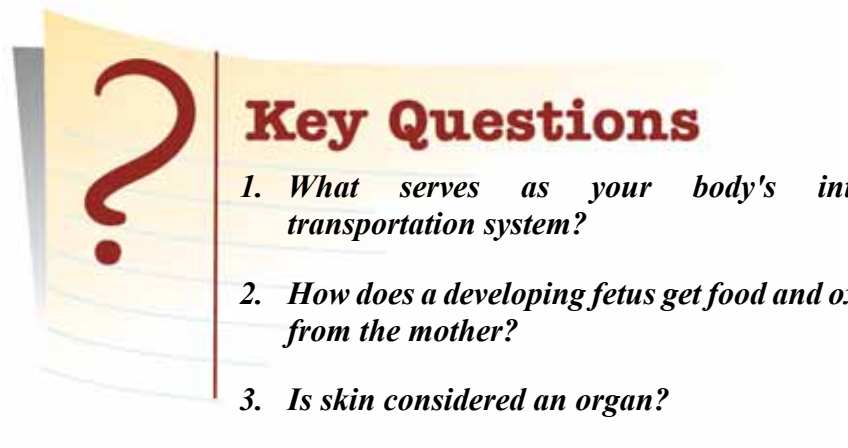
Chapter 16

Human Body Systems

The human body is a busy place! Even when you are sitting down and reading a book, your body's organ systems are actively carrying out their jobs. Your heart beats an average of 70 times each minute, pumping blood to all parts of your body. Your lungs repeatedly take in and expel air. Your skin is constantly shedding dead cells and growing new ones. Your digestive system is working on the last meal you ate. Even when you sleep, your body's systems are at work. Read this chapter to learn all about how circulation, respiration, reproduction, digestion, and other systems work in the human body.



Key Questions

1. ***What serves as your body's internal transportation system?***
2. ***How does a developing fetus get food and oxygen from the mother?***
3. ***Is skin considered an organ?***

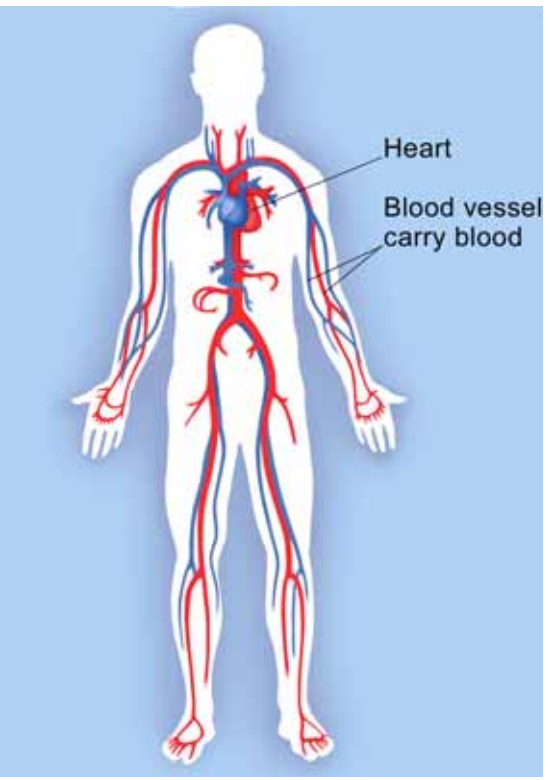
16.1 Circulation and Respiration

You're an animal! To be more specific, you're a mammal. Mammals have complex organ systems. These include skeletal, muscular, digestive, urinary, integumentary, nervous, reproductive, and endocrine systems. **All of your organ systems function because of the contributions of organs, tissues, and cells.** We will begin our study of the human body with the *circulatory* and *respiratory* systems.

The circulatory system

What is the circulatory system?

Your body is made of trillions of cells. Each cell needs oxygen and nutrients. As your cells carry out their functions, they need to get rid of wastes like carbon dioxide. How do substances move to and from your cells? Your body has a transportation system. The **circulatory system** transports blood throughout the body, delivers essential substances to cells, and removes wastes. It is sometimes called the *cardiovascular system*. The circulatory system consists of the *heart*, *blood vessels*, and *blood*.



STUDY SKILLS

Table 15.1 on page 323 gives information about the major organ systems. Use the table to make a set of flash cards. Write the name of a body system on one side of each card. Write its function and major organs on the other side of the card. Use the cards to remember the function and organs of each system.

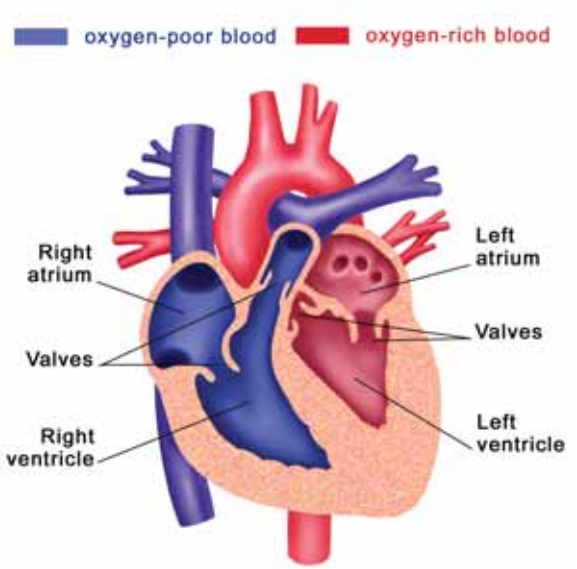
VOCABULARY

circulatory system - the body system that circulates blood throughout the body and delivers essential substances to cells and removes wastes.

The heart

Structure of the heart

What pumps over two million liters of blood per year and weighs only 300 grams? Your heart, of course! The *heart* is a hollow organ found in the middle of your chest. It is made mostly of *cardiac muscle tissue*. The heart *contracts* to pump blood throughout the body. A *contraction* happens when muscle tissue shortens. The right and left sides of the heart have separate functions. The right side of the heart collects oxygen-poor blood from the body and pumps it to the lungs where it picks up oxygen and releases carbon dioxide. The left side of the heart then collects oxygen-rich blood from the lungs and pumps it to the body so that every cell in the body has the oxygen it needs.



Blood flow through the heart

The heart has four chambers (Figure 16.1). Each chamber has a one-way valve at its exit. A **valve** is a flap of tissue that prevents the backflow of blood. When each chamber contracts, the valve at its exit opens. When a chamber relaxes, the valve closes so that blood does not flow backwards. The heart contracts (or beats) in two stages. This causes the *lub-dub* sound you hear. In the first stage the atria contract together. This pumps blood to the ventricles. In the second stage, the ventricles contract together. This pumps blood out of the heart. Then the heart muscle relaxes before the next heartbeat. This allows blood to flow into the atria again.

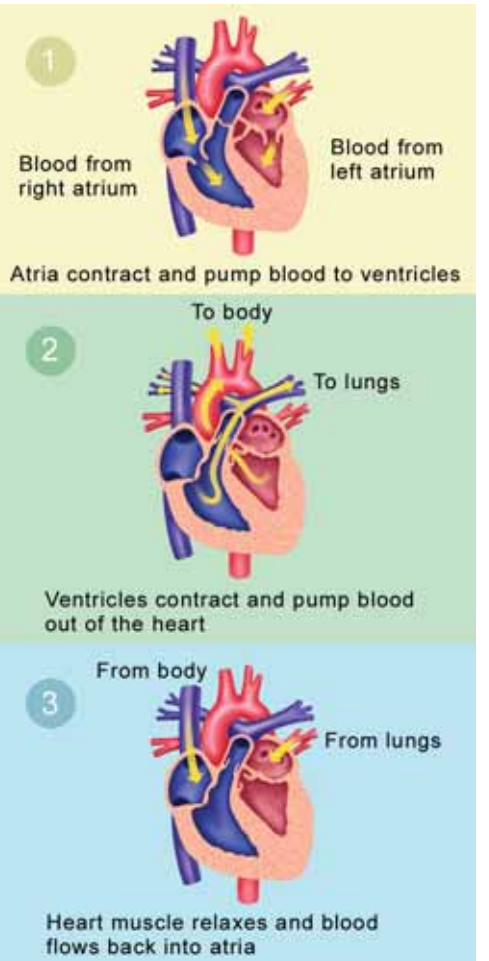


Figure 16.1: *The heart is a muscle that consists of four chambers and a valve between each chamber.*

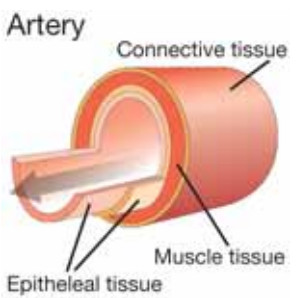
VOCABULARY

valve - a flap of tissue that prevents the backflow of blood.

