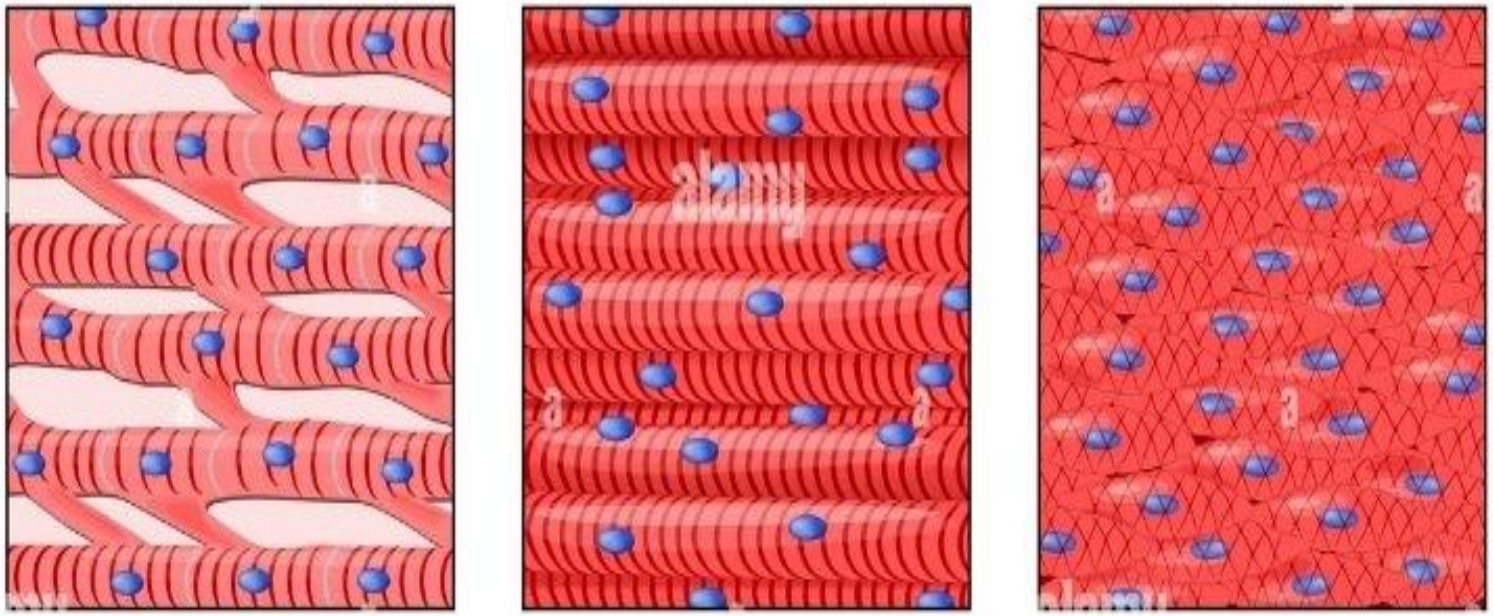
# MUSCLE TISSUE



By

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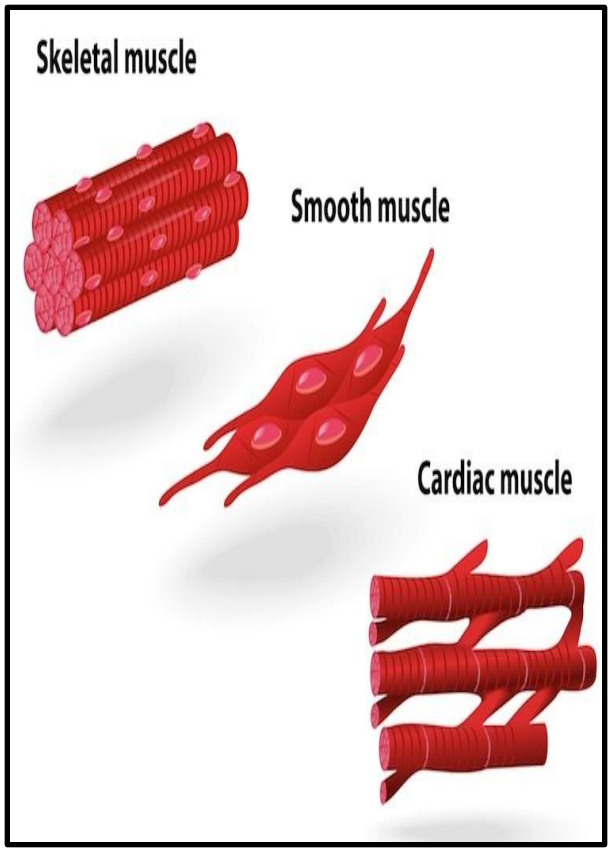
# LEARNING OUTCOMES

1. Recognize the origin of muscle tissue.
2. Know the different types of muscle tissue.
3. Describe the histological structure of each type.
4. Illustrate functions of different muscle tissue.

# Muscle tissue

- ❑ One of the 4 basic tissue in the body.
- ❑ It is mesodermal in origin
- ❑ TYPES:
  - Skeletal muscle
  - Cardiac muscle
  - Smooth muscle



# TYPES of muscle tissue

**1) Skeletal muscle:**

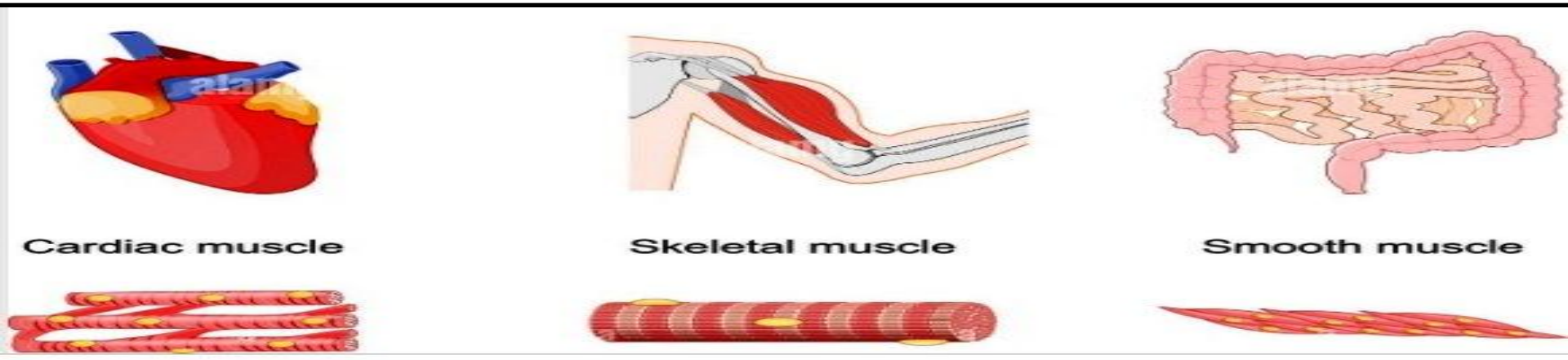
- It is attached to the skeleton.
- It is voluntary in action.
- It exhibits cross striations at light microscope level (striated).

**2) Cardiac muscle:**

- It is the muscle of the heart "the myocardium".
- It is involuntary in action.
- It is striated by light microscope.

**3) Smooth muscle:**

- It forms the wall of blood vessels and viscera.
- It is involuntary in action.
- It *dose not* exhibit cross striations .

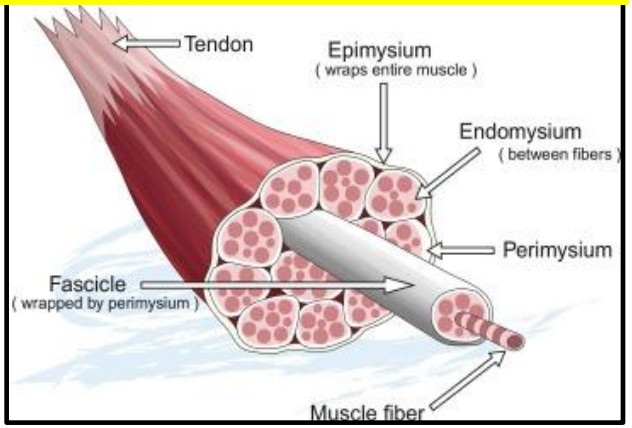


# SKELETAL MUSCLE

- Called skeletal as **most** of them <u>are attached to the skeleton</u>. Others not attached to skeleton as ocular muscles, muscles of face and tongue.
- Their contraction is usually voluntary and under the control of will ***<u>except</u>*** few types of muscle as; pharynx and upper part of esophagus.

**SKELETAL MUSCLE** formed of:
bundles of longitudinally arranged parallel <u>multinucleated muscle cells</u> **(muscle fibers** or myofiber) ***and*** **<u>connective tissue</u>** in-between**.**

**Skeletal muscle cell = Skeletal muscle fiber= Myofiber**



# The connective tissue component of the skeletal muscle

➢ **Epimysium**:

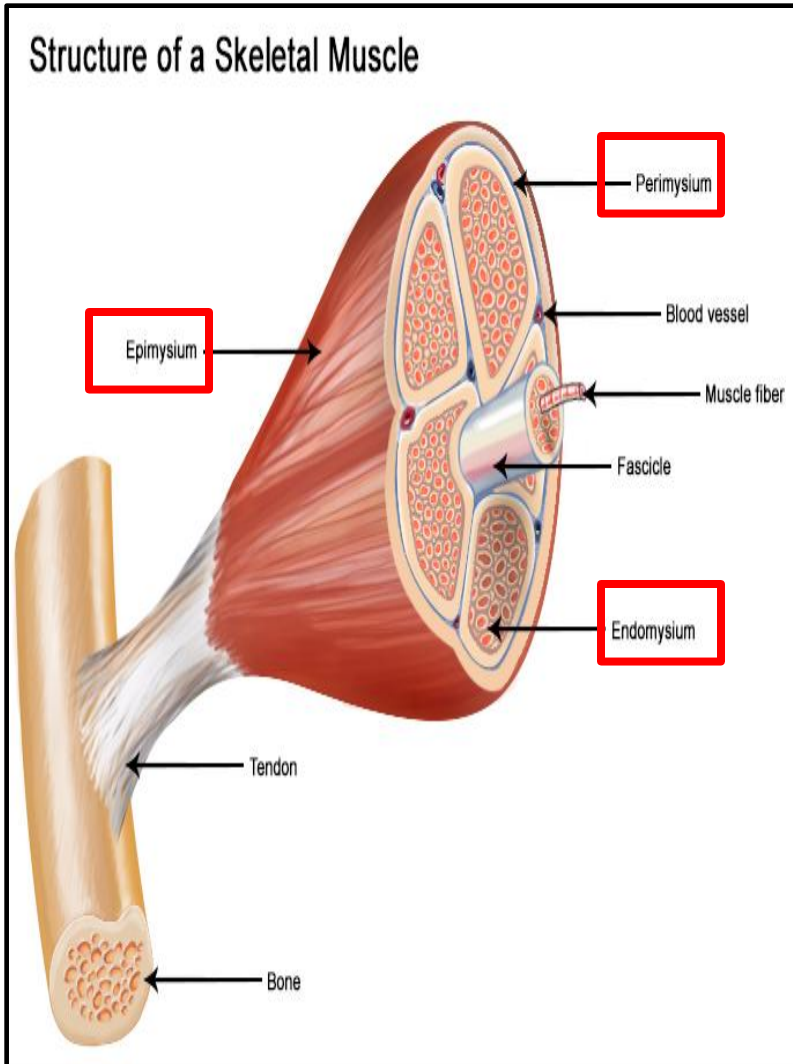
- It is the external sheath of dense C.T
- surrounds the **whole muscle**
- rich in blood vessels and nerve supply.
- Continues as tendons that transmit the force of contraction to bone.

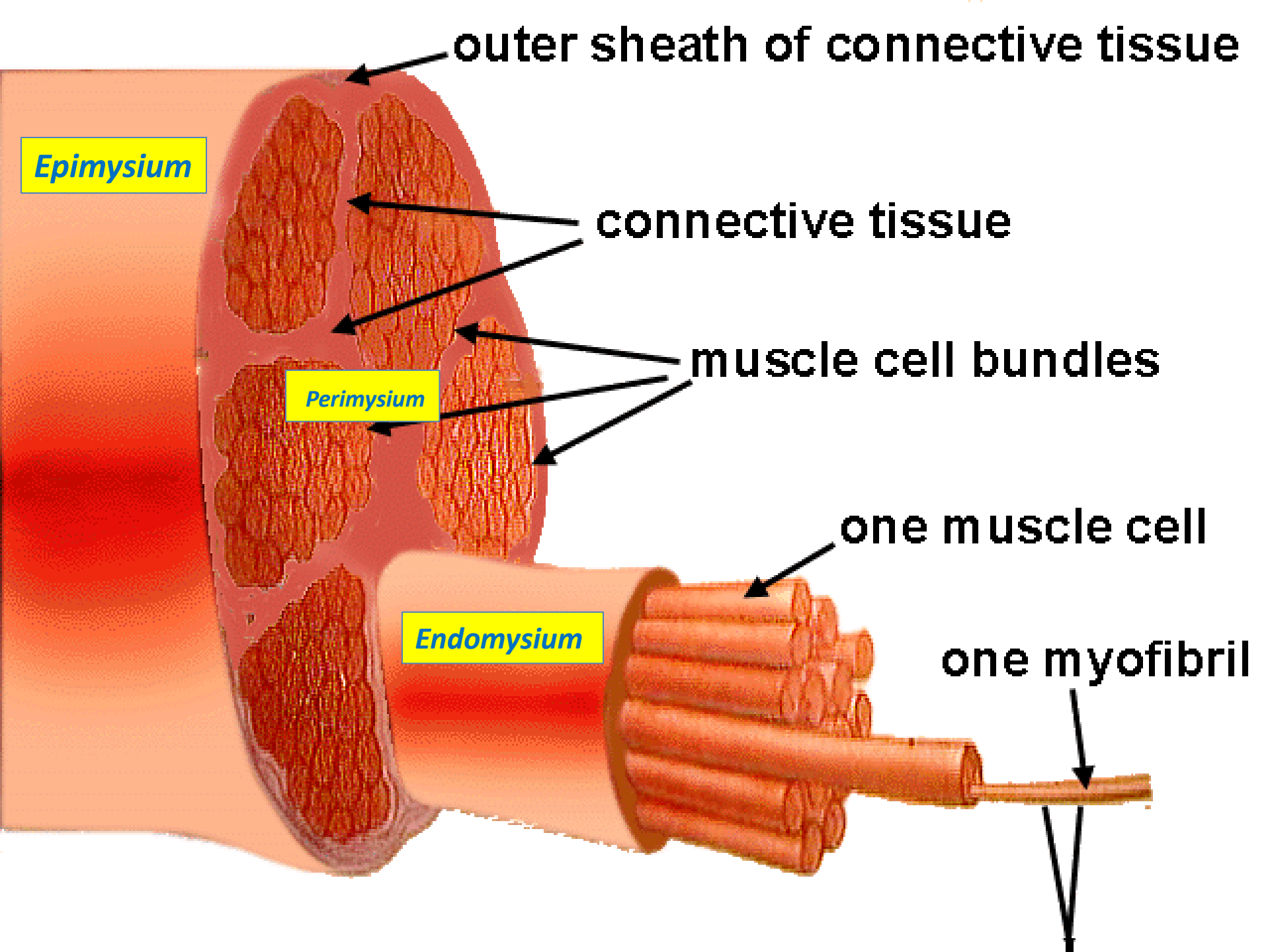
➢ **Perimysium**:

- It is **thin C.T** derived from the epimysium.
- surrounds **each bundle** (fascicle) of muscle fibers. Nerves & blood vessels penetrate the perimysium to supply each fascicle.

