Chapter 7 Human Anatomy and Physiology: Organization of Systems

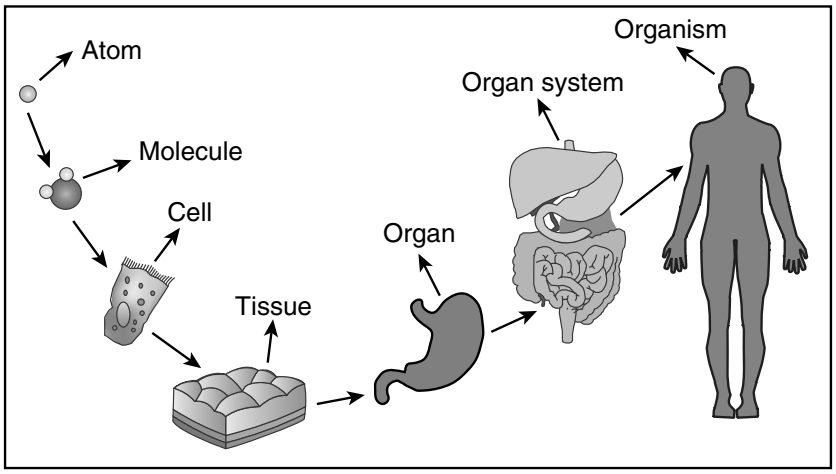
Organization of the Human Body

Human anatomy and physiology is the study of the structures and functions of the human body.

Levels of Organization and Body Cavities

The body can be studied at seven structural levels: **chemical**, **organelle**, **cell**, **tissue**, **organ**, **organ system**, and **organism**.

- **Chemical:** The chemical level involves interactions among atoms and their combination into molecules.
- **Organelle:** An organelle is a small structure contained within a cell that performs one or more specific functions.
- **Cell:** Cells are the basic functional units of life. All cells share many characteristics, but they differ in structure and function.
- **Tissue:** A tissue is a group of cells with similar structures and functions.
- **Organ:** An organ is composed of two or more tissue types that together perform one or more common function.
- **Organ system:** An organ system is a group of organs classified as a unit because of a common function or set of functions.
- **Organism:** An organism is any living thing considered as a whole. Organisms can have anywhere from a single cell to trillions of cells.



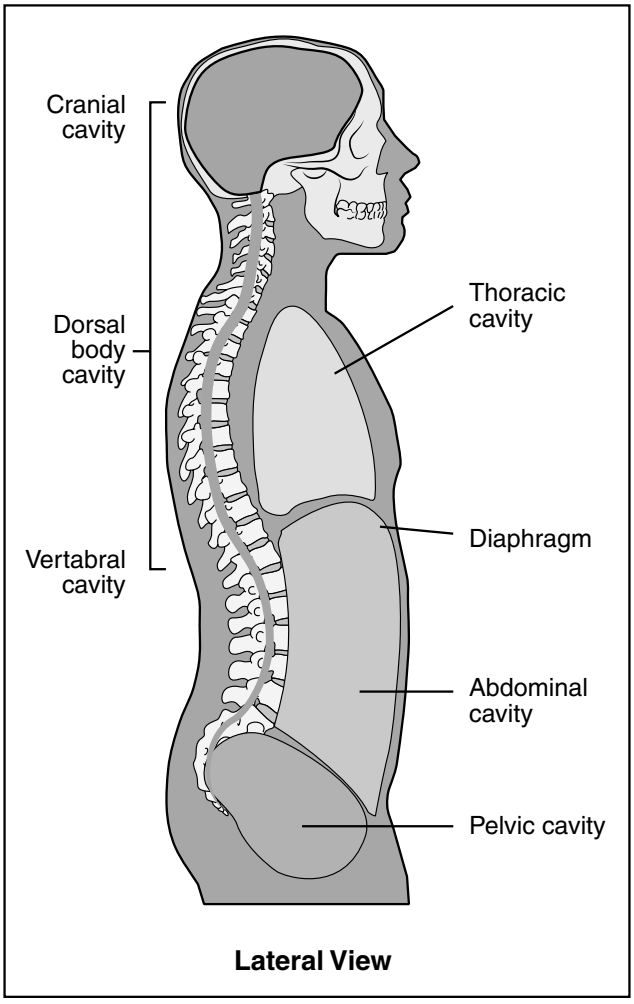
Body Cavities

The human body has many cavities, some of which open to the exterior. A **cavity** is a fluid-filled space in the body that holds and protects internal organs. The **ventral cavity** (front of the body) contains three major cavities:

- The **thoracic cavity** is surrounded by the rib cage and separated from the abdominal cavity by the diaphragm. It is divided into right and left halves by a structure called the mediastinum. It contains the esophagus, trachea, thymus gland, heart, and both lungs, along with other structures.
- The **abdominal cavity** is bounded by the abdominal muscles below the thoracic cavity and contains the stomach, intestines, liver, spleen, pancreas, and kidneys.
- The **pelvic cavity** is enclosed by the bones of the pelvis and contains the urinary bladder, part of the intestines, and the internal reproductive organs. The abdominal and pelvic cavities are sometimes referred to as the abdominopelvic cavity.

The **dorsal cavity** is the back of the human body, and it is subdivided into two cavities: cranial and spinal.

- The **cranial cavity** contains the brain.
- The **spinal cavity** contains the spinal cord.



Example

Which of the following organs is located in the pelvic cavity?

A. Heart B. Intestines C. Liver D. Pancreas

The correct answer is **B.** The intestines are located in both the abdominal and pelvic cavities.

Terminology and the Body Planes and Regions

Directional terms refer to the body in the **anatomical position**, regardless of its actual position. The term *anatomical position* refers to a person standing erect with the feet forward, arms hanging to the sides, and the palms of the hands facing forward.

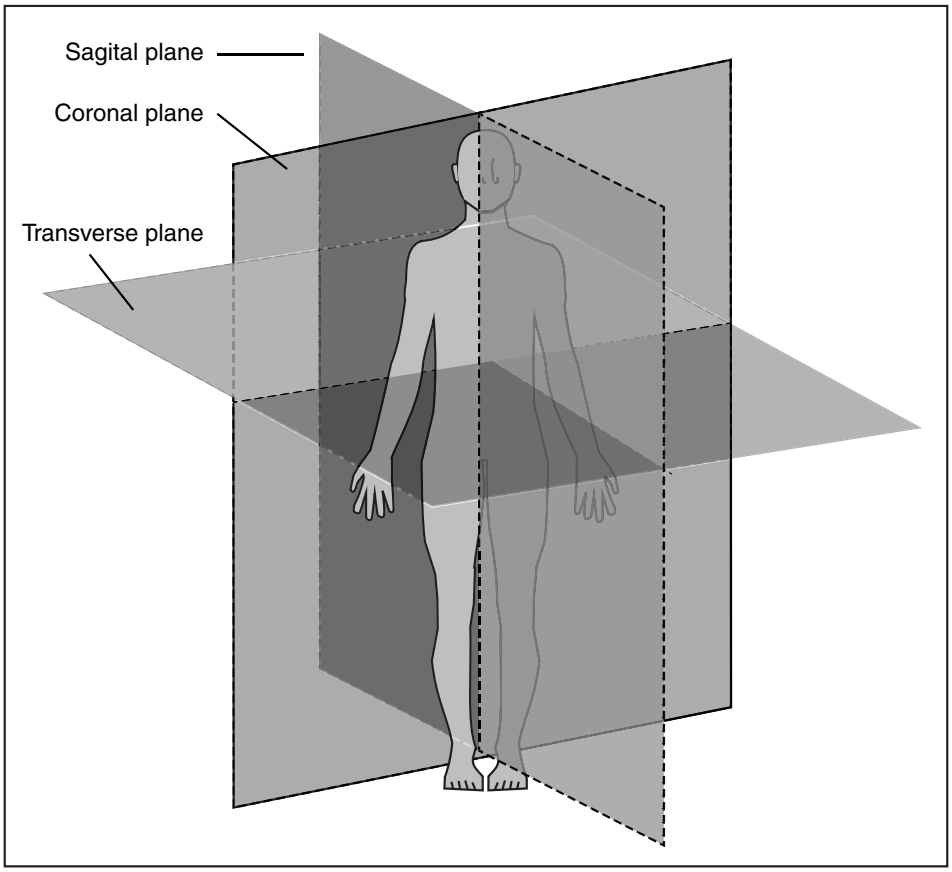
Terminology

Term	Definition
Inferior	A structure below another
Superior	A structure above another
Anterior	Toward the front of the body
Posterior	Toward the back of the body
Dorsal	Toward the back
Ventral	Toward the front
Proximal	Closer to the point of attachment to the body than another structure
Distal	Farther from the point of attachment to the body
Lateral	Away from the midline of the body
Medial	Toward the middle or midline of the body
Superficial	Toward or on the surface
Deep	Away from the surface
Anterosuperior	In front or above
Midline	A median line
Supine position	Lying flat with face and torso facing upward
Prone position	Lying face down

Body Planes

Sectioning the body is a way to look inside and observe the body's structures. The following are the major planes of the body:

- The **sagittal plane** runs vertically through the body and separates the body into right and left parts.
- The **midsagittal plane** divides the body into two equal halves.
- The **transverse plane** runs parallel to the surface of the ground and divides the body into superior and inferior planes.
- The **coronal plane**, sometimes called the frontal plane, runs vertically from left to right and divides the body into anterior and posterior parts.



Body Regions

The body is divided into the following four regions:

- **Upper limb:** The upper limb includes the arm, forearm, wrist, and hand.
- **Lower limb:** The lower limb is divided into the thigh, leg, ankle, and foot.
- **Central region:** The central region includes the neck and trunk.
- **Head region:** The head region includes the entire head.

Example

The wrist is _____ to the shoulder.

A. distal B. lateral C. median D. superior

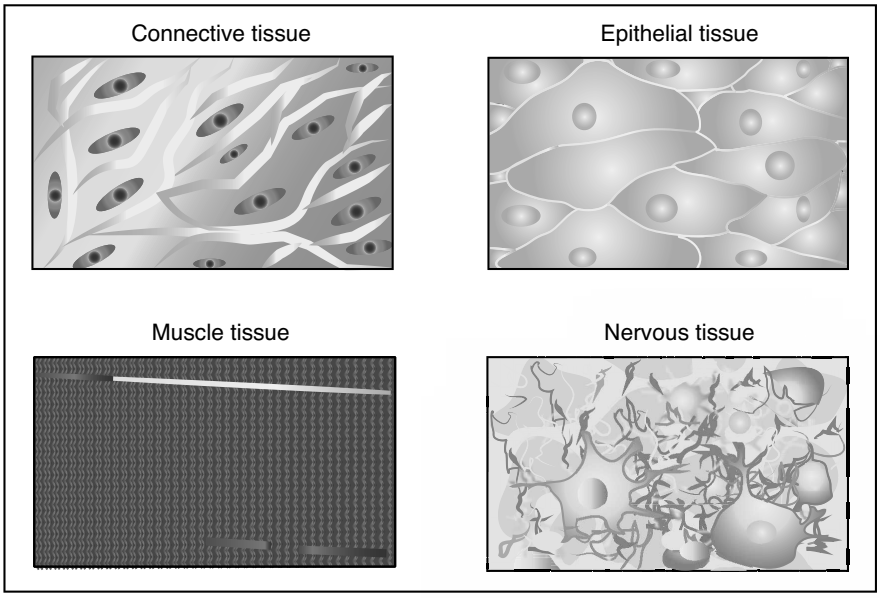
The correct answer is **A.** The wrist is farther from the point of attachment than the shoulder is, so it is distal to the shoulder.

