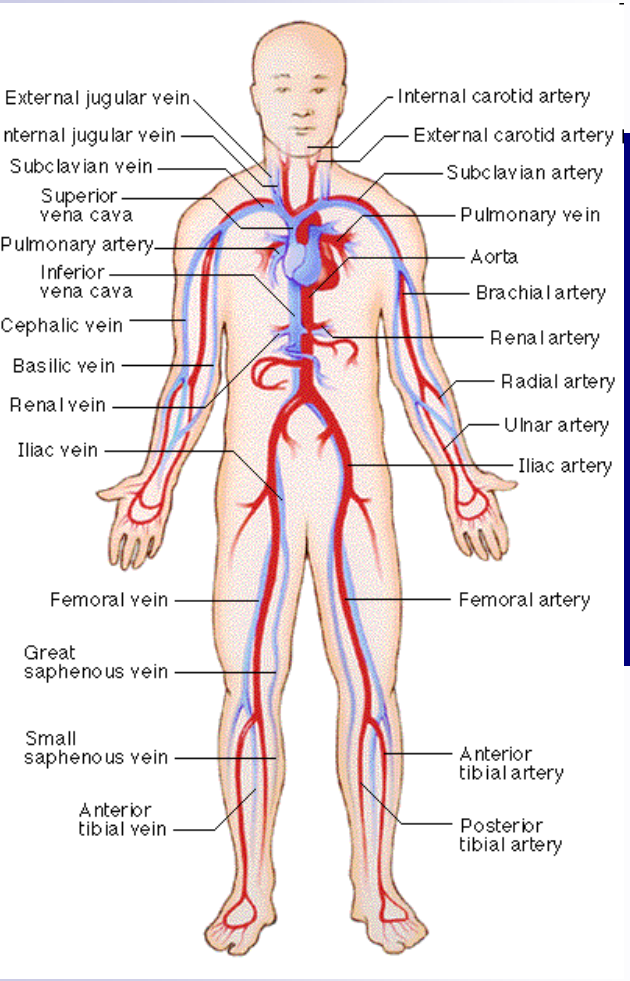
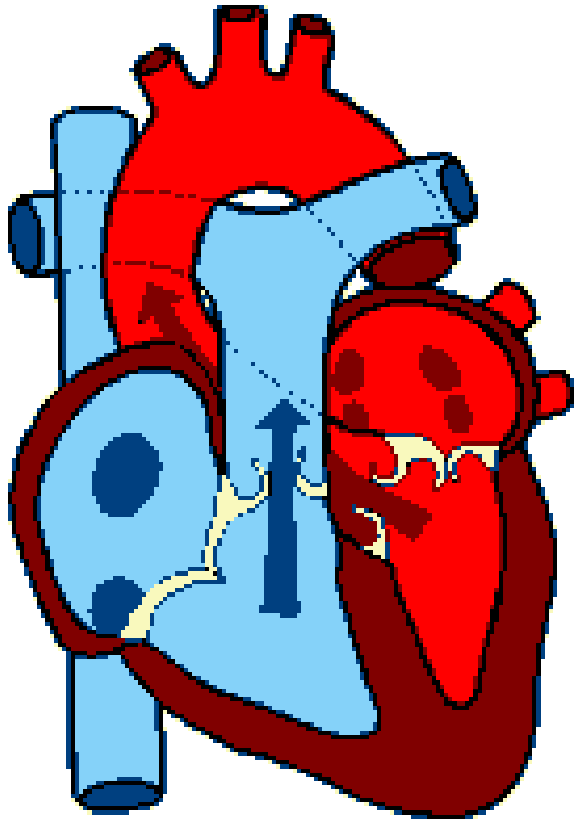


Cardiovascular System

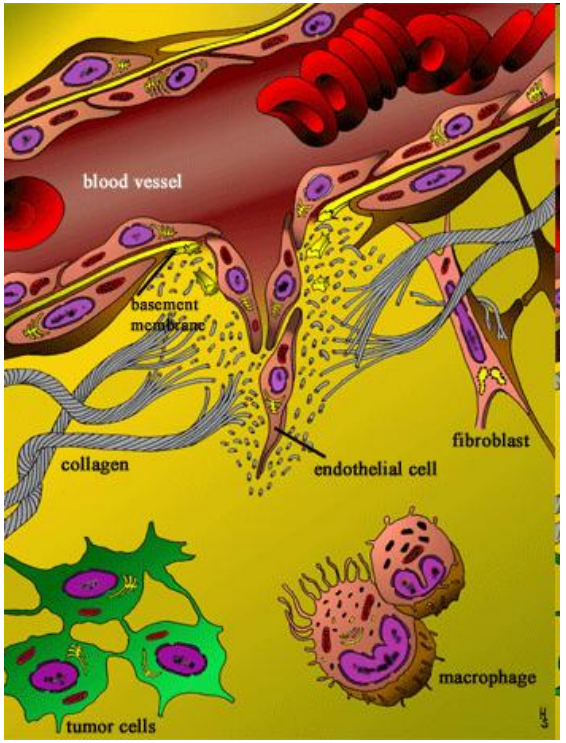
Purpose

- Transport oxygen and nutrients
- Take waste products away from tissues & organs



Things we learned…

- Blood pressure: the force of blood pushing against the walls of blood vessels (arteries)
- Vascularization: formation of the blood vessels
  - Angiogenesis factors: chemicals that stimulate the growth of new blood vessels



BLOOD VESSELS

- Arteries: thickest blood vessel; carries blood Away from the heart
- VeINs: thinner than arteries; carries blood INto the heart
- Capillaries: tiniest blood vessels; thin enough to allow gas exchange

A Deeper Look

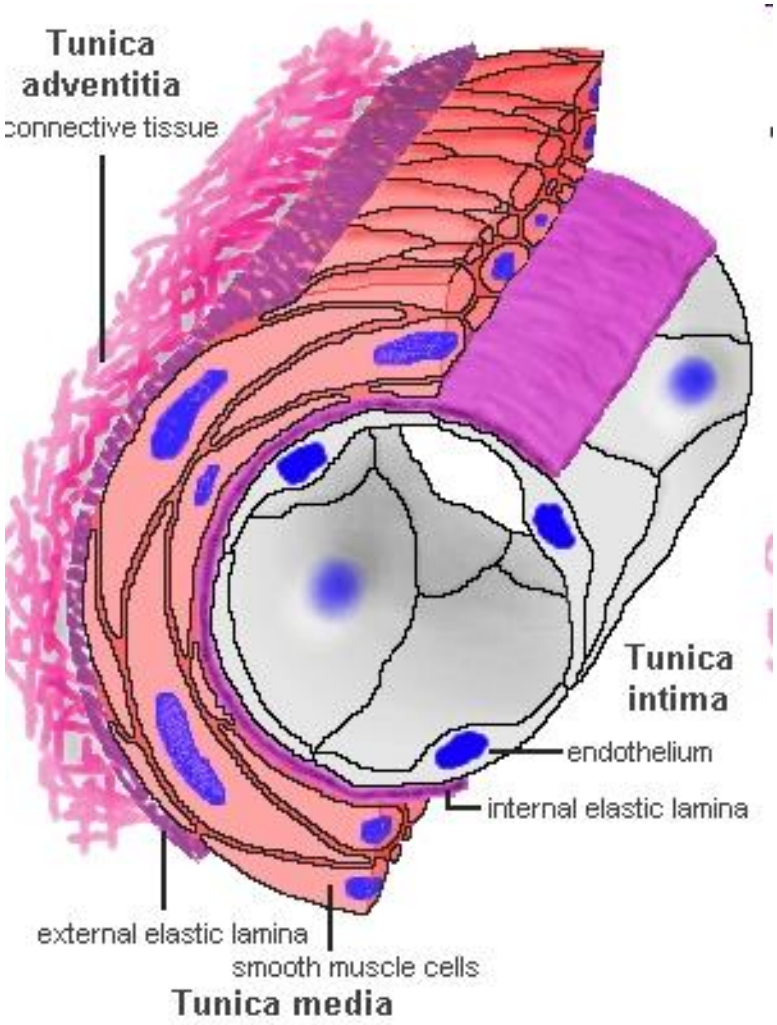
Arteries and Veins: move blood throughout the body

Both consist of 3 layers

- Tunica intima: innermost layer
  - Composed of simple, squamous epithelium
  - Provides the lining of the lumen, which is the central opening of the blood vessel

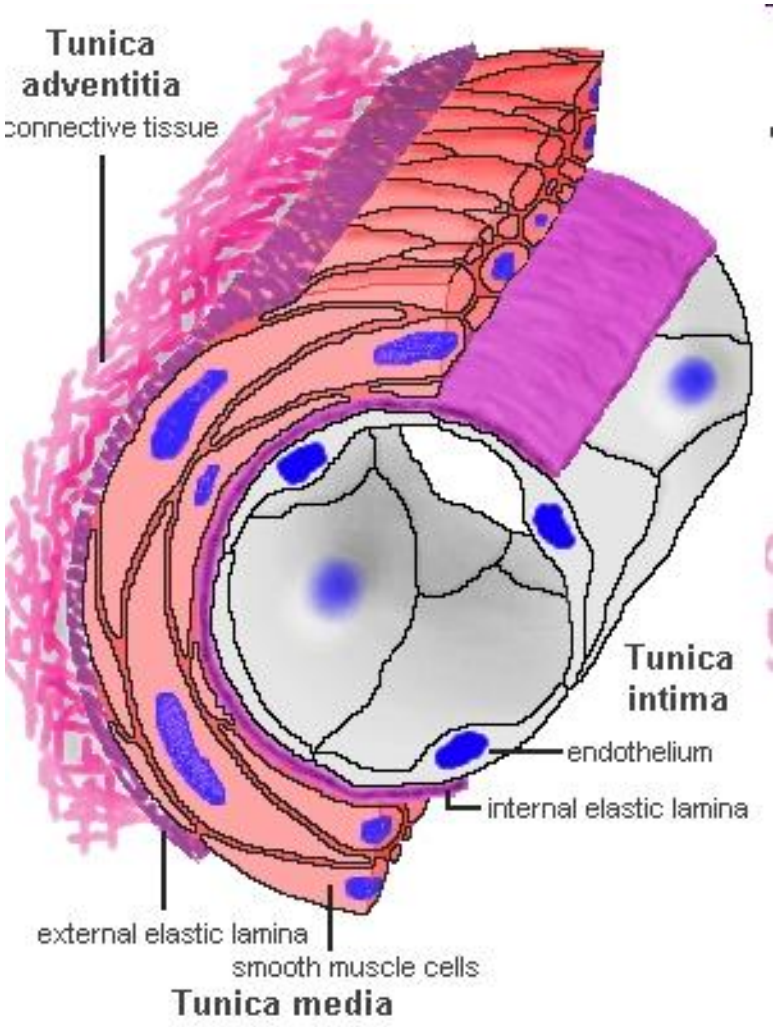
A Deeper Look

- Tunica media: middle layer
  - Composed of smooth muscle
  - Scattered with collagen and elastin fibers



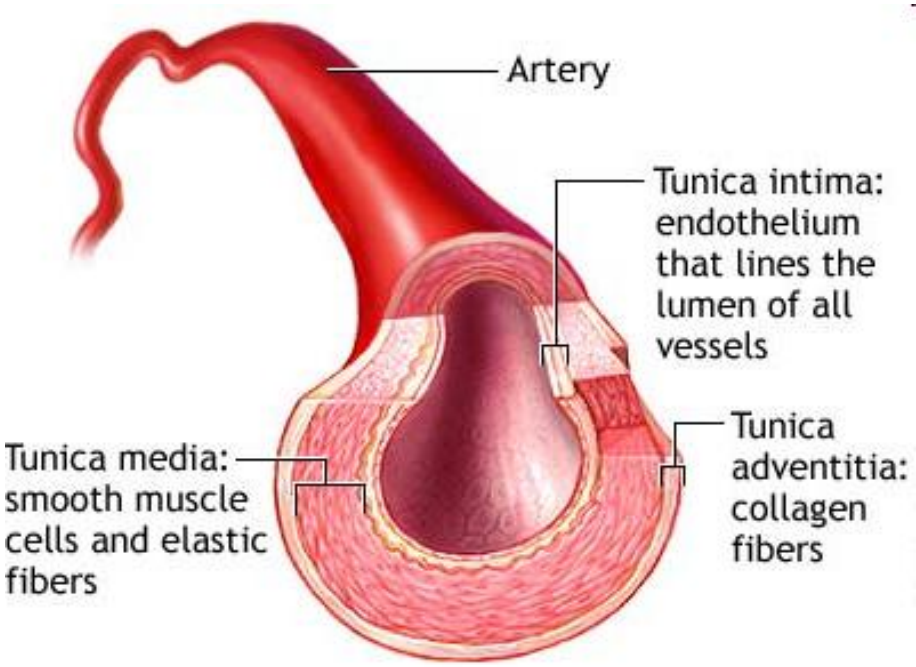
A Deeper Look

- Tunica Adventitia: outermost layer
  - a tough, fibrous connective tissue
  - collagen fibers for strength
  - elastin fibers for flexibility

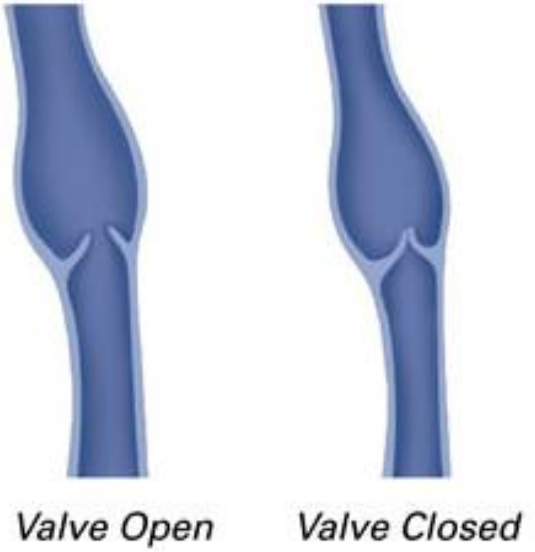


Arteries

- Distributes oxygenated blood throughout body
- Stronger and thicker
- *Thicker* T. media than veins which means it can control blood pressure
- Allows control of blood pressure
  - Vasoconstriction: closing/narrowing of the vessel
  - Vasodilation: opening/widening of the vessel



