."

VERNE N. ROCKCASTLE-CORNELL SCIENCE LEAFLET

By making and using instruments, such as this simple astrolabe, pupils studying astronomy in the new course described here learn how astronomers measure the size and distance of objects in space.

The new course will be published in six separate booklets, each one accompanied by a Teachers' Guide.

Book 1, *Charting the Universe,* deals with positions, distances, and sizes of celestial bodies. The idea of how a parallax and the inverse square law can be used in measuring distances to luminaries is being carefully developed.

Book 2, *The Universe in Motion,* teaches, among other things, to distinguish between apparent and true motions of luminaries. A considerable part of this booklet is devoted to Kepler's laws.

Book 3, *Gravitation,* considers an analysis of dynamics with astronomical applications. It explains *why* celestial bodies move the way they do.

Book 4, *The Message of Starlight,* is an introduction to spectroscopy. The main topics are propagation of light, radiation, and spectra, including those of diverse celestial denizens.

Book 5, *The Lives of the Stars,* discusses the birth and development of stars. Particular emphasis is placed on properties of the star we know best, the Sun.

Book 6, *Galaxies and Cosmology,* deals with the development and structure of star systems and the universe itself.

The writing of Book 1 and the original Book 2 were finished in the summer of 1961. During the 1961-62 school year that material was tried out in about 300 classrooms in 19 states. Approximately 9,000 pupils, mostly in grades 5 and 6, were involved in the trials. Neither the pilot teachers nor their pupils were specially selected. The science training of the participating teachers was diverse, and the intellectual ability of pupils varied from below average to superior. Each district had a local project coordinator, generally a science consultant, a school principal, or an elementary supervisor.

The response of both teachers and pupils to the new material was encouraging. However, the original Book 2 proved to be too great a jump conceptually for many of the children. On the basis of feedback information received from the teachers and coordinator, it

(Continued on page 4T)

This article is reprinted from the Minnesota National Laboratory News Bulletin. Dr. Karlis Kaufmanis is Associate Professor of Astronomy at University of Minnesota.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

PAGE 4 Day into Night

On reading this article, the familiar words of Little Red Riding Hood come to mind; "But Grandmother, what big eyes you have!" And the wolf's reply, "The better to see you with, my dear," is more fact than fiction.

In this story of how a zoo shows visitors the activities of nocturnal animals, children are introduced to one of the most amazing of animal adaptations—the eye. If your science curriculum this year includes the study of eyesight, this article may well serve as an eye opener. If your class has previously taken up this subject, it may interest them to further investigate the eyesight of various forms of animal life.

The article makes these points:

1. We cannot share another organism's experience of sight, but we can guess what it may be like by studying the structure of its eyes.
2. The eyes of higher animals differ in distribution, numbers, and kinds of cells, though basically each contains a lens and a retina.
3. The eyes of nocturnal animals fit them for night life. Many have special protection from strong daylight.

The basic concept: *The organism is a product of its heredity and environment.*

Suggestions for Classroom Use

A straight reading of the article is suggested, letting questions for discussion blossom at the end. Some questions that may arise:

1. *Can any animal see in pitch dark?* No. Everything requires some reflected light to be seen, and there is seldom absolute darkness.
2. *What make a cat's eyes glow at night when a light is shined into them?* A mirror-like surface to the retina, called the **tapetum lucidum,** reflects lights back from the eyes of some animals.
3. *Do animals see color?* As far as scientists can tell, few mammals see color, though many birds, fish, and reptiles can see it.
4. *Do bulls really get excited because they see a red object?* Not always. Scientists have found that bulls pay as much attention to green as to red, more yet to white. They are most aroused by any fluttering object.
5. *How can a dog tell one ball from another?* Perhaps the dog is using another sense, such as smell, or else discriminating between shapes or shades of gray.
6. *Why do some night animals have slit pupils while others do not?* Those with slit pupils—many cats, crocodiles, and snakes—bask in the Sun, and must have greater protection from bright sunlight than night animals that spend the daytime in their dens.

References

An excellent book for children is *The Strange World of Animal Senses,* by Margaret Cosgrove. Dodd Mead & Co., New York, 1961. $3.

The suggestions for using this issue of Nature and Science *in your classroom were prepared by Patricia Ralph, elementary school teacher in the public schools of Huntington, N.Y., and member of our National Board of Editors.*

PAGE 10 Grow a Crystal

Crystals are as fascinating as they are beautiful. These wonderful solid forms do not spring into being, but grow from the outside by adding layer upon layer as molecules of the substance come out of solution and join each other in orderly fashion upon the surface of a seed crystal. This workshop activity, using alum, develops the following concepts:

1. Many substances assume distinctive crystalline form, or regular arrangement of the atoms or molecules of the substance.
2. The molecular patterns of some solids can be broken up in solution, but regroup into crystals upon precipitation.

The basic concept: *Under ordinary conditions, matter can be changed but not annihilated or created.*

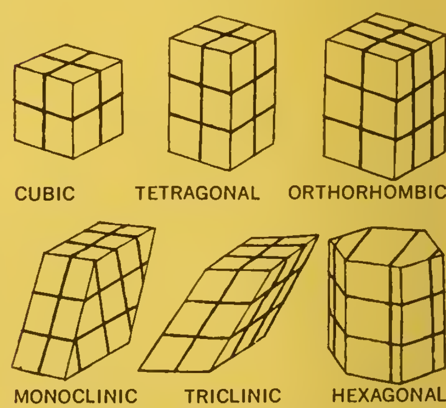
Suggestions for Classroom Use

With younger pupils, this activity may have to be teacher-organized. Depending on your group, you may want to supplement or substitute one of the other crystal activities suggested here.

Before beginning the reading, go over the vocabulary of the article with the class. Stress *solution, substance, irregular, precipitate, stock culture, saturated,* and *supersaturated.* Have children recall experiences with sugar that would not dissolve, or salt that was left in a pot after the water had boiled away.

Activities

1. A very simple activity with appeal for the young is making rock candy. Here's how. Add 2 cups of sugar to 1 cup of boiling water, dissolve and cool. Suspend a string into the solution and leave undisturbed. After a while crystals of sugar will form on the string. The string can then



Crystals form when atoms or molecules fit together in one of these six basic patterns, or "crystal systems." Each system differs from the others in the angles at which its axes meet or the number of different-length sides it has, or both.The basic pattern of salt crystals is a cube.

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

be placed in another saturated sugar solution and the crystals observed to grow larger.

2. Grow a "depression plant." This popular crystal garden gets its name from the fact that it is both decorative and cheap. Mix together 6 tbsp. of water, 6 tbsp. of salt, 6 tbsp. of laundry bluing, and 1 tbsp. of household ammonia. Pour over a shallow bowl containing several pieces of coke or charcoal briquets, allowing the coke to extend out of the solution. In a few hours a white growth of crystals will erupt all over the coke. Adding a few drops of colored ink to the coke beforehand will tint the crystals. The garden will keep growing until all the liquid evaporates, but can be reactivated by adding a little more ammonia. If allowed to dry, the crystals crumble easily.

3. Have children bring in ordinary household substances such as sugar, salt, and borax. Obtain hypo (sodium hyposulfite) and copper sulfate from a drugstore. Look at a few crystals of each substance through a microscope. From solutions of each, collect some precipitated crystals and compare their shapes with crystals of the same substance which were not dissolved.

References

Crystals, by Raymond A. Wohlrabe, J. B. Lippincott Co., Philadelphia, 1962, $3.50. 206 pp., illus. Gives the history, structure, uses, and characteristics of crystals and suggestions for growing and studying them.

PAGE 13 Superior Trees

This article might be subtitled "All That Glitters Is Not Gold," for it shows children that in science, as in virtually every other field, the careful practitioner does not jump to hasty conclusions. A good scientist pursues his hypothesis with a series of checks and double-checks. In this case, the plant breeder intent on developing superior trees does not rely on his first impressions, but attempts to test a tree's qualities by controlled experiments. He looks for specimens that are genetically superior, not merely growing in a favorable environment.

The article also makes the point that tree-breeders are confronted with the problem of a tree's long life. Plant scientists working with vegetables or flowers are able to gather their evidence from mature plants within a few years. Although Christmas trees mature in eight to 12 years, and pulp species mature in about 20 years, most timber trees take much longer to reach full growth. A tree-breeder cannot wait out the full growth of most trees, so he uses seedlings and grafts to test trees that may be superior.

The article makes these points:

1. If a tree is superior genetically it will produce superior seedlings or superior grafts. If its excellence is due more to favorable growing conditions than inherent qualities, its seedlings and grafts will show no special superiority.

2. Tree scientists must devise methods for testing superior trees without waiting for their seedlings to mature.

The basic concept: *The organism is a product of its heredity and environment.*

Activities

1. Take a "superior tree-spotting" walk. Children may speculate on possible reasons for good appearance (soil, air, light, care on part of owner, and so on). Point out that the "superiority" of a tree depends on its intended use. Foresters looking for a good timber tree seek one with a straight trunk and few side limbs. However, a sugar maple with many side limbs and a bushy profile is best for shade and for maple syrup production.

2. Some children may wish to look into other modern forestry methods, such as finding ways to use all parts of a felled tree, patterns of harvesting, and insect control.

THE NEXT ISSUE of *Nature and Science* introduces young people to the fascinating world of birds' eggs. There is as much variety in the eggs as there is in the birds.

A SCIENCE MYSTERY explores the causes of the DSL—the Deep Scattering Layer in the oceans thought to be caused by plankton that migrate toward the bottom by day and the surface by night.

Cloud types and their association with changes in the weather will be the subject of our Wall Chart.

A SCIENCE WORKSHOP encourages your pupils to conduct some experiments in the behavior of mealworms.

PAGE 14 In a Drop

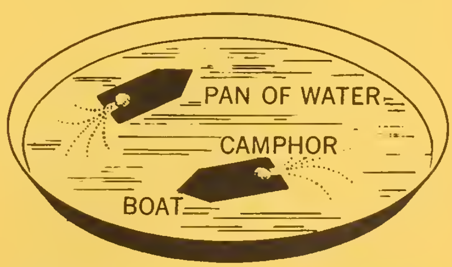
This article will introduce your pupils to some of the physical concepts of surface tension in fluids. Surface tension is the resistance of the surface film of a liquid to rupture. This phenomenon appears at the surface of a liquid or at the meeting surfaces of liquids of different densities. The author, David Webster, is a staff member of Educational Services Incorporated.

Activities

While the article is self-explanatory, here are two more ways your pupils can observe the effects of surface tension:

1. You can use camphor (obtained from a drugstore) to reduce surface tension and so produce motion. Cut a few "boats" from soft wood or stiff paper *(see diagram),* each about two inches long. Next cut a notch in the rear large enough to hold a piece of camphor about the size of a pea. The camphor should be about one-third submerged. Float the boats in a pan of water. The reduction of surface tension by the camphor at the rear of the boat will cause the boat to move forward.

2. Dust a film of talcum powder on the water in a pan. With a wet piece of soap touch the water near the edge of the pan. You will see that the powder begins to move to the opposite side of the pan. By weakening the attraction between molecules forming the surface of the water, the soap reduces the surface tension at the point of contact. The tension on the opposite side of the pan remains the same, with the result that the powder is "pulled" to that side.



Camphor placed at the rear of stiff paper "boats" moves them forward on water by reducing surface tension at the rear.

A New Astronomy Course . . .
(Continued from page 1T)

was decided to divide the original Book 2 into two new booklets: Book 2, *The Universe in Motion,* and Book 3, *Gravitation.*

The revised Books 1 and 2 were made available for classroom use in the latter part of 1962. Again they were tested in a variety of school and classroom situations involving more than 11,000 children. This time 17 teachers of the Twin Cities area and Owatonna participated in the testing procedure. Jack A. Lown, Administrator of the Minnesota National Laboratory, served as the project coordinator on this phase of the experiment.

The enthusiasm of the participating teachers was clearly demonstrated by their faithful attendance at in-service training sessions in St. Paul on Saturday mornings. Snowstorms and slippery highways did not prevent even Owatonna educators from coming to the meetings. Since then 26 Minnesota teachers have expressed their desire to participate in the project this coming winter. It is an increase of 50 per cent.

In addition to Dr. Wyatt, the co-director, four other astronomers—Dr. Benjamin Peery of the University of Indiana, Dr. Henry Albers of Vassar College, Dr. Gibson Reaves of the University of Southern California, and the author—spent part of the summer of 1963 as members of a writing conference. In close cooperation with elementary school science specialists from New York, Philadelphia, and Chicago areas, the group again revised editions of Books 1 and 2 and finished work on the new Book 3, *Gravitation.* Copies may be obtained for $1.50 each from Elementary-School Science Project, University of Illinois, 805 W. Pennsylvania Ave., Urbana, Ill.

Book 4 is in a mimeographed form, ready for testing in a few classrooms this spring. About half the work on the two remaining booklets is done. It is hoped that all will be ready for testing during the 1964-65 school year.

Naturally, the staff of the project is eager to know how successful the new texts have been. The only criterion on this for the time being is the reaction of participating teachers and project coordinators.

To get a more objective evaluation of the program, special tests developed by Dr. Peter Shoresman of Wayne University will be used this year. It will be interesting to learn how much the effectiveness of the new materials was influenced by the mathematical training and age of the pupils and diverse elements in the backgrounds of their teachers.

Even without formal tests, two major problems are apparent in development of the new astronomy course. A letter to coordinators and pilot classroom teachers last spring from the project co-directors noted these in the following words:

"The mathematics involved continues to be the major difficulty encountered by teachers in handling the first book. We have conscientiously attempted to place our materials in situations where modern mathematics programs are in use, and in these districts we do find that teachers and children experience little difficulty.

"It has been almost the universal reaction that our teachers' guide for *Charting the Universe* needs considerable expansion. Teachers desire background astronomical information plus *complete* answers to all problems presented in the book for children."

Such a request was not unexpected. Elementary school science teachers generally have very little, if any, training in astronomy. It remains to be seen whether the devotion and courage of a few hundred pilot teachers alone will provide clues for solving this nationwide problem ■

N&S VIEWS

New Science Books for Children

BECAUSE OF A TREE, by Lorus and Margery Milne. Atheneum, 1963, $3.95; 152 pp., illus.

The Milnes have written many fine natural history books, and they usually succeed in presenting the complexities and mysteries of science in an accurate and entertaining way. This book is no exception.

It is devoted to the fascinating topic of ecology—the interrelationships of plants and animals with their environment. Nine types of trees are covered, from maples to redwoods, and even a dead tree (perhaps most interesting of all). The book explains how each tree lives in a different environment and is surrounded by animals and other plants that are adapted to the same environment.

No book is perfect, and this one has a few factual errors and tends to imply that trees actively try to attract other organisms to live near them. Nearly all of the illustrations are excellent; a few are inaccurate, and one is upside down.

A list of books for additional reading is included. Any youngster or adult who reads this book will look at the trees around him with new insight, because of a greater awareness of the interdependence of all living things. — LAURENCE PRINGLE, *Associate Editor,* N&S

WOODCHUCKS AND THEIR KIN, by Charles L. Ripper. William Morrow & Co., 1963, $2.75; 64 pp., illus.

This type of children's book makes reviewing a pleasure.

The writing is simple, straightforward, and extremely well coordinated with the illustrative material. The illustrations are superior in quality. They capture the reader because they tell a story, show the habitat of the animal, and leave the child with a vivid picture of the mammal being described. Man's unfortunate economic relationship with some of these rodents is frankly discussed, but there remains a basic plea for their preservation and appreciation. Many of the known life history facts are described; there is no speculation.

The book deals specifically with several abundant and important groups of rodents known commonly in Canada and the United States as woodchucks, marmots, prairie dogs, chipmunks, and ground squirrels. All of these animals are squirrels, but they are primarily ground dwelling squirrels.—HOBART M. VAN DEUSEN, *Assistant Curator of Mammalogy, The American Museum of Natural History*

MAN AGAINST STORM, by Miles F. Harris. Coward-McCann, Inc., 1962, $2.95; 120 pp., illus.

The author packs information about winds, hurricane hunting, computers, climate, the Weather Bureau, and vocational aspects of weather into this profusely illustrated book. The pace is rapid, and the explanations are necessarily brief and incomplete. However, this is a good teaser. On reading it, one desires more information. A list of additional readings should, therefore, have been provided.

The writing is inclined to be uneven, the harder sections being quite challenging to the uninitiated. However, Mr. Harris has done considerable research into historical figures and procedures which provide the background for present-day techniques.

An elementary school child who really wants to know something about the history of weather forecasting as well as modern methods will find the book of value. — FRANKLYN M. BRANLEY, *Astronomer, The American Museum-Hayden Planetarium*

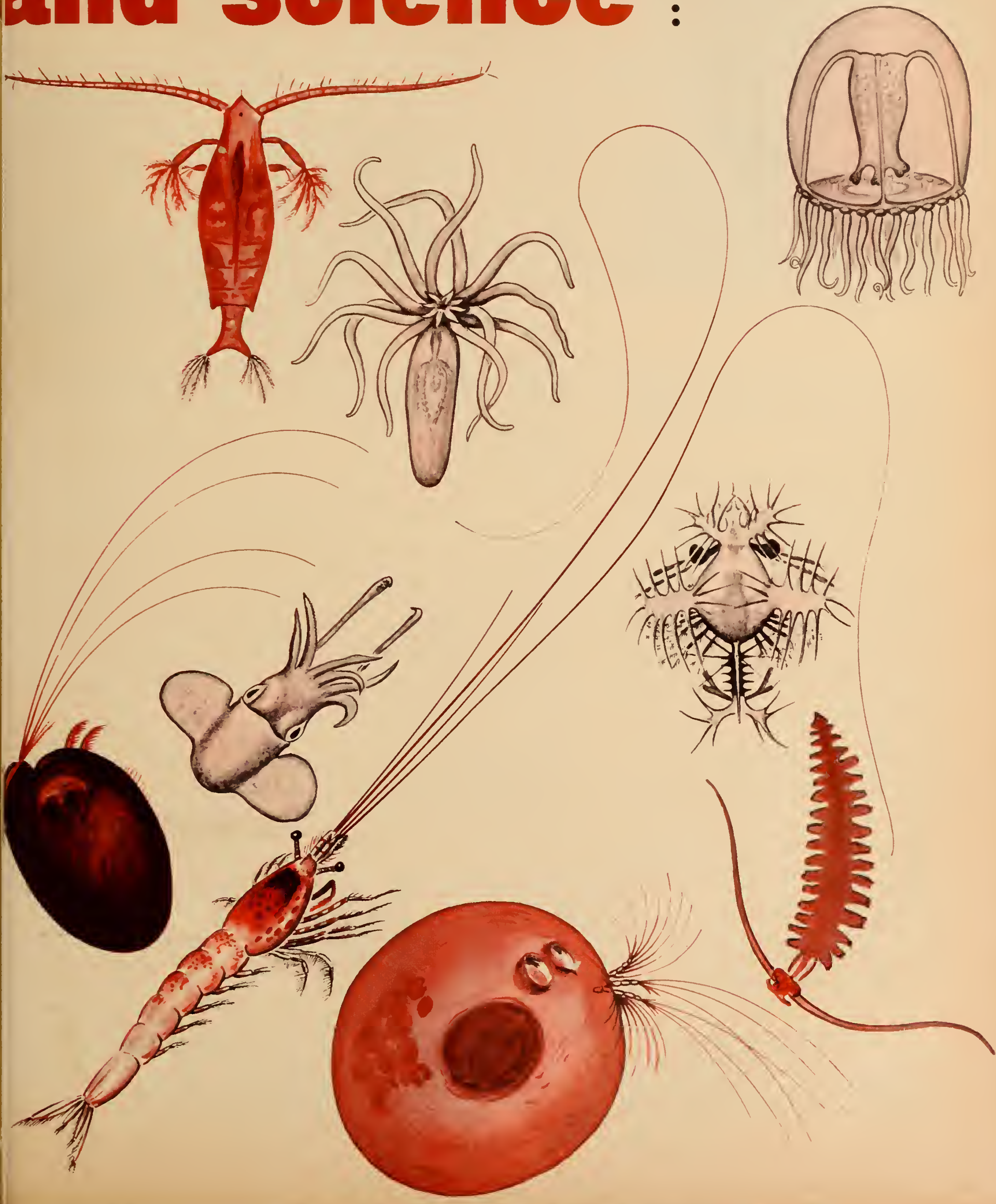
nature and science

VOL. 1 NO. 12 / MARCH 20, 1964

Millions of these strange-looking animals live in the oceans. Scientists are studying them to solve the...

MYSTERY OF THE DSL

see page 3



SCIENCE WORKSHOP

MEALWORM WATCHING

Do mealworms see? Do they feel? What makes a mealworm back up? Here are some ways you can investigate the behavior of these little animals.

Shine a flashlight on a mealworm. What does it do?

■ You may be a birdwatcher. At least, you probably know people in your neighborhood who spend hours on the lookout for interesting kinds of birds.

This article will tell you how to become a mealworm watcher. At first glance, mealworms may seem pretty dull compared to watching sea gulls or hawks, but you will soon find that mealworms can be a good deal more fascinating than you might suspect. Besides, they are far easier to take care of than birds, and you can do your mealworm watching whenever it is convenient for you.

Watching mealworms is not just a hobby; it can be a kind of real scientific research. Hundreds of scientists around the world spend all their time watching animals—everything from worms to gorillas—trying to figure out how the animals behave, how the animals react to such things as heat and cold and hunger and to other animals. The things they learn from their observations may be useful—for example, how to control harmful insects, how to keep animals thriving in the National Parks, how to understand the human brain better.

To become a mealworm watcher, you will need:

1. Mealworms. You may find mealworms under a rotten log, but this is difficult and you probably won't find them except in the summer. Your best bet is to try the local pet store, which probably will have mealworms on hand since they are often used as food for chameleons or toads. They should not cost more than a penny or two each. If you can't get them nearby, you might have your teacher order them through a biological supply house (which is quite expensive) or you might chip in with some friends and send away to the Brockton Worm Hatchery, Brockton, Mass., which will ship you a package of 200-300 mealworms for $1.25 ($1.75 to the West Coast).

2. Food. Breakfast cereals such as corn flakes or wheat flakes make a good food for your mealworms. They live right in the cereal and feed on it too. Every couple of days, add a banana skin and some lettuce; this keeps the cereal moist. But don't let the cereal get too wet or it will get moldy.

3. Containers. You will need one container, perhaps a glass jar with about one-half inch of cereal in the bottom.

Can Mealworms Be Made To Back Up?

Certain things will make a mealworm back up. There are several things you might try: putting an obstacle in its path; tapping it on the head with a straw; putting a drop of water on its head; putting your finger in front of it; shining a flashlight on it; holding a hot bulb near it; blowing on it from a couple of inches away. Make a chart like this:

What was done	Times Tried	Mealworm Continues Forward	Mealworm Goes Backward	Rank
Flashlight ½ inch away	101	52	49	

Each method should be tried many times. When you have finished, see which method was most effective in making the mealworm back up. Mark it "1st" in the column headed "Rank," mark the second most effective method "2nd," and so on.

Do Mealworms See?

Put a mealworm in the middle of an empty test box. (Use an empty shoe box or cigar box with a strip of Scotch tape around the rim so it is too slippery for the worm to climb out.) Block the worm's forward motion by holding a mirror across its path. What does the mealworm do? Why? Do the same thing with a piece of cardboard. Does the mealworm act as it did when the mirror blocked its way?

Next, flash a beam of light from a flashlight at the worm. Is the mealworm motionless? Does it move? Keep a score sheet handy to mark down your findings.

Place a block of wood several inches thick in the middle of the box. What does your mealworm do? Next put three pieces of cardboard inside the box, but set them with spaces between each piece *(see diagram)*. Do you believe mealworms can see? Can you find any eyes?

Do Mealworms Feel?

Tap gently on the head of a mealworm with the tip of a pencil. What does your worm do? Take a straw and carefully touch the worm. Now gently blow through the straw and watch the actions of your mealworm. What do your investigations tell you? What else can you try?

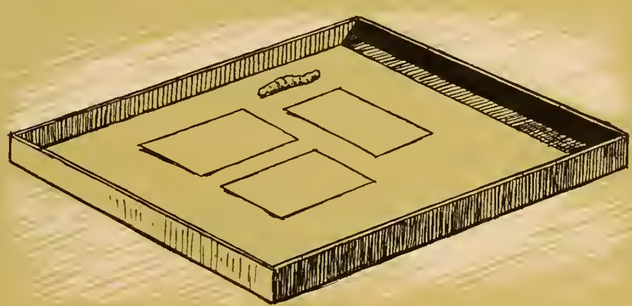
Put a mealworm in an empty box and let it explore. From watching the worm, you will notice that it tends to follow "walls." How do you suppose mealworms sense the presence of a wall? How would you follow a wall? You would see it. But suppose you were blind; what would help you then? Your arm or the side of your body could be used to find the wall and keep in touch to follow it. What would a mealworm do?

To find out whether a mealworm must see the wall in order to follow it, you might test the worm by putting its box in the dark. But then how will you know where it goes? If you scatter a little powder over the bottom of the box, the worm should leave a trail as it moves about.

You will have to examine a mealworm's body to find out how it follows a wall without seeing. Use a magnifying glass or a microscope. What do you see? You find a pair of pointed antennae on its head, hooks on the end of each leg, and fine "hairs" on the legs and underside of the body. One or more of these structures could serve as a touch-sensing device. Which did your mealworm use? Try your test on another mealworm and watch its motions through a magnifying glass. What did it tell you? Investigate several mealworms' actions. Write down your observations and compare them. Did all the mealworms tested use the same body structure to sense and follow the wall?

Why Does a Mealworm Stay under the Corn Flakes?

Can you figure out why the mealworms like to stay in the cereal? Here are some possible reasons: because it is their food supply; because it is dark; because they "like" a weight on their backs; because it is quiet; because it has an odor that is pleasing for them. Can you figure out a way of checking these theories?



Pieces of cardboard laid flat make "walls" for mealworms.

You might check the "weight" theory by putting something other than cereal on the mealworm's backs. Does it have the same effect? Try something that is about the same weight as cereal but lets light through—shredded cellophane, for example.

Do mealworms like the cereal because of the darkness? Try putting cereal into a completely dark box and see whether the mealworms still linger in the food.

To see if mealworms eat the cereal, you might try some other kind of food and test three or four mealworms, each in its own little matchbox, with just a few flakes of the kind of food you want to test. Do mealworms prefer corn flakes over wheat flakes or oat flakes? Put a flake of each cereal (all about the same size) into a box with several worms and see which is eaten first.

Can you think of other ways to study the behavior of these animals? ■

CLOUDS

AND THE WEATHER THEY BRING

■ As the weather changes, so do the kinds of clouds in the sky. Weather scientists, called *meteorologists,* who predict the weather have long used clouds as clues to weather changes.

Clouds are identified by their shapes and their height above the ground. The photographs and diagram on these pages 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. Here are a few signs of fair weather and stormy weather to look for:

SIGNS OF APPROACHING STORMY WEATHER

★ High scattered clouds thicken, increase, and lower.

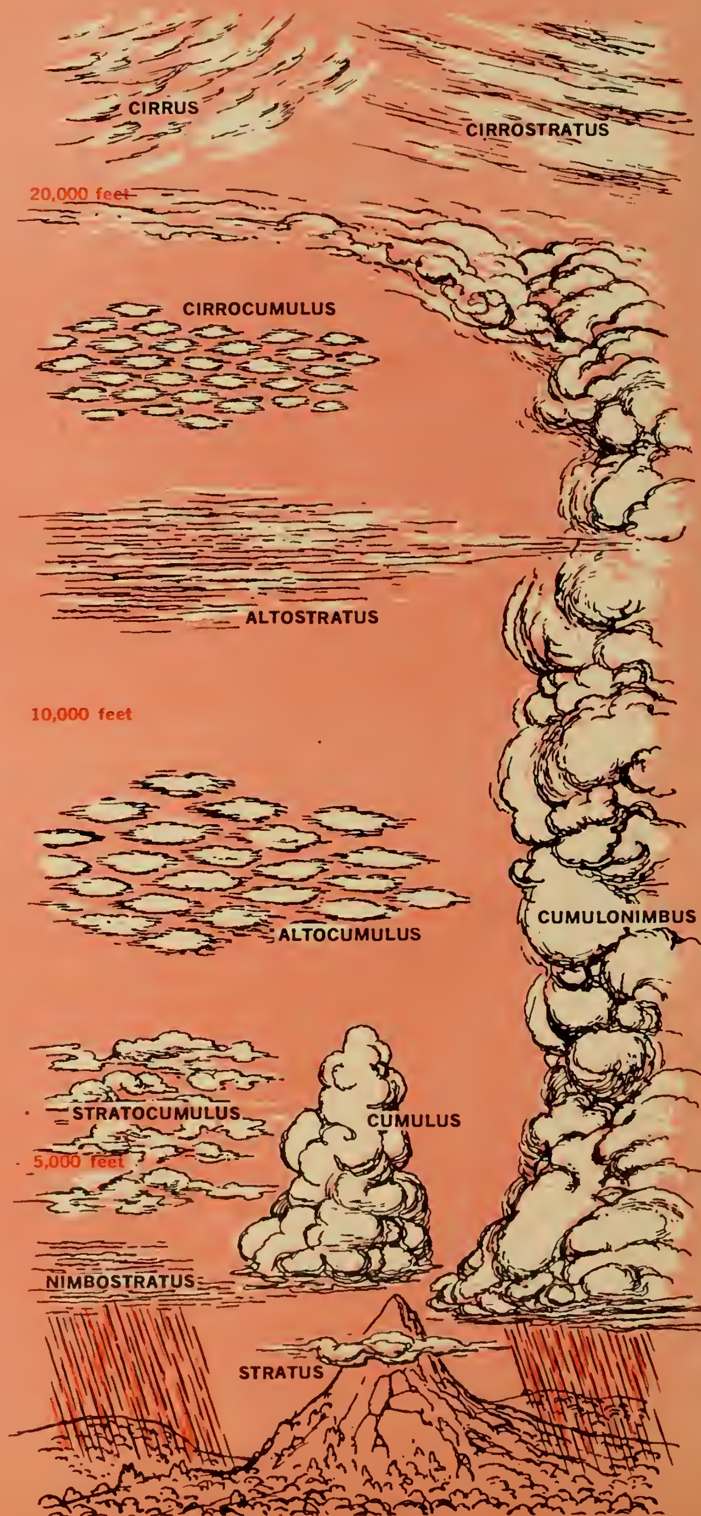
★ A long line of clouds darkens the western horizon.

★ 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.



The height of a cloud is a clue to its identification. The highest clouds that we usually see are thin cirrus clouds. Stratus clouds are the lowest. Cumulonimbus clouds have low bases, but tower high in the sky.

Altostratus clouds from about 7,000 tc Sun usually shines They produce stead

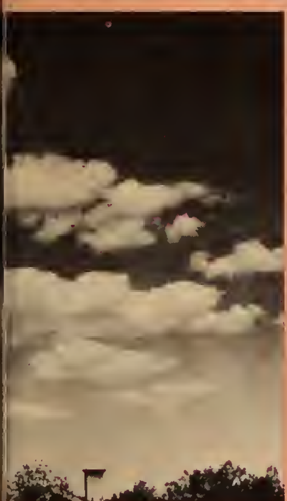
Cumulus clouds ha weather cumulus cl cumulus clouds (s and have a boilin thunderheads.

Stratus clouds are droplets. They may only a few thousan cloud at ground lev by a stratus cloud.

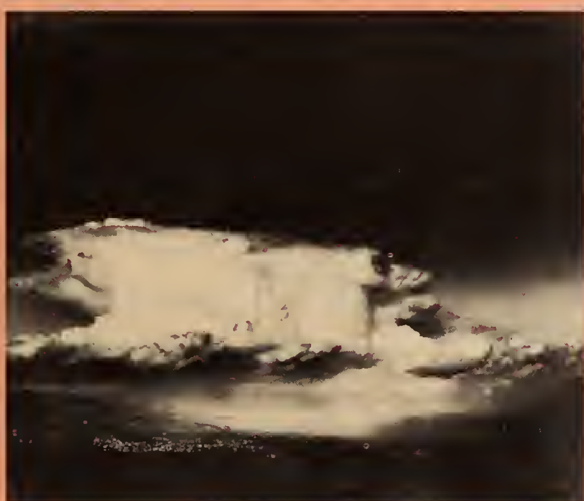
gray overcast, and range
feet above the ground. The
hrough altostratus clouds.
in or snow.

Cirrus clouds are high, delicate wisps that are usually signs of good weather. No rain or snow falls from these ice crystal clouds. However, stormy weather may develop when cirrus clouds merge with cirrostratus clouds.

Cirrocumulus and cirrostratus clouds are usually at least 20,000 feet above the ground. Like cirrus, no rain or snow falls from these ice crystal clouds. Cirrocumulus clouds are often arranged in ripples (above) and are called a "mackerel" sky. Cirrostratus clouds are thin sheets (above, lower left) that sometimes cover the whole sky. They do not block the sun or keep shadows from forming.

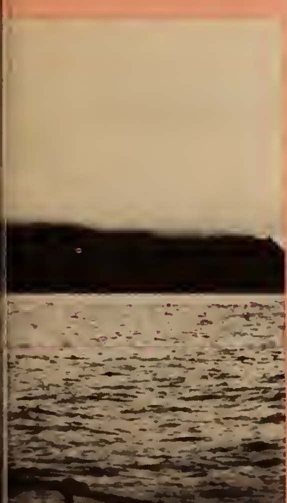


ases and fluffy tops. Fair
like puffs of cotton. Other
m) tower high in the sky
. They may develop into



Cumulonimbus clouds, or thunderheads, have dark, ragged bases that sometimes reach to within a few hundred feet of the ground. The tops of these clouds are often anvil-shaped. Heavy rain, snow, or hail may fall from cumulonimbus clouds.

Altocumulus clouds range from 7,000 to 20,000 feet above the ground. They may be in isolated patches or parallel bands (above), and sometimes produce light rain or snow. Altocumulus clouds often develop from altostratus clouds.



g-like, and made of water
whole sky and are usually
h (see diagram). A stratus
This island is nearly hidden

Nimbostratus clouds are low, thick, and dark gray, with ragged bases. This type of cloud usually produces steady rain or snow, and is made up of both water droplets and ice crystals.

Stratocumulus clouds are low, gray, and often arranged in patterns. They look like altocumulus clouds, but are lower and darker. Light rain or snow may fall from stratocumulus clouds.

eggs and more eggs

From the tiny egg of the hummingbird to the giant egg of an ostrich there are amazing differences. Size, shape, color, weight, and taste can differ almost as much as the birds themselves.

by John Sidney

■ A bird's egg is one of nature's great masterpieces. Its size, shape, color, weight, and taste can differ almost as much as the birds themselves.

Birds' eggs come in many different shapes. Some birds, like the domestic hen, lay oval-shaped eggs. The owl, kingfisher, penguin, and titmouse lay round eggs. The eggs of the grebe, pelican, cormorant, and bittern are pointed at each end. The curlew, the plover, the sandpiper, and the gull lay pear-shaped eggs which taper from the broad end.

Protection in Shape

Why are birds' eggs different in shape? Egg shapes differ because of many things. For instance, guillemots, which do not make nests, often lay their eggs, which are shaped like a top, on the ledges of cliffs. If the eggs were round, they might be knocked off the ledges by the birds. Because they are shaped like a top, they roll around in a small circle instead of rolling off the ledges. Here is an example of safety in shape.

Birds such as the Green Plover lay four large, pear-shaped eggs with their narrow ends pointed inward, almost touching. Because of their shape, more eggs can be held in the nest. Some birds such as the Adelie Penguin, lay eggs among the stones on beaches, or inland from the sea. In color and shape the eggs may be similar to the stones. This may help protect the eggs from animals that eat the birds' eggs. In the case of Adelie Penguins, the gull-like skua eats the eggs.

It seems that the birds whose eggs are best protected from prowling animals lay the fewest eggs. For instance, the guillemot lays only one egg at nesting time.

Some perching birds lay fewer eggs than many birds that nest on the ground. Again, this would seem to be because the perching birds are safer from prowling animals. The raven, which nests on cliff ledges and the tops of telegraph poles, lays up to eight eggs at one nesting. The ground-nesting Bob-white Quail of North America lays up to 16 eggs. However, there is no set rule that the number of eggs laid depends on the location of the nest. The number of eggs a bird lays during one nesting, called a *clutch,* depends on many things—enemies, plenty or little food, and so on. Clutch size also depends on the number of eggs the bird can keep covered with its body during incubation.

The greatest egg-producer of all birds is the barnyard fowl, a product of 3,000 years of breeding by man. Most hens lay an egg every day or so, day after day. A good hen produces 300 eggs in a year and 3,000 in a lifetime. Its ancestor, the Jungle Fowl of Asia, lays only 30 to 40 eggs a year. Also, the Jungle Fowl's eggs are half the size of the domestic hen's.

These avocet eggs fit snugly together with their narrow ends pointed inward. Avocets are crow-sized shore birds.

Big Eggs and Little Eggs

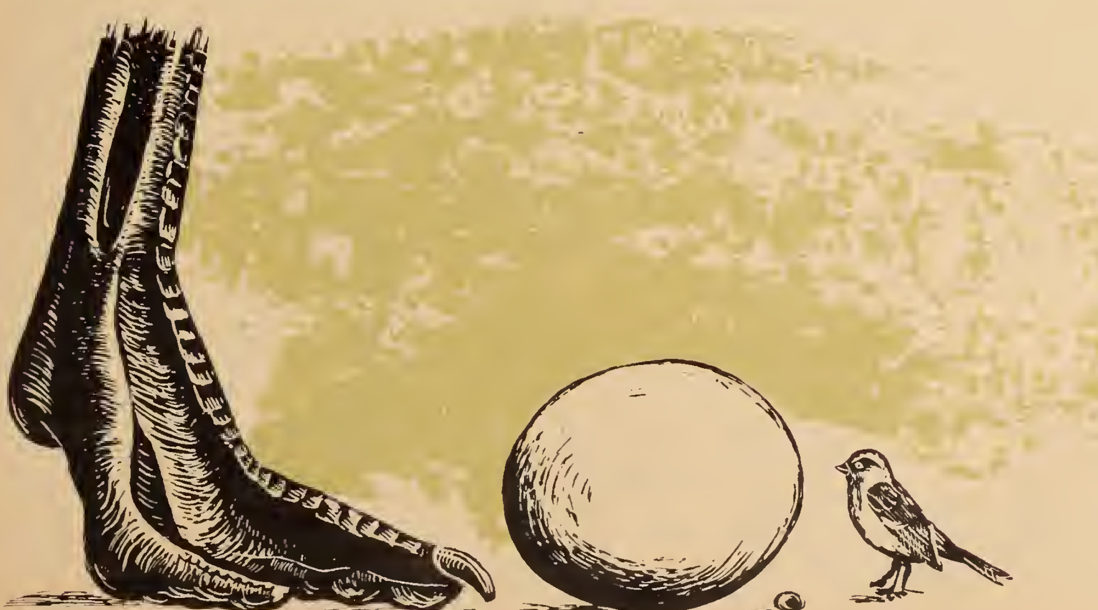
There's a wide variety in the size and weight of birds' eggs—from the tiny quarter-inch-long eggs of humming birds to the seven-inch-long eggs of ostriches. It takes almost 29 hummingbird eggs to weigh an ounce, but one ostrich egg weighs about three pounds. In between these extremes is the domestic hen's egg of two-and-a-half ounces. A naturalist once broke hen's eggs into an empty ostrich egg shell to find out how many hen's eggs one ostrich egg would hold. The answer was 18.

Ostrich eggs are small, however, compared to the eggs of the now extinct Elephant Bird, or Roc, of Madagascar (an island off the southeastern coast of Africa). Eggs of this huge flightless bird, discovered on Madagascar, measured 13.5 by 9.5 inches. Their shells held about two gallons of liquid! You could break six ostrich eggs, or 148 hens' eggs, or 30,000 hummingbird eggs into one of them. Another extinct bird, the Moa of New Zealand, laid an egg twice as large as an ostrich egg.

Scientists have found that the size of birds has something to do with the weight of the eggs they lay. In general, large birds lay *relatively* smaller eggs than small birds do. For instance, a small bird, such as a finch, lays an egg about one-ninth of its weight. A very large bird, such as an ostrich, produces an egg weighing only 1/50th of its body weight.

The flightless Kiwi of New Zealand lays probably the largest egg in relation to the size of the bird. Although the Kiwi weighs only four pounds it lays an egg one pound in

(Continued on the next page)



An ostrich egg (far left) weighs about three pounds and is much larger than a finch egg (left). Yet notice how small the ostrich egg is compared with the size of the bird. An ostrich egg is only 1/50th of the bird's body weight. A finch's egg is about 1/9th of the bird's body weight.

This photograph shows the speckled egg of a cowbird in the nest of an Indigo Bunting. Cowbirds are the only North American birds that do not hatch their own eggs.

weight. If the ostrich did as well in egg size as the Kiwi, an ostrich egg would weigh 75 pounds, instead of three.

There are exceptions to this rule that large birds lay *relatively* smaller eggs than smaller birds do. Although an Old World cuckoo (one living outside North and South America) may weigh the same as a robin or blackbird, its eggs weigh only a small fraction of an ounce (about three grams). The eggs of the robin and blackbird weigh seven to nine grams. The reason for this difference is interesting.

These cuckoos do not hatch their own eggs. They let other birds do the work for them. A female cuckoo lays each of her eggs in a nest of smaller birds, usually one to a nest, and then may abandon them. Because these cuckoo eggs are like the eggs of the other, or *host,* birds, the host bird hatches them along with its own eggs. Cowbirds are the only birds of North America that also use host birds to hatch their eggs.

Color for Protection

Birds' eggs come in an amazing range of colors and markings, and many blend perfectly with their surroundings. For instance, a plover's greenish-buff, black-flecked eggs blend so well with its surroundings that it takes a keen-eyed person to find them. The eggs of some ducks are the same pale, greenish-gray color as the surrounding reeds. The eggs of the Canada or Spruce Grouse are a bright buff color, blotched and boldly spotted with shades of brown. They blend perfectly with the ground where the birds nest.

But the eggs of all ground-nesting birds are not colored to blend in with their surroundings. In these instances, it is the birds that are very difficult to see when sitting on their nests.

Sometimes a white or whitish color helps the female bird find her eggs. For example, many eggs laid in dark nests or holes are a brilliant white, and perhaps may enable the brooding bird to see them more easily. Some eggs are glossy white or light in color and may serve another purpose—to reflect back sunlight and guard the embryo inside the egg against too much heat.

Flavors of Birds' Eggs

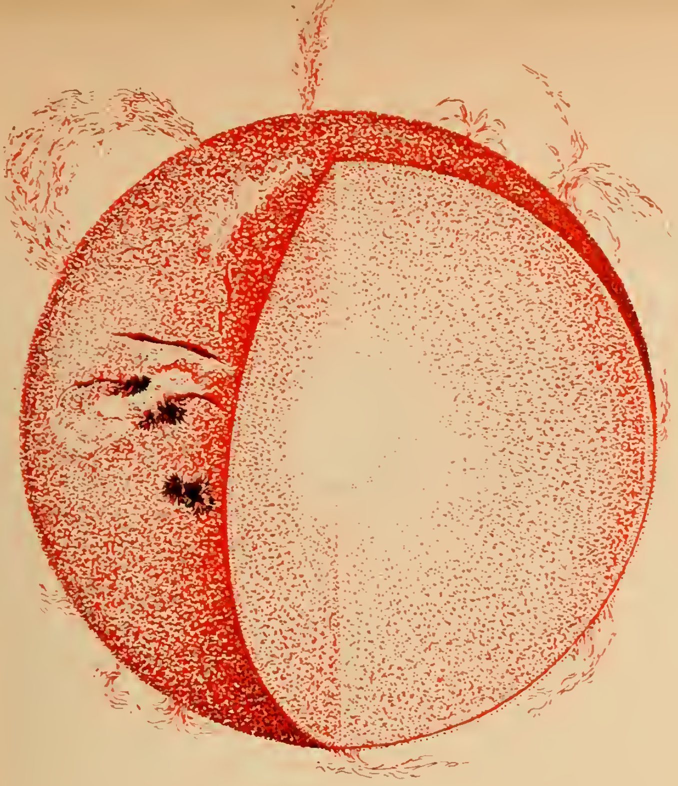
The color, exposure, and taste of some birds' eggs seem to provide a pattern of protection. Many brightly-colored eggs are laid in open, unprotected places—easy for predators to reach. Yet they are not touched. Why? Is it because their bright color is a sign of an unpleasant, bitter taste?

Studies made by Dr. Hugh B. Cott and four other scientists at the University Museum of Zoology at Cambridge, England, show that the flavor and coloration of eggs are related. Egg-eating animals such as snakes, cats, hedgehogs, and mongooses leave brightly colored eggs alone. Scientists believe that such distinctive coloring can be a form of protection for birds' eggs.

Of the 81 species of birds' eggs tested by Dr. Cott, many were sour or bitter. They were also the most striking in color. These eggs were usually bright white or white spotted with red or brown. Birds that lay eggs unpleasant to human taste include Tree Sparrows, House Wrens, Little Terns, and swallows. Among the bitterest to the taste were the eggs of the puffin, which lives on the desolate Aleutian islands of the Alaskan coast, along the Pacific coast as far south as southern California, along the New England coast, and northward from the Bay of Fundy.

At the other extreme, Dr. Cott found that many of the best flavored eggs were those with drab colorings and markings. What could be drabber than one of the most tasty of all eggs—the dull tan eggs of domestic hens? ■

"Sorry, it slipped."



This view into the sun shows its center, where temperatures may reach 15,000,000° C. Hot gases burst from the sun's surface and flare thousands of miles out into space.

INSIDE A STAR

by Franklyn M. Branley

The sun holds many secrets of what happens inside other stars —how they shine, why some are green or golden, and how they are born and die.

■ What is a star? For many, many years this question baffled astronomers. One reason, but not the only one, is that the stars are so far away. They are so distant that we can see them only as points of light. Even the most powerful telescopes do not show the stars as disks of light —as we see the moon as a disk.

There is, of course, one exception—the sun. This star is close enough to us so that we see it as a large disk. Because the sun is an average star, as we learn more about it we also learn more about the other stars.

During 1957 and 1958—when many nations pooled their scientific talents for the International Geophysical Year (IGY)—astronomers around the world studied the sun 24 hours every day. Never in history had they given so much attention to our local star. The sun was very active during that time. Great streamers of hot gases burst out of the sun to heights of many thousands of miles.

During 1964 and 1965 astronomers will again watch the sun closely. This time the sun is expected to be quiet. So the next two years will be called the International Years of the Quiet Sun, or IQSY (*Ik*-see).

Although we say that the sun is an average, or medium-sized star, it is so large that more than a million earths could fit inside of it. Yet there are stars hundreds and thousands of times larger than the sun. One of them is Betelgeuse, the bright red star you can see in the right shoulder of the constellation Orion, the hunter. It is a supergiant star that may be 800,000,000 miles in diameter—more than 800 times larger than the sun.

Among the stars that are smaller than the sun is a companion of Sirius, the brightest star in the night sky. The companion is so small that we can see it only by using the most powerful telescopes. This dwarf star is only about three times larger than the earth. The star's material is packed so tightly together that a pint of it would weigh about 53,000 pounds!

How Do Stars Shine?

Some stars are thousands of times hotter and brighter than the sun. Other stars are cooler and dimmer. The sun is a medium-hot star. The temperature at its surface is about 6,000 degrees (Centigrade). We cannot measure the temperature deep inside the sun, but we believe that it gets higher and higher toward the center. Near the center the temperature may be as high as 15,000,000 degrees! And this brings us to the question of how stars shine.

No fire could possibly cause such high temperatures, so the sun cannot be burning as a fire on the earth burns.

The sun's heat and light are produced in quite a different way. Temperatures of millions of degrees can be caused in only one way—when the cores, or *nuclei*, of atoms are broken apart or joined together in great numbers. The atomic "fuel" of the sun and other stars is hydrogen. Near the center of the sun the cores of the hydrogen atoms are packed tightly together and are moving at very great speeds. When they bump into each other something happens to them. In a series of changes that take a long, long time the cores of four hydrogen atoms join and make a core of one helium atom. When this happens, heat, light, and other kinds of energy are set free. This joining of hydrogen atoms inside a star, and the release of energy, make the star shine. The joining process is called *fusion* and the same process is involved in an H-bomb explosion.

In the sun, many millions of tons of hydrogen are changed into many millions of tons of helium every second. At this rate, why hasn't the sun used up all of its

(Continued on the next page)

hydrogen and "gone out?" The sun has such vast amounts of hydrogen that it will keep shining for billions of years more, just as it has been shining for more than five billion years already. Guess how much material there is in the sun. The answer is 2,000,000,000,000,000,000,000,000,000 tons.

How Are Stars Formed?

No one knows exactly how stars are formed. Many astronomers believe that stars are being born all the time. They know there are large amounts of gas and dust between stars *(see photograph)*, and they think that the gas and dust slowly pack together. As they pack tighter and tighter, the temperature goes up and up.

There is so much material in a star that the temperatures from packing reach many millions of degrees. That is when the cores of atoms begin to join and make the star shine.

The sun seems to be made of various layers of gases. The layer that we see when we look at the sun is called the *photosphere,* which means "light sphere." It is this layer that serves as a light bulb for the earth and other planets. The distance across this layer, measured from one edge of the disk to the opposite edge, is 864,000 miles.

But the sun is actually much larger than this. We can think of the sun as having an atmosphere of gases that are spread out so thinly in space that we cannot easily detect them. The outer part of the sun's atmosphere reaches out at least as far as the planet Mercury. It may even surround the earth!

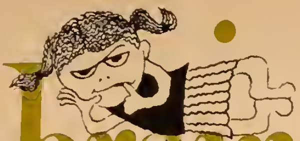
PROJECT

In the handle of the Big Dipper there is a bright star named Mizar. Very close to Mizar is a very dim star named Alcor. In ancient times, so a story goes, Alcor was used to test the vision of men entering the army. If they could see the dim star Alcor, they passed the test. If you have good eyes and look carefully you should be able to see Alcor without a telescope.

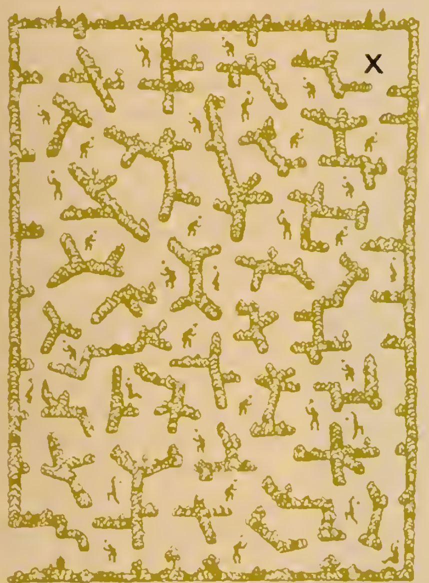
No one knows exactly how many stars there are in the universe, or in the Milky Way. The Milky Way is the giant family, or *galaxy,* of stars that the sun belongs to. Astronomers now think there are about 100,000,000,000 stars in our galaxy, and that our galaxy is only one of billions of galaxies in the universe. So the total number of stars in the universe is anyone's guess.

Stars are big or small, bright or dim, hot or cool, near or far. There are red stars, green stars, and others that are blue, yellow, gold, purple. How are stars born and how do they die? How do they change color during their lives? Exactly what happens to a star after it stops shining? These are only a few of the many, many questions astronomers are trying to answer. Possibly the observations of the sun made during the International Years of the Quiet Sun will help us come closer to some of the answers ■

BIRTHPLACE OF STARS: The Great Nebula in the constellation Orion is a glowing cloud of gas many millions of miles in diameter (six light-years). Conditions within this cloud are just right for stars to be formed. There is enough material, heat, and pressure so that great amounts of the gas and dust form gigantic clouds that eventually become stars when their "nuclear furnaces" ignite. The cloud is made to glow by four bright stars within the cloud.



brain-boosters



■ The Trouble with Treasure

Tom found an old map that showed the location of some treasure (marked with an "x"), that was buried in a garden maze of hedges. When he entered the garden, however, several other treasure hunters were already searching and digging there.

Only Tom knew where the treasure was hidden. To avoid arousing the suspicions of the other men, he sneaked by as many of them as possible as he walked to the treasure.

He managed to reach the treasure while meeting just four men. Can you discover the route he followed?

■ The Spy's Message

Mr. Smith runs a radio and television repair shop in a large city, but he is also a spy. One day, a man brought in a radio for repairs. Along with it was a note, containing a hidden message from another spy.

Only one letter of each word in the note is used in the secret message. The key letters have the same position in each word. See if you can find the secret message that is hidden in the spy's note:

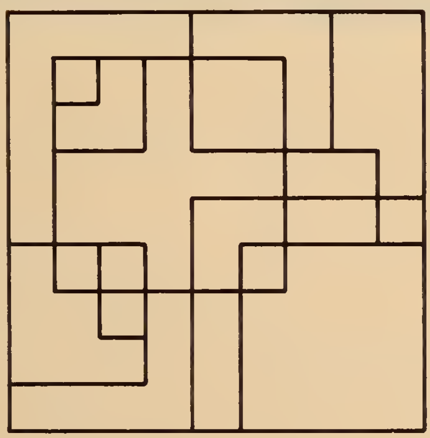
"Having trouble. Inspect loudspeaker. Believe antenna connected improperly, but do whatever you can."

■ A Weighty Problem

A boat floating on a pond has some heavy pieces of iron in it. If the iron is thrown overboard, does the level of the water rise, stay the same, or fall?

If you have trouble solving this puzzle, you might make a miniature boat from a jar top, float it in a bowl of water, and put some marbles or other heavy objects in it. With a crayon or pen, carefully mark the level of the water in the bowl. Then drop the marbles into the water.

What happens to the water level of your "pond?" (Hint: Use a small bowl so that the jar top covers most of the water's surface. If you have to lift the "boat" out of the water to drop the marbles in, be sure to replace it.)



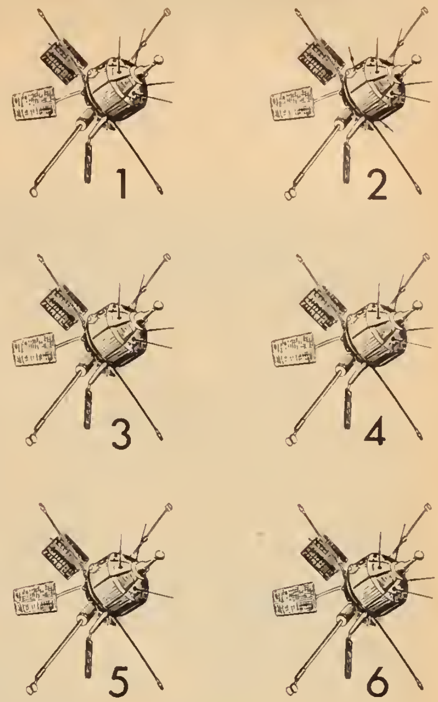
■ How Square Are You?

How many squares can you find in this figure?

■ Colored Cubes

Can you make an ice cube that is colored all the way through? Pour some water into a large baby food jar, or a larger jar, and add several drops of food coloring or ink. Add a few drops to one jar, then try many drops in a different jar.

Put the jars in your freezer and leave them there until the colored water turns to ice. What happens to the color? How can you make ice that's colored all the way through?

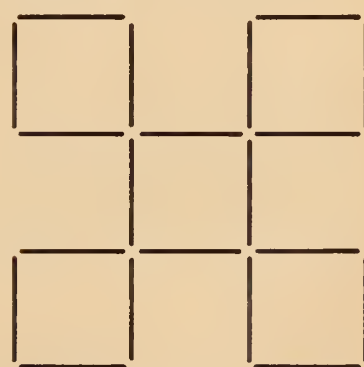


■ Match the Satellites

At first glance, these six satellites may seem alike. However, if you look carefully, you will find only two that are identical twins.

Solutions to Brain-Boosters appearing in the last issue

Move the Matches: By moving just four matches, you can form these five squares from seven squares.



Sally's Birthday: Her birthday was on December 31, and she was speaking on January 1. Thus, the day before yesterday (Dec. 30), she was 12. Now she is 13. She will become 14 on Dec. 31 of this year and will be 15 on that date next year.
Travels of an Explorer: Dr. Lost began and ended his journey at the North Pole.
The Impossible Puzzle: It is impossible.
How High a Pile: The stack of paper would be over 10 million inches, or more than 100 miles high.

Rhinoceroses

These Black Rhinoceroses have lookout scouts. Small tick birds perch on the backs and flanks of the animals and give warning of danger by chattering noisily. Rhinoceroses take dust and mud baths to rid themselves of insects such as ticks. The birds, which eat the insect pests, help out by picking over the heads and backs of the rhinoceroses. They even go into the rhino's ears in their search for insects. This is a photograph of one of the famous habitat groups at The American Museum of Natural History.

■ Did you know that the low-slung and clumsy-looking rhinoceros came from the same ancestor as horses? Rhinoceroses have a horse-like snort and shrill squeal. Also like a horse, they have three equal toes and a hard sole of horn-like material on each foot. And in spite of its size and bulk, a rhinoceros can gallop along at a speed of 35 miles an hour or so.

Rhinos have long been killed by hunters and by poachers who sell the animals' horns for "magic" and "medicinal" powders. As a result, the animals are disappearing rapidly. Most of those left are in national park areas of Africa and Asia.

