

Muscle tissue

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

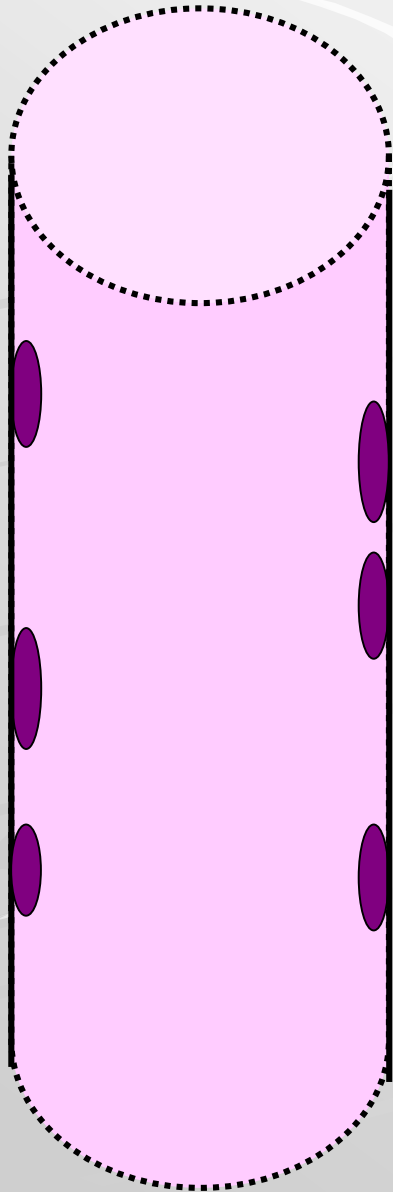


General characteristic of muscle tissue

- ✦ Origin: mesoderm and mesenchyme
- ✦ Excitability
- ✦ Contraction + relaxation \Rightarrow 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**

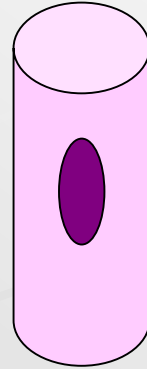
rhabdomyocyte



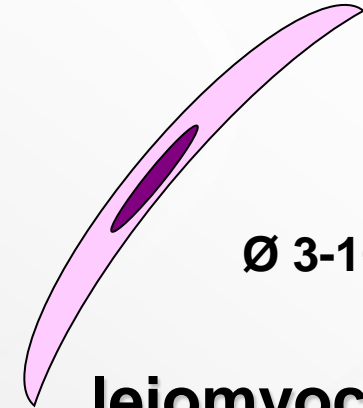
$\text{Ø } 25\text{-}100 \mu\text{m}$

MUSCLE CELLS (-myocytes)

kardiomyocyte



$\text{Ø } 15 \mu\text{m}$



$\text{Ø } 3\text{-}10 \mu\text{m}$

leiomyocyte

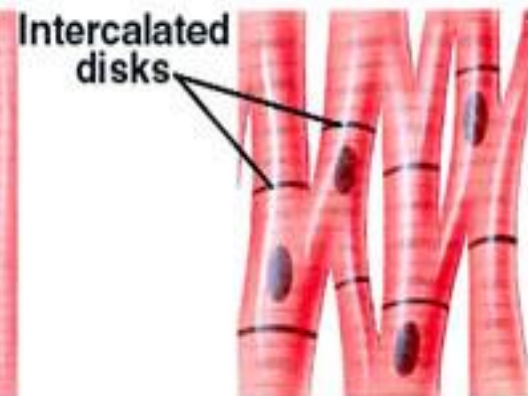
Types of Muscle



Smooth muscle



Skeletal muscle



Cardiac muscle

Muscle tissue in LM

Activity

Skeletal muscle



Nuclei

Cross sections

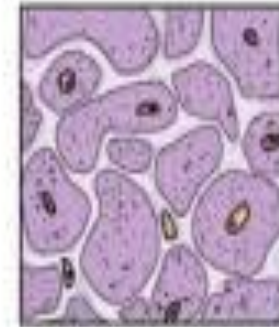


Strong, quick discontinuous voluntary contraction

Cardiac muscle

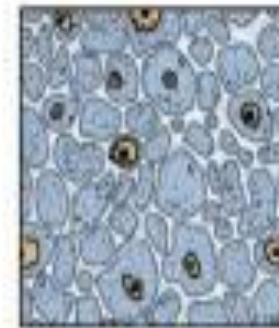
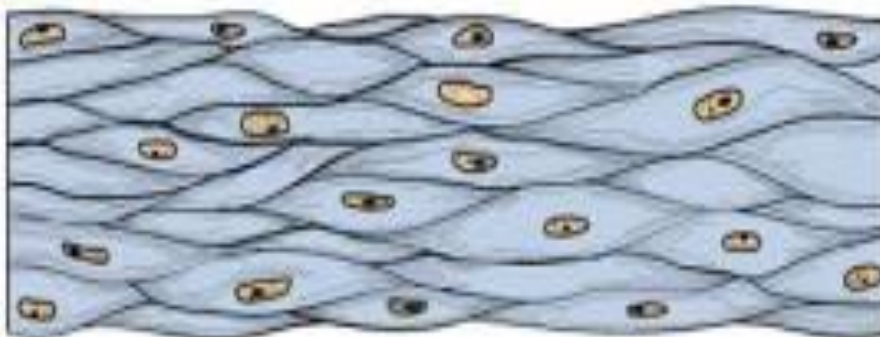