➢ **Endomysium**:

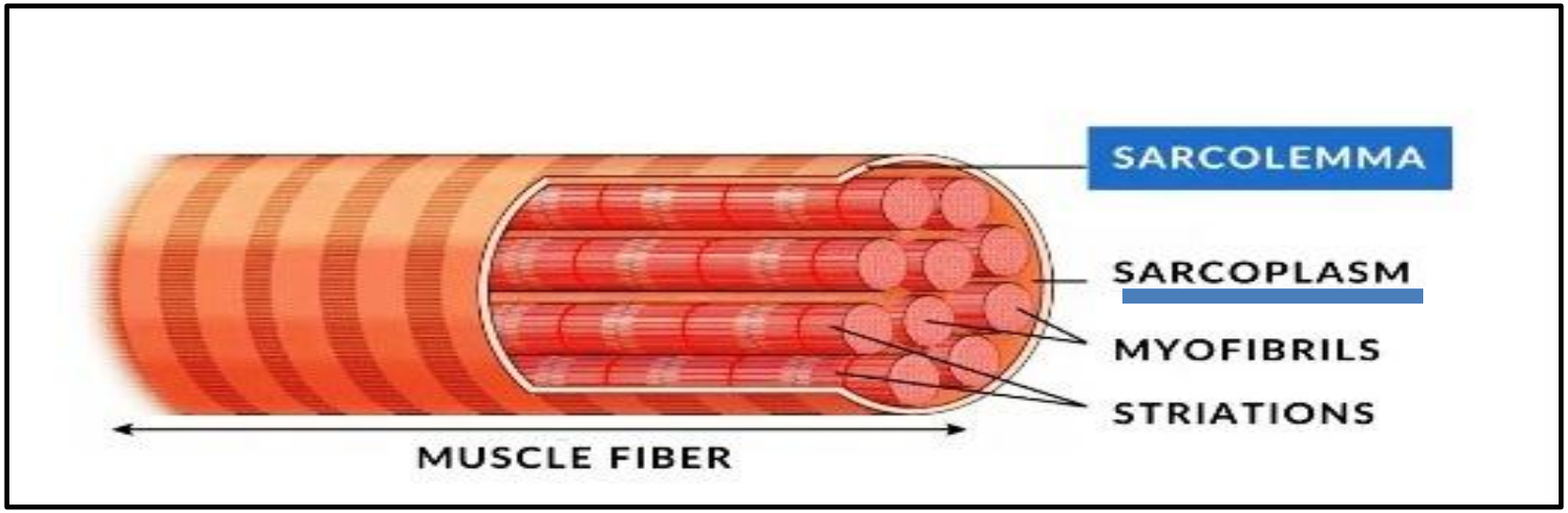
- It consists of very thin layer of reticular fibers surround **each muscle fiber** within the fascicle.
- Contains nerve fibers & capillaries network.




outer sheath of connective tissue
Epimysium
connective tissue
muscle cell bundles
Perimysium
one muscle cell
Endomysium
one myofibril

# SKELETAL MUSCLE FIBER

- Cytoplasm called sarcoplasm.
- The cell membrane called sarcolemma.
- Diameter: about (10-100 µm)
- Length: several centimeters in "up to 40cm“
- Skeletal muscle fibers are longitudinally arranged and parallel to each others.



# Structure of skeletal muscle fiber (cell) *(L/M)*

***Shape:***

- long and cylindrical.

-non-branching except in the muscles of the face and tongue.

***Structure:***

**1-Cell membrane*:***

Each muscle fiber is surrounded by a cell membrane called sarcolemma, associated from outside by a basal lamina.

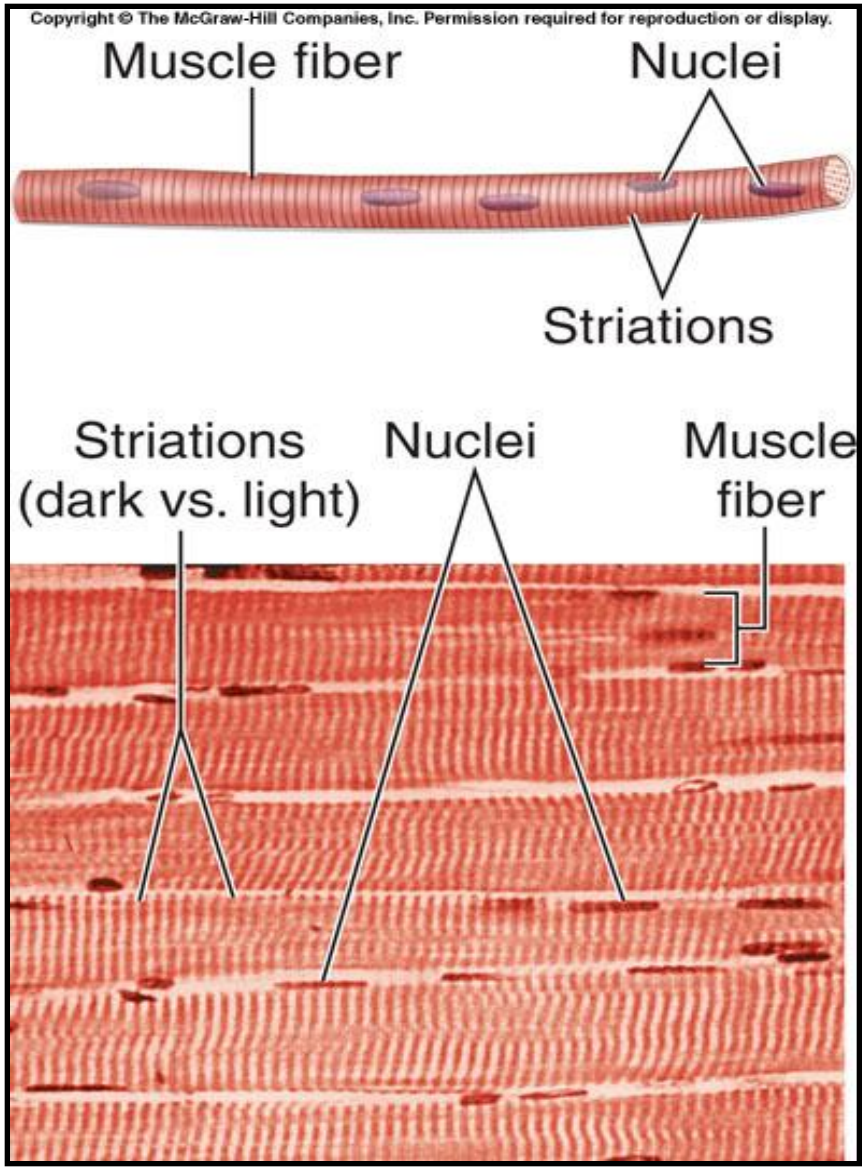
**2-Nucleus**:

- The muscle fibers are multinucleated.

- The nuclei are ovoid and *located just beneath and parallel to the sarcolemma.*

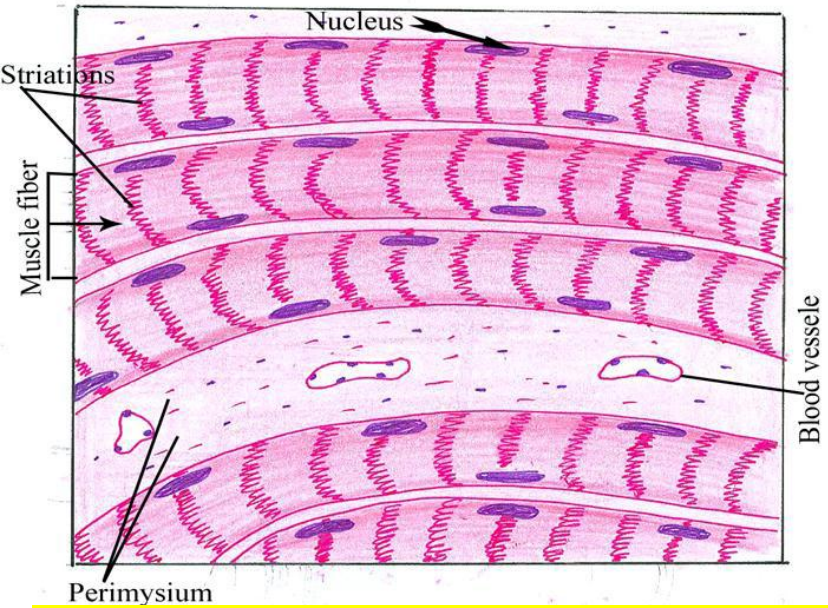
**3-Cytoplasm (Sarcoplasm):**

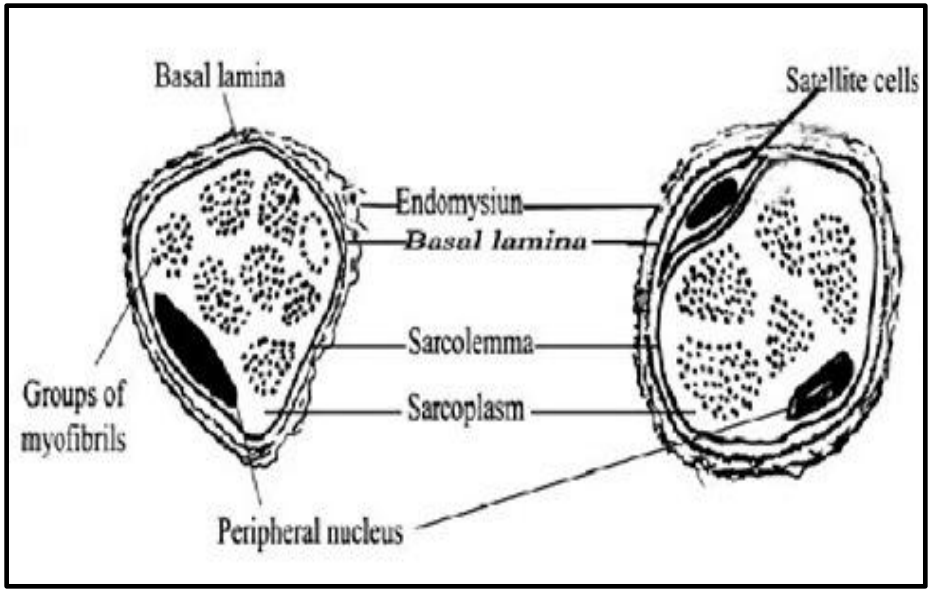
It is deeply acidophilic and filled with long, cylindrical, parallel fibrils called ***myofibrils.***



**In longitudinal sections (LS):**
muscle fibers show cross striations of alternating light and dark bands.

**In transverse sections (TS):**
- Muscle fibers appear rounded or polygonal in shape.
- The myofibrils appear as dots arranged in groups.



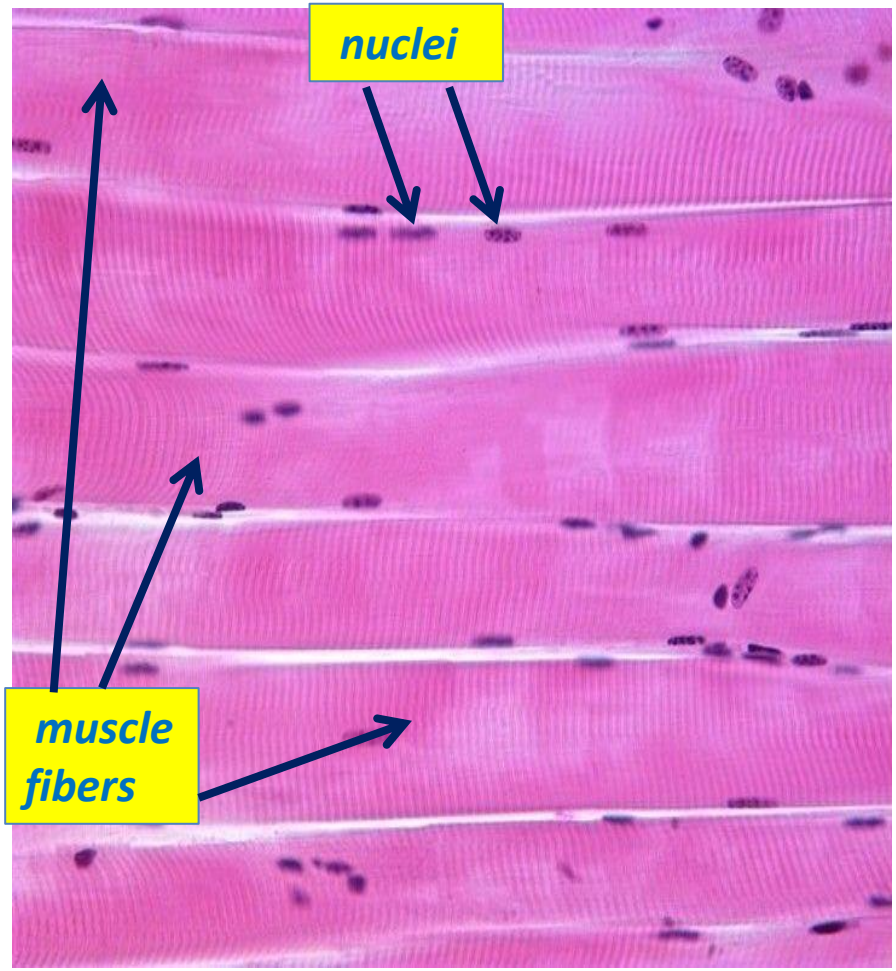




**Satellite cells:**

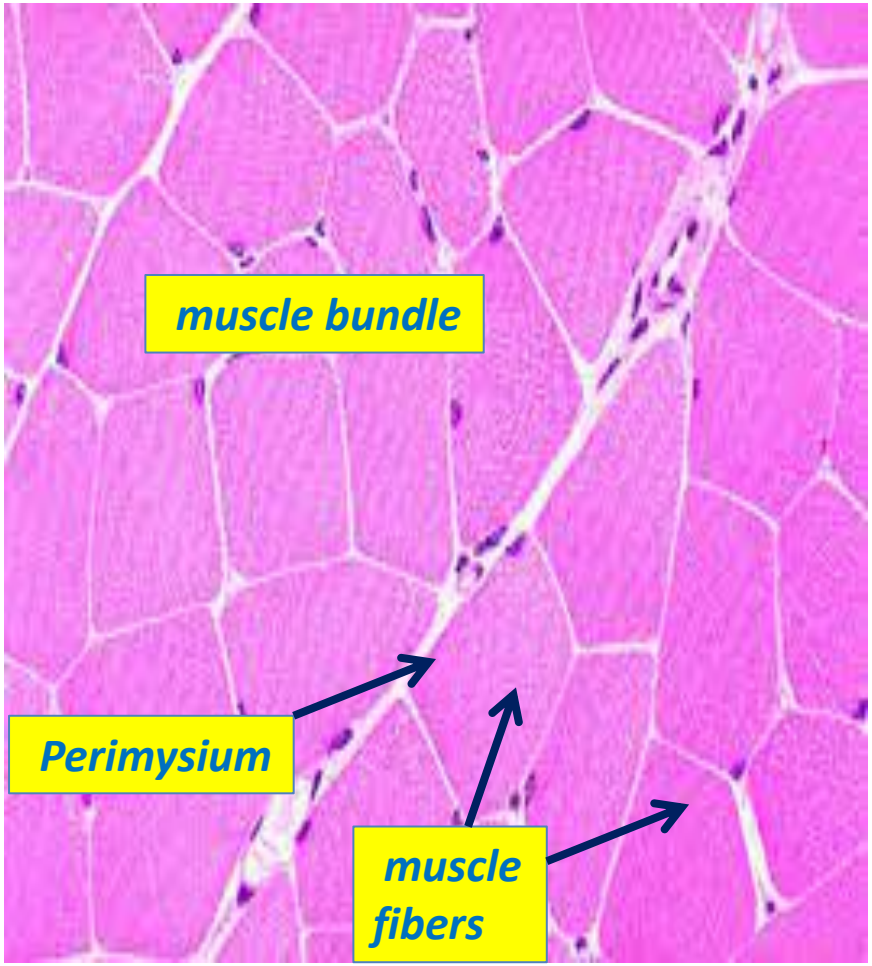
- They are small cells present between the sarcolemma of the muscle fiber and its basal lamina.
- Each has a single nucleus and acts as a stem cell.
- They are responsible for the repair of small defects of the skeletal muscles by formation of new muscle fibers

# SKELETAL MUSCLE

## LS




## TS



# E/M of the muscle fiber

**The sarcoplasm of the skeletal muscle fiber contains:**

1. ***Myofibrils***

2. ***SER*** (sarcoplasmic reticulum)

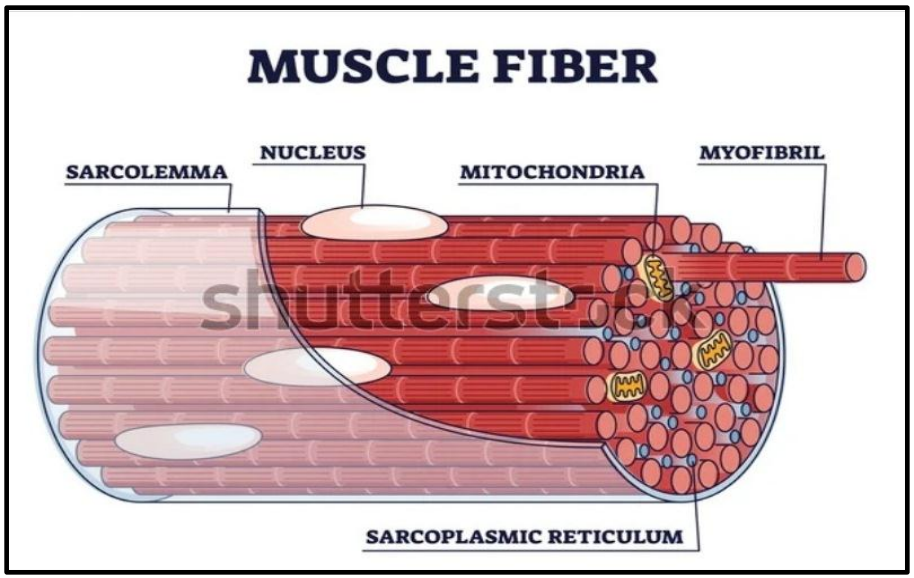
3. ***Long mitochondria*** are found in the juxta nuclear and form longitudinal rows between the myofibrils

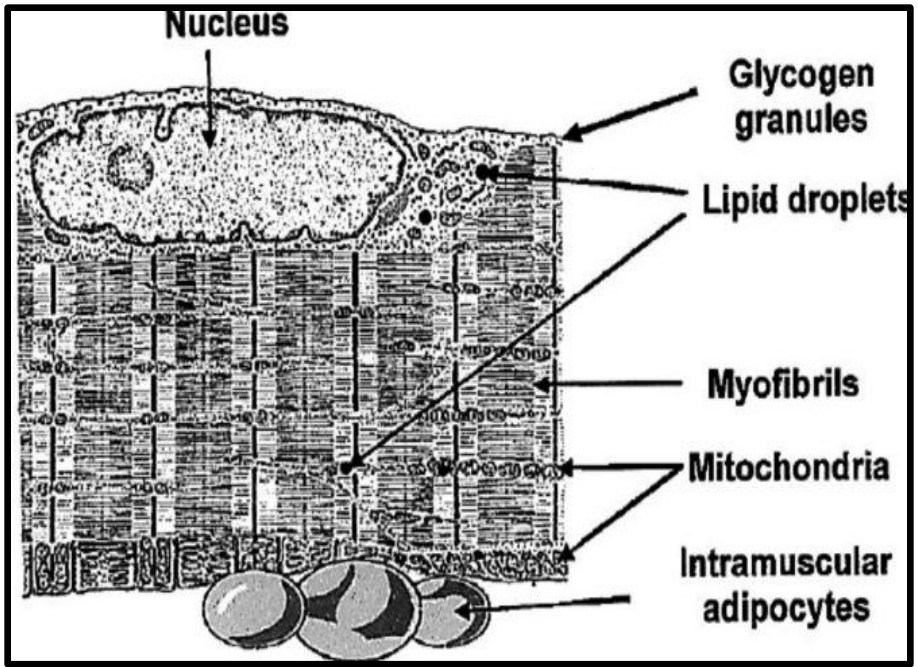
4. ***A small Golgi*** is associated with one nuclear pole.