Rhinoceroses eat only plants. The two-horned Black Rhinoceros of Africa—the most commonly known—is found mainly in the park areas of Tanganyika and Kenya. It has a triangular upper lip that is well shaped for *browsing,* that is, pulling leaves and twigs off certain trees. The animals stand about five-and-a-half feet high and weigh from 2,000 to 3,000 pounds. They travel in small groups of two or three, with the calves following close at the heels of their mothers. The fastest and most evil-tempered of the rhinoceroses is the Black. It charges murderously without apparent reason. In the wild, Black Rhinoceroses may live to an age of 25.

The two-horned White Rhinoceros of Africa is a more peaceful animal. The White stands six-and-a-half feet high, which makes it the largest of the vegetarian land mammals except for the giraffe and the elephant. The White Rhinoceros is a *grazer*. It carries its head low to the ground and sweeps up grasses with its square-cut lips. It travels in larger groups than the Blacks, and the calf walks ahead of its mother, who prods it in the rump with her long horn.

The large, one-horned Indian Rhinoceros—often called the "iron-plated" rhinoceros—looks like a prehistoric animal. Its thick skin is studded with round lumps and it has great folds of skin around the head and neck.

The one-horned Javan Rhinoceros is slimmer and smaller than its Indian cousin. It stands four-and-a-half feet high and weighs about 2,000 pounds. Its thick skin is mottled with a pattern of scale-like discs. The Javan is now very rare, but a few are still left in the Kahilu Game Sanctuary in lower Burma.

Fossil remains show that there were many more rhinoceroses on the Earth three million years ago than there are today, and there were many more different kinds. Because rhinoceroses like to wallow in mud, they are easy targets for hunters. And since only one calf is born at a time, and the female does not mate again for two years, the rhinoceroses are dying out. They are one of many animals on the "danger list" of extinction.—MARION B. CARR

nature and science

TEACHER'S EDITION / VOL. 1 NO. 12 / MARCH 20, 1964

N&S VIEWS

Cornell Science Leaflets
Valuable Source of Science Teaching Ideas

■ A wealth of practical information and ideas for teaching science in elementary and junior high grades is available in current and back issues of the *Cornell Science Leaflet*. These are a series of inexpensive pamphlets published by the New York State College of Agriculture at Cornell University.

These 32-page pamphlets, issued quarterly at a subscription price of $1 a year, bring a variety of timely, soundly described, and interestingly treated topics. They present basic information, suggest indoor and outdoor activities, and give additional references for use in the classroom or library.

Begin With Things, Not Ideas

In December 1896, Cornell began to publish these leaflets, designed to help teachers of elementary schools in the teaching of nature study. They have served elementary and junior high schools continuously through six decades, and through the changes that science and technology have wrought in the lives of both teachers and pupils. The leaflets have been distributed to nearly every state and to many foreign countries.

The *Cornell Rural School Leaflet*, as it was called at first, was designed to evoke the interest of children and teachers in their natural surroundings. Over the years, the leaflets covered caterpillars and their moths or butterflies, fossils, birds, mammals, lawns, predators, trees and their products, and many phases of conservation. Throughout the leaflets ran this philosophy: It is better to begin with things than with ideas. A child must first see and experience before he can draw conclusions.

Liberty Hyde Bailey, the great botanist and first author of the *Cornell Rural School Leaflet*, wrote: "Nature-study is seeing what one looks at and drawing proper conclusions from what one sees." It was on this basis of direct experience with the living things in one's environment that the early leaflets were written.

Recent leaflets retain the same quality of direct experience. Now published under the name *Cornell Science Leaflet*, the leaflets stress both the physical and biological environments.

Leaflets have been published on such topics as fungi, light, sound, simple machines, reptiles, atoms, static electricity, and many others. Here are some especially useful issues:

► "Little Climates" (Vol. 55, No. 1, Oct. 1961) suggests many outdoor investigations into the fascinating world of microclimates.

► "Science Experiments in the Classroom" (Vol. 55, No. 3, April 1962) suggests investigations into such diverse subjects as electromagnets, weight, thermometers, propulsion, and even bathtub rings.

► "Science Equipment in the Elementary School" (Vol. 56, No. 2, Dec. 1962) lists simple, inexpensive equipment that teachers can use in the classroom.

VERNE N. ROCKCASTLE, CORNELL SCIENCE LEAFLETS

To find out how much of an apple is water, these children are calibrating a spring balance they made by following directions in the *Cornell Science Leaflet* on "Science Experiments in the Classroom." These leaflets provide much helpful information for science teaching.

These may be obtained by writing to *Cornell Science Leaflet*, Stone Hall, Cornell University, Ithaca, New York. Subscriptions ($1 per year) can begin with any volume, including the 1963-64 school year.

Back Numbers Available

Here is a complete list of back numbers that are still available. The price is 25 cents per leaflet except as otherwise specified.

Vol. 52—No. 1, Earth and Beyond (20¢); No. 2, Ancient Sea Life (10¢); No. 3, Chemicals in Action (10¢); No. 4, Birds (10¢).

Vol. 53—No. 1, Keeping Animals in the Classroom; No. 2, Simple Machines; No. 3, Light; No. 4, Reptiles.

Vol. 54—No. 1, Sound; No. 2, Weather; No. 3, Seeds; No. 4, Amphibians.

Vol. 55—No. 1, Little Climates; No. 2, Plants Without Flowers; No. 3, Science Experiments in the Classroom; No. 4, Food Chains.

Vol. 56—No. 1, Photography; No. 2, Science Equipment in the Elementary School; No. 3, Fungi; No. 4, Conservation ■

One Physicist Looks at Science Education
by Robert Karplus

(Extracts from an address prepared for a meeting of the American Association of Physics Teachers in New York City last January. A physicist, Dr. Karplus is associated with the Science Curriculum Improvement Study at University of California, Berkeley, conducted under a National Science Foundation grant.

■ Given that science is a vital part of the general education of every citizen, there are strong reasons why science teaching should begin in the elementary school and not be postponed to later years. In the age range from six to 14 years the child's thinking undergoes a gradual transition from concrete to abstract. At the beginning of this period the child is achieving mastery of his muscles and gaining the ability to carry out physical manipulations; in his thinking he is dependent on direct experience. At the end of the transition the child is achieving a degree of mastery of mind; he is able to focus his thought consciously and to

(Continued on page 4T)

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

PAGE 3 Mystery of DSL

This article should suggest to your pupils that each discovery carries within it the seeds of a new mystery. In this case, advances in the techniques of echo-sounding led to the discovery of the Deep Scattering Layer (DSL) in the oceans; observation of the behavior of certain forms of marine life indicated that they might be the cause of the DSL in one place. Now scientists are investigating the DSL in other places to see whether it is caused by the same animals.

The article makes these points:

1. The ocean abounds in drifting plant and animal life, called plankton, which ranges in size from microscopic, one-celled organisms to "colonies" that act as a single animal and may be several inches or more in size. Plankton is the basic food source for marine animals.

2. Some species of plankton have the ability to rise or sink in the water to maintain the necessary environment of light, temperature, and food for survival.

3. Colonies of certain jellyfish are called siphonophores, and each colony has a gas-bubble "elevator" that enables it to sink and avoid bright light, then rise as the daylight fades. The movements of siphonophores and the sound-reflecting capacity of their gas bubbles seem to be linked to the presence of the Deep Scattering Layer.

These points exemplify the basic concept that *there is an interchange of materials and energy between living things and their environment.*

Suggestions for Classroom Use

Point out that planktonic plants and animals are also found in fresh water lakes and ponds and the population is often more dense there than in bodies of salt water. The green scum that forms on stagnant ponds in the summertime is a form of plant plankton called *algae.* Algae are simple plants that produce their own food. Some are one-celled; others are 200-foot-long seaweeds. All plant plankton are algae.

Discuss the importance of green plants as the foundation of life in the water as well as on land. Plant plankton is much smaller than the familiar land grasses, bushes, and trees, but most green plants need light to make food. And all animals, on land or in water, depend ultimately on plants for food.

Explain that while a siphonophore acts like a single animal, it is composed of a number of jellyfish. Some of them perform motor functions (pulsating to move the colony slowly, or producing gas for the gas-bubble "elevator"); some gather food (by catching or "stinging" other organisms); some digest the food, and so on.

Your pupils may benefit from a review of sound waves and echoes *(see "Finding Your Way by Echoes,"* N&S, *Nov. 1, 1963 and Teacher's Edition).* Point out that while sound waves might pass right through, or be absorbed by, the soft body of a jellyfish, they make the siphonophores' gas bubbles vibrate like a drum, sending out their own sound waves in all directions.

Activities

1. Many marine animals eat plankton; others eat fish that feed on plankton. Have a class committee prepare a chart that shows a "food chain" in the ocean. The plant plankton are eaten by protozoa, marine larvae, small fish, worms, crustaceans, and mollusks. These in turn are eaten by larger crustaceans and fish, and so on. Very large animals such as whales, walrus, Polar Bears, sharks, and man are last in the "chain." However, some animals, such as the Blue Whales (the largest known animal) feed directly on plant plankton. When the larger sea animals die, their bodies decompose and help provide the chemicals from which plant plankton make food.

2. Have some pupils investigate and report to the class on the use of algae as food for humans. Algae have been suggested as a possible answer to the world's future food problems and especially to the problem of supplying food in outer space.

Reference

The illustrated edition of Rachel Carson's *The Sea Around Us* that is listed in the student's edition is designed especially for children. The regular edition of this classic book is available in paperback (50 cents) by New American Library—Mentor, New York, N.Y.

The suggestions for using this issue of Nature and Science *in your classroom were prepared by Patricia Ralph, elementary school teacher in the public schools of Huntington, N.Y., and member of our National Board of Editors.*

PAGE 6 Mealworms

By investigating the action and reactions of mealworms, your pupils will learn quite a bit about these animals and—more important—they will be practicing the methods of testing, observing, recording, and drawing conclusions that scientists use in studying the behavior of all animals.

The following investigations, those in the student's edition, and the article on page 4T were developed by David Webster, of Elementary Science Study, Educational Services Incorporated, 108 Water Street, Watertown, Mass. He will welcome your comments and suggestions on the use of this material.

Suggestions for Classroom Use

You might get a batch of mealworms as suggested in the article and

(Continued on page 3T)

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

distribute them to your pupils. Have them make some investigations in the classroom and others at home, reporting their findings to the class.

After your pupils have completed their investigations on making mealworms back up, discuss their findings in relation to the worms' natural habitat. For example, do mealworms withdraw from light? Do they tend to follow "walls"? Would it be harder for a bird to find a mealworm if it were in dim light? If it were not out in the open?

Discuss the difference between seeing obstacles and simply detecting light and dark. Mealworms can detect light, but they don't appear to detect objects visually. Have your pupils close their eyes so they can tell when the light is on or off but can't see objects.

Activities

1. Have your pupils test a mealworm's sensitivity by touching the hairs along its body; touching the body, first lightly, then more heavily; making these tests with a pointed pencil, then with the eraser end. To which stimulus does the worm respond most strongly?

2. One scientist found that when a mealworm comes to the end of a "wall," it generally turns in the direction of the wall. Have your pupils see whether this is so. Also, set up two "walls" just far enough apart for a mealworm to move between them. See whether it goes straight out at the end of the walls.

3. Show your pupils the drawings below that illustrate how caterpillars and some other worms move. Have them observe mealworms in motion through a magnifying lens and draw pictures showing how they travel.

PAGE 10 Wonder of Eggs

The advent of spring, with birds flying north to nest, should spark interest in this article. The ideas expressed in it are more important than the many bird names. The ideas are these:

1. The structural design of bird eggs protects them from breakage.
2. The number of eggs a bird lays depends on such things as enemies and available food.
3. Relative to their size, large birds tend to lay smaller eggs than small birds.
4. Eggs, or in some cases the nesting birds, are protectively colored.

The basic concept is that *organisms are adapted to their environment.*

Suggestions for Classroom Use

After discussing differences in birds' eggs, ask your pupils in what other ways birds differ. Bird feet, beaks, and nests, for example, vary greatly and provide good examples of how organisms adapt to their environment.

PAGE 13 Inside a Star

This article on the composition of stars will acquaint your students with the purposes of scientific work taking place in the International Years of the Quiet Sun (IQSY) during 1964 and 1965. This is an extension of studies made during IGY several years ago. The story makes these points:

1. Stars vary in brightness, color, and size.
2. Stars give off their own light by nuclear activity (fusion of hydrogen atoms).
3. No one knows for certain exactly how stars are formed, but the process may be something like this: Great clouds of dust and gas in space "condense" into a *protostar.* When the pressure is sufficiently high and the temperature inside reaches about 10 million degrees, nuclear reactions take place (converting hydrogen into helium) and the star shines.

Basic to these is the concept that *the Universe and its component bodies are constantly changing.*

Suggestions for Classroom Use

Unless you have a budding chemistry genius in your class, none of your pupils will be able to distinguish between *burning* and *fusion.* Many children think that stars produce light and heat by burning something. If you can dispel this notion—even though you may not be able to make them understand what fusion is all about—you will be helping them in one way.

Fire, or burning, produces heat and light through chemical reactions between atoms and molecules. Fusion involves reactions of the nuclei of atoms in which atoms of one element are converted into atoms of a different element, e.g., hydrogen into helium. In the process heat, light, radioactivity, and other forms of energy are produced at a rate far exceeding that of chemical reactions.

Some caterpillars move like this—

Some worms move like this—

Draw a few pictures to show how a mealworm moves—

One Physicist Looks . . .
(Continued from page 1T)

manipulate abstract relationships without constant reference to specific examples. These formative years are the time when the individual develops the basis for his view of the natural world.

There is a temptation to postpone science instruction until the youngsters have reached the intellectual maturity of the middle teens. Educational efforts at this stage, however, reach only the fraction of the student body which is favorably disposed toward science because of earlier favorable experience at home or at school. . . .

Just what elementary science should be is under study by many groups, including the Science Curriculum Improvement Study with which I am associated.

One of our conclusions is that it is most important for each student to learn to carry out experiments to find his own answers to questions, even if the answers differ from those of everyone else. By repeating experiments and comparing notes, the class as a whole can achieve a good understanding of a phenomenon under study. In other words, the pupil's own observations are the most important source of information for him. The teacher, textbooks, encyclopedias, and other references are sources of information too, but they are less important and they are overruled in case of a genuine contradiction between them and a direct observation. In order to be significant sources of information, the pupil experiments have to provide experiences that are different from ordinary ones. The differences may have to do with the range of materials being studied, with the instruments that are used, and with the kinds of living organism that are available.

In this view of elementary science education, the teacher plays a much more important and difficult role than that of an authority who knows all the answers. To permit the children to perceive phenomena in a meaningful way and to integrate their inferences into generalizations of lasting value, the educational program must be carefully planned and the teacher must act as guide and discussion leader who relates the successive experiences to one another. In this way, the abstract concepts that are at the basis of the modern scientific point of view are built up. As the children make further observations, they will look at them more scientifically. The abstractions will form a link between their earlier experiences and later experiences, so that the children can bring their knowledge to bear in a systematic way ■

THE NEXT ISSUE of *Nature and Science* explores the reports of "sea monsters" through the ages and attempts to account for them.

The optical advantages of seeing with two eyes are explained in an article on binocular vision.

Our WALL CHART uses some striking photographs to show the mechanics of objects in motion.

How To Investigate the Behavior of Animals

(From "Behavior of Mealworms," an Elementary Science Study pamphlet)

■ During investigations of mealworm behavior (*see page 2T*), thought might be given to some of the errors commonly made when experimenting with animals. Here is a list of six criteria for good experimentation.

Criteria for Experiments

1. In order to know if the animal is doing something different, one must first know its usual behavior.
2. An animal must be given a choice if it is to show a preference for one thing over something else.
3. What is done to an animal must be described in detail.
4. The description of what the animal does in the experiment must be complete.
5. The same experiment should be done more than once.
6. The conditions should be controlled so that the animal responds only to what is being tested.

"Experiments" To Be Criticized

The following descriptions of hypothetical experiments may be distributed and pupils asked to decide which of the six criteria are violated in each example. There is no single right answer. In many cases, two, three, or even more responses may be considered correct. The purpose of having the children write an answer is to force them to consider the experiments carefully. Discussion of the "answers" should elicit a lively debate.

1. I wanted to see if mealworms liked high places. I put my mealworm on a book and raised it five feet above the floor. This was done about 25 times with several different worms. Every time except once the mealworm crawled around the book until he fell off onto the floor. It took from 8 seconds to 6 minutes and 15 seconds for this to happen. The one mealworm which didn't fall off just sat on the book and didn't move. I don't think mealworms like heights.
2. I tested my dog to see his reaction to music. So every night after his dinner, for two weeks, I put him in the playroom and turned on some music. On almost every night he was asleep within 10 minutes. It seems that music makes my dog go to sleep.
3. I wanted to find the effect of noise on a kangaroo. The noise was made by exploding a two-inch firecracker 10 feet behind the animal. This was done 10 times to each of five different kangaroos. I saw that sometimes after the "bang" the kangaroo jumped higher than usual.
4. Does my snake like to eat baby chicks or rats? I answered this question by putting a five-day-old chick in the snake's cage. My snake swallowed the chick in 10 minutes. The next night I put a four-inch white rat into the cage. The next morning the rat was still uneaten. My snake prefers to eat chicks rather than rats.
5. I have heard that bats get into people's hair. I found a bat and sneaked into my sister's room and let it loose. It flapped around the room three times and suddenly flew into her red hair and boy did she scream! Now I know that this superstition is really true: if there are people around, bats will try to fly into their hair.
6. My problem was to find out if coldness would affect the behavior of June bugs. I put 20 fully grown bugs in a metal box 12 inches square with a cover. The June bugs ran all around the bottom of the box. Then I put four ice cubes inside the box at one end. After 10 minutes all the insects had moved to the end of the box away from the ice cubes. I think that June bugs seek to avoid cold and therefore move away from it.
7. I read in a book that leeches swim to the bottom of an aquarium when an electric current is passed through the water. I put 15 leeches in a tank and turned on the electricity. The leeches continued to swim around as before. I can only conclude that the book was wrong.
8. I found out that mealworms prefer to live in bran rather than sawdust. I made a small pile of each, six inches apart, and placed a mealworm between them. In 52 seconds the mealworm had walked to the pile of bran and disappeared into it. After one hour he was still under the bran ■

nature and science

VOL. 1 NO. 13 / APRIL 3, 1964

SEA MONSTERS—FACT OR FANCY?

See page 3

Dolphins, or porpoises, sometimes swim along in a line. Their leaping and diving bodies probably have been mistaken for some kind of huge sea animal.

British are fond of their Nessie and want to keep the story alive, even if there is no monster to be kept alive.

How To See a Monster

Scientists see little truth in reports of giant serpents or monsters of the sea. The key word, of course, is *monsters*. A "monster" can be just about anything our imaginations want it to be. Many sailors of old who told stories of sea "monsters" undoubtedly had seen *something* in the water, but what? In many cases it could have been a large sea animal that was already known, but had never before been seen by the observer. In other cases, it could have been a rare species, unknown to scientists or sailors. We still have much to learn about life in the oceans. As recently as 1938, a species of whale never known before was discovered near New Zealand.

Also in 1938, a "living fossil" was discovered off the coast of South Africa. It was a large fish called a *Coelacanth (see photo)* which had been known only from fossils before then. Until 1938, scientists believed that the last of these fish had died out 70 million years ago. Several more living Coelacanths have been caught since then. But because they are only about five feet long, they could not have been mistaken for a giant sea serpent.

What Could the Sea Serpents Be?

Scientists are sure that sea serpents are not true snakes. They use the word "serpent" only when they refer to the snakes, a group of long-bodied reptiles that lack feet.

There are about 50 kinds of snakes that spend all or most of their lives in the sea *(see page 16)*. However, none of these snakes is longer than seven or eight feet. Sea serpents are always described as being 20 or more feet long.

Most reported sightings of sea serpents were made in the open sea, far from land. Sea snakes, except for one species, live mostly in shallow water close to shore. This is another reason why scientists do not believe that sea snakes are the objects of the sea serpent stories.

If the observer did not know what he was looking at, but wanted to see a "monster," he could mistake a group of porpoises, or dolphins, for sea serpents. These animals often swim along in a line, gracefully and smoothly curving out of and back into the water. From a distance, their arched backs resemble the curves and coils of a monstrous snake *(see photo)*. But only a decidedly odd snake would swim this way. When in water, a snake moves its head and body from side to side.

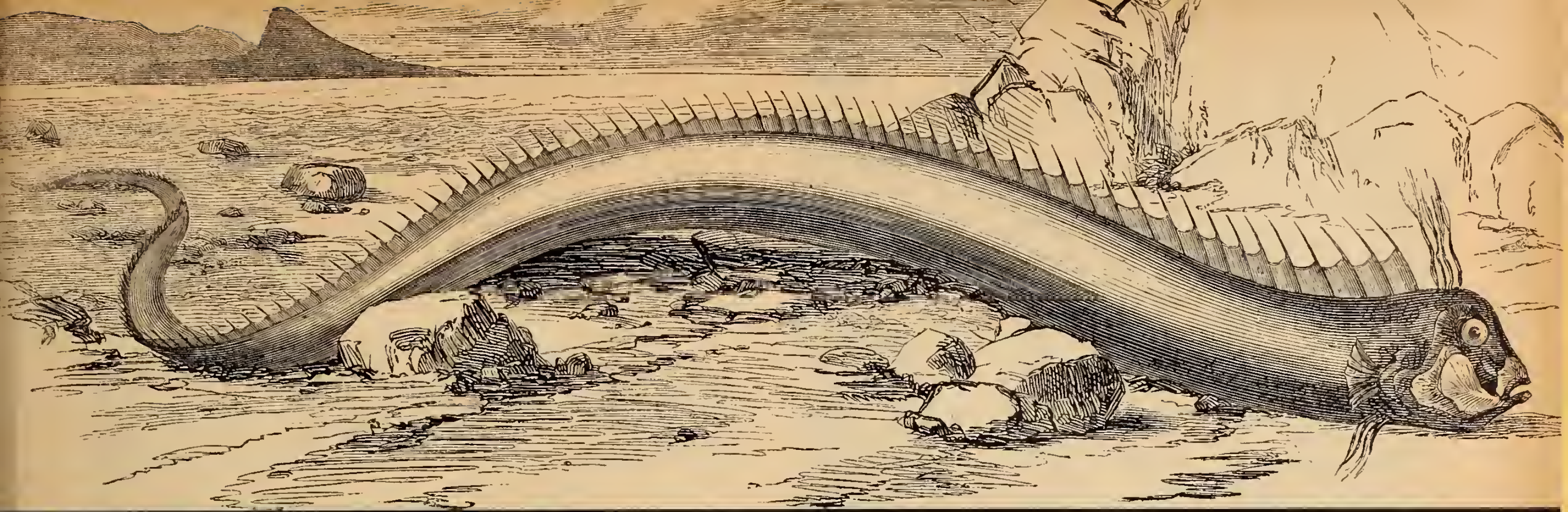
Another source of sea serpent stories may be the Giant Oar Fish *(see photo)*, which may grow to 30 feet long. Oar fish have a long, snake-like body and sometimes swim at the ocean's surface. Also, these fish have a long back fin that is colored bright red just behind the fish's head. Many reports of sea serpents mention that the animal had a "red mane."

Sometimes giant squids come to the ocean's surface. They may have 30-foot-long tentacles. Also, the largest known fishes—the Basking Shark and the Whale Shark—often swim at the surface, and could be mistaken for a sea serpent. Both of these fishes sometimes grow to be 50 feet or so long. People with strong imaginations might "see" a serpent when they are really looking at long strips of sea weed or pieces of floating debris. Even a tricky effect of wind on the water or a flock of low-flying birds can produce a serpent-like pattern.

Are "Sea Serpents" Giant Eels?

Interest in sea serpents has increased with a recent discovery. In 1959, the late Dr. Anton Brunn, a Danish ex-

Some scientists think that there may be several large, unknown animals in the oceans. Coelacanth fishes like this one were unknown to scientists until the year 1938.



The Giant Oar Fish (bottom) grows to about 30 feet. In the past it has probably been mistaken for a sea monster. Compare this photograph of a Giant Oar Fish with the drawing (top) of a "sea serpent" found in Bermuda in 1860.

pert on life in the ocean depths, caught a young, or *larval,* eel near the coast of Africa. It was six feet long and was brought up from a depth of 1,000 feet.

Normally, an eel larva is only about 2.5 inches long when it is at the same stage of development as the 6-foot-long larva was. A 2.5-inch-long eel larva grows into an adult eel two or three feet long. Scientists believe that a 6-foot-long-eel larva could grow into a 60-to-70-foot-long adult. In 1960, a three-foot-long eel larva of a different kind was found off the coast of New Zealand. Scientists estimate that it might have become a 30-foot-long adult. However, in both cases, the larva may have reached its adult stage without losing its juvenile appearance, just as some adult salamanders still resemble their larvae.

So far, no adult eel from these giant larvae has been found. However, such a beast seen at the ocean's surface might fit the familiar description of a sea serpent. An eel, however, is a fish. Scientists point out that eels would not be likely to swim with their heads out of the water for long, because they must be under water to breathe.

Some people believe that there may be one or more large sea animals that have not been discovered yet. Dr. Robert J. Menzies of the Marine Laboratory at Duke University, in North Carolina, believes that one of the places where huge sea animals may dwell is the deep trench in the ocean floor off the west coast of South America.

"I know that some of the stories told about sea monsters and sea serpents sound weird," Dr. Menzies says. "But it would be even more ridiculous to pooh-pooh them completely and not even look for the monsters. I have searched for them as a part of other oceanographic studies. I am not prepared to say that there are such things; neither would I deny they exist."

If scientists ever discover a sea animal that could be called a "sea monster," it will probably be some unknown species of fish, squid, or whale. Scientists are sure that the huge, fire-breathing sea monsters that sailors used to report will never be found, because scientists believe they do not exist ■

A rabbit's eyes are located on the sides of its head. Each eye sees in a half-circle or more, so the animal can see things even behind its head.

ARE TWO EYES BETTER THAN ONE?

WHETHER AN ANIMAL LOOKS AT SOMETHING WITH ONE EYE OR TWO CAN MAKE A BIG DIFFERENCE IN WHAT IT SEES.

■ Have you ever watched a robin feeding on a lawn? Watch one some day. The bird will hop along, suddenly stop, and then cock its head to one side. Is it listening for worms?

No, it is looking for them. To examine an object closely, a robin turns its head so that one eye only is looking at it. Robins are one of many kinds of animals that have their eyes on the sides of their heads, instead of in front, like humans.

How does the world look to such animals?

Seeing in Three Dimensions

When a robin looks at a worm with just one eye, it is using "one-eyed," or *monocular,* vision. However, when it looks at an object in front of it with both eyes, it uses "two-eyed," or *binocular,* vision. Whether an animal looks at something with one eye or two can make quite a difference in what it sees.

This simple experiment tells you something about how your eyes work for you. When you look at an object with both eyes, you usually see it in depth as a solid shape. Since your two eyes are set a few inches apart, each eye sees the object you are looking at from a slightly different angle. When your eyes are focused on an object, the light-sensitive cells in each eye send impulses to the brain, where sight takes place *(see "Turning Day into Night,"* N&S, *March 6, 1964).* In your brain, these impulses from each eye form an image that has depth as well as height and breadth.

You can also judge distance from one object to another best when you use both eyes. However, your memory of how common things, such as trees and houses, look from different distances can help you judge the size and distance of objects when you see them with only one eye.

People with normal vision can see everything within a half-circle, or 180°, without moving their heads. However, not all of the vision within that area is binocular. In other words, you see objects at the edge of your vision with one eye only. If you turn your eyes far to the left, for example, your right eye cannot see beyond your nose. Thus humans have a zone of monocular vision on each side of a wide zone of binocular vision *(see diagram).*

PROJECT

Close one eye. Hold a pencil, eraser end up, at arm's length. Then take another pencil in your other hand and try to bring its eraser down on top of the other pencil with a quick movement. Can you do it?

Try it several times. What happens? Now try it with both eyes open. Do you notice a difference?

Seeing Behind Your Head

Some animals have no binocular vision at all. They include a few fishes, some penguins, and the large whales. Their eyes are placed so that they can never look at an object with both eyes at the same time. No one knows what the world looks like to these animals. It may look as flat as the photographs in this magazine look to you. But this is not necessarily a handicap. In some unknown way, the animals without binocular vision can judge distances. There is a theory that birds with side-set eyes can judge distances by how much the muscles inside the eye have to pull on the lens to focus it on an object. Also, animals that have poor eyesight usually have other highly developed senses, such as smell or hearing. Bats, for example, send out sound pulses to find their way about *(see "Finding Your Way by Echoes,"* N&S, *Nov. 1, 1963).*

One kind of bird—the Woodcock—has a narrow range of binocular vision both in front of and *behind* its head. Its eyes are set far back along the sides of its head, and each eye sees more than 180° on a side. Where the range of both eyes overlaps in front and back, the bird has binocular vision (*see diagram*). Since Woodcocks get most of their food by probing in mud for worms, sight behind their heads helps protect them from attack. Rabbits and squirrels also have wide monocular views that overlap, giving them vision in all directions.

Scientists believe that the kinds of animals that are often attacked by other animals must have a wide range of vision in order to survive. On the other hand, the animals that catch their food by chasing and attacking usually have front-set eyes, which are best for estimating distances. An owl swooping down on a mouse must be able to keep its prey in sight and avoid smashing into the ground. Owls have front-set eyes and about 60° of binocular vision. Mice and other rodents have only about 30° of binocular vision, but can see in almost a full circle.

Scientists have found this difference in eye position in other groups of animals. The fishes with the widest range of binocular vision are predators, such as trout and pike. Among the turtles, plant-eating species have a binocular field of only about 18°. The snapping turtle, which catches fish and other animals, has 38° of binocular vision ■

PROJECT

Notice the eye position of different kinds of animals that you see. Look at dogs, cats, horses, and different kinds of birds. Which ones have eyes set at or near the front of their heads?

The range of an animal's vision depends partly on where its eyes are positioned. Humans and owls have front-set eyes which give wide binocular vision (shown in solid color). However, they cannot see very far to the side or behind their heads. Robins and Woodcocks have a small range of binocular vision. The Woodcocks can see in a complete circle.

April 3, 1964

LAWS THAT CAN'T BE BROKEN

Text by Kenneth L. Franklin
Photographs by Berenice Abbott

■ People have laws to obey. Those who break laws may be arrested. Moving objects—balls, wrenches, planets—obey laws, too. But it is impossible for them to break these physical laws.

Some of these laws of motion have been known to men for only 350 years or so. Knowledge of these laws allows scientists and engineers to predict how well a machine will work, or where a rocket or space satellite will go. If moving parts of a machine are going too fast for the eye to see or if a ball is falling too fast, we can "stop" the motion by photographing the object in less than a thousandth of a second.

These photographs were made by taking a series of pictures, 1/30th of a second apart, on th

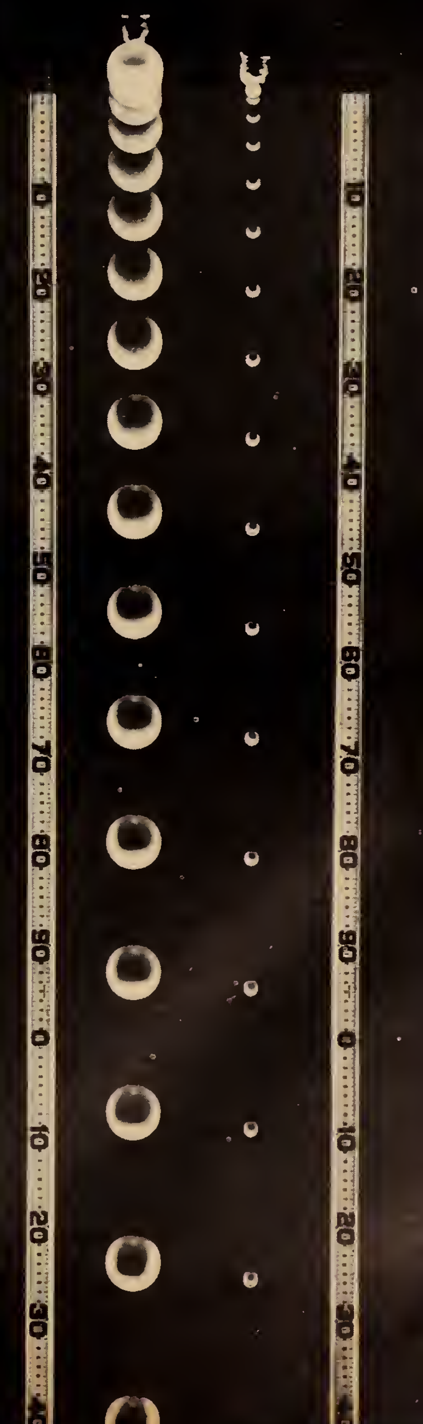
Uneven objects are more complicated than smooth, rou balls, but they also obey the same laws. The wrench sho here can be balanced by holding it at the black cross. Mo weight is located at the end with the jaws than at the end w the hole, but the jaws are closer to the balance point—called t *center of mass*—than the hole is. When the wrench is spun ho zontally through the air, the balance point moves equal distanc between flashes, just as a ball would. As the wrench spins wh it is moving forward, notice how the lighter end with the ho moves farther around the balance point, and the heavier ja move in a smaller path. By the same law of motion, a child the end of a seesaw moves farther up and down than his fath who is sitting closer to the balance point of the seesaw.

Two golf balls left the box at exactly the same tin While one was dropped straight down, the other one was push out sideways. Because both balls are obeying the same law falling bodies, both are increasing their downward speed at t same rate between the exposures. You can see this by looki across the white lines and comparing the positions of the falli balls. The sideways motion of the pushed ball does not affect falling speed.

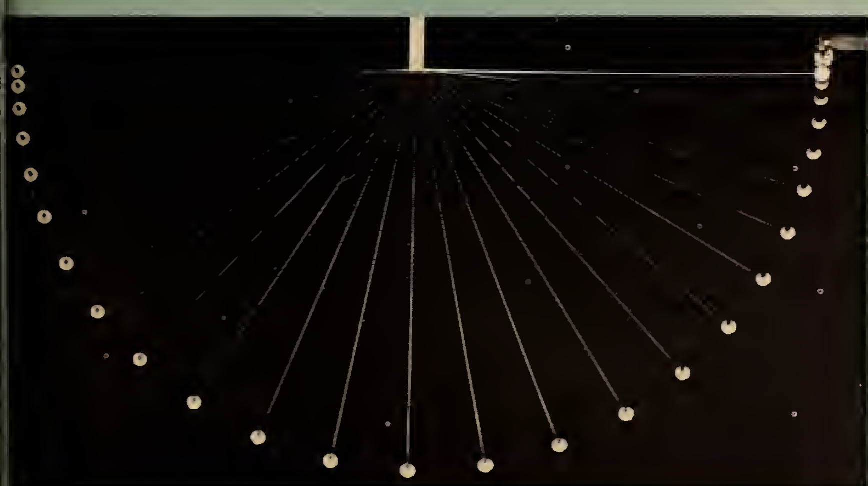
ne film. Between clicks of the camera shutter, : object continued to move, obeying the physical vs of motion. One-thirtieth of a second later, : shutter clicked again, catching the object in a v position. The shutter clicked again and again, a steady rhythm, catching the object in a differ- : position each time and recording its position the same sheet of film.

It takes high school mathematics to state the vs of motion in a way useful to scientists. But se remarkable pictures help a person under- nd that a falling body moves faster and faster it drops, and that a swinging body rises just as as it falls. Can you see and understand any ier laws of motion by studying these pictures? ■

These two balls started to fall at the same time. Notice that the longer the balls fall, the farther they travel between clicks of the shutter. Since the time between clicks is equal, the balls must be falling faster and faster. The small ball keeps up with the large ball all the way. A heavy object does not fall faster than a light object, for all objects obey the same law of falling. If you removed all the air from a long glass tube and dropped a feather and a marble from the top, you would see both objects hit the bottom at the same time. This experiment would not work except in such an airless tube, because air resistance would slow down the feather.

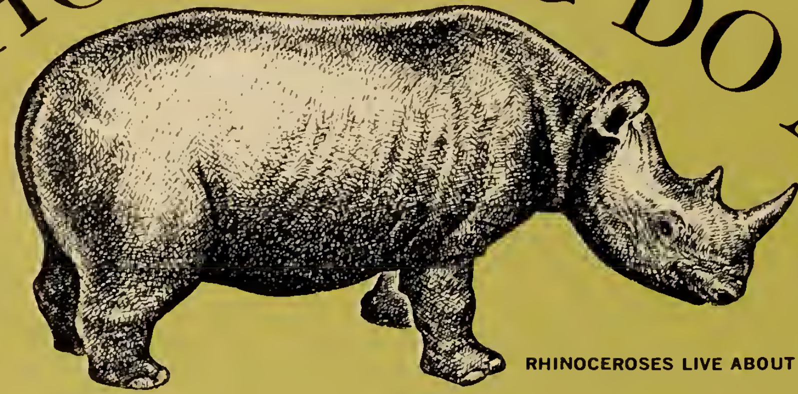


Swinging from a string that is tied to a point, this ball changes vertical, or up-and-down, motion into horizontal, or sideways, motion. At what position does the ball stop moving? Where is the ball ving fastest? Slowest? After the ball has fallen to the bottom, why s it rise again? Where would the ball go if the string broke at the tom of a swing? Or at the upper left position? Or half-way up to t position?



HOW LONG DO ANIMALS LIVE?

HOUSEFLIES LIVE 2 WEEKS TO 3 MONTHS



RHINOCEROSES LIVE ABOUT 25 YEARS

■ Elephants, horses, spiders, bats, dogs, hamsters.

Can you put these animals in a list so that the one you think lives the longest is on top, the next longest second, and so on? When you have made your list, check it with the information in the next paragraph.

Horses are considered old at age 20, but some live into their 40's, and one is reported to have reached age 62. Elephants have a life span of about 50 years. Spiders live from eight months to four years; one is reported to have lived 20 years. Bats may reach the age of 20. Cats and dogs are considered old when they reach age 10 or 11. Hamsters live for about two years.

Most of the figures we have for the life span of animals are based on studies of animals living in zoos, on farms, or in homes. Here they are protected from their enemies and kept in good health. Relatively little is known about how long animals live in the wild.

"Aging" Animals in the Wild

To measure the life spans of animals in the wild accurately we would have to observe many elephants, many spiders, or many of whatever animal interested us. And we would have to do this from the time an individual animal was born until it died. In most cases this is impossible to do. How, then, do scientists learn anything about the life span of animals living in the wild?

One way is to band them. Young animals, including fish, are trapped and marked with a tag or band, then released. If they are caught again months or years later, the date on the band tells how long the animal has been alive.

Some animals have built-in "bands" that reveal their ages. The teeth of horses show their ages quite accurately. The ages of bighorn rams can be read by counting the seams on their horns. But few animals reveal their ages so easily. Many people think that you can tell the age of a rattlesnake by counting the number of separate rattles on its tail—one rattle for each year. But this is *not* a reliable age calendar. Many snakes lose some of their end rattles; others may add two in a year instead of one.

Scientists who study animals say that large animals tend to live longer than small ones. This may be because large animals have fewer natural enemies. Very few wild animals, large or small, die of old age. If they do not die of disease or starvation, other animals kill them.

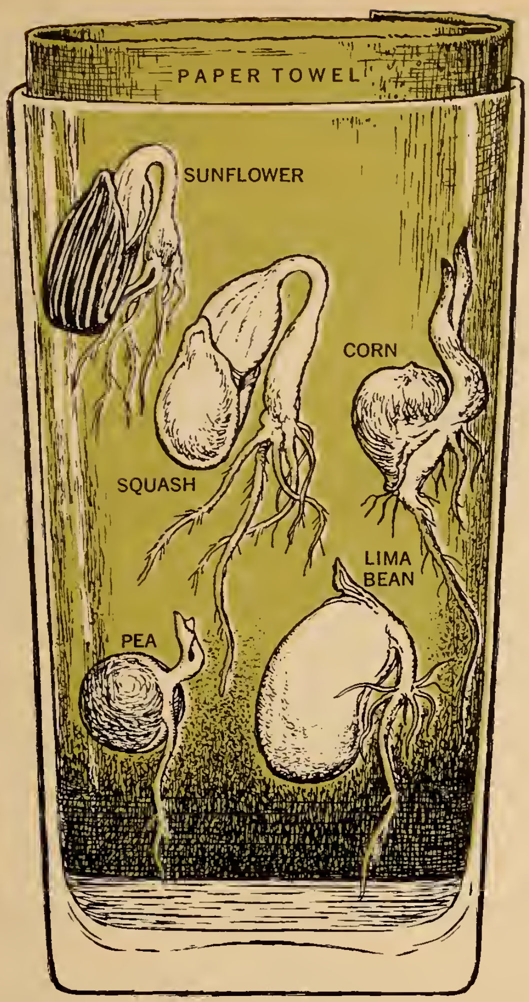
One thing we know for a fact is that aging takes place as the body cells die. But just what does this mean when we compare the life span of large animals with the life span of small ones? For one thing, large animals have more cells to spare than smaller animals.

But this theory about aging has yet to be proved. We do know that bigness alone does not mean that a large animal will live longer than a smaller one. For example, the mammal with the longest known life span is not the elephant or the rhinoceros, but man.—VIRGINIA COIGNEY

BEAVERS LIVE ABOUT 19 YEARS

We know surprisingly little about how long animals live in the wild. Ages of the animals shown here are based on the lives of animals living in zoos and laboratories.

In spring small fruit flies gather around decaying bananas and grapes. How long do fruit flies live? How would you find out? Plan your own investigation and carry it out.



By doing these projects you can investigate the hidden life inside seeds

by Millicent E. Selsam

WHAT MAKES A SEED SPROUT?

This article is adapted from Play with Seeds, *copyright © 1957 by Millicent E. Selsam. Reprinted by permission of the publishers, William Morrow and Company.*

■ Each spring, dry and seemingly lifeless seeds change into an amazing variety of plants—from grasses to trees. Some seeds fall naturally onto the ground. Others are planted by man. But before they grow into the various plants we recognize, all seeds must sprout, or *germinate.*

Why don't the seeds sprout when they are in a package? As you probably know, certain conditions are required for a seed to germinate. Water, air, heat, and light all affect the seed.

Many seeds will sprout any time they are given water and warmth. Others have to go through a resting stage, called *dormancy,* first. This delay is a great advantage in places where the winters are cold. If seeds sprouted as soon as they fell to the ground in autumn, the young seedlings would be killed by the cold. Seeds with a dormant stage, however, can lie on moist ground without sprouting and will survive even through freezing weather.

PROJECT

Sprinkle some corn seeds over wet paper towels on six small pie tins or plates. (You might try pumpkin and other seeds also.) Then cover the plates. Allow one batch of seeds to germinate for about five days at room temperature. The seedlings will then be about one inch high. While these seeds are germinating, plan ahead so that the other batches of corn seeds soak in their plates for 24 hours, 18 hours, 5 hours, 3 hours, and 1 hour, respectively. Then place all six plates into the freezing compartment of the refrigerator. Let them freeze for a day. Then take out the plates and allow them to stand at room temperature. Keep them moist. What happens to the seedlings? Which batches sprout?

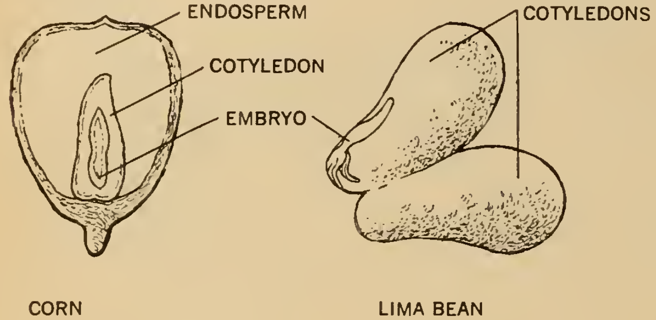
Seeds that go through dormancy often have hard, tough seed coats through which water cannot enter. This is why they do not sprout right away.

Tough seed coats have kept plants from sprouting for many years. One-thousand-year-old seeds of the Indian lotus have been discovered in Manchuria. Buried deep in the soil, the seeds had never sprouted. When they were brought into a plant laboratory and soaked, nothing happened. But when their seed coats were nicked, water entered, and the seeds immediately swelled and sprouted!

A tough seed coat is not the only reason for a seed's failure to sprout. Sometimes the seed is not ripe enough when it falls to the ground in autumn. As it lies in the moist, cold soil over the winter, ripening changes take place. By spring it is ready to sprout. Scientists have found that they can make many dormant seeds sprout by giving them a similar moist, cold treatment for a month or two. The damp treatment causes chemical changes in the seeds that enable them to germinate.

(Continued on the next page)

Every seed contains something *(see diagram),* called an *embryo.* The top of the seed's embryo grows out into stem and leaves and the bottom grows into roots. Around the embryo is food for the young plant. And surrounding both embryo and food is the *seed coat.* All seeds are not exactly alike, but all of them will have these three main parts.

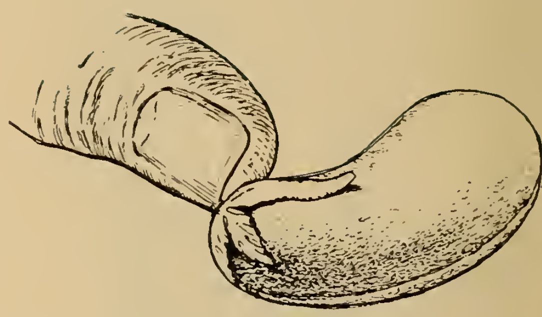


Look at different kinds of soaked seeds to find out which kinds have two cotyledons and which kinds have one.

PROJECT

Plant several different kinds of seeds and watch for differences in growth. An easy way to watch how they grow is to plant the seeds—small ones, like grass or mustard are best—in a glass that has been lined with a paper towel. Wet the paper so that it sticks to the surface of the glass. Put about an inch of water into the bottom of the glass with the paper touching the water so it will stay wet (see **"Climbing Water,"** N&S, **Jan. 10, 1964).** Now put your seeds between the wet paper and the glass. If you soak the seeds first, they will sprout faster.

Do the different seeds take different amounts of time to sprout? Keep records of the time it took each kind of seed to sprout. Do all of the cotyledons grow straight up?



You can push the embryo off a bean seed with your thumb.

If you look at soaked seeds from such plants as sunflowers, beans, and oranges, you will find the embryo nestled between two large, fleshy seed leaves, called *cotyledons (see diagram).* These cotyledons are packed with food that is used by the young plant when it starts to grow. When we eat beans, peas, or almonds, we eat the food the young seedling would have used in its early growth.

If you examine soaked seeds of corn or wheat, you will find that they have only one cotyledon instead of two. But extra food is packed around the cotyledon in food-storing cells called *endosperm.*

As the young plants come out of the seed and grow, they use the food stored in it. But you can take the embryo out of a seed and grow it without the cotyledons or endosperm if you supply it with substitute food. Taking the embryos out of seeds is not a difficult operation *(see diagram).*

First try removing the embryos of bean seeds, which are quite large. Soak the beans and then slip the seed covers off. Now gently slide one cotyledon off the other. You are left with the embryo attached to a cotyledon. Put your thumb at the center point of the embryo and push gently. The embryo will slip off the cotyledon. You may make a few mistakes at first, but with a little practice you will be able to detach the embryo undamaged. When you can do this easily, try the following investigation■

INVESTIGATION

Make up a sugar solution by dissolving half a teaspoonful of sugar in a glass of water. Put paper towels down on two dishes. Wet one with plain water and wet the other with the sugar solution. Label the dishes. Now lay the embryos on the paper, about 10 to each dish. Put glass covers over them to prevent evaporation yet admit light **(see diagram).** If the embryos get moldy, try two other groups of embryos.

Do the embryos in plain water grow at all? What about the embryos in the sugar solution? What must be providing the extra food? See how large you can get the embryos to grow. Will they continue growing into large plants? In special plant laboratories, scientists can grow full-sized plants from plain embryos in solutions. What do you suppose they do to succeed in this?

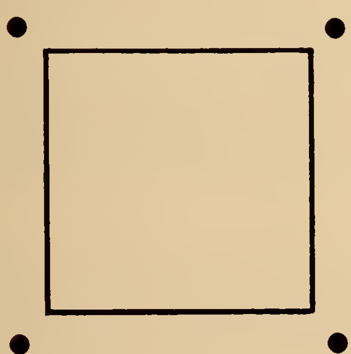
BEAN EMBRYOS ON PAPER SOAKED IN PLAIN WATER

BEAN EMBRYOS ON PAPER SOAKED WITH SUGAR SOLUTION

brain boosters

■ **The Frog's Diet**
A frog ate 100 flies in just five days. Each day the frog ate six more flies than he had eaten the day before. How many did he eat on each of the five days?

■ **The Architect's Problem**
This diagram shows an aerial view of a square house that has a tree growing at each of its corners. An architect is asked to design a larger square house that will still be enclosed by the four trees. Can you draw a larger square within the four trees?



■ **Pick the Apple**
Only one apple is left on this tree. To pick it, you must start at the bottom of the tree and climb the branches. Do not cross a line.

■ **Diamonds Again**
The February 7 issue of *Nature and Science* contained an answer to a puzzle called "Little Diamonds." It showed how to connect nine small diamonds by drawing four straight lines.

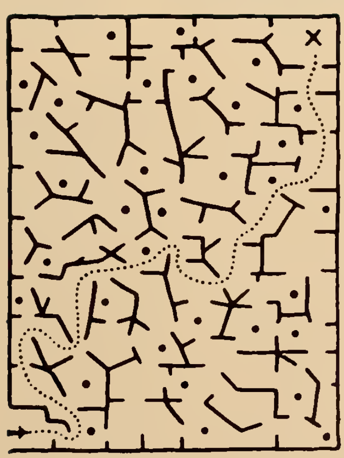
Since then, a *Nature and Science* reader has sent us another solution, connecting the nine diamonds by using just three straight lines.

Can you figure out the answer?

■ **Case of the Spreading Plant**
A tropical water lily was planted in a pond and quickly began to spread over its surface. Each day the plant covered twice the surface that it had covered the day before.

At the end of 30 days it had covered the entire surface of the pond. Can you figure out what day the water lily covered just half of the pond?

Solutions to Brain-Boosters appearing in the last issue of Nature and Science



The Trouble with Treasure: This is the route that Tom followed, passing just four men on his way to the treasure.
The Spy's Message: "Get ready to run."
Match the Satellites: Numbers 3 and 6 are identical.
How Square Are You?: There are 16 squares.
A Weighty Problem: When the iron is thrown overboard, the water level will fall, because the iron pushes aside less water on the bottom of the pond than it does while in the boat.
Colored Cubes: If you followed the directions properly, you found a sphere of colored ice in the center. If you were able to make ice that was colored all the way through, write and tell us how you did it and what materials you used.

HOW IT WORKS

MAKE YOUR OWN ELECTRIC MOTOR

How does an electric motor work? With a battery, a magnet, and some wire, you can find out.

by HARRY MILGROM

■ Electric motors are used to run all kinds of machines —from small battery-operated toys to huge locomotives. How many motors are there in your house? You will find one in the electric refrigerator, the vacuum cleaner, the washing machine, the electric clock, the record player, the electric mixer, the electric razor, and in other household appliances.

Every motor, no matter how large or small, operates because of the magnetic forces produced by electricity. You can watch the action of these magnetic forces if you make a model motor and experiment with it.

1. Cut about two feet from the 7-foot piece of hookup wire. Remove about 1 inch of insulation from both ends.

2. Wind the piece of wire you just cut around the ruler 7½ times. About 3 inches of wire should be left at each end of the wire coil *(see diagram 1)*.

3. Slip the coil off the ruler. Wrap the end wires around the short sides of the coil to hold it together. Carefully adjust the ends of the wire to form an axle on which the coil can spin around *(see diagram 2)*. Make the axle as straight as you possibly can. If it is straight and well aligned, the coil will turn freely when your motor is finished.

Is the wire coil magnetic? Will the horseshoe magnet attract it? Try it and find out.

Next move the coil around the compass. Does the compass needle change its position?

4. Place the coil near the compass so that the wire axle of the coil and the compass needle point in the same direction *(see diagram 3)*.

5. Now cut two lengths of hookup wire each 2½ feet long and strip about an inch of insulation off each of the ends. Next, connect the coil to the dry cell by attaching a bared end of each wire to each terminal of the cell. Complete the electric circuit by putting the free ends of the connecting wires in contact with the bared ends of the coil *(see diagram 4)*.

What happens to the compass needle when an electric current goes through the coil? Position the compass as shown in diagram 4. The electric current flowing through the coil magnetizes the coil and its sides become magnetic poles similar to those in a magnet.

You can identify these poles by means of one of the "laws of magnetism," which states that *unlike poles attract each other*. If one end (say the north pole) of the compass needle swings towards one side of the coil, then that side must be a south pole. The other end (south pole) of the needle will swing toward the opposite side of the coil, the north pole.

Making Your Motor Work

Now you can find out how to use the force of magnetic attraction to make the coil turn.

6. Wrap the two wires around the wooden base, as shown in the diagram, and make little loops in the ends. Both loops should be at the same height above the base so that the axle of the coil fits into them and holds the coil level, not at a slant.

Also, the coil should be suspended between the poles of the magnet as shown. Once you have fitted the bare wide ends of the coil into the loops, you can make a small loop at each end of the axle wires. This will keep the coil from slipping out of the upright loops *(see diagram 5)*. Now connect the two wires from the base to the battery.

This setup will permit electricity to leave the battery, flow through the wire, through the coil, through the other wire, and back into the battery again. Also the coil will be free to swing around.

You may have to push the coil at first to start it spinning.

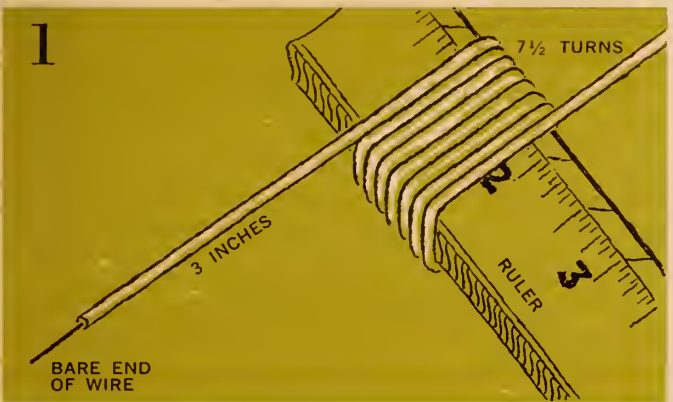
You have just built one of the simplest models of an electric motor. What makes it run?

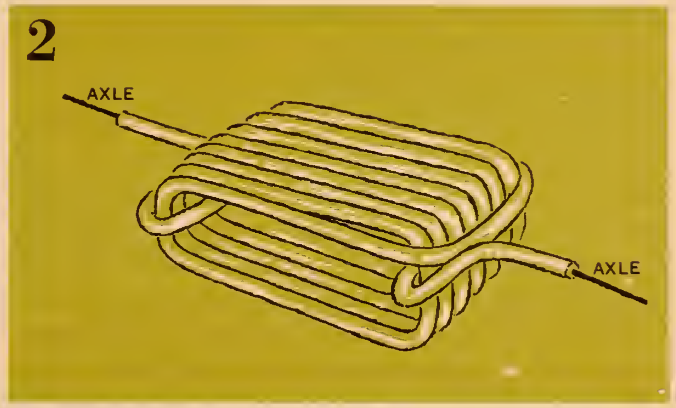
As soon as electricity flows through the coil, it becomes magnetized. The north pole of the magnet attracts the south side of the coil, and the south pole of the magnet attracts the north side of the coil. The force of magnetic attraction makes the motor run.

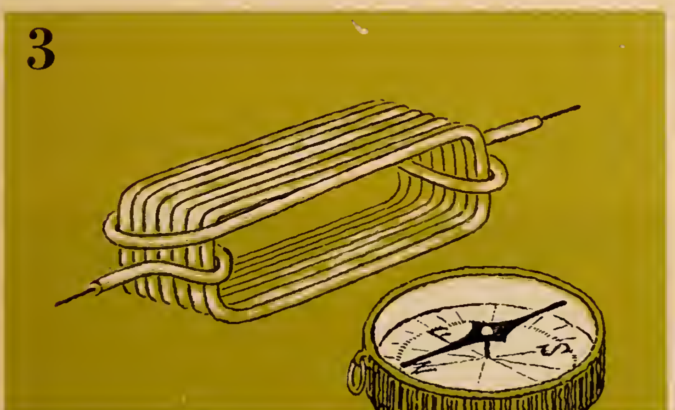
As the coil rotates it jiggles up and down in the loops of the wire supports. Each time the coil moves up the circuit is broken. The current halts and the magnet stops attracting the coil. However, the coil keeps it turning. When the coil drops down, the circuit is closed and the magnet gives the coil another flip. The coil will spin around in this way as long as the dry cell supplies electricity and remains connected.

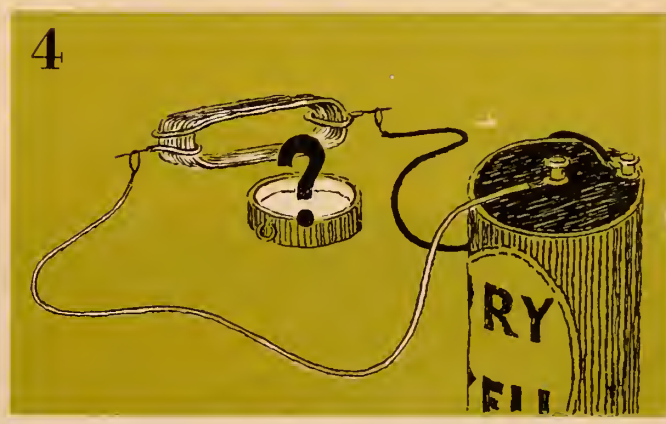
So you see that the operation of electric motors is based upon two principles. First, a coil of wire is magnetized by an electric current. Second, the poles of a magnet attract the opposite poles of a coil and cause it to turn.

