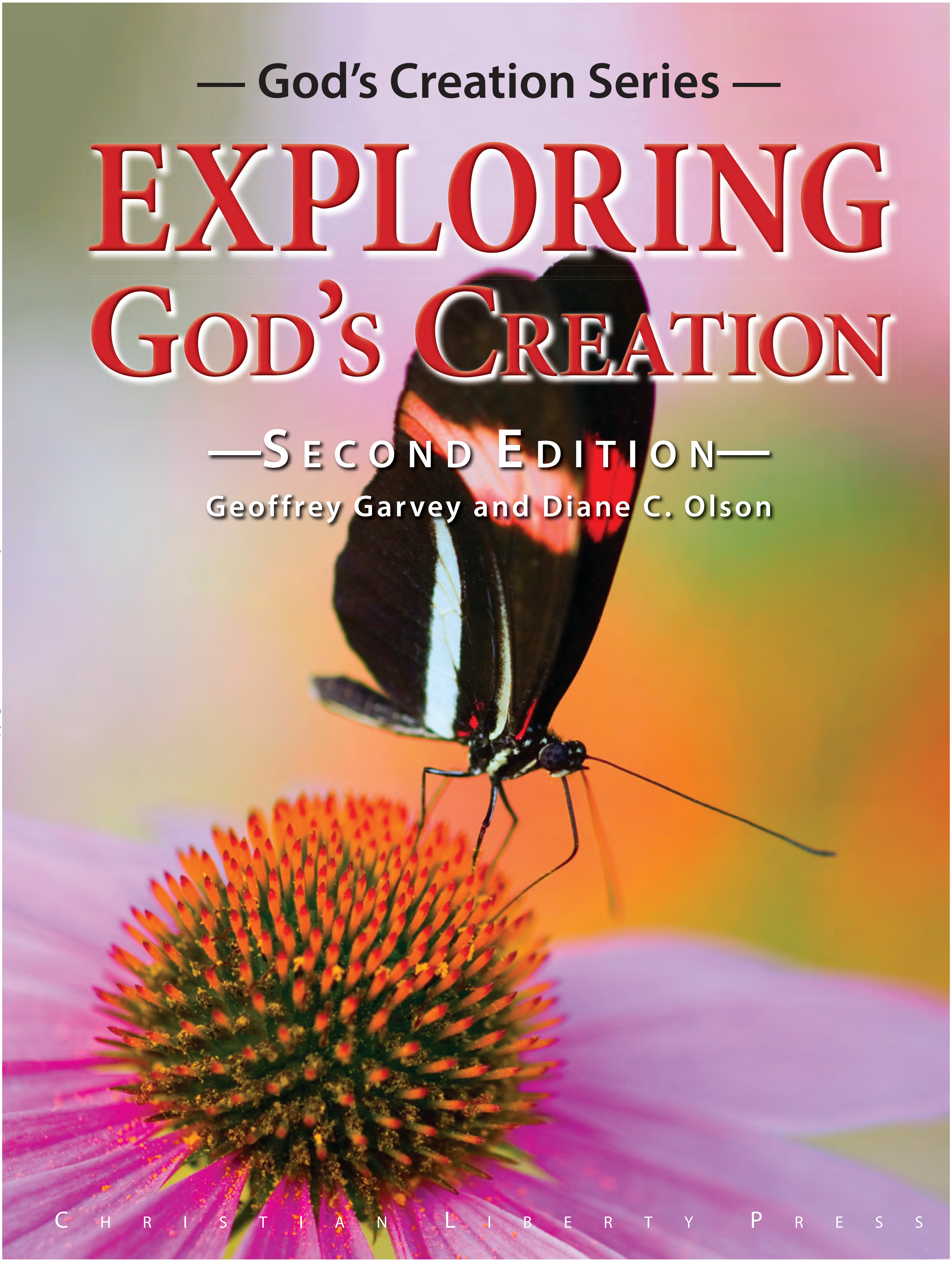
— God's Creation Series —

EXPLORING GOD'S CREATION

—SECOND EDITION—

Geoffrey Garvey and Diane C. Olson



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Author: *Geoffrey Garvey and Diane C. Olson*
Consultant: *Robert Stack*
Copyediting: *Diane C. Olson and Eric L. Pfeiffelman*
Graphics: *Bob Fine* and *Edward J. Shewan*
Photo Illustrations Model: *Tanner Liston*
Cover Design: *Bob Fine*
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Preface

In *Exploring God's Creation, Second Edition* (copyright © 2021 by Christian Liberty Press), students are exposed to the ways scientists look at nature, matter, energy, weather, and the universe. This textbook also spotlights hands-on learning. Students will touch and handle, look and prod, feel and hear some of the amazing objects in God's marvelously designed world.

Some of the experiments will have risks of spills; and some, especially those around the stove, will require close adult supervision. These are marked with a Safety-First symbol. If more than one student is participating, they should take turns. In no case should anyone sit and just watch!

God put the world into our care with the commands of Genesis 1:28–29. Our caregiving responsibility requires at least three ingredients: to love God's world, to believe we are empowered to take care of it, and to have the hope that we are equipped to do so. These three ingredients come with our faith, and it is our hope that this book will provide opportunities for students to develop that love, to strengthen that belief, and to broaden that hope.

> *Then God blessed them, and God said to them, "Be fruitful and multiply; fill the earth and subdue it; have dominion over the fish of the sea, over the birds of the air, and over every living thing that moves on the earth." And God said, "See, I have given you every herb that yields seed which is on the face of all the earth, and every tree whose fruit yields seed; to you it shall be for food."*
>
> *—Genesis 1:28–29*

the Staff of Christian Liberty Press
Arlington Heights, Illinois

Chapter 1
Machines


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Have you ever wondered how men of old could have possibly built the great pyramids of Giza and other "wonders of the world" without the aid of cranes and bulldozers and other modern equipment? The answer is, they used **simple machines**!

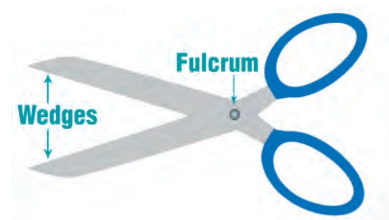
Simple Machines

As we begin our study of simple machines, let's discuss some terms used by scientists to describe machines and their many benefits. The first term is **force**. A force is simply a push or a pull. If you push or pull a book across a tabletop, you are applying a force to it. As the book moves across the tabletop, you are exerting an **effort** (force) on it and accomplishing **work**. As you ride a bicycle, your legs exert forces on the pedals as you push on them; you are accomplishing work as you ride down the sidewalk.

So what are simple machines? They are inventions that make work easier. They are called "simple" because they have only one or two parts. Long ago, most simple machines were made of wood, stone, bronze (also known as brass), or iron. Today, the same machines might be made of modern materials, such as plastic, steel, or aluminum. The basic way these machines work, though, remains the same.

Below is a list of six simple machines and examples of each.

Simple Machine	Examples
lever	pry bar, scissors (has 2 levers & 1 fulcrum), broom
inclined plane	ramps, wood plank (or plane)
wheel and axle	bicycle, steering wheel
wedge	axe, knife, chisel, log-splitter
screw	wood screw, bolt, screw jack
pulley	flagpole pulley, rigging on a sailboat



Simple machines make work easier in several ways. First, they can increase the amount of force a person exerts. Scientists refer to this particular benefit as **mechanical advantage**. An example of this would be a pry bar. Most of us would never be able to apply enough effort force to pull a nail out of a board using our bare hands. But we could easily remove the nail with the aid of a pry bar or hammer with a claw.

Second, machines can change the direction of the force that has been exerted. A pulley is a good example of this. A pulley attached to the top of a flagpole enables the flag to be hoisted up by pulling down on a rope attached to the pulley.

Third, a machine can increase the speed at which a force acts. A broom is an example of this type of machine.

