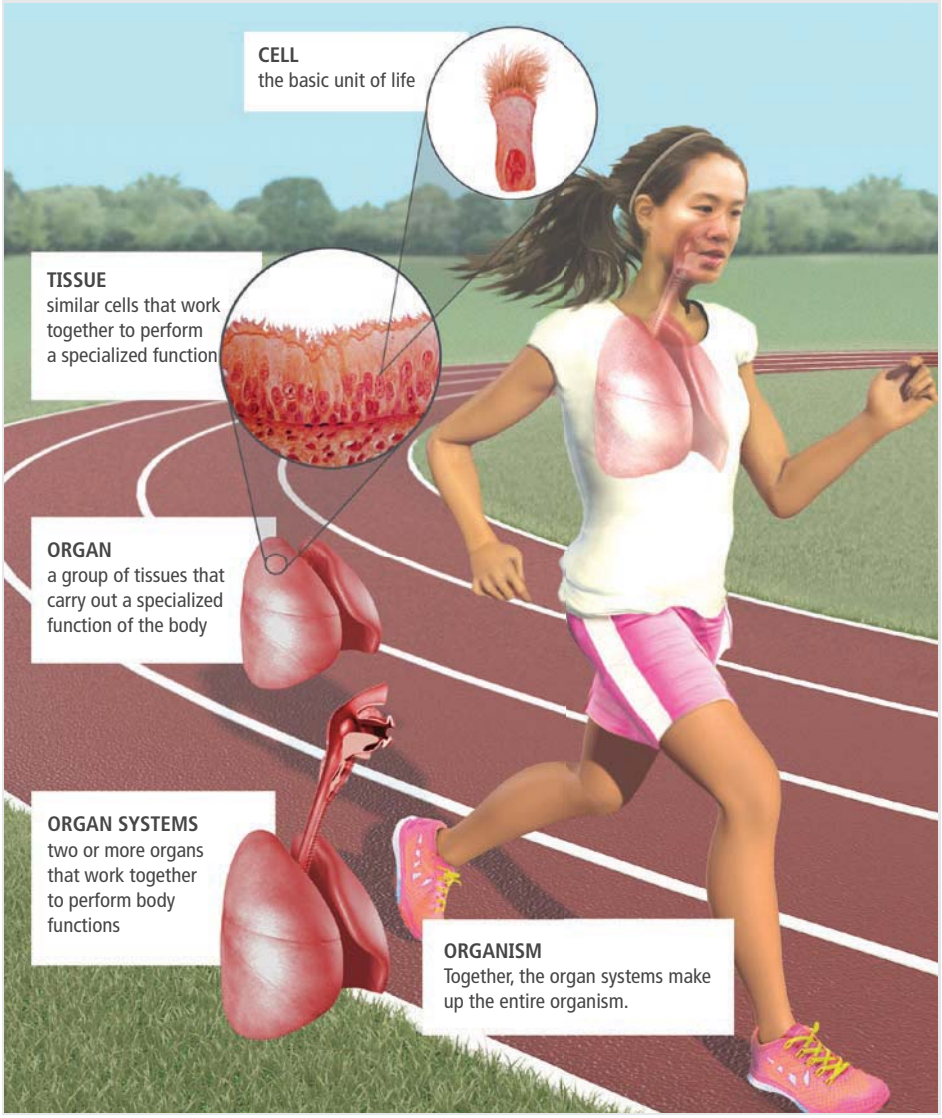
Interacting Systems in Organisms

Over the course of a day, you complete many different tasks. Whether you are eating, sleeping, or talking to a friend, systems within your body are interacting at different levels. Scientists organize multicelluar organisms into five basic levels beginning with cells and moving to increasingly complex structures. These five levels of organization are shown in the human respiratory system in Figure 2.