Veins



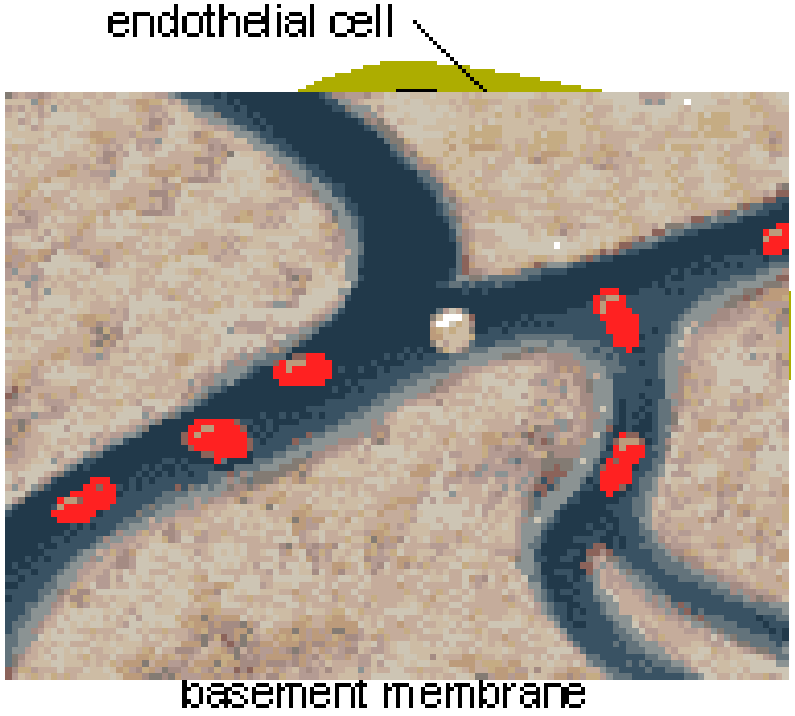
- Returns deoxygenated blood to the heart
- Less elastin
- Thinner T. media, which primarily maintains rigidity of the vessel
- Moves blood at a lower pressure → relies on contraction of skeletal muscles, respiratory activity, and the passing of blood through capillaries
- Contain valves that prevent backflow

Small Vessels and Capillaries

- Arterioles: branch from arteries; control blood flow to particular parts of an organ or tissue; respond to chemicals produced by the body
- Venules: branch from veins diameter is usually larger than arterioles; exchange materials (i.e., oxygen, nutrients, chemicals)

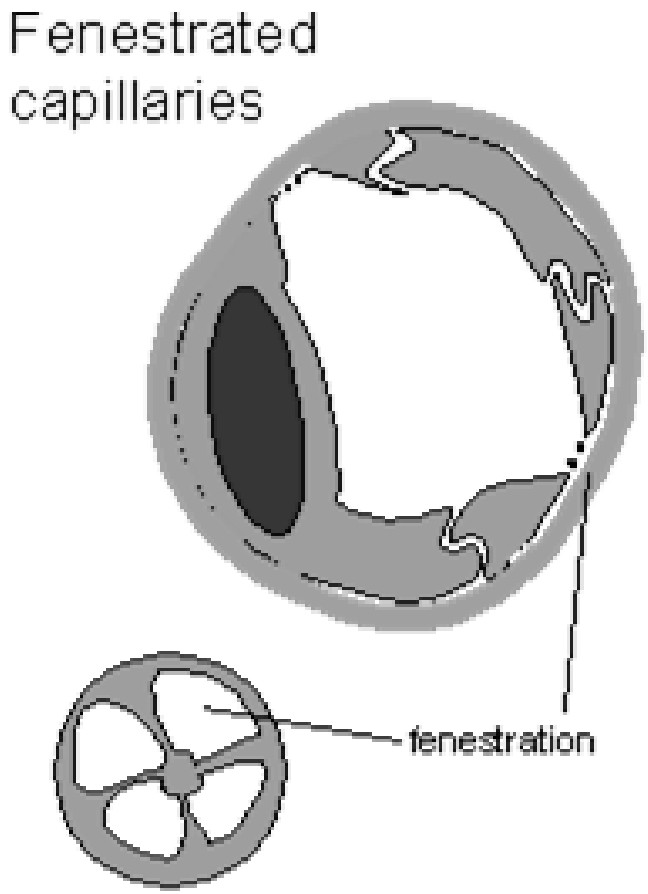
Small Vessels and Capillaries

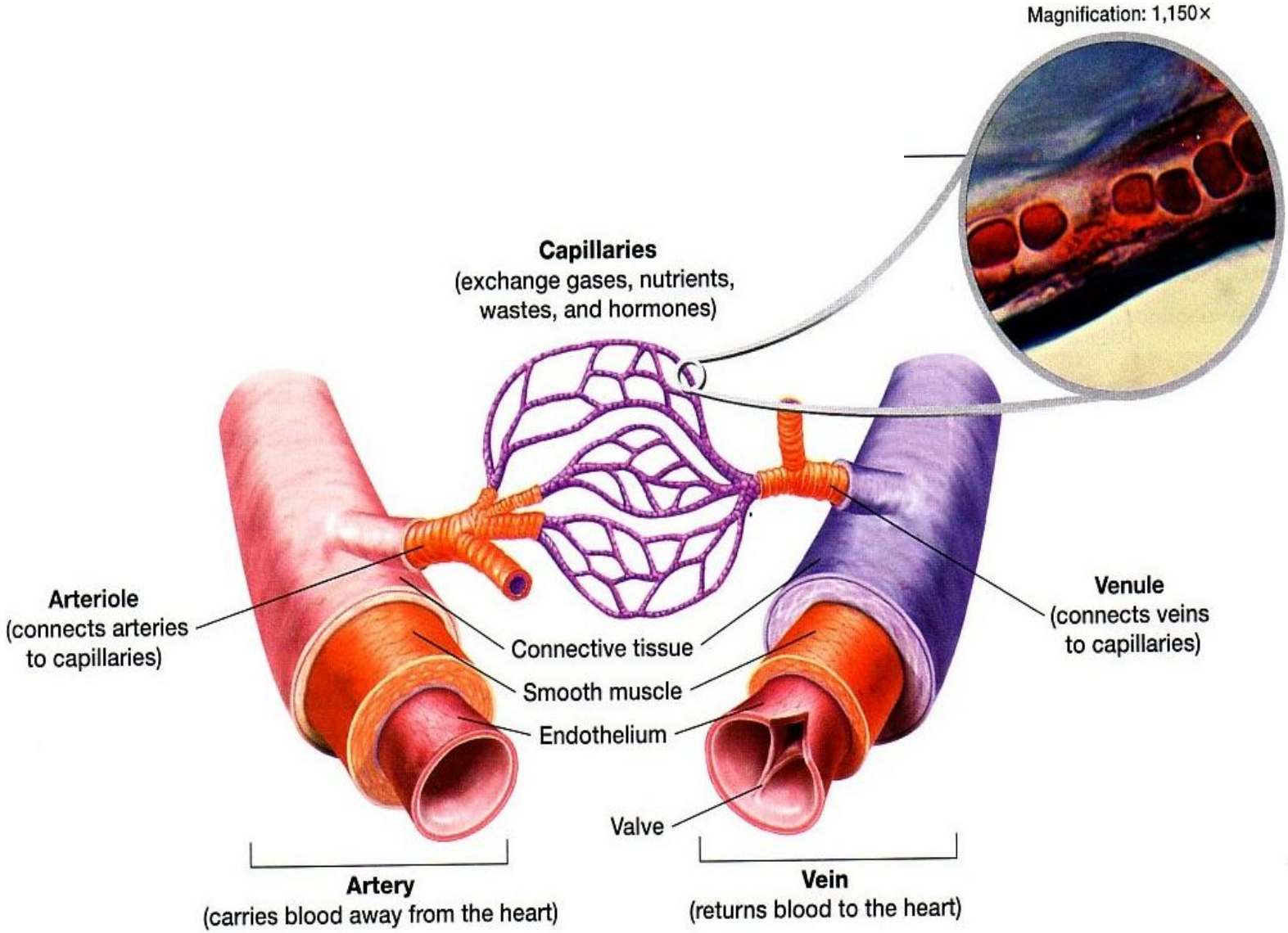
- Capillaries: have no tunica adventitia or smooth muscle
  - **Continuous**: made of *endothelial cells*; tight connections limit the types of cells that can pass; found in the central nervous system (CNS), lungs, muscles and skin



Small Vessels and Capillaries

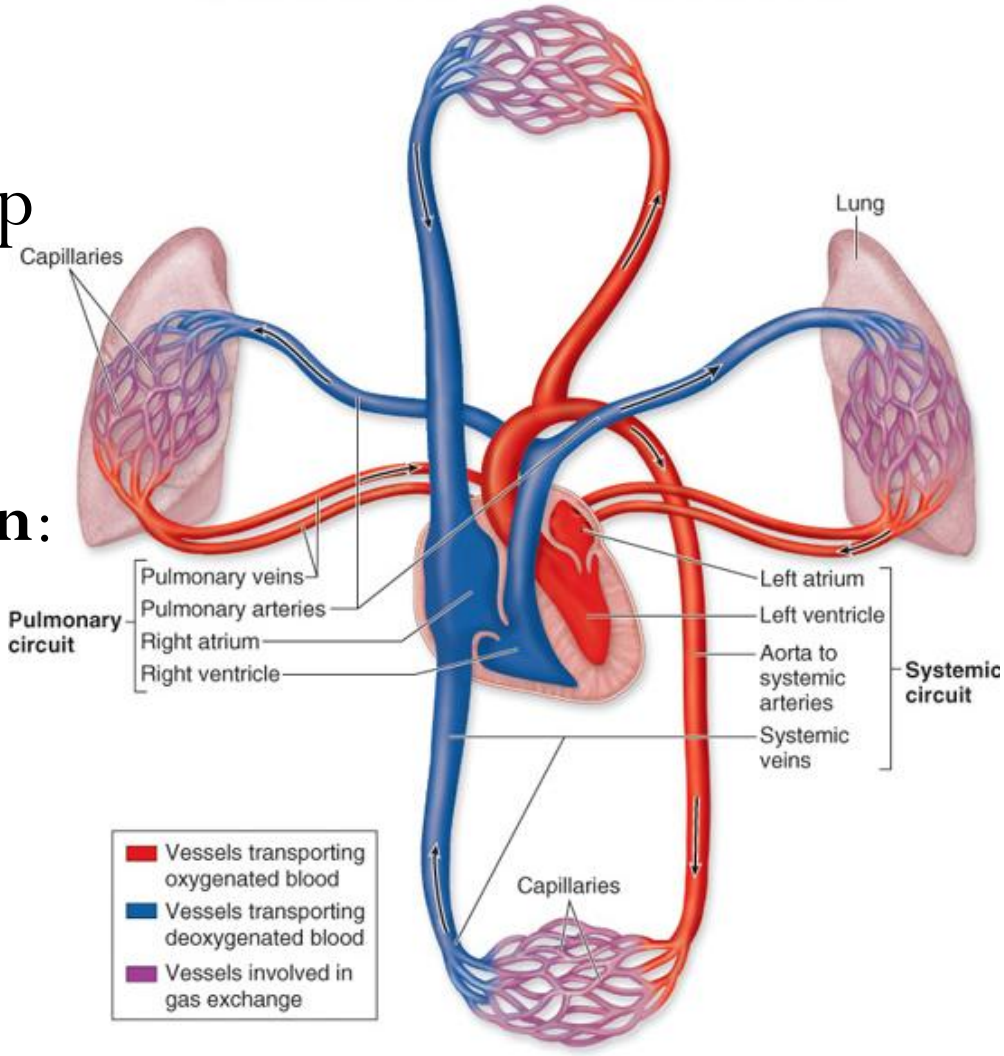
- **Fenestrated**: have openings that allow easier exchange of materials; found in the digestive, endocrine, and urinary systems




Magnification: 1,150×
Capillaries
(exchange gases, nutrients, wastes, and hormones)
Arteriole
(connects arteries to capillaries)
Venule
(connects veins to capillaries)
Connective tissue
Smooth muscle
Endothelium
Valve
Artery
(carries blood away from the heart)
Vein
(returns blood to the heart)

