THE CARDIOVASCULAR SYSTEM

CVS MODULE

Semester 1, Year 3

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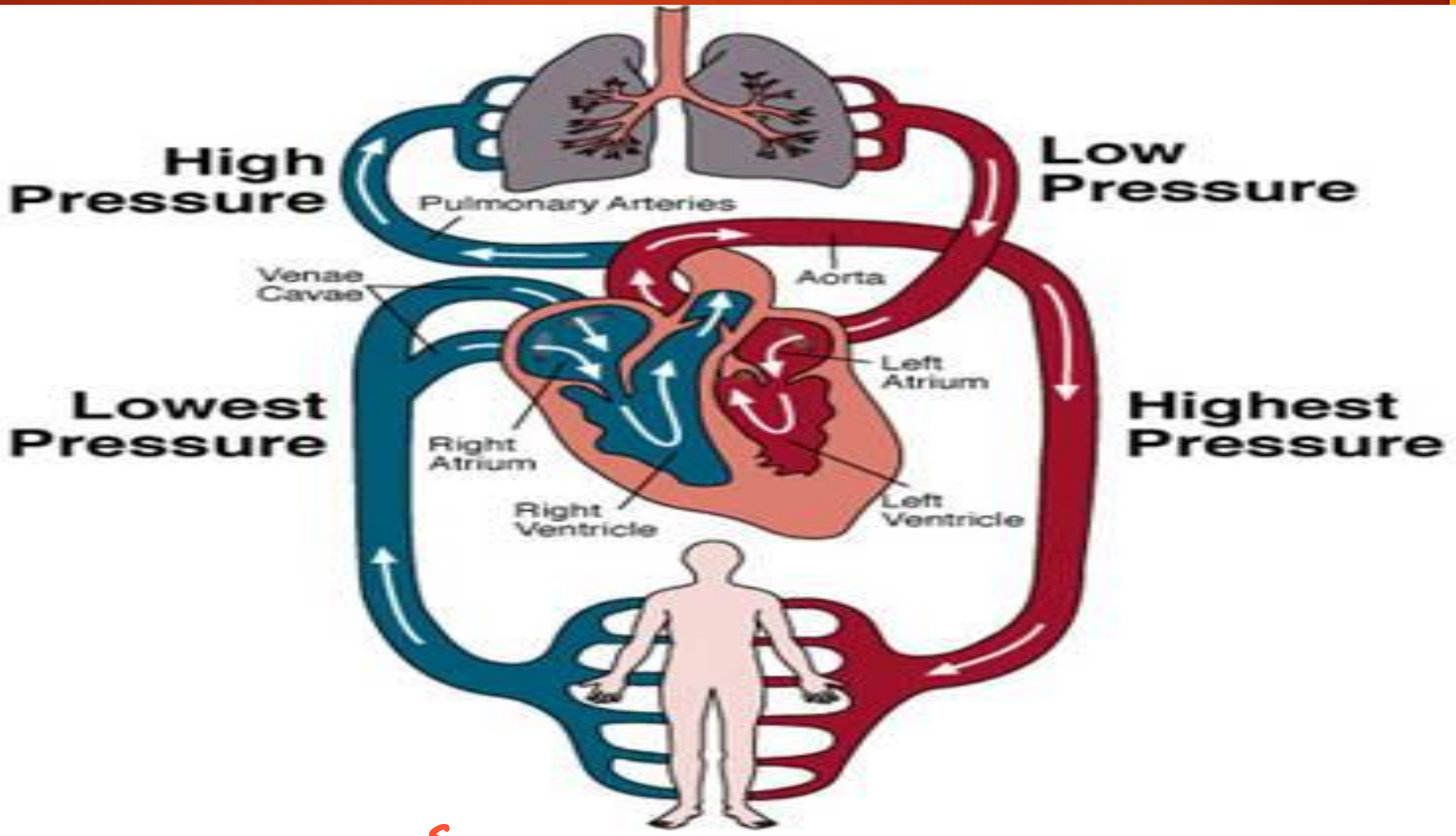
Circulatory system



circulatory Sys

1. The Cardiovascular System
2. The Lymphatic system

The Cardiovascular System

Heart
BV

Heart: serves as pumping unit of blood

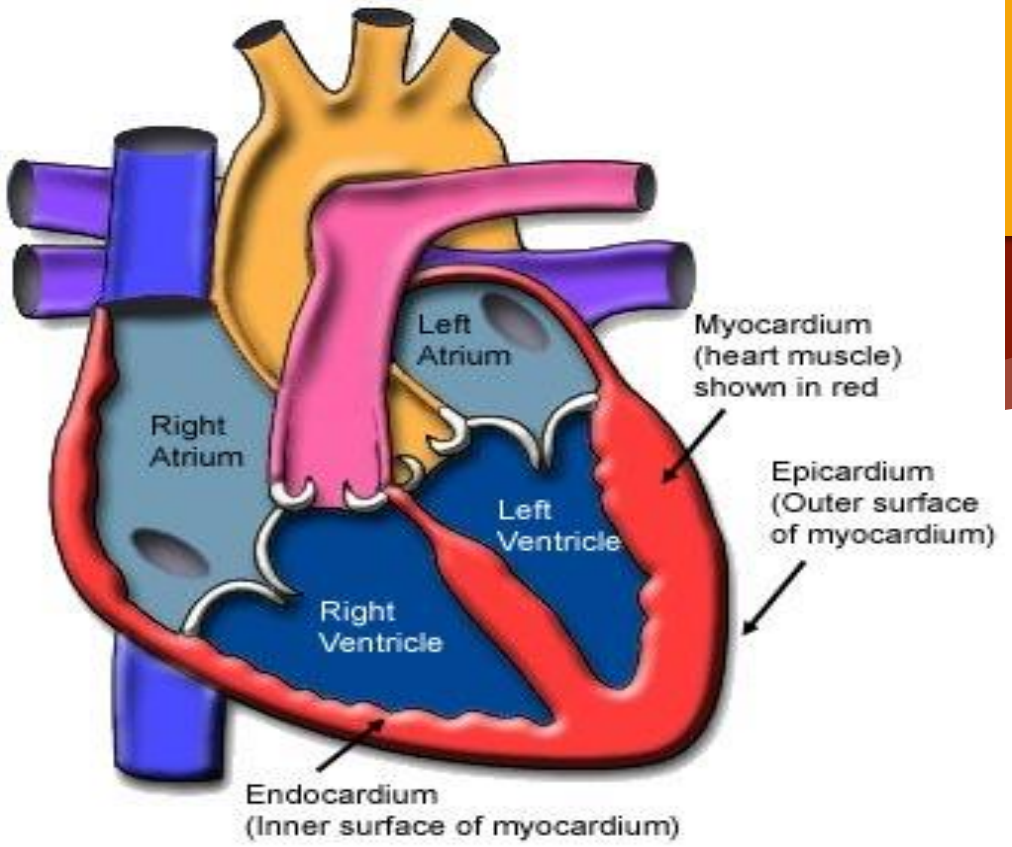
Arteries: Transport bl. from heart to peripheral tissues.

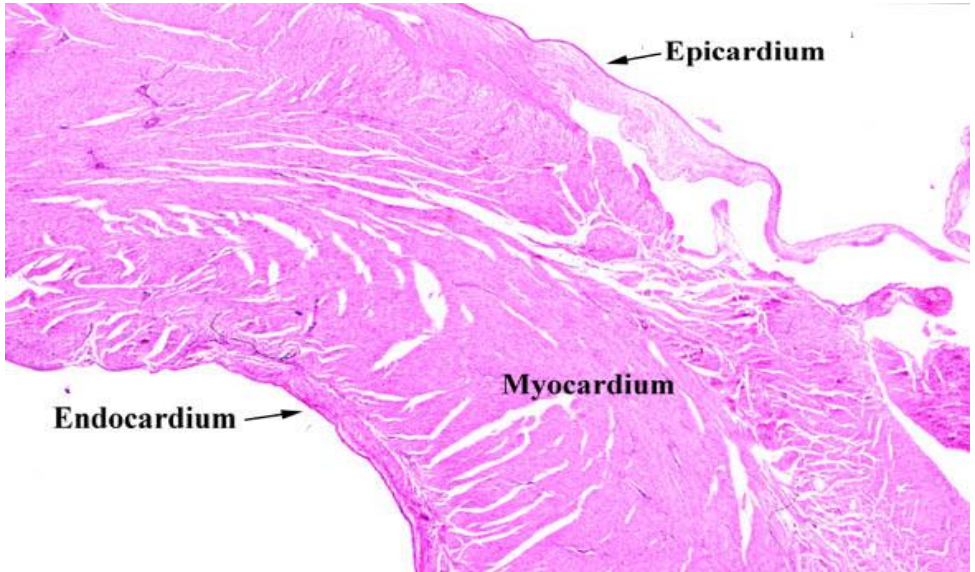
Capillaries: where exchange of materials occurs.

