# Human Biology

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# CHAPTER 1 Human Biology

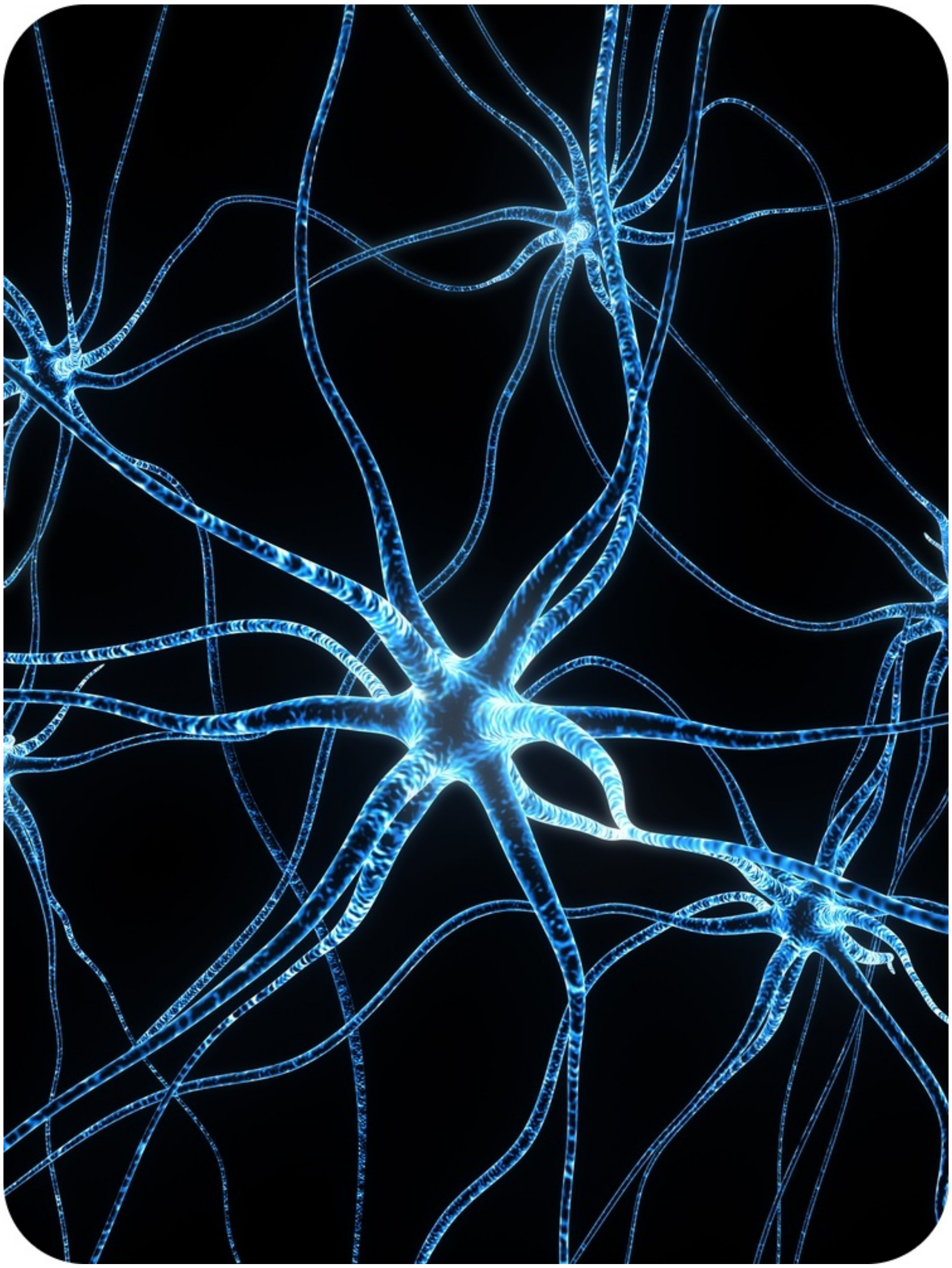
## CHAPTER OUTLINE

## Introduction

*Human Biology* provides an overview of the physiology of humans, from the skin inward. In addition to the skin, the skeletal, muscular, nervous, circulatory, respiratory, digestive, excretory, immune, and reproductive systems are described.

# 1.1 Organization of the Human Body

- List the levels of organization in the human body.
- Identify the four types of tissues that make up the body.



**Do cells work together?**

Cells, like these nerve cells, do not work in isolation. To send orders from your brain to your legs, for example, signals pass through many nerve cells. These cells work together to perform a similar function. Just as muscle cells work together, bone cells and many other cells do as well. A group of similar cells that work together is known as a tissue.

## Organization of Your Body: Cells, Tissues, Organs

**Cells** are grouped together to carry out specific functions. A group of cells that work together form a **tissue**. Your body has four main types of tissues, as do the bodies of other animals. These tissues make up all structures and contents of your body. An example of each tissue type is pictured below (**Figure** 1.1).

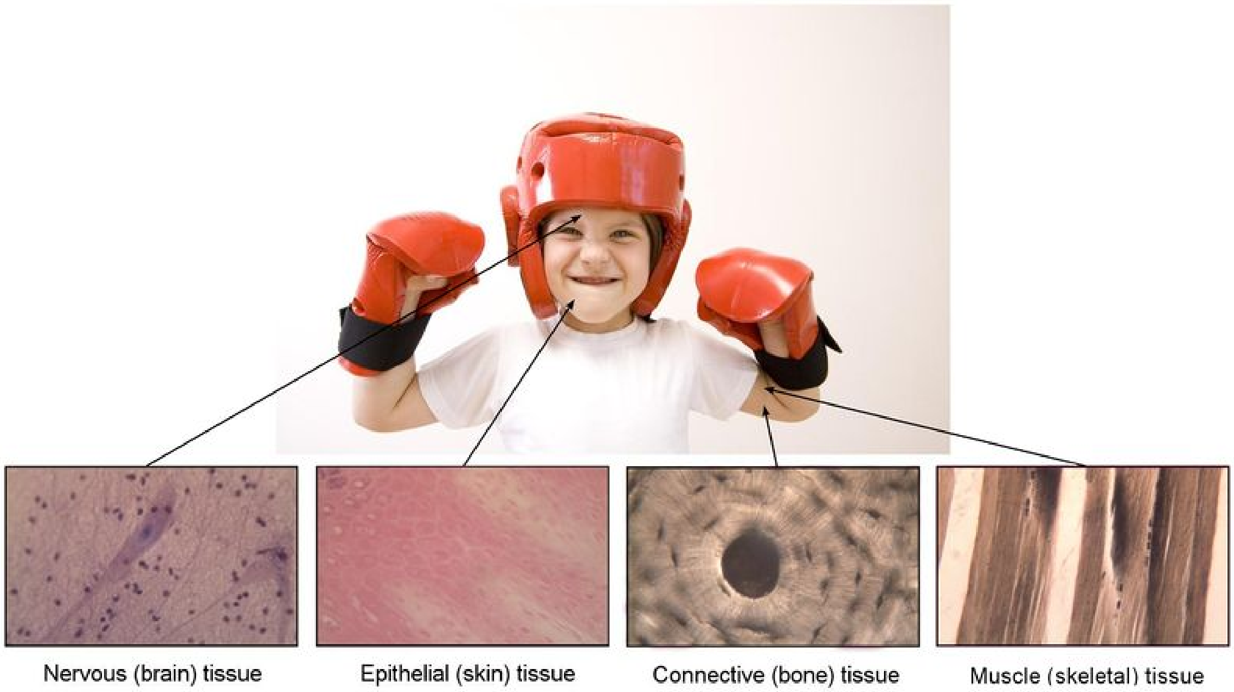



FIGURE 1.1
Your body has four main types of tissue: nervous tissue, epithelial tissue, connective tissue, and muscle tissue. They are found throughout your body.

1. **Epithelial tissue** is made up of layers of tightly packed cells that line the surfaces of the body. Examples of epithelial tissue include the skin, the lining of the mouth and nose, and the lining of the digestive system.
2. **Connective tissue** is made up of many different types of cells that are all involved in supporting and binding other tissues of the body. Examples include tendon, cartilage, and bone. Blood is also classified as a specialized connective tissue.
3. **Muscle tissue** is made up of bands of cells that contract and allow movement.
4. **Nervous tissue** is made up of nerve cells that sense stimuli and transmit signals. Nervous tissue is found in nerves, the spinal cord, and the brain.

### Groups of Tissues Form Organs

A single tissue alone cannot do all the jobs that are needed to keep you alive and healthy. Two or more tissues working together can do a lot more. An **organ** is a structure made of two or more tissues that work together. The heart (**Figure** 1.2) is made up of the four types of tissues.

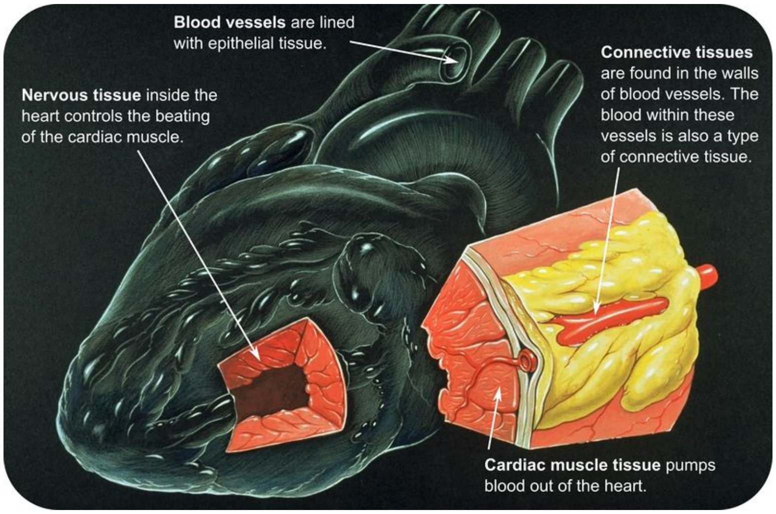



FIGURE 1.2
The four different tissue types work together in the heart as they do in the other organs.

### Groups of Organs Form Organ Systems

Your heart pumps blood around your body. But how does your heart get blood to and from every cell in your body? Your heart is connected to blood vessels such as veins and arteries. Organs that work together form an **organ system**. Together, your heart, blood, and blood vessels form your **cardiovascular system**.

What other organ systems can you think of?

### Organ Systems Work Together

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. |

## Vocabulary

- **cardiovascular system**: Organ system made up of the heart, blood, and blood vessels.
- **cells**: Basic unit of structure and function of a living organism; the basic unit of life.
- **connective tissue**: Group of cells that are all involved in supporting and binding other tissues of the body; i.e. tendon, cartilage, bone, and blood.
- **epithelial tissue**: Layers of tightly packed cells that line the surfaces of the body.
- **muscle tissue**: Bands of cells that contract and allow movement.
- **nervous tissue**: Group of nerve cells that sense stimuli and transmit signals; found in brain, spinal cord, and nerves.
- **organ**: Structure made of two or more tissues that work together.
- **organ system**: Organs that work together to serve a common purpose.
- **tissue**: Group of similar cells working together.

## Summary

- The levels of organization in the human body include: cells, tissues, organs, and organ systems.
- There are four tissue types in the body: epithelial tissue, connective tissue, muscle tissue, and nervous tissue.

## Practice

Use the resources below to answer the following questions.

- **Human Body Plan** at http://vimeo.com/37349968 (2:28)


MEDIA
Click image to the left for more content.

1. What kind of symmetry does the human body plan show? Explain fully what this means.
2. How does this symmetry extend to our senses?
3. How much of our body is made of muscle? What does this muscle allow us to do?
4. How are oxygen and nutrients delivered to the cells of the body?

Go here to see the placement of some organs and body parts. See how fast you can assemble the systems.

- **All Systems Go** at http://sciencenetlinks.com/interactives/systems.html

### Review

1. What are the four levels of organization in an organism?
2. List the four types of tissues that make up the human body.

# 1.2 Homeostasis

- Describe homeostasis and how it is maintained.

**How does your body react to cold?**

These people may be having fun in the icy water, but their bodies are struggling to react to the cold. For example, they may begin to shiver. Shivering helps the body return to a stable temperature. The body is always working to achieve stability, or homeostasis.

## Homeostasis and Feedback Regulation

When you walk outside on a cool day, does your body temperature drop? No, your body temperature stays stable at around 98.6 degrees Fahrenheit. Even when the temperature around you changes, your internal temperature stays the same.

This ability of the body to maintain a stable internal environment despite a changing environment is called **homeostasis**. Homeostasis doesn't just protect against temperature changes. Other aspects of your internal environment also stay stable. For example, your body closely regulates your fluid balance. You may have noticed that if you are slightly dehydrated, your urine is darker. That's because the urine is more concentrated and less water is mixed in with it.

### Maintaining Homeostasis

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** 1.3).

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.

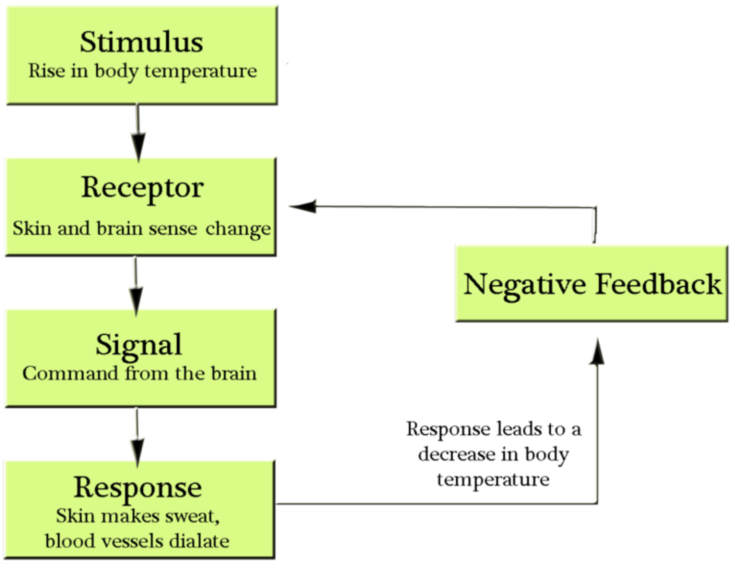



FIGURE 1.3
Feedback Regulation.

### 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.

### Vocabulary

- **homeostasis**: Ability to keep a stable internal environment; the ability of the body to maintain a stable internal environment despite a changing environment.
- **hormone**: Chemical messenger molecule.
- **negative feedback**: Response to a stimulus that keeps a variable close to a set value.
- **positive feedback**: Response to an event increases the likelihood of the event to continue.

### Summary

- Homeostasis is the ability of the body to maintain a stable internal environment despite a changing external environment.
- Homeostasis is maintained primarily through negative feedback, when a response to a stimulus keeps a variable close to a set value.

### Practice

Use the resources below to answer the questions that follow.

- **Homeostasis** at http://www.phys.unsw.edu.au/biosnippets/

1. What are three variables affected by homeostasis? What is the normal human range for these variables?
2. What is negative feedback? What is a sensor and an effector? How does this relate to homeostasis?
3. How does temperature affect enzymes? Why is this important to organisms? How do the enzyme systems of ectotherms differ from the enzyme systems of endotherms?
4. How is the body temperature of ectotherms related to environmental temperatures?
5. What happens if a fish is exposed to a rapid change in water temperature? What mechanism is involved in this response?

- **Homeostasis** at http://www.think-bank.com/iwb/flash/homeostasis.html

1. List four internal conditions that organisms regulate?
2. What happens to blood flow in your body when your internal temperature increases?
3. What happens to blood flow in your body when your internal temperature decreases?
4. How does your body react to maintain water levels in your body? What is ADH? What is its function?
5. What are the roles of insulin and glucagon? What do they help the body regulate?

## Review

1. What is homeostasis?
2. What is the difference between negative feedback and positive feedback?

# 1.3 Skin

- Describe the function and structure of the skin.

**Why is your skin important?**

Some people put a lot of time and money into maintaining their skin. They may use special creams and lotions. While expensive creams may not be necessary, it is a good idea to take care of your skin. It does a lot of things for you, from protecting you from disease to sensing your environment.

## Your Skin

Did you know that you see the largest organ in your body every day? You wash it, dry it, cover it up to stay warm, and uncover it to cool off. Yes, your skin is your body's largest organ.

Your skin is part of your **integumentary system** (**Figure** 1.4), which is the outer covering of your body. The integumentary system is made up of your skin, hair, and nails.

### Functions of Skin

FIGURE 1.4
Skin acts as a barrier that stops water and other things, like soap and dirt, from getting into your body.

The skin has many important functions. The skin:

- Provides a barrier. It keeps organisms that could harm the body out. It stops water from entering or leaving the body.
- Controls body temperature. It does this by making sweat (or **perspiration**), a watery substance that cools the body when it evaporates.
- Gathers information about your environment. Special nerve endings in your skin sense heat, pressure, cold, and pain.
- Helps the body get rid of some types of waste, which are removed in sweat.
- Acts as a sun block. A pigment called **melanin** blocks sunlight from getting to deeper layers of skin cells, which are easily damaged by sunlight.

### Structure of Skin

Your skin is always exposed to your external environment, so it gets cut, scratched, and worn down. You also naturally shed many skin cells every day. Your body replaces damaged or missing skin cells by growing more of them. Did you know that the layer of skin you can see is actually dead? As the dead cells are shed or removed from the upper layer, they are replaced by the skin cells below them.

Two different layers make up the skin—the epidermis and the dermis (**Figure** 1.5). A fatty layer lies under the dermis, but it is not part of your skin.

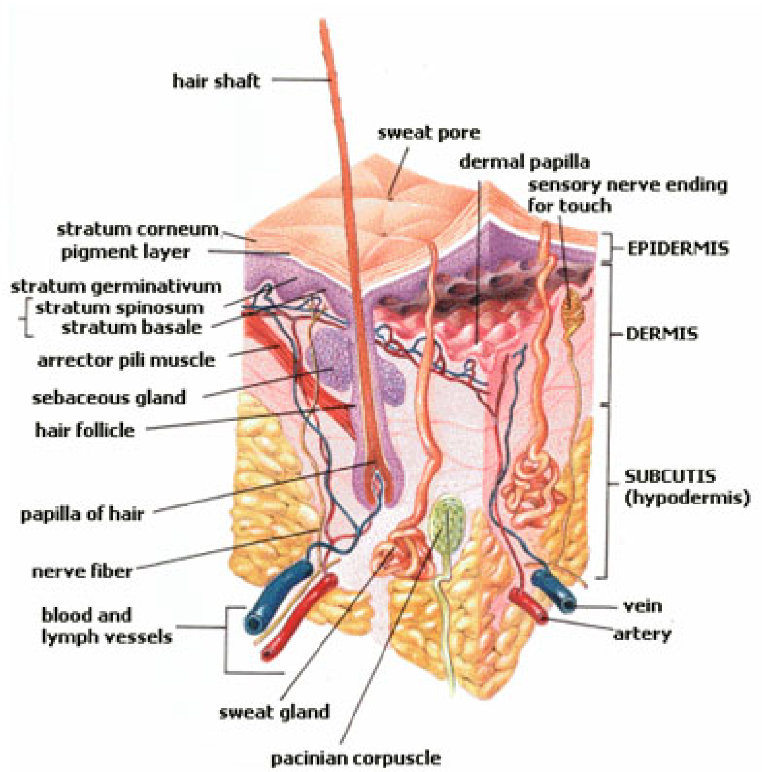



FIGURE 1.5
Skin is made up of two layers, the epidermis on top and the dermis below. The tissue below the dermis is called the hypodermis, but it is not part of the skin.

### The Epidermis

The **epidermis** is the outermost layer of the skin. It forms the waterproof, protective wrap over the body's surface. Although the top layer of epidermis is only about as thick as a sheet of paper, it is made up of 25 to 30 layers of cells. The epidermis also contains cells that produce melanin. Melanin is the brownish pigment that gives skin and hair their color. Melanin-producing cells are found in the bottom layer of the epidermis. The epidermis does not have any blood vessels. The lower part of the epidermis receives blood by diffusion from blood vessels of the dermis.

### The Dermis

The **dermis** is the layer of skin directly under the epidermis. It is made of a tough connective tissue. The dermis contains hair follicles, sweat glands, oil glands, and blood vessels (**Figure** 1.5). It also holds many nerve endings that give you your sense of touch, pressure, heat, and pain.

Do you ever notice how your hair stands up when you are cold or afraid? Tiny muscles in the dermis pull on hair follicles which cause hair to stand up. The resulting little bumps in the skin are commonly called "goosebumps" (**Figure** 1.6).

FIGURE 1.6
Goosebumps are caused by tiny muscles in the dermis that pull on hair follicles, which causes the hairs to stand up straight.

### Oil Glands and Sweat Glands

Glands and hair follicles open out into the epidermis, but they start in the dermis. Oil glands (**Figure** 1.5) release, or secrete an oily substance, called **sebum**, into the hair follicle. Sebum "waterproofs" hair and the skin surface to prevent them from drying out. It can also stop the growth of bacteria on the skin. It is odorless, but the breakdown of sebum by bacteria can cause odors. If an oil gland becomes plugged and infected, it develops into a pimple. Up to 85% of teenagers get pimples, which usually go away by adulthood. Frequent washing can help decrease the amount of sebum on the skin.

**Sweat glands** (**Figure** 1.5) open to the skin surface through skin pores. They are found all over the body. Evaporation of sweat from the skin surface helps to lower skin temperature. The skin also releases excess water, salts, and other wastes in sweat.

## Vocabulary

- **dermis**: Layer of skin directly under the epidermis; made of a tough connective tissue.
- **epidermis**: Outermost layer of the skin.
- **integumentary system**: Outer covering of your body, including skin, hair, and nails.
- **melanin**: Brownish pigment that gives skin and hair their color.
- **perspiration**: Sweat, made almost completely of water, with tiny amounts of other chemicals like ammonia, urea, salts, and sugar.
- **sebum**: Oily substance secreted in the skin.
- **sweat gland**: Small gland that secretes sweat.

## Summary

- Skin serves many functions, from acting as a barrier that keeps particles and water out of the body, to helping to cool the body.
- Skin is made up of two layers, the epidermis and the dermis.

## Practice

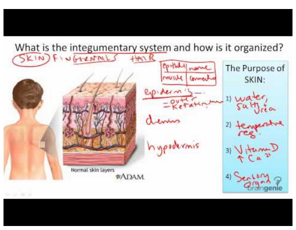
Use the resources below to answer the questions that follow.

- **The Human Skin** at http://www.youtube.com/watch?v=d-IJhAWrsm0 (1:08)

MEDIA
Click image to the left for more content.

1. What is the relationship of the epidermis to the dermis?
2. What is the importance of the basal layer? Is this part of the epidermis or the dermis?
3. What structures can you find in the dermis?

- **Integumentary System Structure and Function** at http://www.youtube.com/watch?v=PaHOd5fyKfE (2:59)




MEDIA
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1. What four functions of an organism is the skin involved in?
2. What is the hypodermis? What kinds of tissue are found here? Why is it important to controlling homeostasis that this occurs below the blood vessels of the skin?
3. What is the function of keratin? Why is this important to organisms?

## Review

1. What are some functions of the skin?
2. Describe the structure of the skin.

# 1.4 Nails and Hair

- Describe the structure of hair and nails.

**Why do you have arm hair?**

Hair covers much of our bodies. But why? Think of the way that you can sense something brush against your arm. Your arm hair is important in providing this type of sensation and making you aware of your environment. Also, hair can trap heat and keep your body warm.

## Hair and Nails

Along with the skin, the integumentary system includes the nails and hair. Both the skin and hair contain the tough protein, **keratin**. The keratin makes your nails and hair tough and strong.

### Nails

Fingernails and toenails both grow from nail beds. As the nail grows, more cells are added at the nail bed. Older cells get pushed away from the nail bed and the nail grows longer. There are no nerve endings in the nail. Otherwise cutting your nails would hurt a lot!

Nails act as protective plates over the fingertips and toes. Fingernails also help in sensing the environment. The area under your nail has many nerve endings. These nerve endings allow you to receive more information about objects you touch.

### Hair

Hair sticks out from the epidermis, but it grows from the dermis (**Figure** 1.7). Hair grows from inside the **hair follicle**. New cells grow in the bottom part of the hair, called the bulb. Older cells get pushed up, and the hair grows longer. The cells that make up the hair strand are dead and filled with keratin.

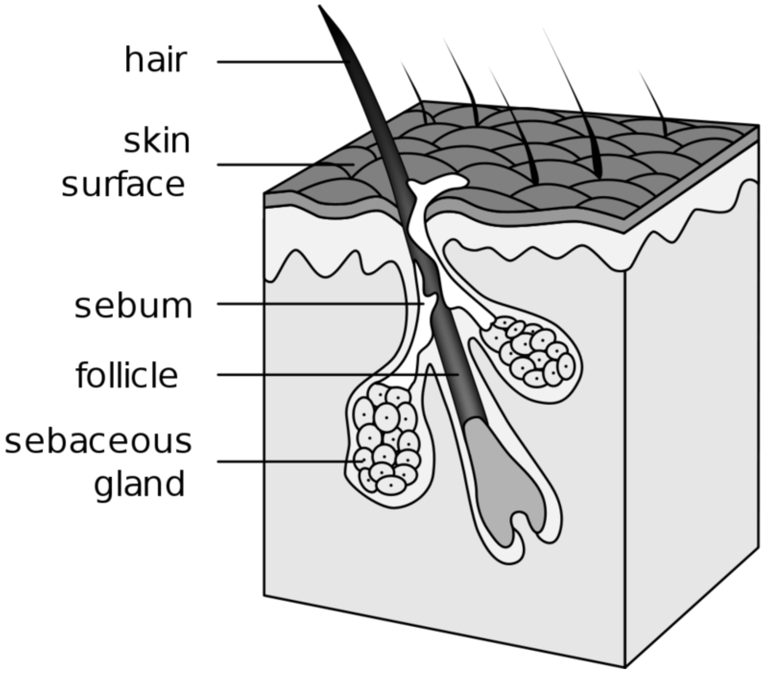



FIGURE 1.7
Hair, hair follicle, and oil glands. The oil, called sebum, helps to prevent water loss from the skin.

Hair, especially on the head, helps to keep the body warm. The air traps a layer of warm air near the skin and acts like a warm blanket. Hair can also act as a filter. Nose hair helps to trap particles in the air that may otherwise travel to the lungs. Eyelashes shield eyes from dust and sunlight. Eyebrows stop salty sweat and rain from flowing into the eye.

### Vocabulary

- **hair follicle**: Cavity containing the root of a hair.
- **keratin**: Tough protein in nails and hair.

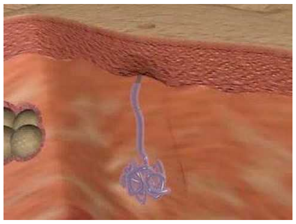
### Summary

- Hair and nails are made of keratin, a tough protein.
- Nails act as protective plates over the fingertips and toes.
- Hair serves many functions such as acting as a filter and keeping the body warm.

### Practice

Use the resources below to answer the questions that follow.

- **Skin, Hair, Nails** at http://www.youtube.com/watch?v=IAAt_MfIJ-Y (1:12)



MEDIA

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1. What is the function of your nails? How do they grow?
2. What is the function of the oil glands in your skin?
3. What are the functions of hair? How does the importance of these functions vary between organisms?

- **Integumentary System** at http://www.youtube.com/watch?v=tOHrIXfO6eU (4:03)


MEDIA

Click image to the left for more content.

1. What is the function of the integumentary system in the interior of your body?
2. If the integumentary system did not extend to the interior of the body, what problems could this cause for infection?
3. What is an appendage?
4. Why do people call the skin the largest sense organ in the body? What kinds of things does it sense?
5. What do we need to produce vitamin D? Where is it produced?

## Review

1. What are two functions of your nails?
2. What are two functions of your hair?

# 1.5 Keeping Skin Healthy

- Describe how to take care of your skin.

**Why shower every day?**

Of course, showering every day keeps you feeling and smelling fresh. But keeping clean is also good for your health! For example, a shower or bath washes away bacteria and viruses that could harm you.

## Keeping Skin Healthy

Your skin is your largest organ and constantly protects you from infections, so keeping your skin healthy is a good idea.

### Avoiding Sunburn

Some sunlight is good for your health. **Vitamin D** is made in the skin when it is exposed to sunlight. But getting too much sun can be unhealthy. A **sunburn** is a burn to the skin that is caused by overexposure to UV radiation from the sun's rays or tanning beds.

Light-skinned people, like the man pictured below (**Figure** 1.8), get sunburned more quickly than people with darker skin. This is because pigments in the skin act as a natural sunblock that help to protect the body from UV radiation.

Children and teens who have been sunburned are at a greater risk of developing skin cancer later in life. Long-term exposure to UV radiation is the leading cause of skin cancer. About 90 percent of skin cancers are linked to sun exposure. UV radiation damages the genetic material of skin cells. This damage can cause the skin cells to grow out of control and form a tumor. Some of these tumors are very difficult to cure. For this reason you should always wear sunscreen with a high sun protection factor (SPF), a hat, and clothing when out in the sun.

FIGURE 1.8
Sunburn is caused by overexposure to UV rays. Getting sunburned as a child or a teen, especially sunburn that causes blistering, increases the risk of developing skin cancer later in life.

### Keeping Clean

Keeping your skin clean is important because dirty skin is more prone to infection. Bathing every day helps to keep your skin clean and healthy. Also, you know that taking a bath or shower helps prevent body odor. But where does body odor come from? During the day, sweat, oil, dirt, dust, and dead skin cells can build up on the skin surface. If not washed away, the mix of these materials can encourage the excess growth of bacteria. These bacteria feed on these substances and cause a smell that is commonly called body odor.

## Vocabulary

- **sunburn**: Burn to the skin that is caused by overexposure to UV radiation from the sun's rays or tanning beds.
- **vitamin D**: Any of a group of sterols necessary for normal bone growth; found in milk, fish, and eggs and can be produced in the skin on exposure to sunlight.

## Summary

- Bathing every day helps to keep your skin clean and healthy.
- Excessive exposure to UV radiation from the sun or tanning beds is the leading cause of skin cancer.

## Practice

Use the resource below to answer the questions that follow.

- **Good Nutrition For Healthy Skin and Hair** at http://www.youtube.com/watch?v=bkdYEGJifDE (1:13)

MEDIA
Click image to the left for more content.

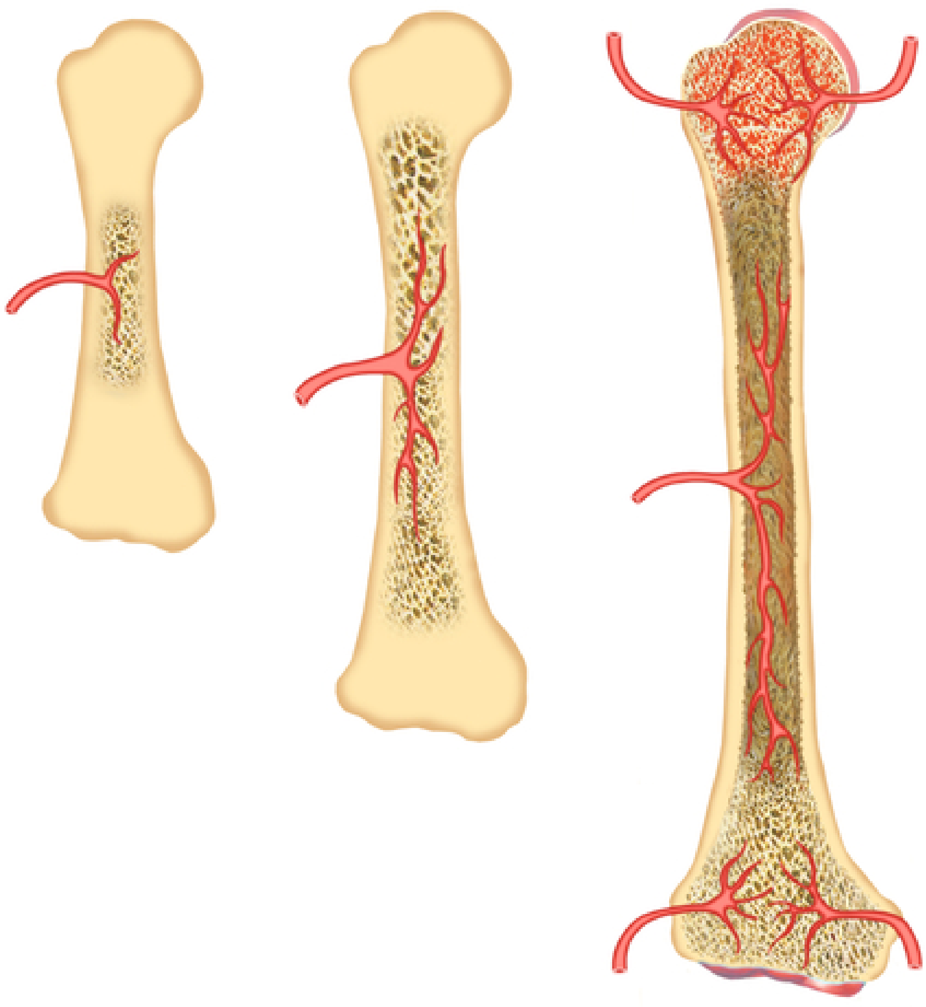
1. What nutrients are important for healthy skin?
2. What are good sources for these nutrients?
3. What is one of the roles that zinc plays in healthy skin?

## Review

1. Why is keeping your skin clean important?
2. Why is it important to avoid too much sun exposure?

# 1.6 Human Skeletal System

- Identify the main parts and functions of the skeletal system.
- Describe the structure of bones and how bones grow.



**Are bones alive?**

From seeing a skeleton, you might think that bones are just dead, hollow structures. But in a living person, those hollow spaces are full of living cells. Bones have a blood supply and nerves. Bones are a living tissue.

## Your Skeleton

How important is your skeleton? Can you imagine your body without it? You would be a wobbly pile of muscle and internal organs, and you would not be able to move.

The adult human skeleton has 206 bones, some of which are named below (**Figure** 1.9). Bones are made up of living tissue. They contain many different types of tissues. **Cartilage** is found at the end of bones and is made of tough protein fibers. Cartilage creates smooth surfaces for the movement of bones that are next to each other, like the bones of the knee.

**Ligaments** are made of tough protein fibers and connect bones to each other. Your bones, cartilage, and ligaments make up your **skeletal system**.

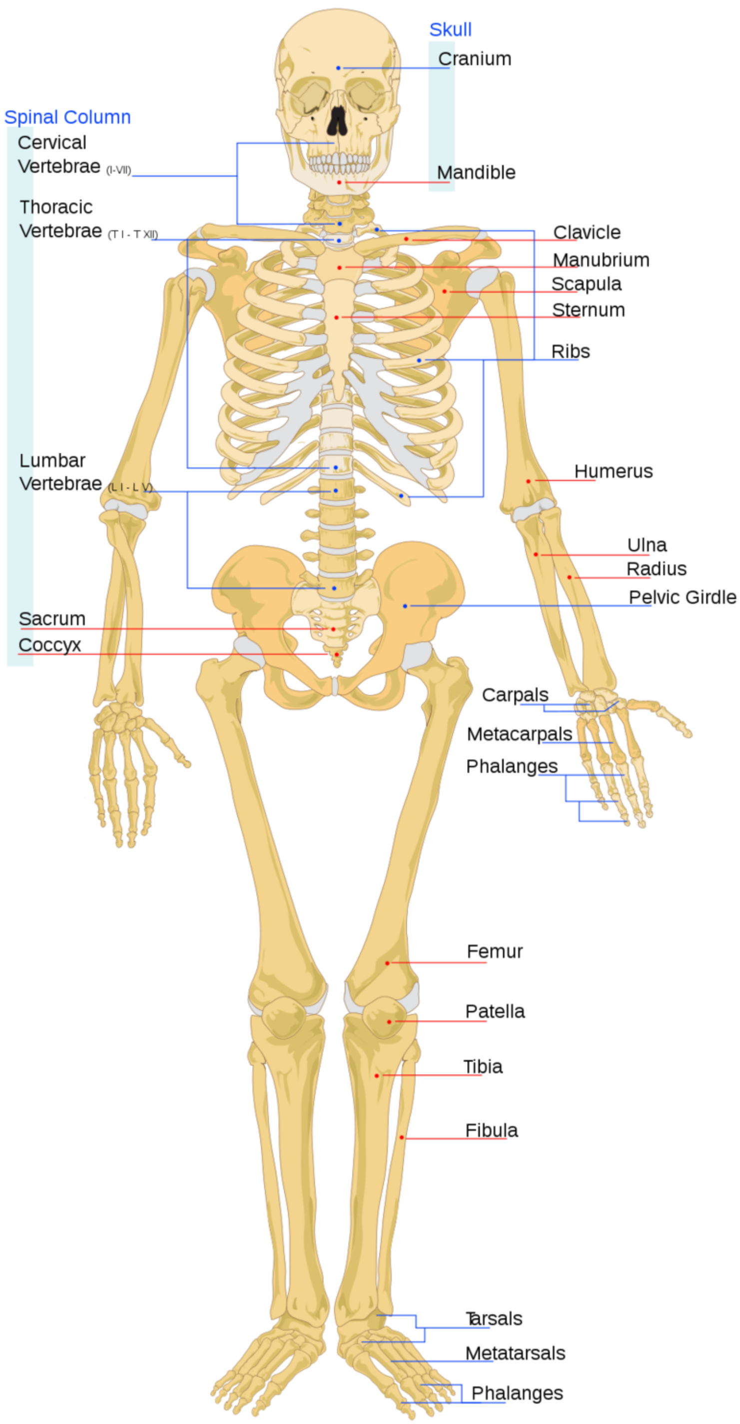



FIGURE 1.9

The skeletal system is made up of bones, cartilage, and ligaments. The skeletal system has many important functions in your body.

### Functions of Bones

Your skeletal system gives shape and form to your body, but it also plays other important roles. The main functions of the skeletal system include:

- Support. The skeleton supports the body against the pull of gravity, meaning you don't fall over when you stand up. The large bones of the lower limbs support the rest of the body when standing.
- Protection. The skeleton supports and protects the soft organs of the body. For example, the skull surrounds the brain to protect it from injury. The bones of the rib cage help protect the heart and lungs.
- Movement. Bones work together with muscles to move the body.
- Making blood cells. Blood cells are mostly made inside certain types of bones.
- Storage. Bones store calcium. They contain more calcium than any other organ. Calcium is released by the bones when blood levels of calcium drop too low. The mineral, phosphorus is also stored in bones.

### Structure of Bones

Bones come in many different shapes and sizes, but they are all made of the same materials. Bones are organs, and recall that organs are made up of two or more types of tissues.

The two main types of bone tissue are compact bone and spongy bone (**Figure** 1.10).

- **Compact bone** makes up the dense outer layer of bones.
- **Spongy bone** is found at the center of the bone and is lighter and more porous than compact bone.

Bones look tough, shiny, and white because they are covered by a layer called the **periosteum**. Many bones also contain a soft connective tissue called **bone marrow** in the pores of the spongy bone. Bone marrow is where blood cells are made.

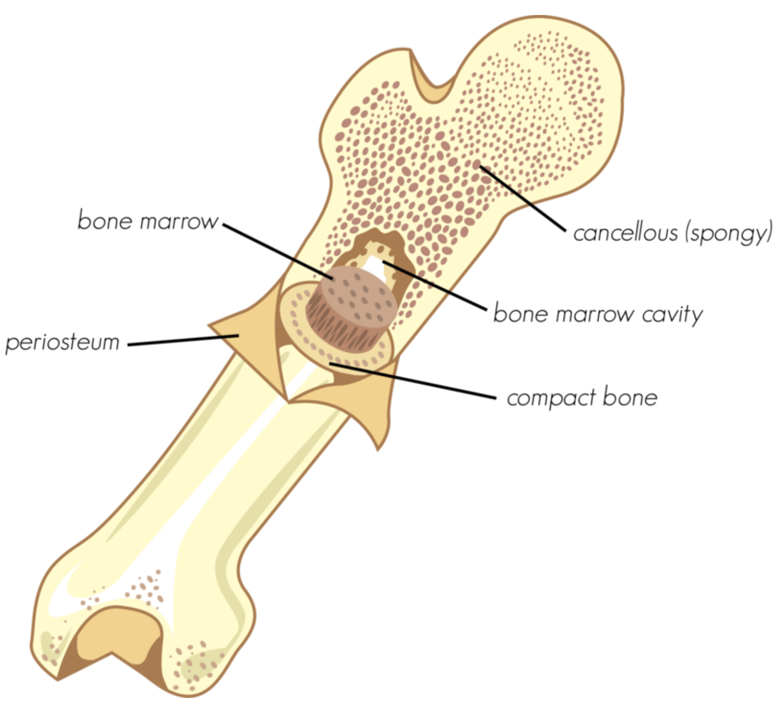



FIGURE 1.10
Bones are made up of different types of tissues.

### Bone Growth

Early in human development, the skeleton consists of only cartilage and other connective tissues. At this point, the skeleton is very flexible. As the fetus develops, hard bone begins to replace the cartilage, and the skeleton begins to harden. Not all of the cartilage, however, is replaced by bone. Cartilage remains in many places in your body, including your joints, your rib cage, your ears, and the tip of your nose.

A baby is born with zones of cartilage in its bones that allow growth of the bones. These areas, called **growth plates**, allow the bones to grow longer as the child grows. By the time the child reaches an age of about 18 to 25 years, all of the cartilage in the growth plate has been replaced by bone. This stops the bone from growing any longer. Even though bones stop growing in length in early adulthood, they can continue to increase in thickness throughout life. This thickening occurs in response to strain from increased muscle activity and from weight-lifting exercises.

## Vocabulary

- **bone marrow**: Soft connective tissue in spongy bone; makes blood cells.
- **cartilage**: Dense connective tissue that provides a smooth surface for the movement of bones at joints.
- **compact bone**: Dense outer layer of bone that is very hard and strong.
- **growth plate**: Area of growing tissue near the ends of the long bones in children and adolescents.
- **ligament**: Band of fibrous connective tissue that holds bones together.
- **periosteum**: Tough, fibrous membrane that covers the outer surface of bone.
- **skeletal system**: All the body's bones, cartilage, and ligaments.
- **spongy bone**: Light, porous inner layer of bone that contains bone marrow.

## Summary

- Bones, cartilage, and ligaments make up the skeletal system.
- Functions of the skeletal system include providing support, protecting the soft organs of the body, aiding in movement, and making blood cells.

## Practice

Use the resource below to answer the questions that follow.

- **Human Skeleton** at http://www.getbodysmart.com/ap/skeletalsystem/skeleton/menu/menu.html

1. What makes up the axial skeleton? What makes up the appendicular skeleton?
2. What is the scapula commonly known as? What is it's function? What other bone helps in this function?
3. How many thoracic vertebrae do humans have? Where are they located in the spinal column?
4. To which type of vertebrae do ribs attach?

## Review

1. List four functions of the skeletal system.
2. Describe the types of tissue that make up a bone.

# 1.7 Skeletal System Joints

- Describe the different types of joints and how they work.

**Why does his knee hurt?**

As you age, you might start noticing pain in your knees or elbows. These are examples of joints. Joints are the part of the skeletal system that connect your bones. Joint pain is a common problem as people age.

## Joints and How They Move

A **joint** is a point at which two or more bones meet. There are three types of joints in the body:

1. **Fixed joints** do not allow any bone movement. Many of the joints in your skull are fixed (**Figure** 1.11).
2. **Partly movable joints** allow only a little movement. Your backbone has partly movable joints between the vertebrae (**Figure** 1.12).
3. **Movable joints** allow the most movement.

Movable joints are also the most common type of joint in your body. Your fingers, toes, hips, elbows, and knees all provide examples of movable joints. The surfaces of bones at movable joints are covered with a smooth layer of cartilage. The cartilage reduces friction between the bones. Four types of movable joints are shown below.

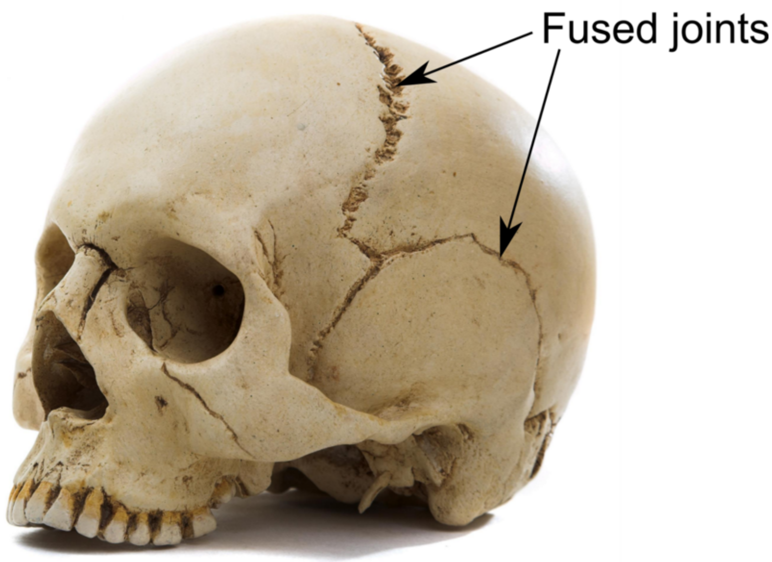



FIGURE 1.11
The skull has fixed joints. Fixed joints do not allow any movement of the bones, which protects the brain from injury.

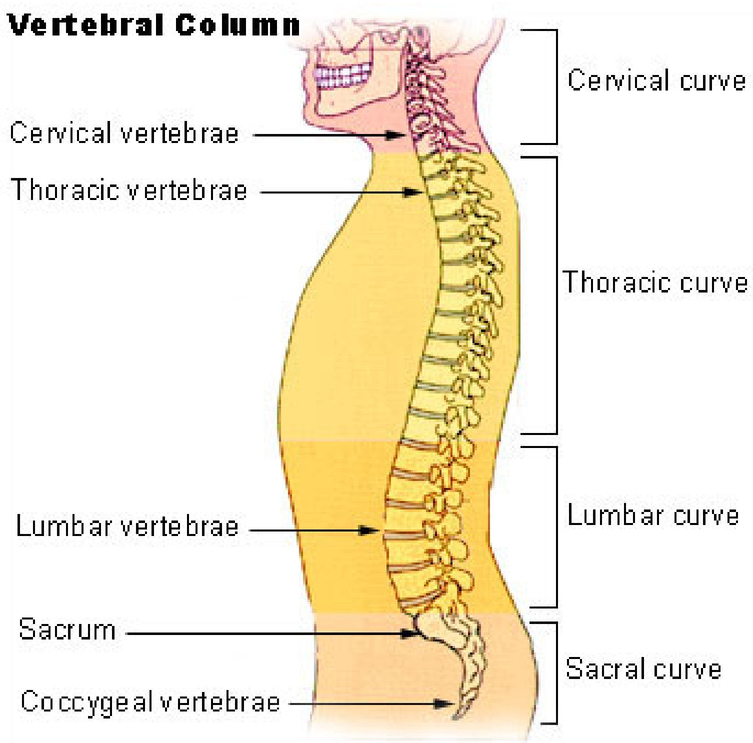



FIGURE 1.12
The joints between your vertebrae are partially movable.

1. In a **ball-and-socket joint**, the ball-shaped surface of one bone fits into the cup-like shape of another. Examples of a ball-and-socket joint include the hip (**Figure** 1.13) and the shoulder.

2. In a **hinge joint**, the ends of the bones are shaped in a way that allows motion in two directions, forward and backward. Examples of hinge joints are the knees (**Figure** 1.14) and elbows.

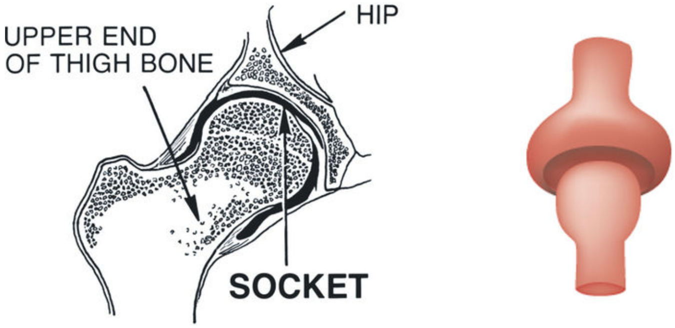



FIGURE 1.13
Your hip joint is a ball-and-socket joint. The "ball" end of one bone fits into the "socket" of another bone. These joints can move in many different directions.

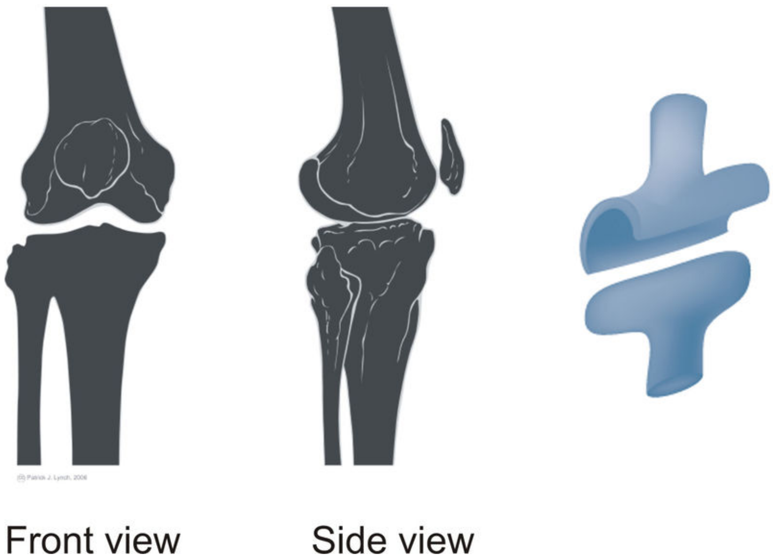



FIGURE 1.14
Hinge Joint. The knee joint is a hinge joint. Like a door hinge, a hinge joint allows backward and forward movement.

3. The **pivot joint** (**Figure** 1.15) only allows rotating movement. An example of a pivot joint is the joint between the radius and ulna that allows you to turn the palm of your hand up and down.

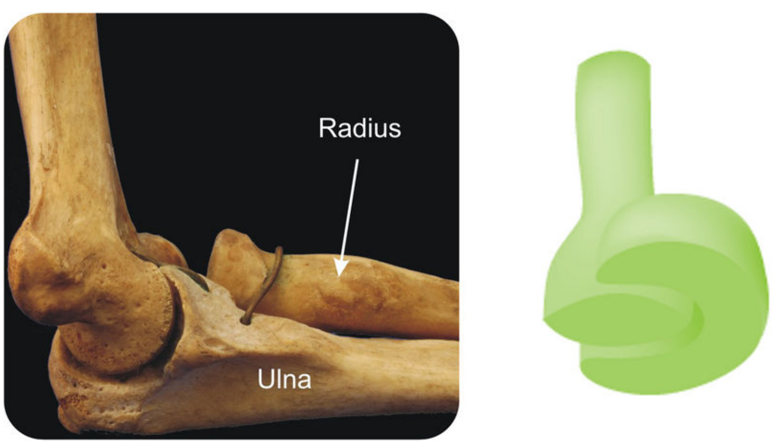



FIGURE 1.15
Pivot Joint. The joint at which the radius and ulna meet is a pivot joint. Movement at this joint allows you to flip your palm over without moving your elbow joint.

4. A **gliding joint** is a joint which allows only gliding movement. The gliding joint allows one bone to slide over the other. The gliding joint in your wrist allows you to flex your wrist. It also allows you to make very small side-to-side motions. There are also gliding joints in your ankles.

## Vocabulary

- **ball-and-socket joint**: Joint where the ball-shaped surface of one bone fits into the cup-like shape of another; examples include the hip and shoulder.
- **fixed joints**: Joint that does not allow movement.
- **gliding joint**: Joint that allows only gliding movement.
- **hinge joint**: Joint that only allows motion in two directions, forward and backward; examples include the knees and elbows.
- **joint**: Point at which two bones meet.
- **movable joints**: Joint that allows the most movement.
- **partly movable joints**: Joint that allows only very limited movement.
- **pivot joint**: Joint permitting only rotating movement.

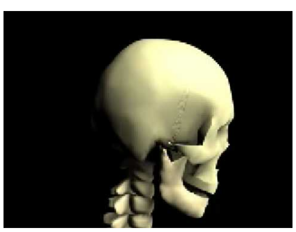
## Summary

- Joints, a point at which two or more bones meet; they can be fixed, partly movable, or movable.
- Types of movable joints include the ball-and-socket joint, hinge joint, pivot joint, and gliding joint.

## Practice

Use the resource below to answer the questions that follow.

- **Joints of the Skeleton** at http://www.youtube.com/watch?v=VsBJ4oUff10 (0:45)



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1. Why do we have both fixed and moveable joints? What is an example of a fixed joint? How would an organism be affected if this joint was moveable?
2. What are the best joints for movement?
3. What is synovial fluid? Where is it located? What is its function?
4. What is the function of the knee cap?

## Review

1. What's the difference between a fixed joint and a movable joint?
2. Describe the four types of movable joints.

# 1.8 Keeping Bones and Joints Healthy

- Describe problems of the skeletal system and steps you can take to keep your bones and joints healthy.

**Why drink milk?**

Milk is naturally a good source of calcium. Vitamin D is also often added to milk. Both these nutrients help build strong bones.

## Keeping Bones and Joints Healthy

You can help keep your bones and skeletal system healthy by eating well and getting enough exercise. Weight-bearing exercises help keep bones strong. Weight-bearing exercises work against gravity. Such activities include basketball, tennis, gymnastics, karate, running, and walking. When the body is exercised regularly by performing weight-bearing activity, bones respond by adding more bone cells to increase their bone density.

### Eating Well

Did you know that what you eat as a teenager can affect how healthy your skeletal system will be in 30, 40, and even 50 years? **Calcium** and **vitamin D** are two of the most important nutrients for a healthy skeletal system. Your bones need calcium to grow properly. If you do not get enough calcium in your diet as a teenager, your bones may become weak and break easily later in life.

**Osteoporosis** is a disease in which bones lose mass and become more fragile than they should be. Osteoporosis also makes bones more likely to break. Two of the easiest ways to prevent osteoporosis are eating a healthy diet that has the right amount of calcium and vitamin D and to do some sort of weight-bearing exercise every day. Foods that are a good source of calcium include milk, yogurt, and cheese. Non-dairy sources of calcium include Chinese cabbage, kale, and broccoli. Many fruit juices, fruit drinks, tofu, and cereals have calcium added to them. It is recommended that teenagers get 1300 mg of calcium every day. For example, one cup of milk provides about 300 mg of calcium, or about 30% of the daily requirement. Other sources of calcium are pictured below (**Figure** 1.16).

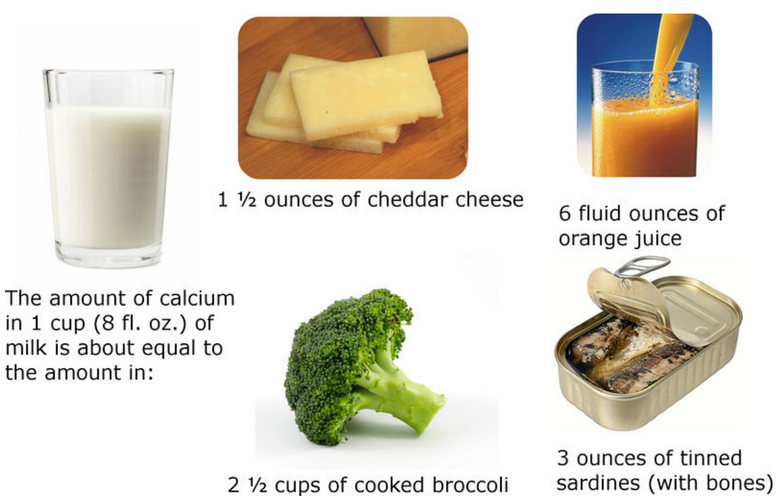



FIGURE 1.16
There are many different sources of calcium. Getting enough calcium in your daily diet is important for good bone health.

Vitamin D is unusual since you don't have to rely on your diet alone to get enough of this vitamin. Your skin makes vitamin D when exposed to sunlight. Pigments in the skin act like a filter that can prevent the skin from making vitamin D. As a result, people with darker skin need more time in the sun than people with lighter skin to make the same amount of vitamin D.

You can also get vitamin D from foods. Fish is naturally rich in vitamin D. Vitamin D is added to other foods, including milk, soy milk, and breakfast cereals. Teenagers are recommended to get 5 micrograms (200 IU) of vitamin D every day. A $3\frac{1}{2}$-ounce portion of cooked salmon provides 360 IU of vitamin D.

### Bone Fractures

Even though they are very strong, bones can **fracture**, or break. Fractures can happen at different places on a bone. They are usually caused by excess bending stress on the bone. Bending stress is what causes a pencil to break if you bend it too far.

Soon after a fracture, the body begins to repair the break. The area becomes swollen and sore. Within a few days, bone cells travel to the break site and begin to rebuild the bone. It takes about two to three months before compact and spongy bone form at the break site. Sometimes the body needs extra help in repairing a broken bone. In such a case, a surgeon will piece a broken bone together with metal pins. Moving the broken pieces together will help keep the bone from moving and give the body a chance to repair the break. Below, a broken ulna has been repaired with pins (**Figure** 1.17).

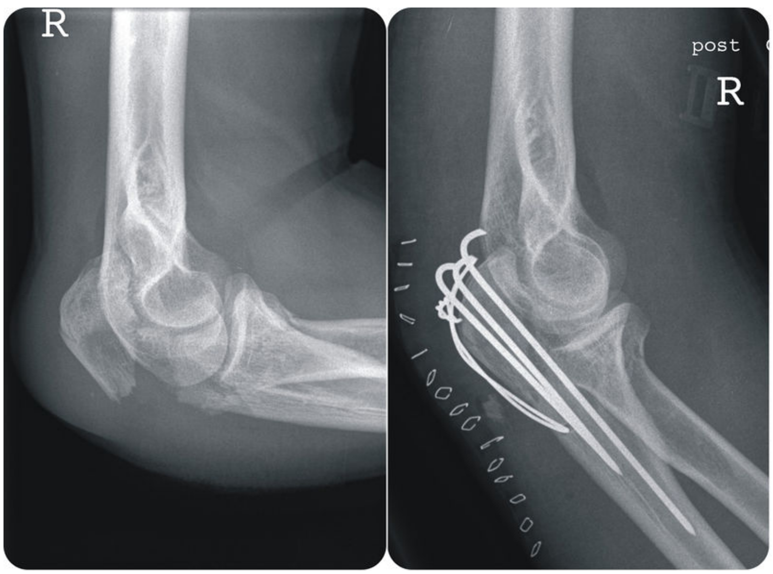



FIGURE 1.17
The upper part of the ulna, just above the elbow joint, is broken, as you can see in the X-ray to the left. The x-ray to the right was taken after a surgeon inserted a system of pins and wires across the fracture to bring the two pieces of the ulna into close proximity.

### Cartilage Injuries

**Osteoarthritis** occurs when the cartilage at the ends of the bones breaks down. The break down of the cartilage leads to pain and stiffness in the joint. Decreased movement of the joint because of the pain may lead to weakening of the muscles that normally move the joint, and the ligaments surrounding the joint may become looser. Osteoarthritis is the most common form of **arthritis**. It has many contributing factors, including aging, sport injuries, fractures, and obesity.

### Ligament Injuries

Recall that a **ligament** is a short band of tough connective tissue that connects bones together to form a joint. Ligaments can get injured when a joint gets twisted or bends too far. The protein fibers that make up a ligament can get strained or torn, causing swelling and pain. Injuries to ligaments are called **sprains**. Ankle sprains are a common type of sprain.

### Preventing Injuries

Preventing injuries to your bones and ligaments is easier and much less painful than treating an injury. Wearing the correct safety equipment when performing activities that require such equipment can help prevent many common injuries. For example, wearing a bicycle helmet can help prevent a skull injury if you fall. Warming up and cooling down properly can help prevent ligament and muscle injuries. Stretching before and after activity also helps prevent injuries.

## Vocabulary

- **arthritis**: Inflammation of a joint causing pain and swelling.
- **calcium**: Element that is a component of bone; a necessary element in nerve conduction, heartbeat, muscle contraction, and many other physiological functions.
- **fracture**: Break in bone.
- **ligament**: Short band of tough connective tissue that connects bones together to form a joint.
- **osteoarthritis**: Condition in which cartilage breaks down in joints, causing stiffness and pain.
- **osteoporosis**: Disease in which bones become more fragile and likely to break.
- **sprains**: Injuries to ligaments where a joint is put through a range of motion greater than its normal range.
- **vitamin D**: Any of a group of sterols necessary for normal bone growth; found in milk, fish, and eggs and can be produced in the skin on exposure to sunlight.