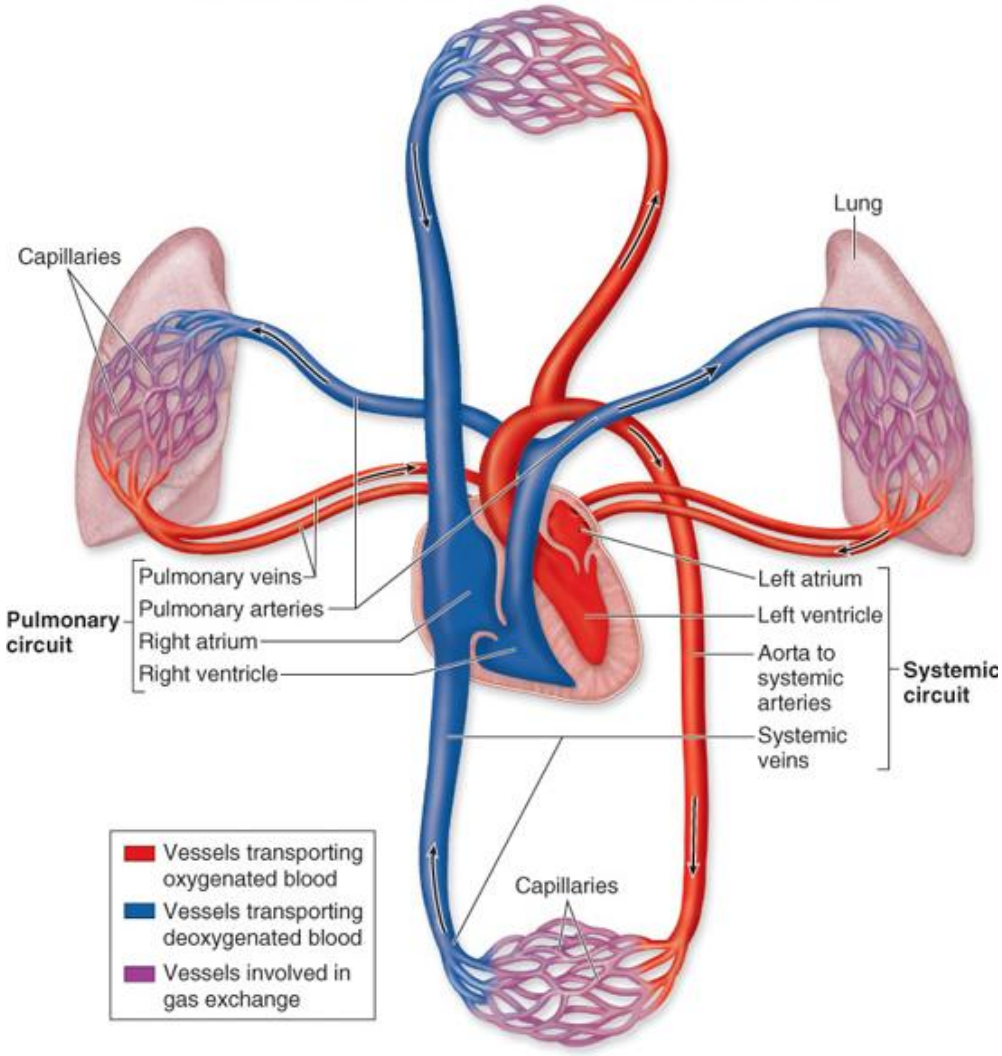
Heart

- Muscular, two-part pump that forces blood throughout the body
  - **Pulmonary circulation**: the right side of the heart that pumps blood to the lungs



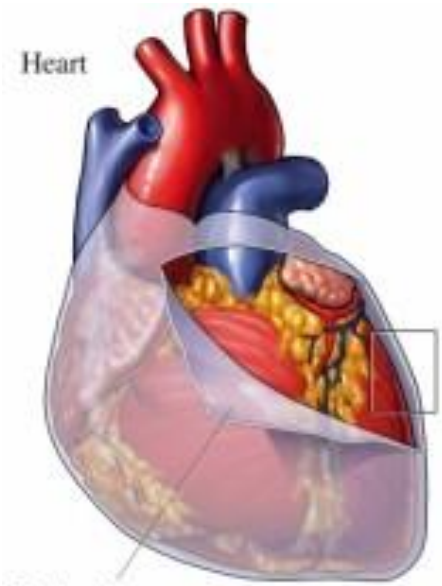
Heart

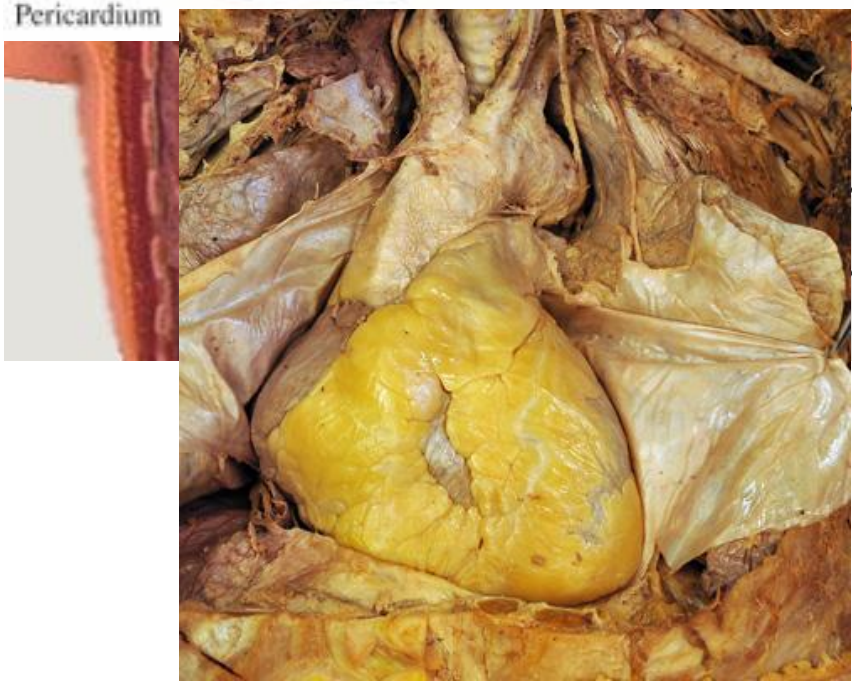
- Systemic circulation: the left side of the heart; receives blood from the lungs and sends it to the body (system)



Heart

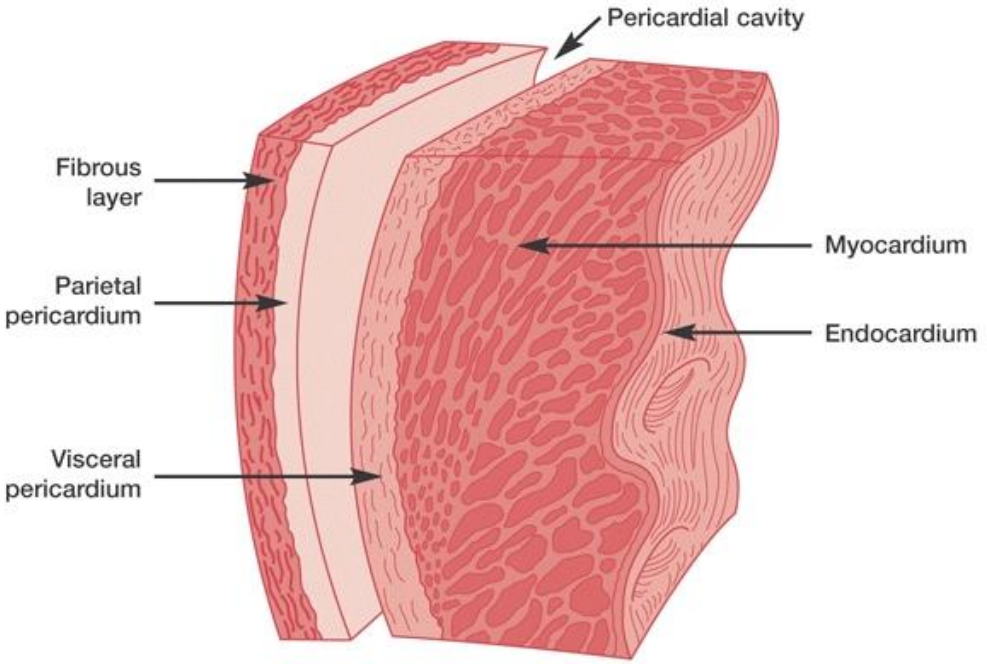
- Heart is nestled in the mediastinum, between the lungs
  - Separated from the lungs by the cavity membrane called the pericardium
    - Filled with **serous fluid** which lubricates and protects the heart as it beats





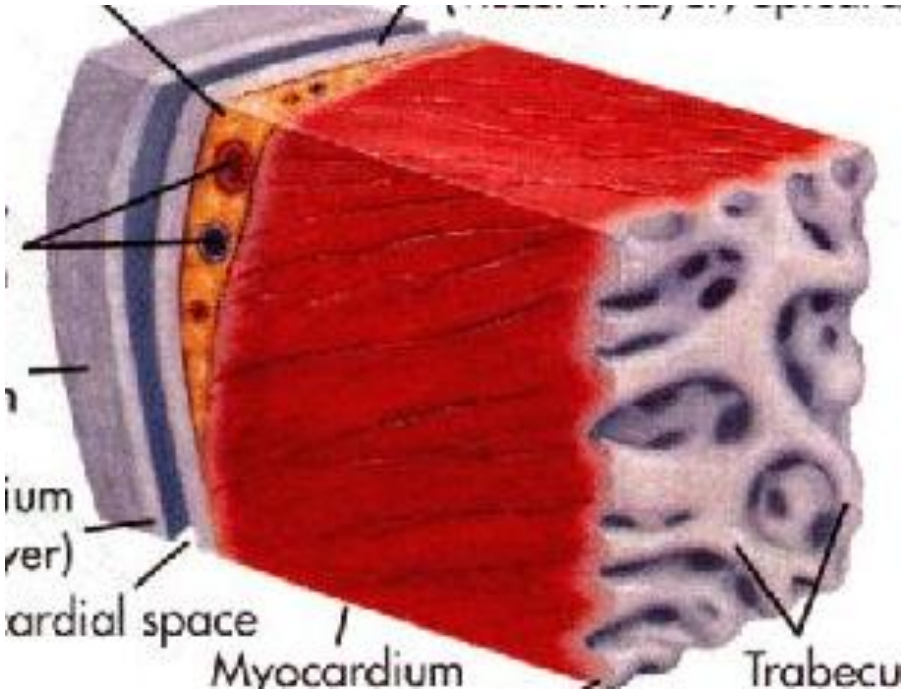
Heart

- Has three layers
  - Fibrous pericardium: protects the heart & attaches it to surrounding structures
  - Serous pericardium: lubricates the heart to prevent friction
  - Pericardial cavity: contains the serous fluid



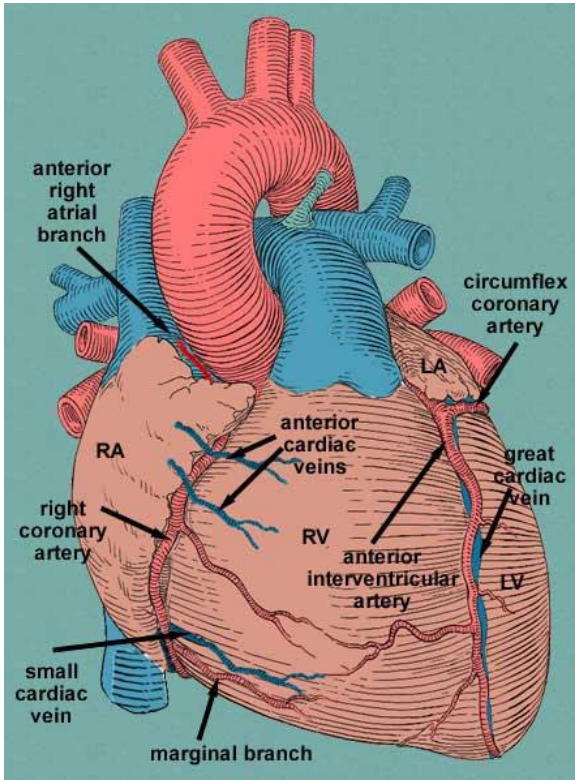
Heart

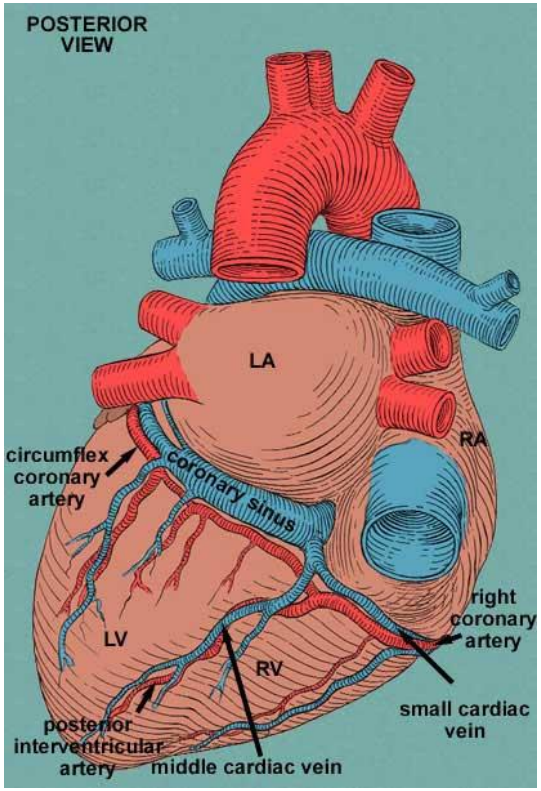
- Heart contains three layers of cardiac muscle
  - Epicardium: outermost layer of the heart
  - Myocardium: middle layer; makes up the muscle of the heart wall that contracts to pump blood
  - Endocardium: innermost layer of the heart



Heart

- Coronary blood vessels: provides the constant supply of oxygen and nutrients needed by the heart



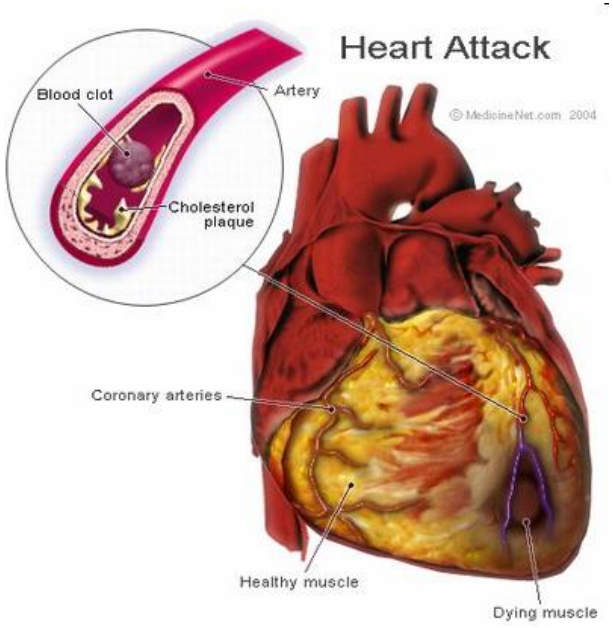


Heart

- Coronary blood vessels: provides the constant supply of oxygen and nutrients needed
  - Coronary arteries: bring blood to the myocardium of the heart
  - Coronary veins: collects "used" blood from the myocardium

Heart

- **Blockage** of the coronary blood vessels can lead to
  - cardiac ischemia: lack of sufficient oxygen
  - cardiac infarction: death of cardiac muscles



