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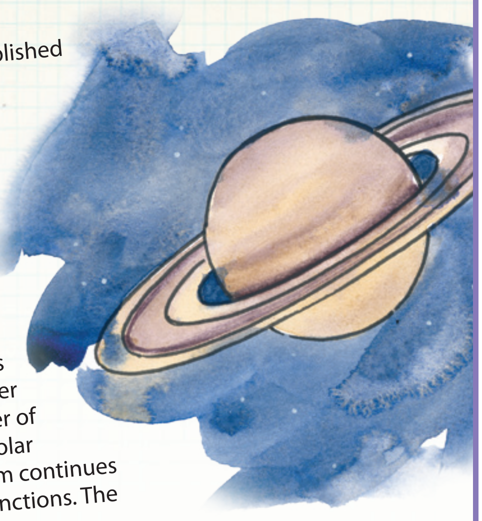
Solar System

In the 1500s Polish astronomer Copernicus published his theory about the order of the universe. He believed that the sun was the center of the universe and that the planets revolved around the sun. Most people believed that the planets, stars, and even the sun revolved around the earth. Copernicus's idea was not new, but he was the first in about two thousand years to use mathematics to prove his idea. Copernicus's theory was debated by other scientists and leaders of the time. Only after many years did scientists such as Sir Isaac Newton and Johannes Kepler prove that although the sun is not the center of the universe, it is indeed the center of our solar system. Today, research into our solar system continues to shed light on how the whole universe functions. The heavens really do shout the glory of God.



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TEACHER HELPS

Chapter preview
Other preview and prereading activities may include using a K-W-L chart, a probe, or an anticipation guide.

Student Text diagrams
Diagrams from the Student Text are included on the Teacher's Toolkit CD.

SCIENCE BACKGROUND

Aristarchus
Aristarchus (310–230 BC) was the first to calculate the sizes of and distances between the sun, Earth, and the moon. Although his measurements were not completely accurate, he correctly determined the relative sizes of the sun, Earth, and the moon. He also stated that Earth revolves around the sun and that the moon is closer to Earth than the sun.

Objectives
- Recognize that God's creation is orderly
- Preview the chapter content

Introduction
Can you imagine the devastation that would occur if we could not depend on the normal cycle of day and night? From the very beginning of Creation, God established "the evening and the morning" (Gen. 1:5). The entire universe maintains an orderliness that allows man to calculate where heavenly bodies will be located at any specific time. Even the mathematical systems that allow us to calculate these movements are a gift from God.

Teach for Understanding
Provide time for the student to complete Looking Ahead, Activity Manual page 171. For part B, encourage the student to think of things he would like to learn about Pluto and the International Space Station. He should write his answers in question form, such as, "Why is Pluto no longer a planet?"

Provide the answers for part A and allow the student to check his work. After the chapter is finished, you may choose to have him look back at this page and check his understanding of the items he missed.

As time allows, discuss student questions from part B about Pluto and the International Space Station. You may choose to provide trade books or other resources to help answer questions that are beyond the scope of this chapter.

Allow the student to leaf through the chapter, looking at the headings, pictures, captions, charts, etc., and discuss the things he thinks he will be learning about.

What is the title of this chapter? Solar System

Which solar system objects are shown in the photo? Earth, Mars, and the moon

Other than planets, what else is the chapter about? space exploration, the moon, the sun

Activity Manual
Preview, page 171
The Looking Ahead page is intended to assess the student's prior knowledge before beginning the chapter.

Lesson 127

Student Text pages 260–63
Activity Manual page 172

Objectives
- Explain how a rocket uses thrust to launch
- Describe characteristics of space exploration tools such as rockets, space shuttle, satellites, and probes
- Distinguish between a space shuttle and a probe
- Identify ways that living in space is different from living on Earth

Materials
- bicycle helmet
- package of dehydrated food (e.g., packaged noodle mix, powdered drink mix)
- small electronic device
- model of a three-stage rocket (optional)

Vocabulary
satellite
probe
International Space Station

Introduction
Display the helmet, food, and electronic device.

What do these items have in common? Accept any answer.

The students are not likely to recognize the connection between the items shown and space exploration. After they have offered several guesses, continue the discussion.

Each of these items was developed as a result of space exploration. The foam used in a bicycle helmet was developed for use in aircraft seats. The process of dehydrating food produced food that was lightweight and took less space. Electronic devices were miniaturized to fit inside a spacecraft.

Teach for Understanding
Purpose for reading
How have the last fifty years of space travel and technology affected how we live and what we know about the solar system?

How is a space probe different from a space shuttle?

Discussion
When were rockets probably first used and by whom? 1,000 years ago; the Chinese

Who is credited with starting modern rocket science? Robert Goddard, an American

What did he do? launched the first liquid-fueled rocket

What German led a team to develop rockets for space travel? Wernher von Braun

What challenges must a scientist plan for a rocket to overcome in order for it to go into space successfully? Possible answers: Earth's gravity, atmosphere, and orbit

Space Exploration

At first, man had to rely on his eyesight to study the night sky. Later small telescopes helped him gather more information. New information and ideas replaced old ideas as man continued to study and learn. Within the last hundred years, much technology has been developed that allows us to learn even more about our solar system. As we continue to discover things about our universe, the power and glory of God become even more obvious.

Rockets

The development of rockets has been essential to space exploration. The Chinese were probably the first people to invent rockets, about 1,000 years ago. Their rockets used gunpowder and were used as weapons. In 1926 American Robert Goddard launched the first liquid-fueled rocket. Though his rocket went only 12.5 m (41 ft) high and traveled only about 97 km/h (60 mi/h), it signaled the beginning of modern rocket science. By 1942 Germany had produced the V-2, a long-range rocket used as a weapon during World War II.

In 1955 Wernher von Braun (VAIR-nur vahn brown), the German who developed the V-2, began working for the United States and led a team to develop rockets for space travel. To overcome Earth's gravity and establish an orbit around Earth, a rocket must reach a speed of 27,350 km/h (17,500 mi/h). To travel beyond Earth's orbit requires even greater speed.

Rockets work in a way similar to jet engines. Hot gases being pushed very quickly out of a nozzle, or small opening, in the rocket's engines create thrust, or forward force. Newton's third law of motion says that for every action there is an equal and opposite reaction. As the hot gases are pushed out, the gases push against the rocket. You probably have demonstrated this

SCIENCE BACKGROUND

Rocketry
Rocketry actually involves all of Newton's laws of motion. At takeoff a tremendous force is necessary for the spacecraft to overcome inertia (Newton's first law). The greater the mass of the spacecraft is, the more force is needed to lift it off the launch pad (Newton's second law). As stated in the Student Text, liftoff is also an example of Newton's third law. The laws of motion are discussed in Chapter 9, *Motion and Machines*.

LANGUAGE

Astronaut
In Latin *astro* means "star," and *naut* means "sailor" or "ship." An *astronaut* is a "star sailor."

What other words can you think of that contain the roots *astro* or *naut*? Possible answers: astroturf, astronomy, cosmonaut, nautical

SCIENTIST

Wernher von Braun
Although Wernher von Braun developed the V-2 rocket, which was used against London in World War II, his dream was that rockets would be able to leave Earth's orbit. This dream caused him to be arrested by the Gestapo in Nazi Germany.

After he was released, he arranged the surrender of his rocket team to the Americans.

SCIENCE & HISTORY

Though at times space travel seems commonplace and ordinary, it is never without risks. During a training mission in 1967, an *Apollo* spacecraft on the ground caught fire and killed three astronauts. *Apollo 13* was almost lost to drift in space because of an explosion on the way to the moon. In 1986 the space shuttle *Challenger* exploded soon after liftoff. Seven crew members were killed. The entire shuttle fleet was grounded while changes were made to a thin rubber ring that had failed to work properly and had caused the explosion.

After a few years the shuttle fleet again began making frequent trips into space. In 2003 the space shuttle *Columbia* broke apart while reentering Earth's atmosphere. Another seven crew members were lost. Again the shuttle fleet was grounded while scientists tried to determine the cause of the accident and to take appropriate action to avoid its reoccurrence. Despite the tremendous list of things that could go wrong, the space program has had remarkably few accidents. But every time a life is lost, we are reminded that reaching for new frontiers is always dangerous and that life is brief (James 4:14).

principle using a balloon. If you blow up a balloon and then let it go, the balloon sails away in an opposite direction from the air moving out of the balloon.

The Space Shuttle

Early space missions to the moon used huge three-stage rockets to send people into space. Each rocket could be used only one time. Then in 1981 the United States launched the first space shuttle, a reusable space vehicle. Though it launched much like a rocket, it returned to Earth like a glider airplane. A shuttle could carry up to eight crew members. The crew members were not always regular astronauts. They were specialists who worked with the shuttle's cargo or with experiments that are part of the mission. The shuttle's main task was to transport equipment, but it also served as the "bus" for astronauts traveling to and from the International Space Station. In fact, the shuttle program's complete name was the Space Transportation System (STS). The space shuttle program ended in 2011. Now many American scientists and engineers are working on other spacecraft that can also carry people and equipment into space.

space shuttle *Endeavor*

Discussion

What does Newton's third law of motion say? For every action there is an equal and opposite reaction.

How does Newton's third law relate to rockets? As hot gases leave the rocket, they push the rocket in the opposite direction.

What kind of rockets were used to go to the moon? huge three-stage rockets

Refer to the *Saturn 1* rocket photo. Rockets from the Saturn rocket series were used to go to the moon. If available, show the stages of the model rocket.

How was the space shuttle different from a regular rocket? Possible answers: It was reusable. It returned to Earth like a glider airplane. It could carry more cargo and a larger crew.

Why was the shuttle program named the Space Transportation System? The shuttle was designed to carry equipment and astronauts to and from the International Space Station.

Discuss any space craft liftoffs and landings that the student may have seen.

Discuss *Science & History*.

What are some examples of space travel accidents? Apollo spacecraft that caught on fire; *Apollo 13*, *Challenger*, *Columbia*

Why is space travel so dangerous? People traveling in space cannot easily leave a damaged spacecraft and survive. The spacecraft supplies what is needed for the crew to live and return to Earth. Because of this, even small failures can have disastrous results.

Do you think the benefits of space travel are worth the risks involved? Answers will vary.

TECHNOLOGY

Saturn rockets

Three-stage Saturn series rockets were used by NASA for the Apollo missions to the moon. Each rocket was a series of sections stacked in the order of their use. Each section separated from the remaining rocket after performing its function. The first, or bottom, stage ignited to provide the thrust necessary to lift the rocket off the ground. The ignition of the second stage boosted the rocket into position for orbiting the earth. The third stage then ignited to give the rocket the velocity to maintain the orbit, and sent the rocket toward the moon. The command and service modules then aligned with the lunar module to prepare for the third stage to separate.

To return to Earth, the service module provided the thrust needed to leave the Moon's orbit. The only part of the huge rocket to return to Earth was the small, cone-shaped command module that had left Earth at the top of the rocket.

BIBLE

Life is a vapor

Relate truths from James 4:14 with the information in *Science & History*.

How does the verse describe life? as a vapor that appears and disappears

What should our response be to the shortness and uncertainty of life? We should be sure of our salvation, and we should live each day for God's glory.

Discussion

What is a satellite? an object that orbits another object in space

What was the first artificial satellite to orbit Earth? *Sputnik I* **Who launched it and when?** the Soviet Union on October 4, 1957

How big was *Sputnik*? about the size of a basketball; 83 kg

How did the launch of that satellite affect the world? It unofficially began the "space race."

Why were the United States and the Soviet Union so concerned about the "space race"? The countries were not friendly, and each was afraid the other would gain control of space.

Is there still a "space race" today? No, the United States and Russia sometimes cooperate in space exploration.

The Soviet Union is now divided into many smaller countries, of which Russia is the largest.

Which kinds of satellites are orbiting Earth today? Possible answers: the Hubble Space Telescope; satellites for tracking weather, spying, and communication

Why do you think satellites look like stars? Answers will vary.

Name some things that your family uses that rely on signals from satellites. Possible answers: satellite television, GPS, some radios, satellite phones

What is a probe? a research spacecraft sent beyond Earth's orbit

How is a probe different from a space shuttle? A probe can travel longer and farther and does not have astronauts aboard like a shuttle does.

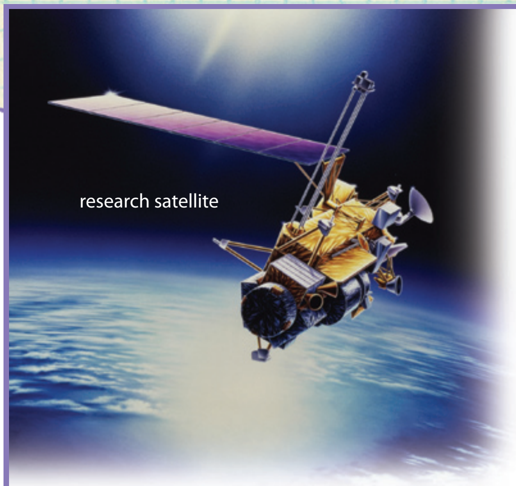
Why would a probe use a robotic arm? to gather and analyze samples

Compare a lander with a rover. A lander is a probe that is able to land on a surface. A rover is a probe that is able to move about the surface after landing.

Discuss *Science & Math*.

What happened to the *Mars Climate Orbiter*? It probably burned up in Mars's atmosphere or crashed.

Why were the scientists' measurements off? the two teams used different measuring systems


research satellite

Satellites

A **satellite** is an object that orbits another object in space. In addition to Earth's natural satellite, the moon, many manmade satellites orbit Earth. The first artificial satellite ever to orbit the earth was *Sputnik I*. Launched by the Soviet Union (USSR) on October 4, 1957, *Sputnik* was about the size of a basketball and weighed 83 kg (183 lb). It took only ninety-eight minutes to orbit the earth. The launch of *Sputnik* unofficially began what was called the "space race." Because of the political tension between the Soviet Union and the United States, each country tried to keep the other from gaining control of the realm of space. Today, Russia and the United States sometimes cooperate in space exploration.

Satellites have many purposes. The Hubble Space Telescope is a satellite of Earth that is used for space exploration. It has sent back thousands of images of stars, galaxies, and nebulas. Other satellites are used for communication. Satellites enable you to talk to someone on the other side of the world or to watch a live news report from a distant country. Satellites are also used for tracking the weather, for international spying, and even for distance education.

You can usually see several satellites in the night sky. Some look like shooting stars, except that they move more slowly and stay in sight longer. Thousands of satellites orbit the earth every day.

Probes

Probes are research spacecraft sent beyond Earth's orbit. They do not have astronauts aboard, so they can travel longer and farther. Probes can relay images of planets. Some explore planets by orbiting them and taking images which they transmit back to Earth. Others actually land on the surface and use robotic arms to collect samples for analysis. These special probes are called *landers*. If the lander is able to move about on the surface, it is a *rover*. A few probes such as *Voyager 1*, *Voyager 2*, and *New Horizons* are, or will be, sent out beyond our solar system to explore deep space.

SCIENCE & MATH

In 1999 NASA lost the *Mars Climate Orbiter* because of a simple mathematical error. One team of scientists did calculations using the English system while the other team did calculations using the metric system. As a result their measurements were off, and the probe probably either burned up in Mars's atmosphere or crashed.

SCIENCE BACKGROUND

Space animals
Dogs and monkeys went to space before men. The first animal to be sent into space was a dog named Laika. It was sent to space by the Russians on *Sputnik II* one month after *Sputnik I* was launched.

Measurement systems
The United States is one of the few countries that still uses the English system of measurement. Metric measurements are most often used for scientific research so that data is easily interpreted by anyone who uses it.

