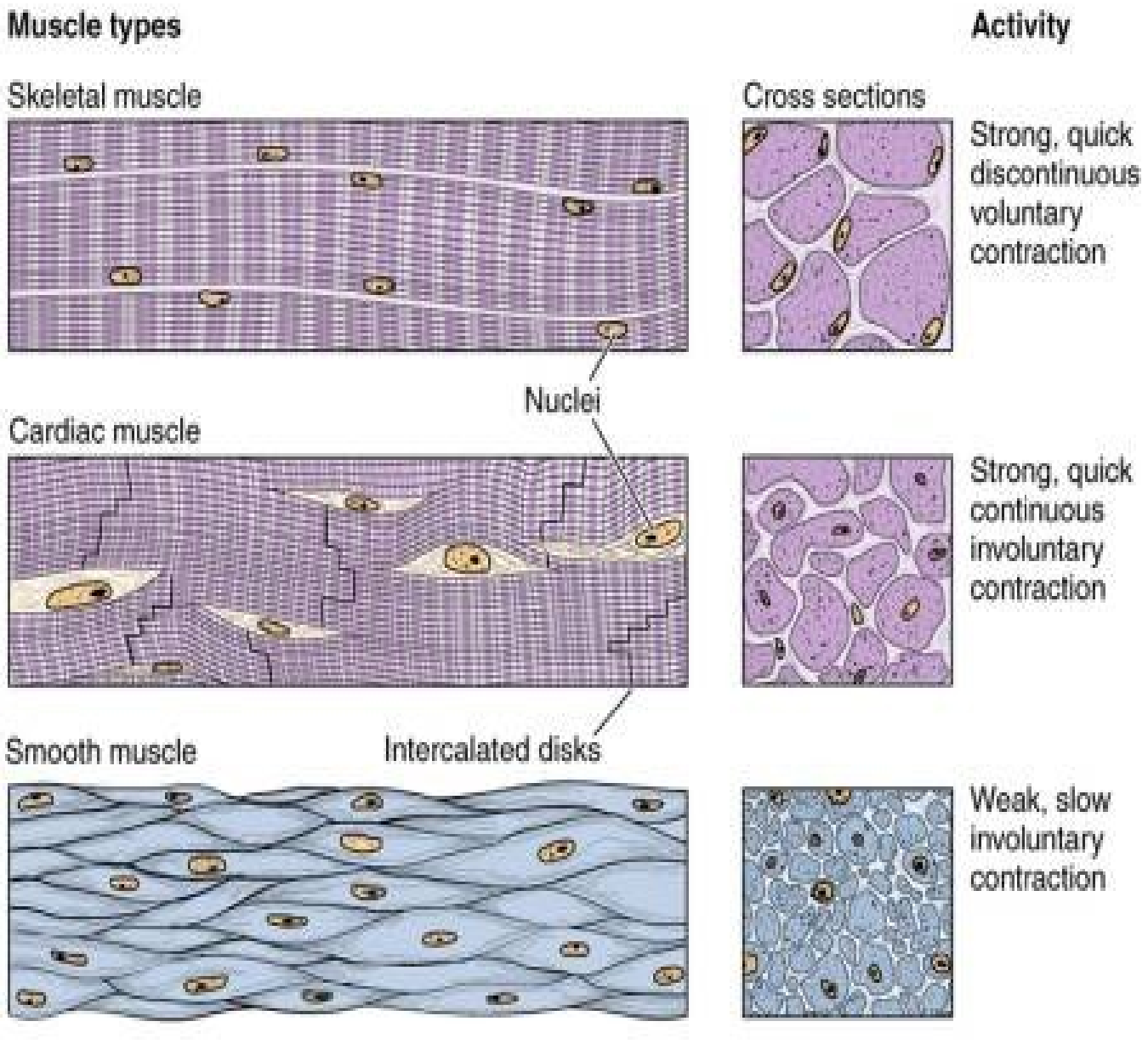
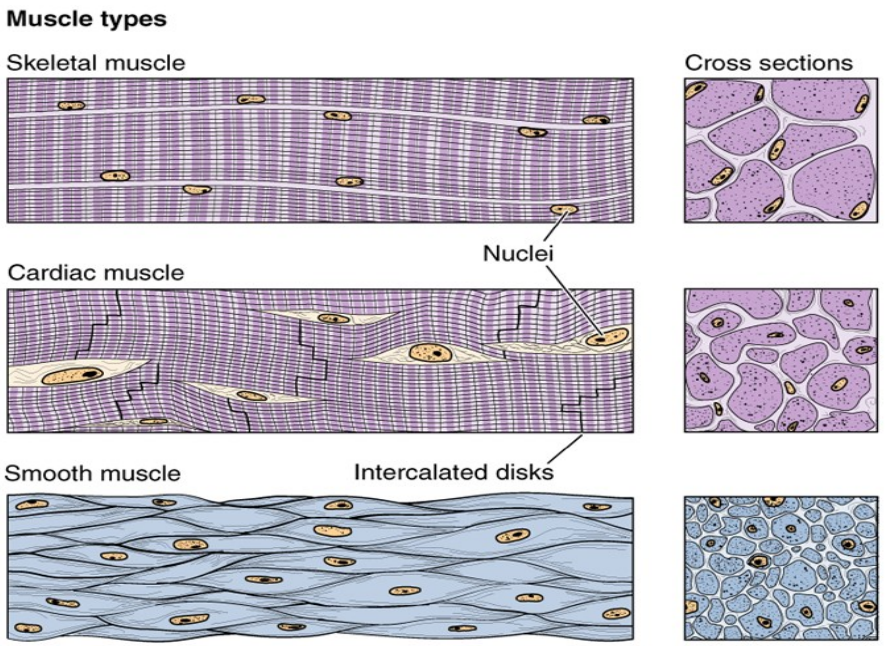
Muscle tissue

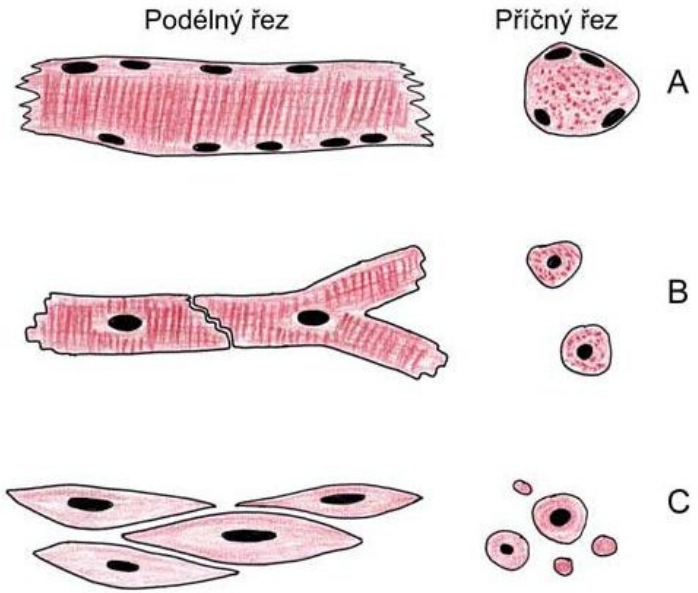
Muscle tissue

1) Striated skeletal muscle tissue.
2) Striated cardiac muscle tissue.
3) Smooth muscle tissue.



Muscle tissue





Muscle tisssue

- Origin: mesoderm and mesenchyme
- Excitability
- Contraction + relaxation ⇒ movement
- Composition: muscle cells + connective tissue, blood vessels
- Long axe of cells is oriented paralelly with direction of contraction

mys/myos (muscle) **sarx**/sarcós (meat):

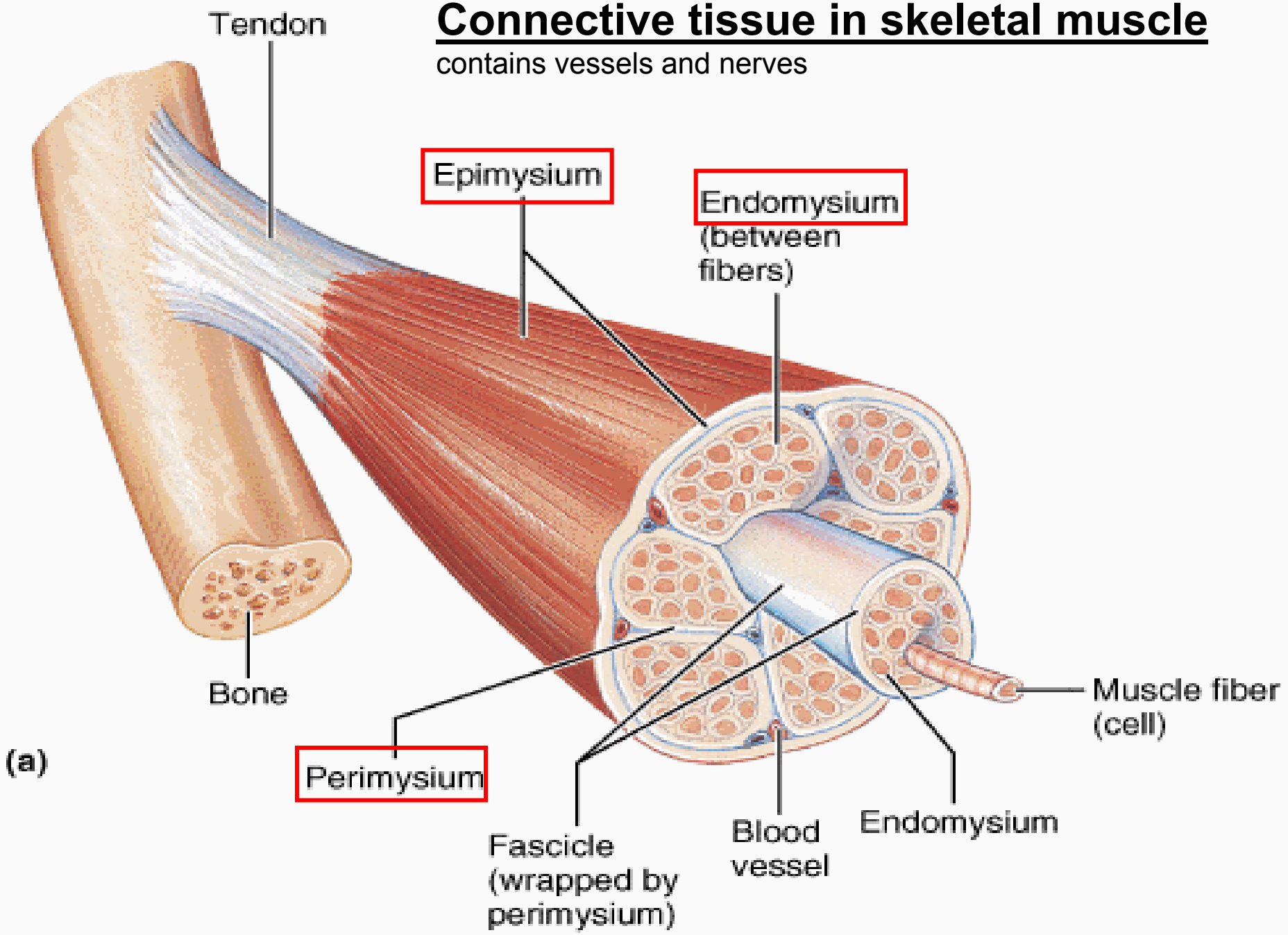
cell membrane = sarcolemma cytoplasm = sarcoplasm
sER = sarcoplasmic reticulum

Muscle tissue – connective tissue

- Endomysium – around each muscle cell (fiber)
- Perimysium – around and among the primary bundles of muscle cells
- Epimysium – connective tissue „capsule“ covering the surface of muscle

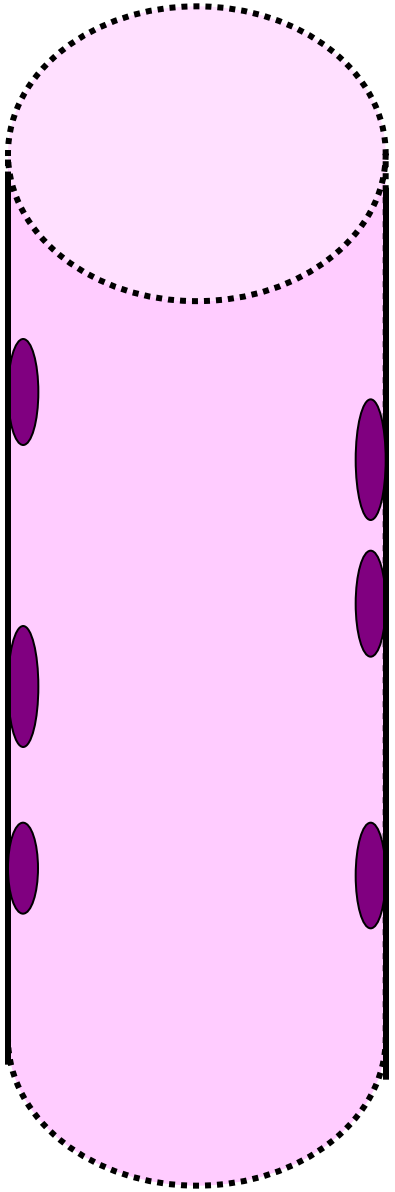
Connective tissue in skeletal muscle

contains vessels and nerves



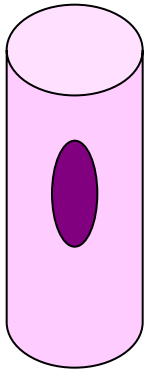
MUSCLE CELLS

rhabdomyocyte

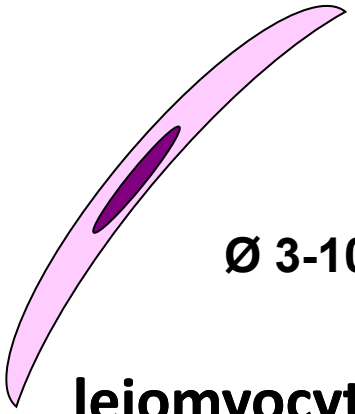


Ø 25-100 µm

kardiomyocyte



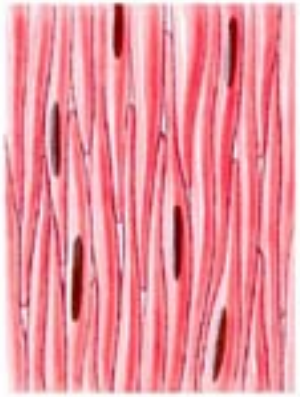
Ø 15 µm



Ø 3-10 µm

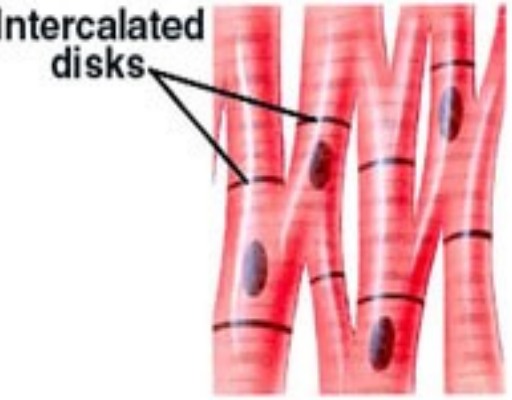
leiomyocyte

Types of Muscle



Smooth muscle

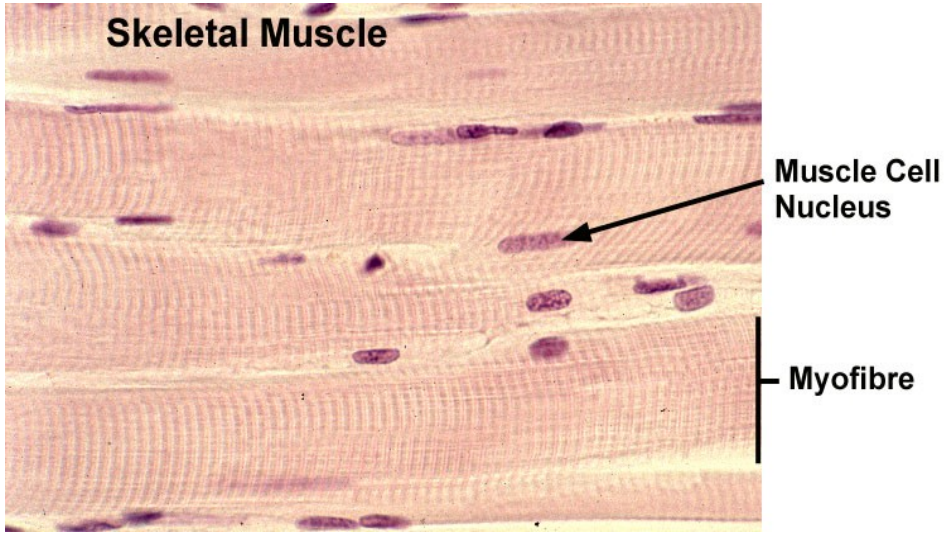
Skeletal muscle

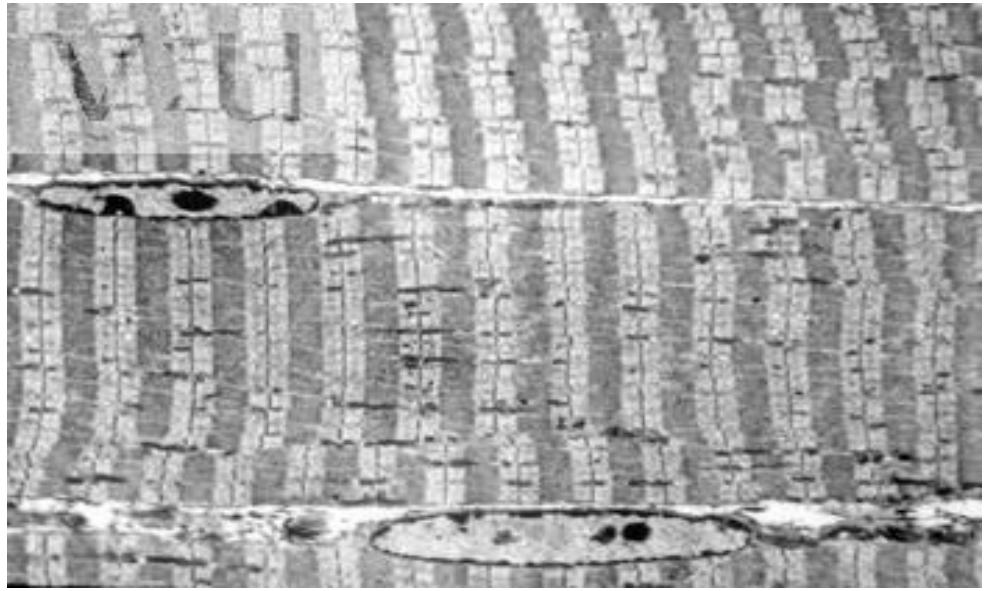


Cardiac muscle

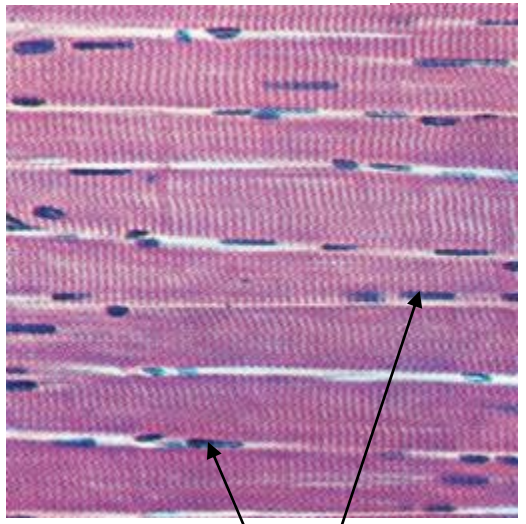
Cross striated skeletal muscle tissue

- **morphological and functional unit: muscle fiber (rhabdomyocyte)** – elongated, cylindrical shape, multinucleated cell (=syncytium) – nuclei are located at the periphery (beneath sarcolemma), myofibrils show cross striation
- diameter of muscle fiber: 25-100 μm
- length: milimeters - centimeters (up 15)





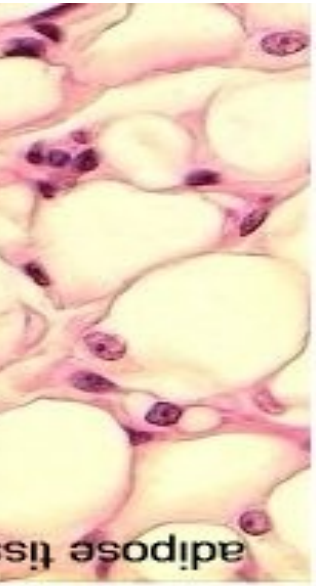
Skeletal muscle:
longitudinal section
of muscle fibers