A tissue is a group of similar cells that work together to carry out a specific function. For example, cells in the epithelial tissue of your lungs have tiny hair-like extensions called cilia. Together, these ciliated cells act like a conveyer belt to sweep foreign particles and pathogens out of the lungs. Groups of tissues form organs such as the lungs, sinuses, and nose. Each of these organs has a specialized function in the body. Multiple organs interact to carry out whole-body functions. In the respiratory system, the nose and sinuses filter, moisten, and warm the air before it enters the lungs.

FIGURE 2: Multicellular organisms have a hierarchical structural organization. Each system, such as the respiratory system, is made up of interacting components.



Collaborate Describe a task you perform each day that requires different systems within your body to interact.

Analyze How do structures in the respiratory system interact to protect the lungs? How might a sinus infection affect the rest of the respiratory system?

Organ Systems

An organ system is two or more organs that work together to perform body functions. Organ systems interact to help the organism maintain internal stability, or homeostasis. For example, the muscular system interacts with the circulatory system to help pump your blood and deliver oxygen and nutrients to cells. Some of the components and functions of organ systems in the human body are shown in Figure 3.

FIGURE 3: Organ Systems in the Human Body

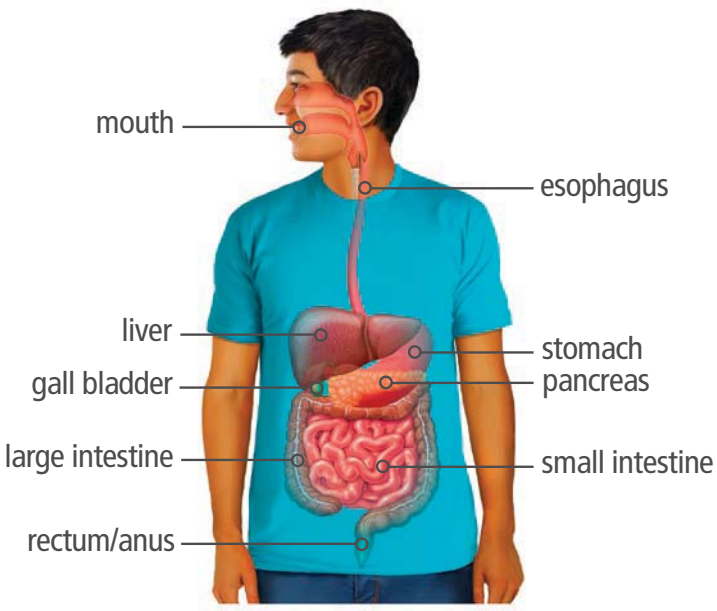
System	Organs and Other Components	Primary Functions
Circulatory	heart, blood vessels, blood, lymph nodes, lymphatic vessels	transports oxygen, nutrients, hormones, and wastes; helps regulate body temperature; collects fluid lost from blood vessels and returns it to the circulatory system
Digestive	mouth, pharynx, esophagus, stomach, small and large intestines, pancreas, gall bladder, liver	breaks down and absorbs nutrients, salts, and water; transfers digested materials to the blood; eliminates some wastes
Endocrine	hypothalamus, pituitary, thyroid, parathyroids, adrenal glands, pancreas, ovaries, testes	produces hormones that act on target tissues in other organs to influence growth, development, and metabolism; helps maintain homeostasis
Excretory	skin, kidneys, bladder	filters blood and eliminates waste products; helps maintain homeostasis
Immune	white blood cells, thymus, spleen	protects against disease; stores and generates white blood cells
Integumentary	skin, hair, nails, sweat and oil glands	protects against infection, UV radiation; regulates body temperature
Muscular	skeletal, smooth and cardiac muscles	produces voluntary and involuntary movements; helps to circulate blood and move food through the digestive system
Nervous	brain, spinal cord, peripheral nerves	regulates body's response to changes in internal and external environment; processes information
Reproductive	*male*: testes, penis, associated ducts and glands *female*: ovaries, fallopian tubes, uterus, vagina	produces and transports reproductive cells; provides the environment for embryonic development in females
Respiratory	nose, nasal cavity, pharynx, trachea, lungs	brings in oxygen for cells, expels carbon dioxide and water vapor
Skeletal	bones, cartilage, ligaments, tendons	supports and protects vital organs; allows movement; stores minerals; bone marrow is site of red blood cell production

Analyze Many organ systems interact with the circulatory system. If a person's circulatory system did not function properly, how might other systems, such as the respiratory and digestive systems, be affected? How would homeostasis, or internal stabilty, be affected by these system imbalances?