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





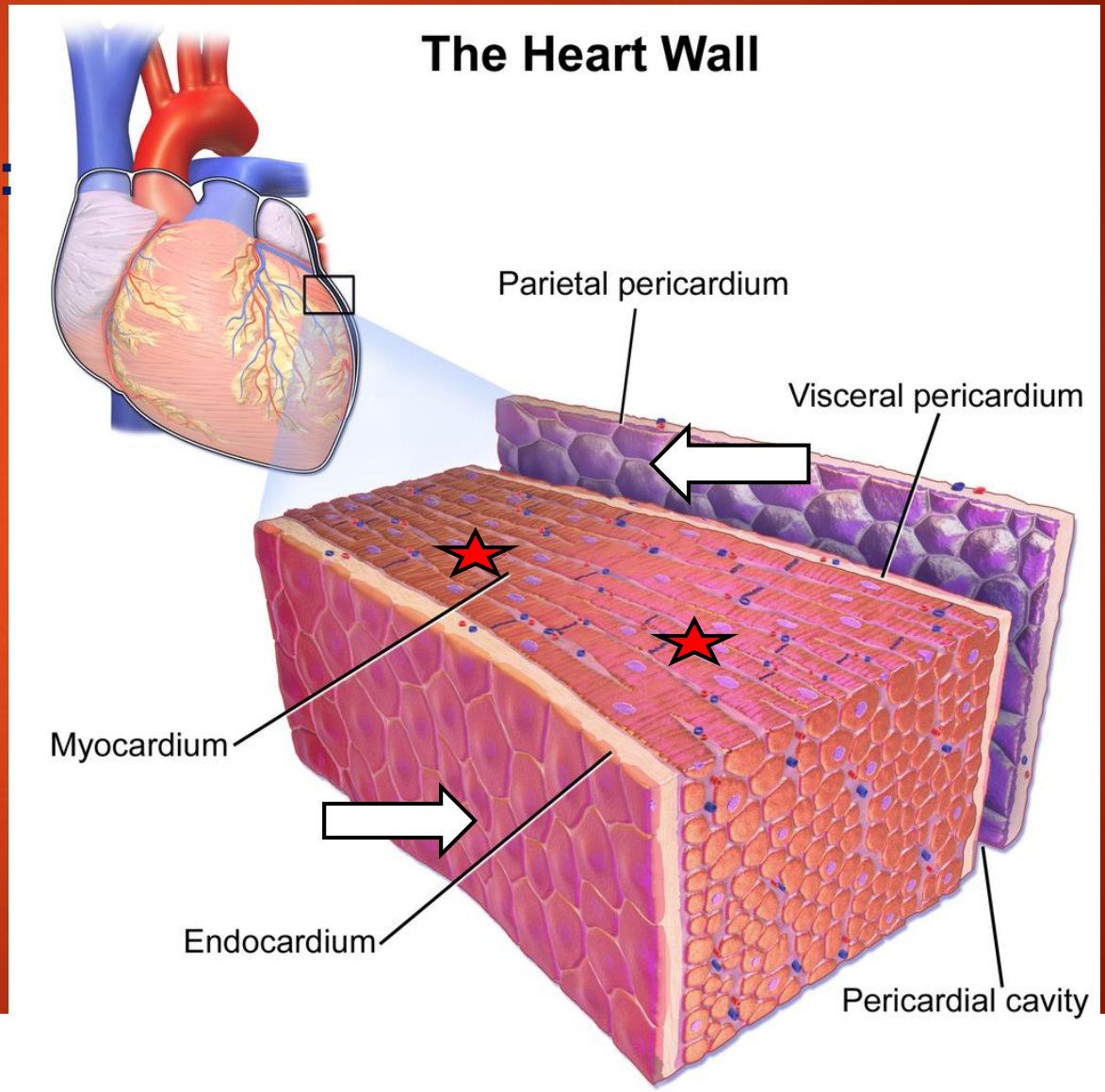
Structure of the wall of Heart

FORMED OF THREE LAYERS:

A-THE EPICARDIUM

B-THE MYOCARDIUM

C-THE ENDOCARDIUM



Microscopic structure of heart wall

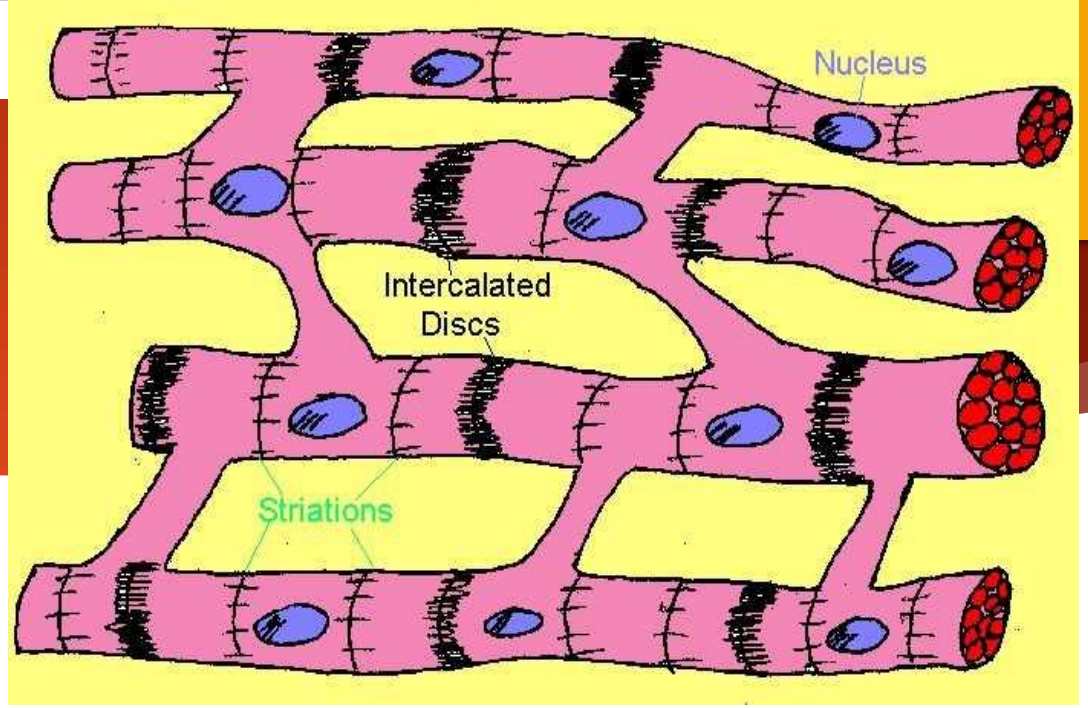
1- **Endocardium**: inner lining layer, formed of:

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:

b muscular layer



- 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.

So thickening more in ventricle.

3- Epicardium:

b part of pericardium

Represents visceral layer of pericardium (serous membrane)

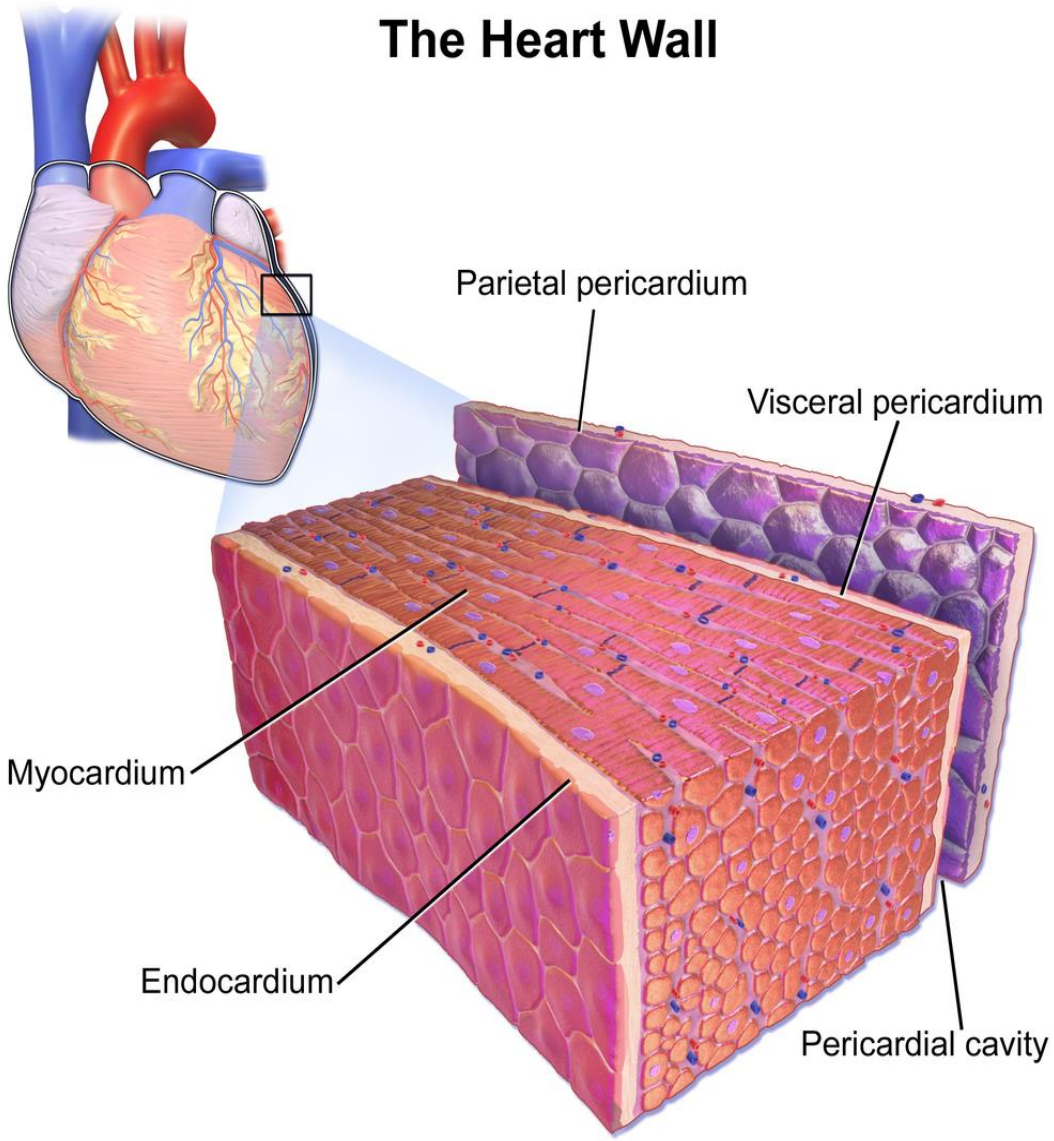
Covers outer surface.

