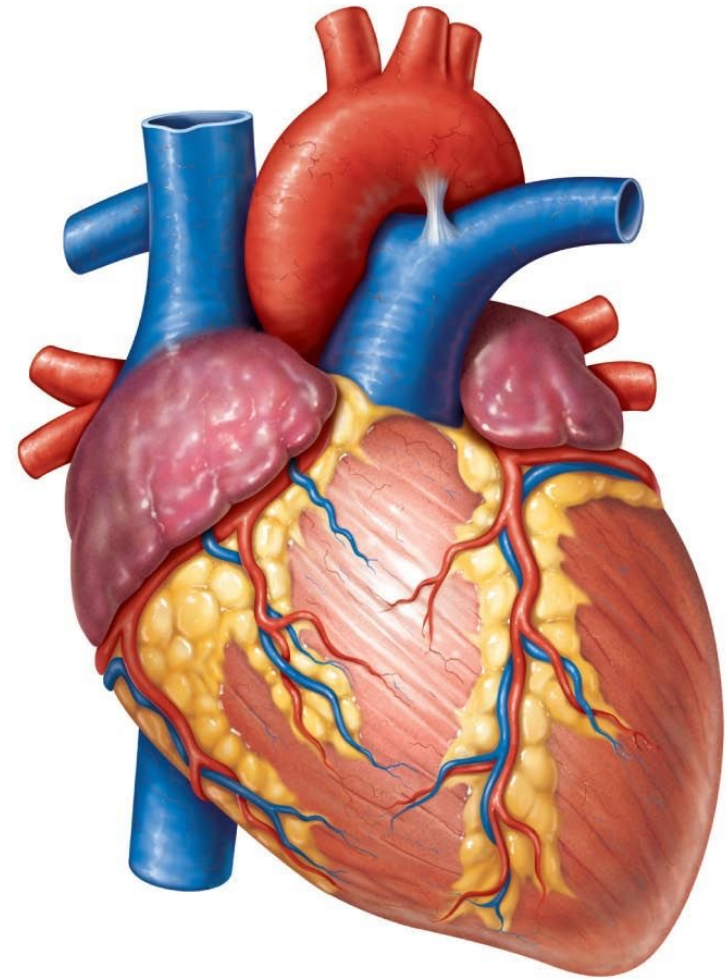


# LAB 3: THE CARDIOVASCULAR SYSTEM

Protocol slides  
PCB 3702L  
FIU

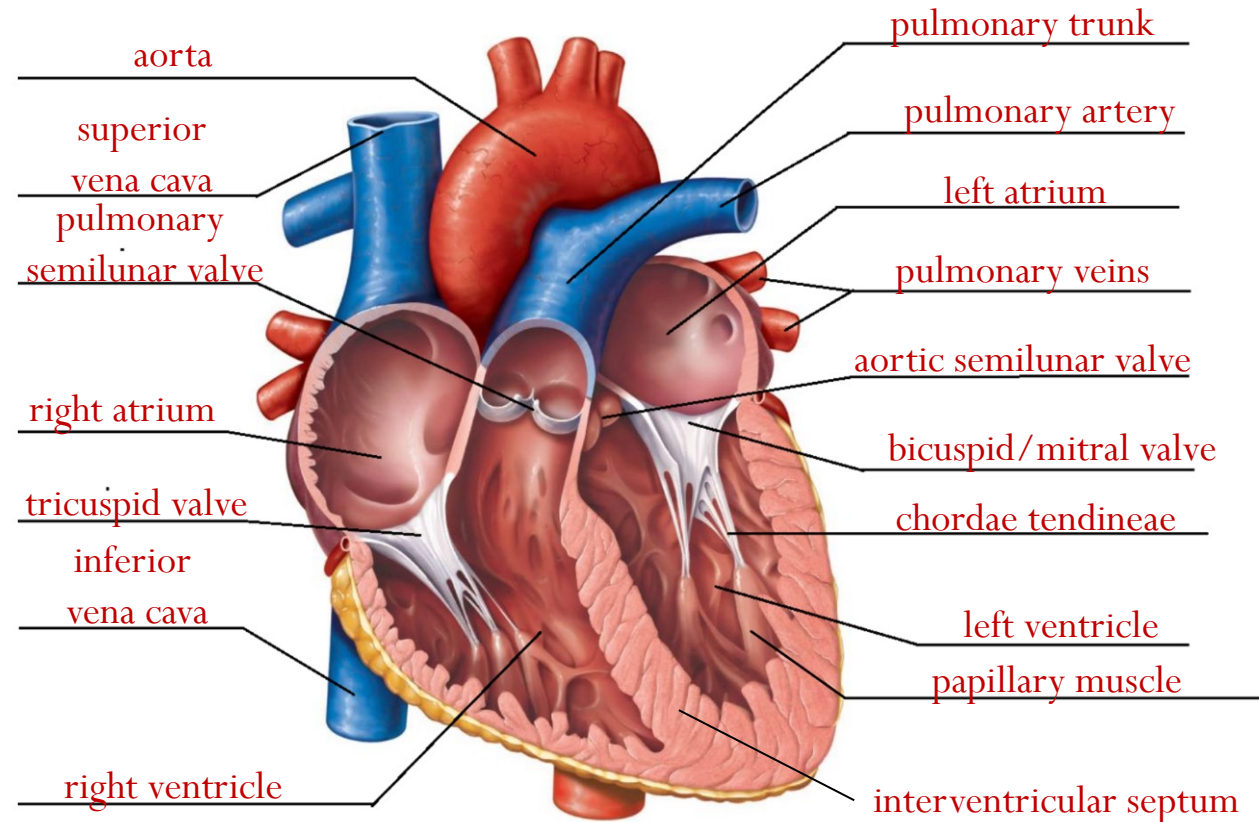
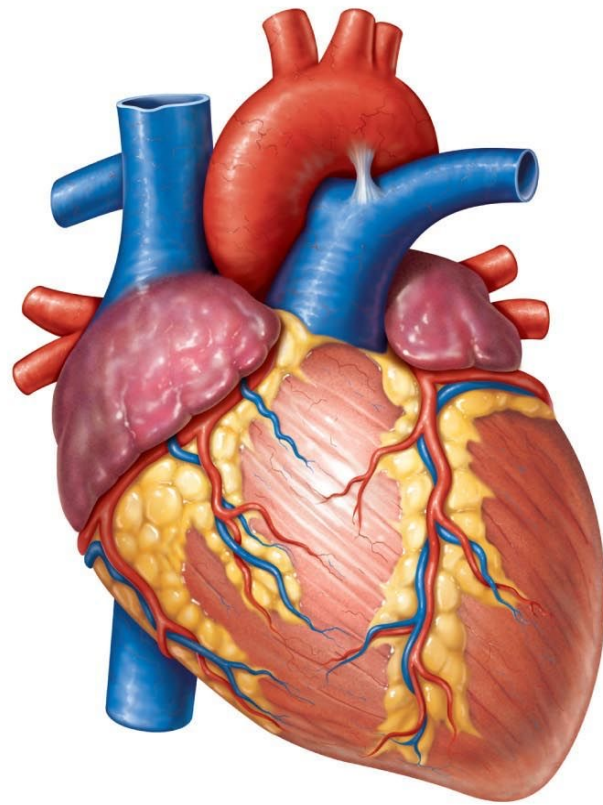
# LAB 3 PROTOCOL OBJECTIVES

1. Identify heart structures and functions while performing heart dissection.
2. Describe blood pressure procedures.
3. Explain the importance of using leg cuffs after surgery.