Intercalated disks



Strong, quick continuous involuntary contraction

Smooth muscle



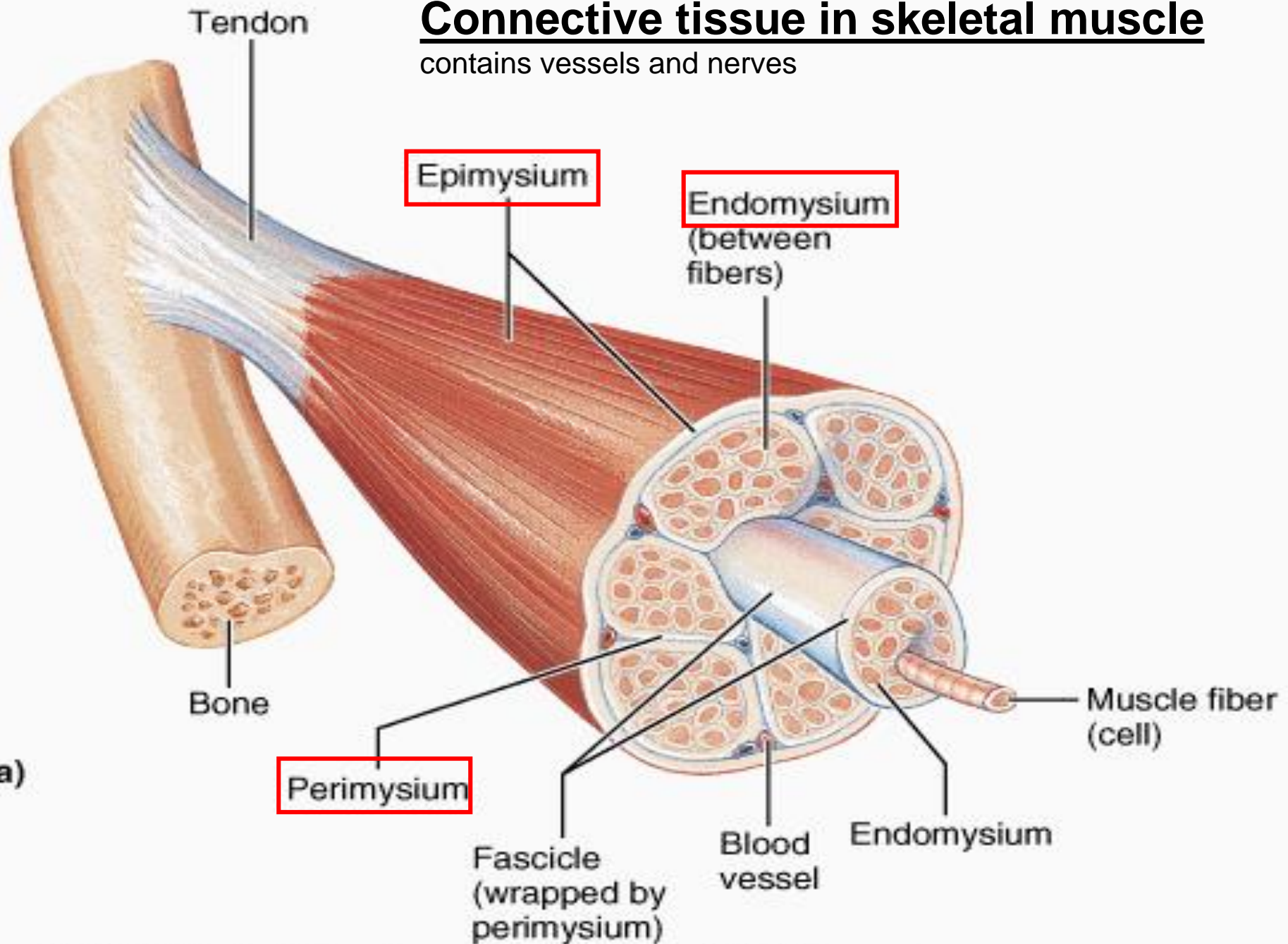
Weak, slow involuntary contraction

Connective tissue of muscle

- ◆ **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

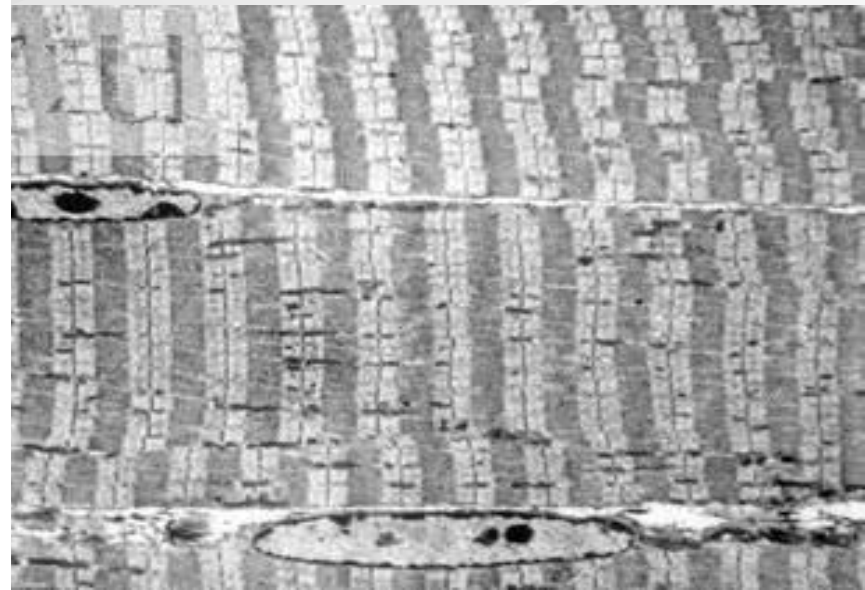
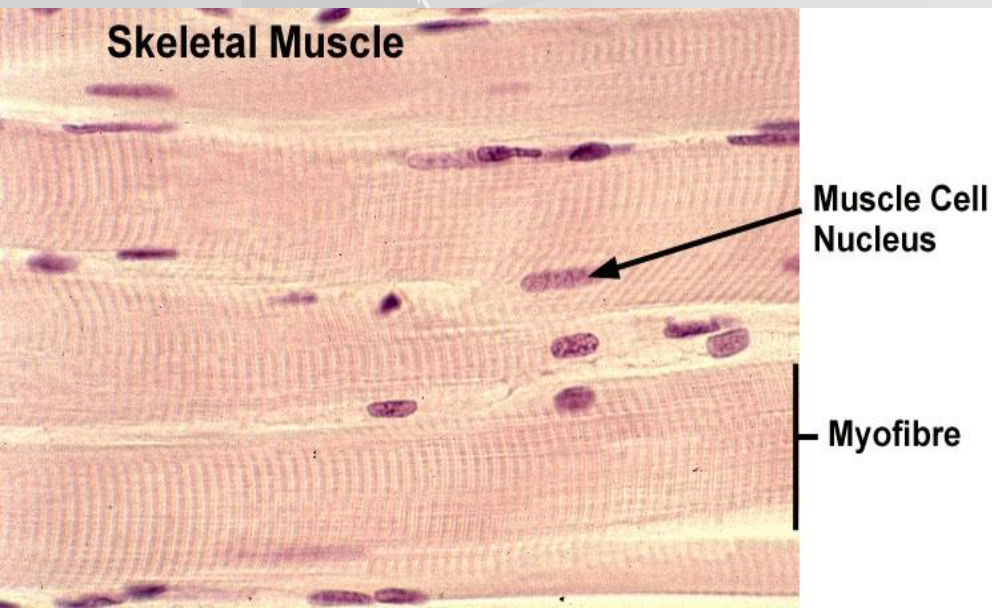
contains vessels and nerves



(a)

1) 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: millimeters - centimeters (up 15)



Skeletal muscle cell (fiber)

< rhabdomyocyte >

Remember used terms:

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

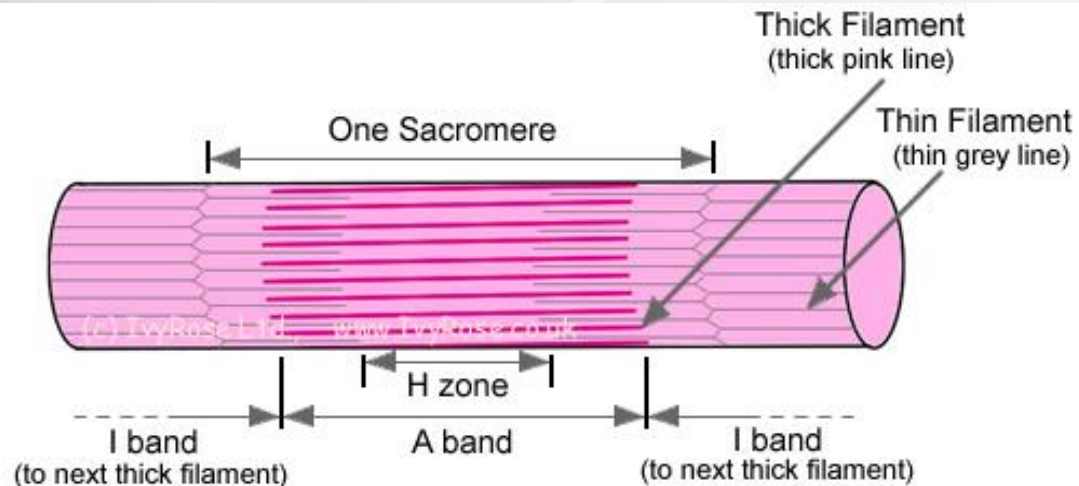
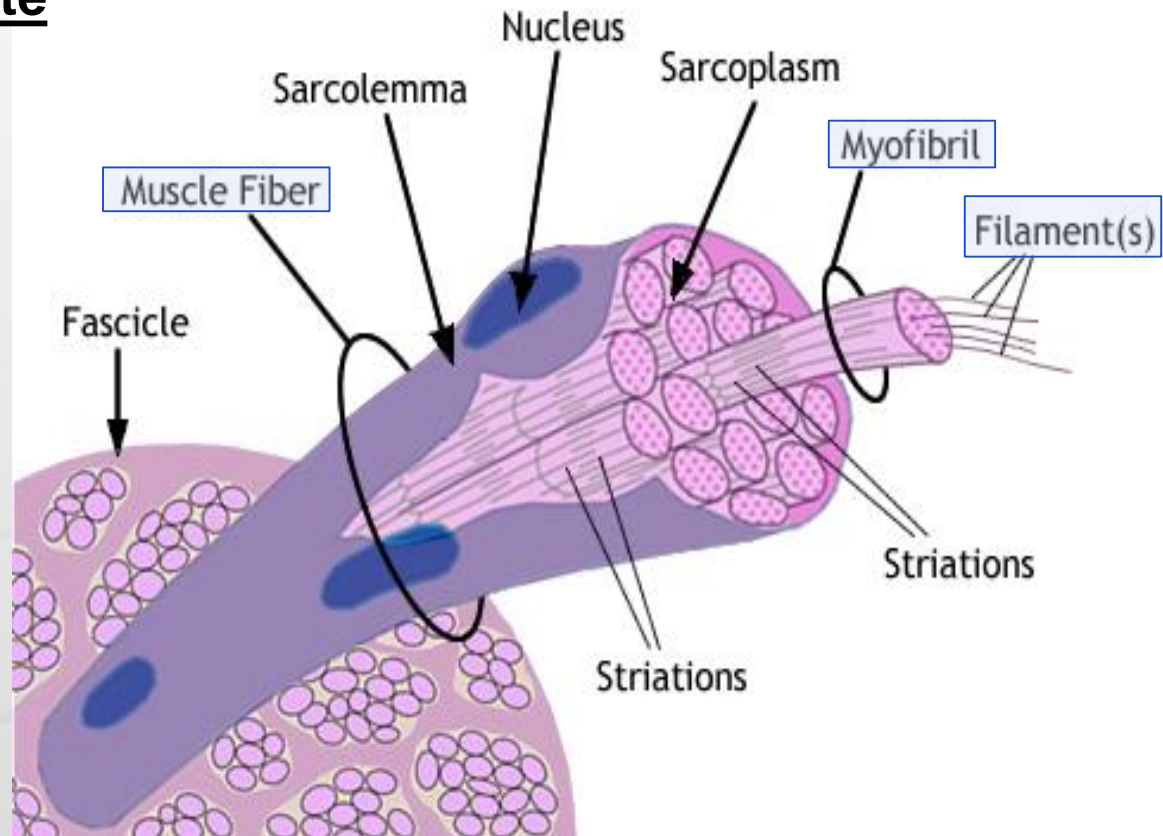
Sarcolemme + t-tubules,

In sarcoplasm:

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

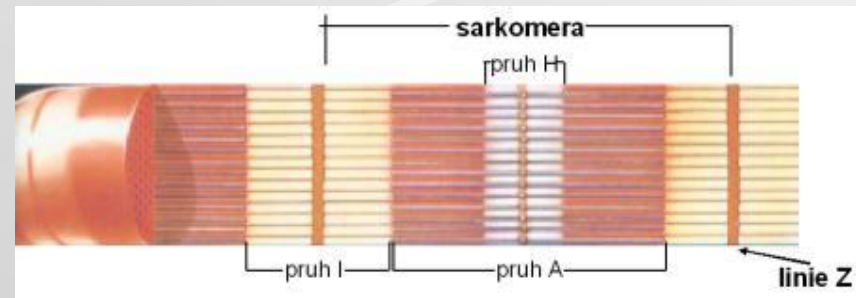
Sarcoplasmic reticulum
(smooth ER) – reservoir
of Ca^{2+}

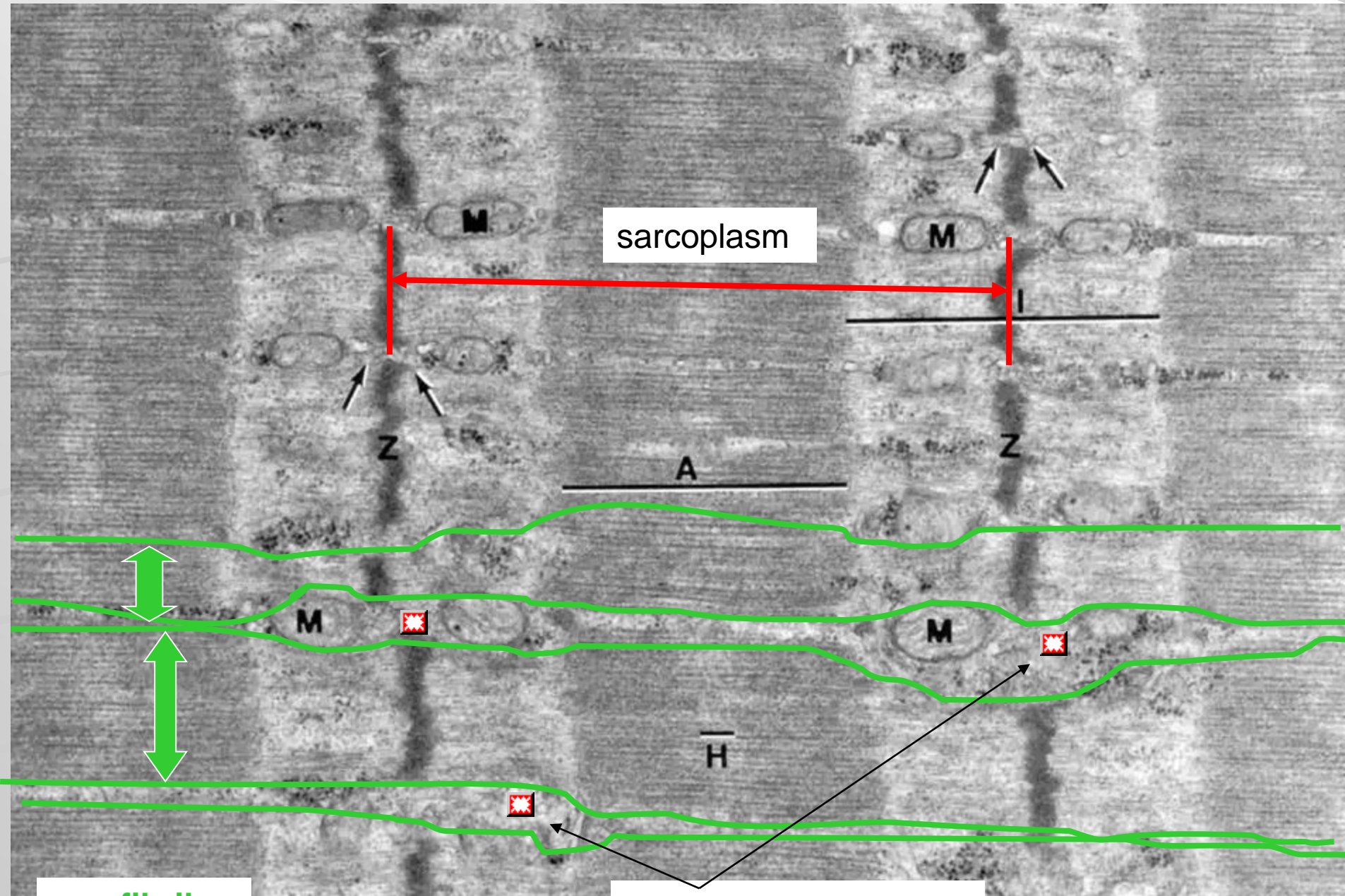
Myofibrils (parallel to the
length of the muscle fiber)



Myofibrils

- ✦ elongated structures [\emptyset 0.5 – 1.5 μ] in sarcoplasm of muscle fiber,
- ✦ are oriented parallelly 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.



