MY FIRST BRITANNICA

Physical Sciences
and Technology

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Physical Sciences and Technology

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Spiral-shaped galaxy.
© Myron Jay Dorf/Corbis

Physical Sciences and Technology

I N T R O D U C T I O N

Where does medicine come from? What was Gutenberg's gift?
Are aliens waiting for us in outer space?
Can eyes ever hear?

In Volume 2, ***Physical Sciences and Technology,*** you'll discover answers to these questions and many more. Through pictures, articles, and fun facts, you'll journey through space, meet great inventors, and investigate wonderful things about the world.

To help you on your journey, we've provided the following guideposts in *Physical Sciences and Technology*:

- **Subject Tabs**—The colored box in the upper corner of each right-hand page will quickly tell you the article subject.
- **Search Lights**—Try these mini-quizzes before and after you read the article and see how much—*and how quickly*—you can learn. You can even make this a game with a reading partner. (Answers are upside down at the bottom of one of the pages.)
- **Did You Know?**—Check out these fun facts about the article subject. With these surprising "factoids," you can entertain your friends, impress your teachers, and amaze your parents.
- **Picture Captions**—Read the captions that go with the photos. They provide useful information about the article subject.
- **Vocabulary**—New or difficult words are in **bold type**. You'll find them explained in the Glossary at the back of this volume. And there's a complete listing of all Glossary terms in the set in the ***Reference Guide and Index***, Volume 13.
- **Learn More!**—Follow these pointers to related articles throughout the set.

And don't forget: If you're not sure where to start, where you saw something before, or where to go next, the Index at the back of this volume and the ***Reference Guide and Index*** (Volume 13) will point the way.

Have a great trip!

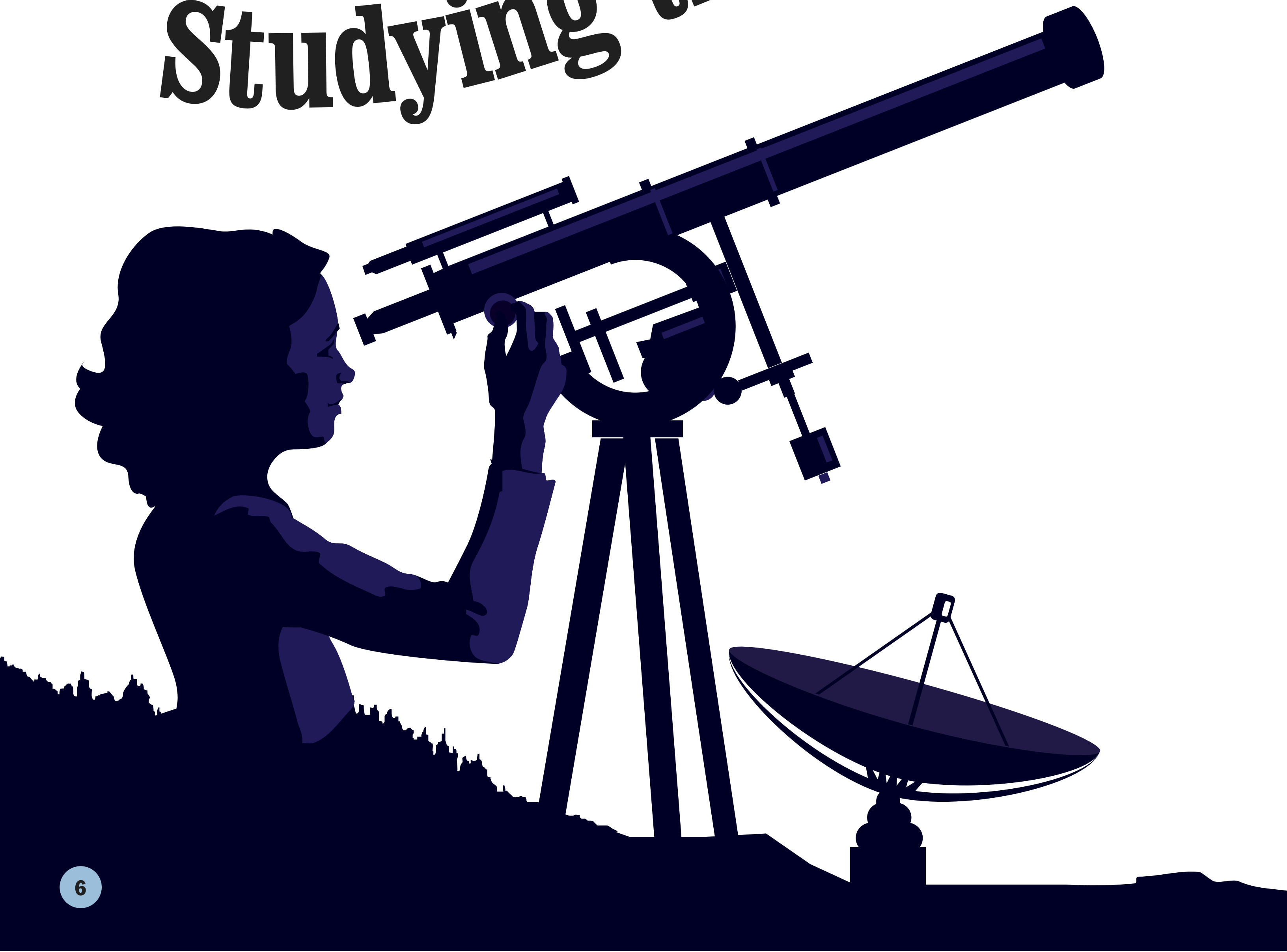
MY FIRST BRITANNICA

SEARCH LIGHT

Which of these things do astronomers study?

- stars
- planets
- moons
- astronauts
- comets

Studying the Stars



DID YOU KNOW?
Sunlight takes about eight minutes to travel the 93 million miles from the Sun to the Earth.

Look at the sky. What do you see?

If it's day you'll see the Sun. If it's night you'll see the Moon. And if the sky is clear you'll see stars. In big cities you may see only a few hundred stars. But out in the country or on the ocean you'll see many thousands. You may even see planets and, if you're lucky, a **comet**.

There are people who look at the sky for hours and hours, night after night. They study the stars, the planets, and other objects in the sky. These people are called "astronomers." The word "astronomy" comes from the Greek for "star" and "arrangement."

Astronomers study the universe in many different ways. Some watch faraway objects. Others work in **laboratories**, where they look at samples of **meteorites**, rocks from the Moon, and space **debris** from other planets. Some try to make models of different objects people have studied.

Not all astronomers get paid for the work they do. Some do it for a hobby. Such people are called "amateur astronomers."

How do astronomers study objects that are millions, even billions, of miles away? They use powerful telescopes that make things look large enough to be seen in detail. Some telescopes are small enough to be held in the hand. Others are as big as a school bus!

LEARN MORE! READ THESE ARTICLES…
GALILEO GALILEI (VOLUME 4) • TELESCOPES (VOLUME 2) • UNIVERSE (VOLUME 2)

Answer: They study all of these except for astronauts.

Infinite Space

The universe is a vast **expanse** of space that contains all matter and energy, from the smallest particle to the biggest galaxy. It contains all the planets, the Sun, stars, asteroids, our Milky Way Galaxy, and all the other galaxies too.

No one knows how big the universe is. Astronomers believe that it is still growing outward in every direction.

How did it all begin? No one knows that for sure either.

Most scientists believe that at first everything was one incredibly solid, heavy ball of matter. This ball exploded billions of years ago—and the universe was born. The moment of this explosion is called the "big bang." It is from this moment that time began.

After the explosion the early universe was small and extremely hot. As it cooled, it expanded and pieces spread out. Small pieces formed the basic

SEARCH LIGHT

If the universe is still growing, is it moving toward or away from the Earth?

elements hydrogen and helium. Other pieces began to join together, and objects began to form. Over billions of years the objects became galaxies, stars, and planets.

This is still only a theory, an idea. But different parts of it have proved true over the years. Astronomers try to **investigate** the theory all the time. One way they do this is to use a "spectroscope." A spectroscope measures the color of light coming from an object. Changes in the color indicate whether an object is moving away from or toward the Earth.

Because of spectroscope readings scientists believe that the universe is still growing outward in every direction.

LEARN MORE! READ THESE ARTICLES…
ATOMS (VOLUME 2) • GALAXIES (VOLUME 2)
SOLAR SYSTEM (VOLUME 2)

DID YOU KNOW?
Scientists believe that much of the universe may be made of something called "dark matter." This hidden mass may be a substance that human beings have never before encountered.

Answer: Everything in the universe is moving away from everything else. You can see how this works if you put black dots on a balloon, blow it up, and watch the dots spread apart.

Distant Fire

All stars are basically enormous balls of fire. They are made up of gases that give off both heat and light as they burn. Their power comes from nuclear energy, the same source that both powers atomic bombs and produces electricity in many parts of the world.

The life of a star spans billions of years. A star is born from clouds of dust and the **element** hydrogen. This cloud mass forms a spinning ball that pulls all the material toward the center. It becomes more and more dense, or thick, as the material comes together. It also becomes extremely hot. Eventually it becomes so hot that the hydrogen gas begins to glow. The glowing gas ball is called a "protostar" ("proto" means "beginning" or "first").

A protostar becomes a star when it starts a process called fusion. This happens when hydrogen atoms combine to form the element helium. The fusion process releases a huge amount of energy in the form of heat and light. A star can continue to glow for millions of years.

When the star finally runs out of hydrogen for the fusion reaction, it starts to cool. Some stars expand into "red supergiants" when they run out of hydrogen. If the conditions are right, these red supergiants then explode in a huge, violent blast called a "supernova." In some cases, what is left may become a black hole. Black holes are like giant vacuum cleaners in space that suck up everything around them, including light.

Our Sun is still a young star, though it is already billions of years old. It will be many more billions of years before it begins to die. So there's still time to finish your homework.

DID YOU KNOW?

After our own Sun, the nearest star to Earth is Alpha Proxima Centauri. It is 4.2 light-years away, or almost 25 trillion miles from Earth.

SEARCH LIGHT

True or false? Black holes were once stars.

LEARN MORE! READ THESE ARTICLES…
GALAXIES (VOLUME 2) • NUCLEAR ENERGY (VOLUME 2)
UNIVERSE (VOLUME 2)

It's hard to believe, when you look up at the night sky, that all those twinkling stars are actually enormous balls of fire.

Answer: TRUE. Black holes are former stars that have collapsed inward and now swallow up all material and light around them.

Star Clusters

When we look at the sky at night, we may see thousands of stars shining brightly. They look as if they are just scattered around the sky. But actually, most stars are clustered together in huge groups. These groups are called "galaxies."

Our Sun is part of a galaxy. It is the Milky Way Galaxy. On a very clear night, if you look carefully at the sky, you might see part of this whitish band of stars stretching from one side to the other.

The universe is so huge that the Milky Way Galaxy is only one of many. Astronomers think that there are billions of galaxies in the universe. Each of these galaxies may contain trillions of stars, many much bigger than our own Sun! The Milky Way itself contains several billion stars.

Some galaxies have no regular shape. Others, like the Milky Way, are shaped somewhat like giant merry-go-rounds. Each has a center around which stars move in circles.

It is hard to see the other galaxies in the sky with the naked eye. Even though they are incredibly large, they are also incredibly far away. Scientists must use powerful telescopes to study other galaxies. For this reason it takes a long time to learn even a little bit about another galaxy. And there's still a great deal we haven't learned about our own galaxy.

SEARCH LIGHT

Find and correct the error in the following sentence: There are many, many universes in the galaxy.

LEARN MORE! READ THESE ARTICLES…
SOLAR SYSTEM (VOLUME 2) • TELESCOPES (VOLUME 2)
UNIVERSE (VOLUME 2)

DID YOU KNOW?

Constellations, unlike galaxies, are groups of stars that people imagined as connecting to make pictures in the night sky. Named mostly for animals and mythological figures, constellations still help astronomers and navigators locate certain stars.

Our galaxy, the Milky Way, is shaped somewhat like a giant merry-go-round. Its billions of stars move in circles around a center.

Answer: There are many, many galaxies in the universe.

Life Beyond the Earth

Could there be life elsewhere in the universe? There are some people who think that it's possible. They have given the idea a name, extraterrestrial life. "Extra" means "beyond" and "terrestrial" means "of the Earth," so altogether the name means "life beyond the Earth."

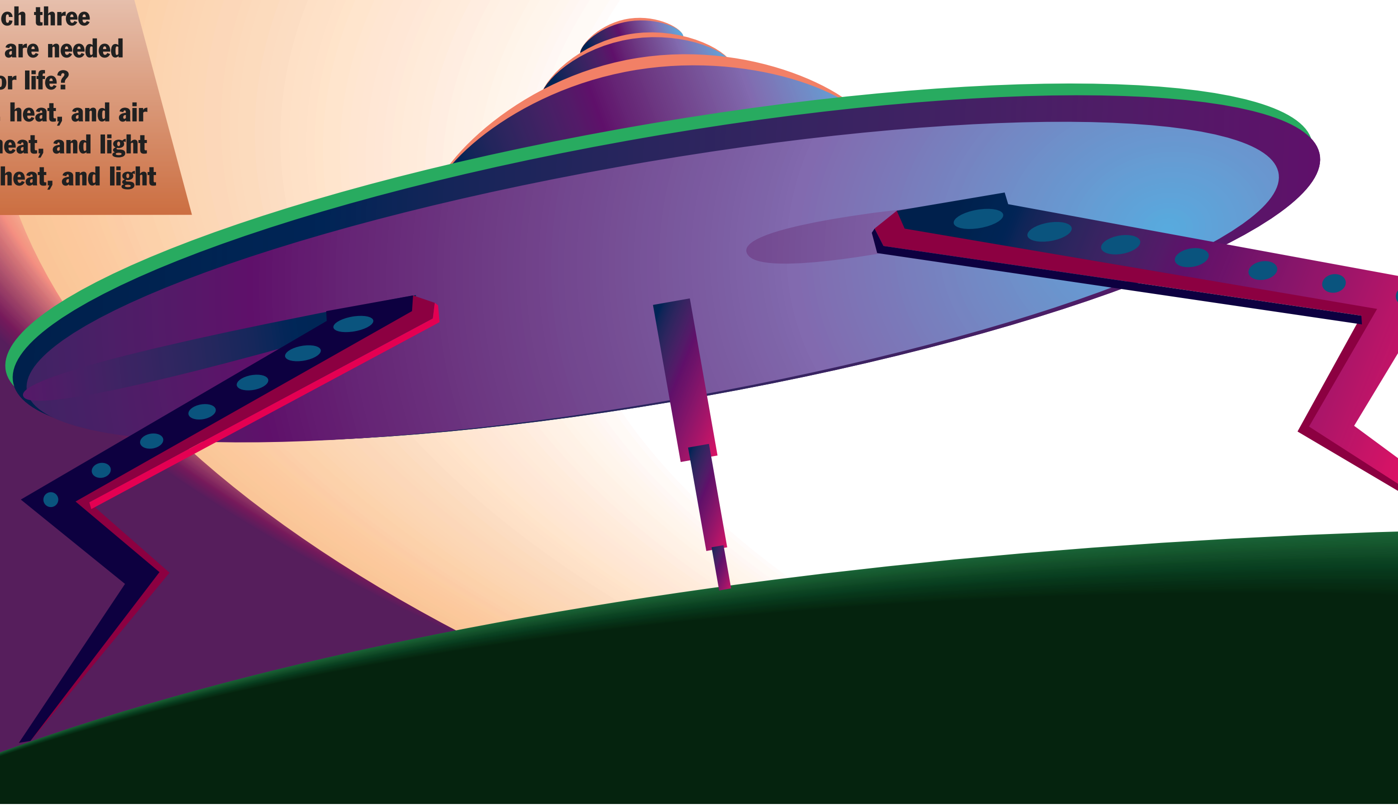
Most scientists believe that for another planet to have life on it, it must have an **atmosphere** (air), light, heat, and water like the Earth does.

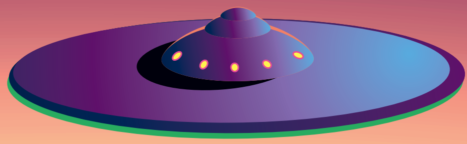
We get our light and heat from the Sun. The universe is filled with millions of stars like our Sun. Scientists are trying to find out if these stars have planets, maybe Earth-like planets. If there is such a planet, then it could have life on it.

It's not easy to find extraterrestrial life. The universe is an immense place to search. Some scientists believe that if there is intelligent life elsewhere, it may send radio signals to us. So far, the only signals that scientists have found are the natural ones that come from stars and planets themselves.

SEARCH LIGHT

In addition to an atmosphere, which three things are needed for life?
a) water, heat, and air
b) dirt, heat, and light
c) water, heat, and light



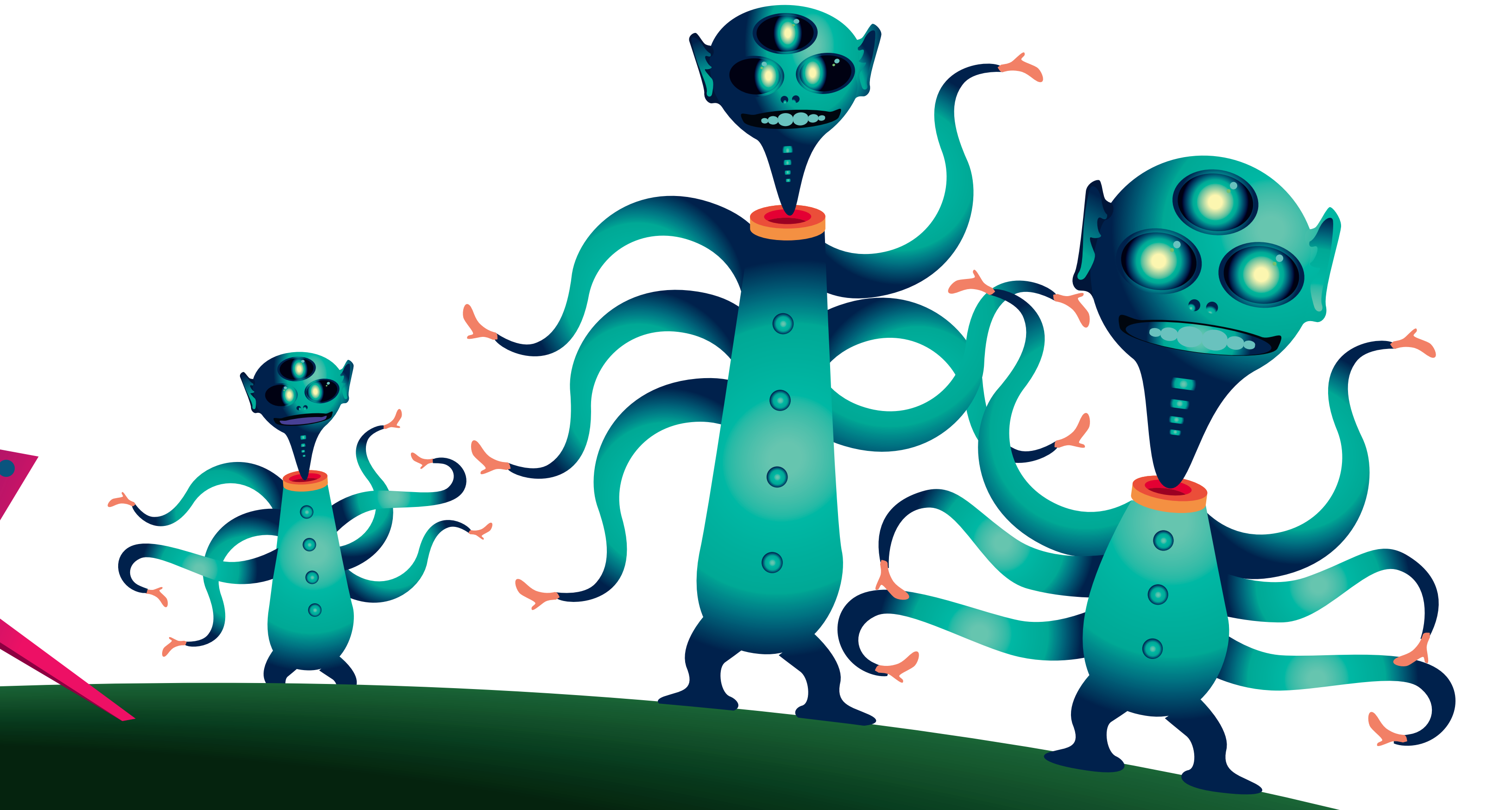


DID YOU KNOW?
Today the Foo Fighters are a rock band, but in World War II American pilots gave that name to mysterious UFOs—floating lights they saw over Germany.

Whether it is possible or not, the idea of beings on other planets has excited people for years. Some believe that aliens from other worlds have even visited Earth. They call these aliens "extraterrestrials," or "ETs." Some even claim to have seen ETs and their spaceships, which are called "unidentified flying objects," or simply "UFOs."

What do you think, are there creatures living on other planets? And how do you think they would live?

LEARN MORE! READ THESE ARTICLES…
ASTRONAUTS (VOLUME 2) • SPACECRAFT (VOLUME 2) • UNIVERSE (VOLUME 2)



Answer: c) water, heat, and light

Exploring the New Frontier

Once the Moon was the only important thing in **orbit** around planet Earth. Today many objects circling the Earth have been launched into space by human beings. All these orbiters, including the Moon, are called "**satellites**." Those launched by people are called "**artificial** satellites."

Communications satellites send telephone, television, and other electronic signals to and from places on Earth. Weather satellites take pictures of the clouds and wind systems. Various scientific satellites gather information about outer space. There are even "spy" satellites to take pictures for the military. And there are space stations.

In the late 20th century the United States, Russia, the European Space Agency, Japan, and Canada joined forces to build the International Space Station (the ISS). It is meant to have people on it all the time. In 1998 the first two ISS **modules** were launched and joined together in space. In November 2000 the first three-person crew, an American and two Russians, occupied the still-growing station.

Large space stations are planned for the future. These will have many people working in them all the time. They may be like airports are today, where a person changes planes to go to a specific destination. But from a spaceport people would change spacecraft to travel to the Moon, another planet, or another space station.

DID YOU KNOW?

In order to leave the Earth's gravity and visit a space station, you must travel at a speed of 7 miles per second.

SEARCH LIGHT

Why is a space station called a satellite?

LEARN MORE! READ THESE ARTICLES…
MOON (VOLUME 2) • PLANETS (VOLUME 2)
SOLAR SYSTEM (VOLUME 2)

In November 2000 the first three-person crew, an American and two Russians, occupied the still-growing International Space Station.

Answer: Since space stations orbit a planet, they are, by definition, satellites.

Going Up in Space

Space is what we call the area that's 100 miles or more above Earth's surface. Below that boundary is Earth's **atmosphere**—the layer of gases including the air we breathe. In space there is no air to breathe. And it is very, very cold.

Russia and the United States were the first countries to send people into space. Russia's space travelers are called "cosmonauts," which means "space sailors." Those from the United States are called "astronauts," meaning "star sailors."

In 1961 cosmonaut Yuri Gagarin became the first man to travel into space. In 1969 U.S. astronaut Neil Armstrong became the first man to walk on the Moon. Sally Ride, in 1983, was the first American woman astronaut.

Today people travel into space inside **space shuttles** that ride piggyback on a rocket into space. After blastoff, the Earth outside the shuttle moves farther and farther away until it looks like a big blue-and-white sea outside the astronauts' window.

In space anything not tied down will float—including the astronauts themselves! Earth's gravity has become too weak to hold things down. In fact, it's hard to tell what "down" means in space.

The shuttle's many special machines help astronauts exist in space. The main computer helps fly and control conditions within the shuttle. A long metal arm lets the astronauts handle things outside their ship. And many other machines are carried along for experiments.

Today most space shuttle trips are to space stations, where astronauts and cosmonauts can live while they work in space.