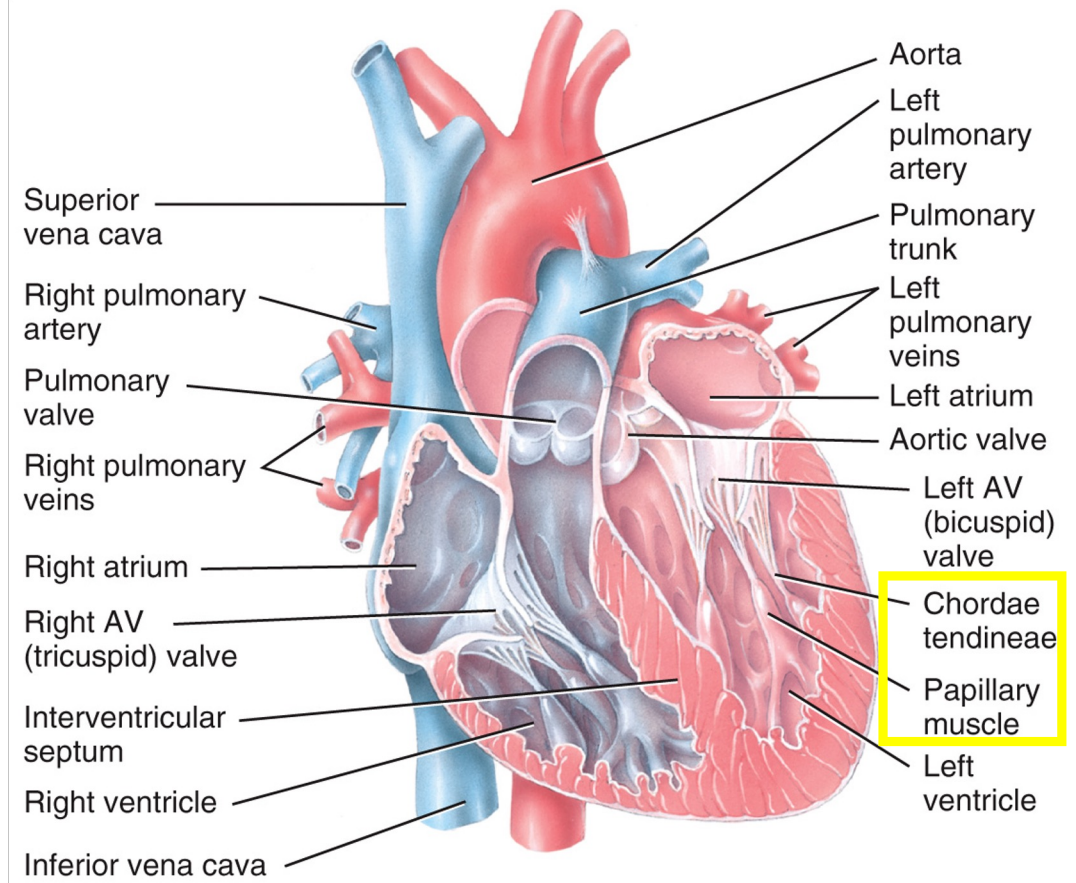
# ANATOMY OF THE HEART



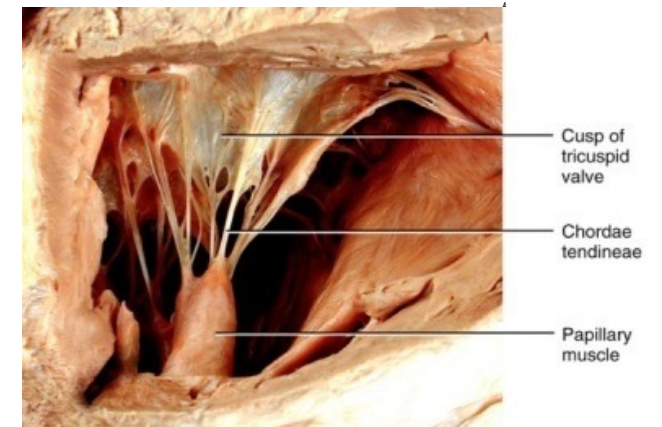
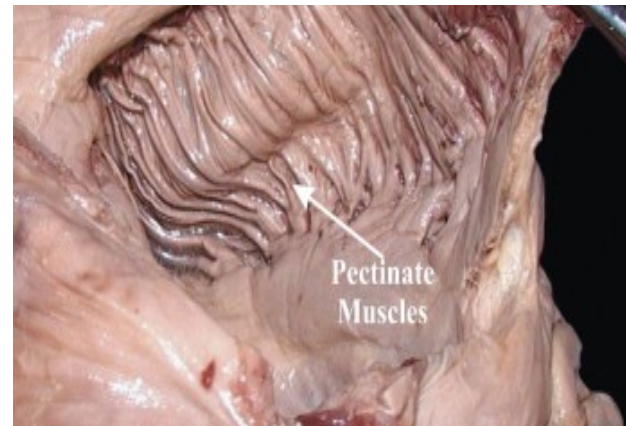
(T/F) Arteries *always* carry oxygenated blood, while veins *always* carry deoxygenated blood.

# IMPORTANT CARDIAC STRUCTURES

- Pectinate Muscles
- Papillary Muscles
- Chordae Tendineae



(b) Frontal section of heart





# HEART VALVES

- The heart valves allow blood to flow in only one direction

## ATRIOVENTRICULAR VALVES

- Between the atria and ventricles

- Right side: *tricuspid valve*

- Left side: *bicuspid valve/mitral valve*

"TRY BEFORE YOU BUY"

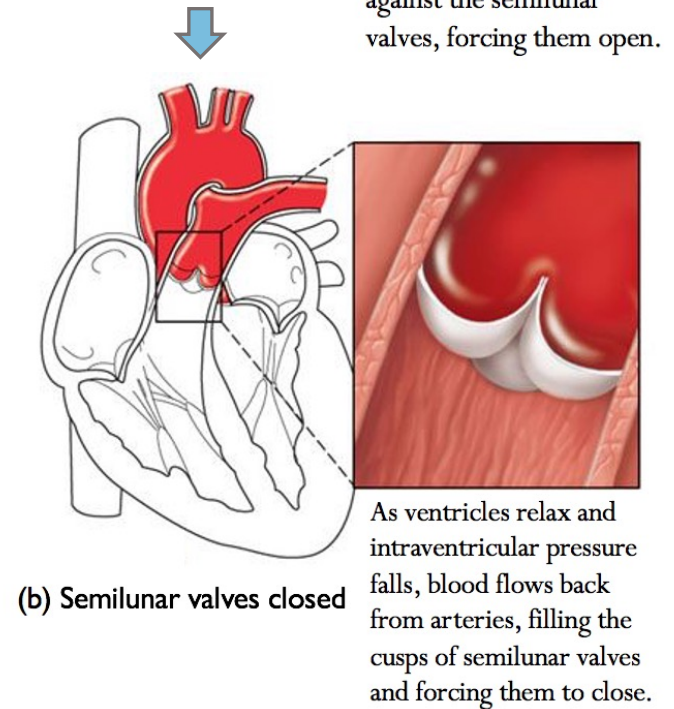
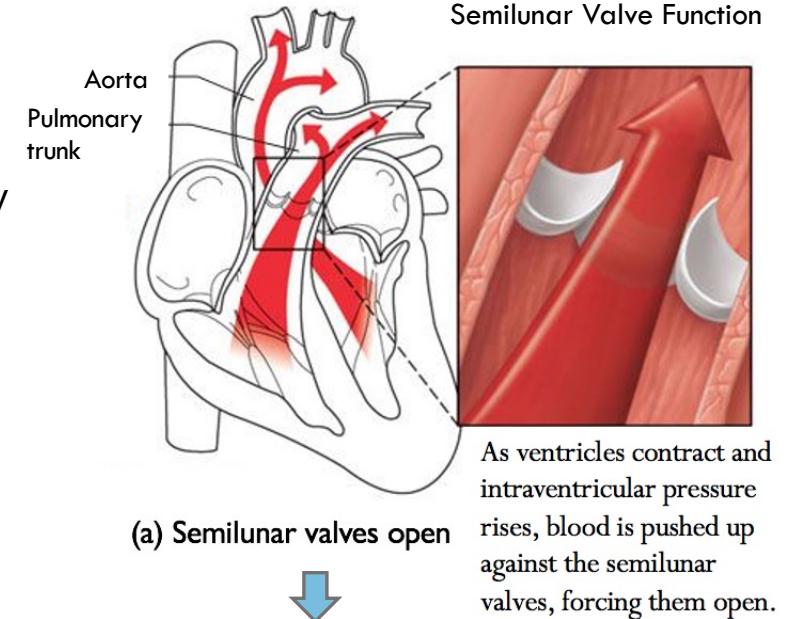
## SEMILUNAR VALVES

- Between the ventricles and arteries

- Right side: *pulmonary semilunar valve*

- Left side: *aortic semilunar valve*

### Semilunar Valve Function



Anterior

Pulmonary valve  
(right semilunar valve)

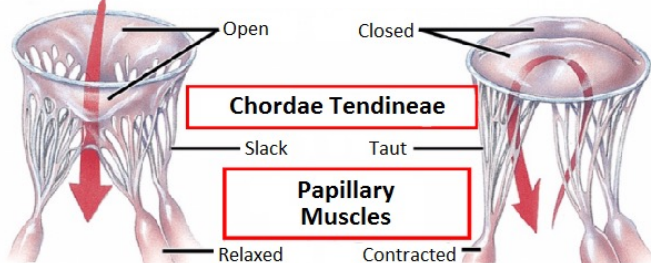
Aortic valve  
(left semilunar valve)

Mitral valve  
(left atrioventricular valve)

Tricuspid valve  
(right atrioventricular valve)

