



## Biology Lecture 7 – The Cardiovascular System; The Respiratory System

Examcrackers MCAT Comprehensive Course, Charles Feng  
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### The Cardiovascular System

#### Systemic Circulation

Left ventricle → aorta → arteries → arterioles → capillaries → venules → veins → superior/inferior vena cava → right atrium → right ventricle

#### Pulmonary Circulation

Right ventricle → pulmonary arteries → lungs → pulmonary veins → left atrium → left ventricle

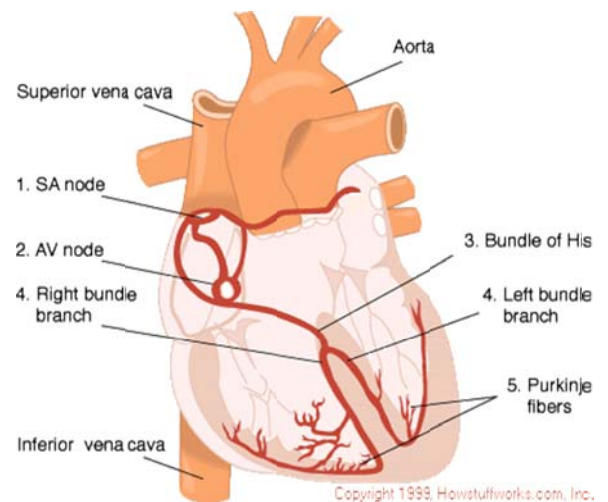
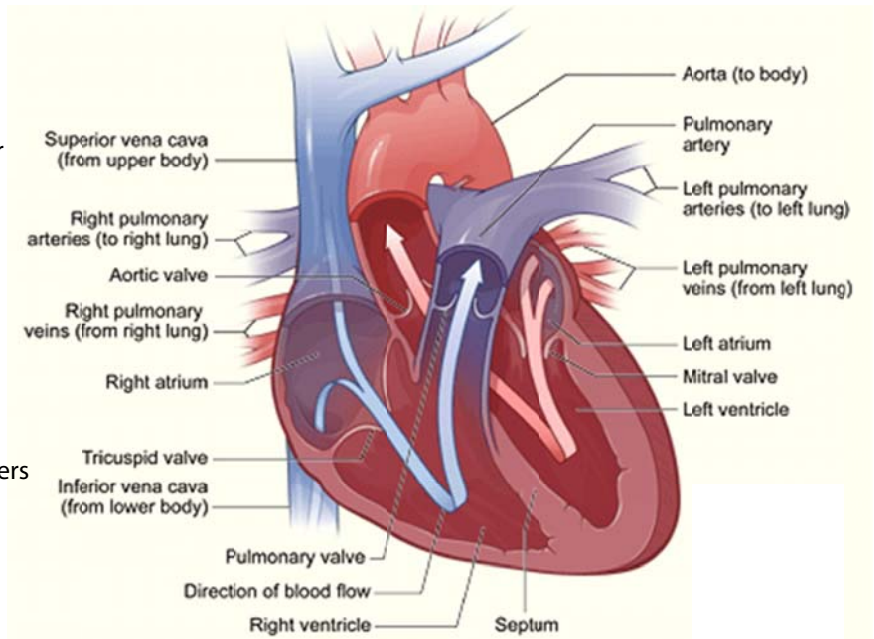
#### Electrical Pathway

Sinoatrial node (SA node, in atrium) → atrioventricular node (AV node, between atria) → bundle of His (between ventricles) → Purkinje fibers (in ventricles)

- SA node sends electrical signals by itself
- *Vagus nerve* slows down SA node frequency (parasympathetic)
- Cardiac cells connected by gap junctions in a *syncitium*

#### Vessels

- *Arteries/arterioles*: elastic, smooth muscle
- Epinephrine (sympathetic) causes smooth muscle to contract, increases BP
- *Capillaries*: tiny blood vessels, one cell thick, allow nutrients & gases to path thru
  - Movement of fluid regulated by osmotic vs. hydrostatic pressure:
  - Osmotic pressure stays the same, hydrostatic pressure higher on arteriole side
- *Veins/venules*: stores most of body's blood, have one-way valves to prevent backward flow
- Blood flow is slowest in capillaries b/c in total they have most cross sectional area ( $A_v = A_v$ )
- Blood pressure is highest in arteries, lowest in capillaries, low in veins
- Skeletal muscle contraction help blood move through veins





