Standards: SC.6.L.14.2, SC.6.L.14.3

Cell Theory

Key Words • cell • organism • cell theory • single-celled organism • multi-celled organism • homeostasis

Getting the Idea

From the smallest bacteria to the largest whales, all living things are made up of similar building blocks. These building blocks are called cells. In this lesson, you will learn how we came to understand these tiny units of life.

Cells

All living things have one thing in common—they are made up of cells. The **cell** is the basic unit of life. The cell is the smallest unit that can carry out all the functions of life. Cells take in water and other materials and get rid of wastes. Cells release and use energy. Cells reproduce, or make more cells of the same kind.

An **organism** is a living thing. Some organisms have only one cell. Other organisms, such as humans, are made up of trillions of cells.

The Discovery of Cells

Most cells are too small to be seen with just your eyes. Because cells are so small, scientists did not discover them until the microscope was invented.

The English scientist Robert Hooke was the first person to use the word *cell* for the basic unit of living things. In 1663, Hooke used a simple microscope to examine a thin slice of cork. The cork looked as though it was made up of many little boxes. The boxes reminded Hooke of the cells, or small rooms, that monks lived in. He used the word *cell* to describe the units that made up the cork. He published his discovery in 1665.

The Dutch lensmaker Anton van Leeuwenhoek became the first person to see living cells. Van Leeuwenhoek's microscope was very simple. But it was strong enough to let him see living things in a sample of pond water. Because these tiny organisms were moving, van Leeuwenhoek called them animalcules, or little animals. The discovery of these organisms changed the science of biology forever.

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More Discoveries Lead to the Cell Theory

By the 1800s, more powerful microscopes were available. Scientists used them to examine many living things. The German scientist Matthias Schleiden used the new microscopes to study plants. Based on his studies, Schleiden concluded that all plants are made up of cells. Another German scientist studied the cells of animals. In 1839, Theodor Schwann published his conclusion that all animals as well as plants are made up of cells.

In 1855, German doctor Rudolph Virchow made another discovery about cells. Virchow stated that cells are produced only by other living cells. Over the years, many other scientists confirmed the observations of Schleiden, Schwann, and Virchow. The work of all these scientists led to the development of the **cell theory**. The cell theory contains three parts:

Cell Theory
1. All living things are made up of one or more cells.
2. The cell is the basic unit of all living things.
3. All cells come from other living cells.

Single-Celled Organisms

The first part of the cell theory says that all living things are made of one or more cells. An organism that has only one cell is called a **single-celled organism**. This single cell does everything the organism needs to survive. This includes making or taking in food, releasing energy, getting rid of waste, and reproducing. Most single-celled organisms can be seen only with a microscope.

Multi-Celled Organisms

An organism that has more than one cell is called a **multi-celled organism**. The cells that make up multi-celled organisms often have specific jobs. Some cells carry oxygen and carbon dioxide to other cells. Other cells move the organism. Still others carry messages throughout the organism.

Most animal and plant cells are so small that they are only between 1 and 100 micrometers in diameter. One micrometer (μm) is equal to one millionth of a meter.

The human body has at least 200 different kinds of cells. These cells include muscle cells, blood cells, nerve cells, skin cells, and bone cells.

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Keeping a Balance

Homeostasis is the ability of living things to maintain a balanced internal environment. For example, a cell must keep the right balance between too little and too much water. If a cell's surroundings become drier or wetter, the cell must be able to take in or get rid of water. Your body must keep itself at a fairly constant temperature. If the temperature around you gets too warm, your body cools off by sweating. If your body gets cold, it warms up by shivering.

The cell of a single-celled organism does everything. It digests food, gets rid of waste, and takes in oxygen. It does not need to work with other cells to stay alive. The cells of multi-celled organisms carry out different jobs, so they must work together. Suppose the digestive cells stopped breaking down food. Then other cells would not have enough energy to do their jobs. Most likely, the organism would not survive. You will learn more about how cells work together in Lessons 23 and 24.

Discussion Question

How are the cells of single-celled organisms and multi-celled organisms alike? How are they different?

