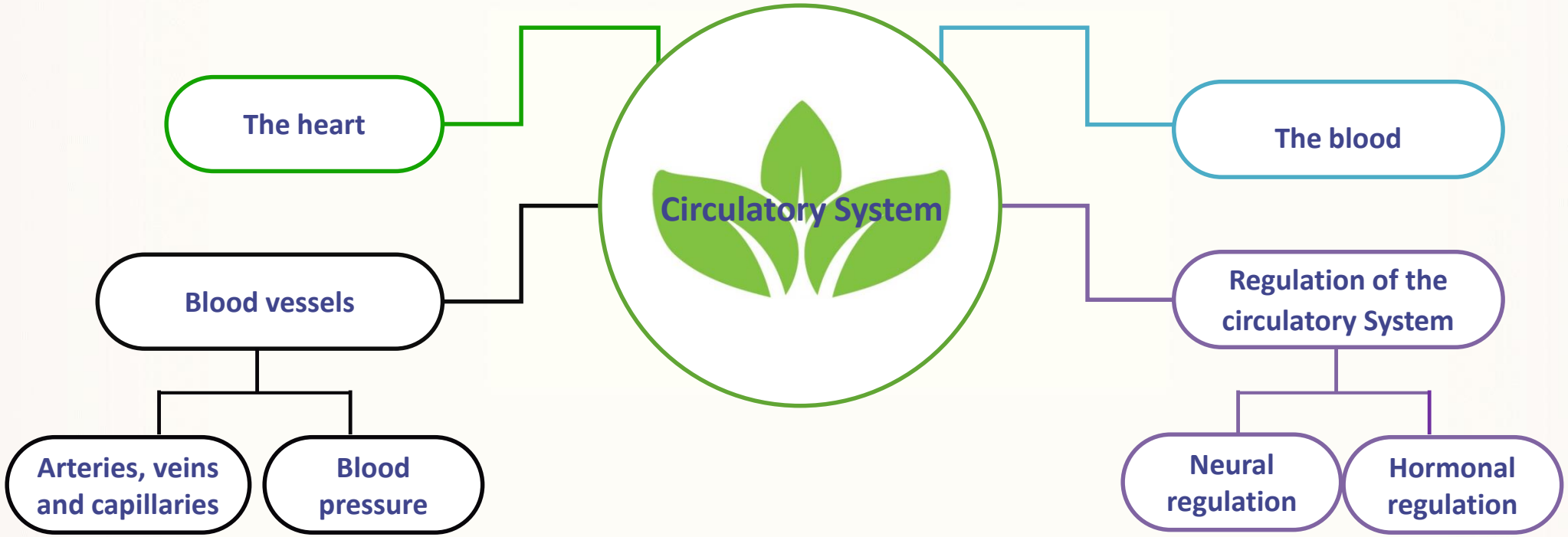
Mind Map


Circulatory System
The heart
Blood vessels
Arteries, veins and capillaries
Blood pressure
The blood
Regulation of the circulatory System
Neural regulation
Hormonal regulation

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Introduction

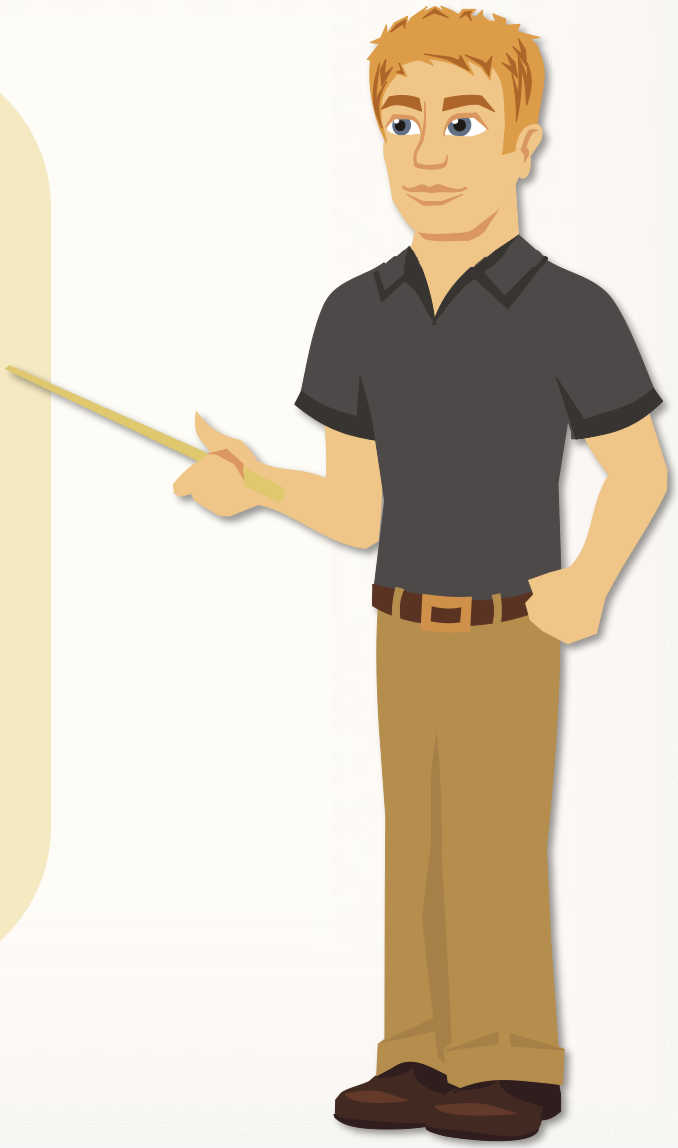
Definition

It is a fluid-filled network of tubes (or vessels) through which materials move between the environment and the cells of a multicellular animal. It is composed of the heart, blood, and vascular system (Arteries, arterioles, capillaries, venules and veins).

Function:

The cardiovascular system:

- distributes materials needed by cells: food, oxygen, and hormones.
- carries waste products and carbon dioxide away from the cells.



Objectives

- Describe the different parts of the circulatory system.
- Describe the structure and function of the heart.
- Describe the structure and function of the blood vessels.
- Explain the blood pressure and hypertension.
- Describe the different components of the blood and their functions.
- Explain the neural and hormonal regulation of the circulatory system and mainly of the blood pressure.

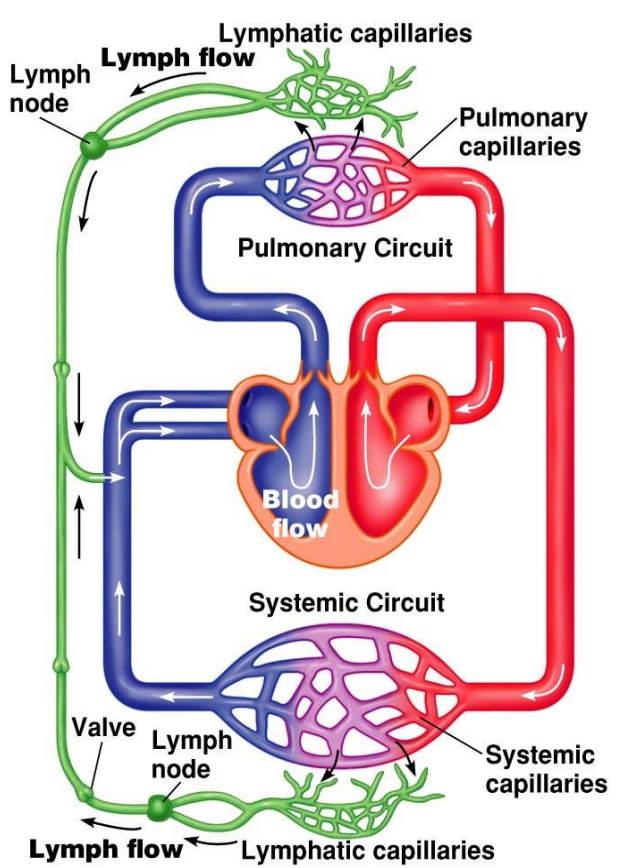
Activity

Can you comment the photo?

The heart

Anatomy

- The heart is a double pump, delivering blood to the lungs for oxygenation, and then to the body.
- Blood leaves the heart through arteries, and returns to the heart through veins
- The heart rate (no. of heartbeats/min) is regulated by a conducting system (the heart beats about 100,000 times per day!)= 70-80 beats/min.
- The left side of the heart pumps oxygenated blood to the body while the right side of the heart pumps deoxygenated blood to the lungs where oxygen can be absorbed by the hemoglobin carrying red blood cells.

