Circulation and gas exchange

Diffusion with some help

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 ______ blood) and **ventricles** (chambers that _____ blood out)
- **Arteries** contain blood moving _____ from the heart and ______ capillaries
- **Veins** contain blood moving ______ the heart and _____ 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; maintains pressure

**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

An electrocardiogram shows the current conducted to the skin.
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 factors

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

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**Arteries and veins**

**Blood flow**

**Blood**

**Leukemia**

**Cardiovascular disease**

**Gas exchange**
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

Fig. 42.22
Fig. 42.23
Fig. 42.24
Fig. 42.29