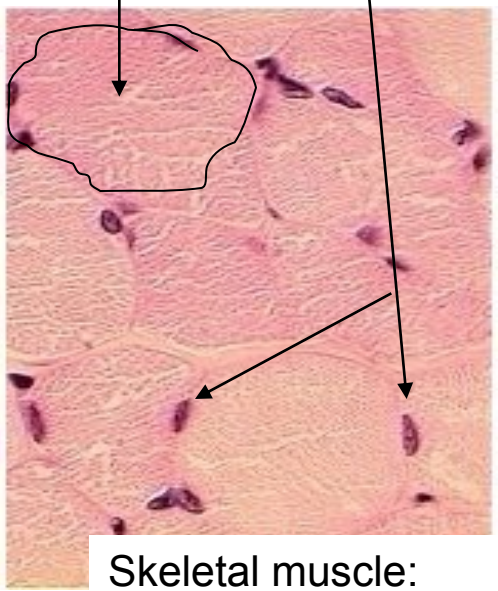


see nuclei at the periphery
and cross striation

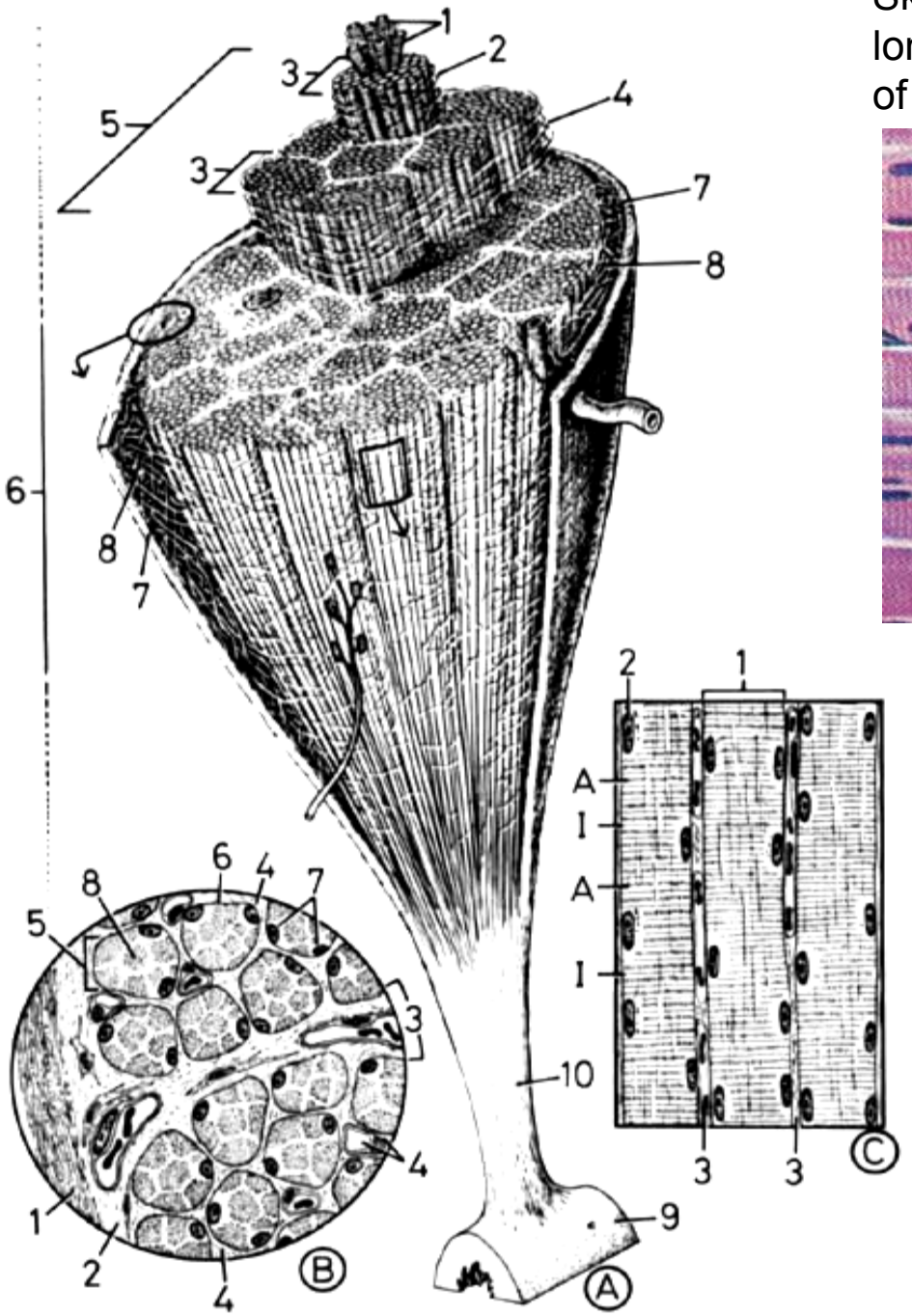
myofibrils in sarcoplasm

nuclei





Skeletal muscle:
cross section trough
muscle fibers



Skeletal muscle

Used terms:

Sceletal muscle cell (fiber) **<** rhabdomyocyte **>**

Muscle fiber = myofiber = syncitium = rhabdomyocyte

Muscle fiber – morphologic and functional unit of skeletal muscle

[Ø 25 – 100 μ]

Myofibrils – compartment of fiber sarcoplasm

[Ø 0.5 – 1.5 μ]

Myofilaments – actin and myosin, are organized into sarcomeres (several in the length of myofibril) [Ø 8 and 15 nm]

Sarcomere – the smallest contractile unit

[2.5 μm in length]

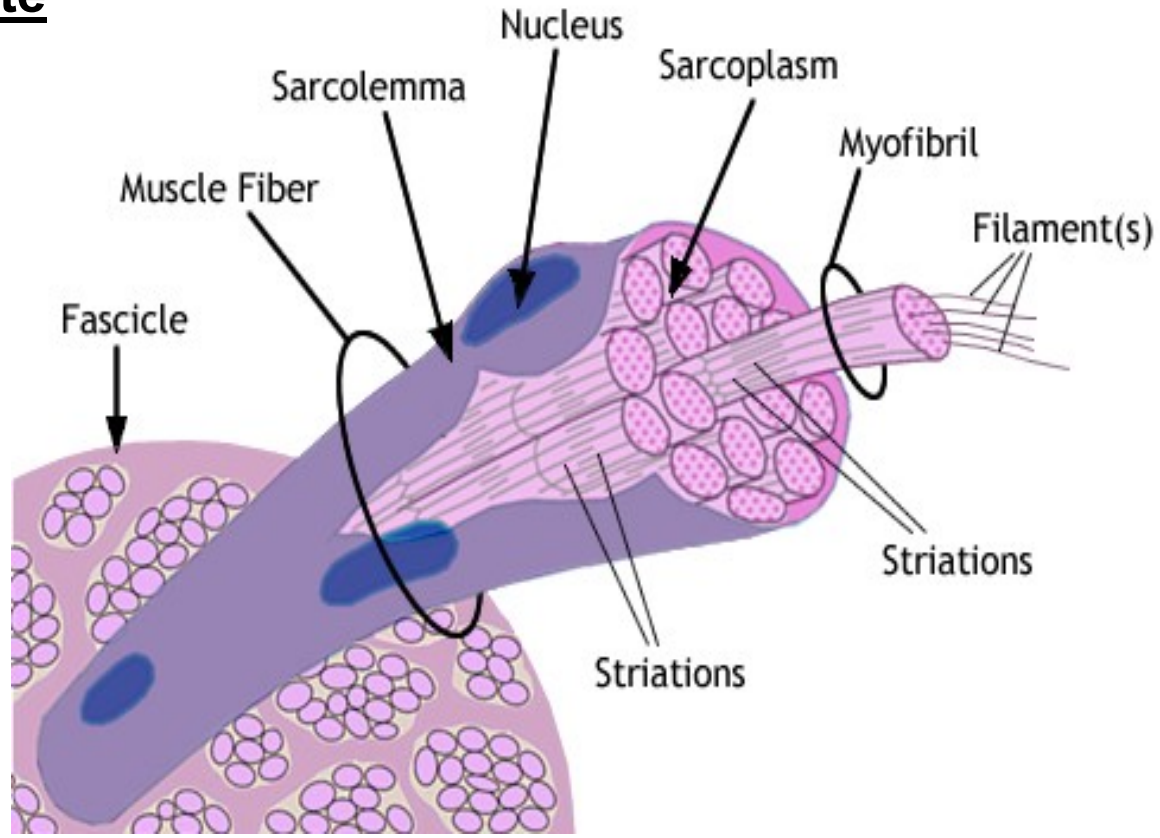
Structure or rhabdomyocyte

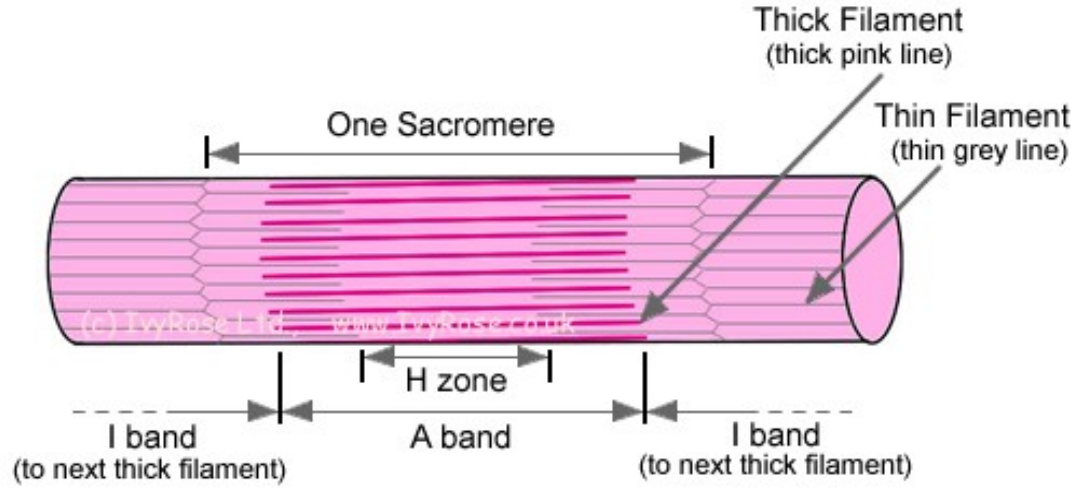
Sarcolemme + **t-tubules**,

In **sarcoplasm**:
Nuclei,
Mitochondria,
Golgi apparatus,
Glycogen (beta granules)
(*sarcoplasm with organelles forms columns among myofibrils*)

Sarcoplasmic reticulum (smooth ER) – reservoir of Ca^{2+}

Myofibrils (parallel to the length of the muscle fiber)





Skeletal muscle

- Myofibrils :

- elongated structures [Ø 0.5 – 1.5 μ] in sarcoplasm of muscle fiber,

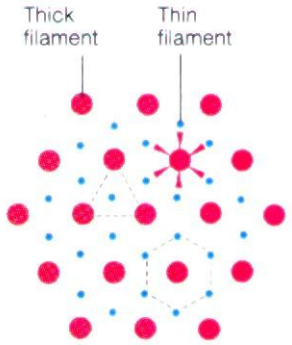
- are oriented parallely to the length of the fiber,

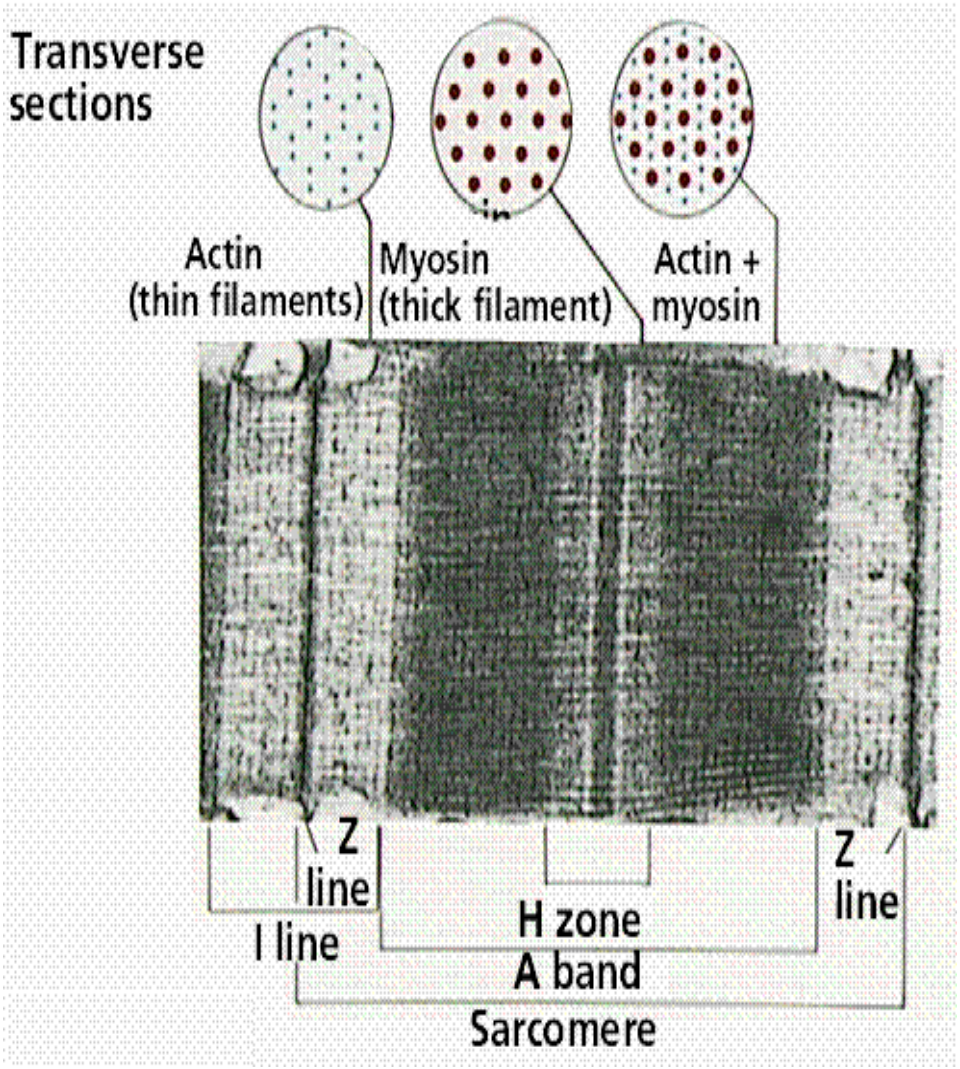
- contain 2 types of myofilaments: actin and myosin, arranged into the smallest contractile units – sarcomeres

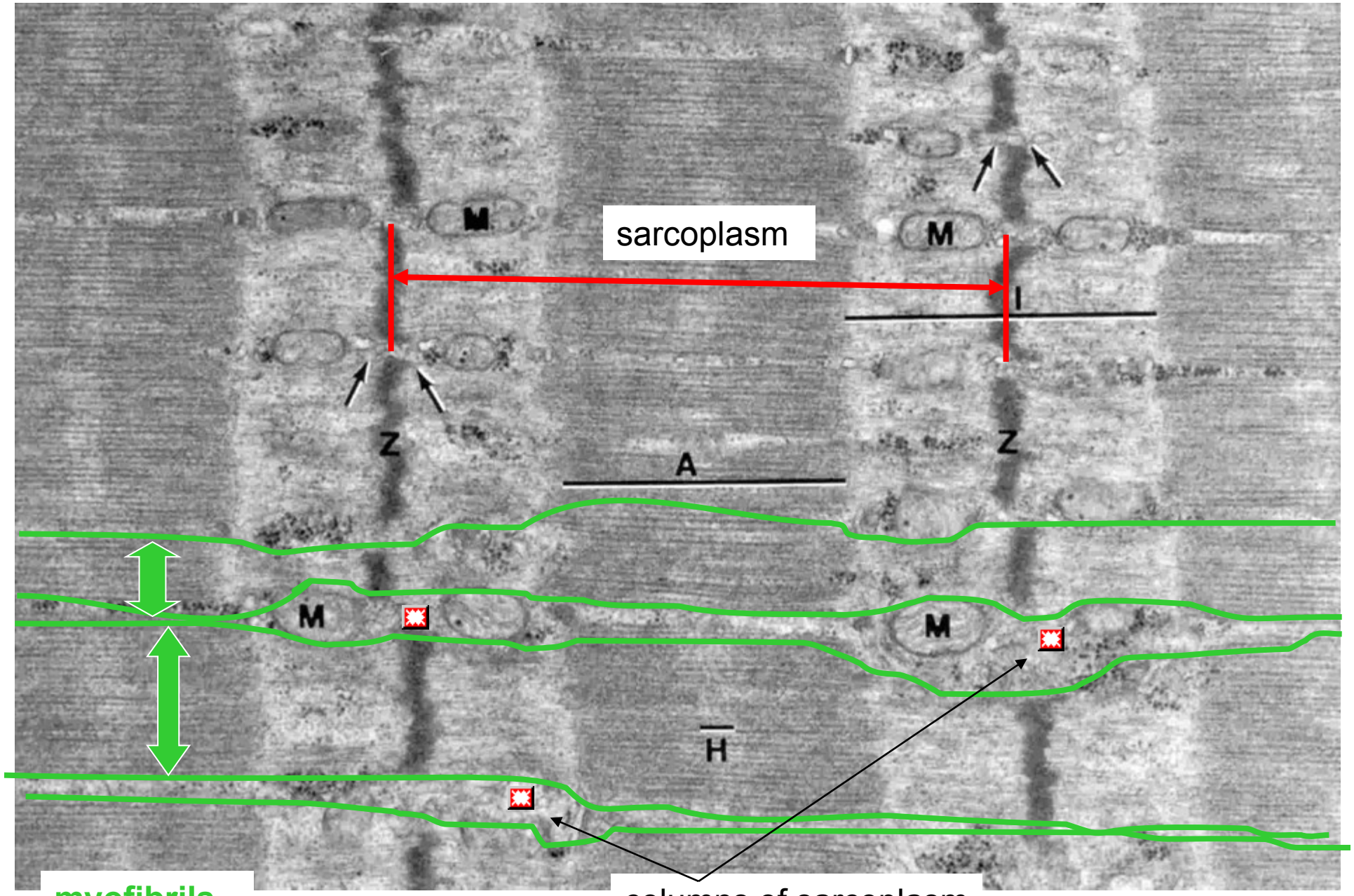
- organization of myofilaments causes cross striation of myofibrils.

