

Functions of the Circulatory System: Transports oxygen, nutrients, and other substances throughout the body, and removes wastes from tissues

Heart Structure

- About the size of your fist
 - Composed almost entirely of muscle
 - In the walls of the heart, 2 thin layers of epithelial and connective tissue form a sandwich around a muscle layer *myocardium*
 - Powerful contractions of the *myocardium* pump blood through the circulatory system
 - - Heart is divided in 4 chambers:
 - A wall called the *Septum* separates the right side of the heart from the left side
 - The *Septum* prevents oxygen-poor and oxygen-rich blood from mixing
 - On each side of the *Septum* are an upper and lower chamber
 - Each upper chamber (*Atrium, plural Atria*) receives blood from the body
 - Each lower chamber (*ventricle*) pumps blood out of the heart
1. Right Atrium
 2. Left Atrium
 3. Right Ventricle
 4. Left Ventricle

*Orientation is determined by the patient's point of view

Blood Flow Through the heart

- Blood enters the heart through the right atrium (from body)
- Blood enters the heart through the left atrium (from lungs)
 - When atria contract, blood is pushed to the ventricles
 - Flaps of connective tissue called *Valves* are located between the atria and ventricles
 - When blood moves from the atria into the ventricles, those valves open
 - When the ventricles contract, the valves close, preventing blood flowing back into the atria
 - Valves are also located at the exits of each ventricle
 - Keeps traffic moving

The Heart's Blood Supply

- Needs a constant supply of oxygen and nutrients
- Does not get much of its oxygen and nutrients from blood
- Pair of blood vessels, *Coronary arteries*, branch from aorta and run through heart tissue, supply blood to the heart muscle
 - *Coronary arteries* and the vessels that branch from them are relatively narrow
 - If blocked, heart muscles could run out of oxygen and could begin to die (EX. heart attack)

Circulation

- Although it is one organ, the heart functions as two pumps
 - One pump pushes blood to the lungs
 - Other pump pushes blood to the rest of the body
- The two pathways of blood through the body are called pulmonary circulation and systemic circulation

Heartbeat

- Heart must be pumped in a coordinated way
- Two networks of muscle fibers coordinate the heart's pumping action:
 - One in the atria
 - One in the ventricle
- When a single muscle fiber in either network is simulated, the entire network contracts

Control of Heart Rate

- Varies depending on your body's need to take in oxygen and release carbon dioxide
- Eg. Heart Rate could increase to about 200 bpm (beats per minute)
- Heart rate is not directly controlled by nervous system
 - The autonomic nervous system influences the activity of the SA nodes.

- Neurotransmitters released by the sympathetic nervous system increase heart rate
- Those released by the parasympathetic nervous system decrease heart rate

Blood Vessels

- Oxygen rich blood leaving the left ventricle passes into the aorta
 - Aorta is the 1st of a series of vessels that carries blood through systemic circulation and back to the heart
- As blood flows through three types of blood vessels—arteries, capillaries, and veins

Blood Pressure

- When heart contract, it produces a wave of fluid pressure in the arteries, known as blood pressure
- Although blood pressure falls when heart relaxes between beats, the system still remains under pressure due to the elasticity of the arterial walls.
 - Without pressure, blood would stop flowing throughout the body

Sphygmomanometer: Inflatable cuff with a pump and meter

- Used to measure blood pressure
- Wrapped around upper arm and pumped until blood flow through artery that runs down the arm is blocked
- As pressure is released, listen for a pulse with a stethoscope and record the number from meter
 - This number represents the systolic pressure (force in the arteries when the ventricles contract)
- When pulse sound disappears, a second number is recorded
 - This number represents the diastolic pressure (force in arteries when ventricles relax)

*Typical blood pressure for a healthy teen or adult is below 120/80

The body regulates blood pressure:

1. Sensory receptors in blood vessels detect blood pressure and send impulses to the brain stem.

- When blood pressure is high, the autonomic nervous system releases neurotransmitters that relax muscles in blood vessel walls
- When blood pressure's low, neurotransmitters released to cause smooth muscles in vessel walls to contract

2. Kidneys

- Affect the volume of blood
- Triggered by hormones produced by the heart and other organs
- The kidneys remove more water from the blood and eliminate it in urine when blood pressure is high or conserve more water when blood pressure is low.

