AP Biology—Chapter 42 Lecture Notes

Circulation and Gas Exchange

The objective of circulation is to move body fluid, containing important substances and metabolic waster around the body
The purpose of gas exchange is to increase surface area for obtaining oxygen and releasing carbon dioxide
*these two processes are closely tied, as are the organ systems that perform them

1. Circulation

--primitive aquatic organisms (hydra, flatworm, etc.) rely on muscular movement to circulate fluids
--mollusks and arthropods have open circulatory systems that push body fluid (not called blood) to different chambers of their body (sinuses)
--earthworms and vertebrate animals have a closed circulatory system with pumps (hearts) that push blood through tubes (blood vessels); the earthworms have five muscular aortic arches that act as hearts

A. Types of Blood Vessels
   i. **A**rteries—take blood **A**way from the heart
   --are thick-walled and elastic; under high pressure
   ii. Veins—bring blood to the heart
   --are thick walled an not as elastic; under low pressure; contain valves to prevent backflow
   iii. Capillaries—site of exchange of materials in the body (are one cell thick); under low pressure; most numerous blood vessel in the body

B. The Heart
   i. Atria—receive blood from veins
   ii Ventricles—pump blood away from the heart in arteries
   iii. Valves prevent backflow of blood in the heart; heart beat in a stethoscope is due to valves slamming against the walls of the heart ("Lub-dub")
   iv. The sino-atrial node and atrio-ventricular node regulate heart rate (under nervous control)
   v. Number of chambers reflects metabolism: Fish have two-chambered hearts and are ectothermic; amphibians and *most* reptiles have three-chambered hearts and are ectothermic; birds and mammals have a four-chambered heart and are endothermic
   *there is no mixing of blood in a four-chambered heart; the septum divides the right (deoxygenated) side from the left (oxygenated) side

C. Pulse and Blood Pressure
   i. Pulse is the expansion of an artery (measured in beats/min.)
   ii. Blood Pressure is measured by a sphygmomanometer (blood pressure cuff)
   --Systolic pressure (higher number) is the pressure in an artery when the ventricles *contract*
   --Diastolic pressure (lower number) is the pressure in an artery when the ventricles *relax*

--120/70 might be considered a *normal* blood pressure, but it varies greatly from person to person

D. Circulatory Problems

i. Heart Attack—one or more of the coronary arteries get clogged (partially or fully) with plaque; this leads to death of heart tissue fed by that artery

ii. Stroke—arteries feeding the brain get clogged; can lead to brain damage of tha area fed by that artery

E. Solutions

i. Balloon angioplasty—balloon is inflated to crush plaque and restore blood flow

ii. Balloon angioplasty with stent—metal mesh surrounds balloon; it expands with the balloon; it stays in the artery and prevents it from collapsing

iii. Coronary bypass—blood vessels are grafted from the aorta beyond blocked coronary artery; this is much more invasive and requires entering the chest

2. Gas Exchange

--primitive aquatic organisms (hydra, etc.) have all cells in direct contact with water. Oxygen easily diffuses in and carbon dioxide easily diffuses out

--primitive terrestrial organisms (earthworms, etc.) have moist skin that allows diffusion of oxygen and carbon dioxide

--aquatic arthropods have gills filled w/capillaries that increase surface area for diffusion of oxygen and carbon dioxide

--terrestrial insects have spiracles that branch into trachea, which further branch to provide each cell w/its own gas exchange tube

--spiders have book lungs

--aquatic vertebrates (fish and amphibians) have gills; terrestrial vertebrates (amphibians, reptiles, birds, and mammals) have lungs

A. Gills

i. filled with capillaries (site of exchange)

ii. water current is *opposite* that of blood flow (counter-current exchange)

iii. opening of a fish mouth closes gill cover; closing mouth opens gill cover, pushing water over gills

B. Lungs

i. fill by positive (frog) or negative pressure (human); the diaphragm creates negative pressure, when it contracts

ii. trachea (wind pipe) branches to two bronchi, which branch to bronchioles

iii. bronchioles terminate in alveoli, which are surrounded by capillaries; this is where gas exchange occurs

C. Partial Pressure

i. gases move from a region of higher to lower partial pressure

ii. partial pressure of oxygen is higher in alveoli than in blood; partial pressure of carbon dioxide is higher in blood than in alveoli

iii. differences in partial pressures allow oxygen to diffuse into the blood and carbon dioxide to diffuse out

D. Respiratory Pigments

i. help transport oxygen and sometimes carbon dioxide

ii. hemocyanin transports oxygen in some arthropods (contains a copper group that binds oxygen)

iii. hemoglobin transports oxygen in vertebrates; it is a macromolecule w/four protein subunits; binding of one oxygen increases affinity for more oxygen; release of oxygen triggers the opposite effect
iv. as blood pH decreases, hemoglobin loses affinity for oxygen; this would happen at muscles and areas of increased respiration (those most in need of oxygen)→hemoglobin is best able to release oxygen to these locations!
v. carbon dioxide is transported by bicarbonate ion in the blood; red blood cells convert carbon dioxide to bicarbonate via carbonic anyhdrase