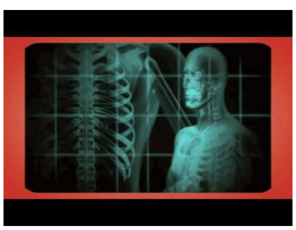
## Summary

- You can keep your bones healthy through weight-bearing exercises and getting enough calcium and vitamin D in your diet.
- Possible problems of the skeletal system include osteoporosis, osteoarthritis, fractures, and sprains.

## Practice

Use the resource below to answer the questions that follow.

- **Healthy Bones and Joints** at http://www.youtube.com/watch?v=jHwJq1TJE18 (1:47)



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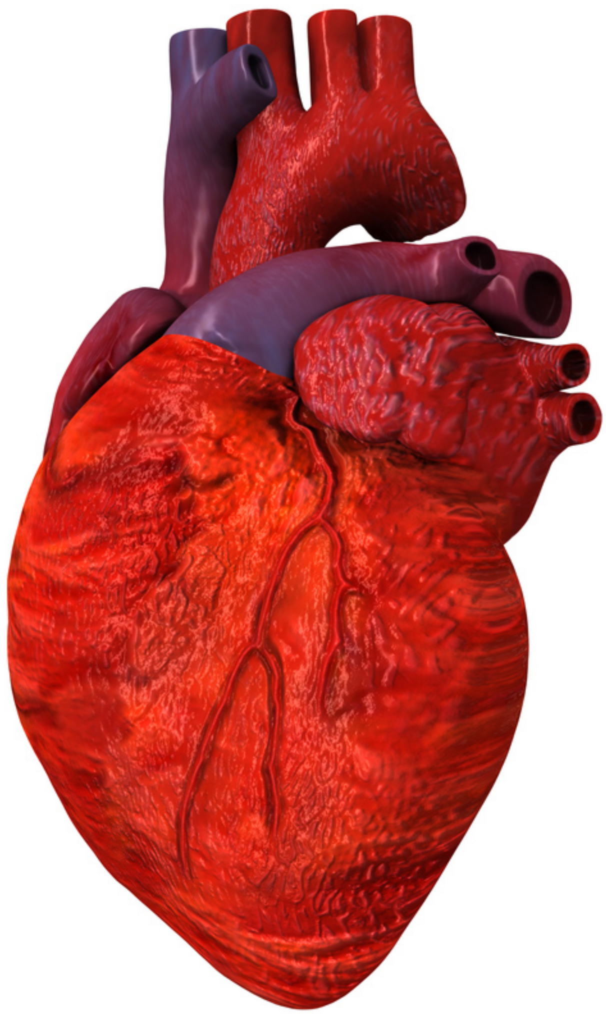
1. How much calcium does the average person need per day? What are good sources of calcium? What vitamin helps you process calcium?
2. How do weight-bearing exercises help your bones?
3. How can table salt (NaCl) be bad for your bones?

## Review

1. What are two good habits to keep your skeletal system healthy?
2. What is osteoarthritis?

# 1.9 Smooth, Skeletal, and Cardiac Muscles

- Identify the three muscle types in the body.



**Does the heart have muscles?**

When you think of muscles, you might think of biceps and the external muscles you see in a bodybuilder. However, some muscles are found deep inside your body. The heart, for example, is a very muscular organ. It has to pump blood all around your body.

## Types of Muscles

The **muscular system** consists of all the muscles in the body. This is the body system that allows us to move. You also depend on many muscles to keep you alive. Your heart, which is mostly muscle, pumps blood around your body.

Each muscle in the body is made up of cells called muscle fibers. **Muscle fibers** are long, thin cells that can do something that other cells cannot do—they are able to get shorter. Shortening of muscle fibers is called **contraction**. Nearly all movement in the body is the result of muscle contraction.

You can control some muscle movements. However, certain muscle movements happen without you thinking about them. Muscles that are under your conscious control are called **voluntary muscles**. Muscles that are not under your conscious control are called **involuntary muscles**.

Muscle tissue is one of the four types of tissue found in animals. There are three different types of muscle in the body (**Figure** 1.18):

1. **Skeletal muscle** is made up of voluntary muscles, usually attached to the skeleton. Skeletal muscles move the body. They can also contract involuntarily by reflexes. For example, you can choose to move your arm, but your arm would move automatically if you were to burn your finger on a stove top.
2. **Smooth muscle** is composed of involuntary muscles found within the walls of organs and structures such as the esophagus, stomach, intestines, and blood vessels. These muscles push materials like food or blood through organs. Unlike skeletal muscle, smooth muscle can never be under your control.
3. **Cardiac muscle** is also an involuntary muscle, found only in the heart. The cardiac muscle fibers all contract together, generating enough force to push blood throughout the body.


FIGURE 1.18
There are three types of muscles in the body: cardiac, skeletal, and smooth.

## Vocabulary

- **cardiac muscle**: Involuntary muscle found only in the walls of the heart.
- **contraction**: Shortening of muscle fibers.
- **involuntary muscle**: Muscle that is not under your conscious control.
- **muscle fiber**: Long, thin cell that has the ability to contract, or shorten.
- **muscular system**: Consists of all the muscles in the body, especially the ones that help you move.

- **skeletal muscle**: Voluntary muscle that is attached to bones of the skeleton and helps the body move.
- **smooth muscle**: Involuntary muscle that is found in the walls of internal organs, such as the stomach.
- **voluntary muscle**: Muscle that is under your conscious control.

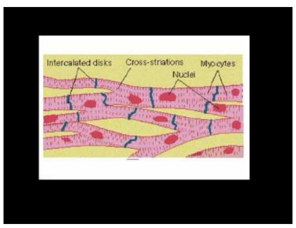
## Summary

- Muscles that are under your conscious control are called voluntary muscles, while muscles that are not under your conscious control are called involuntary muscles.
- The three types of muscles in the body include skeletal muscle, smooth muscle, and cardiac muscle.

## Practice

Use the resource below to answer the questions that follow.

- **Three Types of Muscles** at http://www.youtube.com/watch?v=Y9yTwS4v0Gc (4:04)

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1. Why are some muscles called "voluntary" and some called "involuntary"?
2. How is it beneficial for an organism to have both voluntary and involuntary muscles? Think carefully, and explain your answer fully.
3. What is the function of skeletal muscles? What is the function of cardiac muscles? How do these different functions relate to the structural differences between the types of muscle?
4. Where are smooth muscles found? What is the function of smooth muscles? Given the function of smooth muscles, are you surprised by where they are found? Why or why not?

## Review

1. Which two of the three types of muscles in the body are involuntary?
2. Distinguish between skeletal muscle and smooth muscle.

# 1.10 Muscles, Bones, and Movement

- Describe how skeletal muscles and bones work together to move the body.

**Do muscles come in pairs?**

This woman is doing a stretch for the muscles on the back of her legs, the hamstrings. She also has a muscles on the front of her legs, directly opposite the hamstrings. These are the quadriceps. The hamstrings and quadriceps work together as a pair to move your legs back and forth while you run.

## Muscles, Bones, and Movement

Skeletal muscles are attached to the skeleton by tendons. A **tendon** is a tough band of connective tissue that connects a muscle to a bone. Tendons are similar to ligaments, except that ligaments join bones to each other.

Muscles move the body by contracting against the skeleton. When muscles contract, they get shorter. By contracting, muscles pull on bones and allow the body to move.

Muscles can only contract. They cannot actively extend, though they can move back into the non-contracted neutral position. Therefore, to move bones in opposite directions, pairs of muscles must work in opposition. Each muscle in the pair works against the other to move bones at the joints of the body. The muscle that contracts to cause a joint to bend is called the **flexor**. The muscle that contracts to cause the joint to straighten is called the **extensor**. When one muscle is contracted, the other muscle from the pair is always elongated.

For example, the biceps and triceps muscles work together to allow you to bend and straighten your elbow. When you want to bend your elbow, your biceps muscle contracts (**Figure** 1.19), and, at the same time, the triceps muscle relaxes. The biceps is the flexor, and the triceps is the extensor of your elbow joint.

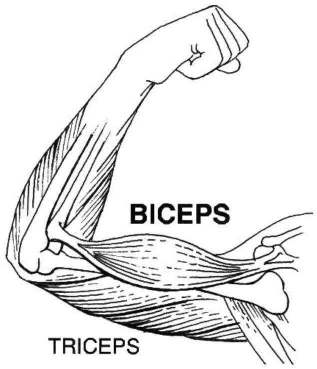


FIGURE 1.19
The biceps and triceps act against one another to bend and straighten the elbow joint. To bend the elbow, the biceps contracts and the triceps relaxes. To straighten the elbow, the triceps contract and the biceps relax.

## Vocabulary

- **extensor**: Muscle that contracts to cause a joint to straighten.
- **flexor**: Muscle that contracts to cause a joint to bend.
- **tendon**: Tough connective tissue that attaches muscle to bones.

## Summary

- Muscles move the body by contracting against the skeleton.
- Muscles work together in pairs to bend or straighten the joint.

## Practice

Use the resource below to answer the questions that follow.

- **Muscles and Movement** at http://www.youtube.com/watch?v=1SGM06DiXLc (1:38)


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1. How does the biceps muscle move when you bend your arm? How does the triceps muscle move when you bend your arm?
2. How does the triceps muscle move when you straighten your arm? How does the biceps muscle move when you straighten your arm?
3. Why can muscles only pull and not push? How is this related to muscles working in pairs?

## Review

1. How are skeletal muscles attached to the skeleton?
2. Explain why many skeletal muscles must work in opposing pairs.

# 1.11 Muscles and Exercise

- Describe how exercise affects the muscular system.

**What is aerobic exercise?**

When you hear the word "aerobic," an aerobics class may come to mind. But that's just one type of aerobic exercise. Aerobic exercise is any exercise that strengthens your cardiovascular system—playing basketball or swimming, for example.

## Muscles and Exercise

Regular physical exercise is important in preventing **lifestyle diseases** such as cardiovascular disease, some types of cancer, type 2 diabetes, and obesity. Regular exercise also improves the health of the muscular system. Muscles that are exercised are bigger and stronger than muscles that are not exercised.

Exercise improves both muscular strength and muscular endurance. **Muscular strength** is the ability of a muscle to use force during a contraction. **Muscular endurance** is the ability of a muscle to continue to contract over a long time without getting tired.

Exercises are grouped into three types depending on the effect they have on the body:

- **Aerobic exercises**, such as cycling, walking, and running, increase muscular endurance and cardiovascular health.
- **Anaerobic exercises**, such as weight training or sprinting, increase muscle strength.
- Flexibility exercises, such as stretching, improve the range of motion of muscles and joints. Regular stretching helps people avoid activity-related injuries.

### Anaerobic Exercise and Muscular Strength

Anaerobic exercises cause muscles to get bigger and stronger. Anaerobic exercises use a resistance against which the muscle has to work to lift or push away. The resistance can be a weight or a person's own body weight (**Figure** 1.20).

FIGURE 1.20
Anaerobic exercises involve the muscles working against resistance. In this case the resistance is the weight of a barbell.

### Aerobic Exercise and Muscular Endurance

Aerobic exercises are exercises that cause your heart to beat faster and allow your muscles to use oxygen to contract. If you exercise aerobically, overtime, your muscles will not get easily tired, and you will use oxygen more efficiently. Aerobic exercise (**Figure** 1.21) also helps improve cardiac muscle.

### Muscle Injuries

Sometimes muscles and tendons get injured when a person starts doing an activity before they have warmed up properly. A warm up is a slow increase in the intensity of a physical activity that prepares muscles for an activity. Warming up increases the blood flow to the muscles and increases the heart rate. Warmed-up muscles and tendons are less likely to get injured. For example, before running or playing soccer, a person might jog slowly to warm muscles and increase their heart rate. Even elite athletes need to warm up (**Figure** 1.22).

When you don't do a proper warm-up, several types of injuries can occur. A **strain** happens when muscle or tendons tear. Strains are also known as "pulled muscles." Another common injury is **tendinitis**, the irritation of the tendons. Strains and tendinitis are usually treated with rest, cold compresses, and stretching exercises that a physical therapist designs for each patient.

Injuries can also be prevented by proper rest and recovery. If you do not get enough rest, your body will become injured and will not react well to exercise, or improve. You can also rest by doing a different activity. For example, if you run, you can rest your running muscles and joints by swimming.

### Vocabulary

- **aerobic exercise**: Activity that increases muscular endurance and cardiovascular health.

FIGURE 1.21
When done regularly, aerobic activities, such as cycling, make the heart stronger.

FIGURE 1.22
Warming up before the game helps the players avoid injuries. Some warm-ups may include stretching exercises.

- **anaerobic exercise**: Activity that increases muscle strength.
- **lifestyle disease**: Diseases that appear to increase in frequency as countries become more industrialized and people live longer; can include heart disease, obesity, type 2 diabetes, and some kinds of cancer.
- **muscular endurance**: Ability of a muscle to do continous work over a long period of time.
- **muscular strength**: Amount of force that your muscles can exert against resistance.
- **strain**: Tearing of a muscle or tendon.
- **tendinitis**: Irritation of the tendon.

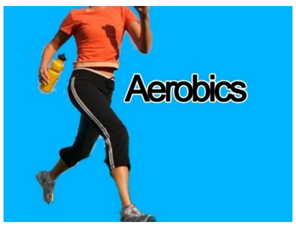
## Summary

- Aerobic exercise helps improve the cardiovascular system, while anaerobic exercise causes muscles to get bigger and stronger.
- Muscle strain and tendinitis can be prevented by warming up before rigorous exercise and allowing your muscles to rest and recover.

## Practice

Use the resources below to answer the questions that follow.

- **What is Aerobic Exercise?** at http://www.youtube.com/watch?v=7g65AeKO6Dw (2:05)

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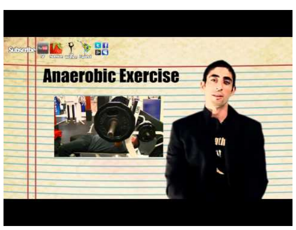
1. What makes an exercise aerobic?
2. What are some of the benefits of aerobic exercise?
3. How does aerobic exercise benefit your heart?

- **What is Anaerobic Exercise?** at http://www.youtube.com/watch?v=kqEX1MQXCt8 (2:42)

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1. What makes an exercise anaerobic?
2. What are some of the benefits of anaerobic exercise?
3. How can anaerobic exercise affect your skeletal system? Explain your answer fully.

- **Health Benefits of Yoga** at http://www.youtube.com/watch?v=X-TuG4a-GJs (3:37)

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1. How old is the practice of yoga?
2. What are some of the benefits of yoga exercise?

### Review

1. What are the health benefits of aerobic exercise?
2. Describe two types of muscle injuries.

# 1.12 Food and Nutrients

- Explain why the body needs food.

**What happens when you don’t eat?**

Refusing one meal won’t stunt your growth. But lack of proper food over a period of time can lead to malnutrition. That means, the body is not getting enough nutrients to grow and stay healthy. Kids who are malnourished may not grow as tall as they would otherwise.

## Why We Need Food

Did you ever hear the old saying, “An apple a day keeps the doctor away”? Do apples really prevent you from getting sick? Probably not, but eating apples and other fresh fruits can help keep you healthy. The girls pictured below are eating salads (**Figure** 1.23). Why do you need foods like these for good health? What role does food play in the body?

FIGURE 1.23
These girls are eating leafy green vegetables. Fresh vegetables such as these are excellent food choices for good health.

Your body needs food for three reasons:

1. Food gives your body energy. You need energy for everything you do. Remember that **cellular respiration** converts the glucose in the food you eat into **ATP**, or cellular energy.
2. Food provides building materials for your body. Your body needs building materials so it can grow and repair itself.
3. Food contains substances that help control body processes. Your body processes must be kept in balance for good health.

For all these reasons, you must have a regular supply of nutrients. **Nutrients** are chemicals in food that your body needs. There are five types of nutrients:

1. **Carbohydrates**.
2. **Proteins**.
3. **Lipids**.
4. **Vitamins**.
5. **Minerals**.

Carbohydrates, proteins, and lipids are categories of organic compounds. They give your body energy, though carbohydrates are the main source of energy. Proteins provide building materials, such as amino acids to build your own proteins. Proteins, vitamins, and minerals also help control body processes.

### Vocabulary

- **ATP (adenosine triphosphate)**: Usable form of energy inside the cell.
- **carbohydrate**: Organic compound such as sugar and starch that provides an energy source for animals.
- **cellular respiration**: Process of breaking down glucose to obtain energy in the form of ATP.
- **lipid**: Organic compound that is insoluble in water and includes fats, oils, and waxes.
- **mineral**: Chemical element, such as calcium or potassium, that is needed for body processes.
- **nutrient**: Chemical in food that your body needs.

- **protein**: Organic compound composed of amino acids and includes enzymes, antibodies, and muscle fibers.
- **vitamin**: Organic compound needed in small amounts for the body to function properly.

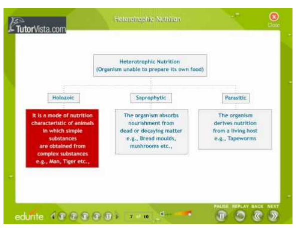
## Summary

- Your body needs food to obtain energy, to get building blocks for your body, and to get substances that help control body processes.
- Nutrients, chemicals in food that your body needs, include carbohydrates, proteins, lipids, vitamins, and minerals.

## Practice

Use the resource below to answer the questions that follow.

- **Nutrition** at http://www.youtube.com/watch?v=2xbD6–X0IA (6:39)




MEDIA

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1. What do organisms use "food" for?
2. What is a heterotroph? Are humans autotrophic or heterotrophic?
3. What are the three types of heterotrophic organisms?

## Review

1. Why does your body need food?
2. What are nutrients?

# 1.13 Types of Nutrients

- Identify the roles of carbohydrates, proteins, and lipids.

**What nutrients are in this meal?**

There are many different nutrients that are present in this meal. For example, the steak is a source of protein. The french fries are a source of carbohydrates. Both these nutrients help supply the body with energy.

## Nutrients

Carbohydrates, proteins, and lipids contain energy. When your body digests food, it breaks down the molecules of these nutrients. This releases the energy so your body can use it.

### Carbohydrates

**Carbohydrates** are nutrients that include sugars, starches, and fiber. There are two types of carbohydrates: simple and complex. Pictured below are some foods that are good sources of carbohydrates (**Figure** 1.24).

### Simple Carbohydrates

Sugars are small, simple carbohydrates that are found in foods such as fruits and milk. The sugar found in fruits is called fructose. The sugar found in milk is called lactose. These sugars are broken down by the body to form glucose ($C_6H_{12}O_6$), the simplest sugar of all. Through the process of **cellular respiration**, glucose is converted by cells into energy.

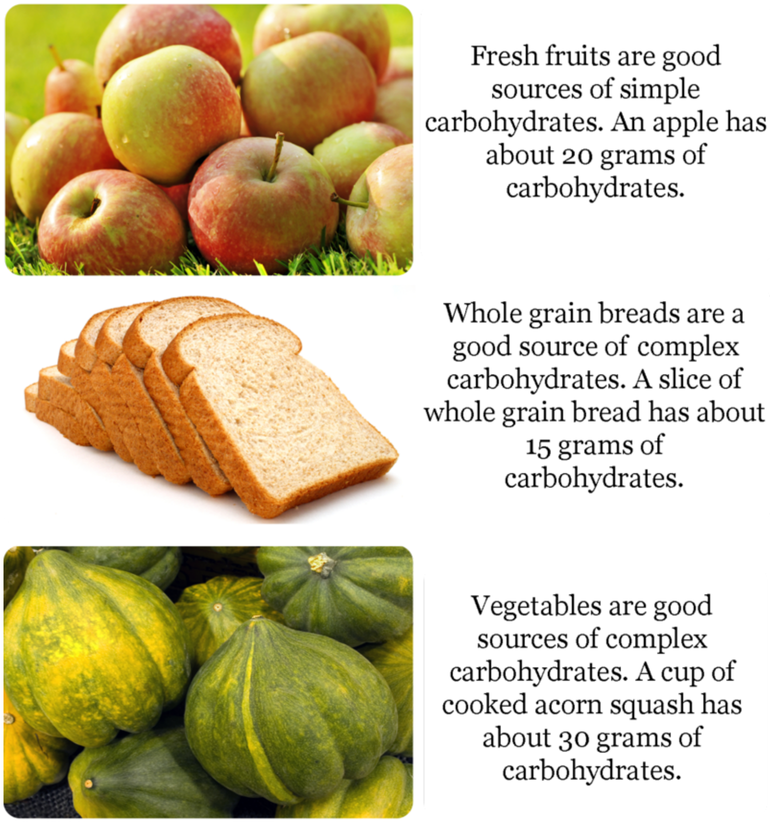


FIGURE 1.24

Up to the age of 13 years, you need about 130 grams of carbohydrates a day. Most of the carbohydrates should be complex. They are broken down by the body more slowly than simple carbohydrates. Therefore, they provide energy longer and more steadily.

### Complex Carbohydrates

**Starch** is a large, complex carbohydrate. Starches are found in foods such as vegetables and grains. Starches are broken down by the body into sugars that provide energy.

**Fiber** is another type of large, complex carbohydrate that is partly indigestible. Unlike sugars and starches, fiber does not provide energy. However, it has other important roles in the body. For example, fiber is important for maintaining the health of your gastrointestinal tract. Eating foods high in fiber also helps fill you up without providing too many calories. Most fruits and vegetables are high in fiber. Some examples are pictured below (**Figure** 1.25).

### Proteins

**Proteins** are nutrients made up of smaller molecules called **amino acids**. The amino acids are arranged like "beads on a string." These amino acid chains then fold up into a three-dimensional molecule, giving the protein a specific function. Proteins have several important roles in the body. For example, proteins make up muscles and help control body processes.

If you eat more than you need for these purposes, the extra protein is used for energy. The image below shows how many grams of protein you need each day (**Figure** 1.26). It also shows some foods that are good sources of protein.

### Lipids

**Lipids** are nutrients, such as fats that store energy. Lipids also have several other roles in the body. For example, lipids protect nerves and make up the membranes that surround cells.

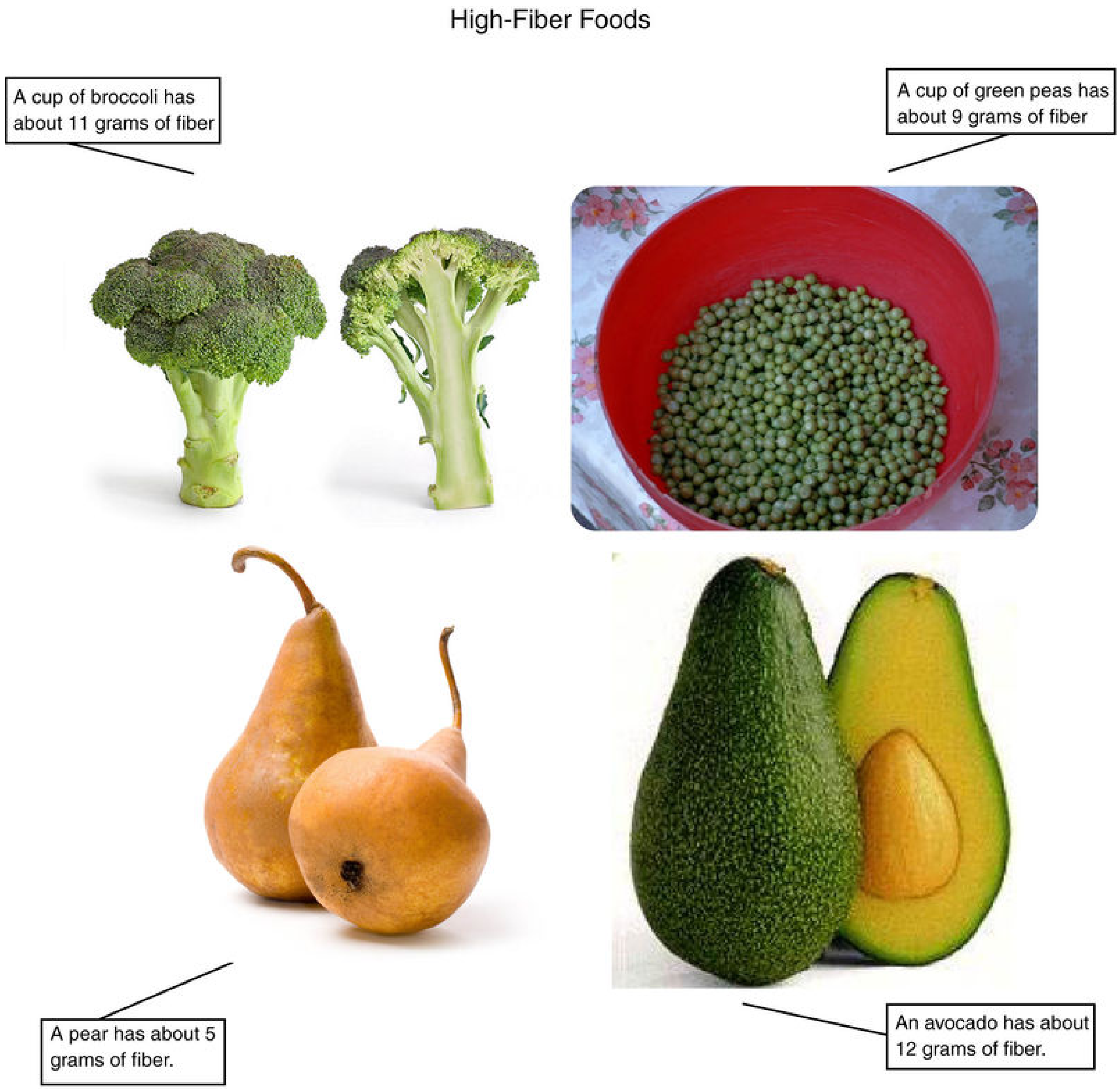


FIGURE 1.25
Between the ages of 9 and 13 years, girls need about 26 grams of fiber per day, and boys need about 31 grams of fiber per day.

Fats are one type of lipid. Stored fat gives your body energy to use for later. It's like having money in a savings account: it's there in case you need it. Stored fat also cushions and protects internal organs. In addition, it insulates the body. It helps keep you warm in cold weather.

There are two main types of fats, saturated and unsaturated.

1. **Saturated fats** can be unhealthy, even in very small amounts. They are found mainly in animal foods, such as meats, whole milk, and eggs. Saturated lipids increase cholesterol levels in the blood. Too much cholesterol

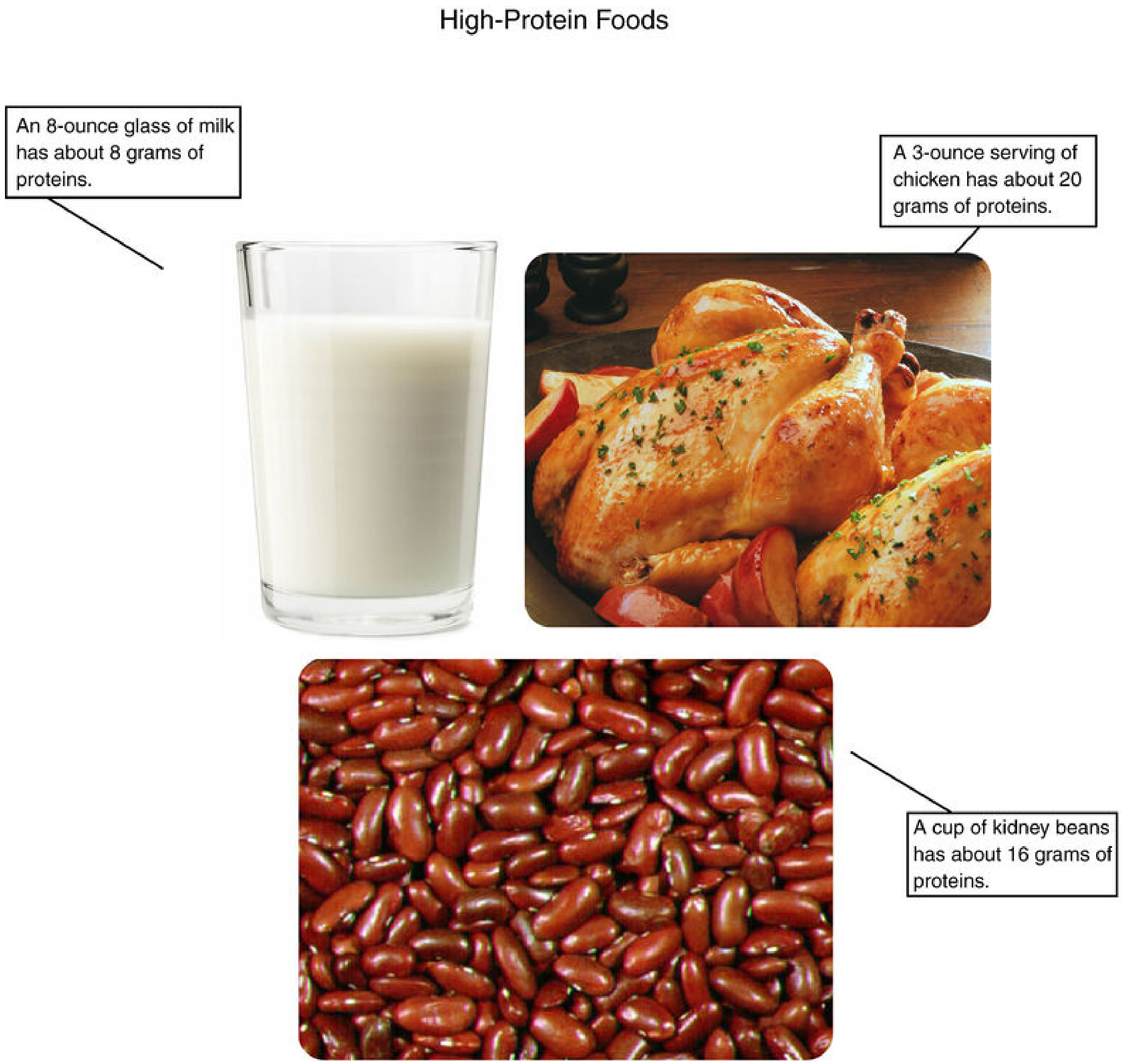


FIGURE 1.26
Between the ages of 9 and 13 years, you need about 34 grams of proteins a day.

in the blood can lead to heart disease. It is best to limit the amount of saturated lipids in your diet.

2. **Unsaturated fats** are found mainly in plant foods, such as vegetable oil, olive oil, and nuts. Unsaturated lipids are also found in fish, such as salmon. Unsaturated lipids are needed in small amounts for good health. Most lipids in your diet should be unsaturated.

Another type of lipid is called **trans fat**. Trans fats are manufactured and added to certain foods to keep them fresher for longer. Foods that contain trans fats include cakes, cookies, fried foods, and margarine. Eating foods that contain trans fats increases the risk of heart disease.

Beginning with Denmark in 2003, many nations now limit the amount of trans fat that can be in food products or ban these products all together. On January 1, 2008, Calgary became the first city in Canada to ban trans fats from restaurants and fast food chains. Beginning in 2010, California banned trans fats from restaurant products, and in 2011, from all retail baked goods.

### Vocabulary

- **amino acid**: Small molecule used to build proteins.
- **carbohydrate**: Organic compound such as sugar and starch that provides an energy source for animals.
- **cellular respiration**: Process of breaking down glucose to obtain energy in the form of ATP.
- **fiber**: Carbohydrate that is partially indigestible.
- **lipid**: Organic compound that is insoluble in water and includes fats, oils, and waxes.
- **protein**: Organic compound composed of amino acids and includes enzymes, antibodies, and muscle fibers.
- **saturated fat**: Fat derived from animal foods that increases cholesterol levels.
- **starch**: Large, complex carbohydrate that can be broken down to supply the body with energy.
- **trans fat**: Manufactured fat used in processed and fried foods that increases the risk of heart disease.
- **unsaturated fat**: Fat derived from plant foods that is part of a healthy diet.

### Summary

- Carbohydrates, proteins, and lipids provide energy and have other important roles in the body.
- Unsaturated fats are better for your health than trans fats or saturated fats.

### Practice

Use the resource below to answer the questions that follow.

- **Nutrients Your Body Needs** at http://www.pbs.org/wgbh/nova/body/nutrients-body-needs.html

1. What does your body use iodine for? What are good sources of iodine? What are some of the problems of iodine deficiency?
2. What does your body use magnesium for? What are good sources of magnesium? What problems come from magnesium deficiency?
3. What does your body use riboflavin for? What are good sources of riboflavin? What can happen if your diet is deficient in riboflavin?

### Review

1. Which nutrients can be used for energy?
2. Why is it important that you get enough proteins in foods?

# 1.14 Vitamins and Minerals

- Give examples of vitamins and minerals, and state their functions.

**How do you get your vitamins?**

You may take a vitamin pill. That is a good way to make sure you are getting most of the vitamins your body needs to grow. But the best way to get your vitamins is through eating a healthy diet.

## Vitamins and Minerals

Vitamins and minerals are also nutrients. They do not provide energy, but they are needed for good health.

### Vitamins

**Vitamins** are organic compounds that the body needs in small amounts to function properly. Humans need 13 different vitamins. Some of them are listed below (**Table** 1.2). The table also shows how much of each vitamin you need every day. Vitamins have many roles in the body. For example, Vitamin A helps maintain good vision. Vitamin $B_9$ helps form red blood cells. Vitamin K is needed for blood to clot when you have a cut or other wound.

**TABLE 1.2: Vitamins Needed for Good Health**

| Vitamin | Necessary for | Available from | Daily amount required (at ages 9–13 years) |
|---|---|---|---|
| vitamin A | good vision | carrots, spinach, milk, eggs | 600 $\mu$g (1 $\mu$g = 1 $\times$ $10^{-6}$ g) |
| vitamin $B_1$ | healthy nerves | whole wheat, peas, meat, beans, fish, peanuts | 0.9 mg (1 mg = 1 $\times$ $10^{-3}$ g) |

**TABLE 1.2:** (continued)

| Vitamin | Necessary for | Available from | Daily amount required (at ages 9–13 years) |
|---|---|---|---|
| vitamin $B_3$ | healthy skin and nerves | beets, liver, pork, turkey, fish, peanuts | 12 mg |
| vitamin $B_9$ | red blood cells | liver, peas, dried beans, leafy green vegetables | 300 $\mu$g |
| vitamin $B_{12}$ | healthy nerves | meat, liver, milk, shellfish, eggs | 1.8 $\mu$g |
| vitamin C | growth and repair of tissues | oranges, grapefruits, red peppers, broccoli | 45 mg |
| vitamin D | healthy bones and teeth | milk, salmon, tuna, eggs | 5 $\mu$g |
| vitamin K | blood to clot | spinach, Brussels sprouts, milk, eggs | 60 $\mu$g |

Some vitamins are produced in the body. For example, vitamin D is made in the skin when it is exposed to sunlight. Vitamins $B_{12}$ and K are produced by bacteria that normally live inside the body. Most other vitamins must come from foods. Foods that are good sources of vitamins include whole grains, vegetables, fruits, and milk (**Table** 1.2).

Not getting enough vitamins can cause health problems. For example, too little vitamin C causes a disease called scurvy. People with scurvy have bleeding gums, nosebleeds, and other symptoms.

### Minerals

**Minerals** are chemical elements that are needed for body processes. Minerals that you need in relatively large amounts are listed below (**Table** 1.3). Minerals that you need in smaller amounts include iodine, iron, and zinc.

Minerals have many important roles in the body. For example, calcium and phosphorus are needed for strong bones and teeth. Potassium and sodium are needed for muscles and nerves to work normally.

**TABLE 1.3: Minerals Needed for Good Health**

| Mineral | Necessary for | Available from | Daily amount required (at ages 9–13 years) |
|---|---|---|---|
| calcium | strong bones and teeth | milk, soy milk, leafy green vegetables | 1,300 mg |
| chloride | proper balance of water and salts in body | table salt, most packaged foods | 2.3 g |
| magnesium | strong bones | whole grains, leafy green vegetables, nuts | 240 mg |
| phosphorus | strong bones and teeth | meat, poultry, whole grains | 1,250 mg |
| potassium | muscles and nerves to work normally | meats, grains, bananas, orange juice | 4.5 g |
| sodium | muscles and nerves to work normally | table salt, most packaged foods | 1.5 g |

Your body cannot produce any of the minerals that it needs. Instead, you must get minerals from the foods you eat. Good sources of minerals include milk, leafy green vegetables, and whole grains (**Table** 1.3).

Not getting enough minerals can cause health problems. For example, too little calcium may cause osteoporosis. This is a disease in which bones become soft and break easily. Getting too much of some minerals can also cause health problems. Many people get too much sodium. Sodium is added to most packaged foods. People often add more sodium to their food by using table salt. Too much sodium causes high blood pressure in some people.

## Vocabulary

- **mineral**: Chemical element, such as calcium or potassium, that is needed for body processes.
- **vitamin**: Organic compound needed in small amounts for the body to function properly.

## Summary

- Vitamins and minerals do not provide energy but are needed in small amounts for the body to function properly.
- Some vitamins are produced in your body, while others must come from the foods you eat.

## Practice

Use the resource below to answer the questions that follow.

- **Smart Nutrition** at http://www.youtube.com/watch?v=3wL0BghxeHc (3:42)

MEDIA

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1. Why is calcium so important to teenagers? What are sources of calcium?
2. Why is it important to have enough iron in your diet? What vitamin helps you utilize iron?
3. Why is vitamin D so important to teenagers? What are good sources of vitamin D?

## Review

1. List two vitamins and their roles in the body.
2. List two minerals and their roles in the body.

# 1.15 Choosing Healthy Foods

- Describe how to choose foods wisely for optimal health.

**Which foods would be the best choice?**

Each day you make many food choices. You decide which lunch line to get into. Then you may choose an after-school snack. How can you make the most healthy decisions?

## Choosing Healthy Foods

Foods such as whole grain breads, fresh fruits, and fish provide nutrients you need for good health. But different foods give you different types of nutrients. You also need different amounts of each nutrient. How can you choose the right mix of foods to get the proper balance of nutrients? Three tools can help you choose foods wisely: MyPyramid, MyPlate, and food labels.

### MyPyramid

**MyPyramid** (**Figure** 1.27) is a diagram that shows how much you should eat each day of foods from six different food groups. It recommends the amount of nutrients you need based on your age, your gender, and your level of activity. The six food groups in MyPyramid are:

- Grains, such as bread, rice, pasta, and cereal.
- Vegetables, such as spinach, broccoli, carrots, and sweet potatoes.
- Fruits, such as oranges, apples, bananas, and strawberries.
- Oils, such as vegetable oil, canola oil, olive oil, and peanut oil.
- Dairy, such as milk, yogurt, cottage cheese, and other cheeses.
- Meat and beans, such as chicken, fish, soybeans, and kidney beans.

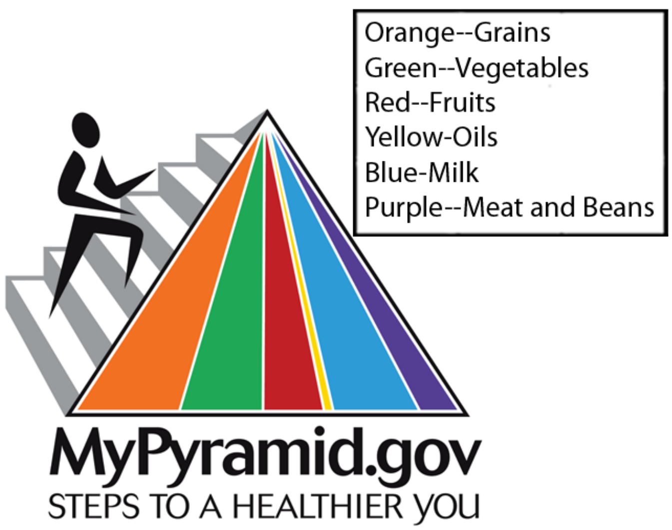


FIGURE 1.27
MyPyramid can help you choose foods wisely for good health. Each colored band represents a different food group. The key shows which food group each color represents. Which colored band of MyPyramid is widest? Which food group does it represent?

In MyPyramid, each food group is represented by a band of a different color. For example, grains are represented by an orange band, and vegetables are represented by a green band. The wider the band, the more foods you should choose from that food group each day.

The orange band in MyPyramid is the widest band. This means that you should choose more foods from the grain group than from any other single food group. The green, blue, and red bands are also relatively wide. Therefore, you should choose plenty of foods from the vegetable, dairy, and fruit groups as well. You should choose the fewest foods from the food group with the narrowest band. Which band is narrowest? Which food group does it represent?

Are you wondering where foods like ice cream, cookies, and potato chips fit into MyPyramid? The white tip of MyPyramid represents foods such as these. These are foods that should be eaten only in very small amounts and not very often. Such foods contain very few nutrients and are called nutrient-poor. Instead, they are high in fats, sugars, and sodium, which are nutrients that you should limit in a healthy eating plan. Ice cream, cookies, and potato chips are also high in calories. Eating too much of them may lead to unhealthy weight gain.

### Healthy Eating Guidelines

- Make at least half your daily grain choices whole grains. Examples of whole grains are whole wheat bread, whole wheat pasta, and brown rice.

- Choose a variety of different vegetables each day. Be sure to include both dark green vegetables, such as spinach and broccoli, and orange vegetables, such as carrots and sweet potatoes.
- Choose a variety of different fruits each day. Select mainly fresh fruits rather than canned fruits, and whole fruits instead of fruit juices.
- When choosing oils, choose unsaturated oils, such as olive oil, canola oil, or vegetable oil.
- Choose low-fat or fat-free milk and other dairy products. For example, select fat-free yogurt and low-fat cheese.
- For meats, choose fish, chicken, and lean cuts of beef. Also, be sure to include beans, nuts, and seeds.

### MyPlate

In June 2011, the United States Department of Agriculture replaced My Pyramid with **MyPlate.** MyPlate depicts the relative daily portions of various food groups (**Figure** 1.28). See http://www.choosemyplate.gov/ for more information.

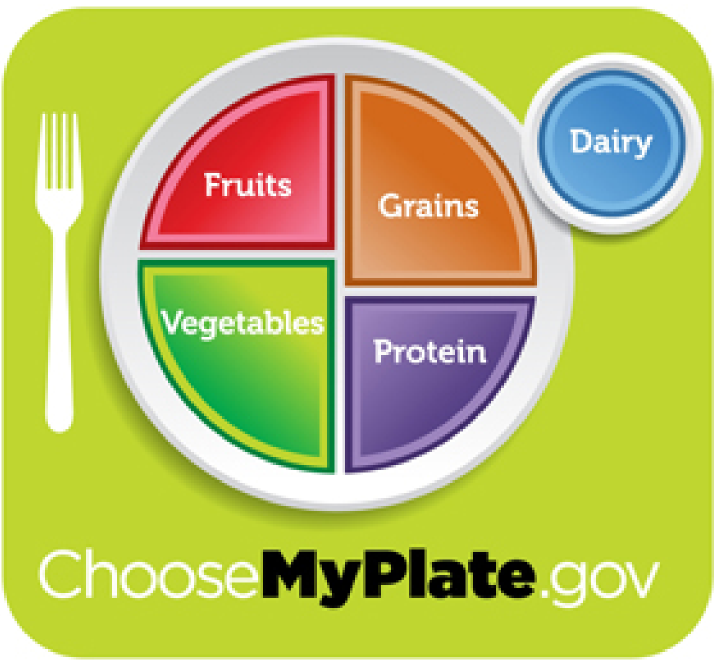


FIGURE 1.28
MyPlate is a visual guideline for balanced eating, replacing MyPyramid in 2011.

The following guidelines accompany MyPlate:

1. Balancing Calories

- Enjoy your food, but eat less.
- Avoid oversized portions.

2. Foods to Increase

- Make half your plate fruits and vegetables.
- Make at least half your grains whole grains.
- Switch to fat-free or low-fat (1%) milk.

3. Foods to Reduce

- Compare sodium in foods like soup, bread, and frozen meals; choose the foods with lower levels.
- Drink water instead of drinks with high levels of sugar.

### Using Nutrition Facts Labels

In the United States and other nations, packaged foods are required by law to have nutrition facts labels. A **nutrition facts label** (**Figure** 1.29) shows the nutrients in a food. Packaged foods are also required to list their ingredients.

The information listed at the right of the label tells you what to look for. At the top of the label, look for the serving size. The serving size tells you how much of the food you should eat to get the nutrients listed on the label. A cup of food from the label pictured below is a serving. The calories in one serving are listed next. In this food, there are 250 calories per serving.

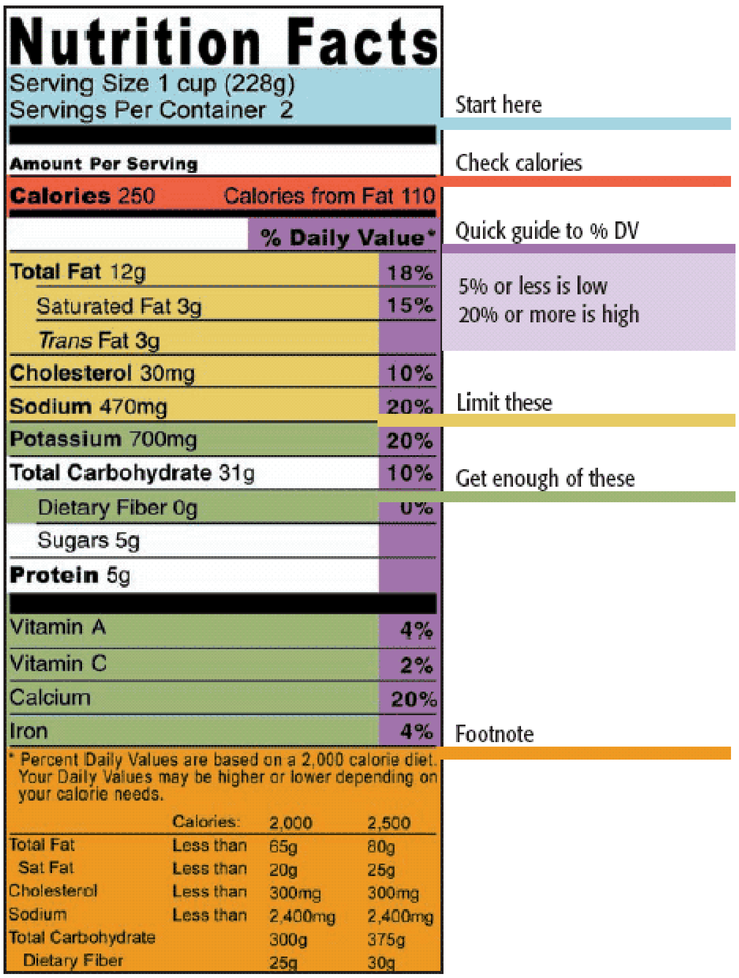


FIGURE 1.29

Reading nutrition facts labels can help you choose healthy foods. Look at the nutrition facts label shown here. Do you think this food is a good choice for a healthy eating plan? Why or why not?

Next on the nutrition facts label, look for the percent daily values (% DV) of nutrients. Remember the following tips when reading a food label:

- A food is low in a nutrient if the percent daily value of the nutrient is 5% or less.
- The healthiest foods are low in nutrients such as fats and sodium.
- A food is high in a nutrient if the percent daily value of the nutrient is 20% or more.
- The healthiest foods are high in nutrients such as fiber and proteins.

Look at the percent daily values on the food label (**Figure** 1.29). Which nutrients have values of 5% or less? These are the nutrients that are low in this food. They include fiber, vitamin A, vitamin C, and iron. Which nutrients have values of 20% or more? These are the nutrients that are high in this food. They include sodium, potassium, and calcium.

### Balancing Food with Exercise

Look at MyPyramid (**Figure** 1.27). Note the person walking up the side of the pyramid. This shows that exercise is important for balanced eating. Exercise helps you use any extra energy in the foods you eat. The more active you are, the more energy you use. You should try to get at least an hour of physical activity just about every day. Pictured below are some activities that can help you use extra energy (**Figure** 1.30).

### Weight Gain and Obesity

Any unused energy in food is stored in the body as fat. This is true whether the extra energy comes from carbohydrates, proteins, or lipids. What happens if you take in more energy than you use, day after day? You will store more and more fat and become overweight.

Eventually, you may become obese. **Obesity** is having a very high percentage of body fat. Obese people are at least 20 percent heavier than their healthy weight range. The excess body fat of obesity is linked to many diseases. Obese people often have serious health problems, such as diabetes, high blood pressure, and high cholesterol. They are also more likely to develop arthritis and some types of cancer. People who remain obese during their entire adulthood usually do not live as long as people who stay within a healthy weight range.

The current generation of children and teens is the first generation in our history that may have a shorter life than their parents. The reason is their high rate of obesity and the health problems associated with obesity. You can avoid gaining weight and becoming obese. The choice is yours. Choose healthy foods by using MyPyramid and reading food labels. Then get plenty of exercise to balance the energy in the foods you eat.

## Vocabulary

- **MyPlate**: Visual guideline for balanced eating.
- **MyPyramid**: Diagram that shows the relative amounts you should eat from six different food groups.
- **nutrition facts label**: Label on food packaging that lists the ingredients and amount of nutrients in a food.
- **obesity**: Condition of having a very high percentage of body fat.

## Summary

- MyPlate, MyPyramid, and food labels are tools that can help you choose the best foods for healthy eating.
- Eating too much and exercising too little can lead to weight gain and obesity.

## Practice

Use the resource below to answer the questions that follow.

- **How To Create A Balanced Meal** at http://www.youtube.com/watch?v=KchFa8QCQSk (4:25)


FIGURE 1.30

All of these activities are good ways to exercise and use extra energy. The calories given for each activity are the number of calories used in an hour by a person that weighs 100 pounds. Which of these activities uses the most calories? Which of the activities do you enjoy?

MEDIA

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1. What should the biggest section of your plate be filled with?
2. What does it mean when vegetables have bright colors?
3. Why are whole grains better for you than refined grains?

## Review

1. Which food group contains soybeans, kidney beans, and fish?
2. What happens if you take in more energy than you use, day after day?

# 1.16 Human Digestive System

- List the functions of the digestive system.

**Do you know when you're digesting food?**

Unless you have an upset stomach, digestion usually happens without you even noticing. You consciously chew up your food, but most of the digestive process takes place without your conscious awareness. Long after you put down your fork, food is still passing through your stomach and small intestine. It may take over a day for a meal to pass all the way through your digestive system.

## Function of the Digestive System

Nutrients in the foods you eat are needed by the cells of your body. How do the nutrients in foods get to your body cells? What organs and processes break down the foods and make the nutrients available to cells? The organs are those of the digestive system. The processes are digestion and absorption.

The **digestive system** is the body system that breaks down food and absorbs nutrients. It also gets rid of solid food waste. The main organs of the digestive system are pictured below (**Figure** 1.31).

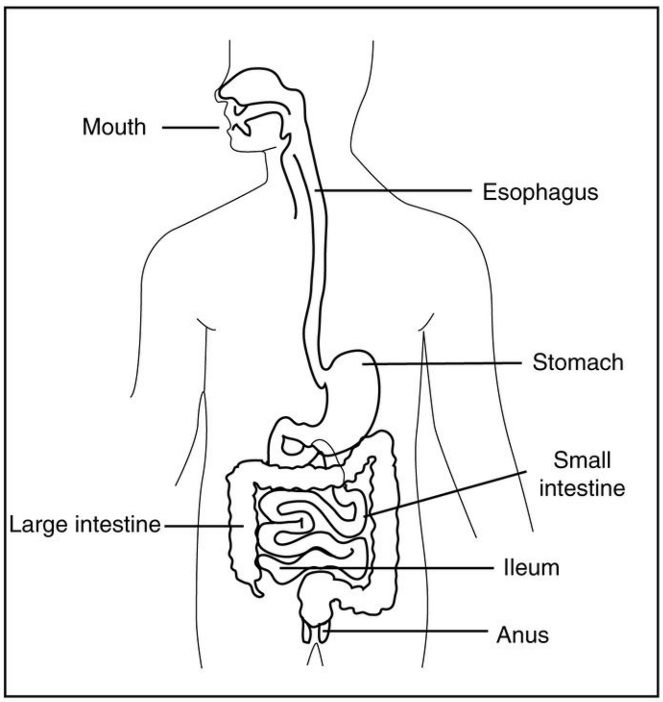



FIGURE 1.31
This drawing shows the major organs of the digestive system.

**Digestion** is the process of breaking down food into nutrients. There are two types of digestion, mechanical and chemical. In **mechanical digestion**, large chunks of food are broken down into small pieces. Mechanical digestion begins in the mouth and involves physical processes, such as chewing. In **chemical digestion**, large food molecules are broken down into small nutrient molecules. This is a chemical process which also begins in the mouth as **saliva** begins to break down food.

**Absorption** is the process that allows substances you eat to be taken up by the blood. After food is broken down into small nutrient molecules, the molecules are absorbed by the blood. After absorption, the nutrient molecules travel in the bloodstream to cells throughout the body.

Some substances in food cannot be broken down into nutrients. They remain behind in the digestive system after the nutrients are absorbed. Any substances in food that cannot be digested and absorbed pass out of the body as solid waste. The process of passing solid food waste out of the body is called **elimination.**

## Vocabulary

- **absorption**: Process that allows nutrients to be taken up by the blood.
- **chemical digestion**: Process by which large food molecules are broken down into small nutrient molecules through a chemical process.
- **digestion**: Process of breaking down food into nutrients.
- **digestive system**: Body system that breaks down food, absorbs nutrients, and rids the body of solid food waste.
- **elimination**: Process of passing solid food waste out of the body.
- **mechanical digestion**: Process by which large chunks of food are broken down into small pieces through a physical process, such as chewing.
- **saliva**: Watery substance located in the mouths of organisms, secreted by the salivary glands.

## Summary

- The digestive system is the body system that breaks down food, absorbs nutrients, and gets rid of solid wastes.
- Digestion is the process of breaking down food into nutrients, while absorption is the process that allows nutrients to be taken up by the blood.

## Practice

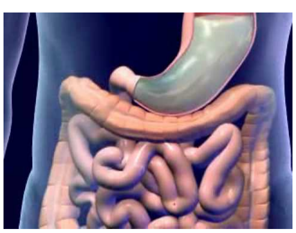
Use the resources below to answer the questions that follow.

- **How Food is Digested** at http://www.youtube.com/watch?v=RsTwabX4ggI (1:44)

MEDIA
Click image to the left for more content.

1. What type of muscles do you think you have in your esophagus?
2. How long does food stay in your stomach? Where does it go next?
3. What is the role of bile in the digestion process?

- **Digestive System** at http://www.youtube.com/watch?v=Z7xKYNz9AS0 (1:49)



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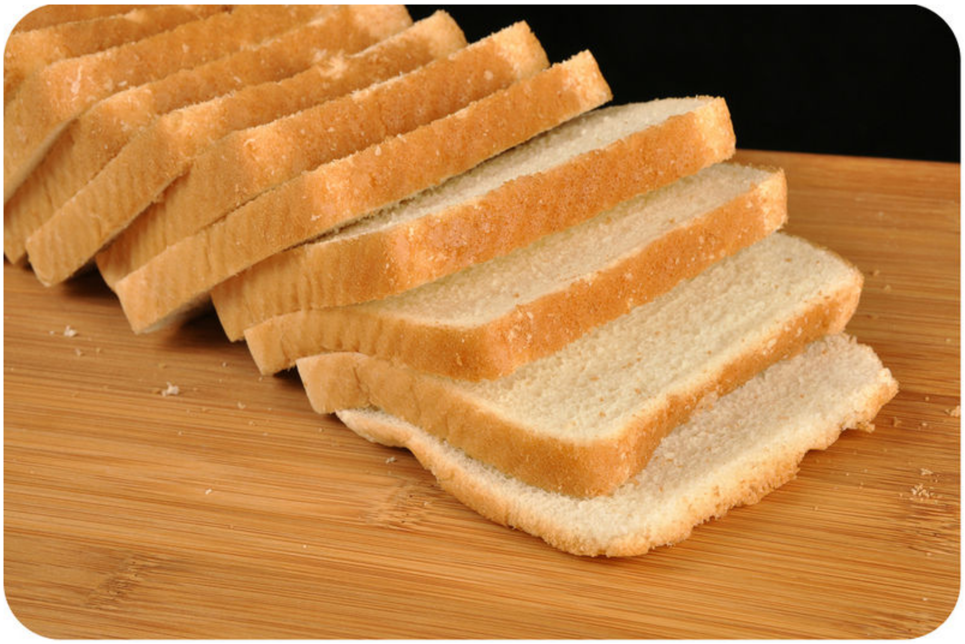
1. Where does digestion start?
2. Where are most of the nutrients from food absorbed? What happens to the nutrients once they are absorbed?
3. What happens in the colon (large intestine)?
4. What does the digestive system do to food?

## Review

1. What are three functions of the digestive system?
2. What is the difference between mechanical and chemical digestion?

# 1.17 Enzymes in the Digestive System

- Explain the role of enzymes in digestion.



**What happens if you suck on a piece of white bread?**

If you kept a bite of white bread in your mouth for a long period of time, it would start to get really mushy. Then it would start tasting sweet. That's because you have enzymes in your saliva. The enzymes break down the complex carbohydrates in the bread into simple sugars.

## The Role of Enzymes in the Digestive System

Chemical digestion could not take place without the help of digestive enzymes. An **enzyme** is a protein that speeds up chemical reactions in the body. Digestive enzymes speed up chemical reactions that break down large food molecules into small molecules.

Did you ever use a wrench to tighten a bolt? You could tighten a bolt with your fingers, but it would be difficult and slow. If you use a wrench, you can tighten a bolt much more easily and quickly. Enzymes are like wrenches. They make it much easier and quicker for chemical reactions to take place. Like a wrench, enzymes can also be used over and over again. But you need the appropriate size and shape of the wrench to efficiently tighten the bolt, just like each enzyme is specific for the reaction it helps.

Digestive enzymes are released, or secreted, by the organs of the digestive system. Examples of digestive enzymes are:

- Amylase, produced in the mouth. It helps break down large starch molecules into smaller sugar molecules.
- Pepsin, produced in the stomach. Pepsin helps break down proteins into amino acids.
- Trypsin, produced in the pancreas. Trypsin also breaks down proteins.
- Pancreatic lipase, produced in the pancreas. It is used to break apart fats.

- Deoxyribonuclease and ribonuclease, produced in the pancreas. They are enzymes that break bonds in nucleic acids like DNA and RNA.

Bile salts are bile acids that help to break down fat. Bile acids are made in the liver. When you eat a meal, bile is secreted into the intestine, where it breaks down the fats (**Figure** 1.32).

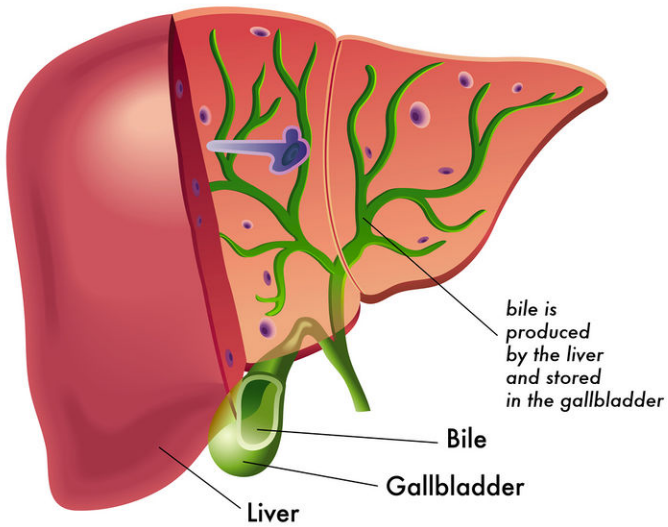



FIGURE 1.32
Bile is made in the liver, stored in the gallbladder, and then secreted into the intestine. It helps break down fats.

### Hormones and Digestion

If you are a typical teenager, you like to eat. For your body to break down, absorb and spread the nutrients from your food throughout your body, your digestive system and **endocrine system** need to work together. The endocrine system sends **hormones** around your body to communicate between cells. Essentially, hormones are chemical messenger molecules.

Digestive hormones are made by cells lining the stomach and small intestine. These hormones cross into the blood where they can affect other parts of the digestive system. Some of these hormones are listed below.

- Gastrin, which signals the secretion of gastric acid.
- Cholecystokinin, which signals the secretion of pancreatic enzymes.
- Secretin, which signals secretion of water and bicarbonate from the pancreas.
- Ghrelin, which signals when you are hungry.
- Gastric inhibitory polypeptide, which stops or decreases gastric secretion. It also causes the release of insulin in response to high blood glucose levels.