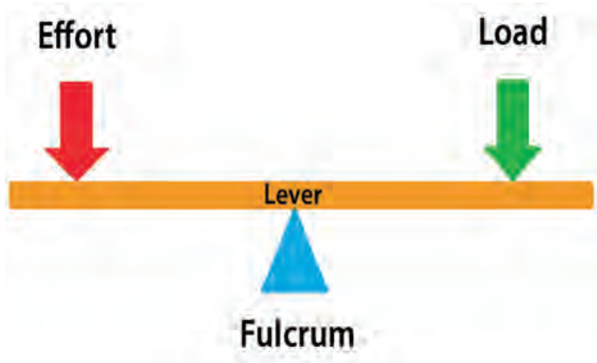
Learning about God's World: *Simple Machines Around You*

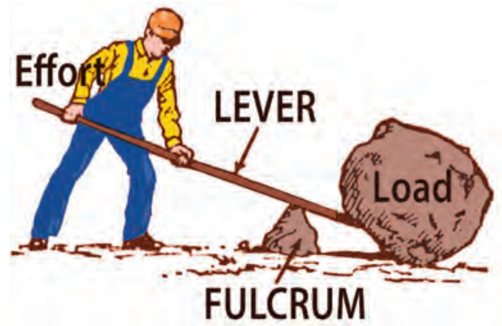
Look carefully for examples of simple machines around your house, church, or school building. Fill out the chart with at least one example of each type. Do not use any examples that are already listed in the book.

Simple Machine	Examples
lever	
inclined plane	
wheel and axle (do not list any vehicles)	
wedge	
screw	
pulley	

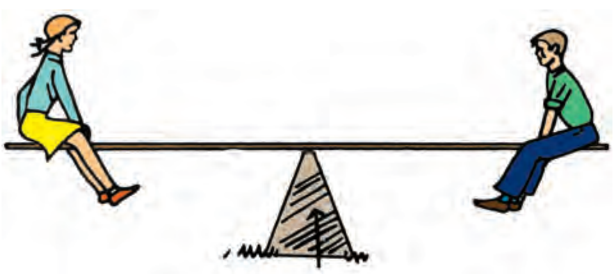
Levers and Mechanical Advantage

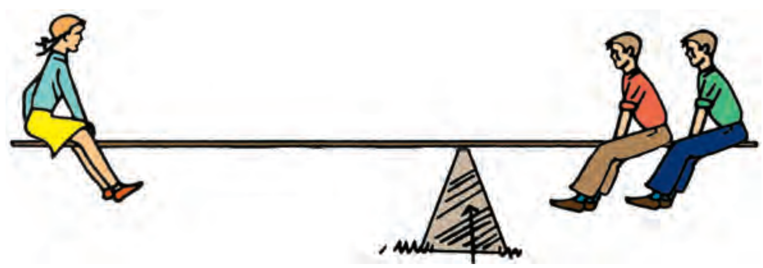
Let's look at the simple machine called a lever. A **lever** consists of a rigid bar and a pivot point called a **fulcrum.** The pry bar and seesaw are good examples of **levers.**





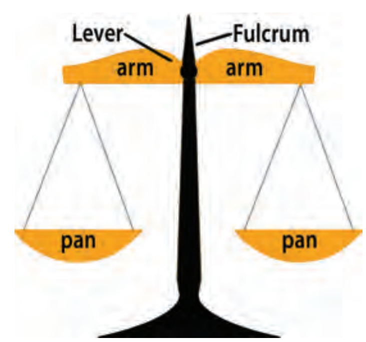
In the picture below on the left, children of equal weight can balance on a teeter-totter if they sit the same distance from the fulcrum. By moving the position of the fulcrum, the girl can balance two boys or even an adult by sitting on the longer arm of the lever, as shown below on the right. Although the force exerted by her body on the teeter-totter is half that of the combined weight of the boys, she is able to use the mechanical advantage of the lever to balance the weight of the two boys.





In the picture above on the right, the girl's mechanical advantage is "2 to 1." Using the lever, she can balance two boys. Suppose the lever were positioned to give the girl a "4 to 1" mechanical advantage. How many boys could she balance?

A lever can also be used to make a scale for weighing things by balancing them in pans. See the image at the right.



> *Who has measured the waters in the hollow of His hand, Measured heaven with a span and calculated the dust of the earth in a measure?* ***Weighed the mountains in scales and the hills in a balance?***
>
> —*Isaiah 40:12*

Learning about God's World: *A Balance*

One simple machine is used to weigh things. Let's build one and see how it works.

You need:

- ⇨ a (12- or 15-inch) ruler
- ⇨ a wire hanger with a cardboard tube
- ⇨ a knife
- ⇨ a marker
- ⇨ about 24 inches of string in two equal pieces
- ⇨ two men's handkerchiefs (or cloths 12 x 12 inches) of the same size
- ⇨ a place to hang the hanger where it can swing free (a broom handle or a 3- or 4-foot pole over the backs of two chairs)
- ⇨ lots of pennies (20 will do, but the more the better)

Making the Balance

Step 1: Use the ruler to find the center of the cardboard tube. Make a very small cut (no more than ¼ inch) at the center, marking it with a "C."

Step 2: Make very small cuts 1, 2, 3, and 4 inches from the center cut in both directions from the "C." Be careful not to cut too far into the tube, or it may bend or break!

Step 3: Tie one end of each string around the four corners of each handkerchief or cloth. (Just the corners!) The sides should hang open a little so you can get pennies in and out.

Step 4: Tie the other end of each string in a loose loop around the cardboard tube of the hanger. You want to be able to move the "handkerchief bags" back and forth easily on the tube.

Step 5: Set the bags at one inch from the center. Hang the hanger where it can swing free, and check the balance. Does it balance straight?

Step 6: Put ten pennies in each handkerchief, and check again. Move both loops to the center and check again. The same number of pennies at the same distance should balance. The balance can be made level by changing the shape of the hanger. (An adult may have to do this part.)

Using the Balance

Step 1: Remove the pennies from the bags, and hang both bags at the ends of the cardboard tube at the 4-inch notch.

Step 2: Put one penny in one of the bags. That side of the tube should now go down. The penny makes it heavier.

Step 3: Put two pennies in the other bag. Now that side goes down. Two pennies is heavier than one penny.

Step 4: Next, move the two pennies 1 inch from the center.

Does the side with the two pennies go up? ______________________________

Why? ______________________________

Let's find out some more about how this works.

Step 5: Put ten pennies in one bag 1 inch from the center and three pennies at the 4-inch mark.

Step 6: Move the ten pennies bag to the 3-inch mark.

Now what happens? ______________________________

Step 7: Try more combinations, and record the results on a separate piece of paper.

What do your investigations show? You should see that the farther from the center a weight is, the stronger the pull it makes on the balance.

Step 8: Record the results of the following combinations:

2 pennies at 1 inch and 1 penny at 2 inches

What happens? ______________________________

5 pennies at 4 inches and 10 pennies at 2 inches

What happens? ______________________________

3 pennies at 2 inches and 2 pennies at 3 inches

What happens? ______________________________

4 pennies at 4 inches and 8 pennies at 2 inches

What happens? ______________________________

What do these combinations tell us? Weight times distance on one side balances weight times distance on the other side. This is an effect of mechanical advantage.

Inclined Planes

Have you ever pulled a wagon or pedaled a bike up a hill? Is it easier or harder than when the ground is level? Is it easier going up or coming down? Is the steepness of the hill a factor?

Are there any wheelchair ramps near your home or at your neighbor's house? Have you ever seen wheelchair ramps at the entrances to churches or other public buildings? Why are ramps easier than stairs for wheelchairs?