Organs

Organ systems can carry out complex functions, because they are made up of organs that work together within the system. An organ is a group of tissues that carry out a specialized function of the body. Figure 4 shows the organs in the digestive system.

FIGURE 4: Organs are components that make up a body system, such as the digestive system. In general, an organ system is made up of organs specific to the function of that system.



The digestive system is a collection of organs that breaks down food into nutrients and energy that can be used by cells. When you eat, the mouth breaks down food mechanically by chewing, and proteins called enzymes in your saliva break down food chemically. Muscles in the esophagus contract to move the chewed food to the stomach. The stomach then uses both mechanical and chemical digestion to break down food into nutrient components that the body absorbs and uses. As muscles in the stomach churn food, it continues to be broken down by gastric juice, which consists of mucus, enzymes, and acid.

The partly digested food passes into the small intestine, where additional digestion takes place. Organs such as the liver and pancreas secrete chemicals into the upper small intestine. These chemicals break food particles into individual nutrients, which are absorbed through the walls of the small intestine and pass into the blood. Any food that remains undigested passes into the large intestine where excess water is absorbed before the solid waste is excreted from the body.

Systems and System Models Make a simple flow chart to illustrate how the organs of the digestive system interact to help you digest food.

Explore Online

Hands-On Lab

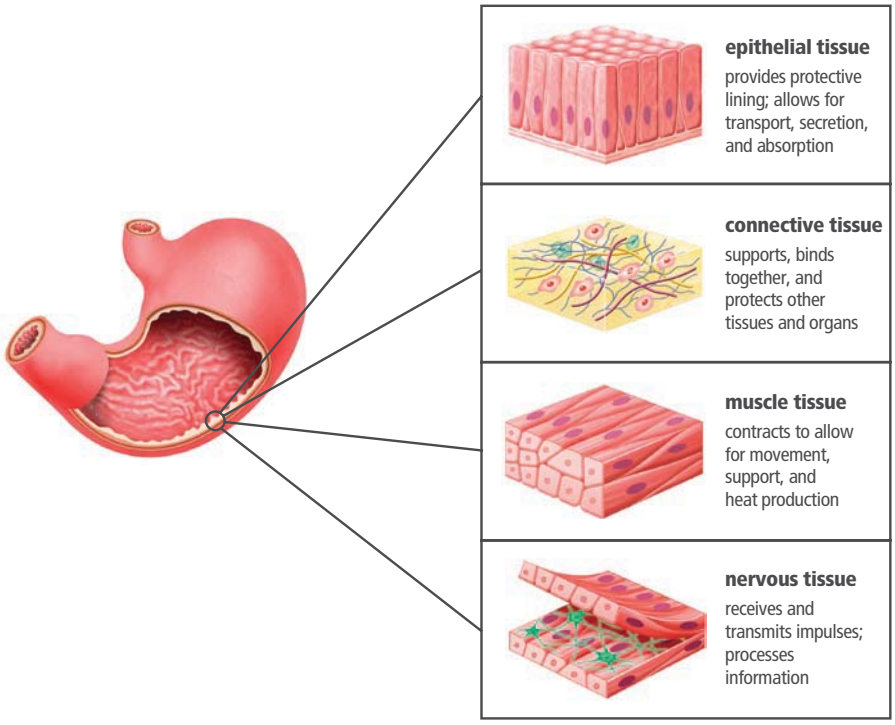
Connecting Form to Function Examine a slice of the roots, stems, and leaves of a plant to explain how their structures relate to their functions.