5. ***Glycogen*** is present in the form of coarse granules in-between myofibrils.

6. ***Few lipid droplets***.

7. ***Myoglobin pigments*** oxygen-binding protein that is responsible for the red brown color of muscle and is related to oxygen supply for the muscle.



# E/M of the muscle fiber

## Myofibrils

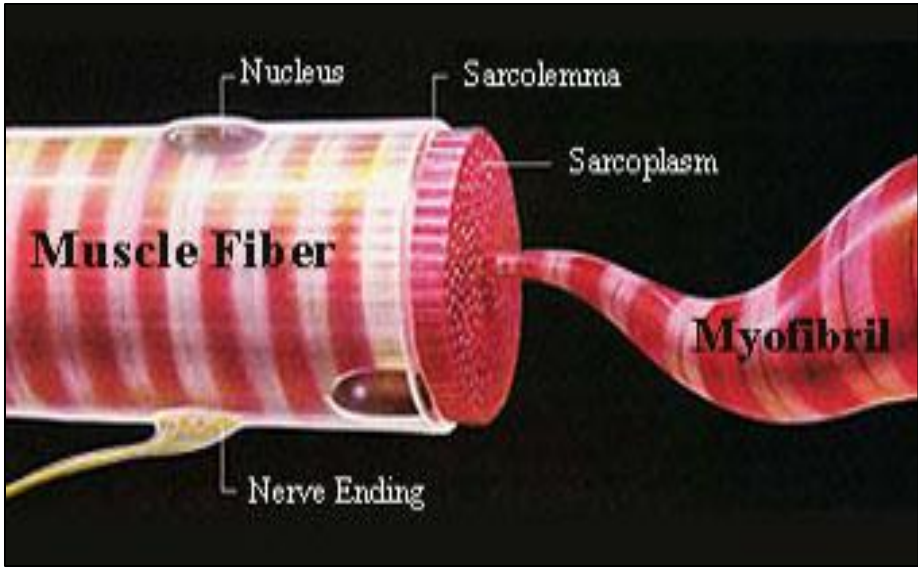
- Each muscle fiber (myofiber) contains a plenty of long, cylindrical **myofibrils** which run parallel to the long axis of the muscle fiber.
- Each myofibril exhibits a repeating pattern of cross striation formed by **alternating dark (A) and light (I) bands.**
- **I band** is bisected by dark line called (Z) line.
- The regular striations done by *special arrangement* of contractile proteins ***(myofilaments).***

**These myofilaments are of two types:**

1. Thin filaments (actin).

2. **Thick** filaments (myosin).

- The smallest repetitive unit in longitudinal section of the myofibril is called **sarcomere.**



# SARCOMERE

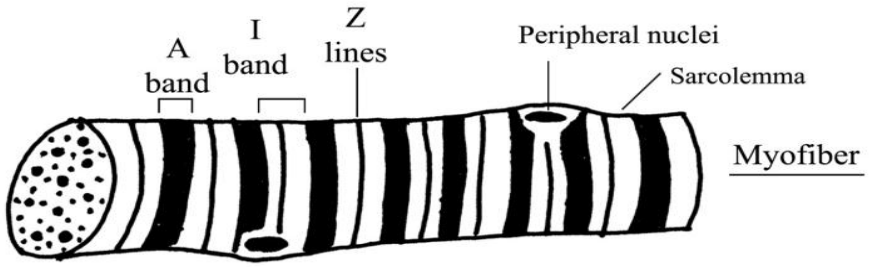
## Definition:

- It is the structural and contractile unit of myofibrils.
- It is the portion of myofibril between two successive Z lines.

## Structure:

**It consists of two types of filaments:**

- Thin (actin) myofilaments
- Thick (myosin)myofilaments




## Arrangement of actin and myosin within the sarcomere:

1. Sarcomere consists of **one complete dark A band separating two halves of light I bands on either side of the A band.**

2. **I band** contains only actin filaments attached to Z line.

3. **Z line** is mainly formed by α-actinin and desmin proteins.

4. **A band**

- contains actin and myosin filaments, these filaments overlap for some distance within the periphery of the band.
- shows a lighter zone in its center called H zone.

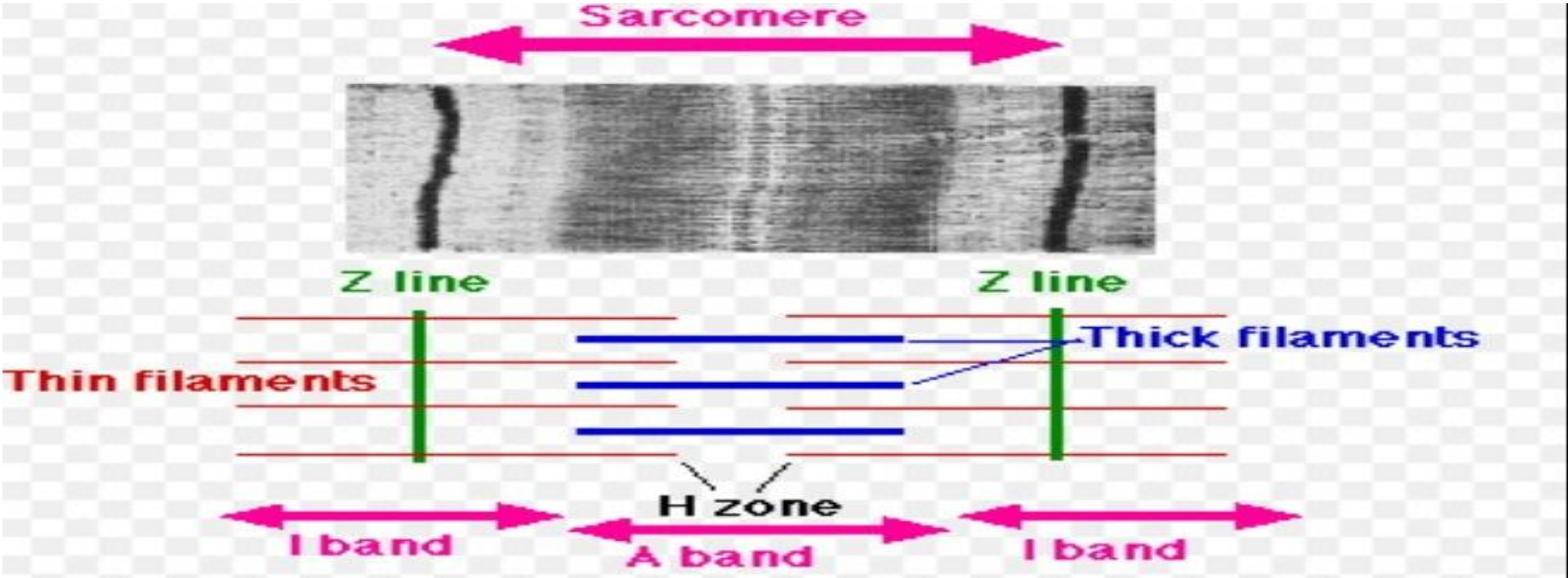
5**. H zone**

- consists only of thick myosin filaments.
- H zone is **bisected** by a dark line called M line where myosin filaments are attached.

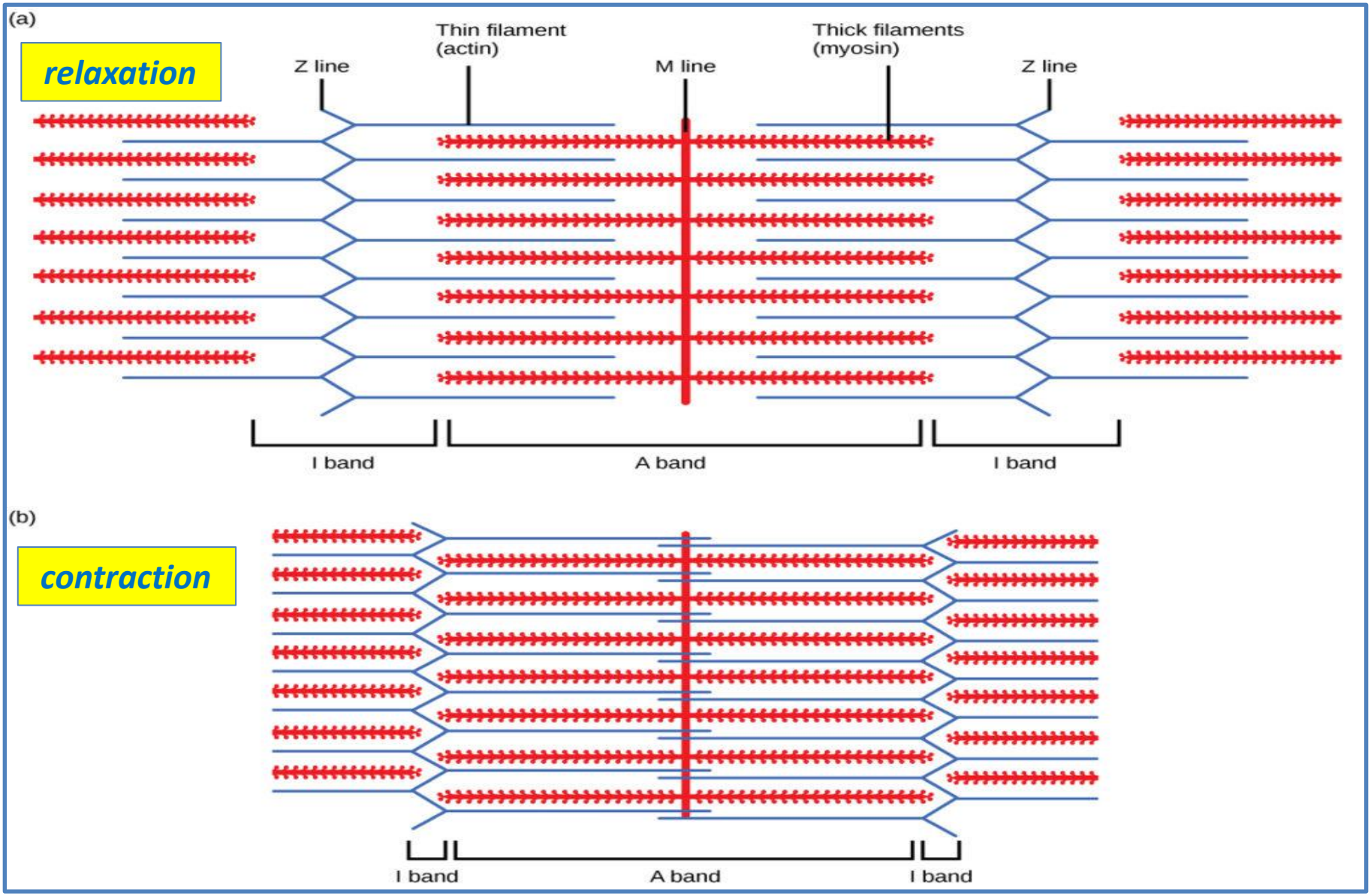
6. **M line**

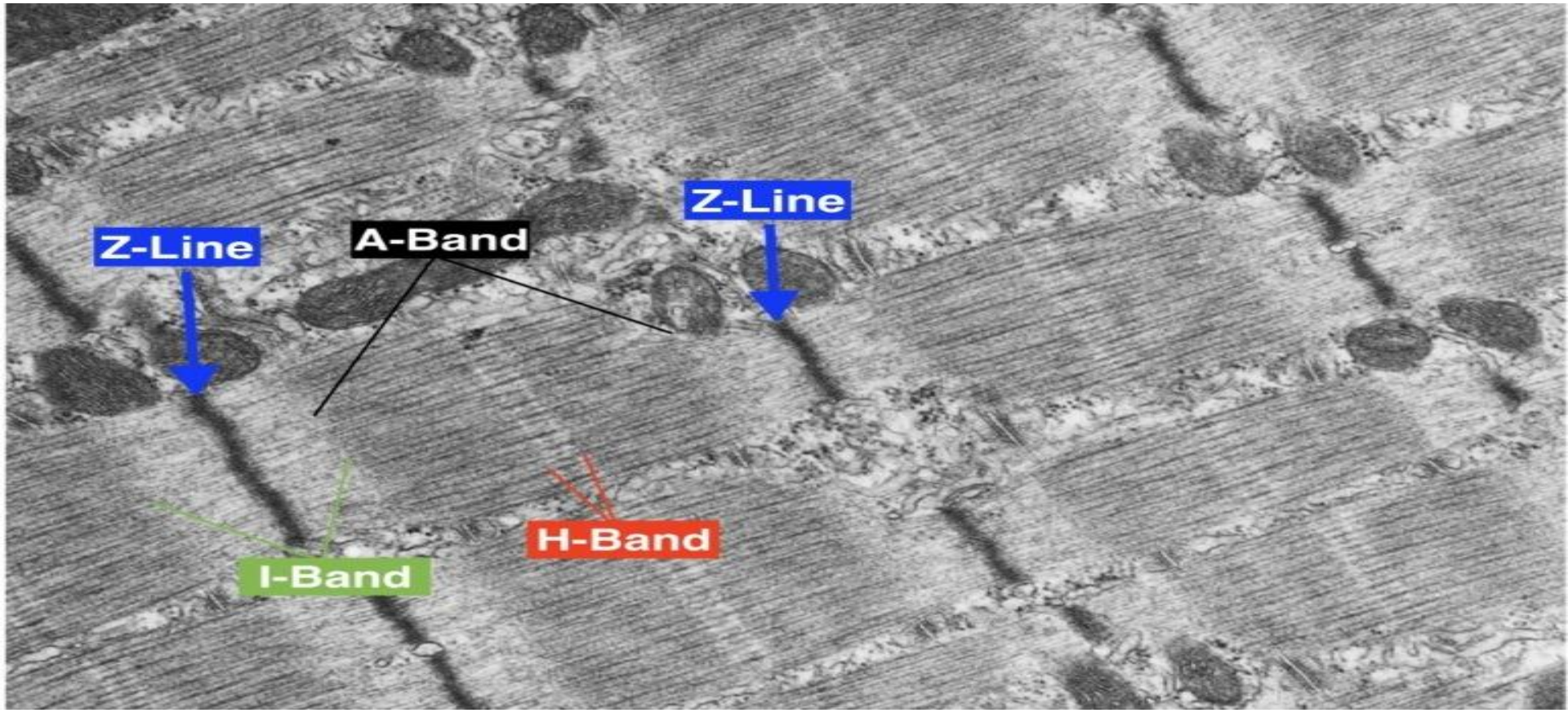
- formed mainly of myosin-binding protein which holds thick filaments in place

7.The sarcomeres of adjacent myofibrils are parallel to each other.

