# *Skeletal Muscle*

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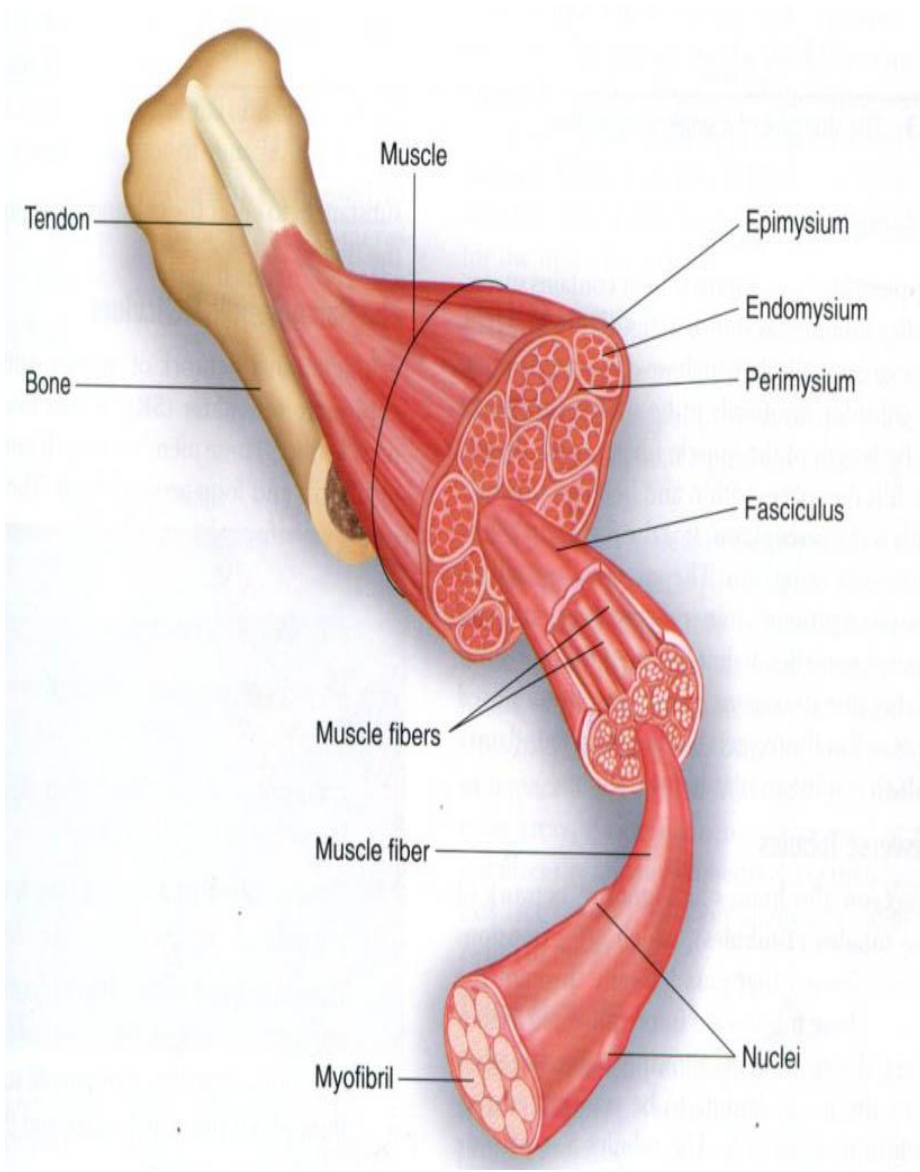
# Skeletal muscle

- Skeletal muscle contains bundles of very long, multinucleated cells with cross-striations. Their contraction is quick, forceful, and under voluntary control.
- They are called skeletal as they are attached to the skeleton

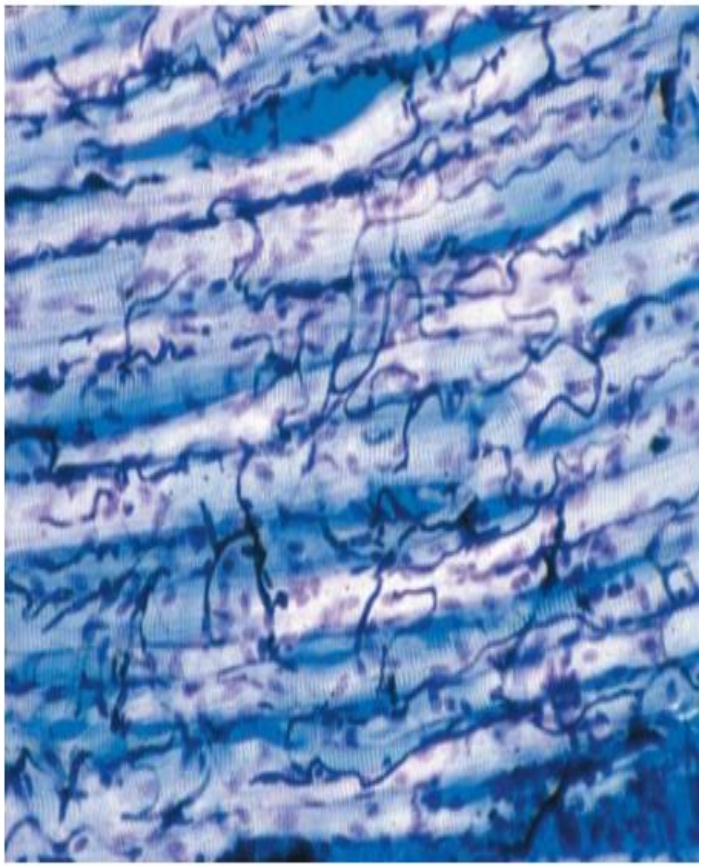


# Organization of a Skeletal Muscle (C.T Coverings)

■ **The epimysium:** an external sheath of dense connective tissue, surrounds the entire muscle. Septa of this tissue extend inward, carrying the larger nerves, blood vessels, and lymphatics of the muscle.