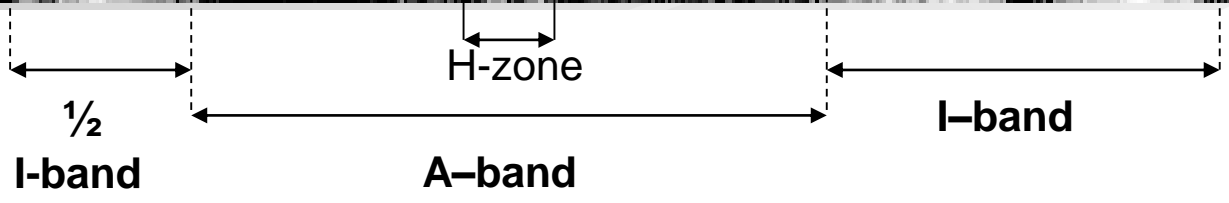
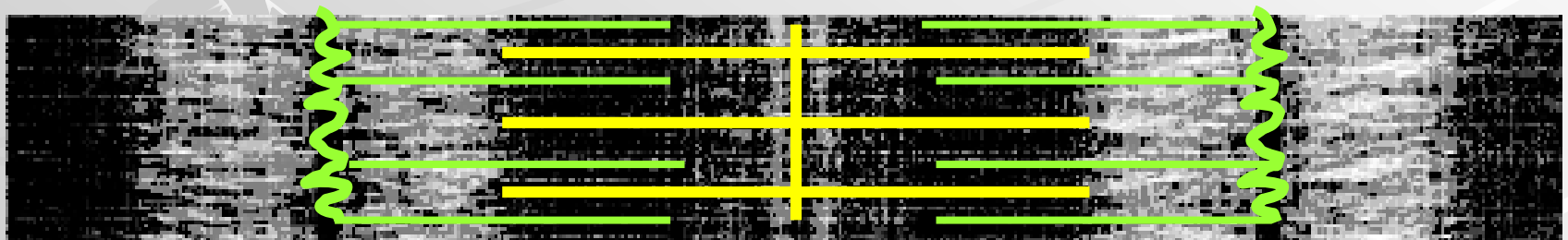
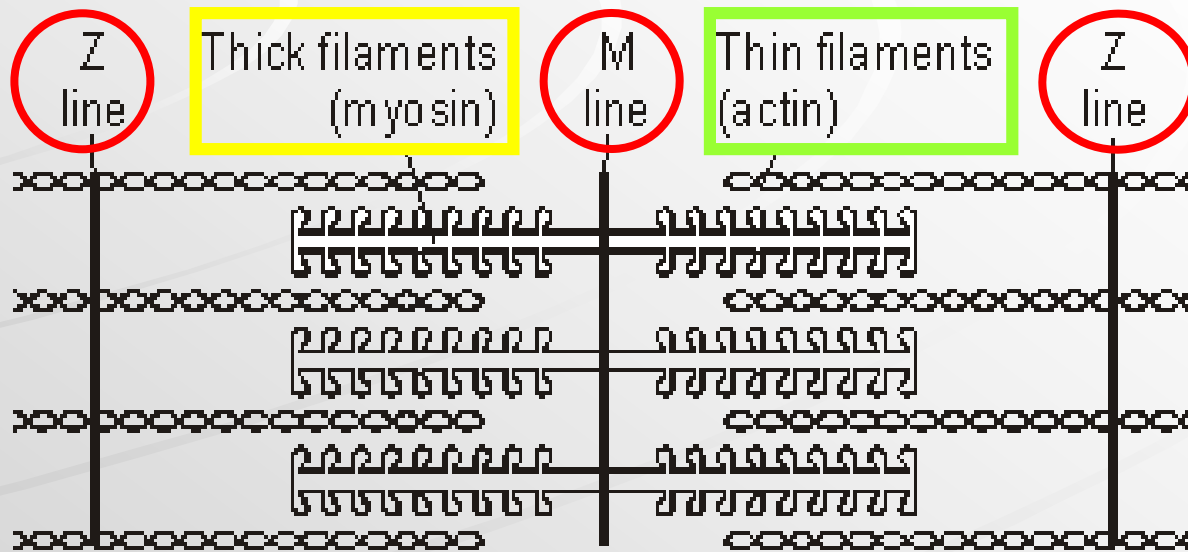


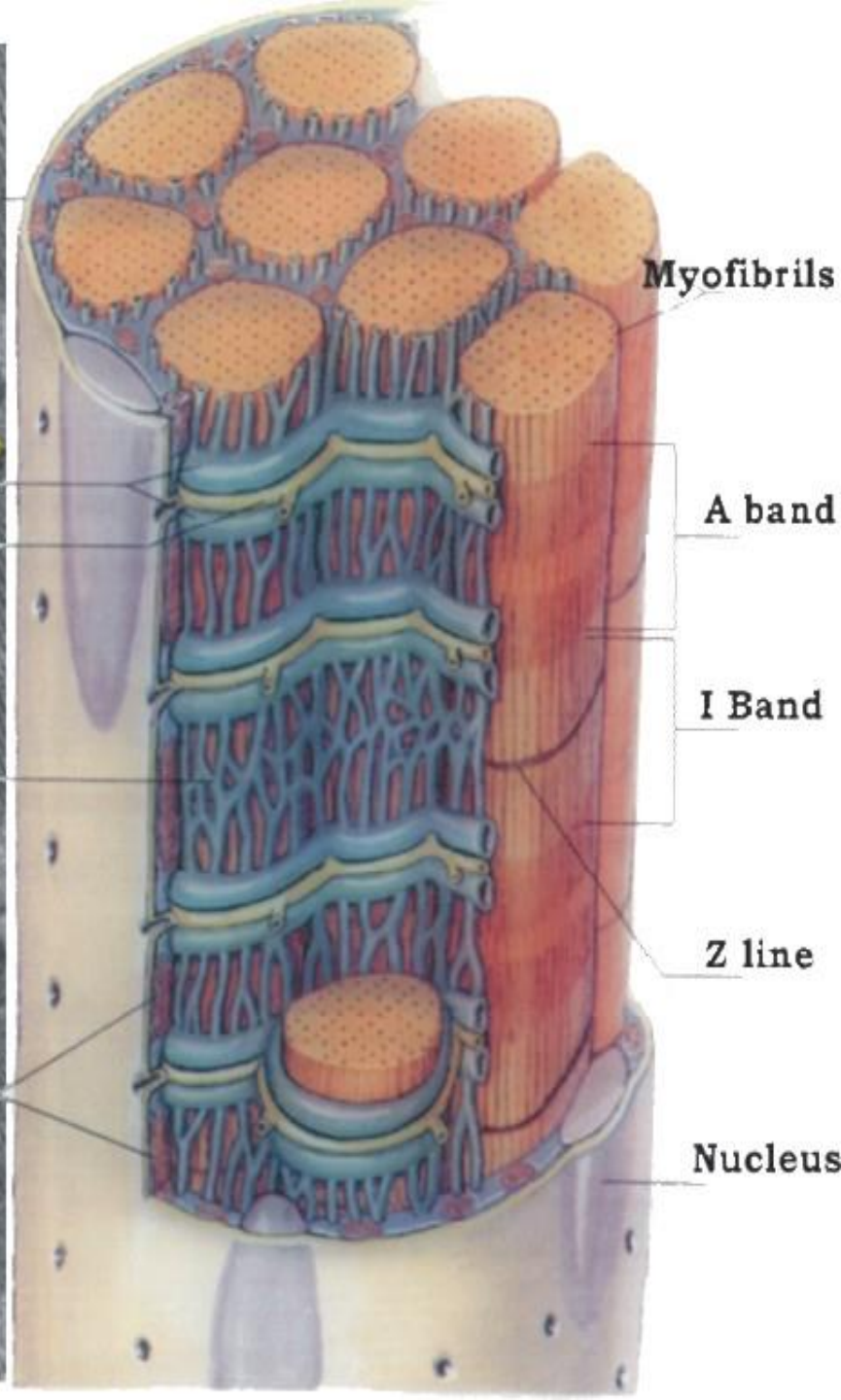
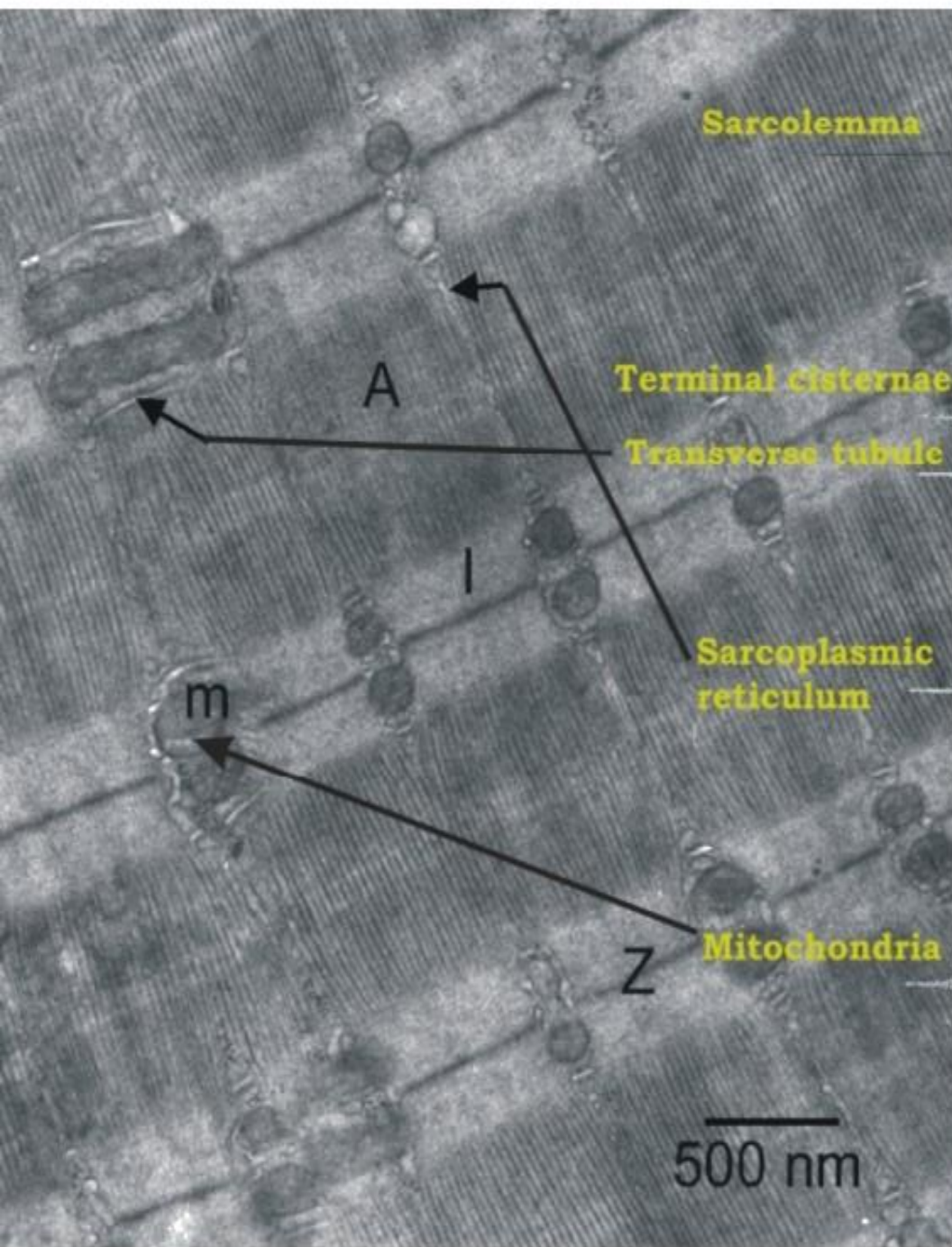
sarcoplasm

