



- *Circulation and Gas Exchange*

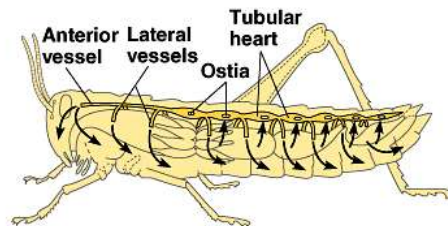
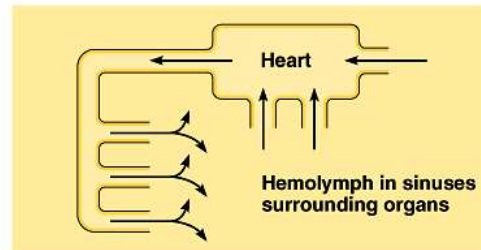
- Sponges (porifera)
- Flat worms (platyhelminthes)
- Round worms (nematoda)
- Segmented worms (annelida)
- Stinging celled (cnidaria)
- Squishy (mollusca)
- Hard shelled (arthropods)
- Spiny skinned (echinoderm)
- With a spine (chordata):
  - fish
  - amphibian
  - reptile
  - mammal

# QOD

- Starting with the animal groups we studied earlier this year, use 3-6 words to describe the circulatory system of each as it moves from simpler to more complex.

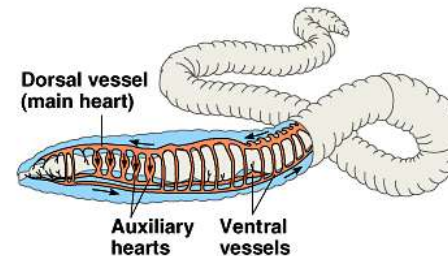
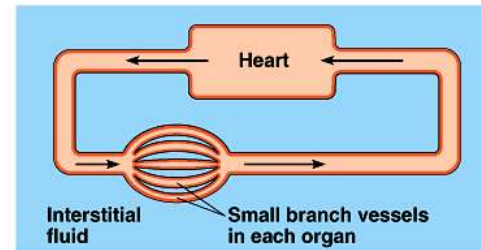
# Circulation system evolution, I

- Gastrovascular cavity (cnidarians, flatworms)
- Open circulatory • hemolymph (blood & interstitial fluid) • sinuses (spaces surrounding organs)
- Closed circulatory: blood confined to vessels
- Cardiovascular system • heart (atria/ventricles) • blood vessels (arteries, arterioles, capillary beds, venules, veins) • blood (circulatory fluid)



(a) Open circulatory system

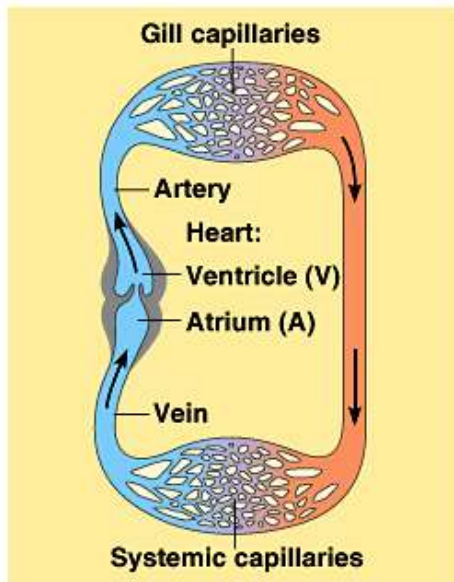
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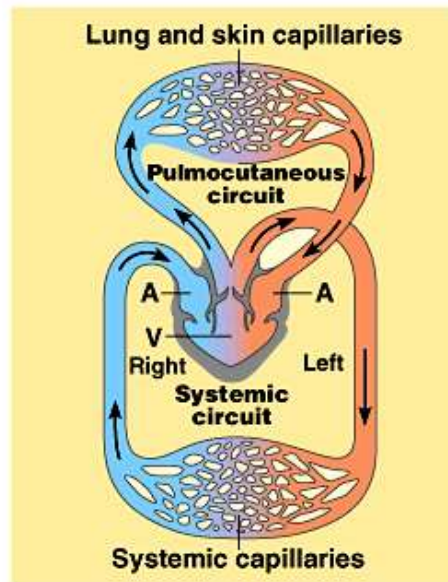
(b) Closed circulatory system