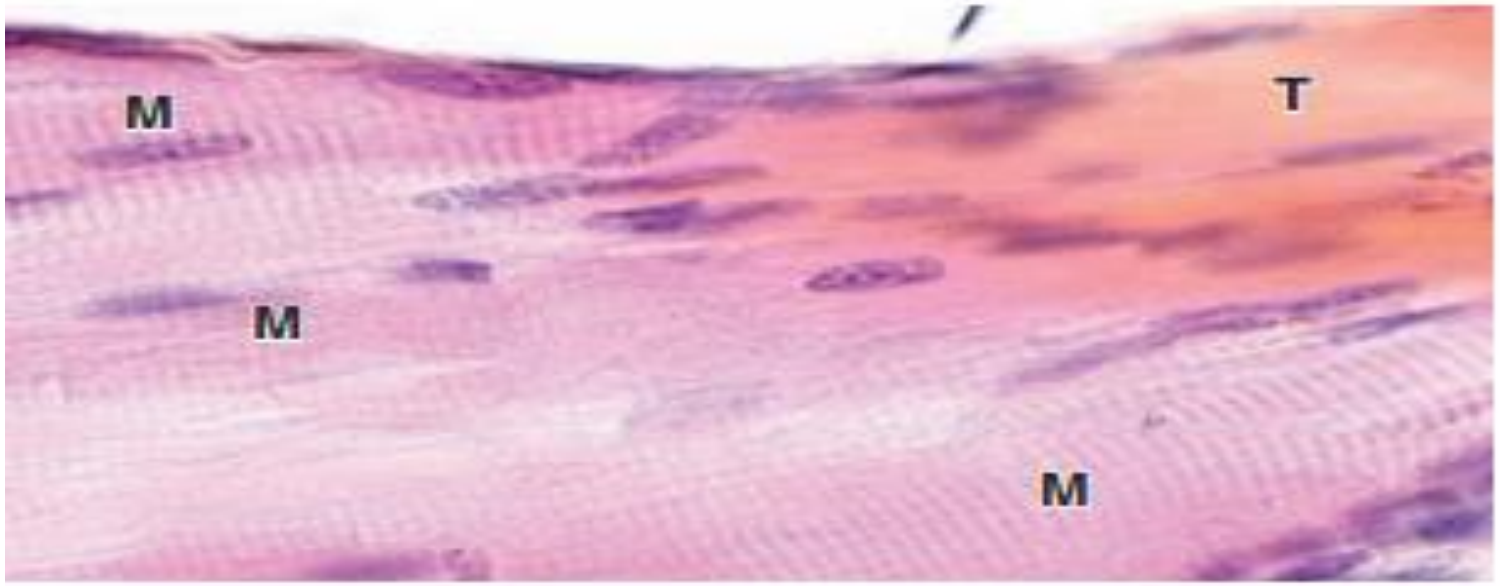
■ **The perimysium:** is a thin connective tissue layer that immediately surrounds each bundle of muscle fibers termed a fascicle. Each fascicle of muscle fibers makes up a functional unit in which the fibers work together. Nerves, blood vessels, and lymphatics penetrate the perimysium to supply each fascicle.

- **The endomysium:** a very thin, delicate layer of reticular fibers and scattered fibroblasts and many blood capillaries. It surrounds the external lamina of individual muscle fiber.



The blood vessels were injected with a dark plastic polymer before the muscle was collected and sectioned longitudinally. A rich network of capillaries in endomysium surrounding muscle fibers is revealed by this method. X200. Giemsa with polarized light.

# Myotendinous junctions




Tendons develop together with skeletal muscles and join muscles to the periosteum of bones. The collagen fibers of a tendon (**T**) are continuous with those in the connective tissue layers around muscle fibers (**M**), forming a strong unit that allows muscle contraction to move the skeleton. X400. H&E.