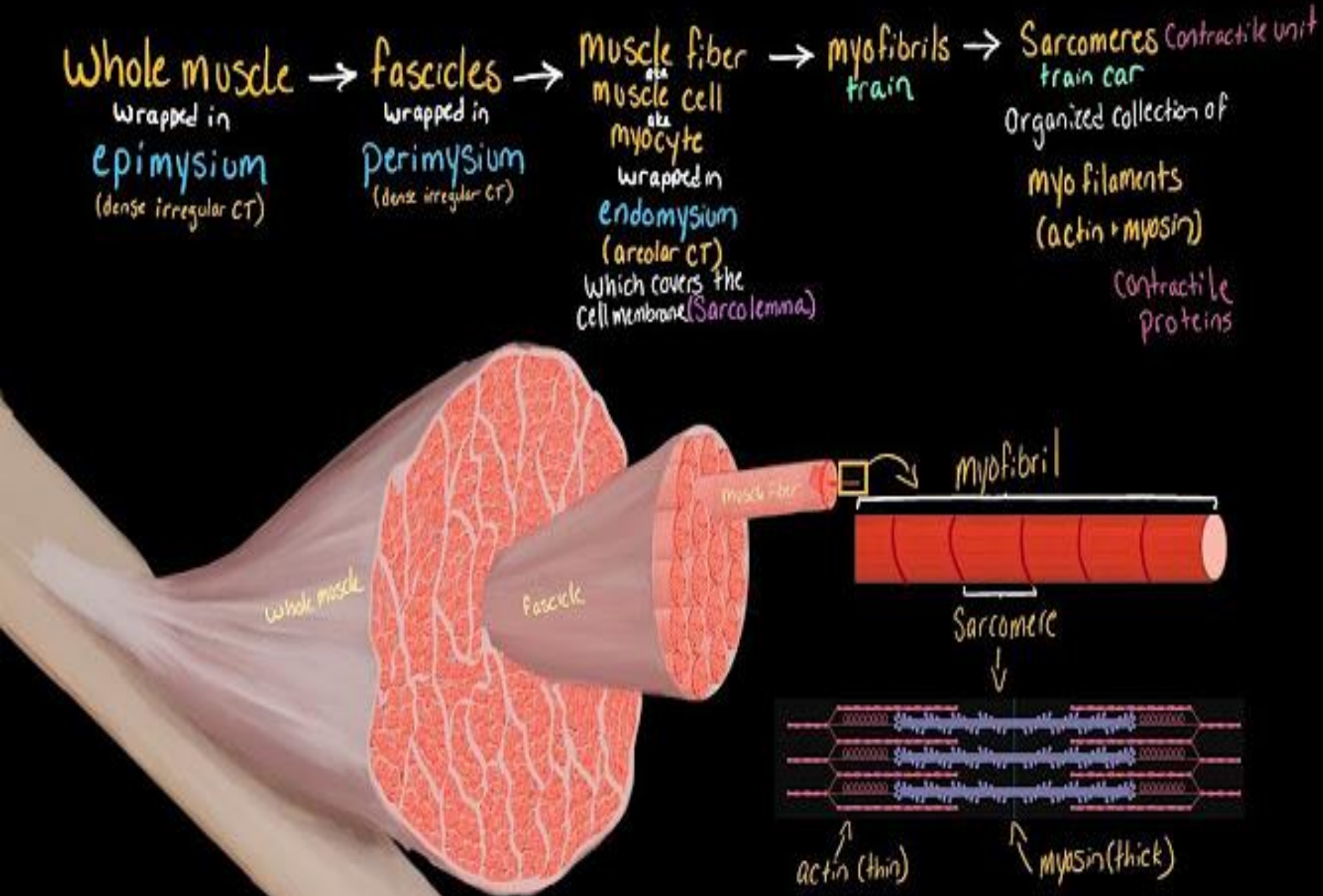


# SARCOMERE


(a)
relaxation
Thin filament
(actin)
Thick filaments
(myosin)
Z line
M line
Z line
I band
A band
I band
(b)
contraction
I band
A band
I band

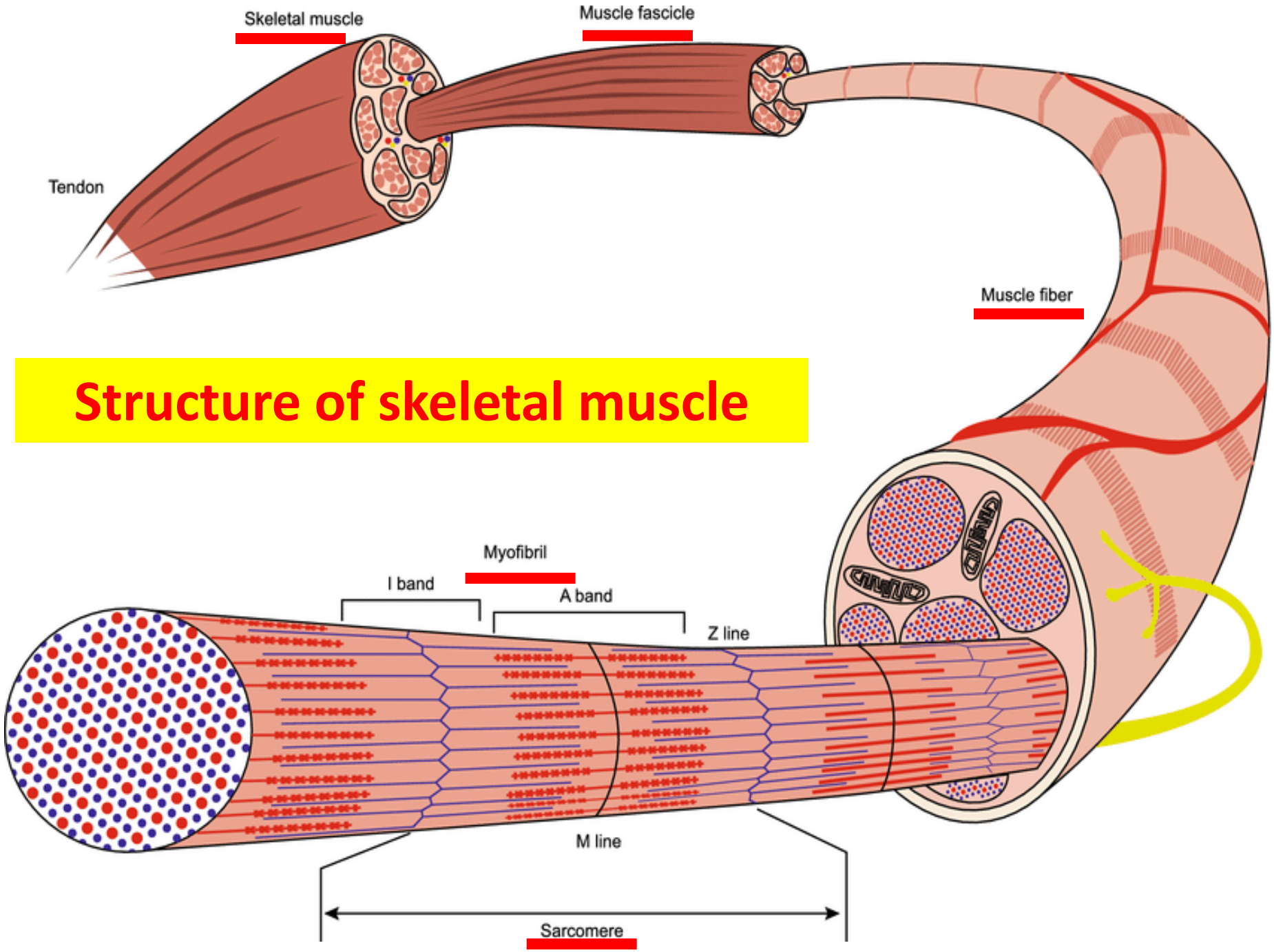



| Bands | A band | I band |
|---|---|---|
| Colour | Dark | Light |
| Filaments | Actin + Myosin | Actin |
| Divided by: | **H** zone + **M** line. | **Z** line. |



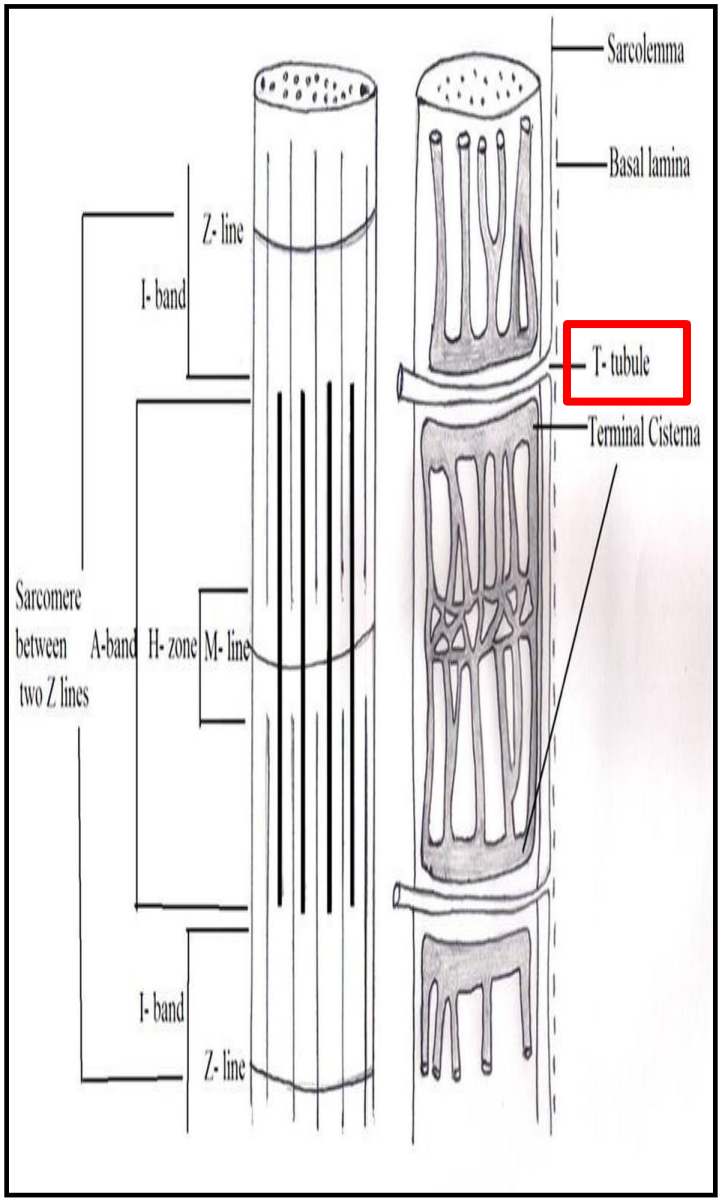

Histological structure of skeletal muscle

# Structure of skeletal muscle



# Transverse tubules (T-TUBULES)

- **Definition**: These are tubular invaginations of sarcolemma into the interior of the muscle fiber.
- **Site:** form anastomosing network that encircle the boundaries of each sarcomere in every myofibrils at the junctions between A and I bands.
- **Each sarcomere** possesses two sets of T tubules one at each A-I junction.
- The lumen of T-tubules is continuous with the intercellular space, and its membrane is continuous with sarcolemma
- **Function:** T-tubules extend deep into the interior of the fiber and facilitate the conduction of waves of depolarization along the sarcolemma.



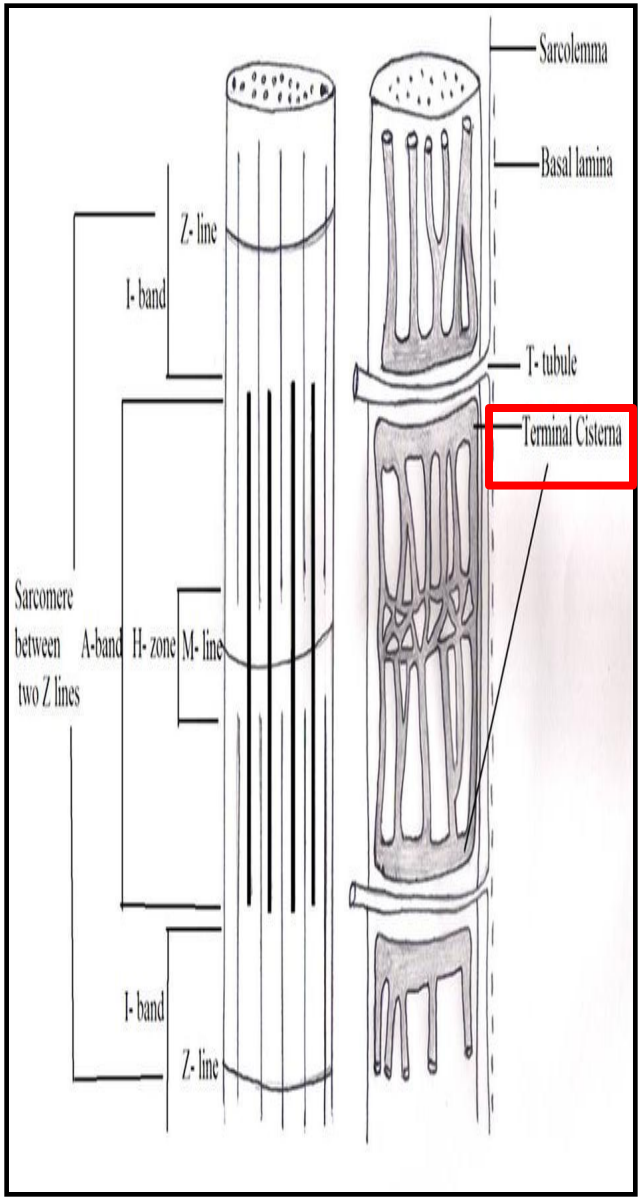
# Sarcoplasmic reticulum (SR)

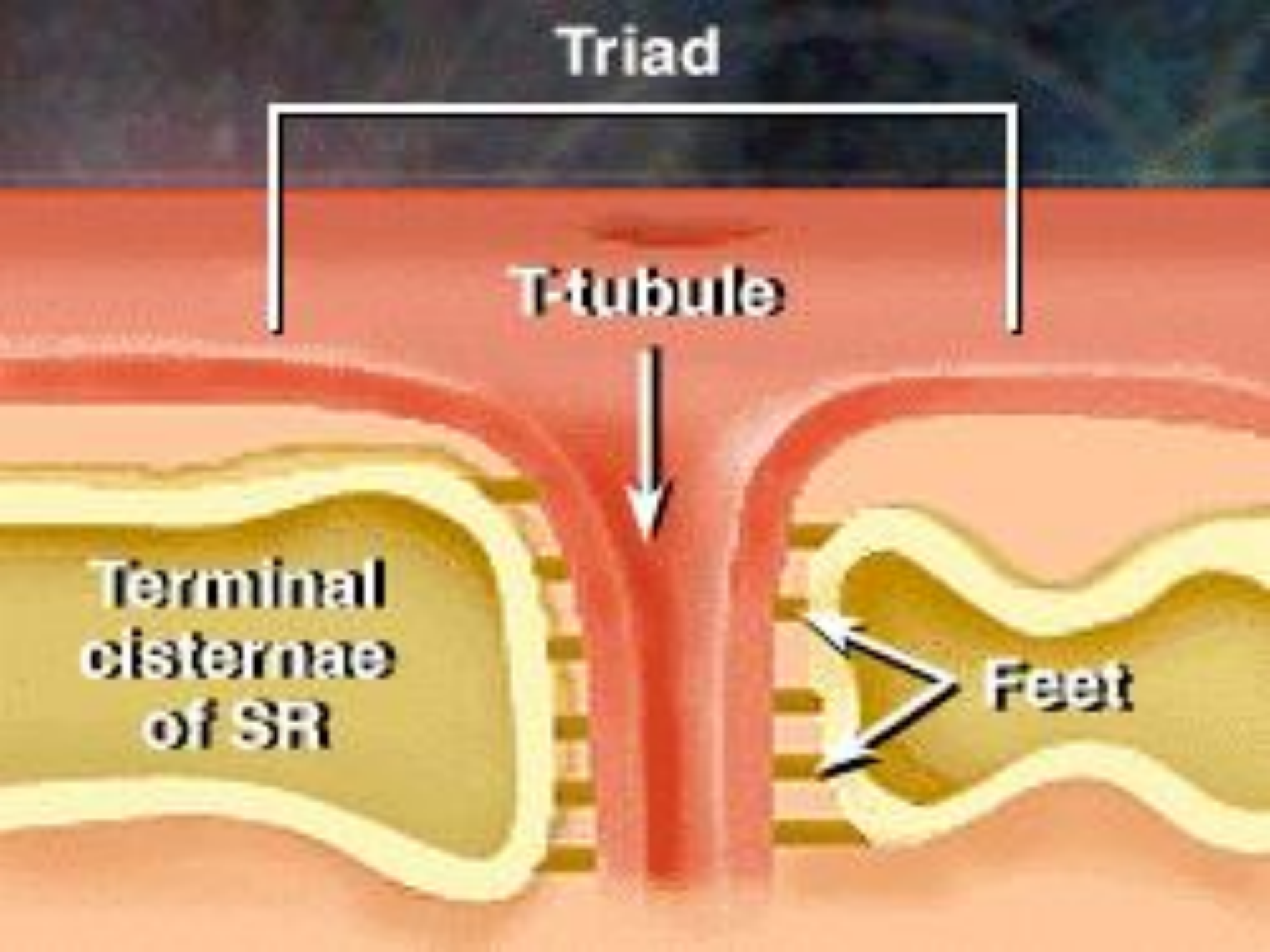
**Definition:**

-It represents a **special type of Smooth Endoplasmic Reticulum.**

**Structure:**

- It forms longitudinal tubules around the A band, with cross connections in the region of the H band.
- At the A-I junctions the tubules form dilated rings around the myofibrils called **terminal cisterna**.
- The **two opposed terminal cisternae** are separated by **T-tubule** of sarcolemma at each A-I band forming the **muscle triad**. Therefore, there are two triads for each sarcomere.
- The T-tubules and adjoining terminal cisternae are joined by small electron dense structures that bridge the gap between their membranes called **junctional feet**.