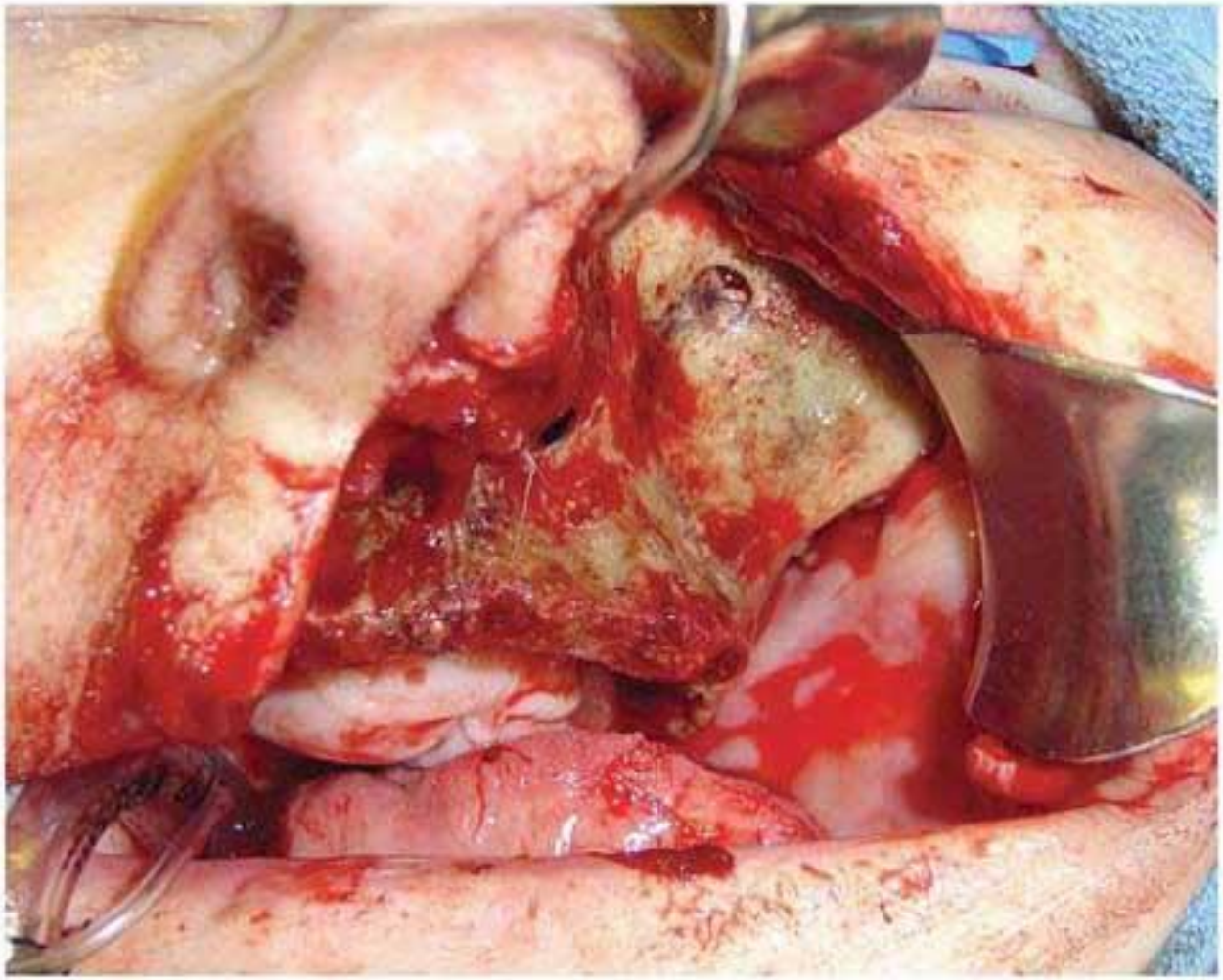
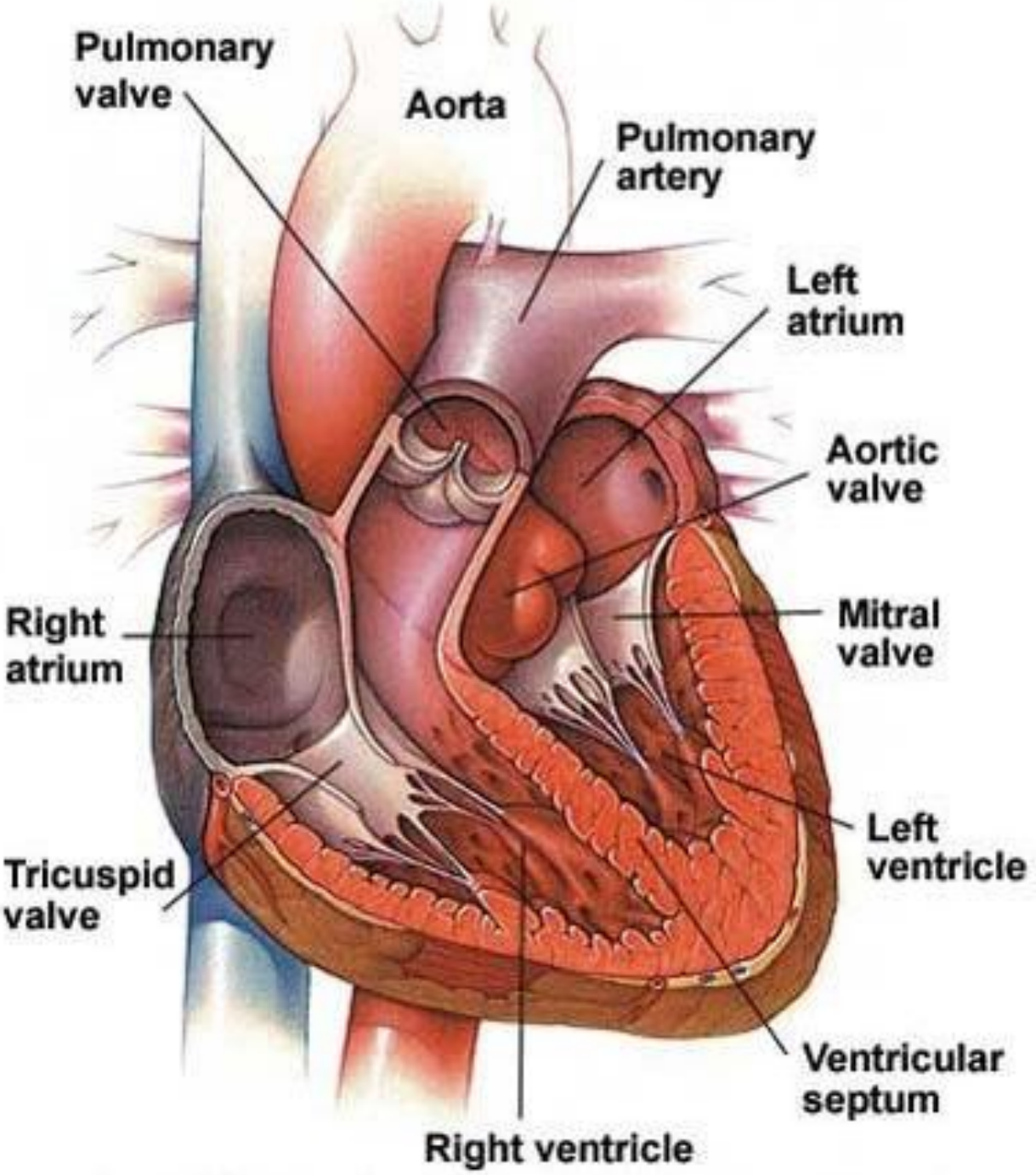


Fig. 3. Surgical exploration reveals an absent infraorbital neurovascular bundle.

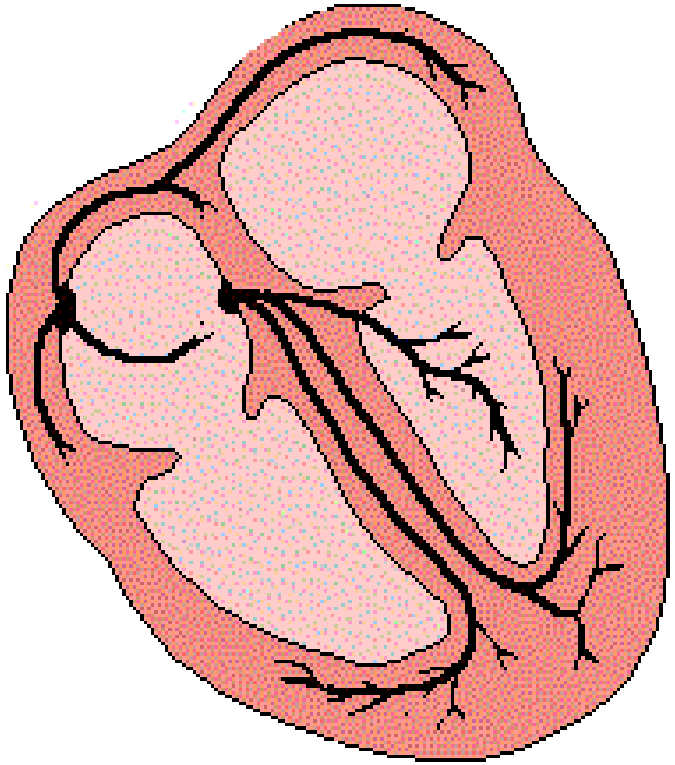
The Adult Heart

- Divided into 5 functional parts
  1. The four heart muscle chambers, divided by a septum, and vasculature (blood vessel network)
  2. Heart valves
  3. Vessels that circulate blood to and from the heart
  4. Electrical conduction system
  5. Autonomic nervous system innervations (supply of nerves)


Pulmonary valve
Aorta
Pulmonary artery
Left atrium
Aortic valve
Mitral valve
Right atrium
Left ventricle
Tricuspid valve
Ventricular septum
Right ventricle