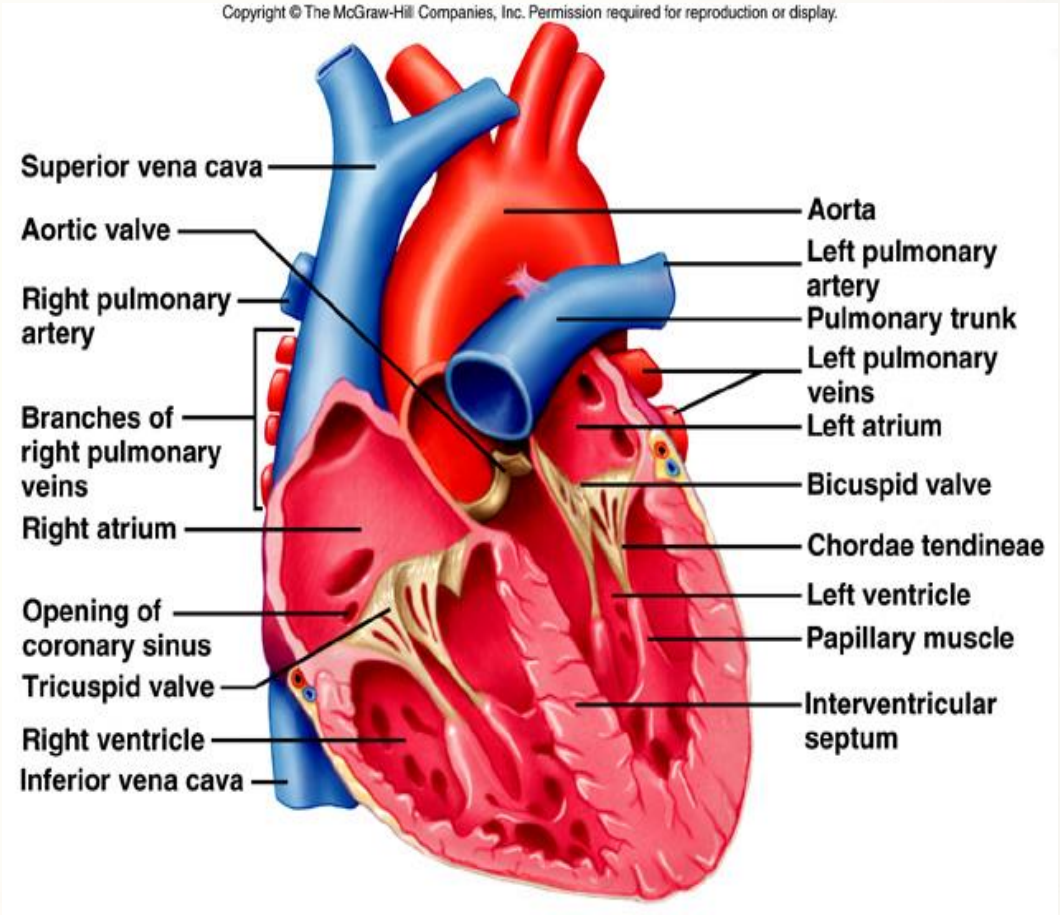


The heart

Anatomy

The heart has four chambers:

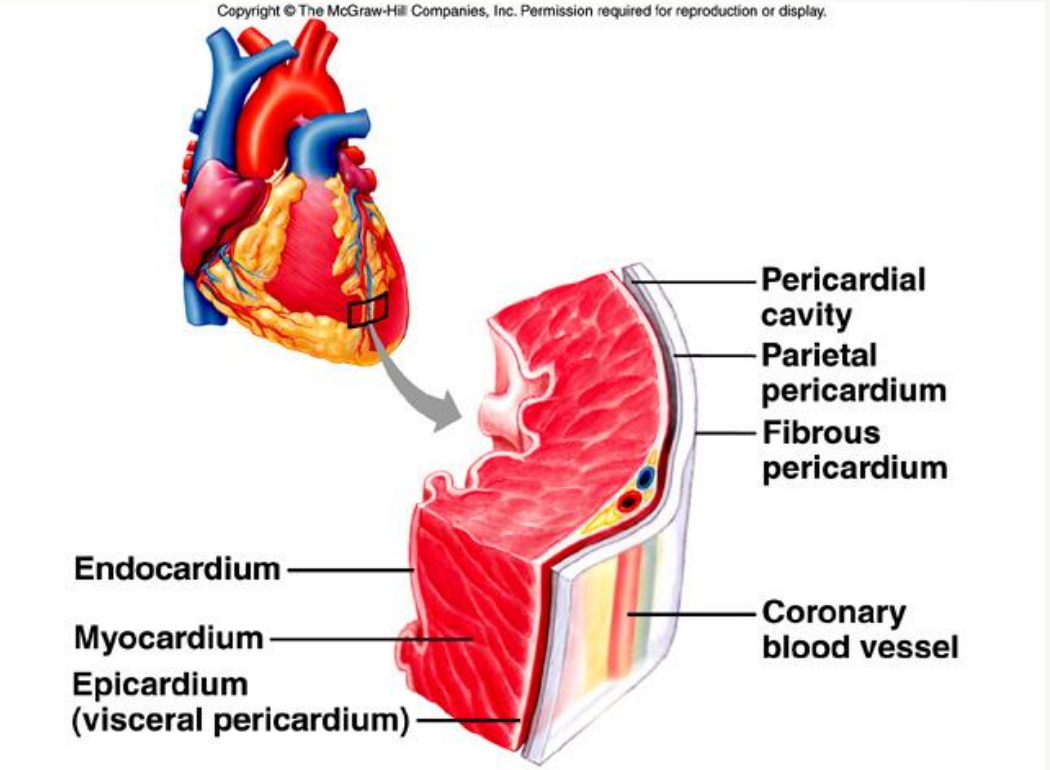
- Two upper chambers are called the atria (one atrium): right and left.
- Two lower chambers called ventricles: right and left (greater in size than atria. Wall of L. ventricle is thicker than R. ventricle).
- A septum divides the atrium and ventricle on each side. Each septum has a valve to ensure one way flow of blood: The right A-V valve (tricuspid) and left A-V valve (bicuspid).



The heart

Anatomy

- It is enclosed in an outer covering consisting of two layers called the pericardium.
- The lining of the inner surface of the heart is called the endocardium. Middle layer is myocardium and the external layer is called epicardium.

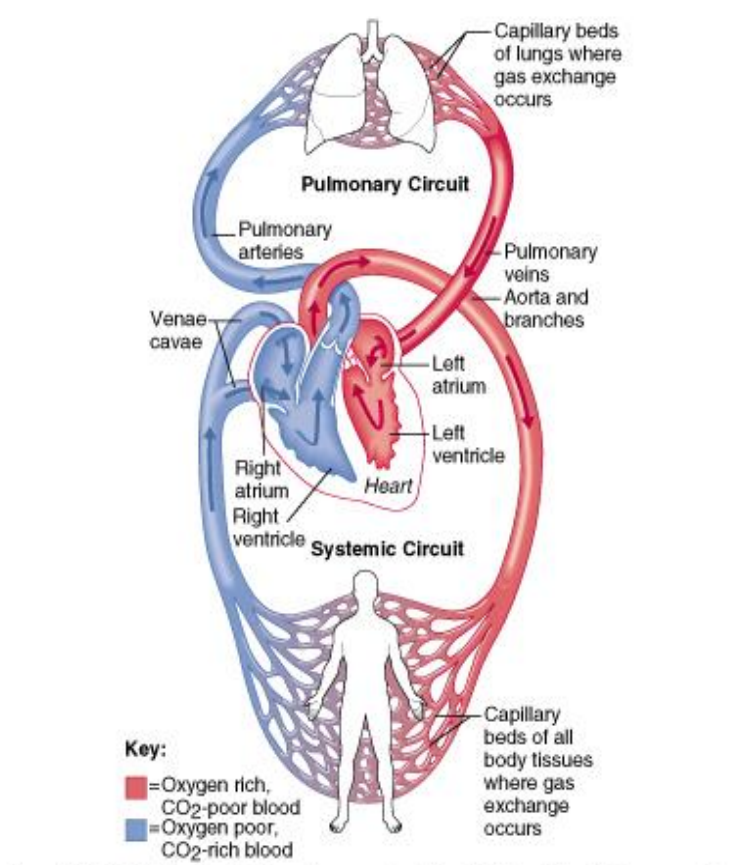


The heart

Pathway of the blood

The heart is actually two pumps, each serving a separate blood circuit:

- Blood vessels that carry blood to the lung form the pulmonary circuit.
- Blood vessels carrying blood to the body form the systemic circuit
- Deoxygenated Blood returning from the body enters the right atrium and passes into the right ventricle.
- The right ventricle pumps the blood to the lungs via the pulmonary trunk. Blood in the pulmonary circuit is oxygen poor and carbon dioxide rich
- Once in the lungs, the blood unloads carbon dioxide and picks up oxygen. Freshly oxygenated, the blood is carried back to the heart by the pulmonary veins pour into L. atrium.
- The left ventricle pumps the oxygenated blood into the aorta and from there into many distributing arteries.