Blood vessels

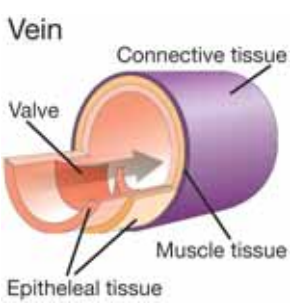
Blood vessels are organs that carry the blood throughout your body. There are three types of blood vessels: arteries, capillaries, and veins. Figure 16.2 shows the structure of these blood vessels.

Arteries **Arteries are blood vessels that carry blood from the heart.** With the exception of the pulmonary artery, they carry oxygen-rich blood. Each time the heart contracts, blood is pumped out at high pressure. Arteries are made of three layers of tissues that help them withstand that pressure. The lining is epithelial tissue. Next is a thick layer of smooth muscle that helps the artery withstand high pressure. The outer layer is made of elastic connective tissue that allows the artery to expand under pressure.



Capillaries **Capillaries are the smallest blood vessels where the exchange of materials with cells takes place.** Capillary walls are only one cell thick and may be so narrow that blood cells must pass through in single file. They form a net-like structure throughout your tissues. Oxygen and other materials diffuse through capillary walls into the tissues and then into cells.

Veins **Veins are blood vessels that carry blood toward the heart.** With the exception of the pulmonary veins, they carry oxygen-poor blood. Like arteries, veins have three tissue layers. But veins have thinner walls because they do not receive blood directly from the heart. The largest veins have one-way valves to keep blood flowing toward the heart.



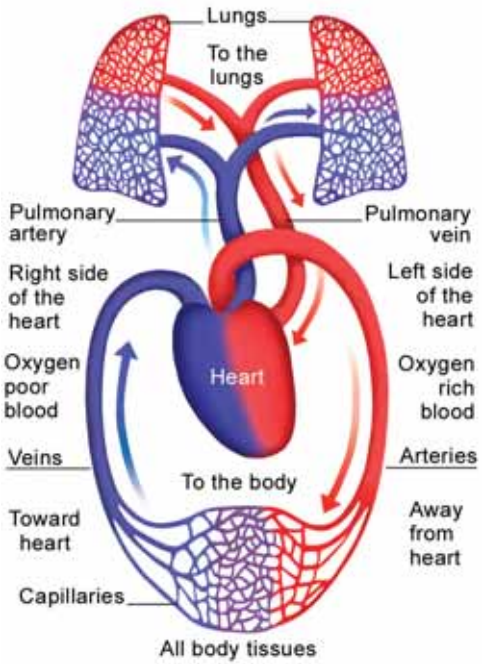


Figure 16.2: *The blood vessel system.*

VOCABULARY

arteries - blood vessels that carry blood away from the heart.

capillaries - the smallest blood vessels where the exchange of materials with cells takes place.

veins - blood vessels that carry blood toward the heart.

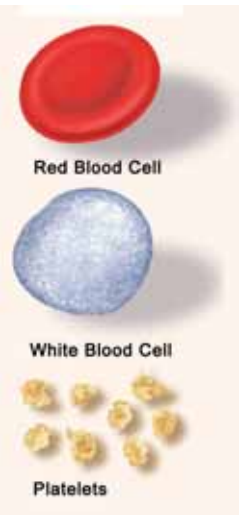
Blood

The function of blood

You have about 5 liters of blood in your body. **Blood** is a circulating connective tissue. It is made of a fluid called plasma, two types of cells (red blood cells and white blood cells), and particles called platelets. The main function of blood is to supply oxygen and nutrients to tissues and to remove waste products like carbon dioxide. Blood also transports hormones, enzymes, and immune cells between tissues and organs. Any interruption in the flow of blood can cause death in a matter of minutes. Interruptions in blood flow may be caused by a heart attack, stroke, or blood clots.

Plasma

About 55 percent of your blood is plasma. **Plasma** is the fluid part of the blood that contains water, dissolved nutrients, sugars, and proteins. Floating in the plasma are red blood cells, white blood cells and platelets.



Red blood cells

About 45 percent of your blood is made of red blood cells. **Red blood cells** transport oxygen to your cells. Red blood cells are red because of a pigment called hemoglobin. Hemoglobin grabs onto the oxygen molecules you inhale and carries them to your cells.

White blood cells and platelets

White blood cells and platelets make up a tiny fraction of your blood. **White blood cells** are part of your *immune system*. They help fight infections by destroying invaders like bacteria and viruses. Some white blood cells engulf invaders. Others produce antibodies that destroy invaders. *Platelets* are particles that prevent blood loss. When you cut or scrape your skin, platelets clump together in the damaged area and form a "plug."

VOCABULARY

blood - a circulating connective tissue made of plasma, cells, and platelets.

plasma - the fluid part of blood.

red blood cells - carry oxygen to cells.

white blood cells - immune cells that destroy invaders.

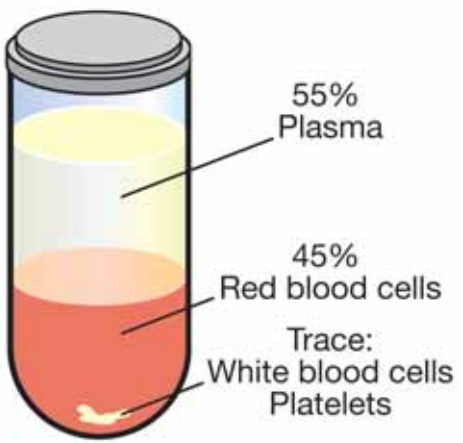


Figure 16.3: *The components of blood.*

Blood pressure

Heart contractions and blood pressure

Did you know that your blood circulates through about 90,000 kilometers of blood vessels in your body? Each heart beat pushes about 90 milliliters of oxygenated blood from the heart into the *aorta*, the body's largest blood vessel. From there, the blood flows to smaller arteries and then capillaries. Eventually, it transfers its oxygen to body cells and returns back to the heart through the veins. Contractions of the heart generate *blood pressure*. The rhythmic change in blood pressure is called a *pulse*. Blood pressure keeps the blood flowing in the right direction. Valves prevent backflow of blood.

Heart contractions generate blood pressure.

What is blood pressure?

Blood pressure is a measure of the force of blood pushing against the walls of the arteries. It is measured in *millimeters of mercury* (mm Hg). A pressure of 100 mm Hg means the pressure is great enough to push a narrow column of mercury 100 mm high. Normal blood pressure is 120/80 mm Hg. The top number is called the systolic pressure. *Systolic pressure* is the maximum force exerted against artery walls each time the heart contracts. The lower number is called diastolic pressure. *Diastolic pressure* is the force exerted on the arteries when the heart relaxes (Figure 16.4).

How to measure blood pressure

A *sphygmomanometer* is used to measure blood pressure. The cuff is pumped up with air to restrict blood flow in the arm. As the pressure in the cuff is released, blood starts flowing again. You can hear the flow in a stethoscope. The number at which blood starts flowing is the measure of the systolic pressure. Pressure in the cuff continues to release. The point at which no sound is heard indicates the pressure in the system when the heart is relaxed—the diastolic reading.

VOCABULARY

blood pressure - a measure of the force of the blood pushing against the walls of the arteries.