Human Tissues

A **tissue** is a group of cells with similar structure and function and similar extracellular substances located between the cells. The table below describes the four primary tissues found in the human body.

Tissue	Structure	Function	Example
Connective	characterized by extracellular material that separate cells from one another	enclosing and separating connecting tissues to one another supportive and moving storing cushioning and insulating transporting protecting	cells of the immune system and blood
Epithelial	classified according to the number of cell layers and shapes	protecting underlying structures acting as barriers permitting the passage of substances secreting substances	skin, linings of internal organs
Muscle	cells of muscles resemble long threads and are called *fibers*	providing movement	heart, organs of digestive system
Neural	cells are composed of dendrites, cell bodies, and axons	coordinating and controlling many body activities	brain, spinal cord

Four Types of Tissue



Example

Which type of tissue controls when the heart beats?

A. Connective B. Epithelial C. Muscle D. Nervous

The correct answer is **D.** Although the muscle tissue is responsible for the actual movement of the heart, the neural tissue "tells" the heart when to beat.

Homeostasis and Feedback Mechanisms

Homeostasis is the existence and maintenance of a relatively constant environment within the body. Each cell of the body is surrounded by a small amount of fluid, and the normal functions of each cell depend on the maintenance of its fluid environment within a narrow range of conditions, including temperature, volume, and chemical content. These conditions are known as **variables**. For example, body temperature is a variable that can increase in a hot environment or decrease in a cold environment.

There are two types of feedback mechanisms in the human body: negative and positive.

Negative Feedback

Most systems of the body are regulated by **negative feedback mechanisms**, which maintain homeostasis. *Negative* means that any deviation from the set point is made smaller or is resisted. The maintenance of normal blood pressure is a negative-feedback mechanism. Normal blood pressure is important because it is responsible for moving blood from the heart to tissues.

Positive Feedback

Positive feedback mechanisms are not homeostatic and are rare in healthy individuals. *Positive* means that when a deviation from a normal value occurs, the response of the system is to make the deviation even greater. Positive feedback therefore usually creates a cycle leading away from homeostasis and, in some cases, results in death. Inadequate delivery of blood to cardiac muscle is an example of positive feedback.

Example

Childbirth is a response to hormones in a woman's body. What type of feedback mechanism is at work during childbirth?

A. Neutral feedback
B. Positive feedback
C. Negative feedback
D. Need more information

The correct answer is **B.** During childbirth, the frequency and strength of the contractions increases until the contractions are powerful enough to deliver the baby.

Let's Review!

- The body can be studied at seven structural levels.
- The human body has multiple body cavities.
- Directional terms refer to the body in the anatomical position.
- Sectioning the body is a way to look inside and observe the body's structures.
- The four primary tissues found in the human body are connective, epithelial, muscular and nervous.
- Homeostasis is the existence and maintenance of a relatively constant environment within the body.
- The two types of feedback mechanisms in the human body are negative and positive feedback mechanisms.

The Cardiovascular System

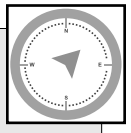
This lesson introduces the anatomy of blood and its connection to the cardiovascular system. Explore the parts that make up the cardiovascular system and how this system functions.

Anatomy of Blood

Blood is a type of fluid connective tissue that circulates throughout the body, carrying substances to and away from bodily tissues. It has a pH of about 7.4 and is more viscous than water. Blood consists of three types of formed elements, an extracellular matrix called **plasma,** molecules, cell fragments, and debris. The formed elements consist of red blood cells, white blood cells, and platelets. They are also referred to as **erythrocytes**, **leukocytes**, and **thrombocytes**, respectively. The following table details key characteristics of these elements.

Characteristic	Red Blood Cells	White Blood Cells	Platelets
Scientific Name	Erythrocytes	Leukocytes	Thrombocytes
Size (Diameter)	0.0008 mm	0.02 mm	0.03 mm
Function	Participate in gas exchange, primarily with oxygen and carbon dioxide	Protect the body from foreign substances by eliciting an immune response	Aid in blood clotting and wound healing

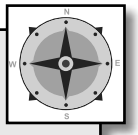
Plasma is different from other types of connective tissue because it is a fluid. Consisting of about 92% water, formed elements remain suspended in the matrix where they are circulated throughout the body.



DID YOU KNOW?

The average volume of blood in the human body, for a 70-kilogram person, is 5 liters. Blood accounts for roughly 8% of a person's body weight.

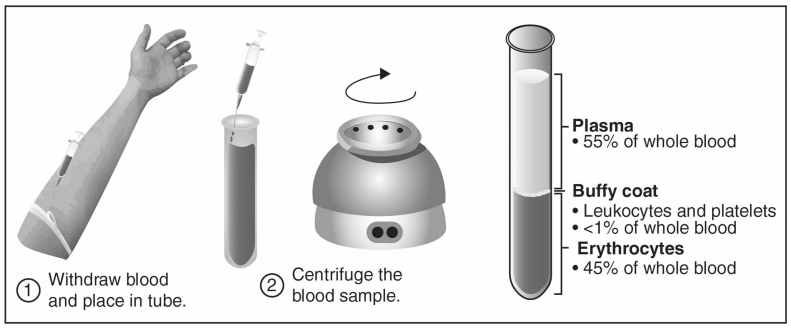
Consider the following image, which illustrates the composition of blood in a person's blood sample. When a blood sample is spun in a centrifuge, less-dense plasma floats on top of a reddish mass that consists of red blood cells. There is also a thin white layer called the **buffy coat** that consists of white blood cells and platelets. This layer is found between the reddish mass and plasma layers.



KEEP IN MIND

Blood viscosity is indirectly proportional to blood flow throughout the body. If the viscosity of blood is high, blood flow decreases. When blood viscosity is low, or blood is thin, blood flow increases.

Example



A laboratory technician needs to determine the leukocyte count in a patient. From which part of a blood sample are these cells extracted?

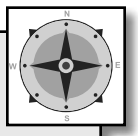
A. Water B. Buffy coat C. Liquid plasma D. Reddish mass

The correct answer is **B.** Buffy coat contains white blood cells (or leukocytes) and platelets in blood.

Functions of Blood

Transportation, regulation, and protection are three primary functions of blood. Blood transports the following substances throughout the body:

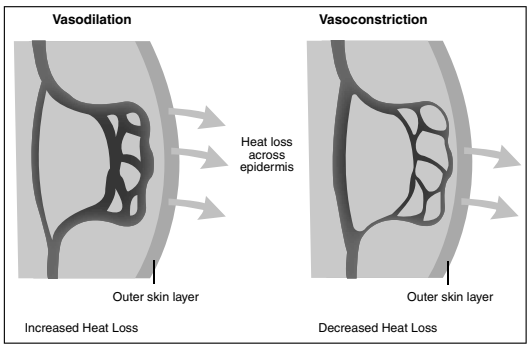
- Gases: Blood delivers oxygen from the lungs to all cells in the body. It also transports carbon dioxide to the lungs for elimination from the body.
- Nutrients: Blood transports nutrients from the digestive tract and storage sites in the body to various places in the body.
- Wastes: Blood transports waste products to the liver, where they are excreted as bile. Waste products also travel by blood to the kidneys when they need to be excreted as urine.
- Hormones: Blood transports hormones from the glands where they are produced to their target organs.



KEEP IN MIND

Albumin is the main protein in blood, accounting for roughly 60% of the plasma proteins in blood. It plays a role in water balance and functions as a carrier protein, shuttling certain molecules throughout the body.

Although blood's primary function is to distribute substances throughout the body, it also has regulatory functions. These functions include the regulation of body temperature, chemical balance, and water balance. Blood ensures the right body temperature is maintained with help from plasma and the speed of blood flow. Plasma is able to absorb or give off heat. As shown in the following image, when blood vessels expand, or **vasodilate**, blood flows slowly, causing heat loss. This occurs when the temperature of the external environment is high. If external environmental temperatures are low, blood vessels contract, or **vasoconstrict**, causing less heat to be released.



Blood also functions as a form of protection, defending the body against foreign invaders or **pathogens** that harm the body. As blood circulates through the body, it carries white blood cells and **antibodies** that destroy any pathogens they encounter. With the help of platelets and plasma proteins, blood also protects the body from extensive blood loss if a blood vessel is damaged.

Example

Platelets are important because they

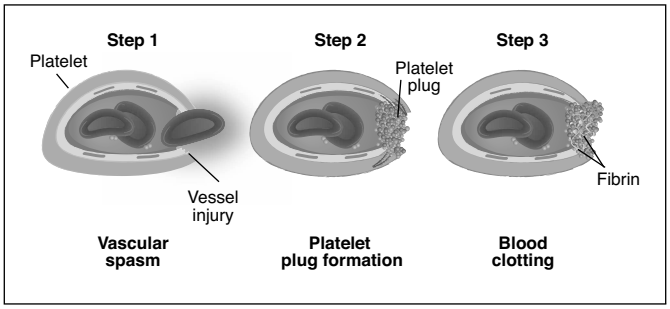
A. give blood its natural color.
B. repair broken blood vessels.
C. transport nutrients to the cells.
D. protect the body against infection.

The correct answer is **B**. At the site of injury or damage to a blood vessel, platelets help repair the damaged area.

Hemostasis

Recall that a function of platelets and plasma proteins is to repair damaged blood vessels. When blood vessels are damaged, a physiological process called hemostasis is activated. **Hemostasis** helps maintain blood in its fluid state and stops blood from leaking out of a damaged blood vessel through clot formation. As shown in the image below, there are three steps of hemostasis.

Steps of Hemostasis



The first step is **vascular spasm**, or vasoconstriction, where the blood vessels constrict to reduce blood loss. Reducing blood loss for several hours, this process works best with small blood vessels. The second step is platelet plug formation. Platelets adhere to the epithelial wall

of the blood vessel and aggregate by sticking together. This creates a temporary seal over the damaged site. In the third step, **blood coagulation** occurs. Also known as **blood clotting**, this process is a series of events that strengthen the platelet plug by using fibrin threads to form a mesh around the plug. The protein mesh functions as a molecular glue, securing the plug to the damaged site. Red blood cells and platelets remain trapped at the damaged site, forming a clot that facilitates wound healing.

Example

What happens after platelets aggregate at a damaged blood vessel site?

A. The site of the wound is healed.

B. The damaged blood vessel constricts.

C. The platelets stick together and form a plug.

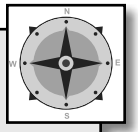
D. Red blood cells are recruited to the injured site.