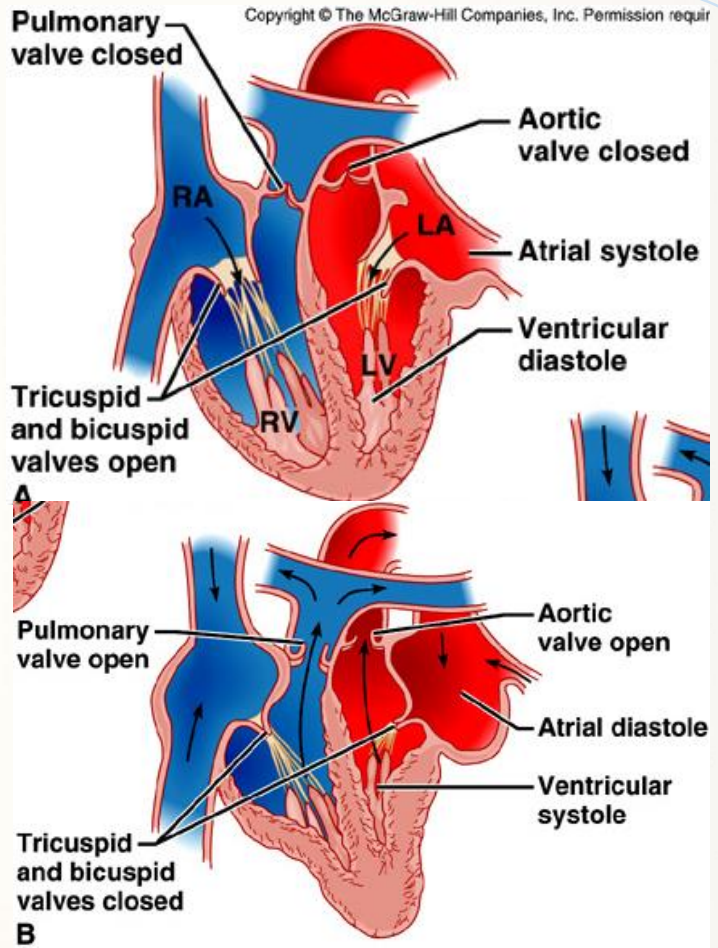


The heart

Coordination of chamber contraction, relaxation

The cardiac cycle consists of:

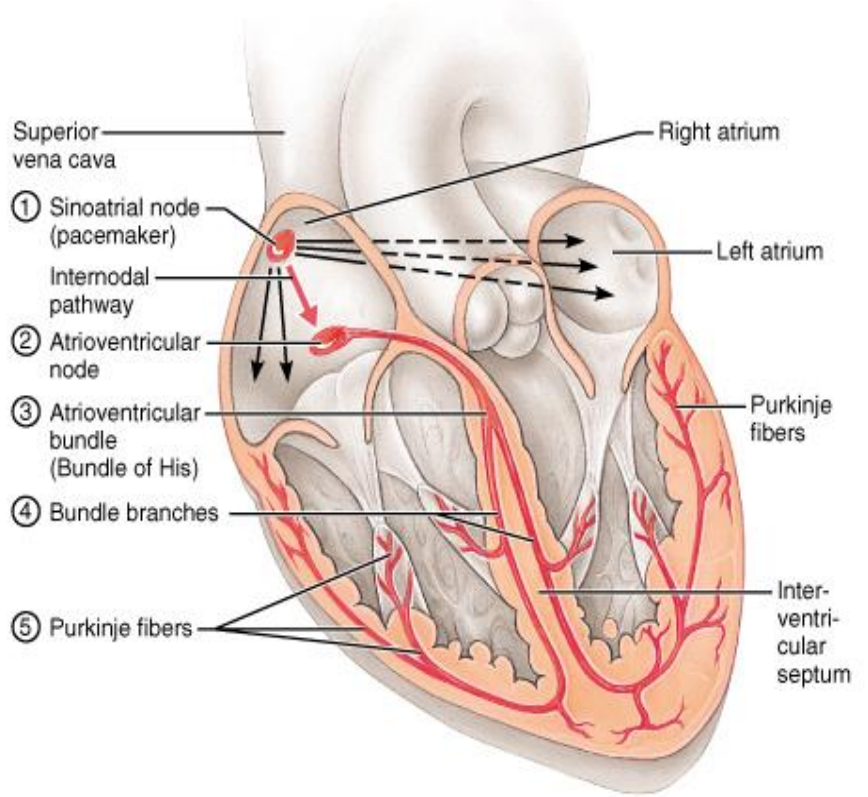
- The atria beating in unison (atrial systole) followed by the contraction of both ventricles, (ventricular systole) then the entire heart relaxes for a brief moment (diastole). Cardiac cycle could be defined as period from one heartbeat till beginning of the next.
- Pressure inside atria rises further as they contract, forcing the remaining blood into the ventricles.
- When ventricles contract, pressure inside them increases sharply, causing A-V valves to close and the aortic and pulmonary valves to open.
- The first sound (lubb) occurs as ventricles contract and A-V valves are closing. The second sound (dupp) occurs as ventricles relax and aortic and pulmonary valves (semi-lunar) are closing.



The heart

The conducting system

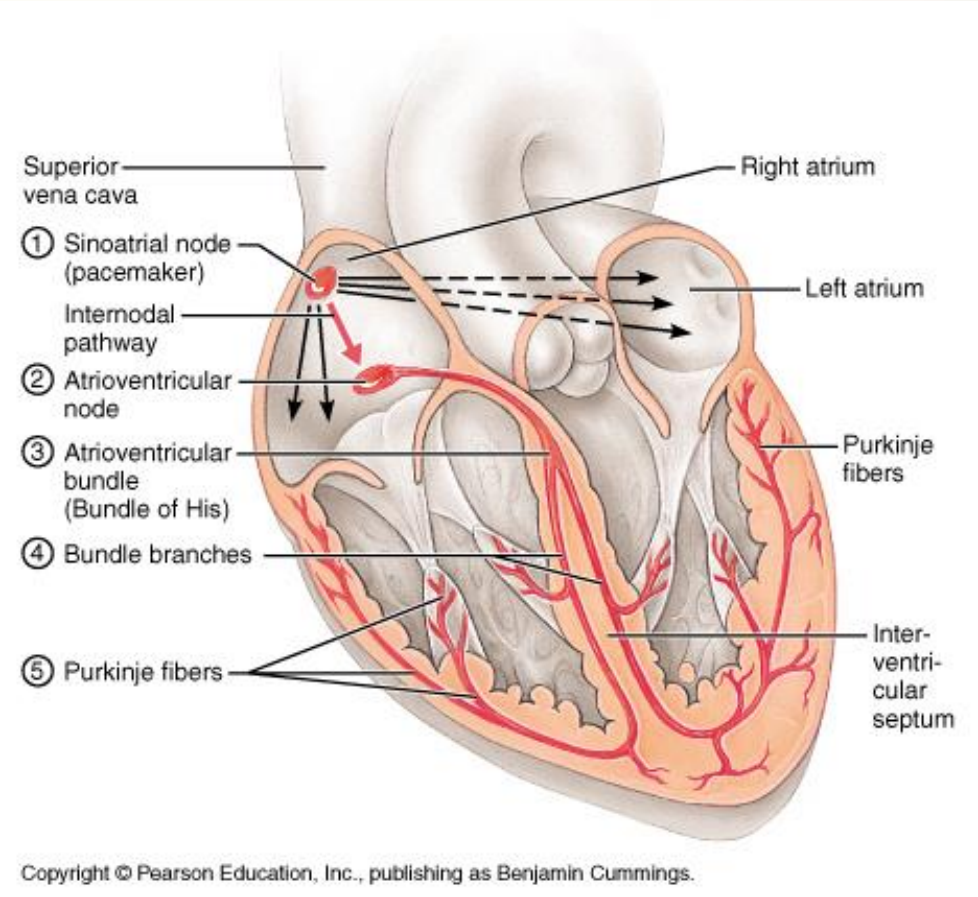
- The cardiac conduction system of the heart is a series of specialized cardiac muscle cells that carries impulses (electrical signals) throughout the heart musculature, signaling the heart chambers to contract in proper sequence.
- The components of the conducting system are:
  - *Sinoatrial (SA) node cells*
  - *Internodal fibers*
  - *Atrioventricular (AV)node cells*
  - *Atrioventricular bundle (bundle of His)*
  - *Right and left branches*
  - *Purkinje fibers*
- The impulse that signals each heartbeat begins at the sinoatrial (SA) node: a crescent shaped mass of muscle cells that lies in the wall of the right atrium just below the opening of the superior vena cava.