Rests on loose C.T. which contains fat cells and coronary blood vessels.

for Absorb Shock

for subbling Heart

Epicardium



THE HEART

Pericardium

1. **Parietal pericardium** outer membrane

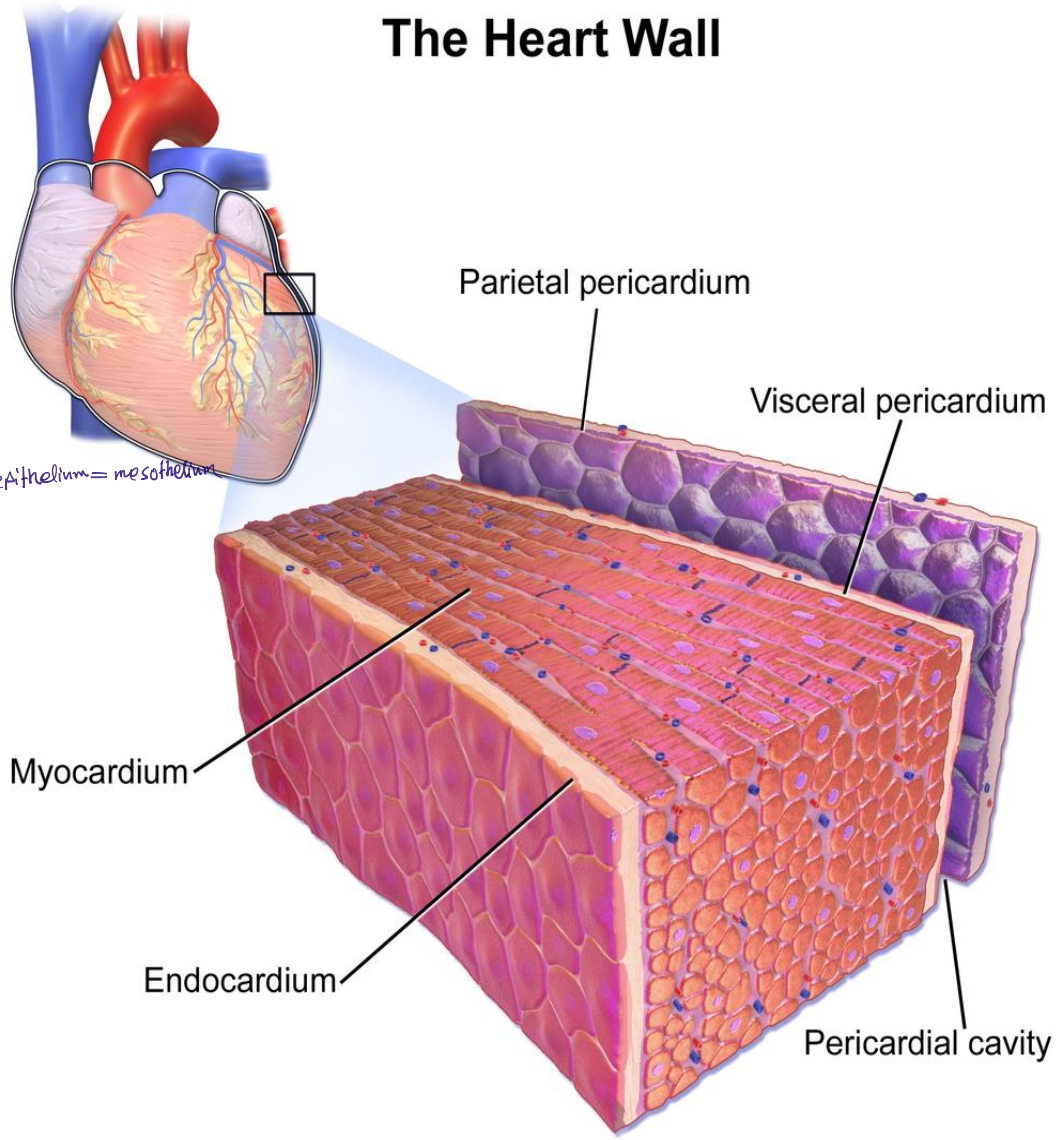
- **fibrous layer** tough, white fibrous C.T
- **-serous layer** a thin fibrous layer on top of a simple squamous epithelium = mesothelium simple squamous mesothelium

2. **Visceral pericardium= epicardium**

=serous layer

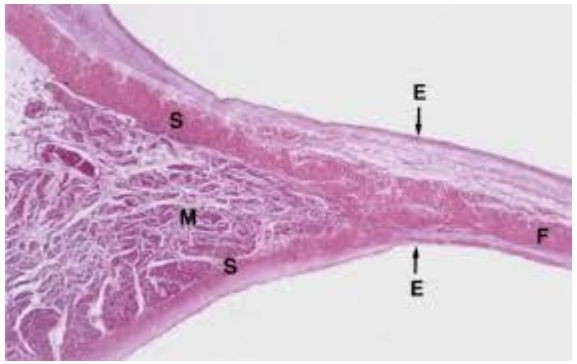
Pericardial cavity filled with **serous fluid** preventing friction

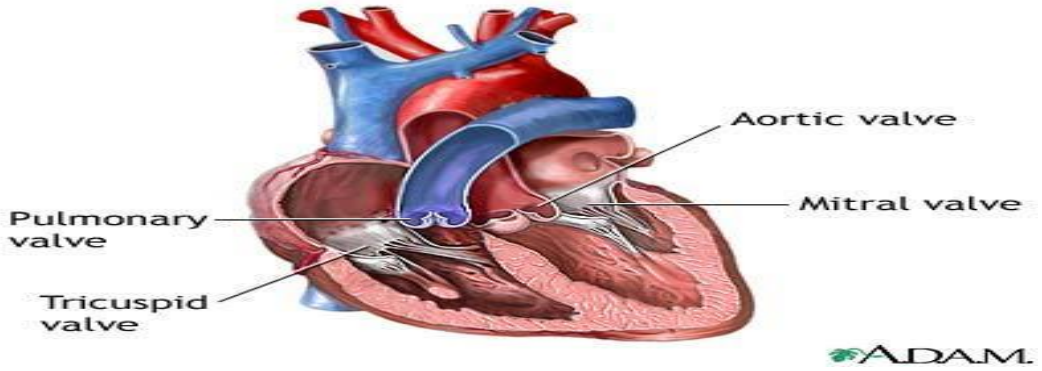
Pericarditis is an inflammation of the pericardium.

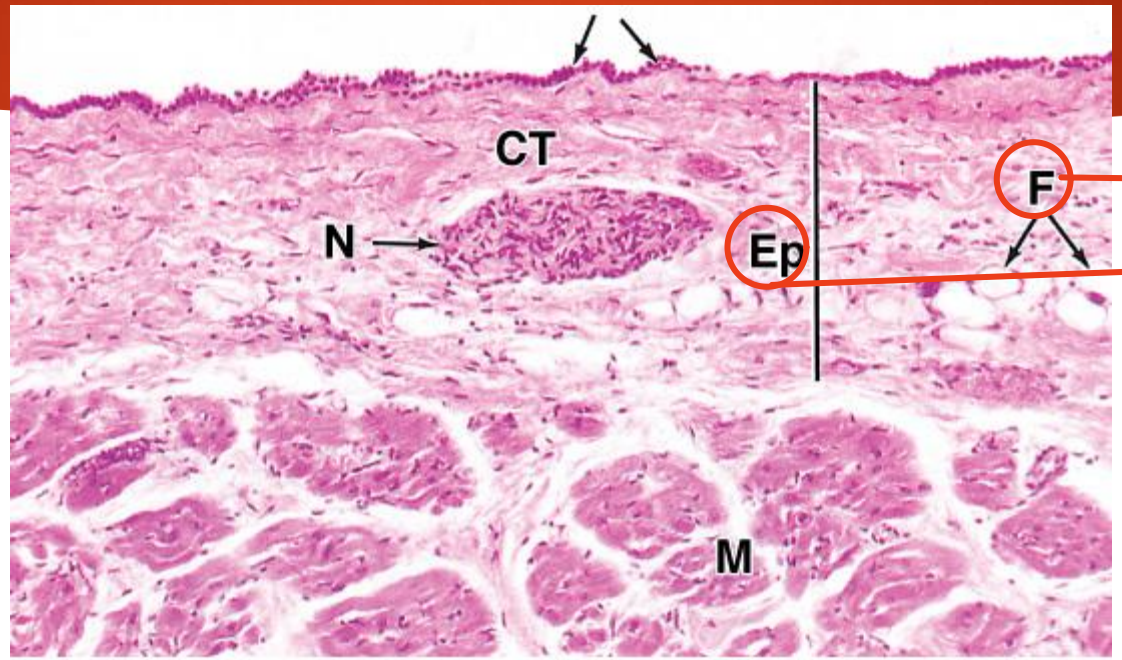


Valves of the heart:

- They are folds of endocadium, 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