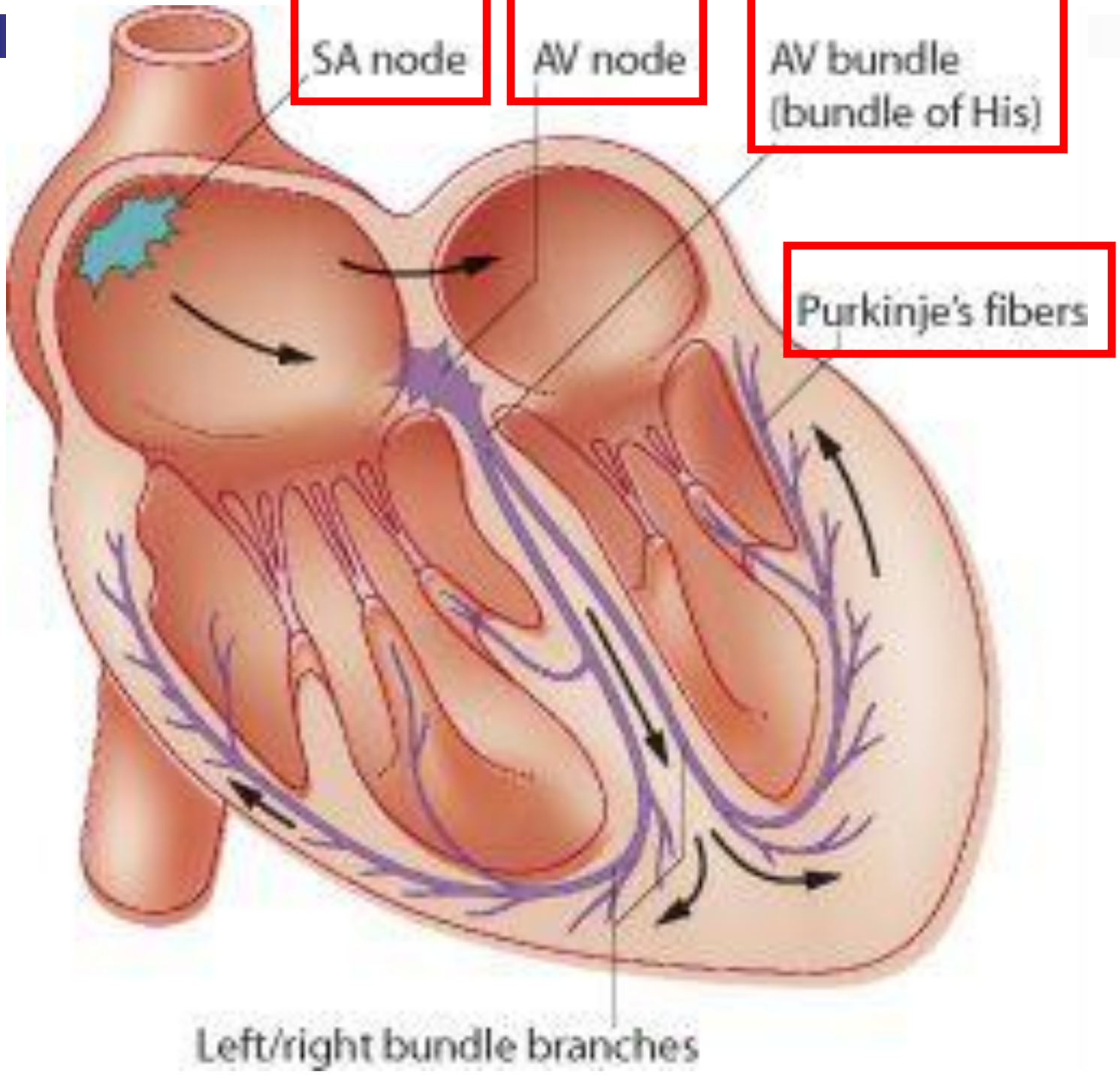
The Adult Heart

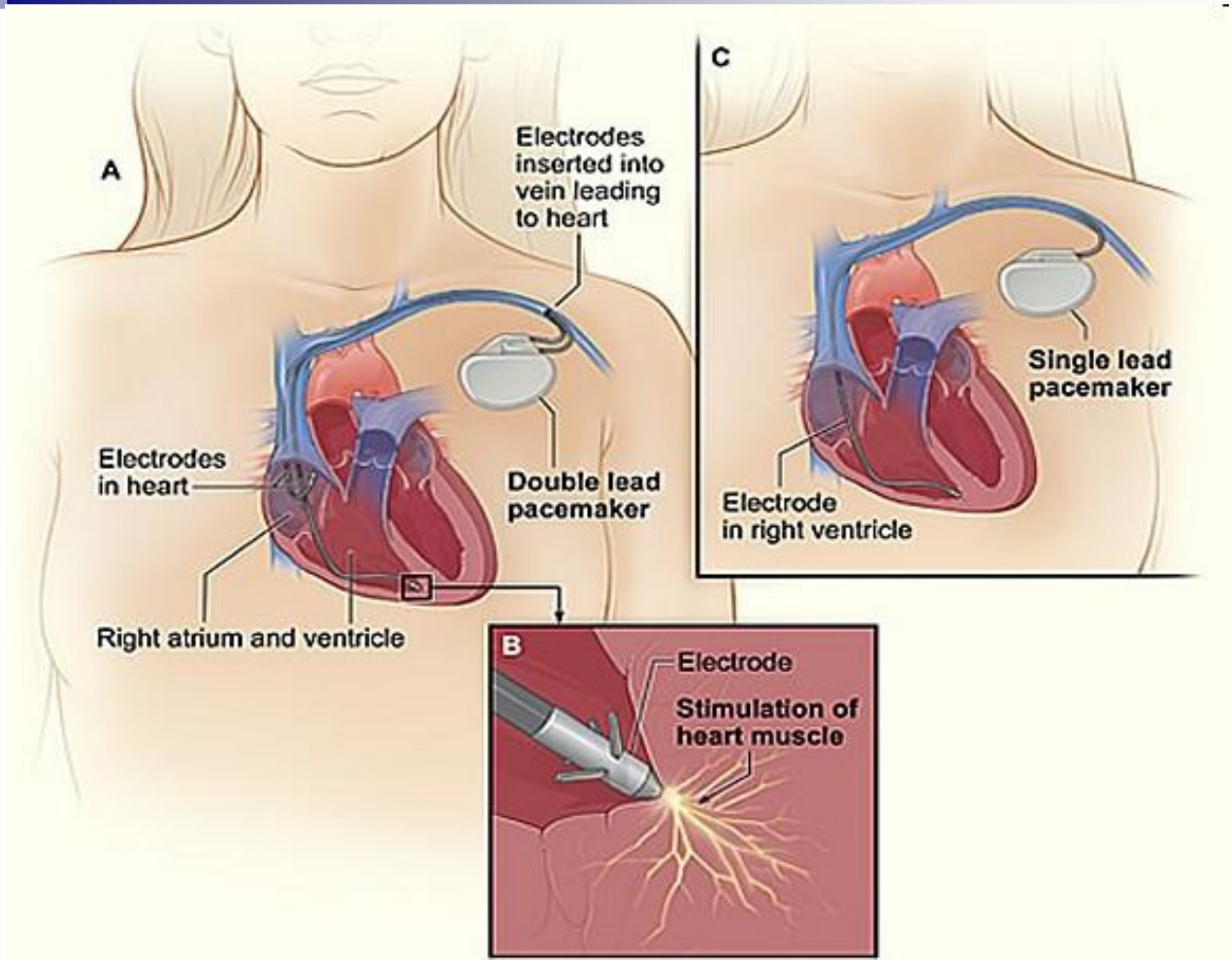
- Electrical Conduction System
  - Made up of specialized cardiac muscle cells that act like a miniature nervous system
  - Produce electrical signals that stimulate the contraction of particular regions of the heart



The Adult Heart

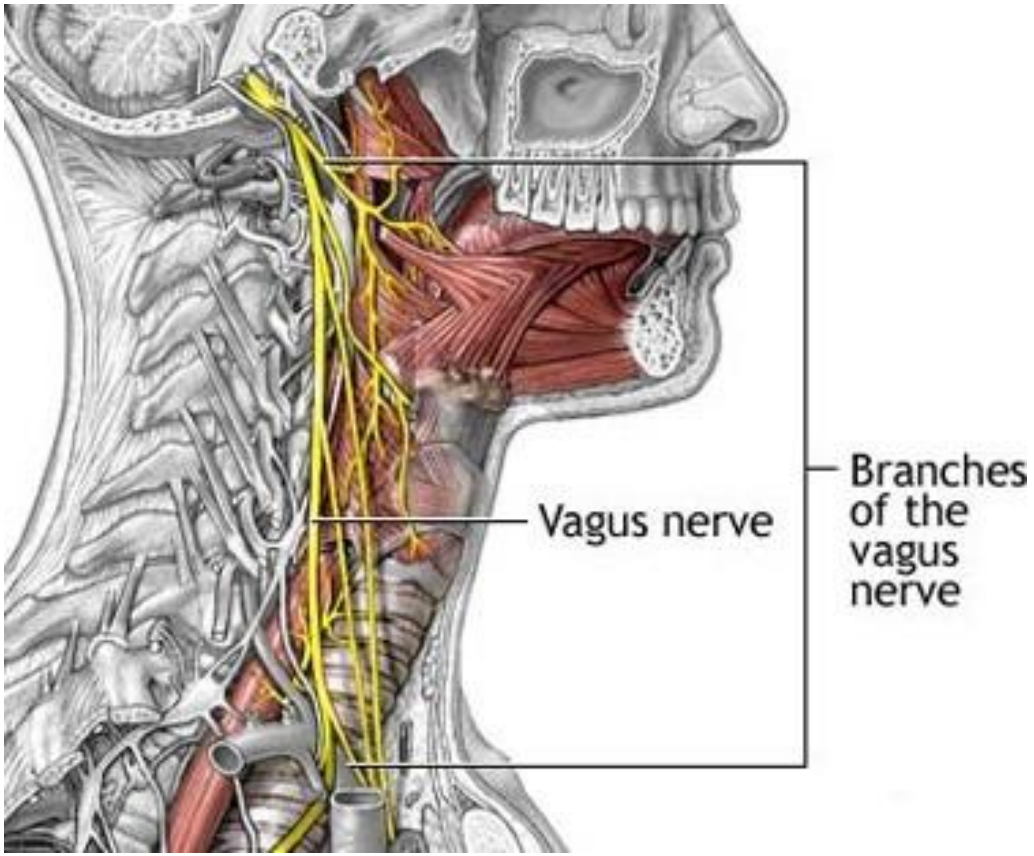
- Made up of the following regions
  - Sinoatrial (SA) node: initiate the heart beat
  - Atrioventricular (AV) node: coordinates atrial and ventricular connections
  - Bundle of His: receive nerve impulses from the atrioventricular node
  - Purkinje system: carry the electric impulses through the ventricles


SA node
AV node
AV bundle
(bundle of His)
Purkinje's fibers
Left/right bundle branches


A
Electrodes inserted into vein leading to heart
Electrodes in heart
Double lead pacemaker
Right atrium and ventricle
B
Electrode
Stimulation of heart muscle
C
Single lead pacemaker
Electrode in right ventricle

The Adult Heart

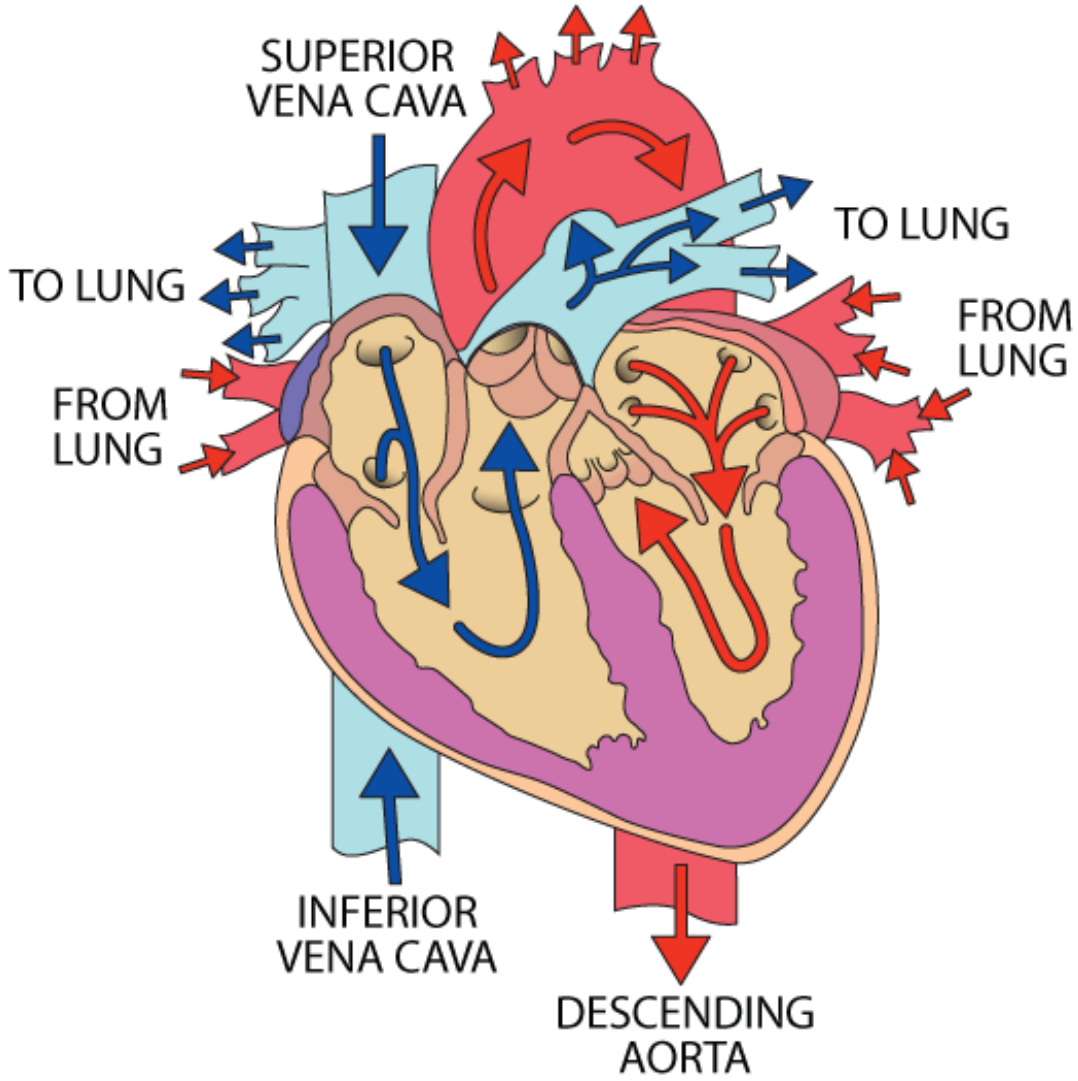
- Autonomic System: regulates heart rate using the vagus nerve



The Adult Heart

- Autonomic System: regulates heart rate using the vagus nerve
  - Sympathetic nerve endings supply nerves (innervate) to the atria, ventricles, AV node, and SA node; increases heart rate in order to take action under stress
  - Parasympathetic nerve endings mainly innervate the atrial muscle and AV node; decreases the heart rate to calm the body

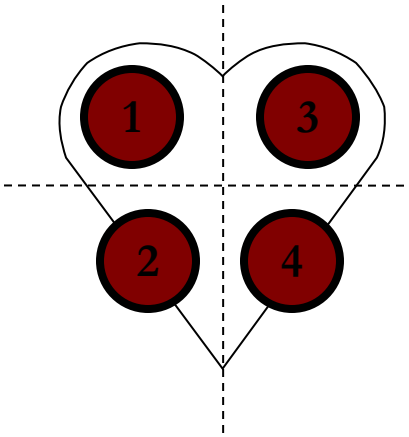
Flow of Blood through the heart

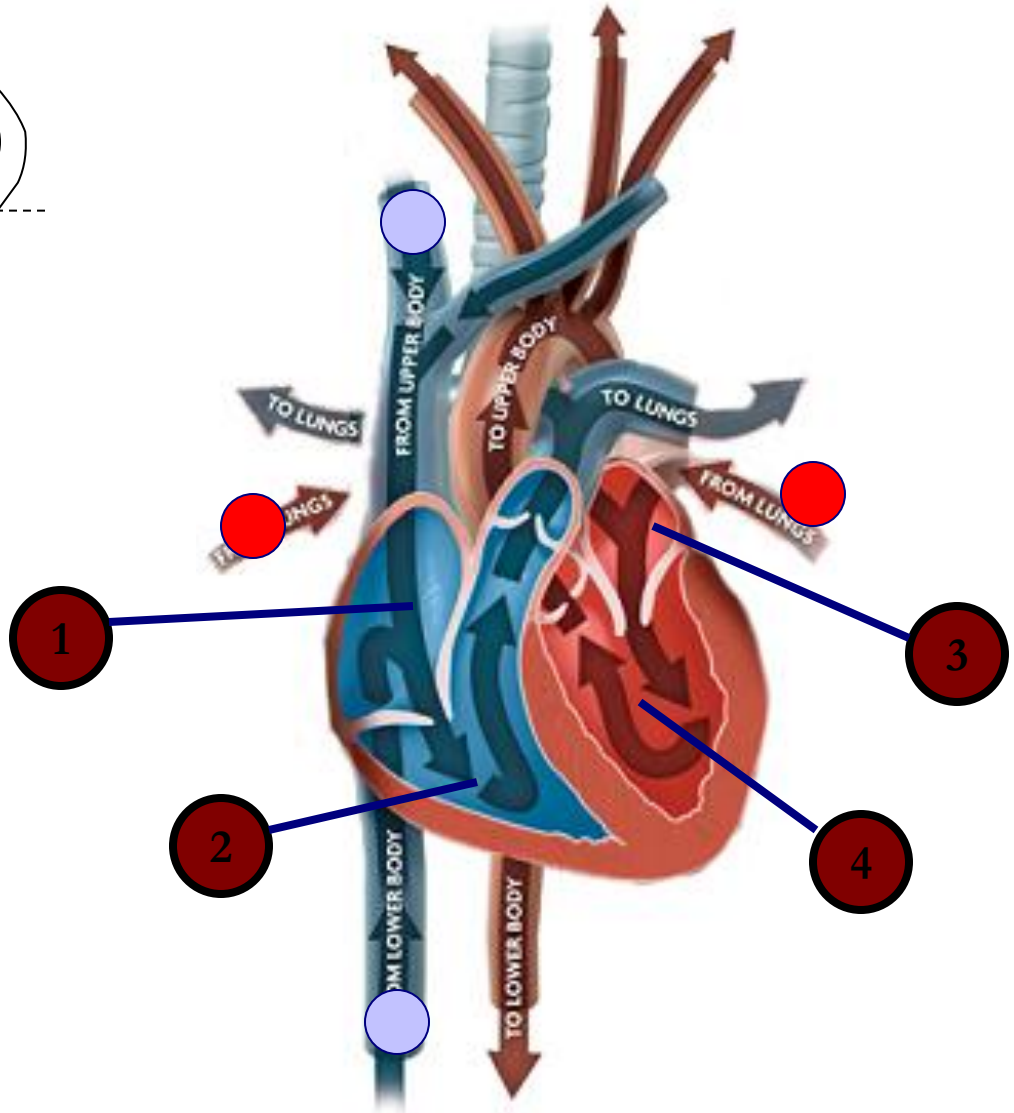


Flow of Blood through the heart

- Deoxygenated blood travels through the superior and inferior vena cava and enters the right atrium
- The tricuspid valve opens allowing blood to enter into the right ventricle
- When the heart contracts, the blood leaves the right ventricle through the pulmonary arteries
- It continues on to the lungs where blood becomes oxygenated

Blood flows through the heart in a specific pathway.





