CARDIAC PHYSIOLOGY

Disclaimer

This content is only for educational and teaching purposes.

Cardiovascular System

- A closed system of the heart and blood vessels .

- The heart pumps blood.

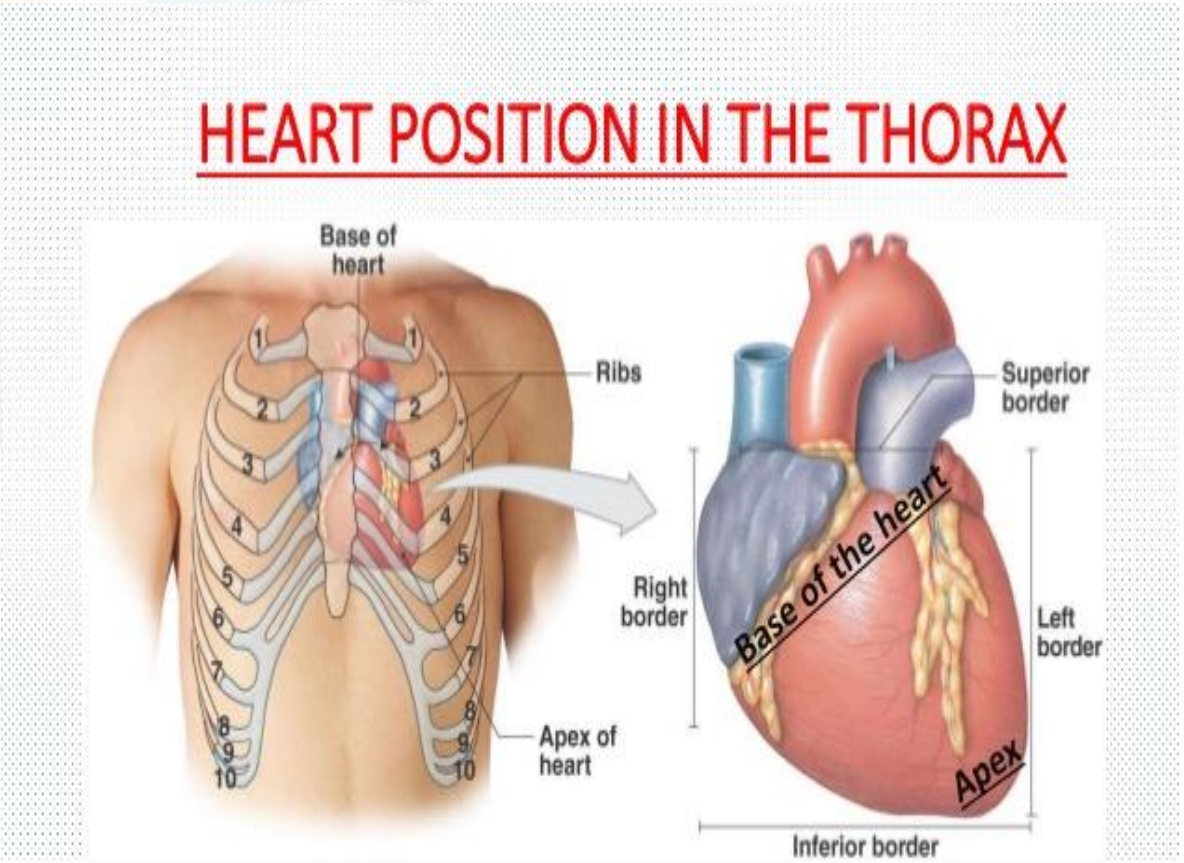
- Blood vessels allow blood to circulate to all parts of the body.

- The function of the cardiovascular system is to deliver oxygen and nutrients and to remove carbon dioxide and other waste products.