The correct answer is **C.** After the platelets aggregate at the damaged site, they stick together to form a plug. Next, blood coagulation occurs when a fibrin mesh forms around the platelet aggregate.

Blood Grouping and Agglutination

There are several different types or groups of blood, and the major groups are A, B, AB, and O. Blood group is a way to classify blood according to inherited differences of red blood cell **antigens** found on the surface of a red blood cell. The type of antibody in blood also identifies a particular blood group. **Antibodies** are proteins found in the plasma. They function as part of the body's natural defense to recognize foreign substances and alert the immune system. Depending on which antigen is inherited, parental offspring will have one of the four major blood groups. Collectively, the following major blood groups comprise the ABO system:

- Blood group A: Displays type A antigens on the surface of a red blood cell and contains B antibodies in the plasma.
- Blood group B: Displays type B antigens on the red blood cell's surface and contains A antibodies in the plasma.
- Blood group O: Does not display A or B antigens on the surface of a red blood cell. Both A and B antibodies are in the plasma.
- Blood group AB: Displays type A and B antigens on the red blood cell's surface, but neither A nor B antibodies are in the plasma.



KEEP IN MIND

A person can be a universal blood donor or acceptor. A universal blood donor has type O blood, while a universal blood acceptor has type AB blood.

In addition to antigens, the **Rh factor** protein may exist on a red blood cell's surface. Because this protein can be either present (+) or absent (-), it increases the number of major blood groups from four to eight: A+, A-, B+, B-, O+, O-, AB+, and AB-. The following table summarizes what blood types a person can receive or donate.

Blood Group	Can accept blood from	Can donate blood to
A	A, O	A, AB
B	B, O	B, AB
AB	AB, A, B, O	AB
O	O	AB, A, B, O

When determining an individual's blood type, a sample of blood is mixed with an antiserum. If **agglutination**, or clumping, occurs during this process, the antibody has found an antigen with which to interact. This means there are antigens on the surface of the red blood cell to which the antibodies can bind. Evidence of agglutination is used to interpret the final blood type result from a sample.

Example

People with type O blood can accept blood from people with _____ blood.

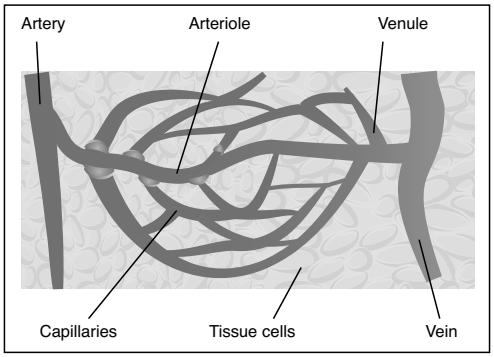
A. type O B. type B C. type AB D. type A

The correct answer is **A.** People with type O blood are universal donors but can accept blood only from people with type O blood.

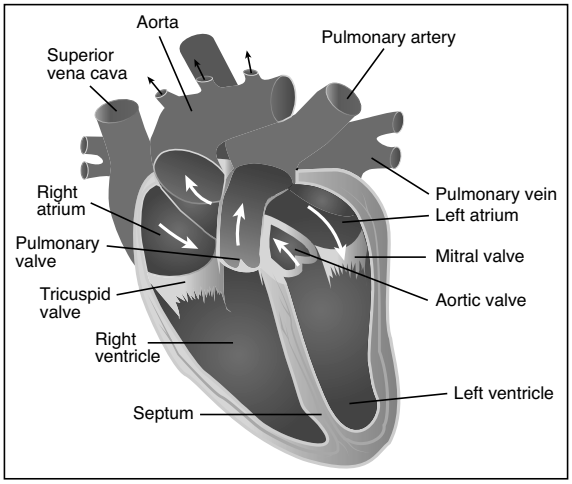
Cardiovascular Anatomy

The **cardiovascular system** circulates substances throughout the body using blood as a transporting mechanism. The organs of the cardiovascular system work together to supply cells and tissues with oxygen and nutrients and remove cellular wastes such as carbon dioxide. Blood, heart, and blood vessels form this system.

Because blood circulation is a closed loop system, blood is contained within the heart or blood vessels at all times. There are three types of blood vessels: arteries, veins, and capillaries. **Arteries** carry blood away from the heart, toward organs and tissues. **Veins** carry blood toward the heart, away from organs and tissues. Arteries branch into smaller blood vessels called **arterioles**, which further divide into capillaries. As shown in the following image, **capillaries** are tiny vessels that form a network around tissues. Veins branch into venules before further dividing into capillaries.



The heart is found between the lungs in the middle of the chest. It rests behind and slightly to the left of the sternum, or breastbone. The human heart is a muscular organ composed primarily of cardiac muscle. It consists of four chambers: two upper chambers called the **atria** and two lower chambers called the **ventricles**. The atria are separated from the ventricles by a muscular structure called the **septum**. Three layers make up the heart wall. These are the **pericardium** or outer layer, the **myocardium** or middle layer, and the **endocardium** or innermost layer. Most cardiac muscle tissue is found in the myocardium.



DID YOU KNOW?

Capillaries have thin walls and a very large surface area. Because of the capillaries' thin walls, blood flow slows to facilitate exchanges between blood and the body's tissues.

In addition to the four chambers, the heart has four valves that regulate blood flow into and out of the heart:

- **Tricuspid valve** regulates blood flow between the right atrium and right ventricle.
- **Pulmonary valve** regulates blood flow from the right ventricle into the pulmonary artery.
- **Mitral valve** regulates blood flow from the left atrium into the left ventricle.
- **Aortic valve** regulates blood flow from the left ventricle to the **aorta**. The aorta is the largest artery in the body.

Example

Which heart layer is composed primarily of cardiac muscle?

A. Myocardium B. Pericardium C. Septum D. Sternum

The correct answer is **A**. The heart is composed of three layers, the middle of which is the myocardium. The myocardium contains cardiac muscle tissue.

Circulation and the Cardiac Cycle

Blood continually flows in one direction, beginning in the heart and proceeding to the arteries, arterioles, and capillaries. When blood reaches the capillaries, exchanges occur between blood and tissues. After this exchange happens, blood is collected into venules, which feed into veins and eventually flow back to the heart's atrium. The heart must relax between two heartbeats for blood circulation to begin. Two types of circulatory processes occur in the body:

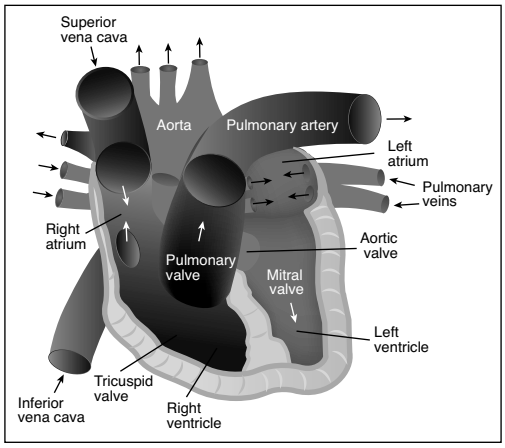
Systemic circulation

1. The pulmonary vein pushes oxygenated blood into the left atrium.
2. As the atrium relaxes, oxygenated blood drains into the left ventricle through the mitral valve.
3. The left ventricle pumps oxygenated blood to the aorta.
4. Blood travels through the arteries and arterioles before reaching the capillaries that surround the tissues.

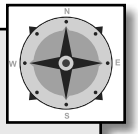
Pulmonary circulation

1. Deoxygenated blood is sent back to the heart via the veins and pooled into the right atrium.
2. Blood travels through the superior vena cava and drains into the right ventricle.
3. The right ventricle contracts, causing the blood to be pushed through the pulmonary valve into the pulmonary artery.
4. Deoxygenated blood becomes oxygenated in the lungs.
5. Oxygenated blood returns from the lungs to the left atrium through the pulmonary veins.

The following image shows the heart's role in systemic and pulmonary circulation.



The complete cycle beginning with atrial contraction and ending with ventricular contraction is called the **cardiac cycle**. When the heart contracts and pumps blood into systemic circulation, this is called **systole**. **Diastole** refers to the period of relaxation when the heart chambers fill with blood.

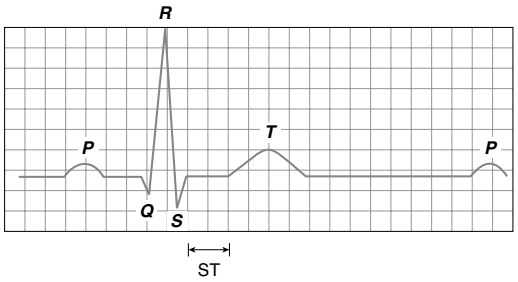


KEEP IN MIND

Blood flow is regulated by many mechanisms in the body. This regulated variable is also directly proportional to blood pressure. If blood volume increases, blood pressure increases. The opposite occurs if blood pressure decreases.

Because the heart is a muscle, it transmits electrical impulses that cause the heart to contract. This electrical activity can be recorded using an **electrocardiogram**, or EKG. An EKG is a graph that shows the heart's rate and rhythm over a period of time. As shown in the following image of an EKG, waves in the graph have different meanings.

The first wave on an EKG is the P wave. This indicates atrial contraction or systole. The QRS complex represents the combination of Q, R, and S waves. This indicates ventricular systole or contraction. The T wave indicates ventricular diastole. The flat line between the S and T wave is the ST segment.



Example

What segment of the electrocardiogram is associated with atrial systole?

A. P wave B. S wave C. ST segment D. QRS complex

The correct answer is **A.** Atrial systole occurs when the atrium contracts. On an EKG, atrial systole is indicated by a P wave.

Let's Review!

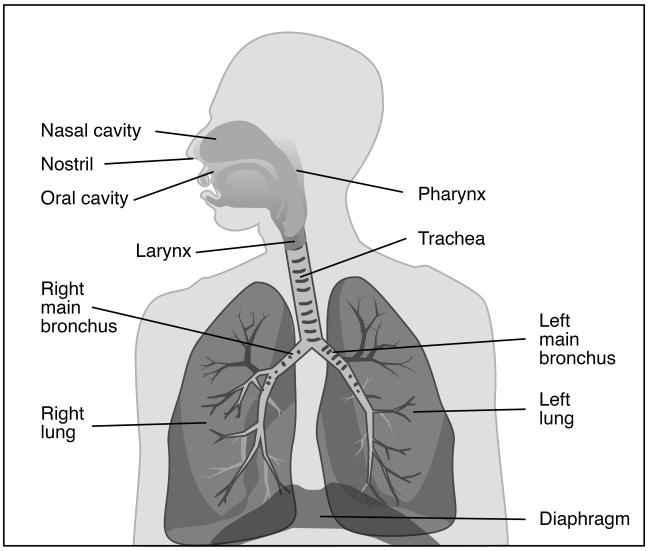
- Blood is a type of connective tissue composed of formed elements, plasma, and other substances.
- Erythrocytes, leukocytes, and thrombocytes are the formed elements that make up blood.
- Blood transports substances throughout the body, regulates physiological processes, and protects the body.
- There are four common blood groups that are determined by inherited differences in antigens on red blood cells.
- Agglutination, or clumping, can be used to help interpret the blood type of a blood sample.
- The cardiovascular system circulates blood throughout the body in a closed loop structure.
- The heart is a muscular organ with four chambers: two atria and two ventricles.
- Deoxygenated blood flows through pulmonary circulation, and oxygenated blood flows through systemic circulation.
- The cardiac cycle refers to the contraction and relaxation states of the atria and ventricles.
- An electrocardiogram, or EKG, is used to record heart beat and rhythm.