Now that you know something about these principles, you may be able to design other simple motors. When you think of an idea for a model, make it and try it out to find out if it works ■



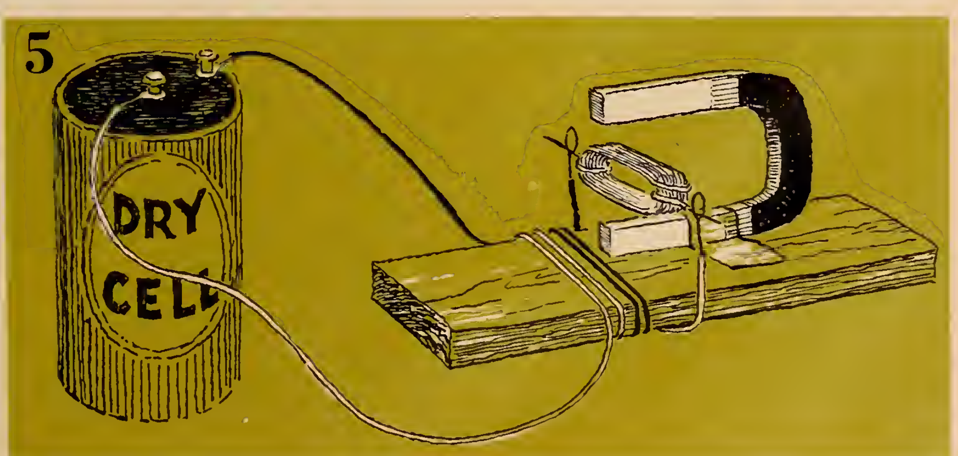






EQUIPMENT YOU WILL NEED

- 7 feet of plastic-coated bell wire
- 1 "U" or horseshoe magnet with poles about 1 inch apart
- 1 #6 dry cell
- 1 magnetic compass
- a wooden ruler or slat (about 1 inch wide)
- piece of wood 5″ x 3″ x ¾″



your MUSEUM at home

Sea Snakes

■ Of the more than 3,000 species of snakes in the world, 50 or so are species of sea snakes. All but one of these are found only in the warm tropical waters that wash the shores of Southeast Asia, Indonesia, and Australia.

Most sea snakes live close to shore, seldom wandering many miles from the coast. But there is an exception. One species, the "common sea snake," or *Pelamis platurus,* travels far from its tropical home waters of Southeast Asia. This snake lives westward through the Indian Ocean as far as the east coast of Africa and eastward through the Pacific Ocean as far as South America.

Sea Snakes Are Air Breathing

The bodies of sea snakes are well-shaped for swimming. They are long, with sides that are somewhat flattened (land snakes have fully rounded bodies). The tails of sea snakes are also flattened and paddle-like, and the snakes swing their tails from side to side to propel themselves through the water. When the sea snakes swim at the surface of the water, only the top of their heads show. The animals breathe through nostrils on the upper side of their snouts.

Sea snakes have to stay under water for a long time when they hunt for food—fishes and sometimes eels. Flaps inside the snakes' nasal passages close and keep out the water. The flaps open again when the snakes come up to breathe.

To find out how long a sea snake can stay under water before it has to come up for air, scientists on a deep sea expedition caught a few specimens, put them in a sealed container that was filled to the top with sea water, and waited. The snakes swam around excitedly—probably using up oxygen faster than they normally would while swimming in the open sea—and took two hours to drown.

Are Sea Snakes Dangerous?

Sea snakes are poisonous and their bite can be as deadly as that of the land vipers. The sea snakes' poisoning mechanisms—their fangs and venom glands—are much like those of cobras and coral snakes. Some sea snakes are not inclined to bite when they are handled. In some areas fishermen remove the snakes from their nets without fear of being bitten. But other species bite readily and have been known to bother bathers.

Sea snakes are helpless on land. They twist and turn in all directions, but they cannot move more than a few inches from their starting point. Some sea snakes *(Hydrophiinae)* never come out of the sea, and their young are born fully developed. Other sea snakes *(Laticaudinae)* spend some time basking in sunlight on rocks.—MARION B. CARR

This common banded sea snake (Laticauda colubrina) is on exhibit at The New York Aquarium. Like other kinds of sea snakes, this one lives in the warm waters of Southeast Asia and Australia.

nature and science

TEACHER'S EDITION / VOL. 1 NO. 13 / APRIL 3, 1964

SECTION 1 OF TWO SECTIONS

N&S VIEWS

A Selection of Guidebooks to Science Investigations and Experiences

by Elizabeth Hone and Mabel Crittenden

■ When children meet something new in science, they react mainly in these ways: What is it? How does it work? So what?

They need books to *uncover* and *discover* science—books that capture their interest, feed it, and lead them on to other investigations. They aren't after a name as much as they want to know what something does, how it behaves, and why.

Here are some of the best of dozens of investigation books that stimulate young people's interest and guide them to new and valuable experiences in many fields of science.

NOW TRY THIS TO MOVE A HEAVY LOAD, by Herman and Nina Schneider. W. R. Scott, 1947, 40 pp., $2.75.

The subtitle, "Let's find out how to move a heavy load, drag it along, lift it up, or roll it away," really tells the whole story. This book is cleverly written, cleverly illustrated to lead the younger pupil to understand how people with basically simple tools can move practically anything anywhere.

The investigations are simply written, amusingly introduced, and use materials that are always at hand. There are 18 of these experiments, grouped according to the method of moving.

FIRST BOOK OF STONES, by M. B. Cormack. Franklin Watts, 1950, 91 pp., ill., $1.95.

This is a fine book to introduce the study of rocks to young people. The hardness scale and other investigations are written into the text, and can naturally lead the child into observing and experimenting with tools and specimens available almost anywhere.

Illustrations in black and white show geologic features (caves, mines) as well as specimens. Rock collecting techniques and collections are discussed. Especially useful in lower grades.

FIRST CHEMISTRY BOOK FOR BOYS AND GIRLS, by Alfred Morgan. Scribners, 1962, 172 pp., ill., $3.50, lib. bdg. $3.31, paper $1.25.

This book includes 64 experiments to do with equipment and materials anybody could gather. Each is preceded by a general, chatty explanation of the usefulness, effect, or property of the materials used, followed by an outline of things needed and explicit directions on how to do the experiment.

The result is explained in terms of what it is, how it is used or produced commercially, and so on. Some write-ups are brief, others fill many pages. Many are illustrated. The experiments vary in complexity.

This book is simple enough to use in lower middle grades, and young people in middle and upper grades will find in it much they can do by themselves.

THE CRAZY CANTILEVER AND OTHER SCIENCE EXPERIMENTS, by Robert R. Kadesch. Harper and Row, 1961, 175 pp., ill., $3.95, lib. bdg. $3.79.

This book is for upper grades and/or enrichment classes. Illustrated with photographs and drawings, it contains 40 experiments that can be easily and economically carried out. They are planned to promote clear thinking, observation, and experimentation.

The experiments are cleverly outlined to entice children to try them. They stimulate the reader to figure out the "why's" and to apply his findings. For example, where should a weight (a box) be placed on the wheels of a "car" to get the best speed for the soap box derby?

Some of the directions get a bit involved, but on the whole they are well done.

HOW TO MAKE A MINIATURE ZOO, by Vinson Brown. Little, Brown & Co., revised ed. 1958, 196 pp., ill., $3.50.

A very popular book with young people who want to know how to catch, trap, feed, and house insects and small vertebrates—both land and water dwelling.

It suggests what is necessary to start and maintain "zoos," from the mayonnaise jar variety to outdoor zoos covering areas of 25 by 35 feet.

School librarians are often asked, "Is there a book that shows how to make good, safe, catch-alive traps?" This book helps fill this need.

SCIENCE PUZZLERS, by Martin Gardner. Viking Press, 1960, 128 pp., ill., $2.

Simple activities (some of them tricks) divided into groupings by subject —gravity, air, and so on. They are fun things—puzzlers—carried out with easily available and inexpensive materials.

They could well be used to stimulate children to learn more about a subject. They are designed to tell something important in science rather than just to entertain or astonish.

THE BOY ELECTRICIAN, by Alfred P. Morgan. Lothrop, Revised Ed. 1948, 402 pp., ill., $3.50.

This thick book is full of investigations into the field of electricity. It is also much more than an experiment book, for it suggests the construction of equipment and devices as well as experiments to perform. It covers the field quite well —from static electricity to electromagnetism to microphones to motors.

Boys in the middle grades, if given the chance and a few bits of wire, can soon be on their way in learning through doing. There is enough in the book to interest young people through many years.

This is not a new book, but it has been revised several times. A companion book is *Boys' Book of Science and Construction,* by Alfred P. Morgan (Lothrop, 1948, ill., $3.50), which treats everything from chemistry to physics to meteorology.

(Continued on page 4T)

Dr. Elizabeth Hone is Professor of Education and Director of the Conservation Foundation's Curriculum Center at San Fernando Valley State College, California. Mrs. Mabel Crittenden, of Menlo Park, California, is an elementary school librarian working with more than 30 teachers.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

PAGE 3 Sea Serpents

The mysteries and marvels of the sea have fascinated mankind for centuries. In the last issue of *Nature and Science* your pupils read about a comparatively new mystery, DSL. Here they meet a question as old as ocean travel: Are sea serpents real?

The article makes these points:

1. There are many known sea animals and other phenomena that can be mistaken for sea monsters.
2. There may be an unknown kind of large sea animal but scientists doubt that any "monster" exists.
3. Reports of unusual phenomena must be thoroughly investigated before being accepted as fact.

Suggestions for Classroom Use

A lively discussion is bound to take place after your class reads this story. Have the children consider other phenomena which have given rise to speculation, such as "unidentified flying objects" and the "abominable snowman" of the Himalayas. Careful investigations have failed to discover any "snowman" or flying saucers. Yet some people like to believe that they exist. You might discuss why people sometimes say, in effect, "My mind is made up. Don't confuse me with facts."

Activity

To demonstrate the questionable reliability of eye-witness reports, arrange for someone, perhaps a member of the class, to enter the classroom dressed in a fantastic outfit composed of many unrelated parts. Have him pass through the room and out again, making strange sounds and movements. Then instruct your pupils to write down what they saw and heard. Have a few of these reports read aloud to see how they compare, then bring the dressed-up person back so each pupil can compare his description with the real thing.

PAGE 6 Two Eyes

Last month a *Nature and Science* article described how the eyes of certain animals are adapted to see in the dim light. This article discusses another aspect of sight — "binocular" vision.

Your pupils will learn that:

1. Having two eyes enables us to perceive the depth of objects and to judge distances more accurately than with one eye.
2. Not all creatures have binocular vision, even though they may have two eyes. In general, eyes must be located near the front of the head for much binocular vision to be possible.
3. Generally, animals that live by attacking others (predators) have greater binocular vision than prey animals.

The basic concept involved is that *organisms are adapted to their environment.*

Suggestions for Classroom Use

Have each pupil hold up two pencils about a foot in front of his eyes, one in each hand, with the point of one touching the eraser of the other. By focusing on a distant wall he will see another pencil between the two he is holding.

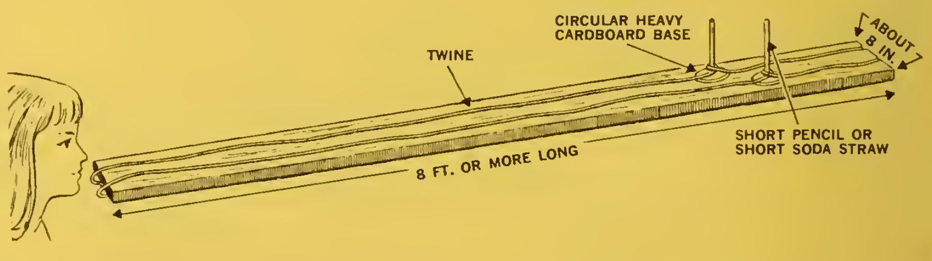
Another way to show that the brain combines the separate images of the eyes into a single image is to have each pupil hold a tube one inch in diameter (a rolled-up paper is fine) up to the left eye. Have him hold his right hand beside it, palm facing himself. When the left eye looks at the tube and the right eye looks at the hand, a hole will appear in the middle of the hand.

Activity

1. The article mentions the great range of a rabbit's vision. Each pupil can measure his own field of vision by this simple device. Have each child fix his eyes on a point directly in front of him with his arms stretched forward, and then slowly move his arms sidewards until he can barely see his hands. (Wiggling the thumbs helps.) Have each child observe the angle his arms make. Does one eye take in more than the other? What happens to the quality of the image as the hands move from front to side? How much wider is the field of vision when the eyes are moved from side to side instead of looking straight ahead?

(Continued on page 3T)

The suggestions for using this issue of Nature and Science *in your classroom were prepared by Patricia Ralph, elementary school teacher in the public schools of Huntington, N. Y., and member of our National Board of Editors.*



You could construct a device similar to this one to demonstrate to your pupils the importance of binocular vision in depth perception. The object is to align the two upright sticks by manipulating the strings. The sticks ride back and forth on circular bases. Have your pupils try to do it first with both eyes, then with only one.

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Using This Issue . . .

(Continued from page 2T)

PAGE 8 Unbreakable Laws

Our WALL CHART photographs show moving bodies such as were first studied by Galileo in the 16th century. Galileo was the first to realize that the physically significant quantities of a system in motion are mass, linear dimensions, position, and time. His studies set the stage for modern physics. Newton condensed Galileo's work into the first of three laws of motion: *The state of motion of a body (direction and speed, including zero speed) can be changed only by the application of a force.*

Suggestions for Classroom Use

Your pupils probably can identify "gravity" as the force that makes an unsupported object fall to the Earth. You might point out that gravity is a force that exists between any two bodies, tending to pull them together. The force of attraction between two bodies is proportional to the mass of each (the amount of matter contained in it) and inversely proportional to the square of the distance between them. The greater the mass of each body, the stronger the attraction; the greater the distance, the weaker the attraction. This will help you answer some questions that may arise, such as the following:

Why does a falling body accelerate, or pick up speed, the farther it falls? According to Newton's first law, a body must change its speed (accelerate) continually if a force — such as gravitation—continues to act on it.

Why do the two balls of different size, dropped at the same time, fall at the same rate of speed? The Earth's mass is attracting each piece of the mass of each ball with equal force. The particles need not even be attached to each other. For example, each book in a dropped stack of books falls with the same acceleration as the whole stack, whether or not they are tied in a bundle.

What causes the swinging ball to fall in a curved path? The Earth's gravity pulls the ball downward while the string keeps the ball at a constant distance from the point to which it is attached.

Why doesn't the ball stop when it reaches the point closest to the Earth? An object that has been lifted up against the pull of gravity has the capacity to do some work when it is released. This is called *potential energy*. At the bottom of its swing, this energy has all been converted into the energy of motion, or *kinetic energy*. This energy carries the ball up the other side and is returned to the form of potential energy.

The ball stops moving at the top of its swing, when all its kinetic energy has been reconverted to potential energy. It moves slowest (zero speed) just at that point, and fastest at the bottom of the swing, when its kinetic energy is the greatest.

Activities

1. Here is a way to find where the ball will go if the string breaks at the bottom of its swing, at the upper end of its swing, or halfway to that position. Attach a ball to a string and tie a loose loop in the end of the string. Push a nail through a piece of cardboard and hang the loop on the point of the nail. When the swinging ball reaches one of these positions, pull the nail out of the board to release the string and note which direction the ball goes.

2. This is a playground activity, for you'll need plenty of space. Instead of throwing a wrench to see how it revolves around its center of mass, attach a heavy ball to one end of a yardstick and a small one to the other end. Find the center of balance of the weighted stick and tie a light strip of cloth around it. When the stick is thrown horizontally, you can see it revolve around the center of its mass.

THE NEXT ISSUE of *Nature and Science* is a Special-Topic Issue on INSECTS. A fascinating account of a museum entomologist studying a parasitic bee in the field reveals some of the ways in which scientists learn about insects.

Other articles describe behavioral and physiological ways in which a variety of insects protect themselves from predators.

An article describing the amazing ways in which ants conduct their lives is followed by directions for building an ant maze and suggestions for using it.

Reference

A good source of information for teachers is "Gravitational Forces and Effects," a 16-page reprint of two articles from *Natural History* magazine by Dr. Kenneth L. Franklin, available for 75 cents from The American Museum-Hayden Planetarium, Central Park West at 79th Street, New York, N. Y. 10024.

PAGE 11 Seeds

This SCIENCE WORKSHOP provides your class several simple, low-cost, and interesting activities that are appropriate at this time of year. Here are some of the ideas that are developed:

1. A seed contains a young plant and a supply of food for it.
2. *Germination* is the sprouting of a seed.
3. While some seeds will germinate whenever there is water and warmth, other seeds will require a period of dormancy before sprouting.

Suggestions for Classroom Use

Studying germination offers a fine opportunity for arithmetic work in working out percentages. Be sure the children understand that percentage of germination — which is marked on seed packages—means the number of seeds out of every hundred that sprout, *not* how many plants may grow from a given packet of seeds. Nor does it indicate the percentage of plants reaching maturity. Can the children think why? (Other factors such as soil, weather, crowding, and disease affect survival.)

The article mentions that in plant laboratories scientists grow full-sized plants from embryos in solution. Minerals and vitamins are added to the solution to take the place of the minerals usually supplied by the soil and the vitamins usually supplied by the cotyledons.

Activity

Make your pupils aware of the energy needed to split the seed cover and push up out of the ground. Pack a small glass jar to the top with bean seeds, then fill the jar with water and cap it tightly. Set the jar in a larger container (to catch broken glass and spilled water). Your pupils may be surprised to find that the seeds expand with enough force to break the jar.

Books That Guide . . .
(Continued from page 1T)

EXPERIMENTS IN OPTICAL ILLUSION, by N. F. Beeler and F. M. Branley. Crowell, 1951, 114 pp., ill., $2.95.

This differs from the usual experiment book in that all the investigations show how one can be fooled into believing something that is not so. It is important for scientists to learn that sometimes "seeing is not believing."

Early chapters explain how the eyes work and what they see—depth, peripheral vision, color. Other chapters group optical illusions by type. There are many illustrations of optical illusions (with directions on how to draw them), and much effort is spent in explaining why the illusion takes place.

This is a good book for the upper-grade pupil. With creative teaching, it could lead to deeper study of light, sight, and related phenomena.

THE BOY ENGINEER, by Edward L. Throm. A Popular Mechanics Book, Golden Press, 1959, 243 pp., ill., $3.99.

This book starts with the engineering projects of early man and continues through the roads and buildings of Greece and Rome; the ships, waterwheels, pumps, and architectural feats of the Middle Ages; engineering accomplishments that produced the Industrial Revolution; and up to our Atomic Age. Drawings show how simple devices work and how some of them can be duplicated.

The last half of the book is divided into chapters on the main facets of engineering. For example a chapter on civil engineering discusses dams, canals, bridges, trusses, roads, tunnels, and so on, and includes experiments the reader can perform and diagrams of things he can make to develop understanding of these engineering achievements.

The appendix tells much about engineering as a career and lists sources of pamphlet material to help pupils plan. For middle to upper-grade pupils.

101 SIMPLE EXPERIMENTS WITH INSECTS, by H. Kalmus. Doubleday & Co., Inc., 1960, 175 pp., $3.50.

The experiments in this book are fascinating; the directions given are clearly stated; and upper-grade pupils can gain much understanding of physiology in general and of insects in particular by carrying out some of these experiments.

They are grouped by subject and cover investigation of body processes and reaction to various stimuli. The book explains how to raise insects and gives addresses of supply houses for use when local collecting is not possible.

Since some understanding of insect structure, habits, etc., is presented, this makes excellent material for advanced or gifted pupils ■

nature and science

VOL. 1 NO. 14 / APRIL 17, 1964

SPECIAL-TOPIC ISSUE

INSECTS

How they grow up
How they escape enemies
How we learn about them

ABOUT THE COVER

The insect on our cover is a *praying mantis,* called a "garden dinosaur" by photographer Edwin Way Teale. The name "praying" mantis comes from the way that mantises often hold their powerful front legs. Actually the spiny forelegs of a mantis are held ready to catch its food.

Some kinds of mantises grow to about six inches long, and they can kill small, young frogs and lizards. Most of their food, however, is insects. Mantises often eat each other.

In the fall, each female mantis lays about 125 to 300 eggs in a case resembling a cocoon on a twig or weed stem. When the eggs hatch in the spring, the young mantises wiggle out of the case and begin hunting for food. They grow to full size by the end of August. Look for mantises this summer. They make interesting pets and can be fed *live* insects such as flies, moths, and grasshoppers.

There are about 1,800 species of mantises, but they are just a small fraction of the many kinds of insects on the Earth. The articles in this special-topic issue of *Nature and Science* discuss some other members of the world of insects.

nature and science

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Contents

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digging for bees

BY JOHN BOWMAN

How a Museum scientist investigated a tiny bee that invades another bee's nest.

Dr. Jerome G. Rozen, Jr.,at a nesting site of ground-nesting bees in Arizona.

■ How many kinds of insects can you think of? Ten? Fifty? *Entomologists*—scientists who study insects—know of more than 85,000 different kinds, or *species,* of flies alone. And they know of about 110,000 species of moths and butterflies, and 275,000 of beetles. Altogether, there are some 680,000 known species of insects. Entomologists believe there may be a million or more others yet to be found.

The way entomologists go about their work of studying insects is as fascinating as the insects themselves. You can get some idea about what these scientists do from a glimpse into the work of Dr. Jerome G. Rozen, Jr., Chairman of the Department of Entomology at The American Museum of Natural History, in New York City.

If you were lucky enough to be able to visit Dr. Rozen's department you would see millions of insects collected from all over the world. And entomologists from all over the world come to the Museum to study them.

Dr. Rozen and his co-workers have a general knowledge about most of the known insects. But each entomologist in his department is concerned with one or more particular groups of insects. Dr. Rozen, for example, is particularly interested in bees.

Two Ways of Investigating Problems

A scientist studying bees, or any other animal for that matter, usually begins by trying to solve some special problem about the animal that interests him—for example, how a certain kind of bee navigates, or how bees have evolved from wasps. He has two basic approaches. One is the *experimental approach.* By setting up experiments in a laboratory, a scientist can control and change different things in an insect's environment—temperature, food, and so on. In this way the scientist can find out how insects behave, or what happens to them, under particular conditions *(see "Mealworm Watching,"* N&S, *March 20, 1964).*

Dr. Rozen feels that much valuable scientific research is done by using the experimental approach. But, he says, "many people mistakenly believe that the experimental approach is the *only* way to test a *hypothesis* (an unproved answer to a problem). In fact, the *observational* approach

(Continued on the next page)

can be just as important to scientists in this regard. Very often the most rewarding research is that which results from using both approaches."

With the observational approach, the scientist does not interfere with the animal he is studying by removing it from its living place and bringing it into the laboratory. If he is studying bees, for instance, he watches their natural behavior in the field.

For some years now, one of Dr. Rozen's special concerns has been *solitary* bees—bees that live alone. When you think of a bee, you probably think of hives or nests of honeybees and bumblebees. These are *social* insects that live in colonies—like ants and termites—and that have a caste system of queens, workers, and sometimes soldiers. With solitary bees, the female makes a nest and lays her eggs in it; when the young develop, each is like the other, goes its own way, and leads an independent life. Although many solitary bees nest close to one another in the ground in what is called a "nesting site," there is little or no shared activity of the kind we think of, say, in a beehive. Of the 2,500 to 3,000 different species of bees in North America, most are solitary bees and look quite different from honeybees and bumblebees.

A Bee That Uses Another Bee's Nest

There are still other kinds of bees which are neither solitary nor social. These are the *parasitic* bees. They are called "parasitic" because during their immature stages they live in the nests of solitary or social bees. The bees whose nest they live in are called the *"hosts."*

About three years ago Dr. Rosen started to study the biology and classification of a group, or *genus,* of parasitic bees called *Oreopasites.* These bees use the nest and food supply of the solitary host bees of the genus *Nomadopsis.* The parasite lays its egg inside a cell of the host bee's nest *(see diagram).* When the parasite bee's egg hatches, the *larva,* or young bee, kills the host bee's egg. It then eats the food, develops, and later emerges as an adult bee.

How did Dr. Rozen go about learning the details of this relationship? Watching the early stages of a bee's life and its activity in an underground nest presents a real challenge.

His first problem was to find the host bees in the open then trace them to their nest. How does a scientist go about finding a tiny bee—no longer than the diameter of a pencil? Most species of bees go to particular kinds of flowers for their food. Once Dr. Rozen locates the food plant of a particular species of bee, there is a good chance he will find a nesting site close by. Parasitic bees are seen most often flying around the nesting site of the host.

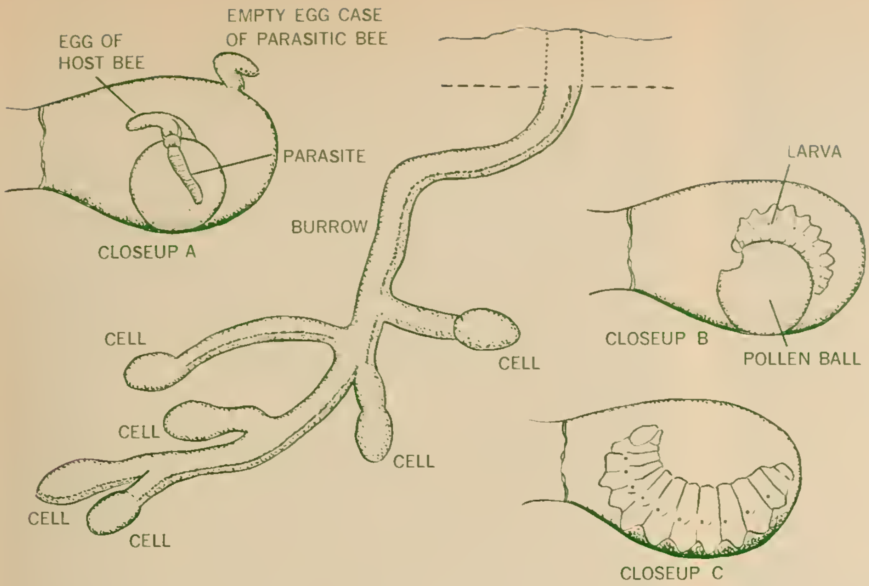
Digging for Bees

As a base of operations in the region where many of these solitary bees are found, Dr. Rozen uses the Southwestern Research Station at Portal, Arizona. This is kept by The American Museum of Natural History as a place for scientists to live and work while they are studying the wildlife of the area.

This region of Arizona often has long dry spells. When it becomes too dry, the flowers do not blossom, which means that the bees can't be located at that time. Last summer Dr. Rozen waited in vain for the rains to bring out the flowers and his bees. Finally he had to leave. As luck would have it, the rains came soon after, and a rich flowering brought out the bees. So, in September, Dr. Rozen flew back to Arizona again.

Let us follow Dr. Rozen to a nesting site to find out just how he observes bees. First he digs a small trench alongside one of the burrows leading down to the nest chamber. He tries to make the trench just miss the burrow and its cells. Next he chips away a little of the dirt and begins to expose the nest cell by cell. He gets his head down as close to the underground burrow as possible and

These three bees on mounting pins are from the Museum's collection. The largest one, a bumblebee of the genus Bombus, is a social bee. The next largest, genus Anthophora, is a solitary bee. The smallest, genus Triepeolus, is a parasitic bee. Although the bees are not shown life size, their relative sizes are accurate. All three are found throughout the United States.



Here is a typical nest of a solitary ground-nesting bee. The female enters the nest through the burrow. After filling a cell with a pollen ball, she lays an egg on top of the ball, and closes the cell. The pollen balls are the food supply for the larvae which emerge from the eggs. Closeup A shows an egg of the host bee being killed by a parasitic bee. Closeup B shows a pollen ball being eaten by a host bee larva. Closeup C shows a host bee larva fully grown, after having eaten its pollen ball. The larva next pupates, eventually emerging as an adult bee.

examines each cell as soon as it is uncovered. There is no danger of being stung, by the way. Neither the host bee nor the parasite has a stinger long enough to penetrate human skin.

Inside the cells he sees various stages of the host and parasite bees. Some cells contain newly laid eggs, with the food supply untouched; some have larvae in advanced stages, with the food supply eaten; occasionally some are found with the young parasite larva in the process of killing the egg of the host. Dr. Rozen says that finding his first parasite's bee's egg was quite a problem. The egg is very small and it is tucked into a hole in the cell wall. He says that he probably overlooked many eggs at first, thinking they were just tiny grains of sand.

Only by digging up many, many burrows and cells has Dr. Rozen been able to piece together a picture of the complicated relationship between the host and the parasite bees. You may wonder how observing cells with eggs or young bees at various stages of development enables a scientist to piece together the complete story of their relationship. When a cell is broken into, the life process stops. Studying only one cell or one nest, then, does not reveal the complete story. It reveals only one small part.

You can understand how Dr. Rozen has worked, though, if you imagine finding a movie film whose individual frames have been cut apart and mixed up. The problem is to put them back together in correct order. In effect, this is what Dr. Rozen has had to do in order to learn about each link in the chain of relationships between the host and parasite bees.

Observing Bees in the Laboratory

After Dr. Rozen has observed as much as he can of a nest, he removes some of the eggs and young bees and takes them to the laboratory for further study. He tries to keep them alive by keeping more or less the same temperature and humidity of the natural nesting site. No matter how careful he is, most of them die fairly soon. Sometimes a larva in a fairly advanced stage survives and develops into an adult bee. Yet even dead specimens yield much information in the laboratory.

Very little expensive equipment is needed to study bees in the field. You can explore a burrow with nothing more than a shovel, trowel, penknife, forceps, and a magnifying lens. The basic "tool" is patient observation.

You may wonder why scientists study bees. "For the same reason they study dinosaurs or skunks," says Dr. Rozen. "Because they are interested in the animals and want to learn all they can about them. Scientists know that there are important uses of such knowledge. For example, understanding how bees live is now beginning to enable us to control the population of 'important' bees. This in turn permits us to get higher fruit and crop yields because of the invaluable part bees play in carrying pollen from one plant to another" ■

If you would like to read more about insects and how to study them, here are some excellent books to look for in your library or bookstore: **Weird and Wonderful Ants,** by Lynn and Gray Poole (Oblensky, 1961, $3.50); **Exploring the World of Social Insects,** by Hilda Simon (Vanguard, 1963, $3.95); **Simple Experiments with Insects,** by H. Kalmus (Doubleday, 1960, $2.95); **Field Book of Insects,** by Frank E. Lutz, is good for identifying insects (Putnam, 1935, $3.95); **Adventures with Insects,** by Richard Hendstrom (Lippincott, 1963, $4.25); **Insect Builders and Craftsmen,** by Ross E. Hutchins (Rand McNally, 1959, $2.95); **Golden Question-and-Answer Book—Insects,** by Alice Gray (Golden, 1963, 50¢); **Insects** (a Golden Nature Guide), by Herbert Zim and Clarence Cottam (Golden, 1956, $1); **The Insect World,** by John Pallister (Home Library, 1963, $2.98); **Insects and Where You Find Them,** by Helen Damrosch Tee-Van (Knopf, 1963, $2.95).

The katydid and moth shown here escape detection by staying perfectly still and blending with the background.

The katydid's leaf-like shape and color protect it. The moth's color pattern alone makes it blend with the tree's bark.

How Insects Escape Their Enemies

Insects have many remarkable ways of avoiding being eaten. Some frighten their enemies, others confuse them, still others just seem to disappear.

BY PAUL VILLIARD

■ Nearly every animal is food for some other animal. Any animal that eats another one is called a *predator*. Insects use many different ways to defend themselves against predators. Many of these ways, which you can observe throughout the summer, are remarkable.

Some insects are armed against predation by having stinging spines, hard shells, or shapes that make them very difficult, or even painful, to swallow. Others keep out of the way of their enemies by being active in different seasons of the year, or during different times of the day or the night than the predator.

Still others spend their lives inside of things—trees, fruits, vegetables—or even inside other animals. There they are well hidden from their enemies and stand a much better chance of survival. The caterpillars of the Goat Moths live inside the trunks of trees. Codling Moth larvae live inside of apples. The Pumpkin Borer is a moth which, in the early stages of its life, lives inside the stems of pumpkin plants until winter time. Then it burrows into the ground, where it remains safe until spring.

Insects That Look Like Something Else

One of the most wonderful ways in which insects escape being eaten is the practice of *mimicry*. In its widest meaning, mimicry is the resemblance of one animal to some other animal, plant, or non-living thing. But some scientists use a narrower meaning. They say that mimicry is limited to one animal resembling another animal.

Many insects match their backgrounds in color so exactly that a predator who hunts for its food by sight finds it difficult to see the insect. Some moths, for instance, are colored just like bark, and when they alight upon the trunk of a tree they are almost invisible. Other insects have their wings colored dark on top and light on the bottom. A predator flying above one of them would find it difficult to see it against the dark background of the Earth. An enemy beneath it would find it hard to see against the lighter sky.

Another type of background matching is called *disruptive* coloring. Here the color pattern of the insect is broken up in such a way that it no longer looks whole. The predator fails to recognize the insect as an edible thing. Many moths and their caterpillars escape predators because of this.

In still another kind of mimicry, the insect takes the shape of something else. The "leaf insect" looks very much like a dead leaf. The "walking stick" is hard to tell from one of the twigs it resembles. The "treehopper," when sitting quietly on a twig, looks like a thorn.

Many insects have the shape of something that is not of interest to a predator. There are tiny beetles that look like seeds. Others, particularly the caterpillars of many moths and butterflies, look just like bird droppings when they are small.

Colors That Warn or Confuse an Enemy

Often an insect that tastes bitter to predators advertises the fact with bright or gaudy *warning colors.* After attacking one or a few of these insects, the enemies soon learn that prey with that particular kind of color is bad tasting, and they leave it alone. Insects with warning colors often stay right out in the open.

The Monarch Butterfly's bad taste to predators helps a different species of butterfly to survive. The Viceroy Butterfly, which tastes very good to predators, mimics the Monarch. Because it resembles the Monarch in coloration, in flight pattern, and in habit, the Viceroy's enemies can't tell it from the Monarch, so they leave it alone.

Many butterflies and moths have what we call *flash colors.* These are used to confuse their enemies just long enough to allow the insect to escape. Flash colors can be used in two ways. Some kinds of butterflies and moths have very brightly colored underwings and plain, drab upper wings. During flight, the bright underwings are visible. If a predator attacks it, the insect quickly alights on an object resembling the coloration of its upper wings. It then folds the upper wings over the bright underwings so that it blends with its background, and escapes detection.

Flash colors used in the opposite way also work very well. If the insect is quietly resting when it is attacked, it snaps open its upper wings, exposing the bright colors underneath. The sudden appearance of the spots of color may confuse the predator just long enough to allow the prey to dart away and escape.

Eye Spots as a Defense

An important protection among many moths and butterflies are *eye spots.* These are relatively large spots on the bottoms of the wings, but they may also be on the top. In time of danger, or when the insect is aware of being threatened, it folds up its wings or turns around and exposes the spots. The sudden effect of great staring eyes is often more than the nerves of the attacker can bear, and it may beat a hasty retreat.

Sometimes a moth will drop to the ground when it is threatened. It then thrashes about in the dry leaves, rapidly exposing and concealing the large eye spots on the hind wings. The combination of "eyes" and noise can be a very effective defense for the insect. A moth which often practices this kind of deception is *Telea polyphemus.* It is one of our largest and most common moths.

All of these methods of defense are examples of ways in which insects have become adapted to their environment. An individual insect that finds itself in circumstances to which it is not adapted dies. When the environment changes so rapidly that most of the insects of a species are ill-adapted to the new conditions, the species may die out in that place. This has happened to many insects around cities, where people change the environment greatly by their building, gardening, and other activities ■

Enemies of the Monarch Butterfly (top) leave it alone because it is bitter-tasting. Although the Viceroy (bottom) is not bitter tasting, predators leave it alone because it so closely resembles the Monarch.

When this Polyphemus Moth senses danger it usually drops to the ground and thrashes about. The combination of noise and the appearance of large "blinking eyes" caused by the eye-spots serves to frighten the enemy.

April 17, 1964

INSECTS THAT USE SHELTERS

Termites sometimes make covered runways from their nests to their food supply. For building materials, they use their excrement, saliva, and bits of wood. The runways protect termites from light and from drying out.

Hornets chew up wood fibers with saliva to make a paper nest. The nest contains several layers of six-sided cells, like a honey comb. Each cell is a nursery for a young hornet. The size of a nest depends on the size of its hornet colony.

■ Every day in the life of an insect is a day of dange danger from the extremes of climate and danger fi enemies. How do insects survive?

Some, such as adult beetles, have tough coats of arn Others live under loose bark, under stones, or in natı crevices where they find safety from their enemies. others, such as those shown on these pages, avoid attack hardships of climate by making shelters of their own.

The building materials that insects use include bits of tl surroundings—twigs, sand grains, clay, gum from pla secretions like silk, wax, and saliva, and their own exc ment, whether fluid or solid. A shelter may be made wh of one material, but usually it consists of a combination things collected and produced by the builder. As a rule, kind of insect builds only one kind of shelter.

An insect does not have to learn to build a shelter.

The "tent" of Tent Caterpillars shelters them at night and during rainy days. It is made from silk that is secreted by the caterpillars. After the caterpillars leave the tent and form cocoons, they develop into moths.

)yster Shell Scales spend their
s under a waxy covering that is
by the insects. Males lack this
hen adults, but have it as nymphs.
cts suck sap from plants.

The larvae of Golden-eyed Lacewings feed on aphids and scale insects. Some larvae cover their backs with cast skins and the remains of their victims. This probably protects the larvae from strong sunlight.

The soft-skinned nymph of a Spittle Bug surrounds itself with froth and keeps from drying out. To make the froth, the nymph pumps air into sap that it takes from the plant that it lives on.

bility is *inherited,* or passed on by parent to young. Because ndividual insects differ, not all of them build equally well.

It is unusual for an insect to remain sheltered throughout ts entire life. Insects that live in burrows, where they are urrounded by food, stay under cover until they are mature. Vhen, as adults, they emerge to find mates and new homes or their offspring, they are armored, often armed, and lways capable of a quick getaway.

Species that have to search for food often hide during he hours when their enemies are active or when it is too ot, too cold, or when other atmospheric conditions do not uit them. They come out to hunt for food while their foes re asleep and the temperature and humidity are comfortble to them. Since even the swiftest and strongest insect ecomes helpless with cold, many species which live in the pen during the summer must find shelter for the winter.

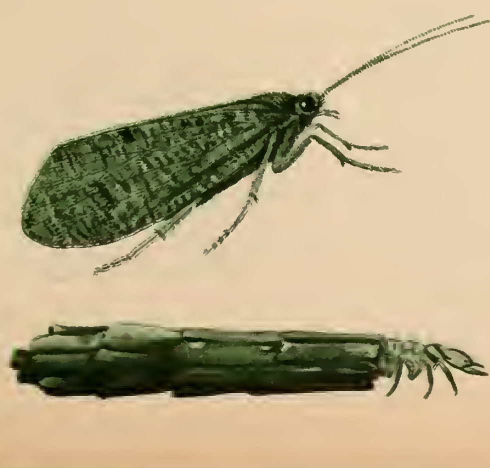
In very hot, dry places insects are in danger of drying up. Here they hide all summer and become active in the coolest and wettest season.

No insect is able to defend itself while it is changing its skin, or *moulting (see page 10).* Most of them hide in a safe place during the moulting period. Pupation *(see page 10)* is another period of helplessness. The pupation-shelters called *cocoons* are among the most familiar forms of insect shelters, but underground cells, such as those made by June bugs, are probably even more common.

Insect shelters are often easier to recognize than are the insects themselves. They may also be easier to find and collect. If you are very careful, you can usually open a cocoon or other shelter without injuring the insect. It is great fun to keep an insect "home" under observation and learn what you can about the animal inside.—ALICE GRAY

pple Gall begins when a wasp lays
side an oak leaf. After hatching,
secretes liquids that irritate the
s and a tumor, or gall, forms. The
; and pupates within the gall.

The larvae and pupae of Caddis Flies live underwater. As soon as the eggs hatch, the larvae of some Caddis Flies make portable shelters from silk and bits of plant. The shelters are also cocoons for the pupae.



The Potter Wasp makes a vaselike nest from mud mixed with saliva. Then the wasp fills the nest with spiders which it has paralyzed with its sting. As the wasp larva develops, it feeds on the spiders.

HOW INSECTS GROW UP

■ A young insect is much smaller than an adult insect of the same kind. Sometimes, but not always, it is also very different in shape, lives in a different place, and eats different food.

For insects, a leathery skin takes the place of a skeleton of bones. The muscles are attached to the inside of it. An outside skeleton works best when it is like a suit of armor, made up of hard plates with joints between them. That is just what most insects have.

Insects Change Their Skins

A suit of armor doesn't stretch much. As the insect grows, a new and larger skin is formed beneath it—all wrinkled up with tiny folds to make it fit inside. Then the insect swallows a lot of air (or water, if it is a water insect) and blows itself up like a balloon. The old skin splits down the back. The insect then drags itself out of its old skin, and the new skin is stretched tight. This process of skin changing is called *moulting,* and the skin which comes off is said to have been *cast.* Some insects moult only a few times in their lives; others as many as 20 times or more.

Female insects produce eggs. A few species carry the eggs inside their bodies until the eggs hatch, so that the young seem to be born, like puppies. Most kinds of insects lay their eggs where the young will find the right kind of food and a good place to live when they hatch out.

Most kinds of insects grow up in one of two ways. When they are hatched, the young of grasshoppers, cockroaches, stink-bugs, and many others look almost exactly like their parents, except that the young have no wings. The wings begin to show as little "pads" on the back when the insect has moulted two or three times, and get bigger at every moult, reaching full size when the insect is mature.

Young insects like this are called *nymphs.* They live in the same places as their parents and eat the same kind of food. Scientists call this kind of growing-up *incomplete metamorphosis.* "Metamorphosis" is a Greek word that means "a change of shape."

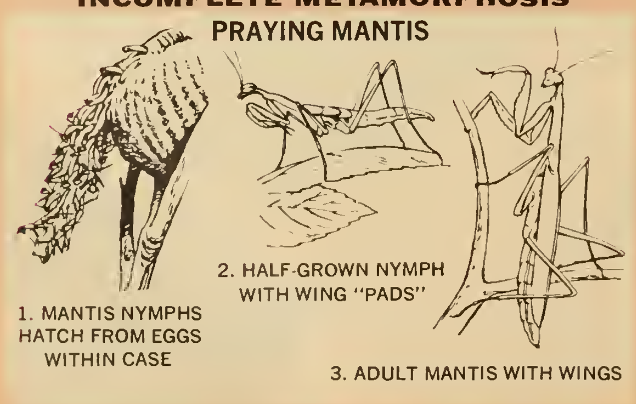
Complete metamorphosis is the scientist's name for development like that of butterflies, beetles, flies, and many other insects whose young don't look anything like the parents. A young butterfly is a caterpillar. A young beetle is a grub. A young fly is a maggot. At this stage in their lives, the young are called *larvae.*

A larva may or may not live in the same place and eat the same food that the adult of the same insect eats. Ladybugs do; both stages live on plants where there are plenty of small, soft insects for them to eat. Butterflies don't. Almost all caterpillars eat leaves; the adults have mouths like sipping straws and can feed only on sap, juice, the nectar of flowers, and other liquids.

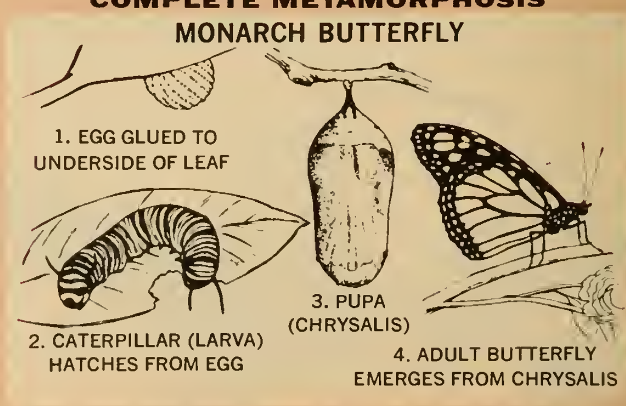
During the time an insect is changing from a larva into an adult, it takes still another shape—the *pupa.* If you have ever cut open a moth cocoon to look inside, you know what one pupa is like. A pupa cannot eat. It is almost always unable to move far or fast, so it is protected either by its color and form or by using a shelter, such as a cocoon or an underground cell.

—ALICE GRAY

INCOMPLETE METAMORPHOSIS

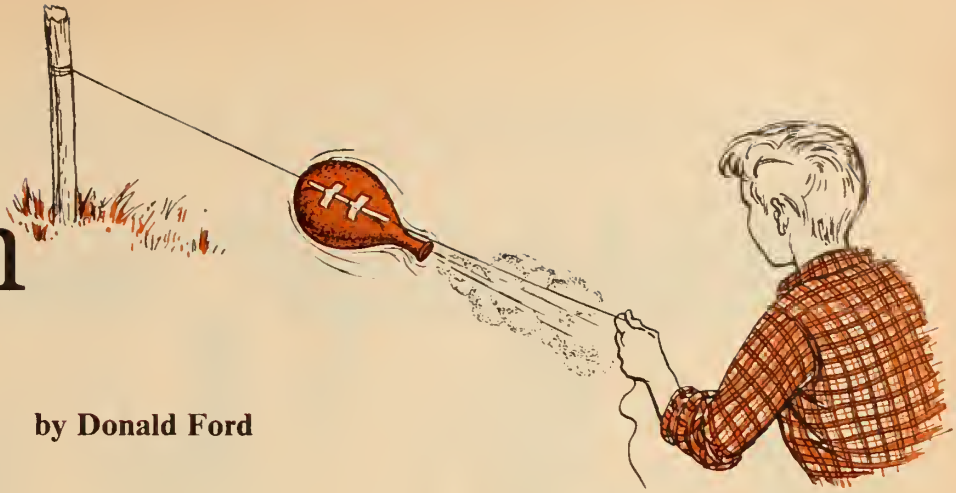


COMPLETE METAMORPHOSIS



make a balloon rocket

by Donald Ford



■ When you fill a balloon with air and let it go, it becomes a sort of rocket. It zooms through the room on a wild course. This article will tell you how to make a straight-flying balloon rocket, and may give you some ideas about how rockets work.

First get a balloon and blow it up. Does air inside the balloon push back into your mouth harder when you start to blow it up or when it is nearly filled with air?

PROJECT

Heating the air in a balloon is another way of "blowing" one up. Slip the nozzle of a balloon over the mouth of a quart soda bottle. Then put the bottle in a pan of boiling water. How big does the balloon get? Why doesn't it get bigger? Try the same thing with a smaller bottle. Does the bigger bottle blow the balloon up more?

You can see how hard a balloon pushes back by filling one with water and then letting the water go. Attach a balloon to the faucet in the bathtub, and fill it with water. Then rest the balloon on the bottom of the tub, with the nozzle pointed up, and release the nozzle. Does the balloon push the water out steadily? When does the balloon push the water the highest? You might stand a yardstick in the tub and measure how many inches the water shoots into the air.

When you fill a balloon with air and let go of the nozzle, air rushes out of the balloon as the water did. Can you guess at what point of a balloon's trip it will go the fastest? To find out, you can make a balloon rocket.

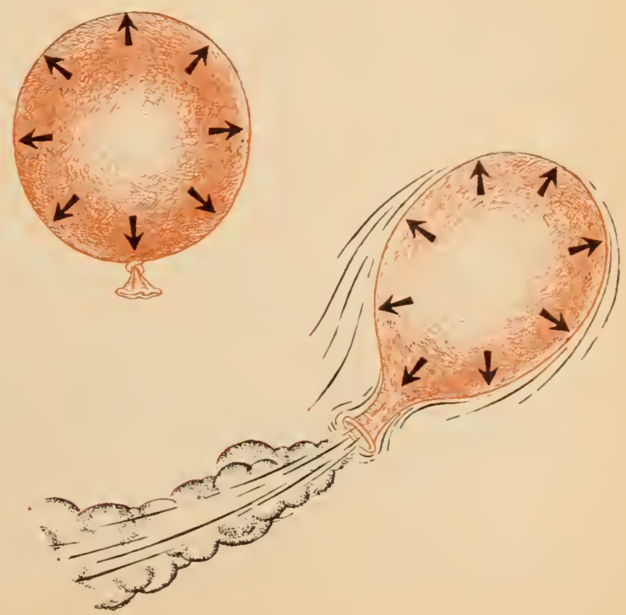
To make a straight-flying balloon rocket, you will need a balloon, a soda straw, about 20 feet of string, and some plastic tape. Push the string through the straw and tie one end of the string to a doorknob, tree, or other support. Blow up the balloon and tape the straw to it (*see diagram*). Pull the end of the string firmly so that the string does not sag. Then let the balloon go.

When does the balloon go fastest? At what point in its trip do you think the strongest spurt of air comes from the balloon's nozzle? How does this compare with the highest stream of water that came from the balloon in the bathtub?

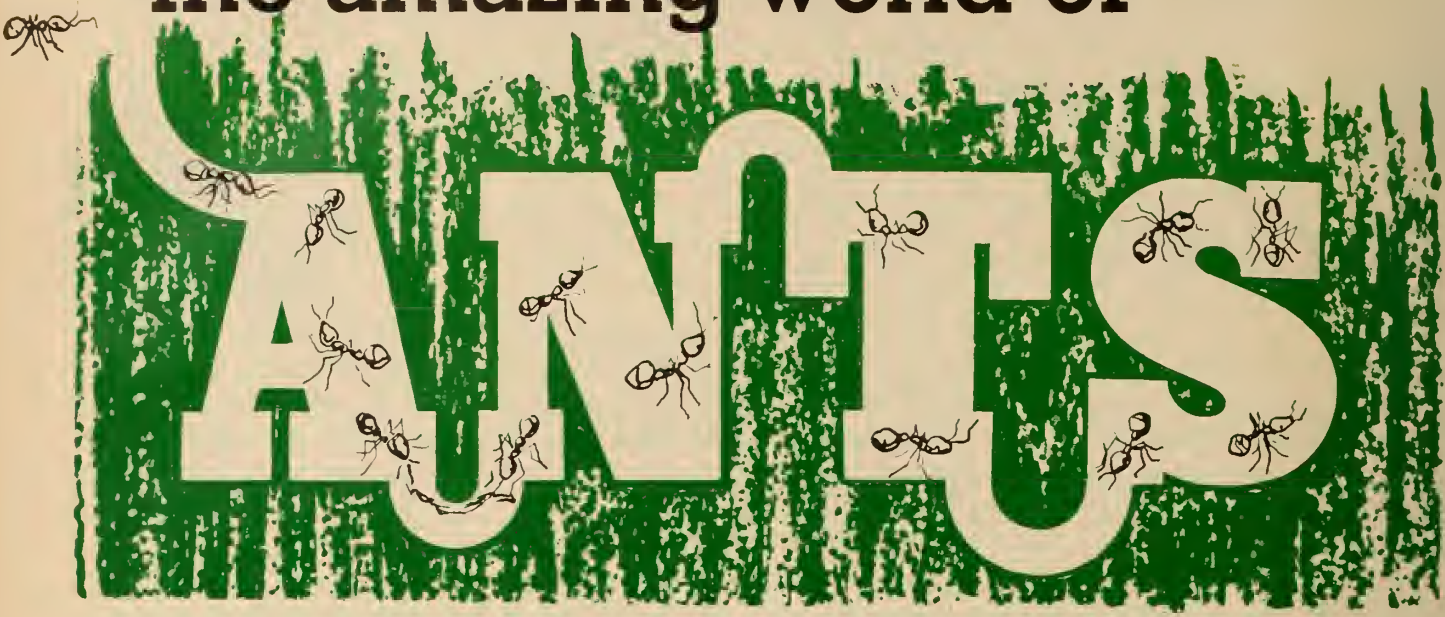
How a Rocket Works

The air (or water) in a balloon pushes against the inside surface of the balloon in all directions; it pushes just as hard in one direction as in any other direction. When you open the balloon's nozzle, the air rushes out through the hole because there is no balloon surface there for it to push against. At the same time, some of the air in the balloon is pushing in the opposite direction (*see diagram*). Its push, or *thrust,* against the side of the balloon opposite the nozzle is what makes the balloon go.

What would happen if you attached two balloons to a straw, with the nozzles of the balloons pointing in opposite directions? Try it. Do you think it would make any difference if one balloon were blown up big, and the other small? If so, in what direction would the straw move? ■



the amazing world of ANTS



BY PAUL SHOWERS

Some ants are skilled gardeners and raise their own food. Others keep "slaves" and store food in them. This article and the one on the following page tell how you can learn about these fascinating insects.

■ Did you ever watch a group of ants swarming over a piece of bread, tearing at it with their powerful jaws? For its size an ant has great strength and will often seize a piece of food several times larger than itself and carry it off to its nest.

Did you ever watch an ant war, with the ants from two different nests locked in deadly combat? Many kinds of ants are savage fighters, biting or sawing off their foes' legs and heads with their jaws, or using their stingers to paralyze or kill the enemy.

How Ants Build Their Nests

There are more than 6,000 different kinds, or *species*, of ants in the world, and they have many different ways of building nests and gathering food. Weaver ants in the tropics build their nests of leaves. They bind the leaves together with silk that is spun by the young ants, called *larvae*. Some forest-dwelling ants make nests of crude paper. They make the paper themselves by chewing wood.

Most ants nest in the ground. In hot, dry regions the desert ants may tunnel down more than 10 feet until they reach the moisture they need to keep alive.

Some kinds of ants have no fixed home but travel from place to place in large armies. These army ants of Central and South America march overland and carry out great raids. They invade the nests of other insects and carry off the young and the adults as food.

Ants feed on many different things. The harvester ants of the southern and southwestern United States gather grain and grass seeds and take them into their nests. There they strip off the husks and store the kernels for future use.

The parasol ants of Central America grow their own food supply underground. These ants cut up the leaves of nearby trees and bushes. Carrying the leaf fragments over their heads like umbrellas, they march down into the nest. There they chew the leaves into a soft mass and carry it into storage tunnels. In these dark gardens a certain kind of plant, called *fungus*, begins to grow on the moist leaf pulp. The fungus, not the leaves, is the food that the parasol ants live on.

Ant Colonies and the "Honeypots"

Ants are called *social insects* because they live together in groups or colonies, never alone. Each ant performs certain duties. Every colony has a queen ant surrounded by soldier ants and various other kinds of workers. The queen lays the eggs, which means that she is the mother of the entire colony. While the soldiers—the largest work-

AN INVESTIGATION

How do ants communicate? Swat a fly and drop its body a few inches from the entrance to an ant nest. How long does it take for the first ant to find this food material? What does the first ant do after finding the fly? How soon do other ants come? How many come? What do they do with the fly?

ers—defend the nest, the medium-sized workers gather food. The smallest workers spend most of their time taking care of the queen and her brood of young ants.

One unusual kind of ant—the honeypot—uses some of the workers of the colony as food storage tanks. The food gatherers bring honey to the nest. There they pump it into the crops, or pouch-like storage stomachs, of other workers. These storage crops, which are called "social stomachs," swell up to such a size that the ants cannot move. All they can do is cling to the ceiling of the nest. There they remain, ready to supply the other workers with food when it is needed.

Scientists interested in the behavior of animals have carried out many experiments to find out how ants see, smell, feel, and if they can learn to solve problems. We know, for example, that ants have a keen sense of smell, located mainly in their feelers. By smell, each ant knows whether another ant is a friend from the same nest or an enemy from a strange nest.

If their feelers are coated with varnish their sense of smell is blocked and strange things can happen. Or, using a fine brush, it is possible to coat an ant's body with vanilla to give it a new and stronger odor. Then two ants from the same nest may fight each other. On the other hand, two coated ants from different nests may get along peaceably, even though they usually are enemies.

How Ants Find Their Way

Trailmaking ants leave behind them invisible pathways of scent as they go to and fro. These trails of chemical scent can lead to a food supply and the trails are followed by other ants of the colony. You might be able to see this happen around your own house. If you find a train of ants, draw your finger firmly across their path and see if this breaks the scent trail.

Other kinds of ants do not rely on scent trails but depend on their eyes, being guided by lights and shadows. If you shine a light on the path they follow to and from the nest, and then change the position of the light, you can confuse them.

A good way to study ants is to build a maze. It is a kind of puzzle for them. You can make your own ant maze and set up a number of problems for the ants. Then you can observe them and learn how they master the maze. On the next page we show you how to build an ant maze ■

Some ants keep ant "cows," or aphids called plant lice. The aphids supply the ants with "honeydew," a sugary liquid which the ants feed on.

This is a Parasol Ant. It is carrying a piece of leaf to the colony nest, where it will be added to a store of chewed leaf material and used to grow fungus which the ants eat.

How do ants find food? Can they discover a new route to it when the old route is closed? What do ants do when they meet? These are just a few of the questions you can find answers to by—

Building Your Own Ant Maze

■ With the directions on the facing page, and with help from an adult member of your family, you can build an excellent ant maze. This article tells you how to do it, how to collect some ants, and how to set up the maze.

By running your ants through the maze, you will discover many interesting things about them—their feeding habits, the way they meet each other, how they find their way about.

How to Collect Ants for Your Maze

When you collect your ants, take a spade, a large spoon, and the nest jar, using an extra lid without holes in it. Two kinds of ants that you can easily find for your maze are (1) the medium-sized black ants that nest in lawns, in gardens, and under rocks in fields, and (2) the gray field ants that often nest under stones.