myofibrils

columns of sarcoplasm

Sarcomere

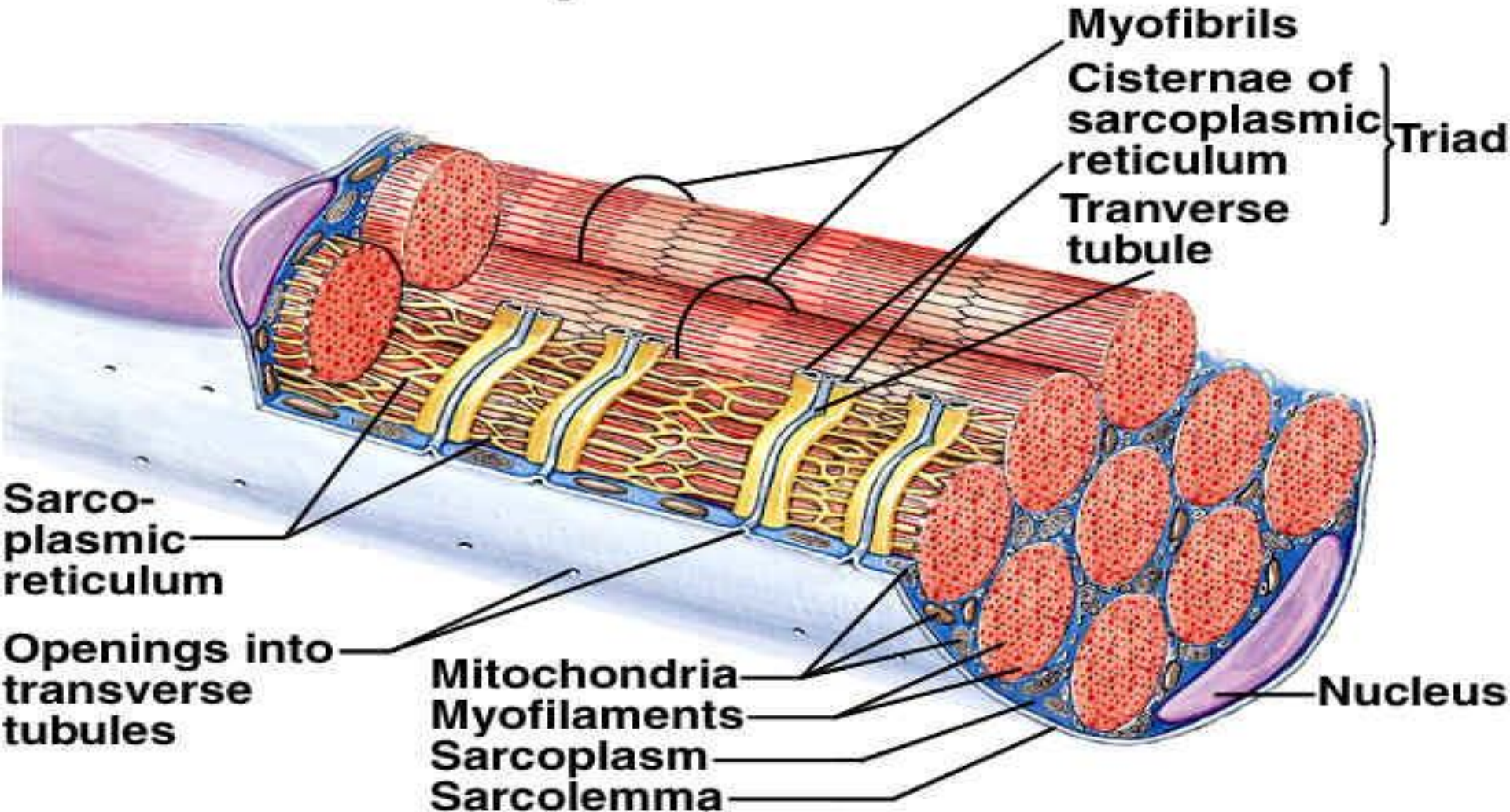




Rhabdomyocyte

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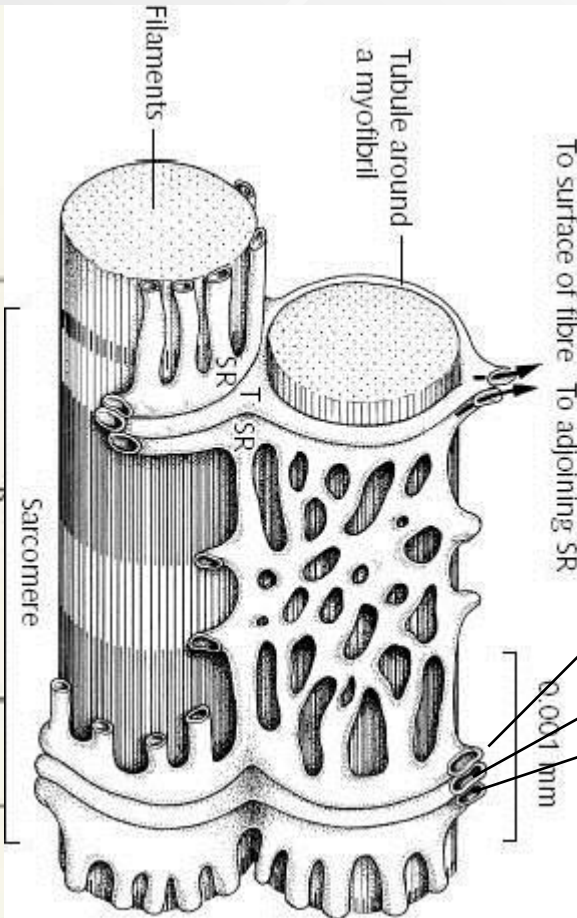
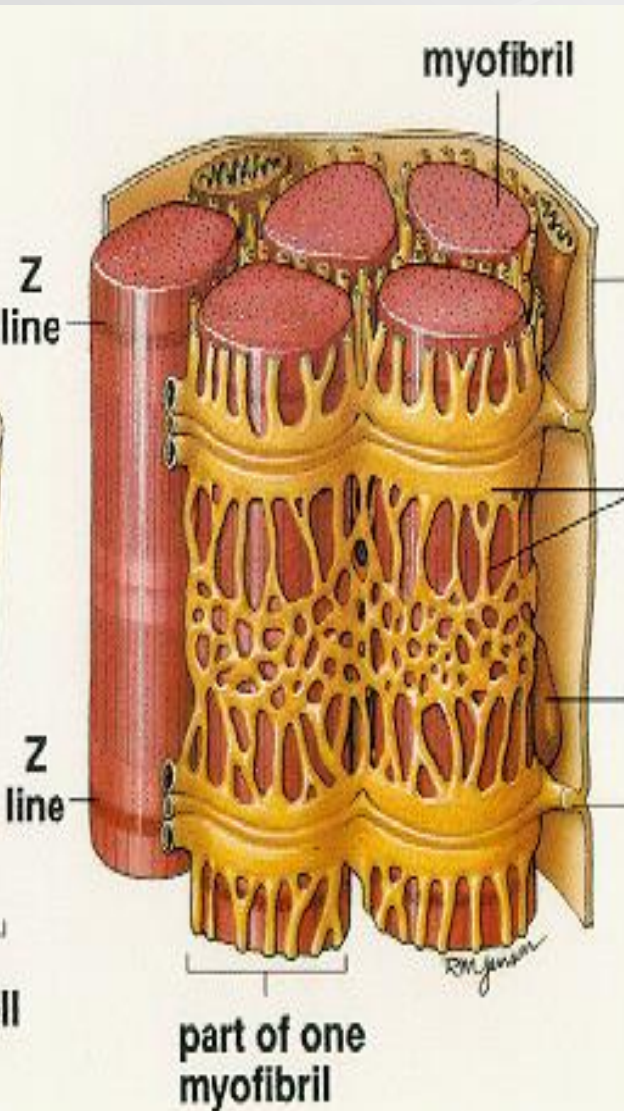
Sarcoplasm Contents



Sarcoplasmic reticulum, t-tubule

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

Function: reservoir of Ca ions

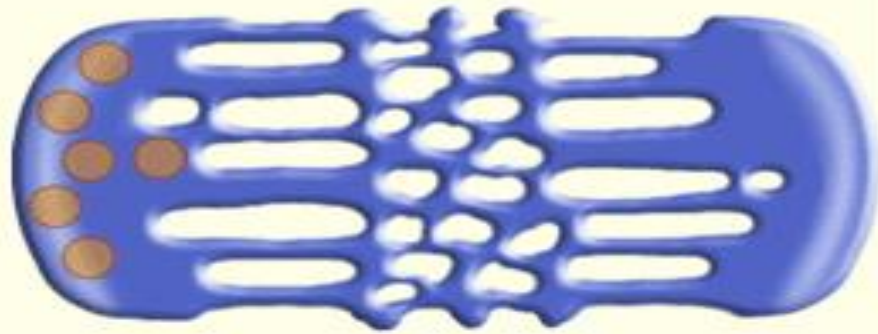


Terminal cisterna
T-tubule
Terminal cisterna } **TRIAD**

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

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,
- ✦ activation of binding sites of actin for myosin,
- ✦ 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.





