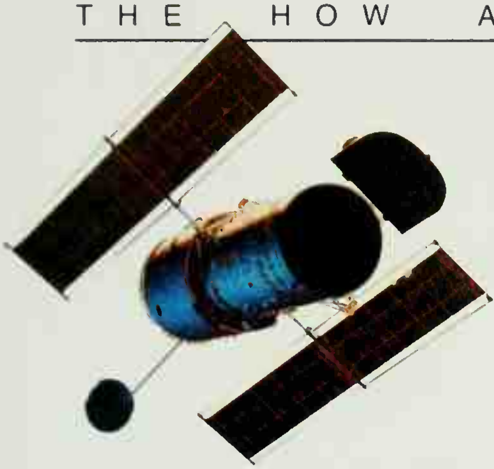
World and Space

Childcraft

THE HOW AND WHY LIBRARY

VOLUME 4



World and Space

World Book, Inc.

a Scott Fetzer company

Chicago London Sydney Toronto

1992 Edition
Childcraft—The How and Why Library
(Reg. U.S. Pat. Off.)

World Book, Inc.
525 West Monroe
Chicago, IL 60661

ISBN 0-7166-0191-5
Library of Congress Catalog Card Number 90-70178
Printed in the United States of America
A/IB

Acknowledgments

The publishers of *Childcraft—The How and Why Library* gratefully acknowledge the courtesy of the following publishers, agencies, authors, and organizations for permission to use copyright material. Full illustration acknowledgments appear on pages 328-329.

John Ciardi: "Why the Sky Is Blue," © 1974, John Ciardi.

Photograph of Japanese helmet, page 75, by Jonathan Norton Leonard and the Editors of Time-Life Books, © 1968 Time, Inc.

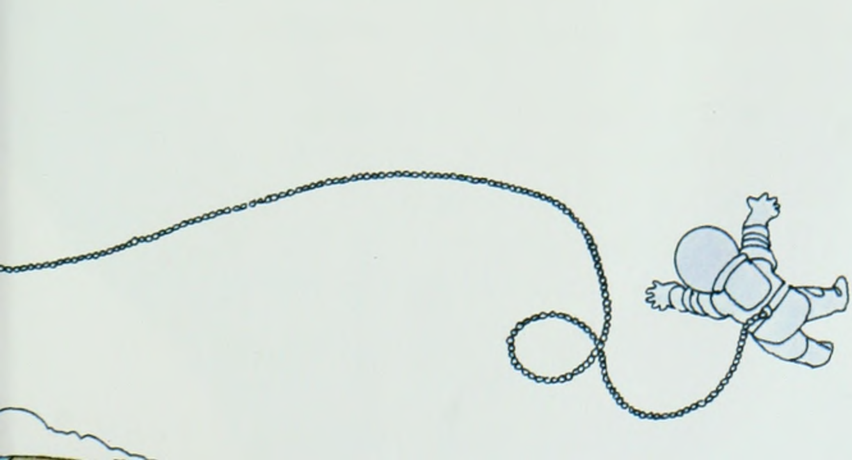
Photograph of Mars, page 248, and photograph of the Great galaxy, page 280, © California Institute of Technology and Carnegie Institution of Washington, from Hale Observatories

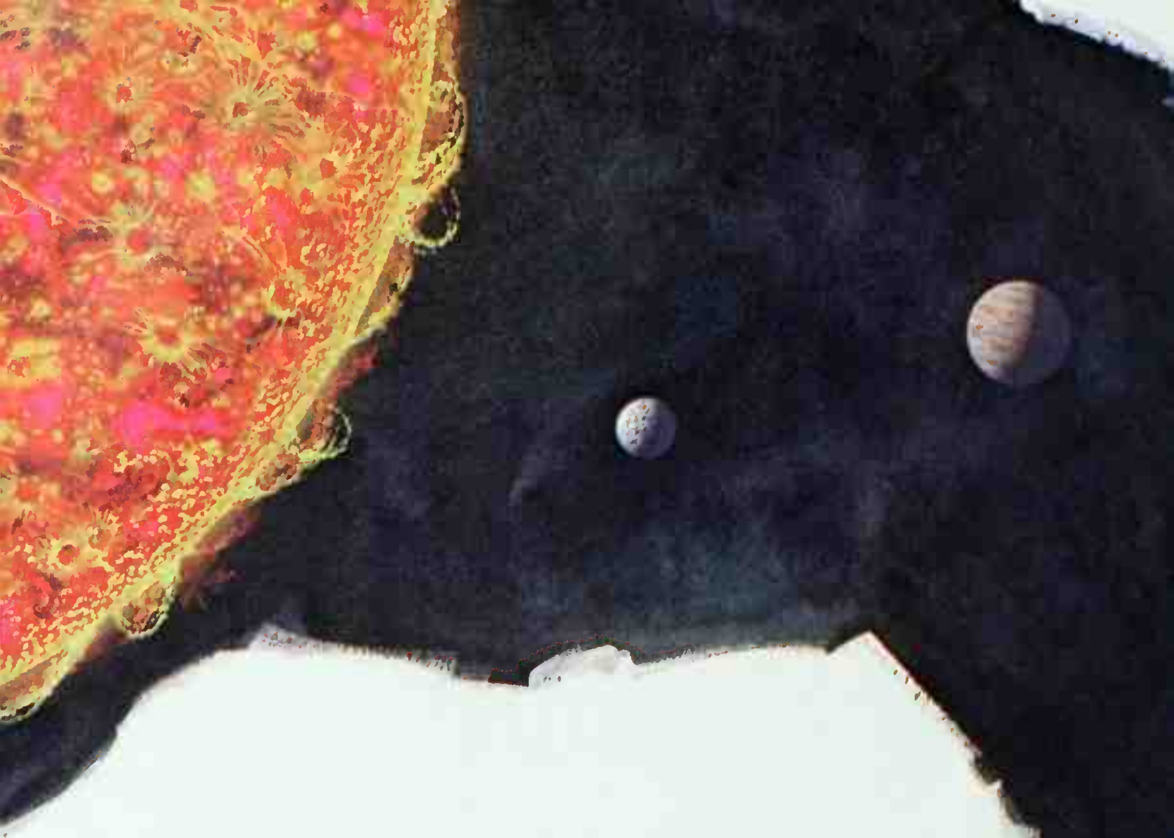
Volume 4

World and Space

Contents

Our Home, the Earth





An island in space

We live on an island. An island in space!

An island is a piece of land with water all around it. The earth is a giant ball of rock and metal with space all around it.

A ball of rock and metal such as the earth is called a planet. Planets are the "prisoners" of stars. They circle around and around the stars they belong to. Earth is one of nine planets that circle around and around our star, the sun.

The sun is an enormous ball of hot, glowing gas. To us, the earth seems big, but it's small compared to the sun. The sun is bigger than a million earths!

The earth has one near neighbor, the moon. The moon is a ball of rock, like earth, but much smaller. It circles around earth just as earth circles around the sun.

The moon is thousands of miles (kilometers) away from the earth. The sun and the other planets are millions of miles away. And the stars that you see twinkling in the sky at night are trillions of miles (kilometers) away. So, the earth is really a tiny island in the great, black emptiness of space. But for us, it's the most important place of all. It's our home.

The spinning world

You may think our world, the earth, is standing still. But it isn't. The earth is spinning around and around, like a huge top.

Push a stick through a ball of clay and then twirl the stick. The clay ball will turn around like a wheel. That's how the earth spins—around a kind of imaginary axle that runs through its middle. This imaginary axle is called the axis. One end of the axis is the North Pole and the other end is the South Pole.

Why can't we feel the earth turn? Because we're so tiny and it's so big. But we know it does turn because that's what gives us our day and night. In the morning, when the sky is bright, we know that our part of the earth is turned toward the sun. In the evening, when the sky grows dark, we know that we've turned away from the sun.

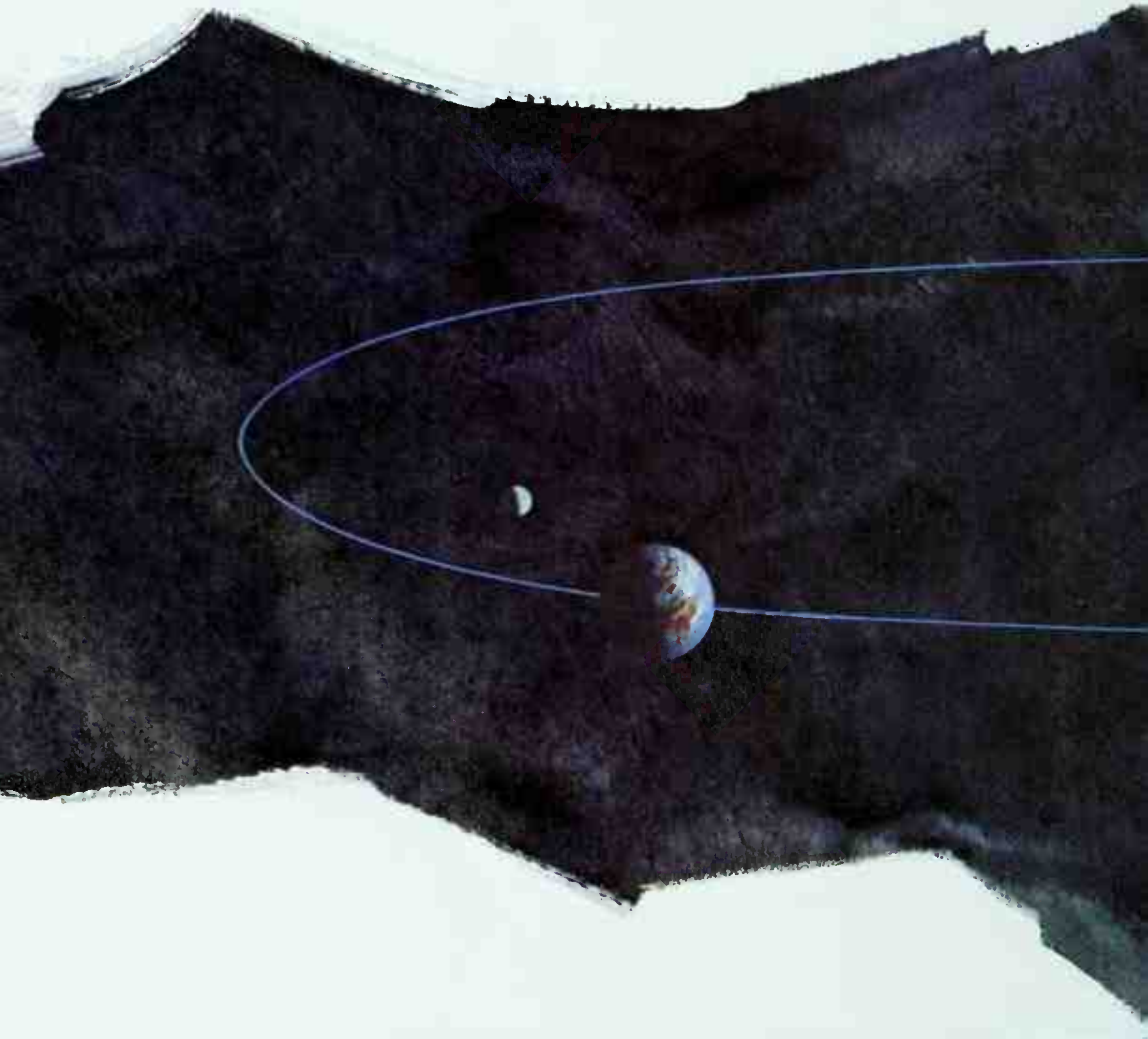
The time it takes the earth to make one complete turn is just a little less than 24 hours—one full day and night.

Around and around the sun

The earth doesn't just spin—it also moves through space.

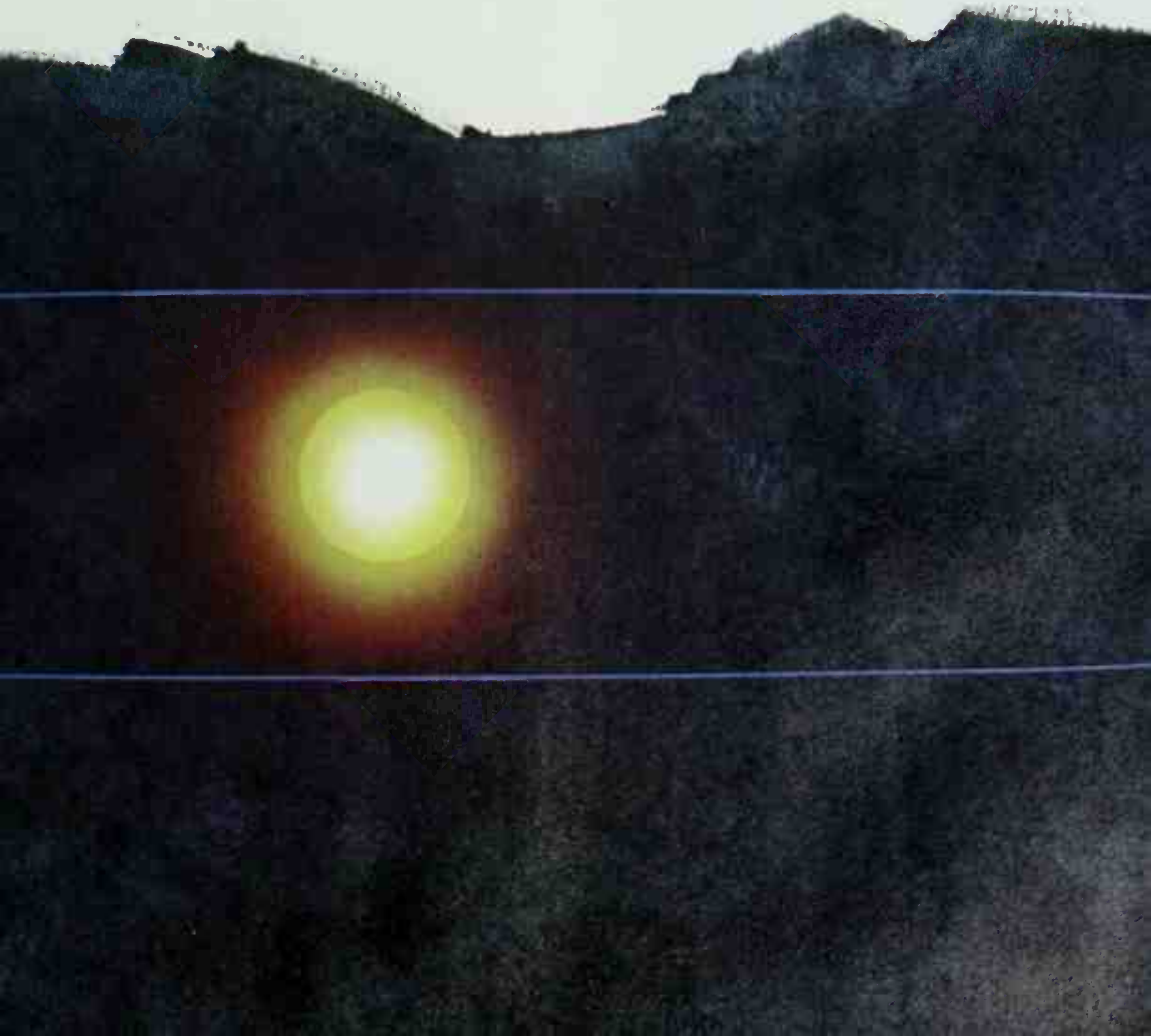
Right this very moment, the earth is rushing through space at tremendous speed—more than 66,000 miles (106,000 kilometers) an hour. It isn't going in a straight line, though. It's whirling around and around the sun, in a kind of stretched-out circle. This circle the earth makes around the sun is called an orbit.

What makes the earth keep moving around and around the sun? Why doesn't it just fly off into space?



Everything in space pulls at everything else. This pull is called gravitation. The bigger a thing is, the stronger its pull. The sun is more than a million times bigger than the earth, so it tugs hard at the earth. It is this strong tug that keeps the earth in orbit. If you fasten some string to a ball, you can whirl the ball around and around, to show the way the earth goes around the sun. The string is like the pull of the sun's gravity—it holds onto the ball. Even though the ball is moving, it can only move in a circle.

The time it takes the earth to go all the way around the sun is a little more than 365 days. This is what we call a year.



How was the earth born?

Why is the earth shaped like a ball? Why isn't it shaped like a block? Or why isn't it round and flat, like a pie? Why does it spin? And why does it whirl around and around the sun?

Most scientists think that the answers to these questions are part of the story of how the earth was born. They think it is a story that began billions of years ago, with a giant, spinning cloud in space.

There are many such clouds in space right now. They are made up of chemicals in the form of gas and dust. Scientists have found that some of these clouds seem to be turning into new stars. And scientists think that, about five billion years ago, our sun and its planets were formed from just such a cloud.

The cloud was hundreds of millions of miles (kilometers) wide! The force of gravitation pulled it into the shape of a huge, flat wheel. And it spun around and around, just like a wheel.

Gravitation slowly pulled the cloud together. Most of the gas collected in the middle of the cloud. It formed a lump that got bigger and bigger. As the lump grew, its gravity became stronger. Then it pulled more and more gas into itself. Because gravity pulls equally from all directions, the lump was squeezed into the shape of a round ball. This was the only shape it could take.

After a long while, there was a gigantic ball of gas in the middle of the wheel-shaped cloud. This was the beginning of the sun.

1. A gigantic cloud of dust and gas drifted in space. Gravity pulled much of the gas into a huge ball in the cloud's center. This was the beginning of our sun.

Farther out, in the rest of the cloud, other balls were forming as gravity pulled bits of dust and gas together. After a while, most of the cloud was used up. There were only balls of gas and dust, whirling around the sun. They were spinning and moving around the sun because the cloud they were made from had been spinning. These balls were the beginning of the earth and the other planets and moons. So that is why the earth is a spinning ball that whirls around the sun.

But if the earth was once a spinning ball of dust and gas, how did it become a ball of rock and metal?

As earth's gravity pulled more dust and gas in, everything was squeezed together—tighter and tighter and tighter! This made the ball grow hotter and hotter! It became so hot that the bits of dust in it, which were mostly rock and metal dust, melted together. The earth became a glowing ball.

But the outside of the earth couldn't stay hot. It began to cool. And when melted rock and metal cools,

2. In other parts of the cloud, gravity pulled dust and gas together forming blobs.

3. The blobs of dust and gas slowly shrank into tight-packed balls. This was the beginning of the earth and other planets.

it gets hard. So the earth became a ball of hard rock and metal, as it is today.

But the earth still hasn't cooled off. The middle is still fiercely hot, and part of the inside is still melted.

There are many other beliefs about how the earth was born. The book of Genesis in the Bible says that God created the earth and all living things. But no one actually *knows* how it happened.


crust
mantle
outer core
inner core

What's inside the earth?

Could you dig a hole to the other side of the earth?

No, you couldn't. The center of the earth is about 4,000 miles (6,400 kilometers) beneath your feet. So, it's almost 8,000 miles (13,000 kilometers) to the other side of the earth. You couldn't dig that far. And for most of that distance, the earth is either solid rock or metal so hot that it's melted! You certainly couldn't dig through that!

When the outside of the earth cooled, it became a kind of shell of rock. We call this the crust. The oceans and the continents lie on top of the crust. Beneath the oceans, the crust is about five miles (8 kilometers) thick. Beneath the land, it is about twenty-five miles (40 kilometers) thick.

Under the crust there is another layer of rock called the mantle. The mantle is made of a different kind of rock than the crust. The deeper the mantle goes, the hotter it gets. It is about 1,800 miles (2,900 kilometers) thick. At its bottom, it is hot enough to melt iron.

Beneath the mantle is a layer of melted metal—metal so hot that it's like thick syrup! This layer is called the outer core. Scientists think the outer core is made of iron and nickel and is about 1,400 miles (2,250 kilometers) thick.

In the center of the earth is the inner core. It's a ball of hot, solid, squeezed-together metal about 1,600 miles (2,570 kilometers) thick.

That's what's inside the earth.

The outside of the earth

We live on the surface of the earth. The surface, or crust of the earth, is made of rock. In some places, it is covered with soil. In many places, it is covered with water. All around it is air.

Some of us live on huge pieces of land called continents. A continent is like a great platform of rock that sticks up a little higher than the rest of the rocky crust.

Some of us live on smaller pieces of land called islands. An island is the top of an underwater mountain or part of a continent that has become separated from the rest of the continent.

The continents and islands where we live are

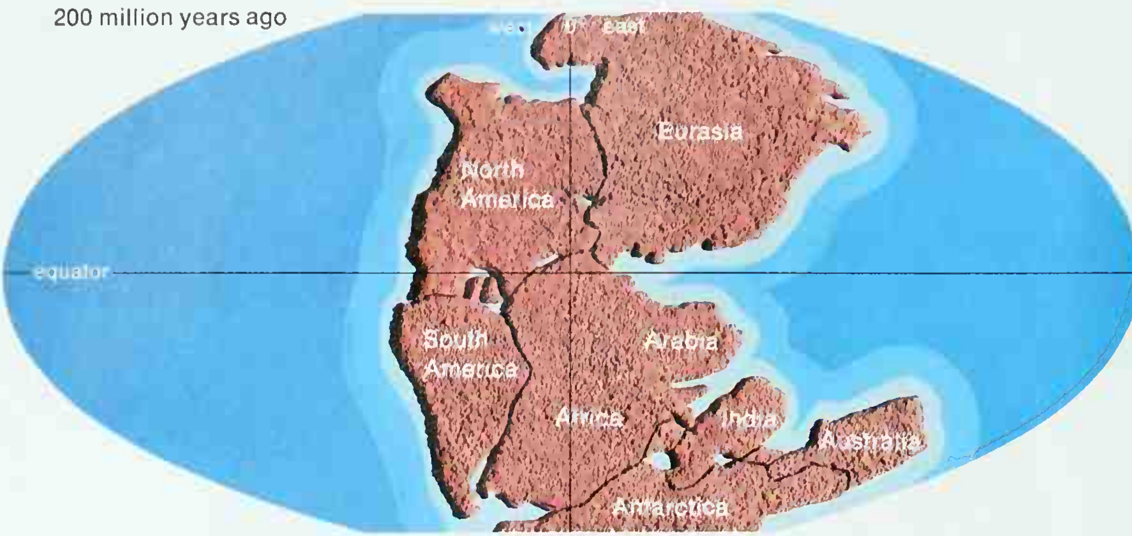
surrounded by water. Water covers nearly three-fourths of the crust of the earth. Most of this water lies in enormous pits that are like great bowls in the rocky crust. These huge "bowls" of water are the oceans. Water also lies in smaller pits in the continents and islands. These inland pits of water are lakes and ponds. Water also flows in rivers and streams, from the high parts of the land down to the lakes and seas.

All around the surface of the earth is a layer of air. This layer of air is hundreds of miles (kilometers) high. The air is thickest next to the land and water. It gets thinner the higher it goes. Where the air comes to an end, outer space begins.

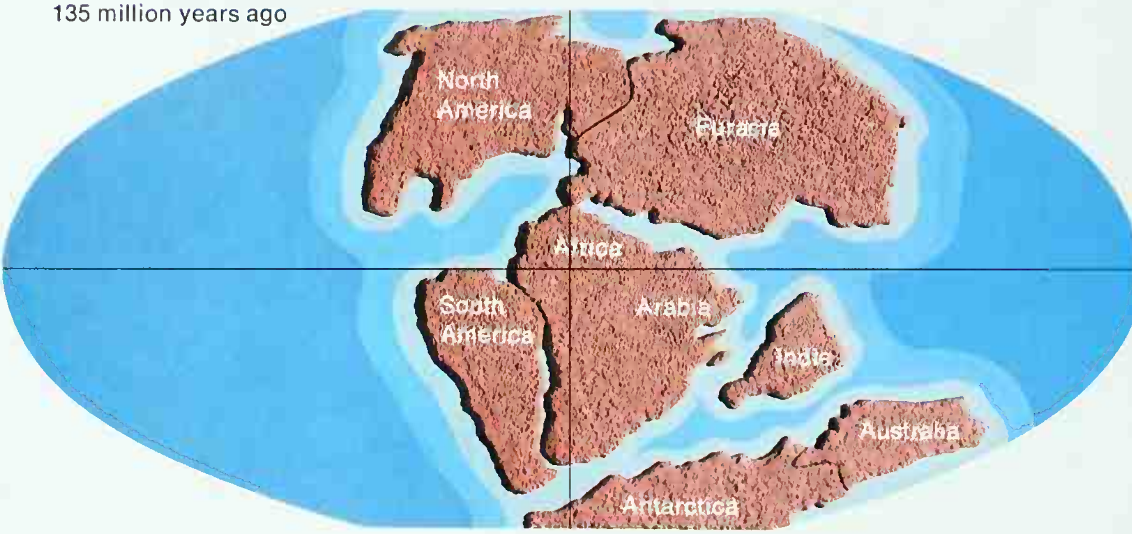
So that's our earth—a big, spinning, moving ball of rock and hot metal, with a thin coating of soil, water, and air on the outside.

Mountains, Valleys, and Plains

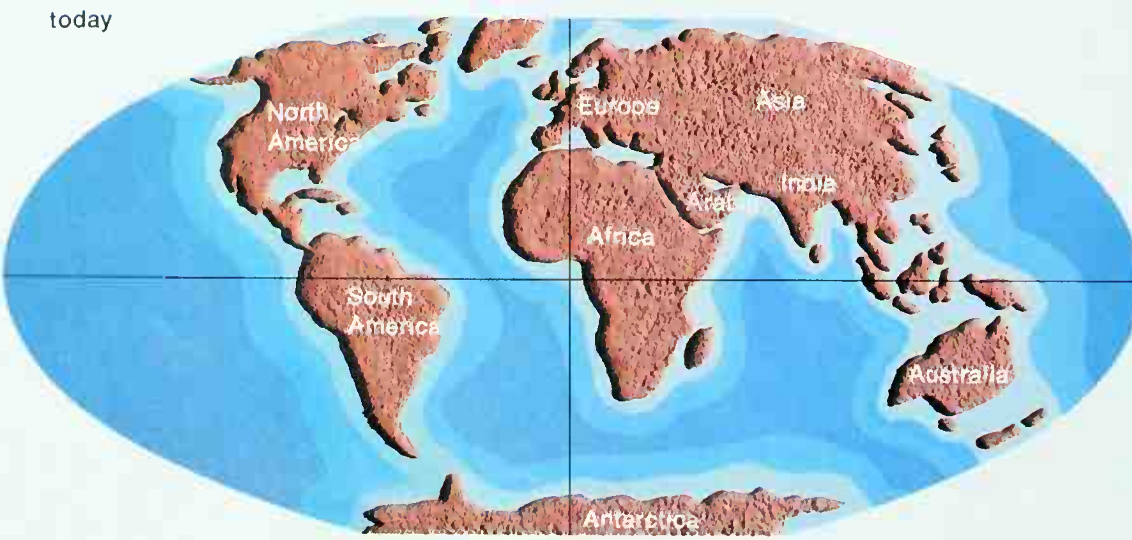
200 million years ago



135 million years ago



today



The moving continents

It may seem to you that the earth's crust is a single piece of rock. You may think this crust covers the outside of the earth just as an apple's skin covers an apple. But the earth's crust is actually made up of a number of enormous separate pieces, called plates. These plates fit together, like the pieces of a puzzle. And they are all moving, very slowly, in different directions.

Scientists are not sure what makes these huge, curved sheets of rock move. They think the plates slide on the hot, soft rock beneath them. The plates move from less than one inch (2.5 centimeters) to eight inches (20 centimeters) a year.

Some of the plates make up part of the ocean floor. Others hold the high masses of rock that rise above the sea and form the continents. As the plates move, they carry the continents and ocean floor with them.

The plates have probably been moving for billions of years. This means that the earth's continents and seas have probably had many different shapes. Scientists think that more than two hundred million years ago the earth's dry land was all bunched together, forming one gigantic continent. Slowly, as the plates moved, the one huge continent broke into two continents. And, as the plates continued to move, both of these continents broke up to form the seven continents we know today.

As the plates keep moving, the continents and seas will keep changing shape. Scientists think that in about fifty million years South America and Africa will be farther apart than they are now. This will make the Atlantic Ocean wider. And Australia may move up and push against Southeast Asia, becoming part of it.

Giant rocks

Mountains are like great, gray giants. They are huge chunks of rock that have been pushed up out of the earth. Some mountains stand all alone, but most are connected together. Long chains of connected mountains are called mountain ranges.

Mountains are not all alike. Many mountains are bare and rocky. Others have green forests and fields of grass growing on their sides. And most high mountains have snow on their tops all year round. This is because the air at the height of a mountaintop is usually cold enough to keep water frozen.

Scientists believe that most of the earth's mountains are many millions of years old. The newest are wrinkled, and have sharp, pointed tops. Older mountains are smooth, with rounded tops. These "old" mountains have been worn down by wind and rain during many millions of years.

Cascade Mountains, Washington

Some mountains are bare and rocky. Others are green with grass and trees. Newer mountains are sharp and pointed. Very old mountains are smooth and rounded by erosion.

Snowy Mountains, Australia

Mount Rundle, Alberta, Canada

The birth and death of a mountain range

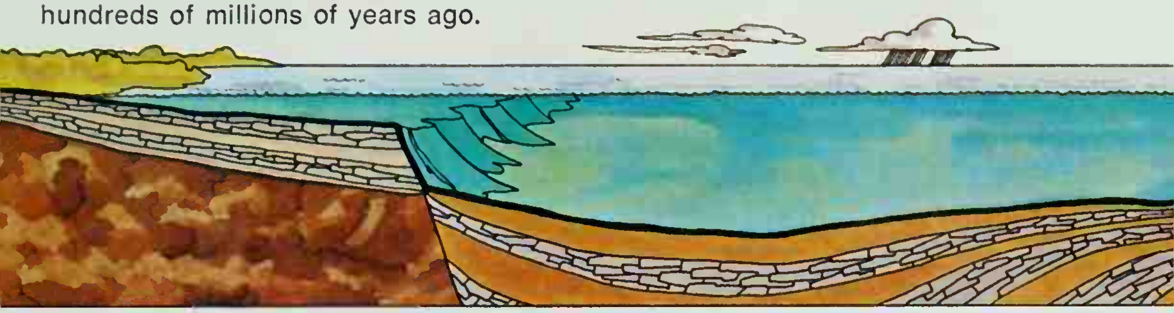
Mountain ranges rise where a sea once met a shore. They start to form when a sea bottom along the edge of a continent begins to fill up with mud and sand. As the mud and sand grow thicker, the sea bottom begins to sink. The mud, sand, and rock drop slowly down into the earth's mantle—the hot rock beneath the crust. They are crushed, squeezed, and melted together by heat and pressure. Hot rock from the mantle is mixed in with them. All this takes many millions of years.

Mountains are born when this mixture of rock is pushed up again by earthquakes and other forces in the earth. As the huge pile of rock rises, it pushes the edge of the land into wrinkles and folds. After many more millions of years, the upper part of the long, lumpy mass of rock has risen high above the land. Mountains now sit where once the sea met the shore.

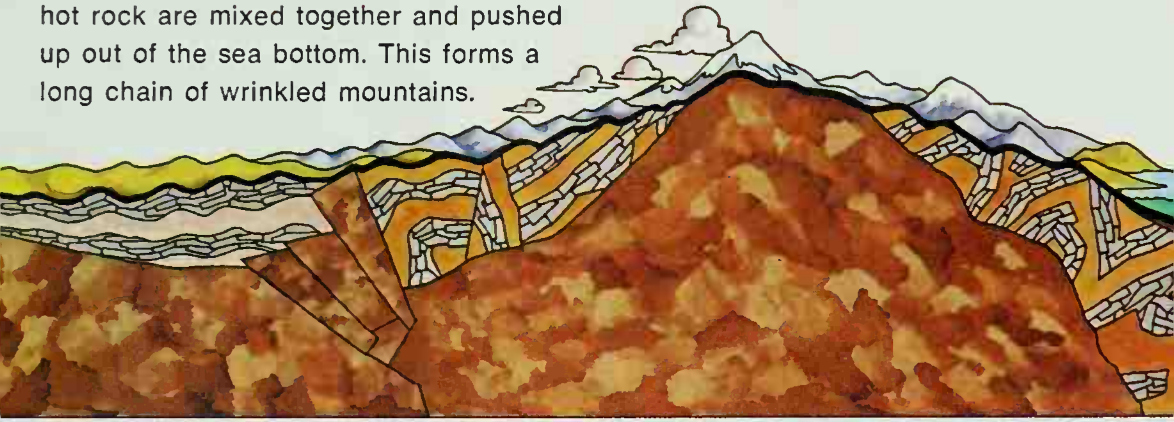
As soon as mountains are born, they begin to wear down. Rain falls on them. Each drop, like a little bomb, breaks off tiny bits of rock. Wind blows off tiny grains of rock and carries them away. Streams and rivers run down the slopes, cutting great grooves. Sometimes, huge masses of ice and snow move down mountainsides, grinding the rock to powder.

For millions of years, all these forces wear tons and tons and tons of rock from mountains. Slowly, the proud, peaked mountaintops are worn down and smoothed out. After many millions of years, nothing is left of a mountain range but a row of small, smooth hills. After more years, even those are worn away.

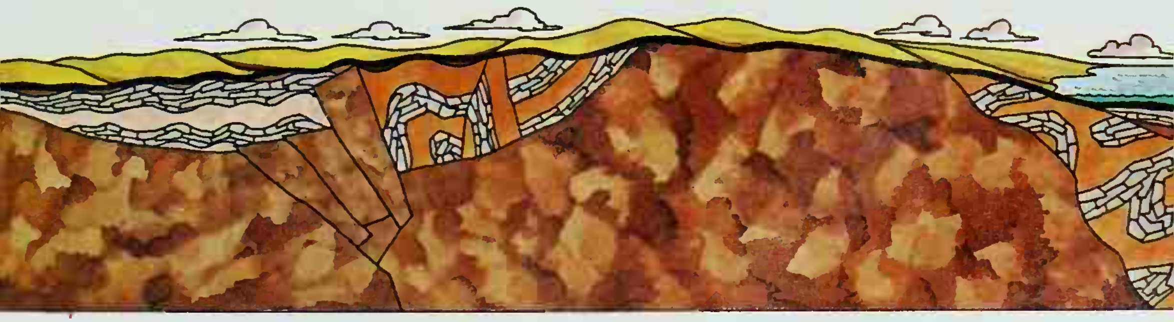
Mountains begin to form on a sea bottom hundreds of millions of years ago.



During millions of years, mud, sand, and hot rock are mixed together and pushed up out of the sea bottom. This forms a long chain of wrinkled mountains.



During many millions of years, wind, rain, and snow slowly wear down mountains.



The highest place in the world

Where do you think the highest place in the world is?

As you may have guessed, the highest place in the world is the top of a mountain. It is the top of Mount Everest, which stands between the countries of Tibet and Nepal, in Asia.

When we want to find out how high a mountaintop is, we can't just measure the mountain—we have to measure all the land it's sitting on, too. To do that, we must go to where the land *begins*—at the top of the sea. That way, we can measure all the land that slopes up from the sea to the very top of the mountain.

When we measure something this way, we are measuring from *sea level.* All the land in the world is either above or below sea level. The top of Mount Everest, the highest place in the world, is 29,028 feet (8,848 meters) above sea level.

On May 29, 1953, Sir Edmund Hillary of New Zealand and Tenzing Norgay of Nepal became the first men to climb to the top of Mount Everest. Since then, many other climbers have made it to the "top of the world."

Mount Everest, between Nepal and Tibet

Mountains of fire

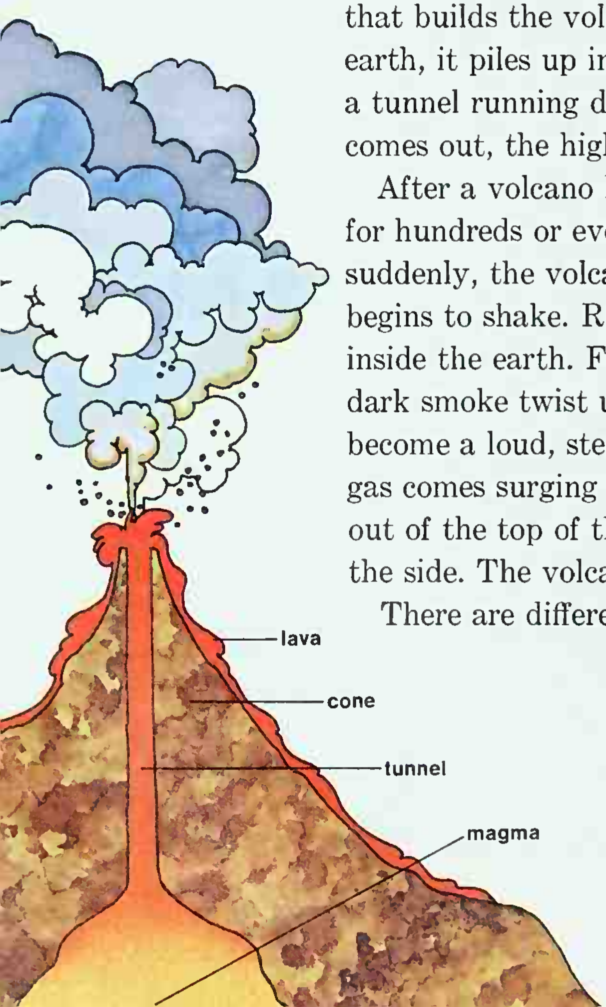
A volcano is a special kind of mountain that actually builds itself! It is made of red-hot rock that pours up out of the earth amid earthquakes, explosions, and towering clouds of smoke and ash.

Scientists think that far down in the earth, where it is fiercely hot, there are "pockets" of melted rock. It is thought that the pressure of gas pushes this melted rock, called magma, up out of the ground.

When magma comes out of the ground it is called lava. It may be as thick as syrup or as thin as watery soup, but it cools into a black, gritty rock. It is this rock that builds the volcano. As the lava pours out of the earth, it piles up into the shape of a cone or dome, with a tunnel running down its middle. The more lava that comes out, the higher and wider the volcano gets.

After a volcano has built itself, it may sit quietly for hundreds or even thousands of years. Then, suddenly, the volcano becomes active. The ground begins to shake. Rumbling noises come from deep inside the earth. From the top of the volcano, clouds of dark smoke twist up into the sky. The rumblings become a loud, steady, rushing roar. Magma or hot gas comes surging up through the tunnel. It may burst out of the top of the volcano or flow out of cracks in the side. The volcano has erupted!

There are different kinds of volcanoes that erupt



Mount Hekla, Iceland


hot lava


cooled lava

in different ways. One kind shoots a stream of glowing lava high into the air, like a giant, fiery fountain. Another kind shoots out solid chunks of red-hot rock and cinders. Some volcanoes pour rivers of lava through cracks in their sides. Some send clouds of glowing, super-hot steam and gas rushing down the mountainside. And some blow themselves to pieces when they erupt!

There are several thousand volcanoes in the world. Many of them do not seem able to erupt any more, and

San Pedro volcano, Guatemala

are called "dead" volcanoes. But some volcanoes that have been "dead" for hundreds of years have suddenly become active and had terrible eruptions. And active volcanoes are liable to erupt at any time. Volcanoes have killed many people and destroyed whole cities.

But volcanoes have done good things, too. The ash that comes from volcanoes becomes some of the richest, most fertile soil in the world. And scientists think that, billions of years ago, much of the earth's first air and water came from gas and steam spouted from volcanoes.

When the earth shivers

"The mountains seemed to walk!"

That is what a Chinese writer said about a terrible earthquake he saw. During the worst earthquakes, the ground shivers and shakes and rumbles. Whole sections of land get pushed out of place, so that mountains truly seem to "walk."

Earthquakes begin in the earth's rocky crust. Pressure

earthquake damage, San Francisco

builds up and begins to push. The force of this push actually bends the rocks, just as you bend a stick. And, suddenly, the rocks snap and break, just as the stick would snap if you kept bending it. This sends shivers through the ground making it quiver and quake.

Earthquakes are actually happening all the time. Every few minutes there is one somewhere in the world. Sometimes an earthquake is very powerful and does a lot of damage. But most earthquakes are so slight they don't even rattle a spoon in a teacup.

It's a Fact

Every two or three minutes there's an earthquake somewhere in the world. The earth is always shivering!

Nature's ditches

What parts of the earth's surface have floors and walls?

Valleys. A valley is like a long ditch scooped out of the ground. The bottom of the ditch is called the floor. The sides are called valley walls.

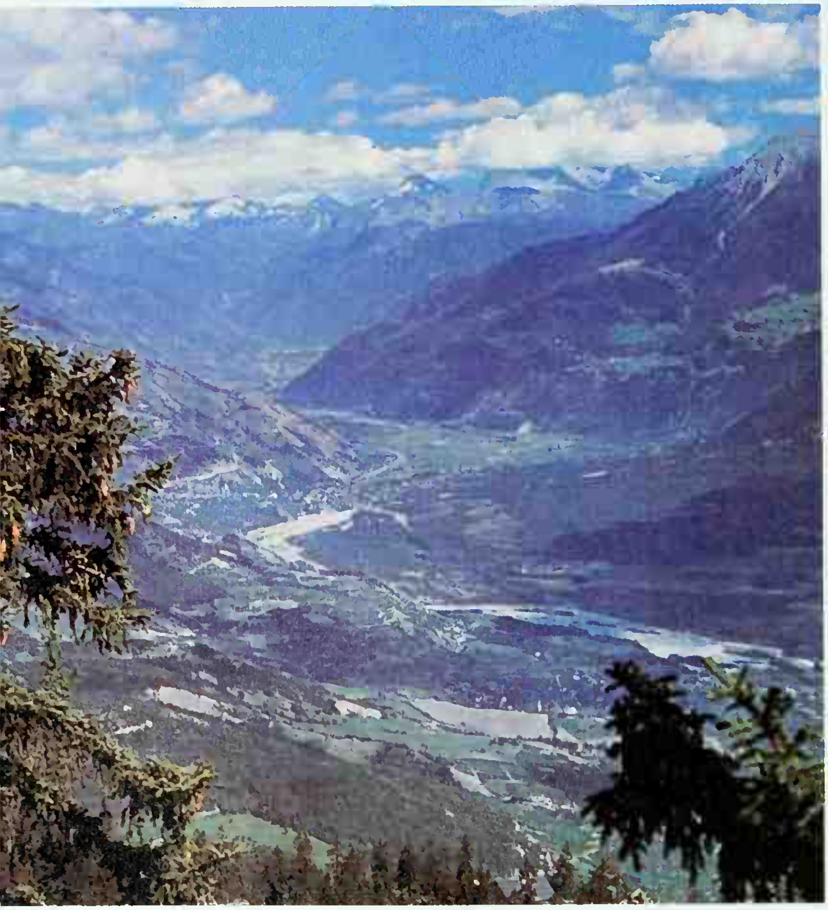
Some valleys are places where the ground has sunk. But most valleys are made by rivers and streams. As water flows along, it tears away bits of the land. As years go by, more and more land is worn away. The river sinks deeper and deeper. Steep walls form on both sides of it. Then wind and rain begin to wear away the walls, making the valley wider. In time, the valley becomes a long, V-shaped ditch, with the river or stream flowing along the floor.

Some valleys have grown so wide that they are no longer V-shaped. Some are U-shaped. Others have become deeper rather than wider. Very deep valleys with steep walls are called canyons or gorges.

Oneonta Gorge, Oregon

A valley is like a long ditch scooped out of the ground. Most valleys are made by rivers that carry away tons of rock and dirt every year. During many thousands of years, the valley grows deeper and broader. Valleys with very steep walls are called canyons or gorges.

Rhône Valley, Switzerland



Canyon de Chelly, Arizona

Dead Sea, between Jordan and Israel

The lowest place in the world

If the highest part of the land is a mountaintop, where do you think the lowest place must be?

That's right—in a valley.

The lowest bit of dry land in the world is the Valley of the Dead Sea, between Jordan and Israel. The land there is 1,312 feet (about 400 meters) below the level of the nearby Mediterranean Sea.

The Valley of the Dead Sea was not made by a river, as many valleys are. It is a fault—a large strip of the earth's crust that has sunk down.

Open country

All over the earth there are great flat places. The level or gently rolling land goes on for miles (kilometers). These flat parts of the earth are called plains.

Most plains are lower than the land around them. It might seem, then, that plains would be on the lowest parts of the land. But this is not always so. Coastal plains are low, and usually slope gently upward from sea level. But inland plains, such as the Great Plains in the United States, are often thousands of feet (meters) above sea level.

Serengeti Plain, Tanzania

an oasis in the Sahara, Algeria

Dry lands

The golden, glowing sun glares down on a vast sea of sand. As far as the eye can see, the sand stretches in great yellow-brown ripples. The air is so hot you can see it shimmer as it rises from the sand. There is not even the tiniest green plant anywhere in sight.

Whenever most people think of a desert, they usually think of an endless, hot sandy land. But there are actually many different kinds of deserts.

Some deserts are rolling, sandy places where hardly any kind of plant can grow. Some are flat plains that are covered with many kinds of plants. Even the world's biggest, hottest desert, the Sahara, has small patches of trees and grass in some places. Such a patch of greenery is called an oasis.

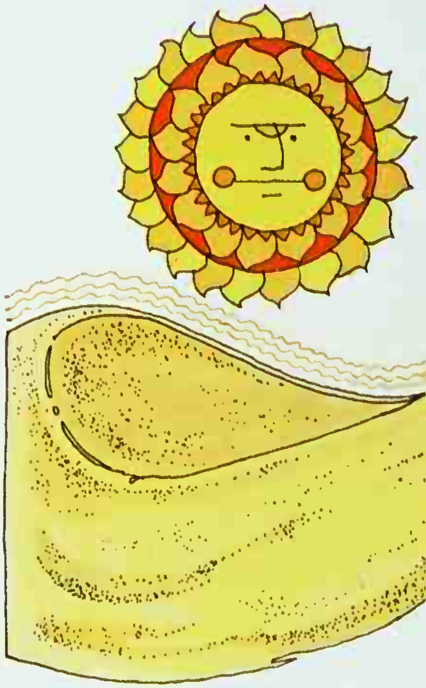
Some deserts are hot all year round. Others are hot in the summer and cold in the winter. Some deserts are great bare places on the shores of seas. Others are rocky places high up in mountains. But all deserts, wherever they may be, are the earth's dry places—places where little rain falls.

It does rain in deserts, but usually only a tiny bit. Some parts of deserts go for many years without rain, then get just a sprinkle. Sometimes a desert is so hot that the rain dries up before it reaches the ground!

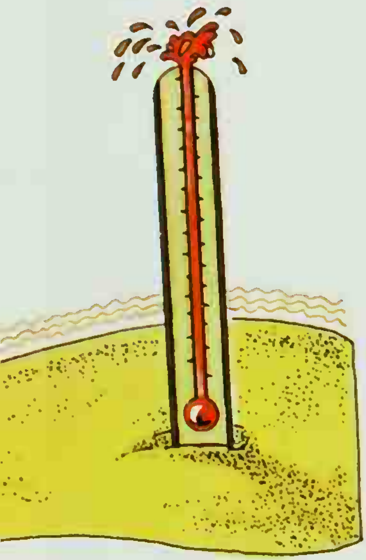
But some deserts get cloudbursts. Then, rain pours down on parts of the desert. In fact, the heavy rain may cause sudden floods. The dry earth can't soak up the water fast enough, and water quickly fills up the desert's low places. But, soon, the ground is again as dry as an old bone.

Scientists can tell that the deserts now on earth were not always here. Most of them are probably only a few million years old. At one time, most of the places we now know as deserts were green and fertile. But something happened. Changes in the wind and weather made rain stop falling on these places. Then, year after year, these lands were baked and dried by the sun until they became the deserts they are today.

Chalbi Desert, Kenya

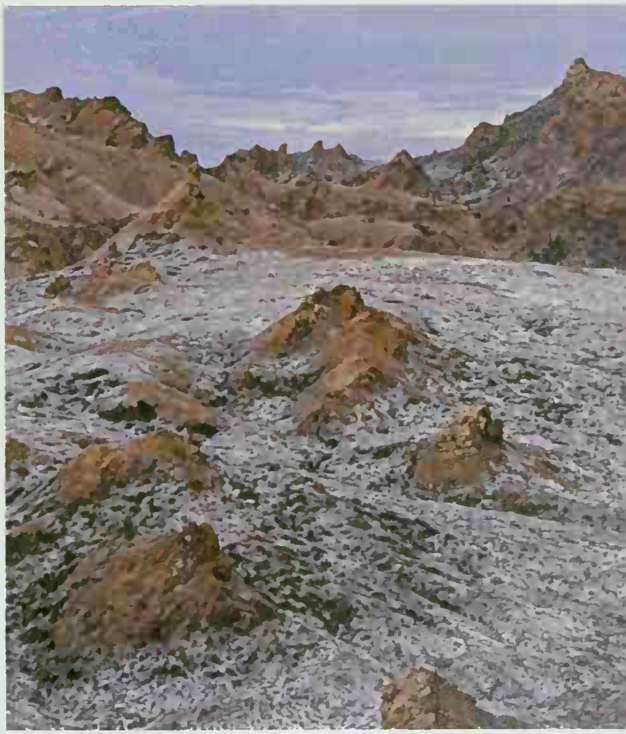


Nullarbor Plain, Western Australia



It's a Fact

The highest temperature of anyplace in the world was recorded in the Sahara—a temperature of 136 degrees Fahrenheit (58° Celsius).



Atacama Desert, Chile

Land in the water

Explosion after explosion of hot rock and ash spurted from the ocean. A thick cloud of steam rose high into the air. Slowly, for many days, a long mound of dark lava rose up out of the water. An island had been born!

An island, of course, is a piece of land with water all around it. But the land doesn't float on the water. What you see is the top of land that sticks up from the bottom of the sea. Most islands far out in the ocean are actually the tops of underwater volcanoes!

Volcanic islands are made when underwater volcanoes erupt, pouring out red-hot, melted rock. The rock quickly cools and hardens in the water, building up into a big, cone-shaped mountain. The island is the top of the cone.

All islands aren't volcanoes. Most islands in lakes and rivers are high pieces of land that stick out of the water. Some islands are formed when the sea separates them from the mainland. Great Britain was not always an island. At one time, a low plain joined it to Europe. Thousands of years ago, the sea covered this plain.

Island of Surtsey, Iceland

Most islands in the ocean are the tops of underwater volcanoes. The picture at left shows such an island being born. Smoke from the underwater volcano is pouring up. *Below,* the top of the volcano has risen from the water.

Lands of ice

Two parts of the earth are bitter cold all year round. These places are the "top" and the "bottom" of the earth—the North Pole and South Pole.

The land around the South Pole is called Antarctica. It is the coldest place on earth. Antarctica is covered with a sheet of ice more than a mile (1.6 kilometers) thick. But beneath the ice there is land, just like other land, with mountains, plains, and valleys.

At the North Pole there is no land. This part of the world is just a huge sheet of ice from four to ten feet (1.2 to 3 meters) thick. Beneath the ice there is only the water of the Arctic Ocean.