Myofibril

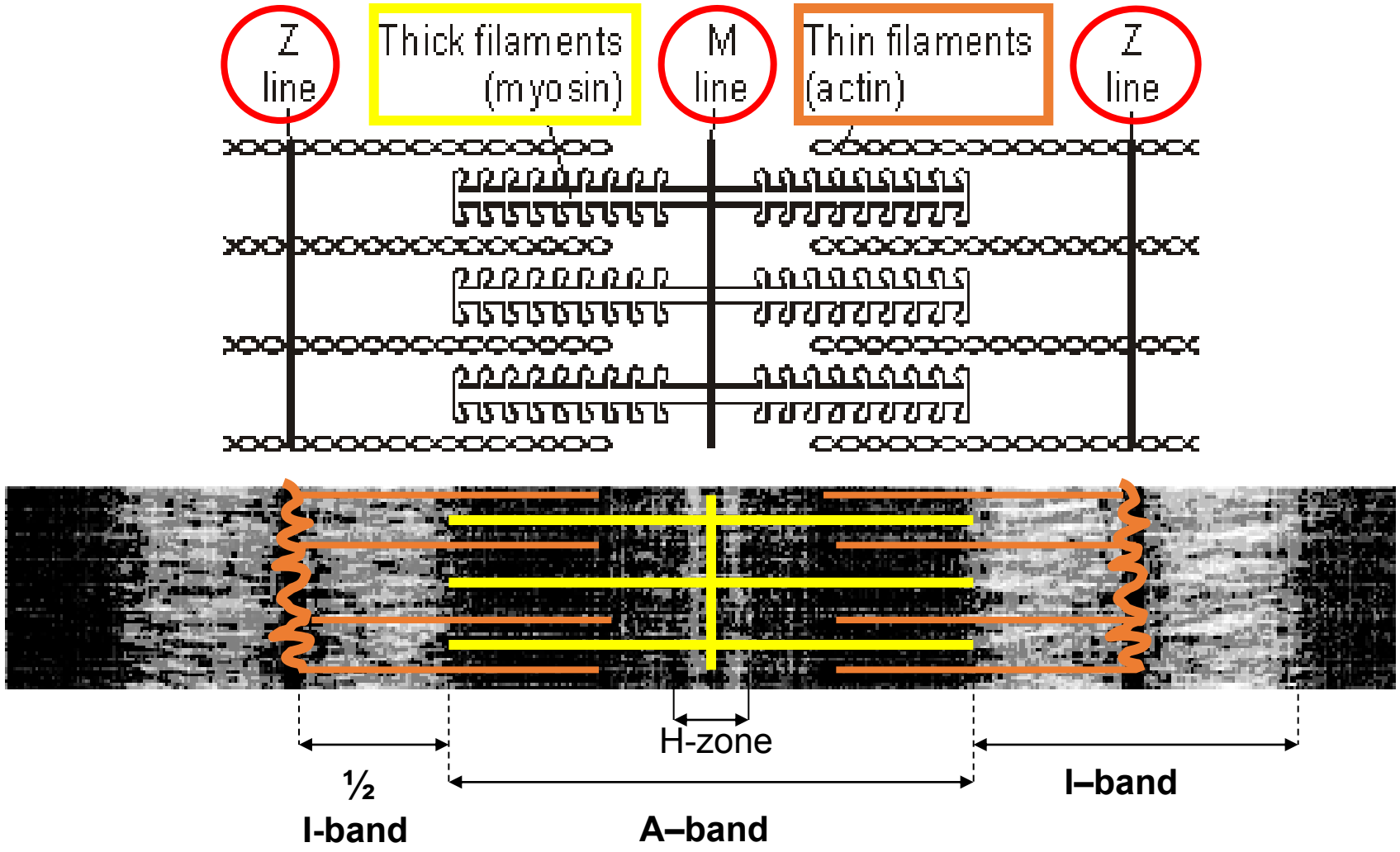
- Actin + myosin myofilaments
- Sarcomere
- Z-line
- M-line and H-zone
- I-band, A-band

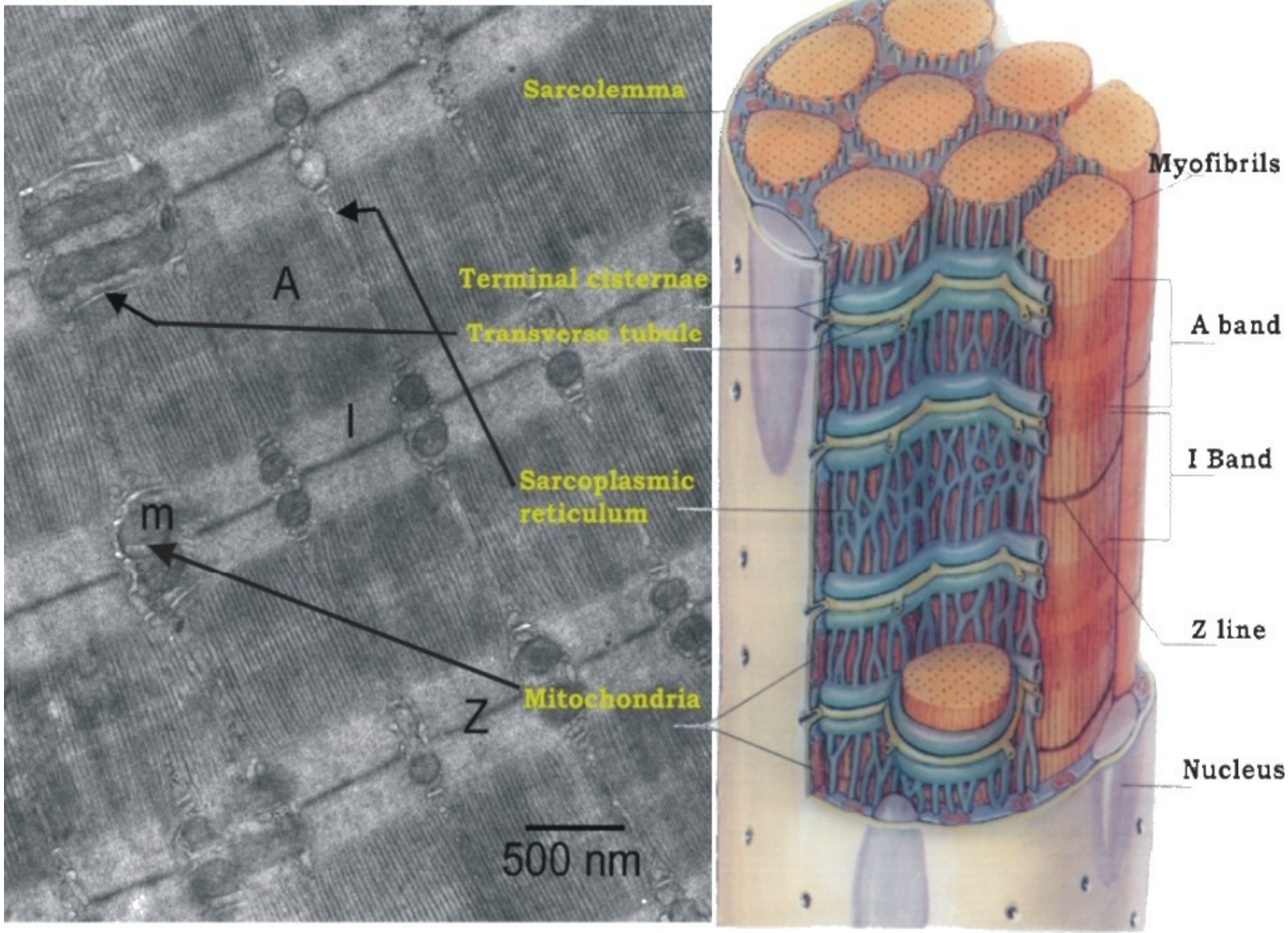




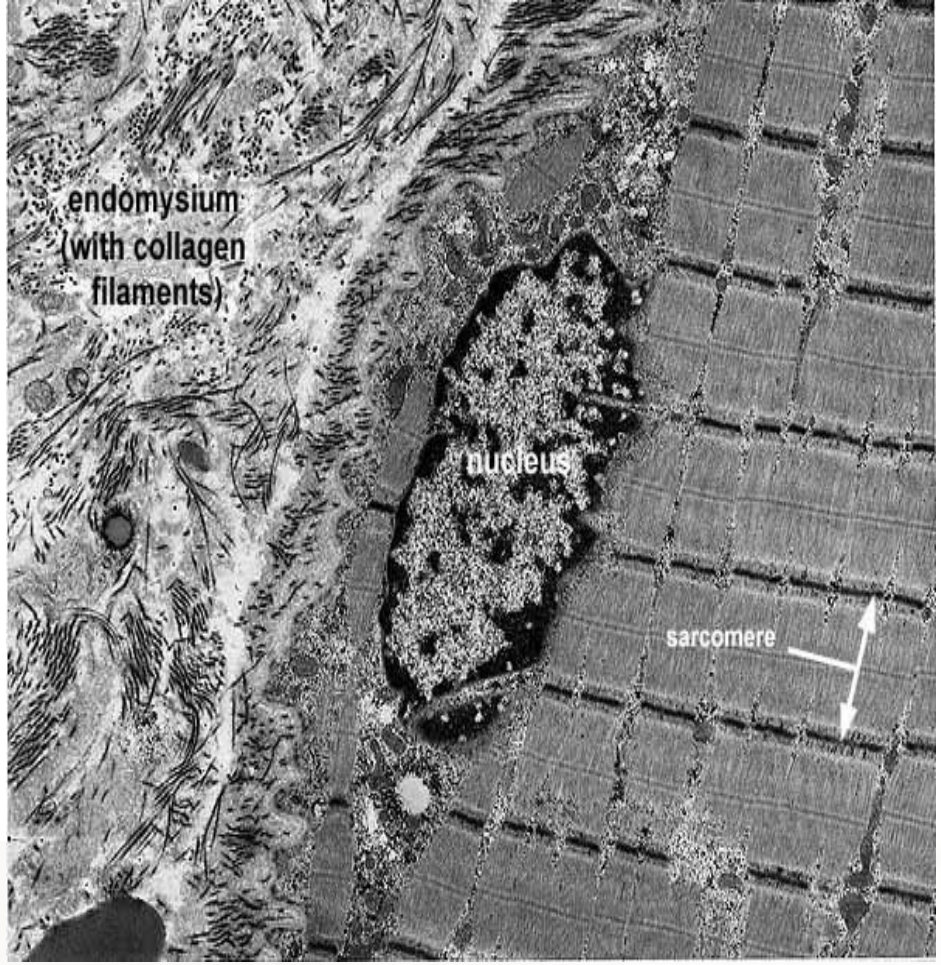

sarcoplasm
M
M
I
Z
Z
A
M
M
H
myofibrils
columns of sarcoplasm

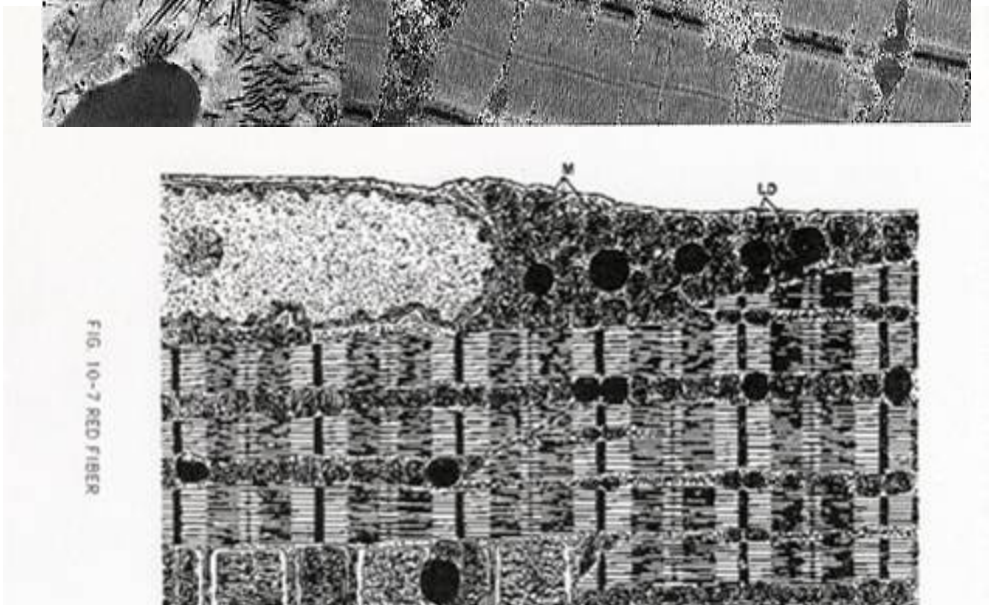
Sarcomere

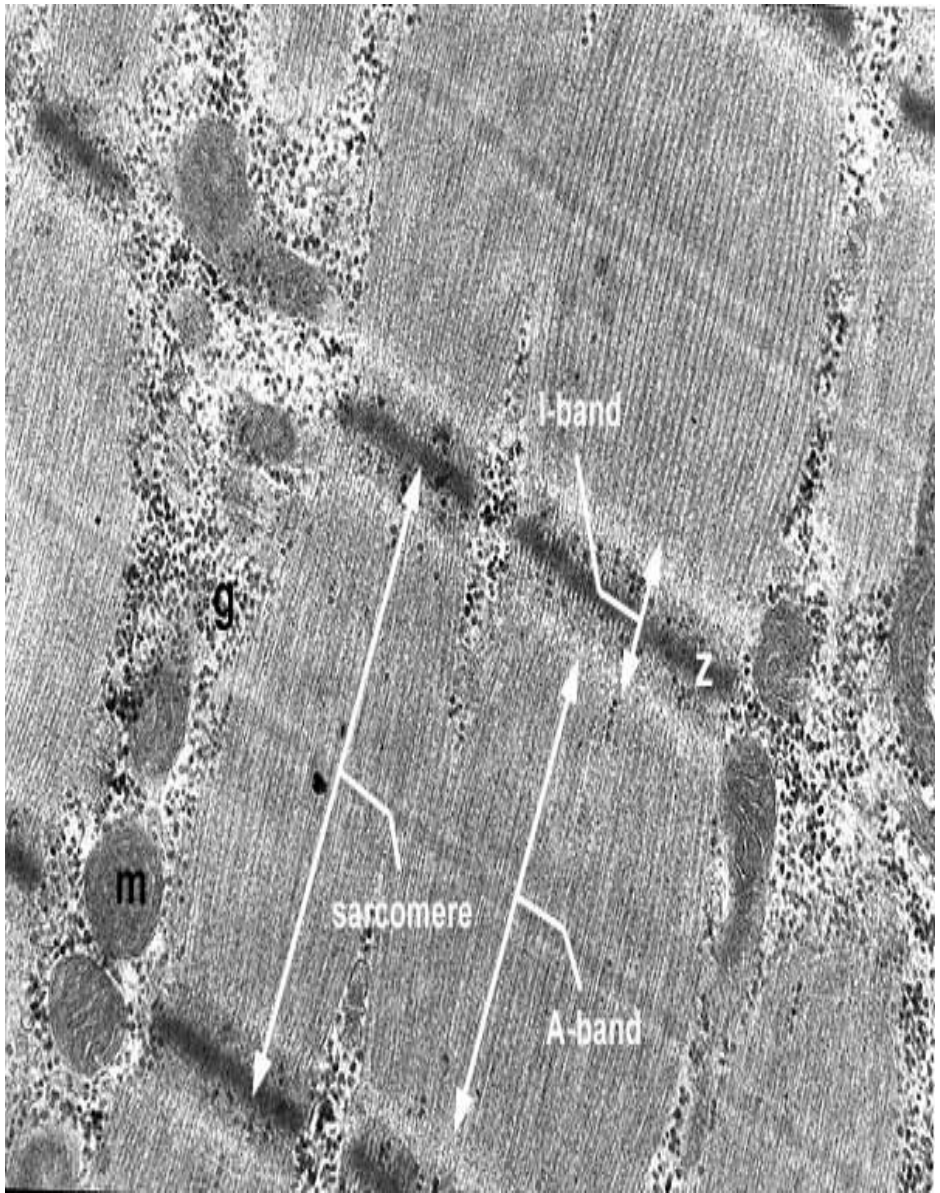

Z line
Thick filaments (myosin)
M line
Thin filaments (actin)
Z line
H-zone
½ I-band
A–band
I–band


Sarcolemma
A
Terminal cisternae
Transverse tubule
I
Sarcoplasmic reticulum
m
Mitochondria
Z
500 nm
Myofibrils
A band
I Band
Z line
Nucleus

