Genre	Comprehension Skill	Text Features	Science Content
Nonfiction	Draw Conclusions	• Captions • Charts • Diagrams • Glossary	Stars and Solar System

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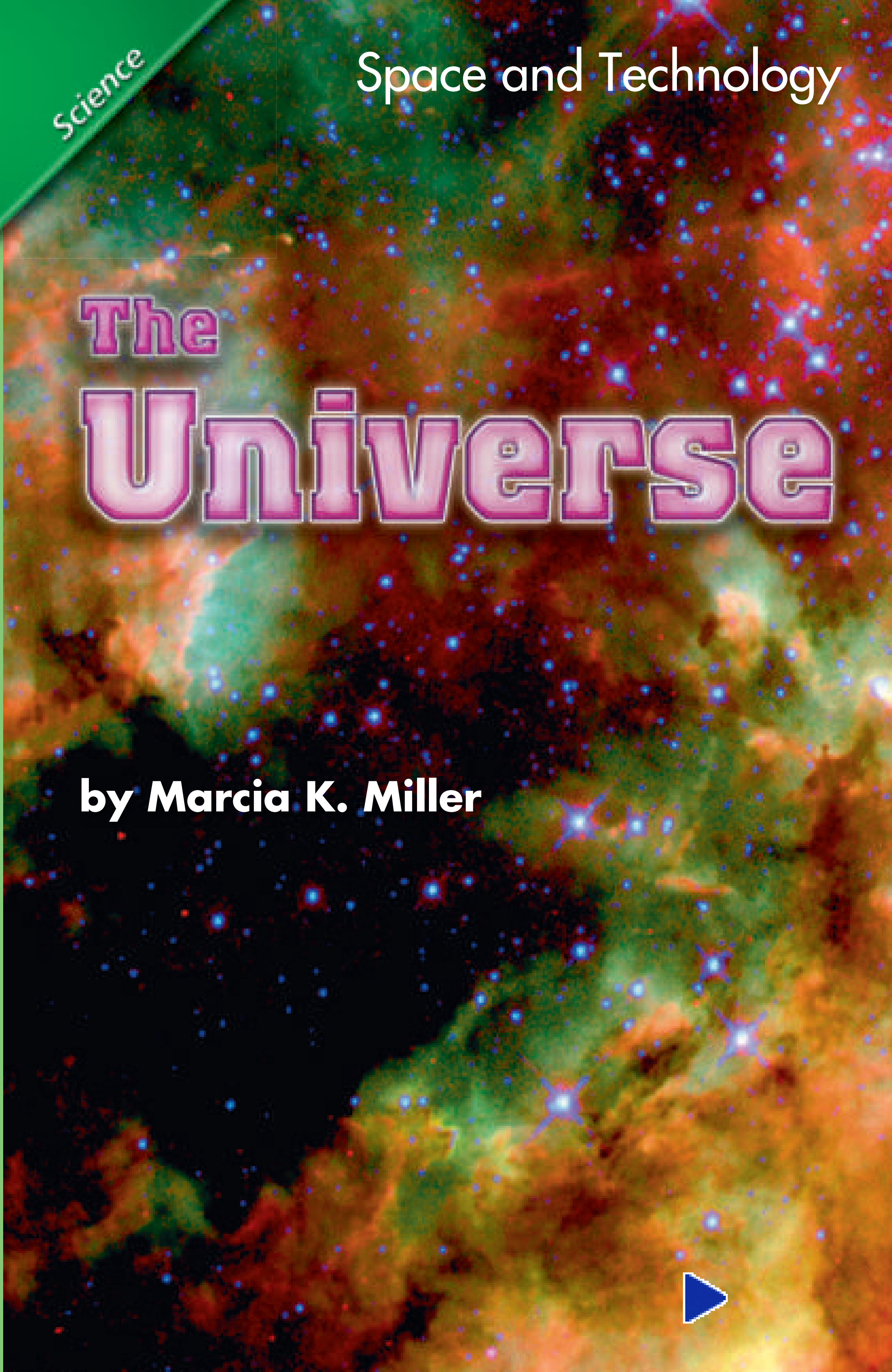