Location

The Heart is a conical, hollow, muscular pump that lies:

- Upon diaphragm
- Posterior to sternum
- Medial to lungs
- Anterior to vertebral column
- Base: lies beneath 2nd rib
- Apex: at 5th intercostals space



Coverings of Heart

PERICARDIUM – a double-walled sac around the heart that protects, anchors and prevents the overfilling of the heart. It also covers the roots of the great vessels. It is composed of:

- A superficial ***fibrous pericardium***
- Deep two-layered ***serous pericardium***

- The **Parietal layer** lines the internal surface of the fibrous pericardium
- The **Visceral layer** lines the surface of the heart

They are separated by the serous fluid ***Pericardial fluid*** which prevents friction as the heart beats.

Pericardial Layers

❑**Epicardium** –

- Protective, outer layer of the heart wall same as the visceral pericardium
- The coronary blood vessels lies in the Epicardium

❑**Myocardium** –

- Middle layer
- Forms the bulk of the heart wall (cardiac muscles)

❑**Endocardium** –

- Inner layer, Smooth surface that permits blood to move easily
- Continuous with lining of blood vessels

Major Vessels of the Heart

- Vessels returning blood to the heart include:
  1. Superior and inferior venae cavae
  2. Right and left pulmonary veins

- Vessels conveying blood away from the heart include:
  1. Pulmonary trunk, which splits into right and left pulmonary arteries
  2. Ascending aorta (three branches) –
     a. Brachiocephalic
     b. Left common carotid
     c. Subclavian arteries