LEARN MORE! READ THESE ARTICLES…
GRAVITY (VOLUME 2) • MOON (VOLUME 2)
SPACECRAFT (VOLUME 2)

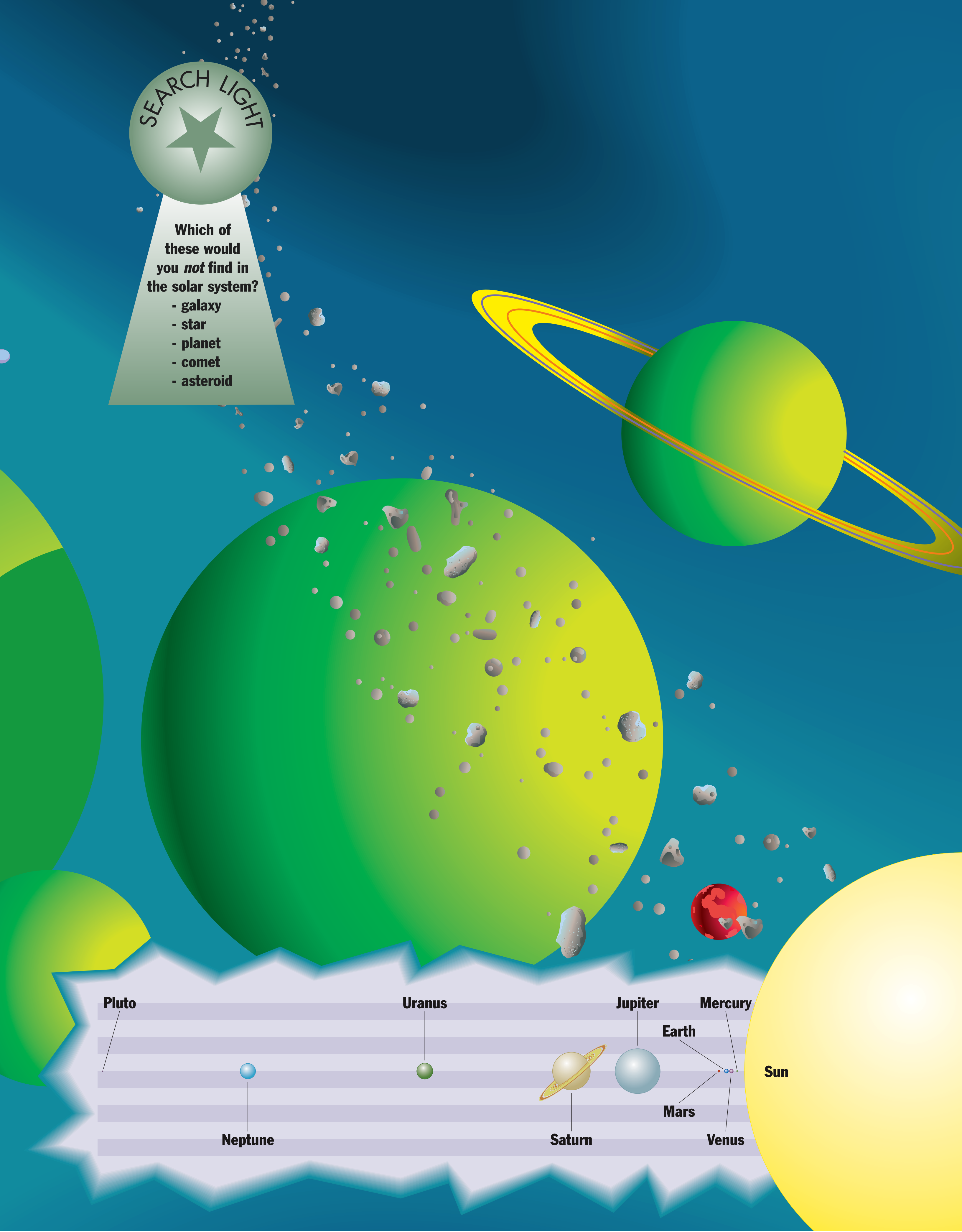
DID YOU KNOW?
Because different planets have different gravities, an astronaut's weight would change from planet to planet. For example, an astronaut weighing 165 pounds on Earth would weigh only 62 pounds on Mars but 390 pounds on Jupiter.

SEARCH LIGHT

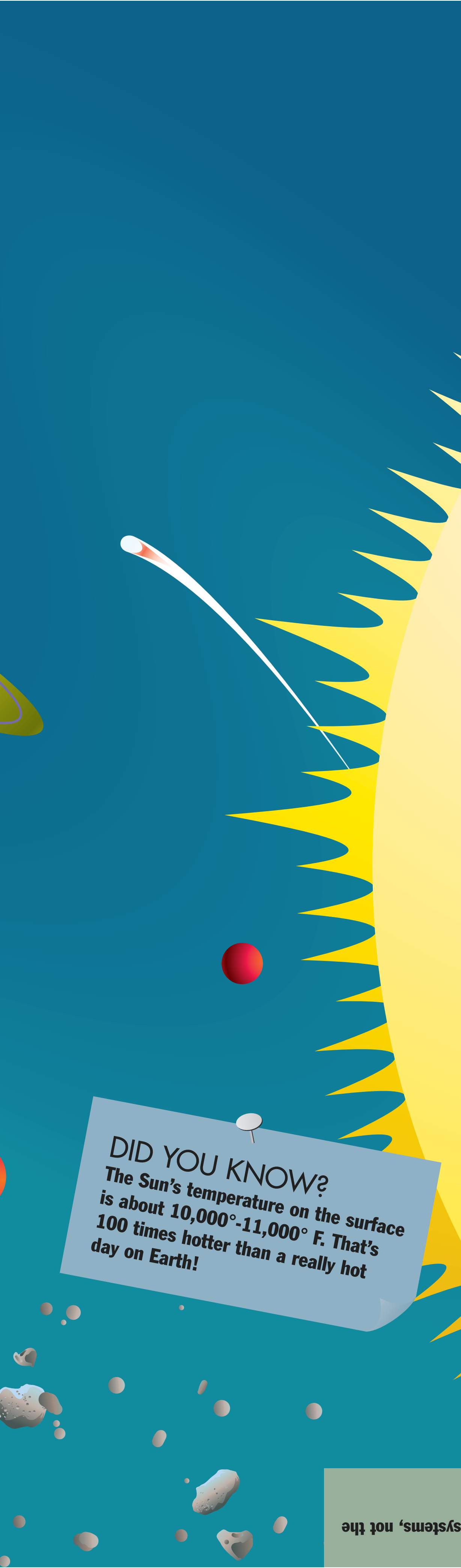
Space is the area
a) more than 100 miles out from Earth.
b) more than 10 miles out from Earth.
c) more than 1,000 miles out from Earth.

Imagine you are lying on your back inside a space shuttle. Two long rockets will help your heavy spaceship get off the ground. With five seconds to go, the fuel in your spaceship starts burning. "Five...four...three...two...one."
NASA

Answer: a) more than 100 miles out from Earth.


SEARCH LIGHT
Which of these would you *not* find in the solar system?
- galaxy
- star
- planet
- comet
- asteroid
Pluto
Uranus
Jupiter
Mercury
Earth
Sun
Mars
Neptune
Saturn
Venus

Family of the Sun



Imagine a huge black space. The Sun moves through this vast space, bringing many smaller bodies with it. These bodies include planets, asteroids, comets, meteors, and tiny **molecules** of gases. The Sun and its companions are known as a "solar system." Many solar systems and stars clustered together make up galaxies.

Astronomers do not know how far out our solar system extends. They think that some objects may be as much as 9 trillion miles away from the Sun.

The Sun provides energy for the rest of the solar system. It also provides the heat and light necessary for life on our planet. And its **gravity** keeps the planets, comets, and other bodies in orbit.

The planets are the largest and most **massive** members of the solar system after the Sun. There are eight known planets: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.

Scientists used to think that there were nine planets. They thought that Pluto was a planet because it revolves around the Sun. But in 2006 they decided that Pluto should be called a dwarf planet. Other bodies that also **orbit** the Sun but are even smaller are called asteroids. Most asteroids lie between Mars and Jupiter.

A comet appears in the sky as a fuzzy spot of light with a tail streaming away from it. It is made up of dust and frozen gases. As this giant dirty snowball moves closer to the Sun, the ice melts and makes what looks like a tail. Halley's Comet is probably the most famous of all.

DID YOU KNOW?
The Sun's temperature on the surface is about 10,000°-11,000° F. That's 100 times hotter than a really hot day on Earth!

LEARN MORE! READ THESE ARTICLES…
ASTEROIDS (VOLUME 2) • GALAXIES (VOLUME 2)
PLANETS (VOLUME 2)

Answer: Galaxies are made up of stars and solar systems, not the other way around.

Minor Planets

On January 1, 1801, a man named Giuseppe Piazzi found a new object in the sky. It was circling the Sun out beyond the planet Mars, and Piazzi thought it might be a comet. Some people thought that it was a new planet. Over the next few years many more objects were seen. All of these were much smaller than a planet. Astronomers now call these objects "asteroids," or minor planets.

There are thousands of asteroids in our solar system. They tend to vary in shape, ranging from large **spheres** to smaller slabs and potato-shaped objects. Some asteroids are big. Most are the size of a boulder. Smaller asteroids form when two big asteroids smash into each other and break up. Astronomers think that there are millions of tiny asteroids in the solar system.

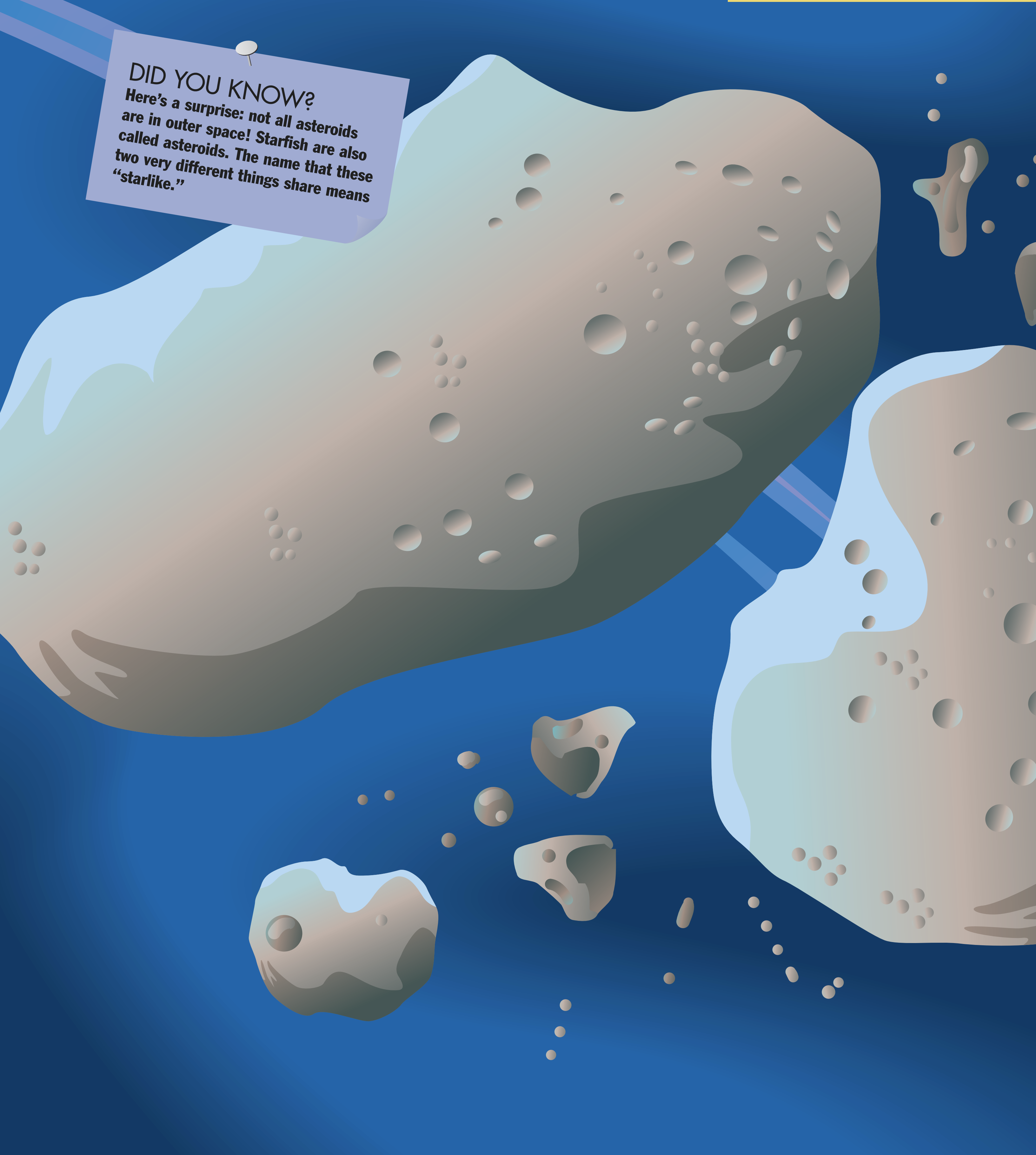
Like planets, all asteroids in our solar system circle the Sun. The path that a planet or an asteroid follows when it circles the Sun is called an "orbit." Most asteroids are found farther from the Sun than Earth, between the orbits of Mars and Jupiter. Some, though, come quite close to the Sun.

Many people believe that millions of years ago an asteroid hit Earth and led to the dinosaurs' dying out. Some filmmakers in Hollywood have even made popular films, such as *Armageddon*, using the idea of an asteroid hitting Earth.

LEARN MORE! READ THESE ARTICLES…
DINOSAURS: A MYSTERY DISAPPEARANCE (VOLUME 1)
PLANETS (VOLUME 2)
SOLAR SYSTEM (VOLUME 2)

SEARCH LIGHT

Fill in the blank: An asteroid might have been involved in the disappearance of the dinosaurs when it crashed into _________.



DID YOU KNOW?

Here's a surprise: not all asteroids are in outer space! Starfish are also called asteroids. The name that these two very different things share means "starlike."

Answer: An asteroid might have been involved in the disappearance of the dinosaurs when it crashed into Earth.

SEARCH LIGHT

If Halley's Comet came around in 1759, 1835, 1910, and 1986, about how many years does it take to appear?

DID YOU KNOW?

American author Mark Twain was born in 1835 on a day when Halley's Comet could be seen in the sky. Just as he predicted, he died when Halley's Comet was again seen in the sky, in 1910.

Rocketing Masses with Fuzzy Tails

The word "comet" comes from a Greek word that means "hairy one." A comet sometimes looks like a star with a hairy tail. But a comet is not a star. Like the Moon, a comet has no light of its own. A comet shines from the sunlight bouncing off it. Like the Earth, a comet goes around the Sun, so it may appear again and again.

But if a comet isn't a star, what is it?

Some scientists think that a large part of a comet is ice. The rest is bits of iron and dust and perhaps a few big chunks of rock. When sunshine melts the ice in a comet, great clouds of gas go streaming behind it. These clouds make the bright fuzzy-looking tail.

Long ago when there were no streetlights and the air was very clean, everyone could see the comets. Unlike the stars that shone every night, comets seemed to appear quite suddenly. So people thought that they would bring bad luck such as floods, hungry times, or sickness.

Edmond Halley, who lived over 200 years ago, discovered about 24 different comets. One that keeps coming back was named for him because he figured out when it would return. Halley first saw it in 1759, and it reappeared in 1835, 1910, and 1986. The next time it comes near the Earth will be in the year 2060.

How old will you be then?

Derke/O'Hara/Stone

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ASTEROIDS (VOLUME 2) • ASTRONOMY (VOLUME 2) • SOLAR SYSTEM (VOLUME 2)

Answer: Halley's Comet generally comes around every 76 years, though sometimes it takes just 75.

SEARCH LIGHT

True or False? On the Moon you would weigh more than you do on Earth.

A Trip to the Moon

Would you like to go to the Moon? Someday you may be able to.

Astronauts have already visited the Moon. They brought their own food, water, and air. You would have to bring these things along too, because the Moon doesn't have them.

Astronaut Edwin E. ("Buzz") Aldrin on July 20, 1969, one of the first two humans to walk on the Moon.
NASA/JPL/Caltech

Compared with the planets, the Moon is very near to the Earth. It is only 239,000 miles away. Spaceships travel fast enough to cover that distance in a matter of hours.

Someday there may be little towns on the Moon. The first ones will probably be covered over and filled with air. When you're inside the Moon town, you'll be able to breathe normally without a space suit or air tanks. But you will need a space suit and an air tank to go outside.

Once you walk outside the Moon town, you will feel a lot lighter. You will be able to take giant steps of more than ten feet. You'll be able to throw a baseball almost out of sight. This is because the Moon has fairly weak gravity, the force that keeps things from flying off into space.

Gravity is also what gives your body weight. You would not weigh as much on the Moon as you do on the Earth. If you weigh 42 pounds on the Earth, you would weigh only 7 pounds on the Moon!

From the Moon you'll see many more stars than you can see from the Earth. They'll also seem much brighter, because you won't be looking through layers of air and pollution. And you'll be able to enjoy this view for two whole weeks at a time. That's the length of the Moon's night!

DID YOU KNOW?

Since there's no wind or water to wipe them out, the astronauts' footprints on the Moon could still be there in 10 million years.

LEARN MORE! READ THESE ARTICLES…
GRAVITY (VOLUME 2) • SOLAR SYSTEM (VOLUME 2) • SPACECRAFT (VOLUME 2)

Answer: FALSE. On the Moon you would weigh less than you do on Earth. To find out what you would weigh on the Moon, take your weight and divide by 6.

NASA/JPL/Caltech

Wanderers in the Sky

Billions of years ago there was a gigantic swirling cloud of gas and dust. This cloud packed together and became extremely hot. Eventually, the center of the cloud formed our Sun. The rest of the cloud clumped together until it formed the planets.

Eight planets in our solar system revolve (circle) around our Sun. Beginning with the one closest to the Sun, they are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.

The planets have been divided into two basic groups. There are Earth-like planets and Jupiter-like planets.

Earth-like planets are close to the Sun and made up of rock and metal. These planets are Mercury, Venus, Earth, and Mars. The other planets are larger and farther away from the Sun. These planets are Jupiter, Saturn, Uranus, and Neptune. These four planets have no solid surfaces. They are made up of gases and liquids.

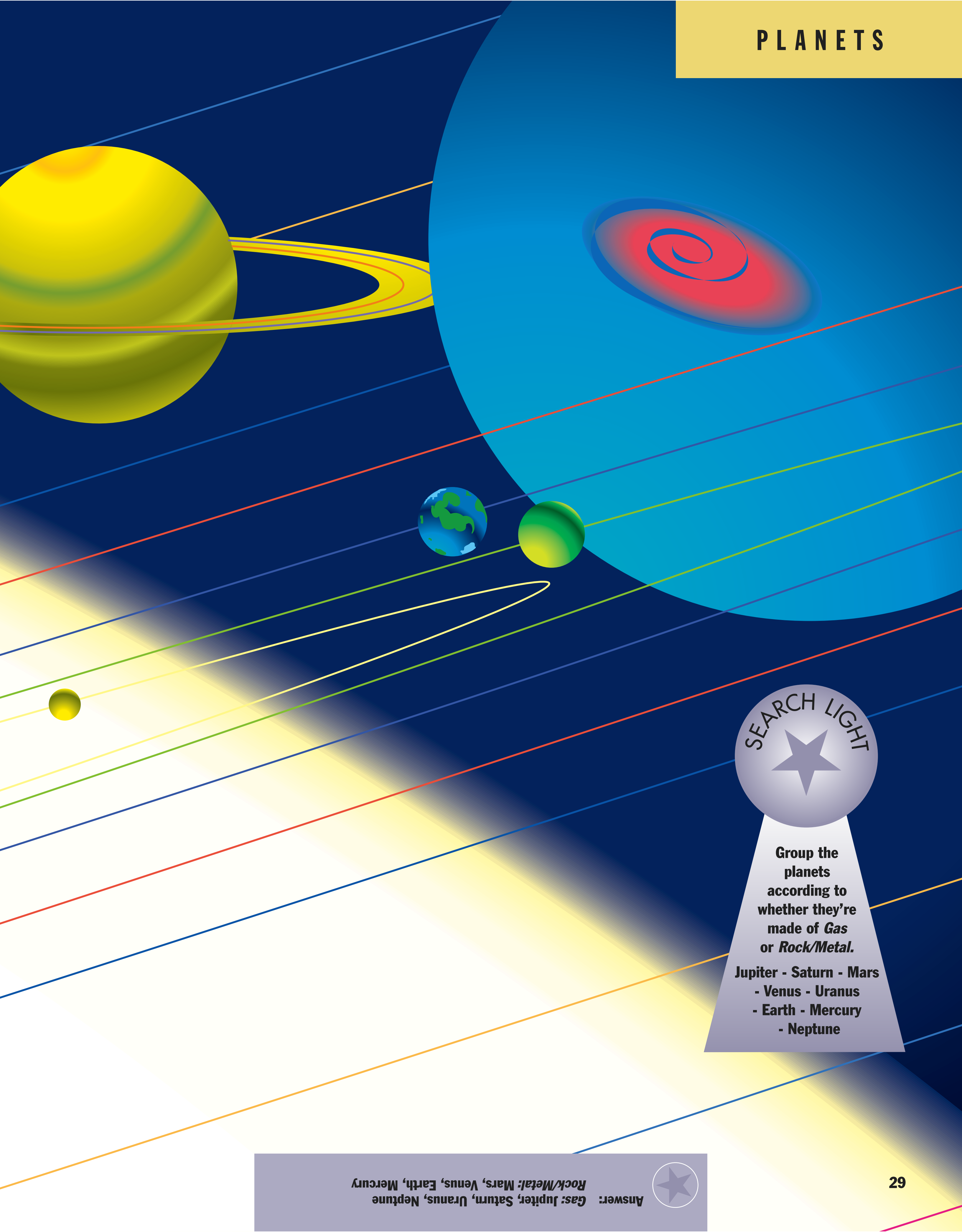
Scientists used to count an object called Pluto as another planet. But Pluto is neither Earth-like nor Jupiter-like. It is very small and frozen. So scientists now call Pluto a dwarf planet.

Each planet **rotates** on its **axis**. An axis is like an imaginary stick going through a planet's center from one end to the other. The planet spins just as if a giant hand had given this stick a mighty twist.

Most planets rotate from west to east. Only Venus and Uranus rotate from east to west. On these planets the Sun seems to rise in the west and set in the east.

LEARN MORE! READ THESE ARTICLES…
ASTEROIDS (VOLUME 2) • SOLAR SYSTEM (VOLUME 2)
STARS (VOLUME 2)

DID YOU KNOW?
Scientists have found three planets orbiting the star Upsilon Andromedae, a star much like our Sun. Some think this means there could be life on one of the planets.



SEARCH LIGHT

Group the planets according to whether they're made of *Gas* or *Rock/Metal.*

Jupiter - Saturn - Mars - Venus - Uranus - Earth - Mercury - Neptune

Answer: *Gas:* Jupiter, Saturn, Uranus, Neptune
Rock/Metal: Mars, Venus, Earth, Mercury

The Planet Nearest to the Sun

Mercury is the first of our eight planets, the closest to the Sun. Because it seems to move so quickly across the night sky, it was named for the wing-footed Roman god. Mercury is visible to the naked eye from Earth, just before dawn and just after sundown.

Mercury is only slightly bigger than Earth's Moon. Its entire surface is airless, though many different gases surround the planet. Mercury is also a place of extreme temperatures. Its hottest temperature is 755° F and its coldest is –280° F.

In 1974 and 1975 the spacecraft Mariner 10 flew close to Mercury, sending back pictures and other information. Scientists found the planet's surface covered with a layer of broken rock called "regolith." Mercury also has large ice patches at its north pole.

Some regions of Mercury are covered with heavy **craters**, probably created when the planet ran into other bodies as it was forming. Other regions show gently rolling plains. These may have been smoothed by volcanic lava flow. The planet also features long steep cliffs called "scarps" in some areas.

Mercury takes 88 Earth days to go around the Sun once, which gives it a very short year. But it takes 1,416 hours to complete one **rotation** about its **axis**, so it has a very long day.

Mercury has a sunrise only once in every two of its years. This is because, after one of its very long days, the Sun is in a different place in Mercury's sky. It takes three of Mercury's days (about 176 of our days) for the Sun to once again rise in the morning sky.

