Integrated Science I

Course No. 2002400

Bureau of Exceptional Education and Student Services
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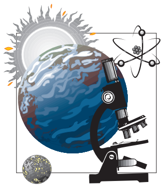

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Curriculum Improvement Project
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Exceptional Student Education

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Table of Contents

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Unit 1: Introduction to the Scientific Processes

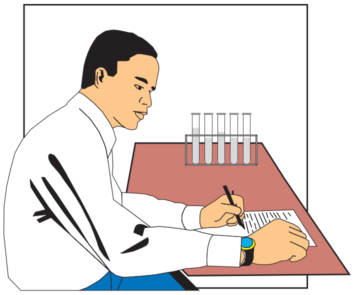
This unit reviews the steps of the scientific method and how they are used to solve problems. Students will review Safety Guidelines on page 5 of the teacher's guide and sign the Lab Safety Contract on page 6 of the teacher's guide. Mastery of 90-100 percent is required on the safety quiz (numbers 1-10) in the student book on page 22 before participating in lab activities.

Student Goals

- Identify the steps of the scientific method used by scientists in solving a problem.
- Know safety rules for science laboratory and classroom.
- Recognize the scientific method being used in everyday problems.
- Recognize that scientific thought undergoes shifts.

Unit Focus

- Know that investigations are conducted to explore new phenomena, to check on previous results, to test how well a theory predicts, and to compare different theories. (SC.H.1.4.1)
- Know that from time to time, major shifts occur in the scientific view of how the world works, but that more often, the changes that take place in the body of scientific knowledge are small modifications of prior knowledge. (SC.H.1.4.2)
- Understand that no matter how well one theory fits observations, a new theory might fit them as well or better, or might fit a wider range of observations, because in science, the testing, revising, and occasional discarding of theories, new and old, never ends and leads to an increasingly better understanding of how things work in the world, but not to absolute truth. (SC.H.1.4.3)



- Know that technological problems often create a demand for new scientific knowledge and that new technologies make it possible for scientists to extend their research in a way that advances science. (SC.H.3.4.2)

Vocabulary

Use the vocabulary words and definitions below as a reference for this unit.

analog	that which has similar characteristics to another thing (like the similarity between the heart and a pulse)
computer simulation	a computer program designed to represent the behavior of something in the physical world
conclusion	an explanation of a problem based on observations and collected data
control group	the part of the experiment without a variable factor; allows the results of experiment to be compared
controlled experiment	an experiment in which all the factors are the same except for the one being tested
data	scientific facts that are collected, usually in the form of numbers
experiment	a way to test a hypothesis or try out an answer to a question
experimental group	part of the experiment that contains the variable factor
fact	an idea that has been proven by experiments

Galileo Galilei	an Italian astronomer and physicist who discovered that objects fall at the same rate regardless of mass
hypothesis	an idea or statement that attempts to explain the relationship of observed factors; an educated guess
laboratory	a place equipped and used for experimental study, research, analysis, testing, or preparation in any branch of science
observation	noticing something, using one's senses (sight, smell, touch, hearing, or taste)
scale model	a man-made version of a physical object that is identical in proportion to the original but which may be smaller in total size
scientific law	a scientific theory that has been tested many times and has produced the same results over a period of many years
scientific method	the steps scientists use to solve problems
theory	a hypothesis that has withstood the test of time
variable factor	the factor being tested in an experiment

Introduction

Many of us have had unanswered questions about our environment—why…? how…? when…? Some of us have gone to find answers. Most of us, however, must depend on more qualified individuals for answers. Most often, those qualified individuals are scientists, investigators in the field of science. They specialize in finding answers in an efficient and organized manner.

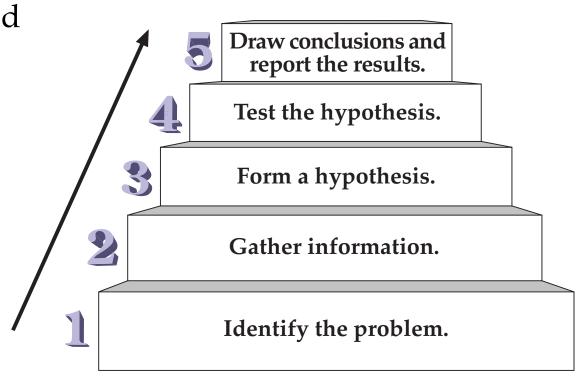
Scientists—investigators in the field of science.

To investigate efficiently and in an organized way, scientists must use a certain method. This method is called the **scientific method**, a way of solving problems using specific steps. Scientists must also be careful to follow safety rules when they conduct **experiments** in the **laboratory**. Scientists follow *laboratory* rules to protect the results of their *experiments* and prevent accidents.

Steps of the Scientific Method

Have you ever observed something in nature and wondered what it is and how it works? If so, you have that in common with scientists. Scientists wonder about nature. They ask questions and design experiments to find the answers to their questions.

Whenever scientists have questions or problems, they use a certain method called the *scientific method* to find answers. It is a way of solving problems using five specific steps: identifying the problem, gathering information, forming a **hypothesis**, testing the *hypothesis*, and drawing **conclusions** and reporting the results. The method allows scientists to look at a specific problem and develop some solutions. Using the scientific method, scientists can look at each possible solution to determine if it is correct.



Steps of the Scientific Method

Step l: Identify the problem

The first step is to identify the problem and develop a question about it. The study of a problem always begins with a question. Scientists must know exactly what the question is so that they can decide how they want to go about finding an answer to it.

In a study about the origins of coquina, a stone made of broken shells found in Florida, scientists had only one question: How did coquina stone made from organisms that lived in the ocean come to be found miles away, far from the beaches and sea?

Step 2: Gather information

Then information is collected about the question. **Observations** are made and recorded. Careful *observations* are important in gathering information. Scientists observe everything they can about a scientific problem. By studying coquina in areas where it seemed unlikely they could have formed, scientist used many ways of collecting information to learn when and where the stone formed.

There are various ways to collect information. Some of the ways are listed below.

Ways to Collect Information

- reading about what other scientists have done on the subject
- using the senses (sight, hearing, smell, touch, or taste) to make observations
- using scientific equipment, such as a telescope

Confirmed observations can become scientific **facts**. A *fact* is an idea that has been proven by experiments. Observations and facts are then recorded. This recorded information becomes **data**. Scientific facts, often in the form of numbers, are called *data*. Scientists must use logical reasoning to interpret their data.

Step 3: Form a hypothesis

Looking at the data gathered, scientists make a guess and suggest what may be the answer to the problem. This guess, which is based on observations, is called a *hypothesis*. A hypothesis is an idea or statement that explains the relationship of observed facts to each other. It is a tool for further study of the problem. A good hypothesis must include specific explanatory information so that it can be tested.

The idea that ocean levels change was a good hypothesis for several reasons. It explained why coquina rocks were found in dry areas as well as under the sea. It predicted that the level of the ocean would not remain constant over long periods of time and could change by either spreading or receding. Very importantly, this hypothesis could be tested.

A Good Hypothesis

- explains how observed facts relate to each other
- predicts new facts
- lends itself to testing; a hypothesis that cannot be tested is of no value

Step 4: Test the hypothesis

Scientists who proposed that the ocean levels could change would not have had a useful hypothesis if they had not found a way to test it. The test of their hypothesis was as important as the hypothesis itself.

Experimentation is the scientific testing of a hypothesis. It must be done in a careful manner. Scientists must repeat experiments many times before they accept the results. They must also test important factors under different conditions.

An experiment consists of two groups, the **experimental group** (which contains the variable being tested) and the **control group** (without the variable). The factor being tested in the experiment is the **variable factor**. A **controlled experiment** is one in which all the factors are the same except for the one being tested.

Scientists must carefully design their experiments to eliminate the possibility of bias (making their results fit their hypothesis). This is why several scientists will work together but separately on the same experiment to ensure accurate results. The experiment must also be repeated many times achieving the same results in order for *conclusions* to be made. A single result does not imply any conclusion.

Scientists must make careful and complete observations.

During and after experimentation, scientists must make careful and complete observations. Accurate records of the results must be made in the form of charts, graphs, or tables. Scientists use these charts, graphs, and tables to analyze their data. They look for similarities and differences between the results. Computer models or simulations can also be used to test collected data or a hypothesis. These analyses are used to help draw conclusions about their hypothesis.

Scientists developed ways to test their hypothesis that ocean levels change over time. They took precise measurements of the ocean levels.

Step 5: Draw conclusions and report the results

After the experiments are completed, conclusions are drawn. Scientists use the conclusions to reevaluate their hypothesis. They must decide if the conclusions confirm or contradict their hypothesis. An experiment does not always confirm a hypothesis. It may show that the hypothesis is partially or totally wrong. If the hypothesis is wrong, the scientist must go back and study the data and facts. The facts will be interpreted a different way. The scientist will develop a new hypothesis to be tested. Even if an experiment supports a hypothesis, the experiment may need to be repeated many times before the hypothesis can be confirmed.

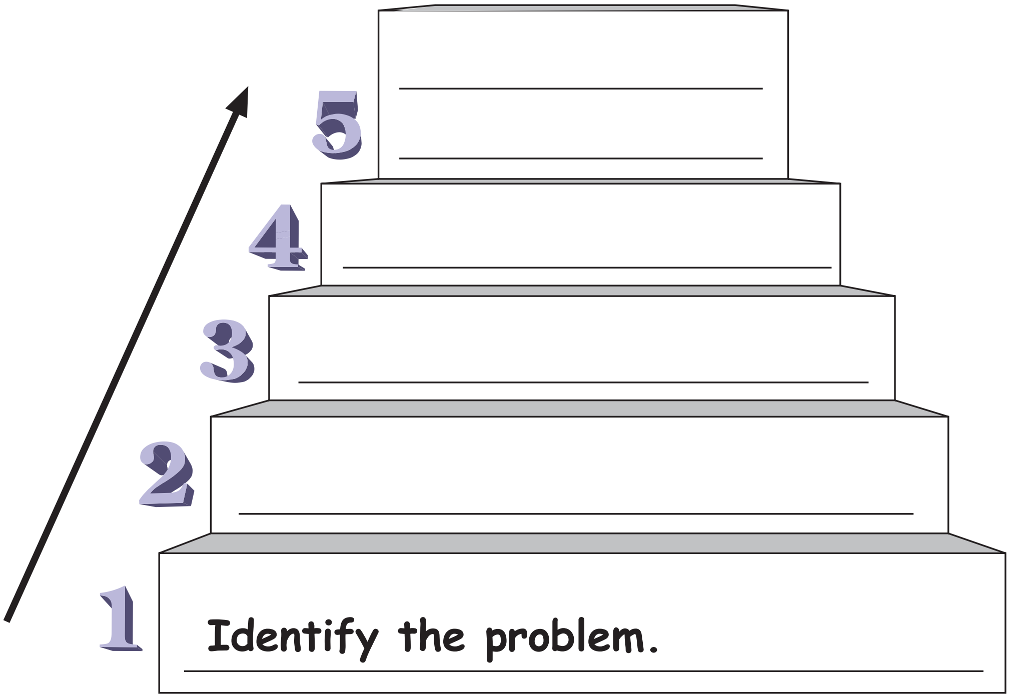
Scientists who studied the question of how and where coquina stones formed learned a great deal. After years of measuring, their conclusions stated that oceans could change. Coquina that was found on dry land could have formed in the ocean.

Practice

Arrange the steps of the **scientific method** *below in the correct order on the lines provided.* **The first step has been done for you.**

Form a hypothesis.
Gather information.
Draw conclusions and report the results.
Test the hypothesis.

The correct order is as follows:



Practice

Use the list above each section to write the correct term for each definition on the line provided.

conclusion
data
experiment
fact
hypothesis
laboratory
observation
scientific method

________________ 1. an idea that has been proven by experiments

________________ 2. an idea or statement that attempts to explain the relationship of observed factors; an educated guess

________________ 3. scientific facts that are collected, usually in the form of numbers

________________ 4. a way to test a hypothesis or try out an answer to a question

________________ 5. noticing something using one's senses (sight, smell, touch, hearing, or taste)

________________ 6. an explanation of a problem based on observations and collected data

________________ 7. the steps scientists use to solve problems

________________ 8. a place equipped and used for experimental study, research, analysis, testing, or preparation in any branch of science

control group
controlled experiment
experimental group
variable factor

____________________ 9. the part of the experiment without a variable factor; allows the results of experiment to be compared

____________________ 10. the factor being tested in an experiment

____________________ 11. part of the experiment that contains the variable factor

____________________ 12. an experiment in which all the factors are the same except for the one being tested

Practice

Write **True** *if the statement is correct. Write* **False** *if the statement is* not *correct.*

__________ 1. An experiment may have only one variable factor.

__________ 2. Experiments always prove the hypothesis to be true.

__________ 3. A good hypothesis can be tested.

__________ 4. A hypothesis attempts to explain the relationship among observed facts.

__________ 5. A fact is an idea that has been proven by experiments.

__________ 6. Careful observation is an important step in scientific study.

__________ 7. Data is usually in the form of numbers.

__________ 8. Logical reasoning has no part in a scientific experiment.

__________ 9. If you get positive results from your experiment the first time, it is okay to stop and report your results.

_________ 10. Observation is done solely with the eyes.

_________ 11. The experiment is the last step of the scientific method.

Scientific Method in Action

Many scientific discoveries have been made by mistakes or by forming the wrong hypothesis. For example, penicillin was discovered as a mold that killed all of a researcher's bacteria. Scientists often ask other scientists from different disciplines to review their research and make suggestions for refining their hypothesis or figuring out why their hypothesis was not supported. Different conclusions may be reached by different teams of scientists working on the same problem. This difference of opinion helps the scientists reach a better understanding of the problem.

It is important to write down the results of experimentation and make them available for other scientists to use. The results may then be used to continue experimentation and to go on and make more new discoveries.

When a hypothesis has withstood the test of time, it is called a **theory**. An accepted *theory*, however, may change as new discoveries in science are made. At times scientists are unsure if old ideas are really true. They investigate these theories.

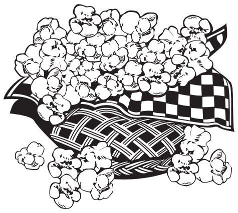
Galileo Galilei
(1564–1642)

Scientists have been using the scientific method for about 400 years. It began with an Italian scientist named **Galileo Galilei** (1564–1642) who tested ideas about nature to explain the way things happen. Before *Galileo*, most people believed that heavier objects fell faster than lighter objects. No one bothered to test this idea. Instead, they accepted it as fact. Then Galileo decided to use the scientific method to investigate this hypothesis. Galileo found that objects fall at the same rate of acceleration regardless of their weight because gravity makes all objects accelerate at the same rate. However, gravity is not the only force at work. Objects are also affected by air resistance, the force air exerts on an object. This was a gigantic change in the way the world was seen and understood. Since that time, many other scientists have conducted investigations about gravity. They too have found that Galileo was right about the way things fall.

Even now, such major changes occasionally take place. It is more common, however, for the changes to be small. Whether big or small, changes take place because scientists all over the world share information. Often many scientists are working on the same problem. If the results among the different scientists are not the same, the hypothesis, approach, or methods may have to be changed. If a hypothesis has been tested many times and seems correct, it is called a *scientific theory*. After a theory has been tested and supported many times, it becomes a **scientific law**. In science, no theory or law is ever considered proven. Galileo showed us the reason for this, and, in fact, what Galileo said about gravity is still considered theory.

Scientific Testing

Suppose you wanted to find out if storing popcorn in the refrigerator would make a difference in the number of kernels that did not pop. You would need to also test popcorn stored at room temperature as a *control*, or the standard for comparison. All other conditions for both batches of popcorn would need to be the same: the same brand, same freshness, same storage time, and same method of preparation. Only one condition, the place of storage, should differ. All other factors are *constants* and cannot change.



Does storing popcorn in the refrigerator make a difference in the number of kernels that do not pop?

Scientists often test their hypotheses by conducting experiments under controlled conditions in the scientific laboratory. In some cases, conditions cannot be controlled. It would be hard to control conditions when investigating the way people behave or the way the trees in a large forest interact. In these cases, it may not be possible or ethical to conduct an experiment in a laboratory. Instead, scientists observe the widest range of natural behavior possible. Scientists may survey large numbers of people. They may record conditions in the forest for years and years. By doing this, scientists gather information that can be compared to laboratory results.

Another way to test theories about parts of the world is to use a **scale model**. Imagine you wanted to know how a building would behave during an earthquake. You couldn't create an actual earthquake in a laboratory. Instead, you might construct a small *scale model* of the building. Then you could shake it, simulating an earthquake. More and more, models using **computer simulations** are being made. One advantage of *computer simulations* is they permit scientists to test theories many times.

Sometimes theories are tested using **analogs**. *Analogs* are things that are similar but not exactly alike. Scientists use the similarities between analogs to learn. For example, you might want to know how a now extinct dinosaur flew. You might study how bats actually do fly. Bats are analogs to dinosaurs because both bats and dinosaurs flew without having feathers. There are some differences between the two, but the scientists study their similarities. With the right preparation, the results of this investigation would be a fairly accurate prediction and would show what it would take to make an extinct dinosaur fly. Try to think of an analog to a human. Could you study the analog to learn things about humans? Whether using analogs, computer simulations, or scale models, scientists work to be sure that their results are generally accurate.

Computers and Science

Computers have become very important in scientific studies. Some experiments are performed entirely by the computer. Scientists can develop computer models or simulations to test collected data or a hypothesis. These computer simulations allow scientists to perform complicated mathematical computations more quickly and reliably. Supercomputers can perform billions of calculations per second. Simulations are also used when experimenting may be very dangerous. Computer models help scientists refine their hypotheses and determine the type of information to be collected. Computers have helped speed up the scientific process. They allow scientists to simulate past events.

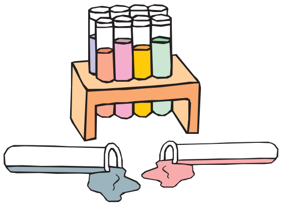
Computers have become very important in scientific studies.

With computers, scientists can share information and collaborate with others doing similar research. Computers also allow teams of scientists from different disciplines to review or duplicate research even if they are not on the same continent. The Internet was originally developed by the Department of Defense as a means of sharing and transmitting such research data quickly. Now we use the Internet to research current scientific discoveries, to ask scientists questions about their research, or to collect data for laboratory experiments or simulations. The Internet has helped the scientific community share current information. It is a great resource for up-to-date information. As with all other resources, however, information from the Internet must be carefully reviewed to determine its accuracy and reliability.

Laboratory Safety Rules

The school science laboratory can and should be a safe place in which to explore interesting and challenging activities. There is, however, one factor that is most important—and that is *safety*!

The rules and procedures on the following page should be followed at *all* times in order to make the science laboratory a safe place.



Make the science laboratory a safe place.

Safety Guidelines

1. Read and follow all directions while working in the laboratory.
2. Wear protective gear, such as aprons, at all times. Wear goggles when working with dangerous or hot chemicals, or any time your teacher instructs you to do so.
3. NEVER taste or directly inhale chemicals. Test the smell of a substance by *wafting* or fanning some of the odor to your nose with your hand. Your teacher can show you how.
4. DO NOT bring food or drink into the lab.
5. Wash hands thoroughly after each lab.
6. DO NOT rub eyes or put hands in mouth.
7. Dress in a way that helps you work safely and efficiently in the lab. Tie your hair back. Wear cotton—it doesn't catch fire as easily as nylon or polyester. Always keep your shoes on while in the lab. Roll up long or loose sleeves.
8. DO NOT look directly down into the mouth of a filled test tube. DO NOT point the mouth of a filled test tube at another student. Liquid can splash into eyes.
9. DO NOT perform any experiments unless the instructor is in the room.
10. Report ALL minor and major accidents to your instructor. Remain calm and do not alarm others by shouting or running.
11. Know the location of the safety shower, eye wash, and fire blanket. Know how to use these important pieces of safety equipment.
12. Turn off gas burners and the gas outlets when no one is using them. NEVER leave a lit burner unattended.
13. Use tongs or gloves to handle hot objects.
14. DO NOT look directly at the sun, with or without equipment, as it may damage your eyes.
15. Keep lab tables clean and neat to prevent accidents. Dispose of waste and used chemicals in appropriate location and manner according to teacher's instructions. Wipe all areas at the end of the lab.
16. MAKE SAFETY A HABIT!

Summary

The sharing of scientific information requires that scientists be able to obtain and report their findings in an efficient and consistent manner. When answering questions, scientists use the scientific method, a series of logical steps to solve problems.

1. Identify the problem.
2. Gather information.
3. Form a hypothesis.
4. Test the hypothesis.
5. Draw conclusions and report the results.

Scientists must handle materials properly. Just as scientists have specific rules and procedures for operating in the laboratory, we too must follow safety rules to make our experiences in the science laboratory safe and rewarding.

Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. a man-made version of a physical object that is identical in proportion to the original but which may be smaller in total size

______ 2. that which has similar characteristics to another thing (like the similarity between the heart and a pulse)

______ 3. an Italian astronomer and physicist who discovered that objects fall at the same rate regardless of mass

______ 4. a hypothesis that has withstood the test of time

______ 5. a scientific theory that has been tested many times and has produced the same results over a period of many years

______ 6. a computer program designed to represent the behavior of something in the physical world

A. analog

B. computer simulation

C. Galileo Galilei

D. scale model

E. scientific law

F. theory

Practice

Find all the **hazards** *in the science lab pictured below. List them on the lines below. Be prepared to discuss them in class.*

Practice

List the locations and uses of the **safety equipment** *below.*

Equipment	Location	Use
safety shower		
eye wash		
fire extinguisher		
fire blanket		
sand		
goggles		
lap aprons		
container for broken glass		

Practice

Write **True** *if the statement is correct. Write* **False** *if the statement is* not *correct.*

__________ 1. If there is something you do not understand about the lab assignment, you should ask your teacher.

__________ 2. Only the teacher needs to know where the safety equipment is and how to use it.

__________ 3. It is a good idea to bring a lunch along to eat while working on lab activities.

__________ 4. Use tongs or gloves to handle hot equipment.

__________ 5. It is important to use good housekeeping habits in the laboratory.

__________ 6. Report all accidents to the teacher, no matter how minor.

__________ 7. Do not wear loose or baggy clothes in the lab.

__________ 8. Safety glasses must be worn when working with dangerous or hot chemicals.

__________ 9. It is important to put your nose directly over a container and breathe deeply to smell a substance in the laboratory.

_________ 10. Open test tubes should never be pointed at yourself or at others.

Write **True** *if the statement is correct. Write* **False** *if the statement is* not *correct. If the statement is* **false**, *rewrite it to make it true on the lines provided.*

__________ 11. It is best to keep the results of your experiment a secret so that no one may steal your ideas.

____

____

__________ 12. A theory can be disproved if new discoveries are made.

____

____

__________ 13. Computer simulation, models, and analogs are other ways to test theories when normal lab techniques cannot be used.

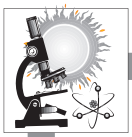
____

____

__________ 14. Occasionally, large shifts in scientific thought occur. More frequently, these shifts are small.

____

____



Practice

Circle the letter next to the **scientific method** *term that correctly completes each statement below.*

1. The factor being tested in an experiment is the ____________ .
   a. variable
   b. hypothesis
   c. observation
   d. control

2. The part of the experiment without a variable factor is the ____________ .
   a. observation
   b. control group
   c. experiment
   d. hypothesis

3. An idea or statement that attempts to explain the relationship of observed factors to each other is a(n) ____________ .
   a. hypothesis
   b. observation
   c. fact
   d. conclusion

4. A way to test a hypothesis or try out an answer to a question is a(n) ____________ .
   a. fact
   b. experiment
   c. observation
   d. data

5. To notice something using one's sight, smell, touch, hearing, or taste is a(n) ____________ .
   a. observation
   b. act
   c. theory
   d. data

6. An explanation of a problem based on observations and collected data is a ____________ .

   a. fact
   b. theory
   c. data
   d. conclusion

7. An idea that has been proven by experiments is a ____________ .

   a. fact
   b. theory
   c. controlled experiment
   d. data

8. Scientific facts that are collected, usually in the form of numbers, are called ____________ .

   a. data
   b. scientific method
   c. controlled experiment
   d. theory

9. A hypothesis that has withstood the test of time is a(n) ____________ .

   a. theory
   b. controlled experiment
   c. scientific method
   d. observation

10. The steps scientists use to solve problems are known as the ____________ .

    a. theory
    b. controlled experiment
    c. scientific method
    d. data

11. An experiment in which all the factors are the same except for the one being tested is a(n) ____________ .

    a. experimental group
    b. controlled experiment
    c. theory
    d. scientific method

12. The part of the experiment that contains the variable factor is the _____________ .

    a. controlled experiment
    b. scientific method
    c. theory
    d. experimental group

13. A hypothesis is _____________ .

    a. an educated guess
    b. a scientific experiment
    c. a scientific laboratory
    d. a scientific law

Unit 2: Matter

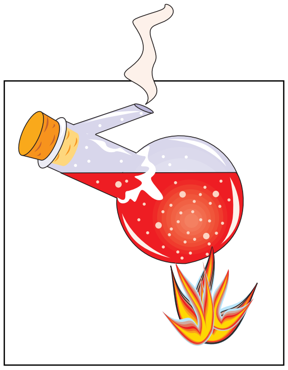
This unit describes the properties of matter. The physical and chemical properties of matter are discussed. Students will learn to recognize the three phases of matter.

Student Goals

- Demonstrate, through the use of scientific instruments, that matter occupies space and has mass.
- Differentiate between physical and chemical properties.
- Name the phases of matter and identify their characteristics.

Unit Focus

- Know that a change from one phase of matter to another involves a gain or loss of energy. (SC.A.1.4.3)



Vocabulary

Use the vocabulary words and definitions below as a reference for this unit.

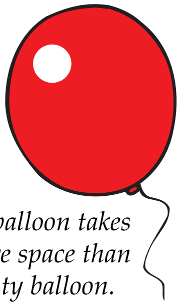
chemical properties	the qualities of matter that indicate whether it can change from one substance to another
chemist	a person who studies chemical operations
chemistry	the science that investigates how matter is made and how it changes
density	the mass per certain volume of a material
forms	kinds or types
gas	the form of matter that has no definite shape or volume
gravity	the force of attraction between all objects in the universe
liquid	the form of matter that has a definite volume but does not have a definite shape
mass	the amount of matter in a substance

matter	anything that has both mass and volume
phase	one of the states of matter of a substance (H_2O occurs in three phases: ice, liquid water, and water vapor.)
physical properties	the qualities of matter that can be observed without changing the matter (color, shape, size, density)
plasma	the form of matter in stars; this is usually gaseous matter under extreme heat and pressure
reacts	changes in response to something
solid	the form of matter that has a definite shape and volume
state	the condition of matter
volume	the amount of space that matter takes up
weight	the force of gravity on an object

Introduction

Look around you. Everything you see is **matter**. What is *matter*? Matter is anything that has **mass** and **volume** (takes up space). *Mass* is the amount of matter in an object. Remember that **weight** is the force of **gravity** pulling on the object. An object's weight depends on its mass and whether *gravity* is pulling on it. Earth does not pull on stars that are far away. Because of this, we cannot really talk about their *weight*. They do have mass, though, and they are matter. All matter takes up space. That means it has *volume*. So we have learned that all matter has mass and volume.

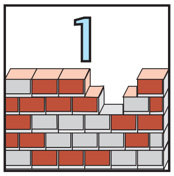
Even air is matter. It has mass and it takes up space. An empty balloon has less mass than a balloon that has been filled with air. The difference between the two is the mass of the air. The full balloon takes up more space than the empty balloon. You can see that air takes up space.



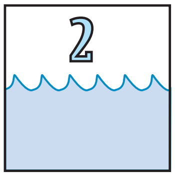
A full balloon takes up more space than an empty balloon.

Not all matter is the same. Look at the different kinds of matter in the room. Books, tables, the air you are breathing, and the water in the sink are all different **forms** or **states** of matter. Scientists call the *form* of matter its **phase**. *Phases* are one way to classify matter. There are four phases of matter. **Gases**, **liquids**, and **solids** are all phases of matter commonly found on Earth. The fourth phase of matter is **plasma**. It is a form of matter found in stars, such as the sun. Although *plasma* is common in the universe, we have little chance to observe plasma. Matter in the plasma phase is extremely high in energy and therefore dangerous to living things. On Earth, plasmas usually do not occur naturally except in parts of flames and in lightning bolts.

Phases of Matter Commonly Found on Earth



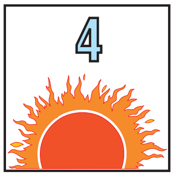
solids



liquids

gases

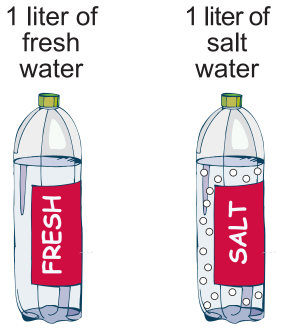
Phase of Matter Commonly Found in the Universe



plasmas

Physical Properties

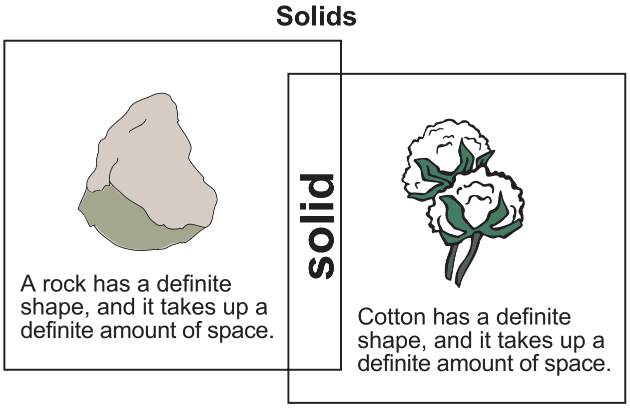
In what ways can you describe matter? Suppose you have a few solids in front of you. How could you describe them? You probably will begin by describing their color, shape, size, or degree of hardness. The characteristics that you observe without changing the matter are called **physical properties**. It is easy to see color, shape, and size, and to feel hardness. Another *physical property* is **density**. *Density* is the amount of mass of a certain material in a certain volume.



The container filled with salt water has more mass than the one with fresh water.

For example, two liter containers are filled with liquids. One container is filled with fresh water. The other container is filled with salt water. The container filled with salt water has more mass than the one with fresh water. That's because salt water has more density than fresh water. The containers have the same volume, but different masses. The difference is in the density of the liquids.

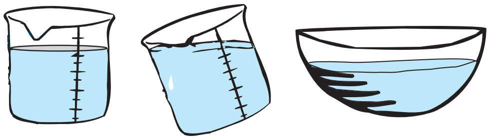
Density is a physical property of matter. Density helps determine the use of many different materials. For example, the comparison of the density of wood and the density of Styrofoam can determine *how* each material is used, and for *what purpose*.



All matter has the general physical properties of mass, weight, volume, and density. However, phase, or state of matter, is also an important physical property.

A *solid* must have a definite shape and take up a definite amount of space. Look at a rock. It has a definite shape, and it takes up a definite amount of space. Therefore, it is a solid. Rocks are hard, but cotton is soft. Is cotton a solid? Think. Cotton has a definite shape. It takes up a definite amount of space, so cotton is also a solid.

Can you change the shape of a rock or the shape of cotton? Just because the shape of something can change, its shape is not indefinite. If something or someone did not change them, then their shapes would remain the same. This is what is meant by a definite shape. A solid is able to keep its definite shape because the tiny particles that make up a solid are packed very close together. The particles are only able to vibrate since they cannot move far out of their places.



A cup of water takes up space in a beaker. If you tilt the beaker or put the water in a bowl, the water changes shape but it is still the same amount of water.

Matter can be a *liquid*. Pour one liter of water into a liter beaker. It takes up space. Tilt the beaker. The water changes shape. Pour the water into a bowl. It still is a liter of water, but it has a different shape. Liquids have a definite volume but not a definite shape. The particles in a liquid are not held as tightly together as they are in a solid. So the particles in a liquid are free to move.

Some matter is in the form of *gas*. Blow up a balloon. The air takes up space or volume. The air inside the balloon has mass. It does not have its own shape. Gases take on the shape of whatever they are in at the moment. They also fill whatever they are in because the particles of gas tend to spread far out from one another. It is possible for a beaker of water to be half empty. However, a balloon filled with air cannot be half empty. Even when a balloon gets smaller, the new shape is always completely full of gas.

Practice

Use the list below to write the correct term for each definition on the line provided.

forms
gravity
mass
matter
phase
state
volume
weight

____________________ 1. anything that has both mass and volume

____________________ 2. kinds or types

____________________ 3. the force of gravity on an object

____________________ 4. one of the states of matter of a substance

____________________ 5. the force of attraction between all objects in the universe

____________________ 6. the amount of space that matter takes up

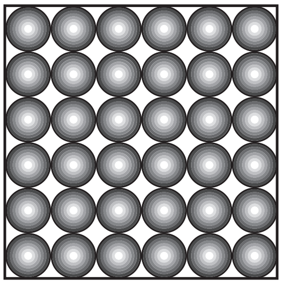
____________________ 7. the amount of matter in a substance

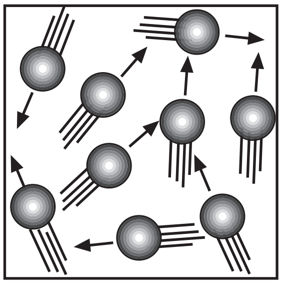
____________________ 8. the condition of matter

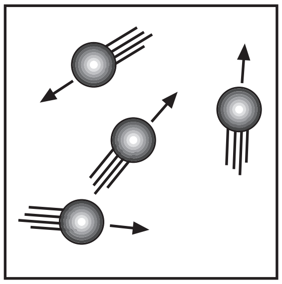
Practice

Use the list below to identify the **phase of matter** *shown in each diagram.*

gas
liquid
solid







________________________ ________________________ ________________________

Practice

Use the list below to complete the following statements.

density
gas
liquid
physical properties
plasma
solid

1. A ________________________ must have a definite shape and take up a definite amount of space.

2. ________________________ is the amount of mass of a certain material in a certain volume.

3. ________________________ is a form of matter found in stars, such as the sun.

4. A ________________________ takes on the shape of whatever it is in at the moment, it has no definite shape *or* volume.

5. The characteristics that you observe without changing the matter are called ________________________ .

6. A ________________________ has a definite volume but *not* a definite shape.

Lab Activity—Part 1: Matter—Mass

Facts:

- Matter has mass and takes up space.

Investigate:

- You will demonstrate, through the use of scientific instruments, that matter has volume and mass.

Materials:

- small gram scale or balance
- graduated cylinder
- balloon
- fishing weights (assorted and lettered)
- water

1. Find the mass of an empty balloon. Record the mass to the nearest milligram on the chart below. (Appendix A contains a chart of metric equivalents and conversions.)

2. Now blow the balloon up and get its mass again. Record the mass to the nearest milligram on the chart.

3. Subtract the mass of the empty balloon from the mass of the inflated balloon. Record the difference on the chart.

mass of the empty balloon	____________ milligrams
mass of the inflated balloon	____________ milligrams
difference in mass	____________ milligrams

a. When did the balloon have greater mass? ____________________

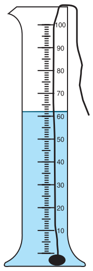
____

b. Why? ____

c. Does the matter inside the balloon have mass? ______________

Lab Activity—Part 2: Matter—Volume

Continuing with the Lab Activity, answer the following.



1. Fill a graduated cylinder with a quantity of water. Record the amount on the chart below.
2. Tie a string to a fishing weight and place the weight into the water. Record the new volume of water on the chart.
3. Record the difference on the chart.

volume of water in cylinder	____________ milligrams
volume of water plus object	____________ milligrams
difference in volume	____________ milligrams

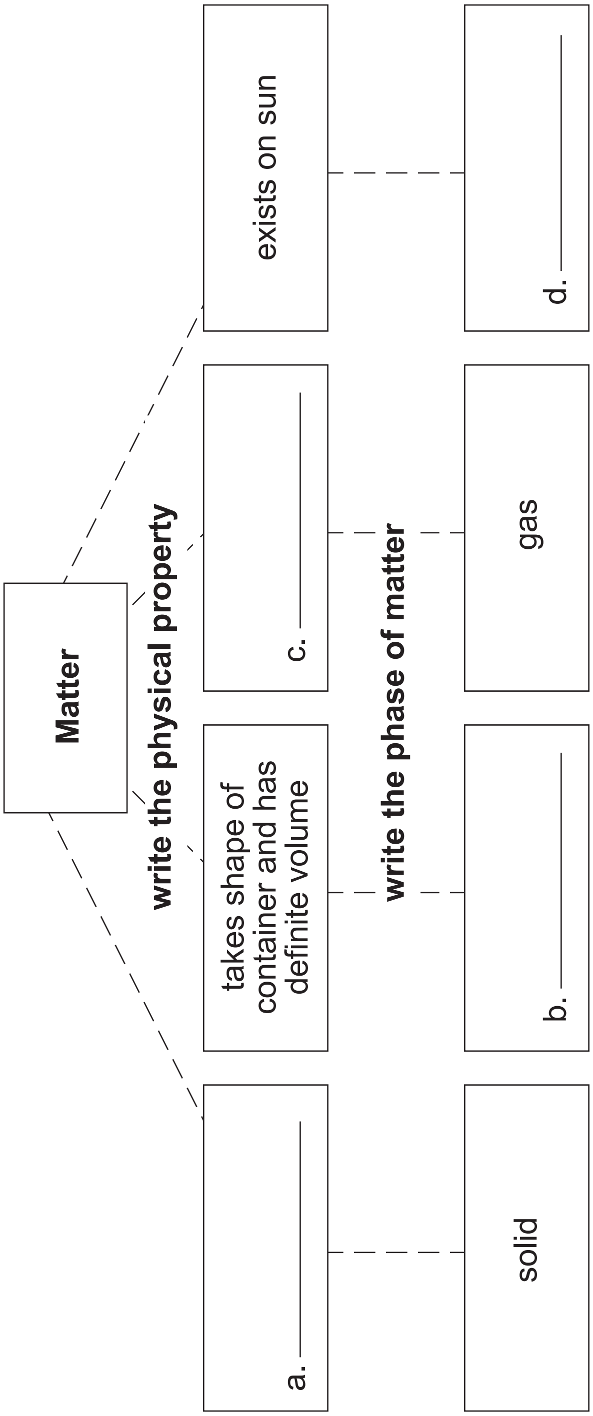
4. Is the new amount of water greater than or less than the first amount of water? ______________________________
5. Did we add more water? ______________________________
6. Why is there a difference between the first amount of water and the second amount of water? ______________________________

   ____
7. Did the fishing weight take up the space where the water used to be? ______________________________
8. Did the fishing weight take up its own space? ______________
9. From these activities, we have learned that matter has

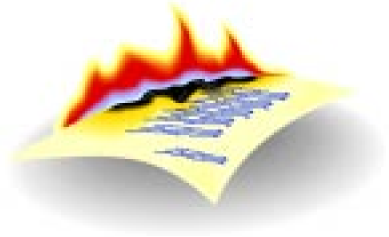
   ________________ and takes up ________________ .

Practice

Complete the following **concept map** *about* **matter**.



Chemical Properties



Paper burns resulting in a chemical property change.

We learned that **chemistry** investigates how matter changes. **Chemical properties** of matter depend on how one substance **reacts** with other substances. Paper burns. That is because it reacts with oxygen in the air. Iron rusts when it reacts with oxygen. Rusting is a result of a *chemical property* change in which a different substance is produced and the matter changes. Some materials produce gases or metals when they react with other materials. **Chemists** study these changes. Sometimes they can improve products by using the chemical properties of matter.

Summary

In this unit, we learned how to recognize matter in its different phases. We found out that matter has mass and volume. We are beginning to recognize some of the physical and chemical differences of matter.

Practice

Use the list below to complete the following statements. **One or more terms will be used more than once.**

chemical properties
chemist
chemistry
reacts

1. __________________________ is the science that investigates how matter changes.

2. __________________________ of matter depend on how one substance __________________________ with other substances.

3. Rusting of iron is a result of a __________________________ change in which a different substance is produced and the matter changes.

4. A __________________________ studies chemical property changes.

Practice

Write **True** *if the statement is correct. Write* **False** *if the statement is* not *correct.*

__________ 1. Air is matter.

__________ 2. All matter is the same.

__________ 3. On Earth, plasma (the fourth phase of matter) usually does not occur naturally except in parts of flames and in lightning bolts.

__________ 4. All matter has the general physical properties of mass, weight, volume, and density.

__________ 5. Since you can change the shape of cotton, it is *not* a solid.

__________ 6. Liquids have a definite volume but *not* a definite shape.

__________ 7. Gases take on the shape of whatever they are in at the moment.

__________ 8. When iron undergoes a reaction to become rust, it is still the same as iron.

__________ 9. Paper that burns no longer has the same physical properties as it did before it was burned.

Use the list below to complete the following statements. **One or more terms will be used more than once.**

fill
gas
liquid
mass
matter
plasma
shape
solid
volume
weight

10. Mass is the amount of ____________________ in an object.

11. The pull of gravity on an object is its ____________________ .

12. Matter must have ____________________ and
____________________ .

13. The four phases of matter are ____________________ ,
____________________ , ____________________ , and
____________________ .

14. A solid must have a definite ____________________ and take up
a definite amount of ____________________ .

15. Liquids have a definite ____________________ but no definite
____________________ .

16. Gases take on the ____________________ of whatever they are in.

17. Gases will completely ____________________ whatever they are
in at the moment.

18. Boiling points and freezing points are examples of
____________________ properties.

Complete the following.

19. Three examples of solids are ________________________ ,
________________________ , and ________________________ .

20. Two examples of liquids are ________________________ and
________________________ .

21. One material that can be a liquid, solid, or gas is
________________________ .

Unit 3: Changes in Matter

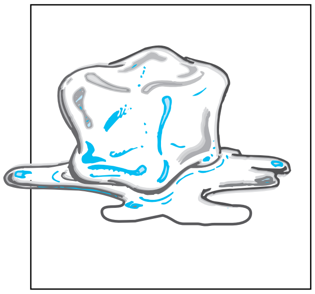
This unit explains physical and chemical changes in matter. Students will learn that phase changes involve energy transfer and changes in the nature of attraction between the molecules.

Student Goals

- Differentiate between physical and chemical changes through laboratory experiences.
- Know that phase changes involve energy transfer.
- Know that changes in phases are changes in the nature of the attractions between molecules.
- State that chemical changes produce new substances and energy moves and/or changes form.
- Understand that there is conservation of mass and energy when matter is changed.

Unit Focus

- Know that the vast diversity of the properties of materials is primarily due to variations in the forces that hold molecules together. (SC.A.1.4.2)
- Know that a change from one phase of matter to another involves a gain or loss of energy. (SC.A.1.4.3)
- Understand that there is conservation of mass and energy when matter is transformed. (SC.B.1.4.2)



Vocabulary

Use the vocabulary words and definitions below as a reference for this unit.

boiling point	the temperature at which a liquid turns to a gas
carbon dioxide (CO_2)	a gas given off when burning takes place
chemical change	change in which a new substance is produced
combustion	the process of burning a substance
composition	the makeup of a substance
freezing point	the temperature at which a liquid turns to a solid
gas	the form of matter that has no definite shape or volume
law of conservation of energy	the law that energy cannot be created or destroyed, only changed from one form to another during a physical or chemical change
law of conservation of mass	the law that matter cannot be created or destroyed, only changed from one form to another during a physical or chemical change

liquid	the form of matter that has a definite volume but does not have a definite shape
mass	the amount of matter in a substance
matter	anything that has both mass and volume
melting point	the temperature at which a solid turns to liquid
molecule	two or more atoms that have a bond of shared electrons
phase	one of the states of matter of a substance (H_2O occurs in three phases: ice, liquid water, and water vapor.)
physical change	any change in the form or phase of matter; no new substances are formed
pressure	the force placed on an object
solid	the form of matter that has a definite shape and volume

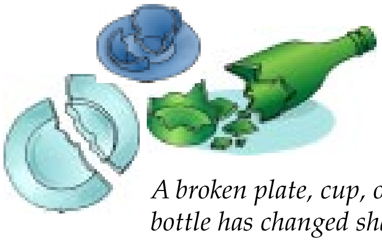
substance	any material or matter
volume	the amount of space that matter takes up

Introduction

Every day you cause changes in **matter**. *Matter* is anything that has both **mass** and **volume**. *Mass* is the amount of matter in a substance. *Volume* is the amount of space that matter takes up. There are many ways to change matter. This unit will discuss what these changes are and how they are different. Matter may change from one **phase** to another by either gaining or losing heat energy.

Physical Changes in Matter

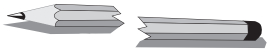
Matter does not always stay the same. The form of matter can be changed by temperature or **pressure**. Squeeze a ball of clay, break a pencil, or drop a glass. What happens? The clay is still clay, the pencil is still a pencil, and the glass is still glass. The size and shape of each piece has changed. These kinds of changes are called **physical changes**. Any change in the form or *phase* of matter is only a *physical change*. There is no change in the **composition** of the matter. No new **substances** are formed. The *substances* remain the same.



A broken plate, cup, or bottle has changed shape, but there is no change in the composition.

Dissolving is a physical change. When you stir salt into water, the salt dissolves and seems to disappear. But the salt is still there. If you leave the salt water exposed to air for several days, the water will evaporate. There will be salt left on the bottom of the container. No new substances are formed in dissolving.

Physical Change in Matter



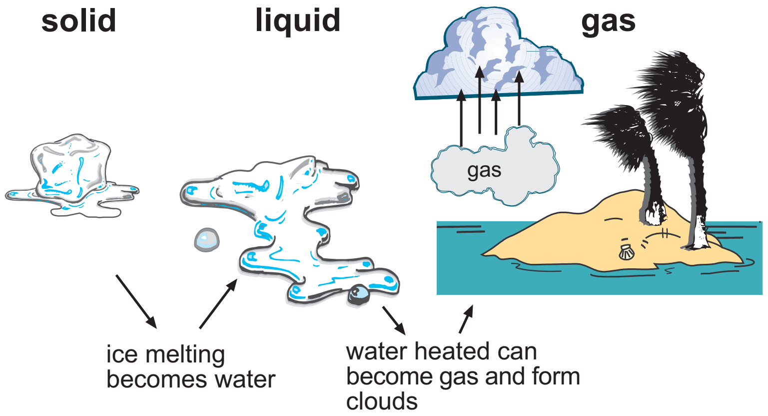
- no change in the composition
- no new substances are formed
- substances remain the same

Changes in the Phases of Matter

We know that matter on Earth normally exists as a **solid**, a **liquid**, or a **gas**. A *solid* substance tends to have less energy than the *liquid* phase of that same substance. A *gas* usually has more energy than the liquid phase of the same substance. The energy content is responsible for the different phases of matter. That is why substances can be made to change phases by adding or taking away energy. Changing the energy content does not change the composition of a substance. All that changes is the nature of the *attraction* or the movement of molecules towards each other. For example, the attraction between the **molecules** is strong in a solid and almost nonexistent in a gas.

Matter can be changed from one phase to another. For example, water can be a liquid. If it is frozen, it will become a solid. Remember, as substances cool they lose heat. This means they lose energy. Ice has less heat energy than liquid water. When water is heated, it can become a gas and form clouds. As substances like water warm up, they gain heat. Boiling water produces water, gas, or steam. Steam has more heat energy than ice or liquid water.

Other materials can be changed from one form to another. When a material melts, it changes from a solid to a liquid. The temperature at which this happens is called the **melting point**. When a substance reaches its **freezing point** or **boiling point**, it also undergoes a physical change from one phase to another, changing some of its physical properties.



Practice

Use the list below to write the correct term for each definition on the line provided.

boiling point
composition
freezing point
mass
matter
melting point
phase
physical change
pressure
substance
volume

____________________ 1. any change in the form or phase of matter; no new substances are formed

____________________ 2. the temperature at which a liquid turns to a gas

____________________ 3. any material or matter

____________________ 4. the makeup of a substance

____________________ 5. the force placed on an object

____________________ 6. the temperature at which a liquid turns to a solid

____________________ 7. the temperature at which a solid turns to liquid

____________________ 8. anything that has both mass and volume

____________________ 9. one of the states of matter of a substance

____________________ 10. the amount of matter in a substance

____________________ 11. the amount of space that matter takes up

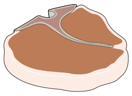
Chemical Changes in Matter

What happens when a piece of paper is burned? Heat, light, and smoke are given off. When the burning is complete, we can say that **combustion** is complete. After combustion there is only a pile of ashes left. Where has the paper gone? The appearance has changed, but much more has happened. The composition of the matter has changed. New substances have been formed. **Carbon dioxide**, water vapor, and ashes are produced. In **chemical changes**, energy moves and/or changes form, and a new substance is produced. Sometimes we see this energy as light. An example of this is the beautiful colors and forms produced by fireworks as a result of chemical changes. At other times, the energy is heat. Combustion is an example of a chemical change that produces heat. Burning wood can warm us. Can you think of a chemical change that takes heat away?

When food is cooked, chemical changes take place. A piece of broiled meat is chemically different from a raw piece of meat. Did the meat produce heat? No, you had to provide the heat to change it. Cooking food is an example of a chemical change that absorbs heat, or takes heat away. Another chemical change occurs when a metal rusts. Oxygen in the air combines with the iron to form a new substance, rust.

Remember, during a chemical change, new substances are formed.

Chemical Change in Matter



- change in the composition
- new substances are formed
- substances do not remain the same

The Laws of Conservation of Mass and Energy

Law of Conservation of Mass

The total mass of all matter stays the same before and after a change. Iron rusts and paper burns, but no matter is destroyed in either reaction. There is always the same total mass of matter at the end of a reaction as there was in the beginning. This is called the **law of conservation of mass**. It states that matter cannot be created or destroyed during a physical or chemical change.

Law of Conservation of Energy

During a physical or chemical change, energy may be converted from one form to another. However, the total amount of energy before and after the change is always the same. This is called the **law of conservation of energy**. It states that energy cannot be created or destroyed during a physical or chemical change.

Summary

There are two ways to change matter. In physical changes, the phase or shape of the substance is altered. No new substance is produced. In chemical changes, new substances are created. A common way to cause chemical changes is through combustion. During a physical or chemical change, mass and energy cannot be created or destroyed.

Practice

Use the list above each section to complete the statements in that section.

carbon dioxide
changes
chemical change
combustion
conservation of mass
energy
mass
phase
physical

1. Breaking a piece of wood is an example of a ________________________ change.

2. During a ________________________ , composition of matter has changed and new substances are formed.

3. In chemical ________________________ , energy moves and/or changes form.

4. If paper combusts, ________________________ , water vapor and ashes are formed.

5. A change in the form or ________________________ of matter is only a physical change.

6. There is a conservation of ________________________ and ________________________ when matter is physically or chemically changed.

7. After ________________________ of a piece of paper, there is only a pile of ashes left.

8. The law of ________________________ states that the total mass of all matter stays the same before and after a change.

One or more terms will be used more than once.

add
boiling water
conservation of mass
liquid
molecules
solid

9. When a material melts, it changes from a ________________________ to a ________________________ .

10. Which has more energy, ice or boiling water? ____________________

11. If water loses enough heat energy, what phase of matter will it enter? ________________________

12. Melting a metal means you ________________________ heat.

13. The law of ________________________ states that matter cannot be created or destroyed during a physical or chemical change.

14. The *attraction* between ________________________ is strong in a solid and almost nonexistent in a gas.

Lab Activity 1: Chemical and Physical Changes

Facts:

- Chemical changes produce new substances.
- Changes in phase are physical changes.
- Heat can be a product of a chemical change.

Investigate:

- You will differentiate between physical and chemical changes through laboratory experiences.

Materials:

- ice
- chalk
- baking soda
- vinegar
- Alka-Seltzer
- water
- dishes
- spoon
- beakers

1. Let a piece of ice melt.

a. Did the ice change form? ____________________________

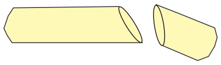
b. What is the new form? ______________________________

c. Did you produce a new substance? ____________________

d. Is this a physical or a chemical change?_______________

e. Record your observation on the chart after question 4.

2. Break a piece of chalk in half.



a. Are the two pieces still chalk? ________________________

b. Did you produce a *new* substance?____________________

c. Is this a physical or a chemical change? ____________________

d. Record your observation on the chart after question 4.

3. Put a small amount of baking soda into a dish. Pour a few drops of vinegar into the dish. Stir the two substances together. Feel the dish.

   a. Does it feel warm? ____

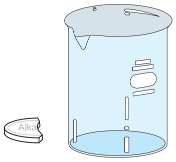
   b. Do you still have vinegar and baking soda? _________________

   c. Could you separate the two substances? ____________________

   d. Is this a physical or a chemical change? ____________________

   e. You have just learned that by mixing vinegar and baking soda, you produce a ________________________ change. Heat is often a product of a chemical change. One of the new substances you formed is carbon dioxide. Carbon dioxide is a gas. It is the same carbon dioxide as the substance formed when paper is burned.

   f. Record your observation on the chart after question 4.



4. Put ½ Alka-Seltzer into a beaker with 100 mL of water.

   a. What do you observe?

   ____

   b. What indicates that a new substance is formed? ____________

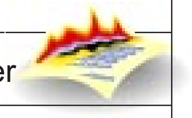
   ____

c. Is this a physical or chemical change? ____________________

d. Record your observation on the chart below.

Record the **physical** *and* **chemical changes** *under the correct heading on the chart below. An example has been provided for each type of change.*

Physical and Chemical Changes

Physical	**Chemical**
Example: boiling water 	*Example*: burning paper 
1.	1.
2.	2.

Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. a gas given off when burning takes place

______ 2. the makeup of a substance

______ 3. the force placed on an object

______ 4. the process of burning a substance

______ 5. material or matter

______ 6. any change in the form or phase of matter

______ 7. any change in which a new substance is produced

A. carbon dioxide

B. chemical change

C. combustion

D. composition

E. physical change

F. pressure

G. substance

Practice

Use the term **liquid**, **gas**, *or* **solid** *to determine the outcome of each of the following actions. Write the correct answer on the line provided.*

Figure out what you would get when…

1. ice melts. ____
2. water freezes. ____________________________________
3. water boils. ______________________________________
4. a liquid gains enough energy to boil. _____________________
5. a solid is heated to its melting point. ____________________
6. steam from a boiling pot collects on the lid of the pot. ________
7. a liquid loses enough energy to reach its freezing point. ______
8. wax is left in the hot sun. _____________________________
9. juice is left in the freezer overnight. ____________________
10. ice cream is left at room temperature. ___________________

Lab Activity 2: Evaporating Salt Water

Facts:

- Dissolving is a physical change.
- Evaporation can be used to separate dissolved solids from the liquid solvent.

Investigate:

- You will examine what happens when salt water evaporates.

Materials:

- water
- table salt
- 250 mL beaker
- spoon
- petri dish

1. Put 50 mL of water in the beaker. Add 2 spoons of salt and stir until the salt is dissolved.
2. Pour salt solution into the petri dish until the bottom of the dish is covered.
3. Leave for several days.
    a. What happened to the salt when you stirred it in the water?

    ____

    b. After a few days, what happened to the water? ____________

    ____

    c. What is left in the bottom of the petri dish? ______________

    d. Could you separate the salt and water? __________________

    e. Is this a physical or a chemical change? __________________

Practice

Classify the following as either a **chemical** *or a* **physical** *change.*

1. ice melting in a drink ________________________________
2. sugar added to lemonade ______________________________
3. mixing vinegar and baking soda to generate bubbles __________
4. grinding peanuts into peanut butter ____________________
5. plants using CO_2 and H_2O to form O_2 and sugar ____________

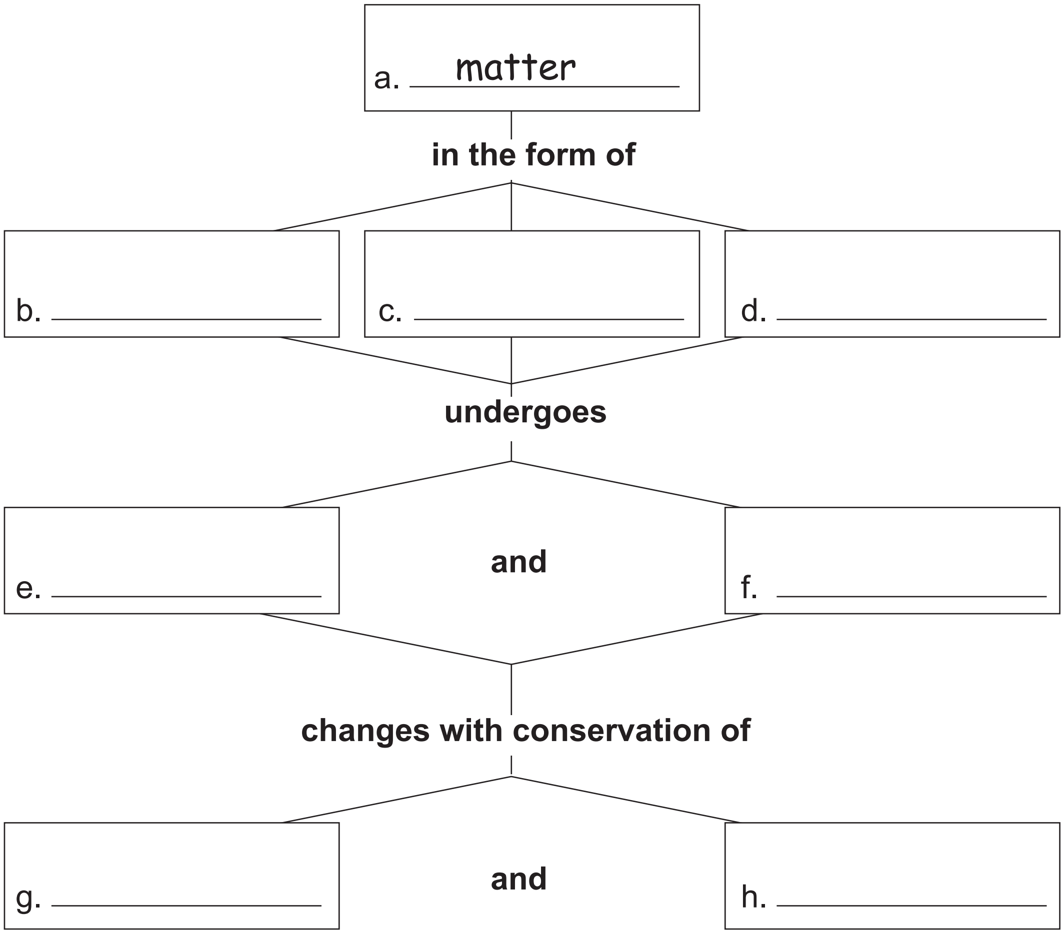
Identify **what happens** *in the following*: *Is energy being* **absorbed** *or* **released***?*

6. chocolate melting ___________________________________
7. liquid aluminum becoming a solid in a mold ______________
8. rubbing alcohol evaporating ___________________________
9. solid carbon dioxide (dry ice) going to CO_2 gas ____________

Practice

Use the list below to complete the **concept map** *about* **matter**. *Write the correct term on the line provided.*

chemical
energy
gas
liquid
mass
physical
solid



Practice

Use the list below to complete the **flowchart** *about* **forces between molecules**. *Rank the terms* **in order of increasing strength of forces between molecules**.

oxygen
syrup
water
wax
wood

____________ ____________ ____________ ____________ ____________

Practice

Write **True** *if the statement is correct. Write* **False** *if the statement is not correct.*

__________ 1. Matter does not always stay the same.

__________ 2. Dissolving is a physical change.

__________ 3. Matter on Earth normally exists as a solid, heat, or energy.

__________ 4. A gas usually has more energy than the liquid phase of the same substance.

__________ 5. The temperature at which a solid changes to a liquid is called the melting point.

__________ 6. When a substance reaches its freezing point or boiling point, it undergoes a chemical change.

__________ 7. In chemical changes, energy moves and/or changes form, and a new substance is produced.

__________ 8. When food is cooked, a chemical change takes place.

__________ 9. The total amount of energy before and after a physical or chemical change is always the same.

_________ 10. Matter can be created but not destroyed during a physical or chemical change.

Unit 4: Structure of Matter

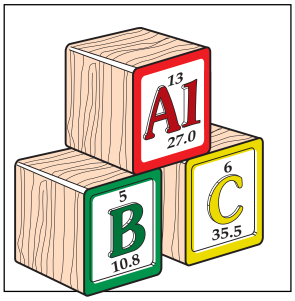
This unit explains the differences among elements, compounds, and mixtures. Students will learn the properties of these substances.

Student Goals

- Define the terms elements, compounds, and mixtures.
- Demonstrate, through laboratory activities, the differences between compounds and mixtures.
- Recognize common elements by their symbols.

Unit Focus

- Know the difference between an element, a molecule, and a compound. (SC.A.2.4.2)



Vocabulary

Use the vocabulary words and definitions below as a reference for this unit.

atom	the smallest unit of an element that is still that element; the basic building block of matter
atomic number	a number used to identify an element and represent its placement in the periodic table; identifies the number of protons in the nucleus of an atom
chemical change	change in which a new substance is produced
chemical properties	the qualities of matter that indicate whether it can change from one substance to another
combustion	the process of burning a substance
compound	a substance formed when two or more elements combine chemically
density	the mass per certain volume of a material
element	a substance that cannot be broken down into a simpler form by ordinary chemical means

formula	the way a chemist tells how two or more elements are combined to make a compound *Example*: H_2O is the formula for water
gas	the form of matter that has no definite shape or volume
hydrogen (H)	the lightest and most abundant of all elements; occurs as a gas when not in other substances
liquid	the form of matter that has a definite volume but does not have a definite shape
mass	the amount of matter in a substance
matter	anything that has both mass and volume
mixtures	two or more substances put together; no chemical reaction takes place and they are easily separated
oxygen (O)	an element found as a gas when not in other substances; it has an atomic number of eight and is involved in burning and rusting
periodic table	a table showing the arrangement of the chemical elements according to their atomic numbers and chemical properties

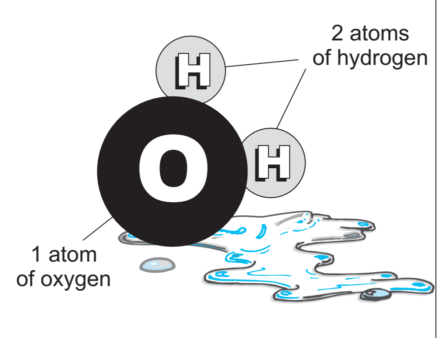
physical change	any change in the form or phase of matter; no new substances are formed
physical properties	the qualities of matter that can be observed without changing the matter (color, shape, size, density)
solid	the form of matter that has a definite shape and volume
substance	any material or matter
symbols	the letters used by scientists to represent the names of the elements
volume	the amount of space that matter takes up

Introduction

You may have wondered how two substances with **oxygen** in them (like water and sugar) could be so different. In this unit, we will discuss what properties these **substances** have that make them unique.

Elements

By now we know that **matter** has **mass**, **volume**, and **density**. We also know that *matter* can be a **solid**, **liquid**, or a **gas**. We have also learned some of the **physical** and **chemical properties** of matter. We know that any change in the form or phase of matter is only a **physical change**. We experimented to show that **chemical changes** produce new *substances*.

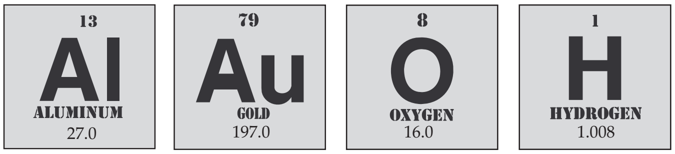

Water Molecule Broken Down into Its Elements

However, what makes up matter? Think about water. Water can be broken down into **hydrogen** and *oxygen*, but the substances of *hydrogen* and oxygen cannot be broken down by chemical means. These substances are called **elements**. *Elements* cannot be broken down by chemical action. All substances are made of elements.

If you look at all the buildings around you, you see that they are different shapes and sizes. But there are also similarities between the buildings. Think of a pyramid and a castle. Both are made of stone blocks, but their blocks have been arranged in very different ways. By doing this, the builders made the structure they wanted.

You can think of elements as building blocks. On Earth, we have discovered about 118 elements. The number of naturally occurring elements totals 92. Some of the elements are human-made and can only be found in very special labs. After these elements are made, they disappear in less than a blink of the eye. These are all the elements that we know exist. Everything is made from these elements.

Some substances are made of only a single element. Aluminum (Al), gold (Au), oxygen (O), and hydrogen (H) are examples of substances with a single element.



examples of substances with a single element

Most elements are *solid* under normal conditions. Few are *liquid*. The mercury (Hg) used in some thermometers is normally liquid.

Many other elements are *gases* under normal conditions. Oxygen (O) and hydrogen (H) are just two of the elements that are gases at room temperature.

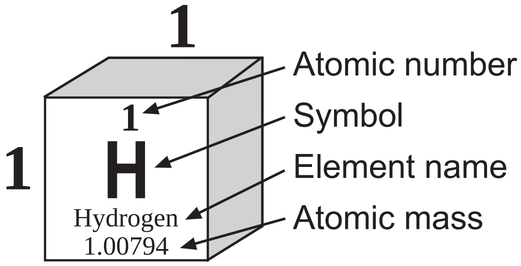
Scientists have a special way of writing the names of elements. They use letters instead of writing the whole word. The letters are called **symbols**. Here are some of the common ones.

Elements	Symbols
Copper	Cu
Aluminum	Al
Iron	Fe
Mercury	Hg
Oxygen	O
Hydrogen	H
Silver	Ag
Gold	Au
Carbon	C

Each of the elements has its own *symbol*. Each element has at least one property that makes it different from another element.

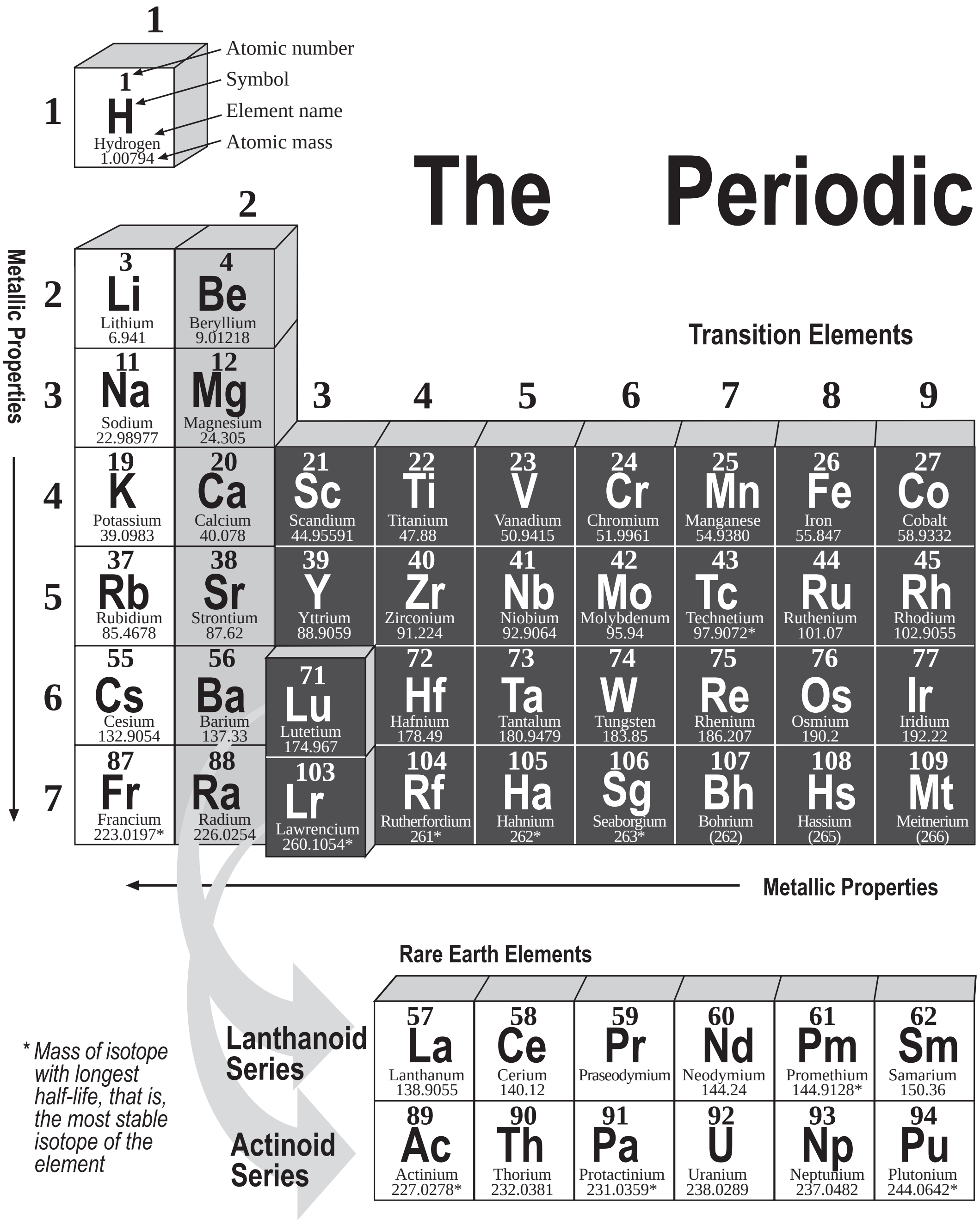
Atomic Number

Scientists decided to make a chart or table based on the **atomic number** of each element. The elements are arranged based on the properties of their **atoms**. An atom is the smallest unit of an element. The chart is called the **periodic table**. The *atomic number* is a number used to identify an element and represent its placement in the *periodic table*. The atomic number identifies the element. Since hydrogen has an atomic number of one (1), it became the first element on the table.



See the periodic table on the following pages. Notice the atomic numbers above each element.

The Periodic



Transition Elements

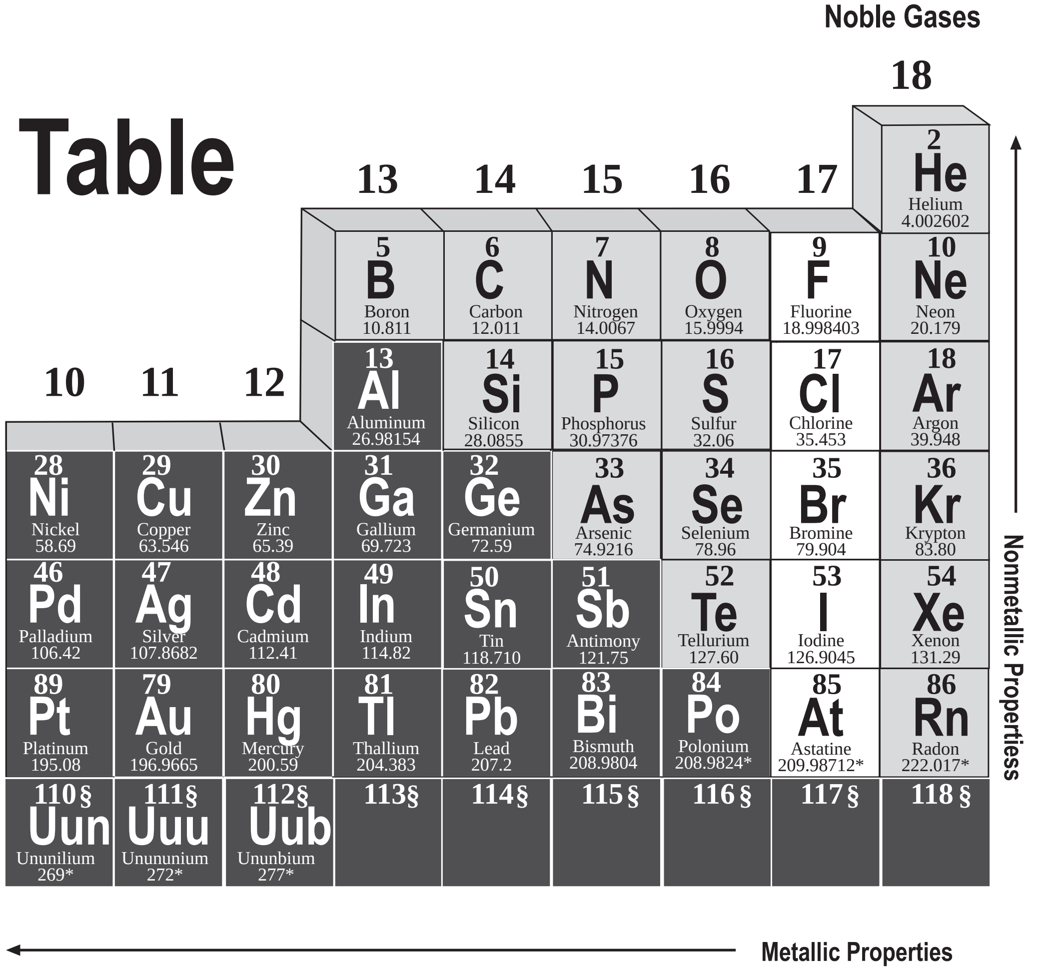
	1	2	3	4	5	6	7	8	9
1	1 H Hydrogen 1.00794								
2	3 Li Lithium 6.941	4 Be Beryllium 9.01218							
3	11 Na Sodium 22.98977	12 Mg Magnesium 24.305							
4	19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.95591	22 Ti Titanium 47.88	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.9380	26 Fe Iron 55.847	27 Co Cobalt 58.9332
5	37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.9059	40 Zr Zirconium 91.224	41 Nb Niobium 92.9064	42 Mo Molybdenum 95.94	43 Tc Technetium 97.9072*	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.9055
6	55 Cs Cesium 132.9054	56 Ba Barium 137.33	71 Lu Lutetium 174.967	72 Hf Hafnium 178.49	73 Ta Tantalum 180.9479	74 W Tungsten 183.85	75 Re Rhenium 186.207	76 Os Osmium 190.2	77 Ir Iridium 192.22
7	87 Fr Francium 223.0197*	88 Ra Radium 226.0254	103 Lr Lawrencium 260.1054*	104 Rf Rutherfordium 261*	105 Ha Hahnium 262*	106 Sg Seaborgium 263*	107 Bh Bohrium (262)	108 Hs Hassium (265)	109 Mt Meitnerium (266)

Rare Earth Elements

Lanthanoid Series	57 La Lanthanum 138.9055	58 Ce Cerium 140.12	59 Pr Praseodymium	60 Nd Neodymium 144.24	61 Pm Promethium 144.9128*	62 Sm Samarium 150.36
Actinoid Series	89 Ac Actinium 227.0278*	90 Th Thorium 232.0381	91 Pa Protactinium 231.0359*	92 U Uranium 238.0289	93 Np Neptunium 237.0482	94 Pu Plutonium 244.0642*

** Mass of isotope with longest half-life, that is, the most stable isotope of the element*

Table



Noble Gases

10	11	12	13	14	15	16	17	18
								2 He Helium 4.002602
			5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.0067	8 O Oxygen 15.9994	9 F Fluorine 18.998403	10 Ne Neon 20.179
			13 Al Aluminum 26.98154	14 Si Silicon 28.0855	15 P Phosphorus 30.97376	16 S Sulfur 32.06	17 Cl Chlorine 35.453	18 Ar Argon 39.948
28 Ni Nickel 58.69	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.723	32 Ge Germanium 72.59	33 As Arsenic 74.9216	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.80
46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.710	51 Sb Antimony 121.75	52 Te Tellurium 127.60	53 I Iodine 126.9045	54 Xe Xenon 131.29
89 Pt Platinum 195.08	79 Au Gold 196.9665	80 Hg Mercury 200.59	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.9804	84 Po Polonium 208.9824*	85 At Astatine 209.98712*	86 Rn Radon 222.017*
110§ Uun Ununilium 269*	111§ Uuu Unununium 272*	112§ Uub Ununbium 277*	113§	114§	115§	116§	117§	118§

Nonmetallic Propertiess

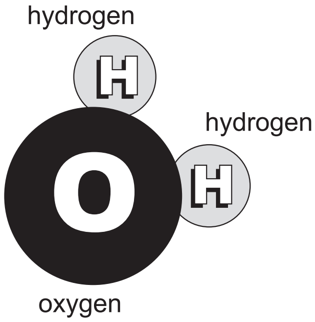
Metallic Properties

63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.9254	66 Dy Dysprosium 162.50	67 Ho Holmium 164.9304	68 Er Erbium 167.26	69 Tm Thulium 168.9342	70 Yb Ytterbium 173.04
95 Am Americium 243.0614*	96 Cm Curium 247.0703*	97 Bk Berkelium 247.0703*	98 Cf Californium 251.0796*	99 Es Einsteinium 252.0828*	100 Fm Fermium 257.0951*	101 Md Mendelevium 258.986*	102 No Nobelium 259.1009*

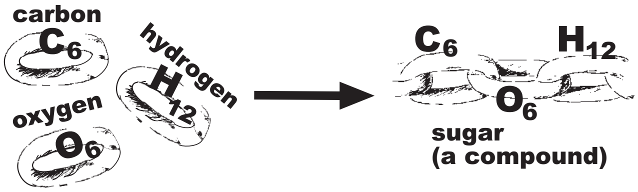
§ *Synthesized elements that are highly unstable. Research on these is continuing and may change what we know about them.*

Compounds

Many substances are made from more than one element. Elements can unite with each other. These united elements form new substances that are very difficult to separate. The new substances are called **compounds**. A *compound* has *chemical* and *physical properties* that are uniquely its own. It may look totally different from the elements that formed it. As you have seen, the atoms of two elements, hydrogen (H) and oxygen (O), combine to form water.


Water Molecule

Sugar is a compound formed by atoms of carbon (C), hydrogen (H), and oxygen (O). Sugar and water do not look like the elements that formed them.



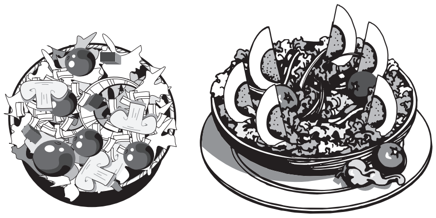
When compounds are formed, the elements always combine in the same proportions. A **formula** tells how elements combine to form compounds. The *formula* for water is H_2O. Compounds always have formulas.

Mixtures

When two elements or compounds are combined, no new substances are produced. No *chemical change* takes place. These substances are called **mixtures**. *Mixtures* can be separated. Each substance in the mixture keeps its own properties. If you mix iron filings with sand, you could separate them because there has been no chemical reaction. There is no new compound; there is only iron and sand.

If we took hydrogen and **combusted** it, or burned it, with oxygen, water would be formed. Water does not have the same properties as hydrogen and oxygen because it is a different compound. Water is always made from two hydrogen atoms and one oxygen atom. Water cannot be made any other way because it is not a mixture.

On the other hand, a mixture can be made in many different ways. Air is a mixture. The elements in the air are not always the same. Tossed salad is a mixture too; salads do not always have the same ingredients. Mixtures do not have formulas. They are not formed by chemical changes.



A tossed salad is a mixture; salads do not always have the same ingredients.

Summary

Now we know that elements are the simplest forms of substances. Gold (Au) is an element. Compounds are formed when a chemical change takes place between two or more elements. Mixtures are formed when two or more substances are put together. No chemical change takes place. The parts of a mixture can easily be separated.

Practice

Use the list below to write the correct term for each definition on the line provided.

atom
atomic number
compound
element
formula
hydrogen (H)
mixtures
oxygen (O)
symbols

____________________ 1. a substance that cannot be broken down into a simpler form by ordinary chemical means

____________________ 2. two or more substances put together

____________________ 3. the letters used by scientists to represent the names of the elements

____________________ 4. a substance formed when two or more elements combine chemically

____________________ 5. the way a chemist tells how two or more elements are combined to make a compound

____________________ 6. an element found as a gas when not in other substances and involved in burning and rusting

____________________ 7. the lightest and most abundant of all elements

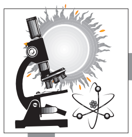
____________________ 8. a number used to identify an element and represent its placement in the periodic table

____________________ 9. the smallest unit of an element that is still that element

Practice

Use the **periodic table** *on pages 78-79 to identify each of the symbols below. Write the name of the* **element** *and its* **atomic number** *on the line provided.*

1. C ____
2. Au ____
3. Ag ____
4. Hg ____
5. Cu ____
6. Fe ____
7. H ____
8. O ____
9. Al ____



Lab Activity—Part 1: Compounds and Mixtures

Facts:

- The substances in mixtures do not combine chemically.

Investigate:

- You will differentiate between a compound and a mixture, and separate the substances in a mixture using physical means.

Materials:

- sulfur
- paper
- iron filings
- ring stand and clamp
- Bunsen burner
- magnets
- test tube

Part 1

1. Pour some sulfur onto a sheet of paper.
2. Add some iron filings. Mix the sulfur and the iron filings together.
   a. Did a chemical change take place? ______________________

   b. Are any new substances formed? ______________________

   c. Did the iron and the sulfur keep their own properties? ______
3. Move a magnet near the sulfur and the iron filings.
   a. Can you separate the iron from the sulfur? ________________

   b. Did the iron and the sulfur form a mixture or a compound?

   ____

Lab Activity—Part 2: Compounds and Mixtures

1. Mix the iron filings and the sulfur on a sheet of paper.
2. Pour the mixture into a test tube.
3. Place the tube in clamp on a ring stand.
4. Heat the tube until it begins to glow.
5. Let the test tube cool.
6. Remove the substance from the test tube.
    a. Can you see the iron? ______________________________
    b. Can you see the sulfur? ____________________________
    c. Could you separate the iron from the sulfur using a magnet?

    ____

    d. Did you make a new substance? ______________________
    e. Is this new substance a mixture or a compound? __________

    Note: This new substance is called iron sulfide.

    f. What are the two elements that formed the substance?

    ____

Practice

Use the list below to complete the following statements. **One or more terms will be used more than once.**

118
aluminum
carbon
chemical
copper
element
elements
gold
hydrogen
laboratories
liquid
mercury
oxygen
silver

1. An ____________________ is a substance that cannot be broken down into a simpler form and from which other substances may be made.

2. There are about ____________________ different kinds of elements.

3. All substances are made from ____________________ .

4. ____________________ is an example of a solid element.

5. Mercury is an element that is normally in a ____________________ form or state.

6. ____________________ changes produce new substances.

7. Some elements are only found in ____________________ .

8. **Au** is the symbol for ____________________ .

9. **Cu** is the symbol for ____________________ .

10. **C** is the symbol for ______________________ .

11. **Al** is the symbol for ______________________ .

12. **Ag** is the symbol for ______________________ .

13. **O** is the symbol for ______________________ .

14. **H** is the symbol for ______________________ .

15. **Hg** is the symbol for ______________________ .

Classify each of the following as an **element** *or a* **compound**.

16. carbon monoxide, CO ______________________

17. cobalt, Co ______________________

18. table sugar, $C_{12}H_{22}O_{11}$ ______________________

19. gold, Au ______________________

Practice

Write **True** *if the statement is correct. Write* **False** *if the statement is* not *correct.*

__________ 1. Two or more elements combine chemically to form a substance.

__________ 2. Sugar is a mixture, not an element.

__________ 3. Compounds are very easy to separate.

__________ 4. Hydrogen and oxygen combine to form water.

__________ 5. Compounds have the same properties as the elements from which they are formed.

__________ 6. A compound is formed when two or more substances are put together and no chemical change takes place.

__________ 7. All mixtures have formulas.

__________ 8. Mixtures can easily be separated.

__________ 9. Oxygen is a compound.

_________ 10. Air is a mixture.

Unit 5: Chemical Formulas and Equations

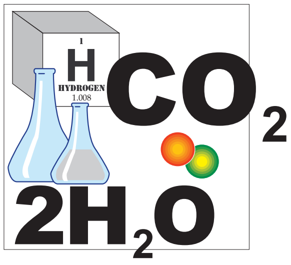
This unit explains chemical formulas and chemical equations. Students will learn that both sides of the equations balance because of the law of conservation of mass.

Student Goals

- Recognize the difference between a chemical formula and a chemical equation.
- Identify a simple balanced chemical equation.
- Identify chemical equations that are examples of the law of conservation of mass.
- Cite evidence, determined from an experiment using chemical equations, to support the law of conservation of mass.

Unit Focus

- Know the difference between an element, a molecule, and a compound. (SC.A.2.4.2)
- Understand that there is conservation of mass and energy when matter is transformed. (SC.B.1.4.2)



Vocabulary

Use the vocabulary words and definitions below as a reference for this unit.

atom	the smallest unit of an element that is still that element; the basic building block of matter
balance	the method by which the numbers and types of atoms on each side of an equation are made equal
chemical equation	a shorthand, symbolic way of telling about a chemical reaction using symbols and formulas *Example*: $\mathbf{NaOH + HCl \rightarrow NaCl + H_2O}$
chemical formula	a group of symbols used to name a compound *Example*: **$NaCl$** is the chemical formula for sodium chloride, common table salt
coefficient	the number in front of the symbol of an element that tells how many molecules of a substance are involved in a reaction *Example*: $\mathbf{2H_2O}$
compound	a substance formed when two or more elements combine chemically

element	a substance that cannot be broken down into a simpler form by ordinary chemical means
law of conservation of mass	the law that matter cannot be created or destroyed, only changed from one form to another during a physical or chemical change
mass	the amount of matter in a substance
matter	anything that has both mass and volume
molecule	two or more atoms that have a bond of shared electrons
subscript	a number in a chemical formula that tells how many atoms of an element are in a molecule *Example*: $\mathbf{H_2}$
substance	any material or matter
symbols	the letters used by scientists to represent the names of the elements
yields	makes or produces

Introduction

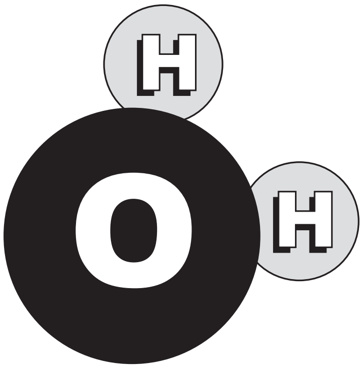
You have learned that **atoms** of different **elements** can combine to form new **compounds**. When this takes place, a chemical reaction occurs. For example, sodium metal (Na) reacts with chlorine gas (Cl_2) to form sodium chloride (NaCl). Hydrogen gas (H_2) combines with oxygen gas (O_2) to make water (H_2O). Scientists have a special way to write about these reactions. In this unit, you will learn to **balance** simple **chemical formula** and **chemical equations**.

sodium metal (Na) reacts with chlorine gas (Cl_2) to form sodium chloride (NaCl)

hydrogen gas (H_2) combines with oxygen gas (O_2) to make water (H_2O)

Chemical Formulas

A *chemical formula* is used to represent a *compound*. Scientists use formulas as a shorthand way to write compounds. **Symbols** stand for the elements in compounds. NaCl is the formula for table salt. The formula shows that the compound, table salt, is made from the elements sodium and chlorine. The formula for water is H_2O. This states that the compound water is made up of hydrogen and oxygen. Notice that the formula for water has a small two after the H. That small number is called a **subscript**. It tells how many *atoms* of the element are in the **molecule**. H_2O means that it takes two atoms of hydrogen and one atom of oxygen to make a *molecule* of water. If there is no *subscript* after the *symbol*, it means there is only one atom.



The compound *water* is made up of 2 hydrogen atoms and 1 oxygen atom.

The formula NaCl shows that salt is made from one atom of sodium and one atom of chlorine. Let's look at some simple chemical formulas.

Name	**Formula**	**Number of Atoms**
hydrogen peroxide	H_2O_2	2 atoms H, 2 atoms O
methane (natural gas)	CH_4	1 atom C, 4 atoms H
carbon dioxide	CO_2	1 atom C, 2 atoms O

When you understand subscripts, it is easy to tell how many atoms are in one molecule of a compound. $C_{12}H_{22}O_{11}$ is the formula for sucrose (common granulated sugar is sucrose). It contains 12 atoms of C, 22 atoms of H, and 11 atoms of O.

Practice

Use the list below to write the correct term for each definition on the line provided.

atom
balance
chemical equation
chemical formula
compound
element
molecule
subscript
symbols

____________________ 1. a substance formed when two or more elements combine chemically

____________________ 2. the smallest unit of an element that is still that element; the basic building block of matter

____________________ 3. two or more atoms that have a bond of shared electrons

____________________ 4. a substance that cannot be broken down into a simpler form by ordinary chemical means

____________________ 5. the method by which the numbers and types of atoms on each side of an equation are made equal

____________________ 6. a group of symbols used to name a compound

____________________ 7. a shorthand, symbolic way of telling about a chemical reaction using symbols and formulas

____________________ 8. the letters used by scientists to represent the names of the elements

Chemical Equations

Elements always combine with each other in a certain way. You know that NaCl is the formula for salt. We could write the sentence, *"Sodium plus chlorine makes sodium chloride."* Scientists use a shorter way to describe this reaction. This shorter way is called a *chemical equation*. Look at the following equation for the formation of sodium chloride:

$$2Na + Cl_2 \longrightarrow 2NaCl$$

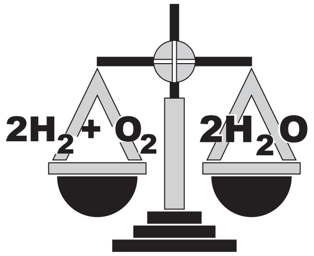
The arrow stands for the word makes *or* **yields**.

The arrow stands for the word *makes* or **yields**. When a chemist reads this equation he might say, *"Sodium plus chlorine* yields *sodium chloride."* Using equations saves time. Think how long it would take to write the following equation in words:

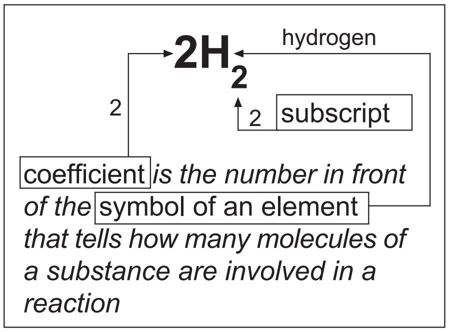
$$NaOH + HCl \longrightarrow NaCl + H_2O$$

It would be simple if all chemical reactions took place with equal parts of all **substances**. However, this is not true. You already know that it takes more atoms of H than O to form water. One equation for water looks like this:

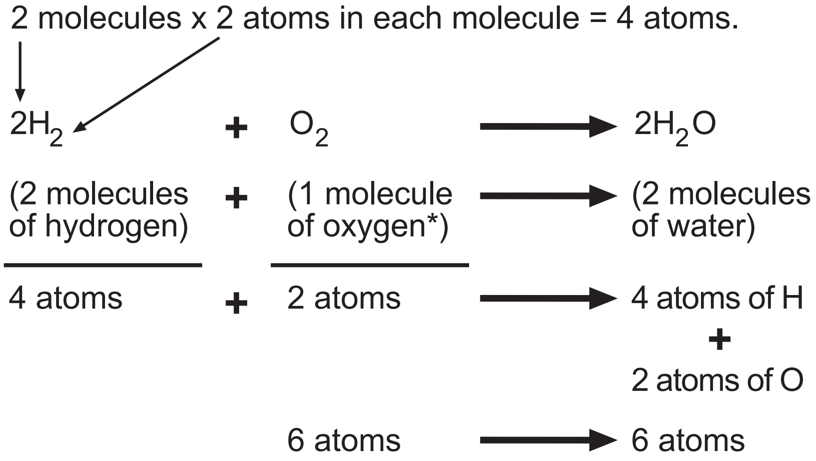
$$2H_2 + O_2 \longrightarrow 2H_2O$$



Think of the two sides of an equation being placed onto a *balance scale*. The left side of the equation must balance the right side. The number of oxygen atoms on the right side of the equation must equal the number of oxygen atoms on the left side. During a chemical reaction, no **matter** is made or lost. All atoms must be taken into account. This means that every atom on the left side of the equation must also be on the right side of the equation.