Predict How might the digestive system and the immune system interact to help protect the body?

Tissues

For an organ such as the stomach to carry out its function of breaking down food, different tissues must work together. A tissue is a group of similar cells that work together to perform a specialized function, usually as part of an organ. In the human body, organs are made up of four general types of tissues—epithelial, connective, muscle, and nervous tissue.

FIGURE 5: Organs such as the stomach are made up of four main types of tissues.



Gather Evidence A tendon is a band of tissue that attaches a muscle to another body part such as a bone. Which type of tissue would tendons most likely contain?

Tissues in the stomach help it carry out its function in the body. Signals from nervous tissue stimulate muscle tissue in the stomach to contract. The walls of the stomach contain three layers of muscle tissue that contract about every 20 seconds. The muscle tissue in the stomach contracts involuntarily, without you having to think about it. The epithelial lining of the stomach is made up of cells that secrete stomach acid and absorb nutrients. The type of epithelial tissue that lines the stomach has column-shaped cells. This type of tissue provides a large amount of surface area for absorption and secretion.

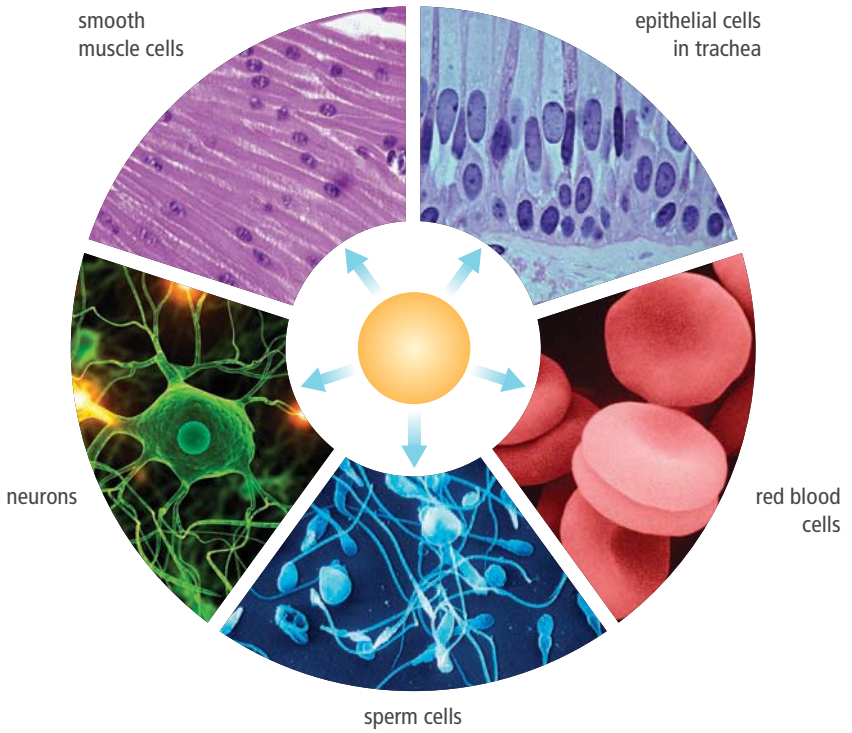
Connective tissue provides support and protection for structures in the body. Some types of connective tissue are fibrous and tough. Other types, such as loose connective tissue, provide support to internal organs and the surrounding blood vessels. The connective tissue that surrounds blood vessels has the property of elasticity. This is important, because as blood pumps through the circulatory system, the vessels within this system must stretch to accommodate blood flow.

Analyze How does nervous tissue interact with muscular tissue in the stomach to break down food? Why is it important for the nervous and digestive systems to work together?

Cells and Cell Differentiation

Humans, like other multicellular organisms, are collections of specialized cells that work together. A cell is the most basic unit of life. The cells that make up an organism arise from a single cell that goes through successive divisions to make new cells. Cell differentiation is the process by which cells become specialized in structure and function.