The Respiratory System

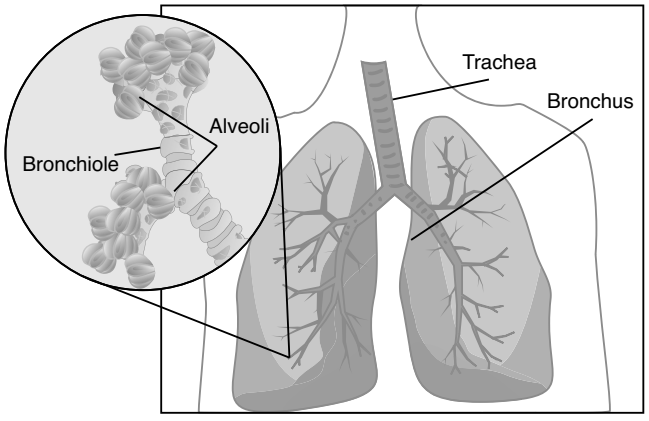
This lesson introduces the anatomy of the respiratory system and how each organ within this system functions. It also discusses the mechanics of breathing and respiration.

Anatomy of the Respiratory System

Every living thing requires oxygen for survival. Humans can live for days without water and for weeks without food. But they can only survive a few minutes without air. The respiratory system's primary function is to bring oxygen into the body, in exchange for carbon dioxide. As shown in the following image, organs of the respiratory system include the nose, nasal cavity, mouth, larynx, pharynx, lungs, and diaphragm.



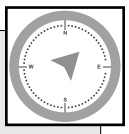
The respiratory organs can be divided into the upper and lower respiratory tract. The **upper respiratory tract** includes the nasal cavity, pharynx, and larynx. The trachea, bronchus, and lungs belong to the **lower respiratory tract**. The **nasal cavity** opens to the nose. The nose and nasal cavity warm and moisten air as a person breathes. As a defensive mechanism, tiny nose hairs and mucus produced by the epithelial mucosa cells in the nose help prevent particles in the air from entering the lungs.



Behind the nasal cavity is the **pharynx**. Both food and air pass through this long tube. Just below the pharynx is the **larynx**, or voice box. It channels air to the trachea and pushes food past the **epiglottis**, which covers the trachea during swallowing to prevent food from entering the lungs. Once food passes the epiglottis, it moves toward the esophagus. When air reaches the **trachea**, or windpipe, it travels down a long tube that branches into **bronchi**. The bronchi enter the lungs. As shown in the image, the bronchi branch into **bronchioles** before reaching tiny air sacs in the lung called **alveoli**. Gas exchange occurs in the alveolar region.

The **diaphragm** is a muscle that plays a large role in breathing. It is found at the base of the lungs and spreads across the bottom of the rib cage, forming the chest cavity. The human body

has two lungs that vary in size and weight. The right lung, which is larger and heavier, has three lobes. The left lung has two lobes.



DID YOU KNOW?

The total surface area of the alveoli in the lungs is roughly the size of a tennis court. Such a large surface area is needed to facilitate gas exchange and ensure the body is oxygenated at all times.

Example

Which organ uses hairs to filter out particles that try to enter the lungs?

A. Alveoli B. Bronchus C. Larynx D. Nose

The correct answer is **D.** The nose is part of the upper respiratory tract. Because it is the site where air enters the body, nose hairs help prevent airborne particles from entering the lungs.

Respiratory Functions and Breathing Mechanics

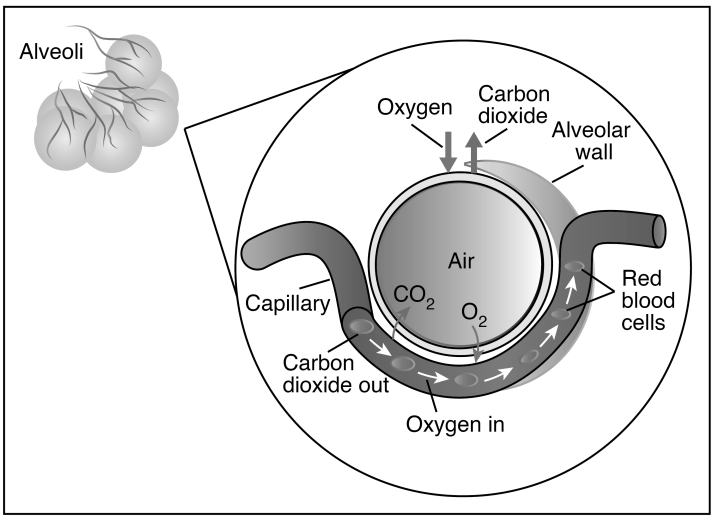
Recall that the primary function of the respiratory system is to provide oxygen to and remove carbon dioxide from the body. In addition to gas exchange, the respiratory system enables a person to breathe. Breathing, or inhalation, is essential to life. It is the mechanism that provides oxygen to the body. Without oxygen, cells are unable to perform their functions necessary to keep the body alive.

The primary muscle of **inspiration** is the diaphragm. Known as the chest cavity, this dome-shaped structure flattens when it contracts. The rib cage moves outward, allowing outside air to be drawn into the lungs. During relaxation, the diaphragm returns to its dome shape and the rib cage moves back to its natural position. This causes the chest cavity to push air out of the lungs.

The respiratory system can be functionally divided into two parts:

- **Air-conducting portion:** Air is delivered to the lungs. This region consists of the upper and lower respiratory tract—specifically, the larynx, trachea, bronchi, and bronchioles.
- **Gas exchange portion:** Gas exchange takes place between the air and the blood. This portion includes the lungs, alveoli, and capillaries.

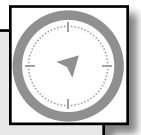
Alveolus Gas Exchange



Oxygen from the air enters the body through the respiratory system. But the

cardiovascular system circulates oxygen throughout the body via the blood. As shown in the image, alveoli are surrounded by a capillary bed in the lung.

This anatomical structure allows blood to absorb oxygen and transport it through a network of blood vessels to cells in various tissues throughout the body. During the process of gas exchange, the blood system absorbs carbon dioxide from cells and carries it to the respiratory system, where it is exhaled from the body.



BE CAREFUL!

When regulating blood gas and pH homeostasis levels, carbon dioxide, not oxygen, must be closely monitored.

The respiratory system works closely with both the cardiovascular and nervous systems to maintain blood gas and pH **homeostasis**. The body must regulate blood pH levels. When there is too much carbon dioxide in the blood, it is acidic (that is, its pH value is too low). If there is not enough carbon dioxide in the blood, it will be too alkaline (its pH value will be too high).

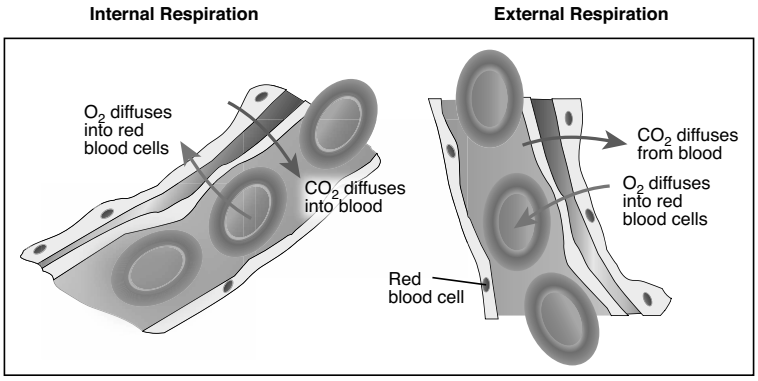
Example

What structure is directly involved in gas exchange?

A. Alveolus B. Bronchiole C. Pharynx D. Trachea

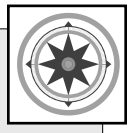
The correct answer is **A.** The alveolus is a tiny air sac found in the lung. Its primary function is to help the respiratory system perform gas exchange.

The Mechanics of Respiration



As shown in the image, the process of gas exchange between the outside air and the body is called **respiration**. It occurs on two levels: internal and external.

- **External respiration** occurs between the lungs and blood. When a person inhales, alveoli fill with oxygen through **diffusion**. Oxygen content is much higher than carbon dioxide levels. While in the alveoli region, blood becomes oxygen-rich. Once oxygenated, the blood leaves the lungs and travels through the left side of the heart, where it is pumped into circulation.



STEP-BY-STEP

The following four steps summarize external respiration:

Step 1. Air moves in and out of the lungs, which is called pulmonary ventilation.

Step 2. Gases are exchanged between air and blood in the lungs by diffusion.

Step 3. Gases are transported by circulation of the blood, with help from the heart.

Step 4. Gases are exchanged by diffusion between blood and tissues throughout the body.

- **Internal respiration** occurs between the blood and tissues. Once blood enters circulation, it reaches the capillaries. Oxygen diffuses through the capillaries into the cells. Carbon dioxide diffuses from the cells into the capillaries. Because carbon dioxide content is higher than oxygen content in blood at this point, it is called oxygen-poor blood. This oxygen-poor blood travels to the right side of the heart. It moves through the pulmonary circuit, where external respiration begins.

Example

What happens during internal respiration?

A. Air is inhaled into the body.

B. Oxygen-rich blood travels to the heart.

C. Air moves into and out of the pulmonary circuit.

D. Oxygen is exchanged for carbon dioxide in circulation.

The correct answer is **D.** During internal respiration, oxygen-poor blood is created as oxygen diffuses into the cells in exchange for carbon dioxide.

Let's Review!

- The respiratory system supplies oxygen to the body and removes carbon dioxide.
- Blood pH levels are regulated by the respiratory, cardiovascular, and nervous systems.
- Respiratory organs are anatomically divided into the upper and lower tract.
- Breathing is a mechanical process that provides oxygen, which is essential to all living things.
- Internal respiration involves gas exchange between blood and body tissues.
- External respiration is a gas exchange that happens between blood and the lungs.

The Gastrointestinal System

This lesson introduces the structures and functions of the digestive system.

