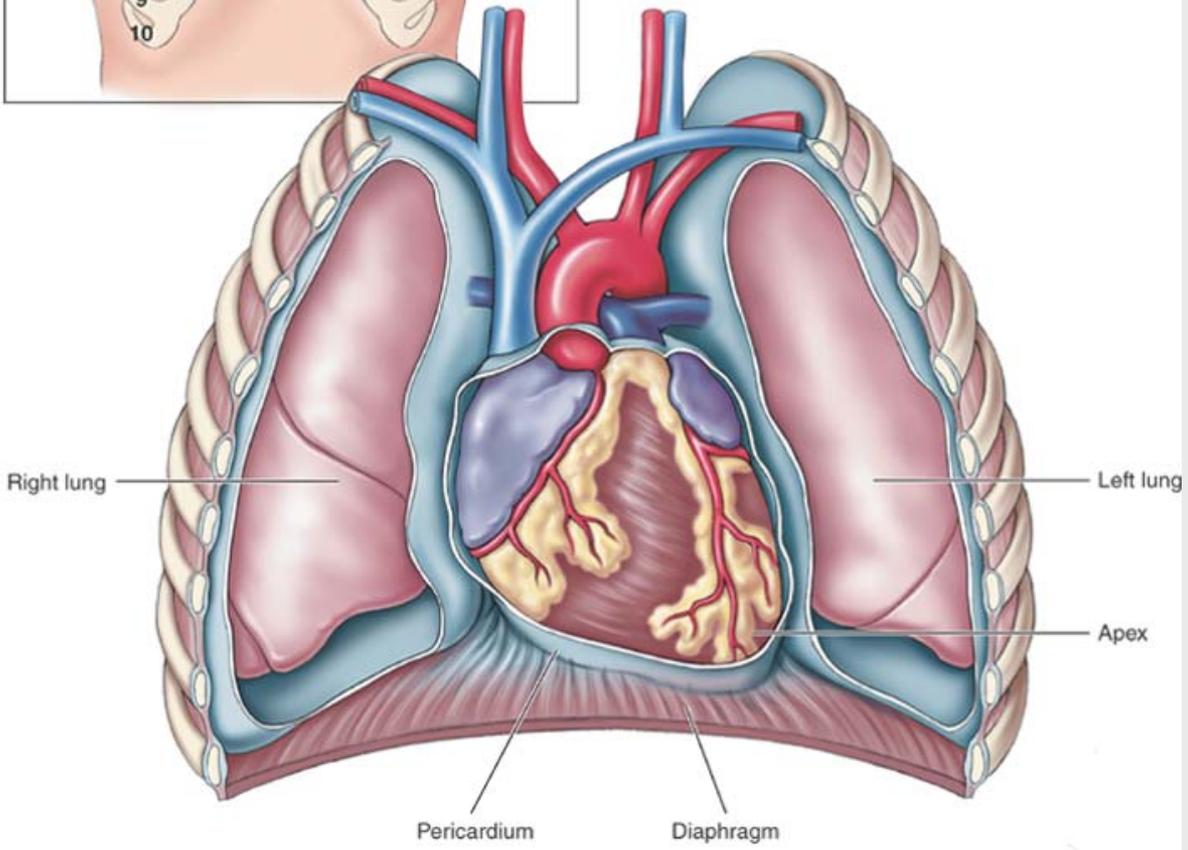
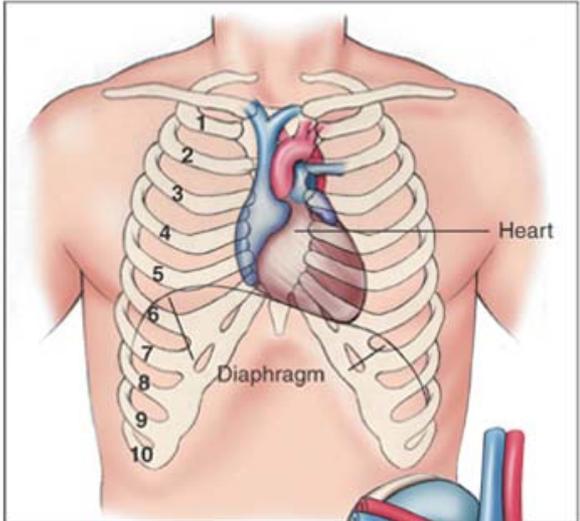


Heart

Rita Carey-Nita

Heart

- The heart is a hollow muscular organ about the size of a closed fist
- Sits inside the chest within the mediastinum, between the lungs
- Lies toward the left side of the body
- Flat upper portion is located at the level of the 2nd rib
- The apex (lower portion) is located at the level of the 5th & 6th rib
- Lies within & is supported by the pericardium



Heart

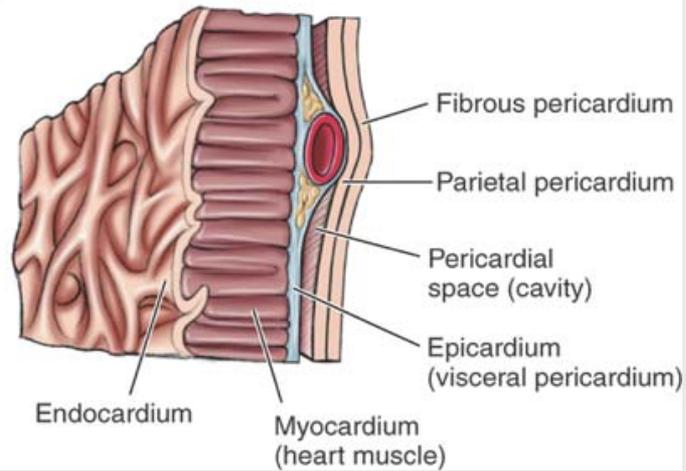
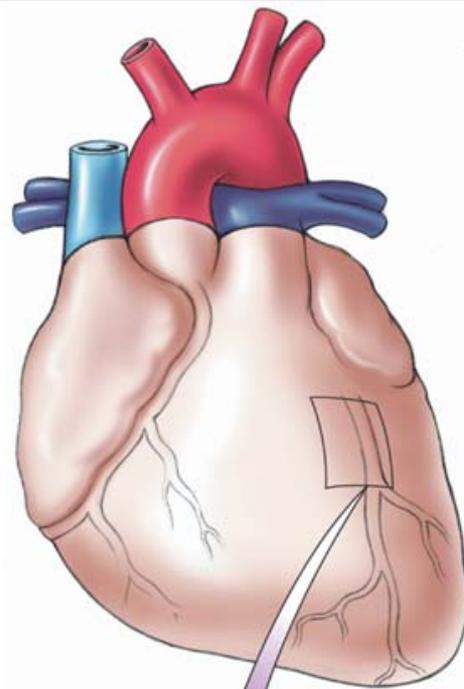
- Function of the heart is to pump blood through the blood vessels of the body, providing oxygen & nutrients to all cells
- The heart pumps on average 72 times/minute