# Circulation system evolution, II

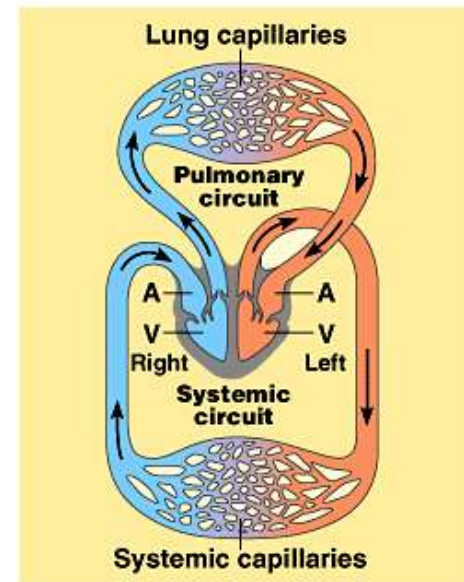
- Fish: 2-chambered heart; single circuit of blood flow
- Amphibians: 3-chambered heart; 2 circuits of blood flow- *pulmocutaneous* (lungs and skin); systemic (some mixing)
- Mammals: 4-chambered heart; *double circulation*; complete separation between oxygen-rich and oxygen poor blood



(a) Fish



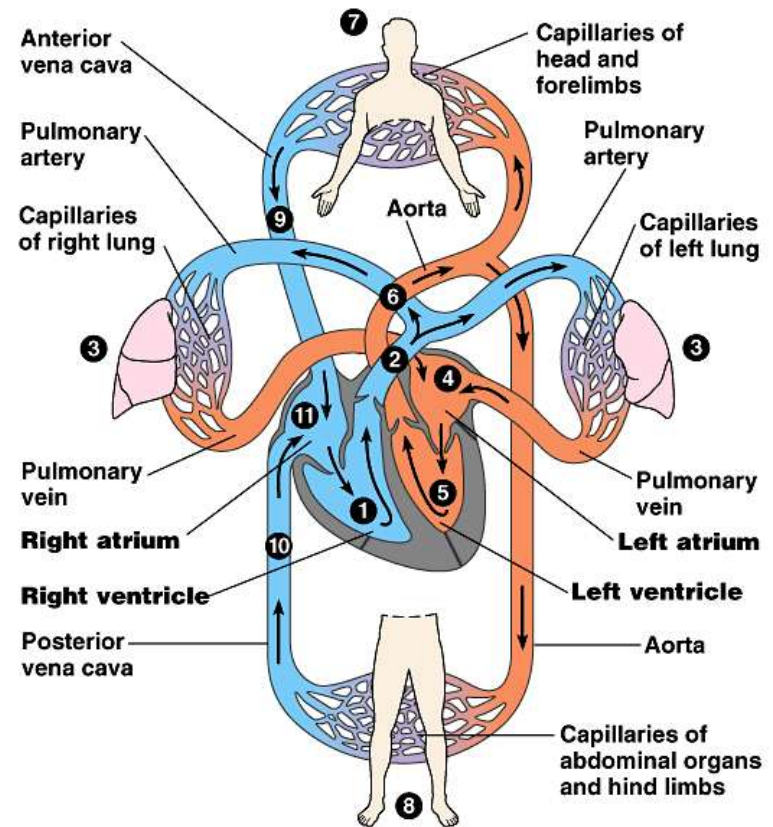
(b) Amphibian



(c) Mammal

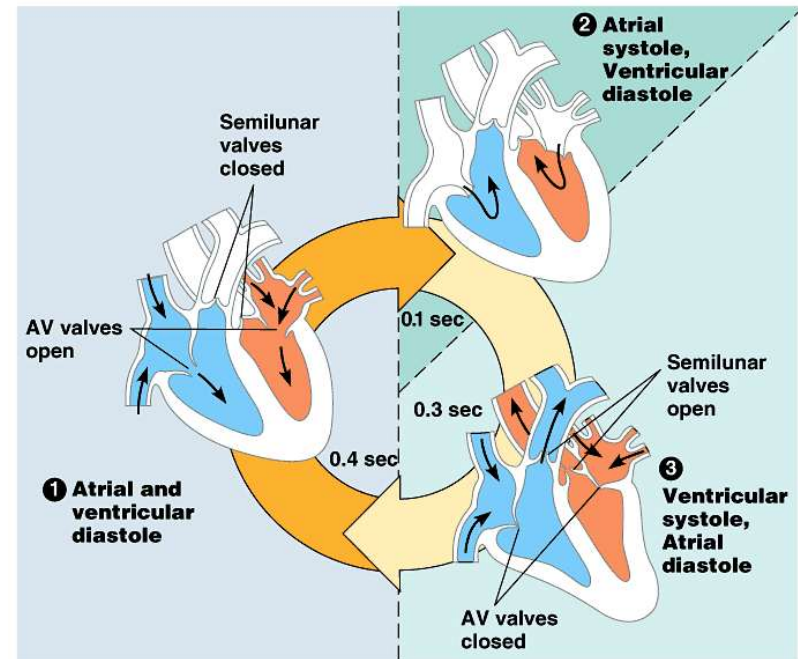
# Double circulation

- From right ventricle to lungs via pulmonary arteries through semilunar valve (pulmonary circulation)
- Capillary beds in lungs to left atrium via pulmonary veins
- Left atrium to left ventricle (through atrioventricular valve) to aorta
- Aorta to coronary arteries; then systemic circulation
