

THE CARDIOVASCULAR SYSTEM



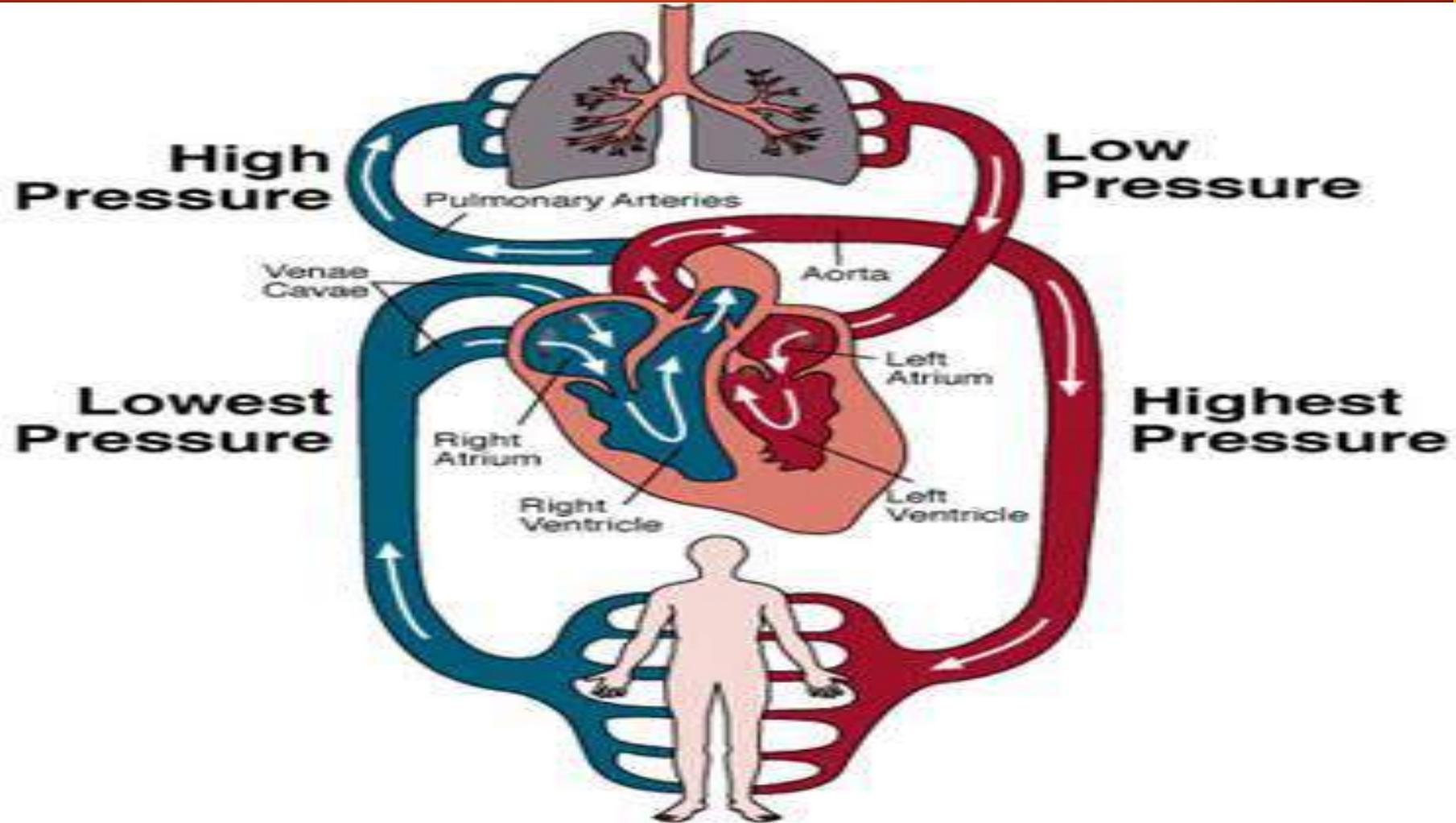
CVS MODULE

Semester 1, Year 3

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Circulatory system



1. The Cardiovascular System
2. The Lymphatic system

The Cardiovascular System

Heart: serves as pumping unit of blood

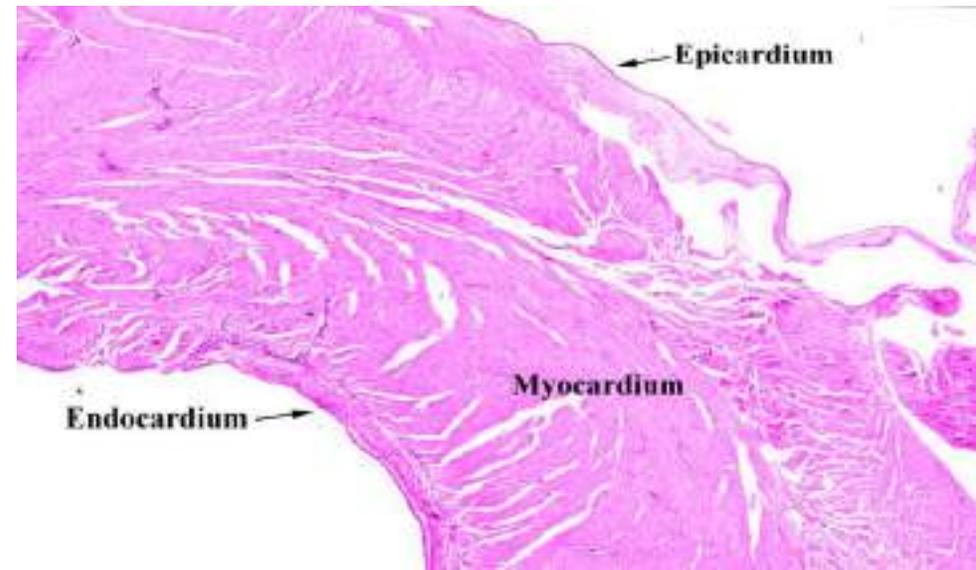
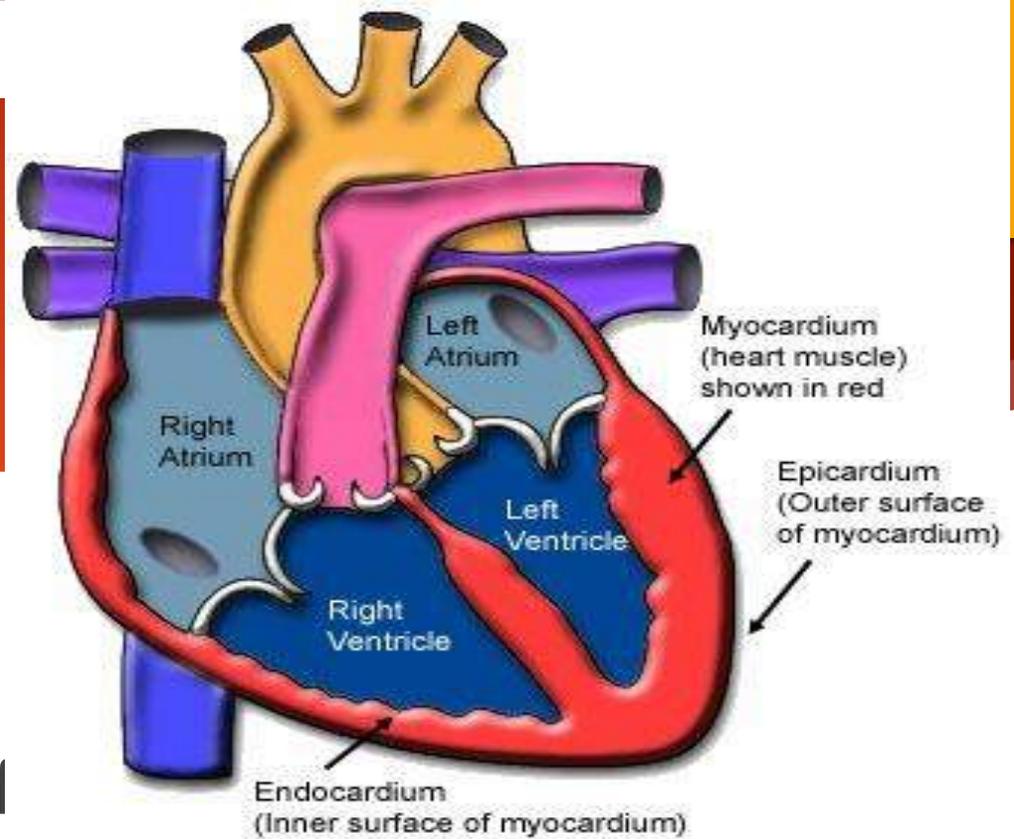
Arteries: Transport bl. from heart to peripheral tissues.

Capillaries: where exchange of materials occurs.