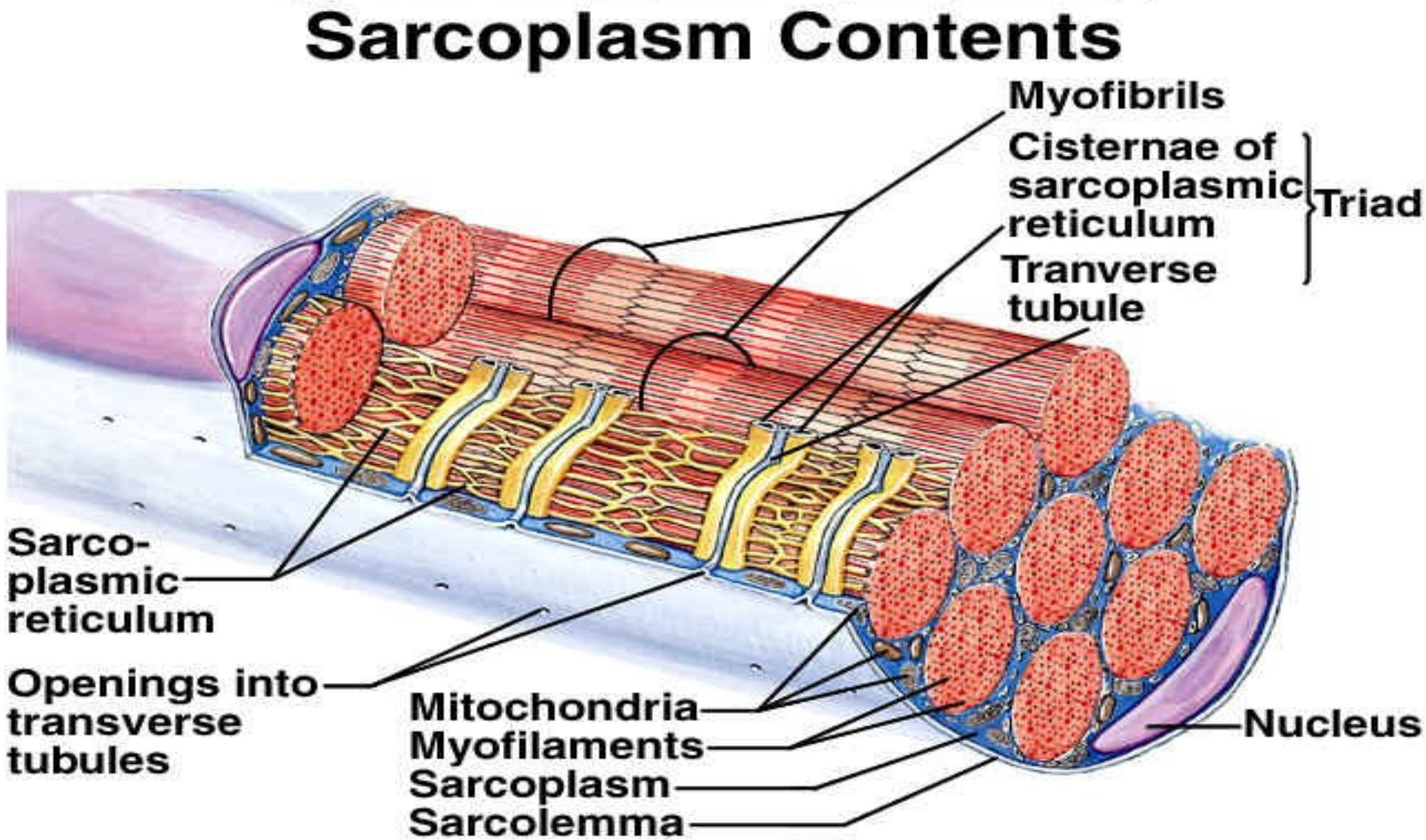
Skeletal muscle in EM



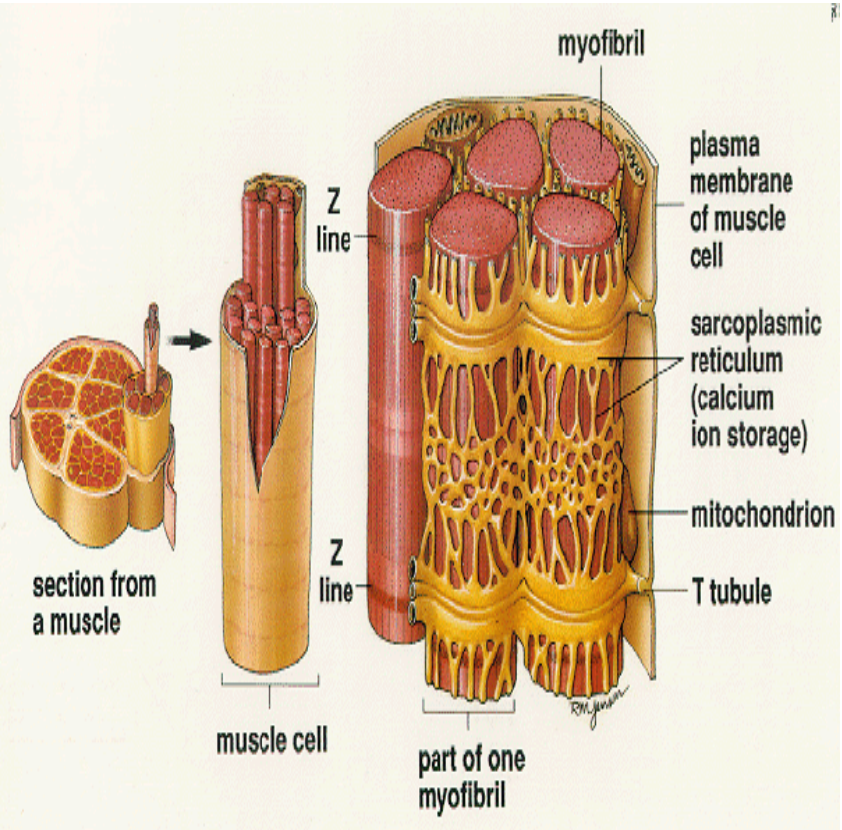


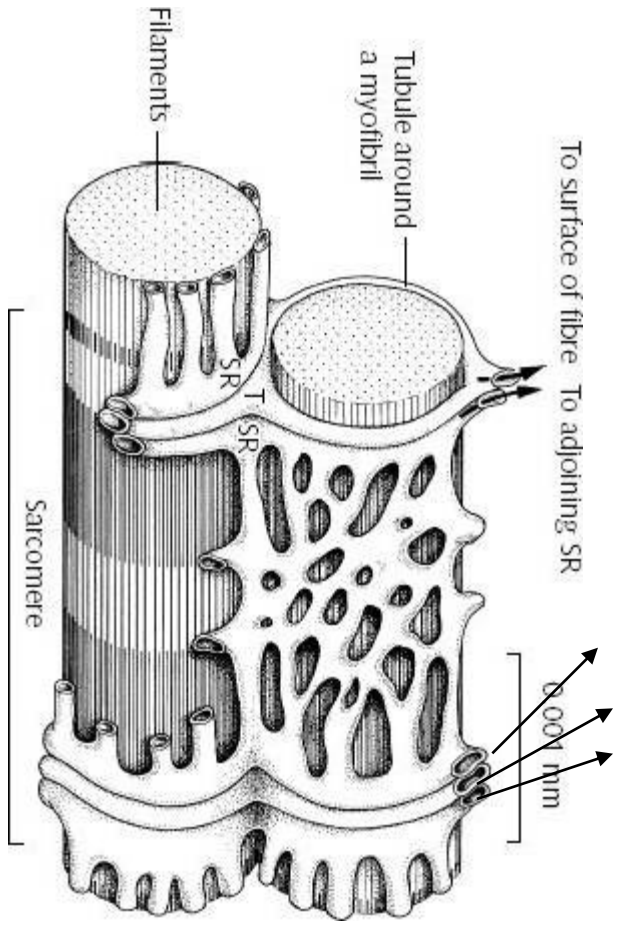


Rhabdomyocyte



Sarcoplasmic reticulum, t-tubule





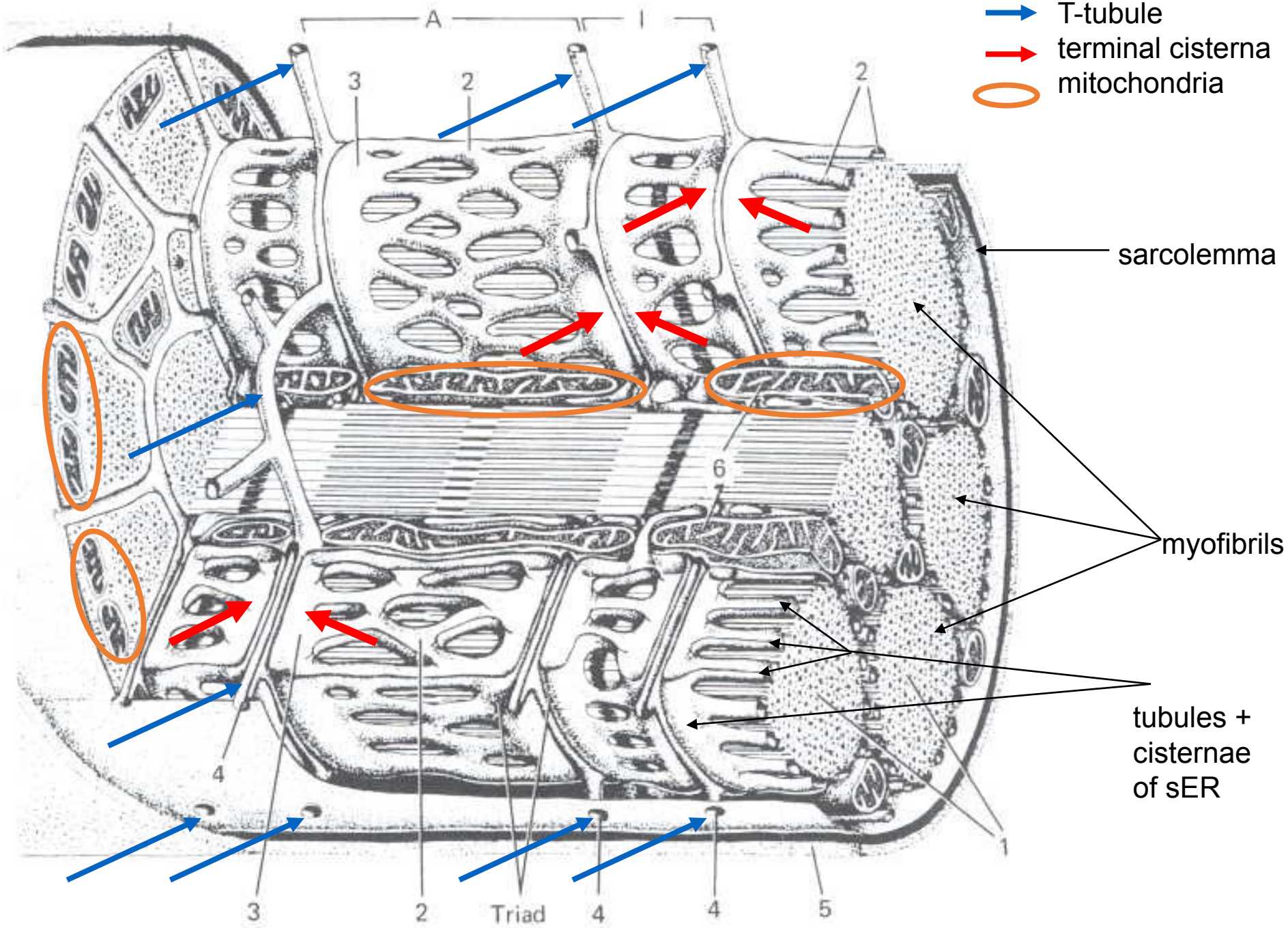
Forms transversal **terminal cisternae** and longitudinal tubules.

Function: reservoir of Ca ions

Terminal cisterna
T-tubule
Terminal cisterna

} **TRIAD**

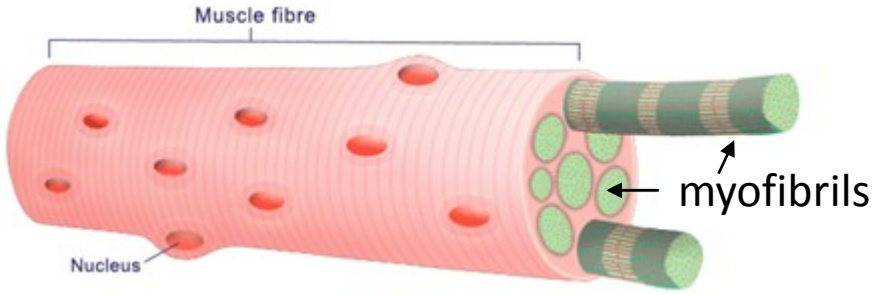
T-tubule is invagination of sarcoplasm and leads action potential to terminal cisternae (they change permeability of membrane for Ca ions)

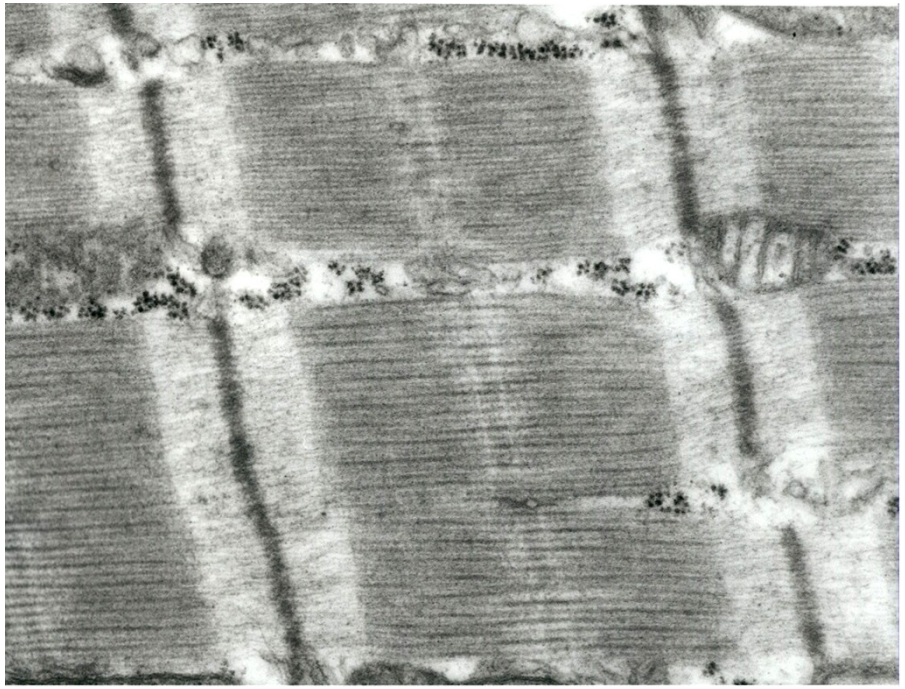

T-tubule
terminal cisterna
mitochondria
A
I
3
2
2
sarcolemma
6
myofibrils
tubules +
cisternae
of sER
4
3
2
Triad
4
4
5
1

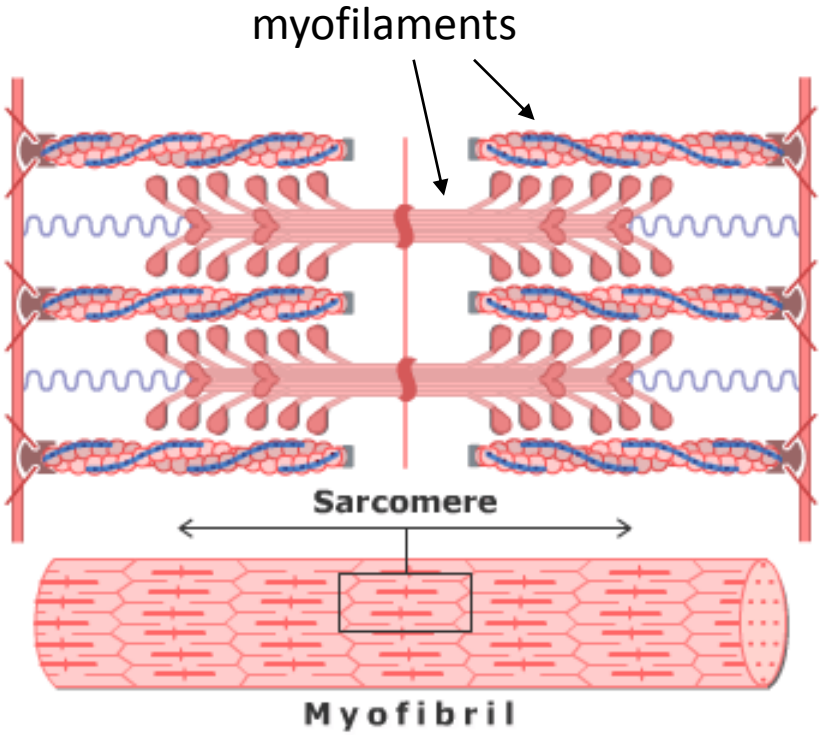
Mechanism of contraction

- Propagation of action potential (depolarization) via T-tubule (= invagination of sarcolemma)
- Change of terminal cisternae permeability – releasing of Ca^{+} ions increases their concentration in sarcoplasm
- Myosin contacts actin and sarcomera shortens by sliding movement – contraction
- Relaxation: repolarization, decreasing of Ca^{2+} ions concentration, inactivation of binding sites of actin for myosin

