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Human Physiology 110: Overview of the Human Body

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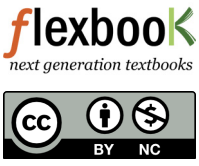

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Contents

CONCEPT 1 Organization of the Human Body

- Outline the levels of organization of the human body.
- Distinguish between cells, tissues, organs, and organ systems.
- List the types of tissues in the human body.
- Give examples of the roles of organ systems.

How is the human body similar to a well-tuned machine?

Many people have compared the human body to a machine. Think about some common machines, such as drills and washing machines. Each machine consists of many parts, and each part does a specific job, yet all the parts work together to perform an overall function. The human body is like a machine in all these ways. In fact, it may be the most fantastic machine on Earth.

The human machine is organized at different levels, starting with the cell and ending with the entire organism (see **Figure** 1.1). At each higher level of organization, there is a greater degree of complexity.

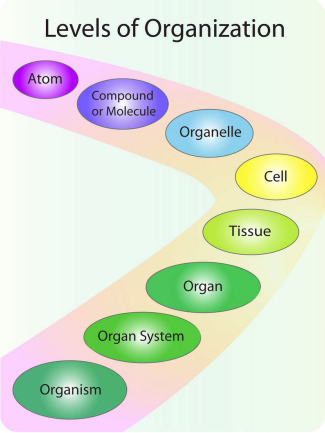
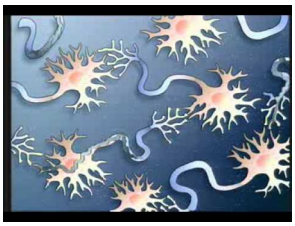


FIGURE 1.1

The human organism has several levels of organization.

Cells

The most basic parts of the human machine are cells—an amazing 100 trillion of them by the time the average person reaches adulthood! **Cells** are the basic units of structure and function in the human body, as they are in all living things. Each cell carries out basic life processes that allow the body to survive. Many human cells are specialized in form and function, as shown in **Figure** 2.1. Each type of cell in the figure plays a specific role. For example, nerve cells have long projections that help them carry electrical messages to other cells. Muscle cells have many mitochondria that provide the energy they need to move the body.



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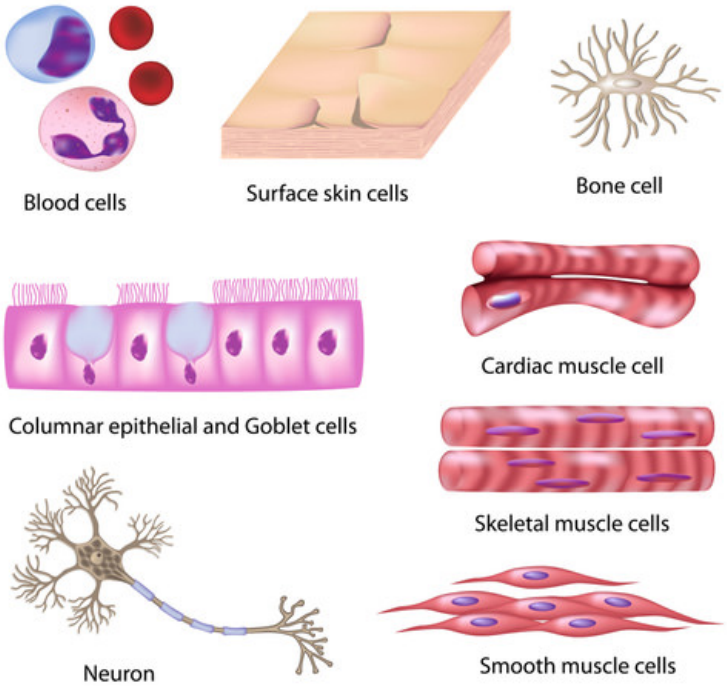


FIGURE 1.2

Different types of cells in the human body are specialized for specific jobs. Do you know the functions of any of the cell types shown here?

Tissues

After the cell, the tissue is the next level of organization in the human body. A **tissue** is a group of connected cells that have a similar function. There are four basic types of human tissues: epithelial, muscle, nervous, and connective tissues. These four tissue types, which are shown in **Figure** 3.1, make up all the organs of the human body.

- **Connective tissue** is made up of cells that form the body's structure. Examples include bone and cartilage.
- **Epithelial tissue** is made up of cells that line inner and outer body surfaces, such as the skin and the lining of the digestive tract. Epithelial tissue protects the body and its internal organs, secretes substances such as hormones, and absorbs substances such as nutrients.
- **Muscle tissue** is made up of cells that have the unique ability to contract, or become shorter. Muscles attached to bones enable the body to move.
- **Nervous tissue** is made up of **neurons**, or nerve cells, that carry electrical messages. Nervous tissue makes up the brain and the nerves that connect the brain to all parts of the body.

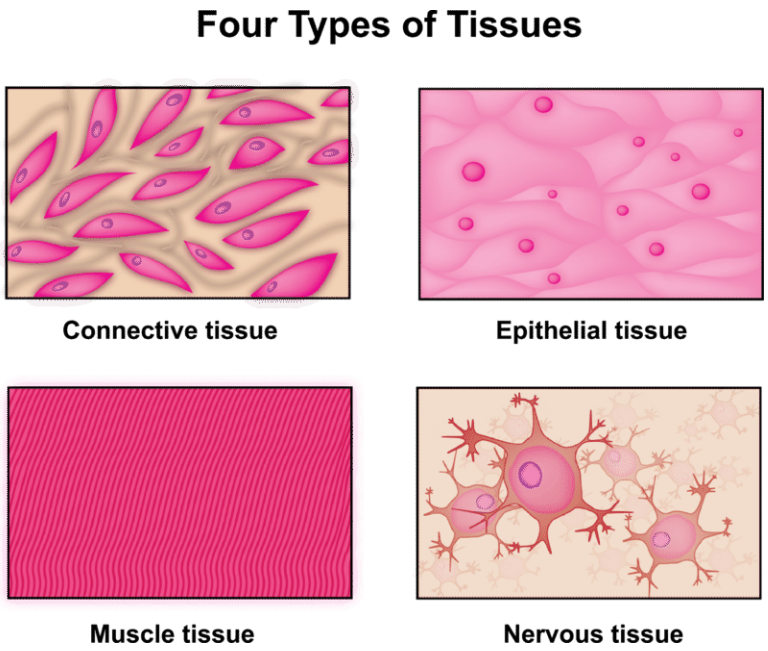


FIGURE 1.3
The human body consists of these four tissue types.

Organs and Organ Systems

After tissues, organs are the next level of organization of the human body. An **organ** is a structure that consists of two or more types of tissues that work together to do the same job. Examples of human organs include the brain, heart, lungs, skin, and kidneys. Human organs are organized into organ systems, many of which are shown in **Figure** 1.4. An **organ system** is a group of organs that work together to carry out a complex overall function. Each organ of the system does part of the larger job.

Your body's 12 organ systems are shown below (**Table** 1.1). Your organ systems do not work alone in your body. They must all be able to work together. For example, one of the most important functions of organ systems is to provide cells with oxygen and nutrients and to remove toxic waste products such as carbon dioxide. A number of organ systems, including the cardiovascular and respiratory systems, all work together to do this.

TABLE 1.1: Major Organ Systems of the Human Body

Organ System	Major Tissues and Organs	Function
Cardiovascular	Heart; blood vessels; blood	Transports oxygen, hormones, and nutrients to the body cells. Moves wastes and carbon dioxide away from cells.
Lymphatic	Lymph nodes; lymph vessels	Defend against infection and disease, moves lymph between tissues and the blood stream.
Digestive	Esophagus; stomach; small intestine; large intestine	Digests foods and absorbs nutrients, minerals, vitamins, and water.
Endocrine	Pituitary gland, hypothalamus; adrenal glands; ovaries; testes	Produces **hormones** that communicate between cells.

TABLE 1.1: (continued)

Organ System	Major Tissues and Organs	Function
Integumentary	Skin, hair, nails	Provides protection from injury and water loss, physical defense against infection by microorganisms, and temperature control.
Muscular	Cardiac (heart) muscle; skeletal muscle; smooth muscle; tendons	Involved in movement and heat production.
Nervous	Brain, spinal cord; nerves	Collects, transfers, and processes information.
Reproductive	Female: uterus; vagina; fallopian tubes; ovaries Male: penis; testes; seminal vesicles	Produces gametes (sex cells) and sex hormones.
Respiratory	Trachea, larynx, pharynx, lungs	Brings air to sites where gas exchange can occur between the blood and cells (around body) or blood and air (lungs).
Skeletal	Bones, cartilage; ligaments	Supports and protects soft tissues of body; produces blood cells; stores minerals.
Urinary	Kidneys; urinary bladder	Removes extra water, salts, and waste products from blood and body; controls pH; controls water and salt balance.
Immune	Bone marrow; spleen; white blood cells	Defends against diseases.