Lesson Review

1. Which statement is part of the cell theory?

   A. Single-celled organisms are made of one cell.

   B. Cells are different in size and shape.

   C. All cells come from other living cells.

   D. Cells sometimes have only one job.

2. Which scientist was the first to use the word *cell* to describe what he saw?

   A. van Leeuwenhoek

   B. Hooke

   C. Virchow

   D. Schwann

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3. To which cells does the cell theory apply?

   A. animal cells only

   B. plant cells only

   C. all cells

   D. single-celled organisms only

4. Which is the **best** definition of *homeostasis*?

   A. the ability of living things to keep a balanced internal environment

   B. the ability to balance organisms

   C. a balance of single-celled and multi-celled organisms in the world

   D. finding a balanced environment to live in

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Standard: SC.6.L.14.4

Comparing Plant and Animal Cells

Key Words • organelle • cell membrane • cytoplasm • nucleus • vacuole • mitochondria • chloroplasts • cell wall

Getting the Idea

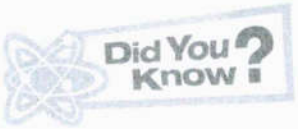
You have read that cells are the building blocks of all living things. All plants and all animals are made up of cells. Plant cells and animal cells both come in different shapes and sizes. These cells have several features that are alike, and some that are very different.

Cells and Life Functions

Most cells are very small and cannot be seen without a microscope. Animal cells are usually smaller than plant cells. Plant and animal cells have different shapes, too. Both plant and animal cells contain smaller parts called organelles. **Organelles** are structures that carry out the functions, or jobs, that keep cells alive. These functions include taking in food, releasing waste, growing, and reproducing.

Both plant and animal cells have a cell membrane. The **cell membrane** is a thin, flexible outer covering. The cell membrane controls what enters and leaves a cell.

The cell membrane has tiny holes in it. Through these holes, the cell membrane allows small particles such as oxygen, sugar, and water to pass. Only certain substances are allowed to pass through. For example, animal cells need to have oxygen come in through the cell membrane. In both plant and animal cells, the cell membrane allows nutrients and water to enter the cell. It allows wastes to leave the cell. Larger particles cannot enter or leave the cell through the cell membrane.



A chicken egg is a single, very large cell. Try leaving an egg in vinegar for two days. The shell will dissolve, but the egg will still be covered by the cell membrane.

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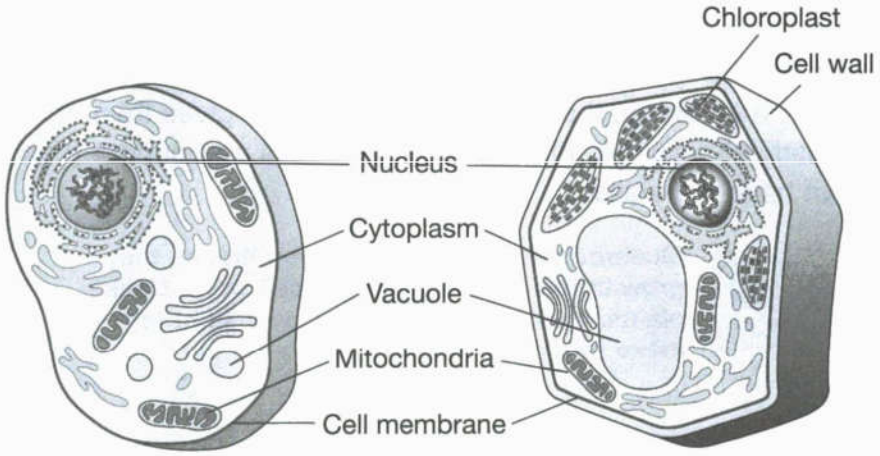
Other Structures of Plant and Animal Cells

The diagram below shows the main structures of animal and plant cells. Most of the structures shown can be found in both kinds of cells. Two structures shown are found only in plant cells.



Animal Cell **Plant Cell**

Most of the inside of a cell is filled with a jelly-like fluid called **cytoplasm**. The name *cytoplasm* means "cell liquid." Cytoplasm is mainly made up of water. The cell's organelles float in the cytoplasm.