Mariner 10 space probe, which sent back to Earth valuable pictures and other data about Mercury.
© Corbis

SEARCH LIGHT

Why would being closest to the Sun make Mercury hard to study? (Hint: Think of two important things the Sun gives us.)

LEARN MORE! READ THESE ARTICLES…
PLANETS (VOLUME 2) • NEPTUNE (VOLUME 2)
SOLAR SYSTEM (VOLUME 2)

DID YOU KNOW?

It's no wonder that Mercury was named after the speedy messenger of the gods. The planet travels at an incredible 30 miles per second.

NASA/Roger Ressemeyer/Corbis

Answer: Being so close to the intense heat and bright light of the Sun makes Mercury hard to study. It's difficult to look at it and hard to send a probe to it that won't melt.

DID YOU KNOW?

Some scientists think that an unusual positioning of the planets Venus and Jupiter may have been the bright Star of Bethlehem reported at the time of Jesus Christ's birth.

A Morning and Evening Star

Venus is the second planet from the Sun. It is named for the Roman goddess of love and beauty, perhaps because it shines so brightly. It sometimes appears brilliantly in the western sky as the "evening star" and brightly in the predawn eastern sky as the "morning star."

Magellan space probe being launched by the space shuttle *Atlantis* in 1989.
© NASA/Roger Ressmeyer/Corbis

Although Venus is the planet closest to Earth, it is difficult to study because it is completely covered by thick layers of clouds. Venus' dense cloud layers do not allow much sunlight to reach the planet's surface. They do, however, help keep the surface very hot. So do the planet's active volcanoes. The temperature on the Venusian surface reaches about 860° F. The highest clouds, by contrast, have a daily range of 77° to –236° F.

Of all the planets, Venus is closest to Earth in size. In fact, Earth and Venus were once regarded as sister planets. Some scientists have suggested that Venus could support some form of life, perhaps in its clouds. Humans, however, could not breathe the air there.

Several spacecraft have visited and sent back information about Venus, beginning with Mariner 2 in 1962. The immensely powerful Hubble Space Telescope has also provided considerable **data** about the planet.

Scientists have learned that the surface of Venus is marked with hundreds of large meteor **craters**. These craters suggest that since it formed, the surface of Venus has changed in a different way from Earth's surface. Earth has only a few large craters that are easy to recognize.

Venus is different from Earth in another way, too. It hasn't got a moon.

How are Venus and Earth alike? What makes them different?

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MARS (VOLUME 2) • PLANETS (VOLUME 2) • SOLAR SYSTEM (VOLUME 2)

NASA/JPL/Caltech

Answer: Earth and Venus are about the same size, and both planets have active volcanoes. Venus might also be able to support some form of life, though probably in its clouds. But Earth is different in having a moon, few meteor craters, and breathable air.

DID YOU KNOW?

The reason Mars appears red is that the planet's soil contains a lot of rusted iron.

The Red Planet

Mars is the fourth planet from the Sun. It is named after the ancient Roman god of war. Since the planet is red in color, it also called the "red planet."

Mars is half the size of Earth. Its thin air is made up mainly of carbon dioxide and other gases, so we wouldn't be able to breathe it. And the Martian surface is much colder than Earth's is. Two small moons, Phobos and Deimos, **orbit** Mars.

The first spacecraft to fly close to Mars was Mariner 4, in 1965. In the 1970s two Viking spacecraft landed there, and in July 1997 Mars Pathfinder set down. These efforts sent back from Mars soil sample reports, pictures, and other **data**—but no proof of life.

Because of similarities between Mars and Earth, however, scientists think there could be some form of life on Mars.

SEARCH LIGHT

What surface feature of Mars holds a record?

Martian surface of rocks and fine-grained material, photographed in 1976 by the Viking 1 spacecraft.
NASA

Like Earth, Mars has ice caps at both poles. But its ice caps are composed mostly of solid carbon dioxide, or dry ice. Liquid water has not been seen on the surface of Mars. However, billions of years ago there may have been large lakes or even oceans on Mars.

Also like Earth, Mars has different seasons. Mars takes 687 Earth days to go around the Sun once. This means its year is almost twice as long as ours. But since it spins on its **axis** once every 24 hours and 37 minutes, its day is just about the same.

Despite being small, Mars has the largest volcano in our solar system, Olympus Mons. It stands about three times higher than Earth's highest point, Mount Everest, and covers an area just a bit smaller than the entire country of Poland.

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EXTRATERRESTRIAL LIFE (VOLUME 2) • SOLAR SYSTEM (VOLUME 2)
SPACECRAFT (VOLUME 2)

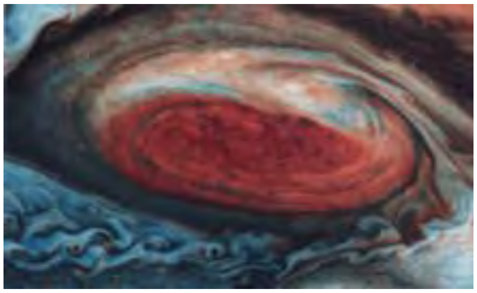
In this image taken by the Hubble Space Telescope in 1997, you can see the north polar ice cap (white area) at the top and some huge volcanoes (the darker red spots) in the left half of the photo.
Phil James (Univ. Toledo), Todd Clancy (Space Science Inst., Boulder, CO), Steve Lee (Univ. Colorado), and NASA

Answer: Mars has the largest volcano in our solar system.

King of the Planets

Jupiter is the biggest planet in our solar system. It is so big that all the other planets could fit inside it at the same time and there would still be room left over. The planet is named after the king of the Roman gods.

Jupiter is a giant ball of gases, mostly the **elements** hydrogen and helium. Helium is the gas that makes balloons float in air, and hydrogen is one part of water. The center of the planet is probably made of a hot liquid, like a thick soup.



Jupiter's Great Red Spot (colors boosted) as seen by Voyager I spacecraft, 1979.
© Jet Propulsion Laboratory/NASA

Jupiter isn't a very welcoming place. It is extremely hot. It is thousands of times hotter than the hottest place on Earth.

Also, storms rage on Jupiter's surface almost all the time. Scientists have seen one storm there that is almost twice as wide as the Earth! It is called the Great Red Spot. It has been raging on Jupiter's surface for at least a few hundred years.

Jupiter has more than 60 moons. Some of them are much bigger than Earth's Moon. One is even bigger than the planet Mercury! Others are tiny, only a few miles across.

Astronomers have found something very exciting on one of Jupiter's moons, called Europa. They believe that it has a huge ocean of water below its surface that may have simple life forms in it.

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GALILEO (VOLUME 4) • SATURN (VOLUME 2)
SOLAR SYSTEM (VOLUME 2)

SEARCH LIGHT

Find and correct the error in this sentence: A storm known as the Big Red Dog has been raging on Jupiter's surface for hundreds of years.

DID YOU KNOW?

Jupiter has more than 60 known moons, and Earth has only 1. But that seems fair, since Jupiter is more than 1,300 times bigger than Earth!

NASA

Answer: A storm known as the Great Red Spot has been raging on Jupiter's surface for hundreds of years.

The Ringed Planet

Saturn is the sixth planet from the Sun. It is named after the god of **agriculture** in Roman mythology. Saturn is visible without a telescope, but its famous spectacular rings can only be seen through such an instrument. The astronomer Galileo was the first to use a telescope to view the planet.

Saturn is a gas planet, like Jupiter, Neptune, and Uranus. Very little of it is solid. Most of Saturn consists of the **elements** hydrogen and helium. It is covered with bands of colored clouds. The thin rings that surround the planet are made of water ice and ice-covered particles. Instruments on the Voyager 1 and 2 spacecraft showed that these **particles** range in size from that of a grain of sand to that of a large building. Voyager 2 took the picture you see here.

SEARCH LIGHT

True or false? Saturn's many rings are made of gas?

Because Saturn is made of different substances, different parts of the planet **rotate** at different rates. The upper atmosphere swirls around the planet at rates between 10 hours and 10 minutes (Earth time) and about 10 hours and 40 minutes. The inner core, which is probably made of hot rocks, rotates in about 10 hours and 39 minutes.

But Saturn takes 29 years and 5 months in Earth time to go around the Sun just once. The Earth goes around the Sun once every 365 days. Saturn's year is so much longer because the planet is so much farther away from the Sun.

Astronomers have found that at least 30 moons **orbit** Saturn. The largest of these is Titan, which is almost as large as the planets Mercury or Mars. In our photograph, you can see two moons as tiny white spots to the lower left of (Dione) and below (Rhea) the planet. Other satellites include Mimas, Enceladus, and Tethys.

DID YOU KNOW?

Saturn is more than nine times the size of the Earth. But the planet is so light that it could float on an ocean of water.

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GALILEO GALILEI (VOLUME 4) • JUPITER (VOLUME 2)
SOLAR SYSTEM (VOLUME 2)

Jet Propulsion Laboratory/NASA

Answer: FALSE. Saturn's many rings are made of ice and ice-covered particles.

King George's Star

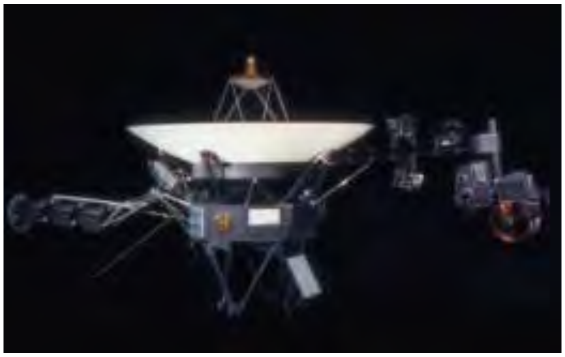
Uranus is the seventh planet from the Sun. Its name is that of the god of the heavens in ancient Greek mythology.

When William Herschel discovered this planet in March 1781, he named it Georgium Sidus (George's Star) in honor of his king, George III of England. Others called it Herschel. In about 1850 scientists began to use the name Uranus.

The spacecraft Voyager 2 visited Uranus some 200 years after Herschel discovered it. Findings confirmed that Uranus is a large gas planet. Small amounts of methane gas in its upper atmosphere give the planet a blue-green color.

It takes Uranus 84 of Earth's years to go around the Sun once, so its year is 84 times as long as ours. But the planet takes only about 17 hours to spin on its **axis** once, so its day is shorter.

Unlike other planets, Uranus lies on its side at an odd angle. It points first one pole toward the Sun, then its equator, and then the other pole. So it is not yet clear which is the planet's "north" pole.



Voyager 2, the spacecraft that reported Uranus' makeup.
© Corbis

As with other gas planets, such as Jupiter, Saturn, and Neptune, Uranus has a system of rings. In some places the rings are so thin that they seem to disappear.

The planet has more than 20 known moons that are made mostly of ice and are heavily **cratered**. The five major ones are Miranda, Ariel, Umbriel, Titania, and Oberon. Their names are those of characters from works by William Shakespeare and Alexander Pope.

SEARCH LIGHT

Find and correct the error in the following sentence: When William Herschel discovered Uranus in 1781, he named it Georgium Sidus for his dog.

LEARN MORE! READ THESE ARTICLES…
PLANETS (VOLUME 2) • SATURN (VOLUME 2) • SOLAR SYSTEM (VOLUME 2)

Jet Propulsion Laboratory/NASA

DID YOU KNOW?

Between Uranus and Saturn lies Chiron, an object first considered an asteroid, then reclassified as a comet. Its name reflects its confused identity: Chiron was a centaur, a half man and half horse in Greek mythology.

Answer: When William Herschel discovered Uranus in 1781, he named it Georgium Sidus for his king.

The Eighth Planet

Neptune is the eighth planet from the Sun. It is named after the Roman god of the sea.

The planet Neptune was discovered in 1846, but little was known about it until the spacecraft Voyager 2 visited it in August 1989.

Artist's idea of Voyager 2 leaving Neptune after it visited that planet (seen in the background).
© Corbis

Neptune is made up mostly of gases. Its bluish color comes from its thick atmosphere of hydrogen, helium, and methane. Like other gas planets, such as Jupiter and Saturn, Neptune has rapid winds and big storms. The winds on Neptune are the fastest known in our solar system, reaching speeds of about 1,250 miles per hour.

The planet rotates quickly, once every 16.1 hours. This means its day is about two-thirds as long as ours. But it has a much longer year. There are about 60,225 days in one Neptune year. That's how many days it takes the planet to **orbit** the Sun. It has been in the same year since its discovery in 1846. Each season on Neptune lasts for 41 Earth years.

Like Saturn, Neptune has rings, but they aren't as noticeable. Neptune also has 13 known moons. Triton is the largest moon. Triton is slowly drawing closer to Neptune. It is believed that it will someday crash into the planet.

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PLANETS (VOLUME 2) • SATURN (VOLUME 2)
SOLAR SYSTEM (VOLUME 2)

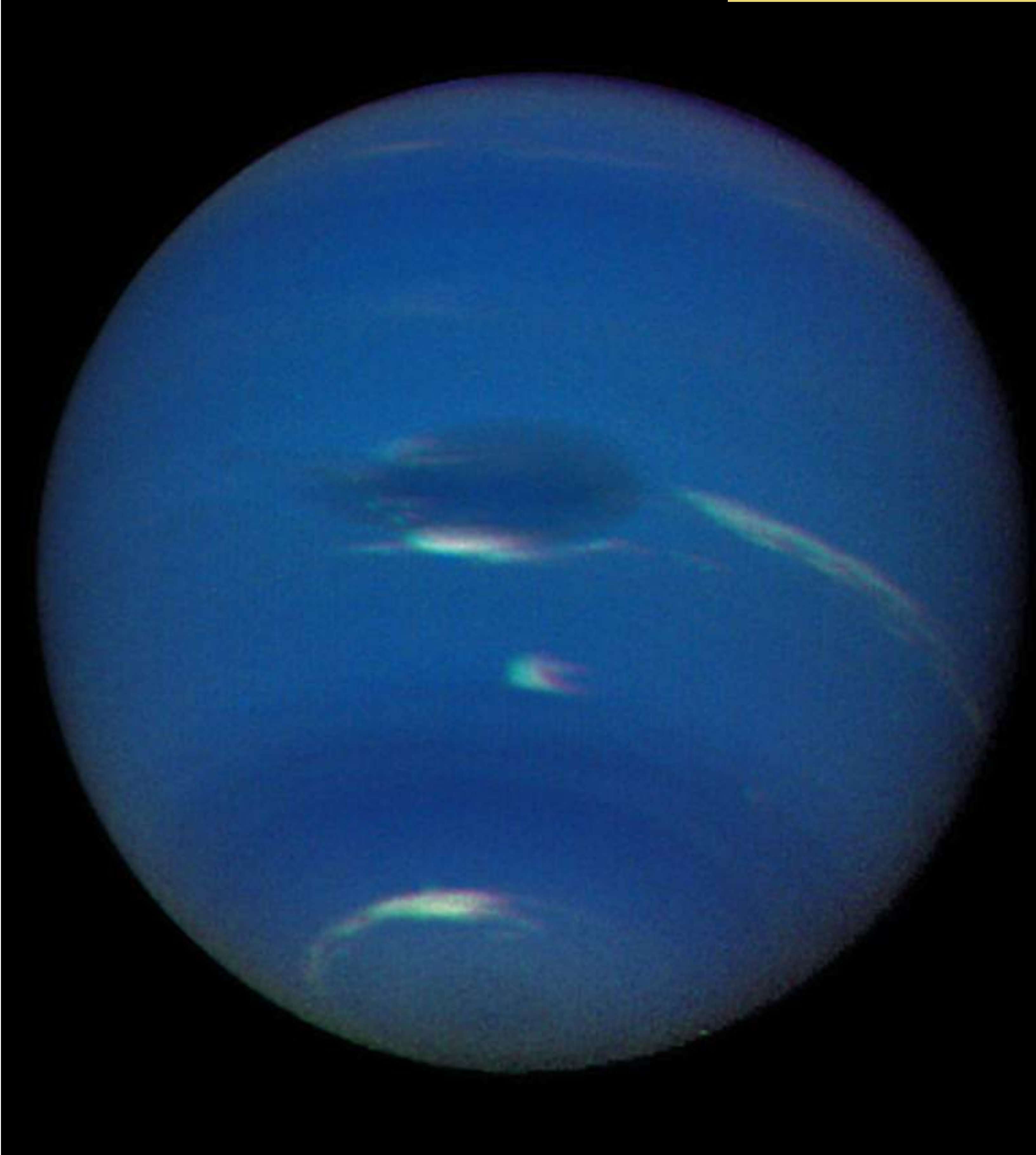
DID YOU KNOW?

It's more than just a little chilly on Neptune. Its average temperature is –373° F. By comparison, Antarctica, the coldest place on Earth, has measured a mere –129° F at its coldest.

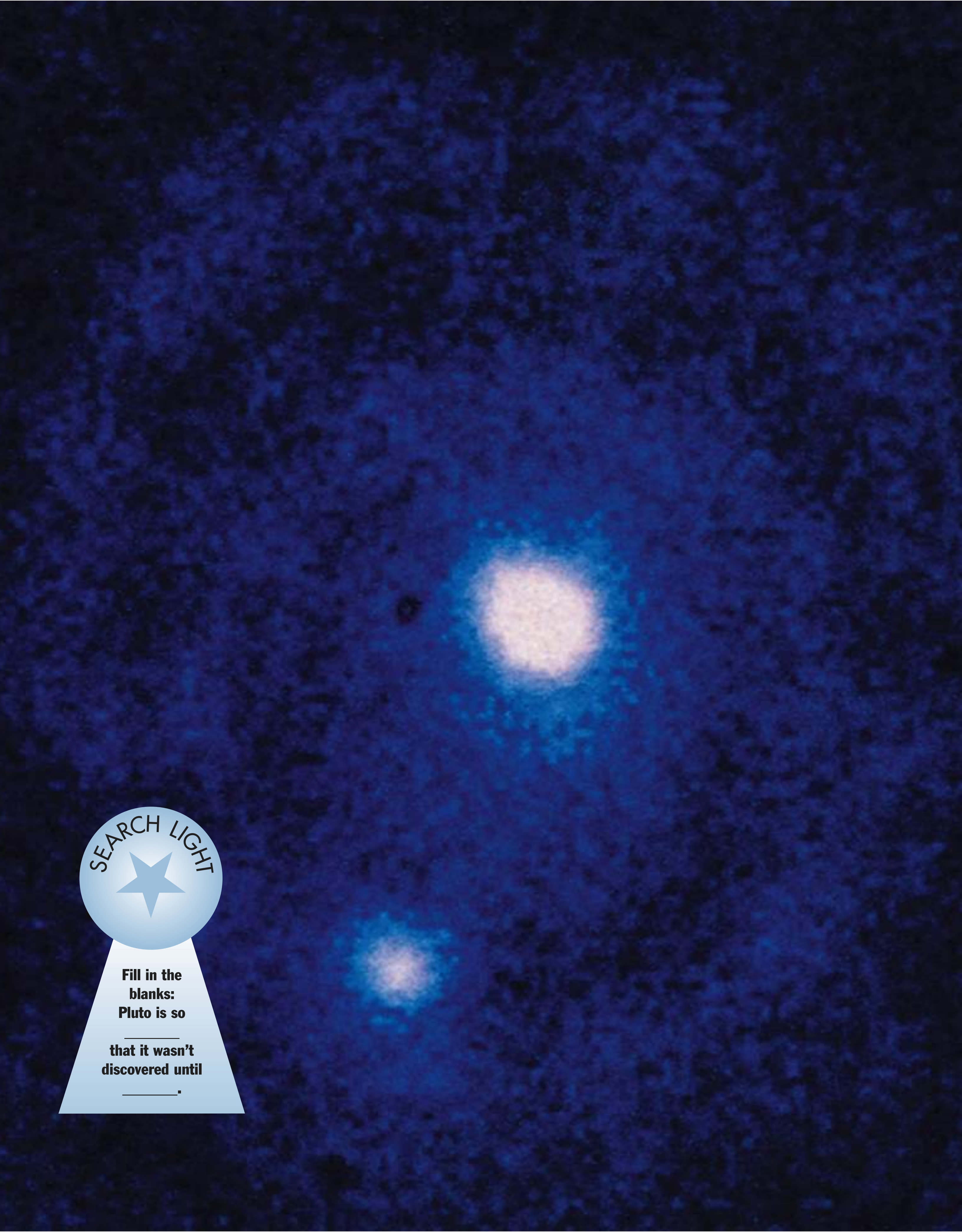
SEARCH LIGHT

Neptune has a shorter day than Earth. So why is Neptune's year so much longer than ours? (Hint: Neptune is the eighth planet from the Sun, and Earth is only the third.)

NASA



Answer: Neptune is so much farther from the Sun than Earth that it takes the eighth planet about 165 times as long to orbit the Sun.



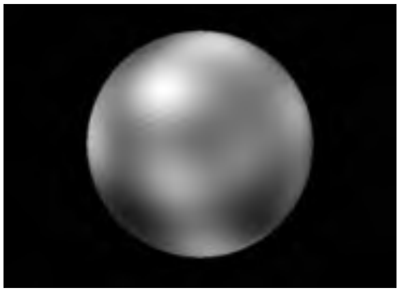
SEARCH LIGHT

Fill in the blanks: Pluto is so ________ that it wasn't discovered until ________.

The Dwarf Planet

In Roman mythology Pluto was the god of the underworld. Pluto is the name given to another dark mystery: a body called a dwarf planet in the far reaches of our solar system.

Pluto is so distant and small that it wasn't discovered until 1930. Only recently have very strong instruments like the Hubble Space Telescope given us some details about the mysterious faraway body.



One of the first photos of Pluto's surface, taken with the Hubble Space Telescope.
Alan Stern (Southwestern Research Institute), Marc Bule (Lowell Observatory), NASA, and the European Space Agency

Pluto is so mysterious that scientists have not been sure what kind of body it is. For many years they called it a planet, but it is different from the other planets.

Tiny Pluto is only about 1,485 miles across from pole to pole. It's not entirely clear what it is made of, but scientists think it may be 50 to 75 percent rock and the rest frozen water and gases. So far from the Sun's warmth, all of Pluto is permanently frozen. Because of its small size and icy makeup and because it travels in a part of the solar system where some comets are thought to come from, Pluto seems more like a giant comet than a planet.

Pluto also spins in the opposite direction from most of the planets. If you were on Pluto, you would see the Sun rise in the west and set in the east. A day on Pluto is equal to six days and 25 minutes on Earth. Pluto's **orbit**, or path around the Sun, is very long. Therefore the dwarf planet's year takes more than 90,155 of our days.

Pluto's moon, Charon, wasn't discovered until 1978. As you can see from the large photo, Charon is about half the size of Pluto—quite large for a moon.

Because it is so different from the planets, scientists decided in 2006 that Pluto should be called a dwarf planet instead of a real planet. They placed several other bodies in the same category.

DID YOU KNOW?
Walt Disney's dog character Pluto was named for the dwarf planet. Pluto the dog first appeared in 1930, the same year that Pluto was discovered.

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NEPTUNE (VOLUME 2) • SOLAR SYSTEM (VOLUME 2) • TELESCOPES (VOLUME 2)

NASA/European Space Agency

Answer: Pluto is so distant that it wasn't discovered until 1930.

Building Blocks of Matter

Everything in the world is made up of molecules. Our bodies, our clothes, our houses, animals, plants, air, water, sky—everything. Molecules are so small, though, that we can't see them with our naked eyes.

But molecules aren't the smallest things. Molecules are made up of atoms, which are smaller still. Atoms are so small that it takes more than a billion atoms to fill the space taken up by one pea!

The word "atom" comes from the Greek word *atomos*, meaning "**indivisible**." But despite what their name suggests, atoms can indeed be divided into smaller pieces. Each atom has a **core** called a "nucleus." Around the nucleus swarm small **particles** called "electrons." The nucleus itself is made up of other small particles called "protons" and "neutrons." And these protons and neutrons are made up of even smaller things called "quarks." So, for now at least, quarks are among the smallest known things in the universe.