The Universe

by Marcia K. Miller

Vocabulary

astronomical unit

constellation

galaxy

light-year

magnitude

nuclear fusion

solar system

star

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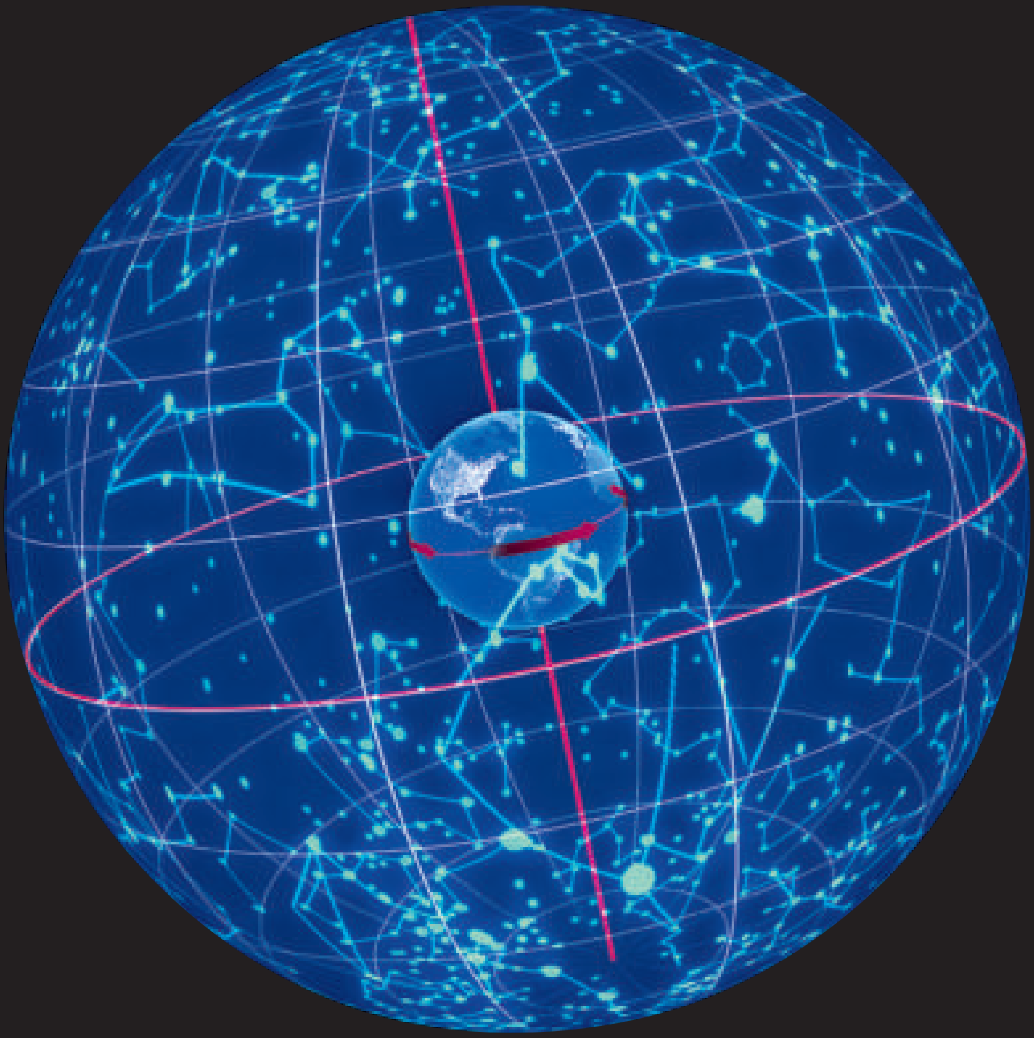

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What is Earth's place in the universe?

The Universe

Astronomy is the study of space and the objects in it. It is one of the oldest sciences. We know that people have been studying the sky as far back as 3500 B.C. Early astonomers could see only small dots of light above them. In 1609 the scientist Galileo was the first person to use a telescope to look at the sky. What he found changed the way people think about space.

Scientists today use very powerful telescopes to look into the sky. We are not sure how far in any direction the universe goes. But each year scientists can see deeper and deeper into space. They study the energy, matter, and empty space that make up the universe.

Earth is part of the Milky Way Galaxy. A **galaxy** is a huge grouping of stars. The universe is made up of clusters of billions of galaxies. Each galaxy has billions of stars.

You can see part of the Milky Way Galaxy in the night sky. It looks like a pale white stripe or band across the sky. If you were far away from the Milky Way, you would see that it forms a flat pinwheel. Our Sun is one of the stars in the Milky Way. It is located in one of the "arms" of the pinwheel. Our Sun looks brighter and bigger than other stars because it is much closer to Earth.

There are three types of galaxies. The Milky Way is a spiral galaxy. Elliptical galaxies are shaped like an ellipse, or oval. Irregular galaxies have no regular shape at all.

The Milky Way Galaxy is a spiral galaxy.

The Planets

The Sun and the bodies around it make up our **solar system.** Earth and eight other planets orbit the Sun in our solar system.

All the planets have orbits that look almost circular, except for Pluto, which has a more elliptical orbit. The Sun's gravity holds all of the planets in their orbits.

A moon is a natural body that orbits a planet. Most planets have one or more moons; only Mercury and Venus have none.