FIGURE 6: All cells in a multicellular organism arise from a single cell. As the organism develops, cells take on unique structures that help them carry out specialized functions.



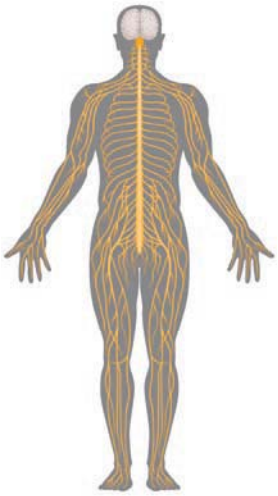
The specialization enabled by differentiation is what allows different types of cells to have different functions. For example, sperm cells have a long tail called a flagellum that allows for movement. Some epithelial cells in the trachea have hair-like extensions called cilia. These structures provide a sweeping motion that helps clear small particles out of the trachea. Neurons have extensions that allow the cell to communicate with many other cells. This allows for the formation of complex, interconnected networks of neurons, such as those in the human brain. Your brain contains billions of neurons with trillions of connections. This allows for communication between the cells of your body, as well as higher functions such as memory and learning.

Language Arts Connection Red blood cells carry oxygen and nutrients to cells. To carry out their function, these cells must bind oxygen and travel through small blood vessels in the circulatory system called capillaries. Capillaries are so narrow that red blood cells must move through them "single file." Write an explanation for how the structure of red blood cells allows them to carry out their function.

Engineering

Nanobots are microscopic robots built on the scale of a nanometer. Engineers are designing nanobots that can help deliver medicine, move through the bloodstream to hard-to-reach areas, and even destory cancer cells. Research a type of nanobot currently under development. How did the purpose of the nanobot affect its design? List some structural features the design has or could have to complete its purpose.

FIGURE 7: The nervous system is made up of the brain, spinal cord, and nerves.



Neurons

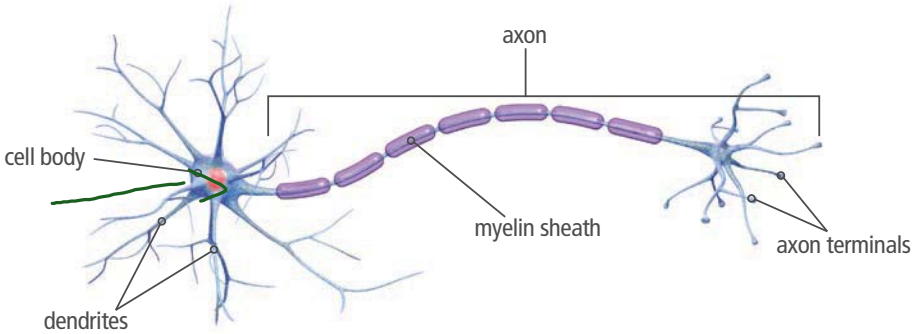
The nervous system is a network of nerves and sensory organs that work together to process information and respond to the environment. The basic unit of the nervous system is the neuron. Neurons are specialized cells that are able to send electrical and chemical signals to help the organism sense information, coordinate a response, and carry out that response.

Humans and other organisms have three types of neurons: sensory neurons, interneurons, and motor neurons. Sensory neurons detect stimuli and send signals to the brain and the spinal cord. Interneurons in the brain and spinal cord receive and process the information from the sensory neurons and send response signals to motor neurons. Motor neurons act on the signal by stimulating muscles to contract.

Systems and System Models Draw a flow chart illustrating how the three types of neurons would interact to help a person pick up an object.

Most neurons have three main parts: the cell body, one or more dendrites, and an axon, shown in Figure 8. The short, branchlike extensions that extend from the cell body are called dendrites. Dendrites receive electrochemical messages from other cells. The axon is a long extension of the cell that carries electrochemical signals away from the cell body and passes them to other cells. The branched endings of the axon are specialized to transmit electrochemical signals to other cells.