Structure of cardiac muscle

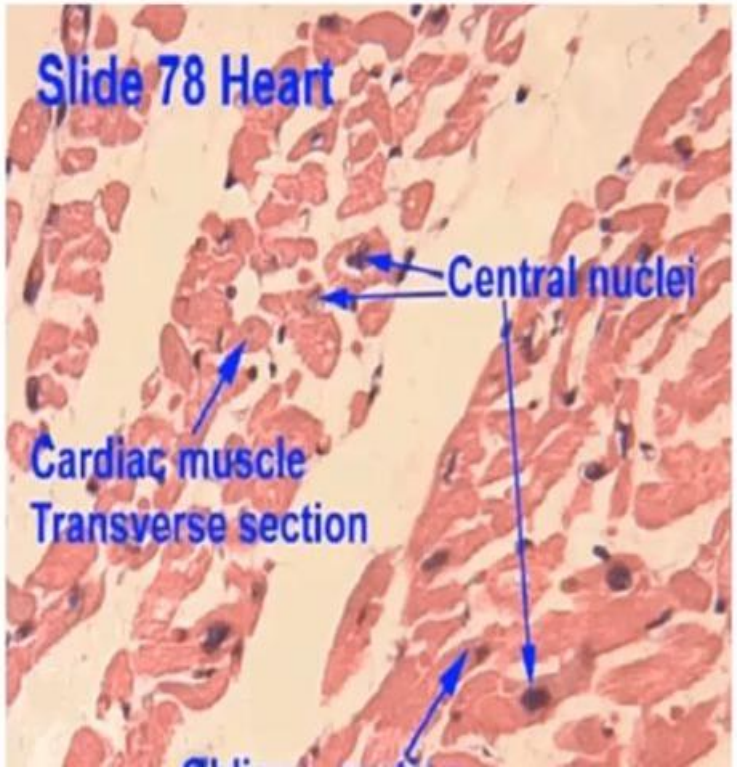
LM

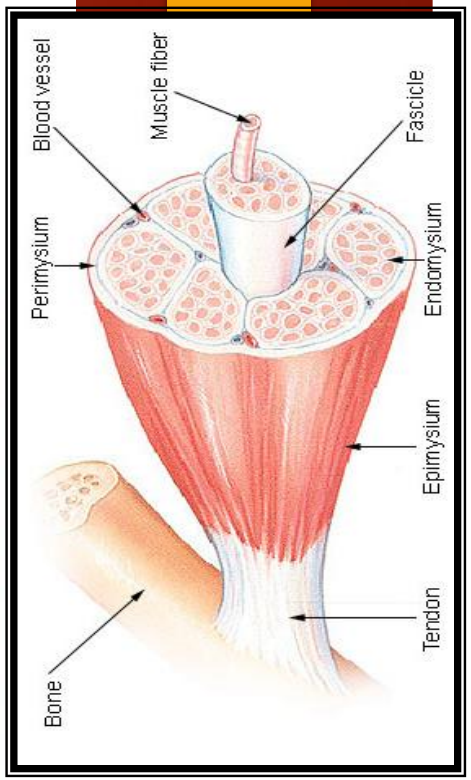
1- Connective tissue

- 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

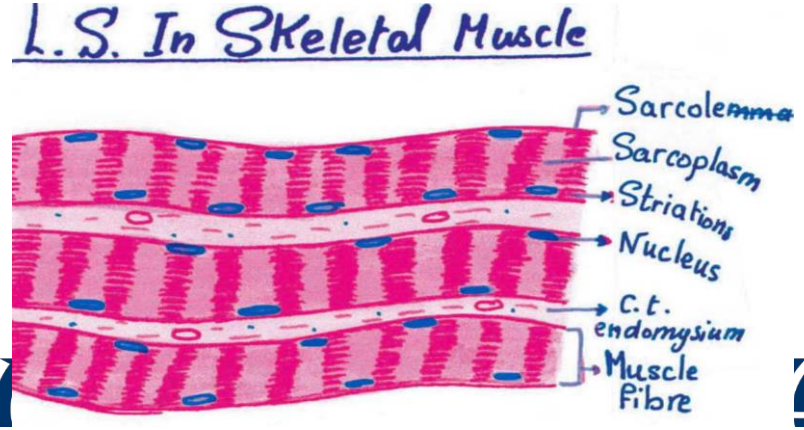
Histological Structure

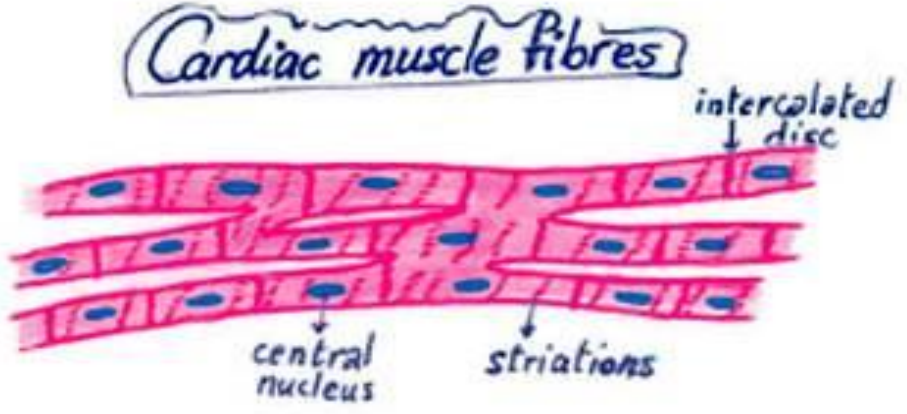
Definition: Cardiac muscle fibers present in the wall of the heart. Mesodermal in origin. Cannot divide

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.



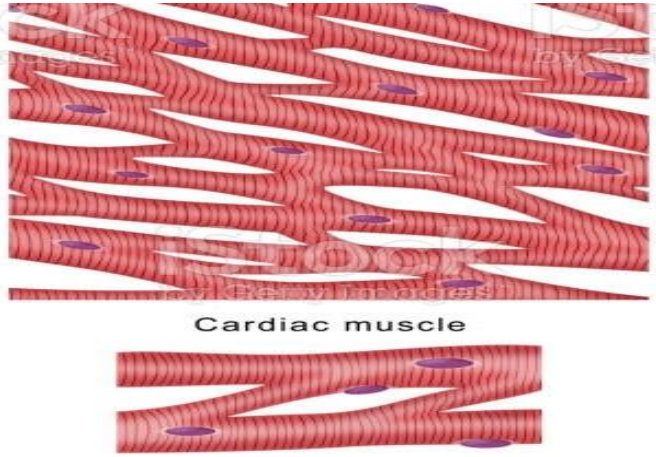


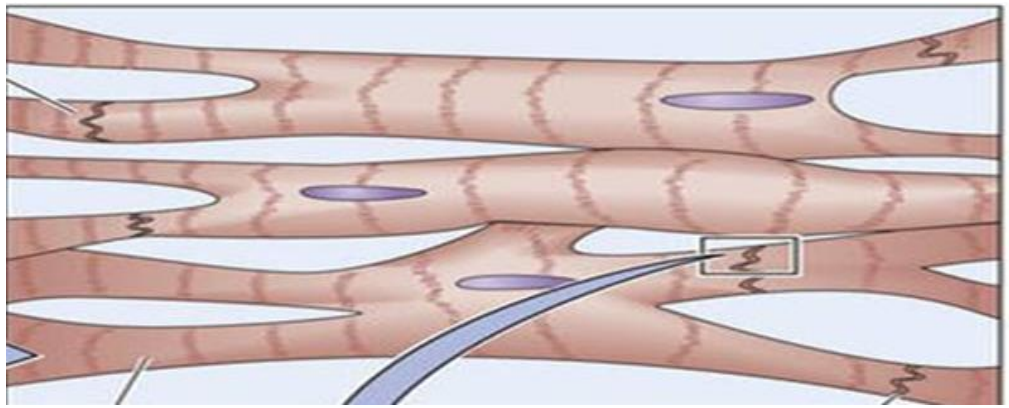
- **Shape:**

- ***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.

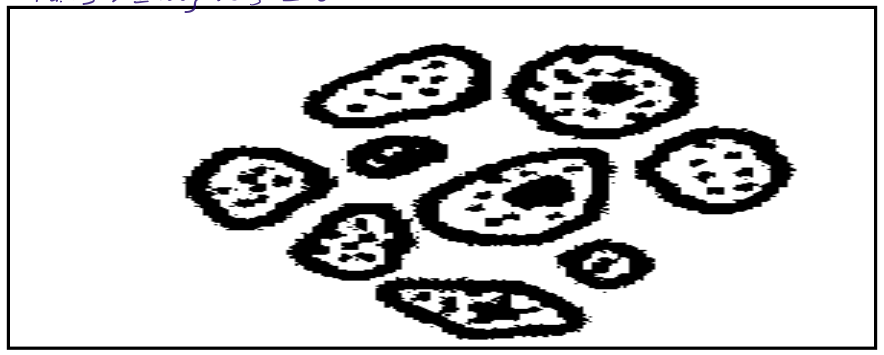


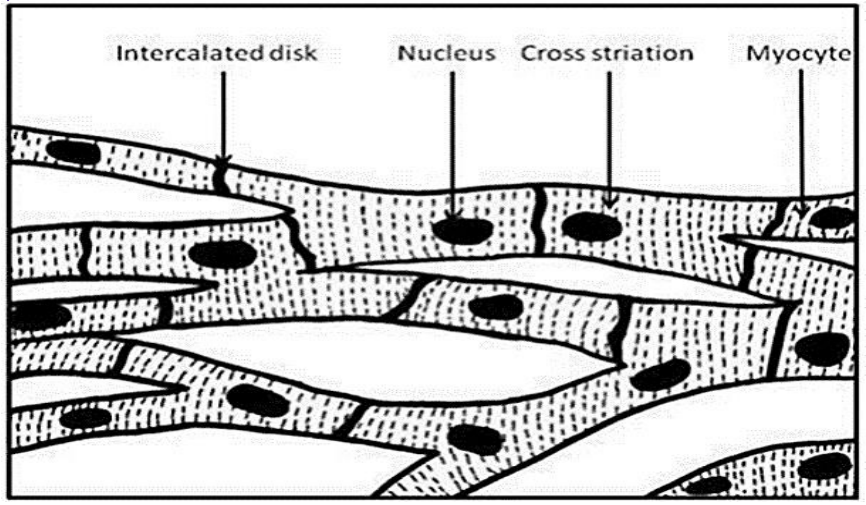


Cardiac Muscle L/M

T.S.