WRITING

Measurement confusion
Mix-ups between using liters and gallons have caused some catastrophes, such as plane crashes. Direct the student to write a persuasive paragraph in support of or against changing the United States' official measuring system to the metric system.

FANTASTIC FACTS

Do you wish you could grow a few inches? While in space, an astronaut's vertebrae spread apart because of the lack of gravity, and the astronaut "grows" one to two inches. When the astronaut returns to Earth, though, his height returns to normal.

International Space Station

The **International Space Station** (ISS) is a facility that orbits Earth and is maintained and used by astronauts from sixteen different countries. Astronauts began building the space station in 1995. They have continued to add onto it while living in it and conducting experiments that will benefit Earth and further our knowledge of space. The astronauts are also learning how living in space over a long period of time affects humans.

Living in space is much different from living on Earth. The weightlessness in space affects how the astronauts eat, sleep, work, and exercise. Astronauts cannot eat anything that produces crumbs because the crumbs would float away. Most of the food is dehydrated, meaning it has had the water removed. Dehydrated food is easier to store and takes up less space than regular food.

Drinking out of a cup in space would cause problems too, because the water would float out of the cup. Astronauts keep their drinks sealed and drink them through straws.

Sleeping in space is also different. Some astronauts float around freely while they sleep. Others choose to strap themselves down in sleeping bags that are secured to the wall. Astronauts have to exercise every day. Without the force of gravity pulling on their muscles and causing them to work harder, their muscles can deteriorate.

QUICK CHECK

1. What does Newton's third law of motion say? How is this law demonstrated by rockets?
2. Why was the shuttle called a "transportation" system?
3. What is a probe?

International Space Station

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Discussion

What is the International Space Station (ISS)? a facility that orbits Earth and is maintained and used by different countries

What is the purpose of the ISS? to conduct experiments where there is a lack of gravity in order to develop new materials that will benefit Earth and to study the effects of living in space on humans

What does *dehydrated* mean? the water has been removed

What are some differences in living conditions that astronauts face while living in space? Possible answers: They must eat food that does not produce crumbs, drink only from closed containers with straws, float or secure themselves while sleeping, and exercise to keep their muscles toned.

How do astronauts try to lessen the effects of zero gravity on their muscles? They exercise regularly.

Discuss *Fantastic Facts*.

Why does an astronaut get taller in space? The vertebrae spread apart because of the lack of gravity.

What are vertebrae? the bones that form the backbone, or spine

Why does the astronaut return to normal height when he returns to Earth? Earth's gravity pulls the vertebrae back into place.

Answers

1. For every action there is an equal and opposite reaction. As gases push out toward the ground, the rocket moves upward in the opposite direction.
2. Space shuttles transported equipment and people to and from the International Space Station and Earth.
3. a research spacecraft sent beyond Earth's orbit

Activity Manual

Reinforcement, page 172

TECHNOLOGY

Value of exploration

Some people question the value of space exploration. However, there are multitudes of things we use every day that are the results of space technology. The miniaturization of computers is probably one of the most obvious. The metal used in braces was developed for antennas in space. Medical technology has been particularly advanced due to space research. The list of practical uses of space technology is lengthy and is continually growing.

HISTORY

Mars probes

Early in 2004 scientists successfully put two probes on the surface of Mars, the Mars Exploration Rover *Spirit* and the Mars Exploration Rover *Opportunity*. The rovers were designed to investigate and send back to Earth extensive data about the surface of Mars. NASA lost contact with *Spirit* in 2010, but *Opportunity* has continued to send back information for much longer than expected. In August 2012, the probe *Curiosity* successfully landed on Mars.

Student Text pages 264–65
Activity Manual pages 173–74

Objectives

- Describe some types of inflatable spacecraft
- Understand the basics of inflatable technology
- Explain the advantages of inflatable spacecraft

Materials

- package of balloons

Introduction

Display the package of balloons.

If you were asked to bring 25 balloons to a party, how would you carry them—blow them up at home or take the balloons to the party and then blow them up? probably take the balloons to the party and then blow them up

Inflate one balloon. Compare the amount of space that the entire package takes up compared to just one inflated balloon.

Purpose for reading

How are scientists applying what we know about balloons to travel in outer space?

What types of spacecraft use this technology?

Teach for Understanding

Discussion

What is one of the main problems of space research today? expense of getting things into orbit

What is one way scientists can lower the cost of space equipment? use inflatable materials

What are some advantages of inflatable spacecraft? They are smaller in size and lighter in weight which makes them cheaper to launch. They also take up less space on the rocket.

What is an acronym? a word formed from the initial letters or parts of a series of words

What does the acronym *NASA* represent? National Aeronautics and Space Administration

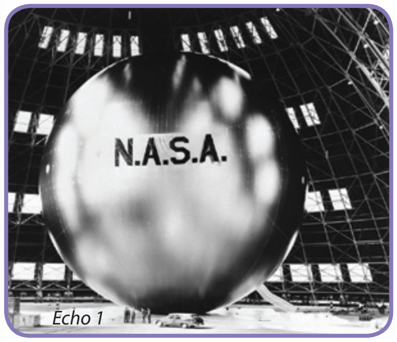
What was *Echo I*? the first NASA communications satellite, an inflatable satellite

Is inflatable equipment a recent idea? No, it has been thought of since the beginning of the space program.

TECHNOLOGY

Inflatable Spacecraft

How would you like to live or travel in space inside something that looks like a giant balloon? Though it sounds strange, this may be a reality in the future.



Echo 1

Scientists at the National Aeronautics and Space Administration **(NASA)**, our government's space agency, have spent billions and billions of dollars on space equipment to make the vehicles and tools safe and useful. To help reduce these high costs, scientists research ways to make space equipment cheaper. One way that would make spacecraft less expensive is to make some of the equipment inflatable. The equipment will be lifted into orbit uninflated, but once in orbit it would fill with gas and can become huge. An inflatable spacecraft has many advantages. It is smaller in size and lighter than other types of spacecraft, which makes it cheaper to launch into orbit. Also, inflatable equipment takes up less space on the rocket that launches it.

Ideas for developing inflatable spacecraft have been around since the beginning of the space program. The first NASA communications satellite, *Echo 1*, was an inflatable satellite. It was launched in 1960 and orbited Earth until 1968. Later, researchers turned to other methods of making satellites and spacecraft. However, some scientists continued to think about the possibilities of inflatable space equipment.

In 1996 the crew on the space shuttle *Endeavor* carried out an inflatable antenna experiment. The antenna was meant to be part of a telescope. They released a small structure that was only about 2 m × 1 m × 0.5 m in size. However, when the antenna structure unfolded and inflated, it was the size of a tennis court. This experiment was considered successful and laid the groundwork for the development of other inflatable equipment.

Also, in the 1990s ideas for an inflatable habitat called TransHab started to take shape. TransHab would be made of layers of thick, bullet-proof material, which could withstand small meteors. It had four floors, including an exercise area, sleeping quarters, and a kitchen. It was intended to be used for travel to Mars, but the government project was canceled in 2000. However, scientists at private companies have continued researching ways to make inflatable habitats for people in space.

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SCIENCE BACKGROUND

Spacecraft companies
The BA 330 are inflatable habitats developed by Bigelow Aerospace, a company which partners with Boeing. The BA 330 habitat is a six-person inflatable space station. Currently Bigelow has two prototypes, *Genesis I* and *Genesis II*, in orbit. The company Space X developed the Falcon rockets which power their *Dragon* spacecraft. The *Dragon* is a free flying reusable spacecraft that is designed for water landings. In August 2012, Space X contracted with NASA to develop the successor to the space shuttle.

Nongovernmental space flights
Several private companies are working to develop spacecraft that can serve the commercial and government human spaceflight market. In May 2012, Space X's *Dragon* spacecraft became the first privately developed vehicle to successfully attach to the International Space Station. Only four governments (United States, Russia, Japan, and the European Space Agency) had done this previously. *Dragon* returned to Earth carrying cargo for NASA. Also in May 2012, Space X and Bigelow Aerospace agreed to a joint marketing effort with Space X offering rides on their *Dragon* spacecraft up to future Bigelow habitats orbiting the earth.

TransHab
The TransHab project was cancelled by Congress and NASA in 2000, but that technology is currently being incorporated into the habitats produced by Bigelow.


Bigelow Aerospace inflatable habitats

These inflatable habitats are also called expandable habitats.

In 2006 an expandable habitat called *Genesis I* was launched into space. Later, in 2007, *Genesis II* was launched. These spacecraft contain many cameras and research equipment as they test various technologies and equipment needed for people to live and work in space in the future.

Inflatable technology is not just for satellites, antennae, and habitats. Scientists have considered ways to make inflatable rovers that can study Mars and other planets. They are also researching ways to use **solar sails**—expandable, sun-powered spacecraft. Scientists hope that some day solar sails will be a reliable way to travel in space. They are made of a strong type of special plastic and coated with a thin layer of aluminum. The whole sail is much thinner than a human hair. The solar sail reflects light off its surface, and the reflected light provides energy that pushes the sail forward. They move slowly at first but gain momentum quickly because there is no air resistance. Solar sails could reach distant planets and other destinations faster than spacecraft powered by engines as long as they received energy from the sun or some other light source. Spacecraft with solar sails could travel through space using the sun's energy in much the same way that a sailboat uses the wind to move through water on Earth.

Solar sails do not take up much room on the rocket or satellite used to send them into orbit. *NanoSail-D*, the first American solar sail, was about the size of a loaf of bread at first, but once it unfurled in space, its sail was 100 square feet in size. It orbited Earth for 240 days and provided much information for scientists.

As more spacecraft and space equipment become inflatable, the possibilities for studying God's universe increase greatly. Inflatable spacecraft give men the opportunity to travel farther and for longer periods than ever before.

solar sail in space

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Antenna experiment

This experiment was part of the ARISE (Advanced Radio Interferometry between Space and Earth) project. It was a sensitive radio antenna that would work with Earth-based radio telescopes to gain information about massive black holes and related phenomena. Currently the project is no longer led by the United States, but similar technology and ideas are being developed by the Japanese space agency, JAXA.

MATH

Calculating cost

Calculate the cost of transporting cargo into orbit as if the cost of transporting 454 g (1 lb) of cargo into orbit was about $10,000. At that price, it would cost $12,500 to carry an object as light as an inflated basketball (570 g) into space.

Calculate the estimated cost of a student going to space as cargo.

Since people are not really cargo, research to find the weight of a space suit, food, water, and other essential supplies to include in the cost of transporting the student into space.

Discuss ways the load could be lightened.

Calculate the cost of carrying other items into space, such as the total weight of the materials used in one of the experiments in SCIENCE 6.

Note: Mass is usually used when calculating payload. For convenience, weight is used for this activity.

Discussion

Use a meter stick to show the size of the inflatable antenna as the measurements are given.

What size was the antenna before it inflated? 2 m × 1 m × 0.5 m

How big was the antenna after it inflated? about the size of a tennis court

Scientists use different methods to inflate space equipment. The way that the antenna inflated was different from the way TransHab was planned to inflate.

Why are scientists testing different inflatable habitats? They are looking for ways to allow people to live and travel in space.

What was TransHab intended to be used for? travel to Mars **What would it have looked like?** Answers will vary but should include the idea that it had four floors and was made of layers of thick, bullet-proof material.

Why do many inflatable spacecraft use bullet-proof material? to allow it to withstand being hit by small meteors

What is another name for inflatable habitats? expandable habitats

Several private companies are experimenting with ways to make space travel possible. Share the Science Background information on page 286 as time allows.

What are some ways inflatable technology is used? satellites, antennae, habitats, rovers, solar sails

What are solar sails? expandable, sun-powered spacecraft

Describe a solar sail. It is made of a strong type of special plastic coated with a thin layer of aluminum. The whole sail is thinner than a human hair.

Does a solar sail have an engine? no **How is it powered?** by reflecting the sun's light

How big was the first American solar sail before it unfurled? about the size of a loaf of bread

What new opportunities are provided through the use of inflatable spacecraft? the opportunity to travel farther and for longer periods; the ability to study more of God's vast universe

Activity Manual

Technology, page 173

Bible Connection, page 174

This page highlights the Christlike qualities in the life of Johannes Kepler.

Student Text pages 266–67
Activity Manual pages 175–76

Objectives

- Hypothesize how design affects the performance of a balloon rocket
- Construct a balloon rocket
- Demonstrate an understanding of Newton's third law of motion

Materials

- See Student Text page
- design materials such as cardstock and construction paper
- foam cups (optional)
- rubber bands (optional)

Introduction

Rockets have been used for special purposes for centuries. They have been used for weapons, fireworks, and space flight. In this activity you will have the opportunity to construct a rocket and learn about thrust, the force that enables rockets to move.

Teach for Understanding

Purpose for reading

The student should read all the pages before beginning the activity.

Procedure

Long, straight balloons will work better for the rockets. You may choose to give some groups round balloons and allow the groups to compare the results.

Provide materials for students to use to add design elements. The foam cups and rubber bands are needed if constructing a multi-stage rocket.

Discuss multi-stage design ideas. An idea and directions are provided in the Direct an Activity for this lesson.

Attach the fishing line to two points in a room, hallway, or outdoors. You may also choose to have two students hold the ends of the fishing line, keeping it taut.

With a piece of tape, mark the starting point on the fishing line.

If individual rockets are made, you may launch several rockets at the same time on different pieces of fishing line.

Try to launch the rocket within one hour after it is inflated. The opening may not open easily if left twisted and closed for a longer period of time.

ACTIVITY

Rocket Race

Rockets need thrust to escape Earth's atmosphere. A balloon can demonstrate thrust. As a balloon deflates, it is propelled in the opposite direction of the flowing air. In this activity you will design and test a "rocket" that uses a balloon for thrust.

Process Skills
- Hypothesizing
- Measuring
- Making and using models
- Observing
- Inferring
- Recording data

Problem

How can I make a balloon rocket propel a long distance?

Procedure

Your balloon rocket must include the following:

- *a clothespin to close the balloon.*
- *a piece of drinking straw attached along the top of your rocket.*

1. Draw and label a diagram of your rocket in your Activity Manual to use as your hypothesis. You may construct a multi-stage rocket, but it must be designed so the second balloon starts deflating after the first stage has deflated.
2. List the additional materials you will use.
3. Build your rocket according to your diagram. Blow up your balloon to the desired size. Twist and secure the end with a clothespin. Add the design elements that you think will make your rocket go farther. Remember that the force propelling your rocket comes from the air escaping the balloon.
4. Cut the drinking straw to whatever size you choose. Securely attach the straw to the upper side of your rocket. Thread the fishing line through the straw.
5. Hold or attach the fishing line so that it is stretched tightly between two people or fixed points. At the appointed time, launch your rocket by removing the clothespin.

Materials
- balloons of various sizes and shapes
- clothespin, spring-style
- drinking straw
- tape
- glue
- 10-meter fishing line
- meter stick or tape measure
- additional design materials of your choice
- Activity Manual

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TEACHER HELPS

Reducing the size of the balloon opening with a rubber band may reduce the airflow, causing the rocket to go a longer distance. This may be helpful if a large balloon is used.

SCIENCE BACKGROUND

This activity correlates with Chapter 9, *Motion and Machines*, in which Newton's third law of motion is discussed.

SCIENCE PROCESS SKILLS

Hypothesizing

What do you use as a hypothesis in this activity? the labeled diagram

Is this a true hypothesis? No, a true hypothesis is a statement.

Could you write a statement to replace your diagram? yes

Allow several students to try writing hypothesis statements. Guide them as they define conditions and make predictions. The statements may be lengthy.

Do you think it is easier to draw a diagram or write a statement for this hypothesis? Answers will vary.

Diagrams are sometimes included with a hypothesis.

6. Measure and record the distance traveled by your rocket. Compare your rocket's results and design to those of other rockets. As time allows, test your rocket design again.