The heart

The conducting system

- The sinoatrial node, the heart's own pacemaker, sets the basic heart rate by generating 70-80 impulses per minute.
- Impulses from the SA node spread in a wave along the cardiac muscle fibers of the atria signaling the atria to contract
- Some of these impulses travel along the intranodal pathway to the atrioventricular (AV) node in the inferior part of the interatrial septum, enters the interventricular septum and divides into right and left bundle branches.
- the Bundle fibers, (crura), become bundles of Purkinje fibers which approach the apex of the heart, then turn superiorly into the ventricular walls



Blood vessels

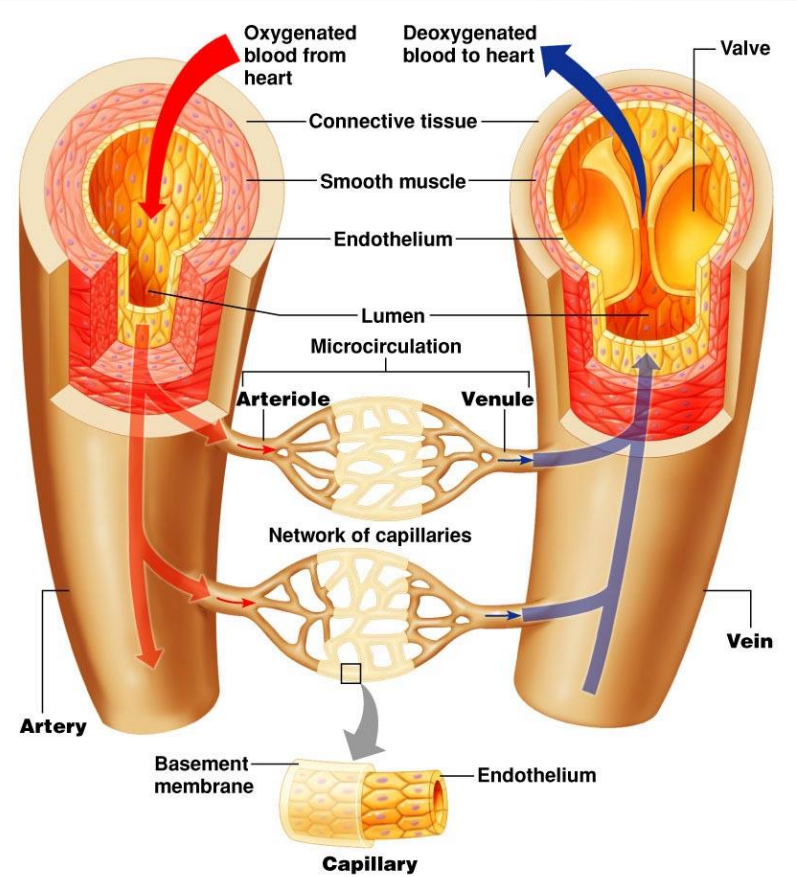
• Arteries and arterioles carry blood away from heart. Their walls are too thick for blood components to pass through.

Returning blood to the heart:

• Venules are continuous with capillaries; take in some returned fluid (rest is retained by tissues or returned to blood via lymphatic system).

• Veins have thinner walls due to the less muscle, but can hold much more blood.

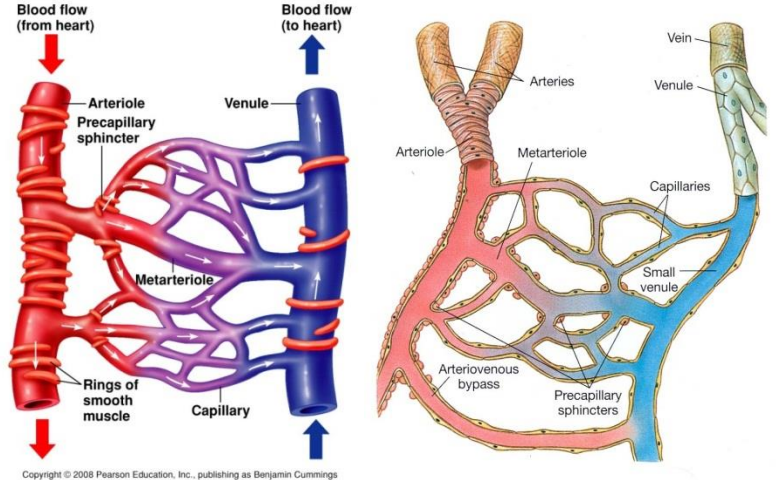
• Many veins in limbs have valves to prevent backflow (Varicose veins arise when pressure on valves is prolonged)

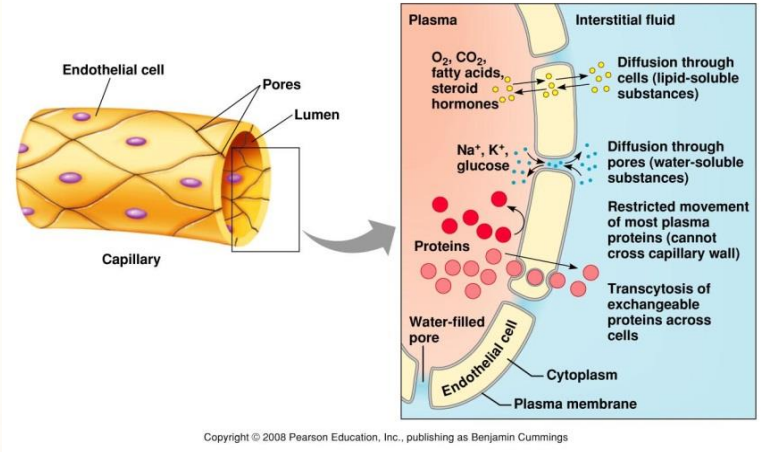


Blood vessels

Capillaries

- Capillaries are the smallest vessels, consisting only of a layer of endothelium through which substances are exchanged with tissue cells.
- Allow exchange of gases, nutrients and wastes between blood and tissues.
- In capillaries, oxygen and nutrients move out by diffusion; CO_2 in (via lipid component of the membrane, channels, etc.).
- Small molecules and lipid soluble molecules move by diffusion through the cell membrane.
- Larger molecules, charged molecules (ions) must pass through membrane channels, exocytosis or in between 2 cells.
- Water movement is controlled by the capillary hydrostatic and osmotic pressures.





Blood vessels

Blood pressure

It is the force exerted against the walls of the arteries. It is affected by heart action, blood volume, peripheral resistance, and blood viscosity.

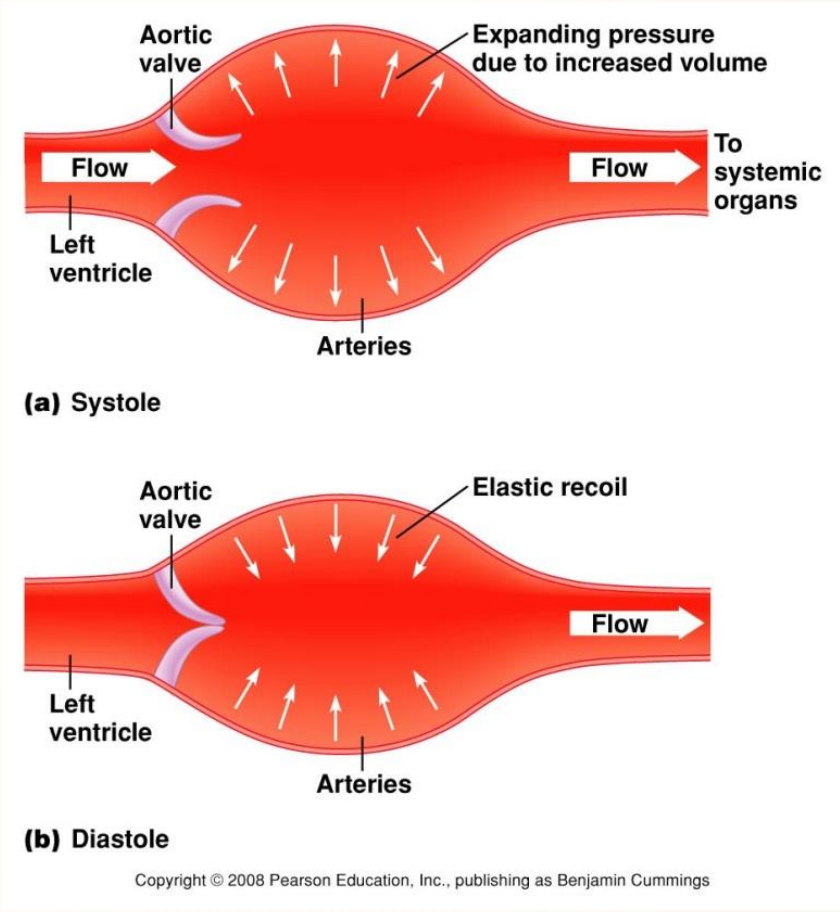
Arterial walls are able to expand and recoil because of the pressure of elastic fibers in the arterial wall.

- Systole = is the result of the contraction of the ventricles (normal 110-140)

(pressure when heart contracts).

- Diastole = pressure when heart relaxes (80).

Arterial blood pressure rises and falls following a pattern established by the cardiac cycle. During ventricular contraction, arterial pressure is at its highest (systolic pressure). When ventricles are relaxing, arterial pressure is at its lowest (diastolic pressure).



Blood vessels

Blood pressure

Category	Systolic (mm Hg)		Diastolic (mm Hg)
Normal	**Below 120**	**and**	**Below 80**
Prehypertension	**120–139**	**or**	**80–89**
Hypertension			
Stage 1	**140–159**	**or**	**90-99**
Stage 2	**160 and above**	**or**	**100 and above**

Blood vessels

Hypertension

- Individuals with hypertension (high blood pressure) have a sustained elevation of pressure in the arteries.
- High Blood Pressure: >140 (systolic)/90 (diastolic)
- Hypertension may go undetected until complications such as heart attack, stroke, or visual problems arise.
- High blood pressure strains the heart, damages the arteries, and increases risk of heart attack, stroke, kidney failure, and blindness
- Reduces with regular exercise, healthy diet (reduced salt, increased potassium and fiber), and moderation of alcohol intake.
- Importance: Blood pressure is a key factor for providing blood (thus oxygen and energy) to organs. Systolic BP must be a minimum of 70 to sustain kidney filtration and adequate blood flow to the brain.

