Science ch. 19

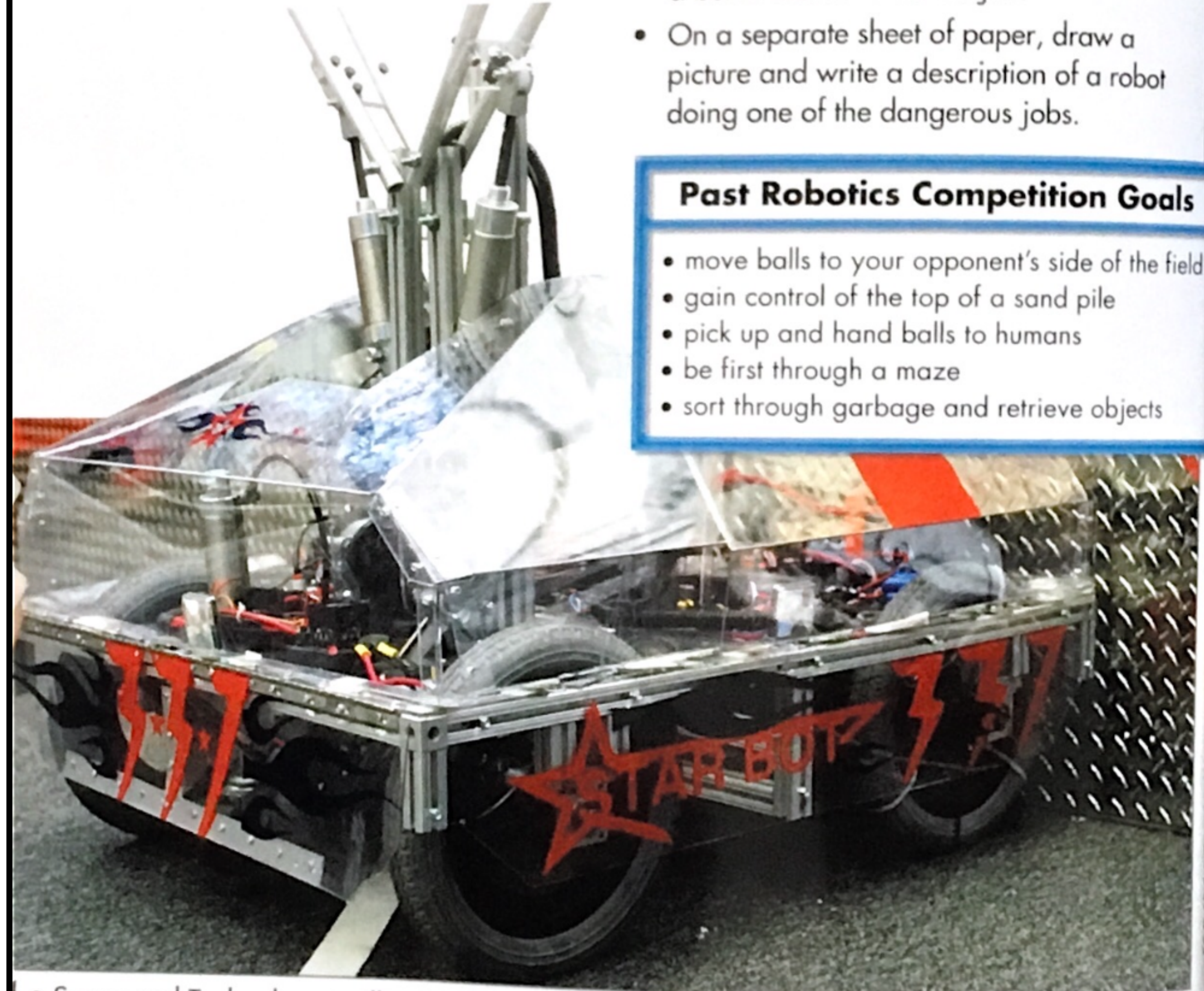
Earth, Sun, and Moon

INOIS

Field Trip

FIRST (For Inspiration and Recognition of Science and Technology)

You can visit a robotics competition in Illinois. High school students from Illinois and around the world build robots. These robots and teams then compete with each other to complete tasks. Sometimes, regional tournaments are held in Illinois. Over 900 teams and 20,000 students from around the world competed in the 2004 tournament.

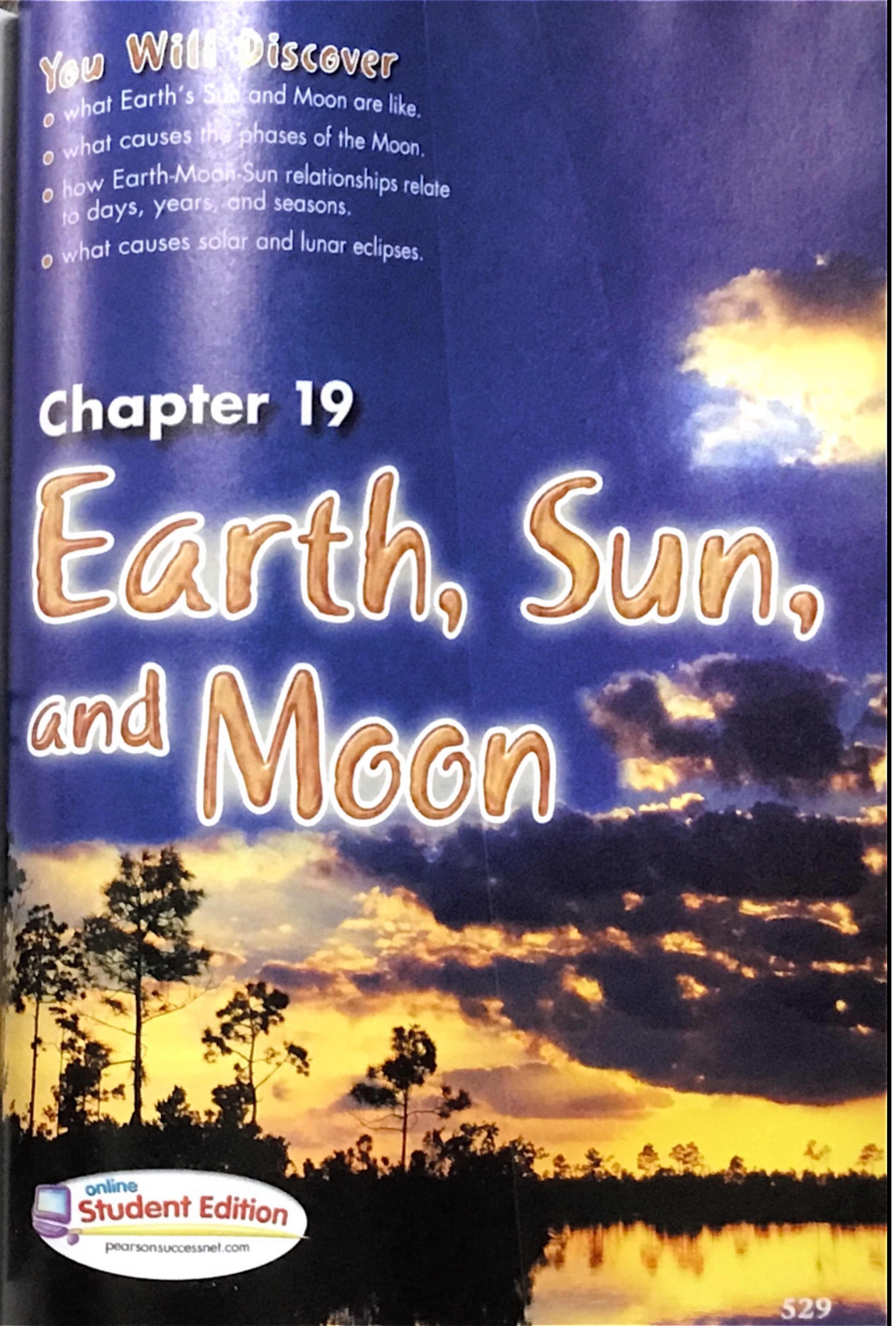


Find out more:

- Research to find out more about robots.
- Think of three dangerous jobs robots could do better than humans. Describe each job and tell why a robot would be a better choice to do the job.
- On a separate sheet of paper, draw a picture and write a description of a robot doing one of the dangerous jobs.