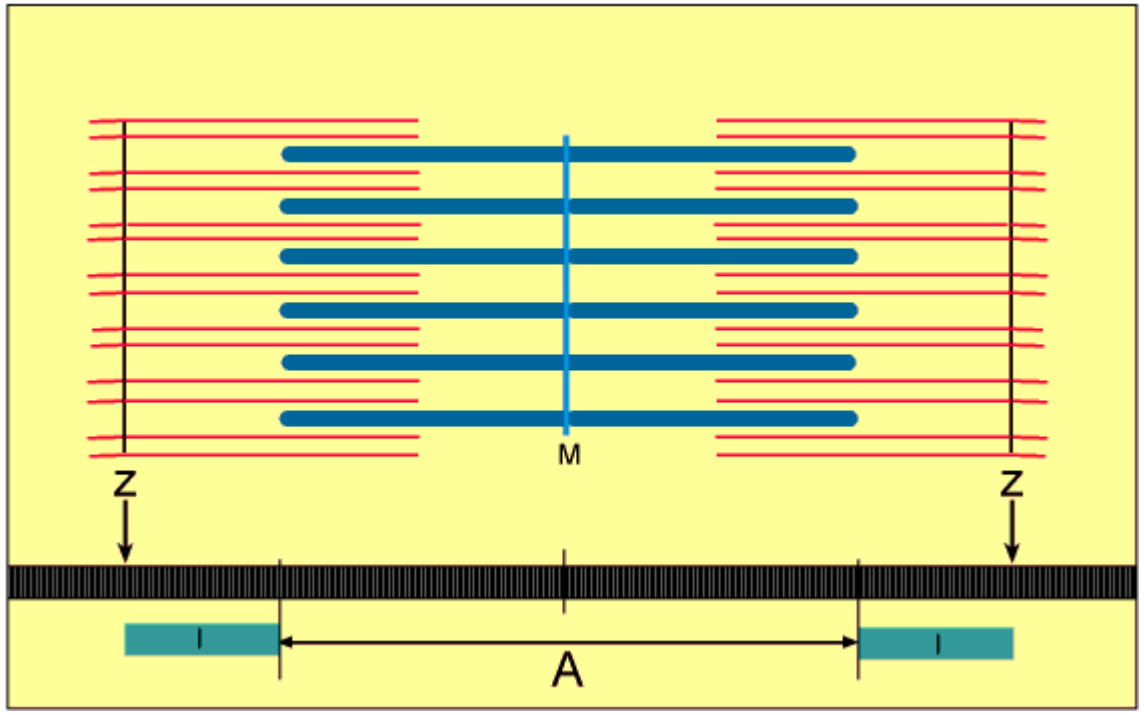
Rhabdomyocyte



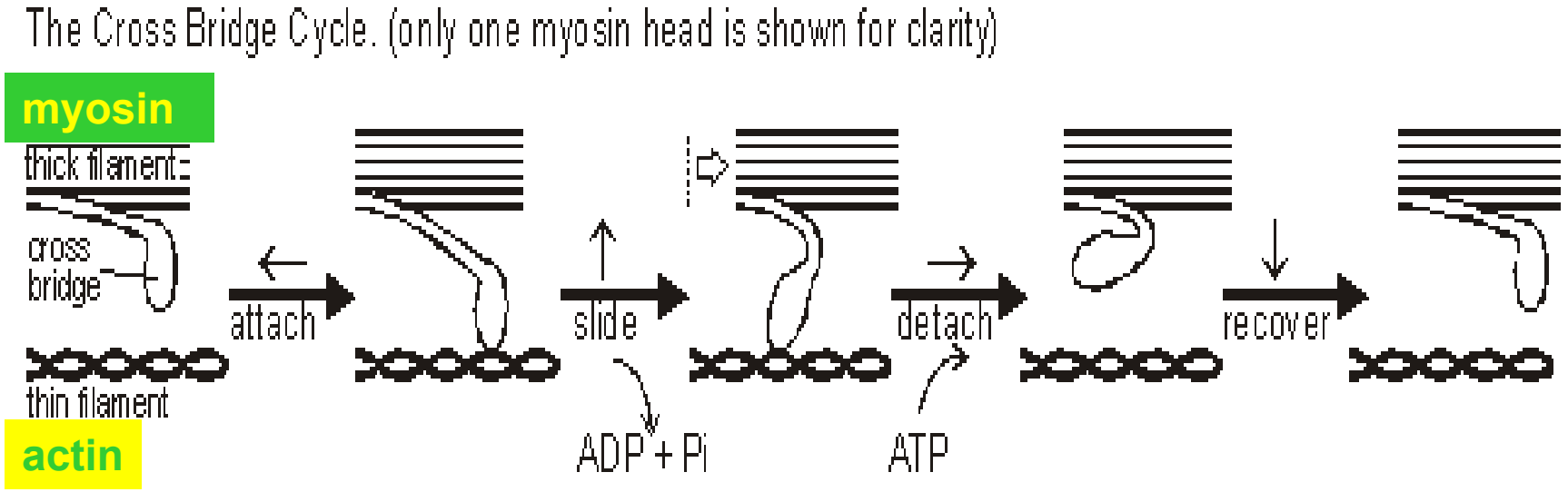


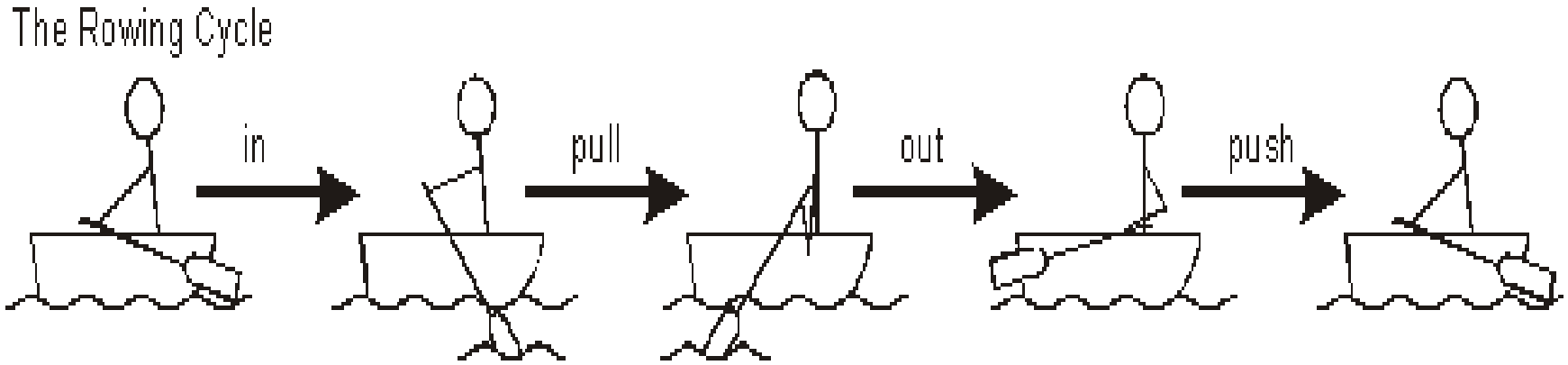


Rhabdomyocyte

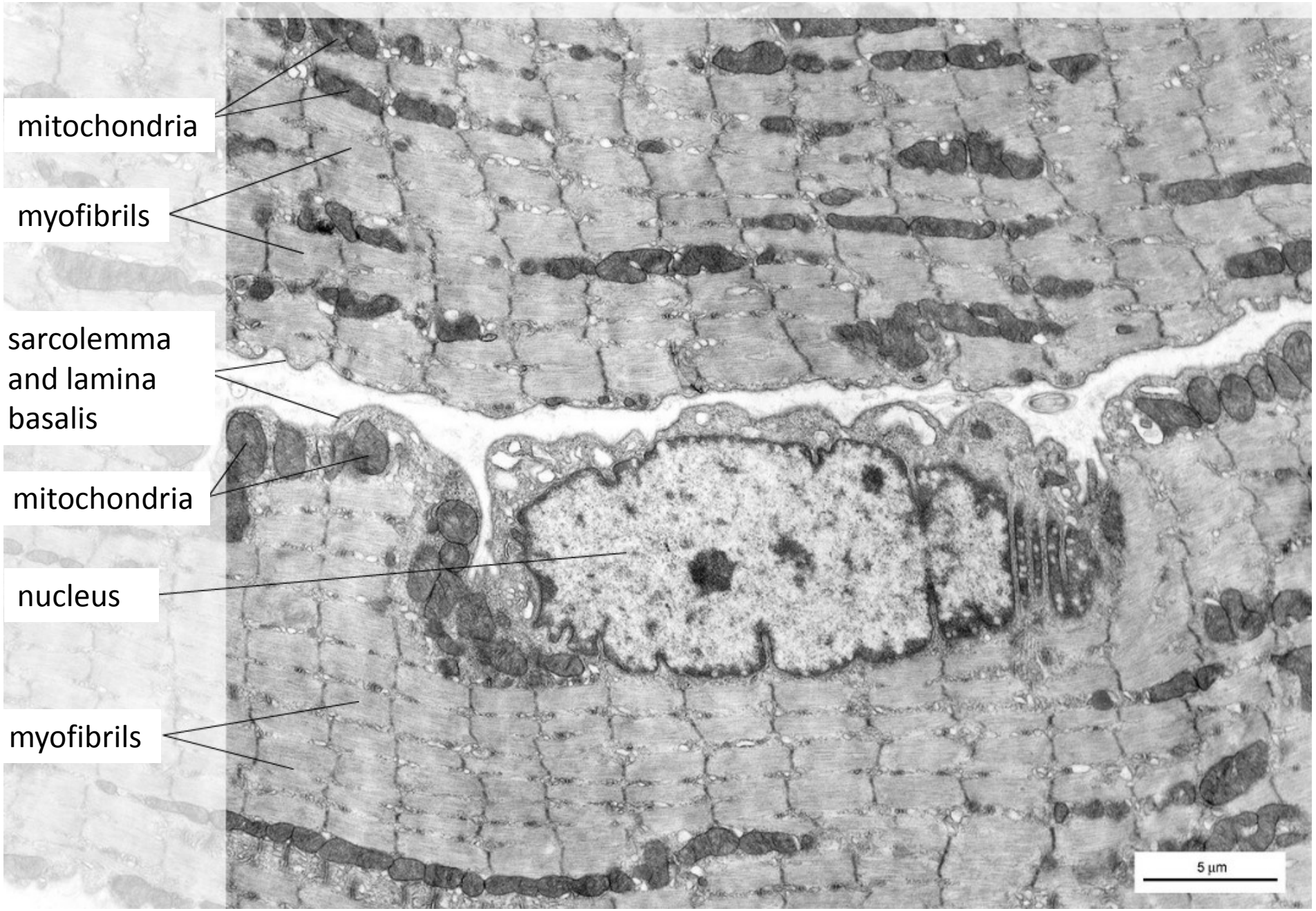


Mechanism of contraction: sliding of myofilaments

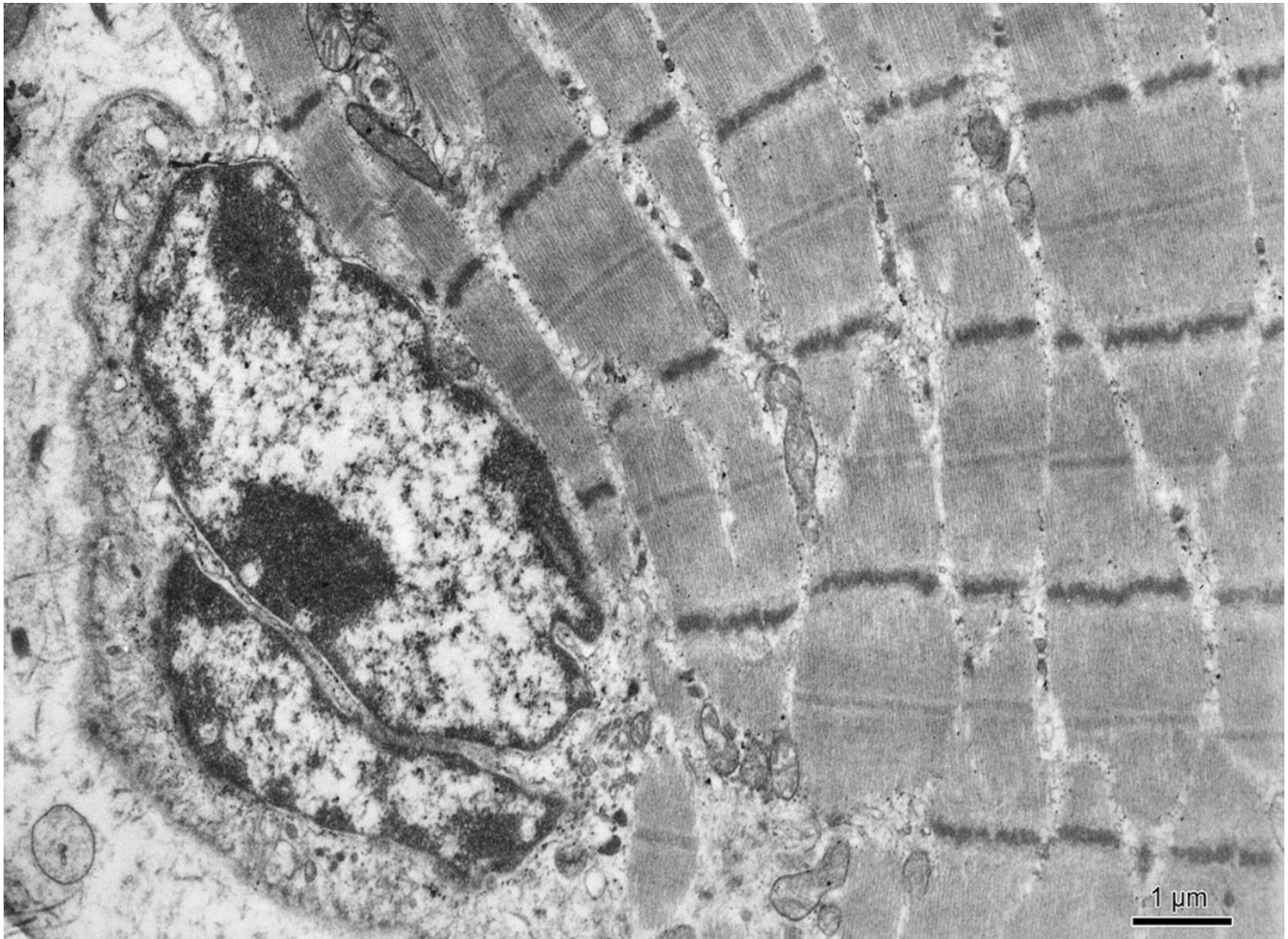




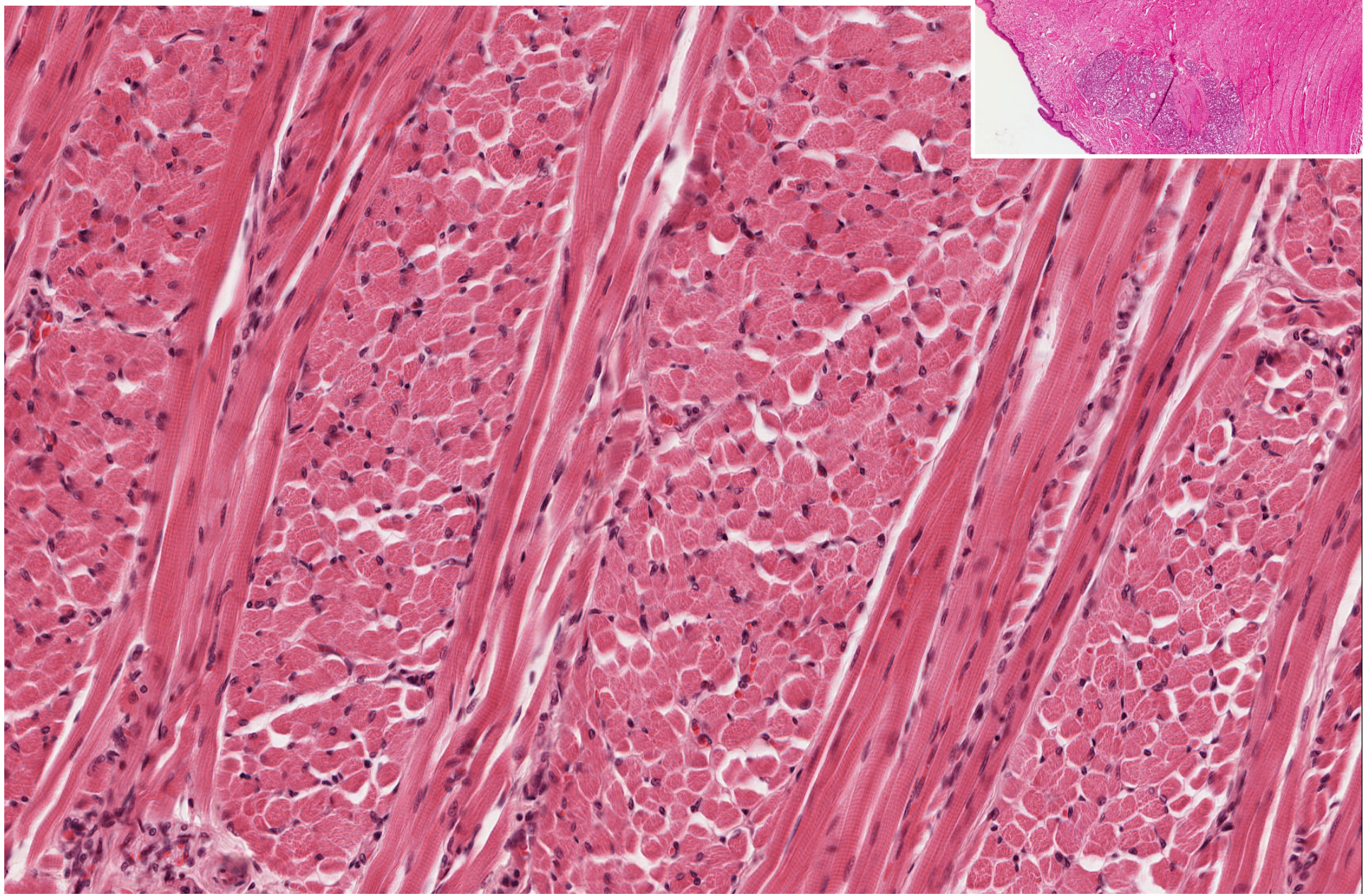
Rhabdomyocytes – oculomotor muscles of rat (TEM)



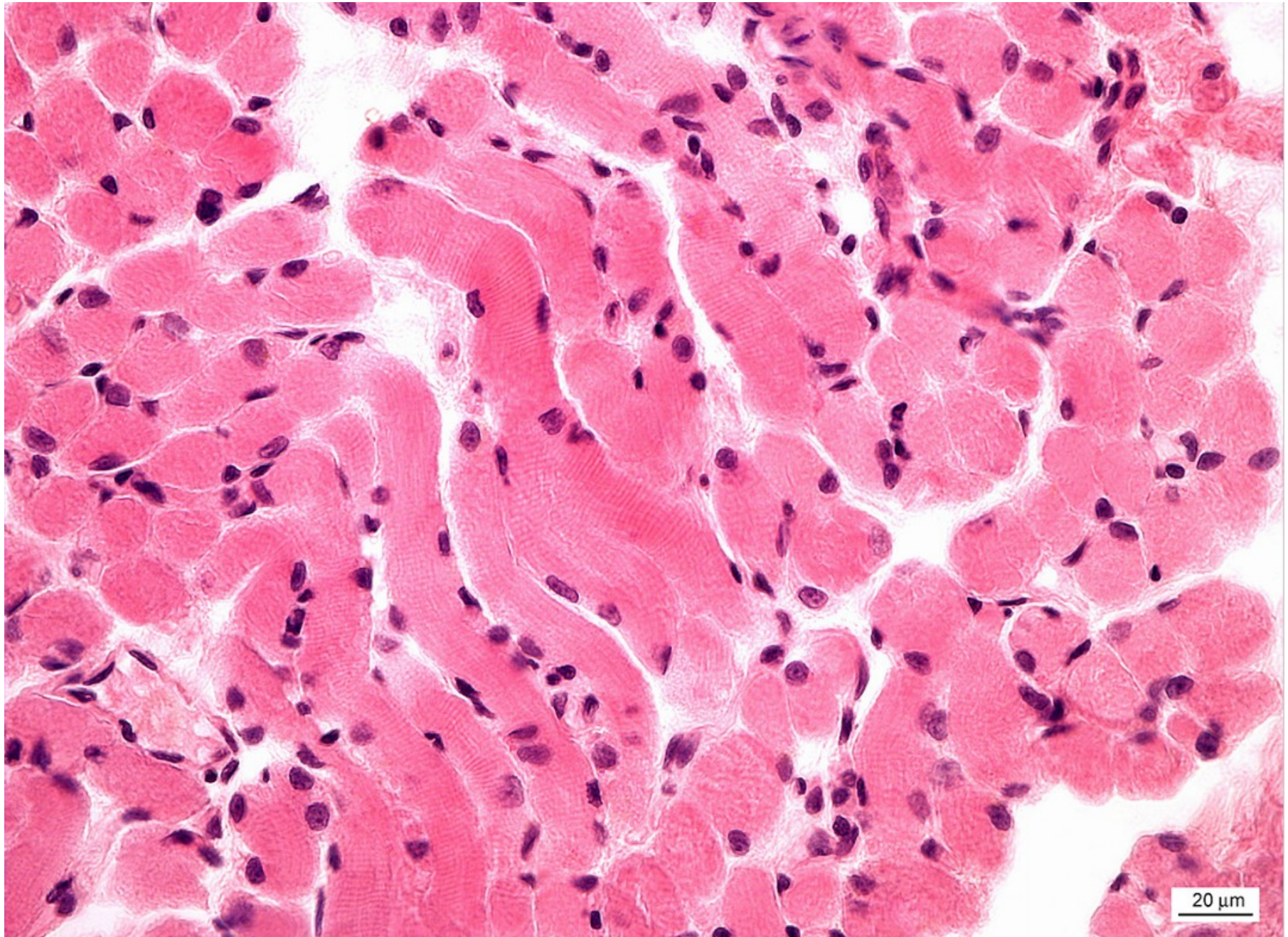
Rhabdomyocyte (TEM)



Skeletal muscle tissue – Apex linguae

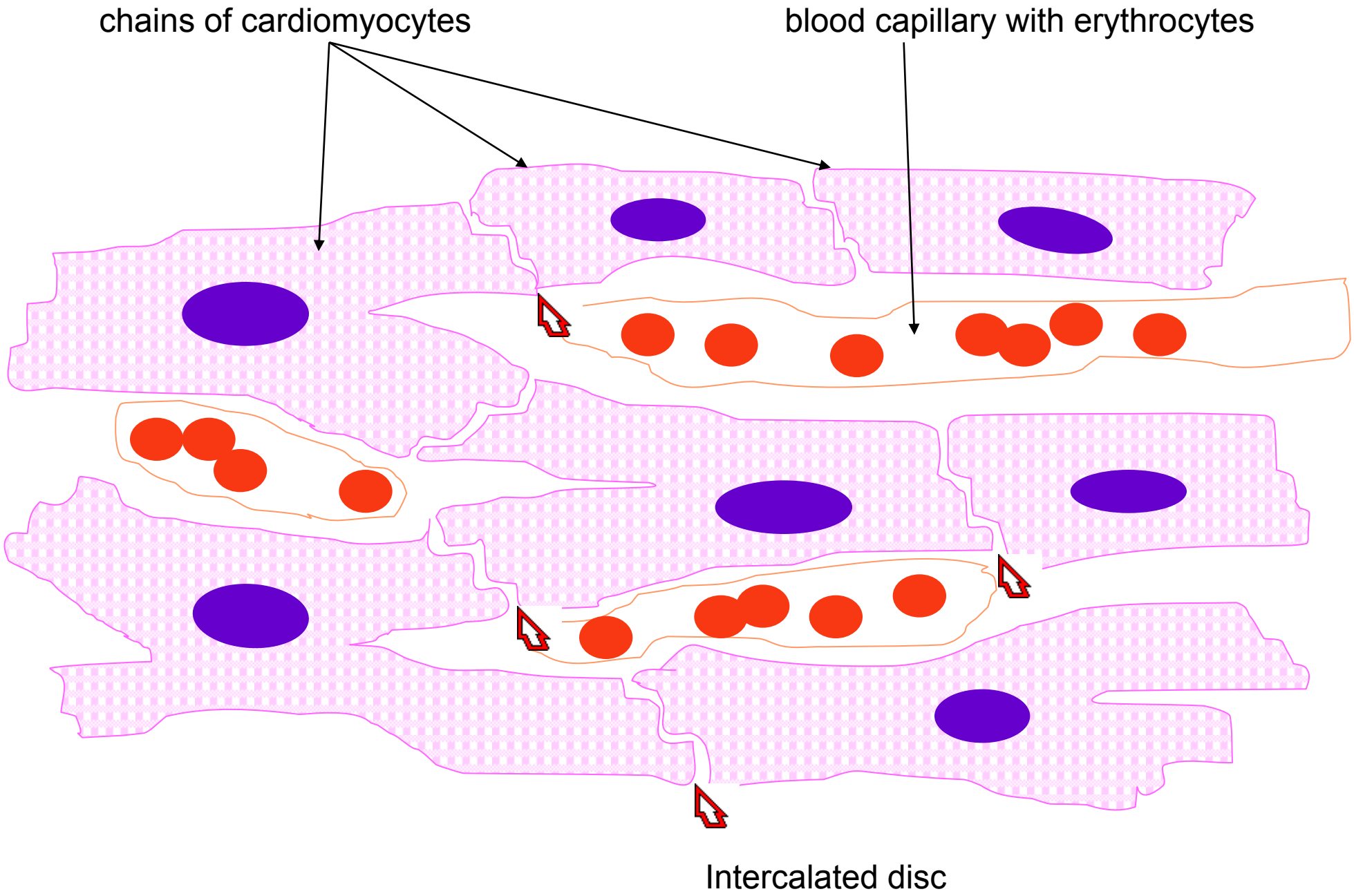


Skeletal muscle tissue (striated)



Cardiac muscle - myocardium

- is made up of long branched fibers, composed of cells – **cardiomyocytes**,
- cardiomyocytes are cylindrical cells, which can be branched on one or both ends (Y, X shaped cells),
- Sarkoplasm: 1 nucleus in the center of cell, striated myofibrils, numerous mitochondria,
- cells are attached to one another by end-to-end junctions – intercalated discs.