The blood

Functions

- Transport of dissolved substances
- Regulation of pH and ions
- Restriction of fluid losses at injury sites
- Defense against toxins and pathogens
- Stabilization of body temperature

Physical Characteristics of Blood

General Characteristics of Blood

- 38°C (100.4°F) is normal temperature
- High viscosity
- Slightly alkaline pH (7.35–7.45). Arterial blood is more alkaline than venous blood.
- Blood volume (liters) = 7% of body weight (kilograms):- Adult male: 5 to 6 liters
  - Adult female: 4 to 5 liters

The blood

Composition of the whole blood

The blood consists of:

- **Plasma**

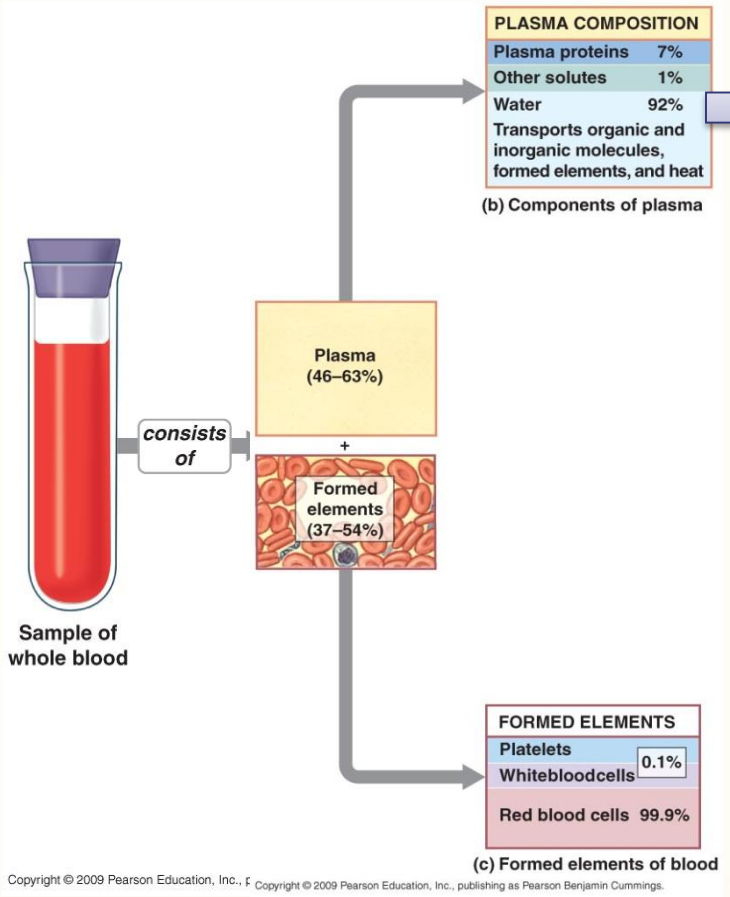
Water, dissolved plasma proteins, other solutes

- **Formed Elements**

- Red blood cells (RBCs) or erythrocytes: Transport oxygen

- White blood cells (WBCs) or leukocytes: Part of the immune system

- Platelets or thrombocytes: Cell fragments involved in clotting



PLASMA PROTEINS	
Albumins (60%)	Major contributors to osmotic pressure of plasma; transport lipids, steroid hormones
Globulins (35%)	Transport ions, hormones, lipids; immune function
Fibrinogen (4%)	Essential component of clotting system; can be converted to insoluble fibrin
Regulatory proteins (<1%)	Enzymes, proenzymes, hormones

OTHER SOLUTES	
Electrolytes	Normal extracellular fluid ion composition essential for vital cellular activities Ions contribute to osmotic pressure of body fluids Major plasma electrolytes are Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, HCO_3^-, HPO_4^-, SO_4^{2-}
Organic nutrients	Used for ATP production, growth, and maintenance of cells; include lipids (fatty acids, cholesterol, glycerides), carbohydrates (primarily glucose), and amino acids
Organic wastes	Carried to sites of breakdown or excretion; include urea, uric acid, creatinine, bilirubin, ammonium ions

mings.

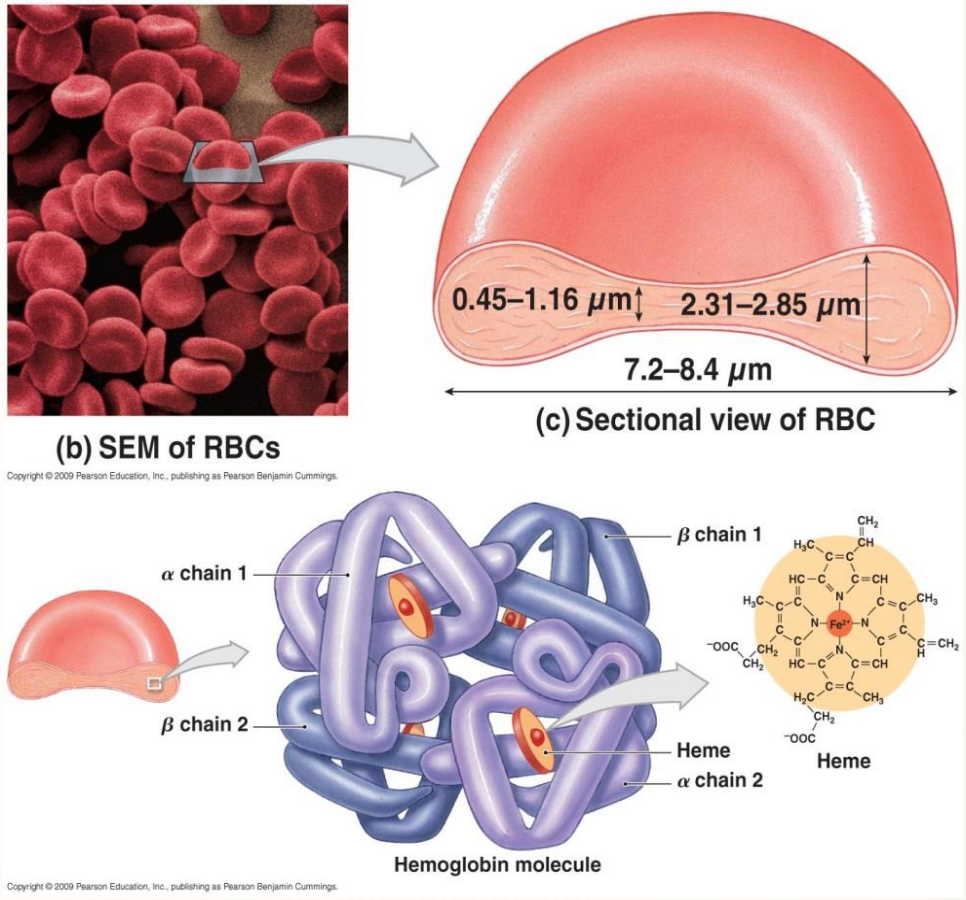
The blood

Red blood cells (RBCs) or erythrocytes

- Red blood cells (RBCs) make up 99.9% of blood's formed elements
- Small and highly specialized discs
- Thin in middle and thicker at edge
- Quickly absorbs and releases oxygen