- Back to heart via two venae cavae (superior and inferior); right atrium



# The mammalian heart

- Cardiac cycle: sequence of filling and pumping
- *Systole*- contraction
- *Diastole*- relaxation
- Cardiac output: volume of blood per minute
- *Heart rate*- number of beats per minute
- *Stroke volume*- amount of blood pumped with each contraction
- Pulse: rhythmic stretching of arteries by heart contraction

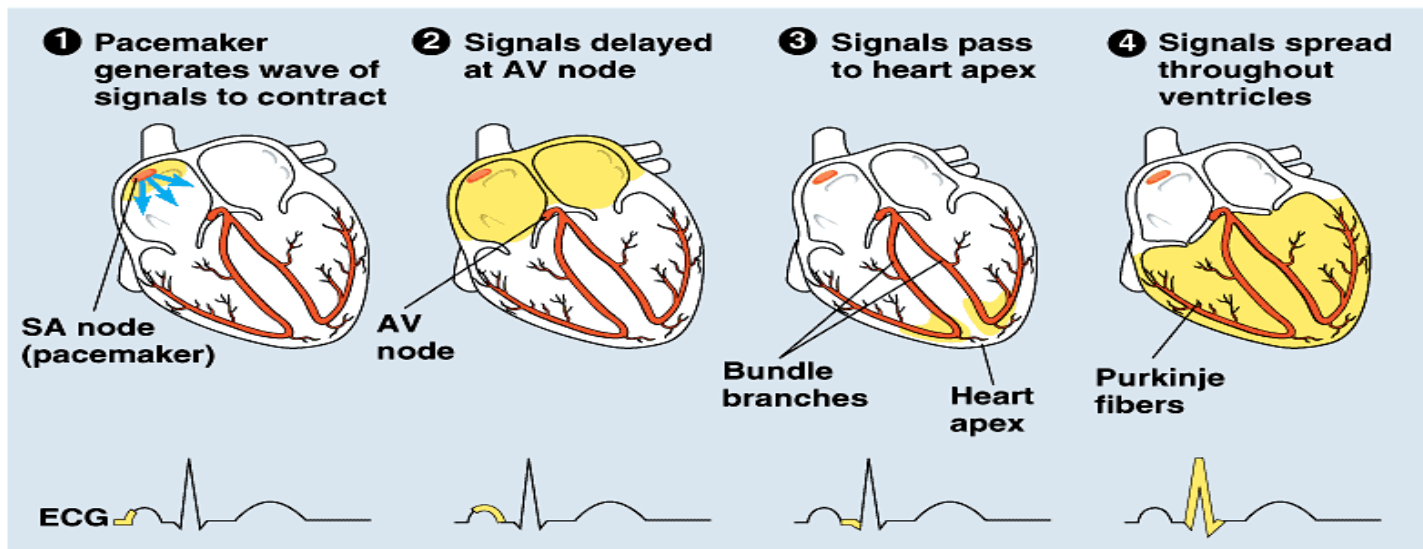


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# The heartbeat

- Sinoatrial (SA) node (“pacemaker”): sets rate and timing of cardiac contraction by generating electrical signals
- Atrioventricular (AV) node: relay point (0.1 second delay) spreading impulse to walls of ventricles
- Electrocardiogram (ECG or EKG)