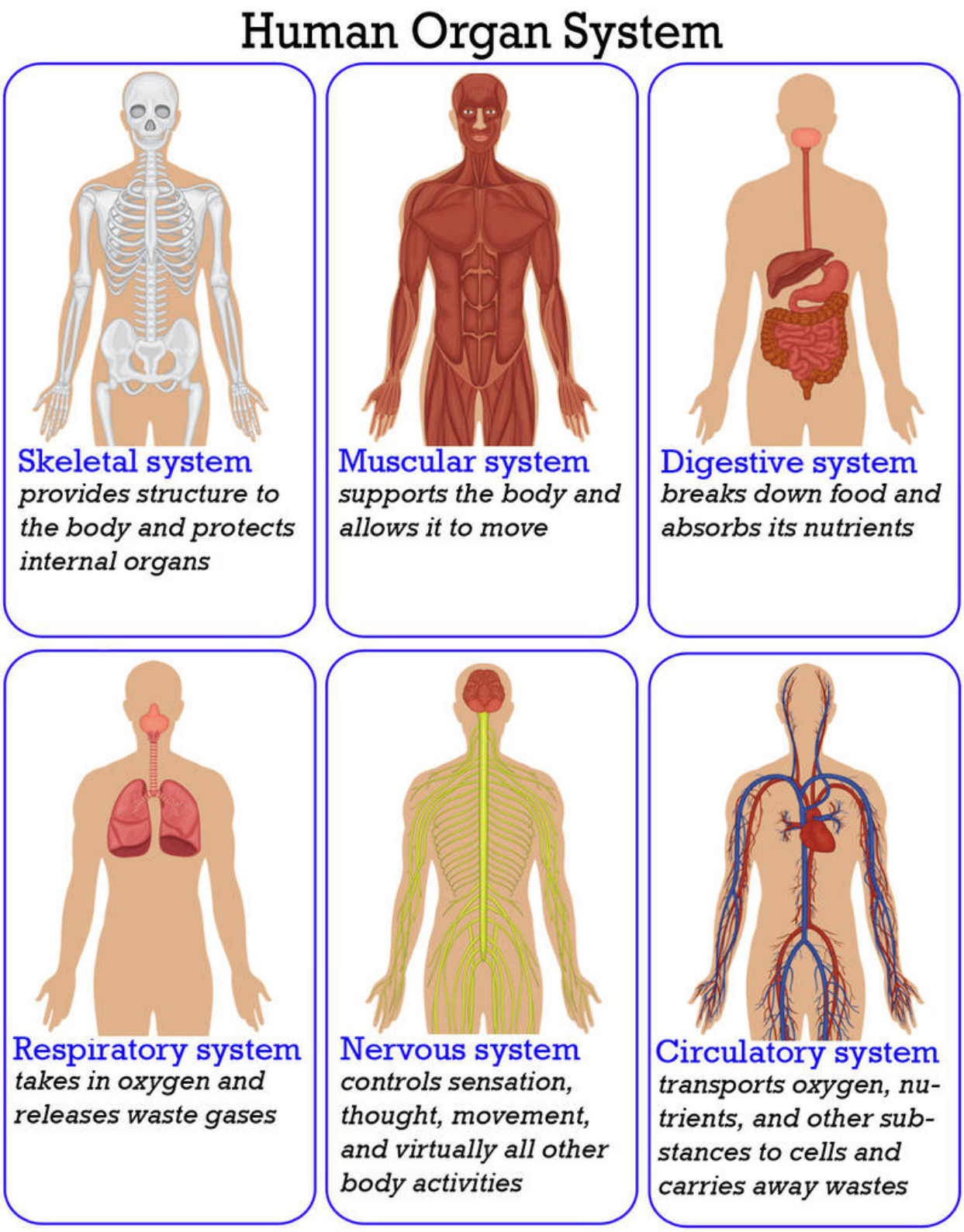


FIGURE 1.4

Many of the organ systems that make up the human body are represented here. What is the overall function of each organ system?

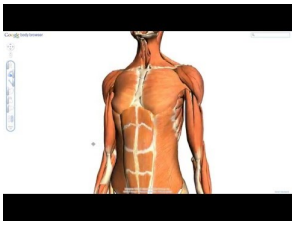
Summary

- The human body is organized at different levels, starting with the cell.
- Cells are organized into tissues, and tissues form organs.
- Organs are organized into organ systems such as the skeletal and muscular systems.

Review

1. What are the levels of organization of the human body?
2. Which type of tissue covers the surface of the body?
3. What are the functions of the skeletal system?
4. Which organ system supports the body and allows it to move?
5. Explain how form and function are related in human cells. Include examples.
6. Compare and contrast epithelial and muscle tissues.

Resources



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References

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3. Zachary Wilson. An illustration of the four tissue types found in the human body . CC BY-NC 3.0
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CONCEPT 2 Cells of the Human Body

- Outline the role of a specialized cell.
- Understand the difference between cells and stem cells.
- Understand the process of cell differentiation, and determine which types of cells undergo differentiation.
- List three types of stem cells.

How is the human body similar to a well-tuned machine?

Over and over, the human body is compared to a complex piece of machinery. Like any common machine, the human body is composed of a variety of parts, each working separately, but also working together.

Cells

Cells are the most basic units of life in your body, and each cell is specialized, with a specific function. Nerve cells transmit electrical messages around the body, and white blood cells attack invading bacteria throughout the body. Other cells include specialized cells in the kidney (such as kidney glomerulus parietal cells), brain (such as astrocytes), stomach (such as parietal cells), and muscles (such as red and white skeletal muscle fibers). Cells group together to form tissues; different tissues work together to form organs. This grouping of cells and tissues is referred to as levels of organization. Complex multicellular organisms, which include flatworms and humans, have different levels of organization. The human body's levels begin with cells and conclude with the entire organism. Flatworms, though they lack specialized circulatory and respiratory systems, also have levels of organization ranging from cells to the entire organism.

Differentiation

Every cell in the body originates from a single fertilized egg called a zygote. The zygote divides repeatedly to produce an embryo. These embryonic cells continue to divide, differentiating into all the cell types present in the body of all humans (and other mammals), from a new-born baby to an elderly adult. **Differentiation** is the process by which an unspecialized cell, such as a fertilized egg cell, divides many times to produce specialized cells. During differentiation, certain genes are turned on, or become activated, while other genes are switched off, becoming inactivated. This process is regulated by the cell. A differentiated cell will develop specific structures and perform certain functions.

A cell that is able to differentiate into all cell types within a body is called **totipotent.** They have "total potential" to differentiate into any cell type. In mammals, only the zygote and early embryonic cells are totipotent. A cell that is able to differentiate into many, but not all, cell types is called **pluripotent.** Such cells have "plural potential" (but not "total potential") to differentiate into *most* cell types. **Figure** 2.2 gives a visual representation of cell differentiation.

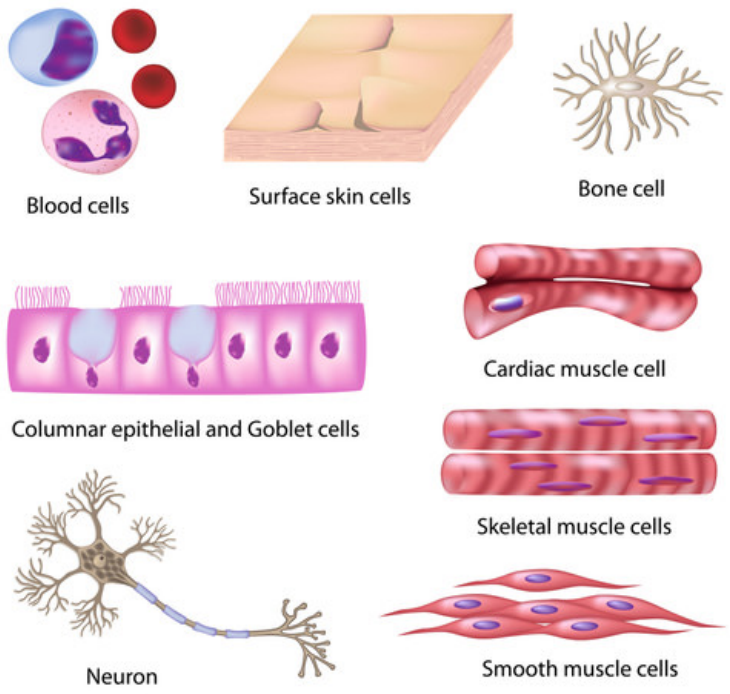

FIGURE 2.1

Different types of cells in the human body are specialized for specific jobs. Do you know the functions of any of the cell types shown here?