Veins: return blood back to heart

The Heart

- ▶ Heart is muscular organ consists of four chambers.
- ▶ Wall of the heart is formed of three coats: endocardial, myocardial and epicardium layer
- ▶ Covered by pericardium



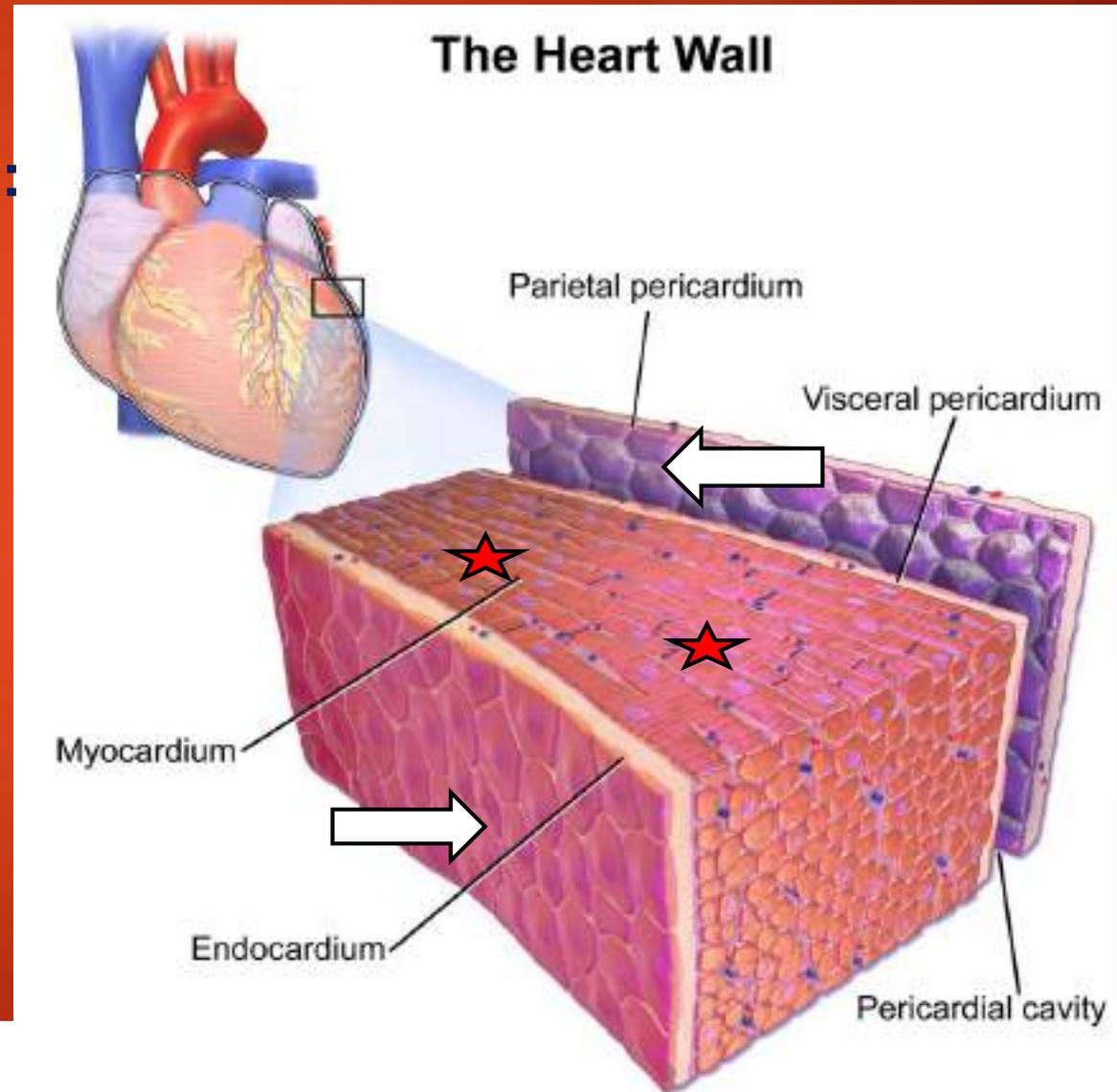
Structure of the wall of Heart

FORMED OF THREE LAYERS:

A-THE EPICARDIUM

B-THE MYOCARDIUM

C-THE ENDOCARDIUM



Microscopic structure of heart wall

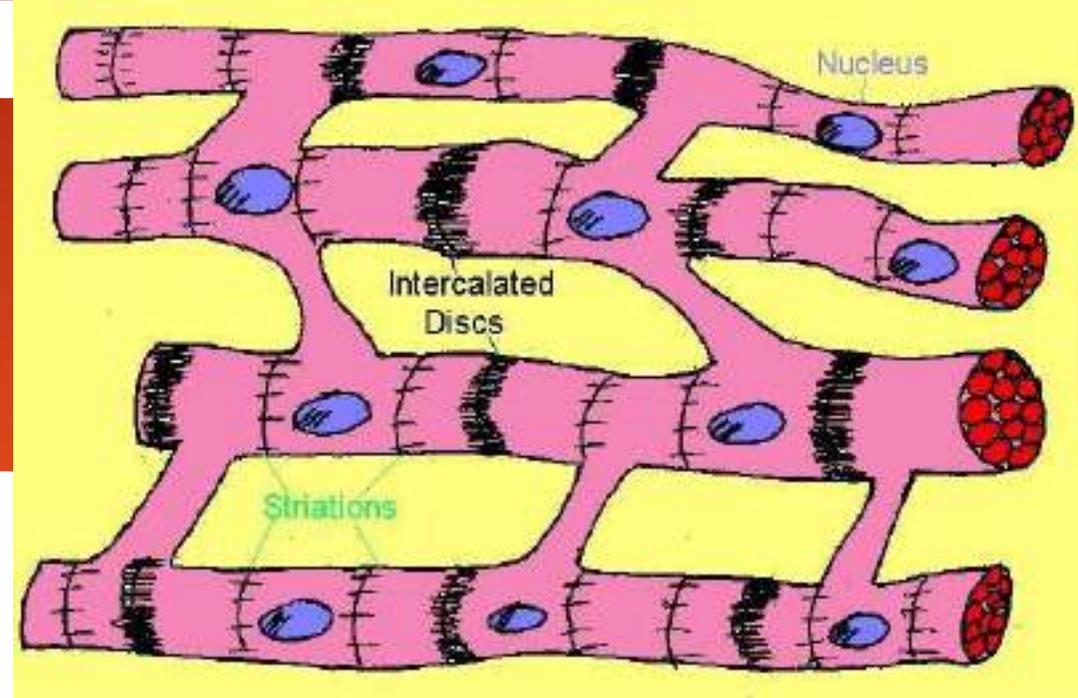
1- **Endocardium**: inner lining layer, formed of:

a. **Endothelium**: simple squamous layer. Cells are joined with tight and gap junctions, resting on a continuous basal lamina.

b. **Subendothelial C.T.**: loose C.T., contains elastic and collagen fibers.

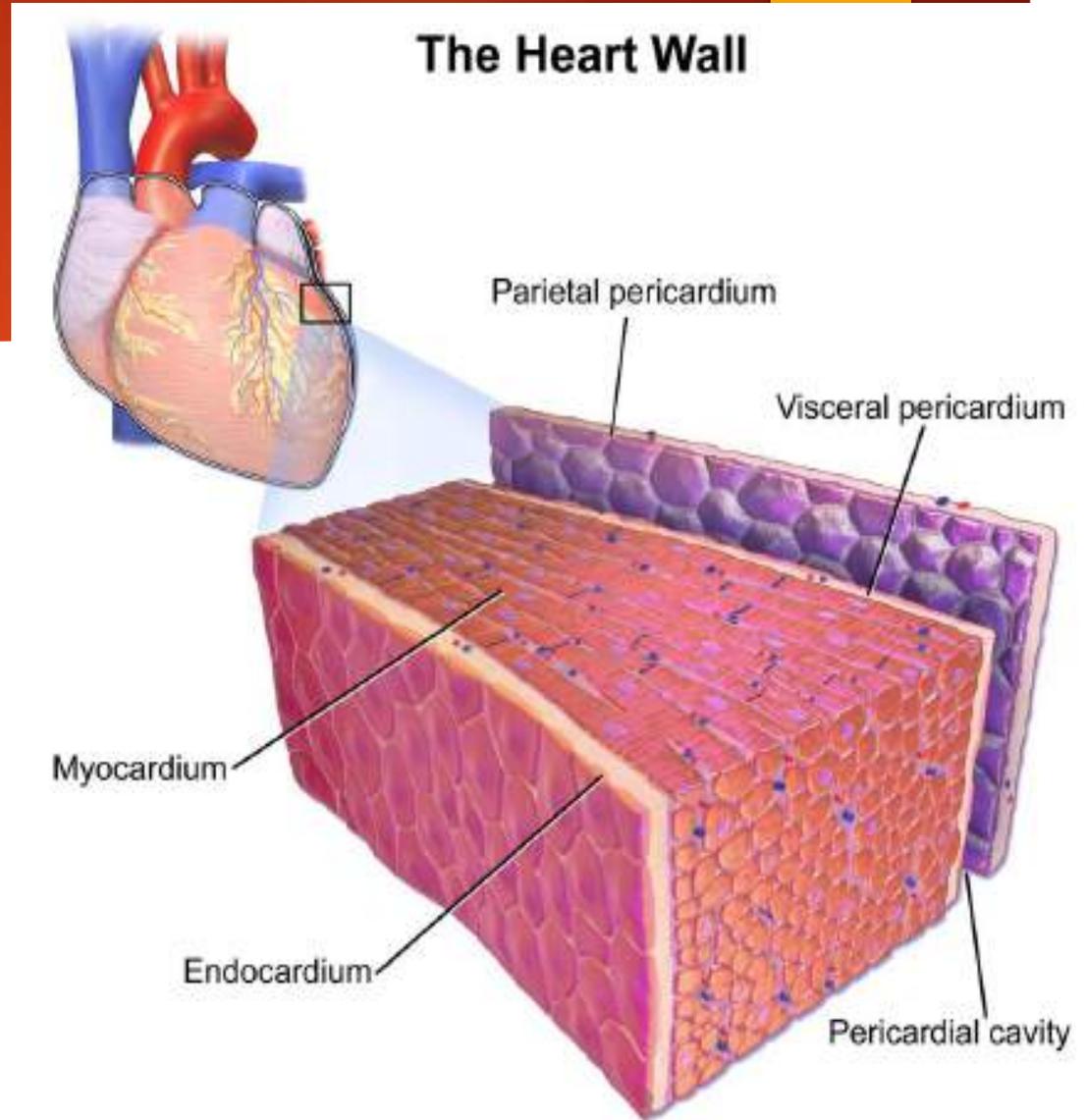
2- Myocardium:

- ▶ Forms main the wall.
- ▶ Formed of network of cardiac muscle fibers that are thinner in atria than ventricle. It contains in-between rich capillary network.



3- Epicardium:

Represents visceral layer of pericardium (serous membrane)
Covers outer surface.
Rests on loose C.T. which contains fat cells and coronary blood vessels.