Conclusions

- Was your hypothesis (design) effective?
- What features of your rocket helped it go farther?

Follow-up

- Change the design to make a balloon rocket go farther.
- Launch several rockets at the same time along different pieces of fishing line. Compare the design of each rocket to its speed and the distance it traveled.

Conclusions

After the activity discuss which design elements were most effective in making the rocket propel further. Guide the student in identifying factors that may have contributed to the success of the rocket. The factors may include the following:

- the size of the balloon
- the velocity of the escaping air
- the shape of the balloon
- the amount of air in the balloon

The student should conclude that the most effective factor was the thrust that resulted from the amount of air that was able to escape from the balloon.

Provide time for the student to answer the conclusion questions in his Activity Manual. Use the questions in the Science Process Skills to discuss hypothesizing.

As time permits, allow the student to make changes to his rocket and test it again based on the knowledge he gained from testing it the first time. If time allows, discuss whether changing the length of the straw would affect the speed or distance traveled. Allow the student to change the length of the straw while keeping his design the same. Remind him to change only one variable at a time.

Activity Manual

Activity, pages 175–76

Assessment

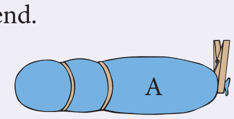
Rubrics

Select the prepared rubric, or design a rubric to include your chosen criteria.

DIRECT AN ACTIVITY

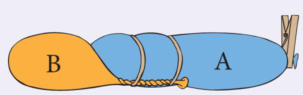
Materials: 2 straight balloons (identified as A and B below), clothespin, 2 rubber bands, 15 cm × 30 cm strip of stiff paper, tape, drinking straw

Make a multi-stage rocket by inflating balloon A completely and closing it with a clothespin. Place 2 rubber bands around the balloon at 5 and 8 cm from the rounded end.



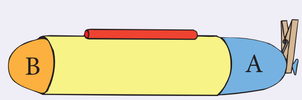
Inflate balloon B about two-thirds full, and push the air toward the rounded end to make the end near the opening (neck) longer. Twist the neck and insert the neck under both rubber bands on balloon A so that balloon B extends from the rounded end of balloon A. Adjust as needed to keep air from leaking.

Wrap and tape the paper strip around both balloons so the rubber bands are covered



and the balloons are aligned.

Attach the straw and launch as a single rocket.



Lesson 130

Student Text pages 268–71
Activity Manual pages 177–78

Objectives

- Identify the parts of the sun
- Describe the characteristics of a solar storm
- Describe relationships between the sun and the planets
- Summarize why Earth experiences seasons

Materials

- sunglasses
- sunscreen
- globe
- protractor

Vocabulary

photosphere	solar prominence
chromosphere	solar wind
corona	aurora
sunspot	revolution
faculae	axis
solar flare	rotation

Introduction

Display the sunscreen and sunglasses.

Why do we use these items? to protect us from the effects of the sun

How can the sun be so far away and still be harmful to us? Answers may vary. Elicit that although the sun is far away, it is very powerful.

The sun, however, is also very important for our survival. Name some ways we depend on the sun every day. Possible answers: Plants need sunlight to survive, and people depend on plants for food. The sun warms the Earth. The sun gives us light.

Teach for Understanding

Purpose for reading

In what ways does the sun affect life on Earth?

What characteristic of Earth determines the seasons?

Discussion

What are some ways the sun affects life on Earth? Possible answers: It provides heat and light. It affects Earth's climate and food supply. Its storms can disrupt our communication and navigation equipment. It can burn our skin and damage our eyes.

How far is the sun from Earth? 150,000,000 km, or 93,000,000 mi

How long does it take the sun's light to reach Earth? less than 8½ minutes

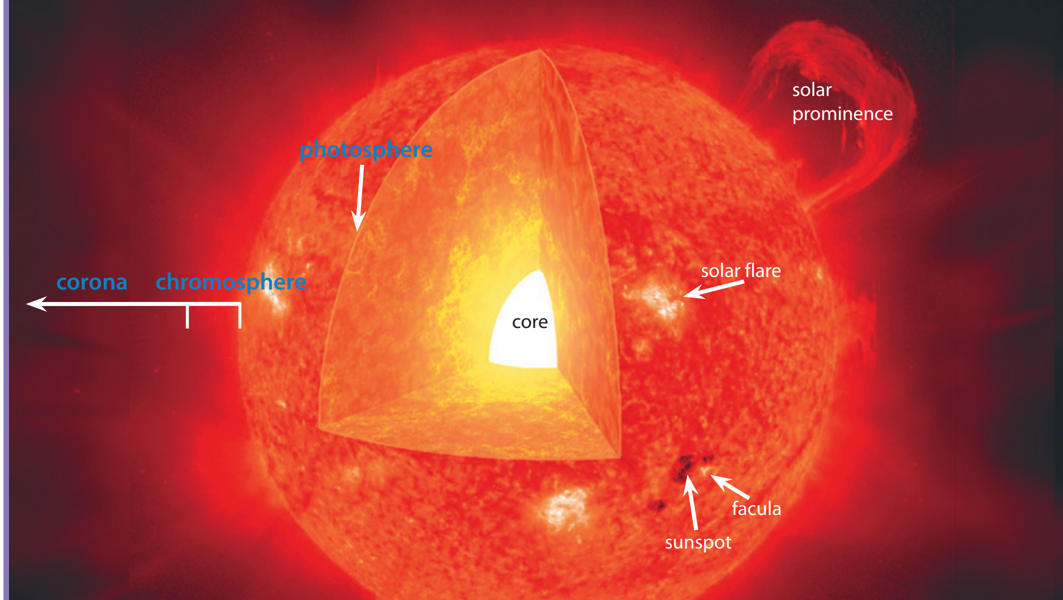
The Sun

Near the edge of the Milky Way shines an average-sized star that has far from average importance. This star, our sun, is the center of our solar system. If God removed the sun, there would be no life on Earth. Our heat, light, nourishment, and climate are all dependent on the sun.

The sun is the only star in the universe close enough for us to study. It is about 150,000,000 km (93,000,000 mi) from Earth. It takes less than eight and a half minutes for light from the sun to reach Earth. Even at this distance, the sun is so powerful that it can burn your skin, and it can damage your eyes if you look directly at it.

Parts of the Sun

The surface of the sun is called the **photosphere**. Because of Earth's great distance from the sun, the photosphere appears smooth to us. However, it is actually bumpy and in constant motion. Gases move up from the interior of the sun and create bulges on the surface like the surface of a pot of boiling water. Above the sun's surface is its atmosphere, called the **chromosphere**. The **corona** is the outermost part of the sun. Located above the sun's chromosphere, the corona can be seen only during a solar eclipse or by special astronomical instruments. The corona is sometimes called "the crown" of the sun.



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SCIENCE BACKGROUND

Sunspots and solar flares

The number of sunspots that occur on the sun appear to have a cycle of about eleven years.

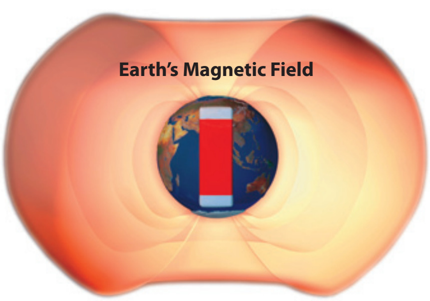
A sunspot is actually many times larger than Earth.

Solar flares release more energy than millions of atomic bombs.

Solar Storms

Just as Earth has storms, the sun also has storms. But these storms do not involve lightning or rain. The storms on the sun are magnetic storms. They can affect life on Earth by disrupting communications satellites and GPS (Global Positioning System) navigation signals. The storms seem to be related to dark spots on the photosphere of the sun, called **sunspots**. Astronomers believe that these spots look dark because they are cooler than the surrounding gases. Sunspots are usually accompanied by **faculae** (FAK yuh lee), bright clouds of gas on the photosphere.

Solar storms may also explode from the sun's photosphere, creating **solar flares**. These flares become twenty to thirty times brighter than the rest of the sun and then fade away in about one hour. An even more spectacular solar event is a **solar prominence**. Solar prominences are huge streams of gas that extend out past the sun's chromosphere and into the sun's corona. Unlike a solar flare, a solar prominence can last for days or even weeks.



aurora

A **solar wind** is made up of electrically charged particles from the sun. Solar storms may cause an increase in the flow of these charged particles. The solar wind carries these particles from the sun to Earth's atmosphere. Earth's magnetic field traps some of the particles and pulls them toward Earth's poles. As the particles collide with atoms and molecules in Earth's atmosphere, they emit energy in the form of beautiful colors of light. People near the North and South Poles are able to view this beautiful light show, called an **aurora** (uh RAWR uh). Near the North Pole an aurora is called *aurora borealis*, or the *northern lights*. An aurora that occurs near the South Pole is called *aurora australis*.

Photosphere
The surface of the sun is called the photosphere. The Greek root *photo* means "light," and the word *sphere* refers to the visible circle of the sun. The photosphere is the source of the sun's light.

Aurora terms
Aurora is the Latin word for dawn. *Borealis* is the Latin word for "northern." *Australis* is the Latin word for "southern."

Why do you think the aurora near the South Pole is called the *aurora australis*? Possible answer: *Australis* means "southern," and this aurora appears in the Southern Hemisphere.

Calculate the speed of light
The sun is 150,000,000 km from Earth.

If it takes 8.3 minutes for the sun's light to reach Earth, how many km per minute is the light traveling? 18,072,289.16 km/min

Calculate the km/min: 150,000,000 km ÷ 8.3 min = 18,072,289.16 km/min.

How many km per second is the light traveling? 301,204.82 km/sec

First calculate the number of seconds in 8.3 min: 8.3 min × 60 = 498 sec. Then calculate the km/sec: 150,000,000 km ÷ 498 sec = 301,204.82 km/sec

Round 301,204.82 km/sec to 300,000 km/sec. This is the generally accepted number for the speed of light. In the field of astronomy and space exploration, the speed of light is a very important concept.

Discussion

Refer to the diagram as each part and feature of the sun is discussed.

What is the surface of the sun called? the photosphere

What is the sun's atmosphere called? the chromosphere

Where is the sun's corona? It is the outermost part of the sun located above the sun's chromosphere.

When can scientists see the corona of the sun? during a total eclipse or when using special astronomical instruments

What kind of storms does the sun have? magnetic storms

What are sunspots? dark spots on the sun's surface

What are the bright clouds of gas around sunspots called? faculae

What is a solar flare? an explosion of a solar storm on the sun's photosphere

Which extends out farther and lasts longer—a solar flare or a solar prominence? a solar prominence

What is a solar wind made of? electrically charged particles

What is seen when these particles collide with atoms and molecules in Earth's atmosphere? an aurora

What is an aurora? energy emitted in the form of beautiful colors

What is another name for an aurora that occurs near the North Pole? aurora borealis, or the northern lights

Why do auroras occur only near the poles? Earth's magnetic field traps some of the particles from the solar wind and pulls them toward Earth at the poles.

Discussion

How can the sun hold the entire solar system in orbit around itself? The sun's huge mass exerts a strong gravitational pull. God created the balance between the sun's gravitational pull and the speed of each planet.

Why are planets closer to the sun at some times and farther away at other times? They have elliptical orbits.

What shape is an ellipse? oval

What is a revolution? one complete orbit that a planet makes around the sun

What makes one year for a planet? one complete trip around the sun; a revolution around the sun

Is the revolution period (year) for each planet the same? no **Why?** The length of time it takes for each planet to go around the sun is different because they move at different speeds through orbits of different lengths.

What is an axis? an imaginary line around which a planet rotates

What is a complete rotation called? a day

What is a hemisphere on Earth? half the Earth

Point out the Northern and Southern Hemispheres on the globe.

What determines the seasons on Earth? the tilt of Earth during its revolution around the sun

Illustrate the tilt of the earth. Draw a vertical line for display. Mark a point near the center of the line. Place a protractor on the right side of the line and measure 23.5° from the top. Draw a second line in a different color that intersects the first line through the center point at 23.5°. This second line illustrates the tilt of the Earth.

The Seasons

The sun contains over 98 percent of the mass of the entire solar system. Its huge mass exerts such a strong gravitational pull that it keeps the planets in orbit around it.

When God created the universe, He set everything in motion. The speed of each planet in our solar system balances the gravitational pull of the sun. The planets stay in regular orbits because of this perfect balance. Each orbit that a planet makes around the sun is called a **revolution**, or year. Because the planets' orbits are elliptical instead of circular, there are certain times in each planet's revolution when it is closer to the sun.

Most areas of the earth have seasonal changes of temperature and light. A common misconception is that the seasons change depending on how close or far away from the sun the earth is in its elliptical orbit. If that were true, people in the Northern and Southern Hemispheres would experience the same seasons at the same time. However, we know that they do not. So what does cause Earth's seasons?

Like the other planets, Earth rotates on an axis. The **axis** is an imaginary line around which a planet rotates. Each complete **rotation** around the axis is a day. Earth's axis, however, is not straight up and down. It is tilted 23½ degrees from the vertical. The four seasons on Earth are determined by Earth's tilt during its revolution around the sun. As Earth travels around the sun, sometimes the Northern Hemisphere tilts toward the sun. At other times the Southern Hemisphere points toward the sun. The hemisphere pointing toward the sun receives the most direct sunlight and experiences summer. The day it receives the most direct sunlight is the longest day of the year in that hemisphere and is called the *summer solstice* (SOHL stis). The *winter solstice* is the shortest day of the year for that hemisphere.

Between summer and winter are autumn and spring, which bring milder temperatures. During these seasons, neither hemisphere points directly toward or away from the sun. Both hemispheres receive about the same amount of sunlight, and day and night are of about equal length in all parts of the world. The beginnings of these two seasons are called the *vernal equinox* (VUR-nul EE-kwuh-nahks) and the *autumnal equinox* (ah-TUM-nul EE-kwuh-nahks). The word *equinox* comes from Latin. *Equi* means "equal," and *nox* means "night," so *equinox* refers to the equal length of day and night.

QUICK CHECK

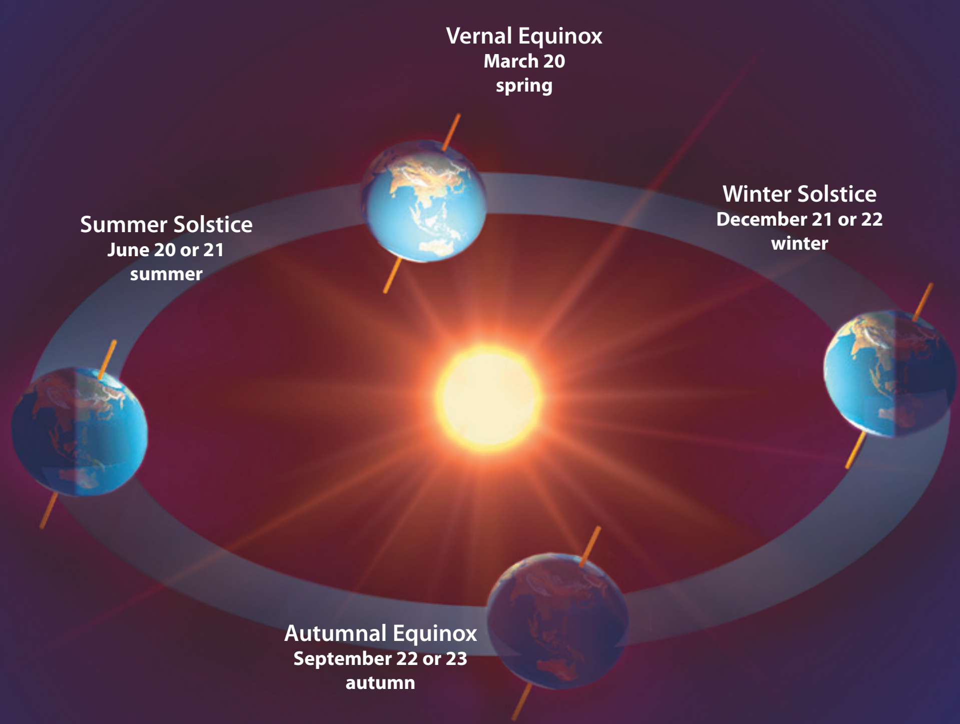
1. How far is the sun from Earth? How long does it take the sun's light to reach Earth?
2. What characteristic of Earth determines the seasons?
3. What is the difference between a planet's rotation and its revolution?