chains of cardiomyocytes
blood capillary with erythrocytes
Intercalated disc

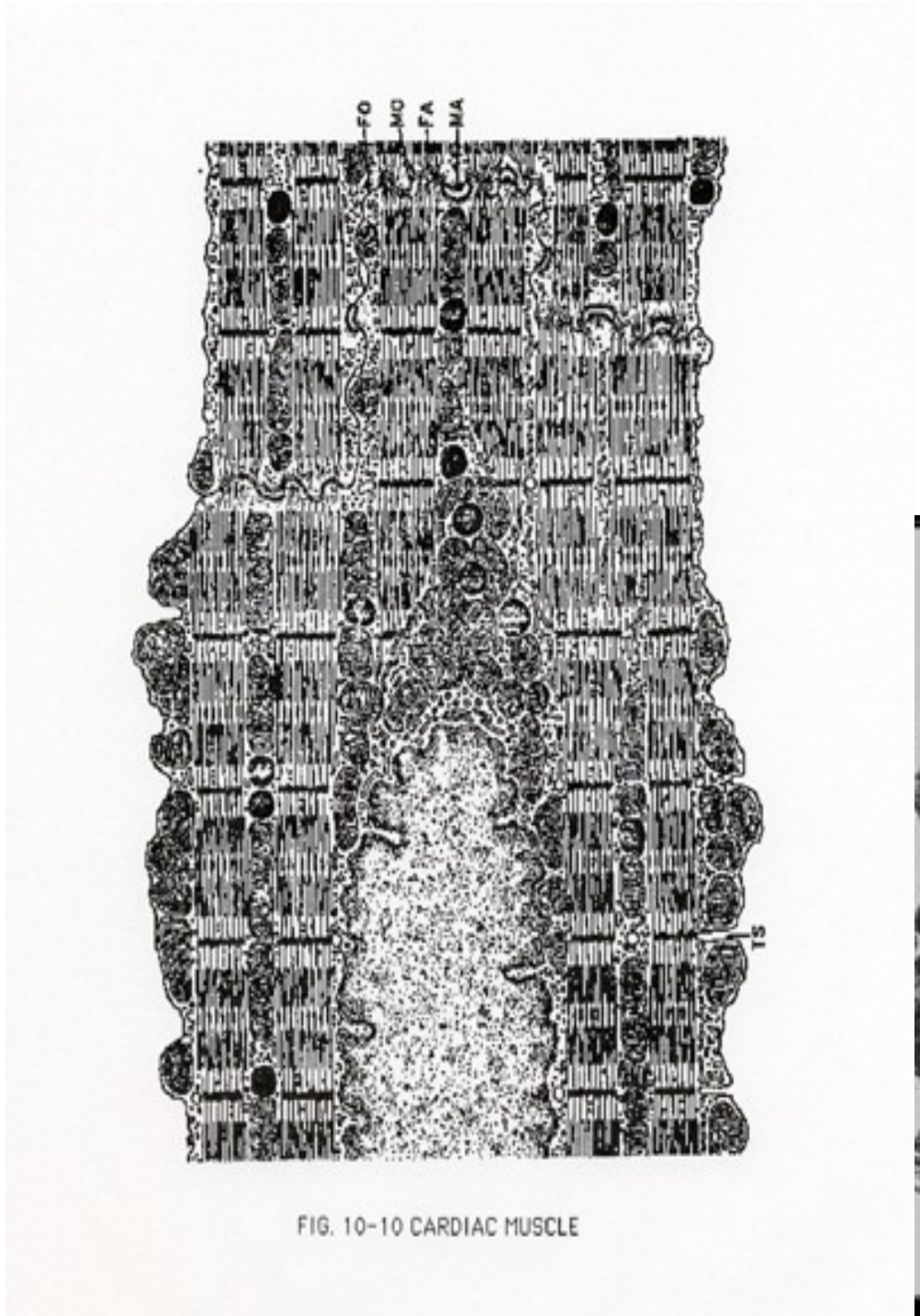
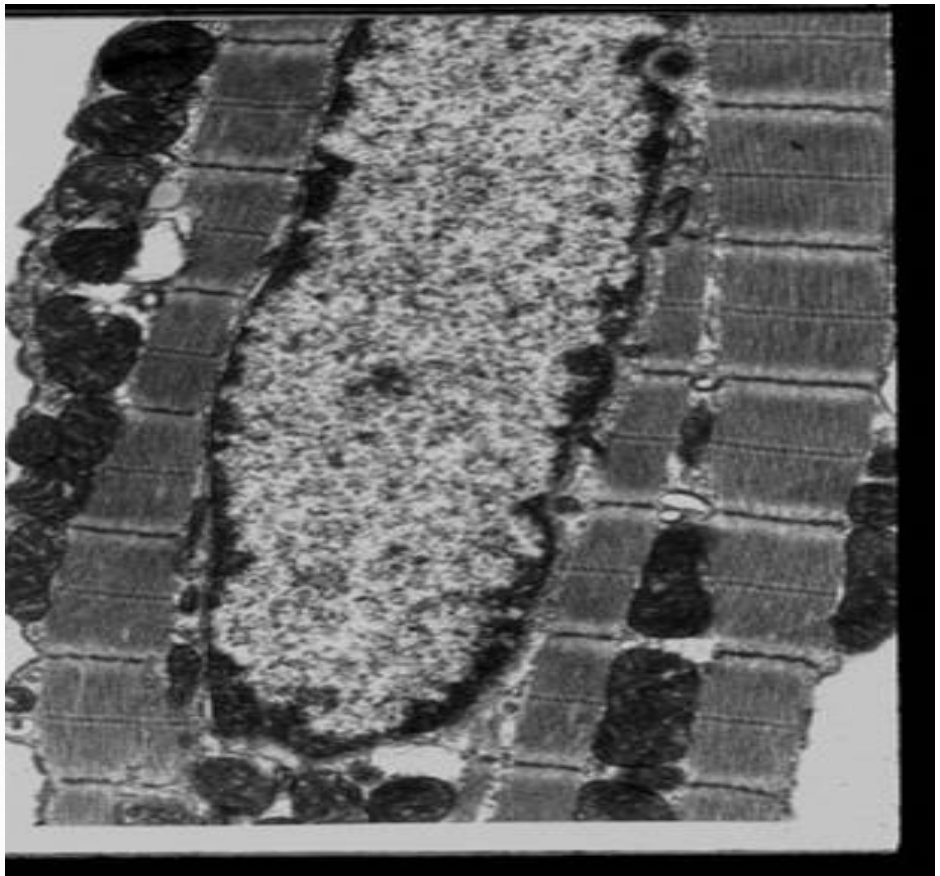
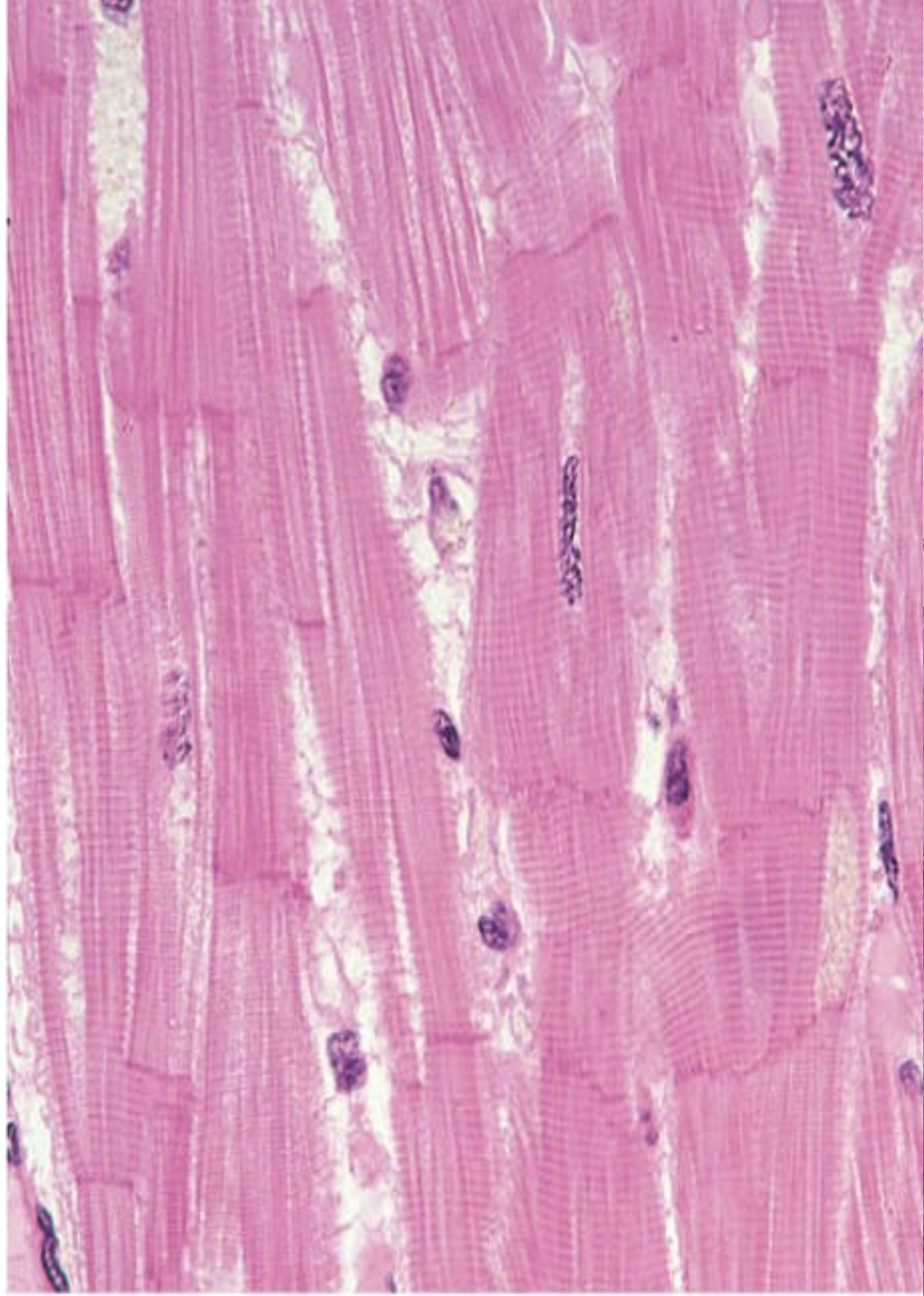
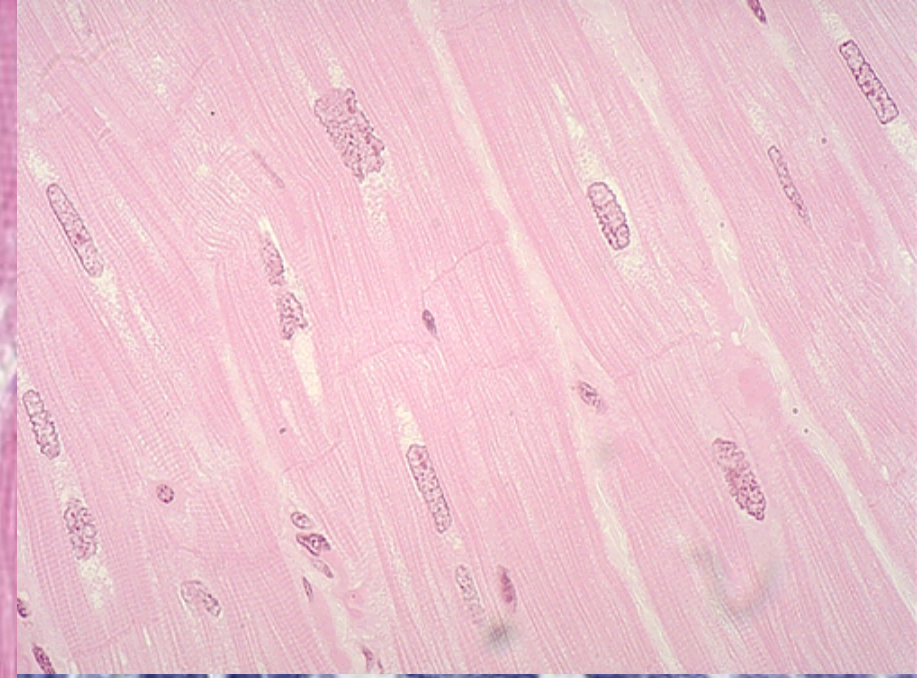


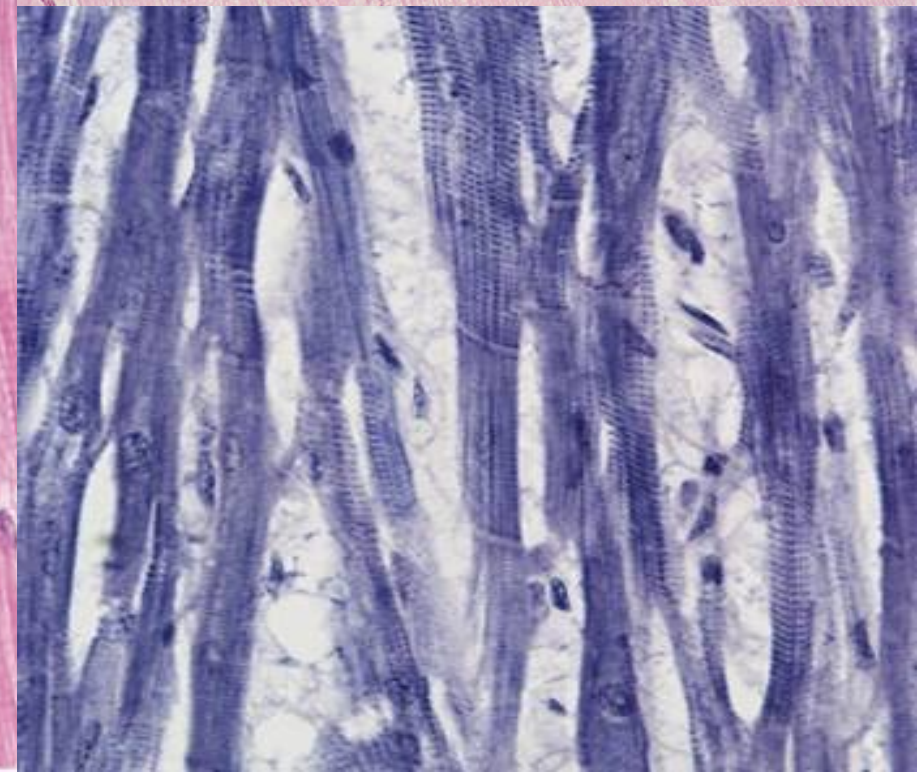
FIG. 10-10 CARDIAC MUSCLE

Schema and electron graph
of a part of cardiomyocyte









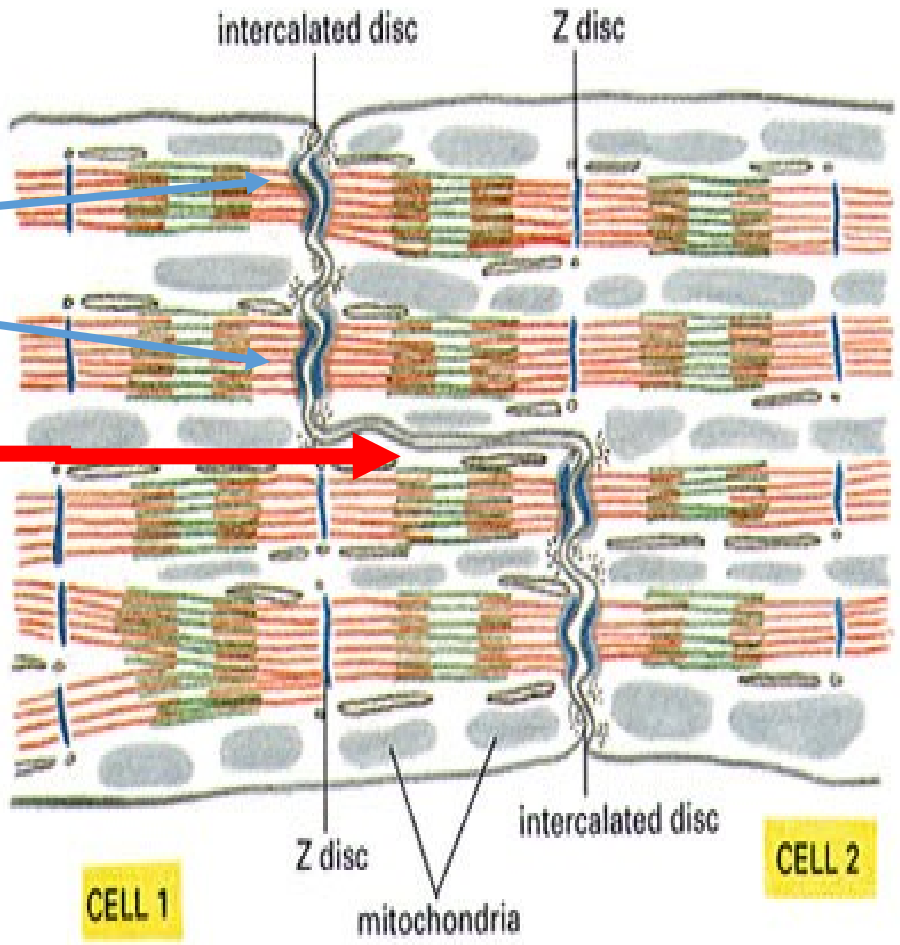
DIFFERENCES BETWEEN CARDIAC AND SKELETAL MUSCLE TISSUES

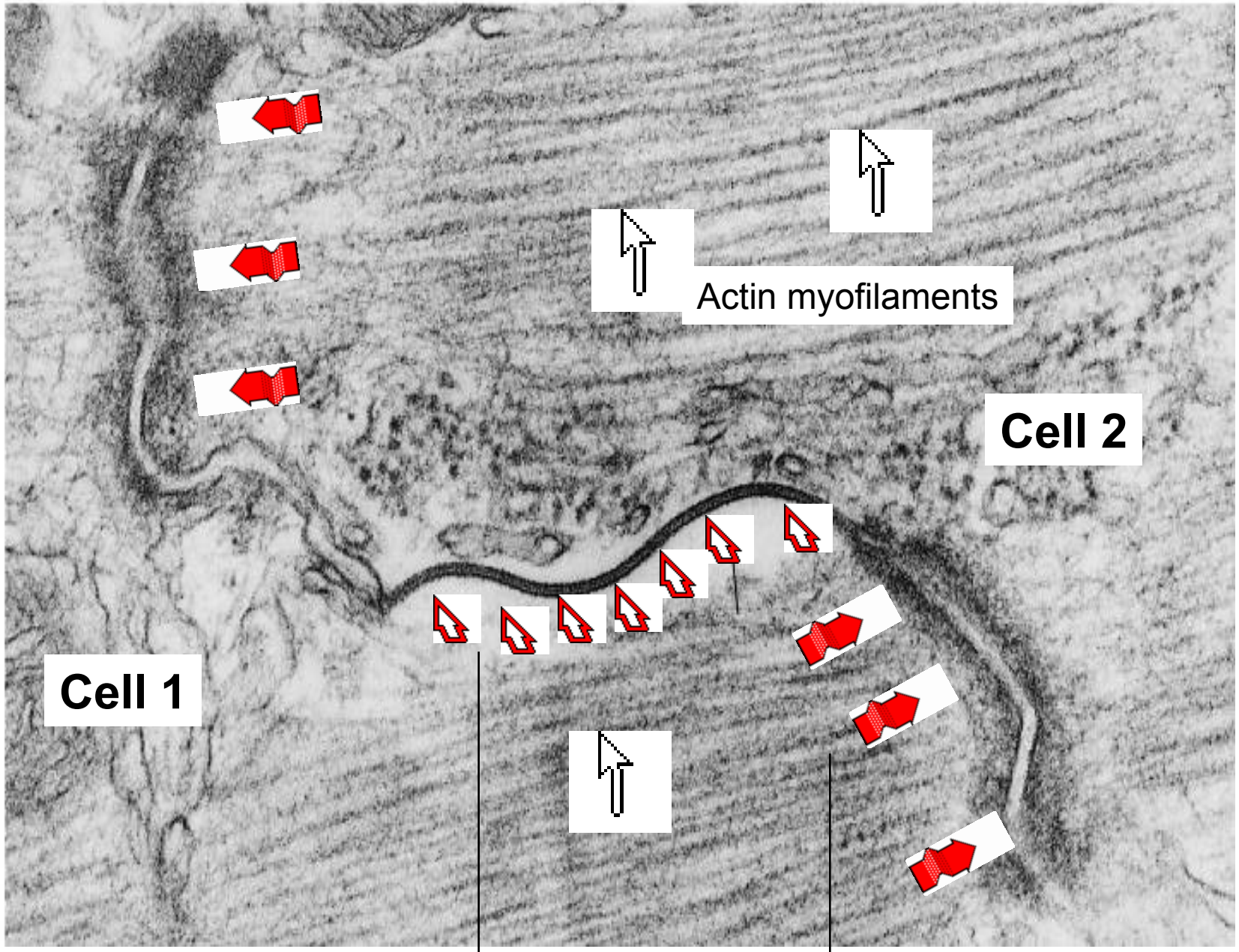
- there are no triads, but diads: 1 t-tubule + 1 cisterna
- t-tubules encircle the sarcomeres at the Z lines rather than at the zone of overlap.
- sarcoplasmic reticulum via its tubules contact sarcolemma as well as the t-tubules
- cardiac muscle cells are totally dependent on aerobic metabolism to obtain the energy needed to continue contracting. The sarcoplasm thus contains large numbers of mitochondria and abundant reserves of myoglobin (to store oxygen). Energy reserves are maintained in the form of glycogen and lipid inclusions.

Cardiac muscle

Intercaleted disc :

- „scalariform“ shape of cell ends
- fasciae adherentes (*adhesion of cells*)
- Nexus (quick intercellular communication – transport of ions, electric impulses, informations)