### Vocabulary

- **endocrine system**: Body system of endocrine glands, each of which releases a hormone directly into the bloodstream to regulate body processes.
- **enzyme**: Protein that speeds up chemical reactions in the body.
- **hormone**: Chemical messenger used to communicate between cells.

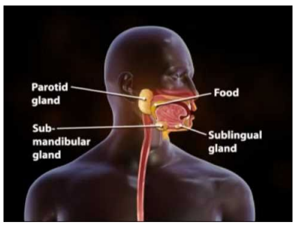
## Summary

- Digestive enzymes speed up the reactions of chemical digestion.
- Hormones, chemical messengers used to communicate between cells, are important in regulating digestion.

## Practice

Use the resource below to answer the questions that follow.

- **Enzymes in the Digestive System** at http://www.youtube.com/watch?v=KED6BHVM97s (0:58)

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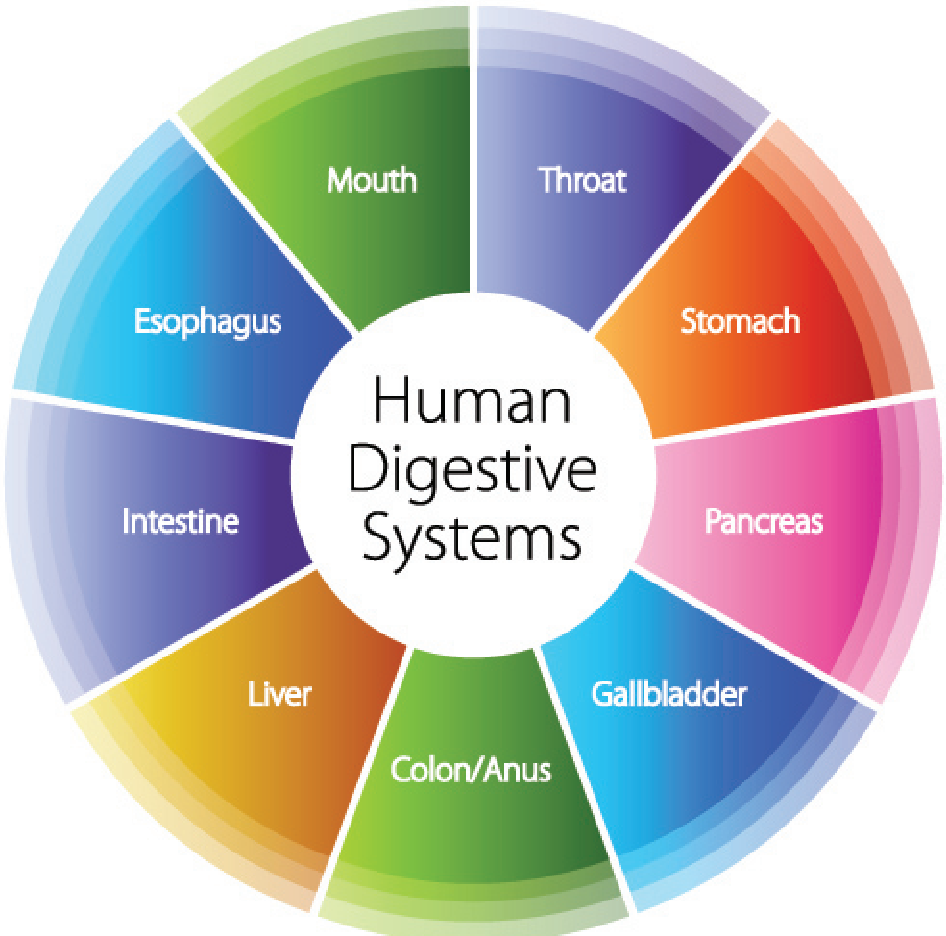
1. What is salivary amylase? Where is it secreted? What does it do?
2. What does pancreatic amylase do? Where does this occur?
3. What does lactase do? What is lactase? Where is it excreted?
4. Where are monosaccharides absorbed?

## Review

1. Explain the role of enzymes in digestion. Give an example to illustrate your answer.
2. Describe an example of how a hormone affects digestion.

# 1.18 Digestive System Organs

- Describe the digestive organs and their functions.




**How many organs of the digestive system can you name?**

Stomach? Mouth? It takes many different organs working together in order to digest your food. Some are part of the pipeline that food passes through. Others made special chemicals that are needed for digestion.

## Organs of the Digestive System

The mouth and stomach are just two of the organs of the digestive system. Other digestive system organs are the esophagus, small intestine, and large intestine. Below, you can see that the digestive organs form a long tube (**Figure** 1.33). In adults, this tube is about 30 feet long! At one end of the tube is the mouth. At the other end is the anus. Food enters the mouth and then passes through the rest of the digestive system. Food waste leaves the body through the anus.

The organs of the digestive system are lined with muscles. The muscles contract, or tighten, to push food through the system (**Figure** 1.34). The muscles contract in waves. The waves pass through the digestive system like waves through a slinky. This movement of muscle contractions is called **peristalsis**. Without peristalsis, food would not be

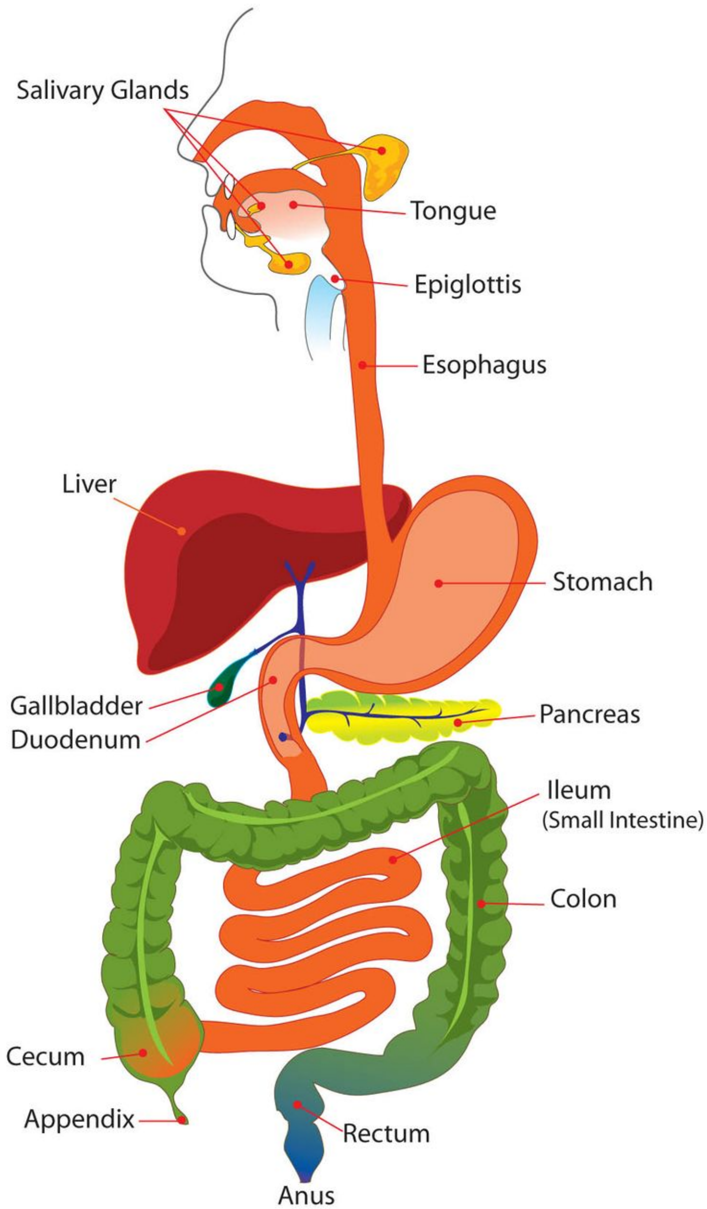



FIGURE 1.33

This drawing shows the liver, gall bladder, and pancreas. These organs are part of the digestive system. Food does not pass through them, but they secrete substances needed for chemical digestion.

able to move through the digestive system. Peristalsis is an involuntary process, which means that it occurs without your conscious control.

The liver, gall bladder, and pancreas are also organs of the digestive system (**Figure** 1.33). Food does not pass through these three organs. However, these organs are important for digestion. They secrete or store enzymes or other chemicals that are needed to help digest food chemically.

### Mouth, Esophagus, and Stomach

The mouth is the first organ that food enters. But digestion may start even before you put the first bite of food into your mouth. Just seeing or smelling food can cause the release of saliva and digestive enzymes in your mouth.

Once you start eating, saliva wets the food, which makes it easier to break up and swallow. Digestive enzymes,

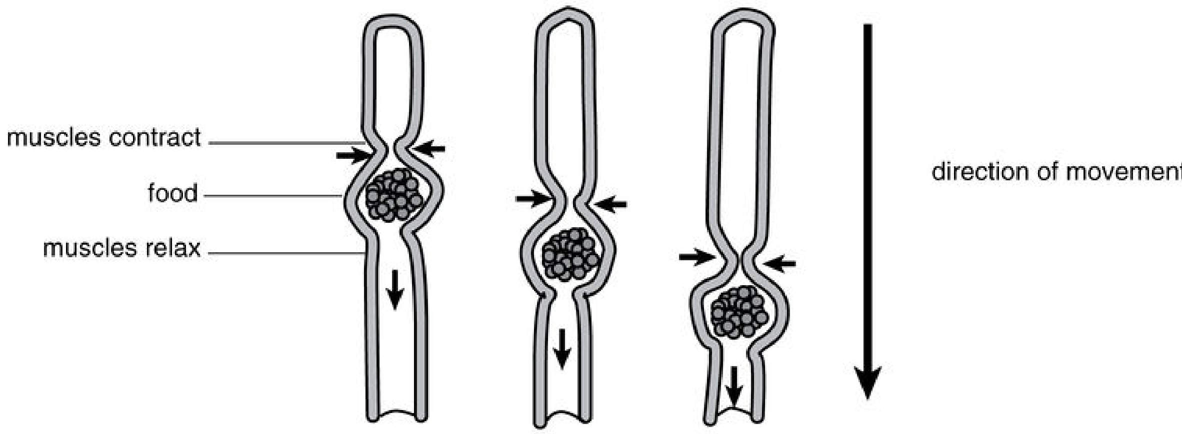



FIGURE 1.34
This diagram shows how muscles push food through the digestive system. Muscle contractions travel through the system in waves, pushing the food ahead of them. This is called peristalsis.

including the enzyme amylase, start breaking down starches into sugars. Your tongue helps mix the food with the saliva and enzymes.

Your teeth also help digest food. Your front teeth are sharp. They cut and tear food when you bite into it. Your back teeth are broad and flat. They grind food into smaller pieces when you chew. Chewing is part of mechanical digestion. Your tongue pushes the food to the back of your mouth so you can swallow it. When you swallow, the lump of chewed food passes down your throat to your esophagus.

The **esophagus** is a narrow tube that carries food from the throat to the stomach. Food moves through the esophagus because of peristalsis. At the lower end of the esophagus, a circular muscle controls the opening to the stomach. The muscle relaxes to let food pass into the stomach. Then the muscle contracts again to prevent food from passing back into the esophagus.

Some people think that gravity moves food through the esophagus. If that were true, food would move through the esophagus only when you are sitting or standing upright. In fact, because of peristalsis, food can move through the esophagus no matter what position you are in—even upside down! Just don't try to swallow food when you upside down—you could choke!

The **stomach** is a sac-like organ at the end of the esophagus. It has thick muscular walls. The muscles contract and relax. This moves the food around and helps break it into smaller pieces. Mixing the food around with the enzyme pepsin and other chemicals helps digest proteins.

Water, salt, and simple sugars can be absorbed into the blood from the stomach. Most other substances are broken down further in the small intestine before they are absorbed. The stomach stores food until the small intestine is ready to receive it. A circular muscle controls the opening between the stomach and small intestine. When the small intestine is empty, the muscle relaxes. This lets food pass from the stomach into the small intestine.

### Small Intestine

The **small intestine** a is narrow tube that starts at the stomach and ends at the large intestine (**Figure** 1.33). In adults, the small intestine is about 23 feet long. Chemical digestion takes place in the first part of the small intestine. Many enzymes and other chemicals are secreted here. The small intestine is also where most nutrients are absorbed into the blood. The later sections of the small intestines are covered with tiny projections called **villi** (**Figure** 1.35). Villi contain very tiny blood vessels. Nutrients are absorbed into the blood through these tiny vessels. There are millions of villi, so, altogether, there is a very large area for absorption to take place. In fact, villi make the inner surface area of the small intestine 1,000 times larger than it would be without them. The entire inner surface area of the small intestine is about as big as a basketball court!

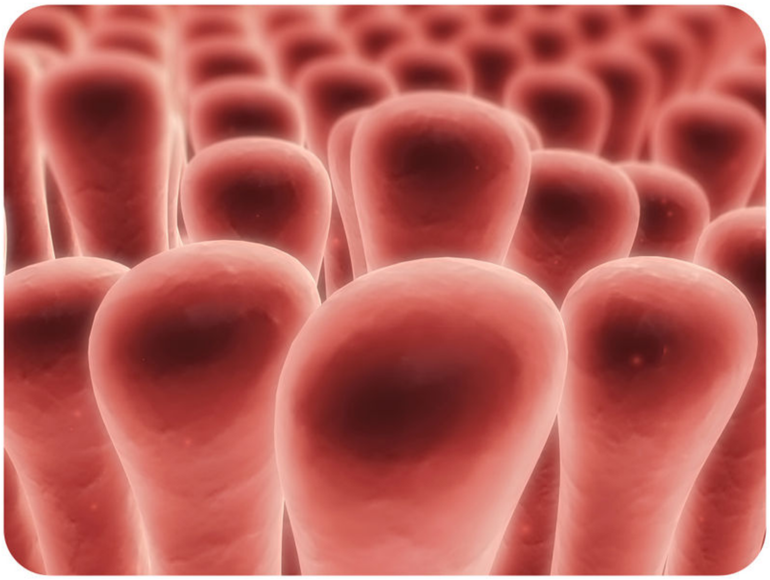


FIGURE 1.35
This is what the villi lining the intestine slook like when magnified. Each one is actually only about 1 millimeter long. Villi are just barely visible with the unaided eye.

The small intestine is much longer than the large intestine. So why is it called "small"? If you compare the small and large intestines (**Figure** 1.33), you will see why. The small intestine is smaller in width than the large intestine.

### Large Intestine

The **large intestine** is a wide tube that connects the small intestine with the anus. In adults, it is about five feet long. Waste enters the large intestine from the small intestine in a liquid state. As the waste moves through the large intestine, excess water is absorbed from it. After the excess water is absorbed, the remaining solid waste is called feces.

Circular muscles control the anus. They relax to let the feces pass out of the body through the anus. After feces pass out of the body, they are called stool. Releasing the stool from the body is referred to as a bowel movement.

### Vocabulary

- **esophagus**: Narrow tube that carries food from the throat to the stomach.
- **large intestine**: Wide tube in which water is extracted to form feces; connects the small intestine with the anus.
- **peristalsis**: Muscle contractions that help food move through the digestive system.
- **small intestine**: Narrow tube in which further digestion and absorption takes place; starts at the stomach and ends at the large intestine.
- **stomach**: Sac-like organ at the end of the esophagus where much of the digestive process takes place.
- **villi**: Small, finger-like projections of the small intestine that increase surface area for absorption.

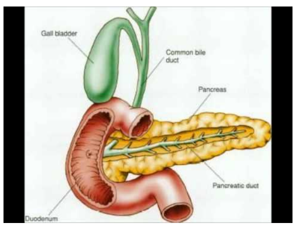
## Summary

- The main organs of the digestive system are the mouth, esophagus, stomach, small intestine, and large intestine.
- The liver, gall bladder, and pancreas contribute chemicals that aid in digestion.

## Practice

Use the resource below to answer the questions that follow.

- **Functions of the Organs of the Digestive System** at http://www.youtube.com/watch?v=NtDTy6KLvYo (2:48)




MEDIA
Click image to the left for more content.

1. What organ starts the digestion process? What does it do?
2. What function does the liver serve in digestion? How does it work together with the gall bladder?
3. What are the functions of the pancreas?

## Review

1. Describe peristalsis, and explain why it is necessary for digestion.
2. In which organs of the digestive system does absorption of nutrients take place?

# 1.19 Bacteria in the Digestive System

- Explain the roles of helpful bacteria in the digestive system.

**Why eat yogurt?**

Yogurt is a good source of calcium. Yogurt also contains active cultures of "good" bacteria. Foods that contain these beneficial bacteria are sometimes called "probiotic."

## Bacteria in the Digestive System

Your large intestine is not just made up of cells. It is also an **ecosystem**, home to trillions of bacteria (**Figure** 1.36). But don't worry. Most of these bacteria are helpful. They have several roles in the body. For example, intestinal bacteria:

- Produce **vitamin B**$_{12}$ and **vitamin K**.
- Control the growth of harmful bacteria.
- Break down poisons in the large intestine.
- Break down some substances in food that cannot be digested, such as fiber and some starches and sugars.

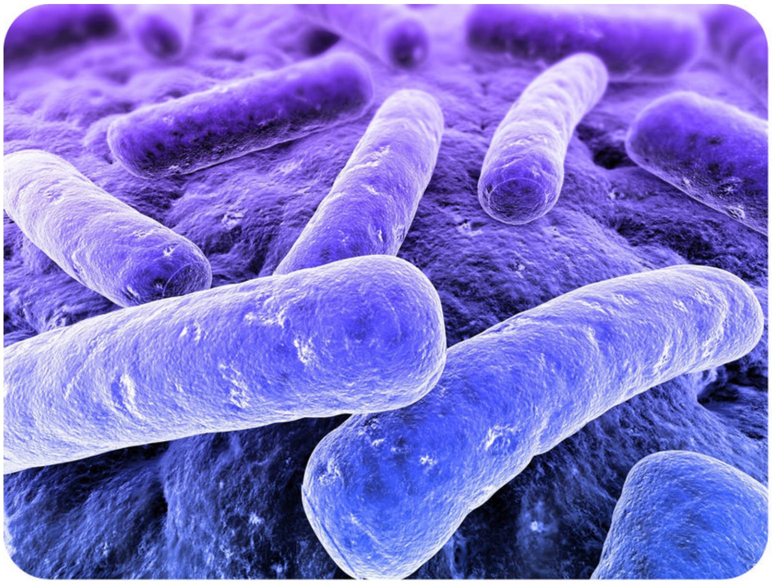


FIGURE 1.36
Your intestines are home to trillions of bacteria.

## Vocabulary

- **ecosystem**: All the living things in an area interacting with all of the non-living parts of the environment.
- **vitamin** $\mathbf{B_{12}}$: Vitamin necessary for healthy nerves.
- **vitamin K**: Vitamin necessary for blood to clot.

## Summary

- Your large intestine is home to trillions of bacteria.
- Bacteria in the large intestine have important roles, such as producing vitamins and controlling the growth of harmful bacteria.

## Practice

Use the resources below to answer the questions that follow.

- **Gut Bacteria: We Are What We Eat** at http://www.youtube.com/watch?v=QwTOI5YoqrA (3:56)


MEDIA
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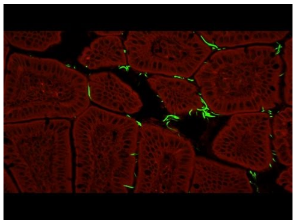
1. How do bacteria influence our digestion?
2. How does what you eat influence the bacteria of your gut? What two categories, with regard to gut bacteria have scientists identified?

3. What link do scientists believe may exist between gut bacteria and disease? Why is this an area of interest for scientists?

- **Our Microbes, Ourselves** at http://www.youtube.com/watch?v=zPO8-M_rcUo (3:07)



MEDIA

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1. How may clean environments affect the microbes in our bodies?
2. How do gut microbes compare between species?
3. What is the hygiene hypothesis?

## Review

1. Identify two roles of helpful bacteria in the large intestine.
2. When you are sick, you might be given an antibiotic to kill harmful bacteria. Antibiotics cannot distinguish between "good" and "bad" bacteria, however. Why might this be a problem?

# 1.20 Health of the Digestive System

- List ways to avoid foodborne illness.

**Have you ever been sick to your stomach?**

You may have even had to stay home from school because of a "stomach bug." It is possible that you caught a contagious illness, or you could have gotten sick from food you had eaten recently. The symptoms are very similar, so it's hard to pinpoint the cause.

## Health of the Digestive System

Most of the time, you probably aren't aware of your digestive system. It works well without causing any problems. But most people have problems with their digestive system at least once in a while. Did you ever eat something that didn't "agree" with you? Maybe you had a stomachache or felt sick to your stomach? Maybe you had diarrhea? These could be symptoms of foodborne illness, food allergies, or a food intolerance.

### Foodborne Illness

Harmful bacteria can enter your digestive system in food and make you sick. This is called **foodborne illness**. The bacteria, or the toxins they produce, may cause vomiting or cramping, in addition to the symptoms mentioned above. You can help prevent foodborne illness by following a few simple rules.

- Keep hot foods hot and cold foods cold. This helps prevent any bacteria in the foods from multiplying.
- Wash your hands before you prepare or eat food. This helps prevent bacteria on your hands from getting on the food.
- Wash your hands after you touch raw foods, such as meats, poultry, fish, or eggs. These foods often contain bacteria that your hands could transfer to your mouth.
- Cook meats, poultry, fish, and eggs thoroughly before eating them. The heat of cooking kills any bacteria the foods may contain, so they cannot make you sick.

### Food Allergies

**Food allergies** are like other allergies. They occur when the immune system reacts to harmless substances as though they were harmful. Almost ten percent of children have food allergies. Some of the foods most likely to cause allergies are shown below (**Figure** 1.37).

Eating foods you are allergic to may cause vomiting, diarrhea, or skin rashes. Some people are very allergic to certain foods. Eating even tiny amounts of the foods causes them to have serious symptoms, such as difficulty breathing. If they eat the foods by accident, they may need emergency medical treatment.

### Food Intolerance

A **food intolerance**, or food sensitivity, is different from a food allergy. A food intolerance happens when the digestive system is unable to break down a certain type of food. This can result in stomach cramping, diarrhea, tiredness, and weight loss. Food intolerances are often mistakenly called allergies. Lactose intolerance is a food intolerance. A person who is lactose intolerant does not make enough lactase, the enzyme that breaks down the milk sugar, lactose. Lactose intolerance may be as high as 75% in some populations, but overall the percentage of affected individuals is much less. Still, well over 10% of the world's population is lactose intolerant.

## Vocabulary

- **food allergy**: Overreaction of the immune system to harmless foods.
- **food intolerance**: Inability of the digestive system to handle certain types of food.
- **foodborne illness**: Illness resulting from eating contaminated food.

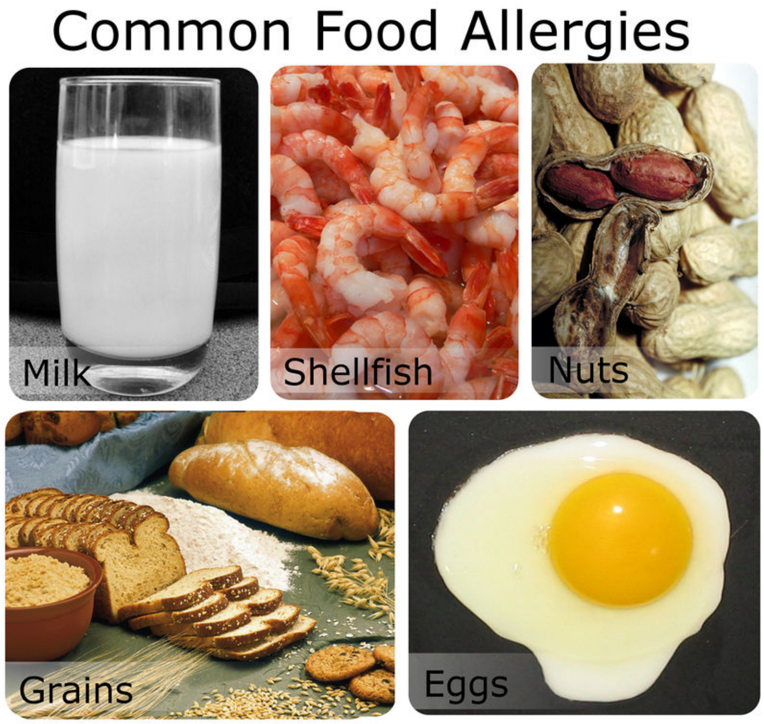


FIGURE 1.37
Some of the foods that commonly cause allergies are shown here. They include nuts, eggs, grains, milk, and shellfish. Are you allergic to any of these foods?

## Summary

- Foodborne illness can be prevented by taking precautions during food preparation.
- Food allergies and food intolerance can upset your digestive system.

## Practice

Use the resources below to answer the questions that follow.

- **Introduction to Food Allergens** at http://www.youtube.com/watch?v=z7_Q7fI5uXA (4:27)


MEDIA
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1. What is a food allergy? How does the body respond to food allergies?
2. What does the phrase "dose related" mean? How does this relate to food intolerance?
3. What are four common symptoms of food allergies?
4. What are the most common food allergens?
5. Do all people of all ages respond in the same way to foods?

- **Prevent Foodborne Illness** at http://www.youtube.com/watch?v=Y5Ao5Npj7wY (1:04)

MEDIA

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1. What is the most basic step to preventing foodborne illness?
2. Why is it a good idea to use one cutting board for fruits and vegetables and another for meats?
3. What can happen if you leave food sitting out exposed?

## Review

1. List two rules that can help prevent foodborne illness.
2. What's the difference between a food allergy and a food intolerance?

# 1.21 Cardiovascular System

- Describe the functions of the cardiovascular system.

**What do you do for "cardio"?**

"Cardio" has become slang for exercise that raises your heart rate. Cardio can include biking, running, or swimming. Can you guess one of the main organs of the cardiovascular system? Yes, your heart.

## Functions of the Cardiovascular System

Your cardiovascular system has many jobs. At times the cardiovascular system can work like a pump, a heating system, or even a postal carrier. To do these tasks, your cardiovascular system works with other organ systems, such as the respiratory, endocrine, and nervous systems.

The **cardiovascular system** (**Figure** 1.38) is made up of the heart, the blood vessels, and the blood. It moves nutrients, gases (like oxygen), and wastes to and from your cells. Every cell in your body depends on your cardiovascular system. If your cells don't receive nutrients, they cannot survive. The main function of the cardiovascular system is to deliver oxygen to each of your cells. Blood receives oxygen in your lungs and then is pumped, by your heart, throughout your body. The oxygen then diffuses into your cells, and carbon dioxide, a waste product of cellular respiration, moves from your cells into your blood to be delivered back to your lungs and exhaled. Each cell in your body needs oxygen, as oxygen is used in cellular respiration to produce energy in the form of ATP.

The cardiovascular system also plays a role in maintaining body temperature. It helps to keep you warm by moving warm blood around your body. Your blood vessels also control your body temperature to keep you from getting too hot or too cold. When your brain senses that your body temperature is increasing, it sends messages to the blood vessels in the skin to increase in diameter. Increasing the diameter of the blood vessels increases the amount of blood and heat that moves near the skin's surface. The heat is then released from the skin. This helps you cool down. What do you think your blood vessels do when your body temperature is decreasing?

The blood also carries hormones, which are chemical messengers, through your body.

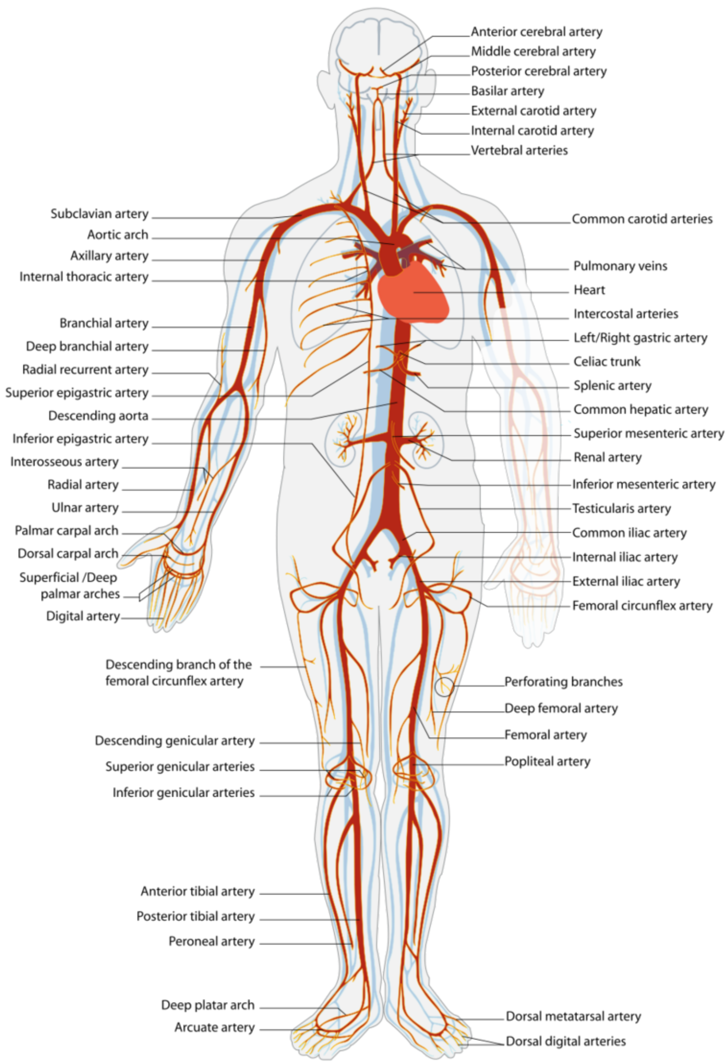



FIGURE 1.38

The cardiovascular system moves nutrients and other substances throughout the body.

## Vocabulary

- **cardiovascular system**: Organs involved in circulating blood and lymph through the body, including the heart, blood vessels, and the blood.

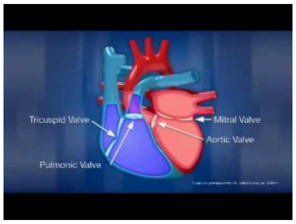
## Summary

- The cardiovascular system is made up of the heart, the blood vessels, and the blood.
- The cardiovascular system moves nutrients, hormones, gases, and wastes to and from your cells.

## Practice

Use the resource below to answer the questions that follow.

- **Intro To The Cardiovascular System** at http://www.youtube.com/watch?v=DAXa4eR1s0M (4:04)




MEDIA
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1. Where does blood enter the heart? Where does it exit the heart?
2. How does blood entering the right side of the heart differ from blood entering the left side of the heart?
3. Why is it important for the heart to have one way valves? How do you think a leaky valve affects the functioning of the heart?
4. What are coronary arteries? What are their function? How are they involved in heart disease?

## Review

1. List two components of the cardiovascular system.
2. List two functions of the cardiovascular system.

# 1.22 Circulation and the Lymphatic System

- Explain how the cardiovascular and the lymphatic systems work together.

**Are your blood vessels leaky?**

None of your blood vessels are leaking this badly, or you'd be in the hospital! But your blood vessels do leak a little bit. Water and solutes pass out of the blood vessels and help form the fluid that bathes your body's tissues. Ultimately the fluid that is lost from the blood vessels is returned through the lymphatic system.

## The Lymphatic System and Circulation

The **lymphatic system** is a network of vessels and tissues that carry a clear fluid called **lymph.** The lymphatic system (**Figure** 1.39) spreads all around the body. **Lymph vessels** are tube-shaped, just like blood vessels. The lymphatic system works with the cardiovascular system to return body fluids to the blood. The lymphatic system and the cardiovascular system are often called the body's two "circulatory systems."

### Role of the Lymphatic System in Circulation

You may think that your blood vessels have thick walls without any leaks, but it's not true. Blood vessels can leak just like any other pipe. The lymphatic system makes sure leaked blood returns back to the bloodstream.

When a small amount of fluid leaks out from the blood vessels, it collects in the spaces between cells and tissues. Some of the fluid returns to the cardiovascular system, and the rest is collected by the lymph vessels of the lymphatic system (**Figure** 1.40). The fluid that collects in the lymph vessels is called lymph. The lymphatic system then returns the lymph to the cardiovascular system. Unlike the cardiovascular system, the lymphatic system is not closed and has no central pump (or heart). Lymph moves slowly in lymph vessels. It is moved along in the lymph vessels by the squeezing action of smooth muscles and skeletal muscles.

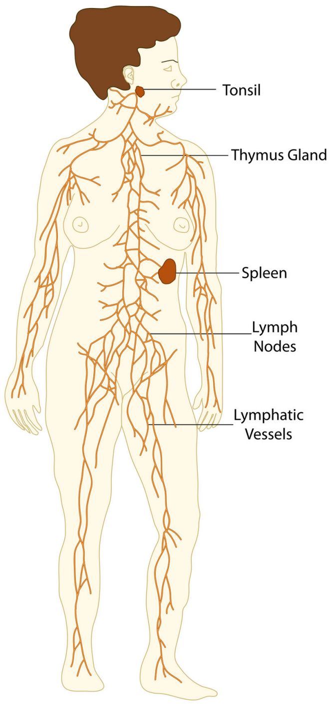


FIGURE 1.39
The lymphatic system helps return fluid that leaks from the blood vessels back to the cardiovascular system.

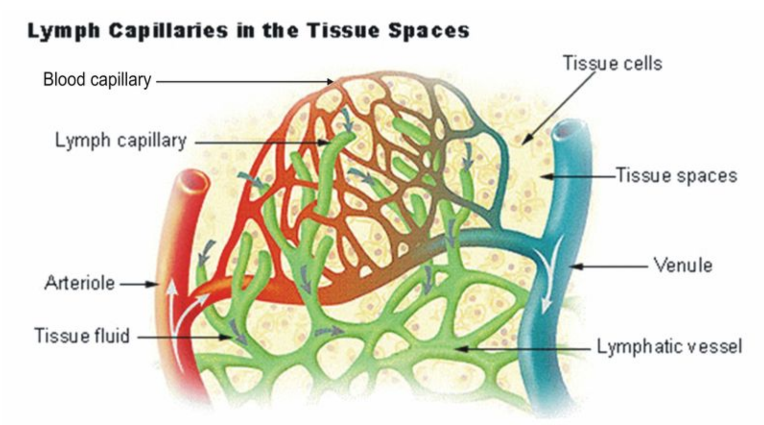


FIGURE 1.40
Lymph capillaries collect fluid that leaks out from blood capillaries.

### Role of the Lymphatic System in the Body's Defenses

The lymphatic system also plays an important role in the immune system. For example, the lymphatic system makes white blood cells that protect the body from diseases. The role of the lymphatic system in the immune response is discussed in additional concepts.

#### Vocabulary

- **lymph**: Clear fluid that drains through the lymphatic system and into the bloodstream.
- **lymph vessel**: Thin-walled tube that carries the lymph through the lymphatic system.
- **lymphatic system**: Network of vessels that carry a clear fluid called lymph; lymphatic organs also play a role in the immune system.

### Summary

- The lymphatic system works with the cardiovascular system to return body fluids to the blood.
- The lymph, the clear liquid found in the lymphatic system, is moved along in the lymph vessels by the squeezing action of smooth muscles and skeletal muscles.

### Practice

Use the resource below to answer the questions that follow.

- **Lymphatic System** at http://www.youtube.com/watch?v=BX8fBlme9vQ (10:35)

MEDIA

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1. Where are lymphatic vessels found?
2. What are the functions of the lymphatic system?
3. What is interstitial fluid?
4. What causes circulation in the lymphatic system?
5. What are the functions of lymph nodes?
6. What effect does removing a person's spleen have on the functioning of the body?

### Review

1. How does the lymph circulate through the body?
2. Where does lymph come from?

# 1.23 Heart

- Describe the structure of the heart and how blood moves through the heart.

**Where is your heart?**

Place your hand on your heart. Did you put your hand on the left side of your chest? Most people do, but the heart is actually located closer to the center of the chest.

## The Heart

What does the heart look like? How does it pump blood? The heart is divided into four chambers (**Figure** 1.41), or spaces: the left and right atria, and the left and right ventricles. An **atrium** (singular for atria) is one of the two small, thin-walled chambers on the top of the heart where the blood first enters. A **ventricle** is one of the two muscular V-shaped chambers that pump blood out of the heart. You can remember they are called ventricles because they are shaped like a "V."

The atria receive the blood, and the ventricles pump the blood out of the heart. Each of the four chambers of the heart has a specific job.

- The right atrium receives oxygen-poor blood from the body.
- The right ventricle pumps oxygen-poor blood toward the lungs, where it receives oxygen.
- The left atrium receives oxygen-rich blood from the lungs.
- The left ventricle pumps oxygen-rich blood out of the heart to the rest of the body.

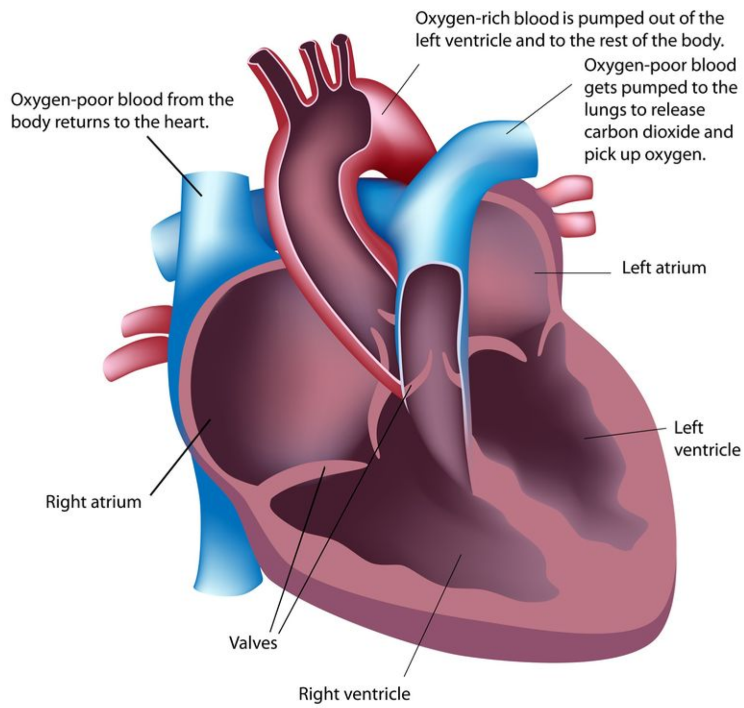



FIGURE 1.41
The atria receive blood and the ventricles pump blood out of the heart.

### Blood Flow Through the Heart

Blood flows through the heart in two separate loops. You can think of them as a "left side loop" and a "right side loop." The right side of the heart collects oxygen-poor blood from the body and pumps it into the lungs, where it releases carbon dioxide and picks up oxygen. The left side carries the oxygen-rich blood back from the lungs into the left side of the heart, which then pumps the oxygen-rich blood to the rest of the body. The blood delivers oxygen to the cells of the body and returns to the heart oxygen-poor.

To move blood through the heart, the cardiac muscle needs to contract in an organized way. Blood first enters the atria (**Figure** 1.42). When the atria contract, blood is pushed into the ventricles. After the ventricles fill with blood, they contract, and blood is pushed out of the heart.

So how is the blood kept from flowing back on itself? **Valves** (**Figure** 1.42) in the heart keep the blood flowing in one direction. The valves do this by opening and closing in one direction only. Blood only moves forward through the heart. The valves stop the blood from flowing backward. There are four valves of the heart.

- The two atrioventricular (AV) valves stop blood from moving from the ventricles to the atria.
- The two semilunar (SL) valves are found in the arteries leaving the heart, and they prevent blood from flowing back from the arteries into the ventricles.

Why does a heart beat? The "lub-dub" sound of the heartbeat is caused by the closing of the AV valves ("lub") and SL valves ("dub") after blood has passed through them.

#### Vocabulary

- **atrium**: Small, thin-walled chamber at the top of the heart where the blood first enters.
- **valve**: Structure in the heart that prevents back-flow and keeps the blood flowing in one direction.
- **ventricle**: Muscular V-shaped chamber that pumps blood out of the heart.

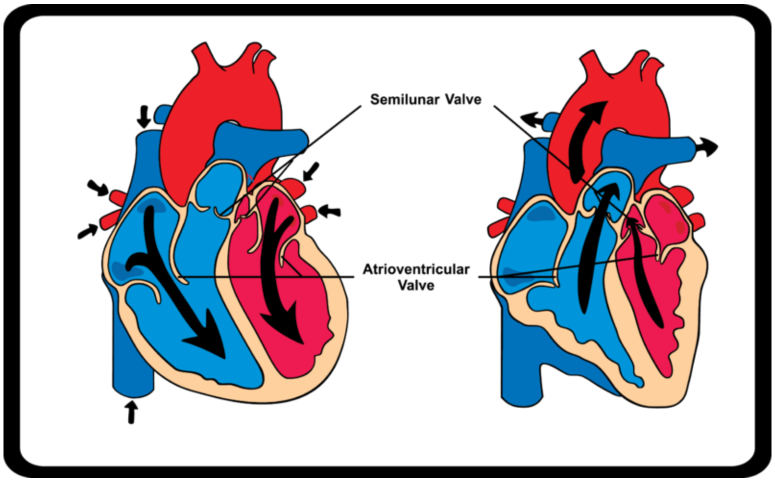



FIGURE 1.42
Blood flows in only one direction in the heart. Blood enters the atria, which contract and push blood into the ventricles. The atria relax and the ventricles fill with blood. Finally, the ventricles contract and push blood around the body.

## Summary

- Blood enters the heart at the atria and then flows into the ventricles, which contract and push blood around the body.
- Valves in the heart keep the blood flowing in one direction.

## Practice

Use the resource below to answer the questions that follow.

- **Working of the Heart** at http://www.youtube.com/watch?v=NF68qhyfcoM (1:36)

MEDIA
Click image to the left for more content.

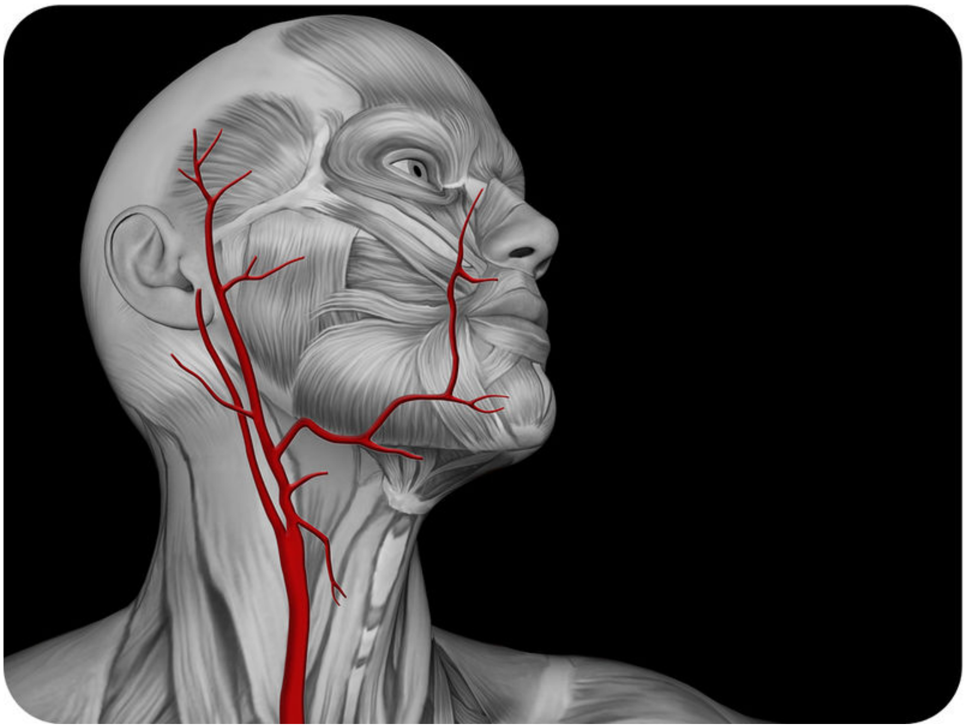
1. How many chambers does a mammalian heart have? What are these chambers called?
2. What are the smallest blood vessels in the body? What is there function?
3. What is the function of the circulatory system? What role does the heart play?
4. What passes from the cells into the capillaries? What passes into the cells from the capillaries?

## Review

1. Where does oxygen-poor blood first enter the heart?
2. What is the purpose of the valves in the heart?

# 1.24 Blood Vessels

- Describe some important arteries and veins.
- Distinguish between systemic circulation and pulmonary circulation.



**Why are these arteries so important?**

The major arteries of the neck are shown here in red. The heart pumps oxygen-rich blood through these arteries to the brain. Without oxygen, the brain cannot survive longer than just a few minutes. So these arteries in the neck are very important.

## Blood Vessels and Blood Circulation

The blood vessels are an important part of the cardiovascular system. They connect the heart to every cell in the body. **Arteries** carry blood away from the heart, while **veins** return blood to the heart (**Figure** 1.43).

### Important Arteries and Veins

There are specific veins and arteries that are more significant than others. The **pulmonary arteries** carry oxygen-poor blood away from the heart to the lungs. These are the only arteries that carry oxygen-poor blood. The **aorta** is the largest artery in the body. It carries oxygen-rich blood away from the heart.

Further away from the heart, the aorta branches into smaller arteries, which eventually branch into capillaries. **Capillaries** are the smallest type of blood vessel; they connect very small arteries and veins. Gases and other substances are exchanged between cells and the blood across the very thin walls of capillaries.

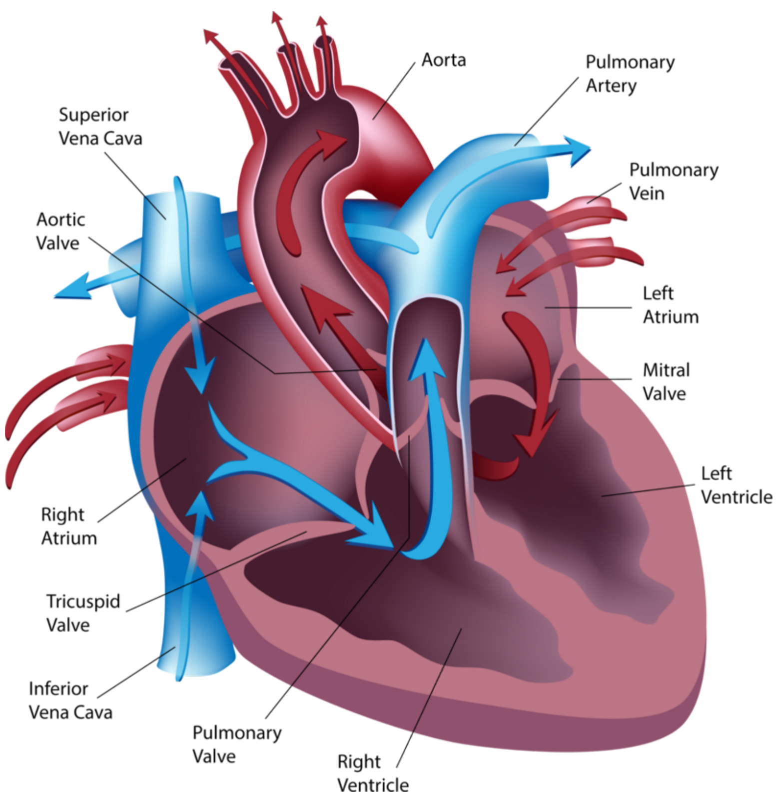



FIGURE 1.43

The right side of the heart pumps deoxygenated blood into pulmonary circulation, while the left side pumps oxygenated blood into systemic circulation.

The veins that return oxygen-poor blood to the heart are the **superior vena cava** and the **inferior vena cava**. The **pulmonary veins** return oxygen-rich blood from the lungs to the heart. The pulmonary veins are the only veins that carry oxygen-rich blood.

### Pulmonary Circulation

**Pulmonary circulation** is the part of the cardiovascular system that carries oxygen-poor blood away from the heart and brings it to the lungs. Oxygen-poor blood returns to the heart from the body and leaves the right ventricle through the pulmonary arteries, which carry the blood to each lung. Once at the lungs, the red blood cells release carbon dioxide and pick up oxygen when you breathe. The oxygen-rich blood then leaves the lungs through the pulmonary veins, which return it to the left side of the heart. This completes the pulmonary cycle. The oxygenated blood is then pumped to the body through systemic circulation, before returning again to pulmonary circulation.

### Systemic Circulation

**Systemic circulation** is the part of the cardiovascular system that carries oxygen-rich blood away from the heart, to the body, and returns oxygen-poor blood back to the heart. Oxygen-rich blood leaves the left ventricle through the aorta. Then it travels to the body's organs and tissues. The tissues and organs absorb the oxygen through the capillaries. Oxygen-poor blood is collected from the tissues and organs by tiny veins, which then flow into bigger veins, and, eventually, into the inferior vena cava and superior vena cava. This completes systemic circulation. The blood releases carbon dioxide and gets more oxygen in pulmonary circulation before returning to systemic circulation.

### Vocabulary

- **aorta**: Largest artery; receives blood directly from the heart.
- **artery**: Blood vessel that carries blood away from the heart toward the lungs or body.
- **blood vessel**: Tube that transports blood; includes the arteries, veins, and capillaries.
- **capillary**: Smallest type of blood vessel that connects very small arteries and veins.
- **inferior vena cava**: Vein that receives blood directly from the heart.
- **pulmonary artery**: Blood vessel that carries oxygen-poor blood away from the heart to the lungs.
- **pulmonary circulation**: Part of the circulatory system that carries blood between the heart and lungs.
- **superior vena cava**: Vein that brings blood back to the heart from the upper body.
- **systemic circulation**: Part of the circulatory system that carries blood between the heart and body.
- **vein**: Blood vessel that carries blood toward the heart from the lungs or body.

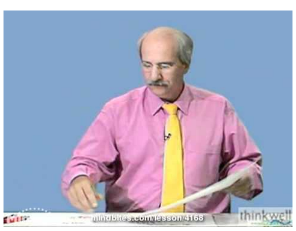
### Summary

- Arteries carry blood away from the heart, while veins return blood to the heart.
- Pulmonary circulation carries blood between the heart and lungs, while systemic circulation carries blood between the heart and body.

### Practice

Use the resources below to answer the questions that follow.

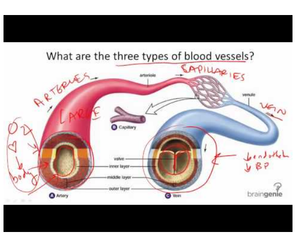
- **Human Circulation: Blood Vessels** at http://www.youtube.com/watch?v=oruunlHsXoQ (3:50)



MEDIA
Click image to the left for more content.

1. What is the difference between capillaries, veins, and arteries?
2. What is endothelium? What vessels have this tissue?
3. What do arteries and veins have that capillaries don't? How does size relate to this difference?

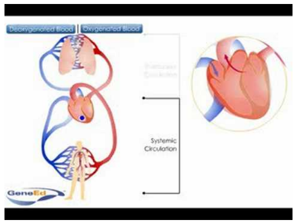
- **Blood Vessel Structure and Function** at http://www.youtube.com/watch?v=whtNDBIhczQ (3:16)




MEDIA
Click image to the left for more content.

1. How does the structure of arteries differ from the structure of veins?
2. How is the structure of arteries and veins related to their function?

- **Systemic and Pulmonary Circulation** at http://www.youtube.com/watch?v=0jznS5psypI (0:30)



MEDIA

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1. What are the three types of circulation of the blood?
2. What is the function of the systemic circulation system?
3. What is the function of the pulmonary circulation system

## Review

1. What's the difference between veins and arteries?
2. Why can the heart be considered to be two separate pumps?

# 1.25 Components of Blood

- Describe the components of the blood.


**What's in your blood?**

These bags of blood will be stored until they are needed for a transfusion. But what exactly is blood? What makes up the blood? Most of your blood is water. However, there are also many other important components of your blood.

## Components of Blood

Did you know that blood is a tissue? Blood is a fluid connective tissue that is made up of red blood cells, white blood cells, platelets, and plasma. The cells that make up blood are pictured below (**Figure** 1.44). The different parts of blood have different roles.

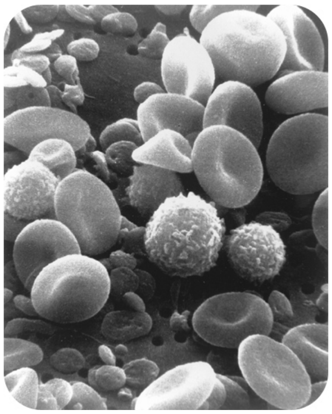


FIGURE 1.44

A scanning electron microscope (SEM) image of human blood cells. Red blood cells are the flat, bowl-shaped cells, the tiny disc-shaped pieces are platelets, and white blood cells are the round cells shown in the center.

### Plasma

If you were to filter out all the cells in blood, a golden-yellow liquid would be left behind. **Plasma** is this fluid part of the blood. Plasma is about 90% water and about 10% dissolved proteins, glucose, ions, hormones, and gases. Blood is made up mostly of plasma.

### Red Blood Cells

**Red blood cells** (RBCs) are flattened, disk-shaped cells that carry oxygen. They are the most common blood cell in the blood. There are about 4 to 6 million RBCs per cubic millimeter of blood. Each RBC has 200 million molecules of hemoglobin. **Hemoglobin** is the protein that carries oxygen. Hemoglobin also gives the red blood cells their red color.

Red blood cells (**Figure** 1.45) are made in the red marrow of long bones, rib bones, the skull, and vertebrae. Each red blood cell lives for only 120 days (about four months). After this time, they are destroyed in the liver and spleen. Mature red blood cells do not have a nucleus or other organelles. Lacking these components allows the cells to have more hemoglobin and carry more oxygen.

### White Blood Cells

**White blood cells** (WBCs) are usually larger than red blood cells. They do not have hemoglobin and do not carry oxygen. White blood cells make up less than one percent of the blood's volume. Most WBCs are made in the bone marrow, and some mature in the lymphatic system. There are different WBCs with different jobs. WBCs defend the body against infection by bacteria, viruses, and other **pathogens**. WBCs do have a nucleus and other organelles.

FIGURE 1.45
The flattened shape of red blood cells helps them carry more oxygen than if they were rounded.

- Neutrophils are WBCs that can squeeze through capillary walls and swallow particles such as bacteria and parasites.
- Macrophages are large WBCs that can also swallow and destroy old and dying cells, bacteria, or viruses. Below, a macrophage is attacking and swallowing two particles, possibly disease-causing pathogens (**Figure** 1.46). Macrophages also release chemical messages that cause the number of WBCs to increase.
- Lymphocytes are WBCs that fight infections caused by viruses and bacteria. Some lymphocytes attack and kill cancer cells. Lymphocytes called B-cells make antibodies.

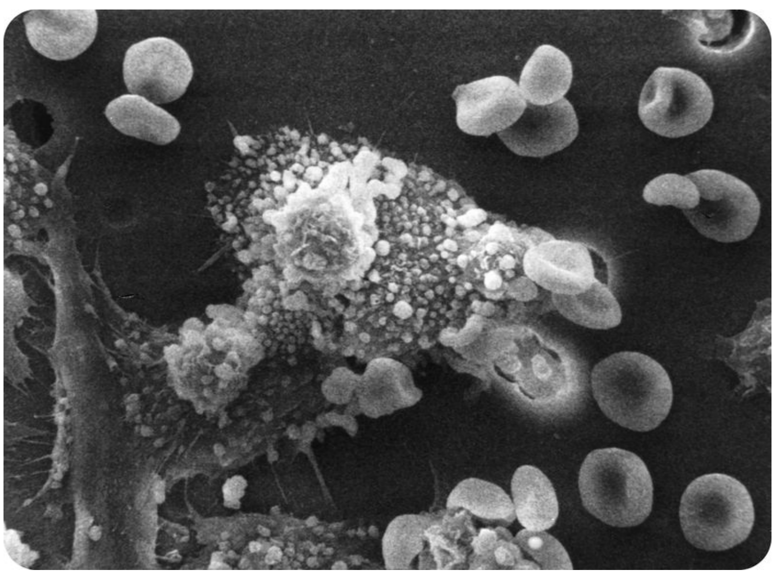


FIGURE 1.46
A type of white blood cell, called a macrophage, is attacking a cancer cell.

### Platelets

**Platelets** (**Figure** 1.47) are very small, but they are very important in blood clotting. Platelets are not cells. They are sticky little pieces of larger cells. Platelets bud off large cells that stay in the bone marrow. When a blood vessel gets cut, platelets stick to the injured areas. They release chemicals called clotting factors, which cause proteins to form over the wound. This web of proteins catches red blood cells and forms a clot. This clot stops more blood from leaving the body through the cut blood vessel. The clot also stops bacteria from entering the body. Platelets survive in the blood for ten days before they are removed by the liver and spleen.

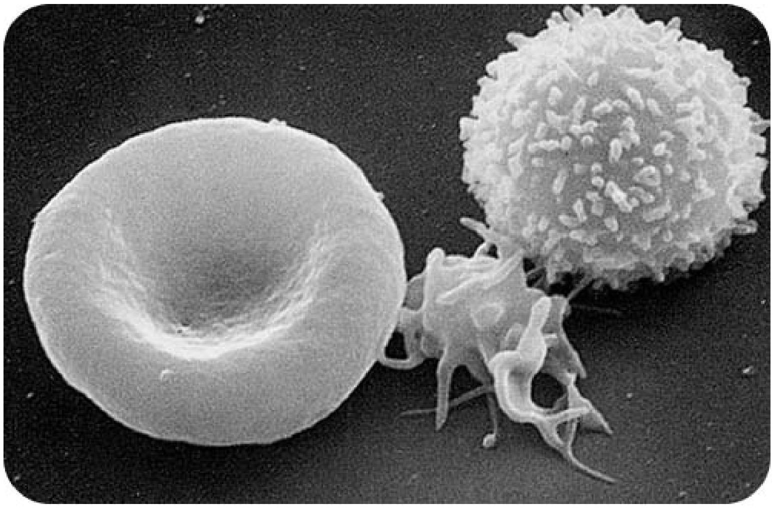


FIGURE 1.47
A platelet lies between a red blood cell, at left, and a white blood cell at right. Platelets are little pieces of larger cells that are found in the bone marrow.

### Vocabulary

- **hemoglobin**: Protein in red blood cells that binds oxygen.
- **pathogen**: Living thing or virus that causes disease.
- **plasma**: Fluid part of blood that contains many dissolved substances.
- **platelet**: Cell fragment in blood that helps blood clot.
- **red blood cell**: Type of cell in blood that carries oxygen.
- **white blood cell**: Type of cell in blood that defends the body against infection.

### Summary

- Plasma, the fluid part of the blood, is mostly made up of water but also contains dissolved proteins, glucose, ions, hormones, and gases.
- Red blood cells carry oxygen, while white blood cells defend the body against infection by bacteria, viruses, and other diseases.

### Practice

Use the resource below to answer the questions that follow.

- **The Components of Blood** at http://www.youtube.com/watch?v=C5qmKirdiic (2:01)


MEDIA
Click image to the left for more content.

1. What is another name for red blood cells? What is the function of red blood cells?
2. Why are red blood cells red?

3. What is another name for white bloods cells (WBCs)? What is the function of white blood cells?
4. What is another name for platelets? What is the function of platelets?

## Review

1. What is the purpose of the white blood cells?
2. What is the purpose of the red blood cells?

# 1.26 Blood Types

- Describe how blood type is determined.

**What's your type?**

As this woman donates blood, you can see her blood collecting in a special bag. This bag is coded with her blood type. That makes it possible for doctors and nurses to match up the blood she is giving to a recipient that has the same blood type.

## Blood Types

Do you know what your blood type is? Maybe you have heard people say that they have Type A or Type O blood. Blood type is a way to describe the type of antigens, or proteins, on the surface of red blood cells (RBCs). There are four blood types; A, B, AB, and O.

1. Type A blood has type A antigens on the RBCs in the blood.
2. Type AB blood has A and B antigens on the RBCs.
3. Type B has B antigens on the RBCs.
4. Type O does not have either A or B antigens.

The ABO blood group system is important if a person needs a blood transfusion. A **blood transfusion** is the process of putting blood or blood products from one person into the circulatory system of another person. The blood type of the recipient needs to be carefully matched to the blood type of the donor. That's because different blood types have different types of antibodies, or proteins, released by the blood cells. Antibodies attack strange substances in the body. This is a normal part of your defenses against disease.

For example, imagine a person with Type O blood was given type A blood. First, what type of antibodies do people with type O blood produce? They produce anti-A and anti-B antibodies. This means, if a person with type O blood received type A blood, the anti-A antibodies in the person's blood would attack the A antigens on the RBCs in the donor blood (**Figure** 1.48). The antibodies would cause the RBCs to clump together, and the clumps could block a blood vessel. This clumping of blood cells could cause death.