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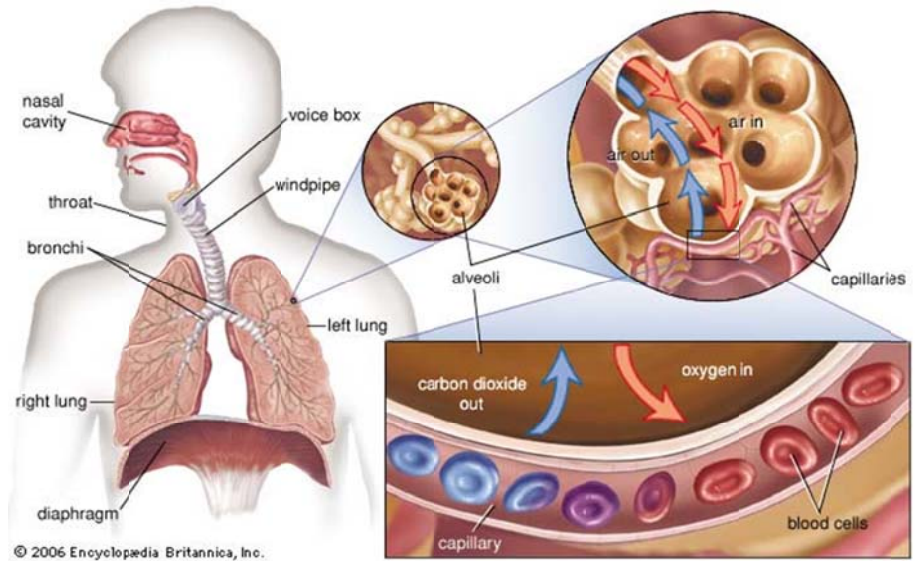
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### Respiratory System

#### Air Pathway

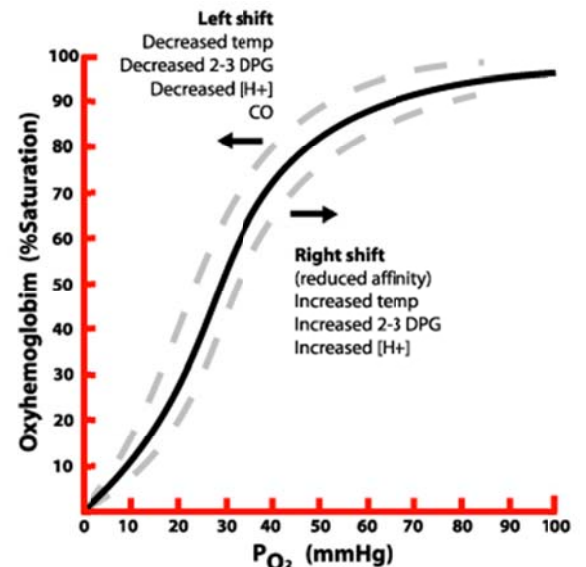
Nasal cavity → pharynx → larynx → trachea → bronchi → bronchioles → alveoli

- *Nasal cavity*: filters/moistens/warms air b/c of hair and mucus
- *Pharynx*: food and air can both path through here
- *Epiglottis*: covers trachea when swallowing, opens when breathing
- *Larynx*: voice box right underneath epiglottis, vocal cords vibrate to make sound
- *Trachea*: main windpipe, made of cartilage, has mucus + cilia on walls
- *Bronchi*: 2 divisions of trachea, one to each lung, also has cilia/mucus
- *Alveoli*: tiny air sacs one cell thick, allows diffusion between gas + capillaries