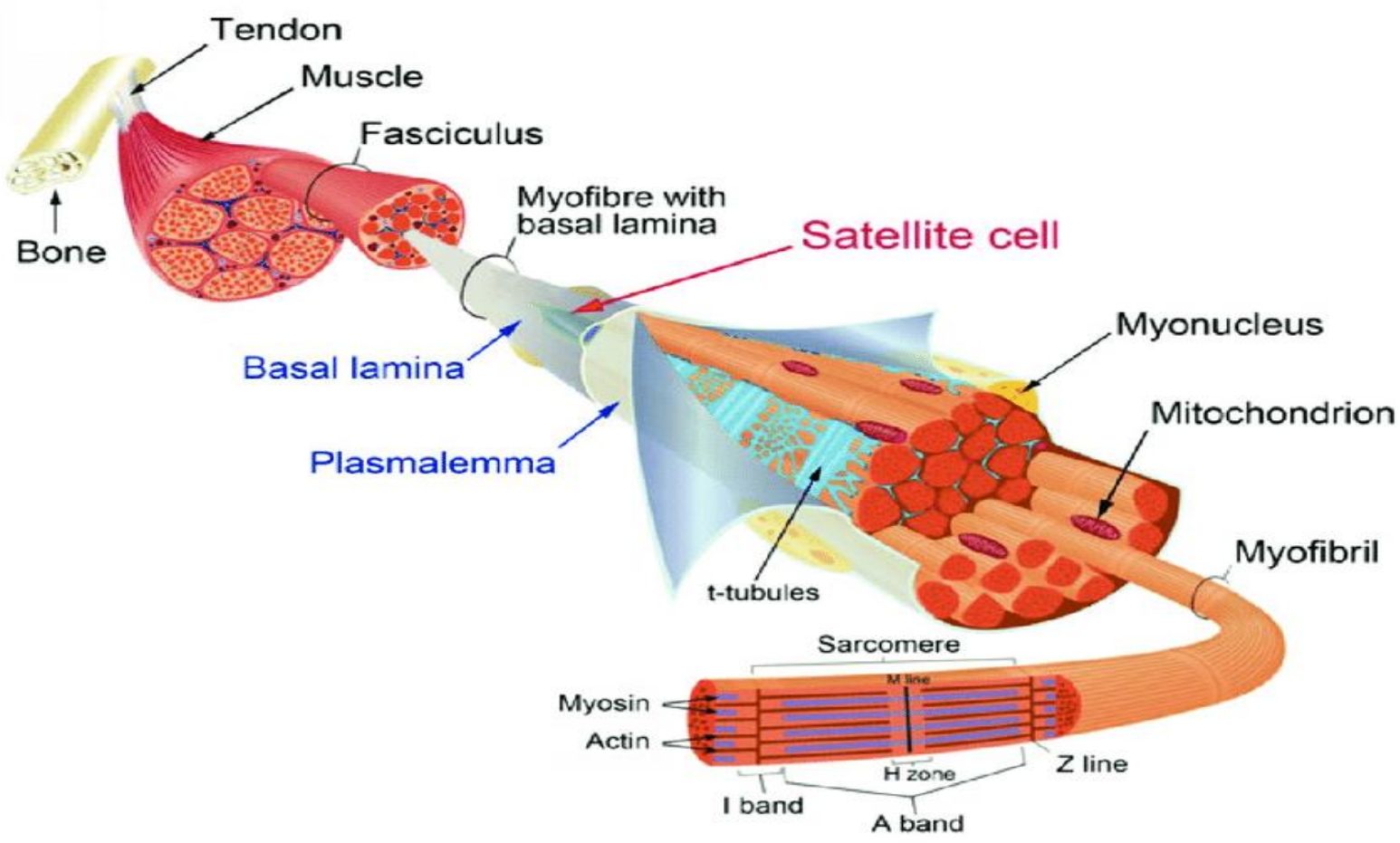
- Collagen in these connective tissue coverings of muscle serve to transmit the mechanical forces generated by the contracting muscle cells.
- Some skeletal muscles taper at their ends, where the epimysium is continuous with the **dense regular connective tissue of a tendon** at myotendinous junctions.
- Ultrastructural studies show that in these transitional regions, collagen fibers from the tendon insert themselves among muscle fibers and associate directly with complex infoldings of sarcolemma.