SCIENCE MISCONCEPTIONS

The seasons are not caused by how close to or far away the Earth is from the sun.

The Seasons

(Northern Hemisphere)



Discussion

Discuss *The Seasons* diagram.

When does a hemisphere receive the most direct sunlight and have the longest day? at the summer solstice

What is the shortest day in a hemisphere? the winter solstice

When the Northern Hemisphere is tilted toward the sun, which season does it experience? summer

Which season does the Southern Hemisphere experience while the Northern Hemisphere is experiencing summer? winter **How can you tell?** It is not receiving the most direct sunlight.

How does the amount of daylight and darkness change as the Northern Hemisphere approaches its summer solstice? The days become longer and the nights become shorter.

What happens at the South Pole during its summer solstice? The sun shines all day and all night, so there is no darkness. **What happens during its winter solstice?** There is no daylight.

What is the beginning of spring? the vernal equinox **The beginning of autumn?** the autumnal equinox

What does equinox refer to? an equal length of day and night

Why does the equator always experience warm temperatures? It always receives direct sunlight.

Answers

1. 150,000,000 km or 93,000,000 mi; less than 8½ minutes
2. the tilt of Earth as it revolves around the sun
3. Rotation is the planet's spin on its axis. Revolution is the planet's orbit around the sun.

Activity Manual

Review, pages 177–78

These pages review Lessons 127 and 130.

Assessment

Quiz 11-A

The quiz may be given any time after completion of this lesson.

DIRECT A DEMONSTRATION

Demonstrate seasons

Materials: lamp with its shade removed, globe

Position the lamp on a desk and darken the room. Hold the globe about 1 m from the lamp at the same level as the bulb. Walk around the lamp. Keep the tilt of the globe the same at all times. Stop the globe in the positions of the summer and winter solstices and of the vernal and autumnal equinoxes.

Why is the temperature always hot at the equator? Why are the Poles always cold? Because of Earth's tilt, the equator always receives direct light from the sun, but the poles do not receive direct light.

Position the globe so the United States is experiencing summer.

Which of the following countries experience summer at the same time as the United States? Argentina? no **France?** yes **China?** yes **Australia?** no

If desired, hold the globe close to the bulb long enough for the globe to feel warm where the light hits it the most.

Lesson
131

Student Text pages 272–75
Activity Manual pages 179–80

Objectives
- Describe similarities among the inner planets
- Summarize how people have gradually learned about the planets
- Identify characteristics of Mercury, Venus, and Mars

Materials
- picture of the solar system

Vocabulary
terrestrial planet
gas giant
planet

Introduction

Display the picture of the solar system. Briefly discuss student ideas.

Have you ever wondered what it would be like to visit one of the other planets in our solar system?

If you were able to get there, could you survive? What adjustments would you need to make to survive?

Teach for Understanding

Purpose for reading

How are the inner planets similar?

What has man used to learn about the planets?

Discussion

Which planets are called the inner planets? Mercury, Venus, Earth, Mars

What does *terrestrial* mean? Elicit that it means relating to Earth and its inhabitants.

Why are the inner planets known as terrestrial planets? They are rocky, dense, and Earthlike in composition.

Do you think it is noteworthy that Earth is the only inner planet that is not full of craters? Explain your answer. Accept any answer, but elicit that it is another evidence of God's design in setting Earth apart as the home for people. **[Bible Promise: I. God as Master]**

Which space bodies exist between Mars and Jupiter? asteroids

What is this area called? an asteroid belt

Which planets are called the outer planets? Jupiter, Saturn, Uranus, Neptune

Why are the outer planets called gas giants? Possible answers: their surfaces are made of gases; each of these planets is made mostly of gases; they are massive in size

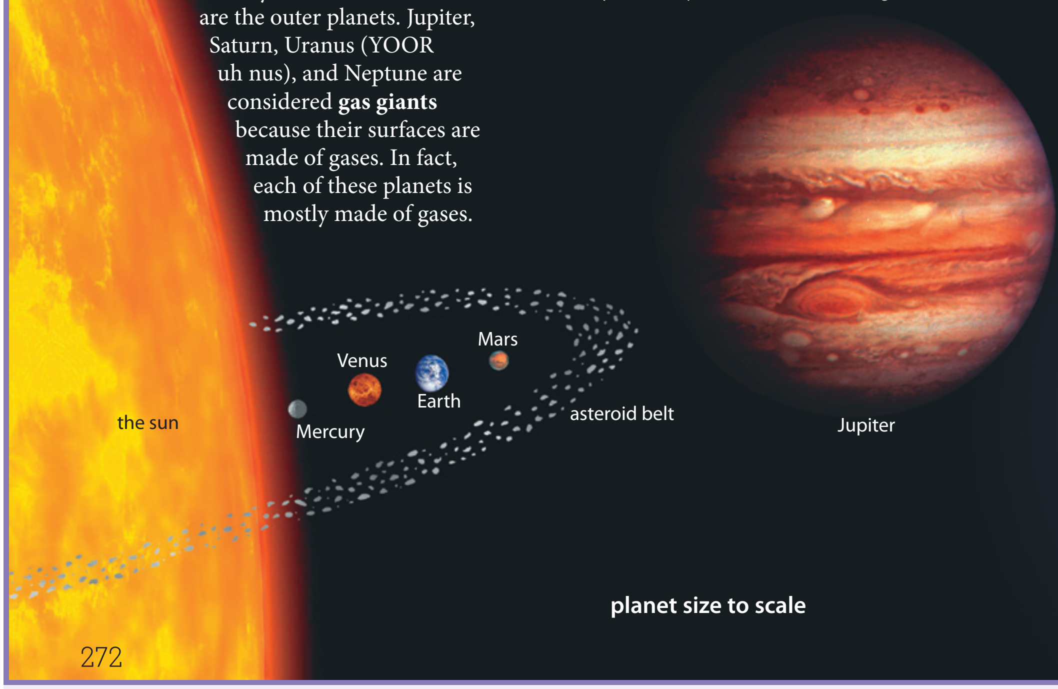
What lies beyond Neptune? an area called the Kuiper Belt, which is full of small, icy objects

The Planets

Eight planets revolve around our sun. We call Mercury, Venus, Earth, and Mars the inner planets because they are closest to the sun. These four planets are also known as the **terrestrial planets** because they are rocky, dense, and Earthlike in composition. These planets are small, solid, and relatively close together. All except Earth are covered with craters. An observer on Earth can see Mercury, Venus, and Mars in the night sky without a telescope.

Between Mars and Jupiter is an area full of thousands of asteroids. This area is called an *asteroid belt*. Beyond the asteroid belt are the outer planets. Jupiter, Saturn, Uranus (YOOR uh nus), and Neptune are considered **gas giants** because their surfaces are made of gases. In fact, each of these planets is mostly made of gases. Only the planet's core might be solid. These planets are massive compared to the inner planets. They are also far away from each other. The distance between any two of the gas giants is greater than the distance between the sun and Mars.

Beyond Neptune is an area called the *Kuiper* (KY pur) *Belt*. This area is full of small, icy objects. One of these objects is Pluto. Pluto was considered to be a planet for many years. But then scientists discovered many other planet-like objects. As scientists discovered more objects, they began to question what a planet really was. In 2006 the International Astronomical Union (IAU) met to settle on definitions and classifications for planets and other solar system objects. At this meeting,



planet size to scale

272

SCIENCE BACKGROUND

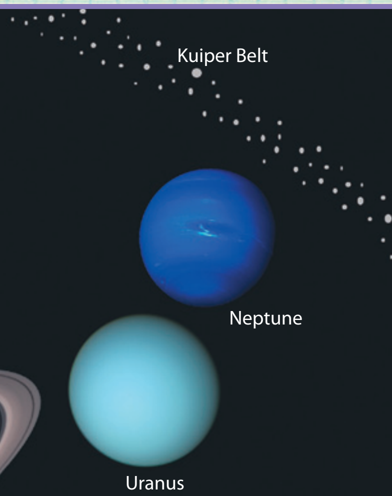
Point of reference
Often a person uses a point, or frame, of reference to relate new information to something familiar. Since we have a good understanding of Earth measurements such as days and years, these Earth measurements are used as reference points to help us understand the rotations and orbits of the other planets.

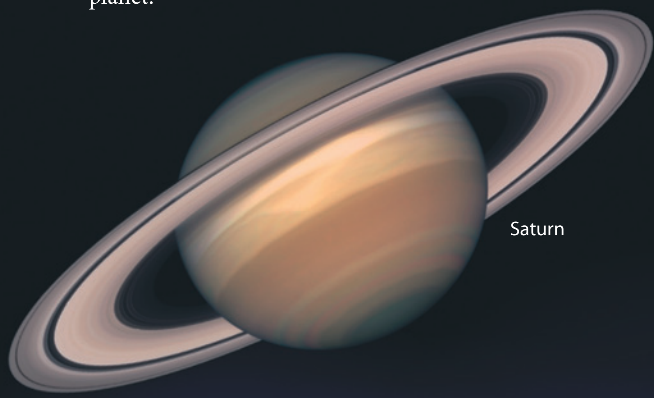
LANGUAGE

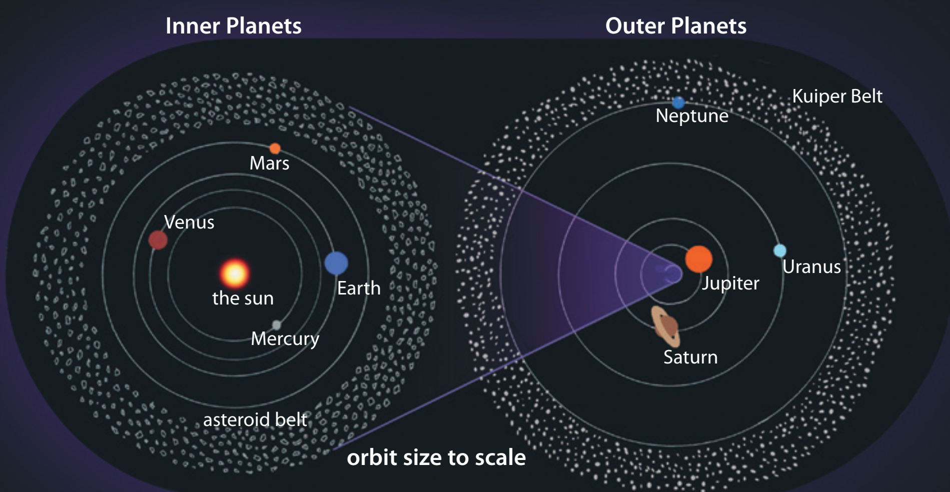
Memory helps
Use a sentence to help the student remember the order of the planets. Use the first letter of each planet as the first letter of each word in the sentence.

Example: My very educated mother just served us nachos.

scientists defined a **planet** as an object in the solar system that orbits the sun and is big enough for its own gravity to keep it in the shape of a sphere. It also does not share the space of its orbit with any other object of significant size, other than moons. Based on the new definition, Pluto is no longer considered a planet. It is now classified as a dwarf planet.







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Discussion

What is a well-known object in the Kuiper Belt? Pluto

How was Pluto formerly classified? as a planet

What happened that caused scientists to question whether Pluto should be considered a planet? Many other planet-like objects were discovered.

What is the International Astronomical Union? a group of scientists who study the skies

How did these scientists define a planet? A planet is an object that orbits the sun, is big enough for its own gravity to keep it in the shape of a sphere, and does not share the space of its orbit with any other object of significant size, other than moons.

What is Pluto now classified as? a dwarf planet

Discuss the planet size and orbit size diagrams.

What does “planet size to scale” mean? In this diagram, the relative sizes of the planets are accurate in comparison to each other although the pictured planets are much smaller than the real ones.

On the planet size diagram, compare the sizes of Mars and Uranus. Then compare those same planets on the orbit size diagram. Why do the sizes of Mars and Uranus look similar on the orbit size diagram? The orbit size diagram shows the size of their orbits as compared to each other and does not show the size of the planets.

Why are there lines on the orbit size diagram going from the edge of the asteroid belt of the Inner Planets into the small center circle of the Outer Planets? to indicate that all of the inner planets’ orbits and the asteroid belt would fit into that small space when compared to the orbit sizes of the outer planets

As time allows, continue asking questions about the diagrams.

TEACHER HELPS

Scales

If the student completed the exploration “A Different Look” in Chapter 10, remind him that the distances of the foil stars were a scale model of the distances of real stars.

The sizes of the sun and planets illustrated in the Student Text are to scale, but the distances between the planets are not to scale. In the diagram of the orbits, the distances are to scale, but the sizes of the sun and planets are not to scale.

LANGUAGE

Terra

The word *terra* is Latin, meaning “land.”

Name other words that contain *terra*. Possible answers: extraterrestrial, terra cotta, territory, terrain

Discussion

Use Activity Manual page 179 during the discussion.

What influences the gravitational pull of an object? its mass

How does Mercury's size compare with the sizes of the other planets? It is the smallest planet.

How does Mercury's size compare with the size of Earth? It is one-third the size of Earth.

Why can't Mercury hold an atmosphere? Mercury has a weak gravitational field because of its small mass.

Why do you think Mercury has so many craters? Possible answers: It has no atmosphere to burn meteors before they hit the planet. The gravity of the sun may pull more space objects toward Mercury.

Why does Mercury have the shortest year in our solar system? It is closest to the sun, so its orbit is smaller than those of the other planets.

Why was Venus called the "Morning Star" and also the "Evening Star"? People thought it was actually two different stars that shone brightly in the morning and in the evening.

Why is Venus considered Earth's twin? It is almost the same size as Earth. It is the closest planet to Earth. Both planets are similar distances from the sun.

In which ways is Venus a hostile environment for humans? Possible answers: The temperatures are too hot for humans to survive. The density of the air would crush humans.

Retrograde means "moving backward."

What does it mean that Venus has "retrograde rotation?" The planet rotates from east to west, which is the opposite of Earth's rotation.

Why did scientists have a hard time gathering data about Venus? Its thick cloud cover prevented observation.

How did scientists eventually find out more about Venus? Space probes such as *Mariner 2*, *Magellan*, and *Venera* penetrated the cloud cover.

The Inner Planets

Mercury: the planet closest to the sun

Mercury is the planet closest to the sun. It can often be seen near the horizon before sunrise and after sunset. Mercury is the smallest planet, about one third the size of Earth. Because of its small size, Mercury has a weak gravitational field and therefore cannot hold an atmosphere.

The temperature on Mercury varies greatly. It reaches more than 400°C (800°F) on the side facing the sun and drops to as low as –190°C (–300°F) on the side facing away from the sun.

Mercury has the shortest year in the solar system. It takes eighty-eight Earth days for Mercury to revolve around the sun. However, it has a very long "day." It takes fifty-nine Earth days for Mercury to rotate on its axis one time.

During 1974 and 1975, cameras onboard the probe *Mariner 10* took the first clear pictures of Mercury. These pictures revealed a barren world scarred by craters, similar to Earth's moon.