Both plant and animal cells have an organelle called the nucleus. The **nucleus** is the control center of the cell. The nucleus directs most of the cell's activities. The nucleus also contains the cell's genetic material, DNA. This material controls how an organism develops.

Plant cells contain vacuoles. A **vacuole** is an organelle that a cell uses to store material. Plant cells have one large vacuole that stores water and other substances. The vacuoles in plant cells help support the plant. Most animal cells have vacuoles, but they are much smaller than those in plant cells. Vacuoles in animal cells store food and waste. In animal cells, vacuoles are often temporary.

Both plant and animal cells have mitochondria scattered throughout their cytoplasm. **Mitochondria** are small organelles that break down sugar. Because this process releases energy, mitochondria are sometimes called the "powerhouses" of the cell. The process mitochondria use to release energy from sugar is called *cellular respiration*.

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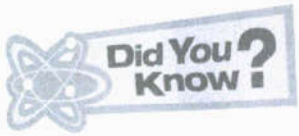
Structures of Plant Cells

Plant cells have two structures that animal cells do not have. A **chloroplast** is a structure in which photosynthesis takes place in a plant cell. In photosynthesis, plants use energy from the sun to change carbon dioxide and water into glucose and oxygen. Glucose is a sugar that the cells use as food. Chloroplasts contain chlorophyll, a green pigment that absorbs sunlight.

The other structure found only in plant cells is the cell wall. The **cell wall** is a rigid structure that surrounds the cell membrane. It supports plant cells and gives them their shape. The cell wall is made mostly of cellulose. In general, animal cells are rounder than plant cells because they do not have cell walls.



Mushrooms are not plants, even though they grow in the ground and have cell walls. Unlike plants, mushrooms cannot use sunlight to make food.

Discussion Question

Suppose you are looking at a cell under a microscope. What are some things that would help you tell if it is a plant cell or an animal cell?

Lesson Review

1. Which structure is the control center of both plant and animal cells?

   A. nucleus

   B. cytoplasm

   C. cell membrane

   D. vacuole

2. What is the function of the cell membrane?

   A. to store water

   B. to control what enters and leaves the cell

   C. to guide most of the cell's activity

   D. to contain the cell's organelles

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3. Which statement is true?

   A. A plant cell has a nucleus, but an animal cell does not.

   B. A plant cell has a cell membrane and a cell wall.

   C. An animal cell has a cell membrane and a cell wall.

   D. An animal cell has mitochondria, but a plant cell does not.

4. In which structure in plant cells are carbon dioxide and water changed into glucose and oxygen?

   A. cell wall

   B. cell membrane

   C. vacuole

   D. chloroplast

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Standard: SC.6.L.14.1

The Organization of Living Things

Key Words • atom • molecule • cell • organism • tissue • organ • organ system

Getting the Idea

Suppose you and your friends want to start a band. Not everyone would play the guitar. It is more likely that each of you would choose a different instrument. One person might choose drums, one might choose keyboards, and another might choose the bass. To succeed, you have to be organized and work together. You all have to play the same song and keep the same beat. Cells have to be organized and work together, too.

Atoms and Molecules

Atoms are the basic building blocks of most matter on Earth. They make up both living and nonliving things. Everything around you is made up of atoms—your body, the floor, trees, a fish, and even air. Different atoms join together to make molecules. A **molecule** is made of two or more atoms joined together.

You can think of atoms as letters. Letters go together to make words, just as atoms combine to make molecules. Words are put together into sentences, just as molecules are combined to form cells.

Cells

The first level of organization in living things is the cell. Remember that a **cell** is the basic unit of life. Remember also that living things are called **organisms**. Animals are multi-celled organisms. In multi-celled organisms, each cell has a certain job. For example, some cells help organisms move. Other cells carry information from one part of the organism to another.