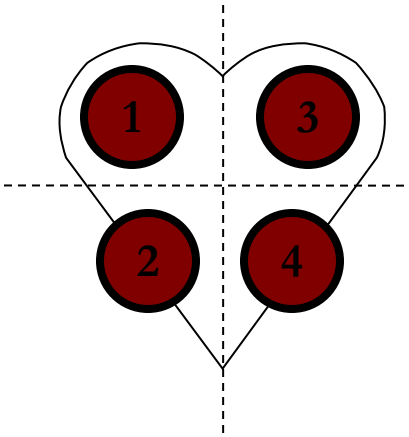
Oxygen-rich blood

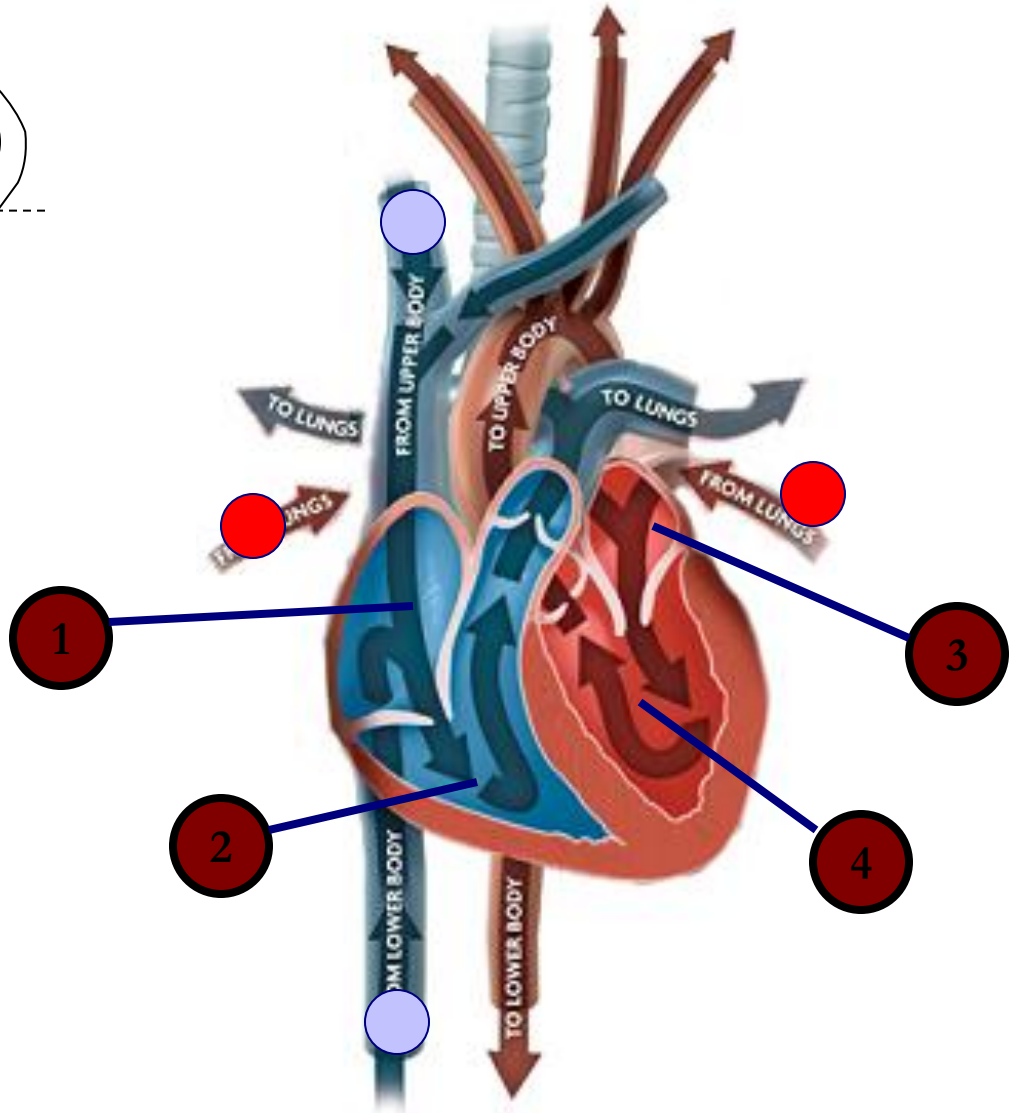
Oxygen-low blood

Flow of Blood through the heart

- Oxygenated blood travels through the pulmonary veins and into the left atrium.
- The bicuspid (mitral) valve opens allowing blood to enter the left ventricle
- When the heart contracts, the blood leaves the left ventricle into the aorta and to the rest of the body

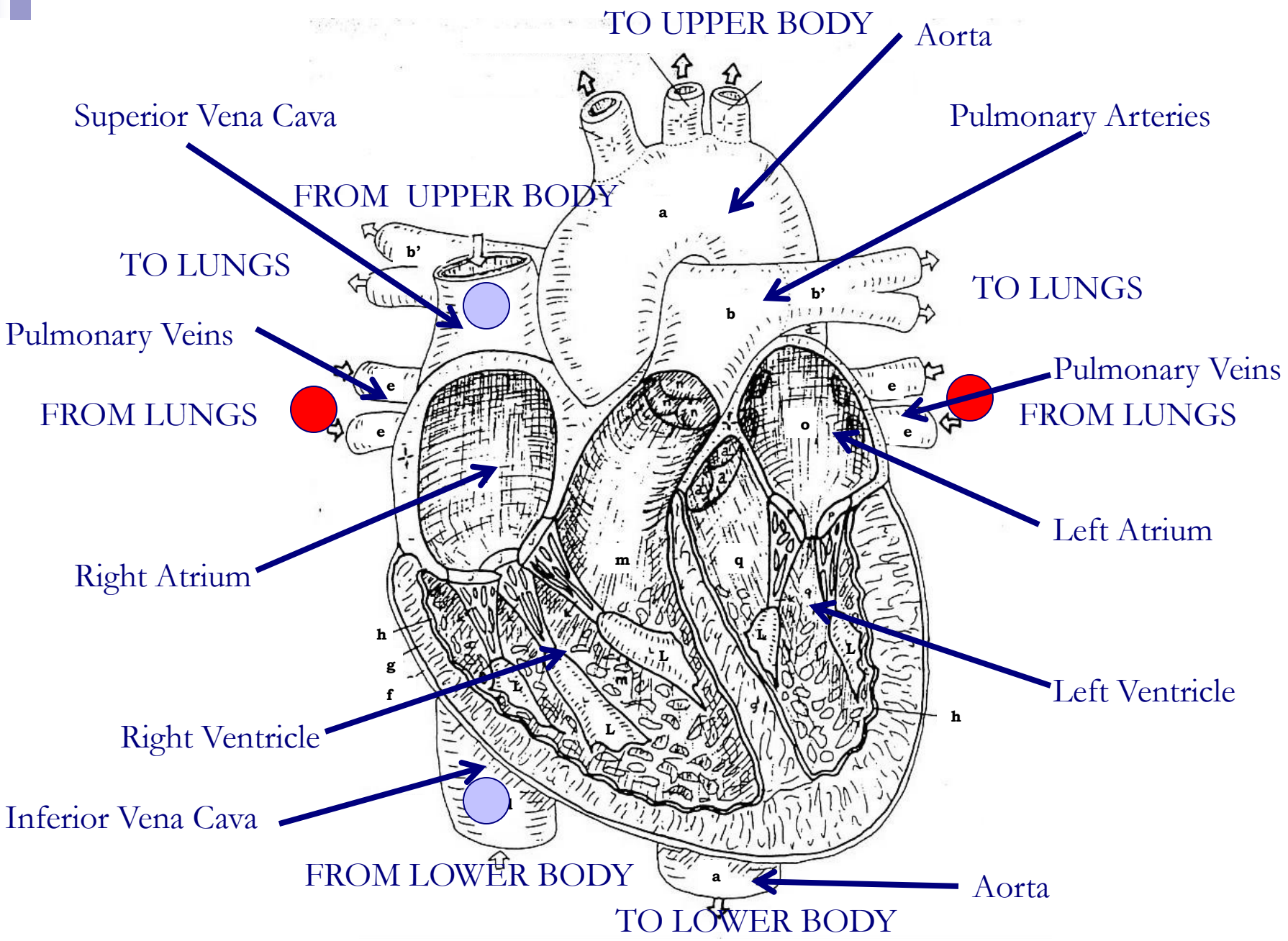
Blood flows through the heart in a specific pathway.





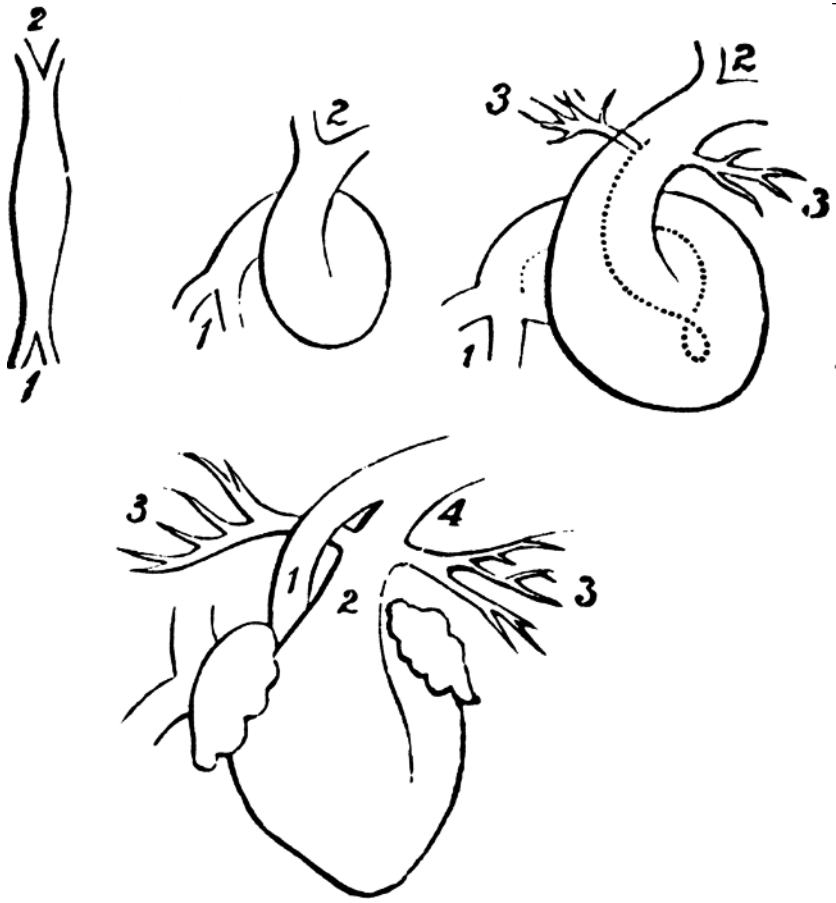
Oxygen-rich blood

Oxygen-low blood


TO UPPER BODY
Aorta
Superior Vena Cava
Pulmonary Arteries
FROM UPPER BODY
TO LUNGS
TO LUNGS
Pulmonary Veins
Pulmonary Veins
FROM LUNGS
FROM LUNGS
Left Atrium
Right Atrium
Left Ventricle
Right Ventricle
Inferior Vena Cava
FROM LOWER BODY
Aorta
TO LOWER BODY

The Fetal Heart

- Starts out as a large blood vessel that folds upon itself; growing at 2 weeks of development