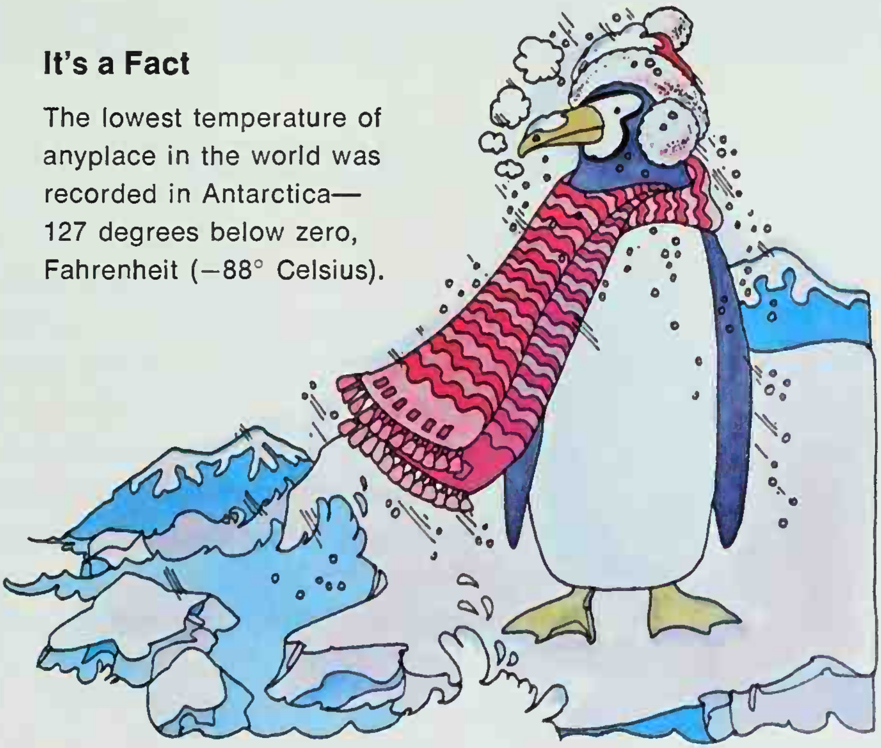
Beaufort Island, Antarctica

Scientists know that ten or twenty million years ago there was no ice at the North and South poles! Palm trees grew in Antarctica, and animals such as those that now live only in hot places lived there! But something happened to turn the two poles into regions of ice.

We don't know why the poles became covered with ice, but we know why the ice does not melt. It is because the sun never shines directly down on the poles. Because the sun is usually low in the sky, the air stays cool. Thus, the poles get much less heat than the rest of the earth. And most of the heat they do get bounces off the shiny, white ice and is reflected back out into space. So the poles never get enough heat to melt all the snow and ice.

It's a Fact

The lowest temperature of anyplace in the world was recorded in Antarctica—127 degrees below zero, Fahrenheit (−88° Celsius).



glacier, Chile

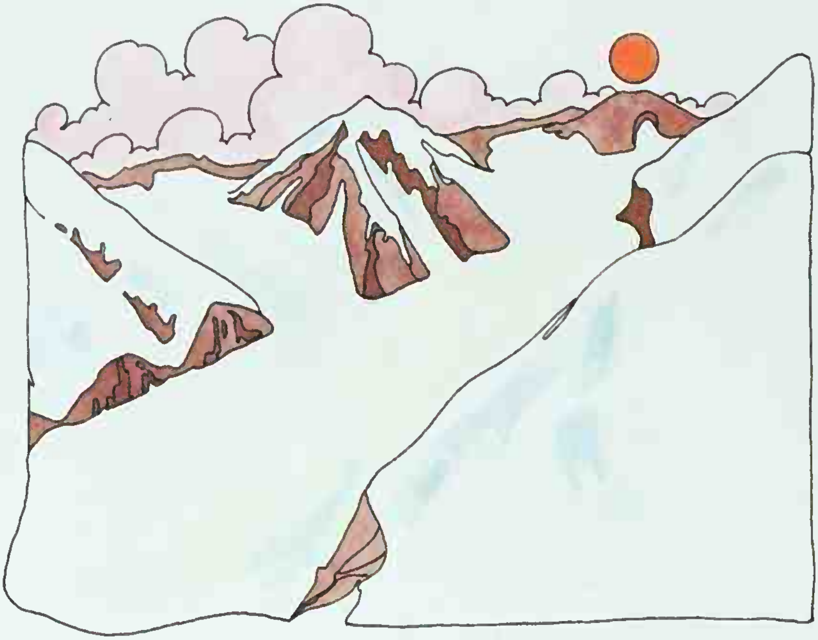
Icy bulldozers

Some of the snow on a high mountaintop melts and runs off. But much of it stays all year round. The snow that stays becomes hard and grainy, like salt. As new snow falls each year, the grainy snow underneath is squeezed together and becomes hard as ice.

The weight of all the snow pressing down squeezes out a stream of ice, like toothpaste is squeezed from a tube. This gigantic stream of ice, creeping down the mountainside, is called a glacier.

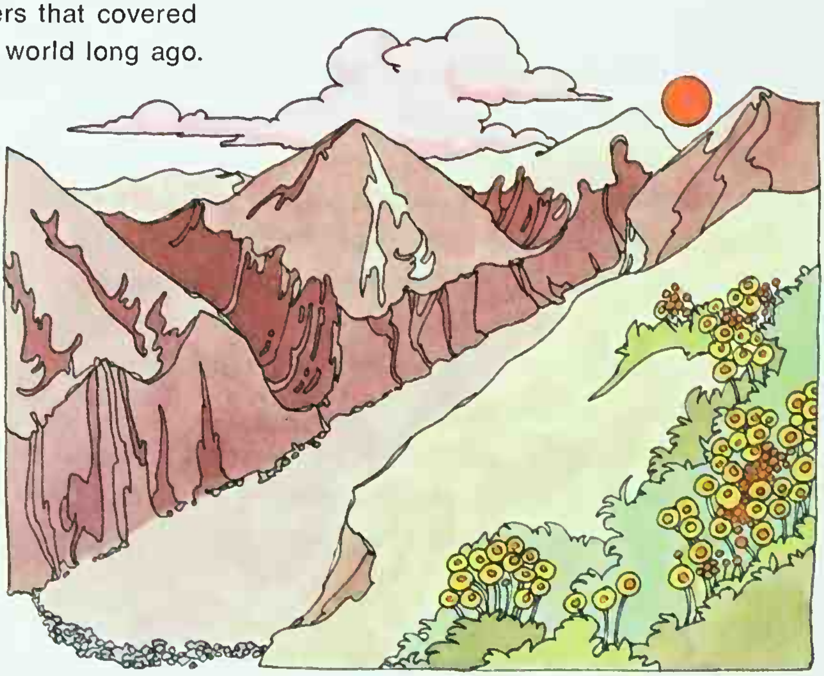
There are two main kinds of glaciers. One kind is like a river of ice. It stretches from near the top of a mountain down into a valley below. The other kind of glacier is like an enormous cake of ice and snow. This kind covers whole mountain ranges and even whole lands. All the land at the South Pole is covered by such a glacier.

Most glaciers move slowly. They travel from only a few inches (centimeters) to about forty feet (12 meters) a day. But, slow as it is, a glacier is like a big, icy bulldozer. It scrapes, gouges, and shovels up the ground over which it moves. It picks up everything



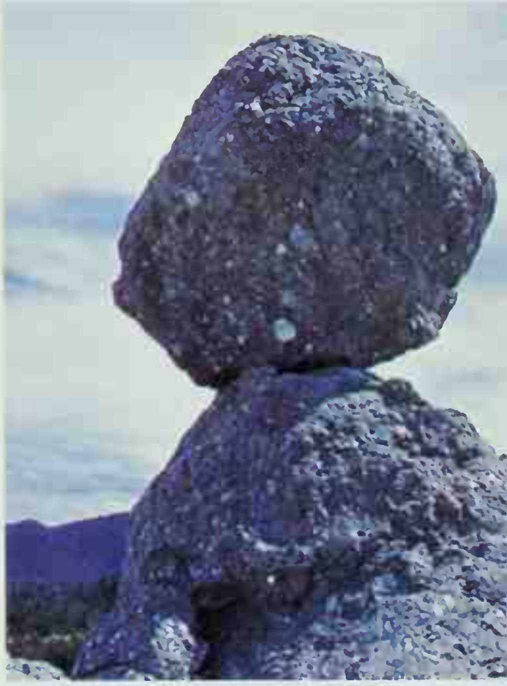
A glacier begins as a pile of snow on a mountaintop. The snow at the bottom of the pile becomes ice. The ice slides slowly down the mountainside.

As a glacier moves, it gouges out tons of rock and widens the valley it passes through. Many valleys were made wider by glaciers that covered northern parts of the world long ago.



lake made by a glacier, New York

boulder left by a glacier, Tasmania, Australia



in its path, from soil to huge boulders, and carries it along. As a glacier passes through a valley, it may dig the valley deeper and wider. As it moves down a mountainside, it may leave long scratches and furrows.

Glaciers make valleys wider and dig out holes for lakes. Long ago, during the time that is called the Ice Age, great glaciers crept far across the land. They dug many ditches and deep holes in some of the places they passed over. Later, these holes filled up with water and became lakes. In some places the glaciers left rich soil that they had picked up as they moved. In other places, they left behind huge boulders that now sit far from the mountains that were once their home.

Soil, sand, and dust

Tiny chips of rock and powdered flower petals. Bits of bats' wings and birds' feathers. Fragments of dried-up caterpillar skin and pieces of mouse whiskers.

That isn't a recipe for a magic potion. It's the "recipe" for soil! Soil is tiny bits of rock mixed with tiny bits of dead plants and animals. When plants and animals die, their bodies decay and fall apart. Rain washes them into the ground, to mix with the rest of the soil.

Sand is tiny bits of rock. Wind, water, and the roots of plants all help to make sand. Wind blowing against rock wears off tiny bits of it. Rain falling on rock, and waves smashing against it, also break off bits. The roots of plants dig into rock and split it into small pieces.

Dust is made up of tiny, tiny bits of sand, soil, animal hairs, bits of plants, and other things carried into the air by the wind. The dust floats in the air for a time, then drifts back to earth again.

sand

dust

soil

Rocks, Stones, and Petrified Bones

The rock factory

The earth is a rock factory. Scientists believe it has been making rocks for billions of years.

The earth makes three different kinds of rocks. One kind is made from hot, syrupy liquids, deep inside the earth. Sometimes, some of this liquid rock pushes its way between two layers of solid rock—making a sort of rock sandwich. Then the liquid cools off and becomes solid, too. Sometimes, when volcanoes erupt, some of the liquid rock is pushed up out of the earth. When it reaches the earth's surface, it cools and becomes solid.

Rock that was once a hot liquid is called igneous rock. Igneous means "of fire." Granite, the hard, light-colored sparkly rock used on the outside of many buildings, is an igneous rock. And so is the black glassy rock called obsidian that some prehistoric people made into knives and arrowheads.

Another kind of rock is made out of "rock powder." Wind and rain wear off tiny, powdery bits of rock from mountains. Rivers carry the powdered rock to the sea, where it sinks to the bottom. Over thousands of years, the bottom layers of powder are squeezed together by the weight of new layers. Slowly, the powdery bits on the bottom are turned into a layer of solid rock. Over millions of years, earthquakes and other forces may lift up the layers of new rock and they become dry land.

Rocks that are made this way are called sedimentary rocks. Sedimentary comes from the word *sediment,* which means "to settle." Limestone and sandstone are sedimentary rocks.

There is also rock that is changed deep in the earth.

granite—an igneous rock

The heat and weight of the earth slowly change it into a different kind of rock. Rocks changed this way are called metamorphic rocks. Metamorphic means "changed."

Slate, a gray-black rock from which blackboards used to be made, is a metamorphic rock that was changed from clay. Marble is a metamorphic rock that was changed from limestone. Most metamorphic rocks are very old. They stay buried unless erosion, an earthquake, or the birth of a mountain lifts them to the earth's surface.

In fact, all the rocks we see were made long, long ago. The oldest rocks ever found on earth are more than three billion years old. But the earth hasn't stopped making rocks—it's making them right now. It takes a long, long time to make a rock.

sandstone—a sedimentary rock

marble—a metamorphic rock

Solid stuff

It takes a lot of things to make cookies—flour, milk, eggs, butter, sugar. But when the cookies are baked, you can't see that there are a lot of things in them. Everything is all mixed together.

A rock is like a cooky. Mixed into most rocks are things that you can't see. Rocks are mixtures of materials called minerals.

Minerals are the solid stuff that the earth is made of. There are about two thousand different kinds of minerals. Some are shiny, some are sparkly, some are dull. Some are hard enough to scratch glass. Others are so soft you can scratch them with your fingernail. There are minerals that look like chunks of ice, minerals that look like clusters of metal cubes, and minerals that look like bunches of fuzzy string or shiny hair.

Minerals are scattered throughout the earth's rocky crust. Many of them are mixed together, but many are by themselves, in huge chunks, little lumps, and broad patches between layers of rock.

minerals

Minerals are the solid material of which the earth is made. There are about two thousand different kinds of minerals. Shown here (clockwise, from the lower left) are: fluorite, azurite, malachite, selenite, and, in the center, wulfenite.

Flat sides and sharp corners

A chunk of mineral may seem to be just a jagged, lumpy, or twisty piece of hard stuff with no special shape. But each kind of mineral is actually made up of tiny shapes called crystals—shapes that have flat sides and sharp corners, such as cubes, squares, and pyramids.

Each kind of mineral is made up of crystals that have the same shape. The mineral halite, which is the salt we put on food, is made up of crystals shaped like cubes. Diamonds are made up of crystals shaped like pyramids. Graphite, which is the "lead" in pencils, is made up of square crystals.

It seems strange to think of hard, lifeless things growing. But crystals actually do grow. They don't grow from the inside, as living things do, however. They grow by joining together. For example, the walls of a cave may be covered with a particular mineral. Water trickling down the walls washes crystals of this mineral onto the cave floor. The water, filled with many tiny crystals, forms a puddle on the floor. As the puddle slowly dries up, the crystals stick together. They form larger crystals. That's how crystals grow—when more and more of them join together.

Some minerals have the same shape as the crystals they are made of. Diamonds usually look like two pyramids with their bottoms stuck together. Graphite comes in flat sheets. Pyrite comes in clusters of shiny, golden cubes. Quartz is often found in clusters of six-sided, pointed shapes.

calcite crystals on a cave wall, South Dakota

quartz crystals in a cave, Arkansas

A crystal garden

When small crystals of a mineral join together, they "grow" into larger crystals. You can see how crystals grow by growing some crystals yourself. Here's what you will need:

6 tablespoons of water
1 tablespoon of ammonia
6 teaspoons of salt
6 pieces of charcoal—the kind used for outdoor cooking

Mix the water, ammonia, and salt together in a measuring cup or a small bowl.

Put the charcoal in a pie pan. Pour the liquid over the pieces of charcoal. Put the pan in a warm place where the water will evaporate quickly.

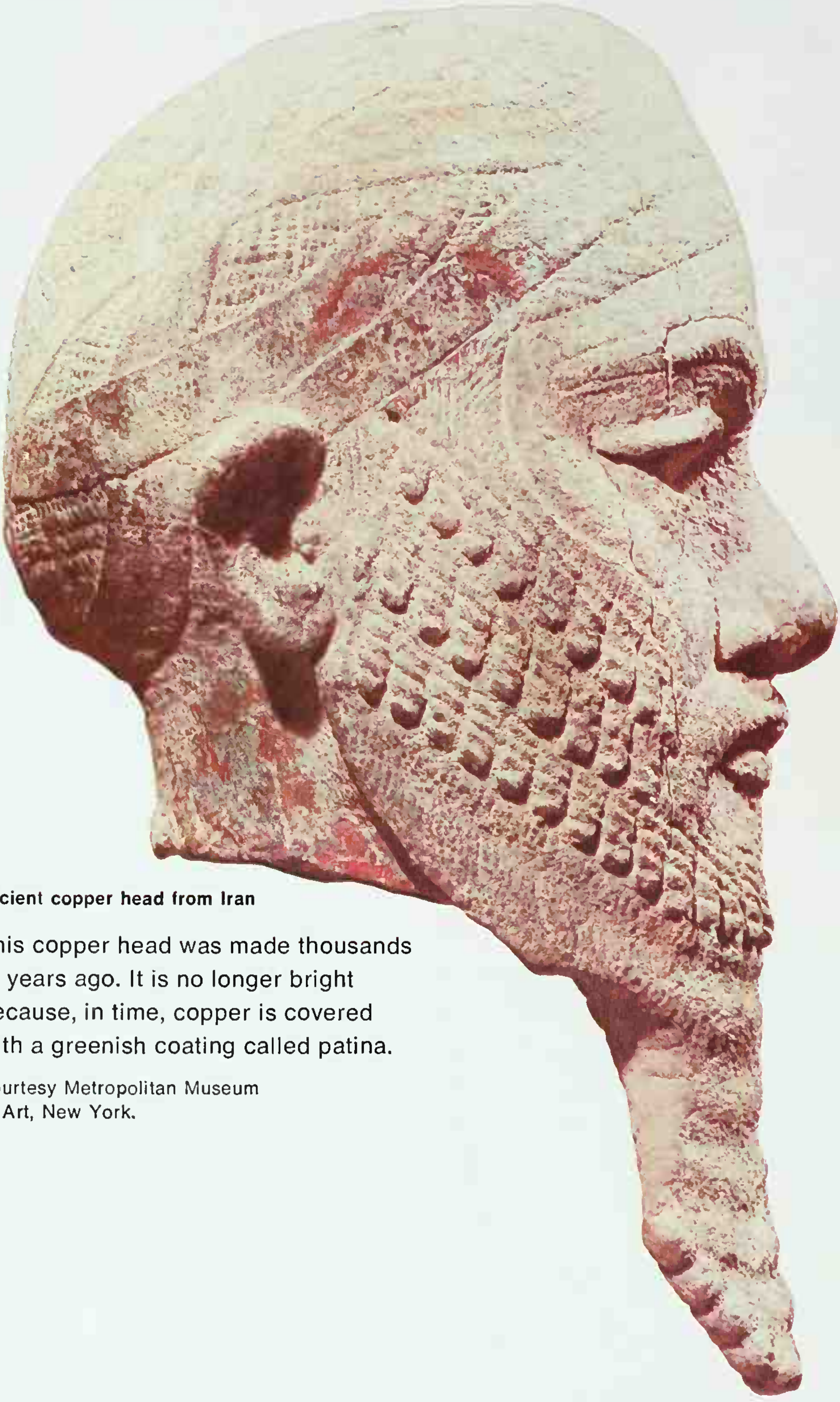
When the water has evaporated, you will find you have grown a fantastic "garden" of crystals.

crystals grown in a dish

You can also grow crystals with nothing more than salt and water. Table salt is a mineral called halite that forms in cube-shaped crystals.

Put a little hot water into a small pie pan or a saucer. Then add several spoonfuls of salt to the water. Stir the water until all the salt dissolves. Put the pan in a place where it will not be moved. Leave it there for a few days.

Slowly, the water will dry up. On the bottom of the pan you will see a lot of shiny, cube-shaped crystals of salt.



ancient copper head from Iran

This copper head was made thousands of years ago. It is no longer bright because, in time, copper is covered with a greenish coating called patina.

Courtesy Metropolitan Museum of Art, New York.

pure copper and copper ore

The Bronze Age minerals

Do you have a brand-new, shiny penny? If so, you know what the mineral called copper looks like. Pennies are made of almost pure copper—a gleaming, reddish-brown metal.

Copper was one of the first metals that people used. During the Stone Age, people had only stones and bones with which to make weapons and tools. But about ten thousand years ago, people found that they could pound and shape lumps of copper into knives, spearheads, and bracelets.

Those people of long ago found great lumps of pure copper in the earth. But people have taken copper out of the ground for thousands of years. Now there is very little pure copper left. Today, most of the copper we find is mixed with other minerals. Minerals that contain copper are called copper ores.

Copper is an important metal. Most of the wires that carry electricity into our houses and factories are made of copper. This is because electricity moves better through copper than through any other common metal.

Tin is another metal that people have used for a long time. It is a bluish-white metal that is heavy and soft, like copper. It comes from a brownish, glassy, mineral called cassiterite. People of long ago often found pebbles of cassiterite in riverbeds. Today, most cassiterite has to be dug out of the earth.

About five thousand years ago, ancient people learned how to mix tin with copper. By melting tin and copper together, they could make a metal called bronze. Bronze is much stronger and tougher than either tin or copper. From bronze, the ancient people made swords, helmets, armor, cups, bowls, and many other things. When people learned to make bronze, it was the end of the Stone Age and the beginning of the Bronze Age.

When we think of tin, we usually think of tin cans. But tin cans are really made of iron or steel covered with a thin coating of tin. The tin gives the cans a shiny look and keeps the iron or steel from rusting.

tin ore (cassiterite)

ancient Chinese
bronze sword

The Iron Age mineral

Safety pins and skyscrapers, scissors and steamships, automobiles and airplanes—none of these things could be made without the mineral called iron.

Iron is a metal, like copper and tin and bronze. But iron is much harder and tougher. It is the best kind of metal for making tools and things that need lots of strength.

There is iron almost everywhere in the earth's crust, but it is almost always locked inside other minerals. Minerals that contain iron are called iron ores. When these ores are heated, the iron flows out as a thick liquid. When the iron cools, it is a hard, dull-looking black metal.

Iron has always been an important metal since people first began using it, about four thousand years ago. It made better, longer-lasting tools and weapons than either stone or bronze. The use of iron brought the Bronze Age to an end. When people began making things out of iron, it was the start of the Iron Age.

Many things, such as fire hydrants, fancy fences, and parts of automobile engines are still made from iron. But much of the iron now taken from the earth is mixed with other materials to make an even harder, tougher metal called steel.

People have known for a long time how to make steel, but it was always very expensive. It was only a little more than a hundred years ago that we learned how to make lots of steel cheaply. So many things are now made out of steel—such as safety pins, scissors, skyscrapers, and automobiles—that it is sometimes said that we live in the Steel Age.

Japanese iron helmet and face mask

This mask and helmet were part of the armor of a Japanese warrior two hundred years ago.

iron ore (hematite)

The Atomic Age mineral

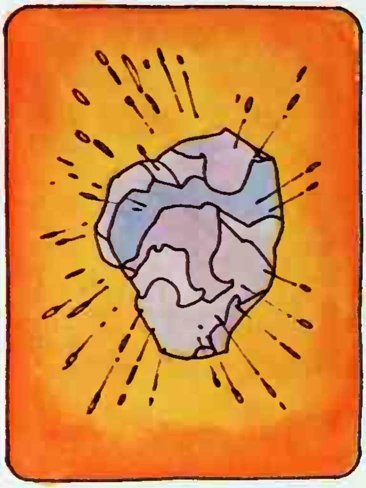
The prospector moved slowly across a rocky, desert hillside. He was searching for a very valuable mineral. But he had no pick or shovel. As he walked along, he held a metal tube over the rocks. A wire connected the tube to a metal box he carried in his other hand.

Suddenly, a popping noise came from the box. Then another. Then the pops came so rapidly they sounded like a machine gun. The prospector let out a whoop of joy. He had found the mineral—uranium.

Uranium is a mineral that is the main source of atomic energy. It is a metal that is radioactive. This means that, in a way, it is "exploding"—that it shoots out tiny bits of itself in all directions. These tiny bits are parts of the atoms of which uranium is made. They are so small they cannot be seen with even the most powerful microscope. But they can be discovered by a machine called a Geiger counter.

It's a Fact

Uranium is a radioactive metal. This means that it is constantly "exploding," or shooting tiny bits of itself out in all directions.



The technician is loading uranium fuel into rods that will be used in a nuclear power plant.

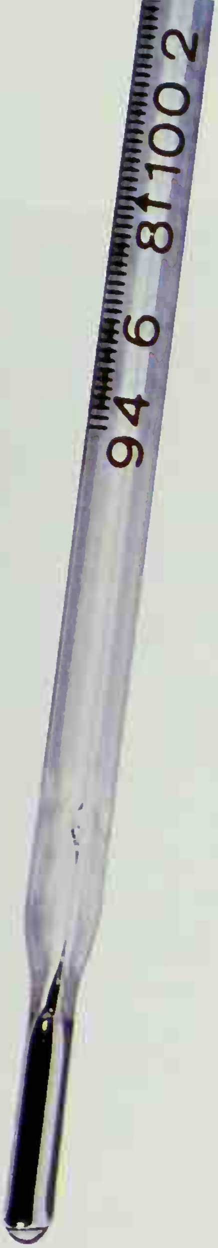
pieces of uranium

uranium ore (pitchblende)

Uranium is never found by itself. It is always mixed with other minerals. Prospectors usually look for it in a mineral called pitchblende. Pitchblende is a lumpy black rock that shines like fresh tar. It is found near the top of the ground. Uranium is also found in a powdery, yellowish mineral called carnotite that forms in a thick coat on sandstone and other rocks.

When uranium is taken out of pitchblende or carnotite, it is a heavy, silver-gray metal. Copper is the metal of the Bronze Age, and iron is the metal of the Iron Age and Steel Age, but uranium is the metal of the Atomic Age—which has just begun.

mercury ore (cinnabar) and mercury



mercury in a thermometer

The dry liquid

Imagine a *dry* liquid—a liquid you can stick your finger into without getting it wet.

There is such a liquid. It's a melted metal that stays melted even when it's cool! No other metal does such a thing.

This strange, liquid metal is called mercury. It comes from a sparkly red rock called cinnabar that is found near hot springs and volcanoes. If you ever had your temperature taken with a fever thermometer, you have seen one way that mercury is used. The silvery stuff inside the thermometer is mercury. Dentists also use mercury, mixed with silver, to fill cavities in teeth.

Mercury is full of surprises. When a little of it is poured onto a slanting surface, the mercury doesn't trickle down in a stream, as other liquids do. The puddle stays together and just slides downhill! Given a push, the puddle breaks into hundreds of tiny globs that roll like little balls. And if the globs are all pushed together, they form a puddle again.

Mercury was named after the Roman god Mercury, who was the swift messenger of the gods. But because mercury moves and quivers as if it were alive, it is sometimes called quicksilver, which means *live* silver.

Mercury is a dangerous poison. It's dangerous to handle because it might get into your mouth and cause sickness. Factories sometimes dump wastes containing mercury into lakes and streams. The mercury then gets into the bodies of fish. If people eat the fish, they may get very sick or even die.

The stone that burns

"I smell brimstone! The Devil must be near!"

Long ago, that's what someone might have said if they smelled sulfur burning. Sulfur was called brimstone, which means "the stone that burns." Because it burned, and came from deep inside the earth, people once thought it had something to do with the Devil.

Sulfur is one of the most common of all minerals. It is often found aboveground, near volcanoes that have thrown it out while erupting. But it is usually found deep underground, mixed with rock. Sulfur looks like little chunks of bright, yellow glass. It burns with a blue flame and gives off a smell like rotten eggs.

Hundreds of years ago, people discovered how to make gunpowder by mixing sulfur with charcoal and another mineral called saltpeter. As time went on, sulfur became used for more and more things. Today, it is used to make medicines, tires, and many other things people use every day.

sulfur

Precious stones

They shine, they sparkle, they flash and shimmer. The crowns of kings and emperors were covered with them, and wealthy people have always worn necklaces, rings, and other jewelry made of them. They are only stones, but they are so beautiful and hard to find that they have been symbols of wealth and power for thousands of years. They are the "precious stones"—diamonds, rubies, emeralds, sapphires, and opals.

Diamonds come from deep in the earth. They are buried in rock that is in or near dead volcanoes. Most diamonds are shaped like two pyramids with their bottoms stuck together. When they are taken from the ground they are dull and grayish. It is only after they are cut and polished that they sparkle and flash.

A diamond is the hardest of all things that come from the earth. It can even cut rocks. The only thing that will scratch a diamond is another diamond. Most diamonds are used to make cutting and grinding tools. Only the biggest, most perfect diamonds become jewels.

Corundum is a stone that's like a cube with two corners cut off, so that it has six flat sides plus a top and bottom, instead of four sides. It is a very common mineral that is usually found stuck in other kinds of rock. But sometimes a piece of corundum has a tiny bit of another mineral, either titanium or cobalt, mixed in

jeweled crown of the Holy Roman Empire

polished opal

natural opal

it—and then it is a clear, blue stone called a sapphire. And, sometimes a tiny bit of a mineral called chromium is mixed into a piece of corundum. That makes it a dark red ruby.

Beryl is a rock that has eight or more flat sides. It is usually found in large chunks of granite or, sometimes, limestone. When a tiny bit of chromium is mixed into a piece of beryl, it makes a beautiful, deep-green stone called an emerald.

One of the most beautiful of all precious stones is mostly just a mixture of sand, water, and the gas called oxygen. This stone, the opal, is often found in large patches near the top of the earth's crust. Opals come in all colors of the rainbow, plus black and brown. When they are cut and polished, they sparkle with many colors and glow as if there is fire locked inside them.

ut and polished ruby

natural ruby

natural sapphire

cut and polished sapphire

The size of a diamond is measured by its weight in carats. This one-carat diamond is shown actual size, compared to a penny.

natural emerald

cut and polished emerald

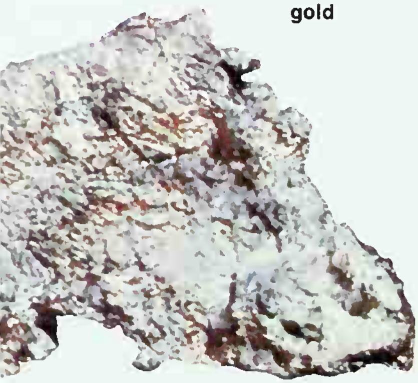
cut and polished diamond

natural diamond

Precious stones are called gemstones. Diamonds, emeralds, rubies, sapphires, and opals are the most precious gemstones, but there are others. The gemstone called a cat's-eye is a beautiful, rich brown with a golden stripe running through it. Jade is usually a deep, glossy green or milky white. Zircon is a flashing, brilliant gemstone that may be pale red, brown, green, violet, or colorless, like a diamond. Turquoise is bright sky-blue or blue-green. These, and many other mixtures of minerals that are gemstones, are used in jewelry and beautiful works of art.

The money minerals

gold



silver

Gold is a bright-yellow metal that looks like sunlight turned to stone. Silver is a pale-gray metal that looks like frozen moonlight. These two minerals are so beautiful and hard to find that people have used them for jewelry and for money for thousands of years.

Gold is found in many places. Usually it is mixed in with other minerals. But big nuggets and tiny grains of gold have been found in rivers. They are brought there when streams wash them out of rocks in the mountains. Pieces of gold have also been found lying on top of the ground. But most gold is now dug out of mines.

Gold is heavy, but it is so soft it can be hammered into sheets thinner than tissue paper. Several minerals look so much like gold that people are often fooled by them. But these other minerals are usually much harder than gold. They cannot be scratched as easily.

Silver is also found in the earth. Chunks of silver often look like bunches of twisted wire or feathers. Silver is not shiny like gold—it is dull gray or black until it is polished. It, too, is very heavy and soft. When gold or silver is made into jewelry, other metals are added to make the gold or silver hard.

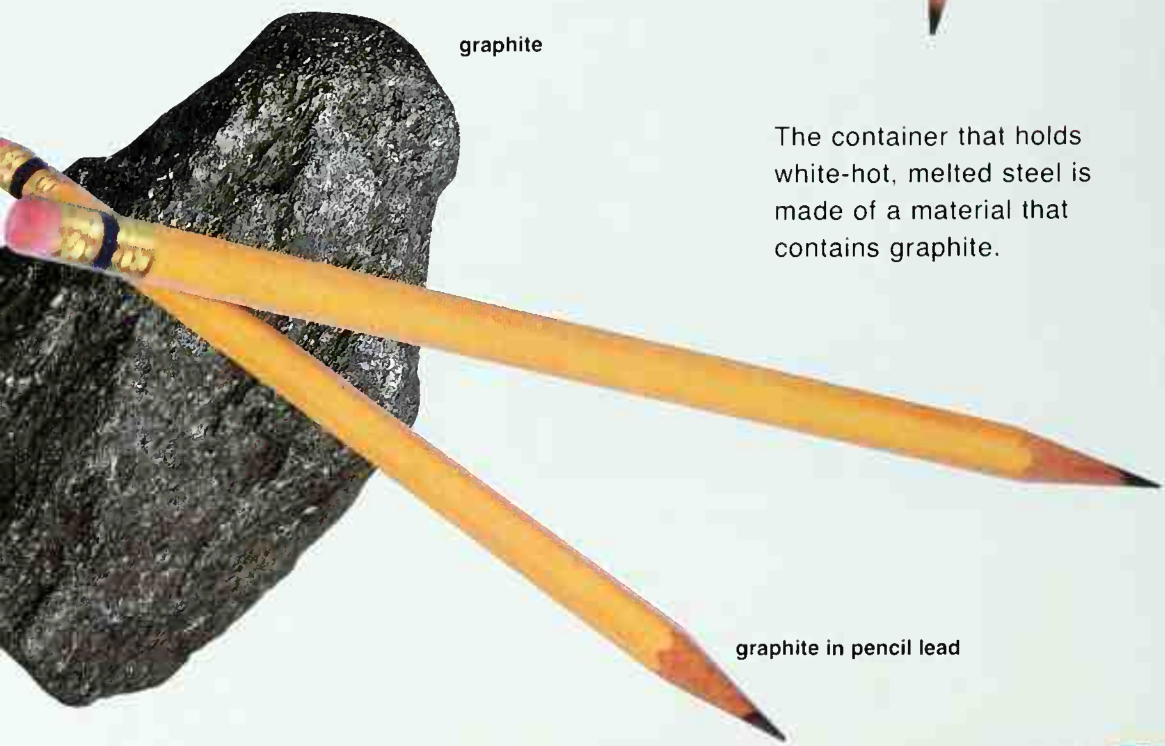
gold and silver coins

A slippery mineral

What is inside the pencil you use to write? It's often called "lead"—but it's not really lead at all. It's a mixture of clay and a soft, black mineral called graphite (GRAF yt). Some graphite is found in the earth, and some graphite is manufactured.

Graphite is not found in hard, many-sided crystals, as some other minerals are. Instead, it is made up of flat layers that easily slide over each other. This makes graphite soft and slippery. When graphite is used in pencils, it slides easily over the paper and leaves a black mark.

Graphite is so slippery that it can sometimes be used in place of oil. People use graphite to "oil" locks, clocks, and all sorts of small machines. And in cold weather, when oil turns thick and hard, graphite stays soft and slippery. In winter, and in cold places, it often works better than oil.

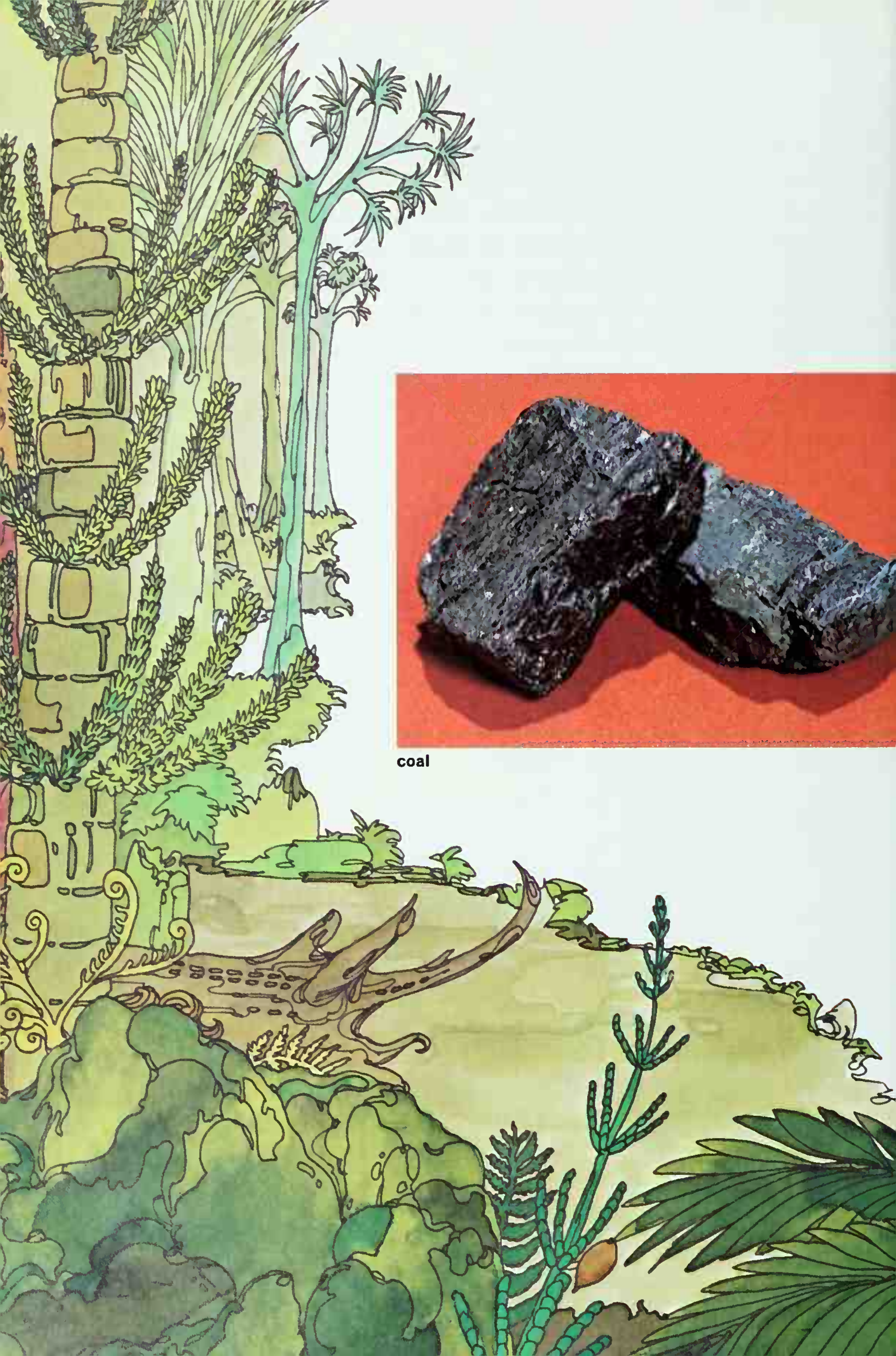


The container that holds white-hot, melted steel is made of a material that contains graphite.

Graphite can be used in other special ways. It does not melt easily, so it is often used to make pots for melting metals. It does not dissolve easily, so it is often used in making tanks that hold strong chemicals.

And, even though a slippery, soft piece of graphite and a hard, sparkling diamond don't look much alike, they are both made of the same kind of material. So graphite is used to make artificial diamonds for cutting and grinding. The diamonds made from graphite work as well as real diamonds do.

a steel foundry



coal

Buried sunshine

Nearly all rocks are made of minerals—things that are not alive and never have been. But there is one kind of rock that is not made of minerals. It is coal, a black shiny rock made of—green plants!

Millions of years ago much of the world was hot and swampy. Strange-looking trees and giant ferns covered most of the land. When these big plants died, they toppled over and sank into the mud. Then they were buried under other plants that fell on top of them. In time, there was a thick layer of dead plants. As the plants rotted, they formed a thick, lumpy brown stuff called peat.

Parts of the land began to sink. Water poured in, bringing mud and sand that covered the peat. Tons of water, mud, and sand pressed down on the peat, squeezing it tightly together. All this weight and squeezing turned the peat into coal.

After millions of years, the earth changed. Places that had been covered with water became dry land. Mud and sand had turned to rock. The great masses of coal were buried deep in the rock.

Today, miners dig coal out of the earth. Coal is burned to heat houses, schools, and other buildings. Burning coal is used to make steam that turns the big machines that make electricity for heat, light, and power. When we burn coal, we are really burning plants that grew millions of years ago. This is why coal is sometimes called "buried sunshine."

Black gold

The oil that keeps your bicycle from squeaking and the gasoline that keeps your parents' car running both come from deep in the earth's crust. Both began as a thick black liquid found in big pools between layers of rock.

Oil is not a mineral. Like coal, it was made from things that were once alive. Oil is found in places where there were seas and oceans millions of years ago. Tiny plants and animals lived along the shores of these seas, just as they do today. When these creatures died, their bodies drifted down to the sea bottom. Over millions of years, billions of these tiny dead creatures formed deep piles.

Sand and mud settled over the piles of dead creatures and formed thick layers. Slowly, these layers were squeezed together by their own weight and the weight of the water pressing down on them. They were squeezed so hard they became layers of rock. Scientists think that the heat and weight of the rock, pressing on the piles of dead, rotting plants and animals, turned them into drops of oil.

Today, people drill down through many layers of rock to find pools of oil. From oil we get gasoline to run the engines of cars, trucks, and tractors. Many kinds of plastics and other things are made from oil. And it is used to heat houses, factories, and schools.

Because oil was first found seeping up between rocks, it was called petroleum—from two Latin words meaning "rock oil." Today, petroleum is usually just called oil. But it is so important, and worth so much, it has been nicknamed "black gold."

crude and refined oil

Crude oil, or petroleum, is often called "black gold." This is because the valuable crude oil is thick and black when it comes out of the ground. It is then sent to a refinery to be made into fuel oil, gasoline, kerosene, and other products.

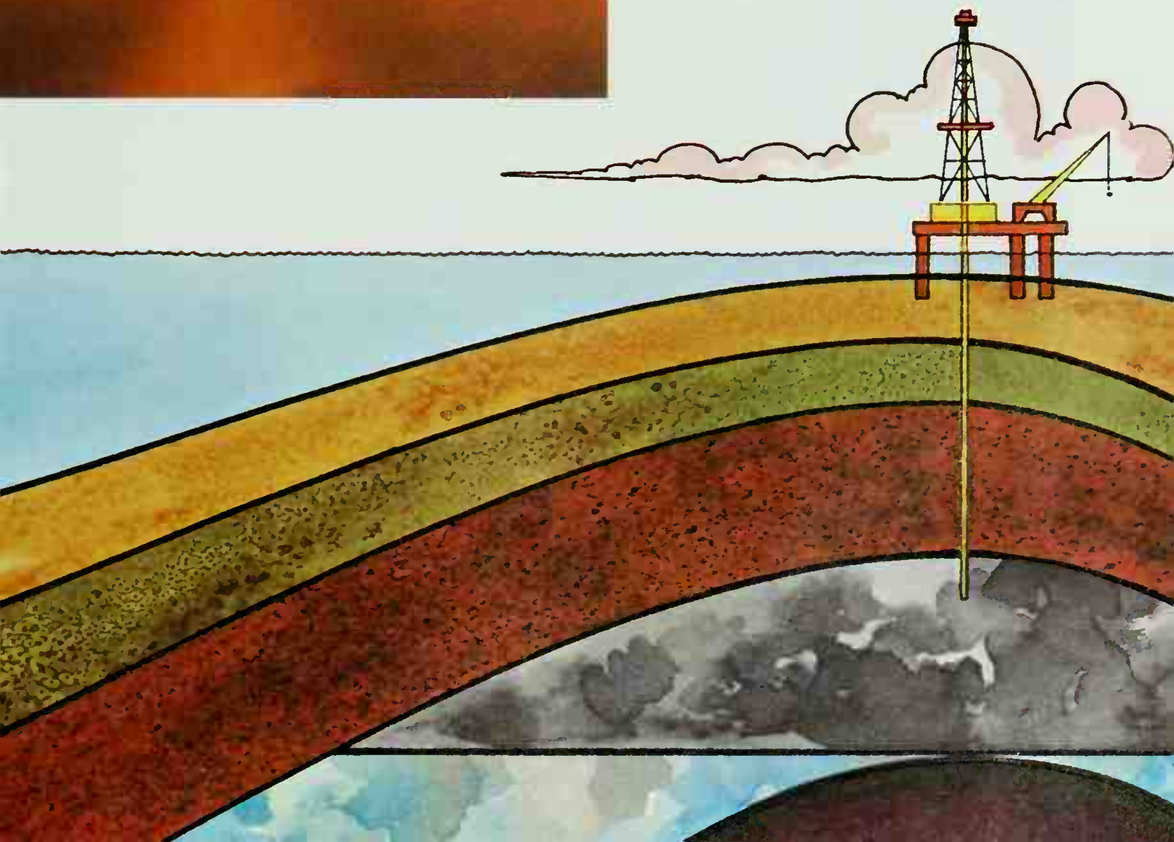


table salt (halite crystals), magnified

A rock we eat!

If someone at the dinner table said, "Pass the rocks, please," what would you give that person?

Salt, of course!

The salt that people use to season food is a mineral called halite. Big lumps of halite are found in the earth's crust. The halite is dug out in chunks and crushed up small enough to fit through the holes in a saltshaker. Halite forms in square crystals. No matter how small it is crushed, it nearly always breaks into the shape of a cube.

Sometimes, a hole is dug down to salt that is in the earth. Water is forced down into the salt, then pumped back up with salt in it. The water is then heated. When it dries up, crystals of pure salt are left. Salt is removed from seawater in much the same way.

People need some salt to keep healthy, and many people think salt makes food taste better. So salt has always been very important to people. In ancient times, salt was so precious and hard to get that it was used as money. The soldiers of ancient Rome were given salt as part of their pay. This part of their pay was called the *salarium*. Our word *salary*, which is another word for pay, comes from the Latin word *salarium*. A man who was not a very good soldier was "not worth his salt." We still say this about people who don't do a good job for the money they are paid.

aluminum ore (bauxite)

The "magic" metal

Have you ever watched someone wrap a sandwich or cover a bowl of food with what looks like a sheet of shining, silver paper? It isn't paper at all—it's a thin sheet of the wonderful metal called aluminum.

Aluminum is a light, silvery metal. It is never found all by itself, as a pure metal. It is always mixed with other minerals. Most aluminum comes from a rock that looks like a bunch of brown pebbles mixed into a piece of gray concrete. This rock is called bauxite.

Aluminum is often called the "magic" metal. It is light, very strong, and won't rust. It can be stretched and rolled into almost any shape. So aluminum is used to make everything from airplanes to pots and pans to chewing-gum wrappers.

This metal has two names. People in the United States call it aluminum (uh LOO muh nuhm). But people in Great Britain, Canada, Australia, and many other countries call it aluminium (al yuh MIHN ee uhm).

a roll of sheet aluminum

Bones in rock

A giant dinosaur, with jaws shaped like the bill of a duck, plodded along the shore of a lake in search of food. Sighting large horsetail plants growing in shallow water, it waded out toward them.

Suddenly, the big dinosaur stepped into a wide, deep hole filled with soft, watery mud. At once, the animal began to sink.

It thrashed about wildly, trying to find solid ground under its feet. The weight of its own body dragged it down. The mud rose to its chest, then to its neck. Slowly, its head went under. Mud filled its mouth and nostrils and it died. That was eighty million years ago.

The dinosaur's body sank to the bottom of the hole. Slowly, the soft parts of the dinosaur rotted away. Only its bones were left.

Over many years, the mud around the bones was packed tightly together. In time, it became clay. Over many more years, the clay turned to rock. And, as still more years passed, the lake dried up. The rock with the dinosaur bones in it was now the side of a cliff.

During all those years, water filled with dissolved minerals often got into the bones. Slowly, all the

hollow places in the bones were filled with dissolved minerals that then hardened.

As millions of years passed, wind and rain slowly wore away the side of the cliff. Finally, so much rock was worn away that some of the dinosaur bones, preserved in the rock all those years, were sticking out.

One day, eighty million years after the dinosaur had died, a group of scientists saw the bones sticking out of the cliff. With pickaxes and crowbars, the scientists removed the bones from the rock.

The scientists packed the bones carefully and sent them to a museum. At the museum, the bones were put together. People could then see the skeleton of the giant creature that had lived so long ago.

Most of the skeletons of prehistoric animals that you see in museums were preserved in rock in this way. Such preserved bones are called fossils. Sometimes, all of the original material is replaced with minerals. Then the fossil is said to be petrified, or turned to stone.

It's a Fact

Trees have been preserved just as dinosaur bones were. In Arizona, there's a petrified "forest" of tree trunks that were turned to stone millions of years ago.


taking fossil bones from rock

Pictures in stone

Tucked away in the earth's rocks there are often "pictures" from the past.

Many times, in ages past, animals walked through mud and left footprints. Slowly, over thousands of years, the mud hardened into rock. The footprints were preserved forever. We have found rocks in which there are footprints of dinosaurs and other animals. We have even found rocks with the footprints of prehistoric people.

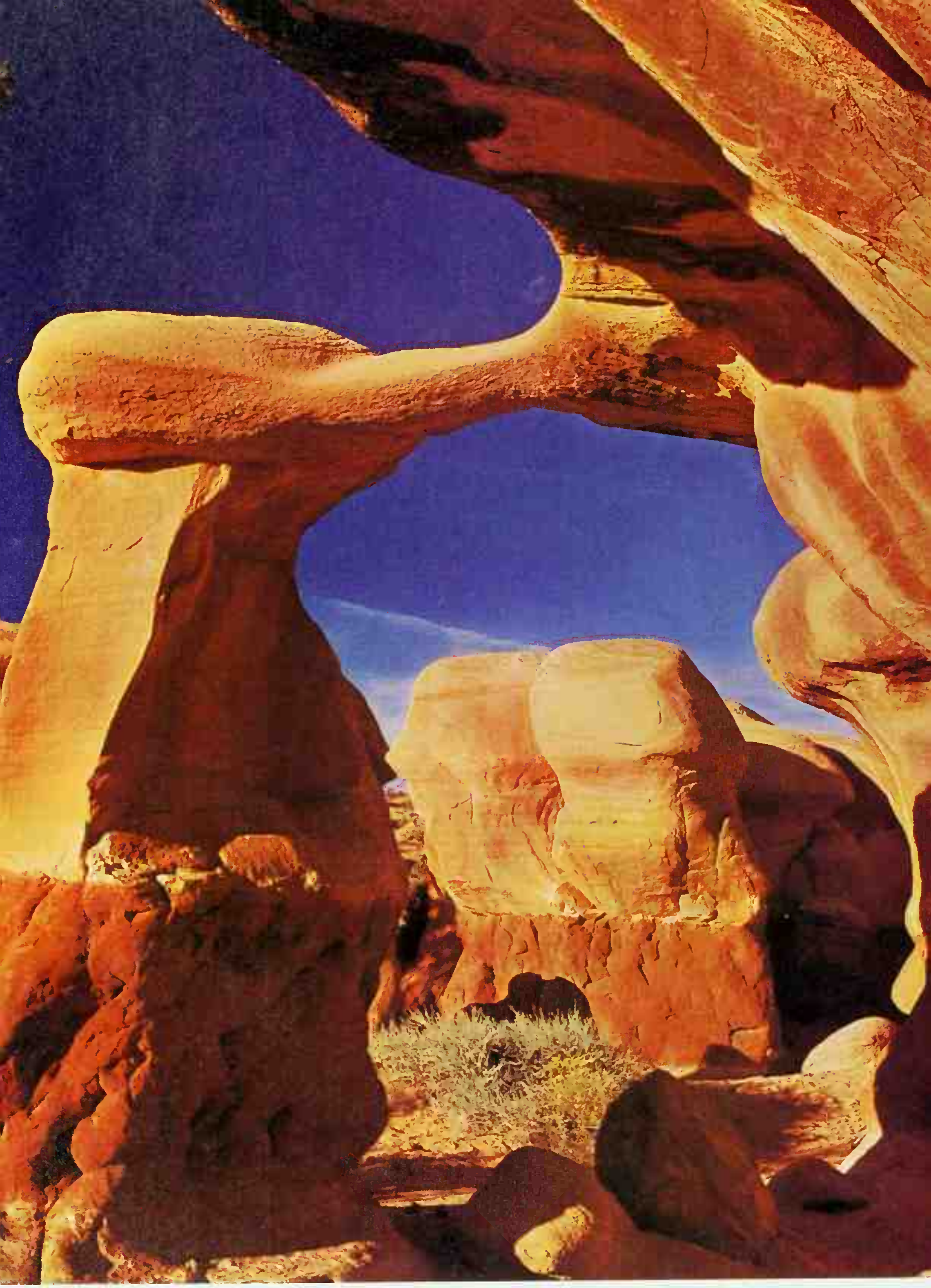
Leaves of ancient plants and feathers from the first kinds of birds also fell into the mud. They, too, left prints that were preserved when the mud hardened into rock.