Asteroids are small bodies made of rock and metal. Over 100,000 of them orbit the Sun. Comets orbit the Sun as well They are small bodies of ice, which orbit in long, narrow ellipses. A comet may pass close to the Sun in part of its orbit, which causes the comet to heat up. Then, it forms a stream of gas and dust that trails it as it moves through space. The far end of a comet's orbit is deep in space.

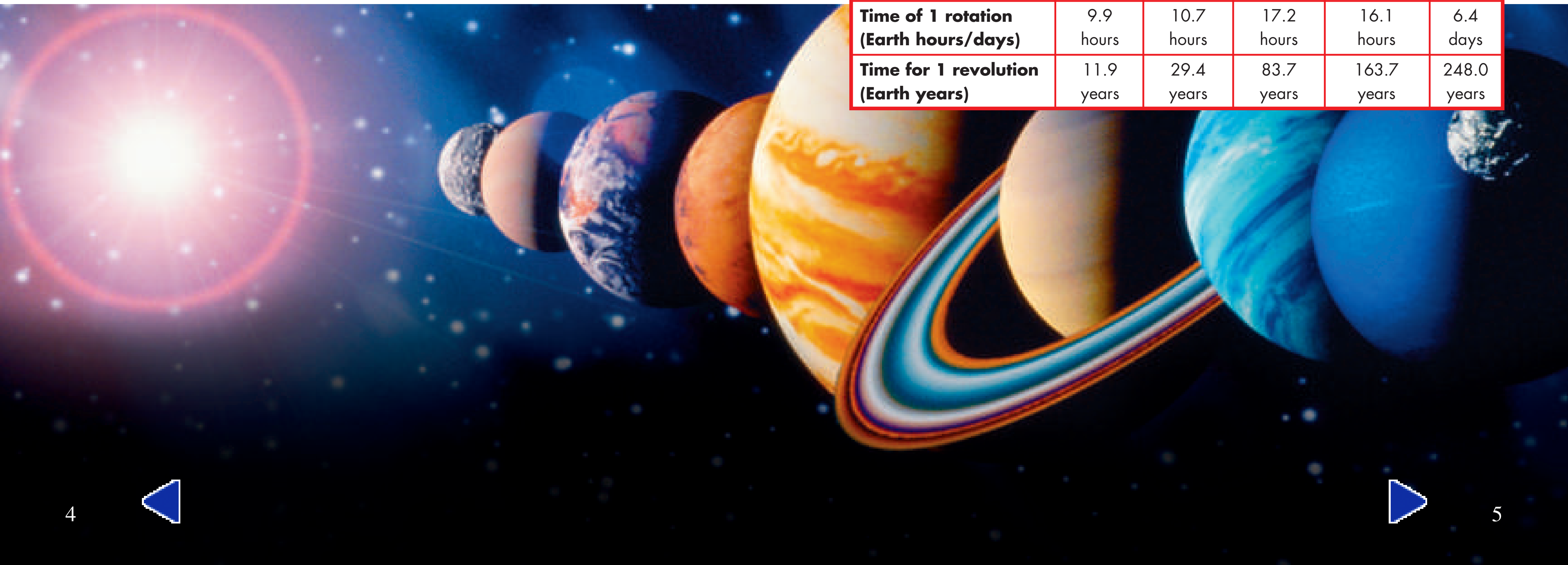
Objects in our solar system are very far apart. Scientists use a special unit to measure these great distances. It is called an astronomical unit (AU). An **astronomical unit** is the average distance Earth is from the Sun. One AU is equal to 149.6 million kilometers.

The Inner Planets

	Mercury	Venus	Earth	Mars
Diameter (km)	4,879	12,104	12,756	6,794
Mass (compared to Earth)	0.055	0.82	1.0	0.107
Average distance from the Sun (AU)	0.39	0.72	1	1.52
Time of 1 rotation (Earth hours/days)	58.7 days	243 days	1 day	24.6 hours
Time for 1 revolution (Earth days)	88 days	224.7 days	365.2 days	687 days

The Outer Planets

	Jupiter	Saturn	Uranus	Neptune	Pluto
Diameter (km)	142,984	120,536	51,118	49,528	2,390
Mass (compared to Earth)	318	95	14.5	17.1	0.002
Average distance from the Sun (AU)	5.2	9.58	19.20	30.05	39.24
Time of 1 rotation (Earth hours/days)	9.9 hours	10.7 hours	17.2 hours	16.1 hours	6.4 days
Time for 1 revolution (Earth years)	11.9 years	29.4 years	83.7 years	163.7 years	248.0 years