THE HEART

Pericardium

1. Parietal pericardium outer membrane

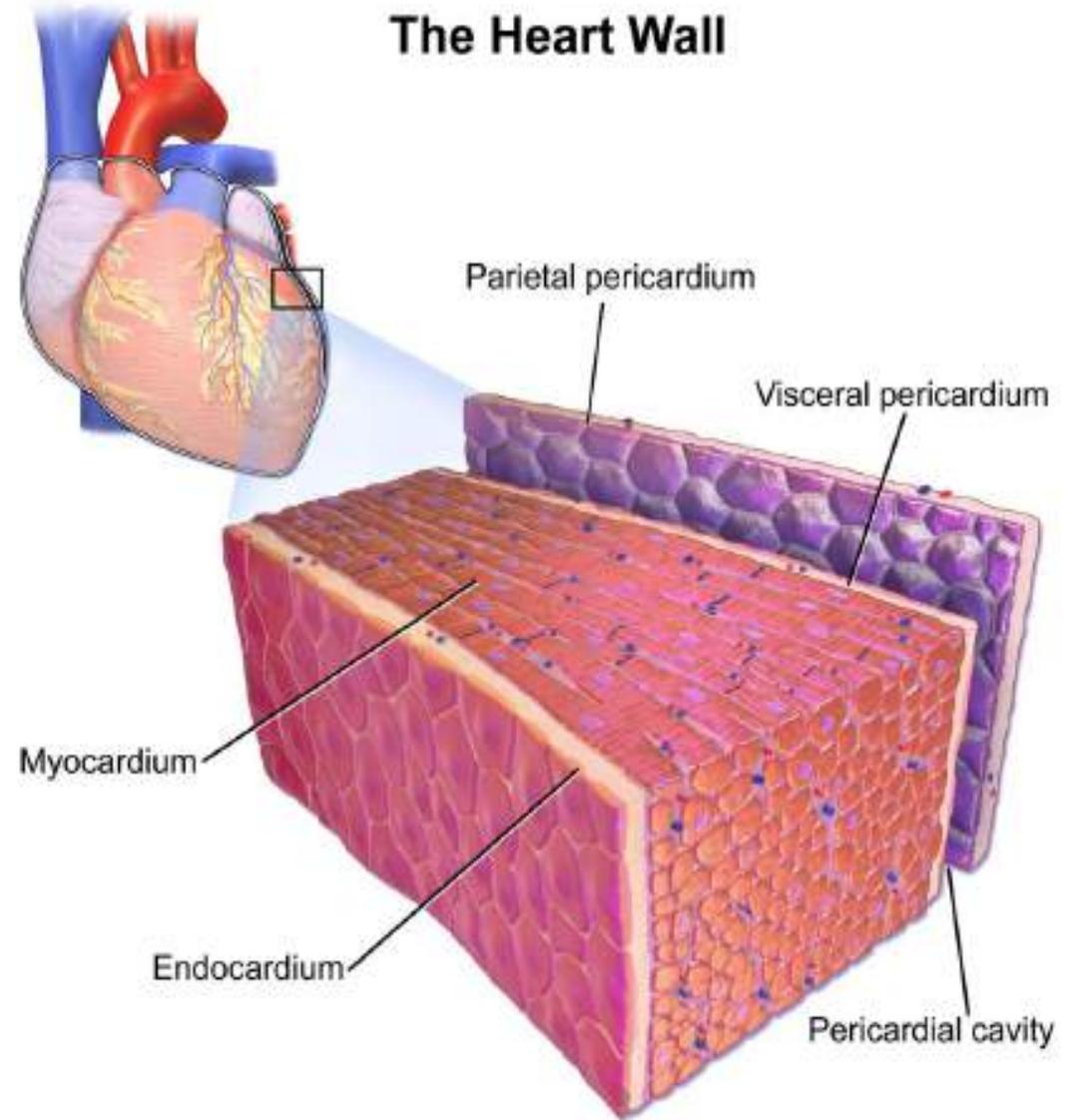
- **fibrous layer** tough, white fibrous
- **-serous layer** a thin fibrous layer on top of a simple squamous mesothelium

2. Visceral pericardium= epicardium

=serous layer

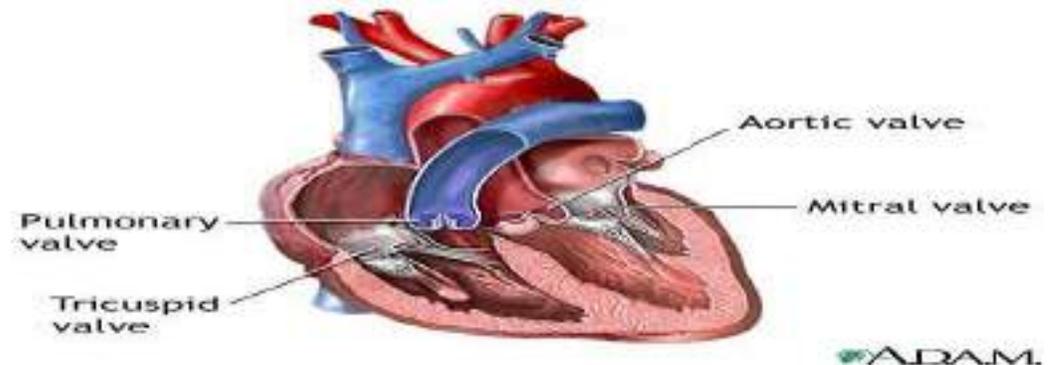
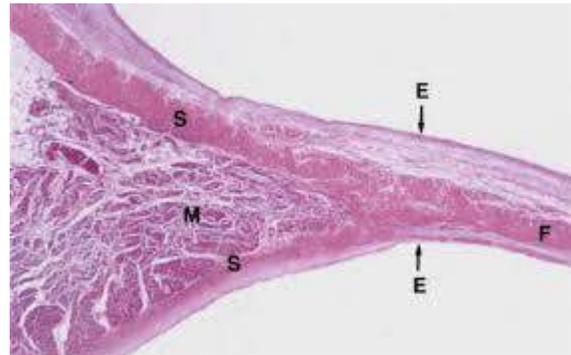
Pericardial cavity filled with **serous fluid**
preventing friction

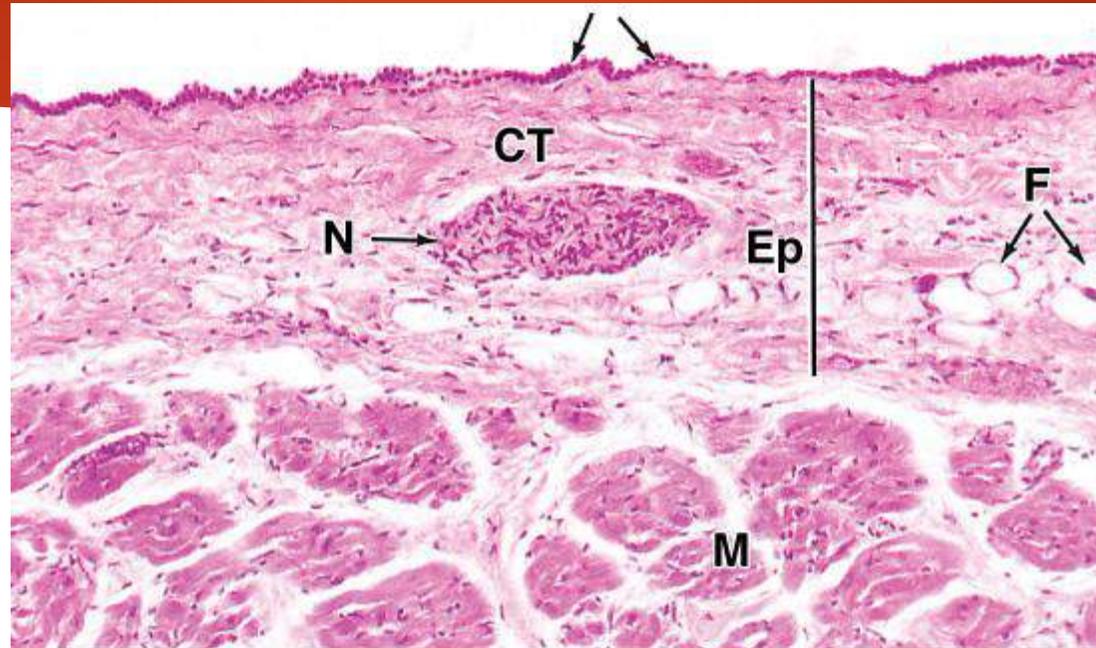
Pericarditis is an inflammation of the pericardium.



Valves of the heart:

- ▶ They are folds of endocardium, covered with endothelium from both sides, with middle supporting plate of dense fibrous C.T. and elastic fibers.
- ▶ They are present between atria and ventricles, at openings of pulmonary artery and aorta. They are similar in structure.





Source: Mescher AL: *Junqueira's Basic Histology: Text and Atlas, 12th Edition*: <http://www.accessmedicine.com>
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Structure of cardiac muscle