To determine the total number of atoms in a molecule, the **coefficient** is multiplied by the subscript for each element. For example, we could look at **$2H_2$**. The *coefficient* of two means that two molecules of hydrogen are involved. To determine the number of hydrogen atoms in two molecules of hydrogen, multiply the coefficient (2) by the subscript ($_2$) as follows: Using this method, the equation for water can be broken down like this:

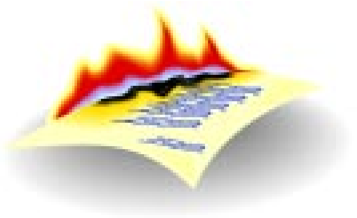


* If there is no number before the symbol of an element, the coefficient is *understood* to be *one*.

Notice that the numbers of each type of atom on each side of the equation are equal. We say that the equation is balanced.

The Law of Conservation of Mass

There are some important laws in chemistry. We know that chemical equations must balance. This is because matter can never be created or destroyed during a chemical reaction. The **mass** of the *substances* is the same before and after a reaction. Matter may change form, but it is never destroyed.



The law of conservation of mass states that matter cannot be created or destroyed—therefore, no matter is destroyed in the burning of the paper.

Iron rusts and paper burns, but no matter is destroyed in either reaction. There is always the same amount of matter at the end of a reaction as there was in the beginning. This is called the **law of conservation of mass**. The law states that matter cannot be created or destroyed during a chemical reaction.

Summary

Chemical formulas are used to name a compound. Chemical equations are the shorthand way of telling what happens during a chemical reaction. All equations must balance. The *law of conservation of mass* states that no matter can be created or destroyed.

Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. anything that has both mass and volume

______ 2. the number in front of the symbol of an element that tells how many molecules of a substance are involved in a reaction

______ 3. the law that matter cannot be created or destroyed, only changed from one form to another during a physical or chemical change

______ 4. makes or produces

______ 5. a shorthand, symbolic way of telling about a chemical reaction using symbols and formulas

A. chemical equation

B. coefficient

C. law of conservation of mass

D. matter

E. yields

Practice

Complete the following outline.

I. Chemical formulas

A. Definitions

1. a group of ________________ used to name a compound
2. tell what ________________ are in the compound

B. Compounds

1. ________________ is the formula for table salt.
2. H_2O is the formula for ________________ .

C. Subscript

1. Definition

____

____

____

2. Example

a. In the formula H_2O, the 2 is called a

________________ .

b. The small 2 after the H shows that there are 2

________________ of hydrogen.

II. Chemical equations

A. Definition ____

____

____

____

B. Chemical equation

1. $2Na + Cl_2 \longrightarrow 2NaCl$ is the ______________________ for the formation of sodium chloride.

C. Balanced equation

1. Definition

   The method by which the numbers and types of atoms on each side of an equation are made

   ______________________ .

2. Example

   $2H_2 + O_2 \longrightarrow H_2O$

D. Coefficient

1. Definition

   The number in front of the symbol of an element that tells how many ______________________ of a substance are involved in a reaction.

2. Example

In the equation $2H_2 + O_2 \longrightarrow 2H_2O$

the large number in front of the H is called a

________________________ .

E. Law of conservation of mass

1. Definition

The law that matter can neither be ________________________

or destroyed in a chemical reaction.

2. Example ____

____

____

Lab Activity: Balancing Equations

Facts:

- Matter cannot be created nor destroyed.

Investigate:

- You will balance a given chemical equation, accounting for all matter.

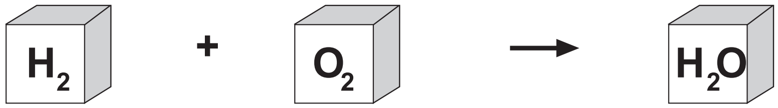
Materials:

- work sheet
- 10 red chips
- 10 blue chips
  (washers or pennies may be used)

Look at Diagram 1 below. It shows a chemical reaction for the formation of water.

Balancing an Equation

Diagram 1



______ **H atoms** + ______ **O atoms** → ______ **H atoms** + ______ **O atoms**

______ **Total atoms** → ______ **Total atoms**

Does this equation balance? ☐ yes ☐ no

Use **Diagram 1** *on the previous page to do the following.*

1. Use the red chips to stand for H atoms. Use the blue chips to stand for O atoms. Remember that the small number, or subscript, tells the number of atoms. Place the correct number of red chips under the H box. Record the number in the space provided.

2. Place the correct number of blue chips under the O box. Record the number.

3. Count the number of H and O atoms in the far right box. Place the correct number of chips under the box. Record the number.

   a. How many H atoms are on the left side of the equation? _____

   b. How many O atoms are on the left side? ____________________

   c. How many total atoms are on the left side of the equation? ______

   d. How many H atoms are on the right side of the equation? ______

   e. How many O atoms are on the right side of the equation? ______

   f. How many total atoms are on the right side? _______________

   g. Does the number of atoms on the left equal the number

      on the right? _____________

   h. Is this equation balanced? _____________

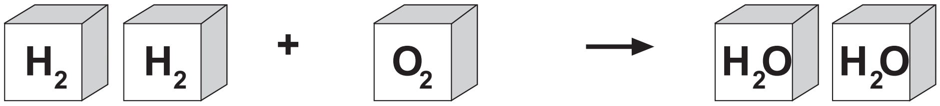
4. Check the appropriate box to show if your equation is balanced.

Use **Diagram 2** *to do the following.*

5. Look at Diagram 2 below. In balancing, you cannot change the number of atoms, but you can change the number of molecules.

Balancing an Equation

Diagram 2



________ **H atoms** + ________ **O atoms** → ________ **H atoms** + ________ **O atoms**

________ **Total atoms** → ________ **Total atoms**

Does this equation balance? ☐ yes ☐ no

6. Place the correct number of H atoms on the left. Record the number.

7. Place the correct number of O atoms on the left side of the equation. Record the number.

8. Place the correct number of H atoms on the right side of the equation. Record the number.

9. Place the correct number of O atoms on the right side of the equation. Record the number.

    a. How many H atoms are on the left? ________________________

    b. How many H atoms are on the right? ________________________

c. Are they equal? ____________

d. How many O atoms are on the left side of the equation? ______

e. How many O atoms are on the right side of the equation? ______

f. Are they equal? ____________

g. Is this equation balanced? ____________

10. Check the appropriate box to show if your equation is balanced.

Use **Diagram 3** *to do the following.*

11. Look at Diagram 3 below.

Balancing an Equation

Diagram 3

________ H_2 + ________ O_2 → ________ H_2O

Does this equation balance? ☐ yes ☐ no

a. Write the correct balanced equation. Each box in the last exercise stood for one molecule. Use the correct coefficient to show the number of H molecules on the left.

b. Write the coefficient for the O molecule. (Remember that one is shown by no coefficient.) Write the correct coefficient for the H_2O molecules.

   1. Is this equation balanced? ____________

   2. Has matter been created? ____________

   3. Has matter been destroyed? ____________

12. Check the appropriate box to show if the equation is balanced.

13. On the line below, write the balanced equation for the formation of H_2O (water).

____

Practice

Identify the **number of atoms of each element** *in the following* **formulas**. *Fill in the chart. The first one has been done for you.*

Formula	Number of Atoms of Each Element
H_2O	2 atoms H 1 atom O
$C_2H_4O_2$	
CO	
$NaHCO_3$	

Practice

Use the list below to complete the following statements. **One or more of the terms will be used more than once.**

balanced
coefficient
equation
formula
subscript
yields

1. A chemical ____________________ is a group of symbols used to name a compound.
2. A chemical ____________________ is a way of telling about a chemical reaction using symbols and formulas.
3. The arrow in an equation stands for *makes* or ____________________ .
4. The 2 in the formula H_2O is called a ____________________ .
5. The ____________________ is a number in a chemical formula that tells how many atoms of an element are in a molecule.
6. The 2 in front of the H in the following equation is called a ____________________ . $2H_2 + O_2\ 2H_2O$
7. When the numbers of each type of atom on each side of the equation are equal, we say that the equation is ____________________ .

atom
balance
compound
conservation of mass
matter

8. All equations must ____________________ .

9. The law of ____________________ states that matter cannot be created or destroyed during a chemical reaction.

10. Chemical formulas are used to name a ____________________ .

11. Every ____________________ on the left side of an equation must also be on the right side of the equation.

12. During a chemical reaction, no ____________________ is made or lost.

13. To determine the total number of atoms in a molecule, the ____________________ is multiplied by the subscript for each element.

Unit 6: Introduction to the Atom

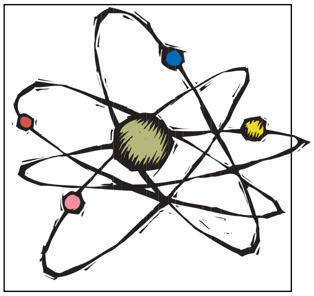
This unit describes the basic structure of an atom and how the atomic model has changed over time. Students will identify the parts of an atom and the charges. Students review the difference between an atom, a compound, and a molecule.

Student Goals

- Define these terms: atoms, molecules, protons, neutrons, nucleus, and electrons.
- Create, through laboratory activities, simple models of molecules.
- Describe the structure of an atom and the behavior of charged particles.
- Locate protons, electrons, and neutrons in an atom model.
- Recognize that the properties of substances are based on the molecular forces.
- Describe how the atomic model has changed over time.

Unit Focus

- Know that from time to time, major shifts occur in the scientific view of how the world works, but that more often, the changes that take place in the body of scientific knowledge are small modifications of prior knowledge. (SC.H.1.4.2)
- Understand that no matter how well one theory fits observations, a new theory might fit them as well or better, or might fit a wider range of observations, because in science, the testing, revising, and occasional discarding of theories, new and old, never ends and leads to an increasingly better understanding of how things work in the world, but not to absolute truth. (SC.H.1.4.3)



- Know that the number and configuration of electrons will equal the number of protons in an electrically neutral atom and when an atom gains or loses electrons, the charge is unbalanced. (SC.A.2.4.1)
- Know that the vast diversity of the properties of materials is primarily due to variations in the forces that hold molecules together. (SC.A.1.4.2)
- Know that a change from one phase of matter to another involves a gain or loss of energy. (SC.A.1.4.3)
- Know that electrical forces exist between any two charged objects. (SC.C.2.4.2)

Vocabulary

Use the vocabulary words and definitions below as a reference for this unit.

atom	the smallest unit of an element that is still that element; the basic building block of matter
attract	move toward each other
bond	the attraction that holds two or more atoms together
charge	a property of an object that causes it to be affected by a magnetic field
compound	a substance formed when two or more elements combine chemically
electron	the negatively charged particle of an atom; the electron moves around the center of the atom (nucleus)
element	a substance that cannot be broken down into a simpler form by ordinary chemical means
energy level	most likely location where the electron can be found around the center of the atom; any of the possible energies an electron may have in an atom

molecule	two or more atoms that have a bond of shared electrons
negative charge	the charge of an electron
neutral	being neither positively nor negatively charged
neutron	the neutral particle found in the nucleus of an atom; a neutron has no charge
nucleus	the center region of an atom around which the electron(s) move
orbital	regions in an atom where electrons are found
positive charge	the charge of a proton; considered opposite of negative
proton	the positively charged particle in the nucleus of an atom
repel	push away from
theory	an explanation that has been tested by repeated observations

Introduction

Did you ever wonder what is in air?

Did you ever wonder what is in air? Have you ever thought about how there are an incredible number of different things in the world? All that you see, touch, and feel is made from tiny units of matter. This unit will introduce you to these unseen building blocks of the universe.

Elements

There are thousands and thousands of different substances in the world. Water is a substance. Sugar is a substance. Oxygen is a substance. All of the substances that we know are made of **elements**. The *elements* are the substances that have unique chemical and physical properties. Elements cannot be broken down into other substances that are unique. Of water, sugar, oxygen, which is the element? One way to find out is through chemistry. If we break down the water, we will get hydrogen and oxygen gas. If we break down the sugar, we get hydrogen, oxygen, and carbon. We cannot use chemistry to break down the oxygen. This means that oxygen is the element. Oxygen is a part of such substances as water, sugar, carbon dioxide, rust, and wood.

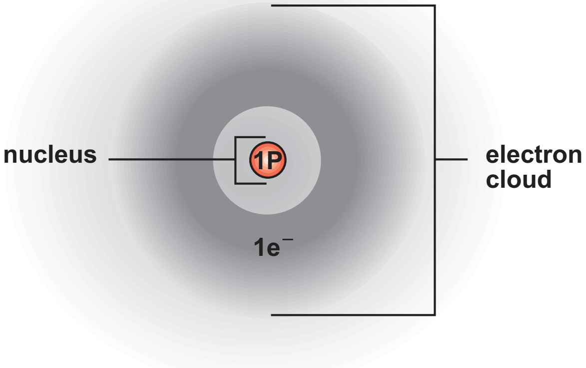
If we break down water, we get hydrogen and oxygen gas.

Atoms

All substances are made of **atoms**. *Atoms* are very tiny pieces of matter. An atom is the smallest unit of an element that is still that element. This may sound strange, but what it means is that an atom of gold is still gold. You cannot see that atom of gold. You cannot feel it. Despite this, it still has the physical and chemical properties of gold. Atoms still have all the properties of the element. An atom is the smallest unit of an element that can go through a chemical change.

Protons and **neutrons** are located in the center region of an atom. This center region is called a **nucleus**. **Electrons** move around like a cloud encircling the outside of a *nucleus*. The number of *electrons* is equal to the number of *protons* in an atom. The number of protons and electrons an atom has is unique for each element. The hydrogen atom is the simplest atom, with one proton and electron.

An atom can gain or lose electrons, a process which can then change its **charge**. Electrons are negatively *charged* particles. If an atom gains extra electrons, it will become **negatively charged** (–). A loss of electrons will create a **positive charge** (+).



One model of the hydrogen atom.

Like other scientific models and theories, the model of the atom has changed to keep pace with new discoveries. Above is one model of the hydrogen atom.

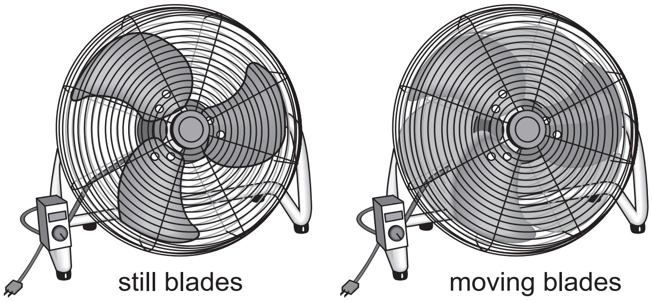
Putting an Atom into Perspective

Let's put the size of a hydrogen atom into perspective. Look at this dash -. The dash is about one millimeter in length. It would take 20 million hydrogen atoms to equal the length of the dash.

An atom is more than 99% empty space. Protons and neutrons make up a very small amount of an atom's volume. Protons and neutrons are 1,800 times larger than its electrons. The electron actually spins very far away from the nucleus. If the model of the hydrogen atom above was drawn to scale

- the electron would be spinning about a quarter mile away from the nucleus.
- the proton would be the size of the Giants Stadium in New Jersey.

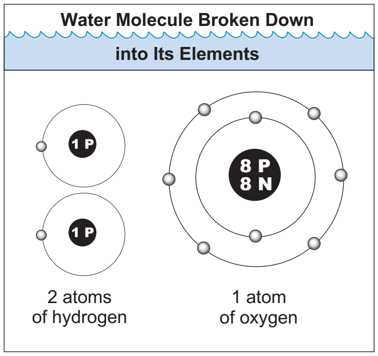
Protons and neutrons behave like small particles, sort of like tiny billiard balls. Although electrons are sometimes shown as small particles spinning around a nucleus, that model is a bit misleading. Electrons are more like waves on a vibrating string than particles. The most probable location of electrons around the nucleus is in the *electron cloud*. (An electron cloud is not actually a cloud.)



You can compare an electron cloud to the blurred area you see when you look at the swiftly moving blades of a fan. You cannot tell the exact location of one blade, but you do know the blade is within the blurred area.

As you can see in the model of a hydrogen atom on the previous page, its proton is surrounded by an electron cloud. You can compare an electron cloud to the blurred area you see when you look at the swiftly moving blades of a fan. You cannot tell the exact location of one blade, but you do know the blade is within the blurred area. The same is true with electrons around a nucleus; you only know their probable location.

There are about 118 different elements. So, there are about 118 different kinds of atoms. These atoms can combine with each other and form many different kinds of substances. One substance made from atoms combining is water. Water is made of two atoms of hydrogen and one atom of oxygen. (Although it is more accurate to show electrons in electron clouds, we will use the following model.)



Within electron clouds, electrons are at various distances from the nucleus. These distances are called **energy levels**.

- Electrons close to the nucleus have low energy.
- Electrons farther away from the nucleus have high energy.

Hydrogen has one *energy level* of electrons. There is only one electron in the *energy level*. The other, larger atom is a similar model of oxygen. Oxygen has two energy levels. The outer energy level has six electrons.

In the next section we will talk about how these atoms combine. When two or more atoms combine, a chemical change takes place.

Practice

Use the list below to complete the following statements.

atom
charge
electrons
elements
energy levels
negatively charged
neutrons
nucleus
positive charge

1. All of the substances that we know are made of ____________________ which have unique chemical and physical properties.

2. A(n) ____________________ is the smallest unit of an element that is still that element.

3. Protons and ____________________ are located in the nucleus.

4. An atom can gain or lose ____________________ , a process which can then change its ____________________ .

5. Electrons are negatively *charged* particles that move around in a cloud encircling the outside of a ____________________ .

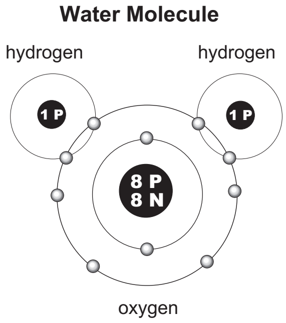
6. If an atom gains extra electrons, it will become ____________________ .

7. A loss of electrons will create a ____________________ .

8. Within electron clouds, electrons are at various distances from the nucleus. These distances are called ____________________ .

Molecules

A **molecule** is formed when atoms share electrons. In chemical reactions, only electrons are involved. This is because only electrons are on the outside of the atoms. Because its electrons are shared, a *molecule* is always made of two or more atoms.



Look at the diagram of a water molecule on the left. It has two hydrogen atoms and one oxygen atom. Notice where the electrons are in the diagram of the water molecule. Each hydrogen atom has its own electron, but each now shares an electron with oxygen. Oxygen has six electrons in its outer energy level. Oxygen now shares electrons with the hydrogen atoms. Because these three atoms are sharing electrons, they form a molecule. Water is the substance made of molecules that have two hydrogen atoms and one oxygen atom.

Some molecules are not made of different types of atoms. For instance, the element chlorine is often seen as a molecule. In this case, two atoms of chlorine share electrons. Even though chlorine is often a molecule, it is still an element. Why is this? **Bonds** are the attraction that hold two or more elements together. If you broke the *bonds* between the water, you would have two gases (hydrogen and oxygen) which are very different from water. If you broke the *bonds* between chlorine atoms, you would still have chlorine. Chlorine is just one of the elements that commonly form molecules. In fact, both oxygen and hydrogen atoms will form molecules when not bonded to other atoms. Now that you know what a molecule is, the next section will discuss **compounds**.

Compounds

A *compound* has two or more atoms of different kinds. Oxygen, remember, is an element. Its molecules are made of two atoms of oxygen. Water, however, is a compound. Its molecules are made of two atoms of hydrogen and one atom of oxygen. The behavior of molecules is determined by the forces holding the molecules together. The molecules in matter help explain the differences between solids, liquids, and gases. In a solid, the molecules are very close together. They cannot move around very easily. The molecules in a liquid are further apart and can move easily. In a gas, the molecules are very far apart. They can move freely. That's why the molecules of a gas always can fill a container.

When matter changes phase, the distance between the molecules changes. Gaining heat usually causes the molecules to move apart. This may cause melting. Freezing, which is a loss of heat energy, causes the molecules to slow down and move closer together.

Freezing, which is a loss of heat energy, causes the molecules to slow down and move closer together.

Reviewing the Atom

Think about what you have learned about the atom. The atom is the smallest unit of an element. An atom of silver still has all the properties of silver. You should also remember that atoms can combine with other atoms to form molecules and compounds.

History of the Atom

How did humans learn about the atom? Atoms are too small to be seen. But as long as 2,000 years ago, the Greeks were curious about matter. They wondered how it was made. Many guesses were made about the atom. At first they guessed that atoms could not be divided into smaller pieces. Today we know that is not true, but these early ideas helped scientists study atoms.

About 150 years ago, an English chemist named John Dalton studied atoms. His **theory** about atoms stated the following:

- Elements are made of atoms.
- All atoms in an element have the same mass.
- Atoms cannot be split apart.
- Atoms combine with atoms of other elements to make new substances.

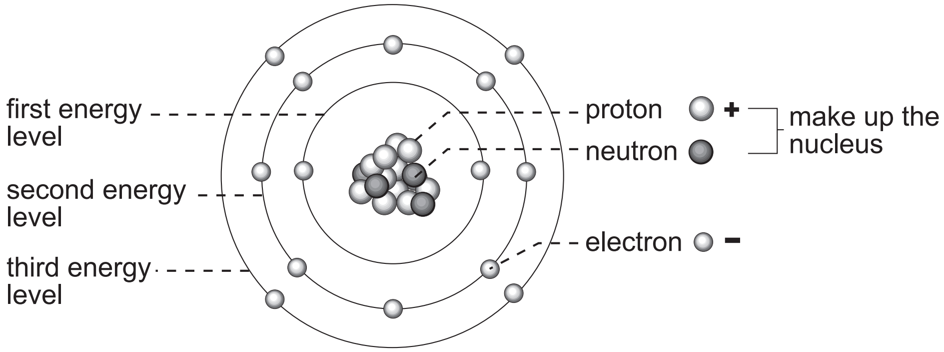
Theories are explanations that have been tested by repeat observations. Some of Dalton's theory has been disproved, but it was the beginning of the modern study of atoms.

There have been many modern inventions that helped scientists study atoms. Scientists can study the atom by breaking it up into electrons, protons, and neutrons. These small parts still cannot be seen. However, the path they leave can be photographed. It's a little like knowing a jet is in the sky by watching the path it leaves.

Inside the Atom

It is hard to imagine anything as small as an atom and that are made of even smaller parts. Except for hydrogen, atoms have *protons*, *neutrons*, and *electrons*. (Hydrogen is made only of a proton and an electron.) As discussed earlier, the center region of an atom, the nucleus, is made of protons and neutrons. Around the nucleus are electrons. Electrons move around the center of the atom. Electrons do not move in fixed paths around the nucleus. The regions in an atom where electrons are found are called **orbitals**. The *orbitals* are within energy levels. Each energy level within an atom can hold only a certain number of electrons. The energy level closest to the nucleus—the lowest energy level—can hold no more than two electrons. The second energy level can hold eight electrons. There can be up to seven energy levels depending on the number of electrons in an atom. Electrons with higher energy are found in energy levels farther from the nucleus.

Parts of the Atom



Each part of the atom is important. The proton has a *positive charge*. In math or science, a positive is shown with a plus (+) sign. A neutron has no charge.

protons have a **p**ositive charge (**+**)

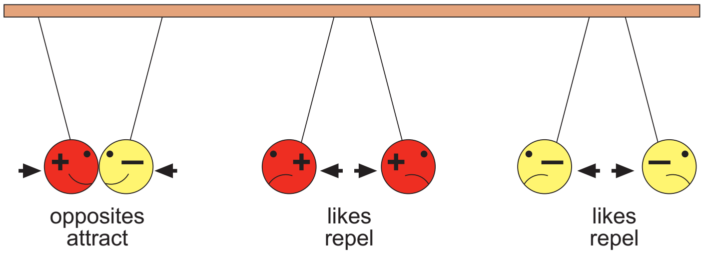
neutrons are **n**eutral (no charge)

electrons have a negative charge (**—**)

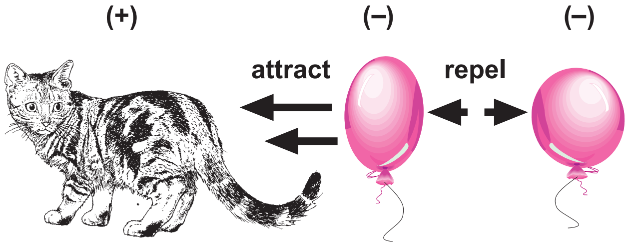
(Neutron sounds almost like **neutral**.) The electron that orbits around the center of the atom has a *negative charge*. Negative is shown by a minus (–) sign. The electrons are the part of the atom that react chemically with other atoms.

Electrical Charge

We said that a proton has a positive charge, a neutron has no charge, and an electron has a negative charge. What do we mean by the word *charge*? It stands for an electrical charge. Things that have the same charge push each other away or **repel**, but things that have different charges will move toward each other or **attract**. The forces that push and pull objects based on their charges are known as electrical forces. These electrical forces are often described by the phrase, "Opposites *attract*, likes *repel*."



Usually matter is *neutral*. It has no charge. In an atom, the number of electrons (–) equals the number of protons (+). It is possible for an electron (–) to be added to an atom. Rub two balloons filled with air on a piece of fur or wood. The atoms in the balloons pick up an extra electron atom from the fur. They now have a negative (–) charge. Place the balloons next to each other. They will move away from each other. Remember, two negatives (–) will push away from or repel each other. What about the fur? It has lost electrons. Now it has a positive (+) charge. Rub a balloon on the fur. The balloon is negative (–) and the fur is positive (+). The balloon should move toward the fur.



Opposites attract, *likes* repel.

Note: Results may vary with changes in humidity.

Summary

We have learned some important facts about atoms. We know that they are the smallest unit of an element that is still the element. Elements are made of only one kind of atom. We know they form molecules when they share electrons. We also know they combine with other atoms to make compounds. Atoms have smaller parts called neutrons, protons, and electrons. We learned that same or like charges move away from each other. Different or unlike charges move toward each other.

Practice

Use the list below to write the correct term for each definition on the line provided.

attract
bond
compound
molecule
neutral
neutron
orbital
proton
repel
theory

____________________ 1. two or more atoms that have a bond of shared electrons

____________________ 2. the attraction that holds two or more atoms together

____________________ 3. a substance formed when two or more elements combine chemically

____________________ 4. an explanation that has been tested by repeated observations

____________________ 5. the positively charged particle in the nucleus of an atom

____________________ 6. the neutral particle found in the nucleus of an atom

____________________ 7. regions in an atom where electrons are found

____________________ 8. being neither positively nor negatively charged

____________________ 9. push away from

____________________ 10. move toward each other

Lab Activity: Atoms and Molecules

Facts:

- Atoms are a fundamental unit of structure.
- Atoms combine to form molecules.

Investigate:

- You will create, through laboratory experiences, simple models of molecules.

Materials:

- toothpicks
- poster board
- two sizes of Styrofoam balls
- glue
- colored markers

Oxygen Molecule

We are going to build a model of an oxygen molecule. An oxygen molecule has two oxygen atoms.

1. Pick up two large Styrofoam balls. Each one stands for an atom of oxygen.
2. Label each ball with an O for oxygen. Remember that the O is the symbol for oxygen.
3. Place a toothpick in one of the O atoms. Connect the other O atom to the end of the toothpick.
    a. How many atoms are connected? ________________________

    b. Are the atoms the same? ________________________________

    c. You have just made a model of a molecule of ______________.
4. Glue the molecule to a piece of poster board.
5. Label your model "Molecule of Oxygen."

Water Molecule

Now we are going to create a model of a molecule of water.

1. Is water an element or a compound? ________________________
2. Since compounds are made from two or more different elements,we will need to use different kinds of balls in our model.
3. Choose one larger ball and label it with an O for oxygen.
4. Choose two smaller balls. Label each with an H for hydrogen.
5. Use toothpicks to connect an H atom to each side of the O atom.

   How many atoms are in the molecule of water? ______________
6. Glue the model to a piece of poster board.
7. Label your model "Molecule of Water."

Illustrations

1. Draw a picture of your oxygen model in the space below. Label the atoms with the correct symbols.

2. Draw a picture of your water molecule in the space below. Label the atoms with the correct symbols.

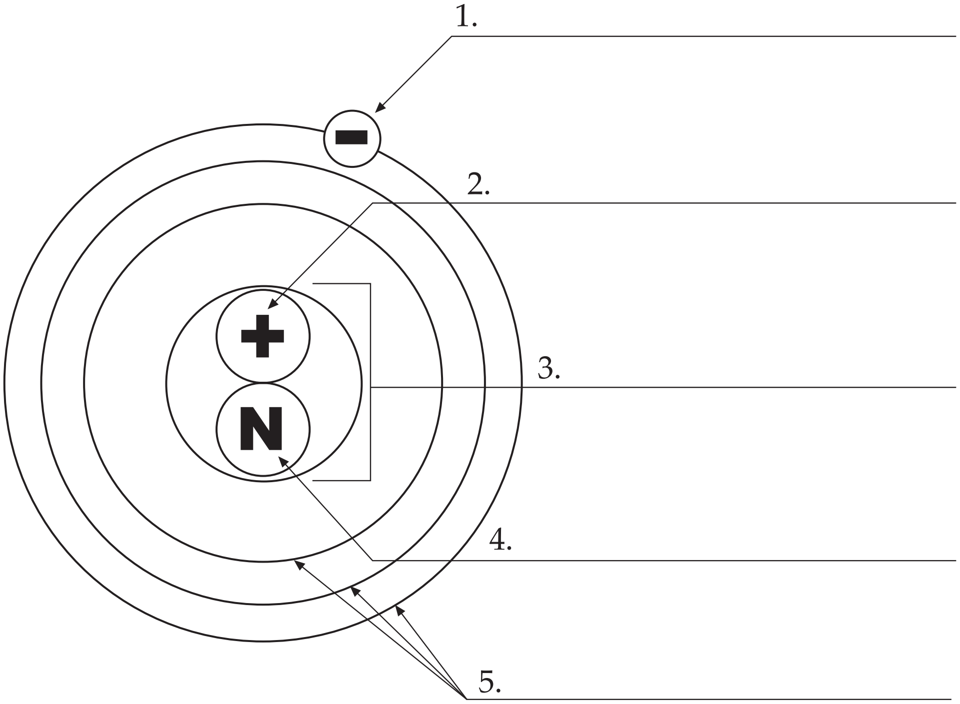
3. Which of the items represented the bond between the atoms?

____

Practice

Use the list below to label the parts of the **atom** *in the diagram below.*

electron
energy levels
neutron
nucleus
proton



Practice

The symbol ⊕ *represents* **protons**. *The symbol* ⊖ *represents* **electrons**. *Write what would happen if the two charges were placed near each other. Use the terms below to answer the following.*

repel (push away)
attract (move toward each other)

__________________ 1. ⊕ ⊕

__________________ 2. ⊖ ⊖

__________________ 3. ⊖ ⊕

__________________ 4. ⊕ ⊖

Practice

Use the list above each section to complete the statements in that section.

atom
atoms
Dalton
distance
forces
Greeks
molecule

1. As long as 2,000 years ago, the ______________________ were curious about matter.

2. About 150 years ago, ______________________ set up a theory that said all elements are made of atoms.

3. Dalton's theory said that ______________________ could not be split.

4. An ______________________ is the smallest unit of an element that is still that element.

5. A ______________________ is two or more atoms that share electrons in a bond.

6. When matter changes phase, the ______________________ between the molecules changes.

7. The behavior of these molecules is determined by the ______________________ that hold them together.

One or more terms will be used more than once.

apart
electrons
nucleus
orbitals
phase
together

8. Heat usually causes molecules to move ______________________ .

9. Freezing usually causes the molecules to slow down and move ______________________ .

10. Changes in ______________________ , like melting, are caused by gaining or losing energy.

11. Except for hydrogen, atoms are made of protons, neutrons, and ______________________ .

12. The center region of the atom is the ______________________ .

13. ______________________ move around the center of the atom.

14. The regions in an atom where the electrons are found are called ______________________ , which are within energy levels.

Practice

Use the list below to complete the following statements. **One or more terms will be used more than once.**

attract
away
farther
negative
no
one
positive
repel
toward

1. Electrons with higher energy are found in energy levels ________________________ from the nucleus.

2. The proton has a ________________________ charge.

3. The electron has a ________________________ charge.

4. The neutron has ________________________ charge.

5. If two positive charges were placed near each other, they would ________________________ .

6. If two negative charges were placed near each other, they would ________________________ .

7. If a negative charge was placed near a positive charge, they would ________________________ .

8. Like charges move ________________________ from each other.

9. Opposite charges move ________________________ each other.

10. Elements are made of only ________________________ kind of atom.

Unit 7: The Periodic Table

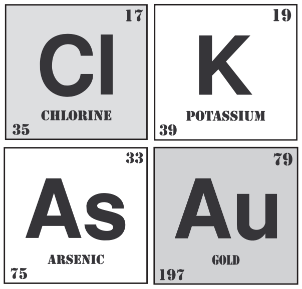
This unit introduces the periodic table and how the table is organized. Students will learn about atomic structure and how to use the periodic table.

Student Goals

- Understand the organization of the periodic table by groups and periods.
- Identify certain elements by their symbols.
- Find information necessary to construct a diagram showing the atomic structure of an element.
- Determine the atomic masses and numbers of certain elements when given the essential data.
- Understand how theories in science develop and evolve, how theories are accepted or rejected, and how theories are based on certain assumptions.

Unit Focus

- Know that from time to time, major shifts occur in the scientific view of how the world works, but that more often, the changes that take place in the body of scientific knowledge are small modifications of prior knowledge. (SC.H.1.4.2)
- Understand that no matter how well one theory fits observations, a new theory might fit them as well or better, or might fit a wider range of observations, because in science, the testing, revising, and occasional discarding of theories, new and old, never ends and leads to an increasingly better understanding of how things work in the world, but not to absolute truth. (SC.H.1.4.3)



- Know that the number and configuration of electrons will equal the number of protons in an electrically neutral atom and when an atom gains or loses electrons, the charge is unbalanced. (SC.A.2.4.1)
- Know that elements are arranged into groups and families based on similarities in electron structure and that their physical and chemical properties can be predicted. (SC.A.2.4.5)

Vocabulary

Use the vocabulary words and definitions below as a reference for this unit.

alchemists	a group of people who searched for a way to turn ordinary metals into gold
atom	the smallest unit of an element that is still that element; the basic building block of matter
atomic mass unit (amu)	a unit of mass equal to the mass of a proton or a neutron; $\frac{1}{12}$ of the mass of a carbon atom
atomic number	a number used to identify an element and represent its placement in the periodic table; identifies the number of protons in the nucleus of an atom
atomic mass	the mass of protons and neutrons found in the nucleus of an atom
combustion	the process of burning a substance
electron	the negatively charged particle of an atom; the electron moves around the center of the atom (nucleus)
element	a substance that cannot be broken down into a simpler form by ordinary chemical means

energy level	most likely location where the electron can be found around the center of the atom; any of the possible energies an electron may have in an atom
group	elements arranged in a vertical column on the periodic table representing similarities in properties
mass	the amount of matter in a substance
matter	anything that has both mass and volume
metal	a substance that has a specific luster, is usually a good conductor of heat and electricity, and can be pounded or drawn into various shapes
neutron	the neutral particle found in the nucleus of an atom; a neutron has no charge
nonmetal	an element that does not have the properties of a metal
nucleus	the center region of an atom around which the electron(s) move
period	arrangement of elements into horizontal rows on the periodic table

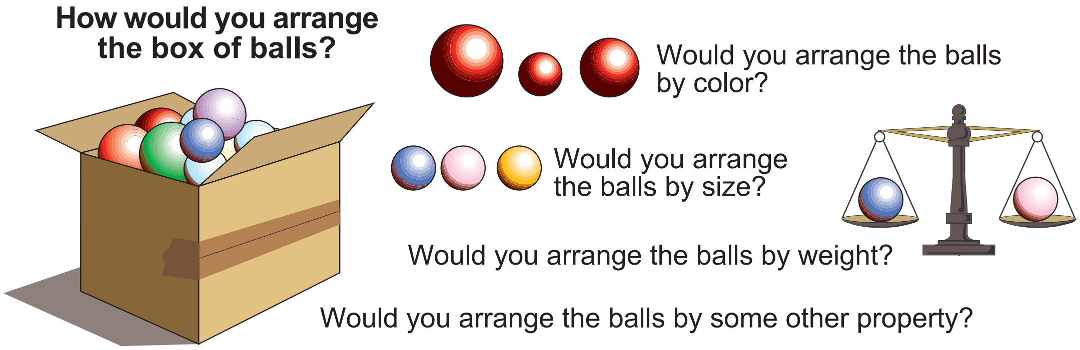
periodic table	a table showing the arrangement of the chemical elements according to their atomic numbers and chemical properties
proton	the positively charged particle in the nucleus of an atom
rare	not common or usual; hard to find
substance	any material or matter
theory	an explanation that has been tested by repeated observations
valence electrons	the electrons in an atom's outermost energy level that are involved in the forming of bonds

Introduction

You have learned what **atoms** are, and in this unit, you will add to that knowledge. You will be introduced to the **periodic table** and how it is arranged. You will also begin to see how scientists can predict behavior of *atoms*.

Periodic Table of Elements

Suppose someone gave you a box filled with different kinds of balls. They asked you to arrange them in order so that you could always find the one you wanted. How would you begin? Would you arrange them by color, size, weight, or some other property?



People who studied **matter** had the same problem. They had a set of **elements** they wanted to arrange in some kind of order, so they tried a few ways. Among the earliest groups of people during the Middle Ages to try to arrange *matter* in an ordered way were the **alchemists**. The *alchemists* wanted to change ordinary **metals** into the *element* gold. As you have learned, chemical changes don't alter elements. The alchemists did not succeed in creating gold. However, they did learn a great deal about elements. This set the stage for modern chemistry.

At one time, it was believed that **substances** burned because of some inner property. This **theory** was widely accepted. Although some scientists could use this *theory* to predict **combustion**, it didn't work well. Then scientists theorized that the element oxygen might exist. The theory stated that when oxygen combined with *substances*, changes took place. Eventually the old theory was discarded. Because the new theory better described the world, it was eventually accepted.

Dimitri Mendeleev, a Russian chemist, gathered facts about the 63 elements that had been discovered by the mid-1800s. He searched for a pattern to organize the elements. He arranged the elements in order of increasing **atomic mass**. The way he had them arranged, the elements in columns had similar physical and chemical properties. There were spaces in the table but Mendeleev boldly said these would be filled with elements that were not yet discovered. His predictions later proved to be correct.

In this way, many elements were discovered. Each time a new finding was made, it was subjected to many tests. If other scientists could not show it was wrong, then the new theory might be accepted. After a while, scientists began to get a better picture of the world.

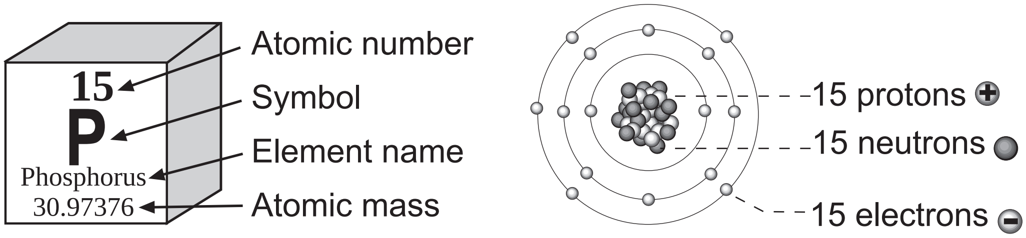
By this time, scientists had quite a group of elements. About 50 years after Mendeleev had developed his *periodic table*, Henry Moseley, a British scientist, determined for the first time the **atomic numbers** of the elements. This discovery led to a change in the arrangement of the periodic table. The modern periodic table is arranged in order of increasing atomic numbers. Since hydrogen has an *atomic number* of one (1), it became the first element on the table. The first 92 elements exist in nature. The elements on the periodic table after uranium were created in laboratories and may exist for an extremely short time. Some of the new elements are very **rare**, or hard to find. Today we generally count about 118 elements. Their atomic numbers range from one to 118. Scientists who discovered or created the new elements were allowed to name them. More elements may be created in the future.

Each time a new finding was made, it was subjected to many tests.

Of course, these new discoveries will be tested. If they do not fit well with what is already accepted, they may be criticized. If in the long run they do work well, then they should help predict new findings. If not, they will be discarded.

Atomic Number

It is often stated that there are about 118 elements. This means that there are essentially 118 different kinds of atoms. How are these atoms different from each other? The atoms of different elements have different numbers of **protons**. The *protons* are found in the center of the atom. The atomic number of any element tells how many protons are in the atom. All atoms of a particular element have the same number of protons. This is why the atomic number identifies the element. Remember also that atoms without a charge have the same number of **electrons** as protons. This is why the atomic number also tells the number of *electrons* in an atom. If an atom has 15 protons, it also has 15 electrons, so its atomic number is 15.

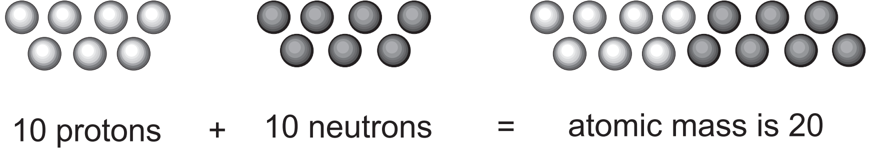


If an atom has 15 protons, it also has 15 electrons, so its atomic number is 15.

Atomic Mass

The center of an atom is called the **nucleus**. It contains protons and **neutrons**. An atom is very small, but it has **mass**. *Mass* is the amount of matter in a substance. It would be impossible to measure the mass of an atom using grams, so a special unit of measure is used. It is called the **atomic mass unit (amu)**.

One proton has the mass of one *amu*. A *neutron* also equals one amu. The *atomic mass* of an atom equals the sum of the number of protons and neutrons. For example, a neon atom has 10 protons and 10 neutrons. Its atomic mass equals 20.



neon atom

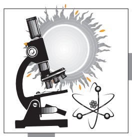
What about electrons? They are so small that they add almost no mass to the atom. For the work in this course, the mass of electrons will be ignored.

The atomic mass of atoms is usually compared to the atomic mass of carbon. Carbon has an atomic mass of 12.

Practice

Circle the letter of the correct answer.

1. The __________ wanted to change ordinary __________ into the *element* gold.
    a. alchemist, metals
    b. chemist, water
    c. scientist, air
2. Mendeleev arranged the elements in order of increasing __________ .
    a. neutrons
    b. electrons
    c. atomic mass
3. Mendeleev, a Russian chemist, gathered facts and searched for a pattern to organize the __________ to create a __________ .
    a. atoms, model
    b. elements, periodic table
    c. alchemists, scientific organization
4. Henry Moseley, a British scientist, determined for the first time the __________ of the elements.
    a. atomic number
    b. proton
    c. neutron
5. Some of the new elements which were created in laboratories are very __________ , or hard to find.
    a. long lasting
    b. natural
    c. rare
6. The center of an atom is called the __________ and contains __________ and __________ .
    a. atomic mass, electrons, elements
    b. nucleus, protons, neutrons
    c. proton, energy levels, theories



7. It would be impossible to measure the mass of an atom using grams, so a special unit of measure is used called the ____________ .

   a. atomic mass unit (amu)
   b. atomic number
   c. electron

8. It is often stated that there are about 118 elements, which means that there are essentially 118 different kinds of ____________ .

   a. alchemists
   b. atoms
   c. periodic tables

9. The ____________ of an atom equals the sum of the number of protons and neutrons.

   a. group
   b. energy level
   c. atomic mass

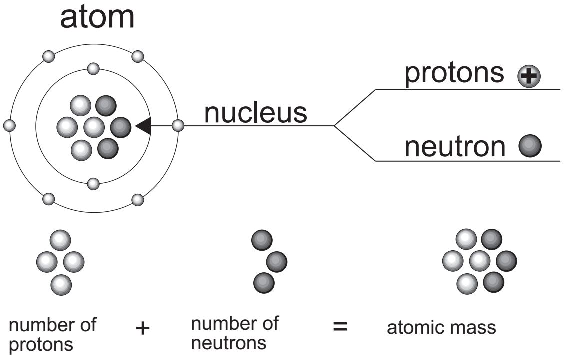
10. ____________ are so small that they add almost no mass to the atom.

    a. Electrons
    b. Metals
    c. Nonmetals

Practice

Complete the following chart. Determine the missing number of **protons**, **neutrons**, *or* **atomic mass** *for each element.* **The first one has been done for you.**

Remember: *The* **atomic mass** *is the total number of* **protons** *and* **neutrons** *found in the nucleus of an atom.*



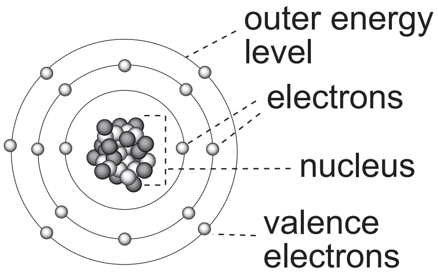
element	number of protons	number of neutrons	atomic mass
cobalt	27	32	59
sodium	11	12	
calcium		20	40
carbon	6	6	
oxygen	8		16
helium		2	4

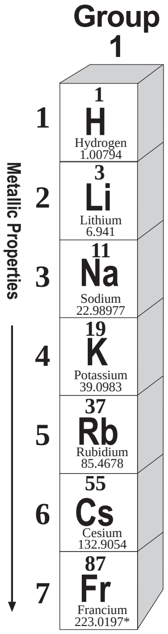
Using the Periodic Table

You have already learned that the periodic table is arranged by atomic number (the number of protons in an element). The table also gives other important information. (See the periodic table on pages 150-151.)

Group

Each column of elements from the top to the bottom is called a **group**. *Groups* of elements have properties that are alike. The elements have properties that are alike because of their electrons. All the elements in a group have the same number of electrons in their atoms' outermost **energy level**. The outermost *energy level* is farthest from the *nucleus*. The electrons in the outermost energy level are called **valence electrons**.

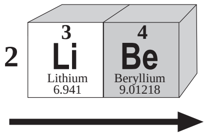




Each group has a letter and a number. All of the elements in Group 1 have one electron in their atoms' outermost energy level. Only because of hydrogen's electron arrangement is it part of group 1; hydrogen has its own set of properties.

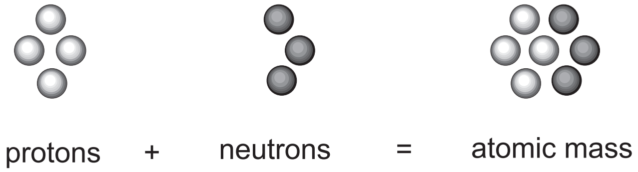
Period

The groups of elements going across on the table are called **periods**. Each period has a number. The elements in a period have different properties. All elements in the left-hand side of a period tend to lose electrons. The atoms of the elements toward the right side of the period tend to gain electrons. All the atoms at the far right neither gain nor lose electrons. Although the elements in a period have very different properties, we can predict these properties.



On most tables, like the one on pages 150-151, there is a heavy line going down the right side. It looks like steps. All of the elements to the left of the line are *metals*; all the elements to the right are **nonmetals**. The elements that are human-made have an asterisk (*) in front of the symbol. When you study the table, you will recognize some common elements and their symbols. You will also become familiar with some new elements.

Remember that the atomic number equals the number of protons (which is also the same as the number of electrons in neutral atoms). Atomic mass is the sum of protons and neutrons. The periodic table arranges the elements by atomic number.



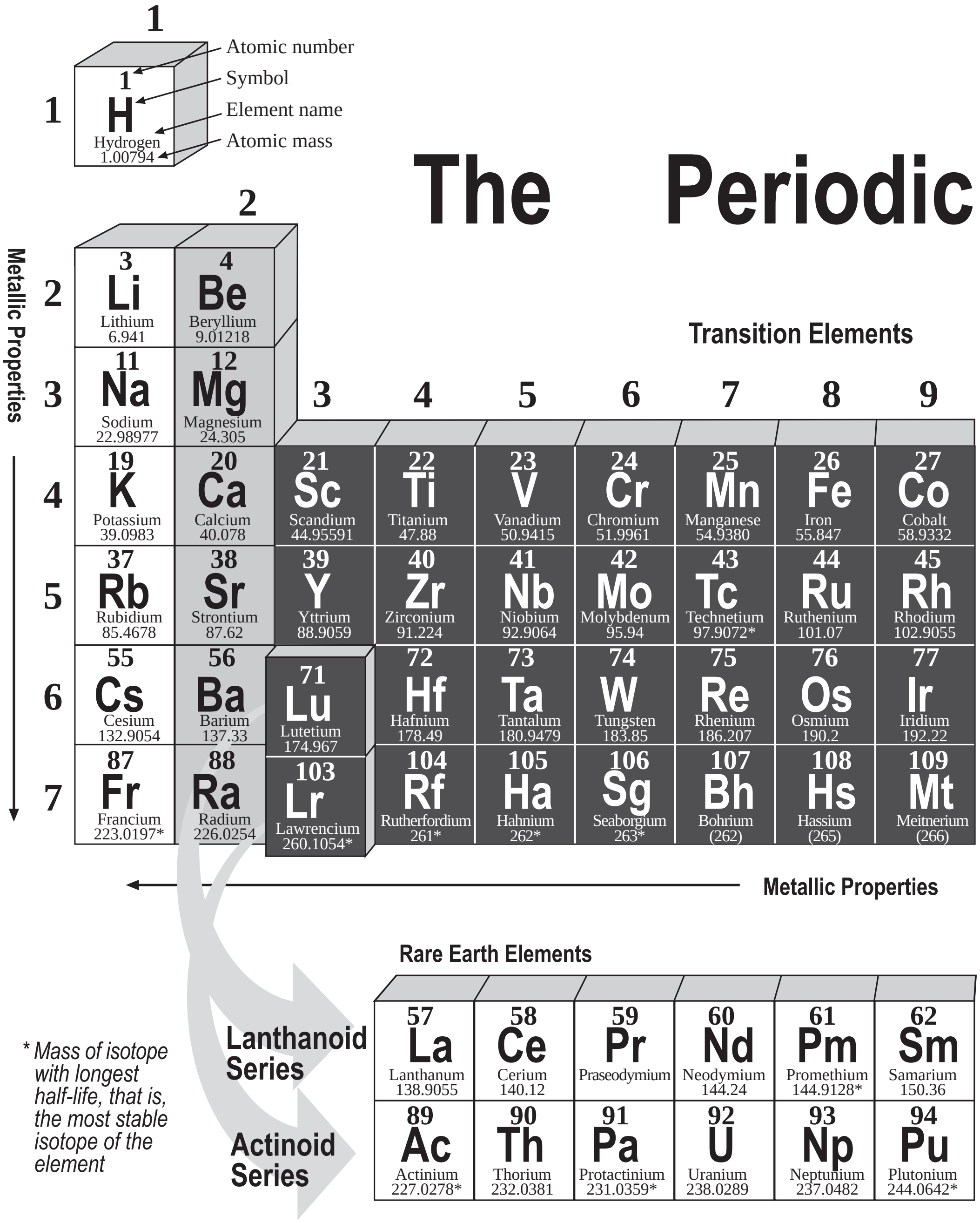
Elements and their symbols are listed in numerical order and grouped based on the atomic number.

Scientists did a great deal of work to create the periodic table. Do you think they knew it would succeed when they started? Although they did not know, they did assume it would work. Chemistry demonstrates one of the fundamental ideas in science. Virtually all scientists see the whole universe as a system. That is, they see it almost as a machine with countless parts.

Your family's car has many parts. A mechanic assumes he can study your car and figure out how to fix it. He assumes this because he knows the different parts relate to each other. In much the same way, scientists believe the parts of the universe affect each other. Sometimes, they work together simply. Other times, the relationship is very complex. However, by studying the relationships, scientists learn. They hope to learn by what rules the universe works. In developing the periodic table, they learned many rules about atoms.

Summary

All atoms have an atomic number equal to the number of protons. In neutral atoms the number of protons and electrons are equal. The periodic table of the elements arranges atoms into groups based on the number of electrons in an atom's outermost energy level. Atoms are also arranged by increasing atomic mass. Atomic mass is the sum of the mass of protons and neutrons in a nucleus. The periodic table was developed in many stages. Theories were tried, tested, and discarded, if necessary. Old theories are replaced only when the new theories are better. The result is an ever-improving view of the universe. Scientists could develop the periodic table only because they assumed the universe is a vast system and they could discover how the universe works. Study the periodic table and chart of symbols and elements that follow.



The Periodic

Transition Elements

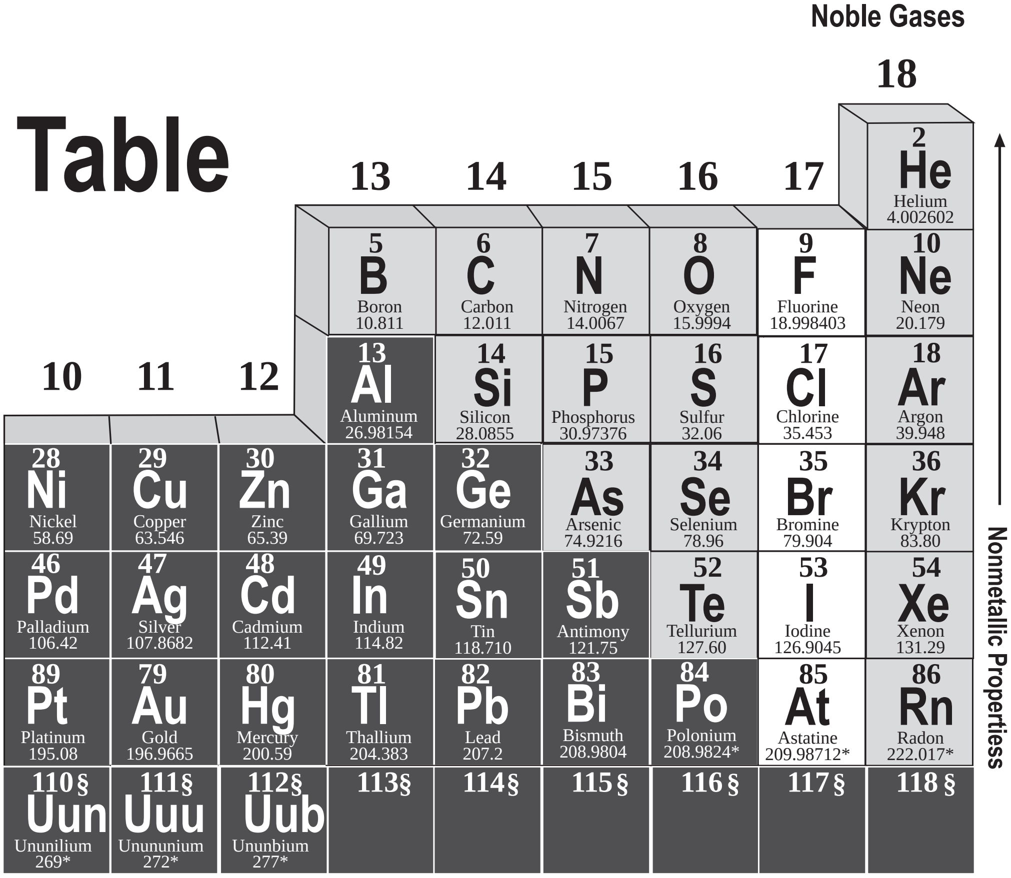
	1	2	3	4	5	6	7	8	9
1	1 H Hydrogen 1.00794								
2	3 Li Lithium 6.941	4 Be Beryllium 9.01218							
3	11 Na Sodium 22.98977	12 Mg Magnesium 24.305							
4	19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.95591	22 Ti Titanium 47.88	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.9380	26 Fe Iron 55.847	27 Co Cobalt 58.9332
5	37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.9059	40 Zr Zirconium 91.224	41 Nb Niobium 92.9064	42 Mo Molybdenum 95.94	43 Tc Technetium 97.9072*	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.9055
6	55 Cs Cesium 132.9054	56 Ba Barium 137.33	71 Lu Lutetium 174.967	72 Hf Hafnium 178.49	73 Ta Tantalum 180.9479	74 W Tungsten 183.85	75 Re Rhenium 186.207	76 Os Osmium 190.2	77 Ir Iridium 192.22
7	87 Fr Francium 223.0197*	88 Ra Radium 226.0254	103 Lr Lawrencium 260.1054*	104 Rf Rutherfordium 261*	105 Ha Hahnium 262*	106 Sg Seaborgium 263*	107 Bh Bohrium (262)	108 Hs Hassium (265)	109 Mt Meitnerium (266)

Rare Earth Elements

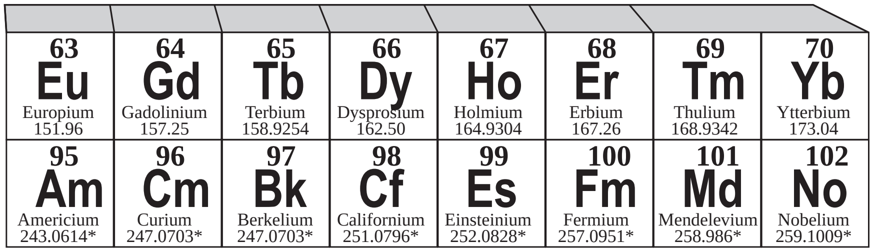
Lanthanoid Series	57 La Lanthanum 138.9055	58 Ce Cerium 140.12	59 Pr Praseodymium	60 Nd Neodymium 144.24	61 Pm Promethium 144.9128*	62 Sm Samarium 150.36
Actinoid Series	89 Ac Actinium 227.0278*	90 Th Thorium 232.0381	91 Pa Protactinium 231.0359*	92 U Uranium 238.0289	93 Np Neptunium 237.0482	94 Pu Plutonium 244.0642*

** Mass of isotope with longest half-life, that is, the most stable isotope of the element*

Table



10	11	12	13	14	15	16	17	18
								2 He Helium 4.002602
			5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.0067	8 O Oxygen 15.9994	9 F Fluorine 18.998403	10 Ne Neon 20.179
			13 Al Aluminum 26.98154	14 Si Silicon 28.0855	15 P Phosphorus 30.97376	16 S Sulfur 32.06	17 Cl Chlorine 35.453	18 Ar Argon 39.948
28 Ni Nickel 58.69	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.723	32 Ge Germanium 72.59	33 As Arsenic 74.9216	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.80
46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.710	51 Sb Antimony 121.75	52 Te Tellurium 127.60	53 I Iodine 126.9045	54 Xe Xenon 131.29
89 Pt Platinum 195.08	79 Au Gold 196.9665	80 Hg Mercury 200.59	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.9804	84 Po Polonium 208.9824*	85 At Astatine 209.98712*	86 Rn Radon 222.017*
110§ Uun Ununilium 269*	111§ Uuu Unununium 272*	112§ Uub Unbium 277*	113§	114§	115 §	116 §	117 §	118 §



63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.9254	66 Dy Dysprosium 162.50	67 Ho Holmium 164.9304	68 Er Erbium 167.26	69 Tm Thulium 168.9342	70 Yb Ytterbium 173.04
95 Am Americium 243.0614*	96 Cm Curium 247.0703*	97 Bk Berkelium 247.0703*	98 Cf Californium 251.0796*	99 Es Einsteinium 252.0828*	100 Fm Fermium 257.0951*	101 Md Mendelevium 258.986*	102 No Nobelium 259.1009*

§ *Synthesized elements that are highly unstable. Research on these is continuing and may change what we know about them.*

Symbols and Elements

H	Hydrogen (1)
He	Helium (2)
Li	Lithium (3)
Be	Beryllium (4)
B	Boron (5)
C	Carbon (6)
N	Nitrogen (7)
O	Oxygen (8)
F	Fluorine (9)
Ne	Neon (10)
Na	Sodium (11)
Mg	Magnesium (12)
Al	Aluminum (13)
Si	Silicone (14)
P	Phosphorus (15)
S	Sulfur (16)
Cl	Chlorine (17)
Ar	Argon (18)
K	Potassium (19)
Ca	Calcium (20)
Sc	Scandium (21)
Ti	Titanium (22)
V	Vanadium (23)
Cr	Chromium (24)
Mn	Manganese (25)
Fe	Iron (26)
Co	Cobalt (27)
Ni	Nickel (28)
Cu	Copper (29)
Zn	Zinc (30)
Ga	Gallium (31)
Ge	Germanium (32)
As	Arsenic (33)
Se	Selenium (34)
Br	Bromine (35)
Kr	Krypton (36)
Rb	Rubidium (37)
Sr	Strontium (38)
Y	Ytterbium (39)
Zr	Zirconium (40)
Nb	Niobium (41)

Mo	Molybdenum (42)
Tc	Technetium (43)
Ru	Ruthenium (44)
Rh	Rhodium (45)
Pd	Palladium (46)
Ag	Silver (47)
Cd	Cadmium (48)
In	Indium (49)
Sn	Tin (50)
Sb	Antimony (51)
Te	Tellurium (52)
I	Iodine (53)
Xe	Xenon (54)
Cs	Cesium (55)
Ba	Barium (56)
Hf	Hafnium (72)
Ta	Tantalum (73)
W	Tungsten (74)
Re	Rhenium (75)
Os	Osmium (76)
Ir	Iridium (77)
Pt	Platinum (78)
Au	Gold (79)
Hg	Mercury (80)
Ti	Thallium (81)
Pb	Lead (82)
Bi	Bismuth (83)
Po	Polonium (84)
At	Astatine (85)
Rn	Radon (86)
Fr	Francium (87)
Ra	Radium (88)
Rf	Rutherfordium (104)
Ha	Hahnium (105)
Sg	Seaborgium (106)
Bh	Bohrium (107)
Hs	Hassium (108)
Mt	Meitnerium (109)
Uun	Ununilium (110)
Uun	Unununium (111)
Uub	Ununbium (112)

Rare Earth Elements

La	Lanthanum (57)
Ce	Cerium (58)
Pr	Praseodymium (59)
Nd	Neodymium (60)
Pm	Promethium (61)
Sm	Samarium (62)
Eu	Europium (63)
Gd	Gadolinium (64)
Tb	Terbium (65)
Dy	Dysprosium (66)
Ho	Holmium (67)
Er	Erbium (68)
Tm	Thulium (69)
Yb	Ytterbium (70)
Lu	Lutetium (71)

Actinide Series

Ac	Actinium (89)
Th	Thorium (90)
Pa	Protactinium (91)
U	Uranium (92)
Np	Neptunium (93)
Pu	Plutonium (94)
Am	Americium (95)
Cm	Curium (96)
Bk	Berkelium (97)
Cf	Californium (98)
Es	Einsteinium (99)
Fm	Fermium (100)
Md	Mendelevium (101)
No	Nobelium (102)
Lr	Lawrencium (103)

Practice

Use the **periodic table** *on pages 150-151 to complete the following chart.*

element	symbol	atomic number	number of protons	number of electrons
hydrogen	H	1		
calcium		20		20
carbon	C			6
nitrogen		7	7	
oxygen			8	8
iron	Fe	26		
copper			29	

Practice

Use the **periodic table** *on pages 150-151 to write the symbols of 10 elements. Write the name of the* **element** *on the line next to the* **symbol***. Two examples have been given.*

	Symbols	**Element**
	Ca	calcium
	O	oxygen
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

Practice

Use the **periodic table** *on pages 150-151 and the charts you completed in practices in this unit to answer the following.*

1. List the following elements in order from the lightest to the heaviest:

   calcium, hydrogen, and iron. ______________________________

2. Name another element in the same group as hydrogen. ________

   ____

3. Name three metals in period 4. ______________________________

   ____

   ____

4. Name three nonmetals in period 4. __________________________

   ____

   ____

5. Name another element in the same period as potassium and

   scandium. ____

6. Write the name of each element with the atomic number given below:

   8: ____

   16: ____

   82: ____

7. **Na** stands for the element ______________________________ .

8. **As** stands for the element ______________________________ .

9. The symbol for helium is ______________________________ .

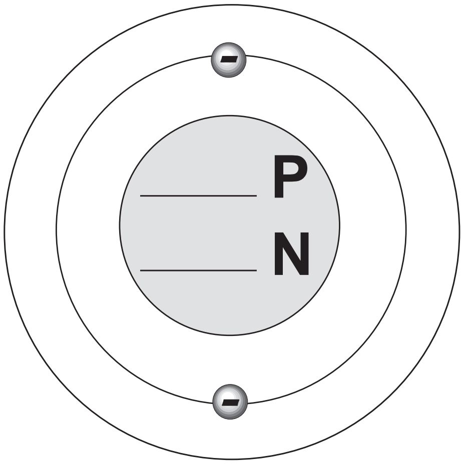
10. The atomic mass for sodium is __________________________ .

Practice

Use the **periodic table** *on pages 150-151 to answer the following.*

1. What is the symbol for the element carbon? ____________________

2. Write the correct number of protons and neutrons of carbon in the diagram below. Since there are already two electrons in the first energy level, draw the correct number of electrons on the outermost energy level.



3. The atomic mass is ____ .

4. The atomic number is ______________________________________ .

5. The number of protons is ___________________________________ .

6. The number of electrons is _________________________________ .

7. The number of neutrons is __________________________________ .

Practice

Use the list above each section to complete the statements in that section. **One or more terms will be used more than once.**

79
118
atomic number
electrons
hydrogen
Mendeleev
Moseley
nucleus

1. In the mid-1800s, the Russian chemist ____________________ arranged the elements according to their atomic mass into a periodic table.

2. The British scientist ____________________ determined the atomic numbers of the elements.

3. The discovery of each element's ____________________ led to a change in the arrangement of the periodic table.

4. There are about ____________________ kinds of atoms.

5. Protons are found in the ____________________ of the atom.

6. The ____________________ of an element tells how many protons are in its atom.

7. If we know the number of protons, we also know the number of ____________________ .

8. Gold has 79 protons, so it has ____________________ electrons.

9. The first element on the periodic table is ____________________ .

1
11
amu
atomic
atomic mass unit
neutron
neutrons
protons
sum

10. The atomic number of hydrogen is ______________________ .

11. The elements are arranged on the periodic table in numerical order based on the ______________________ number.

12. The center of an atom is called its ______________________ .

13. The nucleus of an atom contains ______________________ and ______________________ .

14. A special unit used to measure the mass of atoms is the ______________________ .

15. The abbreviation for atomic mass unit is ______________________ .

16. The mass of a proton is equal to the mass of a ______________________ .

17. A proton and a neutron are both equal to ______________________ amu.

18. The atomic mass of an atom equals the ______________________ of the number of protons and neutrons.

19. An atom with 5 protons and 6 neutrons would have an atomic mass of ______________________ .

different
electrons
elements
energy level
group
period
predict
similar

20. ____________________ do not have much mass.

21. The symbols on the periodic table stand for the names of the ____________________ .

22. A set of elements arranged in a vertical column on the periodic table is called a ____________________ .

23. Groups of elements have properties that are ____________________ .

24. The chemical properties of the elements are based on their ____________________ .

25. All the elements in a group have the same number of electrons in their outermost ____________________ .

26. A ____________________ contains the elements going across the periodic table.

27. The elements in a period have ____________________ properties.

28. Although elements in a period have very different properties, we can ____________________ their properties.

alchemists
fit
improves
left
metals
old
predict
right
simple
system

29. The heavy line on the periodic table that looks like steps separates the ____________________ from the nonmetals.

30. The nonmetals are found on the ____________________ side of the line and the metals on the ____________________ side of the line.

31. One early group to work with the elements tried to turn ordinary metals into gold. These were the ____________________ .

32. As time passes, new theories may replace ____________________ theories.

33. Theories are replaced when they do not ____________________ the observations of scientists.

34. This process ____________________ our view of the universe.

35. Theories that work well fit observations and help ____________________ new findings.

36. One reason the periodic table was made is because scientists assumed the universe is a vast ____________________ .

37. The rules of the universe range from ____________________ to complex.

Unit 8: Chemical Reactions

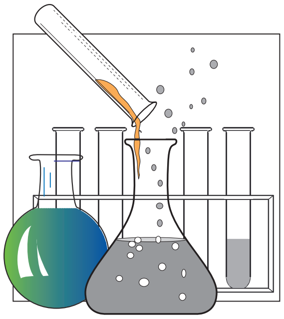
This unit emphasizes the factors that control and affect chemical reactions. Students will learn to represent the configurations of electrons for atoms and compounds and learn how these configurations determine what reactions are possible. Students are introduced to some concepts in biochemistry and are shown how biochemical reactions follow other chemical laws.

Student Goals

- Know that electron configuration in atoms determines how a substance reacts and how much energy is involved.
- Explain how physical factors affect the rates of reactions.
- Determine the electron dot structures for selected atoms and molecules and discuss how the electrons determine what type of bond is formed.
- Know that diversity in the bonds between atoms determines the properties of molecules.

Unit Focus

- Know that the number and configuration of electrons will equal the number of protons in an electrically neutral atom and when an atom gains or loses electrons, the charge is unbalanced. (SC.A.2.4.1)
- Know that the electron configuration in atoms determines how a substance reacts and how much energy is involved in its reactions. (SC.A.1.4.1)
- Know that the vast diversity of the properties of materials is primarily due to variations in the forces that hold molecules together. (SC.A.1.4.2)



Vocabulary

Use the vocabulary words and definitions below as a reference for this unit.

atom	the smallest unit of an element that is still that element; the basic building block of matter
biochemistry	the study of chemicals directly related to life processes
bond	the attraction that holds two or more atoms together
catalyst	a material or substance that increases the efficiency of a reaction without being consumed within the reaction
chemical equation	a shorthand, symbolic way of telling about a chemical reaction using symbols and formulas *Example*: $\mathbf{NaOH + HCl \rightarrow NaCl + H_2O}$
compound	a substance formed when two or more elements combine chemically
covalent bond	a bond between atoms that is made when atoms share their outermost electrons
DNA (*d*eoxyribo*n*ucleic *a*cid)	a complex molecule that controls many functions of living organisms

electron	the negatively charged particle of an atom; the electron moves around the center of the atom (nucleus)
electron configuration	the number and location of electrons; it determines how substances react and how much energy is involved in these reactions
electron dot structure	a model that represents the electron configuration of atoms; it can be used to make predictions about the bonds between atoms
element	a substance that cannot be broken down into a simpler form by ordinary chemical means
energy level	most likely location where the electron can be found around the center of the atom; any of the possible energies an electron may have in an atom
gas	the form of matter that has no definite shape or volume
ion	an atom or group of atoms that has lost or gained one or more electrons and therefore has a net electric charge
ionic bond	a bond between atoms that is formed when atoms gain or lose electrons; by gaining or losing electrons, the atoms become ions

law of conservation of mass	the law that matter cannot be created or destroyed, only changed from one form to another during a physical or chemical change
molecule	two or more atoms that have a bond of shared electrons
nucleus	the center region of an atom around which the electron(s) move
organic	a chemical compound used by living organisms that contain carbon
pressure	the amount of force acting on a substance *Example*: When divers reach the bottom of a pool, the water exerts force against them. This force is often felt as a push against the ears and other body parts.
proton	the positively charged particle in the nucleus of an atom
valence electrons	the electrons in an atom's outermost energy level that are involved in the forming of bonds

Introduction

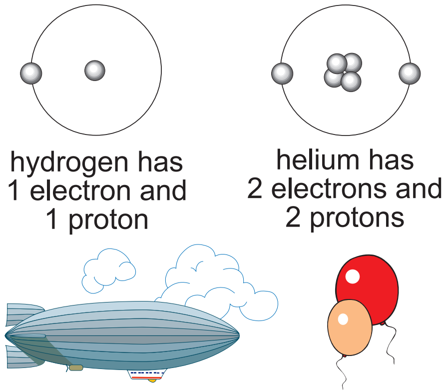
Chemical equations are a shorthand, symbolic way of telling about a chemical reaction. In other words, they describe chemical reactions. The simplest type of reaction takes place when two or more **elements** combine to form a **compound**. There are other kinds of reactions that occur between *elements* and *compounds*. Chemical reactions are the results of the properties and arrangement of **electrons**. All reactions follow the **law of conservation of mass** discussed in Unit 5: Chemical Formulas and Equations. This unit will discuss the factors that control and affect reactions.

The Role of Electrons

Whenever a reaction takes place, *electrons* control and determine what will happen. Some **atoms** have only a few electrons, such as hydrogen (one electron) and lithium (three electrons). Other *atoms* have many electrons, such as gold (79 electrons) and lead (82 electrons). It is not just the number of electrons, however, that determine how an atom will react. Let's compare two elements, hydrogen and helium, and see how they behave.

Hydrogen has one electron and one **proton**. Helium has two electrons and two *protons*. These are the two lightest elements. You might expect for there to be many similarities between the two elements. Both are **gases** and both are colorless and odorless. Additionally, both have been used to inflate balloons and zeppelins (sometimes called blimps). In this regard, because both elements are similar, they have similar uses.

The Two Lightest Elements

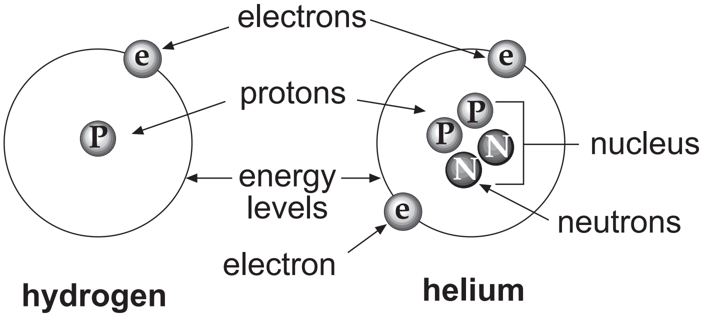


Both gases have been used to inflate balloons and zeppelins (sometimes called blimps).

If you take a moment to glance through previous chapters, though, you may notice something. Hydrogen is continually mentioned as being included in other compounds and **molecules**. The chemical symbol for helium is He. You won't find it in other compounds because of the way its electrons are configured. Hydrogen, on the other hand, is in literally thousands of compounds. Again, this is because of its **electron configuration**.

Electron Configuration

Remember that an atom's electrons are on the outside of the atom. Let's look at the *electron configurations* of hydrogen and helium:

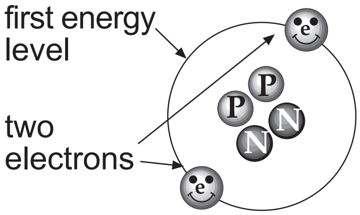


electron configurations of hydrogen and helium

The space or region that the electrons travel as they move around the **nucleus** of the atom is the **energy level**. In the cases of hydrogen and helium, there is only one *energy level*. An electron in the outermost energy level of an atom is called a **valence electron**. The *valence electrons* are the electrons that are involved in making **bonds** with other atoms. The properties of the different elements depend upon how many electrons are in the various energy levels of their atoms. The chemical bonding (combining) ability is determined by the arrangement of the electrons in the outermost energy level. Remember that it is the making and breaking of *bonds* that causes chemical reactions.

In the case of both hydrogen and helium, we can make some rules about electron configuration.

> One of the most important rules is a *tendency* to have two electrons in the first energy level.



Two electrons in the first energy level compares to a happy person getting something they want.

In some ways, you can almost think of the atoms as *wanting* two electrons. When they have the two electrons, the tendency is fulfilled. In a sense, this might be compared to giving a person something that he wants. It might make him happy.

Compare the configuration of hydrogen and helium. Helium already has two electrons. Because of this configuration, helium does not take part in chemical reactions. In fact, it is often used because it will not react. You may have heard of the *Hindenburg*. This was a large zeppelin used to transport people between Europe and the United States. While landing, the hydrogen *gas* used to inflate the zeppelin ignited. The fire spread quickly, and the zeppelin fell to the ground. Today, modern zeppelins and blimps are inflated with helium. Regardless of the amount of spark or heat, helium will not burn. This makes it safer for use in aviation.

Today, modern zeppelins and blimps are inflated with helium.

The reactivity of hydrogen is based on the fact that it has only one electron in its outermost energy level. This means that it will readily react with other atoms. By doing this it can share an electron and fulfill its tendency to have two electrons. One more rule we can make about hydrogen's and helium's electron configuration is as follows:

> They can have no more than two electrons.

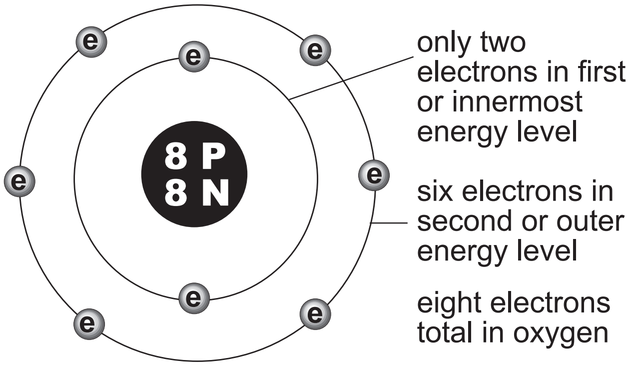
Let's see how this rule works.

Making Water

Hydrogen and oxygen combine to make water. By now, you are familiar with this reaction. To fully understand the properties of water, we must look at the way the *molecules* of water are made. Let's look at the electron configuration of oxygen.

You will see that oxygen has two electrons in its innermost energy level. Regardless of the element, there can be no more than two electrons in this first energy level. Oxygen has

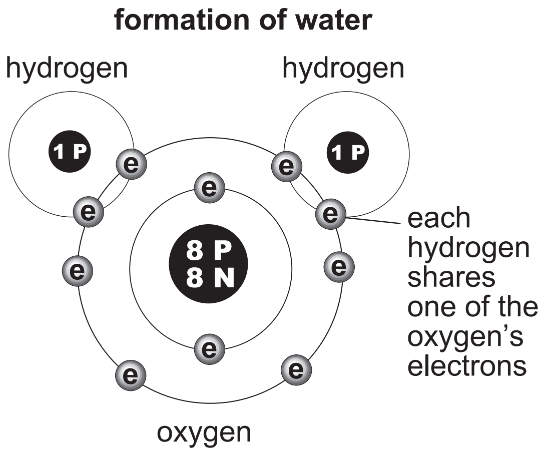
electron configuration of oxygen



eight electrons, so there are six in its second energy level. There are a few other rules describing electron configuration. These apply to other atoms besides those of hydrogen and helium. These rules are as follows:

- Atoms can have up to eight electrons in their outermost energy level but no more. Atoms with eight valence electrons usually do not react.
- Atoms that have fewer than four electrons in their outermost energy level tend to give up electrons.
- Atoms that have four or more electrons in their outermost energy level tend to gain electrons.

Using these rules, what predictions can you make about oxygen? If you said that it will tend to gain electrons you did well. How many electrons could hydrogen have in the case of water? If you said two, you are right.



When water and hydrogen combine to form water, the oxygen shares electrons with hydrogen. The result is that each hydrogen shares one of the oxygen's electrons. This effectively gives each hydrogen two electrons in its outermost energy level. Because the electrons are being shared, oxygen shares the electrons of hydrogen. The result is that oxygen has eight electrons in its outermost energy level.

Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. the negatively charged particle of an atom

______ 2. the form of matter that has no definite shape or volume

______ 3. the electrons in an atom's outermost energy level that are involved in the forming of bonds

______ 4. the positively charged particle in the nucleus of an atom

______ 5. the smallest unit of an element that is still that element

______ 6. the center region of an atom around which the electron(s) move

______ 7. the attraction that holds two or more atoms together

______ 8. the number and location of electrons

______ 9. most likely location where the electron can be found around the center of the atom

______ 10. a substance that cannot be broken down into a simpler form by ordinary chemical means

A. atom

B. bond

C. electron

D. electron configuration

E. element

F. energy level

G. gas

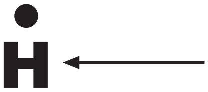
H. nucleus

I. proton

J. valence electrons

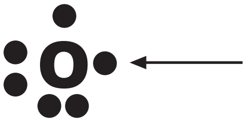
Electron Dot Structures

Picturing the way the rules on page 172 function can be difficult. Because of this, we have a model we can use called **electron dot structures**. *Electron dot structures* model atoms. The model represents the electron configuration of atoms. Electron dot structures are used to make predictions about the bonds between atoms. For instance, hydrogen has one electron. Below is the dot structure of hydrogen.



electron dot structure of hydrogen

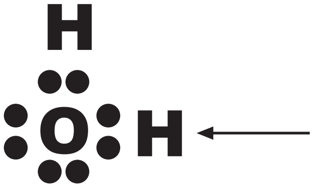
The *electron dot structure* of oxygen is below.



electron dot structure of oxygen

Notice that the structure only shows six electrons. This is because only six of oxygen's electrons are in its outermost energy levels. Only electrons in outermost energy levels are involved in chemical reactions. For this reason, the electron dot structure of oxygen does not show oxygen's two innermost electrons.

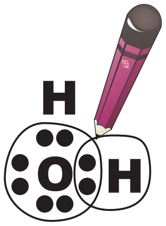
Now let's look at the electron dot structure of a water molecule:



electron dot structure of a water molecule

- Take a pencil and draw a circle around the electrons that are on the edges of the oxygen molecule.
- Count the number of electrons. You should have counted eight electrons.

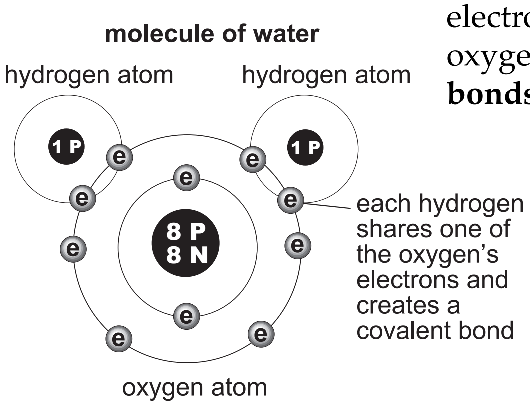
- Now, choose one of the hydrogen atoms.
- Circle the electrons that are around the hydrogen atom.
- Count them. You should have counted two electrons.



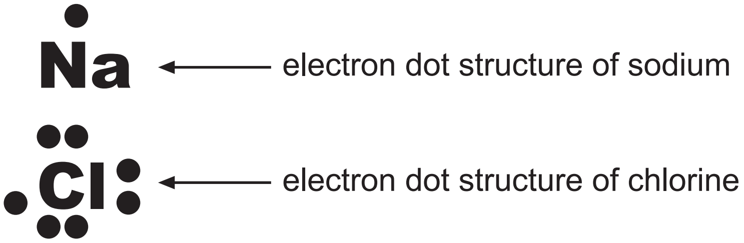
This is the way that the atoms share the electrons.

Other Bonds

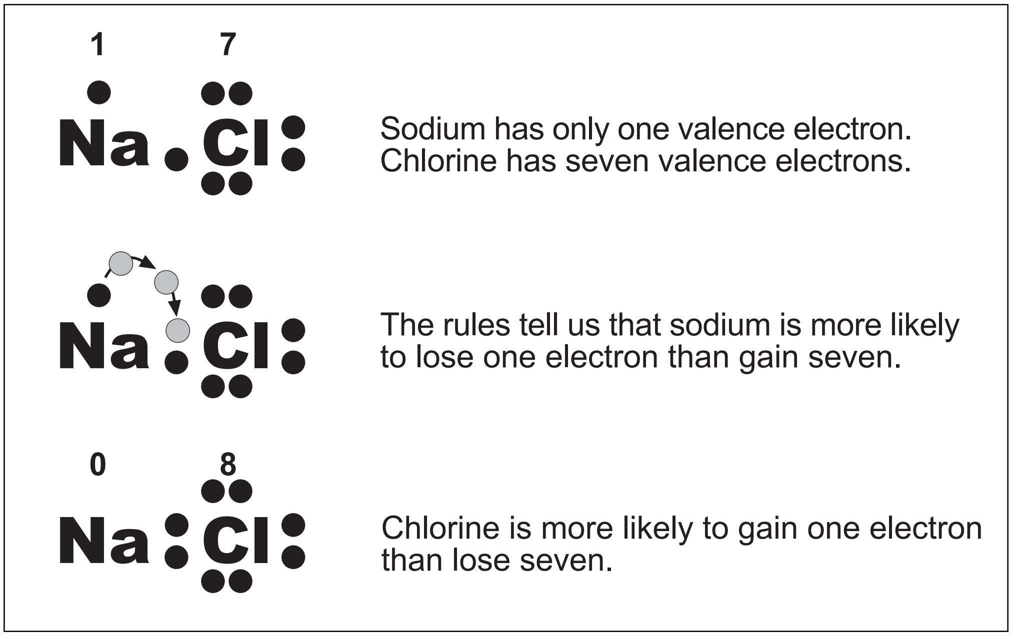
The first example we have shown was a molecule of water. Remember that a molecule is two or more atoms that share electrons. With the electron dot structures, we showed that hydrogen and oxygen share electrons. The bonds created between oxygen and hydrogen were **covalent bonds**. The valence electrons were shared.



In the cases of salts, the bonds between the atoms are not covalent. In sodium chloride (table salt) chlorine does not share electrons with sodium. Instead, sodium is bonded to chlorine by an ionic attraction. An atom becomes ionized when it gains or loses electrons. If an atom gains or loses electrons, it no longer has the same number of electrons (-) as it does protons (+). Because the charges do not cancel as they did before, the **ion** that forms has a net electric charge. It is the opposite charges of the chlorine and sodium that bond them together. They have an **ionic bond**. To determine which atom has which charge, let's look at their electron dot structures:



Notice that sodium has only one valence electron. Chlorine has seven valence electrons. As our rules about electron configuration tell us, both atoms could have up to eight electrons in their outermost energy level. The rules also tell us that sodium is more likely to lose one electron than gain seven.



Chlorine, on the other hand, is more likely to gain one electron than lose seven. The structure of sodium chloride is below:

In this structure, we see that chlorine now has eight electrons. The chlorine now has one more electron than protons. Because electrons have a negative charge, the chlorine now has a negative charge. The sodium has lost an electron. It now has one more proton than electrons. The sodium has a positive charge. It is the opposite charges of the atoms that bond them.

Properties of Substances

The properties of salts and water are very different. Largely these properties are based on the bonds between the atoms. For instance, water is a molecule because it has *covalent bonds*. These bonds are stable. Water does not spontaneously change into another substance. Table salt, on the other hand, has *ionic bonds*. When this salt is put in water, the bonds are broken.

Think back to your study of the periodic table. Remember that atoms of elements in the same group have the same number of valence electrons. So these elements have similar properties.

The properties of various materials is in large part based on electrons. Electrons determine when and how bonds will be formed. They determine when a bond will release or absorb energy. They determine what the properties of the materials will be. Chemical reactions are the results of the activity of electrons.

Other Factors Affecting Chemical Reactions

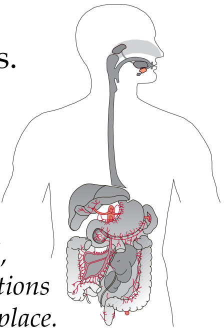
Other factors affect when electrons can or cannot be involved in reactions. Certain conditions make the reactions occur more quickly and completely. These include the following:

Pressure:	When gases are reacting, increasing **pressure**, or the amount of force upon the gasses, increases the chance that atoms will come in contact. The increase in *pressure* improves the speed of the reaction.
Temperature:	When temperature rises, atoms more frequently come into contact. Raising temperature will increase the speed of a reaction.
Catalyst:	A **catalyst** will enable a reaction to occur at lower temperature and/or pressure. This saves effort and energy. *Catalysts* can also improve the speed and completeness of a reaction, but there are not catalysts for all reactions. The lack of a catalyst can slow other reactions that usually require a catalyst.
Concentration:	By increasing the amount of substance in a solution, the speed of a reaction is increased.

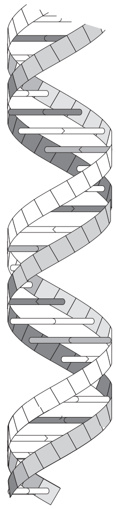
Chemistry in the Body

The factors affecting reactions are especially important in **biochemistry**. The study of the chemistry of living organisms is very complex. The human body, for instance, contains thousands of separate chemicals. In order to digest food, think, or move, many reactions must take place.

Thinking, moving, or digesting are all processes. Each is regulated by a complex series of specific chemical reactions. These reactions, however, must be controlled. Imagine what would happen if your digestive system did not function when you ate food. Your food would rot inside you. The effects would be both unpleasant and painful. Fortunately, healthy people have biochemical responses to food. They digest after they have eaten. When the food is digested, the process stops.



In order to digest food, many reactions must take place.



DNA model

You may wonder how this is all coordinated. Within your body is a chemical code that controls such processes. This code is in a complex molecule known as **DNA (*d*eoxyribo*n*ucleic *a*cid)**. Your *DNA* came from your parents. Like most other molecules in your body, it is **organic**. *Organic* molecules are produced or used by living organisms and contain the element carbon. DNA is the code that controls many of your body's functions.

As we noted, DNA is complex. You might imagine it as a thick book of instructions on how to operate a computer. The person who wrote the book didn't know how you would try to use the computer. Instead, the author tried to include instructions for every process. The result is a thick, complicated book. Now, consider the book again. It is made of only 26 letters. Although there are only 26 letters, they can make hundreds of thousands of words.

The substances that comprise DNA are like the letters in the book. They are combined in one way and then recombined in other ways. The result is that your DNA is very long and complex. This complexity allows your body to cope with all of life. Incredibly, though, there are only four basic units in DNA. That is like trying to write your book with only four letters!

These four substances, though, are like many other organic substances. They can serve many purposes. The important thing is how they are combined with other chemicals. Just like other reactions, each new combination has unique properties.

Summary

Chemical reactions occur when atoms share or transfer electrons. The sharing or transferring of electrons is based on the configuration of electrons. Electron dot structures model these configurations. The properties of substances are based on the configurations of their electrons. Factors such as temperature, concentration, pressure, and catalysts affect the speed of reactions. Reactions within a human body also follow biochemical principles. These organic chemicals can be combined and recombined in many ways.

Practice

Circle the letter of the correct answer.

1. The ____________ is a model that represents the electron configuration of atoms. (Hydrogen is $\overset{\bullet}{\mathbf{H}}$)
    a. organic dot structure
    b. electron dot structure
    c. gas dot structure

2. The bonds created between oxygen and hydrogen were ____________ because the valence electrons were shared.
    a. covalent bonds
    b. atomic bonds
    c. electronic bonds

3. If an atom gains or loses electrons, it no longer has the same number of electrons (-) as it does protons (+). Because the charges do not cancel as they did before, the ____________ that forms has a net electric charge.
    a. proton
    b. catalyst
    c. ion

4. An ____________ is a bond between atoms that is formed when atoms gain or lose electrons.
    a. ionic bond
    b. organic bond
    c. electron bond

5. When gases are reacting, increasing ____________ increases the chance that atoms will come in contact.
    a. gases
    b. pressure
    c. bonds

6. A ____________ is a material or substance that increases the efficiency of a reaction without being consumed within the reaction.

   a. catalyst
   b. nucleus
   c. proton

7. The factors affecting reactions are especially important in ____________ , which is the study of chemicals directly related to life processes.

   a. algebra
   b. reactionary
   c. biochemistry

8. Within your body is a chemical code that controls many functions of living organisms. It is known as ____________ .

   a. DNA
   b. CC
   c. LAF

9. ____________ molecules are produced or used by living organisms and contain the element carbon.

   a. Ion
   b. Organic
   c. Catalyst

Practice

Answer the following using short answers. Give examples where indicated.