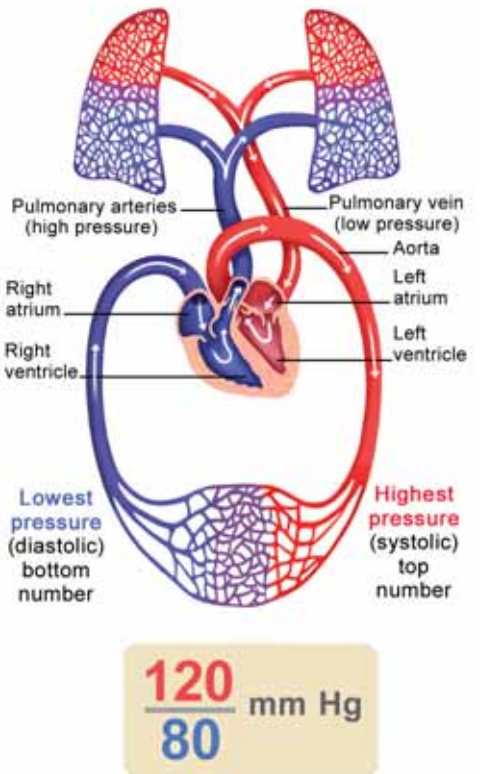


Figure 16.4: *Systolic and diastolic blood pressure.*

The respiratory system

Breathing and respiration

Do you ever notice your breathing? Probably not. Your breathing happens even when you don't think about it. When you breathe, you take in oxygen gas from the air and exhale carbon dioxide gas and water vapor. Your cells use the oxygen for cellular respiration and produce carbon dioxide and water. **Respiration** is the entire process by which the body exchanges and uses gases. Respiration is made possible by the respiratory system. The **respiratory system** consists of the lungs, and passageways that lead to the lungs.

VOCABULARY

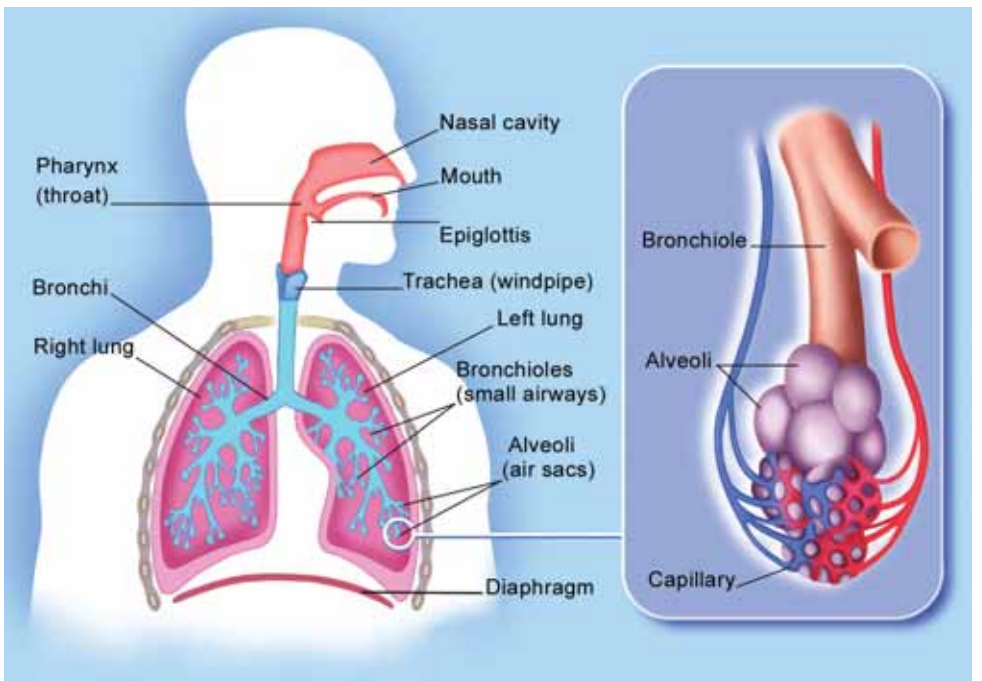
respiration - the entire process by which the body takes in oxygen and gets rid of carbon dioxide and water.

respiratory system - the body system consisting of the lungs, and passageways that lead to the lungs.

alveoli - tiny, sac-like structures of the lungs that are surrounded by capillaries where gas exchange takes place.

Structure and function of the respiratory system

The diagram to the right shows the organs of the respiratory system. When you breathe, air is inhaled through your *nose* and *mouth*. From there, it flows through the pharynx, or throat. The *pharynx* branches into two tubes. The esophagus leads to your stomach. The *larynx*, leads to your lungs. The larynx also contains your voice box. Next, air flows into the trachea, or windpipe. The *trachea* splits into two tubes called *bronchi*. One bronchus (singular) goes to each lung. Each bronchus branches into thousands of tiny tubes called *bronchioles*. Bronchioles end in tiny sacs called alveoli. Each of your lungs contains thousands of alveoli. **Alveoli** are sac-like structures surrounded by capillaries where the exchange of gases takes place. The *diaphragm* is a sheet of muscle that helps draw air into the lungs.



Putting it all together: tracing blood flow

Failure of any part can affect the entire system

Your circulatory and respiratory systems work together to ensure that every cell in your body has the oxygen it needs to perform cellular respiration. **The failure of any part can affect the entire system.** For example, a person may die from a heart attack (failure of the heart). Smoking may lead to inefficient gas exchange in the lungs and cause cardiovascular disease. Blockage of blood vessels may lead to inefficient gas exchange in the brain and cause a stroke. To understand the system, we can trace the flow of blood, starting at the heart. Follow the numbers in Figure 16.5 as you read the following paragraph.

Tracing blood through the system

All blood enters the right side of the heart through two veins. The *superior vena cava* carries oxygen-poor blood from the upper body parts. The *inferior vena cava* carries oxygen-poor blood from the lower body parts (**1**). When the right atrium contracts, the blood goes through a valve and into the right ventricle (**2**). When the right ventricle contracts, blood is pumped through a valve and into the *pulmonary artery* (**3**). From there, blood flows into the lungs where it picks up oxygen (**4**). The now oxygen-rich blood is carried back to the left atrium through the *pulmonary veins* (**5**). When the left atrium contracts, blood goes through a valve into the left ventricle (**6**). When the left ventricle contracts, blood is pumped through a valve and into the *aorta* (**7**). The aorta branches into arteries that lead to upper and lower parts of the body (**8**). Those arteries branch into smaller and smaller arteries and into capillaries (**9**). In the capillaries, blood cells release their oxygen which diffuses into tissues. Carbon dioxide and water are picked up from the body cells. The now oxygen-poor blood flows through the capillaries and into small veins (**10**). Smaller veins lead to larger veins and eventually to the superior and inferior vena cava. This is where the cycle begins again.

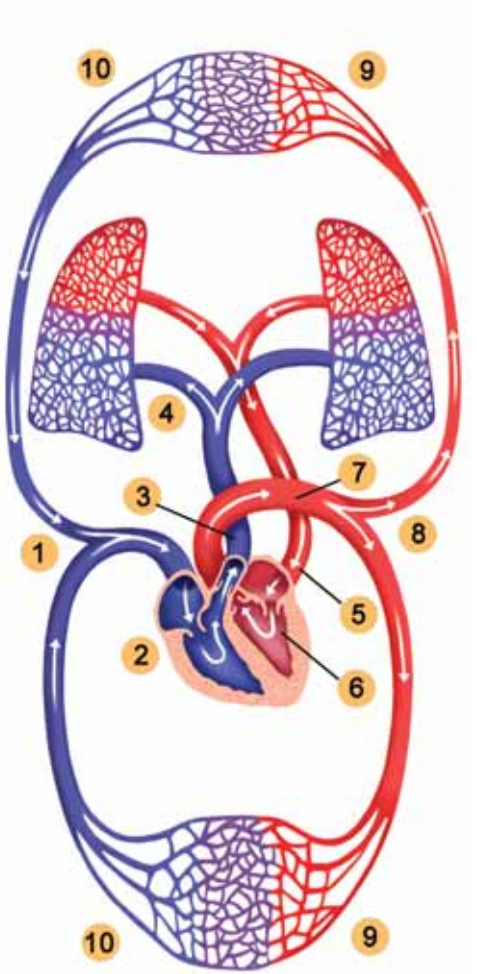


Figure 16.5: *The numbers in the diagram correspond to the numbers in the text to the left. Follow the numbers as you read the text.*