FIGURE 8: The neuron is a specialized cell within the nervous system.



Just as most electric wires are wrapped in an insulating material, many axons are wrapped in a protective covering called a myelin sheath. This covering is formed from a collection of cells that are wrapped around the axon. The myelin sheath protects the axon and helps speed transmission of nerve impulses.

Analyze Diseases such as multiple sclerosis cause the myelin sheath to break down. How would the breakdown of myelin affect the functioning of a neuron?

The nervous system interacts with all the other systems in the body. For example, when you eat, your brain signals your digestive system to start making chemicals and churning your food. Neurons also stimulate muscle tissue in the digestive system to contract, which helps the digestive system move and break down food.

Muscle Cells

Muscles consist of bundles of muscle cells that contract when they are stimulated by the nervous system. A contraction shortens the muscle, causing the bone or tissue to which the muscle is attached to move. Some muscles, such as those in Figure 9, are under voluntary control, so you can choose to move this type of muscle tissue. This type of muscle is called skeletal muscle. Some muscles are under involuntary control, meaning they move in response to nerve signals or hormones, but you do not choose to move them. Smooth muscle in internal organs and cardiac muscle in the heart are under involuntary control.

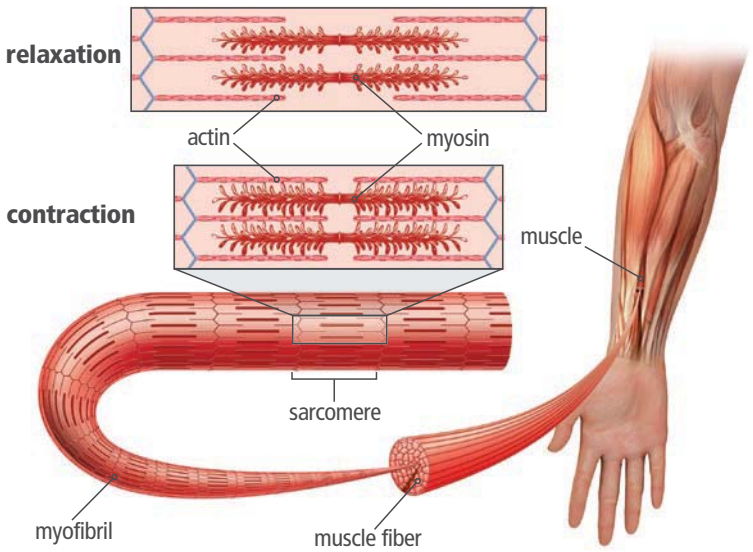
Collaborate With a partner, describe an activity that would require muscles that are under voluntary control and another activity that would require muscles that are under involuntary control.

The specialized structure of muscle cells allows them to contract. Skeletal muscles are made up of long cylindrical bundles that contain muscle fibers. Muscle fibers are bundles of single, thin muscle cells called myofibrils. Each myofibril is made up of several sarcomeres. A sarcomere is the contractile unit of the muscle cell. Sarcomeres contain thin filaments made of actin and thick filaments made of myosin. When a muscle cell is relaxed, actin and myosin are not connected to each other. In contraction, the myosin attaches to the actin and pulls the actin toward the center of the sarcomere. This in turn shortens the sarcomere, and the muscle cell contracts. The contraction of many muscle cells at once shortens the entire muscle.

FIGURE 9: Skeletal Muscles

FIGURE 10: Actin and myosin work together to help a muscle move. During contraction, myosin filaments pull actin filaments toward the center of the sarcomere.

Explore Online



Explain How does the structure of the muscle cell help it carry out its function?

Model Construct a model to illustrate how the nervous and digestive systems might interact to produce the sensation of "butterflies in your stomach." Which organs are most likely involved, and how do they interact when you have this feeling?