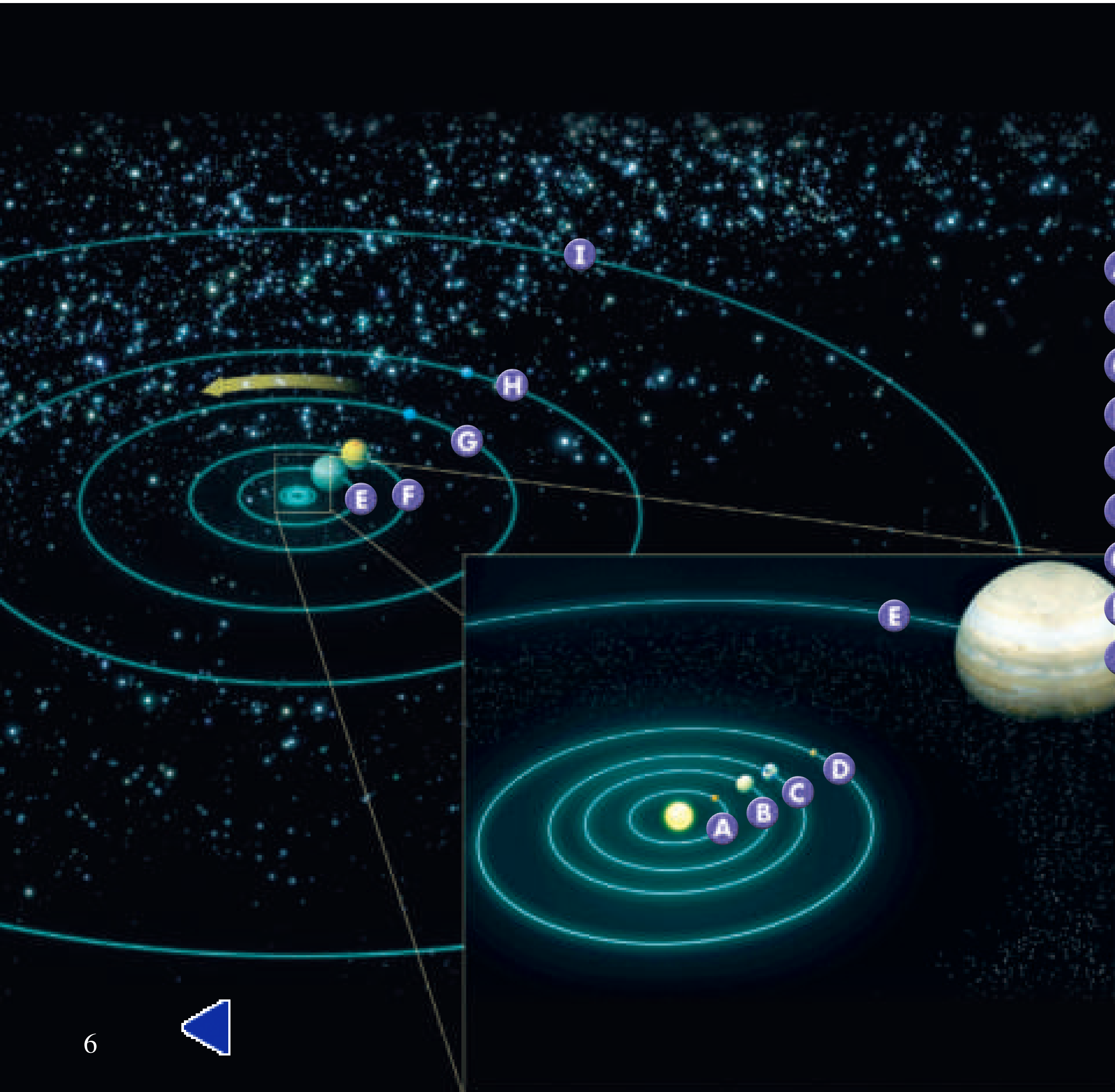


A Model of the Solar System

The model here shows how the planets are arranged, but it cannot show the relative distances between them.

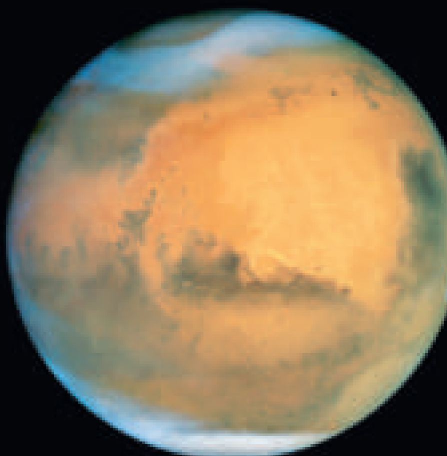
The solar system covers a huge distance. It is impossible to make a scale drawing of it on regular paper. Look at the table on the next page. The small units of measure help you to understand how the planets compare in size and distance.