Learning about God's World: *Inclined Plane*

You need:

- ⇨ a bicycle (tricycles and most riding toys will be too wide)
- ⇨ an outdoor staircase
- ⇨ a board 1 inch thick by 6 inches wide and at least 6 feet long
- ⇨ a box of books weighing 5 to 10 pounds (just light enough for you to lift, but too heavy to hold for very long)

Step 1: Set one end of the board on the first step.

Step 2: *Push* the bicycle up the board. How hard is it?

Step 3: Move the end of the board to the top step. Now try pushing the bicycle.

Is it harder or easier? ____

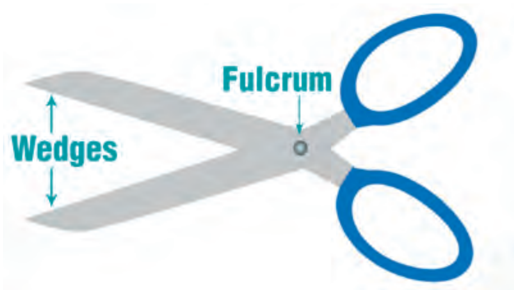
Can you push the bicycle up the board from the bottom to the top step? ________

Step 4: Stand at the bottom of the steps and look up to the top steps. Can you lift a bicycle that high?

Step 5: Now push the box of books up the ramp. Can you make it all the way? Could you lift the box that high?

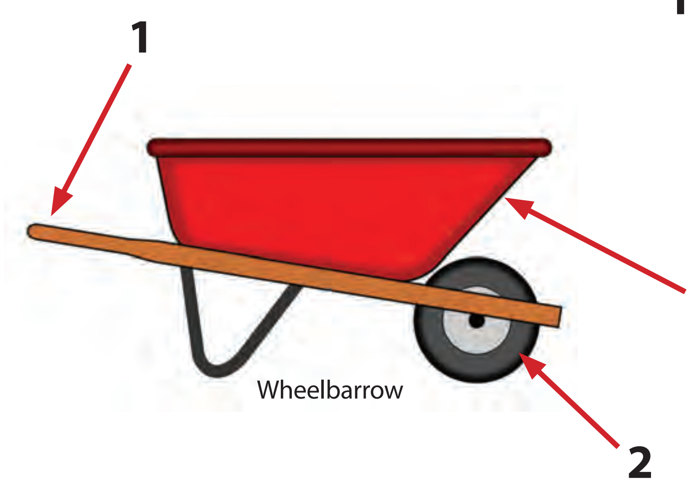
Compound Machines

Most machines combine more than one of the simple machines. These machines are called **compound machines**. For example, a bicycle has wheels and axles, but it also has levers, such as pedals and the handlebar. A bicycle also has screws and bolts holding pieces together.

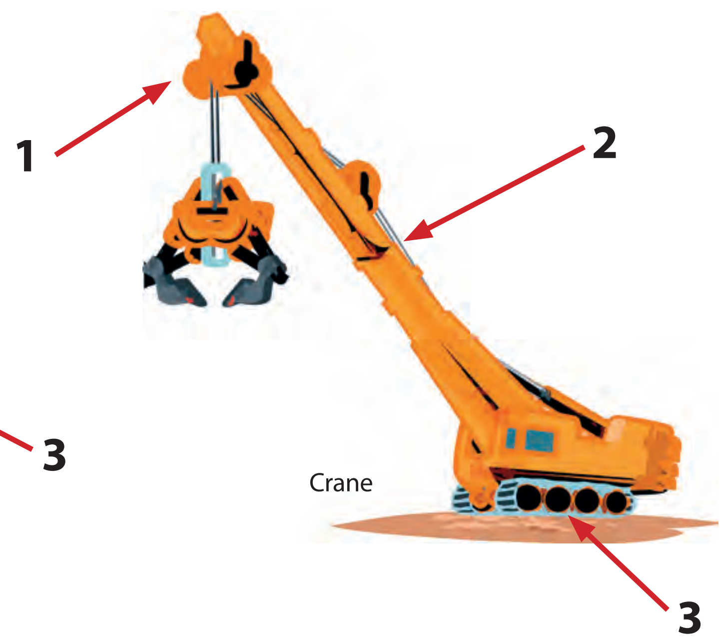


Even something that seems simple can be a compound machine. A shovel handle is a type of lever, and the blade of a shovel is a wedge. A pair of scissors has levers, and the cutting blades are wedges. In fact, most cutting blades are wedges. Of course, any complex machinery, such as cars, computers, appliances, and so forth, are compound machines and use many simple machines in combination.

What simple machines do you see?



Wheelbarrow



Crane

1. ____________________
2. ____________________
3. ____________________

1. ____________________
2. ____________________
3. ____________________

Looking Back

Instructions: Fill in the blanks.

1. A ____________________ is something that makes work easier.

2. A ____________________ is a push or a pull.

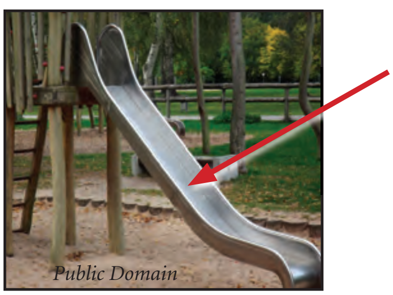
3. I have a scale that balances. If I move the weight on one side closer to the center, that side will go _________________.

4. The pivot point for a lever is called the _____________________.

5. Mechanical ____________________________ means that a simple machine can increase the amount of force.

6. A ____________________ machine combines one or more simple machines.

7. Identify the simple machines shown below.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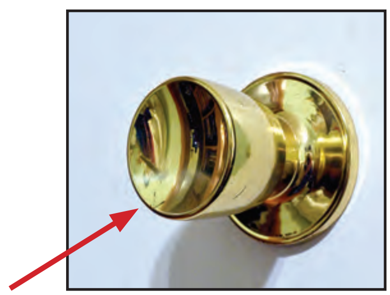
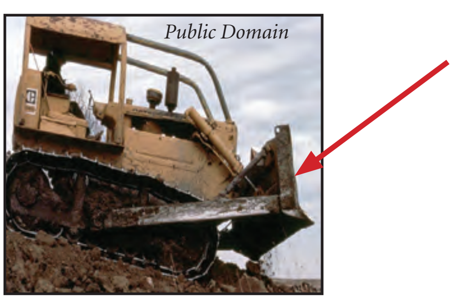


__________________ __________________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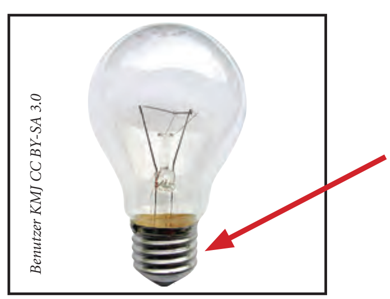
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__________________ __________________

Chapter 10

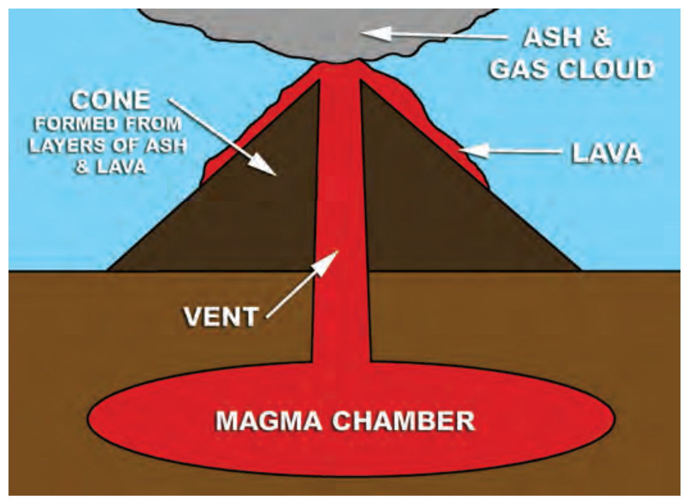
Volcanoes

Do you remember the three forms of matter? (solids, liquids, and gases) Do you remember that things can change from a solid to a liquid to a gas? We saw that ice can change to liquid water when it warms up, and water can be heated to turn into a gas called water vapor.