1. What part do electrons play in chemical reactions?

   ____

   ____

   ____

2. What is electron configuration? ________________________

   Example: ______________________________________

   ____

3. What does an electron dot structure model? ______________

   Example: ______________________________________

   ____

4. Which elements have only one energy level of electrons? ______

   ____

5. What is the greatest number of electrons the element chlorine can have in its outermost energy level?

   ____

   Why? ____

   ____

6. What type of bond is formed when atoms share electrons?

   ____

7. What type of bond is formed when atoms transfer electrons and create atoms with charges?

____

8. What causes many of the differences between substances?

____

____

9. How would increasing the pressure of two gases affect the way they react?

____

____

10. What effects might you expect if you added a catalyst to a reaction?

____

____

____

11. What would happen if your digestive system did not function when you ate food?

____

12. DNA, like other organic compounds, contains what element?

____

13. The code of DNA controls what? ______________________

14. The four substances that make up DNA are a good example of how organic compounds can do what?

_____________________ and _____________________

Practice

Use the **electron dot structures** *below to determine if the elements can react with other elements. (Remember, you must know how many* **valence electrons** *an element can possess. Refer to pages 170-172 and 174-176.) Make a check mark in the appropriate box.*

		structure	react	not react
1.	helium	 helium		
2.	sodium	 sodium		
3.	calcium	 calcium		
4.	argon	 argon		
5.	krypton	 krypton		
6.	carbon	 carbon		

Predict whether an atom will gain or lose **electrons** *in a* **reaction** *by checking the appropriate box. Again, refer to page 170-172 and 174-176 for assistance.*

		number of electrons	gain	lose
7.	carbon	4		
8.	magnesium	2		
9.	fluorine	7		
10.	potassium	1		

Lab Activity: Concentration of Substances and Speed of Reaction

Facts:

- The concentration of substances affects the speed and completeness of reactions.

Investigate:

- You will determine how the concentration of vinegar (an acid) affects its reaction with baking soda (a base).

Materials:

- 120 grams of baking soda
- 2 uninflated balloons
- 150 mL of vinegar
- 50 mL of water
- 2 two 150 mL flasks

1. Place 60 grams of baking soda in 1 balloon.
2. Place 50 mL of vinegar and 50 mL of water in 1 flask.
3. Label the flask as Flask A.
4. Without spilling baking soda into the solution, place the balloon over the mouth of the flask. Set the flask aside.
5. Place 60 grams of baking soda in the second balloon.
6. Place 100 mL of vinegar in the second flask.
7. Label the flask as Flask B.
8. Without spilling baking soda into the solution, place the balloon over the mouth of the flask.
9. Which flask has the greater concentration of vinegar? __________

10. Set both flasks in front of you. Watching carefully, lift both balloons so that the baking soda falls into the vinegar and water solution. Let go of the balloon.

11. Which balloon inflated more quickly? ______________________

12. Using check marks, record your data in the chart below:

	Flask A	Flask B
greater concentration		
lesser concentration		
faster reaction		
slower reaction		

13. What relationship exists between reaction speed and concentration?

____

____

____

Practice

Use the list above each section to complete the statements in that section.

covalent
eight
electron dot structure
electrons
ionic bonds
two
valence

1. Chemical reactions depend on the configurations of

   ____________________________ .

2. Hydrogen and helium can have no more than

   ____________________________ electrons in their outermost energy level.

3. The electrons in an atom's outermost energy level are known as

   ____________________________ electrons.

4. The atoms of carbon or oxygen may have as many as

   ____________________________ electrons in their outermost energy level.

5. ____________________________ can be used to model how the electrons of an atom are arranged.

6. In water, the bonds between hydrogen and oxygen are

   ____________________________ because the electrons are shared.

7. ____________________________ can be found in substances such as salts, where electrons are transferred and not shared.

biochemical
carbon
catalyst
concentration
force
increase
recombine

8. Pressure is the amount of ________________________ acting on or pushing against a substance.

9. If the pressure of two gases is raised, the speed of a reaction between them will ________________________ .

10. A ________________________ can increase the speed of a reaction or enable a reaction to occur at a lower temperature or pressure.

11. If the speed of a reaction is increased by raising the amount of substances in solution, then the ________________________ has been increased.

12. Body processes involve specific reactions that are controlled by ________________________ principles.

13. Organic molecules are vital to living organisms. All of them include the element ________________________ .

14. The ability of the compounds in DNA to combine and ________________________ makes it possible for DNA to be highly complex.

Answer the following using short answers.

15. By lowering temperature, pressure, or concentration, the speed and completeness of reactions can be lowered. When food spoils, a chemical reaction has taken place. What common method of food storage helps prevent spoilage and why?

16. Welding aluminum can be difficult because aluminum reacts with oxygen. To prevent this, the area being welded is flooded with helium gas. The helium displaces oxygen and prevents it from reacting with the aluminum. Why doesn't helium react with aluminum?

17. Internal combustion engines pressurize a mixture of air and gasoline that react by burning. This burning provides the engine with power. Why does the engine provide more power if the gasoline and air are pressurized?

18. Many industrial chemical reactions involve solutions of acids or bases. In many cases, the speed and completeness of the reaction must be high for the industry to make money. What relationship does this need have with the fact that many industrial chemicals are highly concentrated?

____

____

____

Unit 9: Forms of Energy

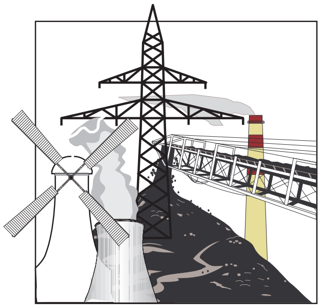
This unit explores how energy can exist in various forms such as mechanical, chemical, electrical, heat, sound, and nuclear. Energy can be converted from one form to another but never created or destroyed.

Student Goals

- Explain how energy can be changed from one form to another.
- Give examples of energy conversion.
- Explain chemical energy and demonstrate it through laboratory experiences.
- Describe the sources of nuclear energy, magnetic and electrical forces, and heat, and understand how the laws of thermodynamics are related to all.
- State that energy cannot be created or destroyed.
- Discuss the importance of energy to all branches of science and comprehend how the structure of the universe is the result of energy and matter.

Unit Focus

- Understand how knowledge of energy is fundamental to all the scientific disciplines (e.g., the energy required for biological processes in living organisms and the energy required for the building, erosion, and rebuilding of the Earth). (SC.B.1.4.1)
- Understand that there is conservation of mass and energy when matter is transformed. (SC.B.1.4.2)



- Describe how magnetic force and electrical force are two aspects of a single force. (SC.C.2.4.3)
- Know that the forces that hold the nucleus of an atom together are much stronger than electromagnetic force and that this is the reason for the great amount of energy released from the nuclear reactions in the sun and other stars. (SC.C.2.4.4)

Vocabulary

Use the vocabulary words and definitions below as a reference for this unit.

atom	the smallest unit of an element that is still that element; the basic building block of matter
atomic energy	energy that is stored in the nucleus of every atom; sometimes called nuclear energy
chemical energy	the energy that is stored in chemicals
electrical energy	the energy of moving electrons; the energy of moving charged particles
electron	the negatively charged particle of an atom; the electron moves around the center of the atom (nucleus)
energy	the ability to do work or cause change
energy conversion	when energy changes from one form to another
gas	the form of matter that has no definite shape or volume
heat energy	the energy of moving molecules; the energy responsible for causing changes in temperature

law of conservation of energy	the law that energy cannot be created or destroyed, only changed from one form to another during a physical or chemical change
light energy	the energy of the electromagnetic spectrum in the range of light
liquid	the form of matter that has a definite volume but does not have a definite shape
magnet	a substance that attracts or pulls on other substances, especially those made of or including iron
matter	anything that has both mass and volume
mechanical energy	the energy of moving things
molecule	two or more atoms that have a bond of shared electrons
nucleus	the center region of an atom around which the electron(s) move
solid	the form of matter that has a definite shape and volume
sound energy	the energy of vibrating materials as detected by human ears

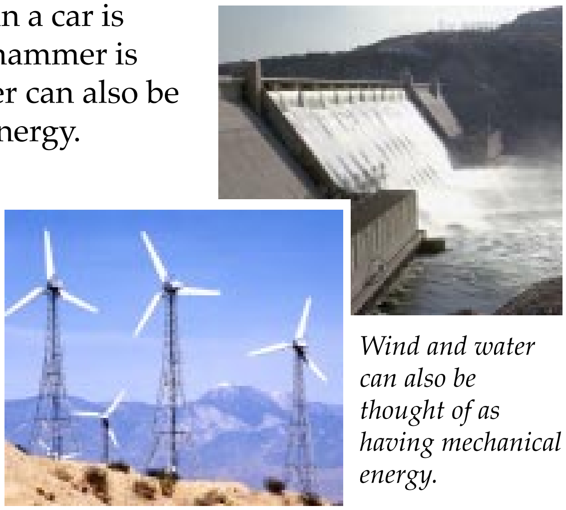
Introduction

You have learned that **energy** is the ability to do work or cause change. There are many different forms of *energy*. We may use one form of energy to run our cars, another to heat our homes, and still another to send television pictures. People use large amounts of energy to help them perform work. Scientists are always looking for new available energy. In this unit, the different forms of energy will be introduced.

Kinds of Energy

The energy in moving things is **mechanical energy**. The movement of pistons in a car is *mechanical energy*. The energy of a hammer is mechanical energy. Wind and water can also be thought of as having mechanical energy.

Electrical energy is caused by the flow of electric currents. Many of the appliances we use every day run on *electrical energy*—the energy of moving **electrons**, or moving charged particles. The energy in **magnets** is a result of the same force that causes electricity.



Wind and water can also be thought of as having mechanical energy.

Electrical energy is caused by the flow of electric currents.

Your body gets energy from the food you eat. This is a form of **chemical energy**. *Chemical energy* is energy stored in chemicals. Many chemicals have stored energy. When coal burns, chemical energy is released. The energy was stored in the coal when the coal was formed millions of years ago.

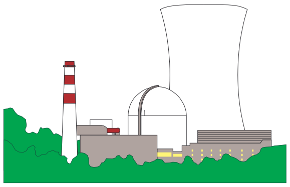
Heat energy is the energy of moving molecules; it is responsible for causing changes in temperature. The form of **matter** can be changed by *heat energy*. Remember that heat can change a **solid** to a **liquid** or a *liquid* to a **gas**. Almost all *matter* contains some heat energy.

Light energy is very common. Some *light energy* comes from the sun to Earth. Radio waves and x-rays are light energy since they spread out and pass through space.

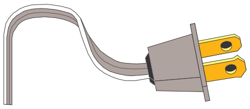
Radio waves and x-rays are light energy since they spread out and pass through space.

Sound can also be a form of energy. Sound can make objects move. Thunder is an example of **sound energy**. When you hear thunder, what you experience are small movements in the air. The small movements are detected by your ears and translated by your brain as sound. *Sound energy* is the energy of vibrating materials as detected by human ears.

Locked deep inside every **atom** is a powerful form of energy. **Atomic energy** or *nuclear energy* can be used to run power plants. It can also be used for destructive purposes, such as nuclear bombs. Nuclear energy is the energy that holds the **nucleus** of an *atom* together, and it is very great.



Nuclear energy can be used to run power plants.

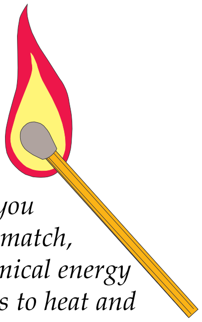


The electricity we use comes from releasing the chemical energy in coal or oil.

Most energy that we use on a daily basis has its recent origins in chemical energy. The electricity we use comes from releasing the chemical energy in coal or oil. The cars and buses in which we ride convert chemical energy to mechanical energy. With chemical energy, it takes large amounts of matter to make large amounts of energy. This is not true of nuclear energy. The forces which hold together an atom are so great that a small amount of matter can release a large amount of energy. It is because of this that nuclear energy can be both useful and destructive.

Changing Energy—Energy Conversion

Energy does not exist in only one form. It also does not stay in only one form. It can change from one form to another. When you light a match, its chemical energy changes to heat and light. The mechanical energy in wind can be *converted* by a windmill to electrical energy.



When you light a match, its chemical energy changes to heat and light.

Conservation of Energy

Where does energy go when it is used? When runners compete in a long race, they use large amounts of energy. Most of the energy is changed into heat. Saw a piece of wood. Feel the blade and the wood. Both will feel warm. The mechanical energy was changed into heat.

Whenever energy changes its form, some of it is converted to heat. The more times a source of energy is converted, the more energy becomes heat. Usually this heat energy is wasted, but scientists try to find ways to keep from wasting this energy, such as using newer models of engines which give off less heat than older models. By giving off less energy as heat, more energy is available for motion. Scientists are also looking for ways to use the heat energy. In one experiment, the heat given off by people in a room was used to heat another part of the building.

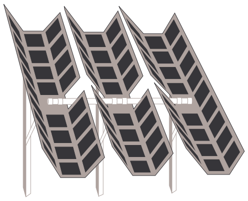
You have already learned that matter cannot be created or destroyed. What about energy? It can change form, but it is never destroyed. The **law of conservation of energy** states that energy is never created or destroyed—only changed from one form to another.

The Importance of Energy

Without energy, nothing would change. Of course, scientists of all types study change and its causes. In effect, scientists study energy. This is true of all scientists. Imagine that you are a marine biologist (who studies life in the oceans). You would not work for very long before you realized that all fish and corals and turtles—all life—would not exist without energy. An understanding of energy is a basic part of all sciences. It is fundamental to understanding how the universe works.

Summary

Mankind uses large amounts of energy. Energy can exist in various forms, such as mechanical, chemical, electrical, heat, sound, and nuclear. Energy can be converted from one form to another. When energy is used, heat energy is formed. Some amount of energy is always lost as heat. Energy can never be created or destroyed. An understanding of energy is fundamental to all branches of science.



solar panels

Practice

Use the list above each section to complete the statements in that section. **One or more terms will be used more than once.**

atomic or nuclear
change
chemical
electrical
heat
light
mechanical
sound
work

1. Energy is the ability to do ____________________ or cause ____________________ .

2. The main forms of energy are ____________________ , ____________________ , ____________________ , ____________________ , ____________________ , ____________________ and ____________________ .

3. The energy of moving things is called ____________________ energy.

4. Energy that comes from the sun is called ____________________ energy.

5. Energy that is stored in chemicals is called ____________________ energy.

6. The energy of moving molecules is called ____________________ energy.

atomic
converted
electrical
fundamental
heat
nuclear
sound

7. The energy of moving charged particles is called
__________________________ energy.

8. The energy of vibrating materials is called
__________________________ energy.

9. Energy that is stored in the nucleus of every atom is called either
__________________________ or __________________________ energy.

10. When energy is changed from one form to another, we say that it has
been __________________________ .

11. Whenever energy changes forms, some is lost as
__________________________ .

12. An understanding of energy is __________________________ to science.

Practice

Use the list below to complete the following statements with the correct **type of energy** *to show the* **conversion***.* **One or more terms will be used more than once.**

chemical
electrical
heat
light
mechanical
sound

Remember: Energy can change easily from one form to another.

1. When you turn on a power drill, ____________________ energy is changed to ____________________ energy.
2. When you light a candle, ____________________ energy is changed to heat and ____________________ .
3. When you slam a door, ____________________ energy is changed to ____________________ energy.
4. When coal burns, ____________________ energy is changed to ____________________ energy.
5. When you play a piano, ____________________ energy is changed to ____________________ energy.

Lab Activity: Chemical Energy

Facts:

- Chemical energy is stored in substances and can be released.

Investigate:

- You will determine that energy stored in chemicals can be released.

Materials:

- test tubes
- stopper to fit test tubes
- baking soda
- vinegar

1. Fill the test tube a little less than ½ full with baking soda.
2. Add vinegar almost to the top of the test tube.
3. Place the stopper in the test tube.
4. Set the test tube down in a rack.

   (CAUTION: Aim the test tube away from your eyes and your lab partners' eyes.)

5. Observe the results.

   a. Did you notice any activity? ______________________________

   b. Is this activity a form of energy? ______________________________

   c. What happened to the stopper? ______________________________

   d. Was work done? ______________________________

6. Let's see if you understood the experiment.

    a. Did you add any outside energy to the reaction? ____________

    b. Do you think the energy came from the substances? _________

    c. The substances are chemicals. What kind of energy is stored in chemicals? ____

    d. Was the energy released from the chemicals? _______________

7. Use the information that you have learned to complete the following information.

    ________________________ energy is stored in chemicals and can be

    ________________________ .

8. Think about this one! Write your response.

    Drain cleaner is put down a drain. Water is added. A reaction takes place. The pipe feels hot. Why?

    ____

    ____

    ____

    ____

Practice

Use the list below to write the correct **type of energy** *for each definition on the line provided.*

atomic energy
chemical energy
electrical energy
heat energy
light energy
mechanical energy
nuclear energy
sound energy

____________________ 1. the energy of moving things

____________________ 2. another name for nuclear energy

____________________ 3. the energy of moving charged particles

____________________ 4. the energy of vibrating materials as detected by the human ear

____________________ 5. energy that is stored in the nucleus of every atom

____________________ 6. energy that comes from the sun to Earth

____________________ 7. energy that is stored in chemicals

____________________ 8. the energy of moving molecules

Practice

Use the list below to complete the following statements with the correct **type of energy** *to show the conversion.* **One or more terms will be used more than once.**

atomic
chemical
electrical
heat
light
mechanical
nuclear
sound

1. When you strike a match, chemical energy changes to

   ________________________ and ________________________ energy.

2. Wind can be converted by a windmill from mechanical energy to

   ________________________ energy.

3. When a hammer hits a nail, some of the mechanical energy is

   changed into ________________________ energy.

4. The muscles in our body change the chemical energy of food into

   ________________________ energy.

5. When you blow air through a whistle, mechanical energy is

   converted into ________________________ energy.

6. In a light bulb, electrical energy is converted into

   ________________________ and ________________________ energy.

7. Some power plants produce electricity from

   ________________________ or ________________________ energy.

8. Turning on a mixer will convert electrical energy into

   ____________________________ energy.

9. Playing the guitar will convert mechanical energy into

   ____________________________ energy.

10. Turning on a fan will change electrical energy into

    ____________________________ energy.

Practice

Complete the following statements with the correct answer.

1. ______________________ energy causes changes in temperature.
2. Heat can change a solid into a ______________________ .
3. Heat can change a liquid into a ______________________ .
4. Almost all matter contains some ______________________ energy.
5. Whenever energy changes form, some of it is always converted to ______________________ and cannot be used.
6. Energy conversion is ____________________________________ ____ .
7. The law of conservation of energy means ____________________ ____ .

Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. another name for atomic energy

______ 2. when energy changes from one form to another

______ 3. the law that energy cannot be created or destroyed, only changed from one form to another during a physical or chemical change

______ 4. the energy of moving molecules

______ 5. the energy of moving things

______ 6. the energy of moving charged particles

______ 7. energy of vibrating materials

______ 8. the energy that is in the nucleus of an atom

______ 9. the energy that is stored in chemicals

______ 10. energy that comes from the sun to Earth

A. atomic energy

B. chemical energy

C. electrical energy

D. energy conversion

E. heat energy

F. law of conservation of energy

G. light energy

H. mechanical energy

I. nuclear energy

J. sound energy

Practice

Write **True** *if the statement is correct. Write* **False** *if the statement is* not *correct.*

__________ 1. Energy is the ability to do work or cause change.

__________ 2. Many of the appliances that we use every day run on electrical energy.

__________ 3. Food has chemical energy.

__________ 4. Heat can change a solid to a liquid.

__________ 5. Atomic or nuclear energy can be used to run power plants.

__________ 6. Energy exists in only one form.

__________ 7. The energy of a hammer is light energy.

__________ 8. The mechanical energy of wind can be converted by a windmill to electrical energy.

__________ 9. When energy changes form, some of it is always converted to heat.

_________ 10. Energy cannot be created or destroyed, but it can change from one form to another.

Practice

Use the list below to complete the following statements with the name of the correct **type of energy** *to show the conversion.* **One or more terms will be used more than once.**

atomic or nuclear
chemical
electrical
heat
light
mechanical
sound

1. When you light a candle, ____________________ energy is changed to heat and ____________________ energy.

2. When you play the banjo, ____________________ energy is changed to ____________________ energy.

3. Some power plants convert ____________________ energy to ____________________ energy.

4. Turning on an electric mixer will convert ____________________ energy into ____________________ energy.

5. A stereo converts ____________________ energy into ____________________ energy.

6. The muscles in our body change the ____________________ energy of food into ____________________ energy.

7. When you saw a piece of wood, the blade of the saw is hot. You have converted the ____________________ energy into ____________________ energy.

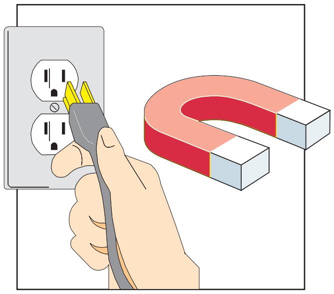
8. When you strike a match ________________________ energy is changed to ________________________ and ________________________ energy.

Unit 10: Electricity and Magnetism

This unit describes the general characteristics of electricity and magnetism. Students will learn that electricity and magnetism are related.

Student Goals

- Describe how objects may acquire positive or negative charges, based on experiments with static electricity.
- Describe how a dry cell produces electricity.
- Explain how a generator works.
- Describe the difference between direct and alternating current.
- List three conductors and three insulators.
- Explain the difference between static and current electricity.
- Construct series and parallel circuits.
- Relate electricity to electromagnetic radiation.
- Diagram the lines of force for attracting and repelling magnets.
- Describe magnetic forces on Earth.
- State the law of magnetic poles.
- Name three ways to make a magnet.
- Explain how an electromagnet works, and relate the connection between electricity and magnetism.
- Understand that electricity and magnetism are two aspects of a single electromagnetic force.



Unit Focus

- Know that most observable forces can be traced to electric forces acting between atoms or molecules. (SC.C.2.4.5)
- Know that electrical forces exist between any two charged objects. (SC.C.2.4.2)
- Describe how magnetic force and electrical force are two aspects of a single force. (SC.C.2.4.3)

Vocabulary

Use the vocabulary words and definitions below as a reference for this unit.

Electricity

atom	the smallest unit of an element that is still that element; the basic building block of matter
alternating current (AC)	electrical current that flows in one direction, then in the other direction; changes direction many times every second; abbreviated *AC*
armature	the coil inside the generator
battery	a group of two or more electric cells used to create or store electricity
cell	a device that uses chemical reactions to store and produce electricity
circuit	the path a current follows through a conductor
closed circuit	a complete path or circuit which allows electricity to move along it
conductor	a material that allows electricity to pass through it
current	the flow of electrons along a path

direct current (DC)	electrical current that flows in only one direction; abbreviated *DC*
electric field	the region around a charged object in which other charged objects experience an electric force
electric force	the force of attraction or repulsion between objects due to charge
electrical energy	the energy of moving electrons; the energy of moving charged particles
electricity	a form of energy in which electrons are flowing
electrocute	to kill by passing electric current through a body
electromagnetic induction	producing a current by moving a coil of wire across a magnetic field
electron	the negatively charged particle of an atom; the electron moves around the center of the atom (nucleus)
energy	the ability to do work or cause change
force	pressure exerted on an object; a push or a pull
generator	a machine that changes mechanical energy into electricity
insulator	a material that will not allow electricity to pass through it

matter	anything that has both mass and volume
mechanical energy	the energy of moving things
molecule	two or more atoms that have a bond of shared electrons
negative charge	the charge of an electron
neutral	being neither positively nor negatively charged
neutron	the neutral particle found in the nucleus of an atom; a neutron has no charge
open circuit	an incomplete path or circuit that does not permit the flow of electricity
parallel circuit	a circuit that provides more than one path for electricity to follow
positive charge	the charge of a proton; considered opposite of negative
proton	the positively charged particle in the nucleus of an atom
series circuit	a circuit that has only one path for electricity to follow
static electricity	the form of electricity caused by a charged (+) or (–) particle; it does not move in a path

Magnetism

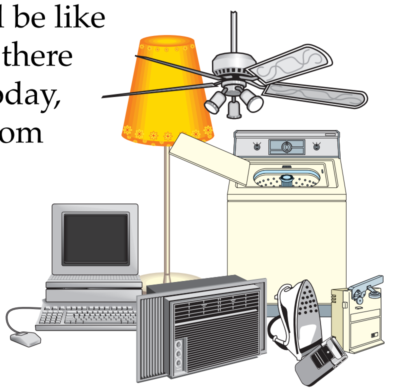
attract	to draw or pull toward itself (e.g., a magnet attracts iron)
compass	an instrument with a magnetized needle that points to magnetic north; used to determine direction
electromagnet	a device that creates a magnetic field made by connecting a coil of wire to an electric current
electromagnetic effect	the tendency of flowing electrons (electricity) to produce magnetic fields and the tendency of moving magnetic fields to cause electrons to flow
electromagnetic energy	the energy that results from the interaction of the electric and magnetic fields
electromagnetic force	the forces of attraction and repulsion between charged particles, resulting in electricity and magnetism
induced	caused, created, or produced
law of magnetic poles	like magnetic poles repel and unlike magnetic poles attract
like poles	the same poles; the poles of magnets that repel each other

lines of force	imaginary lines that show a magnetic field
magnet	a substance that attracts or pulls on other substances, especially those made of or including iron
magnetic	of or relating to a magnet or to magnetism
magnetic field	the space around a magnet where a force is noticeable
magnetic north	the magnetic pole located in the north about 800 miles from the North Pole; also known as the North Magnetic Pole
magnetic south	the magnetic pole located near the South Pole; also called the South Magnetic Pole
magnetic variation	for navigational purposes; the angle between the North Magnetic Pole and the actual geographic North Pole
magnetism	a property of matter that creates forces that attract or repel certain substances
magnetize	to become magnetic; to make into a magnet
nonmagnetic	anything that is not attracted to a magnet

North Pole	the northern end of Earth's axis
north pole	the end of the magnet that points to the north (if free to move)
northern lights	lights that are sometimes seen in the skies of the northern regions and are thought to be caused by the ejection of charged particles into the magnetic field of Earth
poles	the ends of a magnet where the magnetic field is strongest
repel	to push away
South Pole	the southern end of Earth's axis
south pole	the end of the magnet that points to the south (if free to move)
unlike poles	the opposite poles; the poles of magnets that attract each other

Introduction

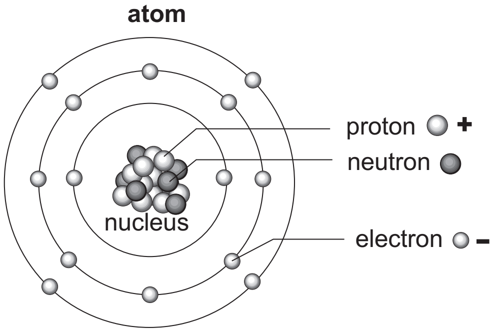
It is difficult to imagine what our lives would be like without **electricity**. As little as 100 years ago, there was little *electricity* in homes and factories. Today, we depend on electricity to run everything from small radios to satellite tracking stations. Most of this electricity is produced by using *magnets*. *Magnetism* and electricity involve the forces of **attraction** and **repulsion**. Some of the general properties of electricity and magnetism will be introduced in this unit.



It is difficult to imagine what our lives would be like without electricity.

Electric Charge and Force

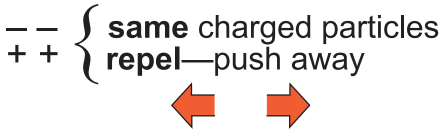
Electricity is a form of **energy**, **electrical energy**, in which **electrons** are flowing. All **matter** contains some electricity. *Matter* is made from **atoms**. *Atoms* contain **protons** that have a **positive charge** (+), **neutrons** that are **neutral** or have no charge, and *electrons* that carry a **negative charge** (–). Most matter has the same number of *protons* as it does electrons; this makes the matter *neutral*. An atom can gain or lose electrons. If an atom gains extra electrons, it will become *negatively charged* (–). A loss of electrons will create a *positive charge*. Between any objects with electric charges, there is always an **electric force** of *attraction* or *repulsion*.



When charged particles come near one another there is either a push or pull (**force**) between the charges.

- A *force* that pulls is the force of attraction between *oppositely* charged particles.

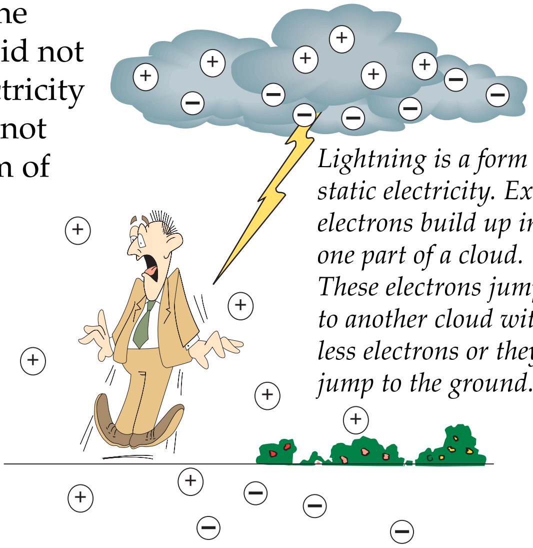
- A force of repulsion occurs when particles of the *same* charge push away from each other.



For example, the attraction of tissue paper to a negatively charged comb or the repulsion of two balloons are examples of this *electric force*. In fact, it is these electrical forces within **molecules** and atoms that cause most observable forces. Your ability to throw a ball, the blooming of a flower, and the working of your car are also examples of forces in action. Each of these can be traced back to electrical force. Electric force does not require that objects touch. This force can happen over a distance. How? Charged particles have **electric fields** around them. An *electric field* is an area over which an electric charge exerts a force.

Static Electricity

When there is a transfer of electrons from one object to another, but no further movement, we call this **static electricity**. *Static electricity* is a build-up of electric charges on an object. Run a brush through your hair. Take a nylon shirt out of a dryer. What happens? You feel a small shock or hear a crackle. This indicates static electricity. At first, there was a charge, but the electrons did not move. Then, when you heard the crack or felt the shock, the electrons moved. This electricity did not move in a path. Because static electricity does not move along a path, it cannot run appliances. Lightning is a form of static electricity. Extra electrons build up in one part of a cloud. These electrons jump to another cloud with fewer electrons or they jump to the ground. When this happens, the air is heated and the sky is filled with bright light. Lightning is dangerous and kills or disables hundreds of people every year.



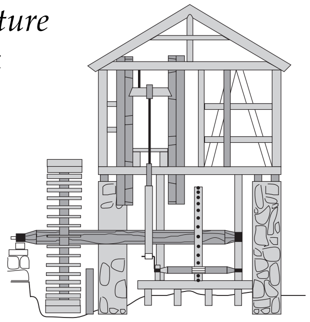
Lightning is a form of static electricity. Extra electrons build up in one part of a cloud. These electrons jump to another cloud with less electrons or they jump to the ground.

Most usable electricity is different from static electricity. It moves along a flowing path. The flow of electrons causes an electric **current**, which runs in a flow or a stream. It is the kind of electricity that we use to run appliances.

Producing Electricity

The kind of battery used in a flashlight is formed from two or more cells.

There are many different sources of electricity. Some electricity comes from **cells** or batteries. A *cell* is a device that uses chemical reactions to store and produce electricity. The kind of **battery** used in a flashlight is formed from two or more cells. These cells are usually dry. That is to say that the chemicals in them are not dissolved in water. A dry cell has a carbon rod set in the center of a zinc can. The rest of the can is filled with a special paste or gel. The chemicals in the paste react with the zinc. Electrons are released and flow to the carbon rod. This flow of electrons is electricity.



Generators can be turned by different sources of energy, such as steam, solar, atomic, and even water.

A **generator** also produces electricity. It contains *magnets* and a large coil of wire called an **armature**. The *armature* turns between the magnets. As the armature turns, it moves across the *magnetic field*, producing electrical *current* in the coil. This process is called **electromagnetic induction**. *Generator*s rely on the fact that electricity and magnetism are two aspects of the same force. Just as we use magnets to produce electricity, we use electricity to make magnets. Generators change the **mechanical energy** of different sources into electricity. They can be turned by different sources of energy, such as steam, solar, atomic, and even water. When a generator stops turning, it no longer produces electricity.

Practice

Use the list below to write the correct term for each definition on the line provided.

armature
battery
cell
current
electric field
electric force
electricity
electromagnetic induction
generator
static electricity

______________________ 1. the form of electricity caused by a charged (+) or (–) particle; it does not move in a path

______________________ 2. the flow of electrons along a path

______________________ 3. the coil inside the generator

______________________ 4. a group of two or more electric cells used to create or store electricity

______________________ 5. a machine that changes mechanical energy into electricity

______________________ 6. the region around a charged object in which other charged objects experience an electric force

______________________ 7. a device that uses chemical reactions to store and produce electricity

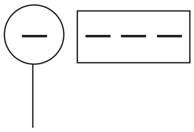
______________________ 8. producing a current by moving a coil of wire across a magnetic field

______________________ 9. a form of energy in which electrons are flowing

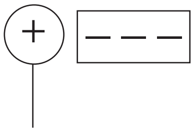
______________________ 10. the force of attraction or repulsion between objects due to charge

Practice

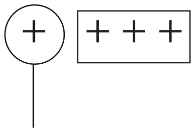
Write **attract** *or* **repel** *on the line beneath each diagram below.*



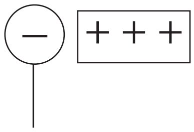
1. ______________



2. ______________



3. ______________

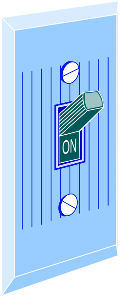


4. ______________

Circuits

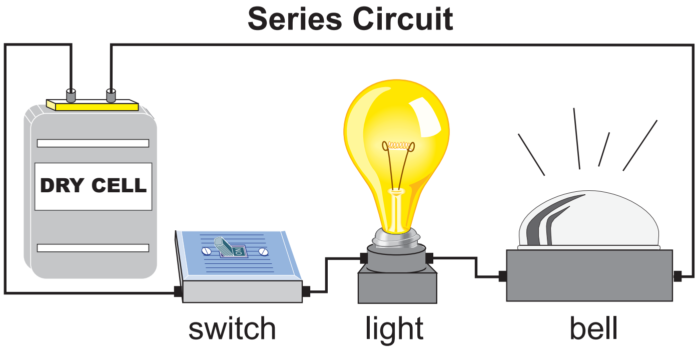
You know that electricity is a flow of electrons. Current electricity must follow a path. The path a current follows is called a **circuit**.

An electric *circuit* can be either *open* or *closed*. A **closed circuit** will allow electricity to move through it. A *closed circuit* is a complete path. An **open circuit** will not allow electricity to move through it. An *open circuit* is an incomplete path. Turn on the light switch in the room. The circuit is complete and electricity will flow. Turn the light switch off. The circuit is open and no electricity will flow.



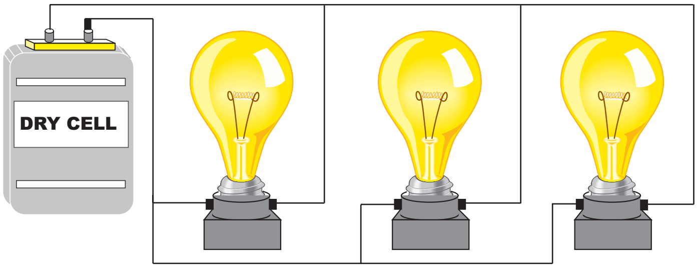
Turn on the light switch in the room. The circuit is complete and electricity will flow. Turn the light switch off. The circuit is open and no electricity will flow.

There are two basic kinds of circuits. Circuits may be either series or parallel. In a **series circuit**, electricity only has one path to follow. Connect a switch, a light, and a bell to a battery. Close the switch. The bell and the light will work. What happens if the light burns out? The circuit will be open. The electricity cannot get past the burned-out light. The bell will not work. When one thing in a *series circuit* burns out, everything else in the series will also stop working. They are not damaged; however, no electricity will flow, so they still will not work. Imagine what would happen if everything in your school was connected to one series circuit.



A **parallel circuit** has more than one path for electricity to follow. The current splits up to flow through different branches. *Parallel circuit*s have the advantage that when one branch of the circuit is opened, such as when you turn off a light, the current continues to flow through the other branches. If one thing on a parallel circuit burns out, the rest of the things will keep working. It is the kind of circuit used in homes and offices.

Parallel Circuit



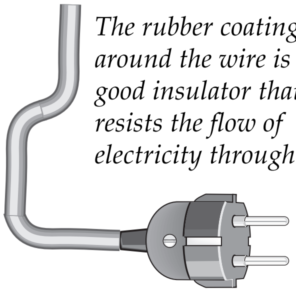
Currents

There are two kinds of currents. One type is **direct current (DC)**. The second type is **alternating current (AC)**. A *direct current* flows in only one direction. A dry cell or *battery* produces a direct current. Direct currents can lose power if they travel long distances through a wire. Remember that *electromagnetic induction* produces a current using a *magnetic field*. The magnetic field produced by a *DC* current is aligned in only one direction. If you use a **compass**, you can detect the direction in which the field is aligned. When you place the *compass* along the path the electrons follow, it will always point the same way.

Alternating currents (AC) change direction many times every second. This is the type of current used in homes and offices. Most household current changes direction 60 times each second. This means that the charges change 60 times each second. Alternating currents can be sent long distances through wires without losing much power. The magnetic fields produced by AC currents are different from those of DC. Because the direction of the current changes, so does the direction of the magnetic field. The result of this is that the field moves away from the wire in first one direction and then another. This varying direction of the electricity and the magnetic field creates an *electromagnetic wave*. This form of energy moves away from the circuit. Because it moves away from its source, we say it radiates.

Conductors and Insulators

Electricity flows. Can it go everywhere? No, it cannot. A material that allows electricity to pass through it is called a **conductor**. An **insulator** will not allow electricity to flow through it.



The rubber coating around the wire is a good insulator that resists the flow of electricity through it.

Think about the wire that carries electricity to your television set. What keeps the electricity in the wire? The rubber coating around the wire is a good *insulator*. It resists the flow of electricity through it. Glass, rubber, and plastic are good insulators. There is no perfect insulator, however, so remember to use caution.

Electricity will travel through a *conductor*. Copper wire is a good conductor. Silver wire also conducts electricity very well, but is more costly to use than copper. Most metals will conduct electricity. Air and water will also conduct electricity.

Safety

Wires that carry electric power can be dangerous. If you touch bare wires, enough charge may flow through your body to hurt you. You may even be **electrocuted** by it. Electrocution means death by exposure to electricity. If you are reading this, you have not been *electrocuted*, but you may have been shocked. Electricity at home must be used with care. Never use anything with loose or broken electric wires. When there is lightning outside, stay off the telephone and away from electrical appliances. The lightning can send an electric current through these various wires and then through you!

Practice

Use the list below to complete the following statements.

alternating current (AC)
circuit
closed circuit
compass
conductor
direct current (DC)
electrocute
insulator
open circuit
parallel circuit
series circuit

1. The path a current follows is called a ____________________ .

2. A ____________________ is a complete path and allows electricity to move through it.

3. An ____________________ is an incomplete path and will not allow electricity to move through it.

4. In a ____________________ , electricity only has one path to follow and when one thing burns out, everything else in the series will also stop working.

5. A ____________________ has more than one path for electricity to follow and if one thing burns out, the rest of the things will keep working.

6. There are two kinds of currents, a ____________________ , which flows in only one direction, and an ____________________ , which can change direction many times every second.

7. If you use a ____________________ , you can can detect the direction in which a magnetic field is aligned.

8. A material that allows electricity to pass through it is called a
_________________________ .

9. An _________________________ will not allow electricity to flow through it.

10. If you touch bare wires, enough charge may flow through your body that you may be _________________________ by it.

Practice

Answer the following using complete sentences.

1. What is electricity? ______________________________

   ____

   ____

2. What is electric force? ______________________________

   ____

   ____

3. What is static electricity? ______________________________

   ____

   ____

   ____

4. How are static electricity and current electricity different? ______

   ____

   ____

   ____

5. Describe how electrical forces are the source of most forces we observe. ______________________________

   ____

   ____

   ____

6. Do household appliances use static or current electricity? ________

7. What is a dry cell? ________

8. How does a dry cell produce electricity? ________

9. What is a generator? ________

10. Describe how a generator uses the electromagnetic effect. ________

11. What is a circuit? ________

12. Which type of circuit is complete and will allow electricity to move along it? ________

13. Which type of circuit is incomplete and blocks the flow of electricity? ________________________________

14. Which type of circuit has only one path for electricity to follow?

____

15. Which type of circuit has many paths for electricity to follow? ___

____

16. Which type of circuit is used in schools and homes? __________

17. Define the term *direct current.* ______________________

____

18. Define the term *alternating current.* __________________

____

19. Describe the difference between direct current and alternating current. ________________________________

____

____

20. Describe the difference in the magnetic field produced by DC and the field produced by AC. ______________________

____

____

21. What name is given to material that allows electricity to pass through it? ________________________________

22. Name three conductors of electricity. ______________________________

____

23. What name is given to material that will not allow electricity to pass through it? ______________________________

24. Name three insulators of electricity. ______________________________

____

25. Describe how AC causes an electromagnetic wave to radiate. ___

____

____

____

____

Lab Activity 1: Positive and Negative Charges

Facts:

- Objects may acquire a positive or a negative charge.

Investigate:

- You will demonstrate static electricity.

Materials:

- plastic ruler
- bits of paper
- piece of wool
- balloon (optional)

1. Hold a plastic ruler over a pile of small bits of paper.

   a. Did the ruler attract the paper? ______________________________

   b. Does the ruler have a charge? ______________________________

   c. Do objects with no charge attract each other? ________________

2. Rub the ruler with a piece of wool a few times.

3. Hold the ruler near the paper.

   a. Does the ruler attract the paper? ____________________________

   b. Does the ruler have a charge? ______________________________

   c. Where did the ruler get the charge? _________________________

   d. This is an example of _________________________ electricity.

4. Optional Activity: Repeat the experiment using a comb or inflated balloon instead of the ruler.

Lab Activity 2: Types of Circuits

Facts:

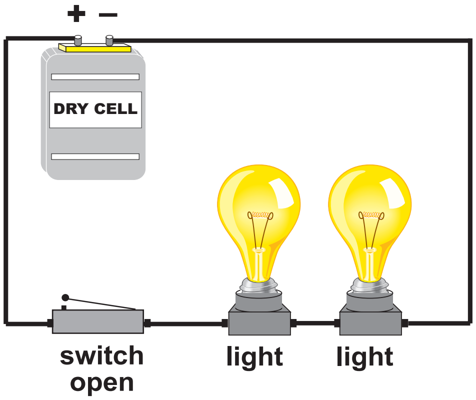
- Electricity follows a path called a circuit.

Investigate:

- You will construct a series and a parallel circuit.

Materials:

- dry cell
- insulated copper wire
- switch
- 2 light bulbs in bases (lamps)



1. Connect the wire to the (+) pole on the dry cell.

2. Connect the wire to one side of the switch. Leave the switch open. Connect the wire to the other side of the switch.

3. Attach the wire to one side of the first bulb. Connect it to the other side. Run the wire to the second bulb.

4. Connect the second bulb in the same way.

5. Connect the end of the wire to the (–) pole on the dry cell.

6. Check your set up with the diagram on page 234.

7. Close the switch.

   a. What happens to the light bulbs? ___________________________

   b. Is the circuit complete? ____________________________________

8. Open the switch.

   a. What happens to the light bulbs? ___________________________

   b. Is the circuit complete? ____________________________________

9. Unscrew the first light bulb.

10. Close the switch.

    a. What happens to the other light bulb? _______________________

    b. What kind of circuit did you construct, series or parallel?

    ____

11. Rewire the circuit using the following outline.

    a. Leave the wire on the (+) pole of the dry cell.

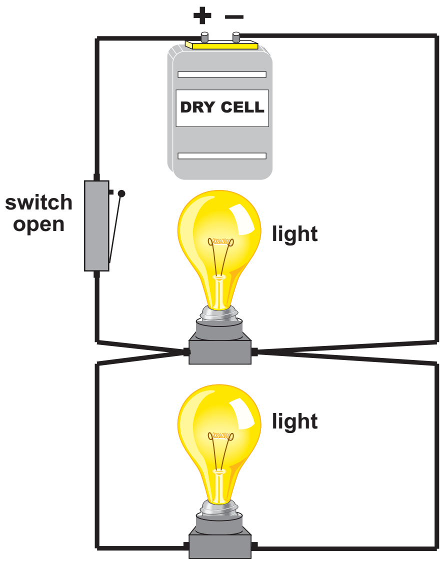
    b. Leave the switch connected.

    c. Leave the switch open.

    d. Connect the wire to one side of the first bulb. Continue the wire to one side of the second bulb.

e. Attach the second wire to the other side of the second bulb. Continue the wire to the other side of the first bulb.

f. Check your circuit with this diagram:



12. Close the switch.

    a. What happens to the bulbs? ______________________________

    b. Is the circuit complete? ___________________________________

13. Open the switch.

    a. What happens to the light bulbs? __________________________

    b. Is the circuit complete? ___________________________________

14. Unscrew the first light bulb.

15. Close the switch.

    a. What happens to the other light bulb? ________________________

    b. Is this a series or a parallel circuit? ________________________

16. Which kind of circuit would you use to wire the lights in a hotel hallway? Why?

    ____

    ____

Practice

Use the list above each section to complete the statements in that section. **One or more terms will be used more than once.**

cell
current
dry cell
electric force
electricity
static

1. __________________________ is a form of energy made of flowing electrons.

2. __________________________ is the force of attraction or repulsion between objects due to charge.

3. __________________________ electricity is the form of electricity caused by a (+) or (–) charged object.

4. __________________________ electricity does not move in a path.

5. __________________________ electricity is a form of electricity caused by a flow of electrons along a path.

6. Lightning is a form of __________________________ electricity.

7. The type of electricity used to run appliances in your home is __________________________ electricity.

8. A __________________________ is a device that utilizes chemicals to create or store electricity.

9. The kind of cell used in a flashlight is a __________________________ .

armature
chemical
closed
electrical
electrons
generator
open
parallel
series

10. A dry cell is a device that changes ______________________ energy to ______________________ energy.

11. A ______________________ is a machine that produces electricity by means of mechanical energy.

12. A generator contains magnets and a large coil of wire. This coil is called an ______________________ .

13. The armature of a generator turns between the magnets, using electromagnetic induction to cause a flow of ______________________ .

14. An ______________________ circuit is an incomplete path or circuit that blocks the flow of electricity.

15. A ______________________ circuit is a complete path or circuit which allows electricity to move along it.

16. There are two basic kinds of circuits. One is a ______________________ circuit, which has only one path for electricity to follow. The other is a ______________________ circuit, which provides more than one path for electricity to follow.

Practice

Use the list below to complete the following statements. **One or more terms will be used more than once.**

AC
alternating
atoms
conductor
copper
DC
direct
electromagnetic wave
forces
glass
insulator
rubber
parallel
plastic
series
silver

1. In a _______________ circuit, when one thing stops working, everything stops working.

2. A _______________ circuit is the kind of circuit used in homes and offices.

3. There are two kinds of currents. One is a _______________ current, which flows in only one direction. The other is an _______________ current, which flows in one direction, then in the other direction, changing direction many times every second.

4. Alternating current can cause an _______________ to radiate away from the circuit.

5. _______________ is the abbreviation for direct current.
   _______________ is the abbreviation for alternating current.

6. A _______________ is a material that allows electricity to pass through it.

7. An ________________________ is a material that will not allow electricity to pass through it.

8. Two examples of conductors are ________________________ and ________________________ .

9. Three examples of insulators are ________________________ , ________________________ and ________________________ .

10. One reason electricity is important is that electrical ________________________ exist between any two charged objects.

11. Electric force is the cause of most observable forces. The force is found between the molecules and ________________________ of objects.

Practice

Circle the letter of the correct answer.

1. ____________ current flows in only one direction.
    a. electrical
    b. direct
    c. parallel
    d. alternating

2. ____________ current flows in one direction, then in the other direction, changing direction many times each second.
    a. electrical
    b. direct
    c. parallel
    d. alternating

3. ____________ is the abbreviation for direct current.
    a. EC
    b. DC
    c. PC
    d. AC

4. ____________ is the abbreviation for alternating current.
    a. EC
    b. DC
    c. PC
    d. AC

5. A material that allows electricity to pass through it is called a(n) ____________ .
    a. conductor
    b. insulator
    c. current
    d. series

6. A material that will *not* allow electricity to pass through it is called a(n) ____________ .

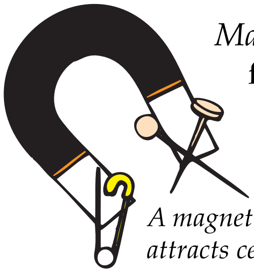
   a. conductor
   b. insulator
   c. current
   d. series

Magnetism

Magnetism is a special type of force. *Magnetism* is a special property of matter. Magnetic forces, like electric forces, involves attractions and repulsions. Magnetism is a force that affects many areas of everyday living.

What Is a Magnet?

A **magnet** is a substance that *attracts* or *pulls* on other substances. Iron, cobalt, and nickel are **magnetic** metals because they are *attracted* to a *magnet*. Anything that is not attracted to a magnet is **nonmagnetic**. Tin, copper, paper, and wood are *nonmagnetic*.

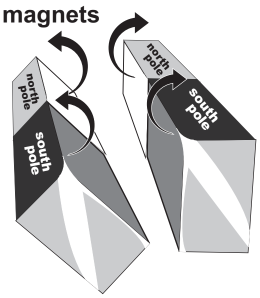


A magnet only attracts certain metals.

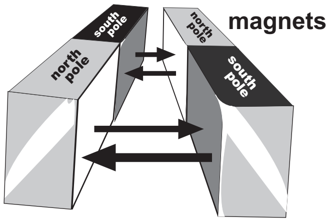
Magnetic force can also *repel*. Two magnets can *push* away from each other when their ends are put together. The ends of a magnet where the force is strongest are called **poles**. The *poles* of a magnet are found by determining which ends have the strongest force. Pass a bar magnet over a box of pins. Most of the pins will stick to the ends of the magnet.

One pole, or end of a magnet, is called the **north pole**. The other end is called the **south pole**. All magnets have a *north pole* and *south pole*.

Pick up two magnets. Put the north pole of one next to the north pole of the other. What happens? They *repel* each other. Try placing a south pole next to a south pole. Again, the magnets will repel each other.



The same poles, or like poles, of a magnet will repel each other.



The opposite poles, or unlike poles, of magnets will attract each other.

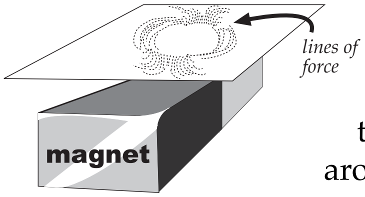
Now put a north pole next to a south pole. Do they repel each other? No, they attract each other. This is called the **law of magnetic poles**. The same poles, or **like poles**, of a magnet will repel each other. The opposite poles, or **unlike poles**, of a magnet will attract each other.

Explaining Magnetism

You know that atoms make up matter. Some atoms are like little magnets. In cobalt, iron, and nickel, the atoms may line up in a special way. When most of the atoms face the same way, the material will be magnetic. In nonmagnetic material, the poles cancel each other out. This is because they are not lined up in the same direction. All magnetism is produced by moving electric charges.

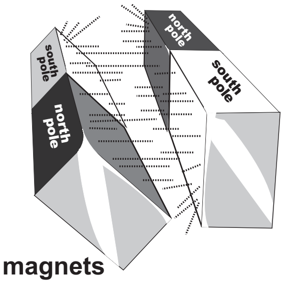
Magnetic Field

You already know that the force of a magnet is strongest at the poles. The rest of the magnet also has some force. Put a piece of paper over a bar magnet. Place some iron filings on top of the paper. Shake the paper slightly. The iron filings will make a pattern. The lines you see are called **lines of force**. The whole pattern is the **magnetic field**. A *magnetic field* is the space around a magnet where a force is noticeable.



When you get too far away from a magnet, the force will not be noticeable. Although magnetism seems like a strong force, we see that it quickly gets weak with distance.

What would the *lines of force* look like in attracting magnets? What would happen to the lines of force if two like magnets were placed together? Remember, opposite forces attract and like forces repel.



Practice

Use the list below to complete the following statements.

attract
like
lines of force
magnet
magnetic
magnetic field
magnetism
nonmagnetic
north pole
poles
repel
south pole
unlike

1. A property of matter that creates forces that attract or repel certain substances is called ________________________ .

2. A ________________________ is a substance that attracts or pulls on other substances.

3. Anything that is attracted to a magnet is called ________________________ .

4. Anything that is not attracted to a magnet is called ________________________ .

5. The ends of a magnet are called ________________________ .

6. The end of the magnet that always points to the north (if free to move) is called the ________________________ .

7. The end of the magnet that always points to the south (if free to move) is called the ________________________ .

8. The law of magnetic poles states that like poles ________________________ and unlike poles ________________________ .

9. The north pole of one magnet and the north pole of another magnet would be considered ________________________ poles.

10. The north pole of one magnet and the south pole of another magnet would be considered ________________________ poles.

11. A ________________________ is the space around a magnet where a force is noticeable.

12. The ________________________ are the lines that show a magnetic field.

Practice

For each diagram below, **draw arrows** *to show* **attraction (→ ←)** *or* **repulsion (← →)** *between the two magnets.*

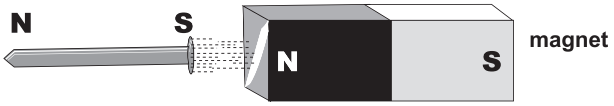
1. 

2. 

3. 

Making a Magnet

Magnetism can be **induced**, or created, in some materials. There are three ways to make a magnet. Place an iron nail against the north pole of a magnet. The force in the magnet will begin to pull at the atoms in the nail. They will line up in straight lines. This will make the nail temporarily magnetic. The end of the nail closest to the magnet's north pole will become the south pole. The other tip of the nail will be the north pole.

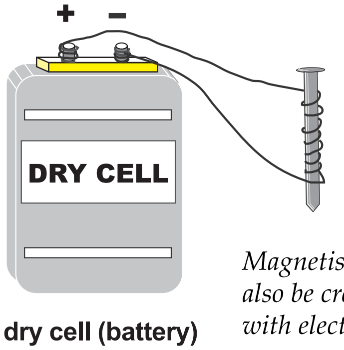


Magnetism can be induced, or created, in some materials.

You can also **magnetize** some materials by rubbing them with a magnet. Run a magnet along the side of a needle. Keep rubbing in the same direction. The atoms in the needle will begin to line up. This will make the needle into a magnet. The longer you rub, the stronger the magnetism will become. Both *induced* magnets will lose their magnetic force after awhile.

Magnetism can also be created with electricity. Connect a wire to the (+) side of a dry cell or battery. Coil the wire around a nail. Attach it to the (–) side of the dry cell.

This will create an **electromagnet**. Electrons travel through the coil of wire and induce a magnetic field causing the nail to act like a magnet. This kind of magnet has many advantages over ordinary magnets. *Electromagnets* can be turned on and off. Their strength can be controlled. This kind of magnet is used in doorbells, electric motors, and telephones.



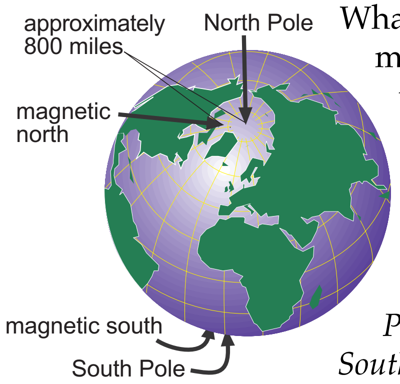
Magnetism can also be created with electricity.

The Electromagnetic Effect

You saw that in the first two examples, a magnet was used to create a new magnet. In this last example, we did not use a magnet. Instead, we used electricity. Electricity is electrons that are flowing in a particular direction. Because these particles are charged, when they flow past the nail it causes a magnetic field to be created. It is this field that makes the nail act as a magnet. When you unplugged the wires, the electrons stopped. This also shut off the magnet.

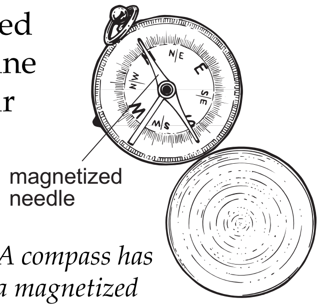
This effect was first described by Michael Faraday. He called it the **electromagnetic effect**. This means that, as we've seen, electricity can create magnets. Magnets, however, can also be used to create electricity, the flow of electrons. Electrons move from areas of negative charge to areas of positive charge. By moving magnets past a length of metal, electrons are made to move. This is how electricity is generated. The energy that results from the interaction of the electric and magnetic fields is called **electromagnetic energy**. Electricity and magnetism are closely related and are usually found together. In many ways, they cannot be separated and are just two versions of the same **electromagnetic force**.

Earth as a Magnet



What makes one pole of a magnet point north? It must be attracted to something. Earth can be thought of as a large magnet. Look at a globe that depicts the Earth. The very top is called the **North Pole**. The opposite side is called the **South Pole**. These spots are not the magnetic poles. **Magnetic north** is located almost 800 miles from the *North Pole*. **Magnetic south** is located near the *South Pole*.

Why is *magnetic north* important? Scientists discovered the magnetic force of Earth could be used to determine direction. Sailors began using compasses to find their way. A compass has a *magnetized* needle that points to magnetic north. Any direction can be located if you know which way is north. For advanced navigation, it is important to know that there is a slight shift in north as you approach the North Pole. This shift is called **magnetic variation**.



A compass has a magnetized needle that points to magnetic north.

Earth acts as a huge magnet. It also has a magnetic field. Earth's magnetic field is responsible for the phenomenon called the **northern lights**. Remember that magnets are closely related to electricity. Because of this, they have effects on charged particles. When charged particles come into Earth's atmosphere near the poles, they interact with the magnetic pole. The result is a release of energy. We see this energy as the *northern lights* or bright-colored areas in the sky.

Summary

Electricity is caused by a flow of electrons. Static electricity is caused by a transfer of electrons. Electrical forces exist between charged objects—this electric force can happen even if objects are not touching. Current electricity moves along a path or circuit. A circuit can be either series or parallel.

Magnetism is a force that attracts or repels substances. Magnets have north and south poles. Poles that are the same repel each other. *Unlike poles* attract. Lines of force surround a magnet. Magnets can be created when atoms line up. The *electromagnetic force* can be used to create magnets or electricity. Earth acts as a magnet. A compass helps locate direction by pointing to the magnetic north.

Practice

Use the list below to complete the following statements.

compass
electromagnet
electromagnetic energy
induced
magnetic north pole
magnetic variation
magnetize
North Pole
northern lights
South Pole

1. Magnetism that is caused by an object touching or being placed near a magnet is called ____________________ magnetism.

2. To make something into a magnet is to ____________________ it.

3. A device that creates a magnetic field made by connecting a coil of wire to an electric current is called an ____________________ .

4. The northern end of Earth's axis is called the ____________________ .

5. The southern end of Earth's axis is called the ____________________ .

6. The magnetic pole located in the north about 800 miles from the North Pole is called ____________________ .

7. A ____________________ is an instrument with a magnetized needle that points to the magnetic north.

8. The energy that results from the interaction of the electric and magnetic fields is called ____________________ .

9. For advanced navigation, it is important to know that there is a slight shift in north as you approach the North Pole. This shift is called ________________________ .

10. Earth's magnetic field is responsible for the phenomenon of bright-colored areas in the sky that is called the ________________________ .

Lab Activity 3—Part 1: Magnetic Fields and Poles

Facts:

- The magnetic field is the space around a magnet where a force is noticeable.
- The lines of force are lines that show the magnetic field.

Investigate:

- You will make a map of a magnetic field and diagram the lines of force for attracting and repelling magnets.

Materials:

- 2 bar magnets
- iron filings
- a sheet of paper

1. Place one bar magnet on your desk.
2. Cover the magnet with a sheet of paper.
3. Sprinkle iron filings on the entire paper.
4. Observe what happens.
5. In the space below, draw a diagram of what you observed.

Answer the following about the Lab Activity 3—Part 1. Use the term **poles** *or* **middle** *to correctly complete the statements.*

6. At the end of the experiment, most of the iron filings were at the

   ______________________ .

7. At the end of the experiment, there were fewer iron filings in the

    ________________________ .

8. From this experiment, you can see that a magnet is strongest at the

    ________________________ .

9. You can also see that a magnet is weakest in the

    ________________________ .

Lab Activity 3—Part 2: Magnetic Poles—Attract or Repel

Continuing with Lab Activity 3, answer the following.

1. Remove the bar magnet from beneath the sheet of paper.
2. Shift the sheet of paper until the iron filings are in one pile in the middle of the paper. Move the paper to the side of your desk. We will use it in a moment.
3. Pick up two bar magnets. Hold one in each hand. Move the north pole of one of the magnets toward the north pole of the second magnet. Observe what happens.

    a. Did the poles attract or repel? ____________________________

    b. Do like poles attract or repel?____________________________

4. Reverse one of the magnets so that the south pole of one is pointing toward the north pole of the other magnet. Move the magnets together. Observe what happens.

    a. Did the north pole attract or repel the south pole? ___________

    b. Do opposite poles attract or repel? ________________________

5. Put the magnets on your desk so that the north poles of each are about one hand's width away pointing toward each other. Place the sheet of paper with the iron filings on top of the two north poles. Observe what happens.

6. In the space below, draw a diagram of what you observed.

You have just drawn the magnetic field between like magnets.

7. Carefully pick up the sheet of paper and iron filings. Change the direction of one of the magnets so that the north pole on one is facing the south pole of the other.

8. Place the paper and iron filings on the magnets. Observe what happens.

9. In the space below, draw a diagram of what you observed.

You have just drawn the magnetic field between unlike magnets.

10. The law of magnetic poles states that like poles

_______________________ and unlike poles _______________________ .

Lab Activity 4: Magnetic North

Facts:

- Earth is a huge magnet.
- All magnets point to the magnetic north.

Investigate:

- You will magnetize a simple needle to create a simple compass.

Materials:

- bar magnet
- steel needle
- thin piece of cork
- bowl
- water
- a compass

1. Fill a shallow bowl with water.
2. Rub a needle with a bar magnet. Be sure to rub in only one direction.
3. Lay the needle on the piece of cork.
4. Place the needle and cork in a bowl of water.
5. Observe what happens.

   You know that the needle is pointing north and south, but which end is pointing to the north?

   ____

   ____

6. Set a compass a few feet away. Check the needle for north.
7. What happened when you rubbed the needle with the magnet?

   ____

   ____

8. In which directions did the needle point when you placed it on the cork in the water? (north and south or east and west)

____

9. Why does the needle of a compass point north?

____

____

____

10. If Earth did not have magnetic poles, would a compass work? Why or why not?

____

____

____

Practice

Answer the following using complete sentences.

1. What are three ways to make a magnet? ____________________

   ____

   ____

   ____

2. How does an electromagnet work? ______________________

   ____

   ____

3. Earth has two magnetic poles. What are they called? __________

   ____

   ____

4. Are the magnetic poles mentioned above the same as the North and South geographic poles of Earth? Explain. _________________

   ____

   ____

   ____

   ____

Practice

Write **True** *if the statement is correct. Write* **False** *if the statement is* not *correct.*

__________ 1. Electricity was invented 200 years ago.

__________ 2. Electricity is a form of energy.

__________ 3. All matter contains some electricity.

__________ 4. An electric field is an area over which an electric charge exerts a force.

__________ 5. Static electricity is a build-up of electric charge on an object.

__________ 6. Static electricity is used to run factories and run our household appliances.

__________ 7. A cell is a device that uses chemical reactions to store and produce electricity.

__________ 8. When a generator stops turning, it still produces electricity for up to six months.

__________ 9. The path a current follows is called a circuit.

_________ 10. The flow of neutrons causes an electric circuit.

_________ 11. In a series circuit, electricity only has one path to follow.

_________ 12. Alternating currents (AC) change direction many times every second.

__________ 13. A material that allows electricity to pass through it is called unlike poles.

__________ 14. A magnet is a substance that repels other substances.

__________ 15. In magnetism, opposite forces attract and like forces repel.

__________ 16. Magnetism can be induced, or created, in some materials.

__________ 17. A compass has a magnetized needle that points to magnetic north.

__________ 18. Earth acts as a huge magnet.

Unit 11: Nuclear Energy

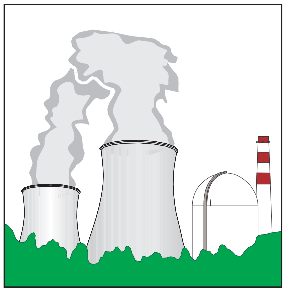
This unit explains that atoms store huge amounts of energy. Students will learn about fission and fusion and also gain knowledge about the nature of nuclear changes and their impact on living things.

Student Goals

- Develop an understanding of the nature, properties, types, and uses πof nuclear radiations.
- Describe how nuclear fission and fusion may be used for energy.
- Define chain reaction, nuclear reactor, and control rod, and describe their interaction in nuclear power plants.
- State positive and negative reasons concerning the continued development of the nuclear fission reactor.
- Define radioactivity.
- Understand the process by which scientific ideas are conceived and developed.

Unit Focus

- Know that a number of elements have heavier, unstable nuclei that decay, spontaneously giving off small particles and waves that result in a small loss of mass and release a large amount of energy. (SC.A.2.4.3)
- Know that nuclear energy is released when small, light atoms are fused into heavier ones. (SC.A.2.4.4)
- Understand that there is conservation of mass and energy when matter is transformed. (SC.B.1.4.2)



- Know that the forces that hold the nucleus of an atom together are much stronger than electromagnetic force and that this is the reason for the great amount of energy released from the nuclear reactions in the sun and other stars. (SC.C.2.4.4)

Vocabulary

Use the vocabulary words and definitions below as a reference for this unit.

atom	the smallest unit of an element that is still that element; the basic building block of matter
chain reaction	a self-sustaining nuclear reaction; it continues without the addition of outside energies
chemical energy	the energy that is stored in chemicals
control rod	a barrier that slows a nuclear reaction by absorbing excess radiation
electromagnetic energy	the energy that results from the interaction of the electric and magnetic fields
electromagnetic force	the forces of attraction and repulsion between charged particles, resulting in electricity and magnetism
electron	the negatively charged particle of an atom; the electron moves around the center of the atom (nucleus)
energy	the ability to do work or cause change
fission	splitting the nucleus of an atom into two lighter parts

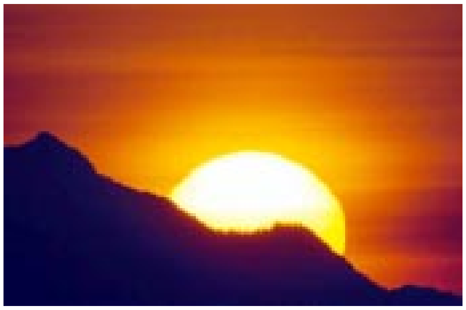
fission reactor	a type of nuclear reactor that splits the nuclei of atoms
fusion	a nuclear reaction in which two or more nuclei are pushed together to form one large nucleus
fusion reactor	a type of nuclear reactor that would combine atoms
gravity	the attraction of matter toward another body of matter *Example*: Earth's gravity holds us on its surface.
half-life	the time it takes one-half of the atoms of a radioactive sample to decay
isotope	an atom or group of atoms with the same atomic number but different atomic mass than other atoms of a specific element; this difference in mass is based on a difference in the number of neutrons within the nucleus of the atom
law of conservation of energy	the law that energy cannot be created or destroyed, only changed from one form to another during a physical or chemical change
law of conservation of mass	the law that matter cannot be created or destroyed, only changed from one form to another during a physical or chemical change

mass	the amount of matter in a substance
matter	anything that has both mass and volume
mechanical energy	the energy of moving things
neutron	the neutral particle found in the nucleus of an atom; a neutron has no charge
nuclear energy	the energy that holds the nuclei of atoms together; it is released in nuclear reactions and may be used to produce heat, electricity, or other forms of energy
nuclear reaction	a reaction that occurs when an atom is split; large amounts of energy are released
nuclear reactor	a machine used to control or create a nuclear chain reaction
nucleus	the center region of the atom around which the electron(s) move; plural: nuclei
proton	the positively charged particle in the nucleus of an atom
radiation	the movement of energy as a wave
radioactive	describing those elements or isotopes that spontaneously decompose and give off radiation

radioactive waste	the waste produced by a nuclear reactor; though unusable it still releases radiation
radioactivity	forms of energy given off by nuclear material
theory of relativity	the theory that there is a fundamental relationship between matter and energy; $E=mc^2$ (E stands for energy, m stands for mass, and c stands for the speed of light.)

Introduction

There are many forms of **energy** in the world. As you learned in the last unit, many of these are derived from the forces of electromagnetism. Gasoline that burns, muscles that contract, and **electrons** that flow are all the result of this **electromagnetic force**. Although we use this force constantly, it is relatively weak when compared to nuclear forces. Just as with *electromagnetic forces*, nuclear forces produce *energy*. The sun is the ultimate source of almost all our energy. The energy of the sun comes from **nuclear energy**.



The sun is the ultimate source of almost all our energy.

Nuclear energy involves the nuclei (plural of nucleus) of **atoms**. Subatomic particles in the **nucleus** of *atoms* are called **neutrons** and **protons**. These particles are **matter**. In Unit 5: Chemical Formulas and Equations, you learned that *matter* cannot be created nor destroyed. What about energy? Energy can change form, but can never be destroyed. This is called the **law of conservation of energy**. (This concept is covered in Unit 9: Forms of Energy). This law applies to the energy you use every day.

Electromagnetic forces provide us with most of the energy we use on a daily basis. Most of this energy has originated in sunlight. For example, sunlight is used by plants. Corn plants store this energy as **chemical energy**. The *chemical energy* comes to you as food. You use the chemical energy for many purposes. You will produce heat, may make sound, or use **mechanical energy**. The energy you use, though, originated in the sun's light. This unit discusses how **nuclear reactions** only appear to break the **law of conservation of mass** and the *law of conservation of energy* and how the result is all the energy you use.

What Is Nuclear Energy?

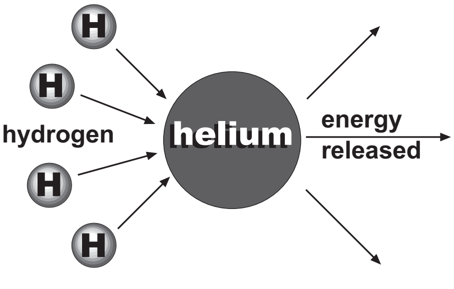
Most of the **electromagnetic energy** we know comes from the outer portions of atoms, the *electrons*. Within the center of the atom, however, is the *nucleus*. The energy that holds tightly together the nucleus of atoms is nuclear energy. Compared to the electromagnetic forces of the atom, the nuclear energy is immense. By releasing some of this energy, the sun creates light. The sun's light gives us energy that runs the world.

The sun's light gives us energy that runs the world.

Most of the energy sources we use today are derived from sunlight. Oil and natural gas, and even wood for fires, are the products of sunlight. Unfortunately, this is not a very efficient way to use the sun's energy. Much of the energy of the sun is lost as heat. Because the world's population grows every day, we find that we need more and more energy. Nuclear energy may be one way of providing that energy. With the use of nuclear energy also comes the serious risk of the escape of harmful radiation, such as in the disaster in 1986 at a nuclear power plant in Chernobyl, in the Ukraine. Many safeguards must be taken to prevent accidents.

How Does the Sun Work?

There are two main ways to release nuclear energy. The sun uses a process known as **fusion**. The sun is made of light gases being held together by **gravity**. Most of this gas is the lightest of elements, hydrogen. In the center of the sun, the hydrogen gas is being pushed together by *gravity*. This pressure is incredibly high. Because of this pressure, there is also a large amount of heat. Under the pressure and heat, the hydrogen changes. Four hydrogen atoms will combine to form one helium atom. When this happens, energy is released.



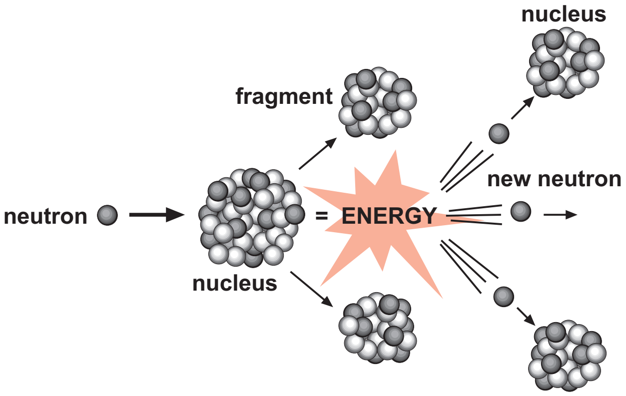
4 hydrogen atoms combine to form
1 helium atom - energy released

You should remember that the law of conservation of energy says energy can neither be created nor destroyed. From where did the energy come? When the four hydrogen atoms were changed into one helium atom, a small part of their **mass** was lost. Compare the *mass* of four hydrogen atoms to one helium atom. The hydrogen atoms have a mass of 4.03188. The mass of the helium is 4.0026. In this case, it looks like we lost a mass of 0.02928. What has actually happened is that this mass has been changed to nuclear energy. The mass was not destroyed, and the energy was not created. They were just changed. The small amount of mass becomes the large amount of energy that comes from the sun.

The process of taking these lighter elements and making a heavier element is called *fusion*. Fusion powers the sun and releases large amounts of energy. Because of the heat and pressure needed, however, scientists have not been able to control fusion. So far, the only use of fusion by humans has been to create highly destructive weapons. No one knows if we will ever find a peaceful use for fusion.

What Is Fission?

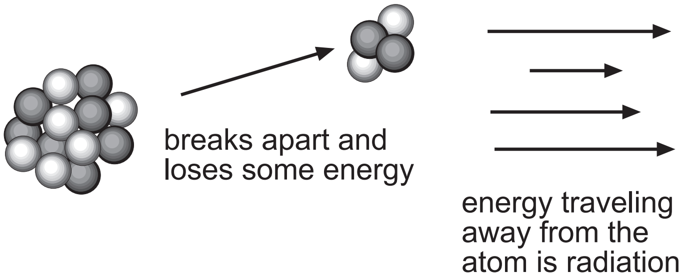
In the previous section, you learned about one way to release nuclear energy, fusion. This section will examine another way of releasing nuclear energy, **fission**. *Fission* occurs when the nucleus of an atom splits and releases some of its nuclear energy. To understand how and why this happens, we need to look at the nucleus of atoms.



Fission occurs when the nucleus of an atom splits and releases some of its nuclear energy.

Remember that the nucleus is made of *neutrons* and *protons*. In any given element, the number of protons in a nucleus never changes. This is not true of the number of neutrons. Consider carbon. Most atoms of carbon have six neutrons as well as six protons. This will give the nucleus a mass of 12. Because the chemical symbol of carbon is C, then this type of atom is called C12. Some carbon atoms, however, may have seven neutrons. The nucleus of such an atom would have a mass of 13 and is called C13. The element is still carbon, but the atom is a little heavier. Other than that, the atom behaves just like an atom with six neutrons, C12. However, if we add another neutron, for a total of eight, the atom will behave differently. This atom will have a nucleus with a mass of 14, but it will still be carbon. It is known as C14. How is C14 different? If left by itself, the nucleus will break apart and lose some energy. The energy will travel away from the atom in the form of a wave, and we know this as **radiation**. *Radiation* is any form of energy that travels in a wave. Nuclear radiation, however, is sometimes dangerous because it has such high energy.

Carbon Atom or C14



You may be wondering if there is a special name for atoms with a different number of neutrons. The name for these are **isotopes**. We discussed three *isotopes* of carbon. Most isotopes of atoms are harmless. Some are **radioactive**. That is, some isotopes, like the C14 isotope, spontaneously produce radiation. *Radioactive* material has nuclei that break down and release energy and neutrons. The element uranium is naturally radioactive and constantly releases energy and radioactive particles. These radioactive particles are made from the protons, neutrons, and electrons of the atom.

Where do the particles go? The particles travel outward. When the uranium nucleus is hit with a particle, it becomes unstable. Eventually it will split in two. Splitting an atom is called fission. When the atoms split they lose a small amount of matter that is changed into a large amount of energy. Not all elements have atoms that can be split. When the uranium atom splits, it throws out more radioactive particles. These particles will split other atoms. This will continue to happen. This reaction is called a **chain reaction**. Besides uranium, there are many other elements that spontaneously produce radiation. These include plutonium, radium, and cesium.

Practice

Circle the letter of the correct answer.

1. The sun's light gives us __________ that runs the world.
   a. energy
   b. fission
   c. isotopes

2. Gasoline that burns, muscles that contract, and electrons that flow are all the result of this __________ .
   a. control force
   b. radiation
   c. electromagnetic force

3. The energy of the sun comes from __________ .
   a. nuclear energy
   b. sunshine
   c. a chain reaction

4. Nuclear energy involves the nuclei of __________ .
   a. a fusion reactor
   b. atoms
   c. radioactive waste

5. Subatomic particles in the __________ of *atoms* are called *neutrons* and *protons*.
   a. fusion
   b. nucleus
   c. control rod

6. Most of the __________ we know about comes from the outer portions of atoms, the electrons.
   a. electromagnetic energy
   b. theory of relativity
   c. electron core level

7. A nuclear reaction in which two or more nuclei are pushed together to form one large nucleus is known as __________ .

   a. fission reactor
   b. nuclear waste
   c. fusion

8. The energy will travel away from the atom in the form of a wave. We call this traveling energy __________ .

   a. radiation
   b. fusion
   c. run-away energy

9. A special name for atoms with a different number of neutrons is called __________ .

   a. atomites
   b. isotopes
   c. chain reactions

10. __________ material has nuclei that break down and release energy and neutrons.

    a. Radioactive
    b. Relativity
    c. Nuclear

11. When a uranium atom splits, it throws out more radioactive particles. These particles will split other atoms. This reaction, which will continue to happen, is called a __________ .

    a. split atom reaction
    b. radioactive reaction
    c. chain reaction

12. __________ occurs when the nucleus of an atom splits into two lighter parts and releases some of its nuclear energy.

    a. Radioactive
    b. Fission
    c. Computer

13. A ____________ is a reaction that occurs when an atom is split and large amounts of energy are released.

    a. proton reaction
    b. nuclear reaction
    c. relativity reaction

14. Not all elements have ____________ that can be split.

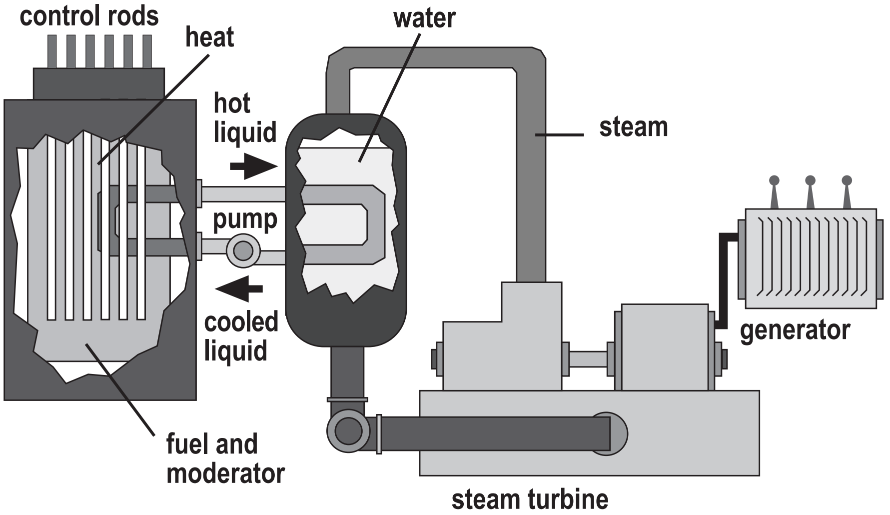
    a. radioactive waste
    b. control rods
    c. atoms

Controlling Nuclear Reactions

Large amounts of energy are released by fission and fusion reactions. Why can't this energy be used to run generators? It can, but first it must be controlled. After learning how to use nuclear energy to destroy, scientists found ways to control it.

Fission can be controlled. It must take place slowly, but at a steady speed. In this way, fission can be used to produce useful energy. A **nuclear reactor** is used to control a nuclear *chain reaction.* All nuclear reactors are **fission reactors**. These use uranium atoms for fuel. They are hit with neutrons. When the reaction begins, a **control rod** is used. A *control rod* is made of a substance that absorbs neutrons. Control rods can be used to slow down fission reactions. By absorbing some of the neutrons, the chain reaction does not become explosive. If the reaction must be speeded up, the rods are removed.

Nuclear Reactor



A *nuclear reactor* produces heat. This heat can be used to run generators. It takes a very small amount of nuclear fuel to produce large amounts of energy. Is this the answer to man's energy needs? There are nuclear power plants being used today. Unfortunately, nuclear fission creates some problems. **Radioactive waste** is one of these problems.

Radioactive Material

Radioactive wastes are no longer useful as fuel, but they are still radioactive. **Radioactivity** can damage or kill living cells. Large doses of radiation can cause severe burns. On the other hand, radiation can be helpful. It can be used to kill cancer cells. Low levels of radiation can be used to find tumors in people, decay in teeth, and breaks in bones.

Think about the *nuclear reactor*. It uses uranium for fuel. Uranium is radioactive. A nuclear reactor produces waste that is radioactive. This radioactive waste is harmful to living things. What happens to this waste? It cannot be destroyed. Some radioactive material may require millions of years to decay. A measure of time required for substances to decay is called **half-life**. The *half-life* is the amount of time it takes for half of the atoms in the radioactive substance to decay. Some of the radioactive waste is stored in underground tanks. Some is sunk deep in the ocean. People worry that these methods of disposal might leak.

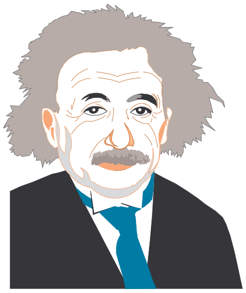
Fusion reactors would not produce radioactive waste. Remember that fusion needs high temperatures. Scientists have not yet figured out how to produce and control these high temperatures. It is hoped that in the future, man may be able to solve some of the problems of nuclear energy.

Albert Einstein and Nuclear Power

Albert Einstein was a physicist who lived from 1879 to 1936. He created the theory that stated mass and energy were related. His theory stated that the energy of matter was equivalent to the mass of the object multiplied by the square of the speed of light. This equation is written as follows:

$$E=mc^2$$

E represents energy. The *m* stands for mass. The speed of light is represented by a *c*. This theory led to many outcomes.



Albert Einstein was a physicist.

When Einstein first conceived of this theory, it was not seen as a formula for making energy. At first, there was resistance to the concept. Had the theory not shown itself to be accurate, it would surely have been rejected. Yet, the **theory of relativity** was not rejected. Despite this, it took decades before the theory could be applied. Its first application was in the creation of atomic bombs. Many other scientists had to add theories and knowledge. Sometimes such knowledge is expected. At other times, it is unexpected.

Again, the application of the theory for bombs was not what Einstein had envisioned. He simply developed a theory. The development of bombs and nuclear reactors and an understanding of the sun were not necessarily expected. Although Albert Einstein made these things possible, he did not have them in mind when working on the theory of relativity.

Summary

Atoms store huge amounts of energy. This energy can be released by fission or fusion. Fusion is the combining of light elements into heavier elements. The sun uses fusion. Fission is the splitting of atoms. Nuclear reactors control the speed of fission reactions. Nuclear power plants produce energy and dangerous radioactive waste. Scientists are searching for ways to eliminate the problems of using nuclear energy. As Einstein's theory of relativity demonstrates, ideas in science are limited by the purpose for which they are conceived, are sometime rejected, may grow from unexpected discoveries, and often grow slowly from many contributors.

Practice

Use the list below to write the correct term for each definition on the line provided.

control rod
fission reactor
fusion reactor
nuclear reactor
radioactive waste
radioactivity
theory of relativity

______________________ 1. a type of nuclear reactor that would combine atoms

______________________ 2. a barrier that slows a nuclear reaction by absorbing excess radiation

______________________ 3. the theory that there is a fundamental relationship between matter and energy; $E=mc^2$ (E stands for energy, m stands for mass, and c stands for the speed of light.)

______________________ 4. the waste produced by a nuclear reactor; though unusable it still releases radiation

______________________ 5. a type of nuclear reactor that splits the nuclei of atoms

______________________ 6. a machine used to control or create a nuclear chain reaction

______________________ 7. forms of energy given off by nuclear material

Lab Activity: Chain Reactions

Facts:

- Chain reactions can be controlled or uncontrolled

Investigate:

- You will demonstrate that chain reactions can be blocked.

Materials:

- set of dominoes or domino-like chips
- chalkboard eraser

1. Stand 10 to 20 dominoes on one end, one behind the other. (Leave about ½ inch between each one.)

2. Push the first one down.

   a. What happens to the rest? ______________________________

   b. Was this reaction controlled or uncontrolled? ______________

3. Line the dominoes up again. Place a chalkboard eraser after the 5th or 6th domino. Continue to line up the rest of the dominoes.

4. Push the first domino.

   a. Did all the dominoes fall? ______________________________

   b. What stopped the dominoes? ____________________________

   c. What controlled the reaction? ___________________________

   d. What part of a nuclear reactor is represented by the eraser?

   ____

Practice

Write **True** *if the statement is correct. Write* **False** *if the statement is* not *correct.*

__________ 1. *Nuclei* is the plural of *nucleus*.

__________ 2. Very small amounts of energy are released by fission and fusion.

__________ 3. The first atomic bomb was a fission reaction.

__________ 4. Fission can be controlled using a nuclear reactor and can be used to produce useful energy.

__________ 5. A nuclear reactor cannot produce heat.

__________ 6. Nuclear power plants produce energy.

__________ 7. Nuclear fission creates radioactive wastes.

__________ 8. Radioactivity can damage or kill living cells.

__________ 9. All isotopes of carbon have the same number of neutrons.

_________ 10. Since radioactive waste cannot be destroyed, it must be stored.

Practice

Answer the following questions using complete sentences.

1. What are two positive reasons for the continued development of the nuclear fission reactor?

2. What are two reasons against the continued development of the nuclear fission reactor?

Unit 12: The Universe and Solar System

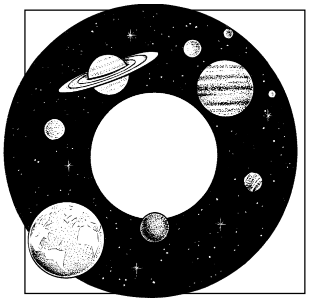
This unit focuses on the origin and composition of the universe and the solar system.

Student Goals

- Construct a model to show the relative distance from the sun to the planets.
- State the scientific theories on how the universe and solar system were formed.
- List the bodies within our solar system.
- Know some ways scientists collect data about our universe.
- Identify information about the universe.
- Know the stages in the development of stars.

Unit Focus

- Know that investigations are conducted to explore new phenomena, to check on previous results, to test how well a theory predicts, and to compare different theories. (SC.H.1.4.1)
- Know that from time to time, major shifts occur in the scientific view of how the world works, but that more often, the changes that take place in the body of scientific knowledge are small modifications of prior knowledge. (SC.H.1.4.2)
- Understand that no matter how well one theory fits observations, a new theory might fit them as well or better, or might fit a wider range of observations, because in science, the testing, revising, and occasional discarding of theories, new and old, never ends and leads to an increasingly better understanding of how things work in the world, but not to absolute truth. (SC.H.1.4.3)



- Know how the characteristics of other planets and satellites are similar to and different from those on the Earth. (SC.E.1.4.2)
- Know that the stages in the development of three categories of stars are based on mass: stars that have the approximate mass of our Sun, stars that are two- to three-stellar masses and develop into neutron stars, and stars that are five- to six-stellar masses and develop into black holes. (SC.E.2.4.1)
- Identify the arrangement of bodies found within and outside our galaxy. (SC.E.2.4.2)
- Know astronomical distance and time. (SC.E.2.4.3)
- Understand stellar equilibrium. (SC.E.2.4.4)
- Know various scientific theories on how the universe was formed. (SC.E.2.4.5)
- Know the various ways in which scientists collect and generate data about our universe (e.g., X-ray telescopes, computer simulations of gravitational systems, nuclear reactions, space probes, and supercollider simulations). (SC.E.2.4.6)

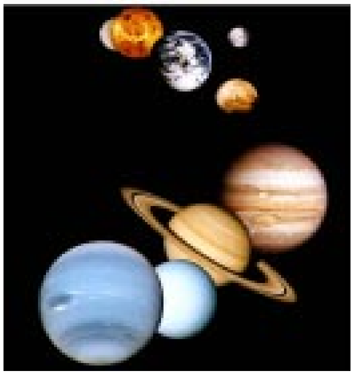
Vocabulary

Use the vocabulary words and definitions below as a reference for this unit.

asteroids	fragments of rock and metal that orbit the sun; many are in a belt between Mars and Jupiter
comet	a mass of dust and ice with a bright gaseous tail that orbits the sun
constellation	a small number of stars that appears to form a shape or image
elliptical galaxies	galaxies that have a very bright center that contain very little dust and gas and are spherical to disklike in shape
galaxy	millions or billions of stars in a system
light-year	a unit of distance equal to the distance light travels in one year; $1 \text{ ly} = 9.5 \times 10^{15} \text{ m}$
meteors	fragments of rocky material from space that burn as they fall through Earth's atmosphere; also known as meteoroids
nebula	a cloud of interstellar gas and dust (*pl.* nebulae)
orbit	(noun) the path of an object revolving around another object; (verb) to revolve in a path around another object

planets	bodies that revolve around a sun and reflect its light
satellite	an object that revolves around a larger object
solar system	the sun and all the planets, their moons, asteroids, meteors, and comets; all objects that move around the sun
spiral galaxies	disk-shaped galaxies that have a center of bright stars and flattened arms that swirl around the center, and look like a pinwheel; the solar system is part of a spiral galaxy
stars	hot, bright bodies of gas constantly exploding in space
stellar equilibrium	the balance between forces in a star including nuclear fusion, gravity, and the explosive force of the star
theory	a hypothesis that has withstood the test of time
universe	all bodies in space and all space between these bodies—all matter and all energy

Introduction

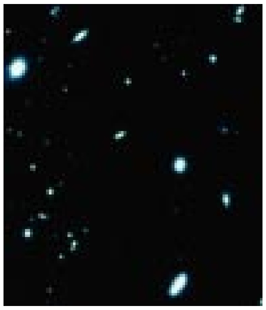


Astronomers have been able to develop a more realistic model of our solar system.

As early humans began to study the sky, they believed Earth to be the center of the **universe**. Their observations were based solely upon the motion of the sun, moon, **planets**, and **stars** that their eyes could see—not an actual, scaled model. In time, the astronomers were able to develop more realistic models of our **solar system** with the sun as the center of the *universe*. Today, we know that even this model has changed. With new technologies, today's scientists are able to learn even more about space, enabling us to understand our world and even worlds beyond our own.