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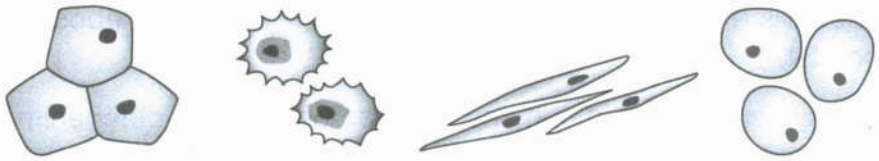
Cells that have specific jobs cannot work alone. Each type of cell depends on other cells to work properly. The muscle cells that help move an animal must have enough oxygen. They depend on the red blood cells that carry oxygen in the blood. The diagram below shows four different kinds of animal cells.



Liver cells Bone cells Muscle cells Fat cells

Tissues

In multi-celled organisms, cells are grouped together and organized. The second level of organization is the tissue. A **tissue** is a group of similar cells that work together. Most if not all the cells in a tissue look alike and have the same parts. These cells do one job. For example, a group of muscle cells form muscle tissue.

Animals, including humans, have four major types of tissue: epithelial tissue, connective tissue, muscle tissue, and nervous tissue. The table below describes each kind of tissue and gives examples of where it is found in the human body.

Types of Human Tissue

Kind of Tissue	Description	Examples
Epithelial	Closely packed cells that cover body structures and line internal structures	Skin, blood vessels
Connective	Connects different parts of the body with each other; has many different forms and functions	Bone, fat, cartilage, blood
Muscle	Contracts to allow movement	Biceps, diaphragm, tongue, heart
Nervous	Transmits and processes information	Spinal cord, brain, nerves

Organs

The third level of organization in many multi-celled organisms is the organ. An **organ** is a group of different tissues that work together to do a particular job. An example of an organ is the stomach. The stomach is made up of several different kinds of tissue, including epithelial, muscle, and connective tissue. These tissues work together to digest food. Your brain, liver, ears, and even your skin are all organs.

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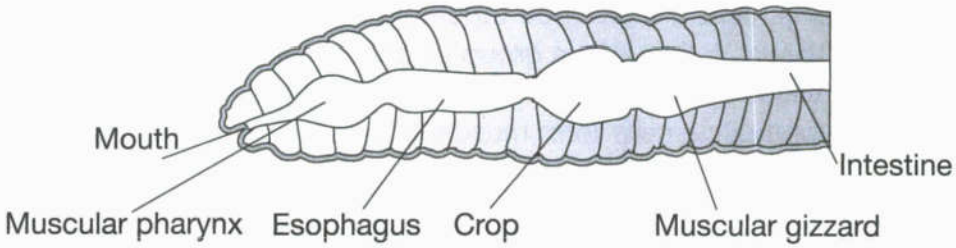
Organ Systems

The fourth level of organization in some multi-celled organisms is the organ system. An **organ system** is a group of organs that work together to perform a particular job. For example, the digestive system includes the mouth, pharynx, esophagus, stomach, small intestine, and large intestine. These organs work together to convert food into simpler molecules that the cells of the organism can use. You will learn more about human organ systems in Lesson 24.

Many of the organ systems found in humans can also be found in other animals. But the organ systems of some animals are simpler. The diagram below shows the digestive system of an earthworm. Compare the organs shown in the diagram to the organs listed in the paragraph above.



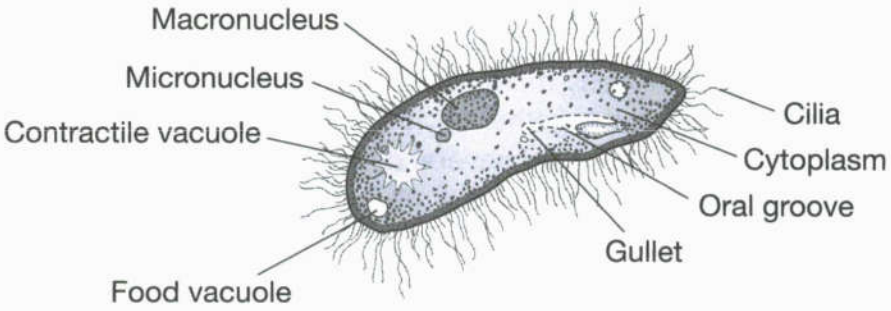
Organisms

The final level of organization in multi-celled organisms is the organism. For example, a dog is a multi-celled organism made up of many organ systems. Each of its organ systems is made up of organs. These organs are made of tissues. The tissues are made of cells that each do one job. The basis of this organization is the cell.