Past Robotics Competition Goals

- move balls to your opponent's side of the field
- gain control of the top of a sand pile
- pick up and hand balls to humans
- be first through a maze
- sort through garbage and retrieve objects



You Will Discover

- what Earth's Sun and Moon are like.
- what causes the phases of the Moon.
- how Earth-Moon-Sun relationships relate to days, years, and seasons.
- what causes solar and lunar eclipses.

Chapter 19

Earth, Sun, and Moon

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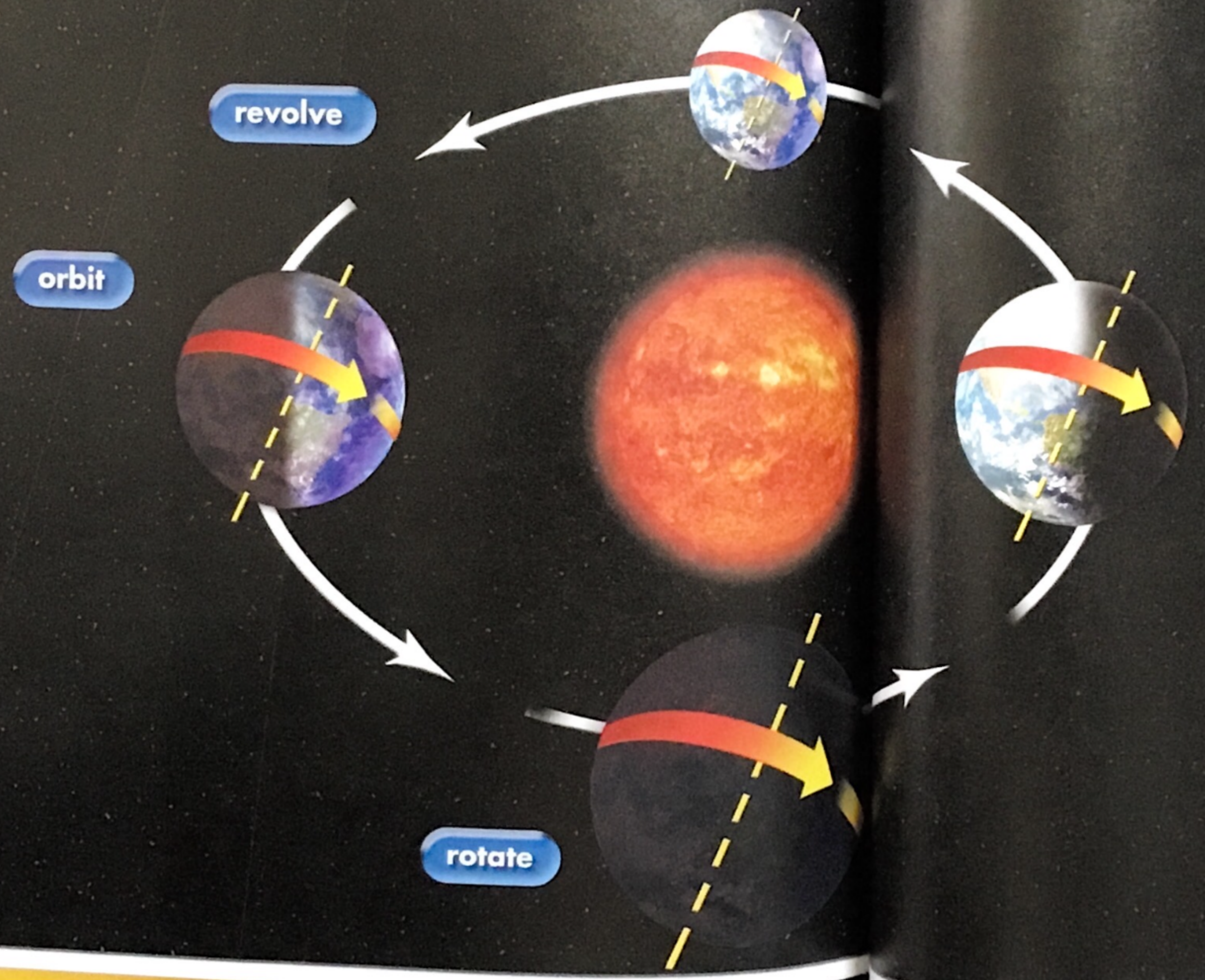
Build Background

What are the effects of the movements of Earth and the Moon?