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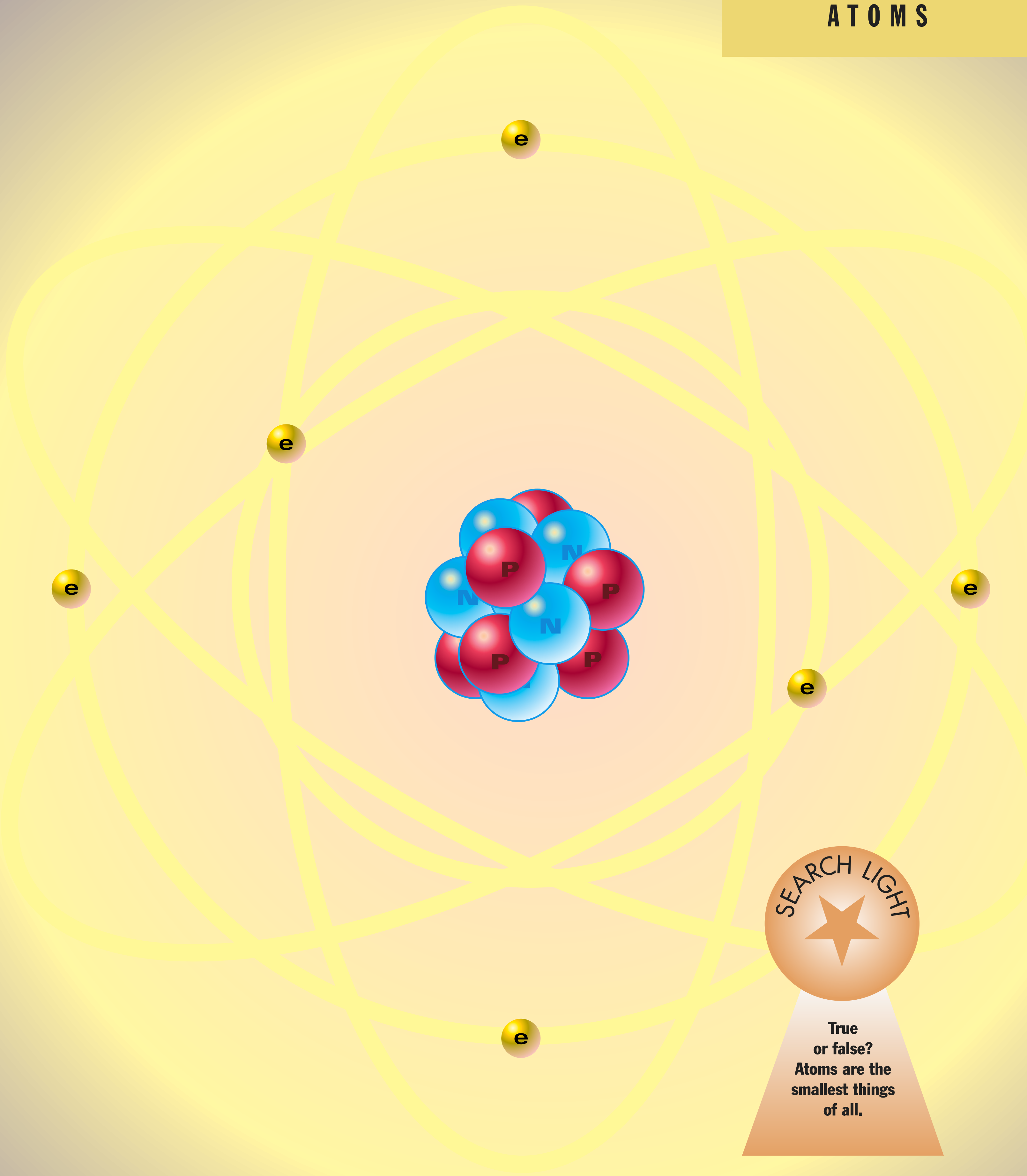
NUCLEAR ENERGY (VOLUME 2)

DID YOU KNOW?
Quarks are so small that scientists have to make up new ways to describe them. They talk about the different "flavors" of quarks—not chocolate or pistachio but "up," "down," "charm," "strange," "top," and "bottom."



SEARCH LIGHT

True or false? Atoms are the smallest things of all.

Answer: FALSE. Atoms can be split into electrons, neutrons, and protons, all of which are smaller than the atom itself. And quarks are even smaller than those.

The Power of Life

Without energy in our bodies, we wouldn't be able to do anything. We couldn't walk, talk, or even play. Energy is usable power. And all energy is related to some kind of motion.

All living things need energy, no matter what they do. Plants get their energy from sunlight. This energy is stored in different **chemicals** inside the plant. This whole process is called "photosynthesis."

Animals that eat plants take the energy stored in the plants. The energy is then stored in chemicals inside the animals as "food energy." The same happens when animals eat other animals.

Plants and animals use energy every day as they grow and do the work of being a plant or an animal. So plants have to keep **absorbing** sunlight, and animals have to keep eating plants or other animals.

It isn't only living things that have energy. A dead tree has hidden energy. When we burn its wood, it gives off warmth, or "heat energy." The Sun too makes heat energy as it constantly burns.

The Sun gives off not just heat but also light, as "light energy." A battery in a flashlight makes it shine, **generating** light energy. But if we put the same battery in a radio, we get music. A battery's energy is known as "electrical energy." And in a toy car that electrical energy produces movement, or "kinetic energy."

If we couldn't use heat, light, or electrical energy, we couldn't drive cars or cook food. We wouldn't have light at nighttime. Basically, we'd have to use the energy of our own bodies. And that would mean eating a lot more and doing a lot less.

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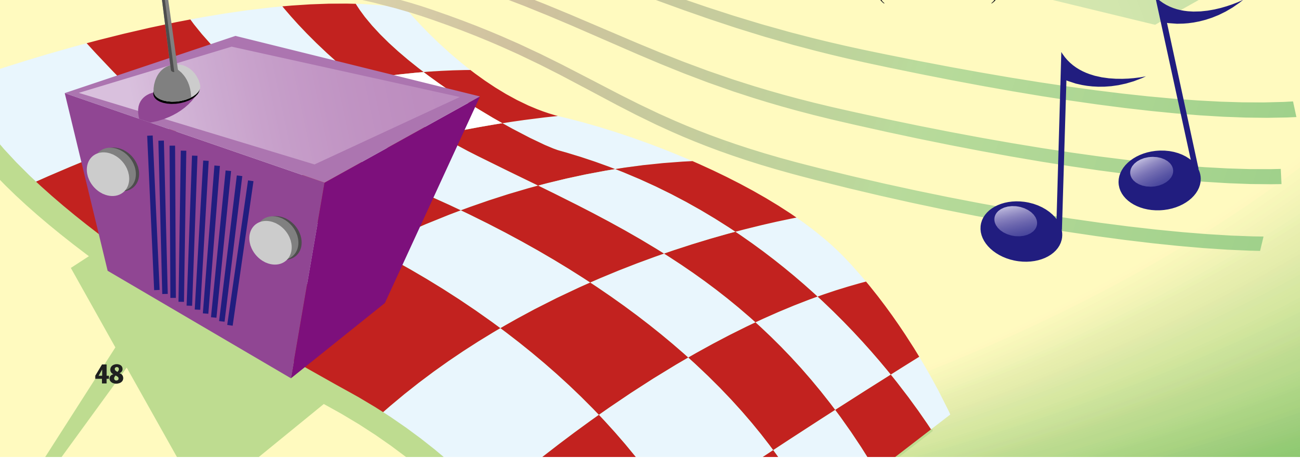
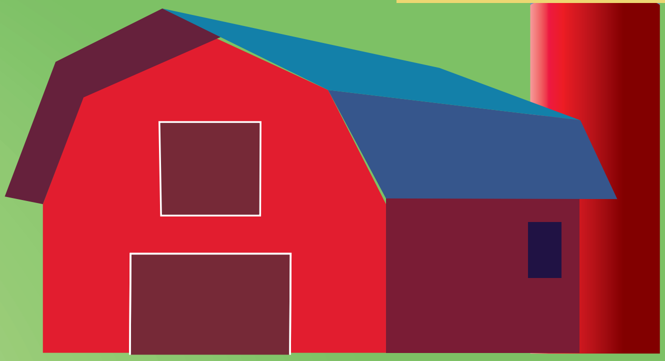
THERMAL POWER (VOLUME 2)



DID YOU KNOW?

Energy from food is measured in calories. A grownup needs to take in about 2,000-2,500 calories a day. Bicyclists in a major race eat three to five times that much, and they still sometimes run out of energy.



SEARCH LIGHT

These sentences are all mixed up. See if you can fix them.

Heat energy comes from the things people or animals eat.

Food energy comes from things that burn.

Answer: Heat energy comes from things that burn. Food energy comes from things people or animals eat.

The Invisible Magnet

Raise your arm. Keep it in that position for as long as you can. What happens?

After some time, your arm begins to hurt. Something seems to be pulling it down. Soon enough, you have to lower your arm.

It's a force called "gravity" that causes you to lower your arm. Gravity acts something like a magnet, tugging away at your arm as if it were a piece of metal.

We can't see gravity or touch it. We can only feel it. The Earth has gravity that pulls down on everything on or near it. It is this force that keeps us all on Earth.

The Moon and the Sun also have gravity. All bodies in the universe have gravity. In fact, gravity helps hold all of them together. Sir Isaac Newton first introduced the idea of gravity, and Albert Einstein added to Newton's ideas.

Gravity works in a two-way system. This means that all bodies have a pull on each other. For example, Earth's gravity forces the Moon to circle around it all the time. In return, the Moon's gravity attracts the waters of Earth's oceans to cause tides.

The force of gravity becomes weaker and weaker as we move away from its source. That is partly why astronauts can float around in outer space. They are too far away for the Earth to have much pull on them.

What do you think would happen if there were no gravity on Earth?

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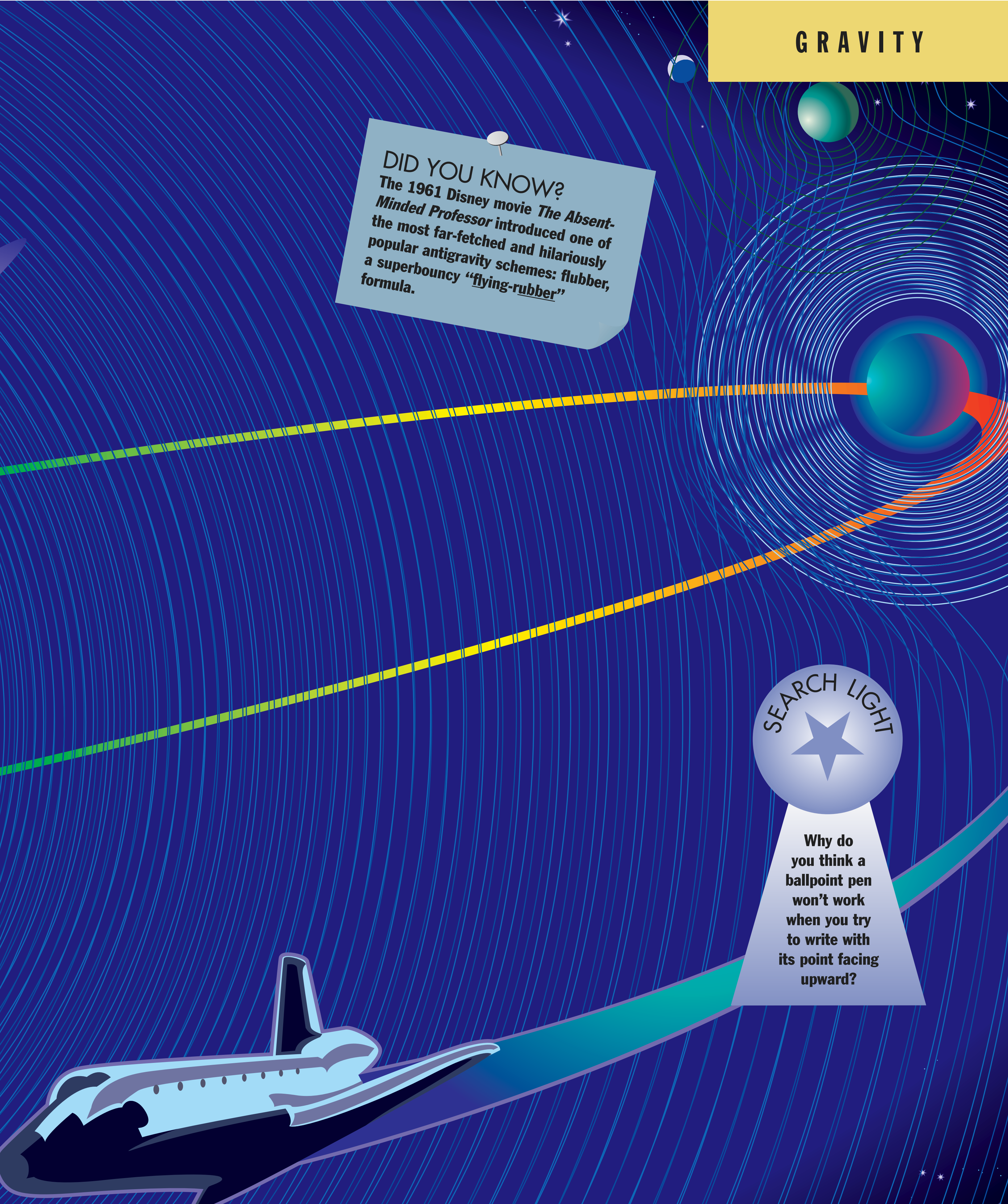


DID YOU KNOW?

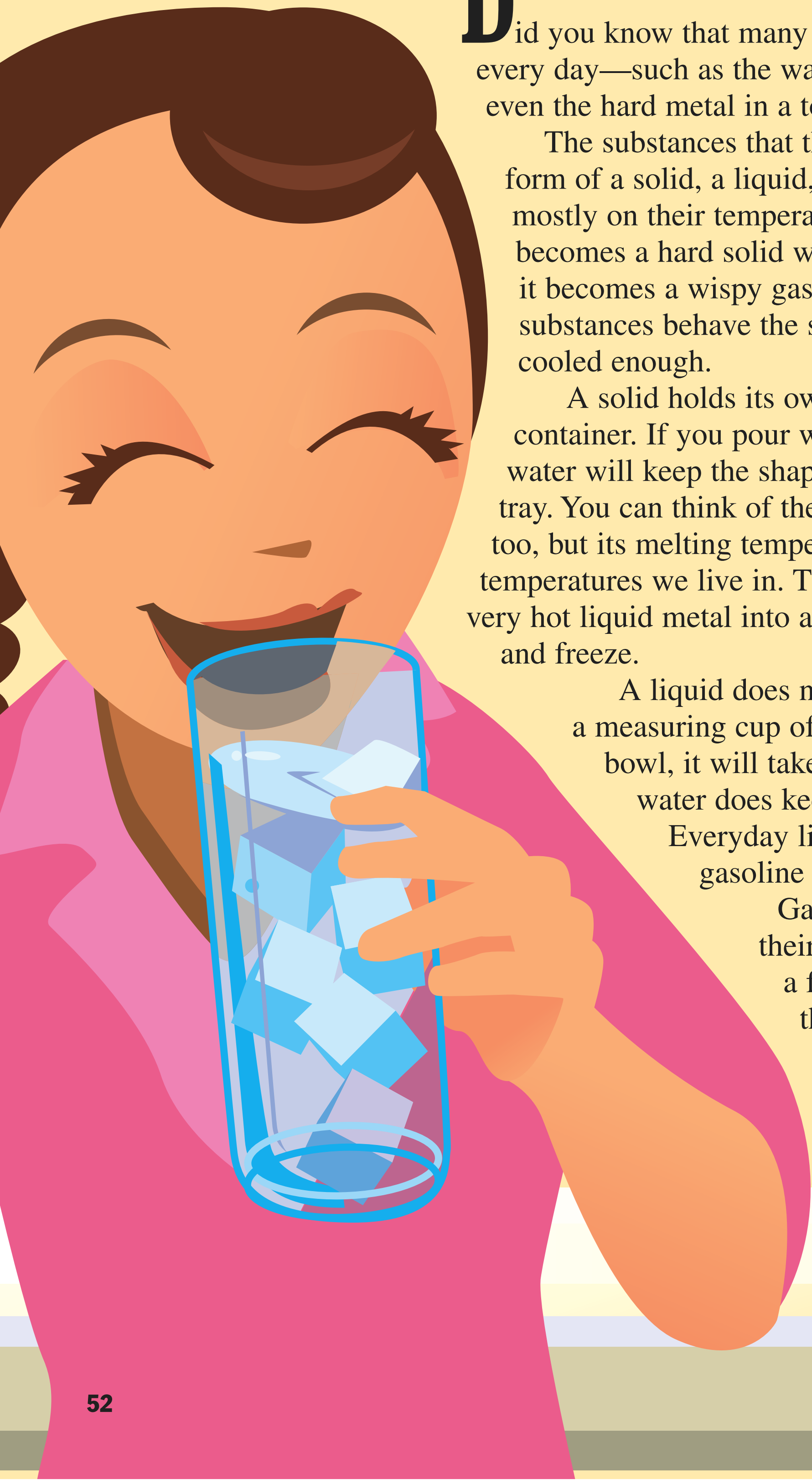
The 1961 Disney movie *The Absent-Minded Professor* introduced one of the most far-fetched and hilariously popular antigravity schemes: flubber, a superbouncy "flying-rubber" formula.

SEARCH LIGHT

Why do you think a ballpoint pen won't work when you try to write with its point facing upward?

Answer: Gravity causes the ink in the ballpoint pen to flow to the wrong end of a pen that's not facing toward the ground. The upside-down pen's point soon runs out of ink.

Same Stuff, Different Forms



Did you know that many of the things you may see or use every day—such as the water in a glass, the air in a football, and even the hard metal in a toy car—are **potential** shape-shifters?

The substances that these things are made of can have the form of a solid, a liquid, or a gas. The form they take depends mostly on their temperature. When water gets cold enough, it becomes a hard solid we call "ice." When it gets hot enough, it becomes a wispy gas we call "steam." Many other substances behave the same way when they are heated or cooled enough.

A solid holds its own size and shape without needing a container. If you pour water into an ice tray and freeze it, the water will keep the shape of the cube-shaped molds in the tray. You can think of the solid metal in a toy car as frozen too, but its melting temperature is much higher than the temperatures we live in. The person who made the car poured very hot liquid metal into a car-shaped mold and let it cool down and freeze.

A liquid does not hold its own shape. If you pour a measuring cup of water into a tall glass or a shallow bowl, it will take the shape of its container. But that water does keep its own size. It measures one cup. Everyday liquids such as milk, paint, and gasoline act this same way.

Gases do not keep their own shape or their own size. When air is pumped into a football, it takes the shape and size of the ball. As more air is pumped in, the ball gets harder but not much bigger. The air changes its size to fit the space inside the ball.

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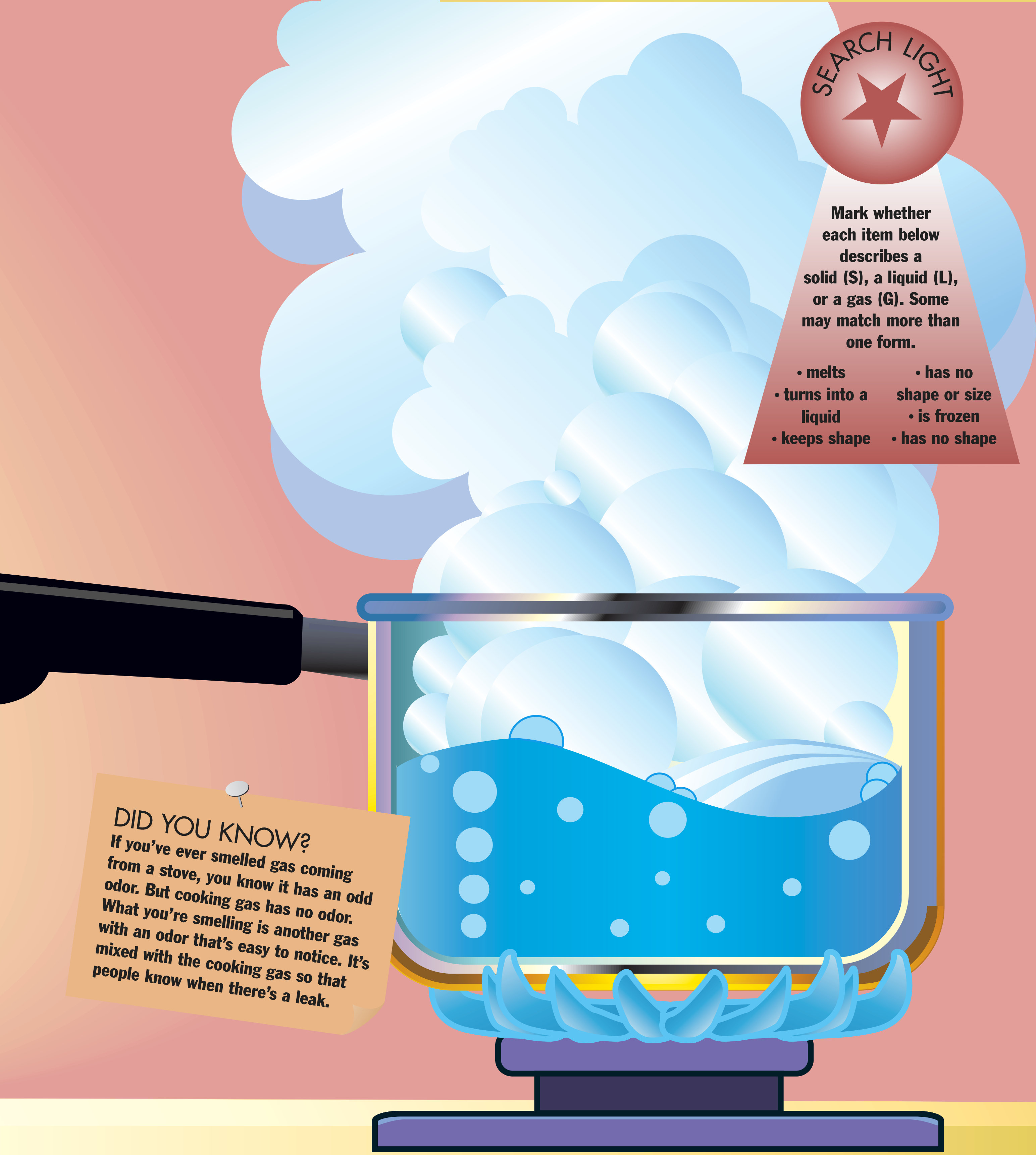

SEARCH LIGHT

Mark whether each item below describes a solid (S), a liquid (L), or a gas (G). Some may match more than one form.

- melts
- turns into a liquid
- keeps shape
- has no shape or size
- is frozen
- has no shape

DID YOU KNOW?

If you've ever smelled gas coming from a stove, you know it has an odd odor. But cooking gas has no odor. What you're smelling is another gas with an odor that's easy to notice. It's mixed with the cooking gas so that people know when there's a leak.

Answer: melts = S; turns into a liquid = S, G; keeps shape = S; has no shape or size = G; is frozen = S; has no shape = L, G

SEARCH LIGHT

Temperature measures how much

a) heat something has.
b) chill something has.
c) pressure something has.

DID YOU KNOW?

It's better to use your hand than your foot to test the temperature of bath water. If you test too-hot bath water with your foot, you're likely to burn that foot. That's because it takes longer for your foot to recognize temperature than it does your hand.

Hot and Cold

We can use our fingers, our tongue, or almost any part of our skin to feel just how hot or how cold something is. This is important because our bodies need just the right amount of heat so that we can live comfortably.

When it's cold and we want to make a room warmer, we turn on the heaters. In the summer when it's hot and we want to make the room cooler, do we add cold to the room?

No. We take away some of the heat. We say something is cold when it doesn't have much heat. The less heat it has, the colder it is.

Air conditioners suck hot air from a room. Pipes inside the air conditioners take a lot of heat out of the air, making it cold. Then a blower fans the cooled air into the room again.

When we want to know exactly how hot or how cold something is, we use a thermometer. A thermometer tells us about temperature—that is, how hot something is. Some countries measure temperature in "degrees Fahrenheit (° F)." Others use a different measuring system of "degrees Celsius (° C)."