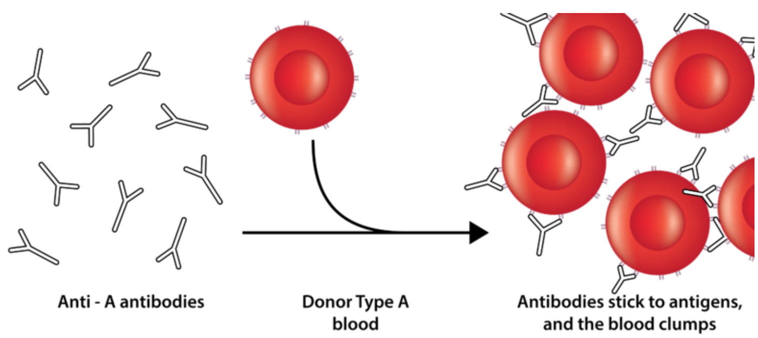



FIGURE 1.48

A person with type O blood has A and B antibodies in his/her plasma; if the person was to get type A blood instead of type O, his/her A antibodies would attach to the antigens on the RBCs and cause them to clump together.

People with type A blood produce anti-B antibodies, and people with type B blood produce anti-A antibodies. People with type AB blood do not produce either antibody.

### The Rhesus Factor

The second most important blood group system in human blood is the **Rhesus (Rh) factor**. A person either has, or does not have, the Rh antigen on the surface of their RBCs. If they do have it, then the person is positive. If the person does not have the antigen, they are considered negative.

### Blood Donors

Recall that people with type O blood do not have any antigens on their RBCs. As a result, type O blood can be given to people with blood types A, B, or AB. If there are no antigens on the RBCs, there cannot be an antibody reaction in the blood. People with type O blood are often called **universal donors**.

The blood plasma of AB blood does not contain any anti-A or anti-B antibodies. People with type AB blood can receive any ABO blood type. People with type AB blood are called **universal recipients** because they can receive any blood type. The antigens and antibodies that define blood type are listed as follows (**Table** 1.4).

**TABLE 1.4: Blood Types, Antigens, and Antibodies**

| Blood type | Antigen type | Plasma antibodies | Can receive blood from types | Can donate blood to types |
|---|---|---|---|---|
| A | A | anti-B | A,O | A, AB |
| B | B | anti-A | B,O | B, AB |
| AB | A and B | none | AB, A, B, O | AB |
| O | none | anti-A, anti-B | O | AB, A, B, O |

## Vocabulary

- **blood transfusion**: Process of putting blood or blood products from one person into the circulatory system of another person.
- **Rhesus factor**: Aspect of blood type that tells whether or not a person has the Rh antigen on the surface of their red blood cells.
- **universal donors**: People with type O blood; they do not have any antigens on their red blood cells and, therefore, can donate blood to people with any blood type.
- **universal recipients**: People with type AB positive blood; they do not make any anti-A or anti-B antibodies and, therefore, can receive any blood type.

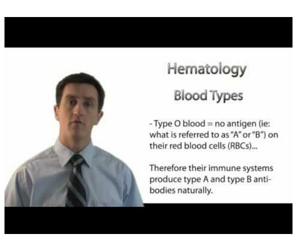
## Summary

- Blood type, which can be A, B, AB, or O, is a way to describe the type of proteins on the surface of red blood cells.
- Another important aspect of blood type is the Rhesus (Rh) factor; a person either has, or does not have, the Rh antigen on the surface of his/her red blood cells.

## Practice

Use the resource below to answer the questions that follow.

- **Understanding Blood Types** at http://www.youtube.com/watch?v=G_-9_CF02qI (2:12)




MEDIA
Click image to the left for more content.

1. What is an antigen? Where can antigens be found?
2. What is an antibody? What is their function?
3. What does type B blood have that type O blood does not?

## Review

1. Why is it important to match blood types when giving a blood transfusion?
2. Why are people with type O blood called "universal donors"?

# 1.27 Blood Diseases

- Describe diseases of the blood.

**What do these foods have in common?**

Red meat, legumes, and spinach are all good sources of iron. Getting enough iron in your diet is important to prevent anemia. Anemia is a blood disease that causes you to feel weak and tired. Although anemia is caused by a nutrient deficiency, other blood diseases are genetic diseases, or forms of cancer.

## Blood Diseases

Problems can occur with red blood cells, white blood cells, platelets, and other parts of the blood. Many blood disorders are genetic, meaning they are inherited from a parent. Some blood diseases are caused by not getting enough of a certain nutrient, while others are cancers of the blood.

### Anemia

**Anemia** is a disease that occurs when there is not enough hemoglobin in the blood to carry oxygen to body cells. **Hemoglobin** is the blood protein that normally carries oxygen from the lungs to the tissues. Anemia leads to a lack of oxygen in organs.

Anemia is usually caused by one of the following:

- A loss of blood from a bleeding wound or a slow leak of blood.
- The destruction of red blood cells.
- A lack of red blood cell production.

Anemia may not have any symptoms. Some people with anemia feel weak or tired in general or during exercise. They also may have poor concentration. People with more severe anemia often get short of breath during times of activity. Iron-deficiency anemia is the most common type of anemia. It occurs when the body does not receive enough iron. Since there is not enough iron, hemoglobin, which needs iron to bind oxygen, cannot be made.

In the United States, 20% of all women of childbearing age have iron-deficiency anemia, compared with only 2% of adult men. The most common cause of iron-deficiency anemia in young women is blood lost during menstruation. Iron deficiency anemia can be avoided by getting the recommended amount of iron in one's diet. Anemia is often treated or prevented by taking iron supplements.

Boys and girls between the ages of 9 and 13 should get 9 mg of iron every day. Girls between the ages of 14 and 18 should get 15 mg of iron every day. Boys between the ages of 14 and 18 should get 11 mg of iron every day. Pregnant women need the most iron—27 mg daily. Good sources of iron include shellfish, such as clams and oysters. Red meats, such as beef, are also a good source of iron. Non-animal sources of iron include seeds, nuts, and legumes. Breakfast cereals often have iron added to them in a process called fortification. Some good sources of iron are listed below (**Table** 1.5). Eating vitamin C along with iron-containing food increases the amount of iron that the body can absorb.

**TABLE 1.5: Sources of Iron**

| Food | Milligrams (mg) of Iron |
|---|---|
| Canned clams, drained, 3 oz | 23.8 |
| Fortified dry cereals, about 1 oz | 1.8 to 21.1 |
| Roasted pumpkin and squash seeds, 1 oz | 4.2 |
| Cooked lentils, $\frac{1}{2}$ cup | 3.3 |
| Cooked fresh spinach, $\frac{1}{2}$ cup | 3.2 |
| Cooked ground beef, 3 oz | 2.2 |
| Cooked sirloin beef, 3 oz | 2.0 |

### Sickle-Cell Anemia

**Sickle-cell anemia** is a blood disease that is caused by an abnormally-shaped hemoglobin protein in red blood cells. Many of the red blood cells of a person with sickle-cell anemia are long and curved (sickle-shaped) (**Figure** 1.49). The long, sickle-shape of the cells can cause them to get stuck in narrow blood vessels. This clotting means that oxygen cannot reach the cells. People with sickle-cell anemia are most often well but can occasionally have painful attacks. The disease is not curable, but it can be treated with medicines.

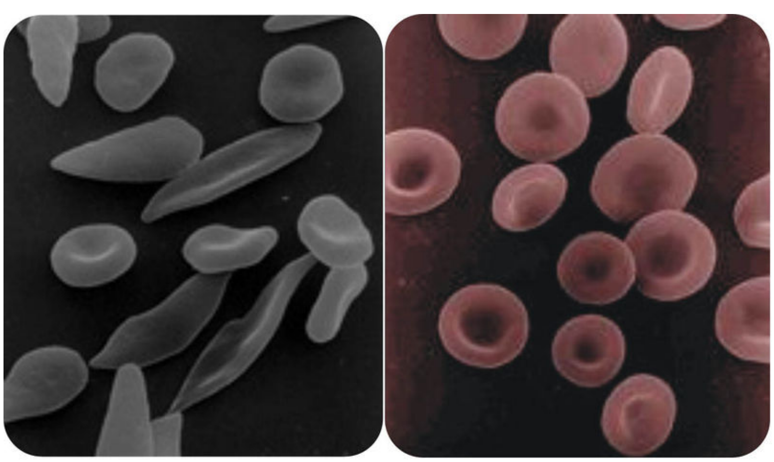


FIGURE 1.49
The red blood cells of a person with sickle-cell anemia (left) are long and pointed, rather than straight, like normal cells (right). The abnormal cells cannot carry oxygen properly and can get stuck in capillaries.

### Blood Cancer

**Leukemia** is a cancer of the blood or bone marrow. It is characterized by an abnormal production of blood cells, usually white blood cells. **Lymphoma** is a cancer of a type of white blood cell called *lymphocytes*. There are many types of lymphoma.

### Hemophilia

**Hemophilia** is the name of a group of hereditary diseases that affect the body's ability to control blood clotting. Hemophilia is caused by a lack of clotting factors in the blood. Since people with hemophilia cannot produce clots, any cut can put a person at risk of bleeding to death. The risk of internal bleeding is also increased in hemophilia, especially into muscles and joints.

## Vocabulary

- **anemia**: Disease that occurs when there is not enough hemoglobin in the blood, usually because of a lack of iron.
- **hemoglobin**: Blood protein that normally carries oxygen from the lungs to the tissues.
- **hemophilia**: Group of hereditary diseases that affect the body's ability to control blood clotting.
- **leukemia**: Cancer of the blood or bone marrow.
- **lymphoma**: Cancer in a type of white blood cell called lymphocytes.
- **sickle-cell anemia**: Inherited blood disease that is caused by abnormally-shaped blood protein, hemoglobin.

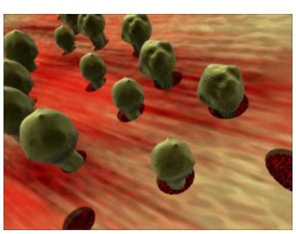
## Summary

- Blood diseases can affect red blood cells, white blood cells, or platelets.
- Blood diseases include sickle-cell anemia, leukemia, lymphoma, and hemophilia.

## Practice

Use the resources below to answer the questions that follow.

- **Aplastic Anemia** at http://www.youtube.com/watch?v=w8-jx1dtg0U (2:41)



MEDIA
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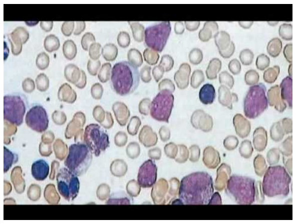
1. What causes aplastic anemia? Why is it considered an autoimmune disease?
2. Where are red blood cells, white blood cells, and platelets formed? Which of these cells are at reduced levels in someone with aplastic anemia?
3. How does "rebooting" the immune system treat aplastic anemia?

- **Blood Cancers** at http://www.youtube.com/watch?v=eNz8YCMJJaY (6:24)



MEDIA

Click image to the left for more content.

1. In what blood cells can cancer develop?
2. What is leukemia? What blood cells are affected?
3. What is myeloma? What part of the blood is affected?

## Review

1. Identify two blood diseases that are inherited.
2. List two good sources of iron in the diet.

# 1.28 Blood Pressure

- Define blood pressure and describe the effects of high blood pressure.

**Why check your blood pressure?**

It's a good idea to have a blood pressure test as part of a routine physical, especially in adulthood. High blood pressure is a risk factor for heart disease and stroke. It's important to know if you have high blood pressure, so it can be treated. A combination of medications and lifestyle changes can be successful in lowering your blood pressure.

## Blood Pressure

The health of your whole body depends on the good health of your cardiovascular system. One measure of the health of your cardiovascular system is blood pressure. **Blood pressure** occurs when circulating blood puts pressure on the walls of blood vessels. Since blood pressure is primarily caused by the beating of your heart, the walls of the arteries move in a rhythmic fashion.

Blood in arteries is under the greatest amount of pressure. The pressure of the circulating blood slowly decreases as blood moves from the arteries and into the smaller blood vessels. Blood in veins is not under much pressure.

The **systolic** pressure is the pressure on the blood vessels when the heart beats. This is the time when there is the highest pressure in the arteries. The **diastolic** pressure is when your blood pressure is lowest, when the heart is resting between beats.

### Healthy Blood Pressure Ranges

Healthy ranges for blood pressure are:

- Systolic: less than 120

- Diastolic: less than 80

Blood pressure is usually written as systolic/diastolic. For example, a reading of 120/80 is said as "one twenty over eighty." These measures of blood pressure can change with each heartbeat and over the course of the day. Pressure varies with exercise, emotions, sleep, stress, nutrition, drugs, or disease.

Studies have shown that people whose systolic pressure is around 115, rather than 120, have fewer health problems. Clinical trials have shown that people who have blood pressures at the low end of these ranges have much better long term cardiovascular health. Blood pressure is measured with a sphygmomanometer (**Figure** 1.50).


FIGURE 1.50
A digital sphygmomanometer is made of an inflatable cuff and a pressure meter to measure blood pressure. This reading shows a blood pressure of 126/70.

**Hypertension**, which is also called "high blood pressure," occurs when a person's blood pressure is always high. Hypertension is said to be present when a person's systolic blood pressure is always 140 or higher, and/or if the person's diastolic blood pressure is always 90 or higher. Having hypertension increases a person's chance for developing heart disease, having a stroke, or suffering from other serious cardiovascular diseases. Hypertension often does not have any symptoms, so a person may not know that he or she has high blood pressure. For this reason, hypertension is often called the silent killer. Treatments for hypertension include diet changes, exercise, and medication.

## Vocabulary

- **blood pressure**: Pressure that circulating blood puts on the walls of blood vessels.
- **diastolic**: Blood pressure when the heart is resting between beats.
- **hypertension**: High blood pressure.
- **systolic** : Blood pressure when the heart constricts.

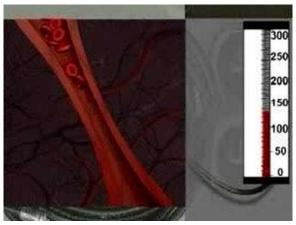
## Summary

- Blood pressure occurs when circulating blood puts pressure on the walls of blood vessels.
- Hypertension, or high blood pressure, can increase the risk of cardiovascular disease.

## Practice

Use the resource below to answer the questions that follow.

- **Blood Pressure** at http://www.youtube.com/watch?v=luppKLO74vg (1:42)




MEDIA

Click image to the left for more content.

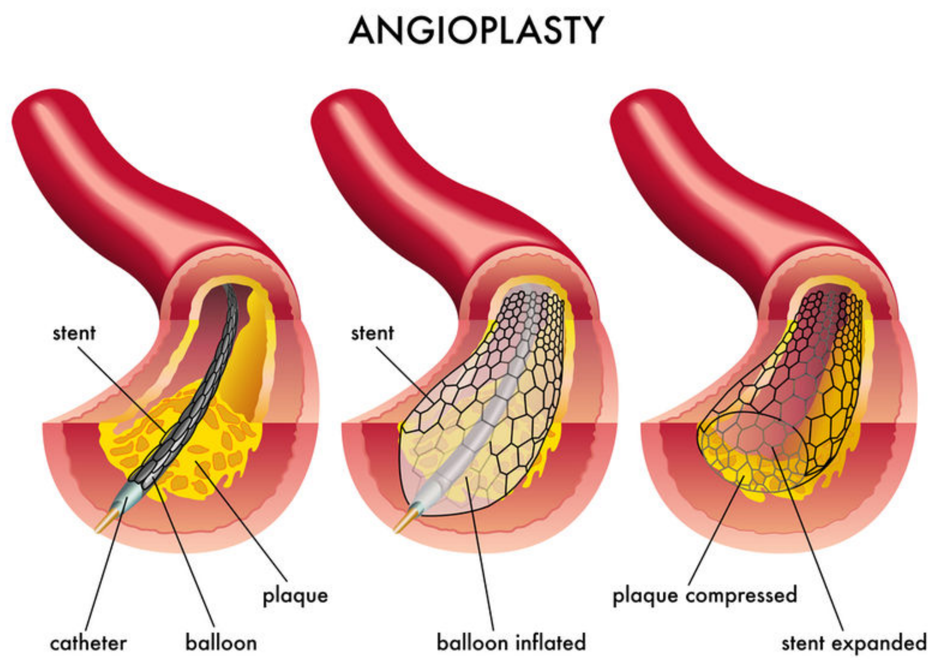
1. What causes your pulse?
2. What is systolic pressure? How is it measured?
3. What is diastolic pressure? How is it measured?

## Review

1. What is the healthy range for blood pressure?
2. Why do you think hypertension is sometimes called a silent killer?

# 1.29 Cardiovascular Diseases

- Describe the various types of cardiovascular disease.




**How do you "fix" arteries?**

When a blood vessel gets clogged, there is no medical equivalent of "Drano" that will clear it out. There is, however, a procedure known as angioplasty. A thin tube with a balloon is threaded through the blood vessels. Once in place, the balloon is inflated to compress the clog against the artery wall.

### Cardiovascular Diseases

A **cardiovascular disease (CVD)** is any disease that affects the cardiovascular system. But the term is usually used to describe diseases that are linked to atherosclerosis.

**Atherosclerosis** (**Figure** 1.51) is an inflammation of the walls of arteries that causes swelling and a buildup of material called plaque. **Plaque** is made of cell pieces, fatty substances, calcium, and connective tissue that builds up around the area of inflammation. As a plaque grows, it stiffens and narrows the artery, which decreases the flow of blood through the artery.

Atherosclerosis normally begins in late childhood and is typically found in most major arteries. It does not usually have any early symptoms. Causes of atherosclerosis include a high-fat diet, high cholesterol, smoking, obesity, and diabetes. Atherosclerosis becomes a threat to health when the plaque buildup prevents blood circulation in the heart or the brain. A blocked blood vessel in the heart can cause a heart attack. Blockage of the circulation in the brain can cause a stroke.

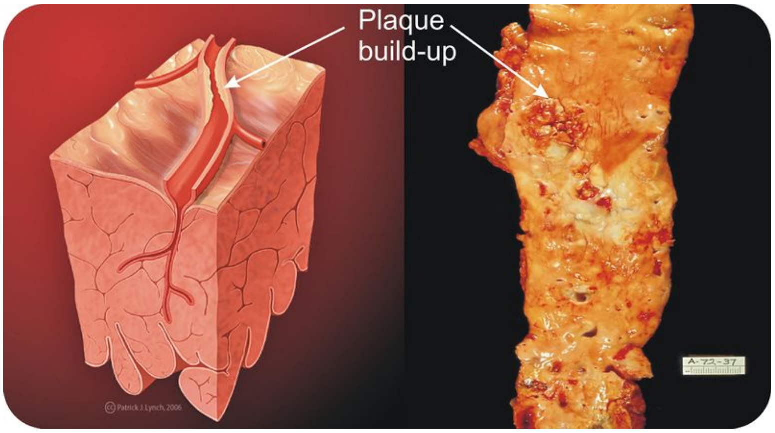



FIGURE 1.51
Atherosclerosis is sometimes referred to as hardening of the arteries; plaque build-up decreases the blood flow through the artery.

### Coronary Heart Disease

Like any other muscle, your heart needs oxygen. Hearts have arteries that provide oxygen through the blood. They are known as **coronary arteries**. **Coronary heart disease** is the end result of the buildup of plaque within the walls of the coronary arteries.

Coronary heart disease often does not have any symptoms. A symptom of coronary heart disease is chest pain. Occasional chest pain can happen during times of stress or physical activity. The pain of angina means the heart muscle fibers need more oxygen than they are getting. Most people with coronary heart disease often have no symptoms for many years until they have a heart attack.

A **heart attack** happens when the blood cannot reach the heart because a blood vessel is blocked. If cardiac muscle is starved of oxygen for more than roughly five minutes, it will die. Cardiac muscle cells cannot be replaced, so once they die, they are dead forever. Coronary heart disease is the leading cause of death of adults in the United States. The image below shows the way in which a blocked coronary artery can cause a heart attack and cause part of the heart muscle to die (**Figure** 1.52).

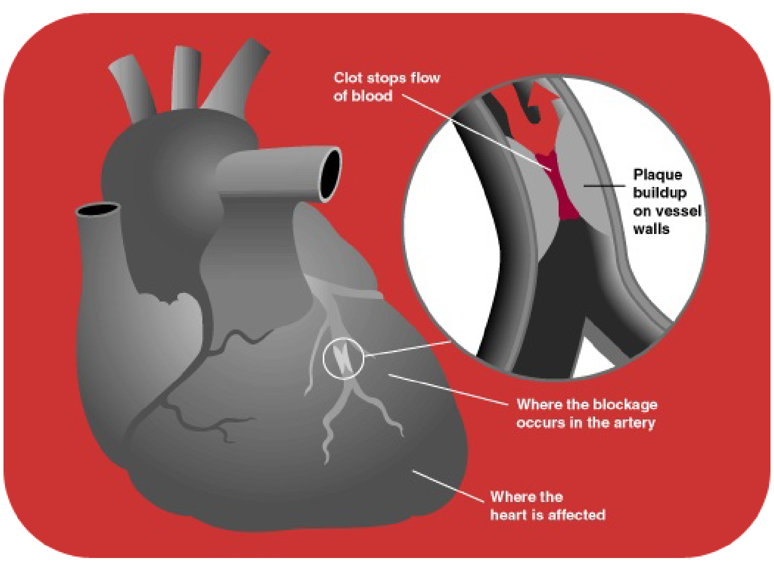



FIGURE 1.52
A blockage in a coronary artery stops oxygen from getting to part of the heart muscle, so areas of the heart that depend on the blood flow from the blocked artery are starved of oxygen.

### Stroke

Atherosclerosis in the arteries of the brain can also lead to a stroke. A **stroke** is a loss of brain function due to a blockage of the blood supply to the brain. Risk factors for stroke include old age, high blood pressure, having a previous stroke, diabetes, high cholesterol, and smoking. The best way to reduce the risk of stroke is to have low blood pressure

## Vocabulary

- **atherosclerosis**: Condition in which plaque builds up inside arteries.
- **cardiovascular disease**: Disease that affects the heart or blood vessels.
- **coronary artery**: Blood vessel that supplies the heart with oxygen.
- **coronary heart disease**: Build-up of of plaque in arteries that supply the heart with oxygen.
- **heart attack**: Blockage of blood flow to heart.
- **plaque**: Deposit of fatty material on the inner lining of an arterial wall.
- **stroke**: Loss of brain function due to a blockage of the blood supply to the brain.

## Summary

- Atherosclerosis is a condition in which the inside of arteries become clogged with plaque, a deposit of fatty material.
- Atherosclerosis can be dangerous when it prevents blood circulation to the heart or the brain, causing a heart attack or stroke.

## Practice

Use the resource below to answer the questions that follow.

- **Understanding Heart Disease** at http://www.youtube.com/watch?v=3cW8__wFXDA (2:25)

MEDIA
Click image to the left for more content.

1. What is coronary artery disease? Where does it occur? What happens to someone who has coronary artery disease?
2. What is congestive heart failure? What causes congestive heart failure? How does this affect your body?

## Review

1. What is atherosclerosis?
2. How are strokes and heart attacks similar?

# 1.30 Cardiovascular System Health

- Identify things you can do to avoid cardiovascular disease.

**Why is smoking bad for you?**

Most people associate smoking with lung disease. But that is not the only health risk of smoking. Smoking is also a major cause of cardiovascular disease.

## Keeping Your Cardiovascular System Healthy

There are many risk factors that can cause a person to develop cardiovascular disease. A **risk factor** is anything that is linked to an increased chance of developing a disease. Some of the risk factors for cardiovascular disease you cannot control, but there are many risk factors you can control.

Risk factors you cannot control include:

- *Age*: The older a person is, the greater their chance of developing a cardiovascular disease.
- *Gender*: Men under age 64 are much more likely to die of coronary heart disease than women, although the gender difference decreases with age.
- *Genetics*: Family history of cardiovascular disease increases a person's chance of developing heart disease.

Risk factors you can control include:

- *Tobacco smoking*: Giving up smoking or never starting to smoke is the best way to reduce the risk of heart disease.
- *Diabetes*: Diabetes can cause bodily changes, such as high cholesterol levels, which are are risk factors for cardiovascular disease.

- *High cholesterol levels*: High amounts of "bad cholesterol," increase the risk of cardiovascular disease.
- *Obesity*: Having a very high percentage of body fat, especially if the fat is mostly found in the upper body, rather than the hips and thighs, increases risk significantly.
- *High blood pressure*: If the heart and blood vessels have to work harder than normal, this puts the cardiovascular system under a strain.
- *Lack of physical activity*: Aerobic activities, such as the one pictured below (**Figure** 1.53), help keep your heart healthy. To reduce the risk of disease, you should be active for at least 60 minutes a day, five days a week.
- *Poor eating habits*: eating mostly foods that do not have many nutrients other than fat or carbohydrate leads to high cholesterol levels, obesity, and cardiovascular disease (**Figure** 1.54).

FIGURE 1.53

60 minutes a day of vigorous aerobic activity, such as basketball, is enough to help keep your cardiovascular system healthy.

FIGURE 1.54

The USDA's MyPyramid recommends that you limit the amount of such foods in your diet to occasional treats.

## Vocabulary

- **obesity**: Condition of having a very high percentage of body fat.
- **risk factor**: Anything that is linked to an increased chance of developing a disease.

## Summary

- A family history of cardiovascular disease increases a person's chance of developing heart disease.
- Having a poor diet and not getting enough exercise are two major causes of cardiovascular disease.

## Practice

Use the resource below to answer the questions that follow.

- **Healthy Heart For Life! - Mayo Clinic** at http://www.youtube.com/watch?v=TYGsqqzCMSE (2:10)


MEDIA
Click image to the left for more content.

1. How much should you move a day to help prevent heart disease?
2. How much should you sleep a day to help prevent heart disease?

## Review

1. What are three risks factors for cardiovascular disease?
2. What are some steps you can take to avoid cardiovascular disease?

# 1.31 Respiration

- Describe how breathing works.

**Why do you breathe?**

We breathe because we need oxygen. Breathing also releases carbon dioxide from our bodies into the air. The respiratory system is the body system that brings air containing oxygen into the body and releases carbon dioxide into the atmosphere.

## How We Breathe

Most of the time, you breathe without thinking about it. Breathing is mostly an involuntary action that is controlled by a part of your brain that also controls your heart beat. If you swim, do yoga, or sing, you know you can control your breathing, however. Taking air into the body through the nose and mouth is called **inhalation**. Pushing air out of the body through the nose or mouth is called **exhalation**. The woman pictured below is exhaling before she surfaces from the pool water (**Figure** 1.55).

How do lungs allow air in? As mentioned above, air moves into and out of the lungs by the movement of muscles. The most important muscle in the process of breathing is the **diaphragm**, a sheet of muscle that spreads across the

FIGURE 1.55
Being able to control breathing is important for many activities, such as swimming. The woman in the photograph is exhaling as she exits the water.

bottom of the rib cage. The diaphragm and rib muscles contract and relax to move air into and out of the lungs. During inhalation, the diaphragm contracts and moves downward. The rib muscles contract and cause the ribs to move outward. This causes the chest volume to increase. Because the chest volume is larger, the air pressure inside the lungs is lower than the air pressure outside. This difference in air pressures causes air to be sucked into the lungs. When the diaphragm and rib muscles relax, air is pushed out of the lungs. Exhalation is similar to letting the air out of a balloon.

How does the inhaled oxygen get into the bloodstream? The exchange of gasses between the lungs and the blood happens in tiny sacs called **alveoli**. The walls of the alveoli are very thin and allow gases to pass though them. The alveoli are lined with capillaries (**Figure** 1.56). Oxygen moves from the alveoli to the blood in the capillaries that surround the alveoli. At the same time, carbon dioxide moves in the opposite direction, from capillary blood to the alveoli.

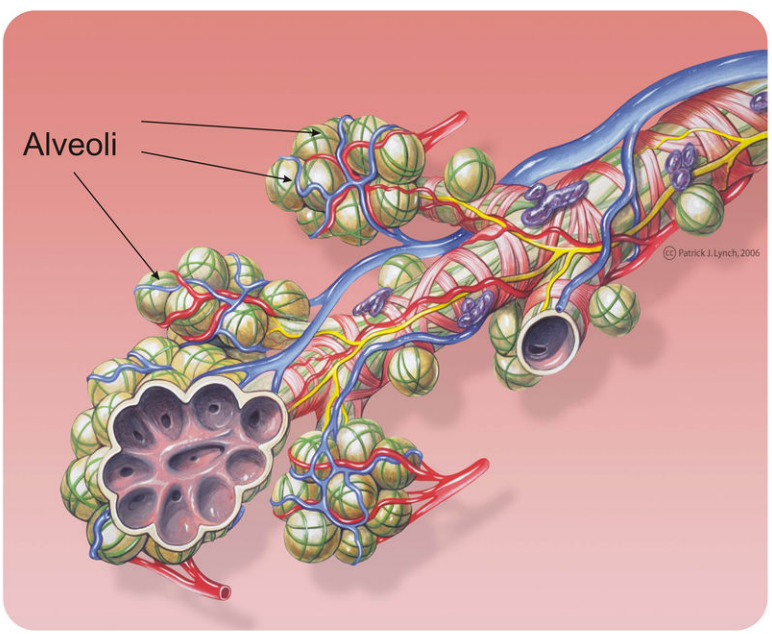



FIGURE 1.56
The bronchi and alveoli. During respiration, oxygen gets pulled into the lungs and enters the blood by passing across the thin alveoli membranes and into the capillaries.

### Breathing and Respiration

The process of getting oxygen into the body and releasing carbon dioxide is called **respiration**. Sometimes breathing is called respiration, but there is much more to respiration than just breathing. Breathing is only the movement of oxygen into the body and carbon dioxide out of the body. The process of respiration also includes the exchange of oxygen and carbon dioxide between the blood and the cells of the body.

## Vocabulary

- **alveoli**: Tiny sacs in the lungs where gas exchange takes place.
- **diaphragm** : Sheet of muscle that spreads across the bottom of the rib cage.
- **exhalation**: Pushing air out of the body through the nose or mouth.
- **inhalation**: Taking air into the body through the nose or mouth.
- **respiration**: Process of getting oxygen into the body and releasing carbon dioxide.

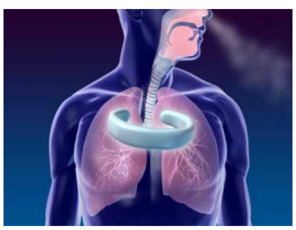
## Summary

- The diaphragm and rib muscles contract when you inhale and relax when you exhale.
- The process of getting oxygen into the body and releasing carbon dioxide is called respiration.

## Practice

Use the resource below to answer the questions that follow.

- **Respiration-Ventilation** at http://www.youtube.com/watch?v=HiT621PrrO0 (1:44)



MEDIA

Click image to the left for more content.

1. What causes air to enter the lung?
2. What happens at the alveolar sacs? Be thorough and complete in your answer.
3. What is the function of the epiglottis? Where is it located?

## Review

1. In what part of the lung does gas exchange occur?
2. What is the difference between breathing and respiration?

# 1.32 Respiratory System Organs

- Identify the parts of the respiratory system.

**What are the organs that help you breathe?**

When you think of the processes of breathing, the lungs probably come to mind. The lungs are the main organ of the respiratory system. However, many other organs are also needed for the process of respiration to take place.

## Organs of The Respiratory System

Your respiratory system is made up of the tissues and organs that allow oxygen to enter your body and carbon dioxide to leave your body. Organs in your respiratory system include your:

- Nose.
- Mouth.
- Larynx.

- Pharynx.
- Lungs.
- Diaphragm.

These structures are shown below (**Figure** 1.57).

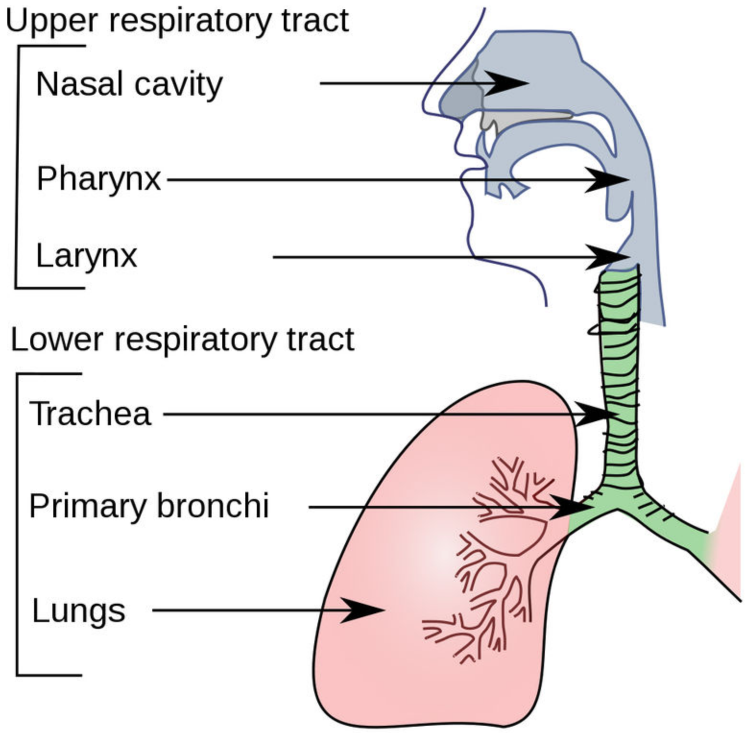



FIGURE 1.57
The organs of the respiratory system move air into and out of the body.

What do you think is the purpose of each of these organs?

- The nose and the nasal cavity filter, warm, and moisten the air you breathe. The nose hairs and the mucus produced by the cells in the nose catch particles in the air and keep them from entering the lungs.
- Behind the nasal cavity, air passes through the **pharynx**, a long tube. Both food and air pass through the pharynx.
- The **larynx**, also called the "voice box," is found just below the pharynx. Your voice comes from your larynx. Air from the lungs passes across thin tissues in the larynx and produces sound.
- The **trachea**, or windpipe, is a long tube that leads down to the lungs, where it divides into the right and left **bronchi**. The bronchi branch out into smaller bronchioles in each lung.
- The bronchioles lead to the alveoli. **Alveoli** are the little sacs at the end of the bronchioles (**Figure** 1.58). They look like little bunches of grapes. Oxygen is exchanged for carbon dioxide in the alveoli. That means oxygen enters the blood, and carbon dioxide moves out of the blood.
- The **diaphragm** is a sheet of muscle that spreads across the bottom of the rib cage. When the diaphragm contracts, the chest volume gets larger, and the lungs take in air. When the diaphragm relaxes, the chest volume gets smaller, and air is pushed out of the lungs.

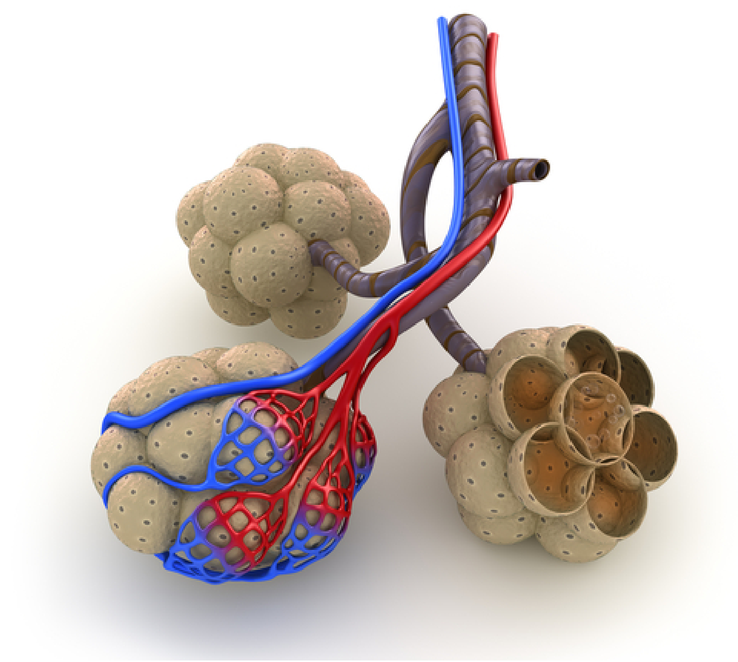


FIGURE 1.58
"Grape-like" alveoli in the lungs.

## Vocabulary

- **alveoli** : Tiny sacs in the lungs where gas exchange takes place.
- **bronchi**: Air passages in the respiratory tract that conduct air into the lungs.
- **diaphragm** : Sheet of muscle that spreads across the bottom of the rib cage.
- **larynx**: Respiratory organ between the pharynx and trachea; also called the voice box because it allows the production of vocal sounds.
- **pharynx**: Long, tubular organ that connects the mouth and nasal cavity with the larynx; food and air pass through it.
- **trachea**: Long, tubular organ, also called the wind pipe, that carries air between the larynx and lungs.

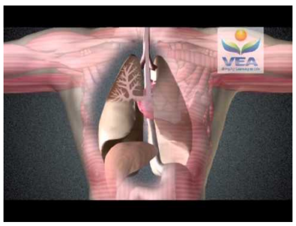
## Summary

- The organs of the respiratory system include the lungs, pharynx, larynx, trachea, and bronchi.

## Practice

Use the resource below to answer the questions that follow.

- **The Respiratory System** at http://www.youtube.com/watch?v=IWXAhe0w_CE (3:09)




MEDIA
Click image to the left for more content.

1. Where is the trachea located and what is its function?
2. What is the relationship between the bronchi, bronchial tubes, and bronchioles? What function does this relationship serve?
3. Why does air funnel into smaller and smaller spaces within the lungs?

## Review

1. Name four organs in the respiratory system.
2. What is the trachea?

# 1.33 Processes of Breathing

- Outline how the respiratory system and the cardiovascular system work together.


**Where does oxygen go in your body?**

Once you take in a breath of air, the oxygen doesn't just stay there in your lungs. It has a lot of traveling to do! Oxygen has to reach each one of your cells. How do you think the oxygen is moved?

## The Journey of a Breath of Air

Breathing is only part of the process of bringing oxygen to where it is needed in the body. After oxygen enters the lungs, what happens?

1. The oxygen enters the blood stream from the **alveoli**, tiny sacs in the lungs where gas exchange takes place (**Figure** 1.59).
2. The oxygen-rich blood returns to the heart.
3. Oxygen-rich blood is then pumped through the **aorta**, the large artery that receives blood directly from the heart.
4. From the aorta, oxygen-rich blood travels to the smaller arteries and, finally, to the **capillaries**, the smallest type of blood vessel.
5. The oxygen molecules move, by diffusion, out of the capillaries and into the body cells.
6. While oxygen moves from the capillaries and into body cells, carbon dioxide moves from the cells into the capillaries.
7. Carbon dioxide is brought, through the blood, back to the heart and then to the lungs. Then it is released into the air during exhalation.

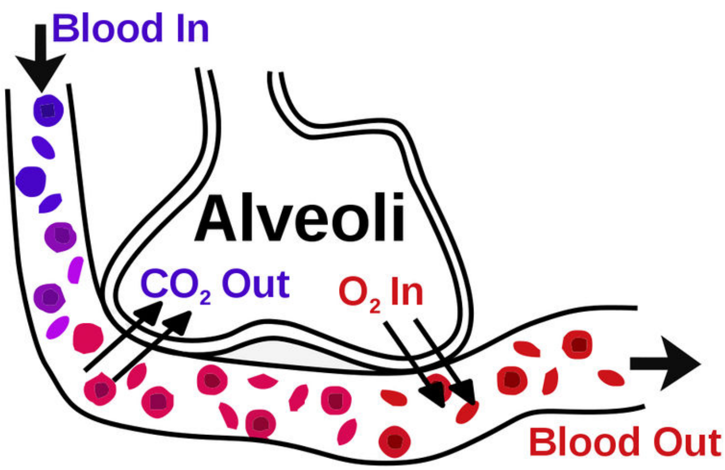



FIGURE 1.59
Gas exchange is the movement of oxygen into the blood and carbon dioxide out of the blood.

### Vocabulary

- **alveoli**: Tiny sacs in the lungs where gas exchange takes place.
- **aorta**: Largest artery; receives blood directly from the heart.
- **capillary**: Smallest type of blood vessel that connects very small arteries and veins.

### Summary

- Oxygen enters the lungs, then passes through the alveoli and into the blood. The oxygen is carried around the body in blood vessels.
- Carbon dioxide moves into the blood capillaries and is brought to the lungs to be released into the air during exhalation.

### Practice

Use the resource below to answer the questions that follow.

- **Gaseous Exchange** at http://www.youtube.com/watch?v=AyUtdqiOgCA (3:09)

MEDIA
Click image to the left for more content.

1. What causes oxygen to enter the blood? Where does this occur?
2. What causes carbon dioxide to exit the blood? Where does this occur?
3. How does hemoglobin carry oxygen through the blood?
4. How does oxygen enter the tissues of the body? Where does this occur?

### Review

1. How does oxygen enter the blood stream?
2. What is the name of the waste gas that is released during exhalation?

# 1.34 Respiratory System Diseases

- Describe some common diseases and conditions affecting the respiratory system.

**What's this boy doing?**

This inhaler can help ease the symptoms of asthma. The boy may have felt an asthma attack coming on. Tightness in his chest and difficulty breathing are common signs of an asthma attack. He is fortunate that asthma can usually be controlled with medicine.

## Diseases of the Respiratory System

Respiratory diseases are diseases of the lungs, bronchial tubes, trachea, nose, and throat (**Figure** 1.60). These diseases can range from a mild cold to a severe case of pneumonia. Respiratory diseases are common and may cause illness or death. Some respiratory diseases are caused by bacteria or viruses, while others are caused by environmental pollutants, such as tobacco smoke. Some diseases are genetic and, therefore, are inherited.

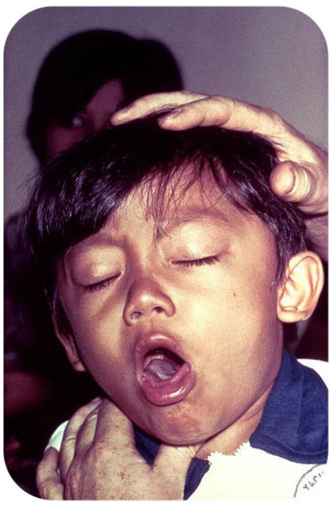


FIGURE 1.60

This boy is suffering from whooping cough (also known as pertussis), which gets its name from the loud whooping sound that is made when the person inhales during a coughing fit.

### Bronchitis

**Bronchitis** is an inflammation of the bronchi, the air passages that conduct air into the lungs. The bronchi become red and swollen with infection. Acute bronchitis is usually caused by viruses or bacteria, and may last several days or weeks. It is characterized by a cough that produces phlegm, or mucus. Symptoms include shortness of breath and wheezing. Acute bronchitis is usually treated with antibiotics.

### Asthma

**Asthma** is a chronic illness in which the bronchioles, the tiny branches into which the bronchi are divided, become inflamed and narrow (**Figure** 1.61). The muscles around the bronchioles contract, which narrows the airways. Large amounts of mucus are also made by the cells in the lungs. People with asthma have difficulty breathing. Their chests feel tight, and they wheeze.

Asthma can be caused by different things, such as allergies. Asthma can also be caused by cold air, warm air, moist air, exercise, or stress. The most common asthma triggers are illnesses, like the common cold.

Asthma is not contagious and cannot be passed on to other people. Children and adolescents who have asthma can still lead active lives if they control their asthma. Asthma can be controlled by taking medication and by avoiding contact with environmental triggers for asthma, like smoking.

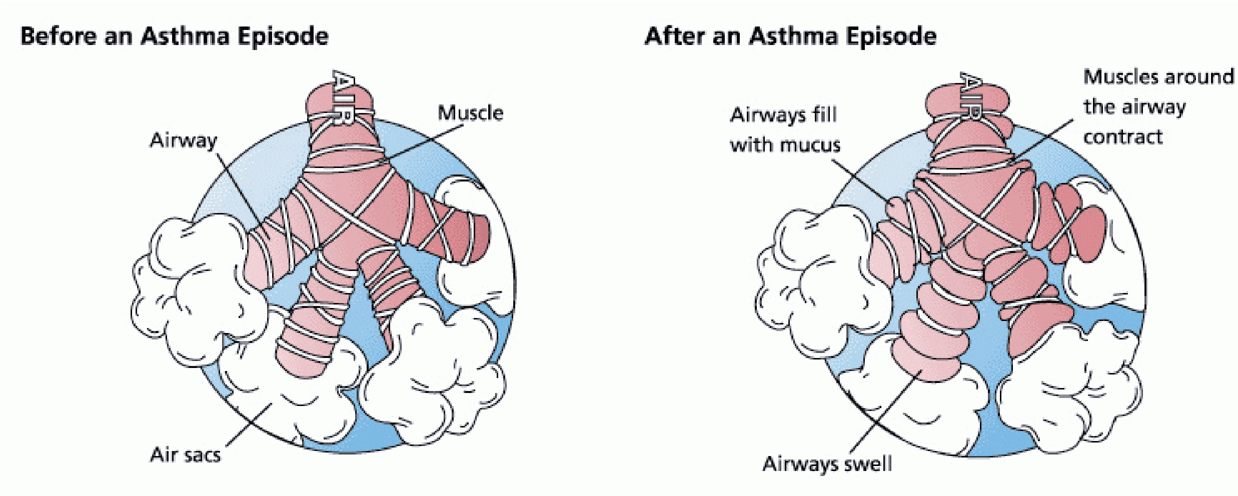



FIGURE 1.61
Asthma occurs when the bronchioles swell and the muscles around the bronchioles contract.

### Pneumonia

**Pneumonia** is an illness that occurs when the alveoli, the tiny sacs in the lungs where gas exchange takes place, become inflamed and filled with fluid. When a person has pneumonia, gas exchange cannot occur properly across the alveoli. Pneumonia can be caused by many things. Infection by bacteria, viruses, fungi, or parasites can cause pneumonia. An injury caused by chemicals or a physical injury to the lungs can also cause pneumonia. Symptoms of pneumonia include cough, chest pain, fever, and difficulty breathing. Treatment depends on the cause of pneumonia. Bacterial pneumonia is treated with antibiotics.

Pneumonia is a common illness that affects people in all age groups. It is a leading cause of death among the elderly and people who are chronically and terminally ill.

### Tuberculosis

**Tuberculosis (TB)** is a common and often deadly disease caused by a genus of bacterium called *Mycobacterium*. Tuberculosis most commonly attacks the lungs but can also affect other parts of the body. TB is a chronic disease, but most people who become infected do not develop the full disease. Symptoms include a cough, which usually contains mucus and coughing up blood.

The TB bacteria are spread in the air when people who have the disease cough, sneeze, or spit, so it is very contagious. To help prevent the spread of the disease, public health notices, such as the one pictured below (**Figure** 1.62), remind people how to stop the spread of the disease.

### Cancer

**Lung cancer** is a disease in which the cells found in the lungs grow out of control. The growing mass of cells can form a tumor that pushes into nearby tissues. The tumor will affect how these tissues work. Lung cancer is the most common cause of cancer-related death in men, and the second most common in women. It is responsible for 1.3 million deaths worldwide every year (**Figure** 1.63). The most common symptoms are shortness of breath, coughing


FIGURE 1.62
A public health notice from the early 20th century reminded people that TB could be spread very easily.

(including coughing up blood), and weight loss. The most common cause of lung cancer is exposure to tobacco smoke.

FIGURE 1.63
The inside of a lung showing cancerous tissue.

### Emphysema

**Emphysema** is a chronic lung disease caused by the breakdown of the lung tissue. Symptoms of emphysema include shortness of breath, especially during exercise, and chronic cough, usually due to cigarette smoking, and wheezing, especially during expiration. Damage to the alveoli (**Figure** 1.64), is not curable. Smoking is the leading cause of emphysema.

### Causes of Respiratory Diseases

Many respiratory diseases are caused by pathogens. A **pathogen** is an organism that causes disease in another organism. Certain bacteria, viruses, and fungi are pathogens of the respiratory system. The common cold and flu are


FIGURE 1.64
The lung of a smoker who had emphysema (left). Tar, a sticky, black substance found in tobacco smoke, is evident. Chronic obstructive pulmonary disease (right), is a tobacco-related disease that is characterized by emphysema.

caused by viruses. The influenza virus that causes the flu is pictured below (**Figure** 1.65). Tuberculosis, whooping cough, and acute bronchitis are caused by bacteria. The pathogens that cause colds, flu, and TB can be passed from person to person by coughing, sneezing, and spitting.

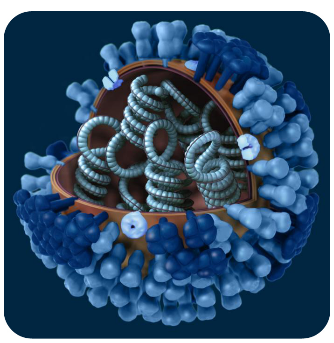


FIGURE 1.65
This is the influenza virus that causes the swine flu, or H1N1. The Center for Disease Control and Prevention recommends that children between the ages of 6 months and 19 years get a flu vaccination each year.

Pollution is another common cause of respiratory disease. The quality of the air you breathe can affect the health of your lungs. Asthma, heart and lung diseases, allergies, and several types of cancers are all linked to air quality. Air pollution is not just found outdoors; indoor air pollution can also be responsible for health problems.

Smoking is the major cause of chronic respiratory disease as well as cardiovascular disease and cancer. Exposure to tobacco smoke by smoking or by breathing air that contains tobacco smoke is the leading cause of preventable death in the United States. Regular smokers die about 10 years earlier than nonsmokers do. The Centers for Disease Control and Prevention (CDC) describes tobacco use as "the single most important preventable risk to human health in developed countries and an important cause of [early] death worldwide."

### Vocabulary

- **asthma**: Illness in which the bronchioles are inflamed and become narrow.

- **bronchitis**: Inflammation of the membrane lining of the bronchial tubes of the lungs.
- **emphysema**: Chronic lung disease caused by the breakdown of the lung tissue.
- **lung cancer**: Disease in which the cells found in the lungs grow uncontrollably.
- **pathogen**: Organism that causes disease.
- **pneumonia**: Illness that occurs when the alveoli become inflamed and filled with fluid.
- **tuberculosis** : Lung disease caused by a genus of bacterium called *Mycobacterium.*

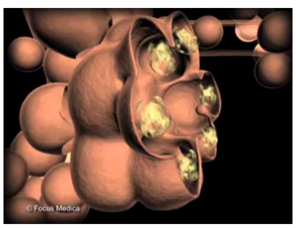
## Summary

- Common diseases and conditions affecting the respiratory system include asthma, bronchitis, lung cancer, tuberculosis, and emphysema.
- Pollution, smoking, and pathogens can also contribute to diseases of the respiratory system.

## Practice

Use the resource below to answer the questions that follow.

- **Respiratory Diseases** at http://www.youtube.com/watch?v=kcZO7h-NROo (1:30)




MEDIA
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1. What is acute bronchitis? What effect does acute bronchitis have on the respiratory system?
2. What is pneumonia? What is the effect of pneumonia on the body? What can cause this condition?
3. What can viral infections of the upper respiratory tract make you susceptible to?
4. Infections of the respiratory system can cause a decrease in the bodies ability to obtain oxygen. What effects can this have on other areas of the body?

## Review

1. How does asthma affect the lungs?
2. Identify two things besides smoking that can cause a respiratory disease.

# 1.35 Respiratory System Health

- Identify what you can do to keep your respiratory system healthy.

**Why sneeze into your elbow?**

Sneezing into your elbow can help stop the spread of a respiratory illness, like the flu or common cold. If you sneeze into your hands, you may then spread germs when you touch a doorknob or other surfaces.

## Keeping Your Respiratory System Healthy

Many of the diseases related to smoking are called **lifestyle diseases**; diseases that are caused by choices that people make in their daily lives. For example, the choice to smoke can lead to cancer and heart disease in later life. But you can make healthy choices instead. There are many things you can do to keep yourself healthy.

### Avoid Smoking

Cigarette smoking can cause serious disease, so not smoking or quitting now are the most effective ways to reduce your risk of developing chronic respiratory diseases, such as lung cancer.

### Eat Well, Exercise Regularly, and Get Rest

Eating healthy foods, getting enough sleep, and being active every day can help keep your cardiovascular system and immune system strong.

### Wash Your Hands

Washing your hands often, especially after sneezing, coughing, or blowing your nose, helps to protect you and others from diseases. Washing your hands for 20 seconds with soap and warm water can help prevent colds and flu.

Some viruses and bacteria can live from 20 minutes to two hours or more on surfaces like cafeteria tables, doorknobs, and desks.

### Avoid Contact with Others When Sick

Do not go to school or to other public places when you are sick. You risk spreading your illness to other people. You may also get even sicker if you catch something else.

### Visit Your Doctor

Getting the recommended vaccinations can help prevent diseases, such as whooping cough and flu. Seeking medical help for diseases like asthma can help stop the disease from getting worse.

## Vocabulary

- **lifestyle disease**: Disease that is caused by choices that people make in their daily lives.

## Summary

- Avoid smoking, get enough exercise, and wash your hands to protect your respiratory system from illness.
- Getting the recommended vaccinations can help prevent diseases, such as whooping cough and flu.

## Practice

Use the resources below to answer the questions that follow.

- **The Genetics of Lung Health and Lung Disease** at http://www.youtube.com/watch?v=Pc8oWAzi1FI (2:57)

MEDIA
Click image to the left for more content.

1. Why are scientists studying the genetics of lung disease?
2. What do scientists hope will come out of this research?
3. How many areas of the genome have scientists found that are associated with COPD?
4. Are these scientists engaged in basic or applied research? Explain your reasoning fully.

- **Smog and Health Effects** at http://www.youtube.com/watch?v=ROf4PeRlJsM (2:31)

MEDIA

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1. How many days a year does Los Angeles have unhealthy air?
2. What are the potential health effects of this air? Who is most at risk? Why do you think risk is higher for these groups?
3. What are you supposed to do on days of unhealthy air?

### Review

1. What are two things you can do to keep your respiratory system healthy?
2. Explain how washing your hands can help you prevent catching a cold.

# 1.36 Excretion

- Identify the functions of the excretory system.

**What happens to your body's waste?**

There is no space for a landfill in your body to contain wastes. You must be able to expel wastes from your body. This is the role of the excretory system.

## Excretion

If you are getting plenty of fluids, your urine should be almost clear. But you might have noticed that sometimes your urine is darker than usual. Do you know why this happens? Sometimes your body is low on water and trying to reduce the amount of water lost in **urine**. Therefore, your urine gets darker than usual. Your body is striving to maintain **homeostasis** through the process of excretion. **Excretion** is the process of removing wastes and excess water from the body.

Urine helps remove excess water, salts, and nitrogen from your body. Your body also needs to remove the wastes that build up from cell activity and from digestion. If these wastes are not removed, your cells can stop working, and you can get very sick. The organs of your **excretory system** help to release wastes from the body.

The organs of the excretory system are also parts of other organ systems. For example, your lungs are part of the respiratory system. Your lungs remove carbon dioxide from your body, so they are also part of the excretory system. More organs of the excretory system are listed below (**Table** 1.6).

TABLE 1.6: **Organs of the Excretory System**

| Organ(s) | Function | Component of Other Organ System |
|---|---|---|
| Lungs | Remove carbon dioxide. | Respiratory system |

**TABLE 1.6:** (continued)

| Organ(s) | Function | Component of Other Organ System |
|---|---|---|
| Skin | Sweat glands remove water, salts, and other wastes. | Integumentary system |
| Large intestine | Removes solid waste and some water in the form of feces. | Digestive system |
| Kidneys | Remove urea, salts, and excess water from the blood. | Urinary system |

## Vocabulary

- **excretion**: Process of removing wastes and excess water from the body.
- **excretory system**: Organ system that removes wastes from the body; includes the kidneys, large intestine, skin, and lungs.
- **homeostasis**: Ability to keep a stable internal environment; the ability of the body to maintain a stable internal environment despite a changing environment.
- **urine**: Liquid waste that is formed by the kidneys when they filter wastes from the blood.

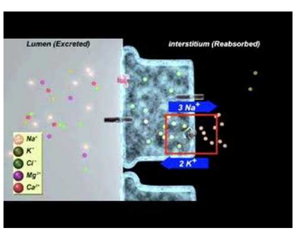
## Summary

- Excretion is the process of removing wastes from the body.
- Organs of the excretory system include the kidneys, large intestine, skin, and lungs.

## Practice

Use the resource below to answer the questions that follow.

- **Excretion** at http://www.youtube.com/watch?v=DNJosKX_PmA (8:47)

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1. What is filtered and excreted in the nephron?
2. What two mechanisms govern filtration in the glomerulus?
3. What mechanism leads to ion exchange through a chloride channel?
4. What mechanism leads to ion exchange through a potassium channel?

## Review

1. What is excretion?
2. List three organs involved in excretion.

# 1.37 Urinary System

- Describe the parts of urinary system.


**Why is urine important?**

You might have had to give a urine sample when you've gone to the doctor for a check-up. Urine is basically your liquid waste. The contents of your urine can tell the doctor if you have certain illnesses.

## The Urinary System

Sometimes, the urinary system (**Figure** 1.66) is called the excretory system. But the urinary system is only one part of the excretory system. Recall that the excretory system is also made up of the skin, lungs, and large intestine, as well as the kidneys. The **urinary system** is the organ system that makes, stores, and gets rid of urine.

### Organs of the Urinary System

1. As you can see above (**Figure** 1.66), the kidneys are two bean-shaped organs. **Kidneys** filter and clean the blood and form urine. They are about the size of your fists and are found near the middle of the back, just below your rib cage.
2. **Ureters** are tube-shaped and bring urine from the kidneys to the urinary bladder.
3. The **urinary bladder** is a hollow and muscular organ. It is shaped a little like a balloon. It is the organ that collects urine.
4. Urine leaves the body through the **urethra**.

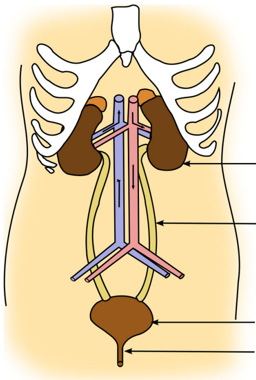



FIGURE 1.66
The kidneys filter the blood that passes through them, and the urinary bladder stores the urine until it is released from the body.

### What is Urine?

**Urine** is a liquid that is formed by the kidneys when they filter wastes from the blood. Urine contains mostly water, but it also contains salts and nitrogen-containing molecules. The amount of urine released from the body depends on many things. Some of these include the amount of fluid and food a person consumes and how much fluid they have lost from sweating and breathing. Urine ranges from colorless to dark yellow but is usually a pale yellow color. Light yellow urine contains mostly water. The darker the urine, the less water it contains.

The urinary system also removes a type of waste called **urea** from your blood. Urea is a nitrogen-containing molecule that is made when foods containing protein, such as meat, poultry, and certain vegetables, are broken down in the body. Urea and other wastes are carried in the bloodstream to the kidneys, where they are removed and form urine.

## Vocabulary

- **kidneys**: Main organ of the excretory system; filters blood and forms urine.
- **urea**: Nitrogen-containing molecule made when foods containing protein are broken down in the body.
- **ureters**: Tube-like organs of the urinary system that move urine from the kidneys to the bladder.
- **urethra**: Tube-like organ of the urinary system that carries urine out of the body from the bladder; in males, it also carries sperm out of the body.
- **urinary bladder**: Hollow, balloon-shaped organ that stores urine.
- **urinary system**: Organ system that makes, stores, and gets rid of urine.
- **urine**: Liquid waste that is formed by the kidneys when they filter wastes from the blood.

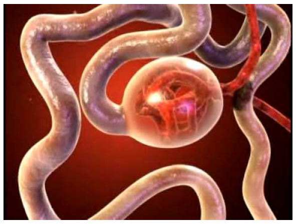
## Summary

- The urinary system is made up of the kidneys, the ureters, the bladder, and the urethra.
- Urine is the liquid that is formed by the kidneys when they filter wastes from the blood. Urine contains water, salts, and nitrogen-containing molecules.

## Practice

Use the resource below to answer the questions that follow.

- **The Nephron** at http://www.youtube.com/watch?v=aQZaNXNroVY (5:46)



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1. What are three components of the renal system? Which part of this system is the main excretory organ of the body?
2. What are three functions of the kidney?
3. What capsule surrounds the glomerulus? How many of the capsules are found in the entire kidney?
4. What is involved in urine formation? Where is urine stored?

## Review

1. What is the difference between the urinary system and the excretory system?
2. What is the purpose of the urinary bladder?

# 1.38 Kidneys

- Outline how the kidneys filter blood.