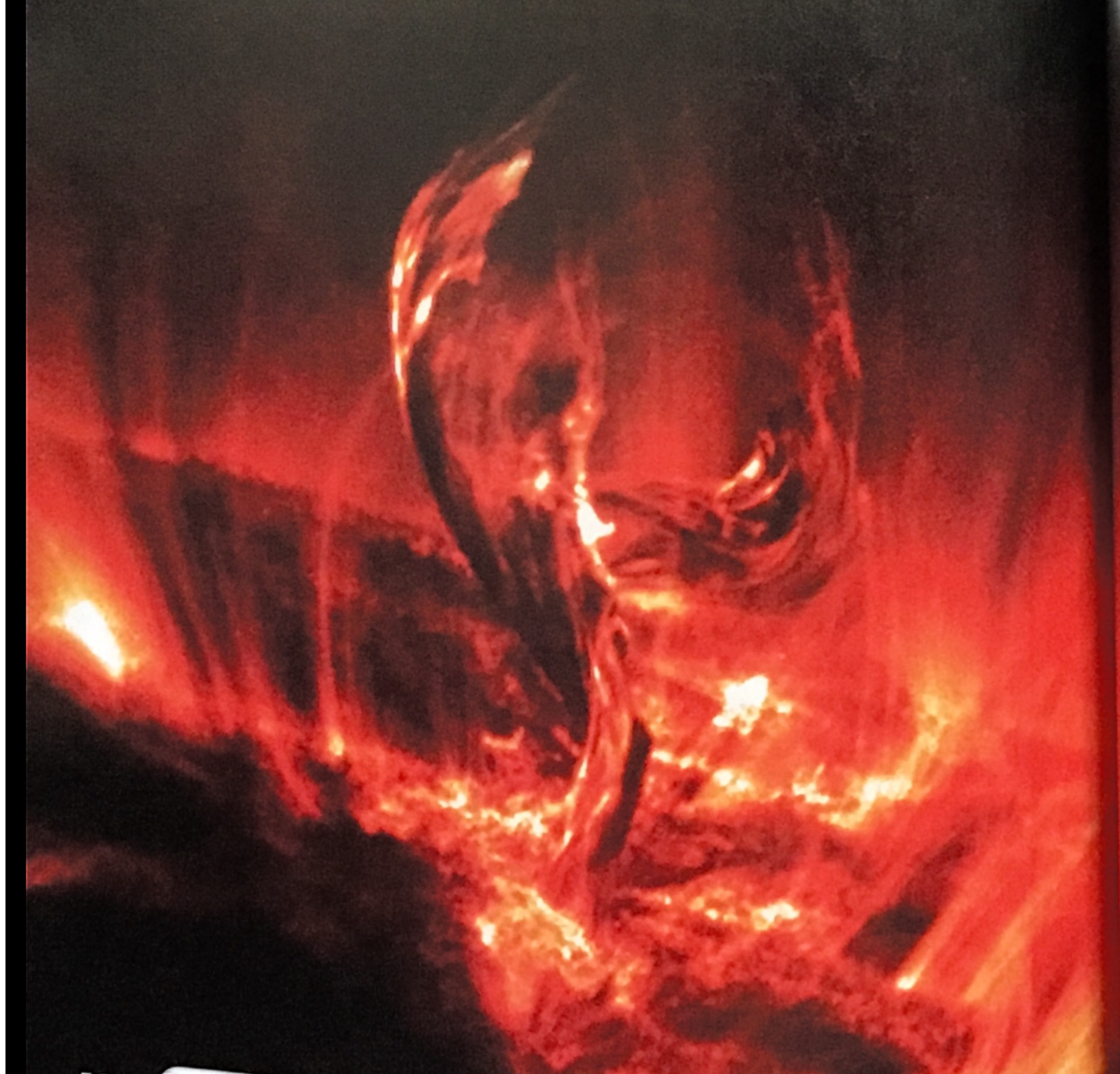


Chapter 19 Vocabulary

rotate page 536
revolve page 536
orbit page 540
solar eclipse page 542
lunar eclipse page 542

You Are There!

A trip to the Sun wouldn't be much fun! Even the coolest regions are thousands of degrees hotter than Earth. But if you could somehow withstand the intense heat, you would see a swirl of glowing gases. Nearby you might see a tremendous ring of gases thousands of miles high. Huge flares of unimaginably hot gases would suddenly burst out into space above you. What are these huge flares?

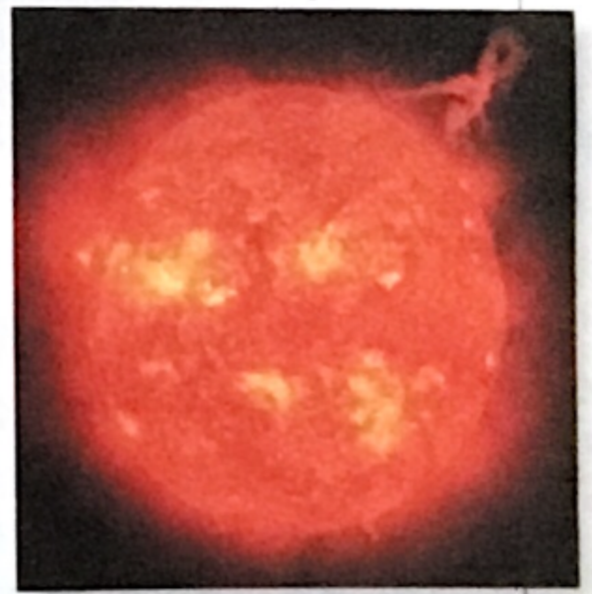


Lesson 1

What are the characteristics of Earth's Sun and Moon?

The Sun provides Earth with the heat and light needed to sustain life. The Moon revolves around Earth. The Moon's phases are caused by its position relative to Earth and the Sun.

Solar prominence



Our Sun

Our Sun is a star, just like all the stars you see in the night sky. The Sun appears larger only because it is much closer to Earth. The Sun looks like a ball of fire, but it isn't burning at all. The Sun is made of hot gases called plasma. The plasma is so hot that it glows, like the glow of the wire in a light bulb.

The inner part of the Sun is a dense core with a temperature around 15,000,000°C. Reactions among particles in the core release energy, part of which provides light and heat for Earth. Life couldn't exist on Earth without energy from the Sun. Plants use the light energy to produce food for themselves and for other organisms that eat plants. Without the Sun's energy, Earth would be a cold, lifeless rock.

The Sun has no solid surface. Outside the core are swirling layers of plasma. Huge loops of gases, called prominences, extend thousands of kilometers out from the Sun. Some prominences are held in place for weeks. Others explode into space. Intense, temporary releases of energy from the Sun's surface are called solar flares. Energy from these flares sometimes reaches Earth. This energy can cause beautiful light displays called auroras, usually seen near Earth's poles.

1. **Checkpoint** What causes the light that the Sun produces?
2. **Main Idea and Details** Write a main idea statement about the Sun from the paragraphs above. Give details to support your main idea.

Earth's Moon

Looking at the Moon on a clear night, you might think that it shines like the Sun. But the Moon has no light of its own. The light you see is the sunlight that reflects off the Moon's surface. Unlike the Sun with its swirling hot plasma, the Moon is like a giant rock in space. The Moon has almost no atmosphere.

The Moon **rotates,** or spins, on its axis while it revolves around Earth. **Revolve** means to "move on a path around an object." Features of the Moon are easy to spot because its same side always faces Earth. Why do we only see one side? The time for one rotation and one revolution of the Moon are the same as Earth days. Each time the Moon revolves around Earth, it also rotates one time.

Phases of the Moon

If you look at the Moon each night for a month, you'll notice that it seems to change shape. Of course, the Moon doesn't really change shape. The phases of the Moon are the different shapes that the Moon seems to have. The shapes change because the size of the lighted part that we can see from Earth changes. Only the half of the Moon that faces the Sun at any time is lighted. The phases you see depend on the positions of the Moon, Earth, and the Sun.

A new moon is the dark phase of the Moon. During a new moon, the side of the Moon facing Earth is not lighted. On nights just after a new moon, the Moon begins to wax. *Waxing* means "gradually growing larger." The Moon is waxing when more of its lighted part can be seen each night. A full moon is the completely lighted phase of the Moon. On nights after a full moon, the Moon begins to wane. *Waning* means "gradually becoming smaller." The Moon is waning when less of its lighted part can be seen each night. The Moon continues to wane until you once again see a new moon, and the cycle continues. A complete cycle of Moon phases occurs about every 29.5 days.

Waxing Crescent
As the Moon begins to wax, a crescent of light begins to show on the side.

First Quarter
As the Moon continues to wax, you can see half of its lighted side.

Waxing Gibbous
The Moon continues to wax. The shape of the Moon we see is now called gibbous.

Full Moon
About two weeks after a new moon, the Moon appears fully lighted. It has completed half its path around Earth.