Stem Cells

An unspecialized cell that can divide and give rise to different specialized cells is called a **stem cell** (**Figure** 2.2). Zygotes and embryonic cells are both types of stem cells. These stem cells, called **embryonic stem cells,** can divide indefinitely and can specialize into any cell type. They are totipotent. In contrast, **adult stem cells,** also known as somatic stem cells, are undifferentiated cells found within the body that divide to replace dying cells and damaged tissues. Adult stem cells can divide indefinitely and generate all the cell types of the organ from which they originate. They can potentially re-grow the entire organ from just a few cells. A third type of stem cell is found in both the blood from the umbilical cord of a new-born baby and the placenta. These "cord blood stem cells" are considered to be adult stem cells because they cannot generate all body cell types, just different types of blood cells. Adult stem cells and cord blood stem cells are pluripotent.

Stem Cells in Medicine

Stem cells are of great interest to researchers because of their ability to both divide indefinitely and differentiate into many cell types. Stem cells have many existing and even more potential therapeutic applications. Such therapies include treatments for cancer, blood disorders, brain or spinal cord injuries, and blindness.

Embryonic stem cells, shown in **Figure** 2.3, are taken from eggs that were donated to research and fertilized in the laboratory. These stem cells may have the greatest potential because they are totipotent and thus have the most potential medical applications. However, embryonic stem cells are relatively controversial. Some individuals and groups have objections to the harvesting of embryonic stem cells because harvesting the stem cells involves the destruction of the embryo. Some researchers are looking into methods of extracting embryonic stem cells without destroying the actual embryo. Other researchers have claimed success in harvesting embryonic stem cells from the embryonic fluid that surrounds a growing fetus. Additionally, stem cells harvested from a donated embryo differ from a potential patient's tissue type. Therefore, just as in organ transplantation, there is a risk that the patient's body may reject the transplanted embryonic stem cells.

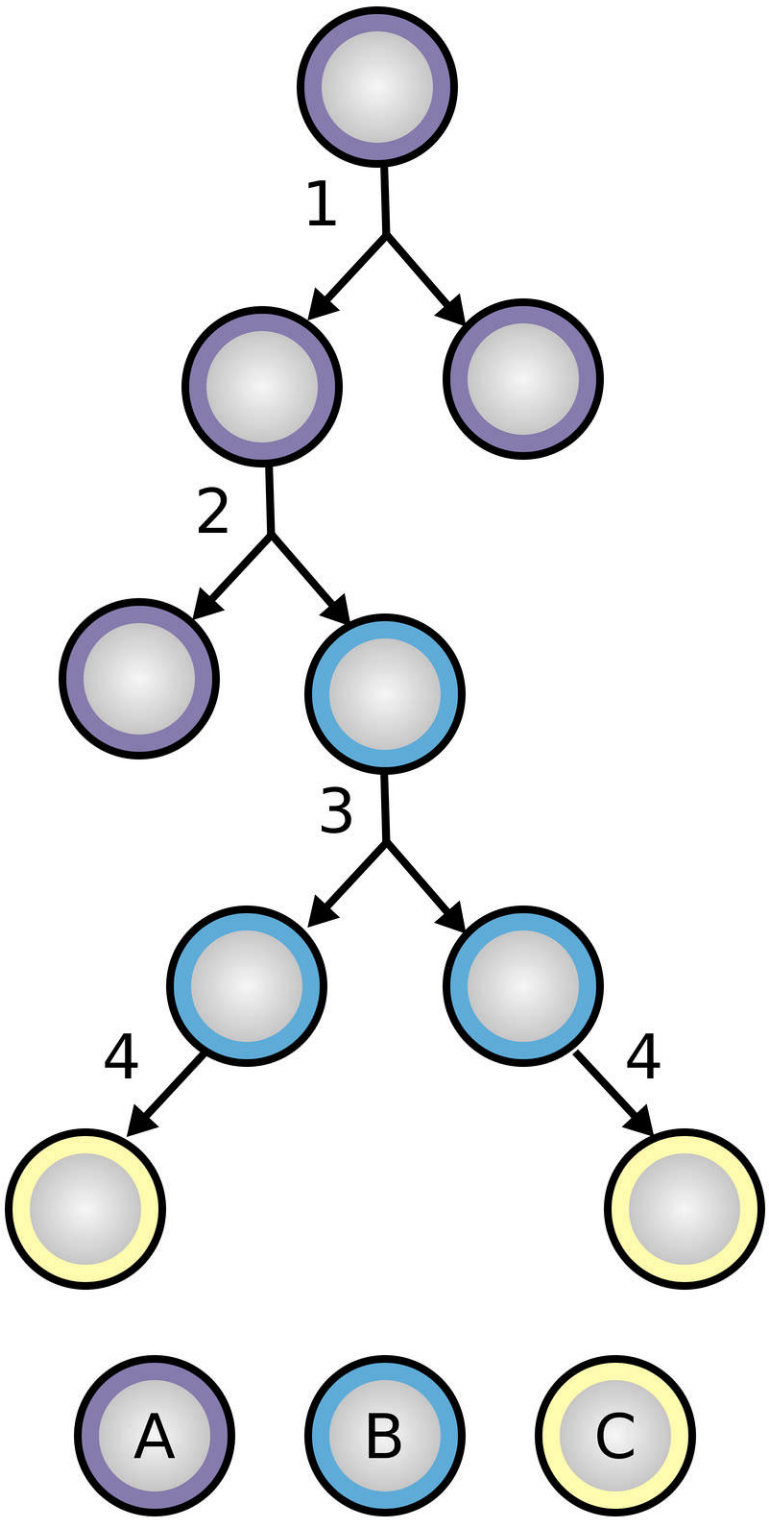

FIGURE 2.2

Division and differentiation of stem cells into specialized cells.

Adult stem cells, including cord blood stem cells, have already been used to treat diseases of the blood such as sickle-cell anemia and certain types of cancer. Unlike embryonic stem cells, the use of adult stem cells in research and therapy is not controversial because the production of adult stem cells does not require the destruction of an embryo. Adult stem cells can be isolated from tissue samples, such as bone marrow, of a patient. Scientists have

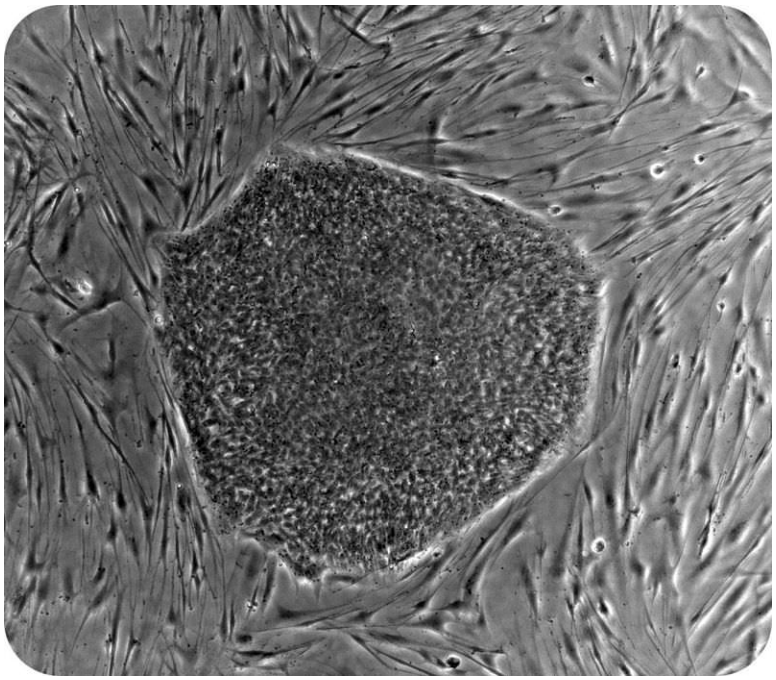

FIGURE 2.3

A human embryonic stem cell colony, which was grown in a laboratory on a feeder layer of mouse cells.

recently discovered more sources of adult stem cells in the body including in body fat, the inside lining of the nose, and the brain. Some researchers are investigating ways to revert adult stem cells back to a totipotent stage.