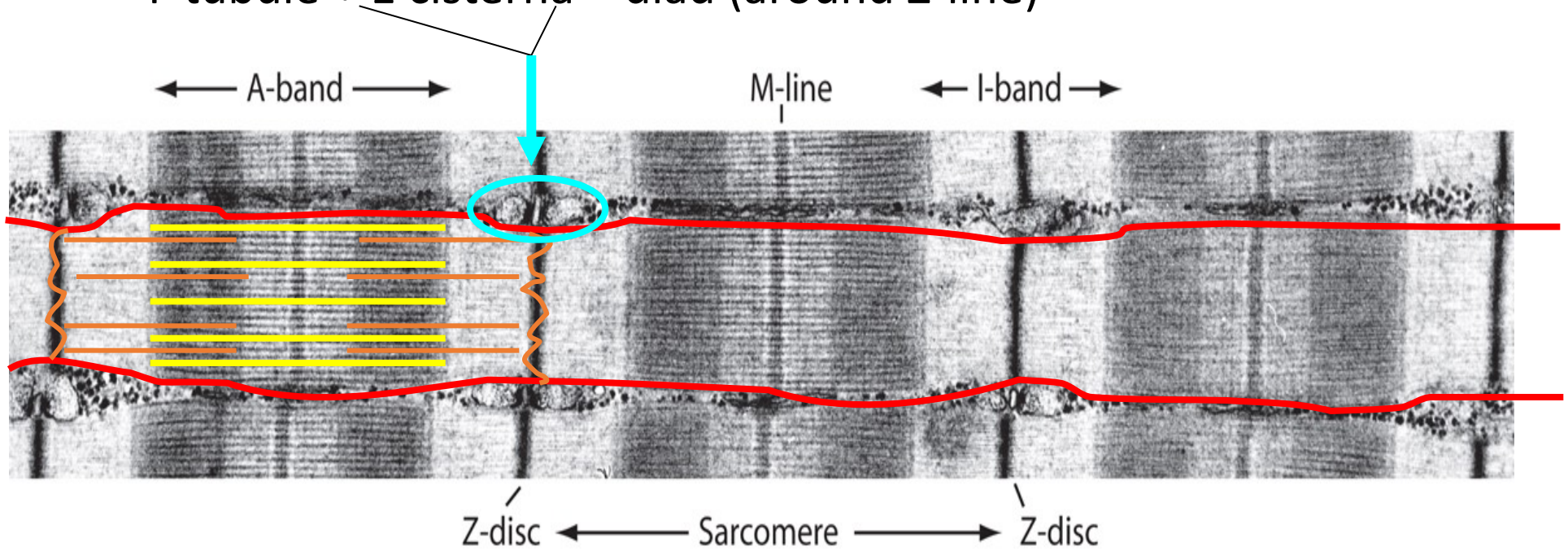


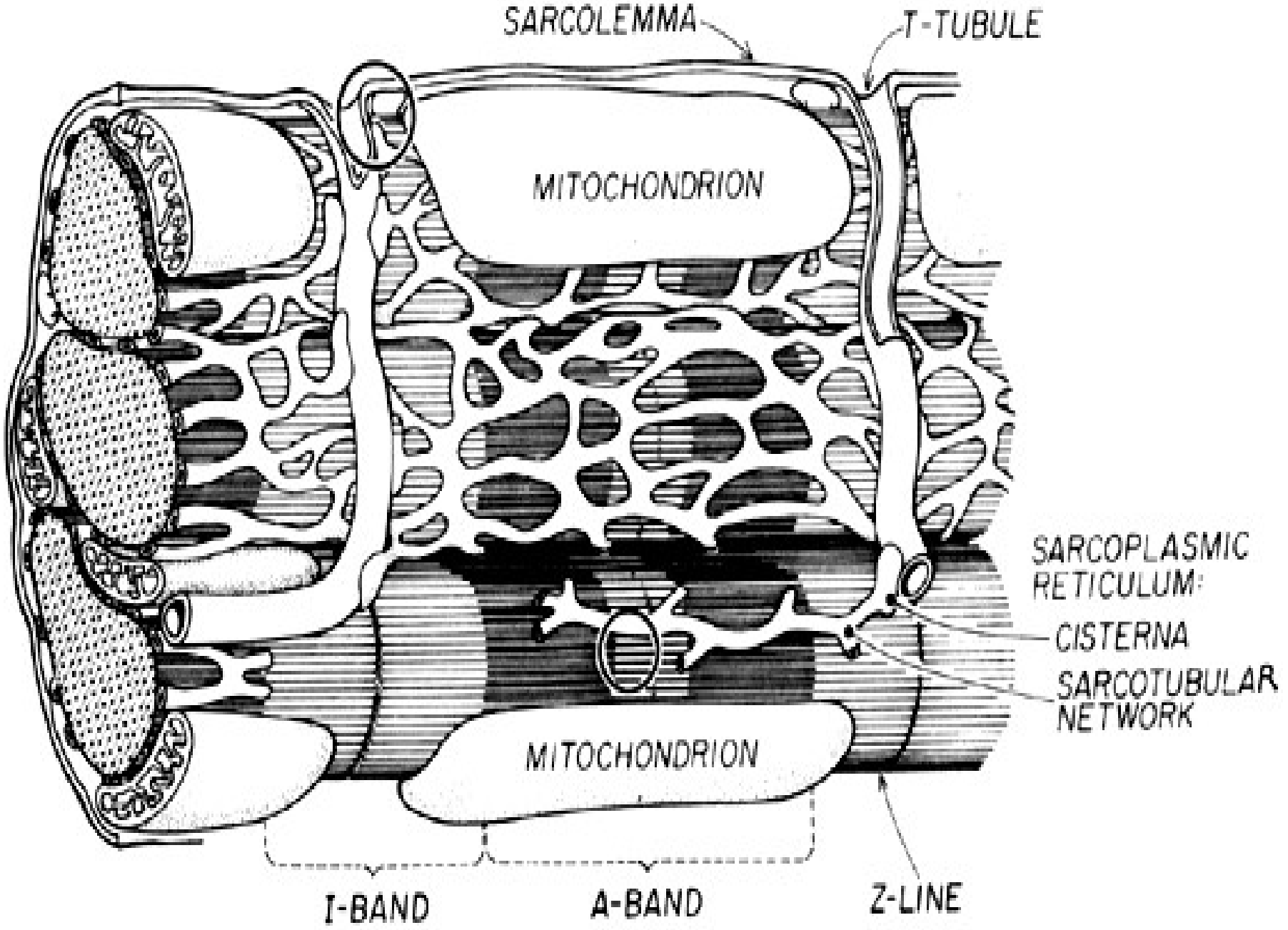


Intercalated disc: nexus fascia adherens

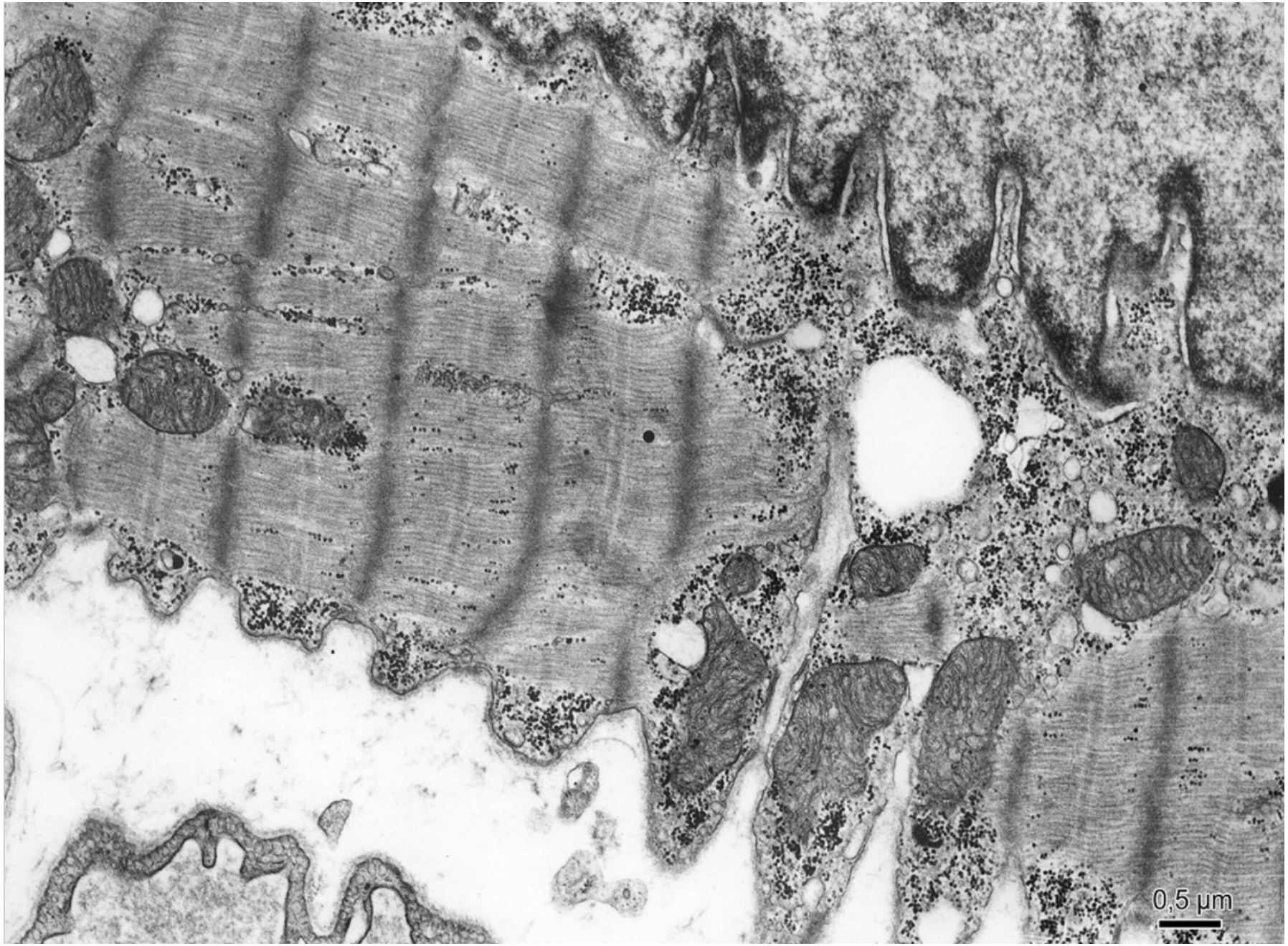
Myofibril of cardiomyocyte

- Actin + myosin myofilaments
- Sarcomere
- Z-line
- M-line and H-zone
- I-band, A-band
- T-tubule + 1 cisterna = diad (around Z-line)

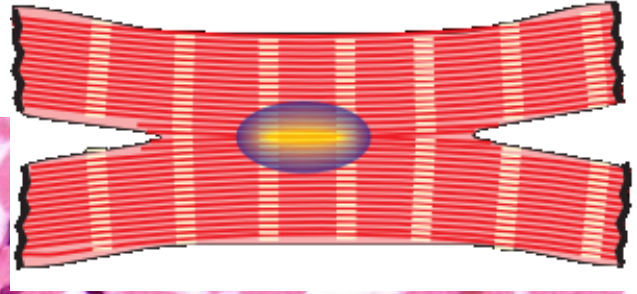



SARCOLEMMA
T-TUBULE
MITOCHONDRION
SARCOPLASMIC RETICULUM:
CISTERNA
SARCOTUBULAR NETWORK
MITOCHONDRION
I-BAND
A-BAND
Z-LINE

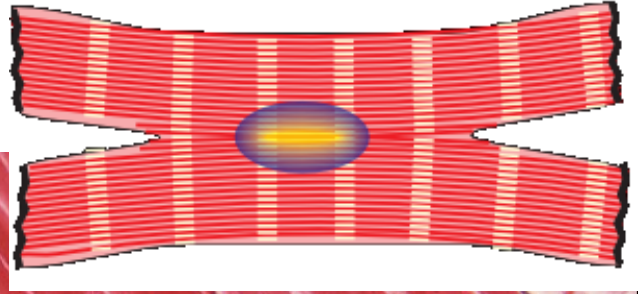
Cardiomyocyte (TEM)

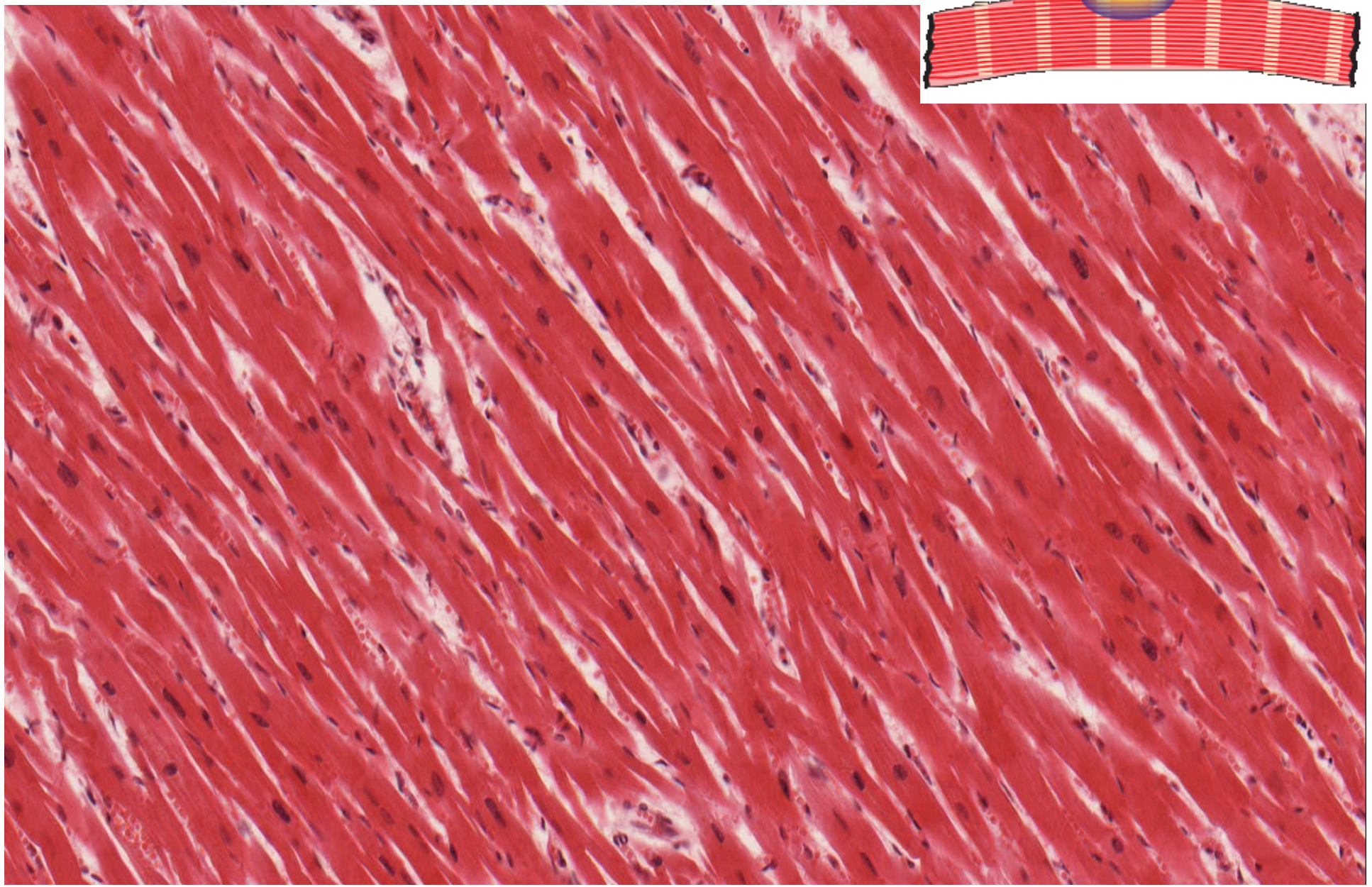


Cardiac muscle tissue (HE) – cross section

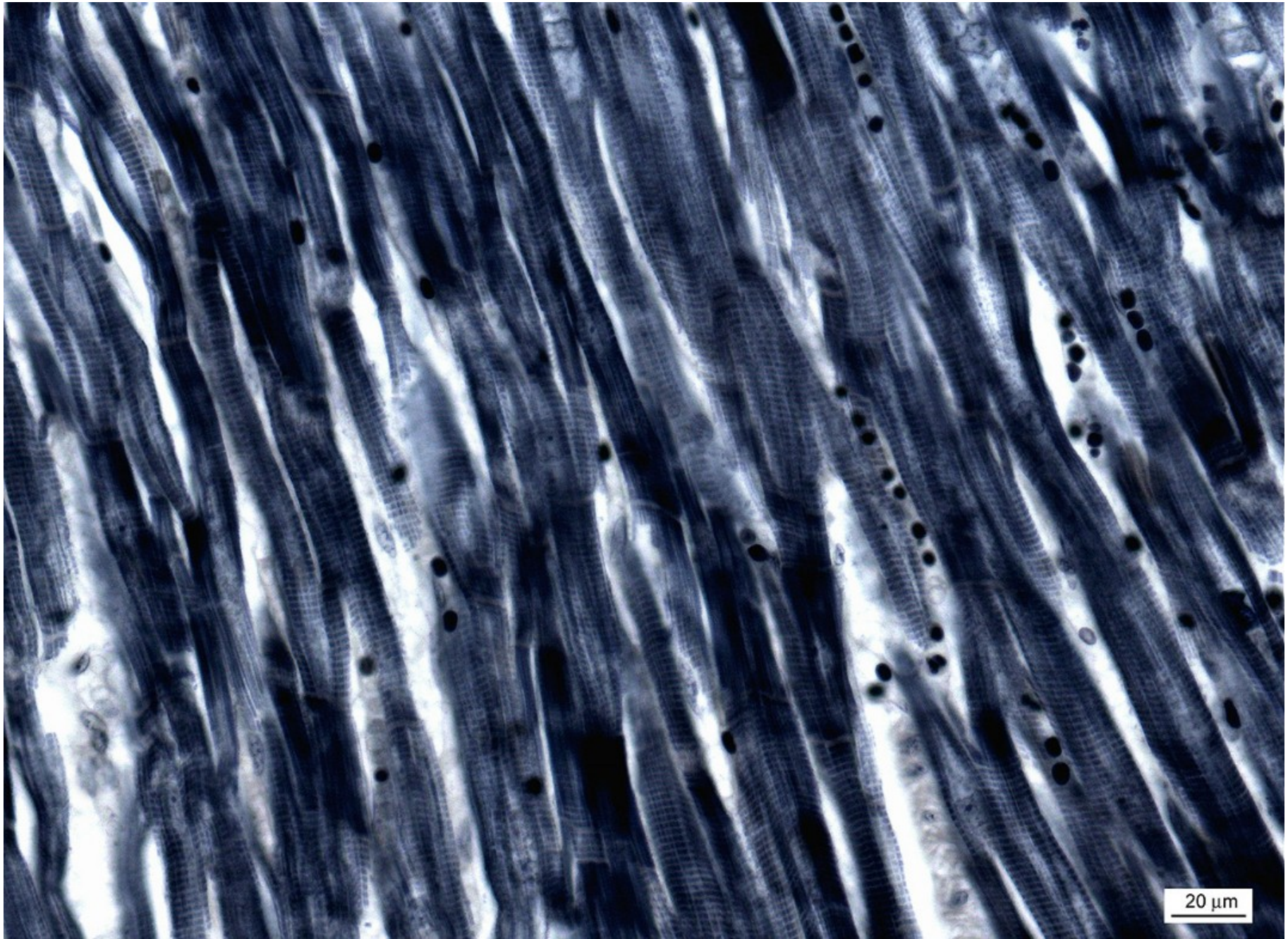


Cardiac muscle tissue (HE) – longitudinal section



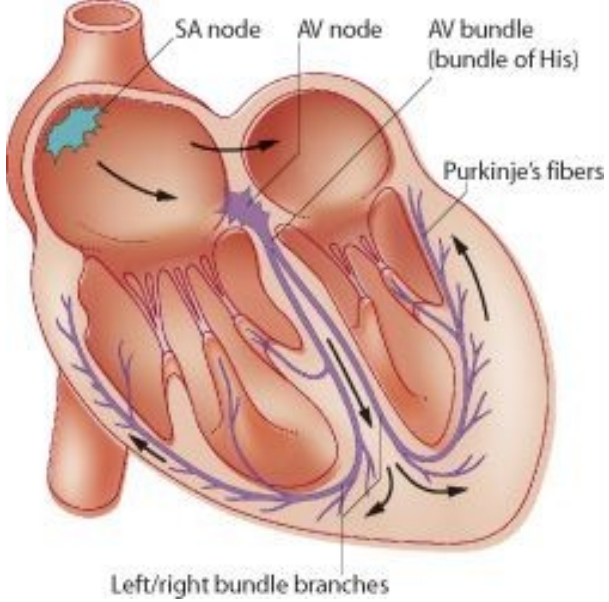


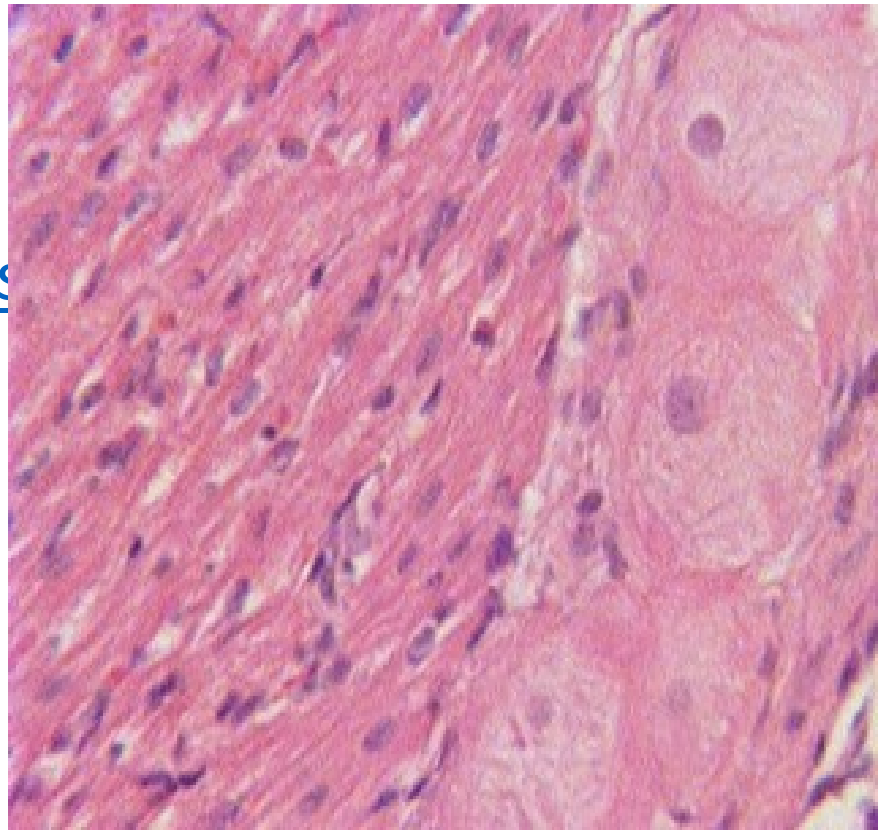
Cardiac muscle tissue (Heidenhein)



Purkinje fibers

- are located in the inner layer of heart ventricle wall
- are specialized cells fibers that conduct an electrical stimuli or impulses that enables the heart to contract in a coordinated fashion
- numerous sodium ion channels and mitochondria, fewer myofibrils





Smooth muscle cells

- spindle shaped cells (leiomyocytes) with myofilaments not arranged into myofibrils (no striation), 1 nucleus in the centre of the cell
- myofilaments form bands throughout the cell
- actin filaments attach to the sarcolemma by focal adhesions or to the dense bodies substituing Z-lines in sarcoplasm
- calmodulin
- sarcoplasmic reticulum forms only tubules, Ca ions are transported to the cell via pinocytic vesicles
- zonulae occludentes and nexuses connect cells