# Blood vessel structural differences

- Capillaries

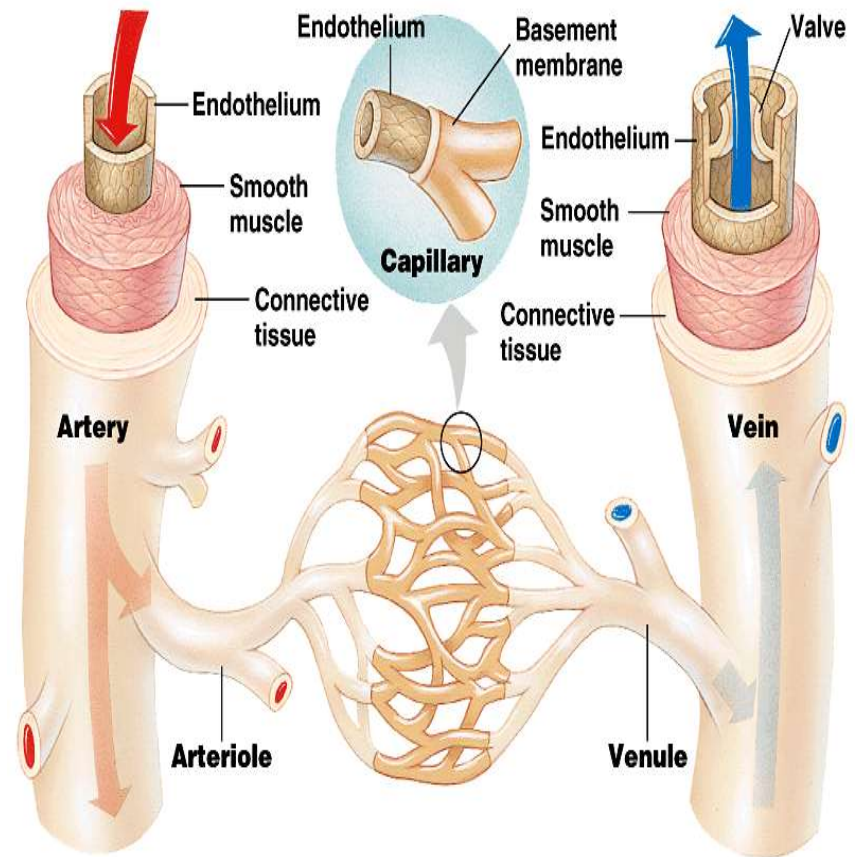
- endothelium; basement membrane

- Arteries

- thick connective tissue; thick smooth muscle; endothelium; basement membrane

- Veins

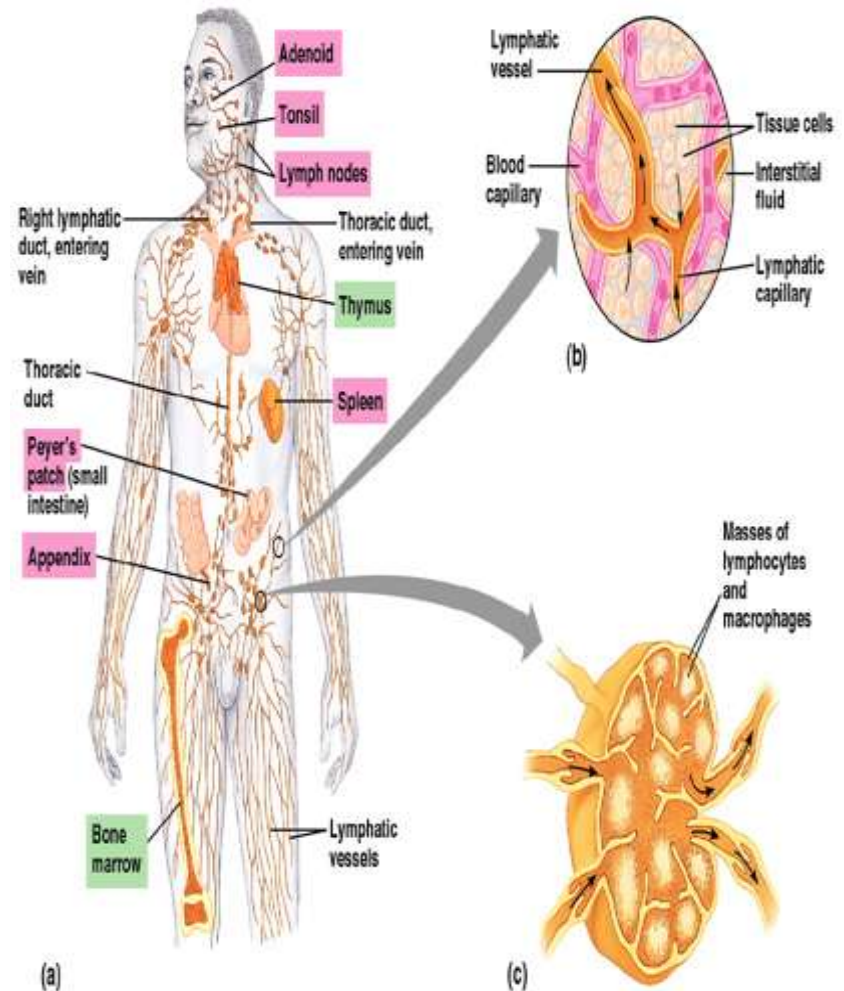
- thin connective tissue; thin smooth muscle; endothelium; basement membrane