# Skeletal muscle

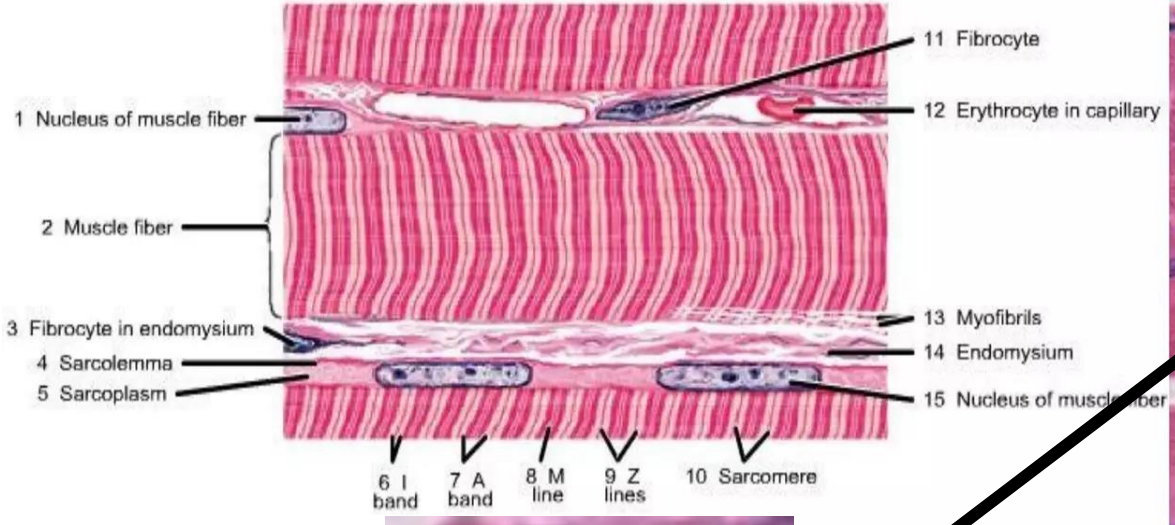
**L.M:**

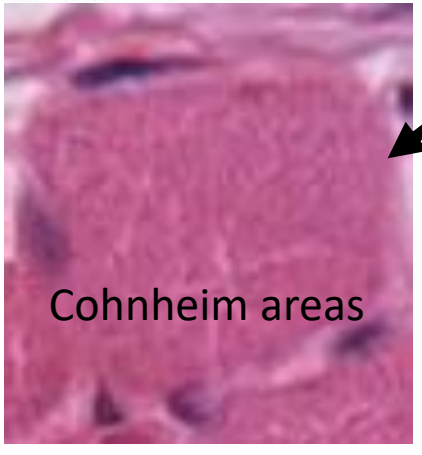
- Muscle fibers are very long tubular cells. They are about (10-100 µm) in diameter and several centimeters in length "up to 40cm".
- Skeletal muscle fibers contain many peripherally placed nuclei located just beneath the plasma membrane (sarcolemma)
- A small population of reserve progenitor cells called muscle **satellite cells** located on the external surface of muscle fibers inside the basal lamina. Satellite cells proliferate and produce new muscle fibers following muscle injury.

