Chapter 6

Muscle Tissue

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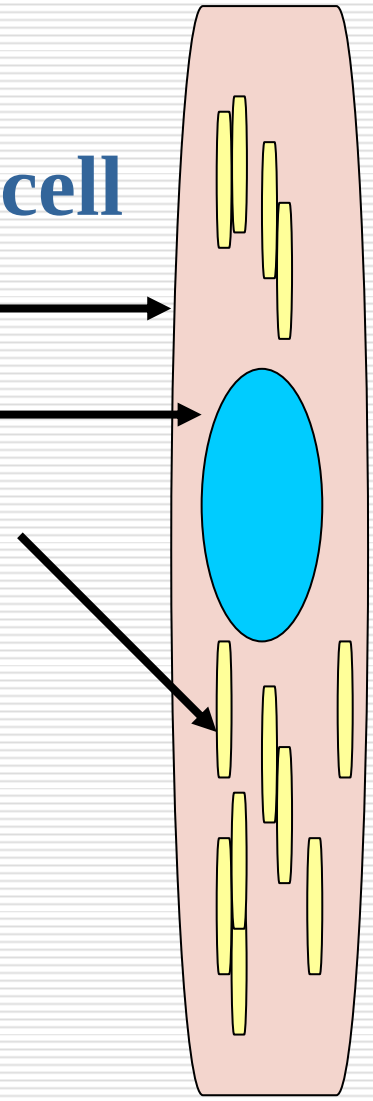
General characteristics

- **Muscle fiber/myofiber/muscular cell**
  - **Sarcolemma (membrane)**
  - **Sarcoplasm (cytoplasm)**
  - **Sarcoplasmic reticulum (SER)**



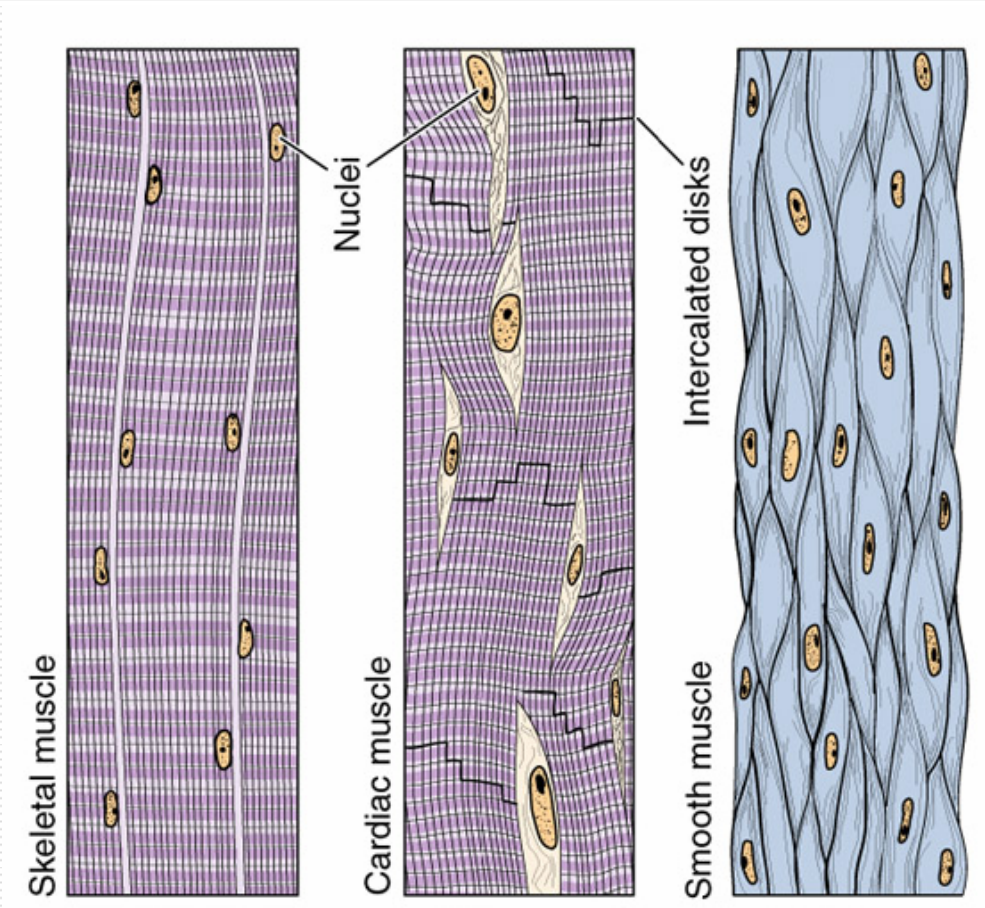
Function

Structure

voluntary ← **Skeletal muscle** } striated

involuntary { **Cardiac muscle**

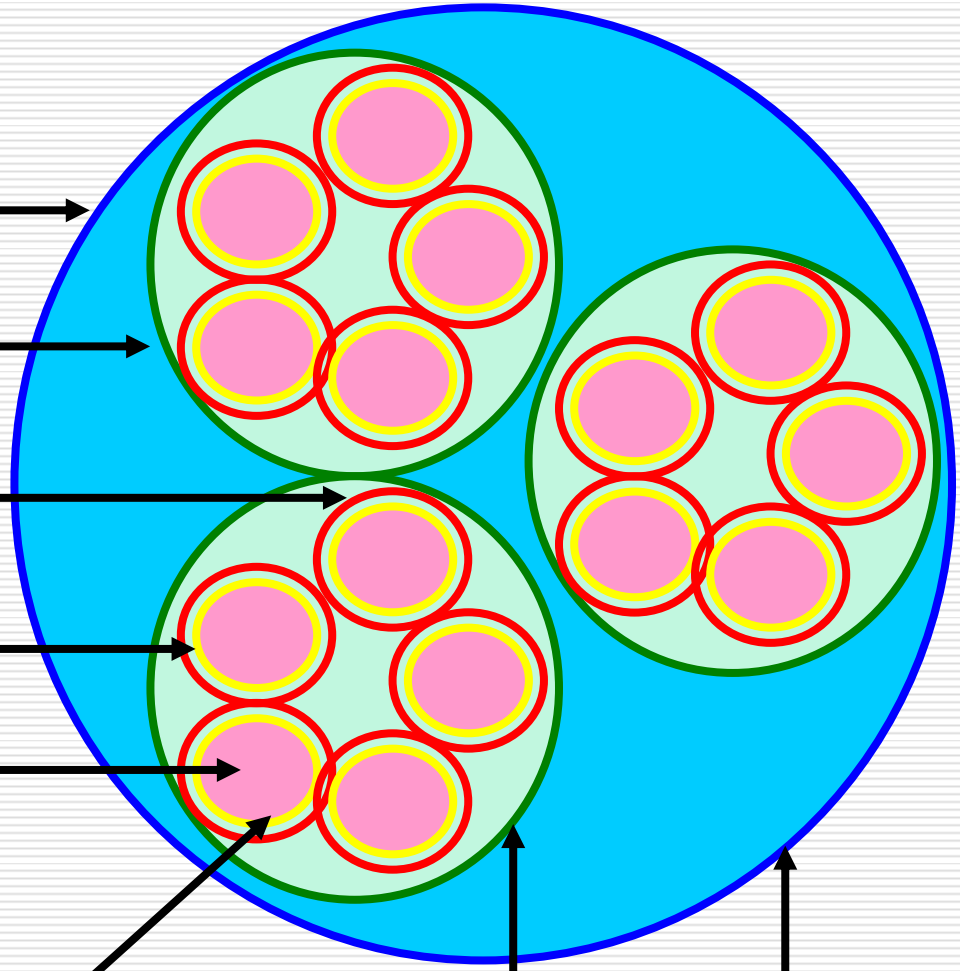
Smooth muscle → unstriated



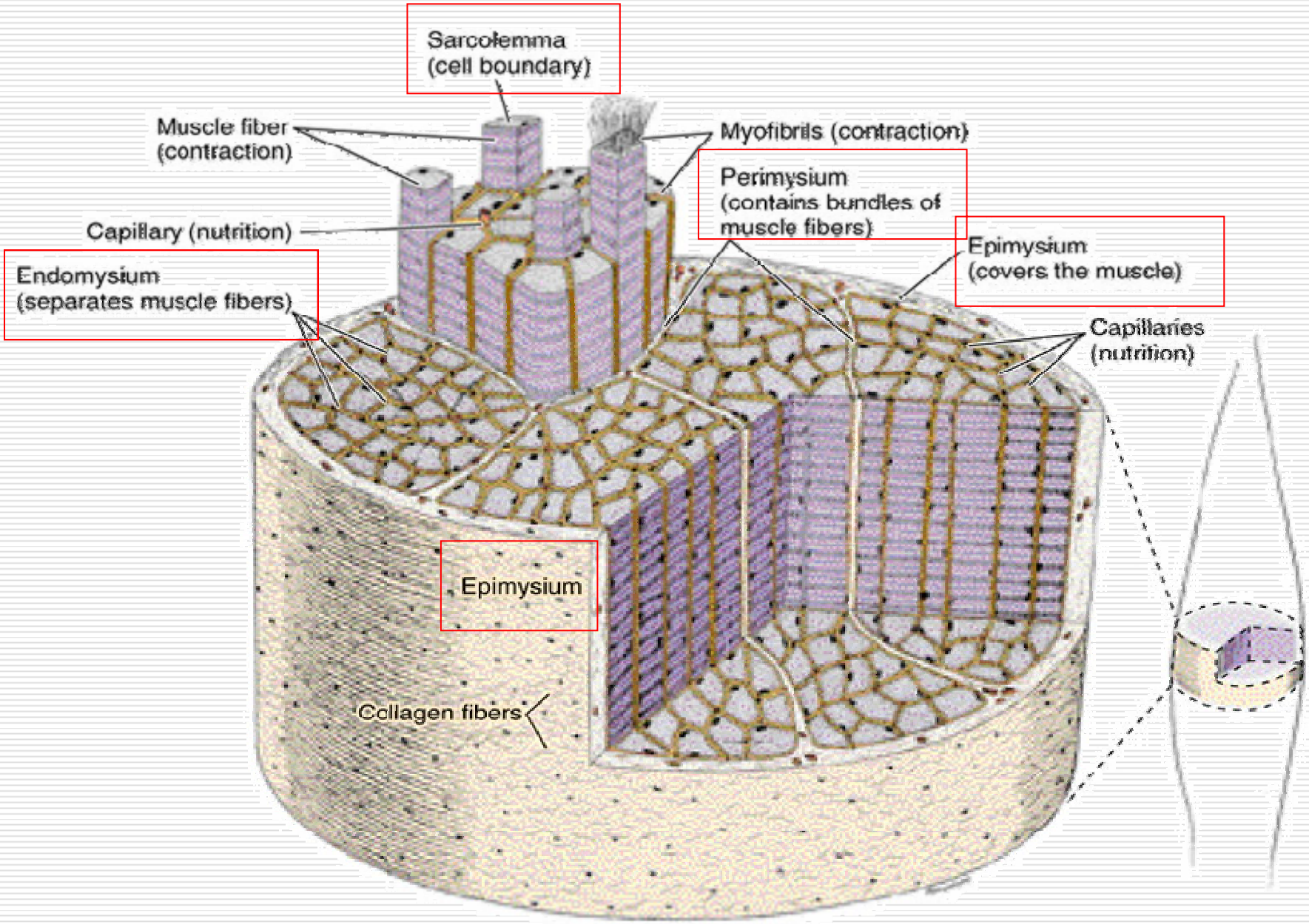
Skeletal muscle

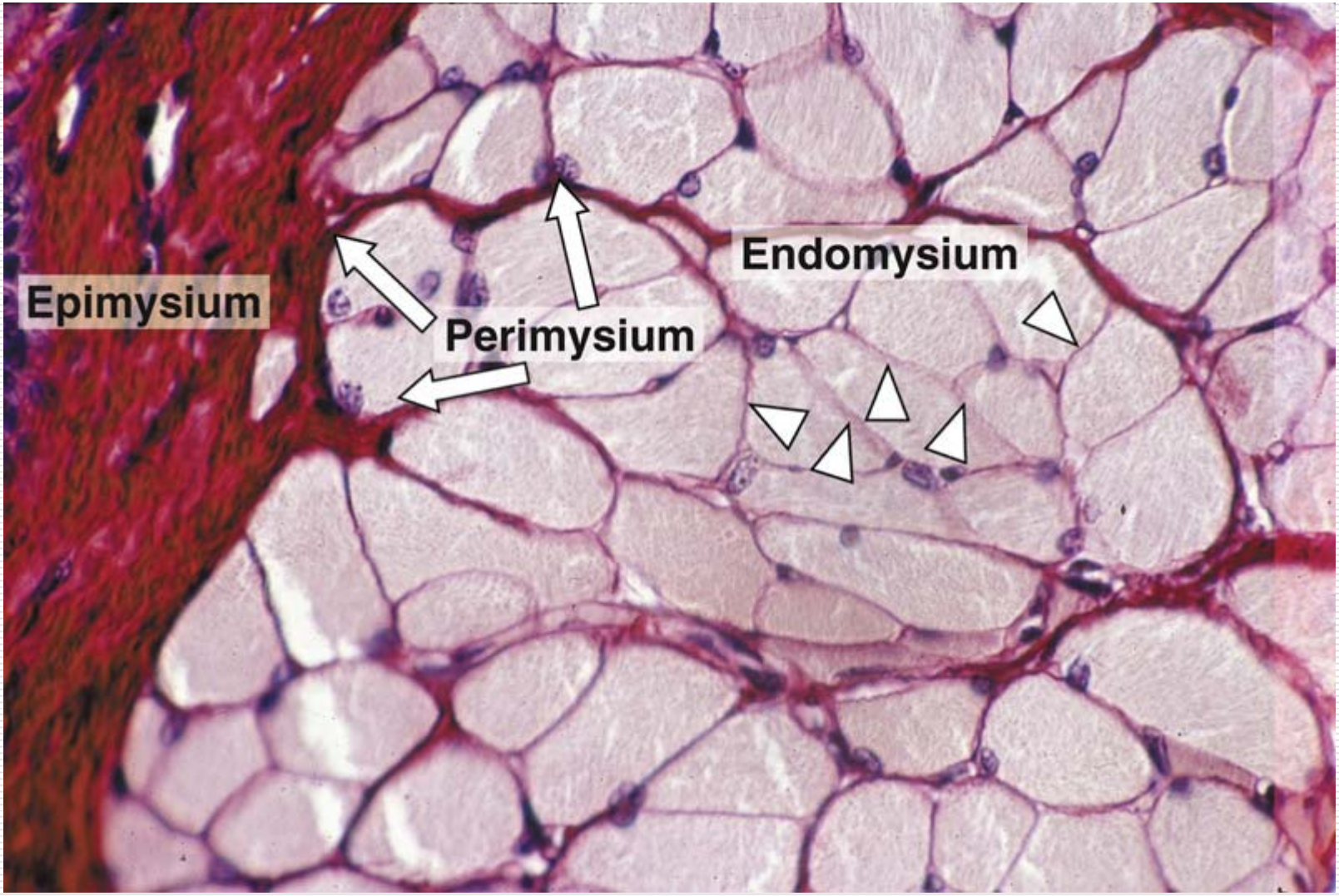
- Organization of Skeletal Muscle
- Fine structure of muscle fibers (LM)
- Ultrastructure (EM)
- Mechanism of contraction