Ancient snails, clams, and other shelled sea creatures died and were covered up with mud. The mud hardened around them. When their soft parts rotted away, and their shells dissolved, a hole was left in the rock—a hole the exact shape of the dead animal. This hole was like a mold. Slowly, it filled up with minerals that hardened into stone. The stone was the exact shape the dead animal had been.

These pictures and shapes in stone are called fossils. They tell us about the plants and animals of millions of years ago.

fossils of fish

fossil of an insect



layers of rock, Escalante Canyon, Utah

Layer cakes of rock

The upper part of the earth's rocky crust is like a layer cake. It is made up of many layers of different kinds of rock, one on top of the other. These layers were built up slowly, one after the other. Here is how this might have happened in one place.

At first, there was only the top of the bare rock crust. Volcanoes erupted, pouring out ash and lava that hardened into a layer of black rock called basalt.

Earthquakes caused this part of the land to sink. Ocean water flowed in to form a smaller body of water called a sea. Rivers dumped tons of sand into the sea for thousands of years. The sand sank down and formed a thick layer on top of the basalt.

Snails, clams, and other little shelled animals moved in from the ocean to live in the sea. When they died, their bodies sank down onto the sand. Their soft parts rotted away and only the shells were left. For millions of years, these shells piled up until they formed a thick layer.

The weight of the shells and the water squeezed the sand together until it became a layer of the rock called sandstone. Squeezed together by their own weight and the weight of the water, the shells were crushed into powder. Minerals in the water glued the powder together. After millions of years, the powdered shells were a layer of the kind of rock called limestone. The layer of limestone was on top of the layer of sandstone, which was on top of the layer of basalt.

This kind of building up of layers of rock is still going on. The layer of mud that now lies at the bottom of a sea will some day be a layer of rock!

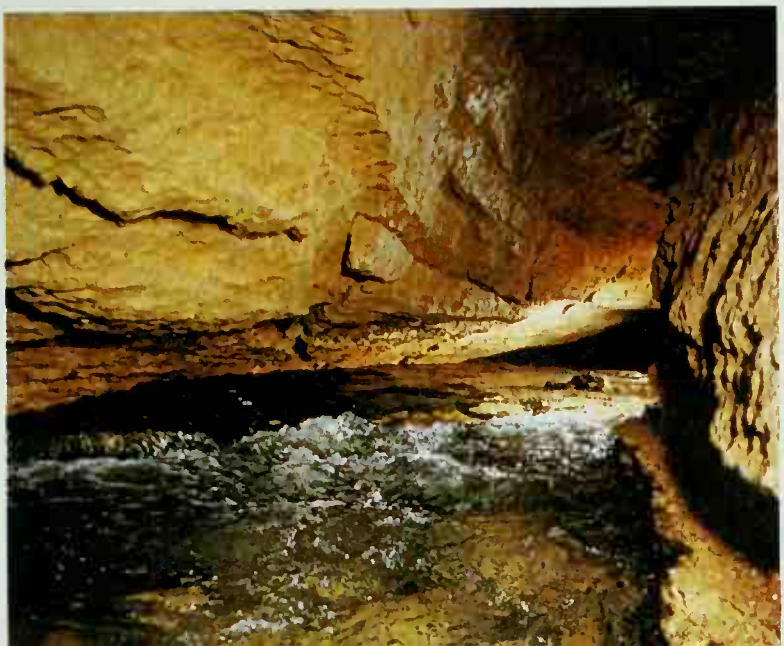
entrance to Russell Cave, Alabama

Holes in rock

A den for bears and a bedroom for bats. A home for prehistoric people. A dark place of gloom and mystery. A sparkling wonderland of strangely shaped rocks. That's a cave!

A cave is simply a hole in the earth. It may be a small hole, not much bigger than a room in a house. It may be a place of long, twisting tunnels and huge caverns. It may be high up on a mountainside or it may be in the ground.

Most caves are in the kind of rock called limestone. These limestone caves are made by water. Water seeps through cracks in the rock. It trickles downward, carrying dissolved limestone with it. Slowly, the cracks grow wider as more and more limestone is carried away. After many thousands of years a cave may have a great many winding passages and broad rooms, all made by the slow trickle of water.



underground water in a cave

Stone icicles

Many a cave is filled with what look like giant stone icicles. Some of these "icicles" hang down from the cave's roof. Others stick up from the floor. They are often as thick as tree trunks. Sometimes, the ones on the ceiling and the ones on the floor meet to form thick pillars. These strange-looking stone "icicles" are usually found in limestone caves.

The "icicles" that hang from the ceiling are called stalactites. They are made by water trickling through cracks in a cave's limestone roof. The water carries tiny bits of the mineral called calcite with it. As some of the water dries, it leaves bits of calcite stuck to the ceiling. Each drop of water adds more calcite. Slowly, as more bits of calcite are added, the stalactite grows longer and longer.

Some of the water drips to the cave floor. This water also has bits of calcite in it. As the water dries up, bits of calcite are left on the floor. Slowly, the calcite piles grow higher and higher. These "icicles" sticking up from the floor of a cave are called stalagmites.

Often, water drips off a stalactite onto the top of a stalagmite below it. Slowly, the two grow toward one another until they finally join.

Many people get stalactites and stalagmites mixed up. They can't remember which hangs from the ceiling and which sticks up from the ground. But there is an easy way to remember. Just remember that *ceiling* begins with *c*, and *stalactite* has a *c* in it. And *ground* begins with *g*, and *stalagmite* has a *g* in it. Then you'll always know that stala*c*tites hang from the *c*eiling and stala*g*mites stick up from the *g*round.

water droplets on stalactites

Stalactites and stalagmites, Carlsbad Caverns, New Mexico

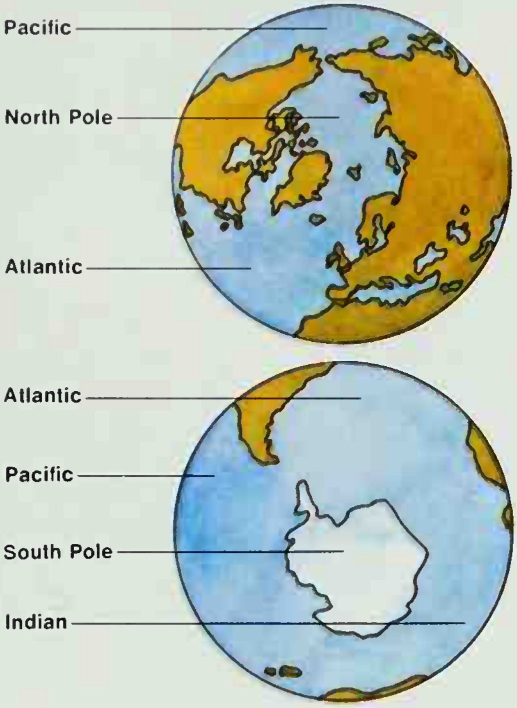
Oceans, Lakes, and Rivers

The deep blue sea

The sea! the sea! the open sea!
The blue, the fresh, the ever free!
Without a mark, without a bound,
It runneth the earth's wide regions round.

From THE SEA
Barry Cornwall

Sailors talk about "the seven seas," but there is really only one big ocean. The lands we live on, even



It's a Fact

There is really only one big ocean. It covers about three-fourths of the earth. You can see this clearly if you look at a globe from the top and bottom.

giant continents such as North and South America, are really just islands in this huge ocean.

Large parts of this one big ocean lie between the continents. These parts have different names. The biggest part is called the Pacific Ocean. The next biggest part is called the Atlantic Ocean. There is also the Indian Ocean near India, the Arctic Ocean around the North Pole, and the Antarctic Ocean near the South Pole.

Smaller parts of the ocean, near islands or between pieces of land, are sometimes called seas. But we also call the whole ocean a sea—the deep, blue sea.

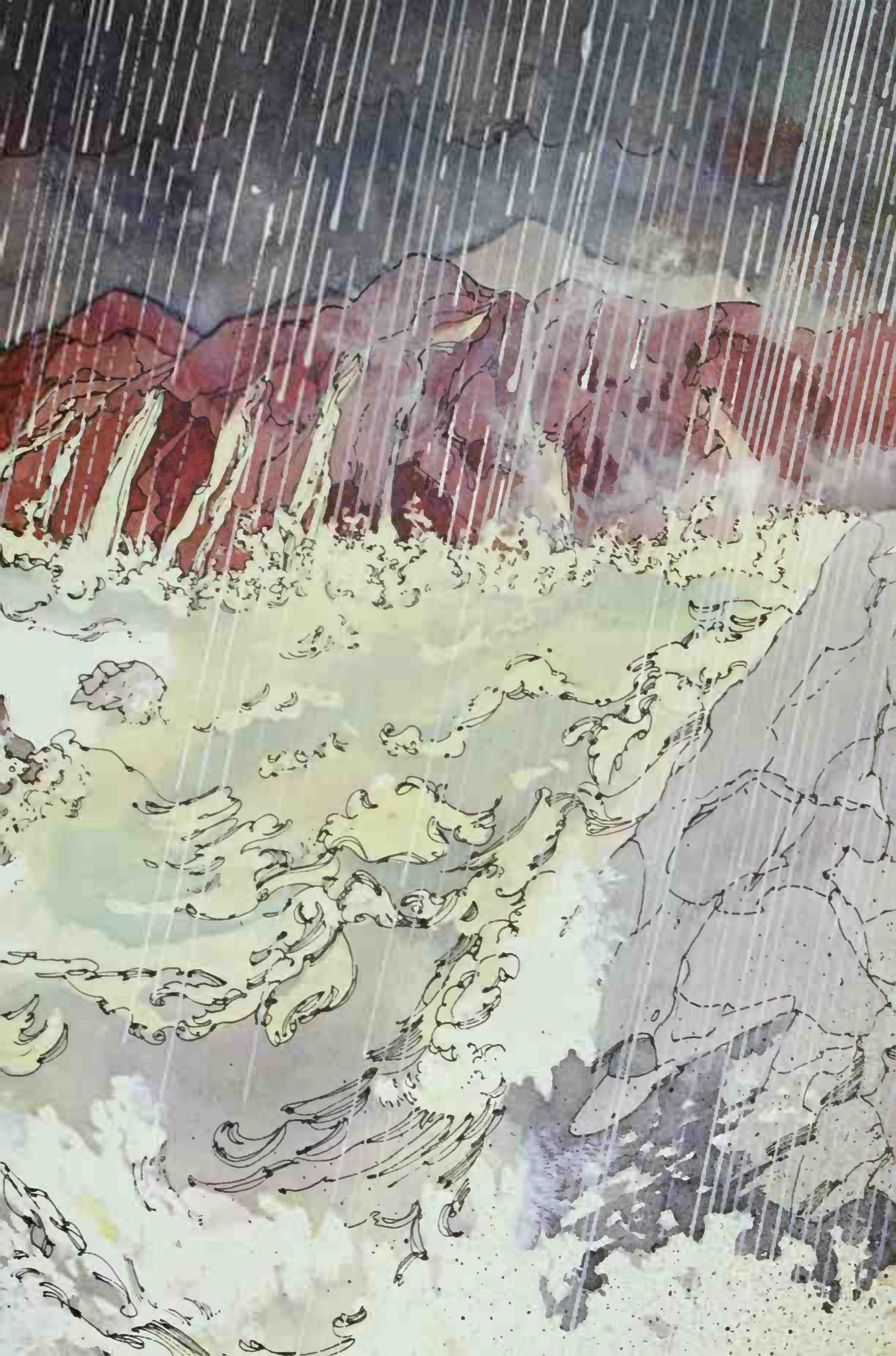
Where did the ocean come from?

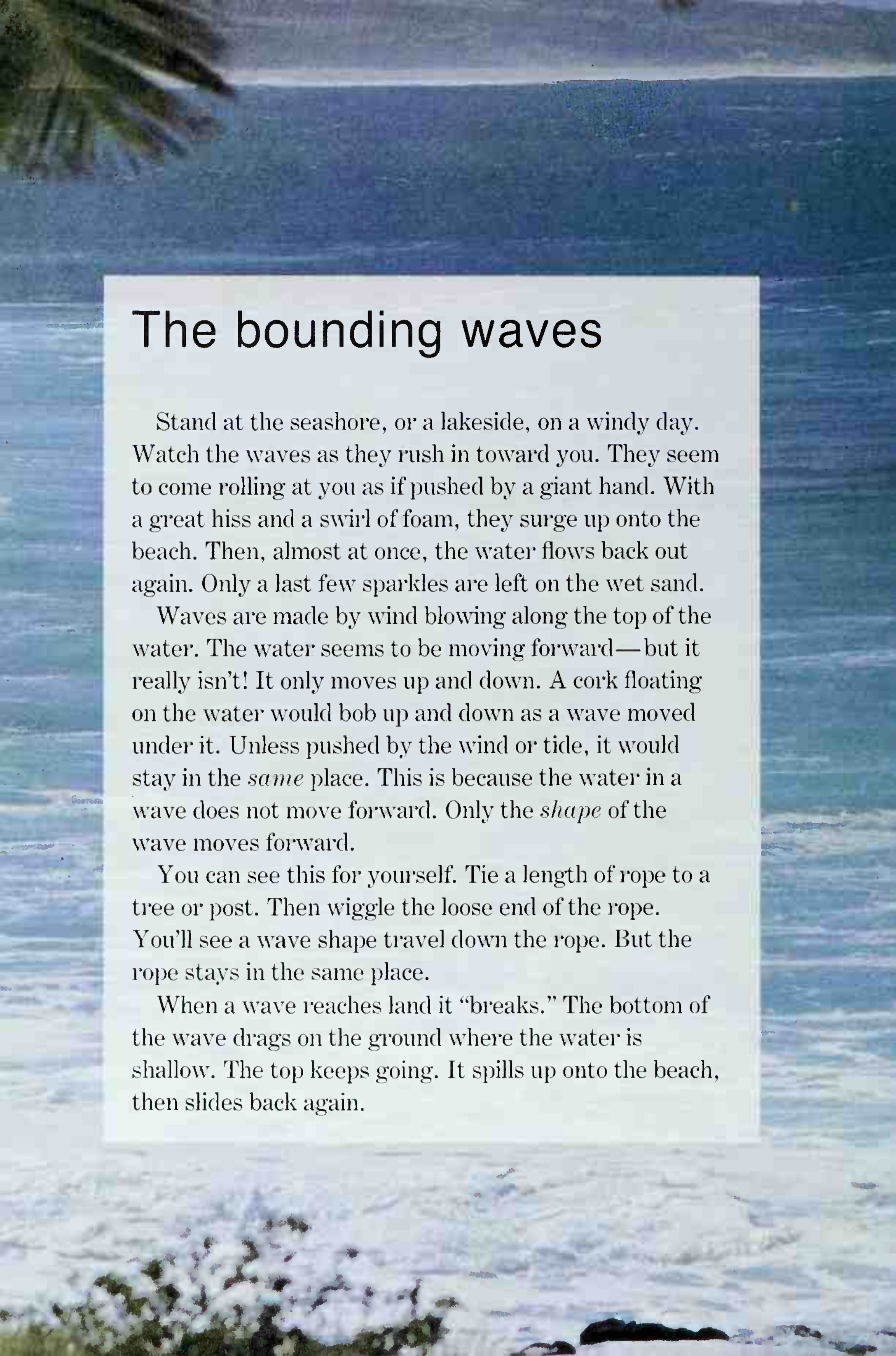
Scientists tell us that billions of years ago the earth was a ball of bare, sizzling-hot rock, with no air or water on it. The outside of the earth slowly cooled, but the inside stayed fiercely hot. Volcanoes roared and rumbled, throwing out tons of melted rock and enormous clouds of hot gases. One of these gases was steam—water so hot it is gas. When steam cools it turns into water.

Some scientists think the steam rose up in clouds. When these clouds cooled, they became water that fell as rain. Slowly, the low parts of the earth's rocky crust filled up with water, forming the ocean.

Other scientists think the steam cooled as it came out of the earth. When it became water, it trickled downhill. During many millions of years, the low places filled up to form the ocean.

Whichever way it happened, the ocean was formed by steam from inside the earth—steam that cooled and became water.





The bounding waves

Stand at the seashore, or a lakeside, on a windy day. Watch the waves as they rush in toward you. They seem to come rolling at you as if pushed by a giant hand. With a great hiss and a swirl of foam, they surge up onto the beach. Then, almost at once, the water flows back out again. Only a last few sparkles are left on the wet sand.

Waves are made by wind blowing along the top of the water. The water seems to be moving forward—but it really isn't! It only moves up and down. A cork floating on the water would bob up and down as a wave moved under it. Unless pushed by the wind or tide, it would stay in the *same* place. This is because the water in a wave does not move forward. Only the *shape* of the wave moves forward.

You can see this for yourself. Tie a length of rope to a tree or post. Then wiggle the loose end of the rope. You'll see a wave shape travel down the rope. But the rope stays in the same place.

When a wave reaches land it "breaks." The bottom of the wave drags on the ground where the water is shallow. The top keeps going. It spills up onto the beach, then slides back again.


high tide


low tide

High tide, low tide

It is early in the misty morning. You are standing on a cliff that overlooks the sea. Gulls soar overhead, calling to one another with shrill cries. Below you, the gray sea crashes against the shore. You can see a wide stretch of rocky beach sloping down to the water.

But if you come back to the same place six hours later, everything will be different! Now, at noon, the sea has risen. The beach has disappeared and the water is lapping against the side of the cliff. And if you come back in six more hours, things will have changed again. You will see the beach, and the sea will be low again.

This rise and fall of the sea is called the tide. Tides are caused by the earth's spin, and by gravitation, the mysterious force that makes things tug at each other. In this case, it is mostly the gravity of the moon tugging at the earth. High tides take place on the part of the earth that is nearest to the moon. The moon's gravity pulls the water slightly away from the earth. At the same time it is also high tide on the opposite side of the world. There, the tug of the moon's gravity is weaker, and the force of the earth's spin pushes the water outward.

As the earth turns, the part of the sea that is high moves away from the moon's gravity. The water sinks back down. After about six hours, this part of the sea is all the way down to what is called low tide.

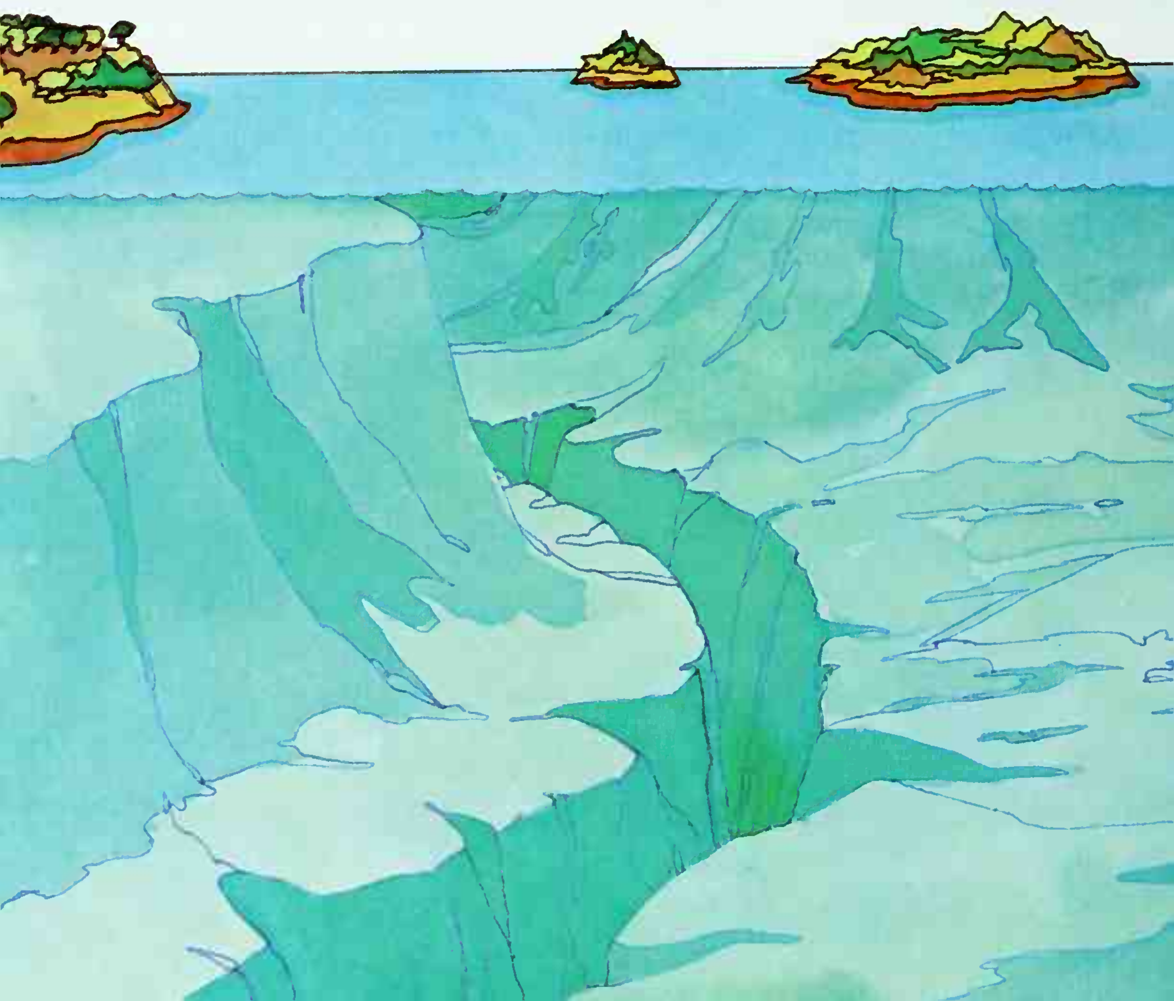
Each part of the sea has two high tides each day—one when it is beneath the moon and one when the moon is on the opposite side of the earth. And, of course, there are also two low tides each day.

The bottom of the sea

What lies beneath the ocean? What's at the bottom of the deep blue sea?

Tall mountains! Great plains! Deep valleys! Volcanoes!

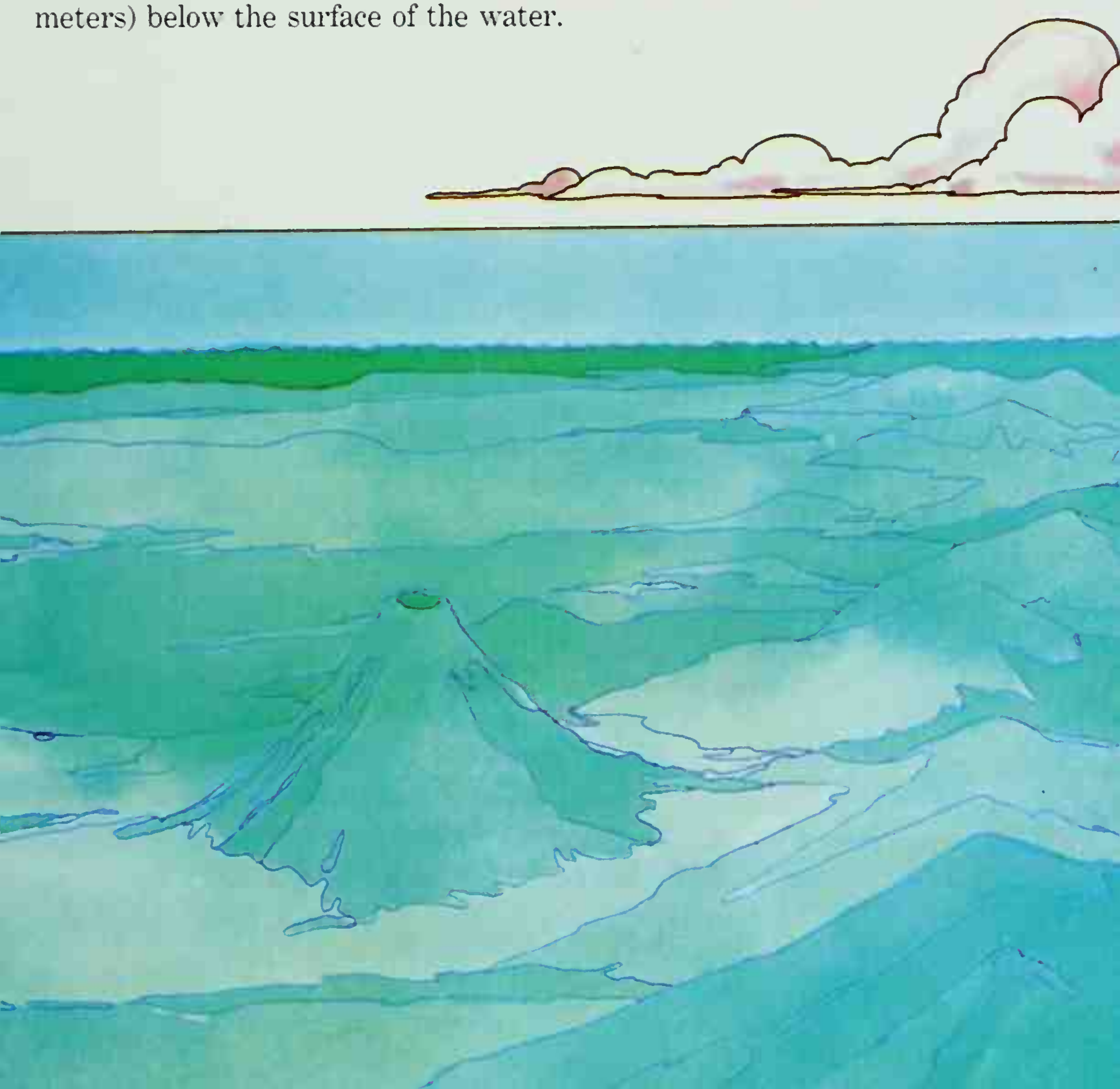
The whole outside of the earth is covered with a rocky crust. The continents and islands, the parts on which we live, are the highest parts of the crust. The lowest parts are covered by the seas and oceans. So the

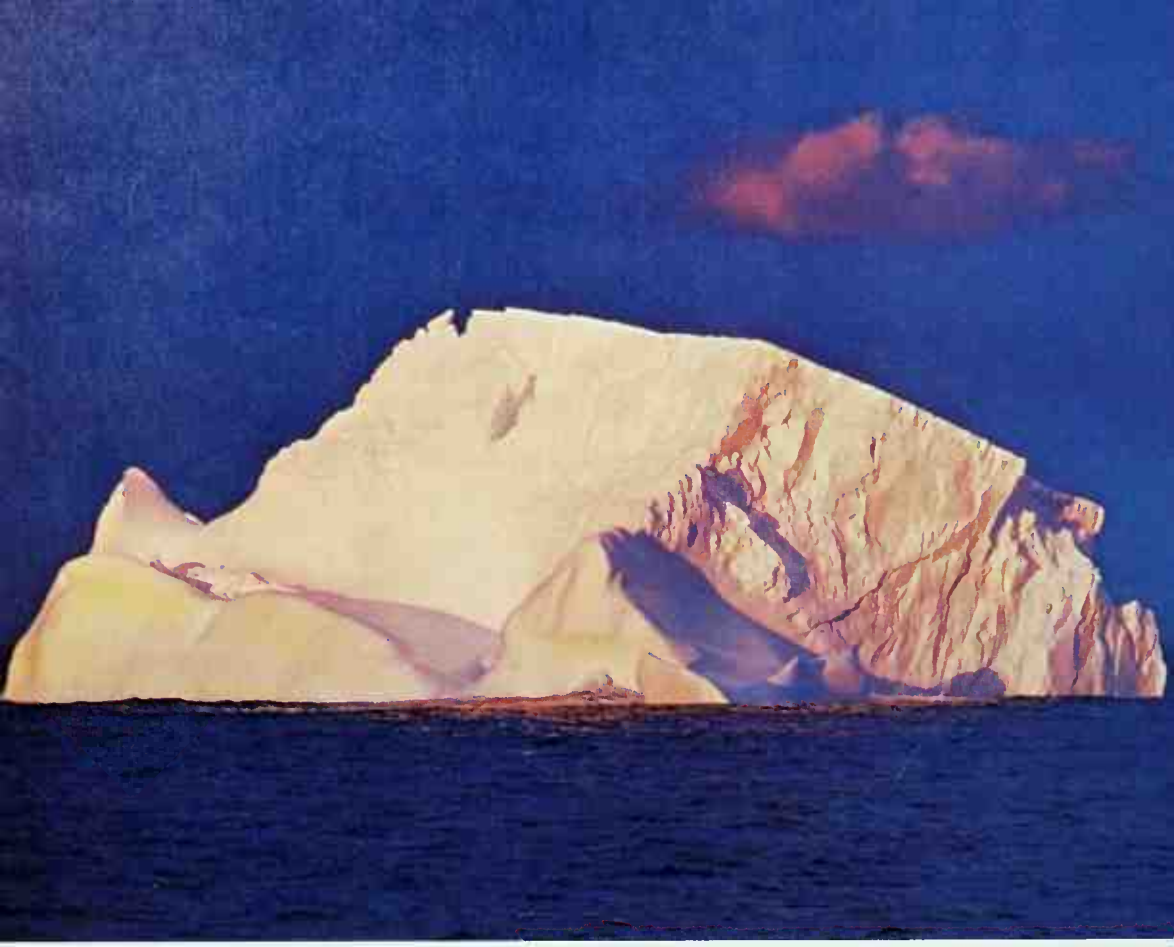


bottom of the sea is really part of the earth's rocky crust. It is much like the part we live on.

There is a great mountain range that runs down the middle of the Atlantic Ocean. It is longer than any mountain range on land. The tops of some of the mountains stick up out of the water, forming islands.

The deepest parts of the ocean are long, narrow valleys called trenches. The very deepest of these, called the Mariana Trench, is in the Pacific Ocean. There, the bottom of the trench is 36,198 feet (11,033 meters) below the surface of the water.





an iceberg near Antarctica

Floating mountains of ice

What is that great, shining shape floating in the cold, gray water of the northern sea? Is it a mountain of snow? Is it an island of ice where the Frost Giants live? Is it the great, cold castle of the Snow King?

No, it's none of these things. It's an iceberg—one of the enormous chunks of ice that float in the ocean near the North and South poles. An iceberg can be as big as a mountain, as wide as an island, and as beautifully shaped as a castle. Many icebergs weigh millions of tons and are many miles (kilometers) wide.

Giant sheets of ice cover the South Pole and a large part of Greenland, near the North Pole. Icebergs are huge pieces that break off from the edges of these ice sheets. The bergs drift along in the ocean until they reach warmer water. Then they begin to melt and break apart. In time, they melt completely and become part of the ocean's water.

An iceberg may stick far up out of the water. It may tower over great ships and make them look like toy boats. But the part above the water is only a tiny bit of the whole iceberg. The part below the surface may be six times bigger than the part we see.

It's a Fact

You can see for yourself that only a small part of an iceberg sticks up above the water. Put an ice cube into a glass of water. Look through the side of the glass. You will see that most of the ice cube is below the surface of the water. The little ice cube in the glass acts just like a giant iceberg in the ocean.

rocky beach


sandy beach

Where the sea meets the land

Wherever the sea touches land, whether it's the edge of a tiny island or the coast of a continent, there is almost always a beach.

A beach is a stretch of sand, pebbles, or mud. The sea makes beaches. Waves, crashing into a rocky shore for thousands of years, toss the rocks around, breaking them into pebbles. Then, for hundreds or thousands of years more, the waves grind the pebbles together. In time, the pebbles are ground into tiny grains of sand. Lakeshore beaches are also formed in this way.

Where a river flows into the sea, a beach is usually made of mud. That's because the river carries mud along with it. The river dumps the mud at the edge of the sea, where it piles up and makes a beach.

bay, Isle of Man

Where the sea pokes into the land

A bay is a place where a tiny bit of the sea, or a lake, pokes into the land. Seen from an airplane, a bay often looks as if a giant had taken a big bite out of the edge of the land and water had come in to fill the hole.

An inlet is also a body of water that pokes into the land. But an inlet is long and narrow—more like a finger than a bite.

Why the sea is salty

You could be out in the middle of the ocean—surrounded by thousands of miles (kilometers) of water—and not have a drop of water you could drink. For seawater is full of salt. If you did drink it, it would simply make you more thirsty.

The sea is salty because rivers dump salt into it. All the rivers that flow down mountainsides and over the land tear loose tons and tons of minerals. Most of these minerals are different kinds of salts. The rivers carry these salts to the sea.

There's never enough salt in a river to make the river water taste salty. But rivers have been dumping salt into the sea for millions of years. By now, there is enough salt in the sea to cover all the land on earth with a layer of salt hundreds of feet (meters) deep!

harvesting salt from the sea, Colombia

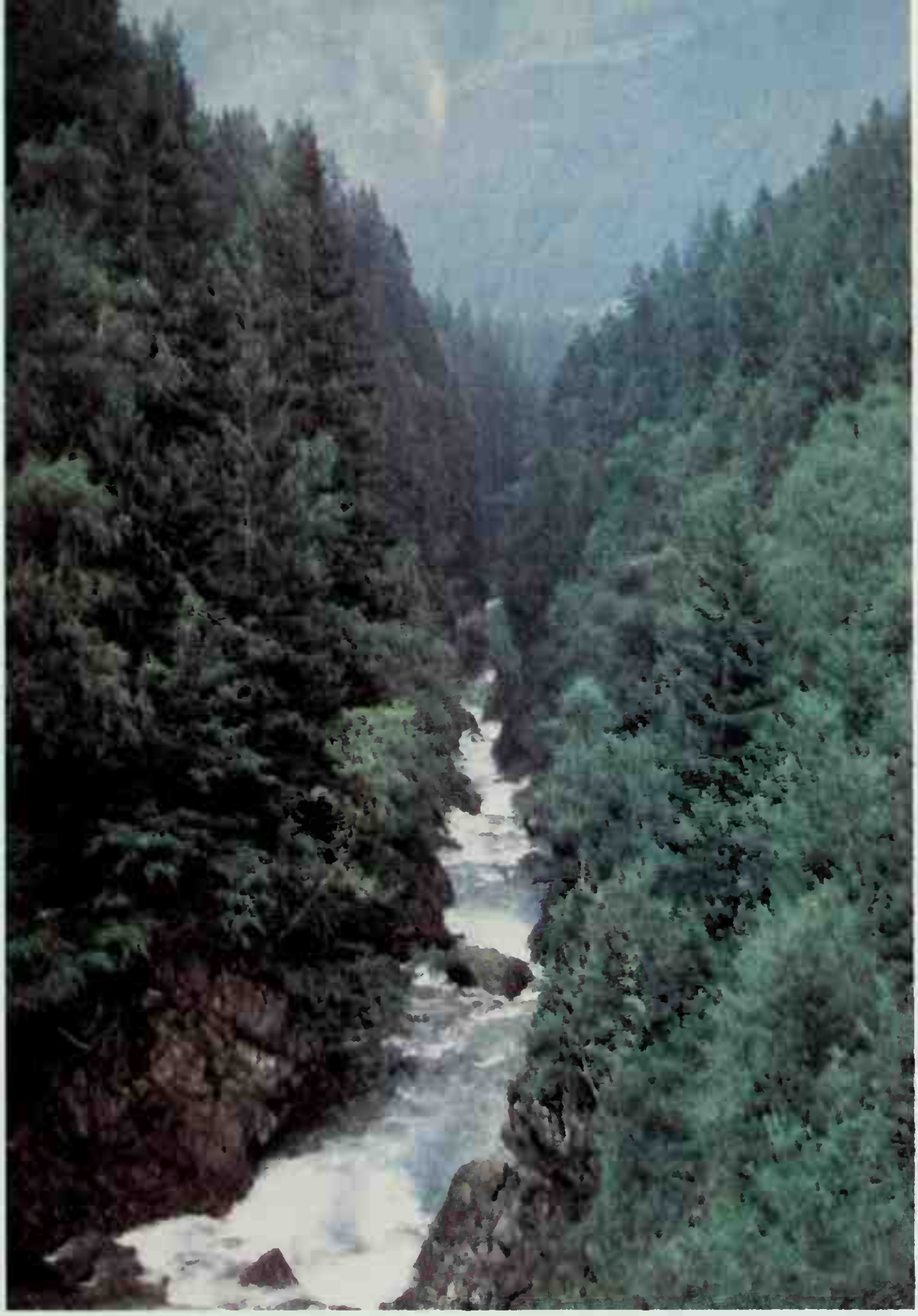
These cone-shaped mounds are piles of salt. As the seawater evaporates, the salt that remains is raked into piles and left to dry in the sun.

The story of a river

A river may begin as a trickle of melting snow, high on a mountaintop. It may begin as a trickle of underground water, bubbling out from under a rock on a mountainside.

The trickle winds down the mountainside, following the easiest path in and out among the rocks. It is so narrow you could step across it. Farther down the mountainside, it is joined by another little trickle. The two of them move along together, forming a wider, faster-moving stream.

narrow mountain stream, Italy



mountain stream, Poland

Soil and stones, carried along by the rushing water day after day, year after year, cut a groove into the mountainside. The bottom of this groove is the bed of the stream. And the high sides of the groove are its banks.

One after another, more trickles join the stream and it grows wider. Now it is a river, fast and wide, rushing down the sloping mountainside.

In one very steep place, the fast-moving river has worn away the soft rock. Only bumps of hard rock are left. These rocks stick up out of the riverbed. The river swirls and foams around them. This part of the river is called the rapids.

rapids in Las Animas River, Colorado

waterfall in Columbia River, Washington

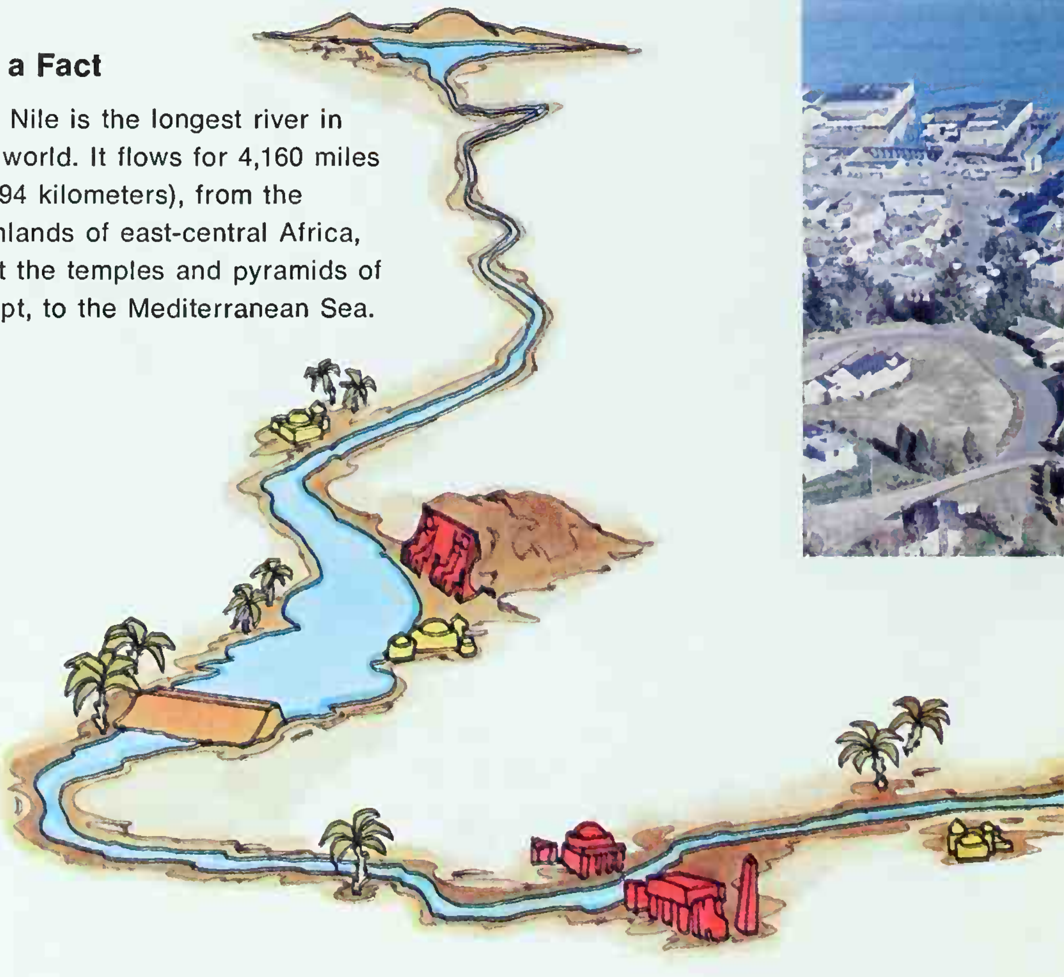
Not far from the rapids, the mountainside ends in a cliff. The rushing river hurries to the edge of the cliff and falls hundreds of feet (meters) in a roaring, tumbling, splashing waterfall.

The bottom of the waterfall is near the bottom of the mountain. The land there slopes very gently, so the river moves more slowly. The river leaves the mountain behind and flows out onto a plain. There, it moves even more slowly, because the plain is almost level.

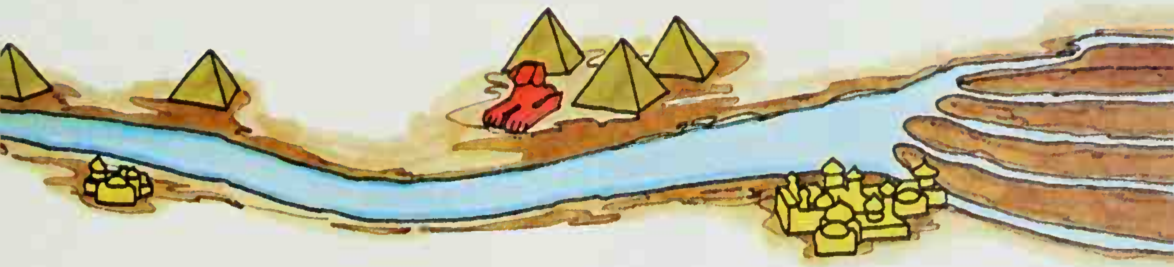
Other rivers from other mountains join the first river. Together they become a great, broad river that flows slowly across the plain on its journey to the distant sea.

It's a Fact

The Nile is the longest river in the world. It flows for 4,160 miles (6,694 kilometers), from the highlands of east-central Africa, past the temples and pyramids of Egypt, to the Mediterranean Sea.



Columbia River, near its mouth
between Washington and Oregon



Where a river meets the sea

What has its head at one end and its mouth at the other end?

A river! The place where a river begins is called its head. And the place where it comes to an end, where it flows into a lake or the sea, is called its mouth.

At the edge of the sea, a river's mouth is often a sort of dumping place. As a river moves through the land, it tears sand and soil from its banks. Rain washes more sand and soil into it. The river carries the sand and soil with it on its journey to the sea.

If there are no strong tides or big waves at the river's mouth, the soil and sand sink down to the bottom. As this soil and sand pile up in the riverbed, a kind of island forms in the middle of the river's mouth. Then the river has two branches that flow into the sea.

Slowly, the island gets bigger. In time, islands form in each of the branches. These islands split the river into still more branches. And after a long, long time, there is a great plain at the river's mouth, with many branches of the river running through it. This plain, usually shaped somewhat like a triangle, is called a delta. It gets its name from a letter of the Greek alphabet called *delta*, which is shaped like a triangle.

The deltas of such rivers as the Mississippi, the Nile, and the Amazon are hundreds of miles (kilometers) wide. These deltas have been growing for thousands of years. They will keep growing for many years to come.

Tongariro River Delta, New Zealand

Flood!

The water is rising! The river is spreading into the streets of the town! It's a flood!

Rivers often cause floods because of too much rain or the sudden melting of lots of ice and snow. A lot of the rain that falls on land runs into the nearest river. Water from melting ice and snow also runs into rivers. So, when there is a long, heavy rain, or lots of melting ice and snow, tons and tons of water may pour into a river.

Just as a bathtub will overflow if you keep running water into it, the river soon spills over its banks and floods the land.

Hurricanes and other bad storms sometimes cause floods along the seacoast. Strong winds push great waves far onto the land. Soon, much of the shore is under water.

a flooded town

Holes full of water

A lake is the exact opposite of an island. An island is a piece of land that has water all around it. A lake, or a pond, is water that has land all around it. Some of the places we call seas, such as the Dead Sea, are really lakes, because there is land all around them.

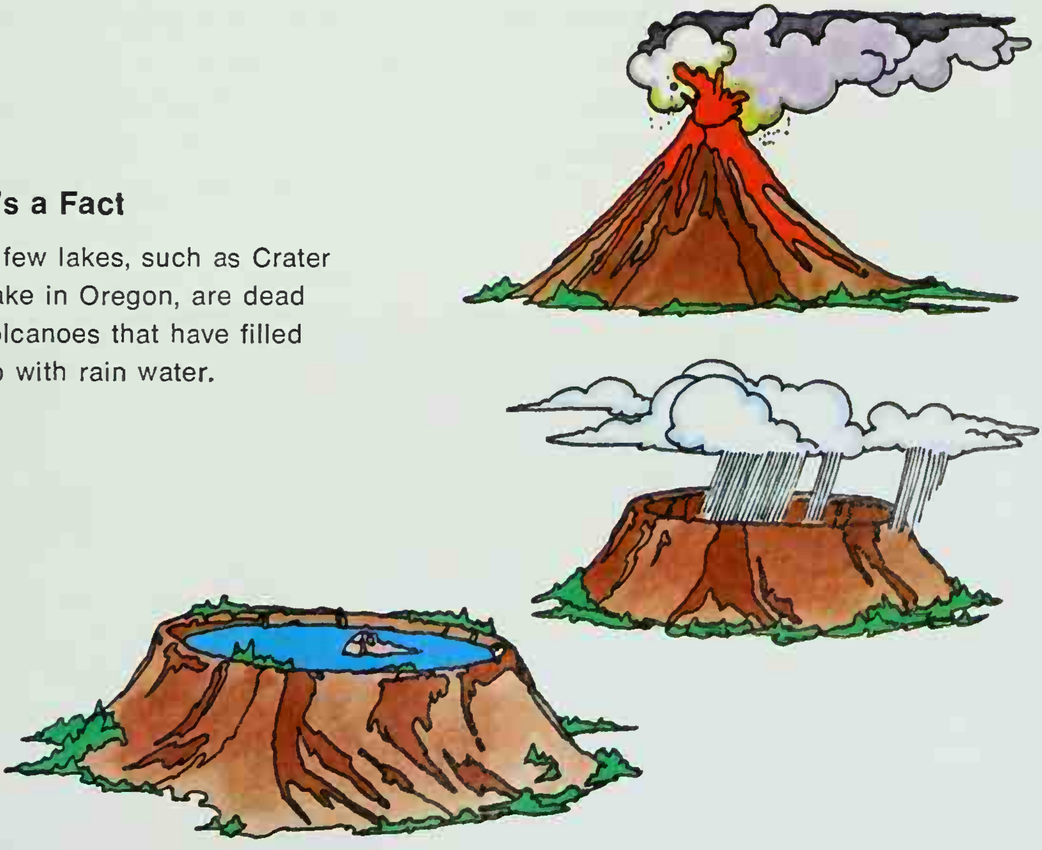
Most lakes are just holes in the ground that are filled with water. Many such holes were dug by glaciers. Long ago, these huge rivers of ice flowed out of the north and covered many parts of the world. As the gigantic glaciers slid slowly along, they gouged out great pits and made valleys wider and deeper. Then, when the glaciers began to melt, the water filled up many of the holes, forming lakes.

Some lakes form when part of the earth caves in, leaving a hole. This happens mostly in places where the ground is limestone. Year after year, rain dissolves away the soft limestone. As the rainwater trickles through the limestone, underground caves and tunnels form. Finally, the tops of these tunnels cave in, leaving what is called a sinkhole. Rain, or water from underground springs and streams, fills the sinkhole and it becomes a lake or pond.

Part of a river can also become a lake. Sometimes a river deposits so much mud and sand that the water backs up and forms a natural lake. Or, people may make a lake by building a dam that causes the flowing water to spread out over the river's banks.

Some lakes were once volcanoes! They formed when the craters of dead volcanoes filled up with rain water.

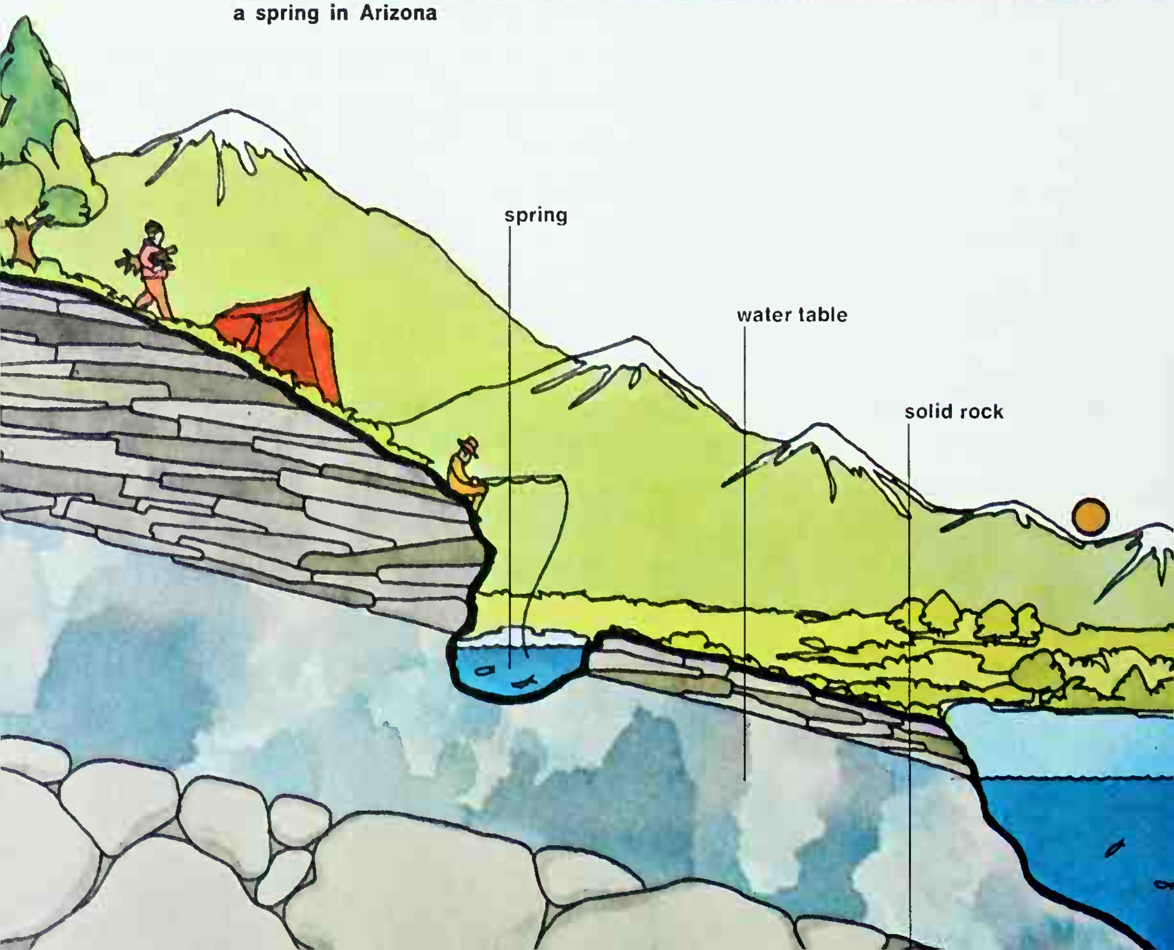
a lake in Germany



It's a Fact

A few lakes, such as Crater Lake in Oregon, are dead volcanoes that have filled up with rain water.

a spring in Arizona



Water beneath your feet

All the earth's water isn't in seas, lakes, ponds, and rivers. A lot of it is beneath your feet—down in the ground.

