

Reading Essentials

An Interactive Student Textbook

Focus On

Life Science



ca7.msscience.com



Glencoe

New York, New York Columbus, Ohio Chicago, Illinois Peoria, Illinois Woodland Hills, California

To the Student

In today's world, knowing science is important for thinking critically, solving problems, and making decisions. But understanding science sometimes can be a challenge.

Reading Essentials takes the stress out of reading, learning, and understanding science. This book covers important concepts in science, offers ideas for how to learn the information, and helps you review what you have learned.

In each chapter:

- **Before You Read** sparks your interest in what you'll learn and relates it to your world.
- **Read to Learn** describes important science concepts with words and graphics. Next to the text you can find a variety of study tips and ideas for organizing and learning information:
 - The **Study Coach** offers tips for getting the main ideas out of the text.
 - **Foldables™ Study Organizers** help you divide the information into smaller, easier-to-remember concepts.
 - **Reading Checks** ask questions about key concepts. The questions are placed so you know whether you understand the material.
 - **Think It Over** elements help you consider the material in-depth, giving you an opportunity to use your critical-thinking skills.
 - **Picture This** questions specifically relate to the art and graphics used with the text. You'll find questions to get you actively involved in illustrating the concepts you read about.
 - **Applying Math** reinforces the connection between math and science.
 - **Academic Vocabulary** defines some important words that will help you build a strong vocabulary.

The main California Science Content Standard for a lesson appears at the beginning of each lesson. This statement explains the essential skills and knowledge that you will be building as you read the lesson. A complete listing of the **Grade Seven Science Content Standards** appears on pages iv to vi.

See for yourself, *Reading Essentials* makes science enjoyable and easy to understand.



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Table of Contents

To the Student	ii
California Science Standards	iv
Chapter 1 Cell Structure and Function	1
Chapter 2 From a Cell to an Organism	15
Chapter 3 Reproduction of Organisms	25
Chapter 4 Genetics	47
Chapter 5 The Process of Evolution	59
Chapter 6 Evolution—Evidence of Change	69
Chapter 7 The Age of Earth	81
Chapter 8 The History of Life on Earth	93
Chapter 9 The Musculoskeletal System and Levers	107
Chapter 10 The Cardiopulmonary System and Pressure	115
Chapter 11 The Eye and Light	125
Chapter 12 The Ear and Sound	139
Chapter 13 The Human Reproductive System	147

Grade 7 Science Content Standards

- 1. All living organisms are composed of cells, from just one to many trillions, whose details usually are visible only through a microscope. As a basis for understanding this concept:**
 - a. Students know cells function similarly in all living organisms.
 - b. Students know the characteristics that distinguish plant cells from animal cells, including chloroplasts and cell walls.
 - c. Students know the nucleus is the repository for genetic information in plant and animal cells.
 - d. Students know that mitochondria liberate energy for the work that cells do and that chloroplasts capture sunlight energy for photosynthesis.
 - e. Students know cells divide to increase their numbers through a process of mitosis, which results in two daughter cells with identical sets of chromosomes.
 - f. Students know that as multicellular organisms develop, their cells differentiate.

- 2. A typical cell of any organism contains genetic instructions that specify its traits. Those traits may be modified by environmental influences. As a basis for understanding this concept:**
 - a. Students know the differences between the life cycles and reproduction methods of sexual and asexual organisms.
 - b. Students know sexual reproduction produces offspring that inherit half their genes from each parent.
 - c. Students know an inherited trait can be determined by one or more genes.
 - d. Students know plant and animal cells contain many thousands of different genes and typically have two copies of every gene. The two copies (or alleles) of the gene may or may not be identical, and one may be dominant in determining the phenotype while the other is recessive.
 - e. Students know DNA (deoxyribonucleic acid) is the genetic material of living organisms and is located in the chromosomes of each cell.

- 3. Biological evolution accounts for the diversity of species developed through gradual processes over many generations. As a basis for understanding this concept:**
 - a. Students know both genetic variation and environmental factors are causes of evolution and diversity of organisms.
 - b. Students know the reasoning used by Charles Darwin in reaching his conclusion that natural selection is the mechanism of evolution.
 - c. Students know how independent lines of evidence from geology, fossils, and comparative anatomy provide the bases for the theory of evolution.
 - d. Students know how to construct a simple branching diagram to classify living groups of organisms by shared derived characteristics and how to expand the diagram to include fossil organisms.
 - e. Students know that extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient for its survival.

4. Evidence from rocks allows us to understand the evolution of life on Earth. As a basis for understanding this concept:

- a. Students know Earth processes today are similar to those that occurred in the past and slow geologic processes have large cumulative effects over long periods of time.
- b. Students know the history of life on Earth has been disrupted by major catastrophic events, such as major volcanic eruptions or the impacts of asteroids.
- c. Students know that the rock cycle includes the formation of new sediment and rocks and that rocks are often found in layers, with the oldest generally on the bottom.
- d. Students know that evidence from geologic layers and radioactive dating indicates Earth is approximately 4.6 billion years old and that life on this planet has existed for more than 3 billion years.
- e. Students know fossils provide evidence of how life and environmental conditions have changed.
- f. Students know how movements of Earth's continental and oceanic plates through time, with associated changes in climate and geographic connections, have affected the past and present distribution of organisms.
- g. Students know how to explain significant developments and extinctions of plant and animal life on the geologic time scale.

5. The anatomy and physiology of plants and animals illustrate the complementary nature of structure and function. As a basis for understanding this concept:

- a. Students know plants and animals have levels of organization for structure and function, including cells, tissues, organs, organ systems, and the whole organism.
- b. Students know organ systems function because of the contributions of individual organs, tissues, and cells. The failure of any part can affect the entire system.
- c. Students know how bones and muscles work together to provide a structural framework for movement.
- d. Students know how the reproductive organs of the human female and male generate eggs and sperm and how sexual activity may lead to fertilization and pregnancy.
- e. Students know the function of the umbilicus and placenta during pregnancy.
- f. Students know the structures and processes by which flowering plants generate pollen, ovules, seeds, and fruit.
- g. Students know how to relate the structures of the eye and ear to their functions.

6. Physical principles underlie biological structures and functions. As a basis for understanding this concept:

- a. Students know visible light is a small band within a very broad electromagnetic spectrum.
- b. Students know that for an object to be seen, light emitted by or scattered from it must be detected by the eye.
- c. Students know light travels in straight lines if the medium it travels through does not change.
- d. Students know how simple lenses are used in a magnifying glass, the eye, a camera, a telescope, and a microscope.

- e. Students know that white light is a mixture of many wavelengths (colors) and that retinal cells react differently to different wavelengths.
- f. Students know light can be reflected, refracted, transmitted, and absorbed by matter.
- g. Students know the angle of reflection of a light beam is equal to the angle of incidence.
- h. Students know how to compare joints in the body (wrist, shoulder, thigh) with structures used in machines and simple devices (hinge, ball-and-socket, and sliding joints).
- i. Students know how levers confer mechanical advantage and how the application of this principle applies to the musculoskeletal system.
- j. Students know that contractions of the heart generate blood pressure and that heart valves prevent backflow of blood in the circulatory system.

7. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:

- a. Select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data.
- b. Use a variety of print and electronic resources (including the World Wide Web) to collect information and evidence as part of a research project.
- c. Communicate the logical connection among hypotheses, science concepts, tests conducted, data collected, and conclusions drawn from the scientific evidence.
- d. Construct scale models, maps, and appropriately labeled diagrams to communicate scientific knowledge (e.g., motion of Earth's plates and cell structure).
- e. Communicate the steps and results from an investigation in written reports and oral presentations.

Cell Structure and Function

Lesson 1 Cells and Life

Grade Seven Science Content Standard. 1.a. Students know cells function similarly in all living organisms.



● Before You Read

Think about living things such as plants and animals. How are plants and animals different from nonliving things? Write your ideas on the lines below. Then read the lesson to learn of early ideas about cells.

● Read to Learn

Early Ideas About Cells

To see most cells, you must have some type of device to enlarge it. Human eyes cannot see things that are that small. There was once a time when no one knew that cells existed. This is because most cells are too small to see. Because people could not see cells, they did not know what living things were made from.

Early Microscopes

A **light microscope** uses light and one or more lenses to enlarge an image. Microscopes changed scientists' beliefs about living things.

Even when a light microscope is used, most parts of a cell are too small to see. Light microscopes can only enlarge images up to about 1,500 times their actual size. However, in the 1930s, the electron microscope was invented. An electron microscope can enlarge images 100,000 times or more. With electron microscopes, scientists can see most of the structures inside a cell. ✓

MAIN Idea

Cells are the smallest unit of life.

What You'll Learn

- the development of the cell theory
- the characteristics of life
- why water is important for a cell
- the four basic substances of a cell

Study Coach

Use an Outline As you read, make an outline to summarize the information in the lesson. Use the main headings in the lesson as the main headings in the outline. Complete the outline with the information under each heading.

Reading Check

- 1. Compare** What is a difference between light microscopes and electron microscopes?

 **Reading Check**

2. Identify What was learned about cells in the 1830s?


Academic Vocabulary
respond (rih SPAHND) (verb) to act or do something in reaction to something else

 **Think it Over**

3. Apply Name two ways you respond to your environment.

The Cell Theory

When scientists discovered cells, they still had much to learn about how cells relate to living things. In the 1830s, a German scientist observed that all plant parts are made of cells.

Around the same time, another German scientist observed the same thing about animals. Nearly two decades later, a German physician proposed that all new cells came from cells that already exist. Together, these ideas became known as **cell theory**. The ideas of the cell theory are listed below. 

1. All organisms are made of one or more cells.
2. The cell is the smallest unit of life.
3. All new cells come from cells that already exist.

Characteristics of Life

Living things may be made of one cell or many cells. Either way, scientists agree that all living things have six characteristics in common. Living things are:

- organized,
- respond,
- grow and develop,
- reproduce,
- maintain certain internal conditions, and
- use energy.

How are cells organized?

Every cell contains structures. Each structure has its own special job. For example, some structures store food. The cell uses food for energy.

Cells in an organism work together in special ways. For example, nerve systems are made up of nerve cells that work together. One job of the nerve system is to send messages to the brain.

How do organisms respond?

All organisms are able to respond in various ways. If someone throws a ball at you, you might try to catch it. This is because you are able to respond to changes in your environment. Your body responds in other ways too. For example, your heart rate speeds up or slows down as needed to deliver the right amount of oxygen to each cell. Your body can also respond to an invasion by a virus or bacterium. There are cells in your body that can recognize these invaders and respond with different processes to get rid of them.

How do organisms grow and develop?

All organisms grow and develop. When an organism grows, it increases in size. Organisms made of many cells usually grow by adding cells. Organisms that are only one cell grow when that cell increases in size.

Development includes all the changes that occur in an organism. For example, you might be able to play a sport or an instrument that you could not ten years ago. As shown below, some organisms go through dramatic changes, such as a caterpillar changing into a butterfly or a puppy growing up to be a dog.



Why do organisms reproduce?

You read earlier in this lesson that all new cells come from cells that already exist. The same is true for organisms. In order for living things to continue to exist, they must reproduce, or create offspring similar to themselves. Not every individual needs to reproduce, but some of each type of organism must do so.

What is homeostasis?

All organisms must keep the right amount of food and water in their cells. They also need to keep the temperature of their body within a certain range. This is the process of maintaining homeostasis. **Homeostasis** (hoh mee oh STAY sus) is when the internal environment is kept within certain limits. These limits are not the same for all organisms. For example, some fish can live only in freshwater, while others need the salt water of the ocean.

Organisms have many different methods for maintaining homeostasis. A human will die if his or her body temperature changes more than a few degrees. Therefore, human bodies sweat, shiver, or change the flow of blood to try to maintain a body temperature of about 37°C. ✓

Picture This

4. Explain to a partner the differences between a caterpillar and a butterfly or a puppy and a dog.

✓ Reading Check

5. List three ways that human bodies maintain a healthy body temperature.

✓ Reading Check

6. Explain How do humans get energy?

Academic Vocabulary
function (FUNK shun) (noun)
purpose

Picture This

7. Highlight the type of water that insulates your body.

Where does energy come from?

All living cells use energy. Our cells get energy from the food that we eat. The energy in food began in the light energy that comes to Earth from the Sun. The Sun is the origin of the energy used by most organisms on Earth. ✓

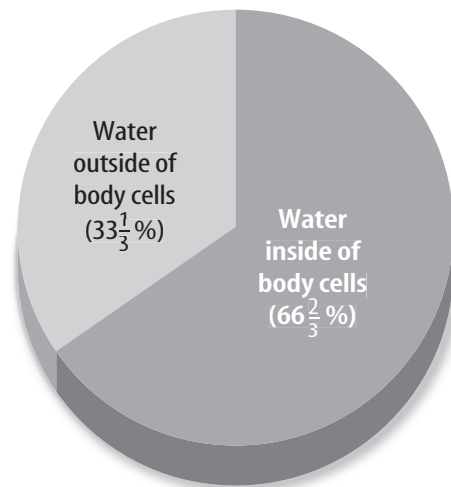
Chemistry of a Cell

When you were younger, you might have played with some kind of building blocks. You probably made many things using different sizes and shapes of blocks. In a similar way, a cell can make different things using atoms and molecules as its building blocks.

You might recall from another science class that atoms combine to make molecules. Most of the molecules in living things are made from six kinds of atoms—sulfur, nitrogen, potassium, hydrogen, oxygen, and carbon. The molecules in cells can combine in many ways to make different substances. Organisms use these substances for thousands of different functions.

How do cells use water?

Water is important for all living things. About two-thirds of your body's mass is water, as shown in the chart below. Most of that water is inside cells, and the rest surrounds cells. Water dissolves many kinds of molecules. This makes it possible for blood, which is mostly water, to transport substances throughout your body. The water that surrounds cells is important too. It insulates your body, which helps maintain homeostasis.



What are cells made from?

You already know that cells are made partly from water. Cells also contain carbohydrates, proteins, nucleic acids, and lipids. Those substances are called macromolecules. Macromolecules are complex molecules. They are usually made of long chains of smaller molecules.

Proteins are needed for almost everything that cells do. A **protein** is made of molecules called amino acids, which are linked together in a folded chain.

Nucleic (noo KLAY ihk) **acids** are made of long chains of molecules called nucleotides. One kind of nucleic acid is deoxyribonucleic (dee AHK sih ri boh noo klay ihk) acid (DNA). DNA contains the genetic information of a cell. The information stored in the DNA is used to make another nucleic acid called ribonucleic (ri boh noo KLAY ihk) acid (RNA). RNA it is used to make proteins.

Lipids are large molecules that do not dissolve in water. The main kinds of lipids are fats, steroids, phospholipids (fahs foh LIH pids), and waxes. The functions of lipids are described in the table below.

Types of Lipids	
Name	Function
Fats	stores large amounts of chemical energy
Steroids	basis of many hormones
Phospholipids	important part of cell membranes
Waxes	regulates the amount of sugar in the blood of animals with backbones

Carbohydrates are made of one or more sugar molecules. They are sources of energy for cells. They also make up part of a cell's structure. Both sugars and starches are carbohydrates.

What have you learned about cells and life?

The cell is the smallest unit of a living organism. Cells need water to survive as do all living things. The four basic substances of cells are proteins, nucleic acids, lipids, and carbohydrates.

FOLDABLES™

A Record Information

Make a concept Foldable, as illustrated, to learn about proteins, lipids, carbohydrates, and nucleic acids. Fold lengthwise and write *The Cell* on the front of the Foldable.

Proteins	Nucleic Acids
Lipids	Carbohydrates

Picture This

8. Highlight the type of lipids that stores energy.

Cell Structure and Function

Lesson 2 The Cell



Grade Seven Science Content Standard. 1.b. Students know the characteristics that distinguish plant cells from animal cells, including chloroplasts and cell walls. **Also covers:** 1.a, 1.c, 1.d, 2.e.

MAIN **Idea**

Cells have structures with specific functions.

What You'll Learn

- the differences between an animal cell and a plant cell
- the differences between a prokaryotic cell and a eukaryotic cell

Mark the Text

Identify Details Highlight each question head. Then use another color to highlight the answer to that question.

Reading Check

- 1. Describe** two ways that a cell wall is different from a cell membrane.

● Before You Read

What do you know about cells? List a few facts on the lines below. Then read the section to learn about the structures found in the cells.

● Read to Learn

Cell Shape and Movement

The cells of plants and animals have many sizes. They also come in a variety of shapes. Sometimes a cell's shape is related to its function. For example, a human red blood cell is shaped to allow it to move through tiny blood vessels. In plants, some cells are hollow. The hollow cells form a tube to carry water and dissolved substances to all parts of the plant.

What is a cell membrane?

Every cell is enclosed by a flexible cover called the **cell membrane**. The cell membrane is made of one or more layers of linked molecules. It protects a cell by preventing dangerous substances from entering. It allows water, food, and waste products to enter or leave the cell, but does not allow other substances to do so.

What is the function of a cell wall?

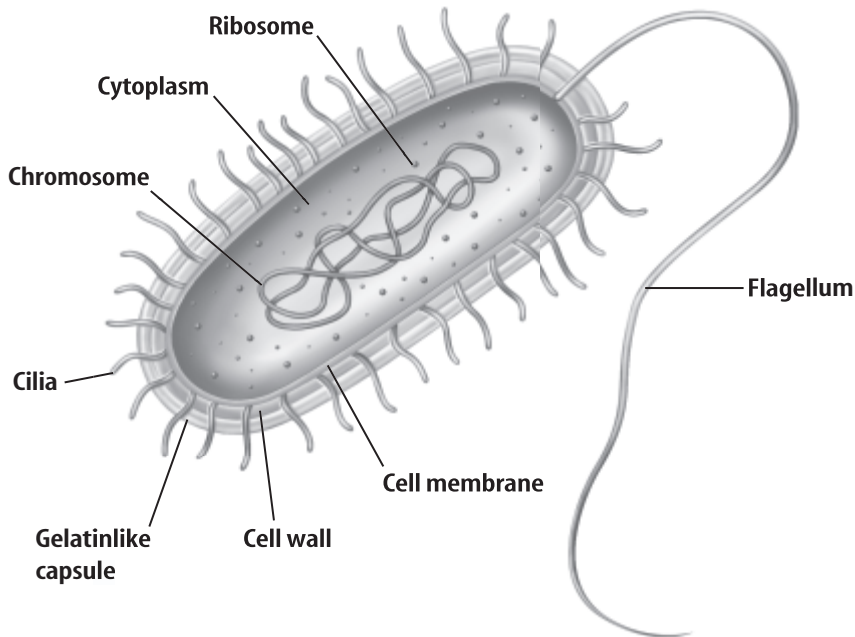
The cells of plants, fungi, and some bacteria have a cell wall. The **cell wall** is a rigid substance that surrounds the cell outside of its cell membrane. The rigid cell wall allows plants and fungi to grow upward against the force of gravity, by maintaining the cell's shape and protecting the cell. Substances can pass freely through a cell wall, unlike a cell membrane.

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What appendages do cells have?

Animals run and fly using appendages such as legs and wings. Some cells have appendages too, as shown in the figure below. A flagellum (fluh JEH lum) (plural, flagella) is an appendage that looks like a tail. Some single-celled organisms have one or more flagella. They use the flagellum to move, much like a fish flaps its tail to move through water. Sperm is an example of a cell with one flagellum.

Cilia (SIH lee uh) (singular, cilium) are another type of appendage. Some single-celled organisms are covered with many cilia. Cilia are short appendages that look like hair. The cilia of some single-celled organisms work together to move the organism. Cilia are also on the surface of some cells that do not move. In this case, the cilia help fluids move across the cell's surface.



What are cytoplasm and the cytoskeleton?

The inside of a cell contains a thick fluid made mostly of water called the **cytoplasm** (SI tuh plaz um). Everything inside a cell is suspended in the cytoplasm.

Each cell also has a cytoskeleton. The **cytoskeleton** is a network of fibers that helps the cell maintain or change its shape. It plays a role in muscle contraction, cell division, and cell movement. The cytoskeleton helps the cell maintain its shape. Both cilia and flagella are able to move because they contain fibers of the cytoskeleton.

Picture This

2. **Highlight** the flagellum in one color and cilia in another color.

Think it Over

3. **Decide** Which cell structure is made up mostly of a fluid?
 - a. cytoplasm
 - b. cytoskeleton

Cell Organelles

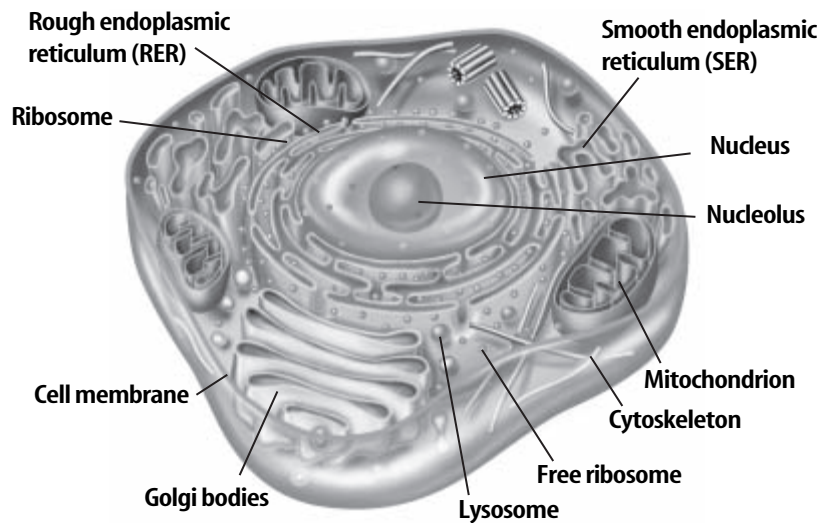
Cells must process energy, store materials, and complete many other tasks. Some cells have structures in the cytoplasm called **organelles** (or guh NELZ) that do these jobs. The organelles found in plant and animal cells are shown below. Each type of organelle has its own special function.

Other types of cells do not have organelles. Bacteria, which are single-celled organisms, do not have organelles.

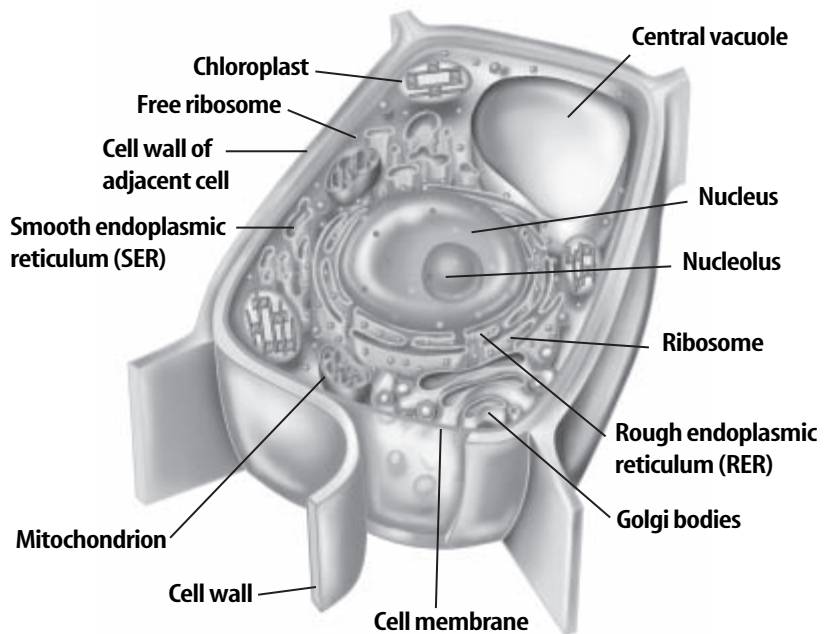
Picture This

4. **Name** two organelles that are found only in a plant cell.

Animal Cell



Plant Cell



What is the nucleus?

The **nucleus** (new KLEE us) is a large organelle found in many cells. It is surrounded by a membrane. Substances can pass into and out of the nucleus through small holes, or pores, in the membrane. The nucleus also contains an organelle called the nucleolus (new KLEE uh luhs). The nucleolus makes structures that make proteins.

The nucleus (plural nuclei) is the control center of a cell because it contains genetic material called DNA. The DNA has information on making all of the molecules in the cell. The long chains of DNA are coiled into structures called **chromosomes** (KROH muh sohmz). Chromosomes have proteins that help the DNA coil. A human cell has 23 pairs of chromosomes. A sheep cell has 27 pairs of chromosomes. Each type of organism has a particular number of pairs of chromosomes in each of its cells. ✓

Where are protein and lipids manufactured?

A cell makes many kinds of molecules to perform its jobs. Protein molecules are built within small structures called **ribosomes** (RI buh sohmz). Ribosomes do not have membranes. They are made in the nucleolus and move into the cytoplasm through the membrane of the nucleus.

Ribosomes can attach to an organelle called the endoplasmic reticulum (en duh PLAZ mihk • rih TIHK yuh lum). The endoplasmic reticulum (ER) is a folded membrane that connects to the nucleus. Rough ER makes and modifies proteins. Smooth ER is important for making lipids and helping cells get rid of chemicals and poisons.

How do cells process energy?

Most plants and some single-celled organisms can make their own food. The food is made in membrane-bound organelles called chloroplasts. A **chloroplast** (KLOR uh plast) uses light energy to make food. It uses light energy, water, and carbon dioxide to make a type of sugar.

All animals must get their food from outside **sources**. An organelle called **mitochondrion** (mi tuh KAHN dree uhn) (plural, mitochondria) changes the energy from food molecules into a form of energy that cells can use. Mitochondria are surrounded by cell membranes. They are sometimes called the power plants of a cell. Cells that require a lot of energy, such as muscle cells, have many mitochondria. Cells that require less energy, such as skin cells, have fewer mitochondria.

✓ Reading Check

5. **Summarize** the importance of the nucleus to the cell.

Academic Vocabulary

source (SORS) (noun) cause; point of origin

Which is the job of the Golgi apparatus?

The Golgi (GAWL jee) apparatus is an organelle that makes, sorts, and ships molecules. It also modifies, stores, and directs the movement of molecules made in the ER. Some cells contain large numbers of Golgi apparatus because they make substances that are needed in other parts of an organism.

When the Golgi apparatus needs to transport a molecule, it puts that molecule into a vesicle. A vesicle is made of membranes and carries molecules throughout the cytoplasm. Vesicles also carry substances that are released from the cell to the cell membrane.

Vacuoles (VAK yuh wohlz) are storage organelles. Small vacuoles contain food molecules, water, or waste products from the cell. An animal cell contains a vacuole called the lysosome (LI suh sohm). A lysosome stores digestive enzymes. A plant cell has a large vacuole called the central vacuole. See the table below for information on the function of various cell structures.

Picture This

6. Identify Circle the cell functions that have to do with movement.

Cell Structure		
Cell Structure	Function	Cell Type
Cell membrane	regulates movement of substances into and out of a cell	all cells
Cell wall	provides shape, protection, and support	plants, fungi, and some bacteria
Flagellum and cilium	movement	some single-celled organisms; flagellum—some sperm; cilium—some animal cells
Cytoskeleton	cell shape and movement	all cells
Nucleus	controls cell functions	most cells except bacterial cells
Ribosome	site of protein production	all cells
Endoplasmic reticulum (ER)	smooth—makes lipids and gets rid of chemicals and poisons rough—makes and modifies proteins	most cells except bacterial cells
Mitochondrion	releases energy	most cells except bacterial cells
Chloroplast	makes food	most plant cells
Golgi apparatus	modifies, stores, and directs the movement of molecules made by ER	most cells except bacterial cells
Vesicle	transports substances	most cells except bacterial cells
Lysosome	stores digestive enzymes	most animal cells
Central vacuole	stores water and plant substances	plant cells

Cell Types

A cell without a nucleus and other organelles is classified as a **prokaryotic** (proh kayr ee AH tihk) **cell**. A cell with a nucleus and other organelles is classified as a **eukaryotic** (yew kayr ee AH tihk) **cell**.

What is another name for prokaryotes?

Prokaryotic cells are always single-celled organisms. These organisms are called prokaryotes (proh KAYR ee ohts). Many prokaryotes have cell walls and flagella.

Prokaryotes are also known as bacteria. Bacteria are a diverse group of organisms. They live in many different environments.

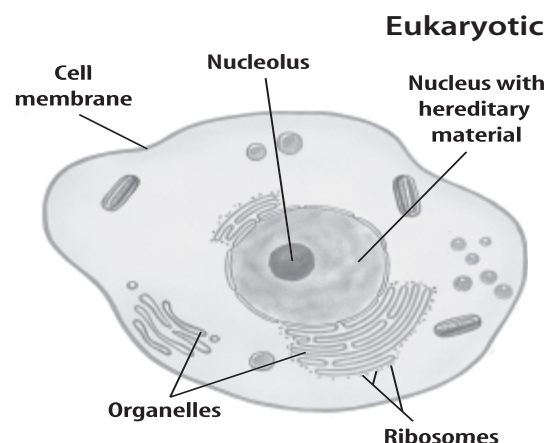
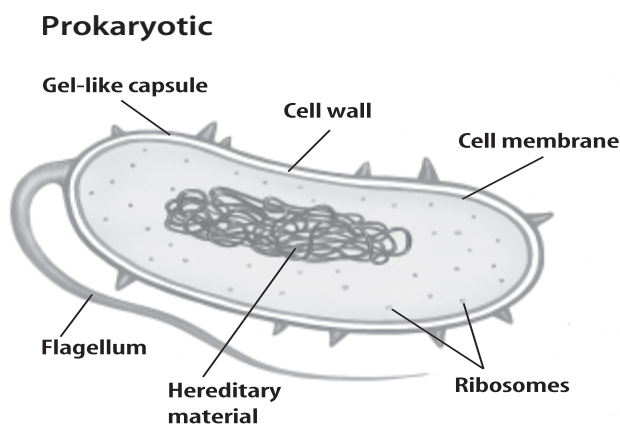
What are eukaryotic cells?

Eukaryotic cells are larger than prokaryotic cells. They also contain different structures. Protists, fungi, plants, and animals are made of one or more eukaryotic cells. Therefore, these organisms are called eukaryotes (yew KAYR ee ohts). Many scientists suggest that eukaryotic cells may have evolved when one prokaryotic cell became part of another prokaryotic cell.

What have you learned about the cell?

The parts of a cell work together to help the cell survive. The cell membrane controls what enters and exits a cell. The cell wall and cytoskeleton determine the shape of a cell. Most cell organelles are membrane-bound. Chromosomes in a cell's nucleus contain genetic information.

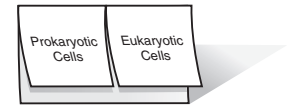
Two cell types are prokaryotic and eukaryotic, as shown below. Prokaryotic cells do not contain any membrane-bound organelles. Eukaryotic cells have a nucleus and other membrane-bound organelles.



FOLDABLES™

B Sketch and Describe

Make a two-tab Foldable. Sketch and label prokaryotic and eukaryotic cells on the front tabs, record what you learn about each, and use what you learn to describe similarities and differences.



Picture This

7. Identify Circle the features that are the same in both types of cells.

Cell Structure and Function

Lesson 1 Cells and Energy

Grade Seven Science Content Standard. 1.d. Students know that mitochondria liberate energy for the work that cells do and that chloroplasts capture sunlight energy for photosynthesis. **Also covers:** 1.b.



MAIN Idea

Cellular respiration and photosynthesis provide energy.

What You'll Learn

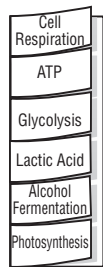
- the basic chemical reaction in photosynthesis
- the importance of pigments in photosynthesis
- the differences between photosynthesis and cellular respiration

Study Coach

Create Notes Use sticky notes to mark places in the text that you find interesting or that you have questions about. Write your comment or question on the sticky note and stick it to the page.

FOLDABLES™

Define Make a six-tab Foldable. Label the tabs as illustrated, define the terms, and explain each as they relate to cell functions under the tabs.



● Before You Read

Plants and animals both need energy to survive. Where do you think that energy comes from? Write your ideas on the lines below. Read the lesson to learn about cellular respiration and photosynthesis.

● Read to Learn

Cellular Respiration

Most automobiles run on gasoline or diesel fuel. These fuels come from crude oil. You cannot put crude oil in a car's engine. Instead, the crude oil must be processed and refined into fuels cars can use. In the last lesson, you learned that the energy stored in food molecules is not in a form cells can use. **Cellular respiration** is a series of chemical reactions that transforms food into a usable form of energy. The usable energy is in molecules of **ATP**—adenosine triphosphate (uh DEN uh seen • tri FAHS fayt).

What are the reactions in the cytoplasm?

Cellular respiration happens in three steps. The first step is called **glycolysis** (gli KAH lih sis). Glycolysis takes place in a cell's cytoplasm. During glycolysis a glucose molecule is broken down into two smaller molecules. The glucose molecule is a type of sugar. Energy is needed to fuel the chemical reactions of glycolysis. The process releases electrons that are used in the last step of cellular respiration.

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What is produced during cellular respiration?

The second stage of cellular respiration happens in mitochondria. This step uses the smaller molecules produced by glycolysis. The smaller molecules are broken down into molecules of carbon dioxide. More electrons are released.

The third step of cellular respiration requires oxygen. This step uses the electrons that were released in the first two steps to produce large amounts of ATP—usable energy—and water—a waste product.

What is lactic acid fermentation?

When a person exercises, his or her muscles use lots of oxygen. As a result, the muscle cells might not have enough oxygen to produce energy through cellular respiration. Instead, the cells release energy through a process called lactic acid **fermentation**. ✓

Lactic acid fermentation begins and ends in the cytoplasm. It does not involve mitochondria or use oxygen. It uses glucose and produces lactic acid, carbon dioxide, and some ATP molecules. However it does not produce as much ATP as cellular respiration does. Cheese and yogurt are made using fungi and bacteria that perform lactic acid fermentation.

What is alcohol fermentation?

Another type of fermentation that releases energy is alcohol fermentation. The process is similar to lactic acid fermentation except it produces ethanol (a kind of alcohol) instead of lactic acid. Like lactic acid fermentation, alcohol fermentation creates carbon dioxide and a couple of ATP molecules. Cellular respiration, lactic acid fermentation, and alcohol fermentation are necessary for life to continue. All three processes produce ATP. The table below compares the three processes.

Processes that Release Cellular Energy			
Process	Oxygen Required	Number of ATP Molecules Available to a Cell	Waste Products
Cellular respiration	Yes	36	water, carbon dioxide
Lactic acid fermentation	No	2	lactic acid, carbon dioxide
Alcoholic fermentation	No	2	alcohol, carbon dioxide

✓ Reading Check

- 1. Generalize** When do cells use lactic acid fermentation?

Picture This

- 2. Identify** What are three waste products created during fermentation?

 **Reading Check**

3. Identify What is the source of energy for organisms that make their own food?

Academic Vocabulary series (SIH reez) (noun) a number of things coming together one after another

 **Think it Over**

4. Synthesize Name two reasons that photosynthesis is important to life on Earth.

Photosynthesis

Some organisms, such as humans, get energy from the food they eat. Other organisms make their own food by using energy from the Sun or other light sources.

Photosynthesis (foh toh SIHN thuh sus) is a series of chemical reactions that makes food in these organisms. 

Why are leaves green?

Plants contain pigments that reflect and absorb light. Chlorophyll (KLOR uh fihl) is a green pigment. Most leaves appear green because they contain more chlorophyll than any other pigment. Some leaves change color in the fall. This happens when the plant stops producing chlorophyll, allowing light to be reflected by different pigments in leaves.

What happens in chloroplasts?

Chlorophyll and other pigments absorb energy from sunlight. The energy is used in a series of chemical reactions called photosynthesis. Photosynthesis takes place in the chloroplasts. It is a process in which light energy, water, and carbon dioxide are used to make sugars. Photosynthesis also produces oxygen, which is released into the atmosphere.

Why is photosynthesis important?

The fruits and vegetables we eat grow because of photosynthesis. Photosynthesis supplies Earth's atmosphere with oxygen, which we must have for our cells to perform cellular respiration. The carbon dioxide produced by organisms during cellular respiration would become toxic if it were not used in photosynthesis.

What have you learned about cells and energy?

Cellular respiration changes unusable energy in food molecules into usable energy. The usable energy is in the form of ATP molecules. Two processes that produce ATP without oxygen are lactic acid fermentation and alcohol fermentation.

Light energy fuels photosynthesis. Organisms that perform photosynthesis have pigments that take in the light energy. Most organisms depend on photosynthesis.

From a Cell to an Organism

Lesson 1 The Cell Cycle and Cell Division



Grade Seven Science Content Standard. 1.e. Students know cells divide to increase their numbers through a process of mitosis, which results in two daughter cells with identical sets of chromosomes. **Also covers:** 1.c, 5.a.

● Before You Read

You are made of millions of cells. Cells are the smallest unit of life. On the lines below, name the types of cells that you think exist in your body. Then read the lesson to learn about the life of a cell.

MAIN Idea

The life of a cell usually includes periods of growth and reproduction.

What You'll Learn

- to recognize the stages of mitosis
- the difference among the cell cycle, mitosis, and cell division

● Read to Learn

The Cell Cycle

Growth and development and reproduction are essential characteristics of life. You have gone through many phases of growth and development as a part of your life cycle. Cells have a life cycle, as well. The plant life cycle, called the **cell cycle**, usually includes phases of growth and development and reproduction.

What are the phases of a cell cycle?

Interphase is the phase of a cell cycle when a cell is preparing to reproduce. Interphase lasts longer than other phases of a cell's cycle. The phase when a eukaryotic cell reproduces is called the mitotic (mi TOH tik) phase. The mitotic phase of a cell cycle has two stages—mitosis, when the cell's nucleus divides, and cytokinesis, when the cell's cytoplasm divides. The mitotic phase produces two new cells.

What is the length of a cell cycle?

The length of a cell cycle is different for different organisms and cells. For some animals, the cell cycle can repeat quickly. For example, a zebra fish grows from a fertilized egg (one cell) to 256 cells in just 2.5 hours. Some forms of bacteria can reproduce every 1 to 3 hours.

Study Coach

Create Two-Column Notes

Draw a line down the center of your paper. As you come to a new section, write the title of the section on the left side of your paper and write the most important fact from that section on the right side of your paper.

FOLDABLES™

A Describe Make a three-tab Foldable. Label the front tabs as illustrated. Describe the three phases of the cell cycle: interphase, mitosis, and cytokinesis.



✓ Reading Check

- 1. State** How many sets of chromosomes are in a nucleus? (Circle the answer.)
- a. 1
 - b. 2
 - c. 3

Academic Vocabulary
injure (IHN jur) (verb) to cause pain or harm

Picture This

- 2. Highlight** the stage of the cell cycle during which organelle replication takes place.

What are the characteristics of interphase?

During interphase a cell performs specific functions, such as producing enzymes in your stomach to help you digest food. A plant cell might perform cellular respiration during interphase.

Recall that there are two sets of chromosomes in a nucleus. Scientists call each pair of similar chromosomes **homologous chromosomes** (huh MAH luh gus • KROH muh sohmz). Homologous chromosomes are similar but not identical. Humans have 23 pairs of homologous chromosomes. ✓

What are the three stages of interphase?

There are three stages that occur in a cell during interphase. These stages are G1, S and G2. During G1 stage, a cell grows, but some cells remain in G1 stage. Cells that remain in G1 stage do not reproduce. Your muscle cells and nerve cells are examples of G1 cells that never reproduce. If you **injure** your muscle cells and nerve cells, the damage might be permanent because the cells are not replaced.

During S stage, the chromosomes inside a cell's nucleus replicate, which means that they make copies of themselves. The copies are called **sister chromatids** (KROH muh tudz). The sister chromatids are held together near the middle of each chromatid in a place called the **centromere**. The two new cells formed by this replication are identical.

What happens during the G2 stage?

During the final stage of interphase, the G2 stage, cells continue to grow and carry out cellular functions. Cells also replicate organelles during this stage. Some organelles can replicate themselves because they contain their own DNA. The table below summarizes the phases of a cell cycle.

Phases of the Cell Cycle		
Phase	Stages	Description
Interphase	G1	Growth and cellular functions
	S	Growth and chromosome replication
	G2	Growth and cellular functions; organelle replication
Mitotic phase	Mitosis	Nucleus divides
	Cytokinesis	Cytoplasm divides

Mitosis and Cell Division

You have learned that the nucleus is the control center of the cell. You have also learned that a eukaryotic cell's cytoplasm contains organelles and other important structures. Mitosis and cell division ensures that when new cells are created, the contents of those cells are copied correctly. **Mitosis** (mi TOH sus) is the name given to the process when the nucleus divides. **Cytokinesis** (si toh keh NEE sus) is the process in which the cytoplasm divides.

Why are mitosis and cell division important?

Multicellular organisms grow by making more cells and replacing cells that die. Through mitosis and cell division, new cells replace short-lived cells. Some organisms reproduce by mitosis and cell division. When this happens, the offspring are identical to the parent. ✓

What are the phases of mitosis?

There are four phases of mitosis. The first phase of mitosis is **prophase**. During this phase two things happen. First, the DNA in a replicated chromosome twists into tight coils. Second, the membrane around the nucleus breaks apart. After this happens, chromosomes can move to other areas of a cell.