Triad
T-tubule
Terminal cisternae of SR
Feet

**Function of SR**

- The lumen of the cisternae contains calciquestrin protein which acts as sequestering agent for the *storage of Ca++ within the reticulum.*

- Depolarization of sarcolemma spreads along T-tubules and causes release of Ca++ from sarcoplasmic reticulum to sarcoplasm and subsequently contraction of muscle occurs.

- When membrane depolarization ends, the sarcoplasmic reticulum actively transports Ca++ back into the cisternae resulting in muscle relaxation.

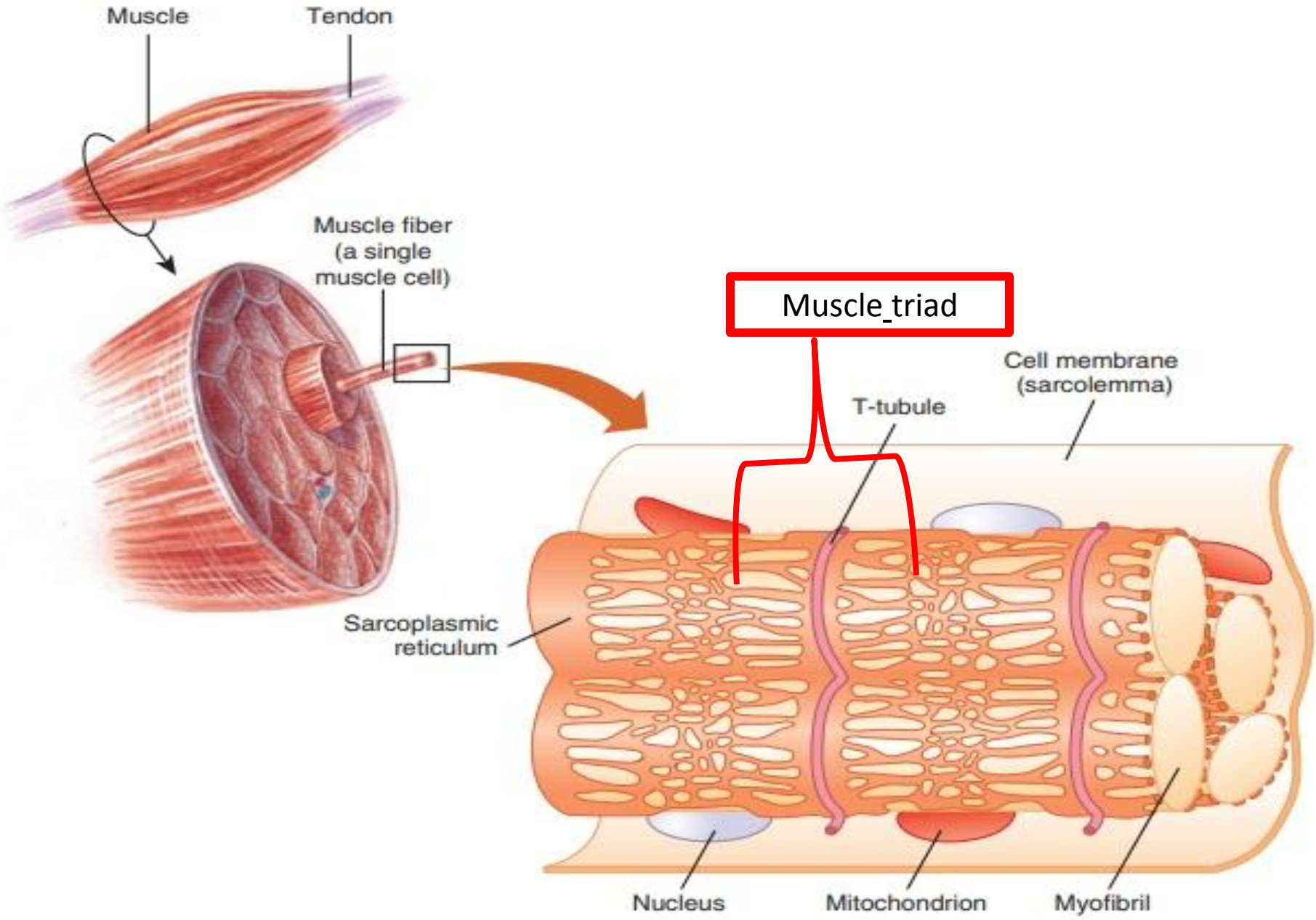
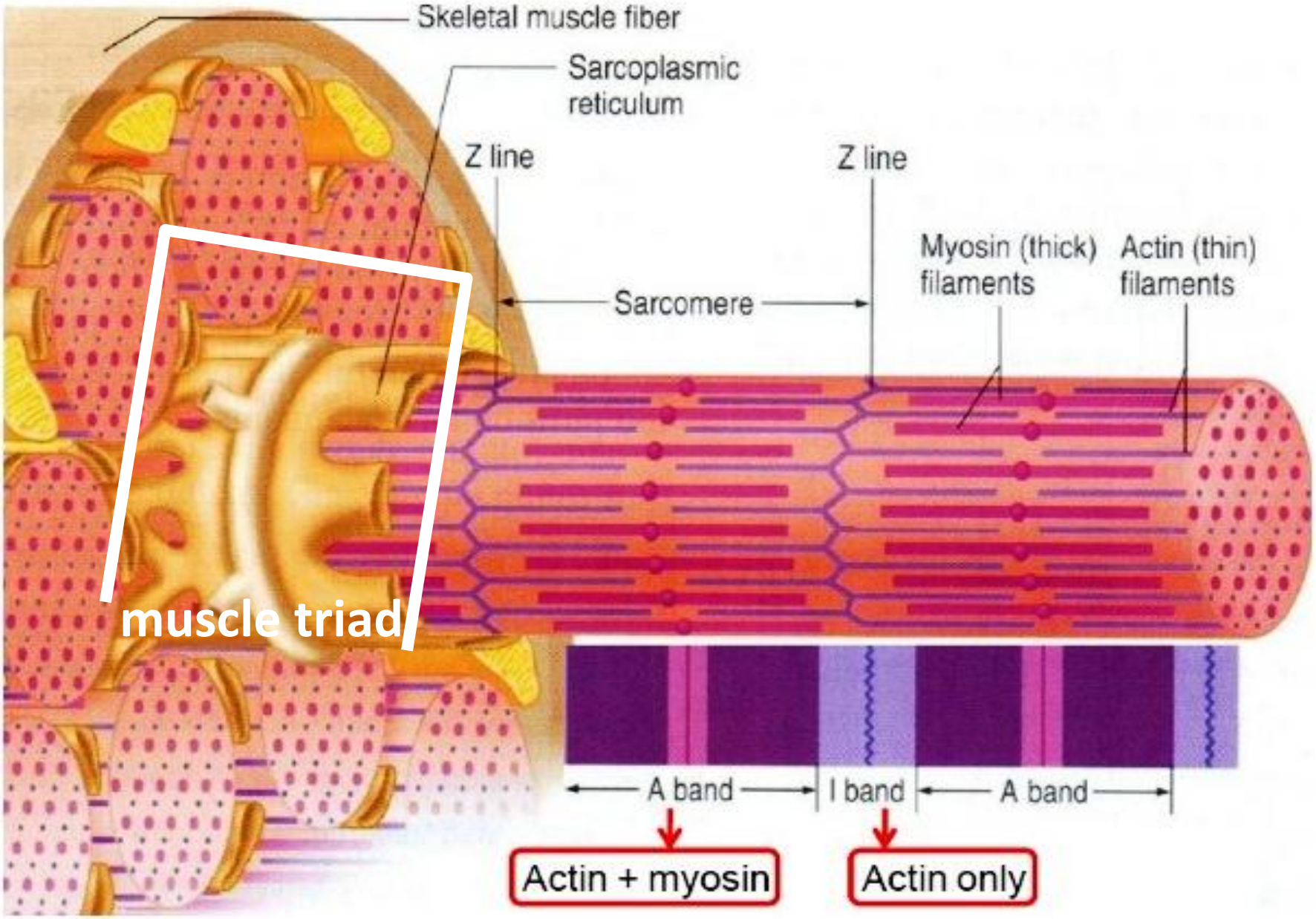



**FIGURE 9-6** Location and fine structure of a muscle fiber.


Skeletal muscle fiber
Sarcoplasmic reticulum
Z line
Z line
Sarcomere
Myosin (thick) filaments
Actin (thin) filaments
muscle triad
A band
I band
A band
Actin + myosin
Actin only

# Types of skeletal muscle fibers

**According to myoglobin concentration in the muscle fibers, they are classified into three types:**

## 1-Red fibers:

- They are small in diameter and have dark color.
- contain abundant myoglobin and numerous mitochondria.
- They are adapted to long, slow contractions.
- They have a great resistance to fatigue.
- Examples: limbs, long muscle of the back in human as they are effective in postural maintenance.

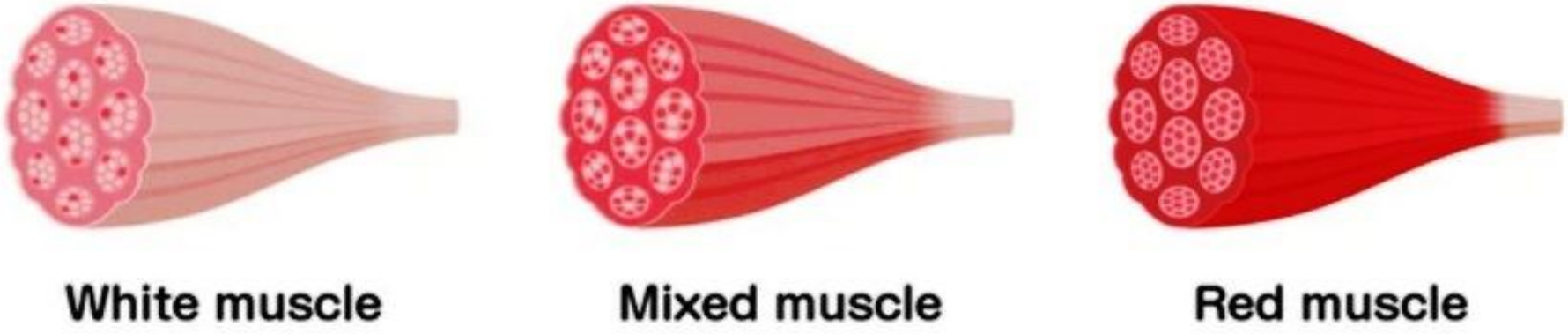
## 2- White fibers:

- They are large in diameter.
- They contain few mitochondria and less myoglobin than red fibers but contain abundant glycogen granules.
- They are adapted to rapid contractions of short duration.
- They fatigue rapidly.
- Examples: Extraocular muscle and muscles of the digits.

## 3- Intermediate fibers:

- They are of intermediate size.
- They have myoglobin, mitochondria, and glycogen less than the red fibers and more than the white fibers.

| Types of fibers | Red | White | Intermediate |
|---|---|---|---|
| Size | Small | Large | IM |
| Myoglobin | Rich | Few | IM |
| Mitochondria | Rich | Few | IM |
| Glycogen (G) | Few | Rich | IM |
| Contraction | Slow long | Fast short | IM |
| Fatigue | Slow | Rapid | IM |
| Site | Limb muscle | Extraocular muscle | Different sites. |



# Innervation of skeletal muscle

- Each skeletal muscle receives *motor* and *sensory* nerve fibers.
- **Myelinated motor nerves** branch within the perimysium, where each nerve gives rise to *several terminal twigs*, each of which lies in a shallow depression on the surface of the muscle fiber.

This structure is called **motor end-plate or myoneural junction**.

# Motor end-plate

**It is composed of:**

**1. Axon terminal:** loses its myelin sheath and forms dilated termination contains**:**

**a)** Numerous mitochondria.

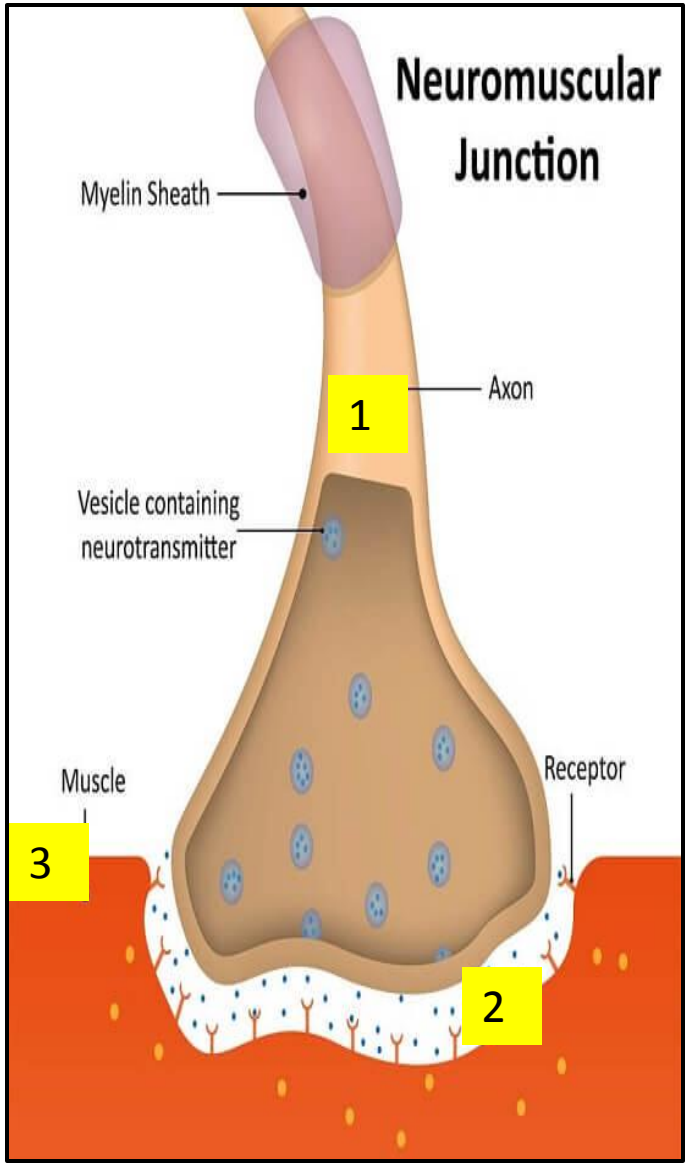
**b)** Abundant synaptic vesicles containing neurotransmitter (acetylcholine).

- **2. Synaptic cleft:** is the space between axon terminal and muscle surface. contains amorphous basal lamina matrix.