Every solid can change to a liquid and a gas—even rocks!

Did you know that things can be cool on the outside while they are still hot inside? Think of a fresh French fry, straight from the fryer. The outside can be cool enough to touch. It can be cool enough to put in your mouth. Then you bite it, and ouch! Hot!

Volcanic Eruptions



The earth is like that. It is very hot inside; in addition, it is not hard all the way through. Hot, melted rock flows many miles below the surface.

This melted rock is called **magma**. The magma rises toward the surface and collects in underground **magma chambers**. When pressure builds up in a magma chamber, the magma will push its way to the surface through a crack in the earth's surface called a **vent**. This is a volcano.

Have you seen cracks in the ground when the weather is dry? Don't worry! A crack has to be miles deep to start a volcano.

Mt. Stromboli Volcano

When the magma pushes its way up to the surface, this is called an **eruption**. Magma that has come to the surface through a vent is called **lava**. After the melted rock erupts from the volcano, the lava will cool and become solid rock. Over time, the rock can build up around the vent and create a cone-shaped mountain. In fact, this mountain is called a **cone**.

Rock that is hot enough to be a liquid is hot enough to turn water and other liquids to gases. Do you think that happens in a volcano? Of course, it does! Water and other liquids that are inside the earth become very hot from the melted rock, or magma, beneath the volcano, and those liquids change to steam and other gases.

Gases bubble up through the lava, and the lava can sputter and splatter and splash as it spews out of the volcano. The lava can also be thrown hundreds of feet into the air, especially if the volcano is partially blocked.

Matthew Bowden © 2018

Try this in a sink. Turn on the water. Put your finger or thumb partially over the spout on the faucet. The water will travel farther and faster. (Watch out for splashes!) The tighter you put your thumb over the spout, the harder the water flows.

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Sakurajima Volcano with Lightning

This is how it is with a volcano. Sometimes, the magma is thin and runny. Then the lava just flows from the vent. Sometimes, the vent is a little blocked, and the gases sputter the lava a little into the air. Sometimes, the vent is mostly blocked, or maybe there is a lot of gas trying to get out, or maybe the lava is very thick. Then the lava really sputters and shoots high into the air. Sometimes, the vent is very blocked and there is a lot of gas trying to get out. Then the volcano might throw huge chunks of rock and globs of lava very high into the air.

Types of Volcanoes

Scientists who study volcanoes are called **volcanologists**. Volcanologists group volcanoes into three basic types.

A **shield** volcano forms when the thin and runny lava just flows from the vent. The cone of a shield volcano is wider than it is high, and it has a gentle slope. The lava can flow for a great distance, which is why the cone is so broad. The volcanoes in Hawaii are shield volcanoes.

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Shield Volcano. Pu'u 'Ō'ō volcanic cone, Kīlauea volcano, Hawaii

A **cinder cone** volcano forms when lava, ash, and rock fragments are thrown into the air and then land

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Stratovolcano. Augustine Volcano, Alaska

right around the vent. The cone is steep and is the shape we usually think of when we think of a volcano. The mountain that forms is usually not much more than 1,000 feet high. Cinder cones are the most common type of volcano.

A **composite** volcano, often called a stratovolcano, is also shaped with a steep cone. A composite volcano can have more than one vent and is usually much larger than a cinder cone. The eruption from a composite volcano can be explosive and very dangerous. However, eruptions from this type of volcano do not happen very often. Composite volcanoes usually have a long rest between eruptions. Mount St. Helens, in Washington, which erupted in 1980, is an example of a composite volcano. Maybe the most famous composite volcano is Krakatoa in Indonesia. When it erupted in 1883, the explosion was so loud that it could be heard over 3,000 miles away!

Learning about God's World: *An Eruption*

We cannot make a real volcano; however, we can build something that looks and acts like one. Find a place that can get messy for this project.

You need:

- ⇨ baking soda
- ⇨ vinegar or lemon juice
- ⇨ modeling clay (at least one pound, or four sticks)
- ⇨ red and yellow food coloring

Step 1: Mold some clay into a volcano shape. Shape it into a peak like a mountain.

Step 2: Push a hole into the top with your thumbs, about 2 or 3 inches deep.

Step 3: Put two tablespoons of baking soda into the hole.

Step 4: Mix three drops of red food coloring and one drop of yellow with the baking soda until it is all orange.

Step 5: Quickly pour a quarter glass of vinegar or lemon juice into the hole. The foam will flow down the volcano like lava.

Learning about God's World: *A Bigger Eruption*

We can also make the kind of volcano that sputters, using a 16-ounce jar with a metal lid.

You need:

- a 16-ounce glass
- a 16-ounce jar with a metal lid
- a piece of wood
- a nail
- a hammer
- metal-cutting scissors
- a turkey baster
- baking soda
- vinegar
- red and yellow food coloring

Step 1: Place the metal lid on a piece of wood, and hammer a nail through the center of the lid. Then remove the nail.

Step 2: Take the metal-cutting scissors, and cut the hole large enough for the end of a turkey baster to fit into the hole.

Step 3: Hammer another hole in the lid halfway between the edge of the lid and the hole in the middle. Be careful of any sharp edges!

Step 4: Pour baking soda into the 16-ounce jar until it is half full.

Step 5: Carefully tighten the lid on the jar. This is the partially blocked vent of your volcano. Place the jar in the sink or in a place that can get messy.

Step 6: *(Optional)* If you have time, build your own volcano around the jar, using paper mâché (you may use laundry starch instead of glue or starch), a thin sheet of foam, or construction paper. Mod Podge® water-base sealer may also be used to seal your volcano. After the paper mâché dries, you may want to paint it.

Step 7: Fill a 16-ounce glass with vinegar.

Step 8: Add some red and yellow food coloring to the vinegar. Stir well.

Step 9: Fill the turkey baster with the vinegar in the glass—the more vinegar, the better!

Step 10: Quickly put the tip of the baster into the hole in the center of the lid; squirt all the vinegar into the jar. Keep the baster in the hole.

Suddenly, red-orange foam will squirt out the small hole in the lid. Keep clear of the spout and enjoy the show!

Step 11: When you are done, be sure to clean up the mess.

©Sunny Awazuhara-Reed DesignPics

Lava Field, Hawaii Volcanoes National Park

Looking Back

Instructions: Fill in the blanks.

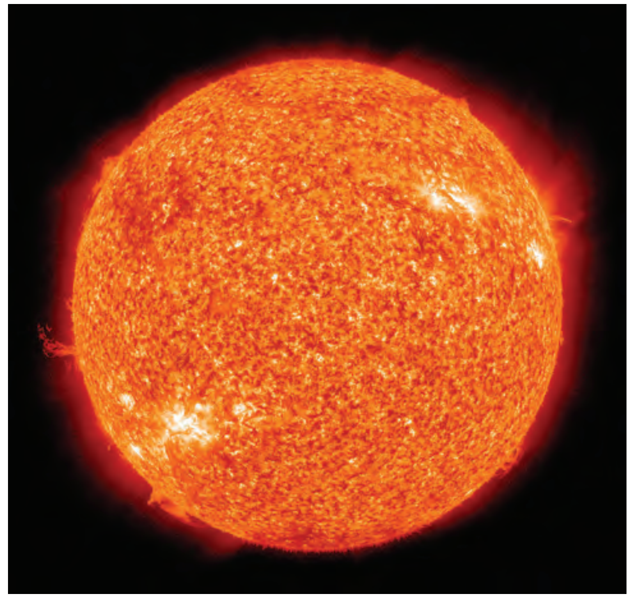
1. When the melted rock is ________________________, it just flows from the volcano.
2. The melted rock can be thrown high in the air when there are ______________ in it.
3. The most common type of volcano is a _________________ cone.
4. A ___________________________ volcano is wider than it is high.
5. A ___________________________ volcano is very large and can have more than one vent.