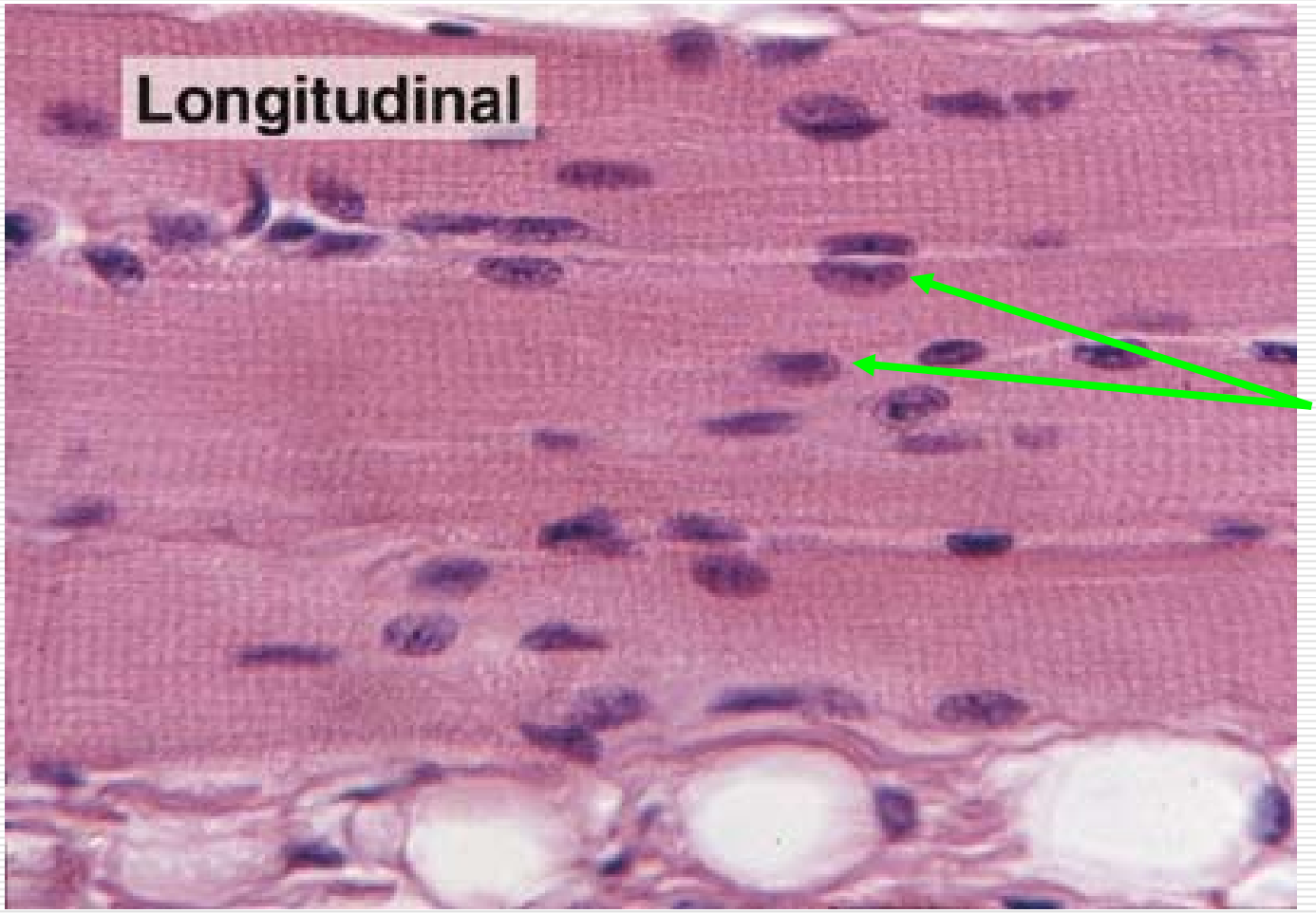
- Epimysium
- Perimysium
- Endomysium
- Sarcolemma
- sarcoplasm



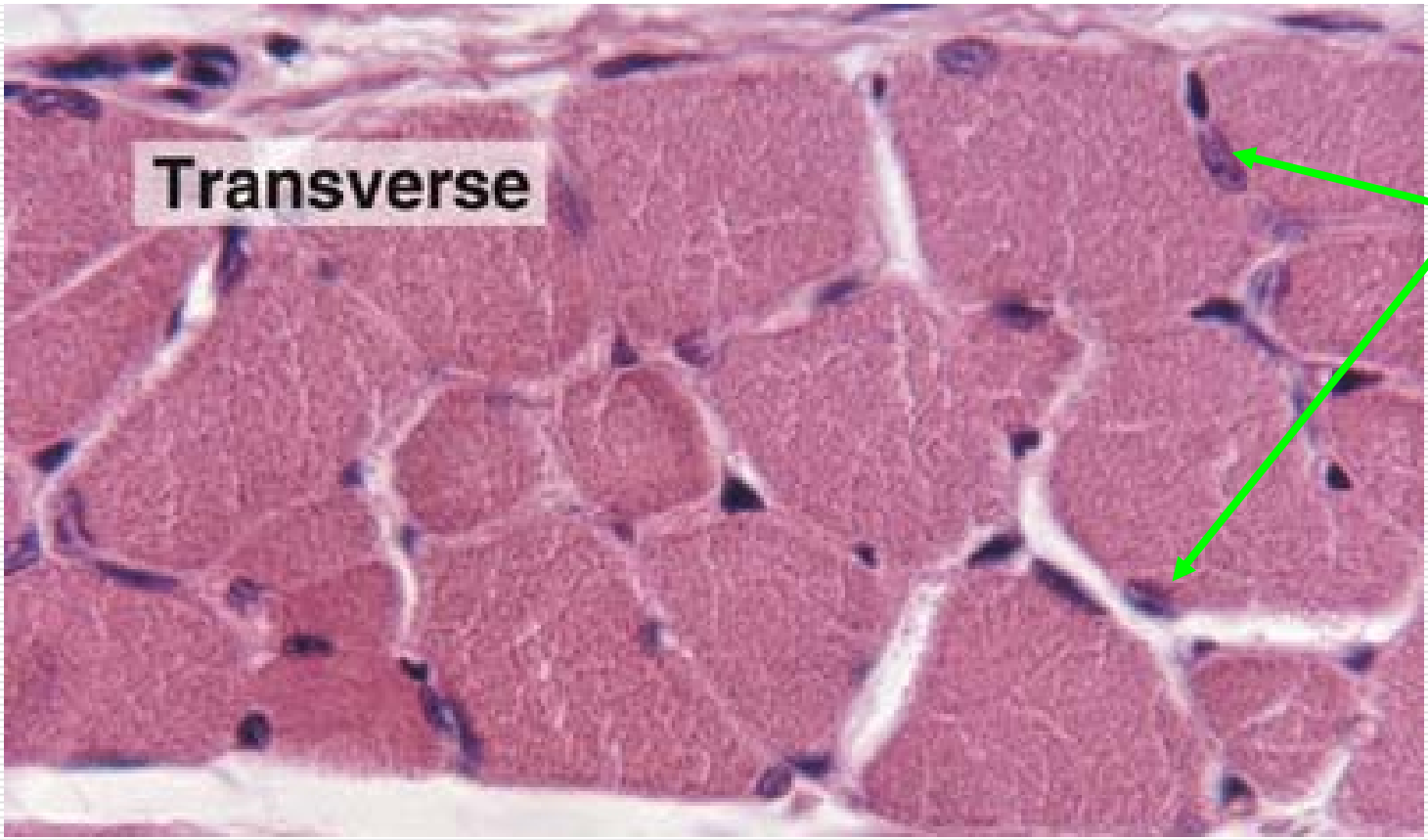
transmit the forces generated by contracting muscle cells


Sarcolemma
(cell boundary)
Muscle fiber
(contraction)
Myofibrils (contraction)
Perimysium
(contains bundles of
muscle fibers)
Capillary (nutrition)
Epimysium
(covers the muscle)
Endomysium
(separates muscle fibers)
Capillaries
(nutrition)
Epimysium
Collagen fibers


Epimysium
Perimysium
Endomysium

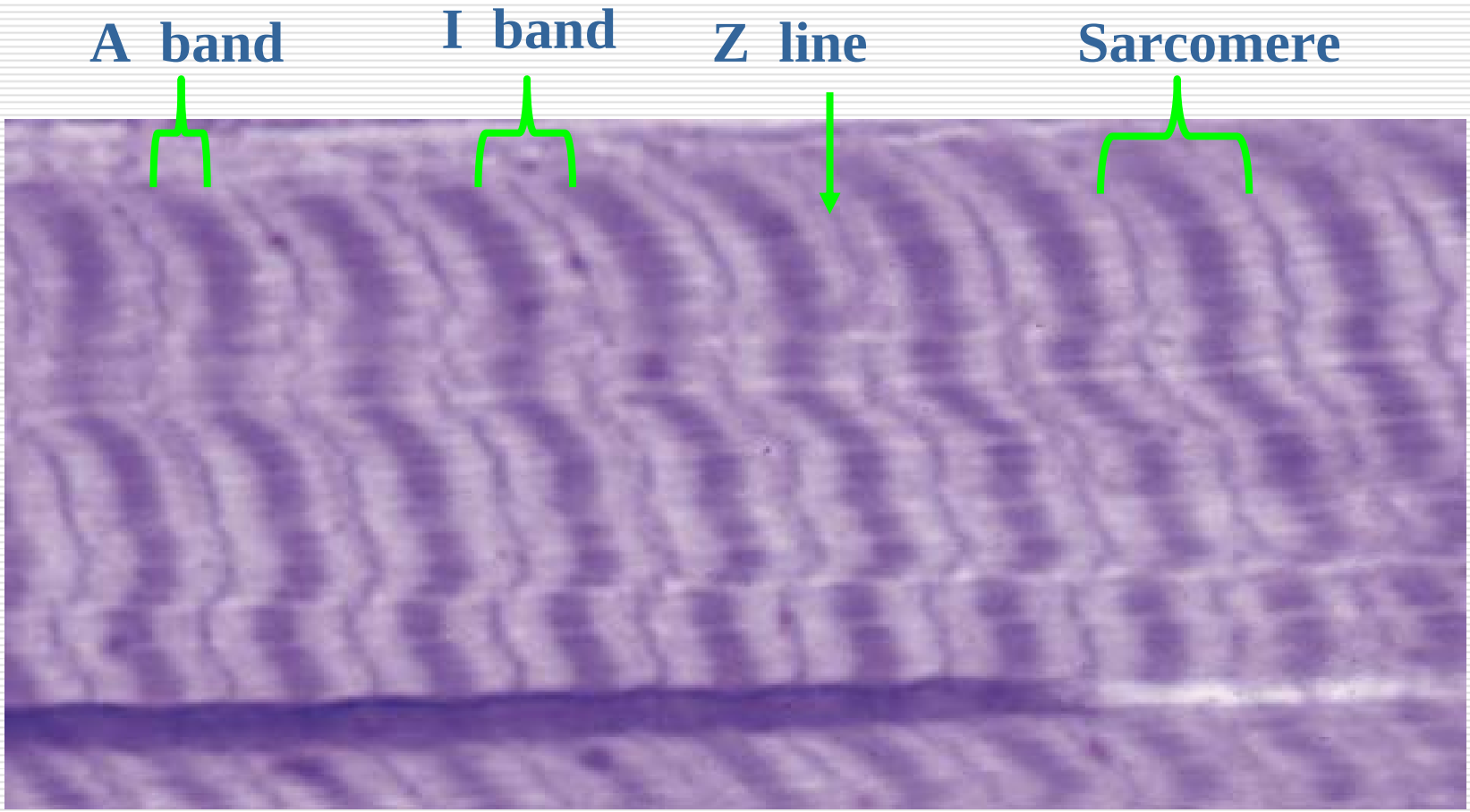


Skeletal muscle fibers are bundles of very long cylindrical multinucleated cells. The ovid nuclei can be seen in the periphery of the cell, just under the cell membrane.



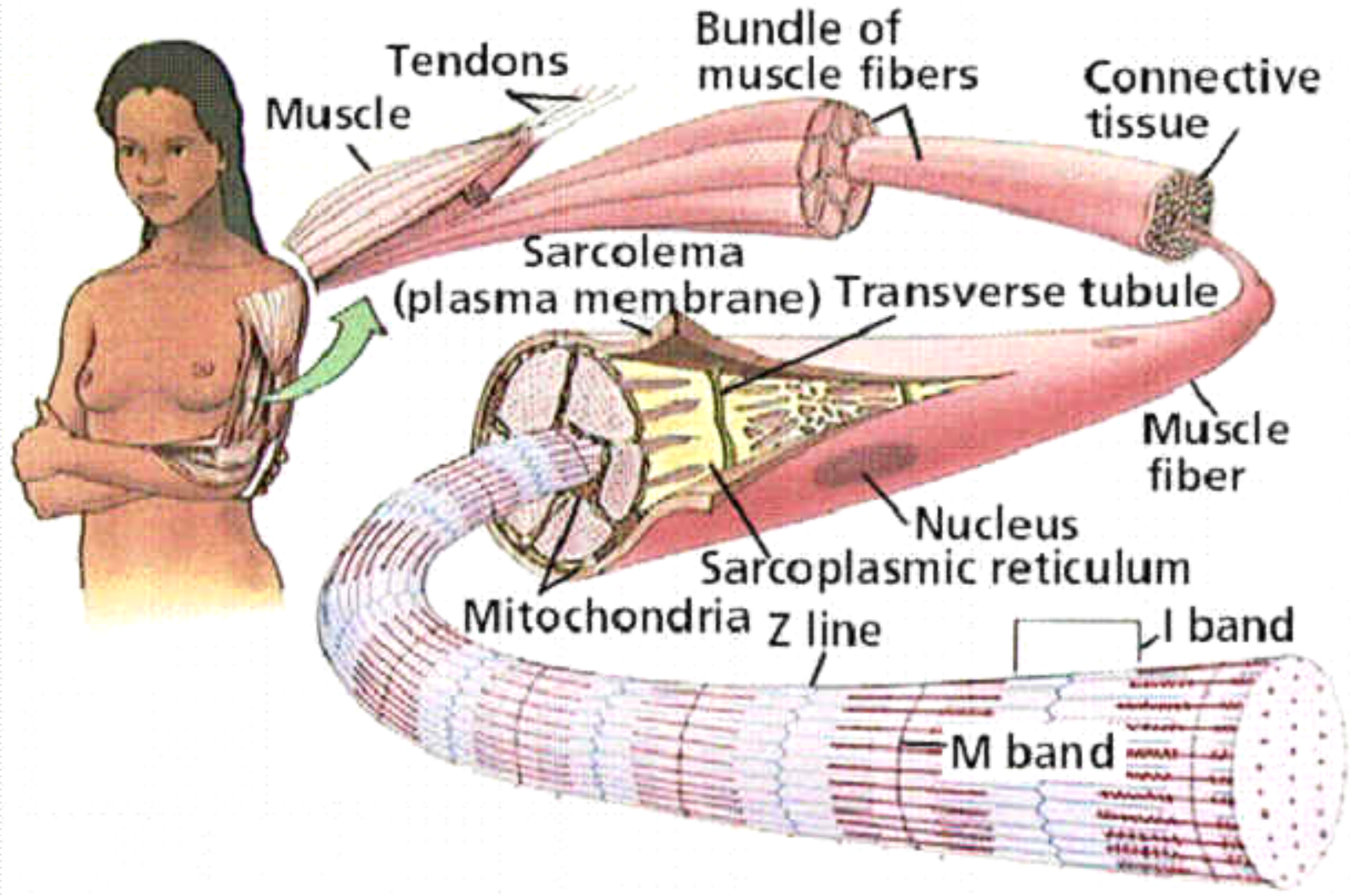
The muscle fibers are irregular in shape and the ovoid nuclei are just under the sarcolemma.