When you find a nest, dig up the clump of earth containing the opening. Look for the ants' tunnel beneath it. Dig along the tunnel carefully, examining each spadeful for chambers of the nest. Scoop up the ants, their cocoons, and the pale, grub-like larvae, and drop them in your nest jar. If you dig far enough, you may capture the queen. She will be considerably larger than the workers around her. Try to get the queen. Without her, your ants will die sooner than they would normally.

After you get your ants home, connect the nest jar with the maze, drop water in the moisture tube, and cover the jar. By keeping out the light you will encourage the ants to build tunnels next to the glass where you will be able to see them. Leave the ants alone for a day or so to get used to their surroundings. Then try some experiments.

How to Observe Your Ants

Put your ants on a regular feeding schedule. This is important. Mix a half teaspoonful of sugar in half a cup of water and store it in a clean bottle. Feed your ants at the same hour every day by using a clean medicine dropper and putting four or five drops of sugar water on a piece of cardboard. Place the piece of cardboard in the feeding chamber. (At this stage, both maze barriers should be left in the open position.) After a while the ants will find their way from the nest into the plastic tube, through the maze, and into the feeding chamber.

Starting half an hour before feeding time, keep a record of where the ants are moving. Every ten minutes during the half-hour, count the number of ants in the feeding chamber. If no ants are in it, enter 0 in your record. After the ants have learned to find their way into the feeding chamber, count the number of ants in the chamber every 10 minutes after feeding time for half an hour, and keep a record of the totals.

Do this exactly the same way for several days. Use a piece of clean cardboard each time you feed them. Be sure the light always shines on the maze and feeding chamber from the same side.

Get a magnifying glass and watch the ants closely. What does an ant do when it finds food? What do the ants do when they meet each other? Do most of them follow one pathway through the maze? How long does it take most of the ants to learn when it is feeding time?

After the ants are used to the trip to the feeding chamber, make a dead end in the maze by sliding the maze barrier B_1 into the passageway to block it off. The barrier must fit snugly in its groove and against the center block (H) so the ants cannot get past. What do the ants do when they come to it? How soon do they find the other way through the maze? How long does it take before most of the ants have learned to bypass the dead end?

When the ants have learned to avoid the barrier, open it again and close barrier B_2. How long does it take them to find the new pathway to the food?

Change the ants' food from time to time. Double the amount of sugar in the mixture. Cut it in half. Try different kinds of food. How do these changes affect the ants? Shift the light from one side of the maze to the other. Does this affect the ants? How?

Not all of these things are easy to do, and you may have to try more than once until you succeed. But you will find that the joy of running tests with your own ant colony is worth all the work.—PAUL SHOWERS

HOW TO BUILD IT

Cut the molding into strips 3½ inches long. With it build two 3-inch fences near the ends of the board, overlapping the ends of the strips. Cement the molding in place. With a small saw cut gates in the fences at (E) and (F) just wide enough so that the ends of a glass tube fit into them snugly. Cut a gate at (G) just wide enough for the flexible tubing. Place the 2-inch-square wooden block (H) exactly in the center of the right-hand fence and cement it down. This fence now has a passageway all around the inside. It is the maze chamber.

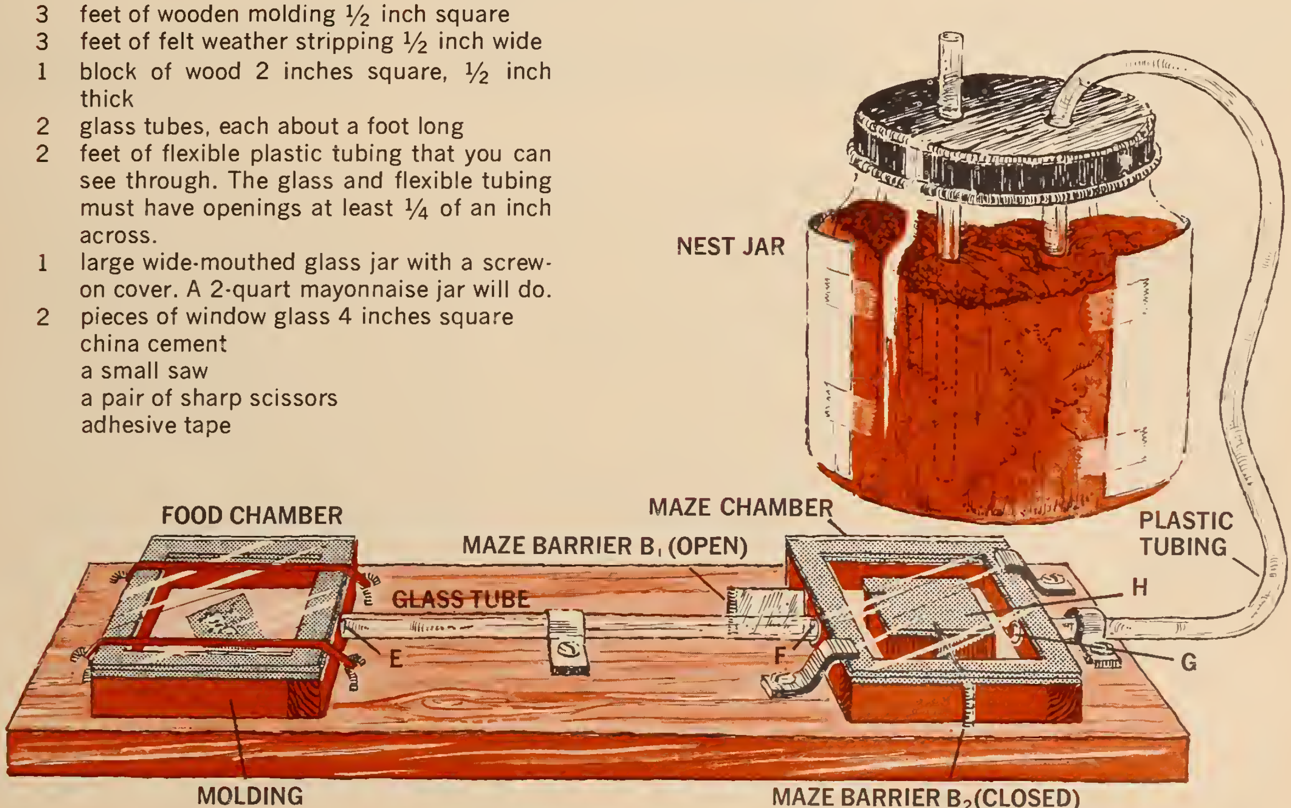
To make the maze barriers, cut a slit the width of the saw blade at B_1 and another at B_2. Now cut out two strips of cardboard in such a way that they slide snugly back and forth in slits B_1 and B_2. The diagram shows the B_2 barrier in the closed position blocking off the passage; the B_1 barrier is shown open. The fence at the other end of the board is the feeding chamber.

Now connect gates (E) and (F) with a glass tube, fitting the ends into the openings. Fit one end of the flexible tubing in gate (G). For tight fits, you can twist rubber bands around the ends of the tube and tubing, or fasten adhesive tape around the ends. Fasten both to the board with strips of tape (or use metal strips and screws as shown in the diagram). Cut some weather stripping into pieces 3½ inches long and with china cement fix them around the top of the maze and feeding chambers. Cover the gateways with the strips, allowing the cement to run down around the ends of the tubing to fill the chinks. Make sure the cement does not clog the tube openings. Cement a weather strip covering on the top of block (H). When the cement is dry, cover the maze and feeding chambers with squares of glass, holding them in place with strips of adhesive tape (or metal). Another way to hold down the glass tops is to stretch rubber bands between screwed hooks (see diagram).

Your ants will need a nest to live in. Fill about half of the large glass jar with earth. Make two holes in the lid. Push the flexible tube from the maze through one hole until part of it barely touches the earth. Push a glass tube through the other hole, forcing it well down into the earth. Ants must have moisture, but not too much. Drop water down the glass tube with a medicine dropper so that the earth around the base of the tube is kept damp. Keep the earth moist but not wet. For tight, ant-proof connections, you can twist rubber bands around both tubes just above and below the lid.

Materials You Will Need

1 smooth board 6 inches wide, 2 feet long
3 feet of wooden molding ½ inch square
3 feet of felt weather stripping ½ inch wide
1 block of wood 2 inches square, ½ inch thick
2 glass tubes, each about a foot long
2 feet of flexible plastic tubing that you can see through. The glass and flexible tubing must have openings at least ¼ of an inch across.
1 large wide-mouthed glass jar with a screw-on cover. A 2-quart mayonnaise jar will do.
2 pieces of window glass 4 inches square
china cement
a small saw
a pair of sharp scissors
adhesive tape



brain-boosters

■ **Balance the Board**

Here is a game that you can play with four nickels, a yardstick, and a sharp-edged object to balance the yardstick on. First see how many different ways you can balance the yardstick by putting the nickels in different positions.

One way is to put a pile of nickels on each end of the yardstick, like this.

You can also keep the yardstick balanced with a pile of three nickels on one side and one nickel on the other.

Can you balance the yardstick by arranging the nickels along the yardstick without piling them? Try it. Once you have figured out several ways of balancing the yardstick by moving coins around, try to solve this puzzle:

Pile all four nickels at the point of balance, or *fulcrum*. Then, keeping the yardstick balanced at all times, what is the least number of moves needed to rearrange the nickels into a pile of three and a pile of one? A move is any new arrangement of two nickels that will not unbalance the yardstick.

How many moves does it take? Three? Five? Ten?

■ **How Much Money?**

When Bill bought his lunch at school, it cost him half of the money that he had brought from home. After school he bought a candy bar for 10 cents, and also had a snack at a diner. The snack cost half of the money he had left. He left a five-cent tip at the diner.

Then Bill spent seven-eighths of his remaining money on a magazine. When he reached home, he had a nickel in his pocket.

How much money did Bill have when he started out?

■ **The Six Beetles**

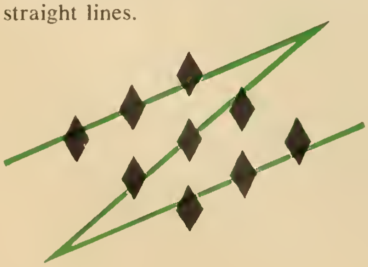
All of these beetles may seem the same, but only two are identical. Can you find the identical pair?

Solutions to Brain-Boosters appearing in the last issue

The Frog's Diet: The frog swallowed 8 flies on the first day, then 14, 20, 26, and 32 on the next four days for a total of 100 flies in five days.

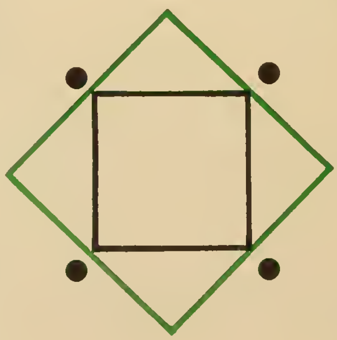
Case of the Spreading Plant: Each day the water lily covered twice the surface that it had covered the day before. If it covered the whole pond after 30 days, then it covered half of the pond on the 29th day.

Diamonds Again: Connect the nine diamonds by drawing these three straight lines.



Pick the Apple: Follow this route to pick the last apple.

The Architect's Problem: Here is how to design a larger house within the four trees.



nature and science

TEACHER'S EDITION / VOL. 1 NO. 14 / APRIL 17, 1964

SECTION 1 OF TWO SECTIONS

The Stuff from Which Questions Are Shaped

(Another in a Series of Articles about New Approaches to Science Teaching in Elementary Schools)

by David Hawkins

■ Last summer more than 100 teachers, science specialists and coordinators, professors of education, and scientists in various fields worked with 150 children in grades K-8 at the second Elementary Science Study Conference, held at the Peabody School in Cambridge, Mass.

They worked out teaching-learning strategies appropriate to a wide variety of science topics in elementary schools, designed materials and ways to use them, and tested their results in trial teaching sessions.

What is the philosophy which underlies such an effort? We of the Elementary Science Study staff have always been reluctant to answer this question in measured and formal prose. After the work is done and is ready to be set before its potential users and critics, then indeed it must be set forth in such a way as to communicate the educational purposes which it is intended to serve and by which we would have it be judged. But the goals of such a venture are not things which can be set down easily and economically at the beginning. They are, in a sense, its final outcome.

Questions Arise from Experience

By now we are far enough along to know some of the special and distinctive aims of our work. In science education at all levels, and certainly at the elementary level, there has been too easy an assumption: that in school children the developmental roots of adult human understanding of the world are already grown and consolidated sufficiently to nourish the above-the-ground growth of conceptual understanding.

A considerable amount of consistent accumulated experience indicates that such assumptions are false. Most school children, and indeed many presumably educated adults, are insufficiently acquainted with their own capacity for fashioning a well-organized understanding of things from the raw material of experience.

This is, I think, one of the things wrong with the too-pat phrase, "discovery method." Back of the experimentally determined answer is the question. Back of the question are the ideas which make its formulation meaningful to the questioner. Back of the ideas are exploration and preconceptual experience in which understanding has its roots.

A laboratory is too often seen only as a way of answering questions, and not often enough seen as a place to acquire the stuff from which questions are shaped.

Watch children filling squeeze bottles with water and squirting it up in the air, or squeezing bubbles out of it under water; painting with water; blowing soap bubbles; floating things on water—is this science?

Maybe it is, maybe it isn't. But watch the children at play with it or, as they doubtless would prefer to say, at work. Notice the absorption, see the inventiveness, let your eyes and ears communicate to you . . . here is the characteristic human involvement with the world. If the situation is optimal you will see learning at a rate that is breathtaking.

Is the older child, as he so often appears, incapable of this degree of autonomy and this intensity of interest? Is he merely regressing to the ultimate norm of adult dullness? Or is it our failure to provide this early rich opportunity which robs children of the assurance of success and the means of pursuing it at a more adult level?

DICK LEBOWITZ, EDUCATIONAL SERVICES INCORPORATED

In making this oversized checker set, fifth graders at the Elementary Science Study Conference School faced problems of scaling, geometric forms, and consistency in units of measure.

Early Learning Is Crucial

We do not know, and it is good to say that at this level there are many things we do not know. But there is a strong hunch that the early learning, or lack of it, is crucial; and where the early learning has been missed there is an equally strong hunch that what has been missed early cannot be faked or by-passed.

Work on lights and shadows goes well in the first or second grade, but let me tell you a story about astronomy in the fifth grade. We read about the solar system and the sizes and distances of the planets. Of course it will not do just to read; we want activity, we want the laboratory. So we start to build a model of the solar system, with globes, balls, marbles, or plasticine spheres. There is no complaint, but the class isn't very much interested, except for one or two.

At this point a visiting science teacher appears and is told about the class's work. He finds it very interesting and asks a very few simple questions.

Did anyone notice when the Moon rose last night? Have you ever noticed that the Sun moves across the sky? "The Moon doesn't rise, the Earth turns." "The Sun doesn't move either." "But does the shadow of the gymnasium move?" Confusion. Finally a consensus that it does.

Next meeting they go out to measure the shift of the shadows of individual sticks they put in the ground. (We are getting down to earth.) One child: "But my shadow changes when I move from one place to another." "Would it be the same now in Belmont?" Uncertainty.

(Continued on page 4T)

David Hawkins is the Director of Elementary Science Study, a program of Educational Services Incorporated, 108 Water Street, Watertown 72, Mass. This article is adapted from a pamphlet, "Highlights of the 1963 Elementary Science Study Summer Conference." Further information may be obtained by writing to Mr. Hawkins.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

The fascinating world of insects is the special topic of this issue of *Nature and Science*. Articles in the student's edition are designed to help your pupils develop an inquiring, objective attitude toward these animals and an appreciation of observation as a part of scientific method. Here is some additional information that should be useful to you in conducting class discussions on the subject.

What Is an Insect?

Insects belong to a group of organisms known as *arthropods*, meaning animals with jointed legs. Arthropods include such animals as lobsters, spiders, and centipedes. True insects are those arthropods that have (1) six legs, (2) three body parts (head, thorax, and abdomen), (3) a pair of antennae, and (4) usually one or two pairs of wings in the adult stage. Thus, spiders and ticks (eight legs) are not insects.

The stages most insects pass through from egg to adulthood are described in "How Insects Grow Up," on page 10.

The struggle of animals for survival involves problems of obtaining food, protection against enemies and adverse conditions, and reproduction. Animals with physical and behavioral characteristics that enable them to survive are said to be adapted to their environment.

Through the ages, insects have proved amazingly successful. They outnumber all other living creatures. There are over 680,000 known species of in-

(Continued on page 3T)

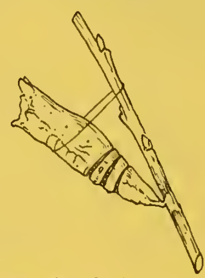
The suggestions for using this issue of Nature and Science *in your classroom were prepared by Patricia Ralph, elementary school teacher in the public schools of Huntington, N.Y., and member of our National Board of Editors.*

SOME OF THE INSECTS AND INSECT SHELTERS YOUR PUPILS ARE ALMOST SURE TO FIND

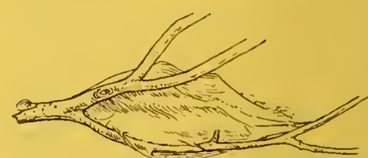
Representatives of these categories occur almost everywhere, though the species vary with locality. Be prepared for surprises. Any specimen is likely to yield one or more parasitic flies or wasps, instead of the insect expected.

Plant galls yield wasps and flies often; moths; beetles, or other insects less frequently. The one shown is the Blackberry Knot gall, caused by a wasp. Emergent adults will almost all feed on sugar water.

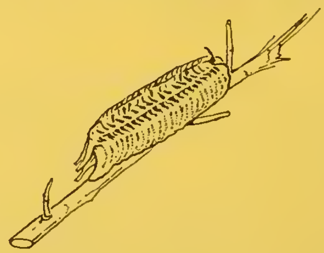
A silk bag thatched with bits of leaves and suspended from a twig is the work of a Bagworm, caterpillar of a Psychid Moth. The tiny black caterpillars that hatch out feed on the foliage of many bushes and trees.



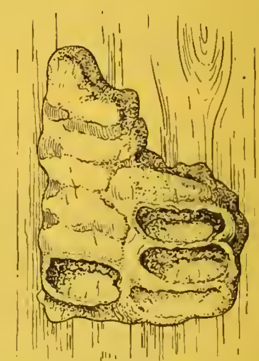
This rough, knobbly chrysalis with a silk thread around its "waist" is that of a Swallowtail Butterfly. The one shown is the Tiger Swallowtail.



A cocoon 2 or 3 inches long made of tough silk is the work of a Giant Silkworm, the caterpillar of a Saturnian Moth. The one shown is the cocoon of a Cecropia Moth.



A cocoon-like nest made of layers of "meringue" is the egg-case of a mantis. The many nymphs will emerge through the "zipper" down the front. They will eat each other, or any small moving creature except ants. A live plant in the cage will maintain the high humidity which young mantids require. Sprinkle it with water occasionally so that the insects may drink the "dewdrops."



A shapeless wad of mud is likely to be the many-chambered nest of a Mud-dauber Wasp. In winter each cell contains a thin brown capsule of a cocoon. The mature wasp is about an inch long and has a long slender waist. It will take sugar water. Some of the cells shown in the diagram were broken open by hand to show the structure of a cell.

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

sects, and some species have billions of members.

In this issue your pupils will encounter some of the adaptations — such as protective coloration, sheltering, unique diets, and ways of gathering food—that have enabled certain insects to survive and proliferate. Encourage your pupils to consider other things that influence survival, such as size, ways of moving about, physical structure, and reproductive behavior.

The basic concept : *Living things are adapted to their environment.*

Insects in the Classroom

Now is the time to expect young people to bring a variety of insects into the classroom. Have your pupils find out as much as they can about the habits of their specimens in order to set up the proper home for them. Insects can be kept in cages made of glass jars, plastic boxes, and window screening, or in a terrarium *(see "Building a Woodland Terrarium,"* N&S, *Sept. 20, 1963).*

There is time before the school year ends for your pupils to collect cocoons of moths, chrysalids of butterflies, egg cases of mantises, plant galls, and other insects and insect shelters. Some may be cut open to see what's inside. Others can be kept in jars to see what comes out of them.

If you do not know the requirements of the emergent insects, offer them very small quantities of assorted animal and plant foods and sugar water just strong enough to taste sweet.

References

In addition to books suggested in the student's edition, here are some that you and your more advanced pupils might find helpful: *Living Insects of the World,* by Alexander B. and Elsie B. Klots (Doubleday, 1963, $12.50); and by the same authors, *1001 Answers to Questions about Insects* (Grosset & Dunlap, 1963, $2.45); *Bees: Their Vision, Chemical Senses, and Language,* by Karl von Frisch (Great Seal, 1956, $1.45).

PAGE 3 Digging for Bees

This lively account of how Dr. Jerome Rozen, Jr., pursues his study of bees introduces young people to some of the research methods used by entomologists.

Suggestions for Classroom Use

This is a good time to clarify the meaning of the terms *hypothesis, fact, observation,* and *problem.*

A hypothesis is an untested idea that may answer or explain a problem.

A fact is an idea that has been tested and proved.

An observation is a noting of an occurrence or a characteristic.

A problem is a question proposed for solution.

Put the following statements on the board and have your pupils identify them:

1. If we loosen the soil around the plants, they will revive. (Hypothesis)
2. Plants need water to grow. (Fact)
3. The plants in the classroom are wilting. (Observation)
4. How can we make our plants grow better? (Problem)

Repeat with some of your own making and have the children make up some to try on each other.

THE NEXT ISSUE OF *Nature and Science* explains important functions of animal skeletons in a WALL CHART and includes a SCIENCE WORKSHOP article that tells how to boil a chicken and assemble the bones into a skeleton.

An article about the discovery of penicillin, which led to the development of other valuable antibiotic medicines, illustrates the role that "accidental" discovery sometimes plays in scientific research.

PAGE 6 Escaping Enemies

Insects are protected against predators in many ways, as explained in the article. Often one insect uses more than one means of protection, either simultaneously or at different hours or seasons. Have your pupils look for examples of multiple protective devices.

Suggestions for Classroom Use

Show your pupils the danger of carrying conclusions too far, by discussing these questions: *Is all coloration protective?* Recall the courtship and fighting of Bettas (N&S, *Feb. 7 and 21, 1964). Is coloration ever disadvantageous? When? For instance, how might the white, winter fur of a weasel endanger him?* When the snow has melted, he is easily seen.

How has man put these principles to use? Discuss military camouflage, hunting clothes, women's makeup.

PAGE 12 World of Ants

Ants are among the most interesting and easiest insects to watch. In the first article Mr. Showers describes some fascinating types of ant behavior which should delight your pupils. In the second, he tells how to set up an ant colony attached to a maze.

Suggestions for Classroom Use

Be sure to prepare the nest jar *before* collecting your ants. To further ensure the building of tunnels near the glass, tape a sheet of paper over part or all of the glass to keep the light out for two or three days.

There are many investigations that your pupils will be able to make with an ant colony. One is the study of ant social castes. The castes can include "reproductives" (queens and males), soldiers, and workers. The workers perform such tasks as building, nursing, foraging, and rubbish disposal.

Your pupils should be helped to understand that such social organizations of insects are a result of sets of inherited behavior patterns rather than of thought or planning on the part of the insects. One should be careful, also, not to attribute human emotions or judgments to the behavior of animals.

Activities

1. Try different kinds of food to see what ants will and will not eat. Remove any uneaten food from the food chamber after a day or so.
2. Observe ants carrying food. Do two ants ever help each other?
3. Put an ant from a different nest into the colony and observe what happens. Isolate a member of the colony outside the nest for two days or so. Observe what happens when it is returned to the nest.
4. Make trails with a pencil on large sheet of paper. Will an ant follow them? Now make trails with the body of a dead ant. What do you observe the ant doing?

The Stuff from Which...
(Continued from page 1T)

At this level with a fifth grade class the children really begin, hesitantly and awkwardly, to get their feet on the ground. Here is pay-dirt. Somehow these children had by-passed an earlier stage of developmental learning. Perhaps they once recited "Light travels in straight lines," but the recitation gave them no tools for investigation.

There is no way for them to go but backward. And yet I think going backward will prove in the long run to be the shortest way toward an ultimately adequate and competent grasp of the great world around them. So don't scorn primary grade materials, such as work on lights and shadows, as food for older children or even adults.

I am sure there are many psychological reasons why children become passive (and "dutiful") vessels that say, "fill me—teach me." But there is a *sufficient* explanation: It is the gap between what a child is expected to learn from books, homework, and recitation, and the sphere of his own direct, active control over the things and energies of his environment. He can't fill the gap.

Enjoyment Is Necessary

Along with the growth of intuition and understanding goes a necessary component which can only be called aesthetic; an enjoyment, a sheer enjoyment, of the phenomena themselves.

Make up a few color tubes (*see "Liquid Layer Cakes,"* N & S, *Oct. 4, 1963)* and play with them. What is this good for? Is it going to lead to an understanding of density or surface tension? Probably not. Well, then, what is it good for? I think part of the answer is that the tubes are just good and one doesn't have to ask immediately what they are good for, or whether they are good for anything at all. Try them out and see if they generate further ideas for exploring the curious behaviors of different sorts of liquids.

Or think about butterflies. Here is much richer scientific fare. But would it have the richness if it were not for the marvelous colors and shapes and movements of these little animals?

Every part of science has its own characteristic phenomena and gives rise to characteristic—one is tempted to say—art forms. Contrast the style of the caterpillars and butterflies with the elegant motion of a 10-foot pendulum.

The phenomena have to be enjoyed because if they are not enjoyed this means they have not been seriously attended to for their own sake; and if they have not been seriously attended to, then the groundwork of later intellectual understanding and still later return to new sorts of phenomena will not have been laid ■

it's our anniversary

JUST ONE YEAR AGO the first announcement concerning NATURE AND SCIENCE was mailed to teachers throughout the country. Since that time over 200,000 youngsters have enjoyed and learned from its pages, and well over 10,000 teachers have discovered a new and highly valuable aid in the teaching of science.

What a wonderful year it has been for us...and, we hope, for you and your pupils. The enthusiasm with which teachers all over the country have received NATURE AND SCIENCE has been most gratifying. This comment from a principal is typical of their response: "Teachers report that it is excellent—probably the best thing in its field that we have seen."

We believe this is true. And our editorial staff and Advisory Board are busy right now preparing NATURE AND SCIENCE issues for next fall which we hope will excel those of the past year. In early September, for example, there will be a Special-Topic Issue on bird migration, explaining how birds navigate by the stars, Sun and Moon; how their internal "clocks" help them; and how they "fuel up" for the trip.

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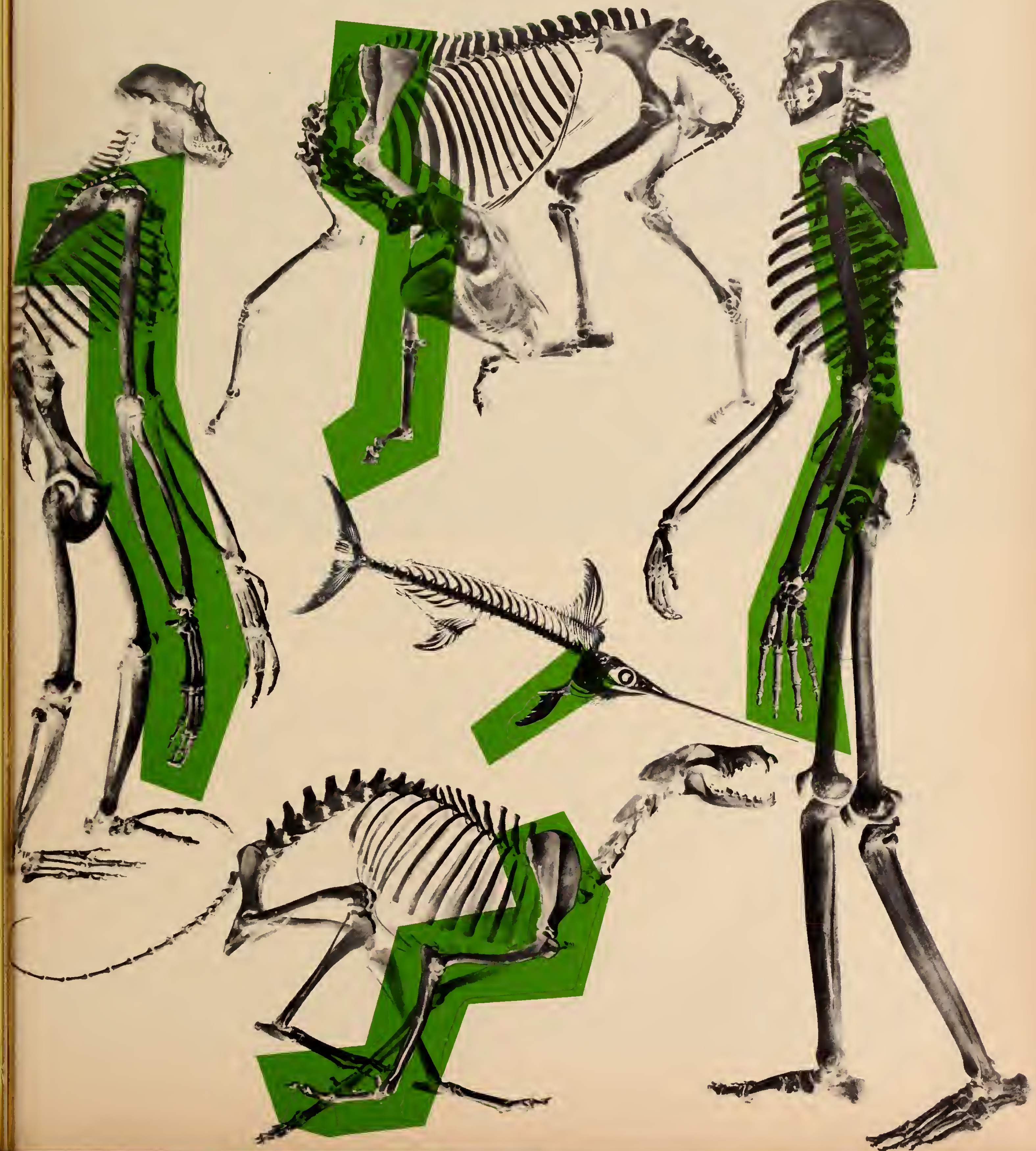
nature and science

VOL. 1 NO. 15 / MAY 1, 1964

How many of these animals can you identify?
(answers on page 2)

MAKING A CHICKEN SKELETON
see page 3



ABOUT THE COVER

The photographs on our cover show the skeletons of five kinds of *vertebrates,* or animals with backbones. The skeletons are those of a man, chimpanzee, donkey, dog (Russian wolfhound), and a swordfish. The skeletons are pictured in reverse, somewhat as they might appear in an x-ray photograph.

When scientists assemble a skeleton, they begin by skinning the dead animal, removing its intestines and other organs, and letting the carcass dry for a few days. Then they put the carcass into a container with a colony of *dermestid* beetles. The larvae of these beetles eat the dried flesh from the bones, leaving them clean and white. It may take several weeks for beetle larvae to clean a large skeleton.

The separate bones are usually put into labeled boxes and stored for future study. Sometimes the bones are put together, like those on our cover, and used as an exhibit.

You can learn a lot about an animal by studying its skeleton. For example, you can find out if an animal swims, flies, or runs by looking at its limb bones. The WALL CHART on pages 8 and 9 shows how the forelimbs of different animals vary, and the article that begins on page 3 tells you how to put together a chicken skeleton.

nature and science

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How do an animal's bones fit together and support its body? With a dead chicken, a little glue, and a lot of patience, you can find out by . . .

MAKING A CHICKEN SKELETON

by David Webster

■ Have you ever seen a big dinosaur skeleton in a museum? If not, you've probably seen pictures of them. Scientists put dinosaur skeletons together from bones they find buried in the ground.

You can make a real skeleton for yourself by putting the bones of an animal together. Doing this is fun, but it is hard work. You must get an animal and boil it for a long time to remove the meat from the bones. This makes the bones come apart. Then you have to glue them together in the right way to form the skeleton.

A chicken is a good animal to use. You can get one fairly easily, and your parents probably won't mind if you cook it on the kitchen stove. The chicken you use should have the head and feet still on. A small butcher shop is one place to buy a whole chicken. Usually the feathers have been taken off with a machine.

Before going any further, tell your parents what you are going to do. You will be using sharp knives and boiling water. It is best if your father or mother can help you. Be sure they know what you are doing, anyway.

You may have trouble putting the feet together after all the bones have come apart. So study them carefully now. Feel the bones in each toe. The longest toe is made up of four bones. Do the other three toes have four bones also? It might help you to make a sketch of each foot showing the length of each toe and the number of bones you can feel.

Getting the Chicken Ready To Boil

To prepare the chicken for boiling, cut off both legs with a sharp knife. Try not to break or cut any bones. You can do this by carefully cutting into the meat where the legs join the body. Pull the leg away from the body and keep cutting until it comes off. You can take off the wings too, in the same way.

Next, you should clean out the insides. Cut a hole in the hind end of the bird with a sharp pair of scissors or knife. Make the hole big enough to put your hand in, but *be careful not to cut any bones.* The hole you make is the same one that is used when putting the stuffing into a turkey. Now reach in and grab all the *entrails,* or guts, you can. Then pull real hard and everything should come

(Continued on the next page)

out. If it is too tough, ask your mother or sister to help pull.

Boiling the Chicken To Get the Bones

Put all the parts of your chicken (except the insides) in a pot and cover them with water. Put it on the stove and let it boil slowly for 1½ to 2 hours. If you don't cook the chicken long enough, the meat will not come off easily. If you cook it too long, the bones will become soft and break. The skull is the weakest part and probably should be taken out after boiling only one-half hour. Add more water when it gets low. It will be easier to put the wings and legs together if the bones are kept separate. You can do this by boiling each leg or wing in a separate pot.

After boiling, the meat should be so soft that it comes off the bones easily. Dump out the chicken broth you have made. (Your mother might want to make soup with it.) Cool the chicken by running cold water over it. Pull off all the meat you can, leaving just the bones and tough meat. The tough meat is mostly muscle. Where are the biggest muscles? What are they for?

Most of the bones should come apart. You can put the bones from each leg and wing in a separate pile. Any bones that are completely cleaned can be set aside. Those that still have meat on them can be boiled a little longer.

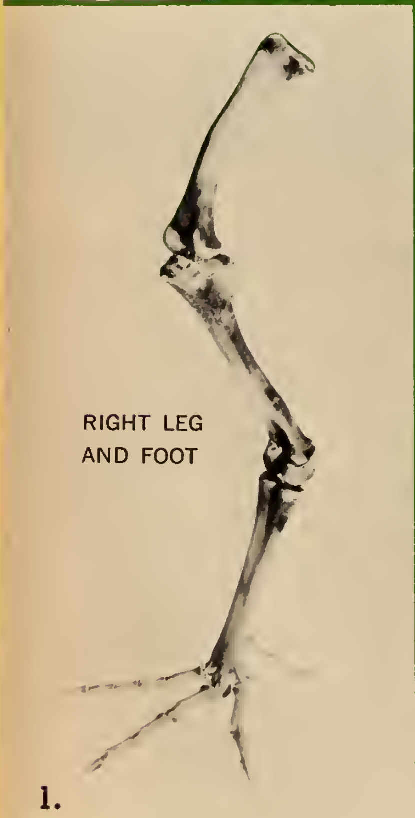
You can use a vegetable brush or toothbrush to remove any meat still stuck to the bones. The toothbrush will get greasy, so use an old one. While brushing the bones, hold them under water running slowly from the faucet. This helps wash the meat away. A stretched-out paper clip is a good tool to push the meat out of small holes. Usually the brain is so soft you can wash it out with water. Lay all the bones on newspaper and let them dry overnight.

How many bones did you get? A chicken has about 120 altogether. If you got 100 or more, you have done well. Now that you have taken them all apart, your job is to put them back together again.

Gluing the Bones Together To Make a Skeleton

Probably the best way to stick bones together is with quick-drying glue like Duco Cement. The bones should be placed on wax paper for gluing so they won't stick on the table. Modeling clay that doesn't get hard (Plasticine) helps hold the bones in place while the glue dries.

Maybe you will want to begin with the legs. Can you find the four bones which are in each leg? *(See photo 1.)* The upper bone has a knob at the top. What purpose



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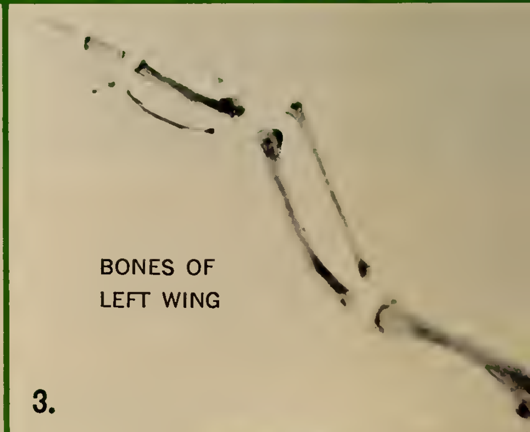

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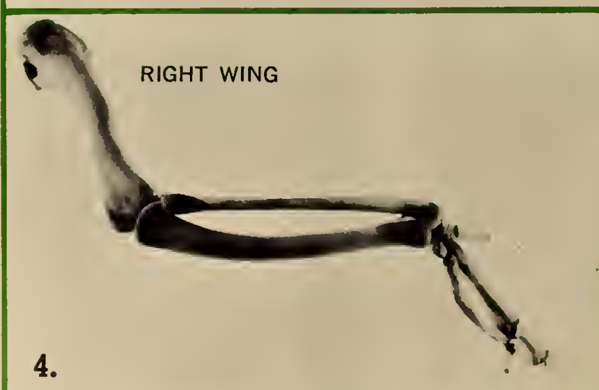

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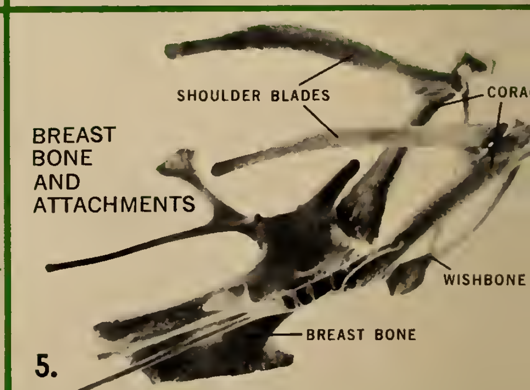

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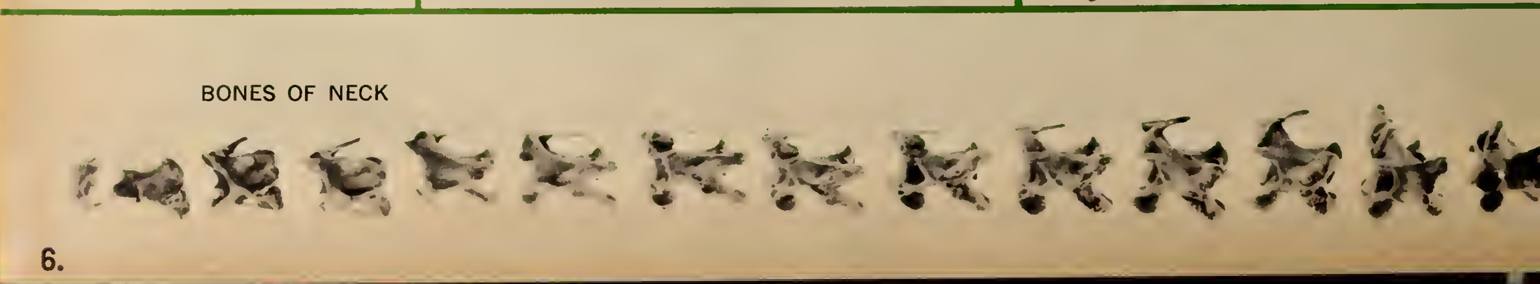

6.

might this have? The middle bone of the leg is the longest in the chicken. Attached to the other side of it is a long, thin bone that does not show in this photo. Look for these three bones the next time you chew on a chicken leg for dinner. The fourth bone is at the bottom of the leg and joins the foot. (This bone is usually cut off by a butcher.) Glue the bones of each leg together on wax paper. The legs should be bent the way they are when the chicken stands.

Now try to find the little bones of the feet. Arrange them in the shape of the feet *(see photo 2)*. The two little knobs on the end of each toe bone point out. Why is the last bone of each toe pointed? When the glue on the leg bones has hardened, the leg can be propped up with a lump of clay. The toes can then be glued in place.

The knob at the top of the leg fits into a hole in the pelvis or hip bone. Can you find the pelvis and the hole for the leg? Hold a leg and the pelvis together and move the leg around. The place where two bones meet and can move is called a *joint*. The type of joint at the top of the leg is called a *ball and socket* joint. Can you see why? Where is the ball? Where is the socket? Can you think of any other things that have ball and socket joints?

Most of the other joints in the leg and toes are called *hinge joints*. In what way are they like a door hinge? How does a ball and socket joint differ from a hinge joint? The joints of your leg are like a chicken leg. Move your leg around to see how the joints work. What kind of joint can move in the most ways?

You can assemble the wings next. How many bones make up each wing? Lay out the wing bones in the proper order *(see photo 3)* and glue them together *(see photo 4)*. Which wing joints are hinge joints? In what ways is the wing like a leg? In what ways is it different?

Can you find where the wings attach? You probably can't until you assemble some bones of the body. The biggest bone you have left is the breast bone. The sharp edge along the bottom is called the *keel*. Do you know what the keel on a sailboat looks like?

Two bones attach to the front of the breast bone *(see photo 5)*. Each of these is a *coracoid* bone. Joined to the top of each coracoid is the wishbone, which comes down in front. This is the V-shaped bone you can feel in a chicken's body below the neck. Two more bones, the shoulder blades, are also attached to the coracoids. When the five bones have been glued on the breast bone, you should be

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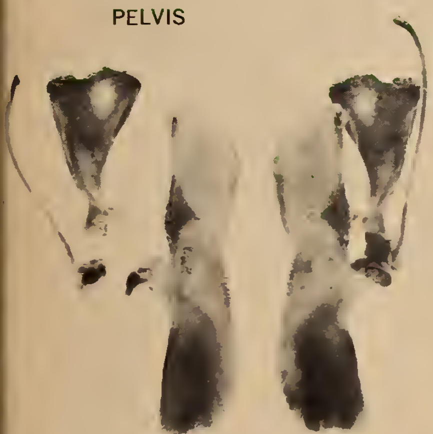
BONES OF TAIL

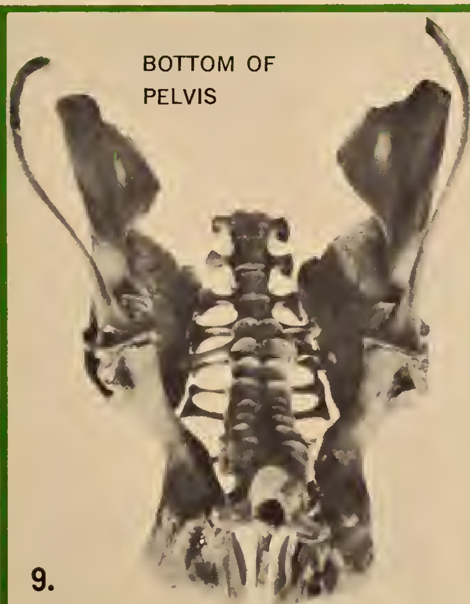
7.

PELVIS



8.

BOTTOM OF PELVIS



9.

11. RIBS OF LEFT SIDE ATTACHED TO BODY VERTEBRAE AND BREAST BONE

VERTEBRAE OF PELVIS AND BODY

10.

VERTEBRAE OF TAIL, PELVIS, BODY, AND NECK

able to find the spots where the wings fit.

The little bones shown in photo 6 form the neck. Each one is called a *vertebra.* They are somewhat the same, but each is a little different from the one next to it. Try putting them together until they all fit properly. Glue them in a bent shape like the neck on page 3. (You might bend a piece of wire and slip the bones onto it, gluing as you go.) What is the hole in each vertebra for? Why is the neck made of many bones instead of just a single long one? Chickens, like many birds, have about 14 bones in their necks. You have only seven. Could more neck bones help a bird turn its head farther around?

The first neck vertebra should fit around the hole in the back of the skull. Does it have the same shape as the other vertebrae? What comes out of the hole in back of the skull? What do you think all the other holes in the skull are for? Does a chicken have a big head or a little one compared to the size of its body?

The tail vertebrae are much smaller than those of the neck *(see photo 7).* These can be glued together like the neck vertebrae. What makes the tail seem so big when the chicken is alive?

Sometimes the pelvis comes apart when boiled. It is made of six bones, three on each side. In photo 8, the three bones on the right side of the pelvis are apart. Those on the other side have been glued together. The 14 vertebrae which attach to the pelvis are usually fused, or connected into one piece. The bottom of the pelvis is shown in photo 9. The fused pelvis vertebrae can be seen inside the pelvis in this picture and also in photo 10.

The body part of the back bone is made of seven vertebrae *(see photo 10).* The ribs attach to these, seven on each side. Look at photo 11, which shows the left side. The ribs with a fork on one end go down from the body vertebrae. Some of these ribs have another little bone stuck to them. Other ribs point up from the breast bone. Putting the ribs in place is the hardest thing to do.

The rest of the vertebrae can now be assembled in proper order *(see photo 12).* The pelvis vertebrae, with the pelvis attached, fit behind the body vertebrae. The tail joins the back end of the pelvis vertebrae. In front of the body vertebrae is the neck and then the head. When the legs and wings are attached, the skeleton is completed *(see page 3).* Notice the wooden stand which has been made to help hold the chicken up.

If you make a chicken skeleton, and have fun doing it, you might want to prepare others. You might try putting together a fish skeleton. You could buy a fish at the market and boil it to remove the meat. What other animals could you get to cook? You could make a skeleton from a frog, if you should find a dead one. Or you could buy a preserved one from a biological supply house. How does a frog's skeleton differ from bird and fish skeletons? ■

(Be sure to see "Wings, Feet, and Flippers" on pages 8-9.)

WHY I STARTED A BONE CLUB

■ When I was four years old, we lived in Lincoln, Nebraska. On Sundays, our family liked to visit the Natural History Museum at the University of Nebraska. The enormous dinosaur skeletons fascinated all of us. I believe this led to my hobby of collecting bones.

One September morning in 1961, my father and I went for a walk in the little New England town in which we now live. We hiked along what had once been a dirt road, but now was no more than a cowpath.

Looking about, I spied something white and knobby, half buried in the earth. I picked it up and found it was a bone. Nearby were other bones. We collected them and learned later that they were the remains of a Shetland pony—one that had a fractured skull and arthritis. I had fun trying to identify the bones and put them together.

In May 1963, some of my friends and I were hiking along a brook. We climbed over a stone wall and found ourselves in a field of white rock-like objects which turned out to be bones! Of course I had visions of a real dinosaur graveyard, but this bone hunter's paradise turned out to be a pig farm. The five of us decided then and there to form a Bone Club.

Every Saturday we would gather at our clubhouse with our equipment and a picnic lunch. Our tools consisted of a jacket or sweater, a whiskbroom, trowel, knapsack, heavy shoes, hiking stick, and a canteen of water. Our work hours were from 10 a.m. to 5 p.m. The owners of the pig farm said we could have all the bones we wanted.

Each person would be assigned a different job every Saturday. Three of us would work in the fields, filling boxes with bones. The "carrier" would run with the box to the clubhouse, where the "sorter" separated the bones into five piles, each with the same amount of bones in it. The day's "haul" would be divided equally, whether one found the bones or not. However, if one had found any skulls that day, they were his to keep. We tried to assemble the bones into skeletons and really learned a lot about the way animals are put together.

Our club doesn't meet during the bad winter months, but I continue collecting bones. Not long ago one of my friends brought me a basket of bones of a dog. There was hair and cartilage still on the bones, so my father and I built a fire on our camp-stove and boiled the bones in a pail. Bones must be free from any hair, fur, or flesh before they can be assembled. (Besides, hair and flesh make them smell!)

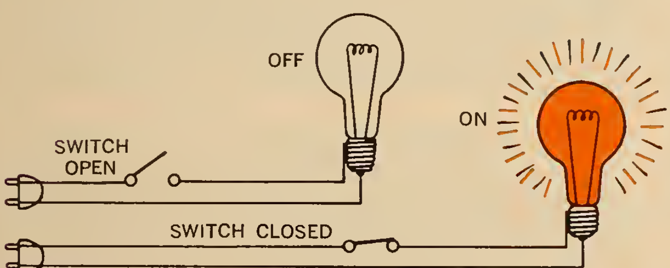
My ambition is to become a paleontologist, and to go to Mongolia to hunt for fossils and bones. One thing is certain, I'll always be interested in bones—BARBARA G. MOIR (age 11)

HOW IT WORKS

Electric Switches

■ Do you know how a flick of a switch turns on a light? A switch joins or "breaks" two wires that carry an electric current *(see diagrams)*.

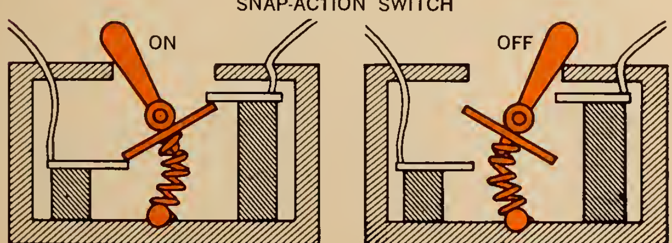
When you push the plug of a lamp cord into a wall outlet, the prongs of the plug connect with wires that carry electricity from an electric power plant to your house and back again. If the switch in the lamp is "closed," the wires are joined and the current flows through one of the wires, lights up the bulb as it passes through, and returns through the other wire back to the power plant. This is called a

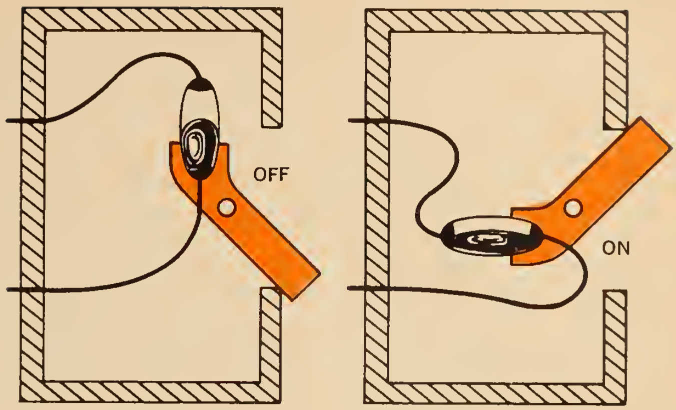


closed *circuit*. When the switch is "open," there is a break in one wire. This break prevents electricity from flowing through the circuit to light up the bulb. When this happens, we say the circuit is open.

Switches You Often Use

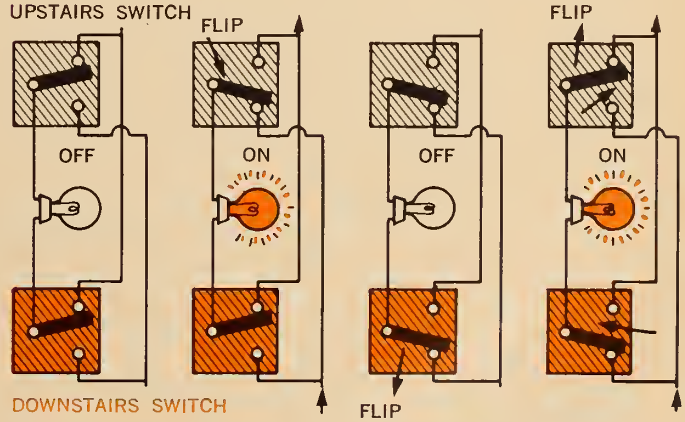
One common electric switch found in homes is the "snap-action" switch. If you snap the toggle "on," a spring clicks the switch to the closed position and the light goes on. What happens is that a metal collar on the toggle joins the two wires so the current can complete the circuit.





When you turn the toggle "off," you lift the collar and break the circuit.

Have you ever worked a "silent" switch, or mercury switch? Mercury is a metal that stays liquid at room temperatures. In a mercury switch, a small capsule with mercury inside is attached to the end of the toggle. The wires that carry the current run into the ends of the capsule. When you flick the toggle to "on," the capsule moves from an upright to a level position. The mercury spreads the length of the capsule, connects the two wires, and current flows through the mercury. When the toggle is turned "off," the capsule is tilted up. Then the mercury runs to the bottom of the capsule. This breaks the circuit and the current cannot flow from one wire to another.



How can a stairway light be turned on or off from either of two switches—one at the bottom of the stairs, the other at the top? Each of the two switches is connected to the light and also to the wires that bring electricity into the house and back to the power station *(see diagram)*. The circuit can be opened or closed by flipping either switch, no matter which position the other switch is in ■

Wings, Feet, and Flippers

■ Nearly all animals with skeletons inside their bodies have front "legs," or forelimbs. These forelimbs may be called arms, wings, legs, or flippers, depending on how the limb is used.

The size and shape of the bones within the forelimb differ too. As each animal developed through millions of years, its limbs have changed, or *adapted,* to a particular way of moving. For example, the wings of most birds are made up of long, slender, hollow bones. The hollowness makes them light, and helps make flight possible.

If you compare your arm with a bird's wing, you will find many differences. Many of the kinds of bones that make up your hand are missing in a bird's wing. However, both an arm and a wing have some of the same kinds of bones. Your upper arm bone is called a *humerus*, and so is the upper bone in a bird's wing *(see diagram)*. The humerus bone is connected to the *scapula,* which we call a "shoulder blade." The two bones in the lower part of your arm are called the *radius* and the *ulna*. A bird also has a radius and an ulna in its wing.

The diagrams on these pages show the forelimbs of nine kinds of animals. Each diagram shows the bones that lie underneath the skin and muscles of the animal's limb. Notice how the humerus, radius, ulna, and other bones differ in size and shape. Imagine that you are given the forelimb of an unknown animal. Could you identify the animal as a swimmer or a flier? What else could you discover by looking at its bones? ■

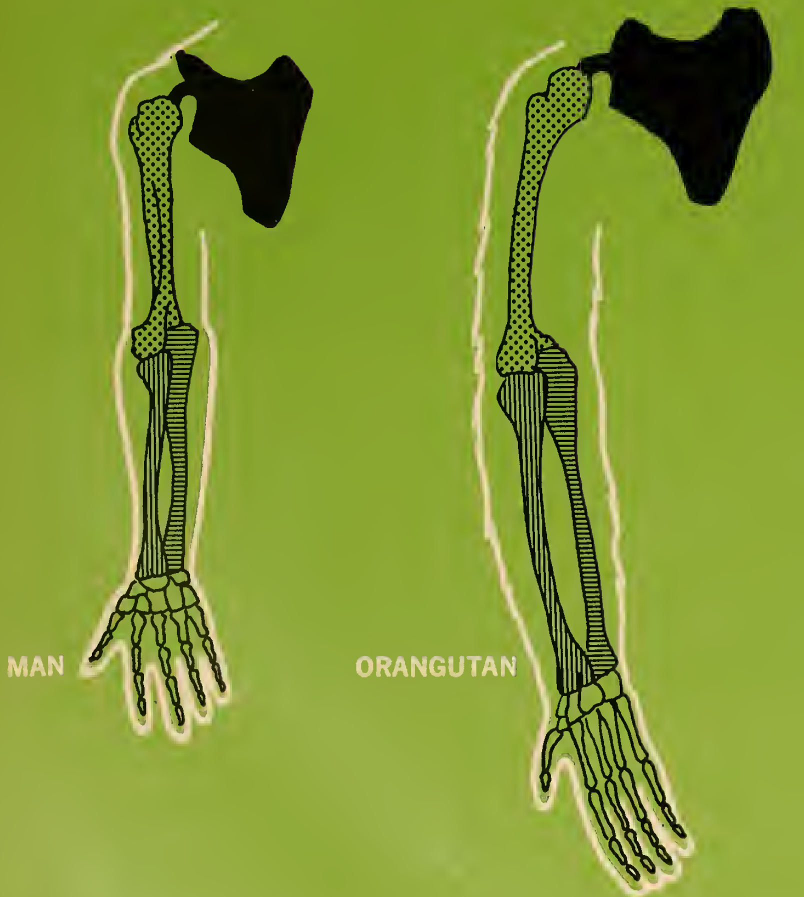
Animals that Swim

Animals that Fly

The forelimbs of both whales and penguins are made up of short, thick bones and are completely covered by muscles and skin. Penguins cannot fly. However, they flap their wings in a flying motion that helps them move about underwater. Whales use their flippers as steering paddles.

