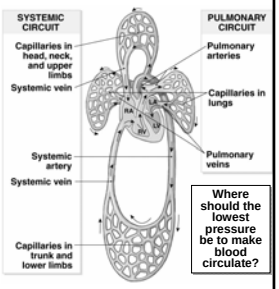
Cardiovascular System

The Heart

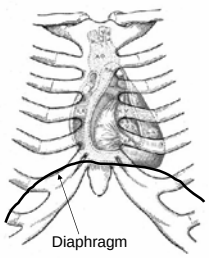
Cardiovascular System – The Heart Overview

- What does the heart do?
  - By timed muscular contractions creates pressure gradients
    - blood moves then from high pressure to low pressure from chamber to chamber
    - The timed muscular contractions occur in each side (pump) of the heart
      - Right side = pulmonary circuit
      - Left side = systemic circuit



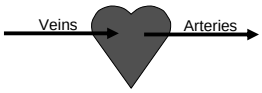
Cardiovascular System – The Heart Overview

- Physical Location & Size:
  - In the medastinum, intermediate to the sternum and vertebral column and intermediate to the right and left lungs, and superior to the diaphragm.. Can you picture it now? ☺
  - Size: approximately the size of your fist!



The Heart - Location Overview

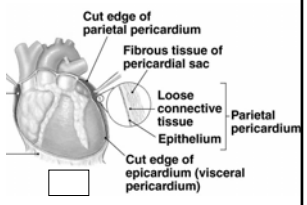
- Location of the heart with respect to the vasculature of the cardiovascular system
  - Between veins and arteries!
    - Veins Visit!
    - Arteries Away!



    - What do capillaries do?
      - Exchange – they are between arteries and veins

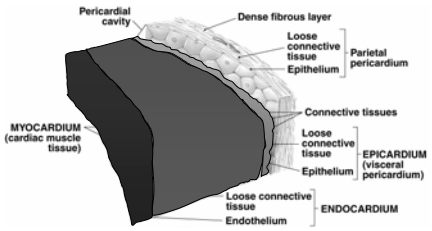
Cardiovascular System – The Heart Overview

- The Pericardial Membranes
  - Create the pericardial cavity.
    . . Why is it needed?
    - The parietal pericardium consists of:
      - An outer membrane of the fibrous parietal pericardium
        - dense irregular connective tissue
      - An inner serous membrane
    - The visceral pericardium consists of:
      - A thin membrane on the surface of the heart



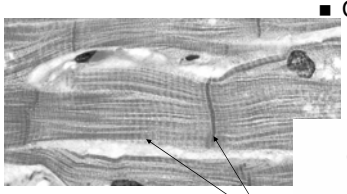
The Heart – Layers

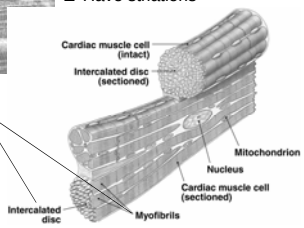
- The Heart Wall
  - Muscle (myocardium) sandwiched between an
  - inner layer (endocardium) and an
  - outer layer (epicardium – same as the visceral pericardium)



The Heart – Cardiac Muscle Features

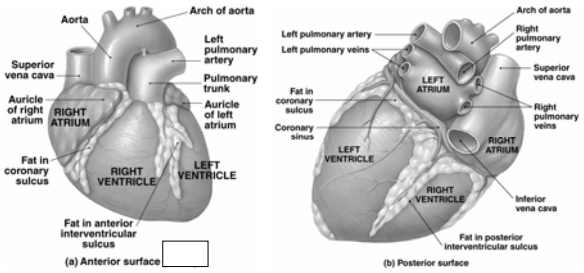
- Cardiac Muscle Cells
  - Shorter than skeletal muscle fibers & are branching
  - Have single nucleus
  - Have striations