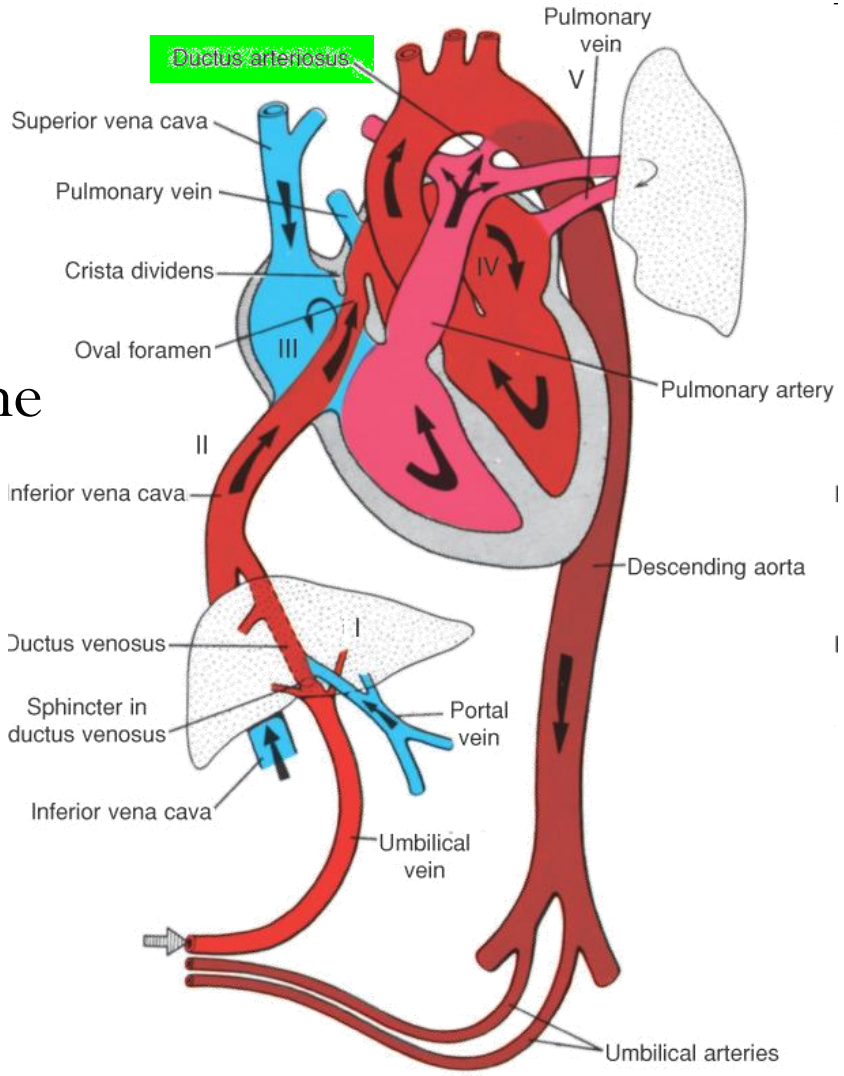
The Fetal Heart

- By the end of week 8, the chambers are completed and functional. There are two different structures (from the adult heart) that adapt it to the conditions inside the mother's body


UTLO
OB
ICT
902
MI
0.4
51
St. Luke's Roosevelt
Emergency Ultrasound
5.1
0.69cm

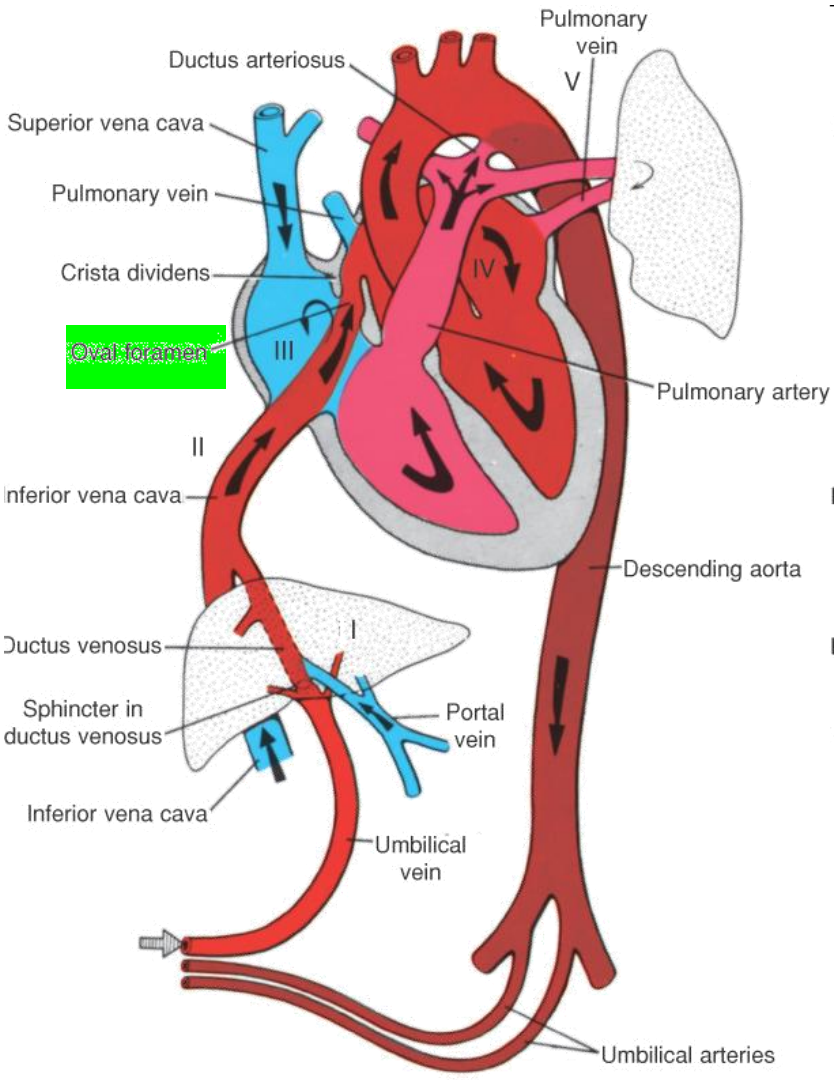
The Fetal Heart

- Ductus arteriosis: diverts blood away from the pulmonary artery and to the aorta



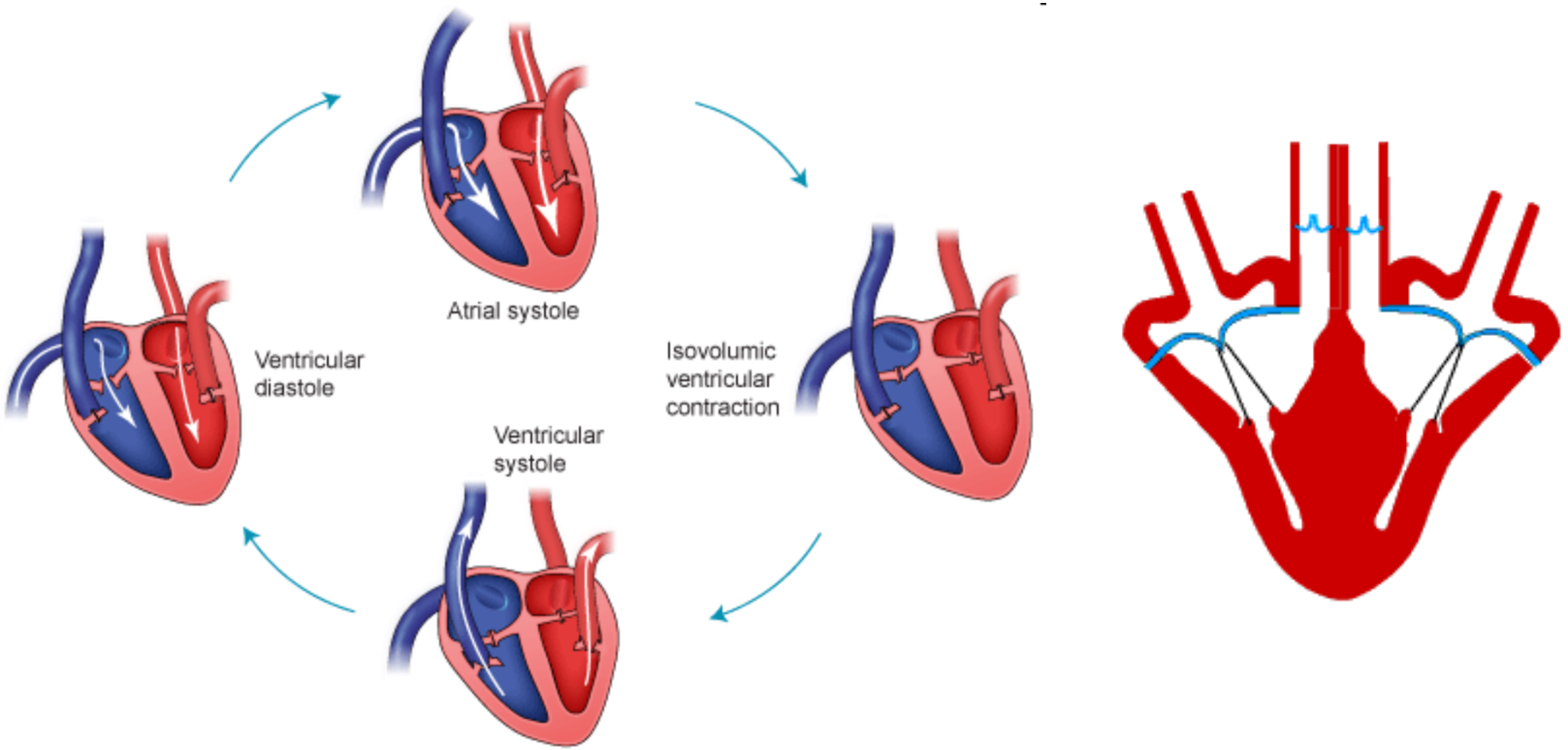
The Fetal Heart

- Foramen ovale: an opening between the right and left atria; reduces blood flow to the lungs
  - This structure may fail to close during development in 1 out of 5 people!



Heart Function

- The cardiac cycle is a measurement of a single cycle of cardiac activity. It is one complete contraction and relaxation of the heart.



Heart Function

- Divided into two stages
  - **Diastole**: ventricles are filled up with blood when the atria contract; ventricles are relaxed
  - **Systole**: contraction of the ventricle; blood leaves the ventricle; atria are relaxed

Electrical Conduction Phases

- SA node receives an electrical signal and causes the atria to contract and stimulation of the AV node
- AV valves open allowing blood to flow from atria to ventricle
- A short delay of the signal allows ventricles to fill up with blood completely

Electrical Conduction Phases

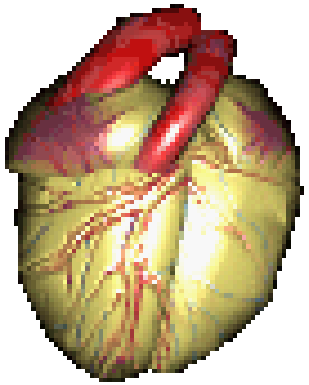
- AV node sends signal to the bundle of His and Purkinje system (Start of Systole Phase)
- Ventricles contract forcing blood upward and pushes the flaps of the AV valves back up to their closed position
- Atria relax and refill with blood

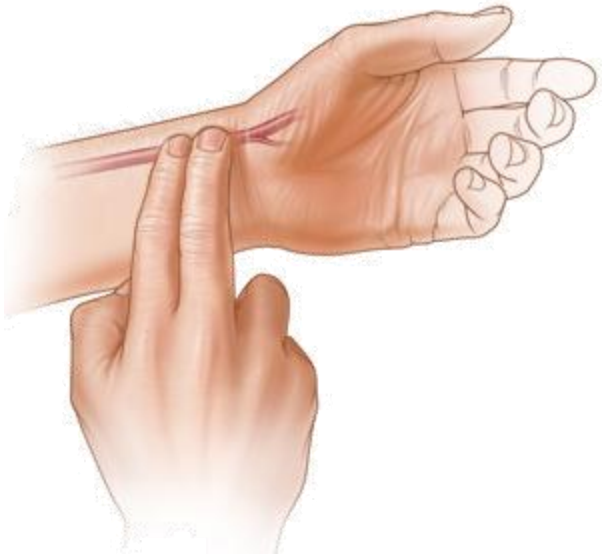
Electrical Conduction Phases

- Semilunar valves open and blood enters into the pulmonary and systemic circulations
- Ventricles relax, semilunar valves close; this starts the diastole and the cycle repeats

Efficiency of the cardiac cycle

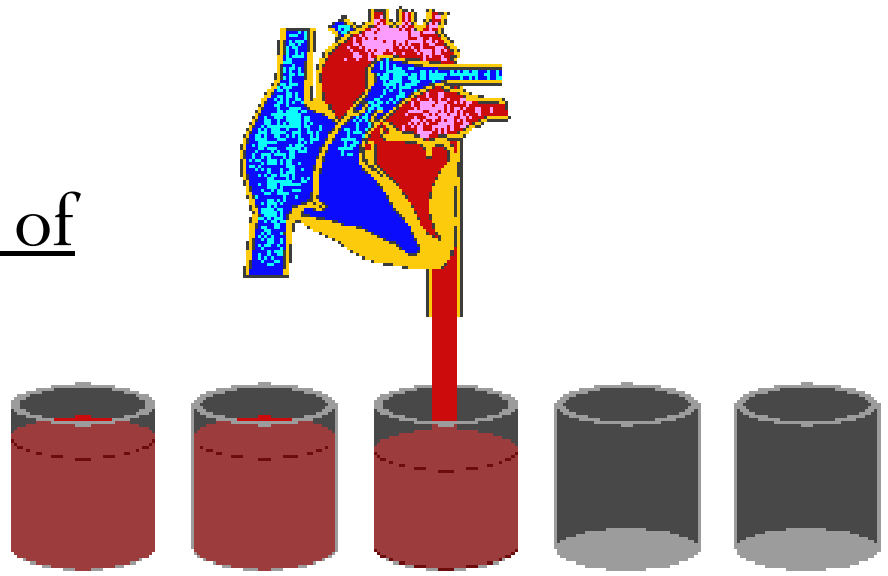
- Heart rate: number of **ventricular** contractions per minute





Heart Function

- Stroke volume: the **amount of blood** pumped by the **ventricle** of the heart with each beat
- Cardiac Output: the amount of blood the heart pumps each minute
- Equation: **CO = HR x SV**

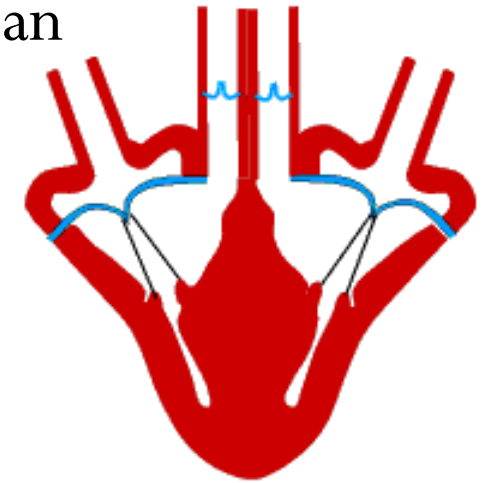


Heart Function

- On average, someone's heart rate (HR) is 75 beats per minute and stroke volume (SV) is 70mL of blood
  - The average output is 525mL/min or 5.25L/min → that's about 2 ½ bottles of soda per min!