During the second phase of mitosis, called **metaphase**, the replicated chromosomes move to the middle of the cell. The pairs of sister chromatids line up end-to-end across the center of the cell. This happens because hairlike fibers pull and push the chromosomes to the middle of the cell.

The next phase of mitosis, **anaphase**, is when the sister chromatids of each replicated chromosome begin to separate. Hairlike fibers extend from each end of a cell and attach to the centromere of the sister chromatids. The fibers pull the centromere apart. The chromatids move from each other toward opposite ends of the cell. The chromatids are then called chromosomes. ✓

The final phase of mitosis is called **telophase**. During telophase, a new membrane forms around each set of chromosomes. The chromosomes become less tightly coiled. This is the reverse of what happens in prophase. At the end of this phase, there are two new nuclei that are identical to each other and the original nucleus. The cell, however, has not divided. The phases of mitosis are shown in the figure at the top of the next page.

✓ Reading Check

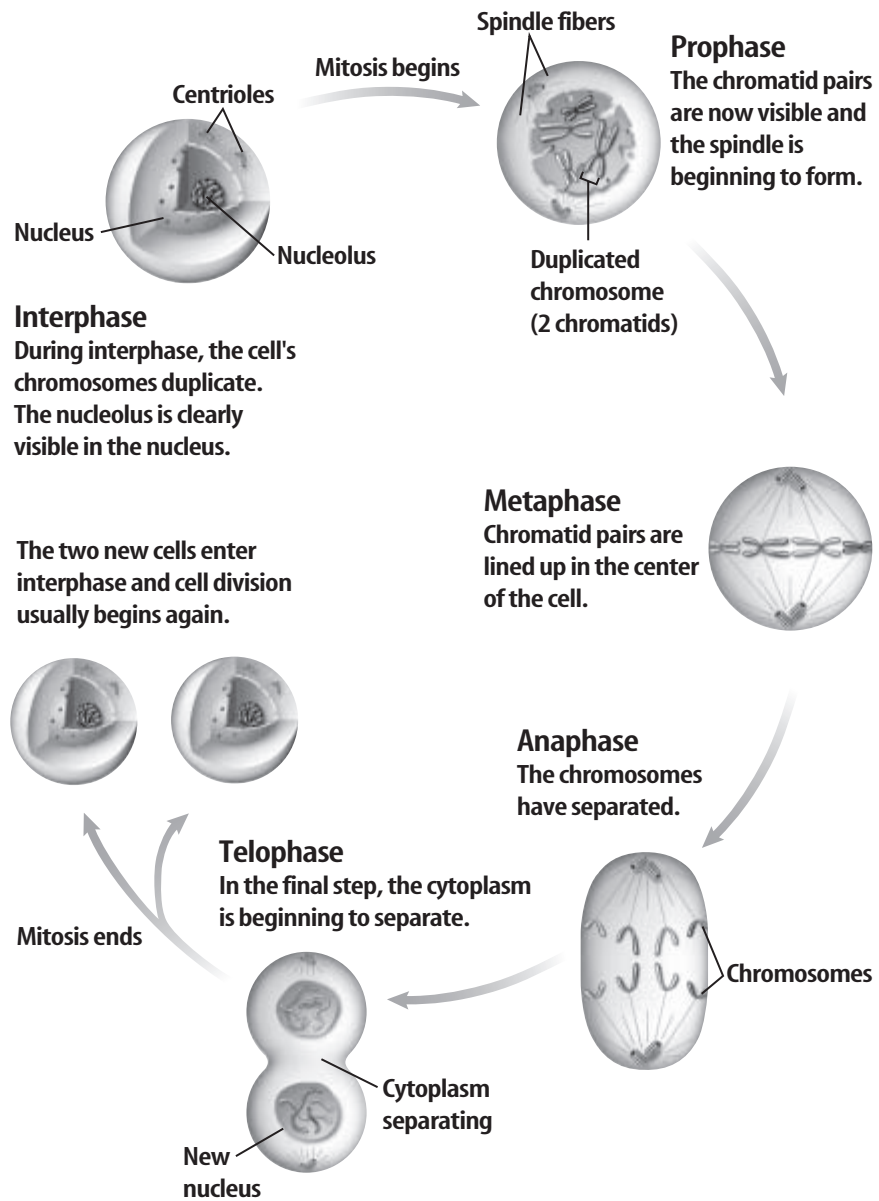
3. Explain How do multicellular organisms grow?

✓ Reading Check

4. Identify What is the third phase of mitosis?

Picture This

5. Describe What happens during metaphase?



The two new cells enter interphase and cell division usually begins again.

✓ Reading Check

6. Define What are daughter cells?

What is cytokinesis?

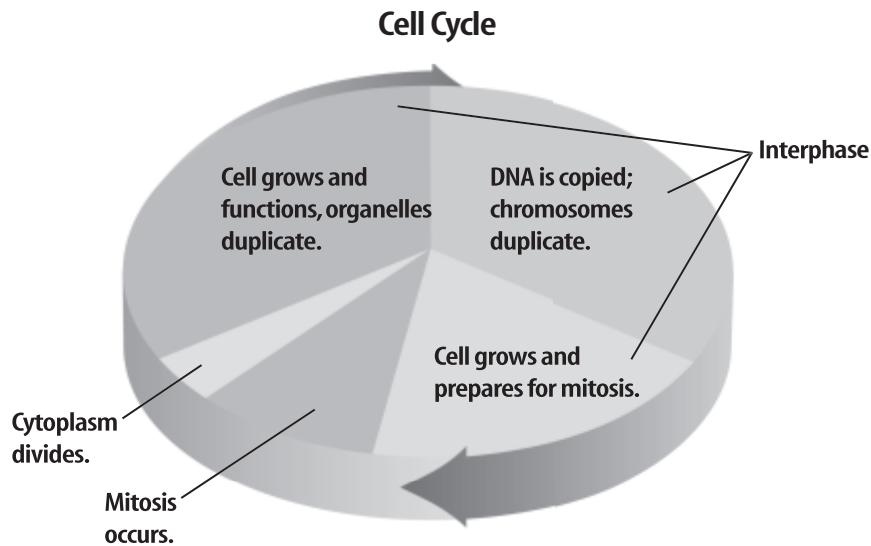
Cytokinesis is the final stage of the cell cycle. During cytokinesis, the cytoplasm and its components divide to form two identical cells called **daughter cells**. ✓

In a cell with a cell wall, such as a plant cell, a **cell plate** forms between the two new nuclei. The cell plate eventually becomes the cell membrane. The new cell walls of the plant daughter cells are built from molecules released by the plant's cell membrane.

During cytokinesis, each daughter cell receives half the cytoplasm. The cytoplasm contains organelles that were replicated during the G2 stage of interphase.

What is the result of cell division?

After mitosis and cell division, the original cell—called the parent cell—no longer exists. However, the chromosomes of the daughter cells are identical to those of the parent cell. That means the daughter cells are genetically identical to each other and to the original parent cell. Because of mitosis and cytokinesis, all the cells in your body, except sperm and egg cells, have identical chromosomes. ✓



What have you learned about the cell cycle and cell division?

Cells have periods of growth and reproduction called cell cycles. The cell cycle is summarized in the figure above. Different cell types have different cell cycle lengths. A cell's nucleus divides in a process called mitosis. The DNA that makes up the duplicated chromosome is packaged in tight coils. The membrane around the nucleus breaks apart, which allows the chromosomes to move around in the cytoplasm. The duplicated chromosomes move to the center of the cell where the chromatids also line up. Sister chromatids separate and move to opposite sides of the cell. Mitosis produces two identical nuclei. Following cytokinesis, two new cells form that are genetically identical. The original cell no longer exists.

✓ Reading Check

7. Explain What happens to the parent cell of an organism after mitosis and cell division?

Picture This

8. Estimate Approximately how much of the cell cycle is interphase?

From a Cell to an Organism

Lesson 2 Levels of Organization

Grade Seven Science Content Standard. 1.f. Students know that as multicellular organisms develop, their cells differentiate. Also covers: 1.c, 5.a.



MAIN Idea

All living things have organized structures and functions.

What You'll Learn

- the difference between plant and animal cells
- the levels of organization from cell to organism

Study Coach

Preview Headings Read each of the question headings. Answer the question using information you already know. Then read the section and answer the question again.

Picture This

1. **Identify** Highlight one structure of the prokaryote and suggest that structure's function.

Before You Read

On the lines below, describe a system you have for keeping things organized, such as storing athletic equipment in one place and clothes in another. Read the lesson to learn more about the organization of cells.

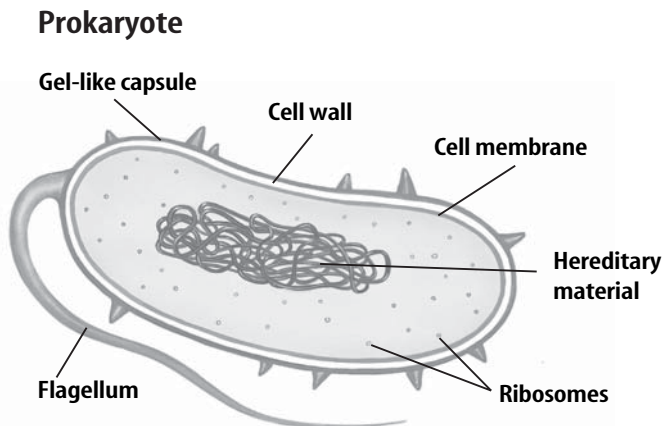
Read to Learn

Single-Celled Organisms

Why should a single-celled organism need to be organized? The organism's one cell does everything necessary for its survival. Some of its functions include waste removal, movement, protection, reproduction, and obtaining necessary nutrients.

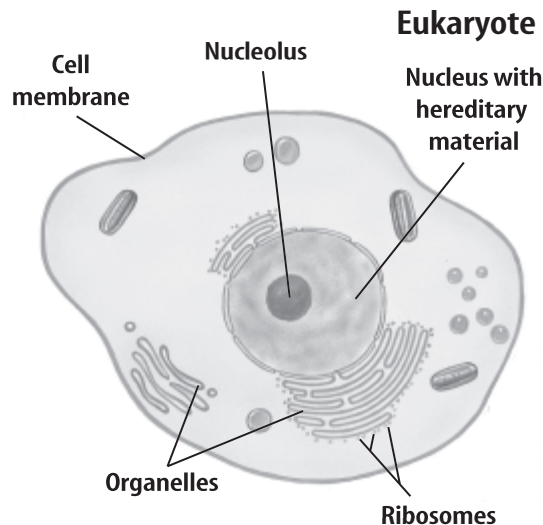
What are prokaryotes?

Prokaryotes are single-celled organisms that do not have membrane-bound organelles, as shown below. For example, bacteria are prokaryotes without nuclei or other organelles, but bacteria still have structures with specific functions.



What are eukaryotes?

Eukaryotes are more complex than bacteria. Each single-celled eukaryote has a nucleus and organelles with specialized functions, as shown below. Amoeba and some fungi are examples of single-celled eukaryotes.



Single-celled eukaryotes exist alone and provide for themselves everything they need to survive. Single-celled eukaryotes are more complex than cells in multicellular eukaryotes. Unlike single-celled eukaryotes, multicellular eukaryotes cannot survive alone.

Some single-celled eukaryotes, however, live and function in groups or colonies. After cell division, the daughter cells stay together. Some scientists propose that it is possible that colonies of single-celled organisms have led to the development of multicellular organisms.

Multicellular Organisms

Multicellular organisms have many cells. They also often have more than one type of cell. Because of their structure, multicellular organisms have a more complex organization than single-celled organisms.

What is cell differentiation?

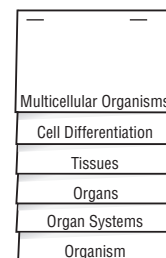
Cell differentiation (dih fuh ren chee AY shun) is a process in which cells become different types of cells. It is how you changed from a single fertilized egg to a complex organism with many types of cells. You grew by mitosis and cell division.

Picture This

2. **Circle** the organelles in this eukaryote.

FOLDABLES™

B Explain Make a layered Foldable and use it to record what you learn about multicellular organisms. Explain the levels of organization under the tabs.



Academic Vocabulary

enable (en A bul) (verb)
to make something possible

Reading Check

3. Define What is a stem cell?

Think it Over


4. Identify Name other organs in your body that must work together to perform a function.

What do chromosomes contain?

Nearly all the cells of an organism have identical sets of chromosomes. These chromosomes contain the instructions of a cell. If cells have identical sets of instructions, how can they be different? They can be different because different cell types use different parts of the instructions on the chromosomes.

Differentiated cells have specialized structures and shapes that enable them to perform specific functions. Brain cells, for example, are a type of differentiated cell. They are highly branched, which enables them to send and receive signals from multiple sources.

What are stem cells?

Some cells in your body are undifferentiated. These cells, called stem cells, can become different types of cells. For example, there are stem cells in the middle of some of your bones. Under the right conditions, these cells could become other types of cells. Differentiated cells cannot become any other type of cell. 

How do some plant cells differentiate?

Some plants cells can differentiate into another type of cell after they have differentiated into a specific type of cell. The leaf of a begonia plant, for example, contains differentiated cells with specialized functions. If you cut a leaf from a begonia plant and place it in soil, the leaf can produce new begonia plants.

What are tissues?

A tissue is a group of cells that work together and perform a function. A muscle fiber, for example, is one kind of tissue in your body. It is made up of many types of muscle cells that work together.

What are organs?

An organ is a group of similar tissues that work together to perform a function. Each tissue must work properly for the organ to function.

Human Organs Your heart, lungs, brain, stomach, and muscles are all examples of organs in your body. A muscle, such as the bicep in your upper arm, is made of bundles of muscle fiber tissue. These cells in the muscle tissue must work together to contract and relax, allowing your arm to move.

Plant Organs Plants also have organs. Plant organs store and transport nutrients, exchange gases, transport water or nutrients, or perform photosynthesis. A leaf is an example of a plant organ. Leaves have tissues that transport substances, provide protection, and are specialized for photosynthesis.

What are organ systems?

An **organ system** is one or more organs that work together and perform one or more functions. For example, the muscles in your body, along with the bones of your skeleton, allow your body to move. These two systems, your muscles and bones, make up your musculoskeletal system. Your heart, lungs, and digestive system also work together. They supply your muscles and bones with what they need to work together. The table below summarizes the human organ systems.

Picture This


5. Identify What is the function of skin?

Human Organ Systems		
System Name	Organs	Function
integumentary (ihn teg yuh men tuh ree)	skin	protect the body and maintain homeostasis
skeletal	bones, cartilage, ligaments, and joints	protect and support the body; provide mineral storage
muscular	muscles	allow movement of the body
nervous	brain, spinal cord, nerves, and sensory receptors	respond and regulate body systems
endocrine (en duh krun)	pituitary, thyroid, parathyroid, adrenals, thymus, pancreas, pineal	produce hormones that control body functions
cardiovascular (kar dee oh vas kyuh lur)	heart, blood vessels	transport blood
lymphatic (lihm fa tihk)	lymph nodes, tonsils, spleen, lymphatic vessels	return fluid to blood and filter blood
respiratory	nasal passages, pharynx, larynx, trachea, bronchi, and lungs	deliver oxygen to and remove carbon dioxide from blood
digestive	mouth, esophagus, stomach, small and large intestines, rectum, and anus	break down food and deliver nutrients and water to the blood
urinary	kidneys, ureters, bladder, and urethra	remove wastes from the blood; maintain homeostasis
reproductive	female—fallopian tubes, uterus, vagina, ovaries; male—scrotum, penis, accessory glands, testes	produce offspring

 **Reading Check**

- 6. Determine** Organ systems are dependent on what to function properly? (Circle your answer.)
- a. other organ systems
 - b. multicellular organisms

What is an organism?

Multicellular organisms are the most complex unit of living things. Multicellular organisms usually have many organ systems. Each organ system has its own function, but it is dependent upon other organ systems to function properly. For example, your circulatory system transports nutrients throughout your body. Nutrients come from the breakdown of food in your digestive system. You would not be able to breathe, move, reproduce, or eat without your nervous system. 

What have you learned about levels of organization?

Even the simplest single-celled organisms are organized. Most single-celled organisms perform all the functions that they need for life inside one cell. Multicellular organisms have many types of specialized cells. Different types of differentiated cells have different functions.

Multicellular organisms have many levels of organization. Multicellular organisms have groups of different cells, called tissues, that function together. Groups of tissues form an organ. Two or more organs that perform a function are an organ system.

Reproduction of Organisms

Lesson 1 Sexual Reproduction and Meiosis

Grade Seven Science Content Standard. 2.b. Students know sexual reproduction produces offspring that inherit half their genes from each parent.
Also covers: 2.a.



● Before You Read

On the lines below, describe how parents and their offspring are alike and yet different. Then read the lesson to learn about how genetic information is passed on through sexual reproduction.

● Read to Learn

What is sexual reproduction?

Sexual reproduction is the production of an offspring that results when the genetic material from two different cells combines. Half of the genetic material comes from the mother and is contained in an **egg** cell. The other half comes from the father and is contained in a **sperm** cell. The fusing of a sperm cell and an egg cell is called **fertilization** (fur tuh luh ZAY shun). The new cell formed from fertilization is called a **zygote** (ZI goht). It develops into a new organism.

What are the advantages of sexual reproduction?

Sexual reproduction is the most common form of reproduction in eukaryotes. The offspring from sexual reproduction receive genetic material from two parents. In every species, sexual reproduction makes a different individual. This means that each individual has a different set of traits. Only identical twins have the same mix of genetic material and that is why they look alike.

The variety of genetic traits in a population is known as genetic diversity. Genetic diversity can help a species survive changing environmental conditions.

MAIN Idea

Meiosis maintains the chromosome number of a species in sexual reproduction.

What You'll Learn

- the importance of meiosis in sexual reproduction
- why offspring resemble their parents

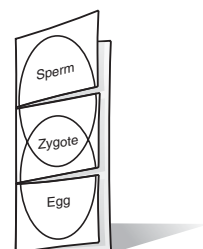
Study Coach

Summarize Main Ideas

Read one paragraph at a time. Then, write one sentence to summarize the main idea in the paragraph.

FOLDABLES™

- A Describe** Make a Venn-diagram Foldable. As you read the lesson, record what you learn about sperm cells and egg cells under the appropriate tabs. Describe the formation of a zygote, or new organism, under the center tab.



Academic Vocabulary
require (ree KWI ur) (verb)
to need


 **Reading Check**

1. Identify one disadvantage of sexual reproduction in organisms.

 **Reading Check**

2. Explain why it is important for reproductive cells to divide in half before they join together to create an offspring.

What are the disadvantages of sexual reproduction?


The major disadvantages of sexual reproduction are the time and energy it requires. Organisms must have food, resources, and time to grow and develop before they can reproduce sexually. It requires energy to produce egg and sperm cells. It also takes energy to transport sperm to the egg for fertilization. Some species require more energy because they produce large quantities of sperm and eggs. Other species produce fewer sperm and eggs, but spend time and energy finding a mate. 

Why is meiosis important?

Meiosis (mi OH sus) is cell division that occurs only in the nucleus of certain reproductive cells, and produces sperm or eggs. Because of meiosis, each sperm cell and egg cell contains half the number of chromosomes that was in the original nucleus.

How does meiosis maintain the diploid number?

The two chromosomes that make a chromosome pair are similar in size, shape, and genetic material, but they are not identical. They are called homologous (huh MAH luh gus) chromosomes. Chromosomes in a homologous pair have genetic material for the same traits, such as hair color or eye color. A cell that contains a pair of homologous chromosomes is a diploid (DIH ployd) cell.

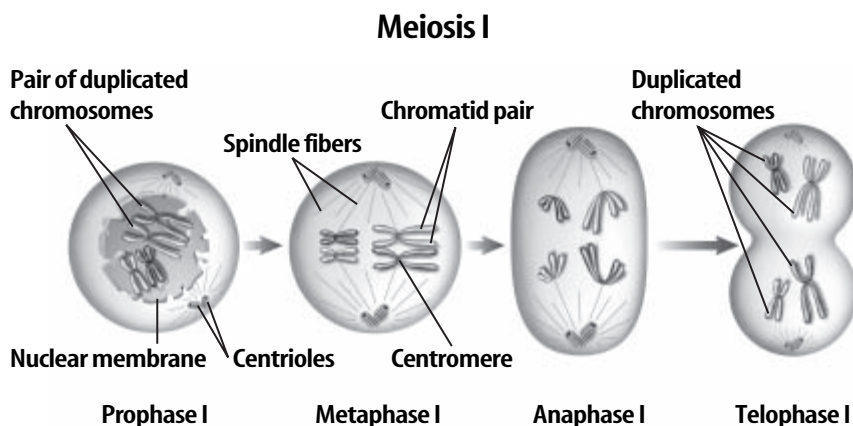
What would happen if two diploid cells fused during fertilization? Each offspring would differ from its parents because it would have twice as many chromosomes as its parents. For a species to continue, it must keep the same number of chromosomes from one generation to the next. For example, humans inherit 46 chromosomes. Without meiosis, the chromosome number would double. Instead of inheriting 46 chromosomes, children would inherit 92 chromosomes. 

How does meiosis create haploid cells?

In meiosis, cells divide and create haploid cells, often called daughter cells. Haploid cells are half the set of the reproductive cell, or parent cell. Haploid cells contain only one chromosome from each homologous pair of the parent cell. Each sperm and egg cell are haploid. When they combine during fertilization, they produce a diploid zygote.

Picture This

3. Determine How many cells form in meiosis I?



What are the phases of meiosis?

The two processes of meiosis are called meiosis I and meiosis II. The phases of each process are called prophase, metaphase, anaphase, and telophase. The figure above illustrates what happens during meiosis I.

What are the phases of meiosis I?

Before meiosis begins, each chromosome is copied. Each copy of the chromosome consists of two identical chromatids, called sister chromatids. The chromatids are held together near their middles, or centromeres.

Prophase I The membrane surrounding the nucleus breaks apart. The copied chromosomes condense and become thick. Then, homologous chromosomes line up close to each other.

Metaphase I The pairs of copied homologous chromosomes line up along the middle of the cell. As you can see in the figure above, the centromere of each chromatid pair attaches to a spindle fiber.

Anaphase I The spindle fibers pull one of each set of sister chromatids to opposite ends of the cell. Each copied chromosome still has two chromatids.

Telophase I A membrane forms around each group of copied chromosomes. Then the cytoplasm divides. At the end of meiosis I, there are two daughter cells. Each new cell has one copied set of chromosomes from each pair of original chromosomes. Sister chromatids are still together. ✓

Academic Vocabulary

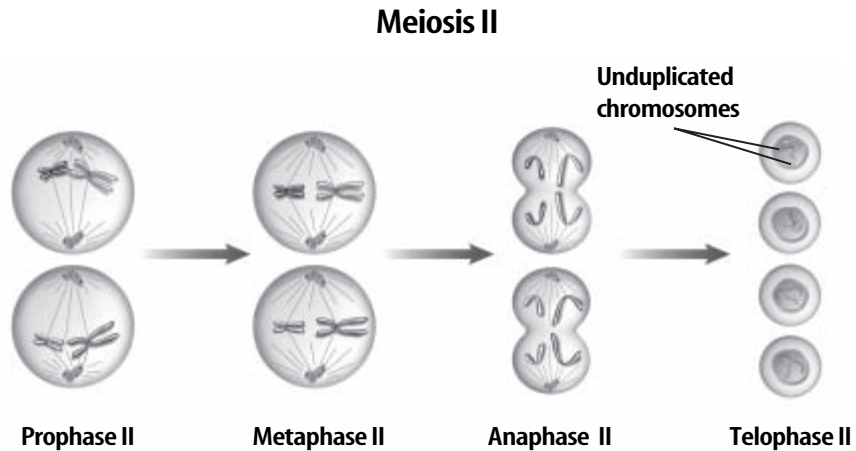
illustrate (IH-lus trayt) (verb)
to make clear using an example or figure

✓ Reading Check

4. Identify How many daughter cells exist at the end of meiosis I?

Picture This

5. State What is the result of meiosis II?



What are the phases of meiosis II?

Each daughter cell formed during meiosis I divides during meiosis II. Meiosis II produces four haploid daughter cells, as shown in the figure above.

Prophase II Chromosomes do not copy themselves before prophase II. The chromosomes move to the center of the cell during prophase II.

Metaphase II Each copied chromosome lines up along the center of the cell.

Anaphase II The sister chromatids of each copied chromosome begin to separate and move to opposite ends of the cells.

Telophase II A nuclear membrane forms around each set of chromatids, now called chromosomes. The cytoplasm then divides, and meiosis II is complete.

What are the results of meiosis?

Meiosis is similar to mitosis, but there are important differences. As you study the chart on the next page, you will notice that both meiosis and mitosis begin with one diploid parent cell. Both meiosis and mitosis take place only in eukaryotic cells. Recall that eukaryotic cells contain a nucleus surrounded by a membrane.

In meiosis, the nucleus of the parent divides twice. The first division happens during meiosis I, the second division occurs during meiosis II. In mitosis, the nucleus only divides once. Meiosis produces four daughter cells. Mitosis produces two daughter cells.

Think it Over

6. Draw Conclusions

Are human hair and skin cells replaced by mitosis or meiosis?

Comparison of Meiosis and Mitosis		
Characteristic	Meiosis	Mitosis
Number of chromosomes in parent cell	diploid	diploid
Type of parent cell	only certain cells of the reproductive systems of eukaryotic organisms	in nearly all eukaryotic cells
Number of divisions of the nucleus	2	1
Number of daughter cells produced	4	2
Chromosome number in daughter cells	haploid	diploid
Functions in the organism	<ul style="list-style-type: none"> • produces sperm and egg cells • maintains species' chromosome numbers in sexually produced offspring 	<ul style="list-style-type: none"> • produces daughter cells genetically identical to each other and parent cell • enables growth of the organism, cell repair, and some reproduction

Meiosis Summary

In this lesson, you learned that sexual reproduction includes fertilization—the fusion of a sperm cell with an egg cell. You also learned that fertilization produces a cell called a zygote. The zygote is a diploid cell. Egg and sperm are called haploid cells.

Sperm and egg cells are produced by meiosis. It is important to remember that all of the eggs or sperm produced by an organism are different. Therefore, each zygote produced by sexual reproduction from the same parents will inherit different genetic material. This genetic variation can be important to the survival of a species.

Picture This

- 7. Determine** Which is a function of meiosis? (Circle your answer.)
- to maintain a species' chromosome number
 - to produce genetically identical cells

Reproduction of Organisms

Lesson 2 Plant Reproduction

Grade Seven Science Content Standard. 5.f. Students know the structures and processes by which flowering plants generate pollen, ovules, seeds, and fruit. **Also covers:** 2.a, 2.b.



MAIN Idea

The life cycle of plants includes a diploid generation and a haploid generation.

What You'll Learn

- reproduction in seedless plants
- reproduction in flowerless and flowering seed plants
- reproductive structures in a flower

Mark the Text

Build Vocabulary Skim each paragraph and circle any words you do not know. After you have read the paragraph, define the circled words. Ask your teacher for help in understanding any words you cannot define.



Think it Over

1. Summarize What are the two generations in the life cycle of all plants?

Before You Read

On the lines below, jot down a list or short description about the flowers, seeds, or nuts you have seen outdoors. Then read the next lesson to learn about the plant life cycle.

Read to Learn

What is alternation of generations?

The only haploid cells in humans are gametes—the egg and sperm cells that join during fertilization to form a diploid zygote. However, the life cycles of plants include haploid and diploid stages, or generations. A life cycle with haploid and diploid generations is said to have alternation of generations.

What is the diploid generation?

During the diploid generation of a plant, certain cells undergo meiosis and produce haploid reproductive structures called **spores**. For some plants, the spore has a hard outer covering and is released from the plant. In other plants, the spore remains within diploid tissues. Spores grow by mitosis and cell division to form the haploid generation of the plant.

What is the haploid generation?

A plant in the haploid generation produces haploid sperm and eggs. Fertilization takes place when a sperm and an egg fuse to form a diploid zygote. This ends the haploid generation. The zygote grows by mitosis and cell division into a new diploid plant.

How do seedless plants reproduce?

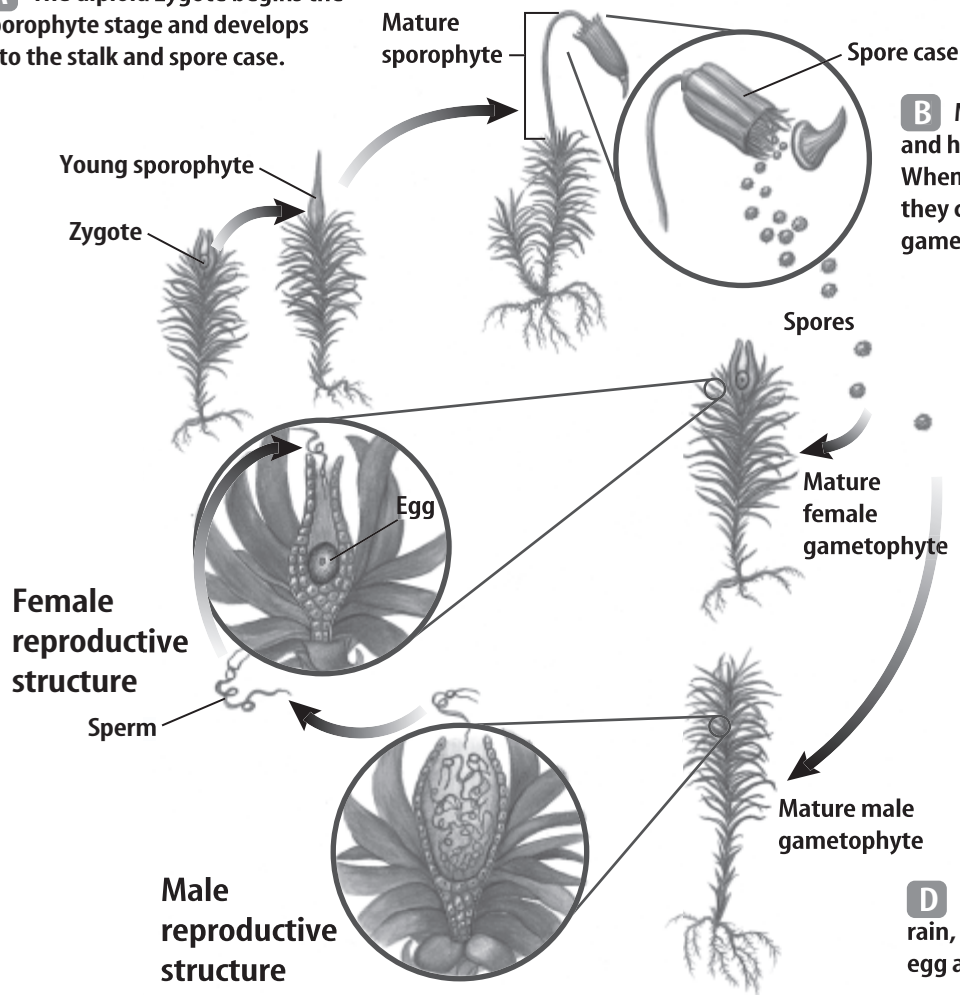
Not all plants grow from seeds. The first land plants to inhabit Earth probably were seedless plants. Seedless plants grow from haploid spores, not from seeds.

The life cycle of a moss is typical for some seedless plants. It begins with haploid spores that grow by mitosis and cell division into haploid plants. The tiny, green moss plants that carpet rocks, bark, and soil in moist areas are haploid plants. They have male structures that produce sperm and female structures that produce eggs. Fertilization results in a diploid zygote that grows by mitosis and cell division into the diploid generation. The diploid generation of mosses is tiny and not easily seen. It produces haploid spores by meiosis, and the cycle repeats, as shown in the figure below.

Picture This

2. Explain Highlight each of the following words in the captions of the figure: *meiosis*, *gametophyte*, *fertilization*, *sporophyte*. Use each of these words as you explain to a partner the life cycle of a moss.

A The diploid zygote begins the sporophyte stage and develops into the stalk and spore case.



B Meiosis occurs in the spore case and haploid spores are produced. When the spores fall to the ground, they can grow into mature gametophytes.

C Sex cells are produced in reproductive structures of male and female moss gametophytes.

D During a heavy dew or rain, the sperm swims to the egg and fertilization occurs.

Reading Check

3. Identify the two groups of seed plants.

FOLDABLES™

B Describe Make a two-tab Foldable. Label the tabs as illustrated. Describe sexual reproduction in gymnosperms and angiosperms under the tabs.



How do seed plants reproduce?

Most of the land plants that cover Earth grew from seeds. Plants that grow from seeds are called seed plants. There are two groups of seed plants—flowerless seed plants and flowering seed plants. ✓

What is the role of pollen grains?

A **pollen** (PAH lun) **grain** forms from tissue in a male reproductive structure of a seed plant. Each pollen grain contains nutrients and has a hard, protective outer covering. Sperm cells form inside pollen grains. Wind, animals, gravity, or water currents can carry pollen grains to female reproductive structures. Plants cannot move and find a mate like most animals can. Pollination (pah luh NAY shun) is when pollen grains land on a female reproductive structure of a plant that is the same species as the pollen grains.

What is the role of ovules and seeds?

The female reproductive structure of a seed plant contains one or more **ovules**. A haploid egg develops inside each ovule. Pollination is when the male pollen is brought to the female ovule. Sperm in the pollen enter the ovule and fertilization occurs.

A **seed** develops from an ovule after fertilization of the egg. It consists of an embryo, a food supply, and a protective covering. The **embryo** (EM bree oh) is an immature diploid plant. It developed from the zygote that formed after fertilization. A seed's food supply provides the embryo with nourishment for its early stages of growth.

How do flowerless seed plants reproduce?

Flowerless seed plants are called gymnosperms (JIHM nuh spurmz). The word gymnosperm means 'naked seed.' Gymnosperm seeds are not surrounded by a fruit. The most common gymnosperms are conifers. Conifers are trees and shrubs with needlelike or scalelike leaves. They include pines, firs, cypresses, redwoods, and yews. Most conifers are evergreen and can live for many years. The male and female reproductive structures of conifers are cones. Cones contain the haploid generation. Male cones produce pollen grains, and female cones produce eggs. Following pollination and fertilization, seeds form as part of the female cone.

How do flowering seed plants reproduce?

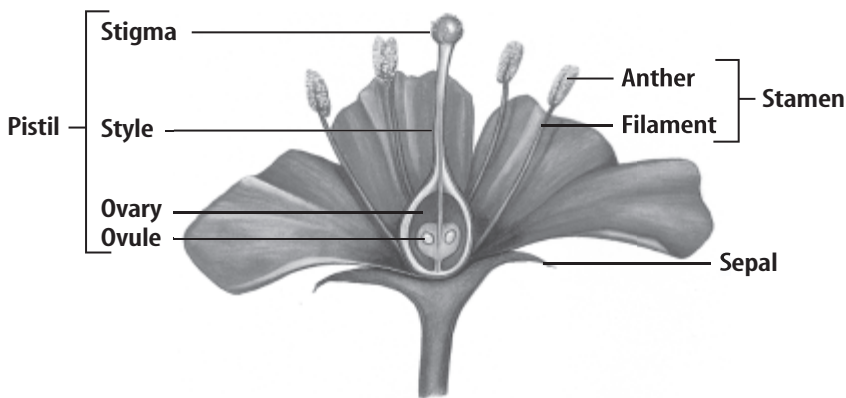
Flowering seed plants are called **angiosperms** (AN jee uh spurmz). Most of the plants you see around you are angiosperms. Almost all of the fruits and vegetables you eat come from angiosperms. Many animals depend on angiosperms for food. About 250,000 species of angiosperms live on Earth today.

What role does the flower play in reproduction?

Reproduction of an angiosperm begins in a flower. A typical flower has male and female reproductive organs surrounded by petals, as shown below. Most flowers have several male reproductive organs but only one female reproductive organ. Some flowers have only male or only female organs.

The male reproductive organ of a flower is the **stamen**. Pollen grains form at the tip of the stamen, in a structure called the **anther**. The **filament** is a long stalk that supports the anther and connects it to the base of the flower.

The female reproductive organ of a flower is the **pistil**. At the tip of the pistil is the stigma, where pollen can land. The **stigma** is at the top of a long tube called the **style**. At the base of the style is the **ovary**. One or more ovules are usually found in the ovary. Each ovule will eventually contain a haploid egg.



Scarlet pimpernel



Think it Over

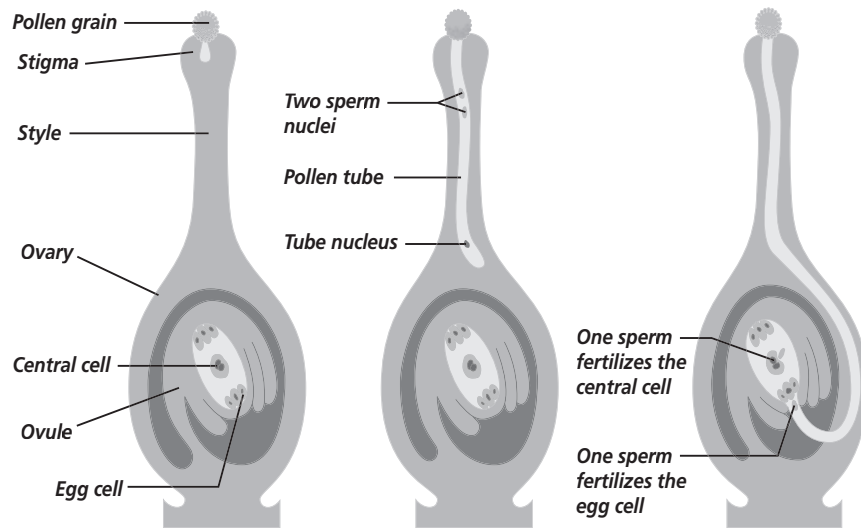
- 4. Apply** Name two fruits or vegetables you have eaten this week.

Picture This

- 5. Locate** Highlight the male reproductive structure. Circle the female reproduction structure.

Picture This

6. Identify Trace the growth of the pollen tube in the final drawing. What has traveled down the pollen tube?



Academic Vocabulary

occur (uh KUR) (verb) to happen; to come into existence

What is an angiosperm's life cycle?

In the typical life cycle for an angiosperm, pollen grains released from the anther travel to the stigma where pollination occurs, as shown above. A structure called a pollen tube grows from the pollen grain into the stigma, down the style, to the ovary at the base of the pistil. Sperm develop from a haploid cell in the pollen tube. When the pollen tube enters the ovule, the sperm are released from the pollen tube.

Fertilization takes place when a sperm fuses with an egg in an ovule of the ovary. The zygote that results from fertilization develops into an embryo. Each ovule and its embryo will become a seed. The ovary, and sometimes other parts of the flower, will enlarge and mature into a fruit that contains one or more seeds. The seeds can sprout and grow into new plants. These plants are genetically related. When the new plants produce flowers, the cycle repeats.

What is fruit and seed dispersal?

Fruits help protect seeds and help scatter or disperse them. For example, some fruits, like that of a dandelion, are light enough to float on air currents. When an animal eats a fruit, the fruit's seeds can pass through the animal's digestive system with little or no damage. For example, a bird eats blackberries. The seeds travel through the bird's digestive system and are deposited on the soil with its wastes. By the time this happens, the bird might have traveled some distance away from the blackberry bush. This means that the animal helped to disperse the seed away from the blackberry bush.



Think it Over

7. Predict Can plants and animals survive without each other? Explain.

Plant Reproduction Summary

In this lesson, you learned that plants reproduce sexually. All plant life cycles include an alternation of generations. That is, plant life cycles alternate between a haploid generation and a diploid generation. Most of the plants you see around you, including trees, flowers, and grasses, are the diploid generation.

Mosses are haploid plants that grew from a haploid spore. The diploid stage in mosses is small and often overlooked. Ferns are diploid plants. The haploid stage in ferns is small and rarely seen. Conifers and flowering plants are diploid seed plants. Diploid seed plants reproduce by forming seeds. In conifers, seeds form as part of a female cone. In flowering plants, seeds form as part of a flower. The haploid stage of seed plants is surrounded by diploid tissue.

Reading Check

8. Identify From which part of the plant life cycle is grass?

Reproduction of Organisms

Lesson 3 Animal Reproduction

Grade Seven Science Content Standard. 2.a. Students know the differences between the life cycles and reproduction methods of sexual and asexual organisms. **Also covers:** 2.b.



MAIN Idea

Animals have specialized structures for sexual reproduction.

What You'll Learn

- the differences between internal and external fertilization
- how embryos develop differently in animals

Mark the Text

Highlight the main idea in each paragraph. Then underline one point that supports the main idea.