Vessels that Supply/Drain the Heart

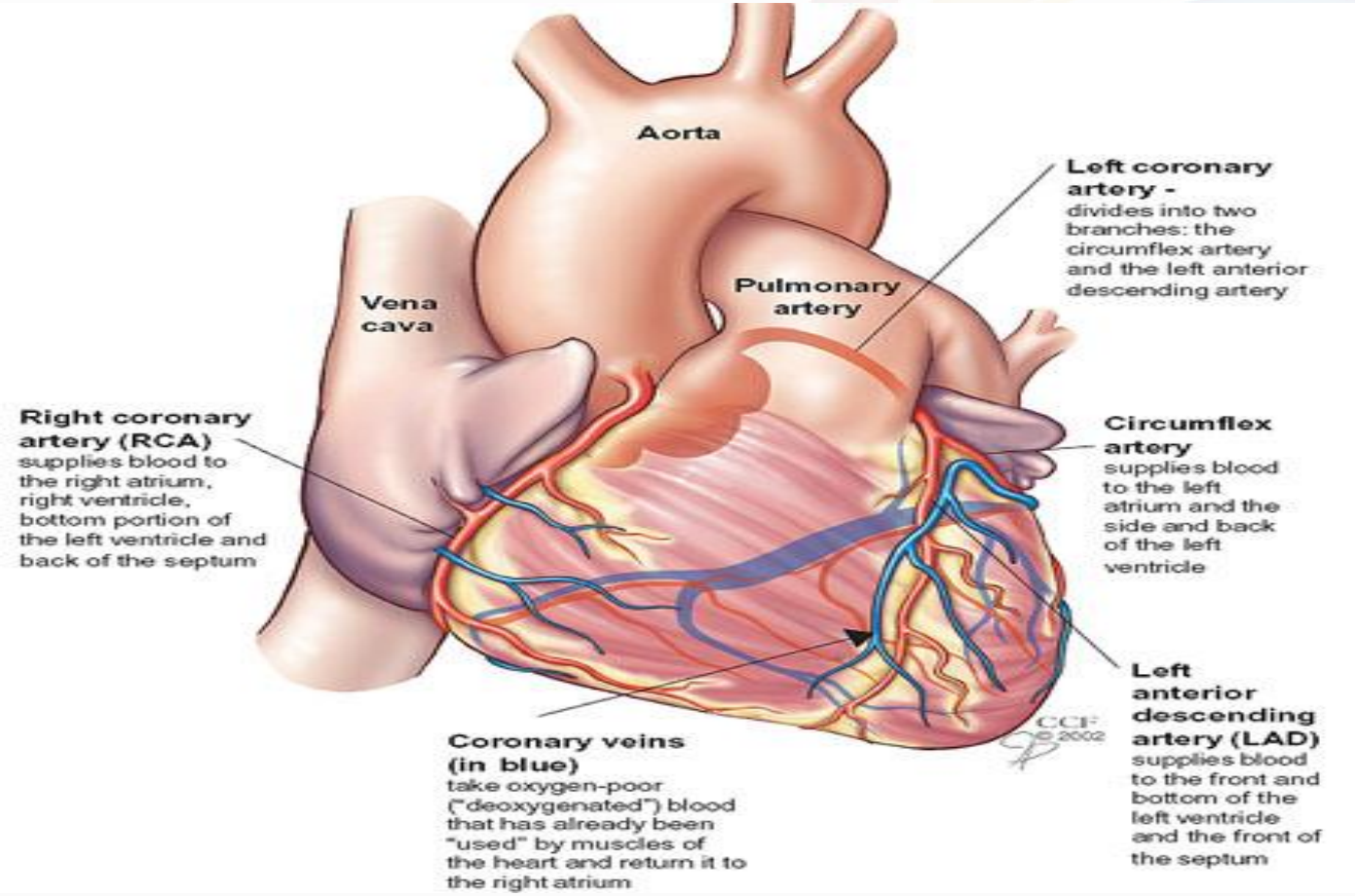
❑**<u>Coronary Arteries</u>**: 2 Main

- Rt. Coronary Artery- branches into marginal arteries; supplies RV and posterior of heart.
- Lt. Coronary Artery- branches into Lt. Anterior Descending and circumflex artery; supplies LV.