Hemoglobin

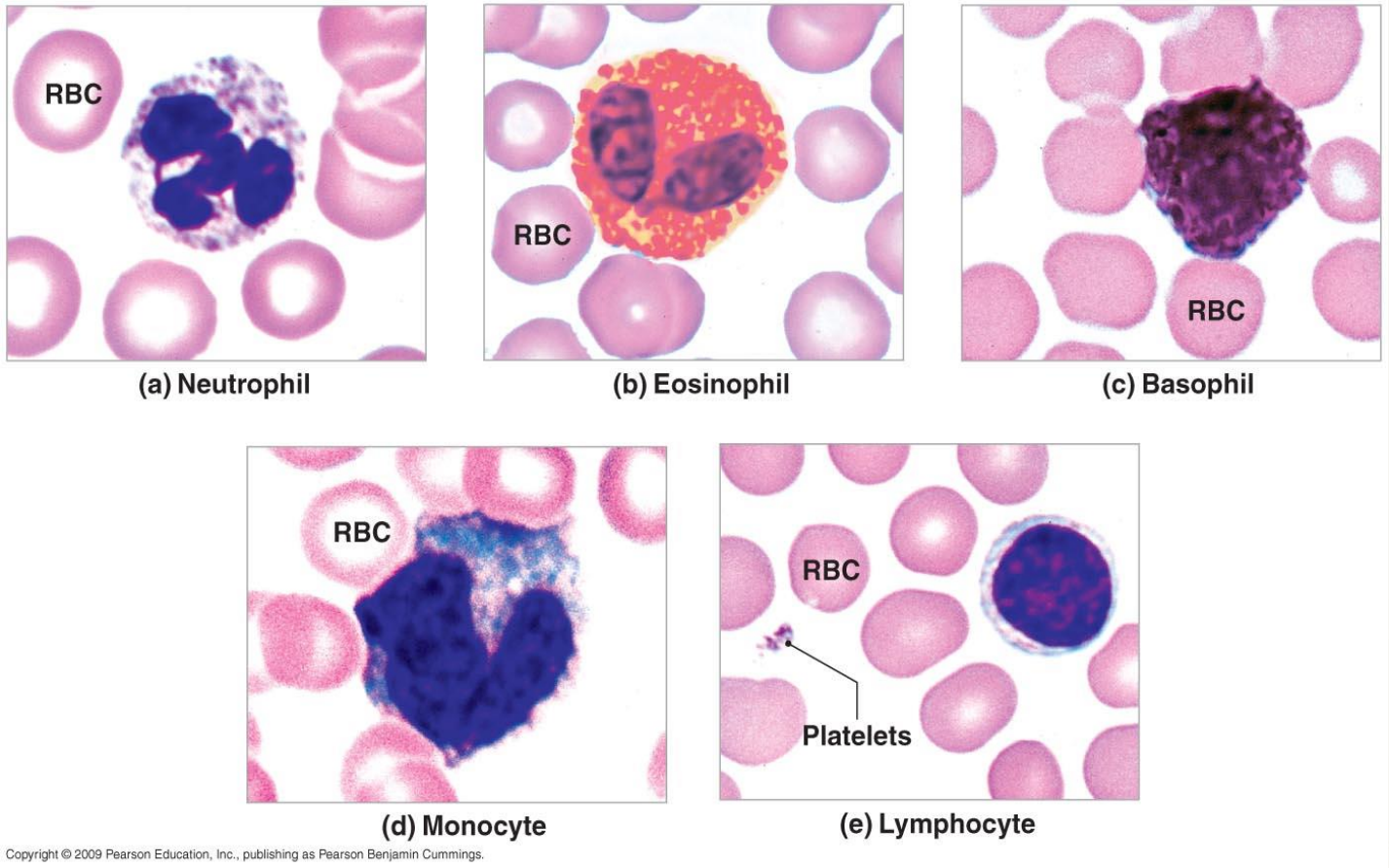
- The red pigment that gives whole blood its color
- Binds and transports oxygen and carbon dioxide
- Complex quaternary structure: four globular protein subunits (2 of one kind, the other 2 of another kind) plus heme (ferrous iron):



The blood

White blood cells (WBCs) or leukocytes

- Can migrate out of bloodstream.
- Have amoeboid movement.
- Attracted to chemical stimuli (positive chemotaxis).
  - Neutrophils
  - Eosinophils
  - Basophils
  - Monocytes
  - Lymphocytes



(a) Neutrophil (b) Eosinophil (c) Basophil

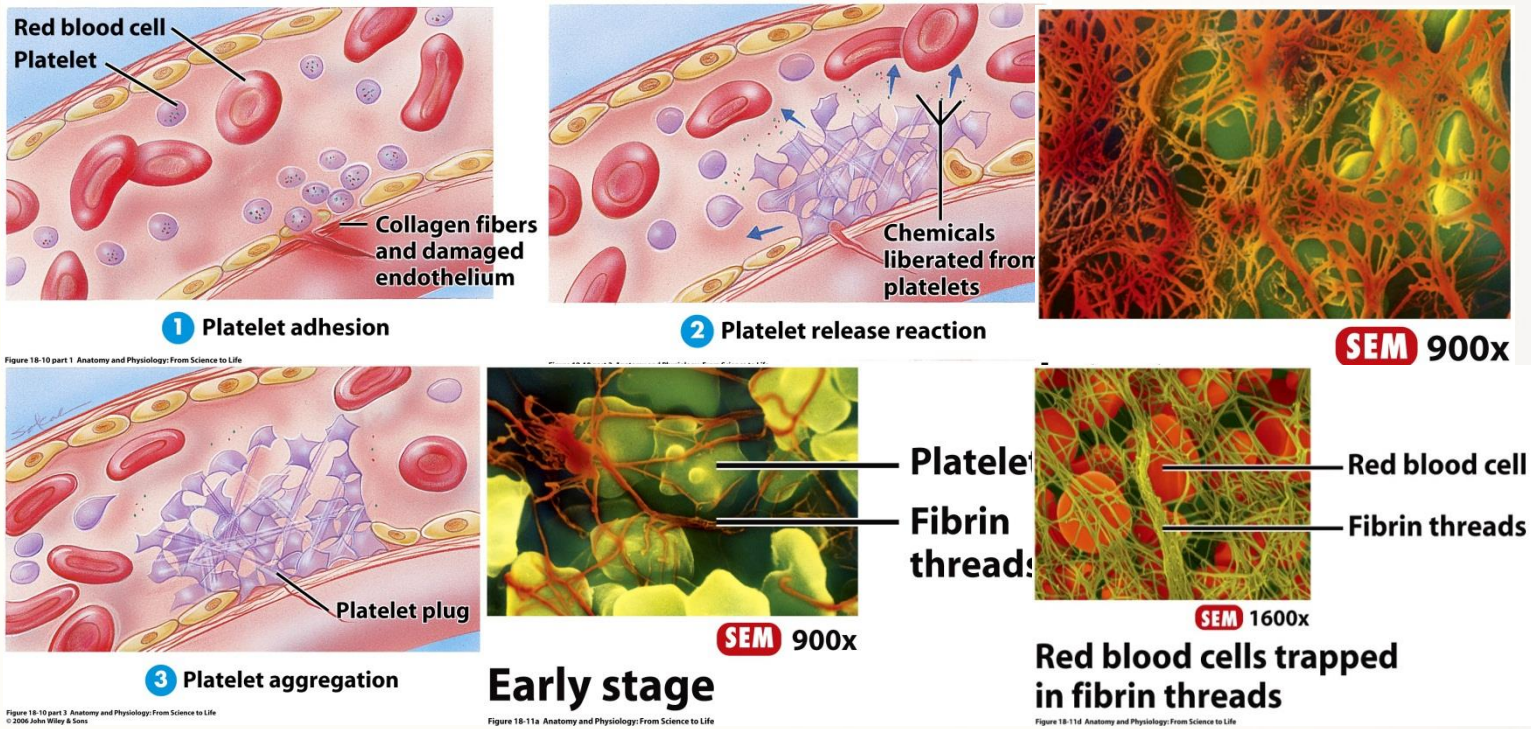
(d) Monocyte (e) Lymphocyte

The blood

Platelets or thrombocytes

Three functions of Platelets:

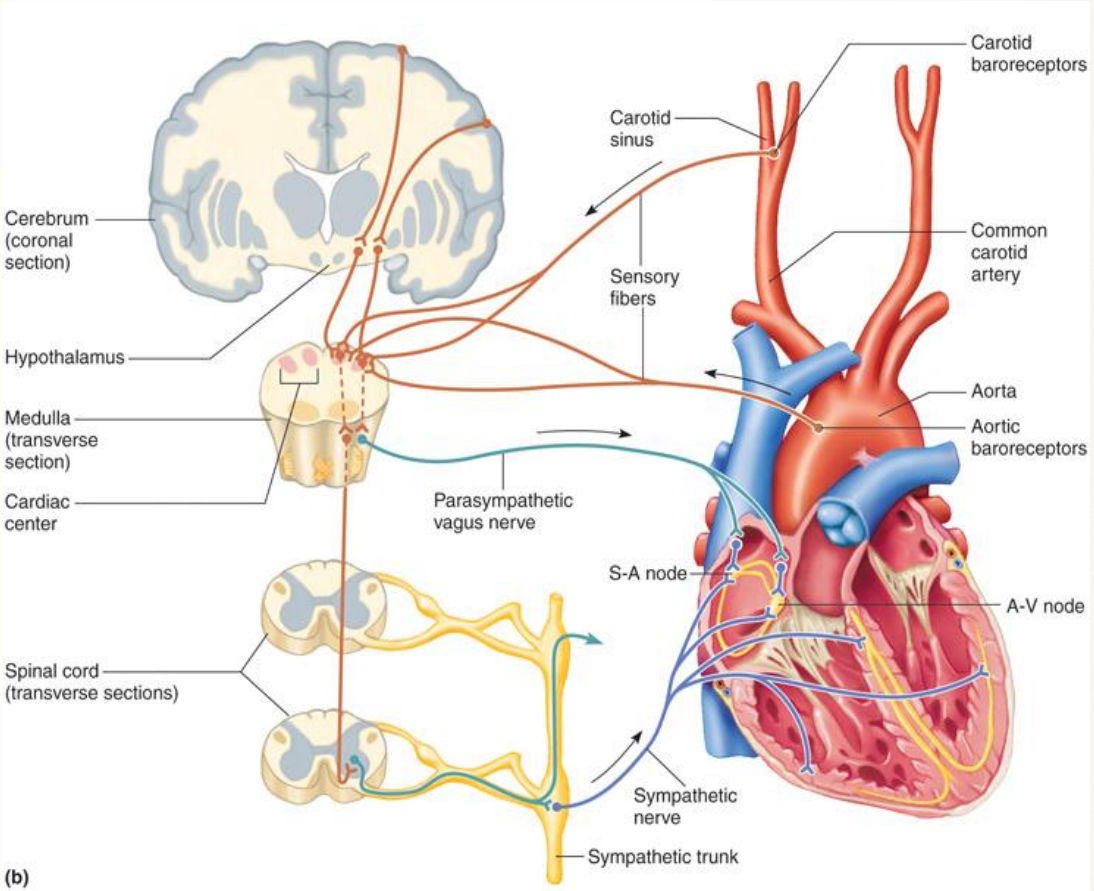
- Release important clotting chemicals: to stop bleeding by forming a plug
- Temporarily patch damaged vessel walls
- Actively contract tissue after clot formation



Regulation of the circulatory System

Neural regulation

- The cardiovascular (CV) center is located in the medulla oblongata
- The Central nerve system (CNS) controls the heart rate through innervating the S-A by branches of the sympathetic (also to myocardium) and parasympathetic divisions.
- The sympathetic Nervous system (SNS) impulses increase the speed of heart rate. It is activated by stress, anxiety, excitement, or exercise.
- The parasympathetic nervous system (PNS) impulses decrease the heart rate by the parasympathetic vagus nerve (from the brain).
- Almost all vessels, such as arteries, arterioles, venules and veins are innervated, except capillaries.