Picture This

- 1. Identify** Where are eggs produced? (Circle your answer.)
- ovaries
 - testes

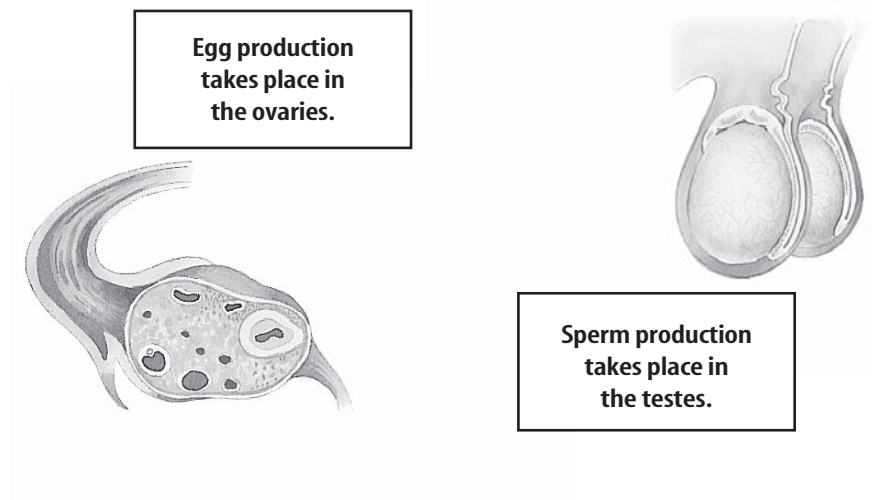
Before You Read

On the lines below, write the names of animal species that have different physical characteristics for males and females. Then read on to learn about the specialized reproductive structures of male and female animals.

Read to Learn

What are animal reproductive organs called?

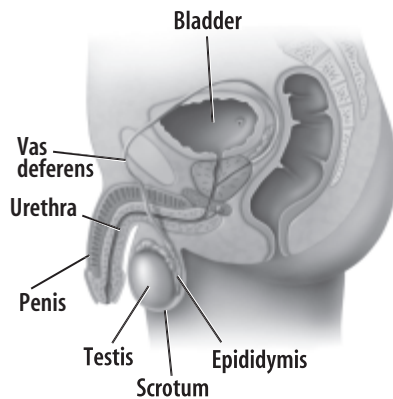
Most animal species that reproduce sexually have separate male and female organisms. Animals often have external physical characteristics that distinguish males from females. In mammals and birds, males are often larger or more colorful than females. The reproductive systems of both male and female animals include specialized reproductive organs called **gonads**, as shown below, that produce sperm or eggs.



What are the male reproductive organs?

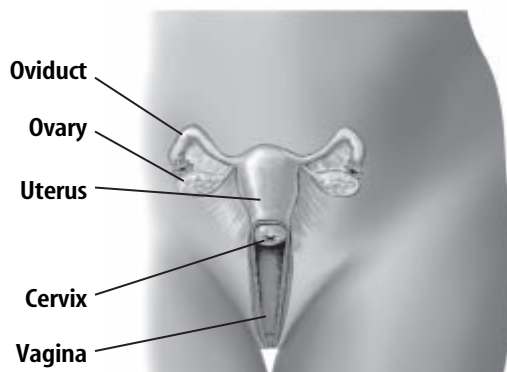
Male animals have gonads called **testes** (TES teez) (singular, testis) that produce sperm, as shown below. Testes contain a network of coiled tubes in which sperm cells form. Sperm have tails that help them to swim through fluid to reach an egg cell. Most male animals have two testes located inside, or near, the abdomen.

Vertebrate animals—animals with backbones—have an additional adaptation for sexual reproduction. Male vertebrates have a gland near the testes which produces fluid that nourishes sperm. This helps sperm travel from the testes to the female's egg.



What are the female reproductive organs?

Female animals have gonads called **ovaries**. Most female animals have two ovaries as shown in the illustration below. However, most female birds have only one ovary. Ovaries produce egg cells. Eggs are larger than sperm and cannot move on their own. Many female mammals are born with all the eggs they will ever have.



Picture This

- 2. Identify** Underline the name of the structure that produces sperm.

Picture This

- 3. Infer** When an egg is released from the ovary, through what structure will it have to travel to reach the uterus?
-

How does animal fertilization occur?

Sexual reproduction requires fertilization. Fertilization is the joining or fusion of a haploid egg cell and a haploid sperm cell. A diploid zygote is the result of fertilization. The way in which a sperm reaches the egg differs from one animal species to another.

What is internal fertilization?

When fertilization happens inside the body of an animal, it is called internal fertilization. For many animals, the male has a specialized structure that can deposit sperm in or near a female's reproductive system. The sperm swim to the egg or eggs. Earthworms, spiders, insects, reptiles, such as the turtle, below, birds, and mammals have internal fertilization.

Internal fertilization ensures that an embryo is protected in the egg's shell until it hatches, or in the case of mammals, until it leaves the female's body. This protection increases the chance that the embryo will survive, develop into an adult, and reproduce.



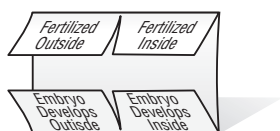
Picture This

4. Determine This newly hatched turtle is making its way to the ocean. Where did it hatch? (Circle your answer.)

- a. on the beach
- b. in the ocean

FOLDABLES™

Compare Make a four-door Foldable. Label the front tabs as illustrated. Under the tabs, describe and compare internal and external fertilization and internal and external development.



What is external fertilization?

External fertilization occurs outside of an animal's body. In most cases of external fertilization, the female animal releases eggs into water. At about the same time a nearby male animal of the same species releases sperm into the water. When a sperm reaches an egg, fertilization occurs. Animals that reproduce using external fertilization include jellyfishes, clams, sea urchins, sea stars, and many species of fish.

Most animals that reproduce using external fertilization do not take care of the fertilized eggs. The eggs and young are exposed to predators and other dangers in the environment. The dangers reduce their chances of surviving. Large numbers of eggs are produced by animals with external fertilization. This helps to ensure that some offspring will survive to become adults that reproduce.

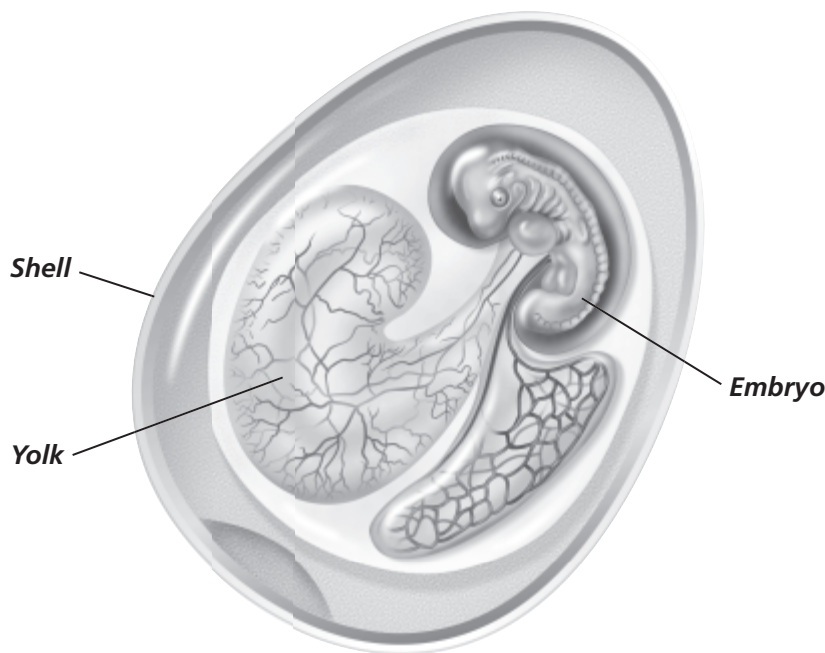
How do animal embryos develop?

The zygote produced by fertilization is only the beginning of an animal's life. Growth of the zygote and other stages of an animal's life happen by mitosis and cell divisions. The zygote grows to an embryo (EM bree oh)—the next stage in an animal's life. A growing embryo needs nutrition and protection from predators and other dangers in the environment.

Different animals have different ways of supplying the needs of an embryo. In some animals, the embryo develops outside the body of the mother. In others, the embryo develops inside the mother.

How do some embryos develop outside their mother?

Most animal embryos develop outside the mother. In most instances, one embryo develops inside each egg, as illustrated in the figure below. Some kind of protective covering surrounds the egg. The covering protects the embryo, helps keep it moist, and discourages predators. Each egg laid by a lizard, snake, and other reptile has a tough, leathery covering. A tough, jellylike substance usually surrounds eggs laid under water. Bird eggs have a hard covering called a shell. Most eggs contain a yolk that provides a food supply for the developing young.



Think it Over

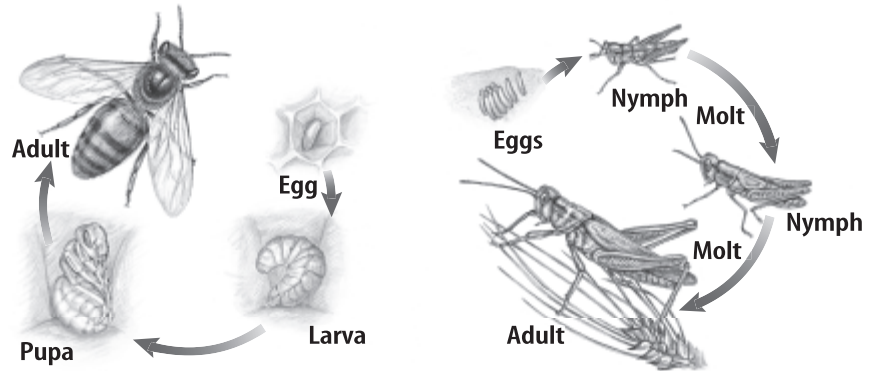
- 5. Predict** Which embryo is more likely to survive? (Circle your choice.)
- an embryo that develops inside its mother
 - an embryo that develops outside in the environment

Picture This

- 6. Locate** Highlight the egg's food supply. Circle the egg's hard covering.

Picture This

7. Identify Highlight the names of the stages that are the same for the grasshopper's metamorphosis and the fly's metamorphosis.



What embryos develop inside their mother?

The embryos of some animals, including most mammals, develop inside the mother. These embryos get nourishment from the mother. An organ or tissue transfers nourishment from the mother to the embryo. However, some embryos, such as those of some snakes, insects, and fishes, develop in an egg with a yolk that is inside the mother. The yolk, not the mother, provides nourishment for the developing young. The young hatch from the eggs while they are inside the mother and then leave the mother's body.

The table below shows how the time between fertilization and the birth of the young depends on the size of the animal and how well developed it is at birth.

Time Between Fertilization and Birth for Some Mammals	
Mammal	Average Number of Days
Mice	21
Dogs	60
Humans	266
Cows	270
Elephants	600

Picture This

8. State Which mammal has the longest period between fertilization and birth?

What is gestation?

The length of time between fertilization and birth of an animal is called gestation. Gestation varies from species to species. Gestation usually relates to the size of the animal at birth—the smaller the animal, the shorter its gestation. For example, gestation for a mouse is about 21 days; a dog, about 60 days; and humans, about 266 days. ✓

How does the gestation of kangaroos differ from most other mammals?

The gestation of a kangaroo is unusual. Gestation for a kangaroo is 35 days. A kangaroo is about 2.5 cm at birth. The newborn kangaroo crawls into a pouch on the mother's abdomen where it continues to develop and grow until it can live on its own.

Animal Reproduction Summary

In this lesson, you learned how animals reproduce sexually. Males produce sperm in organs called testes. Females produce eggs in organs called ovaries. Internal fertilization takes place inside the female's reproductive system. External fertilization takes place in the environment.

Embryos that develop inside the body of the female are nourished and protected until they leave the female's body at birth. Embryos that develop outside the body of the female most often develop inside an egg. An egg has a yolk that provides nourishment to the developing embryo. An egg also has a protective covering.

✓ Reading Check

9. Define What is gestation?

Academic Vocabulary
external (ek STERN ul) (adj.)
on the outside

Reproduction of Organisms

Lesson 4 Asexual Reproduction

Grade Seven Science Content Standard. 2.a. Students know the differences between the life cycles and reproduction methods of sexual and asexual organisms. **Also covers:** 2.b.



MAIN Idea

Asexual reproduction produces offspring that are identical to the parent.

What You'll Learn

- how organisms reproduce with only one parent
- how cloning makes an identical reproduction of the parent

● Before You Read

Have you ever seen a science fiction movie or film about a person who has an exact double, or clone? Do you think that this can happen in real life? Think about and respond below to this question: Would you like to have a clone of yourself? Why or why not? Read on to learn about asexual reproduction and cloning.

Study Coach

Create a Chart Draw a two-column chart. Label one column Advantages. Label the other column Disadvantages. List the advantages and disadvantages of asexual reproduction in the correct column of the chart.

● Read to Learn

What is asexual reproduction?

Asexual reproduction is the production of offspring by one parent without a sperm and an egg joining. Asexual reproduction results in offspring that are genetically identical to the parent organism.

What are the advantages of asexual reproduction?

Unlike sexual reproduction, asexual reproduction does not require a mate. Therefore, an asexually reproducing organism does not have to spend time and energy finding a mate. Another advantage of asexual reproduction is the time that it takes to produce offspring. To reproduce a number of offspring asexually takes less time than to reproduce the same number of offspring sexually. Also, to reproduce an organism asexually that is well adapted to its environment always results in offspring that are equally well adapted to the same environment. ✓

✓ Reading Check

- 1. Identify** Which method of reproduction takes the least time? (Circle your answer.)
 - a. sexual reproduction
 - b. asexual reproduction

What are the disadvantages of asexual reproduction?

The major disadvantage of asexual reproduction is the lack of genetic diversity. Genetic diversity in a population increases the chances that a few individuals will survive a change in the environment.

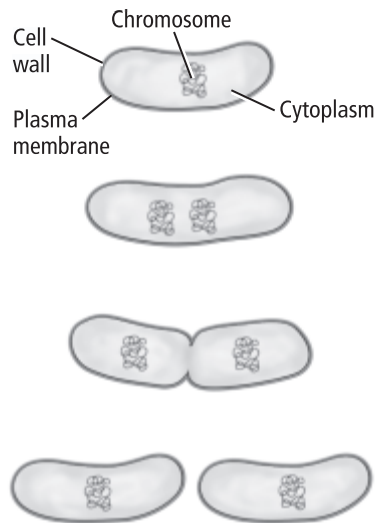
Another disadvantage of asexual reproduction involves genetic changes, or mutations, that can occur. A harmful mutation in cells of an organism might be passed along to offspring reproduced asexually. This could affect the offspring's ability to survive.

What are the types of asexual reproduction?

There are many types of asexual reproduction. However, each type involves cell division. Prokaryotes reproduce asexually by cell division that does not involve mitosis. Asexual reproduction in eukaryotes happens by mitotic cell division.

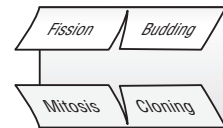
What is fission?

Bacteria are prokaryotic organisms. A bacterium has a small, circular DNA chromosome but no nucleus. Bacteria reproduce asexually by a process called fission, as shown in the figure below. **Fission** produces two cells with identical DNA. Asexual reproduction by fission can occur rapidly. *E. coli*, a species of bacteria found in human intestines, can reproduce asexually every twenty minutes.



FOLDABLES™

D Explain Make a four-door Foldable. Label the front tabs as illustrated. Under the tabs, sketch and explain each type of asexual reproduction: fission, budding, mitosis, and cloning.



Picture This

2. Identify Circle the stage of fission in which the chromosomes first replicate.

Academic Vocabulary
individual (ihn duh VID yew ul)
(adj.) single

 **Reading Check**

3. Identify a plant and an animal that can reproduce through budding.

Picture This


4. Determine How many organisms were needed to produce the strawberry runner?

What is mitotic cell division?

Diatoms are single-celled eukaryotes. They reproduce asexually by mitotic cell division. Mitotic cell division is mitosis followed by cell division. Mitotic cell division produces two genetically identical daughter cells from one cell. Asexual reproduction in a single-celled eukaryote also produces two daughter cells, except that each daughter cell is an individual organism.

What is budding?

Yeasts are single-celled eukaryotes related to mushrooms. Yeast cells reproduce by budding. Some multicellular animals, like the hydra, can also reproduce by budding.

Budding is asexual reproduction in which a new organism forms on the parent organism. The new organism is called a bud and forms by mitosis and cell division. It is genetically identical to the parent. The offspring eventually separates from the parent to live on its own. 

What are plant cuttings?

Many plants reproduce sexually. But some plants can also reproduce asexually. If you cut a green stem from a houseplant and place it in water, roots and leaves can grow and produce a new plant. A stem cutting is genetically identical to the parent plant. Leaf cuttings or root cuttings may also be used to grow some plants.

Some plants reproduce asexually without any help from people. Strawberry plants can produce new plants along stems that grow on the surface of the ground, as shown in the figure below.



What is animal regeneration?

Recall that the process in which cells in an embryo become different types of cells is called cell differentiation. But, as you just read, some plant cells can re-differentiate. That is, some plant cells can change from one cell type and grow into other cell types. You also read that differentiated human cells cannot change and grow into other cell types. However, some animals have cells that can do this.

Asexual reproduction that produces new animals from pieces of an animal's body is **regeneration**. A planarian can asexually reproduce by regeneration. It pinches inward at the center of its body and breaks in half. Each half can grow the missing parts. The two new organisms are genetically identical. ✓

What is cloning?

In the past, the term *clone* was often used to describe the asexually produced, genetically identical offspring of an organism. Today, however, **cloning** usually refers to a method of asexual reproduction developed by scientists and performed in laboratory environments. Cloning produces identical individuals from a cell or from a cluster of cells taken from a multicellular organism.

What is plant cloning?

Plant tissue **culture** is a cloning method that enables plant scientists to produce genetically identical plants from a few plant cells grown in a test tube. Plant tissue culture can be used to produce thousands of identical plants from one plant that has desirable genetic traits. Genetic traits that scientists want to clone include high nutritional value and rapid growth rates.

What is animal cloning?

In 1996, scientists in Scotland cloned a female sheep that they named Dolly. Since then, scientists have cloned other animals, including mice, cows, and a horse.

Cloning animals is a complex process. Although several cloned animals have been produced successfully, they often are not as healthy as animals produced by other reproduction methods. Some animal clones, including Dolly, have had a much shorter life span than animals produced by other reproductive methods. Animal cloning raises ethical issues that people are concerned about. For example, many people think that the cloning of humans should never be allowed.

✓ Reading Check

5. Define What is regeneration?

Academic Vocabulary
culture (KUL chur) (verb) to grow in a prepared medium



Think it Over


6. Draw Conclusions

How might plant tissue cultures help ease the problem of hunger in the world?

 **Reading Check**

7. Determine How does the genetic material of the offspring in asexual reproduction compare to its parent?

Asexual Reproduction Summary

In this lesson, you read that many organisms reproduce asexually, which means they have only one parent. The offspring of asexual reproduction have identical genetic material to their parent. 

Bacteria reproduce asexually by fission. Fission is a type of cell division. Some eukaryotes, including yeast, reproduce asexually by budding. Other eukaryotes reproduce asexually by mitosis and cell division. Parts of plants can grow into new plants. In some animals, a body part can regenerate and form a new individual.

Lesson 1 Foundations of Genetics

Grade Seven Science Content Standard. 2.b. Students know sexual reproduction produces offspring that inherit half their genes from each parent.
Also covers: 2.d.



● Before You Read

On the lines below, explain why you think all dogs from a breed, such as poodles or dalmations, look so much alike. Then read the lesson to learn about how traits are passed from parents to offspring.

● Read to Learn

Early Ideas about Heredity

Recall that a sperm and an egg contain genetic material that combines at fertilization. When the genetic material combines, the traits of an offspring are determined.

Heredity is the passing of traits from parents to offspring.

People used to think that the genetic material from a sperm cell and an egg cell was blended because offspring resembled both parents. Blending inheritance is the idea that offspring are a blend of genetic material from both parents. However, the concept of blending inheritance cannot explain why some traits appear to skip generations, such as two brown-eyed parents having a blue-eyed child. Gregor Mendel helped to answer some of the questions about inheritance.

Gregor Mendel and His Experiments

Gregor Mendel was the first person to record evidence that traits of organisms are passed from parents to offspring, and so establish the basic laws of heredity. Because of his experiments in the mid-1800s, Mendel is known as the father of genetic science. **Genetics** (juh NE tihks) is the study of how traits of organisms are passed from parents to their offspring.

MAIN Idea

Gregor Mendel discovered the basic principles of genetics.

What You'll Learn

- how to model Mendel's experiments
- Mendel's two laws of heredity
- to distinguish between the phenotype and genotype of a trait

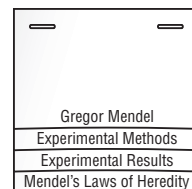
Mark the Text















Identify the Main Point

Highlight the main point of each section. Use a different color to highlight a detail or example that may help you understand the main point.

FOLDABLES™

- A Explain** Make a layered Foldable. As you read the lesson, record what you learn about Gregor Mendel's experimental methods, results, and laws of heredity under the tabs. Explain the importance of Mendel's genetic studies.



Traits Compared by Mendel							
Traits	Shape of Seeds	Color of Seeds	Color of Pods	Shape of Pods	Plant Height	Position of Flowers	Flower Color
Dominant Trait	 Round	 Yellow	 Green	 Full	 Tall	 At leaf junctions	 Purple
Recessive Trait	 Wrinkled	 Green	 Yellow	 Flat, constricted	 Short	 At tips of branches	 White

Picture This

2. Identify How many traits did Mendel study?

Reading Check

3. Explain Why was it important that Mendel controlled the fertilization of the pea plants?

What were Mendel's experimental methods?

Mendel conducted breeding experiments with pea plants, which have flowers that are easy to grow. He chose pea plants because they reproduce quickly and come in many varieties. Study the table above. You can see seven different traits of pea plants. Each trait had only two variations. For example, flower color was either purple or white.

Mendel controlled the fertilization in the pea plants. He could then observe how traits passed from one generation to the next. Recall from Chapter 3 that a flower contains male reproductive organs called stamens. A female reproductive organ is called a pistil. The flowers of pea plants have both stamens and pistils. Mendel allowed some of the plants to self-fertilize as they do in nature. He also cross-fertilized by transferring pollen from one pea plant to another.

True-Breeding Plants Mendel was not the first person to breed, or cross, plants, but his experiments were unique. Mendel used true-breeding plants for each trait. That means that when these plants self-pollinate, they always produce offspring with that trait. For example, when pea plants that are true-breeding for wrinkled seeds self-pollinate, they only produce offspring with wrinkled seeds. Mendel also recorded the inheritance of traits for several generations. Mendel used a mathematical approach. He bred large numbers of plants and counted the number of each kind of offspring. This allowed him to collect and record large amounts of numerical data.

What did Mendel conclude from his experiments?

Mendel concluded that two factors control each inherited trait. He also proposed that when organisms reproduce, each gamete contributes one factor for each trait.

What are dominant factors?

Mendel often crossed true-breeding plants to create hybrids. A hybrid inherits a different form of a trait from each parent. For example, when Mendel crossed a true-breeding, purple-flowered plant with a true-breeding, white-flowered plant, the next generation of hybrid offspring had purple flowers. Can you guess why there were no plants with white flowers? Mendel believed that all the offspring had one genetic factor for purple flowers and one genetic factor for white flowers. He hypothesized that the purple factor blocked the white factor. A genetic factor that blocks the presence of another genetic factor is called **dominant** (DAH muh nunt). If just one dominant factor exists in offspring, the dominant trait, such as purple flower color in pea plants, is observed. ✓

What are recessive factors?

A genetic factor that is hidden by the presence of a dominant factor is called **recessive** (rih SE sihv). When two recessive genetic factors are present in offspring a recessive trait can be observed. An example would be a white flower color in pea plants.

Mendel's Laws of Heredity

Mendel was able to make predictions about how traits are inherited. His predictions are called Mendel's laws of heredity. There are two laws of heredity: the law of segregation and the law of independent assortment. According to the law of segregation, the two factors for each trait segregate, or separate, from each other during meiosis when gametes form. Go back to Chapter 3 for a reminder of how this occurs. ✓

Mendel's law of independent assortment states that the factors for one trait separate independently of how factors for other traits separate, and gametes have all possible combinations of traits. For example, the separation of the two factors for seed color does not affect how the two factors for seed shape separate.

Academic Vocabulary
conclude (kun KLEWD) (verb)
to make a reasoned decision

✓ Reading Check

4. Define What is a dominant factor?

✓ Reading Check

5. State Mendel's two laws of heredity.

Modern Definitions of Mendel's Ideas

Although Mendel did not know about DNA or how cells reproduce, his ideas about inheritance have proven true. The terms used to describe his ideas have changed over time, however.

What are genes and alleles?

A chromosome is made up of DNA and proteins. A **gene** (JEEN) is a section of DNA that has information about a specific trait of an organism. The gene's information about a trait can be different even among the same kind of organisms. As you know, Mendel used pea plants with purple or white flowers. Each pea plant had a gene for flower color. Each plant's gene had either purple or white information. Each form of a gene with different information is called an **allele** (uh LEEL). Mendel called these *factors* instead of alleles. Scientists now know that the alleles of a gene are at the same locations on a pair of homologous chromosomes.

Reading Check

- 6. Explain** What is the difference between a factor and an allele?

Think it Over

- 7. Apply** How would you describe your own phenotype?

What are phenotypes?

How would you describe a dog you have seen? You might say that the dog has a lot of hair, short legs, a long nose, and a loud bark. These observable traits and all characteristics of an organism make up the organism's **phenotype** (FEE nuh tipe). You know that an organism can have different levels of organization, such as organ system, organ, tissue, and cell. Each level of organization has a phenotype. An organism's phenotype includes not only its physical appearance, but also how its organs function, how it reproduces, and many other characteristics.

What are genotypes?

An organism's phenotype results from the interactions of its alleles and genes. The alleles that make up an organism is the organism's **genotype** (JEE nuh tipe). An organism's genotype can refer to one or more genes. The alleles of a particular gene is that gene's genotype.

Eukaryotic organisms have pairs of chromosomes. A genotype for a gene, therefore, consists of two alleles. If the two alleles have the same information, their genotype is called **homozygous** (hoh muh ZI gus). If the two alleles for a gene have different information, their genotype is called **heterozygous** (he tuh roh ZI gus).

What are possible genotypes?

The possible genotypes for the smooth pea phenotype are SS and Ss . Uppercase letters represent dominant alleles, and lowercase letters represent recessive alleles. Both of these genotypes result in a smooth phenotype because the S allele is dominant over the s allele. The wrinkled phenotype is possible only if the two recessive alleles— ss —are present. ✓

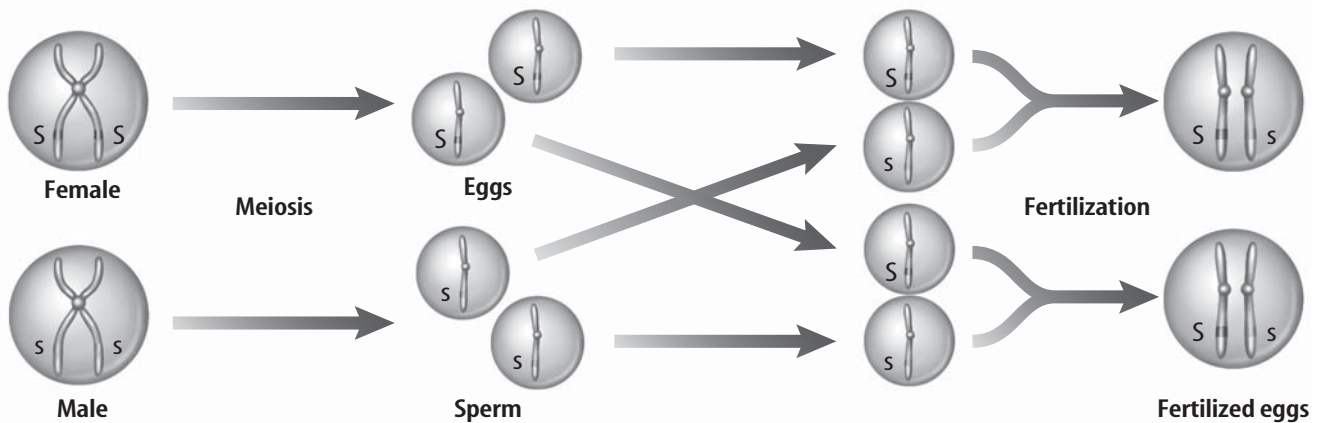
How is the law of segregation explained?

Mendel's **law of segregation** states that two factors for each trait segregate, or separate, from each other during gamete production. In meiosis, homologous-chromosome pairs separate from each other (as shown below in part A). Then, each set of chromatids that make up a replicated chromosome separates into different gametes—egg and sperm (see part B, below). Each gamete only receives one allele (see part C, below).

Reading Check

8. State How are dominant alleles represented in writing?

Chromosomes Separate During Meiosis



A The alleles that control a trait are located on each duplicated chromosome.

B During meiosis, duplicated chromosomes separate.

C During fertilization, each parent donates one chromosome. This results in two alleles for the trait in the new individual formed.

What is the law of independent assortment?

Mendel stated that the separation and movement of two factors for a trait is independent of the separation and movement of the factors for other traits. He called this the **law of independent assortment**. This also explains the movement of chromosomes during meiosis. The daughter cells produced by meiotic cell division receive only one chromosome from each pair of homologous chromosomes. This results in four possible allele combinations for two homologous pairs of chromosomes.


Picture This

9. Explain How does the genotype of the offspring differ from the parents' genotypes in this figure?

 **Reading Check**

10. Explain Why are Mendel's studies important?

Importance of Mendel's Genetic Studies

Mendel's findings were not studied by scientists for many years. In the mid-1800s, no one understood the concept of chromosomes or the process of meiosis. In the 1900s, scientists rediscovered Mendel's work. Now, all research involving modern genetics is based on Mendel's work with pea plants. 

Mendel's Studies: A Summary

Mendel paved the way for future scientists. Mendel's principles about genetics listed below still hold true today for many characteristics.

- Distinct factors, or alleles, refer to an organism's traits that pass from parent to offspring.
- An individual has two alleles for each trait—one from each parent.
- An allele might not be observed in one generation if it is recessive.
- The two alleles for each trait can be the same (homozygous) or be different (heterozygous).
- The two alleles for each trait segregate or separate, from each other during meiosis. This is called the law of segregation.
- The separation and movement of the two alleles for a trait during meiosis is independent of the separation of the alleles for other traits. This is called the law of independent assortment.

Lesson 2 Understanding Inheritance

Grade Seven Science Content Standard. 2.c. Students know an inherited trait can be determined by one or more genes. Also covers: 2.b, 2.d.



● Before You Read

Think about a friend's face and, on the lines below, write down the difference between his or her face and your own. Then read the lesson to learn about the inheritance of traits.

● Read to Learn

Modeling Inheritance

How do plant and animal breeders know how traits will appear in an offspring? The two tools breeders use to identify and predict traits among genetically related individuals are called a Punnett square and a pedigree.

What is a Punnett square?

If the genotypes of the parents are known, then the different genotypes and phenotypes of the offspring can be predicted. A **Punnett square** is a model used to predict possible genotypes and phenotypes of offspring.

In the first figure at the top of the next page, you will see a Punnett square of the possible offspring of homozygous parents—a true-breeding pea plant for yellow seeds and a true-breeding pea plant for green seeds. *Y* represents the dominant allele for yellow seeds, and *y* represents the recessive allele for green seeds. The Punnett square shows that the only possible genotype for hybrid offspring is heterozygous—*Yy*.

The true-breeding pea plant for yellow seeds only can contribute a *Y* allele, and the true-breeding pea plant for green seeds only can contribute a *y* allele. All of the offspring will have the genotype *Yy*. The phenotype will be one trait, yellow seeds, because *Y* is dominant to *y*.

MAIN Idea

Interactions among alleles, genes, and the environment determine an organism's traits.

What You'll Learn

- to interpret a Punnett square and a pedigree
- to distinguish between multiple alleles and polygenic inheritance

Mark the Text

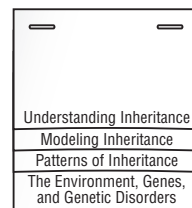
Focus on Vocabulary

As you read the text, underline any words that you do not know. Write the word on the left-hand side of your paper and a definition on the right-hand side.

FOLDABLES™

B Record Information

Make a layered Foldable. As you read the lesson, define, describe, and record what you learn about Punnett squares, patterns of inheritance, and genetic disorders under the tabs.



Picture This

2. Identify In the second figure to the right, shade the squares that represent offspring with yellow seeds.

		True-Breeding Yellow Seed	
		Y	Y
True-Breeding Green Seed	y	Yy	Yy
	y	Yy	Yy

		Heterozygous Seed	
		Y	y
Heterozygous Seed	Y	YY	Yy
	y	Yy	yy

Hybrid-Cross Model What if two of these hybrid offspring were crossed? What would a Punnett square then look like? Examine the second figure, above. The second Punnett square is the cross between two of these heterozygous genotypes—Yy and Yy. The offspring from this cross may include three different genotypes but only two phenotypes, or two traits. Three-fourths, or 75 percent, of the offspring will have yellow seeds (either YY or Yy) and one-fourth, or 25 percent, will have green seeds (yy). In other words, for every four seeds, three should be yellow, and one should be green. Another way to state this is through a ratio. The ratio in this case would be 3:1. This does not mean that every group of four seeds will have three yellow seeds and one green. When studying genetics, you have to count a large number of offspring in order to get accurate results. Mendel determined this fact during his experiments. The more individuals that are counted, the closer the actual numbers will be to the predictions. ✓

✓ Reading Check

3. Explain Why do a large number of offspring have to be counted in order to get accurate results?

What are pedigrees?

Have you ever looked at your family tree? All genetically related members of a family are part of a family tree. A **pedigree** shows the genetic traits that were inherited by members of a family tree. A pedigree usually only indicates the phenotype of individuals. The genotypes of the individuals might not be known but often can be determined.

When looking at a pedigree, you will see circles and squares. Circles represent females, and squares represent males. Connecting lines indicate relationships among members of the family tree. For example, a line connects a set of parents. Branching lines below the parents show their offspring. Pedigrees track common inherited traits. Pedigrees are also important tools in tracking complex patterns of inheritance and genetic disorders in families.

Complex Patterns of Inheritance

Mendel studied traits only influenced by one gene with two alleles. We know now that some inherited traits have complex patterns of inheritance.

What are types of dominance?

Recall what you learned from Lesson 1 about dominant alleles and recessive alleles. The presence of one dominant allele results in a dominant phenotype in a pea plant. Not all allele pairs, however, have a dominant-recessive interaction. ✓

What is incomplete dominance?

Sometimes it seems that traits are blends of alleles. Alleles show incomplete dominance when they produce a phenotype that is a blend of the parents' phenotypes. For example, a pink camellia flower results from incomplete dominance. If you cross a white camellia flower and a red camellia flower, you will get a camellia with pink flowers.

What is codominance?

Another type of interaction between two alleles is the human blood type AB. When both alleles can be observed in a phenotype, this type of interaction is called codominance. If you inherited the B allele from one parent and an A allele from the other parent, you will have type AB blood.

Human ABO Blood Types	
Phenotype	Possible Genotypes
type A	$I^A I^A$ or $I^A i$
type B	$I^B I^B$ or $I^B i$
type O	ii
type AB	$I^A I^B$

What are multiple alleles?

If a gene has more than two alleles, it is said to have multiple alleles. Besides codominance, the human ABO blood group is also an example of a trait that is determined by multiple alleles. There are three different alleles for the ABO blood type— I^A , I^B , and i . The I^A and I^B alleles are codominant to each other, but both are dominant to the i allele. A person can only inherit two of these alleles—one from each parent, as shown in the table above.

Academic Vocabulary

complex (kum PLEKS) (adj)
made up of many parts

Reading Check

- 4. Summarize** What results when a dominant allele is present in a pea plant?
-

Picture This

- 5. Identify** Which blood type is characterized by codominance?
-

✓ Reading Check

6. State What type of chromosomes determine a person's sex or gender?

✓ Reading Check

7. Explain Why can only females pass on maternal inherited traits?

What is sex-linked inheritance?

Recall that humans have 23 pairs of homologous chromosomes in their body cells. Sperm and egg cells, however, have only one chromosome from each chromosome pair. Most homologous chromosome pairs are of equal size. There is one exception—the long X and short Y pair. Chromosomes X and Y are the **sex chromosomes** because they contain the genes that determine a person's gender or sex. ✓

Except for sperm and eggs, each cell in a male has an X chromosome and a Y chromosome. Each cell in a female has two X chromosomes. Because the Y chromosome is shorter than the X chromosome, many genes on the X chromosome are not on the Y chromosome. Each of those genes, then, has only one allele, the one on the X chromosome. A recessive phenotype is usually observed only if the genotype is homozygous. A recessive phenotype is observed in a male when a one-allele gene on a male's X chromosome has a recessive allele. That's why males are more likely than females to have X-linked recessive genetic conditions.

What is polygenic inheritance?

Some traits are determined by only one gene. This one gene, however, can affect more than one trait in an organism. In fact, many traits result from the interactions of more than one gene. **Polygenic inheritance** is when multiple genes determine the phenotype of a trait. When several genes determine a trait, many alleles affect the phenotype, even though each gene has only two alleles. Many phenotypes are possible when polygenic inheritance determines a trait. For example, polygenic inheritance determines your height, weight, and skin color.

What is maternal inheritance?

You have learned that DNA makes up the chromosomes in the nucleus of each cell. But, mitochondria contain DNA too. Mitochondria are scattered throughout the cytoplasm of cells, even egg cells. However, only the tail of a sperm cell has mitochondria. Since the sperm's tail does not enter the egg cell during fertilization, humans inherit mitochondrial genes only from their mothers. This means the inheritance of traits related to mitochondria can be traced from a grandmother to her children and her grandchildren. Maternally inherited traits can be passed to male offspring, but only female offspring can pass the gene on. ✓

Human Genetic Disorders

Imagine that you are reading directions to put a bicycle together. Suppose the directions say to put the handlebars where the seat should go. If you did this, your bicycle would not function the way it should. A similar thing can happen if a mutation, or change, to a gene occurs. An organism with a mutation cannot function as it should. ✓

What are the effects of genetic disorders?

A **genetic disorder** happens when a gene or chromosomal mutation is inherited. Genetic disorders can result in minor or major health problems, or even lead to death. Cystic fibrosis is a common recessive disorder among Caucasians. A recessive phenotype such as cystic fibrosis occurs when two recessive alleles for a trait are inherited.

What problems does cystic fibrosis cause?

People with cystic fibrosis have tissues that produce abnormally thick mucus. This mucus can affect the functions of the respiratory, digestive, and reproductive systems. Without treatment, children with cystic fibrosis usually live five years or less. With treatment, a child with cystic fibrosis might live into their twenties or longer. Some other human genetic disorders are listed in the table below.

Some Human Genetic Disorders		
Genetic Disorder	Type of Disorder	Major Problems
Huntington's disease	Dominant	breakdown of brain tissue; shortened life span
Sickle-cell disease	Codominant	red blood cell destruction; clogged blood vessels
Cystic fibrosis	Recessive	abnormally thick mucus; affects many organ systems
Hemophilia	X-linked recessive	excessive bleeding due to blood clotting problems
Down syndrome	Trisomy—extra chromosome #21	mental disability; heart defects

✓ Reading Check

8. Explain How does a mutation affect an organism?

Picture This

9. Highlight the genetic disorder that affects the blood.



Think it Over

10. Predict How will lack of nutritious food affect a person's phenotype?

Reading Check

11. Think-Pair-Share

List one of the summary statements below. Then explain that statement to a partner. Listen as your partner then explains a different statement to you.

Genes and the Environment

You learned that the genotype determines the phenotype. Genes, however, are not the only factors that affect phenotype. An organism's environmental conditions can also affect a phenotype. For example, your genotype determines the amount of pigment in your skin. You know that if you stay in the sun, your skin color can change temporarily. Skin color in humans is an example of a phenotype that can be altered by environmental factors.

Plant phenotypes also can be affected by the environment. Plants may be genetically identical but have flowers of different colors if the plants grew in different types of soil.

Inheritance: A Summary

The relationship between a phenotype and a genotype can be complex. First, each gene's alleles interact. Then, genes interact with each other and the environment to produce a phenotype. The most important points you have read are:

- Traits might show intermediate phenotypes.
- Traits might show two phenotypes at the same time.
- Traits might be influenced by more than one allele.
- Traits might be influenced by more than one gene.
- Traits might be sex-specific.
- Traits might be influenced by the environment.
- Mutations can cause human genetic disorders, which might lead to abnormal traits.

The Process of Evolution

Lesson 1 Natural Selection



Grade Seven Science Content Standard. 3.b. Students know the reasoning used by Charles Darwin in reaching his conclusion that natural selection is the mechanism of evolution. **Also covers:** 3.a, 3.c.

● Before You Read

On the lines below, write a sentence that explains what you know about the process of evolution. Read the lesson to learn about Darwin and the evidence he found for natural selection.

● Read to Learn

Charles Darwin

Evolution is change over time. Modern scientists refer to evolution as genetic change in a population over time. Charles Darwin was the first person to write about and develop evidence to support evolution.

Charles Darwin was a **naturalist**, a person who studies the natural world, including plants, rock formations, and animals. During a five-year voyage to map the coastline of South America on the sailing ship H.M.S. *Beagle*, Darwin made important observations. From his observations, Darwin developed his theory of evolution, which helps explain the unity and diversity of life. Darwin's theory transformed the natural sciences and serves as the basis of all biological research today.