We can use thermometers to measure air temperature, oven temperature, even body temperature. And your body temperature tells not only whether you feel hot or cold but whether you're healthy.

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LIQUIDS, SOLIDS, AND GASES (VOLUME 2)
MEASUREMENT (VOLUME 2) • THERMAL POWER (VOLUME 2)

Answer: a) heat something has.

Cables, Fuses, Wires, and Energy

You can't see electricity, but you know it's there when you watch an electric light go on, hear the telephone ring, or see the television on.

Electricity comes into your house through thick wires called "cables." The cables join a **fuse** box. From the fuse box run all the electric wires for your house. Each wire connects to an outlet or a switch. From the outlets electricity passes along the plugs and cords that go to a lamp or television.

Electricity moves easily along things that are made of metal, such as silver, copper, or iron. That's why copper wires are used to carry the electricity. Electricity doesn't pass through rubber or plastic. That's why wires carrying electricity are usually coated with rubber or plastic.

This coating is important, because electricity will flow wherever it can. Loose, it can be very dangerous. It can cause shocks, start fires, or even kill.

Did you know that electricity can be used to make a magnet? If a wire is wound into a coil and wrapped around a piece of iron, the iron will become a magnet when electricity is sent through the coil. The iron will then attract other things made of iron and steel. Such a magnet is called an "electromagnet."

As soon as the electricity is turned off, the electromagnet isn't a magnet anymore. If the magnet is holding something when the electricity is turned off, that thing will drop.

SEARCH LIGHT

Fill in the blanks: To prevent shocks, electric wires should be wrapped with _______ or _______.

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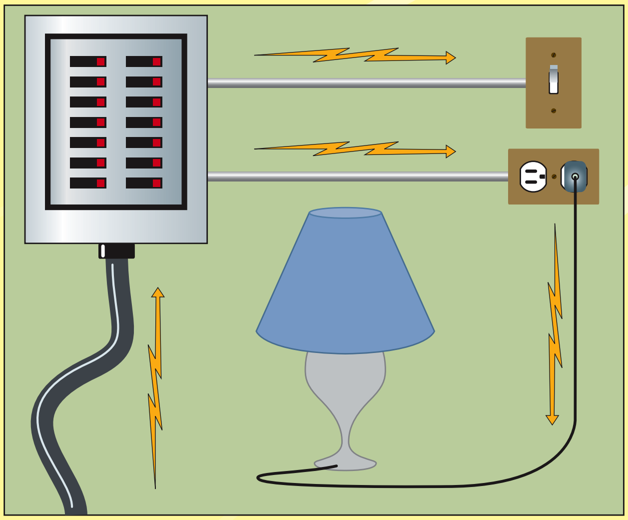
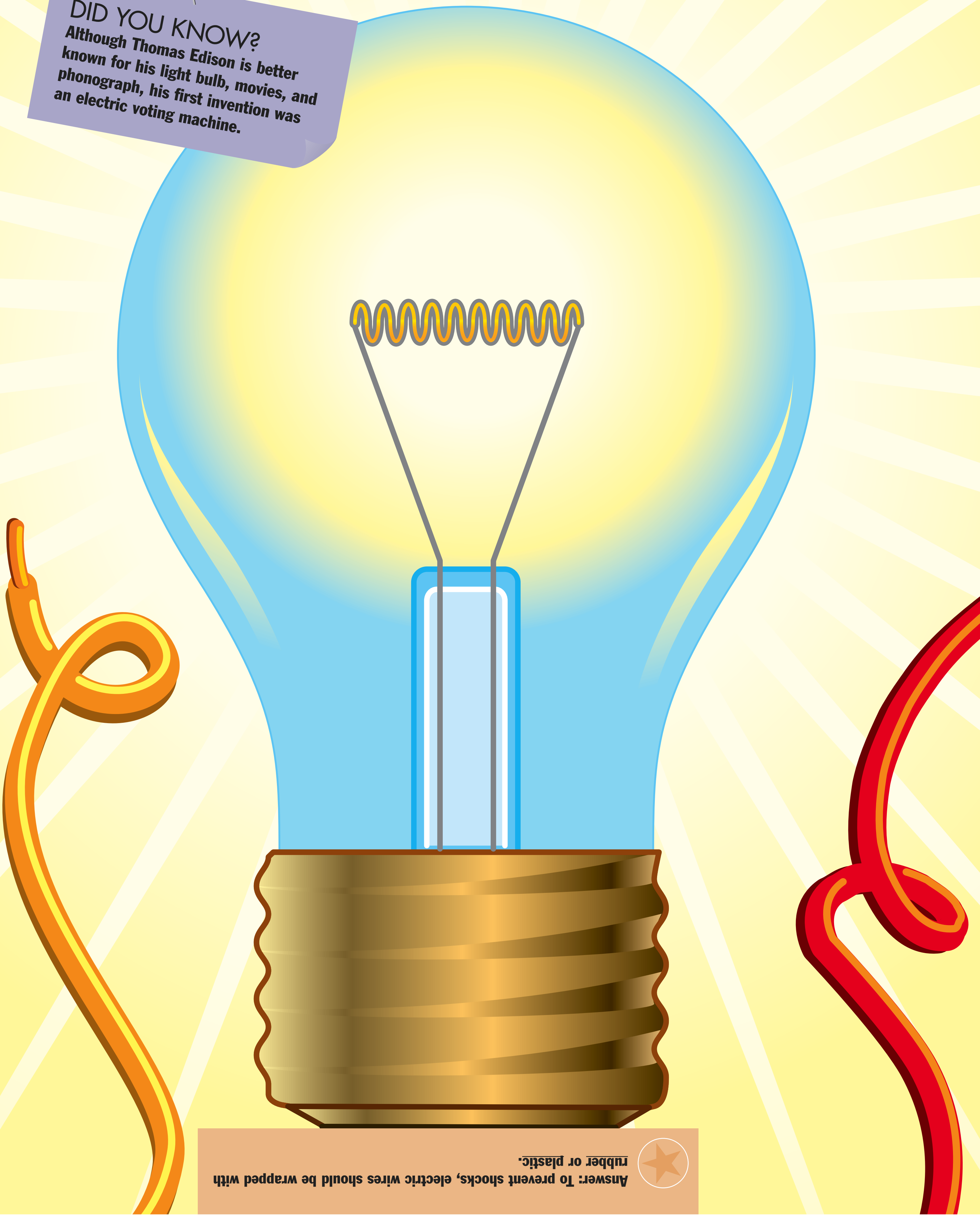
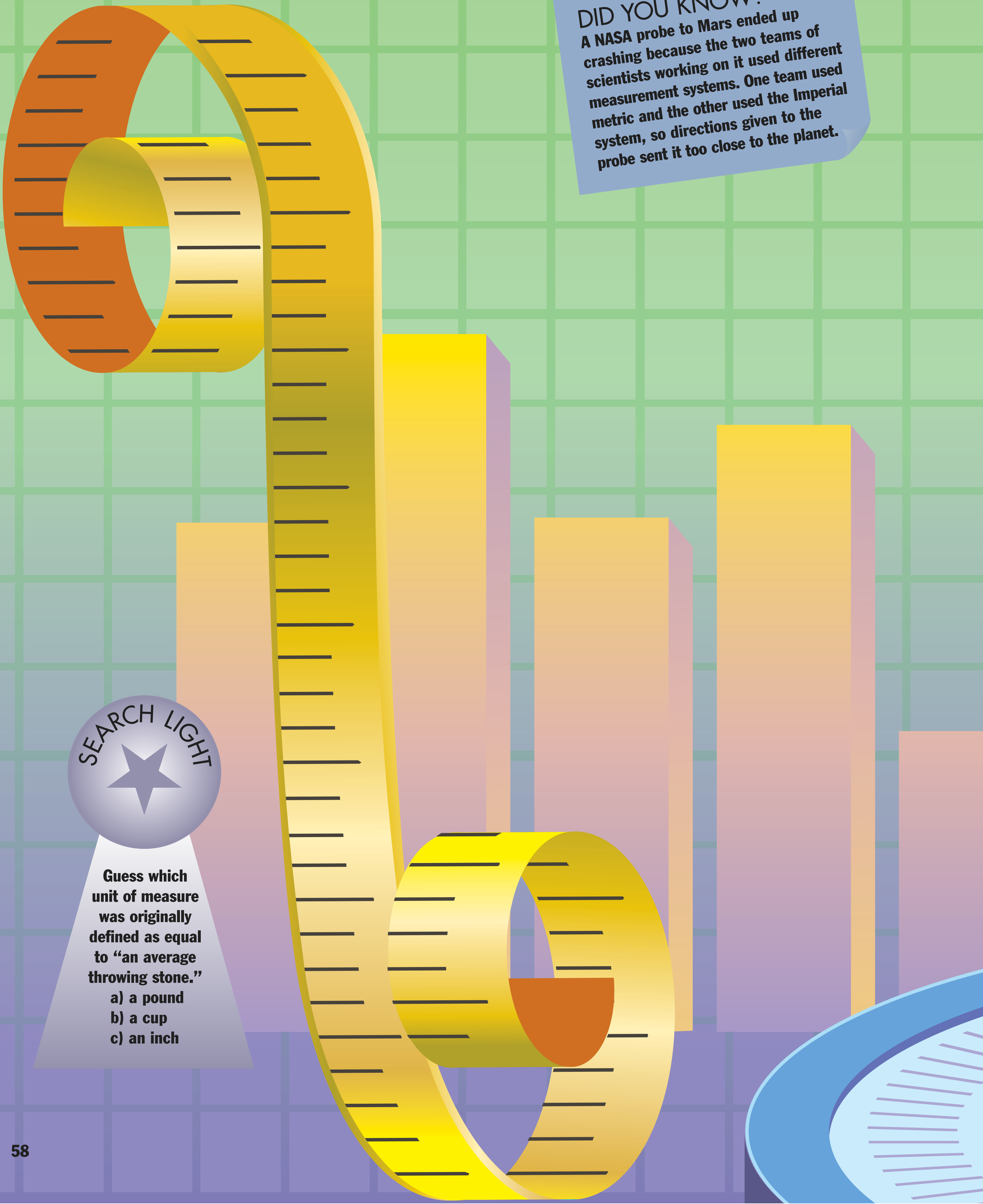
WIND POWER (VOLUME 2)



DID YOU KNOW?
Although Thomas Edison is better known for his light bulb, movies, and phonograph, his first invention was an electric voting machine.



Answer: To prevent shocks, electric wires should be wrapped with rubber or plastic.



DID YOU KNOW?

A NASA probe to Mars ended up crashing because the two teams of scientists working on it used different measurement systems. One team used metric and the other used the Imperial system, so directions given to the probe sent it too close to the planet.

SEARCH LIGHT

Guess which unit of measure was originally defined as equal to "an average throwing stone."

a) a pound
b) a cup
c) an inch

Figuring Out Size and Distance

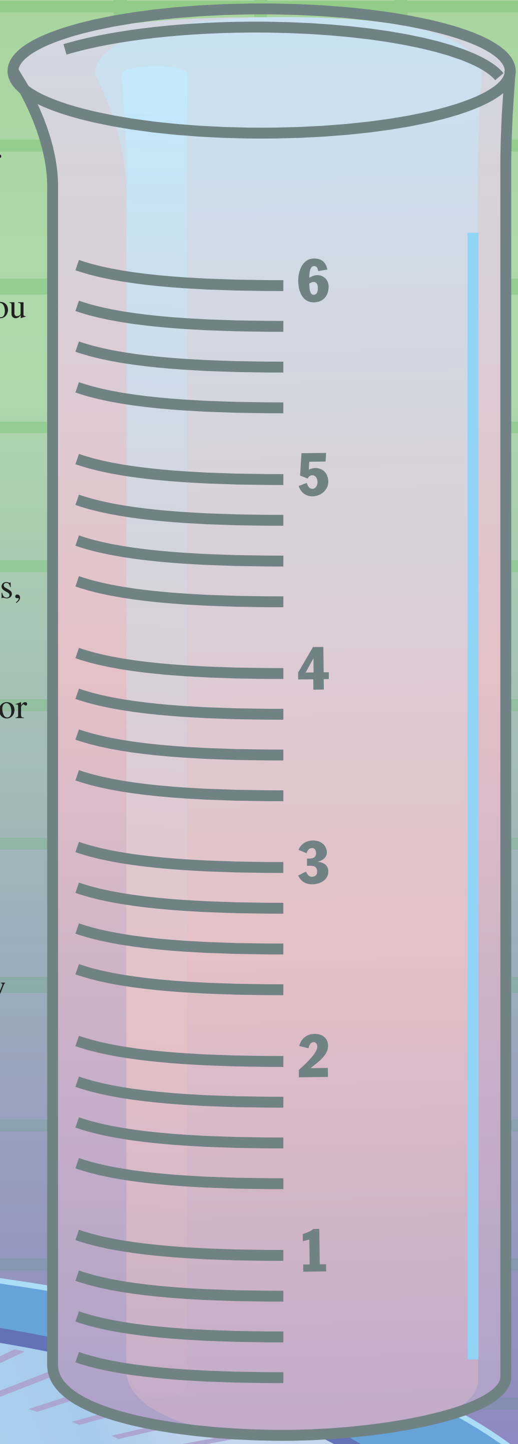
How far away is the nearest chair? You can make your own measurement to tell how many shoes away that chair is.

Stand up where you are and face the chair. Count "one" for your right shoe. Now place the heel of your left shoe against the toe of your right and count "two." Continue stepping, heel-to-toe, right-left, counting each shoe length you walk, until you get to the chair.

Centuries ago, people did just what you are doing now. They used parts of the body to measure things. An inch was about the width of a man's thumb. A foot was the length of his foot. A yard was the distance from the tip of his nose to the end of his thumb when his arm was stretched out. But since everybody's thumbs, feet, and arms were different sizes, so were everybody's inches, feet, and yards.

Finally, in the 1800s, all these terms were standardized–that is, everyone in England agreed on a specific definition for each one. They became part of the English system of measurement, the British **Imperial** System.

Another system, called the "metric system," measures in centimeters and meters, grams and kilograms, and liters. All these measurements can be multiplied or divided by 10. Fortunately, most of the world accepts the Imperial or the metric system as the **standard** of measurement. So we know today that one measurement will mean the same thing no matter where it is used or who is doing the measuring.



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CALENDAR (VOLUME 2) • COMPUTERS (VOLUME 2)
TEMPERATURE (VOLUME 2)

Answer: a) a pound. Though people agreed on a pound as the weight of "an average throwing stone," there were actually as many different "pounds" as there were people!

Looking to Nature for Remedies

Two visitors watched a jaguar fall off its tree limb and lie quietly on the ground. Their guide in this South American forest had brought the cat down with a blowgun dart tipped with curare. Made from certain trees in the jungle, curare **paralyzes** the muscles in the body.

When scientists heard about this remarkable poison, they experimented with it. Although large doses of curare are deadly, they found that tiny doses can help people relax during **surgery**.

Many years ago a doctor might have treated your stomachache with a medicine containing a pinch of gold dust, a spoonful of ashes of a dried lizard, 20 powdered beetles, some burned cat's hair, and two mashed onions!

Not all the old recipes for medicine were as bad as this. Usually medicines were made from tree bark and leaves, berries and seeds, roots, and flowers. Some "folk remedies" have no scientifically proven value, but many modern drugs have been developed from plants, animals, and **minerals**.

The photograph, for example, shows a common flower called "foxglove" whose leaves are used to make "digitalis," which helps people with heart disease. Pods of the opium poppy are used to make painkillers.

Not so long ago a very important medicine was discovered in moldy bread. This medicine, penicillin, and others like it are called "antibiotics." They help fight many diseases by killing **bacteria**.

Today most medicines are synthesized—that is, made from combinations of chemicals rather than from plants or animals. This method is much more **economical** and lets scientists create much larger supplies of important medicines.

SEARCH LIGHT

Find and correct the error in the following sentence: Many medicines today still come from the bark of animals.

LEARN MORE! READ THESE ARTICLES…
MARIE CURIE (VOLUME 4) • LOUIS PASTEUR (VOLUME 4)
RAINFORESTS (VOLUME 1)

DID YOU KNOW?

Deadly nightshade is a highly poisonous plant that was often used in small amounts as a medicine. The tomato is its close relative.

Answer: Many medicines today still come from the bark of trees.

Big Energy from a Small Source

All **matter** is made up of tiny particles called "molecules." In turn, all molecules are made up of even tinier particles called "atoms."

The central part of an atom is called a "nucleus." When the nucleus splits in two, it produces enormous energy. This breaking apart is called "nuclear fission." If two nuclei join and form a bigger nucleus—a process called "nuclear fusion"—even more energy is produced.

The nuclear energy released from fission and fusion is called "radiation." Radiation—the process of giving off **rays**—is a powerful spreading of heat, light, sound, or even invisible beams.

SEARCH LIGHT

What's the main problem with nuclear energy?

One of the first uses of nuclear energy was to build deadly weapons. Atomic bombs built during World War II and dropped on Hiroshima and Nagasaki in Japan largely destroyed those cities and killed many thousands of people. People worldwide now try to make sure these things never happen again.

Today, however, nuclear energy has many helpful uses. Nuclear power plants produce low-cost electricity. Nuclear energy also fuels submarines. And it has also allowed doctors to see more details inside the body than ever before.

But nuclear energy has its **drawbacks**. Nuclear energy produces nuclear waste. Living beings exposed to the waste can suffer radiation poisoning. They may experience damaged blood and organs, effects that can be deadly. And the radiation can remain active for thousands of years wherever nuclear waste is thrown away.

Unfortunately, no country has yet discovered the perfect way for storing nuclear waste. But the benefits make it worthwhile to keep trying.

DID YOU KNOW?

We all actually enjoy the benefits of nuclear energy every day. The Sun, like all stars, is simply one giant nuclear power plant. Its heat and light are the product of nuclear energy.

LEARN MORE! READ THESE ARTICLES…
ATOMS (VOLUME 2) • MARIE CURIE (VOLUME 4)
STARS (VOLUME 2)

Nuclear power plant on the coast of California, U.S.

Answer: Nuclear energy produces poisonous waste that stays deadly for generations. No one has yet come up with a safe and highly reliable way to get rid of the waste.

Energy from Heat

SEARCH LIGHT

Fill in the blank:
When steam escapes, it gives a mighty push. This push is so strong that it was used to move the early _______ engines.

Energy means power—the power to do work. And thermal, or heat, energy can do a lot of work. When heat is applied to water, for instance, it makes the water boil. Boiling water then changes to vapor, or steam, which can apply great force as it escapes a container. Large quantities of steam powered the earliest train engines.

The most important source of thermal energy for our Earth is the Sun's rays. This "**solar** energy" is used to heat houses, water, and, in some countries, ovens used for cooking. Solar power can even be **converted** to electricity and stored for later use.

© Keren Su/Corbis

© Paul A. Souders/Corbis

(Top) Sun's heat focused and used for cooking on solar oven by Tibetan monk. (Bottom) Locomotive fireman shovels coal to burn, boiling water to produce steam power.

To human beings the second most important source of thermal energy is the store of natural fuels on and in the Earth. When these fuels—mainly coal, oil, gas, and wood—are burned, they produce heat. This heat can be used for warmth, made to power a machine directly, or converted into electricity. For example, a car engine burns gasoline (an oil product) for direct thermal power. In some areas coal is burned to produce the electricity that powers people's homes.

In a very few parts of the world, an interesting third form of heat energy comes from "living" heat inside the Earth itself. This "geothermal energy" comes from such sources as natural hot springs and the heat of active volcanoes ("geo-" means "earth"). Naturally escaping steam and hot water are used to heat and power homes and businesses in Reykjavik, Iceland. And though volcanoes are mostly too hot to tap directly, worldwide experiments continue as other major fuel supplies **dwindle**.

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OIL (VOLUME 2) • REYKJAVIK (VOLUME 6) • VOLCANOES (VOLUME 1)

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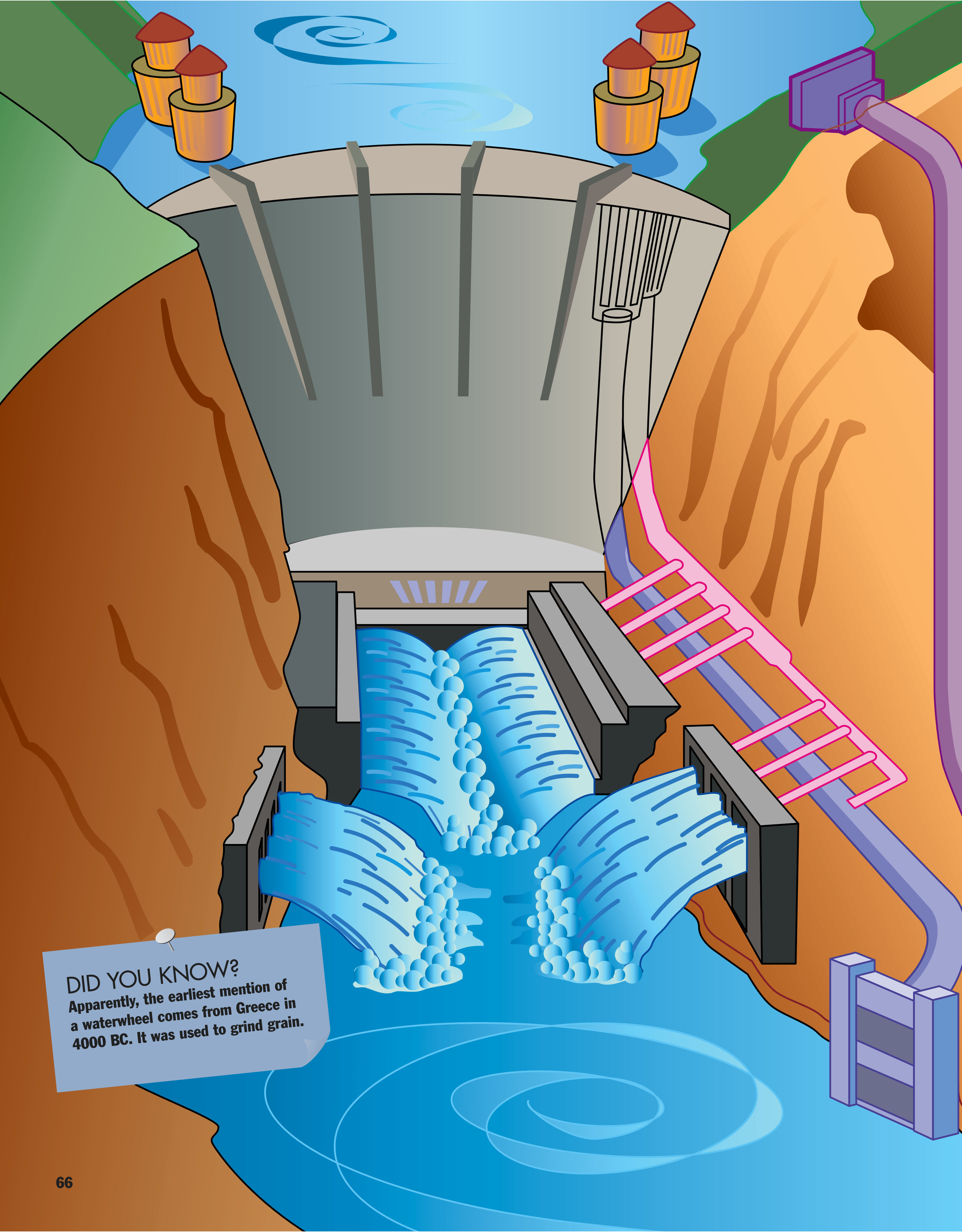
The intense power of the Earth's heat energy sometimes bursts into geysers—hot springs that send roaring columns of steam and boiling water high above the surface. This geyser is the famous Old Faithful in Yellowstone National Park in Wyoming, U.S.

DID YOU KNOW?

Hot-air ballooning, a popular sport in the 1960s, relies on thermal power. A gas burner heats air that is then fed into a large airtight balloon. And because hot air rises, the balloon rises up and away–carrying people or cargo along in its basket or container.

Answer: When steam escapes, it gives a mighty push. This push is so strong that it was used to move the early train engines.



DID YOU KNOW?

Apparently, the earliest mention of a waterwheel comes from Greece in 4000 BC. It was used to grind grain.