Layers of the Heart

- Heart is made up of 3 layers:
 - Endocardium:
 - Innermost layer composed of thin layer of simple squamous epithelium over a layer of connective tissue
 - Smooth & shiny surface allows blood to flow easily
 - Lines valves & vessels entering & leaving heart

Layers of the Heart

- Myocardium:
 - Thick middle layer
 - Thickest of all layers composed of cardiac muscle tissue (actin, myosin & intercalated discs)
 - Allows the heart to contract, propelling blood through blood vessels
- Epicardium:
 - Thin outermost layer
 - Continuous at apex with the inner lining of the pericardium



Heart

- Pericardium:
 - Sling like structure that supports the heart & attaches the heart to sternum & diaphragm
- Pericardial space:
 - serous membrane located between the epicardium & pericardium
 - serous membrane secretes serous fluid (pericardial fluid) that lubricates the surfaces of the membranes allowing them to slide past one another without rubbing or friction

Heart

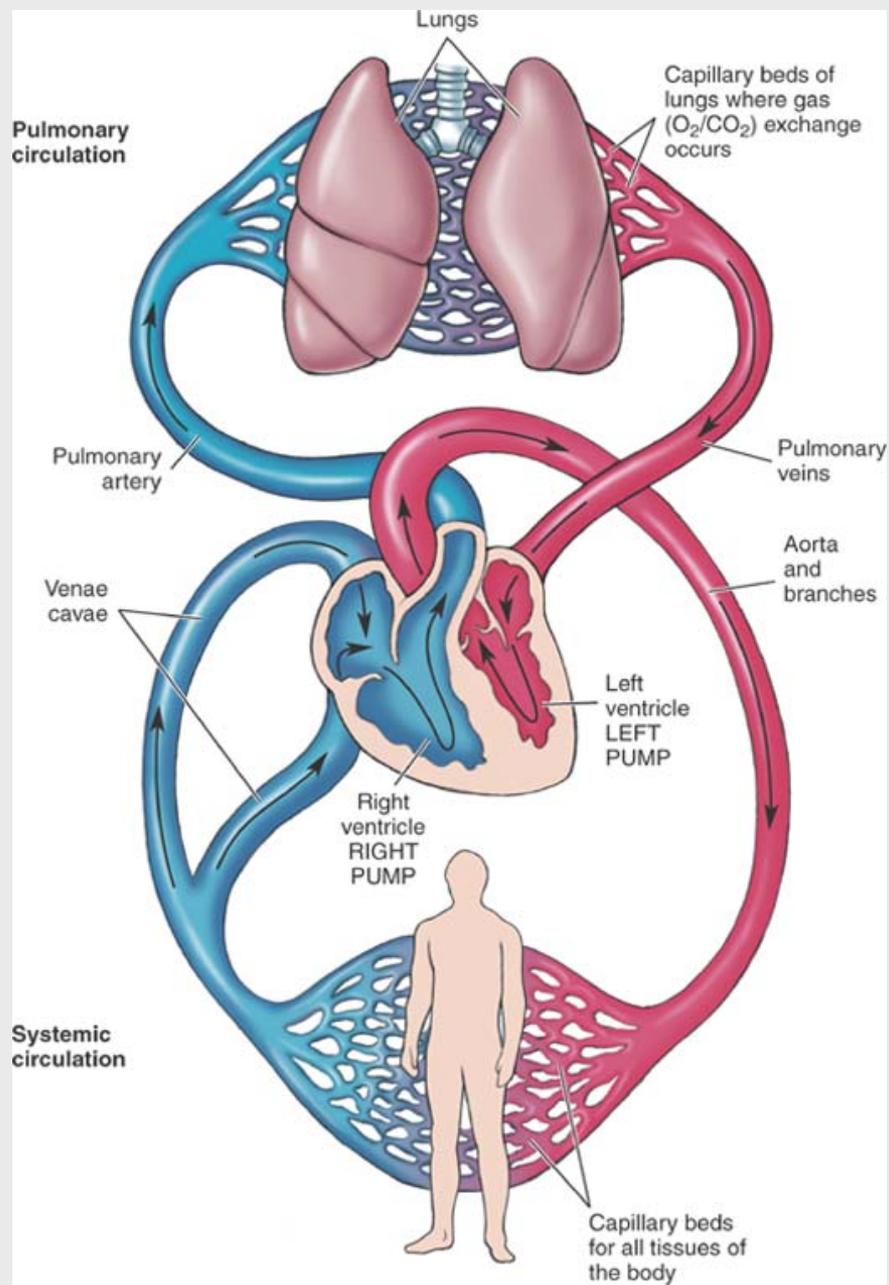
- Two pumps & two circulations:
- The pumps are the:
 - left side of the heart
 - right side of the heart
- The two circulations are:
 - pulmonary circulation
 - systemic circulation

Circulation

- The right side of the heart:
 - Receives deoxygenated blood from the superior & inferior vena cava
 - Pumps blood to the lungs where the blood is oxygenated
 - The blood travels from the right side of the heart to the lungs then back to the left side of the heart
 - This path is called pulmonary circulation
 - Only function of pulmonary circulation is to circulate the blood to the lungs for oxygen & to rid the body of carbon dioxide