By this model, Earth is 1 millimeter in diameter. This is very small. Even at this small size, it needs to be 11.7 meters from a model of the Sun. Now you can see why it is impossible to show the planets to scale in a book. This is true even when we shrink Earth to such a small size.

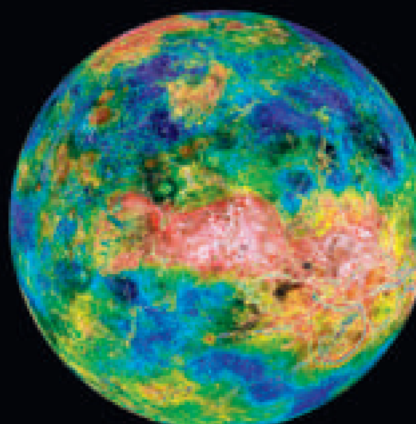


The Solar System: Relative Distances

	Planet	Size (mm)	Distance from Sun (m)
A	Mercury	0.4	4.5
B	Venus	1.0	8.5
C	Earth	1.0	11.7
D	Mars	0.5	17.9
E	Jupiter	11.2	61
F	Saturn	9.5	112
G	Uranus	4.0	225
H	Neptune	3.9	352
I	Pluto	0.2	459



Mars is actually about 4900 kilometers in diameter.



Venus is actually about 100 million kilometers from the Sun.

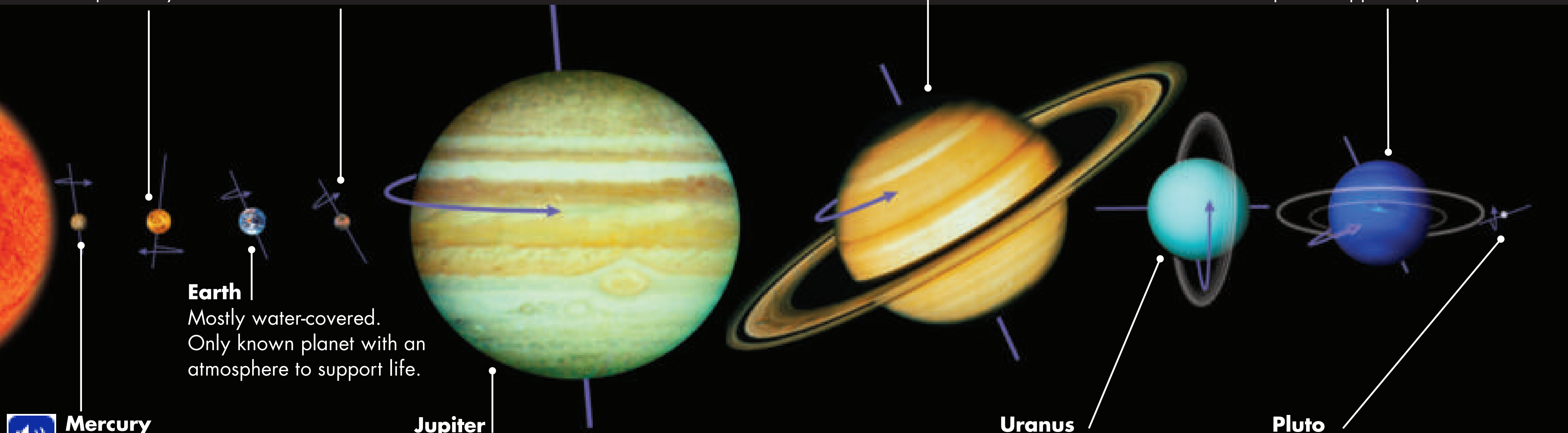
Why Planets Differ

A planet's distance from the Sun is not the only way in which planets differ. It is true that a planet nearer the Sun gets more sunlight than a planet that is farther away. Mars is about twice as far from the Sun as Venus, and this is one reason that Venus is warmer than Mars. But this is only one factor. Venus, Earth, and Mars were similar when they formed billions of years ago, but each has changed over time.

A planet's size affects how strong its gravity is. Larger planets have stronger forces of gravity than smaller ones. Stronger gravity holds more gases near to the planet, forming a thicker atmosphere. Mars has less gravity than either Venus or Earth, so its atmosphere is very thin. It holds in less heat, making Mars very cold.

People once thought that Venus might be very similar Earth. Both planets are about the same size and mass. Scientists have learned, however, that temperatures on Venus can get as high as 475°C. Its atmospheric pressure is about 100 times that of Earth.

Venus is very different from Earth because the thick clouds that cover Venus are made mostly of carbon dioxide. This gas traps and holds in heat, making Venus much hotter than Earth.



What do we know about stars?