**3. Sarcolemma of the muscle fiber:**

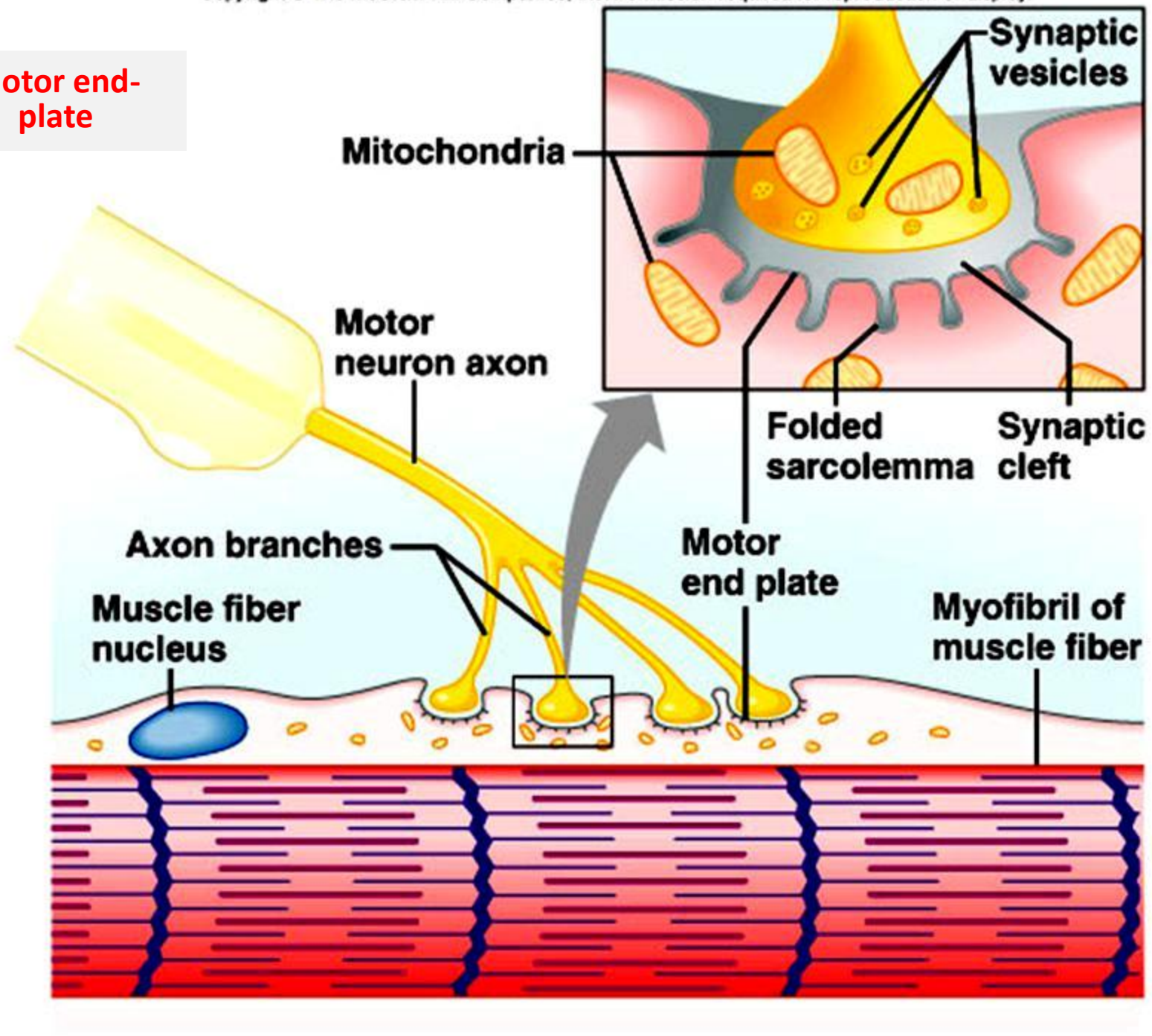
-At the junction, sarcolemma is thrown into numerous deep junctional folds.

-The sarcoplasm below these folds contains several nuclei, numerous mitochondria, ribosomes, and abundant glycogen granules.- The sarcolemma of the junctional folds has acetylcholine receptors.

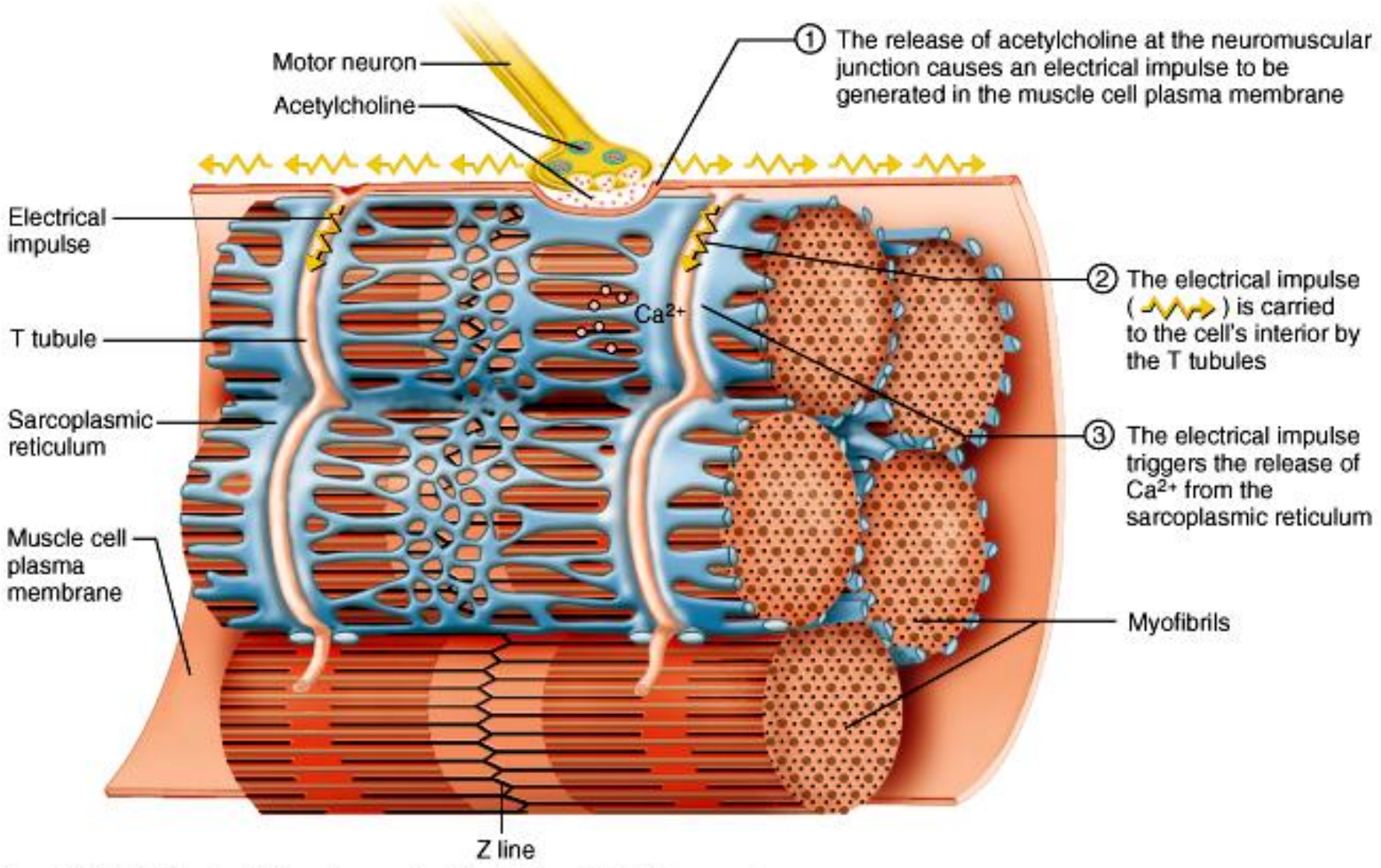


# Motor end-plate





# Muscle contraction



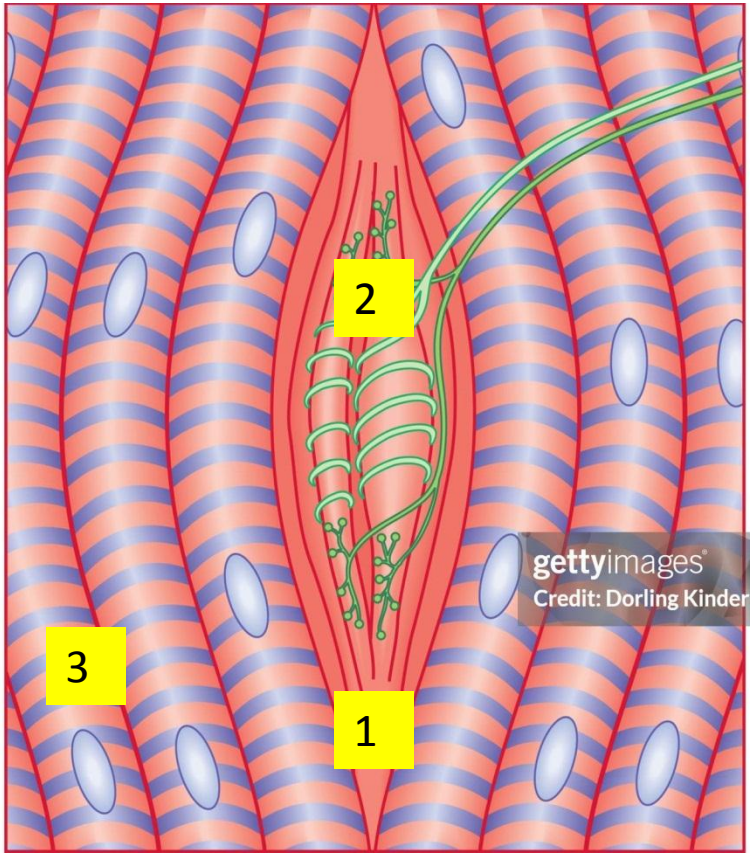
# Muscle spindle

**Function:** type of **receptors** is sensitive to **muscle stretch** and reflexly controls the muscle tone, movement, and posture.

**Site:** They are present between skeletal muscle fibers.

**Shape:** **fusiform structure**

**Structure:** consists of stretchable connective tissue **capsule (1)** containing tissue fluid and few specialized muscle fibers **(intrafusal muscle (2) fibers) ,** muscle fibers outside the capsule are called **extrafusal muscle fibers (3).**



# Muscle spindle

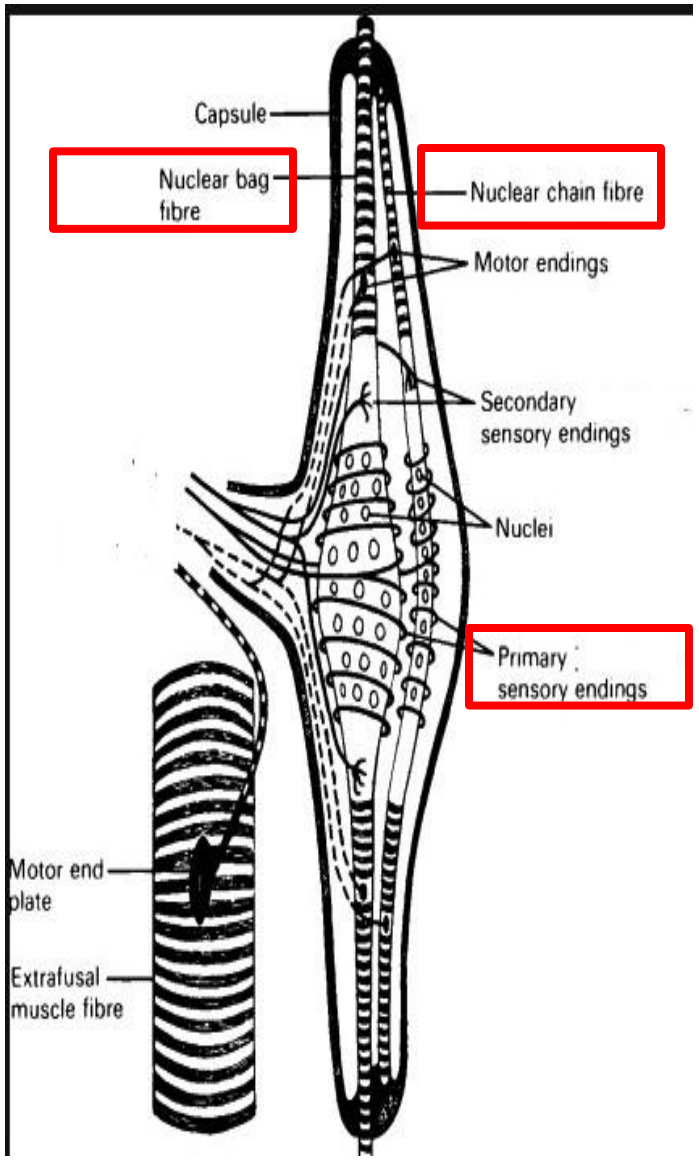
***Fibers (intrafusal muscle fibers) of two types***

**1- Nuclear bag fibers:**

- Thicker and longer
- Have **expanded central part** containing many nuclei.
- Supplied by primary nerve endings that are coiled around the expanded central part.

**2- Nuclear chain fibers:**

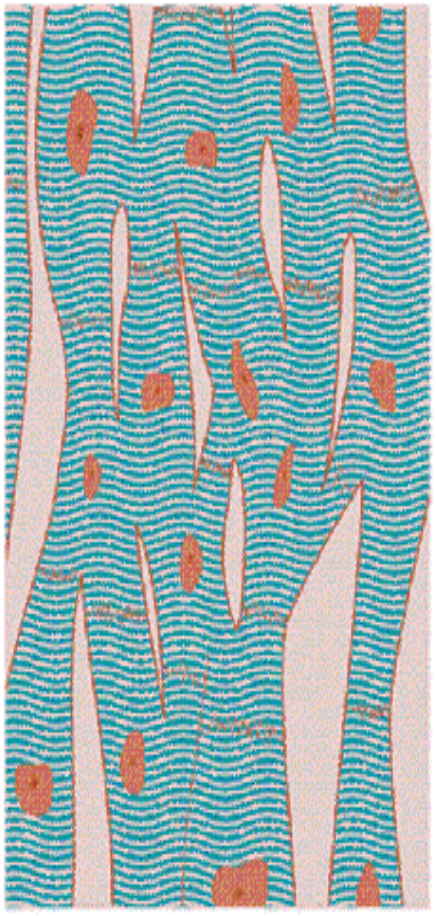
- Thinner and shorter.
- Have **regular diameter**
- the **nuclei are arranged in row.**
- They are also supplied by primary endings around the central part of the fiber. In addition, they are supplied by two secondaries endings, one on each side of the primary ending.



# Cardiac Muscle

- Cardiac muscle is striated muscle found in the wall of the heart (myocardium).
- **Contraction**: rhythmically and involuntary.
- **Striations:** show faint and indistinct transverse striations. Less striation than skeletal muscle.
- **Size:** The cardiac muscle fibers are smaller in size compared with skeletal muscle fibers.

The cardiac muscle **fibers** are composed of **several cardiac muscle cells** (cardiomyocytes).



# Characters of Cardiac Muscle

***LM:***

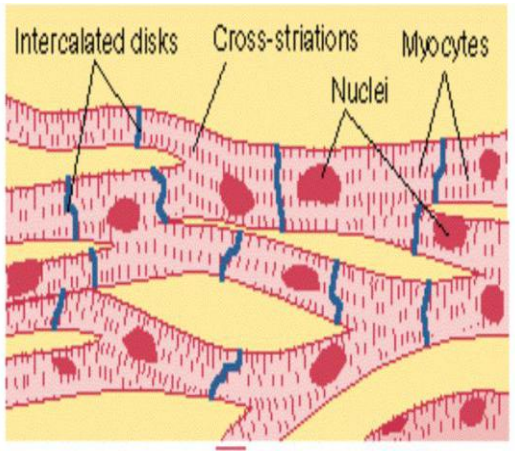
- The cardiac muscle consists of cylindrical fibers that **branch and anastomose** with neighboring fibers.
- **Cardiomyocytes** are attached to each other by junctional structure called **intercalated disc.**

  **Nuclei:** One or two oval or rounded **central nuclei.**

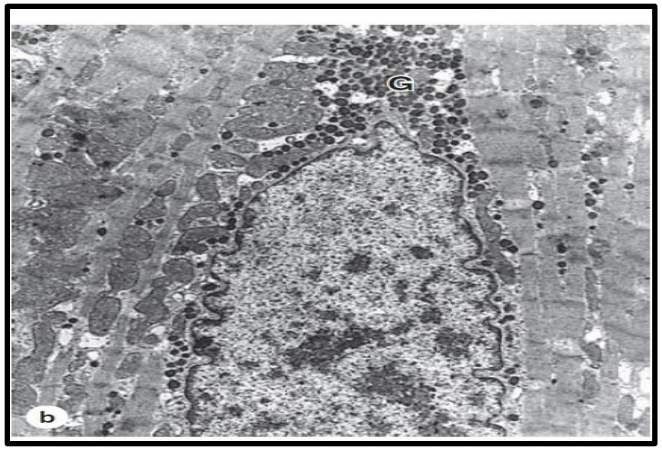
  **Cytoplasm: less acidophilic** than skeletal muscle

***EM:***

- Mitochondria and glycogen granules are **more abundant** in cardiac muscle than in the skeletal muscle.
- The cardiac muscle fibers are **rich in myoglobin.**
- No satellite cells, so they are not regenerated
- Lipofuscin pigments increase in old age.
- **SR** less developed than skeletal muscle.