Summary

- Cells are the most basic units of life found in the human body and any living organism.
- Stem cells undergo the process of differentiation to become specialized cells.

Review

1. What are totipotent and pluripotent cells?
2. What are stem cells? Where do they come from?

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Use the video above to answer the following questions:

1. When did scientists first understand the idea of differentiation?
2. What changes in a totipotent cell to make it specialize?
3. Can a blood stem cell become a muscle, brain, and/or liver cell?

References

1. Image copyright Alila Sao Mai, 2011. http://www.shutterstock.com . Used under license from Shutterstock.com
2. Wykis. http://en.wikipedia.org/wiki/Image:Stem_cell_division_and_differentiation.svg . Public Domain
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CONCEPT 3 Tissues of the Human Body

- Identify the four tissue types found in the human body.

Muscle, connective, skeletal, and epithelial. What do these have in common?

Tissues

A **tissue** is a group of connected cells that have a similar function within an organism. The simplest living, multicellular organisms, sponges, are made of many specialized types of cells that work together for a common goal. Such cell types include digestive cells, tubular pore cells, and epidermal cells. Though the different cell types create a large organized, multicellular structure—the visible sponge—they are not organized into true tissues. If a sponge is broken up by passing it through a sieve, the sponge will reform on the other side.

More complex organisms, such as jellyfish, coral, and sea anemones, have a tissue level of organization. For example, jellyfish have tissues that have separate protective, digestive, and sensory functions. There are four basic types of tissues in the bodies of all animals including the human body. These make up all the organs, structures, and other contents of the body. **Figure** 3.2 shows an example of each tissue type. The four basic types of tissues are epithelial, muscle, nervous, and connective.

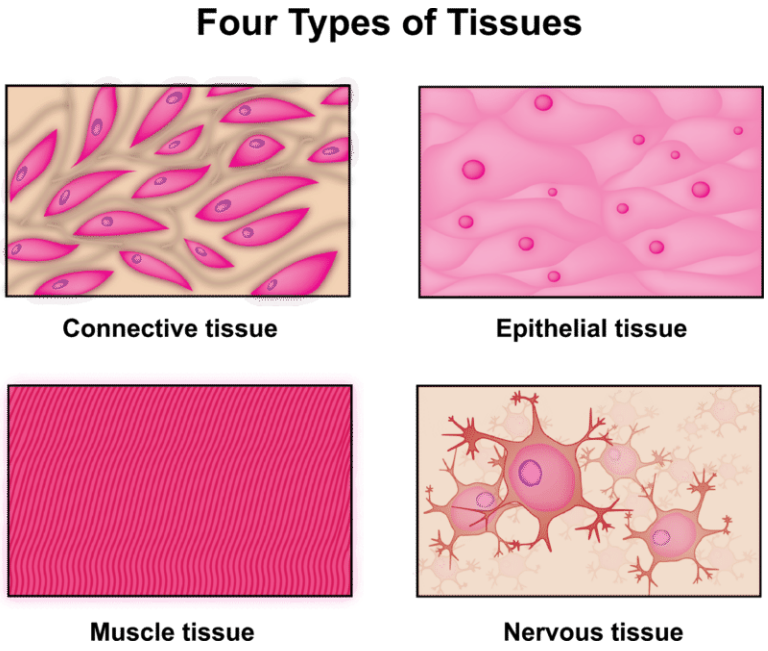

FIGURE 3.1

The human body consists of these four tissue types.

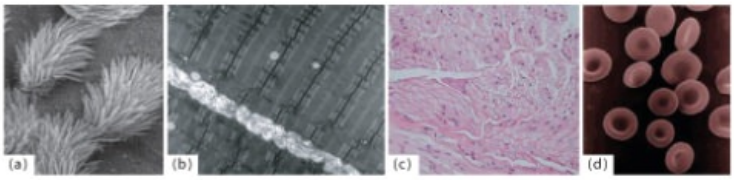

FIGURE 3.2

(a) A scanning electron micrograph (SEM) image of lung trachea epithelial tissue. (b) A transmission electron micrograph (TEM) image of skeletal muscle tissue. (c) A light microscope image of neurons of nervous tissue. (d) Red blood cells, a connective tissue.

Epithelial tissue is made up of a layer or layers of tightly packed cells that line the surfaces of the body. The largest example of epithelial tissue (also the largest organ in the human body) is the skin. Mammalian skin consists of stratified epithelium, which has several layers of cells. The outermost layers of cells, called squamous cells, are flat plate-like cells, while the deeper layers are roughly cube shaped and called cuboidal cells. Epithelial tissue has multiple functions, but it serves primarily to protect, absorb, and secrete. As you probably already know, our skin organ covers our entire body and protects underlying tissues from bacteria, chemicals, and other injury. Epithelial cells also line the small intestine where they absorb nutrients, and similar cells in the glands secrete enzymes and hormones.

Muscle tissue encompasses not only the muscles, such as those in our legs or fingers, that we actively control, but also the tissue that forms most of our internal organs. There are three types of muscle tissue: skeletal, cardiac, and smooth. Skeletal muscle tissue forms what we think of as our muscles; it is attached to our bones by our tendons and can be relaxed or contracted voluntarily. Similar in structure to skeletal muscle, cardiac muscle is found exclusively

in the walls of the heart. The major difference, however, is that cardiac muscle is involuntary and cannot be actively controlled. Similarly, smooth muscle, which forms the muscle layers in internal organs such as the digestive tract and bladder, is an involuntary tissue. Smooth muscle tissue controls slow involuntary movements such as stomach wall contractions and the contractions of arteries to regulate blood flow.

Nervous tissue is made up of the nerve cells (neurons) that form the nervous system, including the brain and spinal cord. These cells are especially responsive to stimuli, allowing nervous tissue to transmit stimuli from the brain to the body extremely rapidly.

Connective tissue connects, supports, or separates other tissues and organs. Connective tissue proper, a form of connective tissue, can be either loose or dense. Adipose tissue, or fat, is loose connective tissue, while tendons and ligaments, composed of collagen, are examples of dense connective tissue. Other forms of connective tissue include blood (fluid connective tissue) and cartilage and bone (both forms of supporting connective tissue).

Summary

- Tissues are composed of cells, and multiple tissues together constitute an organ.
- The human body has four types of tissues: nervous, muscle, connective, and epithelial

Review

1. What are the four types of tissues? Give an example of each.
2. What is the difference between tissue and cellular level organization?
3. Are there any organisms that do not have tissue structures? If yes, what organism(s)?

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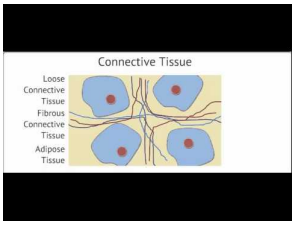

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Use the video above to answer the following questions:

1. What are some different types of connective tissue?
2. What is the extracellular matrix?
3. What are the differences between skeletal, cardiac, and smooth muscle tissue?