Anatomy of the Digestive System

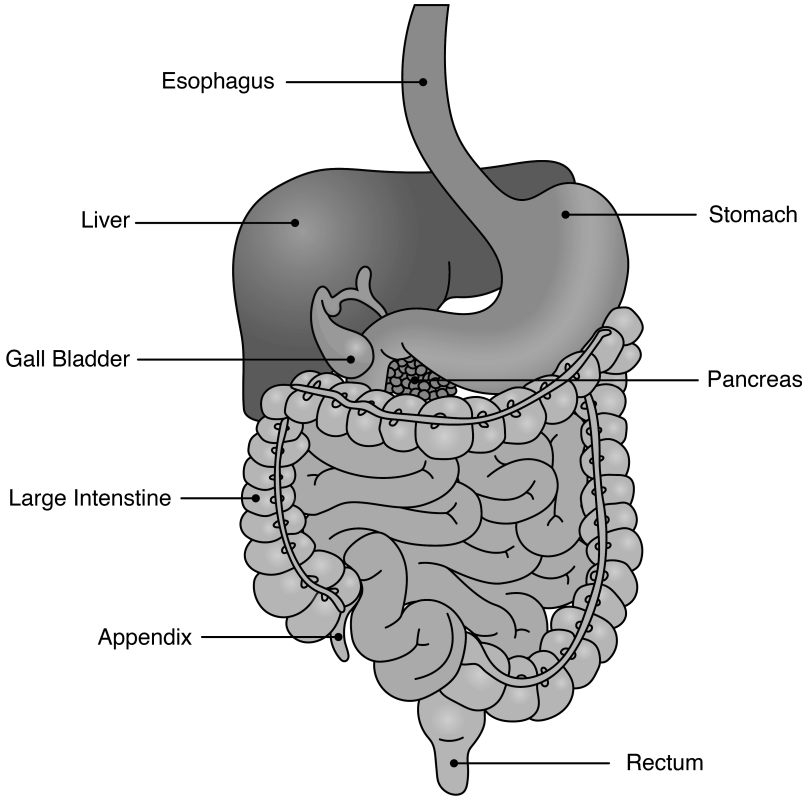
The following are the functions of the digestive system:

1. Take in food.
2. Break down food.
3. Absorb digested molecules.
4. Provide nutrients.
5. Eliminate wastes.

The digestive system consists of the **digestive tract**, which is a tube extending from the mouth to the anus, and the associated organs, which secrete fluids into the digestive tract. The term **gastrointestinal tract** technically refers to only the stomach and intestines.

The Path of Food

Food takes the path outlined below as it moves through the body.



- The **oral cavity**, or the mouth, is the first part of the digestive system. It is bounded by the lips and cheeks and contains the teeth and tongue. Its primary function is to masticate, or chew, and moisten the food.
- The **pharynx**, or throat, connects the mouth to the esophagus.
- The **esophagus** is a muscular tube about 25 centimeters long. Food travels down it to the cardiac sphincter of the stomach.
- The **stomach** is an enlarged segment of the digestive tract.
  - The opening of the stomach is the **cardiac sphincter**.
  - The muscular layer of the stomach is different from other regions because it has folds called **rugae** that increase the surface area.
  - The exit of the stomach is the **pyloric sphincter**.

- The **small intestine** is about 6 meters long and consists of three parts: duodenum, jejunum, and ileum.
  - The duodenum has more **villi** (finger-like projections), has a larger diameter, and is thicker than the other two parts.
  - This increases the surface area in the duodenum, which allows for more absorption of nutrients.
  - The small intestine is the primary site for diffusion of nutrients into the blood.
- The **large intestine** consists of the cecum, colon, rectum, and anal canal. The cecum is located where the small and large intestine meet.
  - The colon is about 1.5 to 1.8 meters long and consists of four parts: the ascending, transverse, descending, and sigmoid colon.
  - The primary function of the large intestine is to compress the waste and collect any excess water that can be recycled.

Example

Digestive organs include structures such as villi and rugae. Which of the following is a purpose they serve?

A. Increase surface area
B. Increase blood supply
C. Increase mucus secretion
D. Increase bacterial content

The correct answer is **A.** Structures such as the rugae and villi increase surface area. This allows for greater absorption.

Accessory Organs

Accessory organs contribute to the process of digestion. Food does not pass through these organs, but they play critical roles in the digestion of food. The accessory organs are listed below.

The **liver** weighs about 1.36 kilograms and is located in the upper-right quadrant of the abdomen. It is divided into two major lobes: the right lobe and left lobe. The liver has multiple functions:

- **Digestion:** Bile salts emulsify and help break down fats into fatty acids and glycerol.
- **Excretion:** Bile contains excretory products from the hemoglobin breakdown.
- **Nutrient storage:** The liver removes sugar from the blood and stores fats, vitamins, copper, and iron
- **Nutrient conversion:** The liver converts some nutrients into others. For example, it coverts amino acids to lipids or glucose
- **Detoxification of harmful chemicals:** The liver removes ammonia from the blood and converts it to urea.

- **Synthesis of new molecules:** The liver synthesizes new blood proteins such as albumins and fibrinogens.

The **pancreas** is a complex organ composed of both endocrine and exocrine tissues that perform several functions:

- It secretes bicarbonate ions, which neutralize acids.
- It secretes digestive enzymes that are important to all classes of foods.
- It produces insulin and glucagon, which regulate blood sugar levels.

The **gallbladder**, nestled under the liver, stores concentrated bile.

The **tongue** is a large, muscular organ that occupies most of the oral cavity. It moves food in the mouth and, in cooperation with the lips and cheeks, holds the food in place during mastication.

Saliva keeps the oral cavity moist and begins the process of chemical digestion with the enzyme amylase. There are three pairs of **salivary glands**:

- **Parotid** (largest, located in front of the ears)
- **Submandibular** (located below the mandible)
- **Sublingual** (smallest, located in the bottom of oral cavity)

These glands produce saliva, which is a mixture of serous (watery) and mucus fluids that contain digestive enzymes.

Example

Which of the following organs maintains a healthy pH level when a person eats an orange?

A. Gallbladder B. Liver C. Pancreas D. Tongue

The correct answer is **C.** One of the functions of the pancreas is to release bicarbonate ions, which neutralize acids.

Digestion

Digestion is the breakdown of food into molecules that are small enough to be absorbed into the bloodstream. There are two types of digestion: mechanical and chemical. **Mechanical digestion** breaks down large food particles into smaller ones and is evident as a person's teeth grind food into smaller pieces. During **chemical digestion**, digestive enzymes break covalent chemical bonds into organic molecules.

Carbohydrates are broken down into monosaccharides, **proteins** are broken down into amino acids, and **fats or lipids** are broken down into fatty acids and glycerol. Monosaccharides, amino acids, fatty acids, and glycerol molecules are small enough to diffuse across the membranes of the digestive system and enter the bloodstream, to be taken where they are needed.

Absorption begins in the stomach, where small, lipid-soluble molecules, such as alcohol and aspirin, can pass through the stomach epithelium into circulation. Most absorption occurs in the duodenum and jejunum, although some occurs in the ileum. Some molecules can

diffuse through the intestinal wall. Others must be transported across the intestinal wall. Transport requires a carrier molecule. If the transport is active, energy is required to move the transported molecule across the intestinal wall.

Enzymes:

Most enzymes are recognizable by the *-ase* ending. Here are some of the most common enzymes:

- **Amylase** is produced in the mouth and breaks down carbohydrates.
- **Pepsin** is produced in the stomach and breaks down proteins.
- **Lipase** is produced in the pancreas and secreted into the small intestine to break down lipids.
- **Peptidase** is produced in the pancreas and secreted into the small intestine to brown down peptides into amino acids.
- **Sucrase** is produced in the small intestine and breaks down sucrose into glucose.
- **Lactase** is produced in the small intestine and breaks down lactose into glucose.

Example

What are the building blocks of carbohydrates?

A. Glycerols
B. Fatty acids
C. Amino acids
D. Monosaccharides

The correct answer is **D.** Monosaccharides are the foundational units of carbohydrates.

Disorders of the Digestive System

The following are disorders of the digestive system.

Stomach:

- **Vomiting** results primarily from irritation of the stomach and small intestine. After the vomiting center has been stimulated, a sequence of events occurs that result in vomiting.
- **Ulcers** occur from a specific bacterium, *Helicobacter pylori*. Ulcers were previously thought to be caused by stress, but they can be treated successfully with antibiotics.
- **Peptic ulcer** is a condition in which the stomach acids digest the mucus lining of the duodenum. These ulcers are sometimes called **duodenal ulcers**. People who experience a great deal of stress tend to secrete as much as 15 percent more HCl than normal, which causes the **chyme**, semifluid food mass, to be highly acidic. There are not enough sodium bicarbonate ions to neutralize the acidic chime, and it eats away at the mucus lining, causing ulcers.

Liver:

- **Cirrhosis** is a disease characterized by damage or death of liver cells, which are replaced by connective tissue. This causes abnormal blood flow in the liver and interferes with normal liver functions.

- **Hepatitis** is an inflammation of the liver. Liver cells can die and be replaced with scar tissue.

Intestine:

- **Irritable bowel disease** is the general term for Crohn's disease or ulcerative colitis.
  - **Crohn's disease** includes a localized inflammatory degeneration that causes the wall of the small intestine to thicken. This disease causes diarrhea, abdominal pain, and weight loss.
  - **Ulcerative colitis** is limited to the mucosa of the large intestine. The involved mucosa exhibits inflammation, including edema, vascular congestion, and hemorrhaging.
- **Irritable bowel syndrome (IBS)** is a disorder of unknown cause in which intestinal mobility is abnormal. Patients exhibit pain in the left lower quadrant, especially after eating, and have alternating bouts of diarrhea and constipation.
- **Malabsorption syndrome** is a spectrum of disorders of the small intestine that result in abnormal nutrient absorption.
- **Appendicitis** is an inflammation of the appendix that usually occurs because of an obstruction.

Example

How is a duodenal ulcer different from an ulcer?

A. Antibiotics are ineffective with ulcers.

B. A duodenal ulcer is only found in adults.

C. An ulcer can occur from a variety of bacteria.

D. An increase in stomach acids can produce a duodenal ulcer.

The correct answer is **D.** Duodenal ulcers can occur as a result of an increase in the acidic levels in the duodenum. Regular ulcers are caused by bacteria.

Let's Review!

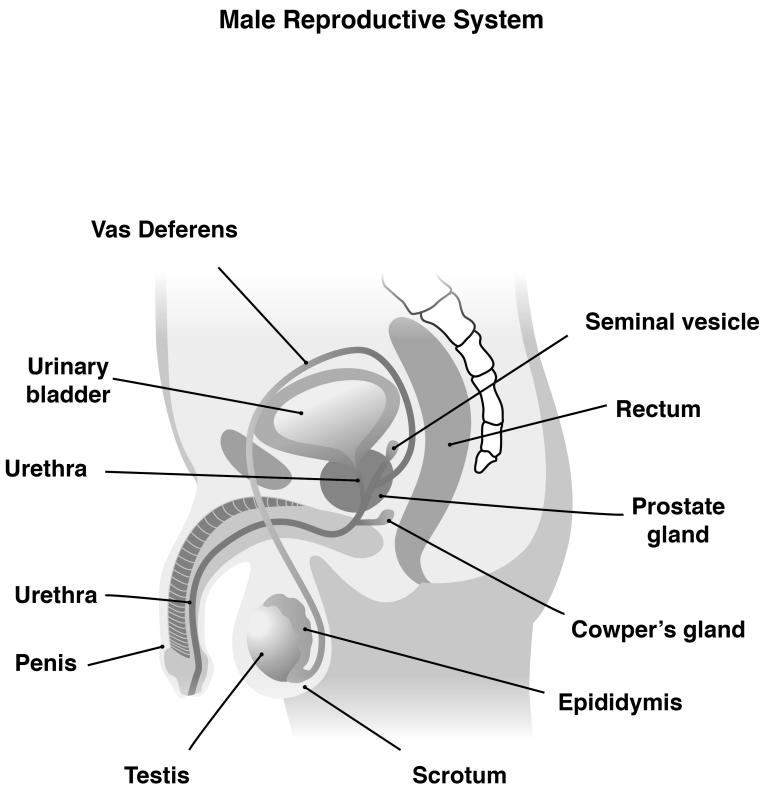
- The digestive system consists of the digestive tract, which is a tube extending from the mouth to the anus, and accessory organs.
- Accessory organs contribute to the process of digestion.
- Food does not pass through the accessory organs.
- Digestion is the breakdown of food into molecules that are small enough to be absorbed into the bloodstream.
- The two types of digestion are mechanical and chemical.