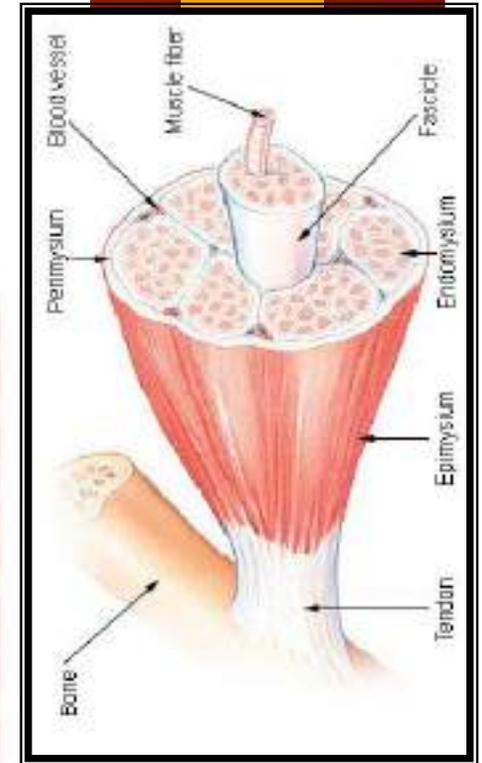
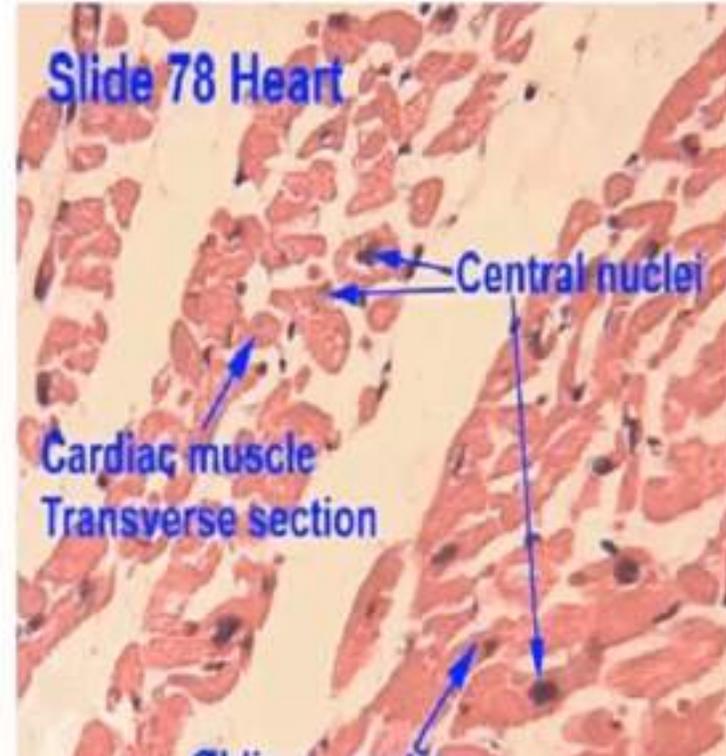
LM

1- Connective tissue

- It consists of:

1- Perimysium: highly vascularized, formed of collagen and elastic fibers, which are present between the bundles of cardiac muscle fibers.

2- Endomysium: a network of reticular fibers surrounds each muscle fiber.



Cardiac Muscle

Histological Structure

Definition: Cardiac muscle fibers present in the wall of the heart.
Mesodermal in origin. Cannot divide
Cannot regenerate: heal by fibrosis

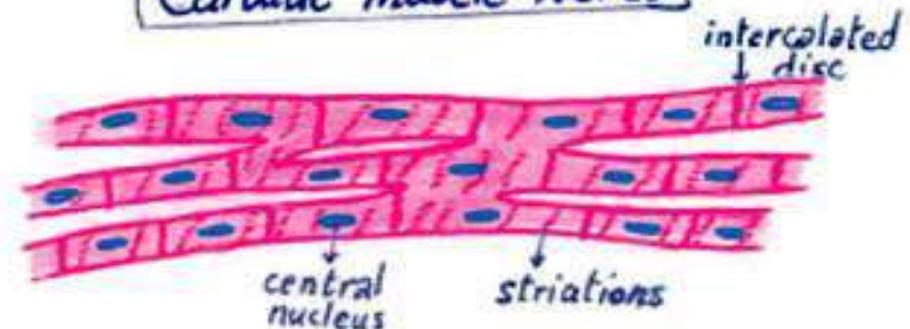
They are **involuntary** in action and show **faint** and indistinct transverse **striations**.

- The cardiac muscle fibers are **smaller** in size compared with skeletal muscle fibers.

L.S. In Skeletal Muscle



Cardiac muscle fibres

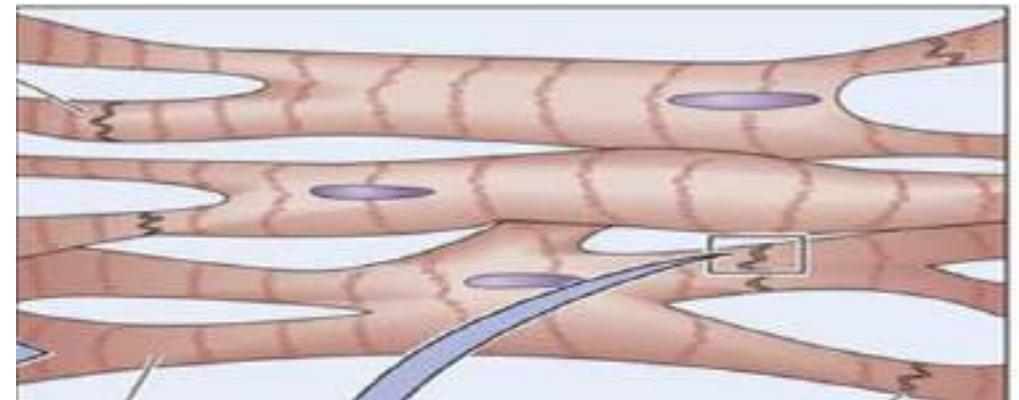
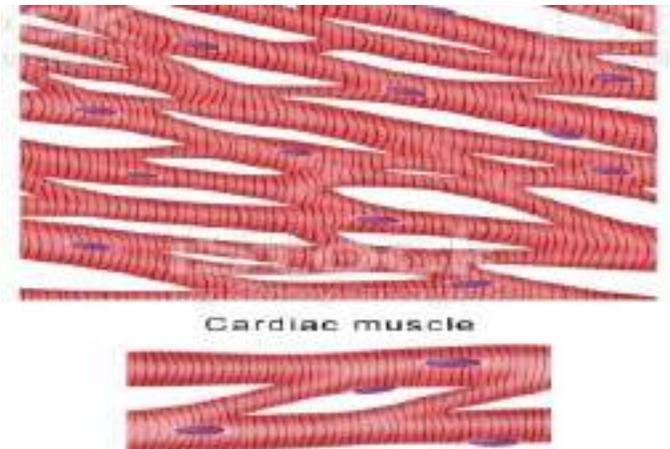


- **Shape:**

- ***LM Cardiac Muscle***

- Cardiac muscle fibers are composed of several cardiac muscle cells (cardiomyocytes). They are cylindrical and branch and anastomose with each other. Cytoplasm show **faint** and indistinct transverse **striations**.

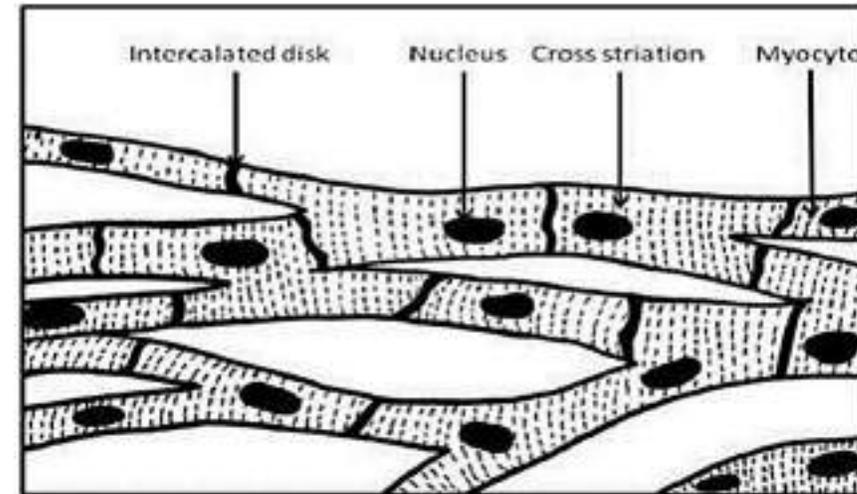
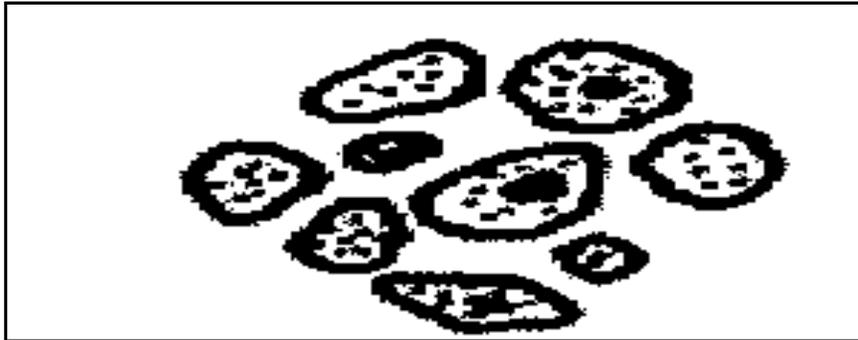
- **Nucleus:** one or two centrally located, oval and pale stained nuclei.



Cardiac Muscle L/M

T.S.

L.S.



Each fibre is formed of cells = myocytes
separated by intercalated disc



▪ 1- EM *Cardiac Muscle*

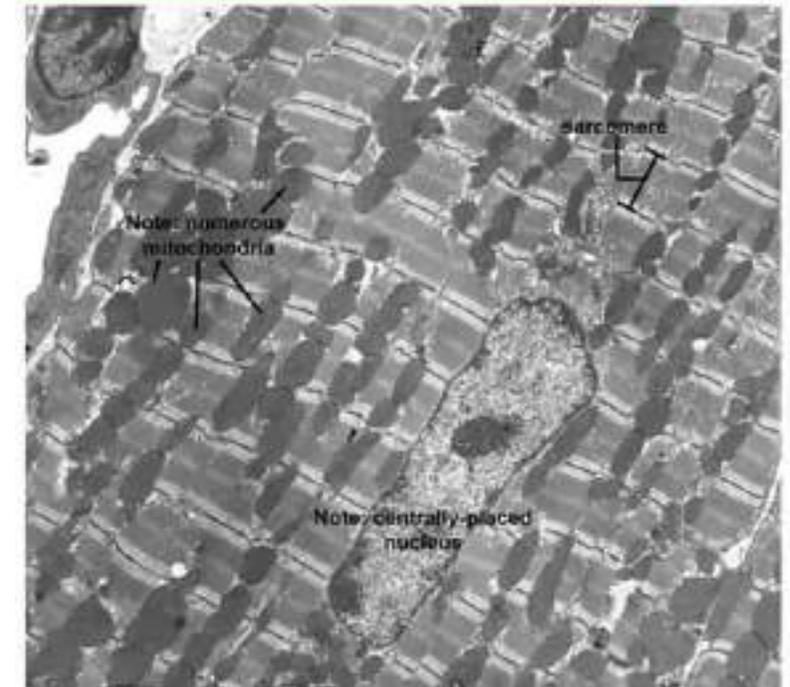
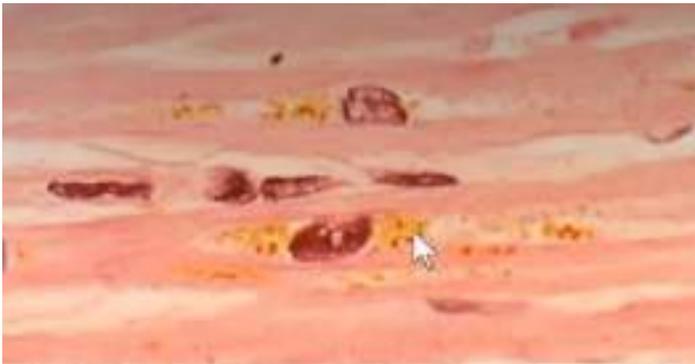
myofibrils: few

Mitochondria more numerous, larger with more cristae

s- ER: one terminal tubule accompany T- tubule

Diad of tubular syst.