What are the Galápagos Islands?

On September 17, 1835, the H.M.S. *Beagle* arrived in the Galápagos (guh LAH puh gohs) Islands. These islands are separated from the mainland of South America by 1000 km. A map of the voyages of the H.M.S. *Beagle* is shown on the next page.

MAIN Idea

Charles Darwin developed a theory of how organisms with the same ancestors can look and behave differently over time.

What You'll Learn

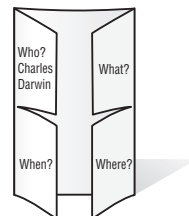
- how Darwin found evidence for natural selection
- the ways organisms adapt to their environments or perish

Study Coach

Ask Questions As you read this lesson, write down any questions you may have about the content. Discuss your questions with another student or your teacher.

FOLDABLES™

A Take Notes Make a four-door Foldable, as illustrated. Record what you learn about Charles Darwin and his research under the tabs.



What were Darwin's observations?

A map of Darwin's voyages aboard the H.M.S *Beagle* is shown below. Darwin made extensive observations and detailed notes of the biology and geology of the locations he visited. Darwin also collected numerous samples to take home. Some of his most interesting findings were of the diversity and uniqueness of the organisms he saw, especially on the Galápagos Islands.

Picture This

2. **Describe** the location of the Galápagos Islands.



What conclusions did Darwin draw from his observations?

Many of the turtles, birds, and lizards on the Galápagos Islands were similar but not the same as organisms that Darwin found on the South American mainland. Darwin reasoned from these observations that perhaps some of the animals and plants on the Galápagos originally came from South America. Then, he reasoned, those plants and animals evolved over time to be different.

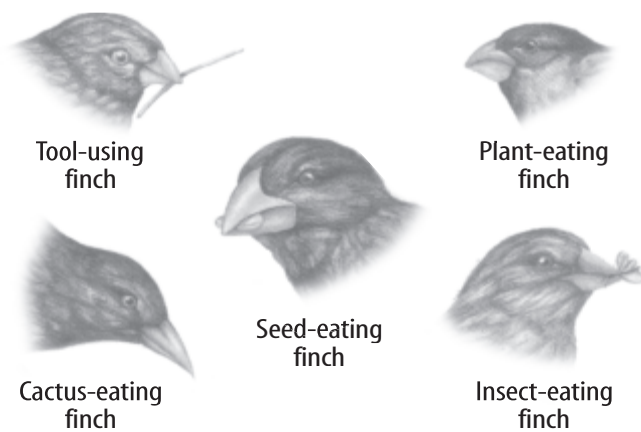
Tortoises Darwin made many interesting observations of the giant Galápagos tortoises, or land turtles. He found tortoises on all of the Galápagos Islands and nowhere else that he visited. What was most interesting to Darwin was that the tortoises varied from island to island in the Galápagos. Darwin wondered why all the tortoises were different from each other even though they lived on islands only 80 km apart.

Finches The birds called finches that Darwin observed in the Galápagos Islands varied from birds he observed in other parts of the world. Darwin described 13 finch species that he observed.

Think it Over

3. **Conclude** Why do you think the tortoises of the Galápagos Islands varied from island to island?

Beak Size and Shape Darwin was impressed by the diversity of finches on the different islands. He was most fascinated by the diversity of beak size and shape in the finches. Darwin observed beak sizes that ranged from small to large. Each beak type was suited for eating a particular food. For example, the large ground finch Darwin described has a large beak that is well suited for cracking open large seeds on the ground. The small tree finch Darwin observed has a long and narrow beak that is best suited for catching insects in the trees. Darwin would later explain that if individuals from an ancestral species of finches in South America were separated for a long enough period of time, the future generations or descendants on the different islands might look and behave differently. Study the illustration below to see some of the variations Darwin observed in finches' beaks. Notice how the beak size and shape is related to the kind of food the finch eats and where it must go to get its food.



Selective Breeding Humans have been breeding plants and animals for thousands of years. In plants the goal of breeding might be to get the largest fruit, the best tasting fruit, the tallest plant, or the prettiest flower. In animals, farmers want the largest hog, the fastest horse, or the cow with the most milk. When a plant or an animal is bred to get specific characteristics, it is known as selective breeding. Selective breeding does not lead to a new species. The organism is still able to breed with other members of its species. For example, dogs have been bred for many special features, such as size and fur length. But dogs are still able to breed with the animal from which they originated—the wolf.

Academic Vocabulary
diverse (di VURS) (adj) having distinct variety

Picture This

4. Identify Circle the finch whose beak is built for digging its food from between the thorns of a cactus.

Reading Check

5. Determine What is the expected result from selective breeding? (Circle your answer.)

- a new species
- specific characteristics

Darwin's Theory of Natural Selection

Darwin and other scientists realized that organisms with traits that allowed them to survive under particular environmental conditions produced more offspring than those organisms without those traits. The traits that allow a species to survive will become very common in that species.

Why is genetic variation necessary in evolution?

Recall that traits are passed on by the genes each parent provides to its offspring. Sometimes changes occur in the genes and new traits are created. If the inherited trait is harmful, the offspring might die. If the inherited trait is helpful, the offspring might survive long enough to reproduce. With time, the helpful trait will become common in many populations of the species. This genetic variation is necessary for evolution to occur. But, survival depends on other factors as well. ✓

How does the “struggle to survive” influence natural selection?

One influence on Darwin's writing was a the work of a fellow scientist named Thomas Malthus. Malthus presented the argument that if the human population were to continue to grow without limits, humans would eventually run out of food and space. If their population grew too large, humans would be faced with a “struggle to survive.”

Darwin had noticed that animals often produce more offspring than could survive. Limited resources, such as food, water, and habitat, allowed only some individuals to survive. Darwin decided that this was a natural process that selected whether an organism could survive. He called this process natural selection.

How do environmental factors influence natural selection?

Darwin's next step was to find out how the organism was selected. He reasoned that an organism that was better prepared to get food or protect its space would be better able to survive. Different habitats can put pressure on animals to survive as well. Darwin suggested that those organisms best prepared for living in specific habitats would survive and be most able to reproduce. Offspring would also be able to survive any changes to their habitat. With enough time, being able to adapt to change could explain the large number of species on Earth today. ✓

✓ Reading Check

6. Explain How does a trait become part of a population?

✓ Reading Check

7. State Which organisms have a better chance to survive?

How did Darwin define natural selection?

Darwin defined **natural selection** as a process by which individuals with traits that are better suited to their environment are more likely to survive and reproduce than individuals without those traits. Inherited traits that increase an organism's chance for survival and ability to reproduce in a particular environment are called **adaptations**. Adaptations spread through a population in future generations if natural selection favors those adaptations.

What is the process of natural selection?

Darwin's idea of natural selection is based on four steps, or requirements. The steps are summarized in the table below.

The Process of Natural Selection	
1. Overproduction	Organisms produce more offspring than can survive.
2. Variation	Differences, or variations, occur among individuals of a species.
3. Inherited Variation	Some variations are passed to offspring. Inherited, or genetic, variation is necessary for evolution by natural selection to occur.
4. Natural Selection	Individuals with helpful variations are better able to survive and reproduce. Over time, the offspring of individuals with helpful variations increase and become a larger percentage of the population.

Evolution and Diversity

In 1859 Charles Darwin published a book titled *The Origin of Species by Natural Selection*. This book included a strong case for evolution by natural selection. Darwin also developed the idea that all organisms have “descended with modification” from common ancestors over a long period of time. That is, all species have changed through time and are related by descent from a common ancestor. Considering the evidence that Earth is millions of years old, Darwin believed there had been enough time for organisms to change and for new species to develop from ancestral species. ✓

Picture This

8. Think-Pair-Share Read the four steps of natural selection. Choose one of the steps that you think is most interesting. Summarize it on the lines below. Then compare your step to one chosen by another student.

✓ Reading Check

9. Explain What did Darwin propose that all organisms share? (Circle your answer.)
a. common age
b. common ancestors

The Process of Evolution

Lesson 2 Adaptation and Extinction

Grade Seven Science Content Standard. 3.e. Students know that extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient for its survival. **Also covers:** 3.a, 3.b.



MAIN Idea

The inability to adapt can lead to extinction.

What You'll Learn

- the importance of adaptations
- the difference between two kinds of adaptations
- three of the causes of extinction

Mark the Text

Underline As you read, underline key words and definitions. Underline any term or word that you don't understand or find confusing.

Picture This

- 1. Identify** Study the figure of two night-dwelling primates. Circle the feature that is adapted for hunting and foraging at night.

Before You Read

On the lines below, write a sentence describing an animal that has special features that are well suited for what it eats or where it lives. Then read the lesson to learn more about adaptations in organisms.

Read to Learn

Adaptations

Humans are very skilled at changing their environment. We have buildings, heaters, and air conditioners to make our environment more comfortable. Other organisms, such as plants, are not able to change their environment to meet their needs. For example, plants cannot walk into a greenhouse when the weather gets cold. Organisms that do have unique characteristics, or adaptations, to live in their specific environments have evolved those adaptations over time by the process of natural selection.

Recall that adaptations are inherited traits that increase an organism's chance of surviving and reproducing in a particular environment. An example of an adaptation in night-dwelling animals, such as the one shown below, is large eyes that are adapted for eyesight in dim light.



How do organisms adapt?

Many people misunderstand Darwin’s theory of natural selection because they misinterpret the word *adaptation*. First, adaptations are the final products of the long process of natural selection. Adaptations occur in groups of organisms as a trait is passed from one generation to another. The organisms that receive the trait are better suited to survive and reproduce.

Second, adaptations are not intentional. Adaptations are naturally selected. That is, not all traits are adaptations. An organism can inherit several traits from just one gene. Some traits can be passed down and linked together with other traits, whether or not they are helpful to an organism. A non-helpful trait may stay in the population because it is somehow linked to another, more helpful trait. Some traits may help an organism survive, while other traits may cause the organism to die off.

An Example of Adaptation There are many examples of adaptations in the natural world. For example, desert rabbits have blotchy, brown coats that help them blend in with their surroundings. Desert rabbits also have long ears that help them stay cool. They give off heat through the extensive system of blood vessels in their ears.

How might natural selection have shaped the ears of the rabbits? The population may have been started with rabbits with different-sized ears. Then, those rabbits with long ears were better able to survive in higher temperatures than rabbits with small ears. So rabbits with long ears would be more likely to live long enough to have offspring than those with smaller ears. The offspring of long-eared rabbits would probably have long ears, too. After many generations of rabbits that lived in the hot environment, it would be hard to find rabbits with small ears. Because the small-eared rabbits would not have thrived as well as the long-eared rabbits, the small-eared rabbits would have left fewer offspring. When the population shifts to mostly long-eared rabbits, the rabbit population has adapted to the environment, and thus evolved by natural selection.

Types of Adaptations

There are many kinds of adaptations. Scientists place adaptations in different categories, such as structural adaptations and behavioral adaptations.

B Take Notes Fold a sheet of paper to make a two-column Foldable. Inside, label the columns *Physical* and *Behavioral*. Record and describe examples of each type of adaptation.



Think it Over

2. Predict What do you think will happen to a long-eared population of rabbits if their environment gradually becomes cold?

Academic Vocabulary
aspect (AS pekt) (noun)
a particular appearance



Think it Over

- 3. Compare** Which of the following organisms is best camouflaged for living in Antarctica? (Circle your answer.)
- a. a seagull
 - b. a parrot

Reading Check

- 4. Identify** What is another name for behavioral adaptations?

What are structural adaptations?

Structural adaptations are aspects of the physical body that help organisms survive and reproduce. You have already read about the desert rabbit's ears. The ears have lots of blood vessels and the blood carries body heat to the ears. The heat is given off to the air and helps the rabbits stay cool.

Camouflage Another type of structural adaptation an organism might have is **camouflage**, or blending in with the surrounding environment. Some lizards have a certain color, or can change color, to blend in with much of their natural surroundings. For example, the lava lizards on the Galápagos Islands are difficult to see because they are of the same black color as the volcanic rocks on which they sunbathe.

Mimicry Organisms might develop another structural adaptation strategy called **mimicry**, in which one species (the mimic) looks like another species (the model) so that a third species (the predator or prey) is deceived or fooled.

In one type of mimicry, the model organism is dangerous or poisonous, and the mimic organism is not dangerous. Thus, predators will stay away from both the model and the mimic.

In another type of mimicry, an organism (the mimic) fools its prey by looking inviting or familiar (the model). This will fool its prey into getting closer so the mimic can eat them.

What are behavioral adaptations?

Behavioral adaptations depend on the actions of the organism. Scientists sometimes call behavioral adaptations instinct or inborn behaviors. Behavioral adaptations enhance the survival and reproduction of an organism. ✓

Many behavioral adaptations are designed to attract mates. For example, some male birds use berries and bright scraps of cloth to decorate their nests. This technique attracts females for mating, which makes it possible for the male birds to pass along their genes to the next generation.

Extinction

When all the individuals of a particular species die off, that species becomes **extinct**. Natural selection can lead to extinction if the environment changes in a way that none of the organisms of a species can survive. Environmental factors that contribute to extinction include climate change, volcanoes, and earthquakes.

What are some causes of extinction?

There are many causes for extinction. They include habitat destruction, loss of genetic diversity, and the introduction of exotic species. Many species are not able to adapt to severe environmental changes.

Loss of Habitat Rates of extinction for individual species are increasing. One important reason is that habitats for plants and animals are becoming smaller as humans develop the land and use more resources. An example of this is the habitat of the cheetah, a large cat found in Africa. With more humans living on and using more land for crops, there are fewer resources available for the cats and their natural prey. Under such conditions, fewer cheetahs can survive. ✓

Loss of Genetic Diversity Genetic variability can be measured by all the gene combinations found in a species. Species need genetic variability to increase the likelihood that some individuals will have the right gene combinations to survive different environmental conditions. Evolution occurs when there is genetic variability. If there are only a few individuals, or if the individuals have limited genetic variability, a major change in environmental conditions can lead to extinction.

A species is considered threatened or endangered if there is little genetic variation left among the members of a species. For example, cheetahs are threatened because there are so few left. The remaining cheetahs have little genetic diversity. This has led to low survival rates, fewer offspring, and more disease in the remaining population. ✓

Competition with Exotic Species Sometimes native species compete with new species introduced into a habitat. The introduced species are known as exotic species. If an exotic species has no natural consumer in the new environment, it might push the native species toward extinction.

The kudzu plant was introduced to the southern United States in the 1930s to help prevent erosion. The vine grows so well there that it can grow up to 30 cm per day. However, kudzu shades forests and kills the trees covered by the vine. The plant grows naturally in Japan where cool weather, diseases, and consumers help keep it under control.

✓ Reading Check

- 5. Determine** How do humans contribute to loss of habitat?

✓ Reading Check

- 6. Define** What term do scientists use to describe a species with little genetic variation?

What is the possible result of the inability to adapt?

Another possible reason that organisms become extinct is the inability to adapt. For example, if a climate changes suddenly, a species might not have any individuals that have genetic traits that will allow them to adapt. Over time the population that cannot adapt becomes smaller and the individuals become less able to reproduce.

The cheetahs described earlier are a prime example. There are few cheetahs on Earth because of loss of habitat. Because there are so few cheetahs, inbreeding is bringing out recessive traits that are harmful to the species. Inbreeding is mating between closely related individuals. This happens in small populations. Inbreeding results in a lack of genetic variability. The remaining cheetahs are not able to adapt as well as a large population with a lot of genetic variation might. Then, should a rapid environmental change occur, the remaining population of cheetahs could quickly become extinct.

Reading Check

7. Identify What are the results of inbreeding?

Darwin's Conclusion's Today

Just as extinction does not always happen at the same rate or in the same way, new species formation occurs at different rates, too. Because the environment is always changing, natural selection is always acting on organisms. Most environmental changes are small and localized, leading to very slow changes among populations over many generations. Think about a large environmental change that would affect many species at the same time. Whether the species lives or becomes extinct depends on whether that species can adapt to the change.

Evolution—Evidence of Change

Lesson 1 Fossils and Evolution

Grade Seven Science Content Standard. 4.e. Students know fossils provide evidence of how life and environmental conditions have changed.
Also covers: 3.c.



● Before You Read

Think about footprints or shoeprints made in the dirt or sand. Describe what information the prints can provide on the lines below. Then read the lesson to learn about the information scientists have discovered from studying fossils.

MAIN Idea

Fossils show how living organisms and the environment have changed over time

What You'll Learn

how fossils provide evidence of evolution

● Read to Learn

What are fossils?

Organisms leave evidence that they were once on Earth. Some of this evidence lasts for only a short time, but some lasts for a long time. **Fossils** are the naturally preserved remains, imprints, or traces of organisms that lived long ago. Fossils can be bones, shells, and footprints. Fossils come in many sizes. Very small fossils, called microfossils, can only be seen with a microscope. Some fossils are larger than humans.

A **paleontologist** (pay lee ahn TAH luh just) is a scientist who studies fossils. Paleontologists study fossils to understand relationships between organisms. They try to find out when different organisms first lived on Earth. Paleontologists also try to learn when organisms died off. Some paleontologists work outside, and others work in a laboratory.

When do fossils form?

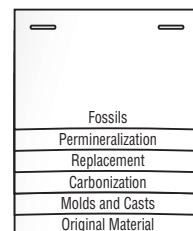
A dead organism can only become a fossil if it is protected from decomposers, scavengers, heavy rains, and acidic soils. Organisms with hard parts, like shells, bones, or teeth, are more likely to become fossils. Scavengers don't usually eat animals with hard parts and those hard parts don't decay as easily as soft parts.

Study Coach

Make Flash Cards As you read, write important questions on note cards. Write the answer to each question on the back of the card. After you read, test yourself by seeing if you can answer the questions without looking at the answers.

FOLDABLES™

A Discuss Make a layered Foldable. Label the front tabs as illustrated. Describe ways fossils form under the tabs. Use what you learn to discuss how fossils you have seen might have formed.



How are fossils formed?

It took a long time for scientists to understand how fossils form. Before the seventeenth century, most people thought that fossils could not be from ancient organisms.

Fossils only form when the right conditions exist. Usually fossils are only part of an organism that once lived. Most of the time, you find preserved hard parts. Sometimes soft parts are also preserved. Scientists have even found whole organisms preserved, but this is very unusual. There are different ways that organisms or their parts may be preserved.

What is permineralization?

The hard parts of a living organism usually have tiny spaces filled with air, blood, or other substances. The substances in the spaces break down after the organism dies, leaving the space empty. When this happens, water in the ground can get into the tiny spaces where minerals may be left behind in a process called **permineralization** (pur mihn ur ul i ZAY shun). Usually silica, calcite, or another mineral is left in the spaces. Permineralization forms a strong, rock-like fossil. The details of the hard part of the organism are preserved. Most bones and trees become fossils through permineralization. Trees that become fossils this way are called petrified wood. ✓

What is replacement?

When replacement occurs, the hard parts of the organism dissolve and minerals replace them. Silica, iron, and pyrite are common mineral replacements. Fossils formed by replacement show the shape of the original organism, but they do not usually show details. For example, a solution of water and dissolved silica might flow into and through a shell of a dead organism. The acidic water dissolves the shell. At the same time, the silica crystallizes and fills the places where the shell had been.

What is carbonization?

Elements such as hydrogen, oxygen, and nitrogen leave an organism once it dies, leaving only a thin layer of carbon. In the process called carbonization, if sediment pushes on a buried organism, an image of the shape of the organism is preserved in the sediment. This image is called a carbon film. Many plant fossils are preserved as carbon films and can be found in coalfields today. Soft materials of animals, such as skin, fur, and feathers, can also be preserved this way. ✓

✓ Reading Check

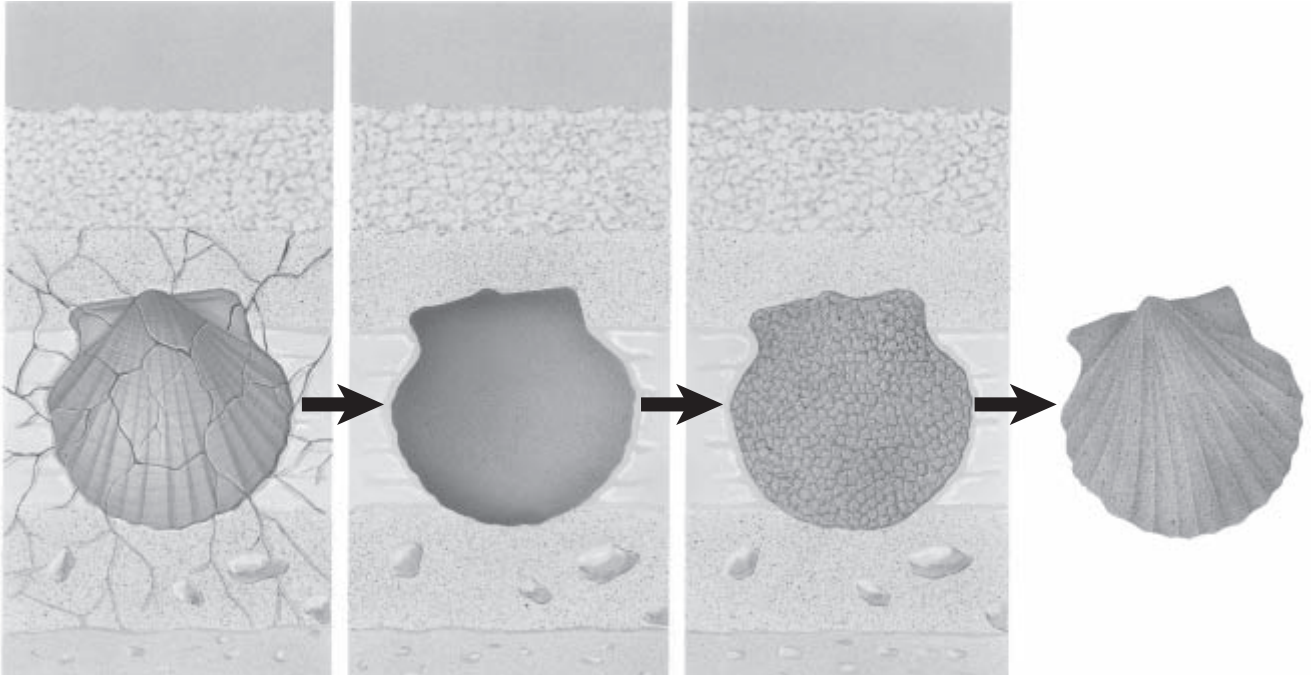
1. **Summarize** How is petrified wood formed?

✓ Reading Check

2. **Clarify** Under what conditions does carbonization happen?

How are molds and casts formed?

Molds and **casts** are formed from the print of an organism. These fossils have no remaining parts from the original organism. Molds can be imprints from a shell or the skin of an animal. Bite marks, footprints, and eggs in a nest can produce molds. If the mold of a shell fills with sediment that hardens into rock a cast is formed, as shown below.



What is original material?

In the movie Jurassic Park, a whole organism was preserved in amber. Amber is the fossilized sap from a very old seed tree. When an organism is preserved in amber, the fossil is called original material. An original material fossil contains the preserved organism with no replacement or change of hard or soft parts. It is unusual to find original material fossils, but they do provide important information when they are found. Most original material fossils were formed more recently than other types of fossils.

What do fossils tell us?

Fossils tell us about evolutionary relationships between organisms. Natural selection is the survival and reproduction of organisms with traits that allow them to live under particular conditions. Over time, species change when organisms that do not have these traits die off. Fossils provide a record of which organisms lived in the past.

Picture This

3. Explain What is the key difference between the shell on the left and the cast fossil on the right?

Academic Vocabulary

found (FOWND) (verb) to locate or discover

✓ Reading Check

- 4. Compare** Which are typically older, fossils found in deep layers of rock or fossils found in shallow layers of rock?

✓ Reading Check

- 5. Explain** Why are there gaps in the fossil record?

How do scientists determine the ages of fossils?

Older rock layers are usually deeper in the Earth. This means that if fossils are found in both shallow rock layers and in deeper rock layers, the fossils in the deeper layers are usually older. This is true unless the rock layers have been moved around. Fossils found in rock layers help scientists determine which species are older and which changes have occurred over time. ✓

What does the fossil record reveal about species and changes in the environment?

The fossil record is made of all known fossils and their placements in the formation of rocks and positions of time. The fossil record provides evidence that supports the evolution of plants and animals. There are breaks, called gaps, in the fossil record because many organisms decayed before they could become fossils. In addition, geological processes have destroyed some fossils. Other fossils have not yet been discovered. The fossil record shows that most species that once lived on Earth are now extinct. ✓

Fossils show how life and the environment have changed over time. Scientists who study fossils have determined that early in Earth's history, life was not as complex as it is today. Scientists use fossils to make models of what organisms might have looked like. They also use fossils to find out if an organism lived alone or in a family group. Sometimes scientists can find out what foods were eaten by an organism. Scientists might also learn about an organism's environment from studying the organism's fossil.

How do fossils provide evidence of the past?

Most plants and animals decompose after dying and do not leave fossil remains. The parts of plants and animals that do become fossils can tell us much about when organisms lived, how they changed, and when they became extinct. Fossils provide clues that paleontologists can use to reconstruct extinct organisms. The locations of fossils in sedimentary rock layers can indicate the relative ages of fossils. The theory of evolution by natural selection best explains the patterns seen in the fossil record.

Evolution—Evidence of Change

Lesson 2 Biological Evidence



Grade Seven Science Content Standard. 3.c. Students know how independent lines of evidence from geology, fossils, and comparative anatomy provide the basis for the theory of evolution.

● Before You Read

All dogs are the same species, but there are differences in the appearance of dogs based on their breed. For example, some dog breeds have long, silky fur, while another breed has short, curly fur. On the lines below, describe how two dogs you have seen are the same and how they are different. Read the lesson to learn about how evolution can result in changes to organisms' physical structures.

MAIN Idea

The theory of evolution by natural selection best explains what is seen in studies of comparative anatomy and molecular biology.

What You'll Learn

to explain that patterns of body structures are the result of evolution

● Read to Learn

Comparative Anatomy

Fossils provide evidence of evolution. In addition to fossils, the comparison of the physical structures of organisms also supports the theory of evolution by natural selection. **Comparative anatomy** is the study of similarities and differences in the structures of organisms. Scientists used comparative anatomy to search for the common ancestor of true flies and scorpionflies. Scientists who study insects know that true flies and scorpionflies are similar. But, a true fly has one pair of large, thin wings and one pair of small sticklike legs behind the wings. A scorpionfly has two pairs of large, thin wings. Scientists predicted that these two types of insects had the same ancestor, but there were no fossils to show this. ✓

Scientists continued to search for the ancestor of true flies with two pairs of wings. Then, in 1976, scientists found fossils of four-winged true flies that showed their prediction was correct. These insect fossils provided evidence to support the theory of evolution.

Mark the Text

Identify Answers

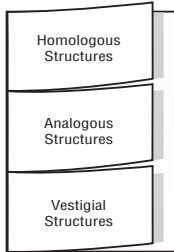
Underline each question head with a colored pencil. Use another color to underline the answer to the question.

✓ Reading Check

- Define** What is comparative anatomy?

FOLDABLES™

B Describe Make a three-tab Foldable. Label the front tabs as illustrated. Describe three structures that help support the theory of evolution.



Academic Vocabulary

affect (uh FEKT) (verb) to influence; to have an effect upon

Picture This

2. Compare Use a different color marker to highlight the similar bones in the whale, crocodile, and bird.

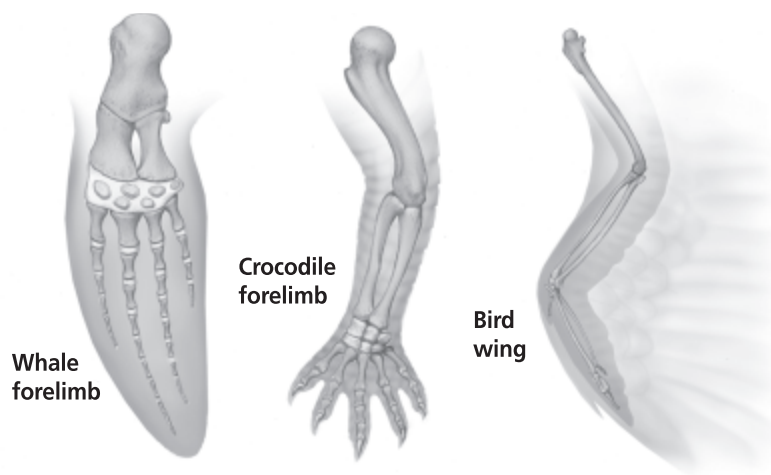
What structures are seen in organisms?

Humans, frogs, bats, birds, and cats all have a common set of three bones—a humerus, an ulna, and a radius. The sizes of these bones are different in each organism, but the shapes of the bones are the same. This shows that at some point in the past, humans, frogs, bats, birds, and cats all shared a common ancestor. However, some of those organisms share more recent ancestors than others.

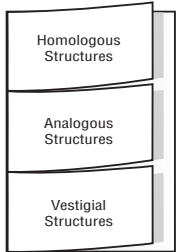
Homologous (huh MAH luh gus) **structures** are the parts of organisms that have similar origins and similar structures. Homologous structures show that two or more species share the same ancestors. As shown in the figure below, the forelimbs of three very different animals are homologous structures.

Analogous (uh NAH luh gus) **structures** are the parts of an organism that are similar in some ways, but have different ancestral origins. For example, both birds and insects have wings. The analogous structures of wings resulted from similar environmental conditions that **affected** the two distantly related organisms.

Vestigial (veh STIH jee ul) **structures** are the parts of an organism that have no function in the present-day organism. Scientists hypothesize that vestigial structures once functioned in an ancestor. For example, most mammals have pelvic bones that support legs. Present-day whales have pelvic bones, but they do not have leg bones. The vestigial structure of the pelvic bones indicated that whales' ancestors had legs. Vestigial structures are genetically connected to a trait that helped the species survive at one time.



B Describe Make a three-tab Foldable. Label the front tabs as illustrated. Describe three structures that help support the theory of evolution.



Academic Vocabulary

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Picture This

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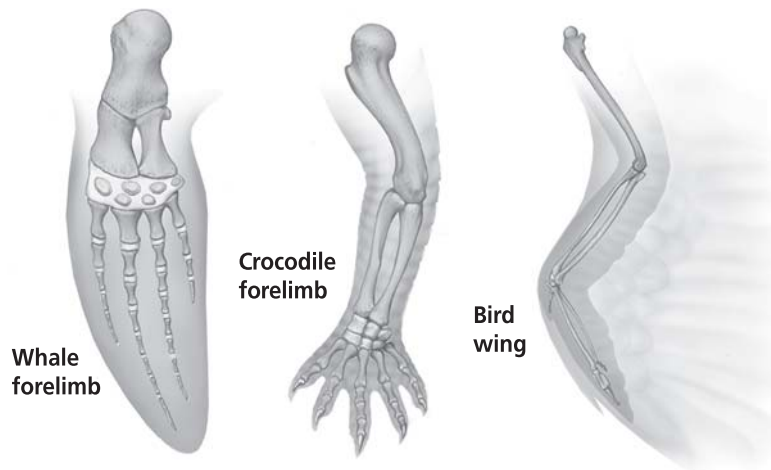
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Evolution—Evidence of Change

Lesson 6 Evolution and Plate Tectonics



Grade Seven Science Content Standard. 4.f. Students know how movements of Earth's continental and oceanic plates through time, with associated changes in climate and geographic connections, have affected the past and present distribution of organisms. **Also covers:** 3.c, 3.e.

MAIN Idea

The movement of Earth's plates has caused changes in land formations and in climates, which has resulted in changes in organisms.

What You'll Learn

- how plate tectonics changes land and environments
- the relationship between plate tectonics and biogeography

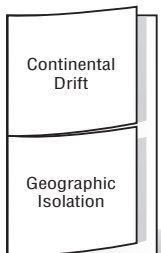
Mark the Text

Identify Main Ideas

Highlight the main ideas in each paragraph as you read the lesson.

FOLDABLES™

C Describe Make a two-tab Foldable. Label the front tabs as illustrated. Describe how continental drift and geographic isolation affect natural selection.



Before You Read

Have you seen changes in your environment that have occurred too slowly to notice at the moment you were looking? On the lines below, describe changes that occur slowly over time. Then read the lesson to learn about how Earth's plates have slowly moved, resulting in changes in organisms.

Read to Learn

Continental Drift

Earth's surface slowly changed over time. These changes have occurred so slowly that they are hard to notice. Earthquakes offer evidence that changes to Earth's plates are still occurring.

In 1912, Alfred Wegener suggested that the continents were once connected. This hypothesis was known as continental drift. Wegener's idea came from the similar shape of the shorelines of Africa and South America. The continental drift hypothesis led to the theory of plate tectonics. When plates move, the environment changes. This causes changes for the organisms that live on the plates.

Organisms develop adaptations to their environment. When there are changes to the environment, natural selection occurs. Natural selection means that organisms that are well suited to their environment will survive. The genes of these organisms will be passed on to their offspring. Even though plates move slowly, the resulting changes to the environment can be large. These environmental changes can cause some species to thrive and other to become extinct.

Geographic Isolation

Geographic isolation occurs when a physical barrier separates populations of species. Once separated, the populations might follow different evolutionary paths because they are in different environments. Geographic features, such as mountains, rivers, and large bodies of water can cause geographic isolation of species. Therefore, the geography of a place can effect how organisms evolve.

Does geographic isolation influence evolution?

Geographic isolation affected many of the organisms Darwin described in his journals and was the cause of much of his research. Darwin found that a species of birds on the Galápagos Islands were similar to those on Ecuador's mainland but with significant differences. Those differences were body size, beak shape, and eating habits. These observations led to the idea of evolution by natural selection. Recall that natural selection means that organisms that are well suited to their environment will survive to reproduce, and organisms that cannot adapt will die out.

What is convergent evolution?

Sometimes distant locations with similar environmental conditions have species with similar traits. These species have evolved separately but under similar conditions. This type of evolution is called **convergent evolution** and results in structural and functional similarities. Research in genetics has shown that such species may look similar but may still have different ancestors. Geographic evolution leads to closely related species that look different. Convergent evolution results in distantly related species that look similar. ✓

How are plate tectonics and evolution related?

Earth's moving plates have affected evolution. Changes in the land, such as the formation of mountains, have resulted in the development of new species. Changes in climate have forced organisms to change as well. This has also resulted in new species. Organisms that are found at different locations on Earth may have similar features that help them survive in similar environments. Some related organisms are now separated because of plate movement. Species can become extinct if the environment changes and they do not have traits that help them survive in the new environment.

Academic Vocabulary

physical (FIH zih kul) (adj)
having substance, can be touched



Think it Over

- 1. Describe** How would change in a bird's body size, beak shape, and eating habits make it better suited to its environment?

✓ Reading Check

- 2. Decide** Are species that have experienced convergent evolution closely or distantly related?

Evolution—Evidence of Change

Lesson 4 Classifying Organisms



Grade Seven Science Content Standard. 3.d. Students know how to construct a simple branching diagram to classify living groups of organisms by shared derived characteristics and how to expand the diagram to include fossil organisms. **Also covers:** 3.c.

MAIN Idea

Scientists use a species' physical structures and evolutionary history to group species.

What You'll Learn

- the classification system developed by Linnaeus
- how the theory of evolution has changed classification of organisms

Study Coach

Create a Quiz For each paragraph you read, think of a question and record it on a card. On the back of each card, write the answer to the question. After you finish reading, use the cards to quiz yourself.

Reading Check

1. Describe How did Linnaeus group organisms?

Before You Read

Scientists organize Earth's organisms much like a librarian organizes books in a library. On the lines below, describe what types of items you organize in your own environment. Read the lesson to learn about the different systems scientists use to organize and classify organisms.

Read to Learn

Historic Classification Systems

The Greek philosopher Aristotle was one of the first people to put organisms into some kind of order. He categorized things as animals, plants, or minerals. He also grouped things by where they lived—in the air, on the land, or in the sea. Aristotle's system was used for hundreds of years. When Europeans began exploring new lands, they found many new plants and animals. European scientists also found that they needed a new classification system to organize all the organisms.

In the mid-eighteenth century, Carolus Linnaeus, a Swedish scientist, developed a classification system that grouped organisms based on similar physical structures. This system of classifying organisms organizes them by levels. The largest group of organisms is called a kingdom and the smallest group is called a species. Species have the greatest number of traits in common. They can also breed and produce offspring that can themselves have offspring. Species can be affected by natural selection and have the ability to evolve. ✓

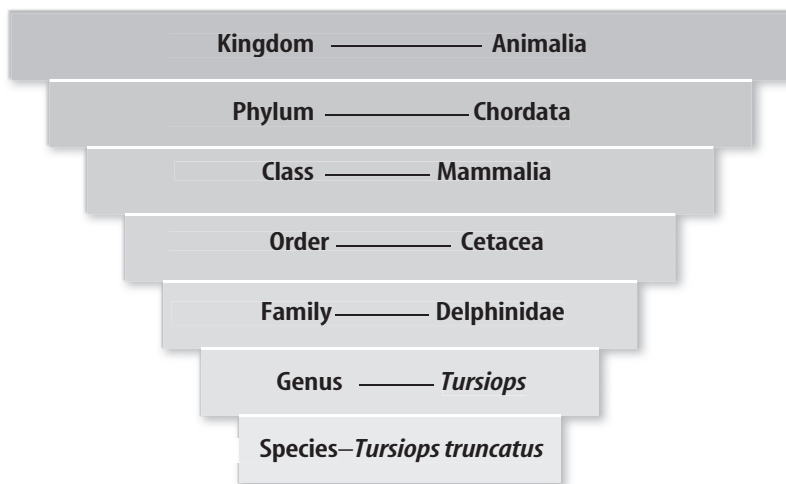
How did Linnaeus name and group species?

Linnaeus developed a system for naming species that is still used today. The species name is a two-word name. For example, the species name for the California black oak is *Quercus kelloggii*.

Groups of species that are similar belong to a genus (JEE nus). The first word of a species name indicates the genus to which the species belongs. All oaks have *Quercus* as the first word of their species name because they are all from the same genus. Similar genera (plural of genus) belong to the same family. Similar families belong to the same order. Similar orders belong to the same class. Similar classes belong to the same phylum. Similar phyla (plural for phylum) belong to the same kingdom.

How are kingdoms determined?

The features of organisms are used by scientists to define a kingdom. These features include cell type, the presence of a cell wall, or whether the organism is single-celled or multicellular. There are six kingdoms: Kingdom Eubacteria, Kingdom Archeabacteria, Kingdom Protists, Kingdom Fungi, Kingdom Plantae, and Kingdom Animalia. The figure below shows how a bottle-nosed dolphin can be classified.

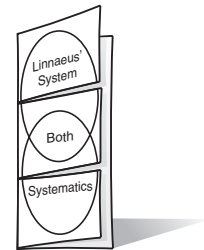


Modern Methods of Classification

Today, classification depends mostly on DNA and molecular biology to identify related organisms. This type of classification is called systematics.

FOLDABLES™

D Compare Make a Venn-diagram Foldable and use it to compare Linnaeus' system of classification with modern methods of classification.



Academic Vocabulary

feature (FEE chur) (noun)
structure or appearance; how something looks

Picture This

2. Classify Circle the names of the kingdom and species of the bottle-nosed dolphin.


 **Reading Check**

3. Explain What is systematics?

 **Reading Check**

4. Describe What is a domain?


What is systematics?

Systematics is a classification system based on the evolutionary relationships between living organisms. Scientists know that the more shared DNA sequences two species have, the more likely they are to share a recent ancestor. Scientists also know that when DNA sequences show that species that were thought to be related are not related, those scientists must go back to compare the species' fossil records. Scientists must also compare the species' anatomy, or physical characteristics. 

What is DNA hybridization?

Another method scientists use to classify organisms is called DNA hybridization. In this method, the differences in overall DNA between two organisms are measured and percentages are determined.

What is the highest level in new classification systems?

Molecular biology has supported the development of a new level of classification. In new classification systems, domain is the highest level, above kingdom. There are three domains—Bacteria, Archaea, and Eukarya. The domains are based on differences in genetic sequences. The Eukarya are organisms that have cells with a nucleus. In the future, the classification system could be changed again based on new findings in molecular biology. 

How are classification of organisms and evolution related?

Classification involves the idea of common ancestors and the theory of natural selection. Aristotle developed the first classification system. Linnaeus used similar physical structures to place organisms into groups. He also developed the species naming system.

The system used today is based on molecular systematics. Classification involves the following levels: domain, kingdom, phylum, class, order, family, genus, and species. The first word of the name of a species identifies the genus. Classification provides an understanding of evolutionary relationships.

The Age of Earth

Lesson 1 Relative Ages of Rocks



Grade Seven Science Content Standard. 4.a. Students know Earth processes today are similar to those that occurred in the past and slow geologic processes have large cumulative effects over long periods of time. **Also covers:** 4.c, 4.d.