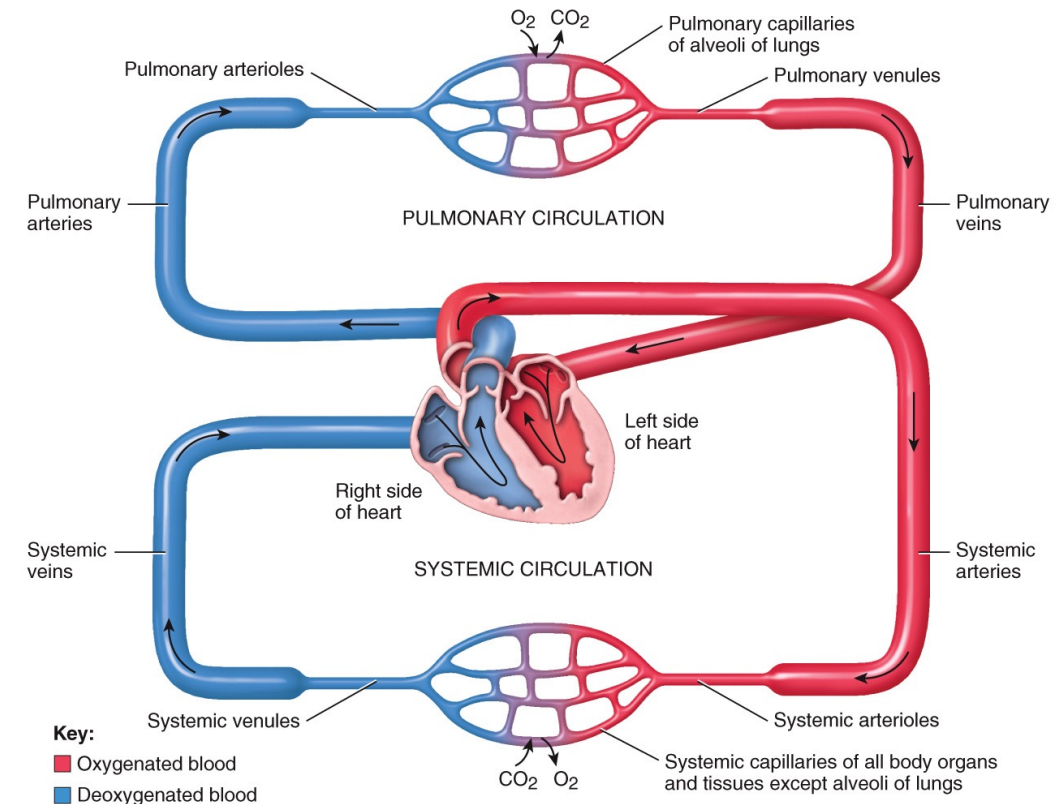
Posterior

### AV Valve Function



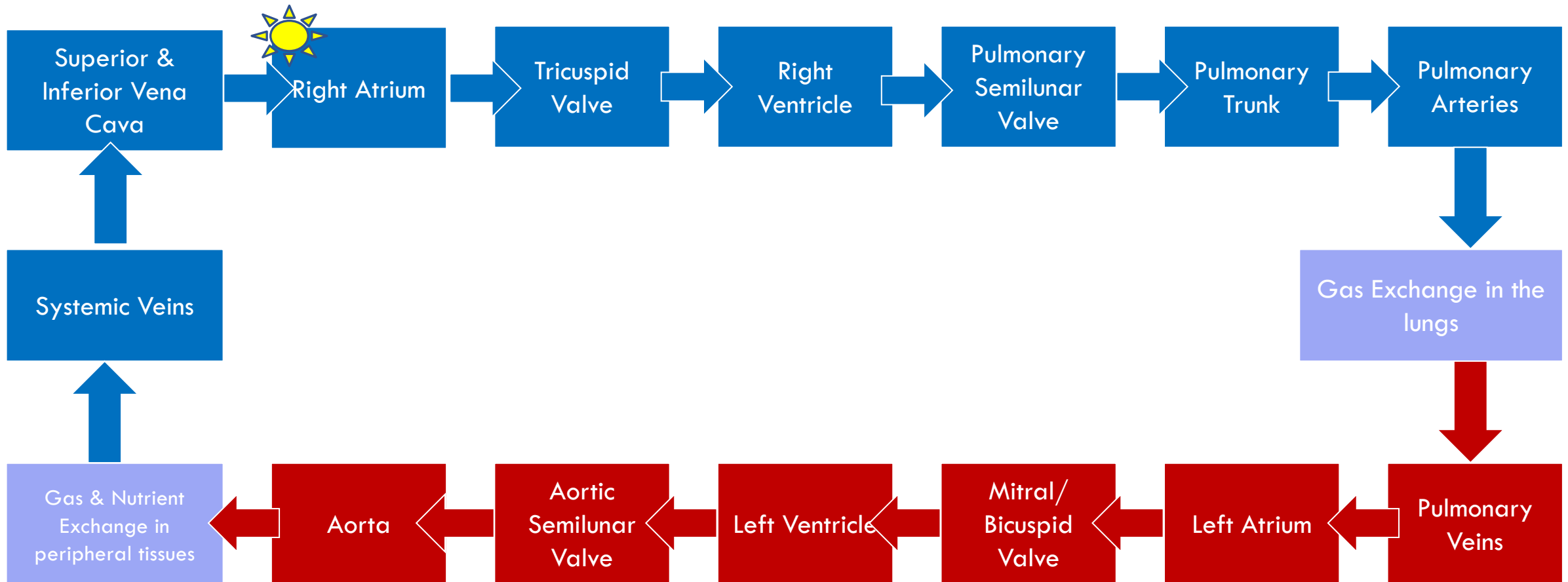
# PULMONARY AND THE SYSTEMIC CIRCUITS

- Each side of the heart works as a separate pump. The right side of the heart pumps blood into the pulmonary circuit, while the left side pumps blood into the systemic circuit.
- **Pulmonary circuit:** between heart and lungs
  - Deoxygenated blood travels to the lungs via pulmonary arteries
  - Oxygenated blood returns to the heart via pulmonary veins
- **Systemic circuit:** between heart and body tissues
  - Oxygenated blood travels to body tissues via aorta
  - Deoxygenated blood returns to heart via superior and inferior venae cavae



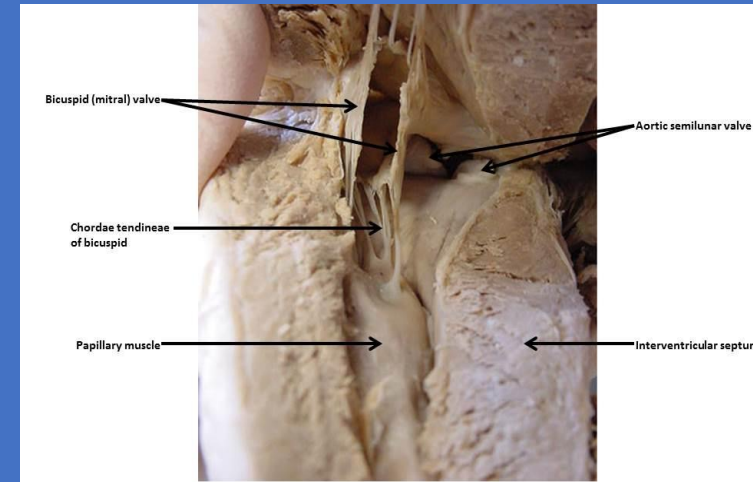
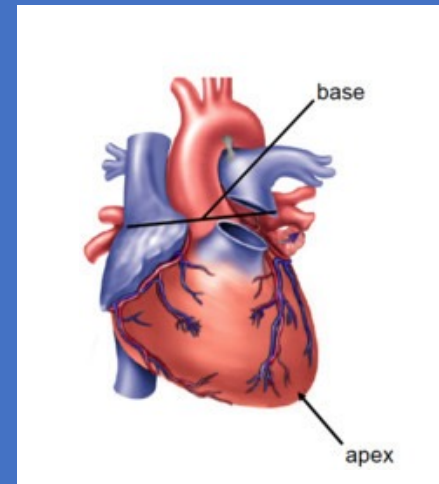
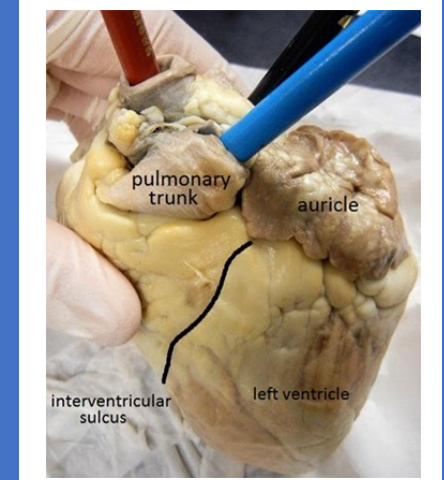
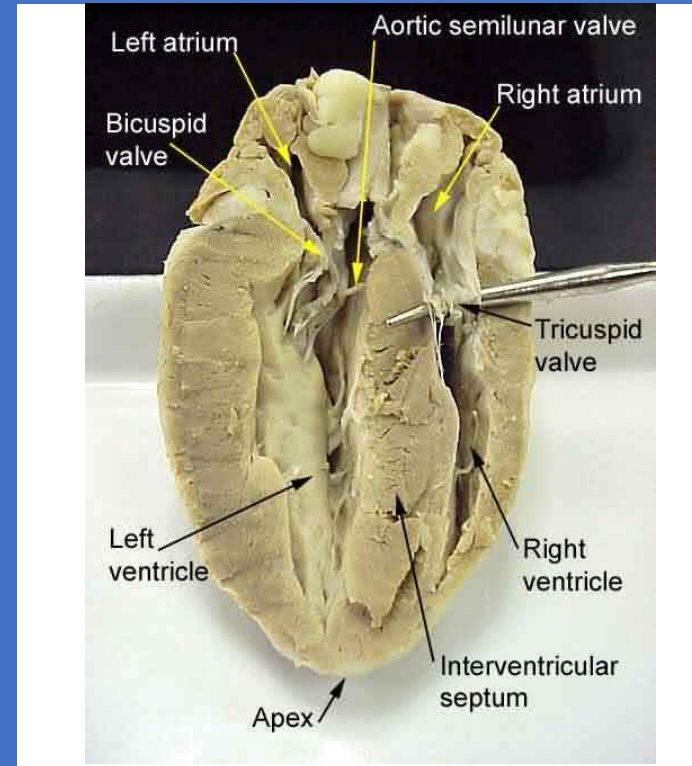


# THE FLOW OF BLOOD



# ACTIVITY 1: SHEEP HEART DISSECTION

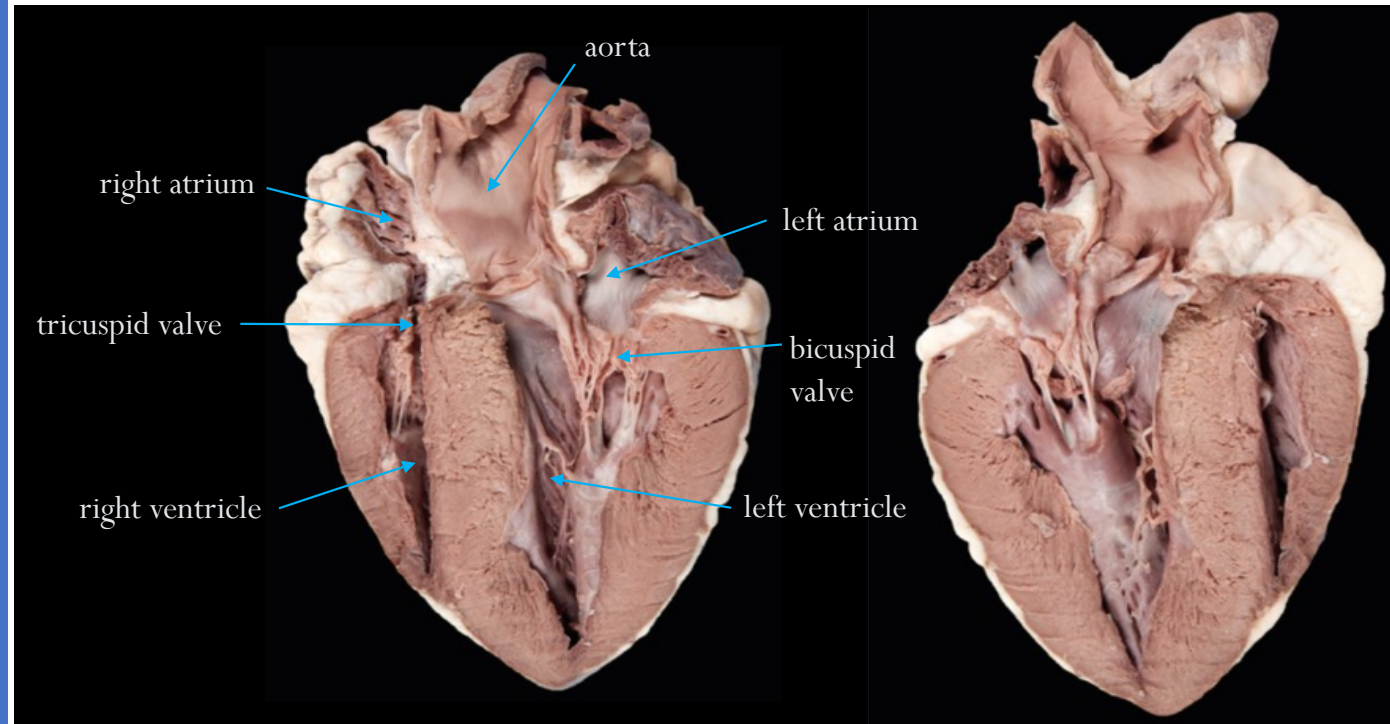
- **Coronal Cut:** Separates anterior from posterior
- The **base** of the heart is the superior, broad portion of the heart, while the **apex** is the lower, pointed tip of the heart
- Anterior interventricular sulcus to determine the anterior portion of the heart
- Be able to identify all structures discussed during class