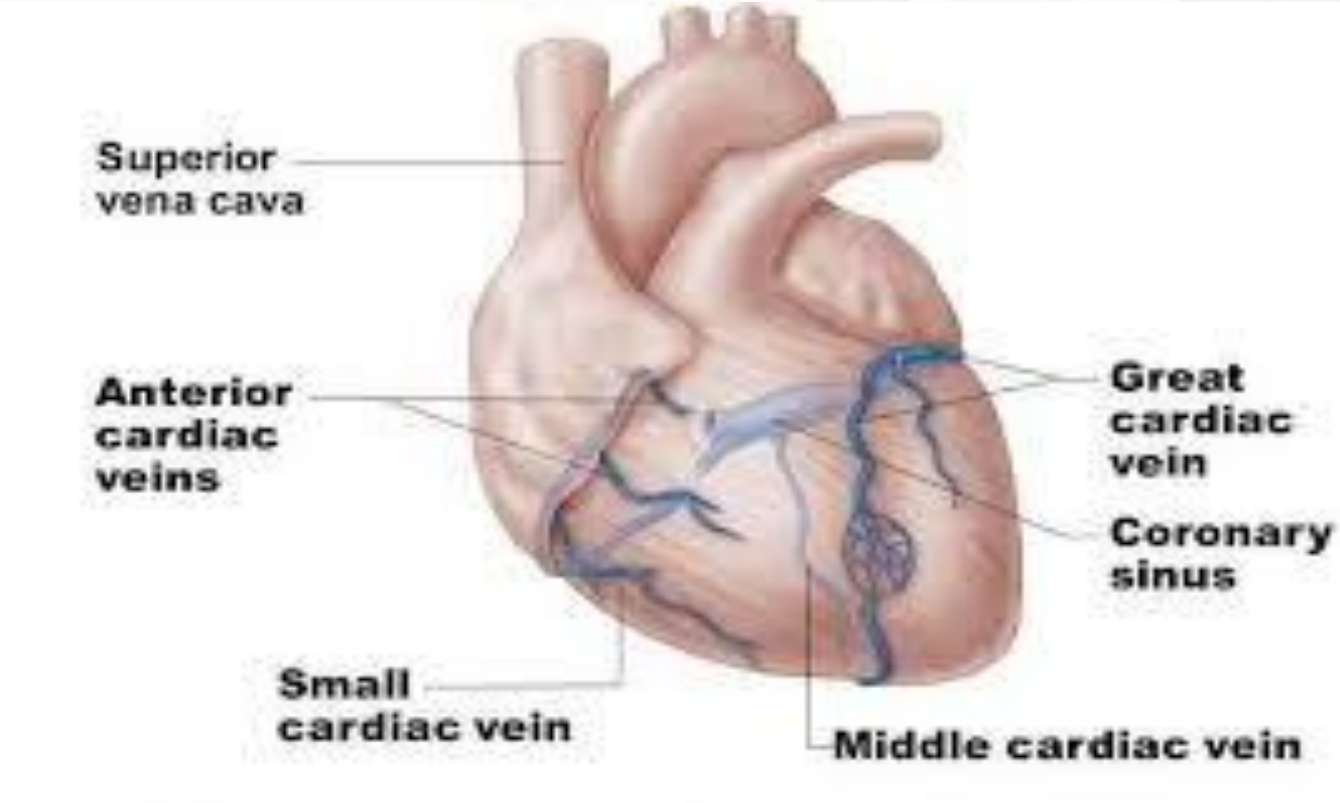
❑**<u>Coronary Veins</u>**

- Small cardiac & Great cardiac veins, Anterior cardiac, Posterior cardiac & Middle cardiac veins
- Transport deoxygenated blood to coronary sinus
- Coronary Sinus drains into RA

Cardiac Arteries