Discussion Question

The diagram below shows a paramecium, a single-celled organism that lives in pond water. How does the organization of a paramecium differ from that of a human? How are a paramecium and a human similar?

Paramecium



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Lesson Review

1. Which of the following correctly shows the levels of organization, from the simplest to the most complex?

   A. organism → organ → tissue → cell → organ system

   B. cell → tissue → organ → organ system → organism

   C. tissue → cell → organ → organ system → organism

   D. organ system → organism → tissue → cell → organ

2. What is the basic unit of life?

   A. cell

   B. organism

   C. atom

   D. molecule

3. Which level of organization involves a group of different tissues working together?

   A. cell

   B. tissue

   C. organ

   D. organism

4. Muscle, epithelial, connective, and nervous are examples of which level of organization?

   A. cell

   B. tissue

   C. organ

   D. organ system

Standard: SC.6.L.14.5

Human Body Systems

Key Words • respiratory system • circulatory system • digestive system • excretory system • musculoskeletal system • nervous system • reproductive system • immune system • homeostasis

Getting the Idea

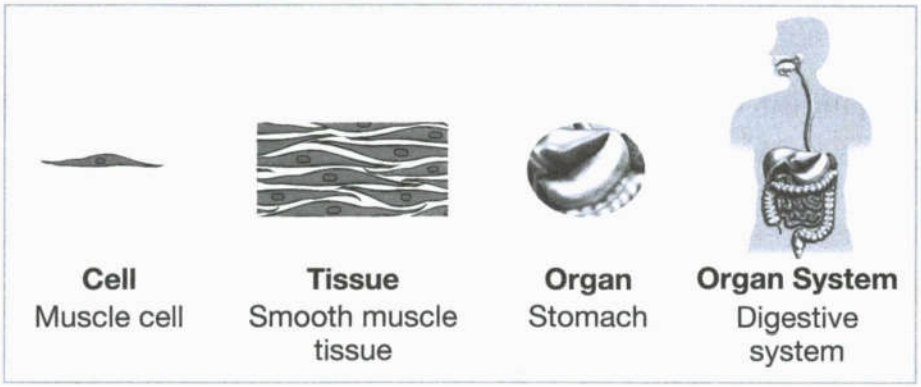
Imagine going to a school that did not tell you what grade you were in, or which teacher you would have, or when your classes would be. You would not know when your classes met, or where to go. Because the school was not organized, you would have a hard time learning. The cells inside a human body must be organized, too. They must work together to keep the person alive.

Organizing Cells into Organisms

Human beings are made up of trillions of cells. Recall from Lesson 23 that the cells of a complex organism, such as a human, are organized into tissues. Tissues are grouped into organs. An organ is made up of two or more types of tissues that work together. For example, the stomach is an organ. All the tissues that make up the stomach work together to digest food.

The organs are organized into organ systems. An organ system is a collection of organs that work together to perform a job. For example, the stomach works with the liver, intestines, and other organs to digest food. Each organ system does a job for the organism.

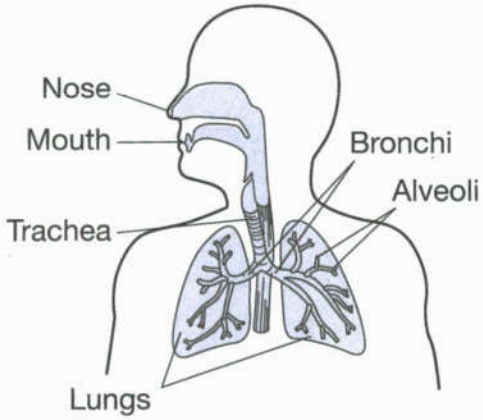
Levels of Organization



Cell	**Tissue**	**Organ**	**Organ System**
Muscle cell	Smooth muscle tissue	Stomach	Digestive system

The Respiratory System

Humans take in and release air by breathing. The **respiratory system** takes in oxygen from the air and releases carbon dioxide back into the air. The *lungs* are sponge-like organs in the chest. They are made up of tiny air sacs called *alveoli* (singular: alveolus). These sacs are very thin and surrounded by blood vessels. Oxygen enters the blood through the thin walls of the alveoli.