Regulation of the circulatory System

Neural regulation

Sympathetic Fibers

- Innervate SA and AV nodes and ventricles
- Release noradrenaline
- Increase heart rate
- Increase contractility (constrictor nerves)
- Increase pressure
- The norepinephrine is released from sympathetic nerve terminals in the heart and in the blood vessels.

Parasympathetic Nerve

- Innervates SA node and AV node
- Releases acetylcholine which may regulate sympathetic release of norepinephrine and vice versa.
- Slows heart rate
- Lowers pressure

Regulation of the circulatory System

Regulation of Blood Pressure (BP): Negative-Feedback Regulation

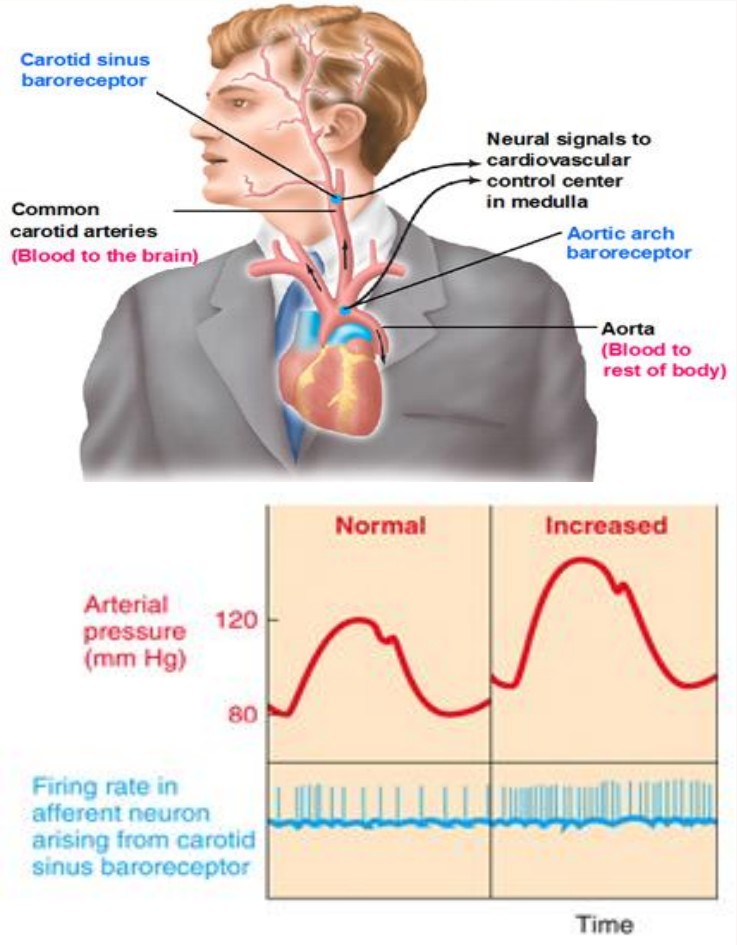
Baroreceptors are mechanoreceptors – sensitive to changes in pressure or stretch located within the walls of the carotid sinus and the aortic arch.

If BP is too high:

- Increase is detected by baroreceptors in the carotid artery or aorta
- Baroreceptors send an impulse to CV center
- CV center interprets that message and sends a signal via parasympathetic motor impulses to the SA Node and arterioles.
- The SA Node decreases heart rate (HR) and BP.
- The arterioles dilate

If BP is too low:

- SA Node increases HR
- Constriction of arterioles



Regulation of the circulatory System

The humoral regulation of circulation is controlled by substances secreted or absorbed into the body fluids.

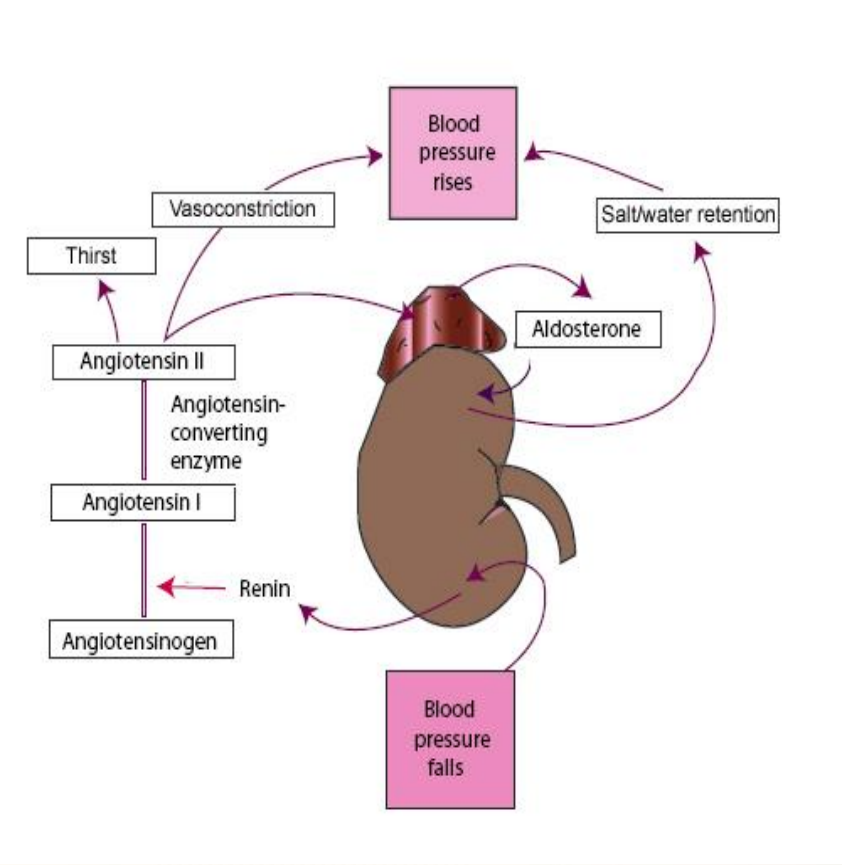
They can cause:

- Vasoconstriction 
- Vasodilation 

Hormones that increase blood pressure (Vasoconstriction)

Renin-Angiotensin-Aldosterone System

- When blood volume falls or blood flow decreases, the renin (an enzyme) is released by kidney.
- The Renin activates the secretion of angiotensinogen by the liver which then circulates in the blood and converted into angiotensin I (prohormone) under the effect of renin .
- Angiotensin I is activated by a lung enzyme, Angiotensin-Activating Enzyme (ACE) and becomes angiotensin II (active hormone).
- Angiotensin II is a powerful vasoconstrictor of blood vessel smooth muscles. It also triggers the secretion of aldosterone by the adrenal cortex.
- The aldosterone promotes reabsorption of both H2O and salt (mainly sodium ions) with increases the blood pressure.
- Angiotensin II stimulates thirst center in hypothalamus and drinking behavior. So blood volume is increased.
- Also angiotensin II stimulates secretion of ADH from anterior pituitary (AP).

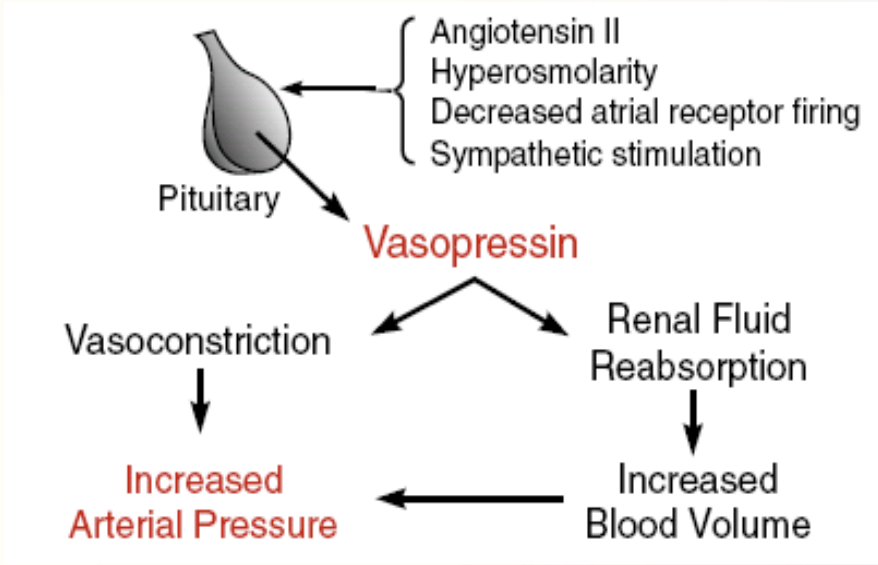


Regulation of the circulatory System

Hormones that increase blood pressure (Vasoconstriction)

Vasopressin = Anti-diuretic hormone (ADH)

- It is secreted by the posterior pituitary in response to dehydration or decreased blood volume.
- It promotes water reabsorption by the kidney tubules → H2O moves back into the blood → less urine formed.
- It causes vasoconstriction and increases the arterial blood pressure.