References

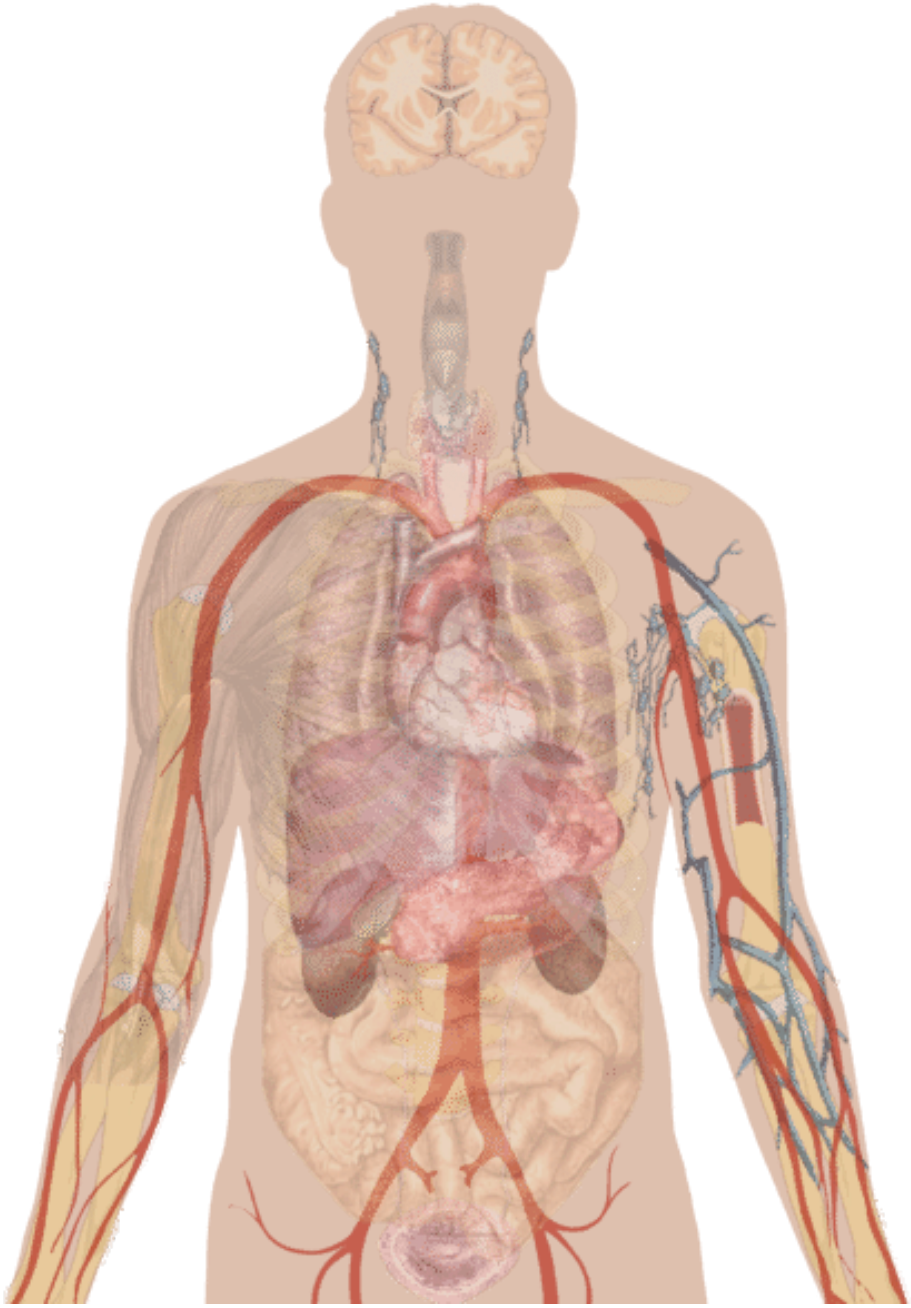
1. CK-12 Foundation - Zachary Wilson. . CC-BY-NC-SA 3.0

2. Drs. Noguchi, Rodgers, and Schechter of NIDDK. http://remf.dartmouth.edu/images/mammalianLungSEM/source/9.html http://remf.dartmouth.edu/images/humanMuscleTEM/source/2.html http://commons.wikimedia.org/wiki/Image:Redbloodcells.jpg . (a) Public Domain (b) Public Domain (d) Public Domain

CONCEPT 4

Human Organs and Organ Systems

- Summarize how tissues and organs relate to each other.
- Identify the defining features of organs and organ systems.
- Understand the relationship between organs and organ systems.



Organs and Organ Systems

Organs are the next level of organization in the body. An **organ** is a structure made of two or more tissues that work together for a common purpose. Skin, the largest organ in the body, is shown in **Figure** 4.1. Organs can be as primitive as the brain of a flatworm (a group of nerve cells), as large as the stem of a sequoia (up to 90 meters (300 feet) in height), or as complex as a human liver. The human body has many different organs including the heart, the kidneys, the pancreas, and the skin. Two or all of the tissue types can be found in each organ. Organs inside the body are called internal organs. The internal organs collectively are often called **viscera.**

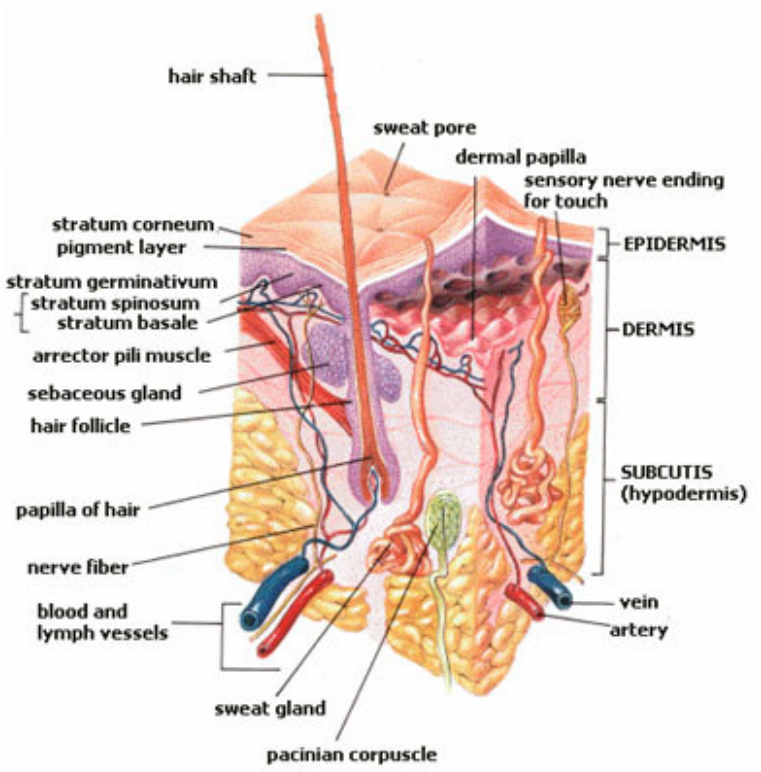


FIGURE 4.1

Your skin is the largest organ in your body. In this cross section image of skin, the four different tissue types (epithelial, connective, nervous, and muscle tissues) can be seen working together.

The most complex organisms have organ systems. An **organ system** is a group of organs that act together to carry out complex, interrelated functions, with each organ focusing on a subset of the task. For example, the human digestive system is an organ system in which the mouth and esophagus ingest food, the stomach crushes and liquefies it, the pancreas and gall bladder make and release digestive enzymes, and the intestines absorb nutrients into the blood. An organ can be part of more than one organ system. For example, the ovaries produce hormones, which makes them a part of the endocrine system; the ovaries also make eggs, which makes them a part of the reproductive system as well. One of the most important functions of organ systems is to provide cells with oxygen and nutrients and to remove toxic waste products such as carbon dioxide. A number of organ systems, including the cardiovascular and respiratory systems, work together to do this.

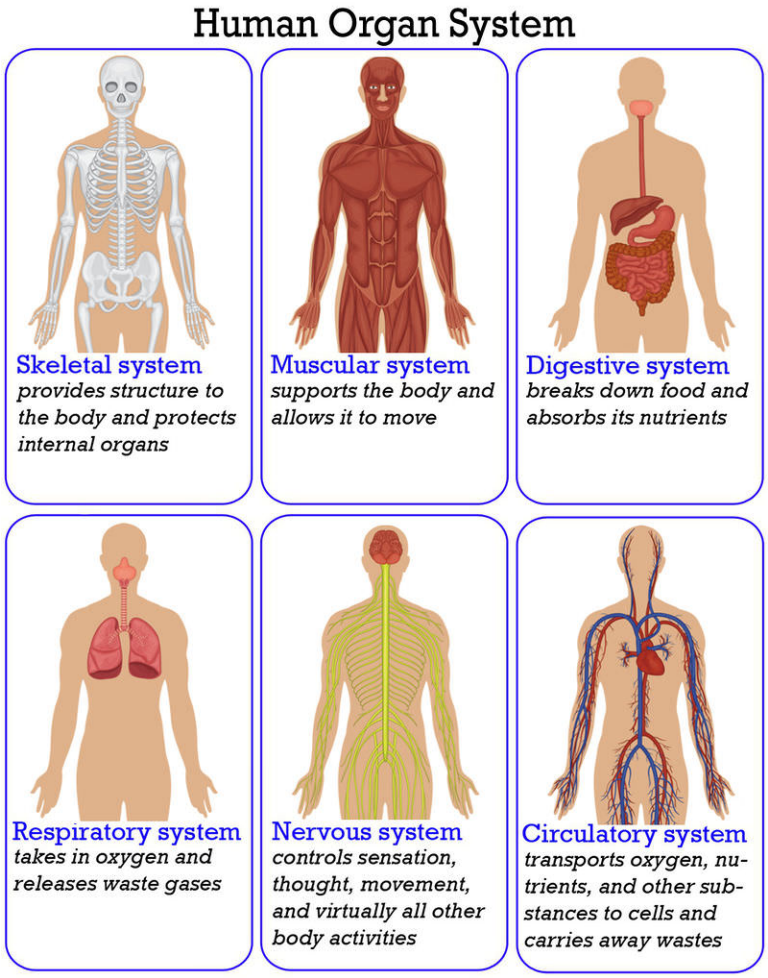


FIGURE 4.2

Many of the organ systems that make up the human body are represented here. What is the overall function of each organ system?