L.S.





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

- 1- EM ***Cardiac Muscle***

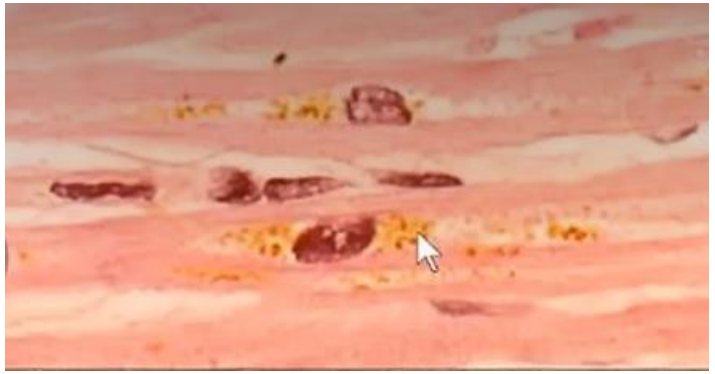
myofibrils: few

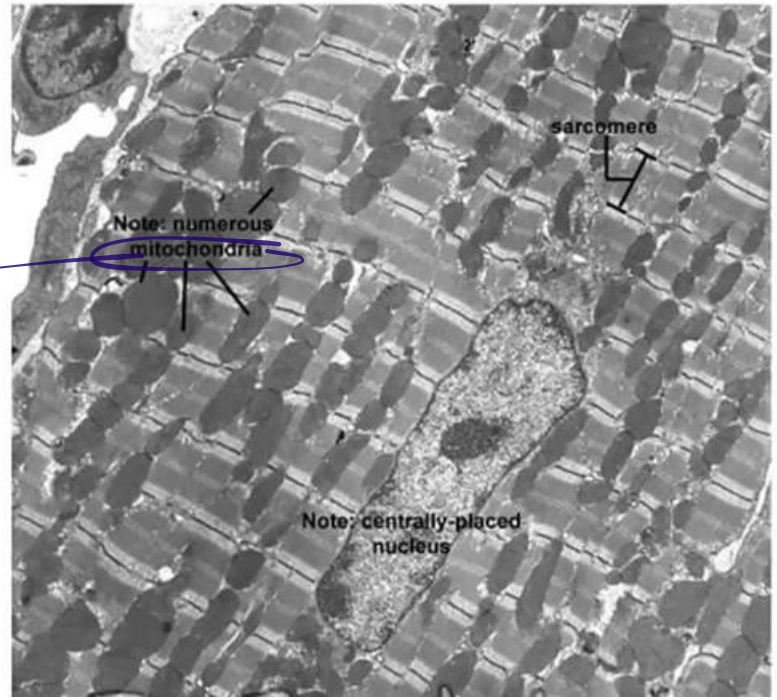
Mitochondria more numerous, larger with more cristae

s- ER: one terminal tubule accompany T- tubule

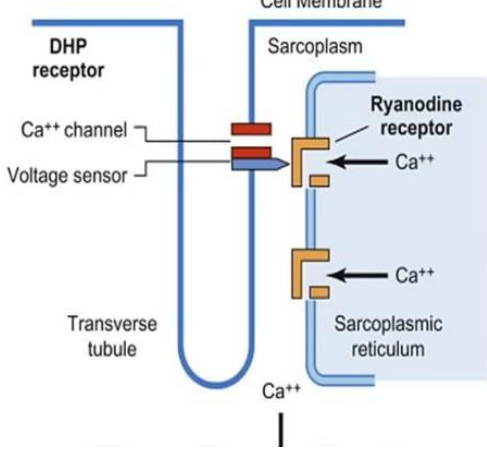
Diad of tubular syst.

Glycogen granules –lipofuscin pigments





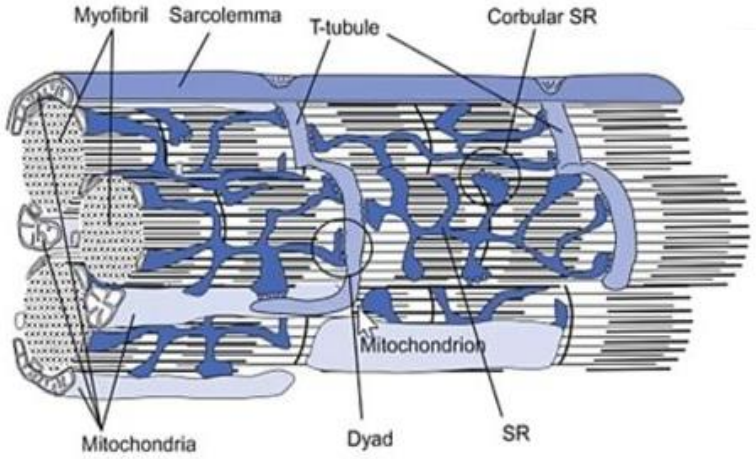
Structure of cardiac muscle
EM
2- T tubules

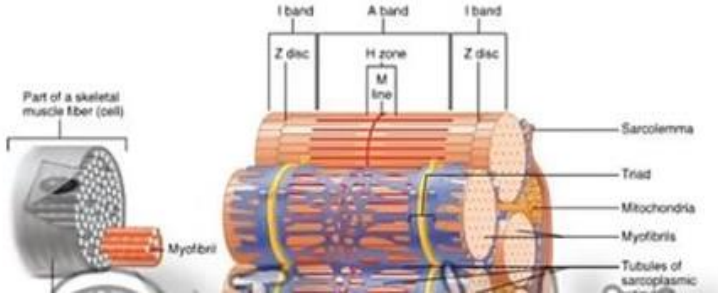


- **Definition:** inward extensions of the extracellular space at the sarcolemma.
- **Site:** at the Z line.
- **Characteristic features:** large & numerous.
- **Function:**

➢ Excitation-contraction coupling.

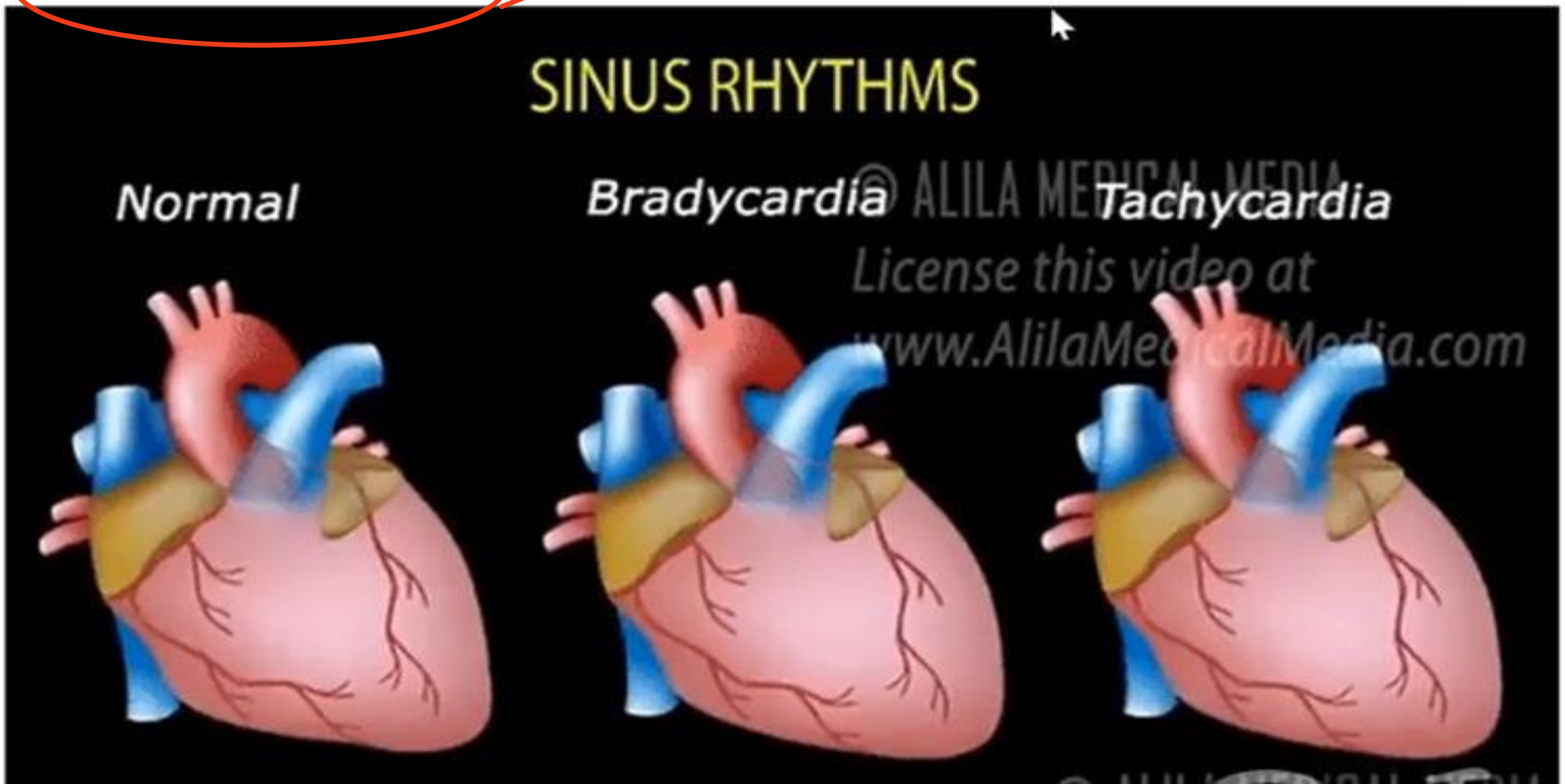
➢ Provide additional surface area for exchange of metabolites between cardiac muscle fibers and the extracellular space.