Origin of the Universe

Scientists have offered many **theories**, or educated guesses, on how the universe began. The *theory* that most scientists accept today is called the *Big Bang* theory.

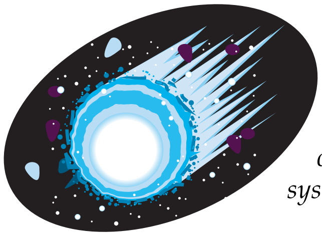


There are also many theories of how the solar system began.

According to this theory, all of the matter and energy found in the universe was once packed together in a single body. Between 15 and 20 billion years ago there was a huge explosion, and matter and energy spread outward in all directions. As the material cooled, gas formed and collected into expanding clouds. As the clouds moved away from the center of the explosion, they cooled and condensed to form **galaxies**. These *galaxies* continued to move away from each other and are still moving today. Within these galaxies today, *stars* form and die while the entire universe continues to expand.

Origin of the Solar System

There are also many theories of how the *solar system* began. Scientists think that about five million years ago, the force of gravity pulled together a large cloud of dust and gas. According to the *Dust Cloud theory*, also known as the *nebular theory*, a slowly rotating cloud of dust and gas—a **nebula**—formed in one of the spiral arms of our galaxy, the Milky Way. As the cloud shrank, its center became so dense and hot that a star, the sun, was formed. Smaller fragments of remaining material began to **orbit** the sun. In time, gravity pulled these small bits of gas and dust together. These small bits then combined to make a few larger masses. These masses formed the *planets* and their **satellites**. When the sun began to shine, the remaining gas and dust were driven back into space, and only the material that had condensed into solid bodies remained.



The Dust Cloud theory, *also know as the* nebular theory, *is one theory of the origin of the solar system.*

Another theory suggests that a star larger than the sun came very close to the sun. The closeness of the larger star caused explosions on the sun. The gases from these explosions condensed into particles which formed the planets.

Practice

Use the list below to write the correct term for each definition on the line provided.

galaxy
nebula
orbit
planets
satellite
solar system
stars
theory
universe

________________________ 1. a hypothesis that has withstood the test of time

________________________ 2. millions or billions of stars in a system

________________________ 3. hot, bright bodies of gas constantly exploding in space

________________________ 4. all bodies in space and all space between these bodies—all matter and all energy

________________________ 5. an object that revolves around a larger object

________________________ 6. a cloud of interstellar gas and dust

________________________ 7. bodies that revolve around a sun and reflect its light

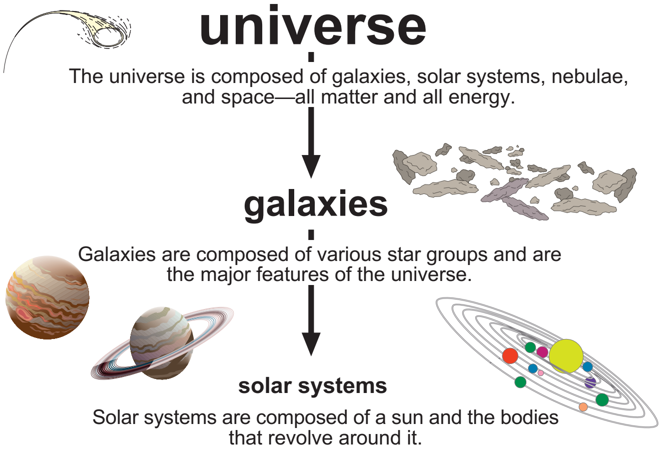
________________________ 8. the path of an object revolving around another object; to revolve in a path around another object

________________________ 9. the sun and all the planets, their moons, asteroids, meteors, and comets; all objects that move around the sun

The Universe

The universe is a system that contains many smaller parts. Galaxies, solar systems, *nebulae*, and space—all matter and energy—are the components that make up the universe.

Galaxies like our Milky Way are composed of various star groups and are the major features of the universe. Within galaxies, there are many different types of stars. Some of these stars are *orbited* by *satellites*. These star groups are called *solar systems*. Our sun is an example of a star with orbiting satellites. Only about one percent of all matter in the universe is found in galaxies.



The universe is composed of galaxies, solar systems, nebulae, and space—all matter and all energy.

Galaxies are composed of various star groups and are the major features of the universe.

Solar systems are composed of a sun and the bodies that revolve around it.

The other 99 percent of matter in the universe is in *space*. Some matter is composed of nebulae, or dust and gas clouds, that are difficult to see without special instruments. The rest is called *dark matter* because we cannot see or detect it.

Measuring Distances

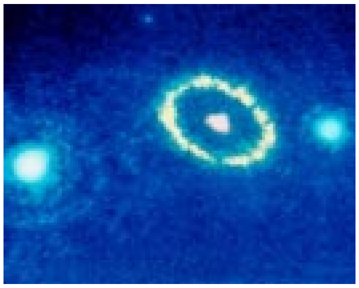
To measure distances in the universe scientists use a unit of distance called a **light-year**. A *light-year* is the distance light travels in one year. The three stars nearest to Earth besides the sun are 4.3 light-years away. When you see their light from Earth, you see light that left the stars 4.3 light-years ago.

Distances within the solar system are commonly given in AUs. AU stands for astronomical unit, the average distance between the sun and Earth. One AU equals 93 million miles or 150 million kilometers. The planet Mercury is .3 AUs from the sun and Earth is one AU from the sun.

The Stars, Planets, and Heavenly Bodies

In the universe, there are many groups of billions of stars called *galaxies*. Galaxies are classified according to their shape. One kind of galaxy is a **spiral galaxy**. It is disk-shaped and looks like a pinwheel with large arms that unwind from the center. Earth's galaxy, the Milky Way, is a *spiral galaxy*. Another common galaxy is an **elliptical galaxy**, which looks spherical to flattened or disklike in shape. They have no arms and very little dust and gas.

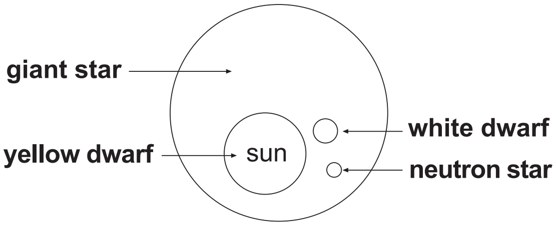
A spiral galaxy is disk-shaped and looks like a pinwheel with large arms that unwind from the center.



An elliptical galaxy looks spherical to flattened or disklike in shape.

Stars

Stars differ in size, brightness, and temperature. Our sun is average in size for a star. Stars come in a variety of sizes and colors. They range from blue to red, from less than half the size of our sun to over 20 times the sun's size. The size and temperature of a star depends on how much gas and dust collects as the star forms. The color of the star depends on the surface temperature of the star. The more mass a star starts out with, the brighter and hotter it will be.



Sizes of Stars

Earth's sun is a medium-sized star and is called a *yellow dwarf*. There are many explosions on the surface of the star as the star uses its nuclear fuel. This nuclear activity, fusion, produces all the star's light and heat.

Fusion is the joining of atoms to form new atoms. In a young star, such as our sun, four atoms of hydrogen join to form one atom of helium. This process releases the heat and light of the sun. As stars age, they use all their hydrogen. At this point, their fuel becomes the helium they produced earlier.

There are many explosions on the surface of the star as the star uses its nuclear fuel.

The fusion reactions in the core of the sun produce an outward force. This outward force balances the inward force due to gravity. With those two forces evenly balanced, the sun has maintained an equilibrium for five billion years.

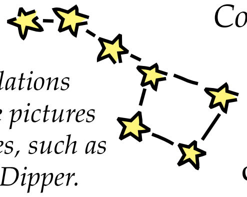
Medium-sized stars (such as our sun) use their fuel (helium) until they reach the red giant phase. In red giants, the outer layers expand, the core contracts, and helium atoms in the core fuse to form carbon. Once the carbon core is stabilized, the end is near. The star will shed its outer layers as a gaseous cloud called a *planetary nebula*. The star continues cooling and shrinking until it has become a white dwarf. The star then radiates its remaining heat into the coldness of space. In the end, it will be a cold dark mass sometimes referred to as a black dwarf. Our sun is expected to produce life-sustaining levels of light energy for about another five billion years.

Stars that are five or more times as massive as our sun follow a slightly different path. When they use up their hydrogen, they eventually grow into a red supergiant (i.e., a very big red giant) and begin to shrink, growing hotter and denser. When the core becomes essentially just iron, the star has nothing left to fuse. In less than a second, the star begins the final phase of its collapse. The core temperature rises to over 100 billion degrees as the iron atoms are crushed together. In one of the most spectacular events in the universe, the explosive shock of the collapsing core propels the material away from the star in a tremendous explosion called a *supernova*. The exploded material moves off into space possibly colliding with other cosmic debris to form new stars, planets, or moons.

If the core remains intact after the supernova, it is called a *neutron star*. However, if the original star was very massive (15 or more times the mass of our sun), a black hole might form. A black hole produces no light (hence it is *black*), but it is extremely massive. Black holes have so much gravity, even light falls into them.

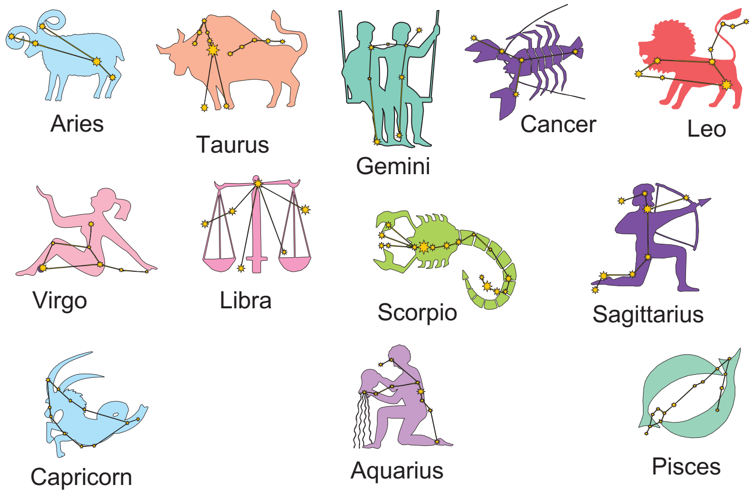
Stars maintain a balance between the great forces that produce radiation and fuel their nuclear fusion. This balance is called **stellar equilibrium**. As large stars grow older, they use up their remaining fuel, and this balance is thrown off, creating great explosions, or supernovas, and collapsing with great changes of gravity into neutron stars or black holes. In these changes, matter is neither created nor destroyed; it changes form and the remaining star particles and gases can now form new stars in the universe.

When people look at the universe, they often see smaller groups of stars called **constellations**.



Constellations look like pictures or shapes, such as the Big Dipper.

Constellations look like pictures or shapes. The Big Dipper and Little Dipper are constellations. The planets, sun, and moon all follow paths within a narrow belt across the sky. There are 12 constellations that appear in this belt. These constellations are called the signs of the Zodiac. The names of the signs of the Zodiac are Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricorn, Aquarius, and Pisces.



There are 12 constellations that are called the signs of the Zodiac.

Orbiting the sun are the nine planets of the solar system. *Planets* do not burn like stars but reflect the light of the sun.

Moons are satellites that orbit the planets. Some planets have no moons, and some have many moons. Earth has one moon. The moon accompanies Earth on its annual journey around the sun.

Masses of dust and ice with a gaseous tail, called **comets**, also revolve around the sun. Halley's Comet is the most well-known comet. It is seen from Earth every 76 years. Halley's Comet was last seen in 1986. It will not be seen again until the year 2062.

Meteors are small pieces of rocky material that sometimes enter Earth's atmosphere. When a meteor enters Earth's atmosphere, it begins to burn. This is called a *shooting star*, but it is not really a star. The rocky fragments of a meteor that hit the surface of Earth are called *meteorites*.

Asteroids are pieces of rock and metal that orbit the sun. Many are located in a belt between the planets Mars and Jupiter. These fragments of matter are similar to that from which planets were formed. They may be a broken-up planet or trapped debris. Asteroids range in size from tiny particles, too small to be seen, to masses 1,000 kilometers in diameter.

Practice

Use the list below to write the correct term for each definition on the line provided.

asteroids
comet
constellation
elliptical galaxies
light-year
meteors
spiral galaxies
stellar equilibrium

________________________ 1. a mass of dust and ice with a bright gaseous tail that orbits the sun

________________________ 2. fragments of rocky material from space that burn as they fall through Earth's atmosphere

________________________ 3. galaxies that have a very bright center that contain very little dust and gas

________________________ 4. galaxies that have a center of bright stars and flattened arms that swirl around the center, and look like a pinwheel

________________________ 5. a small number of stars that appears to form a shape or image

________________________ 6. fragments of rock and metal that orbit the sun; many are in a belt located between Mars and Jupiter

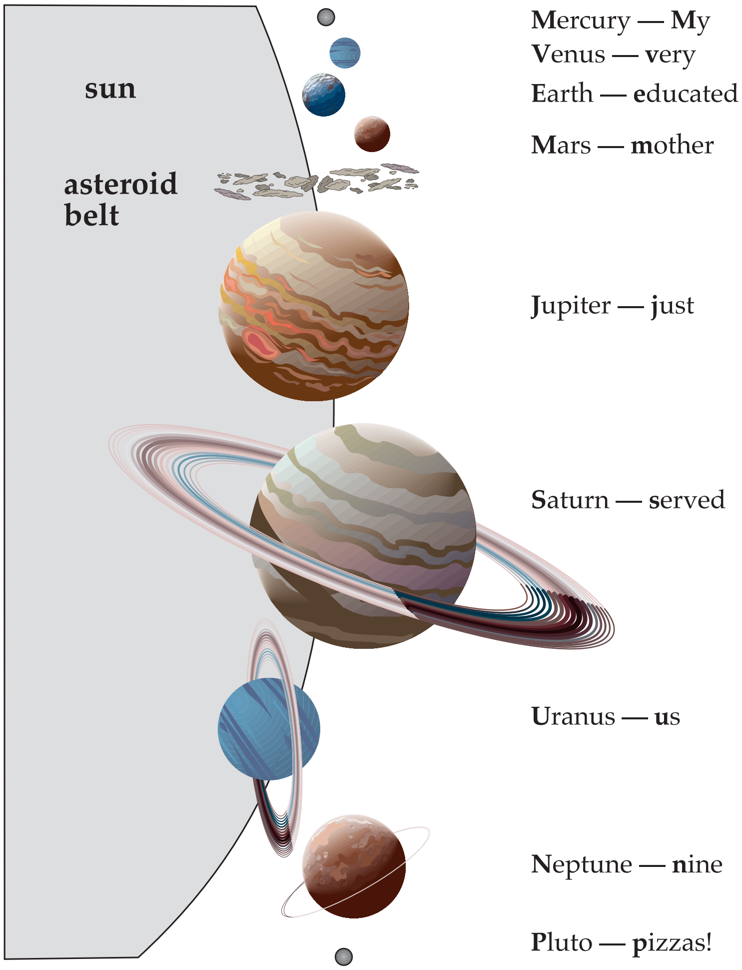
________________________ 7. the balance between the forces in a star

________________________ 8. a unit of distance equal to the distance light travels in one year

Planets

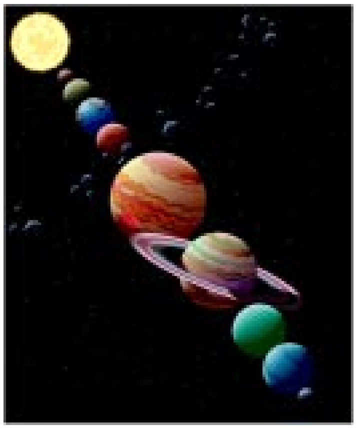
Our solar system consists of nine planets, their satellites, and many other small bodies such as asteroids, comets, and meteoroids. The planets in order from the sun are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto.

It is easy to remember the names of the planets in their order from the sun. Just remember this sentence: My very educated mother just served us nine pizzas!



My **v**ery **e**ducated **m**other **j**ust **s**erved **u**s **n**ine **p**izzas!

Mercury. Mercury is the planet closest to the sun. It rotates very slowly. The side facing the sun is very hot, while the side away from the sun is very cold. The spacecraft *Mariner 10* visited Mercury in 1974. It discovered a barren world with many craters. The craters have remained unchanged for billions of years because Mercury has no atmosphere or weather.



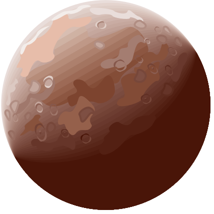
The planets in order from the sun are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto.

Venus. Venus is sometimes called Earth's *sister planet* because it is very similar in size, mass, and density. The atmosphere of Venus is very different from that of Earth. Venus' atmosphere is composed of carbon dioxide. It also has thick clouds of sulfuric acid. These clouds trap heat and create a greenhouse effect, causing extremely high surface temperatures. Venus is also covered by craters, but there is evidence that oceans once existed.

Earth is the third planet from the sun.

Earth. Earth is the third planet from the sun and is a bit larger than Venus. So far as we know, Earth is the only home of life in the solar system. It has one large moon but there are larger moons in the solar system. There are three main zones of Earth: the atmosphere; the hydrosphere (the world's water); and the lithosphere (the solid body of the world). Earth's solid body is divided into three regions: the core; the mantle; and the crust, the outermost layer of Earth and the one to which all human activity is confined.

Mars. Mars was examined by the *Viking* spacecraft in 1976 and revisited by the Mars *Pathfinder* in July of 1997. Its red soil, suspended by windstorms, gives it the name the *red planet*. Many large volcanoes and craters dot the surface of Mars, indicating that the planet was once very active. The solar system's largest known volcano, Mons Olympus, is found here. Mars also has large ice caps. The ice does not melt because the temperature of Mars is well below freezing. Mars has two small moons—Phobos and Deimos.



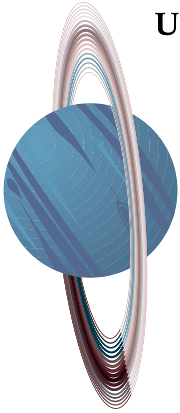
Many large volcanoes and craters dot the surface of Mars.

Jupiter is the largest planet in the solar system.

Jupiter. The largest planet in the solar system is the *gas giant*, Jupiter. Huge storm clouds cover the planet, including the giant red spot which is thought to be like a hurricane three times as large as Earth. In 1979, the *Voyager* spacecraft discovered a thin ring circling the planet. At least 63 moons are known to orbit Jupiter. The first four were discovered by Galileo Galilei in 1610.

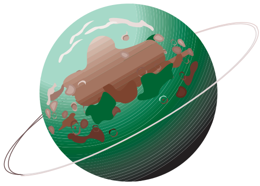
Saturn has a dense atmosphere, storms, and rings.

Saturn. Saturn is very similar to Jupiter. It also has a dense atmosphere, storms, and rings. Saturn's rings, however, are composed of ice and form intricate patterns. There may be as many as 47 orbiting Saturn.



Uranus also has a ring system, but the rings encircle the planet from top to bottom.

Uranus. Uranus is also a *gas giant* like Jupiter and Saturn. The clouds that cover Uranus give it its characteristic greenish-blue color. Uranus also has a ring system, but the rings encircle the planet from top to bottom. This is because Uranus' axis is tilted at nearly a 90° angle, so it appears to have been knocked on its side. Twenty-seven moons orbit the planet.



Neptune is considered Uranus' twin.

Neptune. Neptune is considered Uranus' twin. It is about the same size and has a greenish-blue color. Two thin rings encircle the planet, and it has 13 moons.

Using Newton's law of gravitation, both the French astronomer Urbain Leverrier and the British mathematician John Couch Adams predicted the existence of a new planet that was causing the orbit of Uranus to be different than expected from Newton's law. Neptune was discovered in 1846 by German astronomer Johann Galle in an orbit close to its predicted position.

Pluto. The most distant planet in our solar system is Pluto. It was the last planet discovered, and due to its great distance from Earth its one moon was not discovered until 1978. Pluto is the smallest planet and may be composed entirely of frozen methane and ice.

Earth's moon

The planets orbit around the sun in our solar system just as the moon orbits Earth. What holds the planets in this orbit? Gravity does. It is the universal force of attraction between all objects that tends to pull them toward one another just as objects are pulled towards Earth's surface. Sir Isaac Newton proposed his law of gravity in 1687. Newton's law stated that every particle in the universe attracts every other particle with a force that is proportional to the masses and inversely proportional to the square of the distance between the objects. The force of attraction between any two objects depends upon their masses and the distance between them.

Summary

The nine planets—along with comets, meteoroids, asteroids, and other celestial objects—make up Earth's vast neighborhood. The planets and other heavenly bodies have at least one thing in common. They all share gravitational forces with the sun, forming a large system—the solar system. With the help of space probes, cameras, and other data-gathering equipment placed above Earth's atmosphere, scientists are able to find out more and more about our celestial neighborhood. These scientific studies are making our world seem smaller than we once imagined it to be and the universe more accessible.

Lab Activity: Dimensions of the Solar System

Fact:

- The solar system includes the sun, the nine planets, and all of the other objects orbiting the sun.

Investigate:

- You will construct a model to show the relative distance from the sun to the planets.

Materials:

- adding machine tape
- metric ruler
- string

Dimensions of the Solar System		
Planet	**Distance from the Sun**	
	Millions of km*	**cm***
Mercury	58	
Venus	108	
Earth	150	3
Mars	228	
Jupiter	778	
Saturn	1427	
Uranus	2870	
Neptune	4486	

*scale 1 centimeter (cm) = 50 million kilometers (km)

Procedure

1. Obtain a length of adding machine tape approximately 150 cm long.

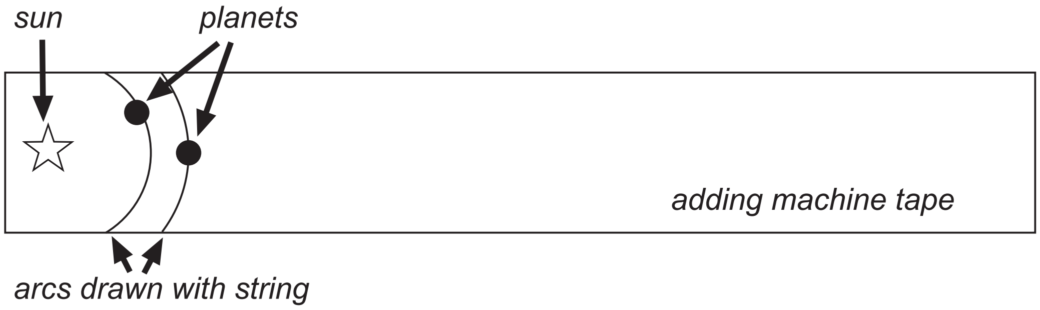
2. Using the chart on the previous page, calculate the distance in cm from the sun for each planet using the scale 1 cm = 50 million km.

$$\text{Example: Earth} \quad 150 \ \cancel{\text{million}}\ \cancel{\text{km}} \times \frac{1\ \text{cm}}{50\ \cancel{\text{million}}\ \cancel{\text{km}}} = \frac{150\ \text{cm}}{50} = 3\ \text{cm}$$

3. Find the spot one centimeter above one edge of your tape. Draw a small star there to represent the sun. (See diagram below.)

4. To plot each planet, measure the distance from the sun and place a mark at the appropriate distance for each planet.

5. Use the string to draw arcs to represent the orbits of the planets.



6. Label the planets.

7. Draw dotted lines between Mars and Jupiter to represent the asteroid belt.

8. All of the planets through Saturn are easily visible to the naked eye.

   Name them. ____

   ____

   ____

9. Each of the planets between Earth and the sun are seen as the *morning star* or the *evening star*. Name them. ____________________

____

____

10. What might be the possible origin of the asteroids? _____________

____

____

____

____

11. Where are the largest planets located? __________________________

____

____

____

____

12. Where are the smallest planets located? ________________________

____

____

____

____

Practice

Answer the following using complete sentences.

1. What is the name of the most commonly accepted theory on how the universe began? ______________________________

   ____

2. When do scientists think that the universe was created? ________

   ____

   ____

3. Before the Big Bang, where was most of the matter and energy found in the universe? ______________________________

   ____

   ____

4. How did this big explosion affect the matter and energy that was already present in the universe? ________________________

   ____

   ____

5. According to the Big Bang theory, how were the galaxies formed? ____

   ____

   ____

6. What continues to happen to the stars in these galaxies today?

____

____

7. What is a slowly rotating cloud of dust and gas called? ________

____

8. What theory states that the shrinking of a large cloud of dust formed the solar system? ______________________________

____

____

____

____

9. Describe another theory of how the planets were formed. _______

____

____

____

____

____

10. What are the four components that make up the universe? ______

____

____

____

____

Practice

Write a paragraph about the following.

1. The origin of the universe according to the Big Bang theory: ____

2. The origin of the solar system according to the nebular theory, also known as the Dust Cloud theory: ____

Practice

Use the list below to complete the following statements.

black hole
neutron star
red giant
red supergiant
supernova
white dwarf
yellow dwarf

1. Earth's sun is a medium-sized star called a

   ____________________ .

2. A medium-sized star as it uses its fuel will become a

   ____________________ then cool and shrink becoming a

   ____________________ .

3. Stars that are more massive than our sun as they use their fuel will grow into a ____________________ . When the star has no fuel left it will explode as a ____________________ .

4. If the core remains intact after the supernova it is called a

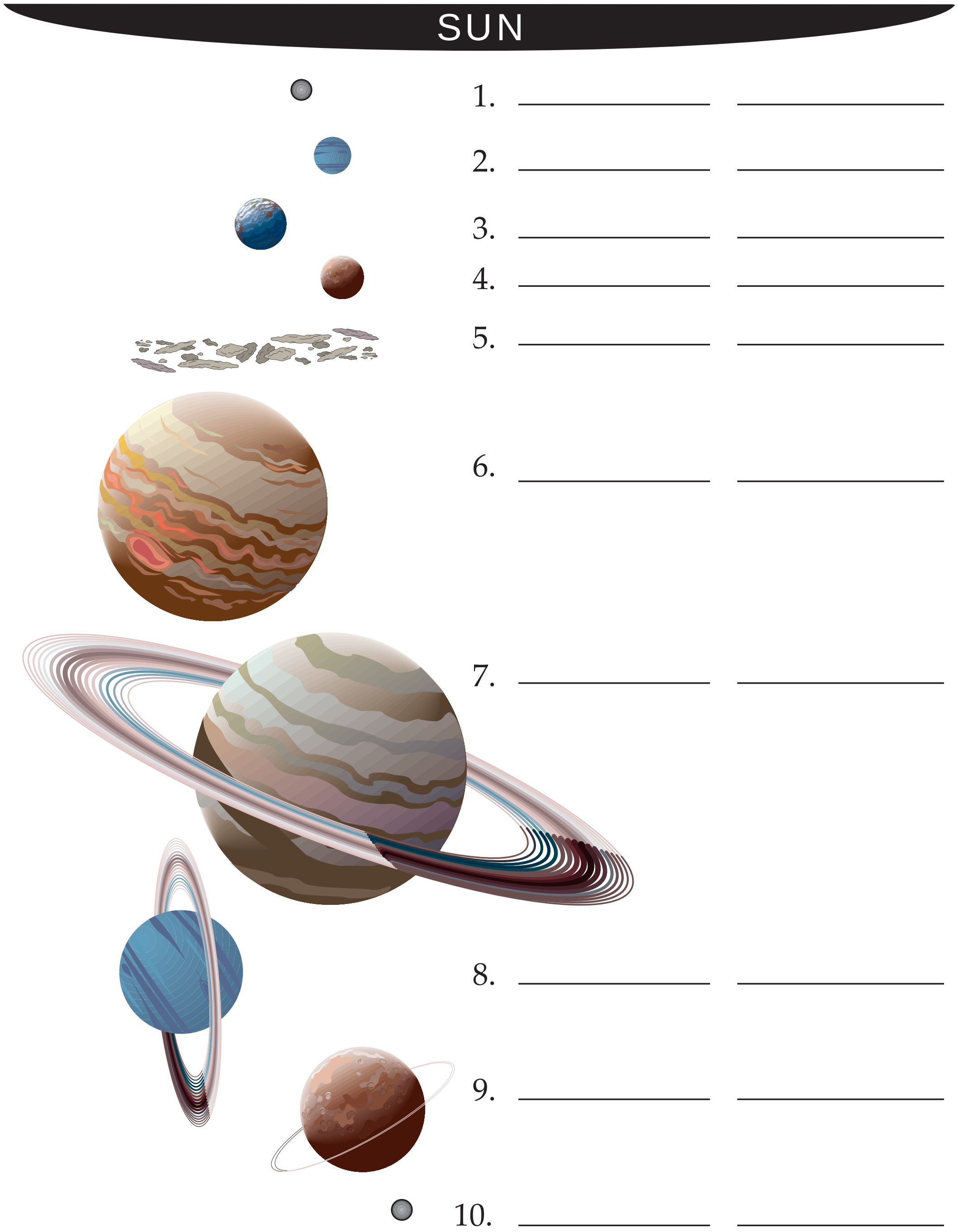
   ____________________ .

5. If the core was very massive it might form a

   ____________________ .

Practice

Label each **heavenly body** *illustrated below and give one characteristic.*



1. ______________ ______________
2. ______________ ______________
3. ______________ ______________
4. ______________ ______________
5. ______________ ______________
6. ______________ ______________
7. ______________ ______________
8. ______________ ______________
9. ______________ ______________
10. ______________ ______________

Practice

Circle the letter of the correct answer.

1. A ____________ is a mass of dust and ice with a bright gaseous tail that orbits the sun.
   a. planet
   b. meteor
   c. star
   d. comet

2. ____________ are bodies that revolve around a sun and reflect its light.
   a. Galaxies
   b. Stars
   c. Meteors
   d. Planets

3. ____________ are hot, bright bodies of gas constantly exploding in space.
   a. Meteors
   b. Elliptical galaxies
   c. Galaxies
   d. Stars

4. ____________ are fragments of rocky material from space that enter Earth's atmosphere and burn as they fall.
   a. Spiral galaxies
   b. Meteors
   c. Elliptical galaxies
   d. Galaxies

5. A ____________ is millions or billions of stars in a system.
   a. constellation
   b. galaxy
   c. meteor
   d. planet

6. __________ galaxies are oval-shaped galaxies which are smooth in appearance and have few clouds of dust and gas.

   a. Constellation
   b. Spiral
   c. Elliptical
   d. Comet

7. __________ galaxies are galaxies that are disk-shaped.

   a. Spiral
   b. Star
   c. Nebula
   d. Elliptical

8. A __________ is a small number of stars that appears to form a shape or image.

   a. comet
   b. constellation
   c. galaxy
   d. meteor

9. A principle based on facts which has withstood the test of time is a __________ .

   a. satellite
   b. planet
   c. solar system
   d. theory

10. All bodies in space and all space between these bodies, and all energy and all matter, compose the __________ .

    a. elliptical galaxy
    b. solar system
    c. spiral galaxy
    d. universe

11. The sun and all the planets, their moons, asteroids, meteors, and comets and all objects that move around the sun compose the _____________ .

    a. solar system
    b. elliptical galaxy
    c. universe
    d. spiral galaxy

12. A _____________ is a cloud of interstellar gas and/or dust.

    a. satellite
    b. nebula
    c. planet
    d. solar system

13. _____________ are fragments of rock and metal that orbit the sun, many of which are located between Mars and Jupiter.

    a. Galaxies
    b. Satellites
    c. Meteors
    d. Asteroids

14. A _____________ is an object that revolves around a larger object.

    a. satellite
    b. galaxy
    c. constellation
    d. comet

15. The moon and planets revolve or _____________ around the sun.

    a. asteroid
    b. comet
    c. solar system
    d. orbit

Practice

Write a paragraph about the following.

1. How do scientists collect data about our universe?

Unit 13: The Earth, the Moon, and the Sun

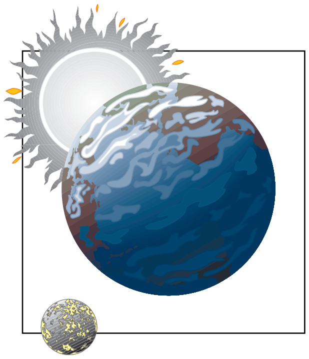
This unit describes the relative positions of the sun, Earth, and moon and changes associated with them. Students will learn about eclipses, tides, and seasons.

Student Goals

- Understand why Earth can support life.
- Describe features of the moon.
- Identify solar and lunar eclipses.
- Identify the phases of the moon and the relative positions of the moon, Earth, and sun.
- Recognize the relationship of tides to the relative positions of the Earth, moon, and sun.
- Understand what causes the seasons.

Unit Focus

- Understand the relationships between events on Earth and the movements of the Earth, its Moon, the other planets and the Sun. (SC.E.1.4.1)
- Know how the characteristics of other planets and satellites are similar to and different from those on the Earth. (SC.E.1.4.2)
- Know the various reasons that Earth is the only planet in our Solar System that appears to be capable of supporting life as we know it. (SC.E.1.4.3)



- Know how climatic patterns on Earth result from an interplay of many factors (Earth’s topography, its rotation on its axis, solar radiation, the transfer of heat energy where the atmosphere interfaces with lands and oceans, and wind and ocean currents). (SC.D.1.4.1)

Vocabulary

Use the vocabulary words and definitions below as a reference for this unit.

corona	the low-density cloud of gases surrounding the sun
craters	holes or bowl-shaped depressions on a moon or planet
ebb tide	the movement of a tidal current away from the shore
elliptical	oval-shaped
equinox	either of the two times of the year when the number of hours of daylight and darkness are the same in both hemispheres; marks the first day of spring and fall; means *equal night*
flood tide	the tidal current associated with the increase in the height of the tide
highland areas	areas on the moon which are high mountain ranges and large craters; appear light in color
lunar eclipse	an event which occurs when Earth blocks the light as it moves between the sun and the moon
lunar month	the measure of time it takes for the moon to pass from one new moon to the next (29½ days)

maria (MAR-ee-uh)	lunar seas or plains on the moon which appear dark
meteors	fragments of rocky material from space that burn as they fall through Earth's atmosphere; also known as meteoroids
moon phase	the changing appearance of the moon which depends on the moon's position relative to the sun
neap tide	tide occurring at the first and third quarters of the moon when the sun, Earth, and moon form a right angle; produces tides in a medium range
orbit	(noun) the path of an object revolving around another object; (verb) to revolve in an orbit around another object
partial eclipse	an event which occurs when part of the sun is blocked out by the moon
penumbra	part of a shadow cast by an object in which light from the source is only partly blocked
revolve	to move around another heavenly body *Examples*: the moon revolves around Earth; planets revolve around the sun
rotate	to spin on an axis *Example*: Earth rotates, causing day and night

seasons	the four divisions of the year characterized by differences in weather and the number of hours of daylight
solar eclipse	an event which occurs when the moon passes between Earth and the sun
solstice	either of the two times a year when the sun is at its greatest apparent distance north or south of the equator; marks the first day of *summer* and *winter*
spring tide	tide that occurs when the sun, moon, and Earth are in a straight line
tide	the rise and fall of the oceans caused by the gravitational attraction between the sun, Earth, and moon
total eclipse	an event which occurs when the sun is completely blocked out by the moon
umbra	the part of a shadow cast by an object in which light from the source is completely blocked

Introduction

Through scientific study and space exploration, we have learned that Earth exists as a part of a larger system called the *solar system*. Within our solar system, the moon and Earth have a very important relationship. The relationship between sun, Earth, and moon affects many of the everyday occurrences that we take for granted—the **tides**, the amount of solar energy, the length of our days and nights, and the **seasons**. Learning about this relationship helps us to understand these daily occurrences and to understand our need for future exploration of the world beyond our Earth.

Earth seen from the moon.

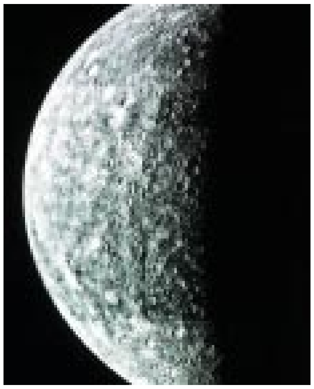
The Relationship of the Earth and the Moon

Earth has one moon. The moon **revolves** around Earth about once a month. The moon also turns, or **rotates**, on its axis one time per month. Because of this, we only see one side of the moon. The moon does not give off light of its own. It reflects the light of the sun.

Earth has a blanket of air surrounding it called an *atmosphere*. The moon does not have an atmosphere because it does not have a strong enough gravitational force to hold a blanket of air around it. Since there is no atmosphere on the moon, there is no water. Without an atmosphere and water, the moon is unable to support life.

Without an atmosphere and water, the moon is unable to support life.

Earth is the third planet from the sun. Earth's atmosphere is different from the other planets. It contains oxygen and water vapor and thus can support life. The atmosphere also protects Earth from extremes in temperatures. Without an atmosphere, the moon is subjected to very high and low temperatures. The dark side of the moon may get as cold as -175° Celsius, and the lighted side may reach temperatures of 130° Celsius.



When viewed from Earth, the surface of the moon has light and dark areas.

When viewed from Earth, the surface of the moon has light and dark areas, which sometimes combine to look like a person's face.
The light-colored areas are **highland areas**. The *highland areas* have mountains that are much higher than any found on Earth. The parts of the moon that appear dark are called **maria**. *Mare* (singular for maria) is the Latin word for *seas*. The maria are flat areas that look like seas, except that they do not have any water in them.

The surface of the moon also has many bowl-like depressions called **craters**. *Craters* vary in diameter from a few inches to over 500 miles. Most of the craters were produced long ago by the impact of **meteors**. In contrast, Earth has only about a dozen well-known craters. Although many *meteors* travel towards Earth, most of those meteors burn up in Earth's atmosphere. The moon, on the other hand, has no atmosphere to affect the meteors' impacts. Additional craters may have been on Earth in early geologic history, but these have been destroyed by erosion.

The surface of the moon also has many bowl-like depressions called craters.

Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. lunar seas or plains on the moon which appear dark

______ 2. to move around another heavenly body

______ 3. holes or bowl-shaped depressions on a moon or planet

______ 4. the rise and fall of the oceans caused by the gravitational attraction between the sun, Earth, and moon

______ 5. the four divisions of the year characterized by differences in weather and the number of hours of daylight

______ 6. areas on the moon which are high mountain ranges and large craters; appear light in color

______ 7. to spin on an axis

______ 8. fragments of rocky material from space that burn as they fall through Earth's atmosphere

A. craters

B. highland areas

C. maria

D. meteors

E. revolve

F. rotate

G. seasons

H. tide

Practice

Answer the following using complete sentences.

1. What are two conditions of Earth that allow it to support life?

   ____

   ____

   ____

2. Is there life on the moon? ______________________________

   Why or why not? ____________________________________

   ____

   ____

   ____

3. Why doesn't the moon have an atmosphere? _______________

   ____

   ____

   ____

4. Why does the moon have much hotter and much colder temperatures than Earth? ______________________________

   ____

   ____

   ____

   ____

5. Why do we sometimes see a person’s face in the moon? ________

____

____

____

6. The word *mare* means sea in Latin, but how do the maria on the moon differ from the seas on Earth? __________________________

____

____

7. Describe the highland areas on the moon. ____________________

____

8. What are the bowl-like depressions on the moon? What caused them? ____

____

9. How large are the craters on the moon? _______________________

____

____

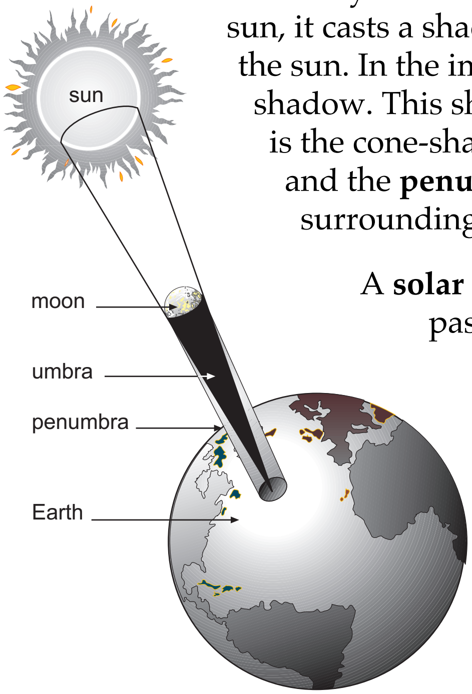
10. Why are the moon’s craters so well preserved? ________________

____

____

____

Solar Eclipse



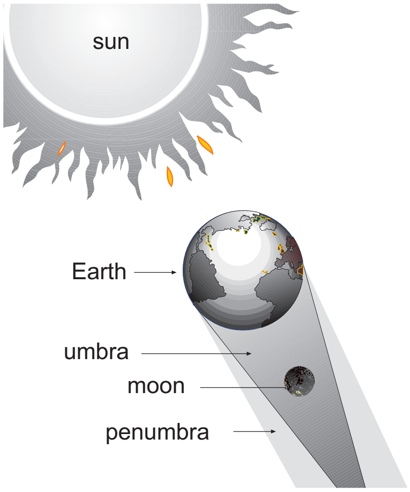
A solar eclipse takes place when the moon passes into a straight line between the sun and Earth.

As a body follows its **elliptical orbit**, or path, around the sun, it casts a shadow thousands of miles long away from the sun. In the image to the left, the moon is casting a shadow. This shadow has two parts—the **umbra**, which is the cone-shaped inner part that is completely dark, and the **penumbra**, which is the partly shaded region surrounding the *umbra*.

A **solar eclipse** takes place when the moon passes into a straight line between the sun and Earth. When the moon is in this position, its shadow moves onto a small area of Earth. During a **total eclipse** of the sun, the moon totally blocks out the sun and, for a short time, becomes dark. Only a halo of light from the sun's rim, called a **corona**, can be seen. Other parts of Earth that fall in the *penumbra* experience a **partial eclipse**, where only part of the sun is blocked by the moon. A *partial eclipse* is seen by many more people than a *total eclipse*.

Lunar Eclipse

When the moon moves into Earth's shadow, we have a **lunar eclipse**. During a *lunar eclipse*, hardly any sunlight reaches the moon and, consequently, it looks very dim. A lunar eclipse will last about three or four hours. It is longer than a *solar eclipse* because Earth's shadow is very wide, and it takes a long time to pass through it. A lunar eclipse can be seen from more areas of Earth than a solar eclipse. Also, there are many more lunar eclipses than solar eclipses.

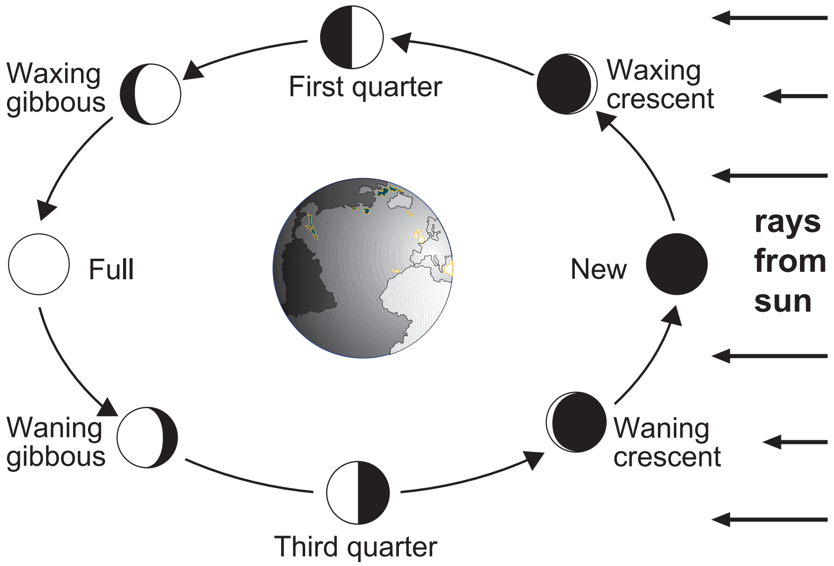


When the moon moves into Earth's shadow, we have a lunar eclipse.

Moon Phases

The moon moves around Earth in exactly the same way that the planets *revolve* around the sun. It takes the moon 27⅓ days to make one trip around Earth. The moon also *rotates* or spins on its axis one time as it revolves around Earth. While the moon is moving around Earth, Earth is also moving around the sun. Therefore, it takes about two more days for the moon to return to its original position in relation to the sun and Earth. It takes a total of 29½ days for the moon to pass from one new moon to the next new moon. This period of time is called a **lunar month**.

As the moon *orbits* Earth, sometimes the side that is lighted by the sun is facing Earth, and at other times part or all of the lighted side is facing away from Earth. The different portions of the lighted side of the moon that are visible as the moon revolves around Earth are known as **moon phases**.



The circle shows the phases of the moon as seen from Earth.

🌑 New Moon—when the moon is in between Earth and the sun, the unlighted side of the moon is facing Earth and cannot be seen

🌒 Crescent Moon—just before and after the new moon; only a slice of the lighted side is seen

🌓 Quarter Moon—halfway between the new moon and full moon; half the moon is dark and half is lighted

🌔 Gibbous Moon—just before and just after a full moon; over half of the moon is lighted; it appears lopsided

🌕 Full Moon—when the moon is on the opposite side of Earth from the sun; the entire lighted side is facing Earth

Practice

Use the list below to write the correct term for each definition on the line provided.

corona
elliptical
lunar eclipse
lunar month
moon phase
orbit
partial eclipse
penumbra
solar eclipse
total eclipse
umbra

________________ 1. the measure of time it takes for the moon to pass from one new moon to the next

________________ 2. oval-shaped

________________ 3. the changing appearance of the moon which depends on the moon's position relative to the sun

________________ 4. part of a shadow cast by an object in which light from the source is only partly blocked

________________ 5. the part of a shadow cast by an object in which light from the source is completely blocked

________________ 6. the low-density cloud of gases surrounding the sun

________________ 7. an event which occurs when Earth blocks the light as it moves between the sun and the moon

________________ 8. the path of an object revolving around another object

________________ 9. an event which occurs when the moon passes between Earth and the sun

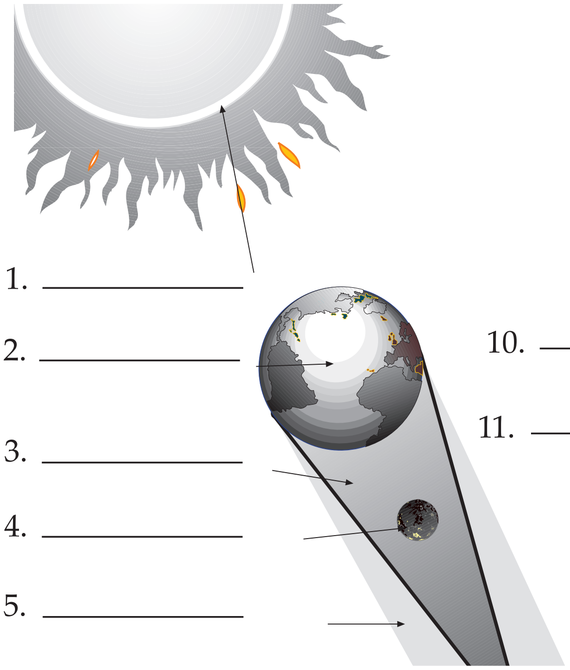
________________ 10. an event which occurs when part of the sun is blocked out by the moon

________________ 11. an event which occurs when the sun is completely blocked out by the moon

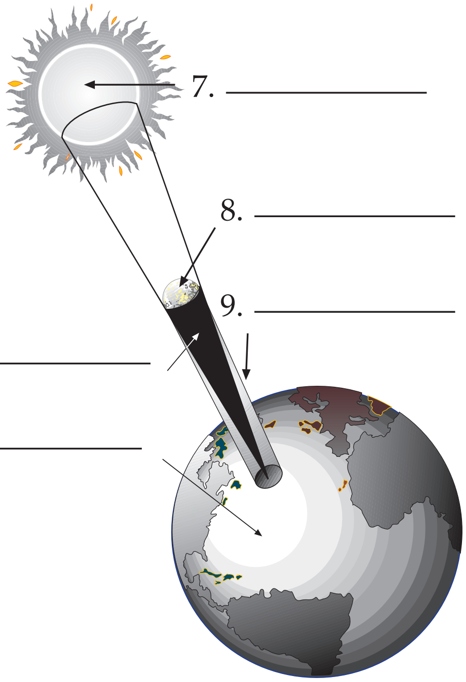
Practice

Identify the two **eclipses** *shown in the diagrams below. Use the list below to label the parts of each. Write the correct term on the line provided.* **One or more terms will be used more than once.**

Earth
lunar
moon
penumbra
solar
sun
umbra



1. ______________
2. ______________
3. ______________
4. ______________
5. ______________



7. ______________
8. ______________
9. ______________
10. ______________
11. ______________

6. ______________ eclipse

12. ______________ eclipse

Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. the time that it takes the moon to make one trip around Earth

______ 2. the amount of time that it takes the moon to go through its phases from one new moon to the next new moon

______ 3. the measure of time it takes the moon to go through its phases

______ 4. the different portions of the lighted side of the moon that we see as it revolves around Earth

______ 5. the number of times the moon rotates during one revolution around Earth

______ 6. where the light of the moon comes from

A. one

B. lunar month

C. 29½ days

D. 27⅓ days

E. phases

F. the sun

Practice

Use the list below to complete the following statements. **One or more terms will be used more than once.**

corona
lunar
lunar eclipse
partial
partial eclipse
penumbra
shadows
solar
solar eclipse
three or four hours
total
umbra

1. Eclipses are caused by the ____________________ cast by either moon or Earth as they pass by one another.

2. The part of a shadow that is cone-shaped and completely dark is the ____________________ .

3. The outer, partly shaded part of a shadow is called the ____________________ .

4. A ____________________ takes place when the moon passes in a straight line between the sun and Earth.

5. During a ____________________ eclipse of the sun, the moon totally blocks out the sun, and for a short time it becomes dark.

6. A halo of light from the sun's rim, called the ____________________ , can be seen around the edges of the moon during a total eclipse.

7. A ____________________ eclipse can be seen by more people than a ____________________ eclipse.

8. A ________________________ occurs when only part of the moon passes in front of the sun.

9. When the moon moves into Earth's shadow, we have a ________________________ .

10. During a lunar eclipse, hardly any sunlight reaches the moon, and it looks very dim for about ________________________ .

11. There are more ________________________ eclipses than ________________________ eclipses.

12. A ________________________ eclipse can be seen from more areas of Earth than a solar eclipse.

Practice

Answer the following questions using the **weather section** *of your* **local newspaper** *or the* **Internet***; then do the activity that follows.*

1. What time will the moon rise today? ____________________
2. What time will the moon set today? ____________________
3. On what date this month is there a full moon ? ____________
4. On what date this month is there a new moon? ____________
5. Go outside and observe the moon tonight after it rises. (Check the time in the newspaper.)
6. Fill out the information on the chart below, noting the date and time of your observation. Draw the shape of the moon that you saw. Use a compass or stationary landmark to determine the location of the moon.
7. Record the same information on the same night of the week for the next three weeks and record your findings.
8. Did your results correspond with the information the newspaper gave?

   Explain. ____

   ____

Date	Time	Shape	Location

Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. phase when the moon is between Earth and the sun; it cannot be seen because the dark side is facing Earth

______ 2. phase when the moon is on the opposite side of Earth from the sun; we see the entire lighted side

______ 3. phase just before and after the new moon; only a slice of the lighted side is seen

______ 4. phase when the moon is halfway between the new moon and full moon; we see one-half of the light side and one-half of the dark side

______ 5. phase just before and after the full moon; looks lopsided

______ 6. the path that the moon takes around Earth

A. crescent moon

B. full moon

C. gibbous moon

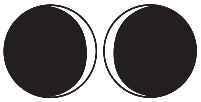
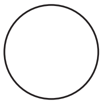
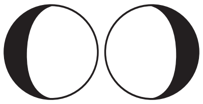
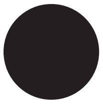
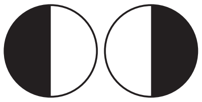
D. new moon

E. orbit

F. quarter moon

Practice

Name each **phase** *of the moon that is shown below. In the column on the right, tell where the moon is in* **relation** *to Earth and sun at each phase.*

		Phase	Position
1.		____________________	____________________ ____________________ ____________________ ____________________
2.		____________________	____________________ ____________________ ____________________ ____________________
3.		____________________	____________________ ____________________ ____________________ ____________________
4.		____________________	____________________ ____________________ ____________________ ____________________
5.		____________________	____________________ ____________________ ____________________ ____________________

Tides

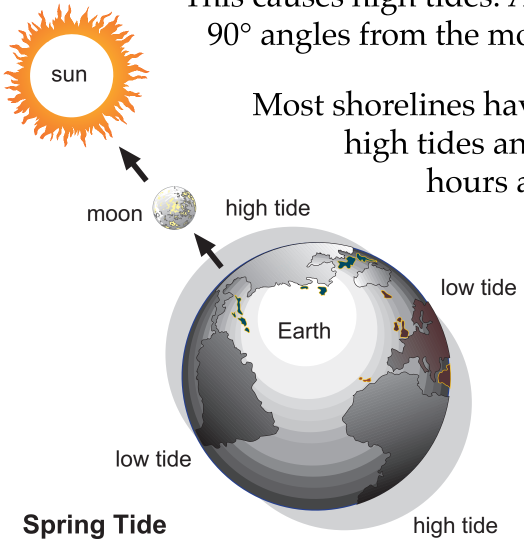
If you have gone to a beach and stayed a few hours, you probably have noticed that the ocean water does not stay at the same level. The water level of the ocean rises and falls at regular time periods. At certain times of the day the water is higher than at other times. This regular rise and fall of the ocean water is called *tides*.

The moon effects the tide more than the sun because it is so much closer to the Earth.

Tides are the movements of the ocean water caused by the gravitational attraction among the sun, Earth, and moon. Both the moon and sun affect the tides, but the moon's effect is greater than the sun's effect because it is so much closer.

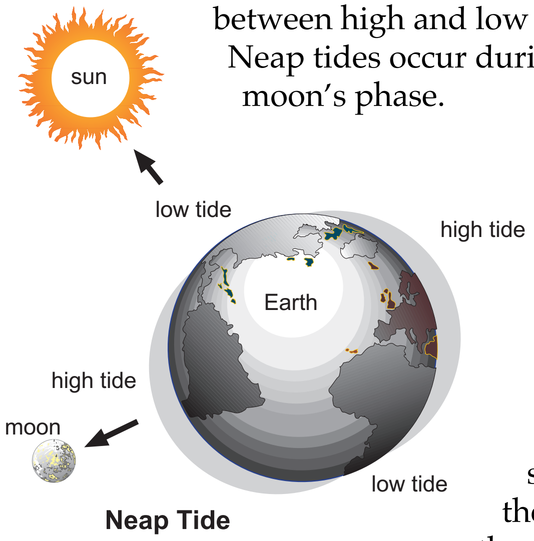
There are high tides and low tides. Tides do not change suddenly. High tides move in slowly. When the water reaches its highest level, it is called *high tide* or **flood tide**. Then, it slowly moves out until it reaches its lowest point called *low tide* or **ebb tide**. A low tide or *ebb* always follows a high tide or *flood tide*. The pull of the moon draws the water to the side of Earth closest to the moon and pushes it to the side of Earth opposite the moon. This causes high tides. At the same time, the side of Earth at 90° angles from the moon will have low tides.

Most shorelines have four tides every day. There are two high tides and two low tides. There are about six hours and 12 minutes between a high tide and a low tide. Twice every month the sun, moon, and Earth are all in a straight line. The combined gravitational pull of the sun and moon causes higher than average high tides and lower than average low tides. These are called **spring tides**. *Spring tides* occur during a full moon and a new moon.



Spring Tide

The moon, Earth, and sun are also at right angles (90°) twice a month. During this time, the gravity forces work against each other creating **neap tides**. During *neap tides*, the high tides are lower than normal and the low tides are higher than normal. Therefore, the difference between high and low tides is less during a neap tide. Neap tides occur during the first and third quarter of the moon's phase.



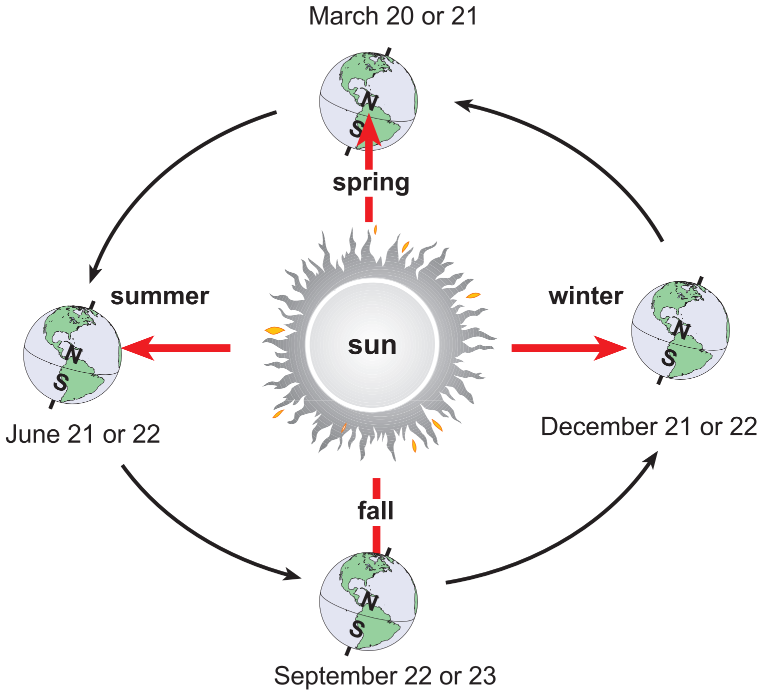
Neap Tide

There are usually two high tides and two low tides every 24 hours. Earth makes one turn on its axis in 24 hours. Meanwhile, the moon is also moving in its orbit around Earth. Earth must rotate 24 hours and 50 minutes before the moon returns to the same position overhead. The moon, then, has also moved. This results in the tides being 50 minutes later each day. For example, if it is high tide at 9:00 a.m. on Monday, the high tide will be at 9:50 a.m. on Tuesday. Low tides and high tides are about six hours apart. As Earth rotates, different locations on Earth pass through high and low tides.

Most locations in Florida experience two high tides and two low tides during a 24-hour period. This is called a *semidiurnal tide*. The heights of the high tides and low tides are about the same. Some places only experience a single high tide and a single low tide a day due to their location. This is a *diurnal tide*. Other places may experience mixed tides with varying heights of high and low tides during a 24-hour period.

Seasons

The *seasons* are the four divisions of the year characterized by differences in temperature, weather, and the number of hours of daylight. Seasons are caused by the tilt of Earth on its axis. Earth's tilt causes the duration of daylight hours to vary and the angle at which the sun's rays strike a given location to change as Earth makes its yearly revolution around the sun.



Seasons

Summer begins on June 21 or 22 in the Northern Hemisphere. During summer, the Northern Hemisphere is tilted toward the sun, and thus receives more direct rays. At the same time, the Southern Hemisphere is pointed away from the sun and receives the indirect rays of the sun. Therefore, it is winter in the Southern Hemisphere and summer in the Northern Hemisphere.

Winter begins on December 21 or 22 in the Northern Hemisphere, when it is tilted away from the sun. At the same time, the Southern Hemisphere is tilted towards the sun and is having summer.

Two times a year neither pole leans towards the sun. During these times Earth is in such a position in its orbit that its axis is neither tilted toward nor away from the sun. The vertical rays of the sun strike the equator. On these two days, called the *spring* or *fall* **equinox**, daylight and night hours are the same in both hemispheres. Day and night are 12 hours long everywhere on Earth.

On March 20 or 21, the spring equinox begins in the Northern Hemisphere. September 22 or 23, the fall *equinox*, is the beginning of fall. Again, the seasons are opposite in the Southern Hemisphere.

As the seasons change, the number of hours of daylight and darkness also changes. The first day of summer, June 21 or 22, has the greatest number of daylight hours and is called the *summer* **solstice**. The sun is the farthest north of the equator on this day because the North Pole is tilted most directly toward the sun.

After the summer *solstice*, daylight hours begin to decrease in the Northern Hemisphere until the winter solstice. Three months after the summer solstice comes the fall equinox. At that time, September 22 or 23, daylight and darkness are equal. Fall begins in the Northern Hemisphere, and spring begins in the Southern Hemisphere.

Daylight hours continue to decrease above the equator and increase below the equator until December 21 or 22, the winter solstice. The solstice has the least amount of daylight of the year and marks the beginning of winter in the Northern Hemisphere. At this time, the sun is the farthest south of the equator.

After the spring equinox, daylight hours continue to increase in the Northern Hemisphere until the summer solstice—the longest day.

After the winter solstice, days continue to grow longer in the Northern Hemisphere until the summer solstice. Three months after the winter solstice comes the spring equinox. On that day, Earth's axis leans neither toward nor away from the sun, and day and night are equal in both hemispheres. March 20 or 21 is the beginning of spring north of the equator and the beginning of fall in the Southern Hemisphere.

After the spring equinox, daylight hours continue to increase in the Northern Hemisphere until the summer solstice—the longest day. At this time, the cycle of the seasons begins again.

At the equator, the number of hours of daylight is always the same as the number of hours of darkness. As you move towards the poles, the hours become more uneven. The tilt of Earth on its axis causes the polar areas to have uneven hours of daylight and darkness. The poles have 24 hours of daylight in summer and 24 hours of darkness during the winter.

Summary

Our moon is very different from Earth. While the moon rotates on its axis and revolves around Earth, Earth revolves around the sun. These three heavenly bodies create different shadows as they change positions. At certain times these shadows result in eclipses—lunar, solar, or total. As the moon rotates and revolves, different portions of the lighted side are visible from Earth. As a result, the moon appears to change its shape, or go through phases. The moon's gravitational pull on Earth (as well as the sun's) causes our changing ocean tides.

Our moon is very different from Earth.

Practice

Use the list below to write the correct term for each definition on the line provided.

ebb tide
equinox
flood tide
neap tide
solstice
spring tide

____________________ 1. tide that occurs when the sun, moon, and Earth are in a straight line

____________________ 2. tide occurring at the first and third quarters of the moon when the sun, Earth, and moon form a right angle; produces tides in a medium range

____________________ 3. either of the two times of the year when the number of hours of daylight and darkness are the same in both hemispheres; marks the first day of spring and fall; means *equal night*

____________________ 4. the tidal current associated with the increase in the height of the tide

____________________ 5. either of the two times a year when the sun is at its greatest apparent distance north or south of the equator; marks the first day of *summer* and *winter*

____________________ 6. the movement of a tidal current away from the shore

Practice

Use the information about the **high** *and* **low tides** *of a specific location from the* **local newspaper** *or* **Internet** *to fill out the chart below for three consecutive days. Record the* **high** *and* **low tides** *for each date. Be sure to use the* **same** *location each time!*

Date	High (a.m.)	Low (a.m.)	High (p.m.)	Low (p.m.)

Use the **local newspaper** *to answer the following using short answers.*

1. When is the next first-quarter moon? ______________________________
2. When is the next full moon? ______________________________________
3. When is the next third- or last-quarter moon? ____________________
4. When is the next new moon? _______________________________________
5. On what dates would you expect to find a spring tide? __________

   ____
6. On what dates would you expect to find a neap tide? ___________

   ____
7. How much later is the evening high tide than the morning high tide on your first day of observation? ______________________________

   ____

8. How much later is the morning high tide the second day than the first day? ______________________________

9. Do the high and low tides occur at the same time on all the Florida beaches? ______________________________

   How do you know? ______________________________

   ____

   ____

   ____

10. Name two reasons why you might want to know when the tides will be high and low. ______________________________

    ____

    ____

    ____

    ____

    ____

    ____

    ____

Practice

Answer the following using complete sentences.

1. Define tides. ____

   ____

   ____

   ____

2. How many high tides are there normally in a 24-hour period? ___

   How many low tides? ________________________________

3. Does the sun or moon have a greater gravitational pull on our ocean

   waters? ____

   Why? ____

   ____

   ____

   ____

4. What kind of tides do we have when the sun, Earth, and moon are

   all in a straight line? _________________________________

5. When do spring tides occur? ___________________________

   ____

6. When do neap tides occur? ____________________________

   ____

7. Describe the ocean water level during a spring tide. ____________

____

____

8. How are the sun, moon, and Earth lined up during a neap tide?

____

____

9. Do the sun and moon's gravitational forces work together or against each other during a neap tide? ________________________________

____

10. During which type of tide is the difference between high and low tide the greatest? ____

11. If there is a high tide at 10:00 p.m. one night, at what time will the high tide be the next night? ________________________________

12. Why are the high tides and the low tides a few minutes later each day? ____

____

____

____

____

____

____

Practice

Answer the following using complete sentences.

1. In what three ways do the seasons differ from each other? ______

   ____

   ____

2. What causes Earth to have seasons? ____________________________

   ____

3. Which way is Earth tilted when the Northern Hemisphere is

   having summer? ____

4. Which way is Earth tilted when the Northern Hemisphere is

   having winter? ____

   ____

   ____

5. Do both hemispheres have the same seasons at the same time? __

   Why or why not? ____

   ____

   ____

6. When are the sun's rays pointed directly over the equator instead

   of at one of the poles? ____

   ____

7. What is it called when the sun is farthest north of the equator?

____

8. What else happens at this point mentioned in question 7? _______

____

9. What is it called when the number of hours of daylight and darkness are the same? ______________________________

10. The equinox also marks the first day of what two seasons? ______

____

11. Where on Earth are the length of the days and nights always the same? ______________________________________

12. What parts of Earth have 24 hours of daylight in the summer and 24 hours of darkness in the winter? __________________

____

13. What seasons begin on the following dates in the Northern Hemisphere?

June 21 or 22: ____________________________________

December 21 or 22: ________________________________

March 20 or 21: ___________________________________

September 22 or 23: _______________________________

Practice

Circle the letter of the correct answer.

1. The path of an object revolving around another object is a(n) ____________ .

    a. eclipse
    b. atmosphere
    c. rotation
    d. orbit

2. An oval-shaped path of one object that revolves around another object is a(n) ____________ orbit.

    a. elliptical
    b. revolution
    c. eclipse
    d. rotation

3. Earth ____________ or spins on its axis, causing day and night.

    a. rotates
    b. revolves
    c. orbits
    d. craters

4. The rise and fall of the oceans caused by the gravitational attraction between sun, Earth, and moon is a(n) ____________ .

    a. eclipse
    b. crater
    c. tide
    d. highland

5. Either of the two times of the year when the number of hours of daylight and darkness are the same in both hemispheres is called a(n) ____________ .

    a. continental climate
    b. ozone
    c. equinox
    d. marine climate

6. The __________ is either of the two times a year when the sun is at its greatest distance north or south of the equator; it marks the first day of summer and winter.

   a. tropical zone
   b. polar zone
   c. temperate zone
   d. solstice

7. An event which occurs when the moon passes between Earth and the sun is a(n) __________ .

   a. atmosphere
   b. lunar eclipse
   c. solar eclipse
   d. highland

8. An event which occurs when Earth blocks the light as it moves between the sun and the moon is a(n) __________ .

   a. atmosphere
   b. solar eclipse
   c. highland
   d. lunar eclipse

9. The light areas on the moon which are mountain ranges and large craters are called __________ .

   a. orbits
   b. maria
   c. highland areas
   d. revolutions

10. The dark areas on the moon which are the lunar seas or plains are called __________ .

    a. highlands
    b. craters
    c. revolutions
    d. maria

11. The holes or bowl-shaped depressions on a moon or planet are ____________ .

    a. moon phases
    b. maria
    c. highlands
    d. craters

12. The four divisions of the year characterized by differences in weather and the number of hours of daylight are called ____________ .

    a. temperate zones
    b. polar zones
    c. marine climates
    d. seasons

13. The moon ____________ around Earth.

    a. revolves
    b. rotates
    c. marie
    d. craters

14. The tide that occurs when the sun, moon, and Earth are in a straight line is called a(n) ____________ .

    a. ebb tide
    b. flood tide
    c. spring tide
    d. neap tide

15. The tide that occurs at the first and third quarters of the moon, when sun, Earth, and moon form a right angle, is called a(n) ____________ .

    a. ebb tide
    b. flood tide
    c. spring tide
    d. neap tide

16. The changing appearance of the moon which depends on the moon's position relative to the sun is the ___________ .

    a. lunar month
    b. moon phase
    c. partial eclipse
    d. penumbra

17. The measure of time it takes for the moon to pass from one new moon to the next (29½ days) is a ___________ .

    a. highland
    b. revolution
    c. lunar month
    d. moon phase

Unit 14: Space Exploration

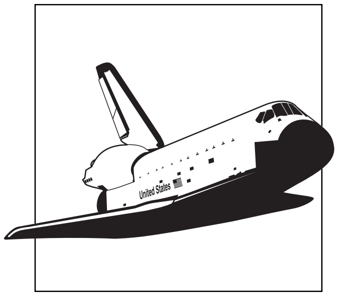
This unit scans developments in astronomy, from the early astronomers to instruments astronomers currently use in collecting information about space.

Student Goals

- Research astronomers of the past.
- Examine how information about Earth and space are gathered.
- Explore Internet sites to gain knowledge about space missions or satellites.
- Know that funds for science research come from the federal government, industry, and private foundations.

Unit Focus

- Understand that no matter how well one theory fits observations, a new theory might fit them as well or better, or might fit a wider range of observations, because in science, the testing, revising, and occasional discarding of theories, new and old, never ends and leads to an increasingly better understanding of how things work in the world, but not to absolute truth. (SC.H.1.4.3)
- Know that technological problems often create a demand for new scientific knowledge and that new technologies make it possible for scientists to extend their research in a way that advances science. (SC.H.3.4.2)
- Know that funds for science research come from federal government agencies, industry, and private foundations and that this funding often influences the areas of discovery. (SC.H.3.4.4)



Vocabulary

Use the vocabulary words and definitions below as a reference for this unit.

artificial	human-made
astronaut	a person who flies in a rocket or space shuttle
astronomer	one who studies astronomy or makes observations of celestial phenomena
astronomy	the science of celestial bodies and their properties
communications satellite	a satellite that receives, amplifies, and relays signals
cosmic ray	ray of very short wavelength and great power that hits Earth from beyond its atmosphere
detector	device for indicating the presence of a certain substance
geocentric	Earth-centered
heliocentric	sun-centered
lunar	of or relating to the moon; designed for use on the moon

NASA	the abbreviation for the National Aeronautics and Space Administration
orbiter	a spacecraft designed to orbit a celestial body without landing on its surface
payload	the load carried by a spacecraft
satellite	an object that revolves around a larger object
solar system	the sun and all the planets, their moons, asteroids, meteors, and comets; all objects that move around the sun
space probes	rocket-launched vehicles that carry instruments, cameras, and other data-gathering equipment for deep-space measurements
space shuttle	a reusable spacecraft that carries astronauts into space and returns them to Earth
space stations	living quarters in space, equipped with all the necessary instruments to work and live
telecommunication	communication over a distance
telescope	instrument for making distant objects appear larger and therefore nearer; may use lenses, mirrors, or an antenna

transmitter	instrument that sends signals from one place to another
transponders	devices used on satellites for receiving, amplifying, and re-broadcasting signals to the Earth
universe	all bodies in space and all space between these bodies—all matter and all energy
weather satellites	satellites that continuously monitor weather conditions

Introduction

As early as 500 B.C., **astronomy**—the science or study of celestial bodies and their properties—was practiced by scholars. Pythagoras (500 B.C.), a Greek philosopher and mathematician, was observing Earth's shadow on the moon when he concluded that the Earth must be a sphere. Around 200 B.C., Eratosthenes, a Greek **astronomer**, (276-195 B.C.) used geometry to estimate the *circumference*, or distance around the Earth. Eratosthenes also measured the tilt of the Earth's axis, 23.5 degrees, which causes the *seasons*.

Eratosthenes (276- 195 B.C.) used geometry to estimate the circumference of the Earth.

These scholars used crude instrumentation to seek the answers about the Earth and beyond. The invention of the **telescope** around 1600 led to more discoveries. Although he did not invent the *telescope*, Galileo Galilei (1564-1642), an Italian *astronomer*, introduced the use of the telescope for *astronomy* in 1609. Today's technology and sophisticated instrumentation have allowed us to go far beyond the early astronomers in the study of our celestial neighborhood.

Origins of Astronomy

Humankind has always been interested in the skies or *heavens*. Many early civilizations (including the Egyptians and Babylonians) recorded their observations and ideas on astronomy. The early Greeks are credited with many discoveries. Aristotle, a Greek who lived about 500 B.C., believed that everything in the sky revolved around Earth. This is known as the **geocentric** *theory*. The Greeks proposed the first models of the **universe**. In one of these first models, Ptolemy (2nd century A.D.) also supported the *geocentric* view that Earth was the stationary center of the *universe*—a view popular at that time.

The Polish astronomer Nicholas Copernicus (1473–1543) was one of the first to challenge that view. He proposed that Earth was a planet, like the other five known planets, and that it revolved around the sun—the center of the universe. This is known as the **heliocentric** *theory*.

Later astronomers, such as Tycho Brahe (1546-1601), collected data to attempt to disprove this controversial theory. In the early 1600s a German astronomer, Johannes Kepler (1571-1630) used this data to support the Copernican theory. Kepler also proposed three laws that described the movement of the planets.

Probably the most well known of the early astronomers is the Italian astronomer Galileo Galilei. He is considered the *father of modern astronomy*. Galileo built his own telescopes and made many astronomical observations. He discovered the first four moons of Jupiter, the rings of Saturn, sunspots, and he studied the craters of our moon. Galileo was persecuted for his views. He held that the sun was the center of our **solar system**. For holding this *heliocentric* theory, he was sentenced to house arrest for the last 10 years of his life.

Even before Galileo first pointed his telescope skyward, people were interested in the movements of the sun, moon, and stars. The moon is perhaps the most studied celestial object. The first astronomical phenomenon to be understood was the cycle of the moon. Today we know that cycle as the phases of the moon. The early Greek scholars realized that *solar eclipses* were simply the obscuring of the sun as the moon passes directly between Earth and the sun.

Today we are able to gather information about the *solar system* through the use of **space probes**. *Space probes* are rocket-launched vehicles that carry instruments and equipment used to gather and record data in deep space. These probes have a radio system to send pictures and information to Earth.

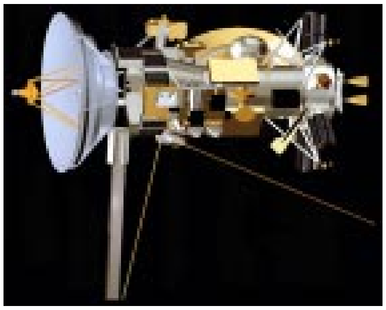
Today we are able to gather information about the solar system through the use of space probes.

The first American space probe was launched on January 31, 1958 and was known as Explorer I. It had a Geiger counter to detect **cosmic rays**. This was the first of the Explorer probes. Over 70 of them were launched. The Pioneer spacecrafts were the first to travel through the asteroid belt and study the planets. Pioneer 10 was launched on March 2, 1972 and is now over eight billion miles away in the Kuiper Belt. Other space probes have included Mariner 1-10, Viking 1 and 2, and Voyager 1 and 2. Voyager 1 is now the most distant human-made object in the solar system. The Deep Space Network (DSN) supports Voyager 1 and 2. The Voyager spacecrafts, though launched in 1975, are still heading out of our solar system.

Space probes are rocket-launched vehicles that carry instruments and equipment used to gather and record data in deep space.

Launched in 1989, the Galileo spacecraft traveled more than four and a half billion kilometers (nearly three billion miles). It circled Jupiter 34 times, sending back 14,000 pictures and other data over the course of seven years, crashing into Jupiter in September 2003. The Cassini-Huygens mission to Saturn was launched in October of 1997. After gravity assists from Venus, Earth, and Jupiter, Cassini arrived at Saturn on July 1, 2004.

The MErcury Surface, Space, ENvironment, GEochemistry, and Ranging (MESSENGER) mission was launched from Cape Canaveral, Florida in August 2004. MESSENGER will be in position to enter Mercury orbit in March 2011. During flybys set for January 2008, October 2008, and September 2009, MESSENGER will map nearly the entire planet in color; image most of the areas unseen by Mariner 10; and measure the composition of the surface, atmosphere, and magnetosphere. It will be the first new data from Mercury in more than 30 years.



The Cassini-Huygens mission to Saturn was launched in October of 1997.

Practice

Use the list below to complete the following statements.

astronomer
astronomy
comic rays
geocentric theory
heliocentric theory
space probes
telescope

1. As early as 500 B.C., ____________________—the science or study of celestial bodies and their properties—was practiced by scholars.

2. Eratosthenes, a Greek ____________________ , used geometry to estimate the circumference of the Earth.

3. The invention of the ____________________ around 1600 led to more discoveries about space.

4. Aristotle, a Greek who lived about 500 B.C., believed that everything in the sky revolved around Earth. This idea is known as the ____________________ .

5. Copernicus proposed that Earth was a planet, like the other five known planets, and that it revolved around the sun—the center of the universe. This is known as the ____________________ .

6. ____________________ are rocket-launched vehicles that carry instruments and equipment used to gather and record data in deep space.

7. Explorer I had a Geiger counter to detect ____________________ .

Practice

Use library **reference materials** *to answer the following.*

1. What were the major scientific accomplishments of the following astronomers?

Pythagoras (500 B.C.): ______________________________________

____

____

Ptolemy (2nd century A.D.): __________________________________

____

____

Copernicus (1473-1563): ____________________________________

____

____

Kepler (1571-1630): ____

____

____

Galileo (1564-1642): _______________________________________

____

____

2. Describe how space probes are used. ____________________

____

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____

3. Name three space probes and give two facts about each space probe. ____

____

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Practice

Write **True** *if the sentence is correct. Write* **False** *if the sentence is* not *correct.*

__________ 1. Galileo was a Greek philosopher who believed that Earth was the stationary center of the universe.

__________ 2. The Polish astronomer Nicholas Corpernicus proposed that Earth was a planet and that it revolved around the sun.

__________ 3. Eratosthenes, a Greek astronomer, estimated the circumference of Earth.

__________ 4. Pythagoras, an Italian astronomer, built his own telescopes.

__________ 5. Galileo discovered the first four moons of Jupiter.

__________ 6. Johannes Kepler supported the Copernican theory and developed his own laws of planetary motion.

__________ 7. The first astronomical phenomenon to be understood was the cycle of Earth.

__________ 8. Today we are able to gather information about the solar system through the use of space probes.

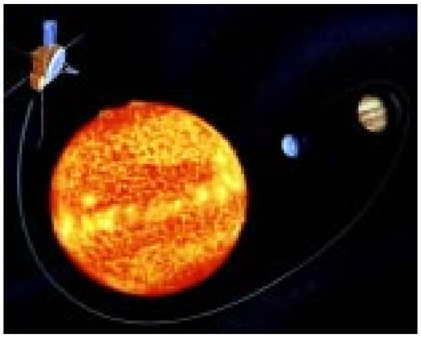
__________ 9. The first American space probe was launched on January 31, 1958 and was known as Explorer I.

_________ 10. The Voyager spacecrafts, launched in 1975s, only lasted two years in space.

_________ 11. A solar eclipse is the obscuring of the sun as the moon passes directly between Earth and the sun.

Gathering Information about Earth and Space

Artificial satellites and unmanned rockets have been used to pave the way for our travel into space. Unmanned rockets are powered by controls from stations on Earth. The direction, location, and speed of the rockets are controlled by using special computer or radio signals. A number of *artificial* **satellites** have been launched into space. Many of them receive and send radio and television signals which have improved worldwide communications. Other types of *satellites* include remote sensing, navigation, search and rescue and reconnaissance.



Unmanned rockets are powered by controls from stations on Earth.

It is difficult to go through a day without using a **communications satellite** at least once. Do you know when you used a *communications satellite* today? Did you watch television? Did you make a long-distance phone call, use a cellular phone, a fax machine, a pager, or even listen to the radio? Well, if you did, you probably used a communications satellite, either directly or indirectly.

Communications satellites allow radio, television, and telephone transmissions to be sent live anywhere in the world. Before satellites, transmissions were difficult or impossible at long distances. The signals, which travel in straight lines, could not bend around the round Earth to reach a destination far away. Because satellites are in orbit, the signals can be sent instantaneously into space and then redirected to another satellite or directly to their destination.

Satellites can have a passive role in communications. For example, satellites can be used just to bounce signals from the Earth back to another location on the Earth. Other satellites play a more active role. They carry electronic devices called **transponders** and can receive, amplify, and re-broadcast signals to the Earth.

The first **telecommunication** satellite launched in 1960 was called the Echo I. It was a plastic balloon with a thin aluminum coating. This coating was much like a mirror—it reflected light and radio waves. The Echo I was used to relay or reflect telegrams, telephone calls, and pictures back to

Earth, crossing oceans and continents. Television pictures are relayed the same way. (The prefix *tele-* means *at or from a distance*.)

Communications satellites are now used by many nations. The Intelsat—the world's largest satellite system—has 102 member nations and 250 ground stations. This satellite system provides a 240 channel link between the United States and Europe. The Intelsat system was used by the United States to relay the landing of *Apollo 11* on the moon. It is also used for the transmission of telephone, educational, medical, and other types of communication. More and more satellites are being placed in orbit as we expand our use of *telecommunications* (cell phones, beepers, satellite television, and the Internet). Many companies and agencies now have their own satellites, and personal satellites are not far off in the future.

The Intelsat system was used by the United States to relay the landing of Apollo 11 *on the moon.*

Three lunar probes took pictures of the moon that helped scientists choose a spot for the Apollo *moon landing.*

Lunar probes have included Clementine and the Lunar Prospector mission. On December 3, 1996, it was announced that data acquired by the Clementine spacecraft indicated that there was ice in the bottom of a crater on the moon. The Lunar Prospector mission to the moon was launched in fall of 1997. The mission ended on July 31, 1999, when the spacecraft was directed to crash into a crater near the moon's south pole as part of an experiment to confirm the existence of water ice on the moon.

Space flights have been made safer because of the information gathered by these satellites and rockets. The *Mercury* space capsule provided scientists with data and experience in space flight itself. The *Gemini* space capsules provided **astronauts** with experience in controlling spacecrafts and working in space. Vehicles docked in space while the *astronauts* walked in space. The three **lunar** probes—Ranger, Lunar Orbiter, and Surveyor—took pictures of the moon that helped scientists choose a spot for the *Apollo* moon landing. The

Surveyor probe actually landed on the moon, giving scientists an abundance of valuable information.


astronaut walking in space

In the 18th century, scientists used hot-air balloons to measure weather conditions. Today, we have more than 8,000 weather stations around the world that make observations about our weather conditions. Reports are made by airplane pilots, ships at sea, and radar stations. Satellites are also used to monitor our weather. They are able to observe Earth's oceans and other areas where there are no weather stations. The **weather satellites** send back pictures that show how weather changes from hour to hour. These pictures help us to follow large weather patterns, and they improve the accuracy of our weather predictions. Television stations show daily satellite pictures of weather patterns.

Global Positioning Systems (GPS), which are now in cell phones, are space-based radio positioning systems that provide 24-hour three-dimensional position, velocity, and time information to users anywhere on or near the surface of Earth. These measurements are used for critical navigation applications. The Navigation Signal Timing and Ranging (NAVSTAR) system, operated by the United States Department of Defense, is the first GPS system available for nonmilitary uses. GPS is currently available in some cars and for marine navigation systems. GPS is also used to measure the movements of Earth's crust, to track the weather, and to help locate earthquakes.

By combining GPS with computer mapping techniques, we will be better able to identify and manage our natural resources. Intelligent vehicle location and navigation systems will let us find more efficient routes to our destinations, saving millions of dollars in gasoline costs and also preventing the cause of tons of air pollutants. Travel aboard ships and aircraft will be safer in all weather conditions.

Practice

Use the list below to write the correct term for each definition on the line provided.

artificial
astronaut
communications satellite
lunar
satellite
telecommunication
transponder
weather satellites

____________________ 1. an object that revolves around a larger object

____________________ 2. communication over a distance

____________________ 3. human-made

____________________ 4. a person who flies in a rocket or space shuttle

____________________ 5. of or relating to the moon; designed for use on the moon

____________________ 6. satellites that continuously monitor weather conditions

____________________ 7. a satellite that receives, amplifies, and relays signals

____________________ 8. device used on satellites for receiving, amplifying, and re-broadcasting signals to the Earth

Practice

Write **True** *if the sentence is correct. Write* **False** *if the sentence is* not *correct.*

__________ 1. A lunar probe is a special instrument designed to be launched into space to gather information about the moon.

__________ 2. *Apollo* and *Gemini* were probes sent into space to make direct observations of our solar system.

__________ 3. The only way to study the moon is indirectly by instrumentation.

__________ 4. Unmanned rockets are powered by controls from stations on Earth.

__________ 5. The first telecommunication satellite launched in 1960 was called the Echo I.

__________ 6. The three lunar probes were Cowboy, Sunshine Orbiter, and Democracy.

__________ 7. Today, we have more than 8,000 weather stations around the world that make observations about our weather conditions.

__________ 8. The weather satellites can only send back pictures that show how weather changes every three days.

__________ 9. Global Positioning Systems (GPS) are space-based radio positioning systems that provide 24 hour three-dimensional position, velocity, and time information to users anywhere on or near the surface of Earth.

_________ 10. By combining GPS with computer mapping techniques, we will be better able to identify and manage our natural resources.

Sources Used to Collect Information

The collection of information about Earth and space requires the use of some very specialized equipment. The satellites used for information collection often have much of this specialized equipment built into them. The *weather satellites* that send information to Earth about the weather can take pictures of cloud covers. Hurricanes can be tracked, allowing enough time to give hurricane warnings. Temperature **detectors** help us learn how temperature changes at different heights in the atmosphere. *Cosmic ray detectors* gather information about cosmic radiation, which is harmful to people. To collect scientific data, microphones are mounted on the satellite to record the sound of meteors hitting the satellite. These recordings give scientists information for improving satellites and increasing knowledge of meteors.

In the development of the space program for the United States, the National Aeronautics and Space Administration (**NASA**) agency has used manned space travel to gather information about Earth and space. The early missions of the *Apollo* spacecraft provided data and practice for landing on the moon. Subsequent landings on the moon provided over 2,000 samples of moon rock for study. Television cameras aboard today's spacecraft send pictures of the moon, Earth, and other planets back to scientists on Earth.

Once the Apollo program was completed, *NASA* felt it was necessary to develop a reusable spacecraft. This led to the new era of human space travel aboard the reusable spacecraft known as the **space shuttle**. The *space shuttle* consists of an **orbiter**, two solid rocket boosters, and a liquid fuel tank. The shuttle allows technological research in the microgravity environment of an orbit and serves as a vehicle in which to transport astronauts, materials, satellites, and other **payloads**. Astronauts take animals into space to test the effects of microgravity on their physiology. Additionally, astronauts themselves are studied to see how space flight affects a

NASA developed a reusable spacecraft know as the space shuttle.

person's breathing, heart action, muscle tension, body temperature, and other physiological functions. The shuttle carries such *payloads* as communications satellites, telescopes, special scientific experiments, and scientific equipment to be placed in orbit. The shuttle also serves as a transport vehicle to bring astronauts to and from the International Space Station. After each mission is completed, the *orbiter* glides back to Earth and lands like an airplane glider. The two solid rocket boosters are jettisoned off at take-off and land in the Atlantic Ocean to be retrieved and reused. Radio **transmitters** are used to send information to receiving stations on the ground. Antennas detect all kinds of radiation around the spacecraft.

The shuttle is a vehicle which can transport astronauts, materials, satellites, and other payloads.

The United States and Russia have also launched **space stations** with living quarters, work space, and all the equipment and systems necessary for astronauts to work and live. The *space stations* carry telescopes, cameras, computers, and anything needed for research projects.

America's first experimental space station was called Skylab, which was designed for long missions. Skylab had three manned missions from 1973-1974. The Skylab program objectives were to prove that humans could live and work in space for extended periods and to expand our knowledge of solar astronomy. It was the site of nearly 300 scientific and technical experiments: medical experiments on humans' adaptability to zero gravity, solar observations, and detailed Earth resources experiments.

America's first experimental space station was called Skylab.

The first phase of the International Space Station, the Shuttle-Mir Program, began in 1995 and involved more than two years of continuous stays by astronauts and cosmonauts (Russian astronauts) aboard the Russian Mir Space Station and nine Shuttle-Mir docking missions. Knowledge was gained in technology, international space operations, and scientific research. Currently, the International Space Station orbits the Earth. Led by the United States, this space program draws upon the scientific and technological resources of 16 nations including the United States, Canada, Japan, Russia, 11 nations of the European Space Agency, and Brazil. With a permanent human presence in space aboard the International Space Station, there will be new advances in space technology, and a chance for different scientific fields to test new theories and complete experiments in microgravity.

On Earth, all telescopes are used to concentrate signals received from space. Some telescopes use mirrors or lenses to concentrate light waves to view images of planetary objects. Other telescopes, called *radio telescopes*, use large reflecting dishes and antennas to receive radio waves. From the ground, scientists study Earth and space indirectly, through telescopes or planetary probes that gather important information about other planets and send this information back to Earth.

The Hubble Space Telescope is designed to see 10 times more clearly into space than other Earth-based telescopes; it can detect objects one-billionth as bright as the human eye can see. The Hubble telescope circles Earth every 97 minutes, 370 miles (595 kilometers) above the atmosphere. Designed to last 15 years and be serviced every three years, the 43-foot Hubble was put into orbit and began transmitting data back to Earth in 1990. An international project, the telescope contains equipment developed by the European Space Agency and a variety of United States institutions.

The Hubble telescope circles Earth every 97 minutes, 370 miles (595 kilometers) above the atmosphere.

The Hubble telescope's primary mirror (the benchmark by which telescopes are measured) is relatively small at 94.5 inches wide (2.4 meters). A flaw in the mirror was corrected in 1993, and the Hubble has performed remarkably well since then.

The telescope is so sensitive that it can detect the equivalent of a flashlight beam from 250,000 miles away—the distance from Earth to the moon. Since the telescope is located beyond Earth's atmosphere, the telescope can receive ultraviolet and infrared light that doesn't reach Earth's surface.

The Hubble telescope has already given scientists new glimpses into the universe.

The Hubble Space Telescope can be pointed anywhere in space except close to the sun, moon, or Earth's lighted side as the light is simply too bright for its sensitive instruments. Two antennas send out data and receive instructions from the ground via NASA's Tracking and Data Relay Satellite System. A receiving antenna is located in White Sands, New Mexico. The scientific data is then transmitted to other sites. The Hubble telescope has already given scientists new glimpses into the universe from discovering new galaxies to witnessing the formation of a black hole. It will be a useful tool for future scientific discoveries. The Hubble Ultra Deep Field (HUDF) has identified what may turn out to be some of the earliest star-forming galaxies. A good web site to view Hubble images is <http://hubble.stsci.edu/gallery/showcase/text.shtml>.

NASA Research

Although many of us are unaware of them, the NASA space program has had far-reaching effects that touch our daily lives. Technologies developed for the space program have been transferred to uses that are quite different from their original applications. These transferals have had an impact on many areas of life.

In the area of space research, NASA's technologies have created safer space travel for astronauts, provided more accurate information about the solar system, and improved command missions where unmanned satellites can probe space and gather important information. Any dangerous effects of space travel on astronauts are outweighed by the information that NASA is able to gather and put to use. This includes the remote possibility of finding homes for people on other planets.