The different organ systems of the body are shown in **Table** 4.1. Sometimes the cardiovascular system and the lymphatic system are grouped together into one single system called the circulatory system.

TABLE 4.1: Major Organ Systems of the Human Body

Organ System	Function	Organs, Tissues, and Structures Involved
Cardiovascular	Transports oxygen, nutrients, and other substances to the cells, and transports wastes, carbon dioxide, and other substances away from the cells; it can also help stabilize body temperature and pH.	Heart, blood, and blood vessels.
Lymphatic	Defends against infection and disease. Transfers lymph between tissues and the blood stream.	Lymph, lymph nodes, and lymph vessels.
Digestive	Processes foods and absorbs nutrients, minerals, vitamins, and water.	Salivary glands, esophagus, stomach, liver, gallbladder, pancreas, small intestine, and large intestine.

TABLE 4.1: (continued)

Organ System	Function	Organs, Tissues, and Structures Involved
Endocrine	Provides communication within the body via hormones. Directs long-term change over other organ systems to maintain homeostasis.	Pituitary gland, pineal gland, thyroid, parathyroid gland, adrenal glands, testes, and ovaries.
Integumentary	Provides protection from both injury and fluid loss and provides physical defense against infection by microorganisms. Controls temperature.	Skin, hair, and nails.
Muscular	Provides movement, support, and heat production.	Tendons, skeletal, cardiac, and smooth muscles.
Nervous	Collects, transfers, and processes information. Directs short-term change over other organ systems in order to maintain homeostasis.	Brain, spinal cord, nerves, and sensory organs (eyes, ears, tongue, skin, and nose).
Reproductive	Produces gametes (sex cells) and sex hormones; ultimately produces offspring.	Fallopian tubes, uterus, vagina, ovaries, mammary glands, testes, vas deferens, seminal vesicles, prostate, and penis.
Respiratory	Delivers air to sites where gas exchange can occur between the blood and cells (around body) or blood and air (lungs).	Mouth, nose, pharynx, larynx, trachea, bronchi, lungs, and diaphragm.
Skeletal	Supports and protects soft tissues of the body. Provides movement at joints, produces blood cells, and stores minerals.	Bones, cartilage, and ligaments.
Urinary	Removes excess water, salts, and waste products from the blood and body. Controls pH.	Kidneys, ureters, urinary bladder, and urethra.
Immune	Defends against microbial pathogens (disease-causing agents) and other diseases.	Leukocytes, tonsils, adenoids, thymus, and spleen.

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Summary

- Organs are structures composed of two or more tissues; organ systems are systems composed of two or more organs.
- Organ systems carry out complex tasks, with each organ completing one aspect of the task.

Review

1. What is the difference between an organ and an organ system?
2. How many major organ systems are there? What are they?

References

1. . http://upload.wikimedia.org/wikipedia/commons/3/34/Skin.jpg . Public Domain
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CONCEPT 5

Homeostasis

- Define homeostasis.
- Describe the importance of maintaining homeostasis.
- Discuss the roles of the endocrine and nervous systems in maintaining homeostasis.

What happens if stability is disrupted?

Remove one stone and the whole arch collapses. The same is true for the human body. All the systems work together to maintain stability or homeostasis. Disrupt one system, and the whole body may be affected.

Homeostasis

All of the organs and organ systems of the human body work together like a well-oiled machine. This is because they are closely regulated by the nervous and endocrine systems. The **nervous system** controls virtually all body activities, and the **endocrine system** secretes **hormones** that regulate these activities. Functioning together, the organ systems supply body cells with all the substances they need and eliminate their wastes. They also keep temperature, pH, and other conditions at just the right levels to support life processes.

Maintaining Homeostasis

The process in which organ systems work to maintain a stable internal environment is called **homeostasis**. Keeping a stable internal environment requires constant adjustments. Here are just three of the many ways that human organ systems help the body maintain homeostasis:

- Respiratory system: A high concentration of carbon dioxide in the blood triggers faster breathing. The lungs exhale more frequently, which removes carbon dioxide from the body more quickly.

- Excretory system: A low level of water in the blood triggers retention of water by the kidneys. The kidneys produce more concentrated urine, so less water is lost from the body.
- Endocrine system: A high concentration of sugar in the blood triggers secretion of insulin by an endocrine gland called the pancreas. Insulin is a hormone that helps cells absorb sugar from the blood.

So how does your body maintain homeostasis? The regulation of your internal environment is done primarily through negative feedback. **Negative feedback** is a response to a stimulus that keeps a variable close to a set value (**Figure** 5.1). Essentially, it "shuts off" or "turns on" a system when it varies from a set value.

For example, your body has an internal thermostat. During a winter day, in your house a thermostat senses the temperature in a room and responds by turning on or off the heater. Your body acts in much the same way. When body temperature rises, receptors in the skin and the brain sense the temperature change. The temperature change triggers a command from the brain. This command can cause several responses. If you are too hot, the skin makes sweat and blood vessels near the skin surface dilate. This response helps decrease body temperature.

Another example of negative feedback has to do with blood glucose levels. When glucose (sugar) levels in the blood are too high, the pancreas secretes insulin to stimulate the absorption of glucose and the conversion of glucose into glycogen, which is stored in the liver. As blood glucose levels decrease, less insulin is produced. When glucose levels are too low, another **hormone** called glucagon is produced, which causes the liver to convert glycogen back to glucose.

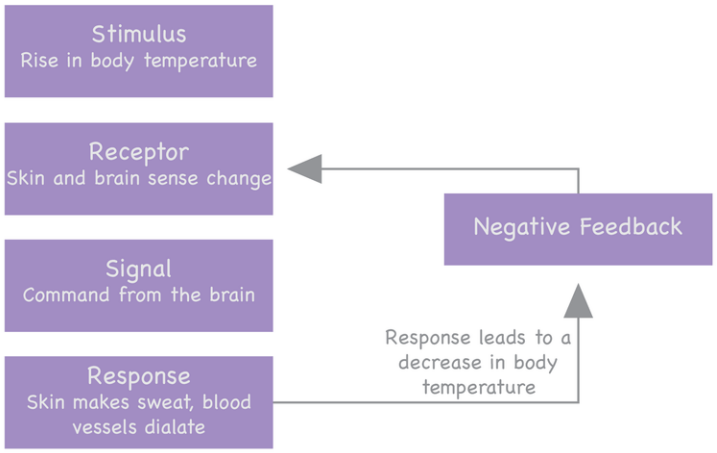


FIGURE 5.1

Feedback Regulation. If a raise in body temperature (stimulus) is detected (receptor), a signal will cause the brain to maintain homeostasis (response). Once the body temperature returns to normal, negative feedback will cause the response to end. This sequence of stimulus-receptor-signal-response is used throughout the body to maintain homeostasis.

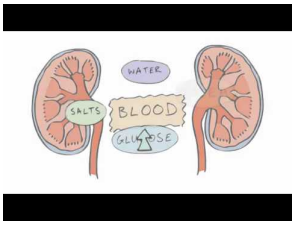
Positive Feedback

Some processes in the body are regulated by positive feedback. **Positive feedback** is when a response to an event increases the likelihood of the event to continue. An example of positive feedback is milk production in nursing mothers. As the baby drinks her mother's milk, the hormone prolactin, a chemical signal, is released. The more the baby suckles, the more prolactin is released, which causes more milk to be produced. Other examples of positive feedback include contractions during childbirth. When constrictions in the uterus push a baby into the birth canal, additional contractions occur.

Failure of Homeostasis

Many homeostatic mechanisms such as these work continuously to maintain stable conditions in the human body. Sometimes, however, the mechanisms fail. When they do, cells may not get everything they need, or toxic wastes

may accumulate in the body. If homeostasis is not restored, the imbalance may lead to disease or even death.



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Summary

- All of the organ systems of the body work together to maintain homeostasis of the organism.
- If homeostasis fails, death or disease may result.

Review

1. What is homeostasis?
2. Describe how one of the human organ systems helps maintain homeostasis.
3. A house has several systems, such as the electrical system, plumbing system, and heating and cooling system. In what ways are the systems of a house similar to human body systems?