Instructions: Match each term to the meaning.

cone	underground melted rock
eruption	melted rock that comes out of a volcano
lava	when melted rock pushes its way to the surface
magma	deep crack in the earth's surface
magma chamber	underground area where melted rock collects
vent	mountain that forms from cooled rock

2017 eruption of the Sabancaya volcano, Peru

Chapter 16
The Solar System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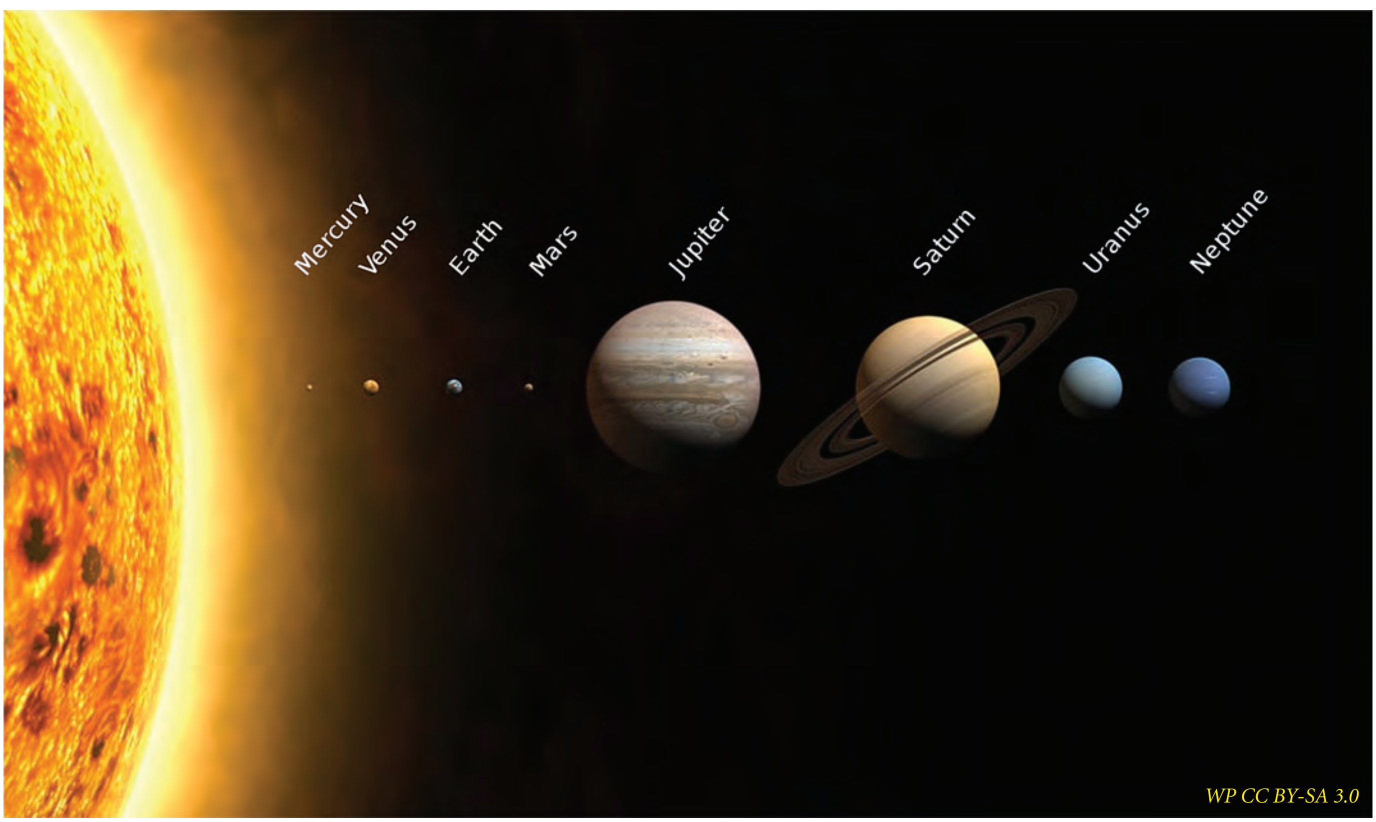
The sun rules the day (Psalm 136:8), as the Bible declares. We have already learned that plants need the sun to live. Animals also need plants to live. The sun's heat keeps the air on Earth warm enough for us all to live. The sun makes all life on Earth possible.

The Sun

The sun is at the center of a place in the universe we call the **solar system**. The solar system consists of the sun and all objects that **orbit** (move around) the sun. There are eight planets and many smaller objects that orbit the sun.

The sun is so hot that anything within a few thousand miles of it would burn up instantly. At that temperature, of course, there are no solids or liquids, only gases. The sun is made up



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of the following elements: hydrogen (71%), helium (27%), oxygen (0.97%), carbon (0.4%), small amounts of other elements, and even a little iron (0.014%).

Earth is the third planet from the sun. Earth takes one year to go around the sun once. In fact, it is Earth's trip around the sun that defines our year.

Earth is about 93 million miles (150 million kilometers) away from the sun. Even after traveling so far, the sun's light is still strong enough to warm our planet. Actually, this warmth is just the right amount for people, animals, and plants. God knew exactly what He was doing when He put us on Earth.

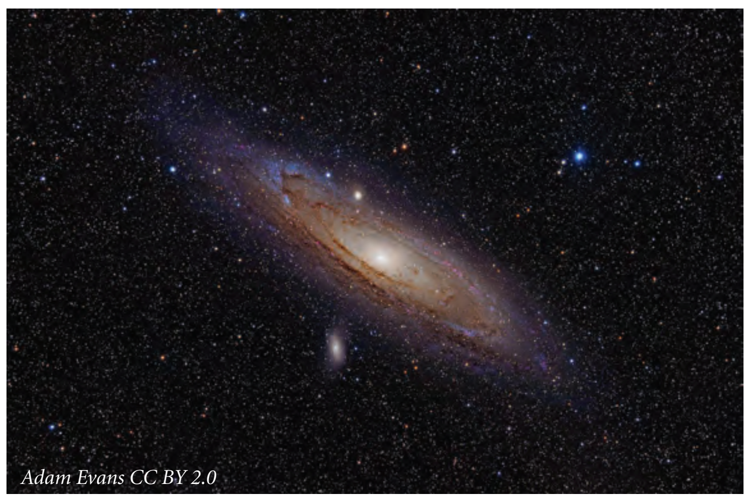
We have studied how all food begins with plants. Plants make food from sunlight, carbon dioxide, and water. Plants could not make anything without the sun. It is God's plan to give life on Earth through sunlight.

The Sun's Place in Space

The sun is one star in a large group of stars called a **galaxy**. The galaxy in which our sun exists is called the **Milky Way**. The Milky Way looks like a crowded patch of stars in the sky because these stars are so close to us.

Of course, "close" in the universe is not the same as "close" in our neighborhood! The closest other galaxy is the Andromeda Galaxy, which is about 15 quintillion miles away. That is 15,000,000,000,000,000,000 miles; in other words, if you were to drive at 55 miles per hour to the Andromeda Galaxy, it would take you 2.5 trillion years to arrive.

God has made quite a large universe!



The Andromeda Galaxy

Learning about God's World: *Energy from the Sun*

Did you ever get into a car on a summer day after the car had sat in the sun for an hour? Did the inside of the car get hotter while it sat in the sun? The sun's light is very strong. If we use a magnifying glass to concentrate it, it can start a fire. Let's see what the sun can do.