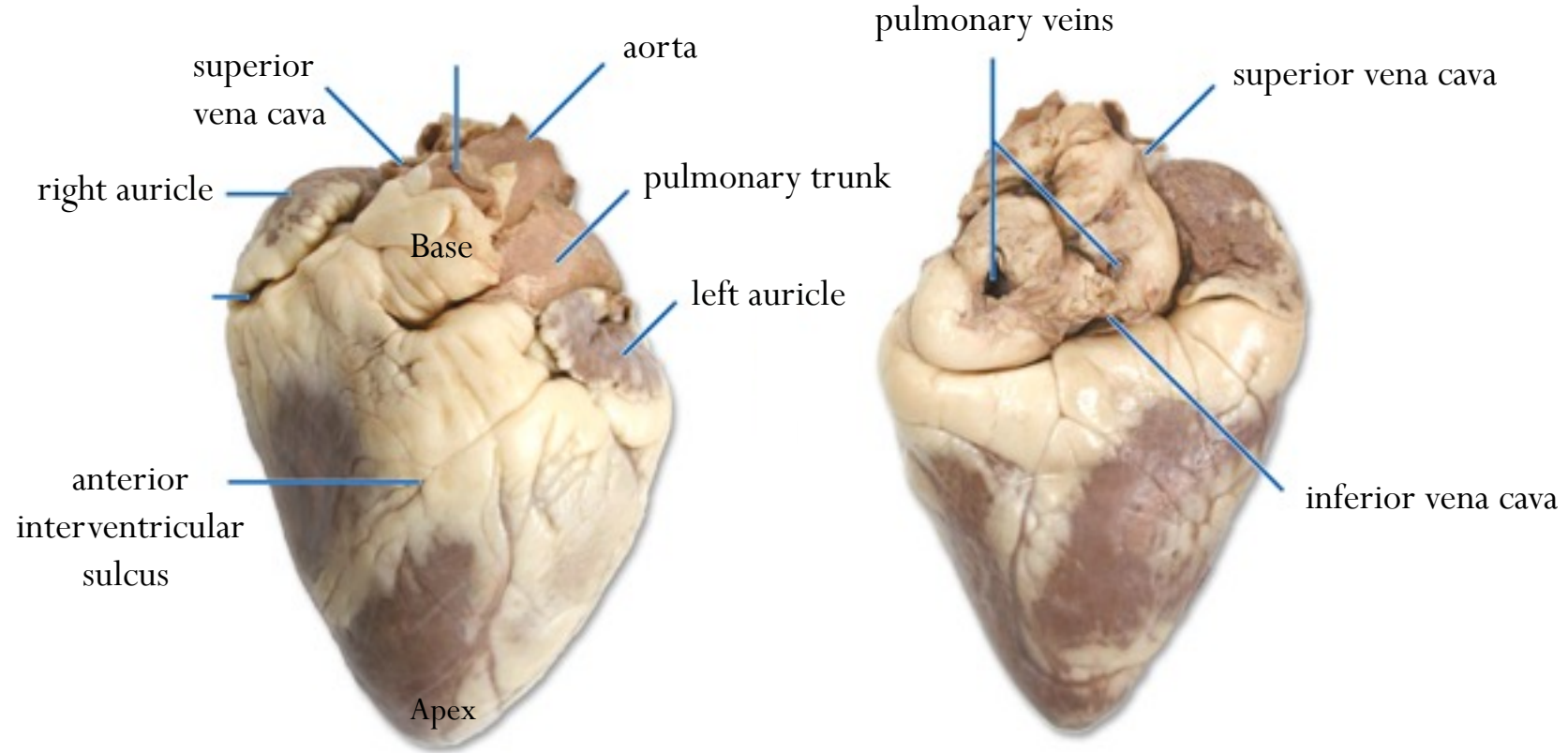


# IDENTIFYING HEART STRUCTURES

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# SHEEP HEART DISSECTION



*Anterior View of Sheep Heart*

*Posterior View of Sheep Heart*



# IDENTIFYING STRUCTURES - CONTINUED

- Which side of the heart is considered the “low O<sub>2</sub>” side? Why?
  - The right side is low in oxygen; it brings deoxygenated blood from the rest of the body
- Which ventricle has more myocardium and why?
  - The left ventricle because it needs to be able to sustain greater pressure, which allows blood to travel throughout the systemic circulation

