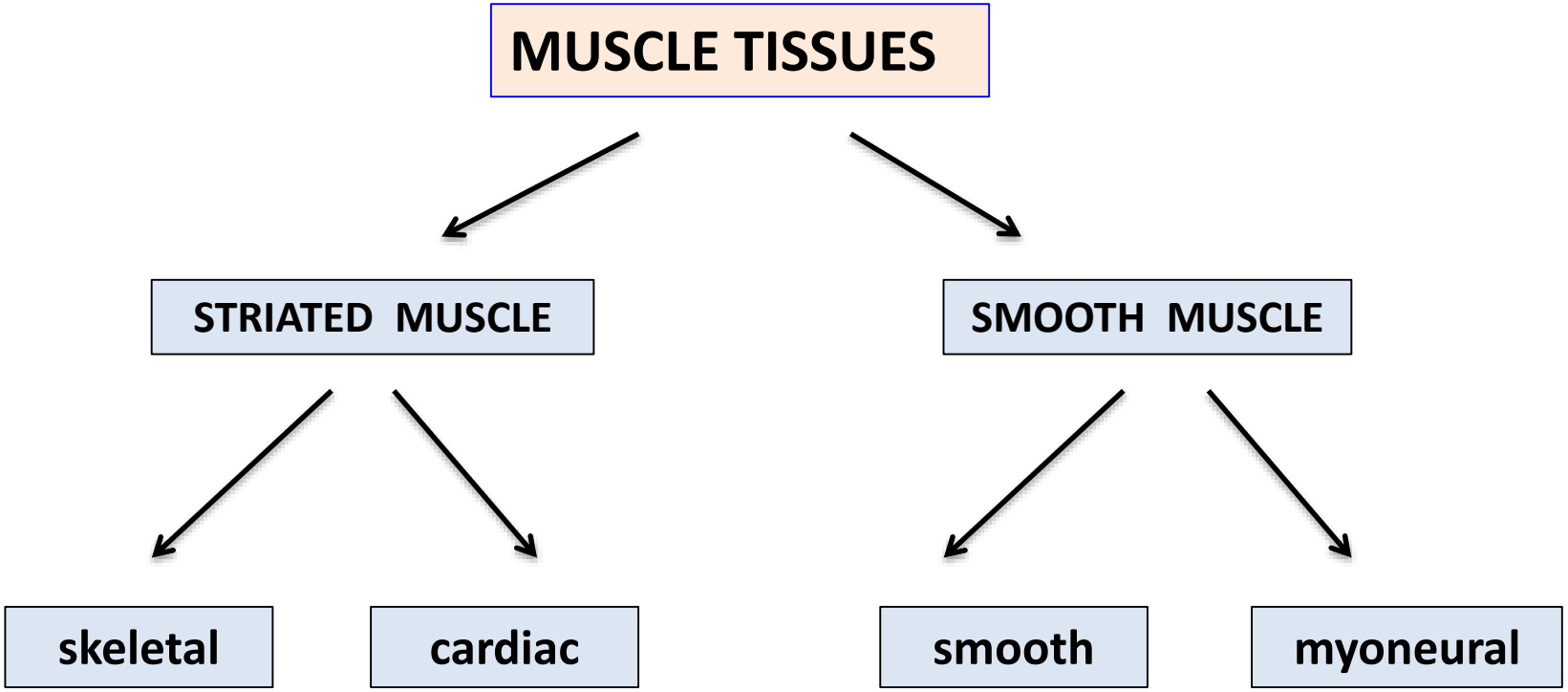
MUSCLE TISSUES

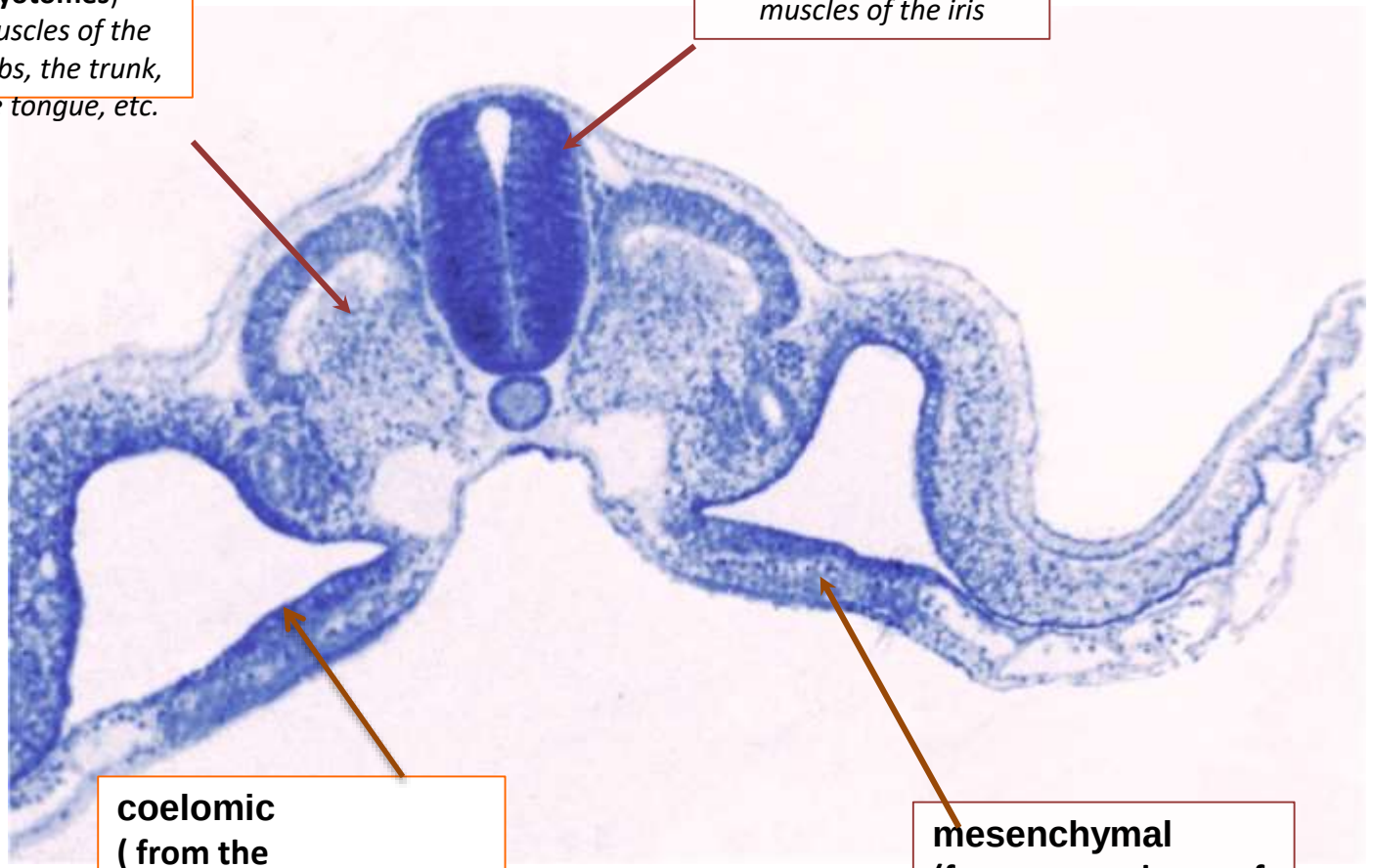
Department of Histology, Embryology, and Cytology
of the General Medicine Faculty, RNMR