16.1 Section Review

1. What are the organs of the circulatory system?
2. What is the function of the right side of the heart? What is the function of the left side of the heart?
3. What is a valve? What is the function of a valve?
4. What causes the *lub-dub* sound of your heartbeat?
5. Match each component of the circulatory system with its function:

Organ system	Function
1. blood	a. pump blood
2. arteries	b. carry oxygen
3. red blood cells	c. prevent blood loss
4. capillaries	d. carry oxygen-poor blood to the heart
5. heart	e. transport gases and nutrients
6. veins	f. protect the body from invaders
7. white blood cells	g. carry oxygen-rich blood to the body
8. platelets	h. carry gases and nutrients into tissues

6. Why do the wall of arteries need to be thicker than the walls of veins?
7. Describe the structure of the lungs. Use the words bronchi, bronchioles, alveoli, and capillaries in your description.
8. Explain why each event could cause damage to your body:
   a. heart attack
   b. smoking
   c. stroke

CHALLENGE

Draw a flow chart that traces a drop of blood through your body. Use the following terms in your flow chart:

right ventricle

left ventricle

right atrium

left atrium

capillaries

arteries

veins

superior and inferior vena cava

aorta

pulmonary artery

pulmonary veins

lungs

oxygen-rich blood

oxygen-poor blood

16.2 Human Reproduction

Like most animals, humans reproduce sexually. As you have read, you started out as a single, fertilized egg called a zygote. The egg came from your mother and the sperm came from your father. In this section, you will learn about the process of human reproduction.

VOCABULARY

testes - produce sperm and testosterone.

hormone - a chemical that regulates body functions.

semen - a mixture of sperm and fluid that is ejaculated during sexual intercourse.

The male reproductive system

The components of the male reproductive system

Figure 16.6 shows the organs of the male reproductive system. **The male reproductive system produces sperm and transfers it to the female reproductive system.** The **testes** produce sperm and the male hormone, *testosterone*. A **hormone** is a chemical that regulates body functions. Testosterone regulates the development of male traits and the production of sperm (male sex cells). The testes are stored in the external *scrotum*. The scrotum is about 3°C cooler than body temperature (37°C). The cooler temperature allows sperm to develop. Sperm are produced in tightly-coiled tubes inside of the testes called *seminiferous tubules*. The *epididymis* temporarily stores mature sperm cells. Each sperm cell has a flagellum (shown left).

The path of sperm

A tube called the *vas deferans* passes from each epididymis into the body. The *prostate gland* produces some of the fluid that mixes with sperm as it travels through the vas deferans. The mixture of sperm and fluid is called **semen**. During sexual arousal, millions of sperm travel from the vas deferans, down the urethra, and are ejaculated out of the penis. *Ejaculation* is the abrupt discharge of semen. The *urethra* is a tube that runs through the penis. The penis is the organ that transfers sperm into the female's body.

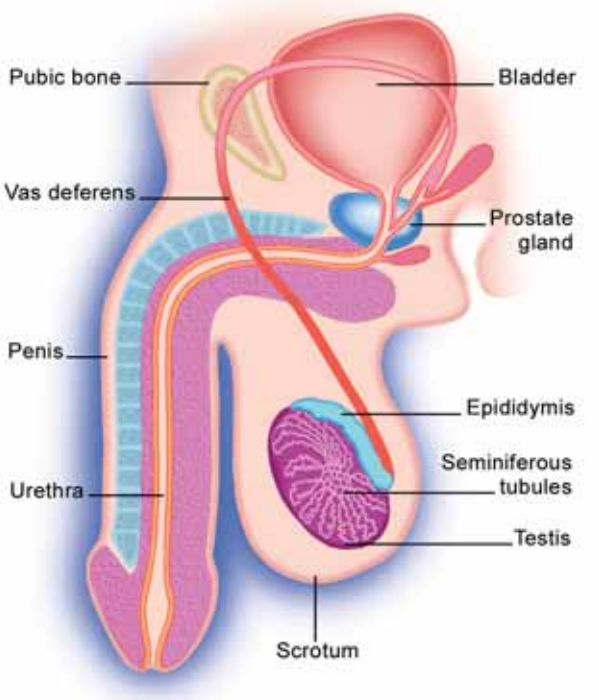


Figure 16.6: *The male reproductive system.*

The female reproductive system

The components of the female reproductive system

Figure 16.7 shows the female reproductive system. **The female reproductive system produces eggs, ensures development of fertilized eggs, and gives birth.** The ovaries are about the size of a large olive. **Ovaries** produce the eggs, also called *oocytes*. Ovaries also produce the female hormones *estrogen* and *progesterone*. The female hormones regulate the production and release of eggs and regulate the development of female traits. The *vagina* is the passageway that receives sperm during sexual intercourse.

Ovulation

Puberty is the time of life when male and female sex organs become mature. A woman has an estimated 300 to 400 thousand eggs contained within her ovaries at the time of puberty. At puberty, a woman begins to ovulate. **Ovulation** is the release of a mature egg from the ovary. An egg matures in a structure of the ovary called a **follicle**. During ovulation, a mature follicle ruptures through the ovary wall. Once released, the egg travels down one of the fallopian tubes that lead to the uterus. The **uterus** is the organ where a baby grows and develops.

The menstrual cycle

Each month starting at puberty, the tissue lining the uterus thickens to prepare for pregnancy. If fertilization occurs, the zygote moves down the fallopian tube and embeds in the thickened tissue. If fertilization does not occur, the egg deteriorates. Then, the tissue layer, along with the deteriorated egg, is discharged through the vagina. This process is called *menstruation* and lasts for about 5 days. After menstruation, the tissue lining the uterus thickens again. Ovulation occurs about two weeks into the cycle. The entire process is called the *menstrual cycle*. It repeats each month from puberty until late middle age.

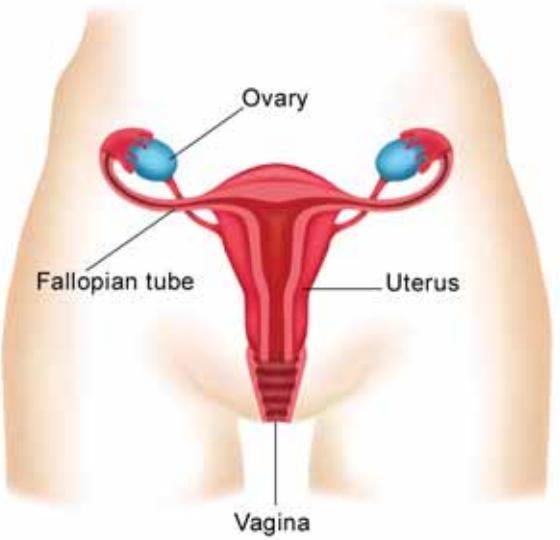


Figure 16.7: *The female reproductive system.*

VOCABULARY

ovaries - female organs that produce eggs and female hormones.

ovulation - the release of a mature egg from the ovary.

follicle - a structure of the ovary where an egg matures.

uterus - the organ where a baby grows and develops.

Fertilization and pregnancy

The start of the human reproductive process

The human reproductive process begins when a man ejaculates sperm into a woman's vagina during sexual intercourse. Some sperm may exit the penis before ejaculation occurs. Thus, sexual activity that does not involve ejaculation could also lead to the release of sperm into the vagina, fertilization, and pregnancy.

What happens during fertilization

Figure 16.8 shows the process that occurs from fertilization to pregnancy. Once inside the vagina, many sperm die because of the acidic environment. Surviving sperm use their flagella to swim through the uterus and up the fallopian tube. When they reach the egg, the sperm surround it. They release an enzyme that breaks down the proteins in the egg's outer covering. As soon as a single sperm gets through that covering, a reaction occurs that keeps any other sperm from entering. The membrane of the egg then fuses with the sperm. Next, the sperm's flagellum and mitochondria break down. At that point, the sperm is only a nucleus. This explains why all mitochondrial DNA is inherited from the mother, as you read in Chapter 10. When the sperm and egg nuclei fuse, fertilization is complete.