Streams of Energy

We have only to hear the roar of a waterfall to guess at the power of water. Its force is also clear anytime we see the damage caused by floods. But the water power can be extremely useful as well as destructive.

One excellent aspect of water power is that the water can be reused. Unlike such fuels as coal and oil, water does not get used up when **harnessed** for power. And it doesn't pollute the air either.

The power of water lies not in the water itself but in the flow of water. The power produced by water depends upon the water's weight and its height of fall, called "head." Generally, the faster that water moves, the more power it can generate. That's why water flowing from a higher place to a lower place, as a waterfall does, can produce so much energy.

© Hubert Stadler/Corbis

Since ancient times humans have used the energy of water for grinding wheat and other grains. They first **devised** the waterwheel, a wheel with paddles around its rim. As the photograph shows, the wheel was mounted on a frame over a river. The flowing water striking the blades turned the wheel.

Later, larger waterwheels were used to run machines in factories. They were not very reliable, however. Floodwaters could create too much power, whereas long rainless periods left the factories without any power at all.

Today streamlined metal waterwheels called "turbines" help produce electricity. The electricity produced by water is called "hydroelectric power" ("hydro-" means "water"). Enormous dams, like the one pictured here, provide this **superior** source of electricity.

SEARCH LIGHT

Fill in the blank: Unlike gas or coal power, water power doesn't cause air ______.

LEARN MORE! READ THESE ARTICLES…
ELECTRICITY (VOLUME 2) • TSUNAMIS (VOLUME 1)
VICTORIA FALLS (VOLUME 8)

Answer: Unlike gas or coal power, water power doesn't cause air pollution.

Hundreds of wind turbines like these in Denmark are set up on "wind farms" in constantly windy areas to produce large amounts of electricity.

SEARCH LIGHT

Which of the following are advantages of wind power?
It's cheap.
It works everywhere.
It's clean.
It's endless.

DID YOU KNOW?

The total wind power of our atmosphere, at any one time, is estimated to be 3.6 billion kilowatts. That's enough energy to light 36 billion light bulbs all at once.

Energy in the Air

Wind power has been used for many hundreds of years. Its energy has filled the sails of ships and powered machines that grind grain, pump water, drain marshes, saw wood, and make paper. Wind provides a clean and endless source of energy.

In the 1890s windmills in Denmark became the first to use wind power to generate electricity. But it took the major energy crisis of the 1970s to focus people's thoughts seriously again on using wind energy to produce electricity.

Traditional windmills in the Netherlands.
© ML Sinibaldi/Corbis

Windmills provide power to make electricity when their sails are turned by wind blowing against them. Originally the sails were long narrow sheets of canvas stretched over a wooden frame. Later windmills used different materials and designs. Usually there are four sails shaped like large blades.

When the sails turn, the axle they are attached to turns as well, much as car wheels turn on their axles. The axle causes various **gears** to turn, which then causes a large crankshaft to turn. The crankshaft is a long pole running the length of the windmill tower. At its other end the crankshaft is attached to a generator, a motor that can make and store electricity. So when the wind blows, the generator runs, making electricity.

Today modern efficient wind machines called "wind turbines" are used to generate electricity. These machines have from one to four blades and operate at high speeds. The first of these wind turbines appeared in the mid-1990s.

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CYCLONES AND TORNADOES (VOLUME 1) • NETHERLANDS (VOLUME 6) • SHIPS (VOLUME 2)

Answer: Wind power is cheap, clean, and endless. Unfortunately, it's not a usable way to generate power in areas with little or no wind.

SEARCH LIGHT

What modern machine's name sounds a lot like "ornithopter," the flapping-wing machine that people tried to fly?

The First Flights

From the earliest times people wanted to fly, but no one knew how. Some people thought it would help if their arms were more like bird wings. So they strapped large feathery wings to their arms. Not one left the ground. A few even tried machines with flapping wings, called "ornithopters." These didn't work either.

DID YOU KNOW?
In 1986 Dick Rutan and Jeana Yeager made the first nonstop round-the-world flight in an airplane. They did the whole trip without refueling.

Then in 1799 a scientist named George Cayley wrote a book and drew pictures explaining how birds use their wings and the speed of the wind to fly. About a hundred years later, two American brothers named Orville and Wilbur Wright read Cayley's book. Although they were bicycle makers, they decided to build a flying machine.

The Wright brothers' machine, *Flyer I*, had the strong light wings of a **glider**, a gasoline-powered engine, and two **propellers**. Then, from a list of places where strong winds blow, they selected the Kill Devil Hills near Kitty Hawk, North Carolina, U.S., as the site of their experiment.

In 1903 Orville, lying flat on the lower wing of *Flyer I*, flew a distance of 120 feet. That first flight lasted only 12 seconds. The next year the Wrights managed to fly their second "aeroplane," *Flyer II*, nearly 3 miles over a period of 5 minutes and 4 seconds.

Soon Glenn Curtiss, another bicycle maker, made a faster airplane called the "1909 type." Not long after that Louis Blériot from France did something no one had tried before. He flew his plane across the English Channel. He was the first man to fly across the sea.

The age of flight had begun.

LEARN MORE! READ THESE ARTICLES…
BIRDS (VOLUME 11) • SHIPS (VOLUME 2) • SPACECRAFT (VOLUME 2)

The Wright brothers had read that wind was very important for flying. That's why they chose the windy hill in North Carolina.

Answer: How about the "helicopter"? The "-opter" part of both words means "wing." A helicopter's name means "whirling wing." An ornithopter's means "bird wing."

How Henry Ford Made the American Car

Henry Ford was born near Dearborn, Michigan, U.S., in July 1863. As a boy, he loved to play with watches, clocks, and machines—good experience for the person who would build the first affordable car.

Cars had already been built in Europe when Ford experimented with his first **vehicle** in 1899. It had wheels like a bicycle's and a gasoline-powered engine that made it move. It was called a Quadricycle and had only two speeds and no reverse.

Within four years Ford had started the Ford Motor Company. His ideas about making automobiles would change history.

Carmakers at the time used parts others had made and put them all together. Ford's company made each and every part that went into its cars. What's more, the company made sure that each kind of part was exactly the same.

In 1908 Ford introduced the Model T. This car worked well and was not costly. It was a big success, but the company couldn't make them quickly enough to satisfy Henry Ford.

In 1913 he started a large factory that made use of his most important idea: the assembly line. Instead of having workers go from car to car, the cars moved slowly down a line while workers stood in place adding parts to them. Each worker added a different part until a whole car was put together.

This meant more autos could be built more quickly at a lower cost. By 1918 half of all cars in the United States were Model Ts. Ford's company had become the largest automobile manufacturer in the world. And Ford had revolutionized the process of **manufacturing**.

SEARCH LIGHT

True or false? Henry Ford built the very first automobile.

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AIRPLANES (VOLUME 2) • OIL (VOLUME 2)
TRANSPORTATION (VOLUME 2)

DID YOU KNOW?

Henry Ford is reported to have once said that his customers could get a Model T in "any color they like, as long as it's black."

Henry Ford's first car was the Quadricycle, seen here with Ford driving. It had only two forward speeds and could not back up.

Answer: FALSE. Henry Ford built the first inexpensive automobile. Gottlieb Daimler, a German, gets credit for building the very first automobile.

Louis Braille completed his raised-dot alphabet for the blind when he was only 15 years old. A person can even learn to read music through the Braille system.

SEARCH LIGHT

Louis Braille invented his Braille alphabet when he was 15. At that age, how many years had he been blind?

Books to Touch

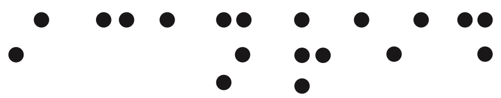
More than 175 years ago in France, young Louis Braille thought of a way to help blind people read and write. He himself could not see. He had hurt his eyes when he was just 3 years old, while he was playing with his father's tools.

Fortunately, Louis was a clever child. When he was 10 years old, he won a **scholarship** to the National Institute for Blind Children in Paris.

At the school Louis heard about how Captain Barbier, an army officer, had invented a system of writing that used dots. It was called "night writing," and it helped soldiers read messages in the dark. These messages were of small, bump-like dots pressed on a sheet of paper. The dots were easy to make and could be felt quickly.

Louis decided to use similar dots to make an alphabet for the blind. It was slow to be accepted but was eventually a great success. His alphabet used 63 different dot patterns to represent letters, numbers, punctuation, and several other useful signs. A person could even learn to read music by feeling dots.

Today blind people all over the world can learn the Braille alphabet. Look at these dots:



In an actual Braille book, the tips of your fingers would be able to cover each small group of dots.

Can you guess what this pattern of dot letters spells?

It spells the words "I can read."

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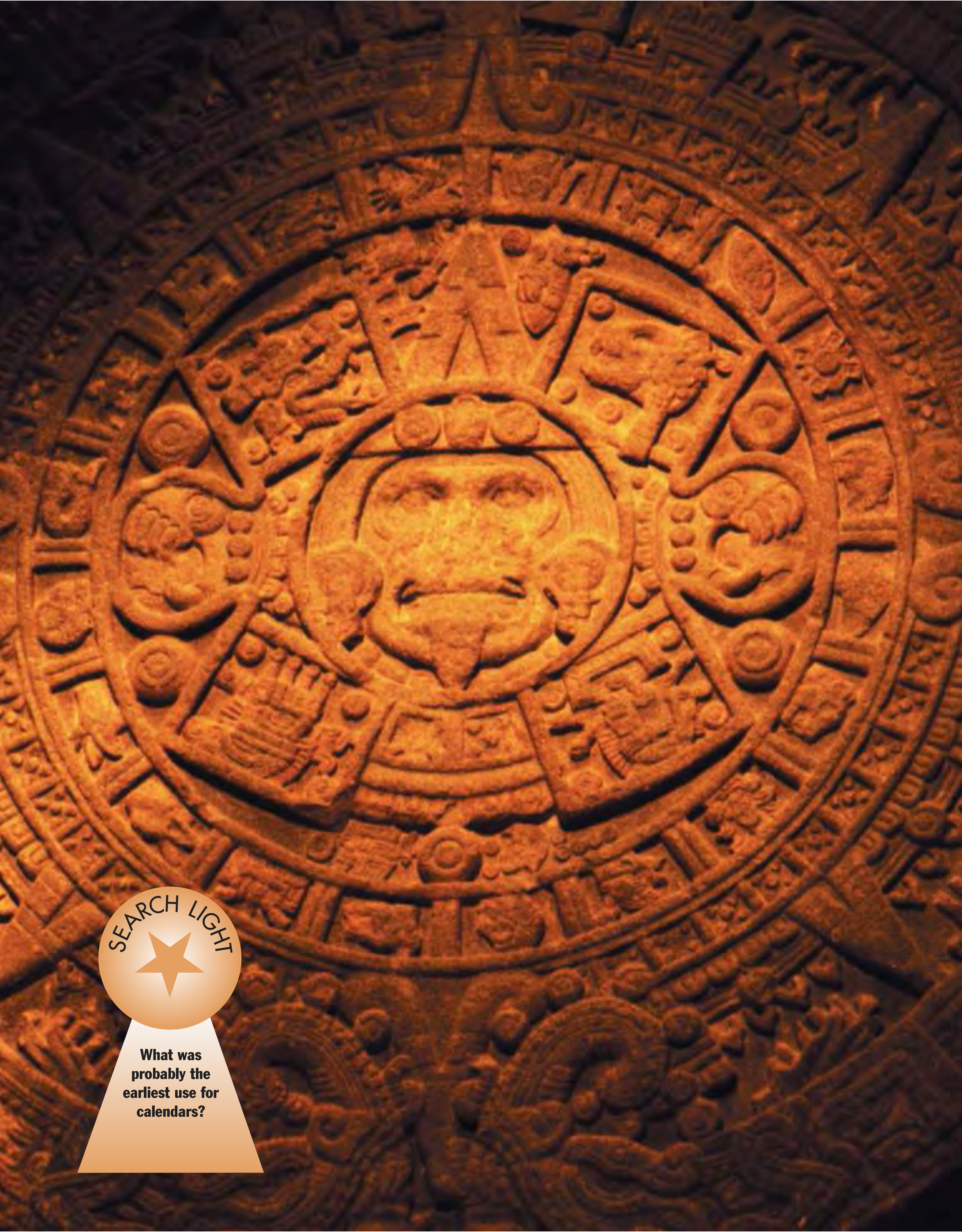
HELEN KELLER (VOLUME 4)
PRINTING (VOLUME 2) • SIGHT AND SOUND (VOLUME 2)

DID YOU KNOW?
On its Web site, the American Foundation for the Blind has a great area where you can learn Braille yourself. Go to http://afb.org and click on "Braille Bug."

Answer: Louis Braille had been blind for 12 years when he invented his alphabet.



SEARCH LIGHT

What was probably the earliest use for calendars?

Charting the Year

A calendar, like a clock, provides a way to count time—though calendars count days and months rather than minutes and hours. The modern calendar has 12 months of 30 or 31 days each (February has 28, sometimes 29). The calendar year has 365 days, which is about how long it takes the Earth to circle the Sun once. That makes it a **solar** calendar.

DID YOU KNOW?
The Chinese calendar names each year for one of 12 animals. In order, these are: rat, ox, tiger, hare, dragon, snake, horse, sheep, monkey, fowl, dog, and pig. The year 2003 is the Year of the Sheep (or Ram), 2004 the Year of the Monkey, and so on.

Today's calendar, with a few changes, has been in use since 1582. Pope Gregory XIII had it designed to correct errors in the previous calendar. For this reason it is called the "Gregorian calendar."

The oldest calendars were used to figure out when to plant, harvest, and store crops. These were often "**lunar** calendars," based on the number of days it took the Moon to appear full and then **dwindle** away again.

Jewish calendar (in Hebrew) from the 1800s.
© Archivo Iconografico, S.A./Corbis

The traditional Chinese calendar is a lunar calendar. It has 354 days, with months of either 29 or 30 days.

Many calendars have religious origins. In Central and South America, the ancient Aztec and Mayan calendars marked **ritual** days and celebrations. Jews, Muslims, and Hindus have religious calendars, each with a different number of days and months.

All these calendars have one thing in common: they're wrong. None of them measures the Earth's year-long journey around the Sun precisely. Extra days must be added to keep the count in step with the actual seasons. We add an extra day to February every four years. (Actually, even our corrections are wrong. Once every 400 years we *don't* add that day.)

But if we didn't make some kind of correction, we'd eventually have New Year's Eve in the middle of the year!

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MAYAN CIVILIZATION (VOLUME 4) • MEASUREMENT (VOLUME 2) • MOON (VOLUME 2)

This ancient Aztec calendar stone weighs about 25 tons. Its central image of the Aztec sun god, Tonatiuh, indicates the important role religion plays in how major civilizations measure time.
© Randy Faris/Corbis

Answer: The earliest calendars were likely used to tell the right time to plant and harvest crops.

SEARCH LIGHT

Find and correct the error in the following sentence: A set of instructions that a computer uses to solve problems and do work is called "memory."

The Machines That Solve Problems

The first computers were expensive room-sized machines that only business and government offices could afford. Today most computers are smaller, and many people have one in their own home or school. These "personal computers" (PCs) first appeared in the mid-1970s.

A Palm Pilot, one of the tiny but powerful modern computers.
© RNT Productions/Corbis

Computers can find the answers to many math problems and can simplify work that has many steps and would otherwise take lots of time. They can do this because they can remember, in order, the individual steps of even long and complicated instructions.

The sets of instructions for computers are called "programs" or "software." A computer's brain is its microprocessor—a tiny electronic **device** that reads and carries out the program's instructions.

Because they are programmed in advance, you can use computers to solve math problems, remember facts, and play games. Computers can also help you draw, write papers, and make your own greeting cards.

Computers need two kinds of memory. "Main memory" is what handles the information that the computer is using as it is doing its work. Main memory operates amazingly fast and powerfully to speed up a computer's work. The second kind of computer memory is **storage** for its programs and for the results of its operations. The most important storage space is on the computer's hard drive, or hard disk. CD-ROMs, DVDs, and flash drives are removable storage devices.

Since 1990 very small computers have been developed. Today there are laptop or notebook computers, as well as handheld computers. Handheld computers weigh only a few ounces, but they can handle more **data** more quickly than most of the first giant computers.

DID YOU KNOW?
It was a weaving machine, a loom, that led to the first computers. At one time looms used punched cards to set weaving patterns. Early computers used this system of coding in their programming "languages."

LEARN MORE! READ THESE ARTICLES…
ELECTRICITY (VOLUME 2) • INTERNET (VOLUME 2)
PRINTING (VOLUME 2)

Answer: A set of instructions that a computer uses to solve problems and do work is called a "program" [or "software"].

Network of People

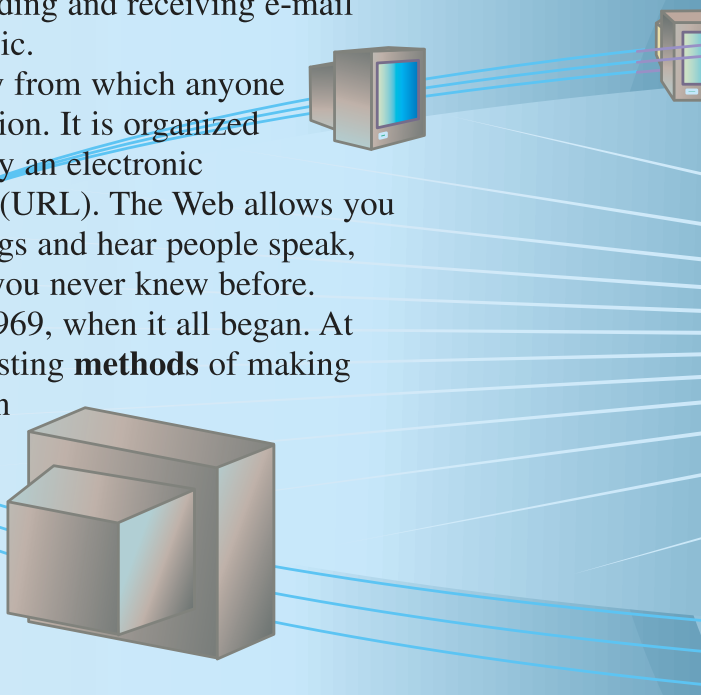
You can do things with your friends and family even when they are thousands of miles away simply by sitting at your computer. The Internet makes this possible.

As the name suggests, the Internet is like a large net whose every strand connects a different computer. It is an international web linking millions of computer users around the world. Together with the World Wide Web (WWW, or Web), it is used for sending and receiving e-mail and for sharing information on almost any topic.

The Web is an enormous electronic library from which anyone connected to the Internet can receive information. It is organized into tens of millions of sites, each identified by an electronic address called the “uniform resource locator” (URL). The Web allows you to view photographs and movies, listen to songs and hear people speak, and find out about **countless** different things you never knew before.

The Internet has come a long way since 1969, when it all began. At that time the U.S. Defense Department was testing **methods** of making their computers survive a military attack. Soon their networks were extended to various research computers around the United States and then to countries around the world.

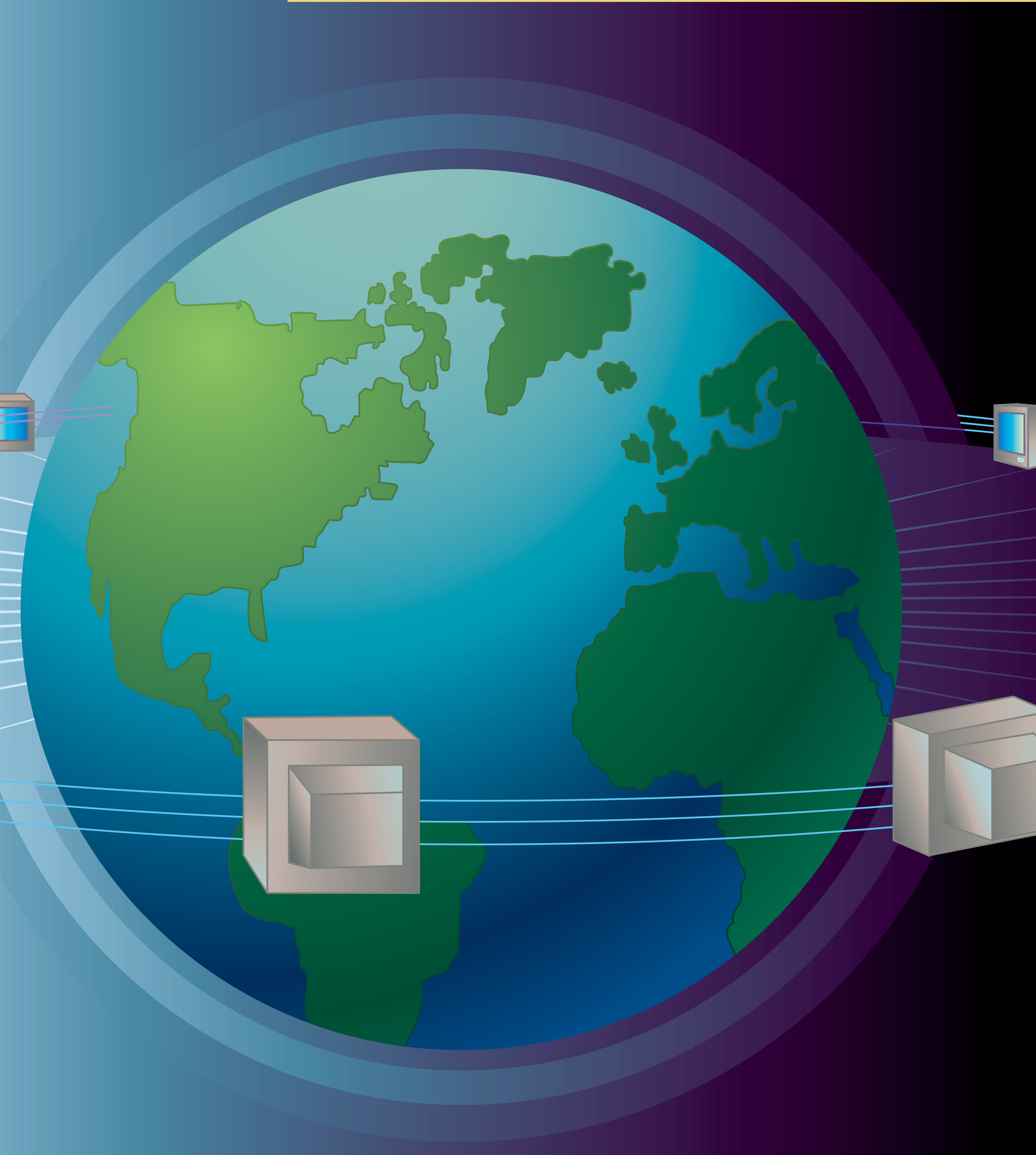
By early 1990 the Internet and the World Wide Web had entered homes. Today many people wonder how they ever got by without the Internet.



LEARN MORE! READ THESE ARTICLES…
COMPUTERS (VOLUME 2)
RADIO (VOLUME 2)
TELEPHONES (VOLUME 2)

DID YOU KNOW?
Radio took about 38 years to gain 50 million listeners. TV took about 13 years to have 50 million viewers. The Internet took only 4 years to get 50 million users.

SEARCH LIGHT
True or false? The Internet is less than 20 years old.



Answer: FALSE. The Internet is more than 30 years old.

Photos That Move

Sitting in a darkened movie theater, caught up in the adventures of Frodo Baggins or Batgirl, you might find it difficult to believe that you're watching a series of still photographs. These still photos are projected onto the screen so fast, one after another, that you're tricked into seeing movement.

Motion picture film comes in long wound **spools** or **cartridges**. A camera records pictures on the film at either 18 or 24 shots per second. Sometimes there are three or four cameras that shoot a scene from different angles. Sound is recorded at the same time but with separate equipment.

Later, the film is **edited** by cutting out parts that the director doesn't want. The parts being kept are then put together to tell the story. The sound and the pictures are joined together on a single piece of film to create the finished movie.

DID YOU KNOW?

When a system that added sound to silent movies was invented, the major movie companies thought it would be a big failure. One small company, Warner Brothers, thought it might be interesting and soon produced the first "talking pictures."