When rain falls, much of the water seeps down through the soil. It keeps going until it reaches solid rock that it can't get through. Then it spreads out, filling every nook and cranny in the ground.

The top of this underground water is called the water table. When there is a lot of rain, the water soon fills all the open spaces. Then the water table gets higher.

In some places the water table comes all the way to the top of the ground. Then, water bubbles out and makes a natural fountain called a spring. Sometimes a spring is the start of a river.

Underground water is usually cool and clean and good to drink. People often dig wells to get this water. There is some underground water almost everywhere in the world—even in deserts. But in a desert the water is very, very far down.

a spring in California

Hot-water fountains in the earth

On a bare, rocky patch of land sits a cone-shaped hump of rock with a hole in its top. Suddenly, with a hiss, a great, silvery spray of steam shoots up out of the hole. A geyser has erupted.

Geysers are the earth's hot-water fountains. Some geysers shoot out steam every few months. Others go off several times an hour. Some of the most famous geysers shoot steam more than a hundred feet (30 meters) into the air.

Geysers are found in groups in several parts of the world. They are near places where cold water from a river or lake drains down into the ground until it reaches hot rocks below the earth's crust. The hot rocks turn the water into steam. The steam pushes up through cracks in the earth and comes shooting out into the air. Sometimes the steam cools off before it reaches the surface. Then, hot water comes bubbling up out of the ground.

Grotto Geyser, Wyoming

Air, Wind, Clouds, and Weather

A wrapper of air

Long ago, people believed that the sky was a shiny metal roof stretched over the earth! Now, of course, we know what the sky really is. It's simply air—a covering of air around the earth. Air is wrapped around the earth somewhat like the skin of an orange is wrapped around the fruit inside. This wrapper of air is called the atmosphere (AT muh sfihr).

The atmosphere touches the ground everywhere. It is held to the earth by the pull of the earth's gravity. Close to the ground, where the pull of gravity is strongest, the wrapper of air is thick. Farther away, where the pull of gravity is not so strong, it gets thinner. Finally, many miles from the earth's surface, the atmosphere thins out and disappears. Where it ends, outer space begins.

earth's atmosphere

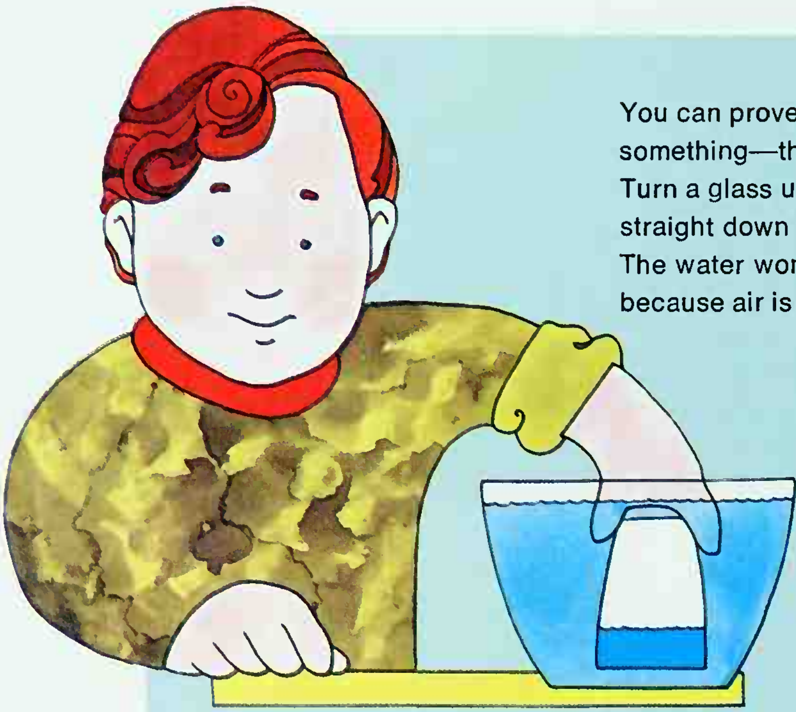
The bluish haze is the earth's wrapper of air. The white ripples are clouds. This photograph was taken from the Gemini 6 spacecraft.

Is air something?

Air doesn't seem to be made of anything. It has no color, taste, or smell. And you can see right through it. But it *is* made of something. It is made up of many kinds of gases. And these gases are made up of tiny, tiny things called molecules.

Actually, everything is made up of molecules—rocks, plants, animals, water, and gases. The molecules in a rock are packed close together and hardly move. The molecules in a liquid, such as water, are farther apart and move rather fast. But the molecules of a gas are quite far apart and zip about rapidly. That's why gases are so "thin" and invisible.

For us, the most important of all the gases in the air is the one called oxygen. The only reason we breathe is to get oxygen into our bodies. We couldn't



You can prove that air is made up of something—that it takes up space. Turn a glass upside down and push it straight down into a bowl of water. The water won't fill up the glass because air is trapped in the glass.

live without it. Almost every kind of animal and plant in the world must have oxygen or it will die.

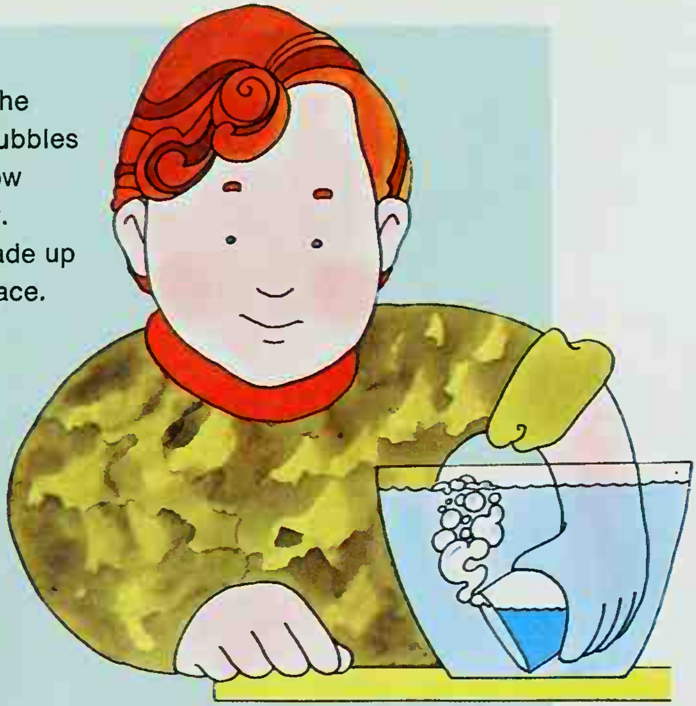
Only about one-fifth of the air is made up of oxygen. Most of the air—nearly four-fifths of it—is a gas called nitrogen. The rest of the air is made up of many different gases.

There is also a great deal of water vapor and bits of dust floating in the air. But these things are not really part of the air itself.

If air is just thin, floating gases, why doesn't it drift away into outer space? What keeps the gases from just floating away until they are gone?

The answer to that is gravity. Earth's gravity pulls at all the molecules of air, just as it pulls at you. The air can no more float off into space than you can!

Turn the glass on its side so the air can escape. You will see bubbles of air rush out of the glass. Now the glass will fill up with water. You have proved that air is made up of something that takes up space.



Why is the sky blue?

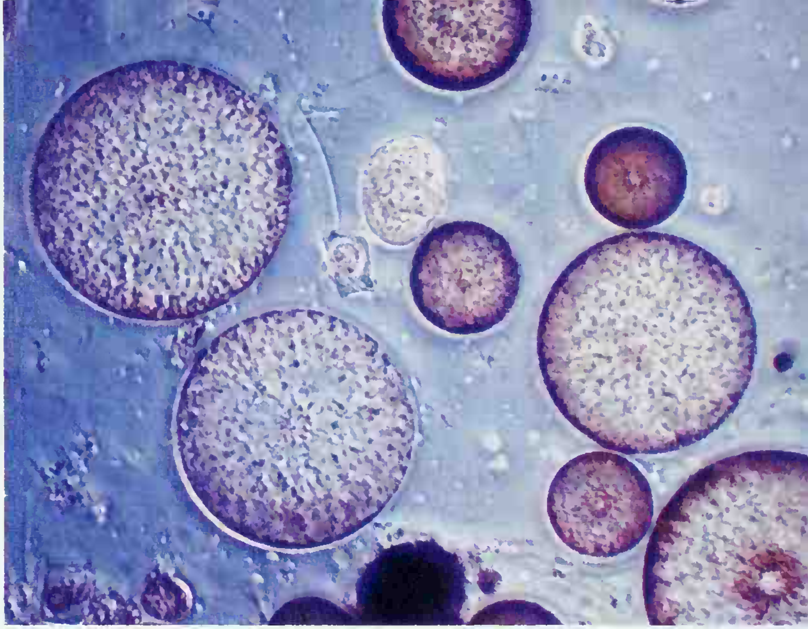
I don't suppose you happen to know
Why the sky is blue? It's because the snow
Takes out the white. That leaves it clean
For the trees and grass to take out the green.
Then pears and bananas start to mellow
And bit by bit they take out the yellow.
The sunsets, of course, take out the red
And pour it into the ocean bed
Or behind the mountains in the west.
You take all that out and the rest
Couldn't be anything else but blue.
—Look for yourself. You can see it's true.

WHY THE SKY IS BLUE
John Ciardi

This is a fun way to explain why the sky is blue, but it isn't true, of course. The sky really gets its color from the sunlight passing through the air.

Sunlight contains all the colors of the rainbow. These colors are scattered as the sunlight passes through the molecules of gas that form the air. On a clear day, when the sun is high in the sky, blue is scattered most of all. It is reflected into your eyes from all parts of the sky. So, the sky looks blue.

But at sunrise and sunset, the sun appears low in the sky. Its light passes through particles of smoke and dust close to the ground. These particles scatter all the colors except red and orange. So, the sun looks like a big orange-red ball. The red and orange reflect off the bottoms of low clouds and make the sky look red or pink.



magnified diatoms

Where the air came from

Scientists think the earth's atmosphere has changed during the billions of years since the earth was formed. At first, the atmosphere was probably very different from what it is now. It began to change as some of the gases went off into space.

For many millions of years the earth was fiercely hot. Clouds of hot gases from inside the earth came out of cracks and volcanoes. As these clouds spread out, they became part of the atmosphere. These gases changed the atmosphere, but, you couldn't have breathed the air. It had no oxygen to keep you alive. It was made up mostly of steam, and gases called nitrogen and carbon dioxide.

But as the earth grew cooler, some of the steam broke up into the two gases steam is made of—and one of those gases is oxygen. So, some oxygen became part of the air. Much of the steam became water, and formed the first ocean.

After millions of years there were billions of tiny green plants in the ocean. These plants, called diatoms, made their own food out of water, sunlight, and carbon dioxide gas, just as green plants do today. When plants make food, they give off oxygen, so for millions of years the little diatoms put oxygen into the air, helping to make the kind of atmosphere we have now.

Air can push!

You're like a fish living at the bottom of the ocean. But you live at the bottom of an ocean of air! Miles (kilometers) of water are piled up above the fish, and miles of air are piled up above you.

All that air is heavy. It has weight. The weight of the air presses against you, even though you don't feel it.

Here's how you can tell that air is pressing on things. You'll need:

a drinking glass (it must be glass—not paper or plastic)

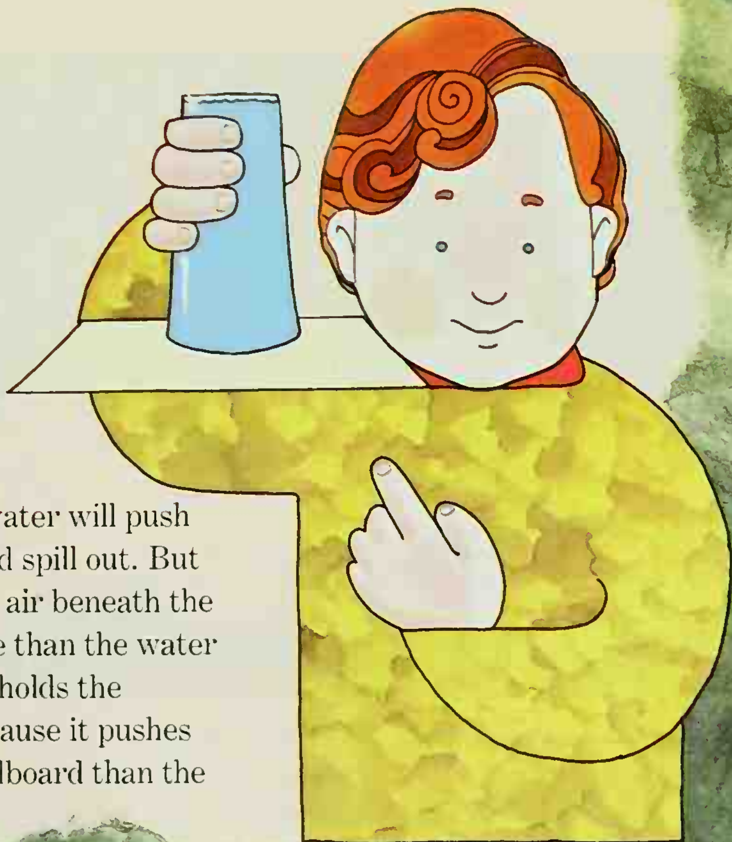
water

stiff cardboard

your sink, or a dishpan

Fill the drinking glass with water to the very top. Put the stiff cardboard over the glass. Make sure the cardboard covers the whole top.

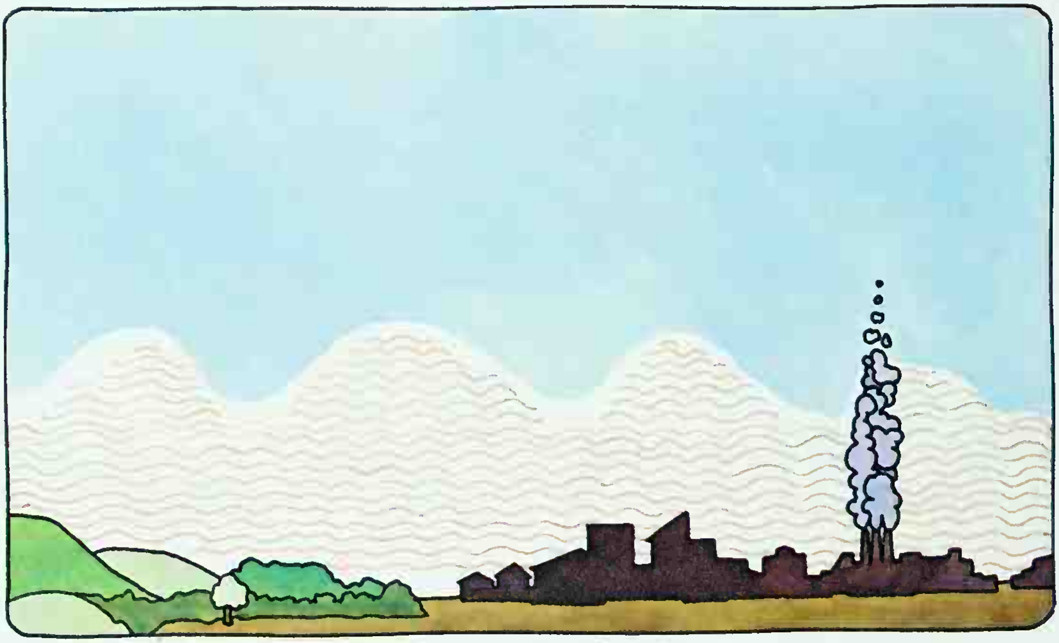
Now, hold the cardboard in place with one hand and carefully turn the glass upside down. Do this over a sink in case the cardboard slips. When the glass is upside down, take your hand off the cardboard.



You may think the water will push the cardboard away and spill out. But this won't happen! The air beneath the cardboard weighs more than the water in the glass. So the air holds the cardboard in place, because it pushes harder against the cardboard than the water does.

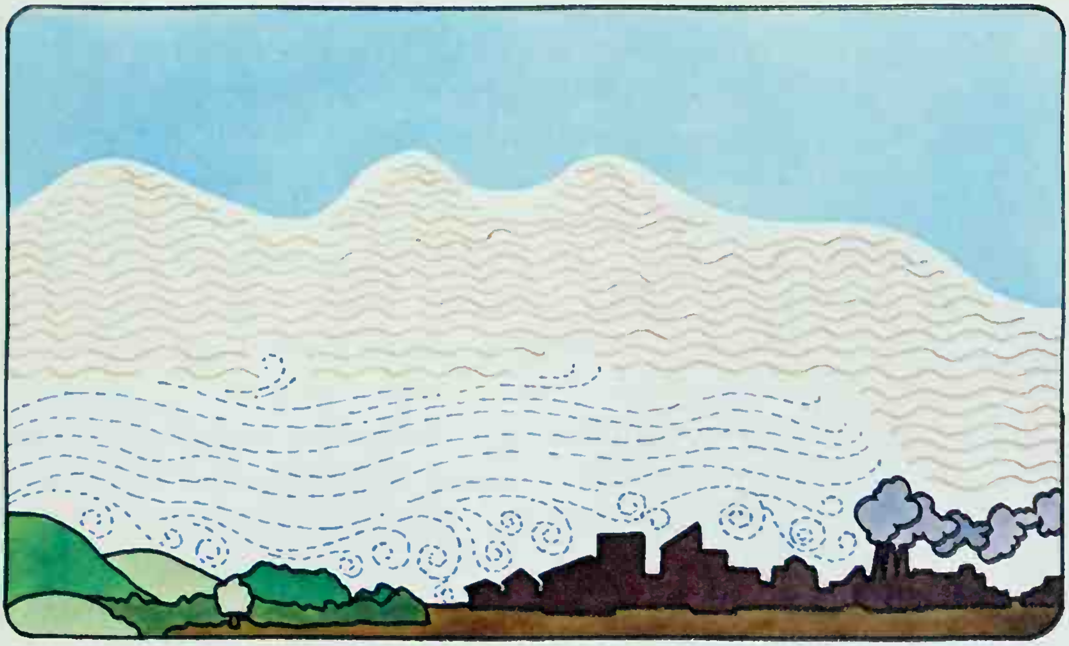
What makes wind blow?

The wind moves over the land. It sways the tops of tall grass in meadows and sets leaves a-rustle in the woods. It scatters the smoke from chimneys. It lifts up limp flags and makes them flap. It touches your cheek with cool, quick fingers and impishly ruffles your hair. Wind is moving air. And it is the sun that makes air move.



Sunlight falling upon the earth warms the ground in many places. The heat from the ground then warms the nearby air. As the air grows warmer, it starts to rise.

The earth spins around like a big top. As it spins, each part of the earth, in turn, comes into the sunlight. The sun's light warms the earth. The heat makes the molecules of gas in the air move faster and spread apart. This warm air rises up, in a kind of big, invisible cloud. As the warm air rises, cooler air from other places flows in to replace the warm air. This moving, cooler air is the wind. When you feel the wind blow, you are feeling the movement of the cooler air pushing in to take the place of the warm air.



As the warm air rises, cooler air from a cooler spot rushes in to take its place. The movement of this cooler air is the wind. Wind is just moving air.

The moving air

When the air seems calm, and you can't feel a wind, it doesn't mean that the wind has stopped blowing everywhere. For there isn't just one wind, there are many. In one place, there may be a soft breeze. In another place, there may be a fierce gale. In one place, the wind may blow from the north. In another place, it may blow from the south.

There may even be two different winds in the same place! Near the ground, a wind may be pushing all the smoke from chimneys in one direction. But up in the sky, another wind may be making the clouds scurry in another direction.

Earth's air is always moving. It may move only a few feet (meters)—from a cool, shady park into a hot street. Or, it may move great distances—from the middle of the ocean to a place far inland. But wherever and whenever the air moves, there will be a wind.

High above the clouds, more than five miles (8 kilometers) up in the sky, are the fastest of all winds. These winds are called jet streams—long, narrow currents of air that sometimes move as fast as three hundred miles (483 kilometers) an hour.

Much of the time, jet streams are connected together. Then they form one great, rushing river of wind that circles the earth. This great wind moves from west to east. When a jet airplane takes off for a long trip from west to east, the pilot usually heads up into the jet stream. The strong wind of the jet stream gives the plane a powerful push. This great tail wind can sometimes cut the regular flight time almost in half.

How hard is the wind blowing?

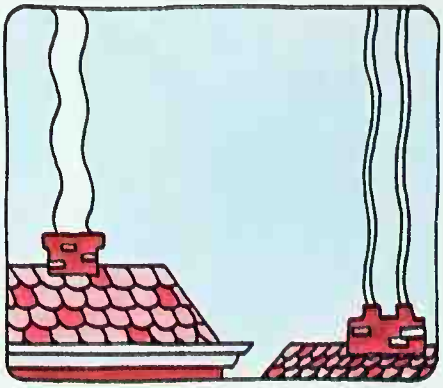
A gentle breeze ruffles your hair. A strong breeze may turn your umbrella inside out. On these pages you will find out how to tell how hard the wind is blowing by watching what it does. And you will learn the names we give to different speeds of wind.

In *calm air*, smoke rises straight up. The wind is blowing less than 1 mile (1.6 kilometers) per hour.

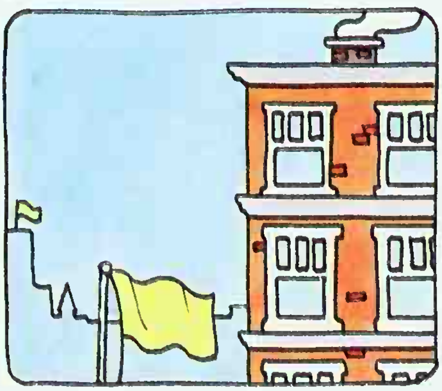
In *light air*, smoke drifts slightly, but weather vanes do not move. Wind speed is 1–3 miles (1–5 kilometers) per hour.

A *light breeze* moves weather vanes and makes leaves rustle. Wind speed is 4–7 miles (6–11 kilometers) per hour.

calm



gentle breeze



A *gentle breeze* makes leaves and small twigs move and light flags flutter. Wind speed is 8–12 miles (12–19 kilometers) per hour.

In a *moderate breeze*, small branches sway and dust and paper blow about. Wind speed is 13–18 miles (20–28 kilometers) per hour.

In a *fresh breeze*, small trees sway and waves break on lakes. Wind speed is 19–24 miles (29–38 kilometers) per hour.

A *strong breeze* makes big branches sway and may turn umbrellas inside out. Wind speed is 25–31 miles (39–49 kilometers) per hour.

In a *moderate gale*, whole trees sway and it is hard to walk against the wind. Wind speed is 32–38 miles (50–61 kilometers) per hour.

strong breeze

moderate gale

A *fresh gale* breaks twigs off trees and makes walking very difficult. Wind speed is 39–46 miles (62–74 kilometers) per hour.

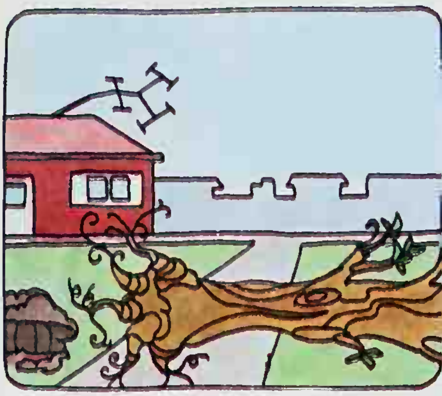
A *strong gale* blows off roofs and may do slight damage to buildings. Wind speed is 47–54 miles (75–88 kilometers) per hour.

A *whole gale* will uproot trees and often do much damage to buildings. Wind speed is 55–63 miles (89–102 kilometers) per hour.

A *storm* causes widespread damage, but is very rare on land. Wind speed is 64–73 miles (103–117 kilometers) per hour.

A *hurricane* causes violent destruction. Wind speed is 74 miles (117 kilometers) or more per hour.

whole gale



Measuring wind speed

Weather forecasters, aviators, sailors, and some other people often need to know exactly how hard the wind is blowing. To find out, they use an instrument called an anemometer (an uh MAHM uh tuhr). An anemometer measures the speed of the wind.

You can make a simple anemometer for yourself. You'll need:

four paper cups
two strips of heavy cardboard, 4 × 12 inches (10 × 30 centimeters)
thin cardboard or heavy paper, 4 × 6 inches (10 × 15 centimeters)
crayon
pencil
scissors
tape
long nail with a large head
ruler

Measure and cut the heavy cardboard strips. Put the strips together to make a cross, like a plus sign. Tape the strips together.

Then make a small hole in the middle of the cross and push the nail through the hole.

Color stripes on one of the cups, so that it looks very different from the others. Then cut two four-inch (10-centimeter) slits down the opposite sides of each cup.

Slide one cup onto each arm of the cross. Push the arms through both slits. The ends of the arms should stick out about 1/2 inch (12 millimeters) beyond the cups. All of the cups should face in the same direction.

Roll the piece of thin cardboard around a pencil to make a six-inch (15-centimeter) tube. Tape the tube together. Put the nail in the tube, so that the cross with the cups rests on top. Your anemometer is ready to use.

Pick up the bottom of the tube and hold your anemometer out in the wind. The cross with the cups will spin. Count the number of times the striped cup moves past your arm during thirty seconds.

Divide the number you got by twenty-two. This will give you the wind speed in miles per hour. For example, if the striped cup went around forty-four times, divide forty-four by twenty-two. You get two—so the wind speed is two miles per hour.

To find the wind speed in kilometers, multiply your answer by 1.6. Two times 1.6 is 3.2 kilometers per hour.

Whirlwinds!

It is late afternoon in the summer. The air is hot and sticky. In the distance, a long line of clouds is gathering. There is a rumble of thunder.

The line of dark clouds comes swirling over the prairie. Small, shaggy lumps of cloud hang from the bottoms of some of the larger clouds. A crackling rain of hail comes pouring down, and the sky flickers with lightning.

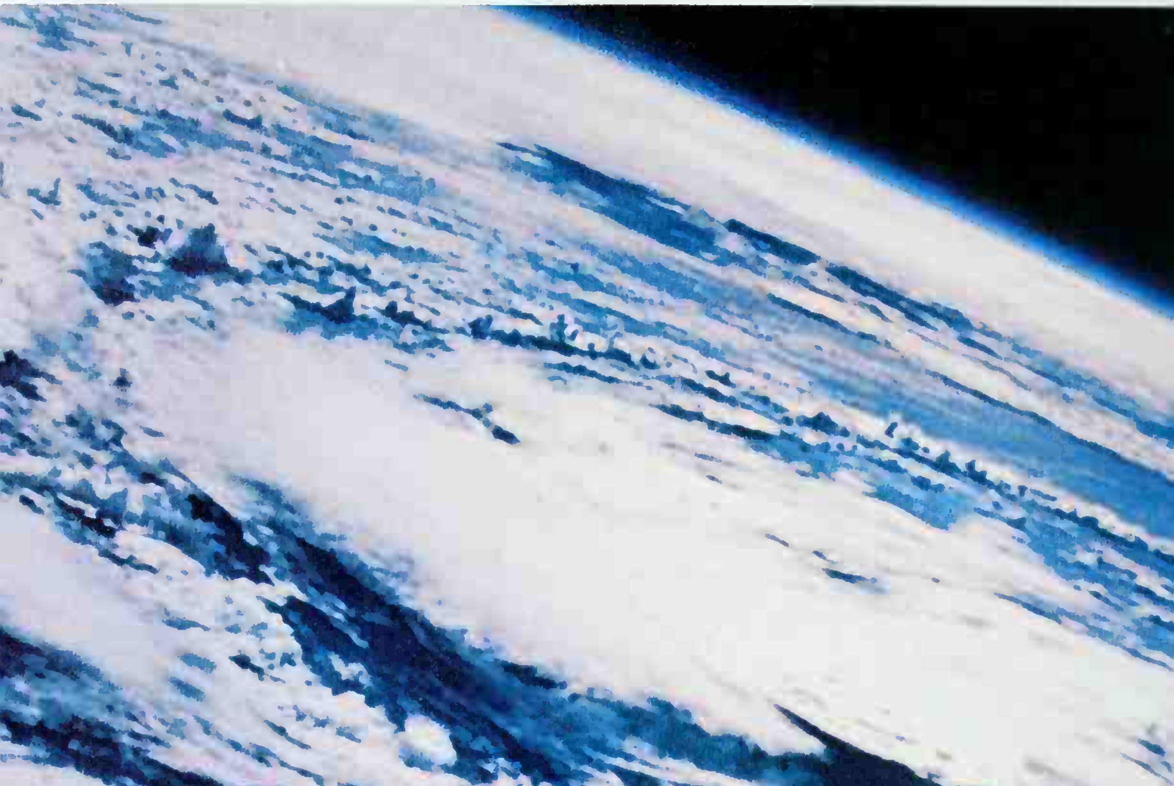
Suddenly, from the lumpy mass at the bottom of a cloud, a dark cone sweeps down toward the earth. It looks like a huge, twisting snake hanging from the cloud. There is a terrible roaring noise!

It's a tornado!

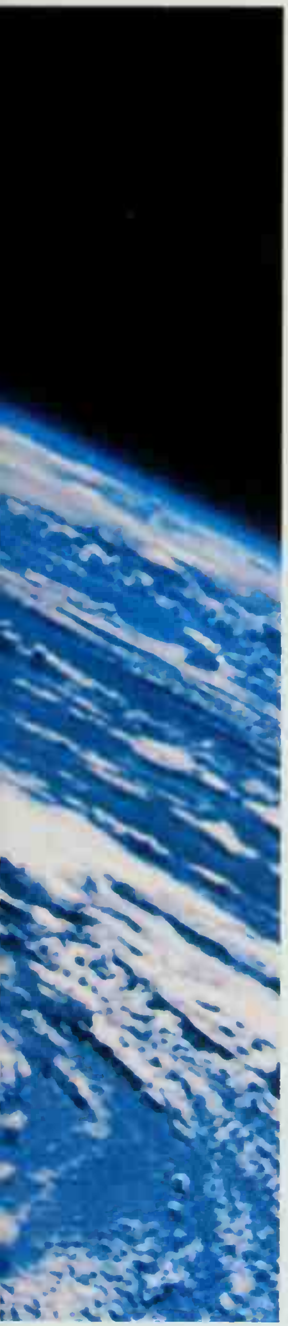
Tornadoes are sometimes called whirlwinds or twisters. A tornado is a spinning, whirling wind that forms a long tube of air. Where the tube touches the ground, terrible things happen! The whirling wind can pick up a heavy truck and throw it through the air. It can pull houses apart and knock big, thick trees over.

Tornadoes are caused when there is warm, moist air beneath cold, dry air. The warm air rises up and cools quickly, letting go of its heat and water. This makes hail and rain fall. Air comes rushing in from all sides to take the place of the rising warm air. Because the wind blows from several different directions, the air begins to whirl.

Tornadoes can happen in many parts of the world. But most tornadoes happen over the central part of the United States.



the eye of a hurricane photographed from a space satellite



The storm with an eye

A hurricane is a storm that's shaped like a doughnut. It's a great, whirling circle of clouds, hundreds of miles (kilometers) wide. In the middle is a hole where the air is perfectly calm. This hole is called the "eye" of the hurricane.

No one knows for sure what causes hurricanes. A hurricane begins over the ocean, near the equator, where the air is very hot, wet, and still. As great masses of this warm, wet air rise up, towering rain clouds form. Sometimes, something happens to start the clouds whirling. Then, warm air in the center of the clouds forms into an eye. When the wind reaches a speed of seventy-four miles (119 kilometers) an hour, the storm is called a hurricane.

A hurricane is a great, boiling, whirling circle of wind and rain. The wind of a hurricane is terrible, indeed. It may blow at two hundred miles (322 kilometers) an hour. It causes huge ocean waves that rush ahead of the hurricane. If these waves reach land, they can cause sudden, terrible floods. If a hurricane blows over land, the wind can tear up big trees by the roots and push over whole buildings.

People in the path of the eye of a hurricane know that they will be hit by two storms. First, there is a long line of clouds—the front of the circle. The wind begins to blow hard. Then harder. Rain comes pouring down. The sound of the blowing wind and rushing rain is like steady thunder.

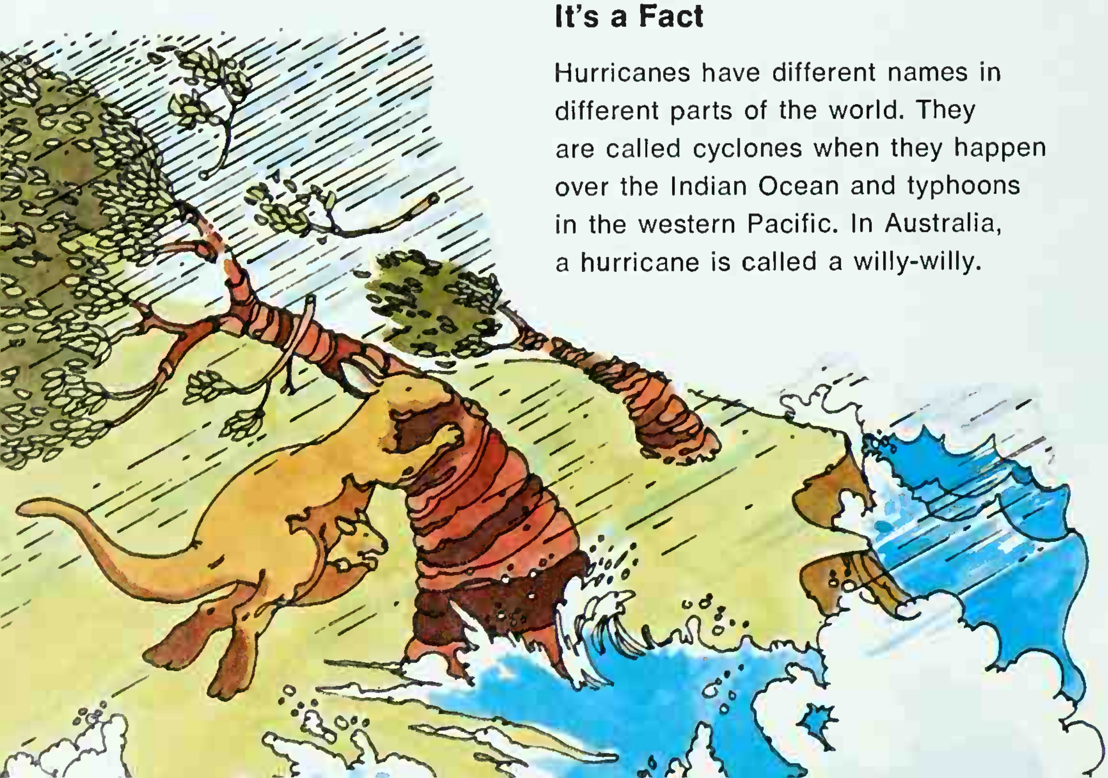
Then, the wind dies down. The rain stops. The air grows very hot and still. The eye of the hurricane is passing over. It may take an hour or more to pass.

Then the back of the circle arrives. Once more the howling wind blows and the driving rain pours down. The wind and rain rage again, for a time. Finally, the back of the circle moves on, carrying the wind and rain to another place.

The United States National Weather Service uses an alphabetical list of first names to identify hurricanes. Each season, the first hurricane is given a name that begins with A.

It's a Fact

Hurricanes have different names in different parts of the world. They are called cyclones when they happen over the Indian Ocean and typhoons in the western Pacific. In Australia, a hurricane is called a willy-willy.



strong winds push great waves ashore during a hurricane

Dust devils and dust storms

A tornado is a whirling wind that comes down from the sky and touches the ground. Dust devils and sand pillars are whirling winds that go from the ground up into the sky.

Whenever hot air rises, it causes a wind. On a hot, dusty prairie, or a desert, rising hot air often begins to spin. Then, it carries up a whirling cloud of dust or sand.

On a prairie, or on a dusty city street, these whirling clouds are called dust devils. They never get very high. But in a desert they sometimes go whirling up in a thick cloud a thousand feet (304 meters) high. Then, they are often called sand pillars.

Sometimes, when a large mass of hot desert air rises up, the wind that rushes in to take its place causes a sandstorm or dust storm. The wind sends the sand rushing through the air. Great clouds of dust rise up, turning the whole sky black. A desert storm can often blow for hours, or even days.

dust devil

Floating water in the air

Clouds. Sometimes they look like big gobs of whipped cream in the sky, and sometimes like soft, floating feathers. Sometimes they're white as milk, and sometimes as dark and gloomy as an angry frown. But what are clouds? Where do they come from?

A cloud is simply billions and billions of tiny, tiny droplets of water or ice all clustered together. And the water that makes clouds comes from the earth.

When you perspire on a hot, sunny day, you're helping to make a cloud. When a mud puddle dries up in the sunshine, it's going to become part of a cloud. Every day, the heat of the sun dries up tons and tons of water from everywhere on earth—from lakes and rivers, from the ocean, and from mud puddles, plant leaves, and perspiration. All this water is turned into water vapor, which is water in the form of gas. This gas goes floating up into the air.

The water vapor is warm from the sun's heat. But as it rises higher and higher, it begins to cool. When it gets cool enough, it turns back into water or ice. Then, tiny droplets form around tiny, tiny bits of dust in the air. These droplets make up the clouds.

Some clouds are all water, some are all ice, some are a mixture. You might think the water and ice would be so heavy it would fall to the ground, but the droplets are so very tiny that even the slightest wind is enough to keep them floating through the air. However, sometimes things happen that make many droplets collect together and become large drops. Then the cloud falls to earth—as a shower of raindrops.

stratus clouds

Shapes in the sky

There are many different kinds of clouds, and each kind has a name. Most clouds are named for their shapes.

The clouds that look like great sheets pulled across the sky are called stratus clouds. *Strato* means "sheetlike." These are the kinds of clouds that are closest to the ground.

When a stratus cloud is dark, with a steady rain falling from it, it is a nimbostratus cloud. *Nimbus* means "rain," so a nimbostratus cloud is a "rain sheet."

Cumulus clouds are the ones that look like fluffy balls of cotton, or scoops of ice cream all piled up. *Cumulus* means "pile" or "heap." When a cumulus cloud rises high into the air and grows dark and heavy

cumulus cloud

with rain, it is called cumulonimbus—a "pile of rain." These are the kinds of clouds that cause thunderstorms and tornadoes.

Stratocumulus clouds cover much of the sky, like stratus clouds, but are piled up, like cumulus clouds. It's easy to see how they got their name.

Alto means "high," and altocumulus clouds are higher than stratus clouds. They may be as much as 20,000 feet (6,296 meters) above the ground. They don't look much like piles, though. Sometimes they look like lumpy, white ripples stretched across the sky. Then they are called altocumulus undulatus clouds. *Undulatus* means "ripple."

The highest clouds of all are cirrus clouds. They are made of ice droplets, and look like thin, wispy streaks or curls. And *cirrus* means "curl of hair." Sometimes, cirrus clouds are piled together. Then they are called cirrocumulus clouds. When there are lots of such cirrocumulus clouds, people say it's a "mackerel sky," because the clouds look like the scales of the fish called a mackerel.

cirrus clouds

Squeezing water from air

Water is almost always in the air around you, even when you can't see it or feel it. Here is an experiment that will show you how clouds form when cold air and warm air come together. You'll need:

a drinking glass (glass—not paper or plastic)

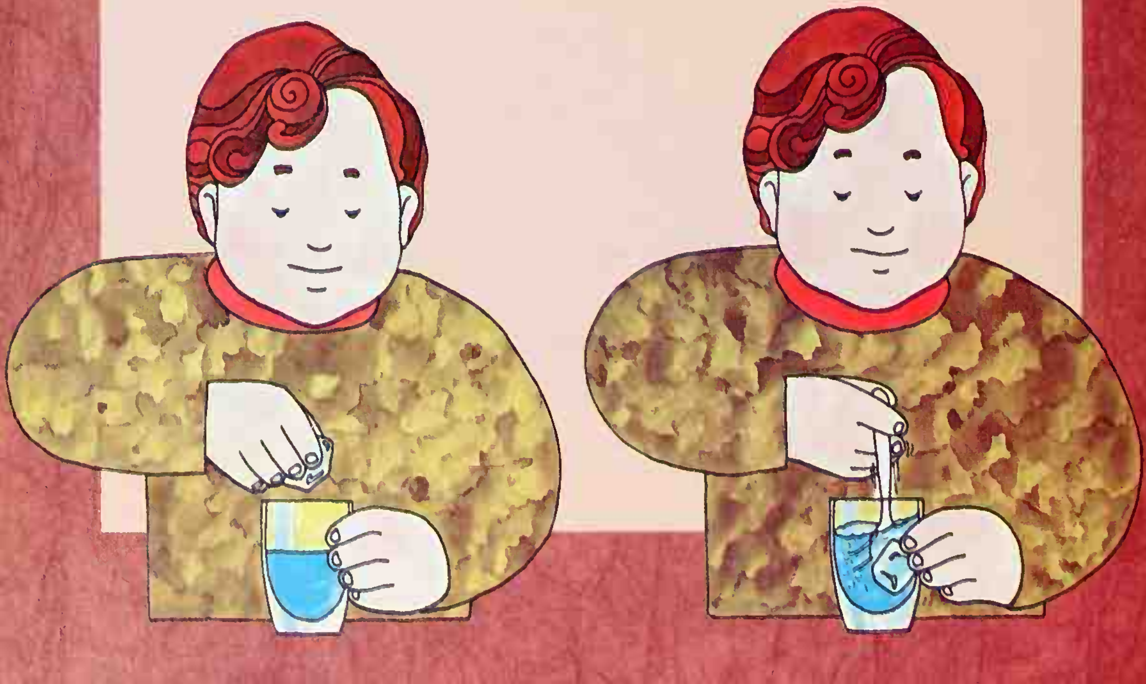
ice cubes

a spoon

a pot of water

Do this experiment in the kitchen. To make sure the air is damp, have a pot of water boiling on the stove. (Ask someone for help if you need it.)

Fill the glass halfway with water. Make sure the outside of the glass is dry. Then put some ice cubes in the water and stir them slowly. After a few minutes, you will see that the outside of the glass looks frosty and feels wet. What happened?



water droplets
forming on a
cold glass

The outside of the glass was dry when you began, but the warm air in the kitchen was damp. It was full of water vapor—water in the form of a gas.

Water vapor is made up of tiny things called molecules. These molecules of water vapor are spread out and moving around in the air. But when some of the molecules touch the cold glass, they condense, or come together, to form water droplets on the glass.

Clouds form in the same way. Warm air, with water vapor in it, meets cold air. Where they meet, the water molecules get very cold. They condense and become tiny droplets of water or bits of ice.

fog under the Golden Gate Bridge, California

Clouds on the earth

Eeee-rump! Eeee-rump! The growly sound of a foghorn echoes in the night. A thick, gray fog creeps in from the ocean and settles over the waterfront. You can hardly see your hand in front of your face. It's like being in the middle of a cloud.

As a matter of fact, that's just what fog is. It's a cloud that touches the earth, instead of floating high in the sky.

Like every other kind of cloud, fog forms when warm, moist air meets cool air. Fog often forms when warm, moist air passes over the cold water of an ocean, lake, or river. The warm air quickly cools. Then the water vapor in it becomes millions of tiny droplets of water—a cloud that rolls in from the water and spreads out over the land.

Fog forms over land in much the same way. This happens when ground that has been warm all day begins to cool off. As the warm air above the ground cools, the water vapor in the air turns into droplets of water. Then there's a fog that hugs the ground.

Homemade clouds

You can make a cloud! In fact, you probably have made clouds many, many times. All you need is a cold day.

Just open your mouth and blow a puff of breath into the cold air. For just a moment, you'll see a cloud. It's only a tiny, smoky, whitish patch in the air. But it's a real cloud.

Clouds are made when warm, moist air hits cold air. That's what happens when you breathe on a cold day. Your breath is warm from being inside your warm body. And your breath is full of water vapor—water in the form of a gas. When your breath hits the cold air, the water vapor instantly turns into many tiny droplets of water. The droplets form a cloud, just like the clouds in the sky. But the cloud is so tiny that it quickly spreads out and vanishes in the air.

Clouds airplanes make

Have you ever looked up and seen a jet airplane high in the sky? Sometimes you will see what looks like a trail of white smoke stretched out behind the plane. This trail is a cloud made by the jet.

The air high in the sky is cold and frosty. Hot gas, left over from burned fuel, comes out of the jet's engines. There is a lot of water vapor in this hot gas. When the water vapor hits the cold air, it instantly condenses into tiny water droplets or ice crystals. So the jet leaves a long, white cloud behind it.

These long clouds that a jet makes are called contrails, which is short for "condensation trail." Contrails are also called vapor trails. Contrails sometimes cause rainstorms or snowstorms.

Sparkling spider webs

Early in the morning, when the sun chases the night's shadows from lawns, gardens, and meadows, the ground is full of sparkles. Dewdrops, like tiny jewels, are everywhere. They glitter on spider webs, glisten on leaves, and gleam on blades of grass.

But if the ground was dry the day before, and there was no rain during the night, where did all the sparkling dewdrops come from?

Dew forms on still, clear nights when the air is warm and moist and the ground is cool. When the sun goes down, leaves and grass and spider webs and other things out in the open grow cool. As the moist air touches them, it grows cool, too. Then, the molecules of water vapor in the air rush together. They form tiny drops of water that coat the leaves, grass, spider webs, and other things. These tiny drops slowly run together and form the bigger drops of dew that greet the morning sunshine.

You can make dew with your breath. When you are inside on a cold winter day, blow your breath gently against a windowpane. A small, grayish patch will form on the glass. Blow some more and tiny drops of water will form. Blow again and the drops will begin to run together and make bigger drops. This is how dew forms.

How much did it rain?

You've probably heard weather forecasters on radio or television tell how many inches or centimeters of rain fell during a storm. But how do they know how much rain fell?

Scientists measure rainfall with an instrument called a rain gauge. Rain falls into the gauge during a storm. Afterwards, scientists measure the amount of water in the gauge.

You can make a simple rain gauge out of a clean coffee can and a ruler. Place the can in the open, away from trees, so that rain can fall directly into it. Bury it partly, or wedge it with heavy stones so it can't move.

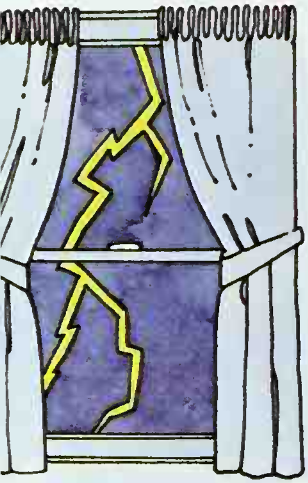
As soon as the rain has stopped, measure the amount of water in the can. Make sure the end of your ruler touches the bottom of the can. Lift the ruler straight up and see how much of it is wet. Then you will know how many inches or centimeters of rain fell.

Flash and bang

Oh, oh—you're caught in a rainstorm! The sky is dark and angry and rain is spattering down all around you. Suddenly, a zigzag flash of lightning brightens the sky for just an instant. Almost at once, there's a tremendous ripping sound and then a crash of thunder!

What causes these bright flashes and loud crashes that make a rainstorm so scary and exciting?

Lightning is caused by electricity. Each tiny drop of water in a rain cloud has a tiny charge of electricity. There are billions of water drops in a cloud, so the whole cloud has a powerful charge of electricity. Sometimes the charge inside the cloud is so powerful that electricity flashes from one part of the cloud to another. And sometimes, when the cloud comes near another cloud with an electric charge, or near the ground, electricity rushes between them. So, the flash we see when lightning snakes through the sky is really a huge electric spark.



A flash of lightning heats up the air around it. The heated air goes rushing out in all directions. It slams into the cold air, making it shake. This is what causes the crash of thunder.

It's a Fact

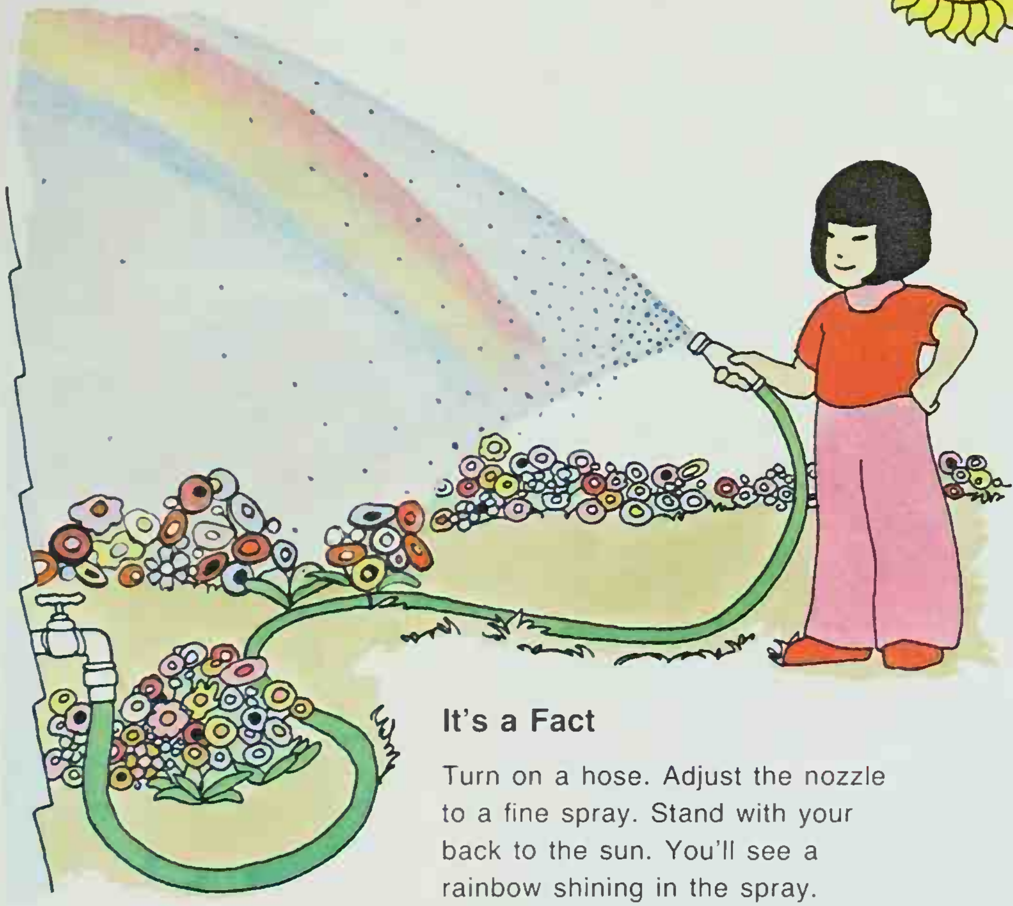
You can tell how far away lightning is. Count the seconds between the flash and the thunder. Every five seconds equals one mile (1.6 kilometers).