Glycogen granules –lipofuscin pigments

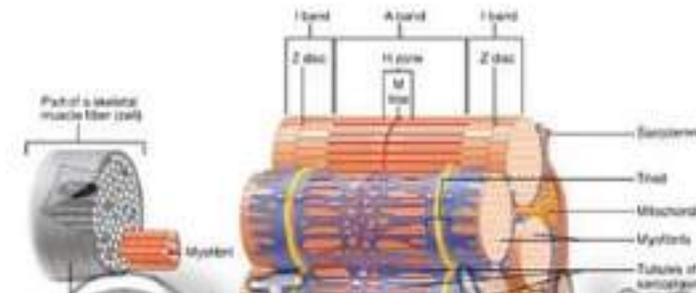
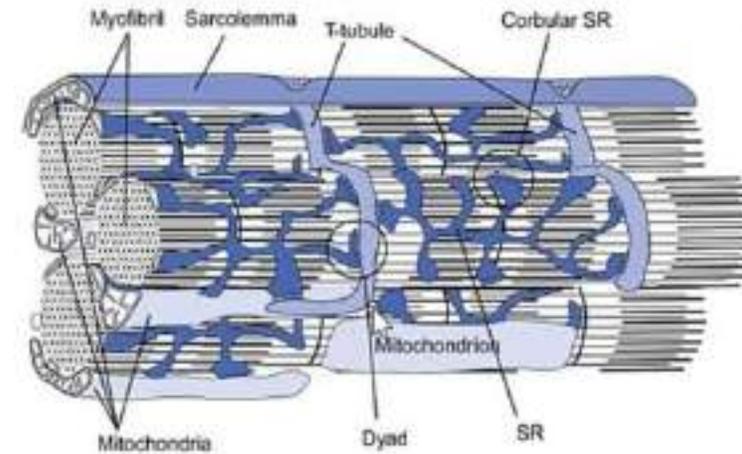
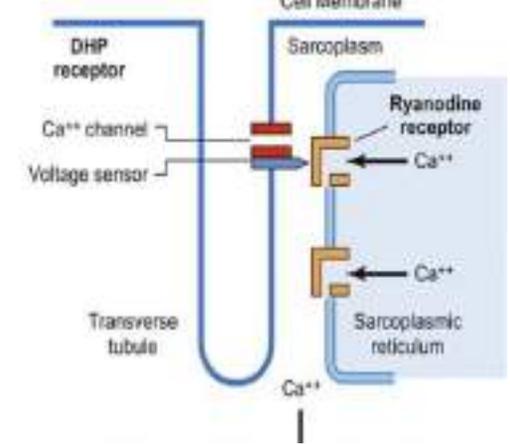


Structure of cardiac muscle

EM

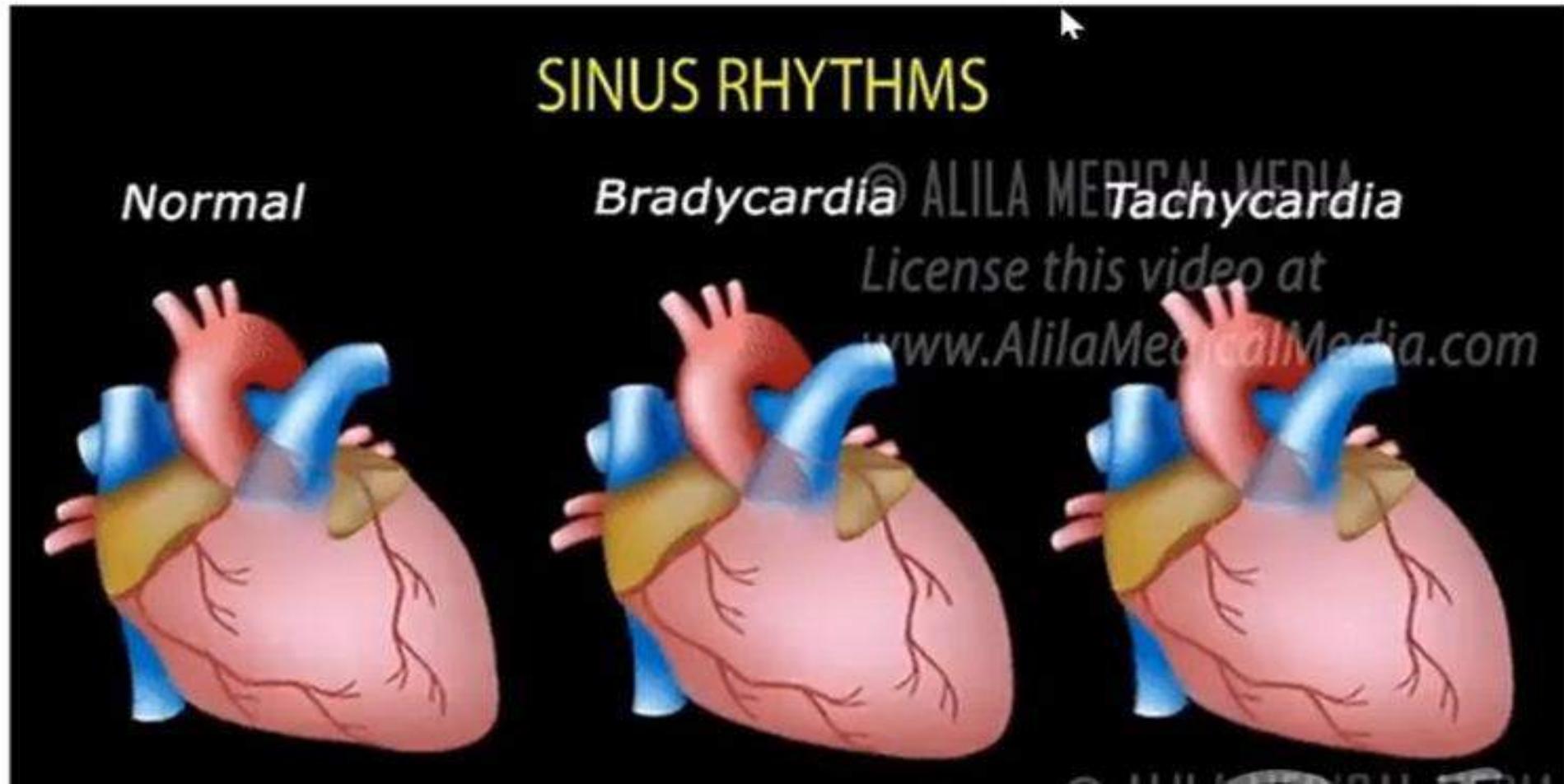
2- T tubules

- **Definition:** inward extensions of the extracellular space at the sarcolemma.
- **Site:** at the Z line.
- **Characteristic features:** large & numerous.
- **Function:**
 - Excitation-contraction coupling.
 - Provide additional surface area for exchange of metabolites between cardiac muscle fibers and the extracellular space.



Cardiac Arrhythmia

Role of calcium

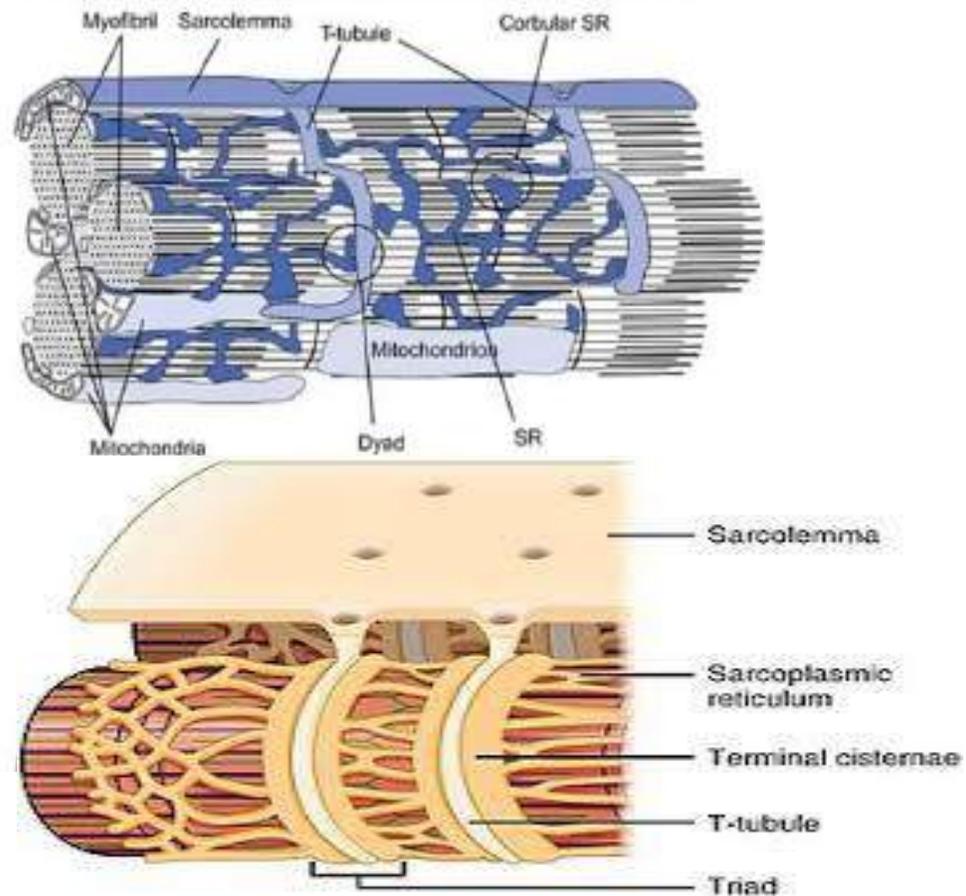


Structure of cardiac muscle

EM

3- Sarcoplasmic reticulum

- It is less organized than the skeletal muscle.
- It consists of narrow anastomosing sarcotubules *without the continuous terminal cisternae* that encircle the whole myofibrils, instead, scattered small expansions of sarcotubules are in close apposition with the T tubules forming *diads*.