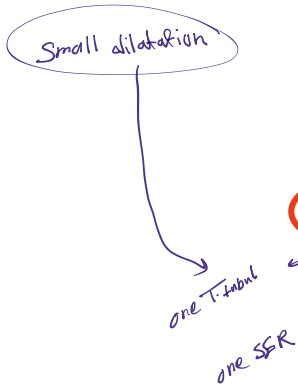
Cardiac Arrythmia

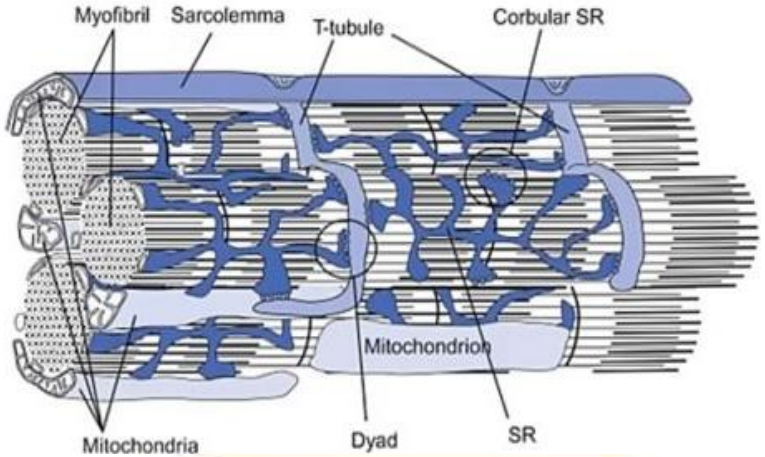
Role of calcium

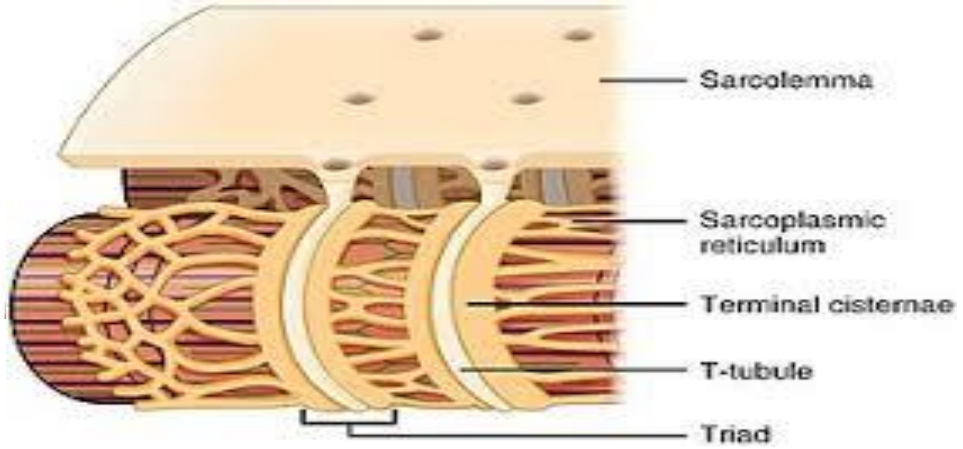


Structure of cardiac muscle
EM
3- Sarcoplasmic reticulum

- 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:

muscle fiber ⇐ Z

- 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)

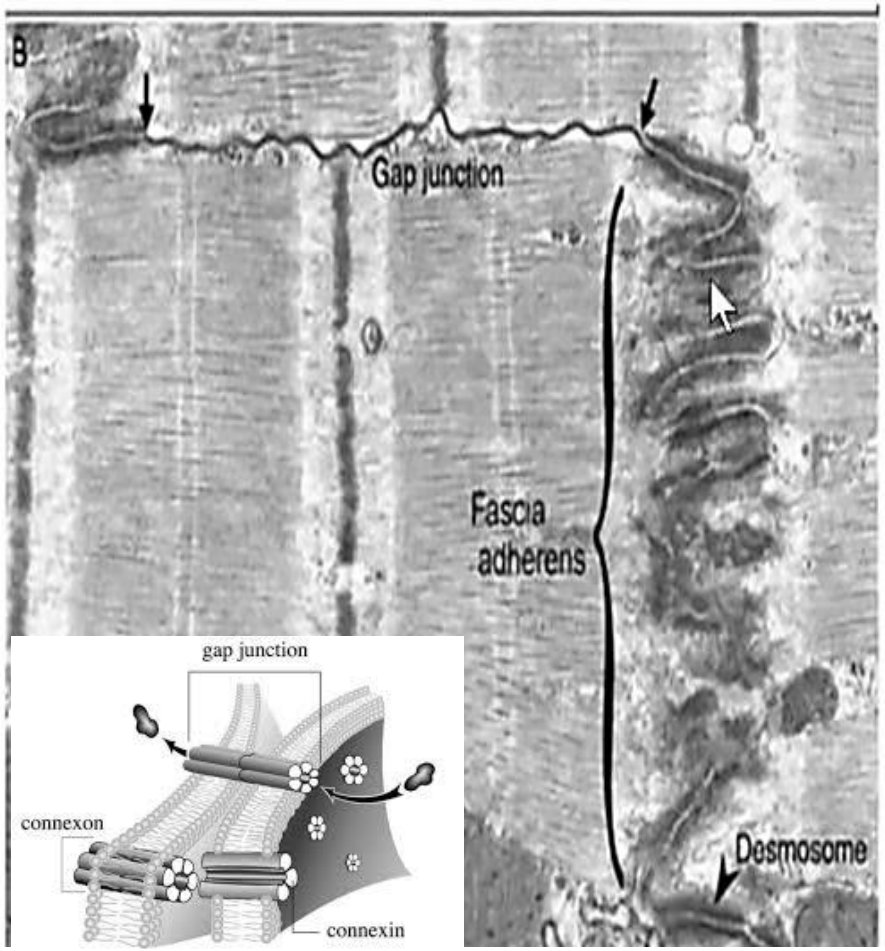
to prevent separation during strong contraction.

- Function: provide strong adhesion between the adjacent cardiomyocytes.

2- Longitudinal portion:

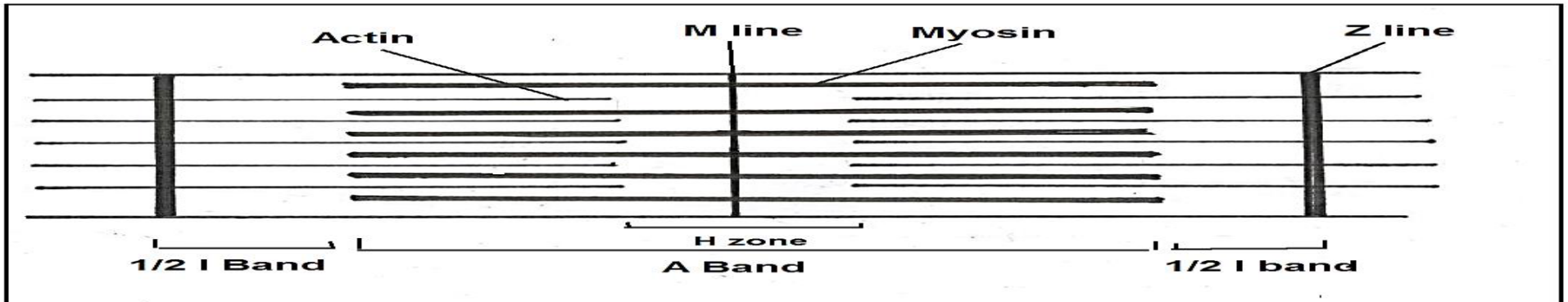
muscle fiber ⇐ Z

- Site: runs parallel to the myofilaments
- Structure: many gap junctions. → for channel to enter cat rabidly for contraction occur all time
- Function: allow rapid spread of excitation between the adjacent cardiomyocytes.