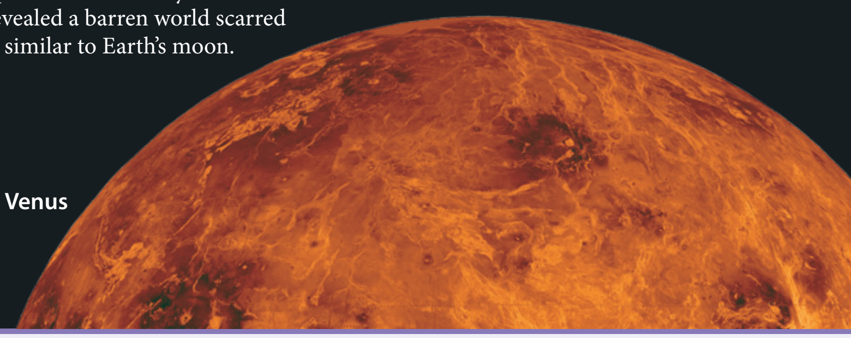
Venus: the Evening Star

Venus is the brightest object in the morning and evening sky because its thick cloud covering reflects sunlight well. Centuries ago observers thought that Venus was actually two separate stars, and they called it "The Morning Star" and "The Evening Star."

Venus is sometimes referred to as Earth's twin. The two planets are almost the same size and are similar distances from the sun. Venus is also the closest planet to Earth. However, the two planets are actually very different.

Venus would not be a friendly place for human visitors. Its atmosphere is 96 percent carbon dioxide. Carbon dioxide traps the sun's heat, similar to the way in which a car with its windows rolled up on a hot day traps heat. In fact, even though Mercury is closer to the sun, the thick cloud that covers Venus causes it to be hotter than Mercury. Temperatures on Venus reach 460°C (860°F)—hot enough to melt lead! Venus also has an atmosphere so dense that it would crush a person in just a few seconds.

Unlike most of the planets, Venus has a retrograde rotation. It rotates from east to west instead of west to



COMPLETE THE PAGE

Activity Manual page 179

You may choose to have the student complete this while he reads the pages or during the discussion of the pages.

DIRECT AN ACTIVITY

Use a graphic organizer to make comparisons

Draw a Venn diagram with two intersecting ovals. (A blank Venn diagram is included on the Teacher's Toolkit CD.) Direct the student to label one outer section *Earth* and the other outer section *Venus*. List differences of Earth and Venus in each corresponding section. List any similarities of Earth and Venus in the center overlapping section. Direct the student to make another Venn diagram to compare and contrast Earth and Mars.

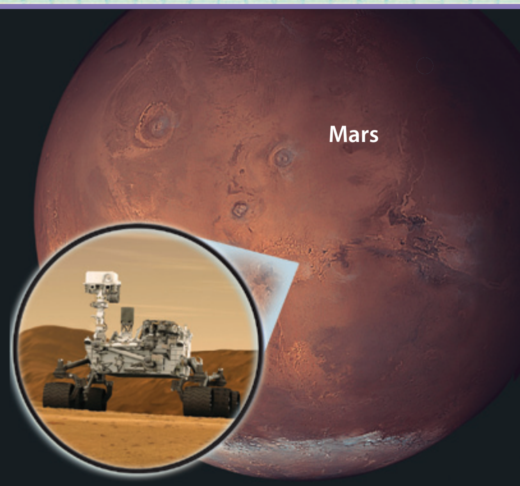
east as Earth does. Venus's period of rotation and revolution are almost the same. A year on Venus is equal to 224.7 Earth days, and a day on Venus is equal to 243 Earth days.

Little was known about Venus's atmosphere and surface until spacecraft penetrated its thick cloud cover. But since Venus is so close to Earth, many space probes, such as *Mariner 2*, *Magellan*, and *Venera*, have visited the planet.

Mars: the red planet

Earth is the third planet from the sun. The fourth planet, Mars, is the last of the inner planets. Though it is smaller than Earth, Mars is the planet most like Earth. Mars has a tilt similar to Earth's, so it also experiences seasonal changes. Its polar ice caps grow and shrink, depending on the season. Because of its thin atmosphere and distance from the sun, Mars is very cold, having an average temperature of −63°C (−81°F). But on a sunny summer day it might reach 30°C (86°F). Unlike Earth's nitrogen and oxygen atmosphere, Mars's atmosphere is mainly carbon dioxide.

One of the brightest objects in the night sky, Mars is visibly red. Iron oxide, or rust, in its soil causes its rusty color. Although Mars is dry like a desert, it has some land features that cause some scientists to believe Mars might have had liquid water at one time. Currently scientists suspect the presence of liquid and frozen water under the surface of Mars.



Curiosity on Mars

A day on Mars is twenty four and a half Earth hours—almost the same length as an Earth day. A year on Mars, however, is about 687 Earth days, almost twice as long as an Earth year.

Because Mars is more like our own planet than any other, the idea that life might exist on the planet has fascinated people for centuries. Several rovers landed on Mars and studied many different things. The Mars rovers *Spirit* and *Opportunity* sent back many photos since landing on Mars in 2004. None of these probes have found evidence of any type of life, past or present, on the planet.

QUICK CHECK

1. Name the planets, starting closest to the sun and moving outward.
2. How is Mars like Earth?

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SCIENTIST

Percival Lowell (1855–1916)
Percival Lowell, an amateur astronomer, spent much of his life trying to prove that there was intelligent life on Mars. Through a telescope he observed lines on the planet and interpreted them to be canals built by intelligent life. He further believed that dark patches on the planet were areas of vegetation and lighter patches were deserts. Lowell published several books and convinced many people that life did indeed exist on Mars.

HISTORY

Radio drama
Lowell's theory became so widespread that it became the theme of books and other forms of entertainment. In 1938 actor Orson Welles presented a radio drama that included a news report that Martians had invaded Earth. Many people who heard the drama thought it was a real news report. Panic spread quickly, and many people locked themselves into their houses or fled for cover.

DIRECT AN ACTIVITY

Examine space discoveries
Provide time for the student to research the findings of a Mars or other space exploration mission. Create a chart to compare and interpret the findings from a Christian worldview. Use the chart to discuss questions such as, "If water is found, does that definitely mean life existed there in the past?"

Discussion

Which planet is the fourth from the sun? Mars

How is Mars like Earth? Possible answers: It has a similar tilt, experiences seasons, has an atmosphere, and has days of about the same length.

Why does Mars have seasonal changes? It has a tilt similar to Earth's tilt.

What happens to the polar ice caps on Mars as a result of its seasons? They grow and shrink.

What causes Mars to be cold? its thin atmosphere and distance from the sun

Could you survive the temperature on Mars? Answers will vary. Elicit that the temperature on Mars is sometimes comfortable, but not usually.

Could you live by breathing the air on Mars? no **Why?** The air on Mars is mostly carbon dioxide. Humans need oxygen to live.

Why is Mars red? Iron oxide in the planet's soil causes the planet to be red.

What has caused people to think that Mars may have had liquid water? certain land features

What kinds of land features do you think might give scientists that idea? Accept any reasonable answers. Guide the student to recall information about weathering and erosion from Chapter 2.

The length of a day on Mars is almost the same as Earth's. How is its year different? A year on Mars is almost twice as long as a year on Earth.

Why would Mars have a longer year? It is farther from the sun.

Why have people wondered whether life might exist on Mars? Mars is the planet most like Earth.

The rover *Curiosity* landed on Mars in August 2012. It is the first nuclear-powered rover. *Spirit* and *Opportunity* were solar powered.

Use Direct an Activity to discuss space exploration from a Christian worldview.

Answers

1. Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune
2. Possible answers: similar tilt; experiences seasons; has an atmosphere; days are about the same length

Activity Manual

Reinforcement, pages 179–80

These pages are also used in Lessons 132 and 134.

Lesson 132

Student Text pages 276–79
Activity Manual pages 179–82

Objectives

- Explain some ways God made Earth unique
- Describe why the same side of the moon always faces Earth
- Restate details about the *Apollo 11* mission
- Describe the causes of solar and lunar eclipses

Vocabulary

solar eclipse
totality
lunar eclipse

Introduction

Which planet do we live on? Earth

What does the Bible tell us about the origin of Earth? that God created it

In this lesson we will notice how Earth's design is evidence of God's care for us.

Teach for Understanding

Purpose for reading

How is the moon different from Earth?

In what positions do the earth, moon, and sun have to be for a solar eclipse or a lunar eclipse to happen?

Discussion

Use Activity Manual page 179 during the discussion.

In what ways is Earth unique? It is the only planet where people can survive in their natural state. The temperatures are neither too hot nor too cold for people to survive. It is the only planet where water exists in liquid form on the surface.

What can we learn about God by observing the uniqueness of Earth? Answers will vary, but elicit that Earth demonstrates God's care for us in providing Earth for our use.

How often does Earth rotate? once every 24 hours

Why is this rotation important? It allows the atmosphere and surface of Earth to receive adequate heating and cooling to maintain an overall moderate climate.

How long is Earth's revolution? 365 ¼ days

What is a leap year? every fourth year, in which an extra day is added to catch the calendar up with Earth's revolution

What are the benefits of Earth's atmosphere? Earth's atmosphere helps maintain the sun's warmth, filters the sun's harmful rays, and protects Earth from meteorites.

Earth

Earth: home sweet home

Earth also is an inner planet, situated between Venus and Mars in its orbit around the sun. Of all the planets, God made Earth unique. We know that God created the other planets too, but Earth is where He put man. Earth is special because it is the only planet on which man can survive in his natural state.

God has placed Earth at the perfect distance from the sun, neither so close that it is too hot nor so far that it is too cold. The moderate temperature allows water to exist as a liquid. Water is essential for all life and shows another way God has planned for man's needs.

Earth rotates once every twenty-four hours. This rotation allows the atmosphere and surface of Earth to receive adequate heating and cooling each day to maintain Earth's overall moderate climate. Earth orbits the sun every 365¼ days. For three of every four years, our calendars show only 365 days. Every fourth year we add an extra day, February 29, to catch the calendar up with Earth's actual revolution. We call this year with an extra day a *leap year*.

Gravity holds Earth's atmosphere in place. The atmosphere helps maintain the warmth from the sun. It also filters out the sun's harmful rays and protects us from meteors that otherwise might crash onto Earth's surface.

Evolutionists believe that Earth came into being by chance. But as we observe the intricate processes that occur only on Earth, we can see that Earth's marvelous design points to an all-powerful Creator.

The Moon

Earth has one natural satellite, the moon. Because the moon has no atmosphere, there are no sounds, no clouds, no rain, and no colors in the sky. Lack of an atmosphere also means that the moon has no protection from charged particles from the sun or from meteorites. Therefore, unlike Earth, the moon is full of craters. Most meteors burn up in Earth's atmosphere without hitting Earth's surface, but the moon has no protection from them.

The moon rotates once on its axis as it makes one revolution around

the moon

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COMPLETE THE PAGE

Activity Manual page 179
You may choose to have the student complete this as he reads the pages or during the discussion of the pages.

SCIENCE BACKGROUND

Natural satellites
The moon is Earth's one natural satellite. Many planets have one or more natural satellites orbiting around them. The word *moon* has come to be used in place of the words *natural satellite*. Astronomers often use these words interchangeably.

Earth's atmosphere
The atmosphere is more than just a layer of gases surrounding the earth. It is a moving source of life for all creatures. It also protects us from the vacuum of space. Without the atmosphere, our world would be as barren and dead as the moon or Mercury.

Moon's atmosphere
Since the moon has weak gravity, it has a thin atmosphere. However, the gases needed for life are not present in the required amounts.

Moon exploration
Even though no person has traveled to the moon since 1972, the moon is still being studied and explored. Instruments left on the moon by the Apollo missions continue to collect information about the moon such as moonquakes and heat flow. Two probes, *Ebb* and *Flow* were sent to the moon in September 2011 to map the moon's gravity.

Earth. Consequently, the same side of the moon always faces Earth. Until man began sending spacecraft to the moon, observers wondered whether the back side would be different from the front side. When astronauts finally circled the moon, they discovered that the back side of the moon is similar to the side we see.

The moon does not give off its own light. Instead, it reflects the light from the sun. The moon appears to change shape as different areas of its surface are lighted by the sun. We call this the changing phases of the moon. The moon takes about twenty-nine and a half days to pass from one new moon to the next.

FANTASTIC FACTS

Have you ever heard of someone being called "loony"? The word loony is a shortened form of the word *lunatic*, which comes from *luna*, the Latin word for moon. The phases of the moon were believed to influence people's behavior, so some people who acted strangely during a full moon were called lunatics.

DIRECT A DEMONSTRATION

Demonstrate why the same side of the moon always faces Earth

Materials: globe

Place a globe or another object representing Earth in the center of the room. Direct a student to use his body to represent the moon. Tell him to walk around "Earth" but keep the front of his body toward "Earth" at all times. Point out that during his revolution around Earth, he also rotates once in relationship to the room. His revolution around Earth and his rotation occurred at the same rate, which kept the same side of the moon facing Earth at all times.

Discussion

What is a satellite? any object that orbits around another object

How does the lack of an atmosphere cause the moon to be different from the earth? It has no sounds, no clouds, no rain, no colors, no protection from charged particles from the sun or meteorites, causing it to have many craters.

Why was space travel necessary to determine what is on the backside of the moon? The moon's rotation and revolution are the same, so the same side of the moon always faces Earth.

Why does the moon appear to have light? It reflects light from the sun.

How long does it take for the moon to pass from one new moon to the next? 29½ days

What causes the phases of the moon? Different areas of the moon are lighted by the sun at different times.

Look at the Phases of the moon diagram. Give the meaning of the following words. Possible answers: **waning:** becoming smaller; **gibbous:** more than half of the moon is showing; **crescent:** less than half of the moon is showing

Discuss *Fantastic Facts*.

Where does the word *loony* come from? It is a shortened form of *lunatic*, which is from *luna*, the Latin word for *moon*.

Why were people sometimes called lunatics? It was believed that the phases of the moon affected people's behavior, so if someone acted strangely during a full moon, he was called a lunatic.

Discussion

Which president issued a challenge to put a man on the moon? President John F. Kennedy

What name was given to the project to put an American on the moon? Project Apollo

In what year was the first moon landing? 1969

Who were the astronauts on board *Apollo 11*? Neil Armstrong, "Buzz" Aldrin, and Michael Collins

How many days did it take to reach the moon? 3

Discuss the lunar module photo.

What was the lunar landing module? the spacecraft that actually landed on the moon

The command module orbited the moon while Neil Armstrong and Buzz Aldrin were on the moon.

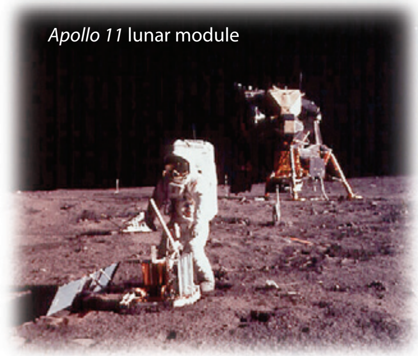
Why did the astronauts need protective space suits? Possible answers: The moon has no air for men to breathe. The thin atmosphere means there is no protection from the harmful rays of the sun.

What now-famous statement did Neil Armstrong make as he stepped onto the moon? "That's one small step for man, one giant leap for mankind."

What did Armstrong mean by that statement? Accept any answer, but elicit that his first step on the moon demonstrated that man was making great strides in science by successfully putting a man on the moon.

How many more moon landings were made by the United States? 6

Why do you think astronauts brought back the rocks, pebbles, dust, and sand? Answers will vary. Elicit that scientists wanted to analyze objects from the moon.



Apollo 11 lunar module

Project Apollo

In May of 1961, President John F. Kennedy issued a challenge to the American people to put a man on the moon before the end of that decade. Project Apollo was begun to accomplish that mission. Eight years later, the United States was ready to send a man to the moon on the *Apollo 11* mission.