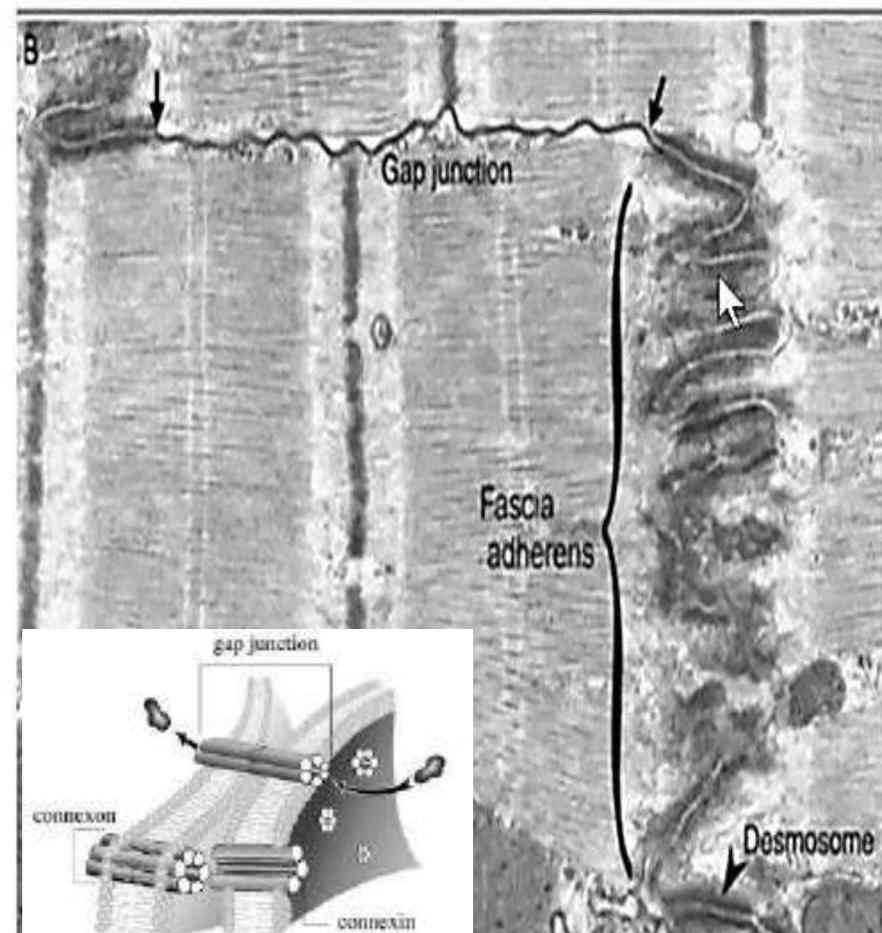


Structure of cardiac muscle

EM

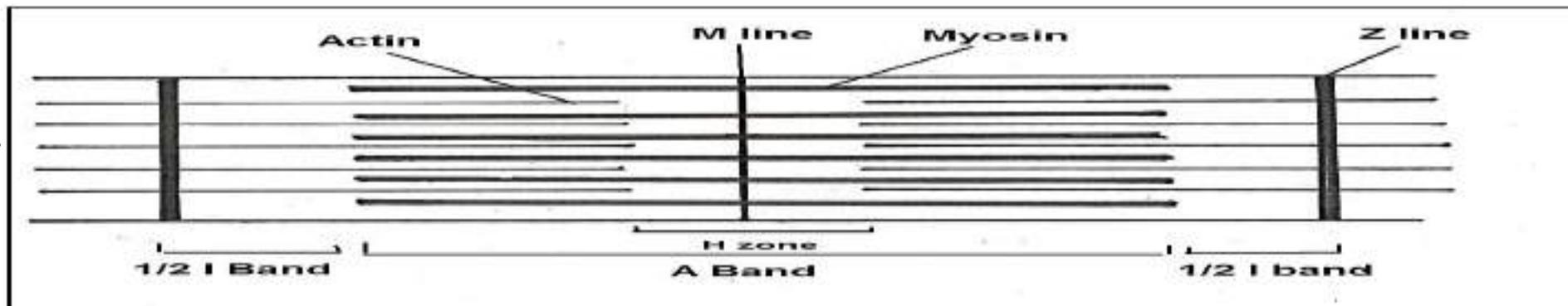
4- Intercalated discs

- **Definition:** specialized junctions of cell membranes of adjacent cardiomyocytes.
- **Site:** extend across the fiber at the level of the Z lines.
- **Shape:** stepwise.
- **Structure:**
 - 1- Transverse portion:
 - **Site:** runs across the fibers perpendicular to the myofilaments at the level of the Z line.
 - **Structure:** It is formed of fascia (zonula adherens) and macula adherens (desmosomes attached to desmin)
 - **Function:** provide strong adhesion between the adjacent cardiomyocytes.
 - 2- Longitudinal portion:
 - **Site:** runs parallel to the myofilaments
 - **Structure:** many gap junctions.
 - **Function:** allow rapid spread of excitation between the adjacent cardiomyocytes.

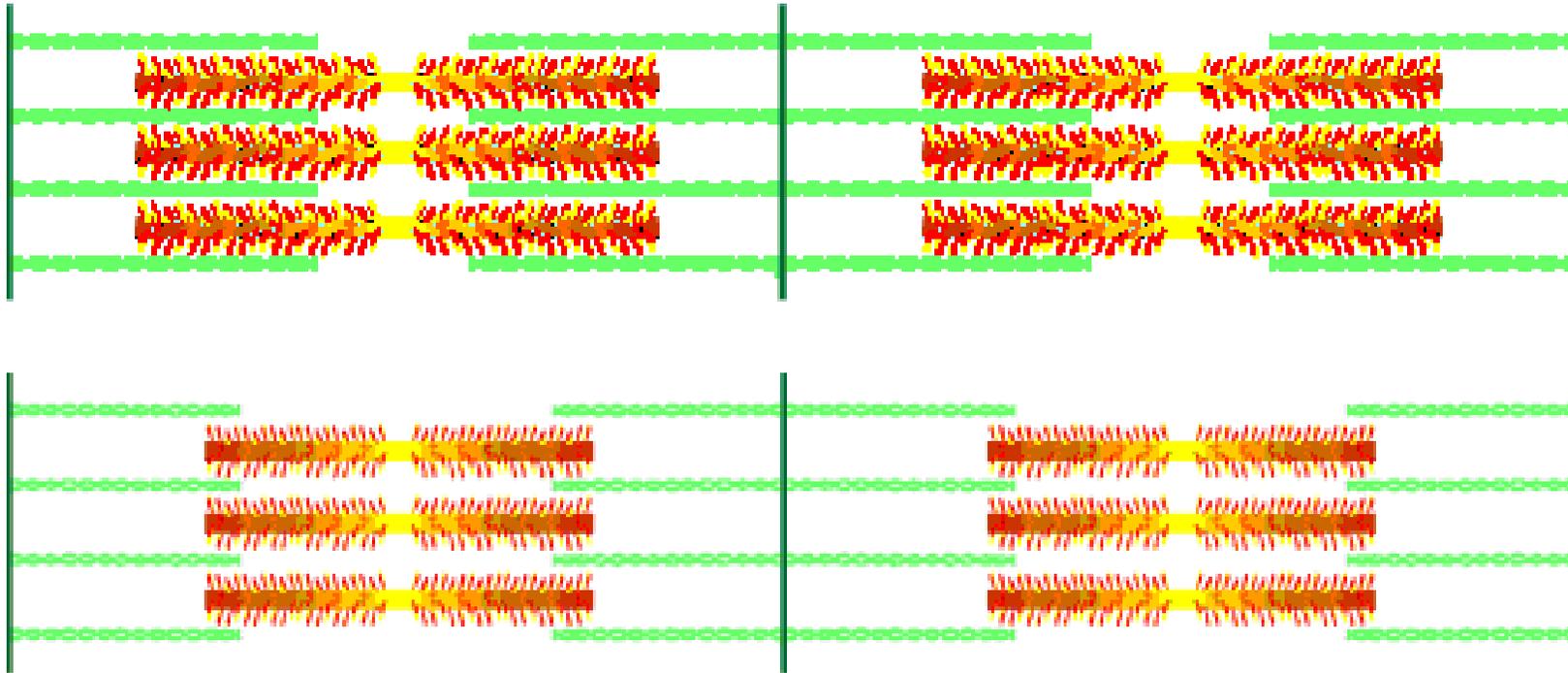


Sarcomere

1. It is the part of the myofibril between **two successive Z** lines.
2. It is the **functional** unit of the muscle fiber.
3. Each contains **1 complete A(dark)** band separating **2 halves I (white) bands**.
4. During contraction: actin glides over myosin → shortening of sarcomere & disappearance of H- zone. Only I- band is shortened while A- band is constant