Circulation

- The left side of the heart:
 - Receives the oxygenated blood from the lungs & pumps out the aorta to all the organs of the body
 - The path the blood take from the left side of the heart to the organs of the body & then back to the right side of the heart is called systemic circulation



Chambers of Heart

- Heart has 4 chambers:
 - 2 atria & 2 ventricles
- The atria:
 - Right & Left Upper chambers of heart
 - Receive blood
- The ventricles:
 - Right & Left Lower chambers of heart
 - Pump blood out of heart

Chambers of Heart

- Right & left heart are separated by septum
 - Interatrial septum separates atria
 - Interventricular septum separates ventricles

Chambers & Vessels

- Right atrium:
 - Is thin-walled cavity
 - Receives unoxygenated blood from large veins
 - Superior vena cava collects blood from the heart & upper body region
 - Inferior vena cava receives blood from the lower part of the body

Chambers & Vessels

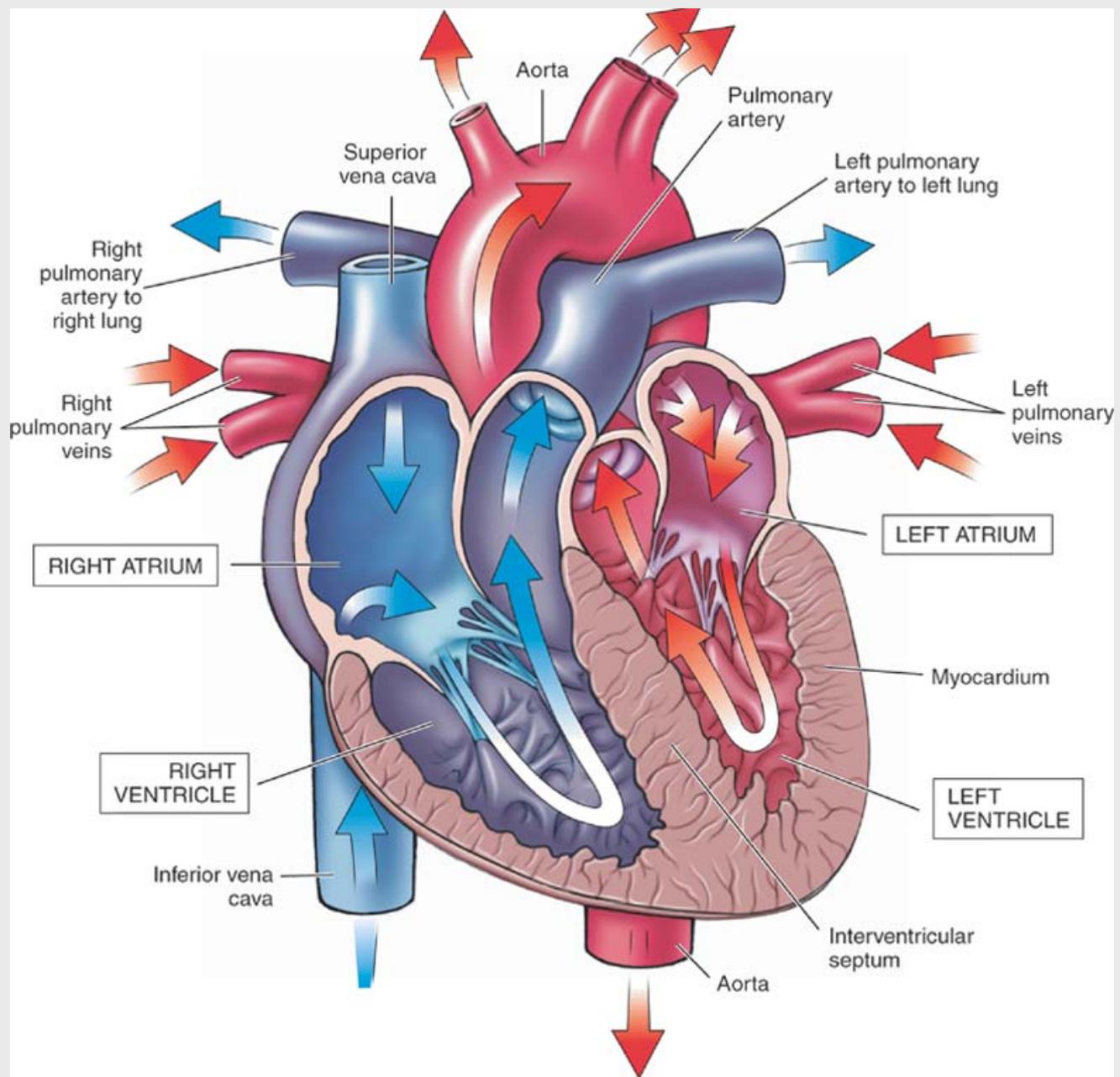
- Right Ventricle:
 - Receives unoxygenated blood from the right atrium
 - Pumps blood to lungs through the pulmonary artery
 - Pulmonary artery splits into right & left branches delivering oxygen to the right & left lung
 - Main function of right ventricle is to pump blood to the lungs

Chambers & Vessels

- Left Atrium:
 - Thin walled cavity
 - Receives oxygenated blood from the lungs through the 4 pulmonary veins

Chambers & Vessels

- Left Ventricle:
 - Receives oxygenated blood from the left atrium
 - Primary function is to pump blood into systemic circulation
 - Blood leaves the left ventricle through the aorta
 - Thick walled cavity needed to generate enough force to pump the blood out of the heart into systemic circulation



Heart Valves

- The purpose of heart valves is to keep the blood flowing in a forward direction
- 4 valves
 - 2 valves are located between the atria & ventricles are called **atrioventricular valves** or AV valves called entrance valves
 - 2 other valves are called **semilunar valves** which are considered exit valves