On July 16, 1969, Neil Armstrong, Edwin E. ("Buzz") Aldrin, and Michael Collins left the earth aboard *Apollo 11*. Neil Armstrong commanded the mission. The pilot of the lunar landing module was Buzz Aldrin. Michael Collins piloted the command module.

The three-stage rocket took three days to reach the moon. As the lunar module approached the moon, Armstrong looked for a safe landing spot. When the lunar module was nearly out of fuel, Aldrin called out how many seconds of fuel were left. Armstrong finally found a landing spot, and they landed with fuel left for only twenty seconds.

The astronauts waited for the moon dust to settle before they opened the hatch. Clad in a protective spacesuit, Neil Armstrong went down the ladder first. As he stepped from the landing pad onto the moon's surface, he said, "That's one small step for man, one giant leap for mankind." Buzz Aldrin soon joined his fellow crewman.

Armstrong and Aldrin had only about two hours to complete their work on the moon, but they took time to set up cameras so TV viewers on Earth could watch. They also set up an American flag. Aldrin stood at attention beside it while Armstrong took his picture. The men collected two cases of moon rocks and dust and set up several experiments. They left a plaque that read

> "Here men from the planet Earth first set foot upon the Moon, July 1969, A.D. We came in peace for all mankind."

The United States made six more moon landings between 1969 and 1972. Ten American astronauts walked on the moon. Altogether they spent seventy-nine hours working outside the landing craft. They brought back 382 kg (842 lb) of moon rocks, pebbles, dust, and sand.

Astronauts from *Apollo 11*

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Conduct an interview
WRITING
Direct the student to interview someone who was alive during the first moon landing. The student should write down the information from the interview to share with others. Some information the student could gather is as follows: memories of the first moon landing, including the person's age at the time, where he was, if he watched the landing live on television, and how he felt about humans landing on the moon. Other information the student may gather from the interview could include what the world was like at that time and any changes the person has seen since then.

Tasks of astronauts
HISTORY
Each of the three crewmen of the *Apollo 11* mission had specific jobs to do. The lunar module was the craft that landed on the moon. Both Armstrong and Aldrin left the lunar module to walk on the moon and perform the other tasks. Collins remained in orbit around the moon in the command and service modules. At the completion of the mission, all three men returned to Earth in the command module.

The phase of an eclipse when the moon appears to cover the sun completely is called a **totality**. Because the moon is relatively small, the area of Earth that will witness a total covering of the sun during an eclipse is a path averaging one hundred miles wide. The rest of the earth will see only a partial eclipse. Witnessing a totality is a very rare and special treat.

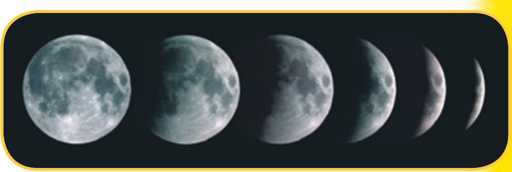
A lunar eclipse is more common than a solar eclipse. About every six months a lunar eclipse can be seen somewhere in the world. A **lunar eclipse** occurs when the moon passes through the shadow of the earth. When the moon is in totality, it reflects beautiful colors, such as violet or apricot.

Eclipses

A **solar eclipse** is a spectacular and rare event that occurs when the moon passes between Earth and the sun and casts its shadow on Earth. When we view it from Earth, the moon appears to be exactly the same size as the sun. In reality, the sun is many times larger than the moon or Earth, but since the moon is so much closer to Earth, the moon and the sun appear to be the same size. During a solar eclipse, the moon's circle covers the sun completely, leaving only the sun's corona visible. Some astronomers call it a "remarkable coincidence" that the moon when viewed from Earth appears to be exactly the same size as the sun, creating this amazing phenomenon. Of course, Christians know that it is no coincidence. Although they may not understand why, Christians recognize that this event is part of the handiwork of God and that it declares His glory.

QUICK CHECK

1. Why do we always see the same side of the moon from Earth?
2. Which *Apollo* mission was the first to land on the moon?
3. What causes a solar eclipse?



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Discussion

What causes a solar eclipse? The moon passes between Earth and the sun, causing the moon to block the sun's light.

Why can the moon, which is so small, completely hide the sun, which is so large? The moon is closer to Earth, so it appears larger than the sun.

Which part of the sun is seen around the moon during a solar eclipse? the corona

What is a totality? when the moon covers the sun completely during a solar eclipse; when Earth's shadow covers the moon completely during a lunar eclipse

How much of Earth will see a total covering of the sun during a solar eclipse? a path or area averaging about one hundred miles wide

What causes a lunar eclipse? The moon passes through the shadow of Earth.

Which is more common—a solar eclipse or a lunar eclipse? a lunar eclipse

How often do lunar eclipses occur? about once every six months

Discuss times when the student may have seen an eclipse.

Answers

1. The moon rotates once on its axis as it makes one revolution around Earth.
2. *Apollo 11*
3. The moon passes between Earth and the sun and blocks the sun's light.

Activity Manual

Reinforcement, pages 179–80

These pages are also used in Lesson 134.

Review, pages 181–82

These pages review Lessons 131 and 132.

Assessment

Quiz 11-B

The quiz may be given any time after completion of this lesson.

DIRECT AN ACTIVITY

Illustrate how the moon appears to be larger than the sun during a solar eclipse

Materials: penny for each student

Instruct each student to close one eye and hold the penny a few centimeters in front of his open eye. Tell him to look around to find an object that appears the same size as the penny and then to open both eyes and walk to the object to compare the actual size of the object with the actual size of the penny.

LANGUAGE

Memory helps

Relate the name of each eclipse with what is viewed from Earth. *Solar* means "sun." In a solar eclipse, the sun is covered. *Lunar* means "moon." In a lunar eclipse, the moon is covered.

Lesson
133

Student Text pages 280–81
Activity Manual pages 183–84

Objectives
- Construct a solar oven that will melt a marshmallow
- Infer relationships between materials used and results

Materials
- See Student Text page

Introduction

What are some things you have used to open the tight clear plastic wrapper of an item such as a CD or a toy? Possible answers: fingernails, scissors, knives, keys, pens

Objects are sometimes used in ways they were not originally intended when people creatively try to solve problems. Christians need to be creative problem-solvers in order to fulfill their purpose on Earth (Gen. 1:28).

Teach for Understanding

Purpose for reading
The student should read all the pages before beginning the activity.

Discussion
How do you think the scientists felt when faced with this seemingly impossible task? Accept any answers.

Emphasize that scientists use and build on the knowledge that they already have.

ACTIVITY

Spare Parts Solar Oven

A Successful Failure

Process Skills
- Observing
- Inferring
- Identifying variables
- Recording data

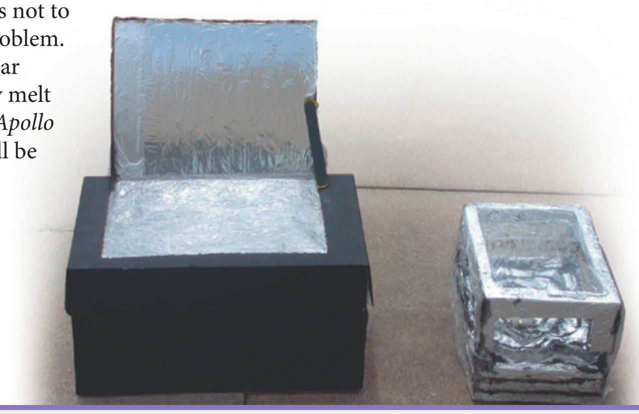
"A successful failure" is the way Jim Lovell described the *Apollo 13* mission to the moon. In 1970 Jim Lovell, Jack Swigert, and Fred Haise were headed to the moon onboard the *Apollo 13* spacecraft. Several days into their flight an accident occurred that damaged the command module and depleted much of its electricity, oxygen, water, and heat. The astronauts were forced to take refuge in the attached lunar module.

Unfortunately, the equipment in the lunar module for filtering the air was designed for only two men. It was not able to filter enough air for three men, and carbon dioxide began building up in the lunar module. The equipment in the command module was usable, but it did not fit the hookups in the lunar module. Without a creative solution to the filtering problem, the crew could not make it back to Earth alive.

The task seemed almost impossible, but the scientists at mission control on Earth were not about to give up. They collected objects that were identical to those the astronauts had on the spacecraft. Using items such as plastic bags, cardboard, and lots of duct tape, the scientists found a solution. The instructions for the device that would save the astronauts' lives were radioed to the spacecraft. The ingenious solution saved the astronauts' lives, and they returned safely to Earth.

Something from Nothing

Thankfully, your task is not to solve a life-threatening problem. Your task is to create a solar oven that will successfully melt a marshmallow. Like the *Apollo* scientists, though, you will be limited in what objects you can use. You may use only the items your teacher makes available to you.



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Scheduling
You could use the lesson day just to design and build the ovens. Incorporate the testing of the ovens and forming conclusions into another day.

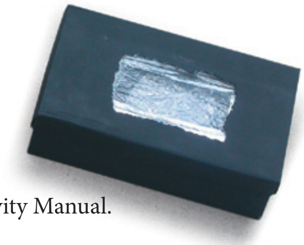
Temperatures
The ovens should reach temperatures of 200–225°F. The student can try heating other foods in the solar ovens.

This activity can be completed outside at any temperature. However, the activity takes less time when the temperature is 60°F or higher.

Boxes
Pizza boxes, shoeboxes, and copier paper boxes work well for this type of activity. Local businesses may be willing to donate boxes.

Problem

How can I create a solar oven that will melt a marshmallow?



Procedure

1. Draw your solar oven design in your Activity Manual.
2. List the materials you use.
3. Explain what features of your solar oven will help it collect heat.
4. Construct your solar oven. Be sure to leave a door or hole to insert the marshmallow if the oven is enclosed.
5. Take your solar oven outside, place a marshmallow inside, and observe.
6. Record your observations.

Materials
cardboard box
marshmallows
watch or clock
Any of the following:
- aluminum foil
- aluminum pie plate
- plastic wrap
- cardboard or card stock
- black and white paper
- black and white paint
- paper towels
- newspaper
- black trash bag
- craft sticks
- string
- scissors or craft knife
- tape
- glue
- paper fasteners
- paper clips
- paintbrushes

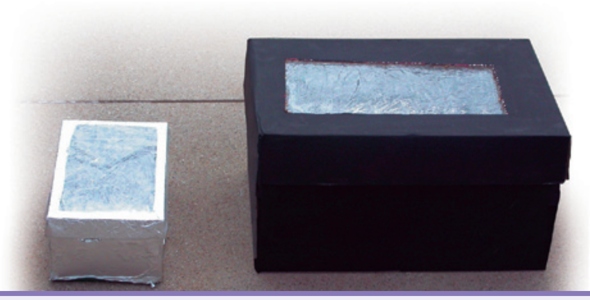
Activity Manual

Conclusions

- Was there a feature of your design that seemed to cause the solar oven to heat well?
- Was there a feature that kept the oven from working?

Follow-up

- Make improvements to your oven and test it again.
- Try heating other foods in your solar oven.



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Procedure

Provide time for the student to design and construct his solar oven. Remind the student to leave an opening for inserting the marshmallow.

As needed, discuss science principles that will help your student:

- Black absorbs light energy, and white reflects light energy.
- The direction and angle of the sun will affect the temperature inside the oven.
- A closed oven will have less air circulation and will be hotter.

Place the oven outside in a sunny spot. Allow the oven to preheat for at least 30 minutes before inserting the marshmallow.

Insert a marshmallow into the oven. Record the amount of time that it takes for the marshmallow to melt. Record any other observations made while the oven is being tested.

Conclusions

Discuss which design elements were most effective for trapping solar heat. Provide time for the student to answer the questions in his Activity Manual.

Use the questions in the Science Process Skills to discuss inferring.

Activity Manual

Activity, pages 183–84

Assessment

Rubrics

Select the prepared rubric, or design a rubric to include your chosen criteria.

WRITING

Historical drama

Direct the student to do further research on the *Apollo 13* mission and write a short play involving four characters—the three astronauts and a voice from mission control. The play should include dialogue for the four characters as the event may have occurred. Allow time for the play to be read aloud.

ART

Creative inventions

The Apollo astronauts used plastic bags, cardboard, hoses, and duct tape to make a useful device. Give the student the same objects, and encourage him to construct his own useful invention.

SCIENCE PROCESS SKILLS

Inferring

Why would someone choose to use black for the solar oven? Answers will vary. Elicit that black items tend to get hot faster and hold heat better.

Why would someone use plastic wrap and foil? Answers will vary. Elicit that it might work like a greenhouse.

What can you infer from seeing the results of the solar ovens? Answers will vary.

Lesson 134

Student Text pages 282–85
Activity Manual pages 179–80, 185

Objectives

- Identify characteristics of each of the outer planets
- Define *dwarf planet*
- Explain why Pluto is classified as a dwarf planet
- Explain how we know information about the outer planets and the Kuiper Belt

Materials

- ruler

Introduction

Describe the worst storm you have experienced. Answers will vary.

What are the names of some of the most severe types of storms on Earth? Possible answers: hurricane, typhoon, tsunami, blizzard

What are some of the conditions of these storms? Possible answers: high winds, rain, extreme temperatures

The other planets also have weather, and some even experience storms.

Teach for Understanding

Purpose for reading

How do the outer planets' days and years compare to those of Earth?

What is a dwarf planet?

Discussion

Use Activity Manual page 180 during the discussion.

What term describes Jupiter and the other outer planets? gas giants

How does the size of Jupiter compare to the sizes of the other planets in our solar system? It is the largest planet. All of the other planets could fit inside Jupiter.

What do some scientists think the Great Red Spot on Jupiter is? a huge hurricane

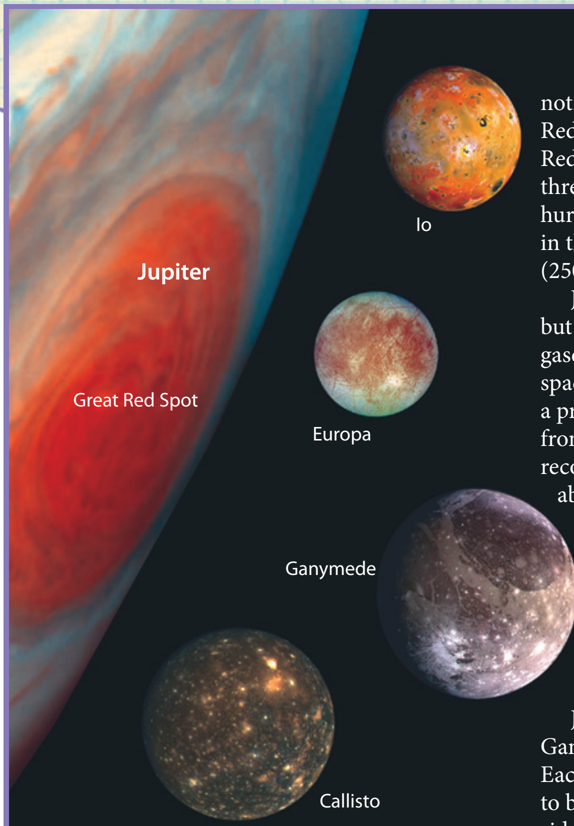
What is the surface of Jupiter like? an ocean of liquified gases

Why does this surface make Jupiter a difficult planet to explore? There is no place for a spacecraft to land.

Which probe released another probe into Jupiter's atmosphere? the probe *Galileo*

How many moons does Jupiter have? four large moons and dozens of smaller moons

Jupiter's moon Ganymede is larger than Mercury. Why is it considered a moon rather than a planet? It orbits Jupiter rather than the sun.