● Before You Read

Have you ever walked along a dirt trail and noticed the different types of rocks embedded in the dirt? Describe where you think rocks of such different sizes and shapes came from. Then read on to find out more about the rock cycle.

MAIN Idea

Geologists can determine the relative ages of rocks by studying the order of rock layers, fossils, and the geological processes taking place today.

What You'll Learn

- how plate tectonics controls metamorphic and igneous processes
- the processes that form sedimentary rocks

● Read to Learn

The Beginning of Modern Geology

James Hutton was a Scottish physician and farmer who lived during the 1700s. He is considered to be the founder of modern geology. Before Hutton, most scientists believed that rocks formed by evaporation of minerals dissolved in sea water. But, by observing rock features and the movement of sediment in streams, Hutton realized there were two processes at work on Earth. One process formed rock and the other tore it down again.

The Principle of Uniformitarianism

Geologists, like all scientists, search for ideas to explain how Earth's processes work. Hutton had an idea that "the present is the key to the past." His principle of **uniformitarianism** states that the processes that are at work today are the same processes that have been at work in Earth's past. The speed of the process and the size of the area may change, but the processes do not. Uniformitarianism (YEW nuh form uh TER ee un izm) allows scientists to look at Earth's surface to interpret the changes that have taken place in Earth's past. ✓

Study Coach

Identify Questions As you read, use sticky notes to mark pages in the text where you have questions. Discuss your questions with another student or your teacher.

Reading Check

1. **Explain** What is the principle of uniformitarianism?

A Take Notes Make a Foldables table and label as illustrated. Use the table to take notes on what you learn about the composition and formation of each type of rock.

	Composition	Formation
Igneous		
Metamorphic		
Sedimentary		

Picture This

2. Identify Circle the names of the three major types of rock.

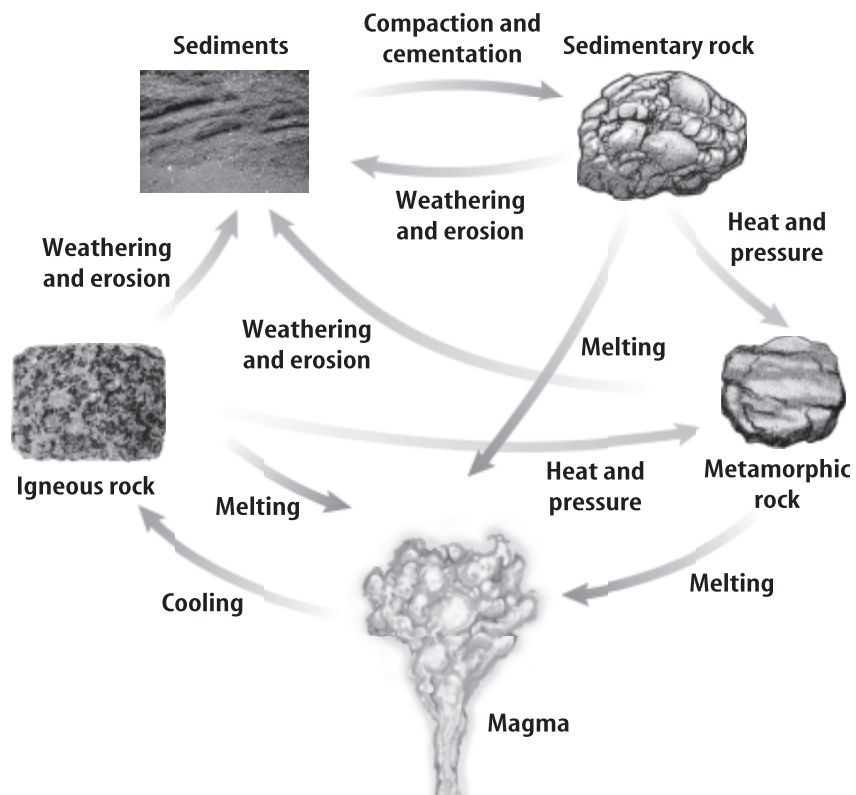
What conclusions did Hutton reach about Earth’s processes?

Hutton carefully observed Earth’s processes and their results. During rainstorms, he watched erosion taking away soil from farm fields. He noticed that rivers always moved sediment along their bottoms. He reasoned that if erosion happened for a long time, it could greatly change Earth’s surface. In fact, with enough time, erosion could destroy mountain ranges. Hutton realized that small changes adding up over long periods of time could change Earth.

The Rock Cycle

James Hutton had begun to recognize what geologists now call the rock cycle. The **rock cycle** is a series of processes that make and change rock, such as heating, melting, cooling, uplift, weathering, burial, and increasing pressure.

Geologists divide rock into three groups. The groups are based on how a rock is formed. You can trace the formation of the three major types of rocks—igneous, sedimentary, and metamorphic—on the figure below. Refer to this figure of the rock cycle as you continue reading the lesson.



Igneous Rocks Igneous rocks are produced when magma solidifies. Different kinds of igneous rock are identified by the size of the crystals they contain. Slow cooling inside Earth produces crystals large enough to be seen with human eyes. Rapid cooling of magma at or near the surface of Earth forms smaller crystals. Some igneous rocks have no crystals because they cool rapidly.

Metamorphic Rock Metamorphic rock is any rock that has been put under extreme heat or pressure. The rocks that are most affected are those that come in contact with hot fluids and magma moving through fractures toward the surface. Pressure may cause the mineral spaces to collapse and become more closely packed. Temperature may cause the minerals to recrystallize and form a new rock material.

Sedimentary Rock The rocks that form from sediments—the tiny particles of eroding rock—are called sedimentary rock. The particles, or sediment, eventually become compacted and cemented into rocks.

What challenge do geologists face when determining the age of rocks?

Estimating the age of each type of rock is a challenge geologist encounter as they observe these rock formation processes. The most important ideas in determining the ages of rocks are related to sedimentary rock formation.

How does sediment form?

Sedimentary rocks form from pieces of pre-existing rocks. Four processes are involved in the formation of these rocks. They are 1) weathering, 2) transportation, 3) deposition, and 4) lithification. Each process changes the physical characteristics of the sediment on Earth's surface.

What is weathering?

The physical breakdown or chemical breakdown of rocks into smaller pieces is called weathering. It is the first step in forming sedimentary rocks. Physical weathering breaks down rocks without changing the mineral composition. Frost wedging, shown in the figure on the next page, is the weathering process that occurs when water freezes and expands in cracks. Frost wedging can force rocks apart, but the rock composition remains the same.

Academic Vocabulary

identify (i DEN tuh fi) (verb) to determine the identity of

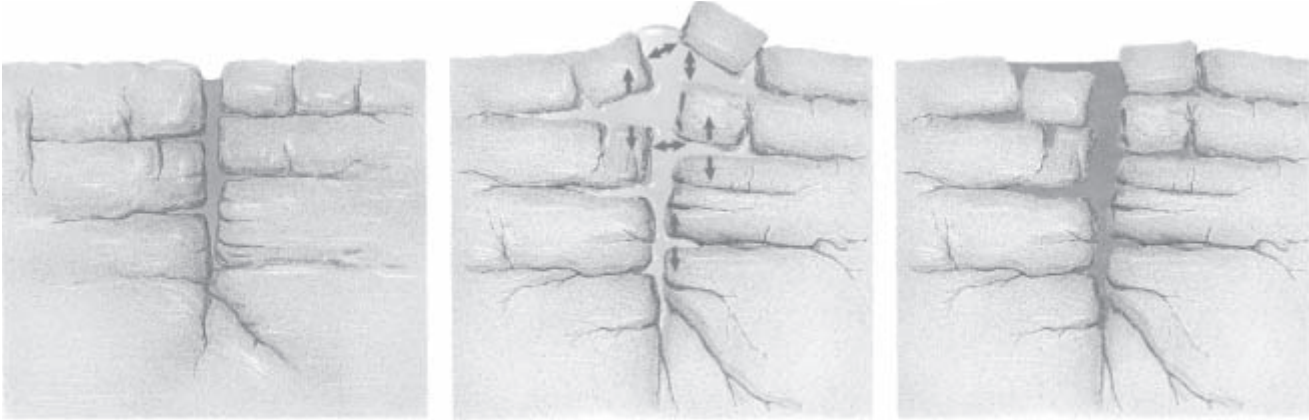
Reading Check

- 3. Explain** What forces result in a metamorphic rock?

Reading Check

- 4. Name** one example of physical weathering.

Ice Wedging



Picture This

5. Describe Over time, what will happen to this rock if freezing continues?

What is the effect of chemical weathering?

Chemical weathering changes the mineral composition of rocks. When the minerals that hold rocks together change, the rocks often fall apart. This crumbling increases the surface area. As the surface area increases, the rate of chemical weathering increases. Most chemical weathering reactions involve water. For example, as rain passes through the atmosphere containing carbon dioxide, the rainwater becomes acidic. Such rainwater can dissolve limestone. Caves are often formed by chemical weathering

What transports sediment?

Transportation continues the process of forming sedimentary rocks. Generally, sediments move downhill to lower areas where they stop. Water, wind, moving ice, and gravity transport sediment.

Sediments vary in size from large boulders to microscopic bits of rock. These different-sized pieces of sediment are called **clasts**. Different amounts of force are needed to move them. The force is applied by gravity as the slope of the landscape changes. When the slope of the landscape is steep, more force can be applied to the clast. The more force that is applied to the clast, the larger the clast that can be moved. During transportation, clasts become rounded and smaller as they knock into each other and chips are broken off. ✓

Fast-moving water can move larger clasts than slowly moving water. Strong wind might move large clasts, while sand and smaller clasts are blown across the landscape by winds of any size. Clasts of all sizes can be moved by glaciers because of the glacier's mass and size, but transportation in a glacier is slow.

✓ Reading Check

6. Define What is another term for sediments?

Picture This

7. Highlight Use different colored markers to sort the various sizes of clasts in this photo.



When does deposition occur?

The third step in the formation of sedimentary rock is deposition (deh puh ZIH shun). Deposition occurs when sediment being transported by moving water, wind, or glacier slows down or stops. This usually happens in low areas on the landscape called depositional environments.

As the sediments are dropped, gravity causes them to form parallel, horizontal layers. Distinct layering is a common feature in sedimentary rocks. Another characteristic of deposition is sorting. Sorting proceeds as the carrier of the sediment slows down. Heavier objects are dropped first. Lighter and lighter objects are carried farther and deposited later.

What is lithification?

The final step in the formation of sedimentary rock is lithification (lih tuh fuh KAY shun). When older sediments are buried under layers of newer sediments, several things happen. The weight of the younger material on top presses down on the older sediments. This is called compaction. Minerals begin to accumulate in the spaces between the grains. Mineral-rich water fills in the pore spaces and cements the clasts together. This is called cementation. This compaction and cementation changes the sediments into rock, as illustrated in the figure on the next page. The sediments have become lithified.

Academic Vocabulary
transport (TRAHNS port)
(verb) to move from one place to another



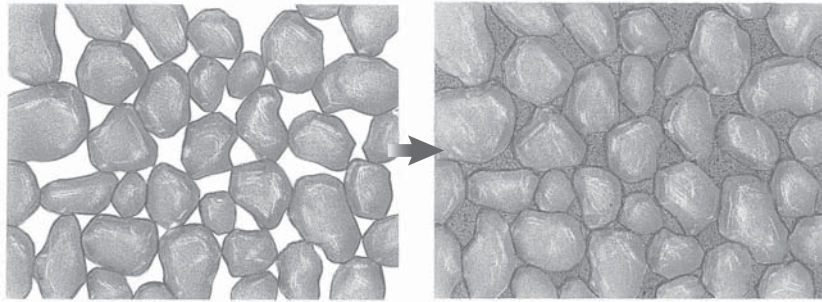
Think it Over

8. Apply Where would the largest rocks be deposited along the course of a fast-moving river?

Picture This

9. Compare If you were holding the sediments pictured here, what differences could you describe?

Compaction and Cementation



Superposition and the Fossil Record

Layers of rock are called **strata** (singular, stratum). In 1669, a Danish physician named Nicolaus Steno presented four principles that helped geologists study strata and interpret the rocks' history. The four principles are superposition, original horizontality, original lateral continuity, and cross-cutting relations.

What is the principle of superposition?

The principle of **superposition** states that the layers on the bottom of an undisturbed sedimentary rock layer were deposited before the layers on top. That means that the rocks on bottom are older than the rocks on top. ✓

How is relative age determined?

Imagine you are facing a cliff that is formed from layers of sedimentary rock. The exact ages of each of the rock layers is not known, but their relative age is known. **Relative age** tells you how old something is when compared to something else. For example, the middle strata are younger than the bottom stratum, but are older than the top stratum.

The principle of superposition is perhaps the most important of Steno's four principles. Geologists use the relationship between strata and age to study the rock layers and determine the geologic events that resulted in their deposition.

What are Steno's three other principles?

The remaining three Steno's principles are:

- Rock layers are originally deposited in horizontal, or nearly horizontal, layers.
- These rock layers usually do not end suddenly.
- A rock layer or feature that cuts across other rock layers is younger than the layer or layers being cut.

✓ Reading Check

10. Confirm In an undisturbed layer of rock, which layer is oldest? (Circle your answer.)

- a. the top layer
- b. the bottom layer

How do fossils help determine relative age?

You have read that the fossil record provides information on changes in life throughout Earth's history. Geologists keep track of which fossils came from which strata. By applying the principle of superposition, geologists use the existence of fossils in specific layers to confirm or assign relative ages to rock strata.

Using Rocks to Determine Relative Age

Estimating when a rock layer formed or the age of certain fossils in those layers is one of the tasks of the geologist. James Hutton came up with the idea of uniformitarianism, which allowed scientists to use geologic processes observed today to interpret geologic events of the past.

Nicolas Steno stated four principles that help scientists determine the order, or the relative ages, of these geologic events. The rock cycle outlines the formation processes of the three main types of rock—igneous, metamorphic, and sedimentary. Following the four steps in the formation of sedimentary rocks helps scientists understand how Earth formed. Layering and fossils are common in sedimentary rocks. Fossils can also be used to determine or confirm the relative ages of rock strata.



Think it Over

- 11. Explain** Using Steno's principles, which rock is younger? (Circle your answer.)
- a boulder protruding from a cliff
 - the floor of a canyon

The Age of Earth

Lesson 2 Absolute Ages of Rocks



Grade Seven Science Content Standard. 4.d. Students know that evidence from geologic layers and radioactive dating indicates Earth is approximately 4.6 billion years old and that life on this planet has existed for more than 3 billion years.

MAIN Idea

Geologists measure the amounts of isotopes in minerals to determine how long ago the minerals formed.

What You'll Learn

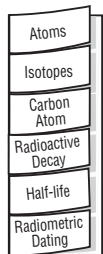
- different types of radioactive decay
- the age of a mineral using the relative amounts of isotopes and the half-life of the parent
- how sedimentary rocks are dated

Study Coach

Two-Column Notes As you read about various dating methods explained in this lesson, write the name of the method on the left side of your paper and make a drawing of the method or technique on the right side of your paper.

FOLDABLES™

B Explain Make a six-tab Foldable. As you read the lesson, record what you learn about how geologists determine Earth's age.



● Before You Read

How do scientists determine the age of a mummy found in the tomb? What kinds of clues do you think the bones or wrappings give? Write your thoughts on the lines below. Then read the lesson to learn about radiometric dating methods.

● Read to Learn

What is Earth's Age?

How would you go about finding out how old Earth is? In the past scientists have tried measuring rates of erosion to see how long it would take to erode mountains. Scientists also tried calculating the time it would take Earth to cool from a molten mass to its present temperature. Each of the attempts they made was unsuccessful at predicting Earth's age. Finally, scientists discovered a natural "clock" that ticked away with great accuracy. This new clock allowed geologists to date the age of Earth, meteorites, and the Moon.

Atoms and Isotopes

Atoms are the microscopic building blocks of all matter on Earth. Atoms are made of protons, neutrons, and electrons. Protons and neutrons are contained in the central area of an atom called the nucleus. Electrons are positioned outside the nucleus.

How many protons are in a carbon atom?

Carbon is one of more than 100 known chemical elements that exist on Earth. An element is defined by the number of protons in its atom. For example, a carbon atom contains six protons while an oxygen atom contains eight protons. Although the number of protons in an atom of any given element is always the same, the number of neutrons can vary.

What are the three carbon isotopes?

Isotope (I suh tohp) is the term for atoms of a given element that have the same number of protons, but a differing number of neutrons. Isotopes of carbon atoms can have six, seven, or eight neutrons. The isotopes are written as carbon-12, carbon-13, and carbon-14. The carbon isotope numbers are found by adding the number of protons and neutrons. Carbon-12 has six protons and six neutrons. Carbon-13 has six protons and seven neutrons. Carbon-14 has six protons and eight neutrons. ✓

What is radioactive decay?

Isotopes of an element may be stable or unstable. Carbon has two stable isotopes and one unstable, or radioactive, isotope. An isotope that has an unstable nucleus breaks down to a stable form through a process called radioactive decay. During **radioactive decay**, an isotope's nucleus gains or loses protons or neutrons. Gaining or losing protons or neutrons in the nucleus is called radiation. Radioactive decay occurs automatically and at a regular rate. This decay is the natural clock that scientists use to find the ages of Earth's rocks. ✓

What is the relationship between the parent isotope and the daughter isotope?

Scientists call the isotope that undergoes radioactive decay the parent isotope. The stable form of the element that forms is called the daughter isotope.

What is the decay rate?

In 1902, Ernest Rutherford and Frederick Soddy discovered that parent isotopes decay into daughter isotopes at a constant rate. This rate is the decay rate.

✓ Reading Check

- 1. Identify** Which part of an atom of a given element is always the same? (Circle your answer.)
 - a. number of protons
 - b. number of neutrons

✓ Reading Check

- 2. Name** the natural clock scientists use to find the age of rocks.

Picture This

3. Highlight the radioactive isotopes that decay to lead.

Half-lives of Selected Radioactive Isotopes		
Radioactive Isotope	Approximate Half-Life	Decay Product
Rubidium-87	48.6 billion years	Strontium-87
Thorium-232	14.0 billion years	Lead-208
Potassium-40	1.3 billion years	Argon-40
Uranium-238	4.5 billion years	Lead-206
Uranium-235	0.7 billion years	Lead-207
Carbon-14	5,730 years	Nitrogen-14

How is half-life measured?

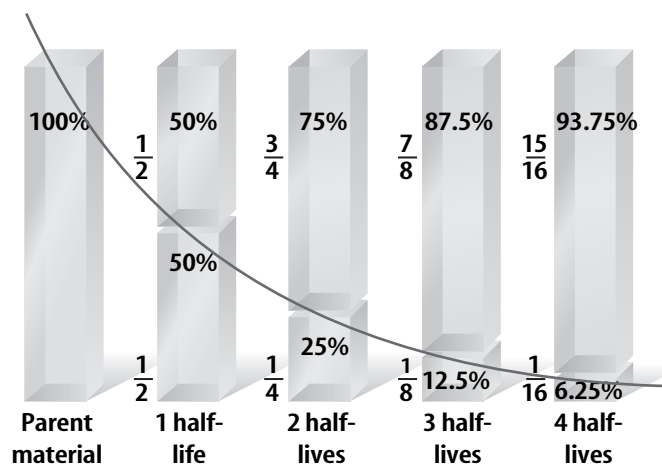
To measure decay rates, scientists compare the amount of parent isotopes and daughter isotopes in a material. The scientists then measure the rate at which the radioactive element gives off protons or neutrons. **Half-life** is the time it takes for a piece of a radioactive element to decay to half of its original mass. The half-lives of some radioactive isotopes are shown in the table above.

How do geologists use half-lives to determine the absolute age of rocks?

Recall that rocks are made up of minerals. Geologists can determine the absolute age of the rock by calculating the absolute age of the minerals that the rock is composed of. They do this by measuring the ratio of parent-isotope to daughter-isotope in the minerals. The figure below shows how during each half-life, one half of the parent material decays to the daughter product.

Picture This

4. Determine What is the percent of parent material in 1 half-life?



Determining Earth's Age

Scientists knew they had found a “natural clock” when they discovered that radioactive isotopes decay at a constant rate. Scientists then wondered if they could find a way to use this “clock” to determine the age of Earth’s oldest rocks—and so determine the age of Earth.

What is radiometric dating?

Radiometric dating is the procedure that scientists use to calculate absolute ages of rocks and minerals. Scientists first measure the amount of parent material in a rock. Then they compare that number to the amount of daughter material in the rock. With that comparison, the number of half-lives the material has been through can be counted. ✓

Igneous rocks are the most common rocks used for radiometric dating. Igneous rocks usually contain only parent isotopes when they formed. Dates calculated from minerals in igneous rocks indicate when the mineral crystallized from magma.

Is radiometric dating used with metamorphic and sedimentary rock?

The age of metamorphic rocks can be difficult to determine. That is because the increase in temperature and pressure during metamorphism can cause a rock to partially melt. When rocks melt, they become igneous. Their radiometric clock gets reset and decay begins again. ✓

Geologists rarely use radiometric dating for sedimentary rocks. This is because the dates from sedimentary rocks indicate when the minerals in the rock formed, not when the sedimentary rock itself formed.

What is the absolute age of Earth?

Geologists wondered whether the constant movement of rocks through the rock cycle would have destroyed Earth’s oldest rocks. Before the 1980s, radiometric dating showed that the oldest-known minerals ranged in age from 3.62 and 3.65 billion years. Then, in 1989, researchers reported finding a 3.96-billion-year-old mineral from a metamorphic rock in Canada. New technology allowed scientists to date other minerals from rock in Canada in 1998 and Australia in 2001. Those minerals were between 4.0 and 4.4 billion years old.

✓ Reading Check

5. Sequence What is the first step scientists use in radiometric dating?

✓ Reading Check

6. Explain Why is it difficult to determine the age of a metamorphic rock?



Think it Over

7. Explain How does the age of the Moon relate to the age of Earth?

Academic Vocabulary

approximate

(uh PROKS uh mut) (adj)

almost or close to

Reading Check

8. State Earth's approximate age.

Meteorites and the Moon Using radiometric dating, meteorites collected in Antarctica have been calculated to be between 4.48 and 4.56 billion years old. Rocks brought back from the Moon are approximately 4.6 billion years old. The closeness of the ages calculated for rocks from meteorites, the Moon, and Earth help to confirm the idea that the entire solar system formed at the same time. So, the absolute age of Earth is about 4.5 billion years, the age of the oldest-known rock in our solar system.

Isotopes and Earth's Age

Scientists use radioactive isotopes to measure the ratio of parent material to daughter material in a substance. This ratio allows scientists to assign approximate ages to the Earth's layers and geologic events. Unstable parent isotopes decay into stable daughter isotopes. The rate at which this decay occurs can be measured. That measurement can be transformed into a unit called a half-life. Using half-life values of certain isotopes allows scientists to calculate the absolute ages of igneous rocks and some metamorphic rocks. Earth's age has been calculated to be about 4.5 billion years, the age of our solar system's oldest rocks.

The History of Life on Earth

Lesson 1 Geologic Time and Mass Extinctions



Grade Seven Science Content Standard. 4.b. Students know the history of life on Earth has been disrupted by major catastrophic events, such as major volcanic eruptions or the impacts of asteroids. **Also covers:** 4.e, 4.g.

● Before You Read

You know that dinosaurs once roamed Earth but then became extinct. Preview the headings in this lesson and on the lines below, write the reasons that you believe could have contributed to the extinction of dinosaurs. Read the lesson to learn more about geologic time.

MAIN Idea

Fossils record life's changes on Earth.

What You'll Learn

- how fossils were used to organize the geologic time scale
- the mass extinction events on the geologic time scale
- how catastrophic events lead to mass extinctions

● Read to Learn

Development of the Geologic Time Scale

The geologic time scale is a record of the changes to life on Earth. Paleontologists (pay lee un TOL uh jihsts), scientists who study the types and ages of fossils in rock layers, use the information they find to organize the geologic time scale into units.

What are index fossils?

Paleontologists base the units of the geologic time scale on whether or not index fossils are present in rock layers. An **index fossil** is the remains of a species that existed over large areas of Earth for a short period of time. The table below explains how an index fossil is selected.

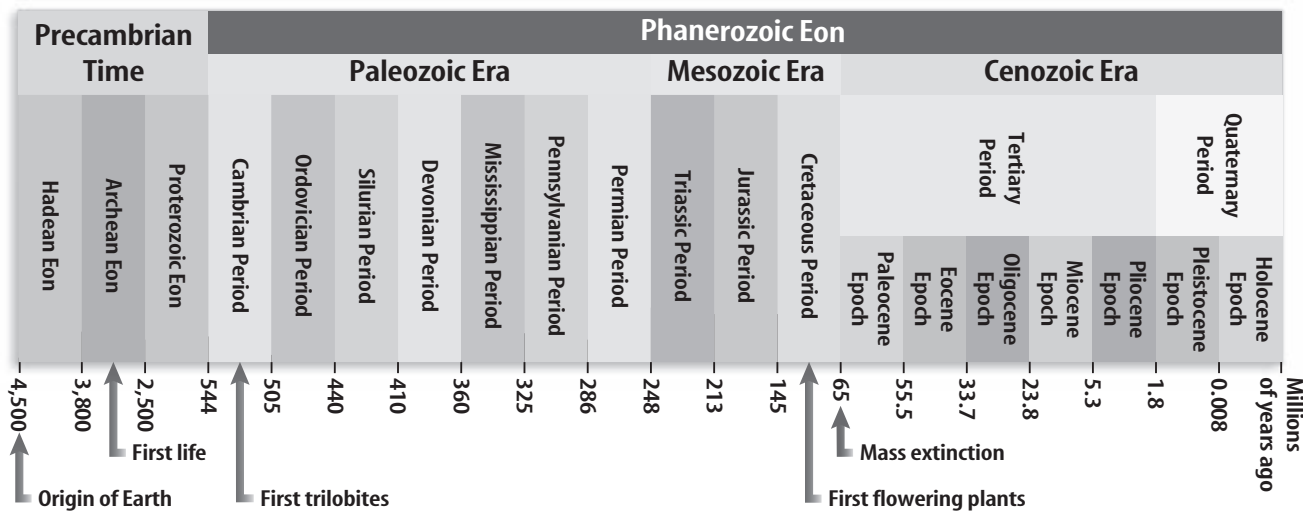
Index Fossil Criteria
1. Species must have hard parts, so they will preserve easily in rock.
2. Species must be geographically widespread, so they are easily found.
3. Species must have lived in many types of environments. This ensures that they will be preserved in many different types of sedimentary rocks.
4. Species must have lived for a short time before they became extinct. This allows rock layers to be divided into small units of geologic time.

Study Coach

Predict Answers Go through this lesson and predict the answer to each question heading. Then, read the lesson to see if your answers are correct.

Picture This

1. **Highlight** the criteria that relates to time.



Picture This

2. Identify What major event occurred at the end of the Mesozoic era?

How is the geologic time scale divided?

The figure above shows the geologic time scale used today. Notice that the divisions of time for each unit do not have the same number of years.

Eras Paleontologists have defined three eras within the Phanerozoic (fan ayr oh ZOH ihk) eon:

- the Paleozoic (pay lee uh ZOH ihk) era, which means “ancient life,”
- the Mesozoic (mez uh ZOH ihk) era, which means “middle life,” and
- the Cenozoic (sen uh ZOH ihk) era, which means “recent life.”

Periods and Epochs Divisions of eras are called periods. The Cenozoic era has been divided into two periods:

- the Tertiary (TER shee ayr ee) period and
- the Quaternary (KWAH tur nayr ee) period.

The Quaternary period began about 1.8 million years ago. The periods have been divided into epochs.

What are mass extinctions?

Several units on the geologic time scale begin and end with mass extinctions. A **mass extinction** is the dying off of many different species of organisms over a short period in geologic time. The extinction of a single species is common. In fact, 99 percent of all species that ever lived on Earth are now extinct. However, the extinction of several species over a short period of time is rare. Mass extinctions do not usually happen suddenly. They may take as long as a few million years. ✓

Reading Check

3. Define mass extinction.

Possible Causes of Mass Extinction

When paleontologists recognized that mass extinctions occurred throughout geologic time, they began to search for catastrophic events that might cause them. A **catastrophic** (ca tuh STRAH fik) **event** is an event that causes a drastic change in the numbers of organisms of one or more species over a short period in geologic time. Paleontologists have identified several types of events that might have caused mass extinction. These events include changes in climate, volcanic eruptions, and asteroid impacts.

Could climate changes have caused mass extinctions?

Scientists have found evidence that some mass extinctions were caused by sudden changes in climate. Recall that climate is an average weather pattern over a long period of time. Species that are unable to survive a change in climate become extinct. Climate change can be caused by several events including some volcanic eruptions and asteroid **impacts**. Global warming and global cooling are two types of climate change that might have caused mass extinctions.

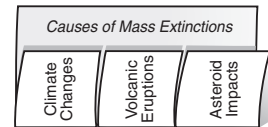
Global Warming Greenhouse gases, like carbon dioxide, are produced by burning fossil fuels, such as coal and oil. Many scientists think greenhouse gases in the atmosphere contribute to global warming, a global increase in atmospheric temperature. When the overall temperature of the atmosphere increases, the temperature of the oceans also increases. Global warming could cause a decrease in oxygen levels in the water because warm water holds less oxygen than cold water. If the oxygen levels drop in shallow waters, where most organisms live, mass extinctions could occur.

Global warming could also melt glaciers, causing water to flow into the oceans. Glacial melting could cause sea levels to rise. Geologists found evidence that warm temperatures, a rising sea level, and shallow areas flooded with oxygen-poor water occurred during the Devonian Period. Some scientists think global warming might have been the cause of the Devonian mass extinctions. ✓

Global Cooling Mass extinctions could also be caused by global cooling, an overall decrease in atmospheric temperatures. Global cooling could cause large amounts of water to be frozen in glacial ice, which would lower sea levels.

FOLDABLES™

A Compare and Contrast Make a three-tab Foldable as illustrated. Compare and contrast events that may have caused mass extinctions.



Academic Vocabulary

impact (ihn PAKT) (noun) to come into contact with great force; to crash

Reading Check


4. List possible effects of global warming.

 **Reading Check**

5. Explain What happens to sea levels during global cooling? Why?

 **Think it Over**

6. Draw Conclusions
How does volcanic haze affect organisms?

Glaciers Form As glaciers formed during periods of global cooling, sea levels went down. Less water in the oceans would mean fewer warm, shallow-water environments. With fewer warm-water environments, there would be less space to support marine ecosystems. Evidence of large glaciers during the Ordovician period makes scientists believe global cooling contributed to that period's mass-extinction event. 

Could volcanoes have contributed to mass extinctions?

Volcanoes can erupt violently, throwing molten rock into the air and on the surrounding land. Volcanoes can also produce nonexplosive eruptions of dust, ash, lava, and gas. Any kind of volcanic eruption can affect climate and organisms.

Basalt Flows Lava can sometimes flow smoothly but in great quantities onto Earth's surface. This flood of molten basalt often occurs along divergent plate boundaries and in isolated hot spots, such as under the Hawaiian Islands. Geologic evidence shows that large basalt flows occurred in Siberia during the Permian mass extinction. The flows are called the Siberian Traps. During the Cretaceous mass extinction, another large basalt flow, called the Deccan Traps, was released in India.

Volcanic Haze The gases produced by basalt flows cause a series of effects. First, sulfur dioxide gas is released into the atmosphere. Sulfur dioxide in the air can result in the formation of acid clouds. These clouds prevent the Sun's warming rays from reaching Earth's surface. At first, global cooling occurs. This is called the volcanic haze effect. But then, over periods of tens to hundreds of thousand of years, global temperatures may increase. That is because heat becomes trapped in Earth's atmosphere by the acid clouds. However, scientists are not certain whether basaltic flows and the gases they emit were enough to cause the Permian and Cretaceous mass extinctions.

Could an asteroid cause mass extinction?

Scientists discovered an asteroid impact site on the Yucatan Peninsula in Central America. Many geologists think this asteroid impact contributed to the Cretaceous mass extinction.

What are the possible effects of an asteroid impact?

Some geologists now suggest that this asteroid impact in Central America sent enough dust and other material into the atmosphere to screen out sunlight. In the months that followed the impact, scientists believe, cold and darkness killed plants and other primary producers. Ecologic systems collapsed and massive extinctions followed. Carbon dioxide released from burning plants and from the decrease in oxygen-producing plankton caused greenhouse conditions for thousands of years. This resulted in a sharp rise in global temperatures.

The Debate Most scientists believe that a large asteroid, or possibly several asteroids, hit Earth at the end of the Cretaceous period. There is also evidence that many species became extinct around the time of the impact. However, paleontologists do not think that the impact caused all of the extinctions.

The fossil record shows that a number of animal species were decreasing in number and diversity long before the asteroid impact. In fact, many species became extinct at least 1 million years before the impact. The fossil record also shows that the extinction rate increased tens of thousands of years before the impact. It appears that while the impact did cause many extinctions, it did not cause all of them.

Is there an extinction pattern?

Mass extinctions occur over a short geologic time span, but they are not sudden events. Fossil evidence indicates that mass extinctions can occur over a few million years or more. What caused the mass extinctions in geologic time? Scientists have not found clear patterns, although there are several types of catastrophic events that can cause mass extinctions. It appears that each mass-extinction event might have been caused by a unique series of events.



Think it Over

7. Compare the effects of volcanic haze and an asteroid impact.

Reading Check

8. Determine What time span is typical for mass extinctions to occur?

The History of Life on Earth

Lesson 2 Early Earth History

Grade Seven Science Content Standard. 4.e. Students know fossils provide evidence of how life and environmental conditions have changed.
Also covers: 4.b, 4.g.



MAIN Idea

Bacteria were the first organisms to evolve on Earth.

What You'll Learn

- the changes in life-forms in the Paleozoic era
- the changes that might have led to mass extinctions

Mark the Text

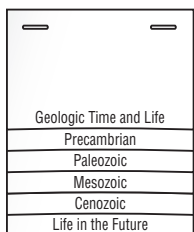
Identify Main Ideas

Underline the main idea in each paragraph of the lesson.

FOLDABLES™

B Record Information

Fold three sheets of paper to make a layered Foldable. Label as illustrated. Under each tab, describe how life changed on Earth during the era. You can complete your Foldable as you read Lesson 3.



● Before You Read

On the lines below, make a list of what you know about fossils. Read the lesson to learn more about how fossils provide evidence of changes on Earth.

● Read to Learn

Life on Earth Changes

Fossils record the history of life on Earth. Paleontologists, who study fossils, discovered that the system used to classify modern organisms could also be used to classify fossils. They observed that fossils from rock layers that are touching are more similar to each other than fossils from widely separated layers. Geologists also recognized that the more recent a fossil was formed, the more it resembles a living organism. In this lesson, you will read about these changes in life during the Precambrian (pree KAM bree un) time.

Precambrian Time

Precambrian time is divided into three eons—Hadean (HAY dee un), Archean (ar KEE un), and Proterozoic (proh ter oh ZOH ihk). The Precambrian time represents 88 percent of Earth's history. Precambrian rocks are difficult for scientists to study because most of the rock has been changed through metamorphism. Recall that it is difficult for scientists to determine the absolute age of metamorphosed rock using radiometric dating. Also, much of the Precambrian rock has been destroyed through plate tectonic activity at subduction zones. As a plate sinks into the mantle, the rock may melt or become metamorphic. Any fossil remains will be destroyed.

Precambrian Fossils Precambrian-aged rocks have fewer fossils than younger rocks. But, the fossils that have been discovered provide a great deal of information about Earth's early atmosphere and environment during this time.

How was the Precambrian atmosphere different from today's atmosphere?

Rocks of Archean age reveal that Earth's early atmosphere was very different from today's atmosphere. Archean sediments contain large amounts of the minerals pyrite and uraninite. The oxygen in today's atmosphere quickly destroys these minerals through the chemical process of oxidation. So, the presence of these minerals in very old rocks shows that Earth's early atmosphere had little oxygen. Because oxygen is required to make ozone, the absence of oxygen also shows that there was no ozone layer during Precambrian time. Atmospheric ozone protects life on Earth from harmful ultraviolet rays.

What were the first organisms?

Fossils of one of the earliest known organisms occur in ancient stromatolites (stroh MA tuh lites). Stromatolites are mounds of alternating thin-layered sediments and photosynthetic cyanobacteria. Cyanobacteria are single-celled, blue-green algae thought to be one of the earliest organisms. Like other photosynthetic organisms, cyanobacteria take in carbon dioxide and release oxygen. Stromatolites were common during the Archaen eon until the late Proterozoic eon, when bacteria-eating animals evolved. Today, stromatolites exist only in water that is too salty and warm for other organisms to survive.

How did Earth's environment change over time?

Recall that Earth's early atmosphere had no oxygen. The earliest organisms did not consume oxygen. In fact, oxygen could kill early organisms. But, because cyanobacteria are photosynthetic, they released oxygen into the atmosphere. Over the next hundreds of millions of years, oxygen levels rose slowly as cyanobacteria and other early life-forms released oxygen. As oxygen levels rose, natural selection favored organisms that could tolerate or even use oxygen. The amount of ozone in the atmosphere also increased during this time, shielding life on Earth from ultraviolet rays. These gradual changes to the atmosphere resulted in major changes in life on Earth.

Academic Vocabulary

reveal (rih VEEL) (verb) to uncover the meaning of; to make known

Reading Check

- 1. Explain** Why are there no large amounts of pyrite and uraninite in modern sediments?

Think it Over

- 2. Determine** What is a photosynthetic organism?

Reading Check

3. Explain What happened to organisms during the Proterozoic Eon?

Picture This

4. Identify Highlight the body segments of the trilobites in the figure.

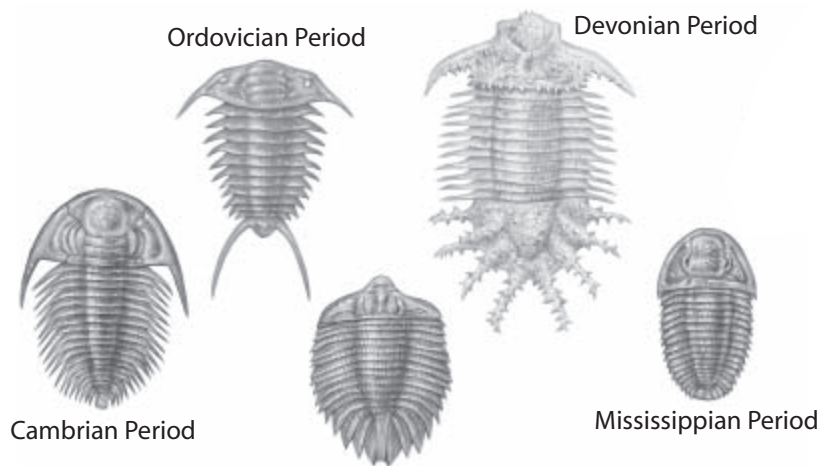
What were the first soft-bodied organisms?
Organisms increased in complexity in the Proterozoic eon. During this eon, the first invertebrate organisms appeared. Invertebrates are animals without backbones. Unusual fossils of soft-bodied organisms, called the Ediacaran (eddy uh KER uhn) fauna, had shapes similar to present-day jellies, worms, and corals. ✓

The Paleozoic Era

The first appearance of fossils of organisms made from hard parts marks the end of the Proterozoic eon. Organisms made from hard parts make better fossils than organisms made of soft parts. Therefore, fossils are easier to find in Paleozoic rocks than Precambrian rocks.

What was the Cambrian explosion?

About five million years after the start of the Cambrian (KAM bree un) period, an event known as the Cambrian explosion occurred. The fossil record shows that during a relatively short time, the number of animals with shells greatly increased. Trilobites, animals with hard outer skeletons, were the most commonly fossilized organisms of the Cambrian period. Some species of trilobites are shown below.



What were the Paleozoic era invertebrates?

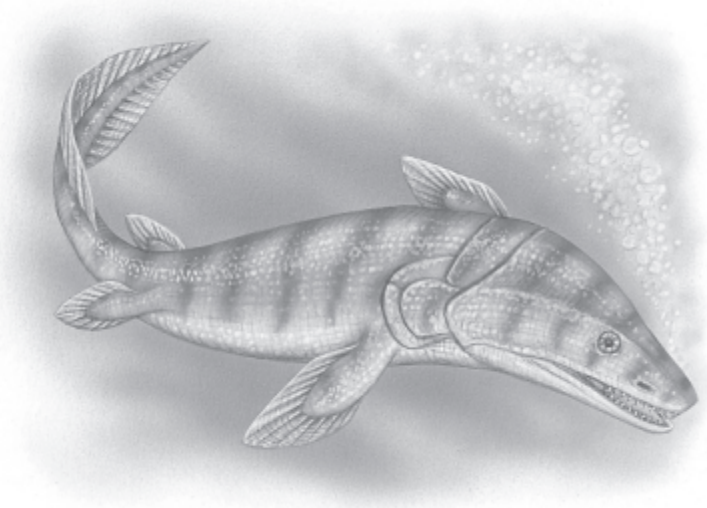
Throughout the Paleozoic era, the oceans contained a wide variety of invertebrate organisms including corals. Insects evolved during the Silurian (si LOOR ee un) period. Some insects grew to great sizes. During this period, cockroaches grew to be as much 10 cm long and some dragonflies had wingspans of 74 cm.