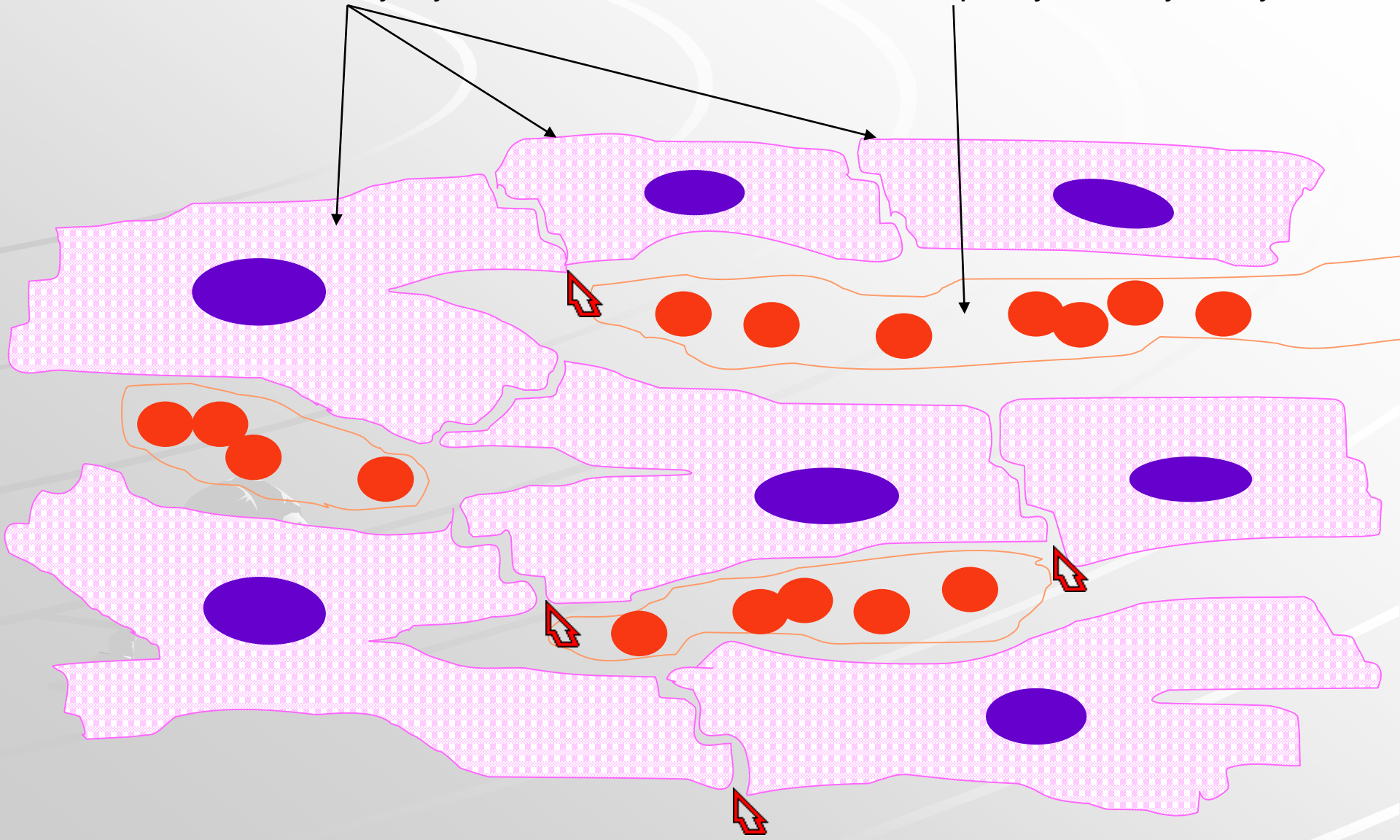
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2) Cardiac muscle - myocardium

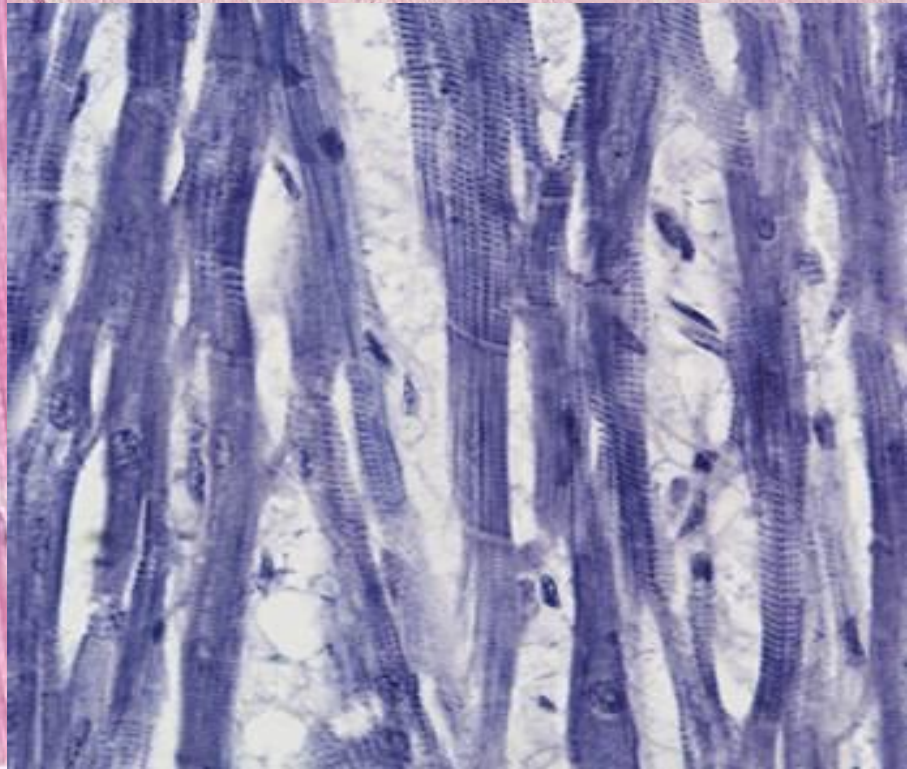
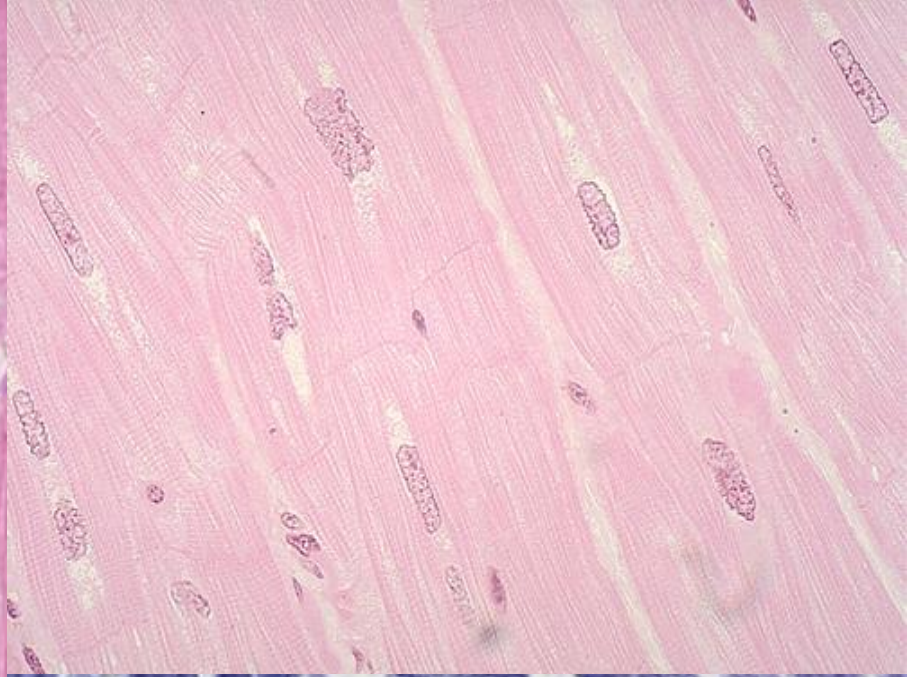
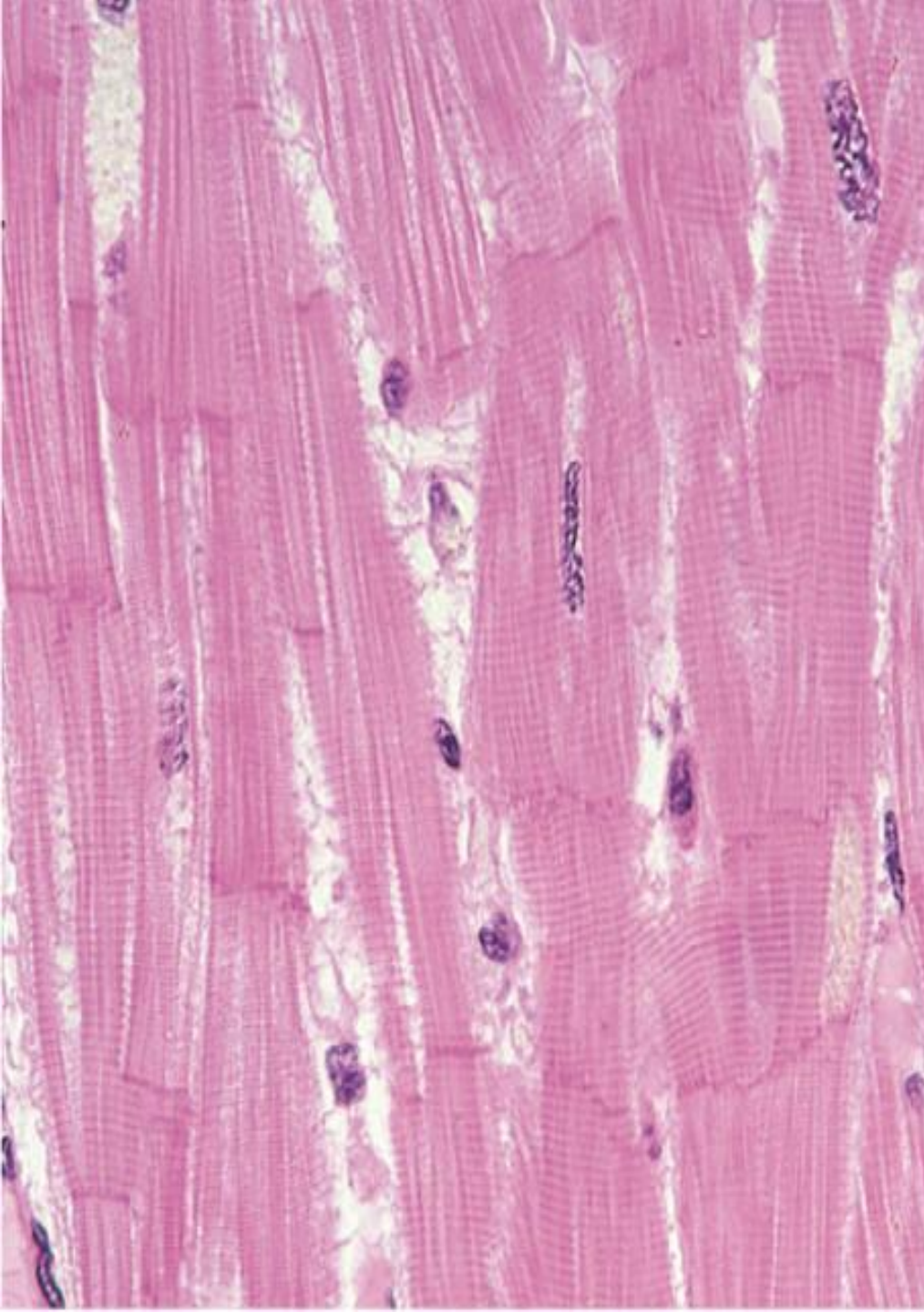
- ✦ is made up of long branched fibers, composed of cells – **cardiomyocytes**,
- ✦ cardiomyocytes are cylindrical cells, which can be branched on one or both ends (Y, X shaped cells),
- ✦ Sarkoplasm: 1 nucleus in the center of cell, striated myofibrils, numerous mitochondria,
- ✦ cells are attached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