#### Gas Exchange

- *Inhaled air*: 79% N<sub>2</sub>, 21% O<sub>2</sub>
- *Exhaled air*: 79% N<sub>2</sub>, 16% O<sub>2</sub>, 5% CO<sub>2</sub>
- Oxygen is carried by hemoglobin inside red blood cells
  - 4 polypeptide protein, each having a *heme* group made of iron and each binding to one O<sub>2</sub>
- *Oxyhemoglobin dissociation curve*: at different pressures of oxygen, different % of hemoglobin will be bound to oxygen
  - HIGH pressures (aka in lungs) cause increased binding, so O<sub>2</sub> can enter erythrocytes
  - LOW pressures (aka in tissues) cause decreased binding, so O<sub>2</sub> can enter tissues
  - The curve can shift depending on environmental conditions:
    - WHAT'S GOING ON IN EXERCISING MUSCLE TISSUE WILL SHIFT IT TO THE RIGHT
    - Higher CO<sub>2</sub> pressure/concentration = rightward shift
    - Higher temperature = rightward shift
    - More acidic (higher [H<sup>+</sup>]) = rightward shift
    - Higher 2,3-DPG = rightward shift
- Carbon dioxide is usually transported as *bicarbonate ion* (HCO<sub>3</sub><sup>-</sup>) b/c of *carbonic anhydrase* in red blood cells
  - This means higher CO<sub>2</sub> concentration = more acidic
- Carbon dioxide also has dissociation curve
  - In lungs, when Hb holds more oxygen, less CO<sub>2</sub> will be able to bind → it's released into lungs



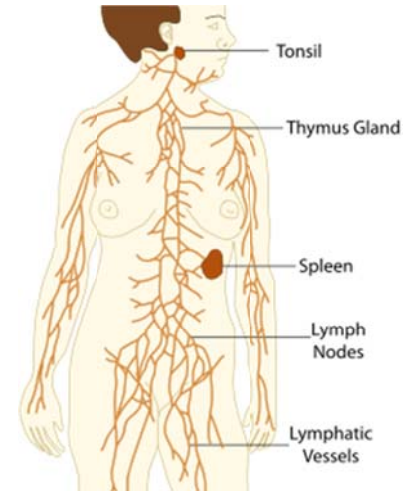


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### Lymphatic System

- Responsible for:
  - Storing fluid to increase/decrease BP
  - Transporting proteins/large particles
  - Carries fatty acids from intestines to thoracic duct (in neck), emptying into veins
  - Lymph nodes have lots of lymphocytes (a type of leukocyte)
- Lymph vessels have one-way valves to force fluid flow in one direction



### Blood

#### Proteins

- *Albumin*: carry fatty acids/steroids
- *Immunoglobulins/antibodies*: play a role in immune system
- *Fibrinogen*: clotting factor, a zymogen which is activated by platelets to form fibrin

#### Erythrocytes

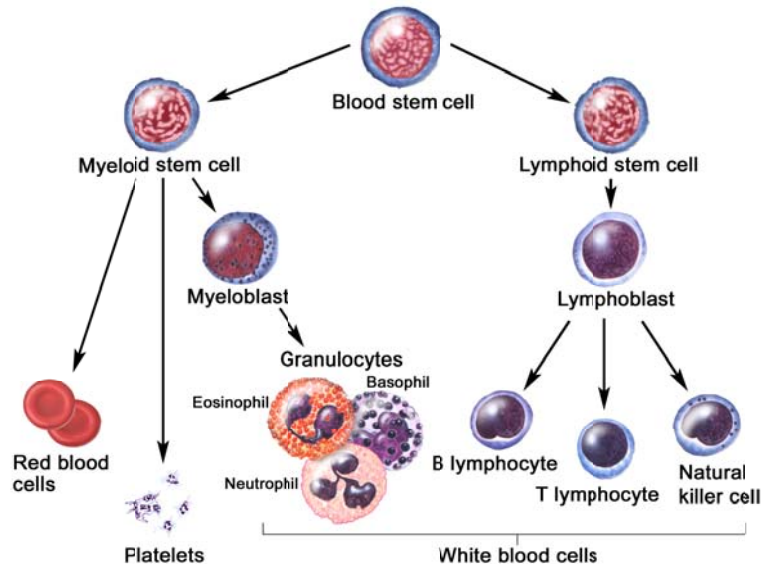
- Produced in bone marrow from stem cells
- No organelles, no nucleus, just contain hemoglobin
- Live for 120 days, recycled in spleen/liver