- cross-striations of alternating light and dark bands
- A band; I band; Z line
- Sarcomere=1/2 I+A+1/2 I ; contractile apparatus

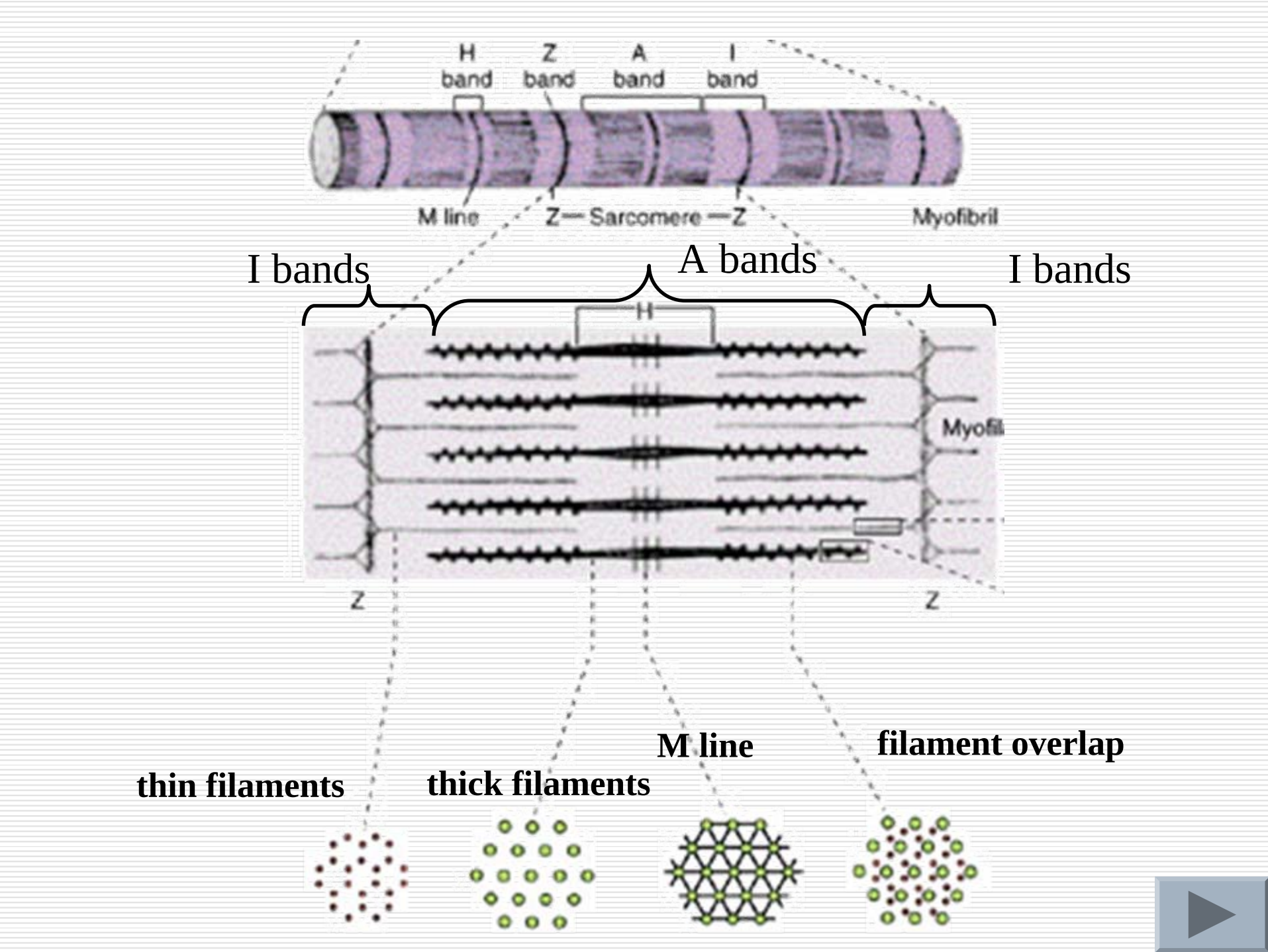


Ultrastructure

- myofibrils
  - Thin filaments
  - Thick filaments
- transverse tubule (T tubule)
- sarcoplasmic reticulum (L tubule)
  - terminal cisternae
  - triad
- other organelles and inclusions



- run parallel to the long axis of the muscle fiber
- consist of end-to-end sarcomeres
- sarcomeres in adjacent myofibrils arrange so regularly


H band
Z band
A band
I band
M line
Z— Sarcomere —Z
Myofibril
I bands
A bands
I bands
Myofil
Z
Z
thin filaments
thick filaments
M line
filament overlap

Components of myofibrils

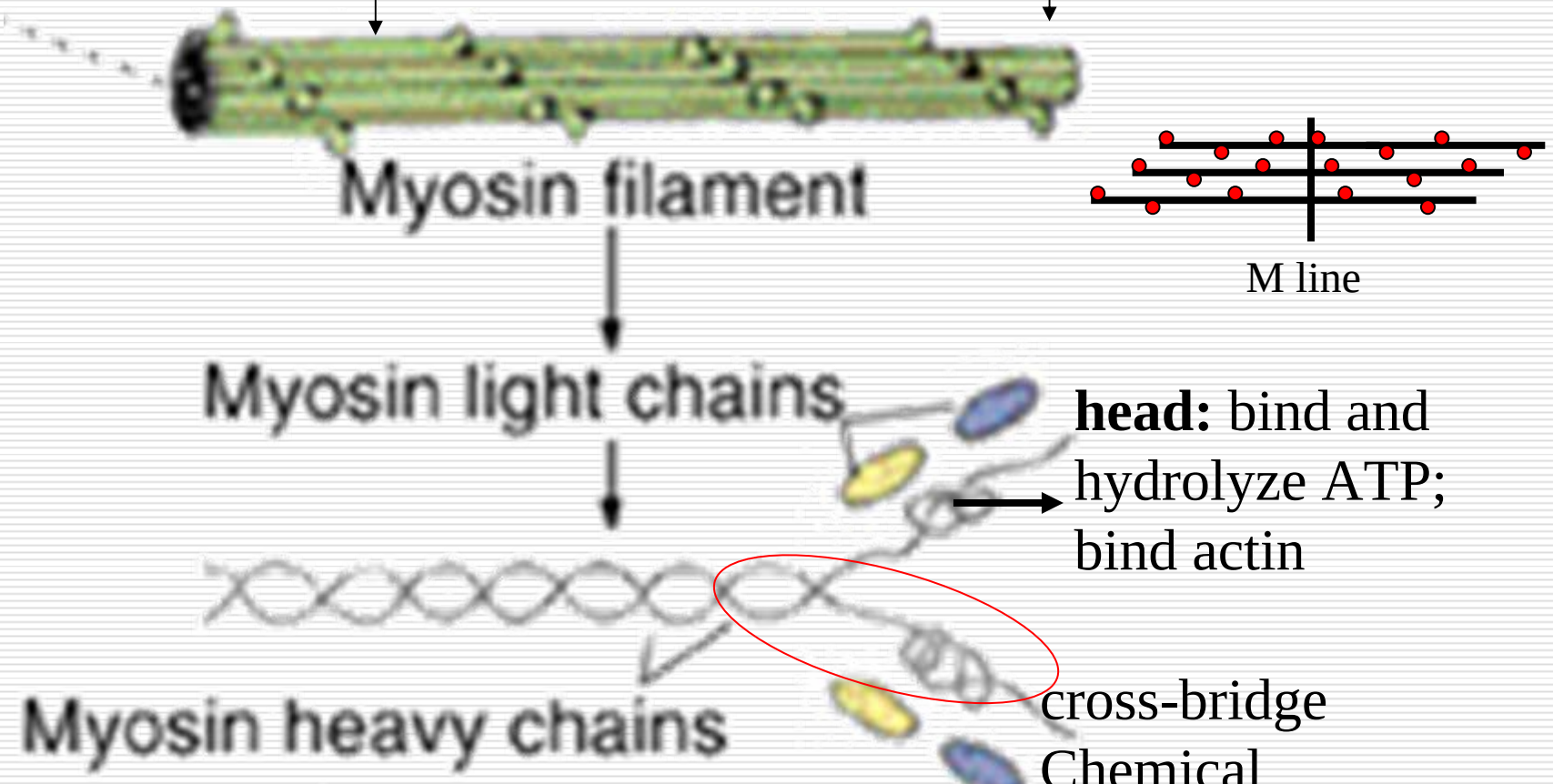
thick myofilament:

- myosin
- cross bridge

thin myofilament:

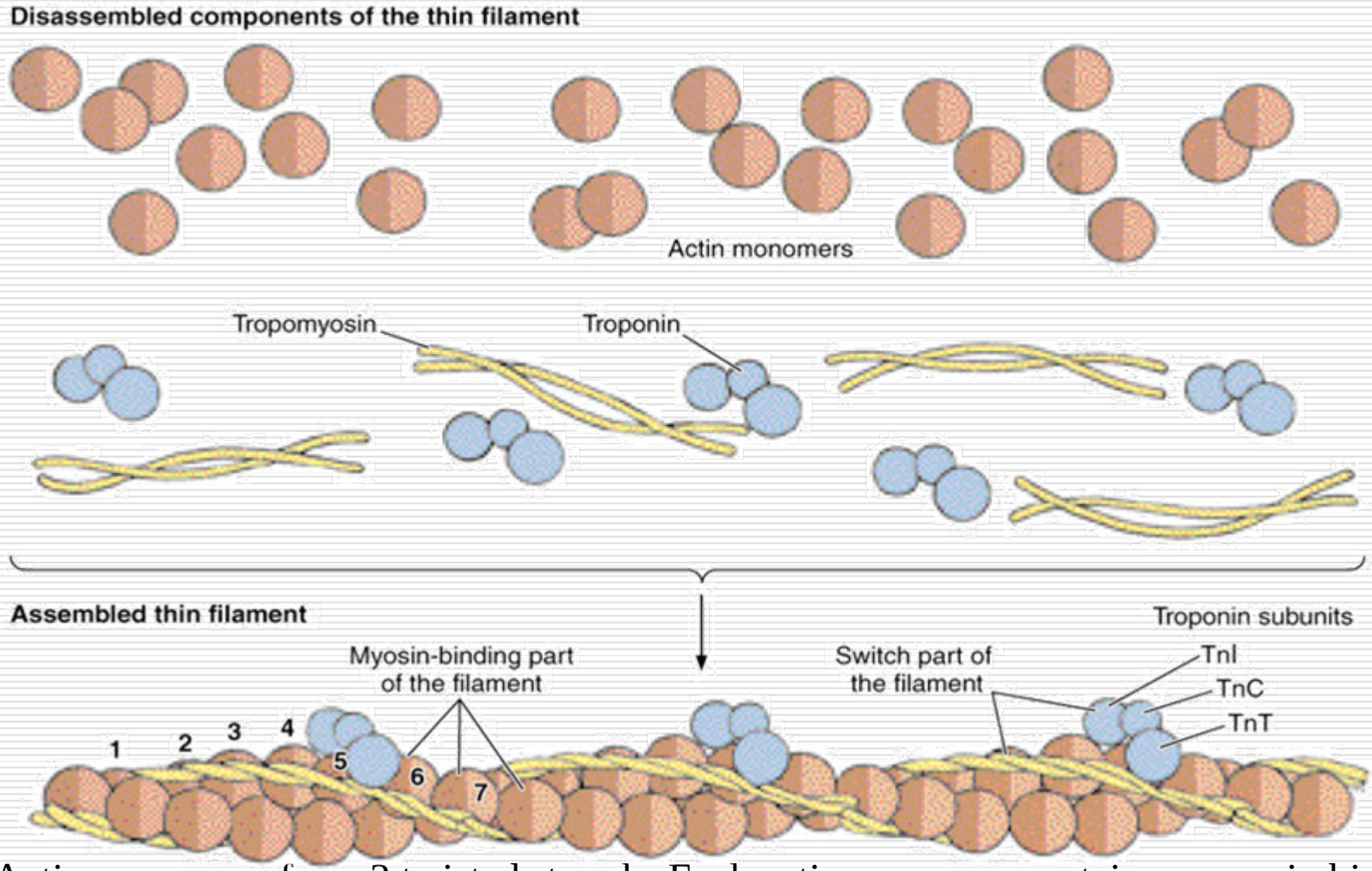
- actin
- tropomyosin
- troponin: TnC; TnT; TnI

rod-like portion + globular head=cross-bridge



head: bind and hydrolyze ATP; bind actin

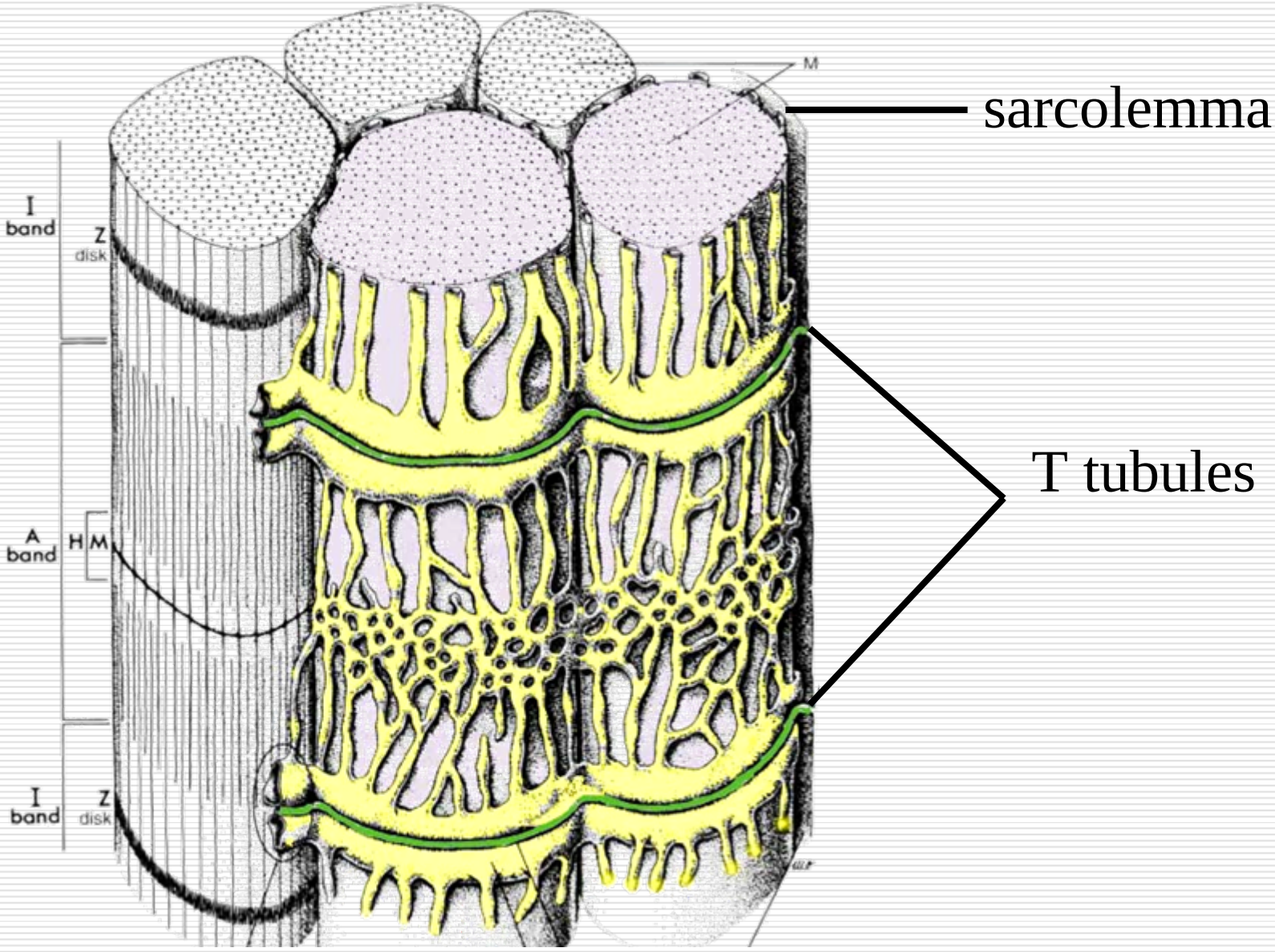
cross-bridge Chemical energy→mechanical energy



Actin monomers form 2 twisted strands. Each actin monomer contains a myosin binding site.