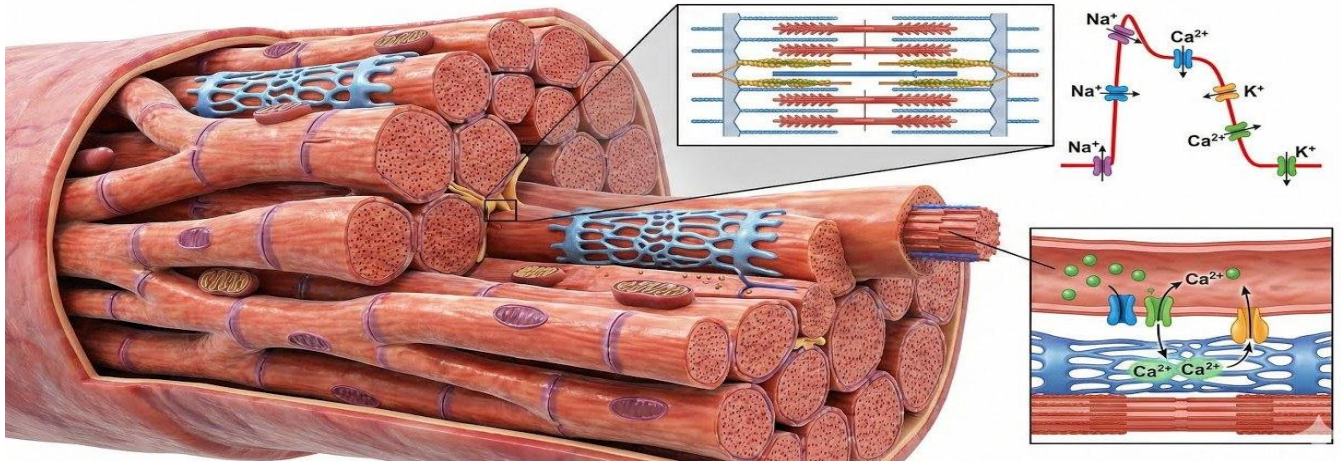
- **Muscle of the ventricles** is much thicker than that of the atria, reflecting its use in pumping systemic blood.




- **Atrial muscle cells**

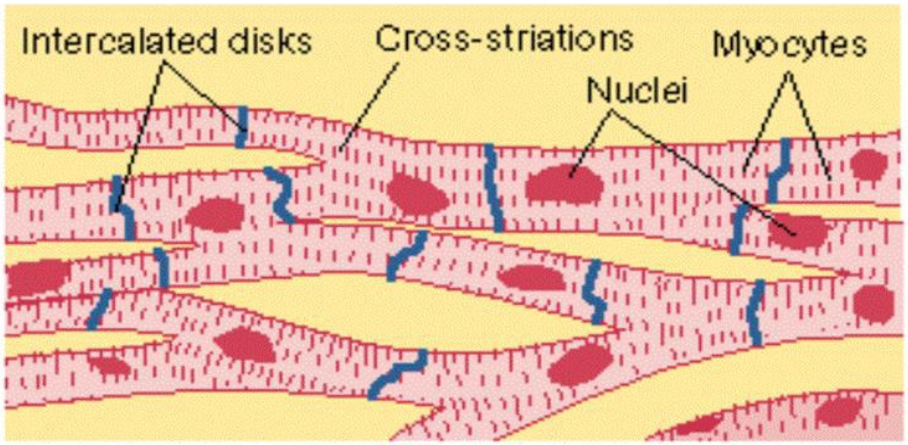
- Smaller
- fewer T tubules.
- **Membrane-limited cytoplasmic granules**, are found near atrial muscle nuclei and are associated with small Golgi complexes.

These granules release the peptide hormone **atrial natriuretic factor** (ANF) that acts on target cells in the ***kidney*** to affect Na+ excretion and water balance.

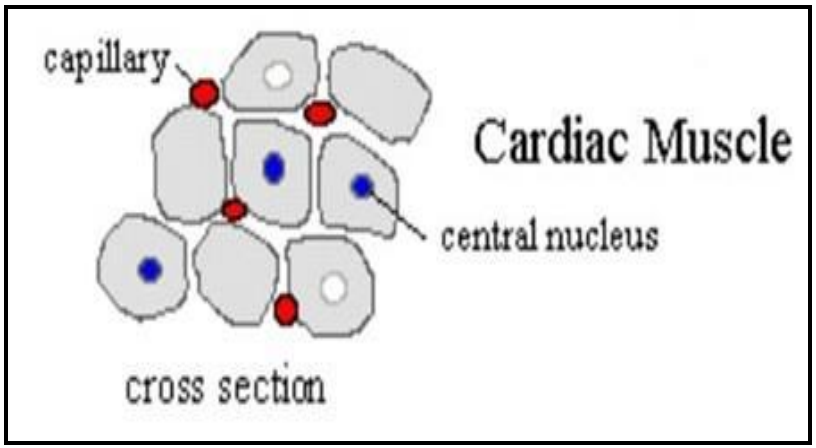


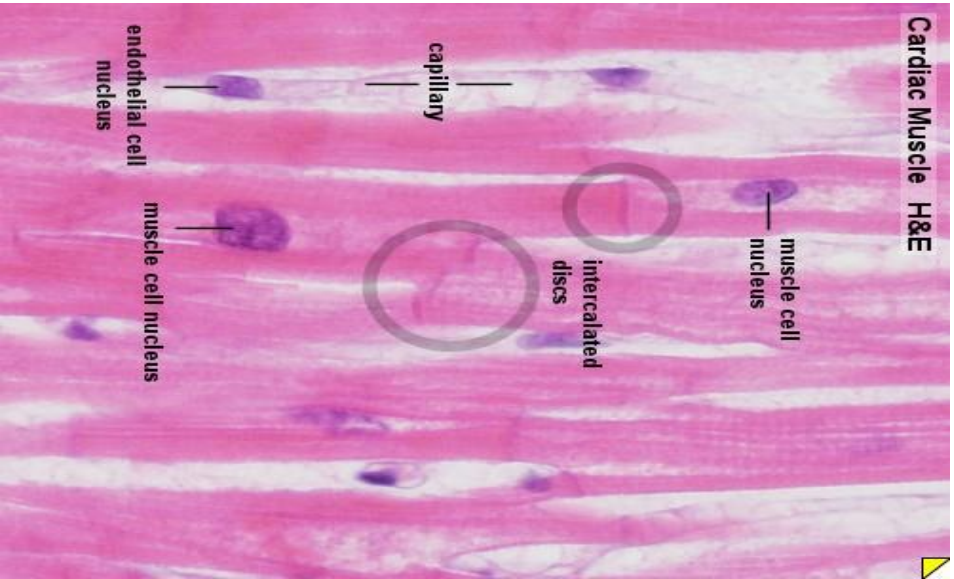
# Cardiac Muscle (LM)

## LS




## TS

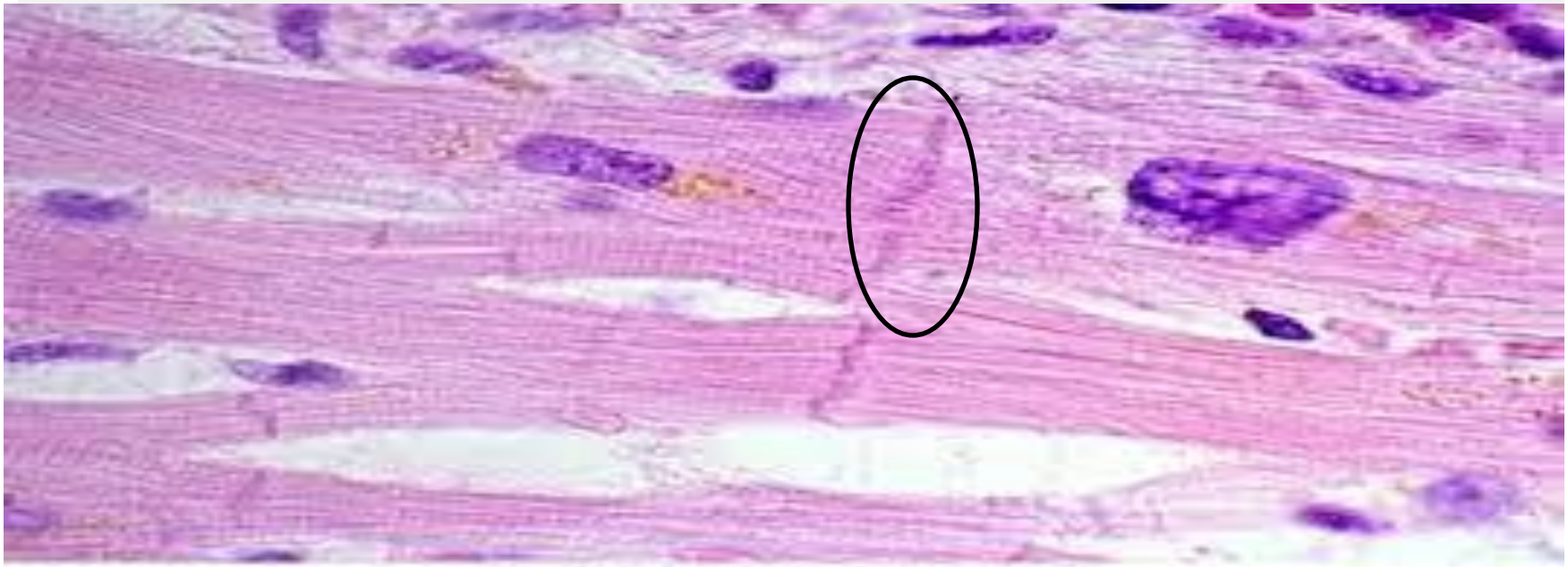



# Intercalated discs

**L/M:**

- Present between the sarcolemma of each 2 successive cardiac muscle cells.
- They cross the fiber in stepwise fashion (step like pattern) usually **at the level of Z lines**



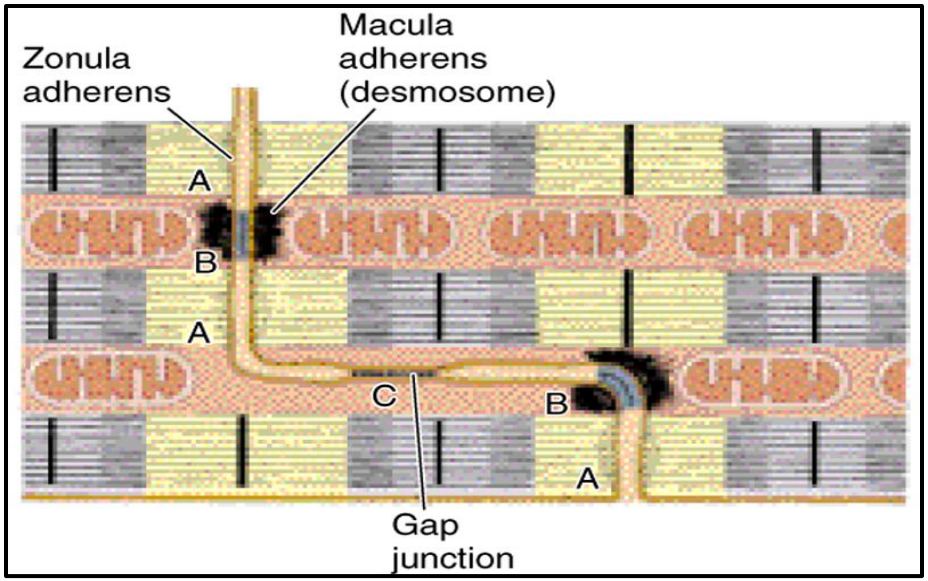
# Intercalated discs (EM)

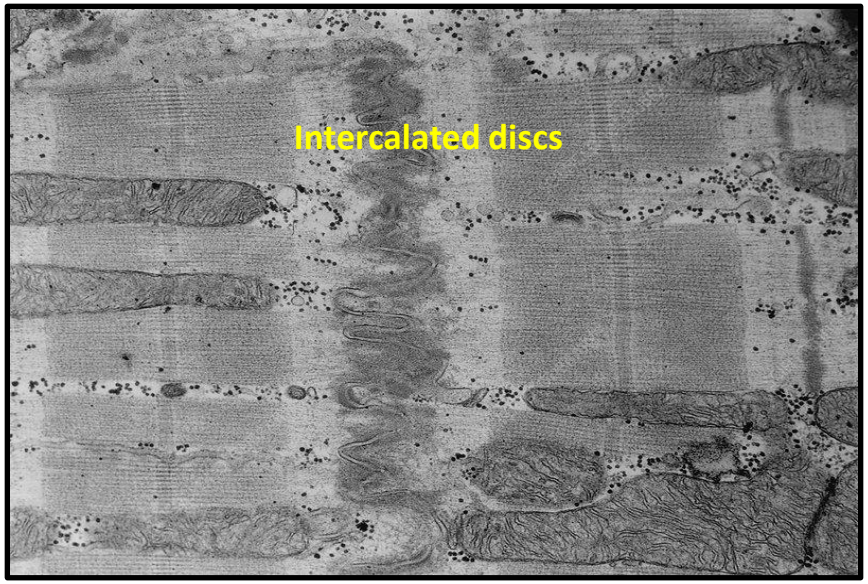
A transverse portion:

- crosses the fiber at right angle at level of **Z lines**.
- It is formed of fascia ***adherens*** & ***desmosomes***.
- it prevents separation of cardiac muscle during contraction.

A longitudinal portion:

- runs parallel to the myofibrils.
- formed of ***desmosome*** & ***gap junction***.
- The gap junction provides continuity between adjacent cells so the cardiac cells act as a syncytium (one functioning unite).



# SMOOTH MUSCLE

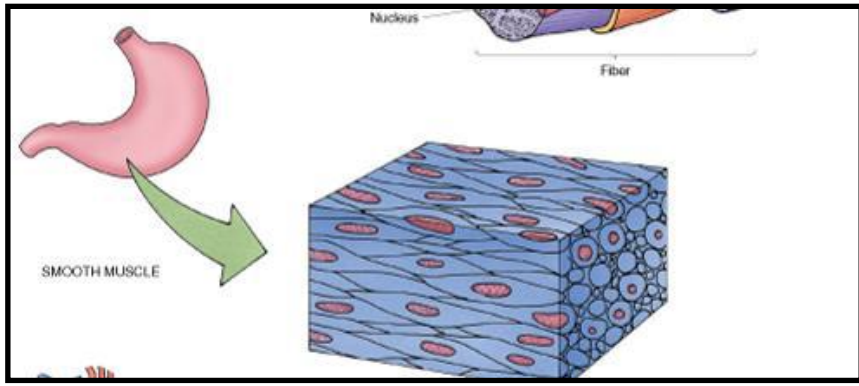
- Involuntary.
- Non striated. The sarcoplasm contains actin and myosin filaments, but **not** arranged in sarcomeres as in striated muscles, so there are **NO striations**.
- **Contraction:** weak, slow, long.
- **Sites:**

*In wall of* blood vessels& viscera: e.g. digestive, genito-urinary and respiratory systems.

- **Function :**

-They form exogenous protein ( as collagen, elastin & proteoglycans)

- Have contractile function.