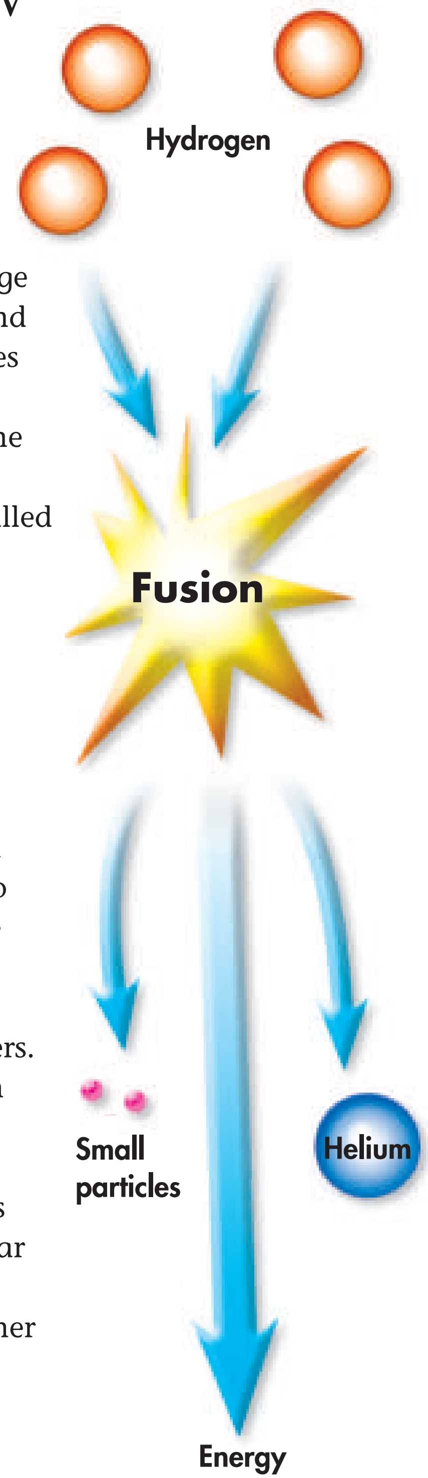
What Stars Are

A **star** is a huge, hot, glowing ball of gas. Stars shine because they produce huge amounts of energy. There is great heat and pressure in the center of a star. This causes the atoms there to bump into each other at very fast speeds. When this happens the nuclei of two or more atoms join, or fuse, into one larger nucleus. This process is called **nuclear fusion.** In this type of fusion, hydrogen nuclei form helium. This gives off huge amounts of energy as radiation. We can see some of this energy as light.

Distances of Stars

Distances in space are too large to describe in units such as kilometers. Even the astronomical unit (AU) is too small to use. Scientists measure distances in space using light-years. A **light-year** is how far light can travel in one year. This is a distance of 9 trillion, 460 billion kilometers. At that speed, light can circle Earth seven times in just one second!

The Sun is the closest star to Earth. The next closest star is Proxima Centauri. It is 4.3 light-years away. Suppose that this star blew up tonight. You would have to wait more than four years to see the flash! Other galaxies and their stars are millions of light-years away. The light you see from them was given off millions of years ago.



Star Brightness

Some stars appear bright because they are much closer than other stars. However, there are other reasons why stars vary in brightness.

Scientists use the term **magnitude** to describe a star's brightness. The brightness we see from Earth is called apparent magnitude. The brightest star we see is our Sun. It has the greatest apparent magnitude. No other star looks brighter to us. Absolute magnitude measures how bright stars would look if they were all exactly the same distance from Earth. Some stars are as much as 156,250 times brighter than the Sun!

Star Color

Stars appear in different colors. Some stars appear blue, while others seem white or yellow, and a few look red. Star color depends on surface temperature. Think about heating a steel bar. At first it glows red. As it gets hotter, its color changes to orange, yellow, white, and then blue. Stars get their color in the same way. The hottest stars are blue and the coolest stars are red. The chart below relates star color to star temperature.

Star Color	Temperature	Example Star
Blue	10,000–50,000°C	Bellatrix
White	7,200–9,500°C	Vega
Yellow	5,300–7,000°C	Sun
Red	2,000–5,200°C	Betelgeuse

Star Life Cycle

Stars shine for billions of years, but they do not shine forever. Like living things, stars change as they age, and eventually they die. A star changes in the size, color, and brightness as it goes through its life cycle.

A star begins in a nebula. This is a huge cloud of hydrogen and other gases. Gravity pulls these gas particles together. A clump of gases is formed. The clump heats up as it pulls in more particles. Nuclear fusion begins when the star's core reaches 10,000,000°C. Energy made by fusion heats gases which then push out as gravity pulls in. When the push of gases becomes greater than the pull of gravity, fusion energy reaches the surface and a star is born!