The Reproductive System

This lesson covers the human reproductive system. Through sexual intercourse, this system enables internal fertilization and delivery of an infant.

The Male Reproductive System

Like all biological systems, the male reproductive system is comprised of several organs. These organs are located outside or within the pelvis.



The main male reproductive organs are the **penis** and the **testicles**, which are located external to the body. The penis is composed of a long shaft and a bulbous end called the glans penis. The glans penis is usually surrounded by an extension of skin called the foreskin (though this often is removed in a cosmetic procedure called **circumcision**). The penis has three internal compartments (the corpus cavernosum) that contain erectile tissue. When a male is sexually aroused, this tissue becomes suffused with blood, increasing pressure, and the penis becomes larger and erect.

The **testes** (analogous to the female ovaries), or testicles, are retained in a pouch of skin called the **scrotum**, with descends from the base of the penis. The scrotum contains nerves and blood vessels needed to support the testicles' functions. The scrotum also regulates the temperature of the testicles by contracting (drawing the testicles closer to the warmer body) or relaxing (allowing the testicles to move away from the warmer body).

Each testicle (or testis) produces **sperm** (analogous to the female ova), which are passed into a series of coiled tubules called the **epididymis**. The epididymis stores and nurtures sperm until they are passed into the **vas deferens**, a tubule that is about 30 centimeters long, extending from the testicle into the pelvis and ending at the ejaculatory duct. The epididymis and vas deferens are supported by several accessory glands (the seminal vesicles, the prostate gland, and the Cowper glands) that produce fluid components of **semen** and support the sperm cells. During male orgasm, semen passes through the ejaculatory duct into the urethra and is ejaculated from the penis through the urethral opening.

Example

Where is the male reproductive system located?

A. The male reproductive system is located entirely within the pelvis.

B. The male reproductive system is located entirely outside the pelvis.

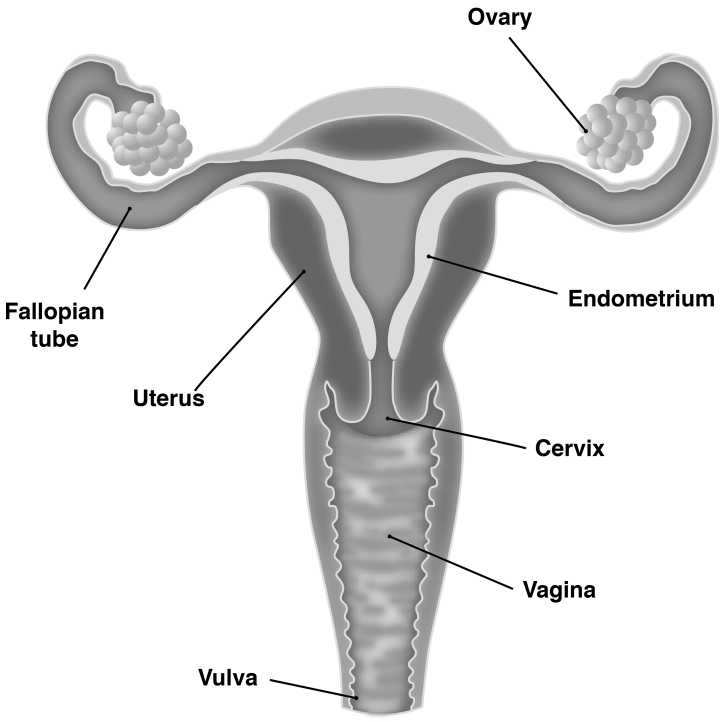
C. The male reproductive system is located primarily within the pelvis, though some components are outside the pelvis.

D. The male reproductive system is located primarily outside the pelvis, though some components are located within the pelvis.

The correct answer is **D.** Most of the components of the male reproductive system (penis, scrotum, testes, and epididymis) are external of the body, though some components (vas deferens and accessory glands) are located within the pelvis. The corpus cavernosum extends from within the pelvis into the penis.

The Female Reproductive System

Like all biological systems, the female reproductive system is comprised of several organs. These organs are located within the pelvis or external to the body.



The main female reproductive organs are the **uterus** (the "womb") and the **ovaries**, which are located in the pelvis. The ovaries (analogous to the male testes) produce several important hormones and the **ova** (analogous to the male sperm). After ovulation, the ovum is transported from the ovary to the uterus though the **Fallopian tube**. If sperm are present in the Fallopian tube, **fertilization** may occur. A fertilized **zygote** embeds in the endometrium of the uterus for gestation; an unfertilized ovum passes out of the body during subsequent menstruation.

The uterus has a lower opening called the **cervix**, which connects the uterus to the vagina. The female reproductive system has several organs that are external to the body, collectively known as genitals or, specifically, the vulva, including the labia (majora and minora), clitoris, and vaginal opening. When a female is sexually aroused, these external organs become suffused with blood, becoming larger and more erect, and the vagina becomes lubricated.

The uterus performs numerous critical functions during reproduction. It provides mechanical protection, nutritional support, and waste removal for the developing embryo (though a complex interfacing with the embryo's placenta). In addition, it is a powerful, muscular organ that is capable of contractions that push the fetus through the vagina at the time of birth.

Example

An embryo develops into a fetus in the _____.

A. Fallopian tube B. ovary C. uterus D. vagina

The correct answer is **C.** The zygote implants into the endometrium (uterine wall) and develops into an embryo; the embryo then develops into a fetus within the uterus.

Reproduction

Human reproduce sexually, with a male partner (the "father") providing sperm and a female partner (the "mother") providing an ovum and all subsequent protection and nourishment until the fetus is delivered.

Post-natal feeding is provided by the female's breasts. Human intercourse consists of the male introducing sperm into the female's reproductive system. Sperm may then pass through the female's reproductive system to the Fallopian tubes where one sperm fertilizes an ovum, creating a zygote. The zygote passes out of the Fallopian tube and implants into the uterine wall to begin gestation. Over nine months, the zygote develops and grows into an **embryo** and then a **fetus**.

At the abdomen, the fetus is connected to the **umbilical cord**, which connects to the **placenta**. The umbilical cord and placenta are formed from fetal tissue. The placenta shares a complex interface with the endometrial lining of the uterus. The endometrium and uterus are maternal tissue. Hormones, food, and fetal waste all pass through the placental/uterine interface and along the umbilical cord. As the fetus grows, the placenta also grows. The fetus is encapsulated in a tough container of fetal tissue, filled with fluid, called the **amniotic sac**.

During the early stages of delivery, the amniotic sac ruptures and the fluid passes through the mother's vagina (this is colloquially known as "water breaking"). Also, the cervix softens and dilates to accommodate the fetus. Powerful muscular contractions of the uterus force the fetus through the cervix and out the vagina, normally with the head emerging first. After the fetus is delivered, hormonal signals in the mother's body cause the endometrial lining to quickly disconnect from the placenta, and the placenta is delivered through the vagina (the "afterbirth").

In some cases, surgical removal of the fetus may be desirable or necessary. This process delivers a live baby and colloquially is known as Caesarean section (or C-section).

Example

An expectant mother's water "breaks" immediately before _____.

A. childbirth B. fertilization C. menstruation D. puberty

The correct answer is **A.** The amniotic sac ruptures, releasing the amniotic fluid, in the early stages of childbirth. This rupturing releases a large amount of fluid and is colloquially known as "water breaking."

Development

Human newborn infants are unable to care for themselves and survive only with a large amount of parental care extending over at least the first several years of life. At birth, humans have all of the basic structures of the adult reproductive system, though some are undeveloped. At about 10–11 years old in females and about 11–12 years old in males, a child enters **puberty**, during which hormonal changes cause the reproductive system to develop fully. Puberty lasts for about 5–7 years.

Menstruation is a cyclical process occurring in the female body, especially the reproductive system, from about the end of puberty until menopause. During each period of menstruation, fluctuating hormone levels cause the uterus to change in anticipation of receiving a zygote. At the midpoint of the menstrual cycle, an ovum is released from an ovary and travels down the Fallopian tube. If the ovum is not fertilized, it passes out of the body along with the endometrium (lining of the uterus), causing menstrual bleeding. If the ovum is fertilized, the zygote implants in the endometrium and pregnancy follows.

There are significant differences between male and female bodies. The primary differences can be noted in the reproductive organs, but numerous other differences are the result of secondary sex characteristics. Male secondary sex characteristics include facial hair and a generally larger body. Female secondary sex characteristics include enlargement of the breasts and widening of the hips.

Example

Which statement best characterizes the changes that occur during puberty?

A. Puberty is a recurring cycle involving fluctuating levels of hormones.

B. During puberty, the male's penis or the female's vulva develops basic structures.

C. During puberty, males and females reach sexual maturity and develop secondary sex characteristics.

D. Puberty occurs during the first trimester of pregnancy and results in the zygote developing into an embryo.

The correct answer is **C.** Puberty occurs during the early teenage years and results in sexual maturity. It is marked by the development of secondary sex characteristics.

Let's Review!

- The reproductive system enables sexual reproduction in humans.
- Components of the reproductive system are often known by multiple names, some of which are common or "slang" terms; the correct biological or medical terms are always preferred.
- The male reproductive system provides the sperm, the carrier of the genetic contribution from the father.
- The female reproductive system provides the ovum, or egg cell, which contains the genetic contribution from the mother. Additionally, the female reproductive system supports fertilization; provides the mechanical protection and nurturing environment needed for embryogenesis and gestation; and performs the actions necessary for the birth of the infant.
- The male testicles are analogous to the female ovaries. There are other similarities in the male and female reproductive systems.
- Sexual maturity occurs during puberty. Humans are capable of reproduction for several decades.