Air enters the body through the nose and mouth. It passes down the *trachea*, or windpipe. The trachea divides into two tubes called *bronchi*, which enter the lungs. The bronchi divide again and again. Each branch ends in an alveolus. Oxygen in the air enters the bloodstream through the alveoli. At the same time, carbon dioxide in the blood is released to the air in the lungs. The air that is exhaled, or breathed out, has more carbon dioxide and less oxygen than the air that was inhaled, or breathed in.

The respiratory system cannot work without the muscles of the body. The diaphragm, a muscle below the lungs, helps the body breathe in and out. The respiratory system is also helped by the circulatory system.

The Circulatory System

The **circulatory system** is the body system that uses blood to carry food and oxygen to the cells of the body. It also carries waste products, such as carbon dioxide, away from the cells. The circulatory system carries chemical messages between different parts of the body. It also distributes substances that help fight diseases.

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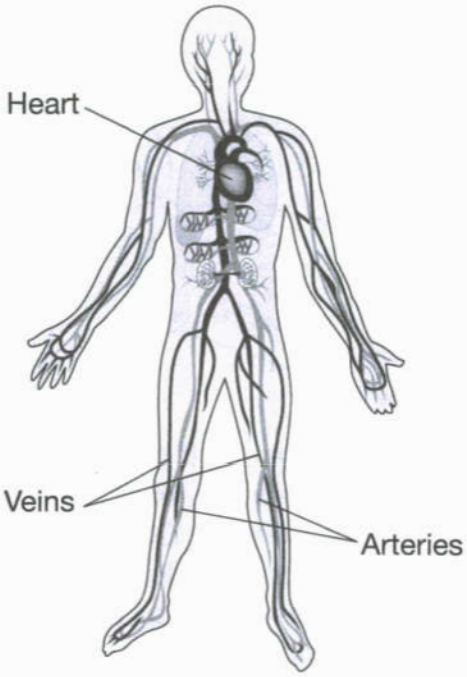
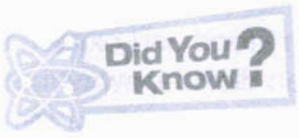
The heart is a muscular organ that contracts to push the blood through the veins and arteries. Arteries and veins are large blood vessels. The arteries carry blood from the heart to the other parts of the body. They branch out into tiny capillaries that exchange substances such as gases and nutrients between the blood cells and the body cells. The veins carry the blood from all parts of the body back to the heart.

Circulatory System



The respiratory and circulatory systems work together to bring oxygen into the body and deliver it to the cells. They also work together to remove carbon dioxide from cells and release it from the body.



Veins look blue because the blood is dark due to low oxygen levels. Arteries look red because the blood is bright red due to high oxygen levels.

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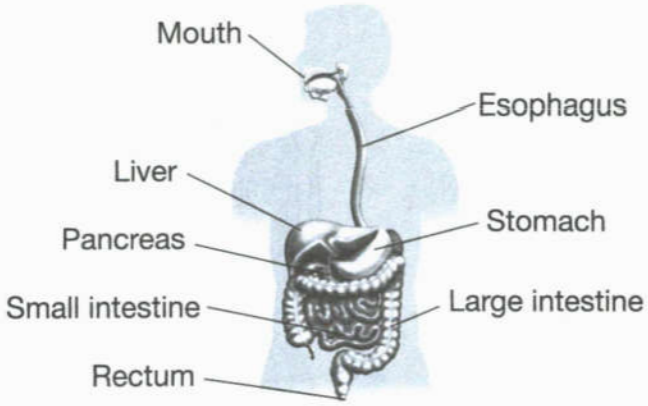
The Digestive System

The **digestive system** breaks food down into substances that the cells can use. The energy stored in the food is passed to the blood and then to all the cells of the body. The digestive system also gets rid of solid wastes from the food.