A nebula is a huge cloud of gases that forms in space.

A small or mid-sized star such as our Sun glows yellow for about 10 billion years.

A red giant forms when nuclear fusion slows after a star has used up most of its hydrogen. The outward force of fusion no longer balances the inward pull of gravity. The star begins to collapse. Heat and pressure cause helium atoms to fuse into heavier atoms. The outer layers of the star expand, cool, and turn red.

A massive star is 10 to 30 times bigger than our Sun. It glows blue for about 1 million to 20 million years, which is most of its life.

Many stars are paired with a partner star. If one star is a white dwarf, its gravity attracts gases from its partner. If enough gases collect around the dwarf, it may explode. It shines so brightly that from Earth it looks like a new star. This is called a nova, from the Latin word for "new."

A white dwarf has a hot, dense, compact core. It is what is left behind after a red giant gradually loses its outer gaseous layers.

A black dwarf is a dead star. It is still a compact, dense body, but because it has used up all its fuel, it does not shine.

A supergiant is like a red giant, but much bigger. Nuclear fusion in its core creates heavier elements, such as iron. The outer layers expand a lot, becoming cooler and redder.

Gravity pulls the outer parts of a supergiant toward its center. Pressure and temperature build until the star explodes, producing a supernova. What is left of the star becomes a neutron star or, rarely, a black hole.

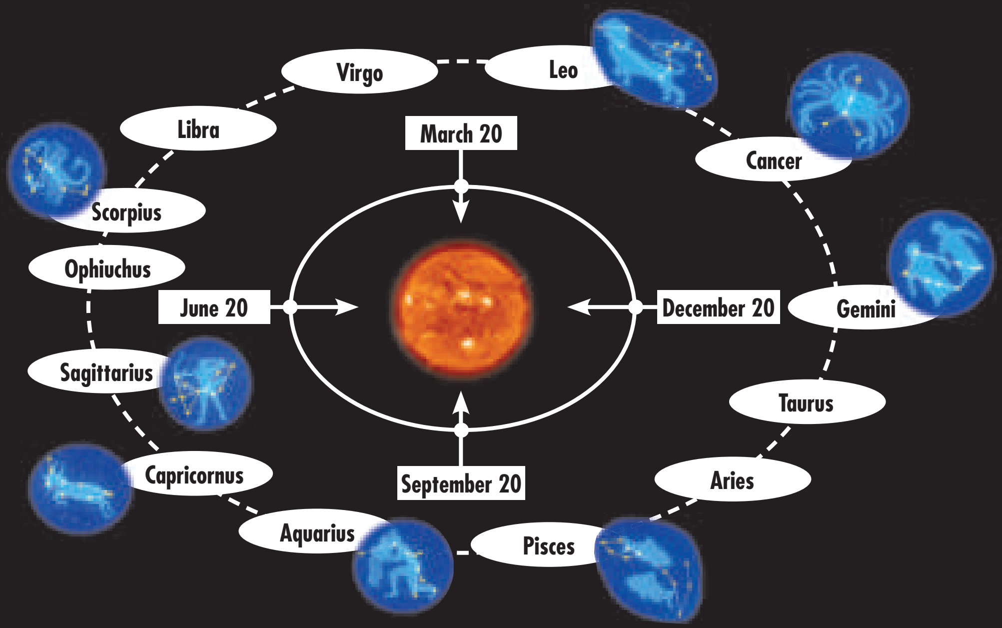
Constellations

The constellation Orion

Have you heard of Gemini, Orion, or Leo? The ancient Greeks first gave these names to groups of stars. They named a total of 48 star groups. The Greeks linked the star patterns with their myths and gods. One example is the story of Orion the hunter. He fell in love with the goddess Artemis, who placed Orion in the night sky after killing him by accident.

Scientists today divide the sky into 88 star groups called **constellations.** Every star is part of a constellation. But stars in the same constellation may not be related in any other way.