**Why are the kidneys important?**

These kidney beans are named after a very important organ in your body. You can't live without at least one kidney. The kidneys have several essential functions. For example, kidneys filter your blood, removing wastes and regulating the amount of water in your body.

## The Kidneys

The kidneys (**Figure** 1.67) are important organs in maintaining **homeostasis**, the ability of the body to maintain a stable internal environment despite a changing environment. Kidneys perform a number of homeostatic functions.

- They maintain the volume of body fluids.
- They maintain the balance of salt ions in body fluids.
- They excrete harmful nitrogen-containing molecules, such as urea, ammonia, and uric acid.

There are many blood vessels in the kidneys (**Figure** 1.67). The kidneys remove urea from the blood through tiny filtering units called nephrons. **Nephrons** (**Figure** 1.68) are tiny, tube-shaped structures found inside each kidney. Each kidney has up to a million nephrons. Each nephron collects a small amount of fluid and waste from a small group of capillaries.

Nitrogen-containing wastes, together with water and other wastes, form the **urine** as it passes through the nephrons and the kidney. The fluid within nephrons is carried out into a larger tube in the kidney called a **ureter**, which carries it to the bladder (**Figure** 1.68).

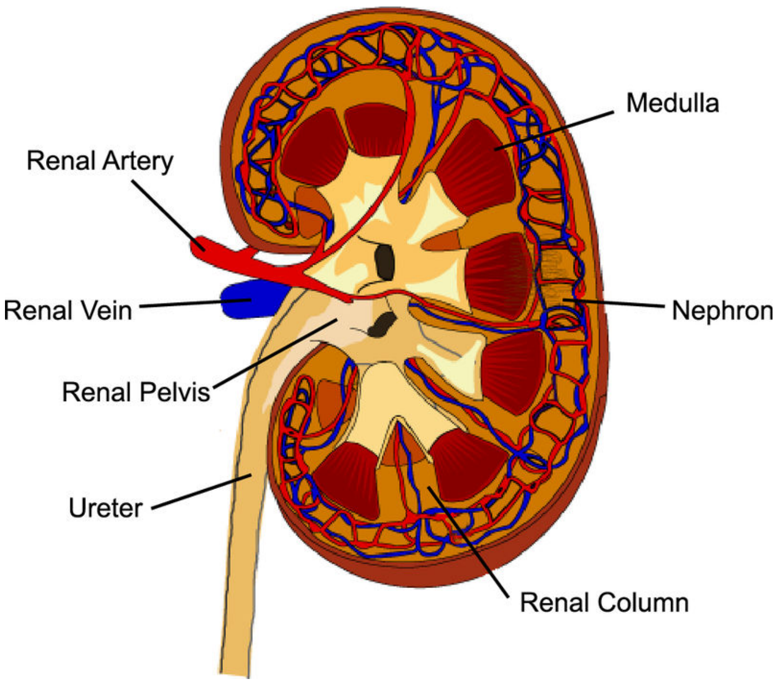



FIGURE 1.67
Structures of the kidney; fluid leaks from the capillaries and into the nephrons where the fluid forms urine then moves to the ureter and on to the bladder.

The kidneys never stop filtering waste products from the blood, so they are always producing urine. The amount of urine your kidneys produce is dependent on the amount of fluid in your body. Your body loses water through sweating, breathing, and urination. The water and other fluids you drink every day help to replace the lost water. This water ends up circulating in the blood because blood plasma is mostly water.

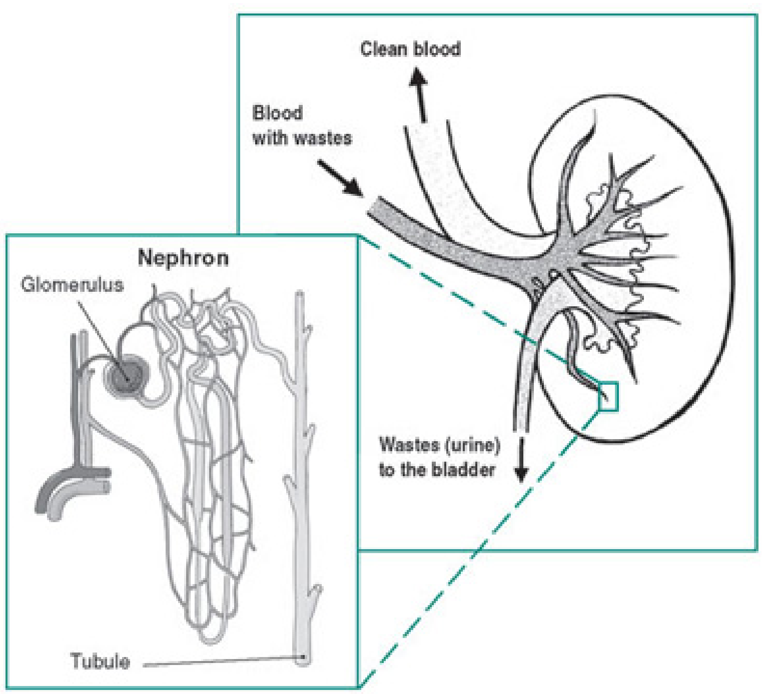



FIGURE 1.68
The location of nephrons in the kidney. The fluid collects in the nephron tubules and moves to the bladder through the ureter.

### Formation of Urine

The process of urine formation is as follows:

1. Blood flows into the kidney through the renal artery. The renal artery connects to capillaries inside the kidney. Capillaries and nephrons lie very close to each other in the kidney.
2. The blood pressure within the capillaries causes water, salts, sugars, and urea to leave the capillaries and move into the nephron.
3. The water and salts move along through the tube-shaped nephron to a lower part of the nephron.
4. The fluid that remains in the nephron at this point is called urine.
5. The blood that leaves the kidney in the renal vein has much less waste than the blood that entered the kidney.
6. The urine is collected in the ureters and is moved to the urinary bladder, where it is stored.

Nephrons filter about $\frac{1}{4}$ cup of body fluid per minute. In a 24-hour period, nephrons filter 180 liters of fluid, and 1.5 liters of the fluid is released as urine. Urine enters the bladder through the ureters. Similar to a balloon, the walls of the bladder are stretchy. The stretchy walls allow the bladder to hold a large amount of urine. The bladder can hold about $1\frac{1}{2}$ to $2\frac{1}{2}$ cups of urine but may also hold more if the urine cannot be released immediately.

How do you know when you have to urinate? **Urination** is the process of releasing urine from the body. Urine leaves the body through the urethra. Nerves in the bladder tell you when it is time to urinate. As the bladder first fills with urine, you may notice a feeling that you need to urinate. The urge to urinate becomes stronger as the bladder continues to fill up.

### Brain Control of Urination

The filtering action of the kidneys is controlled by the **pituitary gland**. The pituitary gland is about the size of a pea and is found below the brain (**Figure** 1.69). The pituitary gland releases hormones that help the kidneys to filter water from the blood.

The movement of water back into blood is controlled by a hormone called **antidiuretic hormone** (ADH). ADH is one of the hormones released from the pituitary gland in the brain. One of the most important roles of ADH is to control the body's ability to hold onto water. If a person does not drink enough water, ADH is released. It causes the blood to reabsorb water from the kidneys. If the kidneys remove less water from the blood, what will the urine look like? It will look darker, because there is less water in it.

When a person drinks a lot of water, then there will be a lot of water in the blood. The pituitary gland will then release a lower amount of ADH into the blood. This means less water will be reabsorbed by the blood. The kidneys then produce a large volume of urine. What color will this urine be?

### Vocabulary

- **antidiuretic hormone**: Hormone that stimulates the kidneys to conserve water by producing more concentrated urine.
- **homeostasis**: Ability of the body to maintain a stable internal environment despite a changing environment.
- **nephron**: Tiny, tube-shaped structure found inside each kidney that filters the blood and produces urine.
- **pituitary gland**: Small structure at the base of the brain that secretes hormones.
- **ureter**: Tube-like organ of the urinary system that moves urine from the kidneys to the bladder.
- **urination** : Process in which urine is released from the body.
- **urine**: Liquid waste that is formed by the kidneys when they filter wastes from the blood.

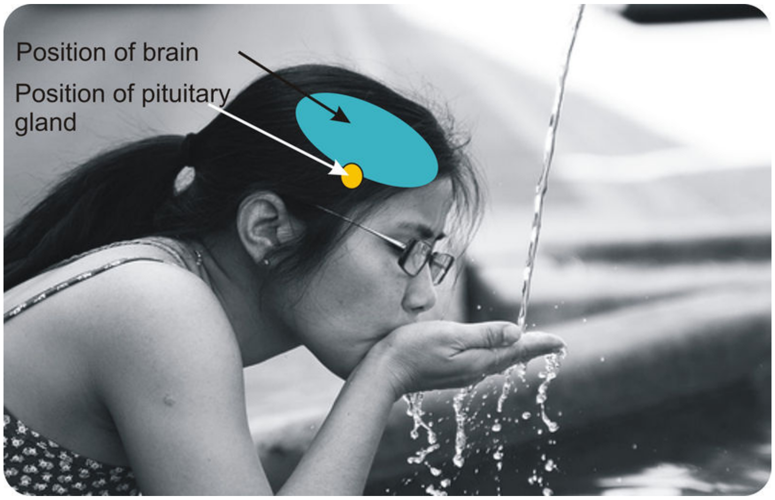



FIGURE 1.69
The pituitary gland is found directly below the brain and releases hormones that control how urine is produced.

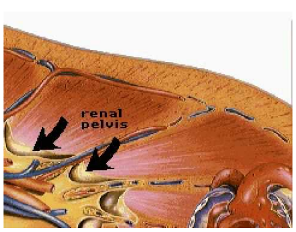
## Summary

- Water and waste molecules move out of the blood capillaries and into the nephrons of the kidney to form the urine.
- ADH is the hormone released by the pituitary gland and controls how water is reabsorbed by the blood from the kidneys.

## Practice

Use the resources below to answer the questions that follow.

- **Anatomy of a Kidney** at http://www.youtube.com/watch?v=Pz5DHAv_Mw4 (1:46)

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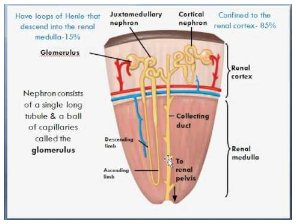
1. What is a nephron? What is its function in the kidney?
2. What happens in the coiled tubules in the kidney?
3. Where is the cortex of the kidney? What structures are located there?
4. Where is the medulla in the kidney? What structures are located there?

- **Kidney Anatomy and Physiology** at http://www.youtube.com/watch?v=7nesHuVEe8M (6:39)

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1. Where does the ureter lead to?
2. What exits the tubules in the outer medulla? What effect does this have on the fluid moving through the tubules?
3. What exits the tubules on the ascending limb? What effect does this have on the fluid moving through the tubules?
4. What controls the permeability of the collecting ducts?

### Review

1. How do the kidneys filter the blood?
2. What does antidiuretic hormone (ADH) do?

# 1.39 Excretory System Problems

- Identify disorders of the urinary system.

**Why drink water?**

It's always a good idea to drink plenty of fluids, especially when you have been exercising. Drinking plenty of water helps to flush away materials that might form kidney stones. Staying hydrated is the best way to prevent kidney stones.

## Problems of the Excretory System

The urinary system controls the amount of water in the body and removes wastes. Any problem with the urinary system can also affect many other body systems.

### Kidney Stones

In some cases, certain mineral wastes can form **kidney stones** (**Figure** 1.70). Stones form in the kidneys and may be found anywhere in the urinary system. They vary in size. Some stones cause great pain, while others cause very little pain. Some stones may need to be removed by surgery or ultrasound treatments.

### Kidney failure

**Kidney failure** happens when the kidneys cannot remove wastes from the blood. If the kidneys are unable to filter wastes from the blood, the wastes build up in the body. Kidney failure can be caused by an accident that injures the kidneys, the loss of a lot of blood, or by some drugs and poisons. Kidney failure may lead to permanent loss of kidney function. But if the kidneys are not seriously damaged, they may recover.


FIGURE 1.70

A kidney stone. The stones can form anywhere in the urinary system.

Chronic kidney disease is the slow decrease in kidney function that may lead to permanent kidney failure. A person who has lost kidney function may need to get kidney dialysis. **Kidney dialysis** is the process of filtering the blood of wastes using a machine. A dialysis machine (**Figure** 1.71) filters waste from the blood by pumping the blood through a fake kidney. The filtered blood is then returned to the patient's body.

### Urinary tract infections (UTIs)

**Urinary tract infections** (UTIs) are bacterial infections of any part of the urinary tract. When bacteria get into the bladder or kidney and produce more bacteria in the urine, they cause a UTI. The most common type of UTI is a bladder infection. Women get UTIs more often than men. UTIs are often treated with antibiotics.

## Vocabulary

- **kidney dialysis**: Process of filtering wastes from the blood using a machine.
- **kidney failure**: Inability of the kidneys to remove wastes from the blood or to maintain homeostasis.
- **kidney stone**: Small hard mass in the kidney that forms from waste minerals.
- **urinary tract infection**: Bacterial infection of any part of the urinary tract.

## Summary

- Disorders of the urinary system include kidney stones, kidney failure, and urinary tract infections.
- Kidney dialysis is the process of filtering wastes from the blood using a machine.

## Practice

Use the resource below to answer the questions that follow.

- **The Basics of Kidney Disease** at http://www.youtube.com/watch?v=wY4VvAjYLBU (6:24)


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FIGURE 1.71
During dialysis, a patient's blood is sent through a filter that removes waste products. The clean blood is returned to the body.

1. What is kidney disease? What is chronic kidney disease? How are they similar, and how do they differ?
2. What is kidney failure? How can people deal with kidney failure?
3. What are the top two causes of kidney disease?
4. How can doctors test for kidney disease? How can they treat kidney disease?

## Review

1. What is a urinary tract infection?
2. Why is kidney failure such a serious health problem?

# 1.40 Nervous System

- Explain the functions of the nervous system.

**What body system helps you learn?**

As these girls are studying, many processes are taking place. Their eyes have to take in the words on the page, and their brains have to process the meaning of the words. The brain also has to assimilate the knowledge so it can be retrieved at a later time. All these processes are controlled by the nervous system.

## Introduction to the Nervous System

Michelle was riding her scooter when she hit a hole in the street and started to lose control. She thought she would fall, but, in the blink of an eye, she shifted her weight and kept her balance. Her heart was pounding, but at least she didn't get hurt. How was she able to react so quickly? Michelle can thank her nervous system for that (**Figure** 1.72).

The **nervous system**, together with the **endocrine system**, controls all the other **organ systems**. Controlling muscles and maintaining balance are just two of its roles. The nervous system also lets you:

- Sense your surroundings with your eyes and other sense organs.
- Sense the environment inside of your body, including temperature.
- Control your internal body systems and keep them in balance.
- Prepare your body to fight or flee in an emergency.
- Use language, think, learn, and remember.

The nervous system works by sending and receiving electrical signals. The signals are carried by **nerves** in the body, similar to the wires that carry electricity all over a house. For example, when Michelle started to fall off her scooter, her nervous system sensed that she was losing her balance. It responded by sending messages to muscles in her body. Some muscles tightened while others relaxed. As a result, Michelle's body became balanced again.

FIGURE 1.72
Staying balanced when riding a scooter requires control over the body's muscles. The nervous system controls the muscles and maintains balance.

## Vocabulary

- **endocrine system**: System of glands that secrete hormones into the bloodstream.
- **nerve**: Bundle of nerve cells.
- **nervous system**: Body system that sends electrical messages throughout the body; controls all other body systems.
- **organ system**: Groups of organs that work together to perform a specific task.

## Summary

- The nervous system sends electrical messages throughout the body and controls all other body systems.
- The nervous system allows you to think, learn, sense your surroundings, and control your internal body systems.

## Practice

Use the resource below to answer the questions that follow.

- **Nervous System** at http://www.getbodysmart.com/ap/nervoussystem/menu/menu.html

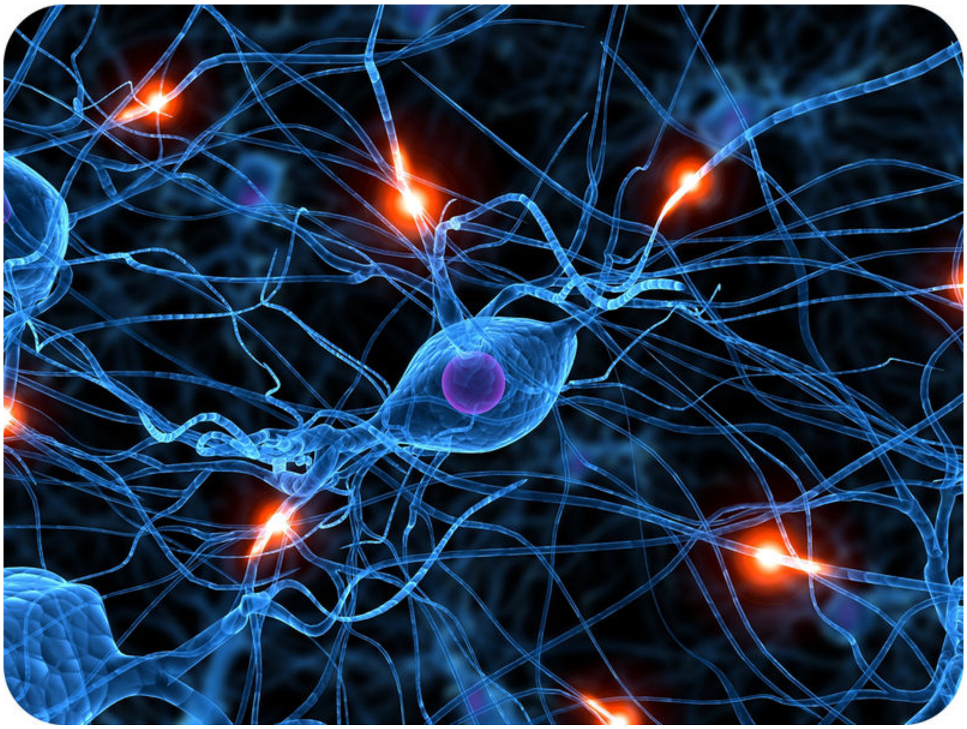
1. What are the major organs of the nervous system?
2. What does the somatic nervous system do? Why is a system like this useful to organisms?
3. What does the autonomic nervous system do? How does it differ from the somatic nervous system?

## Review

1. What are some functions of the nervous system?
2. What type of signals does the nervous system send?

# 1.41 Nerve Cells and Nerve Impulses

- Describe neurons and explain how they carry nerve impulses.



**What do nerve cells look like?**

Note that like most other cells, these nerve cells have a nucleus. They also have other organelles. However, the long, threadlike extensions of the nerve cells are unique. This is where the nerve impulses are transmitted.

## Neurons and Nerve Impulses

The nervous system is made up of nerves. A **nerve** is a bundle of nerve cells. A nerve cell that carries messages is called a **neuron** (**Figure** 1.73). The messages carried by neurons are called **nerve impulses**. Nerve impulses can travel very quickly because they are electrical impulses.

Think about flipping on a light switch when you enter a room. When you flip the switch, the electricity flows to the light through wires inside the walls. The electricity may have to travel many meters to reach the light, but the light still comes on as soon as you flip the switch. Nerve impulses travel just as fast through the network of nerves inside the body.

### What Does a Neuron Look Like?

A neuron has a special shape that lets it pass signals from one cell to another. A neuron has three main parts (**Figure** 1.73):

1. The cell body.

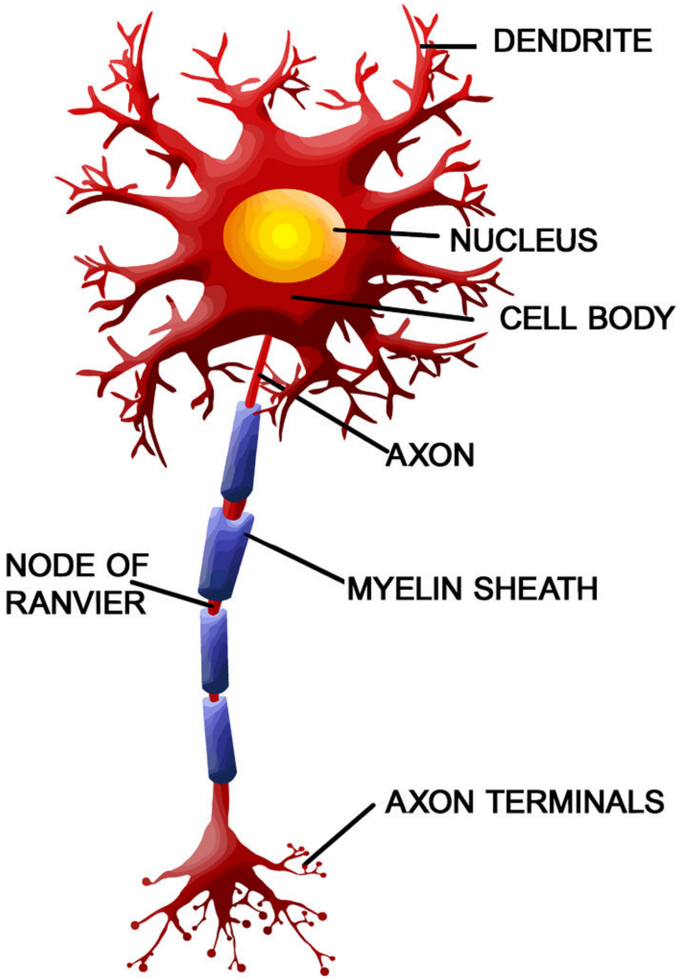



FIGURE 1.73

The axons of many neurons, like the one shown here, are covered with a fatty layer called myelin sheath. The sheath covers the axon, like the plastic covering on an electrical wire, and allows nerve impulses to travel faster along the axon. The node of Ranvier, shown in this diagram, is any gap in the myelin sheath; it allows faster transmission of a signal.

2. Many dendrites.
3. One axon.

The **cell body** contains the nucleus and other organelles. Dendrites and axons connect to the cell body, similar to rays coming off of the sun. **Dendrites** receive nerve impulses from other cells. **Axons** pass the nerve impulses on to other cells. A single neuron may have thousands of dendrites, so it can communicate with thousands of other cells but only one axon. The axon is covered with a **myelin sheath**, a fatty layer that insulates the axon and allows the electrical signal to travel much more quickly. The **node of Ranvier** is any gap within the myelin sheath exposing the axon, and it allows even faster transmission of a signal.

### Types of Neurons

Neurons are usually classified based on the role they play in the body. Two main types of neurons are sensory neurons and motor neurons.

- **Sensory neurons** carry nerve impulses from sense organs and internal organs to the central nervous system.
- **Motor neurons** carry nerve impulses from the central nervous system to organs, glands, and muscles—the opposite direction.

Both types of neurons work together. Sensory neurons carry information about the environment found inside or outside of the body to the central nervous system. The central nervous system uses the information to send messages through motor neurons to tell the body how to respond to the information.

### The Synapse

The place where the axon of one neuron meets the dendrite of another is called a **synapse**. Synapses are also found between neurons and other types of cells, such as muscle cells. The axon of the sending neuron does not actually touch the dendrite of the receiving neuron. There is a tiny gap between them, the synaptic cleft (**Figure** 1.74).

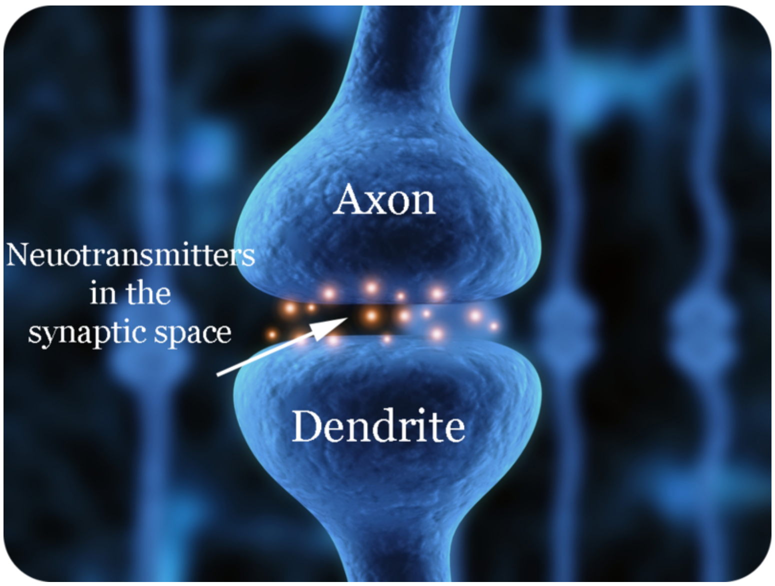



FIGURE 1.74
This diagram shows a synapse between neurons. When a nerve impulse arrives at the end of the axon, neurotransmitters are released and travel to the dendrite of another neuron, carrying the nerve impulse from one neuron to the next.

The following steps describe what happens when a nerve impulse reaches the end of an axon.

1. When a nerve impulse reaches the end of an axon, the axon releases chemicals called **neurotransmitters**.
2. Neurotransmitters travel across the synapse between the axon and the dendrite of the next neuron.
3. Neurotransmitters bind to the membrane of the dendrite.
4. The binding allows the nerve impulse to travel through the receiving neuron.

Did you ever watch a relay race? After the first runner races, he or she passes the baton to the next runner, who takes over. Neurons are a little like relay runners. Instead of a baton, they pass neurotransmitters to the next neuron. Examples of neurotransmitters are chemicals such as serotonin, dopamine, and adrenaline.

You can watch an animation of nerve impulses and neurotransmitters at http://www.mind.ilstu.edu/curriculum/neurons_intro/neurons_intro.php.

Some people have low levels of the neurotransmitter called serotonin in their brain. Scientists think that this is one cause of depression. Medications called antidepressants help bring serotonin levels back to normal. For many people with depression, antidepressants control the symptoms of their depression and help them lead happy, productive lives.

#### Vocabulary

- **axon**: Long, threadlike part of a neuron that transmits nerve impulses to other cells.
- **cell body**: Central part of a neuron that contains the nucleus and other cell organelles.

- **dendrite**: Extension of the cell body of a neuron that receives nerve impulses from other neurons.
- **motor neuron**: Nerve cell that carries nerve impulses from the brain and spinal cord to organs, glands, and muscles.
- **myelin sheath**: Fatty layer that insulates the axon and allows the electrical signal to travel much more quickly.
- **nerve**: Bundle of nerve cells.
- **nerve impulse**: Electrical signal transmitted by the nervous system.
- **neuron**: Nerve cell.
- **neurotransmitter**: Chemical that carries a nerve impulse from one nerve cell to another at the synapse.
- **node of Ranvier**: Any gap within the myelin sheath exposing the axon.
- **sensory neuron**: Nerve cell that carries nerve impulses from the sense organs and internal organs to the brain and spinal cord.
- **synapse**: Place where the axon of one neuron meets the dendrite of another.

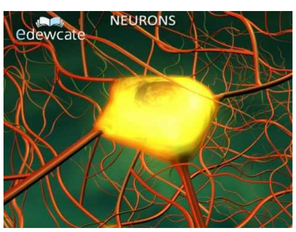
## Summary

- Neurons, or nerve cells that carry nerve impulses, are made up of the cell body, the axon, and several dendrites.
- Signals move across the synapse, the place where the axon of one neuron meets the dendrite of another, using chemicals called neurotransmitters.

## Practice

Use the resource below to answer the questions that follow.

- **Neurons** at http://www.youtube.com/watch?v=jOkp68kUQvc (3:16)

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1. What are the three types of neurons?
2. What neurons are most abundant in our brain?
3. What is the function of sensory neurons? Where do they send information?
4. What is the function of motor neurons? Where do they send information?

## Review

1. Describe a neuron and identify its three main parts.
2. Explain how one neuron transmits a nerve impulse to another neuron.

# 1.42 Central Nervous System

- Describe the structures of the central nervous system.

**What's the control center of your body?**

Your brain is like the control center of your body. It controls your breathing and heartbeat. It helps you to think and learn. The brain is so "central" to all your body systems, it's not surprising that the brain and spinal cord are called the central nervous system.

## The Central Nervous System

The **central nervous system** (CNS) (**Figure** 1.75) is the largest part of the nervous system. It includes the **brain** and the **spinal cord**. The bony skull protects the brain. The spinal cord is protected within the bones of the spine, which are called **vertebrae**.

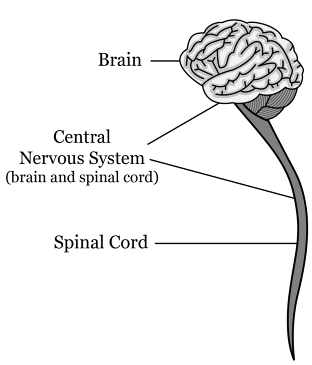



FIGURE 1.75
The brain and spinal cord make up the central nervous system.

### The Brain

What weighs about three pounds and contains up to 100 billion cells? The answer is the human brain. The brain is the control center of the nervous system. It's like the pilot of a plane. It tells other parts of the nervous system what to do.

The brain is also the most complex organ in the body. Each of its 100 billion neurons has synapses connecting it with thousands of other neurons. All those neurons use a lot of energy. In fact, the adult brain uses almost a quarter of the total energy used by the body. The developing brain of a baby uses an even greater amount of the body's total energy.

The brain is the organ that lets us understand what we see, hear, or sense in other ways. It also allows us to use language, learn, think, and remember. The brain controls the organs in our body and our movements as well. The brain consists of three main parts, the cerebrum, the cerebellum, and the brain stem (**Figure** 1.76).

1. The **cerebrum** is the largest part of the brain. It sits on top of the brain stem. The cerebrum controls functions that we are aware of, such as problem-solving and speech. It also controls voluntary movements, like waving to a friend. Whether you are doing your homework or jumping hurdles, you are using your cerebrum.
2. The **cerebellum** is the next largest part of the brain. It lies under the cerebrum and behind the brain stem. The cerebellum controls body position, coordination, and balance. Whether you are riding a bicycle or writing with a pen, you are using your cerebellum.
3. The **brain stem** is the smallest of the three main parts of the brain. It lies directly under the cerebrum. The brain stem controls basic body functions, such as breathing, heartbeat, and digestion. The brain stem also carries information back and forth between the cerebrum and spinal cord.

FIGURE 1.76

Side view of the brain (*left*). Can you find the locations of the three major parts of the brain? Top view of the brain (*right*).

The cerebrum is divided into a right and left half (**Figure** 1.76). Each half of the cerebrum is called a hemisphere. The two hemispheres are connected by a thick bundle of axons called the **corpus callosum**. It lies deep inside the brain and carries messages back and forth between the two hemispheres.

Did you know that the right hemisphere controls the left side of the body, and the left hemisphere controls the right side of the body? By connecting the two hemispheres, the corpus callosum allows this to happen.

Each hemisphere of the cerebrum is divided into four parts, called lobes. The four lobes are the:

1. Frontal.
2. Parietal.
3. Temporal.
4. Occipital.

Each lobe has different jobs. Some of the functions are listed below (**Table** 1.7).

**TABLE 1.7: Cerebrum Lobe Functions**

| Lobe | Main Function(s) |
|---|---|
| Frontal | Speech, thinking, touch |
| Parietal | Speech, taste, reading |
| Temporal | Hearing, smell |
| Occipital | Sight |

### The Spinal Cord

The spinal cord is a long, tube-shaped bundle of neurons, protected by the vertebrae. It runs from the brain stem to the lower back. The main job of the spinal cord is to carry nerve impulses back and forth between the body and brain. The spinal cord is like a two-way highway. Messages about the body, both inside and out, pass through the spinal cord to the brain. Messages from the brain pass in the other direction through the spinal cord to tell the body what to do.

### Vocabulary

- **brain**: Control center of the nervous system.
- **brain stem**: Part of the brain that controls unconscious functions such as heart rate, breathing, and digestion.
- **central nervous system**: Main part of the nervous system; includes the brain and spinal cord.
- **cerebellum**: Part of the brain that controls body position, coordination, and balance.
- **cerebrum**: Largest part of the brain; controls conscious functions such as reasoning and voluntary movements.
- **corpus callosum**: Thick bundle of axons that lies deep inside the brain and carries messages back and forth between the two hemispheres.
- **spinal cord**: Long, tube-shaped bundle of neurons that runs from the brain stem to the lower back; carries nerve impulses back and forth between the body and brain.
- **vertebrae**: Bones forming the spinal column.

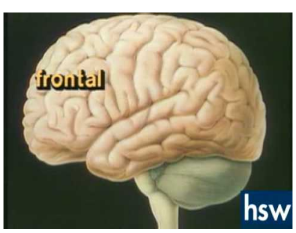
### Summary

- The central nervous system is made up of the brain and the spinal cord.
- The brain consists of three main parts: the cerebrum, the cerebellum, and the brain stem.

### Practice

Use the resources below to answer the questions that follow.

- **The Human Brain** at http://www.youtube.com/watch?v=gVjpfPNpoGA (1:36)




MEDIA

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1. What are two components of the central nervous system?

2. What are the four lobes of the brain?

- **Brain Structure and Function** at http://www.youtube.com/watch?v=Kl_NCSLRKR0 (5:39)

MEDIA

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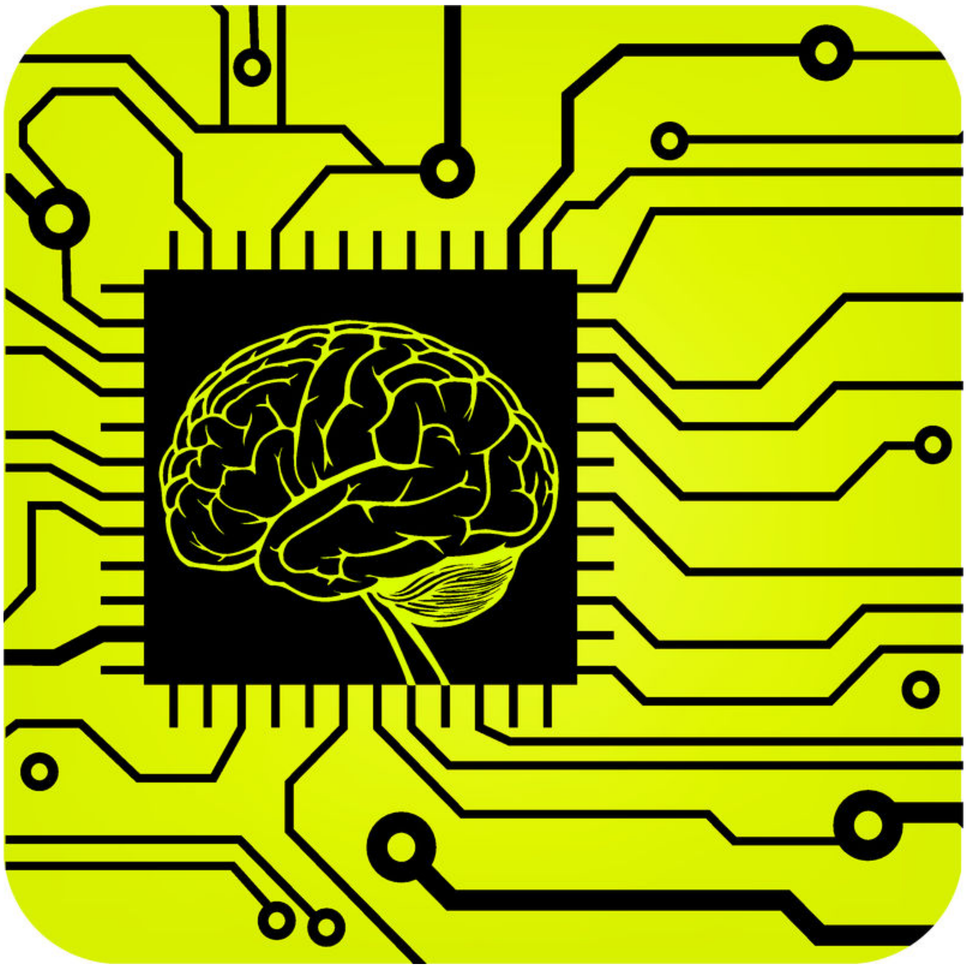
1. What is the cerebral cortex? How does the cerebral cortex of humans compare to those of other vertebrates?
2. What purpose do dendrites serve?
3. How does one neuron connect to another neuron? Explain your answer fully.
4. What are synaptic vesicles? What do they contain? What is their function?

## Review

1. What two structures make up the central nervous system?
2. Compare and contrast the three main parts of the brain.

# 1.43 Peripheral Nervous System

- Outline the divisions of the peripheral nervous system.



**How does your brain connect to the rest of your body?**

You know you have nerves in your fingers and toes because you can feel them. But how does your brain know what's going on in these nerves? You have a network of nerves running from your brain and spinal cord to your fingers and toes and the rest of your body. This network is known as the peripheral nervous system.

## The Peripheral Nervous System

There are other nerves in your body that are not found in the brain or spinal cord. The **peripheral nervous system** (PNS) (**Figure** 1.77) contains all the nerves in the body that are found outside of the central nervous system. They include nerves of the hands, arms, feet, legs, and trunk. They also include nerves of the scalp, neck, and face. Nerves that send and receive messages to the internal organs are also part of the peripheral nervous system.

The peripheral nervous system is divided into two parts, the sensory division and the motor division. How these divisions of the peripheral nervous system are related to the rest of the nervous system is shown below (**Figure** 1.78). Refer to the figure as you read more about the peripheral nervous system in the text that follows.

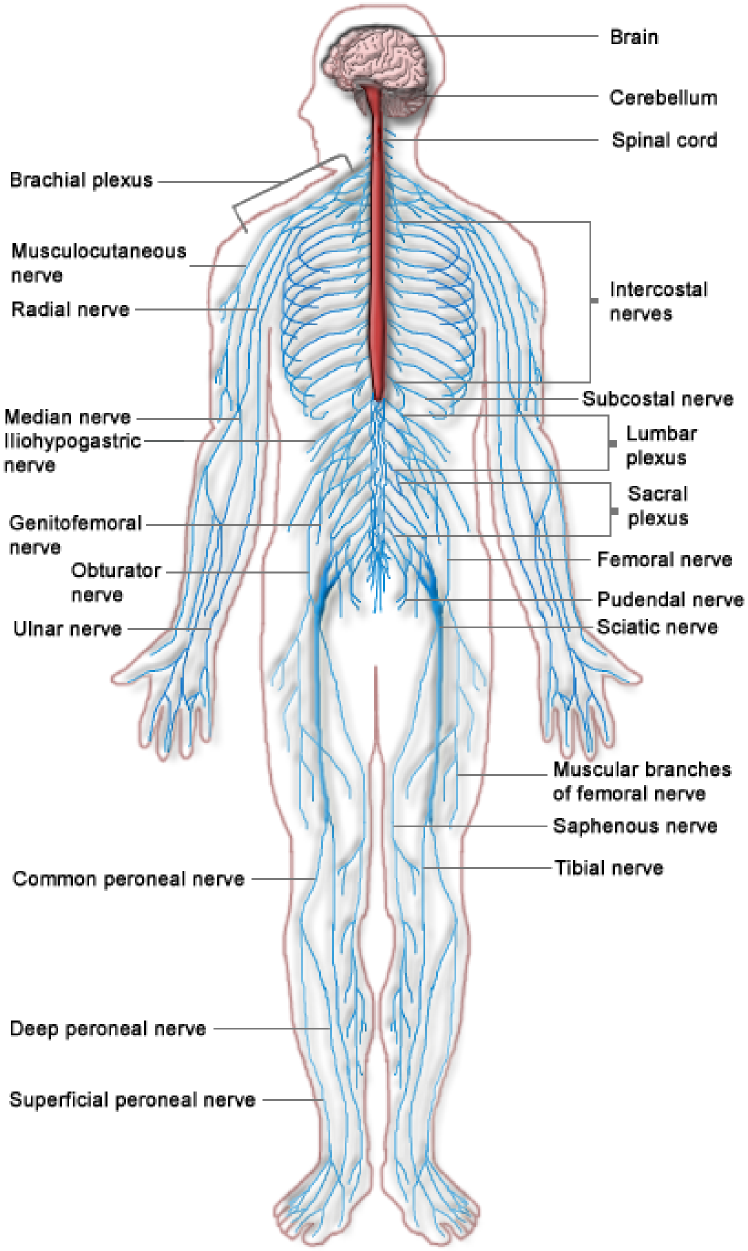



FIGURE 1.77
The blue lines in this drawing represent nerves of the peripheral nervous system. Every peripheral nerve is connected directly or indirectly to the spinal cord.

### The Sensory Division

The **sensory division** carries messages from sense organs and internal organs to the central nervous system. Human beings have several senses. They include sight, hearing, balance, touch, taste, and smell. We have special sense organs for each of these senses. What is the sense organ for sight? For hearing?

Sensory neurons in each sense organ receive stimuli, or messages from the environment that cause a response in the body. For example, sensory neurons in the eyes send messages to the brain about light. Sensory neurons in the skin send messages to the brain about touch. Our sense organs recognize sensations, but they don't tell us *what* we are sensing. For example, when you breathe in chemicals given off by baking cookies, your nose does not tell you that you are smelling cookies. That's your brain's job. The sense organs send messages about sights, smells, and other stimuli to the brain (**Figure** 1.79). The brain then reads the messages and tells you what they mean. A certain area

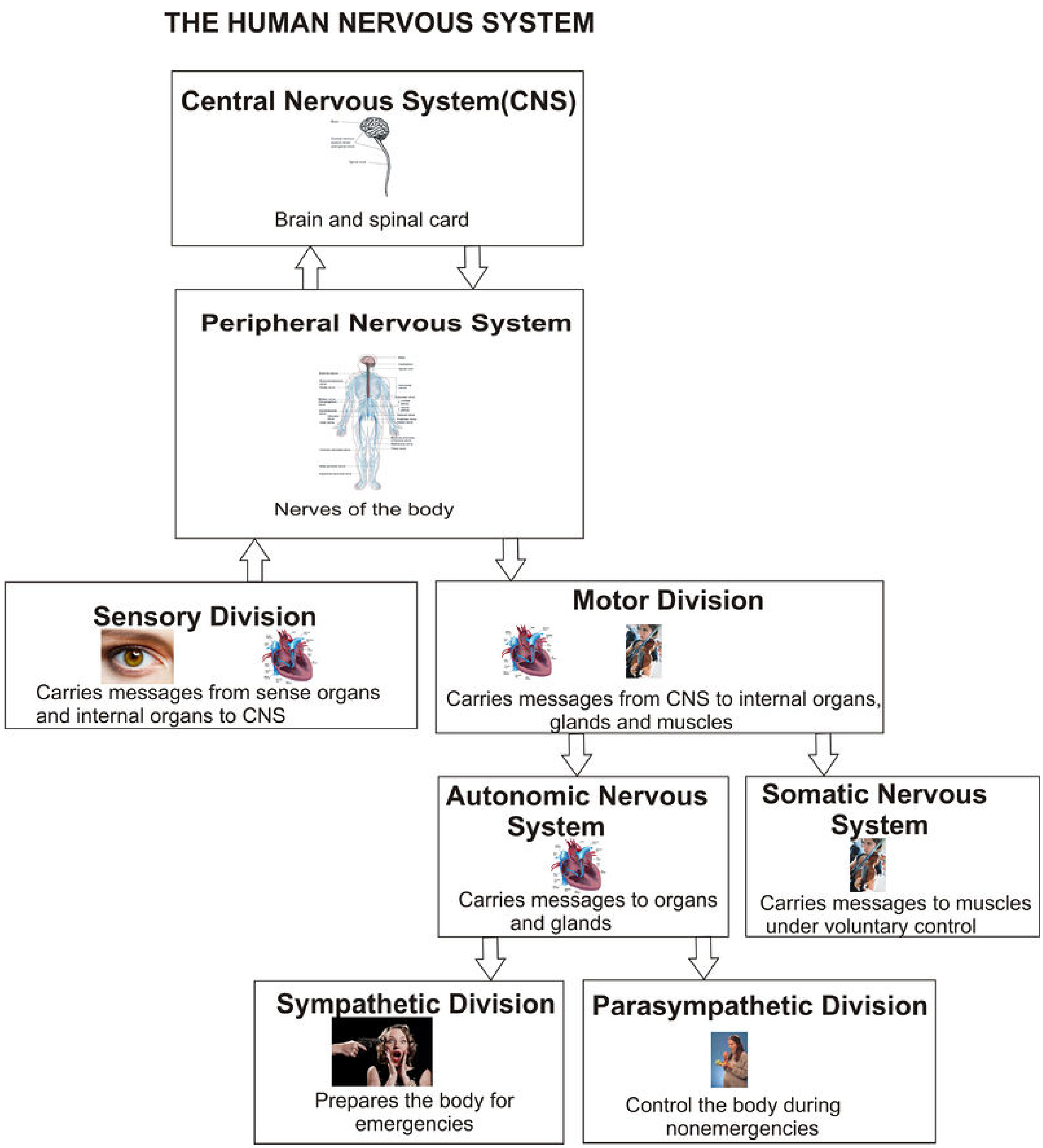



FIGURE 1.78

The central nervous system interprets messages from sense organs and internal organs, and the motor division sends messages to internal organs, glands, and muscles.

of the brain receives and interprets information from each sense organ. For example, information from the nose is received and interpreted by the temporal lobe of the cerebrum.

FIGURE 1.79
Which senses would be stimulated by these raspberries?

### The Motor Division

The **motor division** of the peripheral system carries messages from the central nervous system to internal organs and muscles. The motor division is also divided into two parts (**Figure** 1.78), the somatic nervous system and the autonomic nervous system.

The **somatic nervous system** carries messages that control body movements. It is responsible for activities that are under your control, such as waving your hand or kicking a ball. The girl pictured below (**Figure** 1.80) is using her somatic nervous system to control the muscles needed to play the violin. Her brain sends messages to motor neurons that move her hands so she can play. Without the messages from her brain, she would not be able to move her hands and play the violin.

FIGURE 1.80
This girl's central nervous system is controlling the movements of her hands and arms as she plays the violin. Her brain is sending commands to her somatic nervous system, which controls the muscles of her hands and arms.

The **autonomic nervous system** carries nerve impulses to internal organs. It controls activities that are not under your control, such as sweating and digesting food. The autonomic nervous system has two parts:

1. The **sympathetic division** controls internal organs and glands during emergencies. It prepares the body for fight or flight (**Figure** 1.81). For example, it increases the heart rate and the flow of blood to the legs, so you can run away from danger.

2. The **parasympathetic division** controls internal organs and glands during the rest of the time. It controls processes like digestion, heartbeat, and breathing when there is not an emergency.

FIGURE 1.81
The woman pictured here is just pretending to be frightened, but assuming that she really was scared, think of which division of the autonomic nervous system would prepare her body for an emergency.

Have you ever become frightened and felt your heart start pounding? How does this happen? The answer is your autonomic nervous system. The sympathetic division prepared you to deal with a possible emergency by increasing your heart rate. The fact that this happened in the blink of an eye shows how amazing the nervous system is.

### Vocabulary

- **autonomic nervous system (ANS)**: Division of the peripheral nervous system; controls involuntary activities not under conscious control, such as heart rate and digestion.
- **motor division**: Division of the peripheral system that carries messages from the central nervous system to internal organs and muscles.
- **parasympathetic division**: Subdivision of the autonomic nervous system; controls involuntary activities when there is not an emergency.
- **peripheral nervous system (PNS)**: All the nerves in the body that are found outside of the central nervous system.
- **sensory division**: Division of the peripheral nervous system that carries messages from sense organs and internal organs to the central nervous system.
- **somatic nervous system**: Division of the peripheral nervous system; controls voluntary, conscious movements.
- **sympathetic division**: Subdivision of the autonomic nervous system that deals with emergencies.

### Summary

- The peripheral nervous system consists of all the nerves that are found outside the central nervous system.

- The peripheral nervous system is divided into the sensory and motor divisions, which are then divided into further systems and subdivisions.

## Practice

Use the resource below to answer the questions that follow.

- **PNS** at http://www.youtube.com/watch?v=3aiI2xt3crY (4:01)


MEDIA

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1. What are the two parts of the peripheral nervous system? How do they differ?
2. What do the nerves of the autonomic nervous system connect to?
3. What is meant by a "rest and digest" response? What part of the nervous system is involved with this response?
4. What is meant by a "fight or flight" response? What part of the nervous system is involved with this response?

## Review

1. What are the two major divisions of the peripheral nervous system?
2. Compare and contrast the somatic and autonomic nervous systems.

# 1.44 Human Vision

- Describe how humans see and explain why vision is important.

**How have you used your vision today?**

Maybe you were just doing some schoolwork. Or walking down the hallway. No matter what you were doing, you were probably using your sense of sight. You may depend on your sense of sight so much that it's hard to think of anything you do without it, except sleep. Why is sight so important?

## The Nature of Human Vision

Think about all the ways that students use their sense of sight during a typical school day. As soon as they open their eyes in the morning, they might look at the clock to see what time it is. Then, they might look out the window to see what the weather is like. They probably look in a mirror to comb their hair. In school, they use their eyes to read the board, their textbooks, and the expressions on their friends' faces. After school, they might keep their eye on the ball while playing basketball (**Figure** 1.82). Then, they might read their homework assignment and text messages from their friends.

Sight, or **vision**, is the ability to see light. It depends on the eyes detecting light and forming images. It also depends on the brain making sense of the images, so that we know what we are seeing. Human beings and other primates depend on vision more than many other animals. It's not surprising, then, that we have a better sense of vision than many other animals. Not only can we normally see both distant and close-up objects clearly, but we can also see in three dimensions and in color.


FIGURE 1.82
All eyes are on the ball in this basketball game. Think about how we use the sense of sight in other games.

### Seeing in Three Dimensions

Did you ever use 3-D glasses to watch a movie, like the boy pictured below (**Figure** 1.83)? If you did, then you know that the glasses make people and objects in the movie appear to jump out of the screen. They make images on the flat movie screen seem more realistic because they give them depth. That's the difference between seeing things in two dimensions and three dimensions.

We are able to see in three dimensions because we have two eyes facing the same direction but a few inches apart. As a result, we see objects and people with both eyes at the same time but from slightly different angles. Hold up a finger a few inches away from your face, and look at it, first with one eye and then with the other. You'll notice that your finger appears to move.

Now hold up your finger at arm's length, and look at it with one eye and then the other. Your finger seems to move less than it did when it was closer. Although you aren't aware of it, your brain constantly uses such differences to determine the distance of objects.

FIGURE 1.83
This boy is wearing 3-D glasses; when you look at objects and people in the real world, your eyes automatically see in three dimensions.

### Seeing in Color

For animals like us that see in color, it may be hard to imagine a world that appears to be mainly shades of gray. You can get an idea of how many other animals see the world by looking at a black-and-white picture of colorful objects.

For example, look at the apples on the tree pictured below (**Figure** 1.84). In the top picture, they appear in color, the way you would normally see them. In the bottom picture they appear without color, in shades of gray (**Figure** 1.85).

### Evolution and Primate Vision

Why do you think primates, including humans, evolved the ability to see in three dimensions and in color? To answer that question, you need to know a little about primate evolution. Millions of years ago, primate ancestors lived in trees. To move about in the trees, they needed to be able to judge how far away the next branch was. Otherwise, they might have a dangerous fall. Being able see in depth was important. It was an adaptation that would help tree-living

FIGURE 1.84
Humans with color vision see the apples on this tree; the bright red color of the apples stands out clearly from the green background of leaves.

FIGURE 1.85
Dogs and cats would see the green and red colors as shades of gray; they are able to see blue, but red and green appear the same to them.

primates survive.

Primate ancestors also mainly ate fruit. They needed to be able to spot colored fruits in the leafy background of the trees (**Figure** 1.86). They also had to be able to judge which fruits were ripe and which were still green. Ripe fruits are usually red, orange, yellow, or purple. Being able to see in color was important for finding food. It was an adaptation that would help fruit-eating primates survive.

### Vocabulary

- **vision**: Detecting light with the eyes and forming images.

FIGURE 1.86
With color vision, you can tell which cherries in this picture are ripe, because cherries turn red as they ripen.

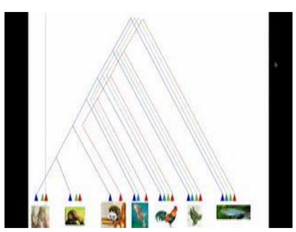
## Summary

- Vision depends on the eyes detecting light and forming images, and then the brain must make sense of the images.
- Humans can see in three dimensions and color.

## Practice

Use the resource below to answer the questions that follow.

- **Evolution of Color Vision** at http://www.youtube.com/watch?v=P1V_bJhvoAE (10:08)



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1. What are the three classes of cone cells in the human eye? How are they involved in color vision?
2. How does the vision of frogs and fish compare to humans? How does the vision of chickens compare to humans?
3. What is one theory why some mammals have only two types of cones? How does recent information of the platypus relate to this theory? Think carefully and answer as completely as you can.

## Review

1. What is vision?
2. Why were depth perception and color vision important for early primates?

# 1.45 How the Eye Works

- Explain how the eye works to produce images.


**How do you see the board?**

As you are sitting in the classroom, you may at first be focused on a paper directly in front of you. Then you may look to the front of the room to see a math problem worked out on the board. How can your eyes focus directly in front of you and then, a second later, at a distance? Your eyes are rather amazing!

## How the Eye Works

The job of the eye is to focus light. The parts of the eye (**Figure** 1.87) help it to carry out its job. Follow the path of light through the eye as you read about it below.

Vision involves sensing and focusing light from people and objects. The steps involved are as follows:

1. First, light passes through the cornea of the eye. The **cornea** is a clear, protective covering on the outside of the eye.
2. Next, light passes through the pupil. The **pupil** is a black opening in the eye that lets light enter the eye.
3. After passing into the eye through the pupil, light passes through the lens. The **lens** of the eye is a clear, curved structure. Along with the cornea, the lens helps focus light at the back of the eye. This is pictured below (**Figure** 1.88).
4. The lens must bend light from nearby objects more than it bends light from far-away objects. The lens changes shape to bend the light by just the right amount to bring objects into focus.
5. The lens focuses light on the **retina**, which covers the back of the inside of the eye. The retina has light-sensing cells called rods and cones. **Rods** let us see in dim light. **Cones** let us detect light of different colors.
6. When light hits rods and cones, it causes chemical changes. The chemical changes start nerve impulses. The nerve impulses travel to the brain through the **optic nerve**.

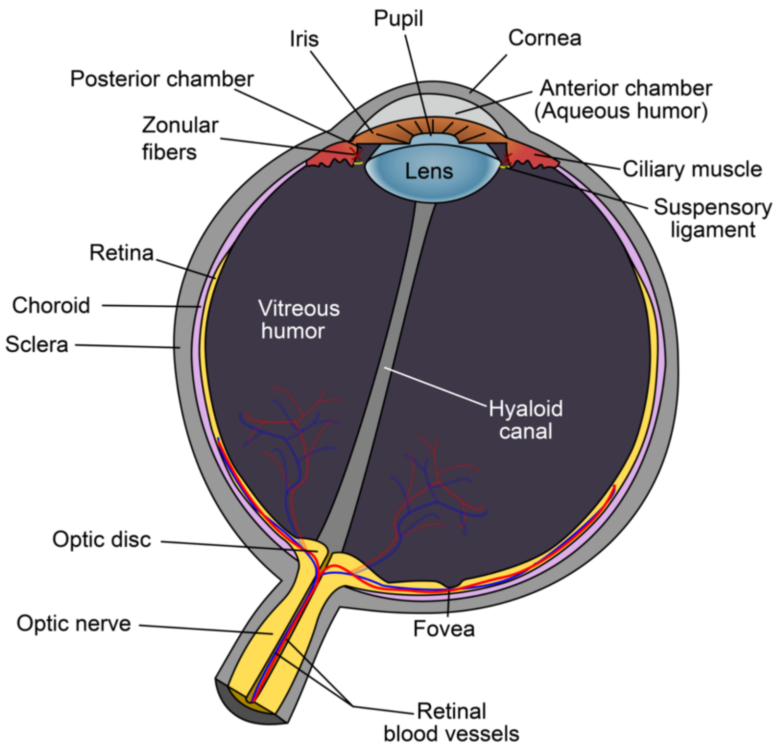



FIGURE 1.87

The human eye is a complex structure that senses light; the light passes through the cornea, pupil, and lens, and is focused on the retina.

7. The brain makes sense of the nerve impulses and tells you what you are seeing.

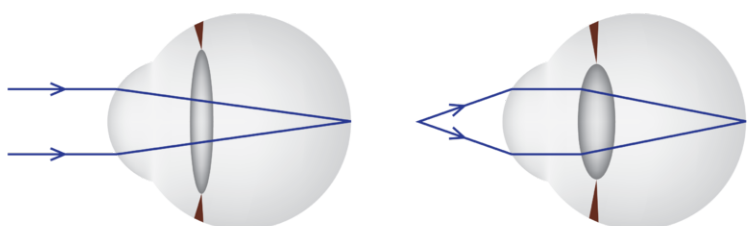


FIGURE 1.88

Light from objects at different distances is focused by the lens of the eye. Muscles in the eye control the shape of the lens so the light is focused on the back of the eye no matter how far the object is from the lens.

## Vocabulary

- **cone**: Cone-shaped cell in the retina of the eye that detects light of different colors.
- **cornea**: Clear, protective covering on the outside of the eye.
- **lens**: Clear, curved structure that helps focus light on the retina at the back of the eye.
- **optic nerve**: Nerve which carries impulses from the eye to the brain.
- **pupil**: Black opening in the eye that lets light enter the eye.
- **rod**: Rodlike cell in the retina of the eye that is sensitive to dim light.
- **retina**: Part of the eye that contains light receptor cells.

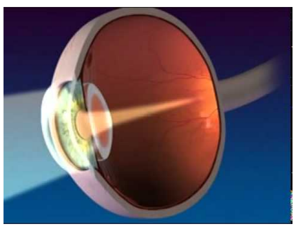
## Summary


- Light entering the eye is focused by the lens on the retina, which sends messages to the brain through the optic nerve.
- Muscles in the eye control the shape of the lens so the light is focused on the back of the eye no matter how far the object is from the lens.


## Practice

Use the resource below to answer the questions that follow.

- **Anatomy and Function of the Eye** at http://www.youtube.com/watch?v=RE1MvRmWg7I (2:00)



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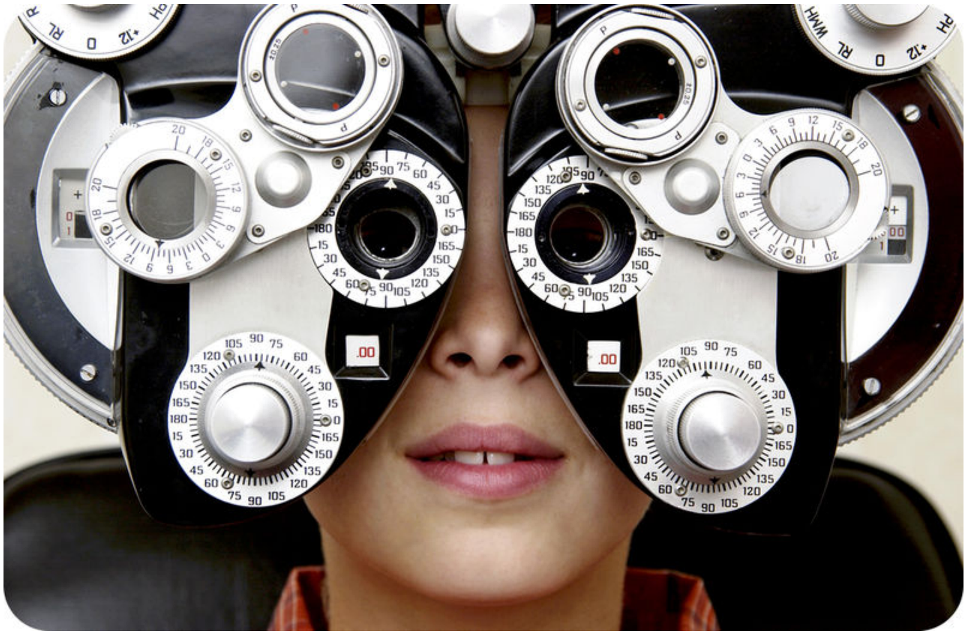
1. What are the three layers of the eye? Which one acts to maintain the eyes shape?
2. Where does light enter the eye? How is the amount of light entering the eye controlled? Why is it valuable to organisms to control how much light enters the eye?
3. What structure contains the rods and cones in the eye? Where are they located?

## Review

1. Outline the path of light through the eye.
2. Describe the role of the lens of the eye.

# 1.46 Vision Correction

- Explain how lenses correct vision problems.