Implantation

The fertilized egg then begins a 5 day journey down the fallopian tube toward the uterus. During the journey, the zygote undergoes many mitotic divisions. By the time it reaches the uterus, it is an embryo that looks like a tiny ball of cells. The next step is called implantation. In **implantation**, the tiny embryo becomes embedded in the lining of the mother's uterus. Implantation is successful only about 30 percent of the time. Once the embryo is implanted, *pregnancy* begins. One of the first signs of pregnancy is that a woman's regular menstrual cycle stops. A pregnant woman may give birth to a baby between 38 and 42 weeks later which is the gestation period for humans.

VOCABULARY

implantation - the process in which an embryo becomes embedded in the lining of the uterus.

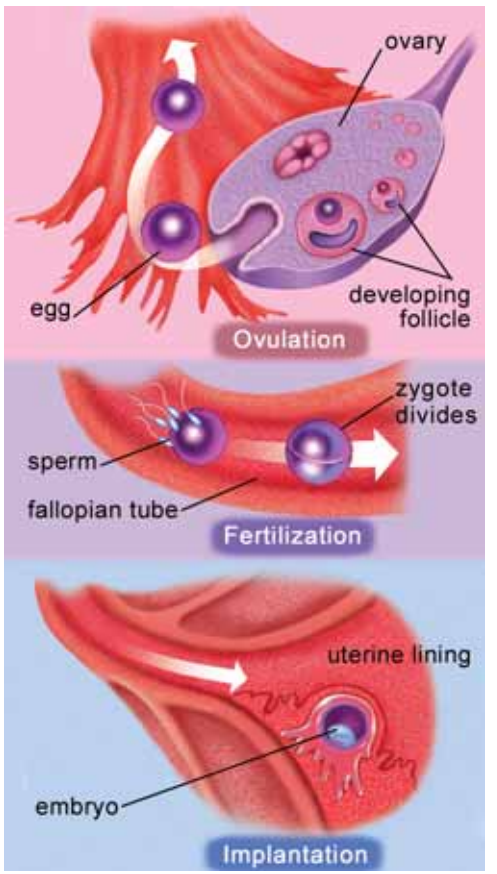


Figure 16.8: *From fertilization to implantation.*

Development and birth

The placenta and umbilical cord

Once the embryo is implanted in the uterus, the placenta begins to grow. Recall that the *placenta* supplies food and oxygen from the mother's blood to the developing embryo. It contains a network of blood vessels that links the embryo to the mother. By the fourth week of pregnancy, the embryo is about 2 millimeters long. It is surrounded by a thin, protective membrane called the *amnion*. Inside the amnion and surrounding the embryo, is *amniotic fluid* that protects the embryo from shocks. The **umbilical cord** has also formed. It contains arteries and veins that connect the embryo to the placenta. It enters the embryo's body at the *umbilicus*, or naval.

The developing fetus

At the eighth week, the embryo has developed enough to be called a **fetus**. A human fetus develops from the end of the eighth week of pregnancy (when the major structures have formed), until birth. Figure 16.9 shows a fetus and the structures that connect it to the mother. The blood of the mother and fetus do not mix together. Oxygen and nutrients pass from the mother's blood to the fetus through the placenta and umbilical cord. Waste products like carbon dioxide pass from the fetus to the mother's blood for removal. Most drugs and alcohol can easily pass through the placenta and into the fetus, as well as many infectious viruses such as the human immunodeficiency virus (HIV).

Labor and birth

After 38 to 42 weeks, the fetus is ready to live outside of the mother. The mother goes through a series of contractions called *labor*. The fetus is pushed, headfirst, through her vagina. The baby is still connected to the placenta by the umbilical cord. When the doctor ties and cuts the umbilical cord, *birth* is complete. The mother continues with labor until the placenta is pushed out of her body.

VOCABULARY

umbilical cord - contains arteries and veins that connect the embryo to the placenta.

fetus - an embryo that has developed for 8 weeks and has formed the major structures.

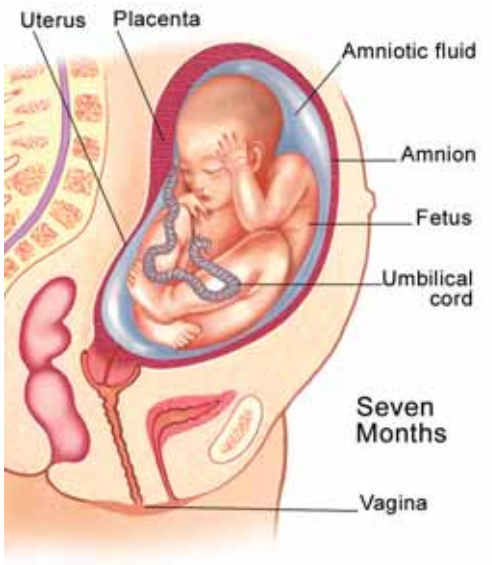


Figure 16.9: *The structures surrounding the fetus.*

16.2 Section Review

1. Match the parts of the male reproductive system listed below, to the letters on the diagram in Figure 16.10.
   urethra, *epididymis*, *testes*, *penis*, *vas deferans*, *scrotum*, *seminiferous tubules*
2. What is a hormone? Name the male hormone and the female hormones.
3. Match the parts of the female reproductive system listed below to the letters on the diagram in Figure 16.11.
   uterus, *ovary*, *fallopian tube*, *vagina*
4. Match each structure to its function.

Structure	Function
1. testes	a. links the mother to the embryo
2. ovaries	b. connects the fetus to the placenta
3. follicle	c. produces fluid that makes up semen
4. prostate gland	d. produces sperm
5. uterus	e. organ where the baby grows and develops
6. placenta	f. contains a developing egg
7. umbilical cord	g. produces eggs

5. Describe the sequence of events that occurs during fertilization.
6. What is implantation? Why is it a necessary step to pregnancy?
7. Why are materials exchanged between mother and fetus through the placenta?
8. Why do doctors advise women to not drink alcohol during pregnancy?

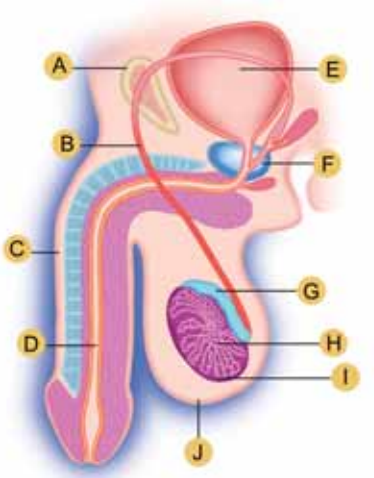


Figure 16.10: *Match the terms in question 1 to the letters in the diagram.*

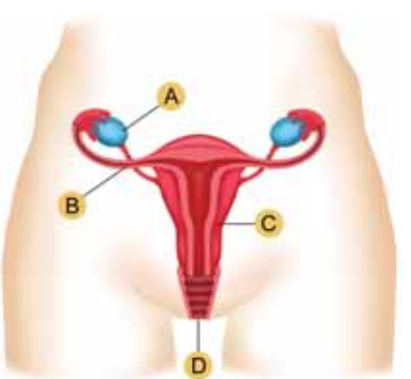


Figure 16.11: *Match the terms in question 3 to the letters in the diagram.*

16.3 Other Organ Systems

Why do you sweat? Why do you sometimes feel hungry? Why does your heart beat faster and you breathe heavier when you exercise? These are examples of how your organs work together to maintain a stable internal environment. Recall that this process is called homeostasis. In this section, you will learn about some of your other organ systems and their role in homeostasis.

The integumentary system

The function of the integumentary system

What is your body's largest organ? It's your skin and it's part of the integumentary system which also includes your hair and nails. The **integumentary system** has several functions described below.

- Your skin is a barrier between your underlying tissues and the outside environment. Skin is the first line of defense for blocking moisture and invaders like bacteria.
- Skin contains sweat glands that help regulate your body temperature. **Sweat glands** work by producing a salty fluid called *sweat* that flows to the surface of your skin when you are hot. As sweat evaporates, it cools your skin.
- Skin contains nerve endings that allow you to sense your environment through touch.