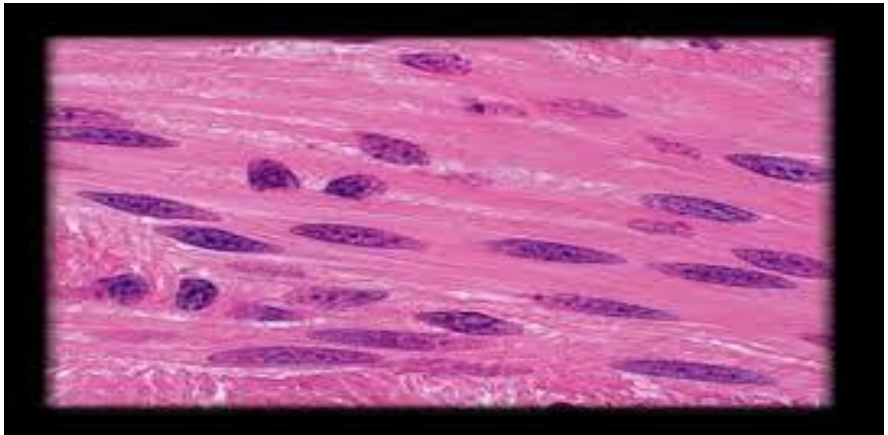


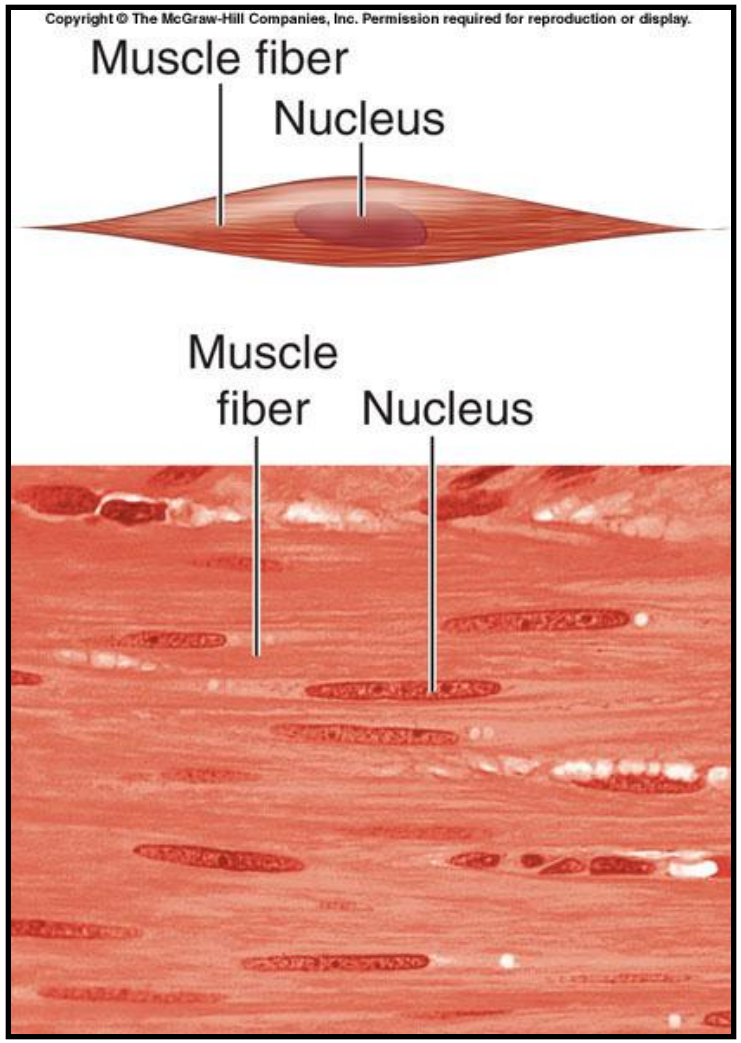
# SMOOTH MUSCLE

## Histological Structure:

### *L/M:*

- Shape:
  - Fusiform elongated cells.
  - Smaller diameter than other types.
- Nucleus: central single oval.
- Cytoplasm: acidophilic.
- Surrounded by: basal lamina and reticular fibers.



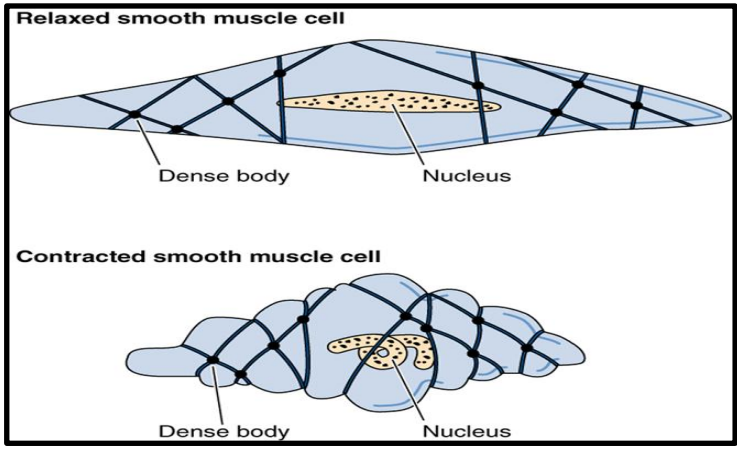


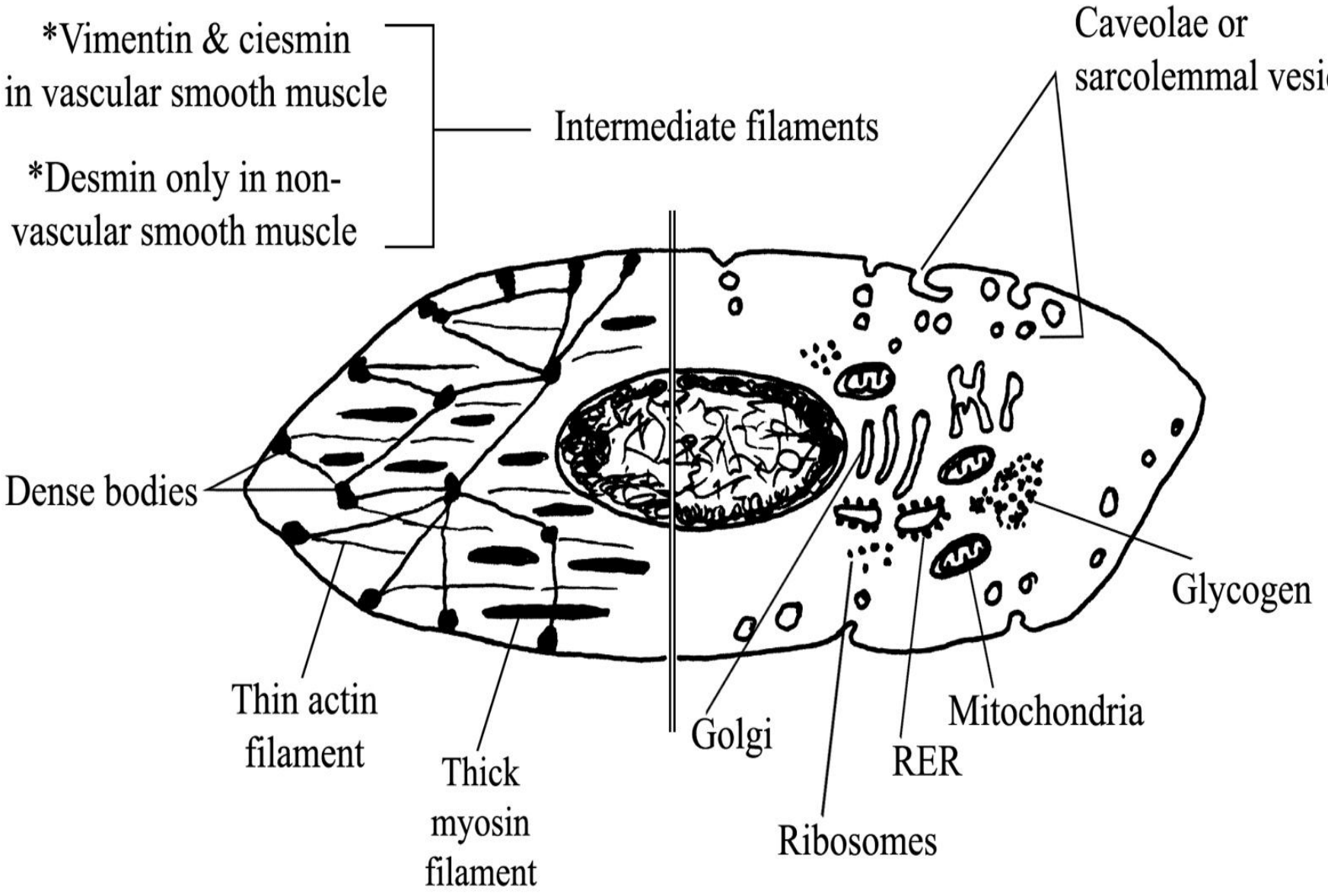
# SMOOTH MUSCLE

## ***E/M***

- ❑ **Connected together by Gap junctions.**
- ❑ **Sarcoplasm:** contains:

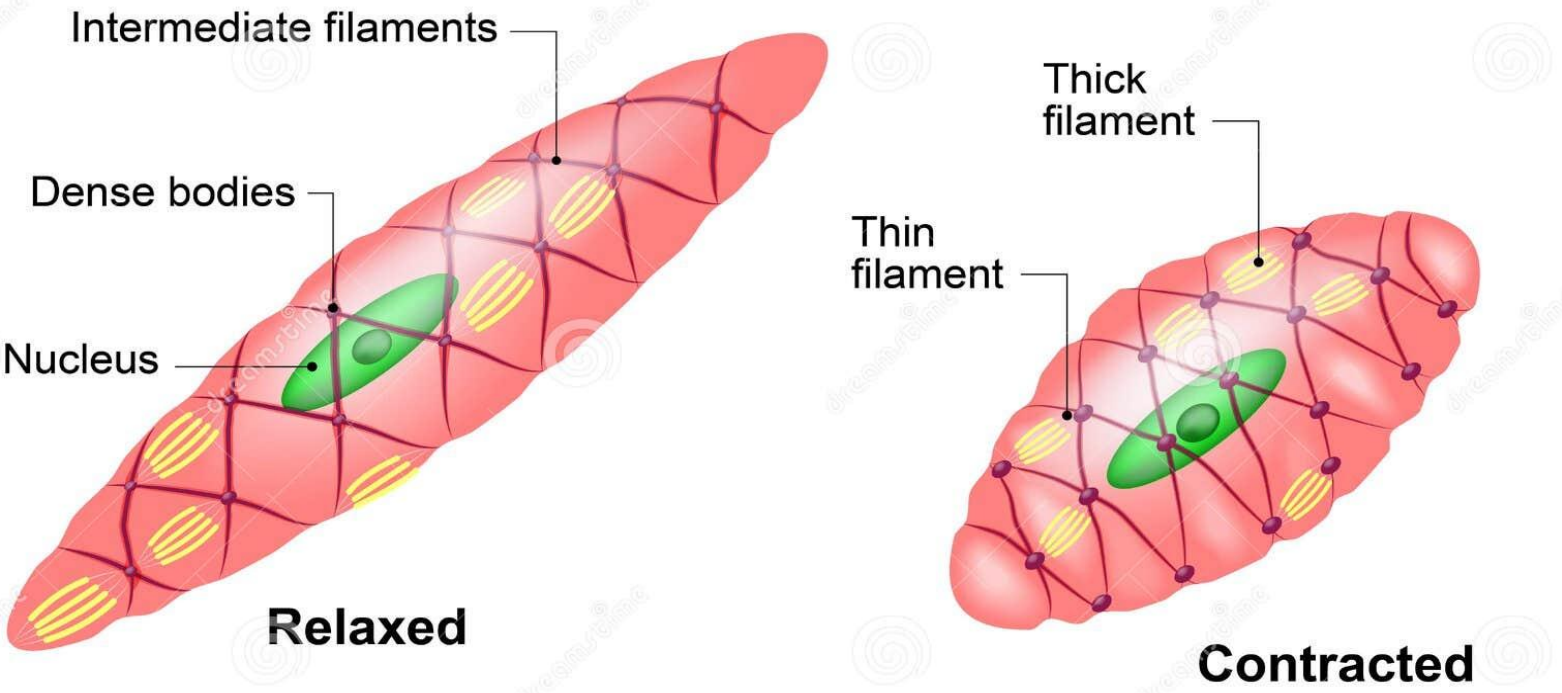
- Mitochondria, glycogen, RER and Golgi.
- **SR:** poorly developed.
- **T-tubules:** absent, replaced by caveolae (release & sequester Ca++)
- **3 types of filaments:** actin, myosin and intermediate. .
- Few microtubules.
- *No sarcomeres, so no striations.*
- **Dense bodies:**
  - Present under sarcolemma and in sarcoplasm.
  - Represent irregular Z–lines.
- Filaments insert into dense bodies.






# Fine structure of smooth muscle

# SMOOTH MUSCLE

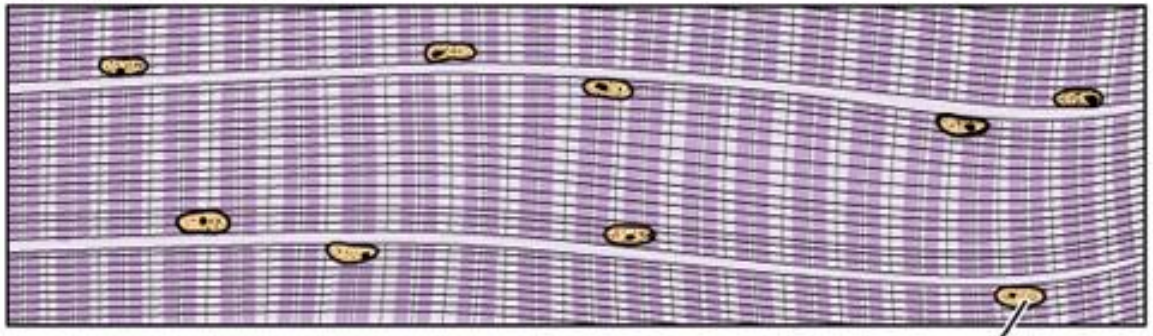


| Types | Skeletal | Cardiac | Smooth |
|---|---|---|---|
| Site | Skeleton | Heart | Viscera |
| Control of will | Voluntary | Involuntary | Involuntary |
| Striations | Striated | Less striated | Non-striated |
| Contraction | Quick | Rhythmic | Slow |
| Increase diameter by | Hypertrophy | Hypertrophy | Hypertrophy & hyperplasia |

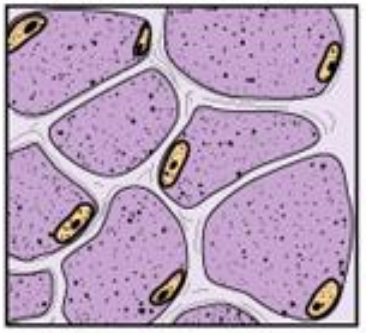
**Muscle types**

**Activity**

Skeletal muscle



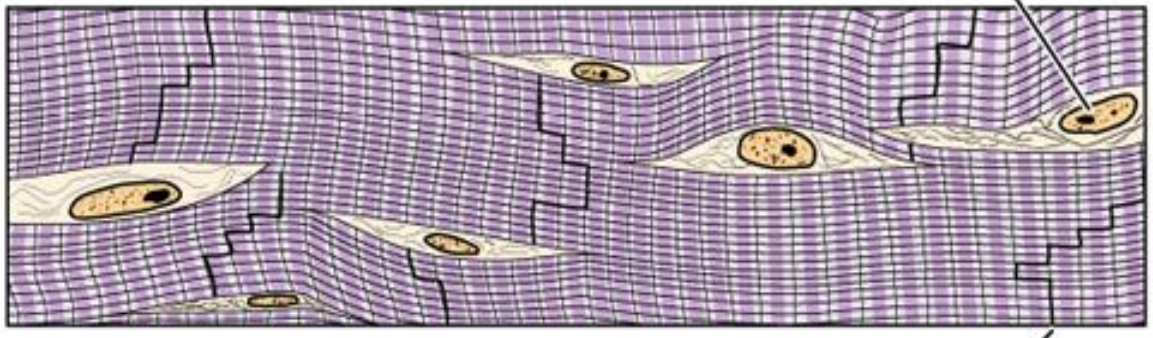
Cross sections

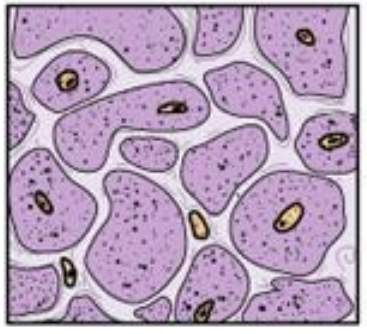


Strong, quick discontinuous voluntary contraction

Nuclei

Cardiac muscle

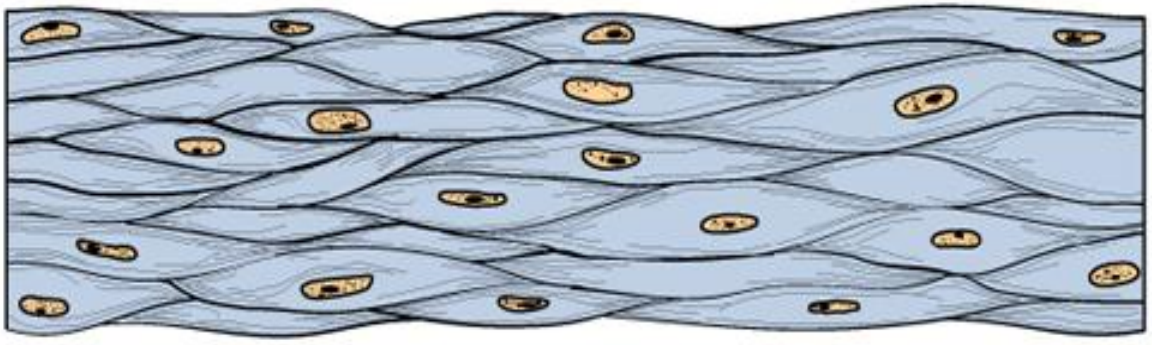


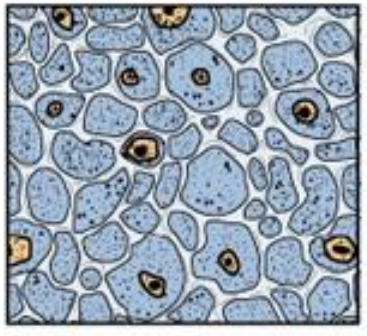


Strong, quick continuous involuntary contraction

Intercalated disks

Smooth muscle





Weak, slow involuntary contraction


Thank
You