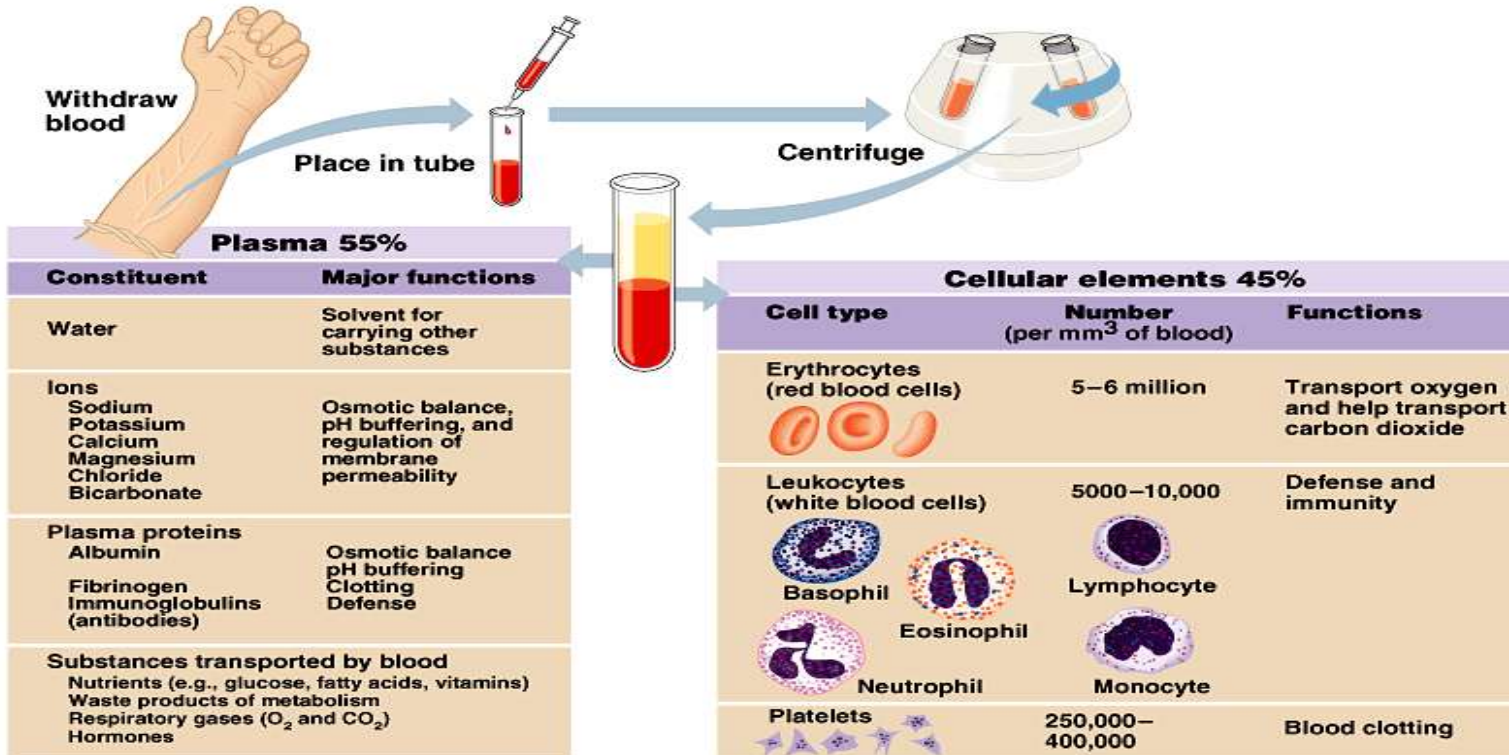
# The lymphatic system

- Lymphatic system: system of vessels and lymph nodes, separate from the circulatory system, that returns fluid and protein to blood
- Lymph: colorless fluid, derived from interstitial fluid
- Lymph nodes: filter lymph and help attack viruses and bacteria
- Body defense / immunity



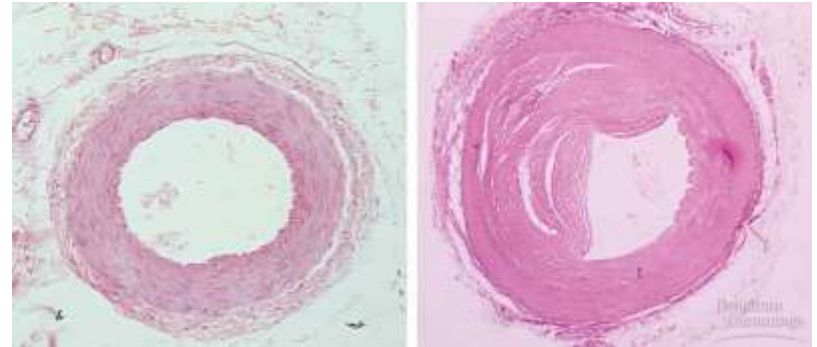