You need:

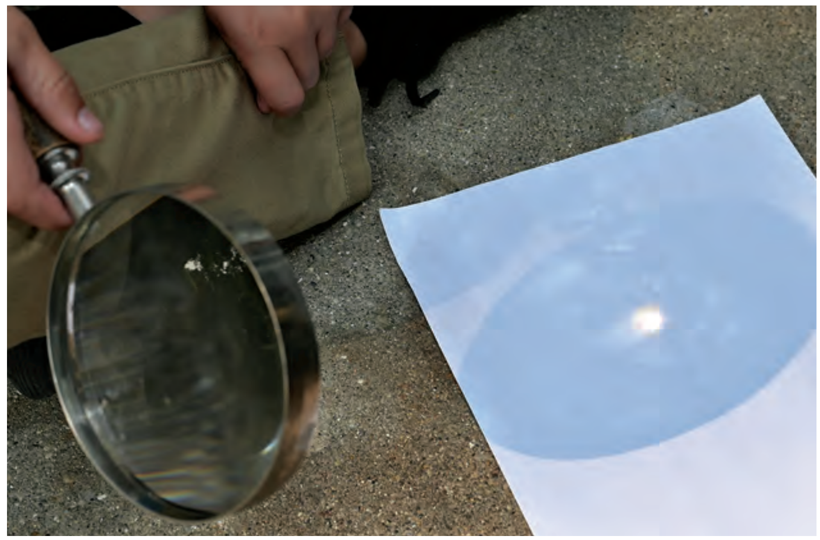
- ⇨ a magnifying glass
- ⇨ a piece of scrap paper
- ⇨ a small, flat piece of wood or a board

Instructions: Pick a sunny day for this experiment. Choose a place where there is no danger of fire spreading—a bare patch of ground or perhaps a metal bucket if there is a lot of dry vegetation around.

Safety First

Step 1: Set the piece of paper on the ground. You can use a piece of wood to keep the wind from blowing it away if necessary.

Step 2: Hold the magnifying glass over the paper until you see the sun's light on the paper. Find the right distance at which to hold the magnifying glass so you make the smallest possible dot of light on the paper.



Step 3: Wait a few moments. What happens?

First, the paper will start to smoke, then turn brown. A hole will burn through the paper. Some kinds of paper will catch fire.

Step 4: Now do the same thing with a flat board. If you are careful, you can burn letters into the wood by moving the dot of light slowly. Can you write your name?

Learning about God's World: *Safely Viewing the Sun*

Safety First

The sun's light is strong enough to burn paper or wood. It is also strong enough to burn our eyes, so we must be careful! We **NEVER**, ever look at the sun through a telescope. Not only could you damage your eye, but you can also damage the lenses in the telescope! So, how can we look at the sun? Try this activity.

You need:

- a thin, stiff piece of cardboard
- a bright, white sheet of paper
- a pin or needle

Instructions: Pick a sunny day for this experiment.

Step 1: Poke a small, clean hole through the center of the cardboard with a pin or needle.

Step 2: Hold the cardboard over the paper the way you did with the magnifying glass. Find the right distance so that a tiny, clear picture of the sun appears on the paper. You know you have the right distance when you see little gray spots on the sun's surface.


Pinhole camera projecting image of the sun

Can you see "flames" shooting from the edge of the sun? You will not be sure you are seeing them right away. At first, you will think your eyes are playing tricks. There really are flame-like things shooting from the sun!

The gray spots you see are called **sunspots**. They are cooler places on the sun. They are not very cool, though. The biggest nuclear bomb would be cooler than these cool places on the sun!

The flames shooting from the sun are part of its **corona** (kə-rō´nə). A corona is a bright circle seen around the sun or moon. Gases from the sun are lit up brightly like fireworks every second of every day.

The Planets

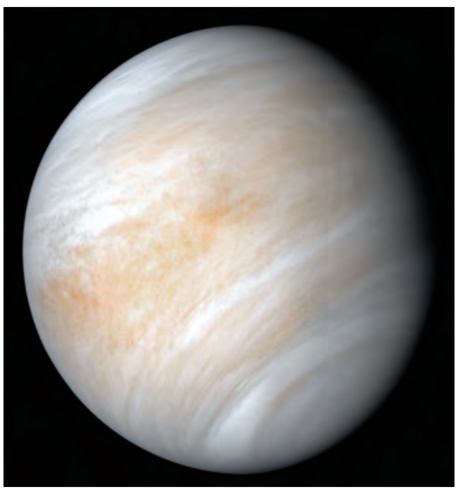
In addition to the sun, the solar system has eight planets and many smaller objects. The planets are all generally spherical, meaning shaped like a ball, and they all spin, which gives them their days and nights. They all have elliptical (oval) orbits and go around the sun in the same direction. However, there are some big differences between the inner planets and the outer planets.

The Inner Planets

The inner planets are the four that are closest to the sun. These are Mercury, Venus, Earth, and Mars. The inner planets are smaller than the outer planets, and each has an iron core and rocky surface. The inner planets have no rings and few, if any, moons.


Mercury *NASA/Johns Hopkins Univ. Applied Physics Laboratory/ Carnegie Inst. of Washington*

Mercury, the planet nearest the sun, is the smallest and the fastest planet. Mercury spins slowly as it rapidly orbits the sun. While one year on Mercury is only eighty-eight Earth days long, one day takes just over fifty-eight Earth days to complete.


Venus *NASA/JPL-Caltech*

Venus is the second planet from the sun. It is sometimes called Earth's twin since its size is close to Earth's. Venus has a thick atmosphere, but you would not want to breathe it since it is mostly carbon dioxide with clouds of sulfuric acid! Venus is the hottest planet because the thick layer of clouds traps the sun's heat.


Earth *NASA*

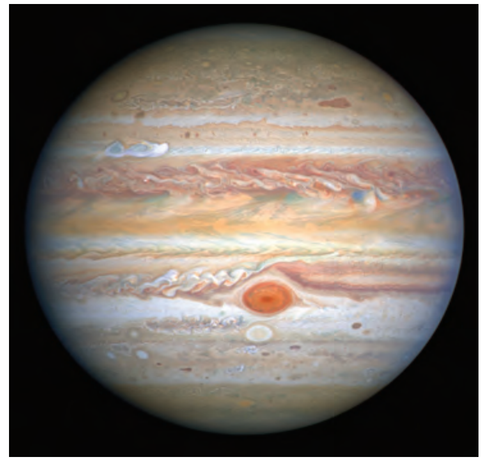
Earth is the third planet from the sun. It is the only planet with liquid water on the surface, and the only planet that is known to support life. We will look at Earth more closely in the next chapter.

Mars, called the red planet, is the fourth planet from the sun and the second-smallest planet. It looks red because of iron oxide on its rocky surface. The largest volcano in the solar system, Olympus Mons, is on Mars. Mars has a thin atmosphere and two moons.