The Urinary System

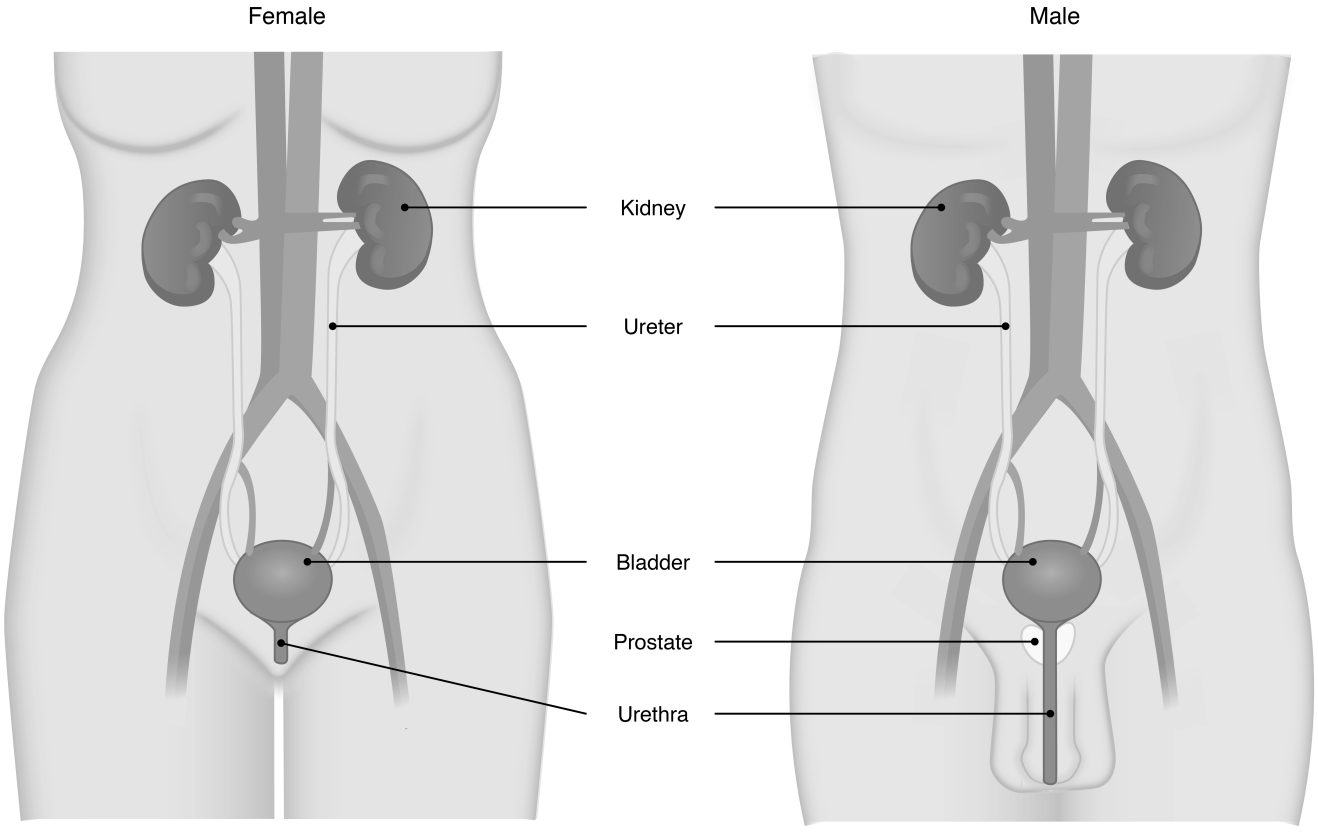
This lesson introduces the anatomy of the urinary system and how it functions. This lesson also explores the role of other body systems, particularly the circulatory and endocrine systems, in aiding with urinary excretion, absorption, and filtration.

Anatomy of the Urinary System

Inside the body, the kidney, ureters, bladder, and urethra make up the **urinary system**, which is also called the renal system. The ureters, bladder, and urethra comprise the **urinary tract**. This system has many functions, some of which are outlined below:

- **Waste elimination:** Urea, creatinine, uric acid, and ammonium are the primary types of nitrogenous wastes excreted from the body. The urinary system also detects and excretes excess water from the blood and out of the body.
- **Osmoregulation of blood and water:** There must be a continual balance of water and salt in the blood. The urinary system, specifically the kidneys, help maintain this balance. It also balances levels of metabolites or electrolytes such as sodium, potassium, and calcium.
- **Hormone secretion:** The kidneys secrete several hormones to regulate processes that range from blood pressure and red blood cell production to calcium uptake via vitamin D.

Several of these functions are performed with help from other body systems, specifically the cardiovascular and respiratory systems.

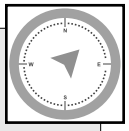


The following table outlines key characteristics of each organ that is labeled in the image above.

Organ	Shape	Characteristics
Kidney	Resembles beans, reddish-brown in color	The body has two kidneys, which excrete wastes in the urine out of the body.
Ureters	Tubular	Send urine from the kidney to the bladder.
Bladder	Pear (when emptied)	Stores urine until the body expels the fluid from the body. Has three openings: two for the ureters and one for the urethra.
Urethra	Tubular	Site where urine from the urinary bladder travels to an external opening. Removes urine from the body.

The primary organ of the urinary system is the kidney. Blood from the heart flows through the kidneys via the **renal artery**. As blood drains from the kidney, it exits through a series of veins, the most prominent of which is the **renal vein**. When urine is produced, it does not drain through the tubes through which blood flows. Rather, urine flows through two ureters before emptying into the urinary bladder. The following steps outline how the urinary system works:

1. Kidney filters and excretes wastes from blood, producing urine.
2. Urine flows down the ureters.
3. Urine empties into the bladder and is temporarily stored.
4. Bladder, when filled, empties urine out of the body via the urethra.



DID YOU KNOW?

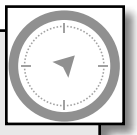
As a person ages, the kidneys and bladder change. This can affect functions such as bladder control and how well the kidneys filter blood. Kidney changes range from a decrease in kidney tissue to decreased filtration capacity. Bladder changes include decreased elasticity (which affects how much urine is stored) and weakened bladder muscles.

Example

Which organ of the urinary system filters blood?

A. Bladder
B. Kidney
C. Ureter
D. Urethra

The correct answer is **B.** There are two kidneys in the body, which are located below the rib cage. The kidneys filter the blood that comes from the heart and remove wastes from the blood.

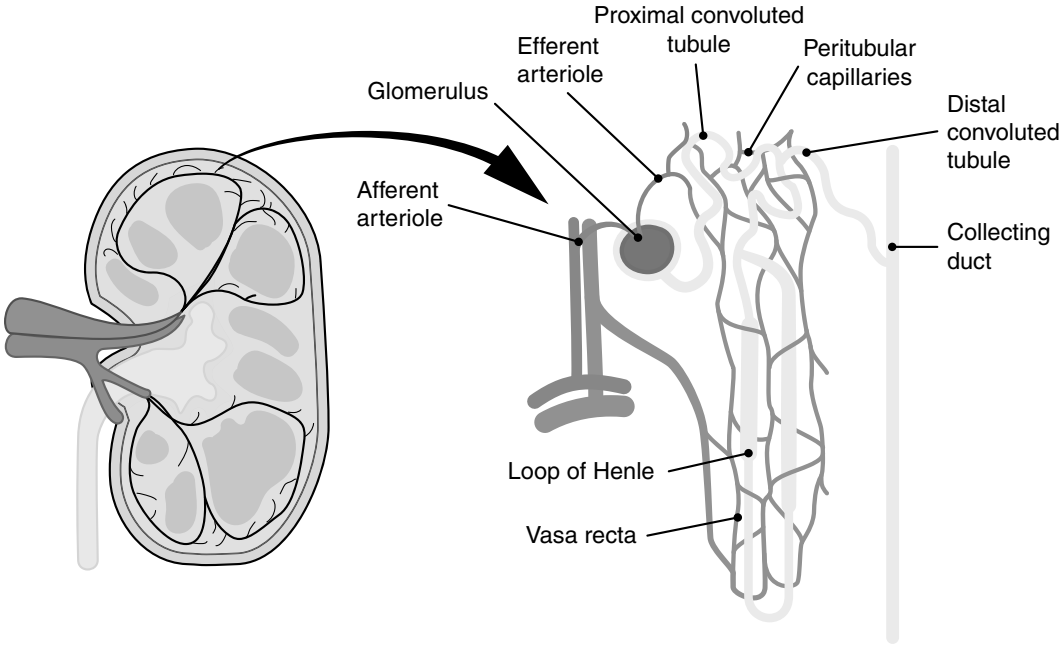


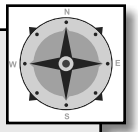
BE CAREFUL!

The kidneys do not make urine. They help regulate water balance, regulate levels of electrolytes such as sodium and potassium, and eliminate metabolic wastes. Urine is a byproduct of these functions.

Nephrons and Urine Formation

The functional and structural unit of a kidney is a **nephron**. One kidney contains more than one million nephrons. An illustration of these functional units is shown below:





KEEP IN MIND

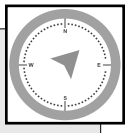
It is helpful to think of each nephron as a tiny filtering structure. Each nephron filters blood and forms urine. With more than one million nephrons in a single kidney, it is no wonder the kidneys are so efficient at filtering and excreting wastes from blood!

The nephron consists of two parts: the **renal corpuscle** and the **renal tubule**. The renal corpuscle can be divided into the **glomerulus** and **glomerular capsule** (or Bowman's capsule). The glomerulus is a type of capillary bed that functions as a filtration system, filtering solutes as blood enters the kidneys from the renal artery. Surrounding the glomerulus is Bowman's capsule. The renal tubule is a duct that connects to the glomerulus and terminates at the tip of the medullary pyramid. This tubule is divided into the following four regions: (1) **proximal convoluted tubule**, (2) **loop of Henle**, (3) **distal convoluted tubule**, and (4) **collecting duct**.

The components that make up the nephron filter blood and form urine. The following steps outline the pathway for urine formation. The steps are divided into three processes:

1. Glomerular filtration:
2. Blood enters the kidney though the renal artery.
3. This artery branches off into capillaries, allowing blood to flow into the glomerulus of the nephron.
4. Blood pressure forces water and solutes (smaller than proteins) to diffuse from blood across the capillary walls and through pores of Bowman's capsule into the tubule.
5. Tubular reabsorption:

6. The filtered fluid flows toward the proximal tubule. This is the major site of reabsorption of water and solutes such as glucose, amino acids, and certain ions.
7. The fluid travels to the loop of Henle, which is another site of reabsorption.
8. Next, the fluid reaches the distal convoluted tubule. Reabsorption and secretion take place in this segment.
9. Tubular secretion:
10. In the final segment, the collecting duct, fluid that remains in the duct is called urine. Reabsorption of some water and its return to the bloodstream may happen at this segment.
11. At this site, creatinine and other nitrogenous wastes are actively secreted into the urine so they can be excreted out of the body.



DID YOU KNOW?

About 180 liters of blood pass through the nephrons of the kidney each day. This explains why much of this fluid and its contents must be reabsorbed.

Example

Where does urine form?

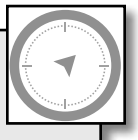
A. Loop of Henle
B. Collecting duct
C. Distal convoluted tubule
D. Proximal convoluted tubule

The correct answer is **B.** The nephron is the functional unit of the kidney. This structure consists of four major components: proximal and distal convoluted tubules, loop of Henle, and collecting duct. As blood travels through each of these segments, it is filtered to create urine in the collecting duct.