Communication is another area in which the transferal of technologies has benefitted our everyday lives. Worldwide communications (television and radio) have been greatly improved and continue to improve daily. Our accuracy in forecasting the weather has increased. There are improved warning systems for dangerous storms.

These technologies have improved our military capabilities. While research has provided us with better defenses against foreign invasion, it has also created a nuclear power race among the more powerful countries.

NASA's technologies have created safer space travel for astronauts.

The many research projects must be funded in some way. Funds for science research come from federal government agencies, industry, and private foundations. Many taxpayers object to the expenditure of the billions of tax dollars that are necessary to complete the research projects. It is difficult, however, to dispute the technological advances that have been made in the United States since our decision to explore that great space beyond our Earth.

Summary

People have been interested in studying the sky and celestial bodies since the earliest times. Observations have been recorded since 500 B.C. Our ideas about the universe changed as discoveries were made by scientists such as Copernicus and Galileo. Today, through research conducted by NASA using sophisticated technology, scientists can gather firsthand information. Astronauts travel safely in space shuttles and collect data from space stations. More distant parts of the universe can be studied with probes and satellites. The technological advances in communication and other areas have benefited us in many ways.

Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. living quarters in space, equipped with all the necessary instruments to work and live

______ 2. device for indicating the presence of a certain substance

______ 3. instrument that sends signals from one place to another

______ 4. the abbreviation for the National Aeronautics and Space Administration

______ 5. a reusable spacecraft that carries astronauts into space and returns them to Earth

______ 6. a spacecraft designed to orbit a celestial body without landing on its surface

______ 7. the load carried by a spacecraft

A. detector

B. NASA

C. orbiter

D. payload

E. space shuttle

F. space stations

G. transmitter

Practice

Use the list above each section to complete the statements in that section.

detectors
NASA
orbiter
satellite system
transmitters
weather satellites
weather stations

1. Today, there are more than 8,000 ________________________ around the world that make observations about our weather conditions.

2. ________________________ send back pictures that show weather changes from hour to hour.

3. The Intelsat is the world's largest ________________________ , and it has 102 member nations.

4. ________________________ are built into satellites to learn how temperature changes at different heights.

5. ________________________ are used to send information to receiving stations on the ground.

6. After completing a mission, the main portion of the four-element shuttle system, the ________________________ , glides back to Earth and lands.

7. In the development of the space program for the United States, ________________________ uses manned space travel to gather information about Earth and space.

funds
planetary probes
space stations
taxpayers
telescopes

8. ____________________ carry telescopes, cameras, computers, and anything needed for research projects.

9. On Earth, ____________________ are used to concentrate information signals received from space.

10. From the ground, scientists study Earth and space more indirectly through telescopes or ____________________ that gather important information about other planets and send this information back to Earth.

11. Many ____________________ object to spending billions of tax dollars to complete research projects, but the technological advances in communication and other areas have benefitted us in many ways.

12. ____________________ for science research come from federal government agencies, industry, and private foundations.

Lab Activity: Exploring Space

Use the Internet to research a mission to explore space.

Fact:

- Through research conducted by NASA using sophisticated technology, scientists can gather firsthand information.

Investigate:

- You will use the Internet to research a mission to explore space.

Materials:

- reference material
- Internet access

Use the list of **Internet sites** *below and other* **reference materials** *to complete this activity.*

Internet Sites:

NASA Web Site
http://www.nasa.gov/home/index.html

NASA Space Shuttle Web Site
http://spaceflight.nasa.gov/shuttle

NASA International Space Station
http://spaceflight.nasa.gov/station/index.html

NASA Classroom of the Future
http://www.cotf.edu/

NASA Observatorium
http://observe.arc.nasa.gov/nasa/core.shtml.html

NASA Observatorium Human Spaceflight
http://observe.arc.nasa.gov/nasa/spacefly/spacefly_index.shtml.html

NASA's Shuttle and Rocket Missions
http://www.nasa.gov/centers/kennedy/missions/schedule.html

Kennedy Space Center
http://www.ksc.nasa.gov/

Project Gemini
http://nkma.ksc.nasa.gov/history/gemini/gemini.html

Project Mercury
http://history.nasa.gov/SP-4003/ch7-2.htm

Eye on the Universe—A Hubble Mission
http://www.thetech.org/hyper/hubble/

Star Journey from National Geographic
http://nationalgeogrpahic.com/features/97/stars/

Space Telescope Science Institute
http://www.stsci.edu/

Satellite Passes—shows positions of current satellites and orbiters over the United States
http://www.bester.com/satpasses.html

GOES Project Science
http://goespoes.gsfc.nasa.gov/

The Satellite Site—What is a satellite? Build one on the Internet.
http://www.thetech.org/hyper/satellite/

Hubble images
http://hubble.stsci.edu/gallery/showcase/text.shtml

1. Name of the space mission or satellite: ______________________

2. Date of mission: ____

3. Major purpose: ____

4. Scientific discoveries made by exploration: ____________________

____

____

5. Why was this mission helpful to the exploration of space and future discoveries? ____

____

____

____

Practice

Circle the letter of the correct answer.

1. An object that revolves around a larger object is a ____________ .

   a. space shuttle
   b. space station
   c. transmitter
   d. satellite

2. The abbreviation for the National Aeronautics and Space Administration is ____________ .

   a. NASA
   b. NAAA
   c. NATA
   d. ASA

3. Rocket-launched vehicles that carry instruments, cameras, and other data-gathering equipment for deep-space measurements are called ____________ .

   a. space probes
   b. space shuttles
   c. detectors
   d. cosmic rays

4. ____________ are living quarters in space, equipped with all the necessary instruments to work and live.

   a. Space shuttles
   b. Satellites
   c. Space probes
   d. Space stations

5. A ____________ is a reusable spacecraft that carries astronauts into space and returns them to Earth.

   a. satellite
   b. space probe
   c. space shuttle
   d. space station

6. __________ is communication over a distance.

a. Telecommunication
b. NASA
c. Astronaut
d. Cosmic rays

7. A person who flies in a rocket or space shuttle is a(n) __________ .

a. satellite
b. cosmic ray
c. astronaut
d. detector

8. __________ are rays of very short wavelength and great power that hit Earth from beyond its atmosphere.

a. Transmitters
b. Detectors
c. Cosmic rays
d. Shuttles

9. __________ means human-made.

a. Telecommunication
b. Detector
c. Cosmic rays
d. Artificial

10. A __________ is a device for indicating the presence of a certain substance.

a. space probe
b. telecommunication
c. transmitter
d. detector

11. A __________ is an instrument that sends signals from one place to another.

a. transmitter
b. detector
c. cosmic ray
d. satellite

12. A(n) ____________ is a spacecraft designed to orbit a celestial body without landing on its surface.

    a. orbiter
    b. transmitter
    c. satellite
    d. space probe

13. The load that is carried by a spacecraft is called the ____________ .

    a. orbiter
    b. payload
    c. space shuttle
    d. satellite

14. An instrument that concentrates signals from space for viewing objects is a ____________ .

    a. transmitter
    b. space probe
    c. satellite
    d. telescope

15. One who studies astronomy or makes observations of celestial phenomena is a(n) ____________ .

    a. astronaut
    b. detector
    c. astronomer
    d. transmitter

16. The science of celestial bodies and their properties is called ____________ .

    a. geology
    b. astronomy
    c. astrology
    d. biology

Unit 15: Plate Tectonics

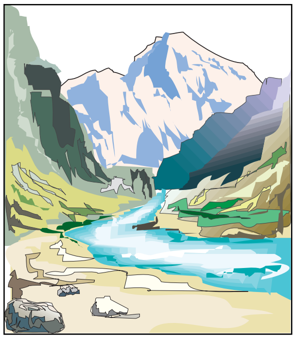
This unit explains plate tectonics. Students will learn about two violent phenomena in the lithosphere—earthquakes and volcanoes.

Student Goals

- Make a model of Pangaea.
- Know about the theories of continental drift and plate tectonics.
- Identify the layers of the earth and their characteristics.
- Construct a seismic-risk map of the United States.
- Examine the location of the active volcanoes on Earth and identify the Ring of Fire.
- Identify the mid-ocean ridges on a world map.
- Know the features of volcanoes.
- Know the land features of the ocean floor.
- Identify the types of mountains and explain how they are formed.

Unit Focus

- Know that from time to time, major shifts occur in the scientific view of how the world works, but that more often, the changes that take place in the body of scientific knowledge are small modifications of prior knowledge. (SC.H.1.4.2)
- Know how climatic patterns on Earth result from an interplay of many factors (Earth's topography, its rotation on its axis, solar radiation, the transfer of heat energy where the atmosphere interfaces with lands and oceans, and wind and ocean currents). (SC.D.1.4.1)



- Know that the solid crust of Earth consists of slow-moving, separate plates that float on a denser, molten layer of Earth and that these plates interact with each other, changing the Earth's surface in many ways (e.g., forming mountain ranges and rift valleys, causing earthquake and volcanic activity, and forming undersea mountains that can become ocean islands). (SC.D.1.4.2)

Vocabulary

Use the vocabulary words and definitions below as a reference for this unit.

abyssal plains	large, flat regions deep on the ocean floor
canyons	deep V-shaped valleys found along the continental slope
continental drift	a hypothesis suggesting that the continents have moved and been in different positions through geologic time
c**ontinental shelf**	relatively flat part of the continent that is covered by seawater; lies between the coast and the continental slope
continental slope	the steeply dipping surface between the outer edge of the continental shelf and the ocean basin proper
continents	the seven major landmasses found on the surface of Earth
convection currents	the circular movements of heat through liquids or gases
core	the innermost layer of Earth which has two parts—the *outer* portion which is liquid and the *inner* portion which is solid

crust	the outer layer of Earth
dome mountains	mountains formed when rocks are pushed up by internal forces within Earth
earthquake	a sudden movement of Earth's crust
epicenter	the point on the surface of Earth directly above the focus of an earthquake
fault	a break in Earth's surface along which movement has occurred
fault-block mountains	mountains formed by the movement of large amounts of rock along a crack in Earth's crust
focus	the true center of an earthquake below Earth's surface
folded mountains	mountains formed as a result of the bending of rocks in Earth's crust
guyots (GEE-oze)	underwater volcanic mountains with flat tops
lava	melted rock (magma) that comes to the surface of Earth
lithosphere	the rigid outer layer of Earth, including the crust and upper mantle

mountains	landforms that are at least 600 meters high
magma	melted (hot liquid) rock found inside Earth
mantle	the molten layer of Earth below the crust
mid-ocean ridge	mountain chain that rises from the ocean basins
mountains	landforms that are at least 600 meters high
Pangaea (pan-JEE-uh)	the large landmass that broke up and drifted to form our present-day continents
plates	pieces of Earth's crust that move about on the mantle
plate tectonics	theory stating that crustal plates on the surface of Earth are continuously moving due to convection currents
Richter scale	scale used to describe the strength of an earthquake
rift	a wide valley that separates two parallel chains of underwater mountains

Ring of Fire	major earthquake zone that forms a ring around the Pacific Ocean; includes the western coasts of North America and South America and the eastern coast of Asia
seamounts	underwater cone-shaped volcanic mountains
seismic waves	waves by which energy moves away from the focus of an earthquake in all directions from the center
seismograph	an instrument used to measure earthquake activity
seismologist	a person who studies earthquakes
trenches	long, narrow cracks in the ocean floor that are the deepest parts of the ocean
volcanic mountains	mountains formed by volcanoes
volcano	a vent in Earth's crust through which hot, liquid rock erupts or oozes; a mountain formed of lava

Introduction

Earth's **crust** is subject to strong forces within and on the surface of Earth. Some of these forces include pushing, pulling, pressure from within, and sliding movements. When these stresses are released, violent events often occur. **Earthquakes** and **volcanoes** are some of the results. Another result is a *tsunami*, a huge ocean wave. A tsunami is caused by a sudden shift of part of the ocean floor during an *earthquake* or the collapse of an oceanic *volcano*.

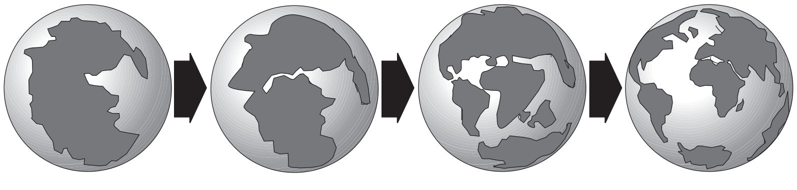
Although Earth's *crust* was once thought to be stationary, we now know that it is in constant motion. This movement results in new formations on Earth's surface, including hot springs, **lava** flows, and fractured valley walls. Understanding **continental drift** and **plate tectonics**, and their theoretical effects on topography, may help us solve the mystery behind the features we see on the surface of Earth.

Continental Drift

Laurasia and Gondwanaland

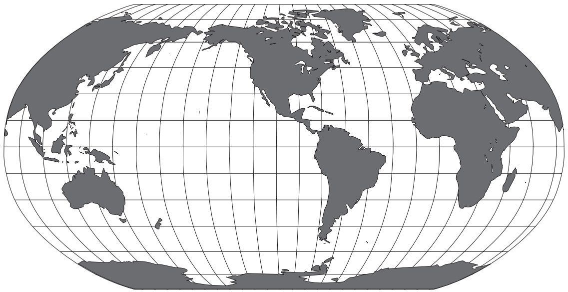
The surface of Earth has seven major landmasses called **continents**. People have believed throughout history that the location of the *continents* was fixed. As world maps were improved, many noted that the shapes of the continents seemed to fit together like pieces of a jigsaw puzzle. This idea seemed foolish because no one understood how continents could move.

In 1912, the German meteorologist Alfred Wegener described his hypothesis of *continental drift*. He suggested that at one time all of the continents were one large landmass called **Pangaea**. Wegener believed that this giant landmass split apart and broke into two large landmasses he called *Laurasia* and *Gondwanaland*. These landmasses then broke apart and, over time, *drifted* across the ocean floor until they reached their present positions.



Landmasses broke apart and, over time, drifted across the ocean floor until they reached their present positions.

This hypothesis was based on several kinds of evidence. One was how the coastlines of the continents seemed to *fit* like pieces of a jigsaw puzzle. Wegener also noted that similar rock structures and fossils were found in neighboring continents across the ocean. Similarities in ancient climate were indicators, as well. His hypothesis was rejected at first, because there was no explanation for the movement of the continents.



present position of the continents

Further evidence in support of Wegener's hypothesis continued to be discovered. Glacial deposits and erosional scratches caused by glaciers were found in both South America and Africa. A 200-million-year-old reptile fossil was found in Antarctica that matched ones found in India and South Africa. Since Alfred Wegener's death, the theory has been generally accepted because more evidence has been found.

Earth scientists now realize that the positions of the continents are not permanent. Continents gradually move over the surface of the globe. During the 1950s and 1960s, new developments led to a broader theory known as *plate tectonics*.

Plate Tectonics

New discoveries showed that the sea floor seemed to be cracked and spreading apart. This discovery led to the theory of **plates** and *plate* movement. This most recent theory is called the *theory of plate tectonics*, which suggests that Earth is separated into large sections called plates—nine large ones and several smaller ones. The large plates include both continental and oceanic crust.

These plates may have separated because of **convection currents**. *Convection currents* transfer heat through liquids or gases. The heated material rises, and the cooler material takes its place. The difference in temperatures of the gases and liquids under Earth's crust caused movement of the plates. The plates floated on an ocean of liquid rock and gases. As the plates separated, they moved at different speeds and in different directions. Today, the plates are still moving. Scientists have measured plate movement using lasers. The plates are drifting about one to 10 centimeters a year depending on the location.

Plates may move apart (form divergent boundaries), move together (form convergent boundaries), or slide past one another (transform boundaries). These movements help explain some of the topographic features we see as well as earthquakes and *volcanoes*. Changes are always taking place along the edges of the plates. Divergent boundaries, plates moving away from each other, create **mid-ocean ridges** and **rift** valleys. The Mid-Atlantic Ridge, the Rift Valley in Africa, and the Red Sea are examples of divergent boundaries. Convergent boundaries, plates moving toward or underneath one another, form mountain ranges, **trenches** and volcanic island arcs. Subduction occurs when one plate is forced underneath another plate forming a *trench*. Many examples of these features can be found in the Pacific Ocean. Transform boundaries result from the sliding of plates along their edges. The San Andreas **fault** in California is an example of this type of boundary.

Volcanoes and earthquakes are often found in areas where the plates are sliding past each other, running into each other, or moving apart. Movement of the San Andreas *fault* caused the San Francisco earthquakes of 1906 and 1989.

Scientists continue to test theories about Earth's crust. Their tests and studies will lead to a better understanding of the structure of Earth.

Practice

Use the list above each section to complete the statements in that section.

continental drift
continents
crust
earthquake
lava
Pangaea
plate tectonics
volcano

1. The theory of ____________________ states that crustal plates on the surface of Earth are continuously moving due to convection currents.

2. Earth's ____________________ is subject to strong forces within and on the surface of Earth.

3. The ____________________ hypothesis suggests that the continents have moved and been in different positions through geologic time.

4. ____________________ is melted rock (magma) that comes to the surface of Earth.

5. When stresses from strong forces from within and on the surface of the Earth are released, violent events often occur such as ____________________ and ____________________ .

6. The surface of Earth has seven major landmasses called ____________________ .

7. Meteorologist Alfred Wegener suggested the hypothesis that at one time all of the continents were one large landmass called ____________________ .

convection currents
faults
mid-ocean ridges
plates
rift
trenches

8. Boundaries resulting from the sliding of plates or a break in Earth's surface are called ____________________ .

9. ____________________ are long, narrow cracks in the ocean floor that are the deepest parts of the ocean.

10. ____________________ transfer heat through liquids or gases.

11. A ____________________ is a wide valley that separates two parallel chains of underwater mountains.

12. ____________________ are mountain chains that rises from the ocean basins.

13. The theory of plate tectonics suggests that Earth is separated into large sections called ____________________ —nine large ones and several smaller ones.

Practice

Write **True** *if the sentence is correct. Write* **False** *if the sentence is* not *correct.*

__________ 1. The continental drift theory is a more recent theory than that of plate tectonics.

__________ 2. The San Andreas fault in California is really a boundary between two plates.

__________ 3. Both the theory of continental drift and plate tectonics believe that all of the landmasses on Earth were once part of one big landmass.

__________ 4. The single landmass that contained all the other land masses was called Laurasia.

__________ 5. Pangaea broke apart to form Gondwanaland and Laurasia.

__________ 6. According to the plate tectonics theory, the continents floated on the water to get to their present places on Earth.

__________ 7. There are 10 major landmasses that make up the surface of Earth.

__________ 8. Plates are no longer moving today.

__________ 9. Alfred Wegener suggested the theory of plate tectonics.

_________ 10. The shapes of the continents seem to fit together like pieces of a jigsaw puzzle.

_________ 11. Convection currents are caused by differences in the temperatures of gases and liquids under Earth's crust.

Lab Activity 1: Continental Drift

Fact:

- The continental drift hypothesis suggests that continents have moved and been in different positions through geologic time. Pangaea is the name of the large landmass that broke up and drifted to form our present-day continents.

Investigate:

- You will make a model of Pangaea.

Materials:

- outline of continents (page 398)
- scissors
- glue
- construction paper or posterboard

1. Trace and cut out the landmasses on the next page.

2. Try to fit the pieces together to form one large landmass.

3. When you have the best fit, tape the pieces to a piece of construction paper or poster board.

4. Draw your version of Pangaea.

5. Which landmasses have the best fit? ______________________________

   ____

   ____

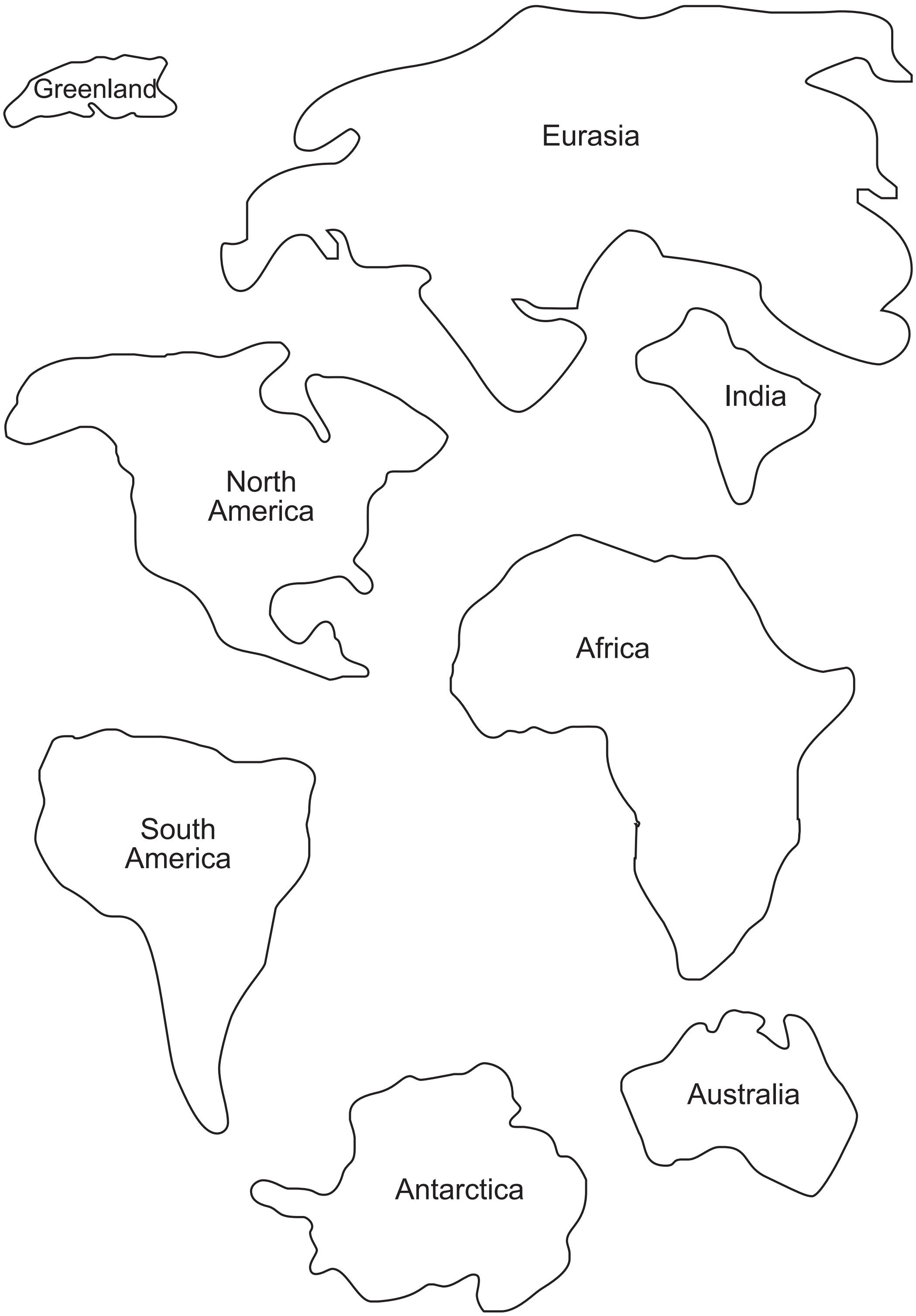
6. Why isn't the fit perfect, if the land masses were once one

   supercontinent? ____

   ____

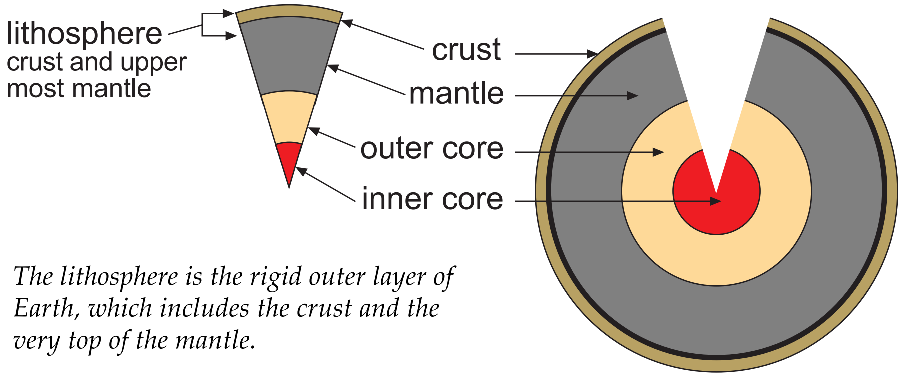
   ____

   ____


Greenland
Eurasia
India
North America
Africa
South America
Australia
Antarctica

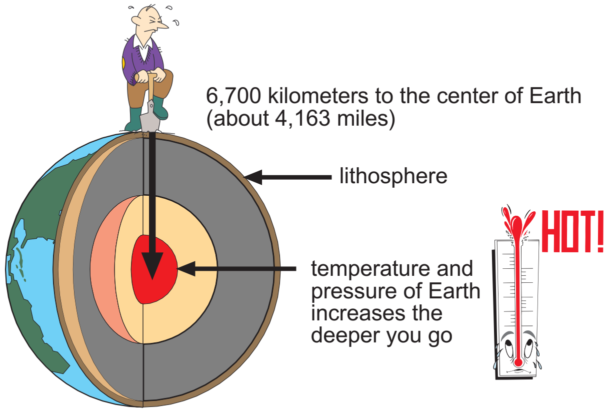
Lithosphere

There are three major layers of Earth. They are the crust, **mantle**, and **core**. Each of these layers is made up of different materials. The **lithosphere** is the rigid outer layer of Earth, which includes the crust and the very top of the *mantle*. To get an idea of the *lithosphere*, think about digging straight down into Earth. You would pass through several different solid layers and would have to dig down about 6,700 kilometers before you would reach the center of Earth. Only about the first 100 kilometers would be the lithosphere.



The lithosphere is the rigid outer layer of Earth, which includes the crust and the very top of the mantle.

Of course, it is impossible to dig to the center of Earth. Scientists have had to use indirect means to learn about the inside of Earth. Indirect means are ways of finding out about Earth without actually touching or seeing the rocks.

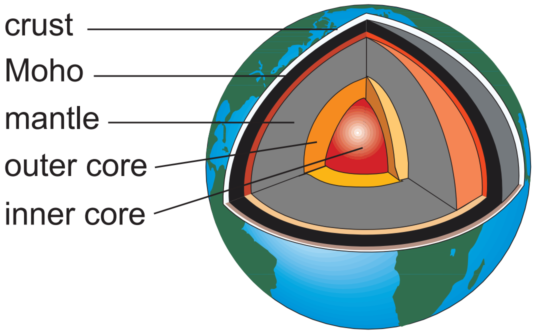


It is impossible to dig to the center of Earth.

Scientists have learned Earth is not the same composition all the way to the center. Scientists draw conclusions from earthquake and volcanic information recorded by instruments. This is how the depth and the temperature of Earth is estimated. Scientists have also found that the temperature and the pressure in Earth increases the deeper you go.

The ground you stand on is called the *soil*. The soil is a very thin layer, about six meters deep. Underneath the soil is *bedrock*, which contains minerals, rocks of various kinds, and ores. Together, soil and bedrock act like the skin of Earth. This skin is called Earth's *crust*. The crust is hard and thin. It can be as thick as 67 kilometers and as thin as eight kilometers in some spots. The continental crust is thicker than the crust under the oceans.

On the diagram below of Earth's layers, there is a very dark line labeled *Moho*. This is short for Mohorovicic discontinuity, the boundary between Earth's crust and mantle. It is named after Andrija Mohorovicic (1857-1936), a Yugoslav geologist. The Moho averages about three miles under the ocean basin floors and 25 miles under the continents. The Moho is not a layer, but a boundary line between the crust and the mantle.



Earth's layers

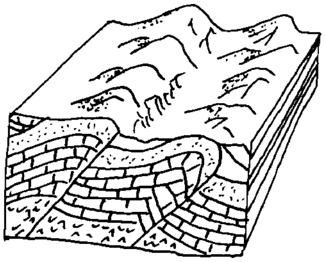
Below the crust is a layer of rock which is heavier and contains more iron than the rock found in the crust. This layer is called the *mantle*. The mantle is between 2,800 and 3,000 kilometers thick. The rock in the mantle seems to be able to flow and move about like a fluid.

The third layer of Earth, the *core*, is beneath the mantle and has two parts. The *outer core* is about 2,000 kilometers thick. The outer core contains melted iron and nickel. At the center of Earth is the *inner core*. It is 2,800 kilometers in diameter at the thickest point. From where the inner core begins to the very center of Earth is about 1,400 kilometers. Scientists believe the inner core is solid and contains iron mixed with some nickel and cobalt.

Mountains

Mountains are landforms that are at least 600 meters above the surrounding lands. The world's largest mountain ranges are **folded mountains**—*mountains* formed as a result of the bending of rocks in Earth's crust. These include the Rocky and Appalachian mountains of the United States, the Himalayan Mountains in Asia, the Alps of Europe, and the South American Andes. These ranges were formed over millions of years.

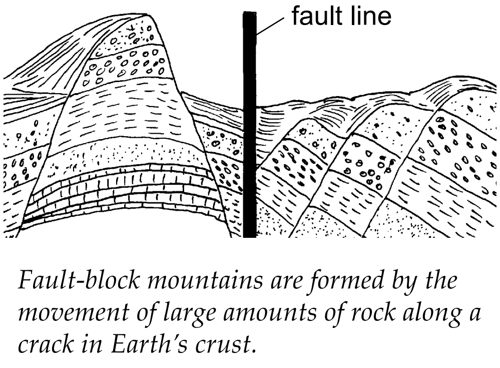
During the formation, sediment is deposited in areas along continental margins where the crust sinks. As the sediments are buried deeper and deeper, the pressure on the sediments increases greatly. Since they are sinking deeper into Earth, their temperature increases. This increase in temperature and pressure causes the sediment to become folded, warped, and twisted. As this happens, the sediments are uplifted to form folded mountains.



Some folded mountains are formed by the collision of crustal plates.

Some *folded mountains* are formed by the collision of crustal plates. These collisions occurred very slowly over long periods of time as the continents moved to their current positions. The Himalayan Mountains were formed when India *crashed* into Asia and pushed up the tallest mountain range on the continents. In South America, the Andes Mountains were formed by the collision of the South American continental plate and the oceanic Pacific plate.

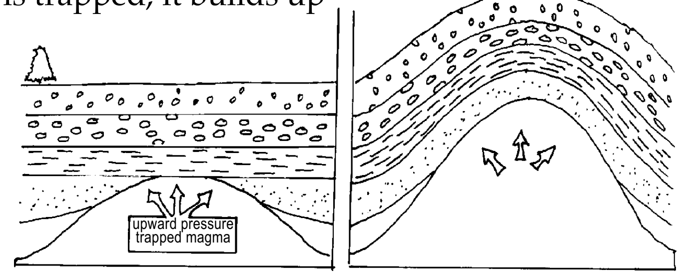
Fault-block mountains are formed by the movement of large amounts of rock along a crack in Earth's crust. Pressure within Earth can break apart Earth's crust. The rock that makes up Earth's crust will split. This breaking or splitting of the rocks is called a fault. The rising land between two faults can become a *fault-block mountain*. The Grand Tetons of Wyoming and the Sierra Nevada mountain range of California are examples of mountains formed by faulting.



Fault-block mountains are formed by the movement of large amounts of rock along a crack in Earth's crust.

Another type of mountain is a **dome mountain**. These mountains are formed when the rocks are pushed up by internal forces within Earth, creating a dome-shaped mountain.

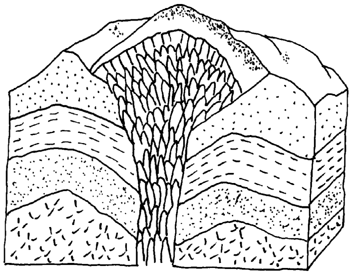
Magma under the surface of Earth has great pressure. If this magma is trapped, it builds up pressure. As it builds up pressure, it pushes upward, causing the layers of rock to rise. Even though these layers of rock are pushed upward, the magma cannot break the crust above it. The crust is then lifted and a dome mountain is formed.



trapped magma builds strong upward pressure

a great domed mountain is formed

Dome mountains are formed when the rocks are pushed up by internal forces within Earth, creating a dome-shaped mountain.



Volcanic mountains are formed by volcanoes.

Dome mountains are rounded. They are not as high as folded mountains or fault-block mountains. In the United States, dome mountains are found in the Black Hills of South Dakota and the Adirondacks in New York.

As the name suggests, **volcanic mountains** are formed by volcanoes. *Lava* and other igneous material from volcanoes have formed mountains in many different areas of the world. The Cascades of Washington (which includes Mount St. Helens) are *volcanic mountains*.

Some Types of Mountains	**Examples**
Folded	Rockies; Appalachians; Himalayas; Alps; Andes
Fault-Block	Sierra Nevada; Grand Tetons
Dome	Adirondacks; Black Hills
Volcanic	Cascades

Practice

Use the list below to write the correct term for each definition on the line provided.

core
dome mountains
fault-block mountains
folded mountains
lithosphere
mantle
mountains
volcanic mountains

____________________ 1. mountains formed when rocks are pushed up by internal forces within Earth

____________________ 2. landforms that are at least 600 meters high

____________________ 3. the molten layer of Earth below the crust

____________________ 4. mountains formed by volcanoes

____________________ 5. the innermost layer of Earth which has two parts—the *outer* portion which is liquid and the *inner* portion which is solid

____________________ 6. mountains formed by the movement of large amounts of rock along a crack in Earth's crust

____________________ 7. the rigid outer layer of Earth, including the crust and upper mantle

____________________ 8. mountains formed as a result of the bending of rocks in Earth's crust

Practice

Look at the diagram below. On the lines, write the names of the **parts of Earth**.

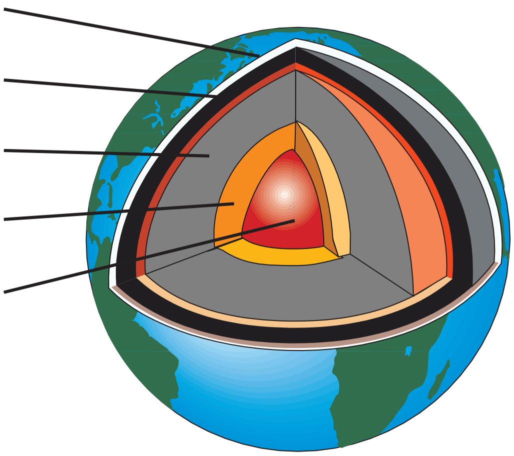
1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________



Complete the following chart.

Layers	Thickness	Material
crust		
mantle		
outer core		
inner core		

Practice

Use the list below to complete the following statements. **One or more terms will be used more than once.**

core
crust
indirect
inner
instruments
lithosphere
mantle
Moho
outer
rock

1. The solid part of Earth is called the ________________________ .

2. The three layers of Earth are ________________________ ,
________________________ , and ________________________ .

3. Scientists draw conclusions from the information recorded by
________________________ .

4. When you find out about something without seeing or touching it, you have learned it by ________________________ means.

5. The ________________________ contains soil and bedrock.

6. The ________________________ is the boundary line between the crust and the mantle.

7. The layer below the crust is called the ________________________ .

8. The mantle is made up of ________________________ core.

9. Under the mantle is the ________________________ core.

10. The center of Earth is called the ________________________ core.

11. The ________________________ core is the layer of melted material.

12. The thinnest layer is the ________________________ .

13. The thickest layer is the ________________________ .

14. The hottest layer with the greatest pressure is the ________________________ core.

15. The coolest layer is the ________________________ .

Practice

Use the list below to complete the following statements.

Adirondacks
bending
Black Hills
dome
dome mountains
fault-block
faulting
Grand Tetons of Wyoming
Mount St. Helens
volcanoes

1. Magma pushes rock layers up to form __________________ .

2. Dome mountains are found in the __________________ of South Dakota and the __________________ in New York.

3. __________________ mountains are not as high as folded or fault-block mountains.

4. The Sierra Nevada Mountains were formed as a result of __________________ .

5. Volcanic mountains are formed by __________________ .

6. __________________ mountains are formed by the movement of large amounts of rock along a crack in the Earth's crust.

7. __________________ is an example of a volcanic mountain.

8. An example of fault-block mountains in the western United States is __________________ .

9. Folded mountains are formed by the __________________ of rocks in Earth's crust.

Practice

Match the **mountains** *below with the correct* **mountain type**. *Write the letter on the line provided.*

______ 1. Sierra Nevada

______ 2. Mount St. Helens

______ 3. Appalachian

______ 4. Black Hills

A. dome

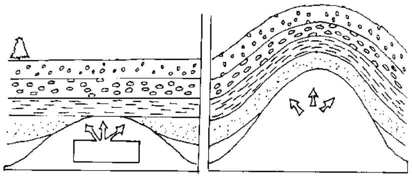
B. fault block

C. folded

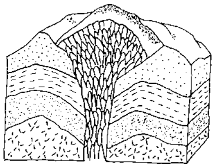
D. volcanic

Identify the **mountains** *below with the correct* **mountain type**. *Write the type on the line provided.*

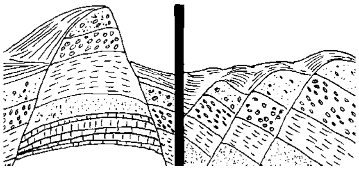
____________________ 5.



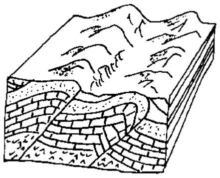
____________________ 6.



____________________ 7.



____________________ 8.



Answer the following using complete sentences.

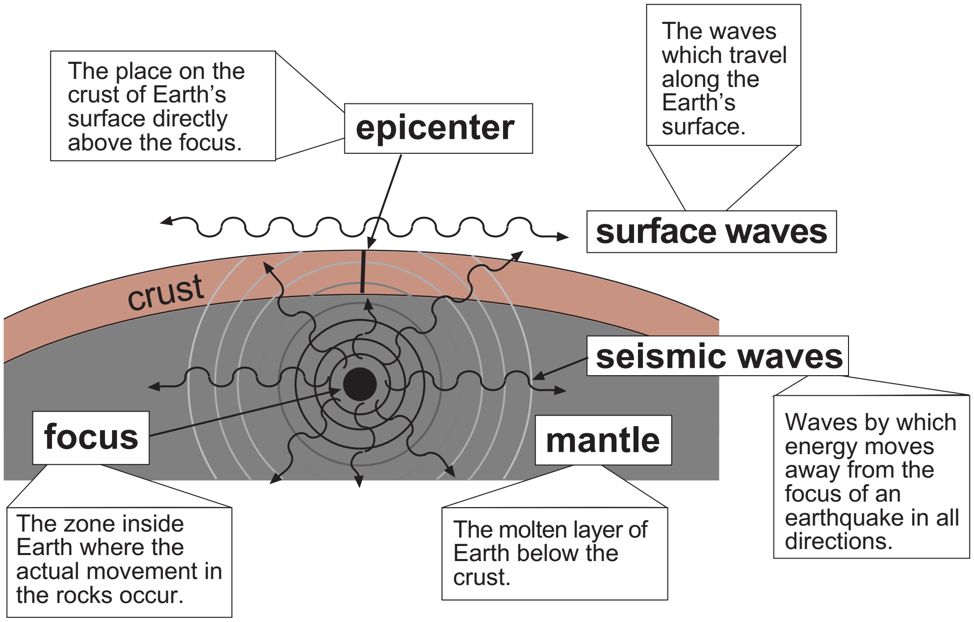
9. Explain how any two of the mountain types are formed. ________

Earthquakes

An *earthquake* is the shaking of Earth's crust caused by plates moving inside Earth. Earth's crust is not one big piece. It is really several plates which float on the liquid, molten part of the mantle. As the plates drift or move, their edges may rub and grind against each other. This grinding, along with an upward push of the rock layers, causes earthquakes.

Earthquakes occur along a fault, *which is a break or crack in Earth's crust.*

Earthquakes occur along a *fault*, which is a break or crack in Earth's crust. As Earth's crust bends on both sides of a fault, pressure builds up. When the rocks cannot stand the pressure anymore, they break. *Faulting* can be caused either by an uplifting that causes the surface to break or by horizontal forces that rip the crust apart. The zone inside Earth where the actual movement in the rocks occurs is called the **focus**. The place on the crust of Earth's surface directly above the *focus* is called the **epicenter**. During an earthquake, energy moves away from the focus in all directions, releasing energy in the form of **seismic waves**. These *waves* are felt as the shocks of an earthquake.



During an earthquake, energy moves away from the focus in all directions, releasing energy.

Scientists called **seismologists** study the inner structure of Earth and the changing surface of Earth in an effort to predict future earthquakes. A **seismograph** is an instrument used to measure the force of an earthquake. Some earthquakes are so slight that they go unnoticed. Other earthquakes are so powerful that the tremors cause rockslides, buildings to fall, the ground to open up, fires and explosions from broken electric and gas lines, and floodwaters released from collapsing dams.

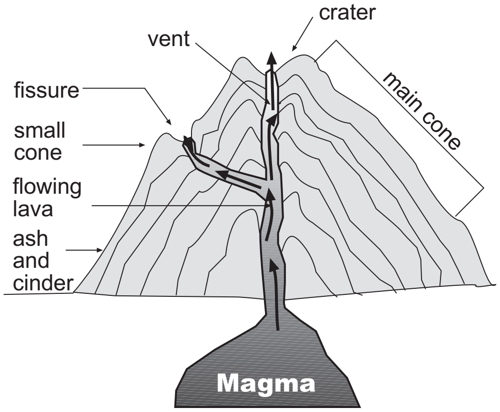
Some earthquakes are so powerful that the tremors cause rockslides and buildings to fall.

When an earthquake is recorded, it is given a number on the **Richter scale**. The *Richter scale* uses numbers from one to 10 to measure the relative strength of an earthquake. The largest earthquakes ever recorded have Richter magnitudes near 8.6. The energy released from these great shock waves is about the same as one billion tons of TNT (an ingredient in explosives). Earthquakes with a magnitude less than 2.5 are not normally felt by humans.

In 1906, an earthquake with a Richter scale rating of 8.25 nearly destroyed the city of San Francisco. An earthquake with a magnitude of 8.4–8.6 occurred in Alaska and lasted three–four minutes. In 1989, another major earthquake occurred in San Francisco. It measured 7.1 on the Richter scale and caused major destruction.

Volcanoes

A *volcano* is an opening in Earth's surface through which melted rock, called **magma**, erupts from inside Earth. *Magma* beneath the surface of Earth builds up great pressure. Scientists believe that it collects in pockets and builds up pressure. This pressure forces the magma upward. Sometimes dome mountains are formed from the pressure. Other times, the pressure becomes so great



A volcano is an opening in Earth's surface through which melted rock, called magma, *erupts from inside Earth.*

that the magma is pushed out onto the surface of Earth. When this happens, it is called an *eruption*. Once the magma flows out of the opening of the volcano, it is called *lava*. A hill or mountain builds up as the lava cools. This is how volcanic mountains are formed.

Volcanoes can also form in the oceans. The **Ring of Fire** is an area in the Pacific Ocean where many of the world's active volcanoes are found. Sometimes the tops of volcanoes stick out above the surface of the ocean, forming islands. The Hawaiian Islands are really the tops of volcanoes.

Sometimes the tops of volcanoes stick out above the surface of the ocean, forming islands.

Volcanoes affect Earth in many ways. They are responsible for changing the surface of Earth by building volcanic mountains. The lava and ash from volcanic eruptions form fertile land that can be farmed. Scientists study volcanoes to learn more about the interior of Earth.

Volcanic mountains are sometimes quiet. A quiet volcano is one where the lava oozes out and spreads over the land. Quiet volcanoes have gently sloping sides. They do not explode.

Explosive volcanoes are ones where the magma blasts to the surface. For the magma to come to the surface with such force, it must be held underground for a long time. The pressure builds up and becomes so great that the magma is pushed out of Earth explosively. With the magma comes rocks, cinders, ash, dust, steam, and poisonous gases. The dust and ash can cause breathing problems in humans and

A quiet volcano is one where the lava oozes out and spreads over the land.

can even cause changes in the weather. Volcanoes can destroy property and lives. Some volcanic eruptions have triggered large earthquakes.

Some volcanoes are dormant, which means that they have erupted in human history but not within the past 50 years or so. They are inactive but may erupt at any time. Other volcanoes are active, like Kilauea in Hawaii, which has erupted more than 50 times in recorded history. Mount St. Helens on the Pacific Coast of the United States is an active volcano which erupted in 1980.

Some volcanoes are dormant, which means that they have erupted in human history but not within the past 50 years or so.

Practice

Use the list below to complete the following statements.

epicenter
fault
focus
islands
magma
plates
Richter scale
Ring of Fire
seismic waves
seismograph
seismologists
volcanoes

1. The zone inside Earth where the actual movement in the rocks occurs is called the ________________________ .

2. The ________________________ uses numbers from one to 10 to measure the relative strength of an earthquake.

3. During an earthquake, energy moves away from the focus in all directions, releasing energy in the form of ________________________ .

4. The place on the crust of Earth's surface directly above the focus is called the ________________________ .

5. Scientists called ________________________ study the inner structure and the surface of Earth in an effort to predict future earthquakes.

6. A ________________________ is an instrument used to measure the force of an earthquake.

7. The ________________________ is an area in the Pacific Ocean where many of the world's active volcanoes are found.

8. A volcano is an opening in Earth's surface through which melted rock, called ________________________ , erupts from inside Earth.

9. Earthquakes occur along a ________________________ , which is a break or crack in the Earth's crust.

10. Sometimes the tops of volcanoes stick out above the surface of the ocean, forming ________________________ .

11. The Ring of Fire is an area in the Pacific Ocean where there are many active ________________________ .

12. An earthquake is the shaking of the Earth's crust caused by ________________________ moving inside Earth.

Lab Activity 2: Earthquakes

Fact:

- Earthquake prone-regions can experience major damage.

Investigate:

- You will make a seismic-risk map of the United States.

Materials:

- map of United States (page 418)
- colored pencils
- pencil

1. Choose a color to represent each of the risk zones in the legend of the map on page 418.

2. Color the squares of the map legend to match the color chosen for each zone.

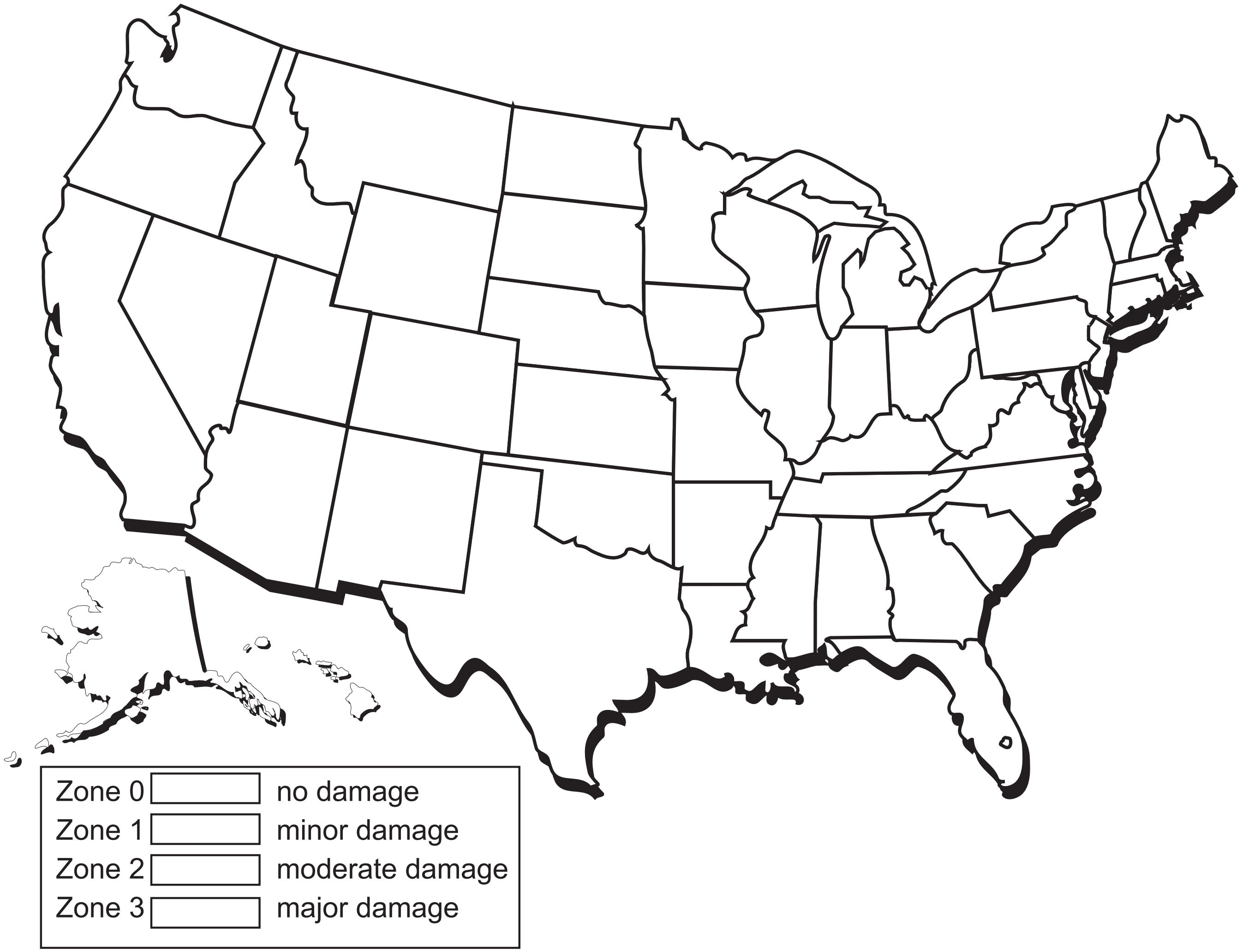
3. Plot the data from the chart on page 417 on the map. Place one dot in the state for each recorded earthquake. Place two dots in the state for each high-intensity earthquake.

4. Since California has such a large number of earthquakes, simply write the number of earthquakes on the state. In parentheses, write the number of high-intensity earthquakes.

5. Color each state according to the legend on page 418. Example: California will be colored for Zone 3.

Earthquake Locations

State	Damaging earthquakes recorded	State	Damaging earthquakes recorded
Alabama	2	Montana	10 (3 high intensity)
Alaska	12 (2 high intensity)	Nebraska	3
Arizona	4	Nevada	12 (3 high intensity)
Arkansas	3	New Hampshire	0
California	over 150 (8 high intensity)	New Jersey	2 (1 high intensity)
Colorado	1	New Mexico	5
Connecticut	2	New York	5 (1 high intensity)
Delaware	0	North Carolina	2
Florida	1	North Dakota	0
Georgia	1	Ohio	6 (1 high intensity)
Hawaii	12 (2 high intensity)	Oklahoma	2
Idaho	4	Oregon	1
Illinois	10	Pennsylvania	1
Indiana	3	Rhode Island	0
Iowa	0	South Carolina	6 (1 high intensity
Kansas	2	South Dakota	1
Kentucky	5	Tennessee	7
Louisiana	1	Texas	3 (1 high intensity)
Maine	4	Utah	9 (2 high intensity)
Maryland	0	Vermont	0
Massachusetts	4 (1 high intensity)	Virginia	5
Michigan	1	Washington	11 (2 high intensity)
Minnesota	0	West Virginia	1
Mississippi	1	Wisconsin	1
Missouri	9 (2 high intensity)	Wyoming	3


Zone 0 ☐ no damage
Zone 1 ☐ minor damage
Zone 2 ☐ moderate damage
Zone 3 ☐ major damage

Practice

Using the information gathered from **Lab 2**, *answer the following using short answers.*

1. In what states have damaging earthquakes occurred? __________

   ____

   ____

2. In what region have damaging earthquakes been concentrated?

   ____

3. What does a concentration of damaging earthquakes indicate about the underlying rock structure of the area? ____________________

   ____

4. Based on this map, in which states might future earthquakes occur?

   ____

   ____

5. In which state is the earthquake risk highest? _________________

   ____

6. Could you be sure that an earthquake could not occur in any area? ____

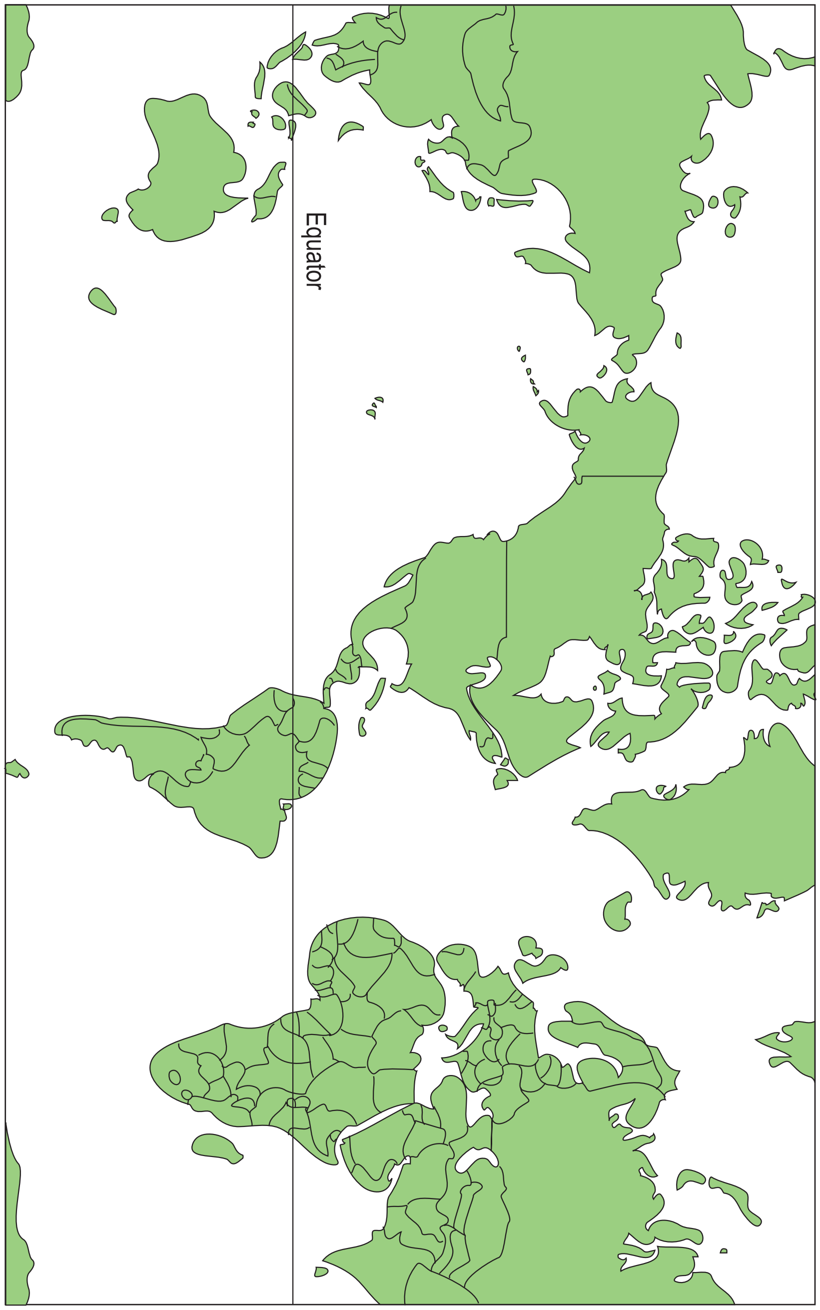
   Why? ____

   ____

   ____

Practice

Use a reference book or the Internet to locate the **active volcanoes** *found on Earth. Mark their approximate location by placing a dot on the map below. Use a marking pen to trace the* **Ring of Fire** *on the map. (If using the Internet, go to the search engine of your choice and type in* **active volcano map***.)*



Practice

Use the list below to complete the following statements. **One or more terms will be used more than once.**

blasts
erupt
gentle
Hawaiian
inactive
lava
magma
mountains
poisonous
Ring of Fire
rocks

1. Melted rock beneath the surface of Earth is called ________________________ .
2. Melted rock that comes to the surface of Earth is called ________________________ .
3. When a volcano erupts, ________________________ comes out of it as well as ________________________ gases.
4. Quiet volcanoes have sides with ________________________ slopes.
5. Quiet volcanoes do not ________________________ .
6. Many of the world's active volcanoes are found in the ________________________ in the Pacific Ocean.
7. Cooled lava collects over time to build ________________________ .
8. Magma ________________________ out from an explosive volcano.
9. Dormant volcanoes are usually ________________________ .
10. Dormant volcanoes can ________________________ at any time.
11. The ________________________ Islands are the tops of volcanoes.

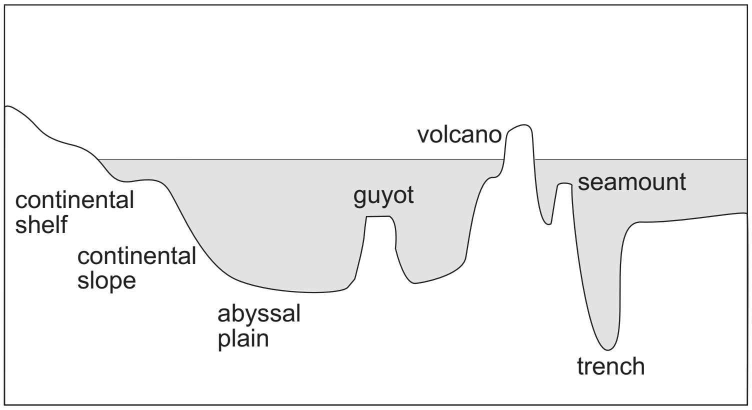
The Ocean Floor

Earth's ocean floor has been studied for more than 100 years. In the 1950s and 1960s, scientists invented new instruments, such as the precision depth recorder, to more accurately study and map the ocean floors. Using these instruments, scientists discovered that the land areas of the ocean floor had many of the same features as the continents.


The area where the land and the ocean water meet is called the shoreline.

The area where the land and the ocean water meet is called the *shoreline*. Beyond the shoreline the ocean floor begins to slope gently downward. This is called the **continental shelf**. The width of the *continental shelf* varies from 200 to 1200 kilometers. At the edge of the continental shelf, the ocean floor drops off at a very steep angle for four or five kilometers. This marks the boundary between the crust of the continent and the crust of the ocean basin. It is called the **continental slope**. Deep V-shaped valleys called **canyons** are found along the *continental slope*. Some of these underwater *canyons* are deeper than any found on the surface of Earth.

Ocean Floor



The ocean basin, or floor, begins at the bottom of the continental slope. There are plains on the ocean basin that are larger and flatter than any found on Earth's surface. They are called **abyssal plains**. The deepest parts of the ocean floor are long, narrow cracks called *trenches*, which cut into the *abyssal plain*. Most of these trenches are found in the Pacific Ocean. The Marianas Trench in the Pacific Ocean is the deepest spot on Earth. It is over 11,000 meters deep.

Many volcanic peaks rise from the plain. Some peaks rise above sea level to form islands like the Hawaiian Islands. Many old volcanic islands are now underwater. Underwater cone-shaped volcanic mountains are called **seamounts**. *Seamounts* with flat tops are called **guyots**.

Some volcanic peaks rise above sea level to form islands like the Hawaiian Islands.

Some of the highest mountain ranges on Earth are located under the ocean. These underwater mountain chains, rising from the plain, are called *mid-ocean ridges*. On the floor of the Atlantic Ocean are underwater mountains named the Mid-Atlantic Ridge. The Mid-Atlantic Ridge is the longest fracture on Earth. It runs around the world from the North Atlantic to the South Atlantic, into the Indian Ocean, across the Pacific, and northward to the Atlantic. This mountain chain is about 65,000 kilometers long. Underwater ridges vary greatly in size and shape. Many ridges in the Pacific Ocean are flat-topped mountains. The Mid-Atlantic Ridge is really two parallel chains of mountains separated by a wide valley called a *rift*.

Important differences between the continents and the seafloor have been noted, too. The ocean basins have many more volcanoes and earthquakes than the continents. The rocks found there differ from the rocks found on Earth's surface. Ocean basins are made of basalt; continents are made of granite. In addition, the crust of Earth is much thinner on the ocean floor than on the surface of Earth.

Summary

Scientists have collected evidence to show that Earth's continents were once one large landmass. Over time the continents separated and drifted to their present locations. By the 1960s, a theory known as plate tectonics suggested that Earth is separated into plates. These plates are still moving, and this movement helps explain volcanoes and earthquakes. The ocean floor has many of the same features as the continents, including mountains and earthquakes, even though there are important differences.

Mountains are landforms at least 600 meters above the surrounding land. Some types of mountains include folded, fault-block, dome, and volcanic mountains.

The lithosphere, or solid part of Earth, has three major layers—crust, mantle, and core. The plates of Earth's crust move. This movement along a fault in the crust may cause earthquakes. The pressure beneath the surface of Earth may cause molten rock to flow from an opening in Earth's crust and form a volcano.

The pressure beneath the surface of Earth may cause molten rock to flow from an opening in Earth's crust and form a volcano.

Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. underwater cone-shaped volcanic mountains

______ 2. relatively flat part of the continent that is covered by seawater; lies between the coast and the continental slope

______ 3. underwater volcanic mountains with flat tops

______ 4. deep V-shaped valleys found along the continental slope

______ 5. large, flat regions deep on the ocean floor

______ 6. the steeply dipping surface between the outer edge of the continental shelf and the ocean basin proper

A. abyssal plains

B. canyons

C. continental shelf

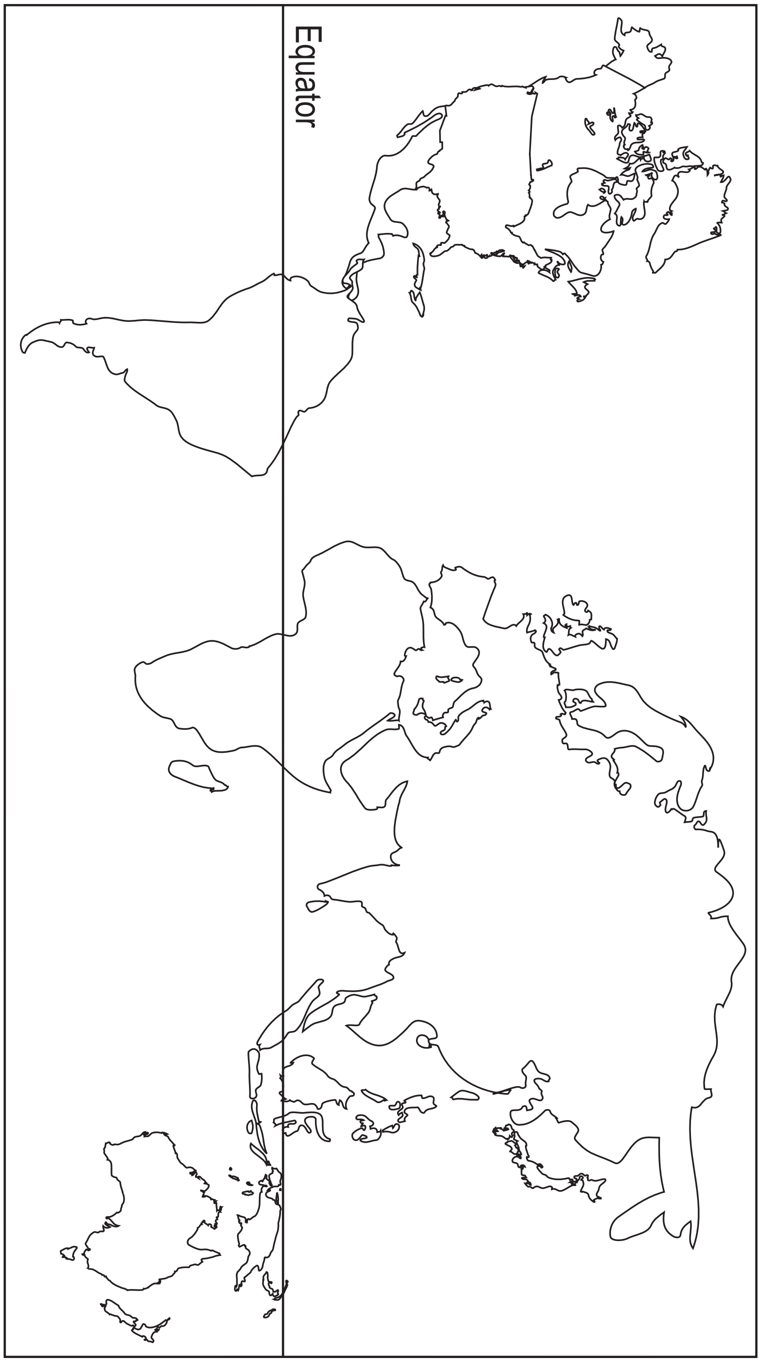
D. continental slope

E. guyots

F. seamounts

Practice

Use reference materials to locate the **mid-ocean ridges**. *Use small triangles to represent peaks to draw the mid-ocean ridge on the map below.*



Practice

Use the list below to complete the following statements. **One or more terms will be used more than once.**

abyssal plains
basin
canyons
earthquakes
Pacific
rift
slope
volcanoes

1. The ocean basins have more ____________________ and ____________________ than the continents.

2. The steep drop-off at the edge of the continental shelf is the ____________________ .

3. ____________________ are deep V-shaped valleys found along the continental slope.

4. Plains found on the ocean floor are flatter and larger than those found on land. They are known as ____________________ .

5. Many ridges in the ____________________ Ocean are flat-topped mountains.

6. Another name for the ocean floor at a depth of more than 4,000 meters is the ____________________ .

7. The Mid-Atlantic Ridge is really two parallel chains of mountains separated by a valley called a ____________________ .

11,000
Atlantic
Indian
instruments
Marianas Trench
Mid-Atlantic Ridge
mid-ocean ridges
Pacific
shelf
shoreline
thinner
trenches

8. The ____________________ is the area where the water and the land meet.

9. In the late 1950s and 1960s scientists invented new ____________________ that let them study and map the ocean floor.

10. The area beyond the shoreline where the ocean slopes gradually downward is called the ____________________ .

11. The deepest parts of the ocean floor are long, narrow cracks called ____________________ .

12. Mountain chains found under the sea are known as ____________________ .

13. The longest mountain range in the world is the ____________________ . It is found in the ____________________ , ____________________ , and ____________________ oceans.

14. The crust of Earth is ____________________ on the ocean floor than on the surface of Earth.

15. The ____________________ is the deepest place on Earth. It is over ____________________ meters deep.

Practice

Circle the letter of the correct answer.

1. Deep V-shaped valleys found along the continental slope are ______ .

   a. trenches
   b. rifts
   c. canyons
   d. plates

2. A wide valley that separates two parallel chains of underwater mountains is a ______ .

   a. basin
   b. canyon
   c. plain
   d. rift

3. Long, narrow cracks in the ocean floor that are the deepest parts of the ocean are ______ .

   a. trenches
   b. faults
   c. mountains
   d. mantles

4. The relatively flat part of the continent that is covered by seawater and lies between the coast and the continental slope is the ______ .

   a. mantle
   b. continental shelf
   c. abyssal plain
   d. trench

5. A large, flat region deep on the ocean floor is a(n) ______ .

   a. basin
   b. abyssal plain
   c. mid-ocean ridge
   d. convection current

6. A mountain chain found under the surface of the ocean is the ______ .

   a. mid-ocean ridge
   b. convection current
   c. continent
   d. basin

7. The ______ is the steeply dipping surface between the outer edge of the continental shelf and the ocean basin proper.

   a. basin
   b. abyssal plain
   c. Pangaea
   d. continental slope

8. The ______ are the seven major landmasses found on the surface of Earth.

   a. continents
   b. plates
   c. trenches
   d. convection currents

9. ______ are pieces of Earth's crust that move about on the surface of Earth.

   a. Rifts
   b. Trenches
   c. Basins
   d. Plates

10. ______ is the large landmass that broke up and drifted to form our present-day continents.

   a. Pangaea
   b. Shoreline
   c. Abyssal plain
   d. Rift

11. ______ are the circular movements of heat through liquids and gases.

   a. Plates
   b. Trenches
   c. Mid-ocean ridges
   d. Convection currents

12. A sudden movement of Earth's crust is a(n) _______ .

a. volcano
b. mantle
c. core
d. earthquake

13. The instrument used to measure earthquake activity is a(n) _______ .

a. epicenter
b. seismograph
c. volcano
d. Richter scale

14. A vent in Earth's crust through which hot, liquid rock erupts or oozes is a _______ .

a. volcano
b. rift
c. mantle
d. mountain

15. A crack in Earth's surface is a _______ .

a. mountain
b. rift
c. trench
d. fault

16. A person who studies earthquakes is a(n) _______ .

a. seismograph
b. seismologist
c. Richter scale
d. epicenter

17. The innermost layer of Earth which has two parts; the outer portion which is liquid and the inner portion which is solid is the _______ .

a. focus
b. magma
c. crust
d. core

18. Magma that comes to the surface of Earth is called ______ .

a. mantle
b. core
c. crust
d. lava

19. An area where many of the world's active volcanoes are found is called the ______ .

a. Ring of Fire
b. fault
c. core
d. epicenter

20. The outer layer of Earth is called the ______ .

a. mantle
b. crust
c. core
d. fault

21. The ______ is the molten layer of Earth below the crust.

a. magma
b. core
c. crust
d. mantle

22. The point on the surface of Earth directly above the focus of an earthquake is the ______ .

a. epicenter
b. core
c. crust
d. mantle

23. The ______ is used to describe the strength of an earthquake.

a. Richter scale
b. seismograph
c. lava
d. seismologist

24. ______ are waves by which energy moves away from the focus of an earthquake in all directions from the center.

   a. Earthquakes
   b. Epicenters
   c. Seismic waves
   d. Volcanos

25. The true center of an earthquake below Earth's surface is the ______ .

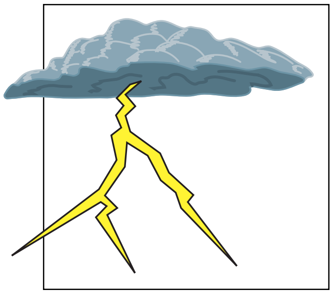
   a. core
   b. fault
   c. mantle
   d. focus

Unit 16: The Atmosphere and Weather

This unit focuses on solar radiation, air masses, winds, and sea currents and their relation to the weather. Students will learn about the components and function of the atmosphere and the connection between weather and climate.

Student Goals

- Identify the primary layers of the atmosphere and their characteristics.
- Explain how the ozone layer protects us and how it is being destroyed.
- Given data, construct a weather map, analyze, and then predict the weather.
- Explain how winds are created and how the Earth's rotation affects their direction.
- Observe the effects of rotation on water.
- Identify major wind systems.
- Using a hurricane tracking map, plot the path of two hurricanes.
- Describe various severe weather situations.
- Know safety precautions for severe weather.
- Identify various cloud types by their appearance (altitude may be included).
- Know about the various forms of precipitation.
- Identify the factors that influence climate.



Unit Focus

- Know how climatic patterns on Earth result from an interplay of many factors (Earth's topography, its rotation on its axis, solar radiation, the transfer of heat energy where the atmosphere interfaces with lands and oceans, and wind and ocean currents). (SC.D.1.4.1)
- Know that changes in a component of an ecosystem will have unpredictable effects on the entire system but that the components of the system tend to react in a way that will restore the ecosystem to its original condition. (SC.G.2.4.2)
- Know that scientists can bring information, insights, and analytical skills to matters of public concern and help people understand the possible causes and effects of events. (SC3.4.3)

Vocabulary

Use the **atmosphere** *and* **climate** *vocabulary words and definitions below as a reference for this unit.*

atmosphere	the mixture of gases surrounding Earth
climate	the weather of an area over a long period of time
continental climate	type of climate found where there are huge land masses
desert	dry areas that receive less than 25 cm of rainfall per year
exosphere	the upper part of the thermosphere; extends into interplanetary space
ionosphere	the lower part of the thermosphere that contains electrically charged particles called ions
jet stream	narrow layer of strong winds that blow from west to east just above the troposphere
marine climate	type of climate found when an area is located near a large body of water
mesosphere	the coldest layer of the atmosphere, just above the stratosphere

ozone	type of oxygen with three oxygen atoms (O_3) found in the upper areas of the stratosphere
polar zone	area of Earth that extends from the poles to 60° north and south latitude and has a very cold climate
stratosphere	the layer of Earth's atmosphere above the troposphere; it contains the ozone layer
temperate zone	the zone of moderate climate with distinct seasonal changes; located between 30° and 60° latitude
thermosphere	the layer of the atmosphere above the mesosphere where the air is very thin and hot; includes the ionosphere and exosphere
tropical zone	area of Earth that extends from 30° north latitude to 30° south latitude; above average temperatures and precipitation
troposphere	the lowest layer of the atmosphere that contains most of Earth's weather
weather	the day-to-day changes in temperature, humidity, wind, and air pressure

Vocabulary

Use the **solar radiation** *and* **air mass** *vocabulary words and definitions below as a reference for this unit.*

air masses	large bodies of air having the same temperature and amount of moisture
barometer	an instrument used to measure air pressure
cold front	forms when a mass of cold air meets a mass of warm air and moves beneath it
conduction	direct transfer of heat energy from one substance to another
convection	transfer of heat energy by moving air or fluid
convection current	the vertical movement of air or water caused by differences in temperature
currents	vertical movements of air or water caused by the uneven heating of Earth
direct rays	rays of the sun that hit Earth at a 90° angle; they create the greatest amount of heat
front	the boundary formed when two different masses of air meet

high-pressure system	system that brings cool, clear skies and dry weather
indirect rays	rays of the sun that hit Earth at greater than 90°; they produce less heat
low-pressure system	system that brings cloudy, rainy, and often stormy weather
occluded front	forms when a cold front overtakes and merges with a warm front
radiation	process by which the sun's rays reach Earth in the form of waves
stationary front	forms when two unlike air masses face each other, but neither moves
warm front	forms when a mass of warm air meets a mass of cold air and moves over it
wind	horizontal movements of air caused by the uneven heating of Earth

Vocabulary

Use the **wind** *and* **current** *vocabulary words and definitions below as a reference for this unit.*

anemometer	an instrument used to measure wind speed
doldrums	the area around the equator where air moves straight up and there is very little wind
horse latitudes	area at about 30° north and south latitude where there is very little wind
land breeze	cool air blowing from land to sea at night
monsoons	winds that blow inland during summer bringing rainy weather and that blow out to sea in winter bringing dry weather
polar easterlies	system of winds that blows cold air from the poles
prevailing westerlies	wind system formed over large land areas that blows from the west to the east
sea breeze	cool air that moves from sea to land during the day

trade winds	system of winds found just north and south of the equator that blows toward the equator from the northeast and southeast
wind vane	an instrument that tells from which direction the wind is coming

Vocabulary

Use the **storm** *and* **precipitation** *vocabulary words and definitions below as a reference for this unit.*

anticyclone	high-pressure system with winds moving clockwise
blizzard	a severe snowstorm with high winds
cirrus	very high, thin, feathery clouds made of ice crystals
cloud	tiny droplets of water suspended in the air
cumulonimbus	cumulus clouds that bring rain; also called thunderheads
cumulus	puffy, white clouds with flat bottoms
cyclone	a low-pressure system with winds moving in a counterclockwise direction
hurricane	a large, powerful low-pressure storm system; a cyclone with sustained winds of 75 mph or more
lightning	a sudden discharge of electricity from clouds
nimbostratus	a dark, low-lying stratus cloud that contains rain

nimbus	a cloud that causes rain to fall
precipitation	moisture that falls to Earth as rain, hail, sleet, or snow
saturated	a term used when the air has all the moisture it can hold
stratus	smooth, layered clouds found low in the sky
thunder	the sound made by lightning
tornado	a violent, funnel-shaped windstorm
tropical depression	a storm formed by a large, low-pressure system over water with winds less than 35 mph
tropical storm	a storm formed when the winds of a tropical depression are between 35 and 74 mph
waterspout	a tornado that forms over water

Introduction

Earth is enveloped in layers of gases called the atmosphere.

Earth is enveloped in layers of gases called the **atmosphere**. These layers are responsible for Earth's **weather** and for protecting us from harmful rays of the sun. *Weather* affects us daily and is a determining factor in many of our decisions. Air pressure, temperature, winds, and humidity change constantly and can produce dangerous conditions like **hurricanes** and **tornadoes**. The day-to-day weather we experience makes up our **climate**. Some areas have a cold, polar *climate* while others have a hot and humid tropical climate. Climate and weather influence our daily lives. Studying Earth's weather and climate changes will help us to understand how to prepare for or prevent dangerous weather conditions and cope with our ever changing environment.

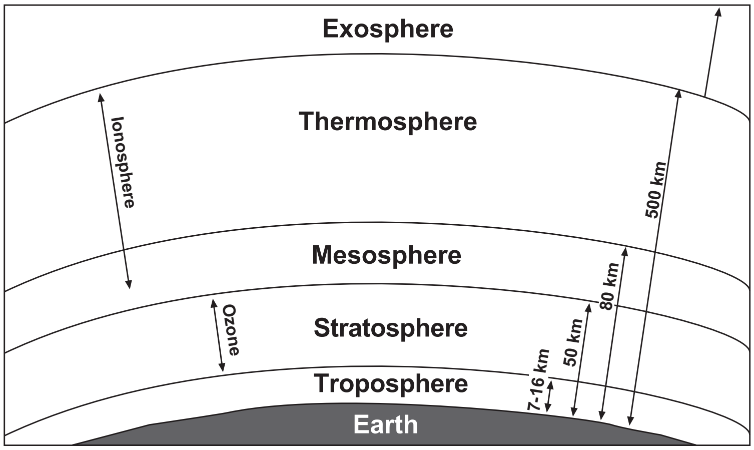
Atmosphere

Earth is surrounded by a mixture of gases called the *atmosphere.* The atmosphere is divided into four layers, based on differences in temperature and gases present. The layer of the atmosphere closest to Earth is the **troposphere**. This is the layer in which we live, and it contains most of our weather. The *troposphere* extends upwards from the surface of Earth for about 7-16 kilometers. The temperature decreases farther up in the troposphere.

Just above the troposphere is a narrow layer of strong winds that blow from west to east called the **jet stream**. Planes flying eastward use the *jet stream* to increase their air speed.

The layer of air above the troposphere is the **stratosphere**. This layer extends to about 50 kilometers above Earth's surface. The air in the lower areas of the *stratosphere* is very cold, but the air in the upper layers is about the same as it is at sea level.

This warmer temperature is due to the **ozone** present there. *Ozone* is a gas with three oxygen atoms (O_3), rather than two oxygen atoms (O_2) present in the air we breathe. Ozone absorbs the sun's ultraviolet rays and heats up the atmosphere. It also shields Earth and keeps ultraviolet rays from reaching Earth's surface. Ultraviolet rays can cause blindness and skin cancer.



layers of the atmosphere

For these reasons, it is important that the ozone layer of Earth not be destroyed. Chemicals known as chlorofluorocarbons (CFCs) that are used in aerosol (spray) cans can destroy the ozone layer. Federal laws have been passed which regulate the use of aerosol cans.

Most of the ozone on Earth is in this layer of the stratosphere; however, some of it is found in lower layers. When **lightning** strikes, ozone is formed. You can smell the presence of ozone when *lightning* strikes. It has a clean, sharp smell.

When lightning strikes, ozone is formed.

Above the stratosphere lies the **mesosphere**, where the temperature is colder. It is, in fact, the coldest part of the atmosphere. This layer extends to about 80 kilometers above the Earth.

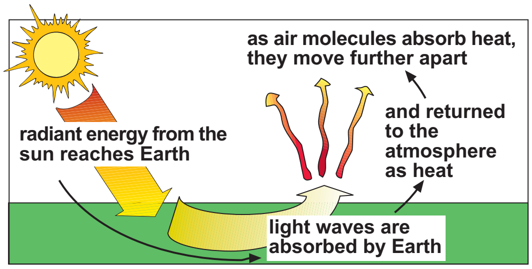
Beyond the *mesosphere* is the **thermosphere**. The *thermosphere* is very hot because of absorption of the sun's energy. The first part of the thermosphere, the **ionosphere**, is a layer of electrically charged particles. These particles are bombarded by energy from space. They become electrically-charged particles called *ions* and *free electrons*. These are useful for communication because they reflect radio waves. The *ionosphere* begins in the mesosphere and extends into the thermosphere to about 500 kilometers.

Earth receives its heat from the sun.

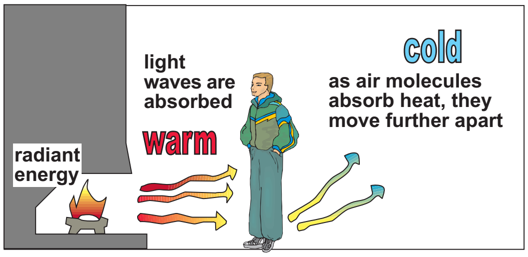
The last layer of the atmosphere is the **exosphere**. Here, the atmosphere is very thin. In other words, atoms and ions are very far apart. Some gases escape into space. The *exosphere* extends for thousands of kilometers upward into interplanetary space.

The Effect of Solar Radiation

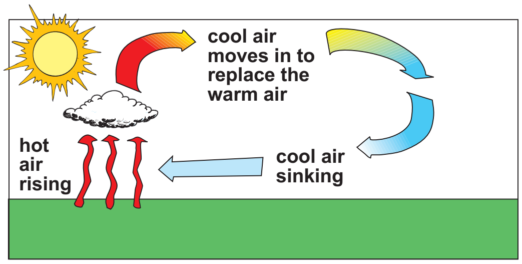
Earth receives its heat from the sun. The sun's energy is spread through the atmosphere in three ways—**radiation**, **convection**, and **conduction**. Radiant energy from the sun reaches Earth in the form of waves by a process called *radiation*. These light waves are absorbed by Earth and returned to the atmosphere as heat. As air molecules absorb heat, they begin to move farther and farther apart. Warm air is therefore less dense, or lighter, and rises.



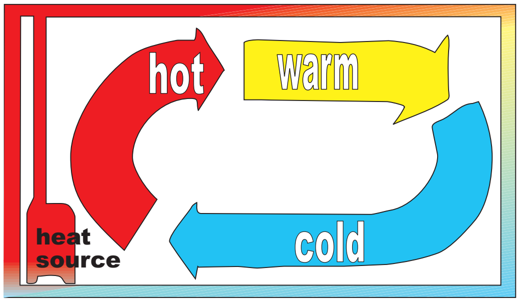
Radiation

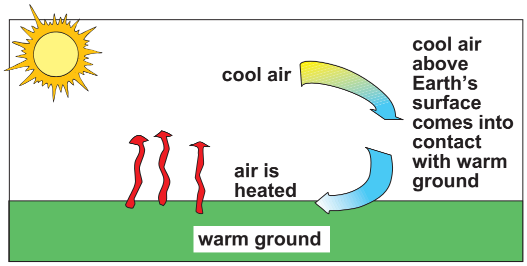


Convection is the process through which heat is transferred by moving air or water. As the warm air rises, denser, heavier, and colder air moves in to replace it. This movement creates a **convection current**. *Convection currents* cause a constant exchange of air until the surface is evenly heated. Most of the heat in the atmosphere is transferred by convection currents.

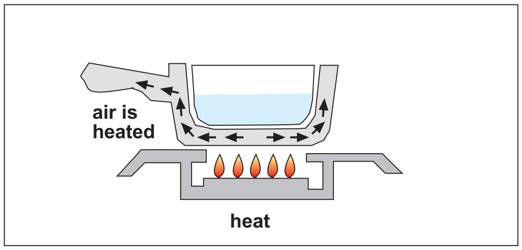


Convection



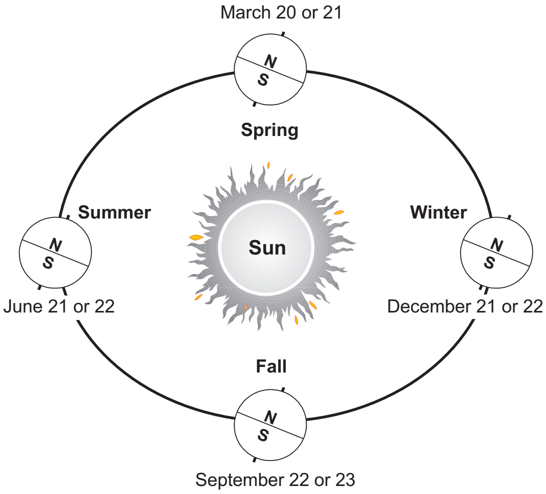


Conduction



The direct transfer of heat energy through contact is called *conduction*. When cool air above Earth's surface comes into contact with the warm ground, the air is heated. Air temperatures closer to the ground are generally warmer than those higher up. Conduction plays only a minor role in heating the atmosphere because land and water are poor conductors of heat.

The angle at which the sun's rays strike Earth varies because Earth is a sphere that rotates on its axis. The sun's rays produce the most heat when they strike Earth at a 90° angle. We call these rays **direct rays**. The area near the equator gets most of the *direct rays* of the sun. The rays that strike Earth on both sides of the equator hit at an



angle that is greater than 90° and are called **indirect rays**. This creates an uneven heating of Earth which causes a system of air currents and winds to be formed. Vertical movements of air are called **currents**, and horizontal movements of air are called **wind**.

Practice

Use the list above each section to complete the statements in that section.

10
atmosphere
jet stream
ozone
stratosphere
troposphere
ultraviolet rays

1. The blanket of air that surrounds Earth is the ____________________ .

2. The layer of the atmosphere closest to Earth that contains our weather is the ____________________ .

3. The troposphere extends for about ____________________ kilometers.

4. A narrow band of winds that blow from west to east, just above the troposphere, in which airplanes sometimes fly, is called the ____________________ .

5. The ____________________ is the layer above the troposphere.

6. The upper layer of the stratosphere is about the same temperature as Earth at sea level because of the presence of ____________________ .

7. Ozone heats the atmosphere by absorbing the sun's ____________________ .

aerosol cans
blindness
exosphere
ionosphere
mesosphere
oxygen
skin cancer
thermosphere

8. Ultraviolet rays from the sun can cause ____________________ and ____________________ .

9. CFCs used in ____________________ destroy the ozone layer.

10. The coldest part of the atmosphere, just above the stratosphere, is the ____________________ .

11. Beyond the mesosphere is the ____________________ , which extends to 500-700 kilometers and is very hot.

12. Within the thermosphere, the part that contains electrically charged particles is called the ____________________ .

13. The last layer of the atmosphere extends for thousands of kilometers into space and is called the ____________________ .

14. Ozone is a gas that contains three atoms of ____________________ per molecule instead of two atoms, as does the gas that we breathe.

Practice

Complete the chart below. Beside each layer of the **atmosphere***, record the* **distance** *each extends into* **space***, and list the important* **characteristics** *of each.*

Layer	Distance	Characteristics
1. troposphere		
2. stratosphere		
3. mesosphere		
4. thermosphere		
a. ionosphere		
b. exosphere		

Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. transfer of heat energy by moving air or fluid

______ 2. the weather of an area over a long period of time

______ 3. vertical movements of air or water caused by the uneven heating of Earth

______ 4. process by which the sun's rays reach Earth in the form of waves

______ 5. direct transfer of heat energy from one substance to another

______ 6. horizontal movements of air caused by the uneven heating of Earth

______ 7. rays of the sun that hit Earth at a 90° angle; they create the greatest amount of heat

______ 8. rays of the sun that hit Earth at greater than 90°; they produce less heat

______ 9. the vertical movement of air or water caused by differences in temperature

______ 10. the day-to-day changes in temperature, humidity, wind, and air pressure

A. climate

B. conduction

C. convection

D. convection current

E. currents

F. direct rays

G. indirect rays

H. radiation

I. weather

J. wind

Practice

Use the list below to complete the following statements.

convection current
currents
direct rays
heat
indirect rays
radiation
sun
wind

1. Earth gets its heat from the ____________________ .

2. The process by which the sun's energy reaches Earth in the form of waves is called ____________________ .

3. Light waves are absorbed by Earth and returned to the atmosphere as ____________________ .

4. A ____________________ is formed when warm air rises and cold air rushes in to take its place.

5. Rays of the sun that hit Earth at a 90° angle are called ____________________ .

6. Rays that strike Earth at an angle of greater than 90° are called ____________________ .

7. ____________________ are vertical movements of air.

8. Horizontal movements of air are called ____________________ .

Practice

Answer the following using complete sentences.

1. How does ozone differ from the oxygen we breathe? ____________

   ____

   ____

2. How does ozone smell? ____________________________

   ____

   ____

3. When can you smell ozone? ________________________

   ____

   ____

4. How does the ozone layer protect us? ________________

   ____

   ____

   ____

5. What can be done to stop people from destroying the ozone layer?

   ____

   ____

   ____

High and Low Air Pressure

L

low pressure map symbol

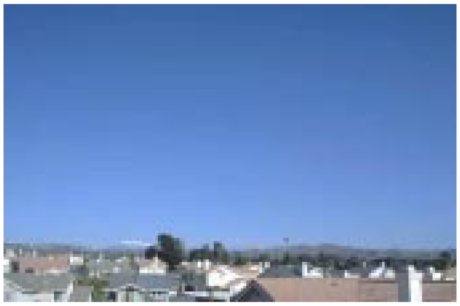
The uneven heating of Earth also causes changes in air pressure. When lighter, warm air rises, it creates an area of low pressure. The *winds* of a **low-pressure system** move upward, spiraling towards the system's center in a counterclockwise direction in the Northern Hemisphere and clockwise in the Southern Hemisphere. *Low-pressure systems* generally bring cloudy, rainy weather that is often accompanied by storms.

Low-pressure systems generally bring cloudy, rainy weather that is often accompanied by storms.

H

high pressure map symbol

The heavier, cooler air in the upper atmosphere sinks, creating an area of high pressure. The winds of a **high-pressure system** move downward, spiraling outward in a clockwise direction in the Northern Hemisphere and counterclockwise in the Southern Hemisphere. *High-pressure systems* bring cool, clear skies and dry weather. Differences between air pressure also cause winds. Air will move from an area of high pressure into an area of low pressure. The strength of the wind will depend on the amount of difference in pressure between the two systems. Air pressure systems cause changes in weather and are measured by a **barometer**.

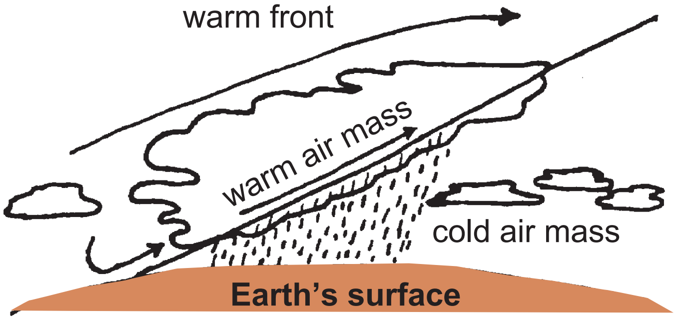


High-pressure systems bring cool, clear skies and dry weather.