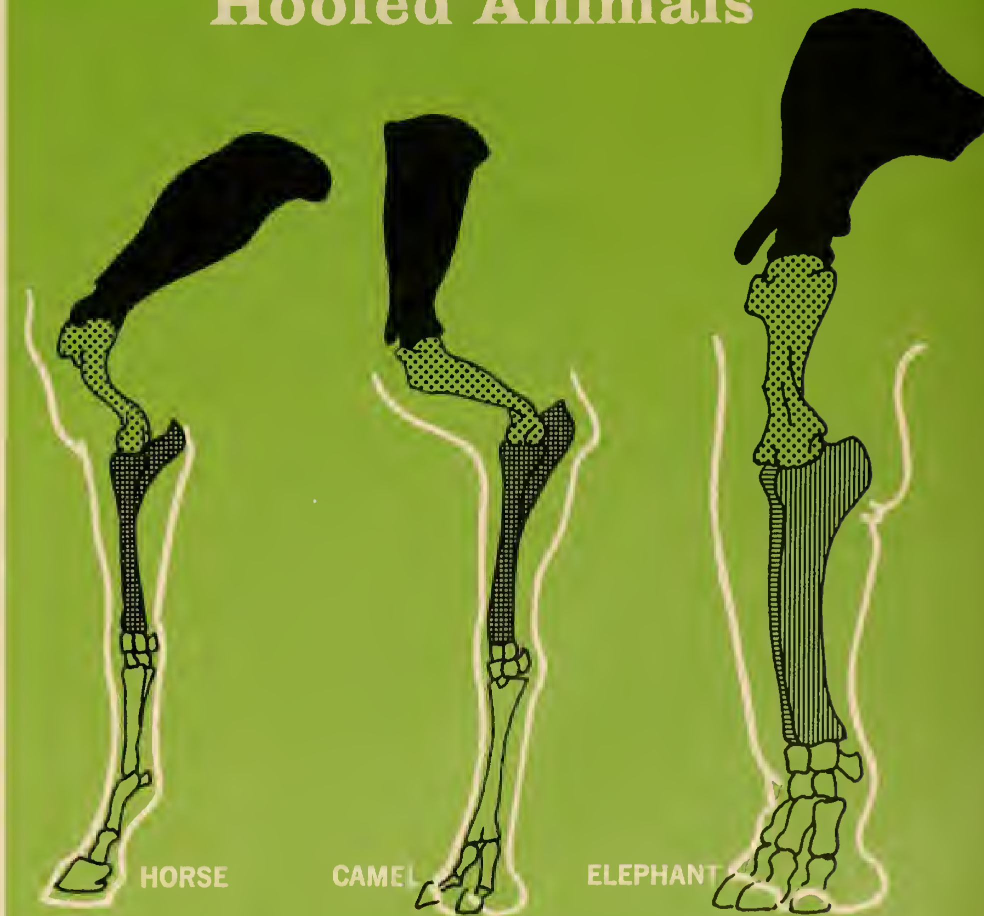
The Osprey, or Fish Hawk, has long, hollow wing bones, and three short fingers that support the long flight feathers of its wings. Most bats have four long, slender fingers that support their wings of skin membranes. Bats sometimes hang from rafters and the ceilings of caves with claws that are on the end of their short thumbs.

Animals with Hands



The arms of humans are short when compared with the arms of Orangutans (a kind of ape). The long arms and fingers of Orangutans are used for travel in the treetops. Their fingers serve as a kind of "hinge" as the animals swing from limb to limb. Human hands are more flexible and are better adapted for holding and manipulating objects.

Hoofed Animals



Animals with hoofs are called ungulates. The radius and ulna bones of some ungulates are fused together, forming one bone. Elephants walk on the tips of five toes and have thick pads which help support the weight of their bodies. Camels have two toes, with a pad between them for support. Modern horses walk on just one toe.

SCAPULA — HUMERUS — ULNA — RADIUS — RADIUS AND ULNA FUSED

THE MOLD THAT DIDN'T BELONG

Scientists have accidents, too. Here's how one accident led to the discovery of a "wonder drug" and the award of a top scientific honor to its discoverer.

by JOHN BOWMAN

■ "Accidents will happen!" How often we all say that—usually to excuse our own carelessness. If you imagine that accidents don't happen in scientific laboratories, you are wrong. Like the rest of us, scientists are human and also make mistakes from time to time. But like any alert and thinking person, a good scientist will profit from an accident, mistake, or chance happening.

There have been many happy accidents in science. One happened about 75 years ago in the private laboratory of a German country doctor, Robert Koch. He saw some colored spots on a piece of boiled potato that had been left on his laboratory table. Instead of throwing it out, Koch carefully examined the spots under a microscope. He saw that each of the spots was composed of only a single kind of mold, rather than a mixture of several molds. Molds are among the simple plants called *fungi,* which have tiny seed-like spores so light that they float around in the air all the time. When mold spores land on food they grow and make the food moldy (*see "Making a Mold Garden,"* N&S, *Jan. 24, 1964).*

At that time, Koch was studying bacteria, which are related to molds. He had been growing bacteria in liquids, but different varieties of bacteria mix easily in a liquid, so it is hard to tell which one may be causing a particular disease. The spots of pure mold on the potato gave him an idea: By growing bacteria on something solid, he might be able to grow *pure* colonies, or cultures. He could then study each different kind of bacteria separately, without others being mixed in. Scientists have used Koch's "pure culture" method to solve many problems in medicine.

About 75 years ago, Dr. Robert Koch accidentally discovered an important way of studying disease-causing bacteria.

It was just such a pure culture that was involved in one of the most famous accidents in science. This took place in 1928 at St. Mary's Hospital in London, England. A Scotch medical researcher, Dr. Alexander Fleming, was studying pure cultures of a bacterium, called *Staphylococcus aureus,* that causes certain kinds of boils and abscesses in people. He was growing the bacteria on a nutrient jelly in glass-covered dishes—a method developed by Koch.

One morning when Fleming was examining the cultures, he noticed that one of the plates was contaminated by a green mold growing in the jelly along with the bacteria. It was like finding a weed growing in the middle of a rose garden. Indeed, molds in bacterial cultures are no more unusual than weeds. Apparently, when Fleming had taken the cover off this particular dish to examine the bacteria, a mold spore settled on the jelly and started to grow.

Some researchers would have thrown away the spoiled bacterial culture. It was ruined for the planned experiment. But Fleming looked closely at the culture he was trying to grow. He noticed that the area all around the mold colony was clear. There wasn't a sign of growing bacteria as there was in the rest of the glass dish. Fleming wondered: Could the mold be producing something that killed the bacteria that grew close to it?

Investigating an Accident

Fleming decided to investigate whether this was what had taken place. First, he took a very small piece of the mold and transplanted it in another culture dish. The mold grew very well. Within a few days it had formed some yellowish drops of liquid on top of the developing culture. Fleming found that this liquid would kill bacteria even when it was diluted with water. Later he found that the yellow liquid would kill other kinds of bacteria, including several that caused serious diseases in man and other animals.

Could the products of this mold be used to help control or cure diseases caused by bacteria? If so, would it still work if injected into the human body? More important, would it kill the disease-producing bacteria without also killing the patient?

These were some of the questions Fleming had to try to answer. Meanwhile, he had to identify the mold. With the help of other scientists, he learned that it was one of the *Penicillium* group (the name comes from the Latin word for "brush" and refers to the appearance of the mold's spore-bearing branches).

This colony of Penicillium mold (center of dish) produces a substance that kills many disease-causing bacteria.

When Dr. Fleming found an unwanted mold growing in a dish with bacteria, he did not throw it out. Instead, he experimented with the mold, which seemed to kill bacteria.

You have probably seen many other members of the *Penicillium* group of molds. The greenish colors in cheeses such as Roquefort and the various "blue" cheeses are due to *Penicillium* molds. So are the green molds that are found on citrus fruits. So *Penicillium* molds are not unusual. By now you have probably guessed what Fleming named the bacteria-killing substance—"penicillin."

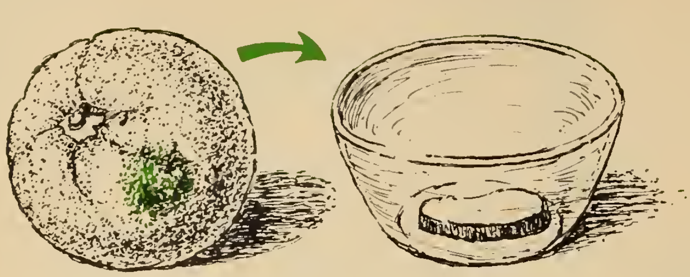
New Problems to Solve

Fleming published the results of his studies on penicillin in 1929. There were, however, many years of work ahead before penicillin could be used medically. The first big problem was to isolate, or separate, pure penicillin from the mixture of substances in the yellow fluid formed by the mold. Another problem was to grow large quantities of the mold to produce enough penicillin for medical use. Tests on animals and, finally, on men had to be made to make sure that penicillin was not poisonous.

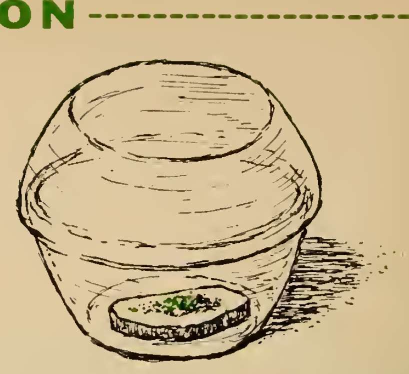
All of this research took time, money, and the cooperation of several scientists. During World War II, research was supported jointly by the United States and Great Britain, and penicillin was made in large quantities. It helped save many lives. In 1945 Fleming and several of his co-workers were awarded one of the scientific world's highest honors, the Nobel Prize in Chemistry.

(Continued on the next page)

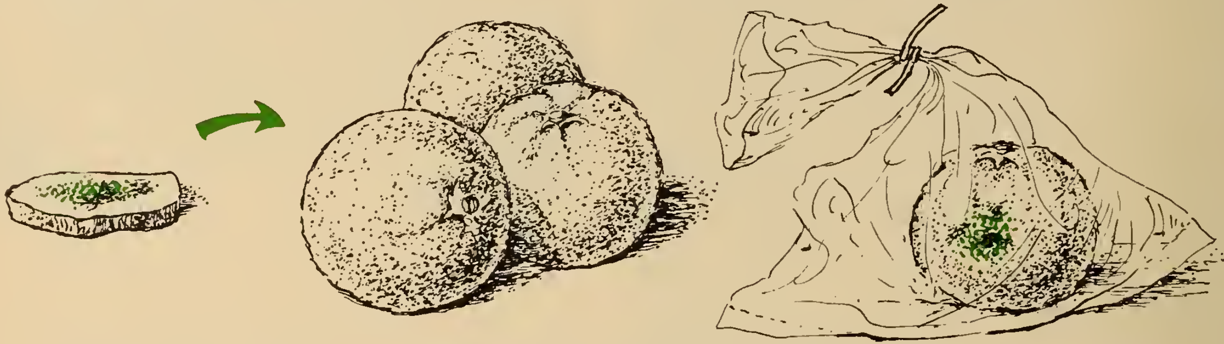
INVESTIGATION



1. Transfer some mold spores from a moldy orange to a sterile potato slice.



2. Cover the potato slice and set the dish in a warm place. Mold should begin to grow in about five days.



3. Transfer mold spores from the potato slice to clean oranges. Put each orange in a separate plastic bag for a week or so and see if mold develops.

Here is how to grow pure cultures of Penicillium mold. Put a rotten orange in a plastic bag so that it will keep moist. Keep the bag in a warm closet or cabinet for a few days until it is covered with green mold. Next you will need something on which to grow a pure culture of mold. A sterilized potato slice is excellent for this purpose. To make it sterile, place a one-inch thick slice of potato in a Pyrex custard cup, cover the cup with an aluminum foil cap and set it in a sauce pan. Pour water into the sauce pan until it is near the top of the custard cup. Then cover the pan and cook the potato slice for about 25 minutes, adding water as needed.

When the potato slice is sterile and cooled, it can be inoculated with a small (almost too small to see) quantity of the mold spores from the fruit. Make an inoculating needle by pushing the eye end of a large sewing needle into the end of a wooden dowel or kitchen match. Sterilize the needle by passing it through a flame, and cool it in the air for about a minute.

By touching the needle tip to the surface of the moldy orange and then touching the needle to a spot on the potato slice, you can transfer spores to start the culture. Transfer spores to different spots on the potato. Re-cover the dish and let your cultures incubate for five days or so in a warm place. You will see, as Koch did many years ago, that a colony of mold tends to grow as a circle in the place where you put the spores. You now have pure cultures of Penicillium with which you can do an experiment that is very important in discovering the causes of diseases.

Proving What Causes a Disease

Robert Koch was very interested in just what caused diseases. He reasoned that:

1) If a particular organism was always found associated with a disease, and

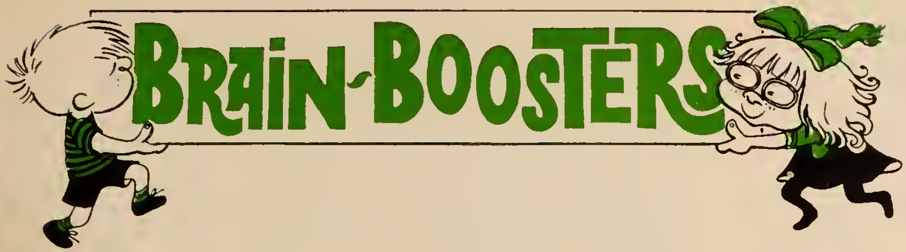
2) If the organisms could always be isolated in a pure culture from the diseased tissues, and

3) If the pure culture, when inoculated back into healthy tissue, caused the same disease,—then, and only then, could scientists say with certainty that the organism was the cause of the disease. These three steps are called "Koch's Postulates," or rules.

In your case, the "disease" is green-mold rot of orange. You have isolated the mold from the diseased tissues (the orange skin) and have now grown the organism in pure culture (on the potato). To see if Penicillium is truly the cause of the green mold, you must inoculate healthy oranges with Penicillium and see if green-mold rot develops.

To make sure that the oranges (six or eight) you use are clean and free from Penicillium spores, first wash them in soap and water and rinse and dry them. Then, with a flame-sterilized needle, pick up a small amount of spores from the surface of the potato culture and jab the needle into three or four healthy oranges. Also, leave three or four oranges uninoculated. If no mold develops on these oranges, you can be fairly certain that all the oranges were healthy before you inoculated some of them. (The uninoculated oranges are scientific "checks" or "controls.")

Incubate each orange in a separate plastic bag for about a week. Did every inoculation result in a rotted spot? Have all of the uninoculated oranges remained healthy? Can you think of any other plant or animal disease for which Koch's postulates can be used?



Brain-Boosters

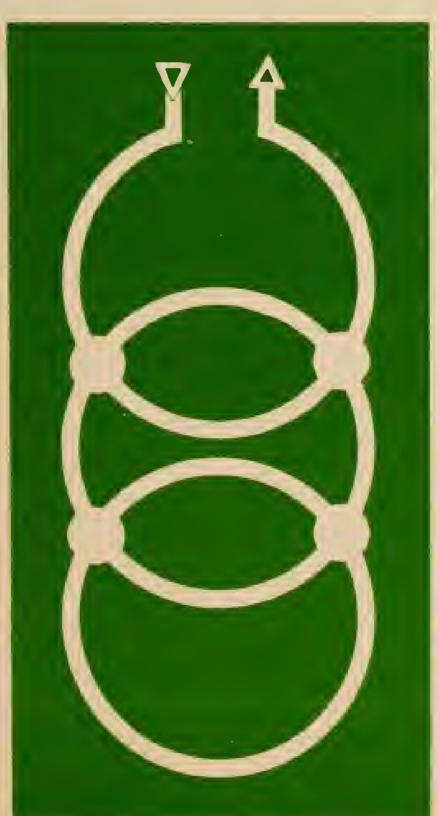
■ Add, Subtract, Multiply
Put a plus, minus, or multiplication sign between each of the first five numbers in these two sets of numbers and see if you can get the answers given at the end of the equations. Can you find more than one solution for each?

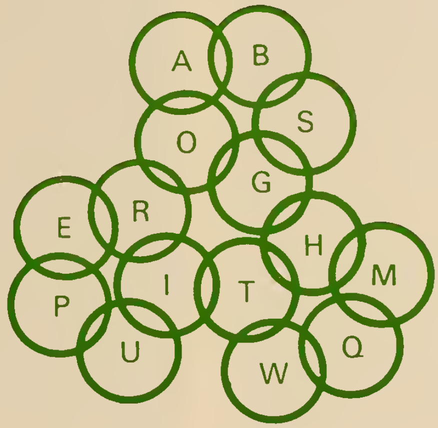
6 4 8 2 4=16

9 7 5 7 3=17

■ The Racing Car Problem
This difficult course was designed for a sports car race. Each car is supposed to travel the entire route without crossing its own path. The cars must enter at the left arrow and leave at the right arrow.

Can you figure out the route to follow?





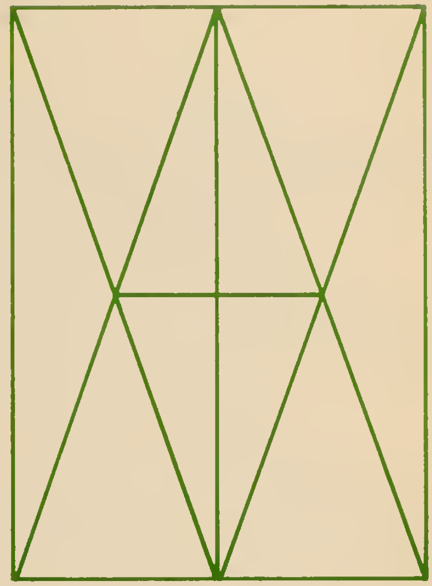
■ Case of the Tangled Bracelet
This bracelet seems to be hopelessly tangled. However, you can unravel it if you open three of the rings long enough to release three other rings. If you choose the right ones, the letters of the six rings involved will form a word that tells you that you are correct.

■ Fish Census
A scientist wanted to discover how many fish lived in a certain pond. First he dragged nets through the water and caught 135 fish. He put tags on them and put them back in the water. Then he netted the pond again and caught 247 fish. There were 35 tagged fish in this catch.

With this information he was able to figure out the approximate number of fish in the pond. How many fish were there?

■ Winners and Losers
Carolyn and Linda were playing checkers. They agreed that the loser of each game would give the winner a piece of candy after they had finished all of the games. When they had finished playing, Linda had won three games and there were no ties. To settle up, the girls agreed that Linda would give Carolyn seven pieces of candy.

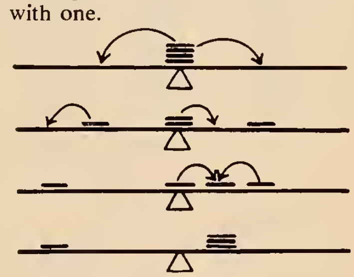
How many games did they play?



■ How Many Triangles?
The longer you look at this figure, the more triangles you can see. How many can you find? Ten? Sixteen? Twenty? More than twenty?

Solutions to Brain-Boosters appearing in the last issue

Balance the Board: By making these three moves, you can move four nickels from the fulcrum so that a pile of three nickels balances with one.



The Six Beetles: Numbers 1 and 6 are identical.

How Much Money?: Bill had $2 when he started out. Since five cents is one-eighth of the money he had left before buying the magazine, he must have had 40 cents at that time. This plus the five-cent tip totals 45 cents, which is one-half of the money he had before paying for his snack, or 90 cents. This amount plus the 10-cent candy bar comes to $1, which is half of the money Bill started with, or $2.

Ordinary sunlight shining through "holes" between the leaves of a tree makes round spots of light (many of them overlapping) in the shadow which the tree casts on the pavement. These spots of light are called Sun dapples.

These Sun dapples in the shadow of the same tree were photographed during an eclipse of the Sun. Look closely at their shapes. Why do you think they are shaped differently from the dapples in the other photograph?

SHADOWS and HOLES

By Phylis Singer

Can a square hole make a round spot?

■ Did you ever watch a baseball game or the construction of a building through a knothole? Little holes can be large windows on the world.

On the next bright sunny day, go outdoors and look at shadows. Make a shadow of your hand. First hold your hand close to the ground, then gradually move it higher. What happens to the shadow? At what height do the fingers get fuzzy?

You can make some larger shadows with some pieces of ordinary notebook paper. Try making a shadow fall on a special place. Mark an "X" on the ground with a piece of chalk or a stick. Can you make the shadow of your paper fall on the X?

Find a bush or a tree that has some shade, then put a small rock somewhere in the shade. Can you make the shadow of your paper fall on the rock?

In the shade of the tree or bush you probably saw lots of rounded bright patches. What do you suppose makes these bright patches? Can there be round holes in the leaves or holes between the leaves?

Make some holes and see for yourself what sort of bright patches the holes make. Take a piece of foil and punch several holes in it with a pencil. Make some of the holes small; make others large. Now put a piece of dark construction paper on the ground and hold your piece of foil over it so that shadows with "holes" in them fall on the construction paper. Hold the foil near the ground, then far away from it. Can you see the rounded bright spot? Does it look at all like the bright spots you saw under the tree or bush?

Try Holes of Different Shapes

Now try something different. Take another piece of foil, but keep your old one. This time make holes that are not round. They should be small holes, but they can be various shapes. Here are pictures of some holes to help you get started:

What is the shape of the bright spots these holes make when you hold the foil over the dark construction paper? What is the shape when you hold the foil high up, as high as you can? What happens at in-between heights? Now take another look at the roundish bright spots in the shade of the bush. If you put the dark construction paper on the ground, you should be able to catch the spots and hold them on the paper as you slowly move the paper higher off the ground. Pick out one spot and watch it carefully.

Does the bright spot change its shape on the paper as you lift the paper? Can you find the hole in the bush that makes the bright spot? When you think you've found it, here is how you can make sure. Put the paper back on the ground and wiggle your finger back and forth across the hole in the bush. If the bright spot blinks on and off you have the right hole.

What is the shape of the hole? Is it round? One thing you probably noticed is that all the bright spots you made yourself, and those you found under the bush, were round —*even though the hole in your foil was not round*. There seem to be round spots under round holes. There also seem to be round spots under holes of other shapes provided you hold the sheet with the holes in it up high.

When you made round spots with *not*-round holes, was there anything you were using that is round? Anything at all? Remember that you were using sunlight. The Sun, after all, does look round. Do you think that the round Sun is the reason that the bright spots are round? ■

PROJECT

Make a shadow with a ball. Without touching the ball or the light, can you break the shadow into two shadows? Can you break it into more than two shadows?

SHARP AND FUZZY SHADOWS

■ Stand in the sunlight, on a smooth floor or sidewalk, and look at the shadows of your feet and head. Are the outlines of these shadows equally sharp? Or is one fuzzier than the other? Now hold out your hand and move it toward the ground, watching its shadow as you move it. What happens to a shadow as the object that makes it moves toward the shadow or away from it?

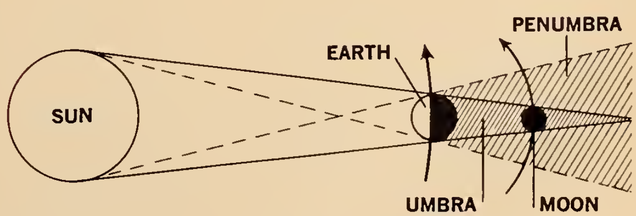
Does the size or distance of the light have anything to do with the size and sharpness of an object's shadow? Here are some ways to find out, with the aid of a pencil, a key, some cardboard, and a lamp with a spotlight shade that extends beyond the end of the light bulb.

Push the pencil through a small piece of cardboard so you can stand the pencil straight up. Move the lamp around the pencil and up and down. In which positions are the longest and shortest shadows cast?

Stack several books on the table and stick the narrow end of a key between two of them, about two inches above the table top. Direct the light straight down on the round end of the key, about a foot above it. Is the shadow of the key sharp or fuzzy? Now use the pencil to punch a tiny hole in a piece of cardboard large enough to cover the end of the lampshade. Move the cardboard across the end of the shade until the ray of light coming through the hole falls on the key. What happens to the shadow of an object when the light source is made smaller?

What would happen to the shadow if you moved the light source farther away? Lift the lamp straight up and see. Is this another way of making the light source smaller?

Perhaps you noticed that when the light source is larger than the object, the shadow has two parts—a dark, inner part that we call the *umbra* and a lighter grey border called the *penumbra*. The umbra is dark because all light is blocked from it by the object. The penumbra is lighter because some light rays from the source get past the edges of the object *(see diagram)*—F.K.L.



When the Moon is on the opposite side of the Earth to the Sun, it sometimes passes through the shadow cast by the Earth. If you were on the Moon when it was in the umbra of the Earth's shadow, no sunlight would reach you; the Sun would be totally eclipsed. If the Moon were in the penumbra of the shadow, you would see only part of the Sun.

your MUSEUM *at home*

Roadrunners

The Roadrunner's name comes from the bird's unusual ability to run at speeds up to 15 miles an hour in short spurts, and 10 miles an hour or so for longer distances. In desert areas of the southwestern United States, the birds can sometimes be seen running along roads in pursuit of lizards, snakes, or scorpions, which the birds eat. The Roadrunner shown here is mounted in one of the famous habitat groups in The American Museum of Natural History.

■ The Roadrunner, a bird of our southwestern deserts and of Mexico, has some amazing, unbirdly ways. For one thing, it is a poor flyer but a fast runner. It can run at speeds up to 15 miles an hour or so in short spurts, and nearly 10 miles an hour for longer distances over level ground. (An average man—not trained as an athlete—can run about 18 miles an hour for short distances.) An adult Roadrunner may reach an overall length of from 16 to 23 or so inches, about half of the total length being its tail.

An Agile Hunter

Roadrunners eat small rattlesnakes and other small snakes, tarantulas and other spiders, scorpions, and many insects. The bird stalks its prey much as a cat does, silently creeping closer until the final pounce. It jumps high into the air to catch grasshoppers that have flown up from the ground trying to escape.

Roadrunners usually smash their live prey against rocks or the ground to stun and kill them before swallowing them whole. If the prey is still alive after being swallowed, the bird brings it up, takes it in its bill and whacks it some more on the ground before swallowing it again.

Most owls and some hawks swallow their food whole, but they cannot digest bones, fur, or feathers. They get rid of these things in little sacs which they cough up and eject from their bills. Roadrunners do not do this, because they can digest every part of the animal they swallow.

The Roadrunner is a timid bird. Usually it comes out in the open only when it is chasing its prey. Yet sometimes it sits and "sings" for an hour or so in the warm early morning sun, announcing its location to friend and foe.

The Roadrunner is protected from its enemies—man, coyotes, hawks, crows, and ravens—partly by its color. The brown, black-streaked, coarse feathers that cover the top of its body and form its long tail give the bird disruptive, or broken, coloration protection *(see* N&S, *April 14, 1964).* The lighter cream color of its underparts blends with the desert and makes the bird hard to see from below.

Because the Roadrunner occasionally eats quail eggs and young quail, and because men shoot adult quail as game, some men in southwestern states try to kill as many Roadrunners as possible. The fact is that Roadrunners eat many more harmful animals than they do quail. Unless this fact is understood by those who want to do away with Roadrunners, the bird may soon join the list of extinct animals.—MARION B. CARR

nature and science

TEACHER'S EDITION / VOL. 1 NO. 15 / MAY 1, 1964

SECTION 1 OF TWO SECTIONS

Let's Take the *Abracadabra* Out of Science Teaching

by Alexander Calandra

■ As every experienced teacher knows, there are "fashions" in teaching, and their value depends on how they are used. The present fashions in education include the teaching of "modern" mathematics, the "discovery" approach, team teaching, the teaching of scientific method, open-ended teaching, and the teaching of critical thinking. Although much of this is good, some of it should be taken with the proverbial grain of salt. Above all, the teacher should avoid being stampeded into the use of techniques which are not suited to his or her situation.

When this difficulty seems to be occurring, the teacher will often find it advantageous to observe very carefully the frank expressions of opinion by students, for these can be most helpful in restoring a proper sense of values.

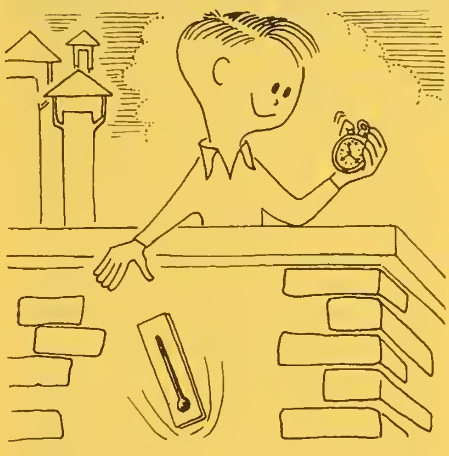
Which Answer Is "Correct"?

Let me relate an incident which illustrates how perceptive and how frank youngsters can often be, and how the comments of these youngsters can be an unbiased guide to the real merit of a new program or teaching technique.

I was once asked by a teacher to help grade an examination question about which a student had made a strong complaint. The question: *Show how it is possible to obtain the height of a tall building with the aid of a barometer.*

The answer the teacher expected was one involving the measurement of atmospheric pressure, but the student answered as follows: "Take the barometer to the roof of the building, attach a long rope to it, lower the barometer to the street, and then measure the length of the rope as the barometer is pulled up to the roof. The length of the rope is the height of the building."

Although this is, of course, a "correct" answer, it had nothing to do with the study of barometers, which had been taken up in class. With this in mind, I



suggested that the teacher give the student another try at the same question. Both the student and the teacher thought this was fair, and the student was given another chance to answer the question while I was there.

The student fidgeted for quite a while without writing anything. This prompted me to ask him if he wanted to give up. "No," he said. He just wanted to select the best answer, since he had many of them.

His next answer was also a surprise. "Take the barometer to the roof of the building, lean over the edge, then let go of the barometer and time its fall. From the amount of time it takes the barometer to fall, you can find the height of the building." At this point the teacher and I agreed that the student showed enough real ability in thinking through a problem that he should be given credit for his answer.

Before I left the student, I asked him if he really had many other answers to the problem. He said, "Indeed I have! If the day is a sunny one, take the barometer to the street level, measure its height, and also measure the length of its shadow. Then by measuring the length of the building's shadow, the height of the building can be obtained by simple ratio and proportion." He told me he had an even simpler and more direct method—one so basic that he was sure I would like it. "In this method," he said, "you use the stairs. As you climb the stairs, you mark the length of the barometer along the wall. This gives the height of the building in barometer units."

When I told him how impressed I was by this display of mental agility, he told me about still another method, which was even simpler and more accurate, although not quite so basic. "In this method," he noted, "you go to the basement apartment where the building superintendent lives and knock on the door. When he answers, tell him, 'Here I have a very fine barometer. If you will tell me the height of the building, I will give you the barometer.'"

At this point I asked the student if he really did not know the kind of answer the teacher wanted. He admitted that he did, but that he was so tired of the "make-believe" rules for scientific thinking that he wanted to show the teacher that, as far as he was concerned, there often were many better ways of getting answers than by following neat rules for making discoveries. He said this was especially true when he already knew the answer he was supposed to be "discovering."

The above anecdote is helpful in pointing out the hazards in giving youngsters pat rules for making discoveries or obtaining answers to problems in science. One way of overcoming these hazards is to have a clear understanding of the basic meaning of science.

As teachers, we must avoid teaching the false impression that science is en-

(Continued on page 4T)

Dr. Alexander Calandra is a Professor of Physics at Washington University in St. Louis. Suggestions for implementing recommendations in this article may be obtained by writing to the author.

THE NEXT ISSUE of *Nature and Science* describes the first archeological confirmation that Norsemen from Europe established a temporary base in North America about 500 years before Columbus sailed to the New World.

How scientists learn about animals and climates of the past by studying fossils is revealed in an account of a fossil mining expedition.

Bridges and what holds them up are the subject of the WALL CHART.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

PAGE 3 Chicken Skeleton

While this article is likely to interest many young people, probably only those most interested in animals—or in building models—will carry it through to completion. Here are some class activities to help your pupils understand the functions of various parts of a skeleton and perhaps stimulate them to try assembling a chicken skeleton.

(The author of "Making a Chicken Skeleton" would appreciate letters from teachers or young people who attempt this project, about their success or difficulties in completing it. Write to David Webster, Elementary Science Study Project, Educational Services Incorporated, 108 Water Street, Watertown, Mass. 02172.)

The suggestions for using the "Chicken Skeleton" article were prepared by Dr. Elizabeth Hone, Professor of Education at San Fernando Valley State College in California, and Edna Chapman, a Staff Member of the California State Nurses' Association. Suggestions for using other articles were prepared by Patricia Ralph, elementary school teacher in the public schools of Huntington, N.Y.

Suggestions for Classroom Use

From your doctor or an x-ray laboratory, try to obtain some x-ray films showing human bones. Put one or more films on a classroom window pane with masking tape. In addition—or if film is not available—hang up a paper skeleton of the kind sold in toy stores for Halloween.

Wait for your pupils to observe and comment. Their observations should give you an opportunity to seed the idea of relationships between structure and function *(see reference 1).*

For example, point out that the large and relatively flat hip and shoulder bones in humans provide surfaces for muscle attachment. The paired lower arm and leg bones permit swivel action of hands and feet. You might invite the assistance of the school doctor or nurse to help your pupils to find the answers to their own questions.

Pupils with manual skill may be able to contribute here by constructing working models of the hand and arm bones *(see reference 2).*

Bring a whole, de-feathered chicken into the classroom. Your pupils can learn quite a bit about the skeleton just by feeling the chicken. Have them bend a leg around to find out how many bones it has, and in which directions the bones can move.

Ask them to see if they can find eyes, eyelids, ears, teeth (birds don't have any), and a nose. Then ask them to compare a chicken's head with their own. Have them turn the head around as much as it can be turned to find out if the chicken can see behind itself.

Have them feel the "bumpy" bones (neck, body, and tail vertebrae), the V-shaped bone in the front of the body where the neck attaches (wishbone), and the long, sharp ridge (keel) that runs down the breastbone (sternum).

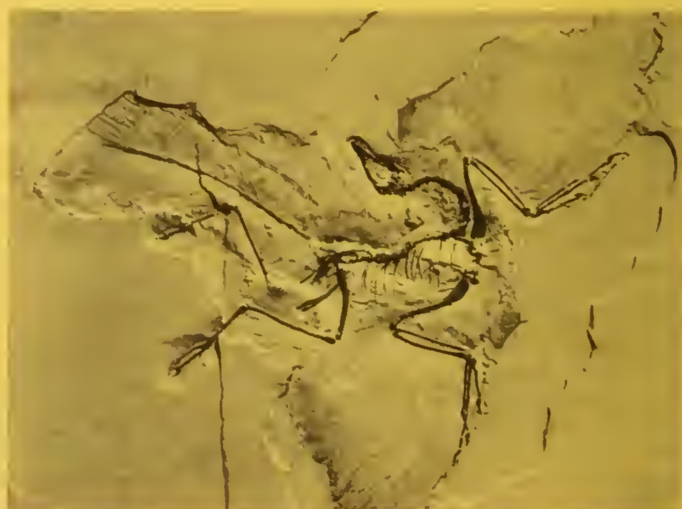
Point out that most birds have such a keel, which strengthens the sternum and also provides a larger area for the attachment of powerful pectoral muscles that move wings *(see reference 3).*

Ask why a chicken's neck is so much longer and more flexible than a human neck. (So it can locate and retrieve food.) Have your pupils compare the size and weight of a chicken's head in relation to its body with the size and weight of the human head in relation to our bodies. Could we hold our heads up straight with a chicken-type neck?

Point out that the chicken's scaly

(Continued on page 3T)

THE AMERICAN MUSEUM OF NATURAL HISTORY



THE AMERICAN MUSEUM OF NATURAL HISTORY

This reconstruction of an *Archaeopteryx*, the earliest known bird, was based on the fossil remains that are shown in photo at right.

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

legs offer evidence that birds were once related to reptiles. Fossil remains of the earliest known bird, *Archaeopteryx,* show that it had the skull, teeth, and tail of a reptile, and the wings, feathers, and gripping toes of a bird *(see reference 3).*

Activities

Encourage your pupils to compare chicken bones to human bones. They should see that the chicken's hip bones, like man's, have a ball and socket joint to permit ambulatory motion of the leg bones; that the chicken's wishbone, which holds the wings away from the sternum, is like man's two collarbones (clavicles) but fused together at the end; that chicken toes and claws differ from humans' because chickens have to scratch in the earth for food and be able to stand on thin objects; that the chicken's wing is both like and unlike a human arm *(see "Wings, Feet, and Flippers," page 8).*

Finally, you might remind your pupils that scientists often reconstruct the skeleton of a long-extinct animal from fossils even though many of the animal's bones are missing. The story of how they manage to do this is told in most books about dinosaurs, and should fascinate anyone who has tried to reconstruct a chicken skeleton *(see reference 4).*

References

1. *Wonders of the Human Body,* by Anthony Ravielli, Viking, 1954, $2.50.

2. *Unesco Sourcebook for Science Teaching,* or *700 Experiments for Everyone (see* N&S TE, *Feb. 21, 1964, page 4T).*

3. *Biology of Birds,* by Wesley E. Lanyon, Natural History Press, 1963, $1.25.

4. *The Wonderful World of Prehistoric Animals,* by William Elgin Swinton, Doubleday, $2.95.

PAGE 10 Penicillin

Pasteur once said that "fortune favors the prepared mind." Sir Alexander Fleming had an inventive mind that was quick to perceive the possibilities in a seemingly unimportant chance event. This article helps put the elements of chance and error in scientific work in a healthy perspective.

SQUIBB DIVISION OF OLIN MATHEISON CHEMICAL COMPANY

Mold cultures growing in these flasks will be transferred to fermenting tanks for large-scale production of antibiotics. Seventeen different types of antibiotics, including penicillin, are produced for use in humans, other animals, and crop sprays.

The investigation suggested at the end of the article can be the springboard to many exciting and enjoyable home or school investigations. Be sure to encourage a few of your pupils to try it.

The subject of this particular investigation is the relationship of microscopic organisms to disease. The concept here is that a particular organism can be considered the cause of a disease if, upon being isolated and injected into healthy tissue, it produces the same disease.

Suggestions for Classroom Use

This is a good time to emphasize the kinship of science to any other serious human endeavor. Ask your pupils if they can recall ways their parents have handled mistakes or unexpected events in their work. What accidents took place in the classroom this year, and how were they used creatively?

The vocabulary of microbiology will be unfamiliar to many of your pupils. Have the class make a list of the new words they are learning. You may also want to include *antibiotic, antiseptic, antitoxin, microbe, serum,* and *vaccine.*

Activities in this area are generally of long duration. It will take about two weeks to complete this investigation. One way to keep interest alive is to have your pupils keep a daily log of the growth of their mold colonies.

Some may guess the outcome. Others may ask, "What is *supposed* to happen?" Try to avoid premature judgments by keeping the investigation open-minded. What *does* happen and *why* are more to the point than what is *supposed* to happen.

Finally, since the children are presented with *Penicillium* as both a bacteria-killer and a cause of disease in fruit, they may be confused and ask if it is beneficial or harmful. Help them to see that it can be both.

PAGE 14 Shadows

This workshop activity will be a pleasant one to take up out of doors on a sunny day.

Your pupils will learn that:

1. Shadows are caused by an object's blocking out light.

2. The circular shape of Sun dapples is due to the circular shape of the source of light, the Sun.

3. The crescent dapples seen during an eclipse are caused by the crescent shape of the light source (Sun) at that time.

Suggestions for Classroom Use

Individual exploration may be stimulated by putting these problems on the board and letting interested pupils select one for investigation.

1. Is the kind of shadow made by a clear bulb the same kind of shadow made by a frosted bulb? Can you predict before you try it out?

2. Can you make the shadow of a straight stick be a curved shadow? Can you make the shadow of a curved stick be straight?

3. Can you think of a way to see around corners?

4. Can you make two shadows touch without having the things that make the shadow touch each other?

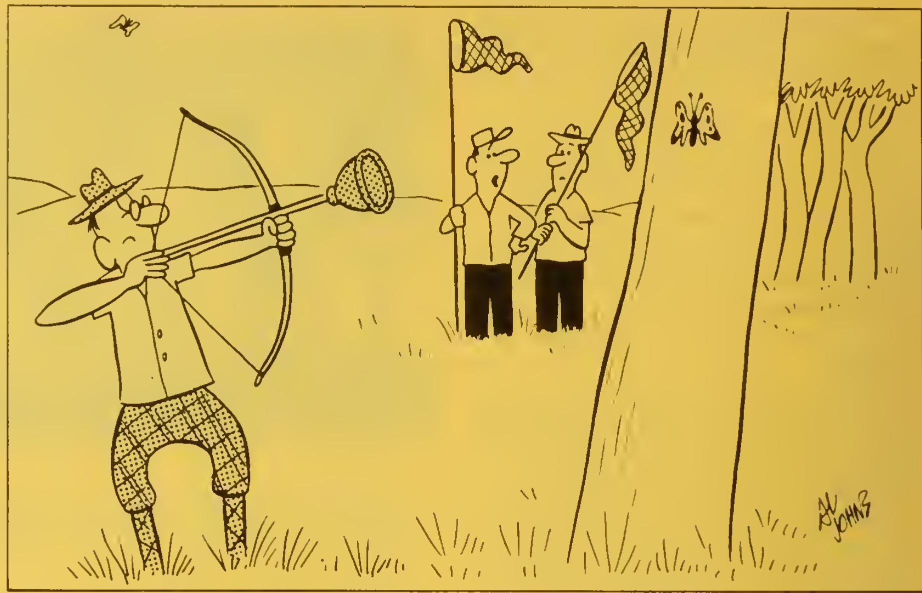
Let's Take the Abracadabra...
(Continued from page 1T)

tirely different from all other subjects. By all means teach scientific method, but make sure to point out that this is not really a method used *only* in science, but that it is used to solve problems in many other subjects.

In teaching scientific method, use a very simple vocabulary. In the elementary grades, avoid the words *observation, hypothesis,* and *verification,* and use the words *look, guess,* and *check* instead. The former words make scientific method look like some kind of mysterious mumbo-jumbo rather than the perfectly normal way the human mind operates, unless it acts on the basis of superstition and emotion.

Although it is justifiable to capitalize on the interest in science that already exists, it is probably a mistake to attempt, in grades 1-5, to stimulate even more interest. In view of the publicity given to space satellites, wonder drugs, nuclear submarines, organ transplants, atomic energy, etc., etc., our youngsters are tremendously interested in science.

The glamorized achievements of science our youngsters read make Merlin the Magician look like a dim-witted clown. Science is the abracadabra of today's youth. Science is the child's dream world come true.



Under these circumstances, efforts to stimulate even greater interest in science make very little sense and, in fact, are apt to do more harm than good. Many of our youngsters, jaded by repeated exposure to sensationalized science, become indifferent to serious study in later years.

I would recommend that serious, systematic science teaching be begun at grade 5, that only basic topics (such as biology, chemistry, and physics) be taught, and that topics taught be part of a larger scheme that has a well-defined direction. This should avoid mixtures of topics, such as weather, magnetism, insects, energy, rocks and minerals, science fairs, plants and animals, etc. ■

nature and science

VOL. 1 NO. 16 / MAY 15, 1964

Who were the adventurous seafaring men who visited North America 500 years before Columbus?

TALES OF THE NORSE EXPLORERS

see page 3

ABOUT THE COVER

The ship on our cover is a Viking warship. "Viking" means "pirate" in Old Norse language. However, not all Norsemen were Vikings. Some of them settled peacefully on the lands that they explored.

The article that begins on page 3 tells about Norsemen who settled briefly in North America 500 years before Columbus's first voyage. The ships in which these long voyages to America were made may have looked something like the ship on our cover. So far, no Norse ships used in those times have been discovered. However, all of the Norse ships that have been found were built with the same techniques and had the same basic design.

The drawing on our cover shows a Viking warship as it probably looked just before going into battle. Shields were hung at the ship's sides to protect the oarsmen from arrows, and a fierce-looking carved "battlehead" was placed on the bow of the ship.

Archeologists believe that, in peaceful times, Norse ships sailed without battleheads. Also, shields were hung on the ship's sides only in preparation for battle or for display in calm weather.

To learn more about these courageous explorers from Norway, see page 3.

nature and science

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Contents

ERRATUM: In the April 3 issue of N&S, p. 14, an article entitled "Make Your Own Electric Motor," by Harry Milgrom, appeared. Due to an editorial error, the following credit should have appeared with the article: "This article is adapted from *Explorations in Science: A Book of Basic Experiments.* Copyright © 1961 by Harry Milgrom. Reprinted by permission of the publishers, E.P. Dutton & Co., Inc. Illustrations in the book adapted by Anne Marie Jauss from original drawings by the author. Harry Milgrom is Assistant Director of Science for the New York City Schools and Director of Science 1, a Saturday program for children at the School of Engineering, Columbia University."

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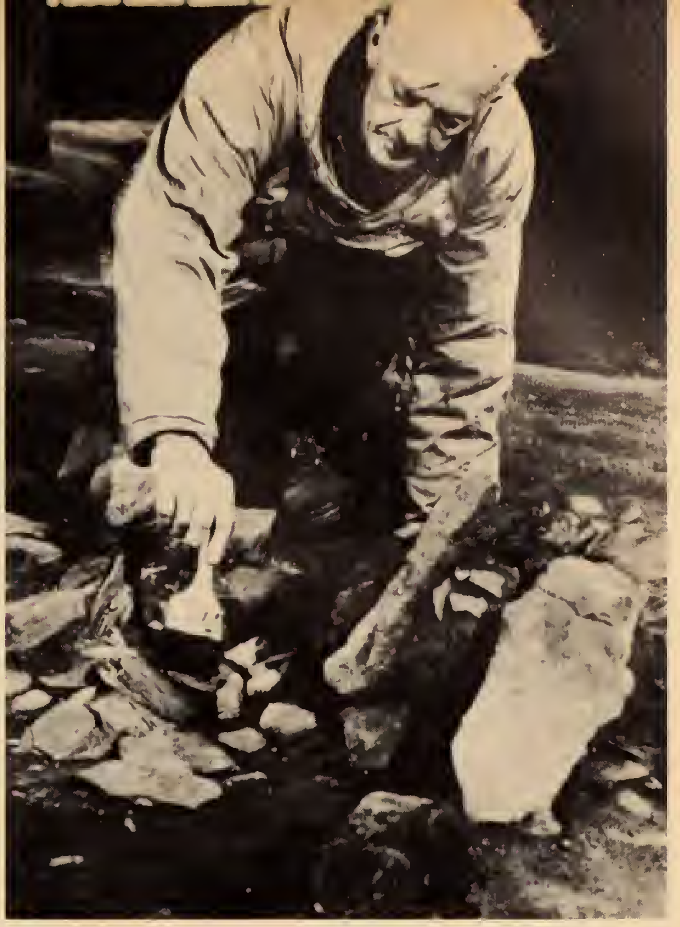
tales of the norse explorers

Archeologists have found traces of European settlers who reached our shores 500 years before Columbus made his voyage.

BY DAVID LINTON



Helge Ingstad, discoverer of the ancient settlement in Newfoundland, brushes off the remains of a fireplace that was once part of a large, Norse-style house. The age of the charcoal remains found in the fireplace indicates that the settlement was active sometime between the years 1000 and 1100.

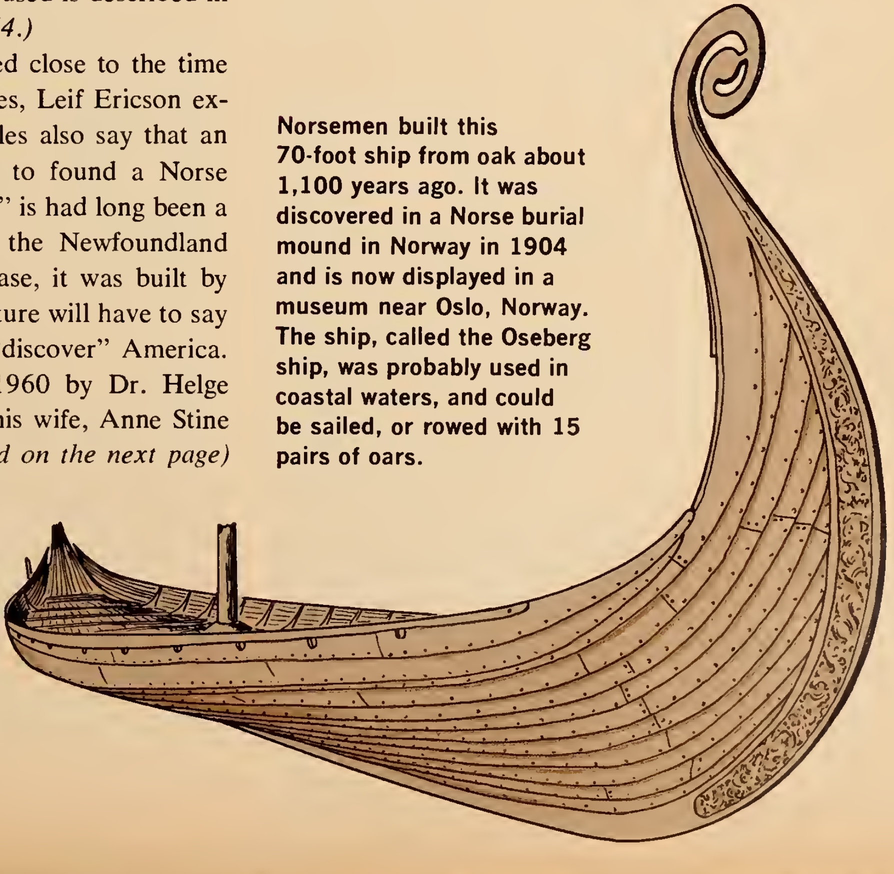
■ At the northern tip of the island of Newfoundland, a Norwegian husband-and-wife team recently found evidence that people from northern Europe visited America 500 years before Columbus set sail for the New World. The discoveries confirm old Norse tales that Norse explorers and settlers had reached the American mainland long, long ago.

The Newfoundland site contains the ruins of nine buildings. In the fireplace of one of them, remains show that iron was produced from a local ore. Scientists who have dated charcoal from the fireplaces say that the wood burned in them grew sometime between the years A.D. 1000 and 1100. (The dating method used is described in *"Dating the Past,"* N&S, *Jan. 10, 1964.)*

This means that the camp was used close to the time when, according to the old Norse tales, Leif Ericson explored a land called Vinland. The tales also say that an attempt was made, without success, to found a Norse colony there. Exactly where "Vinland" is had long been a mystery. It is possible that one of the Newfoundland buildings was Leif's house. In any case, it was built by Europeans, so history books in the future will have to say that Columbus was not the first to "discover" America.

The Norse camp was found in 1960 by Dr. Helge Ingstad, a Norwegian explorer, and his wife, Anne Stine

(Continued on the next page)



Norsemen built this 70-foot ship from oak about 1,100 years ago. It was discovered in a Norse burial mound in Norway in 1904 and is now displayed in a museum near Oslo, Norway. The ship, called the Oseberg ship, was probably used in coastal waters, and could be sailed, or rowed with 15 pairs of oars.

The modern map (right) shows voyages of the Norse discoverers. Eric the Red sailed from Norway to Iceland, and then to Greenland. His son, Leif Ericson, went from Greenland to Norway, and later explored Vinland. Compare this map with the old one (left), drawn in 1590. The old map shows Vinland at the place where Norse relics have now been found—on a peninsula at about the same latitude as southern Ireland. "Frisland" was probably a misreading of "Faroe-islander" (Faroe Islands). No such island exists. Areas colored orange were ruled by the Norse in the 10th century.

Ingstad, an archeologist. For the last three summers scientists from several countries have studied it. In the fall of 1963, Dr. Henry B. Collins, of the Smithsonian Institution in Washington, and Dr. Junius Bird, Curator of Archeology at The American Museum of Natural History, visited the site. They agreed that it must be Norse and was built long before the time of Columbus.

There are three important clues, in addition to the dates of the charcoal:

1. Among the remains were many pieces of iron slag. These showed that the people who used the camp knew how to refine bog iron, a form of iron found near the camp. The Norse knew how to work this iron, but Indians, Eskimos, and later European settlers in Newfoundland did not.

2. One of the rooms was apparently a "byre," a shelter for cows. Neither Indians nor Eskimos kept cattle.

3. Also, the design of the buildings is typically Norse and is similar to that of Norse buildings in Greenland. Greenland was the home of Leif Ericson, the explorer of Vinland, according to the old Norse tales.

Who Were the Norsemen?

The Norsemen who visited and lived in Newfoundland about A.D. 1000 formed the farthest outpost of a civilization that covered a large part of the world then known to Western man. They are usually called Vikings, but that name is somewhat misleading in this case. "Viking" in Old Norse language means "pirate."

The Norse discoverers of America, however, were not pirates, but settlers. Their ancestors had settled in Iceland and on all the islands in the North Atlantic. The settlers were looking for good farm land and, in later years, for wood, which was scarce in the northern islands.

Eric the Red

The farthest of these northern lands—Greenland and Vinland—were discovered, according to the Norse tales, by Eric the Red and his sons. What follows is their story, as handed down in the *sagas,* historical tales that were told by professional storytellers and later written down.

Eric went to Iceland from Norway with his father in about A.D. 950. By that time the Norse had been settling in Iceland for 75 years, and most of the good farm land was already taken. Eric's father died soon after their arrival, and Eric married.

In A.D. 981 Eric was exiled for three years because he had killed some men in an argument. (Neither the killing nor the punishment was at all unusual at that time.) He took his family and servants and set out to explore a land that had been reported to lie west of Iceland.

Eric spent the three years of his banishment exploring the new land and named it Greenland, for, as he said, "men would be all the more drawn to go there if the land had an attractive name." When he returned to Iceland in A.D. 984 his reports of it were so encouraging that many of his friends decided to move there with him.

The following spring 25 ships sailed for Greenland. Some turned back, others were lost, but 14 ships arrived safely. They carried about 350 colonists with their cattle, sheep, goats, horses, and household goods. Each family claimed a farm, and Eric became the chief of the colony.

Fifteen years later Eric's son, Leif, landed on a strange shore where the climate was milder than in Greenland. Leif explored the country and built houses there. The land was called Vinland.

In the years just after A.D. 1000, Eric's sons and other Greenlanders made a number of trips to Vinland. Leif built houses there which were used by later expeditions. The largest expedition was led by Thorfinn Karlsefni with three ships and 160 people. They had all their goods and livestock with them and hoped to make a permanent settlement in Vinland, but the country turned out to be inhabited by primitive people who became unfriendly. After three years, Thorfinn gave up and went back to Greenland. By this time Thorfinn had a son, Snorri, who was the first child of European ancestry to be born in America. This is as much of the story as the surviving sagas tell.

We know of no more attempts to found a permanent colony; however, it is almost certain that Greenlanders visited North America occasionally during the next several hundred years to get wood.

Mystery of Greenlanders' Disappearance

The last of the Norse colonists in Greenland disappeared sometime around 1500. No one knows why. They and their discoveries were almost forgotten, but parts of their story were preserved in Iceland. The Icelanders were very interested in history, especially the history of their own families. Many of them had had relatives among the Greenlanders, and some were descended from those who had been to Vinland.

Many of the ancient Icelandic sagas were copied by priests. Although some were lost over the centuries, a number that refer to Vinland have survived. For years many scholars doubted that the people and places described in the sagas had ever existed, but gradually more and more remains of the Greenland colonies came to light. In 1929 the ruins of Eric the Red's farm in Greenland were found. In addition to the farms, churches, and other buildings, there are tools, parts of furniture, and even clothing—the only examples of ordinary people's clothes from the Middle Ages that are still in existence. The clothes were preserved because they were buried on the bodies of their owners in graves that were quickly frozen and remained frozen for centuries.

This Indian arrowhead and Eskimo carving were found among the ruins of a Norse farm in Greenland. They suggest that the Norse had contact with natives of North America.

The Search for Vinland

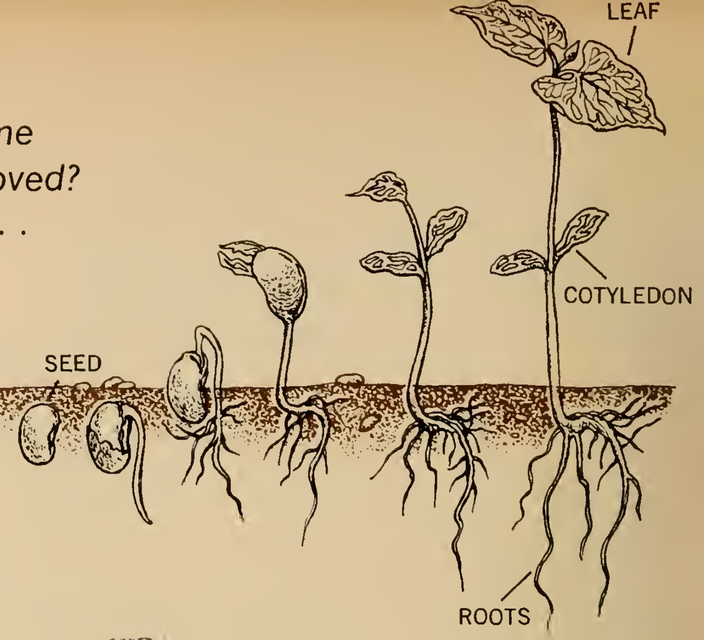
After the first modern book about Vinland was published in 1837, many writers tried to figure out exactly where Vinland was. But the information in the sagas is simply not detailed enough to locate the place.

Curiously enough, one man who tried to find Vinland from the information in the sagas was almost right. W. A. Munn, of St. John's, Newfoundland, suggested in 1914 that the Greenlanders had landed at L'Anse aux Meadows, almost the spot where their camp was found. He thought, however, that they had then moved on and established their camp on another bay a few miles away. If he had been able to visit the area, he might have discovered the ruins of the Norse camp. But accurate dating methods had not yet been invented and the study of Norse farms in Greenland had only just begun. The chances are that he probably would not have been able to convince the scientific world that the site was really Norse. If the site had been dug up at that time the evidence we now find so important might well have been lost ■

Stones in the foreground mark the site of Eric the Red's house near the present Julianehaab in southwest Greenland. The ruins found in Newfoundland are similar to the Norse ruins found in Greenland.

What happens to a young plant when some of its ready-made supply of food is removed? You can find out by experimenting with . . .

"GUINEA PIG" SEEDLINGS



BY RICHARD M. KLEIN

■ Plants, like all other living things, need food for growth. Although a mature green plant can make all of its own food, a young plant, or *seedling,* cannot make enough food to keep growing. A seedling's growth depends on food that is stored in the seed from which it sprouts.