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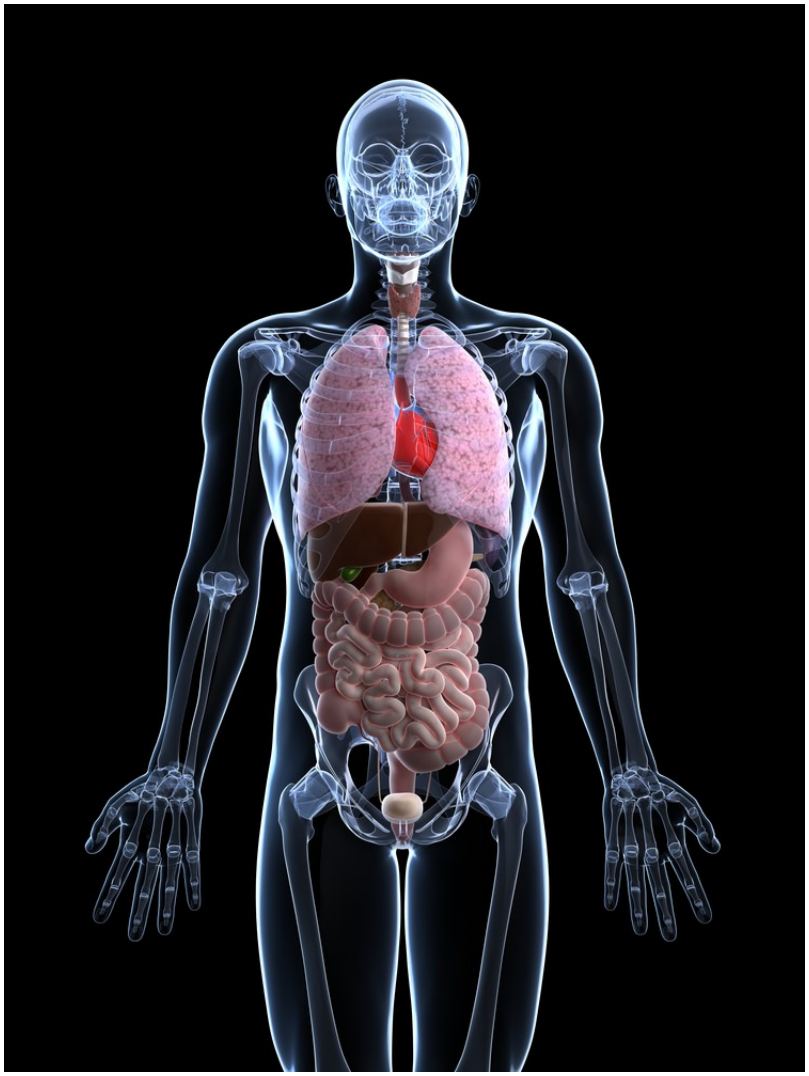
CONCEPT 6 System Interactions in the Human Body

- Name and describe two body systems that work together for a common purpose.
- Summarize the role of the endocrine system in homeostasis.
- Outline the result of a disturbance in the homeostasis of a body system.



What do you get when the body systems interact?

You get an organism. Here we easily recognize parts of the respiratory, circulatory, digestive, and skeletal systems. Though these can function alone, they need to work together to make a living organism. They also need to work with the the endocrine and nervous systems, as well as the other systems.

System Interactions

Each body system contributes to the **homeostasis** of other systems and of the entire organism. No system of the body works in isolation, and the well-being of the person depends upon the well-being of all the interacting body

systems. A disruption within one system generally has consequences for several other body systems. Most of these organ systems are controlled by **hormones** secreted from the pituitary gland, a part of the endocrine system. **Table** 6.1 summarizes how various body systems work together to maintain homeostasis.

Main examples of homeostasis in mammals are as follows:

- The regulation of the amounts of water and minerals in the body. This is known as **osmoregulation.** This happens primarily in the kidneys.
- The removal of metabolic waste. This is known as **excretion.** This is done by the excretory organs such as the kidneys and lungs.
- The regulation of body temperature. This is mainly done by the skin.
- The regulation of blood glucose levels. This is mainly done by the liver and the insulin and glucagon secreted by the pancreas.

TABLE 6.1: Types of Homeostatic Regulation in the Body

	Homeostatic Processes	Hormones and Other Messengers	Tissues, Organs, and Organ Systems Involved
Osmoregulation (also called excretion)	Excess water, salts, and urea expelled from the body.	Antidiuretic hormone (ADH), aldosterone, angiotensin II, and carbon dioxide.	Kidneys, urinary bladder, ureters, urethra (urinary system), pituitary gland (endocrine system), and lungs (respiratory system).
Thermoregulation	Sweating, shivering, dilation/constriction of blood vessels at the skin surface, insulation by adipose tissue, and breakdown of adipose tissue to produce heat.	Nerve impulses.	Skeletal muscle (muscular system), nerves (nervous system), blood vessels (cardiovascular system), skin and adipose tissue (integumentary system), and hypothalamus (endocrine system).
Chemical Regulation (including glucoregulation)	Release of insulin and glucagon into the blood in response to rising and falling blood glucose levels respectively. Increase in breathing rate in response to increased carbon dioxide levels in the blood, release of carbon dioxide into exhaled air from the lungs, and secretion of erythropoietin by kidneys to stimulate formation of red blood cells.	Insulin, glucagon, cortisol, carbon dioxide, nerve impulses, and erythropoietin (EPO).	Pancreas (endocrine system), liver (digestive system), adrenal glands (endocrine system), lungs (respiratory system), brain (nervous system), and kidneys (urinary system).

Endocrine System

The endocrine system, shown in **Figure** 6.1, includes glands that secrete hormones into the bloodstream. Hormones are chemical messenger molecules that are made by cells in one part of the body and cause changes in cells in

another part of the body. The endocrine system regulates the metabolism and development of most body cells and body systems through feedback mechanisms. For example, Thyrotropin-Releasing Hormone (TRH) and Thyroid Stimulating Hormone (TSH) are controlled by a number of negative feedback mechanisms. The endocrine glands also release hormones that affect skin and hair color, appetite, and secondary sex characteristics of both males and females.

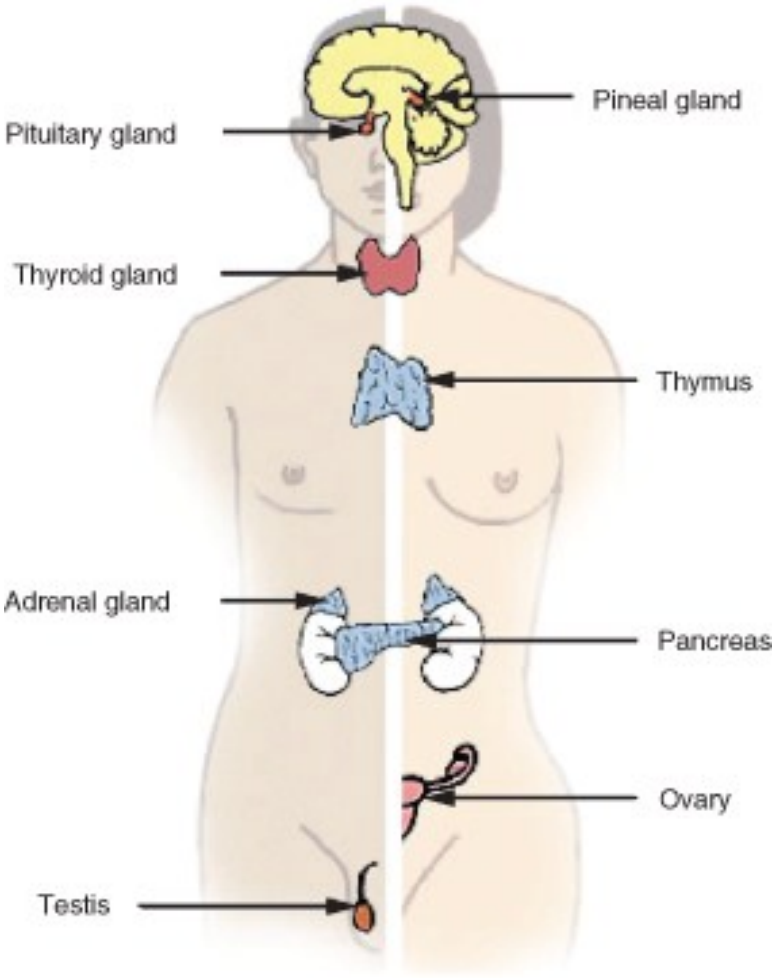


FIGURE 6.1

The endocrine system controls almost every other body system through feedback mechanisms. Most of the mechanisms of the endocrine system are negative feedback loops.