**Why get an eye exam?**

During a routine eye exam, your vision will be evaluated to see if you need glasses or contacts. Also, the eye doctor checks your eyes for diseases that could lead to vision loss.

## Vision Correction

You probably know people who need eyeglasses or contact lenses to see clearly. Maybe you need them yourself. Lenses are used to correct vision problems. Two of the most common vision problems are myopia and hyperopia.

### Myopia

**Myopia** is also called nearsightedness. It affects about one third of people. People with myopia can see nearby objects clearly, but distant objects appear blurry. The picture below shows how a person with myopia might see two boys that are a few meters away (**Figure** 1.89).

In myopia, the eye is too long. Below, you can see how images are focused on the retina of someone with myopia (**Figure** 1.90). Myopia is corrected with a **concave** lens, which curves inward like the inside of a bowl. The lens changes the focus, so images fall on the retina as they should.

### Farsightedness

Farsightedness is also known as **hyperopia**. It affects about one fourth of people. People with hyperopia can see distant objects clearly, but nearby objects appear blurry. In hyperopia, the eye is too short. This results in images

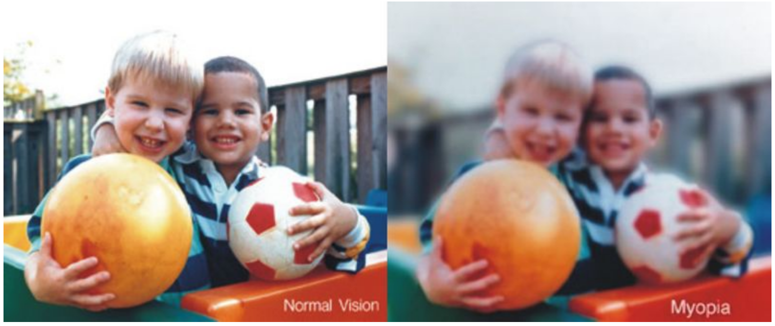



FIGURE 1.89
On the left, you can see how a person with normal vision sees two boys. The right image shows how a person with myopia sees the boys.

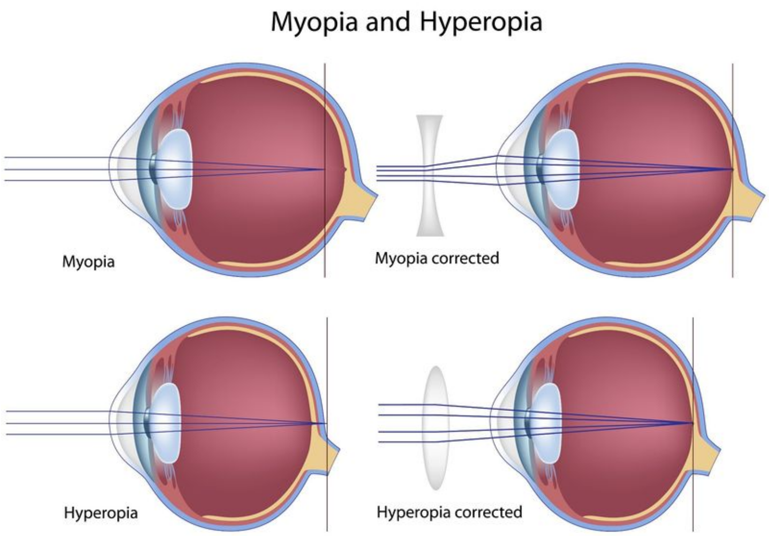



FIGURE 1.90
The eye of a person with myopia is longer than normal. As a result, images are focused in front of the retina (*top left*). A concave lens is used to correct myopia to help focus images on the retina (*top right*). Farsightedness, or hyperopia, occurs when objects are focused in back of the retina (*bottom left*). It is corrected with a convex lens (*bottom right*).

being focused in back of the retina (**Figure** 1.90). Hyperopia is corrected with a **convex** lens, which curves outward like the outside of a bowl. The lens changes the focus so that images fall on the retina as they should.

In addition to lenses, many cases of myopia and hyperopia can be corrected with surgery. For example, a procedure called LASIK uses a laser to permanently change the shape of the cornea so light is correctly focused on the retina.

## Vocabulary

- **concave**: Curving inward like the inside of a bowl.
- **convex**: Curving outward like the outside of a bowl.
- **hyperopia**: Farsightedness.
- **myopia**: Nearsightedness.

## Summary

- Vision problems such as myopia and hyperopia can be corrected with lenses that help focus light on the retina.
- Myopia is corrected with a concave lens, while hyperopia is corrected with a convex lens.

## Practice

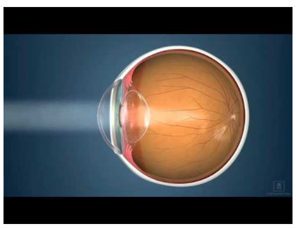
Use the resources below to answer the questions that follow.

- **Myopia, Hyperopia, and Astigmatism Explained** at http://www.youtube.com/watch?v=6YxffFmi4Eo (1:55)


MEDIA
Click image to the left for more content.

1. How can the shape of your eyeball cause you to be farsighted? How does this affect your focal point?
2. How can the shape of your eyeball cause you to be nearsighted? How does this affect your focal point?
3. How can an irregularly formed cornea affect your vision?

- **Nearsighted, Farsighted, and Reading Glasses** at http://www.youtube.com/watch?v=iws1Mfu1k84 (1:39)



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1. What is myopia? If you had this condition, when might you wear glasses?
2. What is hyperopia? If you had this condition, when might you wear glasses?
3. What is an astigmatism? If you had an astigmatism, when might you wear glasses?
4. At what age do many people start needing reading glasses? What causes this condition?

## Review

1. What is hyperopia, and what type of lens corrects it?
2. What causes myopia, and what type of lens corrects it?

# 1.47 Hearing and Balance

- Explain how the ears hear and help maintain balance.

**Feeling dizzy?**

Have you ever gotten off a spinning ride at an amusement park and felt dizzy? Why does this happen? It actually all goes back to your ears! When you stop spinning, the fluid in the canals of your ears is still moving. Sensing the position of the liquid in the canals usually helps you keep balance, so spinning the fluid throws you off balance.

## Hearing and Balance

What do listening to music and riding a bike have in common? It might surprise you to learn that both activities depend on your ears. The ears do more than just detect sound. They also sense the position of the body and help maintain balance.

### Hearing

**Hearing** is the ability to sense sound. Sound travels through the air in waves, much like the waves you see in the water pictured below (**Figure** 1.91). Sound waves in air cause vibrations inside the ears. The ears sense the vibrations.

The human ear is pictured below (**Figure** 1.92). As you read about it, trace the path of sound waves through the ear. Assume a car horn blows in the distance. Sound waves spread through the air from the horn. Some of the sound waves reach your ear. The steps below show what happens next. They explain how your ears sense the sound.

1. The sound waves travel to the **ear canal**. This is a tube-shaped opening in the ear.

FIGURE 1.91
Sound waves travel through the air in all directions away from a sound, like waves traveling through water away from where a pebble was dropped.

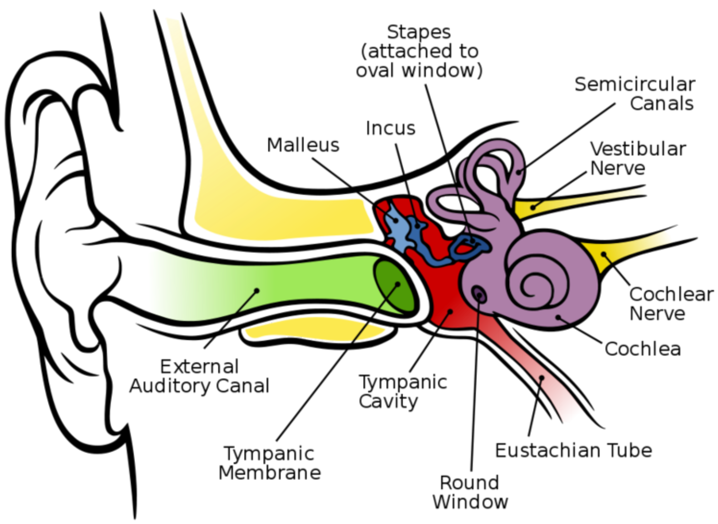



FIGURE 1.92
Read the names of the parts of the ear in the text; then find each of the parts in the diagram.

2. At the end of the ear canal, the sound waves hit the **eardrum**. This is a thin membrane that vibrates like the head of a drum when sound waves hit it.
3. The vibrations pass from the eardrum to the **hammer**. This is the first of three tiny bones that pass vibrations through the ear.
4. The hammer passes the vibrations to the **anvil**, the second tiny bone that passes vibrations through the ear.
5. The anvil passes the vibrations to the **stirrup**, the third tiny bone that passes vibrations through the ear.
6. From the stirrup, the vibrations pass to the **oval window**. This is another membrane like the eardrum.
7. The oval window passes the vibrations to the **cochlea**. The cochlea is filled with liquid that moves when the vibrations pass through, like the waves in water when you drop a pebble into a pond. Tiny hair cells line the cochlea and bend when the liquid moves. When the hair cells bend, they release neurotransmitters.
8. The neurotransmitters trigger nerve impulses that travel to the brain through the auditory nerve. The brain reads the sound and "tells" you what you are hearing.

No doubt you've been warned that listening to loud music or other loud sounds can damage your hearing. It's true. In fact, repeated exposure to loud sounds is the most common cause of hearing loss. The reason? Very loud sounds can kill the tiny hair cells lining the cochlea. The hair cells do not generally grow back once they are destroyed, so this type of hearing loss is permanent. You can protect your hearing by avoiding loud sounds or wearing earplugs or other ear protectors.

### Balance

Did you ever try to stand on one foot with your eyes closed? Try it and see what happens, but be careful! It's harder to keep your balance when you can't see. Your eyes obviously play a role in balance. But your ears play an even bigger role. The gymnast pictured below (**Figure** 1.93) may not realize it, but her ears—along with her cerebellum—are mostly responsible for her ability to perform on the balance beam.

FIGURE 1.93
This gymnast is using the semicircular canals in her ears, along with the cerebellum in her brain, to help keep her balance on the balance beam.

The parts of the ears involved in balance are the **semicircular canals**. Above, the semicircular canals are colored purple (**Figure** 1.92). The canals contain liquid and are like the bottle of water pictured below (**Figure** 1.94). When the bottle tips, the water surface moves up and down the sides of the bottle. When the body tips, the liquid in the semicircular canals moves up and down the sides of the canals.

Tiny hair cells line the semicircular canals. Movement of the liquid inside the canals causes the hair cells to send nerve impulses. The nerve impulses travel to the cerebellum in the brain. In response, the cerebellum sends commands to muscles to contract or relax so that the body stays balanced.

### Vocabulary

- **anvil**: Second of three tiny bones that pass vibrations through the ear.
- **cochlea**: Coiled tube filled with liquid inside the inner ear and lined with hairs that detect vibrations.
- **ear canal**: Tube-shaped opening in the ear.
- **eardrum**: Thin membrane that vibrates like the head of a drum when sound waves hit it.
- **hammer**: First of three tiny bones that pass vibrations through the ear.
- **hearing**: Ability to sense sound.
- **oval window**: Thin membrane that passes vibrations from the stirrup to the cochlea.
- **semicircular canals**: Canals inside the ear that are filled with fluid that moves when the head changes position; helps to maintain the body's balance.
- **stirrup**: Last of three tiny bones that pass vibrations through the ear.

FIGURE 1.94

This bottle of water models the semicircular canals in your ears. When you tip the bottle, the water moves up or down the sides of the bottle; when you tip your head, the liquid inside the semicircular canals moves up and down the sides of the canals. Tiny hair cells lining the canals sense the movement of liquid and send messages to the brain.

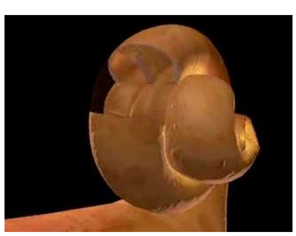
## Summary

1. At the end of the ear canal, sound waves hit the eardrum, which passes vibrations through a series of bones to the cochlea.
2. The parts of the ears involved in balance are the semicircular canals.

## Practice

Use the resources below to answer the questions that follow.

- **Hearing and Balance** at http://www.youtube.com/watch?v=vTiGskc1o48 (1:02)

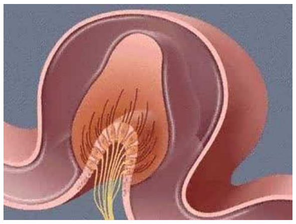


MEDIA

Click image to the left for more content.

1. When sound enters your ear, it starts your eardrum vibrating. Where do the vibrations go next?
2. What part of your ear contains fluid?
3. Where are the nerve sensors that communicate with the brain located in your ear?

- **The Sense of Balance** at http://www.youtube.com/watch?v=mmBB2bu1gEQ (0:41)



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Click image to the left for more content.

1. What gives us our sense of balance?
2. What is a kinocilium? How is this involved in your sense of balance?

## Review

1. Which structure in the ear changes sound waves in the air into vibrations?
2. Which parts of the ear sense changes in the body's position?
3. Why does death of hair cells in the cochlea cause hearing loss?

# 1.48 Touch

- Outline how we sense pressure, temperature, and pain.

**What if you felt no pain?**

It might sound good to you to have a condition where you feel no pain. But actually this type of condition would be very dangerous. What would happen if you strained your back but felt no pain? Instead of resting your back, you might injure it further.

## Touch

When you look at the prickly cactus pictured below (**Figure** 1.95), does the word "ouch" come to mind? Touching the cactus would be painful. **Touch** is the sense of pain, pressure, or temperature. Touch depends on sensory **neurons**, or nerve cells, in the skin. The skin on the palms of the hands, soles of the feet, and face has the most sensory neurons and is especially sensitive to touch. The tongue and lips are very sensitive to touch as well. Neurons that sense pain are also found inside the body in muscles, joints, and organs. If you have a stomach ache or pain from a sprained ankle, it's because of these sensory neurons found inside of your body.

The following example shows how messages about touch travel from sensory neurons to the brain, as well as how the brain responds to the messages. Suppose you wanted to test the temperature of the water in a lake before jumping in. You might stick one bare foot in the water. Neurons in the skin on your foot would sense the temperature of the water and send a message about it to your central nervous system. The frontal lobe of the cerebrum would process the information. It might decide that the water is really cold and send a message to your muscles to pull your foot out of the water.

FIGURE 1.95
The spines on this cactus are like needles; they help keep away animals that might want to eat the cactus.

In some cases, messages about pain or temperature don't travel all the way to and from the brain. Instead, they travel only as far as the spinal cord, and the spinal cord responds to the messages by giving orders to the muscles. This allows you to respond to pain more quickly. When messages avoid the brain in this way, it forms a **reflex arc**, like the one shown below (**Figure** 1.96).

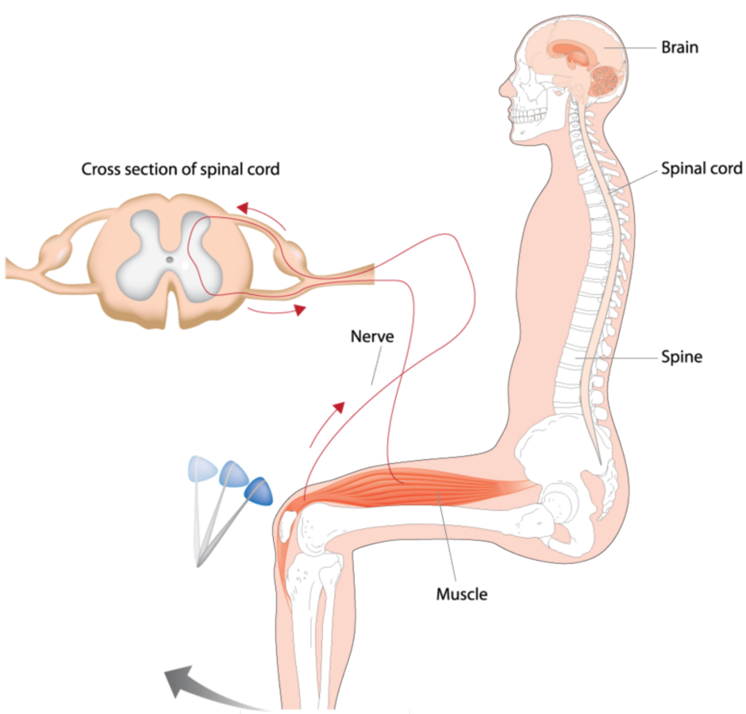



FIGURE 1.96
Reflex Arc: When a reflex hammer taps your knee, you may immediately kick your leg—without even thinking about it. The nerve impulse from your knee travels to the spinal cord, and the spinal cord sends a message to your muscles to kick your leg.

## Vocabulary

- **neurons**: Nerve cells.
- **reflex arc**: Movement of a sensory message to the spinal cord, where it transmits a response to the muscle

without involving the brain.
- **touch**: Sense of pain, pressure, or temperature.

## Summary

- Sensory neurons in the skin sense pain, pressure, and temperature.
- When sensory messages only travel as far as the spinal cord, and skip the brain, this is called a reflex arc.

## Practice

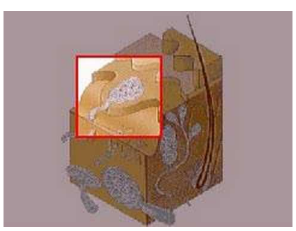
Use the resources below to answer the questions that follow.

- **Human Senses** at http://www.youtube.com/watch?v=Ajw_WJYxAAI (1:05)


MEDIA
Click image to the left for more content.

1. Where do we have touch sensors?
2. How do they communicate with the brain?

- **The Sensory Cortex and Touch** at http://www.youtube.com/watch?v=IC3YTJNu0Ec (1:08)



MEDIA
Click image to the left for more content.

1. Where is the sensory cortex located?
2. What are the "end bulbs of Krause" believed to sense?
3. What do Merkel's disks respond to?
4. What sensors are located in the dermis?

## Review

1. Imagine you touch a smooth stone. How is this sensation transmitted to your brain?
2. How and why do reflex arcs occur?

# 1.49 Taste and Smell

- Describe how we identify different tastes and smells.

**Why are your senses of taste and smell important?**

Imagine you open a gallon of milk, and you suddenly smell a foul odor. Your sense of smell has informed you that the milk has spoiled. So you pour the spoiled milk down the kitchen sink. Your sense of smell has possibly kept you from getting sick!

Your sense of taste is controlled by sensory **neurons**, or nerve cells, on your tongue that sense the chemicals in food. The neurons are grouped in bundles within **taste buds**. There are five different types of taste neurons on the tongue. Each type detects a different taste. The tastes are:

1. Sweet.
2. Salty.
3. Sour.
4. Bitter.

5. **Umami**, which is a meaty taste.

When taste neurons sense chemicals, they send messages to the brain about them. The brain then decides what tastes you are sensing.

Your sense of smell also involves sensory neurons that sense chemicals. The neurons are found in the nose, and they detect chemicals in the air. Unlike taste neurons, which can detect only five different tastes, the sensory neurons in the nose can detect thousands of different odors. Have you ever noticed that you lose your sense of taste when your nose is stuffed up? That's because your sense of smell greatly affects your ability to taste food. As you eat, molecules of food chemicals enter your nose. You experience the taste and smell at the same time. Being able to smell as well as taste food greatly increases the number of different tastes you are able to sense. For example, you can use your sense of taste alone to learn that a food is sweet, but you have to use your sense of smell as well to learn that the food tastes like strawberry cheesecake.

## Vocabulary

- **neuron**: Nerve cell.
- **taste bud**: Tiny bump on the tongue that consists of bundles of neurons that detect chemicals.
- **umami**: Meaty taste.

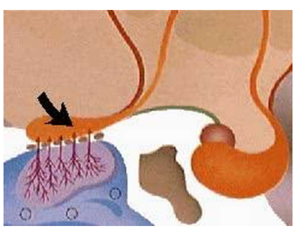
## Summary

- Sensory neurons on the tongue detect five types of tastes: sweet, salty, sour, bitter, and umami.
- Sensory neurons that sense chemicals in your nose allow you to detect smells.

## Practice

Use the resources below to answer the questions that follow.

- **The Olfactory Pathway** at http://www.youtube.com/watch?v=pM7H0Wud_Y0 (0:30)

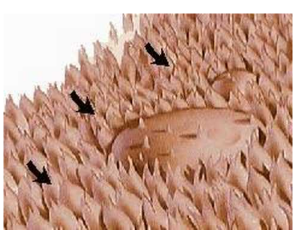


MEDIA

Click image to the left for more content.

1. What is the function of the olfactory cortex?
2. What stimulates the olfactory sensors in the nose?

- **Taste Centers** at http://www.youtube.com/watch?v=RIXtM2u–H8 (1:12)

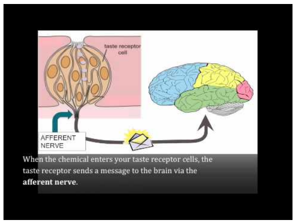


MEDIA

Click image to the left for more content.

1. What covers the surface of the tongue?
2. What four types of sensors can be found on the tongue? Are these distributed evenly over the tongue?
3. How does stimulation of the taste buds stimulate the salivary glands?

- **Sense of Taste and Smell** at http://www.youtube.com/watch?v=N42c52lCQNc (2:14)




MEDIA

Click image to the left for more content.

1. What is a taste pore? What is its function?
2. What is at the end of the receptor cells for taste?
3. What do the olfactory receptors have that the taste receptors also have? Can you think of other areas of the body that have similar structures?

## Review

1. What are the five tastes sensed by neurons on the tongue?
2. Why is your sense of taste affected when you have a stuffy nose?

# 1.50 Diseases of the Nervous System

- Describe diseases of the nervous system.

**Why get vaccinations?**

Like this girl, many people are a little afraid of needles. But this is no reason to avoid vaccinations. Vaccinations can help you avoid serious diseases. For example, a vaccination to prevent meningitis, a serious infection of the nervous system, is now available.

## Diseases of the Nervous System

The nervous system controls sensing, feeling, and thinking. It also controls movement and just about every other body function. That's why problems with the nervous system can affect the entire body. Diseases of the nervous system include brain and spinal cord infections. Other problems of the nervous system range from very serious diseases, such as tumors, to less serious problems, such as tension headaches. Some diseases are present at birth. Others begin during childhood or adulthood.

### Central Nervous System Infections

When you think of infections, you probably think of an ear infection or strep throat. You probably don't think of a brain or spinal cord infection. But bacteria and viruses can infect these organs as well as other parts of the body. Infections of the brain and spinal cord are not very common. But when they happen, they can be very serious. That's why it's important to know their symptoms.

### Encephalitis

**Encephalitis** is a brain infection (**Figure** 1.97). If you have encephalitis, you are likely to have a fever and headache or feel drowsy and confused. The disease is most often caused by viruses. The immune system tries to fight off a brain infection, just as it tries to fight off other infections. But sometimes this can do more harm than good. The immune system's response may cause swelling in the brain. With no room to expand, the brain pushes against the skull. This may injure the brain and even cause death. Medicines can help fight some viral infections of the brain, but not all infections.

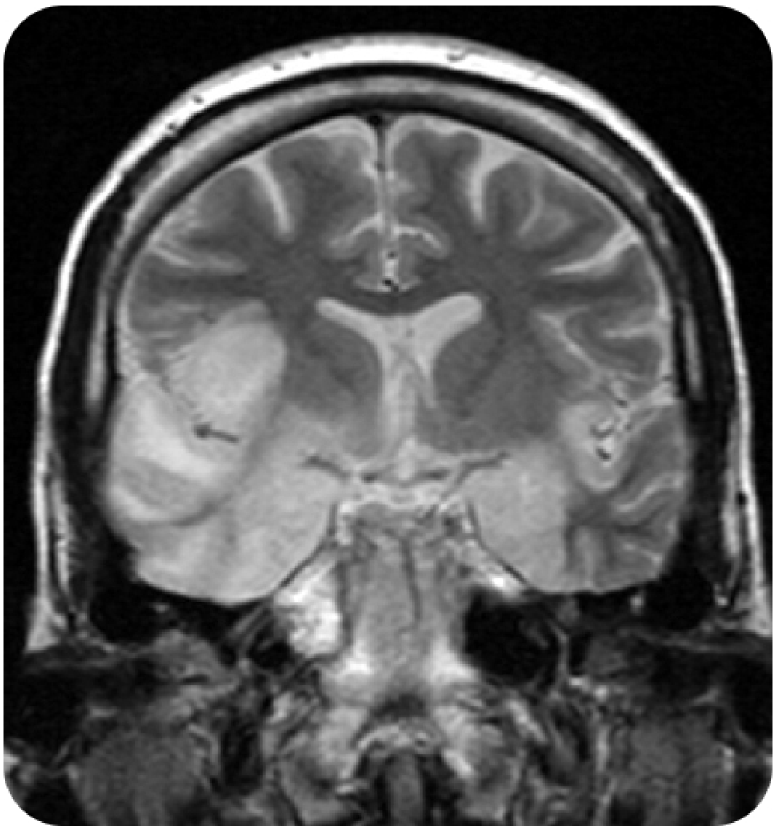


FIGURE 1.97
This scan shows a person with encephalitis.

### Meningitis

**Meningitis** is an infection of the membranes that cover the brain and spinal cord. If you have meningitis, you are likely to have a fever and a headache. Another telltale symptom is a stiff neck. Meningitis can be caused by viruses or bacteria. Viral meningitis often clears up on its own after a few days. Bacterial meningitis is much more serious (**Figure** 1.98). It may cause brain damage and death. People with bacterial meningitis need emergency medical treatment. They are usually given antibiotics to kill the bacteria.

A vaccine to prevent meningitis recently became available. It can be given to children as young as two years old. Many doctors recommend that children receive the vaccine no later than age 12 or 13, or before they begin high school.

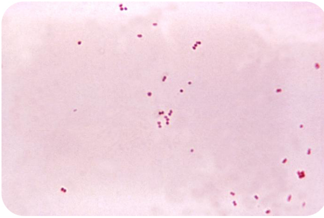


FIGURE 1.98
These bacteria, shown at more than 1,000 times their actual size, are the cause of bacterial meningitis. Despite their tiny size, they can cause very serious illness.

### Reye's Syndrome

A condition called **Reye's syndrome** can occur in young people that take aspirin when they have a viral infection. The syndrome causes swelling of the brain and may be fatal. Fortunately, Reye's syndrome is very rare. The best way to prevent it is by not taking aspirin when you have a viral infection. Products like cold medicines often contain aspirin. So, read labels carefully when taking any medicines (**Figure** 1.99).

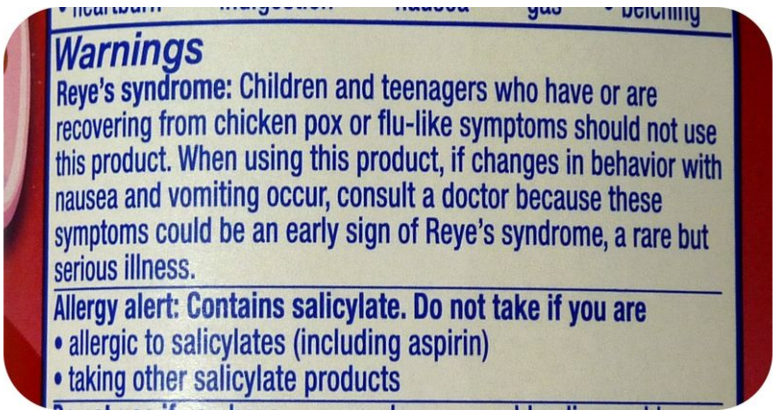



FIGURE 1.99
Since 1988, the U.S. Food and Drug Administration has required that all aspirin and aspirin-containing products carry a warning about Reye's syndrome.

### Other Nervous System Diseases

Like other parts of the body, the nervous system may develop tumors. A **tumor** is a mass of cells that grows out of control. A tumor in the brain may press on normal brain tissues. This can cause headaches, difficulty speaking, or other problems, depending on where the tumor is located. Pressure from a tumor can even cause permanent brain damage. In many cases, brain tumors can be removed with surgery. In other cases, tumors can't be removed without damaging the brain even more. In those cases, other types of treatments may be needed.

**Cerebral palsy** is a disease caused by injury to the developing brain. The injury occurs before, during, or shortly after birth. Cerebral palsy is more common in babies that have a low weight at birth. But the cause of the brain injury is not often known. The disease usually affects the parts of the brain that control body movements. Symptoms range from weak muscles in mild cases to trouble walking and talking in more severe cases. There is no known cure for cerebral palsy.

**Epilepsy** is a disease that causes seizures. A seizure is a period of lost consciousness that may include violent muscle contractions. It is caused by abnormal electrical activity in the brain. The cause of epilepsy may be an infection, a brain injury, or a tumor. The seizures of epilepsy can often be controlled with medicine. There is no known cure for the disease, but children with epilepsy may outgrow it by adulthood.

A headache is a very common nervous system problem. Headaches may be a symptom of serious diseases, but they are more commonly due to muscle tension. A tension headache occurs when muscles in the shoulders, neck, and head become too tense. This often happens when people are "stressed out." Just trying to relax may help relieve this type of headache (**Figure** 1.100). Mild pain relievers such as ibuprofen may also help.

FIGURE 1.100
Sometimes relaxation is the best "medicine" for a tension headache and to help muscles get rid of pain.

A **migraine** is a more severe type of headache. It occurs when blood vessels in the head dilate, or expand. This may be triggered by certain foods, bright lights, weather changes, or other factors. People with migraines may also have nausea or other symptoms. Fortunately, migraines can often be relieved with prescription drugs.

There are many other nervous system diseases. They include multiple sclerosis, Huntington's disease, Parkinson's disease, and Alzheimer's disease. However, these diseases rarely, if ever, occur in young people. Their causes and symptoms are listed below (**Table** 1.8). The diseases have no known cure, but medicines may help control their symptoms.

**TABLE 1.8: Incurable Nervous System Diseases**

| Disease | Cause | Symptoms |
|---|---|---|
| Multiple Sclerosis | The immune system attacks and damages the central nervous system so neurons cannot function normally. | Muscle weakness, difficulty moving, problems with coordination, difficulty keeping the body balanced |
| Huntington's Disease | An inherited gene codes for an abnormal protein that causes the death of neurons. | Uncontrolled jerky movements, loss of muscle control, problems with memory and learning |
| Parkinson's Disease | An abnormally low level of a neurotransmitter affects the part of the brain that controls movement. | Uncontrolled shaking, slowed movements, problems with speaking |
| Alzheimer's Disease | Abnormal changes in the brain cause the gradual loss of most normal brain functions. | Memory loss, confusion, mood swings, gradual loss of control over mental and physical abilities |

## Vocabulary

- **cerebral palsy**: Disease caused by injury to the developing brain that results in impaired muscle coordination.
- **encephalitis**: Infection of the brain that can cause fever, headache, drowsiness, and confusion.

- **epilepsy**: Disease that causes seizures, a period of lost consciousness that may include violent muscle contractions.
- **meningitis**: Infection of the membranes that cover the brain and spinal cord.
- **migraine**: Severe type of headache that occurs when blood vessels in the head expand.
- **Reye's syndrome**: Condition that causes swelling of the brain; can occur among young people who take aspirin when they have a viral infection.
- **tumor**: Mass of cells that grows out of control.

## Summary

- The nervous system can be affected by infections, such as encephalitis or meningitis.
- Other nervous system diseases include tumors, cerebral palsy, epilepsy, and migraines.

## Practice

Use the resource below to answer the questions that follow.

- **Neurological Disorders** at http://www.youtube.com/watch?v=7ivWFEyiahg (9:14)


MEDIA
Click image to the left for more content.

1. What are some examples of neurological disorders?
2. What kinds of deficits can neurological disorders cause? Are all these deficits readily apparent?
3. How does blood supply affect strokes?
4. What is the affect of Multiple Sclerosis? What is the cause? What body systems are involved?

## Review

1. Compare and contrast tension headaches and migraine headaches.
2. Explain why young people should not take aspirin when they have the flu, which is caused by viruses.

# 1.51 Injuries of the Nervous System

- Explain how the nervous system can be injured.


**No diving?**

Make sure you always heed the advice of signs that say "no diving." Diving in shallow water can lead to serious injuries to your nervous system.

## Injuries of the Nervous System

Injuries to the central nervous system may damage tissues of the brain or spinal cord. If an injury is mild, a person may have a full recovery. If an injury is severe, it may cause permanent disability or even death. Brain and spinal cord injuries most commonly occur because of car crashes or sports accidents. The best way to deal with such injuries is to try to prevent them.

### Brain Injuries

The mildest and most common type of brain injury is a **concussion**. This is a bruise on the surface of the brain. It may cause temporary problems such as headache, drowsiness, and confusion. Most concussions in young people occur when they are playing sports, especially contact sports like football. A concussion normally heals on its own in a few days.

A single concussion is unlikely to cause permanent damage. But repeated concussions may lead to lasting problems. People who have had two or more concussions may have life-long difficulties with memory, learning, speech, or balance. You can see an animation of how a concussion occurs by visiting http://www.pennmedicine.org/encyclopedia/em_DisplayAnimation.aspx?gcid=000034&ptid=17.

A person with a serious brain injury usually suffers permanent brain damage. As a result, the person may have trouble talking or controlling body movements. Symptoms depend on what part of the brain was injured. Serious brain injuries can also cause personality changes and problems with mental abilities such as memory. Medicines, counseling, and other treatments may help people with serious brain injuries recover from, or at least learn to cope with, their disabilities.

### Spinal Cord Injuries

Spinal cord injuries make it difficult for messages to travel between the brain and body. They may cause a person to lose the ability to feel or move parts of the body. This is called **paralysis**. Whether paralysis occurs—and what parts of the body are affected if it does—depends on the location and seriousness of the injury. In addition to car crashes and sports injuries, diving accidents are a common cause of spinal cord injuries.

Some people recover from spinal cord injuries. But many people are paralyzed for life. Thanks to the work of Christopher Reeve (**Figure** 1.101), more research is being done on spinal cord injuries now than ever before. For example, scientists are trying to discover ways to regrow damaged spinal cord neurons.

FIGURE 1.101

Former *Superman* star Christopher Reeve was paralyzed from the neck down in a fall from a horse. The injury crushed his spinal cord so his brain could no longer communicate with his body.

## Vocabulary

- **concussion**: Bruise on the surface of the brain that can cause temporary problems such as headache, drowsiness, and confusion.
- **paralysis**: Loss of ability to feel or move parts of the body.

## Summary

- Mild brain injuries, such as a concussion, normally heal on their own, while serious brain injuries can cause permanent physical and mental disabilities.
- Spinal cord injuries can lead to paralysis, when a person loses the ability to feel or move parts of the body.

## Practice

Use the resource below to answer the questions that follow.

- **What Are Damaged Nerves?** at http://www.youtube.com/watch?v=2buwDxESi3w (1:47)

MEDIA

Click image to the left for more content.

1. What kinds of problems can arise from damaged nerves?
2. How do you think symptoms might vary between someone with a damaged peripheral nerve vs. a damaged central nerve? Explain your thinking fully.
3. How can nerves become damaged? Can damaged nerves repair themselves?

## Review

1. What are some possible consequences of a serious brain injury?
2. Explain what causes paralysis.

# 1.52 Keeping the Nervous System Healthy

- List ways to keep the nervous system healthy.

**Do you like doing puzzles?**

Activities that challenge your brain, such as working on a Sudoku puzzle, are good for the health of your nervous system. Just like you need to work out your body to stay in shape, your brain also needs a good work out regularly in order to stay sharp.

## Keeping the Nervous System Healthy

There are many choices you can make to keep your nervous system healthy. One obvious choice is to avoid using alcohol or other drugs. Not only will you avoid the injury that drugs themselves can cause, but you will also be less likely to get involved in other risky behaviors that could harm your nervous system. Another way to keep the nervous system healthy is to eat a variety of healthy foods. The **minerals**, calcium and potassium, and **vitamins** $B_1$ and $B_{12}$ are important for a healthy nervous system. Some foods that are good sources for these minerals and vitamins are shown below (**Figure** 1.102).

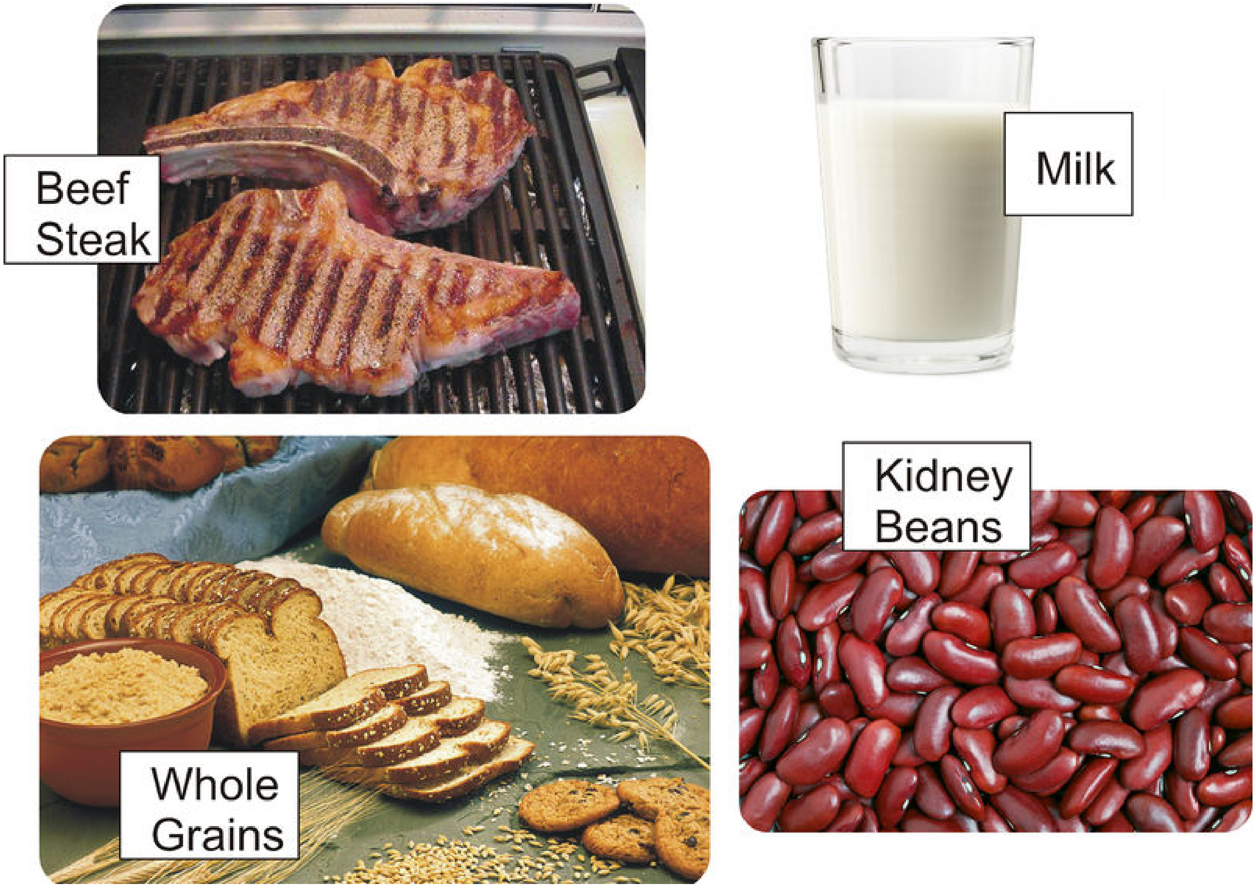



FIGURE 1.102
These foods are sources of nutrients needed for a healthy nervous system.

Daily physical activity is also important for nervous system health. Regular exercise makes your heart more efficient at pumping blood to your brain. As a result, your brain gets more oxygen, which it needs to function normally. The saying "use it or lose it" applies to your brain as well as your body. This means that mental activity, not just physical activity, is important for nervous system health. Doing crossword puzzles, reading, and playing a musical instrument are just a few ways you can keep your brain active.

You can also choose to practice safe behaviors to protect your nervous system from injury. To keep your nervous system safe, choose to:

- Wear safety goggles or sunglasses to protect your eyes from injury.
- Wear hearing protectors, such as ear plugs to protect your ears from loud sounds.
- Wear a safety helmet for activities like bike riding and skating (**Figure** 1.103).
- Wear a safety belt every time you ride in a motor vehicle.
- Avoid unnecessary risks, such as performing dangerous stunts on your bike.
- Never dive into water that is not approved for diving. If the water is too shallow, you could seriously injure your brain or spinal cord. A few minutes of fun could turn into a lifetime in a wheelchair.

FIGURE 1.103
Bicycle helmets help protect from head injuries. Making healthy choices like this can help prevent nervous system injuries that could cause lifelong disability.

## Vocabulary

- **mineral**: Chemical element, such as calcium or potassium, that is needed for body processes.
- **vitamin**: Organic compound needed in small amounts for the body to function properly.

## Summary

- The minerals, calcium and potassium, and vitamins B1 and B12 are important for a healthy nervous system.
- You can make choices that will help keep your nervous system healthy and safe, such as choosing to wear a bicycle helmet.

## Practice

Use the resource below to answer the questions that follow.

- **The First Key To Health—Your Nervous System** at http://www.youtube.com/watch?v=R6_CDcTLpVI (2:30)

MEDIA
Click image to the left for more content.

1. How can the health of your nervous system affect all other body systems?
2. What kinds of problem might you experience if the nerve connection to your stomach were impaired?

## Review

1. What types of foods are important for a healthy nervous system?

2. Name two behaviors that protect your nervous system from injury.

# 1.53 Pathogens

- List common causes of infectious diseases and how they are spread.

**What are germs?**

You know germs can make you sick. They can live anywhere, from on your doorknob to in your food. A more scientific word for germ is pathogen.

## Pathogens

Has this ever happened to you? A student sitting next to you in class has a cold. The other student is coughing and sneezing, but you feel fine. Two days later, you come down with a cold, too. Diseases like colds are contagious. Contagious diseases are also called infectious diseases. An **infectious disease** is a disease that spreads from person to person.

Infectious diseases are caused by pathogens. A **pathogen** is a living thing or virus that causes disease. Pathogens are commonly called "germs." They can travel from one person to another.

### Types of Pathogens

Living things that cause human diseases include bacteria, fungi, and protozoa. Most infectious diseases caused by these organisms can be cured with medicines. For example, medicines called antibiotics can cure most diseases caused by bacteria. Bacteria are one-celled organisms without a nucleus. Although most bacteria are harmless, some cause diseases.

Worldwide, the most common disease caused by bacteria is tuberculosis (TB). TB is a serious disease of the lungs. Another common disease caused by bacteria is strep throat. You may have had strep throat yourself. Bacteria that cause strep throat are shown below (**Figure** 1.104). Some types of pneumonia and many cases of illnesses from food are also caused by bacteria.

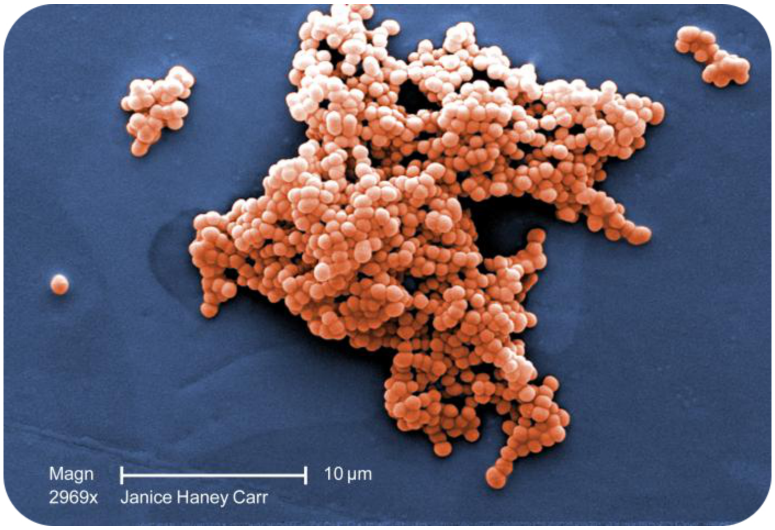



FIGURE 1.104
The structures that look like strings of beads are bacteria. They belong to the genus *Streptococcus*. Bacteria of this genus cause diseases such as strep throat and pneumonia. They are shown here 900 times bigger than their actual size.

Fungi are simple organisms that consist of one or more cells. They include mushrooms and yeasts. Human diseases caused by fungi include ringworm and athlete's foot. Both are skin diseases that are not usually serious. A ringworm infection is pictured below (**Figure** 1.105). A more serious fungus disease is histoplasmosis. It is a lung infection.

FIGURE 1.105
Ringworm isn't a worm at all. It's a disease caused by a fungus. The fungus causes a ring-shaped rash on the skin, like the one shown here.

Protozoa are one-celled organisms with a nucleus. They cause diseases such as malaria. Malaria is a serious disease that is common in warm climates. The protozoa infect people when they are bit by a mosquito. More than a million people die of malaria each year. Other protozoa cause diarrhea. An example is *Giardia lamblia* (**Figure** 1.106).

Viruses are nonliving collections of protein and DNA that must reproduce inside of living cells. Viruses cause many common diseases. For example, viruses cause colds and the flu. Cold sores are caused by the virus *Herpes simplex* (**Figure** 1.107). Antibiotics do not affect viruses, because antibiotics only kill bacteria. But medicines called antiviral drugs can treat many diseases caused by viruses.

### How Pathogens Spread

Different pathogens spread in different ways. Some pathogens spread through food. They cause food borne illnesses, which are discussed in a previous lesson. Some pathogens spread through water. *Giardia lamblia* is one example. Water can be boiled to kill *Giardia* and most other pathogens.

FIGURE 1.106
This picture shows a one-celled organism called *Giardia lamblia*. It is a protozoan that causes diarrhea.

FIGURE 1.107
The *Herpes simplex* virus, which is shown here, causes cold sores on the lips. Viruses are extremely small particles. This illustration is greatly magnified.

Several pathogens spread through sexual contact. HIV is one example, which is discussed in the next lesson. Other pathogens that spread through sexual contact are discussed in a separate lesson.

Many pathogens that cause respiratory diseases spread by droplets in the air. Droplets are released when a person sneezes or coughs. Thousands of tiny droplets are released when a person sneezes (**Figure** 1.108). Each droplet can contain thousands of pathogens. Viruses that cause colds and the flu can spread in this way. You may get sick if you breathe in the pathogens.

FIGURE 1.108
As this picture shows, thousands of tiny droplets are released into the air when a person sneezes. Each droplet may carry thousands of pathogens. You can't normally see the droplets from a sneeze because they are so small. However, you can breathe them in, along with any pathogens they carry. This is how many diseases of the respiratory system are spread.

### Pathogens on Surfaces

Other pathogens spread when they get on objects or surfaces. A fungus may spread in this way. For example, you can pick up the fungus that causes athlete's foot by wearing shoes that an infected person has worn. You can also pick up this fungus from the floor of a public shower. After acne, athlete's foot is the most common skin disease in the United States. Therefore, the chance of coming in contact with the fungus in one of these ways is fairly high.

Bacteria that cause the skin disease impetigo can spread when people share towels or clothes. The bacteria can also spread through direct skin contact in sports like wrestling.

### Pathogens and Vectors

Still other pathogens are spread by **vectors**. A vector is an organism that carries pathogens from one person or animal to another. Most vectors are insects, such as ticks and mosquitoes. When an insect bites an infected person or animal, it picks up the pathogen. Then the pathogen travels to the next person or animal it bites. Ticks carry the bacteria that cause Lyme disease. Mosquitoes (**Figure** 1.109) carry West Nile virus. Both pathogens cause fever, headache, and tiredness. If the diseases are not treated, more serious symptoms may develop.

The first case of West Nile virus in North America occurred in 1999. Within just a few years, the virus had spread throughout most of the United States. Birds as well as humans can be infected with the virus. Birds often fly long distances. This is one reason why West Nile virus spread so quickly.

### Vocabulary

- **infectious disease**: Disease that spreads from person to person.
- **pathogen**: Living thing or virus that causes disease.
- **vector**: Organism that carries pathogens from one person or animal to another.

### Summary

- Infectious diseases are caused by bacteria, fungi, protozoa, or viruses that can travel from one person to another.

FIGURE 1.109
Some diseases are spread by insects. The type of mosquito shown here can spread West Nile virus. The virus doesn't make the mosquito sick. The mosquito just carries the virus from one person or animal to another. The mosquito is a vector.

- Infectious diseases can be spread by a vector, an organism that carries pathogens from one person or animal to another.

## Practice

Use the resource below to answer the questions that follow.

- **Infectious Disease** at http://www.youtube.com/watch?v=oUMCKai3xp4 (5:00)

MEDIA
Click image to the left for more content.

1. What is *Yersinia pestis*? What disease does it cause?
2. What did Louis Pasteur discover about microorganisms? How was this discovery related to disease?
3. What do pathogens have in common?
4. What are ectoparasites? Where do they live? How do they differ from endoparasites?
5. What group of fungi cause many diseases?

## Review

1. What is a pathogen?
2. Explain why using insect repellent reduces your risk of developing Lyme disease.

# 1.54 HIV and AIDS

- Explain how the virus known as HIV causes AIDS.

**What does a red ribbon symbolize?**

This red ribbon is a symbol for support of HIV-positive people and those living with AIDS. As of 2010, an estimated 34 million people are living with HIV worldwide.

## HIV Infection and AIDS

**HIV**, or human immunodeficiency virus, causes AIDS. **AIDS** stands for "acquired immune deficiency syndrome." It is a condition that causes death and does not have a known cure. AIDS usually develops 10 to 15 years after a person is first infected with HIV. The development of AIDS can be delayed with proper medicines.

### How HIV Spreads

HIV spreads through contact between an infected person's body fluids and another person's bloodstream or mucus membranes, which are found in the mouth, nose, and genital areas. Body fluids that may contain HIV are blood, semen, vaginal fluid, and breast milk. The virus can spread through sexual contact or shared drug needles. It can also spread from an infected mother to her baby during childbirth or breastfeeding.

Some people think they can become infected with HIV by donating blood or receiving donated blood. This is not true. The needles used to draw blood for donations are always new. Therefore, they cannot spread the virus. Donated blood is also tested to make sure it is does not contain HIV.

### HIV and the Immune System

How does an HIV infection develop into AIDS? HIV destroys white blood cells called **helper T cells**. The cells are produced by the immune system. This is the body system that fights infections and other diseases.

HIV invades helper T cells and uses them to produce more virus particles (**Figure** 1.110). Then, the virus kills the helper T cells. As the number of viruses in the blood rises, the number of helper T cells falls. Without helper T cells, the immune system is unable to protect the body. The infected person cannot fight infections and other diseases because they do not have T cells. This is why people do not die from HIV. Instead, they die from another illness, like the common cold, that they cannot fight because they do not have helper T cells.

Medications can slow down the increase of viruses in the blood. But the medications cannot remove the viruses from the body. At present, there is no cure for HIV infection.

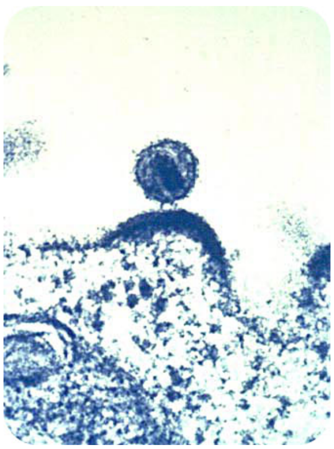


FIGURE 1.110
In this picture, the large structure on the bottom is a human immune cell. It is infected with HIV. A new HIV particle is shown budding out of the immune cell.

### AIDS

AIDS is not really a single disease. It is a set of symptoms and other diseases. It results from years of damage to the immune system by HIV. AIDS occurs when helper T cells fall to a very low level, and the person develops infections or cancers that people with a healthy immune system can easily resist. These diseases are usually the cause of death of people with AIDS.

The first known cases of AIDS occurred in 1981. Since then, AIDS has led to the deaths of more than 25 million people worldwide. Many of them were children. The greatest number of deaths occurred in Africa. It is also where medications to control HIV are least available. There are currently more people infected with HIV in Africa than any other part of the world.

### Vocabulary

- **AIDS**: Acquired immune deficiency syndrome; disease of the immune system characterized by increased susceptibility to secondary infections.
- **helper T cell**: White blood cell that helps fight infections.
- **HIV**: Human immunodeficiency virus; virus that causes AIDS.

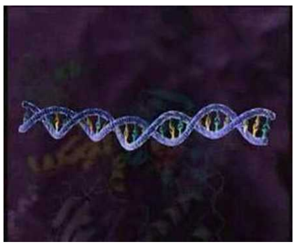
## Summary

- HIV causes AIDS by destroying disease-fighting cells produced by the immune system.
- HIV spreads through contact between an infected person's body fluids and another person's bloodstream or mucus membranes; body fluids that may contain HIV include blood, semen, vaginal fluid, and breast milk.

## Practice

Use the resources below to answer the questions that follow.

- **HIV Replication** at http://www.youtube.com/watch?v=RO8MP3wMvqg (5:13)



MEDIA

Click image to the left for more content.

1. What are the steps of HIV infection?
2. How can understanding all the steps of infection help develop treatments to HIV?
3. What does HIV inject into a cell?

- **HIV Immunity** at http://www.pbs.org/wgbh/evolution/library/10/4/quicktime/l_104_06.html

1. Not all people show the same vulnerability to HIV infection. What did scientists do when they first found indications that this was the case?
2. How can studying people with natural resistance to HIV help develop treatments?

## Review

1. How does an HIV infection develop into AIDS?
2. Explain why HIV does not kill people but causes other illnesses to kill people infected with HIV.

# 1.55 Preventing Infectious Diseases

- State how infectious diseases can be prevented.

**What is this girl doing to prevent the spread of the flu?**

Notice how this girl is covering her nose and mouth with a tissue as she sneezes. This is a good habit that helps prevent her from passing on the flu virus to other people. Notice she is also staying home and resting instead of going out and possibly infecting others with her illness.

## Preventing Infectious Diseases

**Infectious diseases** are diseases that spread from person to person. What can you do to avoid infectious diseases? Eating right and getting plenty of sleep are a good start. These habits will help keep your immune system healthy. With a healthy immune system, you will be able to fight off many pathogens.

You can also take steps to avoid pathogens in the first place. The best way to avoid pathogens is to wash your hands often. You should wash your hands after using the bathroom or handling raw meat or fish. You should also wash your hands before eating or preparing food. In addition, you should wash your hands after being around sick people. The correct way to wash your hands is demonstrated below (**Figure** 1.111). If soap and water aren't available, use a hand sanitizer.

The best way to prevent diseases spread by vectors is to avoid contact with the vectors. For example, you can wear long sleeves and long pants to avoid tick and mosquito bites. Using insect repellent can also reduce your risk of insect bites.


FIGURE 1.111
This picture shows the proper way to wash your hands. Frequent hand washing helps prevent the spread of pathogens.

Many infectious diseases can be prevented with vaccinations. You will read more about vaccinations in another lesson. Vaccinations can help prevent measles, mumps, chicken pox, and several other diseases.

If you do develop an infectious disease, try to avoid infecting others. Stay home from school until you are well. Also, take steps to keep your germs to yourself. Cover your mouth and nose with a tissue when you sneeze or cough, and wash your hands often to avoid spreading pathogens to other people.

## Vocabulary

- **infectious disease**: Disease that spreads from person to person.

## Summary

- A healthy lifestyle and frequent hand washing can help reduce your risk of infectious diseases.
- To avoid infecting others when you are sick, stay home from school, cover your mouth and nose with a tissue when you sneeze or cough, and wash your hands often.

## Practice

Use the resources below to answer the questions that follow.

- **Preventing the Spread of Disease** at http://www.youtube.com/watch?v=uIATPuz12nc (10:49)

MEDIA
Click image to the left for more content.

1. What is a communicable disease?
2. What are some pathways by which germs can pass from one person to another person?

- **Diesease Prevention: It's In Your Hands** at http://www.youtube.com/watch?v=s0zCzuKiYu4 (2:32)

MEDIA
Click image to the left for more content.

1. Why is hand washing effective in preventing the spread of some diseases?
2. How long should you wash your hands to help prevent the spread of disease?

### Review

1. What is the single most important way to avoid pathogens?
2. How can you avoid infecting others when you are sick?

# 1.56 Cancer

- Describe causes and treatments of cancer.

**Why is tanning bad for your health?**

It might be fun to lay out in the sun like these two girls are doing. But getting too much sun can be very dangerous. Overexposure to sunlight raises your risk for skin cancer.

## Cancer

**Cancer** is a disease that causes cells to divide out of control. Normally, the body has systems that prevent cells from dividing out of control. But in the case of cancer, these systems fail.

Cancer is usually caused by mutations. **Mutations** are random errors in genes. Mutations that lead to cancer usually happen to genes that control the cell cycle. Because of the mutations, abnormal cells divide uncontrollably. This often leads to the development of a tumor. A **tumor** is a mass of abnormal tissue. As a tumor grows, it may harm normal tissues around it.

Anything that can cause cancer is called a **carcinogen**. Carcinogens may be pathogens, chemicals, or radiation.

### Pathogens

Pathogens that cause cancer include the human papilloma virus (HPV) (**Figure** 1.112) and the hepatitis B virus. HPV is spread through sexual contact. It can cause cancer of the reproductive system in females. The hepatitis B virus is spread through sexual contact or contact with blood containing the virus. It can cause cancer of the liver.

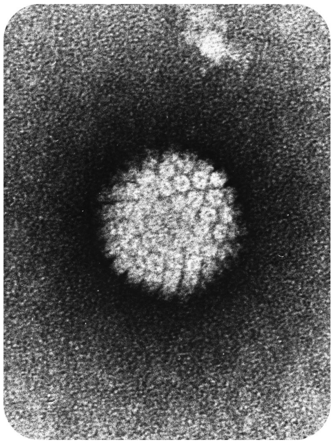


FIGURE 1.112
The mutations that cause cancer may occur when people are exposed to pathogens, such as the human papilloma virus (HPV), which is shown here.

### Chemicals

Many different chemical substances cause cancer. Dozens of chemicals in tobacco smoke, including nicotine, have been shown to cause cancer (**Figure** 1.113). In fact, tobacco smoke is one of the main sources of chemical carcinogens. Smoking tobacco increases the risk of cancer of the lung, mouth, throat, and bladder. Using smokeless tobacco can also cause cancer.

### Radiation

Forms of radiation that cause cancer include ultraviolet (UV) radiation and radon (**Figure** 1.114). **UV radiation** is part of sunlight. It is the leading cause of skin cancer. **Radon** is a natural radioactive gas that seeps into buildings from the ground. It can cause lung cancer.

### Common Types of Cancer

Cancer is usually found in adults, especially in adults over the age of 50. The most common type of cancer in adult males is cancer of the prostate gland. The prostate gland is part of the male reproductive system. Prostate cancer makes up about one third of all cancers in men. The most common type of cancer in adult females is breast cancer. It makes up about one third of all cancers in women. In both men and women, lung cancer is the second most common type of cancer. Most cases of lung cancer happen in people who smoke.

Cancer can also be found in children. But childhood cancer is rare. Leukemia is the main type of cancer in children. It makes up about one third of all childhood cancers. It happens when the body makes abnormal white blood cells.

Sometimes cancer cells break away from a tumor. If they enter the bloodstream, they are carried throughout the body. Then, the cells may start growing in other tissues. This is usually how cancer spreads from one part of the body to another. Once this happens, cancer is very hard to stop or control.

### Treating Cancer

If leukemia is treated early, it usually can be cured. In fact, many cancers can be cured if treated early. Treatment of cancer often involves removing a tumor with surgery. This may be followed by other types of treatments. These treatments may include drugs and radiation, which kill cancer cells.

The sooner cancer is treated, the greater the chances of a cure. This is why it is important to know the warning signs


FIGURE 1.113
The mutations that cause cancer may occur when people are exposed to chemical carcinogens, such as those in cigarettes.

of cancer. Having warning signs does not mean that you have cancer. However, you should see a doctor to be sure. Everyone should know the warning signs of cancer. Detecting and treating cancer early can often lead to a cure. Some warning signs of cancer include:

- Change in bowel or bladder habits.
- Sores that do not heal.
- Unusual bleeding or discharge.
- Lump in the breast or elsewhere.
- Chronic indigestion.
- Difficulty swallowing.
- Obvious changes in a wart or mole.
- Persistent cough or hoarseness.