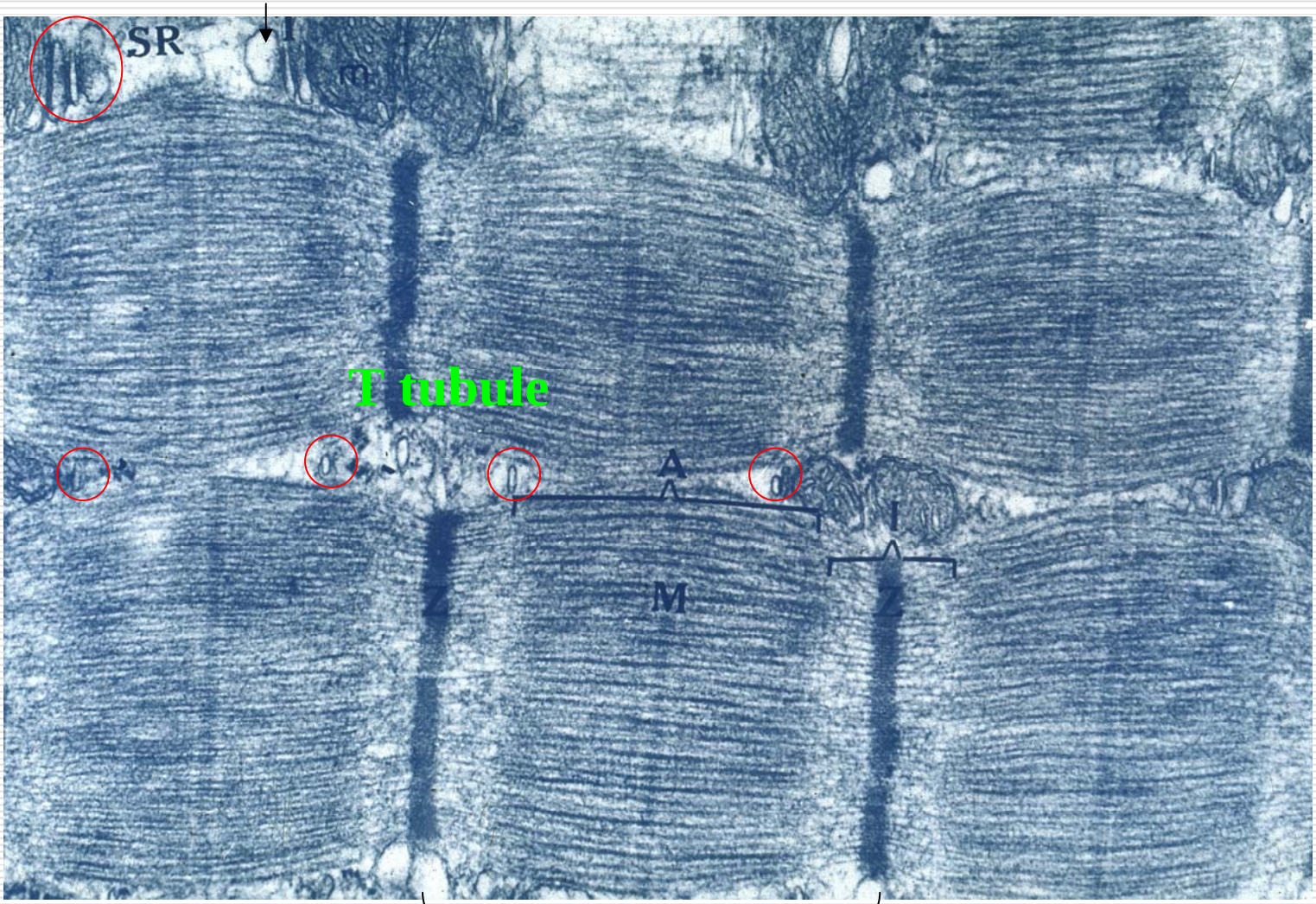
Tropomyosins containing 2 polypeptide chains are bound head to tail, forming filament that run over the actin subunits alongside the outer edges of the groove between 2 twisted actin strands. Each tropomyosin has 7 actin and one TnT binding site.

Troponin contains 3 subunits: TnT attaching to tropomyosin; TnC binding calcium ions; and TnI inhibiting actin-myosin interaction.

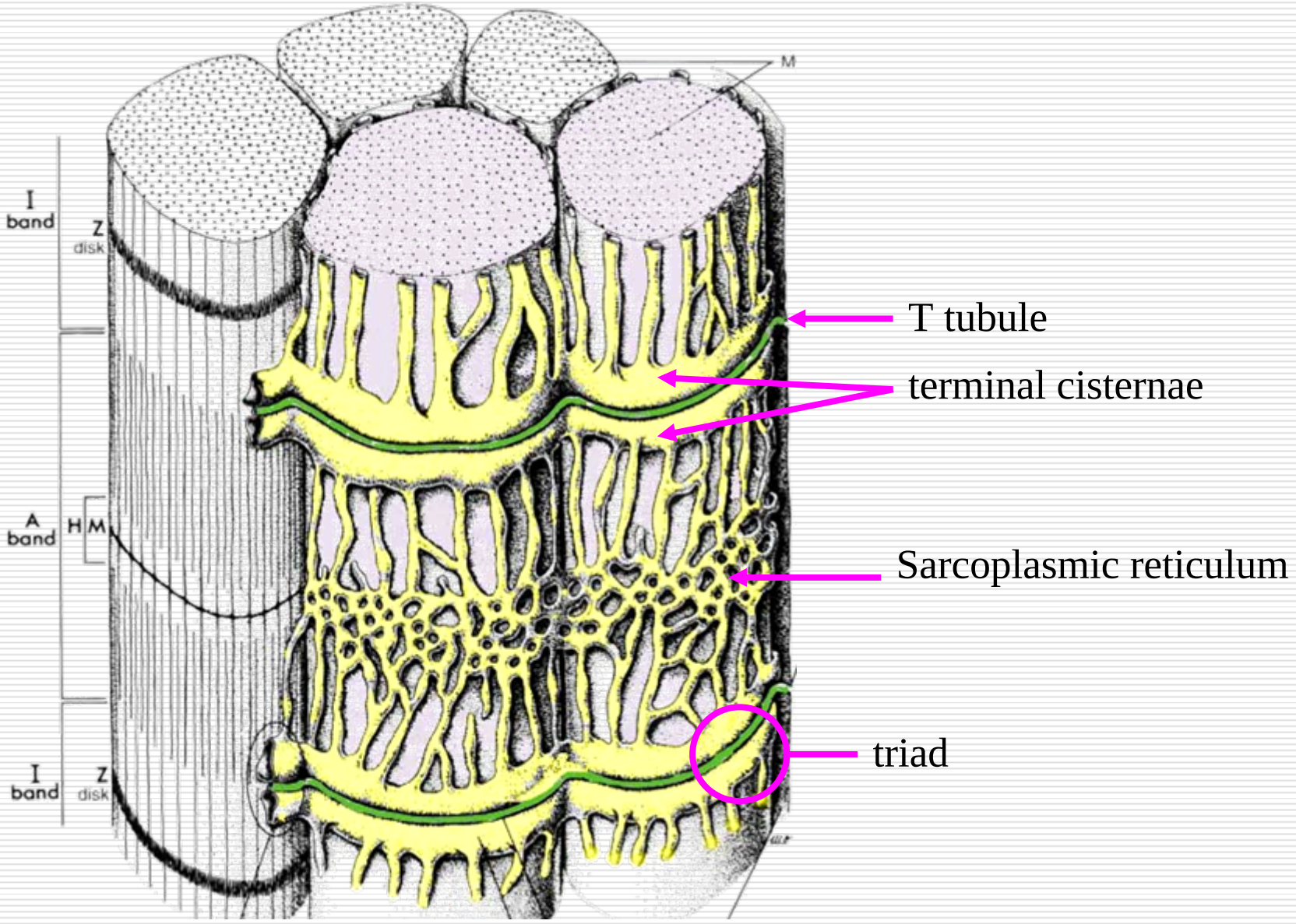


- encircle the boundaries of the A–I bands
- rapidly conduct contraction impulses to every myofibril

triad terminal cisternae

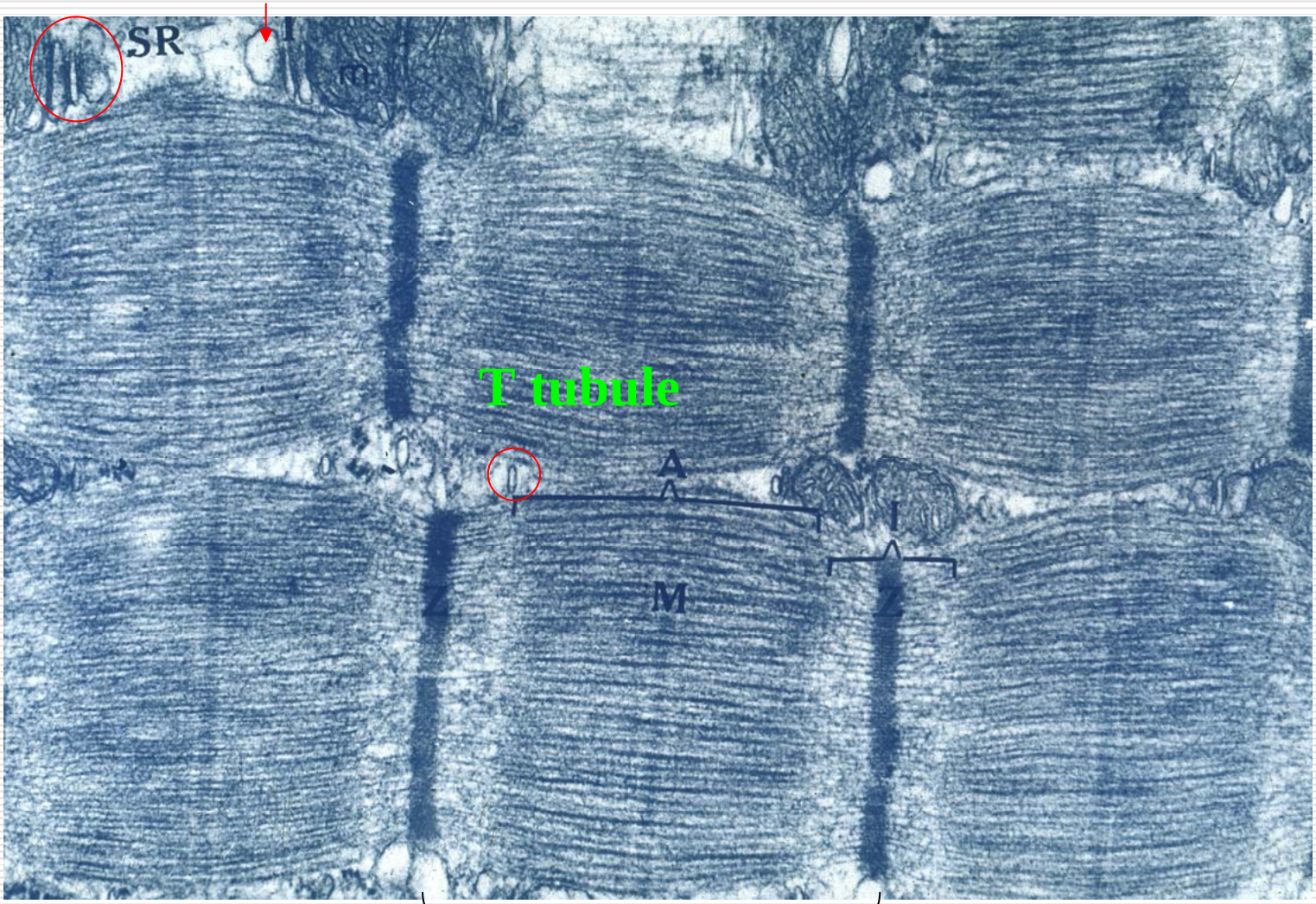


sarcomere



- terminal cisternae: 2 lateral portions adjacent to T tubule
- triad: a T tubule +2 lateral terminal cisternae

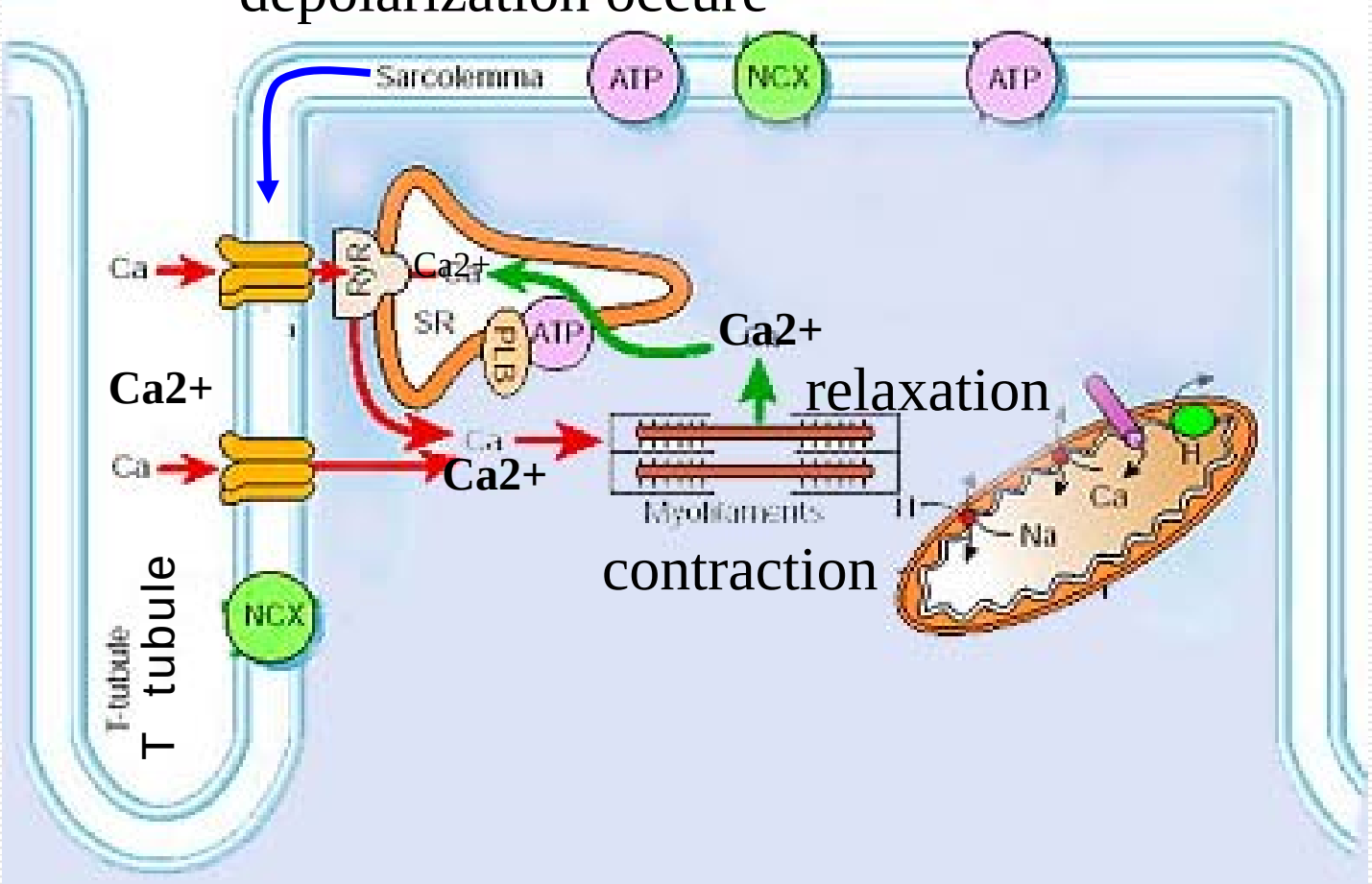
triad terminal cisterna



sarcomere

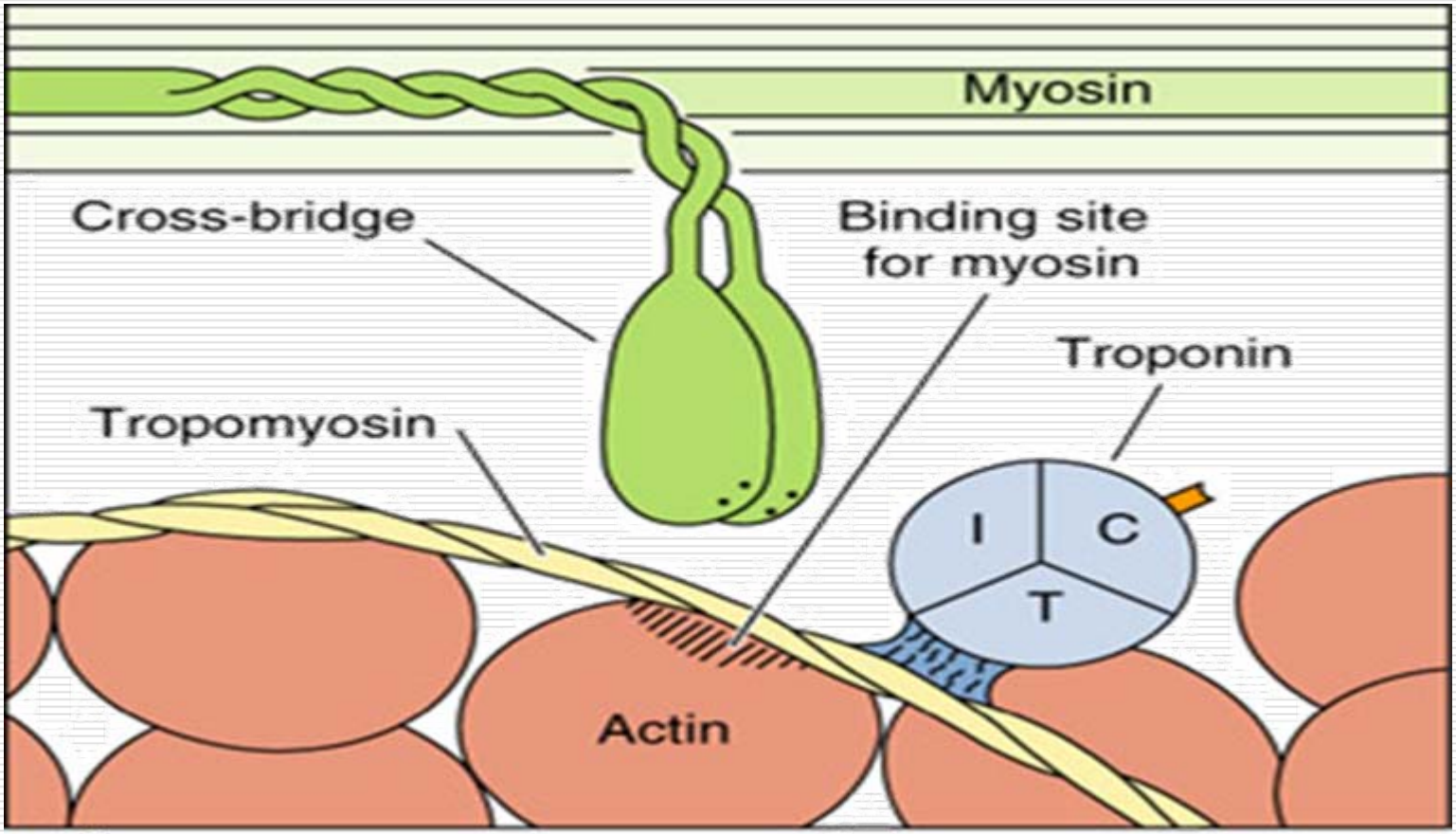
- regulate calcium flow in rapid contraction and relaxation cycles