Urine Excretion and ADH

After blood is filtered through the nephron and the byproduct of urine is produced, urine accumulates in the collecting ducts of the nephron. Eventually, urine enters the ureters, which are muscular tubes. With help from muscle contractions, the ureters contract to move urine into the bladder. Urine is stored until the bladder is about half full.

Upon reaching this level, a neural impulse is transmitted telling a **sphincter** in the bladder to relax and allow urine to exit the bladder. Contraction of this sphincter, which is a muscular tube, is under involuntary control. Urine flows from the bladder into the urethra, which expels urine out of the body. A second sphincter enables urine to leave the body. This process is known as urination.



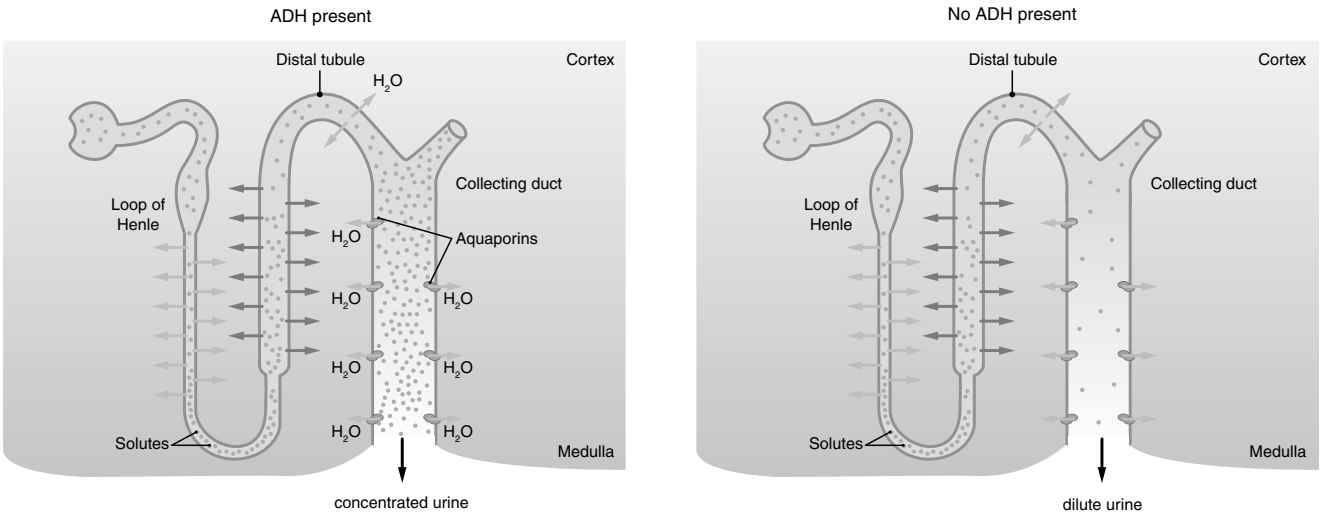
BE CAREFUL!

The urethra in males and females are different sizes due to the reproductive anatomy. The male urethra is about 20 centimeters long. It passes through the length of the penis and terminates at the end of the penis, where urine is removed from the body. The female urethra is about four centimeters long.

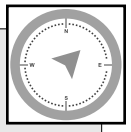
Recall that the urinary system works closely with the cardiovascular system to filter blood and

return important substances back to the bloodstream during tubular reabsorption. To help maintain water and solute concentration either excreted from or reabsorbed by the body, the urinary system works with hormones that are part of the endocrine system to regulate this process. One of these hormones is the **antidiuretic hormone**, also known as ADH. This hormone is secreted from the posterior pituitary gland, which is found at the base of the brain.

One of the most important functions of ADH is to regulate urine concentration and volume by controlling how much water is reabsorbed in the tubules of the nephrons. The following image shows how ADH controls urine formation.



As shown in the image, when ADH is present, there is an increased permeability of water at the distal convoluted tubule and collecting duct. This causes more water to be reabsorbed and retained. It also decreases the volume of urine produced and concentrates the urine. The opposite occurs when ADH is not actively communicating with the kidneys and regulating urine formation.



DID YOU KNOW?

ADH control of urine formation is intimately connected to diabetes insipdus. When people have this disease, ADH does not communicate properly with the kidneys. As a result, symptoms include excessive thirst and frequent urination.

Example

The antidiuretic hormone primarily controls tubular reabsorption of which substance?

A. Calcium B. Creatinine C. Urea D. Water

The correct answer is **D.** Regulating how much water the body excretes or reabsorbs is a key function of the urinary system. To perform this function, kidneys must communicate with the hormone ADH, which is released from the posterior pituitary gland in the brain.

Urinalysis

Medical professionals can determine diseases that affect the urinary system by conducting a **urinalysis**. This type of test can reveal disease that does not necessarily present observable symptoms. Diseases confirmed through urinalysis include diabetes mellitus, different types of glomerulonephritis, and urinary tract infections. Both macroscopic and microscopic urinalysis can be performed.

- **Macroscopic urinalysis:** The first part of this testing involves visual observation of the urine. Normal fresh urine is pale to dark yellow in color. It is also clear and not cloudy. If the color is turbid or the urine is cloudy, there may be excess protein in the urine or the presence of a bacterial infection. Red or brown urine is considered abnormal. It could indicate that blood is present in the urine.
- An urine dipstick test is another type of macroscopic urinalysis. With this test, a plastic dipstick or paper strip is inserted into the urine sample. There are chemicals on the dipstick that cause it to change color when certain substances are present in the urine (at a specific concentration). Medical professionals can compare the color of the dipstick to a standard chart to analyze a urine sample.
- When the liquid is removed, this sediment is mounted to a microscope slide and analyzed using a microscope. Typically, this test is performed to look at blood cells in the urinary tract, bacteria, parasites, or even tumor cells. This test also helps confirm the diagnosis of various urinary problems like kidney disease, cancer, microbial infections, and liver disease.
- **Microscopic urinalysis:** This type of urinalysis requires the use of a light microscope. Typically, a urine sample is spun down, or centrifuged, in a test tube. This causes a sediment consisting of red blood cells, fat cells, and other large particles to aggregate and separate from the liquid portion of the urine.

Example

What is most likely analyzed during microscopic urinalysis?

A. Volume of water in urine
B. Amount of urea excreted
C. Sodium levels in the urine
D. Presence of white blood cells

The correct answer is **D.** During microscopic urinalysis, large substances like blood cells and bacteria are separated from the liquid portion of urine. These substances are placed on a microscopic slide and analyzed to make or confirm a diagnosis.

Let's Review!

- The urinary system eliminates wastes from the body, regulates blood and water levels, and secretes hormones that directly influence various physiological processes in the body.
- The circulatory and endocrine systems work with the urinary system to perform various functions.
- Nephrons are functional units and structures of the kidneys that play a large role in filtration, reabsorption, and secretion.

- After blood enters the kidneys through the renal artery, it is filtered in the glomerulus. Then, it travels through the proximal tubule, the loop of Henle, and the distal convoluted tubule before accumulating as urine in the collecting duct.
- The kidneys form urine as a byproduct, which travels through the ureter before being stored in the bladder and eventually excreted from the body via the urethra.
- Urinalysis is a method used to evaluate the quality of urine and help diagnose various urinary health problems.

Chapter 7 Human Anatomy and Physiology: Organization of Systems Practice Quiz 1

1. **Platelets are important because they**
   A. give blood its natural color.
   B. repair broken blood vessels.
   C. transport nutrients to the cells.
   D. protect the body against infection.

2. **What happens after platelets aggregate at a damaged blood vessel site?**
   A. The site of the wound is healed.
   B. The damaged blood vessel constricts.
   C. The platelets stick together and form a plug.
   D. Red blood cells are recruited to the injured site.

3. **Which of the following enzymes breaks down proteins?**
   A. Amylase
   B. Lactase
   C. Pepsin
   D. Sucrase

4. **What is the primary function of the oral cavity?**
   A. Diffusion
   B. Digestion
   C. Lubrication
   D. Mastication

5. **Which cavity is surrounded by the rib cage and separated from the abdominal cavity by the diaphragm?**
   A. Abdominal
   B. Gastric
   C. Pelvic
   D. Thoracic

6. **_____ are composed of two or more tissue types that together perform one or more common functions.**
   A. Cells
   B. Chemicals
   C. Organs
   D. Tissues

7. **Fertilization is the result of _____.**
   A. meiosis
   B. childbirth
   C. spermatogenesis
   D. sexual intercourse

8. **Humans utilize which type of reproduction?**
   A. Binary fission
   B. Parthenogenesis
   C. Sexual reproduction
   D. Asexual reproduction

9. **Which organ branches off into the bronchi?**
   A. Alveolus
   B. Larynx
   C. Nose
   D. Trachea

10. **What is the function of the pharynx?**
    A. Allow food and air to pass into the body
    B. Warm and moisten air during inhalation
    C. Create a chest cavity at the base of the lungs
    D. Provide structural support to the alveolar region

11. Which is a characteristic of the bladder?

A. Stores urine

B. Filters blood

C. Shaped like a bean

D. Reddish-brown in color

12. After being produced by the kidneys, where does urine flow next?

A. Ureter

B. Urethra

C. Renal vein

D. Renal artery

Chapter 7 Human Anatomy and Physiology: Organization of Systems Practice Quiz 1 — Answer Key

1. B. At the site of injury or damage to a blood vessel, platelets help repair the damaged area. **See Lesson: Cardiovascular System.**

2. C. After the platelets aggregate at the damaged site, they stick together to form a plug. Next, blood coagulation occurs when a fibrin mesh forms around the platelet aggregate. **See Lesson: Cardiovascular System.**

3. C. Pepsin is produced in the stomach and breaks down proteins. **See Lesson: Gastrointestinal System.**

4. D. The primary function of the oral cavity is to break up the food through mastication. **See Lesson: Gastrointestinal System.**

5. D. The thoracic cavity is surrounded by the rib cage and is separated from the abdominal cavity by the diaphragm. **See Lesson: Organization of the Human Body.**

6. C. Organs are composed of two or more tissue types that together perform one or more common functions. **See Lesson: Organization of the Human Body.**

7. D. Fertilization results from sexual intercourse. It may result in childbirth. Meiosis and spermatogenesis are precursors to fertilization. **See Lesson: Reproductive System.**

8. C. Humans utilize sexual reproduction. **See Lesson: Reproductive System.**

9. D. The trachea is a hollow tube in the upper respiratory tract that branches off into bronchi, which extend into the lungs. **See Lesson: The Respiratory System.**

10. A. The pharynx is found right behind the nasal cavity. It is a passageway through which food and air flow. **See Lesson: The Respiratory System.**

11. A. The bladder is a sac-like organ that stores urine after it travels through the ureter. Once the bladder reaches half full, the urine is emptied into the urethra and out of the body. **See Lesson: The Urinary System.**

12. A. Urine is a byproduct of the blood that is filtered in the kidneys. This tubular filtrate travels to the ureter, which is a muscular tube that contracts to push urine to the urethra and out of the body. **See Lesson: The Urinary System.**