What do you think would happen to a seedling if it had no stored food? Would it keep growing? Would it die? To answer these questions, here is an experiment you can try with bean plants.

Bean plants are used so often for experiments on plant growth that they are called the "Guinea pigs" of plant scientists. For your experiment, use Red Kidney beans or other bean seeds. Do not use dried beans from a grocery store, because they are usually too old to grow properly. You can buy packages of bean seeds from a hardware or garden store.

Soak about 50 seeds in water overnight. Then plant about 18 seeds in each of three pots that contain about six or seven inches of soil. The beans should be planted about two inches below the soil surface. When the seeds germinate and push through the soil—after about six days—remove or "thin out" all but 10 plants per pot. Leave the best-looking seedlings to be sure that the plants are as nearly alike as possible. Then, with a pair of fine-pointed scissors, carefully cut off the brownish seed coats from the buds of the plants *(see diagram).*

You will then have exposed the bean *cotyledons,* where the food is stored *(see "What Makes a Seed Sprout?", N&S, April 3, 1964).* They are plump, yellow to pale green in color, and filled with food called *starch.* In between the cotyledons is the delicate growing tip of the plant.

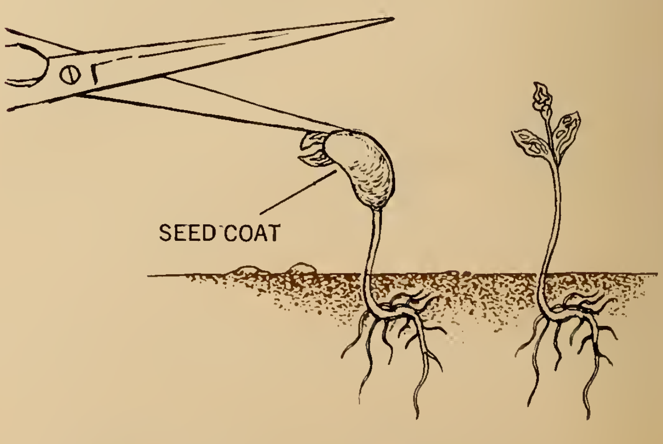
(Dr. Richard M. Klein is Caspary Curator of Plant Physiology at The New York Botanical Garden.)

Label each pot with a number—1, 2, and 3. Do not do anything to the seedlings in Pot 1. These plants will serve as the normal ones, or *controls,* with which the other seedlings can be compared. Now remove one cotyledon from each of the plants in Pot 2 and remove both cotyledons from all 10 plants in Pot 3. Do this with your fingers or a pair of tweezers, taking care not to remove or injure the growing tip of the seedlings.

Let the plants grow for 10 to 14 days, watering them occasionally. Notice how well the seedlings in the different pots are growing. How do the seedlings in Pot 2 and Pot 3 differ from those in Pot 1?

Measuring the Seedlings' Growth

To compare the seedlings' growth accurately, measure the length and weight of each plant. First, use a ruler and measure the distance from the soil line to the point where the cotyledons are found. This distance is called "the length of the hypocotyl." Next measure the distance from



Cut the seed coats from the seeds when they sprout.

the soil line to the tip of the plant—called the "total stem length." Then, using a delicate scale such as a postage scale, weigh each bean seedling after gently shaking the soil from its roots. Finally, cut the leaves from each plant and weigh them, and also cut and weigh the hypocotyls from each plant. Keep a record of each measurement and weighing.

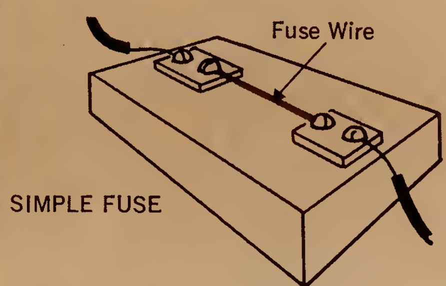
You can put all of your measurements in a table like the one shown on this page. For example, add the 10 measurements of hypocotyl length of the seedlings in Pot 1, divide by 10, and then put this average in the upper left hand box of the table. Work out averages for all of the measurements and weighings and put them in the table. Finally, divide the average measurements and weighings of seedlings from Pot 1 into those of Pot 2 and Pot 3. Compare the percentages you get with 100%—the normal growth of the controls in Pot 1.

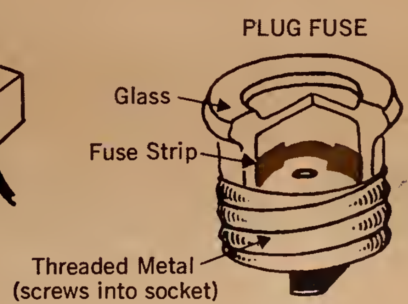
Do the plants from Pot 2 or Pot 3 grow better or more poorly than the control plants? Are the differences the same for all measurements? Suppose you did the same experiment with plants that were grown in the dark for a week after treatment so that they could not manufacture any of their own food. Do you think that the results would be the same? Why not try this experiment too ■

MEASUREMENTS AND WEIGHINGS	POT 1 CONTROLS	%	POT 2 ONE COTYLEDON	%	POT 3 NO COTYLEDONS	%
Average length of hypocotyls (inches)		100				
Average weight of hypocotyls (ounces)		100				
Average length of stem (inches)		100				
Average weight of plant (ounces)		100				
Average weight of leaves (ounces)		100				

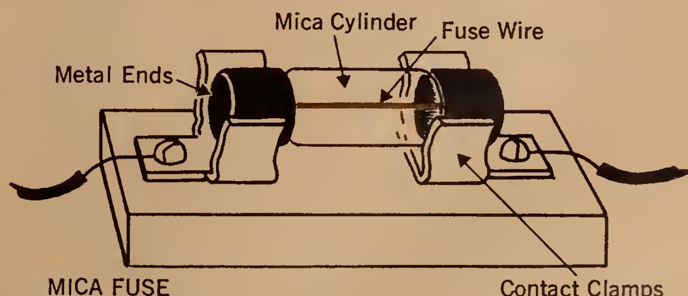
HOW IT WORKS

ELECTRIC FUSES

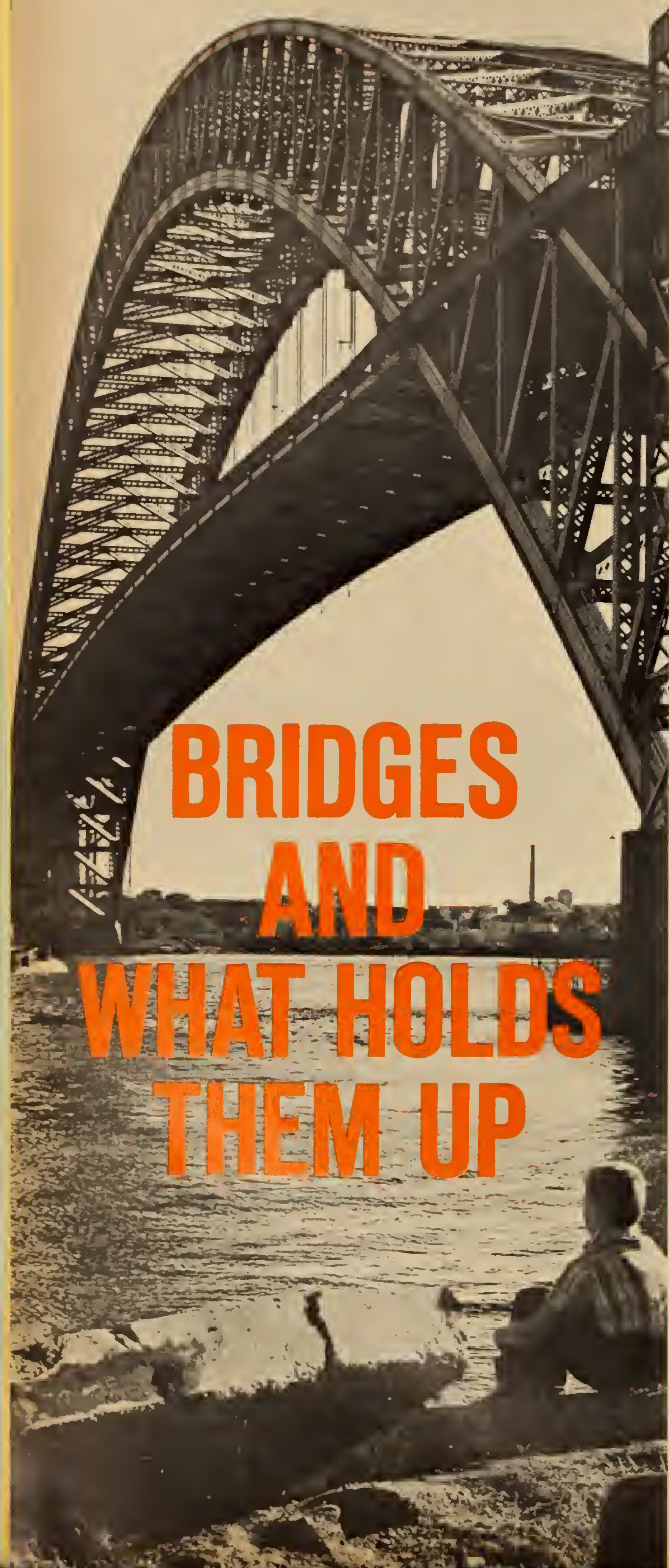




■ A fuse is a kind of switch that automatically opens an electrical circuit when the fuse gets hot enough to melt. *(See "Electric Switches,"* N&S, *May 1, 1964.)* It is usually a short piece of lead (or lead with other metals added to it) that melts at a lower temperature than the rest of the metal wire in the circuit. (Some homes are equipped with circuit breakers that work by magnetic attraction.)

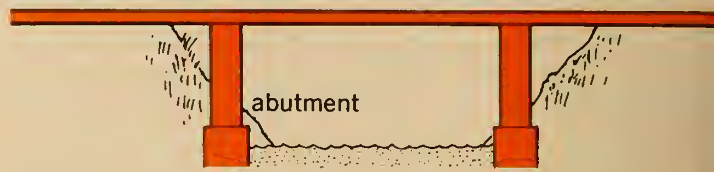


When more current flows through a circuit than the wires are designed to carry, they may heat up enough to set fire to wood or other nearby material. They heat up when the insulation wears off a lamp cord, allowing the two wires within the cord to touch. Or they heat up if a circuit is "overloaded." For example, when too many lamps and other appliances are being used at the same time, all the lights in the circuit may suddenly go out. A fuse has melted, opening the circuit and stopping the flow of electric current before the wires got dangerously hot ■

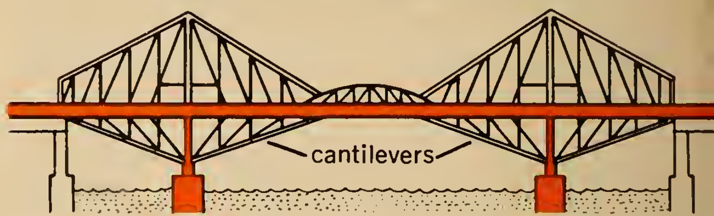


BRIDGES AND WHAT HOLDS THEM UP

SIMPLE BEAM BRIDGE



CANTILEVER BEAM BRIDGE

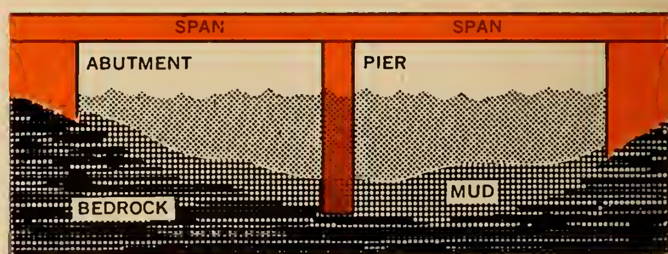


A beam bridge pushes straight down on its abutments. A "co tinuous" beam bridge has one or more piers that help suppo its weight. The abutment ends of a "cantilever" beam bridge a anchored so that a short span can be suspended between the tw cantilever arms.

■ The first bridge made by man was probably just a heavy limb or log thrown across a stream. Since then, men have used stones, wood, brick, concrete, steel beams, and wire cables to build thousands of bridges all over the world. Some of the oldest bridges still standing were built by the Romans across the Tiber River in Italy more than 2,000 years ago.

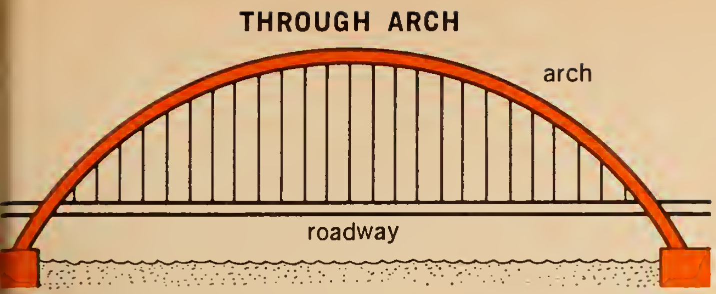
The highest bridge in the world is the Royal Gorge Bridge in Colorado, a suspension bridge 1,053 feet above the Arkansas River. The longest bridge in the world is a 30-mile-long railroad trestle across Great Salt Lake in Utah.

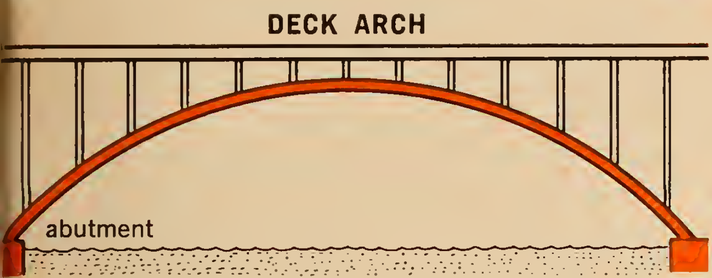
When an engineer plans to build a bridge, he must design it to carry people, automobiles, or trains, and some-



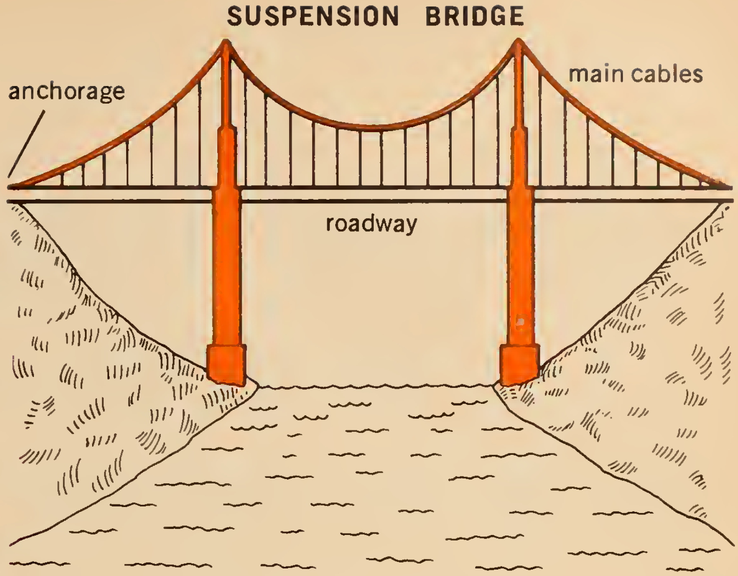
times to allow river or highway traffic to pass underneath. The first part to be built is the foundation, or *substructure (see diagram).*

The substructure supports the bridge and its load. Each end of a bridge is supported by an *abutment*. The foundations that support the middle sections of a bridge are called





ecause an arch bridge pushes downward at an angle against its butments, the abutments must be built on firm ground. Some rch bridges, called "deck" arches, have a roadway running along e top. Others, called "through" arches, have a roadway sus- ended beneath the arch.



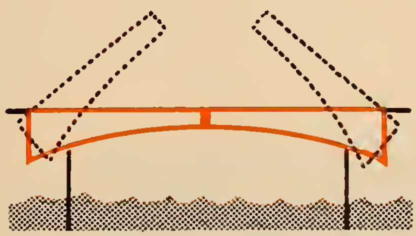
In a suspension bridge, huge cables are hung over two high tow- ers. The cable ends are anchored firmly at each end of the bridge. The roadway is held up by smaller cables that hang from the main cables. The roadway part of a suspension bridge pulls up, in- stead of pushing or pulling down, as with an arch bridge.

he parts of a bridge between the piers and abut- re called *spans*.

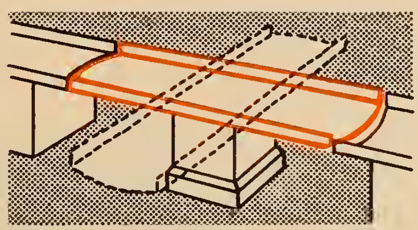
ridge with the longest span in the world is the Golden Gate Bridge of San Francisco. Its main 4,200 feet long. However, that record will be sometime in 1965 when the Verrazano-Narrows n New York is completed. It will have a main span feet. It will connect Brooklyn and Staten Island be the longest and heaviest suspension bridge in d.

eers always try to build bridge foundations on the solid rock beneath the soil or river mud. If the is too deep beneath the soil or mud, piers are piles driven into the ground or river bottom. The t on such materials as sand, gravel, or stiff clay. the substructure is built, a *superstructure* is built Its design depends on such things as the kind of ssing over and under the bridge, the distance be- ores, and where the substructure is placed. For piers cannot block the river or highway traffic bridge.

are three basic kinds of fixed, or non-movable -*beam*, *arch*, and *suspension* bridges. All bridges r a combination of these types. The diagrams on ges show examples of each of these kinds of There are also smaller diagrams showing five movable bridges. You can use these diagrams to ntify the bridges that you see near home and on summer.—Irving D. Kirk

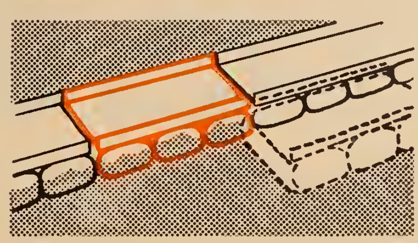


BASCULE BRIDGE: Heavy weights enable the bridge to swing up and down like a drawbridge.



SWING-SPAN BRIDGE: Part of this bridge turns on its pier to let ships pass.

VERTICAL LIFT BRIDGE: The span of this bridge moves up to let ships pass, and down to let traffic go over its roadway.



FLOATING BRIDGE: The roadway of this bridge rests on boats and pontoons. Sometimes part of the bridge may be swung aside to let ships pass.

MINING FOR FOSSILS IN WYOMING

BY MALCOLM C. MCKENNA

How Museum scientists collected fossils from more than 100 tons of 60-million-year-old clay

Mining for fossils begins when the scientists dig up fossil-bearing clays and sand and put them into burlap sacks. Then the clays and sand are taken to a stream for washing.

■ Many people think that fossils are usually found in har rock, but almost anywhere in the world there are ancier beds of sand and clay that contain fossils. One kind c mining for gold in Alaska has turned up thousands of foss remains—and even mummified bodies of mastodons.

In this mining — a kind of *placer mining* — the gol miners spray jets of water against frozen sands and clay in order to break them up to get the gold out. During th spraying process, fossils are washed out along with gold

Collectors of fossil bones wish they could take advan tage of the placer mining done by gold miners at man fossil-bearing deposits, but gold is not found everywhere Most of the places the fossil collectors would like to in vestigate are of no interest to the miners, so the bon hunters must devise their own ways of digging specimen from the ground.

Taking Fossil-Bearing Deposits to Water

Professional fossil bone hunters, called *vertebrat paleontologists,* sometimes dig up tons of sand or clay put it in burlap sacks and carry it in trucks to a stream c pond to wash out the fossils. In 1963, five scientists fror the Department of Vertebrate Paleontology at The Amer ican Museum of Natural History spent the summer place mining for fossils in southern Wyoming. For two months we collected fossils from more than 100 tons of 60-millior year-old clay.

After bringing the sacks of sand and clay to a stream we put the deposits in screen-bottomed boxes. Severa hundred boxes were used, with about 25 pounds in eac box. The boxes were then put into the water to soak *(se photo).* It helps if the water is moving, because the rur ning water gently frees the fossils as the surrounding cla

At the stream, the sacks are emptied into screen-bottome boxes which are set in water to soak. The boxes are shake to help the clays and sand pass through the screens.

softens. Running water also keeps the bottom of the stream free of mud that might clog the screens.

After the clay had soaked for a time, we shook the boxes to help it pass through the screens and leave the fossils behind. When as much clay as possible had gone through the screens, we took the boxes from the water and let the remaining material dry. When dry, the contents—called *concentrates*—were dumped onto canvas tables.

Then we threw away the pebbles and the lumps that were not broken up by the water. Next, all of the bones and teeth of many kinds of small animals, as well as shells and other fossil remains, were picked off the tables and put away. We kept records of where they had been found. The fossils were taken to the Museum for study.

What the Scientists Found

So far, the fossils have not all been studied or even counted. However, we estimate that more than 8,000 complete teeth (and additional thousands of incomplete teeth) of about 30 different kinds of subtropical mammals were collected. There are also thousands of fragments of fossil bones of lizards, fishes, turtles, crocodiles, and birds.

Most of these animal remains are quite small. For example, most of the mammal teeth are less than a quarter of an inch in diameter and some are as small as a pin head. Unless you know what to look for—and how to look—these fossils are never noticed.

Why are these fossils useful? What can we learn from them? For one thing, paleontologists discover the remains of animals that lived millions of years ago and are unknown now. Even though most of the fossils are single teeth from animals that lived long, long ago, we can learn a lot about the animals. Animal teeth differ in many ways. You can easily identify teeth from, say, rabbits or squirrels, and, with practice, even tell one kind of mouse from another by examining their teeth.

Fossils also reveal something about the climate of past ages. If fossil remains of monkeys and large lizards are found, this is a good sign that the region once had a tropical or subtropical climate. The discovery of Polar Bear fossils would be a clue to a past cold climate. Judging from the remains of crocodiles and lizards that we have found in Wyoming, the climate there 60 million years ago may have been like the climate of parts of Mexico today.

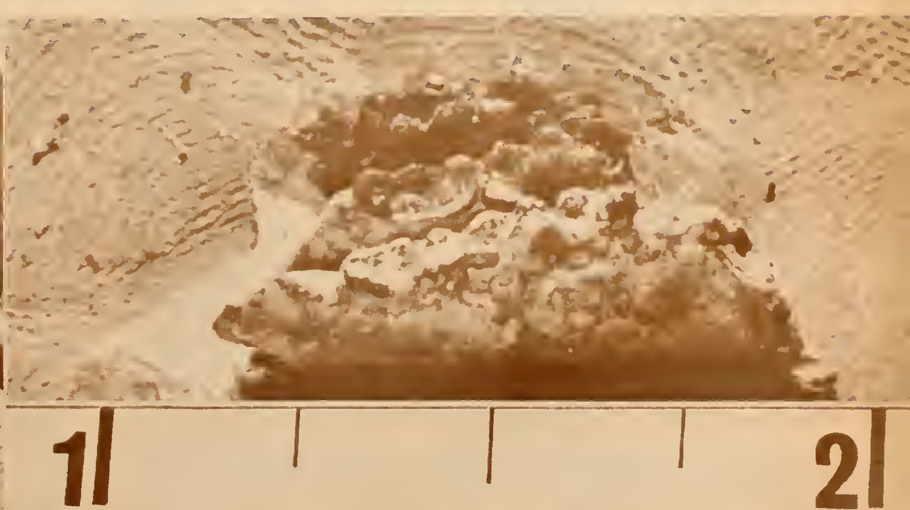
Another kind of information that is very important is the age of the rock that contains the fossils. A particular kind of fossil mammal is likely to be found only in rocks of a certain age. If scientists can find the same fossils in rocks of two widely separated areas, they know that the rocks containing the fossils are about the same age.

Sometimes one group of fossil animals can be identified as the distant ancestors of animals found in another area. Gradually, the "family trees" of many kinds of animals can be worked out as the ages of various fossil deposits become known. In this way a history of animal life is built up by piecing together chapters here and there.

Already in our work in southern Wyoming we have found traces of ancient relatives of monkeys and raccoon-like *carnivores* (meat-eating animals) similar to fossils found in Montana and Europe. These animals spread widely across Asia and Alaska when the climate was warm and humid. The Bering Strait between Siberia and Alaska must have been dry land at that time.

Placer mining of fossils is playing an important part in discovering the ancient life of the past and in finding out how animals spread over the world ■

After washing, the material that remains is dumped onto a table for sorting. The author, right, is showing his daughter Katherine a jaw of an extinct monkey-like animal.



Here are some of the fossils that Dr. McKenna found in Wyoming last summer. These three jaw fragments are from the oldest known monkey-like animals in the world.

THE VOYAGE OF THE BEAGLE

by Millicent E. Selsam

How a young naturalist named Charles Darwin discovered that animals and plants change over thousands of years of time—and how he explained these changes.

Charles Darwin (below) studied the plants and animals of South America as the H.M.S. Beagle sailed along the coast.

■ Marco Polo, Christopher Columbus, Ferdinand Magellan, Vasco de Gama, and Captain James Cook opened up new vistas of the world. Through their voyages, new lands, new peoples, new plants, and new animals were discovered. But there was one sea voyage undertaken by a small British warship, the H.M.S. *Beagle,* that made scientific history as no other voyage had before.

On board was a young Englishman fresh from college, Charles Darwin. Captain Fitzroy, the commander of the *Beagle,* had invited him to come along on the voyage as the ship's naturalist, which meant that he was to observe and collect everything that could be of interest to the scientists of the day. This included plants, animals, rocks, minerals, and fossils. Charles Darwin was not very well trained for the job. But he was a good observer and he was curious about everything. He had a great opportunity too, for the *Beagle* was going out to map the coasts of South America, and possibly to voyage around the world.

The *Beagle* sailed out of Plymouth Harbor, England, on December 27, 1831. It took two months to reach South America and Darwin was seasick much of the time. When he landed in Bahia, Brazil, he was dazzled by the beauty of the tropical vegetation—tall trees, luxuriant vines, gorgeous flowers.

For two years the *Beagle* sailed up and down the eastern coast of South America from Rio de Janeiro to Tierra del Fuego and made two trips to the Falkland Islands. During this time, Darwin went on shore whenever he could and walked or rode on horseback up and down the countryside, stopping now and then to crack rocks with his geological hammer and to collect all the mammals, reptiles, and birds he found interesting. He also made detailed notes describing the things he observed.

Darwin found animals in South America that were unknown to most of the people in Europe. On the pampas of Argentina, Darwin saw *guanacos,* which looked somewhat like small camels; *agoutis,* which resembled rabbits; and *armadillos,* little animals with shells of bony plates.

On the coast of Argentina, Darwin found fossil bones of gigantic animals—huge ground sloths, giant armadillos, and other great beasts. There were no such animals alive then, and Darwin realized that these giant species had died out. Yet these animals apparently were similar in some ways to the living animals Darwin saw around him. The evidence was clear. Animal life had been different in the past; yet it was linked to present-day life.

The *Beagle* sailed through the Straits of Magellan to the Pacific. On the coast of Chile, Darwin got vivid evidence of how the Earth's surface was constantly changing when he experienced an earthquake. He felt the ground move beneath him, and later saw for himself that it had raised the land two to three feet above sea level. From Valparaiso, Chile, Darwin traveled across the Andes Mountains.

High in the mountains he found trees that had been preserved as fossils. Darwin figured that the trees had grown ages ago in volcanic soil at the edge of the Atlantic Ocean, and this land had sunk into the ocean. Buried under mud, sand, and lava from an underwater volcano, the trees did not decay, but some of the chemicals in them were exchanged for minerals that hardened the trees and preserved their shapes. Later the bed of the ocean rose to form a chain of mountains more than 7,000 feet above the level of the sea. Then mountain streams and the wind cut valleys through the lava and the mud and sand that had been changed into rock, leaving the fossil trees.

Still higher up, Darwin found fossil shells of animals that had once lived on the bottom of the sea. They, too, had been buried under thousands of feet of rock that was later thrust up from the ocean, forming high mountains. They, too, had been uncovered by the winds and waters that wore away the rock over the ages. Slowly but surely the young naturalist grasped the sense of geologic time — the ages upon ages during which the Earth's surface has been gradually changing.

In August 1835, the *Beagle* sailed to the Galapagos, a group of volcanic islands about 600 miles off the coast of South America. The animals of these islands—such as giant tortoises and lizards—were even more surprising.

Toward the end of his visit, Darwin discovered that the animals and many of the plants were different on each island of the Galapagos. The natives could tell which island a particular tortoise or bird came from. This was a strange thing, and Darwin puzzled over it. How could plants and animals a few miles apart in the same climate differ so much? If he could answer this question, he realized he would be getting an answer to the bigger question: "How had so many different animals and plants come to be on the Earth?"

What Changes the Earth's Surface?

Five years after the *Beagle* left England, the ship returned home with Darwin still aboard. For 20 years after the voyage, he worked on his tremendous collections of plants, rocks, fossils, and skinned and preserved animals. He got other scientists to help him identify the specimens.

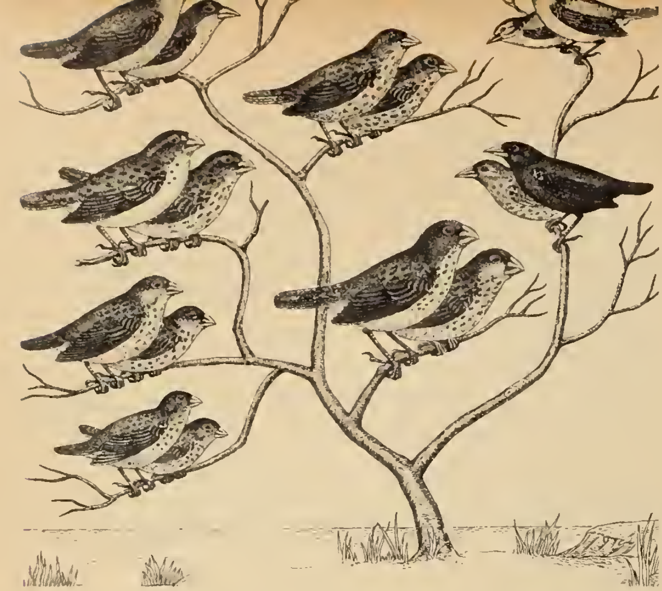
Naturalists of Darwin's time knew from their studies of rocks and fossils that there were different kinds of fossils in successive layers of rock. Most of these scientists tended to believe that these different forms of life were all separate creations. They believed each layer held different kinds of animals and plants because catastrophes such as floods and earthquakes had destroyed life again and again, and after each catastrophe new plants and animals were created.

However, there were some who thought otherwise. During the voyage, Darwin had read the works of Sir Charles Lyell. Lyell was a geologist who proposed that the Earth had been shaped by the same forces that cause changes you can see taking place every day—wind and water wearing down rocks and carrying soil from place to place, volcanoes spouting molten lava, and earthquakes splitting and heaving the Earth's surface.

Darwin had seen these same forces at work and came to agree with Lyell that the Earth was millions of years old. But Darwin added something new. He suggested that living things could have been changed over long periods of time by processes as natural as those that have changed the Earth's surface. The fossil animals he found in South America had convinced him that the animals he found still living there were descended from those extinct creatures. The Galapagos Islands had taught him that animals and plants isolated on islands could develop into different

(Continued on the next page)

Darwin found giant cactus-eating tortoises like these living on some of the Galapagos Islands. He was amazed at the way animals and plants differed from island to island.



These finches living on the Galapagos Islands are an example of how animals change through the ages. Scientists believe that long ago a single kind of finch lived there. Since then, some 14 different species of finches have developed in different kinds of areas on the islands. They differ in size, shape of bill, and feeding habits.

The Voyage of the Beagle *(continued)*

types, so that, in time, each separate island in the Galapagos group would have its own kinds of living things.

How Living Things Changed over the Ages

Darwin organized his facts and slowly developed a theory that explained how living things had changed, or *evolved,* in the course of time. In 1842 he wrote a first draft of this theory, and as the years went by he expanded this first draft to the size of a book. His friends kept urging him to publish it, but he kept delaying. In the meantime, a young naturalist, Alfred Russel Wallace, who had collected animals and plants on many Pacific islands, sent Darwin a manuscript stating the same idea Darwin had developed to explain how living things had evolved.

Darwin was dumbfounded. After more than 20 years of work, someone else had anticipated him! Darwin's friends, who knew how long he had labored on his book, arranged to have a statement about evolution by both Darwin and Wallace announced at the same time. While both held the same theory, Wallace himself was the first to admit that nobody would have accepted the theory without the vast amount of evidence Darwin had collected.

In 1859 Darwin published his book called *The Origin of Species.* Plants and animals, he said, have gradually changed from earlier forms of life by a process of *natural selection.* Animals and plants vary. Some are better suited to their environments than others. Those that are best equipped for getting food and defending themselves from enemies survive. Their heredity is passed on to their offspring. Others less suited to their environment die out. During the course of time, this "struggle for existence" has led to a natural selection of those animals and plants found alive in the world today.

For example, take the horse. The earliest horse we know about lived over 55 million years ago in the forests of North America. Fossils show that it was like a present-day horse in many ways, but it was only about the size of a fox terrier. How did this creature develop into the long-legged horse of today?

Scientists suggest that the first prehistoric horses to go out of the woods onto the plains were chased by other, flesh-eating animals. Horses with the shortest legs would be more likely to be caught by other animals than would horses with slightly longer legs that enabled them to run faster. If more short-legged horses than longer-legged ones were killed before they had a chance to mate and reproduce, the next generation of horses would include more with longer legs, like their parents. And if this process of natural selection continued for several generations, the shorter-legged horses might disappear entirely, leaving the field to those with longer legs.

But the legs of all these horses would not be the same length, either. Those with shorter legs would still be slower runners—and therefore easier for other animals to catch—than the longer-legged horses of their generation. Down through the ages, the horses that could run fastest were better able to survive than those with shorter legs. Slowly, generation after generation, the dog-sized horse of prehistoric times developed into the long-legged animal we know today.

Darwin's ideas raised a storm of discussion. But in spite of opposition, within 10 years they became known all over the world, and *evolution* became the principle basis for studies in biology. Animals and plants could no longer be merely classified into so many separate pigeonholes with every species in its place and a place for every species. They now had to be seen in terms of their origins and family relationships. Biology had at last become a science, thanks to Charles Darwin's remarkable voyage and his capacity to wonder and ask profound questions about simple things ■

You can read more about Charles Darwin and his discoveries in these books, which you can find in your library or bookstore: **The Voyage of the Beagle,** by Charles Darwin (abridged by Millicent E. Selsam), Harper, New York, 1959, $4.50 (a complete version of *The Voyage of the Beagle,* edited and with annotations by Leonard Engel, is available in paperback, The Natural History Library, Anchor Books, 1962, $1.45); **Charles Darwin and Natural Selection,** by Alice Dickinson, Franklin Watts, Inc., New York, 1964, $2.95; **Around the World with Darwin,** by Millicent E. Selsam, Harper, New York, 1960 (this book is out of print but may be in your library).

nature and science

INDEX

Volume 1, Numbers 1-16, 1963-64

KEY:
HIW—How It Works
STI—Special Topic Issue
SW—Science Workshop
WC—Wall Chart
YM—Your Museum

brain boosters

■ Vacation Plans

Mike, Jeff, Mary, and Nancy were talking about their plans for summer vacation. One said, "I'm going to collect rocks and minerals."

Another said, "I'm spending the summer at a girls' camp, and I'm going to learn how to swim."

"I'm going to play a lot of baseball," said another.

"I'm going on a camping trip with my parents," said a fourth.

The baseball player's sister can easily identify feldspar, slate, and granite.

Mary can swim.

Mike doesn't like sports.

From these clues, can you figure out what Mike, Jeff, Mary, and Nancy will each be doing this summer?

■ Making Change

Elizabeth asked Bill if he had change for a dollar. He looked at his change and said, "No, I have seven coins that add up to $1.07, but I can't change a dollar."

"Can you change a half-dollar?", she asked.

"No," said Bill, "I can't even change a quarter, dime, or nickel."

What seven coins did Bill have?

■ Substitution Game

Try substituting different numbers for the letters in this equation to make the answer 100. For example, if you substitute the number 1 for "A" and 2 for "B", the equation reads: $1 + 2 + 11 + 12 = 26$

$$A + B + AA + AB = 100$$

■ Catch the Train

Each morning, Tom drives to the railroad station at an average speed of 30 miles an hour, and just catches his train. One day there was a lot of traffic and he had only averaged 15 miles an hour when he was halfway. Can he still catch the train?

■ Seeing in Circles

Here is a test for your eyes. Which of these eight colored circles fits exactly into the white circle within the black area? Does the black area outside of the white circle make the circle seem larger or smaller than it actually is?

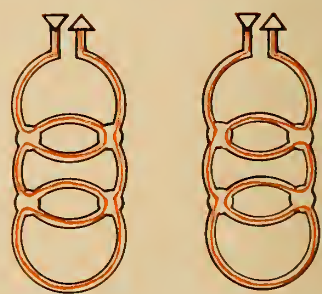
Solutions to Brain-Boosters appearing in the last issue

Add, Subtract, Multiply: Here are some possible answers.

$6 + 4 - 8 \times 2 \times 4 = 16$
$6 - 4 + 8 + 2 + 4 = 16$
$9 + 7 + 5 - 7 + 3 = 17$
$9 - 7 + 5 + 7 + 3 = 17$

Case of the Tangled Bracelet: To untangle the bracelet, open ring R and release ring I, open ring G and release ring O, and open ring H and release ring T. The six letters spell RIGHTO.

Fish Census: One way to solve this puzzle is to set up a ratio. The number of tagged fish in the second catch (35) is to the number originally tagged (247), as the number of fish in the first catch (135) is to the unknown fish population. Multiply 247 times 135 and divide that number by 35. There were approximately 953 fish in the pond.



The Racing Car Problem: Drive along either of these routes.

How Many Triangles?: 24

Winners and Losers: The girls played 13 games. Carolyn won 10 and lost 3, so she received seven pieces of candy from Linda when they settled up.

Solutions to Brain-Boosters in this issue

Making Change: Bill had two pennies, three dimes, one quarter, and a half-dollar.

Substitution Game:
A = 4, B = 6.

Seeing in Circles: Circle no. 5 fits.

Vacation Plans: Since Mary can swim, Nancy must be going to learn how to swim at the girls' camp. Thus Mary must be the sister who can easily identify rocks. She will collect rocks and minerals. Jeff must be the baseball player, since Mike doesn't like to play sports. Mike is going camping with his parents.

Catch the Train: No. The train would be ready to leave when Tom is halfway to the station.

nature and science

TEACHER'S EDITION / VOL. 1 NO. 16 / MAY 15, 1964

SECTION 1 OF TWO SECTIONS

Science Fairs—Pro and Con

by Robert W. Neathery

■ "They...made me realize what children could do, made me want to do more with my group..."

"I just don't know enough about it (science)...I would probably confuse them."

"Some boys and girls have been stimulated to study further..."

"They are just 3rd graders...too young..."

"Can have a definite value, even from the first grade..."

It may be difficult to believe, but all these teachers were talking about the same thing—science fairs for elementary schools. The science fair (mainly on the high school level) is nearly as familiar as the report card, and is a school activity that falls somewhere between school lunches and Bible-reading on the scale of controversial topics.

The above comments show the range of reactions we received when we asked an independent organization to interview elementary teachers in our area. Since 1949, The Franklin Institute has had a science fair in which pupils in grades K-6 have been able to enter exhibits. For the last seven years, the boys and girls in these grades have had a fair specifically for them. So great is the interest in science fair activity that we accept only a few exhibits from local or regional fairs, with the result that The Franklin Institute Elementary Science Fair is highly selective.

So we weren't concerned about how many youngsters were participating, but whether the science fairs in our back yard were doing the job they were supposed to do; namely, to stimulate the teachers and students to venture into some area of science and in the process get an inkling of what science really is.

Cautious Teachers Are Best Prepared

We have a long row to hoe, as the answers above show. We think, from looking at all the answers, that the teachers who say they don't know about science, and are afraid they'll start something that will get out of hand—these teachers are really better prepared for science fair work than those who *think* they know about science but really don't.

What better demonstration of science than such a teacher posing a question and inviting a student or the whole class to help her find the answer? This is science—asking questions, and seeking answers—*not* the answers themselves.

What teacher could be in a better position to demonstrate, and recognize in her students, the basic qualities—human qualities—of a scientist: the *curiosity* to wonder why something happens, or is; the *courage* to ask himself; the *resourcefulness* to hunt information in books and from other people, and to experiment; the *integrity* to throw out hard-won answers that don't quite match the observations; the *fortitude* to keep searching after several failures, or dead-ends; the *ability to reason toward* and the *courage* to state conclusions.

"Wrong" Answers Can Tell Us Much

What many teachers and many, many parents haven't yet learned about science is that answers are never as important as how they're gotten. Through history, man has often learned as much about the world from getting "wrong" answers, as from getting the right ones.

Take the 5th grade youngster who last year won an award in his school science fair, and very nearly won an award in the regional fair at the Institute, with a project that gave him an answer that was definitely haywire: Each day for several weeks, he had lowered a heavy permanent magnet over a series of metal objects, one by one, and measured how close he had to come to the objects in order for them to jump up and stick to the magnet. What he had set out to discover was whether magnetic force varied, day to day or week to week.

His experiment was simple (as many scientists' are), and a bit crude (as many are), and he came to the wrong conclusion (as many scientists sometimes do). He concluded, because the various objects jumped higher some days than others, that magnetic force changed somehow from day to day. His graphs—he had charted distance jumped, day after day, for each object—were a mass of squiggles, and he came to the only conclusion he could, in view of what he knew.

This was a golden opportunity for the science fair judges and his teacher to point out some valuable science lessons, the main one being that he had simply chosen the wrong scale upon which to plot his data. It was so narrow a scale that his experimental method itself introduced variations that he mistook for variations in magnetic force.

And on the other hand, take the 1st grade class which won an award in their local fair, and were accepted to compete in our regional fair, with a project that exhibited virtually none of the basic qualities of a science project.

Their project consisted of trying to pick up various items (paperclip, rubber band, clothes pins) with a little permanent magnet, and then listing those that

(*Continued on page 4T*)

Dr. Robert W. Neathery is Director of the Franklin Institute Science Museum, Philadelphia.

Elementary School Science Fair judges at the Franklin Institute in Philadelphia interview Betsy Lucille Kraus, a 6th-grade pupil whose "Algae Bank" won the top award in the plant biology category. All candidates for top awards are interviewed by the judges to find out how well they understand their subjects and how much outside help they received.

THE FRANKLIN INSTITUTE

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

PAGE 3 Norse Explorers

The discovery of the remains of an early Norse settlement in Newfoundland demonstrates the interplay that often exists between archeology and written history. The main elements, in this case, are as follows:

1. The belief that Norsemen had discovered America long before Columbus was based on the Norse sagas —literature written from stories that had been relayed by word of mouth— rather than on archeological findings.

2. The sagas were regarded by some scholars largely as fiction until ruins of Eric the Red's farm were found in Greenland in 1929.

3. In North America, no traces of Norsemen were found until 1960, when a small settlement was discovered in Newfoundland.

Suggestions for Classroom Use

Discuss with your pupils the difficulty of constructing a story of the past on the basis of physical evidence alone *(see "Who Were the Earliest Americans?" and "Dating the Past,"* N&S,*Jan. 10, 1964).*

Explain the difference between *primary sources* of information, such as reports by people involved, and *secondary sources* of information, such as accounts of their experiences that have been passed down by word of mouth or written down by someone who did not take part in those experiences.

The suggestions for using this issue of Nature and Science *in your classroom were prepared by Patricia Ralph, elementary school teacher in the public schools of Huntington, N. Y., and member of our National Board of Editors.*

HELP WANTED

Do you have a teaching technique that you would like to pass on to others? If so, let us know about it.

We welcome suggestions and articles for the Teacher's Edition that will lead to more effective science teaching in the elementary grades, as well as articles for the student's edition. Articles are paid for on acceptance. All manuscripts should be accompanied by a self-addressed envelope and return postage.

This article and the ones referred to above show how scientists study spearheads, remains of settlements and boats, and so on, to confirm or disprove the accuracy of information obtained from secondary sources (in this case, the sagas).

Activities

1. Suggest that your pupils take a careful look around the house when they get home from school today. Before consulting with their parents, or whatever "historian" is present, they should try to put together a story of what took place at home during the day, from the physical facts alone. A class discussion will bring out details to look for, such as threads on the rug, dirty dishes, cigarette stubs in ashtrays, contents of wastebaskets, and the degree of dampness of the soil in flowerpots.

2. Have someone investigate the Lost Colony of Roanoke in a recent encyclopedia or text. To what extent do archeological findings support historical accounts?

THIS IS THE LAST ISSUE of *Nature and Science* for this school year. All of us who have had the pleasures of creating and producing the magazines—advisers, consultants, editors, and authors — wish you a very pleasant and stimulating summer and hope to serve you again in your classrooms next September.

Many of you will not want your pupils to miss our two activity-packed summer issues: JUNE– summer fun with insects and plants. JULY— all about rocks and minerals.

(For details about ordering the two Nature and Science *summer issues, see* N&S, *April 3, 1964, page 4T.)*

References

1. For pupils wishing to read more about the Norsemen and their way of life—*The First Book of Vikings,* by Louise Dickinson Rich, Franklin Watts, New York, 1962, $1.95.

2. For teachers — *The Norse Atlantic Saga,* by Gwyn Jones, Oxford, New York and Toronto, 1964, $8.

PAGE 6 "Guinea Pig" Plants

This SCIENCE WORKSHOP article tells how to discover the importance of stored food to the early growth of seedlings.

Activity

Here is another way to relate seedling growth to the stored starch in cotyledons. Plant about 60 bean seeds. When they push through the soil, thin them out until there are about 40 to 45 uniform seedlings. Cut off the seed coats. Then have your pupils cut and weigh the cotyledons from five of the plants every two or three days. As time goes by, more and more of the starch will be used by growing seedlings, and each group of cut-off cotyledons will weigh less than the group before. Your pupils can record the average weight of each group of cotyledons on a bulletin-board graph.

At the same time that the cotyledons are weighed, test them for starch. Do this by making an iodine solution of half tincture of iodine and half water. When you drop some of this solution onto a cut area of a cotyledon that contains starch, it will turn dark blue or black. The cotyledons from six-day-old seedlings will be nearly all starch; those from older plants will have only a few spots of starch.

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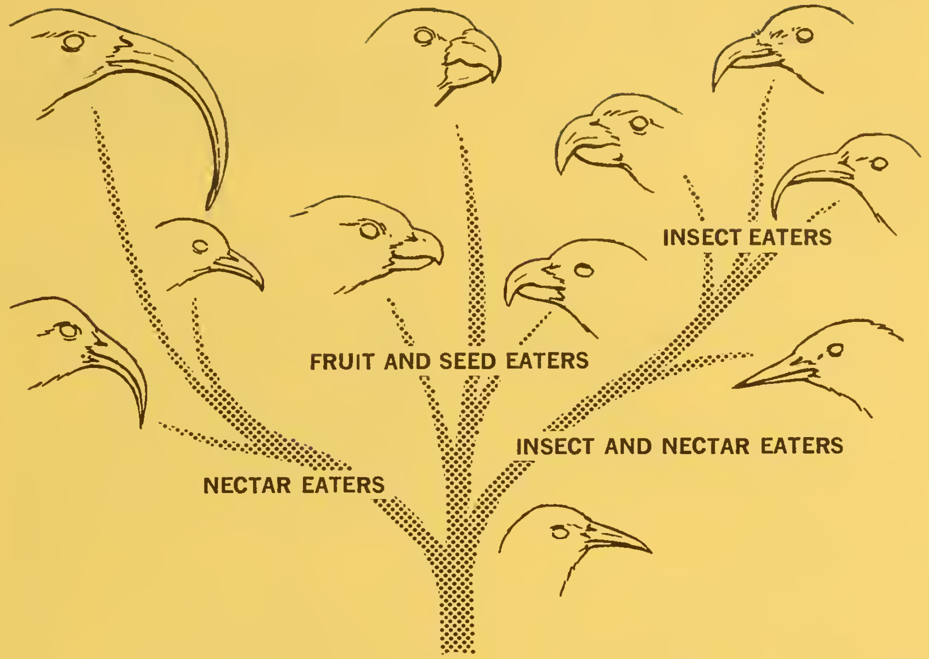
PAGE 10 Fossil Mining

Dr. Malcolm McKenna, who recently led a fossil-hunting expedition in Wyoming, is Assistant Curator of Vertebrate Paleontology at The American Museum of Natural History and a member of our National Board of Editors. He stresses the following points:

1. Fossils help scientists build a picture of animal life in ages past.
2. Fossils help tell something about climate changes over the ages.
3. Geologists can judge the age of earth deposits in a given location by the fossil remains in it.
4. Scientists can sometimes trace the emigrations and evolutionary changes of ancient forms of life by studying fossils.

Activity

Your pupils may wish to do some digging of their own. With permission, they could dig up a small section of the playground and sift the earth deposits through window screening. While it is unlikely that they will come across any fossils, they may make some modest discoveries such as buttons, coins, and marbles.



These Honeycreepers of the Hawaiian Islands show the same diversity as the finches that Darwin found in the Galapagos. Each species of bird is adapted for some particular mode of life or ecological niche. Apparently, when the ancestor of these various species of Honeycreepers arrived in the Hawaiian Islands, it found a diversified tropical habitat and almost no competition with other birds. This family tree shows how several species of Honeycreepers have evolved from a simpler ancestral species by changes in feeding habits. (From "The Biology of Birds," by W.E. Lanyon, Natural History Press.)

PAGE 12 Beagle Voyage

One of the conceptual schemes frequently exemplified in *Nature and Science* articles is the idea that living things have changed over the years. If we were to associate this basic concept with one man, that man would be Charles Darwin. It seems most fitting, then, that we close our first year of publication with a story about Charles Darwin and his historic voyage on the *Beagle*.

Until Darwin's time, biology was a rather static discipline consisting mostly of observing and classifying various forms of living things. It lacked the philosophical substructure that would make it a dynamic, integrated science in its own right. As the article indicates, it was the nature of Darwin's genius to turn, finally, from the accumulation of data to the formulation of a theory embracing them. In doing so he gave biology the unifying theory it needed and laid the foundation for modern work in genetics.

For his theory of the origin of species through natural selection, Darwin owes a great deal to the British economist Thomas Malthus. In his *Autobiography,* Darwin acknowledged finding the clue in Malthus' essay on population.

Darwin's theory is summed up in the following way by William S. Beck in his *Modern Science and the Nature of Life* (Doubleday Natural History Library Series):

"1. The reproductive power of animals is much greater than is necessary to maintain their numbers....

"2. There must be, therefore, a 'struggle for existence' between members of a species and between the different species in the case that several species have the same habitat and food supply.

"3. Animals vary widely—and, presumably, such variation is inherited.

"4. In the struggle for existence, favorable variations have survival value. Unfavorable variations will lead to extermination. This is *natural selection,* the selection of the favored by nature. By accumulation of favorable variations, natural selection leads to gradual change in animals tending toward better and better adaptation and thus to evolution."

Suggestions for Classroom Use

Your pupils can observe some of the same phenomena that led Darwin to his theories on evolution. Some of your pupils may have collections of fossils that include shelled animals and other marine life—evidence of past seas that covered inland areas. You can also visit a local museum to see reconstructions of the ancestors of present-day animals.

Fortunately, most of us live far from active volcanoes, but occasional newspaper articles about volcanic eruptions and earthquakes remind us that the Earth's crust is still changing.

Changes in the form of organisms are usually too gradual for us to observe in our lifetime. However, there are many examples of plant varieties that have resulted from man's manipulation of natural selection. For example, botanists select certain plants with desirable characteristics, crossbreed them with similar plants, and develop such things as giant Shasta daisies, and "stoneless" plums.

For an excellent example of how one teacher handled this subject in the classroom, see *N&S,* Jan. 24, 1964, pp. 1T and 4T.

Science Fairs...
(Continued from page 1T)

the magnet picked up, and those it failed to. No description of their purpose, their method, their conclusions.

Their "project" was more in the nature of a game than a search for an answer, and of course it won no award. That more could be expected of 1st graders was evidenced many times over by projects in the same fair, and on the same topic, by classes that were led to investigate the phenomenon.

In a way, the same fault is often starkly evident in projects involving gadgets that are highly dramatic, but which involve little creative exercise beyond following a circuit diagram, or copying some device and experiment that one finds in textbooks and journals. These projects call for hard and thorough work, but they aren't science.

Actually, teachers are not the only ones who view science fairs with mixed reactions. Scientists do too. Observing that too often the people who arrange and judge science fairs, and some teachers whose students participate, lose sight of those basic qualities we mentioned earlier, the august American Association for the Advancement of Science ticked off some of the problems "...sponsors sometimes have a keener eye for publicity than they do for science...some teachers make participation mandatory ...children (that are) too young are encouraged to enter...a high grade may depend on participation or be given as a reward...gadgetry gets over-emphasized ...showmanship replaces scientific interest...emphasis on competition fosters a kind of intellectual dishonesty..."

Fairs Are a Tool for Teaching

None of these would have become problems if science fairs had been accepted by everyone for what they really are—another tool for teaching.

Fortunately, despite the problems, every teacher who chooses can still use this tool. It can be particularly useful to elementary teachers, because it presents science experiences and concepts without demanding later-grade skills on the part of the teacher.

At any grade level, the gifted science teacher really has no need for a science fair; his students will get all the stimulation they can use in the classroom. But many teachers, particularly the elementary teacher whose job it is to make several rudimentary subjects lively and important, can lean on science fairs for the excitement and incentive they hold for the youngster.

The answer for the interested teacher seems to be this: Use science fairs if they'll help you catch the imagination of your children. Observe your local fair first, or talk to local fair officials, to satisfy yourself that they try to recognize the real scientific qualities of a project—and aren't swayed by mere gadgetry, and that your youngsters will be judged against youngsters of the same grade levels. Be on the lookout for excessive parental help or pressure and try to dispel it if you find it. Encourage group or class projects when you can to make best use of your own time. Don't force a child into school or regional competition if you honestly feel that "losing" will prejudice him against further trying. Try to impress your children with the possibilities in their projects, or new ones after the fair is over. With help from the fair judges if you can get it, help the losers find out for themselves why they didn't win and encourage further work on their own ■

Editor's note: Since elementary-level science fairs are not nearly so common as high school fairs, The Franklin Institute has offered to supply information about their Elementary Science Fair to anyone interested in establishing a fair program in their school or community. Write or visit Mr. Robert W. Neathery, Director of the Science Museum, The Franklin Institute, 20th Street and Parkway, Philadelphia, Pa. 19103.

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nature and science

VOL. 1 SE 1 / JULY 1964

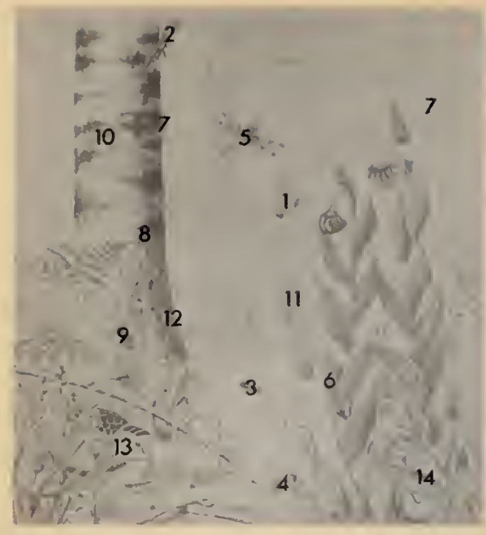
SUMMER EDITION

INSECTS

Rearing Moths and Butterflies...

Identifying Insects...

Firefly Signals... Life in a Pond



ABOUT THE COVER

As you walk through woods and fields this summer, you will see many insects, birds, and other animals. Yet, for each animal you see, there will be many others hidden from your view. The coloration and shape of these animals enables them to blend into the vegetation, tree bark, and dead leaves.

If you look sharply, you can discover some of these hidden animals. Our cover shows 14 of them, drawn in their natural surroundings by artist Su Zan Swain. How many were you able to find?

Bumblebee 1
Walking Stick 2
Black Ground Beetle 3
Fiery Searcher (another kind of Ground Beetle) 4
Dragonfly 5
Ant 6
Inchworm (caterpillar of a Geometrid Moth) 7
Underwing Moth 8
Spider 9
Tree Frog 10
American Toad 11
Snail 12
American Woodcock 13
Garter Snake 14

nature and science

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This is the first of two special summer issues of Nature and Science. Use it as a guide to dozens of summer activities—identifying and collecting insects, rearing your own moths and butterflies, "decoding" the signals of fireflies, exploring a pond, and experimenting with plants and light. This special issue was prepared under the direction of Alice Gray, Department of Entomology, The American Museum of Natural History.

Contents

CREDITS: Cover, p. 2, painting by Su Zan N. Swain; p. 3, drawing by Gaetano di Palma; p. 4, photo by Harry L. Beede; pp. 4, 5, 6, 7, 8, 9, 11, 12, 13, 16, drawings by Graphic Arts Department, The American Museum of Natural History; pp. 10, 14, 15, photos by Paul Villiard, except for photo of Royal Walnut moth, by AMNH.

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THE FLASH SIGNALS OF FIREFLIES

■ Do you know how a firefly uses its flash? These fascinating insects—they are beetles, not flies—use the lamp built into their underside to attract mates. The flashes are signals. With practice, you can learn the flash codes of fireflies and perhaps attract them with a flashlight.