# Blood

- Plasma: liquid matrix of blood in which cells are suspended (90% water)
- Erythrocytes (RBCs): transport O<sub>2</sub> via hemoglobin
- Leukocytes (WBCs): defense and immunity
- Platelets: clotting
- Stem cells: pluripotent cells in the red marrow of bones
- Blood clotting: fibrinogen (inactive)/ fibrin (active); hemophilia; thrombus (clot)



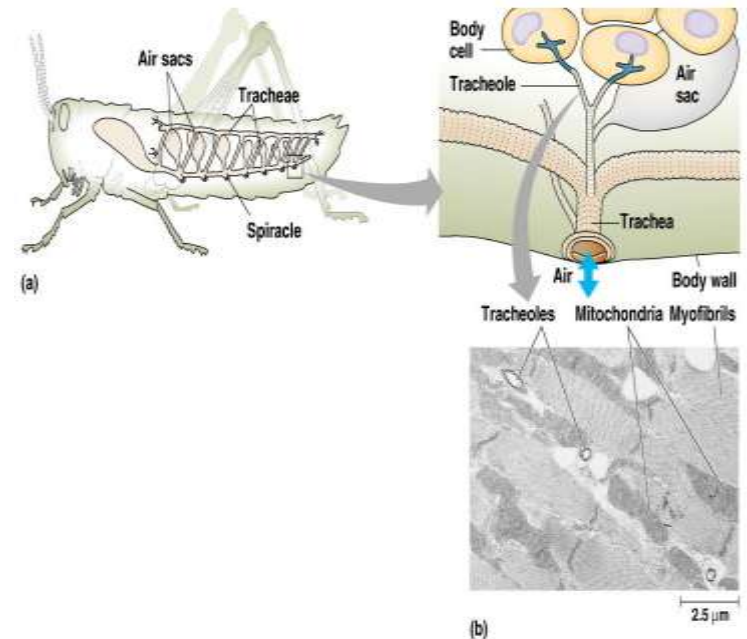
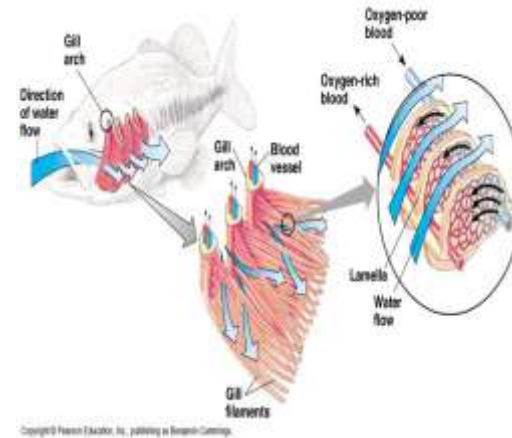
# Cardiovascular disease