Digestive System



In the mouth, the teeth and tongue chew the food and move it around. Saliva is added to the food. Saliva contains a substance called an *enzyme* that helps break down food. The food enters the *esophagus*, a muscular tube that is connected to the stomach.

The stomach is a muscular organ that can expand and contract. It expands to hold the food. It contracts and mixes the food again. Strong juices that help break down food are added to the mixture. The food becomes a liquid. This liquid moves into the *small intestine*. Substances from the pancreas and the liver are added to the mixture.

The small intestine absorbs the nutrients from the food. The nutrients are absorbed into the blood vessels lining the small intestine. The blood carries the nutrients to the cells of the entire body. The mixture then moves to the *large intestine*. Here, the water is partly removed from the liquid, and the remaining matter is stored in the *rectum*.

The Excretory System

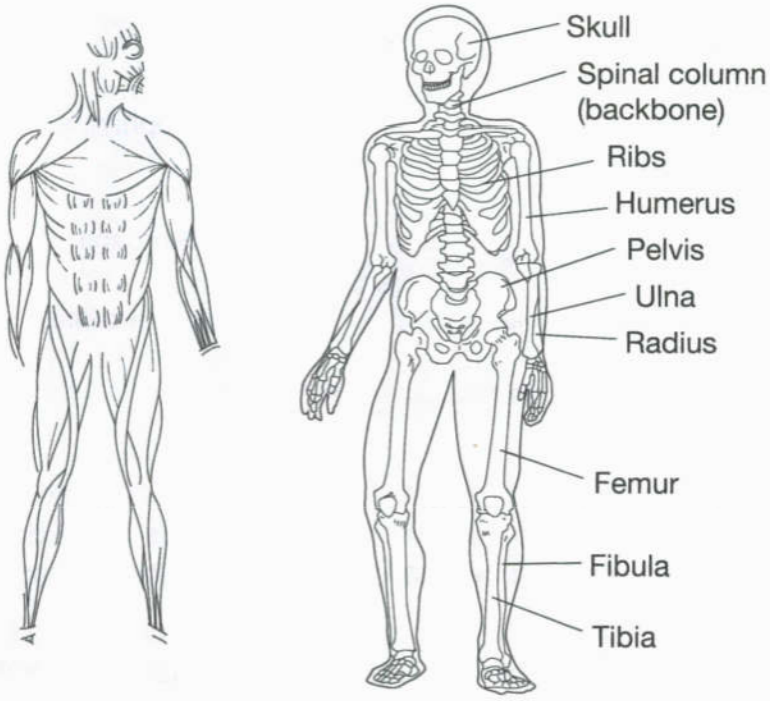
Blood carries nutrients to the cells of the body. It also picks up wastes that have been produced by the cells. The **excretory system** removes those waste products from the blood and releases them from the body. It also controls how much salt and water are in the blood at any time.

The *kidneys* are bean-shaped organs located at the back of the waist. Their job is to filter waste from the blood.

The Musculoskeletal System

The **musculoskeletal system** is made up of two main parts. The *bones* give the body shape and hold it upright. They also cover and protect organs inside the body. The *muscles* move the bones. Our bones and muscles work together to allow us to move.

Musculoskeletal System



Muscles **Bones**

The muscles move the body by pulling on the bones. Muscles contract and relax. When they contract, they tighten and get shorter. When they relax, they get longer. Muscles always work in pairs. One muscle contracts and pulls, while the other muscle relaxes. To move part of the body in the other direction, the second muscle contracts and the first relaxes.

The human body has more than 200 bones. The bones are connected by ligaments at the joints. The ligaments and joints allow the body to change position by bending.

The skull protects the brain and gives the face its shape. The *spinal column*, or backbone, allows a human to stand upright. It also protects the spinal cord, which is a major part of the nervous system. Because the spinal column is made of several smaller bones, humans can bend and twist. The ribs protect internal organs, such as the heart and lungs. The *ulna*, *radius*, and *humerus* are the arm bones. They allow humans to reach and push. The *femur* and *tibia* in the leg allow humans to squat, walk, run, and jump. The *pelvis* connects the legs with the spinal column.