chains of cardiomyocytes

blood capillary with erythrocytes



Intercalated disc

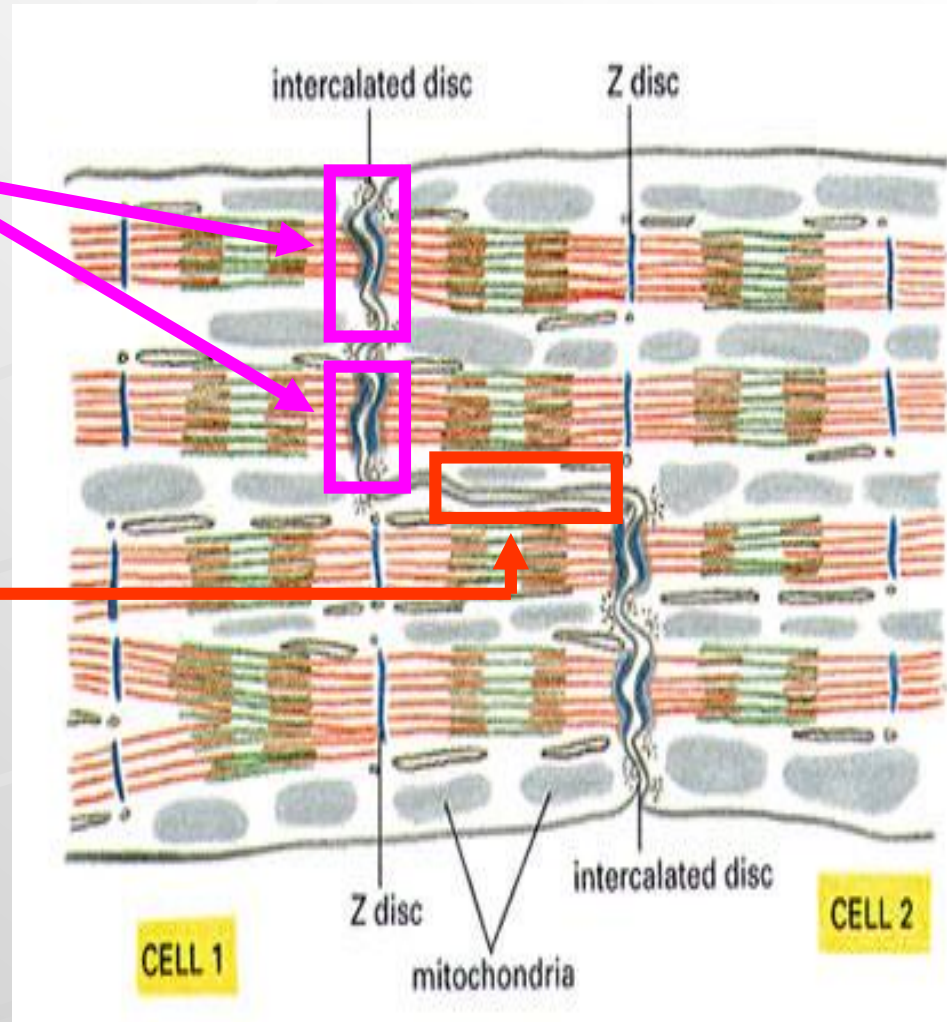


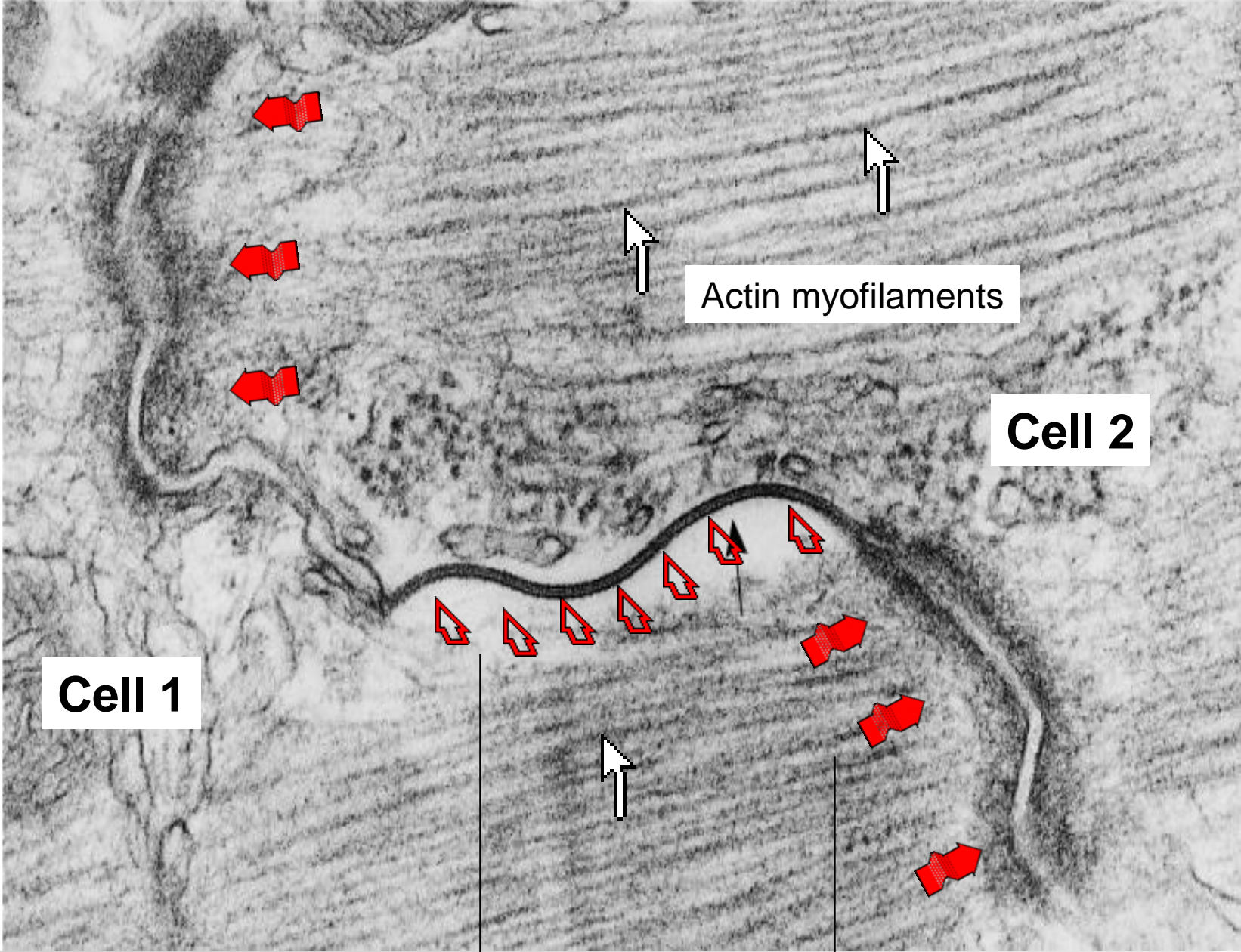
DIFFERENCES BETWEEN CARDIAC AND SKELETAL MUSCLE TISSUES

- ✦ 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 between A/I-bands
- ✦ 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.

Intercalated disc

- ✦ „scalariform“ shape of cell ends
- ✦ fasciae adherentes (*adhesion of cells*)
- ✦ Nexus (quick intercellular communication – transports ions and electric impulses)





Cell 1

Cell 2

Actin myofilaments

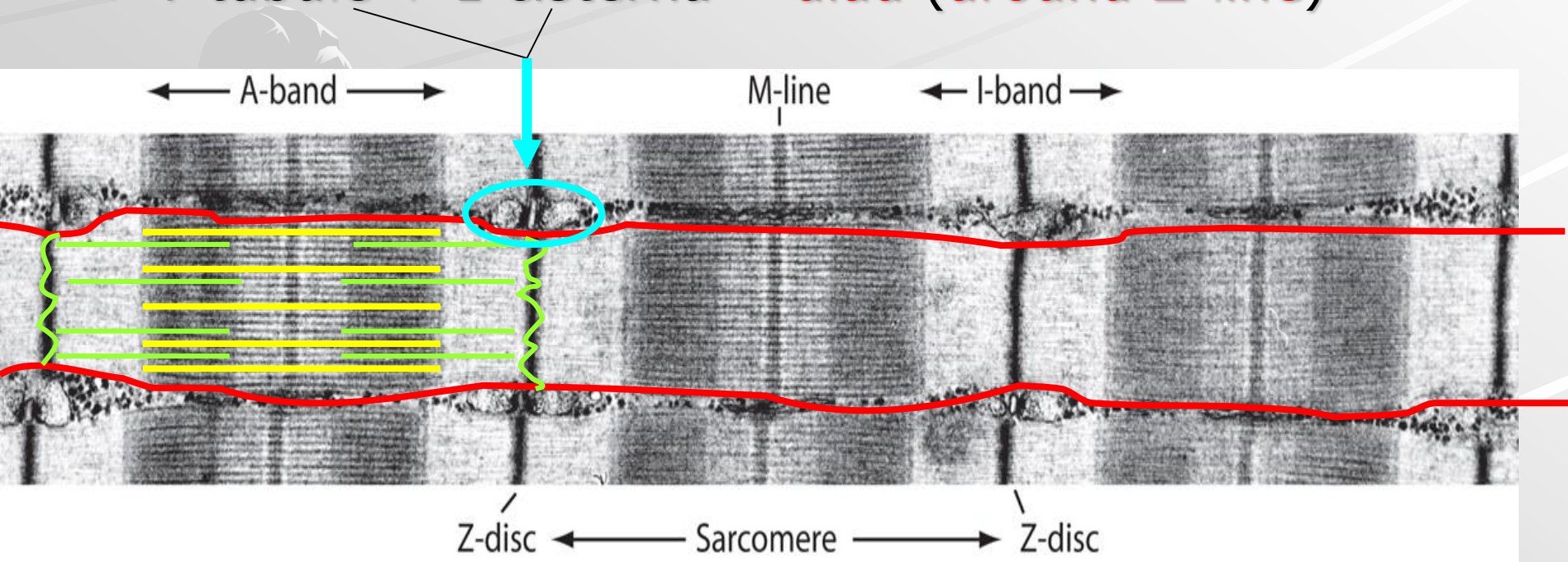
Intercalated disc:

nexus

fascia adherens

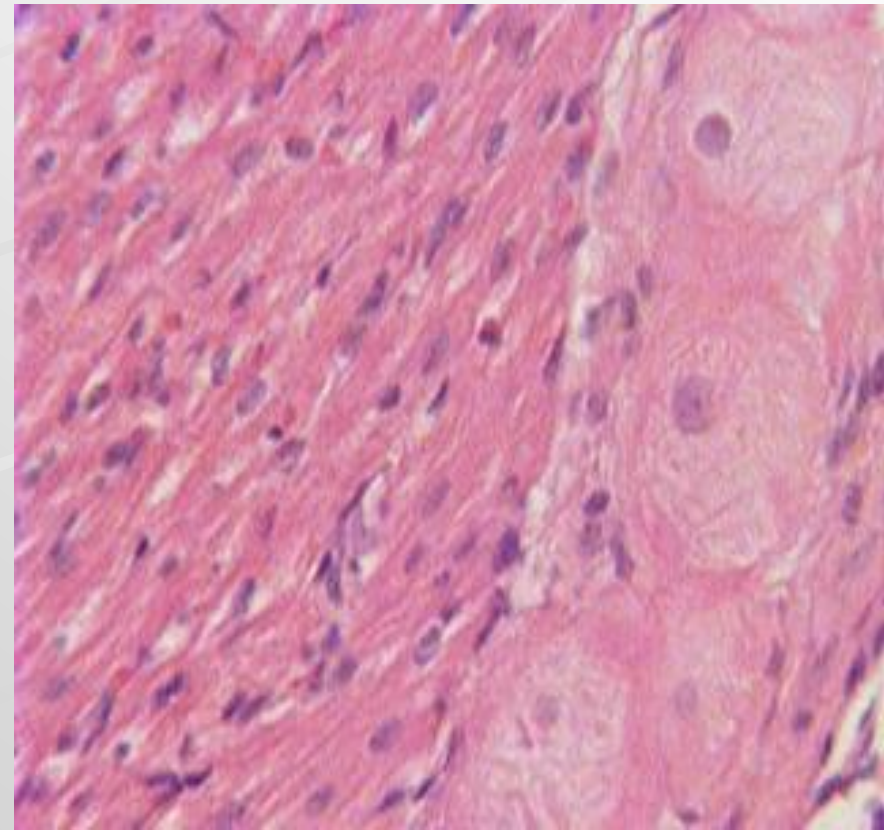
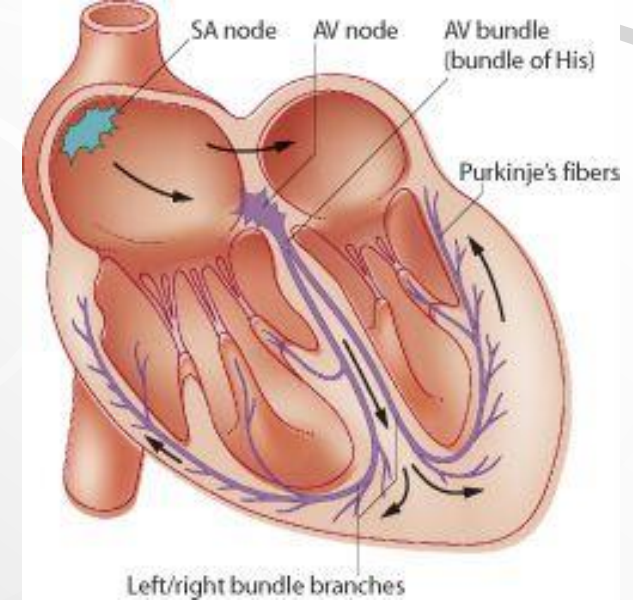
Myofibri of cardiomyocyte

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



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](#)



3) Smooth muscle tissue

- ✦ 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** substituting Z-lines in sarcoplasm
- ✦ calmodulin (as troponin)
- ✦ sarcoplasmic reticulum forms only tubules with Ca ions, which are also transported to the cell through pumps and ions channels in **caveolae**
- ✦ zonulae occludentes and nexuses connect cells

Leiomyocyte

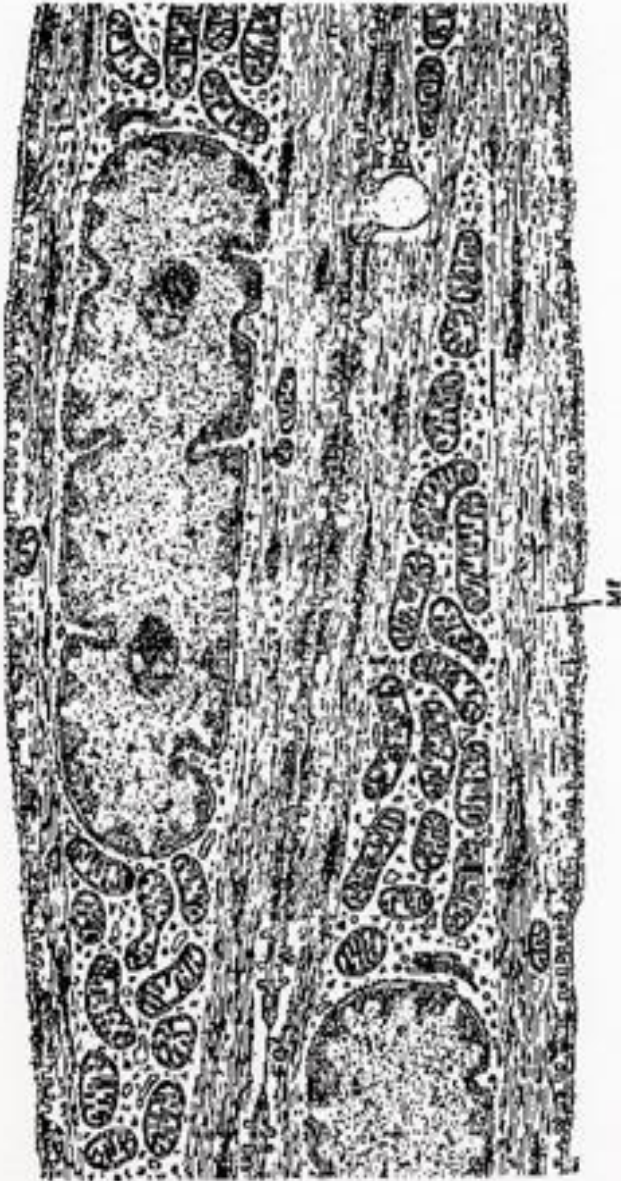
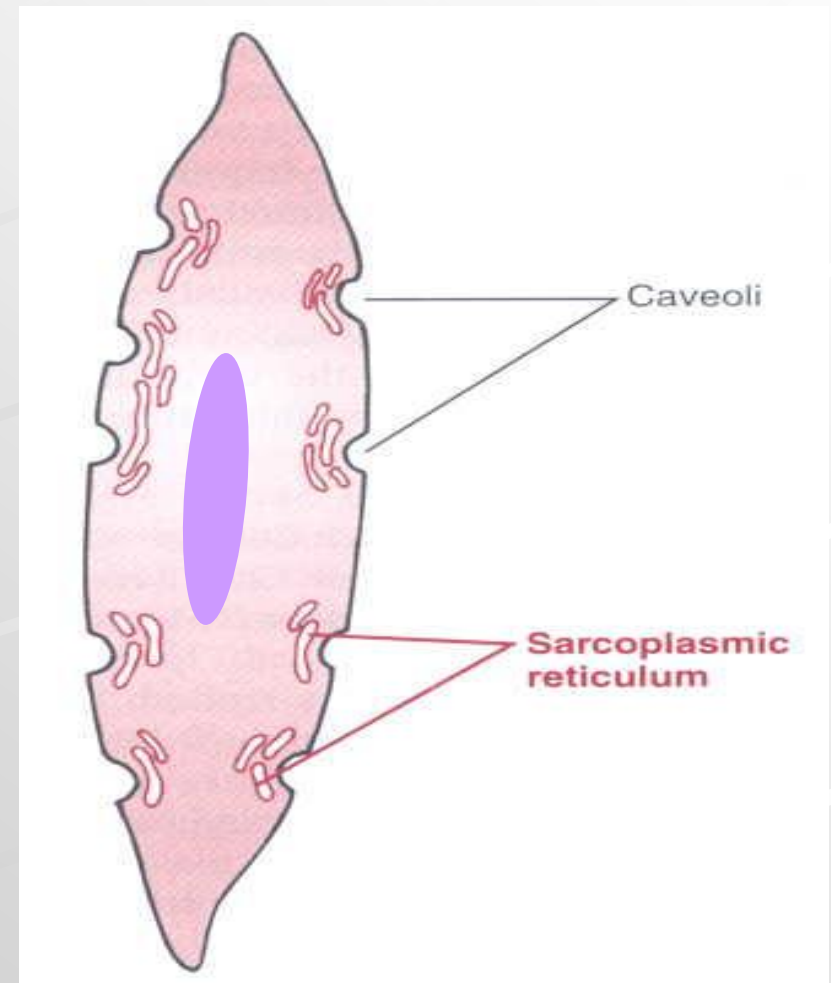