#### Leukocytes

- Produced in bone marrow from stem cells
- Can be granular or agranular
  - *Granular* are first line of defense, target anything foreign and have short lifetime
  - *Agranular* are second line, target specific things and have long lifetime

#### Platelets

- Chopped up megakaryocytes in bone marrow
- No nucleus, but have Golgi, mitochondria, ER, etc.
- When you cut yourself platelets aggregate first to form a plug, then convert prothrombin to thrombin, which converts fibrinogen to fibrin to form a clot





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### Immune System

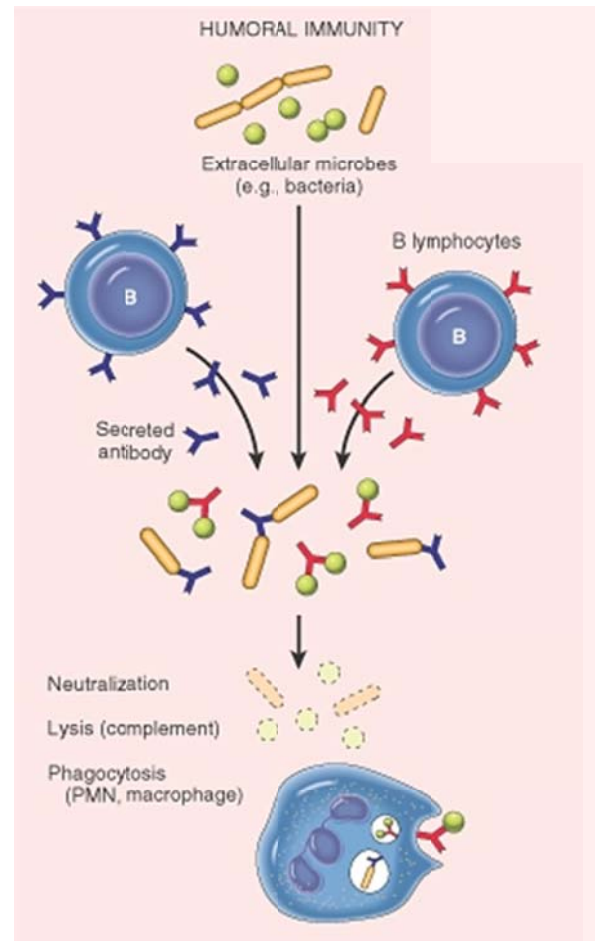
#### INNATE IMMUNITY

1. Skin/digestive system forms first line of defense
2. *Macrophages*, *neutrophils* eat up foreign organisms through phagocytosis
3. *Inflammation* occurs where blood vessels dilate, capillaries become more permeable in order to let more blood cells go to the area

#### ACQUIRED IMMUNITY

##### B cell/humoral immunity:

- *B lymphocytes* mature in bone marrow/liver, make antibodies
- *Antibodies* recognize an antigen on surface of foreign particles, can cause *agglutination*, deactivation or signal cells to eat the foreign substance
- *Primary response*: when an antibody sees a matching antigen, it will cause the B lymphocyte to differentiate into *plasma cells* (which make a ton of antibodies) and *memory B cells* (which “remember” the foreign antigen for the future)
- *Secondary response*: when the same antigen is seen by the body, memory B cells will start producing antibodies quickly to get rid of it
- USEFUL FOR FOREIGN ORGANISMS





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### T cell/cell-mediated immunity

- *T lymphocytes* mature in the thymus
- *Helper T cells* help B lymphocytes to differentiate
- *Suppressor T cells* decrease immune response when unneeded
- *Memory T cells* can remember foreign substances for better response later
- *Killer/cytotoxic T cells* poke holes in foreign cell membranes
- USEFUL FOR INFECTED/CANCEROUS BODY CELLS

### Blood types

- Blood has A and B surface antigens. If your body sees blood cells w/ an antigen not recognized by body, it'll kill it.
- So people with AB blood type have both antigens, if you put their blood into anyone without AB then it'll be destroyed
- People with O blood type have no antigens, so you can put their blood into anyone
- Rh factor is another type of antigen that can cause problems in pregnancy