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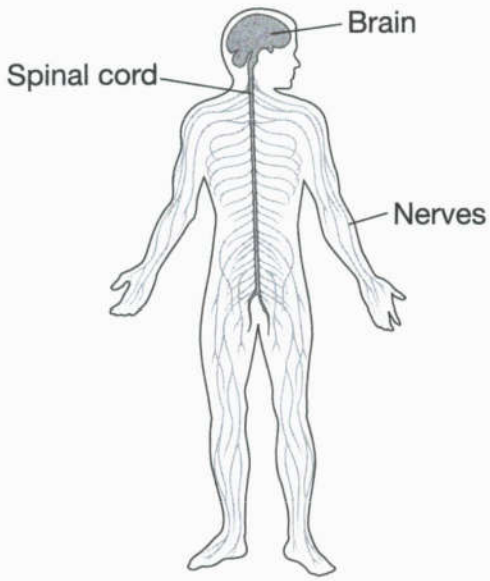
The Nervous System

The **nervous system** is responsible for how the body responds to things it senses. All five senses—sight, hearing, touch, smell, and taste—are part of the nervous system. The ability to respond when you see, touch, hear, smell, or taste something is important for survival.

Nervous System



The *brain* controls most of the body's activities. It receives information and tells the body how to react. The *spinal cord* runs through the bones of the spinal column. This is the main pathway for messages between the brain and the rest of the body. *Nerves* receive messages from inside or outside the body. A message is sent out to the next nerve, which passes it to another nerve, and so on. Soon the message reaches the brain, which makes sense of it.

The Reproductive System

The **reproductive system** is responsible for producing more organisms. In the human body, the reproductive system is used to make more humans.

The *glands* in the body release substances that take messages to the reproductive organs. These chemical messages are called *hormones*. These hormones act like a switch for the adult reproductive system. Although the hormones are released into the blood and carried throughout the body, only the organ the message is addressed to will react to it. A hormone is like a secret message that only one type of cell will understand.

The Immune System

The **immune system** helps prevent and fight against disease. Several kinds of tissue are part of the immune system. These tissues are found throughout the body.

Bone marrow, found inside the bones, makes *white blood cells*. These cells travel in the bloodstream. Some white blood cells make *antibodies* to fight disease. Other white blood cells attack organisms that cause disease. You will read more about these organisms in the next lesson. The *spleen* is an organ that also makes antibodies. Most of the body contains *lymph nodes* that filter body fluids, removing cells that cause disease. The skin is also part of the immune system. It keeps harmful organisms out of the body.

Homeostasis

The organ systems work together to keep the body in a state of internal balance. Recall that the ability of living things to maintain a balanced internal environment is called **homeostasis**. The word means "steady state," but homeostasis is not unchanging. Instead, it is constantly shifting as the environment changes.

The body makes changes to keep things balanced. The body often responds to a change by reversing the change. For example, the nervous system checks the amount of carbon dioxide in the blood. Suppose the nervous system senses that the amount of carbon dioxide is increasing. The nervous system tells the muscles that control breathing to breathe faster. Then, as the breathing rate increases, the amount of carbon dioxide decreases. When the level is low again, the nervous system tells the muscles to breathe more slowly.

Discussion Question

When you are hungry, how do organ systems interact so you can eat and your body can use the food? Describe what happens.

Lesson Review

1. Which organ system breaks down food for the body to use?

   A. reproductive system

   B. excretory system

   C. digestive system

   D. musculoskeletal system

2. Which is **not** a job of the musculoskeletal system?

   A. helping the body move

   B. sending messages throughout the body

   C. protecting organs inside the body

   D. giving the body shape

3. The spinal cord is a part of which organ system?

   A. digestive system

   B. immune system

   C. reproductive system

   D. nervous system

4. What happens as a result of homeostasis?

   A. The body keeps its internal balance.

   B. The body balances on one foot.

   C. The digestive system and the excretory system work separately.

   D. Humans produce other humans.