- Cardiovascular disease (>50% of all deaths)
- *Heart attack*- death of cardiac tissue due to coronary blockage
- *Stroke*- death of nervous tissue in brain due to arterial blockage
- *Atherosclerosis*: arterial plaques deposits
- *Arteriosclerosis*: plaque hardening by calcium deposits
- *Hypertension*: high blood pressure
- *Hypercholesterolemia*:  
LDL, HDL



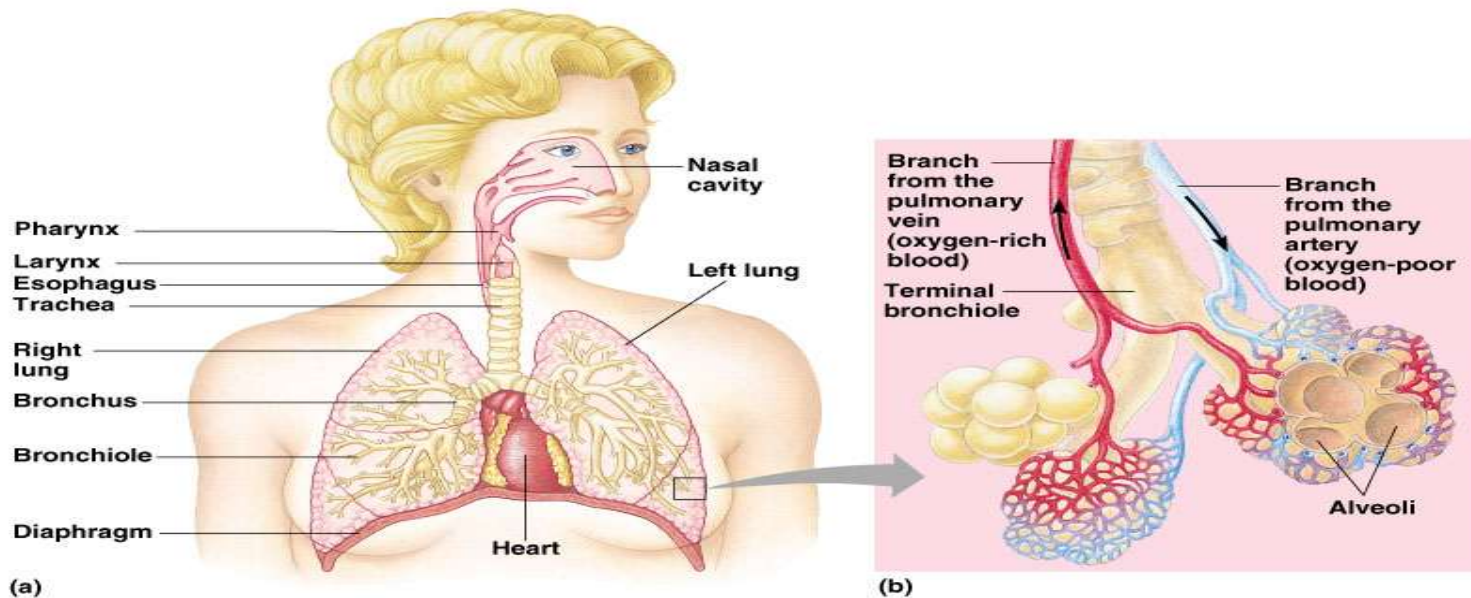
# Gas exchange

- $\text{CO}_2 \leftrightarrow \text{O}_2$
- Aquatic:
  - gills
  - ventilation
  - countercurrent exchange
- Terrestrial:
  - tracheal systems
  - lungs