Leiomyocyte

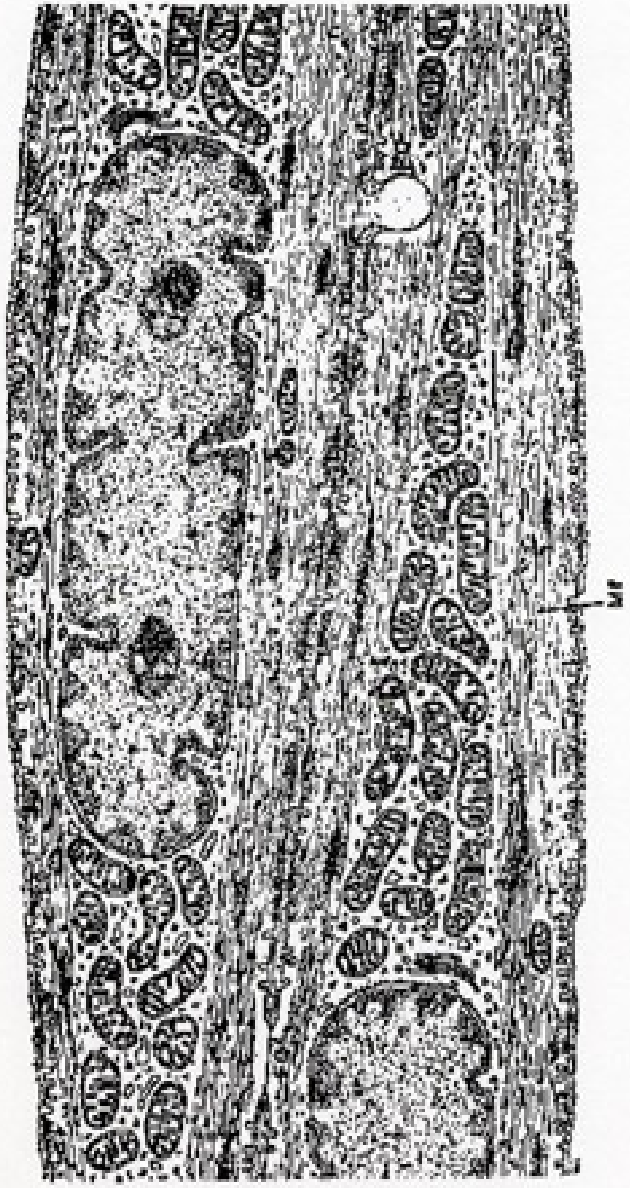
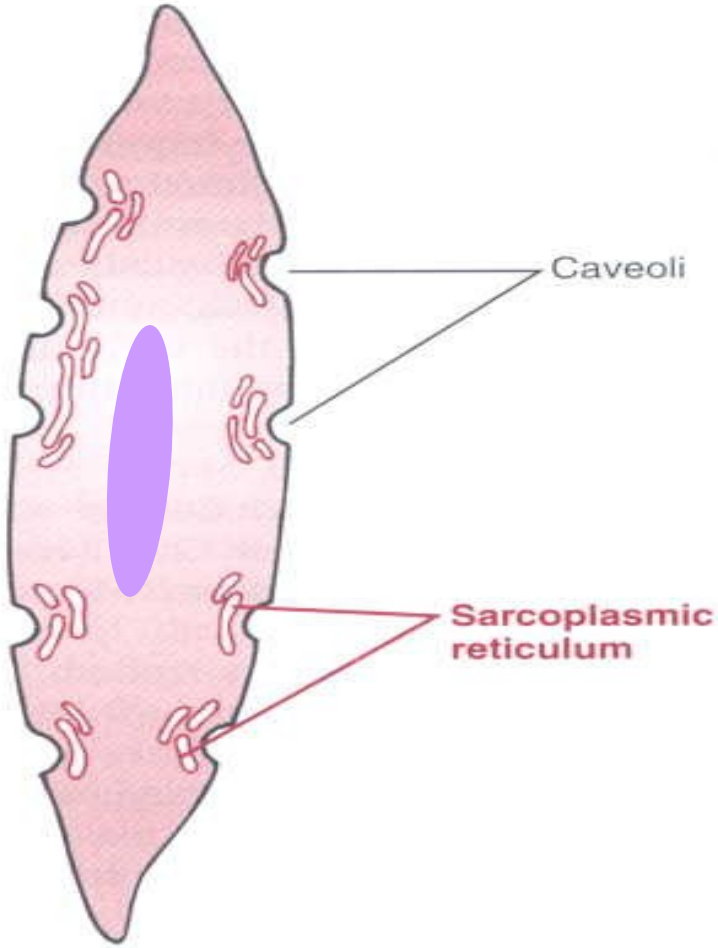
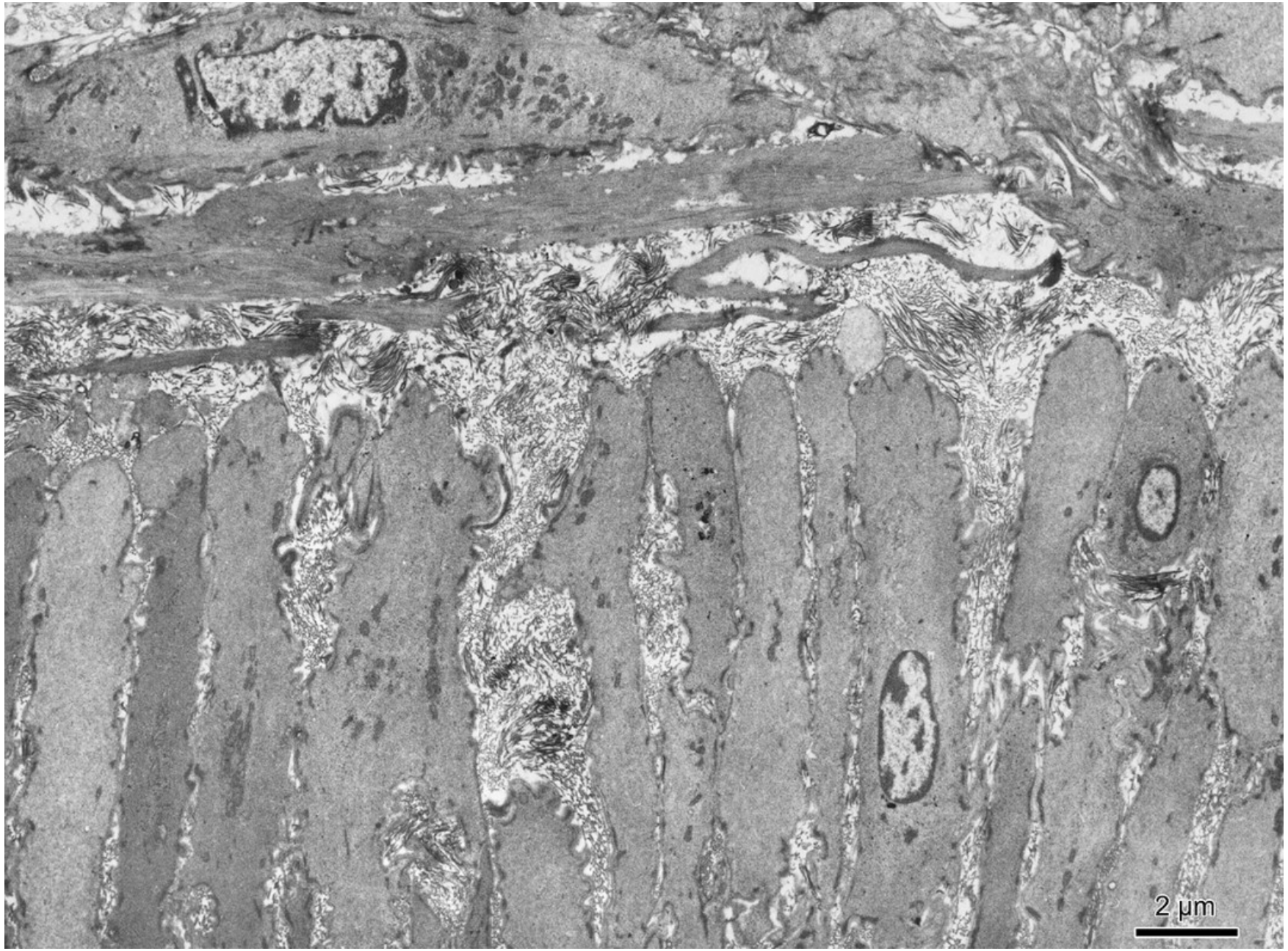


FIG. 10-2 E/M OF SMOOTH MUSCLE

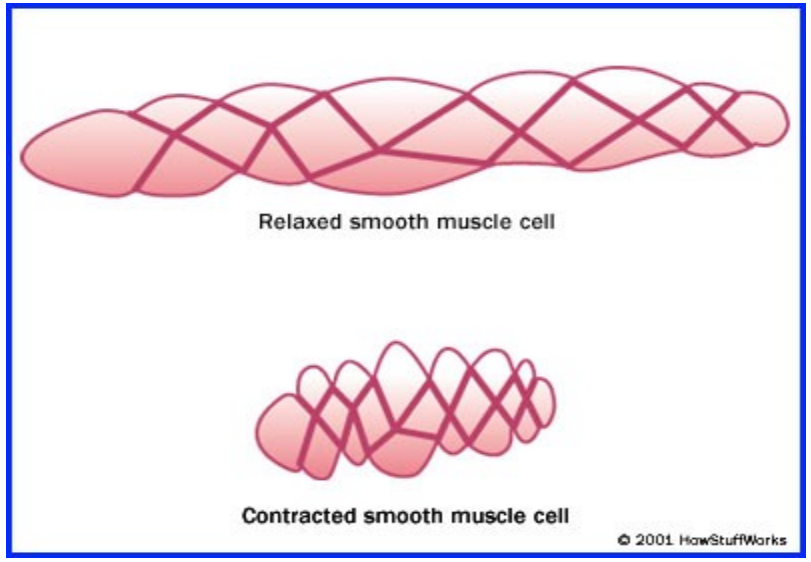
Caveolae are equivalent to t-tubule and in their membrane ions channel are present to bring Ca needed fo Contraction.
Caveolae are in contact with sarcoplasmic reticulum.

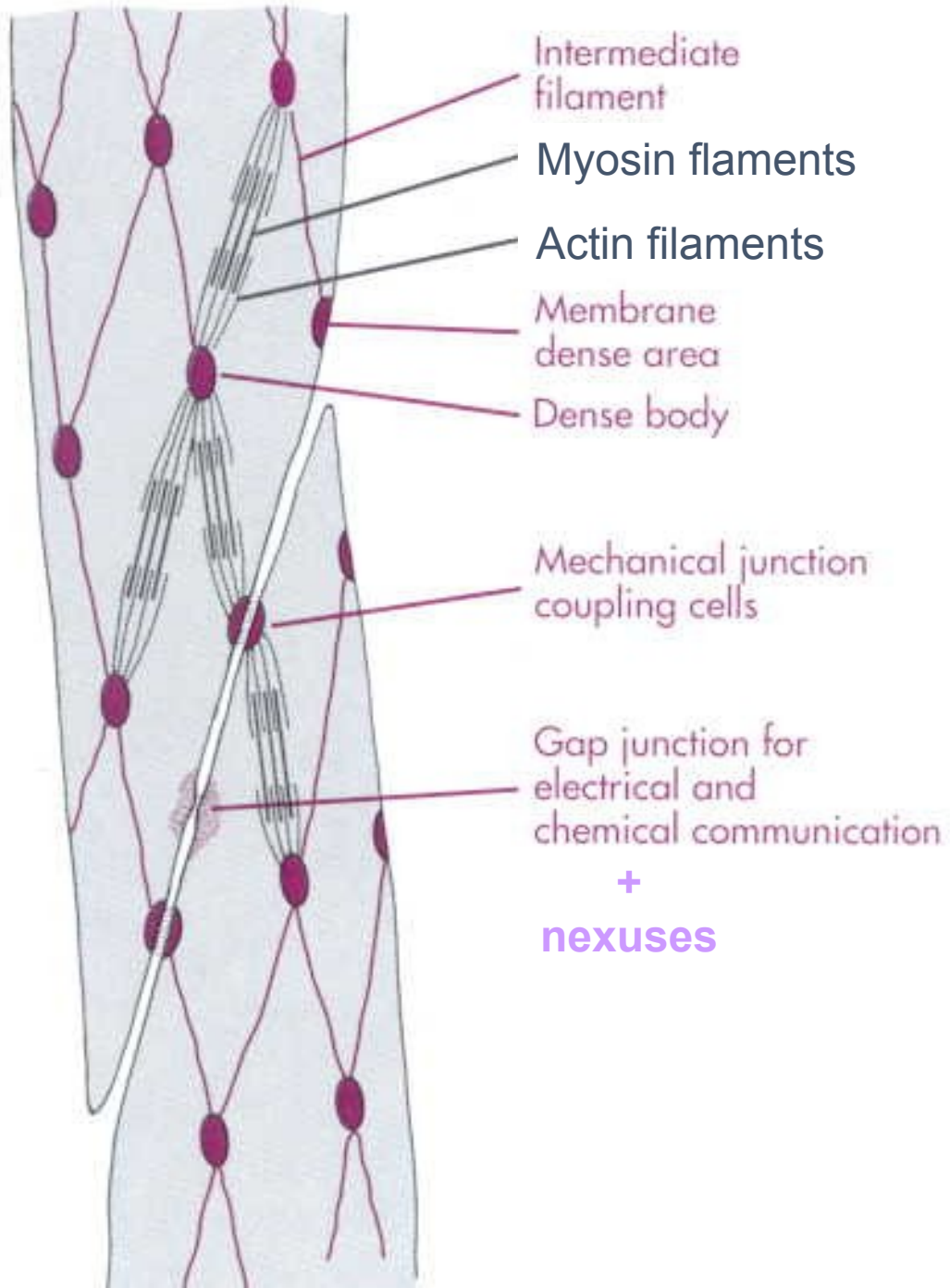


Leiomyocyte (TEM)

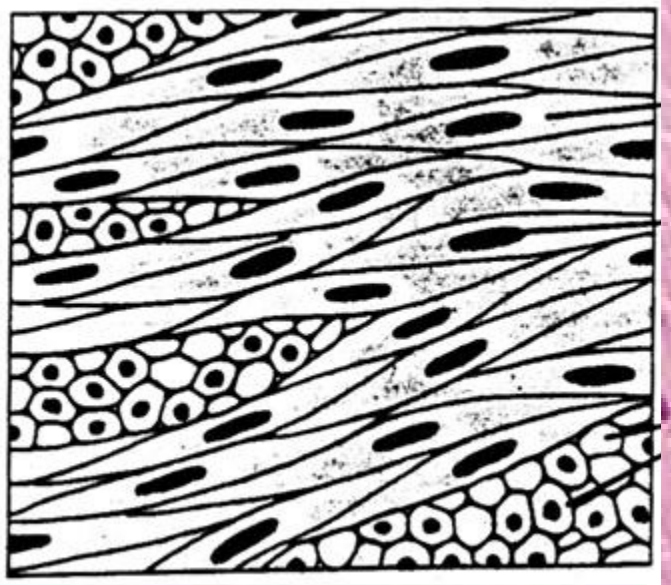


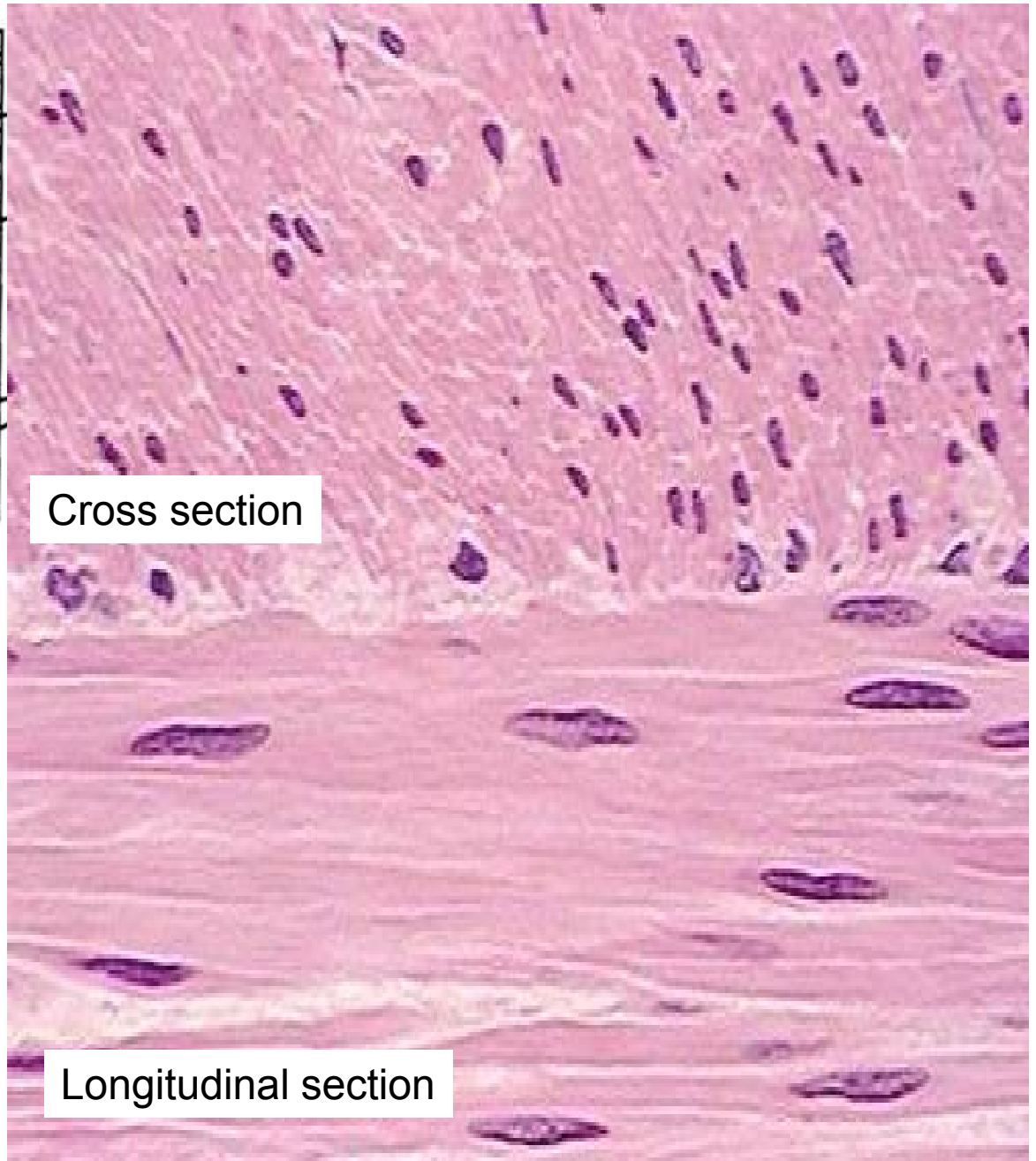
Leiomyocyte:
contractile filaments





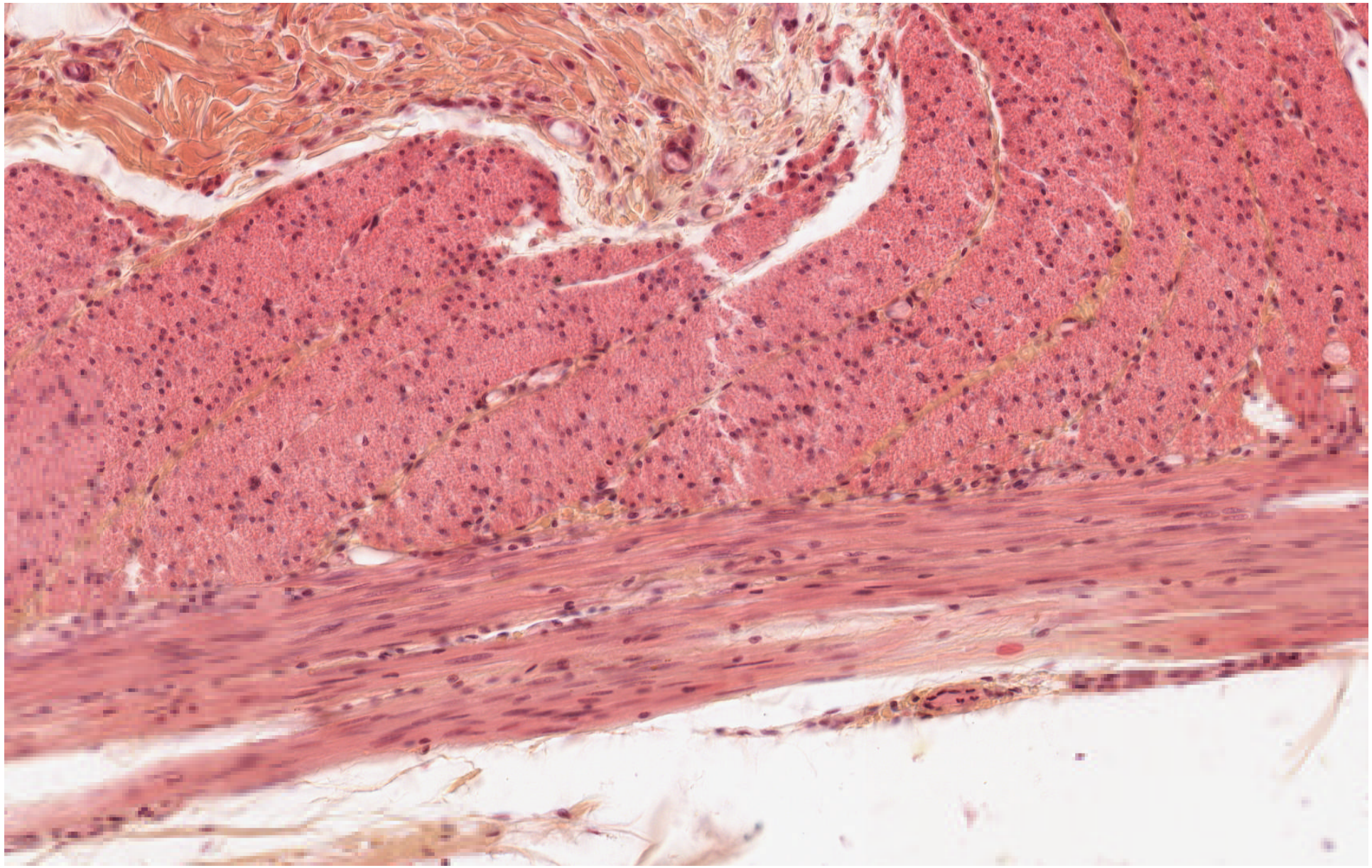
Leiomyocytes are arranged into laeyers of wall of hollow (usually tubular) organs





Smooth muscle tissue – Intestinum tenue (HE)

Smooth muscle tissue – Intestinum tenue (HES)



Muscle tissue

Slides:
Skeletal muscle tissue (2. Apex linguae)
Smooth muscle tissue (16. Intestinum tenue, 17. Intestinum crassum)
Cardiac muscle tissue (64, 65. Myocardium)

Atlas EM:
Rhabdomyocyte (52)
Leiomyocyte (54)
Cardiomyocyte (22, 53)