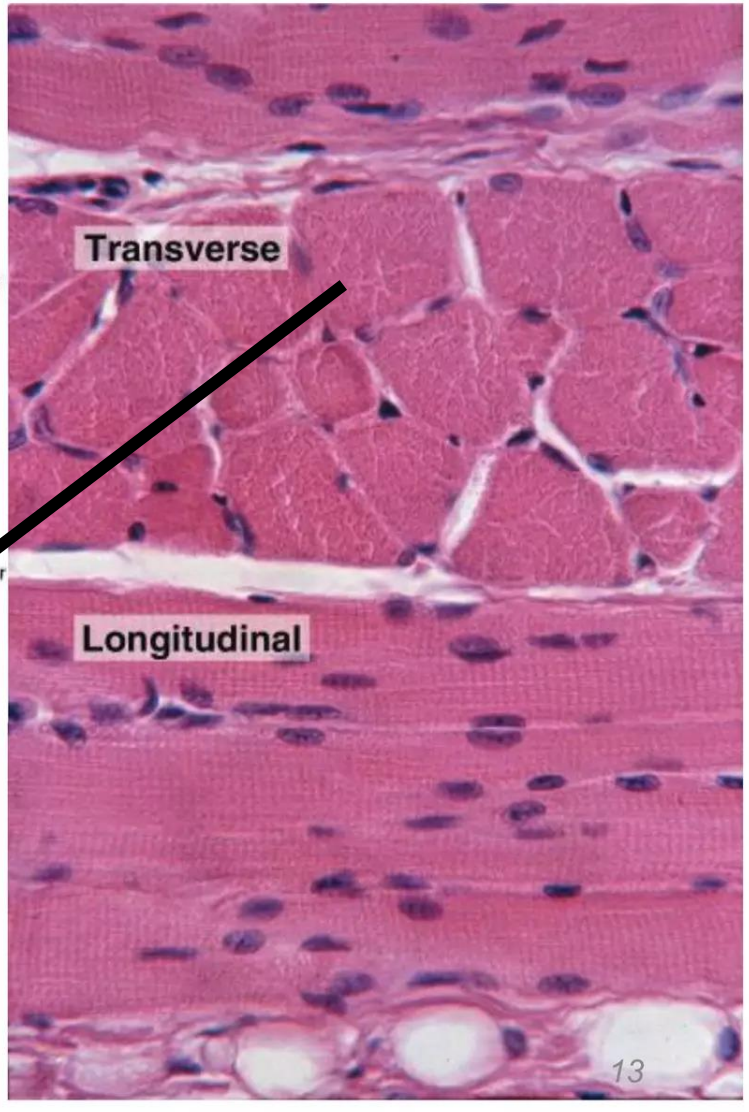
# Satellite cell



# Skeletal muscle –L.S & T.S



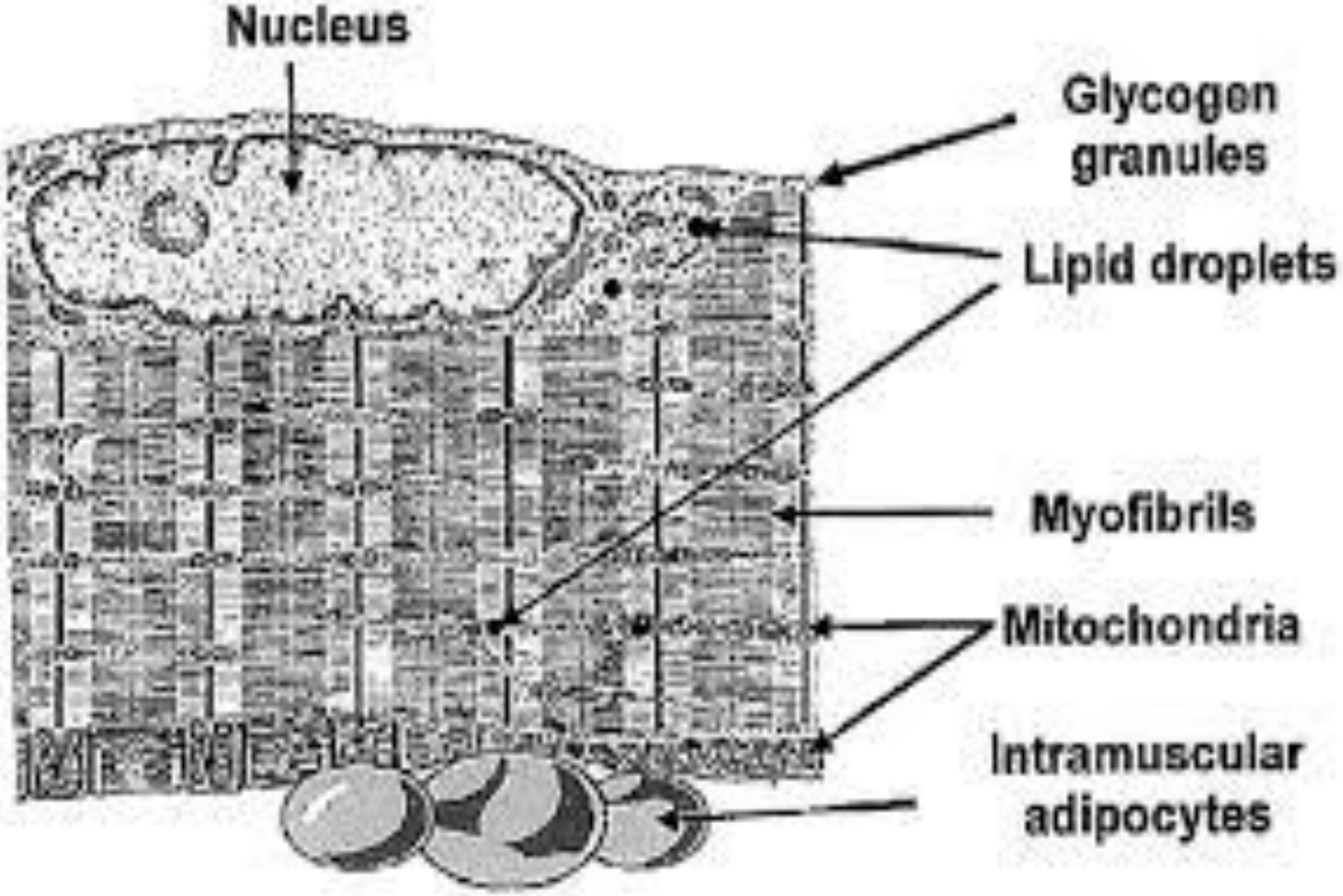



## L.M:

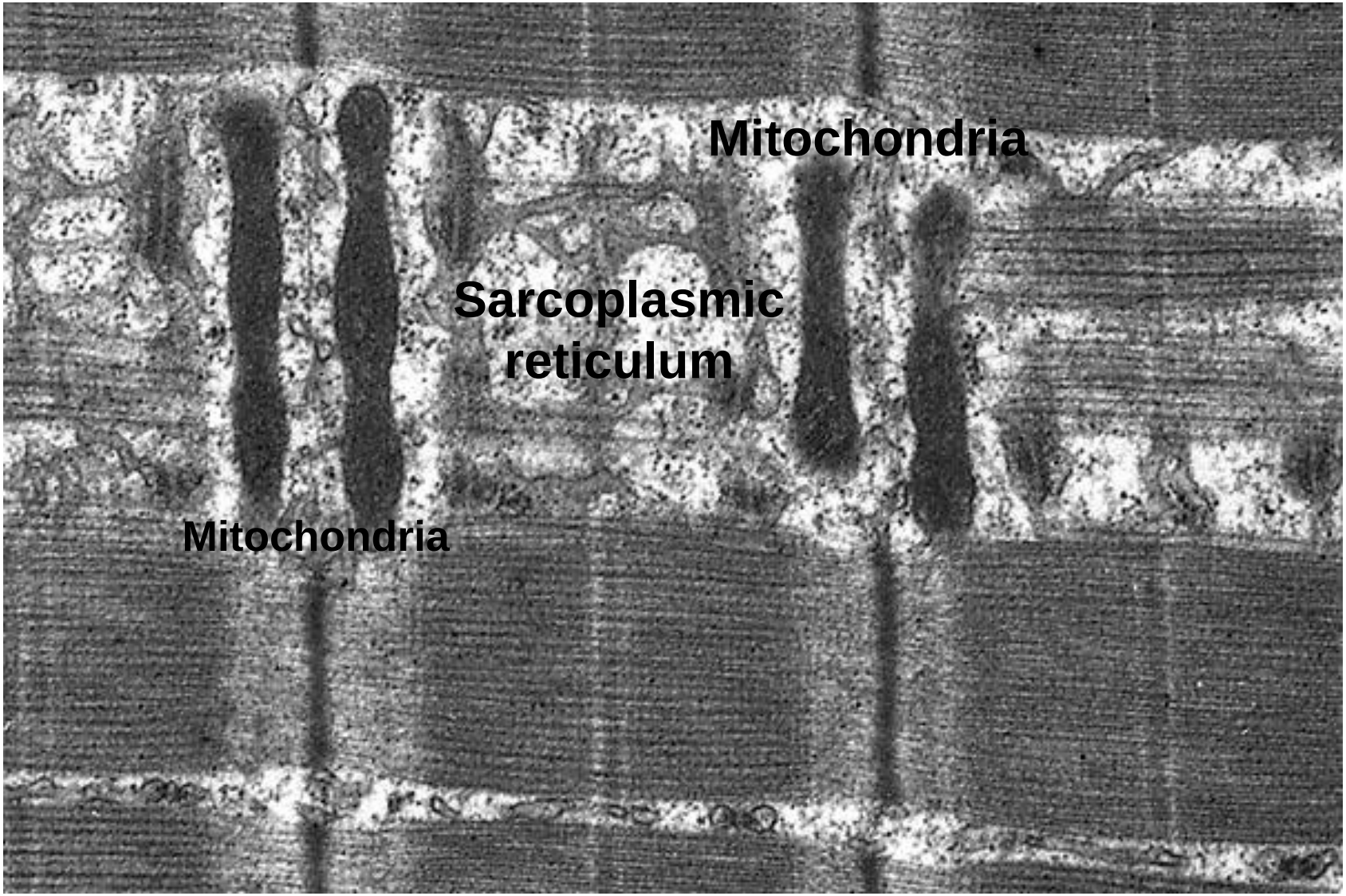
- The cytoplasm (sarcoplasm) contains longitudinal, cylindrical fibrils (myofibrils).
- In longitudinal section, skeletal muscle fibers show cross-striations in the form of alternating **dark (A)** and light (I) bands.