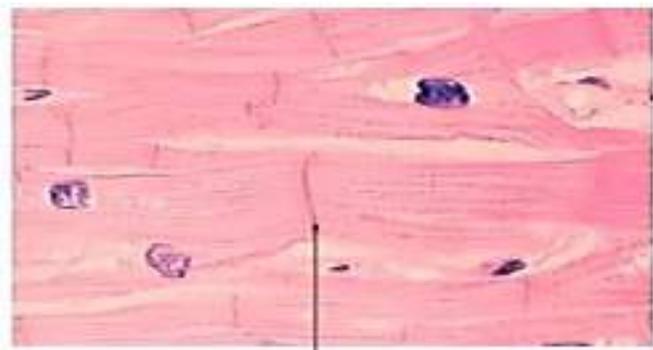


Animation of sliding filaments

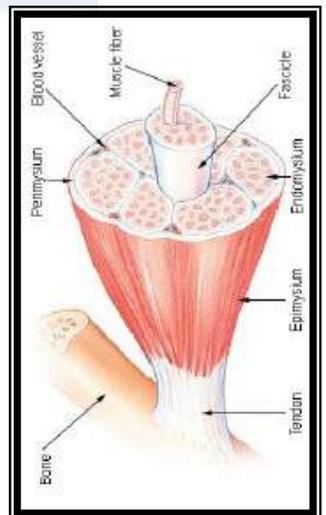
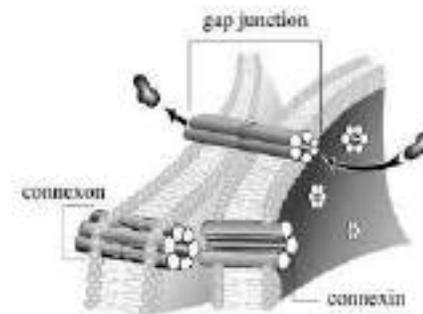
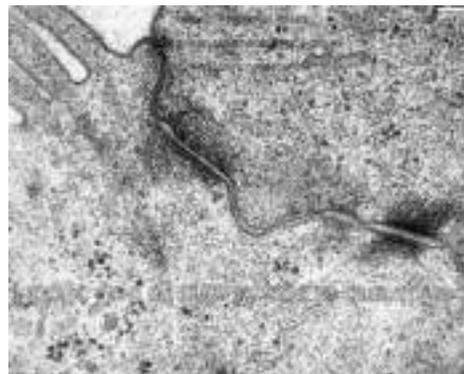


Thick filaments (red/yellow) = myosin motor protein
Thin filaments (green) = actin cytoskeletal protein

Intercalated discs	Transverse portion	Longitudinal portion
Site	Perpendicular to myofilaments, at the level of Z line.	Parallel to myofilaments.
Stress of contraction	↑↑	↓
Structure	1- fascia adherence 2- macula adherence	Gap junctions
Function	Strong adhesion between the cells during contraction	Rapid spread of excitation from one cell to the other



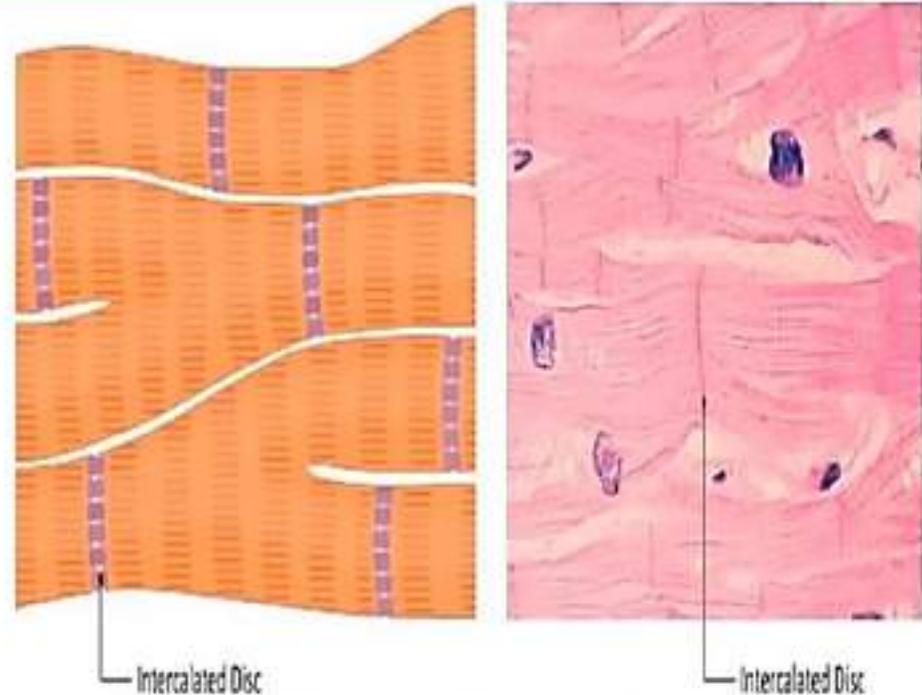
Intercalated Disc



Types of cardiomyocytes

1- Contractile cardiomyocytes

- **Definition:** They are the ordinary cardiomyocytes that form the majority of the myocardium of the atria and ventricles.
- **Function:** contraction.

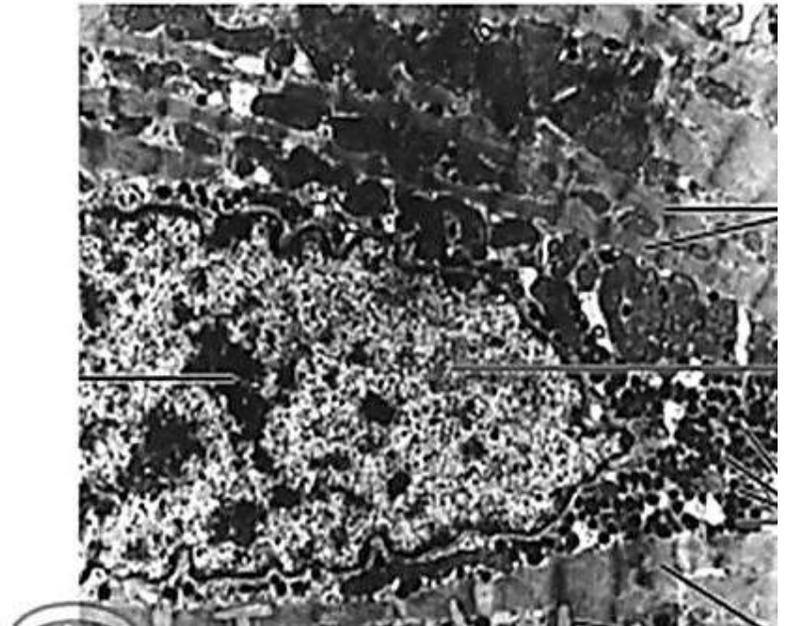


Types of cardiomyocytes

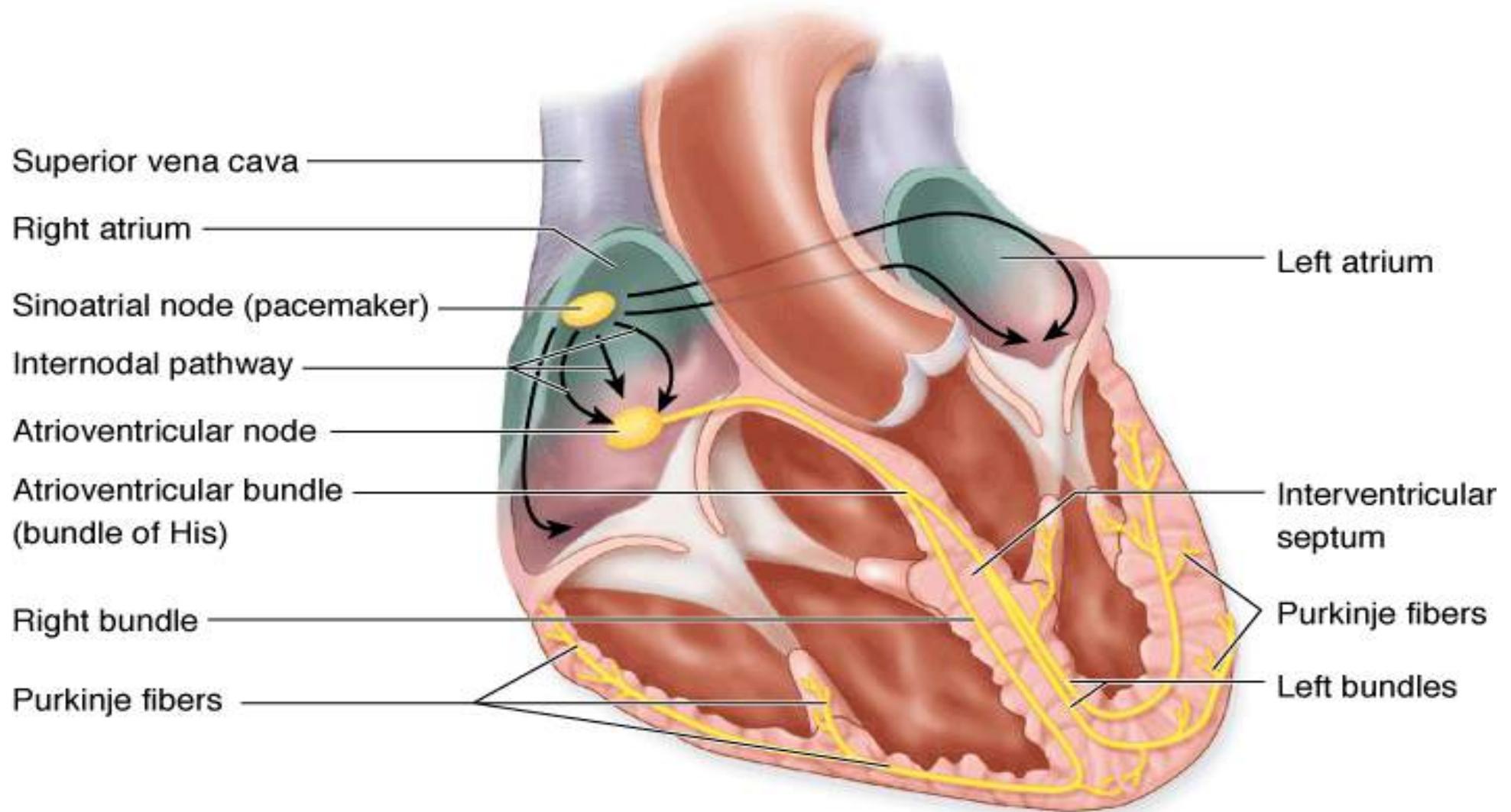
2- Endocrine cardiomyocytes

- **Definition:** They are cardiomyocytes which have an endocrine function.
- **Site:** in the atria, especially the right atrium.
- **Structure:** *They differ from contractile cardiomyocytes in:*
 - 1- They have fewer myofibrils.
 - 2- They have numerous electron dense secretory granules containing *the atrial natriuretic factor* which has a role in control of blood pressure and electrolyte balance.