Left Atrium

Chordae Tendineae

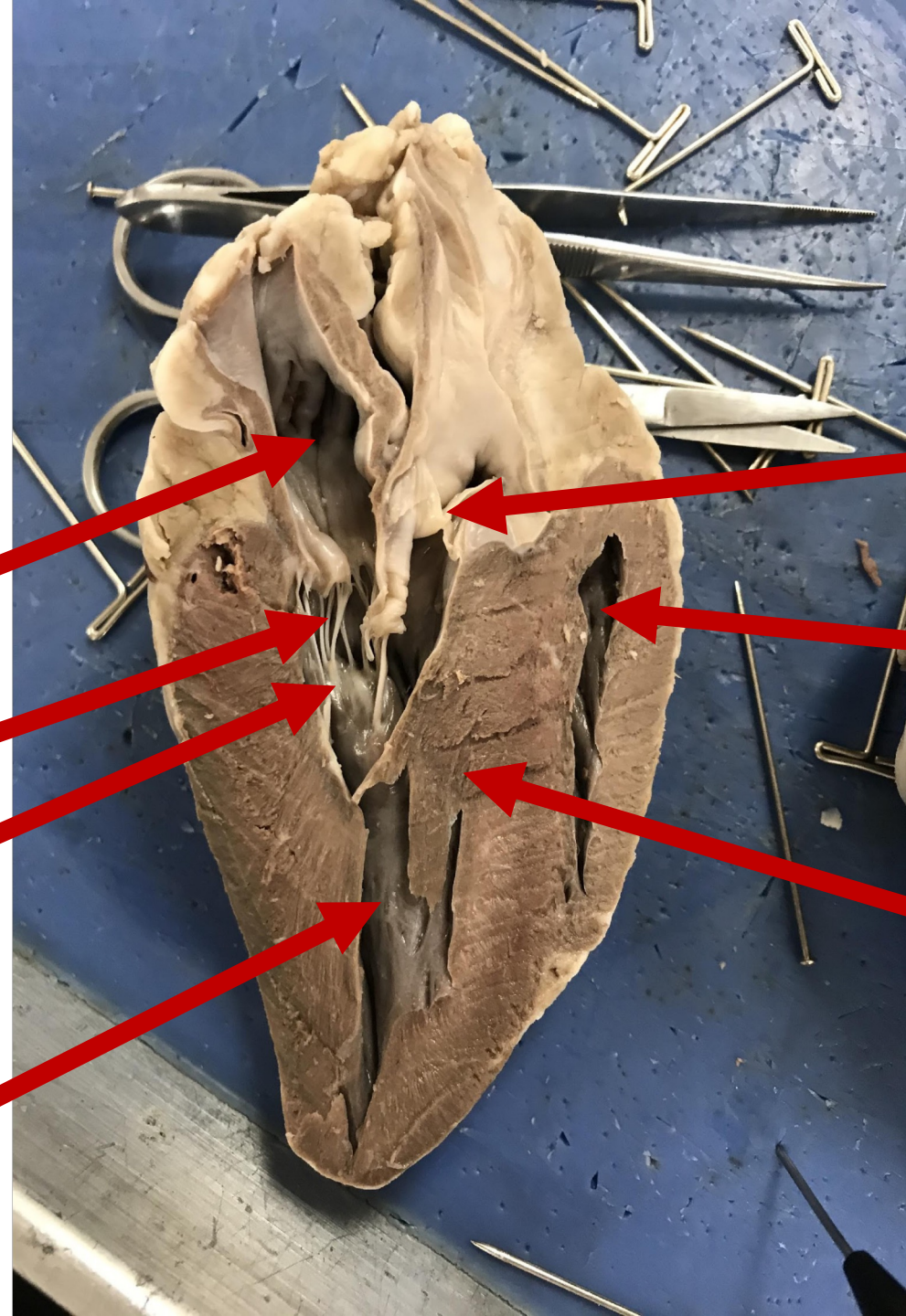
Papillary Muscle

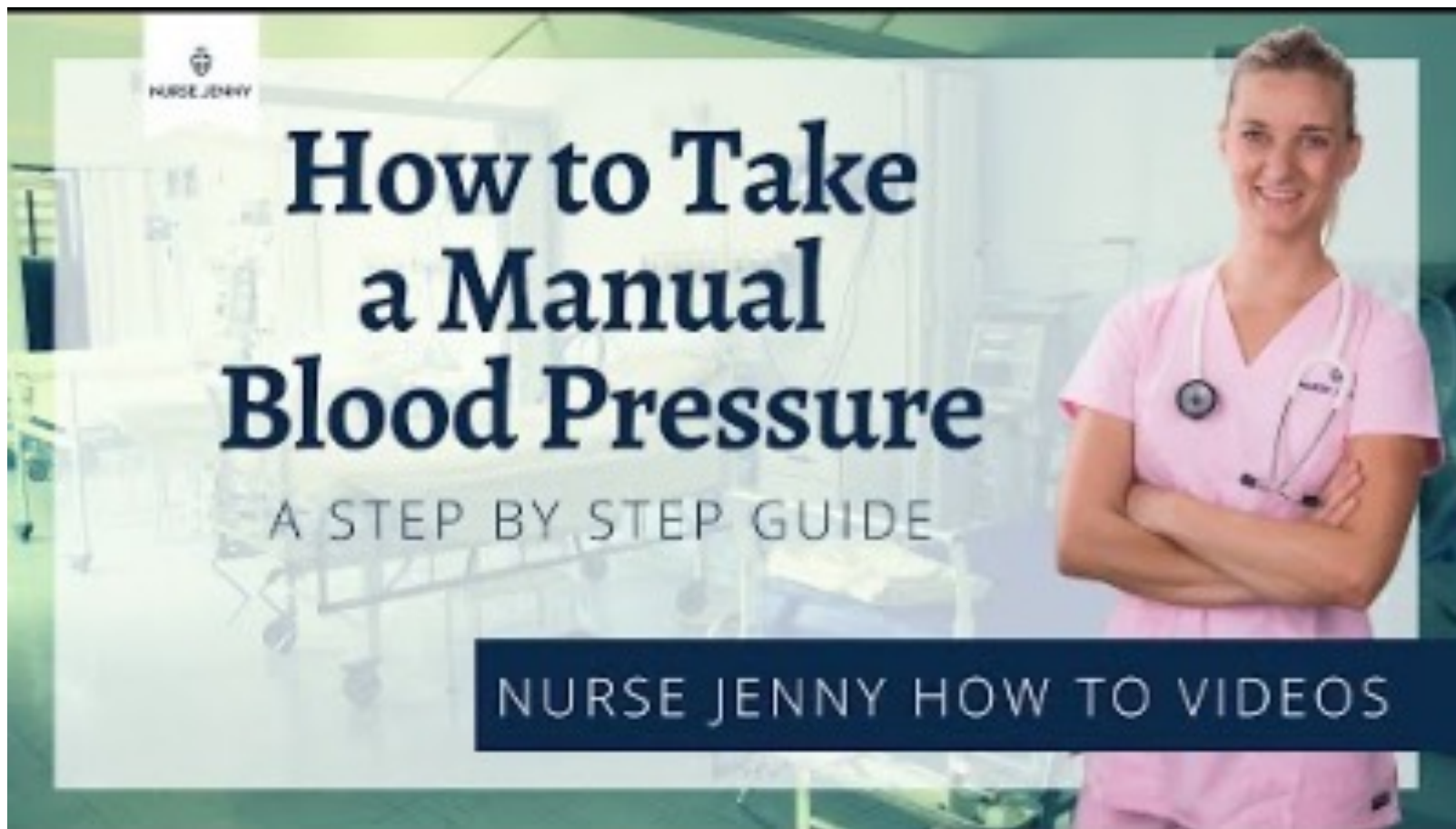
Left Ventricle

Aortic Valve

Right Ventricle

Interventricular Septum



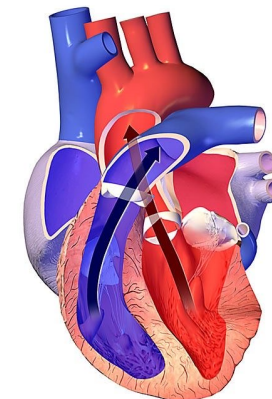
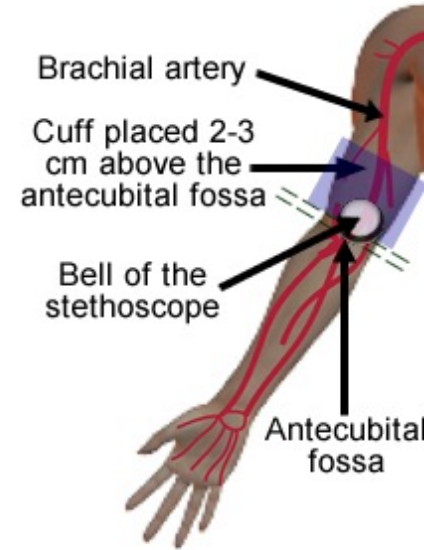


## ACTIVITY 2: HOW TO TAKE BLOOD PRESSURE

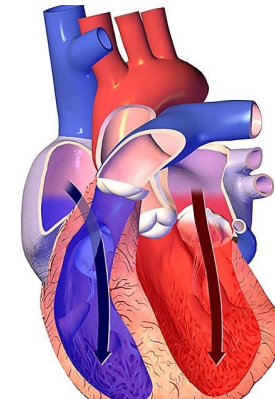


# ACTIVITY 2: TAKING BLOOD PRESSURE

- Blood pressure is the force exerted by circulating blood on the walls of blood vessels, measured in **mmHg**
- Instruments used: **sphygmomanometer and a stethoscope**
- The sphygmomanometer cuff and the bell of the stethoscope are placed just above the **cubital fossa (=antecubital fossa)**, anterior to the elbow
- The pressure is measured over the **brachial artery**
- After inflating the cuff to ~160 mmHg, slowly release the pressure and listen for Korotkoff sounds
  - The first sound heard is the **systolic pressure** and the last sound heard is the **diastolic pressure**



Systole  
(pumping)



Diastole  
(filling)

# CALCULATING PULSE PRESSURE

**Calculate the pulse pressure for the subject BEFORE & AFTER EXERCISE**

**as follows:**

- **Pulse Pressure = Systolic BP – Diastolic BP**
- **Systolic BP = Pulse Pressure + Diastolic BP**
- **Diastolic BP = Systolic BP – Pulse Pressure**

Before Jogging	After Jogging
	After 30 seconds
	After 1 minute
	After 1 minute and 30 seconds

**How do venous pressures compare to arterial pressures? Why?**

- Venous pressures are significantly lower than arterial pressures because veins have thinner, less muscular walls adapted to their role in collecting deoxygenated blood from the body's tissue, encountering significantly lower resistance than arteries, and relying on auxiliary mechanisms like muscle and respiratory pumps, along with one-way valves, to facilitate the return of blood to the heart

**Is pulse pressure lower or higher after exercise?**

- Pulse pressure increases with exercise primarily due to the elevated systolic pressure resulting from increased cardiac output and stroke volume. During exercise, the heart pumps more blood with each beat (increased stroke volume), and it contracts more forcefully, leading to a higher systolic blood pressure

## VEINS

- Carry blood **toward** the heart
- Most carry **deoxygenated** blood
  - exceptions?
    - \* *Pulmonary and umbilical veins*
- Thinner walls and less elastic than arteries
- Many contain valves
  - Why?

## CAPILLARIES

- Interconnect arteries and veins
- Function in gas and nutrient exchange between the blood and tissue cells

## ARTERIES

- Carry blood **away** from the heart
- Most carry **oxygenated** blood
  - exceptions?
    - \* *Pulmonary and umbilical arteries*
- Highly muscular and elastic

# BLOOD VESSELS

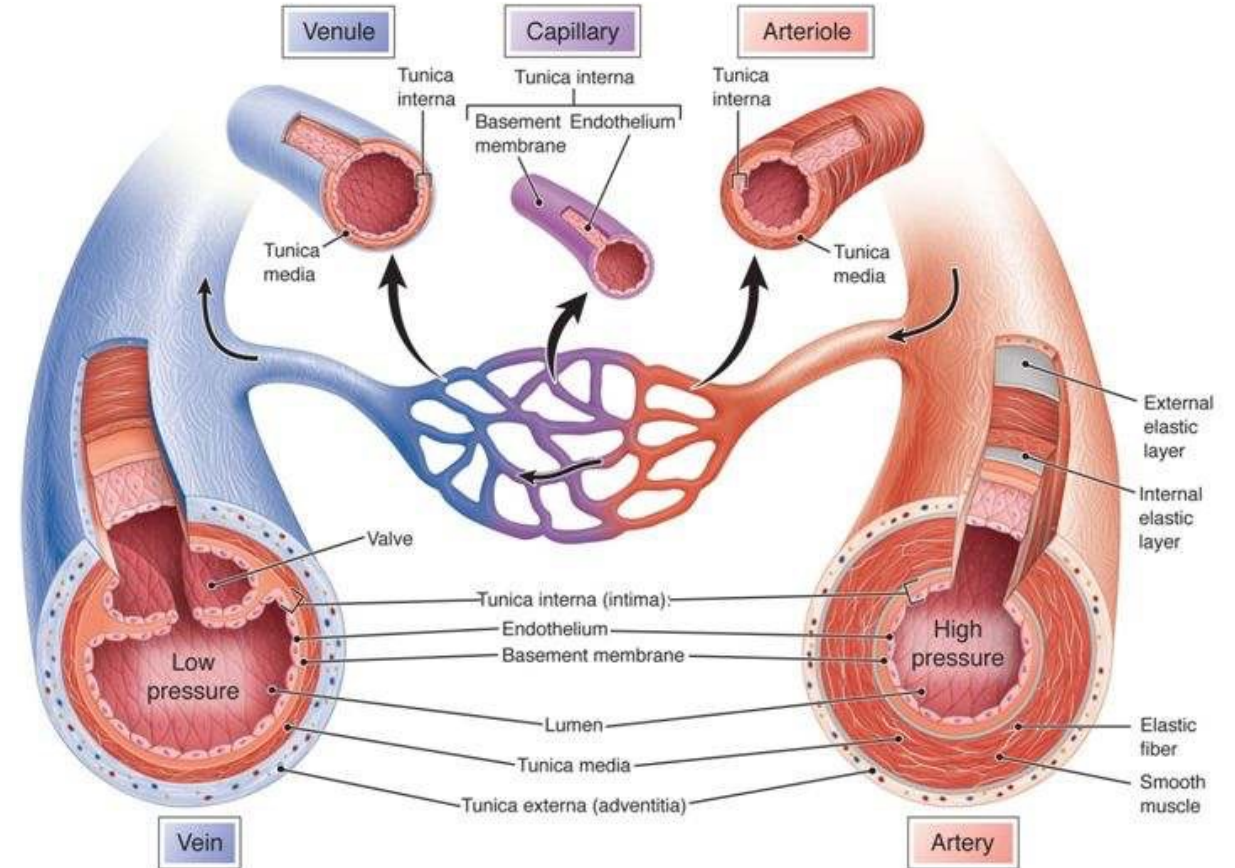
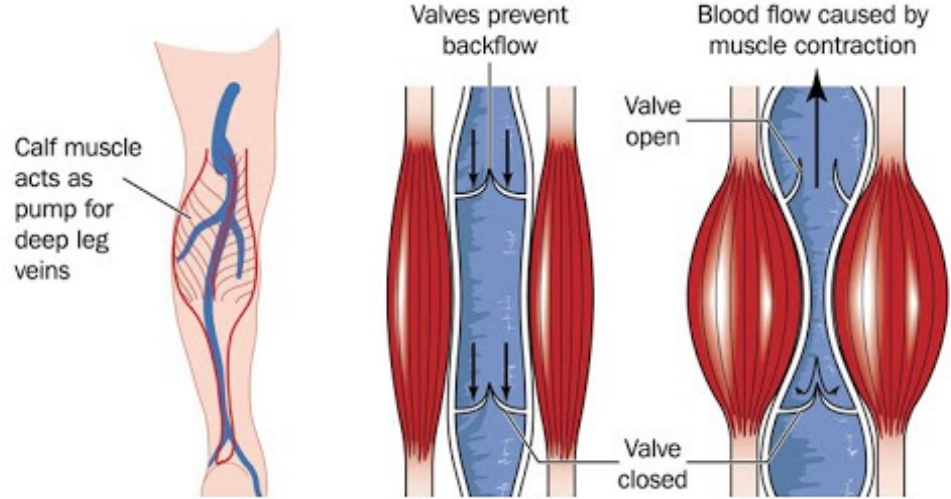


Figure from: McConnell, *The Nature of Disease*, 2<sup>nd</sup> ed., LWW, 2014.