- In transverse sections, the muscle fibers appear rounded or polygonal in shape, the cytoplasm filled with dark dots representing the myofibrils (Cohnheim areas)

# EM


Nucleus
Glycogen granules
Lipid droplets
Myofibrils
Mitochondria
Intramuscular adipocytes

# EM

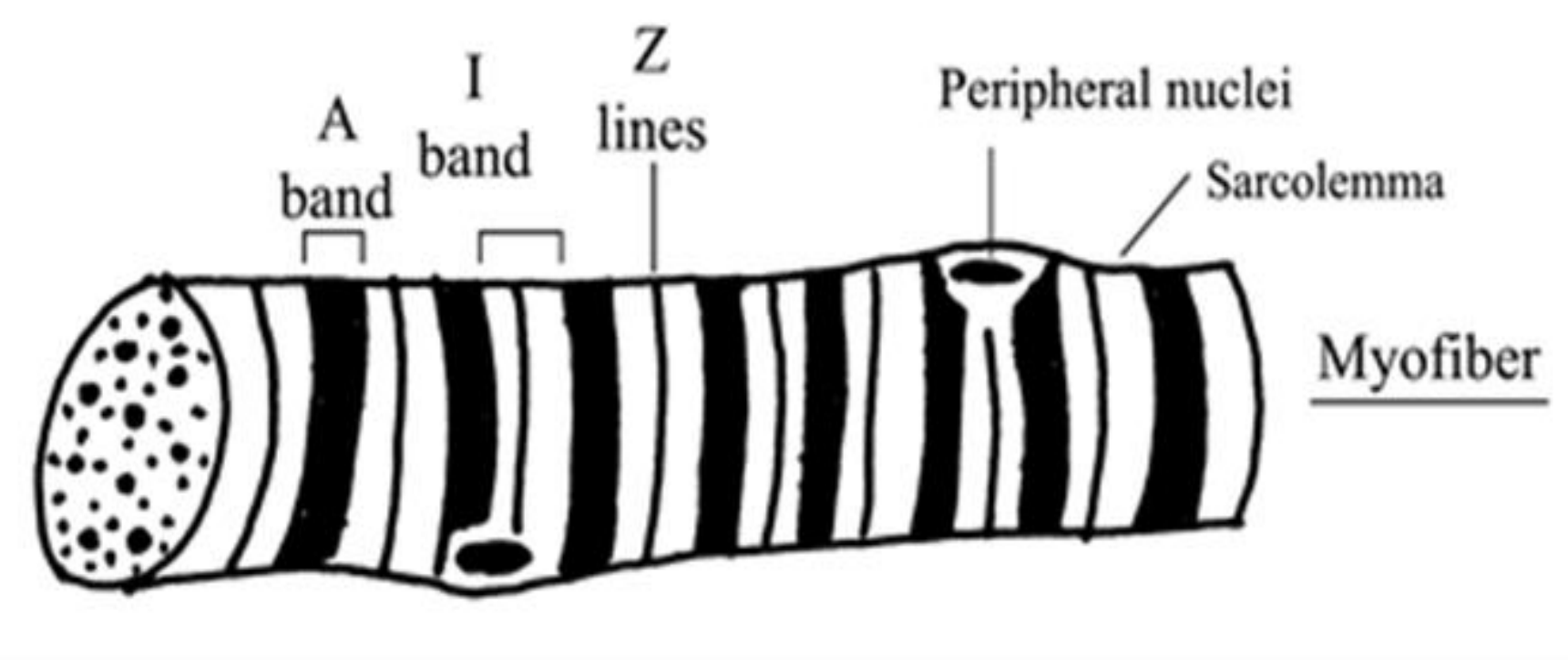


## ***EM: The sarcoplasm of the skeletal muscle fiber contains:***

1. ***Myofibrils****:* they are long, parallel cylindrical structures, formed of the contractile proteins (microfilaments)
2. ***Sarcoplasmic reticulum:*** It is well developed and highly modified SER. It is responsible for storing and releasing of $Ca^{++}$ needed for contraction.
3. ***Long mitochondria*** are found near to the nucleus and form longitudinal rows between the myofibrils.
4. ***A small Golgi*** is associated with one nuclear pole.
5. ***Glycogen*** *and few* ***lipid droplets***.
6. ***Myoglobin pigment*** is iron and oxygen-binding protein that is responsible for the red brown color of muscle and is related to oxygen supply for the muscle.

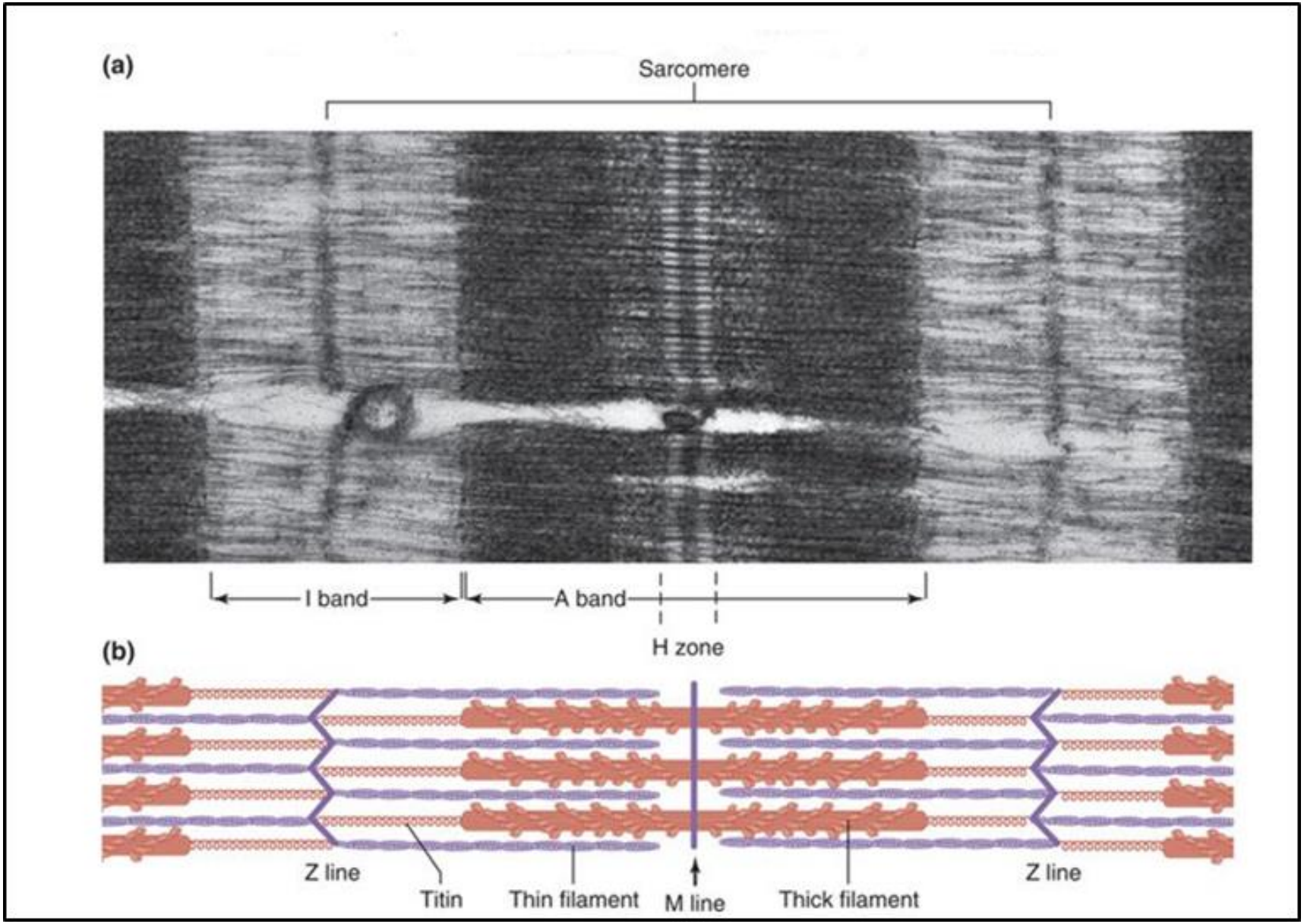
# Myofibrils and myofilaments

- Longitudinally sectioned skeletal muscle fibers show cross striations of alternating light and dark bands. The dark bands are called A bands the light bands are called I bands.
- In the **TEM** , each I band is seen to be bisected by a dark transverse line, the Z disc. The repetitive functional subunit of the contractile apparatus, **the sarcomere**, extends from Z disc to Z disc and is about 2.5 µm long in resting muscle.