The bridge in the sky

Long ago, people thought that rainbows were magic. Some people believed that a rainbow was a bridge that appeared in the sky when the gods wanted to leave heaven and come down to earth. People also believed that if you could find the end of a rainbow—where it touched the earth—you would find a pot of gold.

Today, we know that a rainbow is simply caused by sunlight shining through raindrops. To see a rainbow, you must have the sun behind you and the rain falling in front of you. Sunlight looks white, but it is really made up of many colors. When sunlight enters a raindrop, it breaks up into violet, blue, green, yellow, orange, and red. We see these colors in the rainbow. But because the colors blend, we usually see only four or five of them.

Many rays of sunlight, breaking up into their colors and reflecting off many drops of falling rain, make a shimmering, curved, colorful rainbow. If the rain is heavy, both ends of the rainbow may appear to touch the earth, many miles (kilometers) apart.



It's a Fact

Turn on a hose. Adjust the nozzle to a fine spray. Stand with your back to the sun. You'll see a rainbow shining in the spray.

Beads and balls of ice

Hail and sleet are frozen rain. But they are very different. Sleet is tiny beads of ice. Hail is lumps of ice and snow that may be as big as baseballs!

Hailstones begin as ordinary raindrops in a rain cloud. Gusts of wind carry them up to the highest part of the cloud. Here, where the air is freezing cold, the raindrops turn to ice. Snow forms in this part of the cloud, so the drops of ice get a coating of snow. Then they are so heavy, they fall.

As they fall back into the part of the cloud where other raindrops are forming, they are covered with water. Again, a gust of rising wind catches some of them and lifts them up. The coat of water freezes, and they get another coat of snow. Again, they fall.

Hailstones may rise and fall this way many times. Each time, they grow a little bigger and heavier. Finally, they become so heavy the wind can't lift them any more. They keep falling until they come to earth—where they rattle on roofs, smack against leaves, and bounce on the grass.

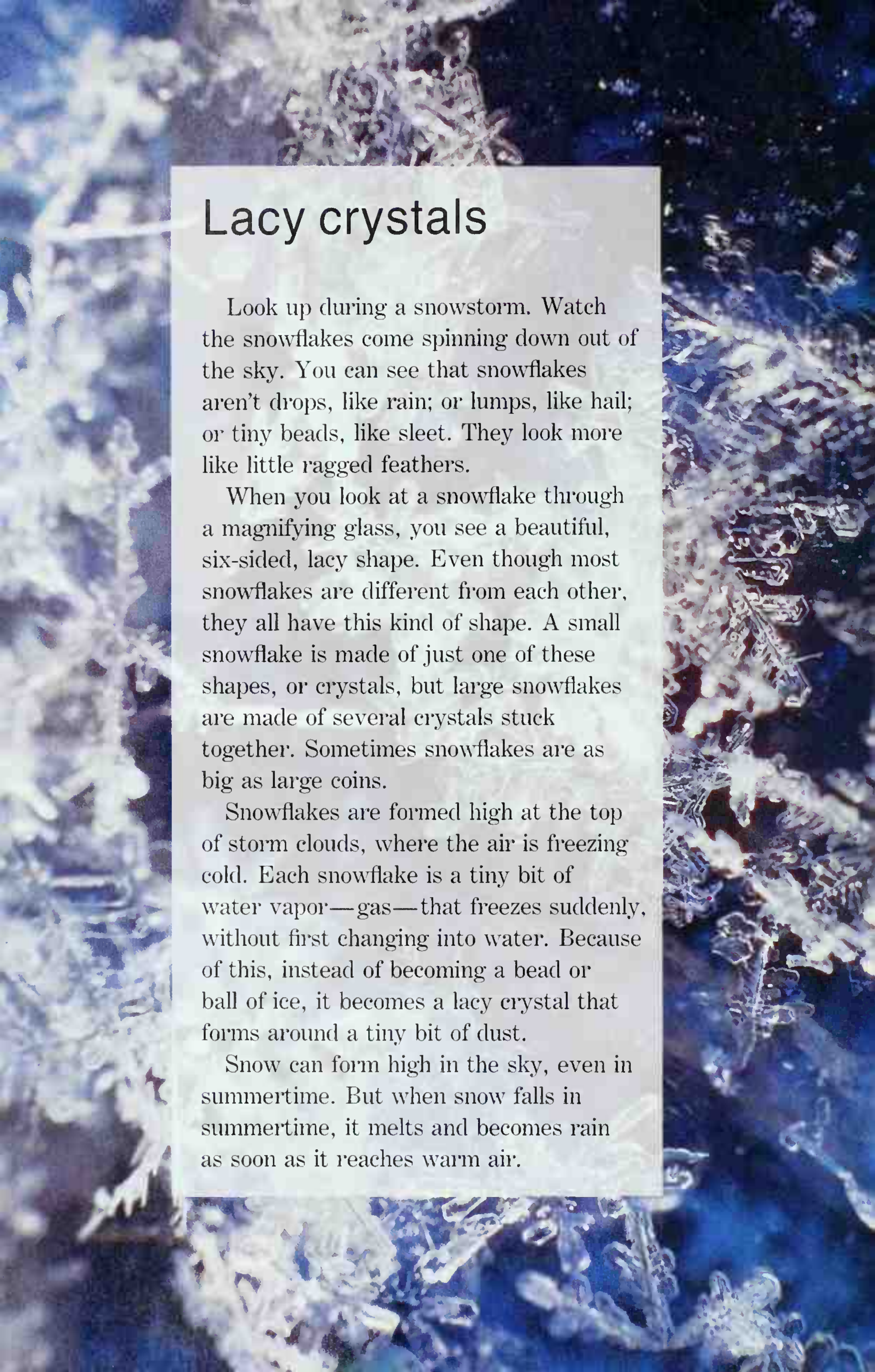
Sleet is made when tiny drops of very cold water in a cloud get mixed with falling snowflakes. The snow and water freeze together into little beads of ice that sting your face and pop against windowpanes.

hailstones in a cornfield

Hailstones begin as raindrops. They are carried up into cold air, where they freeze. As they fall, they are covered with layers of snow and ice. This often makes them grow as big as golf balls—or bigger!

the inside of a hailstone

This large hailstone has been sawed in half to show the many layers of snow and ice inside it.



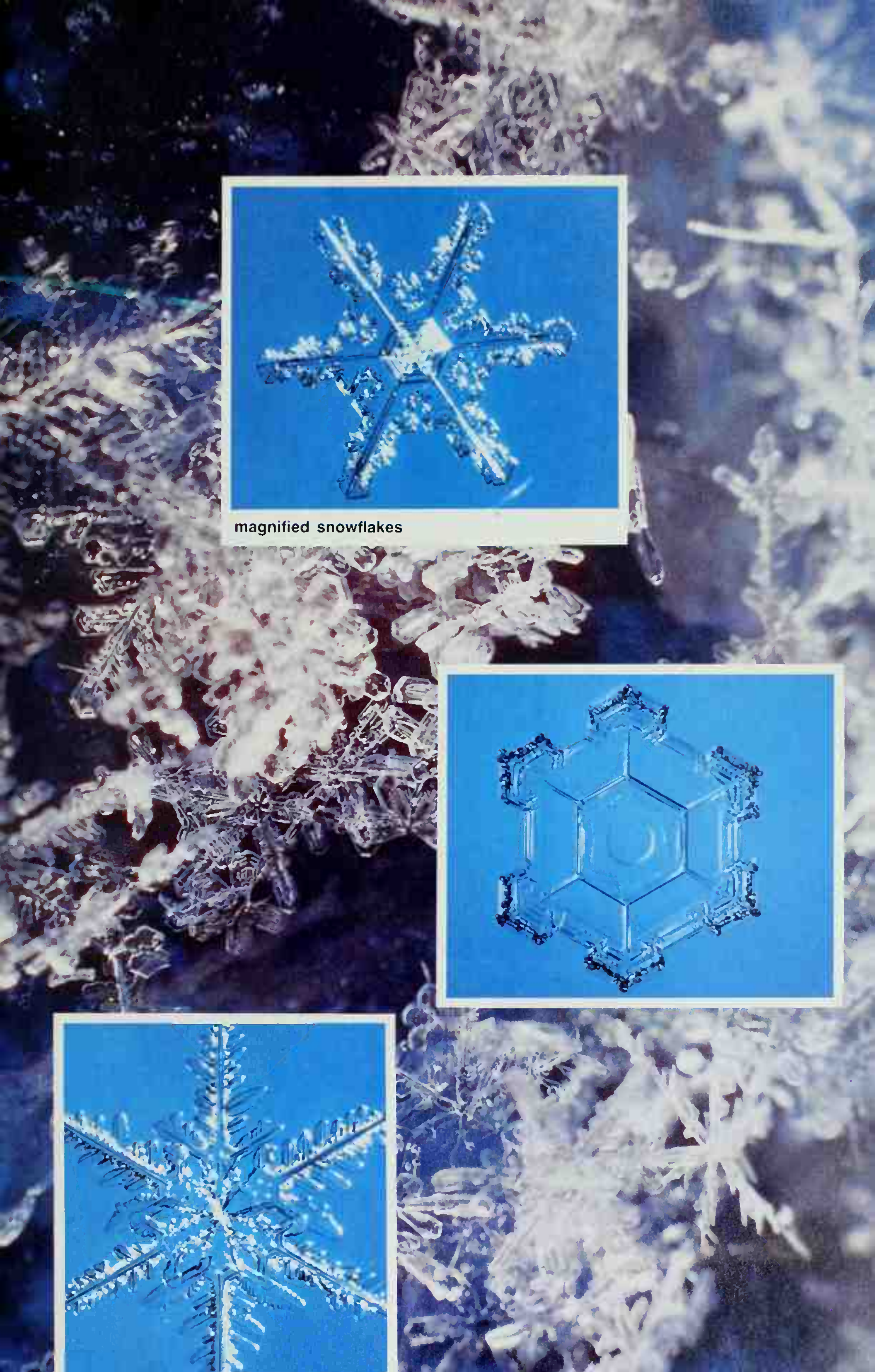
Lacy crystals

Look up during a snowstorm. Watch the snowflakes come spinning down out of the sky. You can see that snowflakes aren't drops, like rain; or lumps, like hail; or tiny beads, like sleet. They look more like little ragged feathers.

When you look at a snowflake through a magnifying glass, you see a beautiful, six-sided, lacy shape. Even though most snowflakes are different from each other, they all have this kind of shape. A small snowflake is made of just one of these shapes, or crystals, but large snowflakes are made of several crystals stuck together. Sometimes snowflakes are as big as large coins.

Snowflakes are formed high at the top of storm clouds, where the air is freezing cold. Each snowflake is a tiny bit of water vapor—gas—that freezes suddenly, without first changing into water. Because of this, instead of becoming a bead or ball of ice, it becomes a lacy crystal that forms around a tiny bit of dust.

Snow can form high in the sky, even in summertime. But when snow falls in summertime, it melts and becomes rain as soon as it reaches warm air.



magnified snowflakes

Sparkly pictures on your window

The door was shut, as doors should be
Before you went to bed last night;
Yet Jack Frost has got in, you see,
And left your window silver white.

He must have waited till you slept;
And not a single word he spoke,
But pencilled o'er the panes and crept
Away again before you woke.

From Jack Frost
Gabriel Setoun

On a cold, crisp day in late autumn or winter, you may wake up to find your windows covered with icy, lacy swirls. They weren't painted by Jack Frost, of course. They were made when tiny droplets of water in the air got so cold they froze on the windowpane.

During the day, the outsides of your windows are warm, both from the heat inside your house and from the sunshine. But when the sun sets, the windowpanes grow cool, then cold. The air touching the window grows cold, too, and all the tiny droplets of water in the air freeze. They suddenly become crystals of ice, stuck to your windowpane. Then you see designs like lacy coils, sparkly feathers, and shiny, silvery leaves.

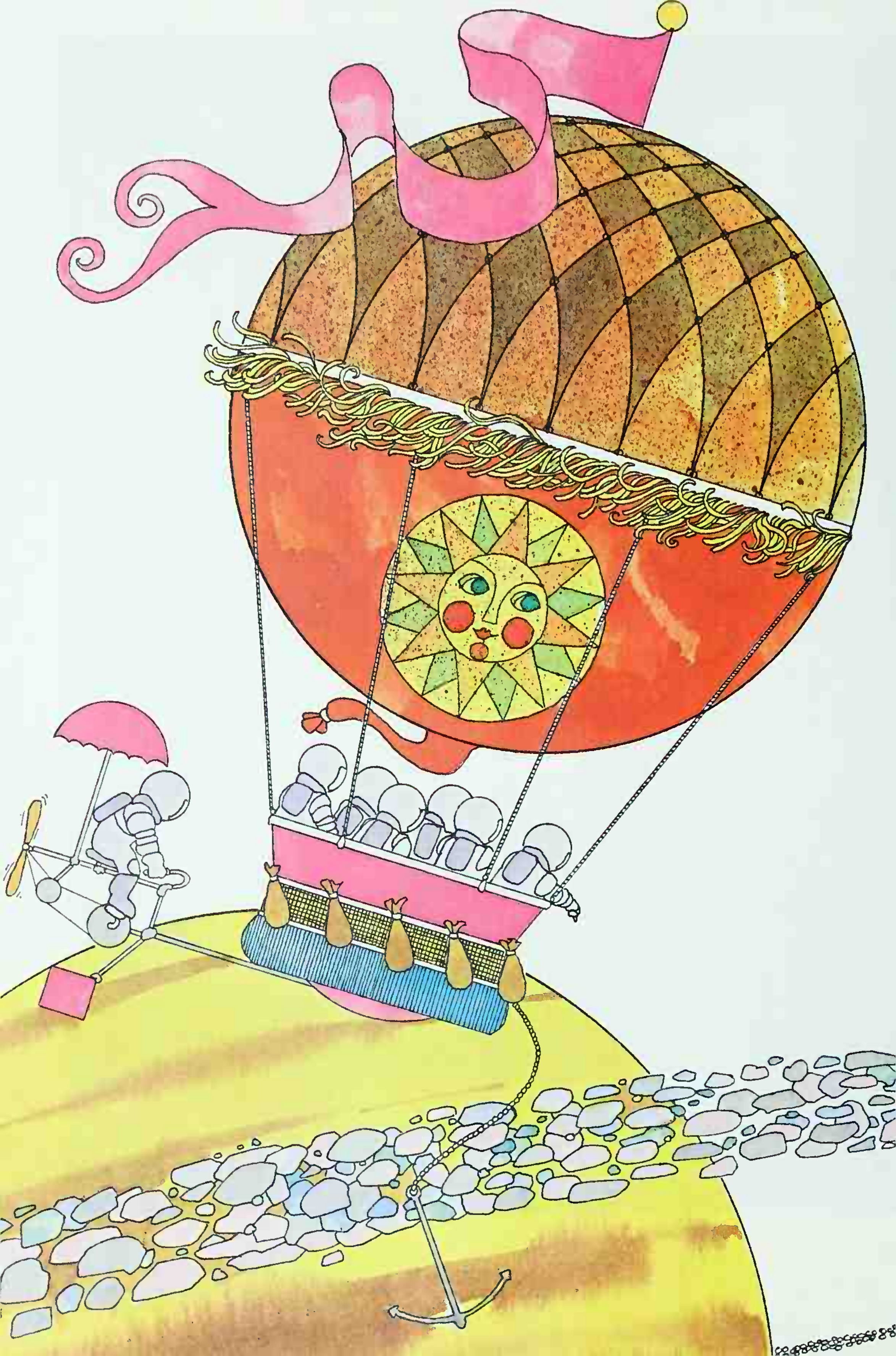
Icy daggers

It's a bitterly cold winter day. Snow lies in a great white sheet on the ground and on the roof of your house. The roof is warm from the heat inside the house, so the snow on the roof is slowly melting. Tiny trickles of water run to the edge of the roof. Drops of water begin to form.

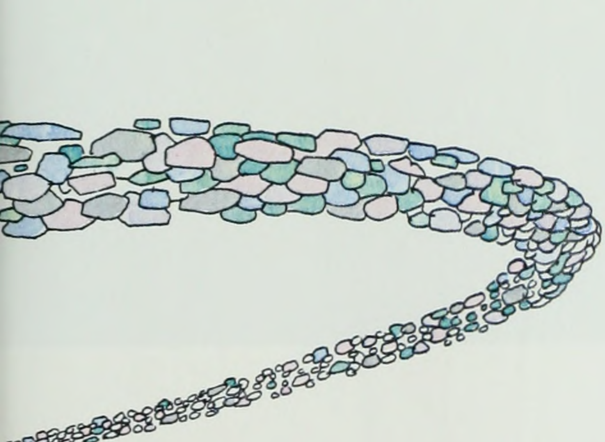
Some of the drops grow bigger and fall to the ground. But many of the drops freeze in the cold air. They become bits of ice hanging along the edge of the roof. The water trickling off the roof runs onto the ice. The bits of ice get thicker and longer as more and more water freezes on them.

All day long, water trickles down the pieces of ice. Water drops form at the end of each piece of ice. The drops hang there for a moment. Before they can fall off, they freeze. Slowly, the pieces of ice become the long daggers we call icicles.

Icicles can be short or long, thin or fat. It depends on how much snow melts and how fast the water drips from a roof or tree branch. An icicle can be shorter than your little finger or as long as your whole body.



Planets, Stars, and Galaxies



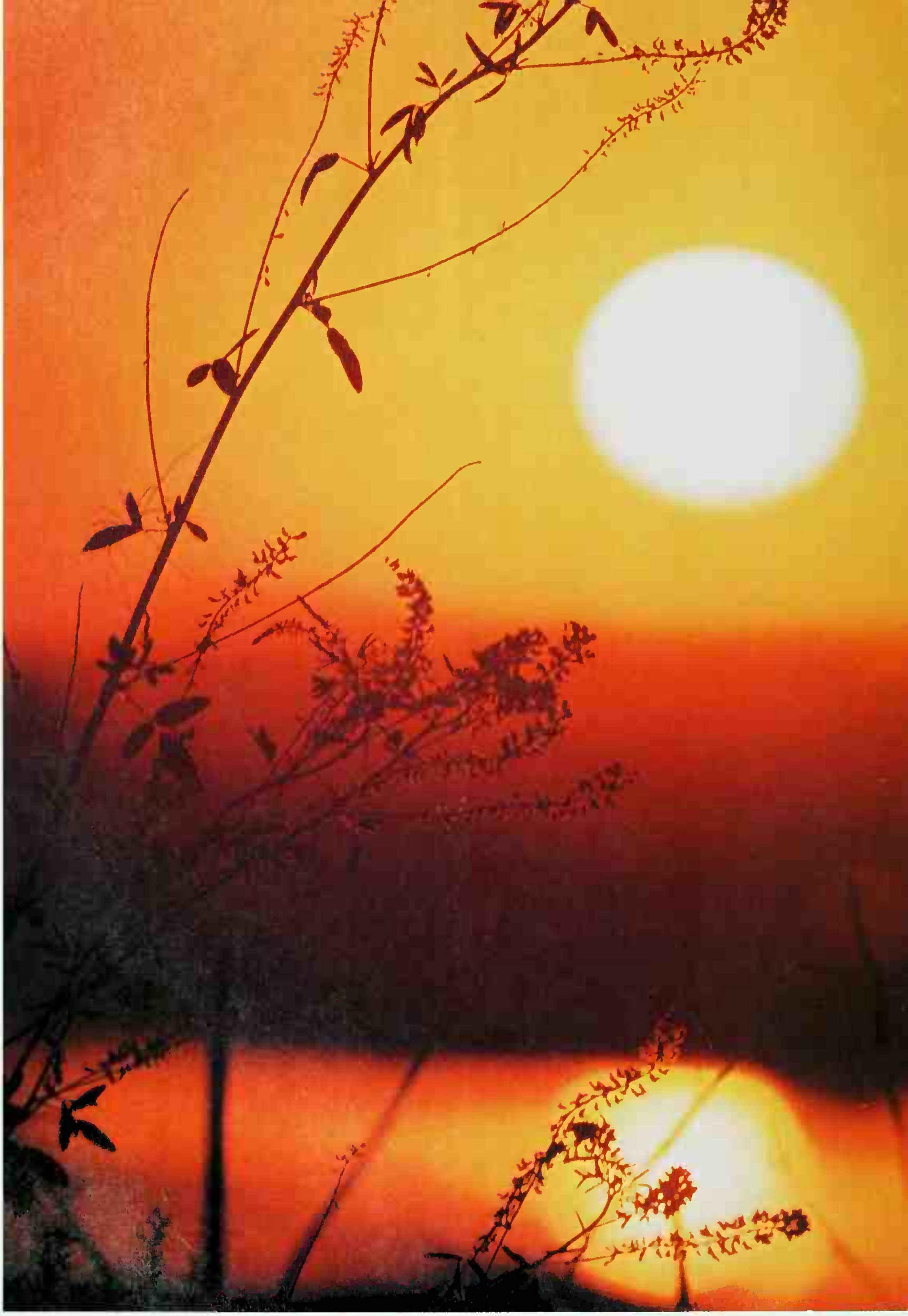
The black emptiness

Space is—emptiness.

It is black because emptiness has no light of its own. It is neither cold nor hot because emptiness has no temperature. And, of course, there is no air or water in space.

But although space itself is emptiness, there are things *in* it. There are billions and billions of stars. There are huge clouds of gas and dust. Comets and chunks of rock called meteoroids rush through parts of space. Waves of light from stars travel through it. Tiny, invisible particles move about. Space is the emptiness that *surrounds* all these things.

Space and all the things in it make up what we call the universe. We do not know how big the universe is, but the things farthest away that we know about are *very* far away. The light they give off takes thousands of millions of years to reach us! Perhaps the universe stretches away in all directions, forever—and never ends!



It's a Fact

About 1,300,000 planets the size of earth could be packed into the sun.

The bright giant

Millions of miles (kilometers) out in space there is a gigantic ball of hot, glowing gas we call the sun.

The sun is actually a star. It is the closest star to us. Its official name is Sol, which was the name of the ancient Roman sun god. From the name Sol comes our word *solar*, which means "of the sun."

The sun is enormous! At least 1,300,000 planets the size of earth could be packed into it. And there would be room left over. And yet, big as the sun is, many other stars are much, much bigger.

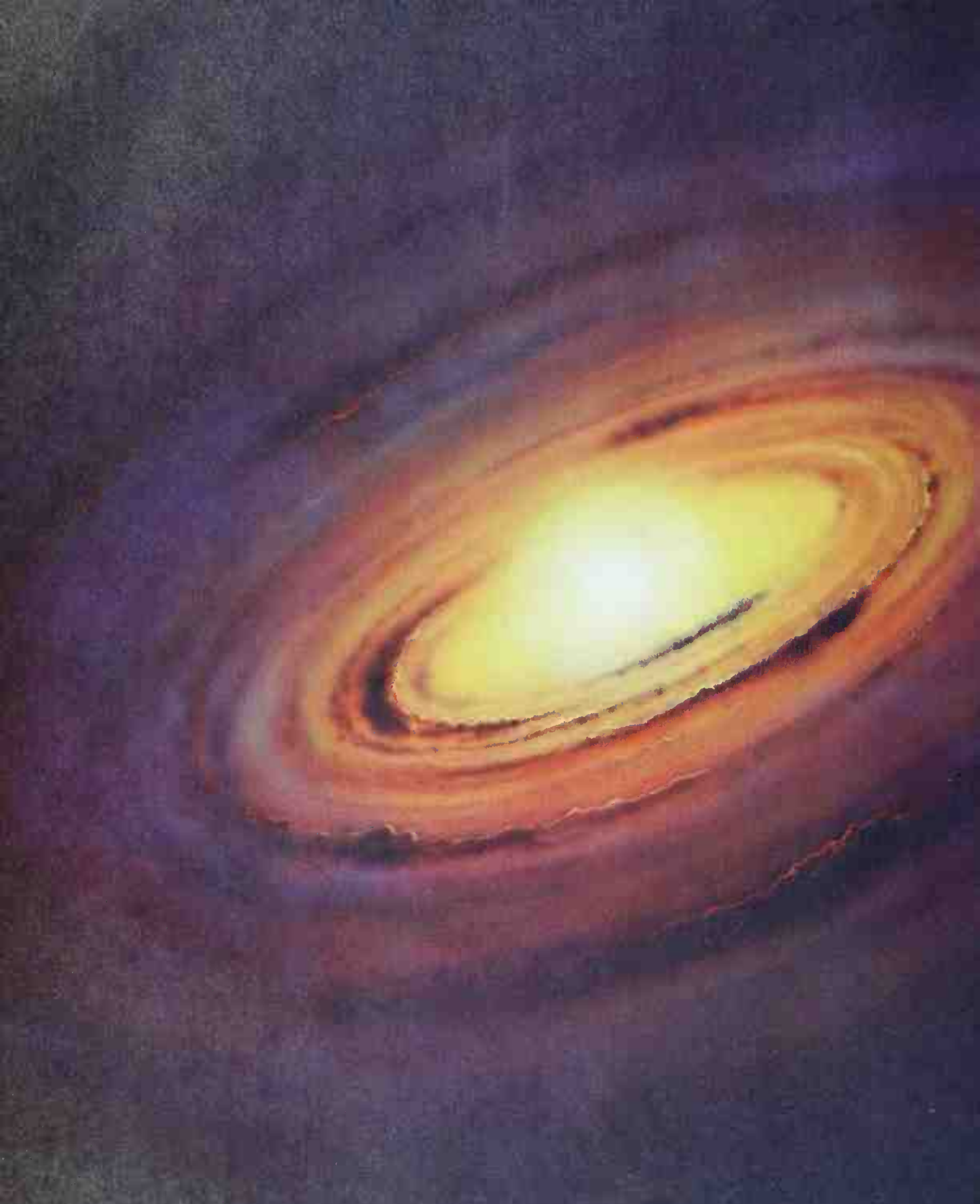
Although it is big, the sun looks small. That's because it is so far away. It is about 93 million miles (150 million kilometers) from the earth. It takes light from the sun about 8 minutes and 20 seconds to cross that enormous distance and reach our world. And light is the fastest moving of all things.

The sun is tremendously hot. The hotter a thing is, the more brightly it glows. The sun glows so fiercely that we can't look straight at it, even though it is so far away. But the sun is not actually *burning.* It isn't a ball of fire. It's a ball of gas, squeezed together so tightly that its center is actually solid. This makes the center tremendously hot. It is really a kind of giant atomic furnace in which the temperature is about 27 million degrees Fahrenheit (15,000,000° Celsius)!

Energy pours up from inside the sun to the surface. The surface is a boiling, bubbling mass from which great spouts of glowing gas leap up—sometimes as much as a million miles (1,609,000 kilometers) into space!

the sun

The sun is a star. It is a giant ball of gas squeezed together so tightly that it is tremendously hot.



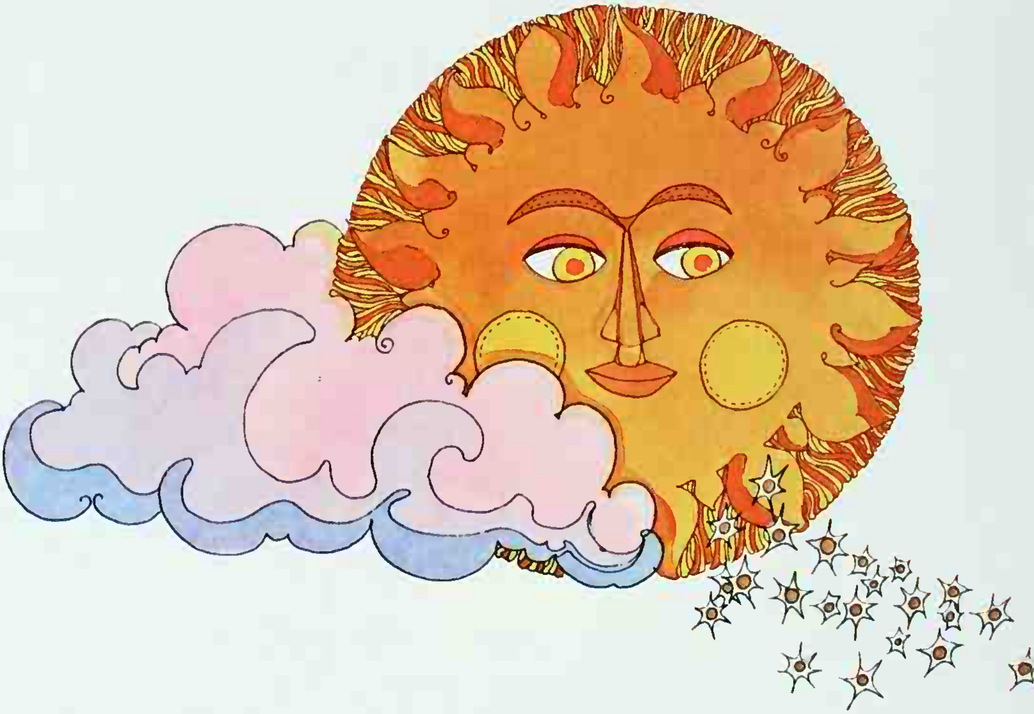
How the sun was born

Most scientists think our sun began as an immense cloud of gas and dust.

Stars that are growing old often shoot out enormous clouds of gas and dust. The gas and dust are made up of all kinds of chemicals. There are many such clouds in space. As these clouds move through space, they pull more and more gas and dust into themselves. Gravity pulls all the gas and dust together, tighter and tighter. Over many millions of years, the center of the cloud of gas is pulled into the shape of a gigantic ball.

Gravity squeezes this gas ball together so tightly its center is more dense than steel! When gas is squeezed together that tightly, it becomes tremendously hot. The center of the gas ball grows so hot that it becomes an atomic furnace. The ball begins to glow with this fierce heat. It has become a star!

This is how all stars seem to form. Right now, out in space, new stars seem to be forming out of clouds of gas. And scientists think this is how our own sun began, about five billion years ago.



The source of life

Without the sun, there could be no life on earth.

Energy pours up out of the raging hot atomic furnace that is the center of the sun. It moves up to the sun's seething, boiling surface and rushes out into space as waves of light.

The waves of sunlight spread out in all directions. They travel at the tremendous speed of 186,282 miles (299,792 kilometers) per second. Most of them speed on into the endless darkness of space. But some head straight toward a small, bluish planet that lies in their path. It is earth.

The waves of sunlight pass through earth's atmosphere and travel down to the planet's surface.

There, the light waves strike the leaves of green plants—trees, bushes, and blades of grass.

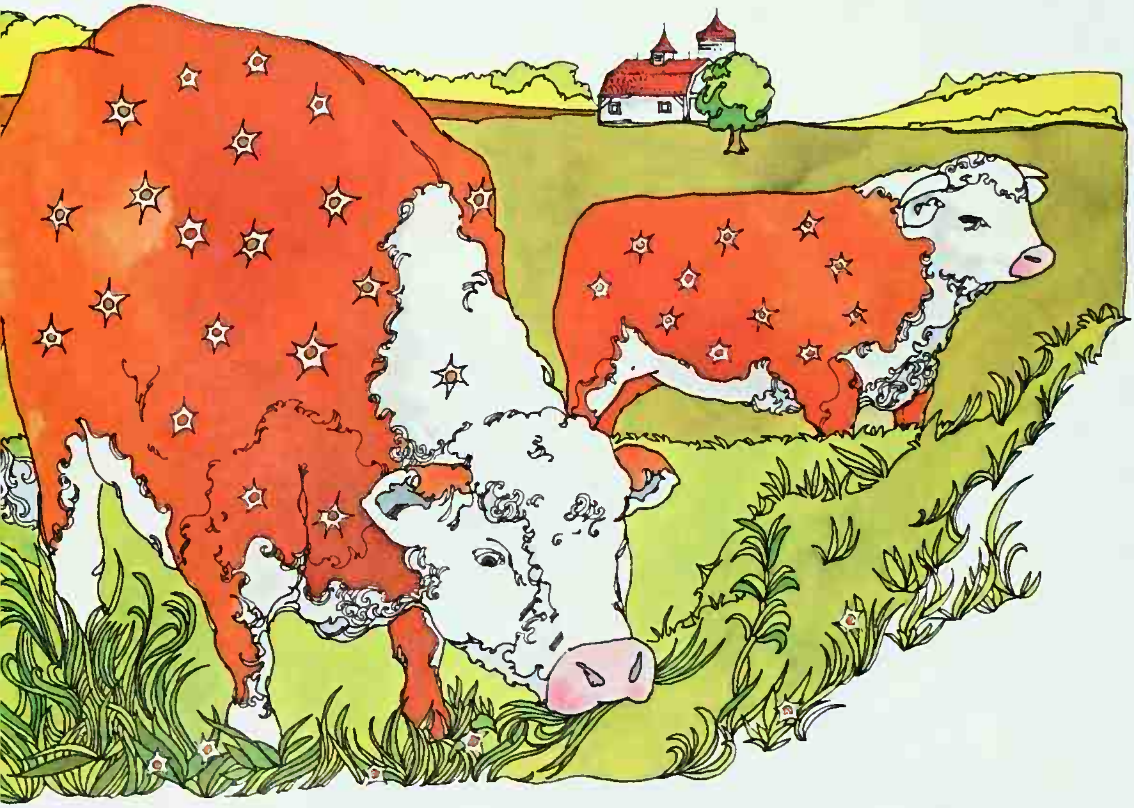
Green leaves are made of millions of tiny cells, like little bags. In each cell there are little blobs of green stuff called chlorophyll. When sunlight passes into a leaf, the little blobs of chlorophyll catch and hold tiny bits of the light—sparks of the sun's energy.

Plant cells are like factories, where the plant's food is made. Using the captured sunlight for power, the green blobs of chlorophyll turn water and carbon dioxide gas into a kind of sugar. This sugar is stored-up energy. The plant uses the stored-up energy for the

power to grow. Without energy from the sun, the plant couldn't grow or live.

A steer moves slowly through a field of grass. Each plant it eats has some of the stored-up energy. The energy is taken in by the steer's body and used for the power to make the steer live and move. Without the stored-up energy it gets from the plants it eats, the steer could not stay alive.

The steer is part of a herd being fattened for market. In time, the steers' bodies will be turned into steaks,



roasts, and hamburgers for people to eat. The energy in the steers' bodies will go into peoples' bodies, where it will be used to keep them alive. And, of course, people also eat many kinds of plants for the energy that's in them.

All living things must take in energy in order to stay alive. And nearly all energy comes from the sun. So the sun gives us much more than just light and heat. It truly gives us life.

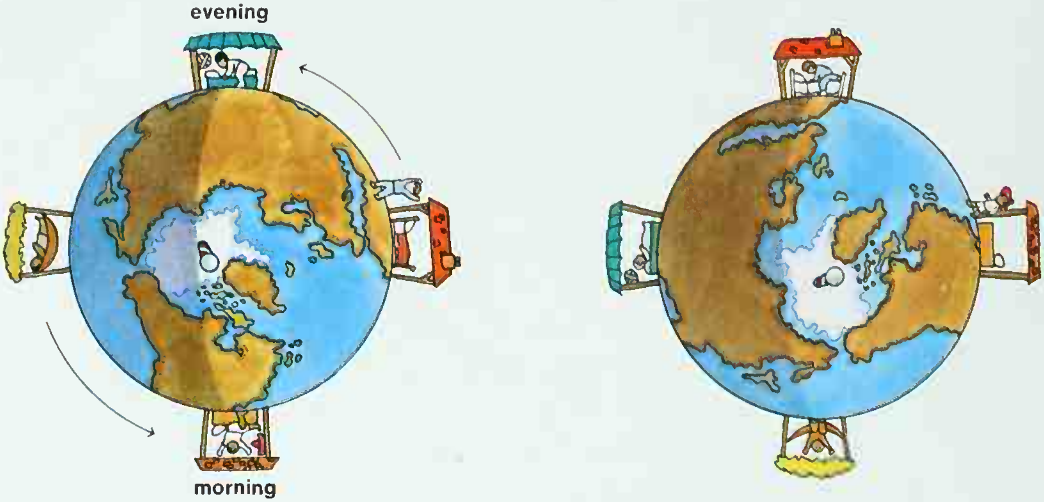
Moving into daytime

Imagine that you have awakened very, very early. You look out of a window. The sky is still black, and the whole world seems dark and silent.

But as you watch for a long time, the sky slowly turns from black to gray. You can begin to see things. The sky grows lighter. A pink glow spreads across the eastern horizon. Suddenly, you can see the tiniest tip of fiery red peeping over the edge of the land. The sun. Slowly, more and more of it becomes visible as it rises up into the sky.

This is the time of day that is called sunrise. But the sun doesn't really *rise*. It just looks as if it is moving up into the sky. What is really happening is that the part of the world you live on is *turning* toward the sun.

Half of the earth is always covered with light from the sun. The other half is always in darkness, for no sunlight can fall upon it. But the earth is always turning. As it turns, everything on it moves from darkness into sunlight, again and again. This is our night and day.



When it is morning for you, your part of the world is turning out of the darkness into the light. At sunrise, you are just on the edge of that half of the world that is in sunlight.

As the earth continues to turn, more and more sunlight falls upon the part of the world where you live. The sky grows brighter, and the sun seems to rise higher. But the sun isn't really moving. *You* are moving beneath it. When your part of the world has moved directly into line with the sun, the sun seems to be at its highest place in the sky. This is the time of day we call noon. The light is strongest then. Shadows are shortest.

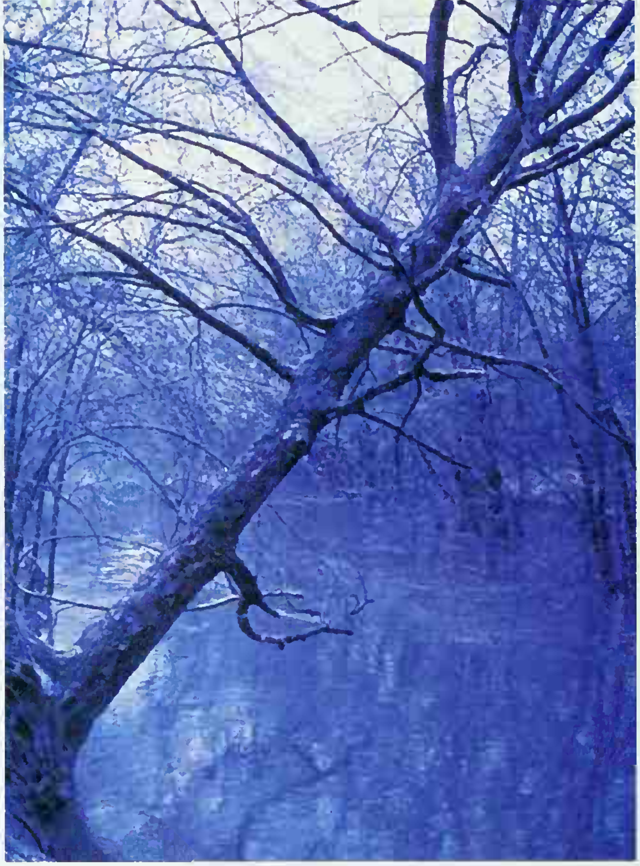
As the earth keeps turning, your part of the world moves away from the sun. This makes it seem as

if the sun is moving down in the sky. Shadows grow longer.

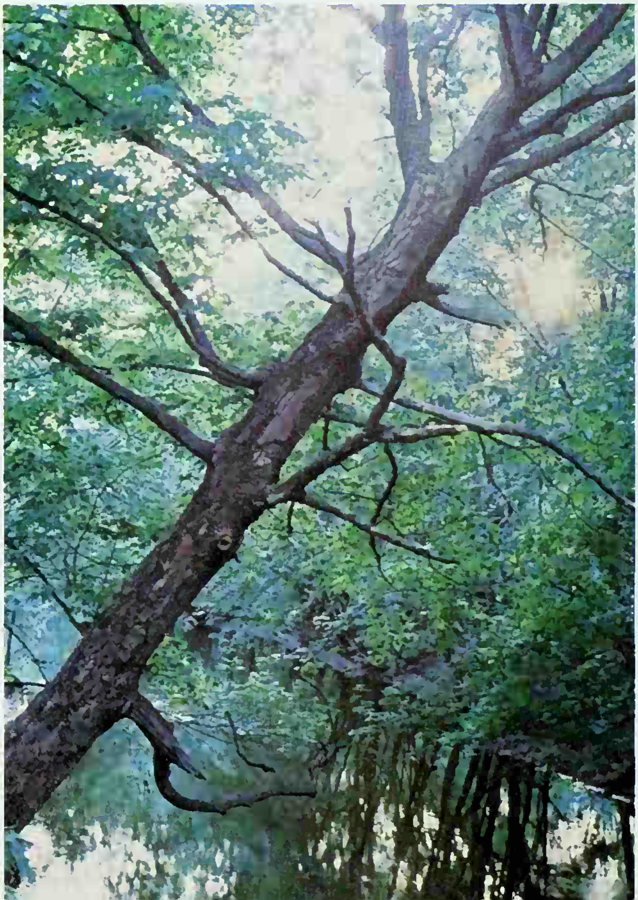
The earth turns until your part of it is once again on the very edge of the half that is in the sunlight. Now it is evening. The sky is darkening as you leave the light behind. This is the time we call sunset, because the sun looks as if it is dropping down behind the curve of the earth. Slowly, the part of the world where you live slips completely out of the sunlight. Now, you are turning toward the darkness of space.

It is night in your part of the world. You're getting ready for bed. But, halfway around the world from you, other children are waking up. Their part of the world has turned to where your part was this morning. For them, the day has begun.

spring



summer



The four seasons

Summer. Trees burst with thick loads of leaves. Flowers nod in soft, warm breezes. Insects buzz. A blue sky holds a bright, hot sun.

Winter. Bare trees stand like bony skeletons against a cold, gray sky. Snow blankets the ground. The sun seems pale and far away.

What causes this difference? Why is the earth warm in spring and summer and cold in winter and fall?

Summer comes to your part of the world when a lot of the sun's hot light falls steadily upon it. Winter comes when not as much of the sun's light reaches your part of the world. Then, the ground and air cool off.

fall

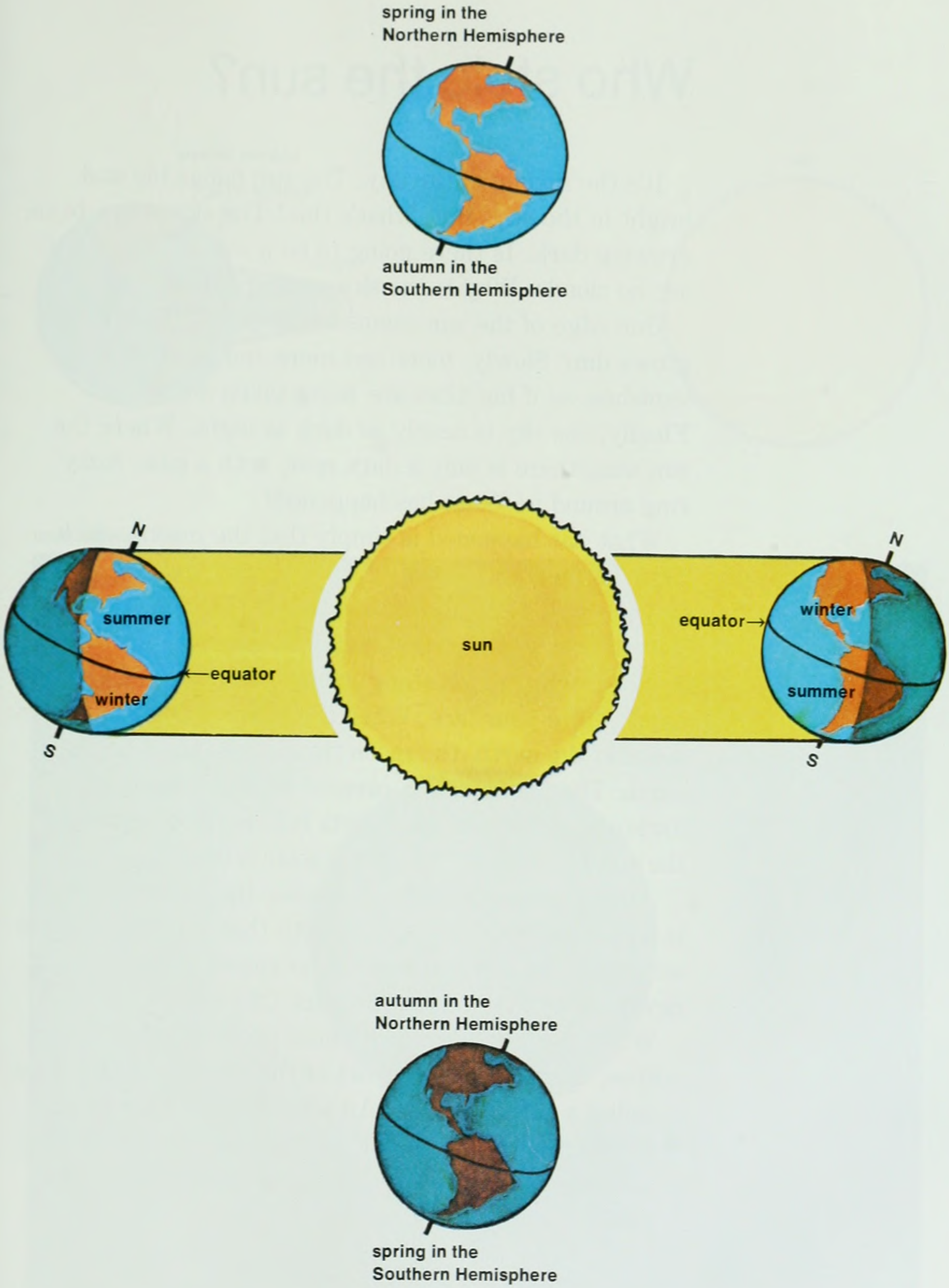
winter

The difference in the amount of sunlight is caused by the tilt of the earth. Earth's North and South poles don't point straight up and down, they are tilted. Thus, when the earth is at one end of its path around the sun, the North Pole is tilted toward the sun and the South Pole is tilted away from the sun. Then, most of the sun's light falls upon the northern half of the world, keeping it warm. This causes summer. Because the southern half of the earth isn't getting as much light, it is cool. This causes winter.

The earth moves on around the sun. When it has moved about one-fourth of the way around, the northern part gets less light than it did, so it grows cooler. This brings autumn to the north. The southern part gets more light than it did, so it starts to warm up. This causes spring in the south.

When the earth has moved halfway around the sun, the North Pole is tilted away from the sun, and the South Pole is tilted toward the sun. Now, the southern part of the world gets the most light and the northern part gets the least. So, people in the northern part shiver in winter's cold, while those in the southern part enjoy summer.

One part of the earth *always* has summer. A band around the middle of the earth, where the equator is, always gets about the same amount of sunlight. So, it always stays hot.


spring in the
Northern Hemisphere
autumn in the
Southern Hemisphere
N
summer
winter
equator
S
sun
N
equator
winter
summer
S
autumn in the
Northern Hemisphere
spring in the
Southern Hemisphere

Who stole the sun?

It's the middle of the day. The sun hangs big and bright in the sky. But, what's this? The sky seems to be growing dark. Is there going to be a storm? No, there are no clouds. Why is the sky getting dark?

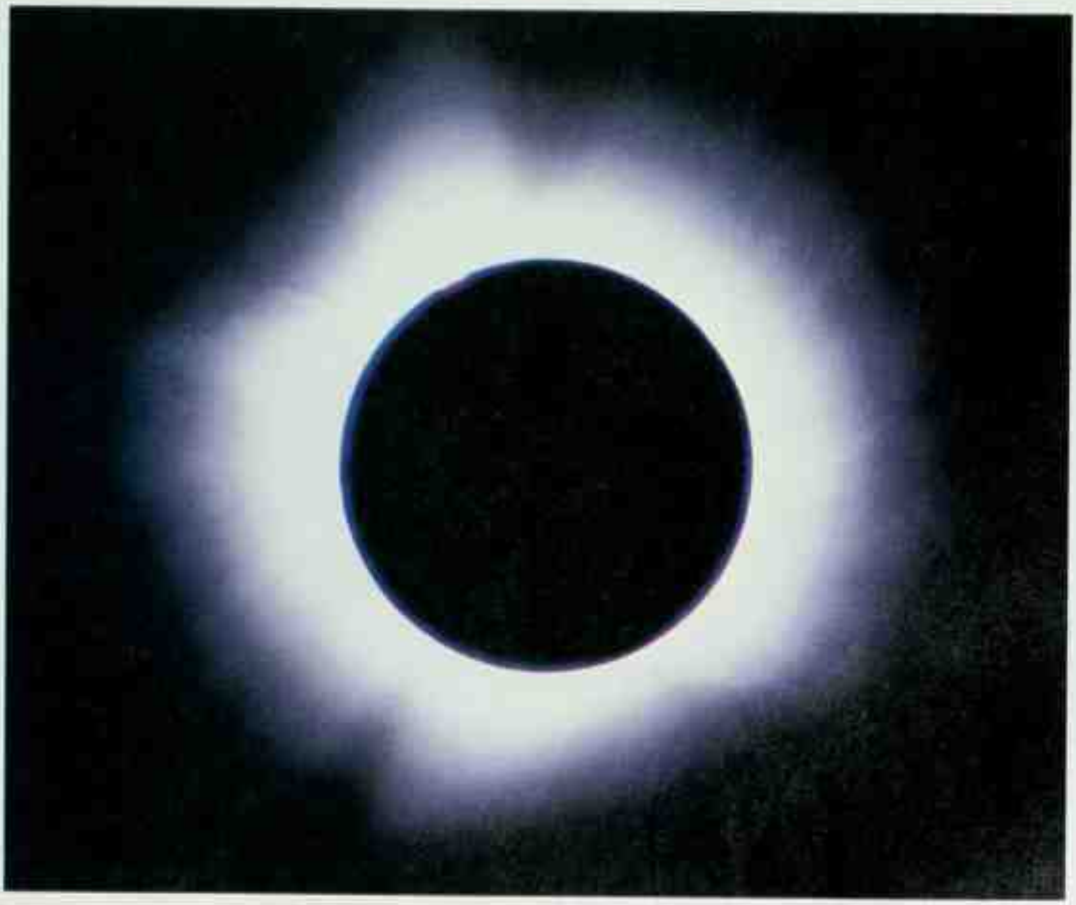
One edge of the sun seems to disappear! The sun grows dim! Slowly, more and more and more of it vanishes, as if big bites are being taken out of it. Finally, the sky is nearly as dark as night. Where the sun was, there is only a dark spot, with a pale, fuzzy ring around it! What has happened?