Heart valves

- **Atrioventricular Valves:**
 - Located between the atria & ventricle on each side to the heart
 - Have cusps or flaps
 - When ventricles are relaxed, cusps hang loose allowing valves to open permitting blood flow from atria to ventricles
 - When ventricles contract, the heart muscle squeezes blood into ventricles pushing cusps upward toward atria in a closed position
 - The AV valves prevent backward blood flow from the ventricles into the atria

Heart Valves

- Cusps are attached to the ventricular wall by a tough fibrous band called chordae tendineae
- As blood pushes the cusps into a closed position, the chordae tendineae are stretched to full length
- The stretched chordae tendineae hold onto the cusps & prevent them from being pushed into the atria

Heart Valves

- Right Atrioventricular Valve:
 - Called *tricuspid valve* because it has 3 cusps
 - Located between the right atria & right ventricle
 - When tricuspid opens, blood flows freely from the right atrium into the right ventricle
 - When the right ventricle contracts, the tricuspid valve closes preventing the blood from flowing back into the right atrium

Heart Valves

- Left atrioventricular Valve:
 - Called the bicuspid valve because it has 2 cusps
 - It is also called the mitral valve
 - Located between the left atrium & left ventricle
 - When the mitral/bicuspid valve is open, blood flows from the left atrium into the left ventricle
 - When the left ventricle contracts, the mitral/bicuspid valve closes preventing the backflow of blood into the left atrium

Heart Valves

- Semilunar Valves:
 - Considered exit valves
 - 2 types:
 - Pulmonic valve
 - Aortic valve

Heart Valves

- Pulmonic Valve:
 - Also called right semilunar valve
 - Located between the right ventricle & the pulmonary artery
 - When the right ventricle relaxes, the valve is in a closed position
 - When the right ventricle contracts, blood from the ventricle forces the pulmonic valve open
 - Blood then flows through the open valve into the pulmonary artery & into the lungs
 - When the right ventricle relaxes, the pulmonic valve snaps closed & prevents the blood from returning to the right ventricle

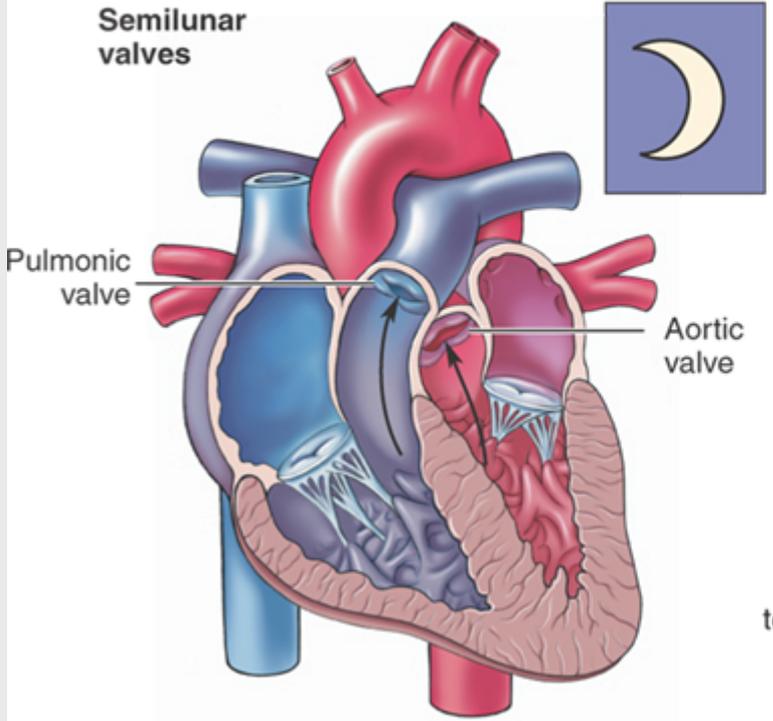
Heart Valves

- Aortic Valve:
 - Also called left semilunar valve
 - Located between the left ventricle & aorta
 - When the left ventricle relaxes, the valve is in a closed position
 - When the left ventricle contracts, blood from the ventricle forces the aortic valve to open
 - Blood flows through the aortic valve into the aorta
 - When the left ventricle relaxes, the aortic valve snaps closed preventing backflow from the aorta into the ventricle