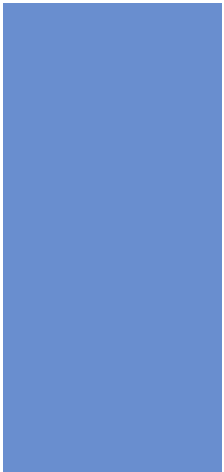
Veins ← Venules ← Capillaries ← Arterioles ← Arteries



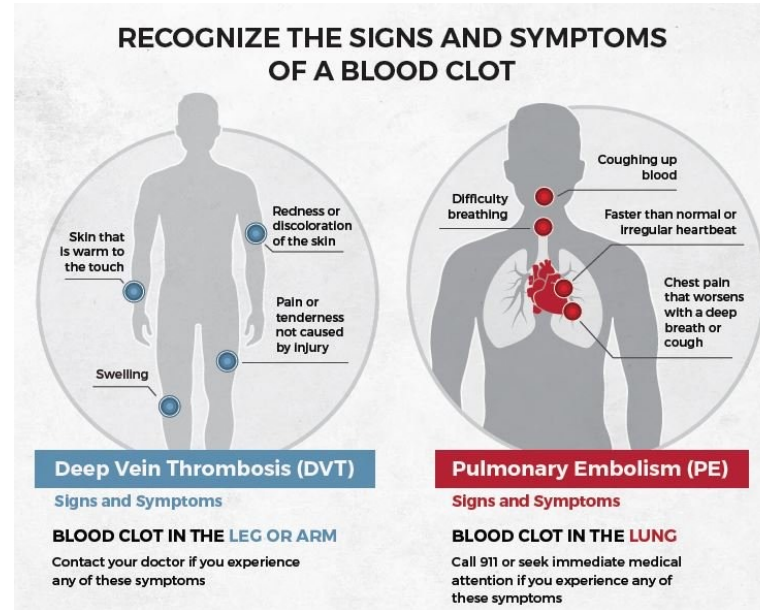


## ACTIVITY 3: LEG CUFFS

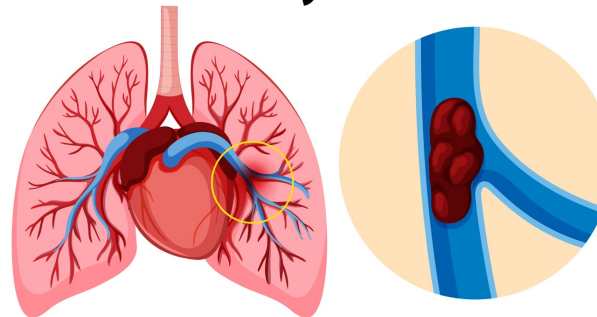
- **Intermittent pneumatic compression (IPC) devices** use inflatable cuffs that compress the lower legs to assist with blood circulation
- **Why would this be used for patients who underwent surgery or are bedridden? What do you think would happen if patients did not have these cuffs?**
  - Patients who have limited mobility or are immobilized through injury or disease lack contractions of leg muscles. As a result, the return of venous blood to the heart is slower and circulation problems may develop, such as **deep vein thrombosis**. IPC devices help prevent this.
  - In worst cases, a deep clot in a leg vein can lodge itself in the lungs, known as a **pulmonary embolism**.



# CLINICAL APPLICATION: DEEP VEIN THROMBOSIS & PULMONARY EMBOLISM

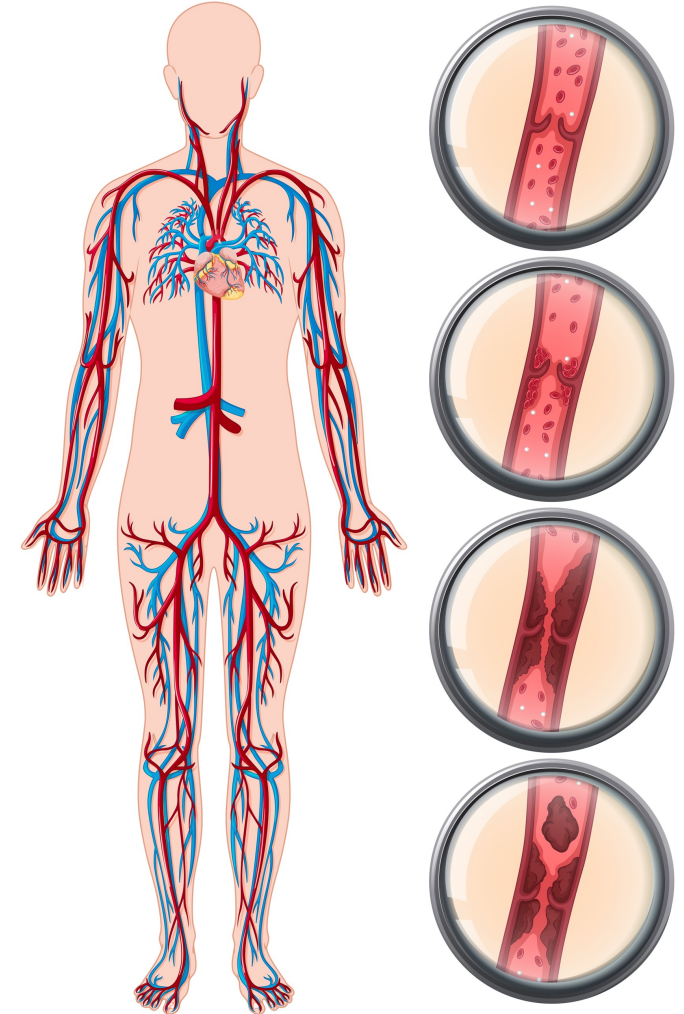


## Pulmonary Embolism



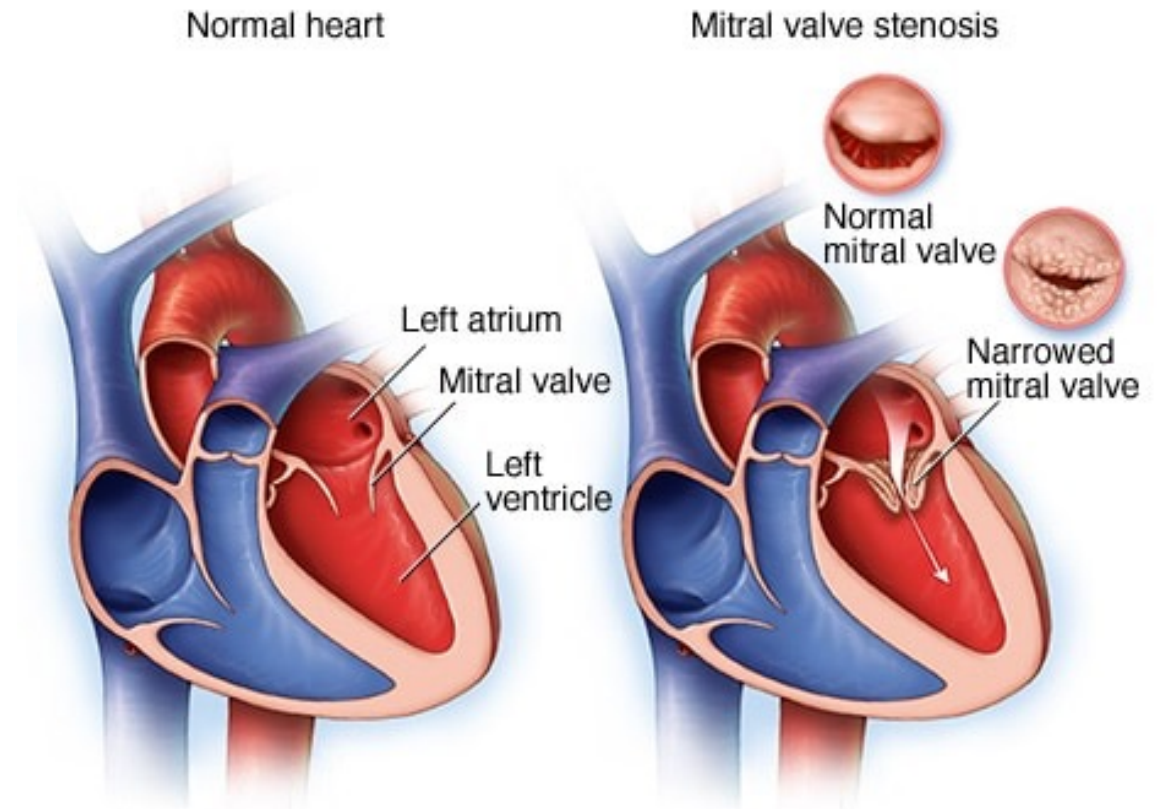
A pulmonary embolism is a serious medical condition that occurs when a blood clot gets stuck in one of the blood vessels in the lungs. This blockage can restrict or stop the flow of blood to the lungs, causing damage to the lung tissue and reducing the amount of oxygen that reaches the rest of the body.

## Deep vein thrombosis (DVT)

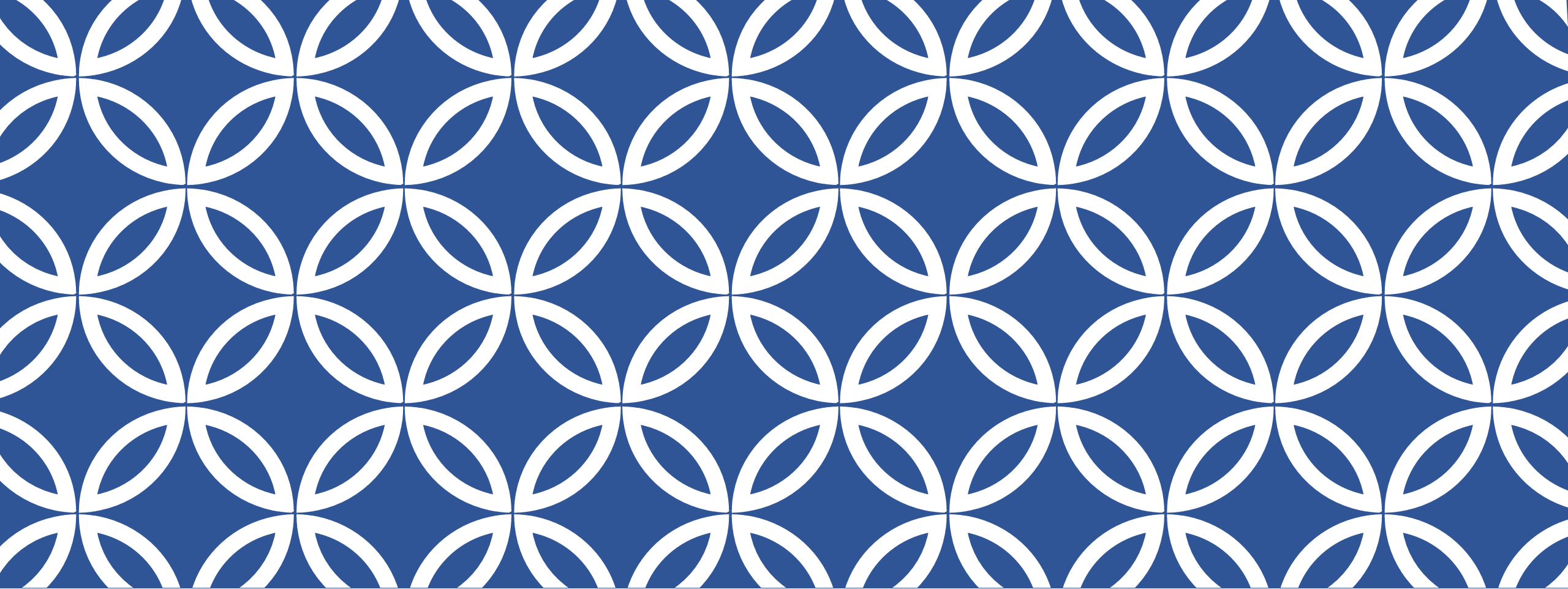


# CLINICAL APPLICATION: MITRAL STENOSIS

- Narrowing of the mitral valve opening, resulting in the restriction of blood flow.
- This condition can cause the mitral valve to become thickened and calcified
- The mitral valve is located on the left side of the heart. It lies between the left atrium and the left ventricle.
- In mitral stenosis, the left atrium may have difficulty emptying blood into the left ventricle due to the narrowed valve. This can lead to the accumulation or pooling of blood in the left atrium.
- An enlarged left atrium can sometimes be identified on an EKG by examining the P wave. Enlargement of the left atrium may result in a larger or abnormal P wave, known as "P mitrale," which can indicate left atrial enlargement.