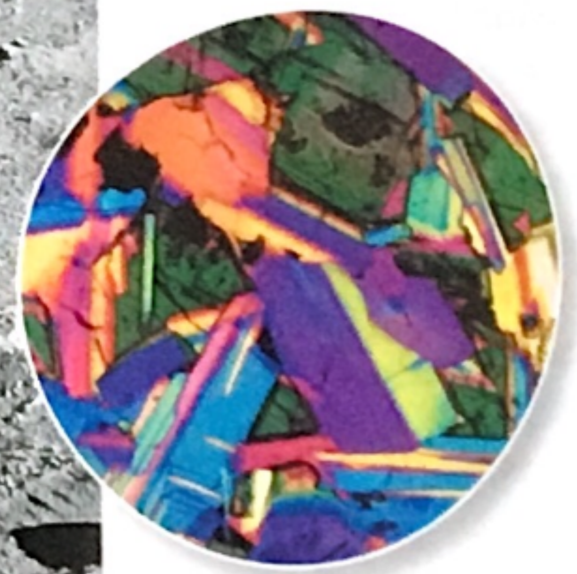
Waning Gibbous
The Moon begins to wane. The gibbous shape is now on the left side of the Moon.

Third Quarter
The Moon has now traveled about three quarters of its path around Earth. The lighted half you see is now on the side opposite that of the First Quarter.

Waning Crescent
The Moon is now waning. Each night, the lighted portion grows smaller until only a thin crescent of light is visible.

Astronauts on this *Apollo 16* mission to the Moon in 1972 collected samples, performed experiments, and took photographs.

Astronaut Buzz Aldrin took this photo of his boot print in the Moon's soil during the *Apollo 11* mission.



The *Apollo 11* astronauts brought rocks from the Moon back to Earth. Scientists studied microscopic views of the rocks to learn about their properties.

Learning About the Moon

Although the Moon has been known to humans since prehistoric times, the first visit to the Moon by a spacecraft didn't happen until 1957. That year the unmanned Soviet spacecraft *Luna 2* landed on the surface of the Moon. Ten years later, *Apollo 11* astronauts Edwin "Buzz" Aldrin and Neil Armstrong were the first humans to land on the Moon. Their landing was followed by five more Moon landings, the last in 1972.

Scientists study information they collected on those journeys to learn about the Moon, Earth, and the entire solar system. Because the Moon has almost no atmosphere, its surface remains undisturbed. Scientists can study the craters and other features of the Moon's surface to help determine the age of the Moon and of Earth.

✓ Lesson Checkpoint

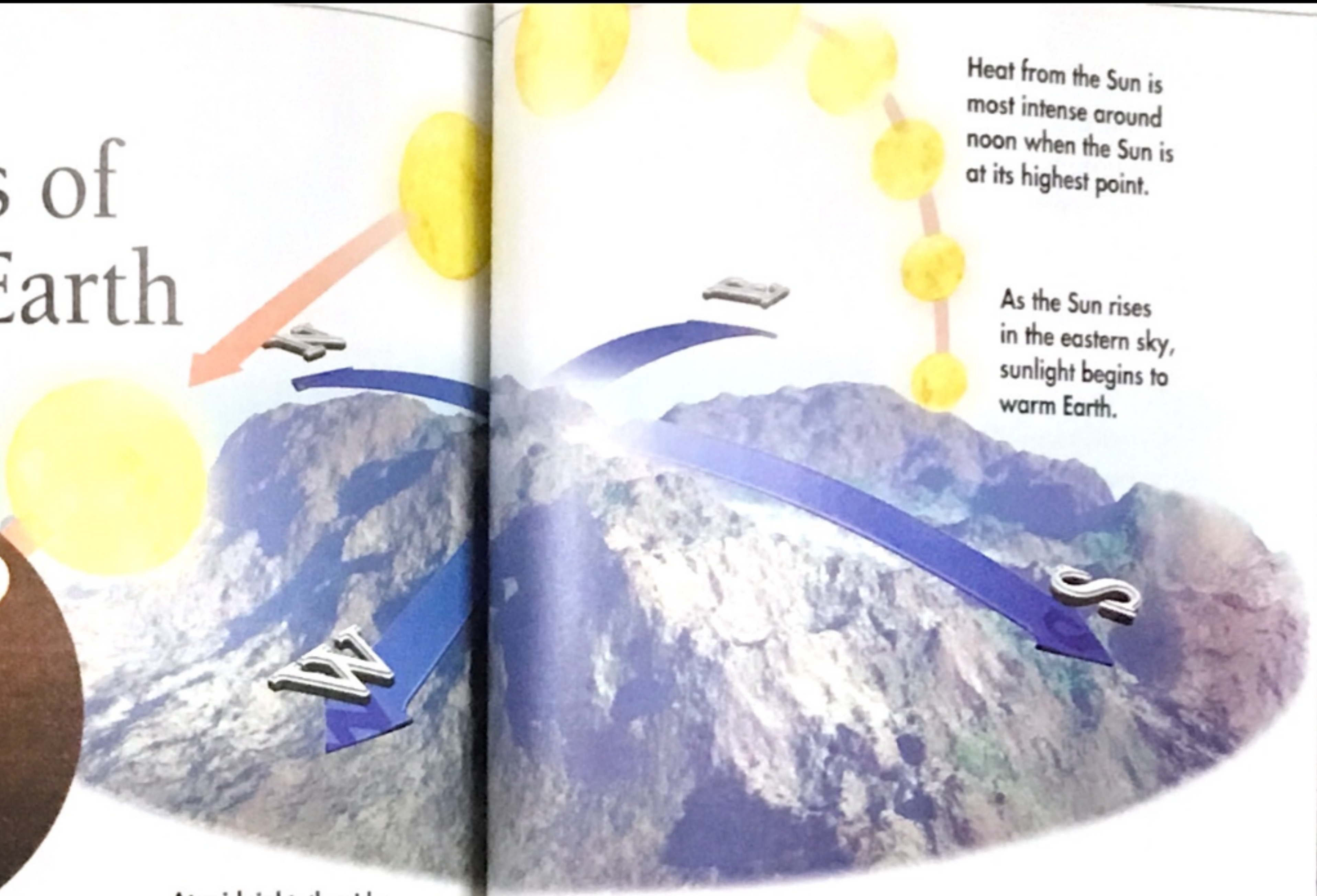
1. Explain why the same side of the Moon always faces Earth. Use the terms *rotate* and *revolve.*
2. **Technology in Science** Space exploration began on October 4, 1957, when the Soviet Union launched *Sputnik 1.* Find out what other spacecraft were launched between that date and the last mission to the Moon in 1972. Draw a time line of those events.

Lesson 2

What are the effects of the movements of Earth and the Moon?

Days, years, and seasons are caused by Earth's rotation, revolution, and tilt on its axis. The changing positions of the Sun, Moon, and Earth can cause solar and lunar eclipses.

In the evening, the Sun appears to sink below the western horizon.



At midnight, the side of Earth opposite to you experiences the noon Sun.

Heat from the Sun is most intense around noon when the Sun is at its highest point.

As the Sun rises in the eastern sky, sunlight begins to warm Earth.

Earth on its Axis

Think about a time thousands of years ago, before telescopes had been invented and before astronauts had ever traveled into space. What did people think of Earth and its Sun? If you look at the daytime sky, the Sun rises in the east and sets in the west. People naturally thought the Sun was moving around Earth.