What has happened is simply that the moon, which moves around the earth, has passed *between* the earth and the sun. The sun is much bigger than the moon, but it is so far away that the moon can cover it up, just as you can cover up a distant house when you hold your hand before your face. When the moon is between the sun and the earth, the moon throws a shadow on the earth. The part of earth covered by the shadow is in darkness. When the moon gets between the earth and the sun this way, it is called a solar eclipse.

A solar eclipse can't be seen over the whole world. It is only seen from the part of earth that is directly in line with both the sun and moon. The moon's shadow is never wider than about 170 miles (274 kilometers).

When the whole sun is covered up, it is called a total eclipse. Sometimes, only part of the sun is covered. That is called a partial eclipse. An eclipse never lasts more than about seven and a half minutes. Never look directly at an eclipse, not even with sunglasses or through film. Your eyes could be badly injured!

total eclipse



Our next-door neighbor

As earth whirls along on its endless journey through space, it has a companion that is always beside it—the moon. The moon is a small planet. It is only about one-fourth as big as earth.

The moon is our nearest neighbor in space. The stars are billions of miles (kilometers) away. The sun is millions of miles (kilometers) away. But the moon is only about 239,000 miles (384,000 kilometers) away. That makes the moon truly a next-door neighbor.

In a way, the moon "belongs" to earth. Just as earth moves around and around the sun, the moon moves around and around earth. It is held in place by the tug of earth's stronger gravity. A planet that is held by another planet this way is called a satellite. The moon is earth's satellite.

The moon is a ball of gray rock, some of which is covered with dust. It has no air or water—and, of course, no plants or animals. Its whole surface is nothing but mountains and plains of rock. When we look up at a full moon, we can often see dark patches. These dark places are the lowlands. They seem to form a shadowy face that people have named "the man in the moon." The brighter parts of the moon are the highlands.

In ancient times, many people worshiped the moon. The Romans, who thought the moon was a goddess, named it Luna. Our word *lunar* means "of the moon."

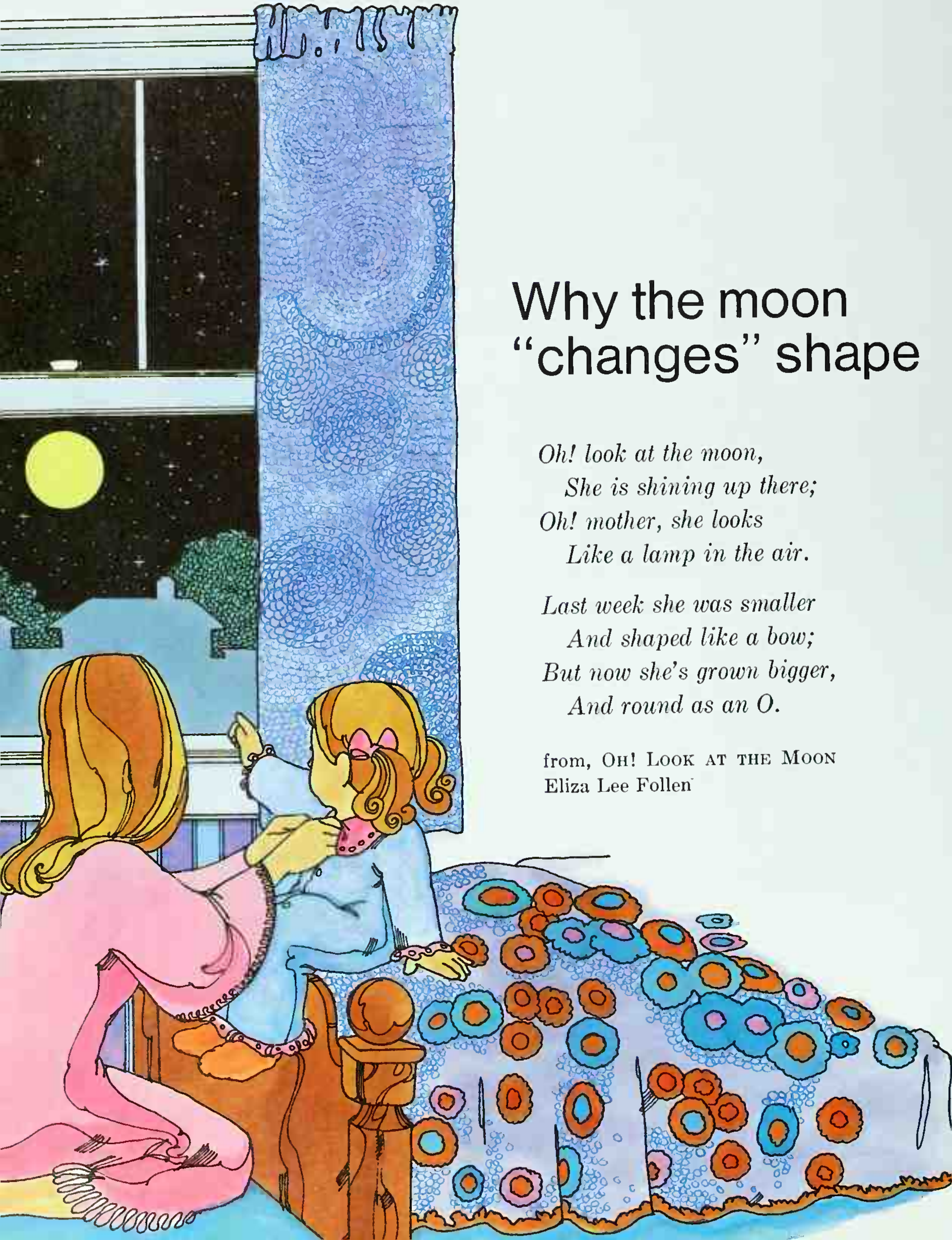
Why the moon shines

Why *does* the moon shine? It isn't a ball of hot, glowing gas, like the sun. It's a ball of cold, hard rock. How can rock give off light?

The answer to that may surprise you. The moon is like a giant mirror. The light it sends to earth is light that is reflected from the sun.

The moon isn't really a very good mirror. It isn't a bit smooth and shiny. In fact, most of the rock on the moon is rough and dark gray. It doesn't really reflect much sunlight. But sunlight is so bright that even the tiny bit that is reflected from the moon makes the moon look like a glowing ball in our sky.

Actually, earth is a mirror, too! It reflects some of the sunlight that falls on it. And it's a better mirror than the moon!



Why the moon "changes" shape

Oh! look at the moon,
She is shining up there;
Oh! mother, she looks
Like a lamp in the air.

Last week she was smaller
And shaped like a bow;
But now she's grown bigger,
And round as an O.

from, OH! LOOK AT THE MOON
Eliza Lee Follen

full moon

half moon

The moon does, indeed, seem to change from a slim bow into a fat, round O and back to a bow again. These changes take place as the moon goes around the earth. We call these changes phases.

In its first phase, the moon can't be seen at all. It is between the earth and the sun. The sun shines on the side of the moon that is turned away from us. Because of this, we can't see the dark side that faces us.

After a day or two, the moon moves

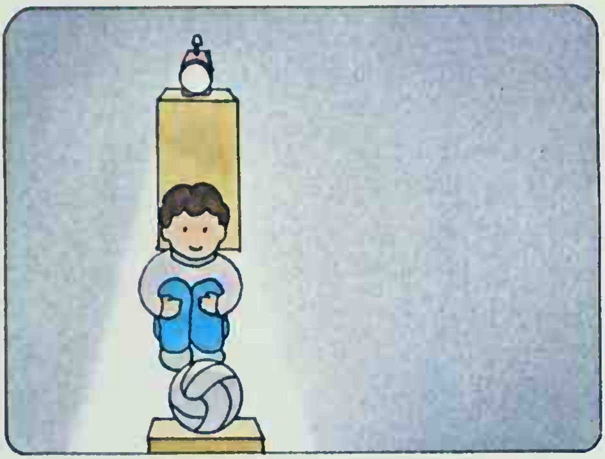
crescent moon

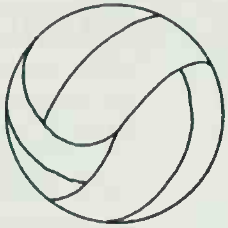
You can see for yourself why the moon has phases. You'll need a bright flashlight, a large ball, and a dark room. The flashlight acts as the sun, the ball is the moon, and you will be the earth.

far enough to one side of us so that we can see a tiny bit of the side that is lit by the sun. From earth, this tiny bit looks like a silvery bow. We call this phase a crescent moon.

After seven days, the moon has moved enough so that we can see half of its sunlit side. This is a half moon.

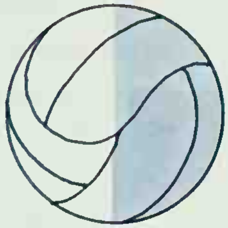
After about two weeks, the moon is halfway around the earth from where it started. Now we can see the whole side of the moon the sun shines on. It is now a bright, round, full moon. As it moves on around the earth it becomes a half moon, then a bow again. Finally, its dark side is again turned to us.





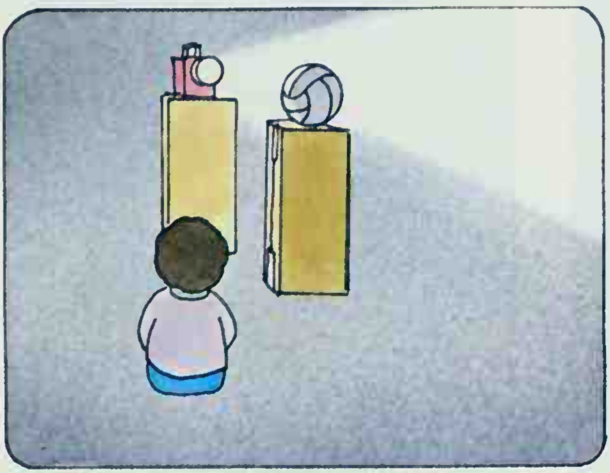
full moon

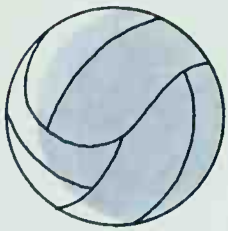
Sit directly between the light and the ball. The whole side of the ball facing you will be in light, just as a full moon is.



half moon

Move the ball to your left. Go back to where you were and face the ball. Only half the ball will be in the light, like a half moon.





crescent moon

Move the ball nearly between you and the light. Most of the ball will be in shadow. Only a small part will be lit, like a crescent moon.

Shadow on the moon

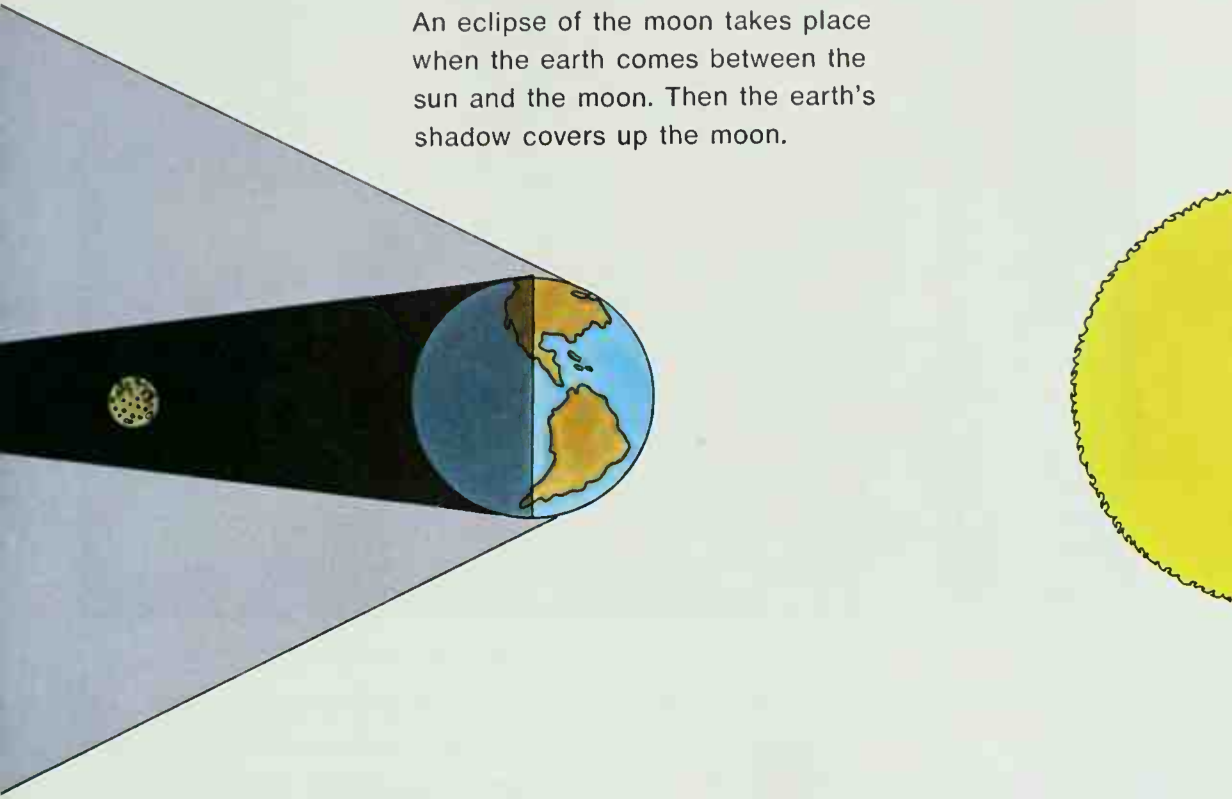
The night is clear and starry. There's a bright, full moon in the sky. But, then, a tiny, curved shadow appears on the edge of the moon. Slowly, the shadow creeps over the moon. More and more of the moon is covered by it! And, finally, the whole moon is in shadow.

That's what happens during an eclipse of the moon. An eclipse of the moon is called a lunar eclipse. It takes place when the earth comes between the sun and the moon. When that happens, the earth casts a shadow on the face of the moon, darkening it.

The moon is seldom completely darkened by the earth's shadow, however. Some of the sunlight passing the earth gets "bent" by the earth's atmosphere. This light is reflected onto the moon. So the moon is still faintly visible. Thus, an eclipse of the moon isn't as exciting as a solar eclipse.

an eclipse of the moon

An eclipse of the moon takes place when the earth comes between the sun and the moon. Then the earth's shadow covers up the moon.



The far side of the moon

For hundreds of years, ever since people have known that the moon was like a planet, they have wondered about something. They have wondered what the far side of the moon was like.

You see, even though the moon spins around, we never get to see all of it. The tug of earth's gravity causes the moon to spin very slowly. In fact, the moon only spins around once in the time it takes to go all the way around the earth. As a result, the same side of the moon always faces the earth. The diagram on the opposite page shows how this happens.

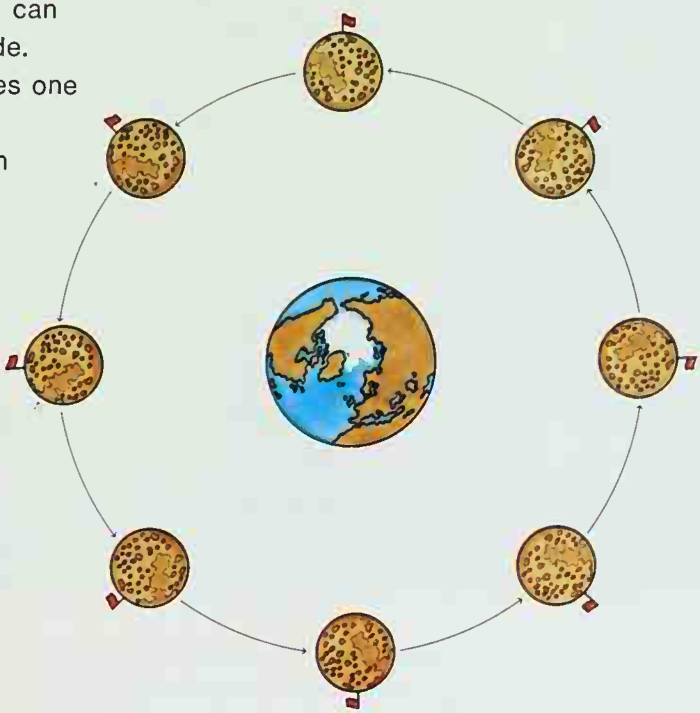
People wondered what the moon's far side was like. Was it bare and rocky, like the side we can see? Or was it different? Was it possible that there might be water, plants, and animals living on the side we cannot see?

We don't have to wonder anymore. In 1959, a Soviet spaceship went around the moon. There was no one on this ship, but there were cameras that took pictures of the moon's far side. Later, other Soviet and American spaceships, some with people in them, took more pictures. The pictures showed that the far side of the moon is just as bare and rocky as the side we see.

So, we now know something that all the billions of people who lived before us didn't know. We know what the far side of the moon looks like.

the far side of the moon

This diagram shows why we can never see the moon's far side. Even though the moon makes one full turn as it goes around the earth, its far side (shown by the flag) is never turned toward us.



On the moon

People have visited the moon and walked on it, so we know what the surface of the moon is like. This big ball of gray rock has broad, flat plains covered with powdery rock dust. There are rugged mountains. And there are thousands of billions of round pits called craters.

The craters were made by chunks of rock that smashed into the moon like bullets. Such chunks of rock, called meteoroids, move around the sun, just as the earth and moon do. During the billions of years since the moon was formed, billions of meteoroids have bumped into it. The moon and the meteoroids were moving so fast when they crashed together, that the meteoroids dug craters in the moon's surface. Now, the moon is pitted and pocked with these craters.

Some of the craters are no bigger than pinheads, some are the size of a car tire, some are hundreds of feet (meters) wide. But most are about five to ten miles (8 to 16 kilometers) wide. The biggest is about seven hundred miles (1,100 kilometers) wide. When the meteoroids struck, they usually threw up walls of rock around the craters they made. The moon's mountains are really the walls of huge craters.

There is no air on the moon to scatter the sunlight, so even in daytime the sky is pitch black and filled with stars. Because the moon turns so slowly, one day on the moon is as long as fourteen days and nights on earth. During the moon's daylight hours, the rocky surface grows so hot it would burn you if you touched

the surface of the moon

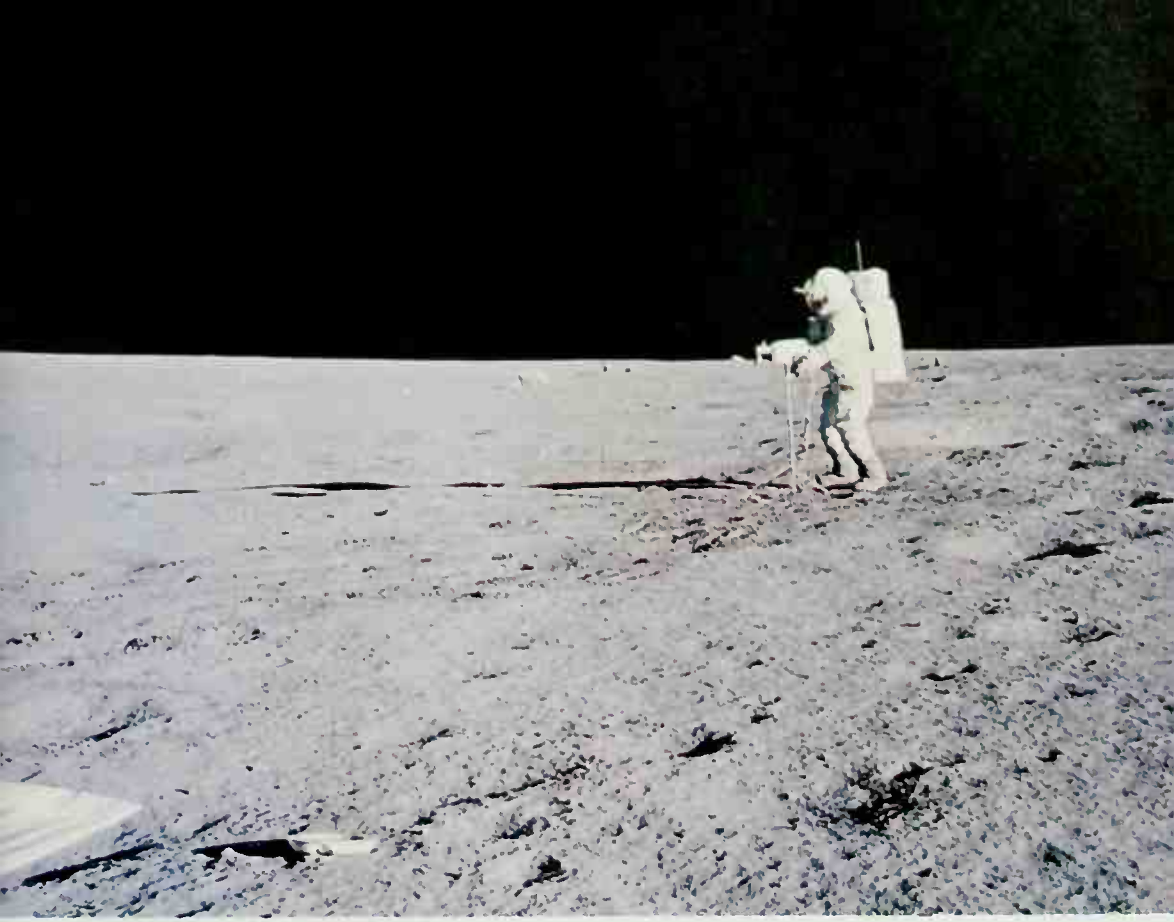
This is the part of the moon where American astronauts landed in 1972. In the background are part of the Taurus Mountains.

it. But during the long night, the moon grows colder than the coldest place on earth.

The moon's gravity isn't as strong as earth's gravity. On the moon, you could jump six times higher than you could on earth, and lift things that would be too heavy for you to lift on earth.

With no air, there is no sound on the moon. And there is no wind to stir the rock dust that lies thickly on the plains. The moon is a still, silent, barren, lifeless place, unlike any part of earth.

a moon crater



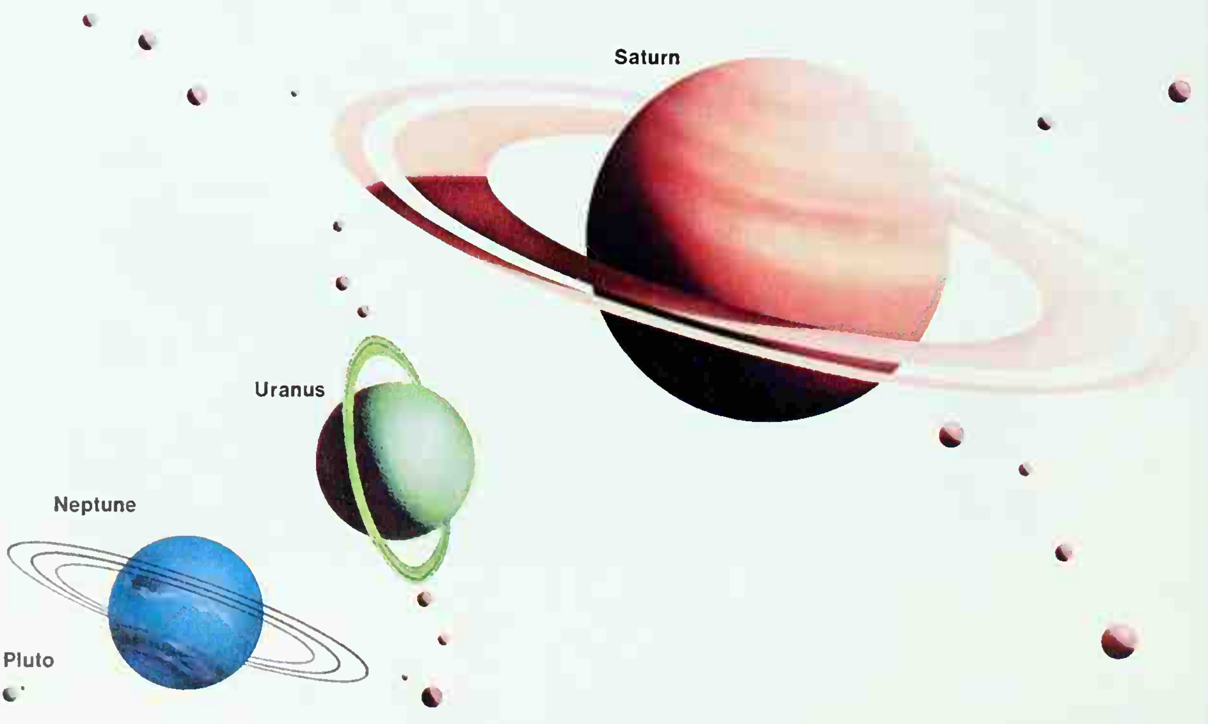
an astronaut walks upon one of the moon's barren plains

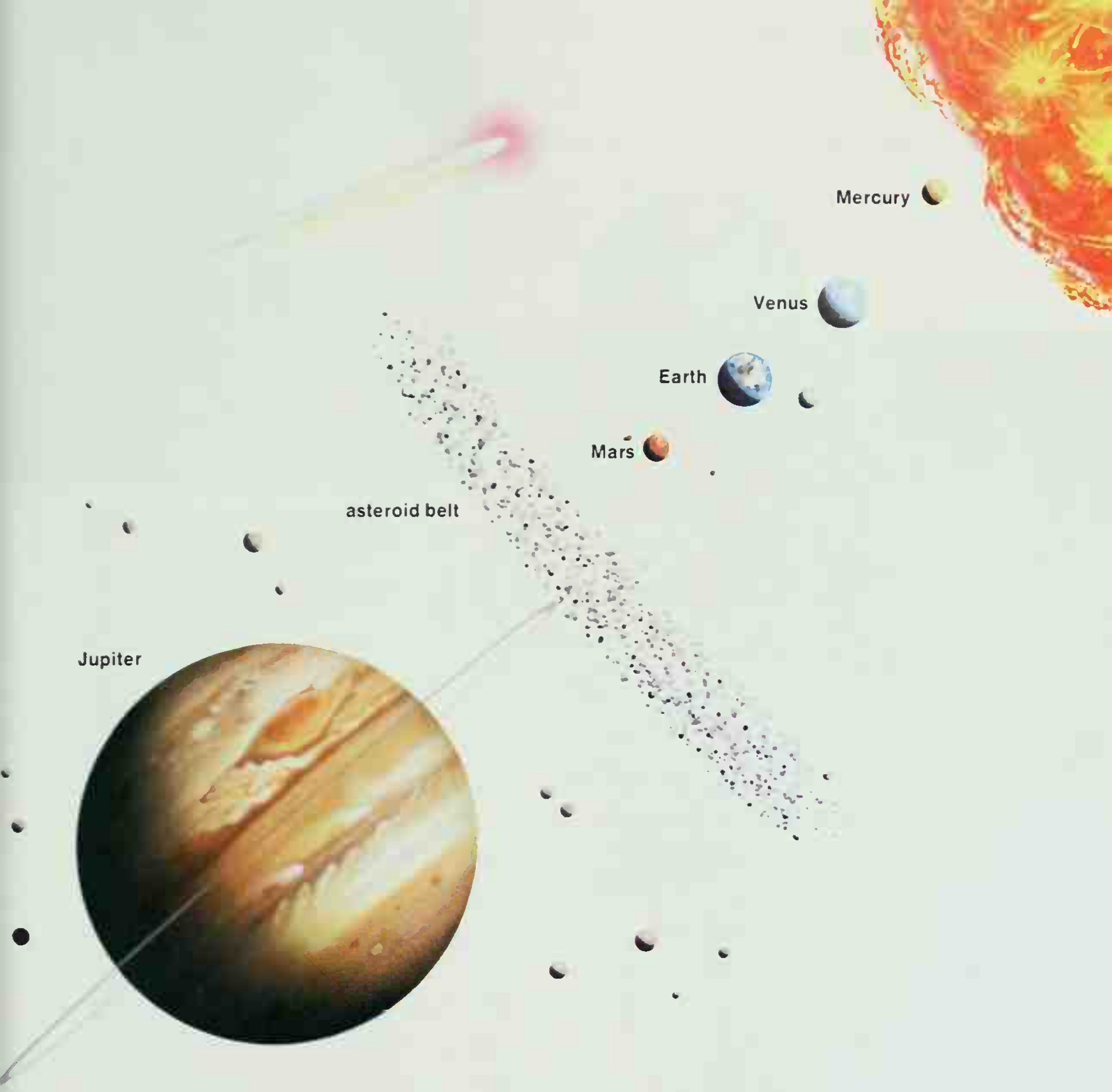
an astronaut's footprint in the powdery moon soil

The sun's family

The planet earth is part of a family. It is one of nine planets that belong to the sun. We can see some of these planets at night, shining like bright stars. Like the earth and the moon, the other planets all shine with reflected sunlight.

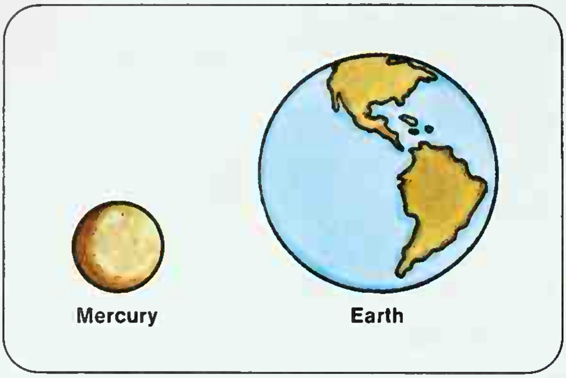
Each planet moves around the sun in a path called an orbit. There are many millions of miles (kilometers) between the planets. Two planets are closer to the sun than the earth; the others are all farther away. Four planets are smaller than the earth; four are much bigger. Seven of the planets have moons, or satellites.





Planets and moons aren't the only things whirling around the sun. There are also billions of chunks of rock and metal called meteoroids. There is a ring of much larger chunks of rock and metal, like small planets, called asteroids. There are comets, clouds of drifting gas, and bits of dust.

All these things are tied to the sun by its gravity. They are the sun's "family," called the solar system.

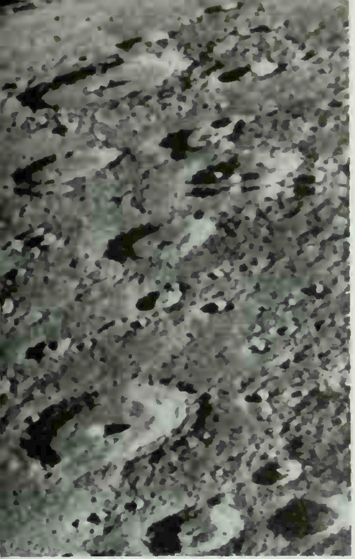


Closest to the sun

The planet closest to the sun is Mercury. It is one of the smallest of the nine planets—only a little more than one-third the size of the earth. Seen from the earth, Mercury appears, disappears, and appears again. This is why it was named after the Roman god Mercury. As the messenger of the gods, Mercury was thought to move swiftly back and forth between heaven and earth.

Mercury, much like our moon, is a bare, rocky ball covered with billions of craters. In Mercury's sky, the sun appears many times bigger and brighter than it looks from earth. This is because Mercury is only about 36 million miles (57.9 million kilometers) away from the sun. The side of Mercury facing the sun is tremendously hot. The other side is fiercely cold.

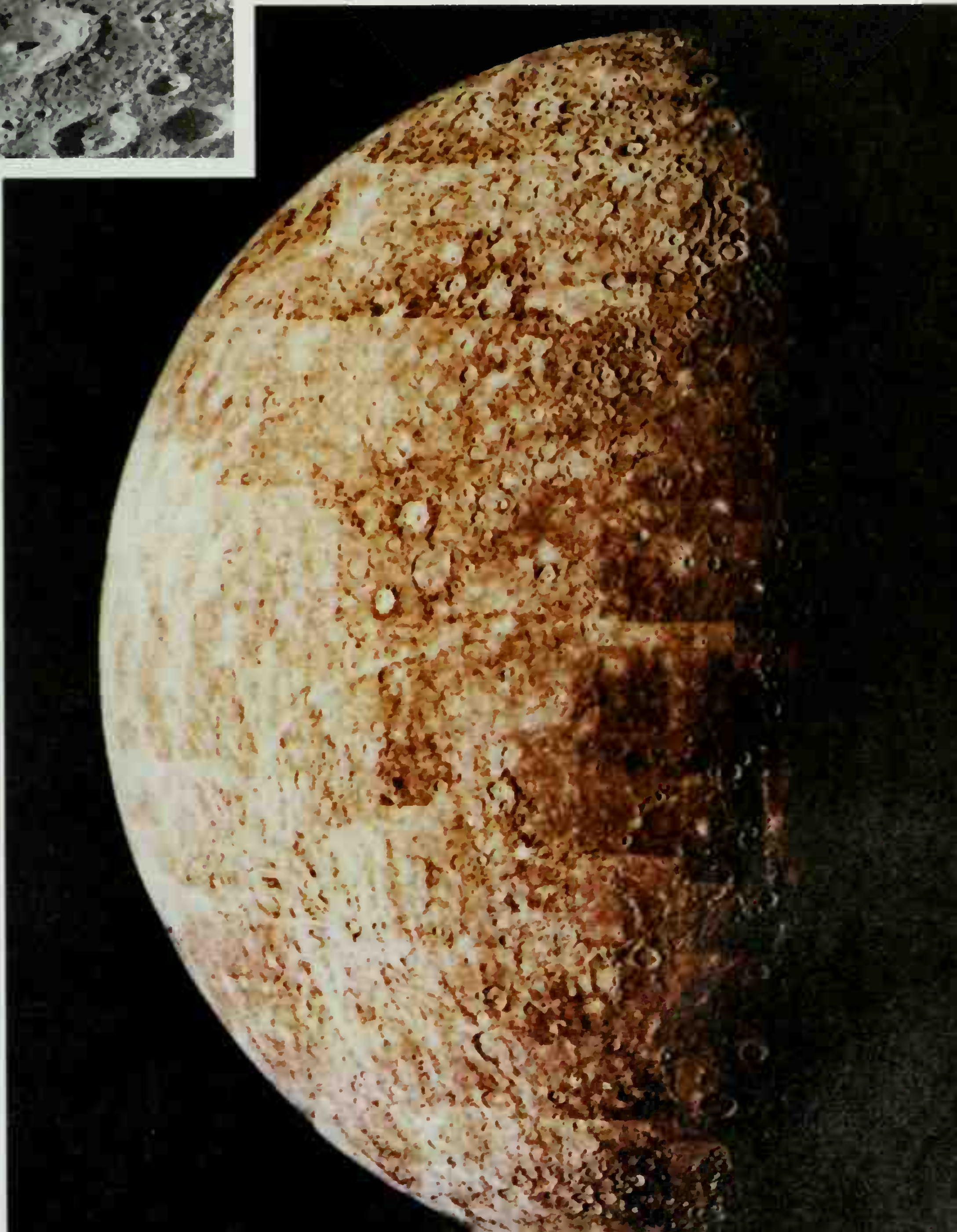
A year on Mercury is only as long as 88 of our days. That's how long it takes Mercury to move all the way around the sun. But a day on Mercury is equal to 59 of our days! Mercury spins around so slowly that its day is nearly as long as its year.

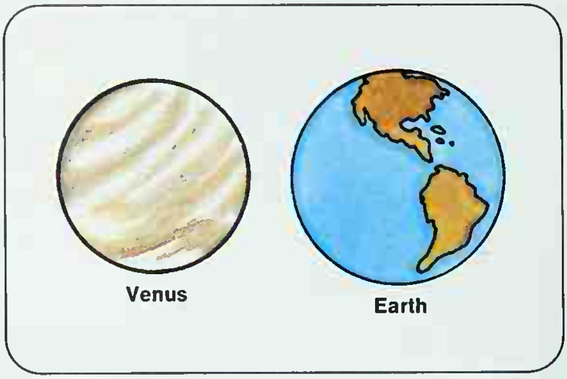


the surface of Mercury

Mercury is very much like our moon. It is a bare ball of rock, covered with craters.

Mercury





Venus

Earth's "twin"

The second closest planet to the sun is Venus. Seen from the earth, it is the brightest of all the stars and planets in our sky. Sometimes it can even be seen in daylight. Because of its beauty, it was named after the Roman goddess of love and beauty.

Venus is nearly the same size as the earth and is often called the earth's "twin." But Venus is really nothing at all like our world.

Like the earth, Venus has an atmosphere—but the "air" of Venus is full of poisonous gases. It is filled with such thick clouds that we can't see the surface of the planet. These clouds contain droplets of sulfuric acid—a chemical so strong it can dissolve metal!

High in Venus' atmosphere, there are terrible windstorms, with winds that blow harder than the strongest hurricanes on earth. The sky is lit by constant flickers of lightning that flash as often as twenty times a minute.

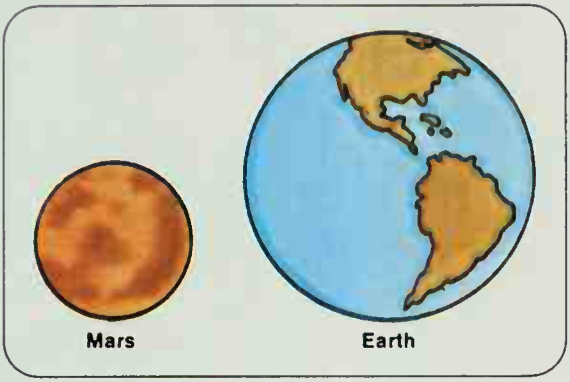
Because Venus is always hidden by clouds, scientists have used spacecraft to photograph its surface and test its soil. We now know that the surface of Venus is so hot it would melt lead. There is no water, nor any other liquid, anywhere. Much of the surface is a huge, rolling plain, but there are also great mountains, long and deep canyons, and big and small volcanoes, some of which may be active.

Venus is about 67 million miles (108 million kilometers) from the sun. Its year is as long as 225 of our days. But its day is as long as 243 of our days. On Venus, a day is longer than a year!

The red planet

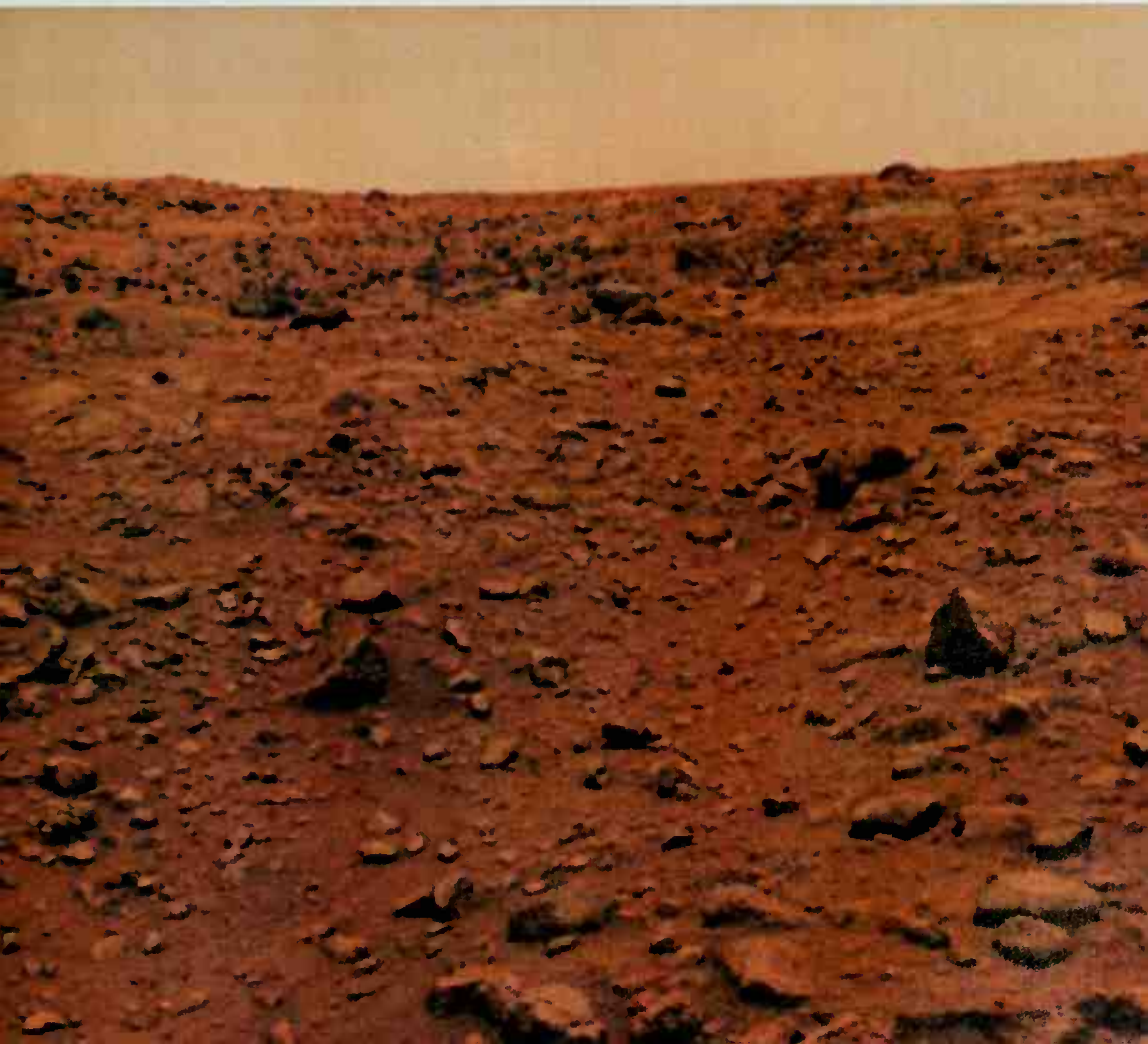
At night, you can sometimes see a bright "star" that shines with a reddish gleam. It is Mars, the "red planet," named after the Roman god of war. Mars is the fourth planet from the sun —about 142 million miles (228 million kilometers) away.

Some parts of Mars look like the moon. But Mars isn't a dead world like the moon. It has a thin atmosphere made up of several gases, and thin blue and thick white clouds move across its sky. Fierce windstorms whirl sand up from the plains



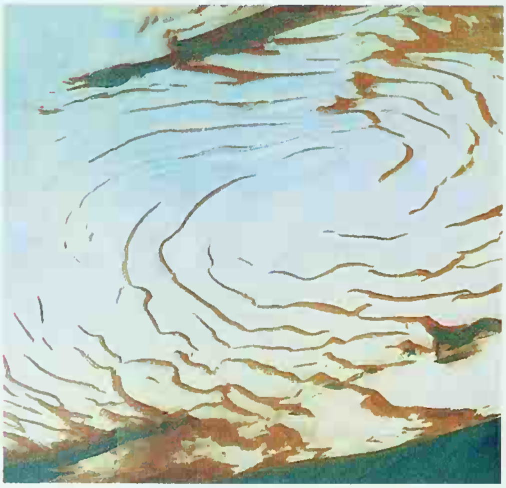
the surface of Mars

This picture was taken by a space vehicle that landed on Mars. The orange sky is caused by red dust in the atmosphere.



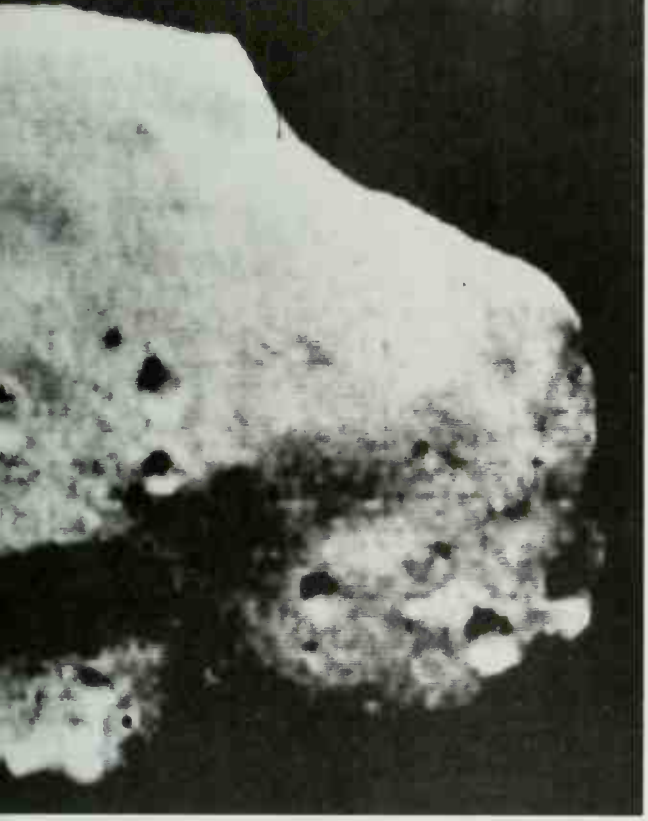
Mars's north pole

The north and south poles of Mars are covered with snow, just like the poles on Earth.



Volcano on Mars

A giant volcano on Mars can be seen near the top of this photograph.



a Martian moon

Phobos, Mars's largest moon, is a lumpy rock about fourteen miles (23 kilometers) wide.

and fill the air with dust. This dust gives the Martian sky its strange orange color.

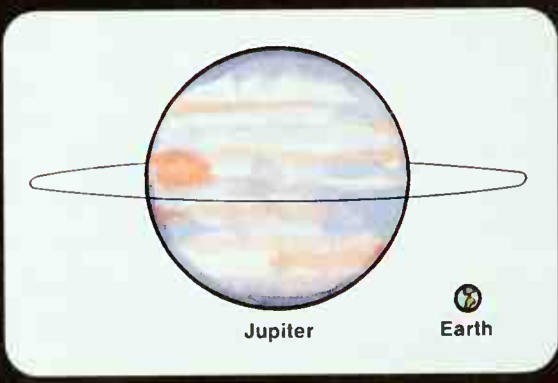
There are volcanoes on Mars. One of them is two times higher and many times wider than Mount Everest, the highest mountain on Earth. There are also canyons on Mars. One of these canyons is as wide as the whole continent of North America. And it is many times deeper than the earth's deepest canyon, the Grand Canyon of the Colorado River in Arizona.

Mars has two little moons that are just lumpy chunks of rock. The largest, called Phobos, is about fourteen miles (23 kilometers) wide. The other, Deimos, is about six miles (10 kilometers) wide.

Mars is only about half as big as the earth. Its year is nearly twice as long as ours, but its day is about the same.

Jupiter

The Great Red Spot seems to be a giant hurricane.



The giant planet

The giant of the sun's family is the planet Jupiter. It's the biggest planet of the solar system—more than eleven times bigger than the earth. Jupiter is named after the king of the Roman gods.

The earth, the moon, and Mars are solid rock, but Jupiter is very different. Although it may have a small rocky core, most of this huge planet is a ball of hot liquid surrounded by thick clouds of gas. The clouds form colored bands around the planet. There is also a strange spot called the Great Red Spot. It seems to be an enormous hurricane, more than three times as wide as the earth is thick. It has been whirling in Jupiter's atmosphere for hundreds of years. And other wild windstorms are always raging in Jupiter's thick clouds.

Jupiter has sixteen moons. The smallest moon isn't as big as most of the earth's mountains. The biggest, called Ganymede, is bigger than the planet Mercury. One moon, called Io, has erupting volcanoes.

Jupiter is surrounded by a very thin ring of dust. This ring may be what is left of a moon that came too close to Jupiter. The tremendous pull of Jupiter's gravity would have torn it apart.

Jupiter is about 484 million miles (778 million kilometers) from the sun. A year on Jupiter is about 12 earth-years long, but a day is only about 10 hours.

Scientists have used space probes to study Jupiter. In 1977, *Voyager 1* and *Voyager 2* were launched in the United States. Both probes flew past Jupiter and Saturn. *Voyager 1* found Jupiter's ring, and *Voyager 2* photographed the four largest moons.

A many-ringed planet

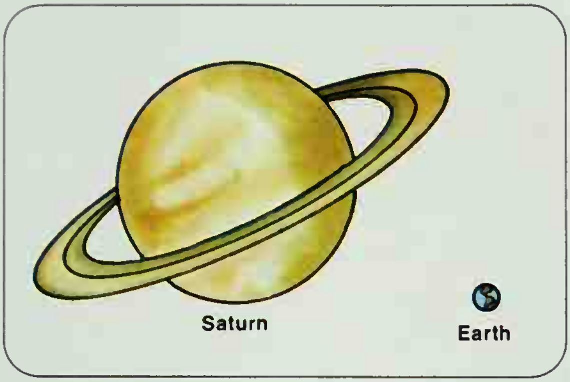
The sixth planet from the sun is Saturn. It is the second largest planet—nearly ten times bigger than the earth. Saturn is named after the Roman god of farming. It has a rocky center, probably covered by a thin layer of liquid, and is surrounded by thick clouds of gas. Big as it is, Saturn isn't even as thick or heavy as a ball of water the same size. In fact, if there were an ocean big enough to hold it, Saturn would float!

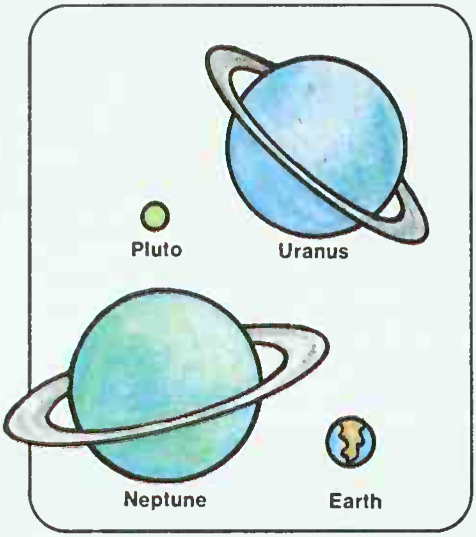
Saturn is surrounded by seven flat rings, one inside the other. These rings are made up of thousands of narrow ringlets. The rings are formed of billions of pieces of ice, from tiny specks to very large "snowballs." The bits of ice circle around Saturn just as the moon circles the earth. Scientists think these bits are either material left over when Saturn was formed, or the remains of an icy moon that broke up.

Beyond its rings, Saturn has twenty-three moons. Most of them are chunks of ice mixed with rock. They range in size from less than 25 miles (40 kilometers) wide to more than 3,000 miles (4,800 kilometers) wide. The largest moon, Titan, is bigger than the earth's moon and has a thick, cloudy atmosphere.

Saturn is about 885 million miles (1.4 billion kilometers) from the sun. Its year is almost 30 earth-years long, and its day is about 10½ hours.

Scientists used the space probes *Voyager 1* and *Voyager 2* to study Saturn. The information from the two probes helped them find nine of Saturn's moons and prove that Saturn had a seventh ring.


Saturn
Earth



visiting the farthest planets

Space probes have visited Uranus and Neptune. Someday, we may send a space vehicle to Pluto, the farthest planet.

The faraway worlds

The seventh, eighth, and ninth planets of the sun's family are very far away. Until recently, we knew very little about them. In 1986, the space probe *Voyager 2* reached Uranus, and in 1989, it reached Neptune. It sent information about both planets back to the earth.

Uranus, the seventh planet, was named after an ancient sky god. It is about 1.8 billion miles (2.9 billion kilometers) from the sun. Uranus probably is made up of frozen gases. It is surrounded by thick clouds of icy crystals. Its year is about 84 earth-years long, and its day is about 16 hours. Uranus has fifteen moons and at least eleven rings.