Cardiac Veins



NERVE SUPPLY TO THE HEART

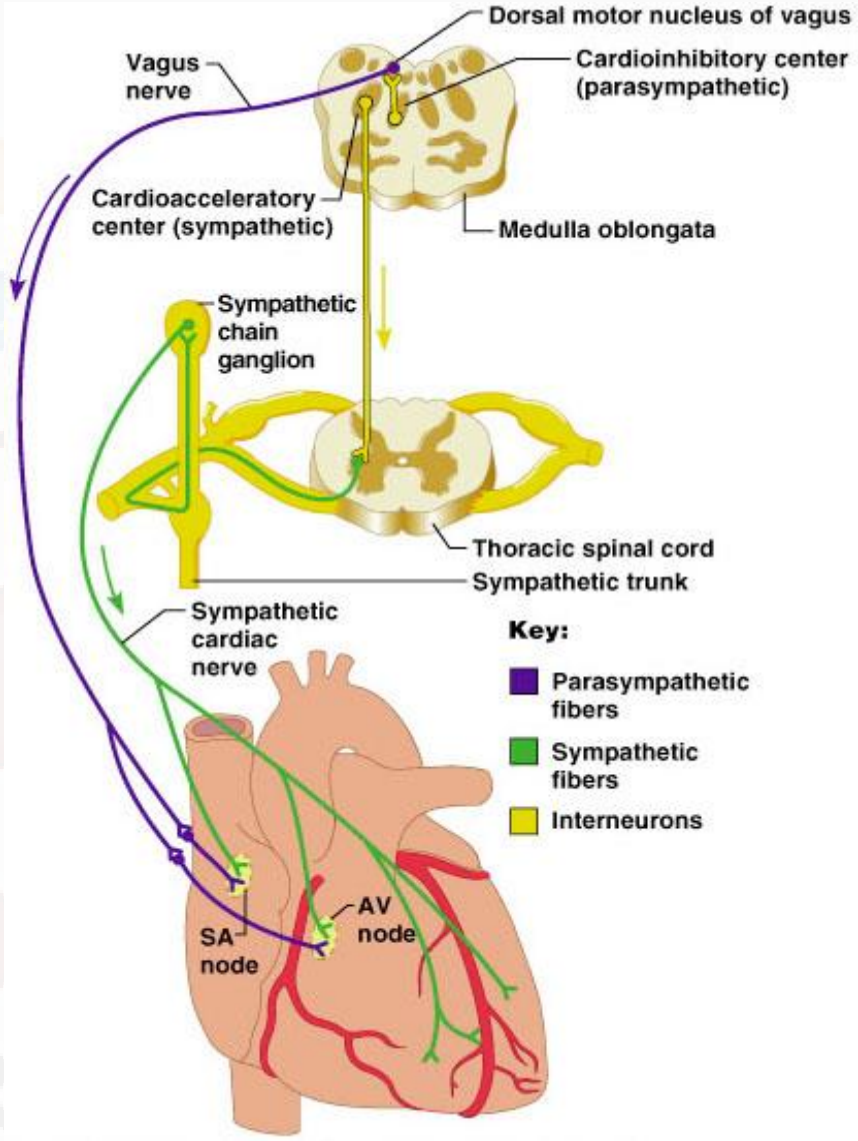
- The fibrous pericardium and the parietal layer of serous pericardium are innervated by **Visceral sensory fibers (**the branches of ***Phrenic nerve***). These fibers carries the sensation of pain.

