BIOL – 3; Chapter 32 - Circulation 04/30/2014

4-chambered hearts consist of two separate pumps:

- 1 pump, consisting of right atrium & right ventricle, deals with deoxygenated blood
  - **Superior & inferior vena cava** – where oxygen-depleted blood enters right atrium through 2 large veins
  - After filling with blood, right atrium contracts, forcing blood into right ventricle
  - Contraction of right ventricle sends oxygen-depleted blood to lungs through pulmonary **arteries** - vessels that carry blood away from heart and to lungs
- Other pump, consisting of left atrium & left ventricle, deals with oxygenated blood
  - Oxygen-rich blood from lungs enters left atrium through **pulmonary veins** & is squeezed into left ventricle
  - Contraction of left ventricle sends oxygenated blood through **aorta** to rest of body
- Valves maintain direction of blood flow
  - When ventricles contract, blood must be prevented from flowing back into atria
    - Blood entering pulmonary artery & aorta must also be prevented from flowing back into ventricles as heart relaxes
  - Directionality of blood flow is maintained by 1-way valves
  - Pressure in 1 direction opens them, but reverse pressure forces them closed
  - **Atrioventricular valves** - allow blood to flow from atria into ventricles, but not the reverse
  - **Semilunar valves** - allow blood to enter pulmonary artery & aorta when ventricles contract, but prevent blood from returning as ventricles relax
- Cardiac muscle is present only in the heart
  - **Cardiac muscle** cells are small, branched, & striated
    - Cells connected by **intercalated discs**- contain desmosomes that link cells together & prevent strong heart contractions from pulling muscle cells apart
    - Cells contain gap junctions allowing electrical signals to spread from 1 muscle cell to another, producing synchronous heart muscle contractions
    - Coordinated contractions of atria & ventricles produce cardiac cycle

        - Heart beats in coordinated fashion
            - Both atria contract & pump blood into ventricles
            - Both ventricles contract & pump blood into arteries that exit heart
            - All chambers relax briefly before cycle repeats
        - This **cardiac cycle** lasts less than 1 second
- Cardiac cycle generates forces that are measured when blood pressure is taken
    - **Systolic pressure**- higher of the two readings- is measured during ventricular contraction
    - **Diastolic pressure**- minimum pressure in arteries as heart rests between contractions
- Blood pressure reading of less than 120/80 is considered healthy; pressure of 140/90 or higher is high blood pressure
    - High blood pressure-**hypertension**-is caused by constriction of small arteries, which causes resistance to blood flow & strain on heart
    - Some people have genetic tendency toward hypertension. It's also associated with smoking, obesity, lack of exercise, high alcohol consumption, stress, & aging
- Electrical impulses coordinate sequence of heart chamber contractions
    - Contraction of heart is initiated & coordinated by **pacemaker**- cluster of specialized heart muscle cells that produce spontaneous electrical signals at a regular rate
    - Heart's pacemaker is **sinoatrial (SA) node**, located in upper wall of right atrium
    - Electrical signals from SA node pass freely into connecting cardiac muscle cells & then throughout atria
    - Electrical signal then passes from right atrium to specialized group of muscle cells between right atrium & right ventricle -**atrioventricular (AV) node**
    - From AV node, signal to contract spreads along specialized tracts of rapidly conducting muscle fibers-**atrioventricular bundle** (AV bundle)- which sends branches to lower portion of both ventricles
    - Here, bundles branch further, forming **Purkinje fibers** -transmit electrical signal throughout ventricle
- Variety of disorders can interfere with complex series of events that produce normal cardiac cycle
    - When pacemaker fails, rapid, uncoordinated, weak contractions –**fibrillation-** may occur
    - Fibrillation may be treated with defibrillating machine, which applies jolt of electricity to heart, synchronizing contractions of ventricular muscle cells, & pacemaker resumes its normal coordinating function

What is blood?:

- Blood has 2 major components:
  - Liquid-**plasma**- comprises about 55% of total blood volume
    - Plasma is primarily water where proteins, salts, nutrients, & wastes are dissolved
      - Proteins are most abundant dissolved molecules by weight & include:
        - **Albumin**-helps to maintain blood's osmotic strength
        - **Globulins**- antibodies that play an important part in immune response
        - **Fibrinogen**- important in blood clotting
  - Cell-based portion, which is about 40–45% of total blood volume & consists of: **red blood cells, white blood cells, & platelets**.
  - Cell-based components of blood are formed in bone marrow.
    - Blood contains 3 cell-based components—red blood cells, white blood cells, and platelets—but only the white blood cells are complete, functional cells
      - Mature red blood cells are not actual cells because they lack a nucleus, which is lost during development
      - Platelets are small fragments of cells
    - All 3 cell components originate from blood stem cells that reside in bone marrow
      - **Stem cells** -unspecialized cells that can divide to produce offspring capable of maturing into 1 or more types of specialized cells
  - Red blood cells carry oxygen from lungs to tissues
    - About 99% of all blood cells, & about 45% of total blood volume, are oxygen-carrying red blood cells-**erythrocytes**
    - Red color of erythrocytes is caused by protein **hemoglobin**- which transports oxygen in blood

What is blood (again)?:

- Each hemoglobin has 4 iron-containing heme groups that can bind 4 oxygen molecules.
  - Oxygenated hemoglobin takes on bright red color