depolarization occure



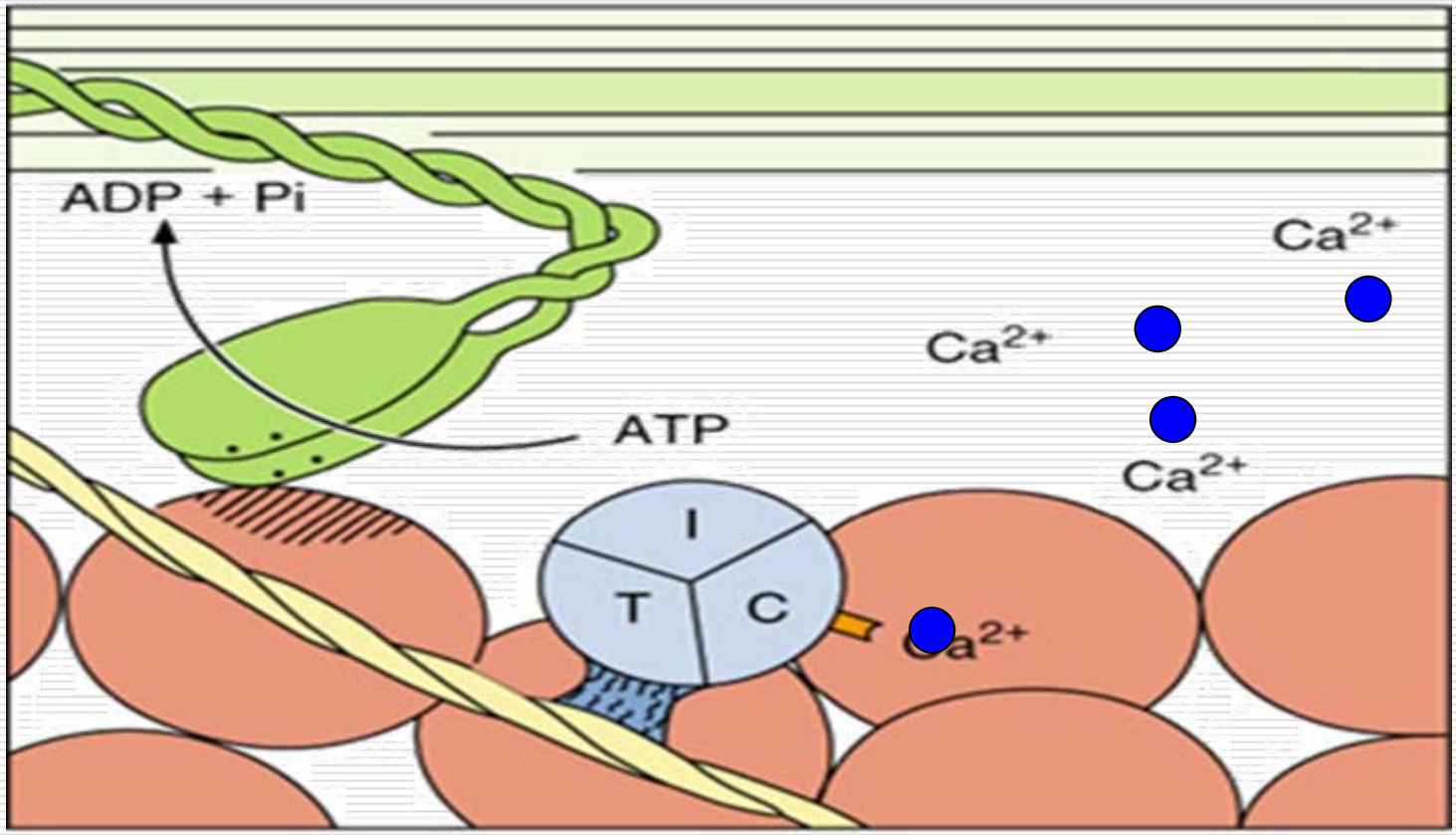
other organelles and inclusions

- Mitochondria
- Golgi apparatus
- Glycogen granules
- Lipid droplets



A resting skeletal myofiber

- TnT of troponin binding to tropomyosin
- myosin binding site on actin is hided by tropomyosin.
- Cross-bridge of myosin is free.



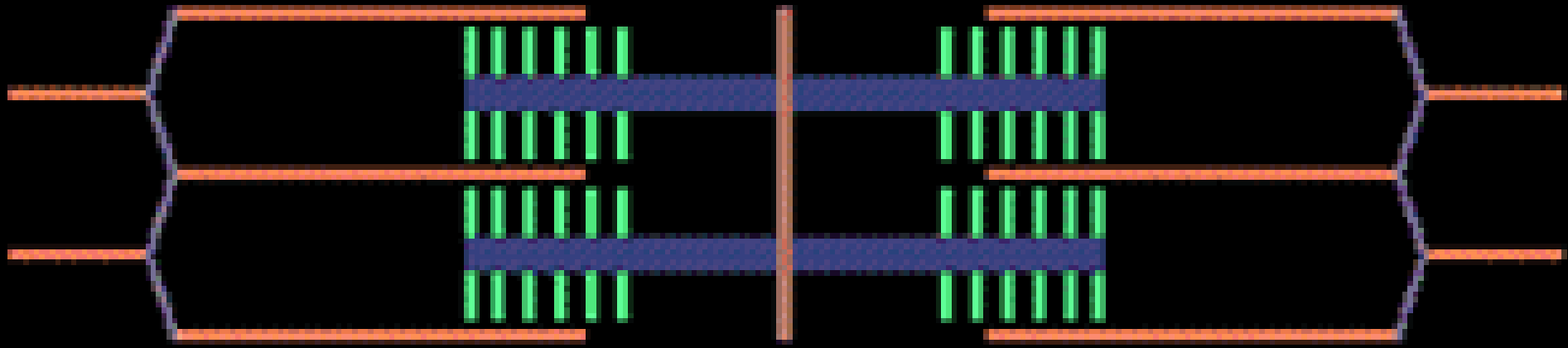
- Ca^{2+} ion binds to the TnC unit of troponin.
- Tropmyosin moves and exposes myosin binding site on actin.
- Myosin head binds to actin and break down ATP into ADP.
- Energy produces a movement of the myosin head.
- Thin filaments slide over the thick filaments.
- This process repeats many times and leads to shortening of myofibers.
- Ca^{2+} ions are removed and myofibers releax.

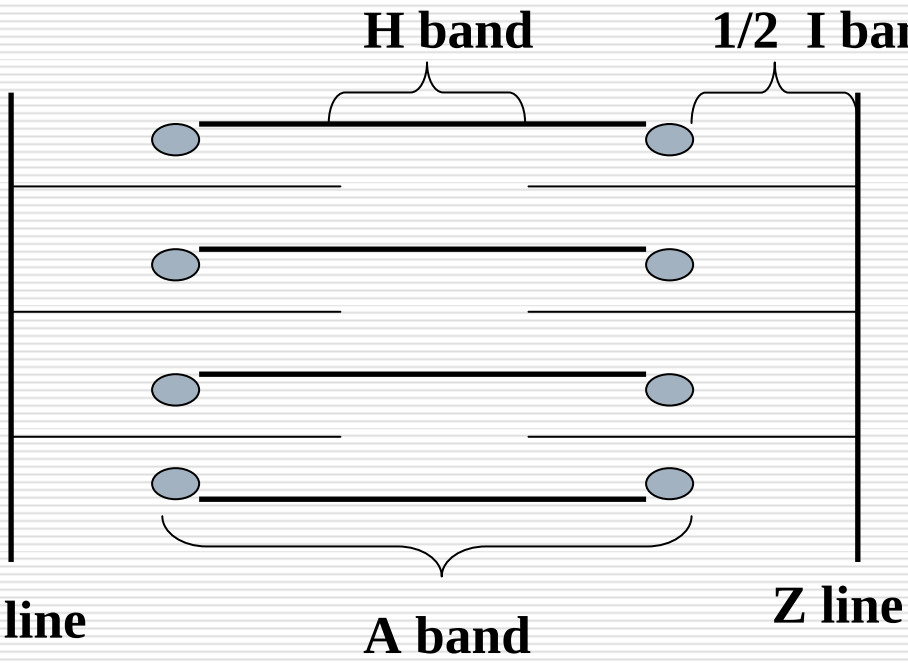
depolarization

T tubule

L tubule

Process repeats 3 times.

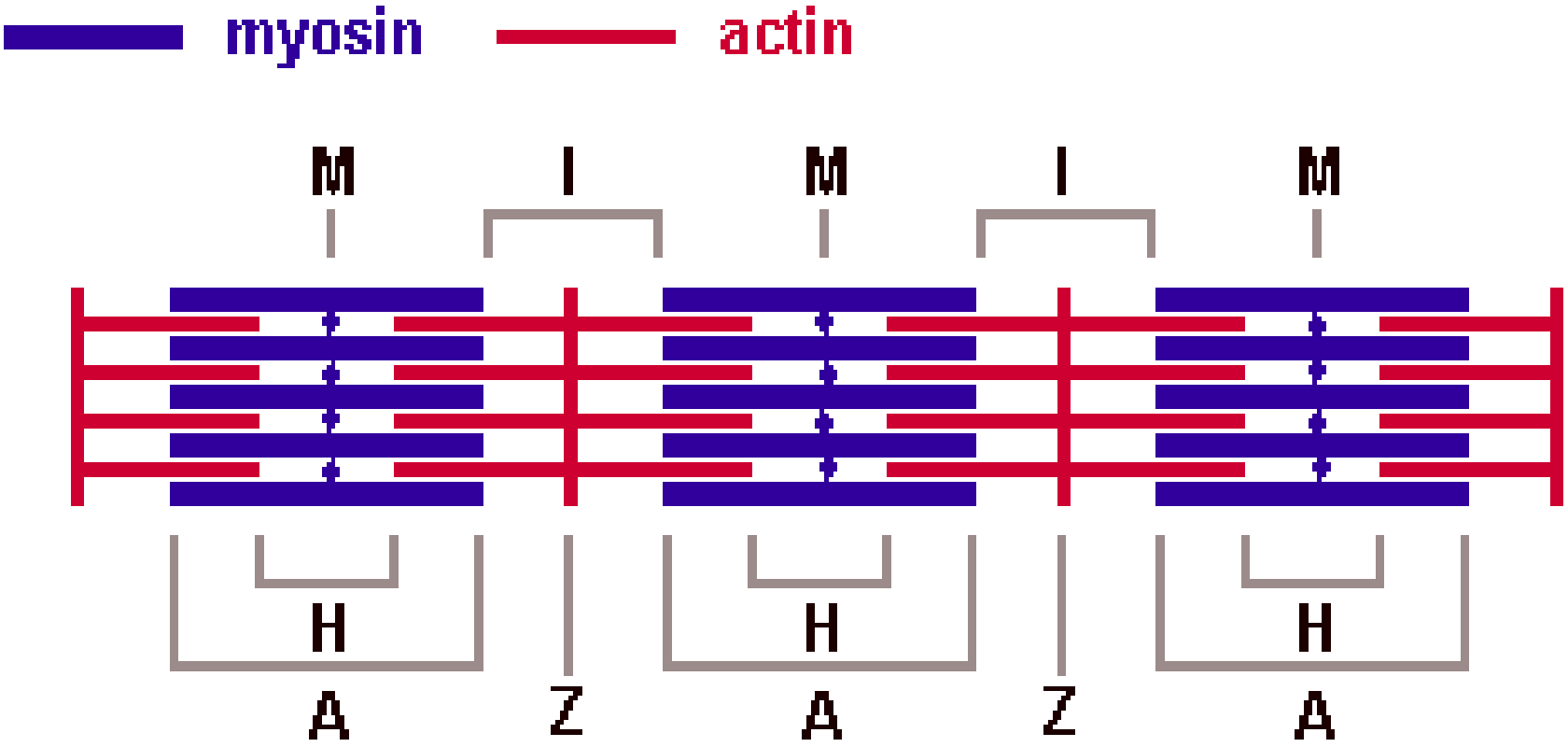




I band decreases

The H diminishes

each sarcomere is shortened.



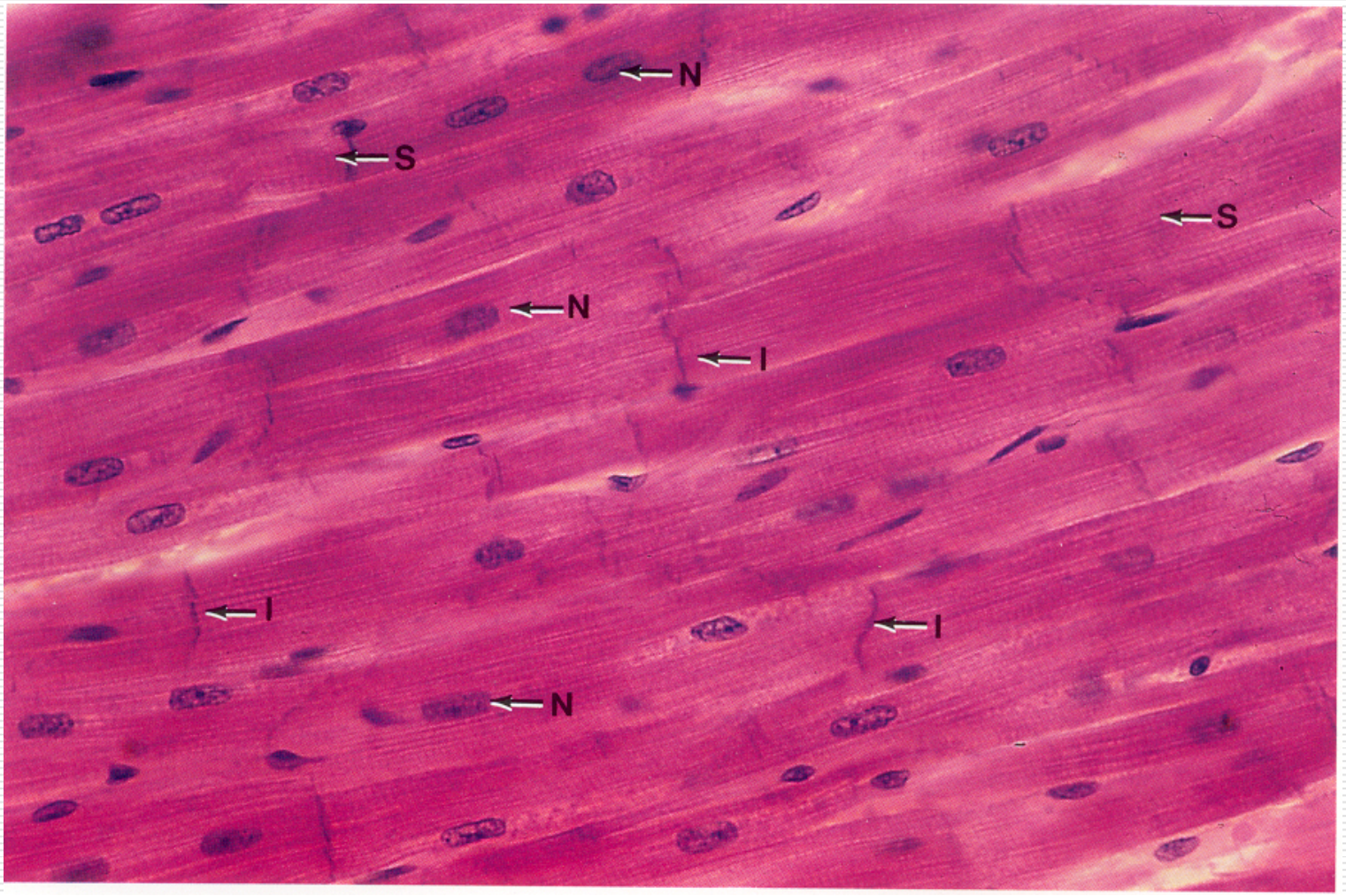
Bands and lines in the contractile apparatus of skeletal muscle