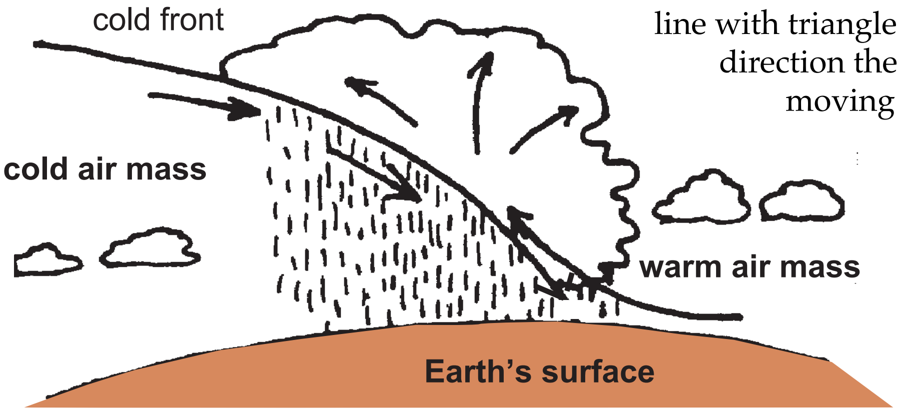
Fronts

Large bodies of air having the same temperature and amount of moisture are called **air masses**. Some *air masses* form over continents and others form over the oceans. Those forming over the oceans have more moisture in them than the ones forming over land. When two different types of air masses meet, a boundary called a **front** forms. *Fronts* usually have stormy or unstable weather. There are four types of fronts: warm, cold, stationary, and occluded.

Warm Front. A **warm front** forms when a mass of warm air meets a mass of cold air. The warm air gradually moves up and over the colder air causing **precipitation** and **clouds** ahead of the *warm front*. High **cirrus** *clouds* form and are followed by **stratus** clouds, causing the *barometer* to fall, and **nimbostratus** clouds producing rain or snow falls for a long period of time. A warm front is indicated by a line with half circles on it (◒◒◒).



Cold Front. A **cold front** forms when a cold air mass pushes a warm air mass in front of it. The cold air wedges under the warm air and lifts it up at a sharp angle, causing the formation of **cumulus** and **cumulonimbus** clouds, which produce thunderstorms and hard rains. *Cold fronts* generally move through an area quite rapidly, with cool, clear weather following. Cold fronts are indicated by a line with triangles facing the direction the front is moving (▼▼▼).



Stationary Front. A **stationary front** forms when two unlike air masses face each other, but there is very little movement of air. The weather associated with a *stationary front* is similar to a warm front. Eventually one front or the other moves, forming either a warm or a cold front. The symbol for this front is a line with half circles on one side and triangles on the other ().

Occluded Front. An **occluded front** forms when a cold front overtakes and merges with a warm front. It is characterized by a combination of weather from both fronts. An *occluded front* is indicated by a line with alternating half circles and triangles on the same side of the line ().

Practice

Use the list below to complete the following statements.

air mass
barometer
counterclockwise
cold
front
high-
lighter
low-
occluded
stationary
warm

1. ____________________ warm air rises and creates an area of low pressure.

2. The winds of a low-pressure system move in a ____________________ direction in the Northern Hemisphere.

3. Cloudy, rainy weather is caused by a ____________________ pressure system.

4. Cool air that is heavy sinks and creates a ____________________ pressure system.

5. A ____________________ is used to measure air pressure.

6. A large body of air having the same amount of moisture and temperature is called a(n) ____________________ .

7. A boundary called a ____________________ forms when two different types of air masses meet.

8. After a(n) ____________________ front, the weather is usually cool and clear.

9. A(n) ________________________ front forms when two fronts meet but neither moves for a period of time.

10. A(n) ________________________ front brings rain or snow that lasts for a long period of time.

11. When a cold front overtakes and merges with a warm front, a(n) ________________________ front forms.

Practice

Match the **front** *with the correct* **symbol**. *Write the letter on line provided.*

______ 1. warm front

______ 2. cold front

______ 3. occluded front

______ 4. stationary front

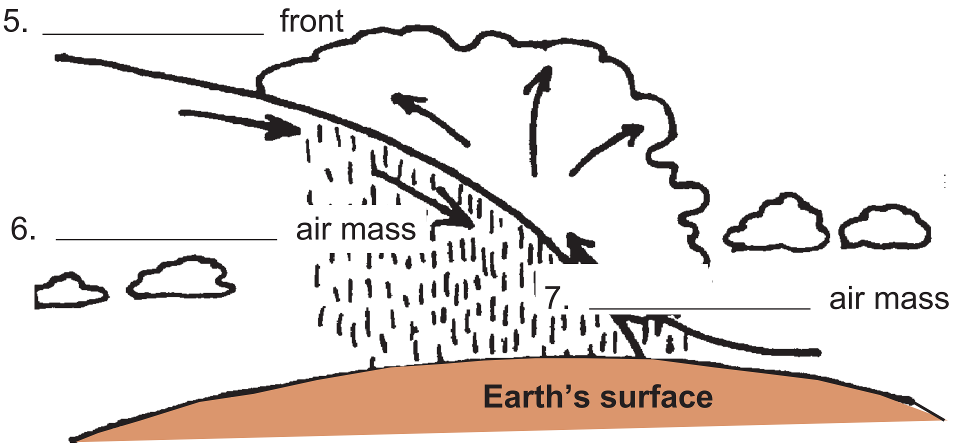
A. 

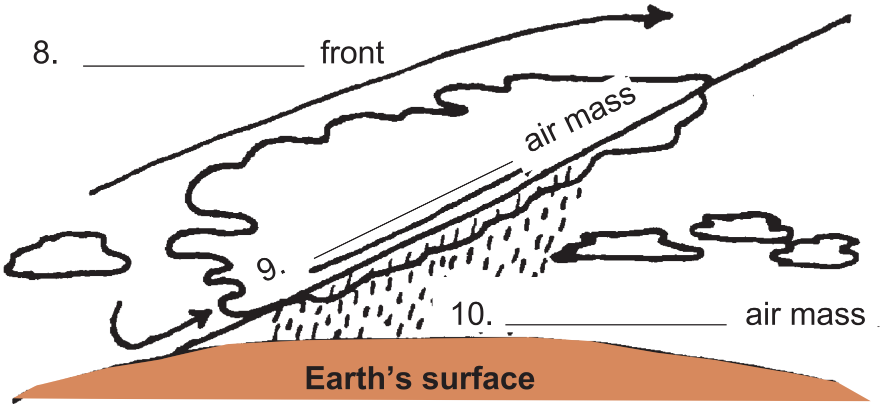
B. 

C. 

D. 

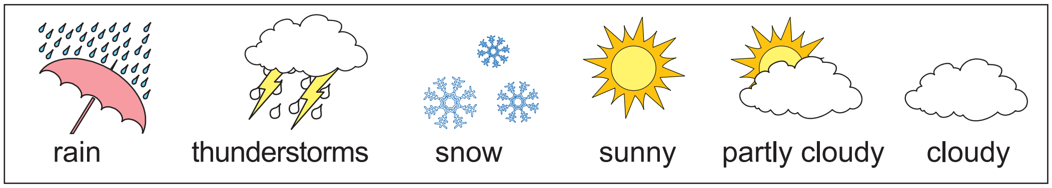
Label the **fronts** *and* **air masses** *shown below. Write* **cold** *or* **warm** *on the lines provided.*





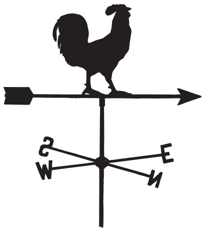
Practice

Use data from the newspaper to construct a **weather map** *for a particular day. Use your knowledge of* **air masses** *to predict the weather for the* **southeast region**.



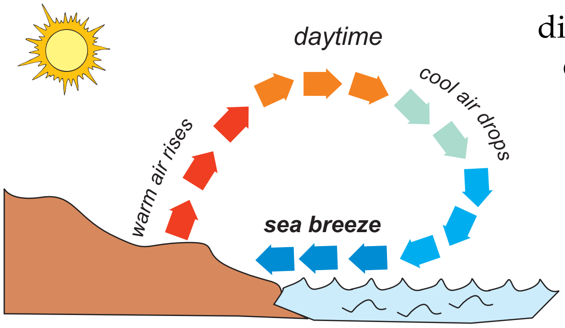
Winds

The differences in air pressure caused by the uneven heating of Earth by the sun result in winds. We use a **wind vane** to indicate the direction from which the wind is blowing. An **anemometer** is used to measure wind speed.



A wind vane indicates the direction from which the wind is blowing.

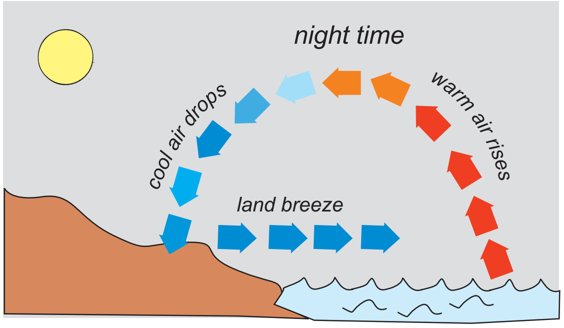
There are different types of wind systems. Local wind systems are caused by the specific conditions of a local area. The surface features of a particular area affect the amount of heat absorbed by the sun. Land absorbs the heat of the sun faster than water does, but it also loses heat faster than the water. This causes an uneven heating of the air and results in local winds. Winds are named for the direction from which they come. For example, a wind coming from the north and going south is called a north wind.



During the day, the warm air above the land rises. Cool air from the body of water moves inland to replace it and creates a sea breeze.

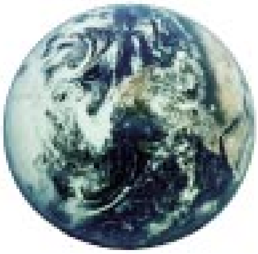
During the day, land near a large body of water heats up faster than the water. The warm air above the land rises and the cool air from the body of water moving inland to replace it creates a **sea breeze**.

At night, the land cools faster than nearby bodies of water. Eventually air above the water will become warmer than that above the land and will rise, causing the cooler air from land to move in and replace it. This movement of air from land to sea is called a **land breeze**.



At night, the land cools faster than nearby bodies of water. Air above the water becomes warmer and rises to create a land breeze.

Wind Systems



The unequal heating and rotation of Earth creates global wind systems, or belts.

The unequal heating and rotation of Earth also creates global wind systems, or belts. The air above the equator is warmer than the air above the polar regions. Warmer air rises and travels towards the poles where it cools and becomes heavier. This cool, heavy air then moves back towards the equator where it is again warmed and rises. This warming and cooling process combines with Earth's rotation to form convection currents that create global winds. There are several wind systems on Earth's surface. They are as follows:

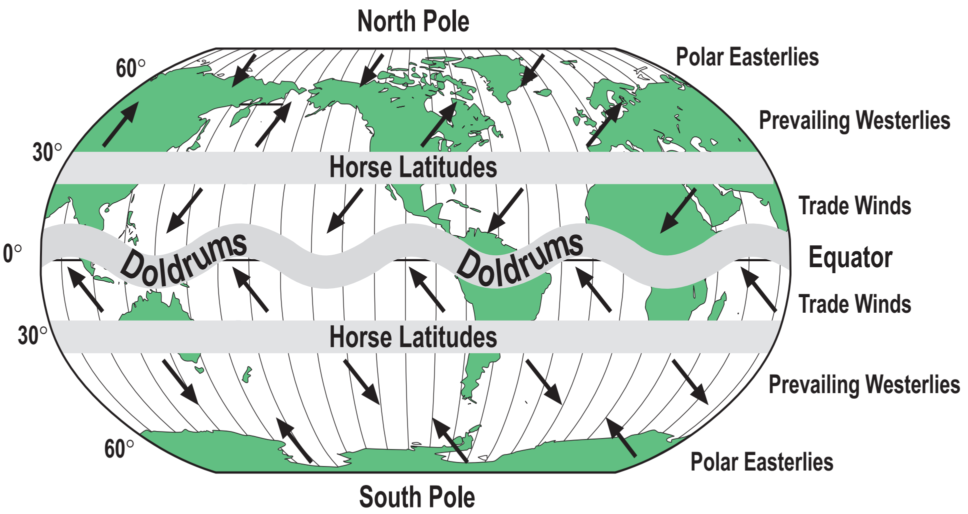
Doldrums. The **doldrums** are a windless zone at the equator. The air seems to be motionless, but actually it is constantly being heated and forced straight up. This causes very little wind or no wind at all except during storms. In the days of sailing ships, many ships were caught in the *doldrums* and lost.

Trade Winds. The wind belt known for the **trade winds** is found just north and south of the equator. In these areas, wind is fairly constant. North of the equator the winds blow from the northeast, and south of the equator they blow from the southeast. Early sailors depended on these winds to get from one continent to another in order to trade, and called them *trade winds*.

Horse Latitudes. Just north and south of the trade winds at about 30° latitude are two narrow regions known as the **horse latitudes**. This is where the air moving from the equator cools and sinks. It is characterized by clear weather and very little rainfall. There is also very little wind in this area. If ships were caught in this region, they sometimes had to throw horses overboard when they were unable to feed them, giving the area its name.

Prevailing Westerlies. North and south of the *horse latitude*s are another wide belt of winds known as the **prevailing westerlies**, named for the direction from which they blow. These winds form in areas of Earth where there are large areas of land. The air over the land heats up and rises, then cools and sinks again, creating a wind belt.

Polar Easterlies. The belt known as the **polar easterlies** extends from 65° north and south latitude to the poles. These winds come from the east and blow cold winds away from the polar areas.



Wind Belts

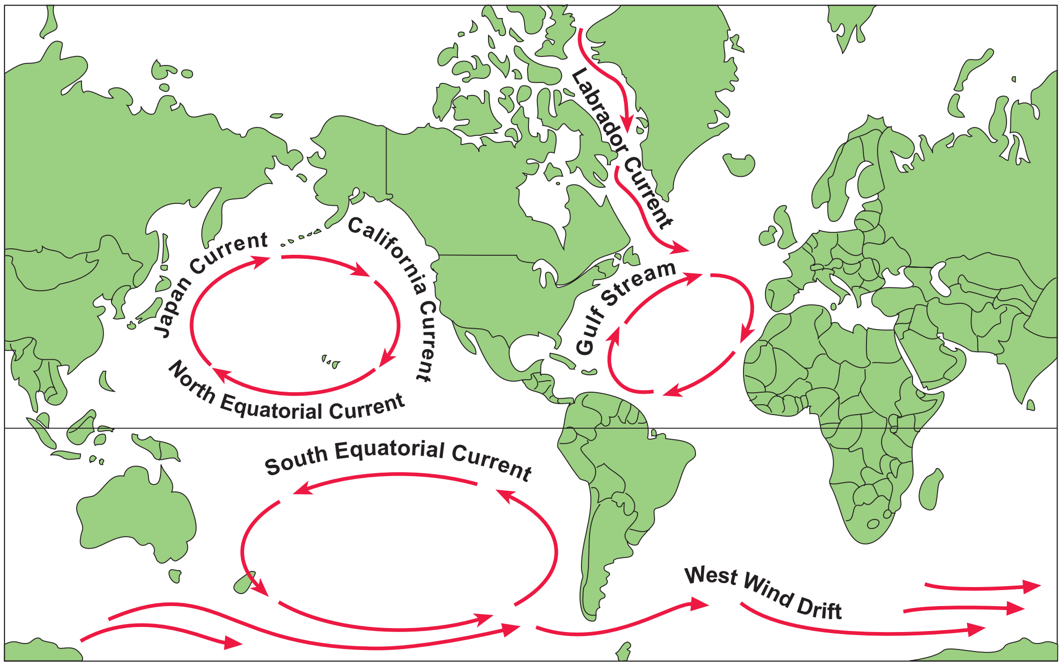
Sometimes winds that blow are seasonal. Winds that blow in one direction one season and in an opposite direction in another season are called **monsoons**. During a *monsoon*, the land becomes hotter than the water, causing winds that blow in from the ocean. These winds bring warm, moist air, producing a rainy season during the summer. In the winter, the land cools more quickly, causing the winds to blow from the land to the oceans, which creates a dry season. A monsoon is actually a very large, long-lasting *land breeze* and *sea breeze*.

Currents

A *current* is a moving, streaming, or plowing body of water or air. Ocean currents are sometimes called the *rivers of the ocean*. Like the rivers on the land, ocean currents flow in nearly the same direction.

The ocean has many currents. These currents are caused by the forces of the sun's heat, Earth's rotation, and the blowing winds.

Changes in the water temperature cause currents. Differences in water temperature start water movement called convection currents. Because the equator of Earth receives direct sun rays, the waters near the equator are warmer than the waters near the north or south pole. Warm water from the equator is pushed toward the poles by winds and Earth's rotation. This warm current transfers its warmth to the lands it flows by and to the cool waters around the poles. The colder water is heavier, so it sinks and moves back to the equator.



Ocean Currents

Ocean currents affect the climate of the continents they flow past. Currents that originate near the equator are warm. The warmth of these currents is transferred to the land and to the cool northern waters. The Gulf Stream is a warm current that helps moderate the winters of the British Isles and Norway and keeps them relatively warm for their latitudes. The Gulf Stream warms our eastern coast of the United States. The Japan Current is also a warm current. It brings a mild climate to parts of British Columbia and Alaska.

Alaskan waters are near the North Pole and nearer to either pole the water cools. Colder, heavier polar waters sink under warm currents and move back toward the equator. The California Current is a colder current that affects the western coast of the United States.

The dense fog of London is an example of the way currents affect the land masses. This heavy fog is caused when the warm, moist air from the Gulf Stream meets the colder air from the Labrador Current.

Practice

Use the list below to write the correct term for each definition on the line provided.

anemometer
doldrums
horse latitudes
land breeze
monsoons
polar easterlies
prevailing westerlies
sea breeze
trade winds
wind vane

____________________ 1. the area around the equator where air moves straight up and there is very little wind

____________________ 2. cool air blowing from land to sea at night

____________________ 3. system of winds that blows cold air from the poles

____________________ 4. an instrument used to measure wind speed

____________________ 5. an instrument that tells from which direction the wind is coming

____________________ 6. system of winds found just north and south of the equator that blows toward the equator from the northeast and southeast

____________________ 7. area at about 30° north and south latitude where there is very little wind

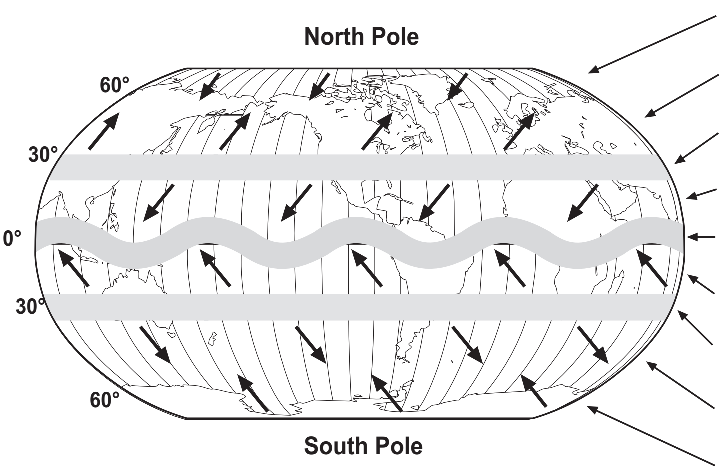
____________________ 8. cool air that moves from sea to land during the day

____________________ 9. wind system formed over large land areas that blows from the west to the east

____________________ 10. winds that blow inland during summer bringing rainy weather and that blow out to sea in winter bringing dry weather

Practice

Label the **major wind systems** *on Earth. Write* **North**, **South**, **East**, *or* **West** *on each line in the chart to show the direction of the* **major air movements**. *The arrows indicate the direction of the movement.*



1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
6. ____________________
7. ____________________
8. ____________________
9. ____________________

10.-15.

Wind		
Direction of movement for latitudes:	Northern Hemisphere	Southern Hemisphere
60° - 90°		
30° - 60°		
0° - 30°		

Lab Activity 1: The Earth's Rotation Creates Winds and Currents

Fact:

- The unequal heating and rotation of Earth creates global wind systems and ocean currents.

Investigate:

- You will observe the effects of rotation on water.

Materials:

- bowl
- water
- lazy Susan tray or rotating piano stool

1. Place a bowl of water on a lazy Susan tray or a rotating piano stool.
2. Gently spin in a counterclockwise direction.
3. Let the water become still.
4. Rotate in the opposite direction.
5. What did you see happen when the water was spun counterclockwise? ____

   ____

   ____

   ____

6. What did you see happen to the water when it was rotated in the opposite direction? ______________________________

____

____

____

7. How did the water movement change? __________________

____

____

____

Lab Activity 2: Water Currents

Fact:

- Changes in the water temperature cause convection currents.

Investigate:

- You will observe water currents that result from heating water.

Materials:

- ice cubes
- rectangular pan
- water
- food coloring
- Bunsen burner

1. Place ice cubes in the center of a rectangular pan.
2. Fill pan with water.
3. Put an immersion heater just below the surface of the water on one side of the pan. (A Bunsen burner can be used. Make sure to heat one side of the pan, not the center.)
4. Add several drops of food coloring close to the heated side.
5. Continue to heat until you can see the movement of the color.
6. In what direction does the colored water move? ________________
7. Does the clear water move? ___________________________________
8. Does the colored water stay at the top? ________________________
9. What climate zone does the ice represent? _____________________

10. What climate zone does the heater represent? ________________

11. Consider what you have observed, in what direction do you think the ocean currents should move? ___________________________

____

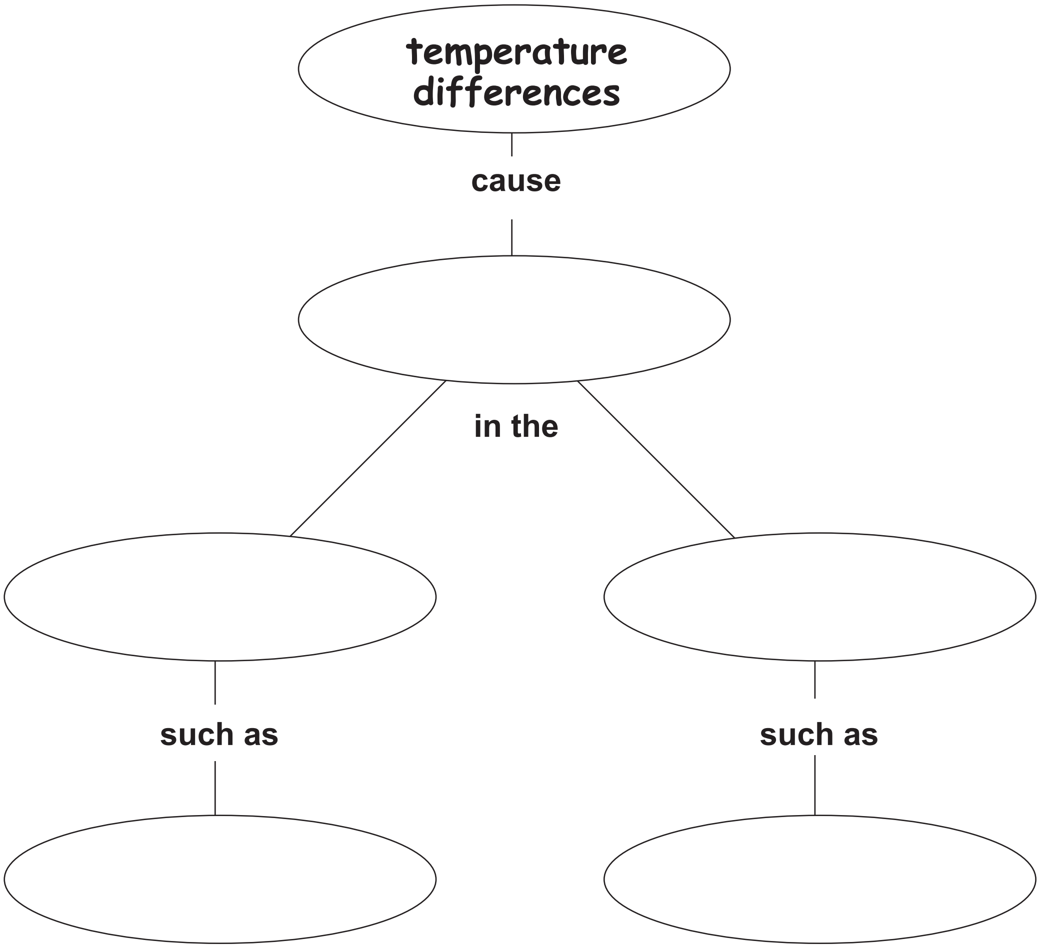
____

____

Practice

Use the list below to complete the following **concept map** *about* **temperature differences**.

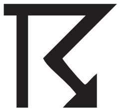
atmosphere
currents
doldrums
Gulf Stream
oceans



Storms

There are many different types of storms that occur on the surface of Earth. They range in severity from minor inconvenience to major disaster.

When two fronts collide, rainstorms and thunderstorms form. A *rainstorm* or steady rainfall that lasts for hours forms when a warm front meets a cold front. There is not usually much danger in a rainstorm except for flooding if the storm lasts long enough.



thunderstorm map symbol

Cumulonimbus clouds cause heavy rains along with thunder and lightning.

Thunderstorms form when a cold front meets a warm front. As warm air rises, it cools and condenses, forming *cumulonimbus* clouds. These clouds cause heavy rains along with **thunder** and lightning. During thunderstorms, electrical charges build up in the clouds. *Lightning* is the sudden discharge of electricity from the clouds. *Thunder* is the sound made by lightning. It is usually heard a few seconds after the lightning is seen because sound travels slower than light.

Blizzards occur during the winter months.

Blizzards occur during the winter months. *Blizzards* combine high winds, below freezing temperatures, and blowing powdery snow. Winds often range from 30 to 45 miles per hour (mph). These severe weather conditions can be dangerous to people and animals.

Low-pressure systems that contain warm air rising in a counterclockwise circular motion are called **cyclones**. The low-pressure systems usually cause rainy, stormy weather. High-pressure systems that have cool, dry air moving downward in a clockwise motion are called **anticyclones**. They bring clear, dry, fair weather. *Cyclones* and *anticyclones* move in opposite directions in the Southern Hemisphere. These systems can be either mild or severe.

hurricane map symbol

A *hurricane* is a large, powerful cyclone. Hurricanes start out as low-pressure areas over the ocean in summer or early fall. As the system builds, it forms a spiral motion and contains a large amount of moisture. When wind speed is less than 35 mph, the storm is called a **tropical depression**. If the storm builds to a wind speed of 35 to 74 mph, it is called a **tropical storm**. When sustained winds reach 75 mph or more, a hurricane is born. Hurricane winds can reach over 200 mph; however, most of the damage from hurricanes comes from the flooding caused by the heavy rains associated with the storm.

A hurricane is a large, powerful cyclone.

tornado map symbol

A *tornado* is a violent, funnel-shaped windstorm that can occur along with thunderstorms or hurricanes. Tornadoes are formed when a mass of warm air is trapped between two masses of cold air. The pressure of the air in the center of the tornado is much lower than the surrounding air, causing winds that can reach 300 mph. The path of a tornado is much smaller than that of a hurricane, but because of its extremely high winds, it can do more damage to the area it strikes. A tornado that forms over the ocean is called a **waterspout**.

Safety Precautions

Storms can cause severe damage. Many safety precautions can be taken to prevent injury and lessen damage.

Rainstorms and thunderstorms rarely cause severe damage, with the exception of flooding. However, if lightning occurs, take the precautions listed on the following page:

Lightning Safety Precautions

1. Stay indoors.
2. Unplug electrical appliances to prevent damage.
3. Avoid using the telephone or other electrical appliances.
4. Do not take a bath or shower.
5. If outdoors, stay away from tall objects like trees and towers. Also, avoid metal objects like golf clubs and aluminum baseball bats.
6. If you are boating or swiming, get out of the water immediately and move to safe shelter away from water.
7. If you feel your hair standing on end, squat with your head between your knees. **Do not lie flat!**

Lightning is a problem in Florida.

Getting struck by lightning can result in burns, loss of hearing, nervous system problems, and death. Lightning is a problem in Florida—especially during the summer and fall.

Hurricanes develop in tropical waters usually between June and November. These storms affect Florida and cause damage from wind and water. Hurricanes cause large-scale destruction and often leave areas without power and telephone service. Therefore, make sure that you have water, nonperishable food, candles, flashlights, a portable radio, batteries, and other items you may need.

A *hurricane watch* means that a hurricane may threaten within 24 hours. *Hurricane warnings* indicate that one is expected to strike within 24 hours. When a warning is issued, take the following precautions:

Hurricane Warning Safety Precautions

1. Leave low-lying areas.
2. Secure boats, outdoor objects, and windows.
3. Fill your car with gas.
4. Leave mobile homes for sturdier shelter.
5. Listen to weather service bulletins.
6. Leave your home for shelter, if advised by authorities.

After the hurricane has completely passed, stay away from heavily damaged areas, flooded areas, and loose wires, and cooperate with emergency officials. Do not mistake the *eye* of the hurricane for the *end*. The eye is a calm area at the center of a hurricane. After it passes, the storm will continue.

Tornadoes can be spawned by hurricanes or occur singly over land or water. Remain indoors or seek shelter in low-lying areas, if outdoors. If inside, open a window a few inches on the side of the house away from the storm, and take shelter in a small interior area like a hallway, closet, or bathroom.

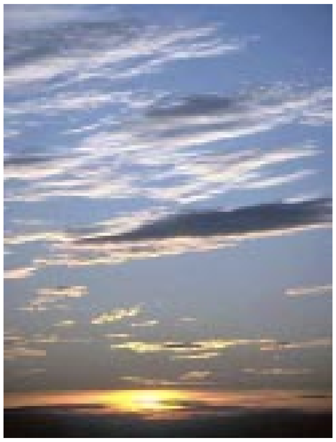
Blizzards are not a common occurrence in Florida. But if you should be where they occur, it is important to stay indoors, if possible. Frostbite and disorientation are common problems. People in northern areas watch weather bulletins and stay close to home as a precaution.

Danger to human life can be lessened by taking appropriate precautions when warnings are issued. It is important to pay attention to signs of severe weather.

Clouds

Clouds are tiny droplets of water suspended in the air. Clouds form when the air becomes **saturated** (has all of the moisture that it can hold). The droplets of water cling to particles of dust, salt, smoke, or even volcanic ash found in the atmosphere and form clouds.

There are three basic types of clouds. They are classified according to their shape and the altitude at which they are formed. There are three basic types:



Cirrus *clouds are thin, feathery clouds that form at very high altitudes.*

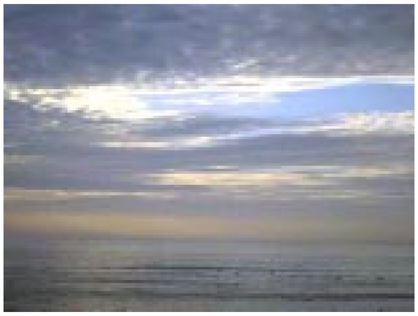
Cirrus. *Cirrus* clouds are thin, feathery clouds that form at very high altitudes. They are made of ice crystals and indicate that snow or rain may be coming in the next few hours.

Cumulus *clouds are puffy with flat bottoms.*

Cumulus. *Cumulus* clouds are puffy with flat bottoms. They look like puffs of cotton in the sky. They form in the middle altitudes and usually indicate fair weather.

Stratus. *Stratus* clouds are the gray, smooth, layered clouds that lie low in the sky. They block out the sun and usually bring rain or drizzle. Stratus clouds that form close to the ground are called fog.

Another term used to describe clouds is **nimbus**, which means *rain*. *Nimbostratus* clouds are low, black, layered clouds that cause long periods of rain. *Cumulonimbus* clouds are often called thunderheads because they are the clouds that cause thunderstorms.



Stratus *clouds are the gray, smooth, layered clouds that lie low in the sky.*

Clouds shield against the heat of the sun. Since clouds are made of droplets of water, more light is reflected off them. As a result there are lower temperatures during the day than if there were no clouds. At night, clouds act as blankets that insulate Earth and keep it warmer. Heat waves radiated by the sun that enter the atmosphere are short waves. As they bounce off the surface of Earth, they become longer. These longer waves cannot pass through the cloud layer and therefore bounce back to Earth's surface, maintaining warmer nighttime temperatures than if there were no clouds. Clouds blanket Earth in much the same way a blanket keeps a person warm on a cool night. Cloud cover can keep crops from freezing when the temperatures unexpectedly drop below freezing.

Precipitation

When clouds form, water droplets may grow larger and larger until they are so heavy that they can no longer remain suspended in the air. Water falls to the ground in one or more forms called *precipitation*. There are several types of precipitation. The type of precipitation formed depends on the weather conditions and temperatures.

Rain is the most common type of precipitation. It forms when the temperature of air below the clouds is above freezing and droplets of water fall from the clouds. If the rain falls in very tiny drops, it is called *drizzle* or *mist*.

When the temperature in the clouds is below freezing and the temperature of the air below the clouds is also freezing, crystals of ice called *snowflakes* form. Each snowflake is unique, but all of them have six points.

When the temperature in the clouds is below freezing and the temperature of the air below the clouds is also freezing, crystals of ice called snowflakes *form.*

Sleet forms when raindrops fall through a layer of air that is below freezing, causing the rain to freeze as it falls to Earth. Sleet also forms when snow melts on its way down and then freezes again; sleet will only fall in the winter. *Freezing rain* forms when conditions on the ground are cold enough to freeze the rain when it lands.

A damaging form of precipitation is *hail*. It can destroy entire crops as well as damage cars and other property. Hail or hailstones are chunks or balls of ice formed in cumulonimbus clouds. A hailstone is formed when a water droplet freezes on a small crystal of ice. Updrafts in the cloud toss the ice balls up in the cloud and then a layer of water freezes on the ice ball. This continues until the hailstone is finally heavy enough to fall to Earth. The average hailstone is about the size of a pea, but sometimes they can get as large as baseballs.

Climates

Weather encompasses the day-to-day changes in the temperature, humidity, wind, and air pressure. *Climate* is the average of conditions that make up an area's weather over a long period of time. Weather changes from day to day, whereas climate remains the same.

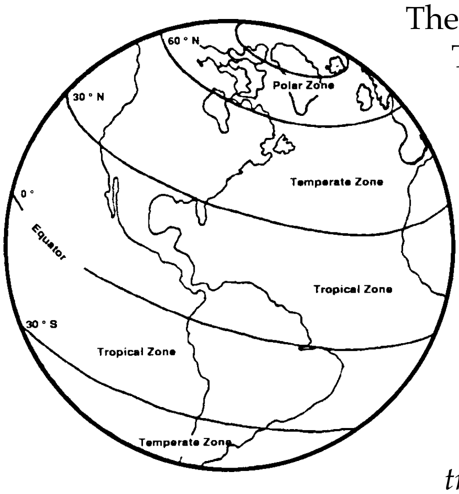
Factors Influencing Climate

An area's climate is influenced by many factors. Some of these include latitude, elevation, and nearness to a major body of water.

The latitude or distance north or south of the equator is a factor in determining the climate of an area. Areas near the equator receive the direct rays of the sun and have warm climates. Likewise, the areas farther from the equator get more *indirect rays* and are cooler, with the coldest areas being at the poles.

Elevation, or height above sea level, is also a factor in determining the climate of an area. The higher the elevation, the colder the climate. Even high mountains near the equator can have snow-capped peaks. Mountains near coastal regions are also important in forming **deserts**. When the moist winds from the ocean rise and meet the mountain range, they drop their moisture in the form of rain on the side of the mountains nearest the ocean or in the form of snow on the mountains. The air that passes to the other side of the mountains is now dry, and the climate on that side of the mountains will also be dry.

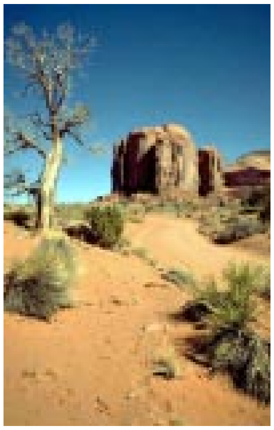
A major body of water near land may have a great influence on the climate. Land near large bodies of water may be humid or moist. Since large bodies of water heat up and cool off much more slowly than land, these areas do not have the extreme temperature changes of large land areas.



There are three main climate zones on Earth.

There are three main climate zones on Earth. They are the **polar zone**, the **temperate zone**, and the **tropical zone**. The *polar zone* begins at each pole and extends to about 60° north or south latitude. Here, the average temperatures remain below freezing and there is little precipitation. Between 60° and 30° latitude on each hemisphere is a region called the *temperate zone*, which has a variance of temperatures and an average amount of precipitation. The *tropical zone* extends from about 30° north latitude to 30° south latitude. It has above-average temperatures and precipitation.

Within these zones there are other climatic types. *Deserts* are areas that receive less than 25 centimeters of rainfall a year. They are usually located along the western border of a large land mass with a range of coastal mountains.



Deserts *are areas that receive less than 25 centimeters of rainfall a year.*

Marine climates are found near large bodies of water. Temperatures in this type of climate do not vary much because the water cools off and heats up much more slowly than the land does. There is also less seasonal change in these areas.

Continental climates are found where there are huge land masses. They are greatly affected by air masses that move in from both polar and tropical regions. They have noticeable seasonal changes and severe temperature changes. Mountain regions located in continental areas also show distinct climatic changes. Higher up in the mountain regions, the climate becomes more like that found in the polar regions.

Summary

Heat and energy are transferred from the sun by Earth's atmosphere through convection, radiation, and conduction. Uneven heating of Earth causes changes in air pressure and air currents. These changes along with the Earth's rotation produce local wind systems and global wind systems. Blowing winds, the sun's heat, and the Earth's rotation combine to create the oceans' many water currents.

Air masses of different types meet and form warm, cold, stationary, or occluded fronts. Colliding fronts cause many different types of storms. In the event of severe storms such as hurricanes and tornadoes, safety precautions should be used to prevent injury or property damage.

When moist air is cooled, water vapor condenses around tiny specks of dust, smoke, or salt to form droplets. Huge numbers of droplets form clouds. When these water droplets get too heavy, they fall to the ground in some form of precipitation—rain, sleet, hail, or snow. Three basic types of clouds insulate Earth and help shield it from the sun's heat.

Climate is the average weather of an area over a long period of time. Factors such as latitude, elevation, and nearness to water affect climate. Earth's atmosphere has four layers. Each layer has different temperatures and gases present.

Practice

Use the list above each section to complete the statements in that section.

anticyclones
blizzards
cyclones
thunder
tropical depression
tropical storm
waterspout

1. ____________________ is the sound made by lightning. It is usually heard a few seconds after the lightning is seen because sound travels slower than light.

2. Snowstorms that combine high winds, below-freezing temperatures, and blowing, powdery snow are called ____________________ .

3. Low-pressure areas that contain warm air rising in a counterclockwise circular motion are called ____________________ .

4. High-pressure systems with cool, dry air moving downward in a clockwise motion are called ____________________ .

5. As a hurricane system builds, it forms a spiral motion and contains a large amount of moisture. When wind speed is less than 35 mph, the storm is called a ____________________ . If the storm builds to a wind speed of 35 to 74 mph, it is called a ____________________ .

6. A tornado that forms over the ocean is called a ____________________ .

cirrus
continental climates
cumulus
deserts
marine climates
nimbus
polar zone
saturated
stratus
temperate zone
tropical zone

7. *Clouds* form when the air becomes ____________________ (has all of the moisture that it can hold).

8. ____________________ clouds are thin, feathery clouds that form at very high altitudes.

9. ____________________ clouds are puffy with flat bottoms and look like puffs of cotton in the sky.

10. ____________________ clouds are the gray, smooth, layered clouds that lie low in the sky and usually bring rain or drizzle.

11. Another term used to describe clouds is ____________________ , which means *rain*.

12. The three main climate zones on Earth include the ____________________ , the ____________________ , and the ____________________ .

13. ____________________ are areas that receive less than 25 centimeters of rainfall a year.

14. ____________________ are found near large bodies of water.

15. ____________________ are found where there are huge land masses.

Practice

Use the **hurricane tracking map** *on the next page to* **plot** *the* **paths** *of hurricanes* **Bonnie** *and* **Andrew**. *Then answer the questions below using short answers.*

Hurricane Bonnie			**Hurricane Andrew**		
Date	Position at 6:00 a.m.		Date	Position at 6:00 a.m.	
1998	Latitude	Longitude	1992	Latitude	Longitude
Aug. 22	21.8° N	68.7° W	Sept. 20	20.7° N	60.0° W
23	23.8° N	71.3° W	21	23.9° N	63.3° W
24	25.2° N	72.1° W	22	25.6° N	67.0° W
25	27.8° N	73.8° W	23	25.5° N	72.5° W
26	31.7° N	77.3° W	24	25.4° N	79.3° W
27	34.5° N	77.5° W	25	26.6° N	86.7° W
28	36.2° N	75.1° W	26	29.2° N	91.3° W
29	39.2° N	69.6° W	27	32.1° N	90.5° W
30	44.3° N	57.0° W	28	35.4° N	84.0° W

1. Where did Bonnie hit land? ________________________________

2. Where did Andrew hit land? ________________________________

3. In which general directions do hurricanes move?□ ____________

   ____

4. Where do most of the hurricanes form that affect Florida? ______

   ____

5. Which areas of the United States are most affected by hurricanes?

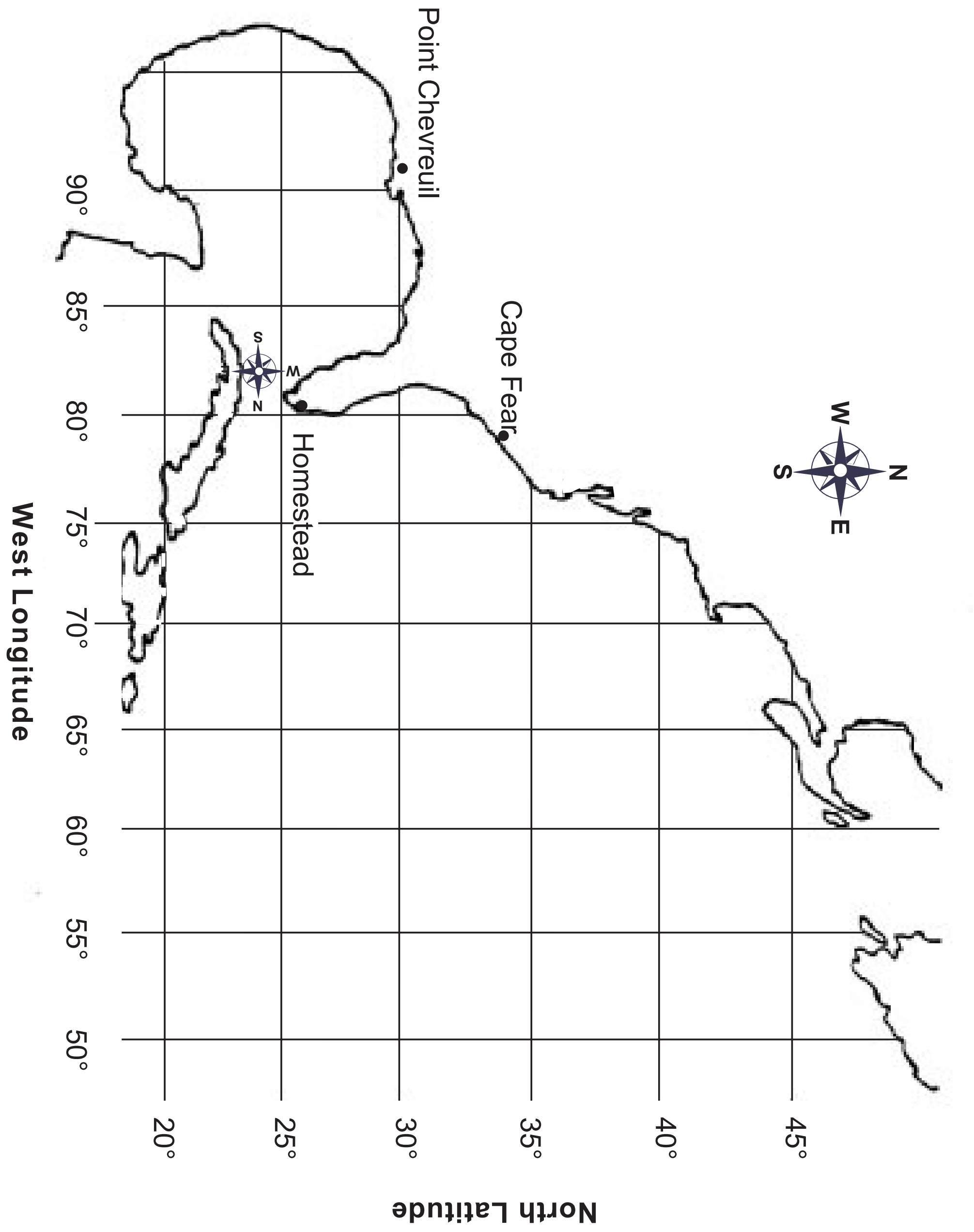
   ____

6. What causes the most damage from a hurricane, wind or

   water? ____

Use the information on the previous page to **plot** *the* **paths** *of* **hurricanes Bonnie** *and* **Andrew** *on the map below. Then answer the questions on the previous page.*

7.



Practice

Answer the following using complete sentences.

1. What danger exists in thunderstorms? ________________________

   ____

   ____

2. What should you do if you are caught outside during a thunderstorm? ____

   ____

   ____

3. What are three precautions to take in the event of a hurricane?

   ____

   ____

   ____

4. What is the difference between a hurricane watch and a hurricane warning? ____

   ____

   ____

5. Where should you seek shelter indoors during a tornado? ______

   ____

   ____

   ____

Practice

Match each description with the correct **type of cloud**. *Write the letter on the line provided.*

______ 1. thin, feathery clouds found at high altitudes

______ 2. clouds that contain rain

______ 3. gray, smooth, layered clouds found low in the sky

______ 4. clouds that cause thunderstorms

______ 5. puffy clouds with flat bottoms found at middle altitudes

______ 6. low-lying, black, layered clouds that bring long periods of rain

A. cirrus

B. cumulonimbus

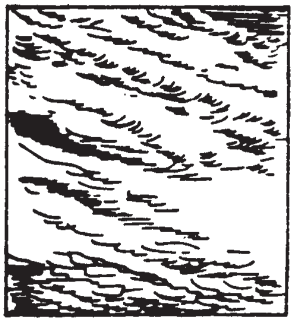
C. cumulus

D. nimbostratus

E. nimbus

F. stratus

Label the three basic **types of clouds**:



7. ____________________

8. ____________________

9. ____________________

Lab Activity 3: Cloud Formation

Fact:

- Clouds are tiny droplets of water suspended in the air.

Investigate:

- You will observe the formation of a cloud due to the change in air pressure.

Materials:

- two-liter plastic bottle with a cap
- water
- match

1. Fill the two-liter plastic bottle half full of water.
2. Drop a burning match into the bottle and screw the cap on tightly.
3. Squeeze the sides of the bottle as hard as you can.
4. Quickly release it.
5. Repeat steps 3 and 4 several times.
6. What do you observe? ______________________________
7. When the bottle is squeezed, what happens to the air pressure inside the bottle? ______________________________
8. When the bottle is released, the pressure decreases, causing the warmed air to cool and the ____________________ forms.

Practice

Complete the chart below for **five** *consecutive days.*

Cloud Observation Chart

Date and time of day	Direction of wind	Type of cloud observed	Description of clouds observed (puffy? wispy? dark? flat?)	Weather conditions at the time
	north			
	east			
	south			
	west			
	north			
	east			
	south			
	west			
	north			
	east			
	south			
	west			
	north			
	east			
	south			
	west			
	north			
	east			
	south			
	west			

Practice

Use the list above each section to complete the statements in that section. **One or more terms will be used more than once.**

75
200
hurricane
lightning
opposite
rainstorm
tornado
tropical depression
tropical storm
waterspout

1. A storm formed when two fronts meet that causes steady rainfall lasting for hours is called a ________________________ .

2. A sudden discharge of electricity from the clouds is called ________________________ .

3. High- and low-pressure systems move in ________________________ directions in the Southern Hemisphere.

4. A large powerful cyclone that begins as a low-pressure system over the ocean in summer or early fall is called a ________________________ .

5. A low-pressure system with winds less than 35 mph is called a(n) ________________________ .

6. A large, low-pressure system with winds from 35 to 74 mph is a ________________________ .

7. A hurricane is formed when sustained winds reach ________________________ mph. Hurricane winds can reach speeds of over ________________________ mph.

8. A violent, funnel-shaped windstorm with winds that reach 300 mph is a ________________________ .

9. A ________________________ is a tornado that forms over the ocean.

10. The path of a ________________________ is smaller than that of a ________________________ , but because of the high winds it can do more damage.

Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. moisture that falls to Earth as rain, hail, sleet, or snow

______ 2. condensation on particles of dust, smoke, or salt

______ 3. forms when the temperature of the air below the clouds is above freezing

______ 4. six-pointed crystals of ice that fall when the temperature of both the clouds and the land is below freezing

______ 5. rain that falls in very tiny droplets

______ 6. rain that freezes after it hits the ground

______ 7. snow melts and freezes again on its way down

______ 8. the most damaging form of precipitation

A. cloud

B. drizzle or mist

C. freezing rain

D. hailstones

E. precipitation

F. rain

G. sleet

H. snowflakes

Practice

Write **True** *if the statement is correct. Write* **False** *if the statement is* not *correct.*

__________ 1. Water droplets must condense on particles such as dust or smoke in order to form clouds.

__________ 2. Precipitation forms when water droplets become so heavy that they can no longer stay suspended in the air.

__________ 3. Snow is the most common type of precipitation.

__________ 4. Rain that forms very large droplets is called drizzle or mist.

__________ 5. In order for snowflakes to form, both the temperature of the clouds and the temperature of the air must be below freezing.

__________ 6. Snowflakes can have four, five, or six points.

__________ 7. Sleet and freezing rain are the same thing.

__________ 8. Sleet only falls in the winter.

__________ 9. The form of precipitation that causes the most damage is sleet.

_________ 10. Hailstones are formed in cumulonimbus clouds.

_________ 11. Hailstones are usually the size of golf balls.

_________ 12. Hailstones move up and down in the clouds several times, forming new layers of ice until they are finally heavy enough to fall.

_________ 13. Snow that melts on its way down and refreezes is called sleet.

_________ 14. The type of precipitation that falls is only determined by the temperature on the ground where it falls.

Practice

Use the list below to label the climate zones on the diagram. **Some of the terms will be used more than once.**

temperate **polar** **tropical**

Practice

Answer the following using complete sentences.

1. What three factors influence the climate of an area? ____________

   ____

   ____

2. Why are areas near the equator warmer? ______________________

   ____

3. How do mountains near coastal regions help in the formation of

   deserts? ____

   ____

   ____

4. Describe the temperature and precipitation in each of the three major climate zones. Fill in the chart below.

zone	**temperature**	**precipitation**

5. Describe the following climate types.

Desert: ____

____

____

____

____

____

Marine climate: ____

____

____

____

____

____

Continental climate: ____

____

____

____

____

____

____

Practice

Circle the letter of the **atmosphere** *and* **climate** *term that correctly completes each statement below.*

1. A dry area that receives less than 25 cm of rainfall per year is a(n) ____________ .

   a. equinox
   b. ozone
   c. polar zone
   d. desert

2. The upper part of the thermosphere is called the ____________ .

   a. ionosphere
   b. jet stream
   c. exosphere
   d. mesosphere

3. The coldest layer of the atmosphere, just above the stratosphere, is called the ____________ .

   a. exosphere
   b. ozone
   c. polar zone
   d. mesosphere

4. The ____________ is the lower part of the thermosphere that contains electrically charged particles called ions.

   a. ozone
   b. mesosphere
   c. exosphere
   d. ionosphere

5. The ____________ is a layer of Earth's atmosphere above the troposphere; it contains the ozone layer.

   a. thermosphere
   b. temperate zone
   c. stratosphere
   d. tropical zone

6. The layer of the atmosphere above the mesosphere where the air is very thin and hot is called the ____________ .

   a. tropical zone
   b. thermosphere
   c. ionosphere
   d. troposphere

7. The day-to-day changes in temperature, humidity, wind, and air pressure are called ____________ .

   a. temperate zones
   b. tropical zones
   c. weather
   d. marine climates

8. The ____________ is the mixture of gases surrounding Earth.

   a. equinox
   b. polar zone
   c. tropical zone
   d. atmosphere

9. The ____________ is a narrow layer of strong winds that blow from west to east just above the troposphere.

   a. mesosphere
   b. jet stream
   c. polar zone
   d. ozone

10. The weather of an area over a long period of time is called its ____________ .

    a. climate
    b. seasons
    c. solstice
    d. tropical

11. The type of climate found when an area is located near a large body of water is called ____________ .

    a. seasons
    b. continental climate
    c. tropical zone
    d. marine climate

12. The type of climate found where there are huge land masses is called __________ .

    a. continental climate
    b. marine climate
    c. tropical zone
    d. seasons

13. The zone of moderate climate with distinct seasonal changes located between 30° and 60° latitude is a __________ .

    a. polar zone
    b. temperate zone
    c. tropical zone
    d. solstice

14. The type of oxygen with three oxygen atoms (O_3) found in the upper areas of the stratosphere is called __________ .

    a. ozone
    b. seasons
    c. climate
    d. solstice

15. The __________ is the layer of air closest to Earth.

    a. troposphere
    b. temperate
    c. thermosphere
    d. mesosphere

16. The area of Earth that extends from the poles to 60° north and south latitude and has very cold climate is called the __________ .

    a. temperate zone
    b. stratosphere
    c. tropical zone
    d. polar zone

17. The lowest layer of the atmosphere that contains most of our weather is called the __________ .

    a. stratosphere
    b. polar zone
    c. troposphere
    d. temperate zone

Practice

Circle the letter next to the **solar radiation** *and* **air mass** *term that correctly completes each statement below.*

1. An instrument used to measure air pressure is a ____________ .

   a. barometer
   b. convection current
   c. direct ray
   d. current

2. The vertical movement of air or water caused by differences in temperature is a ____________ .

   a. current
   b. front
   c. direct ray
   d. convection current

3. Rays of the sun that hit Earth at a 90° angle are called ____________ .

   a. fronts
   b. indirect rays
   c. high-pressure systems
   d. direct rays

4. A system that brings cool, clear skies and dry weather is a(n) ____________ .

   a. low-pressure system
   b. indirect ray
   c. high-pressure system
   d. stationary front

5. A system that brings cloudy, rainy, and often stormy weather is a(n) ____________ .

   a. stationary front
   b. occluded front
   c. convection current
   d. low-pressure system

6. The process by which the sun's rays reach Earth in the form of waves is called ____________ .

   a. wind
   b. warm front
   c. radiation
   d. stationary front

7. Large bodies of air having the same temperature and amount of moisture are ____________ .

   a. currents
   b. convection currents
   c. warm fronts
   d. air masses

8. A front formed when a mass of cold air meets a mass of warm air and moves beneath it is a ____________ .

   a. cold front
   b. current
   c. front
   d. direct ray

9. Vertical movements of air caused by the uneven heating of the Earth are ____________ .

   a. fronts
   b. direct rays
   c. currents
   d. indirect rays

10. The boundary formed when two different masses of air meet is a(n) ____________ .

    a. occluded front
    b. low-pressure system
    c. high-pressure system
    d. front

11. The rays of the sun that hit Earth at more than 90° and produce less heat are called ____________ .

    a. radiation
    b. low-pressure systems
    c. occluded fronts
    d. indirect rays

12. A front that forms when a cold front overtakes and merges with a warm front is a(n) ____________ .

    a. occluded front
    b. stationary front
    c. low-pressure system
    d. warm front

13. A front that forms when two unlike air masses face each other, but neither moves, is a(n) ____________ .

    a. warm front
    b. high-pressure system
    c. stationary front
    d. occluded front

14. The horizontal movements of air caused by the uneven heating of Earth are called ____________ .

    a. stationary front
    b. radiation
    c. occluded front
    d. wind

15. A front that forms when a mass of warm air meets a mass of cold air and moves over it is a(n) ____________ .

    a. occluded front
    b. warm front
    c. stationary front
    d. low-pressure system

16. The transfer of heat energy by moving air or fluid is ____________ .

    a. convection
    b. current
    c. conduction
    d. radiation

17. The direct transfer of heat energy from one substance to another is ____________ .

    a. radiation
    b. conduction
    c. current
    d. convection

Practice

Circle the letter next to the **wind** *and* **current** *term that correctly completes each statement below.*

1. A system of winds that blows cold air from the poles is called __________ .
   - a. sea breezes
   - b. prevailing westerlies
   - c. polar easterlies
   - d. horse latitudes

2. Cool air blowing from land to sea at night is a __________ .
   - a. monsoon
   - b. trade wind
   - c. land breeze
   - d. sea breeze

3. The area around the equator where air moves straight up and there is very little wind is called the __________ .
   - a. monsoons
   - b. doldrums
   - c. land breezes
   - d. horse latitudes

4. An instrument used to measure wind speed is a(n) __________ .
   - a. sea breeze
   - b. land breeze
   - c. anemometer
   - d. wind vane

5. The area at about 30° north and south latitude where there is very little wind is the __________ .
   - a. horse latitudes
   - b. monsoons
   - c. prevailing westerlies
   - d. trade winds

6. Winds that blow inland during summer, bringing rainy weather, and that blow out to sea in winter, bringing dry weather, are called ____________ .

   a. sea breezes
   b. monsoons
   c. polar easterlies
   d. trade winds

7. An instrument that shows from which direction the wind is coming is a(n) ____________ .

   a. anemometer
   b. land breeze
   c. monsoon
   d. wind vane

8. A wind system formed over large land areas that blows from the west to the east is the ____________ .

   a. polar easterlies
   b. monsoons
   c. trade winds
   d. prevailing westerlies

9. Cool air that moves from sea to land during the day is a ____________ .

   a. sea breeze
   b. land breeze
   c. doldrum
   d. trade wind

10. A system of winds just found north and south of the equator that blows toward the equator from the northeast and southeast is the ____________ .

   a. trade winds
   b. polar easterlies
   c. doldrums
   d. prevailing westerlies

Practice

Circle the letter next to the **storm** *and* **precipitation** *term that correctly completes each statement below.*

1. Tiny droplets of water suspended in the air form __________ .

   a. clouds
   b. blizzards
   c. hurricanes
   d. cyclones

2. A high-pressure system with winds moving clockwise is a(n) __________ .

   a. anticyclone
   b. cyclone
   c. tornado
   d. hurricane

3. __________ clouds are clouds that bring rain (they are also called thunderheads).

   a. Cumulus
   b. Cumulonimbus
   c. Hurricanes
   d. Cyclones

4. Moisture that falls to Earth as rain, hail, sleet, or snow is __________ .

   a. saturated
   b. thunder
   c. stratus
   d. precipitation

5. A sudden discharge of electricity from clouds is called __________ .

   a. thunder
   b. precipitation
   c. waterspout
   d. lightning

6. A severe snowstorm with high winds is a ____________ .

   a. tornado
   b. blizzard
   c. cloud
   d. tropical depression

7. Any type of low-pressure system with winds moving in a counterclockwise direction is a ____________ .

   a. hurricane
   b. tropical storm
   c. tropical depression
   d. cyclone

8. Very high, thin, feathery clouds made of ice crystals are ____________ clouds.

   a. cumulus
   b. stratus
   c. cirrus
   d. nimbostratus

9. Puffy, white clouds with flat bottoms are ____________ clouds.

   a. cumulus
   b. stratus
   c. cirrus
   d. nimbostratus

10. A large, powerful low-pressure storm system is a ____________ .

   a. blizzard
   b. cyclone
   c. hurricane
   d. tornado

11. A storm formed when the winds of a tropical depression are between 35 and 74 mph is a ____________ .

   a. tornado
   b. tropical storm
   c. blizzard
   d. cyclone

12. The sound made by lightning is __________ .

    a. cyclone
    b. tornado
    c. thunder
    d. nimbus

13. A dark, low-lying stratus cloud that contains rain is called __________ .

    a. nimbostratus
    b. precipitation
    c. nimbus
    d. stratus

14. Smooth, layered clouds found low in the sky are called __________ .

    a. tornados
    b. nimbus
    c. stratus
    d. cumulus

15. A cloud that causes rain to fall is called a __________ cloud.

    a. precipitation
    b. stratus
    c. cirrus
    d. nimbus

16. A tornado that forms over water is a __________ .

    a. tropical depression
    b. blizzard
    c. cyclone
    d. waterspout

17. A term used when the air has all the moisture it can hold is __________ .

    a. stratus
    b. tornado
    c. thunder
    d. saturated

18. A storm formed by a large, low-pressure system over water with winds less than 35 mph is a ____________ .

    a. tropical storm
    b. blizzard
    c. tropical depression
    d. tornado

19. A violent, funnel-shaped windstorm is a ____________ .

    a. hurricane
    b. tropical storm
    c. tornado
    d. cyclone

Unit 17: Energy Sources

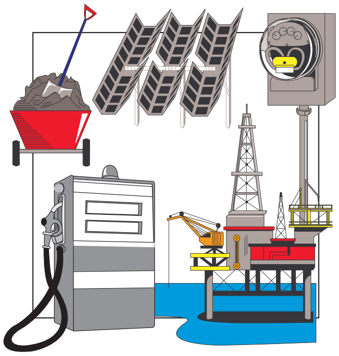
This unit focuses on the identification of energy sources and their uses. Students will review renewable and nonrenewable sources of energy. There is an emphasis on fossil fuels.

Student Goals

- Determine effects of solar radiation on various materials.
- Identify different energy sources.
- Distinguish between renewable and nonrenewable resources.
- Know how fossil fuels are formed.
- Describe the advantages and disadvantages of several energy sources.

Unit Focus

- Know that layers of energy-rich organic materials have been gradually turned into great coal beds and oil pools (fossil fuels) by the pressure of the overlying earth and that humans burn fossil fuels to release the stored energy as heat and carbon dioxide. (SC.G.2.4.1)



Vocabulary

Use the vocabulary words and definitions below as a reference for this unit.

anthracite	the final stage in the formation of coal; it is very hard and burns cleanly
biomass fuel	a burnable fuel made from plant and animal material *Examples*: wood and peat
bituminous	the third stage in the formation of coal; it is soft and gives off a lot of heat when burned
coal	fossil fuel that comes from plants that lived millions of years ago
conserve	to save natural resources for the future
electricity	the type of energy produced by using natural resources such as water, wind, and fossil fuels to power a generator
energy	the ability to do work or move objects
fossil fuel	fuel made from decayed plants and animals that lived millions of years ago preserved below Earth's crust *Examples*: coal, oil, natural gas
geothermal energy	energy produced by the heat from inside Earth's crust

hydroelectricity	electricity produced by falling water
lignite	the second stage in the formation of coal; it is moist and still has bits of woody tissue in it
methane	natural gas used in stoves and for heating homes
natural gas	a fossil fuel in its gaseous state found along with oil deposits
natural resources	materials found on or inside Earth's crust that people can use
nonrenewable resources	materials that are used up faster than they can be replaced in nature or can be used only once
nuclear energy	energy produced by splitting the nucleus of the uranium atom
oil shale	sedimentary rock with oil trapped between its layers
peat	the first stage of the formation of coal; formed from decomposed plants
petroleum or **oil**	liquid fossil fuel formed from plants and animals that lived in the sea
renewable resources	materials that can be replaced in nature at a rate close to their rate of use or used over again

solar cells	a device used to collect energy from the sun and transform it into electricity
solar collectors	large panels that collect solar energy that will be used to heat water, etc.
solar energy	energy from the sun
tidal power	the energy from the two-way flow of the tides used to produce electricity
wind power	energy of the wind used to create electricity

Introduction

It is a well-known fact that nothing lasts forever. Our **energy** resources are no exception. We need *energy* to power our cars and factories, heat our schools and homes, refine metals, make steel, and to do many of the things that we take for granted. Because the price of **petroleum** or **oil** tends to increase and their supply is limited, we are trying to find other methods for producing energy. **Coal**, gas, *oil*, wind, water, the sun, the tides, and nuclear reactions are but a few of Earth's energy resources. Some are **renewable** and some are not. If we understand these resources, and whether they are *renewable* or **nonrenewable**, we can make informed decisions about producing and using energy.

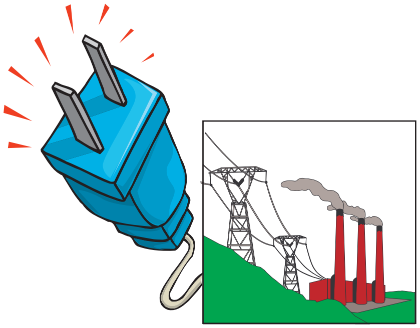
We need energy to power our cars and factories.

The price of petroleum tends to increase and supply is limited.

Sources of Energy

Energy is the ability to do work. We get energy from our **natural resources**. Some energy is used directly, such as burning **natural gas** to cook. Many times we change a *natural resource* into another form of energy, such as **electricity**. *Electricity* is produced by a generator. A generator uses energy from coal, gas, oil, wind, uranium, steam, tides, or falling water to turn the blades of a large wheel called a *turbine*. The turbine turns the coils in the generator to produce electricity.

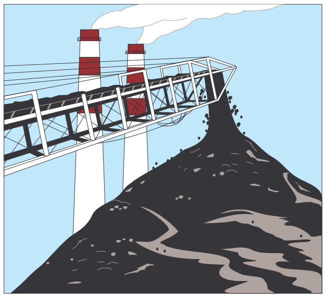
Our major sources of energy include the sun, moving water and wind, tides, **fossil fuels**, nuclear reactions, plant and animal materials, and heat inside Earth's crust.



Electricity is produced by a generator.

Types of Energy

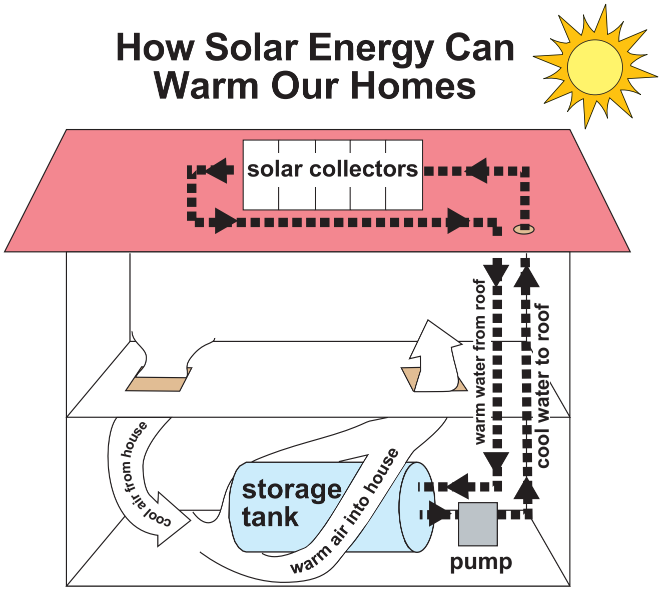
Some of the energy we use comes from natural resources which can be used over and over again, such as water and wind. Other resources, such as soil and forests, can be replaced within a relatively short period of time. These resources are said to be *renewable*; they can be replaced or used over again. Other resources, such as *fossil fuels*, are *nonrenewable*. Fossil fuels—oil, gas, and coal—take millions of years to form. They can be used up faster than they can be replaced in nature or used only once. We must **conserve** our use of nonrenewable resources so that they do not run out in the foreseeable future.



Fossil fuels—oil, gas, and coal—take millions of years to form.

Renewable Resources

Solar Energy. Energy from the sun is called **solar energy**. Many homes and buildings are heated by using **solar collectors**. *Solar collectors* are panels, usually put on the roof of a house, to collect heat to use for hot water, cooking, washing, and heating swimming pools. *Solar energy* can also be converted to electricity through the use of **solar cells**. Using *solar cells* is expensive. They are not used very often, except in spacecrafts.



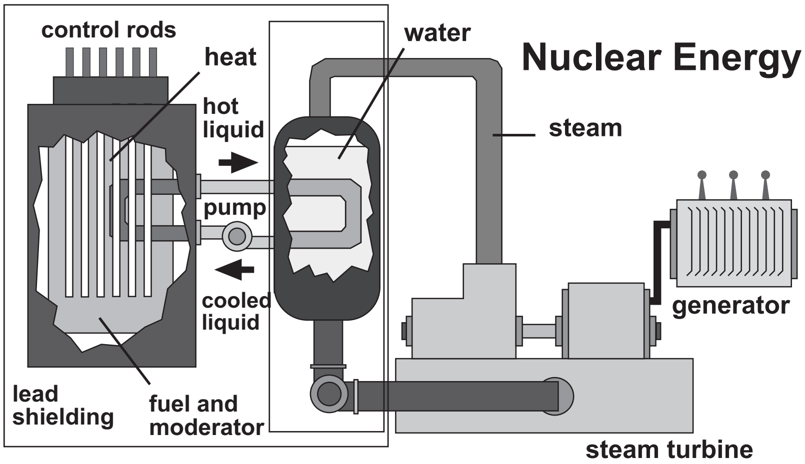
The *advantages* of using solar energy include the following:

1. It is a renewable resource because there is a continuous supply of sunshine.
2. Solar energy does not pollute the atmosphere, land, or water.

The *disadvantages* of solar energy include the following:

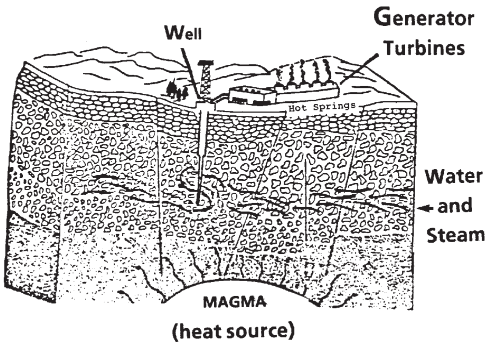
1. It cannot be collected at night.
2. It can only be used in areas that receive a lot of sunshine.
3. It is impractical for large buildings because too many solar panels would be required.
4. Converting solar energy to electricity by using solar cells is currently expensive.

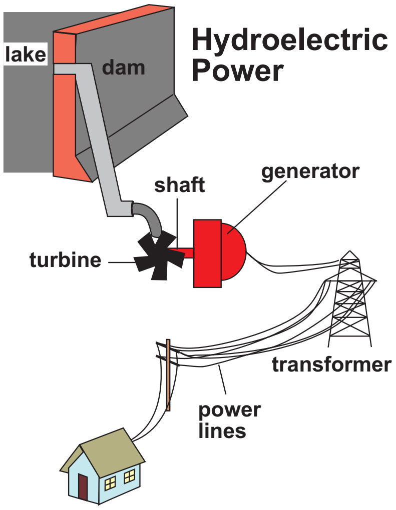
Nuclear Energy. **Nuclear energy** is produced by splitting the nucleus or center of the uranium atom. When the atom splits, a great deal of energy is released as heat. This heat energy is then used to turn water into steam. Then, the steam turns the turbines of generators that produce electricity. A major disadvantage of *nuclear energy* is that it produces radioactive wastes that can destroy cells and change or destroy genetic material. These wastes may leak from storage facilities. The leaked wastes may contaminate the soil or groundwater. In extreme instances, cores may *melt down*. That is, they may become so hot due to faulty power plant operation that they may melt through the floor and shielding.



Geothermal Energy. **Geothermal energy** uses the heat from inside Earth's crust. Wells are drilled into hot water deposits in Earth. The water then escapes to the surface as steam. The steam is then used to run generators to make electricity. Sometimes the hot water comes to the surface naturally in hot springs and geysers. In Iceland, most homes get their hot water from hot springs and geysers. *Geothermal energy* is renewable; however, even if all of the geothermal energy available were used, it could only provide a very small amount of the energy we need.

Geothermal Well





Water Power. Water is one of the major sources of electricity in the United States. Water power produces electricity called **hydroelectricity**. To harness the power of water, a dam is built on a river to control the flow of the water. The flow of the water turns the turbines of generators that produce electricity. Hydroelectric power has many advantages. It is renewable and relatively inexpensive, and does not pollute the atmosphere. One disadvantage is that many times rivers are not located where the power is needed.

Wind Power. The energy of the wind, or **wind power**, can be turned into electrical energy through the use of windmills. Windmills can be used to pump water or grind grain. Prior to the industrial revolution of the 1800s, windmills were very common, but many have been replaced by electric and fossil fuel-operated motors. The recent energy shortages have brought about an increase in new, modern types of windmills that do not require fuels in order to perform the work desired. Because the wind is not predictable in most areas of the world, it is not a widely used resource. Wind is a renewable resource.

Tidal Power. The energy from the two-way flow of the tides through narrow passages can also be used to generate electricity. **Tidal power** is not a widely used source of energy because there are only a few areas in the world with usable tidal conditions. Tides are a renewable resource. Experimental *tidal power* plants have been built in Canada, near the Bay of Fundy, where the vertical difference in low and high tides is 13.6 meters (44.6 feet).

Biomass Fuels. **Biomass fuels** are combustible fuels made from plant and animal materials. Some plants can be converted into alcohol and burned for fuel. Wood can also be burned to create heat. *Biomass fuels* are a renewable resource. Burning garbage is being considered as an alternative to some biomass fuels.

Practice

Use the list below to write the correct term for each definition on the line provided.

coal
electricity
energy
fossil fuel
natural gas
natural resources
nonrenewable resources
petroleum or oil
renewable resources

____________________ 1. the type of energy produced by using natural resources such as water, wind, and fossil fuels to power a generator

____________________ 2. fuel made from decayed plants and animals that lived millions of years ago preserved below Earth's crust

____________________ 3. materials found on or inside Earth's crust that people can use

____________________ 4. liquid fossil fuel formed from plants and animals that lived in the sea

____________________ 5. fossil fuel that comes from plants that lived millions of years ago

____________________ 6. materials that are used up faster than they can be replaced in nature or can be used only once

____________________ 7. materials that can be replaced in nature at a rate close to their rate of use or used over again

____________________ 8. a fossil fuel in its gaseous state found along with oil deposits

____________________ 9. the ability to do work or move objects

Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. energy produced by splitting the nucleus of the uranium atom

______ 2. energy produced by the heat from inside Earth's crust

______ 3. a device used to collect energy from the sun and transform it into electricity

______ 4. energy from the sun

______ 5. a burnable fuel made from plant and animal material

______ 6. energy of the wind used to create electricity

______ 7. the energy from the two-way flow of the tides used to produce electricity

______ 8. large panels that collect solar energy that will be used to heat water, etc.

______ 9. to save natural resources for the future

______ 10. electricity produced by falling water

A. biomass fuel

B. conserve

C. geothermal energy

D. hydroelectricity

E. nuclear energy

F. solar cells

G. solar collectors

H. solar energy

I. tidal power

J. wind power

Lab Activity: Solar Energy

Facts:

- Energy from the sun is called *solar energy*. Solar collectors are used to collect heat to use for hot water, heating, swimming pools, and cooking.

Investigate:

- You will determine what type of materials should be used to collect and store solar energy.

Materials:

- 4 empty aluminum beverage cans, pop tops and labels removed
- 4 thermometers
- black paint
- silver or metallic paint
- 2 clear cellophane squares
- 2 rubber bands
- graph paper
- lamp
- red, blue, green, and black markers

1. Paint two of the cans black. Paint two with the metallic paint. Let dry.

2. Fill all 4 cans ⅓ full with water and insert thermometers into cans.

3. Cover 1 black can and 1 aluminum can with clear cellophane and secure with rubber bands.

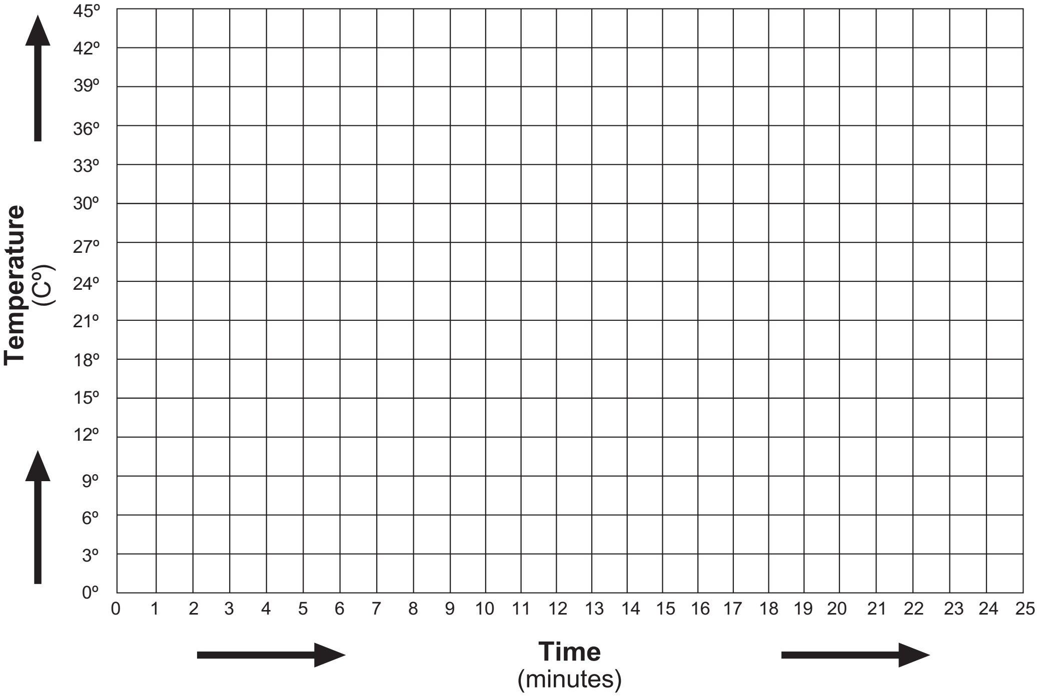
4. Place all 4 cans equal distance from light source (10 to 20 centimeters from lamp with 100 watt bulb).

5. Use the graph on the next page to record the temperature in C° for each can. Take a measurement every minute for 25 minutes. Turn lamp off after 15 minutes.

6. Use the table below as a key to make a graph of the results.

Can	Color	Cellophane	Markers
A	aluminum	no	red
B	aluminum	yes	blue
C	black	no	green
D	black	yes	black

Temperature Graph



7. Place the cans in order from largest to smallest temperature changes.

8. Which can gained heat the fastest? ______________________________

9. Which can held heat the longest? _______________________________

10. Which can lost heat the fastest? ______________________________

11. Is there a relationship between fast "warmers" and fast "coolers"?

____

If so, what is it? ____

____

12. Why do asphalt parking lots and streets become very hot on a

sunny day while concrete sidewalks remain relatively cool? ____

____

____

13. How does the color of material affect the material's ability to absorb

energy? ____

____

____

14. What materials would you use to make a solar collector? _______

____

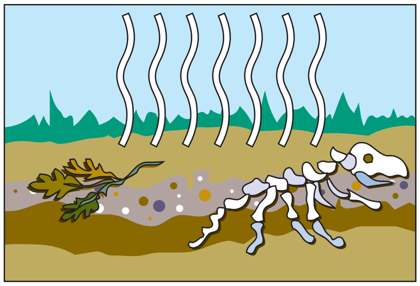
____

15. What materials would you use to store solar energy? ___________

____

____

Nonrenewable Resources

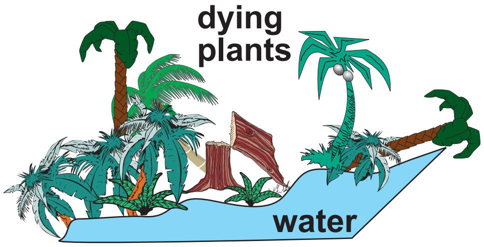


Fossil fuels come from plants and animals that died millions of years ago.

Fossil Fuels. Fossil fuels include coal, oil or *petroleum*, *natural gas*, and **oil shale**. Fossil fuels come from plants and animals that died millions of years ago. Over the years, these remains were chemically changed to produce our fossil fuels. Since millions of years are required to form deposits of fossil fuels, they are nonrenewable resources. These fuels are currently our most important source of energy for industry, transportation, and for use in our homes. Since they are nonrenewable, they must be *conserved*.

The largest deposits of coal and shale are found in North America. Because they are usually buried, it takes considerable effort (strip mining or shaft mining) to extract this fuel. New reserves of oil and gas are being discovered, but many environmental considerations must be weighed before drilling and recovery can begin.

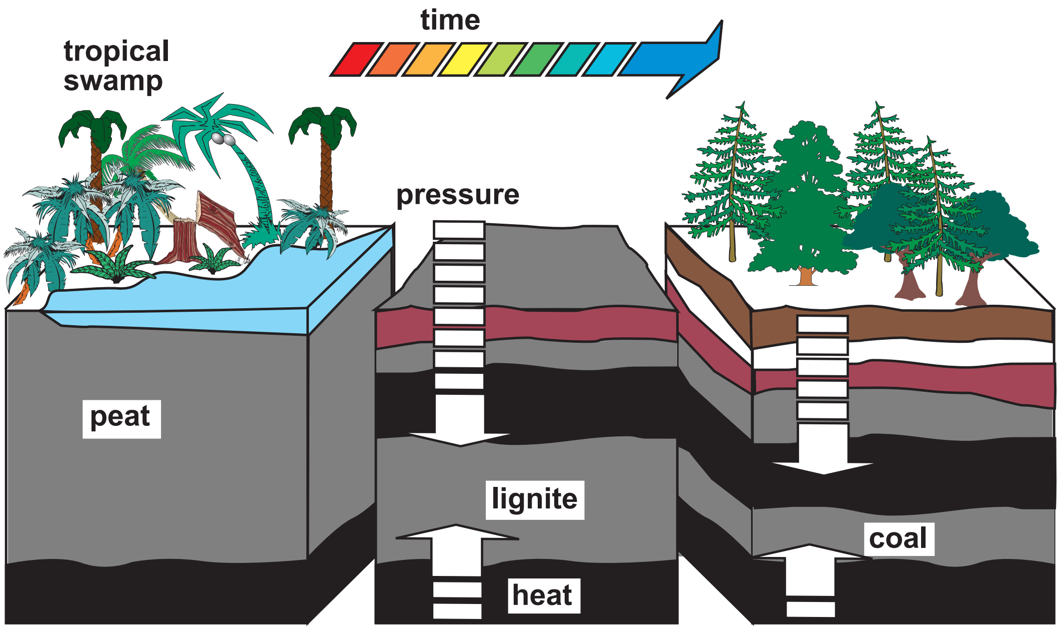
In the United States, *coal* is almost everywhere—it has been found in 38 states. Nearly one-eighth of our country lies over coalbeds. Coal comes from plants that died about 300 millions of years ago. As trees and plants died in swamps, they fell into the water. Since the water was low in oxygen, the trees and other plants did not rot, but piled up. These dead plants were then covered with more dead plants and turned into **peat**.



Coal comes from plants that died millions of years ago.

Heat, pressure, and time eventually turn the *peat* into **lignite** or brown coal. *Lignite* contains bits of woody tissue but retains some moisture; therefore, it does not burn well. **Bituminous**, or soft coal, is the next stage in coal formation. *Bituminous* coal gives off a lot of heat when burned. It is abundant. The last stage of coal formation is the production of **anthracite**. It is the hardest type of coal and burns the most cleanly, but it is very scarce. Coal is used to provide energy for trains and ships and for generating electricity in power plants and factories.

Coal Formation



As trees died in the tropical swamp, dead plant matter built up on the bottom of the swamp. These layers of dead plants turned into peat.

Over time, layers of sediment were deposited. The weight of the sediment compacted the layered plant matter into lignite.

More and more sediment was deposited over the peat. Over millions of years, the weight of the sediment changed the peat into coal.

Petroleum or oil is a liquid fossil fuel formed from plants and animals that lived in shallow coastal waters. Oil is used as a lubricant and to make gasoline, plastics, synthetic fabrics, medicine, building materials, kerosene, wax, and asphalt.

Shale is a sedimentary rock that has oil trapped between its layers. It is plentiful, but it is difficult and expensive to remove the oil from the rock. However, shale oils may be used in the near future.

Natural gas is usually found along with oil. It is the only fossil fuel that can be used as it comes from Earth, without having to be processed first. **Methane** is the most common natural gas. It is used in gas stoves and to heat homes.

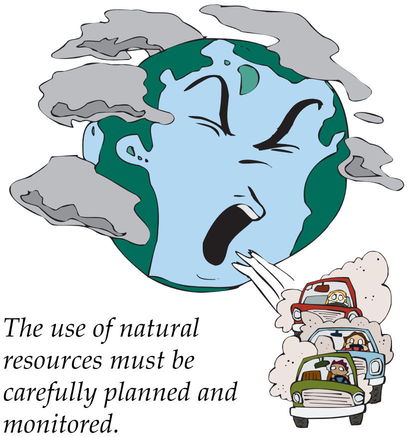
Fossil fuels have some *disadvantages*, however. They include the following:

Disadvantages of Fossil Fuels

1. Fossil fuels are nonrenewable (once used up they cannot be replaced).
2. Many fossil fuels contain traces of sulfur, which causes pollution when burned. If spilled or in contact with living organisms, many fossil fuels are extremely toxic and damaging.
3. It is expensive and often difficult to remove fossil fuels from Earth's surface.

In the last 100 years, the burning of coal, oil, and gas has added carbon dioxide to the air. Some scientists have hypothesized that these increased levels have led to global warming.

Use of Natural Resources



The use of natural resources must be carefully planned and monitored.

It is crucial that the use of natural resources be carefully planned and monitored. Fossil fuels and mineral supplies are continually decreasing, and the world's population continues to rise. Without safeguards and regulations, uncontrolled burning of wood and coal can pollute the air. Inorganic materials from industries and some pesticides can pollute our waters, and nuclear energy pollutants may become a danger to not only humankind but all living creatures.

Efforts at conservation include recycling and the use of alternative energy sources. Coal is more plentiful than petroleum, so the United States is using more coal for energy production every year. Minerals, such as aluminum, can be recycled. Some minerals are found in ocean water, and in the future, these may be used more extensively.

Some of Earth's energy resources are renewable; others are nonrenewable. Several nonrenewable energy sources are being rapidly exhausted. The wise use and conservation of natural resources is necessary to ensure that these resources remain available for future generations.

Summary

Our natural resources supply the energy needed to do work or move objects. Types of energy include solar energy, nuclear energy, geothermal energy, water power, *wind power*, tidal power, biomass fuel, and fossil fuels. Some of the sources of energy are renewable, and others are nonrenewable. Our natural resources must be conserved to safeguard the supply for our future.

Wise use and conservation are necessary to ensure that natural resources remain available for future generations.

Practice

Use the list below to complete the following statements. **One or more terms will be used more than once.**

anthracite
bituminous
lignite
methane
oil shale
peat

1. ______________________ coal is soft and gives off a lot of heat when burned and is abundant.

2. ______________________ is the most common natural gas and is used in gas stoves and to heat homes.

3. Heat, pressure, and time eventually turn the ______________________ into lignite or brown coal.

4. The last stage of coal formation is the production of ______________________ , which is the hardest type of coal and burns the most cleanly. However, it is very scarce.

5. Fossil fuels include coal, oil or *petroleum*, *natural gas*, and ______________________ .

6. After the formation of peat, the next stage in coal formation is the production of ______________________ or brown coal, which contains bits of woody tissue and does not burn well.

7. ______________________ is used in gas stoves and to heat homes.

Practice

Answer the following using complete sentences.

1. What is energy? ____

    ____

2. Where do we get most of our energy? __________________________

    ____

3. Name eight major sources of energy. __________________________

    ____

    ____

    ____

    ____

4. How is electricity produced from other energy sources? ________

    ____

    ____

    ____

    ____

5. List three renewable natural resources from which we can get energy. ____

    ____

    ____

6. List three nonrenewable natural resources from which we can get energy. ____

____

____

7. List two advantages of solar energy. ________________________

____

____

8. List three disadvantages of solar energy. ____________________

____

____

____

9. How is nuclear energy released to create electricity? __________

____

____

____

____

10. How can geothermal energy be used to produce electricity? _____

____

____

____

____

11. What is electricity produced from water called? ________________

____

12. Name three advantages of water power. ________________________

____

____

____

13. What is one disadvantage of hydroelectric power? ______________

____

____

14. For what purpose are windmills used? ________________________

____

____

15. What is the main disadvantage of wind power? ________________

____

____

____

16. Why is tidal power not a widely used resource? ________________

____

____

____

____

17. What is biomass fuel?

18. Name two ways biomass fuel can be used as energy sources.

19. What is our most important source of energy?

20. Name four types of fossil fuels.

21. How is coal formed? ____

____

____

____

____

____

____

22. What is the disadvantage of burning fossil fuels? ______________

____

____

____

____

Practice

Place an **R** *on the line if the natural resource listed is* **renewable**. *Place an* **N** *on the line if it is* **nonrenewable**.

__________ 1. fossil fuels

__________ 2. forests

__________ 3. gold and silver

__________ 4. cotton

__________ 5. nylon

__________ 6. diamonds, rubies, and emeralds

__________ 7. aluminum

__________ 8. paper

__________ 9. hydroelectricity

_________ 10. farmland used for grazing animals

_________ 11. plastic

_________ 12. minerals from Earth

_________ 13. plants

_________ 14. wind power

_________ 15. iron and steel

Name three **natural resources** *that can be* **recycled**, *or used over and over again.*

16. ____

17. ____

18. ____

Practice

Complete each statement below with the correct answer.

1. Fossil fuels come from ____

   ____ .

2. Petroleum is formed from ____________________________________

   ____ .

3. Six uses of petroleum are ___________________________________

   ____

   ____

   ____ .

4. Coal comes from ____

   ____

   ____ .

5. The first stage in the development of coal is _____________________

   ____

   ____ .

6. The second stage in the production of coal is the formation of

   __________________________ , which does not burn well.

7. The type of coal that produces a lot of heat and is very abundant is

   called ____ .

8. The hardest type of coal is called ______________________ .

9. Two uses of coal are ______________________________

____

____

____ .

10. Natural gas is usually found __________________________

____

____ .

11. The type of natural gas we use in stoves and to heat our homes is

____ .

12. The type of fossil fuel that is the most difficult and expensive to remove from Earth is ______________________________ .

13. Shale is ____ .

14. Three disadvantages of fossil fuels are ___________________

____

____

____

____

____ .

15. Burning of coal, oil, and gas add ____________________ to the air.

Practice

Circle the letter of the correct answer.