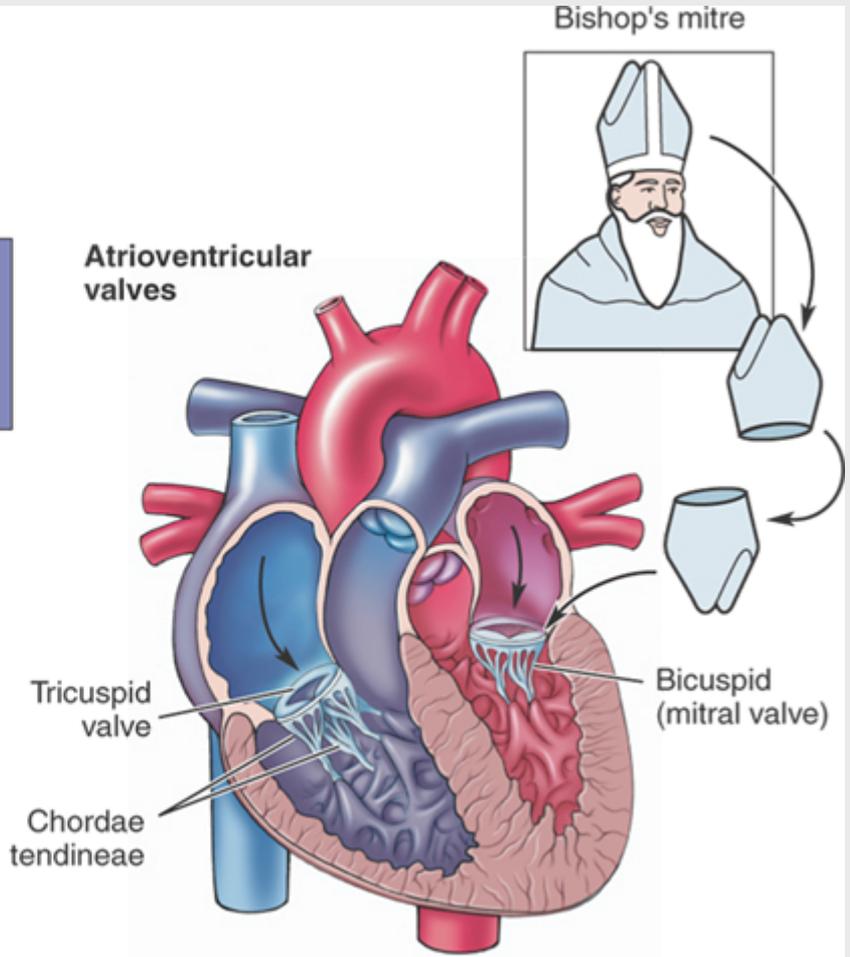
Heart Valves

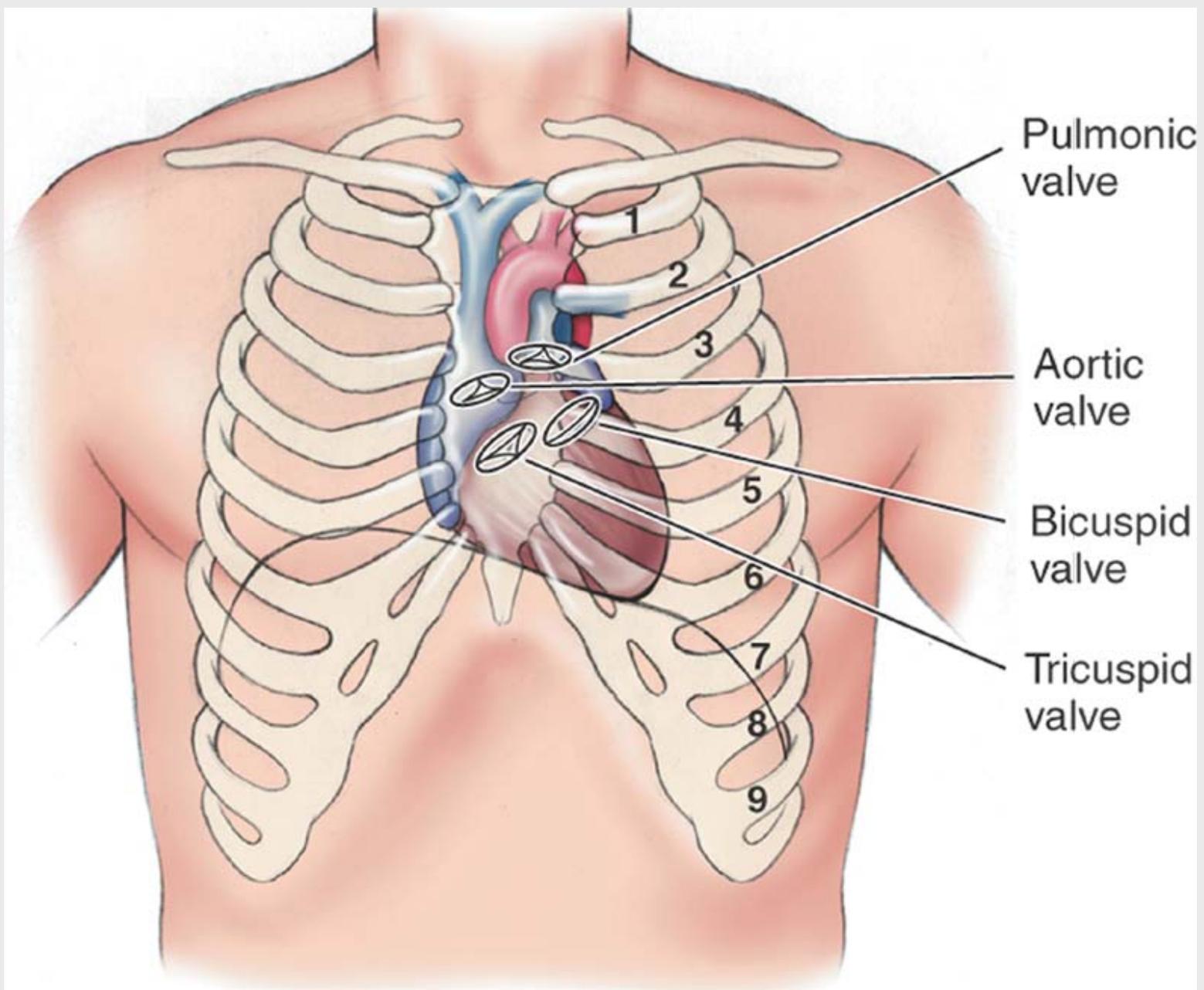
- Semilunar Valves close when the pressure in the pulmonic artery & aorta become greater than the pressure in the ventricles
- Blood from great vessels gets behind the valves & snaps them closed
- The closed semilunar valves prevent the backward flow of blood from the pulmonary artery & aorta into the ventricles

Semilunar valves



Atrioventricular valves





Heart Sounds

- Vibrations caused by the closure of the valves are heart sounds
- The first heart sound, ***lubb***, is due to the closure of the AV valves at the beginning of ventricular contraction
- The second heart sound, ***dupp***, is due to the closure of the semilunar valves at the beginning of ventricular relaxation
- Murmurs are abnormal heart sounds due to pathology of valves

Pathway of Blood

Unoxygenated blood enters the right atrium from the superior & inferior vena cave



Right Atrium



Tricuspid Valve



Right Ventricle



Pulmonic Valve



Pathway of Blood

Pulmonary artery (right & left)