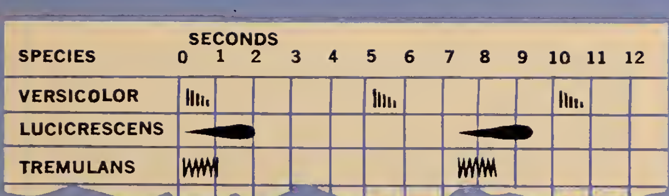
Fireflies that flash during flight are almost always males. The female answers from the ground or from a perch on grass or leaves. Her flash is a little different. When a male sees it, he flies to the female. Only females ready for mating give the right signal, and these signals are answers to the flash of a male of the same species.

The many species of fireflies look so much alike that it is hard to tell them apart, but they are easy to recognize by their behavior. They live in different places and are active at different seasons of the year and at different hours of the night. If you see two or more species flying at the same time, you will notice that they flash different signals. There are slow flashes and quick ones, single flashes or groups, flashes that are close together or spaced far apart. There are bright lights and dim ones; steady, flickering, and fading lights; and lights of very slightly different colors. You may be able to notice other differences.

Scientists use a sort of picture-writing to record the flash signals of fireflies. You too can make a collection of the signals of the fireflies you see.

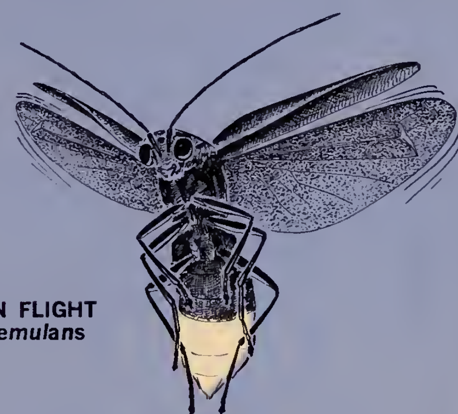
It is hard to watch a clock and an insect at the same time, so get a clock with a very loud tick and *listen* to it instead. Draw your flash picture on graph paper, and allow a square for each two ticks of the clock (one second). Let a horizontal bar or line stand for the light—a broad bar for a bright light, a thin bar for a dim one. Use a zigzag for a flickering light. The time between flashes is sometimes more than the length of the flashes.

Flash signals made by male fireflies of three different species of the genus *Photuris* would look like this:



Versicolor makes five short flashes—the first bright, then each one dimmer—and then remains dark for about four seconds. *Lucicrescens* makes one flash that changes from very dim to bright and lasts two seconds, then it is dark about 5½ seconds. *Tremulans* makes a bright, flickering flash for one second, then is dark for 6½ seconds.

When you make a record, write down the date and the time of night, the place where you saw the fireflies, the color of the light, and any other things you observe.



FIREFLY IN FLIGHT
Photuris tremulans

You will want to record the flashes of females as well as those of males of the same species. The females are harder to find, and not all of them look like beetles. Some are wingless and look more like grubs. These are called "glow worms." A female that has already mated may flash, but she will not give the right signal for attracting males. To be sure that the signal you record is the true mating call, and that the male and female you watch belong to the same species, watch a flashing female until a male comes to her. When you think that the male has seen her, but pays no attention, find another female.

Watching females may give you a surprise. They may be trapping a dinner. There are female fireflies that flash the mating signal of another species. They attract males of that species and eat them. They do not eat the males of their own species, however.—ALICE GRAY

INVESTIGATION

See if you can make the same signal as that made by a firefly. Cover the bulb of a small flashlight so there is only a tiny gleam, then copy the female flash. If your imitation is good enough, male fireflies will fly to you.

Fireflies seem to make flash signals that are not mating calls, but nobody knows how they are used, or if they have any use at all. Perhaps you can find out.

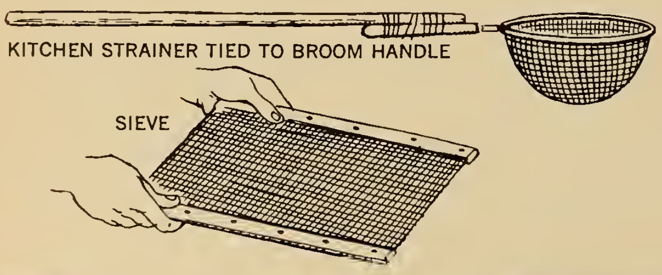
Have you ever watched a Diving Beetle catch its food? Or a dragonfly nymph change into an adult? These and many other surprises await you in . . .

the amazing world of a SUMMER POND

by catherine m. pessino

■ When you think of a pond and its animal life, you probably think first of fishes, frogs, and turtles. They are the pond animals you see most often. But you might try exploring for less familiar animals. They make up most of the pond's inhabitants.

Pond exploring tools can be simple. With a kitchen strainer or dip net you can swoop through the water. If you need a longer reach, a broom handle can be lashed to the strainer. With a sieve you can scoop down into the mud or sand bottom of the pond. To make a sieve, tack fine-mesh window screening to strips of wood *(see diagram).* If you want to examine any of your "catches" closely before bringing them home, put them in a pie tin that has a half inch of water in it and watch them. Since a few of the aquatic insects bite, you might want to pick them up with forceps or tweezers. You can carry your pond animals and plants home in a pail of pond water.



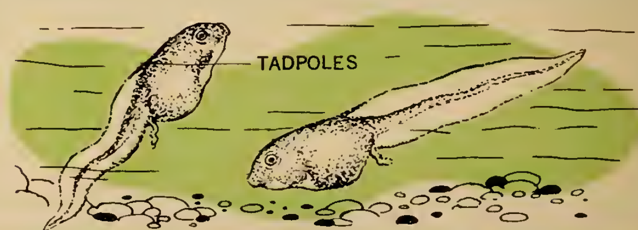
A few swoops of the net through water . . . some scooping up of mud and muck . . . looking carefully at plant stems, floating leaves, and water-lily pads will yield an amazing number of interesting pond animals.

It will be impossible to identify all the animals you catch and to learn their habits in one afternoon, so don't try. Keep only the insects or other animals that you want to observe. When you put the animals in the pail, be sure to place the pail in the shade. If the water becomes warm, the animals will die. (Be sure to return all unwanted animals to the pond. You can catch and study them another time.) Also collect some pond plants—floating ones as well as rooted ones. In the pond the plants shelter the animals from *predators* (enemies).

Here is the way to start learning about these animals.

PROJECTS

1. Watch a Tadpole Change into a Frog (or Toad): Place a tadpole in an enamel pan or plastic basin filled with three inches of water from the pond. In the pond, the tadpole feeds on algae (plants) such as *Spirogyra* and diatoms. At home, feed the tadpole one leaf each of raw spinach and lettuce. Do not feed it again until the leaves have been eaten. Change the water when it looks dirty, and only refill the pan with pond water or water from an aquarium. Gradually the tadpole will grow four legs. When it does, float a piece of wood in the pan so the tadpole will have something to crawl



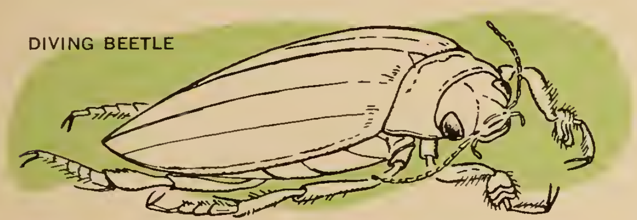
onto. At this stage the tadpole can jump around, so be sure to cover the pan with a piece of wire screen.

While watching and waiting for the changes to take place in the tadpole, record your observations in a notebook. Keeping records is an important part of scientific study. Well-kept records may help with the answers to many questions. Unless you have one of the small tadpoles that *transforms,* or changes, within a few weeks, you will also learn patience, for the tadpoles of the Green Frog and Bullfrog take two, and sometimes three, summers to transform.

There will be changes going on inside the tadpole that you will not be able to see but may be able to think out for yourself. For example, when the tadpole transforms, it is no longer a plant-eater but a meat-eater. Changes must take place in its digestive system. You can read about the changes that take place inside the frog in books listed at the end of this article.

When the tadpole has transformed into a frog or toad, return it to the pond.

2. Observe the Diving Beetle: The Diving Beetle also makes an interesting aquarium animal. If you do not have a tank, use a gallon jar with a wide mouth. Put a layer of sand on the bottom. Plant one or two pond plants and add pond water. After the pond water



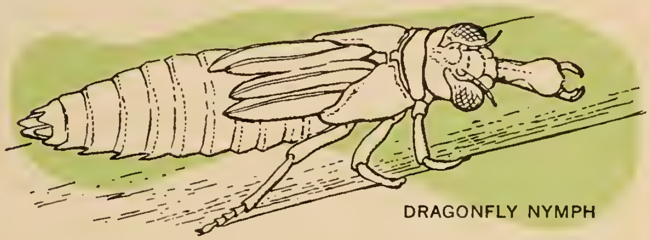
has settled, add the Diving Beetle. Be sure to use forceps, because it bites. A length of nylon stocking held with a rubber band can be used to cover your aquarium.

You will soon see why this animal's common name is Diving Beetle. You will also learn that it is a bloodthirsty, predatory animal that must be well supplied with live food—any insect that isn't too big for the beetle to swallow.

While observing the beetle, see if you can learn the answers to the following: What is the resting position of the beetle? Why? How can it remain under water? Why does it have flattened hind legs? How does it capture its prey? What role does it play in the pond?

3. Observe the Dragonfly Nymph: Another shallow, enameled pan with pond water in it can be used as a home for the dragonfly nymph. Add a few water plants to which the nymph can cling. In the pond, the nymph clings to plants and waits for small animals to swim by. In your aquarium it will take bits of raw hamburger—but you will have to wiggle the meat in front of the nymph. It will not eat unless its food is moving.

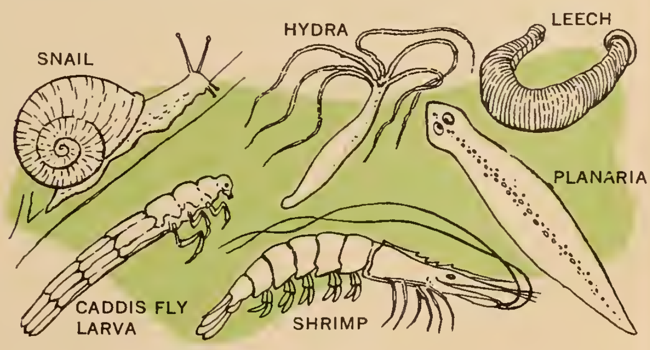
The way it catches its prey will surprise you. You will also be interested to see how it breathes, and how it makes a quick getaway when it senses danger. (Put it in a small dish of water and place a drop of India ink behind—not on—its tail, to see how it breathes and moves quickly.)



If the nymph tries to climb out of the water, it may be ready to transform into an adult. Place in the pan a stick that is long enough to rest above the edge of the pan. The nymph will then be able to climb out of the water. It will do so when it is ready to shed its skin. In the pond, rooted plants provide places where animals can climb in and out of the water. You will be in for a rare treat if you see the adult dragonfly emerge. It is as exciting as watching a moth emerge from a cocoon.

When the adult emerges, let it fly away so it can catch its own food (mosquitoes).

The next time you visit the pond, you may wish to carry home other pond inhabitants for study—a snail, some hydra, a leech, a caddis fly larva, a shrimp, some planaria, and so on ■



These books will help you identify the animals and plants you find in a summer pond: **Field Book of Ponds and Streams,** by Ann H. Morgan, G. P. Putnam, 1930, $5; **Pets from the Pond** (1958) and **In Ponds and Streams** (1955), by Margaret Waring Buck, Abingdon Press, each $1.75 (paperback); **Beginner's Guide to Fresh Water Life,** by L. A. Hausman, G. P. Putnam, 1950, $2.95.

By the flick of a light switch, you can give certain plants different amounts of daylight and...

MAKE FLOWERS BLOOM WHEN YOU WANT THEM

BY RICHARD M. KLEIN

■ Have you ever wondered why crocuses bloom only in the springtime, Black-eyed Susans flower only in midsummer, and chrysanthemums bloom in autumn? Most of us can make lists of plants that bloom only in the spring, or the summer, or the fall. Many important food crops such as spinach, sugar cane, soybeans, and wheat are in flower only at one special time during their growing season.

Scientists, too, have wondered about this striking ability of plants to "know" just when to flower. The biggest advance in our understanding of flowering was made almost by mistake. In 1920, two scientists working for the United States Department of Agriculture in Maryland were trying out breeding experiments on a new, giant variety of tobacco. The plants grew to be about 10 feet high, but they never formed flowers. When the scientists, Dr. Willard Garner and Dr. Harry Allard, transplanted cuttings from the plants into a greenhouse, the plants developed flowers in the winter.

The two scientists decided to see if they could find out why this kind of tobacco didn't flower in the late summer like most other kinds of tobacco. They first tested the effects of different strengths (intensities) of light, and different temperatures, but the plants did not flower. Then they tried to see if the amount of water, or the minerals in the soil, or combinations of these caused the tobacco to flower. All of their experiments failed.

One Last Experiment

Simply because they didn't know what else to do, they decided to change the number of hours per day during which the plants received light. This is really an easy thing to do. The day length can be increased by turning on electric lights over the plants. The day length can be shortened by covering the plants with light-tight covers.

Drs. Garner and Allard were surprised to find that the tobacco plants quickly formed flowers only when the day length was short. So long as the plants received the number of hours of light that are common in the summer, no flowers developed. However, when the day length was about as short as it is in the winter, flowers developed even on very small plants. The scientists called this kind of tobacco a *short-day* plant.

In another series of experiments, the two scientists planted many soybeans. They planted some in the early spring, some in late spring, some in early summer, and some in late summer. They thought that, by this method, they would be able to have flowering plants for their experiments all during the year. To their amazement, all of the soybean plants flowered at exactly the same time—in the early fall. It seemed that soybeans, like the giant tobacco plants, were short-day plants.

What about Summer-Blooming Plants?

Drs. Garner and Allard wondered if plants that normally flower in the middle of the summer (when the days are long) might also be affected by the length of the days. They tried to make some summer-flowering plants bloom in winter by giving them a long day length. For several months, the plants were placed under lights from dusk until late at night. Sure enough, the summer-flowering plants bloomed in winter. The scientists called the plants *long-day* plants. These plants include beets, lettuce, Black-eyed Susans, and potatoes.

Finally, the scientists found that some other kinds of plants would flower any time that they were big enough. Called *day-neutral,* these plants do not require any particular day length to start blooming. Tomatoes, dandelions,

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

corn, and a number of tropical plants such as oranges and mangos are day-neutral plants. They form flowers at any time of the year.

Scientists throughout the world became interested and excited about these discoveries. They began experiments of their own to learn more about how day length affects plant flowering, or "photoperiodism" *(photo* = light, and *period* = time). They discovered that all plants of the same species do not always have the same day-length requirements for flowering. Some tobacco varieties, for example, are long-day plants, others are short-day plants. Still others are day-neutral. The scientists also found that most plants have to be above a certain minimum size and have to be growing well before they will bloom. If scientists grew plants in poor soil, or in very cold or hot temperatures, even giving them the proper number of hours of light per day would not cause the plants to bloom.

Knowledge about photoperiodism of plants is being used to delay or speed up the blooming of certain flowers in greenhouses. For example, Poinsettas, which normally bloom in September, are kept under long-day lighting until shortly before Christmas. Then they are exposed to the normal winter day length, and bloom in time to be sold for Christmas. The same procedure is used in large greenhouses where vegetables grow for the winter market ■

For more information about plants and plant experiments, look for these books in your library or bookstore: **Play with Plants** (1949, $2.78) and **Plants That Move** (1962, $2.95), both by Millicent Selsam, William Morrow and Co., New York; **The Wonderful World of Plants and Flowers,** by Howard Swift, Home Library Press, New York, $2.95; **The First Book of Plants,** by Alice Dickinson, Franklin Watts, New York, 1953, $2.50.

INVESTIGATION

Here is a summer research project on photoperiodism you can try. First, buy seeds of one or more short-day plants, and seeds of one or more long-day plants from a garden store or seed company. Some short-day plants which can be grown in pots are Cosmos, Amaranthus, and Dill (which is used to make pickles). Four good long-day plants are the Dwarf Shasta Daisy, Petunia, Dwarf French Marigold, and the Moss Campion.

Plant about two dozen seeds of a short-day plant in each of two large clay pots filled with soil. Label each pot with the name of the plant, and the planting date. Also start two pots of a long-day plant and label these pots carefully. Follow the directions for planting which are on the seed package. The seeds will germinate and form seedlings in about a week or 10 days. Record the date when the plants appear above the soil. Water the pots every few days, but don't overwater them.

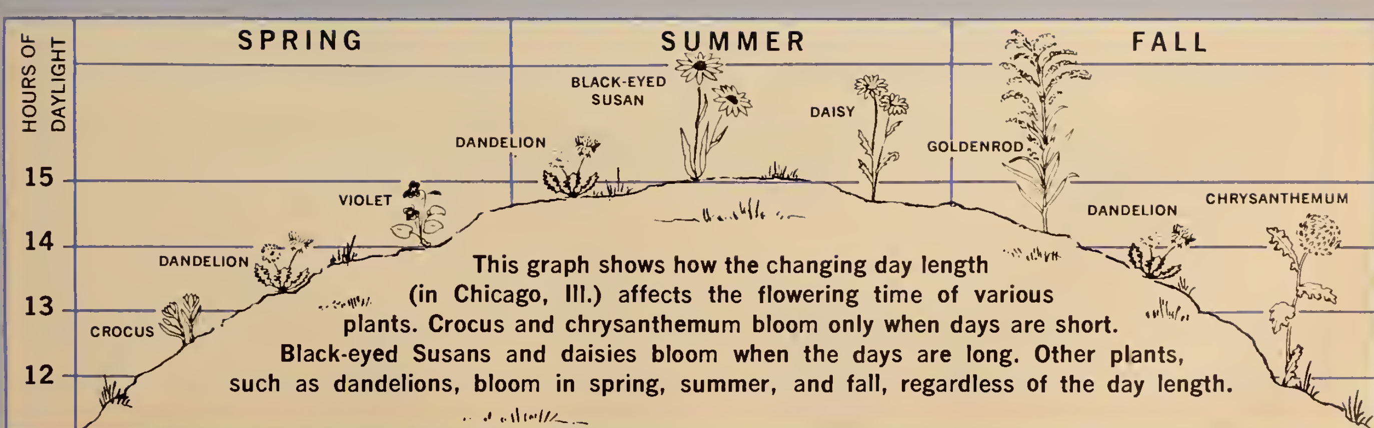
When the young plants are about two inches tall, pull out any that are very small or very large so that you will have 10 plants of the same size in each pot. Keep all of the pots in a place where they receive as much sunlight as possible.

When the plants are about four weeks old, you can start your investigation. Remember that the summer days in North America are long days, averaging about 15 hours of sunlight a day from June through early August. This means that the short-day plants will not normally flower until the days become short in late August or September. To cause them to flower in the middle of the summer, you must reduce the number of hours of sunlight that they receive each day.

To do this, take a cardboard box tall enough to cover one of the pots completely. Make sure that it is light-tight by binding all of the edges and seams with black Mystic Tape. Use the box to cover one of the pots of short-day plants and leave the other pot—the "control" plants—exposed to long days. Cover the experimental pot at about 5 or 6 o'clock each evening and remove the box each morning between 7 and 9 o'clock. This must be done every day for at least 10 days to two weeks.

After the plants have been covered and uncovered for about two weeks, flowers will appear in another two weeks or so. Did the "control" plants exposed to long days (the uncovered pot) form any flowers? Will they form flowers if you leave them growing into the early fall?

The two pots of long-day plants that you left in the natural long days of summer should flower. Can you think of a way to stop them from flowering? What would happen if you covered one pot with a box so that the plants received only about nine hours of light?

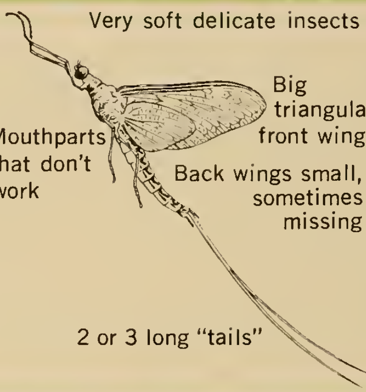
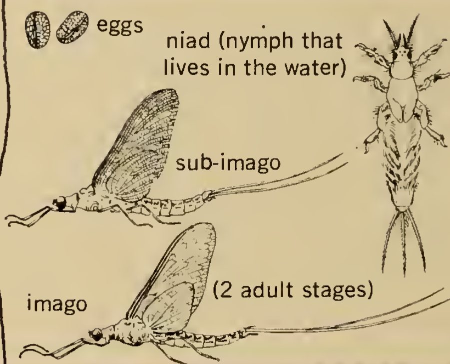
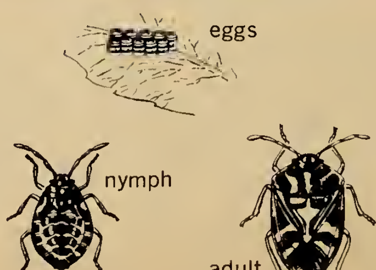


This graph shows how the changing day length (in Chicago, Ill.) affects the flowering time of various plants. Crocus and chrysanthemum bloom only when days are short. Black-eyed Susans and daisies bloom when the days are long. Other plants, such as dandelions, bloom in spring, summer, and fall, regardless of the day length.

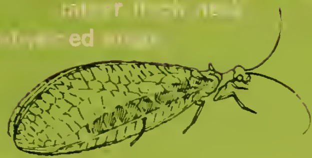
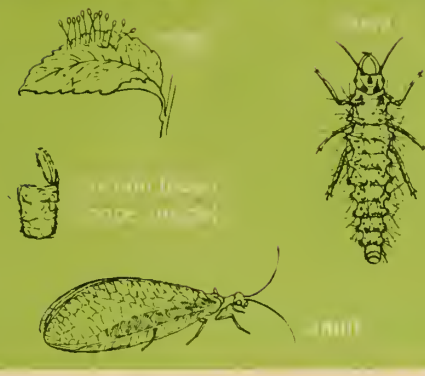
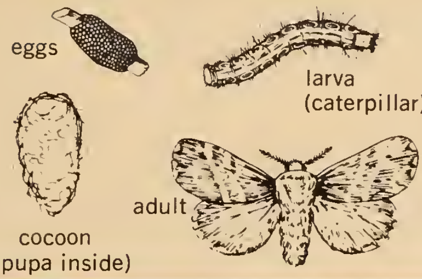
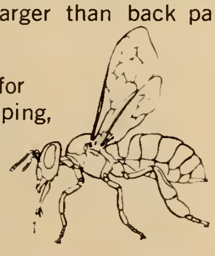
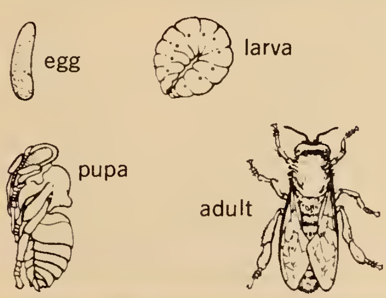
PREPARED BY ALICE GRA

THE LARGER ORDERS OF INSECT

The kinds of insects you are most likely to find this summer belong to one or another of these large groups, called **orders.** In every order, there are some kinds of insects that do not have all of the features listed in the "LOOK FOR" column, but they usually do have enough of them to te you the order to which they belong. An insect that does no fit anywhere in the chart probably belongs to one of th 18 or more smaller orders, which are not shown here.

SCIENTIFIC AND COMMON NAMES	IN ADULTS LOOK FOR:	TYPE OF DEVELOPMENT	MOST GENERAL HABIT
ORTHOPTERA (straight wings) Grasshoppers, Crickets, Katydids, Roaches, Mantids, Walkingsticks. (Some people make 4 orders of these.)		INCOMPLETE METAMORPHOSIS 	Most kinds eat plants. A f catch living animals for fo Many are scavengers, or om vores (eaters of everythin They are often cannibals, least in captivity.
EPHEMEROPTERA (winged insects living only a day) Mayflies	Very soft delicate insects  Big triangular front wings Mouthparts that don't work Back wings small, sometimes missing 2 or 3 long "tails"	INCOMPLETE METAMORPHOSIS 	Most niads feed on tiny wa plants and bits of large ones few eat other water insec Adults can't eat anything, a live for only a short while few hours to about a wee These are the only insects w two adult stages—that is, th moult after they can fly. T sub-imagoes have milky cloudy wings and are not v active. Imagoes have transp ent wings. You usually see th "dancing" in swarms over t water.
ODONATA (with teeth) Dragonflies and Damselflies		INCOMPLETE METAMORPHOSIS 	Niads have mouthparts l "lazy-tongs," catch other wa insects for food. Adults str prey out of the air with a "b ket" made of spiny legs. They very well but can walk hardly all. They can't sting, though p ple think they can. They eat ing insects, mostly mosquito
HEMIPTERA (half wings) True bugs: Cicadas, Leaf Hoppers, Treehoppers, Froghoppers, Aphids, Scale Insects, and others. (This group is often broken into two orders.)	Mouth parts for piercing and sucking True bugs have wings that fold flat over the back The base of the front wing is leathery; the tip is thin  Other hemipterans hold their wings above them like a roof The front pair may be either leathery or thin, but are the same all over	INCOMPLETE METAMORPHOSIS 	Some live in the water, l more on land. Some suck blood of animals. Their bite often very painful. More dr the sap of plants. A few can solid food by injecting sal into it to digest it and th sucking up the "broth." Ma diseases of plants and anim are carried by members of t order.

INCOMPLETE METAMORPHOSIS—Slight and gradual change of shape during growth. In insects, the young are called "nymphs." They look a lot like their parents and have similar habits.

SCIENTIFIC AND COMMON NAMES	IN ADULTS LOOK FOR:	TYPE OF DEVELOPMENT	MOST GENERAL HABITS
NEUROPTERA (nerve wings) Lacewings, Fishflies, Dobsonflies, Antlions, and others. (Some people make several orders out of this group.)	[illegible]  [illegible]	COMPLETE METAMORPHOSIS 	All the larvae are hunters. So are many of the adults. They are beneficial to people because of the number of aphids and other pests which they eat. The larvae of Fishflies and Dobsonflies live in the water, and are food for fish.
LEPIDOPTERA (scaley wings) Moths and Butterflies	Mouthparts form a long coiled tube  Wings covered with tiny scales that come off on your hands like dust	COMPLETE METAMORPHOSIS 	Almost all caterpillars eat plants or plant products. A few prey on other insects, or feed on animal products. Adults take only liquid food, mostly the nectar of flowers. Some cannot feed in the adult stage.
COLEOPTERA (sheath wings) Beetles	[illegible]  [illegible]	COMPLETE METAMORPHOSIS 	This is the largest of all groups of animals. There are at least 250,000 kinds. They live wherever insects can live. One sort or another eats everything that is or ever was alive.
HYMENOPTERA (membrane wings) Sawflies, Ichneumon Flies, Wasps, Bees, Ants and others.	4 wings like cellophane (if any) Front pair larger than back pair Mouthparts for chewing, lapping, and sucking  Female often has long ovipositor or sting	COMPLETE METAMORPHOSIS 	A few are plant eaters. Many are hunters or parasites upon other insects. Adults of many kinds pollenate flowers while feeding on nectar. Many kinds take more care of their young than insects usually do. Several groups of them are social.
DIPTERA (two wings) True flies (include gnats, midges, mosquitoes)	[illegible]  [illegible]	COMPLETE METAMORPHOSIS 	Larvae usually are scavengers or parasites, a few hunters and plant eaters. Adults take only liquid food. Many are blood suckers and carriers of disease.

COMPLETE METAMORPHOSIS—Great and sudden change of shape during growth. In insects the young are called "larvae." They don't look at all like their parents, and often have different habits.

REARING MOTHS AND BUTTERFLIES

This can be a fascinating "hobby within a hobby," for there are many things yet to be discovered about what these insects need to live and how they satisfy their needs.

by Paul Villiard

■ Possibly some of your friends have a collection of moths and butterflies. But how many of them rear their own specimens from eggs? Here is a fascinating hobby within a hobby. By rearing your own moths and butterflies through their four stages *(see pages 8-9)*, you will not only have the thrill of watching these insects change, but you may discover something that no one has ever known before.

The first questions you will ask are "Where can I get butterflies and moths?" and "In what stage can I begin to rear them?" The box on the next page lists a few of the hundreds of breeders who sell eggs, cocoons, and pupae.

If you want to observe the entire life cycle of a moth or butterfly from the start, eggs are the best stage to begin with. But you can also begin with the caterpillar, cocoon, pupa, or chrysalid stage. This would mean finding them outdoors, or buying them from a breeder. If you buy eggs, springtime is the ideal time to begin, but eggs of some species are available into June and some of them into July.

Some species of moths and butterflies lay their eggs in the fall. The eggs *overwinter,* which means that caterpillars do not hatch out of them until the following spring. Most species, however, make a pupa, cocoon, or chrysalid in which they pass the winter. Then they emerge as adults in the spring, mate, and lay their eggs, which hatch in a few days.

As soon as caterpillars hatch from eggs they begin to eat leaves. As they grow, they shed their skins. Weeks later moth caterpillars form a naked pupa (center), or a pupa within a cocoon (right). In spring, moths emerge from the pupae.

Where To Get Moth and Butterfly Eggs

Suppliers ship eggs inside a goose quill or a plastic tube in an airmail letter, so you receive them quickly. In the beginning you should not buy more than one or two different species, and a dozen eggs of each species are plenty to practice with. Moth and butterfly eggs are very reasonable in price.

The names and addresses of some breeders who sell in small quantities, and who are willing to help beginners, are Mr. Paul E. Stone, 409 Henrietta Street, Munith, Michigan; Mr. Duke Downey, Box 558, Sheridan, Wyoming; Mr. Paul Villiard, 217 Drake Avenue, New Rochelle, New York 10805; Mr. Max Richter, The Butterfly Farm, East Durham, New York.

If you order eggs, include eight cents extra to cover the mailing cost. The dealers will send you a price list of their stock if you write to them and enclose a dime.

Insects which are harmful to cultivated plants, domestic animals, or people may not legally be carried into a place where they do not already live. Because not many people know which insects are pests, the federal government controls the importation of living foreign specimens. Some states have laws against bringing live insects over their borders, and a few will not allow the movement or sale of living insects even within the state. If you live in one of these states, you may be obliged to get a permit to have eggs sent to you.

When you buy eggs from a dealer, you must have some kind of enclosure ready for them when they arrive. At first, a plastic sandwich box will do very nicely. Let the eggs hatch in this box. A second sandwich box makes a good nursery for the baby caterpillars. Put a few fresh leaves into the nursery box each day, preferably on top of a paper towel or a piece of blotter cut to fit the bottom of the box. (See page 13 to find out what kinds of leaves your caterpillars will need.) Put the newly hatched caterpillars right in with the leaves. Do *not* put the unhatched eggs in with the leaves. Picked leaves give off carbon dioxide gas which will settle to the bottom of the box and smother the eggs, killing the unhatched caterpillars.

Caring for the Caterpillars

When the caterpillars are tiny and just hatched, you may pick them up ever so carefully with a soft camel's hair water-color brush and put them on the leaves. Always wait about half a day, but not too much longer, before moving them from the hatchery to the feeding box. Put the empty shell right in beside the caterpillar so that it can eat some of it if it wants to. This is very necessary for the good health of some species. Others will die if they are kept from eating the egg shell!

The secret of rearing your caterpillars is plenty of fresh food, clean rearing quarters, and fresh air. Also, handle them as little as possible. Do not disturb them or tap on the lid when you examine them.

Some leaves wilt very rapidly. Those that do should be changed at least twice a day. Others stay fresh longer, so you need to put new ones in only once each morning. As the caterpillars grow, you will need a larger container for them. A brooder made out of a coffee can and a Coleman lamp chimney *(see diagram)* is very good for rearing a few caterpillars, unless they are the huge ones.

When you rear caterpillars in a small space, the container must be kept clean and fresh. They may become infected with a disease if the cages are not kept clean, and disease can spread rapidly through the whole brood. The droppings of caterpillars are called *frass*. Frass is clean and dry when the insects are healthy and are being cared for properly. All pieces of leaves, stems, frass, and other debris should be swept out at least once daily, preferably twice a day.

Depending on what species you are rearing, the caterpillars will continue eating leaves from about three to

(Continued on the next page)

To make this brooder for caterpillars, in the top of a coffee can cut a hole big enough to hold a rubber stopper. Then stick the stems of food plants through the hole in the stopper into water within the can. Use paper to close the stopper's opening so caterpillars do not crawl down the stems. Set a Coleman lamp chimney on top of the can. Cover its top with netting held by a rubber band.

eight weeks (except *io,* which feeds for about 16 weeks, and the *Arctiidae,* which hibernate in the caterpillar stage). After that time they will be ready to spin a cocoon (if they are a cocoon-spinning species). When such caterpillars are ready to spin, they empty their intestines. When you see this liquid excrement coming out, don't think that the caterpillar is sick. The liquid should be cleaned up as soon as you find it, since it may cause disease or sickness for the other caterpillars.

If you don't want to go to the trouble of filling a coffee-can brooder with fresh leaves each day, you can *sleeve* or *cage* the caterpillars *(see diagram).* If you decide to make a sleeve or cage, which will enable your caterpillars to eat right on a living tree or bush, select a good leafy branch that has a clear area near the trunk. Be sure to shake the branch hard to clear it of other insects that may be living on it. Then slip your sleeve over the branch and gather and tie it securely around the inner end of the branch.

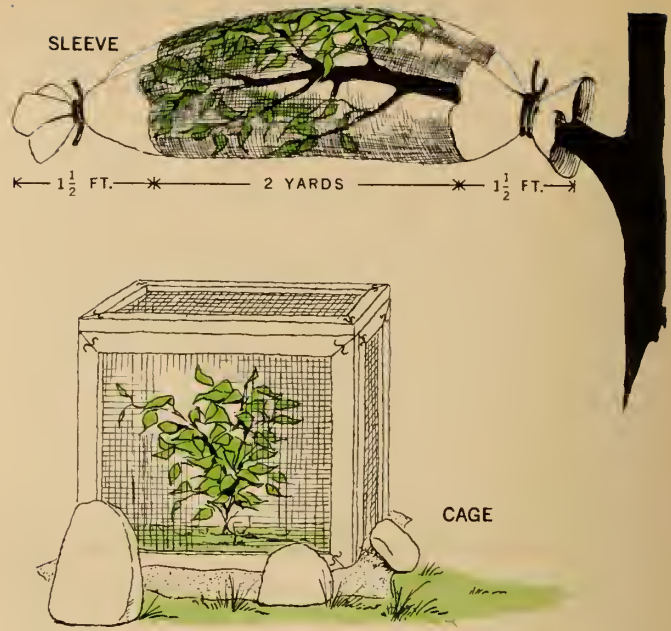
Make sure it is tied tightly enough to keep even tiny insects from crawling through. The outer end may be gathered together just beyond the tip of the branch and also tied securely. This encloses the entire branch just as well as if it were inside a cage, and you may open the outer end of the sleeve to work inside, clean it, pick out dead caterpillars, or just for observation.

Do not put too many caterpillars in one sleeve—no more than eight or 10 to a two-yard sleeve. Remember that when you put very young caterpillars inside a sleeve you may lose sight of them because they are so small. But in several days they will start to grow, and GROW, and GROW! And eat, and EAT, and EAT!

As the caterpillars grow, their skin does not grow with the body. It becomes too tight and has to be shed, or *molted,* in order for the caterpillar to get bigger. This is a very dangerous time. Caterpillars must never be touched or disturbed while they are molting or for at least a day afterward. If you know what to look for, you can easily tell when a caterpillar is ready to molt. It will stay motionless for a full day or two, attached to the side or bottom of the container without feeding. It has spun a silk pad and has attached itself to it. You will kill the caterpillar if you pull it off.

When new food is given to the caterpillars at this time, *never* pull them off of a twig or leaf. Put the twig with them on it in with the fresh food. The caterpillars will walk off of their own accord. Some species eat their discarded skins, so the skins should be left in the feeding area with the caterpillars for a day or two, in case they want to eat them. Remove the shed skin after that time if they do not touch it.

Most species of moths and butterflies are particular about the kind of food they eat. Some are so particular



To keep caterpillars on a living plant, make a sleeve of some close-meshed netting with strong unbleached muslin sewn to the ends. Then tie the sleeve to a branch and put the caterpillars inside. You can also make a cage from five wooden frames screwed together, with screening tacked to the inside. Set the cage over a small shrub and put sand and rock around the bottom to hold the cage firmly to the ground and to keep out predators.

that they will eat only one kind and will starve to death if that food is not given to them. Many kinds of caterpillars eat several kinds of leaves. These are the easiest to raise, because you have more chances of finding a tree or shrub on which to feed them.

Moths That Make Pupae

If the caterpillars you are rearing do not spin a cocoon, then they make a naked *pupa.* At this stage a remarkable thing happens. The caterpillar molts its last skin and its outer surface shrinks and hardens into a thin shell. Within this shell the animal, in its new form, passes the winter. When caterpillars are ready to pupate they become very restless and wander all about, not stopping to eat. Some of them travel great distances if they are not confined. When you observe them doing this, carefully pick them up and put them into a *pupating box.* At this time they may change color, or at least their color darkens and turns muddy. They will feel very hard and tight inside their skins when you pick them up. Do not squeeze them. Very soon after they are in the pupating box they should dig down out of sight. Do not dig them up to see what they are doing. This will kill them.

To make a pupating box you need a tight wooden box of any convenient size, but not less than about 18 inches wide, 36 inches long, and 10 or 12 inches deep. Make a cover for the box out of a frame covered with window screening. The cover should fit tightly all around the top.

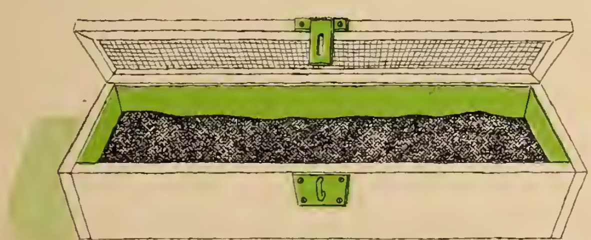
A few small holes bored through the bottom of the box and covered with a square of screening tacked in place will provide drainage if you keep the box outdoors, which is the best place for it. Fill the box to about six inches deep with one part sifted soil, one part clean sand, and two parts well loosened-up peat moss. Mix them well.

If you leave the box outside, put it where it will not be disturbed. Let it rain and snow on the box all winter. This is what happens in the wild. If you decide to take the pupae out of the box to store them indoors, wait until at least two weeks after the caterpillars have dug under. Then *carefully* sift them out of the soil with your fingers to store them for the winter. A month would be even better.

If you decide to store the pupae in the house, here is how to do it. Put them on a paper towel inside a small cardboard box, and be sure to label them. Store them in the bottom of the refrigerator where they will be kept cold, but will not freeze.

What To Do with the Adults

In the spring, when the adults are ready to emerge from their cocoons, pupae, or chrysalids, they should be put



This screen-topped box is used to hold caterpillars that become naked pupae (see text). The box contains a mixture of soil, sand, and peat moss in which the pupae overwinter.

inside a screened cage for the purpose. You can store cocoons the same way, waiting a month after they are spun to put them in the refrigerator.

This will be the most exciting time of all. Except for the butterflies and for the *Catocala* species, most of the insects mentioned here will emerge, dry their wings, and mate within one day or on the second day. When they mate, a male and female will cling together as the male fertilizes the eggs, which the female carries in her body.

When they separate, place the female inside a large paper bag, fold the top over, and hold it closed with a paper clip. She will lay her eggs during the first night. If she is a large female with a lot of eggs, she may take two nights. Leave the eggs stuck to the paper. Cut out little pieces of the paper bag with eggs on them and store them until the eggs hatch. They will do so in about 10 days.

Moths are much easier to rear than butterflies. Moths are much easier to mate, and they lay their eggs with very little trouble in captivity. Butterflies need special conditions for mating and producing eggs. Also, moth eggs can be mailed with little danger of hatching in the post office instead of in your hatchery. Butterfly eggs hatch in a very few days, and the danger of their hatching in the mail is much greater.

Butterflies must be put into a cage outside in bright sunlight. They will need their own fresh-cut or growing foodplants and a large bouquet of fresh flowers so they can suck nectar from them. The flowers should be sprinkled with sugar-water several times a day. If you have a mating, the female will lay her eggs on the foodplant, and the eggs will hatch in a couple of days. Some people have no trouble mating butterflies. Others never have success.

Moths To Look For

Five families of moths and two families of butterflies are given here—a total of 19 species. Among this variety you should be able to find species this season with which to start your rearing. They were picked for their distribution, for their availability, and because they eat common and easily located foodplants.

From the family *Sphingidae* I have selected *Protoparce sexta*—the Tomato Worm. This one eats tomato plants (sometimes the tomatoes themselves), potato plants, and other plants that are related to them. The second member of this family is *Ceratomia amyntor,* which eats elm leaves and which is called the Four-Horned Sphinx. The last member is *Pachysphinx modesta,* the Big Poplar Sphinx. This one feeds on poplar leaves, and will also eat willow leaves. All three of these moths must have some dirt into which they will dig their way when they are ready to pupate, so they will use the pupating box.

Next is the family *Saturnidae.* The first member of this family is one of our largest and most colorful moths, and one that is easy to find and easy to rear—*Samia cecropia,* the *cecropia* moth. It eats many different kinds of trees, but prefers cherry. *Telea polyphemus* is the next selection. The *polyphemus* moth is also well known to most people, and is easy to obtain and easy to rear. It likes oak leaves best but will eat many other trees. *Automeris io* is a very interesting moth. The males and females are differently colored. This is called *diachromism. Io* eats almost anything—even corn leaves—but he takes to cherry leaves best.

These three moths make cocoons. The first two make theirs among the leaves or on the branches of the tree,

(Continued on the next page)

but *io* makes its cocoon on the surface of the ground under a layer of old dry leaves or pine needles. The *io* cocoon is very thin and fragile and can be easily crushed if handled roughly. An inch-thick layer of clean pine needles or dry leaves may be put on top of the soil in your pupating box. *Io* caterpillars will make their cocoons right under the layer, using some of the needles or leaves to strengthen their cocoons.

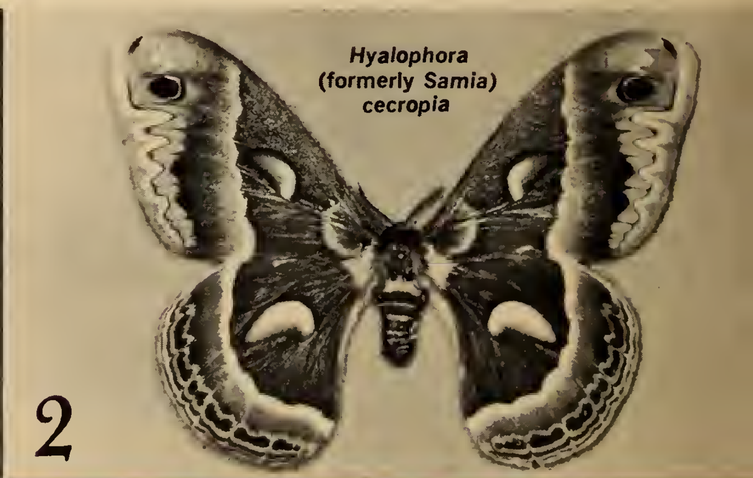
The family *Ceratocampidae* includes some beautiful species and some that are a real challenge to rear. *Eacles imperialis* is known to feed on many trees such as sassafras, Box Elder, maple, and pine. I have had best results with pine. *Citheronia regalis* is a huge caterpillar that sometimes reaches a length of seven inches! It will feed on walnut and hickory. *Anisota rubicunda* is called the Rosy Maple moth and feeds on maple leaves. These three all go underground to make their pupae.

Family number four is *Arctiidae* and this family includes some very interesting moths because the caterpillars hibernate for the winter instead of making a pupa. They feed on dandelion, plantain, and dock. In the spring the caterpillar comes out of hibernation and starts to feed again. They make their pupae about midsummer. The adults emerge a couple of weeks later, mate, and lay their eggs. The eggs hatch in a few days and the caterpillars feed slowly until early fall. At this time they find a sheltered spot under rocks or logs and pass the winter.

The Woolly Bear caterpillar seen crossing the roads in early fall is *Isia isabella.* Pick them up and put them into your pupating box with a few stones piled in a corner. Plant two or three dandelion plants in the soil and leave the box alone all winter. *Apantesis virgo* or any other of the many *Apantesis* moths are handled the same way. *Arctia caia,* called the Garden Tiger moth, is very popular both in this country and in Europe. The caterpillars are beautiful, with fur that looks something like that of a silver fox. You can always buy eggs from a breeder.

The last of the moth families selected is *Noctuidae.* This group includes the beautiful Underwing Moth. *Pyraphyla pyramidoides* is called the American Copper Underwing. It feeds on many shrubs and herbs, but seems to prefer Rhododendron. *Catocala relicta* is a beautiful moth with white stripes on the rear wings and white mottling on the front wings. It feeds on poplar and willow. *Euparthenos nubilis* feeds on locust and has deep orange-red marks on the underwings. Its forewings are gray-brown.


Arctia caia
1


Hyalophora (formerly Samia) cecropia
2


Citheronia regalis
5


Pachysphinx modesta
6

There are a great many species of *Catocala* moths. If you cannot find *relicta,* any of the others will do as well. All three of these moths drink nectar. Adults of these species may be caught by painting a weak solution of sugar and water or honey and water on tree trunks in the evening. Make the rounds well after dark with a flashlight to see what you have attracted.

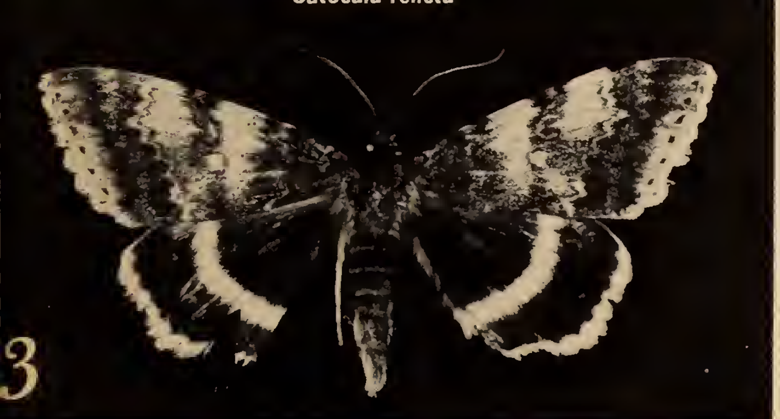
Butterflies To Look For

The first family of butterflies that has a species you can rear easily is the subfamily *Danainae. Danaus plexippus* is our beautiful Monarch butterfly. It feeds on milkweed. When you see these large orange and black butterflies flying in bright sunlight, look on the leaves of the milkweed for tiny yellow eggs, one to a leaf. Pick the entire leaf, and when you have a few, put them into your hatching box. In a day or two they will hatch. Keep the caterpillars supplied with fresh leaves and they will grow.

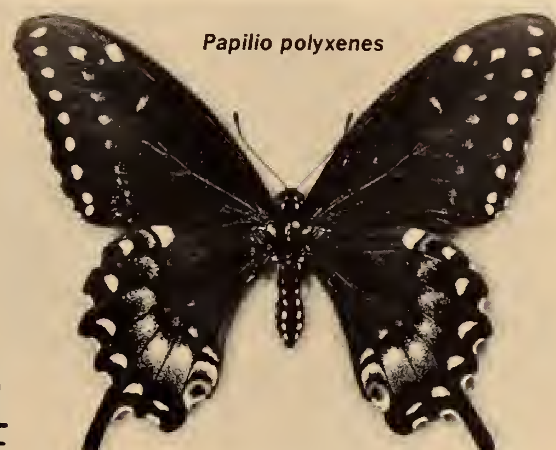
The second family is *Papilionidae*. Our big colorful Swallowtail butterflies belong to this family. *Papilio philenor* is called the Pipevine Swallowtail and feeds on Pipevine or Dutchman's Pipe. *Papilio polyxenes* is sometimes called *Papilio asterias* and feeds on carrot tops, parsley, and related plants. The Spicebush Swallowtail, *Papilio troilus,* feeds on *Benzoin* (or Spicebush).

When you are rearing moths and butterflies, remember that they are living creatures, and every living thing has a different need and a different way of satisfying its need. It is a good practice to keep a notebook and jot down all your observations and each thing you learn as you go along. These notes will be very valuable to you as a reference when you try to rear a new species. Also, always remember that really very little is known about rearing butterflies and moths. Any time you write something down it may be something that no one has ever known before ■

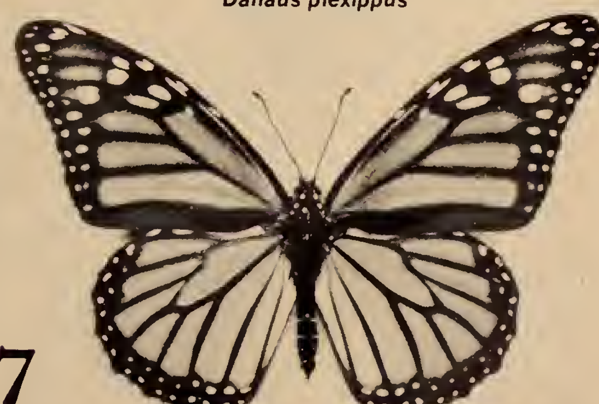
■ Here are some good books about moths and butterflies to look for in your library or bookstore: **A Field Guide to the Butterflies,** by Alexander B. Klots, Houghton Mifflin, 1951, $4.50 (names and habits of butterflies east of the Great Plains); **How to Know the Butterflies,** by Paul A. and Anne M. Ehrlich, William C. Brown Co., 1961, $2.75 (identifies butterflies of America north of Mexico, except Skippers); **The Moth Book,** by W. J. Holland, is out of print but in some libraries (names and habits of North American moths). For interesting general information, see **Butterflies and Moths,** by Richard A. Martin, Simon and Schuster, 1958, $1.49; **Butterflies,** by Dorothy Childs Hogner, Crowell, 1962, $2.90; and **Caterpillars,** by Dorothy Sterling, Doubleday, 1961, $2.75.


Catocala relicta

3


Papilio polyxenes

4


Danaus plexippus

7

These photographs show members of some common families of North American moths and butterflies. The Garden Tiger moth (1) has a two-inch wing span. The cecropia moth (2) has a six-inch wing span and is common almost everywhere east of the Rocky Mountains. There are dozens of species of Underwing Moths (3). Many have brightly colored underwings. The Swallowtail butterflies (4) are the largest in North America. The Royal Walnut moth (5) is brown with yellow spots, and has a five to six-inch wing span. The Big Poplar Sphinx moth (6) is colored gray-brown and rose, and has a four-inch wing span. The Monarch butterfly (7) also has a four-inch wing span and is orange with black and white markings. It migrates south in the fall.

mounting and collecting Moths and Butterflies

■ Here is a simple way to mount moths and butterflies with materials that you may have at home. First you must kill the adult specimen quickly, then spread its wings, dry the specimen, and finally put it under cover.

KILLING JAR: You will need a glass jar with a tight-fitting cover. Put an inch or so of cotton in the bottom of the jar and cover the cotton with a piece of blotting paper cut to fit the jar snugly.

For a pint-sized jar pour in about a teaspoonful of killing fluid and a half teaspoon of water. The water will keep the specimen from drying out before you mount it. A good killing fluid is ethyl acetate (Duco cement thinner). Nail polish thinner also works well. Put the insect in the jar and screw the cover on. Leave the insect in the jar for at least half an hour.

To keep big moths from battering their wings by fluttering in the jar, put the moth in a paper envelope, then put the envelope in the jar. If you can, avoid touching the wings.

SPREADING BOARD: A block of plastic foam covered with paper (if the foam is rough) makes a good spreading board. You can get plastic foam at the flower counter in a dime store. With the point of a knife dig a hole big enough to hold the body of the insect. Push a needle between the bases of the front wings to pin the insect's body into the hole. If necessary, use crossed needles to hold down the back of the body. Now you must arrange the wings. In doing this make sure that the back edges of the front wings form a straight line at right angles to the body. The rear wings should underlap the front wings a little *(see diagram)*.

Cover the wings of one side with a piece of waxed paper and press them down against the block. Now pull them into position one at a time with a fine needle hooked behind a strong vein *(see diagram)* close to the body and outside the edge of the paper. When you have one wing in the proper position, drive the needle through it into the block. When both are in place, pin the paper down firmly. This will hold the wings in place so you can take the needles out. When all four wings are arranged, pull out the needle that holds the front of the body down.

Leave the insect on the block from two days to a week, depending on the size of the specimen. It must dry all the way through or it will mold.

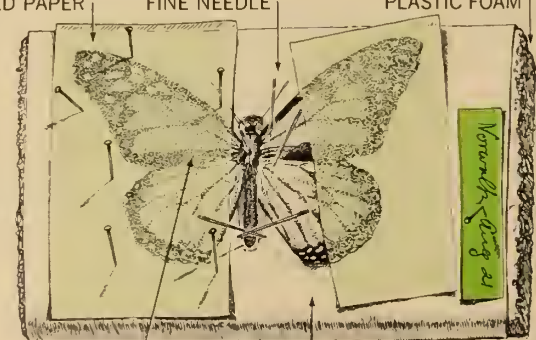
DISPLAYING YOUR SPECIMENS: Get a shallow cardboard box with a lid. The kind used for women's stockings is good. Cut out the middle of the lid, leaving a half-inch edge *(see diagram)*. You will need a piece of thin, clear window glass or stiff, clear plastic to fit inside the lid. Fasten it with adhesive tape. Fill the box with enough cotton to press gently against the "window."

Put your dry, spread specimen on the cotton, as shown. Include a label showing when and where the specimen was collected. Also include the scientific name of the insect. Seal the lid with adhesive tape to keep out insect-eating beetles. Keep your display cases in the dark when you are not looking at them. The colors of moths and butterflies fade quickly in the light.

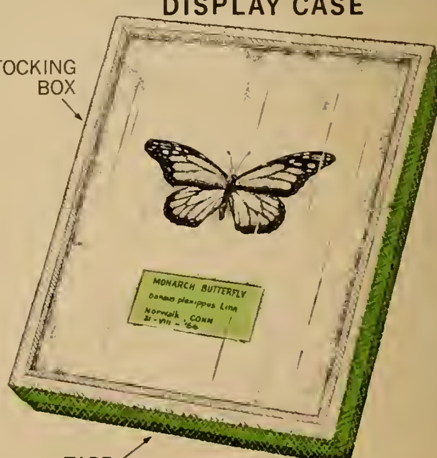
—ALICE GRAY

KILLING JAR

SPREADING BOARD



DISPLAY CASE



nature and science

VOL. 1 SE 2 / AUGUST 1964

SPECIAL ISSUE

ROCKS AND MINERALS

How to find, identify, and collect them

ABOUT THIS ISSUE

The boy on our cover is collecting rocks near Red Bank, New Jersey. He is chipping away at some *conglomerate,* a kind of rock that is a mixture of small pebbles and fine, sand-like material.

Collecting rocks and minerals is a fascinating hobby that you can enjoy all your life. The articles in this issue of *Nature and Science* tell you how to start and build up your own collection.

The article beginning on the next page tells you where and how to look for interesting specimens; the few simple tools you will need, and how to use them; and how to organize your collection.

On page 14 you will find a simple key to help you identify the most common rocks and minerals. The WALL CHART on pages 8 and 9 shows some of the places where you can find certain rocks and minerals and describes the different kinds of rocks that shape the landscape of the United States. You can use special *topographic maps* to mark good collecting sites *(see page 10).*

Another article describes what scientists have discovered about mountain-making, and page 7 features some science puzzles and projects for you to try.

nature and science

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This is the second of two special summer issues of Nature and Science. Use it as a guide to dozens of summer activities (see "About This Issue" on this page). This special issue was prepared under the direction of Christopher J. Schuberth, Senior Instructor in Adult Education, The American Museum of Natural History.

Contents

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HOW TO COLLECT ROCKS

With a few simple tools, a well-kept notebook, and a plan for keeping track of samples, you can build up a fascinating collection of rocks, minerals, and fossils.

by Christopher J. Schuberth

■ Would you like to have a hobby that can give you a lifetime of fun, adventure, and opportunities to learn new things about the Earth? Rock collecting is such a hobby.

It is really very easy to collect rocks. You don't have to stalk them as you do animals. Also, rocks do not fade or lose their beauty; they require absolutely no upkeep.

Even more valuable than the rocks themselves are the things you can observe and enjoy while collecting them. You can see how animals and plants live in different places, and how they change from season to season. You may find fossils that will give you some idea of the strange and interesting plants and animals that lived millions of years ago. And by studying the shape of the land and the kinds of soil and rock you find on it, you can figure out how the land was formed and changed over the ages.

Where To Look

Where do you find interesting rocks? Wherever the *bedrock* is exposed at the surface of the ground. (Bedrock is the continuously solid rock that is under the layers of vegetation, soil, and broken rock.) Bedrock that shows at the surface of the ground is called an *outcrop*. You can find outcrops where roads and railroads cut through hills and mountains, at cliffs and quarry diggings, and in the valleys where streams or glaciers have worn, or *eroded,* paths through the bedrock. If you live in a large city, you may find bedrock where the ground has been dug out for new buildings or bridges, or where tunnels are being cut through the solid bedrock.

If you cannot find places where bedrock can be seen easily, you can find rocks in other areas. One of the best places to visit is a stone-cutting factory. Here you can get small pieces of granite, marble, limestone, serpentine, or other rock. You can also find rocks along roadsides, in the beds or along the banks of streams and rivers, in the dump piles around old mines and quarries, or along a beach where there are many beautiful pebbles.