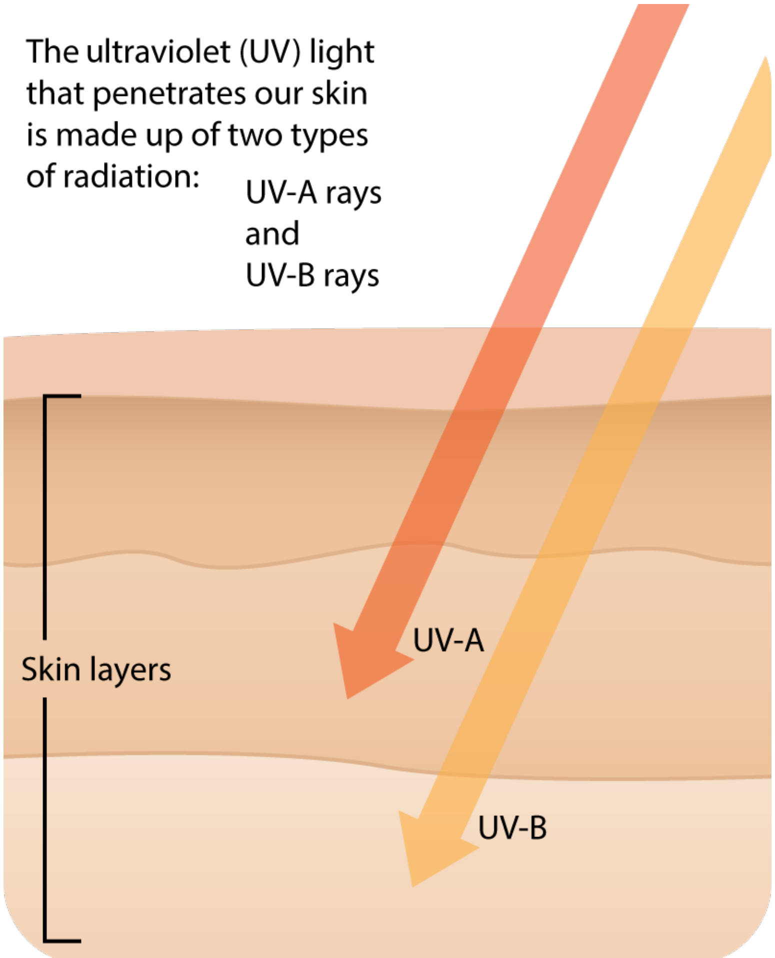



FIGURE 1.114
The mutations that cause cancer may occur when people are exposed to radiation, including the radiation from sunlight.

## Vocabulary

- **cancer**: Disease that causes cells to divide out of control.
- **carcinogen**: Substance that can cause cancer.
- **mutations**: Random errors in genes.
- **radon**: Natural radioactive gas that seeps into buildings from the ground and can cause cancer.
- **tumor**: Abnormal mass of tissue.
- **UV radiation**: Invisible radiation that is a part of sunlight.

## Summary

- Cancer is caused by mutations, which can be caused by pathogens, chemicals, or radiation.
- Cancer can be treated with surgery, drugs, and radiation.

## Practice

Use the resources below to answer the questions that follow.

- **How Cancer Cells Grow and Divide** at http://www.teachersdomain.org/asset/tdc02_vid_oncogene/

1. What is an oncogene?
2. How do receptors made by oncogenes differ from "normal" receptor cells?
3. How does cancer spread through the blood stream?

- **How Cancer Grows** at http://www.teachersdomain.org/asset/tdc02_int_howcancergrw/

1. How are genetic mutations thought to affect the formation of cancer? What are possible sources of these mutations?
2. Cancer cells continuously divide. How does this affect the mutation rates of the cells?
3. What is angiogenesis? How does this help cancer spread?

## Review

1. Define carcinogen and give three examples.
2. Explain how mutations can lead to cancer.

# 1.57 Diabetes

- Explain why diabetes occurs.

**What do these foods have in common?**

These foods are all high in sugar. A person with diabetes has to avoid these types of foods.

## Diabetes

**Diabetes** is a non-infectious disease in which the body is unable to control the amount of sugar in the blood. People with diabetes have high blood sugar, either because their bodies do not produce enough insulin, or because their cells do not respond to insulin. **Insulin** is a hormone that helps cells take up sugar from the blood. Without enough insulin, the blood contains too much sugar. This can damage blood vessels and other cells throughout the body. The kidneys work hard to filter out and remove some of the extra sugar. This leads to frequent urination and excessive thirst.

There are two main types of diabetes, type 1 diabetes and type 2 diabetes. Type 1 diabetes makes up about 5-10% of all cases of diabetes in the United States. Type 2 diabetes accounts for most of the other cases. Both types of diabetes are more likely in people that have certain genes. Having a family member with diabetes increases the risk of developing the disease.

Either type of diabetes can increase the chances of having other health problems. For example, people with diabetes are more likely to develop heart disease and kidney disease. Type 1 and type 2 diabetes are similar in these ways. However, the two types of diabetes have different causes.

### Type 1 Diabetes

**Type 1 diabetes** occurs when the immune system attacks normal cells of the pancreas. Since the cells in the pancreas are damaged, the pancreas cannot make insulin. Type 1 diabetes usually develops in childhood or adolescence.

People with type 1 diabetes must frequently check the sugar in their blood. They use a meter to monitor their blood sugar (**Figure** 1.115). Whenever their blood sugar starts to get too high, they need a shot of insulin. The insulin brings their blood sugar back to normal. There is no cure for type 1 diabetes. Therefore, insulin shots must be taken for life. Most people with this type of diabetes learn how to give themselves insulin shots.


FIGURE 1.115
This is one type of meter used by people with diabetes to measure their blood sugar. Modern meters like this one need only a drop of blood and take less than a minute to use.

### Type 2 Diabetes

**Type 2 diabetes** occurs when body cells are no longer sensitive to insulin. The pancreas may still make insulin, but the cells of the body cannot use it. Being overweight and having high blood pressure increase the chances of developing type 2 diabetes. Type 2 diabetes usually develops in adulthood, but it is becoming more common in teens and children. This is because more young people are overweight now than ever before.

Some cases of type 2 diabetes can be cured with weight loss. However, most people with the disease need to take medicine to control their blood sugar. Regular exercise and balanced eating also help. Like people with type 1 diabetes, people with type 2 diabetes must frequently check their blood sugar.

## Vocabulary

- **diabetes**: Disease in which, either the body does not produce enough insulin, or the cells in the body do not respond to insulin; it causes high blood sugar.
- **insulin**: Hormone that helps cells take up sugar from the blood.
- **Type 1 diabetes**: Disease in which the immune system attacks normal cells of the pancreas, preventing the production of insulin.
- **Type 2 diabetes**: Disease in which the body cells are no longer sensitive to insulin.

## Summary

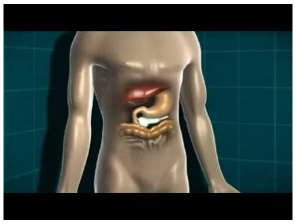
- In type 1 diabetes, the pancreas cannot make enough insulin, the hormone that helps take up sugar from the blood.

- In type 2 diabetes, the body cells cannot use insulin properly.

## Practice

Use the resource below to answer the questions that follow.

- **Diabetes and the Body** at http://www.youtube.com/watch?v=jHRfDTqPzj4 (8:42)



MEDIA

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1. How does a "normal" body respond when it senses that glucose levels in the blood stream are increasing?
2. How does insulin affect blood glucose levels? What mechanism does it act by?
3. What causes type 1 diabetes? How does this affect the body? Why do people with type 1 diabetes urinate a lot?
4. What causes type 2 diabetes? What can prevent glucose entering the cells in type 2 diabetes?
5. How can the liver make the situation worse with type 2 diabetes? Why does the liver respond this way?
6. Which type of diabetes is most likely to be influenced by dietary changes? Explain your reasoning fully.

## Review

1. What can increase your risk of developing type 2 diabetes?
2. Compare and contrast type 1 and type 2 diabetes.

# 1.58 Autoimmune Diseases

- Describe autoimmune diseases and allergies.

**Does pollen make you sneeze?**

If so, you are not alone. It is one of the most common allergies. The runny nose and sneezing associated with allergies results from the immune system working improperly.

## Diseases of the Immune System

The immune system usually protects you from pathogens and other causes of disease. When the immune system is working properly, it keeps you from getting sick. But the immune system is like any other system of the body. It can break down or develop diseases.

AIDS is an infectious disease of the immune system caused by a virus. Some diseases of the immune system are noninfectious. They include autoimmune diseases and allergies.

### Autoimmune Diseases

Does it make sense for an immune system to attack the cells it is meant to protect? No, but an immune system that does not function properly will attack its own cells. An **autoimmune disease** is a disease in which the immune system attacks the body's own cells.

One example is **type 1 diabetes**. In this disease, the immune system attacks cells of the pancreas. Other examples are multiple sclerosis and rheumatoid arthritis. In **multiple sclerosis**, the immune system attacks nerve cells. This causes weakness and pain. In **rheumatoid arthritis**, the immune system attacks the cells of joints. This causes joint damage and pain. These diseases cannot be cured. But they can be helped with medicines that weaken the immune system's attack on normal cells.

### Allergies

An **allergy** occurs when the immune system attacks a harmless substance that enters the body from the outside. A substance that causes an allergy is called an allergen. It is the immune system, not the allergen, that causes the symptoms of an allergy.

Did you ever hear of hay fever? It's not really a fever at all. It's an allergy to plant pollens. People with this type of allergy have symptoms such as watery eyes, sneezing, and a runny nose. A common cause of hay fever is the pollen of ragweed (**Figure** 1.116).

FIGURE 1.116
Ragweed is a common roadside weed found throughout the United States. Many people are allergic to its pollen.

Many people are allergic to poison ivy (**Figure** 1.117). Skin contact with poison ivy leads to an itchy rash in people who are allergic to the plant.

As you have read, some people are allergic to certain foods. Nuts and shellfish are common causes of food allergies. Other common causes of allergies include:

- Drugs such as penicillin.

FIGURE 1.117
Poison ivy plants are wild vines with leaves in groups of three. They grow in wooded areas in most of the United States. Contact with poison ivy may cause a rash in a person allergic to the plant.

- Mold.
- Dust.
- The dead skin cells of dogs and cats, called dander.
- Stings of wasps and bees.

Most allergies can be treated with medicines. Medicines used to treat allergies include antihistamines and corticosteroids. These medicines help control the immune system when it attacks an allergen.

Sometimes, allergies cause severe symptoms. For example, they may cause the throat to swell so it is hard to breathe. Severe allergies may be life threatening. They require emergency medical care.

## Vocabulary

- **allergy**: Over-sensitivity of the immune system when it attacks a harmless substance.
- **autoimmune disease**: Disease in which the immune system attacks the body's own cells.
- **multiple sclerosis**: Disease in which the immune system attacks nerve cells, resulting in weakness and pain.
- **rheumatoid arthritis**: Disease in which the immune system attacks the cells of joints, causing joint damage and pain.
- **type 1 diabetes**: Disease in which the immune system attacks normal cells of the pancreas, preventing the production of insulin.

## Summary

- Autoimmune diseases occur when the immune system attacks normal body cells.
- Allergies occur when the immune system attacks harmless substances that enter the body from the outside.

## Practice

Use the resources below to answer the questions that follow.

- **Malfunction of the Immune System** at http://www.youtube.com/watch?v=YO_ph9wvFkI (2:06)

MEDIA
Click image to the left for more content.

1. How does your immune system respond when you have allergies?
2. What happens when a person has Rheumatoid Arthritis? What sort of disease is this?

- **Disorders of the Human Immune System** at http://www.youtube.com/watch?v=eixF85cv71E (5:35)


MEDIA
Click image to the left for more content.

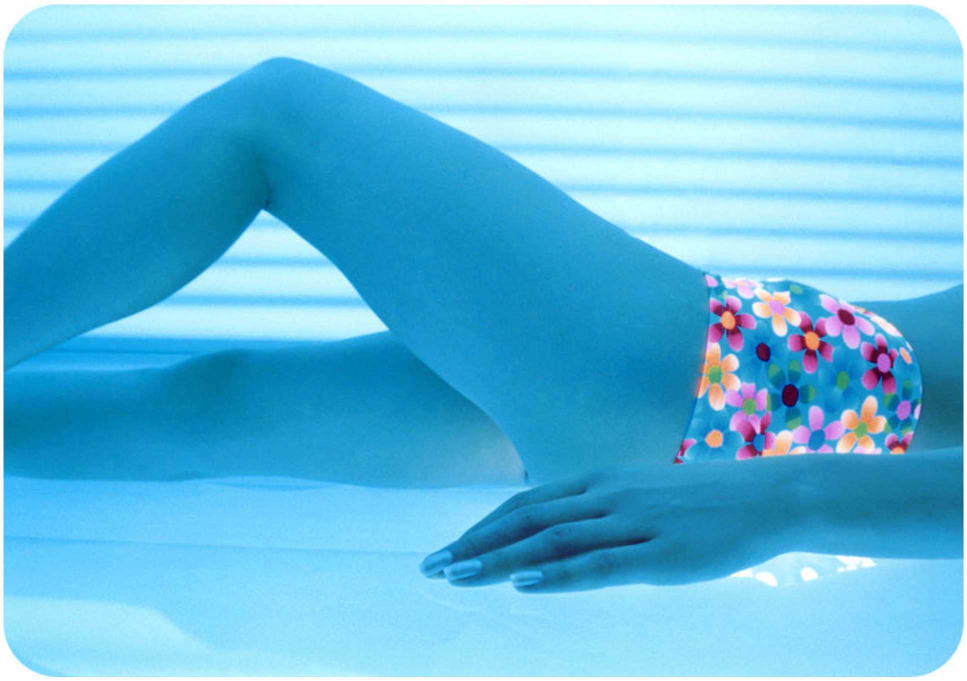
1. How does your immune system typically work?
2. What role does inflammation play in the immune system. Is inflammation a good thing? Why or why not?
3. What are the three types of immune system disorders? How do these types differ?
4. What is hypersensitivity? What is type 1 hypersensitivity more commonly know as?
5. How do the different types of hypersensitivity differ from each other?

## Review

1. What causes rheumatoid arthritis?
2. What causes an allergy?

# 1.59 Preventing Noninfectious Diseases

- Describe how noninfectious diseases can be prevented.



**How can you reduce your risk of developing cancer?**

You can reduce your risk of developing cancer by staying away from certain hazards. For example, the use of tanning beds can lead to skin cancer.

## Preventing Noninfectious Diseases

Most allergies can be prevented by avoiding the substances that cause them. For example, you can avoid pollens by staying indoors as much as possible. You can learn to recognize plants like poison ivy and not touch them. A good way to remember how to avoid poison ivy is "leaves of three, let it be."

Some people receive allergy shots to help prevent allergic reactions. The shots contain tiny amounts of allergens. After many months or years of shots, the immune system gets used to the allergens and no longer responds to them.

Type 1 diabetes and other autoimmune diseases cannot be prevented. But choosing a healthy lifestyle can help prevent type 2 diabetes. Getting plenty of exercise, avoiding high-fat foods, and staying at a healthy weight can reduce the risk of developing this type of diabetes. This is especially important for people who have family members with the disease.

Making these healthy lifestyle choices can also help prevent some types of cancer. In addition, you can lower the risk of cancer by avoiding **carcinogens**, substances that cause cancer. For example, you can reduce your risk of lung cancer by not smoking. You can reduce your risk of skin cancer by using sunscreen. How to choose a sunscreen that offers the most protection is explained below (**Figure** 1.118). Some people think that tanning beds are a safe way to get a tan. This is a myth. Tanning beds expose the skin to UV radiation. Any exposure to UV radiation increases the risk of skin cancer. It doesn't matter whether the radiation comes from tanning lamps or the sun.


FIGURE 1.118
When you choose a sunscreen, select one with an SPF of 30 or higher. Also, choose a sunscreen that protects against both UVB and UVA radiation.

## Vocabulary

- **carcinogen**: Substance that can cause cancer.

## Summary

- A healthy lifestyle can help reduce your risk of developing many noninfectious diseases.
- You can lower your risk of cancer by avoiding habits that expose you to carcinogens, such as smoking and tanning beds.

## Practice

Use the resource below to answer the questions that follow.

- **Individualized Medicine** at http://www.youtube.com/watch?v=26bOFrcRKzE (3:18)

MEDIA
Click image to the left for more content.

1. How does knowledge of a patient's genome help doctors treat patients? Be sure to consider all the ways this information can be used?
2. Why is individualizing medicine particularly important with noninfectious diseases?
3. Do you think knowing your grandparents' genome could be beneficial to your health? Why or why not?

## Review

1. How can you reduce your risk of developing type 2 diabetes?
2. How can you reduce your risk of developing skin cancer?

# 1.60 Barriers to Pathogens

- Describe your body's first line of defense against pathogens.

**What is your nose good for?**

Your nose does a lot of work for you! Obviously, it helps you breathe and provides your sense of smell. But you might not realize that your nose also helps to fight off disease.

## The Immune System's First Line of Defense

Your body has many ways to protect you from pathogens. Your body's defenses are like a castle. The outside of a castle was protected by a moat and high walls. Inside the castle, soldiers were ready to fight off any enemies that made it across the moat and over the walls. Like a castle, your body has a series of defenses. Only pathogens that get through all the defenses can harm you.

Your body's first line of defense is like a castle's moat and walls. It keeps most pathogens out of your body. The first line of defense includes different types of barriers.

### Skin and Mucous Membranes

The skin is a very important barrier to pathogens. The skin is the body's largest organ. In adults, it covers an area of about 16-22 square feet!

The skin is also the body's most important defense against disease. It forms a physical barrier between the body and the outside world. The skin has several layers (**Figure** 1.119). The outer layer is tough and waterproof. It is very difficult for pathogens to get through this layer of skin.

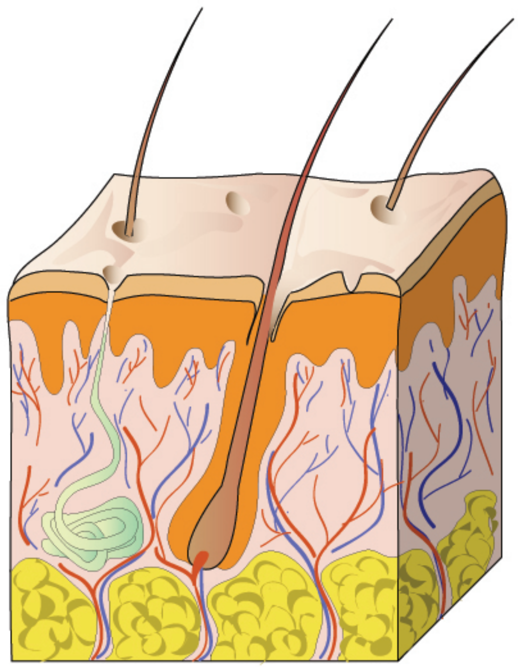


FIGURE 1.119
This drawing shows that the skin has many layers. The outer layer is so tough that it keeps out most pathogens.

The mouth and nose are not lined with skin. Instead, they are lined with **mucous membranes**. Other organs that are exposed to the outside world, including the lungs and stomach, are also lined with mucous membranes. Mucous membranes are not tough like skin, but they have other defenses.

One defense of mucous membranes is the mucus they release. **Mucus** is a sticky, moist substance that covers mucous membranes. Most pathogens get stuck in the mucus before they can do harm to the body. Many mucous membranes also have cilia. Cilia in the lungs are pictured below (**Figure** 1.120). **Cilia** are tiny finger-like projections. They move in waves and sweep mucus and trapped pathogens toward body openings. When you clear your throat or blow your nose, you remove mucus and pathogens from your body.

#### Chemicals

Most body fluids that you release from your body contain chemicals that kill pathogens. For example, mucus, sweat, tears, and saliva contain enzymes that kill pathogens. These enzymes can break down the cell walls of bacteria to kill them.

The stomach also releases a very strong acid, called hydrochloric acid. This acid kills most pathogens that enter the stomach in food or water. Urine is also acidic, so few pathogens can grow in it.

#### Helpful Bacteria

You are not aware of them, but your skin is covered by millions (or more!) of bacteria. Millions more live inside your body. Most of these bacteria help defend your body from pathogens. How do they do it? They compete with harmful bacteria for food and space. This prevents the harmful bacteria from multiplying and making you sick.

FIGURE 1.120
This is what the cilia lining the lungs look like when they are magnified. Their movements constantly sweep mucus and pathogens out of the lungs. Do they remind you of brushes?

### Vocabulary

- **cilia**: Tiny finger-like projections; in the mucous membranes they move in waves and sweep mucus and trapped pathogens toward body openings.
- **mucous membrane**: Lining of inner body surfaces and body openings that produces mucus.
- **mucus**: Sticky, moist substance that traps pathogens and debris.

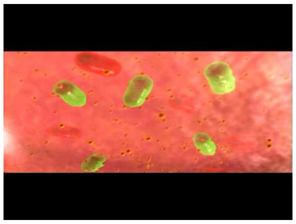
### Summary

- Your body's first line of defense includes the skin and other barriers that keep pathogens out of your body.
- Most body fluids that you release from your body contain chemicals that kill pathogens.

### Practice

Use the resource below to answer the questions that follow.

- **Introduction To How The Immune System Works** at http://www.youtube.com/watch?v=IWMJIMzsEMg (3:16)



MEDIA

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1. How do external barriers help our immune system? What problems would we have if we did not have these barriers?
2. Where is mucus used as a barrier?
3. How do some bacteria aid our immune system?

## Review

1. How does your skin protect you from pathogens?
2. How do helpful bacteria defend your body?

# 1.61 Inflammatory Response

- Explain how inflammation helps protect you from pathogens.

**Have you ever sprained your ankle?**

Did you notice redness and swelling near the injury? These symptoms indicate that your body is attempting to fight off infection.

## The Immune System's Second Line of Defense

The little girl pictured below (**Figure** 1.121) has a scraped knee. A scrape is a break in the skin that may let pathogens enter the body. If bacteria enter through the scrape, they could cause an infection. These bacteria would then face the body's second line of defense.

### Inflammation

If bacteria enter the skin through a scrape, the area may become red, warm, and painful. These are signs of inflammation. **Inflammation** is one way the body reacts to infections or injuries. Inflammation is caused by chemicals that are released when skin or other tissues are damaged. The chemicals cause nearby blood vessels to dilate, or expand. This increases blood flow to the damaged area. The chemicals also attract white blood cells to the wound and cause them to leak out of blood vessels into the damaged tissue.

### White Blood Cells

What do these white blood cells do at the site of inflammation? The main role of white blood cells is to fight pathogens in the body. There are actually several different kinds of white blood cells. Some white blood cells have very specific functions. They attack only certain pathogens.

FIGURE 1.121
This little girl just got her first scraped knee. It doesn't seem to hurt, but the break in her skin could let pathogens enter her body. That's why scrapes should be kept clean and protected until they heal.

Other white blood cells attack any pathogens they find. These white blood cells travel to areas of the body that are inflamed. They are called **phagocytes**, which means "eating cells." In addition to pathogens, phagocytes "eat" dead cells. They surround the pathogens and destroy them. This process is called **phagocytosis**.

White blood cells also make chemicals that cause a fever. A **fever** is a higher-than-normal body temperature. Normal human body temperature is 98.6°F (37°C). Most bacteria and viruses that infect people reproduce fastest at this temperature.

When the temperature is higher, the pathogens cannot reproduce as fast, so the body raises the temperature to kill them. A fever also causes the immune system to make more white blood cells. In these ways, a fever helps the body fight infection.

### Vocabulary

- **fever**: Higher-than-normal body temperature in response to infection.
- **inflammation**: Response of the body to injury or infection that brings on redness, swelling, and pain.

- **phagocyte**: Type of white blood cell that ingests and destroys pathogens and dead cells.
- **phagocytosis**: Engulfing of a large particle, such as a pathogen, by the cell.

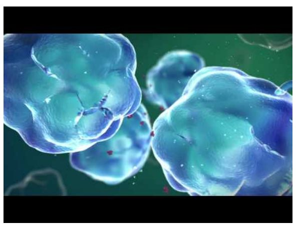
## Summary

- If pathogens enter your body, inflammation occurs.
- White blood cells called phagocytes travel to areas of the body that are inflamed.

## Practice

Use the resource below to answer the questions that follow.

- **Our Immune System** at http://www.youtube.com/watch?v=MI-BLaj5nFk (4:53)



MEDIA
Click image to the left for more content.

1. What is a macrophage? What does it do when it recognizes a "non-self" substance?
2. What are cytokines? What message do they send to the rest of the body's cells?
3. How do macrophages interact with T-cells? Where does this interaction occur?

## Review

1. Describe inflammation.
2. A fever is a sign of infection. Why might it be considered a good sign?

# 1.62 Lymphatic System

- Describe the role of the lymphatic system in the immune response.

**Do you still have your tonsils?**

Many people have their tonsils removed because they can hold on to germs that cause throat infections. Although sometimes they can do more harm than good, tonsils are there to help you. They trap pathogens so that they can be destroyed before they enter farther into your body.

## The Lymphatic System and the Immune Response

If pathogens get through the body's first two lines of defense, a third line of defense takes over. This third line of defense involves the immune system. It is called an **immune response**. The immune system has a special response for each type of pathogen.

The **immune system** (**Figure** 1.122) is also part of the lymphatic system—named for **lymphocytes**, which are the type of white blood cells involved in an immune response. They include several lymph organs, lymph vessels, lymph, and lymph nodes.

### Lymph Organs

The lymph organs are the red **bone marrow**, **tonsils**, **spleen**, and **thymus gland**. They are described below (**Figure** 1.123).

### Lymph and Lymph Vessels

Lymph vessels make up a circulatory system that is similar to the cardiovascular system, which you can read about in a previous lesson. Lymph vessels are like blood vessels, except they move lymph instead of blood.

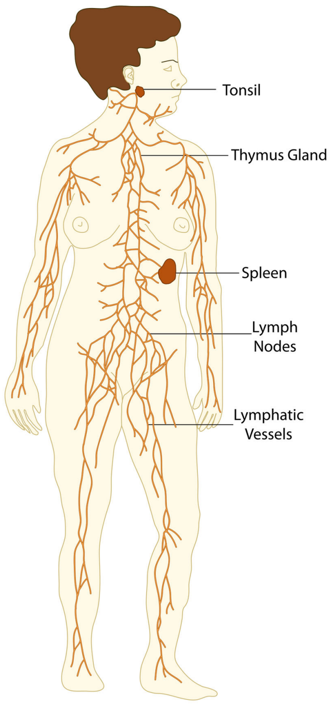



FIGURE 1.122
This diagram shows the parts of the immune system. The immune system includes several organs and a system of vessels that carry lymph. Lymph nodes are located along the lymph vessels.

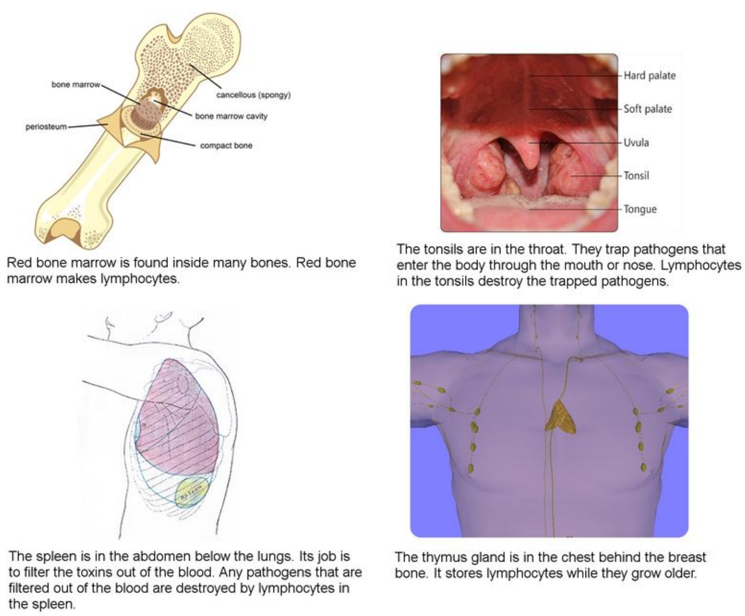



FIGURE 1.123
Each lymph organ has a different job in the immune system.

**Lymph** is a yellowish liquid that leaks out of tiny blood vessels into spaces between cells in tissues. Where there is more inflammation, there is usually more lymph in tissues. This lymph may contain many pathogens.

The lymph that collects in tissues slowly passes into tiny lymph vessels. It then travels from smaller to larger lymph vessels. Lymph is not pumped through lymph vessels like blood is pumped through blood vessels by the heart. Instead, muscles around the lymph vessels contract and squeeze the lymph through the vessels. The lymph vessels also contract to help move the lymph along. The lymph finally reaches the main lymph vessels in the chest. Here, the lymph drains into two large veins. This is how the lymph returns to the bloodstream.

Before lymph reaches the bloodstream, pathogens are removed from it at lymph nodes. **Lymph nodes** are small, oval structures located along the lymph vessels. They act like filters. Any pathogens filtered out of the lymph at lymph nodes are destroyed by lymphocytes in the nodes.

### Lymphocytes

Lymphocytes (**Figure** 1.124), a type of white blood cell, are the key cells of an immune response. There are trillions of lymphocytes in the human body. They make up about one quarter of all white blood cells. Usually, fewer than half of the body's lymphocytes are in the blood. The rest are in the lymph, lymph nodes, and lymph organs.

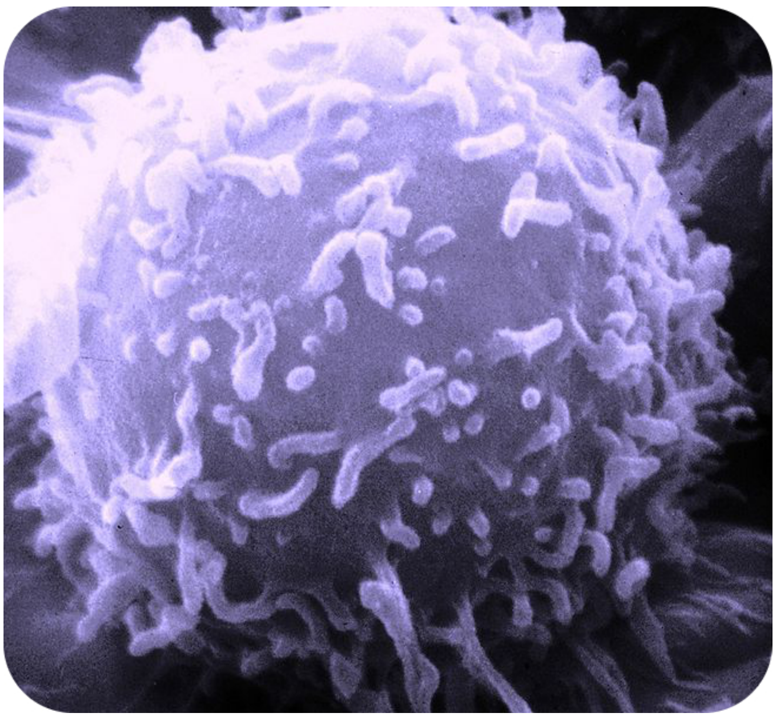


FIGURE 1.124
This image of a lymphocyte was made with an electron microscope. The lymphocyte is shown 10,000 times its actual size.

There are two main types of lymphocytes:

1. B cells.
2. T cells.

Both types of lymphocytes are produced in the red bone marrow. They are named for the sites where they grow larger. The "B" in B cells stands for "bone." B cells grow larger in red bone marrow. The "T" in T cells stands for "thymus." T cells mature in the thymus gland.

B and T cells must be "switched on" in order to fight a specific pathogen. Once this happens, they produce an army of cells ready to fight that particular pathogen. How can B and T cells recognize specific pathogens? Pathogens have proteins, often located on their cell surface. These proteins are called antigens. An **antigen** is any protein that causes an immune response, because it is unlike any protein that the body makes. Antigens are found on bacteria, viruses, and other pathogens.

## Vocabulary

- **antigen**: Protein that is recognized as foreign and causes an immune response.
- **bone marrow**: Soft connective tissue in spongy bone; makes blood cells.
- **immune response**: Body's defense against a specific pathogen.
- **immune system**: Organ system that defends the body from pathogens.
- **lymph**: Clear fluid that drains through the lymphatic system and into the bloodstream.
- **lymph nodes**: Small, oval structures located along the lymph vessels where pathogens are filtered out and destroyed.
- **lymphocytes**: Type of white blood cell that is a key cell in the immune response to a specific pathogen.
- **spleen**: Organ that filters pathogens out of the blood.
- **thymus gland**: Gland that stores and matures lymphocytes.
- **tonsils**: Glands that trap pathogens that enter the body through the mouth or nose.

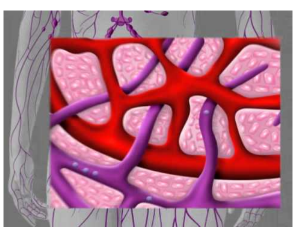
## Summary

- The immune system includes lymph organs, lymph vessels, lymph, and lymph nodes.
- Lymph organs include the red bone marrow, thymus gland, spleen, and tonsils.
- Lymphocytes, including B cells and T cells, are key cells in the immune response.

## Practice

Use the resource below to answer the questions that follow.

- **Lymphatic System** at http://www.youtube.com/watch?v=Kh-XdNnTZUo (1:08)



MEDIA
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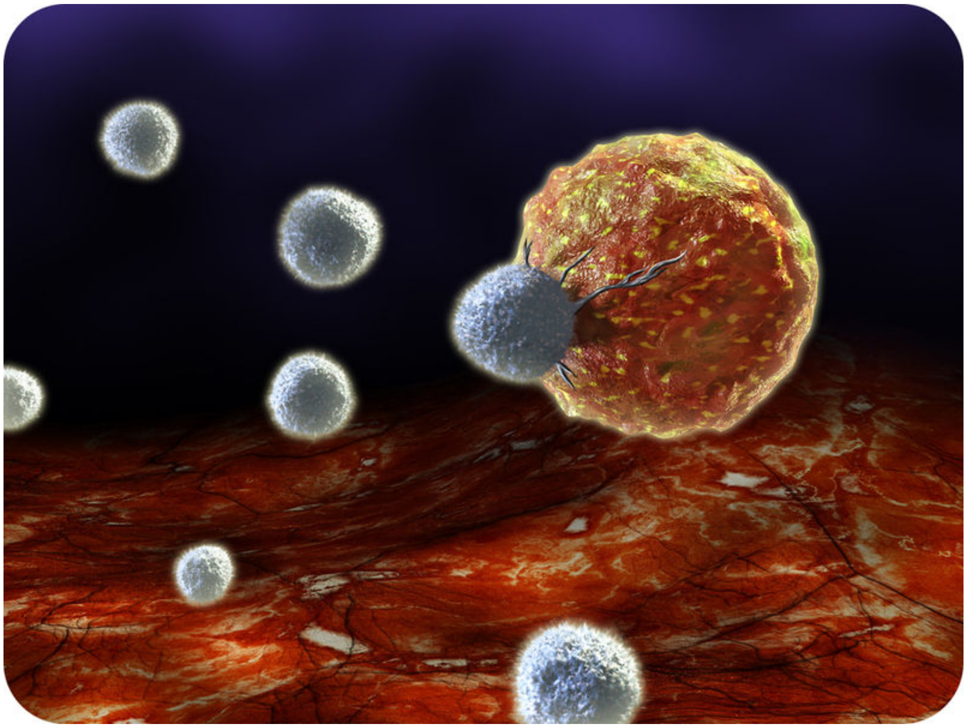
1. What are some of the functions of the lymphatic system?
2. How do the lymph nodes act in the lymphatic system?

## Review

1. What are some examples of lymph organs?
2. What is the role of the lymphocytes?

# 1.63 B and T Cell Response

- Explain how B cells and T cells respond to pathogens.



**What happens when your body recognizes an invader?**

When your immune system detects an invading pathogen, it goes on the attack! Notice how this T-cell is setting out to destroy a cancer cell.

## B and T Cell Response

Some defenses, like your skin and mucous membranes, are not designed to ward off a specific pathogen. They are just general defenders against disease. Your body also has defenses that are more specialized. Through the help of your immune system, your body can generate an army of cells to kill that one specific pathogen.

There are two different types of specific immune responses. One type involves B cells. The other type involves T cells. Recall that **B cells** and **T cells** are types of white blood cells that are key in the immune response.

### B Cell Response

B cells respond to pathogens and other cells from outside the body in the blood and lymph.

Most B cells fight infections by making antibodies. An **antibody** is a large, Y-shaped protein that binds to an **antigen**, a protein that is recognized as foreign. Each antibody can bind with just one specific type of antigen (**Figure** 1.125). They fit together like a lock and key. Once an antigen and antibody bind together, they signal for a **phagocyte** to destroy them.

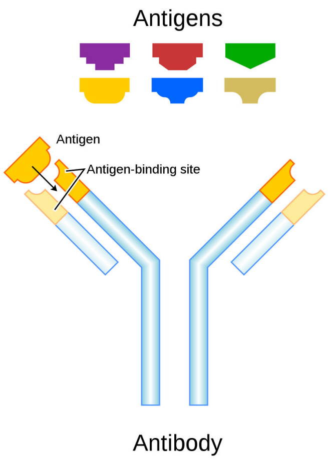



FIGURE 1.125
This diagram shows how an antibody binds with an antigen. The antibody was produced by a B cell. It binds with just one type of antigen. Antibodies produced by different B cells bind with other types of antigens.

### T Cell Response

There are different types of T cells, including killer T cells and helper T cells. **Killer T cells** destroy infected, damaged, or cancerous body cells (**Figure** 1.126). When the killer T cell comes into contact with the infected cell, it releases poisons. The poisons make tiny holes in the cell membrane of the infected cell. This causes the cell to burst open. Both the infected cell and the viruses inside it are destroyed.

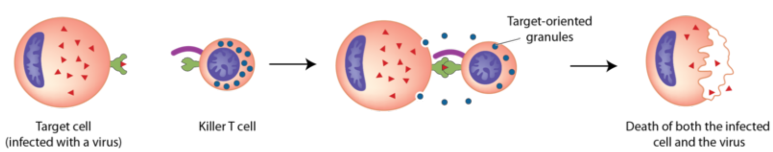



FIGURE 1.126
In this diagram, a killer T cell recognizes a body cell infected with a virus. After the killer T cell makes contact with the infected cell, it releases poisons that cause the infected cell to burst. This kills both the infected cell and the viruses inside it.

**Helper T cells** do not destroy infected or damaged body cells. But they are still necessary for an immune response. They help by releasing chemicals that control other lymphocytes. The chemicals released by helper T cells "switch on" both B cells and killer T cells so they can recognize and fight specific pathogens.

### Vocabulary

- **antibody**: Large, Y-shaped protein produced by B cells that recognizes and binds to a specific antigen.
- **antigen**: Protein that is recognized as foreign and causes an immune response.
- **B cell**: Type of white blood cell that fights infections by forming antibodies.
- **helper T cell**: Cell that releases chemicals that control the immune response.
- **killer T cell**: Cell that destroys infected, damaged, or cancerous body cells.
- **phagocyte** : Cells that engulf and break down pathogens.
- **T cell**: Cells involved in the immune response in which cells infected with pathogens are destroyed.

## Summary

- B cells produce antibodies against pathogens in the blood and lymph.
- Killer T cells destroy body cells infected with pathogens.

## Practice

Use the resource below to answer the questions that follow.

- **Specific Immunity** at http://www.dnatube.com/video/194/Specific-Adaptive-immunity-humoral-and-cell-mediated (1:20)

MEDIA
Click image to the left for more content.

1. What does specific immunity mean? How is it different from general immunity? How are both types useful to the body?
2. What cells are involved in the body's humoral immune response?
3. How do macrophages educate T-cells? How do they accomplish this communication?
4. What do killer T-cells differentiate into? How does this help the body long term?
5. What do B-cells differentiate into? What is the function of these differentiated cells?

## Review

1. Explain how B cells help fight infections.
2. How do killer T cells fight pathogens?

# 1.64 Immunity

- Describe immunity and how vaccinations work.

**Is this boy more fortunate than many children?**

You may not feel lucky to get a shot. But you are very lucky to be able to get vaccinations. In many parts of the world, children do not get routine vaccinations. In 2008, the World Health Organization (WHO) estimated that 1.5 million children under the age of 5 died from diseases that are preventable with vaccinations.

## Immunity and Vaccination

In previous lessons, you learned about B and T cells, special types of white blood cells that help your body to fight off a specific pathogen. They are very necessary when the body is fighting off an infection. But what happens to them after the pathogen has been destroyed?

Most B and T cells die after an infection has been brought under control. But some of them survive for many years. They may even survive for a person's lifetime.

These long-lasting B and T cells are called memory cells. They allow the immune system to "remember" the pathogen after the infection is over. If the pathogen invades the body again, the memory cells will start dividing in order to fight the disease.

They will quickly produce a new army of B or T cells to fight the pathogen. They will begin a faster, stronger attack than the first time the pathogen invaded the body. As a result, the immune system will be able to destroy the pathogen before it can cause an infection. Being able to attack the pathogen in this way is called **immunity**.

Immunity can also be caused by vaccination. **Vaccination** is the process of exposing a person to a pathogen on purpose in order to develop immunity. In vaccination, a modified pathogen is usually injected under the skin by a shot. Only part of the pathogen is injected, or a weak or dead pathogen is used. It sounds dangerous, but the shot prepares your body for fighting the pathogen without causing the actual illness. Diseases you have probably been vaccinated against include measles, mumps, and chicken pox.

### Vocabulary

- **immunity**: Ability to resist a particular pathogen.
- **vaccination**: Process of deliberately exposing a person to a pathogen in order to develop immunity.

### Summary

- Immunity is the ability to resist a particular pathogen.
- Vaccination is deliberate exposure to a pathogen in order to bring about immunity.

### Practice

Use the resource below to answer the questions that follow.

- **What Is Immunity?** at http://www.youtube.com/watch?v=vCBfiQnyiKw (1:23)

MEDIA

Click image to the left for more content.

1. How do vaccines provide immunity? How is the immune response initiated by vaccines similar to the body's natural immune response?
2. Why do some people decide to take vaccines rather than letting the body develop natural immunity?

### Review

1. Define immunity.
2. If you have been vaccinated against measles, you are unlikely to ever have the disease, even if you are exposed to the measles virus. How does this work?

# 1.65 Male Reproductive System

- List the functions of the male reproductive system.

**Why do men and women look different?**

The features that make men unique from women, such as this man's beard, are controlled by the sex hormones. The production of the sex hormones is a key role of the male reproductive system.

## The Male Reproductive System Functions

Dogs have puppies. Cats have kittens. All organisms reproduce, including humans. Like other mammals, humans have a body system that controls reproduction. It is called the **reproductive system**. It is the only human body system that is very different in males and females. The male and female reproductive systems have different organs and different functions.

The male reproductive system has two main functions:

1. Producing sperm.
2. Releasing testosterone into the body.

**Sperm** are male **gametes**, or reproductive cells. When a male gamete meets a female gamete, they can form a new organism. Sperm form when certain cells in the male reproductive system divide by **meiosis**. When they grow older, males produce millions of sperm each day.

**Testosterone** is the main sex hormone in males. Hormones are chemicals that control many body processes. Testosterone has two major roles:

- During the teen years, testosterone causes the reproductive organs to mature. It also causes other male traits to develop. For example, it causes hair to grow on the face and allows for muscle growth (**Figure** 1.127).

- During adulthood, testosterone helps a man to produce sperm.

When a hormone is released into the body, we say it is "secreted." Testosterone is secreted by males, but it is not the only hormone that males secrete. Males also secrete small amounts of estrogen. Even though estrogen is the main female sex hormone, scientists think that estrogen is needed for normal sperm production in males.

FIGURE 1.127
Testosterone, the main sex hormone in males, allows men to build larger muscles than women.

## Vocabulary

- **gamete**: Reproductive cell, such as sperm or egg.
- **meiosis**: Process in cell division during which chromosome number is halved in order to produce gametes.
- **reproductive system**: Organ system that produces gametes and secretes sex hormones.
- **sperm**: Male gamete, or reproductive cell.
- **testosterone**: Main sex hormone in males.

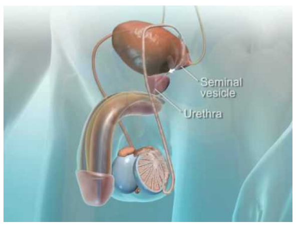
## Summary


- The main functions of the male reproductive system are to produce sperm and secrete testosterone.
- Testosterone, the main sex hormone in males, causes the reproductive organs to mature and other male traits to develop.


## Practice

Use the resource below to answer the questions that follow.

- **Male Reproductive System** at http://www.youtube.com/watch?v=nr5W9trSv8I (2:36)




MEDIA

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1. What is the role of the testicles in reproduction? What temperature is needed for it to perform this function? How does the body try to regulate the temperature of the testicles?
2. What is the role of the seminal vesicles?
3. What is the role of the penis in reproduction?
4. What does the bulbourethral gland do? When does this occur?

## Review

1. What are the two main roles of the male reproductive system?
2. Explain the jobs of testosterone in males.

# 1.66 Male Reproductive Structures

- Identify and describe the functions of the male reproductive organs.

**What organs are unique to the male body?**

Men and women share most of the same organs. We all have skin, a heart, and lungs. Men and women differ only in their reproductive organs.

## Male Reproductive Organs

The male reproductive organs include the penis, testes, and epididymis (**Figure** 1.128). The figure also shows other parts of the male reproductive system.

- The **penis** is a cylinder-shaped organ. It contains the urethra. The **urethra** is a tube that carries urine out of the body. The urethra also carries sperm out of the body.
- The two **testes** (singular, testis) are egg-shaped organs. They produce sperm and secrete testosterone. The testes are found inside of the scrotum. The **scrotum** is a sac that hangs down outside the body. The scrotum also contains the epididymis.

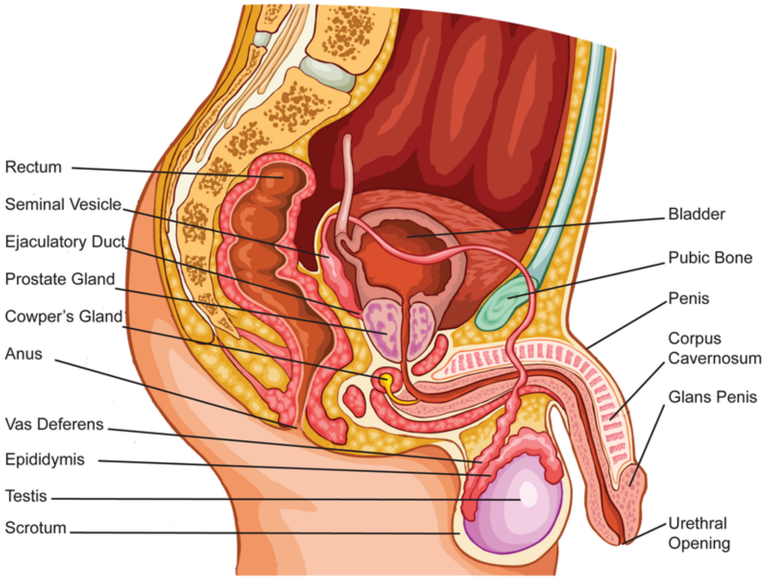



FIGURE 1.128
This drawing shows the organs of the male reproductive system. It shows the organs from the side. Find each organ in the drawing as you read about it in the text.

- The **epididymis** is a tube that is about six meters (20 feet) long in adults. It is tightly coiled, so it fits inside the scrotum. It rests on top of the testes. The epididymis is where sperm grow larger. The epididymis also stores sperm until they leave the body.

Other parts of the male reproductive system include the vas deferens and the prostate gland. Both of these structures are pictured below (**Figure** 1.128).

- The **vas deferens** is a tube that carries sperm from the epididymis to the urethra.
- The **prostate gland** secretes a fluid that mixes with sperm to help form semen. **Semen** is a "milky" liquid that carries sperm through the urethra and out of the body.

## Vocabulary

- **epididymis**: Tube in the male reproductive organs in which sperm mature and are stored until they leave the body.
- **penis**: Cylindar-shaped male reproductive organ containing the urethra through which sperm and urine pass out of the body.
- **prostate gland**: Gland that secretes a fluid that mixes with sperm to help form semen.
- **scrotum**: Sac of skin that holds the testes.
- **semen**: "Milky" liquid that carries sperm through the urethra and out of the body.
- **testes**: Male reproductive organs that produce sperm and secrete testosterone.
- **urethra**: Tube that carries urine and sperm out of the body.
- **vas deferens**: Tube that carries sperm from the epididymis to the urethra.

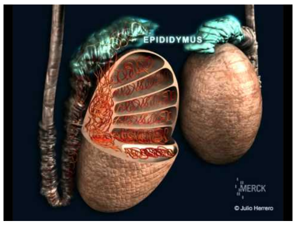
## Summary

- Male reproductive organs include the penis, testes, and epididymis.
- The testes produce sperm and secrete testosterone.

## Practice

Use the resources below to answer the questions that follow.

- **The Male Reproductive System** at http://www.youtube.com/watch?v=yRNqsT_NRcY (1:21)




MEDIA

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1. How long is sperm stored once it is produced?
2. What two types of cells are found in the epididymis? What are the functions of these cells?

- **Male Reproductive Organs** at http://www.innerbody.com/image_repmov/repo10-new3.html

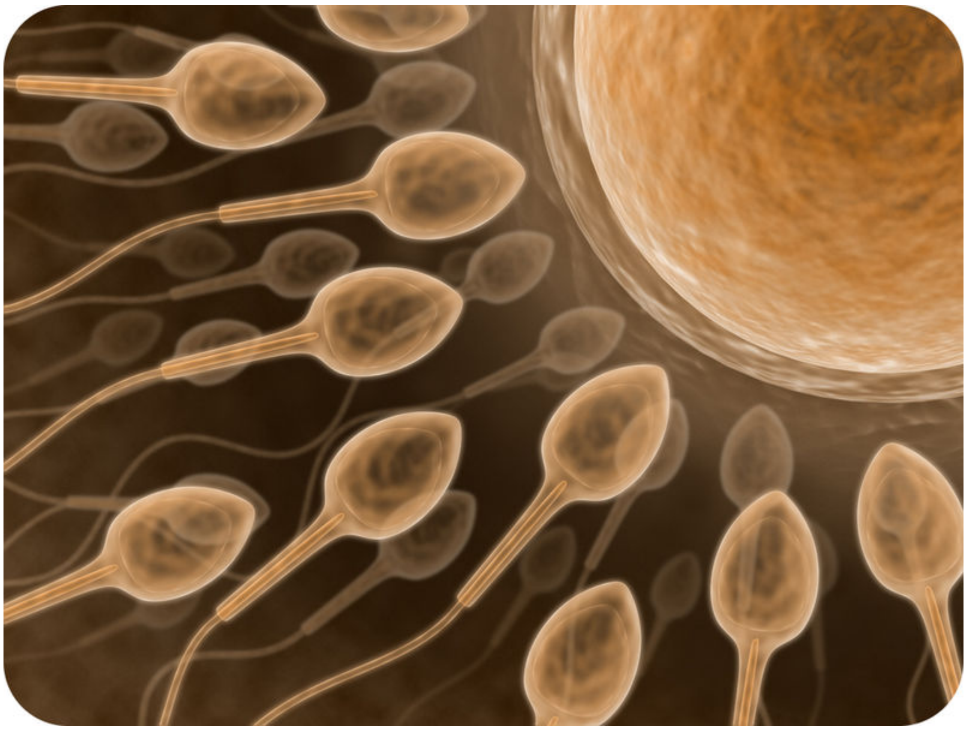
1. What does the prostate gland do? Where is it located?
2. What is the epididymis? Where is it located? What is its function?
3. What is the corpus spongiosum? Where is it located? What is its function?

## Review

1. Arrange the following structures in the order that sperm pass through them: urethra, epididymis, vas deferens.
2. Why is the epididymis needed for reproduction in males?

# 1.67 Human Sperm

- Explain what sperm are and how they are produced.



**How many sperm does it take to fertilize an egg?**

It might only take one sperm to fertilize an egg, but that sperm is not alone. Hundreds of millions of sperm can be released during sexual intercourse.

## Sperm and Sperm Production

**Sperm** (**Figure** 1.129), the male reproductive cells, are tiny. In fact, they are the smallest cells in the human body. What do you think a sperm cell looks like? Some people think that it looks like a tadpole. Do you agree?

### Sperm

A sperm has three main parts:

1. The head of the sperm contains the nucleus. The **nucleus** holds the DNA of the cell. The head also contains enzymes that help the sperm break through the cell membrane of an egg.
2. The midpiece of the sperm is packed with mitochondria. **Mitochondria** are organelles in cells that produce energy. Sperm use the energy in the midpiece to move.
3. The tail of the sperm moves like a propeller, around and around. This pushes the sperm forward. A sperm can travel about 30 inches per hour. This may not sound very fast, but don't forget how small a sperm is. For its size, a sperm moves about as fast as you do when you walk briskly.

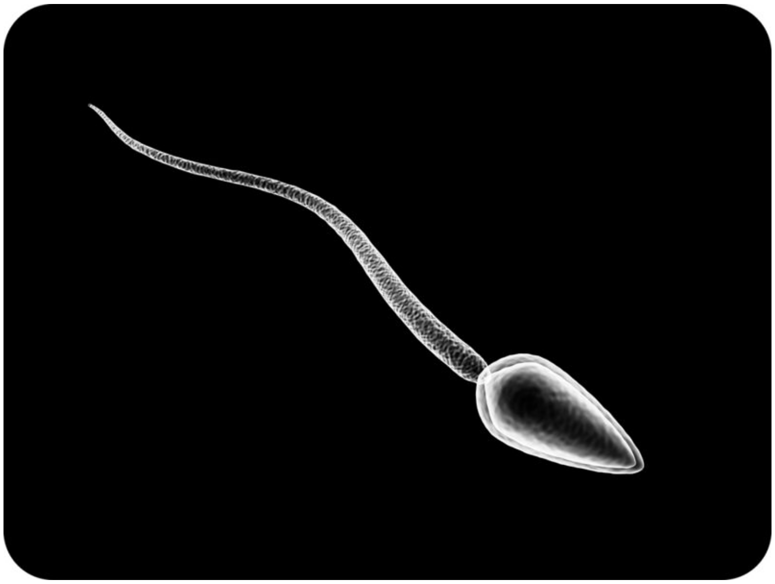


FIGURE 1.129

This drawing of a sperm shows its main parts. What is the role of each part? How do you think the shape of the sperm might help it swim?

### Sperm Production

To make sperm, cells start in the testes and end in the epididymis. It takes up to two months to make sperm. The steps are explained below:

1. Special cells in the testes go through **mitosis** (cell division) to make identical copies of themselves.
2. The copies of the original cells divide by **meiosis**, producing cells called **spermatids**. The spermatids have half the number of chromosomes as the original cell. The spermatids are immature and cannot move on their own.
3. The spermatids are transported from the testes to the epididymis. Involuntary muscular contraction moves the spermatids along.
4. In the **epididymis**, spermatids slowly grow older and mature. They grow a tail. They also lose some of the cytoplasm from the head.
5. When sperm are mature, they can "swim." The mature sperm are stored in the epididymis until it is time for them to leave the body.

Sperm leave the epididymis through the **vas deferens**. As they travel through the vas deferens, they pass by the prostate and other glands. The sperm mix with liquids from these glands, forming **semen**. The semen travels through the urethra and leaves the body through the penis. A teaspoon of semen may contain as many as 500 million sperm!

### Vocabulary

- **epididymis**: Male reproductive organs where sperm mature and are stored until they leave the body.
- **meiosis**: Process in cell division during which chromosome number is halved in order to produce gametes.
- **mitochondria**: Organelle of the cell in which energy is generated.
- **mitosis**: Division of the nucleus.
- **nucleus**: Eukayrotic cell structure that contains the genetic material, DNA.
- **sperm**: Male gamete, or reproductive cell.
- **spermatid**: Non-motile cell in the sperm maturation process that has half the number of chromosomes of the original cell.

- **vas deferens**: Tube that carries sperm from the epididymis to the urethra.
- **semen**: Fluid containing the sperm.

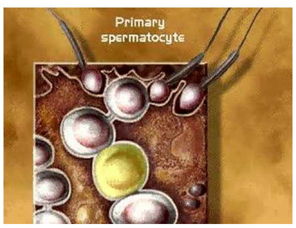
## Summary

- Sperm are male gametes that form in the testes and mature in the epididymis.
- The head of the sperm contains the nucleus, the midpiece is packed with mitochondria, and the tail moves like a propeller.

## Practice

Use the resource below to answer the questions that follow.

- **Spermatogenesis** at http://www.youtube.com/watch?v=POpbN6RHOO0 (0:45)




MEDIA

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1. What produces primary spermatocytes? How many chromosomes do primary spermatocytes have?
2. What produces secondary spermatocytes? How many chromosomes do secondary spermatocytes have?
3. What makes spermatids? How many chromosomes do spermatids have?

## Review

1. What is the function of the tail of a sperm?
2. Explain why sperm production is not completed when spermatids have been produced.

# 1.68 Female Reproductive System

- State the functions of the female reproductive system.

**What causes a girl to develop into a woman?**

Adult female characteristics, such as breasts, develop during the teen years. What causes this to happen? The development of the female traits is caused by the hormones produced by the female reproductive system.

## The Female Reproductive System Functions

Most of the male reproductive organs are outside of the body. But female reproductive organs are inside of the body. The male and female organs also look very different and have different jobs. Two of the functions of the female reproductive system are similar to the functions of the male reproductive system. The female system:

1. Produces **gametes**, the reproductive cells, which are called eggs in females.
2. Secretes a major sex hormone, estrogen.

One of the main roles of the female reproductive system is to produce eggs. **Eggs** (**Figure** 1.130) are female gametes, and they are made in the ovaries. After puberty, females release only one egg at a time. Eggs are actually made in the body before birth, but they do not fully develop until later in life.

Another job of the female system is to secrete estrogen. **Estrogen** is the main sex hormone in females. Estrogen has two major roles:

1. During the teen years, estrogen causes the reproductive organs to develop. It also causes other female traits to develop. For example, it causes the breasts to grow.
2. During adulthood, estrogen is needed for a woman to release eggs.

The female reproductive system has another important function. It supports a baby as it develops before birth, and it facilitates the baby's birth at the end of pregnancy.

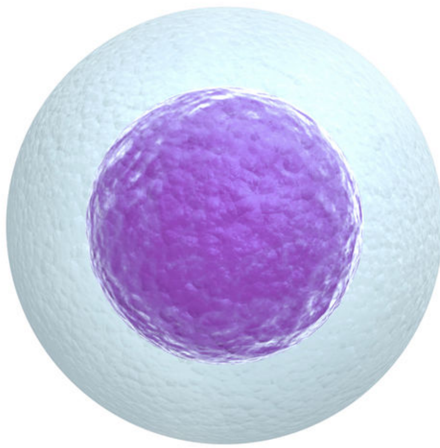


FIGURE 1.130
This human egg is the gamete, or reproductive cell, in females.

## Vocabulary

- **egg**: Female gamete, or reproductive cell.
- **estrogen**: Main sex hormone in females
- **gamete**: Reproductive cell, such as sperm or egg.

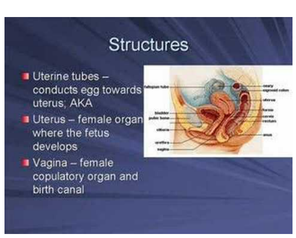
## Summary

- The functions of the female reproductive system are to produce eggs, secrete estrogen, and support a baby as it develops before birth.
- Estrogen, the main sex hormone in females, causes the female traits and reproductive organs to develop and is needed for the release of eggs.

## Practice

Use the resource below to answer the questions that follow.