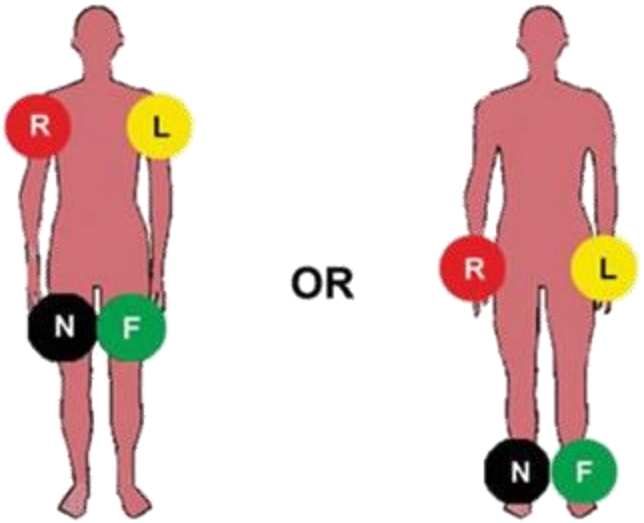
Electrocardiography Basics

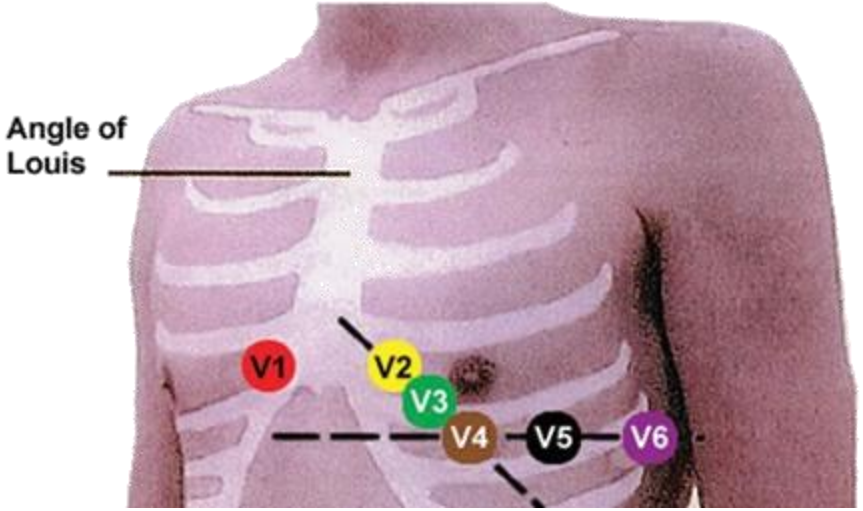
- Electrocardiography measures the electrical activity of the heart
  - Electrical impulses of the heart's conduction system follow a pattern that can be used to determine whether the heart is healthy or diseased; use an electrocardiogram or ECG



Electrocardiography Basics

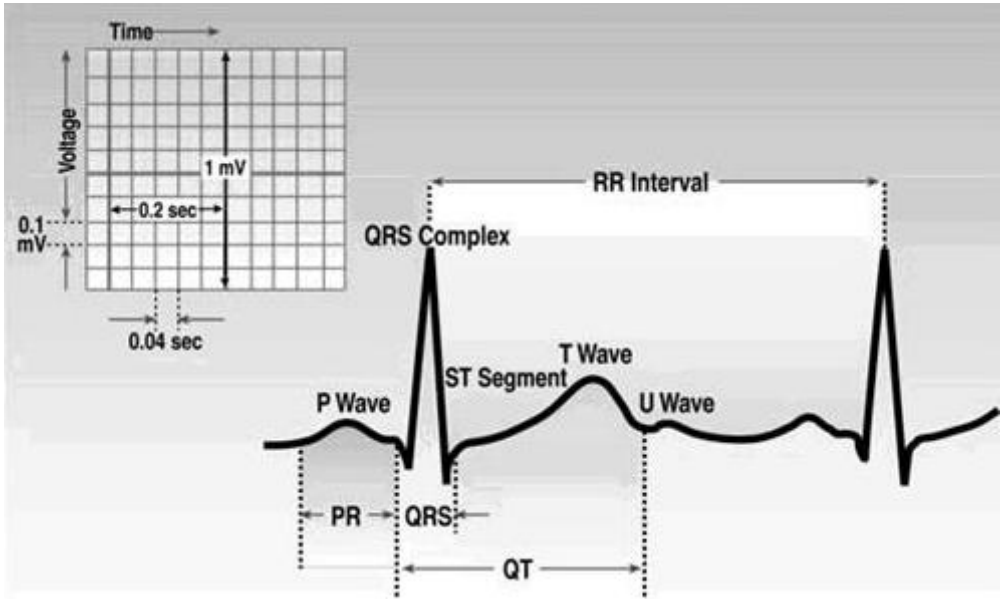
- These electrical impulses can be detected through the skin using electrodes





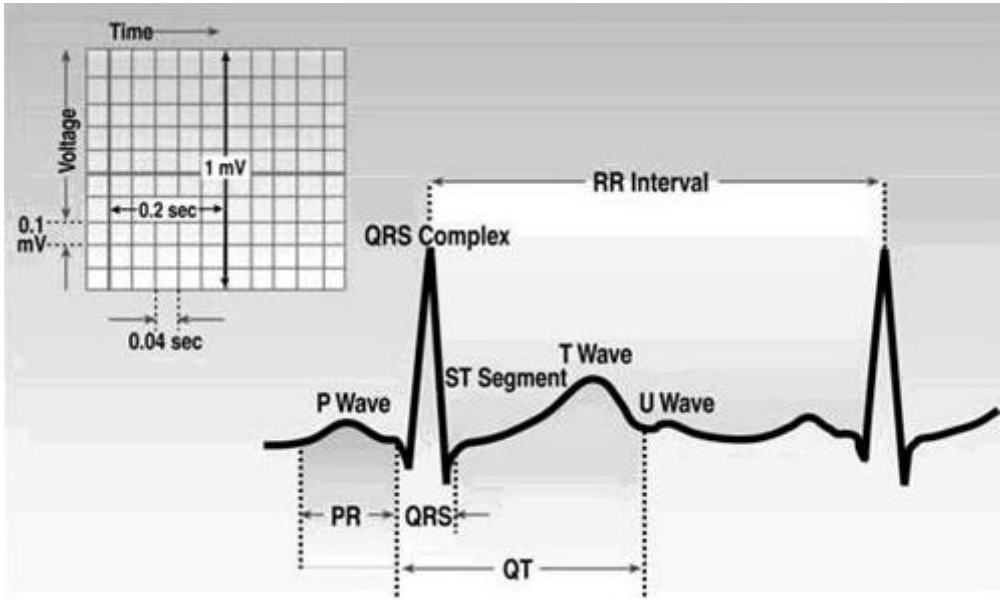
Electrocardiography Basics

- Different patterns, or waves, on an ECG shows the sequence of depolarization (stimulation) and repolarization (relaxation) of the atria and ventricles



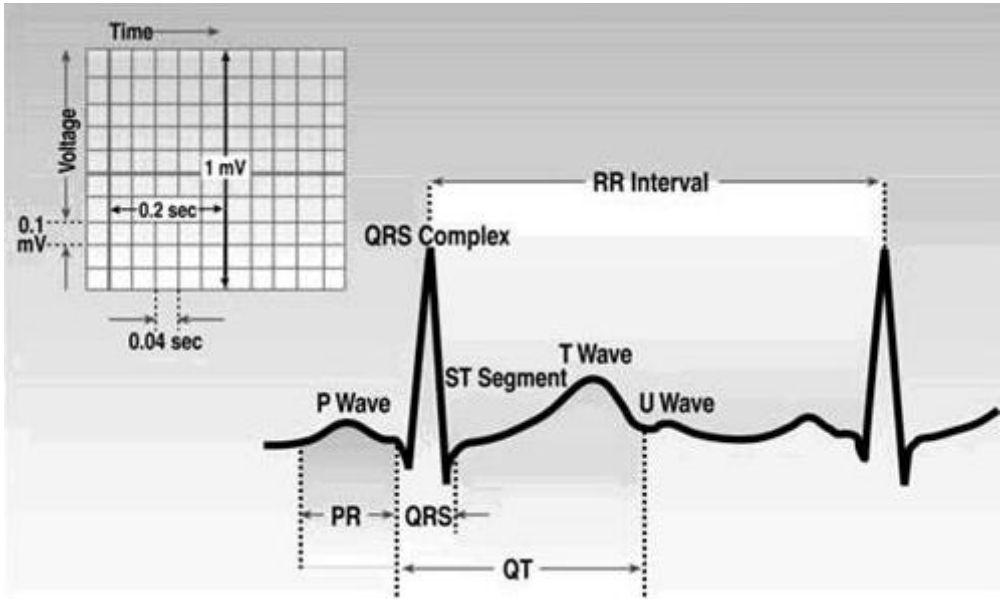
Electrocardiography Basics

- P wave: electrical activity of the SA node and atria
- Q wave: beginning of ventricular deploarization



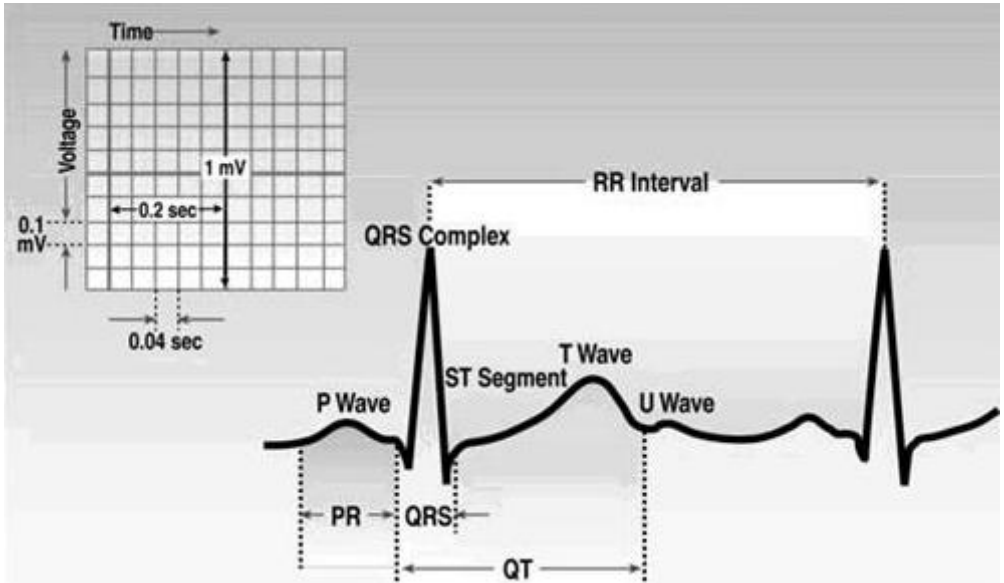
Electrocardiography Basics

- R wave: electrical activity of ventricular contraction
- S wave: end of ventricular contraction
- T wave: beginning of ventricular repolarization



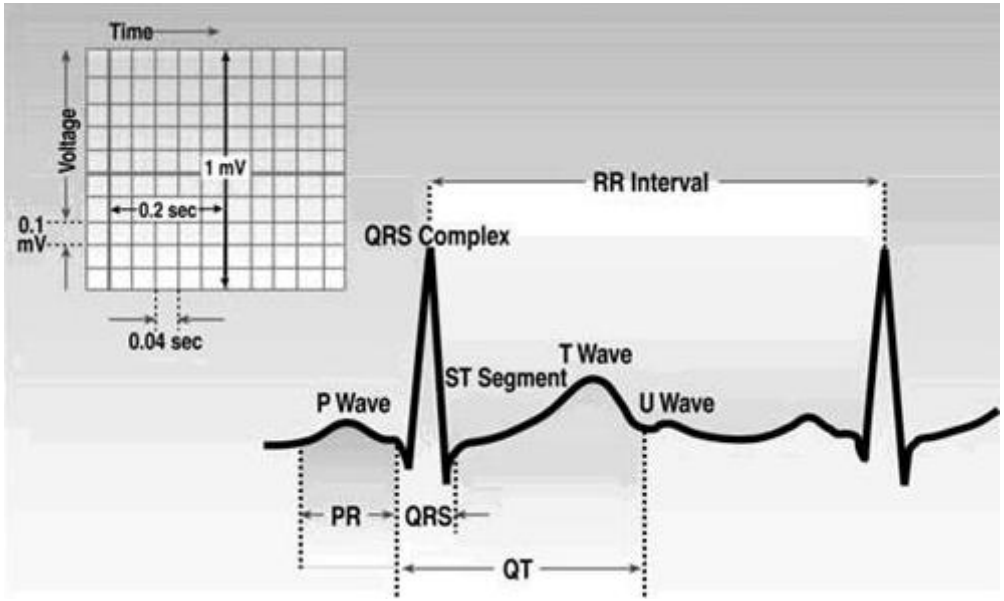
Electrocardiography Basics

- QRS complex: altogether represents a measure of ventricular activity
- PQ interval: represents the timing between atrial depolarization and ventricular depolarization; usually lasts 0.12 to 0.20 seconds



Electrocardiography Basics

- ST (segment) interval: corresponds to the entire ventricular action potential
- QT interval: indicates the time between ventricular depolarization and repolarization; ranges between 0.2 and 0.4 seconds



Electrocardiography Basics

- Heart rate can be determined from the number of waves per minute
  - Each tiny box represents 0.04 seconds
  - Each large box represents 0.2 seconds, which is basically 5 of the tiny ones