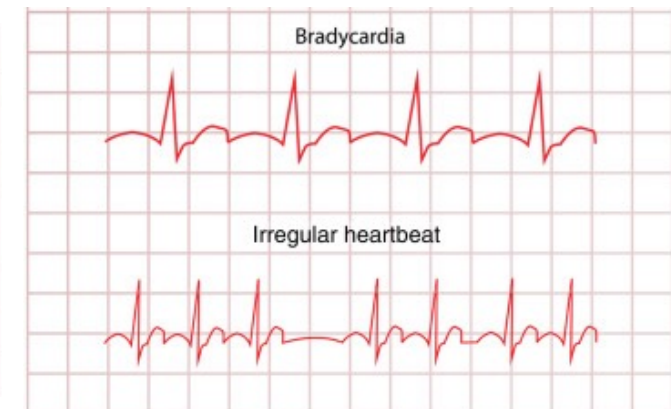


# PRE-LABORATORY CONTENT STUDY AIDS



# ELECTROCARDIOGRAM (ECG OR EKG)

- Graph of the electrical activity of the heart measured with electrodes placed on the skin. The instrument used to make an ECG, is known as an Electrocardiograph. An ECG provides information about heart rate and rhythm
- What do each of the following represent?
  - P wave: **Atrial depolarization**
  - QRS complex: **Ventricular depolarization**
  - T-wave: **Ventricular repolarization**
- When does atrial repolarization occur?
  - There is no wave to show atrial repolarization because the stronger QRS wave masks this event.
- Abnormalities of the ECG can be used to diagnose heart problem.
  - Larger P-wave: **Enlargement of an atrium**
  - Larger Q-wave: **Myocardial infarction; indicates necrosis**
  - Larger R-wave: **Enlargement of a ventricle**

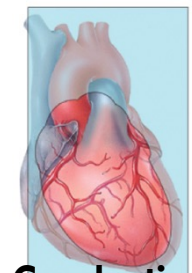


Average adult resting heart rate: 75-85 bpm

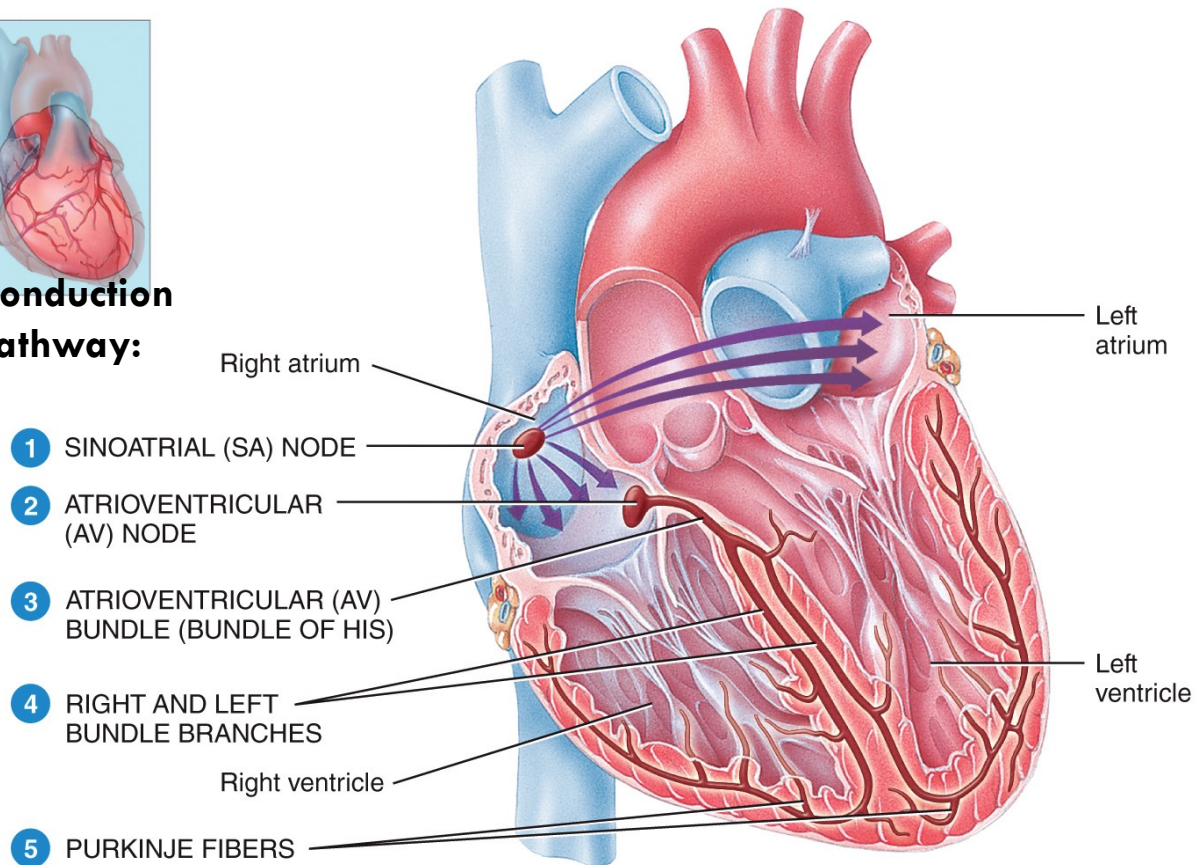
**Tachycardia:** Fast heart Rate  $> 100$  bpm

**Bradycardia:** Slow heart rate  $< 60$  bpm

# THE CONDUCTION SYSTEM OF THE HEART



## Conduction Pathway:



**Intrinsic Conduction System:** Cardiac muscle does not require external stimulation to contract since action potentials are spontaneously generated (this built-in rhythm is called autorhythmicity)

- While the heart does not require neuronal or hormonal stimulation, it can be regulated by both the nervous and endocrine systems

Cardiac muscle is composed of:

1. **Authorhythmic fibers** (=pacemaker cells) that spontaneously generate action potentials. These fibers are noncontractile due to the absence of myofibrils. These cells make up the conduction system of the heart
2. **Contractile fibers** that have the necessary myofibrils to contract but do not have the ability to initiate action potentials; these cells become excited and then contract together in response to action potentials conducted to them from autorhythmic fibers via gap junctions

The SA Node is considered the natural pacemaker.



# THE CARDIAC CYCLE

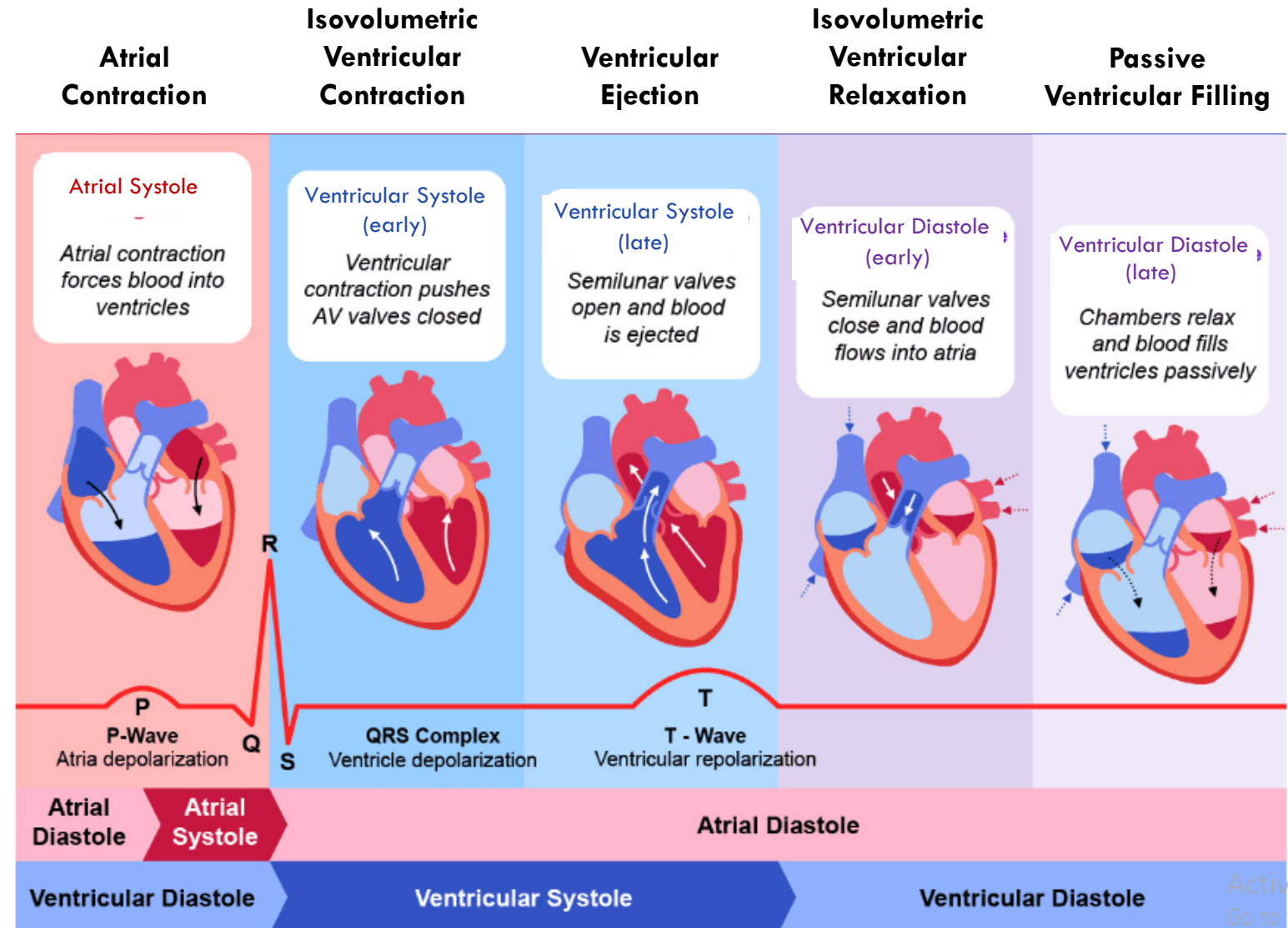
The repeating pattern of contraction and relaxation of the heart's chambers associated with each heartbeat

Both atria contract simultaneously and relax, then both ventricles contract simultaneously and relax

## Events of the cardiac cycle

- Atrial systole
- Ventricular systole
  1. early: isovolumetric ventricular contraction
  2. late: ventricular ejection
- Ventricular diastole
  1. early: isovolumetric ventricular relaxation
  2. late: passive ventricular filling

Avg. length of a cardiac cycle= 0.7-0.8 sec  
corresponding to an average heart rate of **75–85 beats per minute (bpm)**.