- **Female Reproductive System** at http://www.youtube.com/watch?v=SkcddD0LGlM (5:01)




MEDIA
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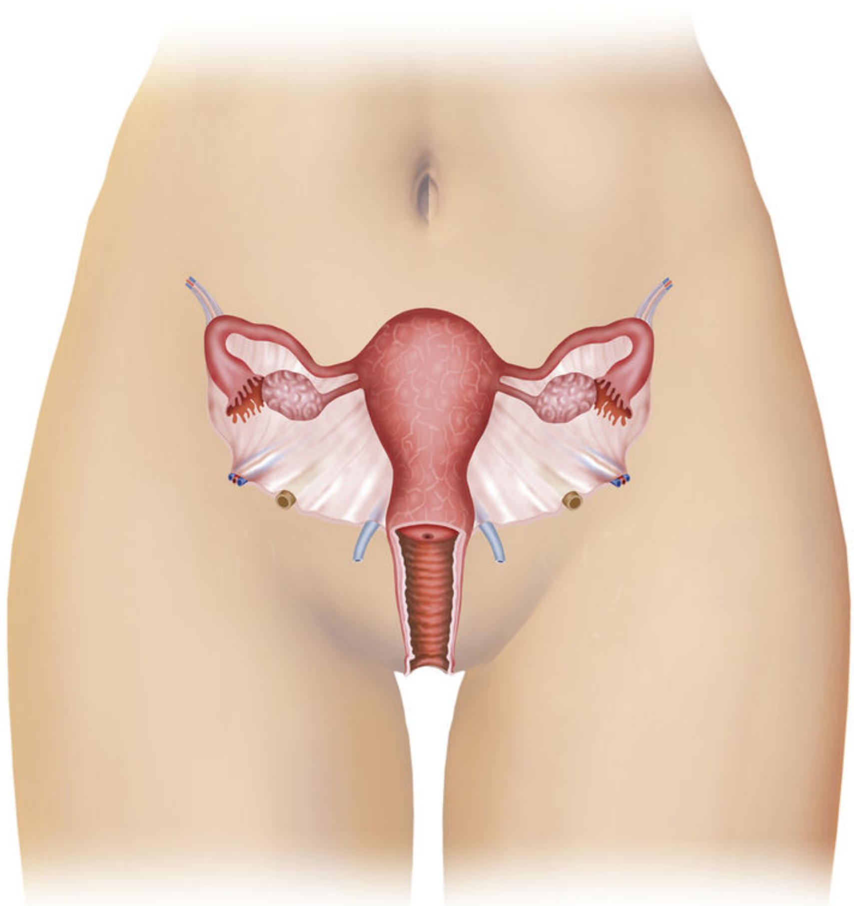
1. What hormones are involved in the female reproductive process?
2. What are ovaries? What is their function?
3. What is the function of the follicles? Where are they located?
4. What is the function of the uterus?

## Review

1. List the two major roles of estrogen in females.
2. What are the main roles of the female reproductive system?

# 1.69 Female Reproductive Structures

- Identify and describe the functions of the female reproductive organs.



**Where are the female reproductive organs?**

Unlike the male reproductive organs, much of the female reproductive organs are internal. This allows them to be well-protected by the body.

## Female Reproductive Organs

The female reproductive organs include the vagina, uterus, fallopian tubes, and ovaries (**Figure** 1.131).

The breasts are not shown in this figure. They are not considered reproductive organs, even though they are involved in reproduction. They contain mammary glands that give milk to feed a baby. The milk leaves the breast through the nipple when the baby sucks on it.

- The **vagina** is a cylinder-shaped organ found inside of the female body. One end of the vagina opens at the outside of the body. The other end joins with the uterus. During sexual intercourse, sperm may be released

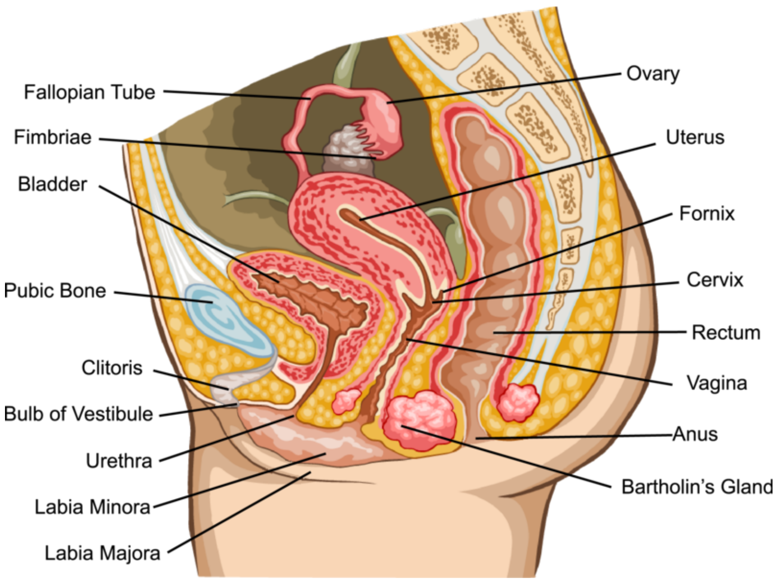



FIGURE 1.131

This drawing shows the organs of the female reproductive system. It shows the organs from the front. Find each organ in the drawing as you read about it in the text.

into the vagina. If this occurs, the sperm will move through the vagina and into the uterus. During birth, a baby passes from the uterus to the vagina to leave the body.

- The **uterus** is a hollow organ with muscular walls. The part that connects the vagina with the uterus is called the **cervix**. The uterus is where a baby develops until birth. The walls of the uterus grow bigger as the baby grows. The muscular walls of the uterus push the baby out during birth.

- The two **ovaries** are small, oval organs on either side of the uterus. Each ovary contains thousands of eggs. The eggs do not fully develop until a female has gone through puberty. About once a month, an egg is released by the ovary. The ovaries also secrete **estrogen**, the main female sex hormone.

- The two **fallopian tubes** are narrow tubes that open off from the uterus. Each tube reaches for one of the ovaries, but the tubes are not attached to the ovaries. The end of each fallopian tube by the ovary has "fingers" (**Figure** 1.131). They sweep an egg into the fallopian tube. Then the egg passes through the fallopian tube to the uterus.

## Vocabulary

- **cervix**: Lower, narrower end of the uterus that connects with the vagina.
- **estrogen**: Main sex hormone in females.
- **fallopian tube**: Female reproductive organ that carries eggs from the ovary to the uterus.
- **ovary**: Female reproductive organ in which eggs form.
- **uterus**: Female reproductive organ in which the baby develops until birth.
- **vagina**: Female reproductive organ that receives sperm during sexual intercourse and provides a passageway for a baby to leave the mother's body during birth.

## Summary

- Female reproductive organs include the vagina, uterus, ovaries, and fallopian tubes.
- The ovaries release the eggs and secrete estrogen.

## Practice

Use the resource below to answer the questions that follow.

- **Female Reproductive Organs** at http://www.innerbody.com/anatomy/female-reproductive/lower-torso

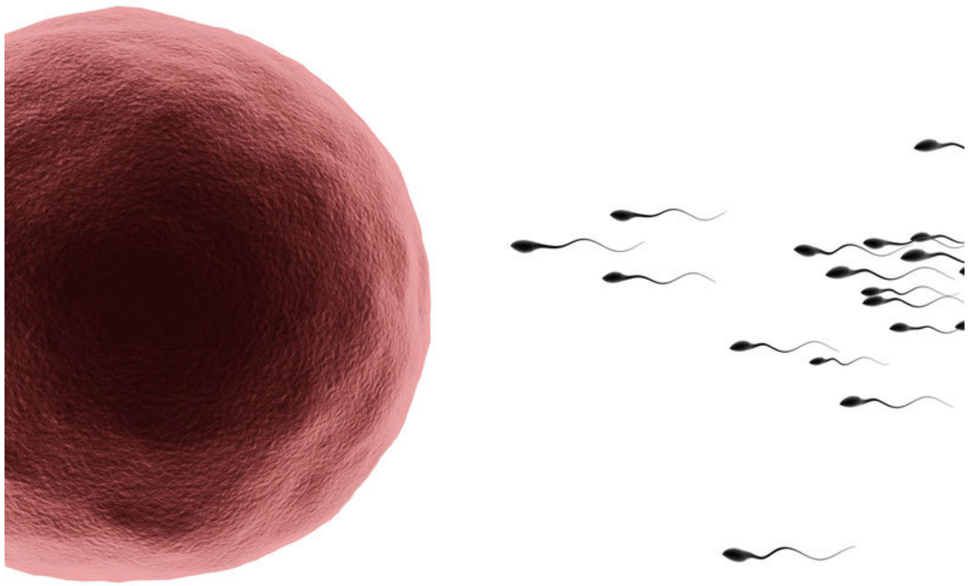
1. What is the vagina? Where is it located? What are the three functions of the vagina?
2. What is a fallopian tube? What does it connect? What commonly takes place here?
3. What are the functions of the ovaries? What hormones are produced here?

## Review

1. What are the functions of the ovaries in female reproduction?
2. What are the functions of the uterus in female reproduction?

# 1.70 Human Egg Cells

- Explain what eggs are and how they are produced.



**How is egg different from sperm?**

Egg and sperm are both gametes, or reproductive cells. Notice how different they are, however. The egg is much larger than the sperm. The egg also does not have a tail. And the female only releases one egg at time, while the male releases millions of sperm at a time.

## Eggs and Egg Production

When a baby girl is born, her ovaries contain all of the eggs they will ever produce. But these eggs are not fully developed. They develop only after she starts having menstrual periods at about age 12 or 13. Just one egg develops each month. A woman will release an egg once each month until she is in her 40s.

### Eggs

Eggs are very big cells. In fact, they are the biggest cells in the human body. An egg is about 30 times as wide as a sperm cell!

You can even see an egg cell without a microscope. Like a sperm cell, the egg contains a nucleus with half the number of chromosomes as other body cells. Unlike a sperm cell, the egg contains a lot of **cytoplasm**, the contents of the cell, which is why it is so big. The egg also does not have a tail.

### Egg Production

Egg production takes place in the ovaries. It takes several steps to make an egg:

1. Before birth, special cells in the ovaries go through **mitosis** (cell division).
2. The daughter cells then start to divide by **meiosis**. But they only go through the first of the two cell divisions of meiosis at that time. They go through the second stage of cell division after the female goes through puberty.
3. In a mature female, an egg develops in an ovary about once a month. The drawing below shows how this happens (**Figure** 1.132).

As you can see from the figure, the egg rests in a nest of cells called a **follicle**. The follicle and egg grow larger and go through other changes. After a couple of weeks, the egg bursts out of the follicle and through the wall of the ovary. This is called **ovulation**. The moving fingers of the nearby **fallopian tube** sweep the egg into the tube.

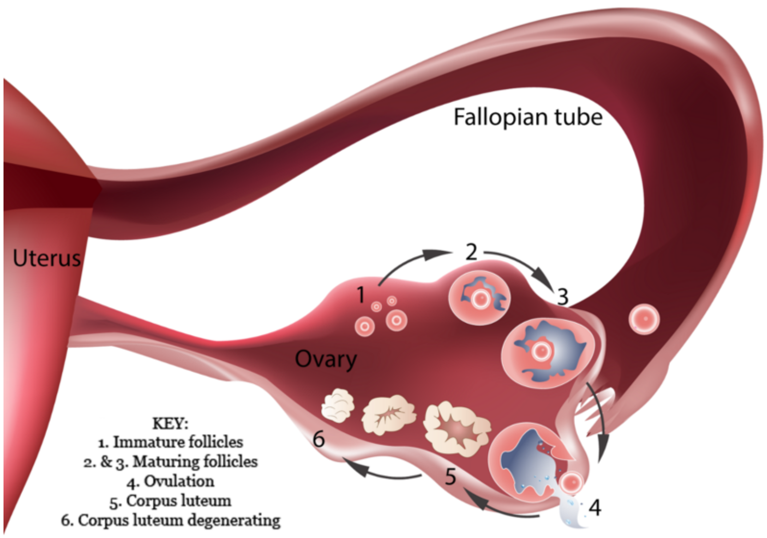



FIGURE 1.132

This diagram shows how an egg and its follicle develop in an ovary. After it develops, the egg leaves the ovary and enters the fallopian tube. (1) Undeveloped eggs, (2) Egg and follicle developing, (3) Egg and follicle developing, (4) Ovulation.

Fertilization occurs if a sperm enters the egg while it is passing through the fallopian tube. When this happens, the egg finally completes meiosis. This results in two daughter cells that are different in size. The smaller cell is called a **polar body**. It contains very little cytoplasm. It soon breaks down and disappears. The larger cell is the egg. It contains most of the cytoplasm. This will develop into a child.

## Vocabulary

- **cytoplasm**: Entire contents of the cell inside the plasma membrane, excluding the nucleus.
- **fallopian tube**: Female reproductive organs that carry eggs from the ovary to the uterus.
- **follicle**: Structure in the ovary where eggs mature.
- **meiosis**: Process in cell division during which chromosome number is halved in order to produce gametes.
- **mitosis**: Division of the nucleus.
- **ovulation**: Release of the egg out of the follicle and through the wall of the ovary.
- **polar body**: Small cells formed by the unequal meiotic divisions of cytoplasm as an egg develops.

## Summary

- Eggs are female gametes that form in the ovaries and are released into the fallopian tubes.
- The eggs are formed before a baby girl is born, but these eggs are not fully developed.

## Practice

Use the resources below to answer the questions that follow.

- **Follicle Development** at http://www.youtube.com/watch?v=dwtFYOLFeNw (1:56)


MEDIA

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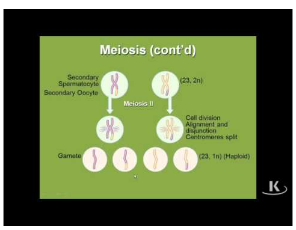
1. What happens during ovulation? What happens to an egg after ovulation?
2. At what point is a zygote formed? How many chromosomes does a zygote have?
3. Where does implantation occur? Where does development occur?

- **Oogenesis** at http://www.youtube.com/watch?v=-IPZItqRjEQ (2:20)

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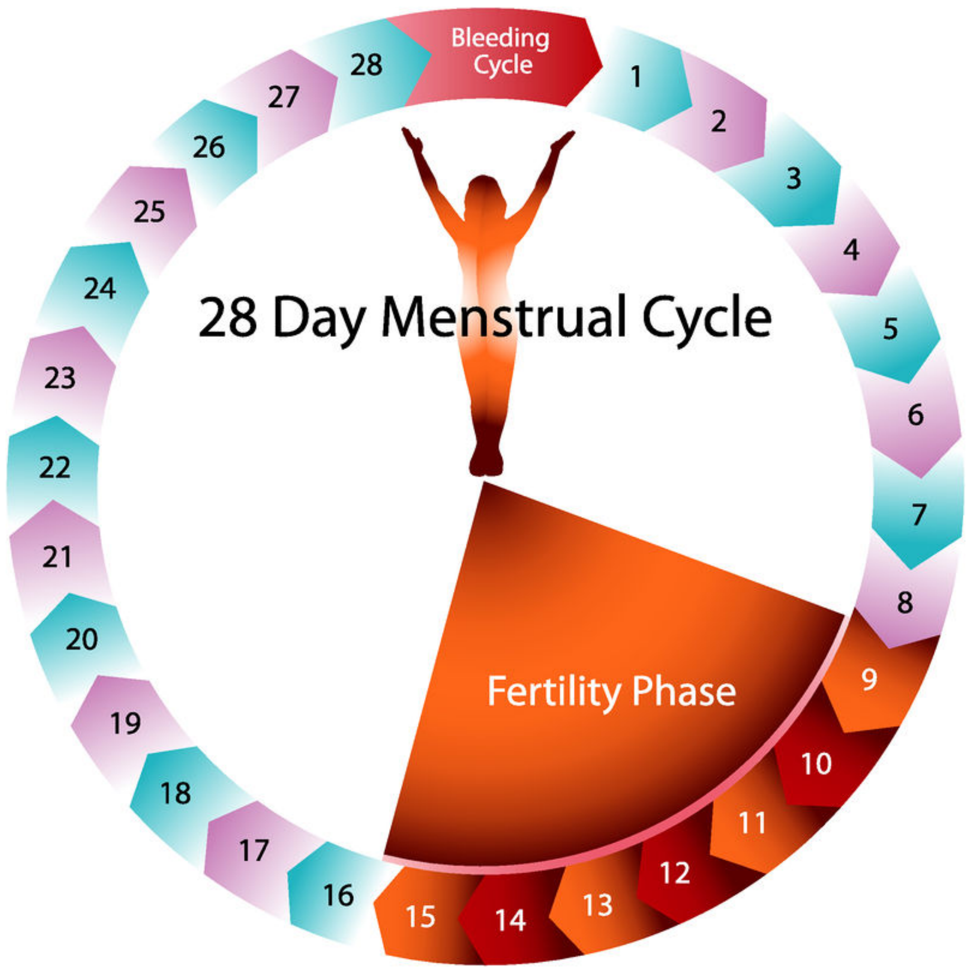
1. At what point in a human female's development do oogonia become primary oocytes?
2. What happens to primary oocytes when a female enters puberty?
3. What happens to a secondary oocyte when it is fertilized?
4. What happens to a secondary oocyte if it is not fertilized?

## Review

1. Describe what happens during ovulation.
2. Explain how an egg develops in an ovary of a mature female.

# 1.71 Menstrual Cycle

- Outline the monthly cycle of the female reproductive system.




**What happens during the menstrual cycle?**

When you think of the menstrual cycle, you probably think of the discharge of blood that happens during menstruation. This is only one small part of the female monthly cycle, however.

## The Female Monthly Cycle

The **menstrual cycle** is a series of changes in the reproductive system of mature females that repeats every month. While the egg and follicle are developing in the ovary, tissues are building up inside the **uterus**, the reproductive organ where the baby would develop. The uterus develops a thick lining covered in tiny blood vessels. This prepares the uterus to receive an egg that could develop into a child.

If a sperm *does not* enter an egg, the lining of the uterus breaks down. Blood and other tissues from the lining break off from the uterus. They pass through the vagina and out of the body. This is called **menstruation**. Menstruation is also called a menstrual period. It lasts about 4 days, on average. When the menstrual period ends, the cycle repeats. Some women feel discomfort during this process (**Figure** 1.133).

Some people think that the average length of a menstrual period is the same as the "normal" length. They assume that shorter or longer menstrual periods are not normal. In fact, menstrual periods can vary from 1 to 8 days in length. This is usually normal.

The average length of the cycle (time between menstrual periods) is about 28 days, but there is no "normal" cycle length.

FIGURE 1.133
Some women experience cramping and pain before and during menstruation.

## Vocabulary

- **menstrual cycle**: Series of changes in the reproductive system of mature females that repeats every month.
- **menstruation**: Process in which blood and other tissues from the lining of the uterus are shed and exit the body.
- **uterus**: Female reproductive organ where the baby develops until birth.

## Summary

- The menstrual cycle is a monthly cycle of changes in the ovaries and uterus.
- During menstruation, blood and other tissues from the lining of the uterus are shed and exit the body.

## Practice

Use the resource below to answer the questions that follow.

- **Ovulation and the Menstrual Cycle** at http://www.youtube.com/watch?v=WGJsrGmWeKE (4:06)

MEDIA
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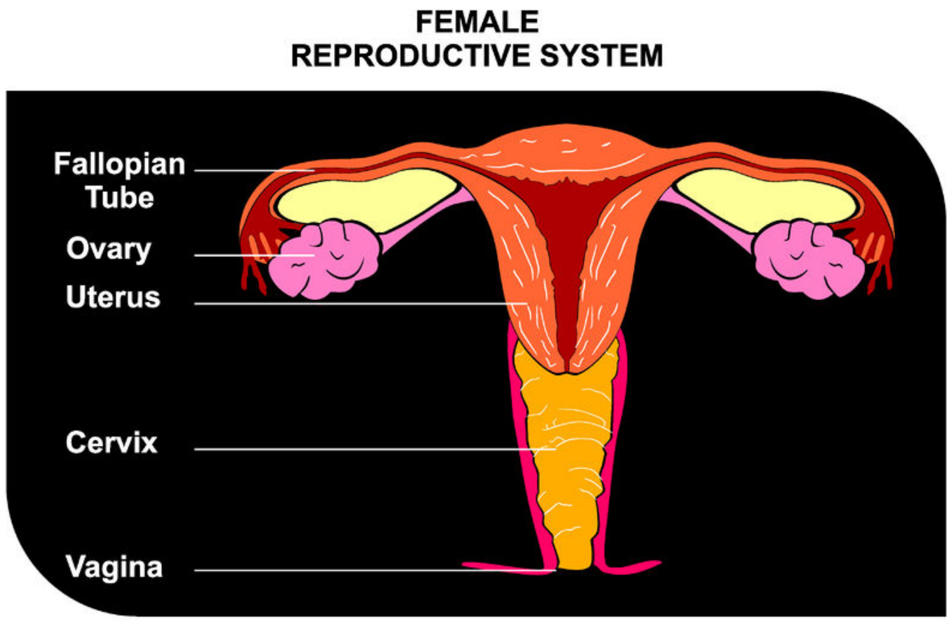
1. What is ovulation?
2. What role does the pituitary gland play in menstruation? What controls the pituitary gland? What does this gland secrete?
3. How do the ovaries respond to a signal from the pituitary gland?
4. What does a peak in LH signal?
5. What role does progesterone play in the menstrual cycle? Where does the progesterone come from?

## Review

1. What happens in the uterus as the egg and follicle are developing in the ovary?
2. Explain what happens during menstruation.

# 1.72 Fertilization

- Explain the process of fertilization.




**Where do sperm meet the egg?**

You might guess that sperm meet the egg in the uterus, the organ where the baby develops. But that is incorrect. The sperm meet the egg in the fallopian tubes that carry the egg from the ovary to the uterus. Then the developing embryo travels to the uterus.

## Fertilization and Implantation

The sperm and egg don't look anything like a human baby (**Figure** 1.134). After they come together, they will develop into a human being. How does a single cell become a complex organism made up of billions of cells? Keep reading to find out.

Sexual reproduction happens when a sperm and an egg cell combine together. This is called **fertilization**.

Sperm are released into the vagina during sexual intercourse. They "swim" through the uterus and enter a **fallopian tube**. This is where fertilization normally takes place.

A sperm that is about to enter an egg is pictured below (**Figure** 1.134). If the sperm breaks through the egg's membrane, it will cause changes in the egg that keep other sperm out. It will also cause the egg to go through meiosis. Recall that **meiosis**, cell division that creates the egg, begins long before an egg is released from an ovary.

The sperm and egg each have only half the number of chromosomes as other cells in the body. This is because when they combine together, they form a cell with the full number of chromosomes. The cell they form is called a **zygote**. The zygote slowly travels down the fallopian tube to the uterus. As it travels, it divides by mitosis many times. It forms a hollow ball of cells.

After the ball of cells reaches the uterus, it fixes itself to the side of the uterus. This is called **implantation**. It usually happens about a week after fertilization.

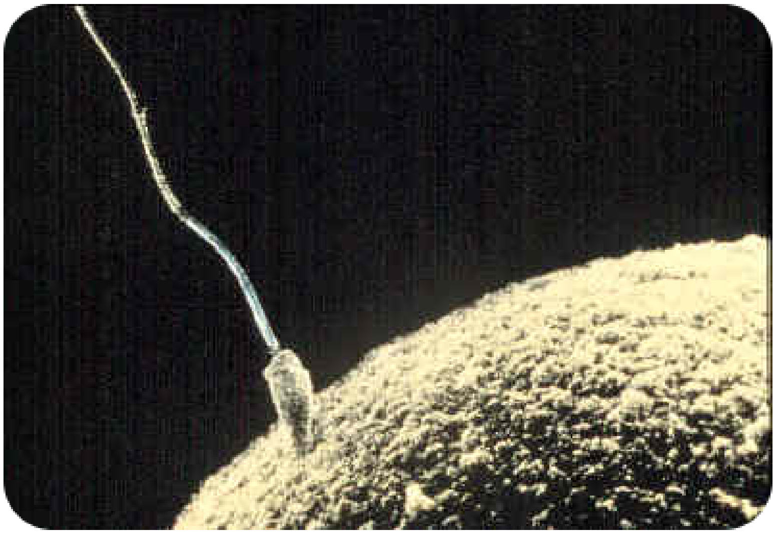


FIGURE 1.134
This sperm is ready to penetrate the membrane of this egg. Notice the difference in size of the sperm and egg.

## Vocabulary

- **fallopian tube**: Female reproductive organs that carry eggs from the ovary to the uterus.
- **fertilization**: Union of the sperm and egg.
- **implantation**: Process in which an embryo fixes itself into the lining the uterus.
- **meiosis**: Process in cell division during which chromosome number is halved in order to produce gametes.
- **zygote**: Cell with a full set of chromosomes that forms when sperm and egg unite.

## Summary

- Fertilization occurs when an egg and sperm come together to form a zygote.
- Implantation occurs when the developing embryo fixes itself to the side of the uterus.

## Practice

Use the resource below to answer the questions that follow.

- **Human Reproduction** at http://www.dnatube.com/video/1127/Human-Reproduction-Fertilization-and-Fetal-Development (3:01)

MEDIA
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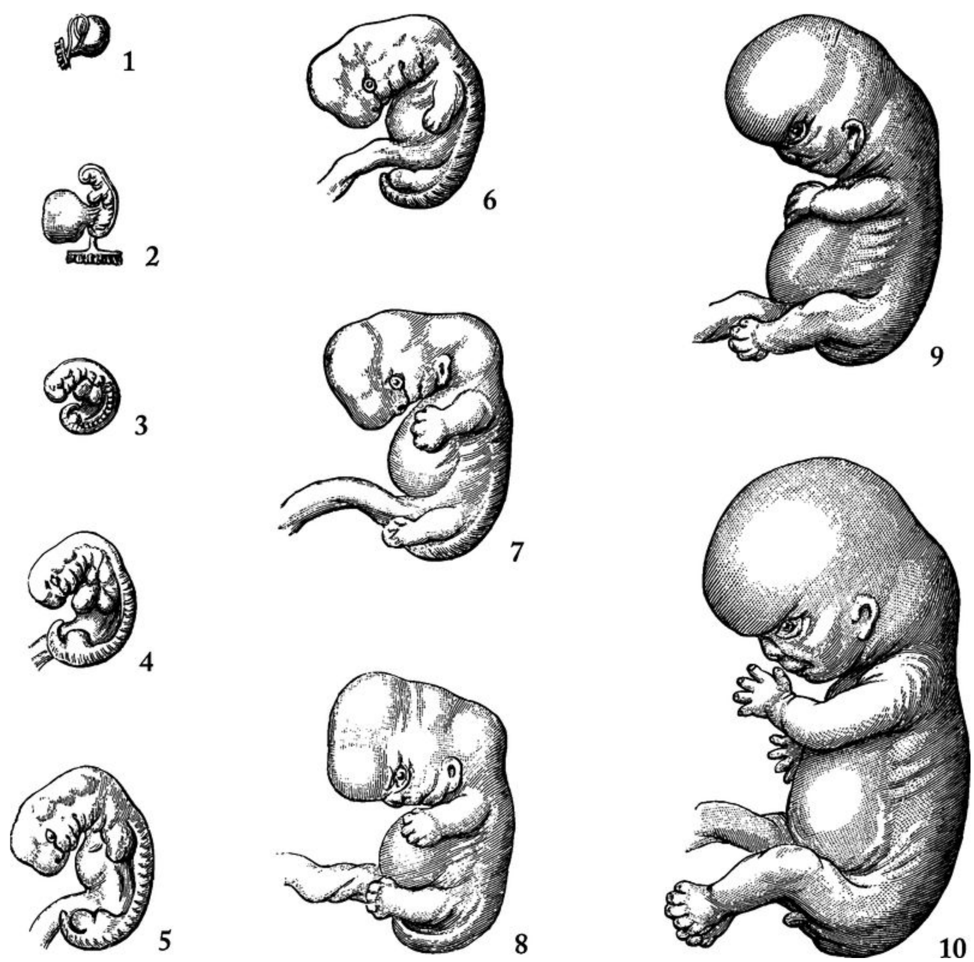
1. How long after fertilization does it take the zygote to reach the uterus?
2. About how many cells is the zygote at the time of fertilization?
3. About how many cells is the embryo at the time of implantation?
4. What prevents the uterine lining from being shed if an egg is fertilized?
5. How does the developing embryo receive nutrition?

### Review

1. What is fertilization?
2. Where does fertilization take place?
3. Where does implantation take place?

# 1.73 Pregnancy and Childbirth

- Identify major events of pregnancy and childbirth.




**Does a growing embryo always look like a tiny human?**

The above picture shows the very early stages of human development. Notice that, at first, the embryo doesn't look very human! It takes time for the human features to take shape.

## Pregnancy and Childbirth

While a woman is pregnant, the developing baby may be called an embryo or a fetus. Do these mean the same thing? No, in the very early stages the developing baby is called an embryo, while in the later stages it is called a fetus. When the ball of cells first implants into the uterus, it is called an **embryo**. The embryo stage lasts until the end of the $8^{th}$ week after fertilization. After that point until birth, the developing baby is called a **fetus**.

### Growth and Development of the Embryo

During the embryo stage, the baby grows in size.

$3^{rd}$ week after fertilization: Cells of different types start to develop. Cells that will form muscles and skin, for example, start to develop at this time.

$4^{th}$ week after fertilization: Body organs begin to form.

$8^{th}$ week: All the major organs have started to develop.

Pictured below are some of the changes that take place during the $4^{th}$ and $8^{th}$ weeks (**Figure** 1.135). Look closely at the two embryos in the figure. Do you think that the older embryo looks more human? Notice that it has arms and legs and lacks a tail. The face has also started to form, and it is much bigger.

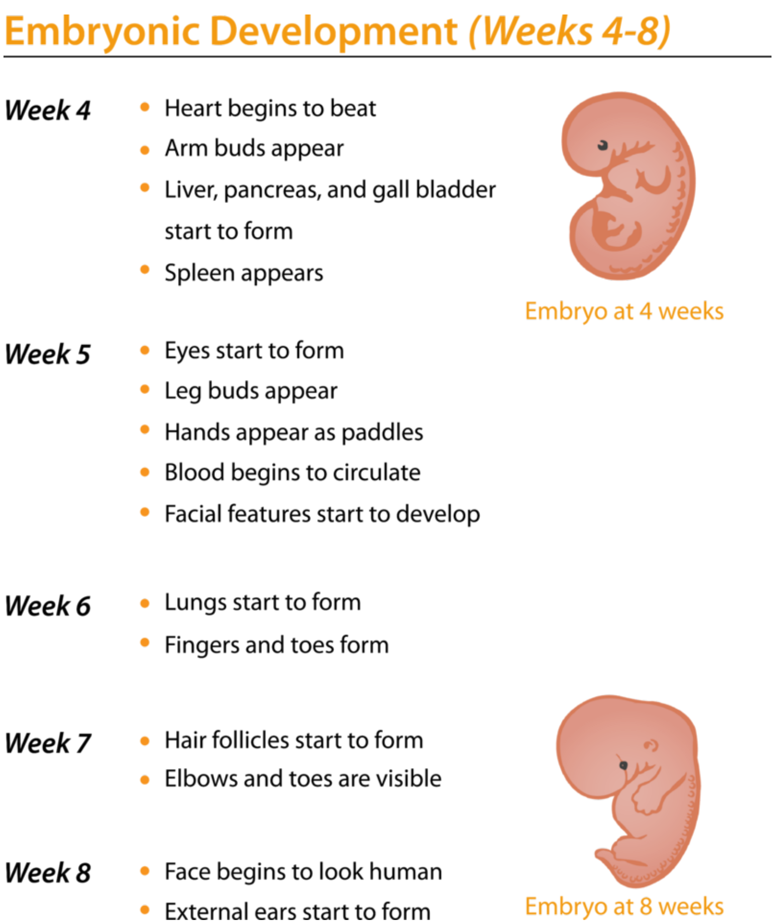



FIGURE 1.135

Embryonic Development (Weeks 4–8). Most organs develop in the embryo during weeks four through eight. (Note: the drawings of the embryos are not to scale.)

### Growth and Development of the Fetus

There are also many changes that take place after the embryo becomes a fetus. Some of the differences between them are obvious. For example, the fetus has ears and eyelids. Its fingers and toes are also fully formed. The fetus even has fingernails and toenails. In addition, the reproductive organs have developed to make the baby a male or female. The brain and lungs are also developing quickly. The fetus has started to move around inside the uterus. This is usually when the mother first feels the fetus moving.

By the $28^{th}$ week, the fetus is starting to look much more like a baby. Eyelashes and eyebrows are present. Hair has started to grow on the head. The body of the fetus is also starting to fill out as muscles and bones develop. Babies born after the $28^{th}$ week are usually able to survive. However, they need help breathing because their lungs are not yet fully mature.

During the last several weeks of the fetal period, all of the organs become mature. The most obvious change, however, is an increase in body size. The fetus rapidly puts on body fat and gains weight during the last couple of months. By the end of the 38$^{th}$ week, all of the organs are working, and the fetus is ready to be born. This is when birth normally occurs.

### The Amniotic Sac and Placenta

During pregnancy, other structures also develop inside the mother's uterus. They are the amniotic sac, placenta, and umbilical cord (**Figure** 1.136).

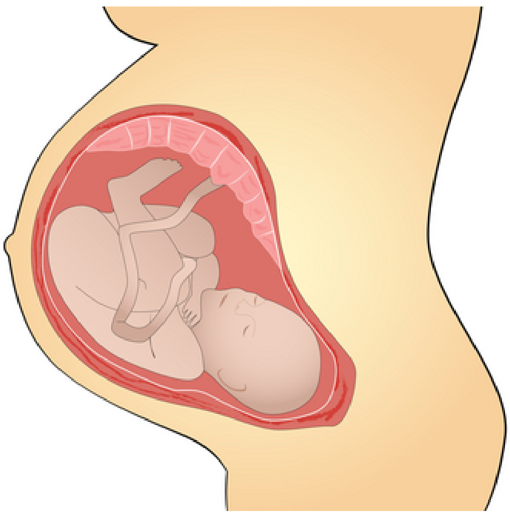


FIGURE 1.136
This fetus is 38 weeks old and ready to be born. Surrounding the fetus is the fluid-filled amniotic sac. The placenta and umbilical cord are also shown here. They provide a connection between the mother's and fetus's blood for the transfer of nutrients and gases.

- The **amniotic sac** is a membrane that surrounds the fetus. It is filled with water and dissolved substances. Imagine placing a small plastic toy inside a balloon and then filling the balloon with water. The toy would be cushioned and protected by the water. It would also be able to move freely inside the balloon. The amniotic sac and its fluid are like a water-filled balloon. They cushion and protect the fetus. They also let the fetus move freely inside the uterus.

- The **placenta** is a spongy mass of blood vessels. Some of the vessels come from the mother. Some come from the fetus. The placenta is attached to the inside of the mother's uterus. The fetus is connected to the placenta by a tube called the **umbilical cord**. The cord contains two arteries and a vein. Substances pass back and forth between the mother's and fetus's blood through the placenta and cord. Oxygen and nutrients pass from the mother to the fetus. Carbon dioxide passes from the fetus to the mother.

It is important for the mother to eat plenty of nutritious foods during pregnancy. She must take in enough nutrients for the fetus as well as for herself. She needs extra calories, proteins, and lipids. She also needs more vitamins and minerals.

In addition to eating well, the mother must avoid substances that could harm the embryo or fetus. These include alcohol, illegal drugs, and some medicines. It is especially important for her to avoid these substances during the first eight weeks after fertilization. This is when all the major organs are forming. Exposure to harmful substances during this time could damage the developing body systems.

### Childbirth

During **childbirth**, a baby passes from the uterus, through the vagina, and out of the mother's body. Childbirth usually starts when the amniotic sac breaks.

Then, the muscles of the uterus start contracting. The contractions get stronger and closer together. They may go on for hours. Eventually, the contractions squeeze the baby out of the uterus. Once the baby enters the vagina, the mother starts pushing. She soon pushes the baby through the vagina and out of her body.

As soon as the baby is born, the umbilical cord is cut. After the cord is cut, the baby can no longer get rid of carbon dioxide through the cord and placenta. As a result, carbon dioxide builds up in the baby's blood. This triggers the baby to start breathing. The amniotic sac and placenta pass through the vagina and out of the body shortly after the birth of the baby.

## Vocabulary

- **amniotic sac**: Fluid-filled membrane that surrounds the fetus.
- **childbirth**: Passage of the baby from the uterus, through the vagina, and out of the mother's body.
- **embryo**: Stage of development that occurs from implantation in the uterus through the eighth week after fertilization in humans.
- **fetus**: Developing human baby at least eight weeks after fertilization.
- **placenta**: Mass of maternal and fetal blood vessels where the the mother's and fetus's blood exchange substances.
- **umbilical cord**: Tube that connects the fetus to the placenta.

## Summary

- A zygote develops into an embryo and then a fetus.
- During pregnancy, the amniotic sac, placenta, and umbilical cord develop inside the mother's uterus.

## Practice

Use the resource below to answer the questions that follow.

- **Anatomy of Childbirth** at http://www.pbs.org/wgbh/nova/body/anatomy-childbirth.html

1. What hormone does the mother secrete at the start of labor? What is the affect of this hormone
2. What signals the start of "active labor"?
3. What happens at the "pushing stage" of childbirth?
4. What is the leading cause of maternal death in developing countries?

## Review

1. Explain the role of the amniotic sac and placenta during fetal development.
2. What is the difference between an embryo and a fetus?

# 1.74 Infancy and Childhood

- List important developments of infancy and childhood.

**Does a baby learn much during his first year?**

The first years of life are full of important milestones as new skills are mastered. For example, at first this baby wasn't even able to roll over on his stomach or hold up his head!

## Infancy and Childhood

The first year after birth is called **infancy**. Infancy is a period when the baby grows very fast. During infancy, the baby doubles in length and triples in weight. Other important changes also happen during infancy:

- The baby's teeth start to come in, usually at about six months of age (**Figure** 1.137).
- The baby starts smiling, paying attention to other people, and grabbing toys.
- The baby begins making babbling sounds. By the end of the first year, the baby is starting to say a few words, such as "Mama" and "Dada."
- The baby learns to sit, crawl, and stand. By the end of the first year, the baby may be starting to walk.

**Childhood** begins after the baby's first birthday and continues until the teen years. Between one and three years of age, a child is called a **toddler**. During the toddler stage, growth is still fast, but not as fast as it was during infancy. A toddler learns many new words. The child even starts putting together words in simple sentences. Motor skills

FIGURE 1.137
This baby is six months old, and his baby teeth have started to come in. Babies often chew on toys or other objects when they are getting new teeth. They may even chew on their toes.

also develop quickly during this stage. By age three, most children can run and climb steps. They can hold crayons and scribble with them. They can also feed themselves and use the toilet.

From age three until the teens, growth is slower. The body also changes shape. The arms and legs get longer compared to the trunk. Children continue to develop new motor skills. For example, many young children learn how to ride a tricycle and then a bicycle. Most also learn how to play games and sports (**Figure** 1.138). By age six, children start losing their baby teeth. Their permanent teeth begin coming in to replace them. They also start school and learn how to read and write. They develop friendships and become less dependent on their parents.

FIGURE 1.138
Children develop better motor skills as they get older.

### Vocabulary

- **childhood**: Phase of life that begins after the first year and continues until the teen years.
- **infancy**: First year of life after birth in humans.
- **toddler**: Child aged one to three years.

## Summary

- The first year after birth is called infancy, after which childhood begins.
- An individual grows quickly and develops new abilities during infancy and childhood.

## Practice

Use the resource below to answer the questions that follow.

- **Infancy Studies Laboratory** at http://www.youtube.com/watch?v=t_Y6wNWbNuE (2:07)

MEDIA
Click image to the left for more content.

1. At what age do the researchers like to see infants to study cognitive development?
2. Why is it important to establish a baseline in research of this nature?
3. How do researchers hope to use information they are collecting to help children with language problems?

## Review

1. What changes happen during infancy?
2. At what stage does a developing human grow the fastest?

# 1.75 Puberty and Adolescence

- Outline changes that occur during puberty and adolescence.

**How do you know you are entering puberty?**

The first signs of puberty appear at different times for different people. A boy might realize he's reached puberty when he starts needing to shave. A girl, on the other hand, starts getting her menstrual period during puberty.

## Puberty and Adolescence

**Puberty** is the stage of life when a child becomes sexually mature. Puberty lasts from about 12 to 18 years of age in boys and from about 10 to 16 years of age in girls.

The age when puberty begins is different from one child to another. Children that begin puberty much earlier or later than their peers may feel self-conscious. They may also worry that something is wrong with them. Usually, an early or late puberty is perfectly normal.

In boys, puberty begins when the pituitary gland tells the testes to secrete testosterone. Testosterone causes the following to happen:

1. The penis and testes grow.
2. The testes start making sperm.
3. Pubic and facial hair grow.
4. The shoulders broaden, and the voice becomes deeper.

In girls, puberty begins when the pituitary gland tells the ovaries to secrete estrogen. Estrogen causes the following to happen:

1. The uterus and ovaries grow.
2. The ovaries start releasing eggs.
3. The menstrual cycle begins.
4. Pubic hair grows.
5. The hips widen, and the breasts develop.

Boys and girls are close to the same height during childhood. In both boys and girls, growth in height and weight is very fast during puberty. But boys grow faster than girls during puberty. Their period of fast growth also lasts longer. By the end of puberty, boys are an average of 10 centimeters taller than girls.

### Adolescence

**Adolescence** is the period of life between the start of puberty and the beginning of adulthood. Adolescence includes the physical changes of puberty. It also includes many other changes. During adolescence:

- Teens develop new thinking abilities. For example, they can think about abstract ideas, such as freedom. They are also better at thinking logically. They are usually better at solving problems as well.
- Teens try to establish a sense of who they are as individuals. They may try to become more independent from their parents. Most teens also have emotional ups and downs. This is partly due to changing hormone levels.
- Teens usually spend much more time with peers than with family members (**Figure** 1.139).

## Vocabulary

- **adolescence**: Period of life between the start of puberty and the beginning of adulthood during which significant physical, mental, emotional, and social changes occur.
- **puberty**: Stage of life during which a child becomes sexually mature.


FIGURE 1.139
These teens are good friends. Like most teens, they spend more time with one another than they do with family members. These teens are volunteering at a charity event. What do you enjoy doing with your friends?

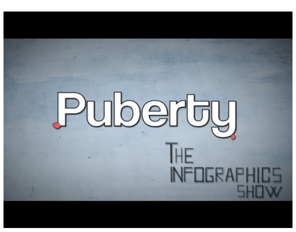
## Summary

- A child becomes sexually mature during puberty.
- Adolescence includes the physical changes of puberty among other changes.

## Practice

Use the resource below to answer the questions that follow.

- **Puberty** at http://www.youtube.com/watch?v=TRyOcLSJDzk (3:04)




MEDIA
Click image to the left for more content.

1. What is puberty? Are the first changes of puberty visible? What are they?
2. What is the average age that girls start puberty? What is one reason puberty can occur earlier for some girls?
3. What is the average age that boys start puberty? What kinds of non-physical changes may they experience?

## Review

1. What changes occur during puberty?
2. Along with physical changes, what else changes during adolescence?

# 1.76 Adulthood and Aging

- Describe the stages of adulthood.

**What does adulthood mean to you?**

You might think sometimes that you can't wait to be an adult! In adulthood you have greater freedom, but you also have greater responsibilities. Like this man, you might have a house and children to take care of.

## Adulthood

When is a person considered an adult? That depends. Most teens become physically mature by the age of 16 or so. But they are not adults in a legal sense until they are older. For example, in the U.S., you must be 18 to vote. Once **adulthood** begins, it can be divided into three stages: (1) early, (2) middle, and (3) late adulthood.

### Early Adulthood

**Early adulthood** starts at age 18 or 21. It continues until the mid-30s. During early adulthood, people are at their physical peak. They are also usually in good health. The ability to have children is greatest during early adulthood, as well.

This is the stage of life when most people complete their education. They are likely to begin a career or take a full-time job. Many people also marry and start a family during early adulthood.

### Middle Adulthood

**Middle adulthood** begins in the mid-30s. It continues until the mid-60s.

During middle adulthood, people start to show signs of aging. Their hair slowly turns gray. Their skin develops wrinkles. The risk of health problems also increases during middle adulthood. For example, heart disease, cancer, and diabetes become more common during this time. This is the stage of life when people are most likely to achieve career goals. Their children also grow up and may leave home during this stage.

### Late Adulthood

**Late adulthood** begins in the mid-60s. It continues until death. This is the stage of life when most people retire from work. They are also likely to reflect on their life. They may focus on their grandchildren.

During late adulthood, people are not as physically able. For example, they usually have less muscle and slower reflexes. Their immune system also doesn't work as well as it used to. As a result, they have a harder time fighting diseases like flu. The risk of developing diseases such as heart disease and cancer continues to rise. Arthritis is also common. In arthritis, joints wear out and become stiff and painful. As many as one in four late adults may develop Alzheimer's disease. In this disease, brain changes cause mental abilities to decrease.

Exercising the body and brain help prevent the physical and mental effects of aging. The stages of adulthood are pictured below (**Figure** 1.140).

FIGURE 1.140
This family picture shows females in each of the three stages of life. Which stage does each represent?

Despite problems such as these, many people remain healthy and active into their 80s or even 90s. Do you want to be one of them? Then adopt a healthy lifestyle now and follow it for life. Doing so will increase your chances of staying healthy and active to an old age.

## Vocabulary

- **adulthood**: Period of life after childhood.
- **early adulthood**: Period of life after adolescence that lasts until the mid-30s.
- **late adulthood**: Period of life that begins in the mid-60s and lasts until the end of life.
- **middle adulthood**: Period of life that lasts from the mid-30s to the mid-60s.

## Summary

- Adulthood is divided into the stages of early, middle, and late adulthood.
- The risk of health problems increases in middle adulthood and late adulthood.

## Practice

Use the resources below to answer the questions that follow.

- **The Owner's Manual To Adulthood** at http://www.youtube.com/watch?v=VVwhMfWRfNA (5:25)


MEDIA
Click image to the left for more content.

1. Why is it important to learn to prioritize activities?
2. What are some techniques people use to manage stress?
3. How can eating well, sleeping, and exercising help people with stress?
4. Do adults get to do whatever they want? Why or why not?

- **Late Adulthood** at http://www.youtube.com/watch?v=N6dn6LzdRkE (2:15)

MEDIA
Click image to the left for more content.

1. Does reaching late adulthood mean you have to give up physical activity?
2. Do people in late adulthood still learn new things?
3. How are other people important to people in late adulthood?

## Review

1. How are early adulthood, middle adulthood, and late adulthood defined?
2. What changes occur during late adulthood?

# 1.77 Sexually Transmitted Infections

- Describe common sexually transmitted infections.


**What is safe sex?**

Safe sex is sexual activity engaged in by people who have taken precautions to protect themselves against sexually transmitted infections. Abstaining from sexual activity, however, is the only way to be absolutely sure that you won't get a sexually transmitted infection.

## Sexually Transmitted Infections

A **sexually transmitted infection (STI)** is an infection that spreads through sexual contact. STIs are caused by **pathogens**, a living thing or virus that causes infection. The pathogens enter the body through the reproductive organs. Many STIs also spread through body fluids, such as blood. For example, a shared tattoo needle is one way an STI could spread. Some STIs can also spread from a mother to her baby during childbirth.

STIs are more common in teens and young adults than in older people. One reason is that young people are more likely to take risks. They also may not know how STIs spread. They are likely to believe myths about STIs (**Table** 1.9).

TABLE 1.9: **Sexually Transmitted Infections**

| Myth | Fact |
|---|---|
| If you are sexually active with just one person, you can't get STIs. | The only way to avoid the risk of STIs is to practice abstinence from sexual activity. |

**TABLE 1.9:** (continued)

| Myth | Fact |
|---|---|
| If you don’t have any symptoms, then you don’t have an STI. | Many STIs do not cause symptoms, especially in females. |
| Getting STIs is no big deal, because STIs can be cured with medicine. | Only some STIs can be cured with medicine; other STIs cannot be cured. |

Most STIs are caused by bacteria or viruses. STIs caused by bacteria usually can be cured with drugs called antibiotics. But antibiotics are not effective against viruses. Therefore, STIs caused by viruses are not treated with antibiotics. Other drugs may be used to help control the symptoms of viral STIs, but they cannot be cured. Once you have a viral STI, you are usually infected for life.

### Bacterial STIs

In the U.S., **chlamydia** is the most common STI caused by bacteria. Females are more likely than males to develop the infection. Rates of chlamydia among U.S. females in 2006 are shown below (**Figure** 1.141). Rates were much higher in teens and young women than in other age groups.

Chlamydia may cause a burning feeling during urination. It may also cause a discharge (leaking of fluids) from the vagina or penis. But in many cases it causes no symptoms. As a result, people do not know they are infected, so they don’t go to the doctor for help. If chlamydia goes untreated, it may cause more serious problems in females. It may cause infections of the uterus, fallopian tubes, or ovaries. These infections may leave a woman unable to have children.

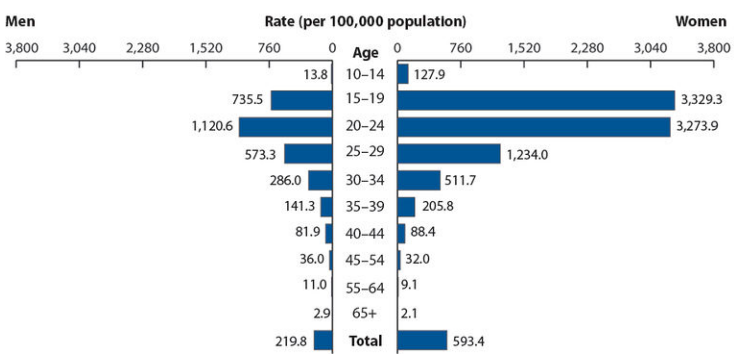



FIGURE 1.141

This graph shows data on the number of cases of chlamydia in U.S. males and females in 2009. Which two age groups had the highest rates of chlamydia? Why do you think rates were highest in these age groups?

**Gonorrhea** is another common STI. Gonorrhea may cause pain during urination. It may also cause a discharge from the vagina or penis. On the other hand, some people with gonorrhea have no symptoms. As a result, they don’t seek treatment. Without treatment, gonorrhea may lead to infection of other reproductive organs. This can happen in males as well as females.

**Syphilis** is a very serious STI. Luckily, it is less common than chlamydia or gonorrhea. Syphilis usually begins with a small sore on the genitals. This is followed a few months later by a rash and flu-like symptoms. If syphilis is not treated, it may damage the heart, brain, and other organs. It can even cause death.

### Viral STIs

Genital warts are an STI caused by human papilloma virus, or **HPV**. They are one of the most common STIs in teens. HPV infections cannot be cured. But a new vaccine called Gardasil® can prevent most HPV infections in females. Many doctors recommend that females between the ages of 9 and 26 years receive the vaccine. Preventing HPV infections in females is important because HPV can also cause cancer of the cervix.

A related herpes virus causes cold sores on the lips (**Figure** 1.142). Both viruses cause painful blisters. In the case of **genital herpes**, the blisters are on the penis or around the vaginal opening. The blisters go away on their own, but the virus remains in the body. The blisters may come back repeatedly, especially when a person is under stress. There is no cure for genital herpes. But drugs can help prevent or shorten outbreaks. Researchers are trying to find a vaccine to prevent genital herpes.

FIGURE 1.142
This lip blister, or cold sore, is caused by a herpes virus. The virus is closely related to the virus that causes genital herpes. The genital herpes virus causes similar blisters on the genitals. If you've ever had a cold sore, you know how painful they can be. Genital herpes blisters are also painful.

**Hepatitis B** is a disease of the liver. It is caused by a virus called hepatitis B, which can be passed through sexual activity. Hepatitis B causes vomiting. It also causes yellowing of the skin and eyes. The disease goes away on its own in some people. Other people are sick for the rest of their lives. In these people, the virus usually damages the liver. It may also lead to liver cancer. Medicines can help prevent liver damage in these people. There is also a vaccine to protect against hepatitis B.

**HIV** stands for "human immunodeficiency virus." It is the virus that causes AIDS. HIV and AIDS are described in a previous lesson. HIV can spread through sexual contact. It can also spread through body fluids such as blood. There is no cure for HIV infection, and AIDS can cause death, although AIDS can be delayed for several years with medication. Researchers are trying to find a vaccine to prevent HIV infection.

### Vocabulary

- **chlamydia**: Sexually transmitted bacterial infection; the most common STI caused by a bacteria.
- **genital herpes**: Sexually transmitted infection caused by a herpes virus; characterized by periodic outbreaks of blisters on the genitals.
- **gonorrhea**: Common sexually transmitted infection caused by bacteria.
- **hepatitis B**: Inflammation of the liver caused by infection with hepatitis B virus; often transmitted through sexual contact.
- **HIV**: Human immunodeficiency virus; virus that causes AIDS.
- **HPV**: Sexually transmitted virus that causes genital warts and cervical cancer.
- **pathogen**: Living thing or virus that causes disease.
- **sexually transmitted infection (STI)**: Infection caused by a pathogen that spreads mainly through sexual

contact.
- **syphilis**: Sexually transmitted infection caused by bacteria that may eventually be fatal if untreated.

## Summary

- Sexually transmitted infections (STIs) are caused by pathogens. They spread through sexual contact or other exchanges of body fluids.
- Examples of STIs caused by bacteria include chlamydia, gonorrhea, and syphilis.
- Examples of STIs caused by viruses include HPV, genital herpes, hepatitis B, and AIDS.

## Practice

Use the resource below to answer the questions that follow.

- **Sexually Transmitted Infections** at http://www.youtube.com/watch?v=OfGYFKxMCRg (4:57)


MEDIA
Click image to the left for more content.

1. How many cases of sexually transmitted infections occur in the United States every year?
2. What can untreated chlamydial and gonococcal infection lead to? How can this have long term effects on people?
3. What does HPV cause?
4. Why might living in an urban area increase a person's chance of contracting a sexually transmitted infection? Do you think this situation is different for non-sexually transmitted infections? Explain your reasoning fully.
5. What are some ways to minimize the risk of contracting a sexually transmitted infection?

## Review

1. It is especially important for females to be protected from HPV infections. Why is this the case?
2. Explain why bacterial STIs are treated differently than viral STIs.

# 1.78 Non-Infectious Reproductive System Disorders

- Identify other reproductive system disorders.

**Why should women perform a monthly breast self-exam?**

If you are a young woman, getting in the habit of performing a monthly breast self-exam is a good idea. Lumps or other subtle changes in the breasts may indicate breast cancer. The outcome is typically better if breast cancer is caught and treated early.

## Other Reproductive System Disorders

Many disorders of the reproductive system are not sexually transmitted infections. They are not caused by pathogens, so they don't spread from person to person. They develop for other reasons. The disorders are different between males and females. In both genders, the disorders could cause a little discomfort, or they could cause death.

### Disorders in Males

Most common disorders of the male reproductive system involve the testes. For example, injuries to the testes are very common. In teens, injuries to the testes most often occur while playing sports. An injury such as a strike or kick to the testes can be very painful. It may also cause bruising and swelling. Such injuries do not usually last very long.

Another disorder of the testes is **cancer**. Cancer of the testes is most common in males aged 15 to 35. It occurs when cells in the testes grow out of control. The cells form a lump called a tumor. If found early, cancer of the testes usually can be easily cured with surgery.

### Disorders in Females

Disorders of the female reproductive system may affect the vagina, uterus, or ovaries. They may also affect the breasts.

One of the most common disorders is **vaginitis**. This is redness and itching of the vagina. It may be due to irritation by soap or bubble bath (**Figure** 1.143). Another possible cause of vaginitis is a yeast infection. Yeast normally grow in the vagina. A **yeast infection** happens when the yeast multiply too fast and cause symptoms. A yeast infection can be treated with medication.

FIGURE 1.143
Bubble baths may be fun, but for women and girls they can cause irritation to the vagina.

A common disorder of the ovaries is an **ovarian cyst**. A cyst is a sac filled with fluid or other material. An ovarian cyst is usually harmless, but it may cause pain. Most cysts slowly disappear and do not need treatment. Very large or painful cysts can be removed with surgery.

Many teen girls have painful menstrual periods. They typically have cramping in the lower abdomen. Generally, this is nothing to worry about. Taking a warm bath or using a heating pad often helps. Exercise can help as well. A pain reliever like ibuprofen may also work. If the pain is severe, a doctor can prescribe stronger medicine to relieve the pain.

The most common type of cancer in females is **breast cancer**. The cancer causes the cells of the breast to grow out of control and form a tumor. Breast cancer is rare in teens. It becomes more common as women get older. If breast cancer is found early, it usually can be cured with surgery.

## Vocabulary

- **breast cancer**: Cancer causing abnormal growth in the cells of the breast.
- **cancer**: Disease that causes cells to divide out of control.
- **ovarian cyst**: Sac filled with fluid or other material within the ovary.
- **vaginitis**: Redness, discomfort, and itching of the vagina.
- **yeast infection**: Condition in which yeast multiply too quickly and cause discomfort in the vagina.

## Summary

- In males, disorders of the reproductive system include injuries to the testes and cancer of the testes.
- In females, disorders of the reproductive system include vaginitis and breast cancer.

## Practice

Use the resources below to answer the questions that follow.

- **Testicular Cancer** at http://www.youtube.com/watch?v=o63hl15cgpI (4:20)

MEDIA
Click image to the left for more content.

1. Testicular cancer is the most common form of cancer for what age group of men?
2. What is the most common sign of testicular cancer? What is it sometimes mistaken for?
3. How treatable is testicular cancer? What kinds of treatment are used?
4. What are the causes of testicular cancer?
5. What is the highest identified risk factor for contracting testicular cancer?

- **Ovarian Cysts** at http://www.youtube.com/watch?v=GH3YJrP0KC4 (1:26)

MEDIA
Click image to the left for more content.

1. What are ovarian cysts? What causes them?
2. Are all ovarian cysts cancerous?
3. What symptoms can ovarian cysts cause?
4. When may surgical removal of ovarian cysts be necessary?

## Review

1. What is an example of a common disorder of the male reproductive system?
2. What is an example of a common disorder of the female reproductive system?

# 1.79 Reproductive System Health

- List ways to keep the reproductive system healthy.


**What protective equipment do these boys need?**

Along with shin guards, a protective cup is useful in preventing injuries. A kicked ball or kick to the groin can really hurt. Wearing a protective cup also prevents a potentially serious injury to the testes.

## Keeping the Reproductive System Healthy

What can you do to keep your reproductive system healthy? You can start by making the right choices for overall good health. To be as healthy as you can be, you should:

- Eat a balanced diet that is high in fiber and low in fat.
- Drink plenty of water.
- Get regular exercise.
- Maintain a healthy weight.
- Get enough sleep.
- Avoid using tobacco, alcohol, or other drugs.
- Manage stress in healthy ways.

Keeping your genitals clean is also very important. A daily shower or bath is all that it takes. Females do not need to use special feminine hygiene products. In fact, using them may do more harm than good because they can irritate the vagina or other reproductive structures.

You should also avoid other behaviors that can put you at risk. Do not get into contact with another person's blood or other body fluids. For example, never get a tattoo or piercing unless you are sure that the needles have not been used before.

If you are a boy, you should always wear a protective cup when you play contact sports. Contact sports include football, soccer, and hockey. Wearing a cup will help protect the testes from injury. You should also do a monthly self-exam to check for cancer of the testes (**Figure** 1.144).

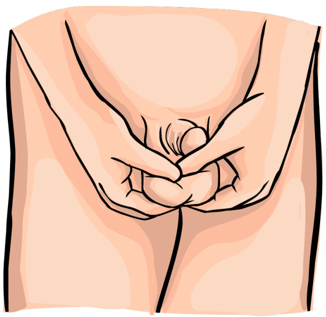


FIGURE 1.144
Teen boys should learn how to examine their testes for lumps that could be a sign of cancer.

If you are a girl and use tampons, be sure to change them every four to six hours. Leaving tampons in for too long can put you at risk of **toxic shock syndrome**. This is a serious condition.

You should also get in the habit of doing a monthly self-exam to check for breast cancer. Although breast cancer is rare in teens, it's a good idea to start doing the exam when you are young. It will help you get to know what is normal for you.

## Vocabulary

- **toxic shock syndrome**: Potentially fatal illness caused by leaving tampons in too long.

## Summary

- To keep the reproductive system healthy, keep the genitals clean and avoid coming into contact with body fluids, like blood or semen.
- To check for cancer, women should perform monthly self-exams of their breasts, and men should perform monthly self-exams of their testes.

## Practice

Use the resource below to answer the questions that follow.

- **Nutrition** at http://www.youtube.com/watch?v=uk_IJ6UWI7M (4:19)

MEDIA
Click image to the left for more content.

1. Think of what you have learned about the functioning of the human body? Think of all the amazing things it can do. Why do you think nutrition underlies so many things?
2. Why do you think multiple small meals a day is better for your body than a few large meals?
3. Why do you think the human body seems to "get used to" whatever kind of food it is eating? Think in terms of all the different metabolic pathways you have learned about.

### Review

1. What is the purpose of a monthly self-exam of the testes?
2. Explain how girls can reduce their risk of developing toxic shock syndrome.

## Summary

The human body. Made of numerous organ systems. Maybe one of the most complex structures ever. But all these systems and structures come together in an exquisite manner to make a fascinating organism. Currently, the end of the line of evolution. The most intelligent of all organisms. An organism that can protect itself from pathogens, has bones for support, muscles to help it move, systems that allow it to respond to the environment, systems to bring oxygen into and around the body, systems to extract nutrients from food and get rid of wastes, and systems to make the next generation. And all these systems and organs and tissues and cells work together to form one complete organism.

# 1.80 References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