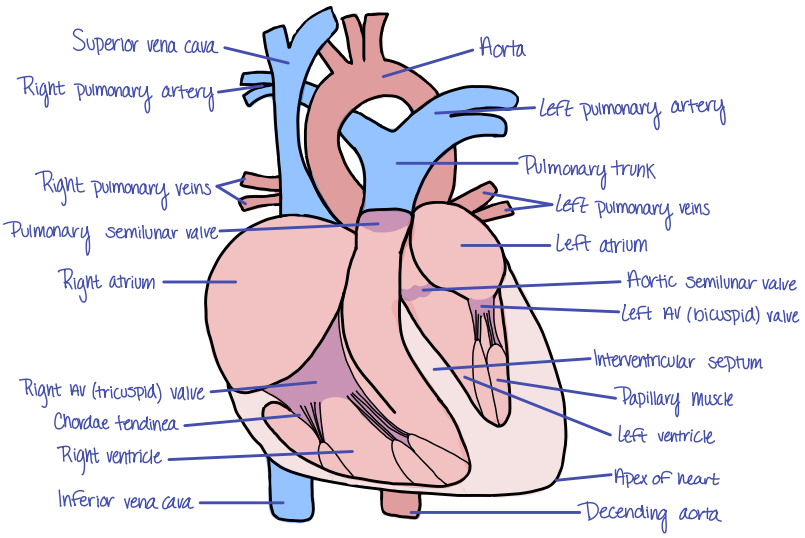
The Cardiovascular System

The heart

↳ generates force to propel blood through blood vessels

- atria: recieve blood that comes back to the heart from the vasculature
- ventricles: recieve blood from the atria + generates force to push the blood away from the heart through blood vessels



Blood vessels

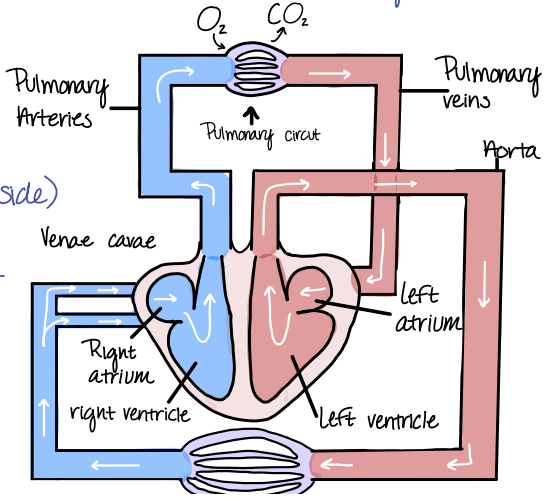
- vesculature: system of blood vessels that carry blood from the heart to different organs
- capillaries: smallest blood vessels, site of exchange of blood + interstitial fluid

Blood

- erythrocytes (red blood cells): most common + contain hemoglobin (carries oxygen)
- leukocytes (white blood cells): defend against invading microorganisms
- platelets (cell fragments): clot blood
- plasma: the liquid portion of blood → made up of dissolved proteins + electrolytes

Path of Blood Flow

- pulmonary circut: comprises all blood vessels in the lungs + that connect lungs and heart (right side)
- systemic circut: encompasses the rest of blood vessels in the body (left side)
  → blood from one side never mixes w/ the other
- heart works in parallel w/ other organs so they



all recieve oxygenated blood + organs can be independently regulated → adjusted to match an organ's metabolic needs

- Anatomy
  - heart is located centrally in the thoracic cavity; surrounded by the pericardium (membranous sac that lubricates heart)
  - epicardium: outer layer of connective tissue
  - myocardium: middle layer of cardiac muscle → contraction + relaxation causes heart pumping
  - endothelium: inner layer of epithelial cells
  - ↳ thicker muscle on the left ventricle b/c it has to pump blood to the entire body
- Heart Beat
  - cardiac cycle: atria contract first, then the ventricles → ventricular pressure exerts an upward force against AV valve → blood enters the arteries → decrease in pressure → valves close

Electrical Activity

- Cardiac muscle is myogenic: contractions are due to signals originating from within the muscle
  - ↳ also has autorhythmicity ability
    - Pacemaker cells: initiate action potentials + establish the rhythem
    - Conduction fibers: transmit action potentials to the heart
  - gap junctions allow for rapid transmission between ions
  - ventricle contraction begins at the apex + spreads upward
- Electrocardiogram (ECG): monitors electrical activity of the heart
  - P wave: upward deflection due to atrial depolarization
  - QRS complex: series of sharp upward + downward deflections due to ventricular depolarization
  - T wave: upward deflection caused by ventricular repolarization

Cardiac Cycle

→ Involves the events of one heartbeat; a complete cycle includes ventricular contraction (systole) and relaxation (diastole)

1) Ventricular filling: mid-diastole, atria + ventricles are completely relaxed → venous return: high pressure in veins causes blood to fill the ventricle

2) Isovolumetric contraction: ventricles contract, but AV + semilunar valves are closed

3) Ventricular ejection: pressure results in blood being ejected into the aorta + pulmonary arteries → ventricular pressure declines

4) Isovolumetric relaxation: all valves are closed

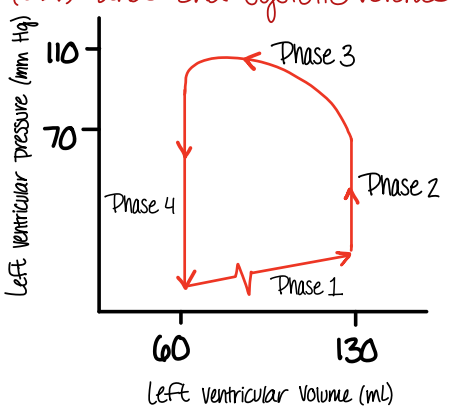
→ mean arterial pressure (MAP): average aortic pressure during cardiac cycle

• Ventricular Volume

- Stroke volume: difference between end-diastolic volume (EDV) and end-systolic volume represents volume of blood ejected from the heart during one beat

→ SV = EDV - ESV → Ejection fraction: SV/EDV

- Pressure Volume Curve →



Cardiac Output

• Cardiac output: rate that a ventricle pumps blood (liters per minute)

• CO = Heart rate x Stroke Volume → For an average adult → CO = 72 beats/min x 0.07 L/beat = 5 L/min

• Intrinsic control: regulation by neural input, circulating hormones, or factors from outside the organ

• Intrinsic control: autoregulation by factors originating within the organ itself

Factors affecting cardiac output

• Neural control of heart rate

- increased activity in sympathetic neurons to the SA node increases frequency of action potentials in the

pacemaker cells

- Hormonal control of heart rate
  - epinephrine increases heart rate + the velocity of action potential conduction
- ventricular contractility on stroke volume: when ventricles contract w/ more force, stroke volume ↑ and increases cardiac output
- no parasympathetic influence on ventricular contractability
- insulin, glucagon + thyroid hormones increase ventricular contractility

→ Starling's law: when the rate of venous return changes, the stretch on the ventricle myocardium changes → ventricle contracts w/ greater/lesser force → changes stroke volume (proportional relationship

- heart failure: when venous return + heart stroke occur at different rates

- preload: end-diastolic pressure → places tension on the myocardium before it begins to contract
- afterload: aterial pressure places tension on myocardium after contraction starts