Anatomy of the skin

Figure 16.12 shows a cross section of the skin. The *epidermis* is the thin, outer layer that you see. The *dermis* lies underneath and is made of connective tissue and protein fibers. It contains the *sweat glands* and *nerve endings*. It also contains *oil glands* that produce oils to waterproof your skin. *Hair follicles* produce the hair on your skin. *Muscle fibers* attached to the hair follicles cause hair to stand up. This action helps regulate temperature. Hair also filters out dust particles from your nose and eyes. The *subcutaneous fat layer* functions as insulation for your body.

VOCABULARY

integumentary system - the body system consisting of the skin, hair, and nails that protects the underlying tissues.

sweat glands - glands in the skin that produce sweat to regulate body temperature.

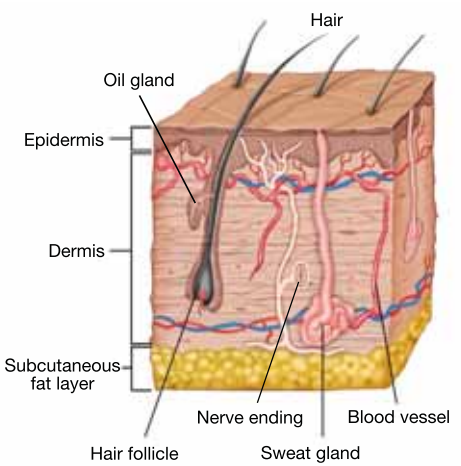


Figure 16.12: *A cross-section of the skin.*

The endocrine system

What is the endocrine system?

The **endocrine system** consists of a group of glands that produce hormones and release them into the blood. The endocrine system controls a variety of important functions such as cell processes, reproduction, and response to stress. The **pituitary gland** is often called the "master gland" because the hormones it releases regulate the release of hormones by other glands. Figure 16.13 shows the locations of endocrine glands and their functions.

VOCABULARY

endocrine system - a group of glands that produce hormones and release them into the blood.

pancreas - a gland that produces insulin and digestive enzymes.

adrenal glands - produce epinephrine, a hormone that prepares the body for stress.

The adrenal gland

Some glands affect many organs at once. The **adrenal glands** produce a hormone called *epinephrine*. Epinephrine prepares several of your organs for stress. When you get scared, it speeds up your heart rate, increases your breathing, and makes more blood sugar available for energy. This prepares your body to either run away from danger or fight for survival. It is called the *fight or flight response*.

Some glands function as part of other organ systems

Some glands also function as part of other organ systems. The **pancreas** releases *insulin*, a hormone that regulates the amount of sugar (glucose) in your blood. It is also part of the digestive system because it produces enzymes that digest proteins, carbohydrates, and fats. The endocrine function of testes and ovaries is to produce male and female sex hormones (testosterone in males, progesterone and estrogen in females). Their reproductive function is to produce sex cells.

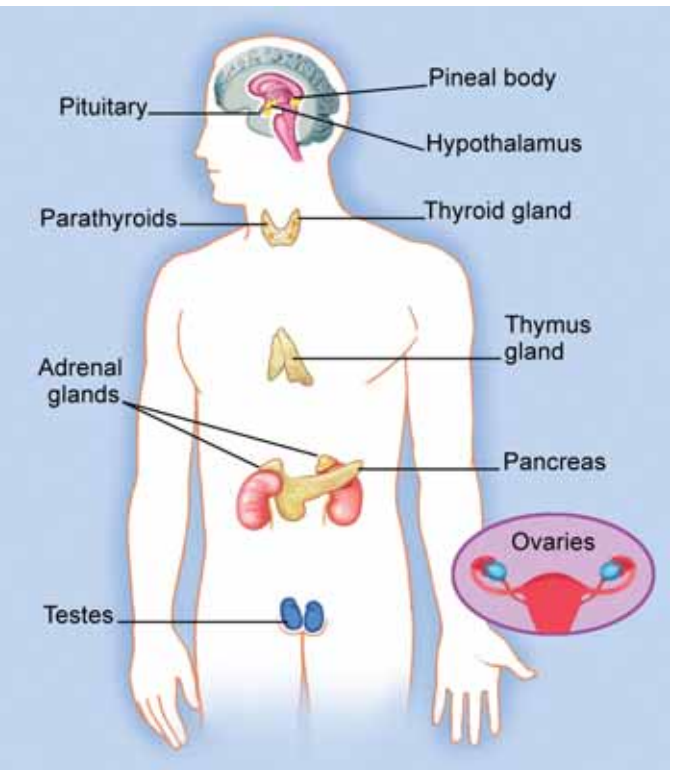


Figure 16.13: *The endocrine system.*

Feedback control systems

What are feedback control systems?

Sophia was hot so she turned on the air conditioner. The thermostat was set to 70°F. After awhile, the air conditioner turned off automatically when the room temperature reached the thermostat setting. A thermostat is a *feedback control* that sends a message to the air conditioner to turn off when a pre-set temperature is reached. Similarly, your body has **feedback control systems** that turn your endocrine glands on or off. These systems control the levels of hormones in your blood.

An example of a feedback control system

Recall that your cells need glucose for cellular respiration. A feedback control system maintains your blood glucose levels. The system involves your pancreas, which produces insulin, and your liver, which stores glucose. When you eat something, glucose from the food is absorbed by your small intestine and enters your blood. When blood glucose rises above normal levels, your pancreas releases insulin into your blood. Insulin tells your liver to take glucose from the blood and store it for future use. When glucose levels return to normal your pancreas stops producing insulin (Figure 16.14).

Diabetes mellitus

Sometimes, a feedback control system does not work properly. This may cause problems for other body systems. A person whose pancreas cannot make enough insulin has a condition called *diabetes mellitus*. That person must monitor blood glucose levels and may need injections of insulin to keep blood glucose levels normal. Chronic high blood glucose levels may cause damage to the eyes, kidneys, nerves, heart and blood vessels.

VOCABULARY

feedback control systems - systems that control the levels of endocrine hormones in the blood.

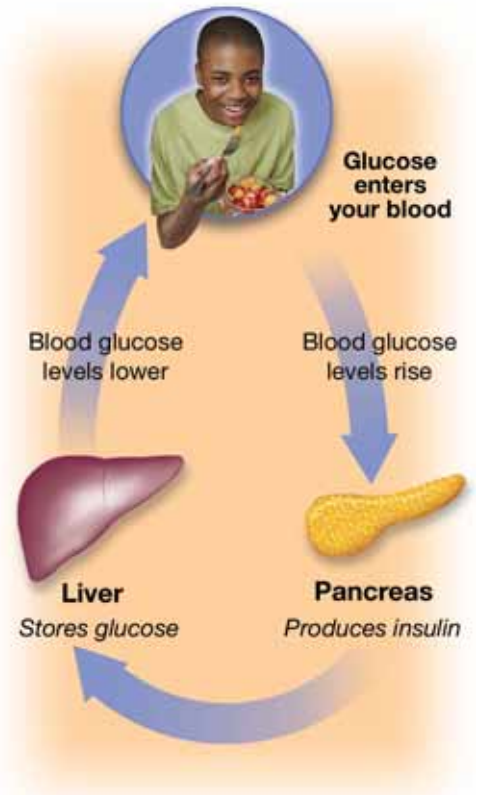


Figure 16.14: *A feedback control system for blood glucose.*

Digestive and excretory systems

What is the digestive system?

The *digestive system* is a group of organs that takes in and digests food, and eliminates solid wastes. You need a digestive system because the food you eat is in large pieces and your cells need molecules for cell processes. Your digestive system breaks food into smaller pieces and then uses enzymes to break those pieces down into molecules. Those molecules are absorbed by the small intestine and enter your blood where they are transported to different parts of your body. The digestive system is basically a long, twisting tube that runs from the mouth to the anus. Most of the digestive organs (like the *stomach* and *intestines*) are tube-like and contain the food as it makes its way through the body. Other organs (like the *liver* and *pancreas*) produce or store digestive chemicals. Figure 16.15 shows the organs of the digestive system.

What is the excretory system?

Your body gets rid of solid wastes through the digestive system. But it must also get rid of chemical wastes that are produced by chemical reactions in your cells. The **excretory system** is a group of organs that *excrete* chemical wastes. These include water, carbon dioxide, salts, and *urea*—a by product of protein reactions. The excretory system includes the kidneys, liver, lungs, and skin. The liver has functions in many organ systems. In the excretory system, it breaks down waste compounds into urea. Urea, along with excess water and salts, is filtered out by your *kidneys*. The liquid produced by your kidneys is called urine. Urine is stored in your bladder—until it gets too full. You can guess what happens next. Sweat glands in your skin also excrete excess water, salts, and urea. Carbon dioxide is excreted through the lungs.