2. Cardiac muscle

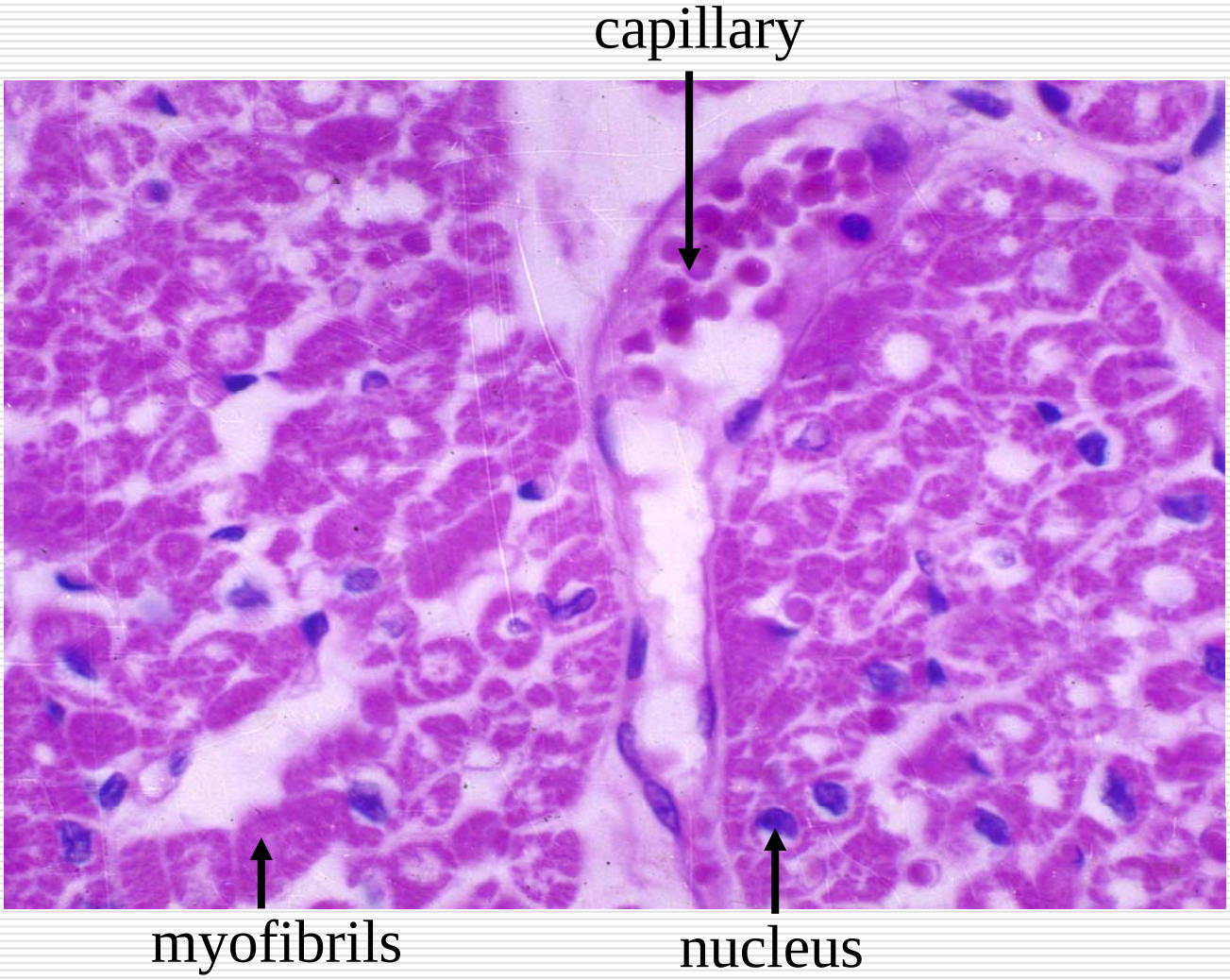
- **Fine structure under LM**
  - intercalated disk
- **Ultrastructure feature**
  - intercalated disk
  - Myofibrils
  - T tubules
  - Sarcoplasmic reticulum, diads
  - Mitochondria
  - Atrial natriuretic factor

Cardiac muscle cells.

short cylindrical cells branch at their ends and connect with adjacent cells. It exhibits a cross-striated banding pattern.

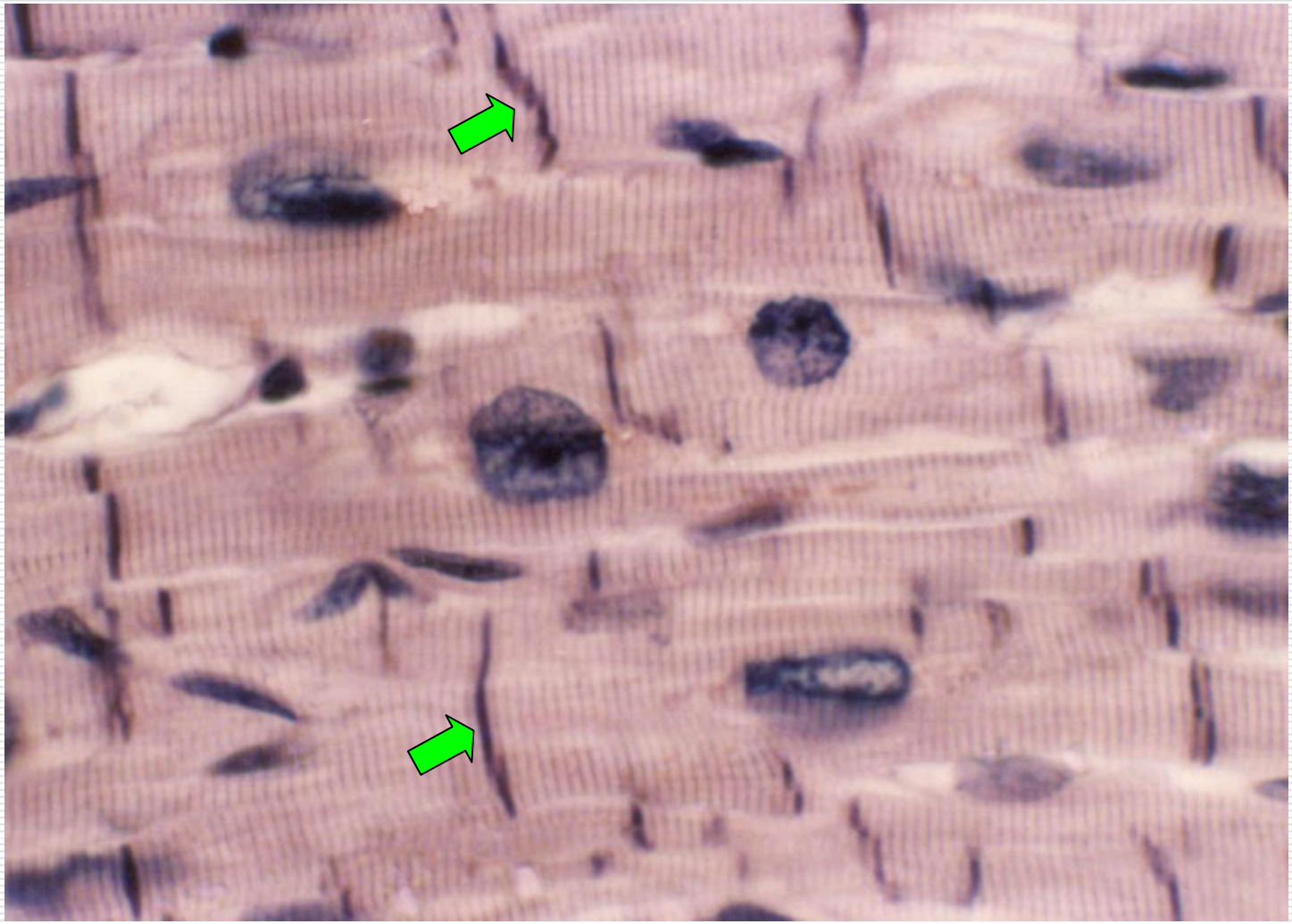


Cardiac muscular cell:
short cylindrical with branches; cross-striated banding pattern
1 or 2 centrally located nuclei; central light stained cytoplsam;
intercalated disc: transverse line, junctional complex

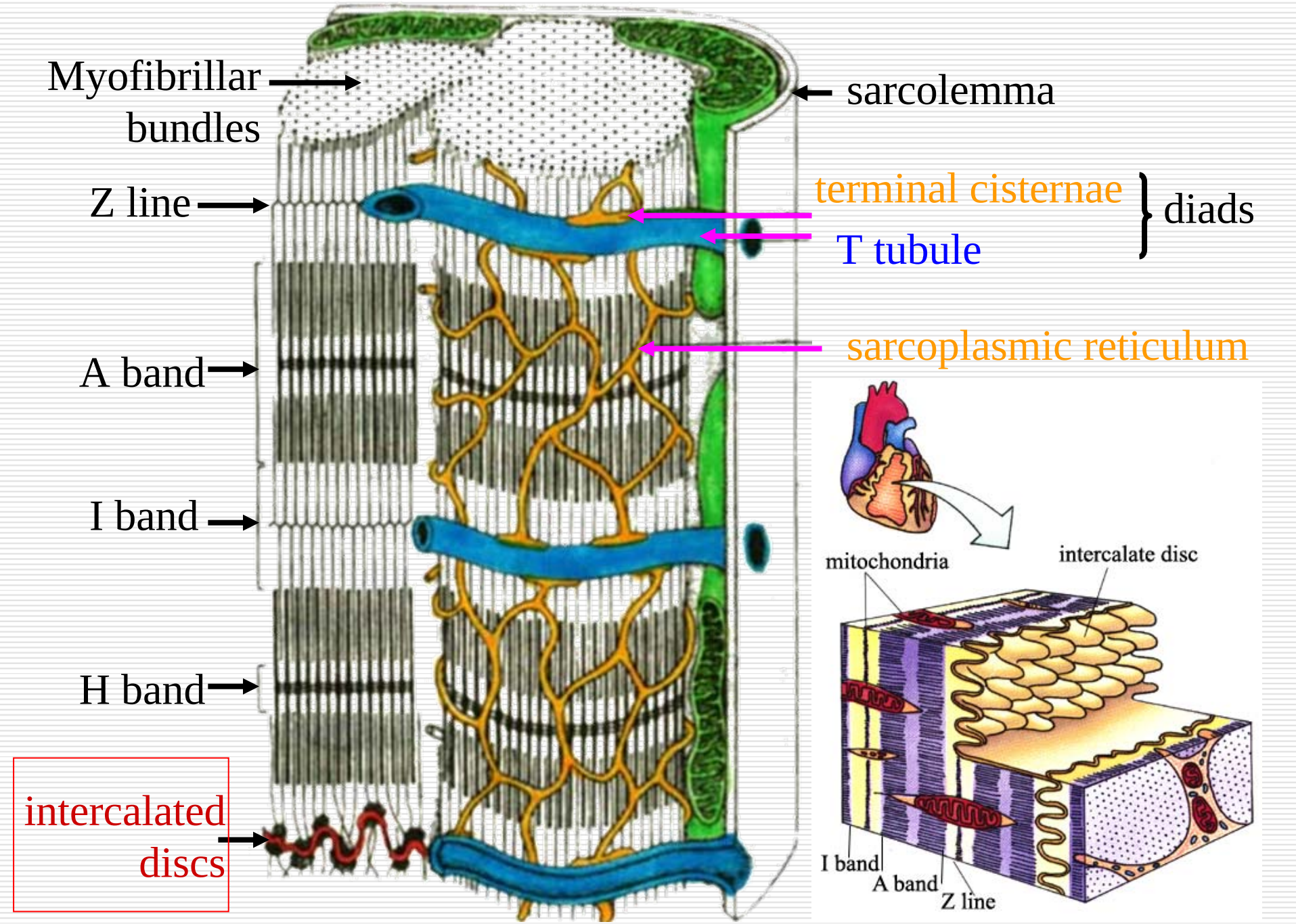


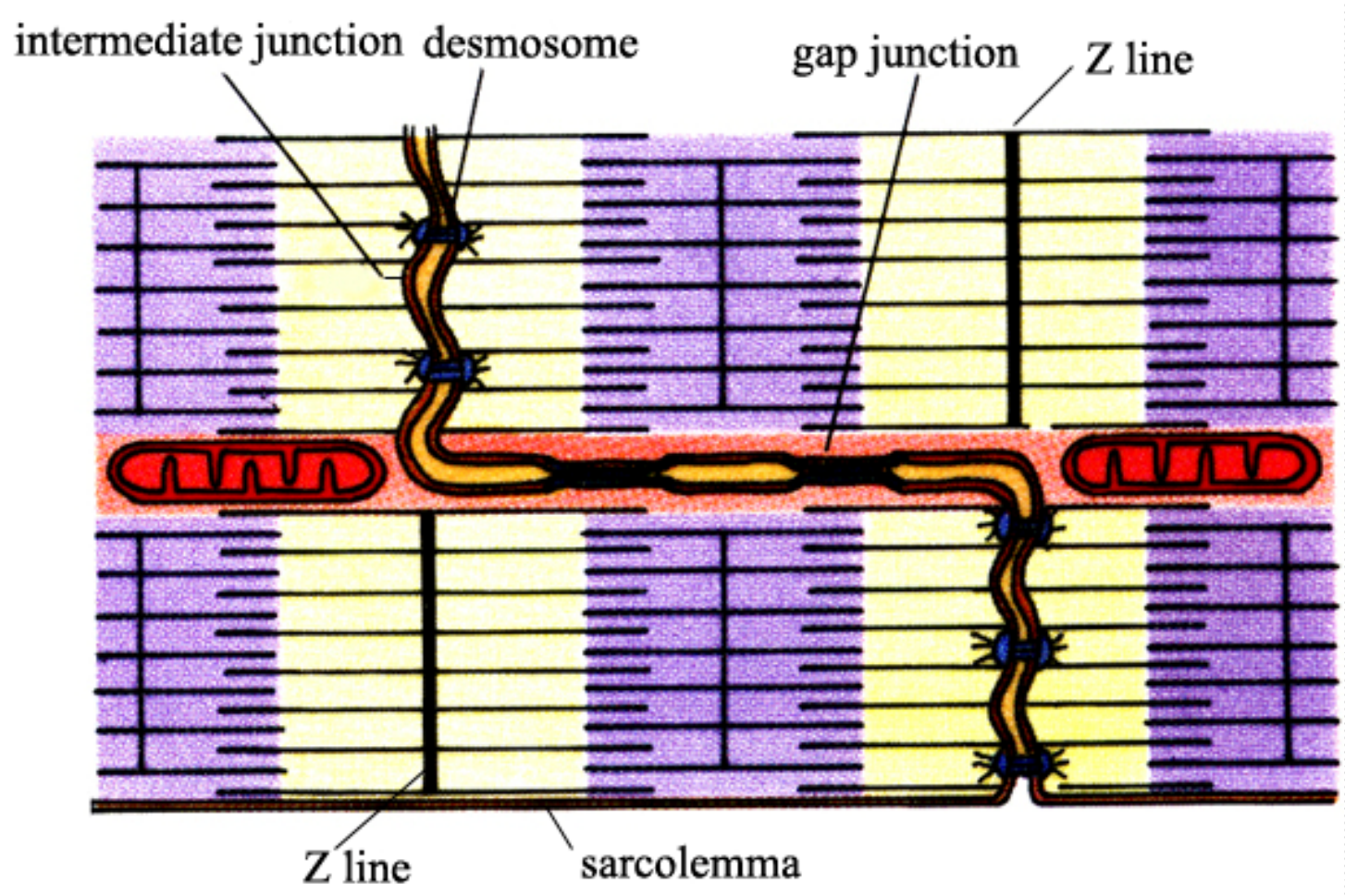
The sarcoplasm immediately surrounding the nuclei is poor in myofibrils, so it presents weaker acidopholia than the rest.