We now know that the Sun is the center of our solar system and that Earth and other planets revolve around the Sun. Earth also rotates on its axis, an imaginary line between its poles. A day is the total time for a planet to make one complete rotation. The Sun seems to revolve around Earth because of Earth's rotation.

If you wake up early in the morning, you might see the Sun just beginning to rise above the eastern horizon. The Sun always seems to rise in the east because Earth spins from west to east. Because you spin along with Earth, the Sun is first visible in the east. You experience daytime as long as the Sun is visible from your location on Earth. Daytime ends when Earth has turned enough that the Sun seems to set in the west. Nighttime is when the Sun is no longer visible to you.

To understand Earth's rotation, picture Earth spinning on a pole. The speed of Earth's rotation at the equator is about 1,670 km/h.

When you wake up on a winter morning, it may still be dark outside. If you wake up at the same time in summer, it may have been light outside for hours. The number of hours of daylight changes throughout the year. Notice on the globe how Earth is tilted on its axis. One half of Earth is usually tilted slightly toward the Sun. That side has more daylight hours and fewer nighttime hours. The other half of Earth has fewer daylight hours and more nighttime hours.

The tilt of Earth's axis has an even greater effect at the poles. When the northern part of Earth is tilted toward the Sun, the Sun never fully sets at the North Pole. The same is true at the South Pole when it is tilted toward the Sun. Daylight and darkness at the poles each last six months.

You may have noticed that the Moon is sometimes visible during the day. The Moon can be seen whenever it is on your side of Earth. This is sometimes during daytime and sometimes during nighttime.

1. **Checkpoint** Why does the Sun seem to rise in the eastern sky?
2. **Math in Science** If an object weighs 300 newtons on Earth, about how much would it weigh on the Moon?

Comparing Sizes

If you stand on the top of a mountain or on an ocean shore and look toward the horizon, you realize that Earth is unbelievably large. Compared to the Sun, however, Earth is just a dot in space. The Sun is more than two hundred times wider than Earth. If the Sun were hollow, more than a million Earths could fit inside. The mass of the Sun is about 330,000 times the mass of Earth. Its gravitational pull is almost 30 times greater than on Earth's surface.

The differences between Earth and the Moon are not as great. Earth is about four times wider than the Moon, and about 50 Moons could fit inside a hollow Earth. Earth's mass is about 80 times the mass of the Moon. The gravitational pull on Earth's surface is about six times stronger than on the Moon's surface. That's why an object that weighs 60 newtons on Earth would only weigh 10 newtons on the Moon.

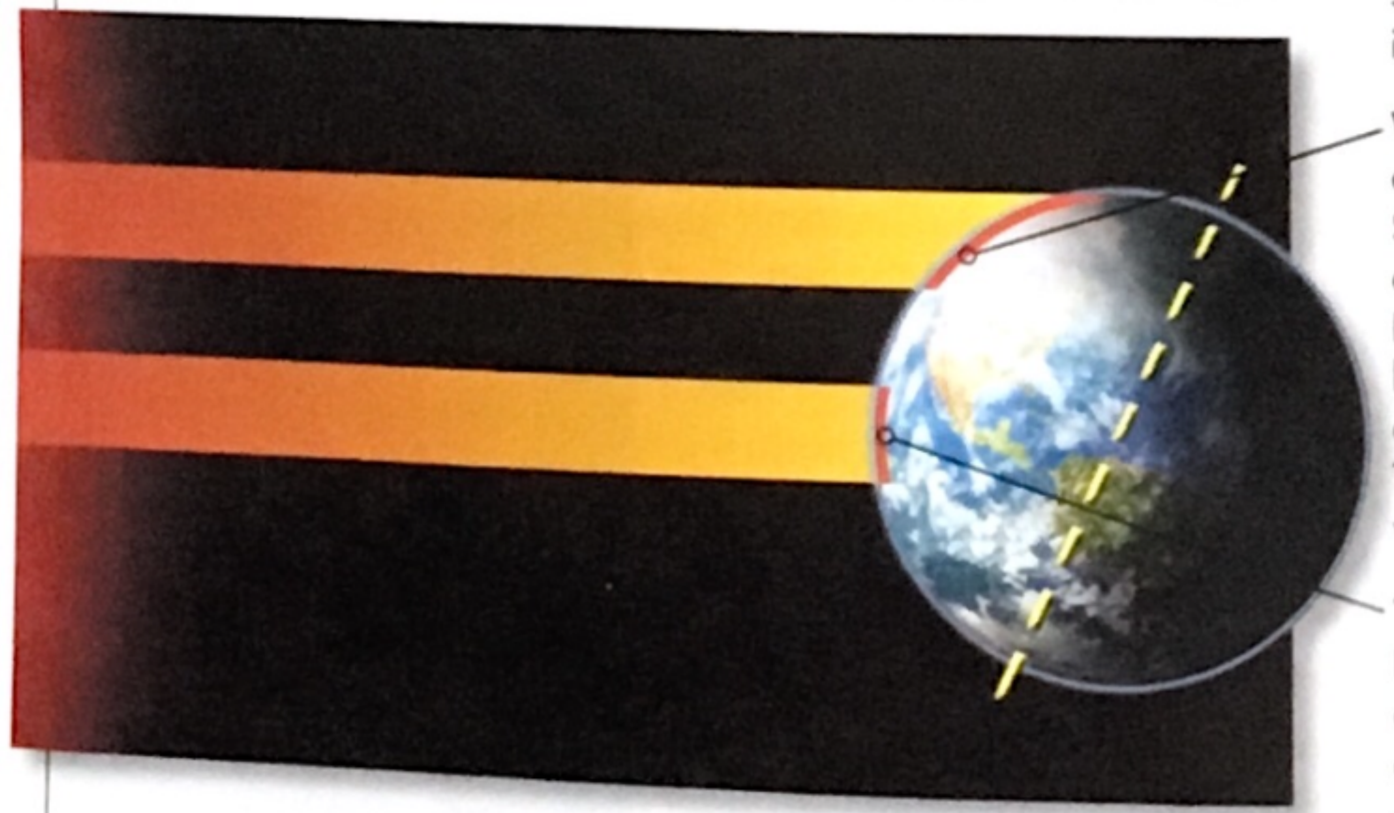
Earth's Orbit and Seasons

Like all objects in space, Earth tends to move in a straight line. The force of the Sun's gravity, however, pulls Earth toward the Sun out of a straight-line path. As a result, Earth revolves around the Sun. An **orbit** is the path of an object that revolves around another object. Earth's orbit around the Sun is an ellipse, a slightly flattened circle. A year, about 365 days, is the total amount of time Earth takes to make one orbit around the Sun.

Because Earth's orbit is an ellipse, it is sometimes slightly closer to the Sun than at other times. People often think summer is when Earth is closer to the Sun, but is this really true? To answer this question, think about standing close to a heater so that your face feels warm. If you step just a few centimeters back, the warmth you feel doesn't change. If you turn around, however, your face no longer feels warm.

The Tilt and the Seasons

In a similar way, the slight difference in the distance to the Sun as Earth moves around its orbit has no effect on seasons. In fact, Earth is slightly closer to the Sun when the northern half has winter. Earth's tilt on its axis causes seasons. The Sun warms the side of Earth that tilts toward it more than it does the side tilted away. When the North Pole tilts toward the Sun, the northern half of Earth has summer and the southern half has winter. When the South Pole tilts toward the Sun, the seasons are reversed. In spring and in fall, neither pole tilts toward the Sun. Both the northern and southern halves of Earth have mild temperatures.