Blood

- Various components of blood also help regulate body temperature, fight infections, and produce clots that help minimize the loss of body fluids from wounds.

○ **Plasma**

- - The human body contains 4 to 6 liters of blood.

- About 55 percent of total blood volume is a straw-colored fluid called *plasma*
- *Plasma is about 90 percent water and 10 percent dissolved gases, salts, nutrients, enzymes, hormones, waste products, plasma proteins, cholesterol, and other important compounds.*
- The water in plasma helps to control body temperature
- Plasma proteins consist of three types:

1. Albumin

- Transport substances such as fatty acids, hormones, and vitamins
- Regulating osmotic pressure and blood volume

2. Globulins

- Transport substances such as fatty acids, hormones, and vitamins
- Some globulins fight viral and bacterial infections

3. Fibrinogen

- Necessary for blood to clot

Red Blood Cells

- Most numerous cells in blood are red blood cells, or erythrocytes
- Main function : Transport oxygen
- They get their crimson color from the iron in hemoglobin, a protein that binds oxygen in the lungs and releases it in

capillary networks throughout the body

- Then red blood cells transport some carbon dioxide to the lungs
- Disks that are thinner in their center than along their edges
- Produced by cells in red bone marrow
- Red blood cells mature: fill with hemoglobin, their nuclei and other organelles are forced out.
- Red blood cells circulate for an average of 120 days
 - Destroyed in the liver and spleen

White Blood Cells

- White blood cells, or leukocytes, are the “army” of the circulatory system
- White blood cells guard against infection, fight parasites, and attack bacteria
 - Body can increase the number of active white blood cells dramatically during a “battle” with foreign invaders
 - Increase of white blood cells= sign that your body is fighting a serious infection
 - White blood cells are not confined to blood vessels
 - Many white blood cells can slip through capillary walls to attack foreign organisms
 - Different types of white blood cells perform different protective functions.
 - Macrophages engulf pathogens.
 - Lymphocytes are involved in the immune response
 - B lymphocytes produce antibodies that fight infection and provide immunity
 - T lymphocytes help fight tumors and viruses
 - Healthy person : White blood cells are outnumbered by red blood cells by almost 1000
 - White blood cells are produced from stem cells in bone marrow
 - Unlike red blood cells, white blood cells keep their nuclei and can live for years

Platelets

- Blood clotting is made possible by plasma proteins and cell fragments called platelets
- The cytoplasm of certain bone marrow cells divides into thousands of small fragments
 1. The fragments are each enclosed in a cell membrane
 2. They then break off and enter the blood as platelets.
 3. When platelets come in contact with edges of a broken blood vessel, their surface becomes sticky,
 4. They cluster around the wound
 5. These platelets release proteins called clotting factors that start a series of reactions

The Lymphatic System

- As blood passes through capillaries, some blood cells and components of plasma move through capillary walls and into the fluid between cells, carrying nutrients, dissolved oxygen, and salts
- Each day about 3 liters of fluid, and the small particles it contains, leaves the blood
 - Most of this fluid, known as lymph, is reabsorbed into capillaries, but not all of it
 - The rest goes into the lymphatic system
- Lymphatic system, network of vessels, nodes, and organs that collects the lymph that leaves capillaries, “screens” it for microorganisms, and returns it to the circulatory system
 - Also involved in the absorption of nutrients and in immunity

Role in Circulation

- Lymph collects in a system of lymphatic capillaries that slowly conducts it into larger and larger lymph vessels
- The lymphatic system doesn’t have a pump to move lymph along
 - Lymph vessels have valves that prevent lymph from flowing backward
- Pressure on lymph vessels from surrounding skeletal muscles helps move lymph through system into larger ducts
 - These ducts return lymph to blood through openings in Subclavian veins (just below the shoulders)
- When injury or disease blocks lymphatic vessels, lymph can accumulate in tissues, causing swelling, *edema*