Atrial endocrine cardiomyocytes



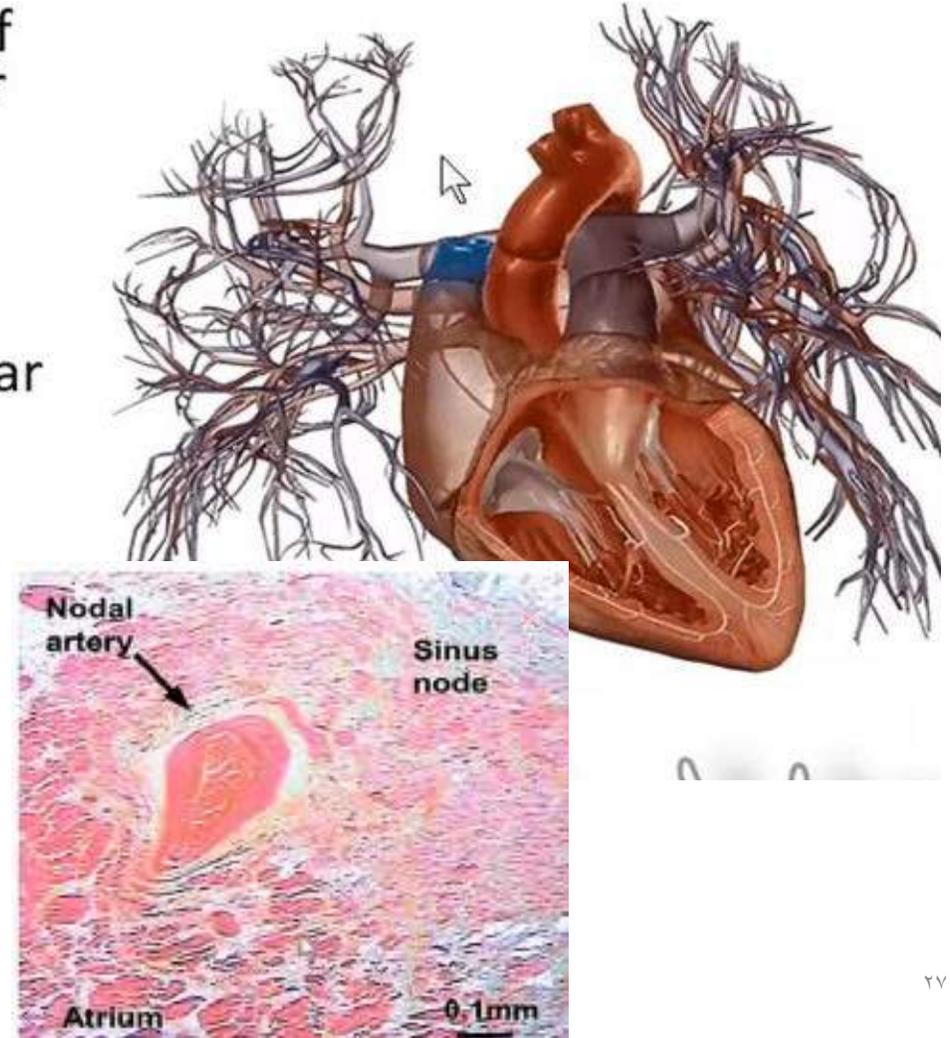
Conduction system of the heart



Types of cardiomyocytes

3-Cardiomyocytes of the conduction system

- **Definition:** modified cardiomyocytes that are specialized in the initiation and propagation of depolarization through the myocardium faster than the contractile cardiac muscle fibers.
- **Types:**
 - a) **Nodal cells:**
 - **Site:** in the sinoatrial node, the atrio-ventricular node and the trunk of the bundle of His.
 - **Structure:**
 - 1-They are smaller than the surrounding atrial muscle fibers.
 - 2- Contain fewer myofibrils.
 - 3- Lack typical intercalated discs.

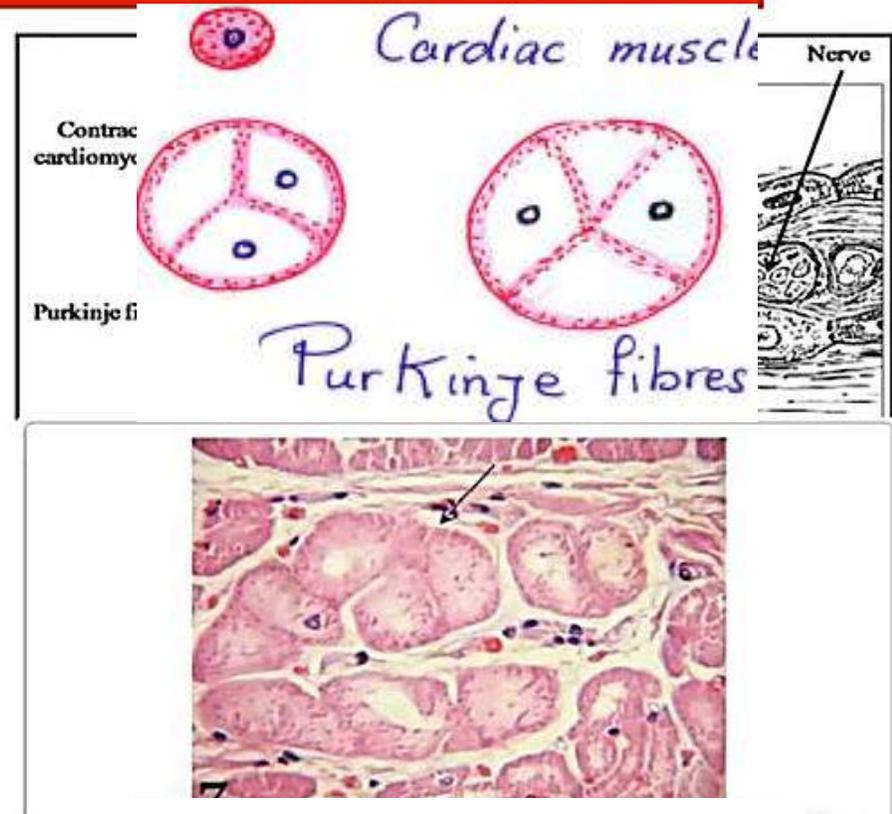


Types of cardiomyocytes

3-Cardiomyocytes of the conduction system

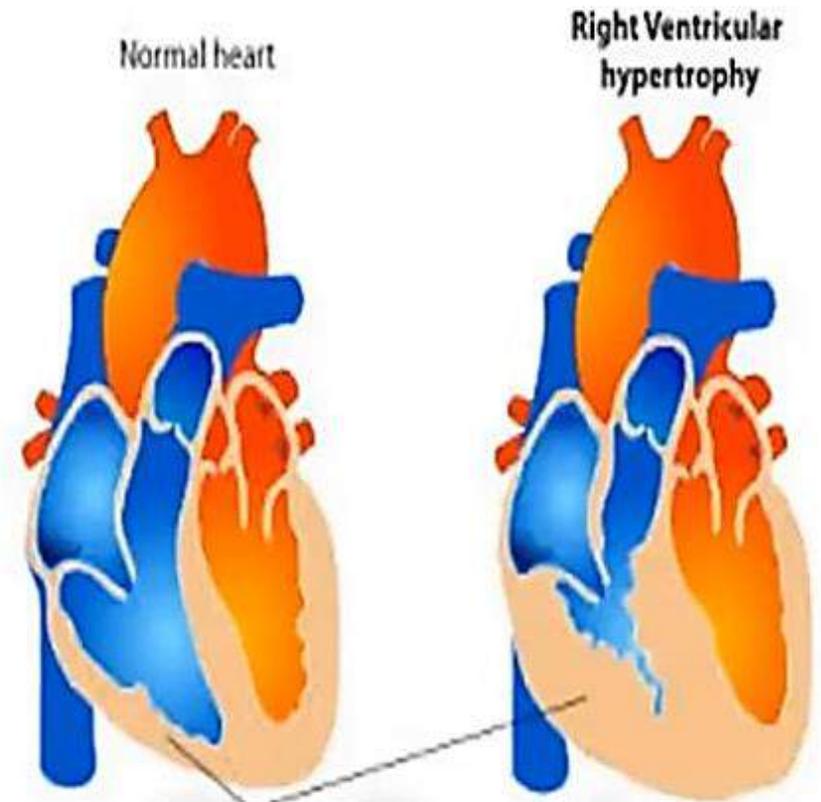
b) Purkinje fibers:

- Site: in the subendocardial layer of the ventricles.
- Structure:
 - 1- They are present *in groups* of two or more.
 - 2- They are often *binucleated*
 - 3- They are *larger* than the ventricular muscle fibers
 - 4- They contain *fewer myofibrils* which are located peripherally.
 - 5- Their cytoplasm is rich in mitochondria and *glycogen*, so they are pale in H&E sections.
 - 6- They do not contain typical intercalated discs, although, they contain many *gap junctions* more than in contractile cardiomyocytes.



Growth & regeneration of the cardiac muscle fibers

- The cardiac muscle fibers *have no ability for regeneration*, because:
 - 1-They are static cell population (can not divide by mitosis).
 - 2- Satellite cells are absent.
- The injured cardiac fibers are replaced by fibrous tissue.
- The heart muscle responds to increased functional demands by *compensatory hypertrophy*.





Thank You
Thank You
Thank You!!!!