1. Materials found on or inside Earth's crust that people can use are called ____________ .

   a. renewable resources
   b. nonrenewable resources
   c. fossil fuels
   d. natural resources

2. Fuels made from decayed plants and animals that lived millions of years ago and were chemically changed below Earth's crust are ____________ .

   a. fossil fuels
   b. nuclear energy
   c. renewable
   d. petroleums

3. ____________ materials can be replaced or used again.

   a. Renewable
   b. Petroleum
   c. Methane
   d. Nonrenewable

4. ____________ materials can be used up faster than they can be replaced in nature or can be used only once.

   a. Petroleum
   b. Methane
   c. Renewable
   d. Nonrenewable

5. A liquid fossil fuel formed from plants and animals that lived in shallow coastal waters is called ____________ .

   a. methane
   b. hydrocarbon
   c. petroleum
   d. renewable

6. ____________ is a fossil fuel in its gaseous state found along with oil deposits.

   a. Peat
   b. Bituminous
   c. Petroleum
   d. Natural gas

7. ____________ is a natural gas used in home heating and gas stoves.

   a. Anthracite
   b. Bituminous
   c. Petroleum
   d. Methane

8. ____________ is a fossil fuel that comes from plants that lived millions of years ago.

   a. Uranium
   b. Biomass fuel
   c. Coal
   d. Natural gas

9. After the formation of peat, the next stage is the formation of ____________ or brown coal. It is moist and still has bits of woody tissue in it.

   a. Biomass fuel
   b. Methane
   c. Bituminous
   d. Lignite

10. ____________ is soft coal that gives off a lot of heat when burned.

    a. Natural gas
    b. Oil shale
    c. Anthracite
    d. Bituminous

11. ____________ is the final stage in the formation of coal. It is very hard and burns cleanly.

    a. Anthracite
    b. Methane
    c. Bituminous
    d. Lignite

12. To ____________ is to preserve natural resources for the future.

    a. renew
    b. energize
    c. conserve
    d. anthracite

13. ____________ is energy from the sun.

    a. Geothermal energy
    b. Nuclear energy
    c. Wind power
    d. Solar energy

14. ____________ is energy produced by splitting the nucleus of the uranium atom.

    a. Geothermal energy
    b. Nuclear energy
    c. Wind power
    d. Solar energy

15. ____________ is energy produced by the heat from inside Earth's crust.

    a. Solar energy
    b. Nuclear energy
    c. Wind power
    d. Geothermal energy

16. ____________ , an energy source made from plant and animal material, is a renewable resource.

    a. Anthracite
    b. Lignite
    c. Coal
    d. Biomass fuel

17. ____________ is the type of energy produced from natural resources such as water, wind, and fossil fuels by using a generator.

    a. Solar energy
    b. Hydroelectricity
    c. Electricity
    d. Nuclear energy

18. ____________ is the ability to do work or move objects.

a. Energy
b. Geothermal energy
c. Solar energy
d. Nuclear energy

19. Electricity produced by falling water is called ____________ .

a. geothermal energy
b. nuclear energy
c. hydroelectricity
d. methane

20. ____________ is sedimentary rock with oil trapped between its layers.

a. Oil shale
b. Methane
c. Bituminous
d. Lignite

21. ____________ produced in the first stage of the formation of coal, is formed from decomposed plants.

a. Peat
b. Lignite
c. Anthracite
d. Bituminous

22. Devices used to collect energy from the sun and transform it into electricity are ____________ .

a. solar collectors
b. oil shale
c. peat
d. solar cells

23. Large panels that collect solar energy used to heat water are ____________ .

a. nuclear energy
b. solar collectors
c. tidal power
d. solar cells

24. The energy from the two-way flow of the tides used to produce electricity is ____________ .

    a. solar cells
    b. nuclear energy
    c. wind power
    d. tidal power

25. The energy of the wind used to create electricity is ____________ .

    a. tidal power
    b. wind power
    c. geothermal energy
    d. nuclear energy

Unit 18: Our Environment

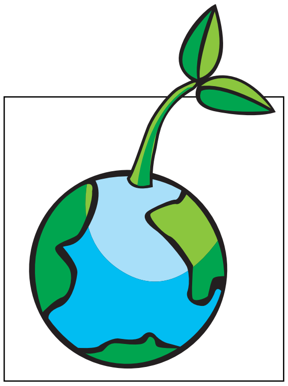
This unit includes information about pollution and environmental quality. Protecting our environment and its natural resources is stressed.

Student Goals

- Demonstrate an understanding of the impact technologies have on the quality of life and the environment.
- Understand how the use of fossil fuels relate to possible impacts of the greenhouse effect.
- Understand the interactions between science and public and private agencies concerning matters of broad, public interest.
- Identify the environmental influences in their neighborhood.
- Identify ways that humans are agents of change and their effect on the environment.
- Recognize ways that society is trying to maintain the balance of nature.
- Identify how society is trying to stop pollution and depletion of natural resources.
- Model the creation and clean up of an oil spill.
- Know forms of land and water pollution.

Unit Focus

- Know that layers of energy-rich organic materials have been gradually turned into great coal beds and oil pools (fossil fuels) by the pressure of the overlying earth and that humans burn fossil fuels to release the stored energy as heat and carbon dioxide. (SC.G.2.4.1)



- Know that changes in a component of an ecosystem will have unpredictable effects on the entire system but that the components of the system tend to react in a way that will restore the ecosystem to its original condition. (SC.G.2.4.2)

- Know that scientists can bring information, insights, and analytical skills to matters of public concern and help people understand the possible causes and effects of events. (SC.H.3.4.3)

Vocabulary

Use the vocabulary words and definitions below as a reference for this unit.

acid rain	rain that contains sulfuric acid; forms as a result of the mixture of air pollutants with moisture in the atmosphere
conservation	measures taken to save natural resources for future use
environment	all of the things that make up your surroundings
fossil fuels	fuels made from decayed plants and animals that lived millions of years ago preserved below Earth's crust *Examples*: coal, oil, natural gas
greenhouse effect	a condition of increased heat resulting from the reflection of the sun's heat back to Earth from the atmosphere
greenhouse gases	chemicals emitted into the atmosphere that add to the overall increase in Earth's temperatures
hydrocarbons	unburned particles of fuel that contain hydrogen and carbon; fossil fuels produce hydrocarbons
litter	waste materials found along roadsides and other public places

natural resources	materials found on or inside Earth's crust that people can use
nitrates	pollutants found in fertilizers and detergents made of nitrogen compounds
nonrenewable resources	materials that are used up faster than they can be replaced in nature or can be used only once
pesticides	chemicals used to kill organisms that are harmful or considered to be pests
phosphates	pollutants found in fertilizers and detergents made of phosphorus compounds
pollutants	substances in the air, water, and land that are harmful to living things
pollution	a change in the air, water, or land that is harmful or unpleasant to living things
recycling	processing materials so they can be used again
renewable resources	materials that can be replaced in nature at a rate close to their rate of use or used over again
smog	a pollutant that contains nitrogen, sulfur, and hydrocarbons; creates a brown haze and unpleasant odor

temperature inversion	occurs when a layer of cool air gets trapped under a layer of warm air and acts like a lid, keeping pollutants near the ground
thermal pollution	the unnatural heating of waters

Introduction

We must use what we know about Earth to improve and safeguard our living conditions, such as the exploration of land for building our homes, observation of air and ocean influences to predict floods and storms, and examination of photographs of geological structures from space to explore new sources of valuable metal deposits.

Protecting the Environment

The **environment** is very delicate. Special care must be taken of the *environment* if it is going to continue to provide an atmosphere that will support life and all of the **natural resources** people need to live. Some of these resources, such as minerals, ores, and **fossil fuels**, cannot be replaced. They are said to be **nonrenewable**. Others, such as the forests, soil, air, and water, can be replaced at a rate close to their rate of use and are **renewable**. People must learn to use resources wisely and conserve or preserve *natural resources* for future use.

Special care must be taken of the environment.

Pollution is a change in the air, water, or land that can be harmful or unpleasant to living things and the environment. *Pollution* upsets the balance of nature, and if not controlled, causes severe environmental problems. These problems could eventually lead to the extinction of entire populations.

Laws can be created to force large corporations and factories to stop polluting the environment.

There are several measures society can take to help preserve the balance of nature. One way is to make people aware of the problems of pollution and the need for **conservation**. This can be accomplished through television and newspaper stories, local campaigns to clean up the environment, and education.

Society can help create laws to force large corporations and factories to stop polluting the environment and to stop overusing the natural resources. Laws are also important to keep individuals from burning trash, improperly dumping garbage, and littering. Regulations, such as those requiring licenses to hunt and fish, and placing limits on the numbers of animals killed, are also important.

Conducting scientific research to help keep nature in balance is another measure of preservation. Some of the projects scientists are working on to accomplish this include the following:

- finding new sources for food
- trying to learn how to control the weather so unusable land can be made usable
- looking for ways to get usable minerals and natural resources from the ocean
- trying to find easier and less expensive ways to get fresh water from ocean water
- trying to find less expensive and easier ways to get the oil out of shale
- looking for new sources of energy
- looking for new ways to stop and clean up the harmful effects of pollution
- exploring space to possibly find new resources, answers to problems on Earth, and perhaps a new place for people to live.

Air Pollution

Unwanted, harmful substances in the air are **pollutants**. Air can become polluted. The amount of air pollution varies depending on the conditions in a particular location. Air *pollutants* especially harmful to human health are **hydrocarbons**, sulfur oxides, particulates, carbon monoxide, and nitrogen oxides. What are these pollutants, and where do they come from?

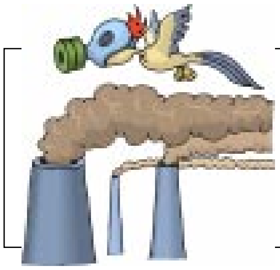
Hydrocarbons. *Hydrocarbons* involved in pollution are compounds of hydrogen and carbon. Hydrocarbons come from spilled or unburned particles of gasoline. Automobiles that do not have proper fuel settings or pollution control devices may produce excessive hydrocarbons.


Automobiles that do not have proper fuel settings or pollution control devices may produce excessive hydrocarbons.

Carbon monoxide. Carbon monoxide is another dangerous gas produced by the incomplete burning of fuels. It is colorless and odorless. Its fumes can cause people to become very ill or die. The exhaust from automobiles, gas heaters, and charcoal grills produces carbon monoxide. Therefore, it is important not to operate a car or grill indoors because carbon monoxide poisoning could occur.

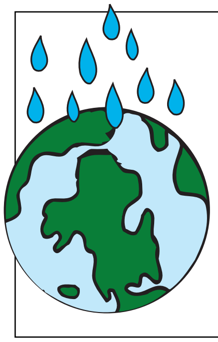
It is important not to operate a car or grill indoors because carbon monoxide poisoning could occur.

Sulfur oxides. *Fossil fuel*s, coal and oil, contain small amounts of sulfur. When the fuels are burned, the sulfur is released and combines with oxygen in the air to form sulfur oxides. Sulfur oxides irritate the eyes, nose, throat, and lungs. If sulfur oxides combine with moisture in the atmosphere, a powerful acid called *sulfuric acid* forms. This acid then falls to Earth in rain or snow. This sulfuric acid damages plant leaves, stains the paint on buildings, and causes lung damage.



Sulfur oxides irritate the eyes, nose, throat, and lungs.

When sulfuric acid combines with rain, **acid rain** is formed. *Acid rain* kills fish, damages crops, and pollutes our water supplies. In Florida, the natural limestone rock helps neutralize the sulfuric acid in groundwater so acid rain is not a serious problem. The northern United States is not as fortunate; there, rock is granite and does not buffer the sulfuric acid as limestone does.



If sulfur oxides combine with moisture in the atmosphere, a powerful acid called "sulfuric acid" forms and then falls to Earth in rain or snow.

Nitrogen oxides. At very high temperatures, nitrogen and oxygen gases in the atmosphere react with each other and form nitric oxide. This gas forms in car engines and comes out of exhaust pipes. Nitric oxide then reacts with oxygen in the air and forms another compound, nitrogen dioxide. The brown haze over many cities is caused by nitrogen dioxide.

Sunlight causes a chemical reaction between nitrogen oxide, sulfur oxide, and hydrocarbon gases. This reaction produces a fog-like pollutant called **smog**. *Smog* got its name from the words smoke and fog. Most smog seems to come from the burning of fossil fuels. Smog usually occurs in areas with a lot of industry or heavy traffic. Smog creates an unpleasant odor, a brown haze in the air, and causes the burning of eyes and inflammation of the lungs.

Smog usually occurs in areas with a lot of industry or heavy traffic.

The condition of the air is dependent on other factors besides pollutants. The amount of pollution in an area also depends on geographical features in the area. Very windy areas seldom have much pollution because the wind carries the pollutants away. On the other hand, areas in valleys or with mountains on one side are more likely to have pollution problems because the pollution cannot escape. Weather conditions also have an effect on pollution. Moisture dissolves some pollutants in the air; however, as that moisture becomes a form of *precipitation*, it can pollute the land and waters instead.

Temperature inversion occurs when warm air acts like a lid and keeps pollutants near the ground.

Sometimes air pollution is made worse when a layer of cool air gets trapped under a layer of warm air. The warm air acts like a lid and keeps the pollutants near the ground. This effect is called a **temperature inversion** and can create dangerously high levels of pollution. When this occurs, people have to be warned to stay indoors until the weather clears.

Particulates. Particulates are tiny particles of dust, soot, ash, and oil. Burning diesel fuels, coal, oil, and wood gives off particulates. People may experience chest pains or coughing as a result. Particulates can cause lung diseases such as bronchitis, asthma, emphysema, and cancer.

Practice

Use the list above each section to complete the statements in that section.

conservation
environment
fossil fuels
natural resources
nonrenewable
pollution
renewable

1. Special care must be taken of the ____________________ if it is going to continue to provide an atmosphere that will support life and all of the ____________________ people need to live.

2. Some resources, such as minerals, ores, and ____________________ cannot be replaced.

3. Natural resources which cannot be replaced are said to be ____________________ .

4. Other resources, such as the forests, soil, air, and water, can be replaced at a rate close to their rate of use and are ____________________ .

5. ____________________ upsets the balance of nature, and if not controlled, causes severe environmental problems.

6. There are several measures society can take to help preserve the balance of nature and make people aware of the problems of pollution and the need for ____________________ .

acid rain
hydrocarbons
pollutants
smog
temperature inversion

7. Unwanted, harmful substances in the air are

   ____________________________ .

8. ____________________________ are compounds of hydrogen and carbon that come from spilled or unburned particles of gasoline.

9. When sulfuric acid combines with rain, ____________________________ is formed.

10. Sunlight causes a chemical reaction between nitrogen oxide, sulfur oxide, and hydrocarbon gases and produces a fog-like pollutant called ____________________________ .

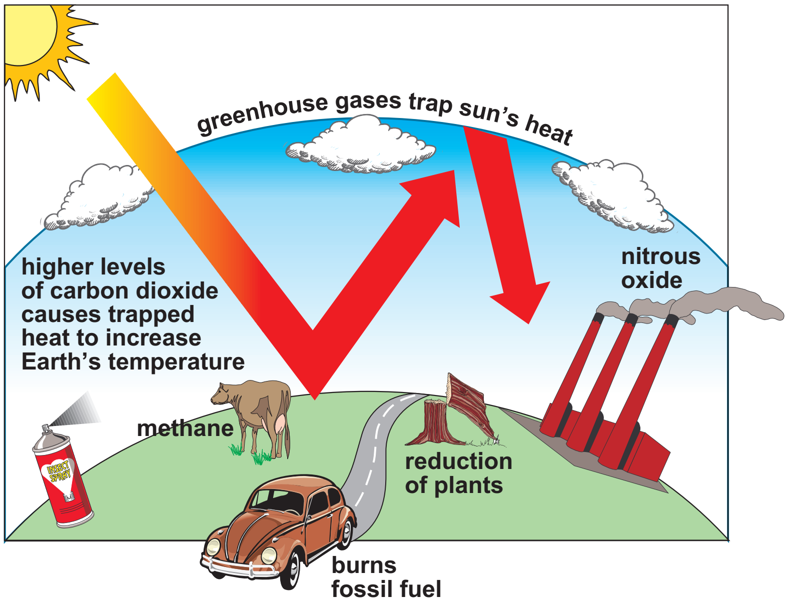
11. Sometimes warm air, acting like a lid, traps a layer of cool air and keeps the pollutants near the ground. This effect is called a

    ____________________________ .

Greenhouse Effect

The **greenhouse effect** occurs when the atmosphere reflects the sun's heat back to Earth, which increases temperatures. Fossil fuels burned to provide power to vehicles, homes, and factories produce chemicals called **greenhouse gases.** One of these *greenhouse gases* is carbon dioxide. Higher levels of carbon dioxide increase the atmosphere's ability to trap heat. This trapped heat may be causing an overall increase in Earth's temperatures. This increase, a process called *global warming*, may have an *adverse* effect on life on Earth.

Greenhouse Effect



The burning of fossil fuels releases carbon dioxide into the atmosphere. During *photosynthesis*, green plants use carbon dioxide for food, and help to remove dangerous levels of carbon dioxide from the air. In order to remove these dangerous levels of carbon dioxide from the air, we rely on green plants to use carbon dioxide in photosynthesis. This process also releases oxygen. Without plants, our lives would not be possible. One effect of building roads and making more parts of the world accessible to vehicles is a reduction in the amount of plant life. An example of this is the destruction of the vast Amazon rainforest. As the amount of plant life decreases and the quantity of greenhouse gases increases, Earth's climate may change, thus adding to global warming.

Controlling Air Pollution

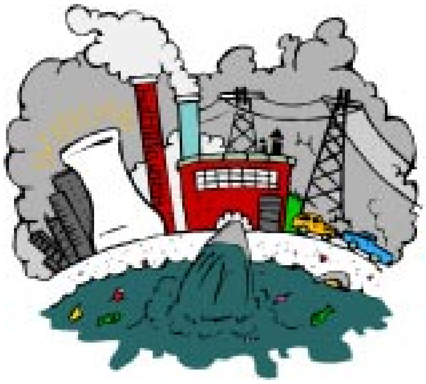
Efforts have been made to control air pollution. Laws were passed requiring that unleaded gas be used in new cars in an effort to stop one type of air pollution. Some other important solutions to the problem include the following:

- Laws have been passed, such as the 1970 Clean Air Act, that require industry not exceed safe levels of pollutants. This law is scheduled to be reviewed every five years.
- Warning systems have been installed in areas with high pollution rates.
- More greenery has been planted in cities to reduce the amount of carbon dioxide and increase the amount of oxygen.
- Pollution control devices have been installed on cars.
- Laws have been passed to prohibit the burning of garbage and leaves in residential and other restricted areas.

Every individual can do his or her part to help reduce air pollution. Actions such as walking, riding bicycles, car pooling, using public transportation, and making sure our cars are in proper working order can help solve the problem of air pollution.

Water Pollution

Water is one of our most important natural resources. We use fresh water to drink, grow food, produce energy, and manufacture products for transportation and recreation. Both the water on the surface of Earth and the groundwater beneath Earth's surface need to be kept free from pollution. As with air, there are many ways that water can be polluted.



Water can be polluted by chemicals from industrial plants, sewage systems, mines, and households.

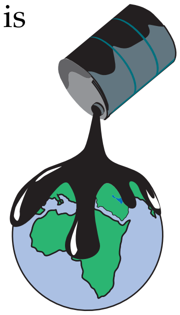
Bacteria and viruses from untreated sewage and animal wastes can cause pollution of the water supplies. This can cause illness and diseases such as typhoid. Water treatment plants and the addition of chlorine to the water are common methods of preventing this type of pollution.

Water can also be polluted by chemicals from industrial plants, sewage systems, mines, and households. **Phosphates** and **nitrates** found in fertilizers, detergents, and cleaning supplies cause algae and pond weeds in lakes to multiply very rapidly, using up all of the available nutrients. When large numbers of these plants die, bacteria that decompose them exhaust the oxygen supply. Many other organisms, such as fish, will then die because of a lack of oxygen. **Pesticides** and other poisonous chemicals pollute waters, killing plant life and fish.

The unnatural heating of waters is called **thermal pollution**. Electric power plants that use both fossil fuels and nuclear fuels produce a lot of heat. Power plants use water to condense steam. When the water is returned to the lakes and rivers, it is warmer than before. This upsets the balance of nature. Some organisms cannot live at these higher temperatures. *Thermal pollution* also disrupts the breeding cycles of some fish. Some people argue that thermal pollution can be beneficial in winter—providing refuge from the cold for manatees, for instance. Manatees congregate in the winter near power plants, such as St. Marks and Crystal River, to take advantage of the warmer waters.

Too much sediment buildup in waterways can create pollution problems. Sand and soil settle to the bottom of rivers and lakes, gradually filling them. These sediments cover up the food supply of fish, causing them to die. Sediment buildup also smothers nonmoving organisms such as oysters and clams and clogs animals' gills, suffocating them. Dredging may then be necessary to open the waterway. Disturbing the bottom by dredging causes other problems such as destroying the nutrients in the sediments and altering the water flow.

Another pollution concern for all bodies of water is the oil spill. Major spills result from tanker collisions in the oceans. These oil spills from tankers spoil our beaches, pollute our ocean water, and cause birds and fish to die. Many cleaning methods are used to remove the oil.

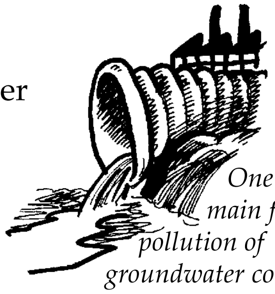


Another pollution concern for all bodies of water is the oil spill.

Some of these methods create other types of pollution, however. Burning the oil releases hydrocarbons into the atmosphere. Adding chemicals to breakdown oil introduces other substances into an already stressed environment. Scraping up or collecting oily debris contributes to the problem of waste disposal and scarce landfills. The benefits of cleaning methods must be considered along with their risks and disadvantages.

Groundwater Pollution

One of the main forms of pollution of groundwater comes from the dumping of chemical wastes, especially radioactive wastes. When it rains, some of the dangerous chemicals seep down into the water table. These chemicals will eventually be pumped up into wells or enter streams, lakes, or oceans as part of the groundwater.



One of the main forms of pollution of groundwater comes from the dumping of chemical wastes.

Protective measures must be taken to keep water pure. Controlling chemical use by farmers, homeowners, and industry and building waste treatment plants are examples of things that can be done to help reduce water pollution.

Land Resources

Glass bottles, aluminum cans, plastic, and paper are common forms of litter. All can be recycled.

Natural resources found on land must also be conserved and protected from pollution. One of the most noticeable forms of pollution on land is **litter**. To help control *litter*, laws can be passed to place fines on littering. **Recycling**, which refers to processing materials so they can be used again, can also help to solve the litter problem. Glass bottles, aluminum cans, plastic, and paper are common forms of litter and can all be recycled.

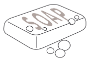
Wastes in landfills, dumps, and septic tanks can cause pollution, if not disposed of properly. The creation of waste management companies and urban sewage treatment plants has helped to eliminate some pollution from these sources.

Chemicals from industry, buried radioactive wastes, and *pesticides* pollute the land when they enter the soil. Plants grown in this soil may contain these dangerous chemicals. These chemicals are then passed on to people and animals who eat the plants.

Land resources must not only be protected from pollution, they must also be conserved so that there are enough resources for future generations. Crops must be rotated and fertilizers added to keep farm land productive. Some land that is unsuitable for farming because it is too hilly can be terraced or contoured. Land too dry to grow crops can be irrigated in order to become productive. Land used for grazing must be carefully controlled to allow the vegetation to grow back before it is used again.

Forests are another valuable land resource. Trees must be replanted to replace the ones cut down. Since trees prevent erosion, foresters must be careful not to cut down too many trees in a particular place at any given time.

Practicing *conservation* and controlling pollution of natural resources will allow people to enjoy the gifts of nature and good health for many years to come. It is important that we become aware of the destructive nature of items that we throw away every day. Some of these items require special disposal methods. Many communities have established hazardous-waste collection sites or other alternatives. Below is a chart of the toxic trash that should be separated from other trash.



Toxic Trash List

- **ammonia**
- **automotive fluids and body filler** for repairing auto body dents and holes
- **batteries** that are disposable or rechargeable (NiCad) batteries
- **caustic cleaners** such as oven cleaners and lye
- **cosmetics** such as fingernail polish and removers
- **electrical devices** with mercury switches
- **florescent light bulbs and their ballasts**
- **fuel** such as charcoal lighter
- **glue, rubber cement, and thinners**
- **herbicides** and their containers (don’t rinse)
- **insect sprays, powders, strips, repellants, and their containers** (don’t rinse)
- **liquid correction paper and thinner**
- **mothballs**
- **motor-oil cans** (don’t rinse)
- **paint, polishers, dyes, and paint thinners** (give away what you don’t use; latex paint can be dried out and disposed of in trash)
- **photographic chemicals**
- **pool chemicals**
- **solvents and spot removers**
- **spray cans**
- **wood preservatives** such as sanding sealer and water sealer
- **and anything labeled “dispose of carefully”**

Summary

There is an interconnectedness of Earth’s systems and the quality of life. Protecting our environment and natural resources is extremely important for the future of Earth. Controlling pollution of air, land, and water is one part of the effort. Each of us has a responsibility as a caretaker of the environment. Many different kinds of scientists are working on solutions to today’s problems.

Practice

Use the list below to write the correct term for each definition on the line provided.

greenhouse effect	**nitrates**	**recycling**
greenhouse gases	**pesticides**	**thermal pollution**
litter	**phosphates**	

____________________ 1. waste materials found along roadsides and other public places

____________________ 2. chemicals used to kill organisms that are harmful or considered to be pests

____________________ 3. processing materials so they can be used again

____________________ 4. a condition of increased heat resulting from the reflection of the sun's heat back to Earth from the atmosphere

____________________ 5. pollutants found in fertilizers and detergents made of nitrogen compounds

____________________ 6. the unnatural heating of waters

____________________ 7. pollutants found in fertilizers and detergents made of phosphorus compounds

____________________ 8. chemicals emitted into the atmosphere that add to the overall increase in Earth's temperatures

Practice

Follow the steps below to conduct an **environmental survey** *of your neighborhood.*

Environmental Influences

Human beings are agents of change, and the rate at which they are changing the environment increases rapidly as their population increases. Only recently have people become aware of their impact on the atmosphere, water, and the crust of Earth.

1. Look over the survey on the next page. General categories for the ways people change the environment are listed on the left side of the page. Across the top are the various areas of the environment that may be affected by the processes and materials which people use.

2. Walk or ride through your neighborhood—at least a 10-block square—taking the survey with you.

3. Place a check in the last column to the right after each type of environmental influence found in your neighborhood. For example, if new houses are being built, put a check (√) after houses.

4. Find the area being influenced in the column headings at the top of the chart. Put an (**L**) in the left half of the box if the influence is large, or (**S**) in the left half of the box if the influence is small. In the right half of the box, put a (+) if the effect is good; put a (–) if the effect is bad.

KEY
(√) Influence found
(L) Large influence
(S) Small influence
(+) Good influence
(–) Bad influence

Ex.—Large, negative influence L −

		Environmental Aspects														
		health		scenery		recreation		temperature		air		water		other		influence
Environmental Influences	**Construction:**															
	houses															
	roads															
	shore structures															
	commercial															
	Traffic:															
	streets															
	highways															
	Chemicals:															
	fertilization															
	weed control															
	insect control															
	Waste Disposal:															
	litter															
	dumps															
	sewage															
	Other:															

Practice

Answer the following using complete sentences.

1. List three ways in which road construction using concrete pavement changes the environment. ______________________________

   ____

   ____

   ____

2. What other ways could people travel which would have fewer adverse effects on the environment? ______________________

   ____

   ____

   ____

3. How does an automobile affect the atmosphere? ____________

   ____

   ____

   ____

   ____

4. If there is smog in your community, what is its source? ________

   ____

   ____

   ____

5. What resources are used in local construction? ________________

____

____

6. What resources are lost to humans when cities move into the surrounding countryside? ___________________________________

____

____

____

7. Describe some solutions to the problems above. _______________

____

____

____

____

____

____

Write **True** *if the statement is correct. Write* **False** *if the statement is* not *correct.*

__________ 8. Human influence can be recognized on your local environment.

__________ 9. The chart on page 565 does not permit the estimation of a negative impact on an environment.

_________ 10. The public can suggest ways to improve and protect the environment.

Practice

Answer the following using complete sentences.

1. Name three ways society can help preserve the balance of nature.

   ____

   ____

   ____

2. Name five ways scientists are trying to maintain the balance of nature. ____

   ____

   ____

   ____

   ____

3. Name three ways laws can help stop the pollution and depletion of natural resources. ______________________________

   ____

   ____

   ____

4. Name three ways people can be made aware of the problems of pollution and the necessity of conservation. _______________

   ____

   ____

Lab Activity: Water Pollution

Facts:

- Oil spills pollute our ocean water and cause animals to die. Many cleaning methods are used to remove the oil.

Investigate:

- You will create and clean up an oil spill.

Materials:

- aluminum pie plate
- new or used motor oil
- pieces of nylon net
- pieces of nylon stocking
- pieces of cardboard
- pieces of string
- pieces of straw
- salad oil
- plastic bowl
- cotton balls
- spoon
- detergent
- eyedropper

Thirty miles from the shore of Santa Barbara, an oil production platform pulled up a worn-out drill. Oil and gas began escaping into the water. Before the leak could be stopped, 700,000 gallons of oil were released. What can be done to clean up the spill?

1. Obtain an aluminum pie plate or similar container. Pour about one inch of water in the plate.

2. Use an eyedropper to place 15 to 20 drops of salad oil on the surface of the water.

3. The problem you face is the same as that faced by the people of Santa Barbara. How can you clean up the oil with the tools at hand? Select any of the materials available and use them to clean up the oil slick. Use a watch with a second hand to determine the amount of time it takes you to clean up the spill. Use the Data Chart on the next page to record your results.

4. Repeat the simulation by adding salad oil to new water. Try at least three different techniques and materials and record the results.

5. Up to this point you have been using a light oil. Now perform the same procedures using a heavier oil—in this case, motor oil. Record your results in the Data Chart below.

6. You have been very lucky. The weather during your oil recovery operations has been fair and calm. Many oil spills occur in stormy weather. To simulate rough weather, carefully make waves in your model ocean. You can make waves by *gently* blowing over the surface or moving a card through the water. Get new water and repeat two of the techniques with heavy oil and rough water. Record your data in the Data Chart below.

7. Select the method you feel works best and modify it as follows. After you have added 15 to 20 drops of heavy oil, add 5 to 10 drops of detergent. Stir the water to mix the oil and detergent. Then proceed to remove the oil and soap mixture with the technique you selected. Record your results in the Data Chart below.

Data Chart

	Material	Time Taken to Clean Spill	Estimate Percent of Oil Cleaned Up	Comments: (e.g., messy, left with oily straw)
Light Oil				
Heavy Oil				
Heavy Oil and Rough Water				
Heavy Oil Plus Detergent				

8. Clean up your lab station. Place the used oil in the container provided by your teacher. Wash the equipment with detergent and store.

9. Which method most rapidly cleaned up the oil spill? ___________

   ____

10. Which method was most effective with light oil? ______________

    ____

    Was the same method most effective with heavy oil? ___________

    If not, which method was most effective with the heavy oil?

    ____

11. The first activities following an oil spill involve attempts to contain the spill. Containment keeps the spill from spreading.

    Which of the materials provided helped to contain an oil spill?

    ____

    ____

    Ocean spills are often contained by placing booms. A boom is a barrier or fence of some type. Floating logs, foam, and rubber tubes have been tried.

    Under what weather conditions would booms work best? ______

    ____

    ____

12. Most of the oil removal techniques which use the materials provided remove the oil by *absorption*. The oil is absorbed by other substances like straw, sawdust, etc. The oil-soaked material is then removed from the water.

Which of the techniques removed oil by absorption? ____________

____

____

Some people say that these techniques simply move the oil spill from the water to the land.

What do you suppose they mean? ______________________________

____

____

13. What effect did the detergent have on your oil spill? ____________

____

____

____

Did the detergent make your cleanup technique more effective or

less effective? ____

Please explain. ____

____

____

____

14. Fire is another technique often used to remove oil spills. The oil spill is ignited and allowed to burn.

Where does the oil from the water go when it is burned? ________

____

____

15. What factors affect the cleaning up of oil spills in the ocean? ____

____

____

____

____

16. Once the oil reaches the beach, other problems occur.

What is one technique you might use to remove oil from beach

sands? ____

____

____

____

Which animals are likely to be most affected by oil on the beach?

____

____

17. Who should be responsible for cleaning up the spills? __________

____

____

18. Some bacteria will use oil as their only food source. Ocean scientists would like to be able to plant these bacteria in oil spills. For these bacteria to be successful in cleaning up spills, the bacteria have to pass several tests. Some of the tests are listed below.

Rank these **tests** *in* **order of importance** *from 1 to 5. In the blank next to the test, write in the order number. The most important test to consider would be number 1, etc.*

______ The cost of the bacteria.

______ The bacteria will eat the oil quickly.

______ The bacteria will eat the oil thoroughly.

______ The bacteria will produce no harmful by-products.

______ The bacteria will disappear when their job is done.

Practice

Use the list above each section to complete the statements in that section. **One or more terms will be used more than once in the first section.**

acid rain
automobiles
carbon monoxide
fossil fuels
hydrocarbons
nitrogen oxides
particulates
pollutants
sulfur oxides
sulfuric acid

1. ____________________ are substances in the air, land, and water that are harmful to living things.

2. Four types of air pollution are ____________________ , ____________________ , ____________________ , and ____________________ .

3. Unburned particles of fuel that contain hydrogen and carbon are called ____________________ .

4. Most hydrocarbons come from ____________________ that are not properly maintained.

5. The sulfur found in ____________________ is a major cause of pollution.

6. Sulfur combines with oxygen and moisture in the atmosphere to form ____________________ .

7. Sulfuric acid in the atmosphere combines with rain to form ____________________ .

automobile exhaust
carbon monoxide
charcoal grills
fog
hydrocarbons
industry
nitrogen oxides
smoke
sulfur oxides
temperature inversion

8. Smog is a chemical reaction between ____________________ , ____________________ , and ____________________ .

9. The word smog came from combining the words ____________________ and ____________________ .

10. ____________________ is a dangerous gas produced by the incomplete burning of fuels.

11. ____________________ and ____________________ are two sources of carbon monoxide.

12. A ____________________ is a layer of cool air trapped under a layer of warm air that keeps pollutants near the ground.

13. The 1970 Clean Air Act has helped reduce the levels of pollutants produced by ____________________ .

Practice

Answer the following using complete sentences.

1. What are four uses for fresh water? ____________________________

   ____

   ____

   ____

2. Where do bacteria and viruses that pollute water come from?

   ____

   ____

3. How can bacteria and viruses be prevented from polluting our

   water supplies? ____

   ____

   ____

4. What effect do phosphates and nitrates have on our water supplies?

   ____

   ____

   ____

   ____

5. How is thermal pollution caused? _____________________________

   ____

   ____

6. How does thermal pollution affect the fish and other organisms?

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____

7. How can sediment buildup cause pollution? ___________________

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8. How do oil spills cause pollution? ____________________________

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9. How can dumping chemical wastes pollute groundwater? ______

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10. Name four ways that we can help prevent water pollution. _____

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Practice

Answer the following using complete sentences.

1. What is one of the most noticeable forms of pollution of the land?

____

____

2. Name two ways littering can be controlled. ____________________

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3. What is recycling? ______________________________

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4. Name at least three kinds of items that can be recycled. __________

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5. How do chemicals from industry and radioactive wastes pollute the land? ______________________________

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6. What else must be done for land resources besides protecting them from pollution? ____

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7. Name four ways land can be made more productive. ____________

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8. How can forest land be protected? ____________________________

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Practice

Circle the letter of the correct answer.

1. ____________ is a pollutant that contains nitrogen, sulfur, and hydrocarbons. It creates a brown haze and unpleasant odor.

   a. Smog
   b. Phosphate
   c. Pesticide
   d. Hydrocarbon

2. ____________ is a change in the air, water, or land that is harmful or unpleasant to living things.

   a. Acid rain
   b. Smog
   c. Pollution
   d. Littering

3. ____________ are chemicals used to kill insects.

   a. Hydrocarbons
   b. Phosphates
   c. Nitrates
   d. Pesticides

4. ____________ are pollutants found in fertilizers and detergents made of nitrogen compounds.

   a. Fossil fuels
   b. Hydrocarbons
   c. Nitrates
   d. Phosphates

5. ____________ are unburned particles of fuel that contain hydrogen and carbon.

   a. Fossil fuels
   b. Pesticides
   c. Hydrocarbons
   d. Nitrates

6. Taking measures to save natural resources for future use is called ____________ .

   a. recycling
   b. conservation
   c. temperature inversion
   d. thermal pollution

7. Rain that contains sulfuric acid is ____________ .

   a. smog
   b. acid rain
   c. thermal pollution
   d. litter

8. Your ____________ is all of the things that make up your surroundings.

   a. litter
   b. smog
   c. environment
   d. conservation

9. Fuels made from plants and animals that lived millions of years ago are ____________ .

   a. smog
   b. pesticides
   c. hydrocarbons
   d. fossil fuels

10. Waste dropped along roadsides and other public places is ____________ .

    a. pesticides
    b. litter
    c. nitrates
    d. phosphates

11. ____________ are pollutants found in fertilizers and detergents made of phosphorus compounds.

    a. Nitrates
    b. Fossil fuels
    c. Hydrocarbons
    d. Phosphates

12. __________ are substances in the air, water, and land that are harmful to living things.

a. Acid rain
b. Fossil fuels
c. Nitrates
d. Pollutants

13. Processing used materials so they can be used again is called __________ .

a. recycling
b. conservation
c. littering
d. temperature inversion

14. The unnatural heating of waters is __________ .

a. pollution
b. recycling
c. smog
d. thermal pollution

15. __________ occurs when a layer of cool air gets trapped under a layer of warm air that acts like a lid, keeping pollutants near the ground.

a. Acid rain
b. Littering
c. Recycling
d. Temperature inversion

Unit 19: Systems of the Human Body

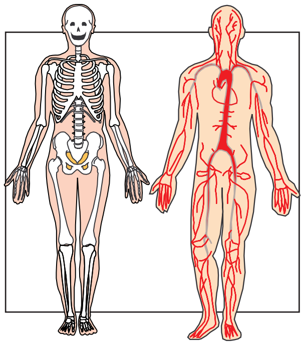
This unit emphasizes our uniquely designed body structures and how they are adapted for their function. Students learn about the skeletal, respiratory, circulatory, digestive, and excretory systems.

Student Goals

- Know the relationships between structure and function in the human body.
- Demonstrate understanding of the design and function of the skeletal, respiratory, circulatory, digestive, and excretory systems.
- Determine pulse rate at rest and after exercise.
- Identify parts of the heart and the location of oxygenated blood.

Unit Focus

- Know that the body structures are uniquely designed and adapted for their function. (SC.F.1.4.2)



Vocabulary

Use the vocabulary words and definitions below as a reference for this unit.

arteries	blood vessels that contain blood traveling away from the heart
atrium	the top chamber of both sides of the heart (*pl.* atria)
bile	a substance produced in the liver and stored in the gall bladder that works specifically to dissolve fat in the small intestine
bones	sections of the skeleton; serve as the framework for the body, anchors for the muscles, factories for blood cells, and storage places for calcium
bronchi	the two branches of the windpipe that descend to the right and left lungs (*sing.* bronchus)
capillaries	tiny blood vessels where pickup of wastes and delivery of oxygen and food takes place; connect arteries to veins
cardiac muscle	tightly woven involuntary muscle that makes up heart muscle
cartilage	a soft, flexible substance that sometimes hardens into bone as it ages

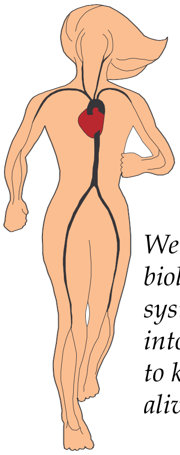
diaphragm	the dome-shaped muscle at the base of the chest cavity that contracts and lowers to draw oxygen into the lungs, then relaxes and rises to push carbon dioxide out
enzymes	proteins that speed up the breakdown of food into molecules in the digestive system; also speed up chemical reactions
epiglottis	a little flap of tissue in the throat that protects the opening to the windpipe
esophagus	the tube that carries food to the stomach
hemoglobin	the protein that colors red blood cells and allows them to carry oxygen to the tissues
involuntary muscles	muscles that operate completely outside of conscious thought, whether we want them to do so or not
larynx	also known as the voice box; a structure in the windpipe in which the vocal cords vibrate with passing air to make sound
ligaments	tough fibers that help hold bones together
nephrons	tiny filtering units in the kidneys

organ	a body structure made up of a number of cell tissues that works as a unit to perform a specific function *Example*: heart, lungs, brain
periosteum	a tough layer of tissue covering the outside of the bone
plasma	the liquid part of the blood
platelets	pieces of larger cells formed in the bone marrow that have no nuclei and are even smaller than red blood cells; they work with proteins in the plasma to clot the blood
red blood cells	small, disk-shaped cells containing hemoglobin; they deliver oxygen to body cells and pick up carbon dioxide
saliva	a fluid released from glands in the mouth that soaks into food and helps in chewing, swallowing, and digesting
skeletal muscles	voluntary muscles that move the bones of the skeleton *Example*: muscles found in arms and legs
smooth muscle	involuntary muscle contained in many parts of the body *Example*: muscles found in walls of stomach, intestines, and blood vessels
solid bone	very dense and strong; a storage place for calcium; usually found around the edges of bones

spongy bone	has many small holes; strong, like solid bone, but more lightweight; usually found at the end of bones
tendons	strong fibers that attach muscles to bone
urea	a waste product that is made up of leftover parts of used proteins and is high in nitrogen
urethra	the passageway out of the body for urine
urine	urea and other waste substances that are collected in the bladder
veins	blood vessels that contain blood traveling back to the heart
ventricle	the bottom chamber of both sides of the heart
voluntary muscles	muscles you choose to use at will
white blood cells	cells that surround and destroy microorganisms that invade the body; larger than red blood cells

Introduction

Every moment, waking or sleeping, we depend on biological systems built into our bodies to keep us alive. We define life itself by the signs that these systems are working. For example, our respiratory system allows us to breathe; our circulatory system gives us a pulse. Our respiratory and circulatory systems—along with many other systems—allow us to have the experience we call *life*. Most healthy people are lucky enough never to have to think about the processes that keep them going. They put a pizza into their digestive systems and forget about it. Their nervous systems help them dodge a bad driver in a parking lot, and they don't think twice. In this unit we will see how all of our body systems operate and interact to help us survive.

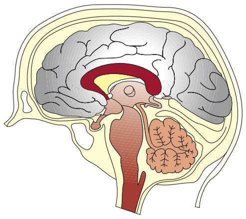


We depend on biological systems built into our bodies to keep us alive.

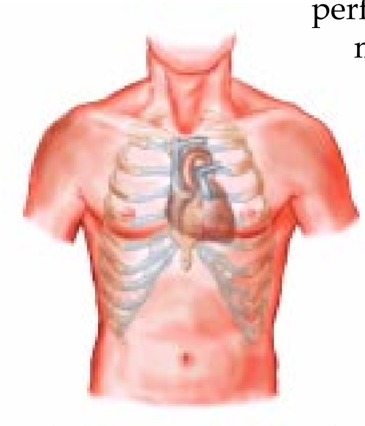
Major Organs

If we're going to survey the biological systems that run the human body, perhaps we should take some time to get our bearings. What are the really important parts of the human body?

People usually refer to these important pieces as "major organs." An **organ** is a body structure made up of a number of cell tissues that work as a unit to perform a specific function. Some major *organs* are easy to think of and locate. For example, the brain is in the head and directs the nervous system. The heart is in the chest and serves as the main pump for the circulatory system. The function and location of other major organs are less obvious. On the following page is a table that lists some major organs, gives a rough idea of their locations in the human body, and describes which body system depends on them.

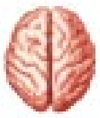
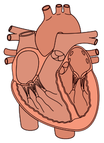
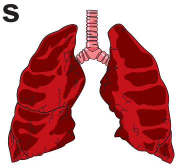
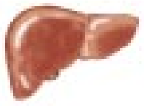
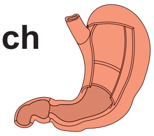
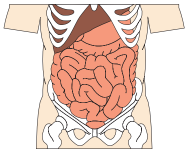


The brain is in the head and directs the nervous system.



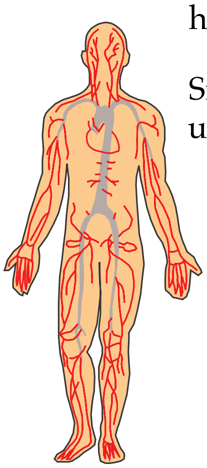
The heart is in the chest and serves as the main pump for the circulatory system.

Major Organs of the Body

Organ	Location	Function
brain 	head	analyzes signals from the sensory organs and directs the central *nervous system*
heart 	chest, slightly left of the center	pumps blood; is the central structure of the *circulatory system*
lungs 	both sides of the chest	provide a place for blood to take in oxygen and give up carbon dioxide; are the central structures of the *respiratory system*
liver 	upper right abdomen	secretes bile to dissolve fats as food is broken down; filters out some toxins taken in with food and drink before nutrients are distributed throughout the body; part of the *digestive systems*
stomach 	upper left midsection	carries out rough breakdown of food; central structure of the *digestive system*
intestines 	central and lower abdomen	finish the breakdown of food and absorb the nutrients; part of the *digestive system*
kidneys 	lower back, each side of the spine	remove waste materials and toxins from the blood; central structures of the *excretory system*

Body Systems

What exactly is a body system? We have learned that an organ is a body structure that performs a specific function. A body system also performs a specific function, but it is made up of one or more organs plus all of their support structures. For example, the circulatory system is made up of the heart plus all of the veins, capillaries, and arteries.



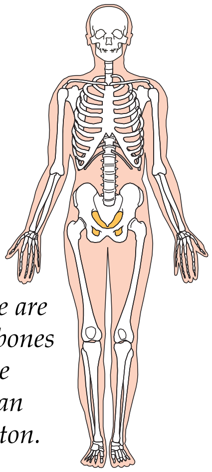
The circulatory system is a body system made up of the heart plus all of the veins, capillaries, and arteries.

Since there are so many body systems, this book uses two units to cover them. But there really is no neat dividing line for grouping body systems into two categories. All human body systems maintain life; all of them enable us to survive. Otherwise we wouldn't have them. Also, all of our body systems function together. Though we'll study them one by one, it's important to remember—and impossible to ignore—how they are all intertwined with one another.

The systems included in this unit are the skeletal, muscular, circulatory, respiratory, excretory, and digestive systems.

Skeletal System

The human skeleton is familiar to most of us from Halloween costumes, if for no other reason. Most people even know the common names of some of their **bones**: for example, the skull, ribs, and backbone. Yet the adult human skeleton is more complex than it might first appear. There are 206 *bones*, in all—22 in the skull alone! While most of us realize that the skeleton is the framework that supports the rest of the body, it's important to realize that it serves other functions as well.



There are 206 bones in the human skeleton.

Functions of the Skeleton

1. Acts as framework for the body.
2. Anchors the muscles by providing places for attachment.
3. Makes blood cells.
4. Stores calcium.

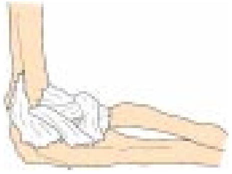
Along with acting as a framework for the body, the bones serve as anchors for the muscles. Because the ends of our muscles are attached to bones by **tendons**, the contraction, or shortening, moves the bones.

The bones serve as anchors for the muscles.

You might think of bones as just a bunch of brittle, white pipes buried deep in our bodies. In fact, bone is *living tissue*. Bone cells produce and store many products the body needs. The soft center of the bones, *marrow*, makes blood cells. The bones also store calcium, a mineral that makes bones strong and also helps the body in other ways.

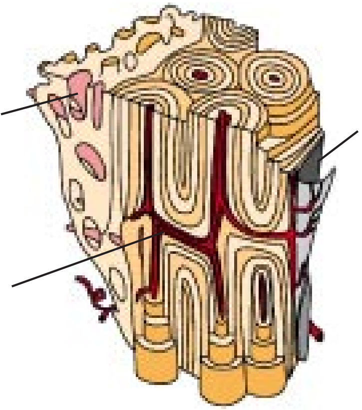
Bone Structure

Bone first develops in humans as **cartilage**, a softer, more flexible substance. As humans grow older, most of the *cartilage* hardens into bone. Some parts of our bodies remain cartilage throughout our lives, such as the tip of the nose and the outside of the ears. Cartilage is also found at the ends of bones at joints. There it acts as a cushion, or shock absorber, between the bones. At moveable joints, such as the elbow and the knee, you'll also find **ligaments**, tough fibers that help hold bones together.



At moveable joints, you'll find ligaments—tough fibers that help hold bones together.

Covering the outside of the bone is a tough layer of tissue called the **periosteum**. It provides a place for muscles to attach to the bone. It also contains nerves as well as blood vessels that supply the bone with blood. These blood vessels and nerves penetrate to the inside of the bone through tiny channels that pass through the bone.



Spongy bone is usually found at the end of bones and has many small holes.

At the middle of the bone is a central cavity filled with marrow. It also contains nerves and blood vessels.

Covering the outside of the bone is a tough layer of tissue called the periosteum. It provides a place for muscles to attach to the bone.

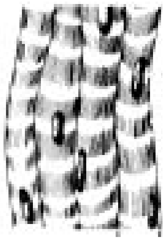
Bones are made up of two types of bone: **solid bone** and **spongy bone**. As the storage place for calcium, *solid bone* is very dense and strong. It is usually found around the edges of bones. *Spongy bone*, as its name would lead you to believe, has many small holes. Though it's strong, like solid bone, it is much more lightweight. Spongy bone is usually found at the end of bones. At the middle of the bone is a central cavity filled with marrow. It also contains nerves and blood vessels.

Muscular System

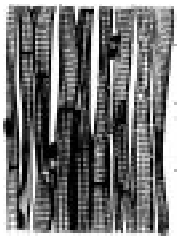
Every moment of our lives we're using muscle. We rub our eyes or scratch our backs and dozens of muscles act in concert to achieve these motions. Even as you read these words, muscles are moving your eyes from left to right and back again. In fact, the muscles involved in the movements mentioned up to now are examples of just the **voluntary muscles**—you could choose not to rub your eyes, scratch your back, or move your eyes to read. We have not even begun to consider **involuntary muscles**—those that operate completely outside of our conscious thought. *Involuntary muscles* include muscles that run the heart, the stomach, the intestines, and the blood vessels—constantly, every moment of our lives.

Three Kinds of Muscle

Skeletal muscles are the muscles that move the bones of the skeleton. We move our arms, legs, and neck, for example, with *skeletal muscles*. These are *voluntary* muscles. When seen under a microscope, skeletal muscle seems striped with light and dark bands.



Skeletal muscles are the muscles that move the bones of the skeleton.


Cardiac muscle makes up our most tireless muscle, the heart.

Cardiac muscle makes up our most tireless muscle, the heart. It also appears striped under magnification. But in *cardiac muscle*, the striping is finer and closer together so that the muscle looks sort of like a tightly woven basket. The heart is the only muscle made of cardiac muscle. This muscle is *involuntary*.

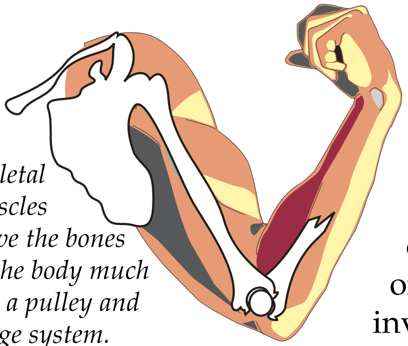
Smooth muscle can be found in many parts of the body. It does not appear at all striped but does, in fact, look smooth. This type of muscle is also involuntary. The stomach, intestines, and blood vessels are examples of body parts that contain *smooth muscle*.


The stomach, intestines, and blood vessels are examples of body parts that contain smooth muscle.

How Muscles Work

Muscles move by shortening or contracting. This happens when the long, slender cells that make up muscle are supplied with energy and activated by a nerve impulse. The process of how these cells actually shorten themselves still isn't clear to biologists. However, the most common theory to explain muscle contraction is that fibers in the muscle cells slide over one another and thus cause the cell to shorten. As the fibers return to their original position, the contractions subside.

Skeletal muscles move the bones in the body much like a pulley and hinge system. For instance, to bend the knee, the rear thigh muscle, which is attached to both the thigh bone and upper shin bone, shortens. This brings the shin and thigh bones closer together, thus bending the hinge of the knee. Each major hinge in the body is usually operated by a pair of muscles, one that controls its bend and one that straightens it again. The muscles involved in these systems are attached to the bones by strong fibers called *tendons*.


Skeletal muscles move the bones in the body much like a pulley and hinge system.

Practice

Use the list below to complete the following statements.

bones
cartilage
ligaments
organ
periosteum
solid bone
spongy bone
tendons

1. A(n) ____________________ is a body structure made up of a number of cell tissues that work as a unit to perform a specific function.

2. There are 206 ____________________ in the human skeleton.

3. The ends of our muscles are attached to bones by ____________________, and the contraction, or shortening, moves the bones.

4. Some parts of our bodies remain ____________________ throughout our lives, such as the tip of the nose and the outside of the ears.

5. At moveable joints, such as the elbow and the knee, you'll find ____________________, tough fibers that help hold bones together.

6. Covering the outside of the bone is a tough layer of tissue called the ____________________.

7. Bones are made up of two types of bone: ____________________ and ____________________.

Practice

Use the list below to write the correct term for each definition on the line provided.

cardiac muscle
involuntary muscles
skeletal muscles
smooth muscle
voluntary muscles

____________________ 1. muscles you choose to use at will

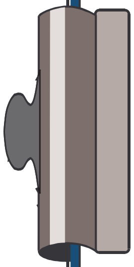
____________________ 2. muscles that operate completely outside of conscious thought, whether we want them to do so or not

____________________ 3. voluntary muscles that move the bones of the skeleton

____________________ 4. tightly woven involuntary muscle that makes up heart muscle

____________________ 5. involuntary muscle contained in many parts of the body

Lab Activity—Part 1: The Skeletal and Muscular Systems



Fact:

- Some injuries involve the skeletal system or the muscular system.
- These injuries may result from sports or everyday activities.

Investigate:

- You will learn the difference between ligaments and tendons.
- You will relate sprains, torn tendons, and tendinitis to certain injuries.
- You will learn the names of certain body muscles, bones, and tendons.

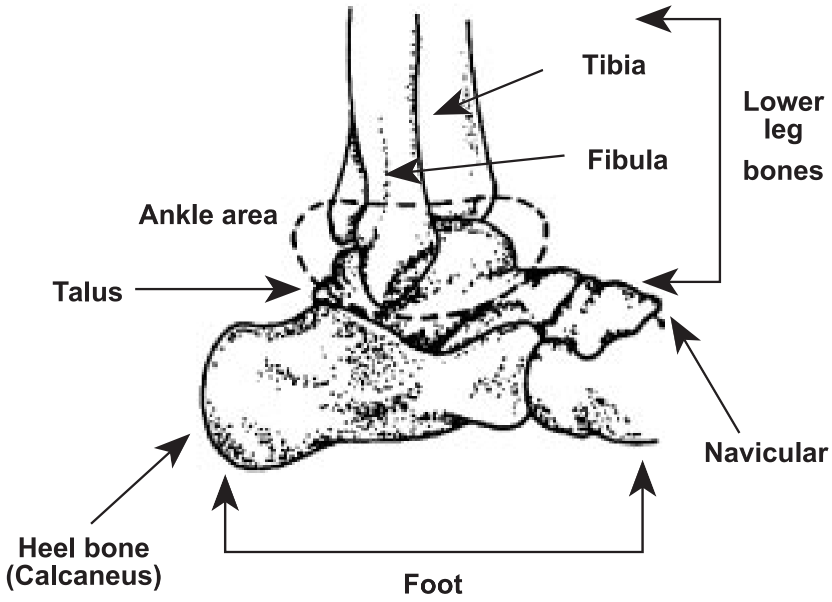
Materials:

- a #2 pencil
- colored pencils: blue and red

1. Examine Figure 2 on the next page. This is a drawing of the bones that are a part of the human ankle.

Figure 1

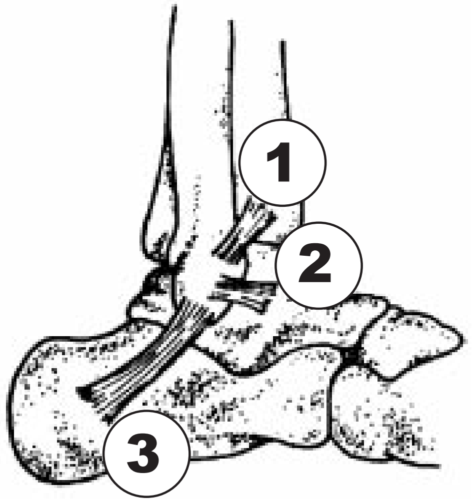
Bones of the Ankle



2. Examine Figure 2. This is a similar drawing of the ankle except that three ligaments have been added. They are marked 1, 2, and 3.

Figure 2

Ligaments of the Ankle



3. Using your collected materials, do the following:
    a. color all leg bones in Figure 2 gray.
    b. color all foot bones in Figure 2 blue.
    c. color all ligaments in Figure 2 red.

4. On Figure 2, do the following:
    a. label the two bones held together by ligament 1.
    b. label the two bones held together by ligament 2.
    c. label the two bones held together by ligament 3.

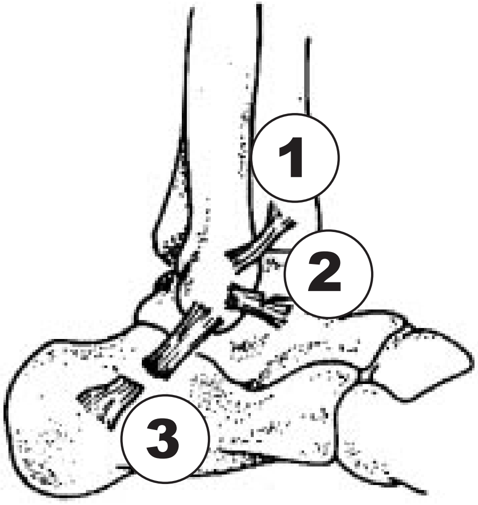
5. Examine Figure 3 showing the three types of sprains. They are marked 1, 2, and 3. They are as follows:

    first-degree sprain—ligaments are only stretched.
    second-degree sprain—ligaments are only partly torn.
    third-degree sprain—ligaments are torn completely.

6. Using your materials and Figure 3, do the following:
    a. color the first-degree sprain gray.
    b. color the second-degree sprain blue.
    c. color the third-degree sprain red.

Figure 3

Sprained Ankle Ligament



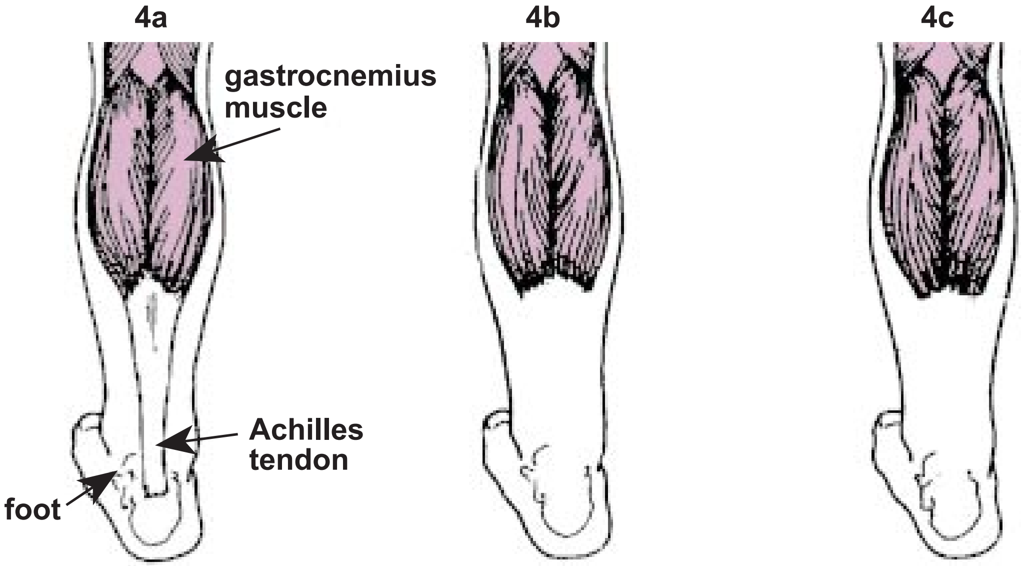
Lab Activity 1—Part 2: Totally Torn Tendons—Tendonitis

1. Locate your calf muscle—your *gastrocnemius* muscle. Run your hand down your calf until you nearly reach the back of your heel. You should now be able to feel a thick cord at the back of your heel. This cord is a tendon—your *Achilles* tendon.

2. Examine Figure 4a. This drawing shows an actual view of the back of a person's leg. The skin has been removed.

Figure 4

The Calf Muscle



3. Finish Figure 4b by showing what a totally torn Achilles tendon would look like. Draw an arrow pointing to the torn area and label it.

4. Finish Figure 4c by showing what tendonitis of the Achilles tendon would look like. Tendonitis is a soreness of the tendon. It is caused by small tears that occur along the tendon. Draw an arrow pointing to the tears and label them.

5. What body parts are held together by ligaments? ______________

____

6. Are ligaments a part of the muscular system or the skeletal system?

____

7. What type of sprain probably takes the least time to heal?

____

8. What type of sprain takes the most time to heal? ____________

____

9. Describe what one might have to do to cause a sprain. ________

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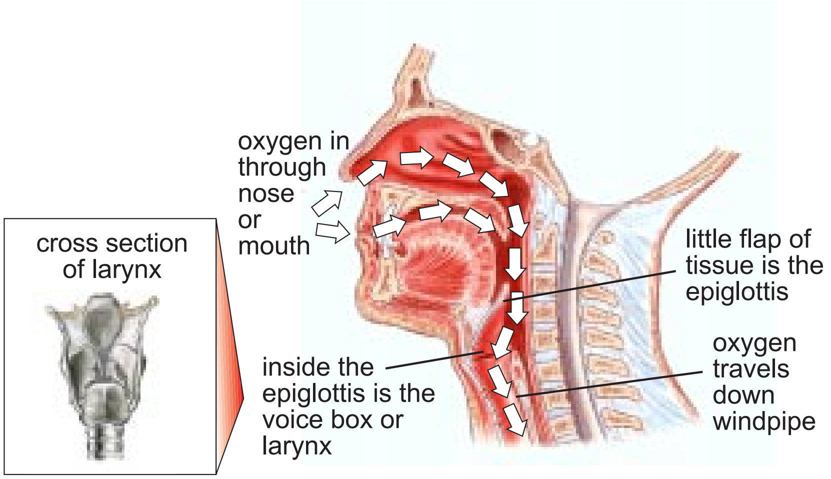
Respiratory System

As you know, human beings must breathe oxygen to survive. This is because oxygen is an element that is crucial to burning the energy we have taken in as food and stored as fats and sugars in our bodies. The chemical process that changes food to energy for our bodies takes place in the cells. However, many of our cells are buried deep inside our bodies far from any oxygen source. So how can each cell in the body receive oxygen?

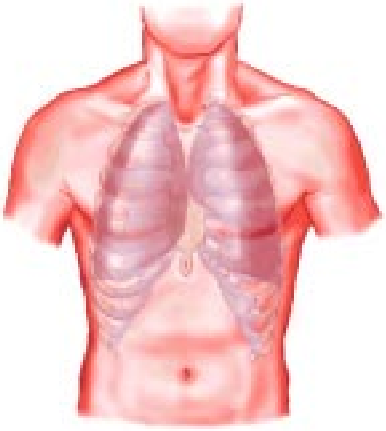
One part of the answer is the respiratory system. This system is as familiar to us as the noses on our faces, but obviously there is much more to it that we can't see. We take in oxygen through the mouth or nose, which filters and warms it. From there the oxygen travels down the windpipe. The windpipe descends from the back of the throat and is protected by a little flap of tissue called the **epiglottis.** Just inside the *epiglottis* is the voice box or **larynx**. The vocal cords of the *larynx* vibrate with passing air to make sound.

The vocal cords of the larynx vibrate with passing air to make sound.



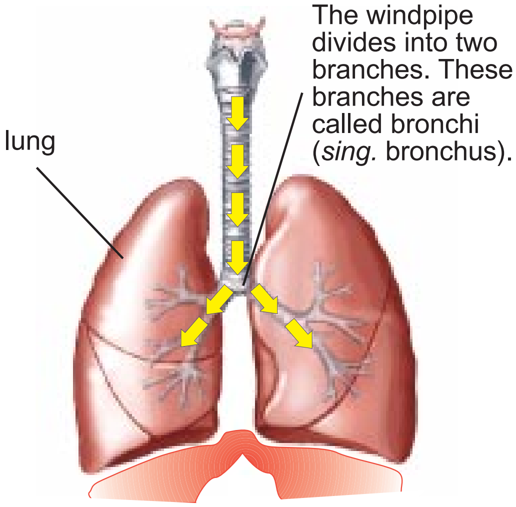
Human beings must breathe oxygen to survive.

Below this point, at the top of the chest, the windpipe divides into two branches. These branches are called **bronchi** (*sing*. bronchus). One of the *bronchi* leads to the right lung and one leads to the left lung. From there the bronchi branch into millions of smaller tubes, each of which leads to a small air sac. Each air sac is surrounded by tiny blood vessels called **capillaries** through which the blood passes. These *capillaries* are so narrow that the blood can only pass one blood cell at a time. As these blood cells pass by the air sac, they give up the carbon dioxide they have picked up from body cells as a waste product in exchange for a fresh load of oxygen. Then the blood returns to the heart, which pumps it back out to the body to deliver oxygen to waiting body cells.


Our lungs in our body.

How We Breathe

By breathing, we draw air containing oxygen into our lungs and push air containing carbon dioxide out. How does this work? In many ways, our breathing equipment functions like a big syringe, with the plunger moving out and in, out and in.



The diaphragm, the dome-shaped muscle at the base of the chest cavity, goes in and pushes carbon dioxide and other gases out of the lungs.

As we take in a breath, the muscles of the ribs contract, pulling the ribs up and out. Then the **diaphragm,** the dome-shaped muscle at the base of the chest cavity, contracts and lowers. The *diaphragm* functions like the plunger in a syringe. As it lowers, the area of the lungs increases, and oxygen moves in to fill up the space. Then, as the diaphragm relaxes and returns to its original position, the area in the lungs decreases again. The diaphragm—plunger—goes in and pushes carbon dioxide and other gases out of the lungs.

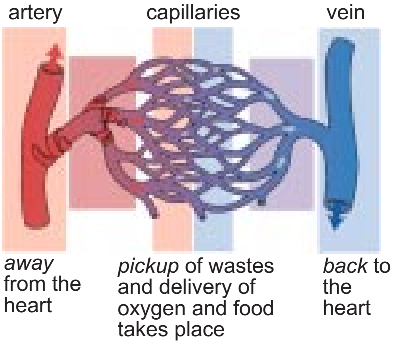
Circulatory System

One way to imagine the circulatory system is as a vast highway system with little delivery trucks traveling around on it. The highway system is *blood vessels*. The delivery trucks are *red blood cells*. The delivery trucks do not move by their own power but are pushed along in small bursts of speed. The power behind them is the *pumping of the heart*.

In studying the respiratory system, we saw how red blood cells picked up carbon dioxide—a waste product from burning food—from the body cells. In the lungs, the red blood cells exchanged their load of carbon dioxide for a load of oxygen. The blood cells also pick up other wastes from body cells and leave them in the kidneys, which filter blood. They move on to other pickup points to load up with products of the digestive system—food nutrients—to deliver to the body cells.

Blood vessels are divided into three types: **arteries**, **capillaries**, and **veins**.

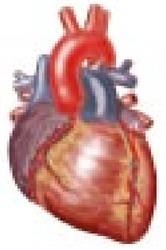
- *Arteries* are blood vessels leading *away* from the heart.
- *Capillaries* are tiny blood vessels where *pickup* of wastes and delivery of oxygen and food takes place.
- *Veins* are blood vessels that *connect* with the *capillaries* to take blood *back to* the heart.



Blood vessels are divided into three types: arteries, capillaries, *and* veins.

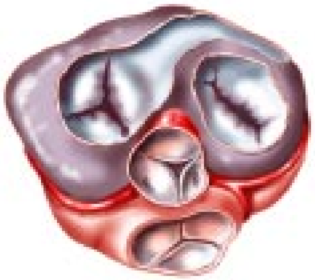
This pickup and delivery system would not work without the powerful pumping of the heart, which pushes blood cells through the blood vessels. How does the heart work?

The Heart—A Two-Sided Pump



The heart is a muscle.

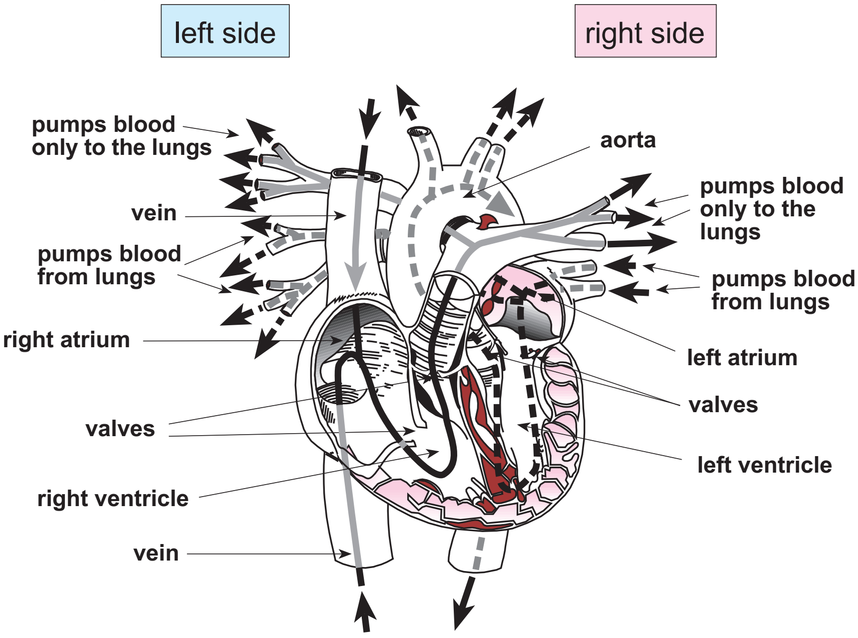
The heart is a muscle with two sides completely walled off from one another. Each side has a top chamber, the **atrium** (*pl.* atria) and a bottom chamber, the **ventricle**. First the top chambers contract, squeezing blood into the bottom chambers. Then the bottom chambers contract, squeezing blood out of the heart into the *arteries* that lead out of the bottom chambers. After each contraction empties one set of chambers, the heart relaxes pressure on the other set of chambers. This increases the space inside, and new blood is sucked in to fill the space. Thus the two sets of chambers take turns being filled and emptied with blood—one set fills as the other set empties. Valves at the out-gates of the atria and *ventricles* prevent the backflow of the blood. It's these two sets of valves closing—first one set, then the other—that we hear as a heartbeat.



Valves at the out-gates of the atria and ventricles prevent the backflow of the blood.

Each side of the heart has a special job.

- The *right* side of the heart pumps blood only *to the lungs*. Receiving blood from the body that contains lots of carbon dioxide and little oxygen, the right side of the heart pumps this blood to the lungs for gas exchange.
- The blood returns to the *left* side of the heart *from the lungs*. There it gets a new push to make its trip back out into the blood vessels of the body.



Heart

oxygen-rich blood	- - - - -	enters heart from lungs and goes out to body
oxygen-poor blood	———	enters heart from body and goes out to lungs

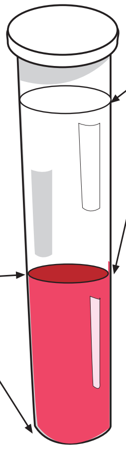
The Structure of Blood

We tend to think of blood as liquid, but in fact blood is made up of a liquid part and a solid part. The liquid part of the blood, called **plasma**, makes up about 55 percent of the total volume. The solid part, blood solids, makes up about 45 percent of the total volume.

Plasma is 90 percent water. Otherwise, it contains the substances listed on the chart below. Proteins in plasma give blood the ability to clot and form scabs, which are necessary to stop bleeding. Proteins also give blood the ability to regulate the amount of fluid contained in cells and the ability to recognize and fight disease. Digested foods float around in the plasma in the form of glucose and fats. Wastes (such as *urea*, which ultimately exits the body in the form of *urine*) are also found in the blood.

Blood

blood settled and separated



Blood Plasma

nonliving part of blood
yellow in color
liquid part of blood

contains:

- water
- proteins
- digested foods
- mineral salts
- cell waste products
- dissolved gases (O_2 and CO_2)
- vitamins (regulate cell functions)
- hormones (chemical messengers)

Blood Solids

living part of blood
red in color

contains:

- red blood cells
  - disk-shaped
  - very small
  - contain hemoglobin
- white blood cells
  - destroy invading microorganisms
  - fight infection
- platelets
  - pieces of larger cells
  - found in bone marrow
  - help clot the blood

Blood solids fall into three categories. **Red blood cells** are disk-shaped and very small. They contain the protein **hemoglobin**, which combines easily with oxygen and carbon dioxide. This is what makes *red blood cells* such good pickup and delivery trucks for these gases throughout the body and in the lungs. **White blood cells** are larger than red blood cells. Their most important function is to surround and destroy microorganisms that invade the body. Thus, when there is an infection in the body, the number of *white blood cells* increases to fight it off. **Platelets** are not really whole cells. They're pieces of larger cells formed in the bone marrow. They have no nuclei and are even smaller than red blood cells. *Platelets* work with proteins in the plasma to clot the blood.

Practice

Use the list below to complete the following statements.

bronchi
capillaries
carbon dioxide
diaphragm
epiglottis
larynx
oxygen

1. As you know, human beings must breathe ________________________ to survive.

2. The windpipe descends from the back of the throat and is protected by a little flap of tissue called the ________________________ .

3. The vocal cords of the ________________________ vibrate with passing air to make sound.

4. The windpipe divides into two branches which are called ________________________ , one leads to the right lung and one leads to the left lung.

5. The bronchi branch into millions of smaller tubes, each of which leads to a small air sac which is surrounded by tiny blood vessels called ________________________ through which the blood passes.

6. By breathing, we draw air containing oxygen into our lungs and push air containing ________________________ out.

7. As we take in a breath, the muscles of the ribs contract, pulling the ribs up and out. Then the ________________________ , the dome-shaped muscle at the base of the chest cavity, contracts and lowers.

Practice

Match the following definitions or **descriptions** *with the correct term. Write the letter on the line provided.*

______ 1. tiny blood vessels where pickup of wastes and delivery of oxygen and food takes place; connect arteries to veins

______ 2. the protein that colors red blood cells and allows them to carry oxygen to the tissues

______ 3. blood vessels that contain blood traveling away from the heart

______ 4. blood vessels that contain blood traveling back to the heart

______ 5. cells that surround and destroy microorganisms that invade the body; larger than red blood cells

______ 6. picked up by the red blood cells in the lungs

______ 7. picked up by the blood cells from body cells

A. arteries

B. capillaries

C. hemoglobin

D. oxygen

E. veins

F. wastes

G. white blood cells

Practice

Use the list below to label the **diagram of the heart**. *Use a* **red pencil to show oxygen-rich blood** *and a* **blue pencil to show oxygen-poor blood**. **One or more terms will be used more than once.**

aorta
lungs
left atrium
left ventricle
right atrium
right ventricle
valves
vein

1. pumps blood only

to ______________________

2. ______________________

3. pumps blood

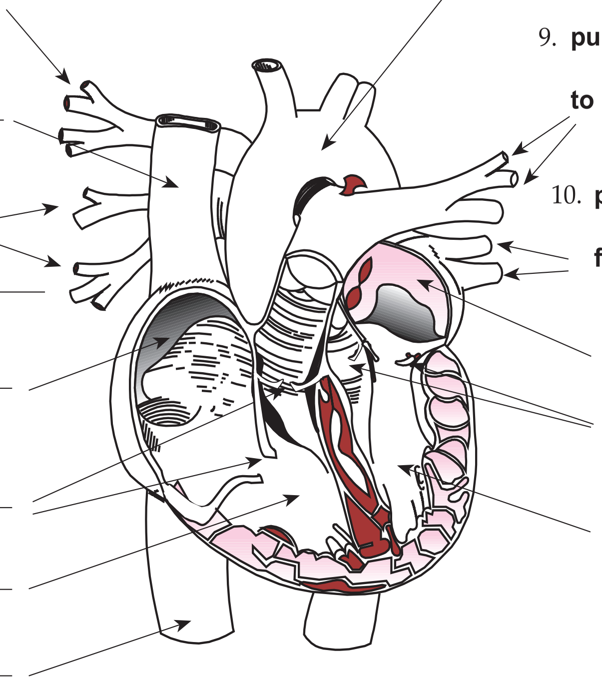
from ______________________

4. ______________________

5. ______________________

6. ______________________

7. ______________________



Heart

8. ______________________

9. pumps blood only

to ______________________

10. pumps blood

from ______________________

11. ______________________

12. ______________________

13. ______________________

Lab Activity 2: Pulse Rates

Fact:

- Every time your ventricles contract, blood is forced suddenly out of your heart and into your arteries. This sudden force makes your arteries jump. This movement of your arteries is called a pulse.

  pulse rate = heartbeat

  Your heartbeat depends on several things like age, activity, fear, and excitement.

  The heart of a rested adult beats 70 to 80 times a minute. A young person's heart beats slightly faster.

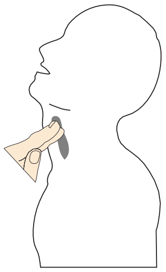
Investigate:

- You will determine your own pulse rate. You will compare your rested pulse rate and pulse rate after exercise.

Materials:

- watch

You can feel a pulse on an artery that is near the skin. Most pulses are taken on the wrist. But you can also take the pulse on the neck. Use your fingers, not your thumb.



1. Take your pulse while you are sitting. Count the number of beats in 15 seconds and multiply by 4 to get the number of pulse beats in one minute. Fill in the Pulse Rate Data Table on the following page.

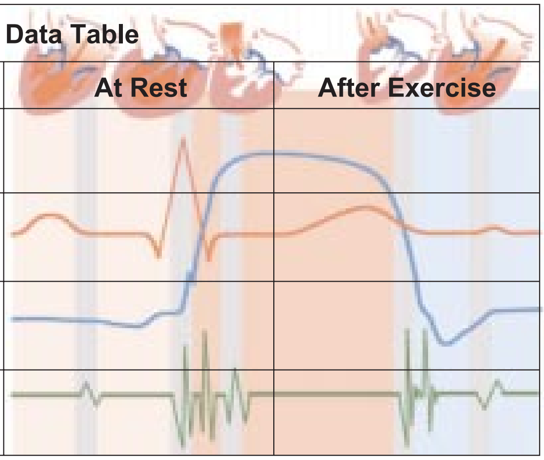
2. Repeat number 1 two more times.

3. Average all three trials from the Pulse Rate Data Table and record below.

4. Exercise by running in place one minute. Count the number of pulse beats as you did in number 1. Fill in below.

5. Repeat number 4 two more times.

6. Average all three trials from the Pulse Rate Data Table and record below.



Pulse Rate Data Table

	At Rest	After Exercise
Trial 1		
Trial 2		
Trial 3		
Average		

7. What was your average pulse rate while you were sitting?

____

8. What was your average pulse rate after you jogged in place for one minute? ____________

9. How does exercise affect the pulse rate? ______________________

____

____

____

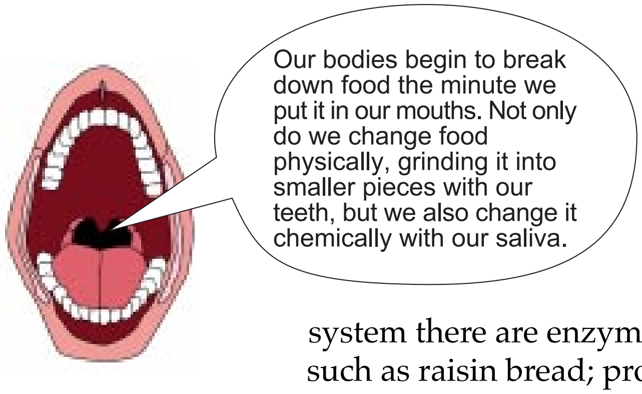
Digestive System

Oxygen and food are the two main things body cells need to carry out their many varied missions, whether they're muscle cells contracting to move bones or white blood cells fighting off invading microorganisms or any other type of cell. We've seen how the respiratory system provides oxygen to cells. But how is raisin bread, beans, or a chocolate bar processed into the tiny molecules that cells need to burn for energy? And how do these molecules reach cells all over the body?

These are the jobs of the digestive system: breaking down food into a form cells can use and aiding or getting this refined food to the cells.

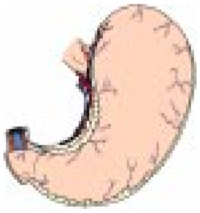
Physical and Chemical Changes That Break Down Food

Our bodies begin to break down food the minute we put it in our mouths. Not only do we change food physically, grinding it into smaller pieces with our teeth, but we also change it chemically with our **saliva**. *Saliva*, a fluid released from glands in the mouth, soaks into the food and helps turn it into a paste. If the food is a carbohydrate, such as raisin bread, saliva begins to change the chemical makeup of the bread with an enzyme. **Enzymes** are proteins that speed up the breakdown of food into molecules. *Enzymes* are very specific to the type of food they affect. In the human digestive system there are enzymes specific to carbohydrates, such as raisin bread; proteins, such as beans or fat.



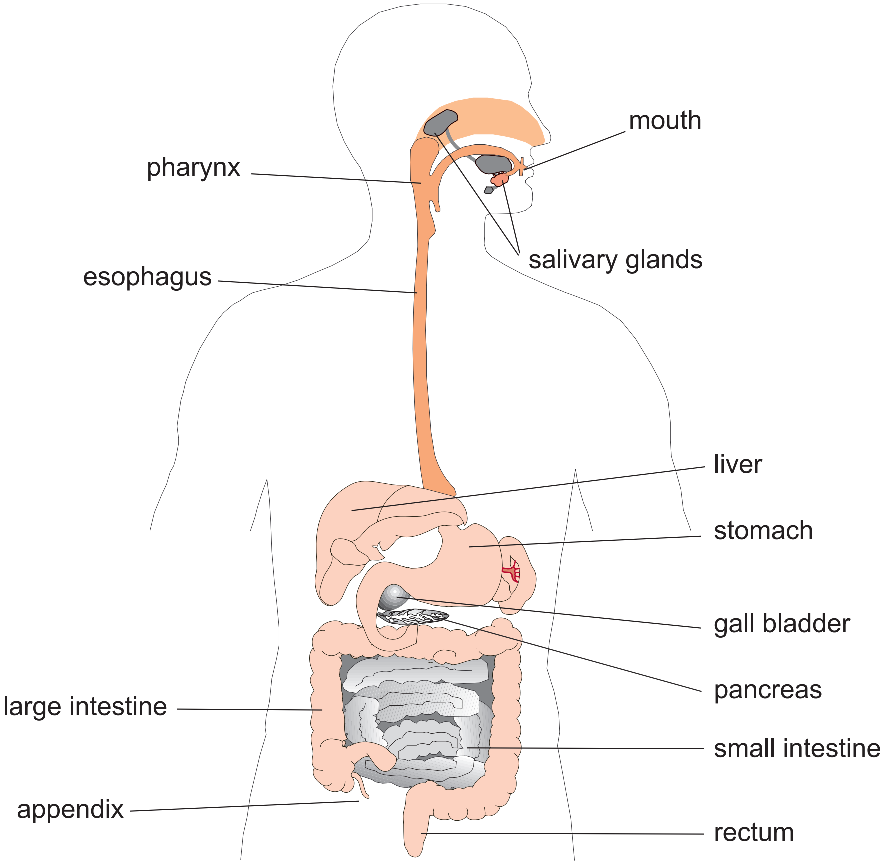
When we swallow, muscles in the throat push the bite of food into the **esophagus**. This is the tube that carries food to the stomach. The *esophagus* also has muscles that push the food down toward the stomach.

The stomach is a muscular bag that holds and works on food for about four hours. Cells inside the stomach make chemicals which include hydrochloric acid and enzymes. After the stomach is finished with the food, it pushes it into the small intestine.



The stomach is a muscular bag that holds and works on food for about four hours.

The small intestine is a tube-shaped organ that's about seven meters long. This is where most of the food processing known as *digestion* occurs. Enzymes from the liver and pancreas work with enzymes produced by the small intestine to break down foods from all three food groups—carbohydrates, proteins, and fat. **Bile**, a substance produced in the liver and stored in the gall bladder, works specifically on fat. The small intestine may handle food for as long as 10 hours before the remnants of what's left pass through.

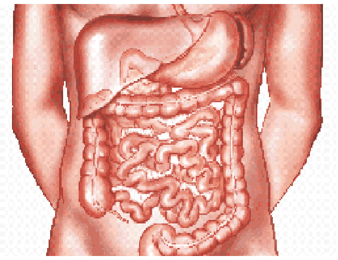


digestive system

The large intestine is a larger tube whose main job is to remove water from the undigested remains of the food that entered the mouth. By this point, all of the usable nutrients in the food have been removed. Undigested food and wastes pass from the large intestine out of the body through the rectum.

How the Body Absorbs Food

The small intestine breaks food down into molecules that cells can use. But how do these molecules get from the small intestine to the cells?



seven meters worth of small intestine

Food molecules are absorbed through the very thin lining of the small intestine into blood passing through underlying capillaries. From there the blood travels to the liver for filtering before it circulates throughout the body. But even seven meters worth of small intestine would not provide enough space to absorb all of the available food molecules if the lining of the intestine were not constructed in a way that maximizes absorption area. The inside of the small intestine is not smooth. It is puckered up into millions of fingerlike knobs called *villi*. This puckering or knobby wrinkling of the small intestine lining increases the amount of area with which food comes into contact.

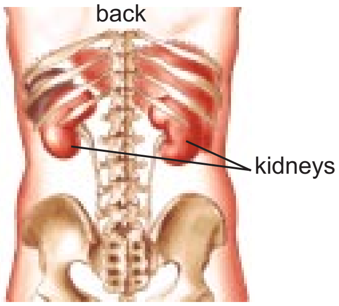
Excretory System

The excretory system is the body's garbage service. Through the excretory organs, the human body gets rid of waste products that could slow down and even poison its other systems. One of these waste products is **urea**, a substance that is made up of leftover parts of used proteins and is high in nitrogen. Another waste product is carbon dioxide.

Though we think of lungs as part of the respiratory system, they're an excretory organ in that they remove carbon dioxide from the body. The skin also excretes some *urea* with water and salt when we perspire, although the main purpose of perspiration is to cool the body.

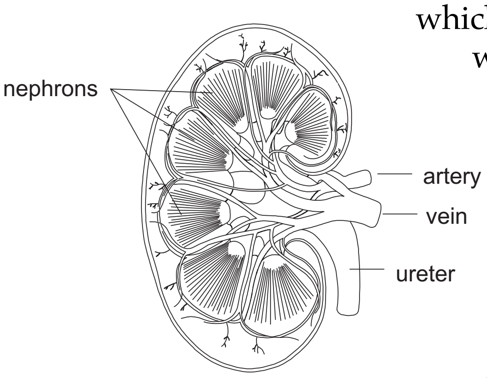
Kidneys—The Major Excretory Organs

The kidneys are the major excretory organs. They are found on either side of the spine in the small of the back, looking like a pair of giant kidney beans.



The kidneys are found on either side of the spine in the small of the back.

Each kidney is made up of many tiny filtering units called **nephrons**. Each *nephron* is made up of a cuplike structure mounted on a tube that leads out of the kidney. The cup holds a tightly coiled capillary. Pressure inside this capillary is very high because the heart pumps blood directly into the arteries that lead to the kidney. Because of this pressure, everything is forced out of the blood except the blood cells. This includes water, mineral salts, food, and urea—much of which the blood needs to keep. But not to worry: all of these things run down into the nephron tube, which the capillary wraps around. The capillary reabsorbs the food as well as the proper amounts of water and mineral salts. The urea and everything else continues down the nephron tube. Eventually they leave the kidney, are gathered in the bladder as **urine**, and leave the body through the **urethra**.



Kidney

Summary

The human body depends on many biological systems to function and survive. All of these systems interact and overlap with one another.

Major organs include the brain, heart, lungs, liver, stomach, intestines, and kidneys. All of these organs play central roles in the systems that run the human body.

The skeleton provides a framework for the body and also accomplishes other important jobs. The muscles move the bones of the skeleton and contribute to the make up and function of most major organs.

The respiratory system provides a place for blood to take up oxygen and give off carbon dioxide: the lungs. The circulatory system allows blood to deliver oxygen and food molecules to body cells and to pick up waste products. The heart pushes blood through the body so that it can accomplish these tasks.

The digestive system breaks down food into molecules that cells can use. The liver and pancreas contribute enzymes to this process. The small intestine is the place where the blood absorbs these molecules.

The excretory system is the human body's garbage service. The kidneys are the main excretory organs. They remove waste products from the blood and regulate the amount of water and mineral salts that blood contains.

Practice

Use the list below to write the correct term for each definition on the line provided.

bile
enzymes
esophagus
nephrons
saliva
urea
urethra
urine

________________________ 1. the tube that carries food to the stomach

________________________ 2. a waste product that is made up of leftover parts of used proteins and is high in nitrogen

________________________ 3. a fluid released from glands in the mouth that soaks into food and helps in chewing, swallowing, and digesting

________________________ 4. a substance produced in the liver and stored in the gall bladder that works specifically to dissolve fat in the small intestine

________________________ 5. the passageway out of the body for urine

________________________ 6. urea and other waste substances that are collected in the bladder

________________________ 7. tiny filtering units in the kidneys

________________________ 8. proteins that speed up the breakdown of food into molecules in the digestive system

Practice

Complete the following outline.

A. Skeletal system

1. Functions of the skeleton

   a. ______________________

   b. ______________________

   c. Makes blood cells

   d. Stores calcium

2. Bone structure

   a. ______________________ —soft, flexible substance

   b. ______________________ —holds bones together

   c. Periosteum—covers outside of bone

B. Muscular system

1. Two types of muscles

   a. Voluntary—*examples:* ______________________ and

   ____

   b. ______________________ —heart, stomach, and intestines

2. Three kinds of muscle

   a. Skeletal
   b. ____________________ —*examples:* stomach and intestines

   c. Cardiac

3. How muscles work

   a. Move by ____________________

   b. Move the ____________________ which are

      attached by ____________________

C. Respiratory system

1. Function: ______________________________________

   ____

2. Parts of the system:

   a. ____________________ —filters and warms the air

   b. Windpipe covered by the ____________________

   c. Voice box or ____________________

   d. ____________________ or branches of the windpipe

   e. Red blood cells—pick up ____________________ and give up carbon dioxide

   f. ____________________ —a large muscle that helps us breathe

D. Circulatory system

1. Power supply: ____________________________

2. Function of red blood cells

    a. Pick up wastes; take to kidneys

    b. Pick up food energy to deliver to ____________________________

3. Three types of blood vessels

    a. ____________________________ —lead away from the heart

    b. ____________________________ —where pickup and delivery takes place

    c. ____________________________ —take blood back to the heart

4. The heart—a two-sided pump

    a. Structure

        (1) ____________________________ —top chamber

        (2) Ventricle— ____________________________ chamber

    b. Function

        (1) Right side—pumps blood to the ____________________________

        (2) ____________________________ side—receives blood from the lungs and sends it out to the ____________________________

5. Blood

   a. Liquid part— ____________________

   b. Solids

      (1) Red blood cells contain ____________________

      (2) ____________________ help fight off infection

      (3) ____________________ help clot the blood

E. Digestive system

1. Jobs of the system

   a. ____________________

   b. Getting the food to the cells

2. Breakdown of food

   a. Mouth—teeth and ____________________
      (enzymes)

   b. Esophagus—carries food to

      the ____________________

   c. Stomach chemicals: ____________________ and

      ____

d. Small intestine

(1) Structure

(a) Length: ____________________ meters

(b) Lining composed of ____________________ to increase absorption area

(2) Description

(a) Uses enzymes from the liver, ____________________ , and small intestine

(b) Process time: ____________________ hours

e. ____________________ intestine—sends undigested food out of the body

F. **Excretory system**

1. Function: ____
2. Waste products— ____________________ and ____________________
3. ____________________ —central organs located in the small of the back on either side of the spine
4. Nephrons filter ____________________ from the blood
5. Urea goes to the bladder as urine, leaves the body through the ____________________

Practice

Use the list above each section to complete the statements in that section.