Pulmonic circulation/Lungs



4 Pulmonary Veins



Left Atrium



Pathway of Blood

Bicuspid/ Mitral Valve



Left Ventricle



Aortic Valve



Aorta



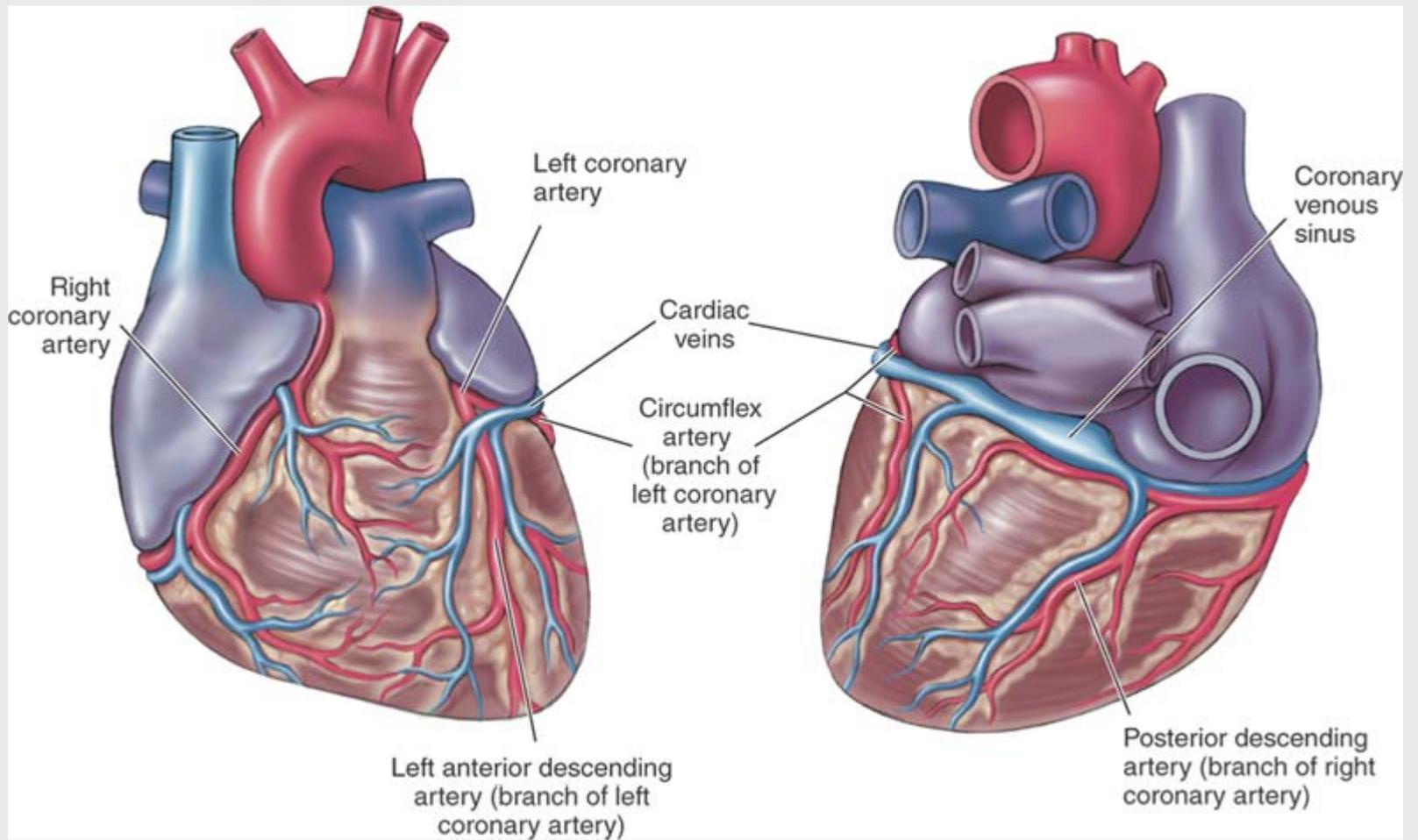
Systemic Circulation

Myocardium Blood Supply

- The myocardium of the heart receives its blood supply from the coronary arteries
- Coronary arteries arise from the aorta just above the aortic valve
- Two main arteries are:
 - Left & Right coronary artery

Coronary Arteries

- Right coronary artery nourishes the right side of the heart, esp. Right ventricle
- Left coronary artery branches into the left anterior descending artery & the circumflex artery which nourish left side of heart, esp. Left ventricular wall
- Coronary veins collect blood that nourishes the myocardium & carries it to the coronary sinus which empties into the right atrium



Cardiac Conduction System

- An electrical signal stimulates the heart muscle to contract & coordinates the pumping activity of the atria & ventricles
- Both atria contract at same time followed by simultaneous contraction of both ventricles
- The conduction system is located in the walls of the heart & in the septum that separates the right & left heart

Cardiac Conduction System

- Conduction System consists of:
 - Sinoatrial node
 - Atrial conducting fibers
 - Atrioventricular node
 - His-Purkinje System

Cardiac Conduction System

- Sinoatrial Node:
 - Pacemaker of the heart
 - Located in the upper posterior wall of the right atrium
 - Electrical signal called cardiac impulse starts in the SA node
 - SA node fires 60-100 cardiac impulses/minute (average 72)