The endocrine system has a regulatory effect on other organ systems in the human body. In the muscular system, hormones adjust muscle metabolism, energy production, and growth. In the nervous system, hormones affect neural metabolism, regulate fluid and ion concentrations, and help with reproductive hormones that influence brain development.

Urinary System

Toxic wastes build up in the blood as proteins and nucleic acids are broken down and used by the body. The urinary system rids the body of these wastes. The urinary system is also directly involved in maintaining proper blood volume. The kidneys also play an important role in maintaining the correct salt and water contents of the body. External changes, such as warm weather, that lead to excess fluid loss trigger feedback mechanisms that act to maintain the body's fluid content by inhibiting fluid loss. The kidneys also produce a hormone called erythropoietin, also known as EPO, which stimulates red blood cell production.

Reproductive System

The reproductive system does little for the homeostasis of the organism. The reproductive system relates instead to the maintenance of the species. However, sex hormones do have an effect on other body systems, and an imbalance in sex hormones can lead to various disorders. For example, a woman whose ovaries are removed early in life is at higher risk of developing osteoporosis, a disorder in which bones are thin and break easily. The hormone estrogen, produced by the ovaries, is important for bone growth. Therefore, a woman who does not produce estrogen will have impaired bone development.

Summary

- The body systems constantly interact with each other to maintain homeostasis.

Review

1. Define homeostasis.
2. What is meant by body system interactions?
3. Give an example of a body system interaction.

References

1. USFG. http://commons.wikimedia.org/wiki/File:Illu_endocrine_system.png . Public Domain

CONCEPT 7 Disruption of Homeostasis

- Understand the causes of homeostatic imbalances.
- Discover two common homeostatic imbalances, their causes, and their results.

What happens if there's disruption?

If homeostasis is disrupted, it must be controlled or a disease/disorder may result. Your body systems work together to maintain balance. If that balance is shifted or disrupted and homeostasis is not maintained, the results may not allow normal functioning of the organism.

Disruption of Homeostasis

Many homeostatic mechanisms keep the internal environment within certain limits (or set points). When the cells in your body do not work correctly, homeostatic balance is disrupted. **Homeostatic imbalance** may lead to a state of disease. Disease and cellular malfunction can be caused in two basic ways: by deficiency or toxicity. **Deficiency** occurs when beneficial pathways are blocked and cells lack adequate quantities of vitamins or minerals. **Toxicity** occurs when cells have an excess of a toxin that poisons the cell. Cells are delicate and require concise levels of every necessary substance; levels that are too high *and* levels that are too low can be extremely dangerous. Cells undergo homeostasis to maintain the ideal levels, but, when homeostasis is interrupted, your body may correct or worsen the problem based on certain influences. In addition to inherited (genetic) influences, there are external influences that are based on lifestyle choices and environmental exposure. These factors together influence the body's ability to maintain homeostatic balance.

A commonly seen example of homeostatic imbalance is **diabetes.** In a diabetic, the endocrine system has difficulty maintaining the correct blood glucose levels, so diabetics must closely monitor their blood glucose levels, as shown in **Figure** 7.1. They must monitor their daily sugar intake and regulate their blood glucose levels with insulin injections. Like most homeostatic imbalances, diabetes is dependent on both genetics and lifestyle.

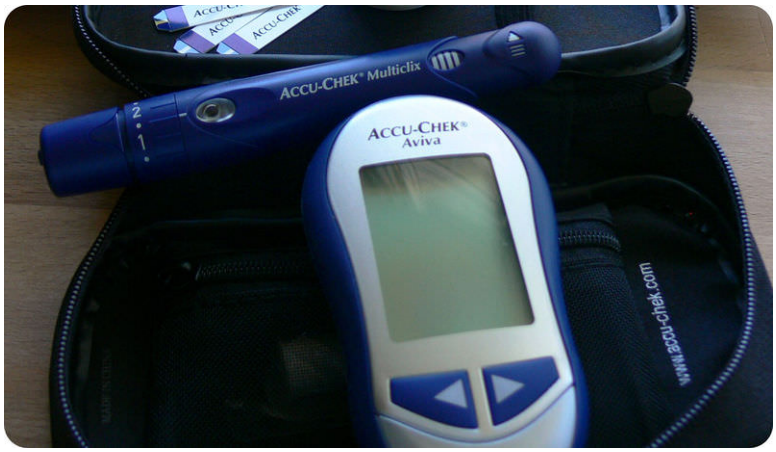


FIGURE 7.1

A person with diabetes has to monitor their blood glucose carefully. This glucose meter analyzes only a small drop of blood.

Internal Influences: Heredity

Genetics

Genes are sometimes turned off or on due to external factors, which we have some control over. Other times, little can be done to prevent the development of certain genetic diseases and disorders. In such cases, medicines can help a person's body regain homeostasis. An example is the metabolic disorder called Type 1 diabetes, which is a disorder where the pancreas is no longer producing adequate amounts of insulin to respond to changes in a person's blood glucose levels. Insulin replacement therapy, in conjunction with carbohydrate counting and careful monitoring of blood glucose concentrations, is a way to bring the body's handling of glucose back into balance. Cancer can be genetically inherited or can result from a mutation caused by exposure to toxins such as radiation or harmful drugs. A person may also inherit a predisposition to develop a disease such as heart disease. Such diseases can be delayed or prevented if the person maintains a healthy lifestyle.

External Influences: Lifestyle

Nutrition

For proper cell function, it is imperative that cells get the vitamins and minerals they need. These vitamins are obtained through our diet, and an imbalanced diet may increase one's risk of disease. For example, a menstruating woman with an inadequate dietary intake of iron will become anemic. Hemoglobin, the molecule that enables red blood cells to transport oxygen, requires iron. Therefore, the blood of an anemic woman will have reduced oxygen-carrying capacity. In mild cases, symptoms may be vague (e.g. fatigue), but, if the anemia is severe, the body will try to compensate by increasing cardiac output, leading to weakness, irregular heartbeats, and sometimes heart failure.

Physical Activity

Physical activity is essential for proper functioning of our cells and bodies. Levels of rest and physical activity both influence homeostasis. Inadequate sleep is related to a number of health problems such as irregular heartbeat, fatigue, anxiety, and headaches. Poor nutrition and a lack of physical exercise can lead to being overweight or obese; these conditions increase a person's risk of developing heart disease, Type 2 diabetes, and certain forms of cancer. Staying fit by regularly taking part in aerobic activities, such as walking (shown in **Figure** 7.2), has been shown to help prevent many of these diseases.

FIGURE 7.2
Pedestrians walking across the street.

Mental Health

Your physical and mental health are inseparable. Our emotions cause chemical changes in our bodies that have various effects on our thoughts and feelings. Negative stress (also called distress) can negatively affect mental health. Regular physical activity helps people cope with distress and has been shown to improve both physical and mental well-being. Among other things, regular physical activity increases the ability of the cardiovascular system to deliver oxygen to body cells including brain cells. For people who have more serious mental and mood disorders, medications that may help balance the amount of certain mood-altering chemicals within the brain are often prescribed. Medication is an external influence that can help stabilize homeostatic disruptions.

Environmental Exposure

Any substance that interferes with cellular function and causes cellular malfunction is a cellular toxin. There are many different sources of toxins including natural and synthetic drugs, plants, and animal bites. Air pollution, another form of environmental exposure to toxins, is shown in **Figure** 7.3. Unfortunately, a commonly seen example of an exposure to cellular toxins is drug overdose. When a person takes too much of a drug that affects the central nervous system, basic life functions, such as breathing and heartbeat, are disrupted. Such disruptions can result in a coma, brain damage, and even death.

These factors have their effects at the cellular level. A deficiency will almost always result in a harmful change in homeostasis, whether caused by internal or external influences. Too much toxicity also causes homeostatic imbalance, resulting in cellular malfunction. By removing negative health influences and providing adequate positive health influences, your body is better able to self-regulate and self-repair, maintaining homeostasis.

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FIGURE 7.3

Air pollution can cause environmental exposure to cellular toxins such as mercury.

Summary

- Homeostatic imbalances can be caused by genetic, lifestyle, or environmental factors, or some combination of all three.

Review

1. What is the difference between deficiency and toxicity?
2. What are the six factors that contribute to homeostatic imbalance?

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