Circulation and gas exchange

Whoever smelled it, dealt it

Overview

- Diffusion, by itself, is unable to transport essential substances throughout a “large” body
- Therefore, a circulation system is essential
- Movement of oxygen and carbon dioxide throughout bodies (circulatory system) plus their movement in and out of cells (respiratory system) are tightly connected processes essential to life

Overview of circulatory systems

- Three components:
  - Circulatory fluid = blood
  - Tubes = blood vessels
  - Muscular pump = heart
- Pressure produced by the heart moves blood through vessels down a pressure gradient, and the blood eventually returns to the heart
- Two types of circulatory systems
  - Open
  - Closed

Open circulatory system

- Arthropods and most mollusks
- Blood and interstitial fluid are not separated; form hemolymph
- Hemolymph pumped through sinuses (spaces around organs) and returned via pores

Closed circulatory system

- Blood and interstitial fluid are separated
- Earthworms, squid, octopus, and vertebrates

A few more terms

- Cardiovascular system of vertebrates
- Hearts are composed of atria (chambers that receive blood) and ventricles (chambers that pump blood out)
- Arteries contain blood moving away from the heart and towards capillaries
- Veins contain blood moving towards the heart and away from capillaries
- Single circulation vs. double circulation
**Single circulation**
- Bony & cartilaginous fishes
- Two-chambered heart
- Blood passes through heart once in each complete circuit
- LOSES pressure after capillary beds

**Double circulation**
- Three- or four-chambered heart; \textit{maintains} pressure
- Blood passes through heart twice in each complete circuit

**Mammalian cardiovascular system**
- Double circulation
- Right: deoxy.
- Left: oxy.
- Pulmonary = ?

**Mammalian heart**
- Wall thickness
- Valves: AV & semilunar
- Lub-dup = valves closing
- A heart murmur is a defect in a valve

**Heart rhythm**
- Sinoatrial (SA) node and atrioventricular (AV) node
  - Specialized cardiac muscle tissue
  - Note direction of signal propagation

**Blood vessels**
- 1 to 3 layers
- All: Endothelium: layer of smooth, flattened cells
- A&V: smooth muscle & connective tissue
  - Both are very elastic
Arteries and veins

- Which is which?

Blood flow

- Systole vs. diastole

Blood

- Specialized connective tissue

Leukemia

- Cancer of tissues that produce blood:
  - bone marrow and lymphatic system
  - Diverse cancer that is usually classified by its rate of progression and which leukocytes are affected
  - Typically, many abnormal leukocytes are formed that do not function correctly and overwhelm functional blood cells
  - Causes unclear, but likely due to genetic mutation and environmental factor

Cardiovascular disease

- Heart attacks—death of cardiac muscle due to prolonged blockage of coronary arteries (which bring oxy blood to heart)
- Strokes—death of nervous tissue in the brain due to blockage or rupture of arteries in head
- Atherosclerosis—chronic condition often leading to the above conditions; plaques (fibrous connective tissue + lipids) narrow arteries

Gas exchange

- Gills
- Tracheal systems
- Lungs
- Water vs. air
  - 4 – 8 vs. 210 ml O₂ per liter
  - Diffusion speed
  - Evaporation
**Gills**
- Continuously pumping water

**Tracheal systems**
- Life on land
  - Small bodies
  - Trachea located throughout body

**Lungs**
- Life on land
  - Large bodies (usually)
  - Lungs localized

**Gas loading and unloading**
- Partial pressures and diffusion
  - Exhaled air
  - Inhaled air
  - Pulmonary arterial and systemic capillaries
  - Alveolar epithelial cells