Cardiac Conduction System

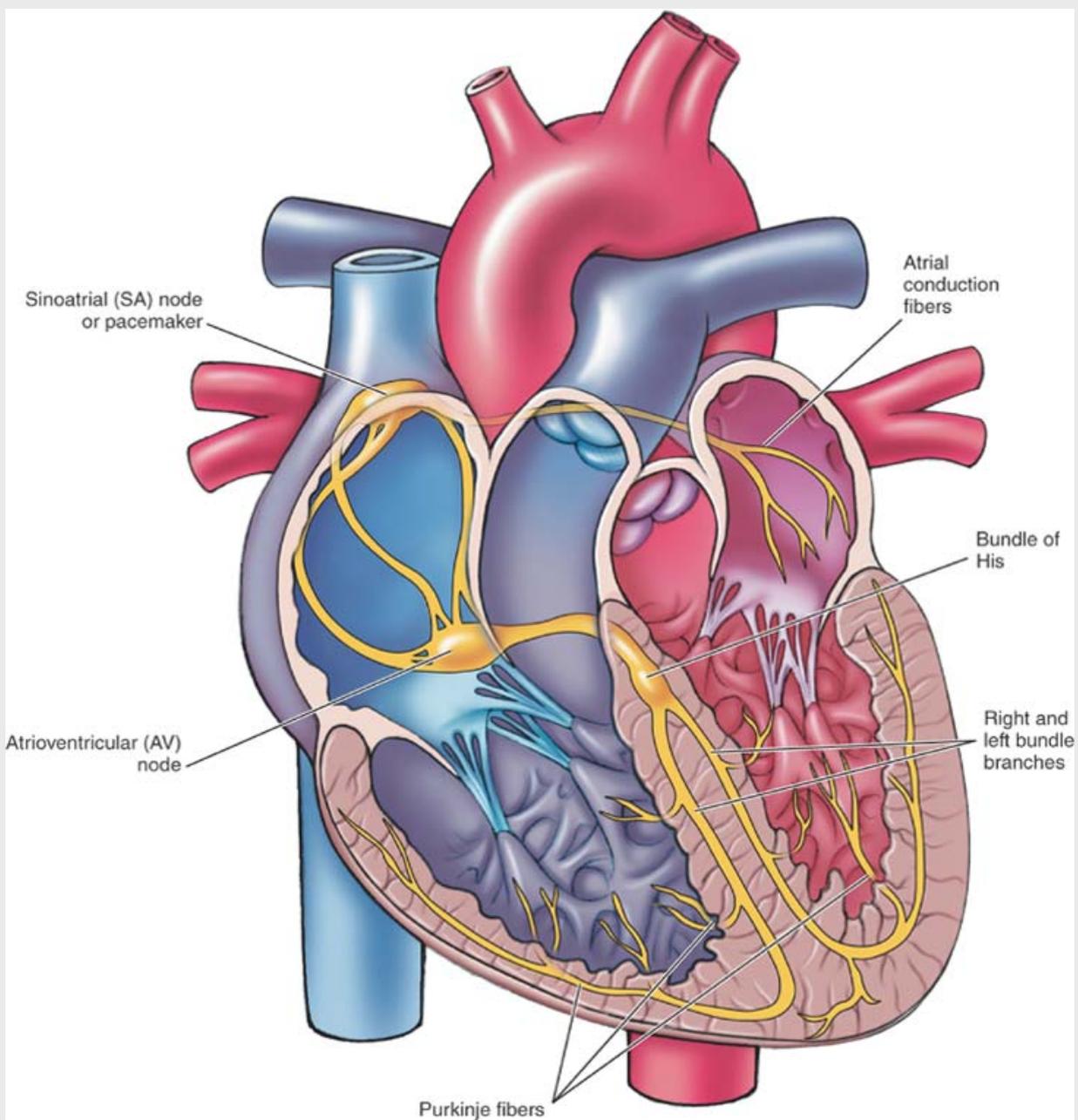
- Atrial Conducting Fibers
 - Cardiac impulse travels from the SA node through both atria along the atrial conducting fibers
- Atrioventricular Node:
 - Located in the floor of the right atrium, near the interatrial septum
 - Cardiac impulse travels from the SA node across the atrial fibers to the AV node

Cardiac Conduction System

- Bundle of His:
 - Once the impulse moves through the AV node it slows & travels to the Bundle of His
 - Bundle of His is specialized conduction tissue located in the interventricular septum
 - The slowing of the impulse through the AV node delays ventricular activation which allows the relaxed ventricle to fill with blood after the atrial contraction

Cardiac Conduction System

- Bundle of His:
 - Two branches:
 - Right & Left Bundle Branches
 - Along these branches are numerous long fibers called Purkinje Fibers
 - Purkinje Fibers are distributed throughout the ventricular myocardium & conduct cardiac impulses very rapidly throughout the ventricles ensuring coordinated contraction of both ventricles



Sinoatrial Node



Atrial conducting fibers



Atrioventricular Node



Bundle of His



Bundle Branches(right & left)



Purkinje Fibers

Sinoatrial (SA) node



Atrial conducting fibers



Atrioventricular (AV) node



Bundle of His



Bundle branches (right and left)



Purkinje fibers

Cardiac Tissue

- Cardiac tissue creates impulses because of:
 - automaticity & rhythmicity
- Automaticity: cardiac impulses arise within the cardiac tissue itself; no extrinsic nerve or factors
- Rhythmicity: cardiac impulses are fired regularly; the heart has rhythm

Wandering Pacemaker

- When an impulse is fired from an area outside the SA node, it is said to be a wandering pacemaker
- Called ectopic focus because it causes an ectopic beat
- At times the AV node will fire a cardiac impulse
- When an impulse comes from an area other than the SA node it can cause serious dysrhythmias