SEARCH LIGHT

True or false? Movies are really just a long string of photographs.

Filmmaking is a long and complicated process, involving many people. The actors are the most visible, but there are many others as well. The director has total control over how the story will be filmed. A whole crew of people help with costumes, choreography, lighting, sound, camera operations, special effects, and the actors' makeup and hairstyles.

After the film has been shot, there are different people to edit it and other people who advertise the movie and get the public talking about it. Finally, the film reaches the movie theaters. There you buy your popcorn or other refreshments and settle into your seat to enjoy the magic world of the finished motion picture.

LEARN MORE! READ THESE ARTICLES…
CINEMA (VOLUME 3) • PHOTOGRAPHY (VOLUME 2) • TELEVISION (VOLUME 2)

Answer: TRUE. When the string of photos is flashed by quickly, the pictures appear to move.

DID YOU KNOW?
The trans-Alaska pipeline carries 88,000 barrels of oil every hour. The oil makes an 800-mile journey to the port town of Valdez, Alaska.

From the Ground to the Filling Station

Up comes the thick black oil from the oil well and...out pours the gasoline into your family's car. But how does the oil become fuel for automobiles?

Petroleum, or crude oil, is oil as it is found deep within the Earth. This raw form has many unwanted substances in it that must eventually be removed in a process called "refining."

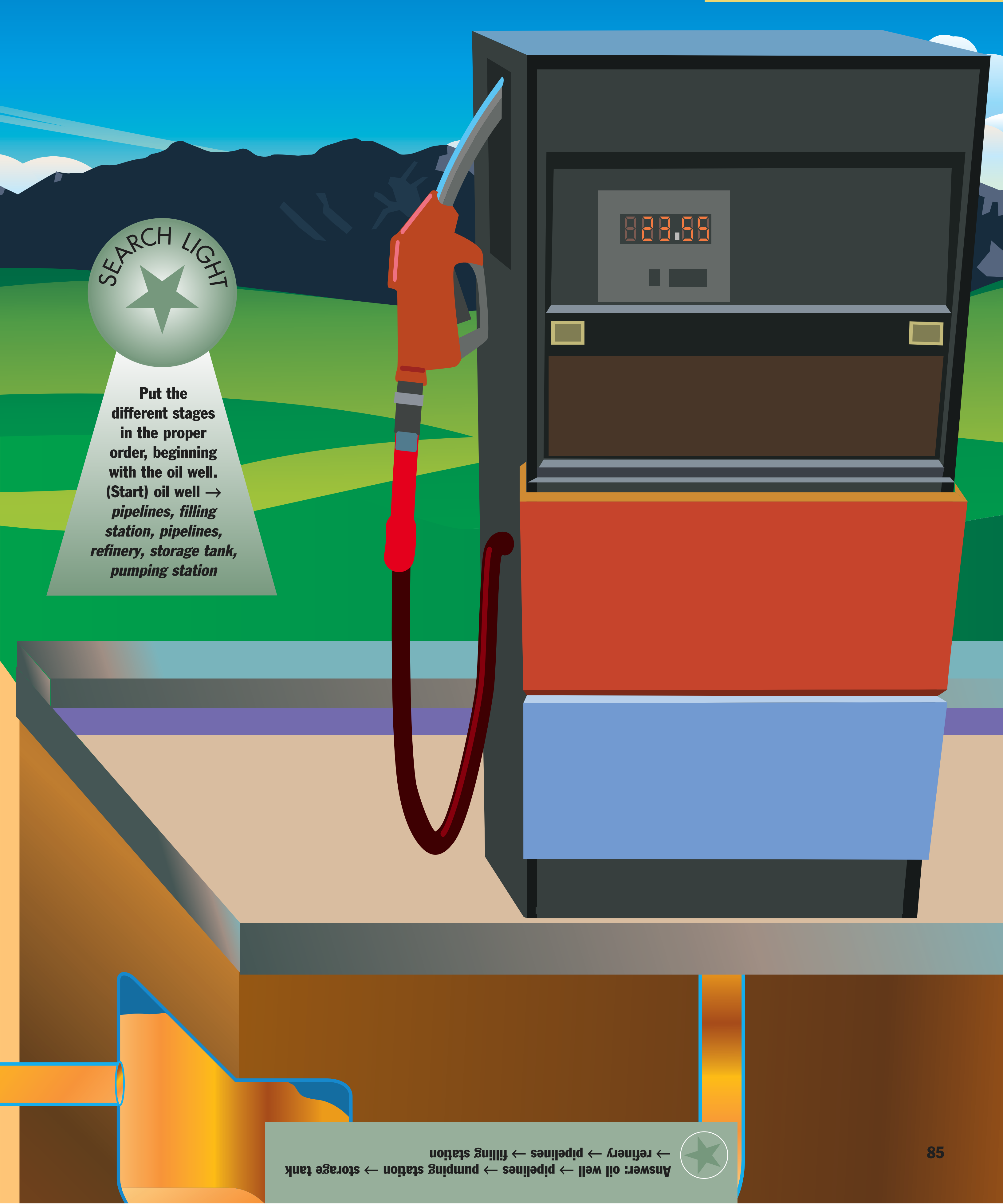
From a well drilled deep into the ground, the oil often goes through long pipelines under the ground. There are pipelines in some very surprising places—under streets, mountains, deserts, frozen lands, and even lakes and rivers.

Pumping stations keep the thick oil moving through the pipes. Each station gives the oil enough of a push to get it to the next station. There are pumping stations built all along the pipelines. Here and there along the pipelines, oil is directed into smaller pipes that take it to huge storage tanks.

From the storage tanks the oil goes into a **refinery**, where it is heated until it is very hot. The hot oil is separated into many different substances. The heavy part that settles down at the bottom is used for road building. Other parts become machine oils and waxes. **Kerosene** and gasoline also separate as the oil is heated. Finally, the lightest parts of the oil—cooking gas and other kinds of gases—are collected.

From the refineries more pipelines carry oil to round storage tanks in tank farms. Gasoline trucks fill up at the storage tanks and take the gasoline to filling stations, where your car and others can then fill up.

LEARN MORE! READ THESE ARTICLES…
AUTOMOBILES (VOLUME 2) • GEOLOGY (VOLUME 1) • POLLUTION (VOLUME 1)



SEARCH LIGHT

Put the different stages in the proper order, beginning with the oil well.
(Start) oil well →
pipelines, filling station, pipelines, refinery, storage tank, pumping station

Answer: oil well → pipelines → pumping station → storage tank → refinery → pipelines → filling station

LANDEL INC
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Turning Trees to Paper

The sheets in your notebook are made of paper that came from a factory. So are the pages of your book.

The factory got the paper from a paper mill. The mill probably made the paper from logs. And the logs were cut from trees that grew in a forest. Pine trees are often used to make paper.

If you visit a **traditional** paper mill, you will see people working at large noisy machines that peel bark off the logs and then cut the wood into smaller pieces. Other machines press and grind this wood into pieces so tiny that they can be mashed together like potatoes. This gooey stuff is called “wood **pulp**.”

After it is mixed with water, the pulp flows onto a screen, where the water drains off, leaving a thin wet sheet of pulp.

Big hot rollers press and then dry this wet pulp as it moves along **conveyor belts**. At the end of the line the dried pulp comes out as giant rolls of paper. These giant rolls are what the paper factories make into the products that you use every day, such as newspapers, paper towels, and the pages of books that you read.

Because we use so much paper, we must be careful how many trees are cut down to make it. Fortunately, today a lot of used paper can be remade into new paper by **recycling**. And you can help save trees by recycling the magazines, newspapers, and other paper that you use in school and at home.

SEARCH LIGHT

Starting with the tree in the forest, arrange these mixed-up steps in the order they should happen in papermaking:

(*Start*) tree →
chop tree, dry, peel bark, roll out sheets, cut wood, press flat, grind into pulp

Learn More! Read these articles…
Pine (volume 10) • Printing (volume 2) • Rainforests (volume 1)

DID YOU KNOW?
According to Chinese historical records, the first paper was made from tree bark, hemp (a plant used to make rope), rags, and fishnets.

In a paper mill like this, the rolls of paper are sometimes as big as the trees they are made from.
© Philip Gould/Corbis

Answer: tree → chop tree → peel bark → cut wood → grind into pulp → press flat → dry → roll out sheets

Drawing with Light

The word "photography" comes from two ancient Greek words: *photo*, for "light," and *graph*, for "drawing."

Photography, the process of taking pictures, requires a camera. Cameras work basically as our eyes do. Light enters the front and shines a picture on the back.

A camera may be any dark lightproof box with a small opening at one end that lets in the light. Most cameras have glass **lenses** to help focus the light into the back of the box.

In your eye light enters through an opening called the "pupil." The camera's opening is its aperture. Your iris controls how much light enters your eye. The camera's shutter does the same. In eyes and in most cameras, the light then passes through a lens. In your eye the picture is

SEARCH LIGHT

Match the parts of the camera to the similar parts of an eye:

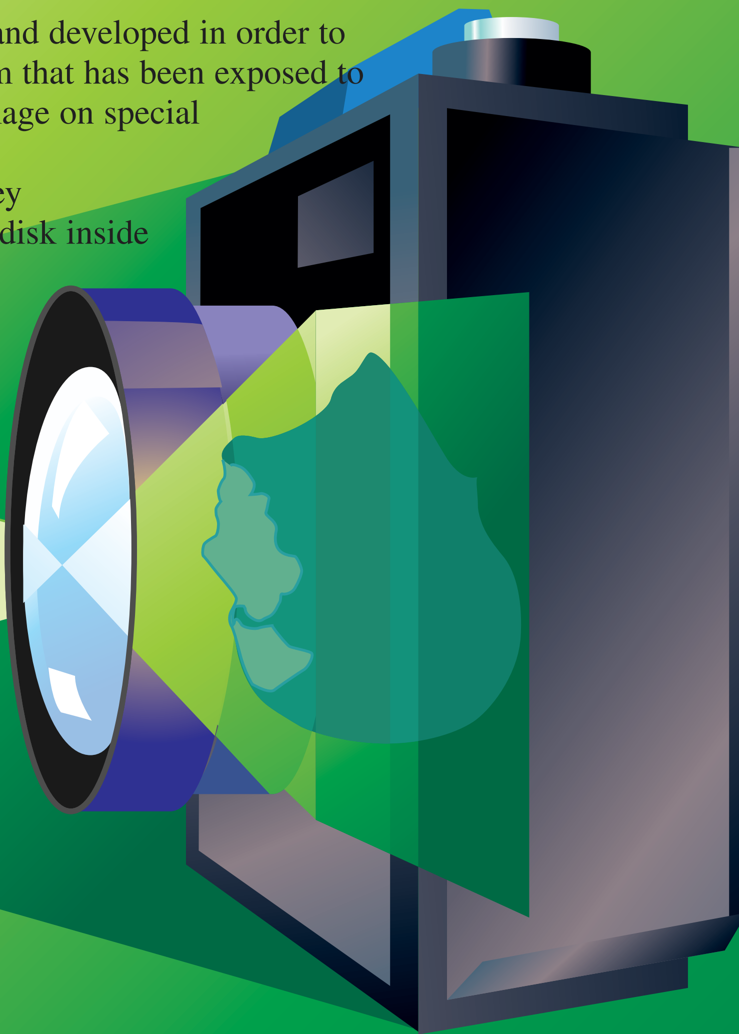
1. lens	**a) lens**
2. retina	**b) film**
3. iris	**c) shutter**
4. pupil	**d) aperture**

produced on the retina, the back lining of the eye. In a traditional camera, film receives and captures the image.

Film is special material that has been treated with chemicals to make it **sensitive** to light. Light shining on film changes the film's chemical makeup. Depending on how much light shines on each part of the film, different shades or colors result.

The film has to be taken out of the camera and developed in order to finish the process of creating a photograph. Film that has been exposed to light is processed with chemicals that **fix** the image on special paper.

Digital cameras do not use film. Instead, they translate the image into numbers recorded on a disk inside the camera. A computer decodes these numbers and displays a picture.



LEARN MORE! READ THESE ARTICLES…
MOTION PICTURES (VOLUME 2) • PAINTING (VOLUME 3)
SIGHT AND SOUND (VOLUME 2)

DID YOU KNOW?
The first photograph—a farmhouse with some fruit trees—was taken in about 1826 by French inventor Joseph Nicéphore Niepce.

Answer: 1a; 2b; 3c; 4d

Gutenberg's Gift

Before about 550 years ago very few people owned books. In fact, there weren't many books to own. Back then most books had to be written out by hand. Some books were printed by using wooden blocks with the letters of an entire page hand-carved into each one. The carved side of the block was dipped in ink and pressed onto paper. Both handwritten and woodblock-printed books took a lot of time, energy, and money. Only rich people could afford to buy them.

Then, in the 1450s, a man in Germany named Johannes Gutenberg had an idea for printing books faster.

First, he produced small blocks of metal with one raised, backward letter on each block. These blocks with their raised letters were called "type." He then spelled out words and sentences by lining up the individual pieces of type in holders.

The second part of his invention was the printing press. This was basically a "bed" in which the lines of type could be laid out to create a page. When he inked the type and then used a large plate to press them against a sheet of paper, lines of words were printed on the paper.

Gutenberg's blocks became known as movable type, which means that he could take his lines apart and reuse the letters. Once he had carved enough sets of individual letters, he didn't have to carve new ones to make new pages.

The Bible was one of the earliest books printed by using Gutenberg's movable type. By 1500 the printing presses of Europe had produced some 6 million books!

SEARCH LIGHT

Why did Gutenberg make the letters on individual pieces of type facing backward? (Hint: Think about looking at writing in a mirror.)

LEARN MORE! READ THESE ARTICLES…
BIBLE (VOLUME 5) • BRAILLE (VOLUME 2)
PAPER (VOLUME 2)

DID YOU KNOW?

The Chinese actually invented a kind of movable type 400 years before Gutenberg. But the Chinese did not invent a press to go with the type.

The artist had to imagine Gutenberg and his first page of print. But the printing press in the background is a fairly accurate image of what the inventor worked with.
© Bettmann/Corbis

Answer: Because the letters were backward on the blocks, they came out facing forward on the paper. Try it yourself!

Guglielmo Marconi, seen here in 1922, received the 1909 Nobel Prize for Physics for his development of a way to send electronic signals without using wires.
© Bettmann/Corbis

SEARCH LIGHT

Fill in the blank: After World War I, radio grew from a two-way communication tool into a popular instrument for ________________.

Thank You, Mr. Marconi

Before there was television, people got much of their news and entertainment from the radio. And many still do!

Invention of the radio began in 1896 when Italian scientist Guglielmo Marconi **patented** a wireless **telegraph** process. Marconi knew that energy can travel in invisible waves through the air and that these waves could be captured electronically to send and receive signals. His invention allowed people to send messages to each other over great distances without having to be connected by wires.

A Marconi wireless telegraph set (1912), the "parent" of the voice-transmitting radio.
© Underwood & Underwood/Corbis

Marconi and others added to his invention, figuring out how to add sound to these messages to make the first radios. These were used simply for sending and receiving messages. During World War I the armed forces used radios for this purpose. It was after the war that radio became popular as a means of entertainment.

During the 1920s radio stations were set up all over the world. In the early days most of the radio programs gave news or **broadcast** lectures and some music. As more and more people began to listen to radio programs, more popular entertainment programs were added. These included comedies, dramas, game shows, mysteries, soap operas, and shows for children.

Radio shows remained highly popular until the 1950s. That's when television began to catch on. And as it happens, television actually works in the same basic ways as radio does! It uses special equipment to send and receive pictures and sound in the form of electronic signals.

Today radio **technology** is used in many ways. Cordless telephones, cellular phones, and garage-door openers all use radio technology. And radio entertainment programs are still going strong.

DID YOU KNOW?
On the eve of Halloween (October 30) of 1938, actor-director Orson Welles's realistic radio drama *The War of the Worlds* accidentally convinced millions of listeners that the Earth was being invaded by Martians!

LEARN MORE! READ THESE ARTICLES…
ECHOES (VOLUME 1) • ELECTRICITY (VOLUME 2) • TELEVISION (VOLUME 2)

Answer: After World War I, radio grew from a two-way communication tool into a popular instrument for entertainment.

From Rafts to Ocean Liners

We don't know exactly how the first human transportation over water happened. But it's not hard to imagine how it might have come about.

Long ago, people used anything that would float to move things across water—bundles of reeds, even jars and covered baskets.

Perhaps one day someone tied three or four logs together. This made a raft. Maybe someone else hollowed out a log as a kind of **canoe**. These log boats could be moved by people paddling with their hands. Later they might have used a stick or a pole to make their boat move faster.

Whoever put the first sail on a boat made a wonderful discovery. Sailing was faster and easier than paddling because it caught the wind and made it do the work.

SEARCH LIGHT

From each of these pairs, pick the type of boat that was developed first:
a) raft or sailboat
b) submarine or canoe
c) paddle wheel or rowboat

Eventually, someone built a ship that used a sail and long paddles, called "oars." When there was little or no wind, the sailors rowed with the oars. In time, sailors learned to turn, or "set," a sail to make the boat go in almost any direction they wished.

Paddles began to be used again much later in giant wheels that moved large boats through the water. A steam engine powered these paddle wheels, which were too heavy to turn by hand. Steamboats cruised rivers, lakes, and oceans all over the world.

Today ships and boats use many different kinds of engines. Most ships use oil to **generate** power. Some submarines run on nuclear power. But on warm days, many people still enjoy traveling on water by paddling, sailing, and even rafting.

DID YOU KNOW?

In 1947 Norwegian scientist Thor Heyerdahl and a small crew sailed some 5,000 miles of ocean on a balsawood raft called the *Kon-Tiki*. It was an experiment to see if ancient Americans could have settled some Pacific islands.

LEARN MORE! READ THESE ARTICLES…
FERDINAND MAGELLAN (VOLUME 4)
SUBMARINES (VOLUME 2) • VIKINGS (VOLUME 4)

Today's ocean liners provide a popular way for people to get from one place to another and to vacation on the way.
© Melvyn P. Lawes—Papilio/Corbis

Answer: a) raft b) canoe c) rowboat

Eyes That Hear, Speech That's Seen

Mary: "Can you come to the store with me?"

Sara: "I'll ask my mother."

If Mary and Sara were like most girls you know, their conversation would not be unusual. But Mary and Sara are deaf, which means that they cannot hear. Still they understand each other.

How?

Well, one way that people who are deaf communicate is by using sign language. Sign language replaces spoken words with finger and hand movements, **gestures**, and facial expressions. People using sign language can actually talk faster than if they spoke out loud.

SEARCH LIGHT

The article mentions several ways that people who are deaf can know what another person is saying. One is lipreading. What is another?

Another way people who are deaf may communicate is through lipreading. People who lip-read have learned to recognize spoken words by reading the shapes and movements speakers make with their lips, mouths, and tongues. Lip-readers usually speak out loud themselves even though they can't hear what others say.

Deaf child learning to speak using touch, sight, and imitation.

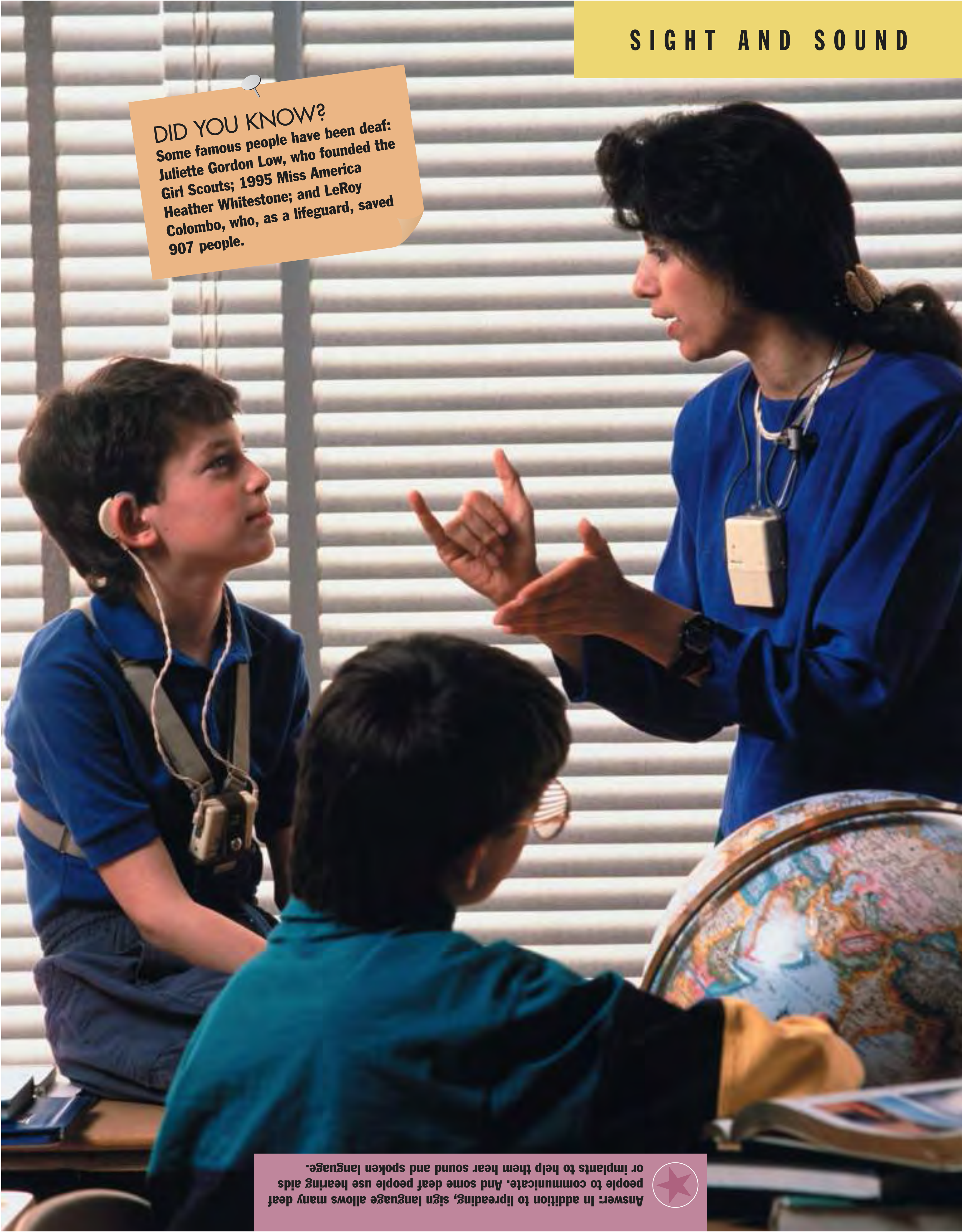
Some people who are deaf use hearing aids or cochlear **implants** to help them hear the sounds and words that others hear. (The cochlea is part of the ear.) Hearing aids usually fit outside the ear and make sounds louder. Cochlear implants are inside the ear and use electrical signals to imitate sounds for the brain. Often, children and adults with hearing aids or implants take lessons to learn to speak as hearing people do.

There are many schools for children who are deaf or hearing-**impaired**. There they may learn all or some of the skills of lipreading, sign language, **oral** speech, and the use of hearing aids and implants. Older students may attend Gallaudet University in Washington, D.C., a school of higher education especially for people who are deaf.

LEARN MORE! READ THESE ARTICLES…

BRAILLE (VOLUME 2) • HELEN KELLER (VOLUME 4) • TELEPHONES (VOLUME 2)

Many deaf children learn to communicate by using sign language.



DID YOU KNOW?

Some famous people have been deaf: Juliette Gordon Low, who founded the Girl Scouts; 1995 Miss America Heather Whitestone; and LeRoy Colombo, who, as a lifeguard, saved 907 people.

Answer: In addition to lipreading, sign language allows many deaf people to communicate. And some deaf people use hearing aids or implants to help them hear sound and spoken language.

Silent Stalkers of the Sea

Because they are meant to spend most of their time underwater, submarines are designed and built quite differently from other ships.

Submarines must be airtight so that water won't come in when they **submerge**. They also need strong **hulls** because the pressure of seawater at great depths is strong enough to crush ships. And submarines need special engines that don't use air when they are underwater. Otherwise, they would quickly run out of air and shut down! So most modern subs are powered by electric batteries when they're submerged. Some are powered by nuclear energy.