- **Parasympathetic fibers** (branch of the ***Vagus nerve)*** that are responsible for slowing down of the heart rate, innervate the visceral layer of serous pericardium.

- **Sympathetic fibers** that increase the rate and force of contraction

- Heart is stimulated by the sympathetic cardioacceleratory center.

- Heart is inhibited by the parasympathetic cardioinhibitory center



Heart Valves

- The Heart valves ensure unidirectional blood flow through the heart

- Responds to changes in pressure

- Two types of valves are present in heart:
  1. Atrio-ventricular valves (AV)
  2. Semi-lunar valves

1. **Atrio-ventricular (AV) valves** lie between the atria and the ventricles & prevents backflow into the atria when ventricles contract. Heart contains 2 Atrio-ventricular valves:

- Left AV valve i.e. Mitral valve is bicuspid
- Right AV valve i.e. Tricuspid

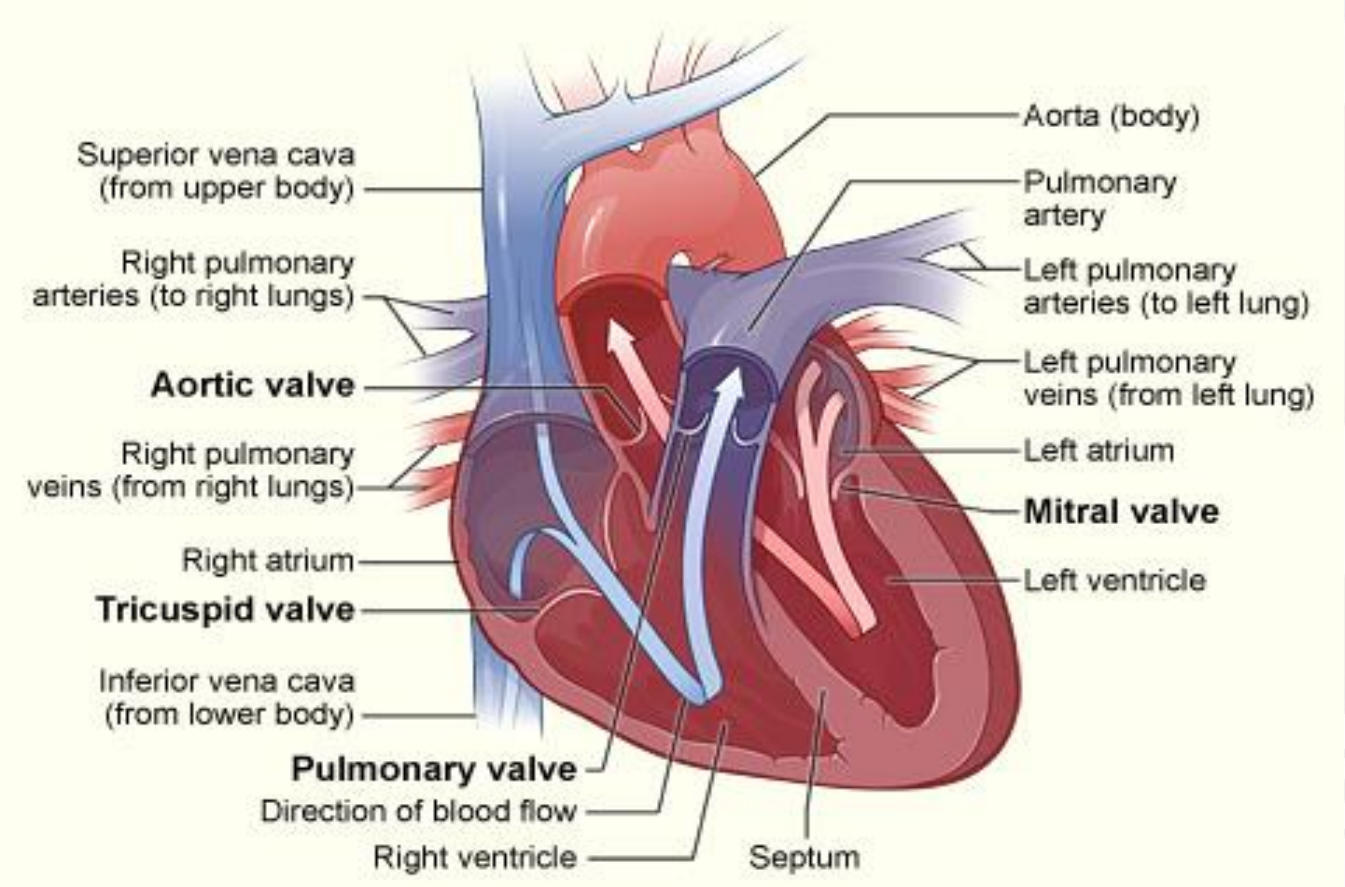
{Chordae tendineae are tiny collagen cords that anchor cusps of valve to papillary muscles}

2. **Semilunar valves** lies b/w the great vessels and ventricles and prevent backflow of blood into the ventricles. Heart contains 2 semilunar valves:

- **Aortic valve** lies between the left ventricle and the aorta

- **Pulmonary valve** lies between the right ventricle and pulmonary trunk

Heart Valves



Septums of the Heart

❑The Heart contains 2 septum:

- **Interatrial septum**: Muscular division between Rt. & Lt. atria. Where the Fossa ovalis also presents i.e. a shallow depression; remnants of foramen ovale (opening in fetus)

- **Interventricular septum** :Thick muscular wall that seperates Rt. & Lt. ventricles.

PATHWAY OF BLOOD THROUGH HEART

- **Right Atrium**: Thinner walls. Receives deoxygenated blood from vena cava. Passes blood through tricuspid valve into right ventricle.
- **Right Ventricle**: Thicker wall than atria. Makes most of the anterior surface of heart. Circulates deoxygenated blood to lungs through the pulmonary valve into pulmonary trunk.
- **Left Atrium**: Receives oxygenated blood from pulmonary vein. Passes blood to left ventricle through mitral valve.
- **Left Ventricle**: Thickest myocardial wall. Forms apex of heart. Receives blood from left atrium & sends it to systemic circulation via aorta.

CARDIAC MUSCLES

1. **Atrial and ventricular muscle fibers**: contracts for longer duration (like skeletal muscle).