The Outer Planets

Jupiter: the largest planet

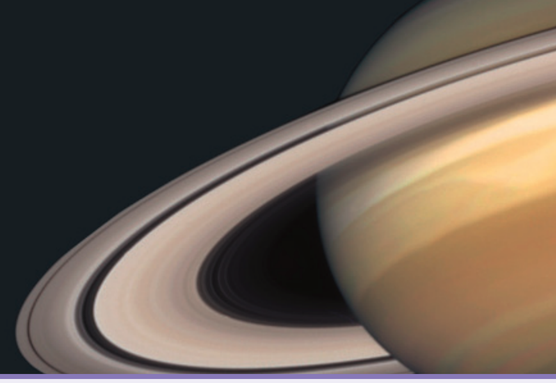
Jupiter is the fifth planet from the sun and is separated from the inner planets by a broad asteroid belt. It is the first of the gas giants. Jupiter is the largest planet in our solar system. All the other planets in the solar system could fit inside Jupiter!

Jupiter looks like a bright star when viewed without a telescope. With a telescope, you can see the most noticeable feature of Jupiter—its Great Red Spot. The football-shaped Great Red Spot is large enough to swallow three Earths. Scientists think it is a huge hurricane that blows nonstop. Winds in the Great Red Spot reach 400 km/h (250 mi/h).

Jupiter probably has a core of metal, but its surface is an ocean of liquefied gases. No solid place exists for a spacecraft to land. However, in late 1995 a probe was sent into the atmosphere from the *Galileo* space probe. It recorded and sent back information for about an hour as it dropped through Jupiter's clouds.

Compared to Earth, Jupiter has a very short day and a very long year. A day on Jupiter is equal to about ten Earth hours, and a year on Jupiter is equal to approximately twelve Earth years.

Jupiter has four large moons: Ganymede, Callisto, Io, and Europa. Each of these moons is large enough to be a planet itself, but they are considered moons because they orbit Jupiter rather than the sun. Jupiter also has dozens of smaller moons, and astronomers find more all the time.



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SCIENCE BACKGROUND

Jupiter missions

The *Galileo* mission to Jupiter ended in 2003 when scientists purposely crashed the probe into Jupiter to avoid contaminating Jupiter's moon Europa. In 2011 a new mission to Jupiter began with the launch of the probe *Juno*. *Galileo's* mission concentrated more on Jupiter's moons, but *Juno* is planned to investigate more about Jupiter. It is hoped that *Juno* will be able to measure the depth of Jupiter's Great Red Spot. *Juno* is expected to arrive at Jupiter in 2016.

HISTORY

Saturn's rings

When Galileo first observed the rings of Saturn, he thought that they looked like cup handles on both sides of the planet.

• COMPLETE • THE PAGE

Activity Manual pages 179–80

You may choose to have the student complete this as he reads the pages or during the discussion of the pages. Briefly review the information on both Activity Manual pages as you conclude the discussion about the planets.

Saturn: the ringed planet

Saturn, the sixth planet away from the sun, is the second largest planet in our solar system. It too is a gas giant, and its core and surface appear to be similar to Jupiter's.

Saturn is known as "the ringed planet" because its rings are brighter and larger than the rings of any other planet. Although Saturn's rings look like a solid band, they are actually made up of many small, frozen particles that reflect the sun's light. Saturn rotates once about every eleven Earth hours. Its revolution, however, takes almost thirty Earth years.

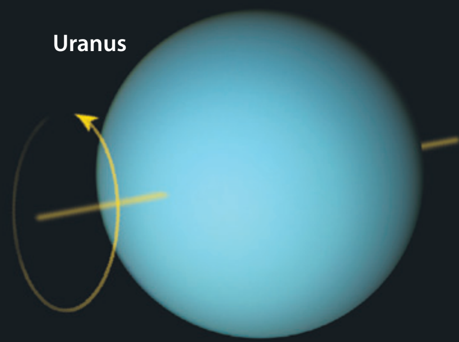
Saturn has more known moons than any other planet in our solar system. More than fifty of Saturn's moons have already been named, although many are small and have irregular shapes. Many of them were discovered or imaged by NASA's *Cassini* mission.

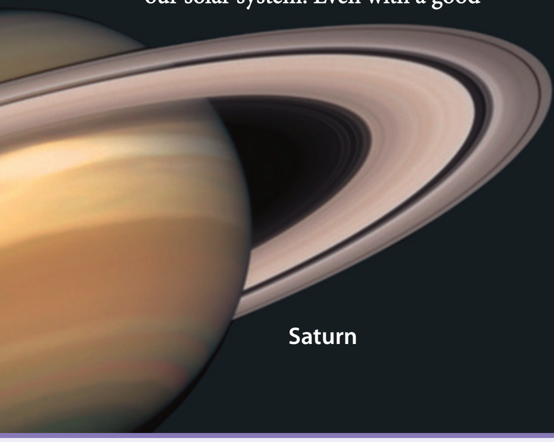
Uranus: the planet that rotates sideways

Uranus is the seventh planet in our solar system. Even with a good telescope, Uranus appears as only a faint blue-green disk in the sky. The space probe *Voyager 2* traveled for eight years before it reached Uranus. The probe revealed a blue-green planet that rotates on its side. Uranus rotates from west to east like most other planets, but the rotation appears to be from the bottom to the top since the planet is tipped over so far. Its rotation takes approximately seventeen Earth hours.

Uranus is so far away from the sun that its side facing away from the sun is not much colder than the side facing the sun. It takes Uranus eighty-four Earth years to orbit the sun. Its curious tilt, however, makes for interesting "days." Each pole spends twenty-one Earth years in endless daylight and another twenty-one Earth years in total darkness.

Like other gas giants, Uranus has a liquid surface. The atmosphere is poisonous methane gas, which gives the planet its bluish color.


Uranus


Saturn

Discussion

How large is Saturn compared to the other planets? It is the second largest planet.

Is Saturn the only planet with rings? no

Why is Saturn considered "the ringed planet"? Its rings are brighter and larger than the rings of any other planet.

What are Saturn's rings made of? many small, frozen particles that reflect the sun's light

Which probe took pictures of some of Saturn's moons? *Cassini*

The probe *Cassini*, paired with the European Space Agency's *Huygens* probe, was launched in 1997. It arrived at Saturn in 2004 and has exceeded its initial mission, continuing to send data about Saturn and its moons. The probe *Huygens* landed on Saturn's moon Titan.

Which spacecraft reached Uranus? the *Voyager 2* probe **How many years did it take to get there?** 8

How is Uranus different from all the other planets? It is tipped over and rotates on its side.

Hold a ruler in a vertical position and rotate it so that the top of the ruler moves downward 98°. This is the angle of the axis of Uranus.

How does the tilt of Uranus affect its days? Each pole spends 21 Earth years in endless daylight and another 21 Earth years in total darkness.

What gives Uranus its bluish color? its methane gas atmosphere

DIRECT A DEMONSTRATION

Demonstrate how small particles can appear to form a solid

Materials: flashlight, flour

Saturn's rings look like a solid band, but they are actually made up of smaller particles that reflect the sun's light. To illustrate this, shine a flashlight in a darkened room. Take a pinch of flour and sprinkle it above the rays of the flashlight. As the flour enters the rays of the flashlight, it appears to be solid when seen from a distance.

LANGUAGE

Moon names

Most of the moons in our solar system were named after classic mythological characters, but the names of Uranus's moons come from characters in Shakespeare's writings—Juliet, Prospero, Puck, and Rosalind.

Direct the student to research the names of several moons in the solar system. He should find out who or what each moon was named after and whether there was a reason for that particular name.

Discussion

How does the weather on Neptune compare to the weather on other planets in our solar system? It has the most violent weather.

How do Neptune's storms appear? as large dark spots

What feature of Neptune makes it similar to Jupiter? Neptune's Great Dark Spot is named after Jupiter's Great Red Spot.

Why would you not be able to see the sun, stars, or moons from Neptune? The planet's cloud cover of methane gas is too thick.

How many Earth years does it take Neptune to orbit the sun? 165

What is the coldest place known in our solar system? Neptune's moon Triton

What are some reasons that humans would not survive naturally on the gas giants? Possible answers: The atmospheres are poisonous. The surfaces are not solid. The temperatures are too cold.

How did we learn much of the information we know about the outer planets? from information sent back by the *Voyager* probes

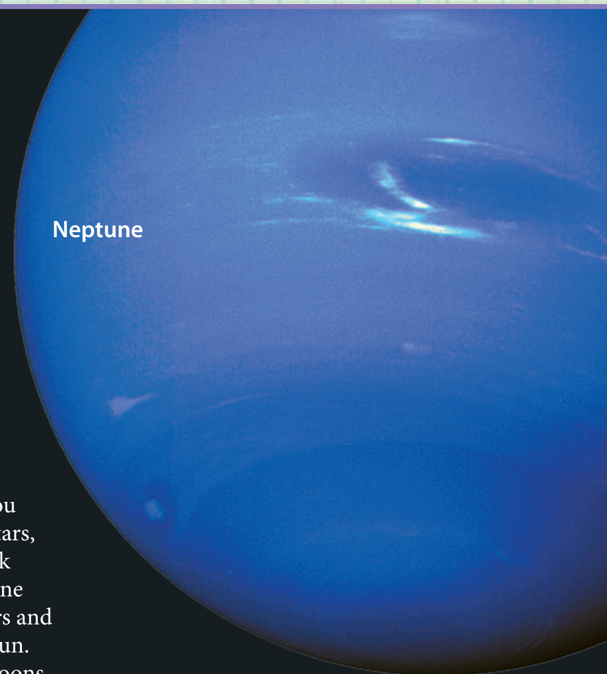
Neptune: the blue planet

Neptune, the last of the gas giants, is a dark and unfriendly world to humans. Neptune has the most violent weather in the solar system. The winds on Neptune reach 2000 km/h (1,240 mi/h)—ten times faster than the winds of a hurricane! Astronomers have observed that Neptune's storms appear as large dark spots. One such spot was named Neptune's Great Dark Spot after Jupiter's Great Red Spot.

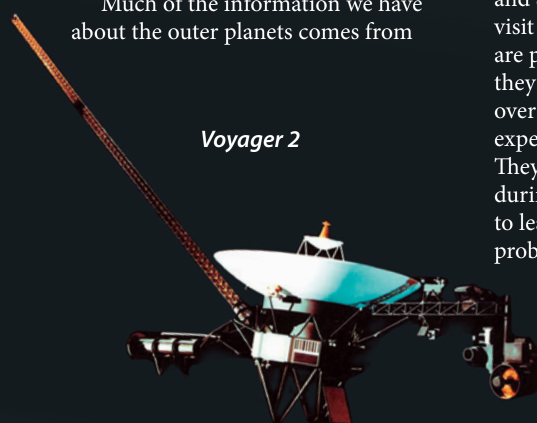
If you were visiting Neptune, you would not be able to see the sun, stars, or moons through the planet's thick cloud cover of methane gas. Neptune rotates in about sixteen Earth hours and takes 165 Earth years to orbit the sun.

Neptune has thirteen known moons, but only two can be observed from Earth. Its largest moon, Triton, is the coldest place known in the solar system. The surface temperature of Triton is −235°C (−391°F).

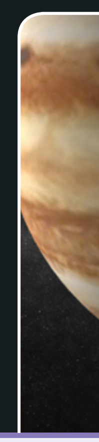
Much of the information we have about the outer planets comes from the *Voyager* probes launched in 1977. *Voyager 1* visited Jupiter and Saturn and sent back large amounts of new information. *Voyager 2* went by Jupiter and Saturn but then continued on to visit Uranus and Neptune. Both probes are past the outer planets now, and they continue to travel through space over thirty years later! Scientists never expected the probes to last that long. They learned a lot about the gas giants during the *Voyager* flybys and hope to learn more about our galaxy as the probes continue to travel.



Neptune



Voyager 2



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Neptune's orbit

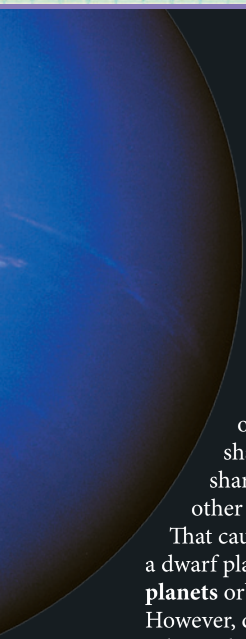
HISTORY

Astronomers first realized that Neptune was a planet in 1846. July 12, 2011, marked the first time since that date that Neptune completed a full orbit around the sun.

Math in astronomy

MATH

Astronomers discovered Neptune using mathematics. Newton's law of gravitation was applied to predict the planet's existence. Uranus's orbit was so erratic that scientists predicted that another planet was affecting it. Through mathematical calculations astronomers figured out where Neptune should be located and found the planet. Pluto was discovered in the same way.



Dwarf Planets

The discovery of other solar system objects beyond Pluto led to the meeting to refine the definition of planets. In 2006 Pluto was reclassified as a dwarf planet instead of a planet. Pluto does orbit the sun, and it is large enough for its own gravity to keep it in the shape of a sphere. However, it shares the path of its orbit with other objects in the Kuiper Belt. That caused it to be reclassified as a dwarf planet. Like planets, **dwarf planets** orbit the sun and are spherical. However, dwarf planets can share their orbit with other objects of a similar size.

Not much is known yet about Pluto and the other icy objects in the Kuiper Belt. Pluto is very far away from the sun and is small and cold. Scientists believe that rock and ice make up Pluto's surface. They estimate that it may be smaller than Earth's moon.

Pluto is not the only object considered to be a dwarf planet. There are currently five dwarf planets, including Pluto. One of them, Ceres (SEER eez), is located in the asteroid belt between Mars and Jupiter. It was discovered in 1801 and used to be considered an asteroid. The other three dwarf planets, Eris (AIR us), Haumea (HOW may), and Makemake (MAH kay MAH kay), are located in the Kuiper Belt.

In January 2006, the probe *New Horizons* was launched with the goal of reaching Pluto in 2015. Scientists plan for it to explore Pluto and its moons and then to continue to explore other objects in the Kuiper Belt. They hope to learn even more about Pluto and other distant solar system objects. The more scientists discover, the more we realize how very big our universe is. Only God could have planned such a vast and detailed universe and brought it into being with His spoken words. The discoveries and information we learn bear witness to God's great glory and power.

New Horizons

QUICK CHECK

1. Why can a spacecraft not land on Jupiter?
2. Which planet rotates on its side?
3. Which planet in our solar system has the most violent weather?
4. What is a dwarf planet? How is it different from a planet?

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Discussion

How is Pluto classified? as a dwarf planet

What is a dwarf planet? an object that orbits the sun, is large enough for its own gravity to keep it in the shape of a sphere, and can share its orbit with other objects of a similar size

How is a dwarf planet different from a planet? A planet clears the path of its orbit. It does not share its orbit with any other object of significant size. Dwarf planets share their orbits with other objects.

Is Pluto large like the gas giants? No, it is small.

What do scientists believe Pluto's surface is made of? rock and ice

How many dwarf planets are there? currently five

What is unique about Ceres? Possible answers: It used to be considered an asteroid but is now classified as a dwarf planet. It is located in the asteroid belt.

Where are most of the dwarf planets located? in the Kuiper Belt

Which probe is expected to reach Pluto and study it? *New Horizons*

As we learn more about the solar system, what awareness comes with this information? God's great glory and power

Answers

1. The surface is liquified gases. It is not solid.
2. Uranus
3. Neptune
4. Like a planet, a dwarf planet orbits the sun and is large enough for its own gravity to keep it in the shape of a sphere. Unlike a planet, it shares its orbit with other objects of a similar size.