Neptune, the eighth planet, was named after the Roman god of the sea. It is about 2.8 billion miles (4.5 billion kilometers) from the sun. Neptune is also mostly made up of gases, but its center may be a mixture of slush and rocks. Its year is about 165 earth-years long, and its day is about 17 hours. Like Jupiter, it has strong winds and a large spot, the Great Dark Spot. Neptune has four rings and eight moons. The largest moon, Triton, has "volcanoes" that give off gases and slushy ice.

Pluto, the ninth planet, was named after the Roman god of the dead. It is about 3.7 billion miles (5.9 billion kilometers) from the sun. At that distance, the sun probably looks like only a very bright star. Pluto is made up of frozen gases, and it is mostly ice. Its year is about 248 earth-years long, and its day is about 6 earth-days. It has one tiny moon.

The tiny planets

Just as there are giant planets in the sun's family—Jupiter and Saturn—there are also "dwarf" planets. These small planets are called asteroids.

Asteroids circle the sun in a ring between Mars and Jupiter. There are thousands of them. Most are less than a mile (1.6 kilometers) across. Some are several hundred miles (kilometers) across. The largest asteroid, named Ceres, is about 600 miles (1,000 kilometers) wide.

The larger asteroids are nearly ball-shaped, like the bigger planets. But the smaller asteroids are bumpy and jagged. They may be pieces of larger asteroids, for asteroids often bump into each other and break into smaller bits. When this happens, they are knocked out of their paths and into new ones. They become meteoroids that sometimes collide with other planets. Such collisions made the craters on the moon, Mars, and Mercury. Bits of asteroids also become the "shooting stars" that we see from earth.

"Shooting stars"

A big lump of rock and metal—a meteoroid—rushes through the blackness of space. For billions of years, ever since the planets were formed, it has been zipping around and around the sun. But now it is about to meet its end. The lump of rock is heading straight toward a huge, blue ball—the earth.

The rocky lump hurtles through space and into the earth's atmosphere. Almost at once it begins to glow red-hot. It is traveling at such tremendous speed that earth's air is rubbing hard against it. This friction makes the lump of rock grow hot, just as your hands get warm when you rub them together.

The rock turns from red-hot to white-hot. Bits of it burn up, leaving a trail of glowing gas. Seen from the surface of the earth, the burning rock looks like a bright streak, flashing across the sky. A child looks up and sees it. "Look, Mother!" the child says. "A shooting star!"

That's what a "shooting star" or a "falling star" is—a meteoroid from outer space that comes into earth's atmosphere and burns up. But when a meteoroid comes into our atmosphere and burns, we call it a meteor.

As many as 200 million meteors come into earth's atmosphere every day. Most of them are quite small, and burn up completely. But if a meteor is big enough, it may not burn up before it hits the ground. It comes smashing into the earth, a white-hot lump that slowly cools off. Then we call it a meteorite—a chunk of metal, or metal mixed with rock, that has come to earth from outer space.

Most meteorites burn away until very little is left of them. But some, that were huge to start with, still weigh many tons. And, several times, the earth has been struck by enormous meteorites that dug huge craters several miles (kilometers) wide and hundreds of feet (meters) deep.

Most meteoroids that strike the earth and other planets are probably pieces of asteroids that have been knocked out of their orbits. Others are probably parts of comets.

This meteorite is about four feet (1.2 meters) wide and weighs 3,275 pounds (1,474 kilograms).

the great Meteor Crater of Arizona

Long ago, a giant meteorite crashed into the earth and made this crater. The crater is about 4,150 feet (1,265 meters) across and 570 feet (174 meters) deep.

A "star" with a tail

Night after night, a long, shining streak hung in the sky. It looked like a big, bright star with a glowing tail. Each night it seemed to grow bigger and brighter. People were terrified. "It's the end of the world," they wailed.

For thousands of years, whenever a comet appeared in the sky, people were afraid of it. Now we know that comets are just part of the sun's family. There are many billions of them, going around and around the sun, just as the planets do. Sometimes a comet's path brings it close to the earth, so that it appears as a long, glowing streak in the night sky.

Most comets are balls of frozen gas, like snow, mixed with dust. The comet does not have a tail until it gets near the sun. Then, the sun's heat melts some of the frozen gas, and gas and dust stream off into space, forming the tail. The tail glows because sunlight shines on the gas and dust and also releases energy from the gas.

The center of a comet's icy head may be about ten miles (16 kilometers) wide. It is surrounded by a cloud of gas as much as a million miles (1,600,000 kilometers) wide. A comet's tail may be as much as a hundred million miles (160,000,000 kilometers) long.

Halley's Comet seen from the earth, New Mexico

Comet Bennett

Why do stars twinkle?

The sun and its family of planets, asteroids, meteoroids, and comets are like tiny specks of dust floating in a gigantic ocean. The endless ocean of space also contains countless billions of other "specks" —the stars.

Stars shine with a steady glow, just as the sun does. But they seem to twinkle. Why? Because, when the light from stars reaches our atmosphere, it gets bent, several times, by layers of moving air.

Five of the "stars" we see in the sky at night are really other planets in our solar system. They shine because they reflect sunlight. But most of the stars are other suns, like our sun, that shine with light of their own. These stars are trillions and trillions of miles (kilometers) away from us.

The nearest star to us is so far that it takes four years for its light to reach us. And light travels at the tremendous speed of 186,282 miles (299,792 kilometers) per second. Some stars are so far that it takes their light thousands, or even millions, of years to reach us! A twinkle of light that you see in the sky tonight may have been given off when dinosaurs lived on earth!

How many stars are there? We don't know exactly, but scientists believe there are billions and billions— more stars than there are grains of sand on all the beaches of the world!

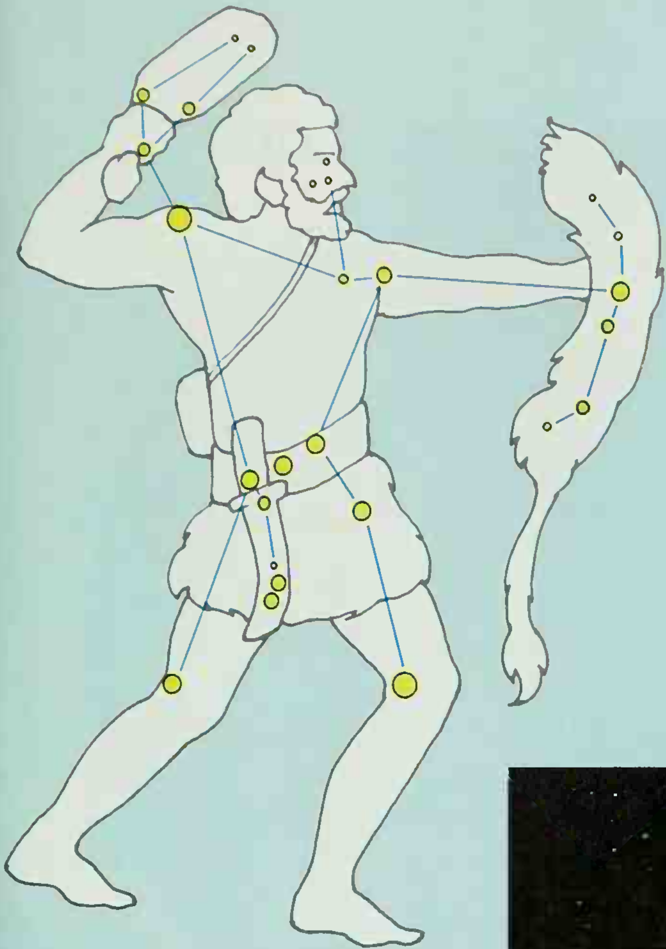
Children sometimes wonder where stars go in the daytime. They don't "go" anywhere, of course. They're still there. It's just that our daytime sky is so bright we can't see the stars.

Star pictures

On a clear night, you may see thousands of twinkling stars. They seem to be scattered helter-skelter all over the sky. But if you look carefully, you will see that groups of stars seem to form shapes.

Long ago, people found that, with a little imagination, each of these star groups looked like a picture of something. One group of stars seemed to look like a hunter with a club, holding the body of an animal he had killed. Another group of stars made a picture that was like a flying swan, with its long neck stretched out and its wings spread. Other star groups were like pictures of a crab, a bull's head, a dragon, a man shooting a bow, and many other creatures and objects.

The star pictures were named after the things they looked like. By knowing the shape of each star picture, and its position in the sky, sailors of long ago could find their way across the sea. If a ship were blown off course by a storm, the captain had only to look at the star pictures to find the right direction again. Today, amateur astronomers still use these star pictures, called constellations, to locate the stars they want to study.



the constellation of Orion

Long ago, people thought that groups of stars looked like pictures of creatures or objects. Each star group was named after the thing it seemed to look like. These star groups are called constellations. This constellation is Orion the Hunter.

Finding constellations

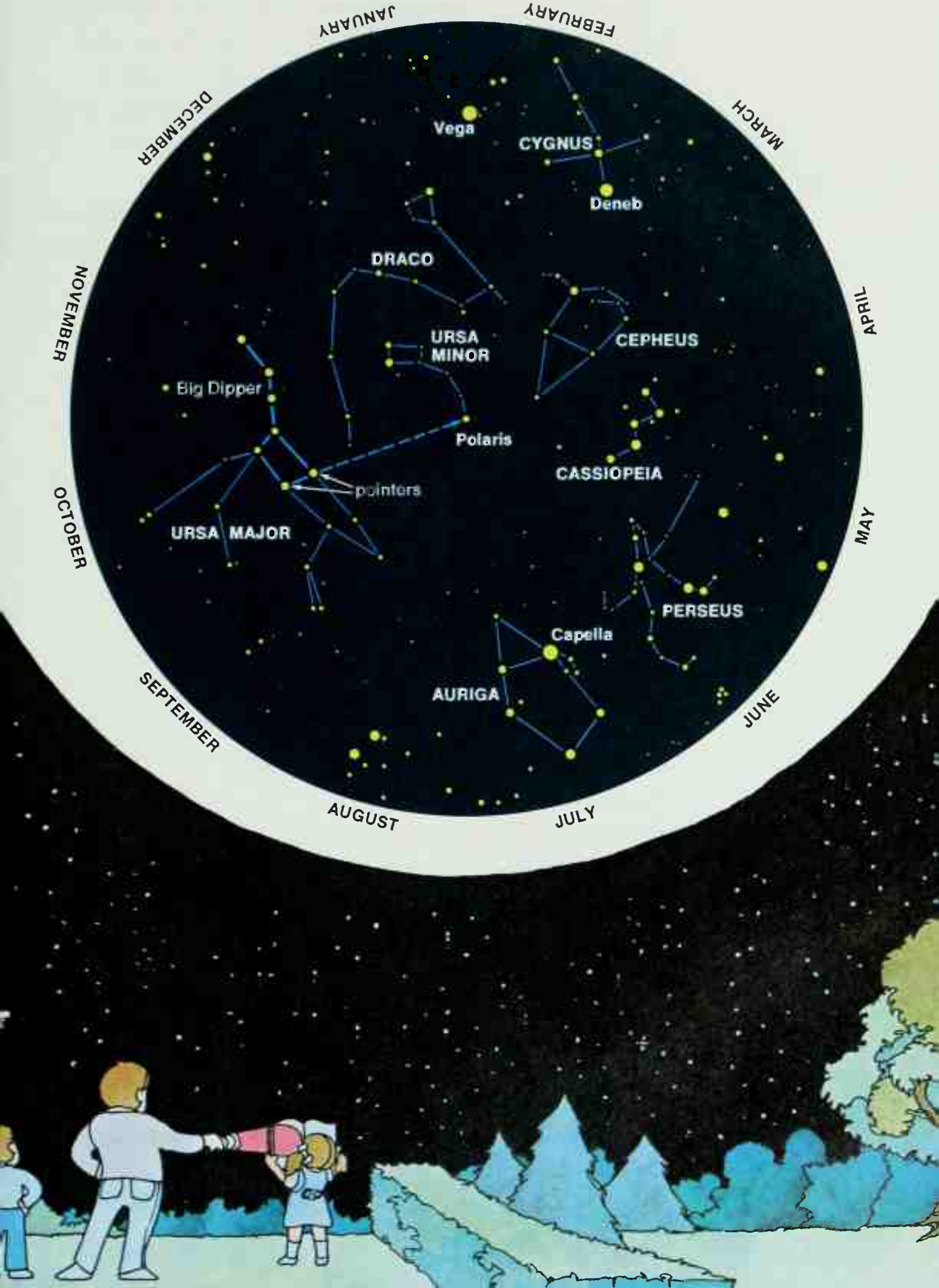
Do you live in the Northern Hemisphere—say, in the United States, Canada, Great Britain, or Japan? Then, during most of the year you will be able to see the constellations shown on the star chart on page 271. Do you live in the Southern Hemisphere—in Australia, New Zealand, or South Africa? If so, during most of the year you will be able to see the constellations shown on the star chart on page 273. And, if you live in the southern United States, Hawaii, or northern Australia, you'll sometimes be able to see some of the constellations on both star charts.

On the charts, the stars in each constellation are joined together with lines to show the shape of the constellation. If you know the shape of a constellation, and where to look for it in the sky, you can usually find it without much trouble.

To use the charts, take this book outdoors at about nine o'clock, on a clear, moonless night. Stand where you can see as much of the sky as possible. If you live in the Northern Hemisphere, face north. In the Southern Hemisphere, face south.

To see the chart, you'll need a flashlight. But cover the light with red cellophane. Otherwise, the light will dazzle your eyes and make it hard for you to see the stars when you look up at the sky.

The constellations move into a different part of the sky each month. So, around the outside of each chart are the names of the months. Hold the book so that the name of the right month is pointed at your chest. Then the chart will show where the constellations will be when you look up at the sky.


JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
Vega
CYGNUS
Deneb
DRACO
URSA
MINOR
CEPHEUS
Big Dipper
Polaris
CASSIOPEIA
pointers
URSA MAJOR
PERSEUS
Capella
AURIGA

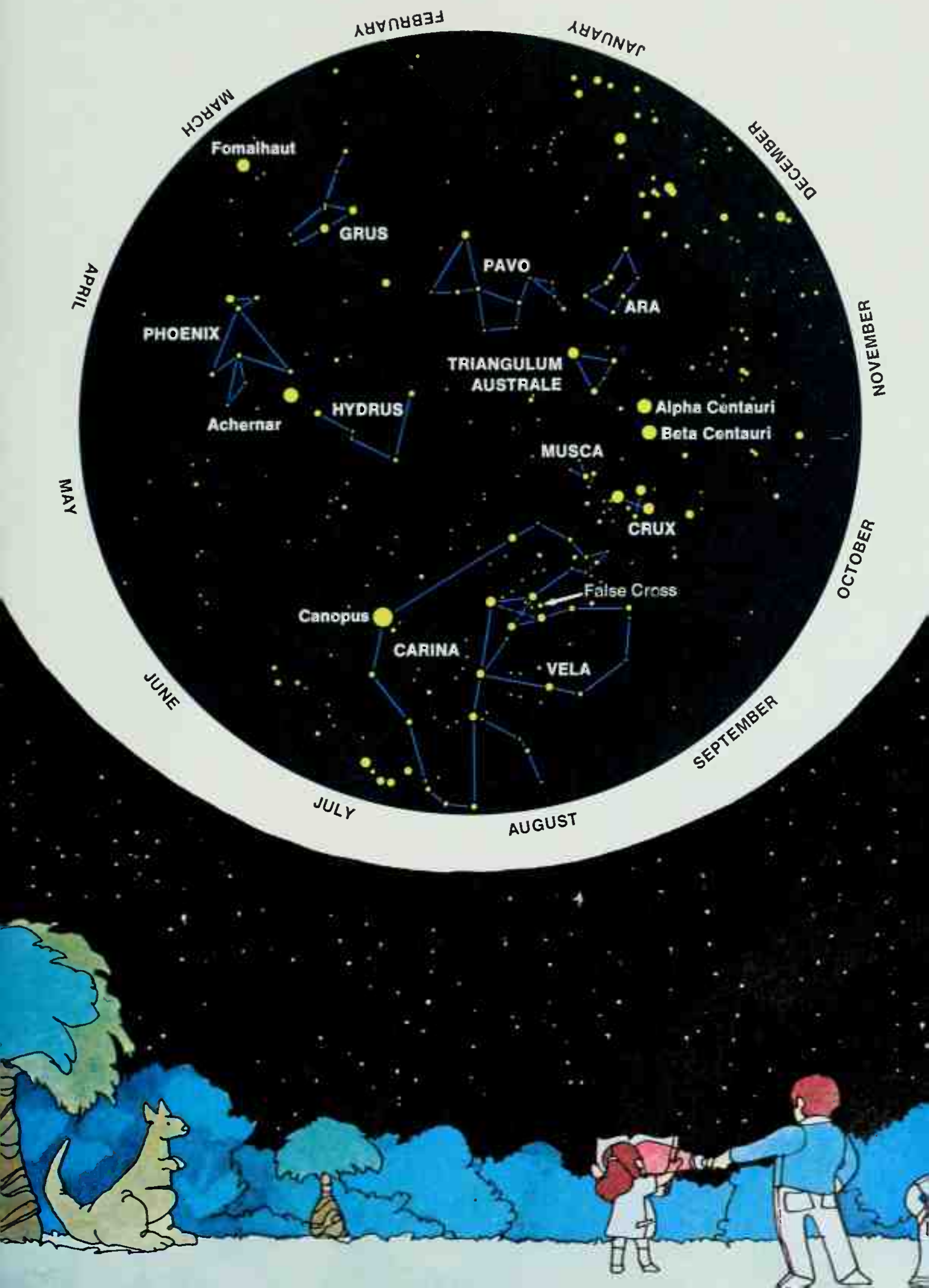
For example, in the Northern Hemisphere, in May, the group of stars Americans call the Big Dipper and the British call the Plough will be straight ahead of you, high in the sky. In the Southern Hemisphere, in June, the constellation called Crux will be straight ahead of you, close to the horizon.

On the charts, each constellation has its Latin name. Some of the names are based on what people thousands of years ago thought the constellation looked like. For example, in the Northern Hemisphere there's a constellation called Draco. That means "Dragon." Ursa Major means "Great Bear." Ursa Minor means "Little Bear," though we usually call this constellation the Little Dipper. Cygnus means "Swan" and Auriga is "the charioteer." Cepheus was a king, and Cassiopeia was a queen. Perseus was a storybook hero who killed a monster and saved a princess.

In the Southern Hemisphere, there is a famous constellation called Crux, which means "cross." It is better known as the Southern Cross. Triangulum Australe means "Southern Triangle." Musca is "Fly," Pavo is "Peacock," and Grus is "Crane." Vela is the "sail" of a ship, and Carina is the ship's "keel," or bottom.

The charts also show a few of the brightest stars, such as Vega and Canopus.

If you live in or near a city, you may not be able to see all of the stars or constellations because of the city lights. But you will nearly always be able to see the brightest stars and some of the constellations.


FEBRUARY
JANUARY
MARCH
DECEMBER
Fomalhaut
GRUS
PAVO
APRIL
ARA
NOVEMBER
PHOENIX
TRIANGULUM AUSTRALE
HYDRUS
Achernar
Alpha Centauri
Beta Centauri
MUSCA
MAY
CRUX
OCTOBER
False Cross
Canopus
CARINA
VELA
JUNE
SEPTEMBER
JULY
AUGUST

Exploding stars!

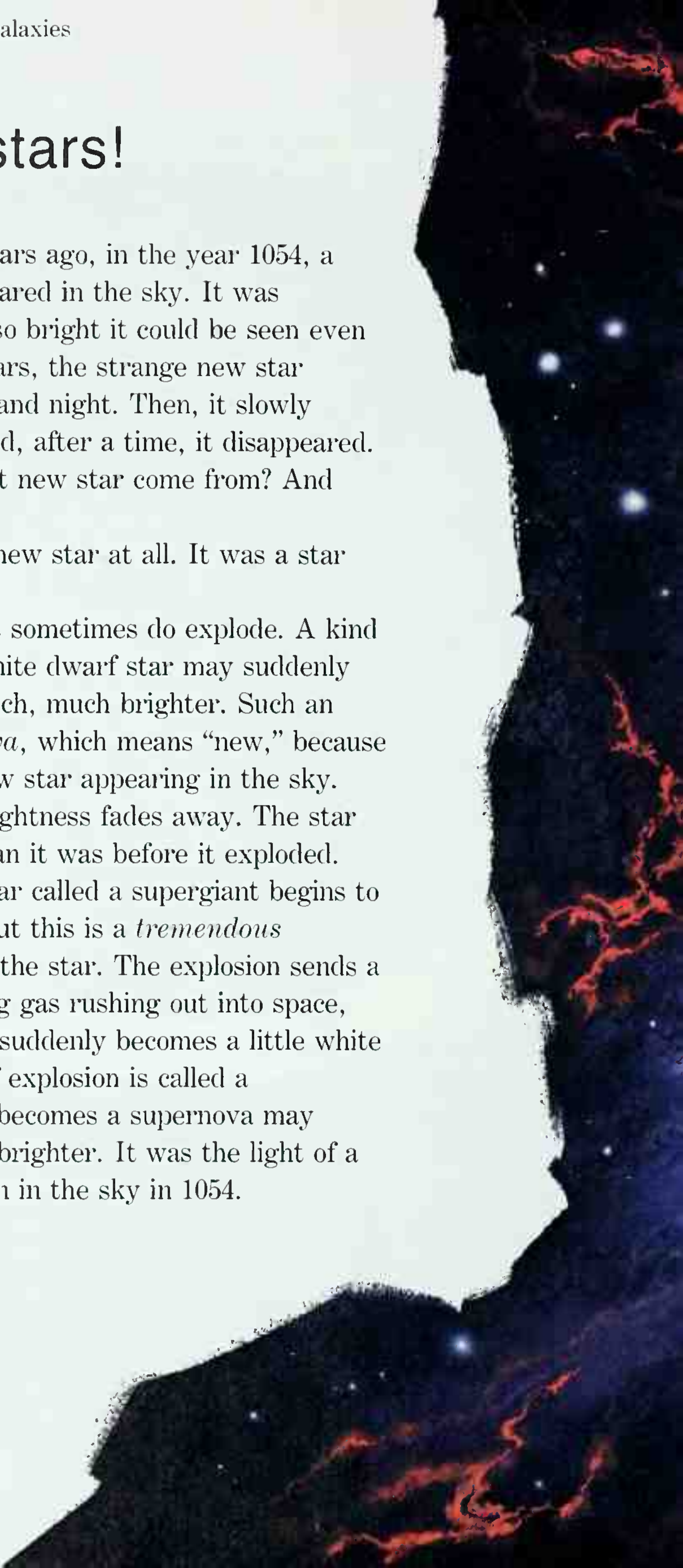
Nearly a thousand years ago, in the year 1054, a new star suddenly appeared in the sky. It was tremendously bright—so bright it could be seen even in daytime. For two years, the strange new star glowed in the sky, day and night. Then, it slowly began to fade away. And, after a time, it disappeared.

Where had this bright new star come from? And what became of it?

Actually, it wasn't a new star at all. It was a star that had exploded.

Certain kinds of stars sometimes do explode. A kind of small star called a white dwarf star may suddenly flare up and become much, much brighter. Such an explosion is called a *nova*, which means "new," because it looks like a bright new star appearing in the sky. But after a time the brightness fades away. The star becomes no brighter than it was before it exploded.

When a very large star called a supergiant begins to die, it, too, explodes. But this is a *tremendous* explosion that destroys the star. The explosion sends a gigantic cloud of glowing gas rushing out into space, and the once-giant star suddenly becomes a little white dwarf star. This kind of explosion is called a supernova. A star that becomes a supernova may become a *billion* times brighter. It was the light of a supernova that was seen in the sky in 1054.



the Veil Nebula

Misty shapes in space

A crab—a ring—a veil. These are some of the shapes taken by giant clouds of gas and dust, called nebulas, in space. The word *nebula* means "mist."

Some nebulas are the remains of stars that exploded long ago. A ring nebula is a shell of gas that surrounds a star, and looks like a ring from a distance. It is caused by an explosion that blew away part of the star.

the Great Nebula

the Ring Nebula

Milky Way Galaxy

Our sun is part of a gigantic cloud of stars called the Milky Way Galaxy.

The Milky Way

On a clear summer night you can sometimes see a bright haze in part of the sky. This haze is called the Milky Way. It looks like a gigantic cloud of stars, close together. Actually, the stars are many trillions of miles (kilometers) apart. But there are so many of them, they look like a glowing cloud.

The Milky Way is part of an even bigger cloud of stars. This star cloud is shaped like a pancake with a bulge in the middle. It contains more than 100 billion stars. This huge mass of stars is called a galaxy—the Milky Way Galaxy.

Our sun is one of the stars in this galaxy. The sun is far out near the pancake's edge. We cannot see all the way to the bulging center. Clouds of gas and dust, like thick fog, block our view.

Just as the earth moves around the sun, the sun and other stars move around the center of the galaxy. But the galaxy is so enormous, and the sun is so far from its center, that it takes the sun about 225 million years to go all the way around!

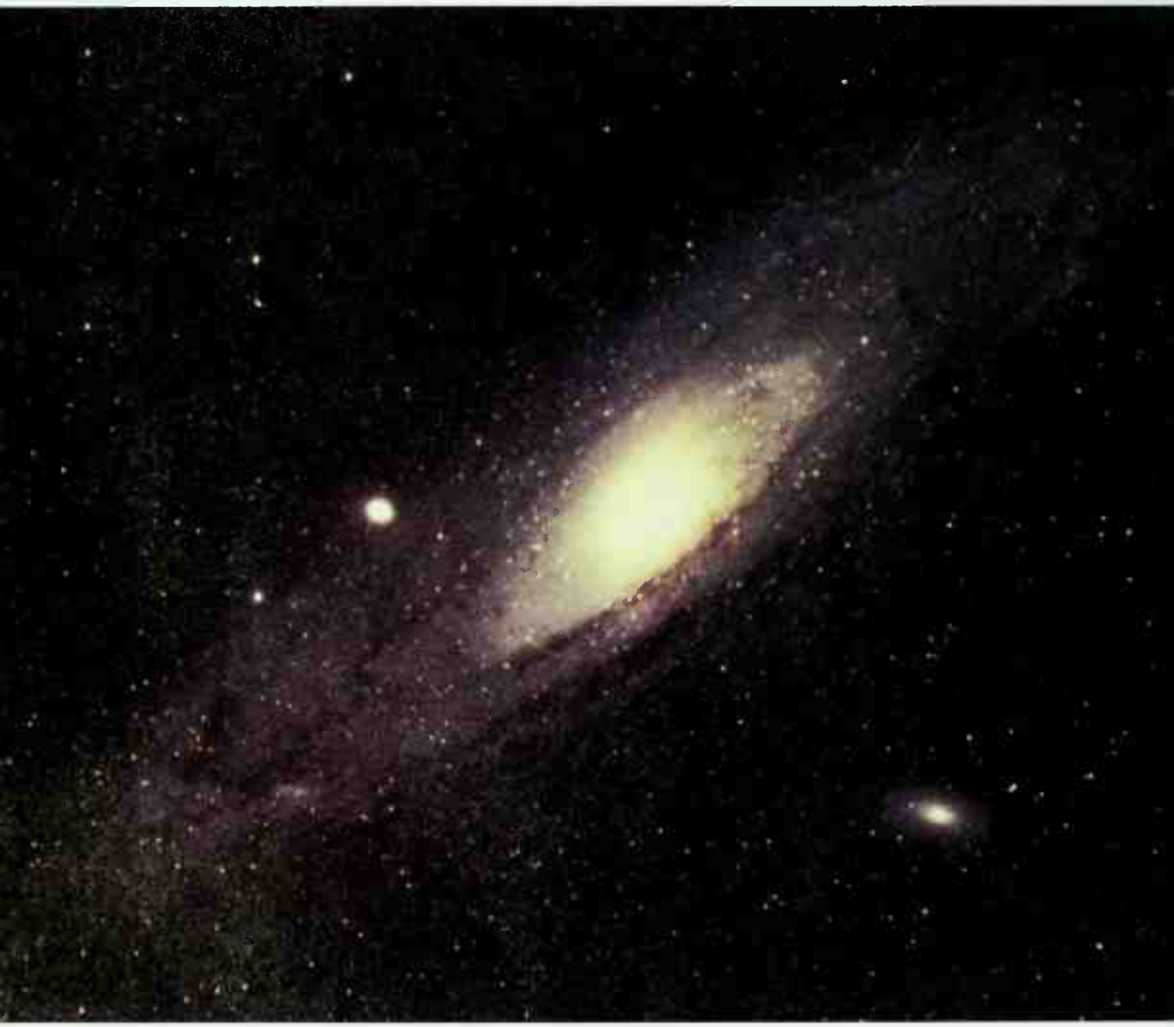
the Milky Way

The glowing cloud we call the Milky Way is made up of billions of stars that are trillions of miles (kilometers) apart. The white line in the photograph is the track of an artificial satellite circling the earth.

Other galaxies

Our galaxy, the Milky Way, has more than a hundred billion stars. But it is not the only such "cloud" of stars in space. There are at least a billion other galaxies, and probably more, and each of them also contains many billions of stars.

the Great galaxy



the Whirlpool galaxy

Waves from space

Right this minute you're being hit by "bullets" from outer space!

Space is full of waves. These aren't the kind of waves you see on an ocean, of course. They are waves of radiation. Radiation is streams of tiny, tiny bits of atoms. These particles are so small you couldn't see them even with the most powerful microscope. They travel at tremendous speed—186,282 miles (299,792 kilometers) per second. They are like little bullets. When they reach earth, some of them go zipping right through you, without you even knowing it!

Radiation is given off by most things in space—stars, quasars, planets, and the huge clouds of gas and dust called nebulae. Radiation comes to earth in the form of light, heat, radio waves, and what we call X rays, cosmic rays, and gamma rays.

Earth's atmosphere shuts some of these things out. Scientists think there is also a kind of "wall" in our solar system that shuts out others. This is a good thing, because if too many of some of these particles entered peoples' bodies, they could cause sickness.

Even though the particles are so small that the waves are invisible, scientists have many machines that can find different kinds of radiation and tell where it comes from.

this radio telescope can locate waves from space

Sky "fireworks"

People who live far enough north or far enough south are often treated to a giant "fireworks" display on clear nights. Great sheets of light seem to hang in the sky, rippling and wavering like curtains in a breeze. The light flickers with colors—frosty-white, pale green, and pink.

These lights are inside the earth's atmosphere, but what causes them comes through space from the sun. Whenever the sun has many sunspots, it shoots out great numbers of tiny particles of energy into space. Many of these particles come to earth.

Near the earth's North and South poles there are magnetic poles. These north and south magnetic poles are like the ends of a big magnet. They attract the particles of energy from the sun. The particles collide with other particles in the earth's atmosphere. This makes them glow, filling the sky with shimmering, shivering light.

In the Northern Hemisphere, these sky "fireworks" are called the aurora borealis, which means "northern lights." In the Southern Hemisphere, they are called the aurora australis, meaning "southern lights."

Where in the World?

the earth as seen from space

The big, blue marble

The earth looks like a big, blue marble to astronauts flying in outer space. It's easy for them to see the round shape of the earth because the astronauts are so far away. But how can you see the shape of the earth while you're standing on it?

Look at a globe. A globe is a model of the earth. It shows you mountains, oceans, lakes, rivers, deserts, grasslands, and forests. Most globes even tilt, just like the real earth.

A globe shows the earth as it really is—round. And it shows the true shapes of the continents. But with a globe, you see only a part of the earth at one time. To see places on the other side, you must turn the globe.

If you want to see the whole earth at one time, you have to look at a map. But a map won't show you the earth as it really is. Mapmakers squeeze and stretch parts of the world when they draw them on a flat map. So, a globe is the best way to see the shape of the earth—unless you have a spaceship.

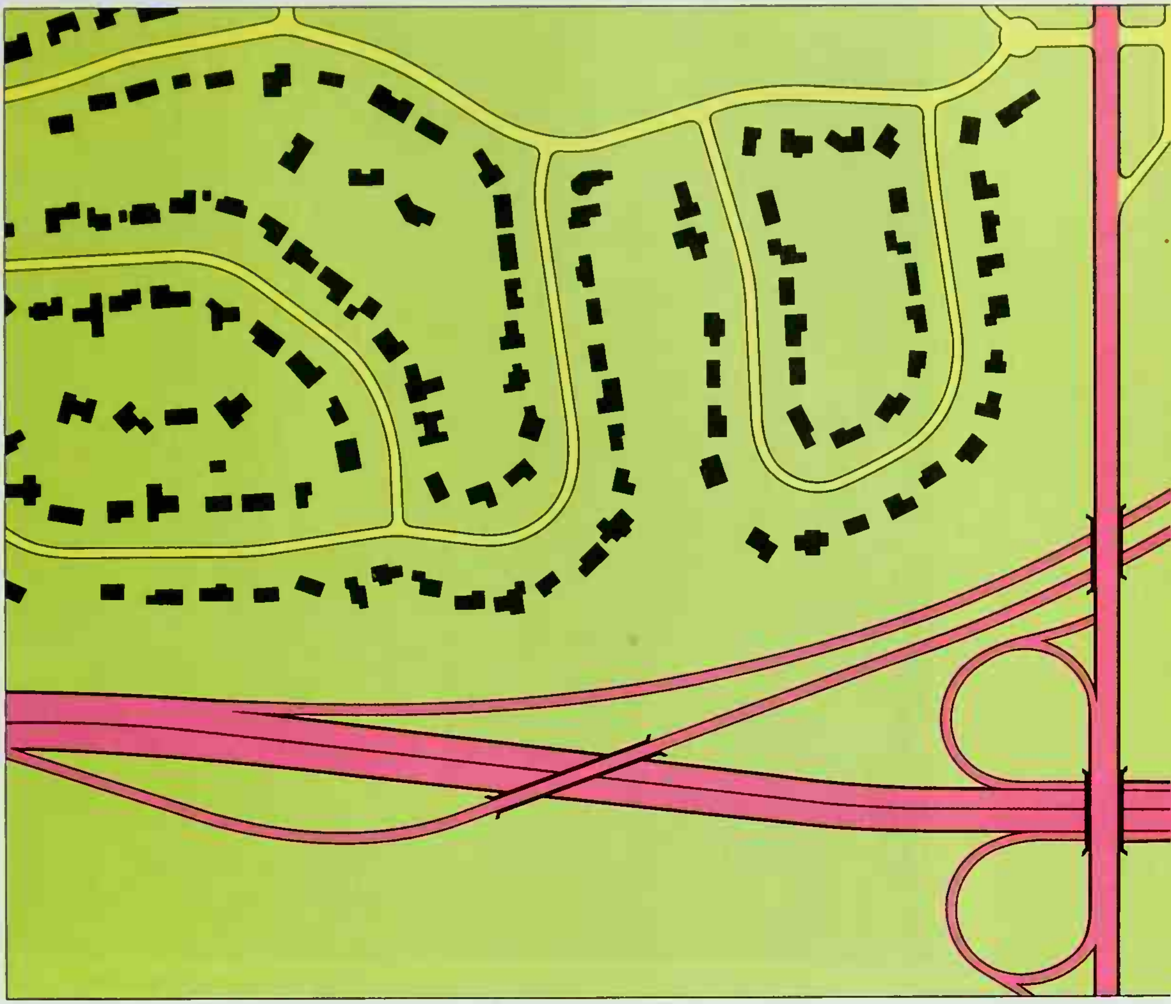
a globe is a model of the earth

photographs taken from airplanes help mapmakers

Places on paper

You can't put a globe in your pocket. A big, round globe is too bulky to carry from place to place. That's why there are maps. Travelers can easily fold paper maps to take with them.

Besides being easy to carry, maps can show a small part of the earth in detail. If you are looking for a small town or a street in a city, you can find it on a map but not on a globe. There isn't room on a globe for such places—even a very large globe.



map made from the photograph on the opposite page

Maps make the earth look flat. They are drawn as if you are high up, looking straight down on the land. When you look at a map, you can see what's beyond a forest or on the other side of a mountain.

How do the people who make maps know so much? They learn about the earth in many ways. But the best way is to use photographs taken from an airplane or satellite. The photographs are put together like pieces of a puzzle. Using the photographs as a guide, the mapmakers—who are called cartographers—draw their maps. They pick only the places that may be important to people who will use the maps.

a meteorologist using a computer map to forecast the weather

a pilot and weather forecaster using flight charts and weather maps


a family using a road map to plan their vacation

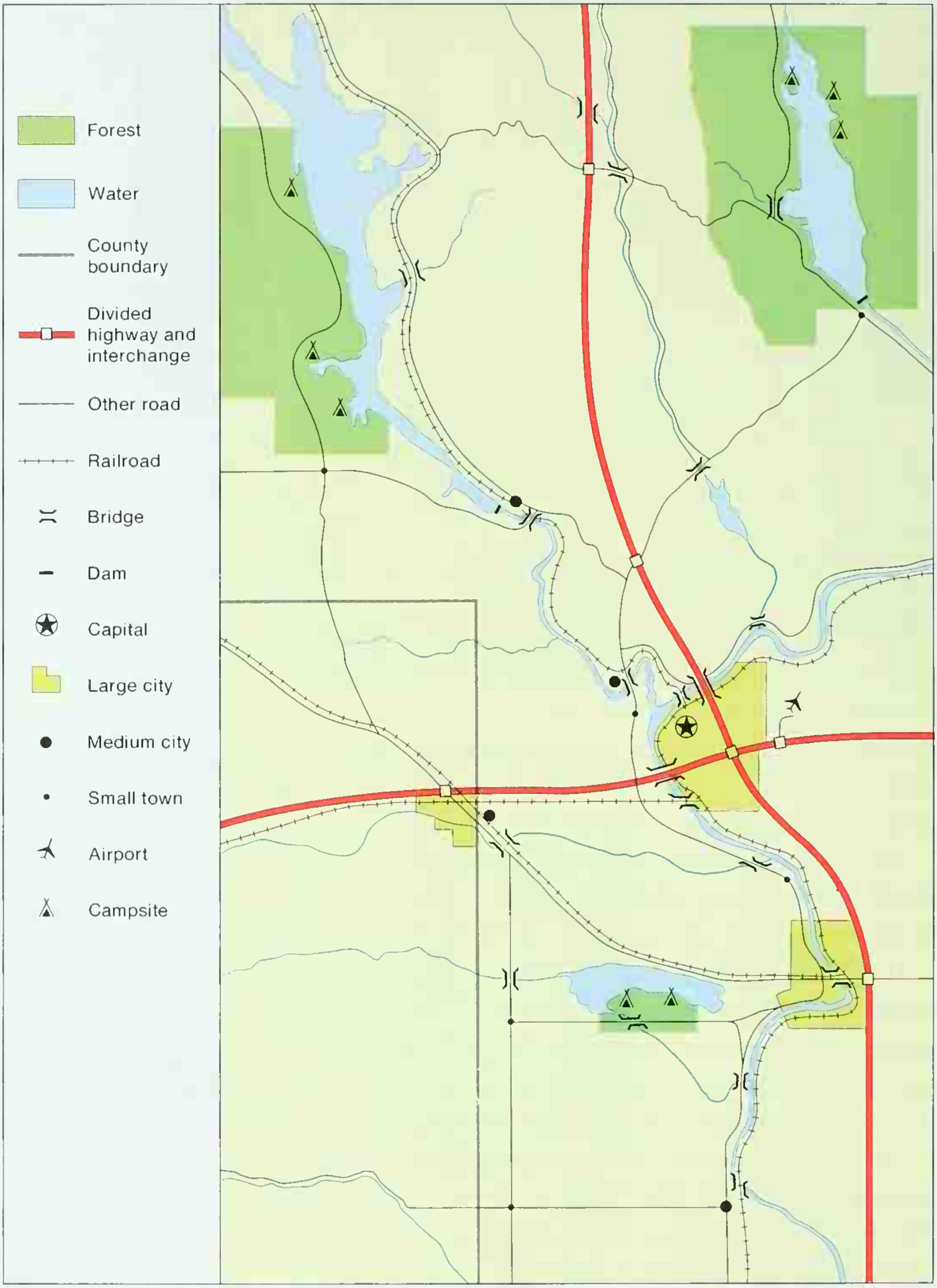
All kinds of maps

Maps show you all kinds of things about the earth and space. The kind of map you probably know best is a road map. This kind of map shows roads, cities, rivers, and important places. You use road maps when you go on auto trips.

Sailors and airplane pilots also use a sort of "road map" called a chart. Their charts show the "highways" of the oceans and skies.

In school, you use maps that show countries, states, provinces, cities, and other important places. You also might use a map that shows how rough or smooth the land is. One kind of map has a raised, bumpy surface. You can see and even feel the earth's hills and valleys!

There are maps that show where people live. Other kinds of maps show the weather, crops, or events of history. There are even maps of the moon, the stars, and the planet Mars!


Forest
Water
County boundary
Divided highway and interchange
Other road
Railroad
Bridge
Dam
Capital
Large city
Medium city
Small town
Airport
Campsite

Map language

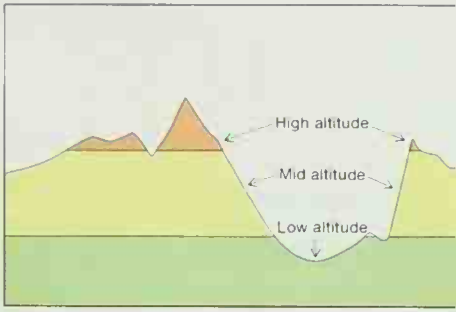
Follow the Yellow Brick Road!

If you were in the Land of Oz, the Yellow Brick Road would lead you to Emerald City. But in real life there are no Yellow Brick Roads to guide us to where we want to go. So, we use maps. And mapmakers use symbols and colors to show us what we want to know.

Map symbols stand for real things on the surface of the earth. Most of the symbols are simple and quite easy to understand. They are usually explained in a box near a corner of the map. And the colors help. Man-made things—such as highways—are usually red or black lines. The wider the line, the bigger the highway. Crossed lines stand for railroad tracks, and dots stand for cities. A star or dot inside a circle means a capital city. And to find an airport, look for a tiny drawing of an airplane.

Water is shown in shades of blue, so those squiggly blue lines show rivers. Sometimes color is used to show the height, or elevation, of the land. Fairly low land might be colored green. High mountains may be dark brown.

The next time you see a map, look again. You'll be surprised to find out how symbols and colors help mapmakers show a lot on a very small map.



How far is it?

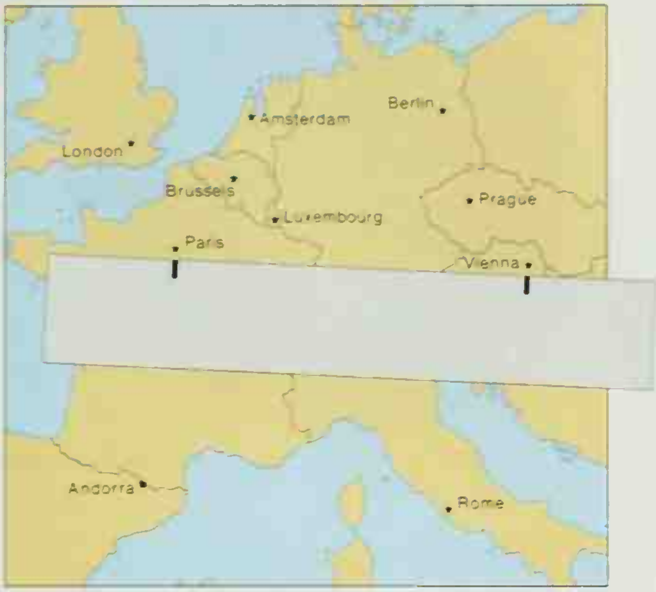
A map may be millions of times smaller than the real land it pictures. So how can you find out how far it is from one place to another?

To find out, you use a "measuring stick" called a scale. Scale means that a certain distance on a map stands for an actual distance on the earth's surface.

Map scales are shown in three different ways. One kind of scale is a straight line on which distances are marked. Each mark stands for a certain number of miles or kilometers. To find the actual distance between two places, measure the distance between them on the map. To do this, line up the two places on the edge of a piece of paper. Make a mark for each place. Then, move the paper down to the scale. Line up one mark with the 0 on the scale and read the distance opposite the other mark.

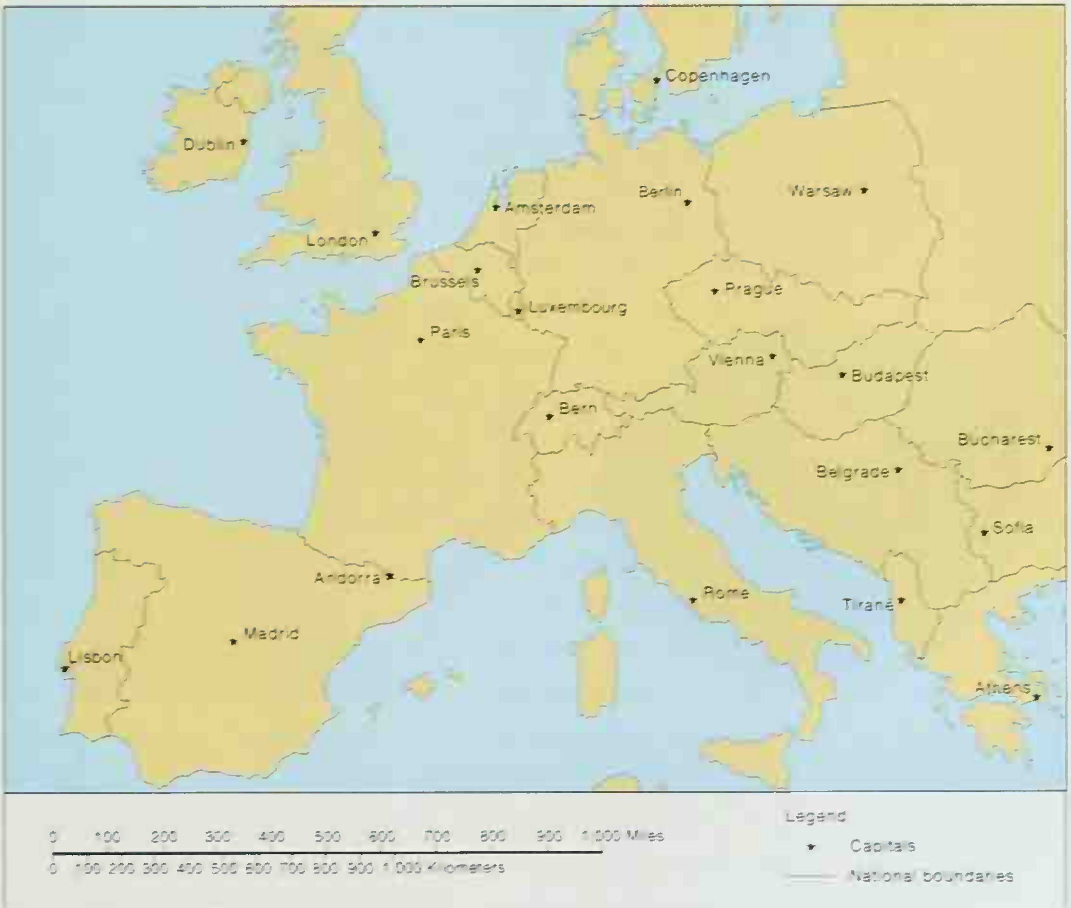
Another kind of scale says that so many inches or centimeters equal so many miles or kilometers. For example, the scale might read: 1 inch = 10 miles, or perhaps 1 centimeter = 20 kilometers. With a ruler, measure the distance between two places on the map. Then, multiply inches by 10 to get miles or centimeters by 20 to get kilometers.

Still another kind of scale is shown as a fraction. If the map has 1/50,000 as its scale, then 1 unit of measurement on the map is 50,000 times larger on the surface of the earth. With this kind of scale, 1 inch or 1 centimeter on the map would equal 50,000 inches or centimeters on the earth.



measuring distance on a map

Find the distance from Paris to Vienna by using a piece of paper and the scale from the map below. About how far is it from Berlin to Madrid, or from Dublin to Athens?



pocket compass

Which way?

Which way are you going? A compass can tell you. A compass is a box with a magnetic pointer or needle that turns. The marked end of the needle always points north. Why? Because it is pulled by a larger magnet—the earth. The earth is a giant magnet. One end is near the North Pole and the other end is near the South Pole. And the north-seeking end of a magnetic needle always points toward the north magnetic pole.

If you want to go east, hold the compass level until the needle stops moving. Then turn the compass case until N, or north, is under the marked end of the needle. Face north and turn to your right—that's east.

You can use the sun as a direction-finder, too. The sun rises close to the east and sets close to the west. Face the rising sun and lift your left arm straight out from your side. You will be pointing nearly north. If you face the setting sun, your left arm will be pointing nearly south. And, at about noon, if you live in the Northern Hemisphere (North America, Europe, or Asia), your shadow will point north. If you live in the Southern Hemisphere (Australia, South America, or southern Africa), your shadow will point south.

On a clear night, you can use the stars to find north. In the Northern Hemisphere, look for the Big Dipper. Find the two pointer stars in the side of the cup. These two stars always point to the North Star, at the tip of the handle of the Little Dipper. The North Star is always in the northern part of the sky, directly over the North Pole.

In the Southern Hemisphere, look for the Southern Cross. The two stars in the longer bar always point south.

Things needed to make a compass

magnet

straight pin or needle

piece of cork about 1 inch (1 centimeter) wide by ¼ inch (1 centimeter) thick

bowl or saucer of water

Rub one end of the pin along the magnet about twelve times. Rub in one direction only. Don't rub back and forth. Lift the pin up each time.
Place the pin on the cork. Gently place the cork in the bowl of water. At first, the pin and cork will swing around. Then the pin will point steadily in one direction. It points along the magnetic line between the earth's North and South poles.


parallels of latitude


meridians of longitude

Lines around the world

Look at a globe or a map of the world. Have you ever wondered why there are so many crisscross lines? There are no lines on the earth, so why put lines on globes and maps?

The lines are put there to make it easy to find places. The lines are like city streets. When two friends meet at the corner of Oak and Main, they are meeting where two streets cross. On a globe or map, the east-west lines cross the north-south lines just like streets. Every place on earth can be found at or near where two of the lines cross.

The east-west lines measure distance north or south of the equator. This is called latitude. Because the lines are parallel—always the same distance apart—we call them parallels of latitude. Latitude is measured in units called degrees. The symbol after each number is a degree sign. Latitude is always given as so many degrees north or south of the equator.

The north-south lines measure degrees east and west. We call this longitude. The lines are called meridians. The starting point is a line called the prime meridian. This line passes through Great Britain. Longitude is given as so many degrees east or west of this line.

Latitude and longitude is one way to find a place. Another way is used on small area maps, such as road maps. Numbers and letters are around the edges of a road map. Lines drawn from the letters cross other lines drawn from the numbers. Such a map will have a list of the places shown. After each place name, there is a symbol, such as C4. Look at the map and you will find the place near where the lines C and 4 cross.

Treasure Hunt

Find the four treasures by using the latitude and longitude given for each one. Work out for yourself the latitude and longitude of places shown on the map.