It is important to remember that such rocks did not come directly from an outcrop. Instead they have been carried a considerable distance from their place of origin by streams or glaciers, or have simply rolled a long way downhill. Geologists frequently call such loose rocks lying around the surface *float*. You cannot find out as much of the geologic story of the bedrock in an area from samples of float as you can from specimens collected directly from an outcrop. The float could have come from tens or hundreds of miles away and from a bedrock completely different from the one in your area. Many of the boulders found in New England and other northern parts of the United States were carried southward hundreds of miles by huge glaciers. However, the float does tell us what kind of bedrock the glaciers moved over.

Collecting Rock Samples

Now that you realize the value of an outcrop and know where to look for rocks, let's see just how you collect rocks

(Continued on the next page)

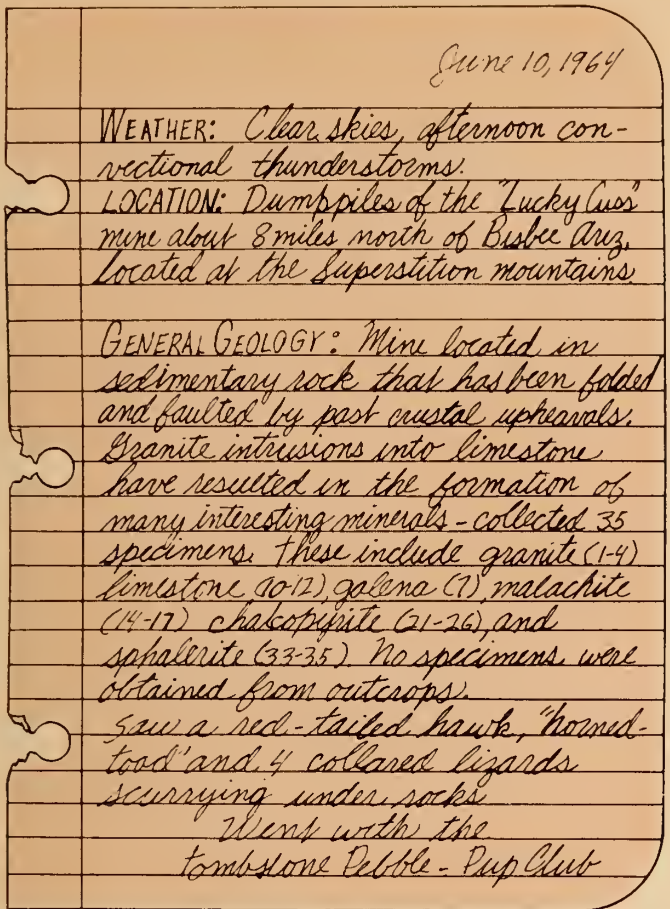
and minerals. You could just dig or walk along a stream bank, pick up rocks, and put them in your pocket. But this kind of collection will not be of much use to you. If you want to be a serious collector, you must collect carefully, use the proper equipment, and keep records.

For this, you will need some simple equipment. Get a small notebook and pencil. Write in your notebook the source and locality of your specimens. Were they taken directly from the bedrock or were they part of the float? (A sample notebook page is shown here to guide you.) You also will need a hammer to break off rock samples. A geologist's hammer is the best one to use, but a plasterer's or bricklayer's hammer will do the job. A carpenter's hammer is not strong enough for hard rocks and breaks rather easily. You will also need a good steel chisel (one for chiselling metal) to split rocks apart, particularly if you're looking for fossils. A hand sledgehammer can be used to break off a small section of a large rock mass, which can then be trimmed with your regular hammer and chisel. A 10-power magnifying lens will give you a closer look at the details of your specimen. A good book describing rocks and minerals is handy to have along. Several are listed at the end of this article. Try to get one or two for your personal library.

If the outcrops you are breaking are particularly hard, wear gloves and non-breakable goggles to protect your eyes from flying chips. Before you put your specimens in a sturdy knapsack or other strong collecting bag, wrap each one carefully in old newspapers. (Delicate specimens can be put in a well-padded plastic container.) Tape the loose ends of the paper together with adhesive tape, number each specimen (on the tape), and *write the number and the date and location of each find* in your notebook.

A sample should be no smaller than the size of your hand, if possible. Take two or three samples of the same kind of rock, but always leave some for other collectors. You will have a bigger collection, and you can find out more about rocks, minerals, or fossils from their individual

This is the equipment you will need to take on rock hunting expeditions if you want to be a serious collector.



Keep a record like this of each trip in your notebook.

differences. You can give extra samples to your school or trade them for other specimens.

Before making a collecting trip, plan it. This is very important, for you must always know exactly *where* you are collecting. The value of a mineral or fossil is much less if you do not know where it came from.

Topographic maps, which show the ups and downs of the land, are helpful in planning a trip. (The article on page 10 tells how to read a topographic map and how to get one of your area.) If you collect along a country roadside, use a road map. On this map, mark your route so that you know exactly where you found your specimens.

If you go to a mine, quarry, digging, or someone's private property, you should always get permission before you collect rocks on the property. If you want to visit a quarry far from your home, write a letter to the company and say you would like to collect there. Any time you are allowed to collect on private property, always thank the superintendent or the owner, and follow the simple rules of good behavior.

No matter where you are this summer, you will find rocks, and if you keep your eyes open you will have many opportunities to build a fine collection. A hike, a picnic at a beach or lake, or a trip with your family will always give you the chance to find good samples of rock.

If you take a long trip this summer, stop and visit rock and mineral dealers along the way. They can tell you what kinds of rocks and minerals are found there, and often suggest good places to look for them. The names and addresses of rock and mineral dealers (as well as a number of good collecting areas) are given in the *Rockhound Buyers Guide,* which may be obtained by writing to Box 510, Del Mar, California. It costs $2.

Arranging and Organizing Your Collection

After you have collected your specimens, arrange and study them right away. First, carefully remove the soil from your specimens with a brush, then wash them in soapy, warm water. If they are not too delicate, rub them with a stiff brush and rinse away all soap in plain water.

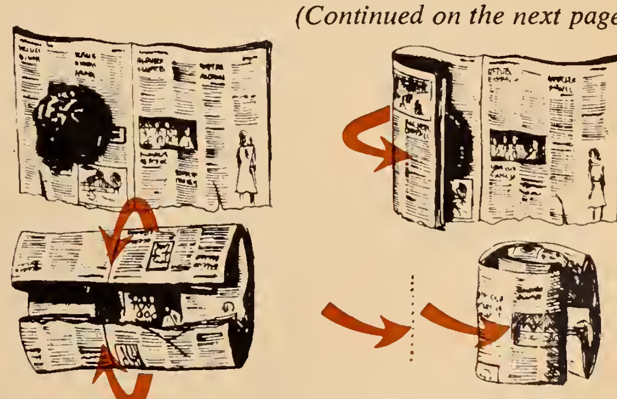
When you arrange your collection, first identify your specimens *(see "Identifying Rocks and Minerals," page 12).* Learn all you can about each rock, mineral, or fossil so that you will recognize each one the next time you see it, even though it may seem to have a slightly different appearance.

After you have identified a specimen, label it. To do this, put a spot of white enamel paint in a corner of the specimen. After the paint has dried, write a number on it with a fine-pointed pen. Cover this number with ordinary colorless spar varnish or clear nail polish to keep it from flaking off.

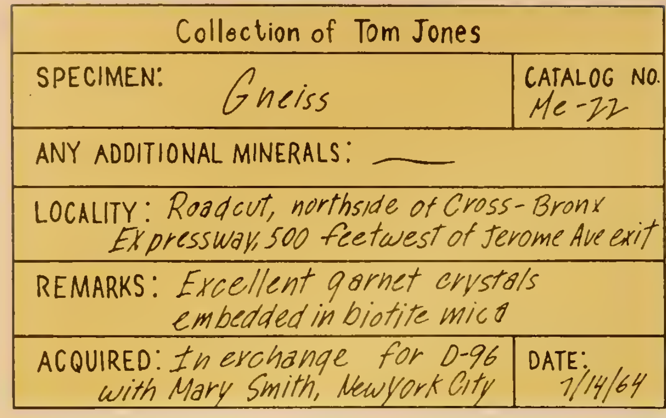
There are many ways to arrange a rock and mineral collection. One way is to put the specimens in their alphabetical order. But this method has no scientific value. The specimens cannot be related to each other.

A better way is to arrange them according to basic types. For example, the letters Ig could stand for *igneous,* S for *sedimentary,* and Me for *metamorphic* rocks; Mi for *minerals;* and F for *fossils.* (The WALL CHART on pages 8 and 9 explains these terms.) Number the specimens of the same type, 1, 2, 3, 4, and so on, and add your initials.

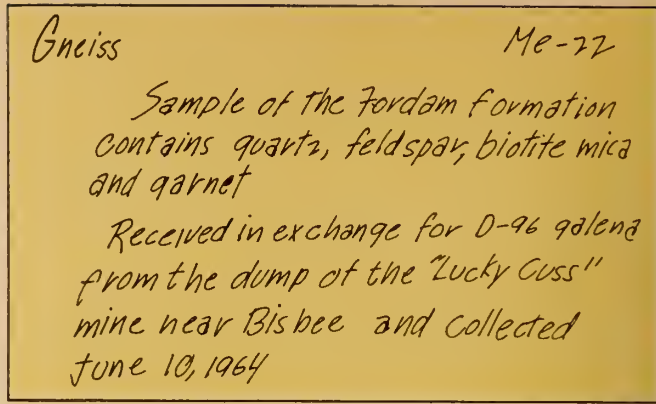
(Continued on the next page)



Wrap each specimen like this and seal it with tape before putting it in your bag. Write a number on the tape and also in your notebook with the date and location of your find.



Write information about each specimen on a catalog card.



Use file cards like this as a guide to your collection.

Next get 3-by-5-inch file cards (you can buy them at a stationery store) and write on each card all the information you have in your field notebook about a single specimen *(see sample).* This will be your *catalog card.* File it in numbered order with cards for other specimens of the same type.

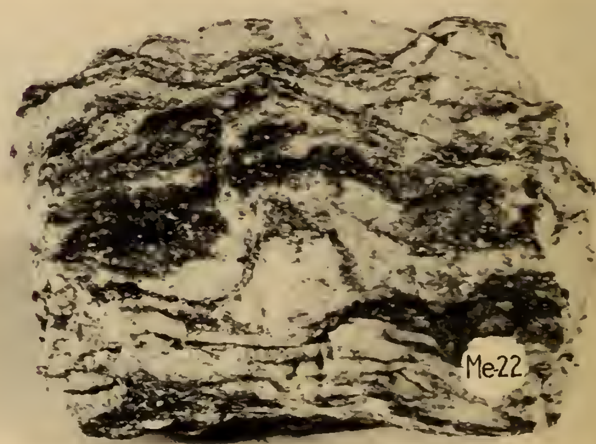
Make another file card for each specimen, putting the name of the specimen in the upper left-hand corner of the card, and the catalog number of that specimen in the upper right-hand corner. Do this with each specimen and file the cards with the names of specimens in alphabetical order.

If anyone wants to see all of your quartz specimens, all you have to do is look up "quartz" in your alphabetical file. The cards under that subject will guide you to the quartz specimens in your collection. If someone wants additional information for any one specimen—such as where you found such a magnificent sample of galena—your catalog file card has the information. As you collect more and more specimens, give away your poorer specimens to make room for better ones collected from similar sites, and trade your extras for new specimens, you may have to change this recording plan a little.

Storing Your Collection

After you catalog your specimens, you will need a place to keep them. Cigar boxes make a good temporary storage place. Ask your local drugstore, candy store, or shopping center for some of their empty boxes. Use strips of heavy cardboard to separate the two or three specimens you store in each box. Old bookcases, chests of drawers, or china closets that no one wants also are good places to store specimens. To keep them from sliding around in a drawer, put each specimen in a shallow cardboard tray, which you can make or obtain from a mineral dealer.

Join a local mineral and rock club and go on field and collecting trips with the members. Always record what you see. Make note-taking a habit. Don't be satisfied with just knowing the name of a mineral, rock, or fossil. Visit a museum of natural history, and write to one of the universities in your state, or to your state geological survey, for information. Write to some of the state geological surveys for their free pamphlets about the rocks, minerals, and fossils of their areas. Find out all you can about your specimens. You may become a local authority not only on the rocks, minerals, or fossils of your area, but also on its general geology ■



Label each specimen with the number on its catalog card.

Here are some books and magazines that will be useful in making your rock collection: **Rocks and Minerals,** edited by Herbert S. Zim, Golden Nature Study Series, Golden Press, 1957, $1; **How To Know Rocks and Minerals,** by R. M. Pearl, Signet Key Book, 75 cents; **Successful Mineral Collecting and Prospecting,** by R. M. Pearl, New American Library, 1962, $2.95; **Fossils,** by W. H. Matthews, III, Barnes and Noble, 1962, $2.25; **A Field Guide to Rocks and Minerals,** by F. H. Pough, Houghton Mifflin Co., 1960, $4.95; **Earth Science** (a bi-monthly magazine), Box 1357, Chicago, Illinois 60690, $2.50 per year; **Gems and Minerals** (a monthly magazine), P.O. Box 687, Mentone, California 92359, $4 per year; **Rocks and Minerals** (a bi-monthly magazine), Box 29, Peekskill, New York, $3 per year.

PROJECTS FOR SUMMER FUN

Hot and Cold Running Crickets

The chirps of crickets are a common sound during summer nights. Some people claim that you can find the temperature by timing a cricket's chirps. To find out if this is true, you'll need a thermometer and a watch with a second hand.

Adult male crickets make chirping sounds by rubbing their wings together. When you hear one, count the number of chirps it makes in 14 seconds. Then add 40. Your answer is supposed to be the Fahrenheit temperature. Does your answer agree with the reading on the thermometer? Do you think it might be warmer or colder where the cricket is sitting?

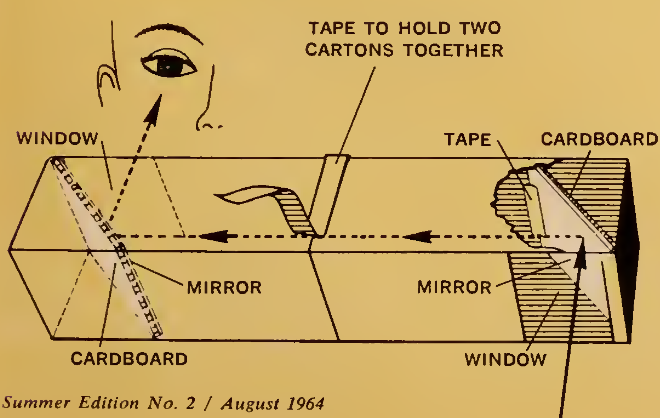
Time the cricket several times. Time the chirps of other crickets. Do you think that crickets are reliable thermometers?

Make a Periscope

Here is a way to build a periscope, which you can use to look over fences and around corners. You will need two one-quart milk cartons, two small mirrors, two pieces of cardboard measuring 2¾ by 3¾ inches, scissors, glue, and tape.

Cut the top off each carton, then tape the two open ends together to make one long, rectangular box. Cut a window in one side of the box near one end, and another window in the opposite side near the other end *(see diagram)*. Glue the mirrors to the pieces of cardboard. Then tape the pieces of cardboard into the cartons so that the mirrors rest at a 45° angle opposite each window. Cover any light leaks with tape.

The dotted lines in the diagram show how an image strikes one mirror and is reflected to the other mirror and into your eyes.



How Far Away?

During a thunderstorm, count the number of seconds between a flash of lightning and the thunderclap that follows. Divide the number of seconds by five. Your answer is the approximate number of miles between you and the bolt of lightning.

Grow a Bird Nest?

Look in thick bushes and in the forks of tree branches to see if you can find the abandoned nest of a robin. Robins' nests are made of an inner wall of mud, grass stems, and small roots.

When you find one, set it in a pan and give it water and sunlight, as you would a plant. Some plants will sprout from seeds the young robins ate but did not digest. Others grow from seeds that are part of the construction material. How many different kinds of plants can you identify? How much do you think you can learn about a robin's diet by growing a nest?

Tonight Go Meteor Watching

At certain times of the year, "showers" of meteors occur. During a meteor shower you may see dozens of these light streaks in the atmosphere. Meteor showers often are produced by the remains of comets that appear to rain down, or *radiate,* from a particular constellation. During nights from July 24 to August 6, look toward the constellation Aquarius for the showers known as the *Eta Aquarids.* You may see as many as 20 meteors an hour. From July 27 to August 17, as many as 50 meteors an hour may be seen in the *Perseids* showers, from the constellation Perseus.

ROCKS THAT MAK

■ The landscape of the United States varies from low plains to high mountains and plateaus that have been cut by deep canyons. Each large area of land is a natural division of the continent and in general has the same kind of bedrock and surface shape. Geologists call such areas *physiographic provinces.*

The physiographic provinces of the United States are shown below with descriptions of the up-and-down shape of the land, or *topography,* and the types of rock found in each province.

Here is a list of the three types of rock, how they are form and some examples of the kinds of rock of each type:

IGNEOUS ROCKS form when hot, molten rock within Earth rises toward the surface, cools, and hardens. Mol rock that hardens before reaching the surface forms an *ignec intrusion* in the surrounding rocks. Granite, basalt, gabbro, sidian, and pumice are igneous rocks.

SEDIMENTARY ROCKS form when layers of mud, sand, a

PHYSIOGRAPHIC PROVINCES OF THE UNITED STATES

LAURENTIAN UPLAND—Many periods of mountain-building followed by erosion affected the rocks of these very old and complex mountains. The rocks are largely metamorphic, more than a billion years old, and contain many igneous intrusions. Glacial drift covers large areas.

NEW ENGLAND PROVINCE—A region of metamorphic rock with many igneous intrusions. It also has gone through several stages of mountain-building and erosion. Rocks are not quite so old as those in the Laurentian Upland. Glaciers have left their imprint on the land.

OLDER APPALACHIANS—Similar to the New England Province, but no signs of glaciation. The Blue Ridge Mountains and a lower, rolling area called the Piedmont are the two sections of this province. A lowland called the Triassic Lowland (because its bedrock was formed in the Triassic Period, about 195 million years ago) lies between this province and the New England Province.

COASTAL PLAIN—A region of flat-lying layers of sedimentary rocks that were once part of the ocean floor at the edge of the continent. It is now exposed above the present eastern shoreline. Fossils, as old as 135 million years can be found.

NEWER (FOLDED) APPALACHIANS—Mountains formed by the bending and some breaking of layers of sedimentary rocks. There are long ridges of harder rocks, such as sandstone and conglomerate, and valleys of limestone and shale. Glacial drift occurs in the northern part. Many fossils of sea animals, from 600 million to about 380 million years old, are found in the sedimentary rocks.

APPALACHIAN PLATEAU—Formed from the uplift of horizontal layers of sedimentary rocks like those in the Folded Appalachians. In places, the rocks have been deeply carved by streams. This province includes the Catskill, Pocono, Allegheny, and Cumberland Plateaus. The northern part was covered by glaciers. Many fossils, from about 380 million to about 230 million years old, can be found.

OZARK PLATEAU AND OUACHITA MOUNTAINS—The Ozark Plateau is like the Cumberland Plateau. The Ouachita Mountains contain folded sedimentary layers like those of the Newer Appalachians.

ROCKY MOUNTAINS—Many complex mountain ranges and some inter-mountain basins formed by folding and breaking the Earth's crust. Igneous, sedimentary, and metamorphic rocks are found throughout this province.

COLUMBIA PLATEAU—Horizontal layers of lava, up to 5,000 feet thick, cover older, worn-down mountains. Spectacular canyons have been carved through this plateau by rivers such as the Snake and the Columbia.

COLORADO PLATEAU—A high region of more or less horizontal sedimentary rocks that has been sculptured by many rivers. The Grand Canyon, carved out by the Colorado River, is an example.

BASIN AND RANGE PROVINCE—Many isolated mountain ranges are separated from each other by lower inter-mountain basins. Each range is commonly less than 100 miles long and up to 15 miles wide. Although there are sedimentary rocks in the basins, the mountains contain mostly sedimentary and igneous rocks.

PACIFIC MOUNTAIN SYSTEM—This province contains all three rock types. There are sedimentary rocks in the mountains of the Pacific Coast ranges. The Cascades are complex mountains with volcanic peaks, and the Sierra Nevadas are mostly composed of intrusive igneous rocks.

INTERIOR PLAINS—A gently rolling region horizontal layers of sedimentary rocks. Long cli are formed by the edges of layers that have resist erosion. Erosion-resisting rocks form small, is lated highland areas, such as the Black Hills South Dakota.

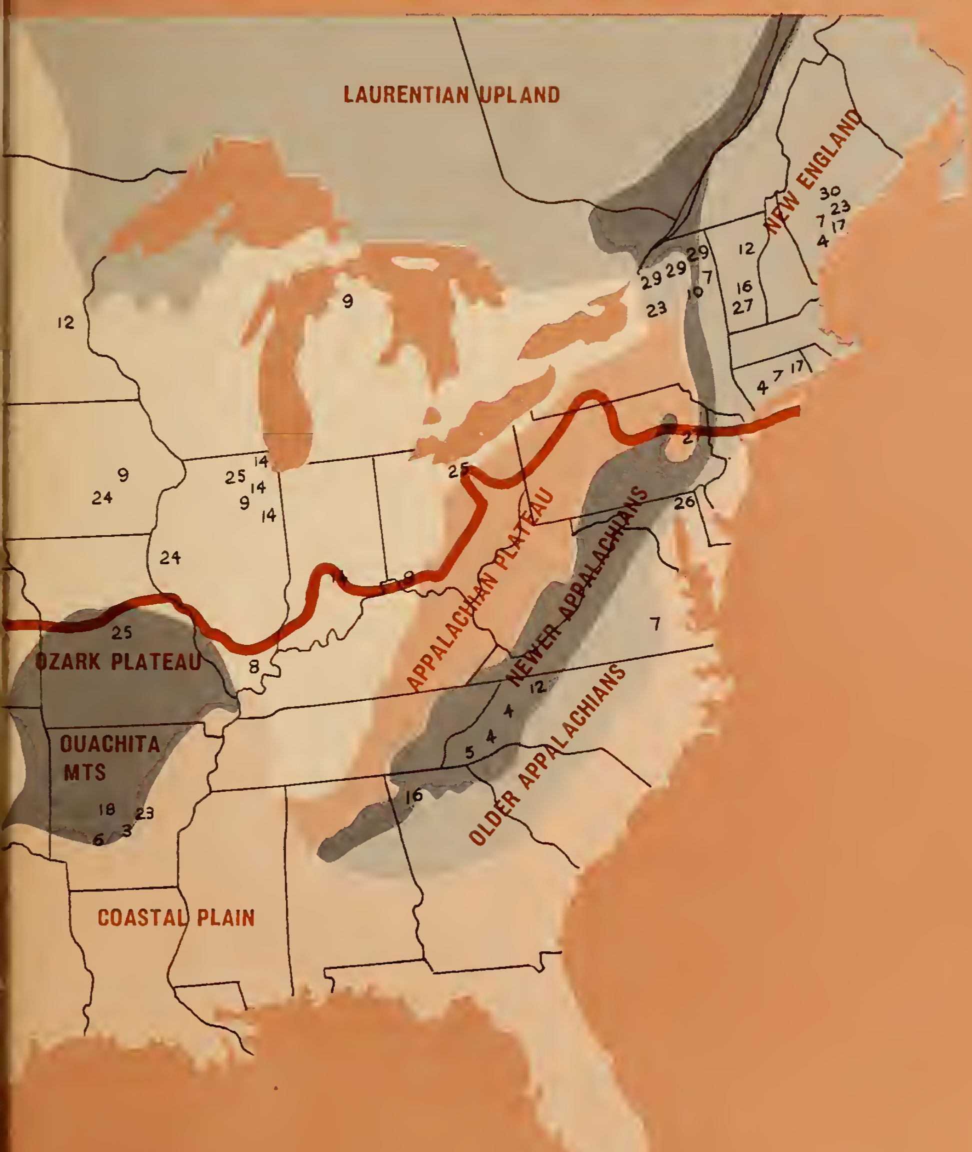
E OUR LANDSCAPE

other sediments are packed under great weight and harden. Shale, sandstone, limestone, and conglomerate are sedimentary rocks.

METAMORPHIC ROCKS are igneous, sedimentary, or even other metamorphic rocks that have been changed in structure, content, and sometimes texture by intense heat, pressure, or chemically active fluids within the Earth's crust. Slate, quartzite, marble, schist, and gneiss are metamorphic rocks.

The numbers on the map mark *some* of the more outstanding places where you can find the various kinds of rocks, minerals, and fossils that are listed at the right of the map.

The colored line across the northern part of the map marks the southern limit reached by advancing glaciers in the last Ice Ages. In an area north of this line, you may find examples of *glacial drift*. This consists of gravel and boulders of different kinds of rock carried from the north by these glaciers ■



SOME PLACES TO LOOK FOR THESE ROCKS AND MINERALS
(listed by state, county, and/or city)

1 **AGATE**—Montana, near Billings (along the Yellowstone River). Oregon, coast and central area. South Dakota, Custer County.

2 **AZURITE**—Arizona, Bisbee.

3 **BAUXITE**—Arkansas, Saline County, Bauxite.

4 **BERYL**—Connecticut, Middletown. Maine, Oxford County, Paris. North Carolina, Alexander County. North Carolina, Shelby.

5 **CORUNDUM**—Montana, near Helena. North Carolina, Macon County.

6 **DIAMONDS**—Arkansas, Murfreesboro (Ouachita Mountains).

7 **FELDSPAR**—Connecticut, Middletown. Maine, Oxford County, Paris. New York, Keesville. Virginia, Amelia.

8 **FLUORITE**—Illinois, Rosiclare.

9 **FOSSILS**—Arizona, Holbrook (petrified wood). Illinois, Coal City (ferns). Iowa, Le Grand (animals without backbones). Michigan, Emmet County, Petoskey (coral). Nebraska, western (early mammals). Ohio, Cincinnati (animals without backbones). South Dakota (early mammals). Utah, Vernal (dinosaurs). Wyoming, Como Bluff (dinosaurs). Wyoming, Fossil (fish); southwestern (petrified wood).

10 **GARNET**—Arizona, Apache County. California, San Diego County, Pala. Idaho, Benawah County. New Mexico, McKinley County. New York, North Creek (Gore Mt.) Utah, San Juan County.

11 **GOLD**—California, Calaveras County.

12 **GRANITE**—Minnesota, St. Cloud. North Carolina, Mt. Airy. Vermont, Barre.

13 **JADE**—Wyoming, Lander.

14 **LIMESTONE**—Illinois, near Chicago, Joliet, and Kankakee. Indiana, south-central.

15 **MALACHITE**—Arizona, Bisbee.

16 **MARBLE**—Georgia, Pickens County. Vermont, Proctor.

17 **MICA**—Connecticut, Middletown. Maine, Oxford County, Paris.

18 **NOVACULITE** (whetstone) — Arkansas, Hot Springs County (Ouachita Mountains).

19 **OBSIDIAN**—Arizona, Maricopa County. Oregon, Lake County.

20 **OPAL**—Idaho, Latah County, Whelan.

21 **OPALIZED WOOD**—Washington, Yakima County.

22 **PUMICE**—New Mexico, north-central area; Valles Mountains west of Sante Fe.

23 **QUARTZ** — Arkansas, Little Rock (Ouachita Mountains). Arizona, near Kingman. Maine, Oxford County. New York, Herkimer County, Middleville. South Dakota, Custer.

24 **QUARTZ GEODES** (quartz crystals inside a ball of chalcedony)—Illinois, Warsaw. Iowa, Keokuk.

25 **SANDSTONE**—Illinois, southwest of Chicago. Missouri, west of St. Louis. Ohio, Lorain County.

26 **SERPENTINE**—Maryland, Rock Springs.

27 **SLATE**—Pennsylvania, Bangor-Pen Argyl. Vermont, Poultney.

28 **SPODUMENE**—California, San Diego County, Pala.

29 **TALC**—California, Inyo County and Northern San Bernardino County. New York, Gouverneur and Talcville.

30 **TOURMALINE**—California, San Diego County, Pala. Maine, Oxford County.

31 **TURQUOISE**—Arizona, Globe-Miami. Nevada, Lander County, Cortez. New Mexico, Sante Fe, Grant and Otero Counties.

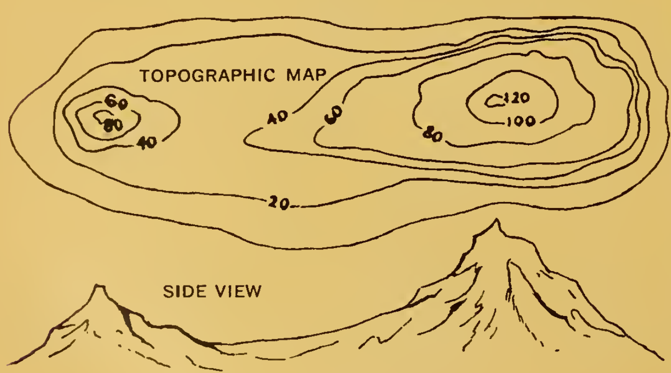
How To Read a Topographic Map

BY MARLYN MANGUS

You can use these special maps to find promising sites to collect rocks and minerals and to mark the good localities you have discovered.

■ Did you know that there are special maps that can help you in collecting rocks and minerals? By learning to read such maps, you can tell a great deal about how an area looks without actually seeing it. You can locate physical features such as rivers, valleys, mountains, and cliffs; also man-made things such as roads, towns, and bridges.

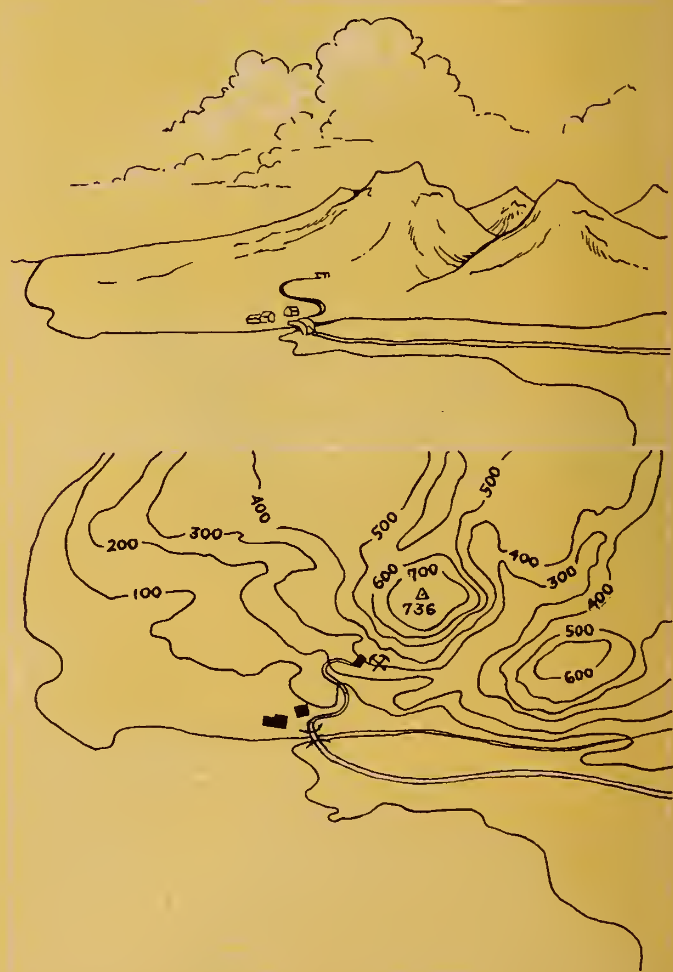
These special maps are called *topographic maps* (from the Greek words *topos,* meaning "place," and *graphein,* "to write"). The maps show the ups and downs of the land by using *contour* lines. Each contour line of a map marks a certain height or elevation above sea level. Every point on a contour line has the same height. For example, a topographic map of an island might look like this:



The first contour line is at sea level—the coast line. In this drawing each contour line is 20 feet higher above sea level than the one outside it. Since the highest point on the island is about 130 feet above sea level, there are seven contour lines.

By comparing the side view of the island with the simple topographic map, you can see that the map shows the shape of the island as well as its elevation. Now look at this diagram of an area that has mountains, valleys, a river, and some man-made features. Compare it with the topographic map of the same area to see how the features are shown on the map. Here are some things to look for:

1. Shore lines of oceans and lakes are natural contour lines, although lake shores do not always fall exactly on a given contour line. For example, a lake shore might be 107 feet above sea level—lying between contour lines at 100 feet and 120 feet.
2. All points on a contour line have the same height above sea level.
3. Contour lines never cross each other.
4. Where contour lines are close together, the slope of the actual hill is steep.
5. Where contour lines are far apart, the slope is gentle.
6. Contour lines curve upstream in river valleys, form-



Compare this diagram (top) with a topographic map of the same area (bottom). Why are the contour lines near the sea coast farther apart than those in the mountain area? Can you tell which direction the river is flowing? (See text.) To identify the man-made features on the topographic map, see the box of symbols (next page).

ing V's. A stream flows opposite to the direction in which the V's point.

7. Contour lines that close within the map area represent hills.

How To Get Your Own Topographic Map

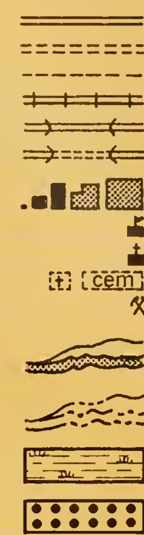
To get a topographic map of your area, write to either the United States Geological Survey, Federal Center, Denver 25, Colorado (if you live west of the Mississippi River), or the United States Geological Survey, Washington 25, D.C. (if you live east of the Mississippi). Ask for a free index circular of topographic maps available for your state. After you know which map or maps you want, send 30 cents for each map to the appropriate agency.

Once you have your own map, compare it with features that you are familiar with in your area. Soon you will be able to tell steep hills from gentle slopes, and tell which way streams are flowing, even before visiting a region. Here is some other information printed on your topographic map:

1. The *scale,* or map-to-ground distance, is printed at the bottom of the map. The scale is usually 1:62,500, meaning that one inch on the map equals 62,500 inches—or about one mile—on the ground.
2. The location of the region is given by degrees of latitude and longitude printed along the edge of the map.
3. Contour lines are printed in brown. Every fifth line, called an *index contour,* is printed in dark brown. The elevation is printed somewhere along these index contours. The vertical distance between contour lines, called the *contour interval,* is printed at the bottom of the map.
4. Man-made features such as buildings are printed in black.
5. Water is shown in blue.
6. The top of the map is always north. East is to the right, west to the left, and south to the bottom. Of course, if you are facing south, you should hold the map so that the bottom (south) end is away from you. If you face west, hold the map so that the north side is at your left, and so on. This is called *orienting* your map.

Now that you have learned to read your map, you can use it to locate promising spots to collect rocks and minerals. For example, investigate areas where close-spaced contour lines are shown on your map. There will probably be exposed rock outcrops on these steep slopes. You may find a symbol for a mine or quarry *(see box),* which is a convenient place for collecting. Once you have marked your collecting sites on the map, you can easily return to them in the future ■

Look for these symbols of man-made features on topographic maps



Improved light-duty road
Unimproved dirt road
Trail
Railroad (double track)
Bridge (on road)
Tunnel

Buildings
School
Church
Cemeteries
Open pit, mine, or quarry

Constant flowing stream

Stream that is dry part of time

Marsh or swamp

Orchard
Bench Mark (location of marker giving exact elevation, for example, 3,899 feet above sea level) — BM △ 3899

PROJECT

Make an island of modeling clay. Push a knitting needle or other small stick straight down through the clay at two high points of the island, leaving two holes. Next, slice horizontal layers of equal thickness by pushing a wire cheese-cutter or a piece of thin wire through the clay. Now lay the bottom slice on a sheet of paper and trace its outline on the paper. Make pencil dots through each of the two holes. Remove the bottom layer of clay and place the second layer on the paper, lining up the holes in the layer with the dots on the paper. Trace the outline of this layer, then the outlines of each smaller layer, in the same way. Your tracings are a contour map of the island.

Identifying Rocks and Minerals

You can find out what kinds of minerals and rocks you have collected and what they are made of by making some simple observations and tests.

■ When you begin to collect rocks and minerals you may be surprised to discover how much they differ—in color, weight, hardness, coarseness or fineness of grain, and shape. These differences depend on what each specimen is made of and how it was formed.

The Earth's crust is made up of three basic types of rock—igneous, sedimentary, and metamorphic. The WALL CHART on pages 8 and 9 tells how each of these types of rock were formed and gives the names of several different kinds of rock of each type. Before you go rock hunting, look at the WALL CHART map to see which types of rock you are most likely to find there.

What Rocks Are Made Of

Before you can identify which kind and type of rock a specimen is, you must find out what it is made of. Rocks are made of substances called *minerals*. Some rocks contain just one mineral, but most are mixtures of two or more minerals. A few minerals, such as iron, copper, gold, silver, and sulfur, are chemicals that we call *elements*. But most minerals are naturally occurring *compounds*. A compound is a combination of elements.

Geologists—scientists who study rocks—have found about 2,000 different kinds of minerals. Most of them are very rare indeed, and you may never see them except in museum collections. One dozen minerals make up more than nine-tenths of the Earth's rocks *(see page 14)*.

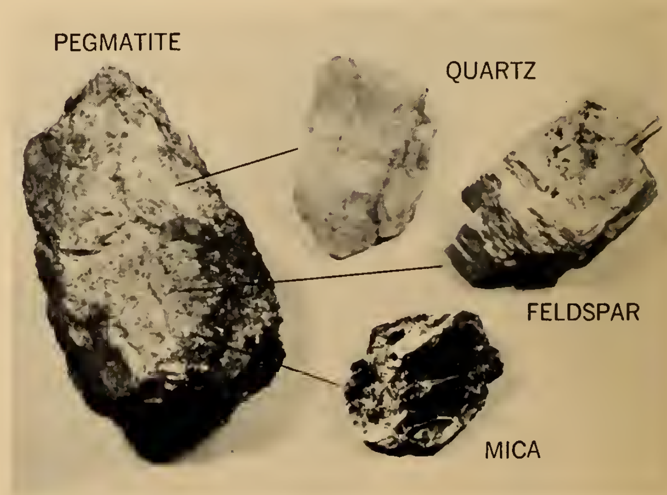
The minerals that make up rocks are usually in the form of blocks or chunks, grains of different sizes, or tiny plates and needles. In many rocks, the mineral particles are too small for you to see and identify without a microscope.

Minerals also form *crystals*, or pieces with flat surfaces that join at definite angles *(see photos)*. You can easily learn to identify crystals by their shapes. Crystals are a collector's delight, because they are not very common and are often beautiful in color and shape.

This article was prepared with the assistance of the late John R. Saunders, who was Chairman of the Department of Education at The American Museum of Natural History for 12 years and was the author of several science books for children. Mr. Saunders died on May 16, 1964.

Sometimes it is difficult to be sure whether a specimen is a rock or a chunk of a single mineral. For example, basalt is a kind of rock composed of three minerals, but they are so dark and finely mixed together that you can't

Minerals in crystal form, like these, are beautiful but not very common. Quartz crystals have six sides not counting the end surfaces. Fluorite crystals are cube-shaped.



Pegmatite is mostly three minerals—mica, quartz, and feldspar. Smaller grains of the same minerals make up granite.

see them separately. Some rocks are composed almost entirely of a single mineral. Sandstone and quartzite are both composed almost entirely of quartz, while marble and limestone are almost entirely calcite. But with a little experience you will soon learn first to identify, then to easily recognize the common rocks and minerals.

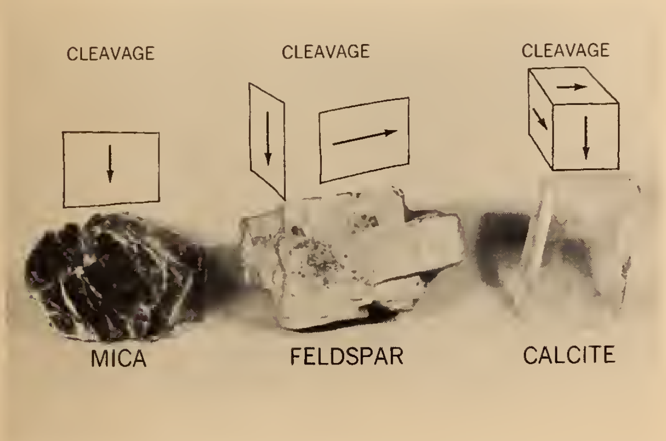
Clues to a Mineral's Identity

To identify a mineral specimen, or minerals in a rock specimen that are large enough for you to see, first make some simple observations and tests. Then check your findings with the key for identifying 12 common minerals, on page 14. Here are the things to look for and test:

1. Color. This is not the best guide, because the same mineral may be found in a wide variety of colors.

2. Luster. What kind of "shine" does the mineral have when light is reflected from its surface? Does it shine like metal? If not, does it appear pearly, waxy, greasy, glassy, silky, or dull? This is the mineral's luster.

3. Streak. Scratch your specimen against the back of a piece of porcelain tile or the unglazed, broken edge of a porcelain dish. If the mineral is softer than porcelain,



Some minerals tend to split, or cleave, along definite planes. Mica splits in just one direction, into sheets, or leaves. Feldspar tends to split in two directions. Calcite tends to split in three directions. Cleavage surfaces are usually fairly flat and shiny.

it will leave a thin, colored streak of powder on the porcelain. *Streak color* is often different from the color of the specimen.

4. Cleavage. Some minerals tend to *cleave,* or split, along definite planes, leaving flat and fairly smooth surfaces *(see photo).* Mica splits easily into leaves, or flat sheets. This is called *one-directional* cleavage. The feldspars have *two-directional* cleavage, splitting into pieces with surfaces that join each other at right angles. Halite,

Schist and gneiss are made of minerals arranged in bands. The bands are very thin in schist, and thicker in gneiss.

or salt, has *three-directional* cleavage, splitting into pieces like cubes. (Minerals that do not split easily along cleavage planes are said to *fracture.*)

5. Hardness. One of the softest minerals found in nature is talc, and the hardest is diamond. If you scratch two minerals together, the harder one will always leave a scratch on the softer one. By scratching your specimen with minerals of known hardness—or with common things such as a fingernail, knife blade, and so on—you can find the *relative hardness* of the unknown mineral. Relative hardness is measured by a scale drawn up over a hundred years ago by the German mineralogist, Friederich Mohs.

(Continued on the next page)

SIGNS OF LIFE IN PAST AGES

One of the most exciting things you can find while collecting rocks is a fossil—the remains, or some direct sign of the remains, of a plant or animal that lived thousands or millions of years ago.

Layers of rock made almost completely of shells, teeth, plant remains, and even bones are sometimes exposed in a quarry or a road-cut. Seashells found tens or hundreds of miles from what is now a shoreline indicate that the area was once covered by an ocean.

You might find an animal's footprint, or the shape of an insect, shell, or leaf that was molded into soft clay thousands of years ago, before the clay hardened into rock. The hard parts of organisms that become buried—their bones or shells, for example—are frequently replaced by minerals that are carried through the rock by water as it moves slowly downward through the ground. This process is called petrifaction and it will produce a piece of mineral shaped exactly like a seashell, bone, or tree trunk. Buried wood gradually petrifies as colorful minerals such as jasper or opal replace the wood tissue and fill in the cells.

He numbered 10 minerals in order of their hardness, from talc (No. 1) to diamond (No. 10). Here is Mohs' Scale of Hardness:

1. Talc	6. Feldspar
2. Gypsum	7. Quartz
3. Calcite	8. Topaz
4. Fluorite	9. Corundum
5. Apatite	10. Diamond

By this scale, the hardness of a fingernail is a little over 2; a copper penny is about 3; a steel pocketknife blade or ordinary window glass is 5½; a tempered-steel file is 6½; unglazed porcelain tile is about 7. You can make the scratch test with these materials, or you can buy a hardness set of the first nine minerals in Mohs' scale from a mineral supply store for about $2. If, for example, calcite leaves no scratch on your specimen but fluorite does scratch it, you know that the hardness of the unknown mineral is between 3 and 4, possibly 3½. Be sure to rub

Basalt and shale have the same texture and often the same color, but shale is formed in layers that are easy to see.

your finger over what appears to be a scratch. If it is just a powder trail from a softer testing mineral, the powder will easily rub off and there will be no scratch left behind.

If the mineral you are trying to identify is not one of the 12 most common kinds, you can probably find out what it is by checking your findings against the mineral descriptions in one of the guidebooks listed on page 6.

What Kind of Rock Is It?

Even if you are unable to tell which minerals are in a rock specimen, you may be able to identify it by answering the questions in the key for identifying 12 common rocks on page 15. Again, if your specimen does not fit any of the descriptions given there, you may find it in one of the guidebooks ■

prepared by CHRISTOPHER J. SCHUBERTH

HOW TO IDENTIFY 12 COMMON MINERALS

You can use this key to identify a specimen of a single mineral or identify individual bits of a mineral in a rock. First find the hardne cleavage, color, streak color, and luster of the specimen, as explain on page 13. From your findings, answer the question on line A. Yo "yes" or "no" answer will steer you to the next question to answer. moving step by step through the key as directed, you can identi the specimen if it is one of the 12 listed here. If it is a less comm mineral, you can check your findings with the mineral descriptions one of the guidebooks listed on page 6.

A. Is the specimen's hardness less than 2½? (Can you scratch it wi a fingernail?) *If yes, see line 1, below. If no, see line B.*
   1. Is cleavage perfect in one direction? *If yes, see line a. If n see line 2.*
      a. If thin sheets are transparent; if thicker pieces are colorl or white to dark brown and black; and if the cleavage su face is shiny, the mineral is .... **MIC**
   2. If there is no definite cleavage, *see line a.*
      a. If it is mostly white, with dull luster and an earthy od when moistened, the mineral is .... **KAOLI**

B. Is the hardness more than 2½ but less than 5½? (Is it too ha to be scratched by a fingernail but will not scratch glass?) *If ye see line 1. If no, see line C.*
   1. Is cleavage three-directional? *If yes, see line a. If no, see line*
      a. Do cleavage surfaces join at right angles? *If no, see line*
         i. If it is mostly white, with pearly luster, the mineral probably .... **CALCIT**
   2. If there is no definite cleavage, *see line a.*
      a. Is the luster metallic? *If yes, see line i. If no, see line*
         i. If it is crimson red in color, the mineral is .. **HEMATIT**
      b. Is the luster dull? *If yes, see line i.*
         i. If it is rusty yellow to pale orange, the mineral is.......... .... **LIMONIT**

C. Is the hardness more than 5½ but less than 7½? (Will it scrat glass but not unglazed porcelain?) *If yes, see line 1. If no, s guidebook.*
   1. When you press a sharp edge of the specimen against gla does it leave only a *faint* scratch? *If yes, see line a. If no, s line 2.*
      a. Is cleavage two-directional? *If yes, see line i. If no, s line b.*
         i. Do the cleavage surfaces join at right angles? *If yes, s lines a) and b). If no, see line ii.*
            a) If it is white, gray, or salmon-pink, the mineral probably .... **FELDSPA**
            b) If it is dark green to black, the mineral is probab .... **AUGIT**
         ii. If the cleavage surfaces do not join at right angles a the color is dark green to black, the mineral is probab .... **HORNBLEND**
      b. If there is no definite cleavage, *see line i.*
         i. Is the luster metallic? *If yes, see lines a) and b).*
            a) If it is pale brass yellow and leaves a black streak, t mineral is .... **PYRIT**
            b) If it is black, leaves a black streak, and attracts compass needle, the mineral is .... **MAGNETIT**
   2. When you press a sharp edge of the mineral against glass, do it leave a *deep* scratch? *If yes, see line a.*
      a. Is the luster glassy, rather than metallic? *If yes, see lin i and ii.*
         i. If it is deep wine-red in color, the mineral is.. **GARNE**
         ii. If it is colorless, milky, or smoky, the mineral is......... .... **QUART**

HOW TO IDENTIFY 12 COMMON ROCKS

You can use this key to identify a specimen of rock if it is one of the 12 common kinds. If you can see individual minerals in the rock, try to identify them first. Then find the answer to the question on line A by examining your specimen. Your "yes" or "no" answer will steer you to the next question to answer. A look at your specimen should enable you to answer each of these questions, and your answers will lead you to the name of the rock. If your specimen is a less common kind of rock, you can check your findings with the rock descriptions in one of the guidebooks listed on page 6.

A. Can you see individual particles of mineral or rock that make up the specimen without using a magnifying lens? *If yes, see line 1. If no, see line B.*

1. Are the minerals distributed at random, or not in any definite pattern? Are the minerals tightly locked together, making the rock hard to split? *If yes, see line a. If no, see line 2.*
   - a. Are the minerals light colored—quartz, feldspar, mica? *If yes, see lines i and ii. If no, see line b.*
     - i. If the particles of minerals are less than one-quarter of an inch in size, but all about the same size, the rock is .... **GRANITE**
     - ii. If the particles vary in size and many are larger than one quarter of an inch, the rock is .... **PEGMATITE**
   - b. Is the mineral interlocking calcite, which will not scratch glass? *If no, see line c. If yes,* the rock is.......... **MARBLE**
   - c. Are the minerals dark colored—feldspar, augite, hornblende? *If yes,* the rock is probably .... **GABBRO**
2. Are the minerals arranged in planes, or bands, which you can see and which tend to make the rock split easily? *If yes, see lines a and b. If no, see line 3.*
   - a. If the planes, or bands, of minerals are quite thin, the rock is .... **SCHIST**
   - b. If the planes of minerals are broad and thick, the rock is .... **GNEISS**
3. Is the specimen composed of rounded particles? *If yes, see lines a and b.*
   - a. If the particles are large pebbles, the rock is.......... **CONGLOMERATE**
   - b. If the particles are sand-sized grains of quartz, which will scratch glass, the rock is .... **SANDSTONE**

B. If you cannot easily see the particles of minerals or rock without using a magnifying lens, *see line 1.*

1. Are the minerals distributed, or not in any definite pattern? Are they tightly locked together, making the rock hard to split? *If yes, see lines a and b. If no, see line 2.*
   - a. If the minerals are dark colored—feldspar, augite, and hornblende, the rock is .... **BASALT**
   - b. If the mineral is light-colored quartz that is fuzed together and will scratch glass, the rock is.......... **QUARTZITE**
2. Are the particles of the rock arranged in layers and is the rock too soft to scratch glass? *If yes, see line a.*
   - a. Does the rock split easily into layers? *If yes, see lines i and ii. If no, see line b.*
     - i. If the luster on the split surface is dull, the rock is .... **SHALE**
     - ii. If the luster on the split surface seems silky, the rock is .... **SLATE**
   - b. If it does not split easily into layers, the rock is probably .... **LIMESTONE**

TYPES OF ROCK

How the three major types of rock—igneous, sedimentary, and metamorphic—are formed is explained in the WALL CHART on pages 8 and 9. Granite, basalt, and gabbro are igneous rocks. Shale, sandstone, limestone, and conglomerate are sedimentary rocks. Slate, quartzite, marble, schist, and gneiss are metamorphic rocks.

What Makes Mountains?

Mountain making is an endless process. As old ones wear away new ones continue to form.

by Laurence Pringle

■ If you travel across the United States, you will cross old mountains like the worn, rounded Appalachians near the East Coast, and young ones like the jagged, towering Rockies near the West Coast. Scientists called *geophysicists,* who study changes in the Earth, are still not sure how mountains are made. However, they are certain that new mountains will always form, just as they see old ones being worn away.

The most puzzling mountains are those that form ranges that stretch for hundreds of miles across continents. By studying these mountains, scientists have found some clues that may help solve the mysteries of mountain-making.

Where Mountains Form

Geophysicists have noticed that many of the world's mountain ranges are located near the edges of continents. Such a chain of mountain ranges runs along the western edge of North and South America. Even those ranges that are not near oceans—for example, the Alps, in Europe—are in areas where ancient seas once covered the land.

Scientists have long realized that most mountains contain rocks and fossils that formed on the floors of shallow seas millions of years ago. Does this mean that the seas were once deep enough to cover these high mountains? Probably not. More likely, the layers of *sedimentary* rocks *(see page 8)* formed in shallow seas, and then were thrust up into the mountains we see today.

From these facts, and from information gathered by drilling deep into the Earth's crust, scientists are trying to figure out how mountains form. Here is a possible step-by-step plan for the formation of a mountain range, based on what has been learned so far.

1. A mountain range is born in the shallow water along the edge of a continent or in an ancient inland shallow sea. For millions of years, the clay, sand, silt, and other sediments wash down from the surrounding land. The sedi-

(continued on the next page)

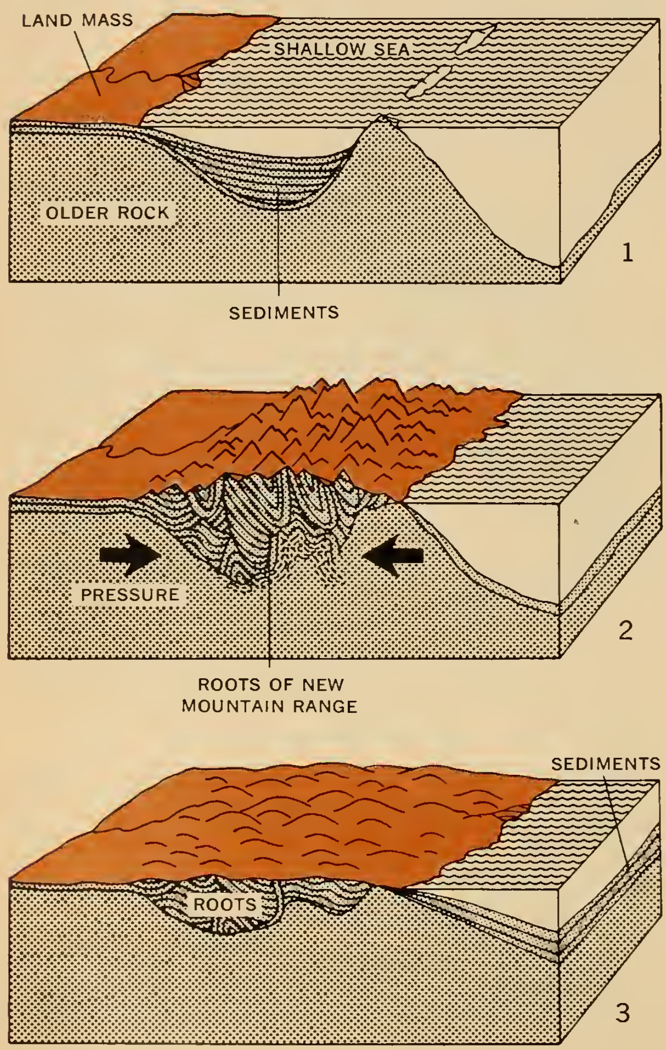
ments settle into a long trough. Scientists believe that the sediments build up at a rate of from 500 to 1,000 feet every million years. Eventually, they are pressed together and change into sedimentary rocks.

2. As more and more sediments are deposited, their great weight of millions upon millions of tons presses into the Earth's crust, continuously deepening the long trough along the continent's edge. The trough and its contents are called a *geosyncline (see diagram).*

3. As the geosyncline deepens, the surrounding crust squeezes the layers of sedimentary rocks together with greater and greater force. When the geosyncline reaches a depth of possibly about 50,000 feet, the pressure and heat become so great that some of the rocks near the bottom of the geosyncline are changed into *metamorphic* rocks. Some of these rocks even melt because of this great heat. Eventually these rocks are pushed upward by all these forces and form mountains.

4. The newly formed mountains tower high above the surrounding land. However, like icebergs, only the top parts of the mountains are visible. Wind, rain, and ice help to erode, or wear away ever-so-slowly, parts of the mountains exposed to the air. Scientists believe that mountains have "roots," which are underground parts of the old geosyncline. The roots reach thousands of feet into the Earth's crust *(see diagram).*

5. It seems that mountains and their roots "float" on the heavier rocks that are below the Earth's crust. As mountains are eroded, they weigh less, and therefore they "float" a bit higher. Because of this, they lose height very slowly. Scientists estimate that if 5,000 feet of rocks and soil were worn away from the top of Mt. Everest, this loss of material would let the mountain "float" upward and the top would be only about 1,000 feet lower than it is now. Meanwhile, the sediments that are washed away from the mountains settle on the surrounding lowlands. The weight of the sediments pushes down on the Earth's crust near the mountains. Scientists call this theory of rising mountains and sinking lowlands *isostasy,* which means "balance," or "equal standing."



Mountains form when sediments are worn from a land mass and settle in a trough in the sea (1). The sediments gradually change into rock. When the layers of rock reach great depth, heat and pressure push the rocks upward, making mountains (2). As the mountains wear away, their "roots" rise, and new sediments build up in the sea (3).

PROJECT

Float a block of wood about six inches square in a tub of water, or at the lake this summer. With a ruler, measure the distance from the top of the block to the water level. Then pour sand onto the block, making a "mountain" of "sediment." What happens to the wood block as you add sediment? Measure its height above the water now, or its depth below the water. If the surface of the block is below water, watch it for a minute or so. What happens?

After many millions of years of erosion, only the last of the root of a mountain range may remain. An example is the Canadian Shield. (The Laurentian Uplands, shown on the map on pages 8 and 9, are part of the Canadian Shield.) It is made up of the oldest known rocks on the North American continent, and was once several mighty mountain ranges. Today it is worn down to an average elevation of only about 1,500 feet above sea level.

Is this theory of mountain building correct? Scientists cannot say for certain. In drilling along the Gulf Coast, they have found more than 40,000 feet of sediments there, deposited by rivers emptying into the Gulf. Millions of years from now mountain ranges may rise from the Gulf of Mexico and the ocean shelf along the eastern edge of the United States ■