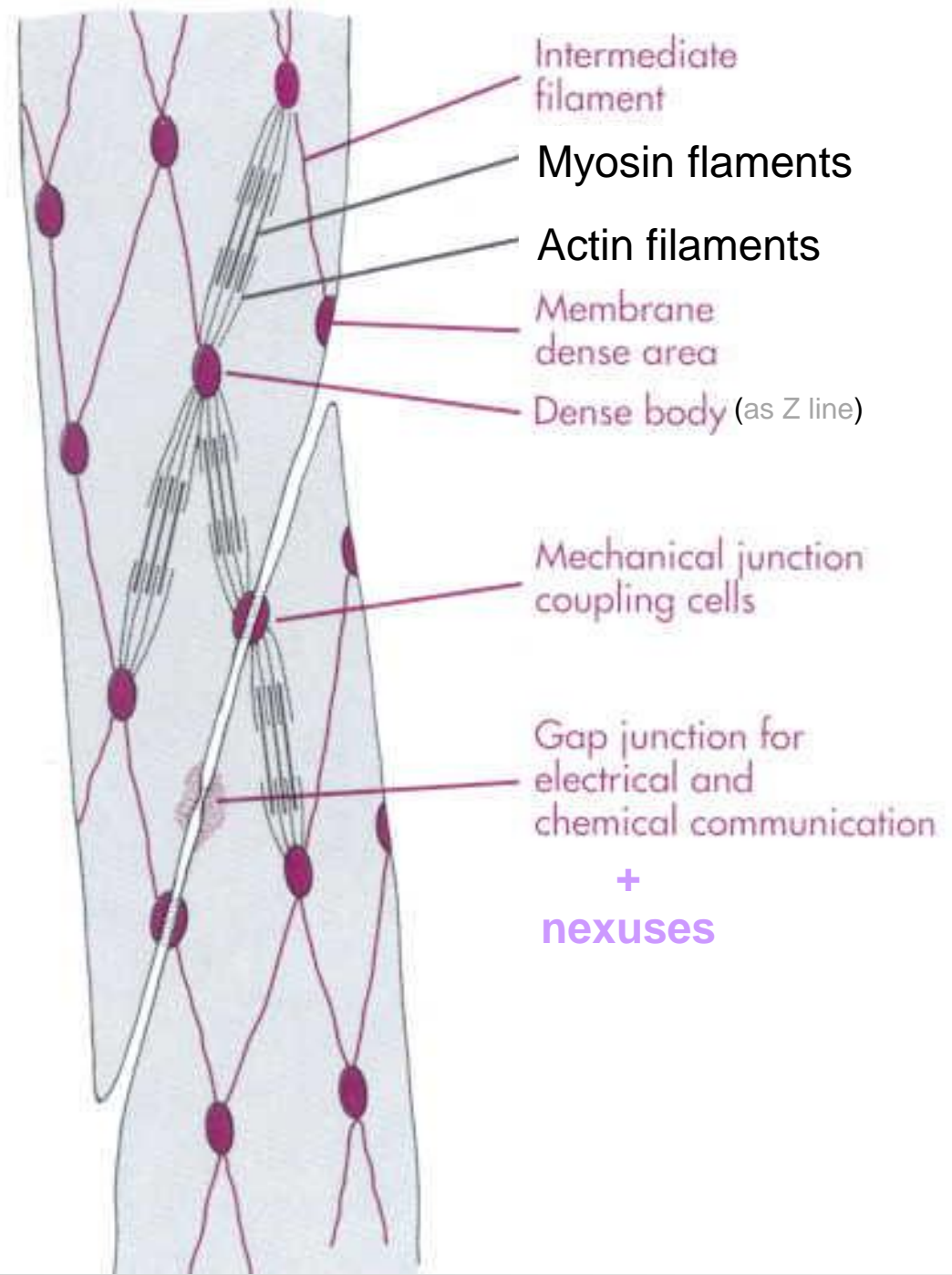
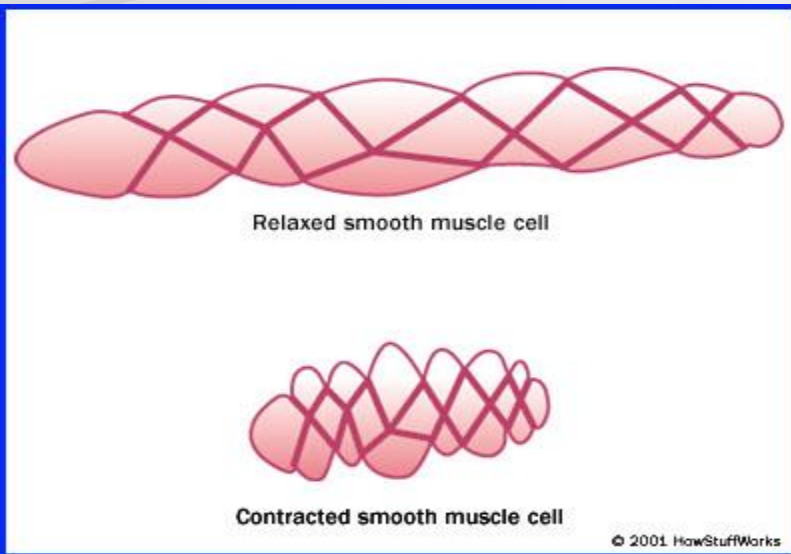
FIG. 10-2 E/M OF SMOOTH MUSCLE

Caveolae are equivalent to t-tubule and in their membrane ions channel are present to bring Ca needed for contraction.

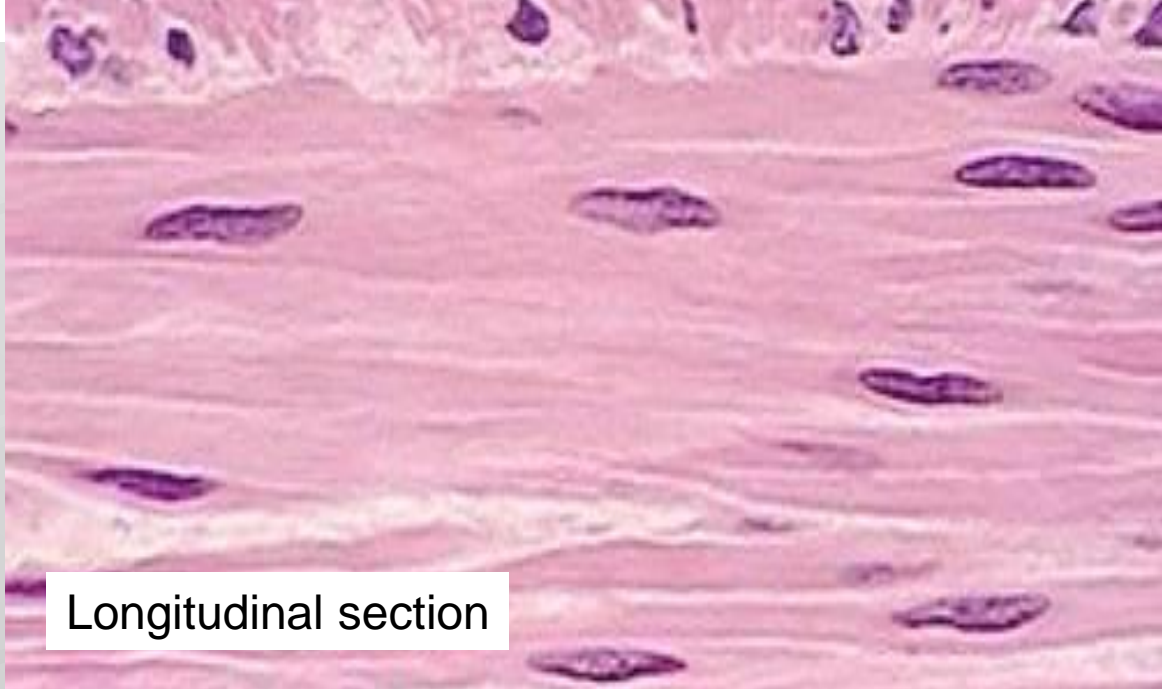
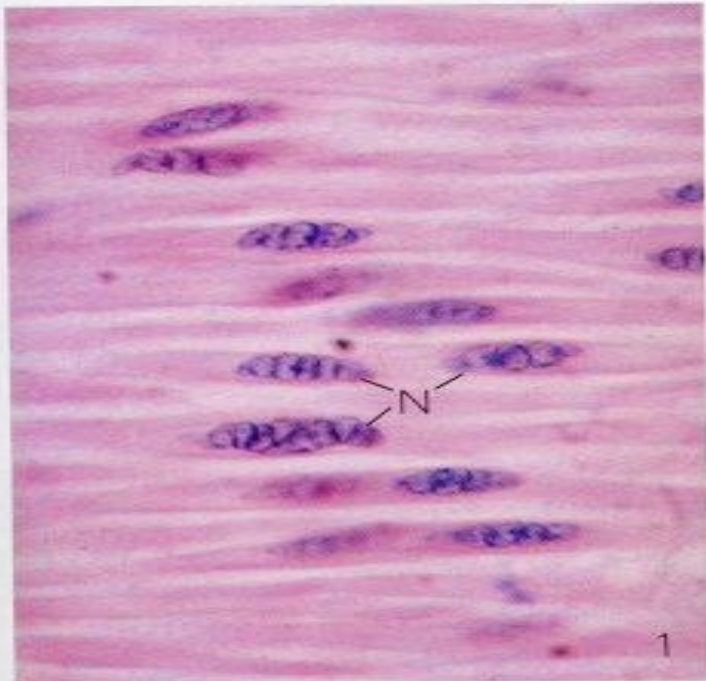
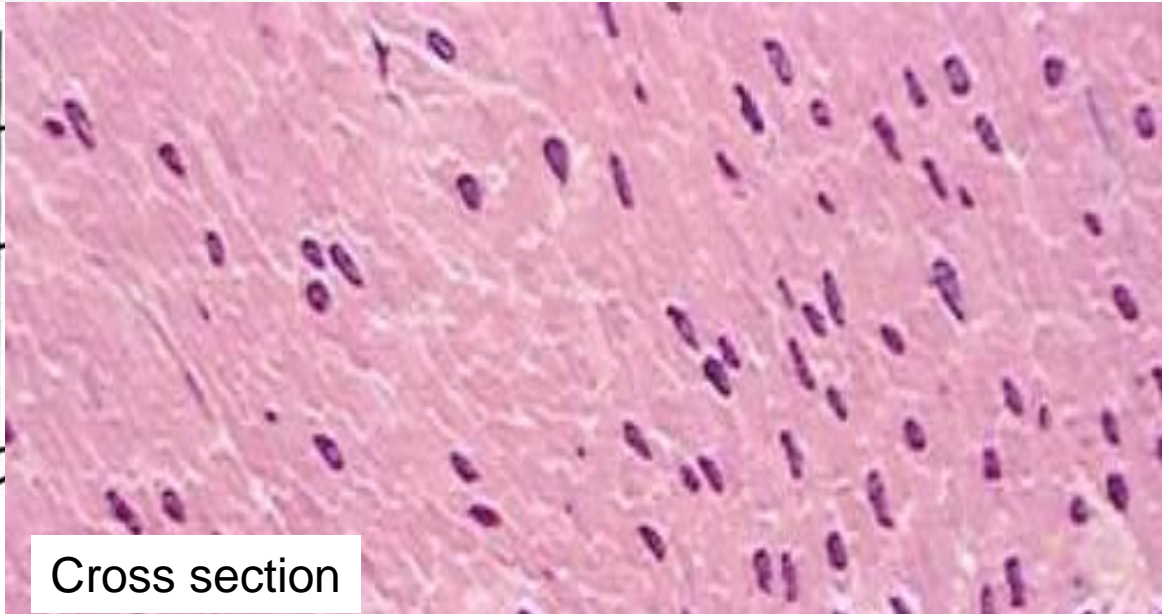
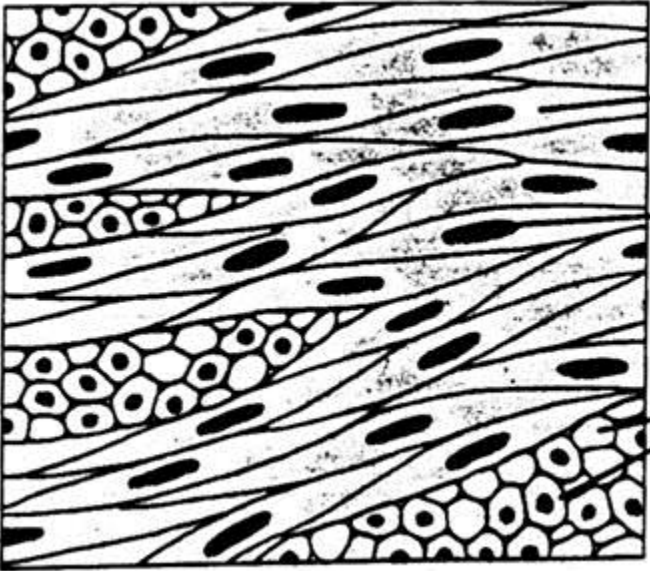
Caveolae are in contact with sarcoplasmic reticulum.



Leiomyocyte: contractile filaments



Leiomycytes are arranged into layers of wall of hollow (usually tubular) organs



Motor end plate