Activity Manual

Reinforcement, pages 179–80

Review, page 185

This page reviews Lesson 134.

Assessment

Quiz 11-C

The quiz may be given any time after completion of this lesson.

SCIENCE BACKGROUND

Ceres

Ceres was discovered in 1801 and was first classified as a planet. Eventually it was reclassified as an asteroid. In 2006, when Pluto was reclassified, Ceres was also reclassified as a dwarf planet.

Exploration

Infrared telescopes and observatories use infrared rays to discover more about things in our universe, such as the rings around Uranus, brown dwarf stars, new comets, and the core of the Milky Way. Some telescopes are ground based, some have been in space above Earth's atmosphere, and others are mounted in aircraft. Astronomers hope that new infrared telescopes will reveal more information about dwarf planets.

WRITING

Commendations

Direct the student to write a paragraph congratulating scientists on the outstanding performances of *Voyager 1* and *Voyager 2*. Tell him to include some of each probe's accomplishments.

Persuasive essay

Direct the student to research more about the decision to reclassify Pluto. He should then write an essay explaining why he agrees or disagrees with the decision.

Activity Manual page 186

Objectives

- Construct a scale model of the solar system
- Gain a greater understanding of the vastness of our solar system

Materials

- softball
- sand
- 2 poppy seeds
- mustard seed
- 2 dried peas
- 2 BBs
- measuring wheel

Introduction

God has created a vast universe. Our solar system is only a small part of it, but even our solar system is so huge that it is difficult for us to imagine. Humans are very tiny in relation to the universe, yet God still loves us.

Read Psalm 8:3–4.

To what does the word *heavens* refer in verse 3? Possible answers: moon and stars, night sky, universe

Who created our moon, the stars, and the whole universe? God

God is powerful enough to have created everything, yet these verses say He is mindful of us. What do you think *mindful* means? Elicit that *mindful* means that God thinks about and cares for us.

To give us an idea of how very small humans are in this vast solar system, we will make a model of our solar system.

Teach for Understanding

Purpose for reading

The student should read the page before beginning the exploration.

EXPLORATION

Solar Walk

Name ______________________

A. The chart lists the relative size of each planet and its distance from the sun. To calculate the distance between each planet, subtract the previous planet's distance from the sun (Column 3) from the current planet's distance from the sun (Column 3). Use the information in the last column to take a solar walk that shows a scale model of the solar system.

Example: Venus's distance from the sun – Mercury's distance from the sun
6.7 – 3.6 = 3.1

Planet	Relative size of planet	Relative distance from the sun in meters	Relative distance from the previous planet in meters
the sun	softball	—	—
Mercury	grain of sand	3.6	—
Venus	poppy seed	6.7	6.7 – 3.6 = ______
Earth	poppy seed	9.3	9.3 – 6.7 = ______
Mars	mustard seed	14.0	14.0 – 9.3 = ______
Jupiter	pea	48.0	______
Saturn	smaller pea	89.0	______
Uranus	BB	180.0	______
Neptune	BB	230.0	______

B. After returning from your solar walk, answer the questions.

1. Did the size of the solar system surprise you? Why or why not? ______________________

2. Why would it be impossible to fit a scale model using the same relative size and distance in a classroom? ______________________

TEACHER HELPS

Measuring

An area about 230 meters (251.5 yards) long is needed to complete this activity. If that much space is not available, include as many planets as you can in the space that you have.

You might be able to borrow a measuring wheel from someone in one of these occupations: builder, realtor, engineer, carpet installer, policeman, or surveyor.

If a measuring wheel is not available, prepare and use a long piece of string that you have marked with tape at each meter.

Marking

Place a bright flag in the grass at each planet so you can look back and see the distances easily.

Since many of the "planets" are small, place them in paper cups if you want to leave them at their markers.

SCIENCE MISCONCEPTIONS

Solar system models

Solar system diagrams and models show the planets in a row. Planets are never lined up like this at one end of the solar system. These models are actually comparing the orbital paths of the planets. Very rarely will the actual distance between any two objects in the solar system match the chart.

WRITING

Planet reports

Assign groups of students to research each of the planets. Stop at each planet on your walk and allow the students to present their research. This writing activity may be done in lieu of Lesson 136.

Procedure

In order to keep the planets in correct proportion to one another, the distances and sizes of the planets must be reduced at the same rate. These calculations have already been made. The student needs to determine the relative distances between the planets before starting the space walk. He is given each planet's relative distance from the sun.

Guide the student in calculating the distances between the planets. Subtract the previous planet's distance from the sun from the current planet's own distance from the sun.

Use a measuring wheel to make accurate measurements. Instruct the student to walk slightly ahead of you and approximate the distance to the next planet by counting his strides, estimating a meter distance with each stride. Stop at each planet to look at the object being used to represent it. Compare the distances of the "planets" from the "sun" and the distances between the "planets."

Activity Manual

Exploration, page 186

Assessment

Rubrics

Select the prepared rubric, or design a rubric to include your chosen criteria.

DIRECT A DEMONSTRATION

Demonstrate the relative sizes of the planets

Materials: assorted balls or round objects

Construct a model of the relative sizes of the planets inside the classroom. The following objects may be used: Mercury—a small bead; Venus—a large marble; Earth—a large marble; Mars—a small marble; Jupiter—a basketball; Saturn—a soccer ball; Uranus—a softball; Neptune—a softball. Using this scale, the sun is 2.4 meters in diameter. You could paint the sun on a large sheet of paper and hang it on a wall.

DIRECT A DEMONSTRATION

Demonstrate the relative distances of the planets' orbits

Materials: masking tape, meter stick

To make a classroom representation of the distances between the planets, place a 4-meter piece of masking tape on the floor. Measure and mark the planet distances from the chart using centimeters instead of meters. At this scale, the planets would be too small to model.

Lesson 136

Activity Manual pages 187–88

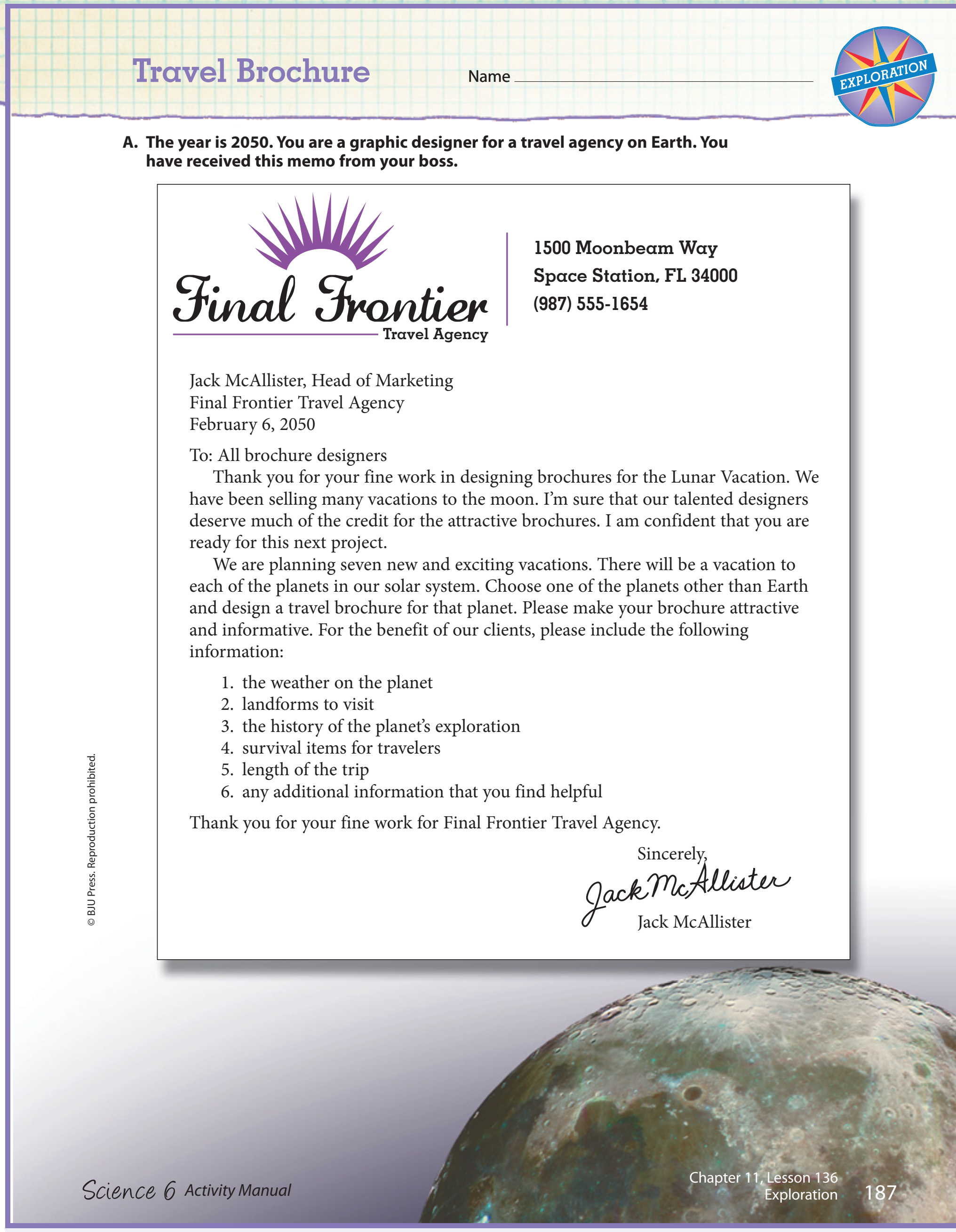
Objectives
- Design a travel brochure for a planet
- Collect data
- Write from research

Materials
- variety of real travel brochures
- resource information about planets

Introduction
If you had the opportunity to plan your family's vacation, where might you go?

How could you learn about vacation places that you have never seen or heard about? Possible answers: advertisements in newspapers or magazines, e-mails, commercials, travel brochures, word of mouth

Today you will design a travel brochure that describes a fictional vacation to a planet in our solar system.



Travel Brochure

Name ____________________

EXPLORATION

A. **The year is 2050. You are a graphic designer for a travel agency on Earth. You have received this memo from your boss.**

Final Frontier
Travel Agency

1500 Moonbeam Way
Space Station, FL 34000
(987) 555-1654

Jack McAllister, Head of Marketing
Final Frontier Travel Agency
February 6, 2050

To: All brochure designers

Thank you for your fine work in designing brochures for the Lunar Vacation. We have been selling many vacations to the moon. I'm sure that our talented designers deserve much of the credit for the attractive brochures. I am confident that you are ready for this next project.

We are planning seven new and exciting vacations. There will be a vacation to each of the planets in our solar system. Choose one of the planets other than Earth and design a travel brochure for that planet. Please make your brochure attractive and informative. For the benefit of our clients, please include the following information:

1. the weather on the planet
2. landforms to visit
3. the history of the planet's exploration
4. survival items for travelers
5. length of the trip
6. any additional information that you find helpful

Thank you for your fine work for Final Frontier Travel Agency.

Sincerely,
Jack McAllister
Jack McAllister

Teach for Understanding

Purpose for reading
The student should read all the pages before beginning the exploration.

TEACHER ★ HELPS ★

Encouraging creativity
Many planets will have limited information. Allow the students to make up many features and create unusual solutions to traveling needs. The value of this activity is in doing research and in exercising creativity within boundaries.

Group work
If students are working in groups, assign each student to research and write one paragraph of the brochure. They could share the responsibility for the design and art elements.

Survival items
A traveler will need oxygen, food, water, housing, transportation, protection from heat, harmful radiation, meteor showers, etc. The types of survival items will vary depending on the environment of each planet.

What to do

B. Follow the directions given by your boss, Jack McAllister, in the memo. Use this space to take notes as you research your planet. Develop your notes into a travel brochure. Be prepared to explain the information you include in your brochure.

1. the weather on the planet ______
2. landforms to visit ______
3. the history of the planet's exploration ______
4. survival items for travelers ______
5. length of the trip ______
6. any additional information that you find helpful ______

What to do

The key to the success and interest in this activity is the teacher. Be enthusiastic. Make the project lighthearted but focused.

Display the sample brochures.

What do all the brochures have in common? Elicit that they each try to get the reader to visit somewhere or do something.

What characteristics make some brochures more interesting than others? Possible answers: pictures; types of details included and how they are written; size of the brochures

Ask questions as needed to encourage students' ideas.

What are the weather conditions on your planet during the day and during the night?

How long is a day on your planet?

What important sites can be seen on your planet?

Which fictional space explorers visited your planet? When did they visit it? What was the name of their spacecraft? What important tests and experiments did they perform while visiting your planet?

What special survival items will you supply for the travelers? What will they need to bring?

What is the most unusual fact about your planet?

Activity Manual

Explorations, pages 187–88

Assessment

Rubrics

Select the prepared rubric, or design a rubric to include your chosen criteria.

Lessons
137–38

Student Text page 286
Activity Manual pages 189–90

Objectives
- Recall concepts and terms from Chapter 11
- Apply knowledge to everyday situations

Introduction
Material for the Chapter 11 Test will be taken from Student Text page 238 and Activity Manual pages 177–78, 181–82, 185, and 189–90. You may review any or all of the material during the lesson.

You may choose to review Chapter 11 by playing "The Solar System" or a game from the Game Bank on the Teacher's Toolkit CD.

Teach for Understanding
Diving Deep into Science
Information on this page reflects the vocabulary and concepts the student should know for the test.

Solve the Problem
In order to solve the problem, the student must apply material he has learned. The student should attempt the problem independently. The answer for this Solve the Problem is based on the material on Student Text pages 260–65. Answers will vary and may be discussed.

Activity Manual
Review, pages 189–90
These pages require written responses to application questions.

Lesson 138

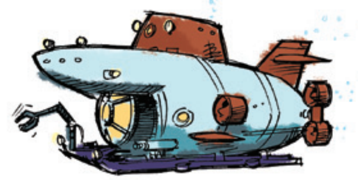
Objective
- Demonstrate knowledge of concepts taught in Chapter 11

Assessment
Tests, Chapter 11

DIVING DEEP INTO SCIENCE

Words to Know
satellite
probe
International Space Station
faculae
aurora
revolution
axis
rotation
terrestrial planet
gas giant
planet
solar eclipse
totality
lunar eclipse
dwarf planet

Key Ideas
Important men in rocket development
History and tools of space exploration
Ways satellites are used
Benefits and uses of inflatable spacecraft
Challenges of living in space
Parts of the sun
Features of a solar storm
Causes of the changing seasons on Earth
Relationship of the planets in the solar system
Characteristics of each planet
How the location and characteristics of Earth evidence God's care
Characteristics of Earth's moon
Causes of solar and lunar eclipses
Difference between a planet and a dwarf planet



Solve the Problem
Your family is going on a hiking and overnight camping trip. All the equipment and supplies that you need will have to be carried in your backpacks. What invention(s) for the space program could help you minimize the weight of your supplies?

Accept any reasonable answer. The dehydrated food in the space program would lighten the load. Small computer devices such as a handheld GPS and a cell phone are helpful also and they are an indirect result of the space program.

Review Game
The Solar System
Prepare a set of eleven cards labeled sun, Mercury, Venus, Earth, Mars, asteroid belt, Jupiter, Saturn, Uranus, Neptune, and Pluto. Place each card in a plain dark envelope. Ask review questions. Each time a student answers correctly, he chooses an envelope, but he does not look inside the envelope.

After all of the envelopes are chosen, instruct the students with envelopes to come to the front of the room. At a signal, each opens his envelope. The students then arrange themselves from left to right, starting with the sun and moving outward. Once they are finished, allow the rest of the class to decide if they are in the correct order. Instruct the students to replace the cards in the envelopes. Shuffle the envelopes and repeat as time allows.

Teacher Notes