206
arteries
capillaries
cardiac
diaphragm
involuntary
ligaments
muscles
skeletal
skeleton
smooth
tendons
veins

1. The circulatory system is made up of the heart plus all of the ______________________ , ______________________ , and ______________________ .

2. The human skeleton has ______________________ bones in all.

3. Our ______________________ is the framework for our body.

4. Our ______________________ are attached to our skeleton.

5. ______________________ help hold our bones together.

6. ______________________ muscles run the heart, stomach, and intestines.

7. The three kinds of muscle are ______________________ , ______________________ , and ______________________ .

8. Muscles are attached to the bones by strong fibers called ______________________ .

9. When we breathe, a large muscle called the ______________________ helps us draw oxygen into our lungs.

One term will be used more than once.

atria
bile
digestive
excretory
four
kidneys
lungs
mouth
plasma
saliva
ventricles

10. The ______________________ filter our blood.

11. The right side of the heart pumps blood only to the ______________________ .

12. The human heart has ______________________ chambers.

13. The top chambers of the heart are each called the ______________________ .

14. The bottom chambers of the heart are each called the ______________________ .

15. The liquid part of the blood is called ______________________ .

16. The ______________________ system breaks down food for the body's cells.

17. Digestion begins in the ______________________ with the teeth and ______________________ .

18. The liver produces ______________________ , which acts on fat.

19. The ______________________ system is the body's garbage service.

20. The ______________________ are the main excretory organs.

Unit 20: More Human Body Systems

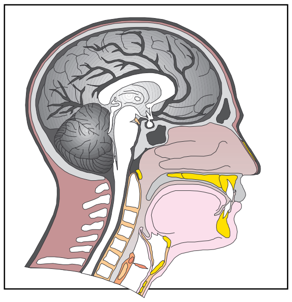
This unit emphasizes the functions of the nervous, endocrine, reproductive, and immune systems.

Student Goals

- Demonstrate understanding of the structure and function of body systems and organs, especially the reproductive, endocrine, nervous, and immune systems.
- Demonstrate a knowledge and understanding of both internal and external factors that affect the behavior of organisms.
- Know that parts of the body communicate through either electrical and/or chemical signals and understand how these signals affect behavior.

Unit Focus

- Know that the body structures are uniquely designed and adapted for their function. (SC.F.1.4.2)



Vocabulary

Use the vocabulary words and definitions below as a reference for this unit.

antibodies	proteins that stick to pathogens and make them harmless
auditory nerve	the nerve that sends information from the ear to the brain
cerebellum	the middle part of the brain; coordinates motor impulses
cerebrum	the uppermost and largest part of the brain; responsible for complex thought processes
cervix	the opening of the uterus
cochlea	a spiral-shaped tube deep inside the ear whose neurons react to sound wave patterns
embryo	the developing individual inside the uterus
Fallopian tubes	tubes that connect the ovaries to the uterus
glands	structures in the endocrine system that produce hormones

hormones	biochemical messengers in the endocrine system
immunization	a small amount of a dead or weakened pathogen that is introduced to the body so that lymph cells can produce specific antibodies to disable the pathogen in its stronger, more dangerous form
ion	a charged particle, atom, or molecule
lymph nodes	special structures in the body that produce antibodies
medulla	the lowermost part of the brain; maintains the involuntary function of vital organs, such as the heart, the intestines, and endocrine glands
menstruation	a monthly discharge released from the uterus when the lining decays after the egg is not fertilized
neurons	long, thin cells that make up the nervous system
olfactory nerve	the nerve that sends information from the nose to the brain
optic nerve	the nerve that sends information from the eye to the brain

ovaries	female sex organs that produce female sex hormones and female sex cells, or eggs
pathogens	disease-causing agents that invade the body
penis	the sex organ by which the male ejects sperm into the female reproductive system
phagocytes	white blood cells that surround and swallow pathogens
placenta	a special organ that provides the embryo with oxygen and nutrients and disposes of its waste products
retina	a surface at the back of the eye that contains neurons that pass on information about the light patterns it receives
scrotum	the sack of skin that houses the testes
semen	a mixture of sperm and other fluids that help the sperm survive
taste buds	little, flask-shaped structures in the tongue containing neurons that react to different tastes

testes	male sex organs that produce male hormones and male sex cells known as sperm (*sing.* testis)
uterus	the sex organ in which the fertilized egg will develop
vagina	a muscle-lined canal connecting the opening of the uterus to the outside of the body

Introduction

In Unit 19, we began our inspection of the human body and the many biological systems that make it work. With Unit 20, we will finish that inspection by looking at the *nervous* system, the *endocrine* system, the *reproductive* system, and the *immune* system. We will also consider the many different types of disease that disrupt or slow down a particular body system or perhaps bring all of the interacting systems to a grinding halt. Once again, it's important to keep in mind how each system overlaps and contributes to the others.

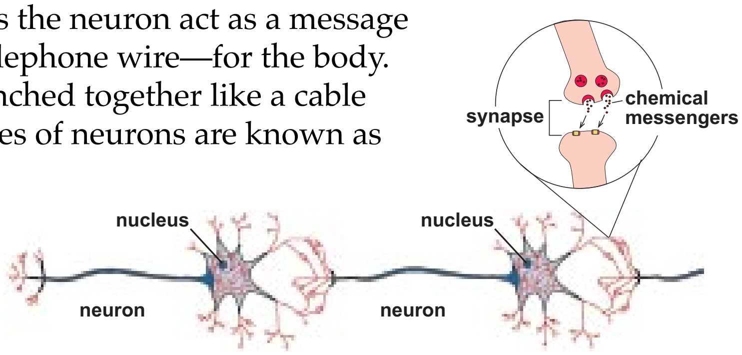
The Nervous System

The nervous system is involved in every movement of every muscle. Nerves are a part of voluntary movements, such as seeing a luscious brownie and reaching for it. They also cause the motion of involuntary muscles, such as the heart's beating or the intestines' pulsing.

The cells that make up the nervous system are called **neurons**. *Neurons* are like parts of an electrical wiring system that carry messages from the sense organs—for example, the eyes, ears, or nose—to the "master control center," the brain. The brain analyzes all of the information it receives and determines what action the body should take. Thus the nervous system can bring about anything from a tiny quiver to a great thought.

Neuron Structure

Like any other cell in the body, the neuron has a nucleus and organelles. Yet the neuron is special in that it has a long, thin shape with branching ends. This shape helps the neuron act as a message pathway—a sort of telephone wire—for the body. Neurons are often bunched together like a cable of wires. These bunches of neurons are known as *nerves*. The spaces between nerve cells are called *synapses*. Messages "jump" these gaps through a chemical process.



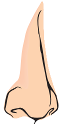
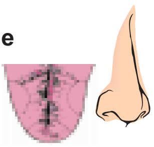
Neurons act as message pathways.

Messages travel along neurons as tiny surges of electricity. Electrically charged atoms of sodium and potassium, called **ions**, are concentrated on opposite sides of the cell membrane of the long neuron fiber. As an electrical impulse moves along the neuron, the cell membrane suddenly allows these *ions* to change sides—sodium ions rush inside the fiber and potassium ions rush out. Thus the nerve impulse moves down the fiber like a wave. It is a wave of chemicals that produce electricity. After the impulse passes a given spot, the concentration of ions returns to its pre-impulse condition. All of this happens in less than one millisecond (one-thousandth of a second)!

The Sense Organs

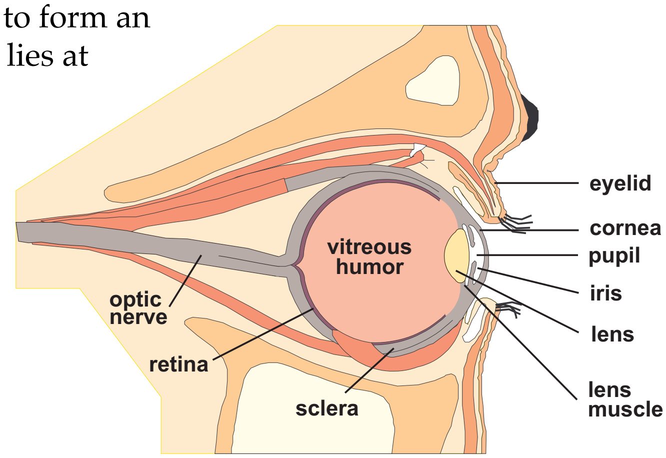
When we think of senses, we usually think of the big five: sight, hearing, smell, taste, and touch. Sense organs take in information from the world around us through neurons and send it to the brain to be processed. The brain then sends back a message along a separate nerve pathway to tell the sense organs what to do next.

The Human Senses

Sense	Sense Organs	Function
sight	**eyes** 	pick up patterns of light; lens forms image on *retina*; impulses from *optic nerve* go to the brain; the brain interprets and decodes the image
hearing	**ears** 	the outer ear directs sound waves through ear canal; sound waves vibrate through the middle and inner ear systems; information travels via the *auditory nerve* to the brain where it is interpreted and decoded
smell	**nose and nasal cavities** 	chemicals in the form of a gas are detected by *neurons*; neurons line the top of the nasal chamber; the *olfactory nerve* carries the message of smell to the brain where it is interpreted as smoke, perfume, or some other odor
taste	**tongue and nose** 	small bumps on the surface of the tongue called *taste buds* cause sense of taste; special nerve cells detect chemicals and send signals to the brain; taste buds sense only sour, sweet, salty, and bitter; our nose and the smell of food helps to determine our food preferences.
touch	**skin** 	five types of nerve cells detect pain, pressure, touch, heat, and cold; signals sent to the brain for decoding; most nerve cells found in the *dermis* (thick inner layer); only nerve cells which detect pain found in the dermis and *epidermis* (thin outer layer)

The Eyes

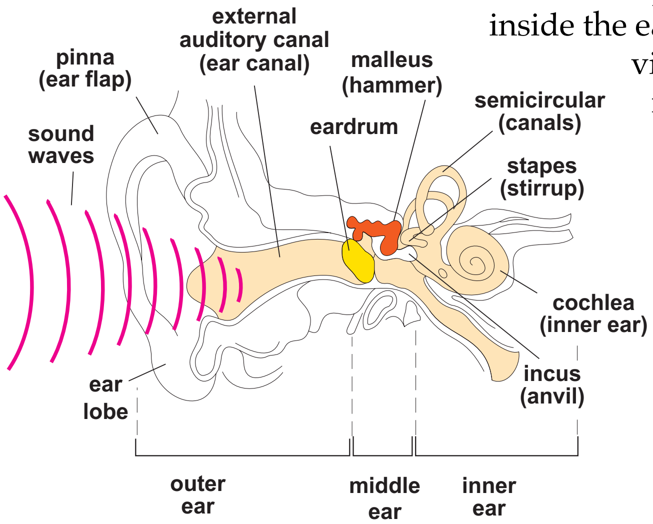
The eye allows us to see by picking up patterns of light, which pass through the lens of the eye to form an image on the **retina**, which lies at the back of the eye. The neurons of the *retina* send impulses to the **optic nerve** according to how much light they take in. From there, the nerve impulses go to the brain, which interprets the signals from the *optic nerve* and, finally, shows us what we perceive as a vision of the outside world.



The eye allows us to see by picking up patterns of light, which pass through the lens of the eye to form an image on the retina.

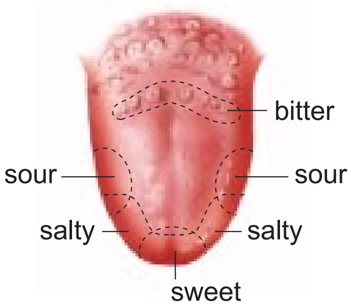
The Ears

The ears perceive sound as air molecules that are set in motion. We call these vibrating air molecules *sound waves*. Sound waves hit the whole body, thus people can sometimes "feel" sounds even if their ears don't work. In healthy working ears, the outer ear structure channels the sound wave down the ear canal to the eardrum. The eardrum picks up the vibration and passes it on to tiny bones inside the ear. These bones pass the vibration on to another membrane that causes fluid inside the spiral-shaped **cochlea** to move. Neurons inside the *cochlea* react as fluid moves past them. The **auditory nerve** gathers this information and sends it to the brain, which interprets the specific patterns of the vibrations as specific sounds. The inner ear also contains tiny hairs that detect gravity and help us keep our balance.



The ears perceive sound as sound waves: air molecules that are set in motion.

The Tongue

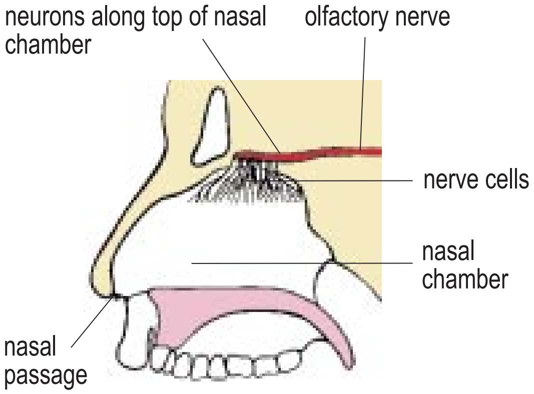


The tongue senses four general flavors.

The tongue gives us the sense of taste through its tiny **taste buds**. These are little, flask-shaped structures with pores in the top. Food dissolved in saliva enters these pores. Then hairlike nerve endings inside react, sending signals to the brain. Research shows *taste buds* can sense only four general flavors: sour, sweet, salty, and bitter. Much of our appreciation of food stems from its smell.

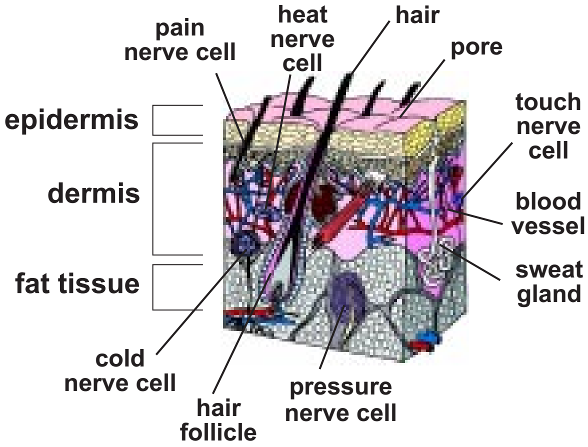
The Nose and Nasal Cavities

Neurons inside the nose and nasal cavities allow us to smell. Smells enter the nose as chemicals floating in the air. Different groups of nasal neurons are sensitive to particular types of chemicals. They send signals that travel through the **olfactory nerve** to the brain where they are interpreted as odors.



Neurons inside the nose and nasal cavities allow us to smell.

The Skin

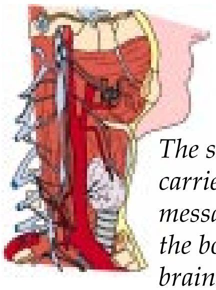


Skin has a sense of touch and can feel pain, pressure, heat, and cold.

Besides the sense of touch, our skin can feel several other conditions: pain, pressure, heat, and cold. Different neurons in the skin are responsible for sensing each of these conditions. According to their job, the neurons are either very close to the skin surface, as with neurons for pain or touch, or deeper in the skin tissue, as with neurons for pressure.

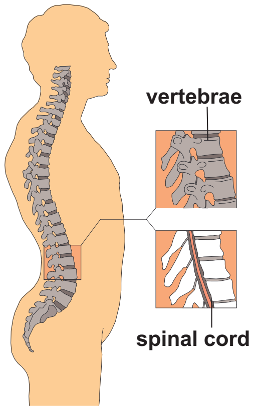
The Spinal Cord

If you think of a nerve—a bundle of neurons—as a telephone cable filled with telephone wires, then you can think of the spinal cord as the mega-cable for the body's nervous system, leading to the main switchboard, the brain. The spinal cord carries sensory messages from the body to the brain, and motor impulses from the brain to the body.



The spinal cord carries sensory messages from the body to the brain.

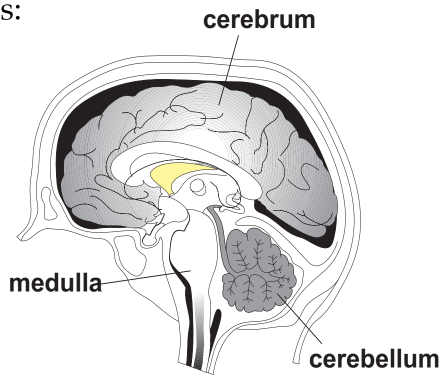
The spinal cord leads directly from the brain and descends about two-thirds of the way down the back. It is protected by the bones of the spinal column called *vertebrae*. The inner part of the spinal cord is made up of "gray matter," the same tissue of densely packed neurons of which the brain is made. The outer part is made of nerve fibers. Many spinal nerves branch off from the spinal cord between the bones of the spine.



The spinal cord is protected by the bones of the spinal column called vertebrae.

The Brain

The brain is divided into three major parts: the **cerebrum**, the **cerebellum**, and the **medulla**. Nerves carry electrical impulses which may have been caused by external or internal factors to the brain. For example, we respond by eating the food that smells good to us. However, pain in our stomach caused by eating spoiled food may cause us to vomit. As we examine how the three parts of the brain function, we will see how the different organs and parts of the body communicate.



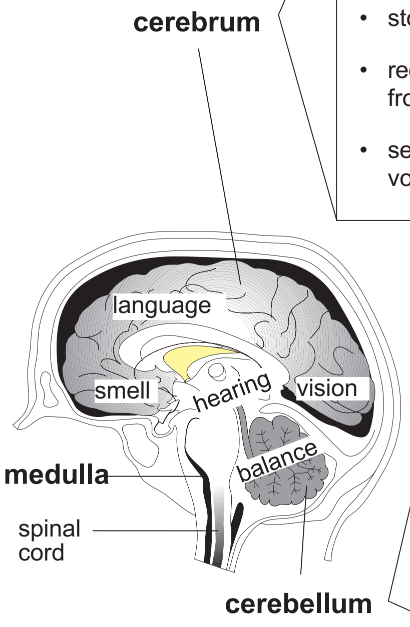
The brain is divided into three major parts.

The upper part of the brain, the *cerebrum*, is the largest part of the brain. It's the cerebrum most people picture when they think of the brain—gray and ridged with deep wrinkles and furrows. The cerebrum is responsible for *complex thought processes* such as language, reasoning, and artistic efforts. It stores information as memories. It also receives and interprets information from the sense organs and sends impulses to the muscles for voluntary motions. The cerebrum is made up of two halves: the right half controls the left side of the body and the left half controls the right side.

The *cerebellum* helps the cerebrum to control *muscular activity*. It coordinates impulses sent to the muscles so that motion is smooth, not jerky. The operation of the cerebellum is involuntary. The cerebellum lies beneath the cerebrum.

The *medulla* is the bottom part of the brain, lying at the base of the skull and at the top of the spinal cord. The medulla controls *vital involuntary motions*, such as the activities of all internal organs. These activities include respiration and the actions of the heart and digestive organs. The medulla also controls the actions of **glands** that release the biochemical messengers of the endocrine system, which we'll look at next.

The Brain, Its Parts, and Its Functions



- responsible for complex thought processes—language, reasoning, and artistic efforts
- stores information as memories
- receives and interprets information from the sense organs
- sends impulses to the muscles for voluntary motions

- controls vital involuntary motions—respiration and the actions of the heart and digestive organs
- controls the actions of *glands* that release the biochemical messengers of the endocrine system

- helps the cerebrum to control muscular activity
- coordinates impulses sent to the muscles so that motion is smooth, not jerky
- operates involuntarily

Practice

Use the list below to complete the following statements.

auditory nerve
cochlea
ions
neurons
optic nerve
retina

1. The cells that make up the nervous system are like parts of an electrical wiring system. They are called ________________________ .

2. Electrically charged atoms of sodium and potassium, called ________________________ , are concentrated on opposite sides of the cell membrane of the long neuron fiber.

3. The eye allows us to see by picking up patterns of light, which pass through the lens of the eye to form an image on the ________________________ , which lies at the back of the eye.

4. The neurons of the retina send impulses to the ________________________ , and from there, the nerve impulses go to the brain.

5. The eardrum picks up vibrations and passes them on to tiny bones inside the ear, which pass them on to another membrane that causes fluid inside the spiral-shaped ________________________ to move.

6. The ________________________ gathers information and sends it to the brain, which interprets the specific patterns of the vibrations as specific sounds.

Practice

Use the list below to write the correct term for each definition on the line provided.

cerebellum
cerebrum
glands
medulla
olfactory nerve
taste buds

____________________ 1. the uppermost and largest part of the brain; responsible for complex thought processes

____________________ 2. the lowermost part of the brain; maintains the involuntary function of vital organs, such as the heart, the intestines, and endocrine glands

____________________ 3. the middle part of the brain; coordinates motor impulses

____________________ 4. little, flask-shaped structures in the tongue containing neurons that react to different tastes

____________________ 5. the nerve that sends information from the nose to the brain

____________________ 6. structures in the endocrine system that produce hormones

Practice

Use the list above each section to complete the statements in that section. **One or more terms will be used more than once.**

brain
eye
hearing
nerves
neurons
sensory
sight
smell
taste
touch

Nervous System

1. ____________________ cause the motion of involuntary muscles such as the heart's beating.

2. The cells that make up the nervous system are called ____________________ .

3. Neurons carry messages from the sense organs to the ____________________ , the "master control center."

4. Bundles of neurons are called ____________________ .

5. Our ____________________ organs take in information from the world around us.

6. The five senses are ____________________ , ____________________ , ____________________ , ____________________ , and ____________________ .

7. The retina and optic nerve are part of the ____________________ .

8. The spiral-shaped cochlea helps us with our sense of ____________________ .

One or more terms will be used more than once.

cerebellum
cerebrum
medulla
neurons
spinal cord
taste buds
touch

9. The ________________________ on the tongue give us the sense of taste.

10. The sense of smell comes from ________________________ inside the nose.

11. Neurons in the skin are responsible for the sense of ________________________ and other conditions such as pain, pressure, and temperature.

12. The primary "cable" for the body's nervous system is the ________________________ .

13. The brain is divided into three major parts: ________________________ , ________________________ , and ________________________ .

14. The largest part of the brain is the ________________________ .

15. The part of the brain that controls muscular activity is the ________________________ .

Lab Activity: The Human Brain

Facts:

- The human brain is divided into a right and a left side.
  - right side—thought to control creativity
  - left side—thought to control the ability to analyze problems
  - right side—controls the left side of the body
  - left side—controls the right side of the body
- In most people, one side of the brain is dominant.

Investigate:

- You will check to see the following:
  - which hand you use most often in certain activities
  - which foot you use most often in certain activities
  - if you see or draw objects more to the right or the left side
- You will find out if the left side or the right side of your brain is dominant.

Materials:

- paper
- red pencil

1. Place a check mark in the proper column in the table on the next page to show which hand you usually use to do the following tasks. *Note: If you use either hand just as often, then check both columns.*

2. Place a check mark in the proper column in the table to show which foot you usually use to do the following tasks. *Note—if you use either foot just as often, check both columns.*

Finding Your Dominant Side

Task	Left	Right
write name		
wave "hello"		
bat		
thumb position with hands clasped		
hold spoon		
catch from falling		
walk down stairs		
walk up stairs		
skipping		
standing		
start to run		
Do numbers 3 - 5, then mark below.		
dog drawing		
circle drawing		
dominant eye		
Totals		

3. Draw, in the space provided on the following page, a simple side view of a dog. Place a check mark in the column of the table that shows the direction your drawing faces **away** from.

dog drawing

4. Draw a circle with your **right** hand in the space provided below. Note the direction in which you made this circle. Now draw a circle with your left hand. Note the direction in which you made this circle. If both circles were drawn clockwise, mark the right column in the table on page 646. If both circles were drawn counterclockwise, mark the left column in the table. If you drew one circle in each direction, check both columns.

left hand

right hand

5. Roll a sheet of paper into a tube. Hold the tube a couple of inches in front of your eyes. Look through the tube at some distant object with both eyes open as shown in the figure below. Then, while looking through the tube at the distant object, close one eye and then the other. The eye that sees the object through the tube is your dominant eye. Place a check mark in the proper column in the table on page 646.

6. Total up the check marks for each column of the table on page 646 and place the total at the bottom of the columns.

The Endocrine System

The nervous system isn't the only means by which our bodies can send messages from one part to another. The endocrine system is a network of organs that produce chemical messengers known as **hormones**. These organs are known as *glands* and are located in many different places in the body. They travel from place to place in the bloodstream. Some *hormones* are complex proteins, and others are not. Specific hormones cause specific changes to take place in certain body parts or organs.

Glands: Their Location and Function

	Location	Function
Pituitary	brain	controls growth and regulates sex organs
Thyroid	throat	regulates use of food in body cells
Parathyroid	throat	controls calcium levels in body
Adrenal	near kidney in central back	produces adrenaline which allows bursts of energy; controls salt levels
Pancreas	near kidney in central back	produces insulin, which controls the amount of sugar in the blood and helps sugar enter cells
Ovary	lower abdomen	controls female sex characteristics in females
Testis	testicles	controls male sex characteristics in males

All of these glands, and the hormones they produce, play important roles in the body. No doubt you've heard of some of them. For example, the pancreas produces insulin. Insulin acts as a gatekeeper for cells, allowing sugar to move from the bloodstream into the cell, where it is used as food. A lack of insulin or the body's inability to use insulin properly causes *diabetes*. People with diabetes do not have or cannot use their own insulin to let sugar into their body cells. Thus there's a high level of sugar in the blood and urine, yet the cells are starving. Depending upon the type of diabetes, this condition can now be corrected by injecting insulin produced from pigs, cows, or sheep or by receiving other medication from your doctor.

The Reproductive System

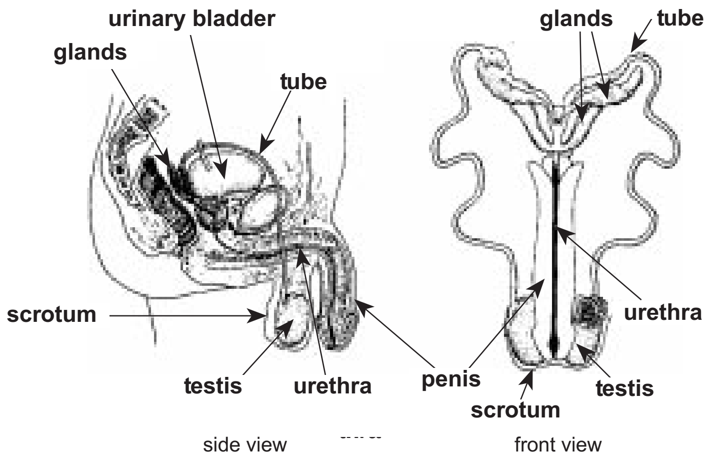
Hormones play a big part in bringing the sexual organs of men and women to maturity. Hormones also play a big part in making the reproductive system work. One of their main functions is to make males and females attractive to each other so that they will mate and produce offspring. As we've seen through our study of other body systems, each system is designed to achieve its goal as efficiently as possible, and the goal of the reproductive system is to reproduce. Humans, however, unlike most other animals, have the ability to rise above the hormonal urges of their reproductive systems. Humans are able to think about what they want for themselves.

One of the main functions of hormones is to make males and females attractive to each other so that they will mate and produce offspring.

In some ways it seems odd to discuss the structure and operation of the human reproductive system as just another biological topic. For most of us, the reproductive system is associated with ideas of love, romance, desire, and commitment. In many ways, however, it is especially important to be objective and knowledgeable about how the reproductive system works. Knowing the facts means that you can control when or if you have children and whether or not you become infected with serious or even deadly diseases.

The Male Reproductive System

The **testes** (*sing.* testis) are the male sex organs that produce male sex cells known as *sperm*. The *testes* also produce testosterone, a hormone that helps create and maintain male sex characteristics. These characteristics include the sex organs themselves as well as other traits such as body hair, muscular development, and a deeper voice. The testes are housed in a sack of skin called the **scrotum**.


Male Reproductive System

Sperm develop from special cells in the testes. These cells divide by meiosis. Meiosis gives each sex cell only half the number of chromosomes as the parent cell. When the male sex cell unites with the female sex cell, the egg, the offspring has the same number of chromosomes as the parents.

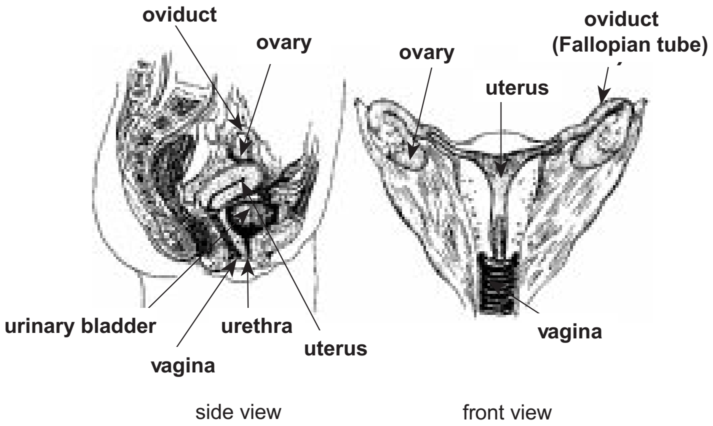
After the sperm leave the testes, they mix with several fluids from other glands. This gives them energy and more resistance to acidity. The resulting mixture is called **semen**. During sexual intercourse, *semen* is ejected into the female reproductive system through a sex organ called the **penis**. As many as 130 million sperm may be ejected at a time.

The Female Reproductive System

The **ovaries** are the female sex organs that produce female sex hormones and female sex cells, or eggs. Like sperm, eggs are produced through meiosis and contain only half the chromosome number of the parent.

In humans, the *ovaries* usually release one egg each month. The egg moves from the ovaries into the **Fallopian tubes**, which are tubes that connect the ovaries to the **uterus**. The *uterus* is the sex organ in which the egg will develop if it is fertilized. Each month, hormones in the body prepare the uterus for the possibility of nurturing a fertilized egg as it develops into another individual. These hormones give the uterus a soft, spongy lining with lots of blood vessels to deliver nutrients. If the egg is not fertilized, this lining decays and drains out of the uterus at the end of the monthly cycle. This discharge is known as **menstruation**. It leaves the uterus through an opening called the **cervix** and exits the body through a canal called the **vagina**. The *vagina* serves as an entry point for sperm during sexual intercourse and also as the birth canal.

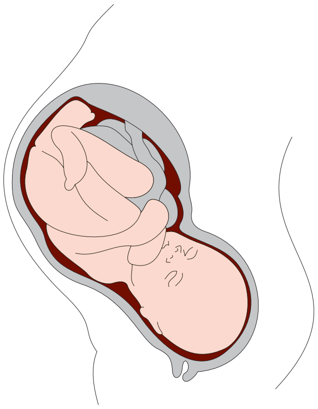
Female Reproductive System



Fertilization and Development

Following sexual intercourse, fertilization normally occurs as an egg is floating down one of the *Fallopian tubes* on its way to the uterus. A sperm must swim up the vagina, through the *cervix*, across the uterus, and up the Fallopian tube to reach the egg. As soon as the sperm penetrates the membrane of the egg, the egg begins to develop into a multicellular individual. Even before it reaches the lining of the uterus, where it attaches itself, the fertilized egg has become a tiny ball of hundreds of cells. Once attached, the developing individual, the **embryo**, begins to receive blood, nutrients, and hormones through the **placenta**. The *placenta* is a special organ that is made of tissue from both the mother and the *embryo*.

After about 40 weeks of development, the child is born. The membranes surrounding the baby break. The tissues of the mother's cervix and uterus relax. The cervix enlarges so that the baby can pass through. Strong muscles in the uterus force the baby out and down the vagina. Moments later, the uterus pushes out the placenta, to which the baby is still attached. Soon after birth, the cord that connects the baby to the placenta is cut. The cord stump attached to the baby withers and falls off after several days, leaving what we know as a navel.



After about 40 weeks of development, the child is born.

Practice

Use the list below to complete the following statements.

chromosomes
hormones
maturity
penis
scrotum
semen
testes
testosterone

1. The endocrine system is a network of organs that produce chemical messengers known as ____________________ .

2. The ____________________ are the male sex organs that produce male sex cells known as *sperm*.

3. The testes produce ____________________ , a hormone that helps create and maintain male sex characteristics.

4. Hormones play a big part in bringing the sexual organs of men and women to ____________________ .

5. The testes are housed in a sack of skin called the ____________________ .

6. Meiosis gives each sex cell only half the number of ____________________ as the parent cell.

7. During sexual intercourse, ____________________ is ejected into the female reproductive system through a sex organ called the ____________________ .

Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. tubes that connect the ovaries to the uterus

______ 2. the opening of the uterus

______ 3. a muscle-lined canal connecting the opening of the uterus to the outside of the body

______ 4. female sex organs that produce female sex hormones and female sex cells, or eggs

______ 5. the developing individual inside the uterus

______ 6. the sex organ in which the fertilized egg will develop

______ 7. a monthly discharge released from the uterus when the lining decays after the egg is not fertilized

______ 8. a special organ that provides the embryo with oxygen and nutrients and disposes of its waste products

A. cervix

B. embryo

C. Fallopian tubes

D. menstruation

E. ovaries

F. placenta

G. uterus

H. vagina

Practice

Circle the letter of the correct answer.

Endocrine and Reproductive Systems

1. The endocrine system is made up of __________ .
   a. brain and neurons
   b. glands and hormones
   c. thyroid and pancreas
   d. nerves and chemicals

2. The endocrine system's chemical messengers are called __________ .
   a. cells
   b. neurons
   c. ions
   d. hormones

3. The __________ gland, located in the brain, controls growth.
   a. pituitary
   b. thyroid
   c. pancreas
   d. adrenal

4. The pancreas produces __________ , which controls the amount of sugar in the blood.
   a. calcium
   b. adrenaline
   c. insulin
   d. hormones

5. People with __________ do not have or cannot use their body's insulin.
   a. diabetes
   b. testicles
   c. ovaries
   d. hormones

6. __________ are chemicals that play a big part in making the reproductive system work.

   a. Glands
   b. Hormones
   c. Chromosomes
   d. Organs

7. The testes, male sex organs, produce __________ .

   a. hormones
   b. sexual intercourse
   c. sperm and testosterone
   d. glands

8. Sperm travel from the penis in a fluid known as __________ .

   a. testosterone
   b. testes
   c. scrotum
   d. semen

9. The female sex organs that produce eggs and female sex hormones are the __________ .

   a. glands
   b. embryo
   c. ovaries
   d. uterus

10. Sperm and egg cells are produced through __________ .

    a. mitosis
    b. meiosis
    c. intercourse
    d. chromosomes

11. The __________ connect the ovaries to the uterus.

    a. Fallopian tubes
    b. vagina
    c. cervix
    d. embryo

12. ____________ occurs when the sperm and egg unite.

a. Menstruation
b. Fertilization
c. Intercourse
d. Fallopian

13. The embryo receives nutrients through the ____________ .

a. vagina
b. cervix
c. uterus
d. placenta

14. Our ____________ is a feature that shows we were attached to the placenta.

a. uterus
b. cervix
c. navel
d. membrane

Disease and the Immune System

As we have reviewed the various systems of the human body, we have studied how they are supposed to work under ideal conditions. Obviously, life is not always ideal. Many people's bodies are damaged by disease. Disease can slow down and stop any of the body's marvelous systems. Thanks to medical research, doctors are often able to prescribe lifestyle changes, drugs, or surgery to help ailing body systems. However, a particular system can be so badly diseased that it cannot function at all. Even if it's propped up by medical means, it's possible that the entire body will shut down and die. Every system supports and interacts with every other system. So if one stops, another is likely to falter.

Diseases that afflict humans fall into several different categories. *Hereditary* disease is disease that people *inherit* from their parents, usually through a defect in their genes. Hereditary diseases include hemophilia and sickle cell anemia. *Degenerative* disease is disease that results from *aging*; parts of the body simply wear out. Arthritis and hardening of the arteries, or arteriosclerosis, which often causes heart problems, are examples of degenerative diseases. Deficiency diseases include problems with body systems that simply *don't work* at the required capacity. For instance, some people's kidneys do not efficiently filter out and excrete impurities from the blood. These people must often rely on dialysis machines to increase the filtering capacity of their kidneys.

Example Classification of Diseases

Hereditary	Degenerative	Deficiency
hemophilia	arthritis	kidney disease
cystic fibrosis	arteriosclerosis	cirrhosis of the liver
diabetes	Alzheimer's disease	congestive heart failure
sickle cell anemia	cancer	lung disease
muscular dystrophy	retinitis pigmentosa	osteoporosis

Contagious diseases are diseases that one person can *catch* from another. These diseases are usually passed on in bacteria or viruses. The body has several defenses against such invaders.

Examples of Contagious Diseases

- influenza
- pneumonia
- chicken pox
- rabies
- salmonella
- malaria
- mumps
- measles
- AIDS
- trichinosis
- dysentery
- hepatitis

How the Body Protects Itself from Contagious Diseases

The first line of defense against contagious disease-causing agents, or **pathogens**, prevents them from entering body tissues. This line of defense includes the skin, tears, mucus, and stomach acid.

The second line of defense against *pathogens* involves white blood cells called **phagocytes**. Scientists think that *phagocytes* find their way to sites of infection by sensing chemicals. These chemicals may be released either from the injured tissue or by the pathogens themselves. The phagocytes surround and swallow the invaders. Certain phagocytes can enlarge to take in as many as 100 or more bacteria.

The third line of defense is what we call the *immune system*. When people are immune to a disease, that means that they cannot become infected with it. Immunity may be natural—present at birth—or acquired since birth.

Bodies Protection against Contagious Diseases

1st line of defense

skin, tears, mucus, and stomach acid—prevent pathogens from entering body tissues

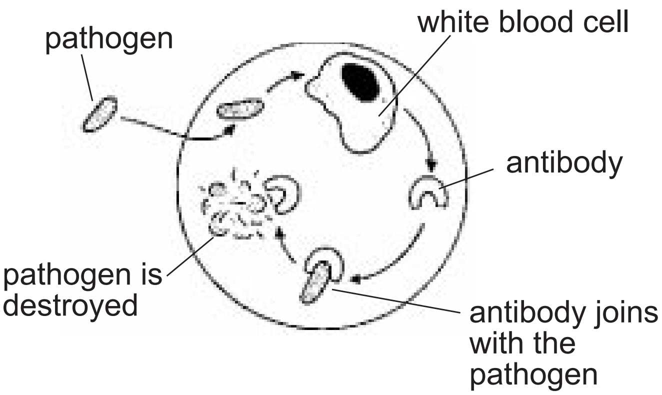
2nd line of defense

white blood cells called phagocytes—destroy disease causing agents called *pathogens*

3rd line of defense

immune system either present at birth or acquired antibodies—makes pathogens harmless

How does a body *acquire immunity* after birth? The body becomes immune to a particular disease by acquiring **antibodies** for it. *Antibodies* are produced in the **lymph nodes**, special immune system structures. Antibodies are proteins that stick to pathogens and make them harmless. Antibodies usually act specifically on certain pathogens.



The bodies normal response is to destroy disease-causing agents called pathogens.

People can acquire antibodies to a pathogen in several ways. Antibodies may be passed on from mother to child, or antibodies may be injected into a person. However, these sorts of immunity, where someone passively accepts antibodies from someone else, may soon wear off. Active immunity, where a person's own body develops antibodies to a pathogen, lasts longer. Active immunity involves exposure to the pathogen. This is the sort of immunity we receive through **immunizations**. The substance we receive in an *immunization* is usually a *dead* or *weakened form* of a pathogen. Exposure to this pathogen allows the *lymph nodes* to develop antibodies that are specific for the pathogen even in its stronger, more dangerous form. Thus the immunization gives the benefits of exposure—antibodies and immunity—while avoiding the risks of major infection.

Summary

In this unit, we finished our inspection of the many body systems that keep us alive. The nervous system is made up of special cells called neurons which carry tiny electrical messages throughout the body. Sense organs take in information and send it to the brain for processing. The spinal cord is a major nerve pathway that allows the brain to communicate with other parts of the body. The brain is made up of three main parts, the cerebrum, cerebellum, and medulla, each of which controls different nervous system functions. The brain and other body systems respond to internal and external conditions.

The endocrine system uses another means of sending messages throughout the body: biochemicals known as hormones. These are produced in glands located in many different places. Hormones control many important functions such as sugar levels in the blood, rate of growth, and the development and function of sex organs.

The reproductive system is largely controlled by hormones. Both males and females have special sex organs that allow them to produce sex cells. Union of sex cells and development of the resulting embryo takes place inside the female. Knowledge of how fertilization occurs, as well as the many diseases that can be passed on during sex, is useful for those who wish to control those events in their lives.

Hereditary, degenerative, deficiency, and contagious diseases are all threats to the efficient operation of body systems. The body has several lines of defense against contagious diseases, including the antibodies of the immune system.

Practice

Circle the letter of the correct answer.

1. __________ is disease that people inherit from their parents, usually through a defect in their genes.

   a. Hereditary disease
   b. Degenerative disease
   c. Contagious disease

2. Skin, tears, mucus, and stomach acids are the first line of defense against contagious disease-causing agents, or __________ , and prevents them from entering body tissues.

   a. immunization
   b. antibodies
   c. pathogens

3. The second line of defense against pathogens involves white blood cells called __________ .

   a. olfactory nerves
   b. phagocytes
   c. hormones

4. The body becomes immune to a particular disease by acquiring __________ for it.

   a. pathogens
   b. antibodies
   c. lymph nodes

5. The substance we receive in an __________ is usually a dead or weakened form of a pathogen.

   a. immunization
   b. antibody
   c. embryo

Practice

Write **True** *if the statement is correct. Write* **False** *if the statement is* not *correct.*

Disease and the Immune System

__________ 1. Disease can slow down or stop the body's systems.

__________ 2. One body system affected by disease will not affect another.

__________ 3. A hereditary disease is a disease that people inherit.

__________ 4. Hemophilia is a degenerative disease.

__________ 5. Sickle cell anemia is a hereditary disease.

__________ 6. An example of a degenerative disease is arthritis.

__________ 7. Deficiency diseases result from body systems that don't work to capacity.

__________ 8. Deficiency diseases can be caught from another person.

__________ 9. Bacteria or viruses cause degenerative diseases.

_________ 10. The body has no natural defense against disease.

Practice

Use the list below to write the correct term for each definition on the line provided.

acquired immunity
antibodies
immune
immunization
lymph nodes
mucus and tears
natural immunity
pathogens
phagocytes

____________________ 1. disease-causing agents

____________________ 2. white blood cells that fight pathogens

____________________ 3. cannot become infected

____________________ 4. an immunity present at birth

____________________ 5. a condition developed after birth to resist disease

____________________ 6. help prevent disease from entering the body

____________________ 7. produce antibodies

____________________ 8. a form of pathogen injected into the body to produce an active immunity

____________________ 9. enable the body to become immune to disease

Practice

Write **True** *if the statement is correct. Write* **False** *if the statement is* not *correct.*

__________ 1. The nervous system is involved in only the movement of the leg and arm muscles.

__________ 2. The cells that make up the nervous system are called neurons.

__________ 3. Neurons are often bunched together like a cable of wires. These bunches of neurons are known as *nerves*.

__________ 4. The eye allows us to see by picking up patterns of color, which pass through the retina of the eye to form an image on the lens, which lies at the back of the eye.

__________ 5. The ears perceive sound as air molecules that are set in motion—these vibrating air molecules are *sound waves*.

__________ 6. The spinal cord leads directly from the brain, descends about two-thirds of the way down the back, and is protected by the bones of the spinal column called *vertebrae*.

__________ 7. The brain is divided into four major parts: the cerebrum, the cerebellum, the cerebral, and the medulla.

__________ 8. The endocrine system is a network of organs that produce chemical messengers known as chromosomes.

__________ 9. The ovaries are the female sex organs that produce female sex hormones and female sex cells, or eggs.

_________ 10. Hereditary disease is disease that people inherit from their parents, usually through a defect in their genes.

_________ 11. The skin, tears, mucus, and stomach acid are the body's first line of defense against pathogens, preventing them from entering body tissue.

_________ 12. The substance we receive in an immunization is usually a dead or weakened form of a pathogen.

Unit 21: Organisms and Their Environment

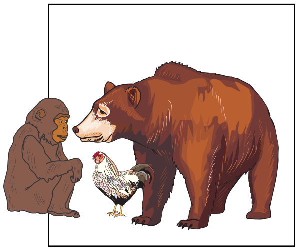
This unit focuses on the great diversity and interconnectedness of life on Earth that results in a flow of energy. Students learn how living systems obey the same laws as physical systems.

Student Goals

- Demonstrate an understanding of the interconnectedness of life on Earth.
- Learn about the interdependence of organisms and why biodiversity is important.
- Understand how energy flows through living systems of producers, consumers, and decomposers.
- Learn that living systems obey the same laws as physical systems, such that matter and energy are neither created nor destroyed, and any change in energy results in a loss of energy as heat.
- Understand that knowledge of energy is fundamental to all sciences.
- Understand the meaning of ecosystem, food chain, food web, and energy pyramid.

Unit Focus

- Know that changes in a component of an ecosystem will have unpredictable effects on the entire system but that the components of the system tend to react in a way that will restore the ecosystem to its original condition. (SC.G.2.4.2)
- Understand how knowledge of energy is fundamental to all the scientific disciplines (e.g., the energy required for biological processes in living organisms and the energy required for the building, erosion, and rebuilding of the Earth). (SC.B.1.4.1)



- Understand that biological systems obey the same laws of conservation as physical systems. (SC.F.1.4.4)

Vocabulary

Use the vocabulary words and definitions below as a reference for this unit.

biodiversity	the variety of species of organisms
carnivore	an organism that eats animals (or consumers) *Example*: lion, shark
community	all the interacting organisms of different species living in the same area
consumers	organisms that must eat other living things to survive
decomposers	living things that eat dead organisms to survive
ecology	the study of habitat in interaction with the community of organisms that live there
ecosystem	a distinct, self-supporting unit of interacting organisms and their environment
environment	the biological and physical things that surround and affect an organism
food chain	transfer of energy from one living thing to another; a chain of living things in which each organism eats the one before it and is eaten by the one after it

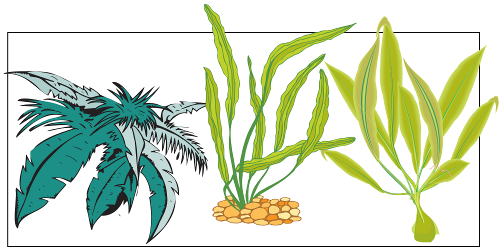
food web	the interconnected feeding relationship in a food chain in a particular place and time
habitat	a place in an ecosystem where an organism normally lives
herbivore	an organism that eats mainly plants (or producers) *Example*: sheep, manatee
omnivore	an organism that eats both plants and animals (or producers and consumers) *Example*: humans, killfish
organisms	living things *Example*: anything plant, animal, or fungus
photosynthesis	the process plants and algae use to make the sugar glucose from water, carbon dioxide, and the energy in sunlight
producers	organisms that can make their own food through photosynthesis
scavengers	organisms that eat the remains of already dead animals and plants
species	the most precise grouping for an organism; directly identifies one particular type of living thing able to produce only among themselves

Introduction

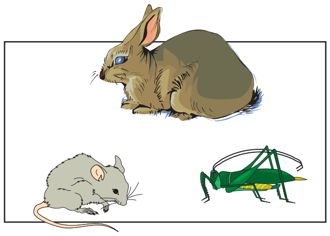
In Unit 18 we examined protecting our **environment** and natural resources that provide us with energy. In Units 3, 5, 9, and 11 we learned how there is conservation of mass and energy when matter is transformed. Now in this unit we will look at how living things need energy in order to live. Living systems obey all the physical laws of science. That is, that matter and energy are neither created nor destroyed.

Environment—Where Organisms Interact

An *environment* includes all the living and nonliving things with which an **organism**, or a living thing, interacts. All the living and nonliving things in an environment are interdependent. That is, they depend on each other. All living things need energy in order to live. They use energy to carry on all the basic life functions. *Organisms* can be classified into three main groups based on how they obtain energy: **producers**, **consumers**, and **decomposers**. Organisms that can make their own food are called *producers*. Producers use light energy to make food by the process of **photosynthesis**. Photosynthetic organisms like plants, phytoplankton, and green algae are producers. *Consumers* are classified according to the type of food they eat. The **herbivores** are the plant eaters. They eat the producers. Organisms such as mice, insects, and rabbits are *herbivores*. The **carnivores** are consumers who eat animals (consumers). Snakes, frogs, and eagles are *carnivores*.



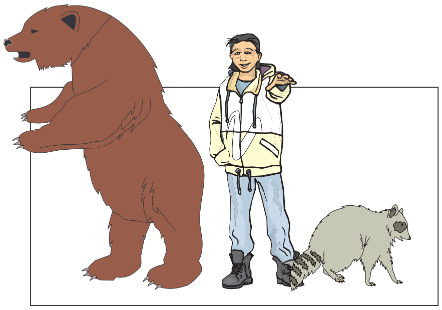
Producers *use light energy to make food by the process of photosynthesis.*



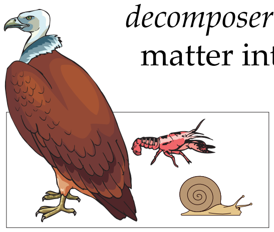
The herbivores are consumers *who eat plants (producers).*

The carnivores are consumers *who eat animals (consumers).*

The consumers that eat both producers and other consumers, or plants and animals, are **omnivores**. Bears, people, and raccoons are examples of *omnivores*. **Scavengers** are consumers who feed on organisms who have recently died. Vultures, crayfish, and snails clean up by eating dead organisms. After plants and animals die, organisms called *decomposers* break down the dead matter into simpler substances. Bacteria and fungi work as decomposers. Plants, to make food, then use these substances. This cycle is repeated over and over in the same **ecosystem**. The matter is cycled within the *ecosystem*, which is a distinct, self-supporting unit of interacting organisms and their environment.



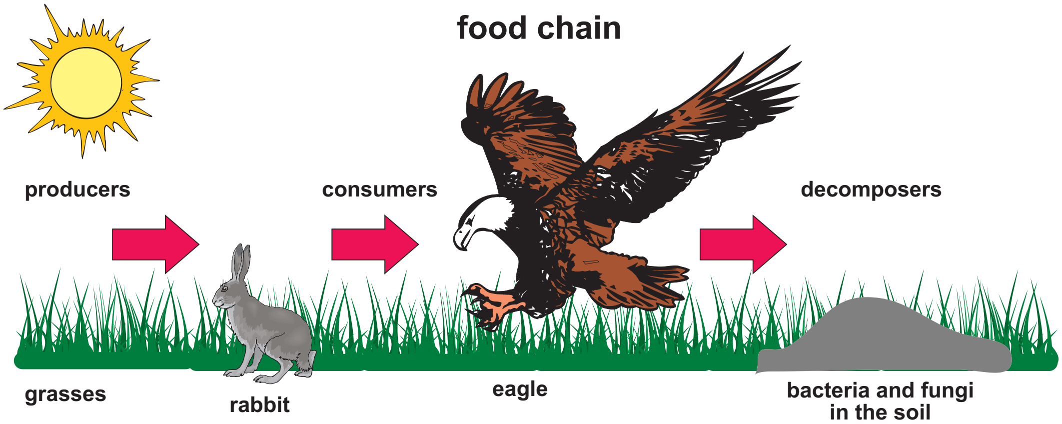
The consumers that eat both producers and other consumers, or plants and animals, are omnivores.



Scavengers *are consumers who feed on organisms who have recently died.*

Food Chain

We can see how every organism on Earth is involved in a **food chain**. All energy for life comes from the sun, and all life relies on energy. All the energy used by plants and animals comes directly or indirectly from the sun. A *food chain* is a way to show the transfer of energy from the sun, to producers, and onto consumers.

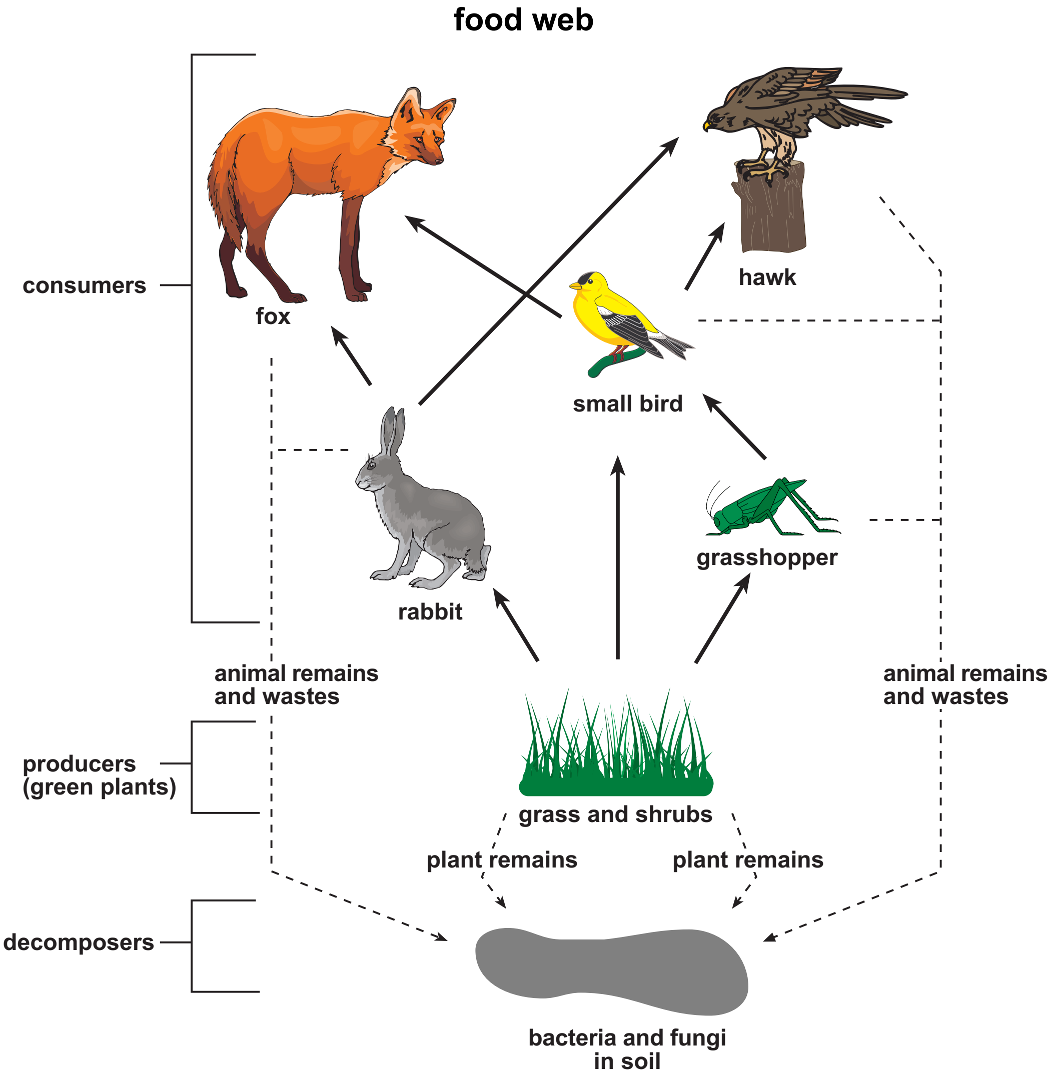


In this food chain, grasses are eaten by the rabbit.

The eagle eats the rabbit.

The dead and decaying remains of all are decomposed and recycled by decomposers.

But interactions among organisms often are more complex because most animals eat more than one type of food. A **food web** includes all the food chains in an ecosystem that are interconnected.

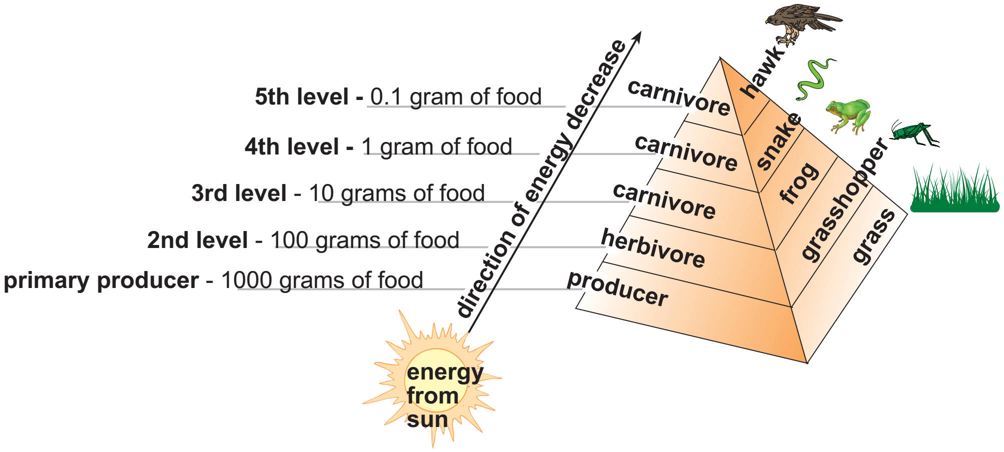


The food chain shows the interconnected feeding relationships in a food chain in a particular place and time

Energy Flows through an Ecosystem

A feeding level is the location of a plant or an animal along a food chain. Each feeding level is basically a "link" in the food chain. Because the plants are producers they form the first feeding level. The consumers that eat plants form the second feeding level. The consumers that eat animals form a third feeding level. Each organism at a particular feeding level uses up some of the energy in the food to carry out its life activities. At each feeding level, however, much of the energy in the food is lost. A large amount of the energy is used up as it is transferred from one feeding level to another. There is less energy available to the organisms at the higher feeding level. Although the food chain models show how energy moves and is recycled, they do not show how some energy becomes heat. This loss of energy can be shown in an energy pyramid below. There is a decreasing amount of energy available at each feeding level. When producers transform energy into chemical energy, most of it is converted into heat energy lost to the environment. And when we look at the amount of energy available from one level to another, there is only about 10 percent of total energy left from the step below.

For example, if a primary producer makes 1000 grams of food, only 100 grams reach the second level of the food chain. The third level of the food chain leaves only 10 grams of the original supply of food. That amount doesn't support a large organism. At the fourth feeding level only 1 gram of food passed up the food chain remains, and the fifth step has 0.1 gram. No more steps in a food chain are possible, since there is so little energy left.



This energy pyramid shows the energy flow and losses of energy at each feeding level.

Practice

Use the list below to complete the following statements.

carnivores
consumers
decomposers
ecosystem
environment
food chain
food web
herbivores
omnivores
photosynthesis
producers
scavengers

1. A(n) ____________________ includes all the living and nonliving things with which an organism interacts.

2. Organisms can be classified into three main groups based on how they obtain energy: ____________________ , ____________________ and ____________________ .

3. Producers use light energy to make food by the process of ____________________ .

4. The ____________________ are the plant eaters and the ____________________ are consumers who eat other consumers. The consumers that eat both producers and other consumers are ____________________ .

5. Matter is cycled within the ____________________ .

6. ____________________ are consumers who feed on organisms who have recently died.

7. A ____________________ is a way to show the transfer of energy from the sun, to producers, and onto consumers.

8. A ____________________ includes all the food chains in an ecosystem that are interconnected.

Diversity in the Food Chain

An organism has a greater chance of survival if there is more diversity in its food chain, because there are

- more kinds of producers at the bottom.
- more kinds of herbivores at the second level.
- many different kinds of omnivores and carnivores at the third level.


different kinds of herbivores at the second level

Because there are more connections between the different levels, a diverse *food web* is not as likely to break down. Food webs can help us understand how energy is used by living systems. Through it you get a better idea of how energy moves to different organism. The web describes a system.


different kinds of omnivores at the third level

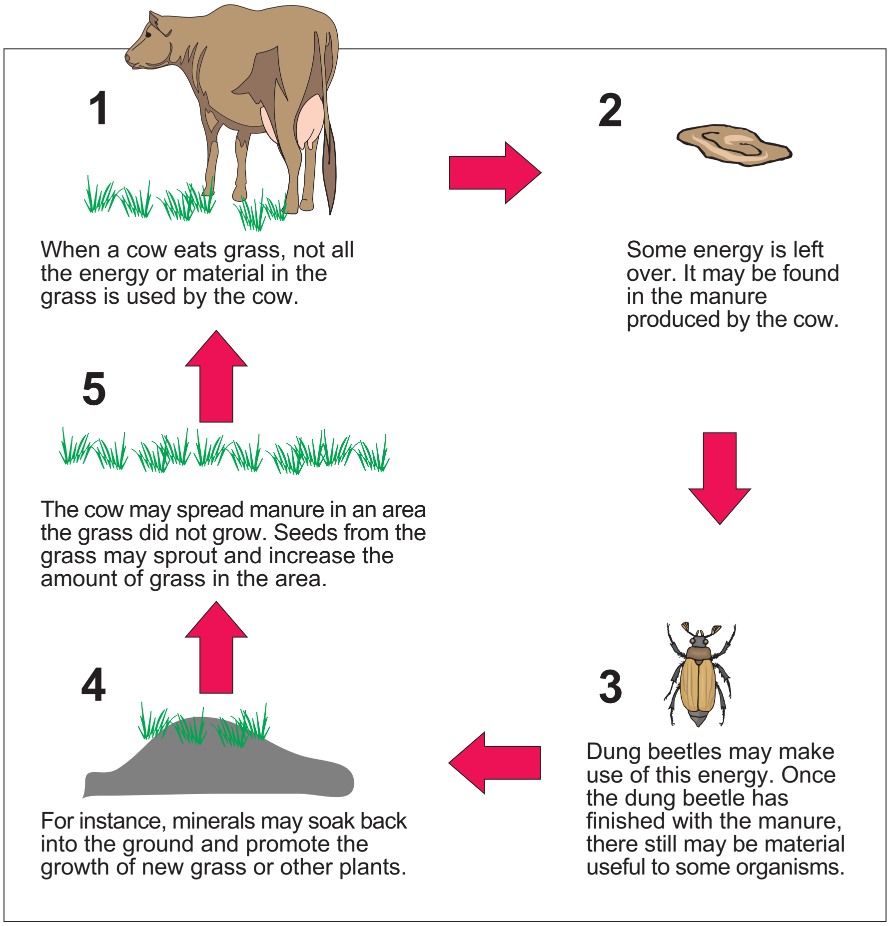
It is important to understand what scientists mean by *system*. A system is a group of interrelated objects and energy. It can be large or small. On the large scale, scientists view the entire universe as a system with energy and objects (matter). The universe is a complex system, so the rules that describe it range from simple to complex. Science, through careful study, tries to find these rules. A food web can be one way of describing rules for a smaller system.

Let's look at an example of a system. A producer that is fairly common is grass. Grass takes a small part of the sun's light energy and makes sugars. The sugars are then consumed by any number of organisms. If a cow happens to be the consumer, the cow will only make use of a small part of the


different kinds of carnivores at the third level

energy. Again, the rest of the energy will become heat. With so much energy being lost as heat, interesting results occur.

One result is that organisms are very good at finding unused or seldom used sources of energy. This results in a high number of different organisms living together. Consider the example of cows and grass. In reality, many organisms besides the cow and the grass live together. When a cow eats grass, not all the energy or material in the grass is used by the cow. Some energy is left over. It may be found in the manure produced by the cow. In this case, dung beetles may make use of this energy. Once the dung beetle has finished with the manure, there still may be material useful to some organisms. For instance, minerals may soak back into the ground and promote the growth of new grass or other plants. Alternatively, the cow may spread manure in an area the grass did not grow. Seeds from the grass may sprout and increase the amount of grass in the area.



1 When a cow eats grass, not all the energy or material in the grass is used by the cow.

2 Some energy is left over. It may be found in the manure produced by the cow.

3 Dung beetles may make use of this energy. Once the dung beetle has finished with the manure, there still may be material useful to some organisms.

4 For instance, minerals may soak back into the ground and promote the growth of new grass or other plants.

5 The cow may spread manure in an area the grass did not grow. Seeds from the grass may sprout and increase the amount of grass in the area.

It's easy to see how the cow relies on the grass in its area, but now we see more. We see that the grass relies on the cow, the dung beetle, and other organisms in order to survive and spread. Such connections are known as *interdependence*. The interdependence is based on the need for energy, and the result is a high variety of organisms.

Interconnectedness and Biodiversity

A **habitat** is the place in an ecosystem where an organism normally lives. Within an ecosystem there is interaction by all of the organisms that choose to live in that environment. All the interacting organisms of different **species** living in the same area are referred to as a **community**. An ecosystem is a finely balanced environment in which living things successfully interact in order to survive. It is the **biodiversity**, or the variety of *species* of organisms of ecosystems, that makes them healthy. The study of how the *habitat* and the *community* affect each other, and how the ecosystem works is called **ecology**.

A disturbance in the balance in one part of the ecosystem can cause problems in another part of the ecosystem. Such disturbances can be the result of nature or of human interference. In many ways, an ecosystem itself functions like a huge creature: it has its own special and recognizable character traits that make it different from other ecosystems. All of its parts must function together to support it. If its supply of energy or water suddenly changes, it can go into shock. If its internal systems are badly injured, an ecosystem can die. As with any living being, though, changes to systems are usually met by efforts to avoid death. Changes can cause unpredictable results. *Biodiversity* helps make it possible for the ecosystem to return to its original condition.

Summary

On Earth there is great diversity and interconnectedness of life. These result from the flow of energy from producers to consumers and to decomposers. Energy and matter are not destroyed in these changes, but energy is lost as unusable heat. Knowledge of the flow of energy is essential to all sciences. Changes in an ecosystem can destroy it or have unpredicted results. Although changes may occur, ecosystems tend to return to their original condition.

Practice

Answer the following using complete sentences.

1. What is a food chain? ______________________________

   ____

   ____

   ____

   ____

2. Having more than one source of food may help keep species from becoming extinct. Why? ____________________________

   ____

   ____

   ____

   ____

   ____

3. What is an ecosystem? ______________________________

   ____

   ____

   ____

   ____

   ____

4. Explain the flow of energy in an ecosystem. ____________________

Practice

Write **True** *if the statement is correct. Write* **False** *if the statement is* not *correct.*

__________ 1. An organism has a greater chance of survival if there is more diversity in its food chain.

__________ 2. A system is a group of interrelated objects and energy.

__________ 3. Because there are more connections between the different levels, a diverse *food web* is very likely to break down.

__________ 4. A producer that is fairly common is grass.

__________ 5. When a cow eats grass, all of the energy or material in the grass is used by the cow.

__________ 6. A habitat is the place in an ecosystem where an organism normally lives.

__________ 7. It is the biodiversity of ecosystems that makes them healthy.

__________ 8. The study of how the habitat and the community affect each other, and how the ecosystem works is called ecology.

__________ 9. A disturbance in the balance in one part of the ecosystem does not cause problems in another part of the ecosystem.

__________ 10. Biodiversity helps make it possible for the ecosystem to return to its original condition.

Lab Activity: Water Pollution

Facts:

- Phosphates are a major source of water pollution.
- Detergents and fertilizers are the most common sources of phosphates.
- Overabundance of phosphate—a nutrient—allows algae to overproduce and use up all the oxygen in the water. This leads to fish kills.
- This process of phosphate pollution leading to oxygen-poor water is called *eutrophication*.

Investigate:

- You will create an experimental system to investigate the effects of detergent as a pollutant.

Materials:

- 3 aquariums
- paper towels
- fluorescent lamp
- detergent with phosphate, 2 g
- detergent without phosphate, 2 g
- *Spirogyra*, a stock culture of algae
- pond water
- balance scale
- wax pencil
- plastic wrap

1. Fill each aquarium two-thirds full of pond water. Label the aquariums #1, #2, and #3. To aquarium #1, add 2 g of detergent with phosphates. To aquarium #2, add 2 g of detergent without phosphates. To aquarium #3, add no detergent.

2. Remove the *Spirogyra* from the culture container and place it briefly on a folded paper towel to absorb the excess water. Make three 25 g samples of *Spirogyra*, and add one sample to each of the aquariums. This procedure must be done quickly to keep the *Spirogyra* from drying out.

3. Cover each aquarium with a sheet of plastic wrap and place all of them 20 cm from a fluorescent lamp.

4. Observe the aquariums twice each week and record your observations in chart form. The observations should include color of the *Spirogyra*, odor of the aquariums, position of the *Spirogyra* in the aquariums, presence of bubbles, relative number of *Spirogyra* present, and any other details you notice.

The Effects of Detergent as a Pollutant

		Color of Spirogyra	Odor of the Aquarium	Position of Spirogyra	Presence of Bubbles	Number of Spirogyra
Aquariums	1.					
	2.					
	3.					

5. After three weeks, remove the *Spirogyra*, and briefly place it on a folded paper towel to absorb the excess water. Clump the *Spirogyra* found in each aquarium and find the mass of each clump using a balance scale.

6. Calculate the increase in mass in each aquarium by subtracting the original mass from the final mass.

7. What is the purpose of aquarium #3? ________________________

____

8. What is the reason for massing each sample that is placed in the aquariums? ____

____

____

9. What is the purpose of the lamp? ____________________

____

____

10. Which aquarium had the greatest increase in the mass of *Spirogyra*?

____

11. How did the color differ in each aquarium? ____________________

____

12. In what part of the aquariums did you find the *Spirogyra*?

____

13. Why do you think the *Spirogyra* was in that part of the aquariums?

____

____

14. If the *Spirogyra* grew very quickly in a lake, pond, or river, what effect do you think it would have on the other organisms in the aquatic ecosystem?

____

____

____

____

15. In which aquarium did the *Spirogyra* show this rapid type of growth? ____________________

____

16. How can you account for the rapid growth?

17. What are the signs that *eutrophication*, or the process of phosphate pollution leading to oxygen-poor water, is occurring in an aquatic ecosystem?

18. If you were in charge of the health and well-being of this aquatic ecosystem, what action would you suggest?

Practice

Use the list below to complete the following statements.

consumers
decomposers
diversity
energy
heat
interdependence
none
original
physical
understand

1. A food web shows the diversity of food sources and the __________________________ of organisms on one another.

2. Energy in an ecosystem flows through producers, __________________________ , and __________________________ .

3. Although changing one part of an ecosystem can have unpredictable results, the tendency is for the ecosystem to return to its __________________________ condition.

4. Scientists believe that by carefully studying the universe and its systems (for example, ecosystems), they can __________________________ how the universe works.

5. As with physical systems and sciences, the amount of usable energy in an ecosystem is always being reduced by the loss of energy as __________________________ .

6. Because all organisms need __________________________ to survive, an understanding of energy is essential to scientists.

7. Whenever energy or matter is changed, ____________________ is lost.

8. Living systems obey all ____________________ laws of science.

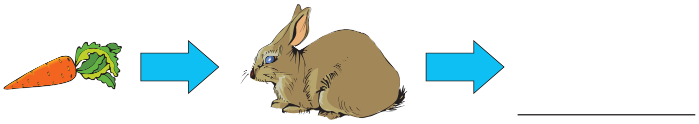
9. The transfer of energy from organisms to others has led to a great ____________________ and interdependence of organisms.

Practice

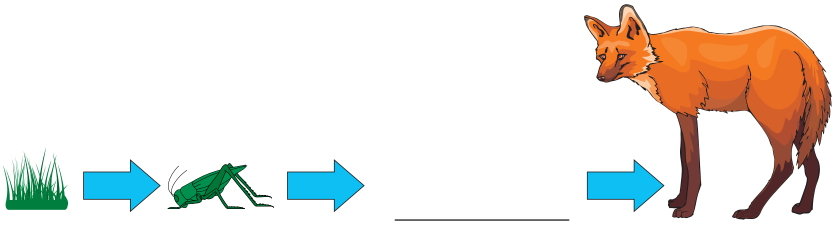
Complete the following **links** *in the* **food chains** *below.*

Three food chains are shown below. One link has been left out of each chain. Identify the organism that is missing. Write your answer on the line provided. (Note that the decomposers have been left out of each chain. Do not list them.) **There may be more than one correct answer.**

1.



2.



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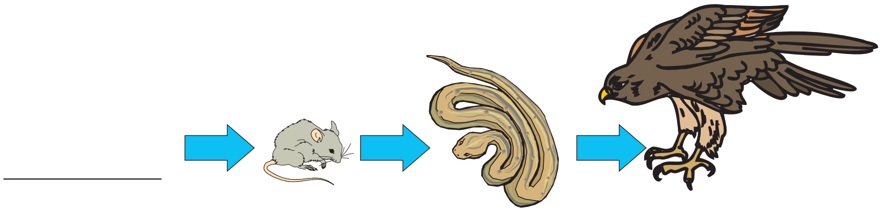
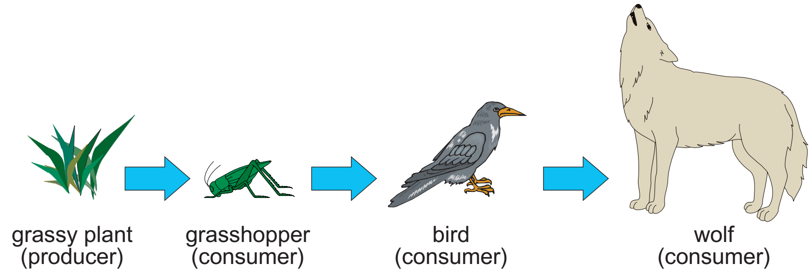
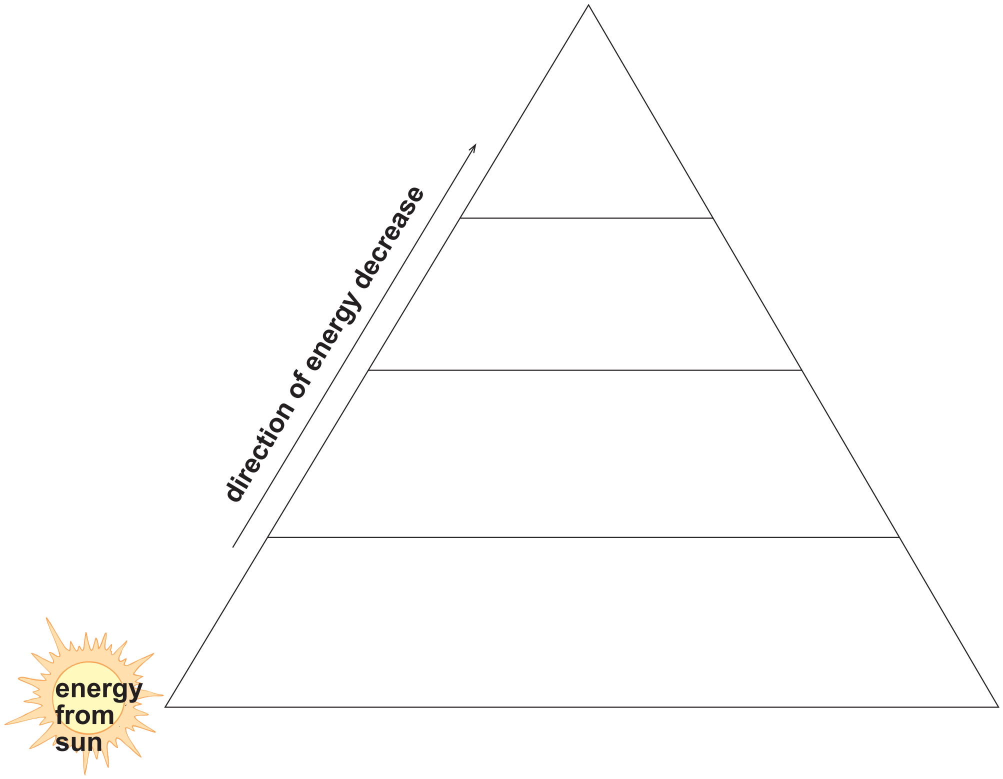


Practice

Using the following **food chain**, *complete the* **energy pyramid** *below.*





Practice

Write **True** *if the statement is correct. Write* **False** *if the statement is* not *correct.*

__________ 1. All the living and nonliving things in an environment are interdependent.

__________ 2. Producers use light energy to make food by the process of eutrophication.

__________ 3. Organisms that can make their own food are called producers.

__________ 4. Organisms such as tigers, eagles, and dogs are herbivores.

__________ 5. Snakes, frogs, and eagles are carnivores.

__________ 6. People are examples of omnivores.

__________ 7. All energy for life comes from the sun, and all life relies on energy.

__________ 8. An organism has a greater chance of survival if there is less diversity in its food chain.

__________ 9. Changes in an ecosystem can cause unpredictable results, but biodiversity helps it return to its original condition.

_________ 10. The amount of energy available in a food web decreases with each higher feeding level.

Unit 22: Science, Society, and the World

This unit is about the relationships between industry, economics, government, technology, scientists, and society.

Student Goals

- Understand that scientists in one area tend to see issues in similar ways. Discuss methods for overcoming this bias to ensure multiple perspectives.
- Describe what technology is, how it progresses, and the forces that control its creation and development.
- Discuss the relationship between technology and the values of both a society and individuals within that society.

Unit Focus

- Know that technological problems often create a demand for new scientific knowledge and that new technologies make it possible for scientists to extend their research in a way that advances science. (SC.H.3.4.2)
- Know that scientists can bring information, insights, and analytical skills to matters of public concern and help people understand the possible causes and effects of events. (SC.H.3.4.3)
- Know that funds for science research come from federal government agencies, industry, and private foundations and that this funding often influences the areas of discovery. (SC.H.3.4.4)

Vocabulary

Use the vocabulary words and definitions below as reference for this unit.

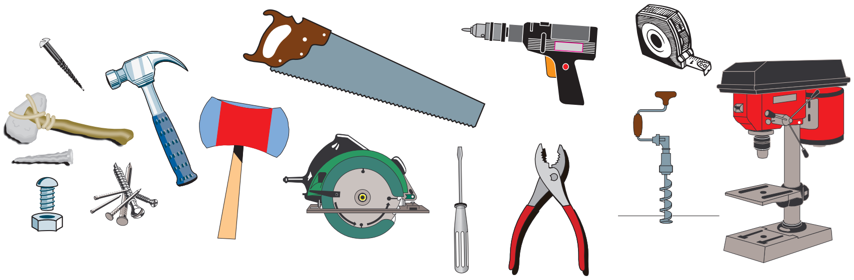
acid rain	rain that has a pH (a measure of acidity in a solution) below that of seven because it carries dissolved acids; this rain causes problems such as water pollution and the rapid corrosion of various substances
bias	a preference than can hinder impartial judgement
by-product	a product or result of a process that is not the one intentionally sought
economy	the system by which money, ownership, and wealth are controlled
grant	money awarded for a specific purpose
industry	the people and machines used to produce products
peer	a person who is on the same level as another; a person with whom you share similar knowledge, background, and goals
society	the way people live together, interact, and rely on one another
technology	the knowledge, skill, and tools that allow people to perform tasks of increasing complexity

Introduction

We began our study of integrated science with the scientific method. To understand how science developed, you needed to know how it worked. Scientists are people who live and work like everyone else. What they do has an impact on the world. Of course, the world affects them, too. We will conclude our study by examining the ways in which science and scientists interact with the world.

Technology in Society

In a **society**, people use many tools as they interact and rely on one another. Think of the many tools it takes to build a house. Each of these tools and the ways they are used was created by humans. The development of these tools is one form of **technology**, or way to perform tasks of increasing complexity. When humans first began building houses, houses were not very complex. The house might have been made of mud, sticks, and some stones. Compare building a house like that to building a modern home. The change in levels of *technology* is great. Where only a few materials were used before, hundreds of materials are now used. Building a modern house is a complex job which has been made easier by technology. It requires many people with highly developed skills. All of these skills and the tools that are used were created by people. This technology is a part of our *society*.

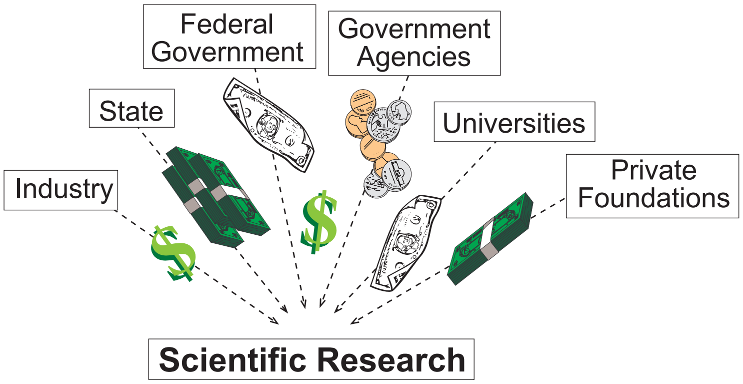


All of these tools were created by people and are a form of technology.

Changes in Technology

There is not a sharp boundary between science and technology. Scientific discoveries lead to technological innovations, and those innovations may lead to further discoveries. Recently, our society has required some changes in house-building technology. Concerns about diminishing resources are among the greatest causes. As we have discussed, energy is a resource. It allows us to do things and change things. People began to view losing energy as a problem. In a home, we lose energy through windows and walls and in many other areas. People began to demand new ways to prevent energy from being lost.

The people and machines that build homes are part of the housing **industry**. The *industry* recognized the demand of people. Because industries are larger than a single company, the resources of an industry are greater than that of a single business. The industry began to fund research. The research focused on ways to conserve energy in the home. Scientists performed this research. The research was geared specifically to energy conservation in homes. One aspect of knowledge, however, is that it can be used in many ways. The result is that technological problems often provide us with new knowledge.



Scientific research can be paid for by many sources.

This new knowledge can be paid for by many sources. Industry, state and federal government agencies, universities, and private foundations all fund scientific research in our society. One way that research is funded is through **grants**. These *grants* are sums of money awarded to groups and individuals for scientific research. Imagine our example about energy conservation. Can you think of a government agency that might offer a grant for energy conservation? Agencies that deal with housing, energy, or the environment might top your list. Now, think about bubble gum. Can you think of any government agency that is highly concerned with bubble gum? Because there probably is none, there are probably no grants for bubble gum research.

The result is that scientists do not usually pay for the research they conduct. Instead, others provide the money needed to do the research. Sometimes, no source can be found to fund a particular area of research. In these cases no research will be done. The **economy** of the world controls when and how much money is available for certain activities. If the bubble gum industry became powerful, the *economy* would reflect this. If there were then a problem with bubble gum technology, money would probably be available for research.

Scientists do not usually pay for the research they do.

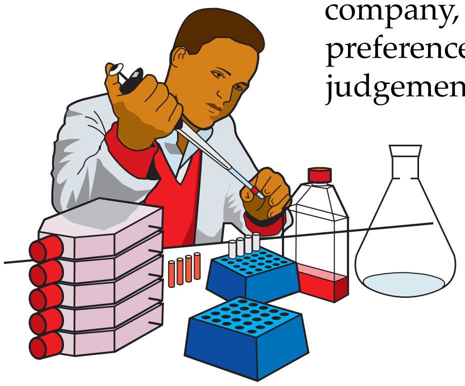
When an area of public and social concern arises, research is often conducted. Scientists apply their analytical skills, their knowledge, and their insights to these problems. When the process is effective, scientists can then help the public understand both the causes and likely outcomes. Consider **acid rain**. Acid rain carries dissolved acids, which can cause problems such as water pollution and corrosion of various substances. Because the problem of *acid rain* became a public priority, scientists have studied it. We now know many of its sources and many of its effects. We also have many predictions about what acid rain may yet do.

Much acid rain is a **by-product** of many of our forms of technology. When you turn on an electrical appliance, you don't intend to create acid rain. The electricity you use, however, may be generated from coal. When coal is burned, acid rain is a *by-product*. The acid rain may cause fish to die. You don't intend for this to happen, but it may happen. Technology has impacts on areas of our lives that we often don't foresee. Sometimes the impacts of technology are beneficial, but sometimes they are not beneficial.

Technology is based on scientific knowledge. We now have a certain amount of knowledge about acid rain. Scientists and others who work with technology are using their knowledge. They are trying to solve this problem. One solution might be to stop burning the fuels that result in acid rain. Would this be practical? Most people would not want to part with their appliances and cars. When solving problems, scientists have to consider such things. They must take human values and abilities into account. If they do not, their solutions will not be successful nor publicly accepted.

For many people, the ability to have numerous electrically powered appliances is of great value. They like this aspect of technology. Sometimes though, they may feel differently. Other people may not value numerous electric appliances. They may feel them to be a nuisance. Although the technology is the same, the responses of different people are not the same.

If you worked as an engineer for an electrical company, you might have a certain **bias**, or preference that could hinder impartial judgement. That is, you would probably not like the idea of doing away with electricity. As a scientist, you would be expected to know your own *bias*. You would be expected to design your research and investigation to compensate for your bias.



Scientists must consider how the new technology they create will change the world.

At the end of your research, you would submit your ideas to your **peers**, or others with similar knowledge, background, and goals. One of the most important aspects of science is that it is open for all to review. Other scientists would review your work. If they found it was done well and was accurate, they would say so. It is important to allow others to review all aspects of the scientific process. This allows the methods to be approved and the outcomes verified. The public could then be notified of your findings. The result may be a new technology.

Summary

Many problems encountered in the world are the result of technology. The search for the solution to problems like acid rain involves many engineers, designers, scientists, and others. The search for solutions advances scientific knowledge. Scientists bring this knowledge to the public and inform them. Scientists must be aware of their own biases. They must make their findings available for review by *peers*. Scientists must consider how the new technology they create will change the world. Funds for such research come from many government and private sources. The value of such technology and research, however, varies for different people and at different times.

Practice

Match each definition with the correct term. Write the letter on the line provided.

______ 1. a product or result of a process that is not the one intentionally sought

______ 2. the knowledge, skill, and tools that allow people to perform tasks of increasing complexity

______ 3. the way people live together, interact, and rely on one another

______ 4. the people and machines used to produce products

______ 5. money awarded for a specific purpose

______ 6. a preference than can hinder impartial judgement

______ 7. a person who is on the same level as another; a person with whom you share similar knowledge, background, and goals

______ 8. rain that has a pH below that of seven because it carries dissolved acids

______ 9. the system by which money, ownership, and wealth are controlled

A. acid rain

B. bias

C. by-product

D. economy

E. grant

F. industry

G. peer

H. society

I. technology

Practice

Circle the letter of the correct answer.

1. The increasing ability of humans to perform complex tasks is made possible by advances in ____________ .

   a. tectonics
   b. technology
   c. bias
   d. peers

2. Everything that people do is related to the ____________ in which they live.

   a. technology
   b. grants
   c. society
   d. by-product

3. Industry includes not only one business or one machine, but all the ____________ involved in producing a certain type of product.

   a. people
   b. acid rain
   c. industries
   d. by-product

4. Although we think of technology as making life easier, technology also causes ____________ for which scientists seek solutions.

   a. economy
   b. problems
   c. bias
   d. grant

5. The ____________ controls when and how much money may be available for technology research.

   a. technology
   b. grant
   c. bias
   d. economy

6. One way industries and the government fund research is through ____________ .
   a. grants
   b. technology
   c. peers
   d. bias

7. When a material is produced unintentionally, it may be called a ____________ .
   a. acid rain
   b. by-product
   c. grant
   d. technology

8. One by-product of using coal for generating electricity is ____________ .
   a. acid rain
   b. by-product
   c. grant
   d. technology

9. A person's preference that can hinder impartial judgement is known as ____________ .
   a. peer
   b. technology
   c. bias
   d. economy

10. One of the foundations of scientific research is the commitment to review of findings by ____________ .
   a. bias
   b. peers
   c. industry
   d. technology

11. Engineers and others who work with technology use __________ to predict possible outcomes.

    a. science
    b. peers
    c. bias
    d. by-products

12. __________ are *not* a source of funds for scientific research.

    a. universities
    b. government agencies
    c. scientists
    d. private foundations

Lab Activity: Acid Rain

Facts:

- One by-product of the industrial world is acid rain.
- Acids dissolve calcium carbonate.
- Chalk is made from calcium carbonate.

Investigate:

- You will try to develop a technology to prevent acid from dissolving chalk.

Materials:

- small piece of latex
- beaker of vinegar or other acid
- 1 stick of chalk, broken in 2 pieces
- paper towel
- rubber band

1. Place a piece of chalk in the beaker containing vinegar or another acid.

   Does the chalk begin to dissolve? ______________________________

2. Predict which material you think will protect the second piece of

   chalk from the acid. ____

3. Wrap the material in #2 around the chalk. Hold it on with the rubber band.

4. Watch the solution.

   Does your second piece of chalk appear to be dissolving? _______

   ____

5. Will the technology you developed prevent the chalk from dissolving? ____________________________________

6. Limestone and marble are stones used in building. They both contain the mineral calcium carbonate. What impact might acid rain have on buildings made with these materials?

7. Describe how you could adapt your chalk-protecting technology to protect buildings from acid rain.

Practice

Use the list above each section to complete the statements in that section.

government agencies
grants
knowledge
peers
research
society
technology

1. The change from relatively simple homes to complex homes is an example of a change in the level of ____________________ .

2. Technology often creates a demand for new ____________________ and this requires scientist to begin new ____________________ .

3. Money for research is often provided in the form of ____________________ that are provided by state and federal ____________________ as well as industry.

4. ____________________ establishes the rules for how all people interrelate and behave toward each other.

5. By being committed to allowing ____________________ to review their research and by making the information public, scientists bring insight into problems for society.

abilities
acid rain
predict
preference
scientific
values

6. Science can describe the causes of problems and __________________________ the possible future results.

7. While one person may be fond of computers, another person may dislike this technology. This demonstrates how different technologies have different __________________________ for different people.

8. Engineers and scientists that try to solve practical, everyday problems. They use __________________________ knowledge and an understanding of human values and __________________________ when making recommendations.

9. The human tendency for bias means that scientists must take into account their own __________________________ that can hinder impartial judgement when doing research.

10. An example of a problem created by technology is __________________________ , which is the result of using coal and other fuels.

Appendices

Metric Equivalents

Measurements

	EQUIVALENTS	ABBREVIATIONS AND SYMBOLS
LENGTH	**meter** 1 meter = 10 decimeters 1 meter = 100 centimeters 1 meter = 1000 millimeters 1000 meter = 1 kilometer	meter = m decimeter = dm centimeter = cm millimeter = mm kilometer = km
VOLUME AND CAPACITY	**liter** 1 liter = 10 deciliters 1 liter = 100 centiliters 1 liter = 1000 milliliters 1000 liter = 1 kiloliter 1 cubic centimeter = 1 milliliter 1000 cubic centimeters = 1 liter	liter = L deciliter = dL centiliter = cL milliliter = mL kiloliter = kL cubic centimeter = cc
WEIGHT	**gram** 1 gram = 10 decigrams 1 gram = 100 centigrams 1 gram = 1000 milligrams 1000 gram = 1 kilogram	gram = g decigram = dg centigram = cg milligram = mg kilogram = kg
TEMPERATURE	**degree** **F** **C** boiling point of water 212° 100° normal body temperature 98.6° 37° freezing point of water 32° 0°	degree = ° Celsius = C Fahrenheit = F

Metric Conversions

÷ 1000	÷ 100	÷ 10	← →	x 10	x 100	x 1000
1 kiloliter **(kL)**	1 hectoliter **(hL)**	1 dekaliter **(daL)**	**1** **liter** **L**	1 deciliter **(dL)**	1 centiliter **(cL)**	1 milliliter **(mL)**
1 kilometer **(km)**	1 hectometer **(hm)**	1 dekameter **(dam)**	**1** **meter** **M**	1 decimeter **(dm)**	1 centimeter **(cm)**	1 millimeter **(mm)**
1 kilogram **(kg)**	1 hectogram **(hg)**	1 dekagram **(dag)**	**1** **gram** **G**	1 decigram **(dg)**	1 centigram **(cg)**	1 milligram **(mg)**

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