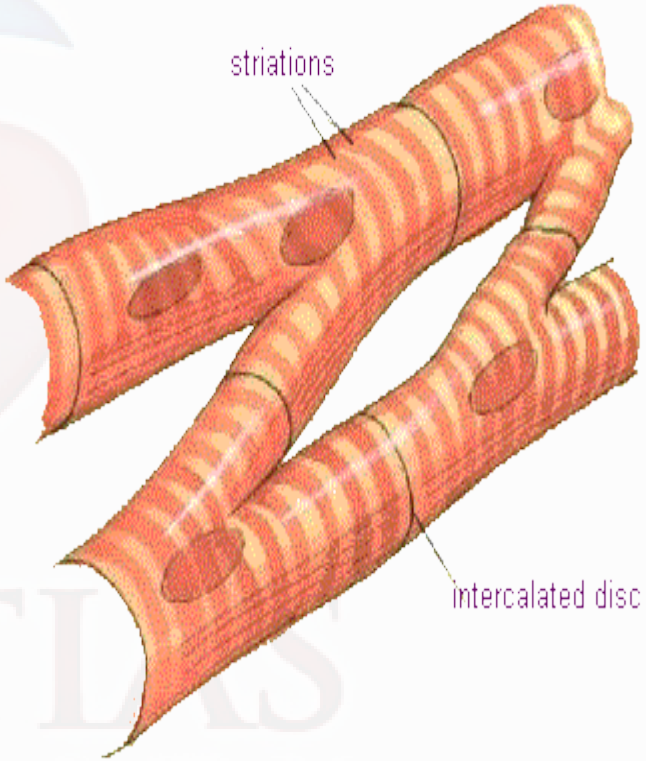
2. **Specialized excitatory & conductive fibers**: contracts very weakly because of few contractile fibrils. Function:

- Generates the automatic electrical discharge in the form of action potentials and
- Conduction of the action potentials through Heart that causes rhythmic beating.

MICROSCOPIC ANATOMY OF HEART MUSCLES

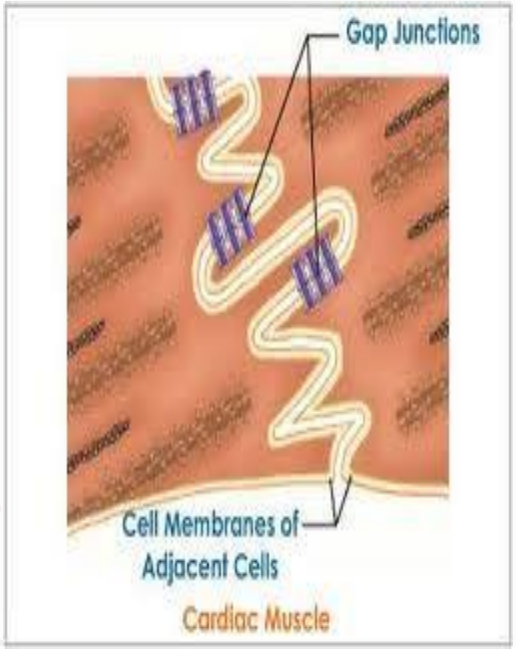
- Cardiac muscle is striated, arranged in latticework, branched, and interconnected.

- They contain ***Actin and Myosin filaments*** that slides over one another during contraction.



CARDIAC MUSCLE AS “SYNCYTIUM”

- Heart muscle contains Intercalated discs that are cell membranes that anchor individual cardiac cells together and allow free passage of ions along the longitudinal axis of the cardiac muscle fibers & hence the action potential is generated.



PROPERTIES OF CARDIAC MUSCLE

- **AUTOMACITY:** Capability of stimulated by nerves as well as self-excitable.
- **RHYTHMICITY:** Heart beats are extremely regular.
- **CONTRACTIBILITY:** Cardiac muscle contracts in response to stimulus.
- **EXCITABILITY:** Ability of cardiac muscles to respond to different stimuli.

- **<u>CONDUCTIVITY</u>:** Impulses produced in the SA nodes are conducted by specialized conducting pathway.

- **<u>DISTENSIBILITY</u>:** Occurs due to compliance of cardiac muscle.

- **<u>FUNCTIONAL SYNCYTIUM</u>**: allows the atria to contract for shorter duration & before ventricular contraction.