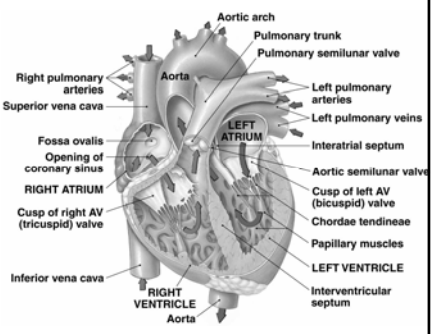
- Depend on aerobic metabolism
- Connected by *intercalated discs*
- *Desmosomes* transmit tension
- *Gap junctions* transmit ions (think action potential transmission)

The Heart – External Features



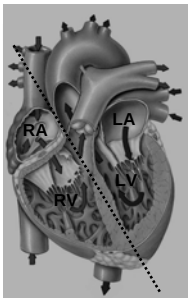
The Heart – Internal Features

- Key Features:
  - Septums
  - Valves



The Hearts Chambers

- Each side of the heart (left and right) has two chambers
  - Atria
    - Superior chambers at the base of the heart, receive blood from the body and from the lungs
  - Ventricles
    - Inferior chambers receive blood from the atria and contract to move blood into the lungs and body



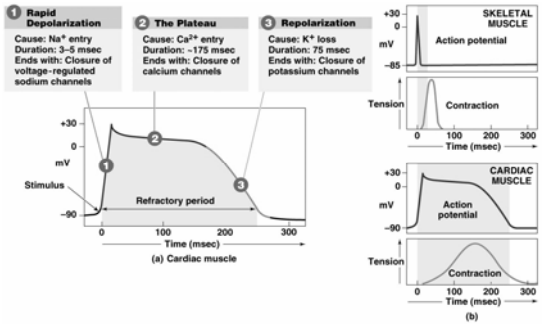
The Heart – Blood Flow

1. Systemic blood enters the Right Atrium via the Superior & Inferior Vena Cava & the Coronary Sinus
2. Blood passes through the right atrioventricular valve (R.A.V) or tricuspid valve to enter the Right Ventricle
3. Contraction of the Right Ventricle forces blood through the Pulmonary Semilunar Valve (Pulmonic Valve) into the Pulmonary Trunk (artery)
4. Pulmonary Arteries transport blood to the lungs, and pulmonary veins transport blood back to the left atrium
5. Blood passes through the left atrioventricular valve (LAV) or bicuspid or mitral valve to enter the left ventricle
6. Contraction of the left ventricle forces blood through the aortic semilunar valve (aortic valve) and into the aorta
7. The aorta and its branches supply the body with arterial blood which is then exchnaged in the tissues and returned to the heart via veins leading into the vena cavae.

The Heart – Coordinating it all

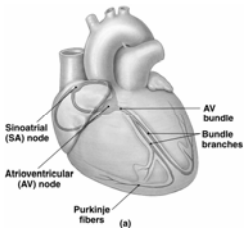
- The Conducting System & The Myocardium
  - Initiates and spreads electrical impulses in heart (CS)
  - Two types of cells
    - *Nodal cells or Pacemaker cells*
      - Reach threshold first
      - Set heart rate
    - *Conducting cells*
      - Distributes stimuli to myocardium
- Myocardium – specialized cells with unique action potential
  - Differences between Cardiac and Skeletal Muscle Cells
    - Cardiac action potential has long *plateau phase*
    - Cardiac muscle has long, slow twitch
    - Cardiac muscle has long *refractory period*
    - Can't be *tetanized*

Cardiac Muscle Action Potential

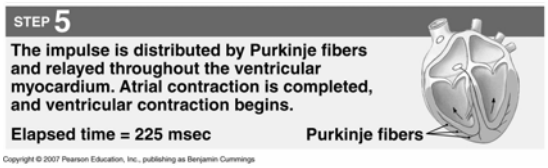


The Heart – The Conduction System

- Pacemaker cells establish heart rate
- Normal pacemaker is *sinoatrial* (SA) *node*
- Impulse spreads from SA node:
  - Across atria
- To *atrioventricular* (AV) *node*
- To AV bundle and bundle branches
- Via *Purkinje fibers* (conduction myofibers) to ventricles