What were the vertebrates of the Paleozoic era?

Animals with backbones, or **vertebrates**, evolved during the early Paleozoic era. The first of these vertebrates lived in the oceans. ✓

Bony Fish Early vertebrates included two groups of bony fish. One group of fish had thin, bony rays, which supported their fins. Scientists think that modern-day fish evolved from these early fish.

Another group of bony fish had thick fins supported by large bones and muscles, such as the ancient fish shown below. Scientists think this group gave rise to amphibians, animals that can live both in water and on land. Amphibians later evolved into reptiles and mammals.



A New Egg During the Pennsylvanian period, a significant development occurred in the process of egg-laying. Up until this period, amphibians laid eggs in the water. Amphibian eggs are not watertight. In fact, water was necessary to carry food and wastes into and out of the eggs. Amphibian eggs must be laid in water to avoid drying out. Then, during the early Pennsylvanian period, amniotes evolved. **Amniotes** (AM nee ohtz) are organisms that lay watertight eggs called amniotic eggs. These eggs did not dry out and could be laid on land. With this advantage, and the appearance of land plants during the Ordovician period, amniotes spread into dry habitats. Both mammals and reptiles, including dinosaurs, evolved from amniotes.

✓ Reading Check

5. Define What is a vertebrate?

Picture This

6. Draw circles around the leg-like fins on the fish shown in the figure.

What were the plants of the Paleozoic era?

The first plants developed in the ocean from green algae. During the Ordovician period, plants began spreading onto land. Since these early plants could not move water and nutrients to all their parts, the plants remained small and lived in low, moist areas. Vascular plants are able to move water and nutrients between their roots and leaves. Once vascular systems evolved, new plants developed quickly. Early vascular club mosses were small, but by the Late Devonian they had become trees. Ferns and groups that include the present-day conifers, such as pine trees, appeared during the Mississippian period. Large swamps containing abundant trees and ferns developed during the Mississippian and Pennsylvanian periods. These plants decayed and became the coal deposits that are an important energy resource today. ✓

✓ Reading Check

- 7. Name** What evolutionary adaptation allowed plants to grow large and above water?

✓ Reading Check

- 8. List** the events that might have caused the Paleozoic era extinctions.

What caused the Paleozoic era extinctions?

The fossil record indicates that mass extinction events occurred during the Ordovician period and the Devonian period. The Paleozoic era ended with the late Permian extinction—the extinction of more than 90 percent of all marine species and more than 70 percent of all land species. Several hypotheses have been proposed to explain the Permian extinction. One proposal is that the uplifting formation of Pangaea left little room for shallow-water life forms as marine terraces became dry land. Another proposal is that the Siberian traps released ash and sulfur into the atmosphere, causing global cooling and the forming of glaciers on land. ✓

Mass Extinctions End the Paleozoic Era

The early Cambrian period saw the expansion on Earth of many new species of life and the development of hard-shelled organisms that would leave fossil evidence of their existence. Before the Paleozoic era ended there would be the evolution of the first fish, land plants, amphibians, and reptiles, all of which had hard parts that left fossil evidence. However, about 250 million years ago, the late Permian extinction resulted in the extinction of most marine and land species. Changes in species diversity usually follow an extinction event. Niches and habitats once inhabited by some organisms became empty and other species moved into these spaces. Extinction of predators allowed other organisms to increase in number and expand in distribution.

The History of Life on Earth

Lesson 8 Middle and Recent Earth History



Grade Seven Science Content Standard. 4.g. Students know how to explain significant developments and extinctions of plant and animal life on the geologic time scale. **Also covers:** 4.e.

● Before You Read

On the lines below, describe what birds and dinosaurs might have in common. Then read the lesson to learn about how common animals of today evolved from ancient life forms.

● Read to Learn

The Mesozoic Era

The three periods of the geologic time scale that make up the Mesozoic era are the Triassic period, the Jurassic period, and the Cretaceous period. Most organisms that survived the Permian mass-extinction event diversified widely during the next 50 million years.

How did reptiles of the Mesozoic era adapt to a changing landscape?

At the beginning of the Mesozoic era, all the continents were joined and formed one landmass called Pangaea. During the Triassic period, Pangaea began to break apart as Earth's plates moved away from one another. Pangaea split in two. Over time, the continents we know today formed.

Some species, such as reptiles, survived the tremendous changes and mass extinction that occurred at the end of the Paleozoic era. In the early Mesozoic era, the climate became drier. The reptile's scaly skin kept in moisture, so reptiles could live in the drier climate. A shell protects reptile eggs, so their young survived as well. Reptiles became the most abundant animals of the Mesozoic era.

MAIN Idea

Life continues to evolve into many of the forms we see on Earth today.

What You'll Learn

- the evolution of organisms on Earth today
- the changes that pressure organisms to evolve
- the diversity of life over time

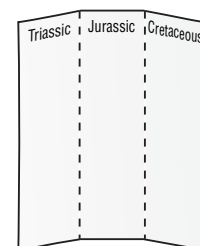
Study Coach

Make a List List each era discussed. Then list facts that you learn about each era.

FOLDABLES™

● Record Information

Fold a sheet of paper into thirds to make a three column chart. Label as illustrated. Record what you learn about vertebrates, invertebrates, and plants that lived during the Mesozoic Era.



Academic Vocabulary
evolve (ih VAHLV) (verb) to grow and change


 **Reading Check**

1. Name an important development during the Triassic period.

 **Reading Check**

2. Determine Why did scientists think at first that dinosaurs were ectotherms?


What were the Mesozoic era invertebrates?

Following the extinction of their predators at the end of the Paleozoic era, the number of stromatolites increased. Several groups of algae evolved during the Jurassic period and large clams called rudistids evolved during the Cretaceous period. An important development during the Triassic period was the evolution of the first reef-building corals. Though most groups of organisms diversified during the Mesozoic era, the insects that became so abundant during the late Paleozoic era declined in number and diversity throughout the Mesozoic era. 

What were the Mesozoic era vertebrates?

In addition to the fish that evolved during the Paleozoic era, the oceans of the Mesozoic era contained predatory reptiles such as plesiosaurs and mosasaurs. Amphibians, reptiles, and mammals that lived on land continued to evolve during the Mesozoic era. Frogs, turtles, crocodiles, pterosaurs, and dinosaurs evolved during this time. **Pterosaurs** were flying reptiles. Many were the size of today's predatory birds. Some pterosaurs had a wingspan of 12 m. Although pterosaurs shared many characteristics with dinosaurs, they were not dinosaurs.

Dinosaurs Dinosaurs evolved during the Triassic period. The first dinosaurs were small, but as new species evolved, they grew bigger. *Apatosaurus* and *Diplodocus* were some of the largest animals that have ever walked on Earth.

Scientists who studied dinosaur fossils first thought that the skulls, feet, and tails of dinosaurs were shaped like same parts of modern reptiles'. Early ideas of dinosaurs made scientists assume dinosaurs had behavior patterns like reptiles. That would mean dinosaurs were **ectotherms**, animals that rely on the surrounding air to regulate their body temperatures. Ectotherms sit in the Sun when they get too cold and move to the shade if they are too warm. 

Recent studies of dinosaur bone structure shows that the structure is more similar to endothermic species than to reptiles. **Endotherms** generate internal body heat to maintain a constant body temperature. Today, scientists think that dinosaurs were endotherms and may have lived more like today's mammals and birds than like reptiles. Evidence led scientists in the 1970s to propose that birds are descended from the dinosaurs.

Birds The discovery of a dinosaur-like skeleton with fossilized feathers in Jurassic-aged rocks provided support for the theory that birds evolved from dinosaurs during the Jurassic period. *Archaeopteryx* is the name that has been given to one ancestral bird species.

Mammals Alongside the dinosaurs, mammals evolved during the Triassic period. Early mammals were small in size and not very numerous or diverse. Then in the late Cretaceous period, mammals began to increase in both number and diversity. As dinosaur species became extinct, mammals were able to move into the niches that dinosaurs once occupied.

What were the plants of the Mesozoic era?

Plants called gymnosperms dominated the plant population of the Mesozoic era. **Gymnosperms** produce seeds but no flowers. Some gymnosperms, such as pine and ginkgo trees, still exist today. Angiosperms evolved near the end of the Mesozoic era. Angiosperms are flowering plants that produce seeds with hard outer coverings. These hard seed coverings gave angiosperms the ability to live in many different environments and to survive in harsh climates. ✓

What are the Mesozoic era extinction events?

Scientists have observed evidence of extinction events in rocks of Mesozoic-era age. The Triassic period ended with a mass-extinction event that killed off approximately 20 percent of all marine families. Another mass-extinction event occurred at the end of the Jurassic period. Several dinosaur groups including some of the largest dinosaurs, such as *Diplodocus*, became extinct during this event. One of the most well known extinction events occurred at the end of the Cretaceous period. Almost 85 percent of all species in the oceans and all of the remaining dinosaurs became extinct, yet many mammal species survived. This event marked the end of the Mesozoic era.

The Cenozoic Era

The Cenozoic era is divided into seven epochs. Unlike other periods, epochs of the Cenozoic periods have been given specific names: Paleocene, Eocene, Oligocene, Miocene, Pliocene, Pleistocene, and the current epoch, the Holocene. During the Cenozoic era, marine life began to recover from the Cretaceous mass-extinction event. The offspring of organisms that survived the Cretaceous extinction event make up the present marine ecosystems.

Reading Check

3. Contrast How are gymnosperms and angiosperms different?

Think it Over

4. Conclude Why were many mammal species able to survive the mass extinctions of the Mesozoic era?

How did land animals evolve during the Cenozoic era?

By the beginning of the Cenozoic era, the modern mammals had evolved. Some mammals returned to the ocean. During the Eocene epoch, whales evolved from carnivorous, or meat-eating, land mammals to the modern marine mammals they are today.

Primates, animals with opposable thumbs and two eyes that look directly forward, evolved during the Eocene epoch. Primates diversified rapidly and lived in both the trees and on the ground. About 4.4 million years ago, during the Pliocene epoch, the hominids evolved. Hominids are descendants of these early primates. Hominids walk upright on two legs. The human species, *Homo sapiens*, belongs to the hominid group. ✓

✓ Reading Check

5. Describe When did hominids evolve?

What were the plants of the Cenozoic era?

Recall that flowering plants evolved near the end of the Mesozoic era. Flowering plants have continued to evolve ever since. Today, there are more than 250,000 species of flowering plants. Fruits, vegetables, and nuts are all produced by flowering plants. Grasses are flowering plants. They evolved during the Eocene epoch. The grasses supported a large diversity of mammals, which enabled the mammals to multiply and diversify.

What happened to cause the Cenozoic-era extinctions?

You may think that extinction events have only occurred in the distant past. Cenozoic mass-extinction events have not occurred on the scale of those previously discussed in this chapter. However, extinctions have occurred during the Cenozoic era. Some extinctions are the result of natural selection while others have been caused by humans.

Complexity Increases over Time

Fossil sequences from the Archean eon to the Cenozoic era show that complexity increases over time. Life began as simple bacteria. Then more complex organisms with shells evolved. Organisms became more diversified and continued to evolve from marine invertebrates to marine and land vertebrates and plants. The fossil record reveals this change. ✓

✓ Reading Check

6. Explain How is life continuing to become complex?

The Musculoskeletal System and Levers

Lesson 1 The Musculoskeletal System



Grade Seven Science Content Standard. 5.c. Students know how bones and muscles work together to provide a structural framework for movement.
Also covers: 6.h.

Before You Read

Imagine a builder that only builds the outside walls of a house. Although the house would be protected from the elements, it wouldn't be a home until the inside was finished. On the lines below, write about what would be needed to complete the house. In this lesson, you will read about parts of the body that work together so that you can move.

MAIN Idea

Muscles, tendons, ligaments, and bones work together to produce movement.

What You'll Learn

- the main characteristics of the skeletal system
- how muscles contract and relax

Read to Learn

The Skeletal System

The hard structures within your body are part of your **skeletal system** (SKE luh tuhl • SIS tum), which provides support, protection, and movement. The human body has over 200 bones that make up the skeletal system. A **bone** is a hard tissue made mostly of cells, collagen, and calcium. Collagen is a protein that forms strong fibers. Calcium is a mineral that adds strength to the collagen fibers.

Bones have different shapes and sizes. Blood vessels and nerves enter and leave bones. Bones have many small, open spaces. The spaces make bones lighter.

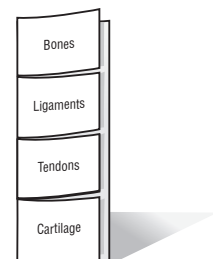
One function of bone is protection. The bones in your skull, for example, protect your brain from injury. The vertebrae in your back protect the spinal cord. Without support from the skeletal system, you would be a soft mass without definite shape. Your muscles attach to bones and allow you to move. The middle of some bones, called marrow, is the place where blood cells are formed.

Study Coach

Write Questions As you read this lesson, write a question for each paragraph. After you're done reading, answer your questions.

FOLDABLES™

A Define Make a four-tab Foldable and label the front tabs as illustrated. Define and record what you learn about bones, ligaments, tendons, and cartilage under the tabs.



Academic Vocabulary
similar (SIH muh lur) (adj.)
 alike; much the same as

Picture This

1. **Identify** the type of joint used in each of the following activities.

raise your arm:

kneel:

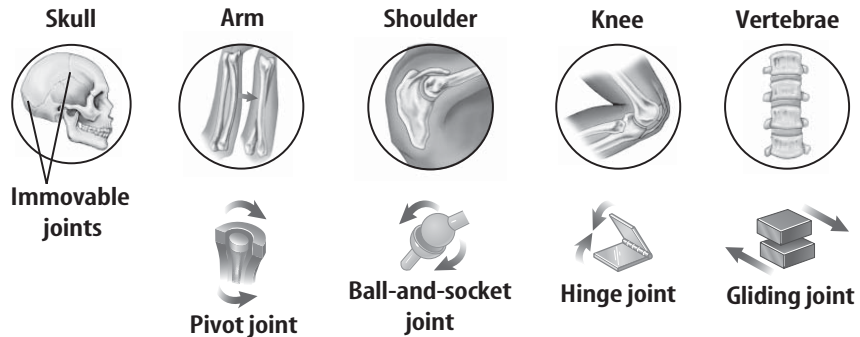
Reading Check

2. **Locate** Where is the saddle joint in the human body?

How do bones connect at joints?

Bones are hard and cannot bend. Yet, your body is flexible. You can bend, twist, and rotate because your bones connect at **joints**, such as those in the figure below.

The softer tissues of the skeletal system help hold bones together at joints. Ligaments connect bones. Ligaments are **similar** to strong rubber bands that stretch when you move. **Cartilage** is a strong, elastic tissue that reduces friction and increases flexibility.



What are the different types of joints?

The structure of a joint determines how the bones that connect at the joint can move. For example, you can twist your lower arm to the right or left without moving your upper arm. Your elbow joint allows this movement.

Hinge Joint The joints in your fingers, elbow, and knee are hinge joints. Hinge joints only allow bones to move back and forth, like the hinges of a door.

Saddle Joint Your thumb has a saddle joint. In a saddle joint, the bones at both ends are shaped like saddles. Compare the movement of your thumb to the other fingers in your hand. The thumb has a wider range of motion. The only saddle joint in your body is your thumb joint. ✓

Ball-and-Socket Joint Your hip and shoulder joints are ball-and-socket joints. They can move in nearly every direction. One bone in a ball-and-socket joint is round. It fits into a cuplike depression of the joint's other bone. An ellipsoid joint is like a ball-and-socket joint, except the end of the bone is shaped like an ellipse instead of being round. The knuckles of your hands are examples of ellipsoid joints.

Pivot Joint You can turn your head from side to side because of a pivot joint between the first two vertebrae in your neck. In a pivot joint, the cylindrical region of one bone fits into a ring-shaped structure of another bone. Pivot joints only allow bones to rotate.

Gliding Joint Two bones that connect at flat surfaces form a gliding joint. The bones in a gliding joint can only move from side to side or front to back. Your ankles and wrists have gliding joints.

Immovable Joint Two bones held firmly together form an immovable joint. An immovable joint allows very little or no movement. Your skull contains immovable joints. When you were born, there were spaces between some of the bones of your skull. These spaces allowed your brain to grow. As you grew, the immovable joints fused the bones in your skull together. ✓

The Muscular System

Muscle (MUH sul) is tissue made of long cells that contract. There are more than 620 muscles in the human body. Muscles are made of bundles of muscle cells called muscle fibers. Muscle fibers are not like other cells. Each fiber contains bundles of small tubes. The tubes are filled with threadlike proteins called muscle filaments. During muscle contraction, the muscle filaments move closer to each other. All the muscle cells of a muscle contract at the same time and the muscle shortens. The muscle fibers move away from each other during muscle relaxation.

What makes our muscles contract?

Muscles have nerve cells that receive signals from the nervous system. The nerve cells start a chemical reaction in the muscle cells that leads to muscle contraction. Muscle cells contain more mitochondria than other cells in order to produce the energy needed for contraction. Many blood vessels supply muscles with oxygen. The mitochondria need oxygen for cellular respiration.

What are the types of muscle?

A voluntary muscle is a muscle that you are able to control, such as your arm or leg. An involuntary muscle is one that you cannot control by thinking about it, such as your stomach or heart. Involuntary muscles work all day, every day. ✓

Academic Vocabulary
region (RIH juhn) (noun) an area

✓ Reading Check

3. Define What is an immovable joint?

✓ Reading Check

4. Compare What is the difference between an involuntary muscle and a voluntary muscle?

 **Reading Check**

5. Name the three types of connective tissues.

Academic Vocabulary

contract (kun TRAKT) (verb) to reduce to a smaller size




Think it Over

6. Compare What is the difference between flexion and extension?

Interactions of the Musculoskeletal System

Your bones need muscles to move. However, muscle contractions alone cannot move your body. In order for you to move, the muscular system needs the skeletal system to provide support for your muscles.

Tendons (TEN dunz) connect bone to muscle. Tendons do not stretch as much as ligaments. Tendons, ligaments, and cartilage are connective tissue. Tendons and ligaments attach to the bones at rough spots on the bones. 

How do opposing muscle groups work together?

The biceps muscle causes your arm to bend. **Flexion** (FLEK shun) is the bending of a limb that decreases the angle between the bones of the limb. Flexion of your arm happens when the biceps muscle shortens during contraction. During this flexion, your biceps muscle shortens, your lower arm moves closer to your upper arm, and your arm bends at the elbow.

Extension (eks TEN shun) is the straightening of a limb that increases the angle between the bones of the limb. Muscles can contract, but they cannot actively lengthen. Opposing muscle groups work together to cause extension. You already read that contractions of the biceps muscle cause your arm to bend. For your arm to straighten, the triceps muscle at the back of your arm contracts. At the same time, the biceps muscle relaxes.

What have you learned?

The musculoskeletal system works to move the body. The skeletal system is made of bones, ligaments, tendons, and cartilage. The skeletal system supports and protects the body.

Joints allow hard bones a wide range of movement. Different joints allow different kinds of movements.

Muscles provide the contractions necessary to move bones. The nervous system works to signal muscles of the need for movement. Opposing muscle groups work together to flex and extend muscles. Smooth movements are possible because opposing muscle groups work together.

The Musculoskeletal System and Levers

Lesson 9 The Body and Levers



Grade Seven Science Content Standard. 6.i. Students know how levers confer mechanical advantage and how the application of this principle applies to the musculoskeletal system. **Also covers:** 5.c, 6.h.

● Before You Read

On the lines below, describe what comes to mind when you think of a simple machine. Would you consider a baseball bat, scissors, or a bottle opener a machine? Why or why not? Read the lesson to learn more about how the muscles, joints, and bones in your body work together like a machine.

MAIN Idea

Muscles and bones act as levers, providing force or speed advantages.

What You'll Learn

- the three classes of levers
- levers in the human body
- advantages of having levers in the body

● Read to Learn

What is a lever?

The ancient Greek mathematician Archimedes (287 B.C.–212 B.C.) is credited with first describing the uses of simple machines called levers. A **lever** (LEE ver) is a simple machine made of anything rigid that pivots around a fixed point. A **fulcrum** (FUL krum) is the fixed point that a lever pivots around. The fulcrum is also known as a pivot point. Levers make work easier. Sometimes levers allow the user to perform a task using less force. Other times the task can be completed in less time or by moving a shorter distance.

The Three Classes of Levers

A seesaw is an example of a lever. On a seesaw, the board you sit on is the lever. The base that the board rests on is the fulcrum. Two forces act upon different parts of a lever. A force is a push or a pull on an object. Force occurs when an object interacts with another object.

Study Coach

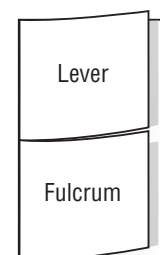
Check for Understanding

As you read this lesson, be sure to reread any parts you don't understand.

FOLDABLES™

B Sketch and Describe

Make a two-tab Foldable. Label the front tabs as illustrated. Describe and sketch lever and fulcrum under the tabs.



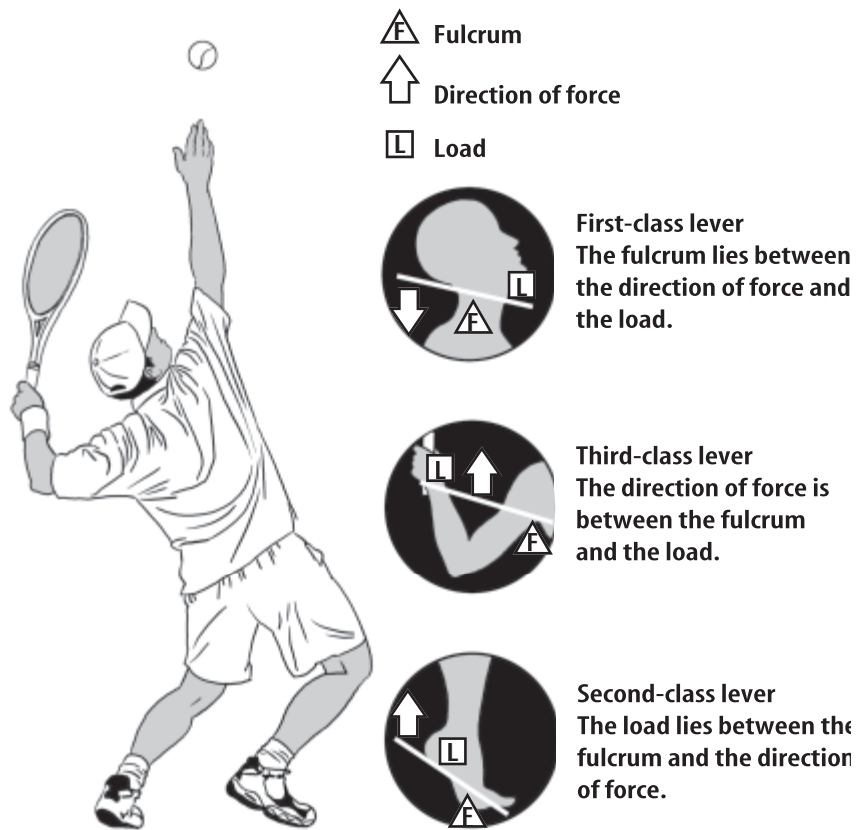
What are two types of force?

The effort force moves an object over a distance. The resistance force opposes the effort force. A child sitting on and moving the seesaw down exerts the effort force. The child being pushed up on the opposite side is exerting the resistance force.

A seesaw is one of three different types of levers. The location of the fulcrum, load, and applied force determines the type of lever. The illustration of a tennis player, below, shows the three classes of levers in the human body.

Picture This

- 1. Identify** On the drawing of the tennis player, circle and label the three types of levers in the body that are used to serve a tennis ball.



What are first-class levers?

The resistance force and the effort force are on opposite sides of the fulcrum in a **first-class lever**. Seesaws and scissors are examples of first-class levers. When you open and close a pair of scissors, the direction of the effort force changes. ✓

What are second-class levers?

The resistance force is between the fulcrum and the effort force in a **second-class lever**. Luggage with wheels on the bottom is an example of a second-class lever. The handle is where you exert the effort force. The weight of the luggage is the resistance force. The wheels act as a fulcrum.

Reading Check

- 2. Determine** How many fulcrums does a pair of scissors have? (Circle your choice.)
- 1
 - 2
 - 3

What are third-class levers?

In a **third-class lever**, the effort force is between the resistance force and fulcrum. This arrangement requires more effort force than the resistance force it produces. This means that using the lever to move the object is more difficult than moving the object without the lever. However, you are able to move the object farther or faster than you could without the lever. Baseball bats, hockey sticks, fishing poles, hoes, and shovels are examples of third-class levers.

Why use levers?

We use levers to make difficult jobs easier. Some levers make it easier to lift heavy objects. Other levers make it easier to move objects faster and farther.

It takes the same amount of work to lift a car whether you lift the car by yourself or use a jack. However, the jack makes it easier to do work. Just like mechanical levers, the bones and muscles in your body are arranged in ways to make work easier.

How do levers create mechanical advantage?

You just read that a lever could decrease the amount of force needed to do a task. **Mechanical advantage** is the ability of a machine to increase the amount of force put into the machine. Mathematically, mechanical advantage (MA) is the **ratio** of the resistance force (F_R) to the effort force (F_E).

$$\text{Mechanical advantage (MA)} = \frac{\text{Resistance force } (F_R)}{\text{Effort force } (F_E)}$$

For example, a lever that exerts a resistance force of 60 to the effort force of 20, has a mechanical advantage of 3. That means the machine tripled the force applied to it. ✓

$$\text{MA} = \frac{60}{20} \quad \text{MA} = 3$$

What advantage do third-class levers provide?

Sometimes we need help moving objects quickly over long distances. Third-class levers can make it easier to move an object a long distance quickly. Recall that a baseball bat is an example of a third-class lever. When you swing a bat, the handle of the bat moves a short distance, but the end of the bat travels a longer distance at a greater speed.



Think it Over

- 3. Summarize** Identify the class of lever for the simple machines listed below.

Tennis racket:

Pliers:

Academic Vocabulary

ratio (RAY she oh) (noun) the relationship in quantity, amount, or size between two or more things; proportion

Applying Math

- 4. Calculate** If a lever has a resistance force of 50 and an effort force of 25, what is the lever's mechanical advantage?

 **Reading Check**


5. Explain What parts of the body work together as levers?

 **Reading Check**

6. Determine What is produced by exerting force over a distance? (Circle your choice.)

- a. resistance
- b. speed
- c. work


How do third-class levers make us faster?

Having bones as levers helps you do work by giving you more efficient ways of using force. This usually allows you to move faster. The end of a swinging baseball bat moves farther and faster than the end grasped by the batter. The same is true for your limbs. Your limbs have multiple joints and therefore multiple levers. Consider the movement of your legs and your feet as you walk. Your feet move much farther and faster than your upper leg when you walk. The levers in your hip and knee joints allow you to have long, quick strides. Levers increase the speed of your arms and hands as well. 

How can the length of a lever affect the way your body works?

Consider arm wrestling. The person who produces the most force will win. Recall that work equals force times distance. Because the length of both arms, the distance, is the same, the person who is able to produce more force will win. If one person's arm is shorter, the person with the shorter arm will have to produce more force to win the match. However, it will be easier for the person with the shorter arm to produce more force because the effort and resistance force are closer together. Less effort is needed to match the resistance provided by the opponent. This is why shorter men and women have a natural advantage in sports such as gymnastics and figure skating.

What have you learned?

A lever is a simple machine that makes work easier. The force applied to a lever can change in size or direction. But the work done by a lever cannot be more than the work put into it. There are three classes of levers. The location of the fulcrum, effort force, and resistance force determine the class of the lever. First-class and second-class levers make work easier by multiplying the force you put into the machine. Third-class levers make work easier by increasing the speed of motion. 

Bones act as levers in your body. Muscles provide the force to move objects. The arrangement of multiple levers needed to perform movements creates an advantage. You have each class of levers in your body, but most levers in the body are third-class levers.

The Cardiopulmonary System and Pressure

Lesson 1 The Pulmonary-Circulatory System

Grade Seven Science Content Standard. 5.b. Students know organ systems function because of the contributions of individual organs, tissues, and cells. The failure of any part can affect the entire system.



Before You Read

You can feel your pulse in your neck, wrist, or ankle. You feel your pulse because of your heartbeat. On the lines below explain how your heartbeat produces a pulse. Then read the lesson to learn about the pulmonary and circulatory systems.

MAIN Idea

The pulmonary and circulatory systems work together.

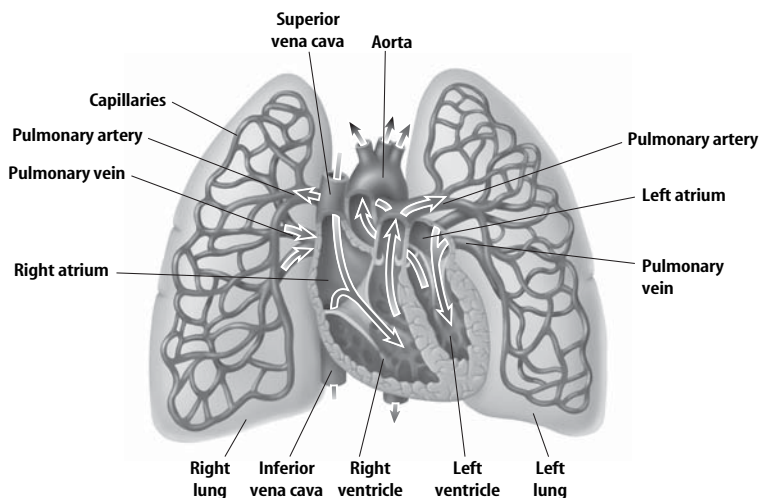
What You'll Learn

- how the pulmonary and circulatory systems interact
- problems that can happen in the circulatory and pulmonary systems

Read to Learn

The Pulmonary System

You need oxygen to live. You get oxygen from the air you breathe. You also need to get rid of carbon dioxide from your body. Carbon dioxide is a waste product of cellular respiration. As shown below, your **pulmonary system** (PUL muh ner ee • SIHS teh) contains tissues and organs specialized for taking in oxygen and removing carbon dioxide from your body.



Study Coach

Write a Question As you read this lesson, write a question for each paragraph. After you're done reading, write the answers to your questions.

Picture This

1. **Explain** to a partner the flow of blood in pulmonary circulation.

A Take Notes Make a Foldables table and label as illustrated. As you read the lesson, use the table to take notes on what you learn about the pulmonary and cardiac systems.

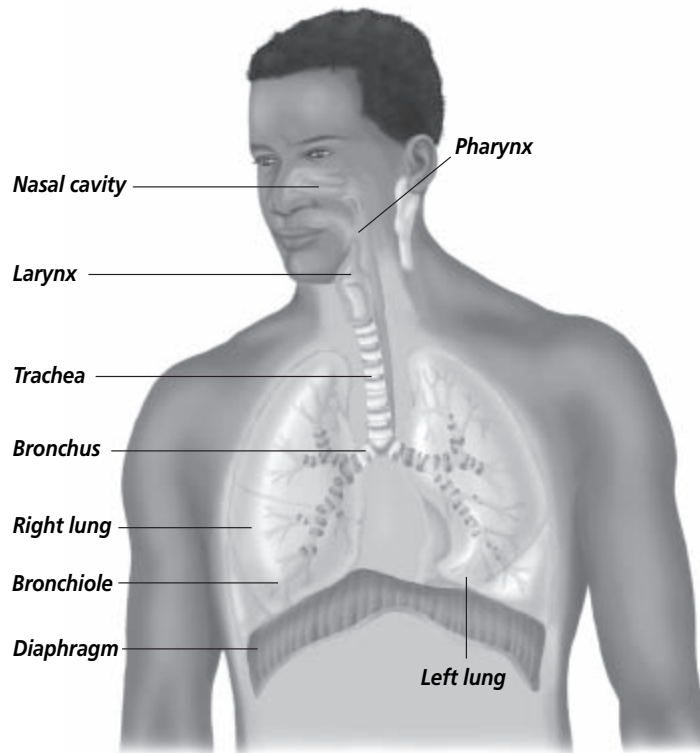
	Function	Organs	Problems
Pulmonary System			
Cardiac System			

Picture This

2. Identify What is the name of the structure that branches into the lung from the trachea?

How do we breathe?

Breathing is the process of air entering and leaving the lungs. When you inhale, you breathe in air. When you exhale, you breathe air out. The muscles between and below the ribs allow the rib cage to expand and contract. The flat muscle below the rib cage is called the diaphragm, as shown in the figure below. When you inhale, the diaphragm contracts and air enters the pulmonary system through your nose or mouth. The inhaled air first passes through the pharynx (FER ingks), a tubelike passageway in the throat. Then air moves into your larynx. Your larynx (LER ingks) is the valve that separates the upper and lower portions of your throat. After passing by the larynx, air goes to the trachea (TRAY kee uh). The trachea forks into two branches, called bronchi (BRAHN ki) (singular, bronchus).



How do your lungs work?

The organs of the pulmonary system in which gas exchange occurs are the **lungs**. Humans have two lungs in their chest cavity. Air enters the lungs through the bronchi. The bronchi then divide into the branched tubes called bronchioles (BRON kee ohlz). At the end of the bronchioles are tiny sacs called alveoli (al VEE uh li) (singular, alveolus). There are millions of alveoli in the lungs. ✓

✓ Reading Check

3. Determine From what structure does air enter the lungs?

Where does gas exchange occur?

The bronchioles and the alveoli provide surface area for gas exchange. Alveoli are surrounded by small blood vessels. The oxygen you breathe and the waste product from the cells—carbon dioxide—are exchanged across a thin membrane between the alveoli and the small blood vessels. The air full of carbon dioxide is exhaled. ✓

What causes pulmonary system problems?

Problems in the pulmonary system can sometimes make it hard to breathe. Pneumonia, suffocation, and asthma are examples of problems that could occur.

Pneumonia One of the leading causes of death in the United States is **pneumonia** (noo MOH nyuh), an infection of the lungs. Viruses, bacteria, fungi, and parasites can cause pneumonia. When a person has pneumonia, fluid builds up in the lungs and gases cannot be easily exchanged. Less oxygen gets to the blood. ✓

Suffocation Food and other objects can become stuck in a person's airway. When this happens, oxygen is not supplied to the lungs. **Suffocation** occurs when the lungs and body do not receive enough oxygen. Breathing gases like carbon monoxide can also cause suffocation.

Asthma The most common long-term disease in children is **asthma** (AZ muh), an inflammatory disease of the airways to the lungs. Allergens cause airways to narrow. This causes chest tightness and coughing. Breathing becomes difficult.

The Circulatory System

Your blood contains oxygen, food, nutrients, and waste products produced by cells. The **circulatory system** transports blood throughout your body.

What does blood contain?

Your blood is a red liquid that contains many substances. The liquid part of blood is called plasma. Plasma is mostly water. Blood is 55 percent plasma. The rest is made up of cells and cell parts. Red blood cells have an iron-containing protein called hemoglobin that carries oxygen. White blood cells fight infections. Blood also has parts of cells called platelets. These clot blood and cause scabs to form when you have a cut. ✓

✓ Reading Check

4. Explain Why is carbon dioxide exhaled?

✓ Reading Check

5. Evaluate List three causes of pneumonia.

✓ Reading Check

6. Name the substance in blood that helps fight infections.

Reading Check

7. Identify What are the four chambers of the heart?

Picture This

8. Determine If veins carry blood to the heart, and arteries carry blood away, is the vena cava a vein or an artery?

How does the heart work?

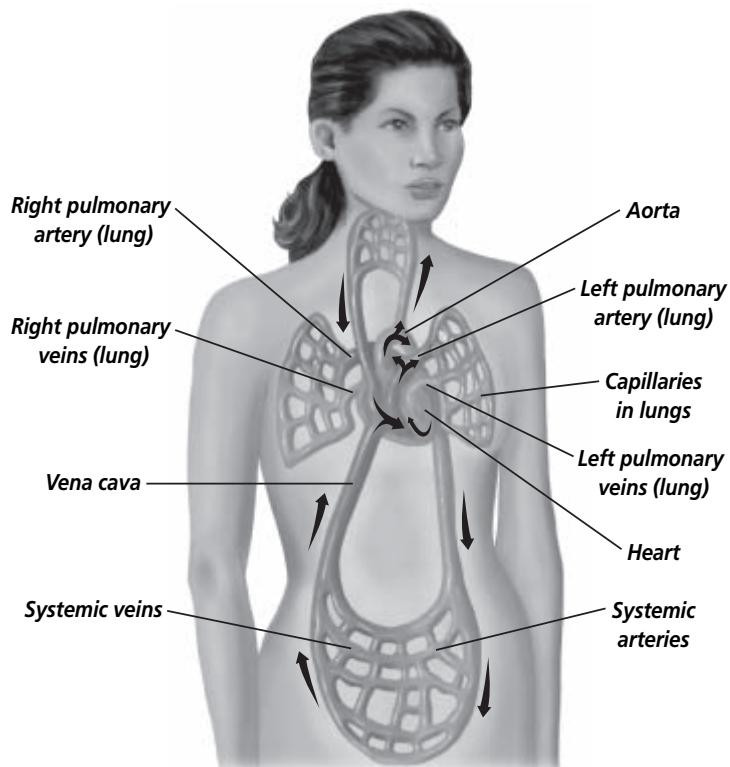
The **heart** is the organ of the circulatory system that pumps blood. The heart is hollow, muscular, and is about the size of your fist. It is found in the chest, between the lungs.

The heart has four chambers. The **atria** (AY tree uh) (singular, atrium) are the two upper chambers of the heart that receive blood. The **ventricles** (VEN trih kulz) are the two lower chambers that pump blood out of the heart.

What is the purpose of blood vessels?

Blood travels to and from the heart in vessels, as shown below. The vessels that carry blood away from the heart to organs in the body are the **arteries** (AR tuh reez). Arteries branch into smaller vessels, then into even smaller vessels called capillaries (KAP uh ler eez). **Capillaries** deliver oxygen and nutrients to the body's organs.

Blood with oxygen flows away from the heart, and blood without oxygen, carrying carbon dioxide, returns to the heart. The capillaries take up carbon dioxide and join with larger vessels that carry blood back toward the heart. These vessels connect to larger vessels called veins. **Veins** carry blood to the heart.



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What problems can occur in the circulatory system?

You can live for days without water. You could live for more than a month without food. You cannot live one hour without oxygen. That means that problems of the circulatory system often lead to serious health problems or death. Diseases of the heart and blood vessels are called **cardiovascular** (kar dee oh VAS kyuh lur) **diseases**. Cardiovascular diseases cause more than half the deaths in the United States.

Heart Attack Coronary arteries supply the heart muscle with blood and oxygen. A **heart attack** occurs if the coronary arteries cannot supply enough blood to the heart. This happens when the coronary arteries get blocked. The heart muscle may die if it does not receive enough oxygen. Symptoms of a heart attack can include chest pain, pain in the arms and back, shortness of breath, and dizziness. ✓

Stroke A **stroke** is the death of brain tissue. A stroke can happen if a blood vessel is blocked or broken. This causes brain tissue to die. A stroke could cause memory loss, loss of muscle control, or loss of nerve function.

Exchanges Between the Pulmonary and Circulatory Systems

The pulmonary and circulatory systems work together. The pulmonary system provides oxygen to the blood and the circulatory system delivers the oxygen. In a similar way, the muscles of the rib cage and diaphragm function only when oxygen-rich blood is provided. Both systems must function properly for you to survive. ✓

How is gas exchanged in the pulmonary and circulatory systems?

The membrane that separates the capillaries and the alveoli does not allow blood to flow into your lungs or air to enter your blood. The membrane allows only gases to move across. No energy is needed for the exchange of oxygen and carbon dioxide—the gases move from regions where they are at a higher concentration to regions where they are at a lower concentration.

✓ Reading Check

- 9. Determine** What is blocked when a heart attack occurs?

✓ Reading Check

- 10. Identify** Which system supplies oxygen to the blood?

Academic Vocabulary
remove (rih MOOV) (verb) to
take away

 **Reading Check**

11. Evaluate Why is it important for alveoli and capillaries to be close together?

 **Think it Over**

12. Apply What have you eaten today that was healthy?

What gases are exchanged?

The structure of your lungs allows a great amount of oxygen and carbon dioxide to be exchanged between the air you breathe in and your blood. That is because the alveoli in the lungs greatly increase the surface area of the lungs.

How is air exchanged in the lungs?

Alveoli are surrounded by capillaries. Oxygen gas is removed from the air you breathe and passes across a thin membrane between the alveoli and the capillaries. At the same time, carbon dioxide passes in the opposite direction. Carbon dioxide passes from the capillaries to the alveoli into the air you breathed in.

When the level of carbon dioxide in the air in your lungs becomes great enough, you exhale without even thinking about it. When you exercise, you produce more carbon dioxide, so you feel the need to exhale more often. Because of this, your breathing rate increases.

You may have heard the word *respiration* used for the term *breathing*. However, they are not the same. Respiration uses oxygen and food to produce carbon dioxide in your cells. Respiration produces energy. Breathing is the physical process of inhaling and exhaling.