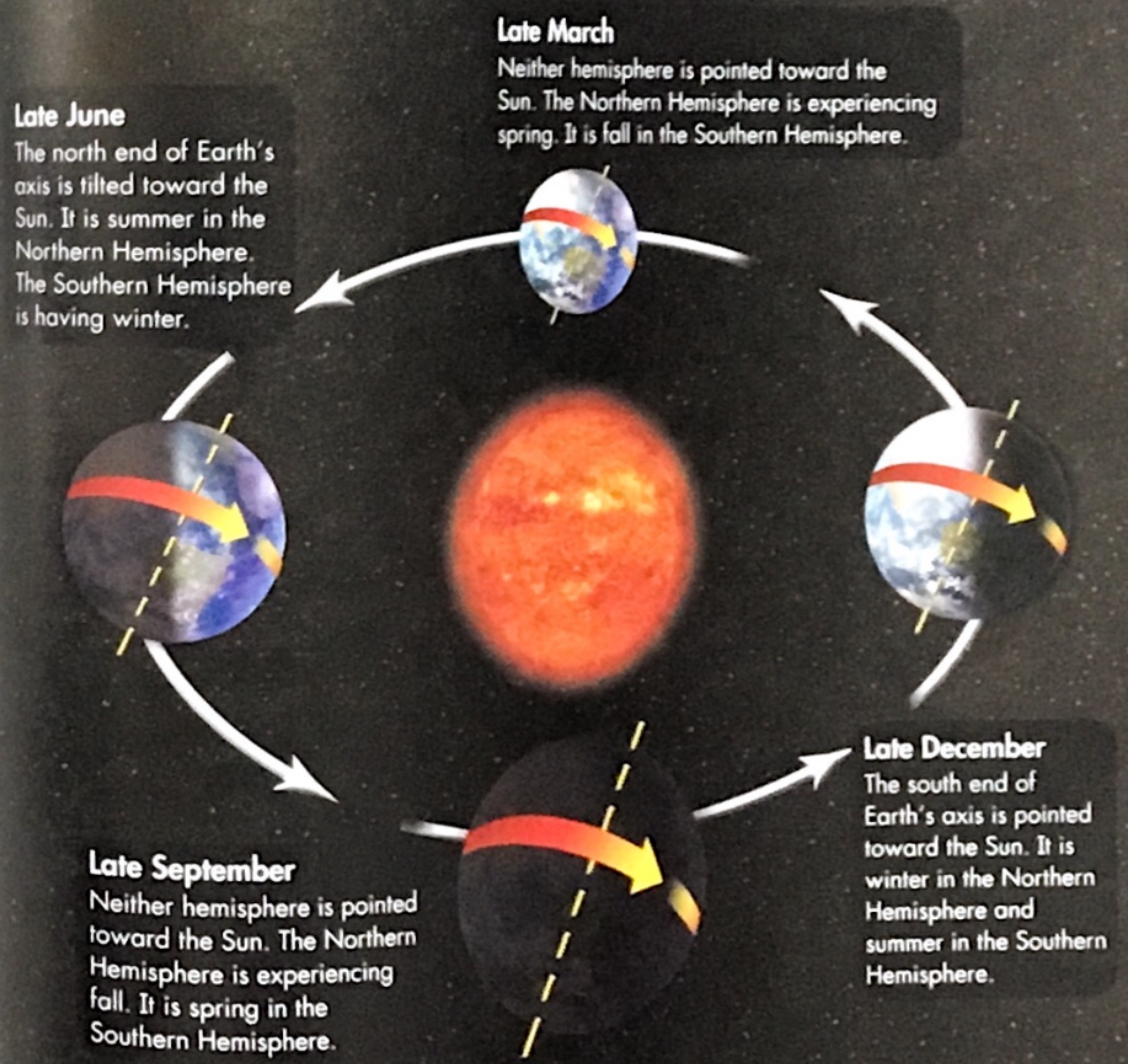
The tilt of Earth's axis affects how directly the Sun shines on Earth as it travels in its orbit.

When the North Pole tilts away from the Sun, the Sun's light is very spread out here. The Northern Hemisphere receives the least amount of energy at this time of year. Temperatures drop, and winter sets in.

The Sun's light strikes the Earth more directly south of the equator. The light is concentrated, not spread out. Concentrated energy gives this region warm summer weather.

In summer, the Sun's rays point almost directly toward you at noon. The direct sunlight makes the days very warm. The shadow you make is very small. As each day passes, the Sun's rays strike you at a greater and greater angle—we say the Sun is lower in the sky. With less direct rays from the Sun, the days are not as warm. Your noontime shadow gets longer and longer. You have winter when the part of Earth where you live is tilted away from the Sun. At noon, the angle of the Sun's rays is large, and you make a long shadow. A year can be defined as the time between the days when your shadow is at its shortest.

1. √ Checkpoint How does your noontime shadow change throughout the year?
2. Writing in Science **Descriptive** Write a paragraph describing seasons if Earth were not tilted on its axis.



Solar Eclipses

If you draw a picture of Earth's orbit around the Sun on a piece of paper, you can't draw the Moon's true orbit around Earth on the same paper. The Moon's orbit is tilted slightly at an angle from Earth's orbit. You can see the effect of this during a new moon. If the new moon occurs in daytime, you can see the Sun. The Moon is a little above or below the Sun because of the tilt of its orbit. Sometimes, however, the orbit of the Moon crosses exactly between the Sun and Earth. The Moon eclipses, or covers, the Sun. A **solar eclipse** occurs when the Moon blocks the light of the Sun.

The Moon makes two types of shadows on Earth during an eclipse. The umbra is the darker, inner part of an eclipse shadow. The penumbra is the lighter, outer part of an eclipse shadow. You can see these on the picture at the right. Even though solar eclipses occur several times a year, each place on Earth only experiences one every few hundred years.

During a solar eclipse, a place on Earth may experience a total or partial eclipse of the Sun or no eclipse at all. A total eclipse is when the umbra passes over an area. For several minutes, the Sun is completely blocked from view. The sky darkens, and the stars are visible in daytime. Because the Moon's shadow is so small, only a small part of Earth experiences a total eclipse. Nearby areas that are in the penumbra experience a partial eclipse. A partial eclipse can also occur when the umbra completely misses Earth and only the penumbra passes over.