Electrocardiogram

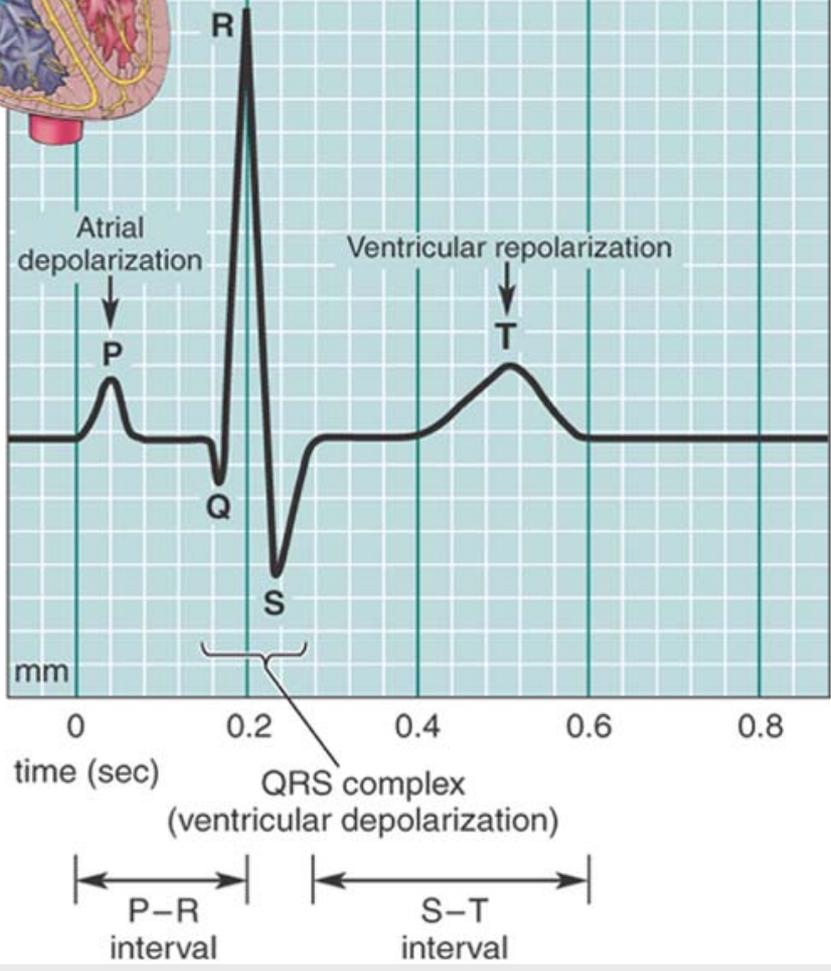
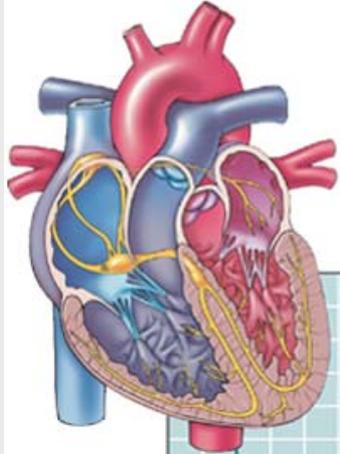
- Electrical activity of the heart can be measured by placing electrodes on the surface of the chest & performing an Electrocardiogram
- Components of test include:
 - P wave
 - QRS complex
 - T wave
 - P-R interval

Electrocardiogram

- P Wave:
 - Atrial depolarization
 - Inflow of sodium ions make the inside of the cell positive
 - Depolarization precedes & triggers contraction of the heart muscle
- QRS complex:
 - Reflects the electrical activity related to ventricular depolarization

Electrocardiogram

- T wave:
 - Reflects electrical activity related to ventricular repolarization; return of the cell to a resting state where the inside is negative
- P-R interval
 - Represents the time it takes for the cardiac impulse to travel for the atria (P wave) to the ventricles (QRS complex)



Cardiac Cycle

- Cardiac Cycle
 - is the sequence of events that occur during one heart beat
 - Coordinated contraction & relaxation of the chambers of the heart
- Systole:
 - Contraction of the heart muscle
 - Systole squeezes blood out of a chamber
- Diastole:
 - Relaxation of the myocardium
 - During diastole blood fills the chambers

Cardiac Cycle

- Atrial Systole:
 - Atria contract & blood is pumped into ventricles; AV valves are open & ventricles are relaxed
- Ventricular Systole:
 - At the end of atrial systole, the ventricles contract
 - Blood is forced against the AV valves causing them to close
 - Blood is pushed the semilunar valves open allowing blood to flow into pulmonary artery & aorta

Cardiac Cycle

- Diastole:
 - For a brief period during the cardiac cycle, both the atria & ventricles are in diastole
 - As the chambers relax, blood flows into the atria
 - Since the AV valves are open much of the blood passively flows into the ventricle
 - This is a period of filling
 - Atrial systole follows
 - The cycle repeats

Cardiac Output

- Cardiac output is the amount of blood pumped by each ventricle in 1 minute
- Normal output is 5 liters per minute
- The entire blood volume pass through the heart every minute
- Cardiac output is determined by two factor:
 - Heart rate & Stroke Volume
- $CO = HR \times SV$
- Cardiac output can be increased by increasing the HR &/or SV

Heart Rate

- Heart rate:
 - Is the number of times the heart beats in a minute
 - Reflects the firing of the SA node
 - Normal adult HR is 60-100
 - Average 72
 - Heart rate differs for various reasons:
 - Size—gender—age—exercise—hormones—stimulation of autonomic nervous system—pathology—medication

Heart Rate

- Size: larger the size, the slower the rate; related to metabolism
- Gender: women's are faster than men
- Age: the younger the person, the faster the rate
- Exercise: increase in activity causes and increase in HR; pulse less at rest
- Autonomic nervous system: stimulation of sympathetic increases HR; stimulation of parasympathetic slows the HR

Heart Rate

- Hormonal influence:
 - Epinephrine & norepinephrine
 - Thyroid hormone
- Pathology:
 - Issues within cardiac conduction itself
- Medications:
 - Certain drugs affect the HR
Digitalis ↓ HR Caffeine ↑ HR
- Variation in Heart Rate
 - Tachycardia: HR greater than 100
 - Bradycardia: HR less than 60

Stroke Volume

- Stroke volume is the amount of blood pumped by the ventricle per beat
- Average resting stroke volume is 60-80 ml per beat
- The ventricles normally pump out only 65% of the blood in the ventricles
- Greater force of contraction can increase stroke volume & the greater amount of blood pumped in one minute
- Two ways stroke volume can be affected:
 - Starling's law & Inotropic effect

Starling's Law

- Starling's law of the heart depends on the degree of stretch of the myocardial fibers
- The greater the stretch, the stronger the force of contraction
- Increase in the amount of blood entering the ventricles causes the ventricles to stretch
- This stretch increases the force of contraction
- Increase in force of contraction will increase stroke volume

Inotropic Effect

- Positive inotropic effect:
 - stimulation of heart by the sympathetic nerves can increase force of contraction therefore increasing stroke volume
 - Certain hormones & medications can also do this
- Negative inotropic effect:
 - Decreases force of contraction which decreases stroke volume
 - Pathology of the heart & certain medications can cause negative inotropic effect