Preventing Problems in the Pulmonary and Circulatory Systems

A healthy lifestyle is the best way to prevent cardiopulmonary problems. Exercise helps blood flow and keeps your blood vessels flexible. Choosing not to smoke will prevent hardening of blood vessels. Also, eating foods that are low in fat and cholesterol will prevent buildup of materials on the walls of your blood vessels.

What have you learned?

The pulmonary and cardiovascular systems work together to provide your body with the oxygen it needs and to remove carbon dioxide. Your lungs are made up of millions of alveoli, which provide a place for gas exchange. Your heart pumps blood through your body, picking up oxygen in your lungs and delivering it to your tissues. Living a healthy lifestyle is the best way to avoid problems in the cardiopulmonary system, such as stroke, heart attack, and pneumonia.

The Cardiopulmonary System and Pressure

Lesson 2 Pressure and the Body



Grade Seven Science Content Standard. 6.j. Students know that contractions of the heart generate blood pressure and that heart valves prevent backflow of blood in the circulatory system. **Also covers:** 5.b.

● Before You Read

In the circulatory system, blood pushes against the walls of blood vessels. In a similar way, a ball becomes firm when you fill it with air. Describe on the lines below what causes the ball to become firm. Read the lesson to find out more about pressure and the circulatory system.

MAIN Idea

Pressure allows you to breathe and keeps your blood flowing.

What You'll Learn

- how to identify the role that pressure plays in the circulatory system

● Read to Learn

What is pressure?

Air in a ball places pressure on the inside walls of the ball. This pressure keeps the ball inflated. **Pressure** is the amount of force per unit area. The SI unit for pressure is a pascal.

How can pressure be changed?

There are two ways to change pressure. Increasing the amount of force applied to an area increases pressure. For example, the force against the walls of a ball increases as more air is pumped into the ball. Pressure also increases as you decrease the size of the area to which a constant force is applied. When a ballerina stands flat on her feet, her body weight is spread over the entire area of her feet. When she stands on her toes, she decreases the weight-bearing area and increases the pressure under her toes.

Study Coach

Check for Understanding

As you read this lesson, be sure to reread any parts you don't understand. Underline sentences as you reread.

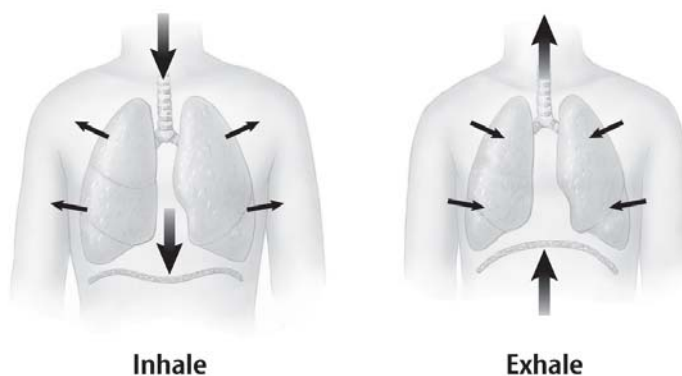


Think it Over

- 1. Explain** what happens when you put air in a bike's tires.

Pressure in the Pulmonary System

When you breathe in, air is pulled into the lungs. The diaphragm is a flat muscle at the bottom wall of your chest cavity. The diaphragm contracts along with your rib muscles. The contraction of the diaphragm allows the chest cavity to expand. The volume of the lungs increases, and this decreases pressure in the alveoli. Atmospheric pressure, the air pressure outside your body, is now greater than the pressure in your lungs. This causes air to move into your lungs. When you exhale, the volume of your lungs decreases and air flows out through your nose and mouth. The figure below shows how your lungs inhale and exhale.

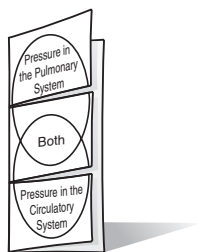


Picture This

- 2. Locate** Circle the diaphragm below the lungs in each figure. Label the lungs in one of the pictures.

FOLDABLES™

- B Describe** Make a Venn-diagram Foldable. As you read the lesson, record what you learn about pressure in each of the systems under the appropriate tabs, and describe what part pressure plays in both systems under the center tab.



Pressure in the Circulatory System

Have you ever tried to use a water hose when the water was turned on low? You probably had a hard time spraying the water. That is because the water in a hose must be under pressure in order to have a strong, far-reaching spray. In a similar way, pressure is needed in the circulatory system. Without pressure, blood vessels would not be able to transport blood to tissues and organs.

How is the heart like a pump?

You use a pump to increase the air pressure of a tire or a ball. In the circulatory system, the heart is the pump. Recall from Chapter 9 that muscle fibers shorten when a muscle contracts. The heart is also a muscle that contracts. When the heart contracts, the volume inside the chamber decreases. Blood is forced out of each heart chamber as the chamber gets smaller. This is similar to how toothpaste is squeezed out of a tube.

How is blood pumped through the heart?

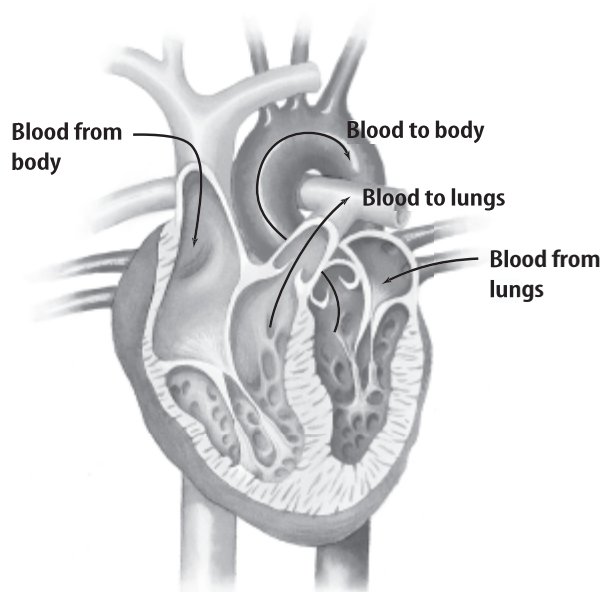
You read in the previous lesson that the heart has four chambers, as shown in the figure below. The flow of the blood through the heart is described in the following steps.

1. The right atrium contracts and pumps blood into the right ventricle.
2. The right ventricle pumps blood out of the heart to the lungs.
3. The blood receives oxygen in the lungs.
4. Blood leaves the lungs and returns to the left atrium of the heart.
5. Blood passes from the left atrium to the left ventricle.
6. The left ventricle pumps blood out of the heart to all the tissues of the body.
7. Blood from all tissues returns to the right atrium.
8. The cycle continues.

How is blood pumped in one direction?

Blood must move in one direction as the heart pumps. The heart and veins have valves. Valves are like doors that can open in only one direction.

Contractions of the heart muscle increase pressure to pump blood through the heart. The opening and closing of valves adds to the change in pressure. For example, when the right ventricle relaxes and the tricuspid valve opens, blood flows from the right atrium to the right ventricle. When the right ventricle contracts, the tricuspid valve closes. When a heart valve closes, blood cannot flow back into the area from which it was just pumped.



Academic Vocabulary
previous (PREE vee uhs) (adj.)
going before in time or order

Reading Check

- 3. Sequence** In what order does blood flow through the chambers of the heart?

Picture This

- 4. Interpreting Diagrams** Use a highlighter to trace the path of the blood as it enters and leaves the heart. Start where the blood comes in from the body.

What happens when the aortic valve opens?

When the aortic valve opens, blood leaves the heart. As blood is pumped into the arteries, it is moving away from the heart. Far from the heart, the blood enters veins. Valves in the heart and veins keep blood flowing in one direction.

What are blood pressure problems?

Have you ever noticed what happens when water pressure to a faucet changes? The water either slows to a trickle or flows out much faster than expected. In a faucet, a change in water pressure that lasts for a short time does not usually cause a problem. However, changes in blood pressure can lead to serious problems in the human circulatory system. These problems include hypertension and shock.

Hypertension Healthy blood vessels are elastic. If they lose elasticity, blood does not flow as well. Sometimes walls of blood vessels get hard or vessels become blocked. This causes **hypertension** (HI pur ten shun), which is a dangerous increase in blood pressure that can cause problems with other organs. Hypertension is a disease caused by genetic, environmental, and dietary factors. A diet that is high in saturated fat, cholesterol, and salt can increase the risk of hypertension.

Shock As with high blood pressure, blood pressure that is too low can be very dangerous and life threatening. **Shock** is a condition in which a large amount of blood is lost, usually in a short period of time. Under certain circumstances, such as internal bleeding, a severe allergic reaction, or traumatic injury, blood leaves the vessels and shock occurs. When this happens, blood pressure decreases. The circulatory system, like a water hose, cannot function properly without pressure. The heart is not able to pump blood to all tissues without pressure. In some emergencies, shock is treated by stopping the blood loss and having a blood transfusion, if blood loss has been severe.

What have you learned?

Pressure on a surface is determined by the area of the surface and the amount of force applied to the area. Pressure in your lungs changes as you breathe. The heart provides the pressure to pump blood to all body tissues. Blood moves through blood vessels in only one direction. Hypertension and shock are two serious problems of the human circulatory system.

Reading Check

5. Define What is another name for very high blood pressure?

Think it Over

6. Summarize What happens when blood pressure is too high or too low?

The Eye and Light

Lesson 1 What is light?

Grade Seven Science Content Standard. 6.a. Students know visible light is a small band within a very broad electromagnetic spectrum. Also covers: 6.e.



● Before You Read

On the lines below, describe what happens when an ocean wave hits the shore. Then, while you read the lesson, think about how light is a type of wave that transfers energy from one place to another just as ocean waves do.

MAIN Idea

Visible light is an electromagnetic wave.

What You'll Learn

- the properties of light waves
- the different types of waves in the electromagnetic spectrum
- why light appears as different colors

● Read to Learn

Light Transfers Energy

When you drop a rock in a pool of water, you disturb the still water. Energy from the moving rock transfers to the water. You see this energy carried out in waves away from the place where you dropped the rock. The waves carry energy to other parts of the pool.

Light waves carry energy from place to place, just as water waves do. A source of light, such as a candle or the Sun, sends out light waves. These waves spread out in all directions. It may be easier to think of a light ray as a narrow beam of light that travels in a straight line. A light source sends out light rays that travel away from the source in all directions.

What are the parts of a wave?

Imagine that you are holding one end of a piece of rope that is tied to a wall. What would happen if you moved your end of the rope up and down? You would create a wave in the rope. The figure on the next page shows what the wave would look like.

The highest points of the wave are called crests. The lowest points are called troughs. **Wavelength** is the distance from one crest to the next or from one trough to the next. ✓

Mark the Text

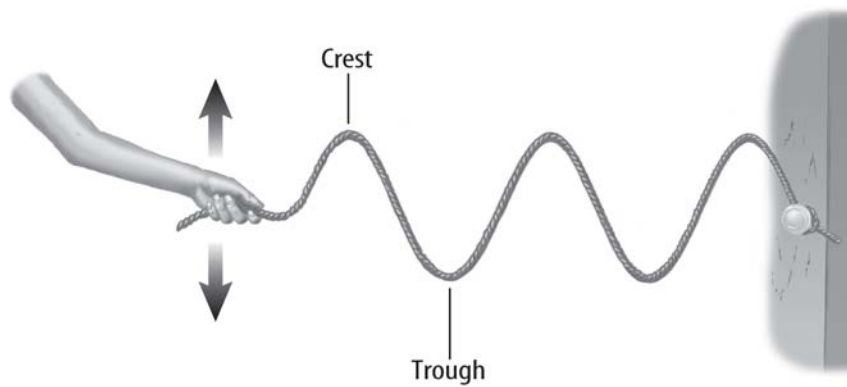
Build Vocabulary Skim the lesson, circling any words that you do not know. After you read the lesson, review the circled words. Write any words you cannot define on a separate sheet of paper and look up the definitions.

✓ Reading Check

1. **Identify** What are the highest points of waves called?
-

Picture This

2. **Label** another crest and trough on the wave in the figure.



FOLDABLES™

- A Compare and Contrast** Make a two-tab Foldable. Label the tabs as illustrated, and describe wavelength and frequency under the tabs. Use what you learn to compare and contrast each.



How is frequency related to wavelength?

Look again at the waves in the rope. The period of a wave is the time that it takes to move the rope from the crest to the trough and back to the crest again. The **frequency** (FREE kwun see) of a wave is the number of wave crests that pass by a place in one second (1 s). You can find the frequency by dividing one by the period of the wave.

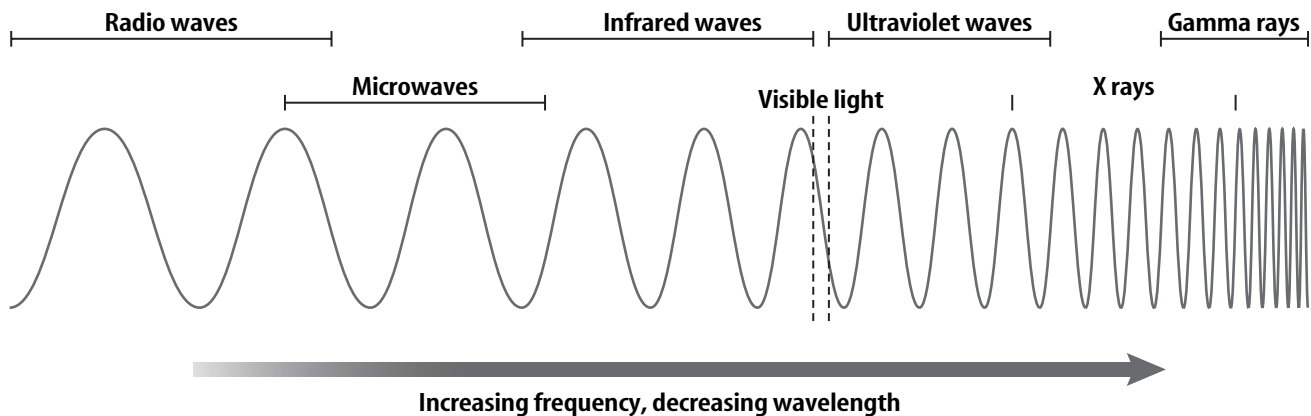
If you move your end of the rope up and down quickly, the frequency of the wave increases. The crests and the troughs of the wave become more crowded on the rope. So as the frequency increases, the wavelength decreases.

If you move the end of the rope more slowly, the crests and troughs become more spread out. As the frequency of the wave decreases, the wavelength increases. This is true for all waves, including light waves. The lower a light wave's frequency, the greater its wavelength will be.

How does light travel?

The substance through which a wave moves is called the **medium**. The medium through which ocean waves move is water. The medium through which a rope wave moves is the rope itself.

Light can travel through mediums such as solids, liquids, and gases, including air. However, unlike ocean waves or waves on a rope, light can travel through empty space where there is no matter. Light is an electromagnetic wave, which is a type of wave that can travel in empty space as well as in matter.



The Electromagnetic Spectrum

There are different types of electromagnetic waves. The **electromagnetic spectrum** (ih lek troh mag NEH tik • SPEK trum) shows the entire range of electromagnetic waves with different wavelengths and frequencies. As shown above, the electromagnetic spectrum is arranged from waves with the longest wavelengths to waves with the shortest wavelengths.

Why does light appear as different colors?

The visible light spectrum is the range of electromagnetic waves human eyes can see. Visible light has short wavelengths. They are usually measured in units of nanometers (nm). One nanometer equals one billionth of a meter. The wavelengths of visible light range from about 700 nm to about 400 nm. The colors that you see depend on the wavelengths of the light that enters your eye. Red light has the longest wavelength. Blue light has the shortest wavelength.

Visible Light and the Electromagnetic Spectrum

Human eyes can see is only a small part of the electromagnetic spectrum. The entire electromagnetic spectrum ranges from waves with wavelengths of thousands of meters to waves whose wavelength is less than the width of an atom. In fact, the electromagnetic spectrum has no upper or lower limits. Whether they are part of the visible spectrum or some other part of the electromagnetic spectrum, all electromagnetic waves transfer energy as they travel from one place to another.

Picture This

3. Identify Which electromagnetic wave has the shortest wavelength?



Think it Over

4. Apply You see a blue ball. What can you say about the wavelengths of the light waves that entered your eye?

Academic Vocabulary

transfer (TRANS fur) (verb) to move or shift

The Eye and Light

Lesson 2 Light and Matter



Grade Seven Science Content Standard. 6.b. Students know that for an object to be seen, light emitted by or scattered from it must be detected by the eye. **Also covers:** 6.c, 6.f, 6.g.

MAIN Idea

Light interacts with matter in different ways.

What You'll Learn

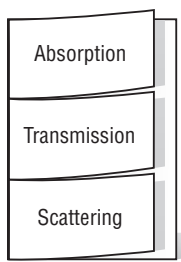
- the law of reflection
- the difference between refraction and reflection

Study Coach

Outline As you read, make an outline of this lesson. Use the headings of the lesson as the first-level items in the outline. List the main points or ideas under each heading.

FOLDABLES™

B Discuss Make a three-tab Foldable. Label the front tabs as illustrated. Describe absorption, transmission, and scattering under the tabs. Use what you learn to discuss the interaction of light and matter.



● Before You Read

What is your favorite color? On the lines below, write about what makes this color special. Read the lesson to find out more about the properties of color.

● Read to Learn

The Interaction of Light and Matter

When light rays hit an object, three things can happen. The light rays can:

- be absorbed by the object,
- be reflected by the object, or
- pass through the object.

How is light absorbed?

When light rays hit an object, some of the energy carried by the light is transferred to the atoms or molecules in the object. The atoms get some of the energy in the light ray and become warmer.

On a warm, sunny day, an asphalt parking lot can become very hot. The asphalt becomes hot because it absorbs some of the energy in the light rays from the Sun. The process of increasing the temperature of a material when light energy transfers energy to atoms or molecules in the material is called **absorption** (ub SORP shun).

An asphalt parking lot will become hotter on a warm, sunny day than the grassy area around the parking lot. The amount of energy absorbed by a material depends on the type of atoms and molecules in the material. Asphalt molecules absorb more light energy than the molecules in grass.

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What is transmission?

Atoms can also reemit, or give off again, all the light energy they receive. **Transmission** occurs when light rays strike an object and go through the object by absorption and reemission. Three things determine whether light is absorbed or transmitted:

- the structure of the object's atoms
- the arrangement of atoms in the object
- the wavelength of the light ray

How is light scattered?

Scattering occurs when an object absorbs light, and then gives off the light in different directions. This happens when objects are not pure or perfect. A glass, for example, may have air bubbles. The air bubbles interfere with the transmission of light. The air bubbles scatter light rays. Clouds and smoke are also made of small particles that scatter light rays. Just like in transmission, the material itself and the wavelength of light determine whether a light ray will be scattered or absorbed.

What materials let most light pass through?

Materials that let no light pass through them are opaque. You cannot see through opaque materials. Materials that let almost all light pass through them are transparent. A clear glass is transparent. Materials that let only some light pass through them are translucent. Waxed paper is translucent.

How fast does light travel?

Light can pass through many different transparent materials. But it travels at different speeds in different materials. The table shows a comparison of the speed of light in different materials. In a vacuum, light travels at about 300,000 km/s. Light travels more slowly through other materials.

The Speed of Light Through Materials	
Material	Speed of Light
Air	about 294,000 km/s
Water	about 227,000 km/s
Glass	about 197,000 km/s
Diamond	about 125,000 km/s

Academic Vocabulary

transmit (trans MIT) (verb) to send from place to place



Think it Over

- 1. Summarize** Look around the room. What material is opaque? transparent?

Picture This

- 2. Compare** About how much faster is the speed of light through water than through a diamond?

Refraction

When light rays move from one transparent material to another, such as from water to air, the light waves can change direction. **Refraction** (rih FRAK shun) occurs when a light ray bends, or changes direction, as it moves from one material into another.

What happens when light rays change speed?

Light rays can move between two materials in which the speed of light differs. When this happens, the change in the speed of light causes the rays to bend. The amount of bending, or refraction, depends on the speed of light in both materials. The greater the difference between the speed of light in the two materials, the more the light will bend. Also, refraction occurs only when light rays enter a material at an angle. If a light ray enters a material perpendicular to the surface, it does not bend. ✓

✓ Reading Check

- 3. Explain** What determines how much a light ray will bend?

What makes up white light?

A prism is a piece of transparent glass or plastic that is usually shaped like a wedge. Light waves slow down as they move from air into a prism. This causes the light waves to bend. Light waves speed up and bend again when they move from the prism back into the air.

White light is made of different colors, or wavelengths, of light. As these different wavelengths of light pass through the prism, some are bent more than others. As a result, the light rays that come out of the prism are separated into the colors of the visible light spectrum.

What happens to colors when they are mixed?

White light can be separated into different colored lights. It is also possible to use different colored lights to make white light. In addition, colors of light can be mixed to create other colors. For example, when green and red lights are mixed, they make yellow light. Red, green, and blue are called primary colors of light because mixing these three colors in different amounts can make almost any color. ✓

✓ Reading Check

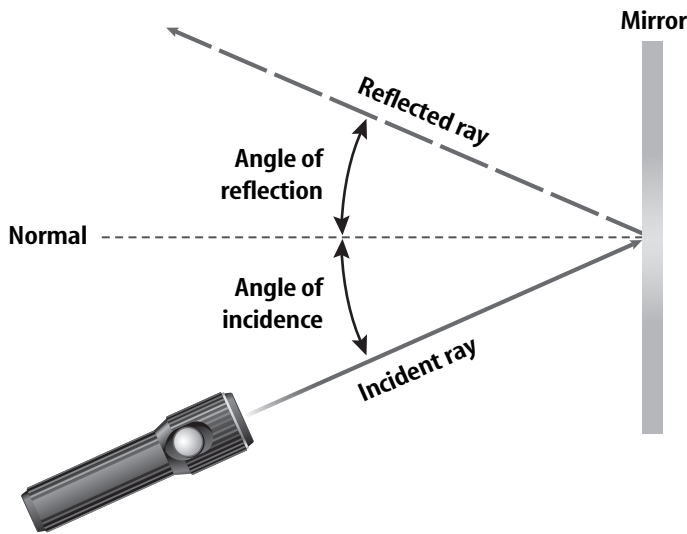
- 4. Identify** the primary colors of light.

Reflection

Light waves can change direction when they speed up or slow down. Light waves also change direction when they are reflected from a surface. Reflection occurs when a light wave strikes an object and bounces off.

What is the law of reflection?

An incoming ray and a reflected ray make an angle with a line perpendicular to the surface of the object the light is striking. The line perpendicular to the surface is called the normal to the surface. The angle between the incoming ray and the normal is called the angle of incidence, as shown below. The angle between the reflected light ray and the normal is called the angle of reflection. The **law of reflection** (rih FLEK shun) states that the angle of incidence is equal to the angle of reflection. Light rays reflected from all surfaces always obey the law of reflection.



How does reflection affect color?

Why do some things look red while others look green? As white light strikes an object, some of the light is absorbed and some is reflected. The reflected light enters your eye and causes you to see the object. The green cover of a book looks green because the materials in the cover absorb all wavelengths of light except green. The green light is reflected to your eyes, and you see the book as green.

What have you learned?

All objects that you see either reflect light or are sources of light. The energy carried by light waves can be absorbed by the atoms in a material. Some of the energy carried by light waves also can be emitted by atoms as new light waves. The interaction of light and matter causes light waves to be reflected and refracted.

Picture This

5. Identify Look at the angles marked in the figure. If the angle of reflection is 20 degrees, what is the angle of incidence?

Think it Over

6. Draw Conclusions

Does your blue shirt absorb or reflect blue light?

The Eye and Light

Lesson 1 Using Lenses



Grade Seven Science Content Standard. 6.d. Students know how simple lenses are used in a magnifying glass, the eye, a camera, a telescope, and a microscope.

MAIN Idea

Lenses bend light to form images.

What You'll Learn

- the function of a lens
- how convex lenses form images
- how optical instruments use lenses

Study Coach

Ask Questions Read a paragraph to yourself, then take turns asking a partner questions about what you have learned. Continue asking questions until you both understand the paragraph. Do the same with the remaining paragraphs in this lesson.

Reading Check

1. Describe What happens to the light rays after they pass through a convex lens?

Before You Read

On the lines below, describe a tool you could use to see something that is very small. What tool helps you see something that is far away? Read the lesson to find out more about using lenses to see things more clearly.

Read to Learn

What is a convex lens?

Many different tools can be used to change how you see things. Eyeglasses change the way light is focused on a person's eye. Magnifying lenses and microscopes make small objects appear large. Telescopes and binoculars make objects that are far away appear closer. All of these things use at least one lens. A **lens** is a transparent object with at least one curved side that causes light to bend.

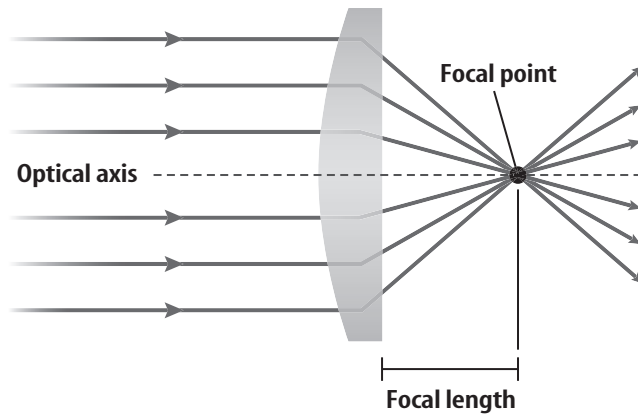
A **convex** (kahn VEKS) **lens** is thicker in the center than it is at the edges. It bulges outward and causes light rays to come together, or converge, as shown on the next page. A concave lens is thinner in the middle than at the edges. Parallel light rays passing through a concave lens spread apart, or diverge.

At what point do the rays of light converge?

Convex lenses are usually made out of glass or plastic. Light travels more slowly in glass and plastic than it does in air. When light passes through a convex lens, the light bends.

The point where all of the rays of light converge is called the **focal** (FOH kuhl) **point**. The distance from the center of the lens, or optical axis, to the focal point is called the **focal length**.

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How do convex lenses form images?

The image formed by a convex lens depends on how far an object is from the lens. If the object is more than two focal lengths from the lens, the image seen through the lens is upside down. The image is also smaller than the actual object.

If the object is less than one focal length from the lens, the image seen through the lens is right-side up. The image is also larger than the actual object.

Optical Instruments

An optical instrument uses lenses to focus light and create images. It can collect more light than your eyes can collect. An optical instrument gathers the light and then forms an image that your eyes can see. Different optical instruments combine lenses in different ways.

How do cameras use lenses?

A typical camera uses several lenses to form an image. To focus the camera, you must move the lenses back and forth until the image you see is clear. In some types of cameras, the image is captured on film. In digital cameras, the image is captured on an electronic light sensor.

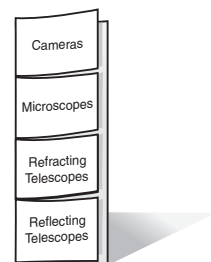
When you take a picture, the camera shutter opens so that light enters the camera. If too much light strikes the film or the light sensor, the photograph is too light. If too little light enters the camera, the photograph can be too dark. To control the amount of light that reaches the film or the light sensor, cameras have a device called a diaphragm or an aperture. The opening in the diaphragm becomes larger or smaller to let more light or less light into the camera.

Picture This

2. Identify Use a highlighter to show where light bends in this diagram.



Describe Make a four-tab Foldable. Label the front tabs as illustrated, and describe the optical instruments under the tabs.



Reading Check

3. Identify the two types of telescopes.

Academic Vocabulary
image (IHM ihj) (noun) a reproduction or representation of a person or object

Reading Check

4. Name three instruments that have lenses.

How do refracting telescopes use lenses?

A telescope is an optical instrument that makes objects appear closer. There are two types of telescopes: refracting and reflecting. A refracting telescope uses two convex lenses placed on either end of a tube. The larger lens is called the objective lens. It collects light and forms an image inside the tube. The smaller eyepiece lens then enlarges this image.

Telescopes must collect light to form images of distant objects. The larger the objective lens is, the more light the telescope can collect.

How do reflecting telescopes use lenses?

Scientists use reflecting telescopes to view the most distant objects. Reflecting telescopes use large, concave mirrors to collect light. Mirrors can be made much larger than objective lenses. The largest telescopes in the world are reflecting telescopes.

In a reflecting telescope, the main mirror captures light and forms an image in the tube of the telescope. Then a smaller mirror reflects the light into an eyepiece lens. The eyepiece lens enlarges the image formed by the mirror.

How do microscopes use lenses?

A microscope is an optical instrument that makes objects appear larger. A microscope uses two convex lenses: an objective lens and an eyepiece lens. The objective lens forms an enlarged image of an object. The image is then made even larger by the eyepiece lens.

What have you learned?

A convex lens can form an image by causing light rays to come together. Lenses are used to form images in optical instruments such as cameras, telescopes, and microscopes. Telescopes use lenses and mirrors to collect light from objects that are too faint and distant to be seen. Microscopes use lenses to magnify objects that are too small to see with your eyes alone. In the next lesson, you will read about how lenses can be used to correct some common vision problems.

The Eye and Light

Lesson 4 The Eye and Vision

Grade Seven Science Content Standard. 5.a. Students know how to relate the structures of the eye and ear to their functions. Also covers: 6.b, 6.d, 6.e.



● Before You Read

Look at yourself in a mirror. Examine your eyes. On the lines below, describe the parts of the eye that you can see. Then read the lesson to learn more about the parts of the eye and find out how the eye works.

● Read to Learn

How the Eye Forms an Image

In the last lesson, you read about how a camera works. The way your eyes work is similar to the way a camera works. Your eye sees light that is given off or reflected from objects. As light enters your eye, the lens in your eye forms an image on the back of your eye. There, special cells change the image into electrical signals. These signals then travel to your brain, where they are interpreted as the object you are looking at.

What is the structure of your eye?

The figure on the next page shows the different parts of the human eye. The eye is nearly round and is about 2.5 cm in diameter. The outer layer of the eye is called the sclera. The front part of the sclera is clear.

Light first enters your eye through the **cornea**. (KOR nee uh) The cornea is a clear area of the sclera. It is a convex lens that causes light rays to come together as they enter the eye. The cornea focuses most of the light in your eye.

MAIN Idea

The eye is a complex organ made of different parts.

What You'll Learn

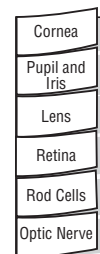
- the parts of your eye
- how your eye forms an image
- how the eye sees colors

Mark the Text

Highlight As you read, highlight the words and phrases that you do not understand. When you finish reading, ask another student or your teacher to help you understand the things you highlighted.

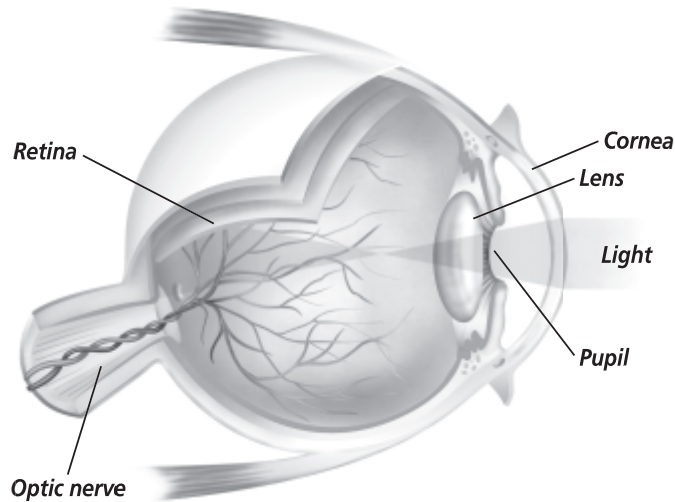
FOLDABLES™

D Explain Make a six-tab Foldable. Label the front tabs as illustrated. Under the tabs, describe how the eye forms an image.



Picture This

- 1. Label** Circle the part of the eye that focuses most of the light.



What controls the light that enters your eye?

After passing through the cornea, light rays then go through the pupil. The **pupil** (PYEW pul) is the dark opening into your eye. The pupil is surrounded by the **iris** (I rus), which is the colored part of your eye.

The iris controls the amount of light that enters inside your eye. When the light is dim, your iris is small and your pupil is large. This allows more light to enter inside your eye. When the light is bright, your iris is larger and your pupil is smaller, so that less light enters inside your eye. ✓

✓ Reading Check

- 2. Define** What is the function of the iris?

Why does the lens of the eye change shape?

After passing through the pupil, light rays then go through the lens. Your eye has a convex lens, like the lens in a magnifying glass. However, the lens in a magnifying glass is made of stiff glass or plastic. The lens in your eye is flexible. This allows the muscles attached to the lens to change shape. When you look at objects that are farther away, the muscles get smaller, or contract. This makes the lens flatter. When you look at objects that are closer, the muscles relax. This makes the lens rounder.

What sends signals to the brain?

The light rays that pass through the lens form an image on the retina of the eye. The **retina** is a sheet of light-sensitive cells at the back of the eye. There are two different types of light-sensitive cells in the retina, called rods and cones.

Rod cells detect light. When light hits a rod cell, a chemical reaction sends an electrical signal to the brain. Rod cells do not detect color. Cone cells react to color and need more light than rod cells.

Seeing Color

Humans can see more than just light. When you look around, you see the world in different colors. The cone cells in your retina detect the colors that you see.

How do cone cells detect color?

There are three types of cone cells. Each type responds to different wavelengths of light. One type of cone cell responds to the wavelengths of red and yellow light. These cells cause you to see the color red. The second type responds to yellow and green light and causes you to see the color green. The third type responds to blue and violet light and causes you to see the color blue.

Light waves that strike the retina cause the three types of cone cells to send signals to the brain. The brain interprets the combination of the signals from the cone cells as the different colors you see. ✓

What are pigments?

Some colors of the objects you see are caused by pigments. A pigment (PIG munt) is a material used to change the color of other materials or objects. When light hits paint, all the different wavelengths are absorbed except the ones you see. For example, when white light hits blue paint, it absorbs all the wavelengths except the blue and some of the green.

Just as with light, there are primary colors of pigments. Most colors can be made by mixing the three primary pigment colors in different amounts. The primary colors of pigments are magenta, cyan, and yellow.

Common Vision Problems

The eye is a complex organ. All of its parts must work correctly for you to see clearly. Some people have vision problems. Three common vision problems are nearsightedness, farsightedness, and color deficiency. Eyeglasses can correct both nearsightedness and farsightedness. ✓

What is color deficiency?

About 8 percent of males and 0.4 percent of females cannot distinguish between red and green. This is known as color deficiency. People with this problem may lack green or red cones. Or, they may have green or red cones that do not function correctly.

Academic Vocabulary

detect (dih TEK) (verb) to discover or determine the existence of

✓ Reading Check

3. Explain What is the purpose of cone cells?

✓ Reading Check

4. Summarize Name three common vision problems.

Academic Vocabulary
vision (VIH zhun) (noun) the method of seeing

Picture This

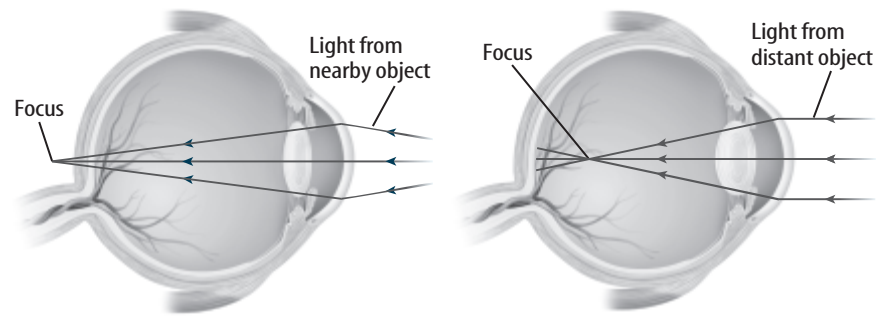
- 5. Identify** Where are light waves focused for farsighted people?
- on the retina
 - in front of the retina
 - behind the retina

What is nearsightedness?

A person who is nearsighted cannot see faraway objects clearly. In a nearsighted eye, images form in front of the retina, rather than on the retina itself. This makes the images blurry. A concave lens can correct this vision problem. A concave lens is thicker at the edges than in the middle. It causes light to spread out. Glasses with a concave lens make light rays spread out slightly before they enter the eye, allowing the image to be focused on the retina.

What is farsightedness?

A person who is farsighted cannot see nearby objects clearly. In this case, images form behind the retina. A convex lens can correct this vision problem. Glasses with a convex lens make light rays converge more before they enter the eye. Then a sharp image is formed on the retina. The figure below compares the two types of vision problems.



What have you learned?

The eye is a complex light-detecting organ. The iris controls the amount of light entering the eye. The cornea and lens of the eye focus incoming light to form images. The images fall on the retina of the eye. The retina contains cells whose specialized function is to respond to light of specific wavelengths. These cells then send electrical signals to the brain, where they are processed and perceived as the objects around you.

Lesson 1 Sound

Grade Seven Science Content Standard. 5.g. Students know how to relate the structures of the eye and ear to their functions.



● Before You Read

On the lines below, describe the softest sound and loudest sound you have heard. Then read the lesson to learn about sound waves.

● Read to Learn

What is sound?

Although sounds can be different, they are also very much alike. For example, vibrations make all sounds and all sounds are transmitted by waves.

What are sound waves?

Recall that light is a wave. Light waves are disturbances that carry energy from one place to another. Sound is also a wave. You know that the vocal cords in your throat vibrate when you speak or sing. The air in your throat is moved by the vibrations. These vibrations continue as a wave from your vocal cords through the air. A vibration is created by energy that moves one molecule of air and passes it on to the next one. In this way, sound is transferred from one place to another.

Sound waves are called **compression waves**. In a compression wave, particles move back and forth in the same direction the sound wave moves. As shown in the figure at the top of the next page, there are some places in the wave where the molecules are crowded closely together. This is called a region of compression. In between two regions of compression, the molecules are spread apart. This is called a region of rarefaction. A region of compression is an area of high density and pressure. A region of rarefaction is an area of low density and pressure.

MAIN Idea

Sound is a compression wave.

What You'll Learn

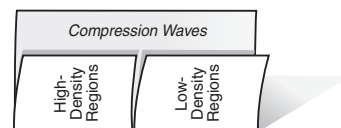
- the properties of sound waves
- why sounds are soft or loud
- to compare high and low sounds

Study Coach

Setting A Purpose Before you read, jot down questions you have about sound, such as what is it, why can some animals hear sounds humans can't hear, or what causes hearing loss. As you read, try to find answers to your questions.

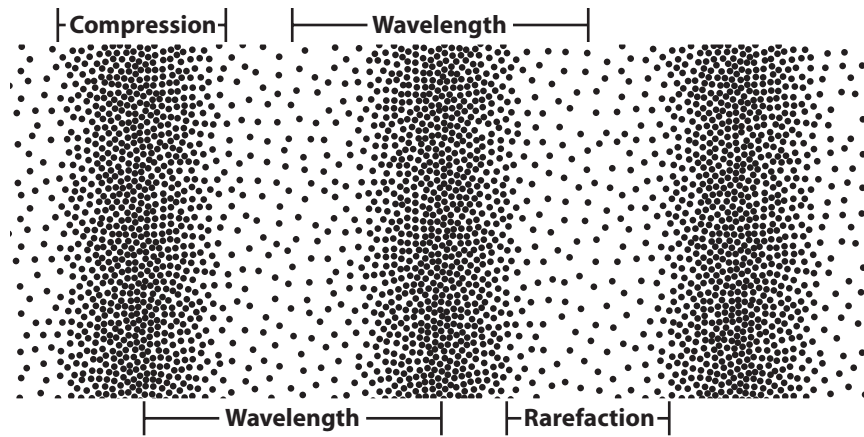
FOLDABLES™

A Define Make a concept Foldable, as illustrated. Define the terms and record what you learn about each as they relate to compression waves under the tabs.



Picture This

- Determine** How many compressions can be seen in the wave in the figure?



What is a wavelength?

Sound waves, like other waves, have a wavelength and a frequency. A wavelength is the distance between the centers of two regions of compression, as shown in the figure above. A wavelength can also be the distance between two centers of rarefaction. The frequency is the number of wavelengths that pass a certain point in one second. Frequency is measured in hertz. Hertz is symbolized by Hz and represents 1/s. If a wave has a long wavelength, few waves will pass a point in one second and the wave has a low frequency.

What is vibration?

When something vibrates, it puts pressure on molecules all around it. As the molecules are pushed together, a region of compression is created. A region of rarefaction is formed when the molecules move inward. The compressions and rarefactions form a sound wave. ✓

✓ Reading Check

- Explain** What two things create a sound wave?

How loud is it?

Think about a sound that is very loud, such as music booming from a car stereo. Now think about a whisper. What is the difference between a loud and a quiet noise?

What is loudness?

Loud sound waves carry more energy than soft sound waves. **Loudness** is a person's perception of how much energy a sound wave carries. It would seem that all sound waves with the same energy have the same loudness, but that is not so. Humans hear sounds with frequencies between 3,000 Hz and 4,000 Hz more loudly than other sound waves with the same energy.