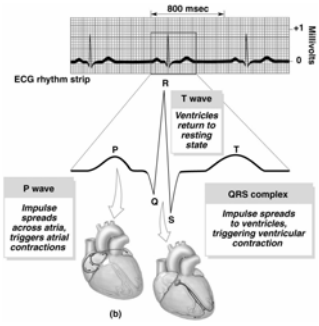


The Heart – The Conduction System



The Heart – Electrical Activity Recorded, The ECG

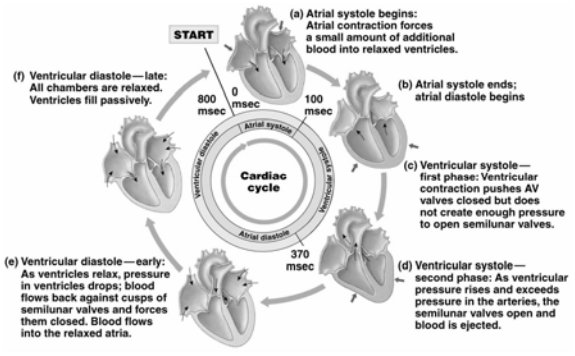
- ECG records the electrical activity of the heart during cardiac cycles
- P wave
  - Atrial depolarization
- QRS complex
  - Ventricular depolarization & atrial repolarization
- T Wave
  - Ventricular depolarization



Putting it all together – The Cardiac Cycle

- Two phases in cardiac cycle
  - *Systole*
    - Contraction phase
    - Both chambers will have periods of systole
  - *Diastole*
    - Relaxation phase
    - Both chambers will have periods of diastole
    - The cardiac cycle is the alternation of these two phases…
      - First atrial systole and ventricular diastole, then atrial diastole and ventricular systole and back to systole…

The Cardiac Cycle



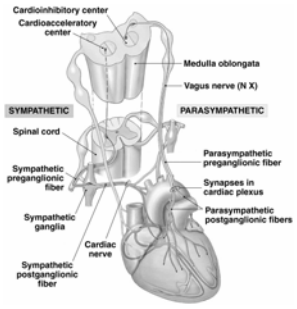
The Heart – Cardiac Output

First…

- Stroke volume
  - The amount of blood that is ejected from the left ventricle during one systolic event
  - Cardiac Output
    - The volume of blood ejected from the left ventricle during one minute
    - Calculated by
      - Stroke Volume X Heart Rate (bpm) = C.O.

The Heart – Cardiac Output

- Factors Controlling Cardiac Output
  - Blood volume reflexes
    - Stimulated by changes in *venous return*
    - VR is amount of blood *entering* heart
    - *Atrial reflex*
      - Speeds up heart rate
      - Triggered by stretching wall of right atrium
    - *Frank-Starling principle*
      - Increases ventricular output
      - Triggered by stretching wall of ventricles
  - Autonomic innervation
    - Parasympathetic innervation
      - Releases acetylcholine (ACh)
      - Lowers heart rate and stroke volume
    - Sympathetic innervation
      - Releases norepinephrine (NE)
      - Raises heart rate and stroke volume



The Heart – Cardiac Output

- Hormone Effects on Cardiac Output
  - Adrenal medulla hormones
    - Epinephrine, norepinephrine released
    - Heart rate and stroke volume increased
- Other hormones that increase output
  - Thyroid hormones
  - Glucagon

The Heart – Cardiac Output

- CNS Control of the Heart
  - Basic control in *medulla oblongata*
  - *Cardioacceleratory center*
    - Activation of sympathetic neurons
  - *Cardioinhibitory center*
    - Governing of parasympathe neurons
  - Other inputs
    - Higher centers
    - Blood pressure sensors
    - Oxygen, carbon dioxide sensors