Because a submarine is all closed up, it must have special instruments to act as its eyes and ears underwater. A periscope is a viewing **device** that can be raised up out of the water to let the submarine officers see what's around them. Another special system, sonar, "hears" what's under the water by sending out sound waves that bounce off everything in their path. These echoes send a sound picture back to the sub.

But why build submarines in the first place? Well, submarines have proved very useful in times of war. They can hide underwater and take enemy ships by surprise.

Submarines have peaceful uses too. Scientists use smaller submarines, called "submersibles," to explore the huge ocean floors and the creatures that live there. People also use submersibles to search for sunken ships and lost treasures. The luxury liner *Titanic* was discovered and explored with a submersible 73 years after it sank in the Atlantic Ocean.

SEARCH LIGHT

Fill in the blanks: Submarines need ______ that don't use up ______.

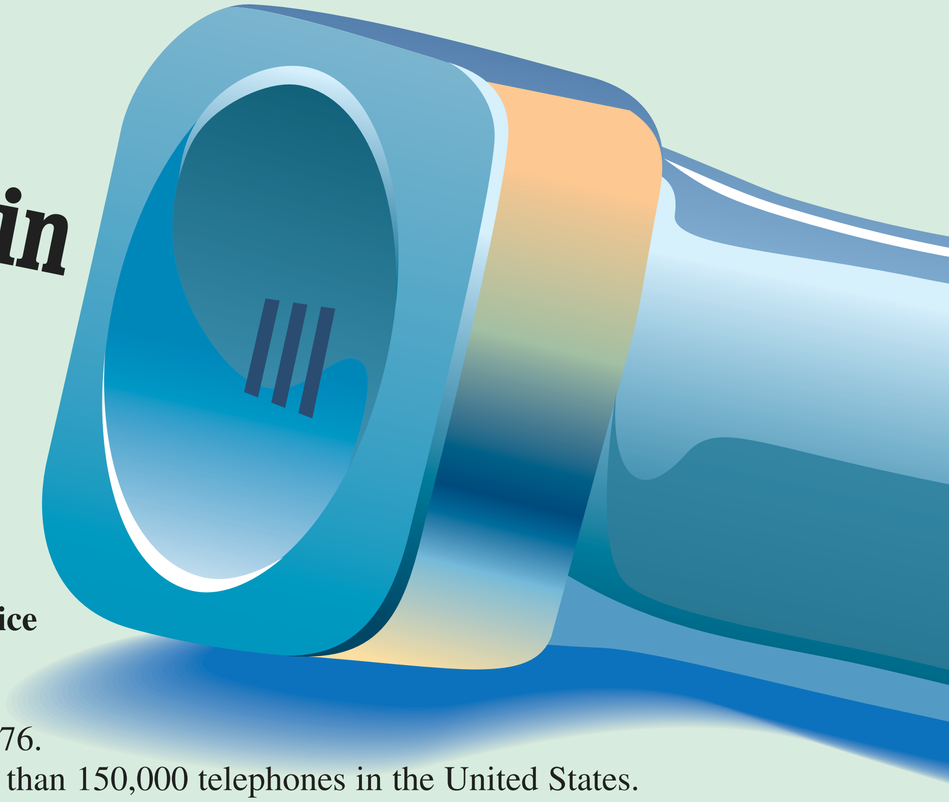
LEARN MORE! READ THESE ARTICLES…
ECHOES (VOLUME 1) • NUCLEAR ENERGY (VOLUME 2)
JULES VERNE (VOLUME 3)

DID YOU KNOW?
The *Nautilus*, the first nuclear sub, was once caught by a fishing net. The unhappy crew of the fishing boat was towed for several miles before the situation was fixed.

When a submarine runs above the water, officers can stand on top of the conning tower. That's the raised deck of the ship.

Answer: Submarines need engines that don't use up air.

Staying in Touch



The telephone is the most popular communication **device** of all time.

Alexander Graham Bell invented the telephone in 1876. In 11 years there were more than 150,000 telephones in the United States. In 2001 there were an estimated 1,400,000,000 telephones worldwide.

Traditional telephones have three main parts: a **transmitter**, a receiver, and a dialer. There is also a switch hook, which hangs up and disconnects the call.

When you speak into the phone, the transmitter changes the sound of your voice into an electrical signal. The transmitter is basically a tiny **microphone** in the mouthpiece. On the other end of the call, the receiver in the listener's earpiece changes that electrical signal back into sound. The receiver is a tiny vibrating disk, and the electrical signal vibrates the disk to make the sounds of the caller's voice.

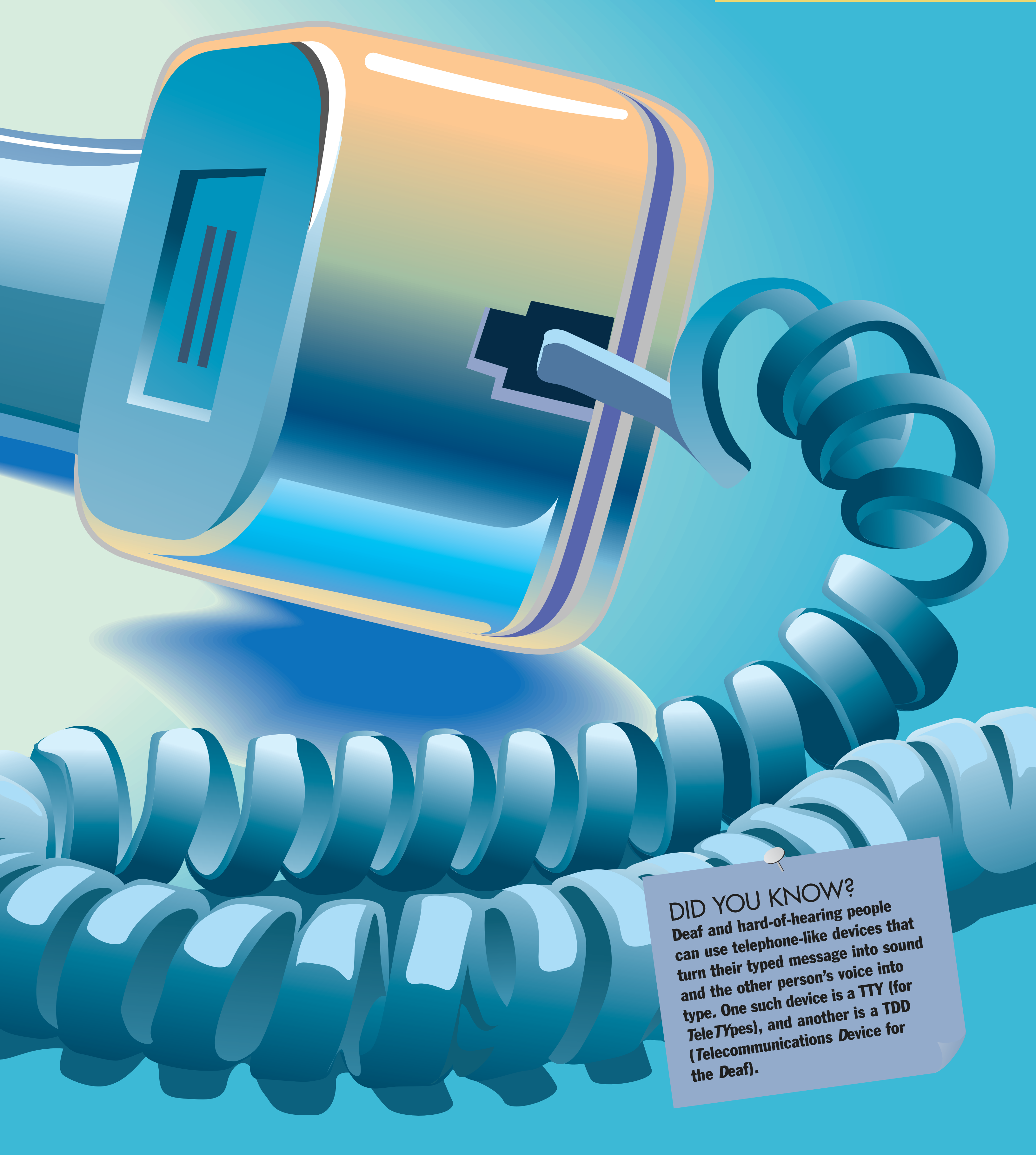
When you make a call, the phone's dialer sends a series of clicks or tones to a switching office. On a rotating dial phone, dialing the number 3 causes three clicks to interrupt the normal sound on the line (the dial tone). On a touchtone phone, a pushed number interrupts the dial tone with a new sound. These interruptions are a form of code. The switching office "reads" the code and sends the call to the right telephone receiver.

Since the 1990s cellular phones have become hugely popular worldwide. Cell phones connect with small transmitter-receivers that each control an area, or "cell." As a person moves from one cell to the next, the cell phone system switches the signal to the new cell.

SEARCH LIGHT

A telephone receiver is a
a) vibrating disk.
b) dial tone.
c) tiny microphone.

LEARN MORE! READ THESE ARTICLES…
ECHOES (VOLUME 1) • ELECTRICITY (VOLUME 2) • RADIO (VOLUME 2)



DID YOU KNOW?

Deaf and hard-of-hearing people can use telephone-like devices that turn their typed message into sound and the other person's voice into type. One such device is a TTY (for *Tele*TYpes), and another is a TDD (*T*elecommunications *D*evice for the *D*eaf).

Answer: a) vibrating disk.

Exploring the Sky

The stars we see in the night sky look like little points of light. But they are vastly larger than they look. Almost all of them are much bigger than our Earth. The stars look tiny because they're so far away. If you rode in the fastest rocket for your entire life, you wouldn't make it even halfway to the nearest star.

Fortunately, telescopes let us explore the stars without leaving the Earth.

DID YOU KNOW?
Special radio telescopes "listen" to the radio signals produced by stars, galaxies, and other objects. One group of radio telescopes in New Mexico, U.S., includes 27 "dish" antennas spread over 24 miles.

A simple telescope is tube-shaped and has a special kind of **magnifying** glass, called a "**lens**," at each end. Other telescopes use mirrors or both lenses and mirrors to enlarge the faraway view. Lenses and mirrors gather the light from an object, making it seem brighter and easier to see.

Telescopes make stars and planets seem closer. And telescopes let us see much farther than we normally can. Through a simple telescope you can see the rings of Saturn, as well as galaxies outside our own Milky Way. Giant telescopes on mountaintops can view objects much farther away and see with much greater detail. Their lenses and mirrors are often enormous and therefore enormously powerful.

Some modern telescopes don't even look like the ones most of us might look through. These devices, which must travel into space beyond the Earth's atmosphere, can sense light and other **radiation** that's invisible to unaided human eyes. These sensitive instruments, such as the Infrared Space Observatory and the Hubble Space Telescope (pictured here), have shown scientists such wonders as the dust in space between galaxies and the birth and death of stars.

SEARCH LIGHT

Find and correct the error in the following sentence: Telescopes make faraway objects seem faster than they look with the unaided eye.

LEARN MORE! READ THESE ARTICLES…
ASTRONOMY (VOLUME 2) • GALILEO (VOLUME 4) • SATURN (VOLUME 2)

Behind the Hubble Space Telescope, you can see the Earth's atmosphere outlined.
NASA

Answer: Telescopes make faraway objects seem <u>closer</u> than they look with the unaided eye.

The World in a Box

The British Broadcasting Corporation (BBC) offered the first public television (TV) programming in 1936. But World War II stalled the development and popularity of the new invention.

In the United States TV didn't find much of an audience in the beginning. People preferred radio programs. Early TV was black and white, the pictures were small and fuzzy, and the sound wasn't great. But when the 1947 World Series of baseball was shown on TV, many Americans watched and afterward decided to buy TV sets.

SEARCH LIGHT

True or false? In the beginning most people weren't very interested in the new invention known as "television."

The first TV programs—mostly comedies, variety shows, soap operas, and dramas—were based on popular radio shows. Gradually, detective programs, game shows, sports programs, newscasts, movies, and children's shows joined the lineup.

TV networks—groups of stations linked together as a business—made money from TV programs by selling advertising time to various companies. Most networks still make their money from commercials.

Broadcast TV works much as radio does. Special equipment changes images and sound into electrical signals. These signals are sent through the air and received by individual **antennas**, which pass the signals on to the TV sets. There they are read and changed back into images and sound.

Color TV became popular about the mid-1960s, cable TV in the '70s, videocassette recorders (VCRs) in the '80s, and digital videodiscs (DVDs) in the '90s. That **decade** also saw the arrival of digital high-definition TV, with sharper, clearer images and better sound.

Earth-orbiting satellites have improved TV broadcasting. In fact, the only things that haven't changed much are the kinds of shows people watch and enjoy!

LEARN MORE! READ THESE ARTICLES…
JIM HENSON (VOLUME 3) • RADIO (VOLUME 2) • THEATER (VOLUME 3)

Big-screen TV and video recording have made the viewing experience very different from TV's early days. Now we can watch ourselves on TV!
© Jose Luis Pelaez, Inc./Corbis

DID YOU KNOW?

All the first television shows were live—that is, you saw everything as it was happening. And if people made mistakes, you saw those too.

Answer: TRUE. Early TV had poor picture and sound quality, and people preferred to listen to radio and use their imaginations.

Before There Were Automobiles

Long ago most people had to walk wherever they wanted to go on land. Later, when large animals began to be **domesticated**, some people rode camels, horses, donkeys, oxen, and even elephants.

Then came the discovery of wheels. The people of Mesopotamia (now in Iraq) built wheeled carts nearly 5,000 years ago. But so far the earliest cart that has actually been found is one made later than those in Mesopotamia, by people in ancient Rome. It was simply a flat board. At first, people themselves pulled carts. Later, they trained animals to do this.

As people used more and more carts, they had to make roads on which the carts could travel easily. In Europe and North America carts developed into great covered wagons and then into stagecoaches. Pulled by four or six fast horses, stagecoaches first bounced and rolled along the roads in the mid-1600s. They became important public transportation during the 19th century.

It wasn't until the steam engine was invented that a better means of transportation developed—and that was the train. Steam **locomotives** used steam pressure from boiling water to turn their wheels.

DID YOU KNOW?
In the days of stagecoaches a 350-mile journey could take 36 hours and 24 changes of horses. Today it would take less than six hours and one tank of gas.

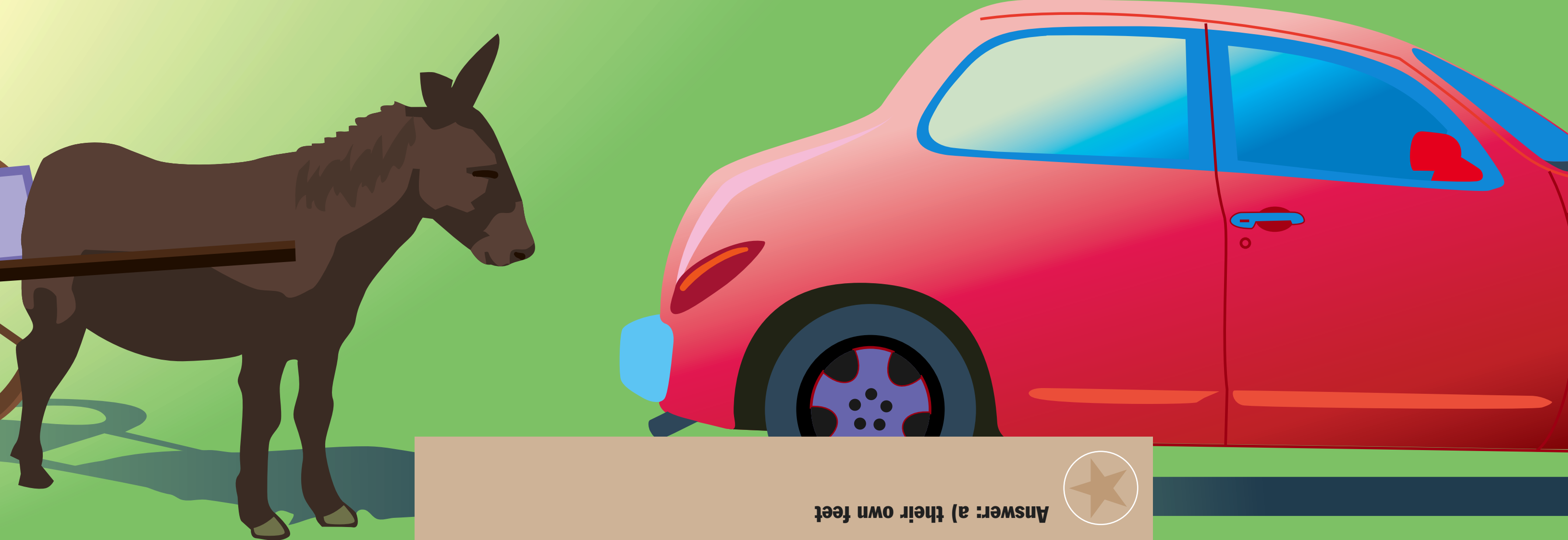
The first passenger train service began in England in 1825. Soon trains were rushing hundreds of thousands of people wherever iron tracks had been laid.

The first automobiles were not built until the late 1890s. Some of the earliest were made in the United States and England, though they were slow and broke down a lot. They looked much like carts with fancy wheels. What most of us recognize as a car wouldn't come along for several more years.

LEARN MORE! READ THESE ARTICLES…
AUTOMOBILES (VOLUME 2) • CAMELS (VOLUME 12) • SPACECRAFT (VOLUME 2)

SEARCH LIGHT

What were the first things people used to get around?
a) their own feet
b) carts
c) donkeys



Answer: a) their own feet

Making Cloth

"Shu-dul-ig! Shu-dul-og!"

The shuttle in this weaver's left hand flies back and forth, carrying its thread.

A shuttle is part of a loom, a machine that makes cloth. Cloth is composed of threads crisscrossing each other.

"Warp" threads run up and down lengthwise on the loom. The shuttle carries the "weft" thread back and forth, passing it over and under the sets of warp thread. This is how simple cloth like muslin is woven. Making patterned and other fancy cloth is a more complex weaving process.

The threads for weaving cloth are made of fibers—thin, wispy strands often tangled together. Some fibers come from animals, some from plants, and some from synthetic (artificial) sources. Fine silk fibers come from the cocoon of a silkworm—actually the caterpillar stage of a moth. People learned to spin fibers into threads a very long time ago.

SEARCH LIGHT

Which of the following descriptions matches the term "weft"?
a) cross threads
b) up-and-down threads
c) weaving machine
d) source of silk

The most commonly used animal fiber is wool. Most wool is the hair of sheep, but some comes from goats, camels, llamas, and several other animals. Woolen cloth keeps you nice and warm when it's cold outside.

Cotton is a plant fiber. Some cotton fibers are so thin that just one pound of them can be spun into a thread 100 miles long! Work clothing and summer clothes are often made of cotton.

Fine silk cloth is shiny and smooth. It costs more than cotton because silkworms need a lot of care. And each silkworm makes only a small amount of silk.

Today weaving by hand has become mostly a specialized **craft**. As with much other manufacturing, modern cloth is usually produced by machines.

LEARN MORE! READ THESE ARTICLES…
COMPUTERS (VOLUME 2) • COTTON (VOLUME 10) • SHEEP (VOLUME 12)

DID YOU KNOW?

The strongest piece of weaving anywhere is a spiderweb. One strand of spider silk is thought to be stronger than an equal-sized piece of steel.

Answer: a) cross threads

GLOSSARY

absorb to soak up

agriculture farming

antenna dish, rod, or wire for sending or receiving radio waves or other energy

artificial made by human beings rather than occurring in nature

atmosphere the envelope of gases that surrounds a planet

axis imaginary pole going through the center of the Earth or other heavenly body

bacterium (plural: bacteria) tiny one-celled organism too small to see with the unaided eye

broadcast to send out a program or message to a public group, usually by radio, television, or the Internet

canoe a small, light, and narrow boat having sharp front and back ends and moved by paddling

cartridge sealed container

chemical one of the combined substances making up living and nonliving things

comet chunk of frozen space debris that has a shiny tail and orbits the Sun

convert to change

conveyor belt a loop of material that can move objects from one worker or workstation to the next for the steps needed to make a product

core central part

countless too many to count

craft (noun) a skill or trade; (verb) to make skillfully, usually by hand

crater bowl-shaped dent in a surface

cratered marked with bowl-shaped dents

data factual information or details

debris trash or fragments

decade ten-year period

device tool or piece of equipment

devise to figure out, invent, or plan

diameter the length of a straight line through the center of an object

domesticate to tame

drawback problem or bad side

dwindle to become smaller or less

economical cheap and efficient

edit to cut down to a different or shorter version

element in science, one of the simplest substances that make up all matter

expanse large area

fix in photography, to make an image lasting

fuse an electrical safety device

gear a toothed wheel that works as part of a machine

generate to create or be the cause of

gesture movement of the body, arms, hands, or legs to express feelings or thoughts

glider a soaring aircraft similar to an airplane but without an engine

gravity force that attracts objects to each other and keeps planets circling the Sun

harness to control, much as an animal may be hitched up and controlled by its harness

hull hard outer shell of a seed or a boat or ship

impaired damaged or limited

imperial having to do with an emperor or empire

implant (noun) object inserted within living tissue; (verb) to insert securely or deeply

indivisible unable to be divided

investigate to look into or study

kerosene fuel for lanterns

laboratory place where science tests and experiments are done

lens (plural: lenses) curved piece of glass that concentrates rays of light

locomotive railway vehicle that carries the engine that moves train cars along

lunar having to do with the Moon

magnify to make something appear larger

manufacture to make from raw materials, by hand or by machine

massive heavy or large

matter physical substance or material from which something is made

meteorite a mass of material from space that reaches the Earth's surface

method way or system

microphone a device that changes sound to electrical signals, usually in order to record or send sound

mineral naturally occurring nonliving substance

module independent unit made to be part of a larger structure

molecules the smallest possible pieces of a particular substance

oral having to do with the mouth

orbit (verb) to travel around an object; (noun) an object's path around another object

paralyze to make someone or something unable to move

particle tiny bit

patent (verb) to legally protect the rights to make, use, or sell an invention; (noun) document that legally protects the ownership and use of an invention

potential possible

propeller a device that uses blades that fan outward from a central hub to propel (move) a vehicle, such as a boat or an airplane

pulp mashed-up pasty glop; fleshy material of a soft fruit

radiation energy sent out in the form of rays, waves, or particles

ray beam

recycle to pass used or useless material through various changes in order to create new useful products from it

refinery factory that treats crude petroleum and separates it into different parts

ritual a formal custom or ceremony, often religious

rotate to spin or turn

rotation spinning or turning

satellite natural or man-made object that circles another object, usually a planet

scholarship an award of money to help pay for a person's education

sensitive easily affected

solar having to do with the Sun

space shuttle rocket-launched airplane-like vehicle that transports people to and from space

sphere ball or globe

spool reel for winding lengths of materials such as tape, thread, or wire

standard commonly accepted amount or number

storage space to keep or hold onto things

submerge to put under water

superior better than

surgery a medical procedure or operation for treating a disease or condition

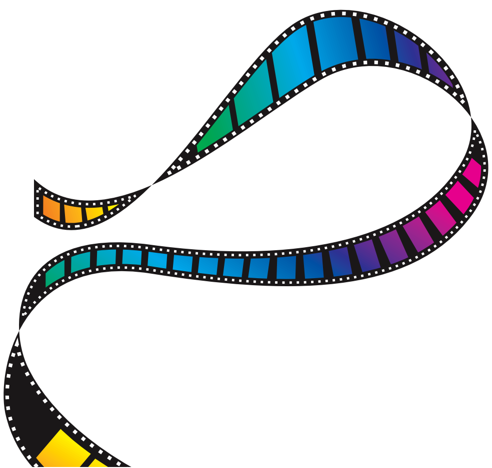
technology the theories and discoveries of science put into practice in actual actions, machines, and processes

telegraph a device for sending coded messages over long distances by using electrical signals

traditional usual; well known because of custom or longtime use

transmitter a device that sends messages or code

vehicle a device or machine used to carry something



I N D E X