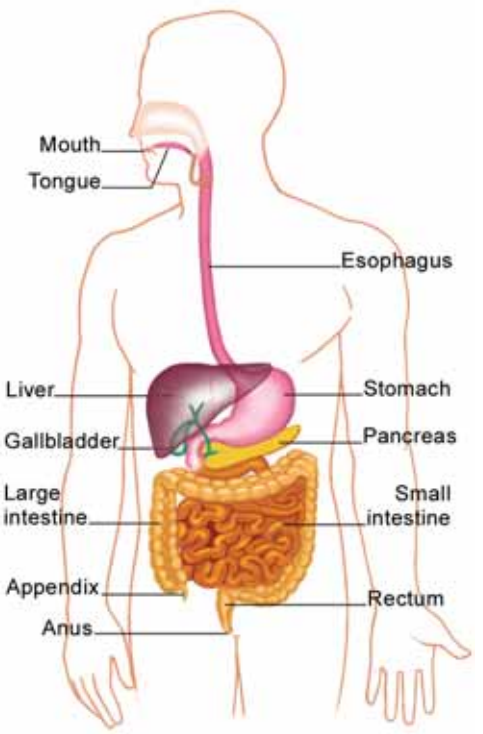


Figure 16.15: *The organs of the digestive system.*

VOCABULARY

excretory system - a group of organs that excrete chemical wastes.

16.3 Section Review

1. Name three functions of skin.
2. How does the skin contribute to homeostasis?
3. What is the endocrine system?
4. Match each endocrine gland to the hormone it produces:

Gland	Hormone
1. testes	a. epinephrine
2. ovaries	b. testosterone
3. pancreas	c. progesterone
4. adrenal glands	d. insulin

5. Why is the pituitary gland called the "master gland?"
6. Name two organs found in the digestive system.
7. Name two organs found in the excretory system.
8. What is a feedback control system and why is it important for endocrine gland function?
9. The excretory system gets rid of chemical wastes. Name a process that produces each chemical waste:
   a. urea
   b. carbon dioxide
10. Each organ below functions in more than one organ system. For each organ below: (1)name two organ systems for which it has functions; and (2)name its function in each system.
    a. sweat glands
    b. lungs
    c. liver
    d. pancreas

CHALLENGE

Use the following terms to create a concept map:

circulatory system
endocrine system
digestive system
heart
blood vessels
blood
hormones
insulin
pancreas
diabetes mellitus
feedback control system
glucose
liver

HEALTH CONNECTION Effects of Smoking on Reproduction

According to the March of Dimes, an organization that works to improve the health of babies, an estimated 20 percent of women in the United States smoke, many of them while they are pregnant. Cigarette smoking is linked to the development of heart disease, cancer, and many respiratory conditions. It can be harmful to the fetus as it develops in the womb and to the baby at birth, leading to premature birth, low birthweight, and respiratory disorders. Smoking also can affect a women's reproductive health before pregnancy. Studies show that smoking may reduce a women's ability to become pregnant.

Toxic smoke

There are over 4,000 chemicals in cigarette smoke. Carbon monoxide and nicotine are two that are known to be harmful to a fetus. When a pregnant woman smokes, these chemicals pass through her blood stream into the placenta, the tissue that provides oxygen and nutrients to the fetus. Carbon monoxide and nicotine cause the vessels that supply blood to the fetus to narrow, thus preventing enough food and oxygen from reaching the developing baby.

Mothers and babies at risk

Women who smoke during pregnancy are at risk for having premature and low birthweight babies (a low birthweight is under 5½ pounds). These babies may be small because of poor growth before birth and/or early delivery (nine months being full term). In 2002, 12.2 percent of babies born to American women who smoked were of low birthweight. Meanwhile, only 7.5 percent of babies born to nonsmoking women were of low birthweight. Pregnant women who are regularly exposed to secondhand smoke also are at risk for having premature and low birthweight babies. And these babies then are at risk for serious health problems.

Children born to mothers who smoked during the pregnancy may have more colds, earaches, and respiratory problems than children born to nonsmoking mothers. Sudden Infant Death Syndrome (SIDS) is another risk for infants whose mothers smoked while pregnant. SIDS is the sudden and unexplained death of an infant under a year old. Studies show that babies whose mothers smoked while pregnant are up to three times more likely to die of SIDS than babies born to nonsmokers.

Smoking affects future generations

Women who smoke while pregnant risk health problems not only in their children, but also in their grandchildren. This means that smoking's harmful effects can reach two generations of a family. Researchers call this the "grandma effect." Scientists have found that when a pregnant woman smokes, her future grandchildren may have double the risk of developing asthma. Asthma is a respiratory disorder that causes wheezing, coughing, and tightness in the chest. This may happen to a child whose mother did not smoke during the pregnancy but whose grandmother smoked while pregnant.

How does this grandma effect happen? Some scientists believe that chemicals in cigarette smoke may change the DNA in a female fetus's eggs. DNA is the molecule that stores all of a person's genetic information. Eggs are the

female sex cells that are produced in a fetus while she is in the womb. It is thought the chemicals in smoke may change the genes that program the fetus's immune system. These altered genes may then trigger the development of asthma.

Efforts to reduce smoking

There are many organizations working to reduce the number of smokers in the United States. The March of Dimes supports research on the risks of smoking during pregnancy and provides information to pregnant women and their doctors. The Centers for Disease Control (CDC) also provides educational resources about the risks of smoking, with its aim being that, by 2010, less than 1 percent of pregnant women will be smoking.

Questions:

1. What impact do the toxic substances in cigarette smoke have on the development of a fetus?
2. What complications may occur in women who smoke both before they are pregnant and during their pregnancy?
3. List several smoking risks that may occur in developing fetuses and in newborns.
4. What is the "grandma effect"? What impact can a woman's smoking have on her grandchildren?

CHAPTER ACTIVITY Build a Lung Model

Animals need oxygen to survive. Land animals get oxygen from the air they breathe. The respiratory system consists of the airways, lungs, and muscles that work together to let air in and out of the body. In this activity you will build a model of a single lung and see for yourself how breathing really works.

For this activity, your group will need:

- 1 empty water bottle (the kind with the pull-top cap)
- 2 balloons (good-sized helium party balloons)
- duct tape
- scissors

What you will do

1. Poke a hole in the bottom of the empty bottle and use the scissors to carefully cut a small nickel-sized hole in the bottom of the bottle. (use caution - the bottom plastic is thick.)
2. Cut the neck off of one of the balloons and stretch the balloon over the entire bottom of the bottle. Secure with duct tape.
3. Unscrew the pull-top and pop up the opening so the cap is in the "open" position.
4. Slide the second balloon over the popped-out part of the cap and rest the cap on top of the bottle upside-down, with the balloon hanging into the bottle.
5. To operate your lung model, gently pull down on the middle of the balloon that is covering the bottom of the bottle. Watch what happens to the "lung" inside the bottle.

Applying your knowledge

1. Make a sketch of your lung model and label the parts of the model that represent the:
   a. diaphragm
   b. chest cavity
   c. lung
   d. airway
2. Use several sentences to explain why air enters the model lung when you pull down on the balloon that covers the bottom of the bottle.
3. Use several sentences to explain how breathing works in the human respiratory system.
4. How many times do you breathe in one minute? Work with a partner to determine your average number of breaths per minute and record your data. Compare your results with classmates. What is the class average for breaths per minute?
5. Research a lung disease. Some examples are: pneumonia, asthma, emphysema, chronic bronchitis, lung cancer. Use the internet and library for your research. Find answers to the following questions:

- What part of the respiratory system is affected?
- What are the symptoms?
- What are possible causes?
- What treatments are necessary?