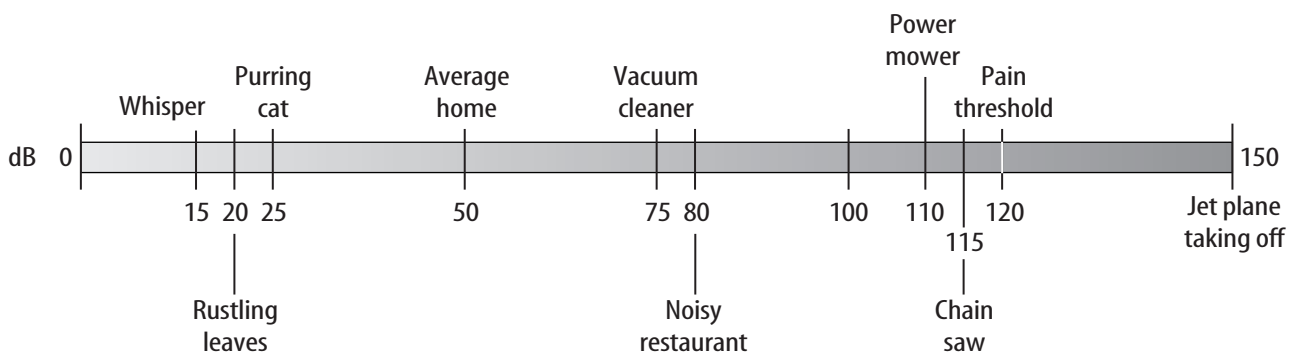
How is amplitude related to loudness?

The amount of energy a wave carries depends upon its amplitude. **Amplitude** (AM plih tood) depends upon how spread out the molecules are in the regions of compression and rarefaction. Suppose a wave has compressions with molecules that are tightly packed together. If it also has rarefactions with molecules that are spaced far apart, it will have a large amplitude. The object, such as a speaker, that created the sound wave transferred a lot of energy. This forced the molecules together or spread them far apart. The more energy a sound wave carries, the greater the amplitude and the louder the sound. **Conversely**, sound waves with smaller amplitudes have quieter sounds.

What is the decibel scale?

Your perception of the amount of energy in a sound wave is measured on the **decibel** (DES uh bel) **scale**, shown in the figure below. The decibel scale measures a sound wave based on powers of 10. The symbol for a decibel is dB. The sound of 0 decibels is the quietest sound that humans can hear. A sound of 10 dB has 10 times more energy than a sound of 0 dB. A sound that is 20 dB has 100 times more energy. A sound that is 30 dB has 1,000 times more energy. ✓

A sound that has about 85 dB can damage your hearing. Of course, the damage will depend upon the loudness of the sound and the length of time you are exposed to the sound. For example, listening to an 85-dB sound for more than 8 hours can cause hearing damage. Garbage disposals, lawn mowers, heavy traffic, and noisy restaurants can have 85-dB sounds. A car horn, video arcade, power saw, and a crying baby all produce sounds of 110 dB. Listening to such sounds for only a minute and a half can cause damage to your hearing.



Academic Vocabulary

converse (kun VURS) (adj) to be reversed in order; opposite

Picture This

3. Use Diagrams How many decibels is the sound level of a purring cat?

Frequency and Pitch

Recall that the frequency of a sound is measured by the number of cycles the object causing the sound completes per second. It is similar to a car with a revved engine making a louder sound than when it is idling. The revved engine sounds louder because the car's engine shaft completes more revolutions per minute when it is operating at a high speed than when it is idling. Faster cycles of sound means a higher frequency of sound. Pitch relates to the frequency of the sound. The **pitch** of a sound is how high or how low the sound is. The higher the pitch of a sound is, the higher the frequency of the sound. The words *pitch* and *frequency* are often used to mean the same thing. ✓

✓ Reading Check

4. Explain How are pitch and frequency related?

Picture This

5. Compare Which species in the table can hear the largest range of sounds?

The human ear can detect sound waves with frequencies between about 64 Hz and 23,000 Hz. Dogs and other animals can respond to higher frequencies, as shown below. If a trainer blows a dog whistle, you may not hear it, but the dog will respond. That's because a dog whistle has a higher frequency than the human ear can detect. Bats, whales, porpoises, and dolphins detect high-frequency sound waves.

Range of Hearing	
Species	Approximate range (Hz)
Human	64–23,000
Cat	45–64,000
Mouse	1,000–91,000
Bat	2,000–110,000
Beluga whale	1,000–123,000
Elephant	16–12,000
Porpoise	75–150,000
Tree frog	50–4,000

What have you learned?

Vibrations cause sound waves by moving molecules closer together and then farther apart. Sound travels by high-density and low-density compression waves. The loudness of a sound wave depends upon the amplitude and the frequency of the sound wave. A decibel scale measures your perception of the loudness of a sound. The pitch of a sound, how high or low it is, depends upon the frequency of the sound.

The Ear and Sound

Lesson 2 The Ear and Hearing

Grade Seven Science Content Standard. 5.g. Students know how to relate the structures of the eye and ear to their functions.



● Before You Read

On the lines below, describe in what ways you think a tape recorder is like your ear. Then read the lesson to learn about how the ear detects sound.

MAIN Idea

The ear detects sound waves that pass through the three parts of the ear.

What You'll Learn

- to identify the parts of the ear
- to describe the way ear detects sound

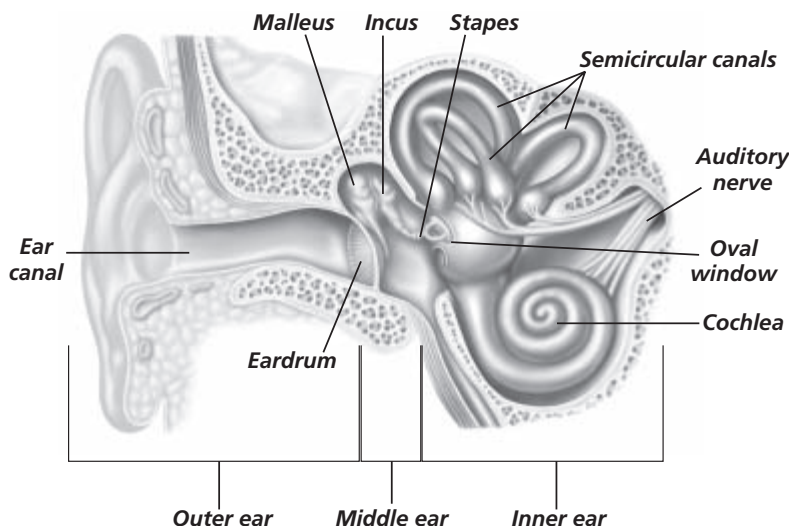
● Read to Learn

Structures of the Ear

The human ear is made up of three parts: the outer ear, the middle ear and the inner ear, shown in the drawing below. The external ear—the part you see—and the auditory canal are parts of the outer ear. These parts collect sound waves and transfer them to the middle ear. The eardrum and three tiny bones in the middle ear conduct sounds to the inner ear. The inner ear contains intricate structures that detect different frequencies of sound. These structures send signals to the brain.

Study Coach

Take Notes Write the bold heading of each section on the left-hand side of your paper. On the right-hand side, write three facts about the topic that you discovered from your reading.

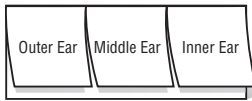


Picture This

1. **Identify** Where are the malleus, incus, and stapes of the ear located? (Circle the answer.)
 - a. outer ear
 - b. middle ear
 - c. inner ear

FOLDABLES™

B Explain Make a three-tab foldable. Label the front tabs, as illustrated. Sketch the outer, middle, and inner ear on the top front tabs. Record what you learn about the structure of the ear under the tabs.



✓ Reading Check

2. Describe How can you adjust the pressure in the eustachian tube?

What is the outer ear?

The visible parts of your ears on each side of your head are the external ears, but they are only one part of the outer ear. The **external ear** is made up of folds of cartilage and skins. These folds adjust the sound waves that enter your ear. Your brain can then interpret the origin of the sound waves.

Another part of the outer ear is called the **auditory canal**. The auditory canal collects sound waves from the external ear and then passes the sound waves to the middle ear. When you put your finger into your ear, you can feel the beginning of the auditory canal. The auditory canal leads to your middle ear.

What is the middle ear?

Look again at the figure on the first page of the lesson. It shows the first part of the middle ear that sound waves reach. It is called the **tympanic membrane**, but you may refer to it as the eardrum. The eardrum is a thin layer of skin that vibrates when sound waves hit it.

Vibrations of the tympanic membrane cause three tiny bones to transmit sounds waves. These waves go through the middle ear to the inner ear. These tiny bones are known by their Latin names. The **malleus** (MAYL ee us) is also called the hammer. The **incus** is called the anvil. The **stapes** (STAH pehs) is called the stirrup. Two small muscles control the tension on the eardrum and the bones of the middle ear. By changing the tension, these muscles can protect the eardrum from large vibrations caused by loud sounds.

Within the middle ear is a fluid-filled vessel called the eustachian (yoo STAY shun) tube. The malleus, incus, and stapes rest in this tube. The eustachian tube connects the middle ear to the throat. You can adjust the pressure in the eustachian tube and in your middle ear by swallowing. You may have yawned or chewed gum when on airplanes or in elevators to help equalize the pressure in your middle ears. ✓

What is the inner ear?

The bones of the middle ear move and transfer vibrations from the tympanic membrane to the inner ear. These vibrations are transferred by a membrane called the oval window. The vibrations are then passed on to the fluid in a snail-shaped structure called the **cochlea** (KOH klee uh). The cochlea is lined with sensory cells. The sensory cells closest to the middle ear sense high-frequency sound waves. The sensory cells farther from the middle ear sense low-frequency sound waves.

Sensing Sound

Movement causes you to hear something. All of the sensory cells in the cochlea have little hairs that stick out of them. When a vibration hits the hairs, they bend. The cells then send a signal to the brain. The brain can tell the frequency of the sound wave by determining the location of the bent hairs. The brain can also determine the loudness of a sound. The further a hair is deflected, or bent, the louder the brain recognizes the sound to be.

Hearing Damage

Hearing damage can occur in almost any part of the ear. Conductive hearing loss is when sound is not transmitted through the outer and middle ear. Damage to the cochlea causes sensorineural hearing loss.

What causes conductive hearing loss?

Conductive hearing loss can be caused by colds or allergies. They can cause a temporary buildup of fluid in the middle ear, creating an infection that puts pressure on the eardrum. If the eardrum does not vibrate properly, a person cannot hear properly.

Damage to the cochlea can occur because of aging or exposure to loud noises. If the hairs on the sensory cells in the cochlea are bent for too long or too much, damage can occur. People who spend a lot of time at loud concerts or working around loud machinery can suffer from hearing loss.

Can hearing damage be corrected?

Conductive hearing loss usually can be treated. For example, if fluid has accumulated in the middle ear that resulted in infection, medicine can clear up the infection and restore hearing. Sensorineural hearing loss, however, is permanent. Such damage can only be corrected with hearing aids. People who have badly damaged inner ears can have surgery to put cochlear implants in their ears.

Hearing in Other Mammals

Most mammals use a system for hearing that is similar to the hearing system of humans. However, some mammals possess qualities that allow them to hear certain sounds better than humans can.



Think it Over

- 3. Identify** What type of sound does not bend the hairs in the sensory cells of the cochlea very much?
- a loud sound
 - a soft sound
 - high-frequency sound

Academic Vocabulary

temporary (TEM pur rer ee)

(adj) lasting a short time

Reading Check


- 4. Compare** What is the difference between conductive hearing loss and sensorineural hearing loss?

 **Reading Check**

5. Name one advantage of redirecting sound.

 **Think it Over**

6. Contrast What is the difference between redirecting sound and echolocation?

Redirecting Sound Have you ever watched a dog or a cat move its ears around? You might have noticed that these animals rotate their ears often, especially when they are hunting or tracking something. Dogs and cats and some other animals use their external ears to redirect sound into their auditory canals. This helps them to determine which direction sound is coming from. Redirecting sound into their external ears can also help animals detect the smallest sounds, giving them the ability to hear predators and prey more easily. 

Echolocation You know that a light wave reflects off a shiny surface. In the same way, sound waves can reflect off hard surfaces. A reflected sound wave is called an **echo**. If the reflecting surface is far away, it will take longer for an echo to bounce back.

Echolocation is a method that some mammals use to navigate and hunt. Bats, for example, make high-frequency calls and then listen for echoes. A bat can determine the position and identity of an object when it hears an echo. Dolphins and whales use echolocation, too. By making clicks that bounce off objects in the ocean, dolphins and whales are able to navigate.

The Human Ear

The human ear is made up of many tiny parts that work together. These parts interpret sound waves for the brain. Sound is conducted through tiny bones and fluid-filled chambers. The bending of tiny hairs determines the type of sound a person hears. Hearing can be temporarily or permanently damaged by illness or injury to the ears. Sometimes hearing loss cannot be restored or can be restored only partially, so it is important to protect your hearing.

Some animals are able to move their outer ears to better collect sound. Other animals are able to determine the position of objects by the reflection of the sounds that the animals make. This reflection of sound is called echolocation.

The Human Reproductive System

Lesson 1 Reproductive Systems



Grade Seven Science Content Standard. 5.d. Students know how the reproductive organs of the human female and male generate eggs and sperm and how sexual activity may lead to fertilization and pregnancy.

● Before You Read

On the lines below, write one fact that you know about human reproduction. Then read on to find out more about how the male and female body are adapted for reproduction.

MAIN Idea

Human reproductive systems are adapted for the production of offspring.

What You'll Learn

- the development of sperm and egg
- the path traveled by a sperm cell
- the stages of ovulation and the menstrual cycle

● Read to Learn

Male Reproductive System

Differences exist between the bodies of adult males and adult females. Men usually have more body hair and deeper voices than women. Their bodies also tend to be larger and more muscular. These features develop as boys get older. At the same time, their reproductive systems are developing.

What are the male reproductive organs?

Males have reproductive organs both inside and outside the body. The male organs on the outside of the body are the **penis** (PEE nus) and the testes. The penis is the male organ that transfers sperm to a female's reproductive tract. The testes (TES teez) produce sperm. They are in a baglike structure called the **scrotum** that hangs outside the male's body cavity. This position keeps the testes slightly cooler than the rest of the body. The normal internal body temperature is too warm for sperm production.

Sperm are made in a part of the testes called **seminiferous tubules** (se mih NIHF rus • TOOB yewlz). Sperm travel from seminiferous tubules to a storage organ within the scrotum called the **epididymis** (eh puh DIH duh mus). The epididymis connects to tubes called the vas deferens (VAS • DEF uh runz).

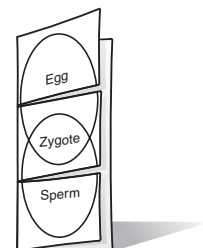
Study Coach

Make Two-Column

Notes As you read, organize your notes in two columns. In the left column, write the main idea of each paragraph. In the right column, write details about the main idea.

FOLDABLES™

A Record Make a Venn-diagram Foldable. As you read the lesson, record what you learn about eggs, sperm, and fertilization producing a zygote.



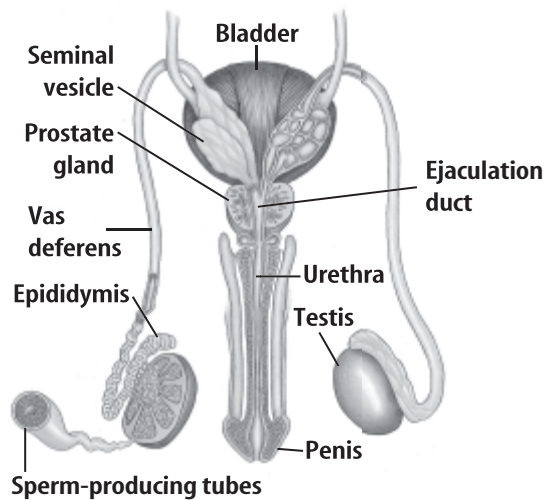
How are sperm transferred?

When a male is sexually stimulated, the tissues of the penis fill with blood. This firms the penis and causes an erection. In a process called ejaculation, sperm leave the epididymis. Sperm can also leave the penis before ejaculation, without the male's knowledge.

Sperm leave the body through the vas deferens. Then they go through a short ejaculation (ih ja kyuh LAY shun) duct. This duct connects to another tube, called the **urethra** (yoo REE thruh). The urethra extends to the end of the penis. It carries sperm out of the body. The urethra also carries urine. However, ejaculation and urination never occur at the same time.

Picture This

- 1. Label** Trace the path of sperm during ejaculation.



How are sperm produced?

Sperm production occurs by meiosis in cells that line the seminiferous tubules. It takes 65–75 days to produce a sperm cell. Sperm begin to be made when a male enters puberty (PYEW bur tee). This is usually between 10 and 16 years of age. Sperm can continue to be produced for the rest of a male's life.

What is semen?

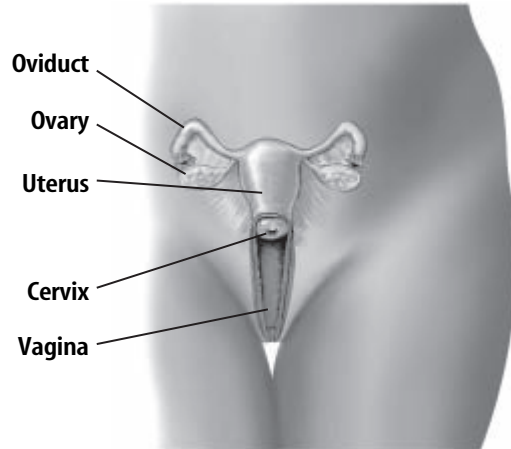
A male's reproductive system produces fluid for sperm to move in. The mixture of fluid and sperm is called semen (SEE mun). Most of the fluid is made in glands called the seminal vesicles. The rest is made by the prostate gland. During ejaculation, about 2 mL to 5 mL of semen are released from the penis. This contains 100 to 650 million sperm. ✓

Reading Check

- 2. Explain** How many sperm are released during ejaculation?

Female Reproductive System

A female's reproductive system, shown below, produces eggs. It is also the place where a fertilized egg can grow and develop into a baby. You read earlier in this lesson that a male begins producing sperm when he reaches puberty. However, a female begins producing eggs before she is born.



What are the female reproductive organs?

Unlike a male, all of a female's reproductive organs are inside her abdomen. Two folds of skin, called the labia (LAY bee uh), protect the opening to the reproductive system. Beyond the opening, inside the female's body, is a thin-walled chamber called the **vagina** (vuh JI nuh). The vagina is the chamber where semen is deposited. The female reproductive organs are described below.

- **Uterus** (YEW tuh rus) is the place where a fertilized egg can develop. It is lined by a tissue called the endometrium (en doh MEE tree um). The uterus expands in size during pregnancy.
- Cervix (SUR vihks) is the opening of the uterus into the vagina. During childbirth, the cervix gets wider, or dilates, so that the baby can pass through.
- Ovaries (singular, ovary) are the organs that produce eggs.
- **Fallopian tubes** (fuh LOH pee un • TOOBS) are the tubes that connect the ovary to the uterus. They contain cilia that wave back and forth to move eggs into the uterus. ✓

Picture This

3. Identify How many ovaries does the female reproductive system have?

✓ Reading Check

4. Explain What is the purpose of cilia in the fallopian tubes?

Reading Check

5. Identify By what process are human eggs produced?

Academic Vocabulary release (rih LEES) (verb) to set free; to let go

Reading Check

6. Draw Conclusions
Name one reason the egg attaches to the endometrium.

How are eggs produced?

A human egg is produced by meiosis. Before a female is born, cells in her developing ovaries begin meiosis but stop at the first phase, prophase I. These cells are called primary oocytes (OH uh sites). They remain unchanged until a female begins puberty.

Most human females begin puberty between the ages of 9 and 13. At that time, a female's body begins producing chemical signals that cause primary oocytes to continue meiosis. The cells stop at the second stage of meiosis, metaphase II. They are now called secondary oocytes. These secondary oocytes are the egg cells. Most females produce one egg cell every four weeks. An egg cell does not complete meiosis until fertilization occurs.

Egg cells are surrounded and nourished by cells of the ovary. A **follicle** (FAH lih kul) is an egg cell and its surrounding cells. A female at puberty has about 400,000 follicles. **Ovulation** (ahv yuh LAY shun) is the release of an egg from a follicle into a fallopian tube.

What is the menstrual cycle?

Before a follicle releases an egg, other changes happen in a female's body. The changes that take place before, during, and after ovulation are called the **menstrual cycle** (MEN stroo ul). A menstrual cycle lasts about 28 days. The first day of a menstrual cycle is the first day of menstrual flow.

What is menstrual flow?

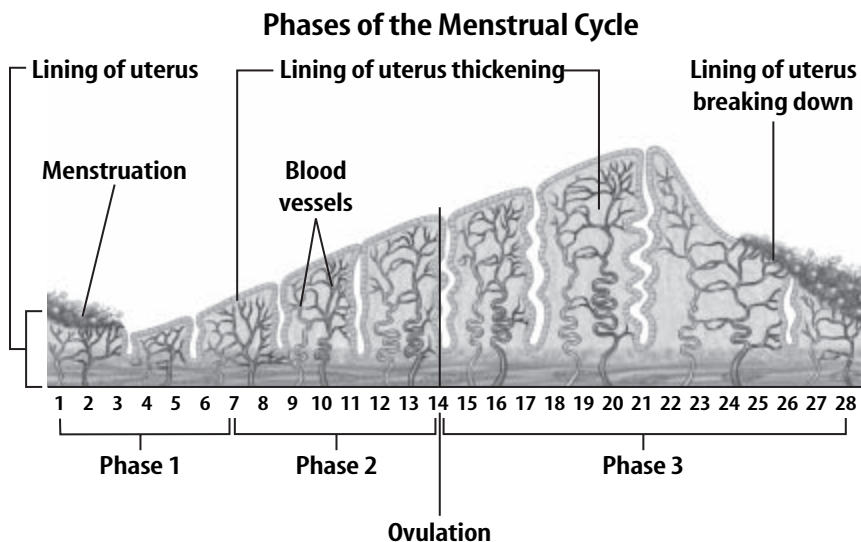
You read that the endometrium is a tissue that lines the uterus. During each menstrual cycle, the endometrium becomes thicker and the number of blood vessels in it increases to support a fertilized egg. If a released egg is not fertilized, the endometrium breaks up and sloughs off. The pieces of endometrium, some blood, and the unfertilized egg leave the vagina as menstrual flow or menstrual bleeding. Menstrual flow usually lasts about four to seven days.

After menstrual flow stops, the endometrium begins to rebuild. Its thickness increases. The number of blood vessels that it contains also increases. The endometrium is preparing to protect and nourish the next egg. At the same time, another egg is developing in the ovaries.

Picture This

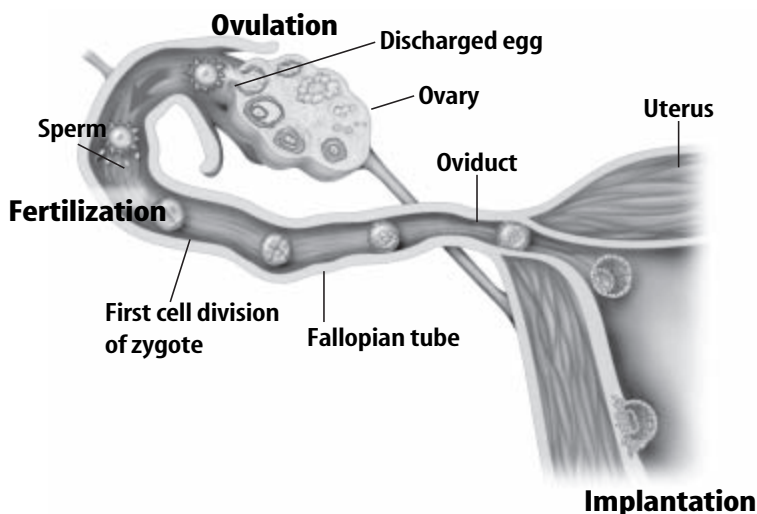
7. Determine About how many days long is the menstrual cycle? (Circle your answer.)

- a. 7
- b. 28



What is ovulation?

The changes to the uterus during the phases of the menstrual cycle are shown in the figure above. About two weeks after the first day of menstrual flow, ovulation occurs. That is when an egg is released. It takes about 24 to 48 hours for an egg to move down the fallopian tube and into the uterus. If the egg is fertilized, a zygote forms. It attaches to the endometrium and menstrual bleeding does not occur. This is usually one of the first signs of pregnancy. However, if an egg is not fertilized, the endometrium will break apart and the menstrual cycle will begin again.



What are hormones?

Hormones are chemical messengers that regulate the timing of the menstrual cycle and ovulation. Hormones are produced in glands located throughout the body.

Picture This

8. Identify Where does fertilization take place?

What is menopause?

The stage of life at which women stop ovulating is called menopause (MEN uh pawz). Menopause occurs between the ages of 46 and 54 in most women. It marks the end of females' menstrual cycles.

Fertilization

In humans, a sperm can only fuse with an egg in the fallopian tubes. For this to happen, the sperm must be there near the time of ovulation.

Sperm are deposited in or near a female's vagina. They swim up through her reproductive tract. Millions of sperm enter the vagina at one time, but most will not reach an egg. Some sperm swim away from the fallopian tubes. Others enter the fallopian tube that does not contain an egg. Other sperm have genetic or physical defects that prevent them from fertilizing an egg.

More than one sperm usually reaches an egg. Once a sperm attaches to an egg, however, chemical reactions occur. The chemical reactions prevent other sperm from entering that egg. Only one sperm fertilizes an egg.

Sperm can live up to three days inside a female's reproductive system. Therefore, fertilization and pregnancy can happen even if sexual intercourse occurs before a woman ovulates. There are effective birth control methods that males and females can use to prevent pregnancy. However, abstinence—avoiding sexual intercourse—is the only birth control method that is 100 percent certain to prevent pregnancy.

Reproductive Systems Summary

In this lesson, you learned that the male reproductive system includes several organs, such as the testes. The testes are where sperm are produced. Other male organs contribute fluid to the semen in which sperm move.

The female reproductive system also consists of several organs, including the ovaries. The ovaries are where eggs develop. A menstrual cycle lasts about 28 days. The menstrual cycle includes the building up of the endometrium, ovulation, and, if fertilization does not take place, menstrual flow. If an egg is fertilized and a zygote implants in the endometrium, the menstrual cycle stops and pregnancy begins.

Reading Check

9. Explain List two reasons why many sperm do not reach an egg.

Academic Vocabulary

contribute (kun TRIB yewt)

(verb) to play an important part in bringing about a goal or result

The Human Reproductive System

Lesson 2 Development Before Birth

Grade Seven Science Content Standard. 5.e. Students know the function of the umbilicus and placenta during pregnancy.



Before You Read

Describe two ways that a pregnant woman can affect the health of her fetus. Then read the lesson to learn about how a fetus develops before birth.

MAIN Idea

The normal development of a fetus depends on the good health of the mother.

What You'll Learn

- the importance of the placenta and umbilical cord
- the developmental stages of a fetus

Read to Learn

Fetal Development

All sexually produced organisms begin life as a zygote. Zygotes form when a sperm fertilizes an egg. In a human, the zygote's cells begin to divide about 24 hours after fertilization. After about seven days it is a hollow ball of more than 100 cells. This is the embryo.

The embryo implants into the endometrium. Its cells continue to divide. A week later, the cells begin to separate into three layers. Different body structures will be formed from each layer. Over a period of about nine months, a human embryo develops into a baby.

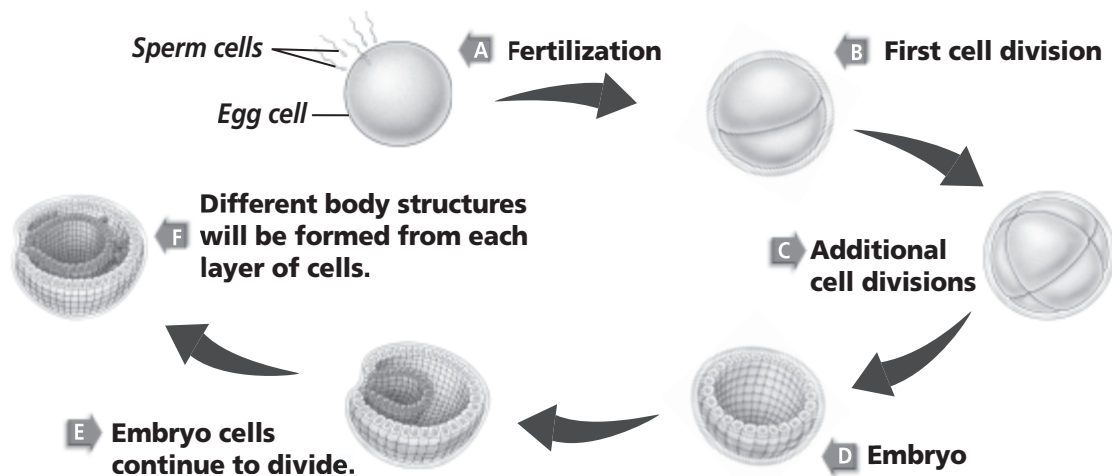
Mark the Text

Identify Main Points

Highlight the main idea in each paragraph. Underline the details that support the main idea.

Picture This

1. **Identify** Circle the embryo stage in the figure.



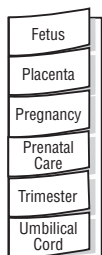
Picture This

2. Estimate How much longer is the fetus at the end of the second trimester than the embryo at 12 weeks?



B Define and Record

Make a six-tab Foldable. Label the front tabs as illustrated. Define and record what you learn about the fetus, placenta, pregnancy, prenatal care, trimester, and umbilical cord under the tab.



What happens during pregnancy?

The development of a baby inside a female's uterus is called **pregnancy**. In humans, pregnancy usually lasts about 38 weeks from fertilization to birth. This means that most babies are born about 40 weeks, or nine months, after the start of the last menstrual cycle. There are many changes that take place during pregnancy. It is helpful to think about the nine months of pregnancy in three parts, called **trimesters**. The stages of pregnancy are explained in the table below.

Stages of Pregnancy	
Stage	Development
First trimester	<ul style="list-style-type: none">• At the end of the first trimester of pregnancy (about 12 weeks), an embryo is about 7.5 cm long and it weighs about 23g.• The embryo's heart is beating, it has all the structures that will become its major organ systems, and it can move its arms and legs.
Second trimester	<ul style="list-style-type: none">• At the end of the second trimester (about 24 weeks), a fetus is about 25-35 cm long. It kicks frequently.• The embryo is now called a fetus (FEE tus). A pregnant female begins to feel the fetus's movements. A baby born at this stage would need intensive medical care.
Third trimester	<ul style="list-style-type: none">• During the third trimester, a fetus usually triples in size.• A baby born early in this stage of development probably would survive. However, it might need medical care.

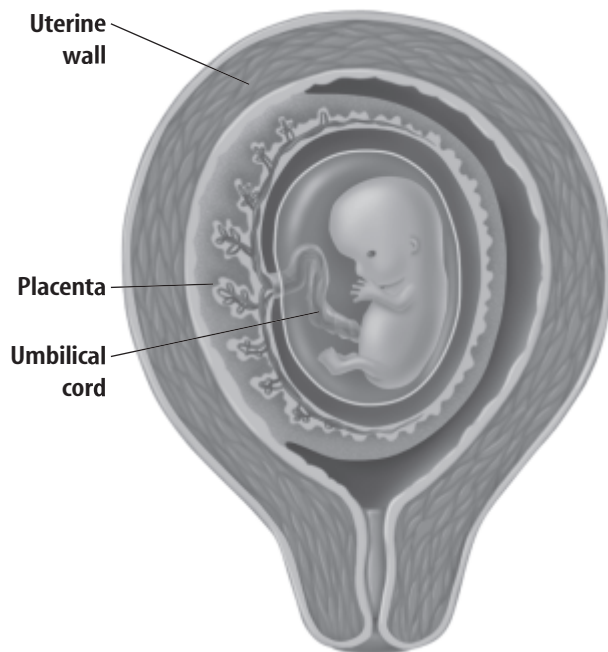
What is the function of the placenta?

A growing fetus needs oxygen and nutrients. It gets these from its mother. A fetus also rids itself of wastes such as carbon dioxide by passing them to its mother. These exchanges take place through the **placenta** (pluh SEN tuh). The placenta is a disk-shaped organ. It is made of tissues from the fetus and tissues of the endometrium. The placenta is attached to the uterus.

The placenta begins to form when an embryo is implanted in the endometrium. The placenta contains blood vessels from both fetus and mother. However, the blood vessels of a pregnant woman and her fetus are not connected to each other.

What is the function of the umbilical cord?

A fetus is connected to the placenta through its **umbilical** (um BIH lih kul) **cord**, shown below. The umbilical cord contains two arteries and one vein. Substances enter and leave the fetus' body through this umbilical cord. The umbilical cord is connected to the fetus at its navel, or belly button. After the baby is born, the umbilical cord is cut.



Fetal Health

Everything that happens in a female's body during pregnancy has an effect on her fetus. The fetus needs energy and nutrients to form its bones, skin, and other structures. All of this must come from its mother. Therefore, it is important for a pregnant woman to take good care of her health. Anything that can harm her health can also harm the fetus developing inside her body.

What is prenatal care?

Health care that aims to protect the health of a pregnant woman and her developing fetus is **prenatal care**. Research has shown that a pregnant woman who receives prenatal care from a certified health care provider has a better chance of delivering a healthy baby. Prenatal care includes information on nutrition, avoiding environmental dangers, and preventing viral infections.

Picture This

3. Identify Circle the umbilical cord.

Reading Check

4. Explain Why is prenatal care important?

✓ Reading Check

5. Identify How do nutrients get from the mother to the fetus?

Academic Vocabulary

medical (MED ih kul) (adj)
related to physicians or the practice of medicine

✓ Reading Check

6. Name the structures through which a fetus gets oxygen and nutrients.

How does the fetus get nutrients?

A fetus depends on its mother for all of its nutrients. Vitamins, minerals, proteins, fats, and carbohydrates pass from mother to fetus through the placenta. A pregnant woman needs to eat a diet that includes dairy products, proteins, fruits, vegetables, and whole grains, to support her growing fetus. ✓

How can viruses affect the fetus?

You have probably had a cold, flu, chicken pox, or measles or some other infection caused by a virus. Most viruses do not cause serious health problems in adults, but may cause great harm to a growing fetus. Viral illnesses such as genital herpes (HUR pee-z) and AIDS can be passed from a pregnant woman to her fetus. Some viruses can cause birth defects or death of newborn babies.

A virus that is deadly to both adults and newborns is the human immunodeficiency virus (HIV) that causes AIDS. An HIV-infected, pregnant woman can lower the odds of having an HIV-infected baby if she sees a physician early, has good medical care, and takes HIV-fighting drugs.

What effect can drugs and alcohol have?

A pregnant woman who uses drugs or alcohol puts herself and her fetus in danger. These substances can enter the body of a fetus through the placenta. Alcohol and drug use increases the chances of the baby being born too early. The baby may have learning difficulties. Some illegal drugs, such as cocaine and heroin, can cause the death of a fetus. In addition, a pregnant woman who uses needles to inject drugs increases her risk of being infected with viruses such as HIV.

Development Before Birth Summary





A human zygote develops into a hollow ball of cells that implants into the lining of the endometrium about one week after fertilization. Over the next several weeks, this embryo develops into a fetus. A fetus obtains oxygen and nutrients from the mother through the placenta and umbilical cord. Pregnancy normally lasts about 38 weeks from fertilization. ✓

A pregnant woman can help ensure her baby has the healthiest possible start to life by getting good prenatal care, eating a nutritious diet, and avoiding exposure to drugs, alcohol, nicotine, and other harmful substances.

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PERIODIC TABLE OF THE ELEMENTS

Columns of elements are called groups. Elements in the same group have similar chemical properties.

-  Gas
-  Liquid
-  Solid
-  Synthetic

State of matter

The first three symbols tell you the state of matter of the element at room temperature. The fourth symbol identifies elements that are not present in significant amounts on Earth. Useful amounts are made synthetically.

Element — Hydrogen
 Atomic number — 1
 Symbol — H
 Atomic mass — 1.008

1	Hydrogen 1 H 1.008								2
2	Lithium 3 Li 6.941	Beryllium 4 Be 9.012							
3	Sodium 11 Na 22.990	Magnesium 12 Mg 24.305	3	4	5	6	7	8	9
4	Potassium 19 K 39.098	Calcium 20 Ca 40.078	Scandium 21 Sc 44.956	Titanium 22 Ti 47.867	Vanadium 23 V 50.942	Chromium 24 Cr 51.996	Manganese 25 Mn 54.938	Iron 26 Fe 55.845	Cobalt 27 Co 58.933
5	Rubidium 37 Rb 85.468	Strontium 38 Sr 87.62	Yttrium 39 Y 88.906	Zirconium 40 Zr 91.224	Niobium 41 Nb 92.906	Molybdenum 42 Mo 95.94	Technetium 43 Tc (98)	Ruthenium 44 Ru 101.07	Rhodium 45 Rh 102.906
6	Cesium 55 Cs 132.905	Barium 56 Ba 137.327	Lanthanum 57 La 138.906	Hafnium 72 Hf 178.49	Tantalum 73 Ta 180.948	Tungsten 74 W 183.84	Rhenium 75 Re 186.207	Osmium 76 Os 190.23	Iridium 77 Ir 192.217
7	Francium 87 Fr (223)	Radium 88 Ra (226)	Actinium 89 Ac (227)	Rutherfordium 104 Rf (261)	Dubnium 105 Db (262)	Seaborgium 106 Sg (266)	Bohrium 107 Bh (264)	Hassium 108 Hs (277)	Meitnerium 109 Mt (268)

The number in parentheses is the mass number of the longest-lived isotope for that element.

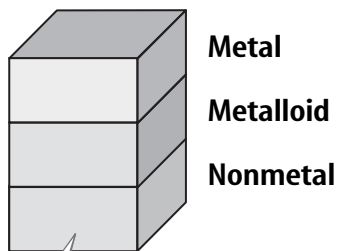
Rows of elements are called periods. Atomic number increases across a period.

The arrow shows where these elements would fit into the periodic table. They are moved to the bottom of the table to save space.

Lanthanide series

Actinide series

Cerium 58 Ce 140.116	Praseodymium 59 Pr 140.908	Neodymium 60 Nd 144.24	Promethium 61 Pm (145)	Samarium 62 Sm 150.36
Thorium 90 Th 232.038	Protactinium 91 Pa 231.036	Uranium 92 U 238.029	Neptunium 93 Np (237)	Plutonium 94 Pu (244)



10			11			12			13			14			15			16			17			18		
Nickel 28 Ni 58.693	Copper 29 Cu 63.546	Zinc 30 Zn 65.409	Gallium 31 Ga 69.723	Germanium 32 Ge 72.64	Arsenic 33 As 74.922	Selenium 34 Se 78.96	Bromine 35 Br 79.904	Krypton 36 Kr 83.798	Boron 5 B 10.811	Carbon 6 C 12.011	Nitrogen 7 N 14.007	Oxygen 8 O 15.999	Fluorine 9 F 18.998	Neon 10 Ne 20.180	Aluminum 13 Al 26.982	Silicon 14 Si 28.086	Phosphorus 15 P 30.974	Sulfur 16 S 32.065	Chlorine 17 Cl 35.453	Argon 18 Ar 39.948	Helium 2 He 4.003					
Palladium 46 Pd 106.42	Silver 47 Ag 107.868	Cadmium 48 Cd 112.411	Indium 49 In 114.818	Tin 50 Sn 118.710	Antimony 51 Sb 121.760	Tellurium 52 Te 127.60	Iodine 53 I 126.904	Xenon 54 Xe 131.293	Platinum 78 Pt 195.078	Gold 79 Au 196.967	Mercury 80 Hg 200.59	Thallium 81 Tl 204.383	Lead 82 Pb 207.2	Bismuth 83 Bi 208.980	Polonium 84 Po (209)	Astatine 85 At (210)	Radon 86 Rn (222)									
Darmstadtium 110 Ds (281)	Roentgenium 111 Rg (272)	Ununbium * 112 Uub (285)		Ununquadium * 114 Uuq (289)																						

* The names and symbols for elements 112–114 are temporary. Final names will be selected when the elements' discoveries are verified.

Europium 63 Eu 151.964	Gadolinium 64 Gd 157.25	Terbium 65 Tb 158.925	Dysprosium 66 Dy 162.500	Holmium 67 Ho 164.930	Erbium 68 Er 167.259	Thulium 69 Tm 168.934	Ytterbium 70 Yb 173.04	Lutetium 71 Lu 174.967
Americium 95 Am (243)	Curium 96 Cm (247)	Berkelium 97 Bk (247)	Californium 98 Cf (251)	Einsteinium 99 Es (252)	Fermium 100 Fm (257)	Mendelevium 101 Md (258)	Nobelium 102 No (259)	Lawrencium 103 Lr (262)