A rich network of capillaries winds among the cells.

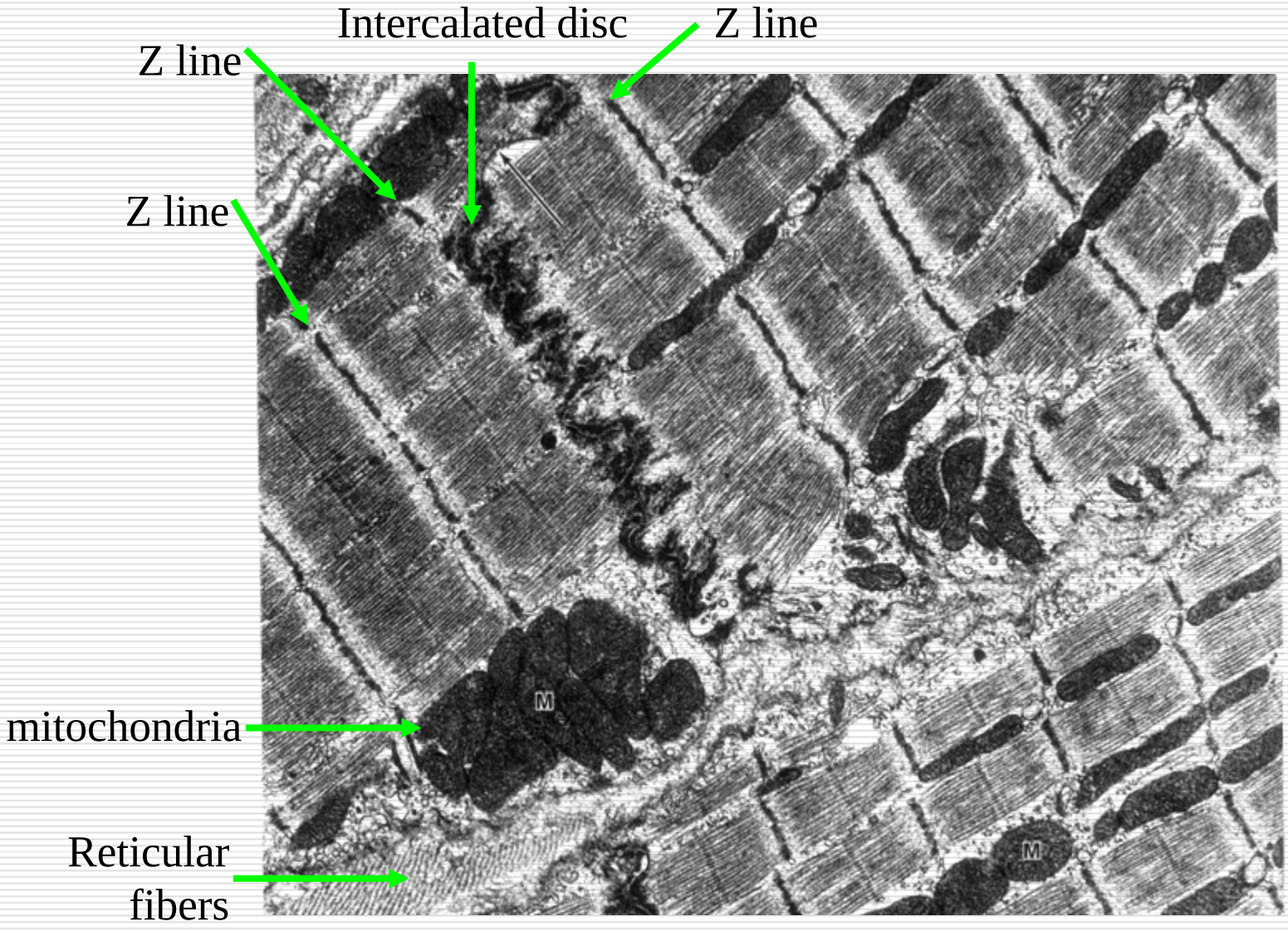


intercalated discs are junctional complexes between adjacent cells, appear as black thick straight lines. The thin lines between intercalated discs are Z lines.


Myofibrillar bundles
sarcolemma
Z line
terminal cisternae
T tubule
diads
sarcoplasmic reticulum
A band
I band
H band
intercalated discs
mitochondria
intercalate disc
I band
A band
Z line

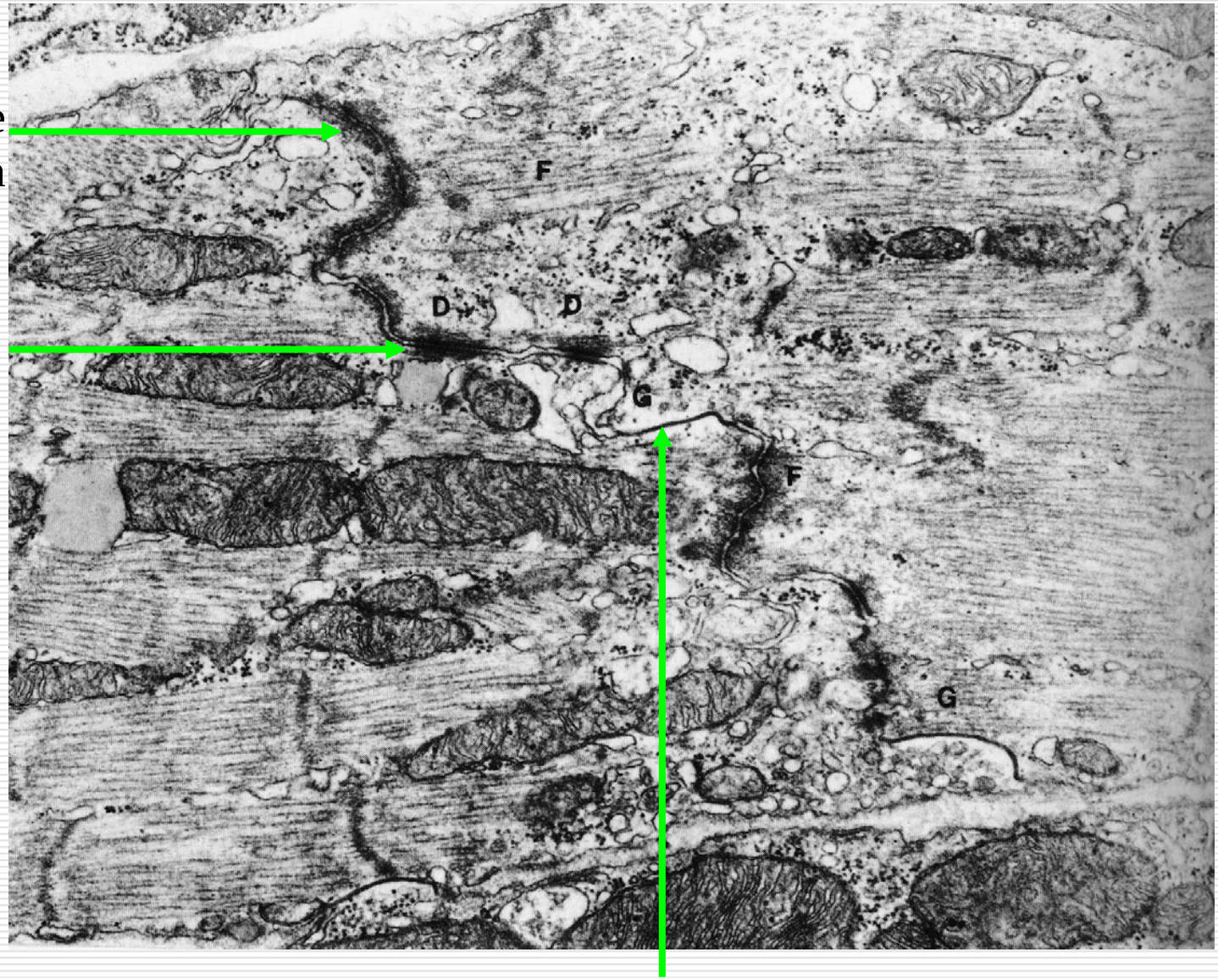


Intermediate junction: anchoring sites for actin filaments of the terminal sarcomeres
Desmosome: prevent cardiac cells pulling apart under constant contractile activity
Gap junction: provide ionic continuity, allow cells contract together


Intercalated disc
Z line
Z line
Z line
mitochondria
Reticular fibers
M
M

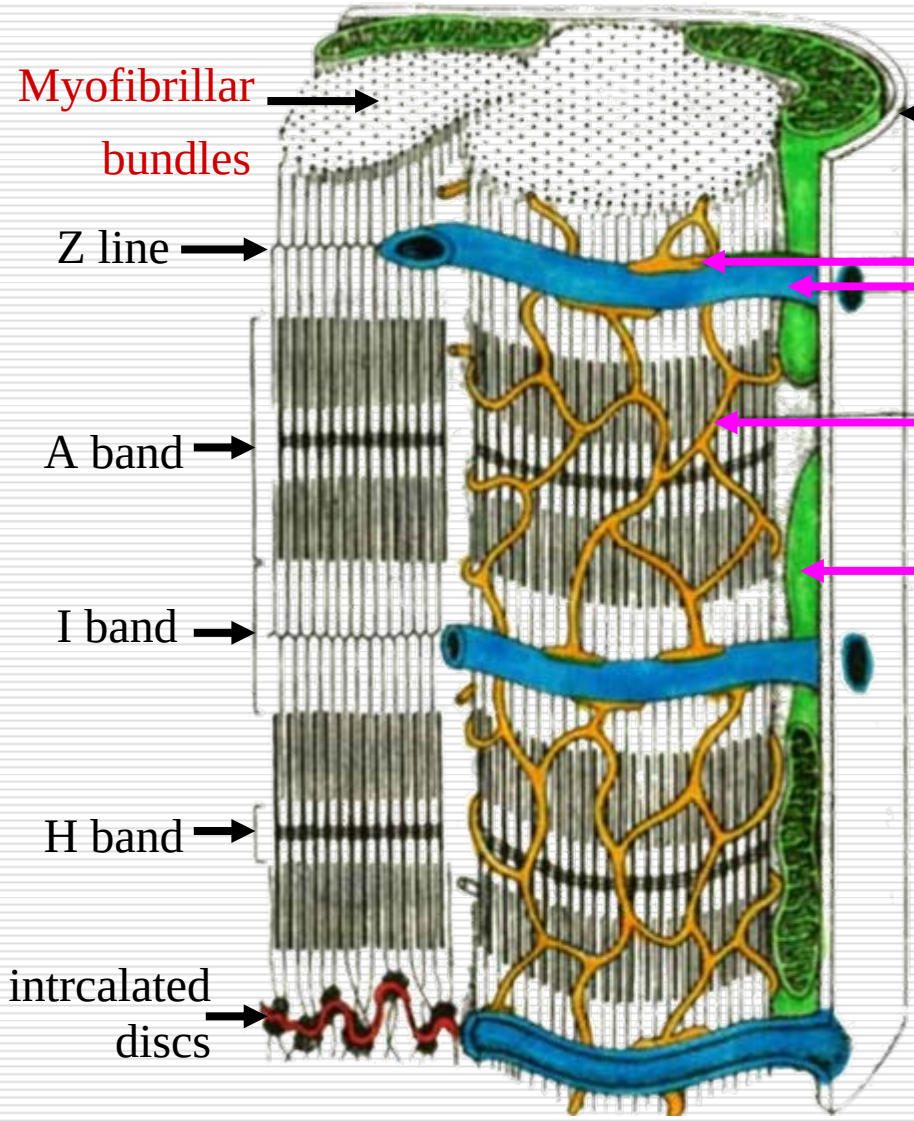
Intermediate junction

desmosome



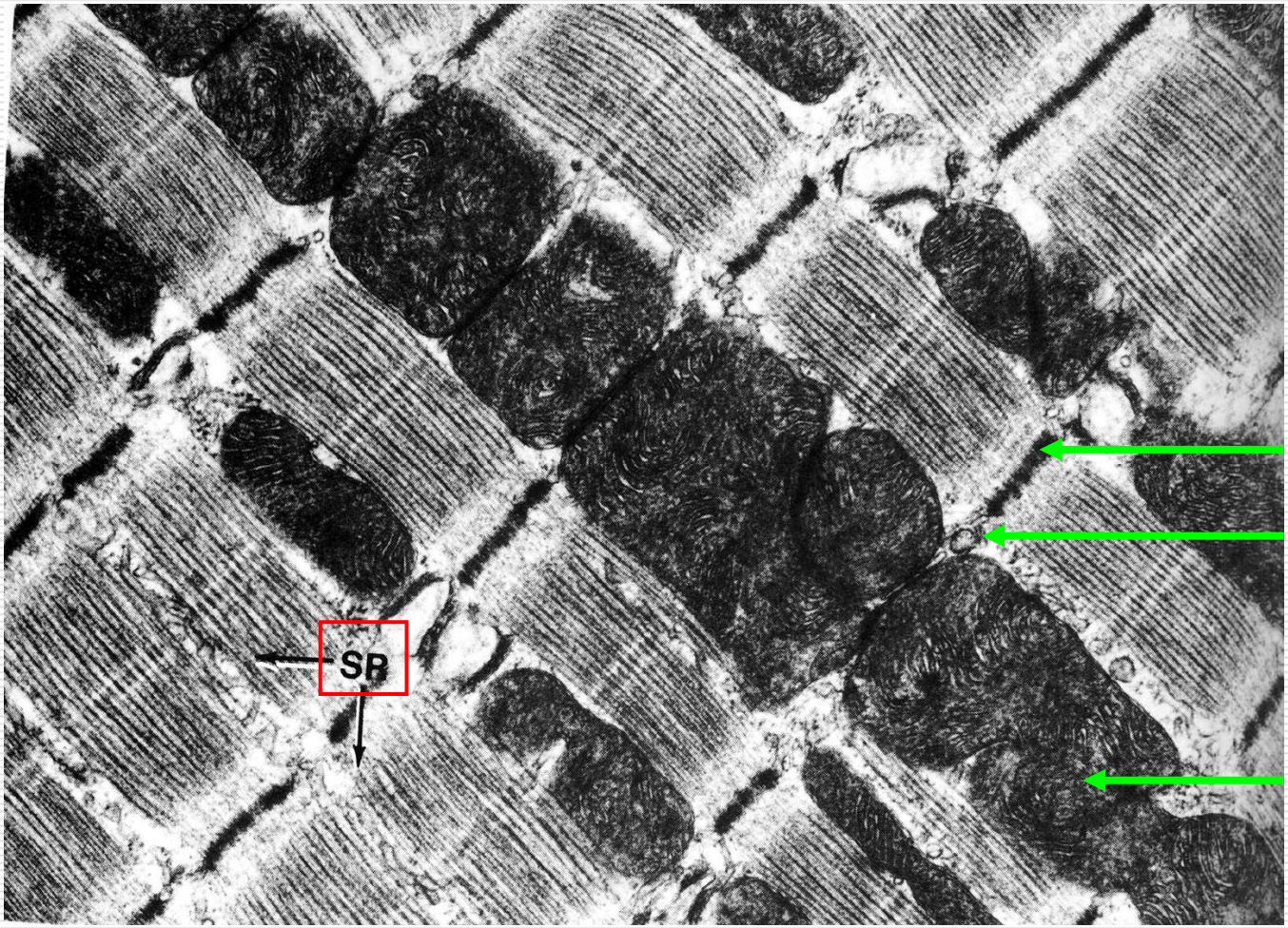
Structure of Intercalated disc

Gap junction



Myofibrillar bundles: incompletely divided by portions of the sarcoplasm and large mitochondria

T tubules: more, larger, the level of the Z band
Sarcoplasmic reticulum: undeveloped, irregular
diads: one T tubule + one sarcoplasmic reticulum cisterna
Mitochondria: more numerous, larger