Norepinephrine and epinephrine

- Are released by sympathetic nerve terminals in the blood vessels and by the medulla of adrenal gland.
- It increases the rate and force of heart contractions.
- Circulating Epinephrine and Norepinefrine from the adrenal medullae have almost the same effects on the different organs as the effects caused by direct sympathetic stimulation, except, the effects are longer lasting.

the effects are longer lasting.

Other solutes: Ca2+ ions

Hormones that decrease blood pressure (Vasodilation)

Nitric oxide (NO) = local regulator (a gas)

- Increased blood flow in arterioles causes the release of NO by the vascular endothelial cells (endothelium relaxing factor).
- It diffuses into adjacent vascular smooth muscle where it activates soluble guanylate cyclase, produces cGMP and causes vasodilatation (This causes small arteries upstream to relax).

Atrial Natriuretic Peptide (ANP)

It is secreted by the atria in response to the increase of atrial pressure. It causes vasodilation through the relaxation of vascular smooth muscle.

Bradykinin

This is a vasodilator substance which is formed in tissues during inflammation or increased tissue activity. Bradykinin is a mediator of vasodilatation in sweat glands and digestive glands when they become activated.

Other solutes

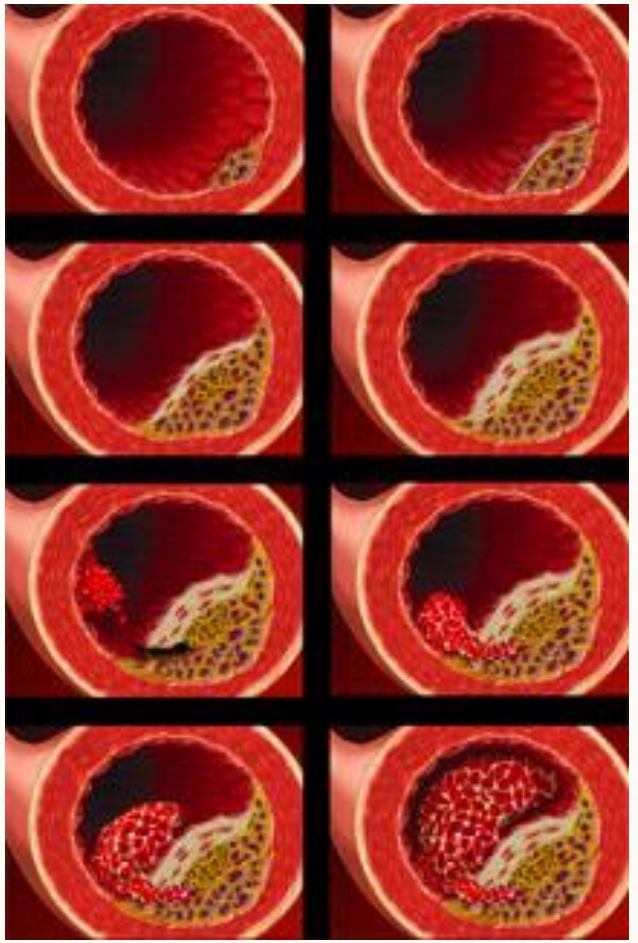
K+ ions, Mg2+ ions, H+ ions, CO2

Cardiovascular Diseases (CVD)

Cardiovascular diseases include those that affect the heart and those that affect the peripheral vascular system. The heart and blood vessels may be primarily attacked by these diseases or they may be secondarily affected as a consequence of another disease.

Atherosclerosis:

- Arteries are narrowed by deposits of fat, cholesterol, and other substances called plaques.
- Once narrowed by a plaque, an artery is vulnerable to blockage by blood clots.
- Blockage in the coronary arteries (coronary heart disease) can lead to a heart attack.
- Blockage in the brain can cause a stroke.



Cardiovascular Diseases (CVD)

Heart attack (myocardial infarction)

Damage to, or death of, part of the heart muscle, sometimes resulting in a failure of the heart to deliver enough blood to the body; myocardial infarction.

Arrhythmia

An irregularity in the force or rhythm of the heartbeat.

Sudden cardiac death

A non-traumatic, unexpected death from sudden cardiac arrest, most often due to arrhythmia (in association with underlying heart disease).

Peripheral Vascular Disease

Disease of the peripheral vessels. The lack of proper circulation (caused by blockages in arteries that feed the legs) may cause fluids to pool in the extremities. Symptoms include leg pain, cramping, numbness, tingling, coldness and loss of hair to the affected limbs. The disease process may be extensive before the person is symptomatic, as the heart and brain are more sensitive to a decreased blood flow as compared to the extremities.

Cardiovascular Diseases

Risk factors that can't be changed:

Heredity

Children of parents with CVD are more likely to develop it themselves

Being Male

CVD is the leading killer of both men and women but men face a greater risk of heart attack than women, especially earlier in life. Estrogen production may offer premenopausal women some protection against CVD.

Age

The risk of heart attack increases significantly after age 65. Over 70% of all heart attack victims are over age 65.

Race/Ethnicity

Death rates from heart disease vary among the ethnic groups. African Americans have a much higher rate of HTN, heart disease and stroke than other groups. Asian Americans historically have had lower rates of CVD than white Americans.

Cardiovascular Diseases

Risk factors that can be changed:

Cigarette/Tobacco Use:

- About 1 in 5 deaths from CVD can be contributed to smoking
- Women who smoke and use contraceptives have 39 times more risk of heart attack and 22 times more likely to have a stroke than women who do not smoke and take contraceptives.
- Smoking damages the linings of the arteries and causes platelets to be stickier.
- Carbon monoxide in smoke displaces oxygen in the blood, reducing the amount of oxygen available to the heart.

Cholesterol:

Any body who has a liver produces cholesterol. It is also obtained through the foods we eat. It refers to the fatty substance that circulates the blood stream and is an important component for cell membranes, sex hormones, nerves. Cholesterol is carried in protein-lipid packages called lipoproteins (LDL and HDL).

- Low-density lipoprotein (LDL) = unhealthy ("bad") cholesterol; (containing more cholesterol than protein) excess amounts are deposited in artery walls and can clog arteries and increase the risk for CVD.
- High-density lipoprotein (HDL) = healthy ("good") cholesterol; shuttle unused cholesterol back to the liver for recycling. (less cholesterol than LDL)

Cardiovascular Diseases

Risk factors that can be changed:

Obesity

In 1998, obesity was declared a major risk factor for heart disease. Greater than 30% are above the recommended weight.

Triglycerides

Greater than 190 mg/dl tends to increase blood thickness resulting in sluggish blood flow which makes it more difficult in delivering oxygen and nutrients to the heart.

Triglycerides (mg/dl)	Status
Less than 150	Normal
150–199	Borderline high
200–499	High
500 or more	Very high

Cardiovascular Diseases

Ways to Reduce Your Heart Attack Risk

- Quit Smoking
- Know and manage your blood cholesterol level
- Maintain a healthy body weight
- Exercise regularly
- Healthy Eating Plan
- No alcohol consumption
- Know and manage your blood pressure
- Handle stress and anger effectively

Summary

- The circulatory system is made up of two major pieces: the heart to pump the blood around the body and the blood vessels to guide the blood to different places like the brain.
- Heart is a four chambered, hollow muscular organ.
- Coronary circulation – the circulation of blood within the heart.
- Pulmonary circulation – the flow of blood between the heart and lungs.
- Systemic circulation – the flow of blood between the heart and the cells of the body.

Summary

- Blood Vessels -A closed network of tubes.
- Arteries carry blood from heart to tissues of body (Carry oxygen rich blood, with the exception of pulmonary arteries).
- Capillaries are Smallest blood vessels that are important for bringing nutrients and oxygen to tissues and absorbing CO2 and other waste products.
- Once blood has passed through the capillary systems it must be returned to the heart by veins.
- Systolic pressure- the first number taken, is the force felt in the arteries when the ventricles contract.
- Diastolic pressure- the second number taken, is the force of the blood on the arteries when the ventricles relax.

Summary

- The force of blood on the wall of the arteries is known as blood pressure.
- Neural control (cardiac center) of circulation is centered in the medulla oblongata.
- The humoral regulation of circulation is controlled by substances secreted or absorbed into the body fluids such as angiotensin II, Renin, ADH and NO.