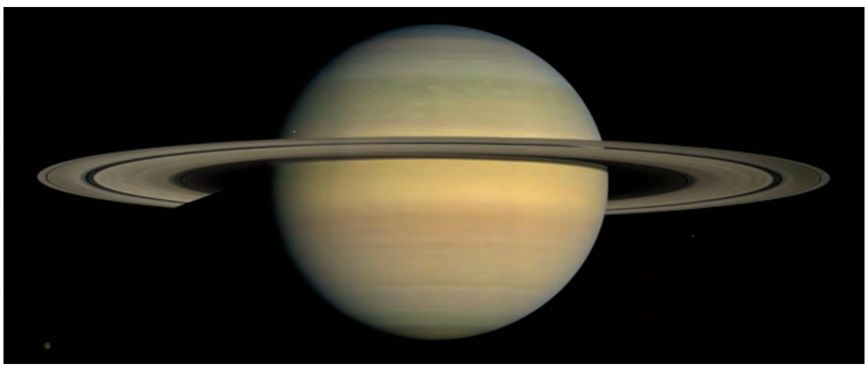
Mars
NASA/JPL-Caltech

The Outer Planets

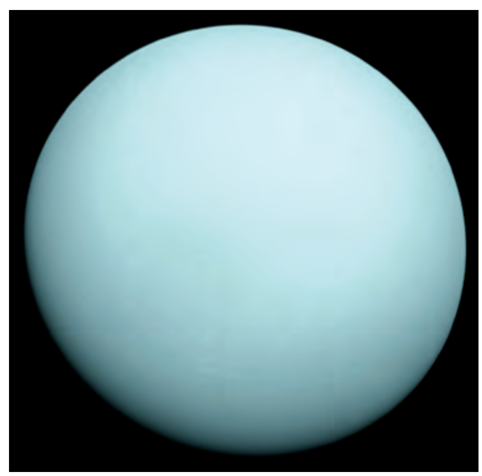
The four outer planets—Jupiter, Saturn, Uranus, and Neptune—orbit farther away from the sun. The outer planets are huge and are called gas giants and ice giants. Unlike the rocky inner planets, the giants have no solid surfaces. Each giant is composed mainly of the gases hydrogen and helium surrounding a liquid metal core. All of the outer planets have rings, and they all have many moons. They also spin very rapidly, making a day seventeen Earth hours or less.


Jupiter *NASA, ESA, STScI, A. Simon (Goddard SFC), M.H. Wong (U-Cal, Berkeley), the OPAL team*

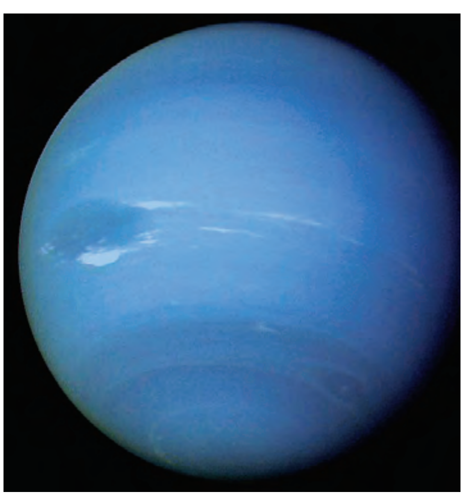
The gas giant **Jupiter**, the fifth planet from the sun, is the largest planet in the solar system. Its famous Great Red Spot is a hurricane-like storm that is twice the size of Earth.


Saturn *NASA/JPL/Space Science Institute*

The gas giant **Saturn** is the sixth planet from the sun. It is the second-largest planet and is known for its spectacular system of rings.


Uranus *NASA/JPL*

The ice giant **Uranus** is the seventh planet from the sun. Uranus is unique because it spins on its side. Methane in the atmosphere gives it a light blue color. It is the coldest of all the planets, even though it is not the farthest from the sun.



The ice giant **Neptune** is the eighth planet from the sun. It is called Uranus's twin because the two are very close in size. Methane in the atmosphere gives Neptune a dark blue color. One unique feature of Neptune is that one of its moons actually orbits the planet backwards.

Neptune
NASA/JPL

Smaller Objects

Beyond Neptune is the **Kuiper Belt** (kī´pər bĕlt), a ring of objects that orbit the sun. There are at least three dwarf planets in the Kuiper Belt, the best known of which is Pluto. Up until 2006, Pluto was considered to be a planet, but it is now called a dwarf planet, mainly because it is not alone in its orbit. There are other dwarf planets and thousands of smaller objects in the same area. Most of the smaller objects are "ices," chunks of frozen water, methane, ammonia, and other substances.

Pluto *NASA/APL/SwRI*

Vesta – The 2nd most massive object in the asteroid belt
NASA/JPL-Caltech/UCAL/MPS/DLR/IDA

Closer to home, the **asteroid belt** orbits the sun between Mars and Jupiter. It is a ring of billions of objects, mostly made of rock and metal. Some of the asteroids are large, and one is designated a dwarf planet. However, most of the objects in the asteroid belt are boulders and smaller rocks.

Learning about God's World: *Solar System Facts*

Variety in God's creation is not limited to just our planet. Fill out the chart to see how the planets in our solar system are different. Some of the information can be found in this text, but for other items you will need to look online or in another source.

Compared to the whole galaxy, our solar system is very small, but it is still big compared to us. Maybe this will help you to grasp the large distances involved.

If the sun were the size of a basketball, Earth would be the size of the head of a pin and would be 85 feet away. Jupiter would be about an inch in diameter and would be about 442 feet away. Neptune, though, would be almost a half mile away.

Inner Planets

	Mercury	Venus	Earth	Mars
Type of Planet (rocky or gas/ice giant)				
Diameter				
Length of Day				
Length of Year				
High and Low Temperatures				
Number of Moons				
Interesting Feature				

Outer Planets

	Jupiter	Saturn	Uranus	Neptune
Type of Planet (rocky or gas/ice giant)				
Diameter				
Length of Day				
Length of Year				
High and Low Temperatures				
Number of Moons				
Interesting Feature				

Looking Back

Instructions: Fill in the blanks.

1. The sun is mostly made of which gas? ______________________________
2. The bright circle around the sun is its ____________________________.
3. Are sunspots warmer or cooler than the rest of the sun? _________________________
4. Our solar system is located in the ______________________________________ galaxy.
5. All the planets in the solar system have ______________________________ orbits.
6. The _________________________ Belt is located beyond Neptune.
7. The asteroid belt is located between the planets _____________ and ______________.

Instructions: Match each planet to its description.

Earth	smallest and fastest planet
Jupiter	hottest planet
Mars	planet that spins on its side
Mercury	planet known for its rings
Neptune	the red planet
Saturn	only planet with liquid water on its surface
Uranus	planet farthest from the sun
Venus	largest planet in the solar system

Chapter 27
Other Invertebrates

Giant squid

Do you remember that animals that have backbones are called vertebrates? Remember that the animals that do not have backbones are called invertebrates. Most of the animals on our earth are invertebrates. We have already learned some things about insects. Let's look at some more fascinating invertebrate creatures.

Invertebrate Characteristics

Invertebrates come in many different sizes. For example, many insects are very small. However, giant squids can be as long as fifty feet or more. Both are invertebrates.

All invertebrates are cold-blooded. Remember, this means that they do not make their own heat. They must get warm by being in a warm place.

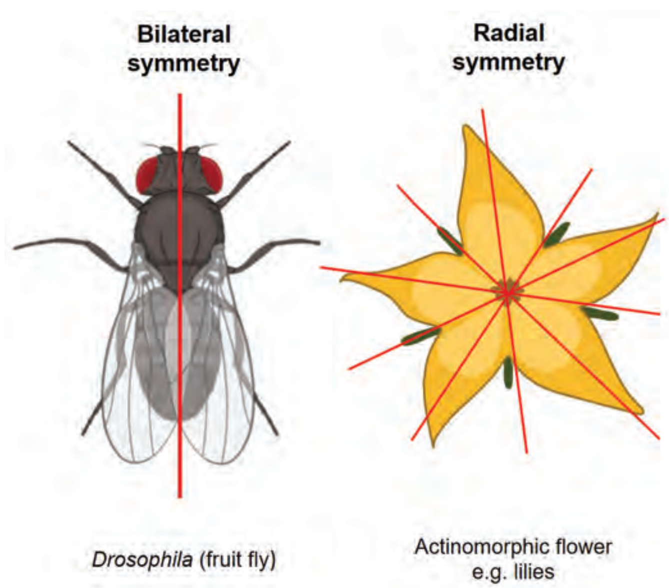
Because most invertebrates do not have skeletons on the inside, they have soft bodies. Instead of inside skeletons, many invertebrates have a hard outer covering such as a shell or an exoskeleton (skeleton on the outside of the body).

Most invertebrates live in the water or spend at least some part of their lives in water. Most invertebrates change form as they grow, either having complete or incomplete metamorphosis.