Chapter 16 Assessment

Vocabulary

Select the correct term to complete the sentences.

capillaries	respiration	feedback control system
red blood cell	alveoli	umbilical cord
blood pressure	ovaries	endocrine system
arteries	testes	pancreas
valve	hormones	sweat glands
veins	follicle	fetus
plasma	semen	adrenal glands
circulatory system	implantation	respiratory system
white blood cell	ovulation	integumentary system
blood	uterus	

Section 16.1

1. Made up of the heart, blood vessels and blood, the _____ transports substances to and from the cells.
2. The failure of a heart _____ to properly close could cause the blood to flow backwards in the vessels.
3. _____ carry blood away from the heart.
4. The network of small blood vessels that allow oxygen and other substances to flow into tissues are _____.
5. Thin walled vessels that return blood to the heart are _____.
6. Made of specialized cells, plasma and platelets, _____ transports nutrients, wastes and other substances throughout the body.
7. Red and white blood cells are suspended in a fluid called _____.
8. A blood cell containing the oxygen carrying molecule hemoglobin is a _____.
9. A blood cell that helps fight infections is a _____.
10. _____ is a measure in mm Hg of the force that blood exerts on the walls of blood vessels.
11. An organism exchanges of oxygen, carbon dioxide and water with the environment through the process of _____.
12. The _____ consists of the lungs and their associated passages.
13. Sac-like structures within the lung that allow gas exchange are _____.

Section 16.2

14. Production of sperm and testosterone take place in the _____.
15. _____ such as testosterone help regulate body functions.
16. _____ is formed of sperm and fluid from the prostrate gland.
17. Organs that produce eggs and female sex hormones are the _____.
18. Beginning at puberty, females release mature eggs from the ovary in a process called _____.
19. Developing eggs mature in _____ of the ovary.
20. Development and growth an embryo happens in the _____.
21. After the fertilized egg travels down the fallopian tube, the process of _____ must take place in order for pregnancy to continue.
22. The placenta supplies nutrients and oxygen to the embryo via the _____.
23. After the eighth week of pregnancy, the _____ has all the major structures of an adult.

Section 16.3

24. The skin, nails and hair are major components of the _____.

25. Without ____, the body would be unable to regulate body temperature.
26. The _____ is made up of glands that secrete regulatory hormones.
27. The _____ aids in digestion and blood sugar regulation.
28. The _____ produce epinephrine, which triggers a fight or flight response to stress.
29. Without our complex _____, the body could not control the effects of hormonal secretions from endocrine glands.

Concepts

Section 16.1

1. A lack of energy is a symptom seen in some types of blood disorders. Which component of the blood is most likely the cause and why?
2. Which statement correctly describes blood pressure?
   a. Accidental loss of blood would increase systolic pressure.
   b. Sphygmomanometers measure pressure exerted on the walls of blood vessels returning to the heart.
   c. A blood pressure reading of 110/73 mm Hg signifies that the force exerted on arterial walls during the relaxation of the heart can push a column of mercury 73 mm high.
   d. Vessels returning to the heart have thicker walls to accommodate higher blood pressures.
3. Accidentally, surgeons reverse the aorta and pulmonary arteries of a heart transplant patient. Now the right ventricle pumps blood out through the aorta and the left ventricle is connected to the pulmonary artery. How would this change blood flow? Why would this need to be corrected quickly?
4. Outline the path an oxygen molecule would take as it traveled from the outside environment to your tissues.
5. Which of the following is true?
   a. Blood moves most quickly in the capillaries.
   b. Heart valves force blood through the heart
   c. More than half of your blood is made of red blood cells.
   d. Large veins have one-way valves to channel blood back towards the heart.
6. Lung tissue damage caused by smoking can lead to the slowing of blood from the heart to the lungs. Which structure is most likely weakened by the increased pressure caused by the backup?
   a. Right ventricle
   b. Aorta
   c. Left ventricle
   d. Pulmonary artery

Section 16.2

7. Which of the following correctly traces the path of sperm out of a man's body.
   a. Vas deferens-prostrate gland seminiferous tubules, urethra
   b. Seminiferous tubules-epididymis-vas deferens-urethra
   c. Seminiferous tubules-vas deferens-epididymis-urethra
   d. Epididymis-seminiferous tubules-vas deferens-urethra
8. The levels of which of the following would not be analyzed in the case of a couple not being able to conceive children?
   a. Testosterone
   b. Estrogen and progesterone
   c. Sperm production
   d. Epinephrine

9. Fraternal twins are the result of two eggs being fertilized by separate sperm. Outline the series of events that happen within a woman that would lead to a fraternal twin pregnancy.
10. How does the fetus receive nourishment during development?
11. Which of the following is true about drug and alcohol consumption during pregnancy?
    a. Drug and alcohol use is not a risk because the maternal blood and fetal blood do not mix.
    b. Only drugs can pass through the placenta to the fetus.
    c. Organ and tissue damage can result as both drugs and alcohol pass easily through the placental lining to the fetus.
    d. Alcohol is dangerous to the fetus only if the mother drinks beyond her legal limits.

Section 16.3

12. Third degree burns involve the deeper dermal layers of the skin. Why are these more dangerous than first degree burns involving only the epidermal layers?
13. Describe how sweat glands regulate homeostasis in the body.
14. In a person with diabetes mellitus, the level of which hormone would fail to increase in the blood after eating a chocolate bar?
    a. epinephrine
    b. insulin
    c. testosterone
    d. progesterone
15. Of the following, which would have the most widespread effects if damaged?
    a. Pituitary gland
    b. Testes
    c. Adrenal gland
    d. Pancreas
16. How are the organs of the excretory system different from those of the digestive system?
17. Of the following, which does not have a role in the production or excretion of urea?
    a. Liver
    b. Bladder
    c. Kidney
    d. Stomach

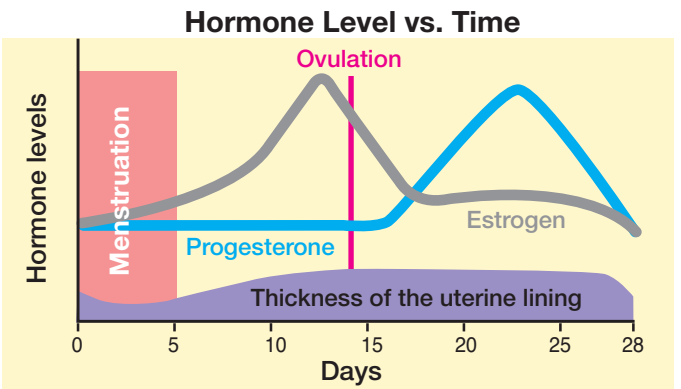
Math and Writing Skills

Section 16.1

1. The average male American lifespan is 72 years. Assuming the average resting heart rate for a male is 72 beats per minute, calculate the number of times the heart of an average male will beat over his lifetime.
2. The average amount of blood a person has is 5 liters. If 55% of that blood is plasma, how many liters of plasma does the average person contain?
3. Write a short story that describes the journey of a red blood cell through the human circulatory system.

Section 16.2

4. The graph below shows the hormone levels in a woman's blood during her menstrual cycle. Examine the graph and then answer the questions below.



   a. Which hormone controls the thickening of the uterine lining?
   b. Which hormone controls ovulation?
   c. What happens when the levels of both hormones decline?

Section 16.3

5. Make a line graph that shows the levels of insulin and glucose in your blood before and after eating a candy bar. Plot time on the *x*-axis and insulin/glucose level on the *y*-axis. You do not need to worry about the numerical values of the variables. Just estimate what the curve of each line would look like.

Chapter Project

Placental Health

It is important for a pregnant woman to maintain a healthy lifestyle, since oxygen and nutrients pass from her blood to the fetus through the placenta and umbilical cord. For this project you will create a tri-fold brochure that teaches the importance of the placenta and umbilical cord. Make a brochure that could be displayed in the waiting room of a doctor's office. Make your brochure creative and informative so people will want to read it. You need to list four sources of information on the very back of your brochure. Only two of the sources can be websites. Things to include in your brochure:

1. Labeled sketch that shows fetus, placenta, and umbilical cord in the uterus.
2. List of behaviors or choices that result in harmful substances reaching the fetus through the placenta.
3. List of diseases that can be transferred from the mother to the fetus through the placenta.
4. "Do's and Don'ts" to maintain a healthy pregnancy.
5. Places to go for more information (4 sources; only 2 websites).