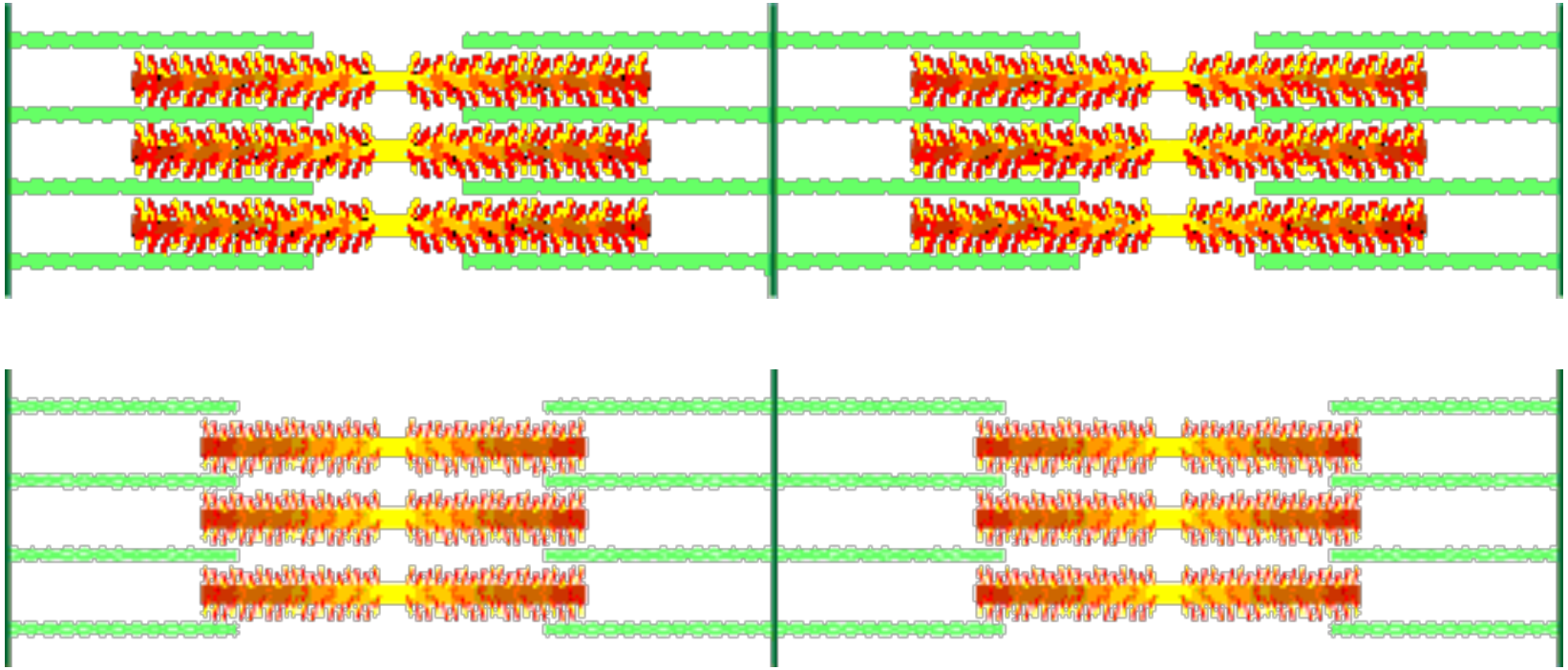


Sarcomere

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



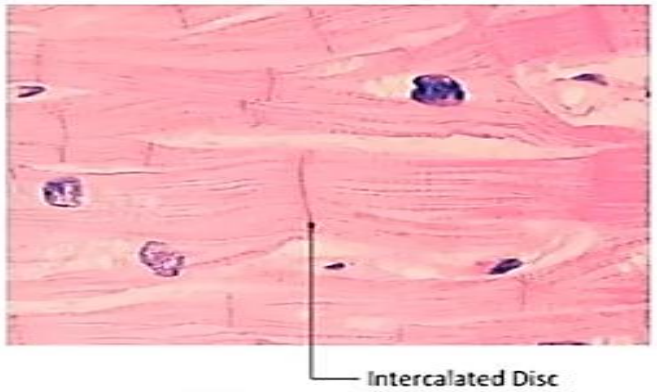
Animation of sliding filaments

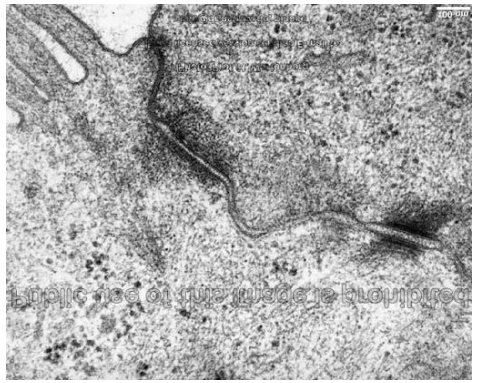


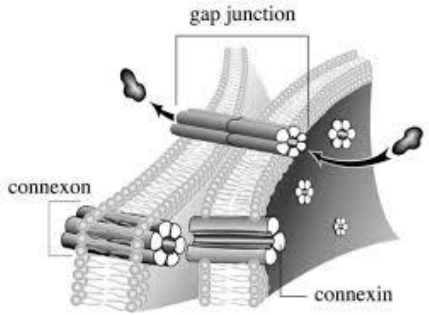
During Contraction
I band → تصغر
A ← → ثابتة

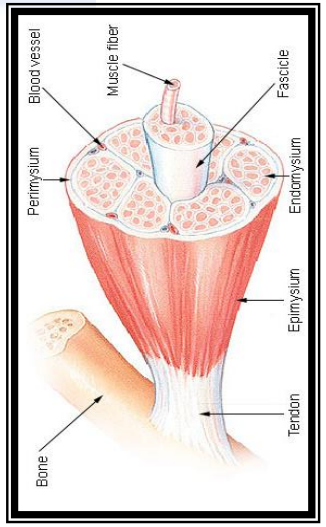
Thick filaments (red/yellow) = myosin motor protein
Thin filaments (green) = actin cytoskeletal protein

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



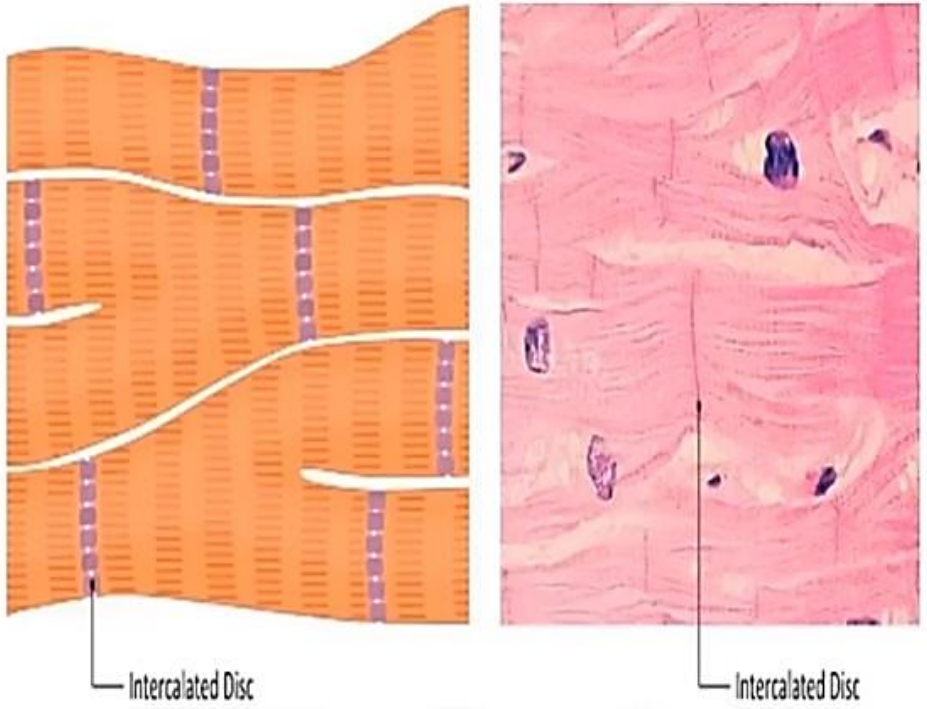






Types of cardiomyocytes
1- Contractile cardiomyocytes

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



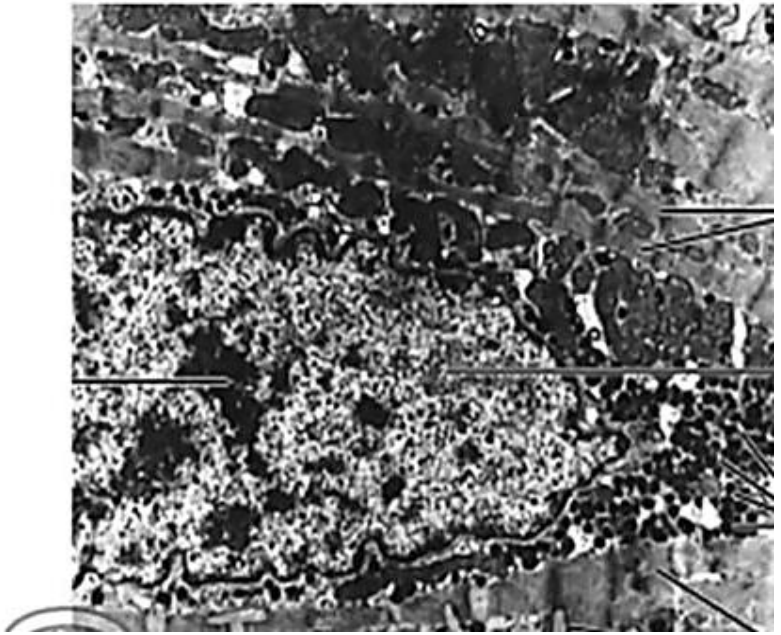
Types of cardiomyocytes
2- Endocrine cardiomyocytes