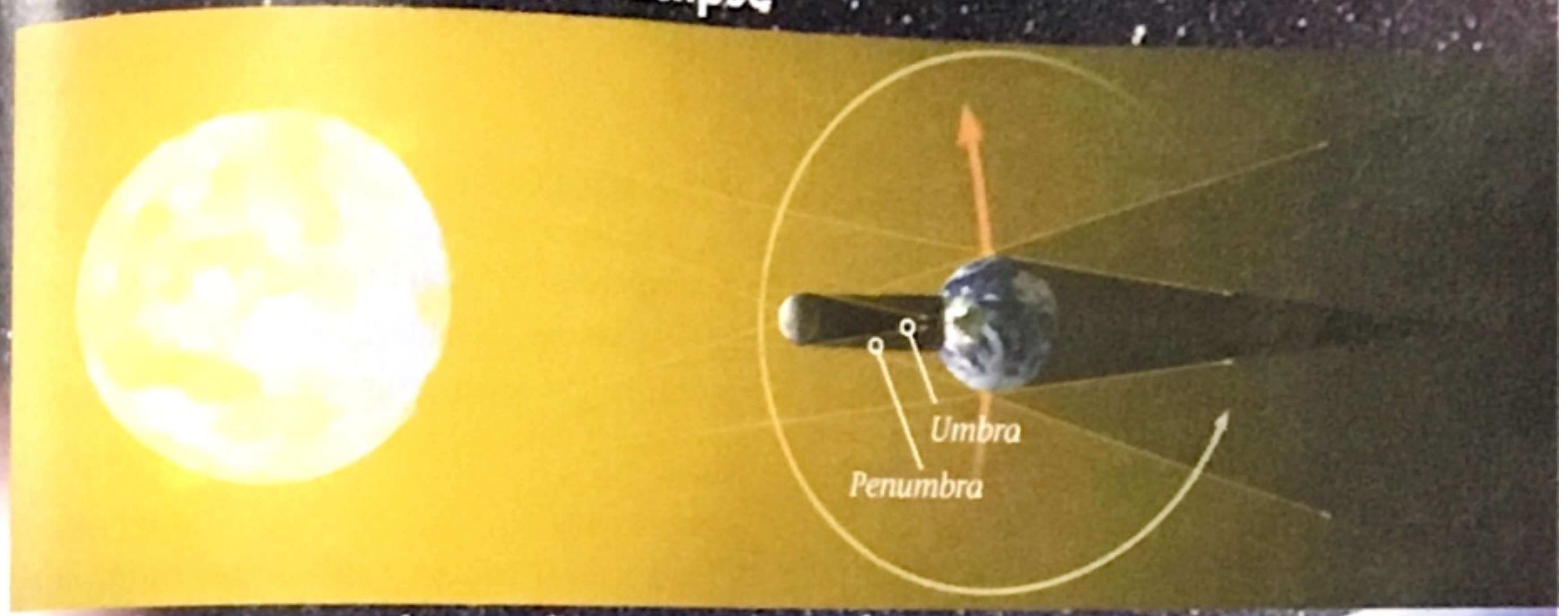
It's important to remember that you should never look directly at the Sun. A good way to view an eclipse is by using two pieces of white cardboard. Place one piece of cardboard on the ground. Place a pinhole in the center of the other piece. Point the pinhole at the Sun so that you see a round image on the other cardboard. The round spot of light you see on the paper is a pinhole image of the Sun.

Lunar Eclipses

A different kind of eclipse can occur during a full moon, when Earth is between the Sun and the Moon. A **lunar eclipse** happens when the Moon passes through Earth's shadow. You can safely watch a lunar eclipse. During a total eclipse, you might see the Moon passing through Earth's shadow for almost two hours. The time is shorter for partial eclipses. Unlike a solar eclipse, a lunar eclipse can be seen by most parts of Earth where it is nighttime. Lunar and solar eclipses occur about twice a year, but because lunar eclipses are visible from half the Earth, you are much more likely to see one.

Time-lapse photo of a lunar eclipse

Total Solar Eclipse



Lunar Eclipse

Lesson Checkpoint

1. What are two ways an area can experience a partial eclipse?
2. **Main Idea and Details** Write details to support this main idea: During a solar eclipse, the Moon blocks the light of the Sun.
3. **Writing in Science** **Expository** During a total lunar eclipse, the Moon appears slightly red. Research to find the cause of this effect and write a paragraph explaining it.

SPEED IN Space

Objects in space travel great distances at speeds much faster than humans travel on Earth. The Moon travels around the Earth at a speed of about 3700 kilometers per hour!

One of the world's fastest runners set a record in a 100 meter race with an average speed of 10.2 meters per second. Compare this speed with the speed of the Moon given above.

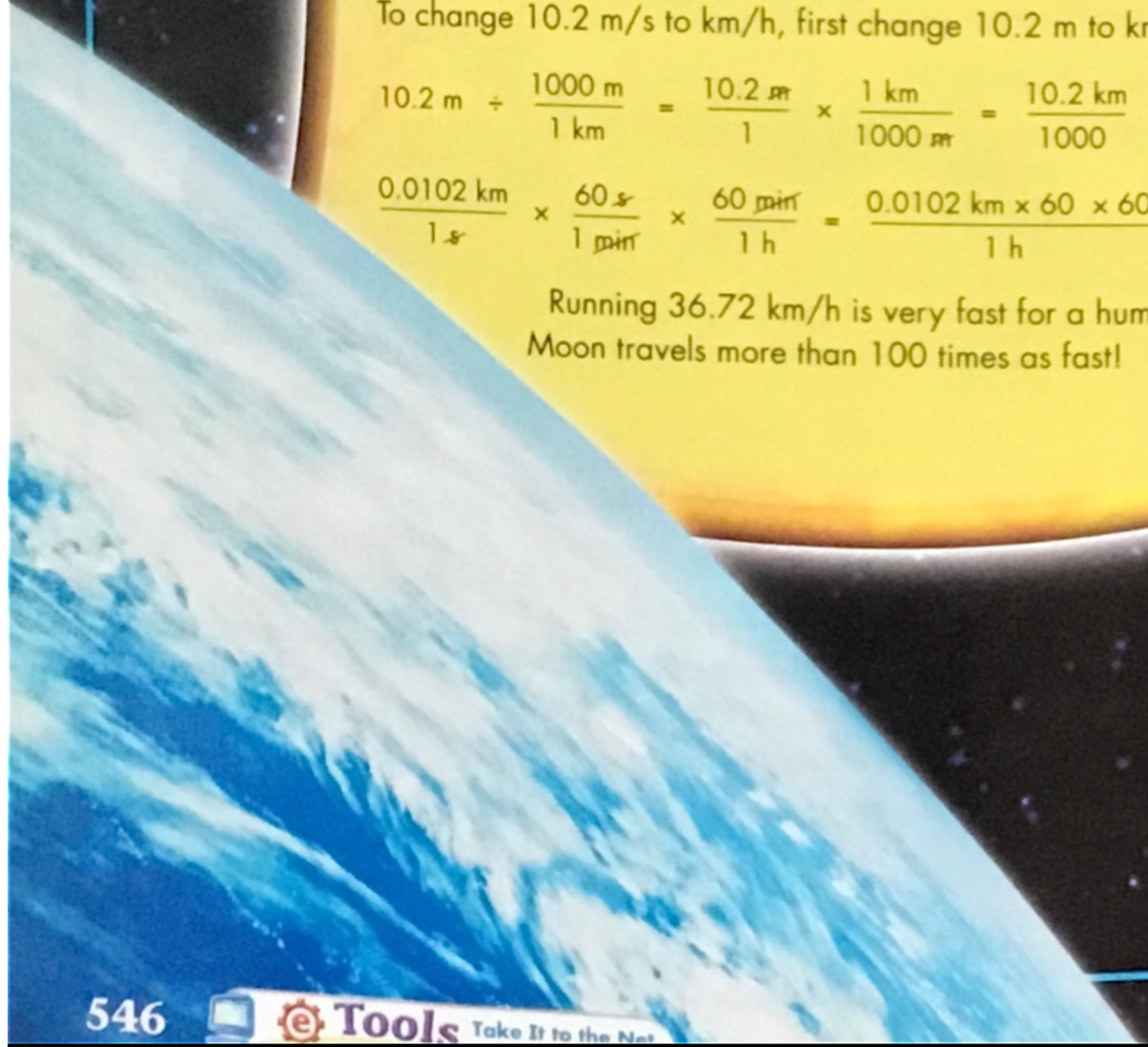
Speed is one type of rate. To compare rates, it is usually necessary to express them using the same units. One way to do this is to analyze the units used for one of the rates and use them to divide and simplify the rate.