Role in Nutrient Absorption

- The lymphatic system also plays an important role in the absorption of nutrients
- A system of lymph vessels runs alongside the intestines
- The vessels pick up fats and fat-soluble vitamins from the digestive tract

- Then transport these nutrients into the bloodstream

Circulatory System Diseases

- Often the first sign of circulatory problems is an event that affects the heart or brain.
- Tissues in these vital organs begin to die within moments if their oxygen supply is interrupted
- Three common and serious diseases of the circulatory system:
 1. Heart disease
 2. Stroke
 3. High blood pressure
- Individuals with high blood pressure are at higher risk for both heart disease and stroke
- Heart disease is the leading cause of death in the United States

Heart Disease

- Heart muscle requires a constant supply of oxygen
- Most common Heart disease: When blood flow through these vessels is obstructed.
- EX: *Atherosclerosis* : Fatty deposits, plaques build up in artery walls and eventually cause the arteries to stiffen
 - Over time, plaques often bulge into the center of a vessel and restrict blood flow to heart muscle
 - Chest pain, known as *angina*, can be a sign of restricted blood flow
 - Eventually, heart can be weakened or damaged by oxygen deprivation, leading to heart failure
- If the cap on a plaque ruptures, a blood clot may form that completely blocks an artery
 - A heart attack occurs as heart muscle cells become damaged and possibly die
 - Heart attacks can also damage the SA or AV nodes
 - Which can affect the heart's ability to beat in a coordinated way
- Arteries severely narrowed by *Atherosclerosis*, use of drugs, and smoking can also lead to a heart attack.
 - Heart attack symptoms:
 - Nausea
 - Shortness of breath
 - Chest pain
 - Pain in the neck, jaw, or left arm.

Stroke

- The sudden death of brain cells when their blood supply is interrupted is called a *stroke*
 - Some strokes are caused by a blood clot that block a blood vessel in the brain
 - A stroke can also occur if a weak blood vessel breaks and causes bleeding in the brain
 - Symptoms of stroke:
 - Severe headache
 - Numbness
 - Dizziness
 - Confusion
 - Trouble seeing or speaking
- - The results of a stroke vary: depending on which part of the brain it affects
- - Some strokes cause death... Other strokes may cause paralysis or loss of speech.
 - - Prompt medical treatment may lessen the severity of a stroke.

High Blood Pressure

- High blood pressure, or *hypertension*, is usually defined as a reading of 140/90 or higher
- Hypertension often has no symptoms
 - People may have it for years and not know
- Heart damage occurs as the heart struggles to push blood through vessels.
- Hypertension also causes small tears in blood vessels, which sets the stage for atherosclerosis
- Likewise, the stiffened arteries that result from atherosclerosis can contribute to high blood pressure
 - Diet, exercise, and prescription drugs can help control hypertension
 - Uncontrolled hypertension can lead to heart attack, stroke, and kidney damage

Understanding Circulatory

- There are several factors that increase the risk of heart and stroke.
- Although many risk factors can be controlled, this can be difficult.
 - In some cases, medications may not be accessible or may not be effective.
 - EX. Blood cholesterol levels can be difficult to control. (until today where scientists now understand more about Blood cholesterol levels)
- - *Cholesterol* is a lipid that is part of animal cell membranes
 - Used in the synthesis of some (1) hormones, (2) bile, and (3) vitamin D.
 - Cholesterol is transported in the blood primarily by two types of lipoproteins:
 - 1. Low-density lipoprotein (LDL)
 - Cholesterol carrier that is most likely to cause trouble in the circulatory system because it becomes part of plaque
 - 2. High-density lipoprotein (HDL)
 - Often called good cholesterol, generally transports excess cholesterol from tissues and arteries to the liver for removal from the body
 - Measures of a person's blood cholesterol actually are measures of lipoproteins
 - Normal total blood cholesterol levels range from 100 to 200 milligrams per deciliter (mg/dL)

Sources of Cholesterol

- - The liver manufactures cholesterol
 - - Cholesterol then transported through the blood to tissues
- - Humans also consume cholesterol in meat, eggs, dairy products, and fried foods
 - EX: if those foods are high in saturated or trans fats