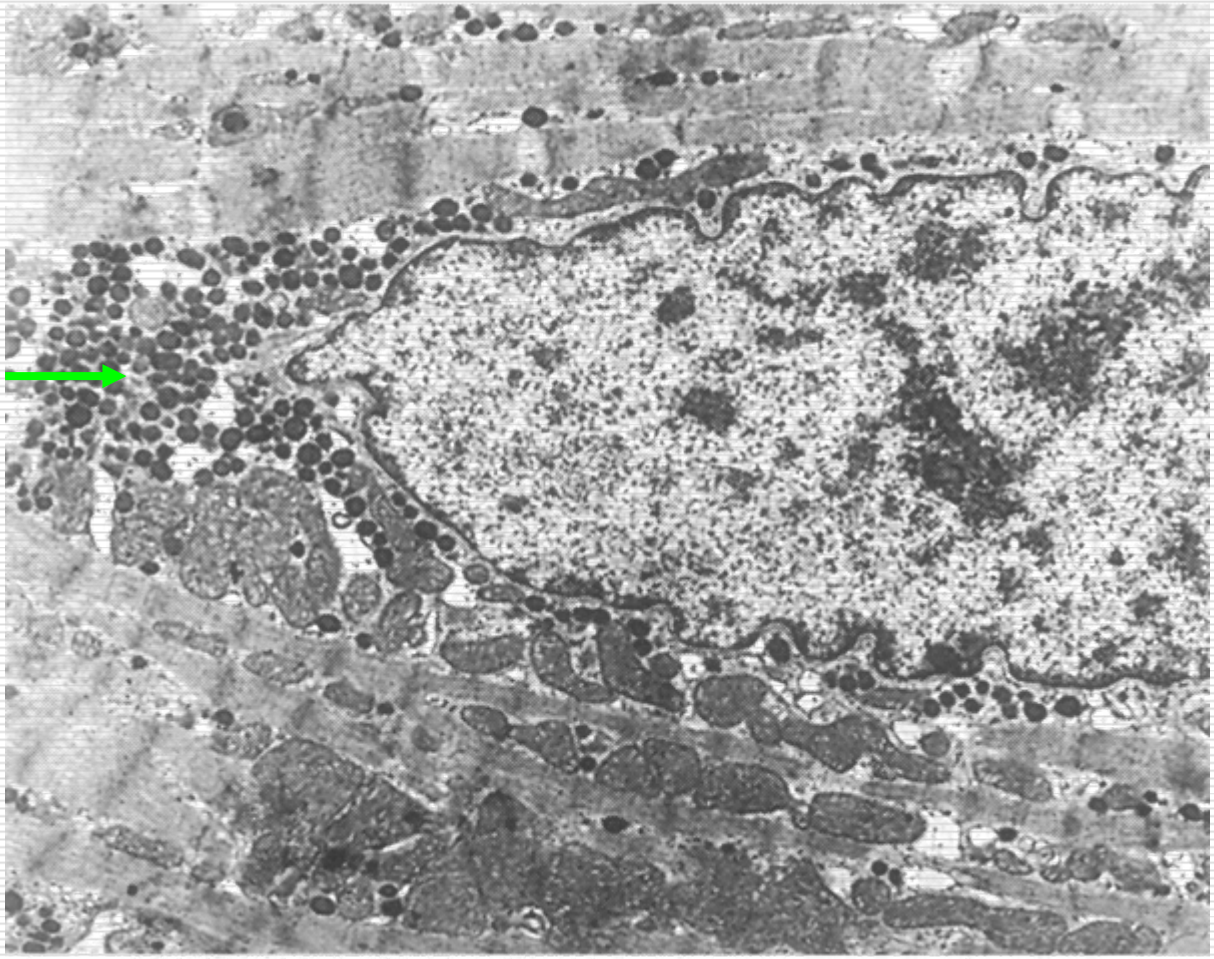


T tubules: the level of the Z band

sarcoplasmic reticulum

Mitochondria: more numerous, larger

granules



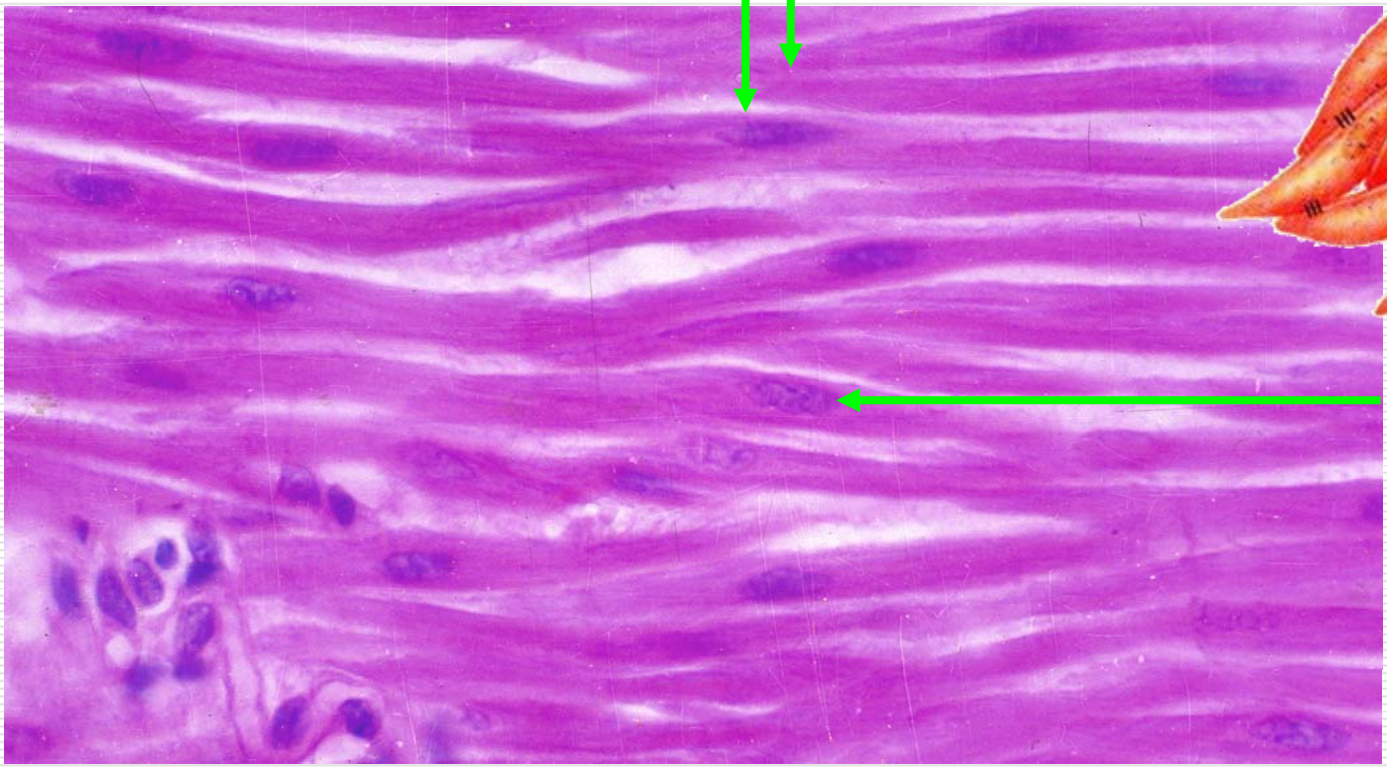
atrial natriuretic factor:
In muscle cells of the atrium;
act on the kidneys to cause sodium and water loss

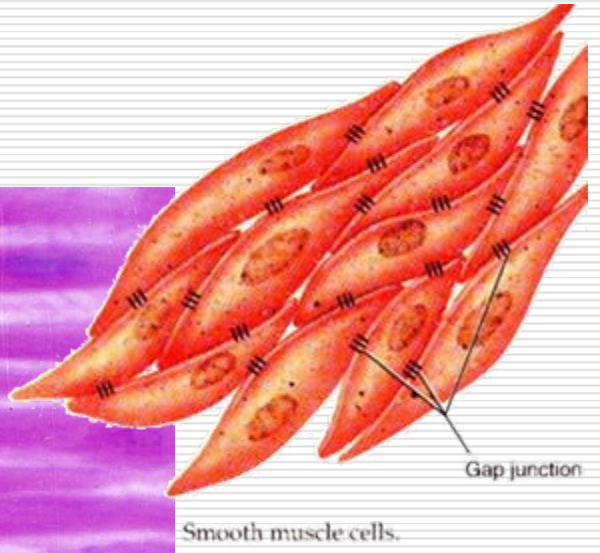
3. Smooth muscle

- **Fine structure under LM**
  - cell body
  - nucleus
- **Ultrastructure under EM**
  - sarcoplasmic reticulum
  - myofilaments
  - cytoskeleton

narrow part

broad parts





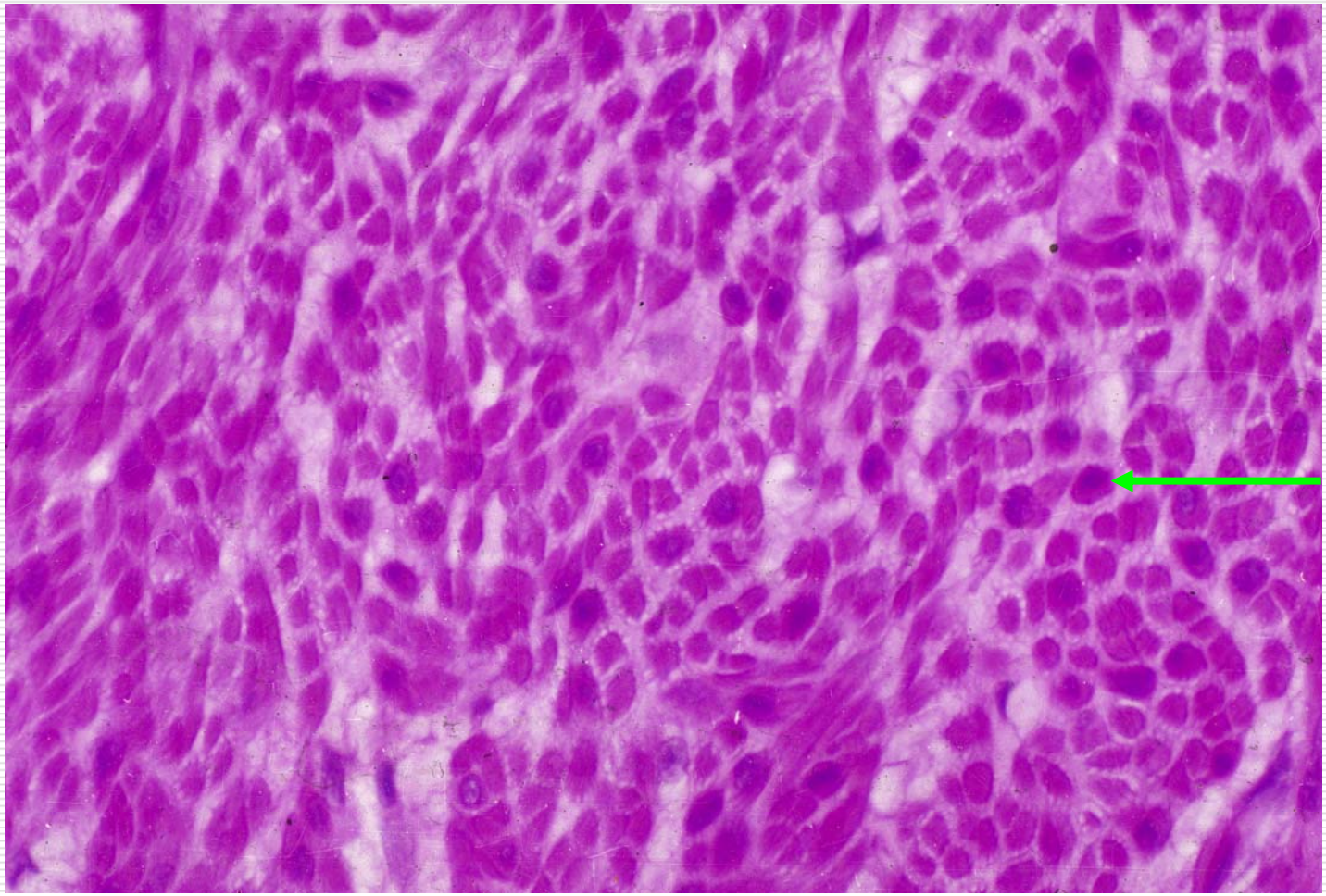
nucleus

fusiform cells arranged in layers

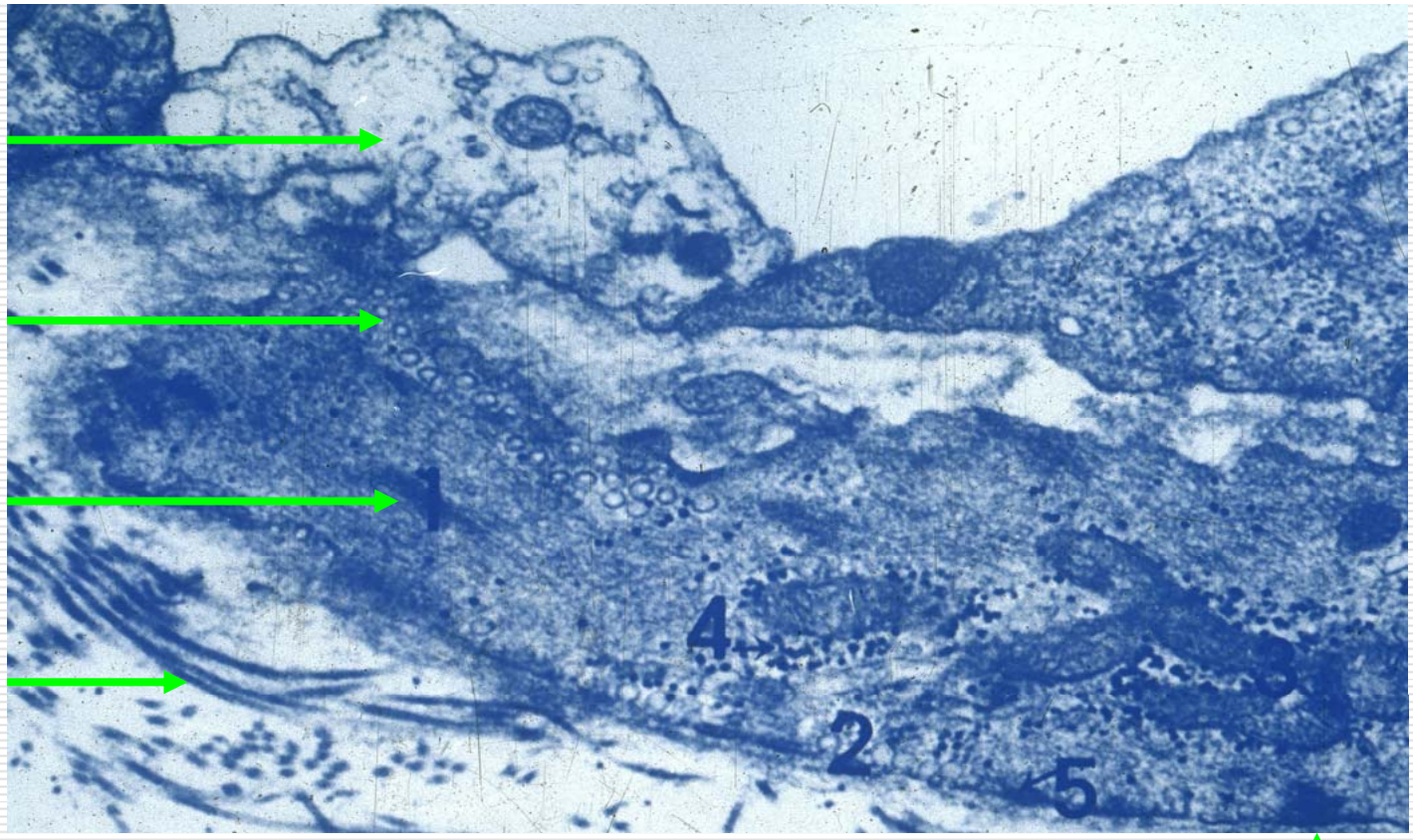
largest at their midpoints and taper toward ends.

narrow part of one cell lies to the broad parts of adjacent cells

single rod-like nucleus located in the center .



a range of diameters
only the largest profiles containing a nucleus



caveolae : counterparts of T tubules
myofilaments :thin filaments and thick filaments
cytoskeleton: dense patches, dense bodies, intermediate filaments
abundant gap junctions , poor nerve supply

Key points

- Master the light microscopic structure and function of three types of muscle tissues
- Master the difference between skeletal and cardiac muscular cells in EM (ultrastructure)
- Master the function of atrial natriuretic factor
- Master the structure and function of intercalated disc
- Master the terms of sarcomere, T tubule, L tubule, triad, biad, terminal cisterna