Body Shapes

Invertebrates have three basic body types. The most common is **bilateral symmetry**. This means that the body can be divided into two identical or nearly identical halves. One side is a mirror image of the other.

An animal that has **radial symmetry** has similar parts extending out in a regularly repeating pattern around a central point. Therefore, dividing the body into two identical halves can be done in more than one direction. Sea stars and jellyfish are examples of radial symmetry.



Charl Hutchings – CC BY 4.0 (Modified)

Asymmetry means "no symmetry." This means that the animal's body shape does not divide into identical halves. Sponges, for example, have no symmetry.

Types of Invertebrates

There are many different types of invertebrates. Here are some of them.

Arthropods (*Arthropoda*)

Arthropods are the largest group of invertebrates. "Arthropod" means "jointed feet." An arthropod has jointed legs, an exoskeleton, and usually a segmented body. All arthropods have bilateral symmetry (two matching or nearly matching sides). Because they have exoskeletons, all arthropods grow by molting. The old exoskeleton must be removed so that the animal can grow a larger one.

Spider

Lobster


Centipede

The arthropod group can be divided into four. We have already looked at insects. The other three groups are arachnids, crustaceans, and myriapods (creatures with many feet). See the chart below for some differences among the four groups.

	Insects	Arachnids	Crustaceans	Myriapods
number of legs	6	8	10	many
number of body parts	3 (head, thorax, abdomen)	2 (cephalothorax, abdomen)	2 (cephalothorax, abdomen)	many segments
number of antennae	2	0	4	2
examples	bees, butterflies, beetles, ants	spiders, scorpions, ticks, mites	crabs, lobsters, crayfish, woodlice	centipedes, millipedes

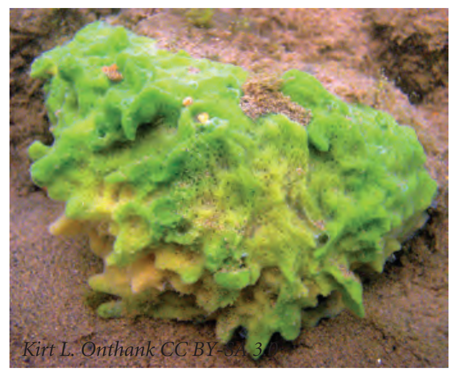
Mollusks (*Mollusca*)

Mollusks have soft bodies. In fact, "mollusk" means "soft." Mollusks have bilateral symmetry. Most mollusks have hard shells for protection. A mollusk also has a foot that it uses to move around and to catch food. Most mollusks live in water and breathe with gills, but a few live on land.

A mollusk has a **mantle**, which is a covering for its internal organs. The mantle creates the material that becomes the mollusk's shell. This shell is made of a compound called calcium carbonate. If you have been to the beach, you have probably seen some of the many different kinds of shells that mollusks grow.

From the description above, you have probably figured out that clams, oysters, and snails are all mollusks. However, you may be surprised to hear that octopuses and squids are also mollusks. They have soft bodies, and they also have mantles, just like the other mollusks, but they do not grow shells. In fact, because an octopus has such a soft, flexible body, it can squeeze into surprisingly tight spaces.

Sponges (*Porifera*)



The name "porifera" means "pore-bearing." Sponges have pores (holes) all over their bodies. Sponges do not have symmetry, and they live only in the water. Most live in the oceans, but a few live in lakes or rivers. They anchor themselves to something and do not move around.

Since they do not move and they do not have a head, they look like colorful plants, but sponges are animals. Can you guess why? Sponges do not make their own food like plants do. They take in oxygen and food through their pores.

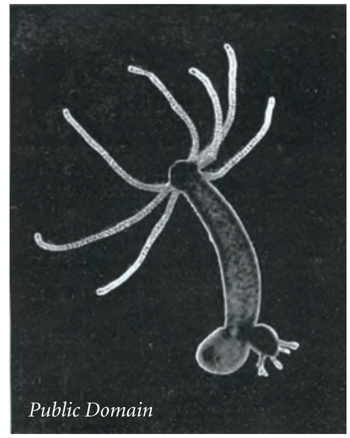
When a sponge has a baby (called a larva), the larva will swim for a couple of days and then find a firm place to settle. It will anchor to that spot and grow into an adult. The conditions of that place affect the sponge's shape and size, so no two sponges are identical. A sponge will normally live for about 20 years.

Coelenterates (*Cnidaria*)

Jellyfish, anemones, corals, and hydras are coelenterates. Coelenterates have a hollow body, which is why their name means "hollow intestine." The mouth is surrounded by tentacles, so they have radial symmetry. They live only in the water.

The tentacles have stinging cells to stun and capture any creatures that the coelenterate wants to eat. A coelenterate takes food into its hollow body, digests it, and then sends the waste back out the mouth.

Coelenterates have two body forms, the polyp and the medusa. The **polyp** form is tube-like with the mouth and tentacles facing upwards. It is usually anchored on something solid, much like a sponge. The **medusa** form swims and has a bell or umbrella shape with the mouth and tentacles hanging down. In some coelenterates, such as the jellyfish, the life cycle includes both forms.


Public Domain

Hydra

Echinoderms (*Echinodermata*)


© Thomas Kline / Design Pics

Sea Urchin

The name "echinoderm" means "spiny skin." Echinoderms have an internal skeleton (endoskeleton) made of the compound calcium carbonate. The skeleton is covered by a skin, but many echinoderms have spines or spikes of calcium carbonate that stick out through the skin.

Echinoderms live only in the oceans. There are none on land, nor in the lakes or rivers. They have various shapes, sizes, and colors. The best known of the echinoderms are the sea stars (also called starfish). Other echinoderms are sea urchins, sea lilies, sea cucumbers, sand dollars, and brittle stars.

An interesting feature of echinoderms is that the larval (baby) form has bilateral symmetry and swims. However, the adult form has radial symmetry and lives on the ocean floor.


Pam Brophy —CC BY-SA 2.0

Starfish

Echinoderms have no blood, but they have canals in the body filled with water. This is called a **water vascular system**. The water in the canals delivers food and oxygen to the parts of the body. The water vascular system also helps the echinoderm to move.

Echinoderms have many little **tube feet** that have tips something like suction cups. Muscles control how much water is in the tube feet, making the tube feet expand and contract. In this way, the echinoderm can "walk" and catch food with its tube feet.

Probably, the most interesting feature of echinoderms is that they can grow replacements for lost parts. For example, if a sea star loses a limb, it can grow a new one!

Learning about God's World: *Research Report*

Pick an invertebrate that interests you, and find some facts about it. Fill out this research report.

My interesting invertebrate is ____.

Description

Does it have bilateral symmetry, radial symmetry, or asymmetry?

Does it have limbs? If so, how many and what kind?

What size, shape, and color is it when it is young?

What size, shape, and color is it when it is an adult?

How long does it usually live?

Abilities

Does it move?

If so, how does it move? How fast does it move?

What protection does it have?

What is an interesting ability or habit that it has?

Lifestyle

Where does it live?

Does it live alone or in groups?

What does it eat?

How does it catch its food?

What eats it?

Does it care for its babies? If so, how?

Looking Back

Instructions: Answer the questions in the space provided.

1. Name an invertebrate group in which the members have bilateral symmetry.

2. Name an invertebrate group in which the members have radial symmetry only as adults.

3. How do we know that a sponge is an animal, not a plant?

4. Which arthropods have eight legs, two body parts, and no antennae?

5. Name the two body forms that a coelenterate can have.

6. Name a feature that is common to all invertebrates.

Instructions: Match the invertebrate to its description.

Arthropod	mouth surrounded by stinging tentacles
Coelenterate	soft body, usually with a shell
Echinoderm	jointed feet and exoskeleton
Mollusk	spiny skin, internal skeleton
Sponge	pores in body, anchored to something