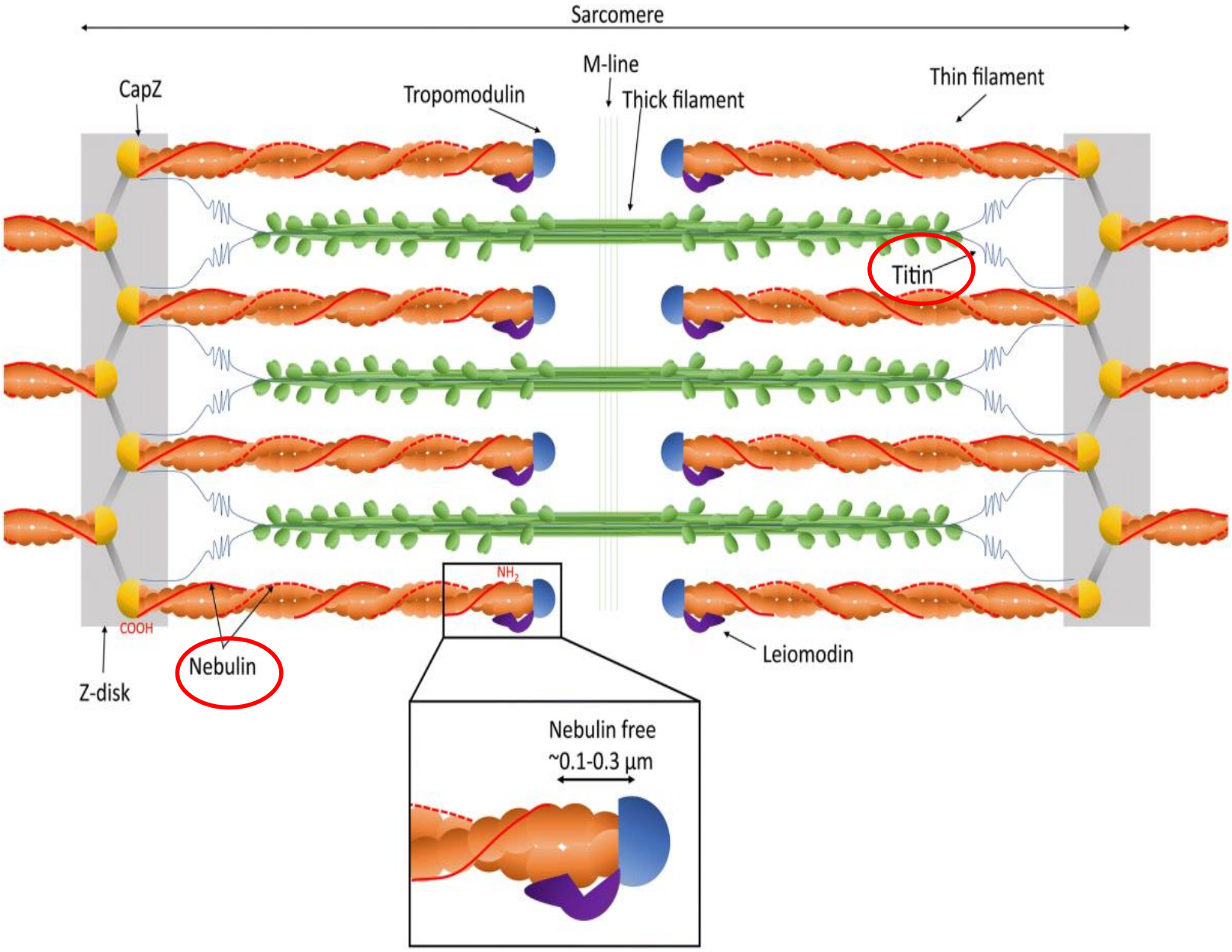

**Sarcomere is the part of the myofibril between two successive Z lines. Sarcomere is the functional unit of the muscle fiber. Each sarcomere contains one complete A band separating two halves I bands on both sides of the A band.**

# EM


(a)
Sarcomere
I band
A band
H zone
(b)
Z line
Titin
Thin filament
M line
Thick filament
Z line

- The A and I banding pattern in sarcomeres is due mainly to the regular arrangement of thick and thin myofilaments, composed of **myosin** and **F-actin**, respectively.

- A band contains myosin and actin myofilaments.
- H zone is a paler central region in the A band and consists only of myosin myofilaments.
- H zone is bisected by dark M line, which is the site of attachment of myosin myofilaments.
- I bands contains actin myofilaments only which are attached to Z lines.


Sarcomere
CapZ
Tropomodulin
M-line
Thick filament
Thin filament
Titin
COOH
Nebulin
Z-disk
NH2
Leiomodin
Nebulin free
~0.1-0.3 µm

- Actin filaments are anchored perpendicularly on the Z disc by the actin-binding protein **α-actinin**

- An important accessory protein in I bands is **titin**, the largest protein in the body, with scaffolding and elastic properties, which supports the thick myofilaments and connects them to the Z disc. It is spanning from the Z-disc to the M-line within the sarcomere

- Another very large accessory protein, **nebulin** which binds each thin myofilament laterally, helps anchor them to α-actinin, and specifies the length of the actin polymers during myogenesis.

- Bisecting the H zone is the M line containing a myosin-binding protein **myomesin** that holds the thick filaments in place.

- Despite the many proteins present in sarcomeres, myosin and actin together represent over half of the total protein in striated muscle.