- **Definition:** They are cardiomyocytes which have an endocrine function.
- **Site:** in the atria, especially the right atrium.
- **Structure:** *They differ from contractile cardiomyocytes in:*

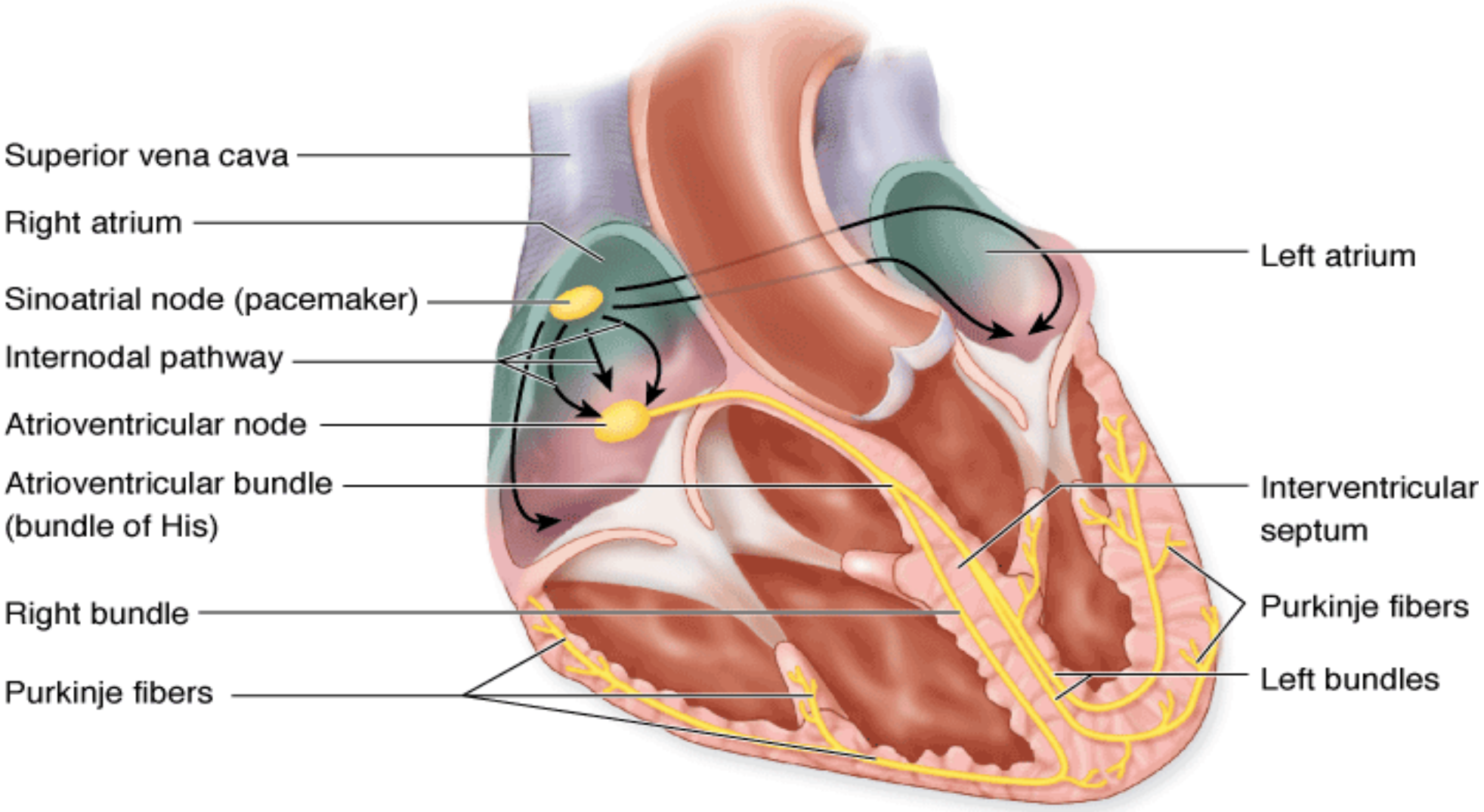
1- They have fewer myofibrils.

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



Source: Mescher AL: *Junqueira's Basic Histology: Text and Atlas, 12th Edition:* http://www.accessmedicine.com

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:**

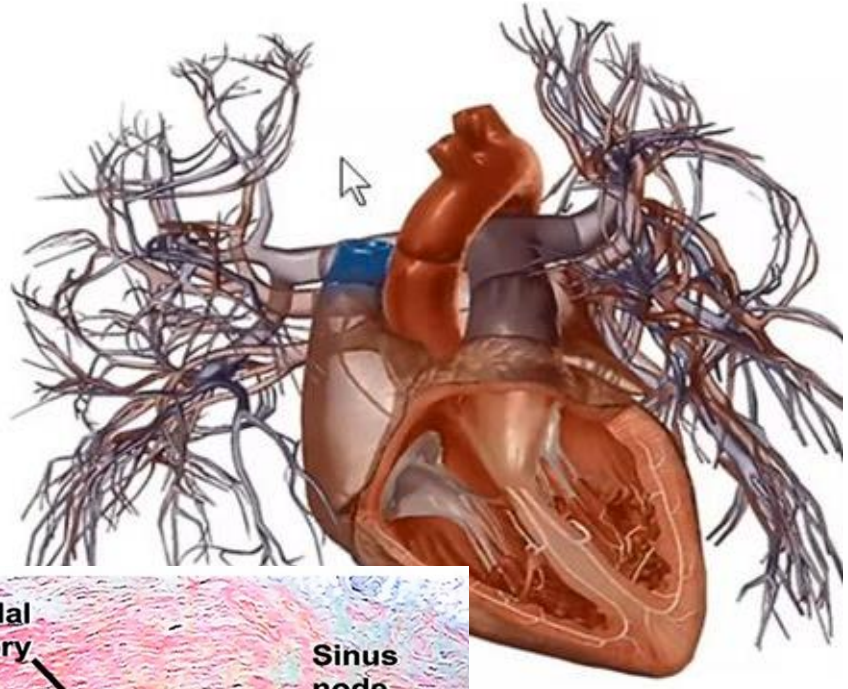
a) Nodal cells:

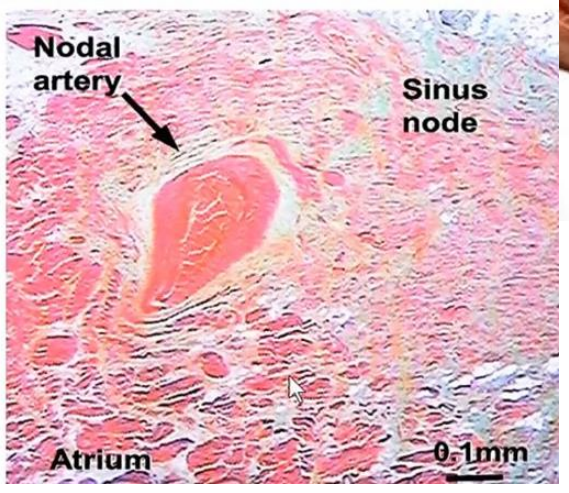
- Site: in the sinoatrial node, the atrio-ventricular node and the trunk of the bundle of His.
- Structure:

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.

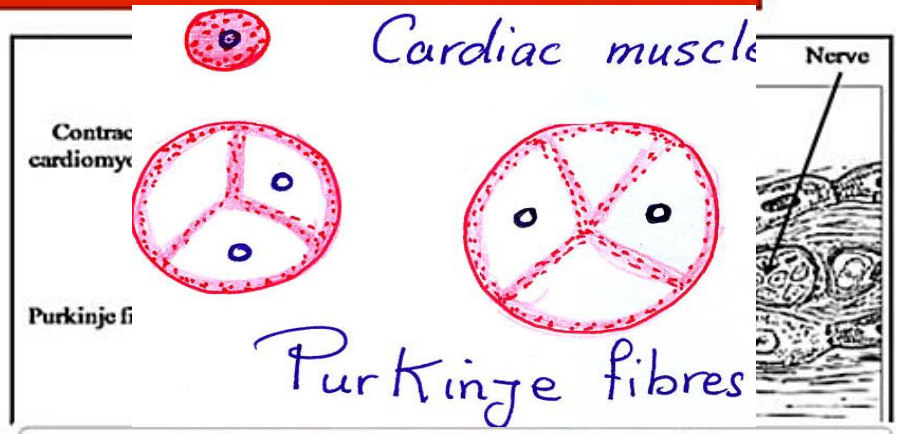
2- They are often *binucleated*

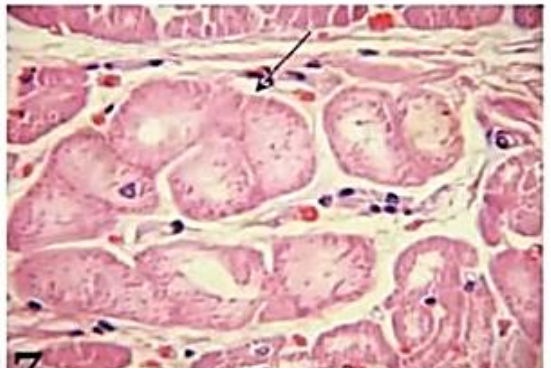
3- They are *larger* than the ventricular muscle fibers

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*.