# Mammalian respiratory systems

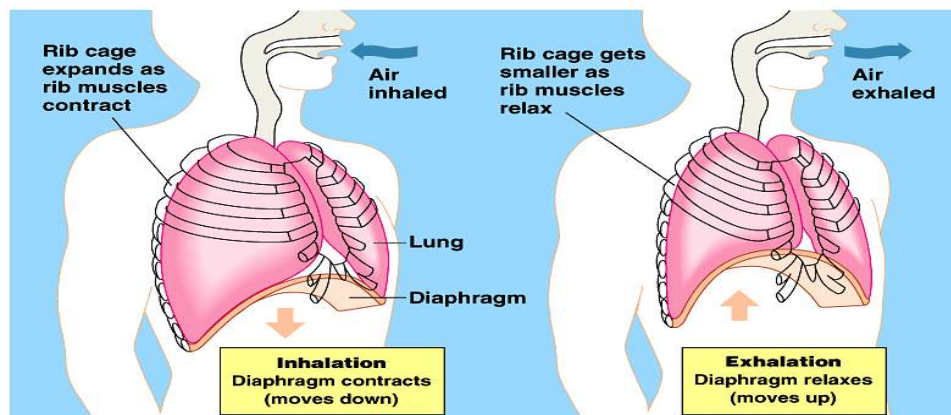
- Larynx (upper part of respiratory tract)
- Vocal cords (sound production)
- Trachea (windpipe)
- Bronchi (tube to lungs)
- Bronchioles
- Alveoli (air sacs)
- Diaphragm (breathing muscle)





# Breathing

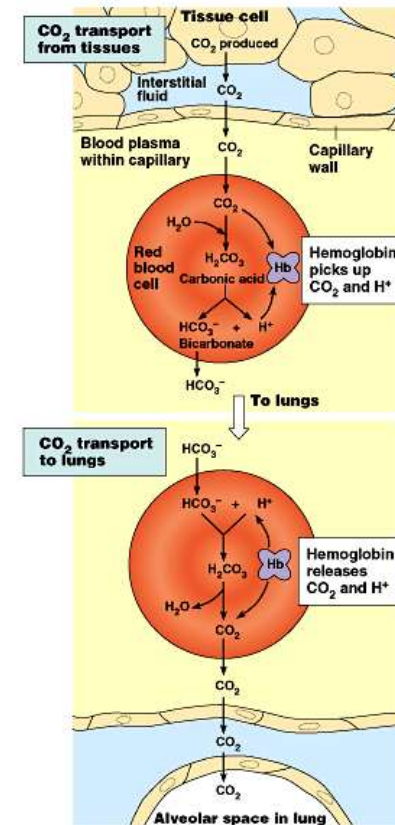
- *Positive pressure breathing*: pushes air into lungs (frog)
- *Negative pressure breathing*: pulls air into lungs (mammals)
- *Inhalation*: diaphragm contraction; *Exhalation*: diaphragm relaxation
- *Tidal volume*: amount of air inhaled and exhaled with each breath (500ml)
- *Vital capacity*: maximum tidal volume during forced breathing (4L)
- Regulation: CO<sub>2</sub> concentration in blood (*medulla oblongata*)





# Respiratory pigments: gas transport

- Oxygen transport-
- *Hemocyanin*: found in hemolymph of arthropods and mollusks (Cu)
- *Hemoglobin*: vertebrates (Fe)
- Carbon dioxide transport-
- Blood plasma (7%)
- Hemoglobin (23%)
- Bicarbonate ions (70%)
- Deep-diving air-breathers-
- *Myoglobin*: oxygen storing protein



# Human Systems Project

- Choose a human system
- Prepare a video, song, or presentation which provides the following information:
  - Role of this system in maintaining animal life
  - Functional unit
  - Detailed description of how the system functions in humans
  - Comparative description of how the system functions in simpler animals