ACTION POTENTIAL IN CARDIAC MUSCLE

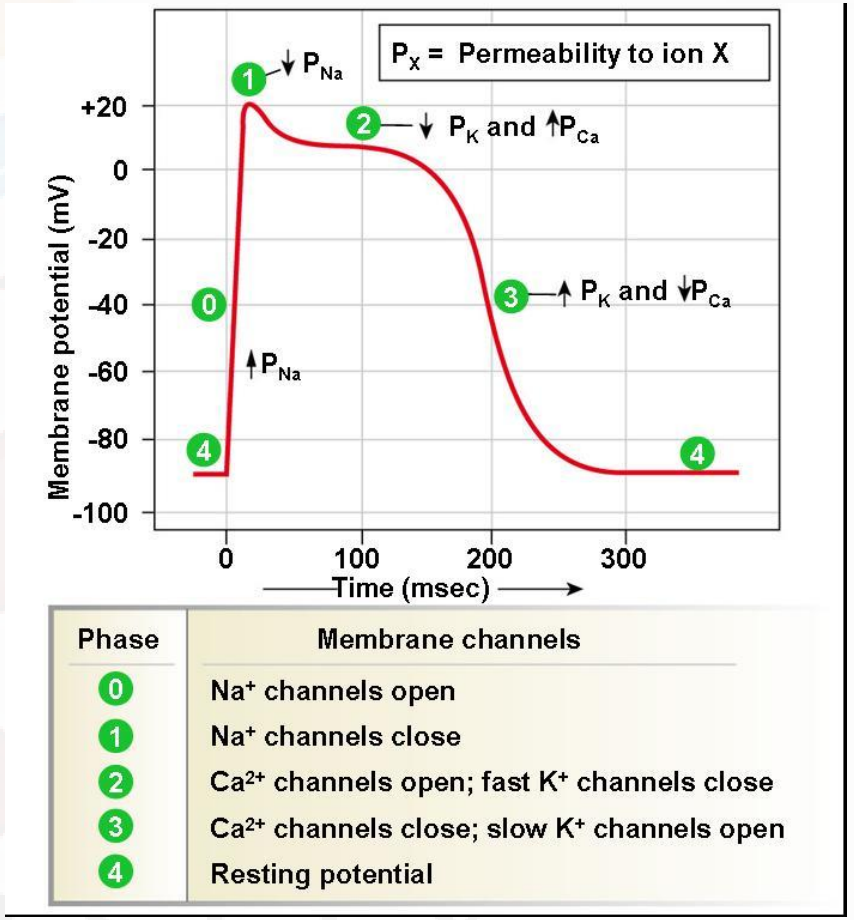
- In cardiac muscle, the action potential is caused by opening of two types of channels:

  (1) the *fast sodium channels and*

  (2) the slow calcium channels (also k/a calcium-sodium channels)

- Calcium channels are slower to open and remain open for several tenths of a second. During this time, a large quantity of both calcium and sodium ions flows through the cardiac muscle fiber and maintains a prolonged period of depolarization, causing the plateau in the action potential.

- When the slow calcium-sodium channels closes at the end of 0.2 to 0.3 second and the influx of calcium and sodium ions stops, the membrane permeability for potassium ions increases rapidly; this rapid loss of potassium from the fiber immediately returns the membrane potential to its resting level, thus ending the action potential.



Phase	Membrane channels
0	Na^+ channels open
1	Na^+ channels close
2	Ca^{2+} channels open; fast K^+ channels close
3	Ca^{2+} channels close; slow K^+ channels open
4	Resting potential

References

- Guyton and Hall Textbook of Medical Physiology - 12th-Ed
- https://images.app.goo.gl/E5BQY1pFsniiCbLV7
- https://images.app.goo.gl/kXnMFpKWQRJJh8Ru8
- Cardiovascular and Pulmonary Physical Therapy Evidence to Practice Frownfelter Donna, Elizabeth 5th EDITION.
- https://images.app.goo.gl/o5ezHkVWosiVd9di7

Thank You.