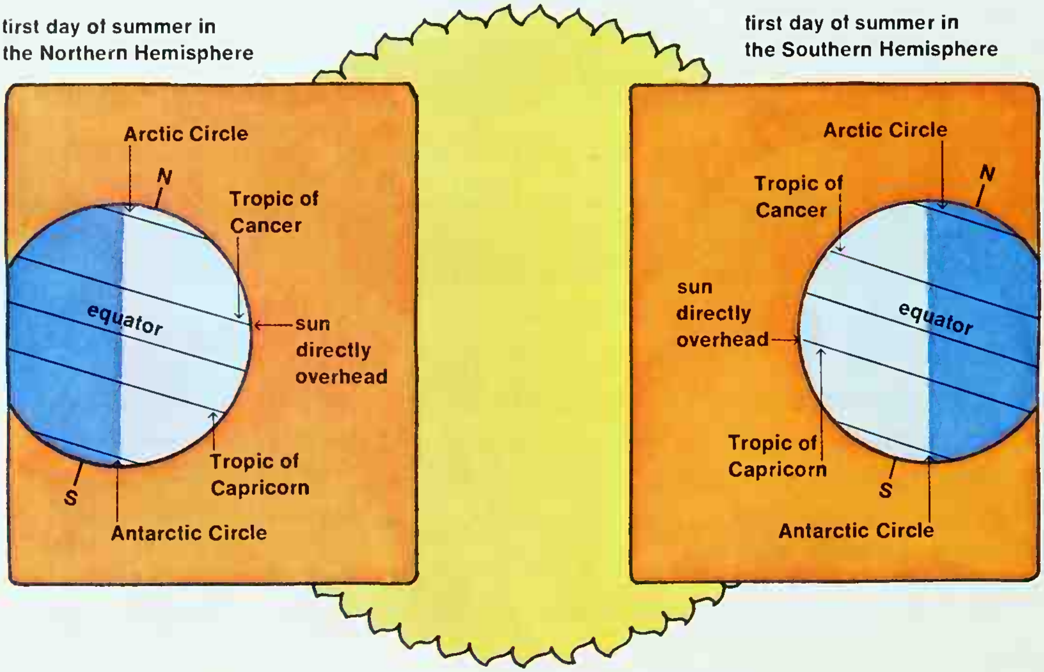
	treasure ship	latitude 2° north longitude 2° east
	buried treasure	latitude 2° south longitude 0°
	pieces of eight	latitude 1° north longitude 2° west
	golden idol	latitude 0° longitude 1° west

The sun's boundary lines

Do you know why most globes are tilted on their stands? It's because the earth is tilted. Because of this tilt, different places on earth get different amounts of sunlight. Special lines on globes and maps mark the edges of these different places.

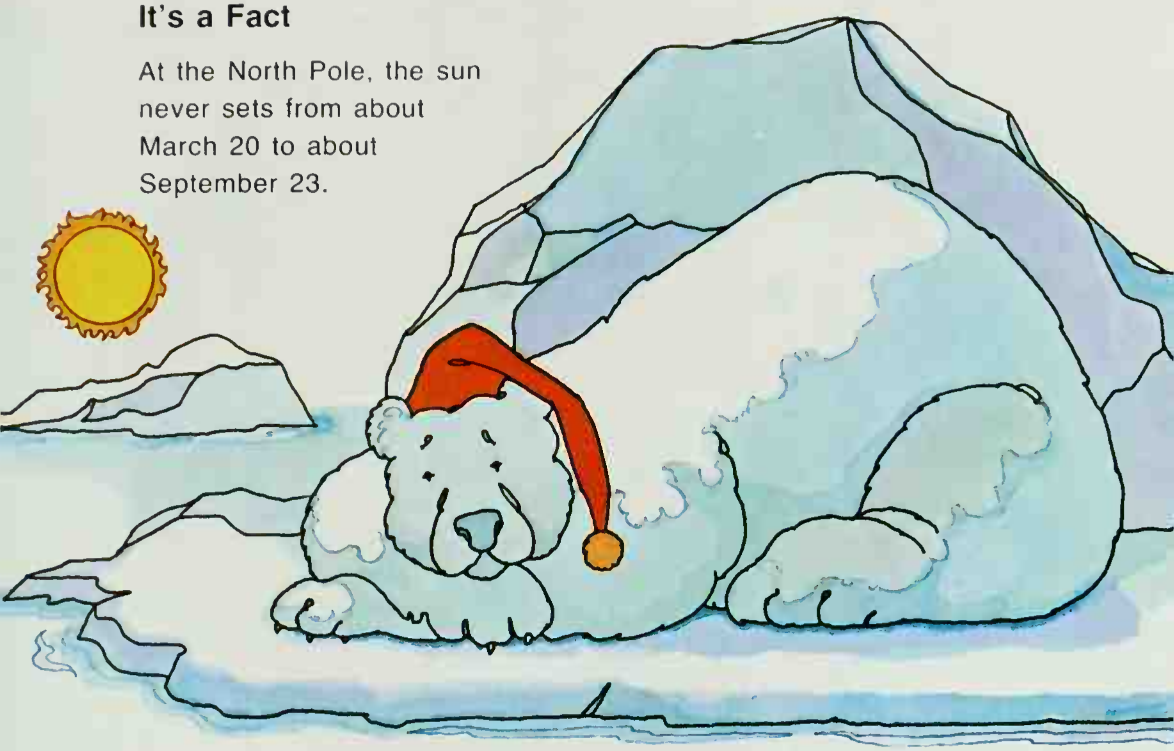
Halfway between the North and South poles is the imaginary line we call the equator. At the equator, it is always daylight for twelve hours each day. So days and nights are the same length all year long.

North of the equator is an imaginary line called the Tropic of Cancer. South of the equator is another line called the Tropic of Capricorn. Both lines are named for star constellations. Once a year the sun is directly over the Tropic of Cancer. That's the first day of



It's a Fact

At the North Pole, the sun never sets from about March 20 to about September 23.

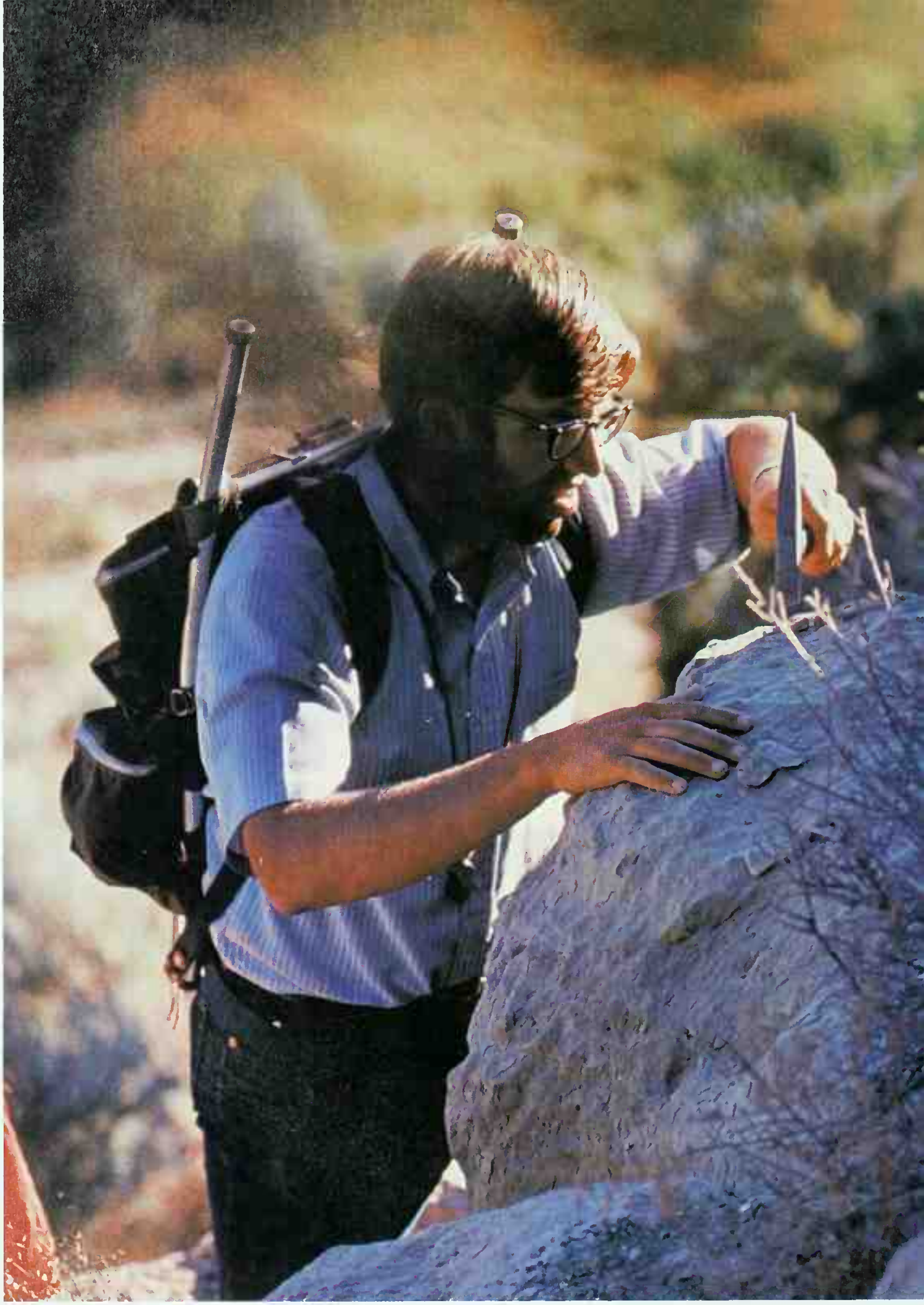


summer in the Northern Hemisphere. Once a year, the sun is directly over the Tropic of Capricorn. That's the first day of summer in the Southern Hemisphere.

Near the North and South poles are two other imaginary lines—the Arctic Circle and the Antarctic Circle. In the region between the Tropic of Cancer and the Arctic Circle, the sun always shines down at a slant. The same thing is true in the region between the Antarctic Circle and the Tropic of Capricorn. So in these regions, days are long during part of the year and short during another part of the year.

North of the Arctic Circle is a region sometimes called the "Land of the Midnight Sun." In the summer, there are days when the sun never sets. You can go out at midnight and see the sun! But in the winter, there are days when the sun never rises. The same thing is true south of the Antarctic Circle.

People Who Study the World and Space



geologist chipping off a
rock sample for laboratory study

Learning about the earth

Who wants to study rocks? Geologists do.

Geologists are scientists who "read" rocks as though they were history books. Rocks have a history of their own. They show geologists what the earth was like millions of years ago, how it has changed since then, and how it is still changing. By studying rocks, geologists learn where rivers once flowed—where volcanoes once erupted—and where plants and animals once lived.

Many geologists travel all over the world. They explore mountains, swamps, deserts, and even the bottom of the ocean. As geologists learn more about the structure of the earth, the search for oil, coal, and other sources of energy becomes easier. Valuable minerals, such as gold, tin, and copper, are found by geologists, too.

Before geologists become geologists they may be "rock hounds." Rock hounds collect rocks as a hobby. But if rock hounds become geologists, they do much more than study rocks. Geologists study everything about the earth. That is what the word *geology* means. It comes from two Greek words, *ge,* which means "earth" and *logos,* which means "study." And now geologists study rocks brought back from the moon!

Learning about prehistoric life

Scaly dinosaurs and flying reptiles disappeared from the earth about sixty-five million years ago—long before there were people. Yet there are pictures of these animals in books. How do we know what these prehistoric animals looked like if no one ever saw a live dinosaur or a flying reptile?

Scientists called paleontologists tell us what the plants and animals of long ago were like. They examine fossils—the remains of plants and animals left in stone and other places. These include fossil bones, teeth, footprints, and leafprints. From such fossils, paleontologists can tell a great deal about living things of the past—how big they were, what they looked like, how they walked, and even what food they probably ate!

Where are fossils found? The search for fossils goes on just about everywhere. Fossils have been uncovered on high mountaintops, under layers of ice, in steep cliffs along rivers, and in coal mines. The oldest fossils ever found are simple plants that lived more than three billion years ago.

searching for fossils

This paleontologist is looking at the fossil skeleton of a mammoth.

fossil insect

This insect was trapped in tree sap millions of years ago. When the sap hardened, the insect was sealed in forever.

Cave scientists

Watch your head—there's a stalactite! Oops, don't trip over the stalagmite! Where are you? In a cave!

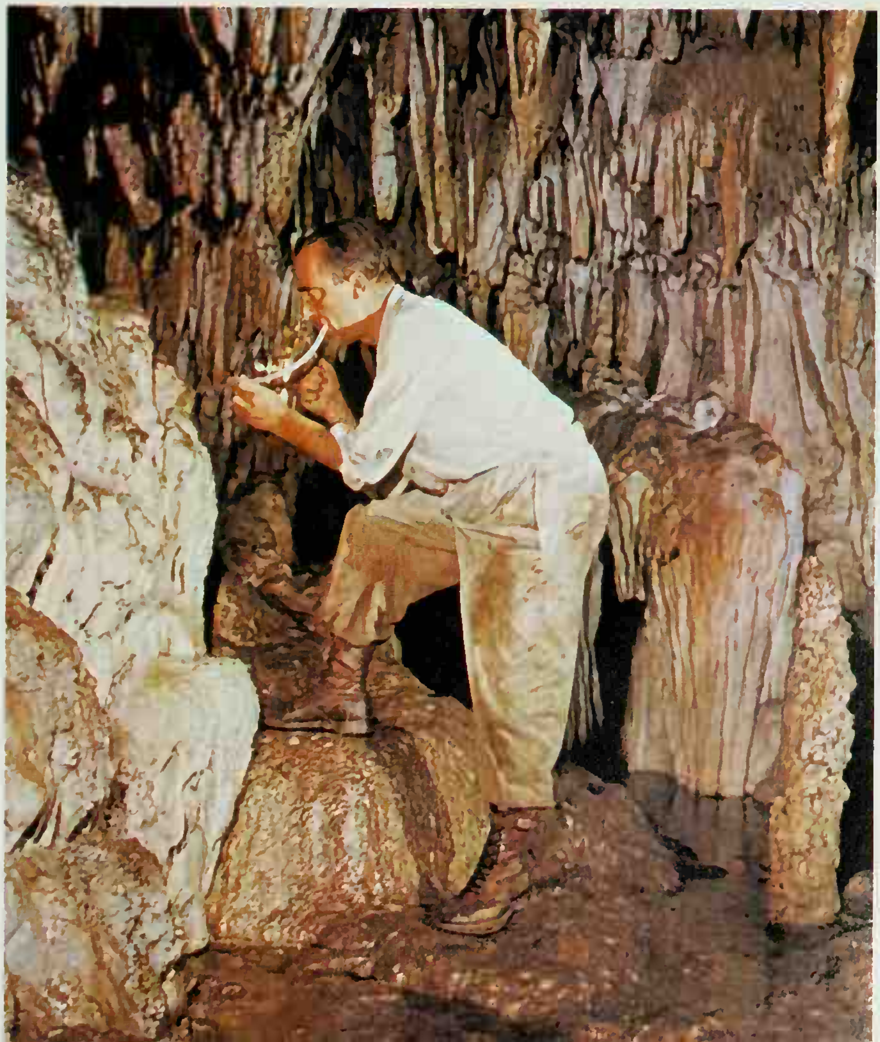
Scientists who study caves are called speleologists. Most caves are dark, slippery tunnels of rock and water. Exploring them can be dangerous. So speleologists wear protective clothing and headlamps. And they carry rope and other tools. These scientists want to find out about the changes a cave goes through. They also want to know how long each change lasts and what happens to a cave during this time.

Some caves are like underground art museums. The limestone formations look like beautiful sculptures. And man's earliest art—painted more than twenty-five thousand years ago—has been found on cave walls.

Where is the deepest cave? No one knows. But in a cave in France, explorers climbed down almost three thousand feet (910 meters).

cave scientists at work

A group of cave explorers (left) crawl through a narrow underground tunnel. A scientist (below) makes tests in a limestone cave in Mexico.



Watching for earthquakes

Earthquakes happen all the time. We don't feel most of them. They are just small shakes in the earth. But some earthquakes make the ground tremble, rattle dishes, and even cause buildings to shake. And a few earthquakes smash and crumple buildings.

Seismologists are scientists who study earthquakes. Seismologists can't go underground to watch the rocks push, snap, and break. Instead, seismologists watch instruments called seismographs. These instruments help keep track of earthquakes all over the world—even the quakes we can't feel.

Seismographs are usually set on solid rock or inside vaults. There, they do not pick up vibrations caused by man-made things. But when an earthquake makes the earth shake, tremble, and shiver, it also moves a pen in the seismograph. The pen draws squiggly lines on a roll of paper.

Scientists use seismographs in groups of three. This way they can measure the east-west, north-south, and up-and-down ground motions of the earth.

A few times, seismologists have been able to predict earthquakes. But there is still much to learn about what causes earthquakes and when they will happen.

seismologist checking a seismograph

A seismograph is used to record movements of the earth near the top of Mount Asama in Japan.

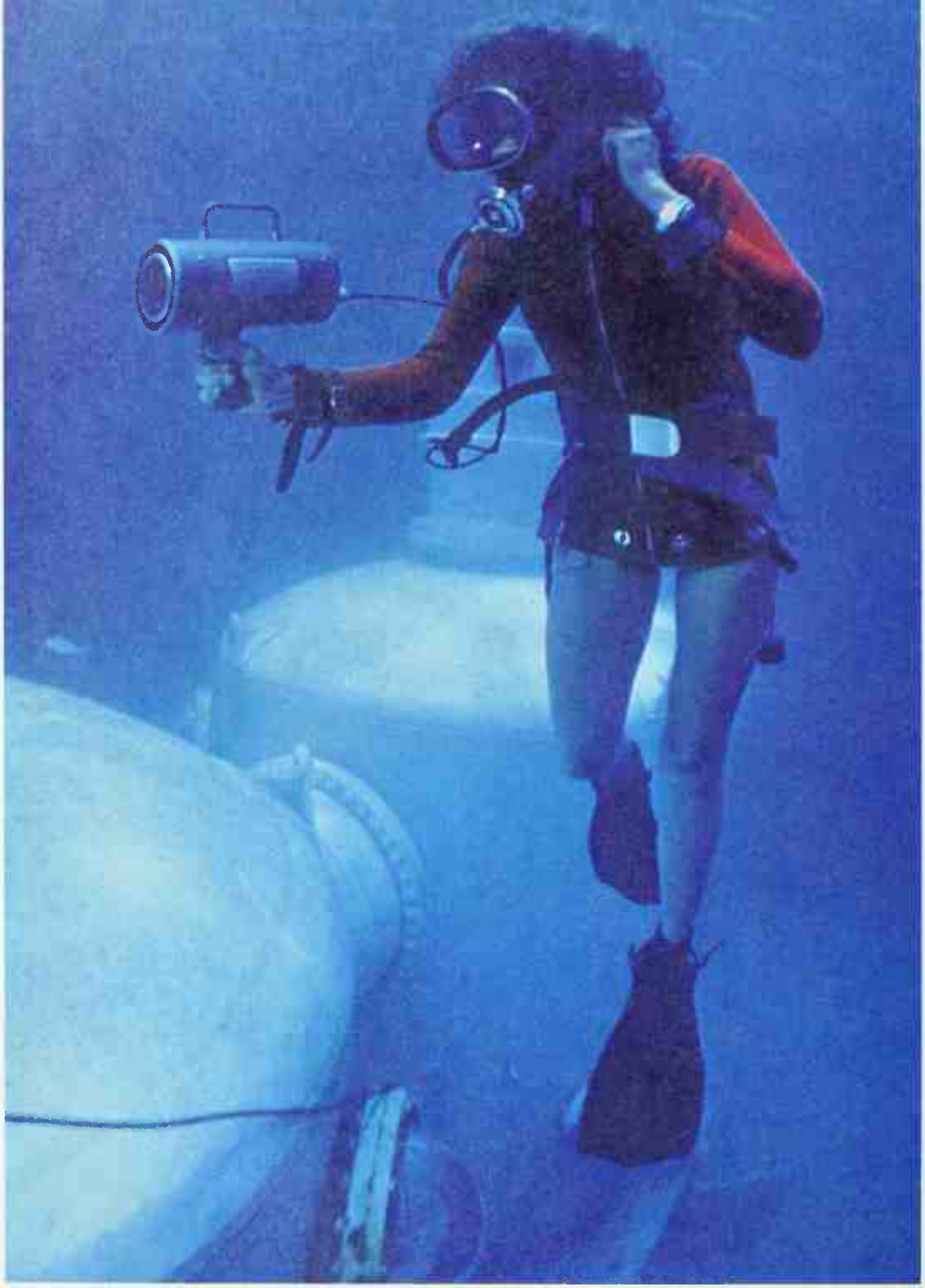
volcanologist collecting samples of hot lava

Volcano watchers

The ground shakes and quivers. Deep in the earth there is a roaring rumble. Suddenly, there is a giant explosion! A cloud of steam, mixed with dust and chunks of rocks, shoots out of the top of the volcano. A river of hot, boiling lava—melted rock—pours out of cracks. The lava flows down the sides of the volcano, burning everything in its path.

After the lava cools, scientists called volcanologists may visit the volcano to study it. Someday, scientists hope to forecast volcanic eruptions. So, to learn more, they climb to the top of the volcano to collect gases. They draw the gas from the boiling bubbles inside. Changes in the gas warn volcanologists when a volcano might erupt.

Several machines help scientists watch volcanoes, too. A tiltmeter measures the slant of the earth's surface. When the slant changes around a volcano, it's a sign that the volcano could erupt. A seismograph is used, also, to show any warning rumbles, shakes, and quivers in the earth. Being a volcanologist means plenty of watching and waiting.



living under water

An oceanographer uses a device called a sonar to locate underwater sounds. Behind her is the underwater house she stays in.

Learning about the sea

How long can you hold your breath under water? A few seconds? A minute? Whatever the length of time, you can't stay under water very long.

But scientists called oceanographers often swim under water for hours. Some oceanographers even live beneath the ocean's surface for months at a time!

Oceanographers use air tanks, diving suits, or even small submarines while under water. And when oceanographers stay under water for days at a time, they live in a canlike house right on the ocean floor. There, scientists spend hours outside their underwater shelter studying everything around them.

There are many kinds of oceanographers. Some make maps of the rocky ocean floors. Other sea scientists map the direction and strength of the moving water. Still other oceanographers study the plants and animals that live in the ocean.

sampling the ocean bottom

Japanese oceanographers check and bottle samples of mud and sand brought up from the ocean floor. They will study the mud to find out what's in it.

Watching the weather

Everyone is a weather watcher. But no one knows for sure what the weather will be like tomorrow or next week—not even meteorologists.

Meteorologists are scientists who study the weather and try to forecast it. Sometimes their forecasts are wrong because weather conditions can change quickly.

In a way, meteorologists are like detectives. They look for all kinds of clues to help them discover what kind of weather is coming. They check the wind for speed and direction. They keep records of temperature, air pressure, and the amount of water in the air. They follow the progress of storms. With radar, they can find approaching storms as far away as two hundred miles (320 kilometers).

Meteorologists also have "weather spies" in the sky. One such spy is a large, gas-filled balloon. The balloon carries instruments high into the sky. Wind speed, temperature, and other weather conditions are automatically radioed to the weather stations below.

The highest sky spies are weather satellites. These satellites circle the earth and photograph cloud cover and any gathering storms. The pictures are then radioed to earth.

Meteorologists gather weather reports from all over the world. Using this information, they draw weather maps. With the help of computers, forecasts are made and sent to weather stations and then on to you.

Will it rain tonight? Will the sun shine tomorrow? Meteorologists try to let you know ahead of time.

measuring weather

This gas-filled balloon carries instruments to measure the weather.

studying weather

A meteorologist uses a bank of computers to study weather information.

Studying the stars

What is the shape of the universe? Why do stars sometimes explode? Is there life on other planets? Scientists called astronomers and astrophysicists try to answer these and other questions.

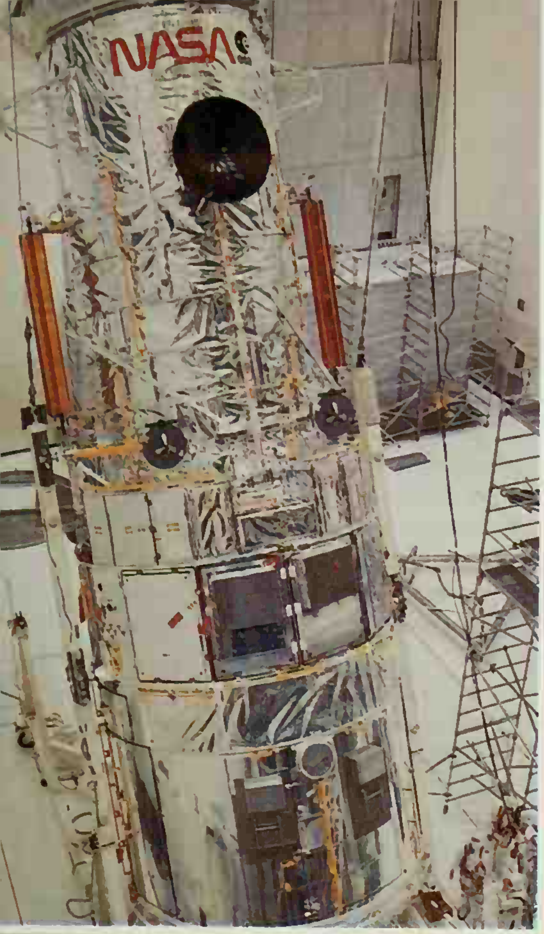
Most astronomers do much of their work at places called observatories. There, they use telescopic cameras to take photographs of stars. They study hundreds of photographs to find out the movements of stars and to look for new objects in space. With mathematics, they figure out how far away stars are and how fast they move.

Astronomers also listen to sounds that come from space. To do this, they use radio telescopes that pick up radio waves. The astronomers try to find where the sounds are coming from and what makes them.

Astrophysicists want to know what the things in space are made of. For example, they can tell by the different colors in the light of a star what chemicals are in the star. They also study other planets to try to find what they are like. From the work of all these space scientists, we are learning more and more about the amazing universe in which we live.

astronomer, Chile

How far away are the stars? How many stars are there? Astronomers use telescopes, special instruments, and math to answer questions like these.



Hubble Space Telescope

artist's idea of Hubble Space Telescope in orbit around the earth

Books to Read

If you like to read about the world and space, you'll find a wide variety of books to read and enjoy. A few of them are listed below. Your school or your public library will have many others.

Ages 5 to 8

Air Is All Around You Revised Edition by Franklyn M. Branley (Crowell, 1986)
You can't see it, but air is everywhere, even in some places that will surprise you.

The Big Dipper and You by E. C. Krupp (Morrow, 1989)
If you ride in a spaceship that travels as fast as the *Voyager*, it would take you 10 billion years to get to the Big Dipper. This book will get you there much faster.

Comets by Ruth Radlauer and Charles H. Stembridge, Ph.D. (Childrens Press, 1984)
What are comets? Where do they come from? This book is full of astounding information.

The Great Lakes by Kathy Henderson (Childrens Press, 1989)
Did you know that more standing fresh water can be found in the Great Lakes than anywhere else in the world? That's one-fifth of all the earth's standing fresh water. Read this book to find out more about the five Great Lakes.

The Magic School Bus Inside the Earth by Joanna Cole (Scholastic, 1987)
The magic school bus goes on a field trip inside the earth. Ride along to learn how the earth formed and find out about different kinds of rocks.

Mars by Seymour Simon (Morrow, 1987)
Read about and see amazing photographs of the earth's closest neighbors in the solar system. You can also find books about other planets and the sun by the same author.

One Day in the Desert by Jean Craighead George (Crowell, 1983)
Deserts are dry; deserts are sandy; deserts can be very hot and very cold. How do plants and animals live there? Read about daily life in the desert in this book.

My Place in Space by Robin and Sally Hirst (Orchard Books, 1988)
In this picture book, Henry and his sister Rosie ride the bus home. The bus driver asks Henry if he knows where he lives. Henry knows more than his address; he knows the exact location in the universe.

The Sun: Our Neighborhood Star by David J. Darling (Dillon Press, 1984)
This book answers questions that you might have about the sun and its connection to the earth. It also tells when the eclipses of the sun occur from 1984 to 1999.

Why Doesn't the Earth Fall Up? by Vicki Cobb (Lodestar, 1989)
Find out how the force of gravity keeps things on earth from floating off into space.

Ages 9 to 12

The Arctic and Antarctic by Cass R. Sandak (Franklin Watts, 1987)
Explore the polar regions at the top and bottom of the earth, around the North and South poles.

Earthquakes: Nature in Motion by Hershell H. Nixon and Joan Lowery Nixon (Dodd, Mead, 1981)
Discover why the earth quakes, the signals we look for to predict earthquakes, and even how we might "turn them off"!

Earth Songs by Myra Cohn Livingston (Holiday, 1986)
These poems celebrate the earth—its continents, hills, forests, and seas. They are enhanced by Leonard Everett Fisher's beautiful paintings. Also, look for **Space Songs** by the same author.

50 Simple Things Kids Can Do to Save the Earth by The Earth Works Group (Andrews & McMeel, 1990)
Learn what you can do to make the earth a healthy place for people everywhere.

The Galaxies by David Darling (Dillon, 1985)
This book tells what galaxies are and how they were formed.

How Did We Find Out About Volcanoes? by Isaac Asimov (Walker, 1981)
The author tells how people have viewed volcanoes from ancient times to the present. He even tells about volcanoes that are not on earth.

Mountains by Keith Lye (Silver Burdett, 1986)
Are all mountains alike? How are they formed? Do they ever change? You may be surprised by the answers to these and other questions.

Mountains and Earth Movement by Ian Bain (Bookwright Press, 1984)
Learn why the earth moves and what happens when parts of the earth move.

My First Book of Space by Robert A. Bell (Simon & Schuster, 1985)
This informative book about our universe is illustrated with NASA photographs and art.

101 Questions and Answers About the Universe by Roy A. Gallant (Macmillan, 1984)
As the director of a planetarium, the author spent a lot of time talking to children. In this book, he answers questions that children have asked him most frequently.

Satellites and Space Stations by Moira Butterfield (London, Usborne, 1985)
Satellites play a vital role in world communications, astronomy, and many other areas. Learn what space stations are and how people work and live in them.

Science Activities for Children by Willard J. Jacobson and Abby B. Bergman (Prentice-Hall, 1983)
These activities are a fun way to help you understand some important ideas in science. Several chapters contain activities related to our world and space.

Solids, Liquids and Gases: From Superconductors to the Ozone Layer by Melvin Berger (Putnam, 1989)
Gain a deeper understanding of the three forms of matter by performing scientific experiments.

Space Laboratories by Gregory Vogt (Franklin Watts, 1987)
Laboratories in space help us understand our universe. Learn about past, present, and future space laboratories.

New Words

Here are some of the words you have met in this book. Many of them may be new to you. Others are just hard to pronounce. Since you'll see them again, they're good words to know. Next to each word you will see how to say the word: ammonia (uh MOHN yuh). The part shown in capital letters is said a little more loudly than the rest of the word. Under each word are one or two sentences that tell what the word means.

ammonia (uh MOHN yuh)
Ammonia is a colorless gas. It is often dissolved in water and used for cleaning.

anemometer (an uh MAHM uh tuhr)
An anemometer is an instrument that measures the speed of the wind.

asteroid (AS tuh royd)
An asteroid is one of many small planets that revolve around the sun.

astrophysicist (as troh FIHZ uh sihst)
An astronomer who studies the physical and chemical characteristics of planets and stars is called an astrophysicist.

atmosphere (AT muh sfihr)
The atmosphere is all the air that surrounds the earth.

aurora australis
(aw RAWR uh aw STRAY lihs)
The aurora australis is bands of light in the night sky in the Southern Hemisphere.

aurora borealis
(aw RAWR uh bawr ee AL ihs)
The aurora borealis is bands of light in the night sky in the Northern Hemisphere.

azurite (AZH yuh ryt)
Azurite is a copper mineral that has a blue color. It is used for jewelry.

basalt (BAS awlt or buh SAWLT)
Basalt is a dark-colored rock that was once red-hot lava.

bauxite (BAWK syte or BOH zyt)
Bauxite is a brownish or grayish mineral. Its ore is the chief source of aluminum.

calcite (KAL syt)
Calcite is a mineral. It is the chief substance in limestone, chalk, and marble.

carbon dioxide
(KAHR buhn dy AHK syd)
Carbon dioxide is a colorless, odorless gas that is in the earth's atmosphere.

carnotite (KAHR nuh tyt)
Carnotite is a yellow-colored, powdery, radioactive mineral that is one of the sources of uranium.

cartographer (kahr TAHG ruh fuhr)
A person who makes maps or charts is called a cartographer.

cassiterite (kuh SIHT uh ryt)
Cassiterite is a mineral ore. It is the chief source of tin.

chromium (KROH mee uhm)
Chromium is a shiny, gray metal that does not rust.

cinnabar (SIHN uh bahr)
Cinnabar is a mineral. It is the chief source of mercury.

cirrocumulus (sihr oh KYOO myuh luhs)
Cirrocumulus clouds are rows of small, fleecy, white clouds, often called a "mackerel sky."

cirrus (SIHR uhs)
A cirrus cloud is a thin, fleecy, white cloud of ice crystals that forms at a high altitude.

cobalt (KOH bawlt)
Cobalt is a metal often found with nickel and copper.

comet (KAHM iht)
A comet is a bright object in space. It looks like a star with a tail.

condensation trail
(kahn dehn SAY shuhn trayl)
A condensation trail, or contrail, is a stream of water droplets or ice crystals that can be seen forming behind highflying aircraft in the upper atmosphere.

constellation (kahn stuh LAY shuhn)
A constellation is a group of stars that appears to have special shape when viewed from the earth.

corundum (kuh RUHN duhm)
Corundum is a very hard mineral. Rubies and sapphires are kinds of corundum.

Crux (kruhks)
Crux, a Latin word that means "cross," is a constellation in the Southern Hemisphere. It is usually called the Southern Cross.

crystal (KRIHS tuhl)
A crystal is something that has hardened into a shape that has smooth, flat surfaces that meet in sharp edges and corners.

cumulonimbus
(kyoo myuh loh NIHM buhs)
Cumulonimbus is a heavy cloud mass with high peaks; a thundercloud.

cumulus (KYOO myuh luhs)
A cumulus cloud has a rounded top and a flat bottom. It is usually seen in fair weather.

detail (dih TAYL or DEE tayl)
A detail is a picture of a small part of something. It is sometimes shown larger than the whole thing.

diatom (DY uh tahm)
A diatom is a tiny water plant.

erosion (ih ROH zhuhn)
Erosion is the slow wearing away of soil or rock.

fluorite (FLOO uh ryt)
Fluorite is a mineral with a glassy luster.

fossil (FAHS uhl)
A fossil is the remains or traces of an animal or plant that lived long ago. A fossil may be a footprint, a bone, or the outline of a leaf.

gauge (gayj)
A gauge is a measuring instrument.

Geiger counter (GY guhr KOWN tuhr)
The Geiger counter is an instrument that detects radioactivity.

geyser (GY zuhr or GY suhr)
A geyser is a spring that shoots up hot water and steam.

glacier (GLAY shuhr)
A glacier is a huge mass of gritty ice that slides slowly over the land.

graphite (GRAF yt)
Graphite is a soft, black mineral used with clay to make the "lead" for pencils.

halite (HAL yt or HAY lyt)
Common table salt is the mineral called halite.

hematite (HEHM uh tyt or HEE muh tyt)
Hematite is iron ore that is sometimes called blood ironstone because of its red color.

igneous (IHG nee uhs)
Rock that was formed when it was heated to a liquid state is called igneous rock. *See also* **metamorphic; sedimentary.**

indigo (IHN duh goh)
Indigo is a deep violet-blue color.

magma (MAG muh)
Magma is the hot, melted rock beneath the earth's crust.

malachite (MAL uh kyt)
Malachite is a green mineral.

meridian (muh RIHD ee uhn)
A meridian is an imaginary line around the earth. Meridians meet at the North and South poles. We use

meridians to measure distance east or west. *See also* **parallel.**

metamorphic (meht uh MAWR fihk)
Metamorphic means changed. A metamorphic rock is one that has been changed by heat and pressure. *See also* **igneous; sedimentary.**

meteor (MEE tee uhr)
A meteor is a chunk of metal or stone (a meteoroid) that has entered the earth's atmosphere from outer space and is burning up from friction. It is often called a shooting star.

meteorite (MEE tee uh ryt)
A meteorite is a meteor that has reached the earth without burning up.

meteoroid (MEE tee uh roihd)
A meteoroid is a chunk of rock that is moving through space.

meteorologist (mee tee uh RAHL uh jihst)
A meteorologist is a person who studies the atmosphere and its effect on weather.

molecule (MAHL uh kyool)
A molecule is the tiniest part into which any substance, such as water, can be divided without changing into something else.

nebula (NEHB yuh luh)
A nebula is a huge cloud of gas or dust in space.

nimbostratus (nihm boh STRAY tuhs)
Nimbostratus is a low, dark-gray layer of rain or snow clouds.

nitrogen (NY truh juhn)
Nitrogen is a gas that has no color, odor, or taste. It makes up almost 80 per cent of the air we breathe.

obsidian (ahb SIHD ee uhn)
Obsidian is a hard, dark, glassy rock that forms when lava cools.

oceanographer
(oh shuh NAHG ruh fuhr)
A person who studies the ocean and the different kinds of ocean life is called an oceanographer.

paleontologist
(pay lee ahn TAHL uh jihst)
A paleontologist is a person who studies the plants and animals of long ago.

parallel (PAR uh lehl)
Lines that are parallel are the same distance apart everywhere. The imaginary lines circling the earth above and below the equator are called parallels. We use these parallels to measure distance north or south. *See also* **meridian.**

patina (PAT uh nuh)
Patina is a coating often found on the surface of old bronze or copper.

petrified (PEHT ruh fyd)
Something that is petrified has been changed into stone.

petroleum (puh TROH lee uhm)
Petroleum is a dark, oily liquid found in the earth. Gasoline and oil are made from petroleum.

Polaris (poh LAIR ihs)
Polaris, the North Star, is in the northern constellation Ursa Minor, usually called the Little Dipper. Polaris is above the North Pole. It is used in the Northern Hemisphere to find north.

pulsar (PUHL sahr)
A pulsar is a very tiny star that sends out short, regular bursts of radio waves.

pyrite (PY ryt)
Pyrite is a yellow mineral that looks like gold.

quadruplet (KWAHD roo pliht)
A quadruplet is any group or combination of four.

quartz (kwawrts)
Quartz is a very hard mineral.

refinery (rih FY nuhr ee)
A refinery is a place where metal, petroleum, or sugar is made as pure as possible.

saltpeter (sawlt PEE tuhr)
Saltpeter is a salty, white mineral used in making gunpowder.

satellite (SAT uh lyt)
A satellite is a natural or artificial object that revolves around a planet.

sedimentary (sehd uh MEHN tuhr ee)
Anything that is sedimentary is made from sediment—small bits of matter left by water, wind, or ice. Rocks formed from minerals that settle in this way are sedimentary rocks. *See also* **igneous; metamorphic.**

seismograph (SYZ muh graf)
A seismograph is an instrument that measures and records movements in the earth, especially earthquakes.

seismologist (syz MAHL uh jihst)
A seismologist is a person who studies earthquakes and other movements of the earth.

selenite (SEHL uh nyt)
Selenite is a form of the mineral gypsum. It is used in making plaster and cement.

sonar (SOH nahr)
Sonar is an instrument that uses sound waves to find the direction and distance of objects under water.

speleologist (spee lee AHL uh jihst)
A speleologist is a person skilled in the study of caves.

stalactite (stuh LAK tyt)
A stalactite is an icicle-shaped deposit of calcite hanging from the roof or sides of a cave.

stalagmite (stuh LAG myt)
A stalagmite is a deposit of calcite forming a stone column that rises up from the floor of a cave.

titanium (ty TAY nee uhm)
Titanium is a metal used in making steel.

turquoise (TUR koyz or TUR kwoyz)
Turquoise is a blue-to-green gemstone.

uranium (yu RAY nee uhm)
Uranium is a radioactive metal.

volcanologist
(vahl kuhn NAHL uh jihst)
A scientist who studies volcanoes is called a volcanologist.

wulfenite (WUL fuh nyt)
Wulfenite is a mineral that contains a metal used in making steel.

zircon (ZUR kahn)
Zircon is a mineral often used as a gem.

Illustration acknowledgments

The publishers of *Childcraft* gratefully acknowledge the following artists, photographers, agencies, and corporations for illustrations in this volume. Page numbers refer to two-page spreads. The words "*(left)*," "*(center)*," "*(top)*," "*(bottom)*," and "*(right)*" indicate position on the spread. All illustrations are the exclusive property of the publishers of *Childcraft* unless names are marked with an asterisk (*).

1:	*(top left)* NASA *; *(top right)* Rare Coin Co. of America, *Childcraft* photo; *(center left)* NASA *; *(center right)* *Childcraft* photo; *(bottom left)* James Conahan; *(bottom right)* E. S. Ross *
4-5	James Conahan
6-19	Herb Herrick
20-21	James Conahan
22-23:	George Suyeoka
24-25:	Ray Atkeson, DPI *
26-27:	*(left)* Alan Band Associates *, *(right)* R. N. Mariscal, Bruce Coleman Inc. *
28-29	James Conahan
30-31	Paolo Koch, Rapho Guillumette *
32-33:	James Conahan, Alan Band Associates *
34-35:	*(left)* C. Bonongton, Woodfin Camp, Inc. *; *(center)* Walter Bonatti, Pictorial Parade *; *(right)* B. Kielczynski, Bruce Coleman Inc. *
36-37:	*(left)* Paul X. Scott, Sygma *, *(right)* James Conahan
38-39	Bruce Coleman Inc. *
40-41	*(left)* Alan Band Associates *; *(right)* Esther Henderson, Rapho Guillumette *
42-43	*(left)* Bjorn Bolstad, from Peter Arnold *, *(right)* Leonard Lee Rue III, Bruce Coleman Inc. *
44-45	Giorgio Gualco, Bruce Coleman Inc. *
46-47	*(left)* Norman Myers, Bruce Coleman Inc. *; *(center photo)* J. R. Brownlie, Bruce Coleman Inc. *, *(right)* John Moss, Colorific *, James Conahan
48-49	Icelandic Photo & Press Service *
50-51	Guy Mannering, Bruce Coleman Inc. *; James Conahan
52-53	J. Alex Langley, DPI *
54-55:	*(left)* James Conahan; *(center)* J. M. Brunley, Bruce Coleman Inc. *; *(right)* J. Verheyden, Bruce Coleman Inc. *
56-57	*(left)* Deirdre Wroblewski *; *(right)* *Childcraft* photos by Hoppock Associates
58-59:	James Conahan
60-63	Bill Ratcliffe *
64-65:	Field Museum of Natural History, *Childcraft* photos
66-67:	*(top)* Robert H. Glaze, Artstreet *, *(bottom)* John Gerard *
68-69:	*(left)* James Conahan; *(right)* James Conahan, *Childcraft* photo
70-71.	*(left)* Metropolitan Museum of Art *; *(right)* Field Museum of Natural History, *Childcraft* photo
72-73:	Field Museum of Natural History, *Childcraft* photo
74-75:	*(top)* Early Japan by Jonathan Norton Leonard and the Editor of Time-Life Books © 1968 Time Inc. (Paulus Leeser) *, *(bottom)* Field Museum of Natural History, *Childcraft* photo
76-77:	*(left)* James Conahan; *(right)* Department of Energy *; Field Museum of Natural History, *Childcraft* photo
78-79	*Childcraft* photos
80-81.	Field Museum of Natural History, *Childcraft* photo
82-83	Erich Lessing, Magnum *
84-85:	*(left)* Field Museum of Natural History, *Childcraft* photo; Robert Weldon, Gemological Institute of America *; Robert Weldon, Gemological Institute of America *, Field Museum of Natural History, *Childcraft* photo; Robert Weldon, Gemological Institute of America *, Jeffrey Kurtzeman; *(right)* Field Museum of Natural History, *Childcraft* photo; T. Hammid, Gemological Institute of America *, *Childcraft* photo, *Childcraft* photo; Robert Weldon, Gemological Institute of America *
86-87:	*(left)* Field Museum of Natural History, *Childcraft* photo; *(right)* Rare Coin Co. of America, *Childcraft* photo
88-89	*(left)* E. R. Degginger *; David R. Frazier, *(right)* Shaw McCutcheon, Superstock *
90-91.	James Conahan; Field Museum of Natural History, *Childcraft* photo
92-93.	*Childcraft* photo, James Conahan
94-95.	*Childcraft* photo
96-97.	*(left)* Field Museum of Natural History, *Childcraft* photo; *(right)* Kaiser Aluminum & Chemical Corp.
98-99	James Conahan
100-101	James Conahan; David Muench *
102-103.	*(top)* E. R. Degginger *; *(bottom)* Bill Ratcliffe *
104-105:	David Muench *
106-107.	*(left)* Thomas Henley, Tom Stack & Assoc. *, *(right)* Marvin E. Newman, Woodfin Camp, Inc. *
108-109	*(top)* Robert H. Glaze, Artstreet *, *(bottom)* David Muench *
110-111	James Conahan
112-113:	Henry Monroe, DPI *, James Conahan
114-115	James Conahan
116-117:	David R. Frazier *
118-119	Kirsty McLaren
120-121	James Conahan
122-123	Francisco Erize, Bruce Coleman Inc. *; James Conahan
124-125:	*(left)* Peter Fronk, Van Cleve Photography *, *(right)* Bill Brooks, Bruce Coleman Inc. *
126-127:	*(left)* Aerofilms, Ltd. *; *(right)* Artstreet *
128-129.	*(left)* Morton Beebe, DPI *, *(right)* Ed Barans, DPI *
130-131	*(left)* Claude Haycraft, Van Cleve Photography *; *(right)* Ray Atkeson, DPI *
132-133:	Oregon State Highway Division *, James Conahan
134-135	G. R. Roberts *
136-137:	AP/Wide World *
138-139	James Conahan; Vance Henry, Taurus *
140-141	*(top)* Rodney Allin, Bruce Coleman Inc. *, James Conahan; *(right)* Ray Atkeson, DPI *
142-143:	Barbara Van Cleve *

144-145: James Conahan
146-147: NASA *
148-149: James Conahan
150-151: *(top)* Barbara Van Cleve *; *(bottom)* Grant Heilman *
152-153: Roman Vishniak *, James Conahan
154-163: James Conahan
164-165: *(left)* James Conahan; *(right)* Childcraft photo
166-167: John Stanford, Iowa State University (R. D. Dockendorff) *
168-169: National Oceanic & Atmospheric Administration *
170-171: James Conahan; Daniel Farber, Rapho Guillumette *
172-173: Rod Borland, Bruce Coleman Inc. *
174-175: John Deeks *
176-177: *(left)* E. R. Degginger *; *(right)* Tom Stack *
178-179: Hubbard Scientific Company (J. A. Day) *
180-181: *(left)* James Conahan; *(right)* *Childcraft* photo
182-183: San Francisco Convention & Visitors Bureau (Sandor Balatoni) *
184-185: *(left)* *Childcraft* photo; *(right)* Grant Heilman *
186-187: E. R. Degginger *
188-189: *Childcraft* photo
190-191: James Conahan; John Deeks *
192-193: John Deeks *; James Conahan
194-195: *(top)* Rural Life Photo Service *; *(bottom)* National Center for Atmospheric Research *
196-197: *(left)* Clyde H. Smith *; *(right)* Teisaku Kobayashi *
198-199: Grant Heilman *
200-201: Robert H. Glaze *
202-203: James Conahan
204-205: Orien Ernest, *Astronomy Magazine* *
206-207: Glenn Van Nimwegen *; James Conahan
208-209: U.S. Naval Research Laboratory *
210-211: Herb Herrick
212-215: James Conahan
216-217: Tom Stack *
218-219: James Conahan
220-221: Tom Stack *
222-223: James Conahan
224-225: James Conahan; George East *
226-227: Dan Marrill, Van Cleve Photography *
228-229: T. C. Brandt, Van Cleve Photography *
230-231: James Conahan; *(top)* NASA *; Lick Observatory *
232-233: James Conahan
234-235: James Conahan; Steve Larson
236-237: NASA *; James Conahan
238-241: NASA *
242-243: Herb Herrick; Roberta Polfus
244-245: James Conahan; NASA *
246-247: James Conahan, NASA *
248-249: © California Institute of Technology and Carnegie Institution of Washington, from Hale Observatories *, *(top)* James Conahan; *(bottom)* NASA *
250-251: *(upper left)* NASA *; *(lower left)* A. McEwen, U.S.G.S., Flagstaff Image Processing Facility; *(right)* Jet Propulsion Laboratory *
252-253: NASA *; James Conahan
254-255: James Conahan; NASA *
256-257: *(left)* James Conahan; *(right)* Jet Propulsion Laboratory *
258-259: Herb Herrick
260-261: Patrick Michaud, *Astronomy Magazine* *
262-263: *(left)* Field Museum of Natural History, *Childcraft* photo; *(right)* Arizona Office of Tourism *
264-265: *(left)* Department of Astronomy, University of Michigan; *(right)* Astronomical Society of the Pacific *
266-267: James Conahan
268-269: James Conahan; Minolta Corporation *
270-271: *(top)* Product Illustration, Inc.; *(bottom)* James Conahan
272-273: *(top)* Product Illustration, Inc.; *(bottom)* James Conahan
274-275: Herb Herrick
276-277: U.S. Naval Observatory *
278-279: Herb Herrick; U.S. Naval Observatory *
280-281: *(left)* © California Institute of Technology and Carnegie Institution of Washington, from Hale Observatories *, *(right)* U.S. Naval Observatory *
282-283: *World Book* photo
284-285: F. Yasuhara *
286-287: James Conahan
288-289: *(left)* NASA *; *(right)* *Childcraft* photo by Brent Jones
290-291: Chicago Aerial Survey *; *Childcraft* art
292-293: *(left)* © Cameramann Int'l, Ltd. *; *(right)* *Childcraft* photo by Brent Jones
294-297: *Childcraft* art
298-299: *Childcraft* photos; James Conahan
300-301: *(left)* *Childcraft* art, *(right)* James Conahan
302-305: James Conahan
306-307: Standard Oil Co. (Ind.) *
308-309: *(left)* © Peter A. Silva, Picture Group *; *(right)* E. S. Ross *
310-311: *(top)* Ted Spiegel, Black Star *; *(bottom)* Leo Choplin, Black Star *
312-313: *Childcraft* photo by Kyodo News Service
314-315: U.S. Geological Survey *
316-317: *(left)* Flip Schulke, Black Star *, *(right)* *Childcraft* photo by Kyodo News Service
318-319: *(top)* Stephen Krasemann, Science Photo Library *; *(bottom)* Hank Morgan, Science Photo Library *
320-321: *(left)* NASA *, Douglas Kirkland, Contact Stock *, *(right)* NASA *

Cover: Roberta Polfus

Index

This index is an alphabetical list of the important topics covered in this book. It will help you find information given in both words *and* pictures. To help you understand what an entry means, there is often a helping word in parentheses, for example, **Achernar** (star). If there is information in both words and pictures, you will see the words *(with pictures)* after the page number. If there is *only* a picture, you will see the word *(picture)* after the page number. If you do not find what you want in this index, please go to the General Index in Volume 15, which is a key to all of the books.