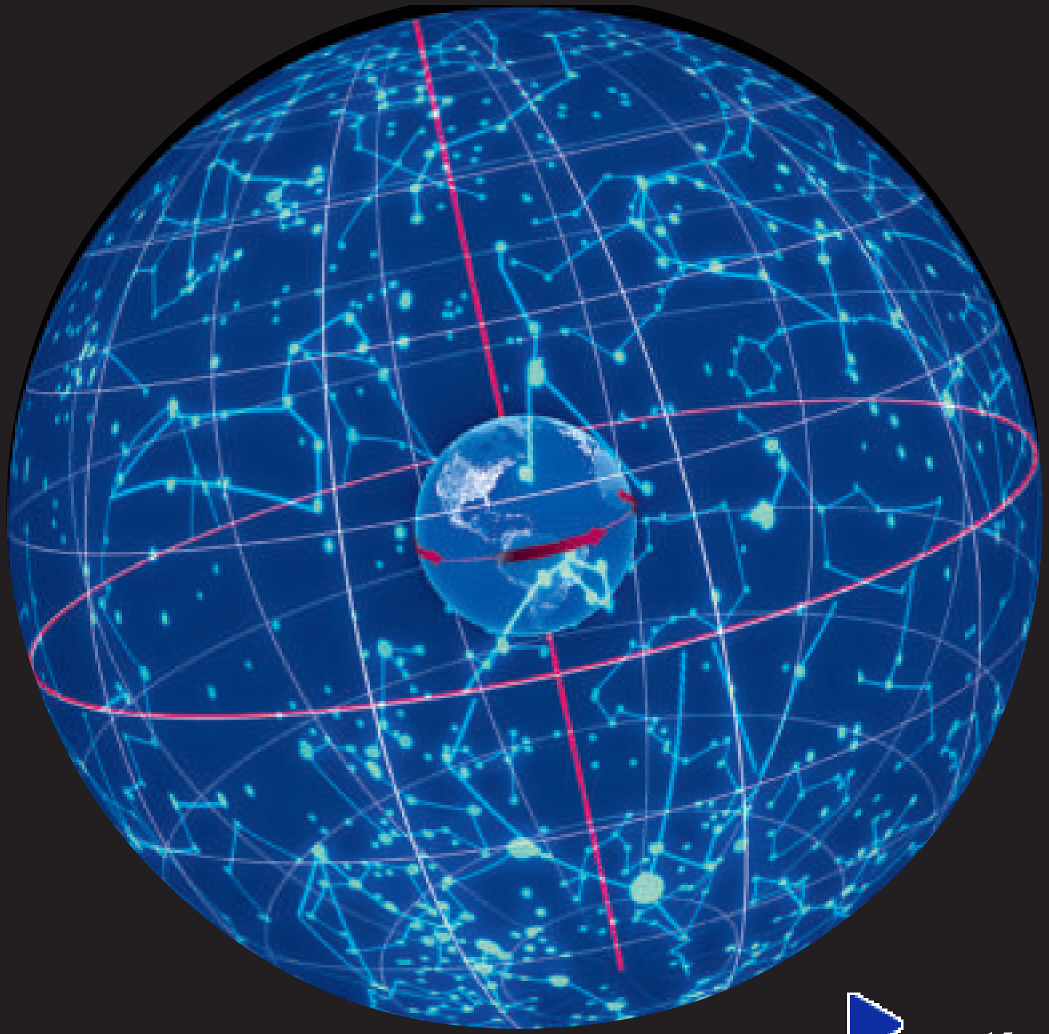
Ursa Major means "big bear." It is one of the best-known constellations. The Big Dipper is part of Ursa Major. The two stars at the end of the bowl of the Big Dipper always point to the North Star, which is always over the North Pole.



Constellation Movement

Do you watch the stars? If so, then you know that patterns in the night sky change from hour to hour. A starry sky looks different in the early evening than it does in the early morning. Star patterns also change with the seasons. In the Northern Hemisphere, we see Orion high in the winter sky. But in summer we lose part or all of Orion as it dips below the horizon.

Changes like these should not surprise you. You know that the Sun appears to move across the sky during the day. Stars appear to move in the night sky. Both changes are actually due to the movements of Earth. Earth rotates on its axis as it orbits the Sun. These movements affect the star patterns we see.



Glossary

astronomical unit the average distance of Earth from the Sun, about 149.6 million kilometers

constellation one of eighty-eight named star groups visible from Earth at night

galaxy a huge grouping of stars

light-year the distance light can travel in one year

magnitude the term scientists use to describe star brightness

nuclear fusion the process in which the nuclei of two or more atoms join, or fuse, into one larger nucleus, giving off energy

solar system the Sun and the nine planets and other bodies that orbit around it

star a huge, hot, glowing ball of gas

What did you learn?

1. What galaxy does our solar system belong to? What type of galaxy is it?
2. List the planets of our solar system in order from the Sun.
3. What does a star's color tell you about it?
4. **Writing in Science** Planets vary in many ways. For instance, they vary in how long it takes them to make one complete revolution around the Sun. Is there a link between the size of a planet's orbit and how long it takes the planet to make one revolution around the Sun? Use your own words to write about this question. Use facts given in the charts on page 5 to support your answer.
5. **Draw Conclusions** The star Antares is about 620 light-years from Earth. The star Betelgeuse is about 430 light-years away. With this data, can you tell which star is brighter in the night sky? Explain.