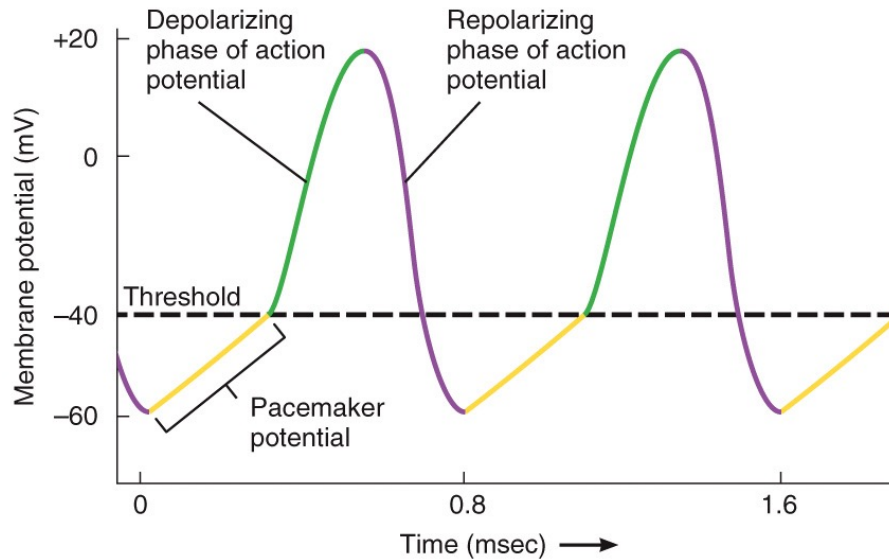


\* **Systole** = contraction phase

\* **Diastole** = relaxation phase

*When used without reference to atria or ventricles, these terms refer to ventricular systole and diastole*

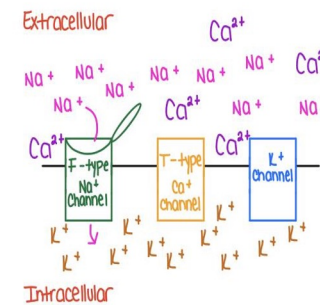
# PACEMAKER POTENTIAL AND ACTION POTENTIALS IN AN AUTORHYTHMIC CARDIAC MUSCLE FIBER



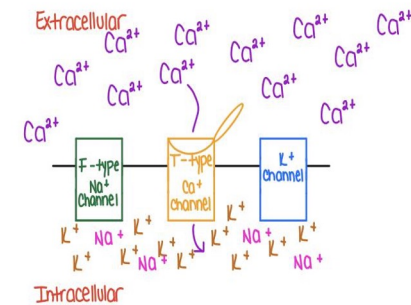
Membrane channels involved

- Pacemaker potential: During first half of pacemaker potential, voltage-gated  $K^+$  channels close and F-type  $Na^+$  channels open; during second half of pacemaker potential, T-type voltage-gated  $Ca^{2+}$  channels open
- Depolarizing phase: L-type voltage-gated  $Ca^{2+}$  channels open
- Repolarizing phase: L-type voltage-gated  $Ca^{2+}$  channels close; voltage-gated  $K^+$  channels open

L-type: Long lasting  
F-type: Funny shape  
T-type: Transient (slow)

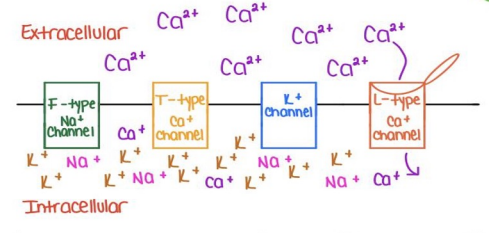


1st Half

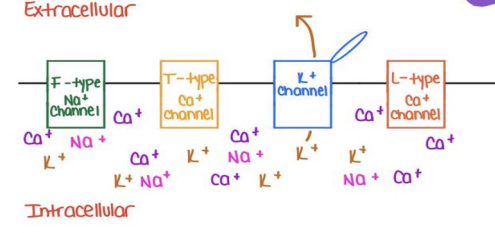


2nd Half

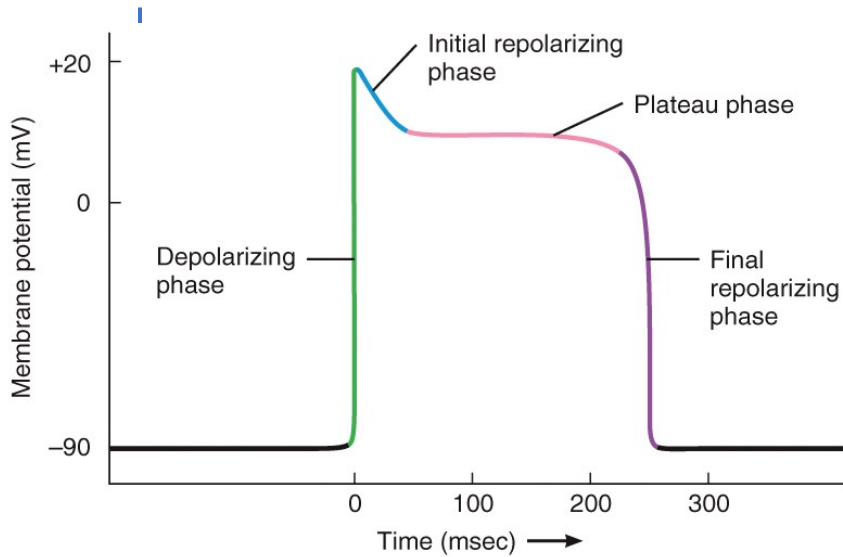
Depolarizing



Repolarizing



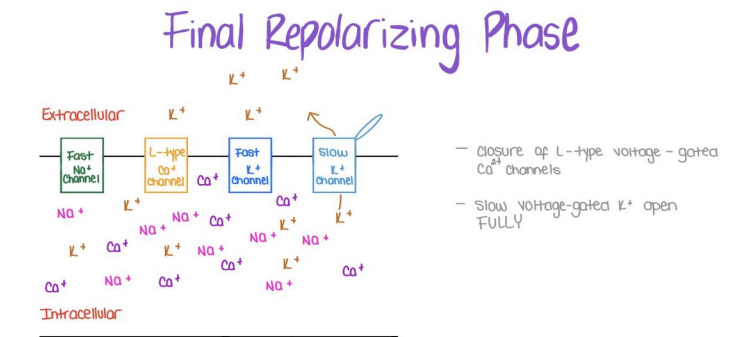
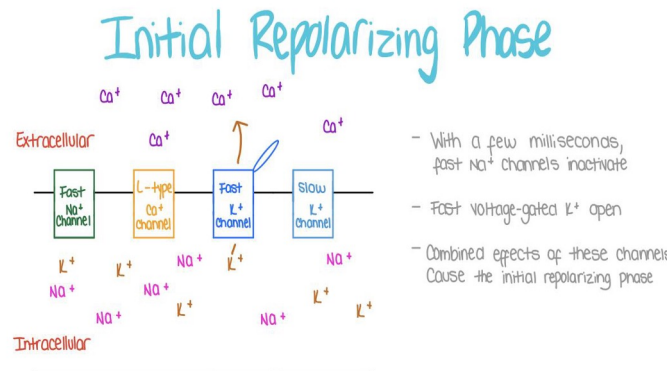
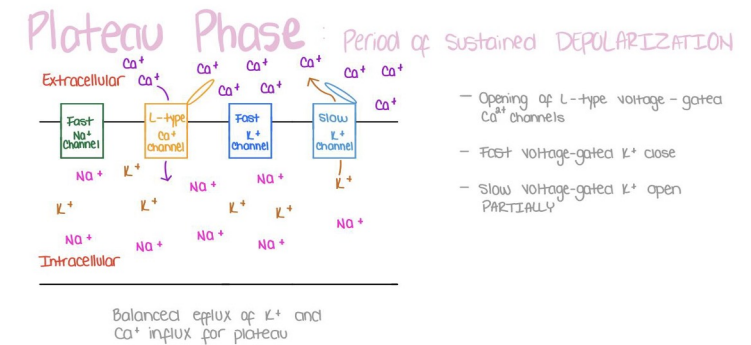
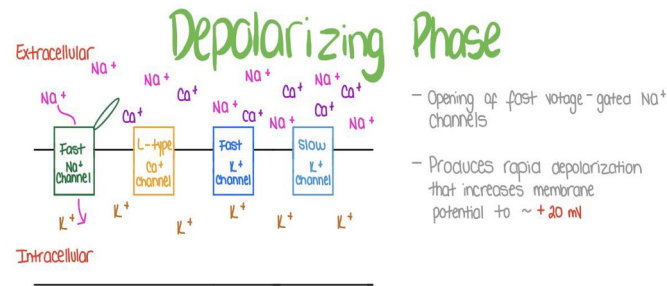
# ACTION POTENTIAL IN A CONTRACTILE CARDIAC MUSCLE FIBER



## Membrane channels involved

- Depolarizing phase:** Fast voltage-gated  $\text{Na}^+$  channels open
- Initial repolarizing phase:** Fast voltage-gated  $\text{Na}^+$  channels close and fast voltage-gated  $\text{K}^+$  channels open
- Plateau phase:** L-type voltage-gated  $\text{Ca}^{2+}$  channels open, fast voltage-gated  $\text{K}^+$  channels close, and slow voltage-gated  $\text{K}^+$  channels partially open
- Final repolarizing phase:** L-type voltage-gated  $\text{Ca}^{2+}$  channels close and slow voltage-gated  $\text{K}^+$  channels fully open

L-type: Long lasting  
F-type: Funny shape  
T-type: Transient (slow)



Myocardial Resting Potential  $\sim -90 \text{ mV}$