To change 10.2 m/s to km/h, first change 10.2 m to km.

$$10.2 \text{ m} \div \frac{1000 \text{ m}}{1 \text{ km}} = \frac{10.2 \text{ m}}{1} \times \frac{1 \text{ km}}{1000 \text{ m}} = \frac{10.2 \text{ km}}{1000} = 0.0102 \text{ km}$$

$$\frac{0.0102 \text{ km}}{1 \text{ s}} \times \frac{60 \text{ s}}{1 \text{ min}} \times \frac{60 \text{ min}}{1 \text{ h}} = \frac{0.0102 \text{ km} \times 60 \times 60}{1 \text{ h}} = 36.72 \text{ km/h}$$

Running 36.72 km/h is very fast for a human, but the Moon travels more than 100 times as fast!



Use the information on page 546 to answer each question.

1. Earth travels around the Sun at a speed of 30,000 meters per second. Express this speed in kilometers per hour.
2. As Earth rotates on its axis, a point on the equator is traveling at 1,674 kilometers per hour. Express this speed in meters per second. Round your answer to the nearest meter.
3. The Moon makes one revolution around Earth in about 27 days and 7 hours. About how far does the Moon travel in that time?
4. The average distance from Earth to the Moon is 384,400 km. If you could travel to the Moon—a distance of about 384,400 km—at highway speeds, about how many weeks would it take? The speed limit on many American highways is about 100 km/h.

Lab zone Take-Home Activity

Use library resources to research the Apollo space missions to the Moon. Then write a story about traveling to the Moon yourself. Include your average speed, traveling time, and length of stay on the Moon.

Chapter 19 Review and Test Prep

Use Vocabulary

lunar eclipse (p. 542)	**rotates** (p. 536)
orbit (p. 540)	**solar eclipse** (p. 542)
revolve (p. 536)	

Use the vocabulary term from above that best completes each sentence.

1. The Moon _____ on its axis.
2. The _____ of Earth is its path around the Sun.
3. A(n) _____ occurs when the Moon completely blocks out the Sun's light.
4. The time for Earth to _____ around the Sun once is a year.
5. A(n) _____ occurs when the Moon passes through Earth's shadow.

Explain Concepts

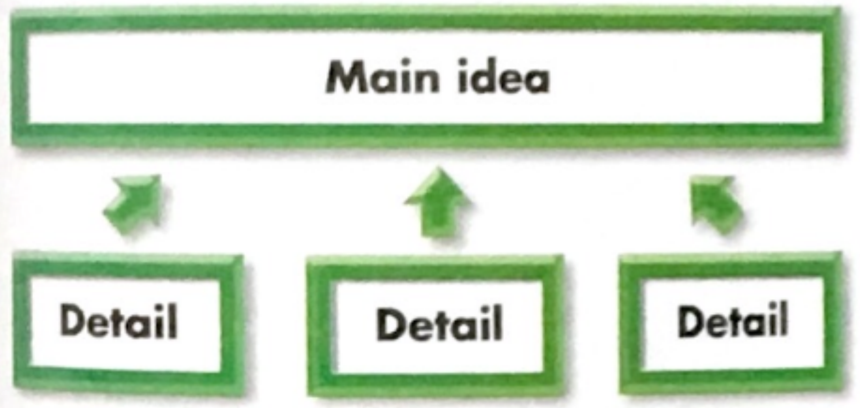
6. Why are you more likely to see a lunar eclipse than a solar eclipse?
7. How does Earth's motion relate to a day and a year?
8. What causes seasons?
9. Explain why your shadow is shorter in summer than in winter.
10. Create a drawing to explain the phases of the Moon.

Process Skills

11. **Infer** Why are scientists able to predict when solar and lunar eclipses occur?
12. **Model** Make a model that shows how Earth revolves around the Sun.
13. **Predict** The picture shows the setup for an experiment to see how the angle of light hitting a surface affects temperature. Which thermometer on the globe do you predict will have a higher temperature? Why?

Main Idea and Details

14. Make a graphic organizer like the one below for each lesson in this chapter. Fill in the main idea and supporting details for each lesson.



Test Prep

Choose the letter that best completes the statement or answers the question.

15. Which of the following is a reasonable time that a total solar eclipse might take?
    - Ⓐ 5 minutes
    - Ⓑ 30 minutes
    - Ⓒ 1 hour
    - Ⓓ 2 hours
16. Which phase can you see when the Moon is waning?
    - Ⓕ first quarter moon
    - Ⓖ half moon
    - Ⓗ new moon
    - Ⓘ third quarter moon
17. During which season is the part of Earth where you live tilted toward the Sun?
    - Ⓐ fall
    - Ⓑ spring
    - Ⓒ summer
    - Ⓓ winter
18. The Sun is made up of
    - Ⓕ solid rock.
    - Ⓖ auroras.
    - Ⓗ liquids.
    - Ⓘ plasma.
19. Explain why the answer you chose for Question 16 is best. For each of the answers you did not choose, give a reason why it is not the best choice.
20. **Writing in Science** **Narrative** Write a journal entry about a visit to the Sun. Explain what you see and feel on your visit. Remember to include what you see as you look from the Sun and the sky.

Reducing Drag to Save Fuel

Compare NASA's experimental truck cab with the new cab design.

When you think about NASA, you probably think of space travel and exploration. However, the work of some NASA scientists has helped improve travel right here on Earth. For example, the shape of some trucks you see on the road has been influenced by NASA technologies.

Until the 1970s, truck cabs were shaped like boxes with sharp corners. These sharp-cornered trucks would pass a NASA aerospace engineer as he rode his bike to and from work every day. The speed and shape of the trucks resulted in very strong and uneven wind gusts that pushed the scientist and his bike toward the side of the road. After the trucks passed, he would get pulled back toward the road. He realized that the forces pushing and pulling him could be costing the truck drivers money—they made the trucks use more fuel.

The force that the scientist experienced was partly the result of drag, a force that works against the motion of moving objects. A truck must use energy to overcome drag. A truck with a box-shaped cab uses a lot of fuel to overcome drag.

The scientist decided to help trucks glide through air instead of push through it. In the process, the trucks would encounter less drag and become more fuel-efficient. NASA researchers were working on the effects of drag and wind resistance on different kinds of aircraft and the space shuttle. They applied this knowledge to the design of large trucks. The researchers changed the box-shaped cab of the truck by rounding out its corners and edges. Then they observed the changes in drag. Trucks with the new cab design used much less fuel. This new design is now widely used.

Lab zone Take-Home Activity

How would you design a truck's trailer? Trailers still have a box shape for the purpose of storing cargo. Draw a trailer that would limit the force of drag. Write a paragraph that explains your design.