MUSCLE TISSUES
STRIATED MUSCLE
SMOOTH MUSCLE
skeletal
cardiac
smooth
myoneural

SOURSES OF MUSCLE TISSUE DEVELOPMENT

somatic
(**from myotomes**) – *muscles of the limbs, the trunk, the tongue, etc.*

neural
(**from the mesenchyme of neural crest**) – *muscles of the iris*



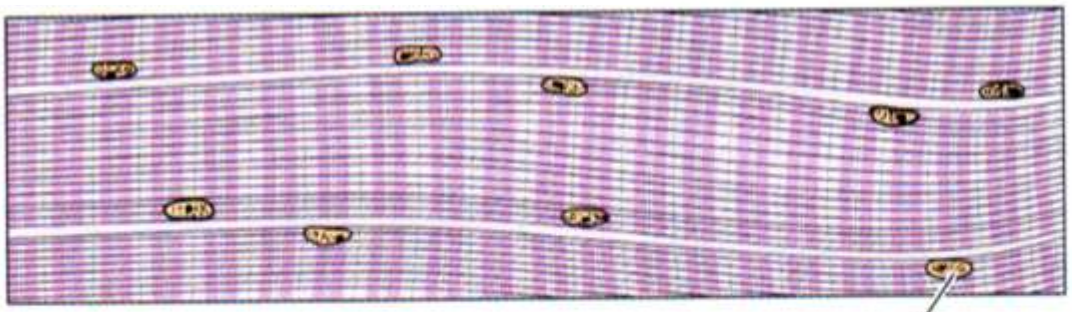
coelomic
(from the myoepicardial plate of visceral layer of splanchnotome – *myocardium of the heart*)

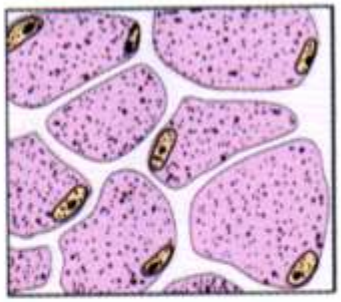
mesenchymal
(from mesenchyme of mesodermal origin – *muscle tissue of the viscera, vessels, and the endocardium*)

MUSCLE TISSUE TYPES

Skeletal muscle

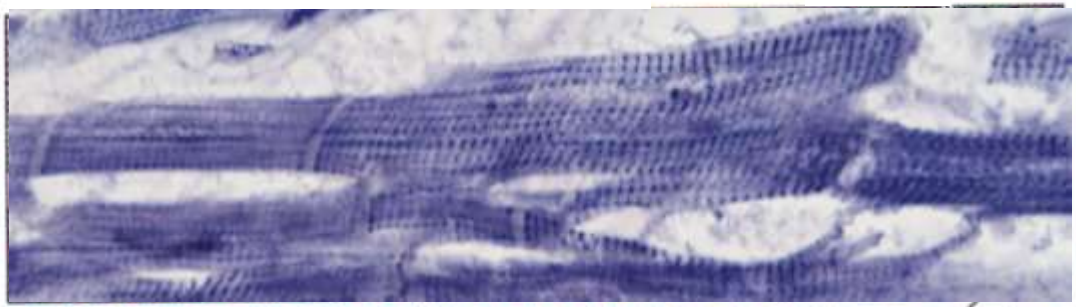
Cross sections

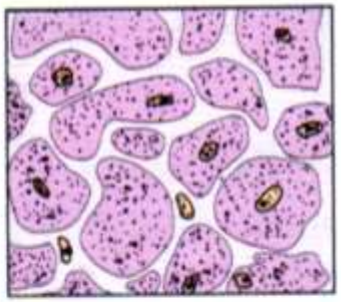




nuclei

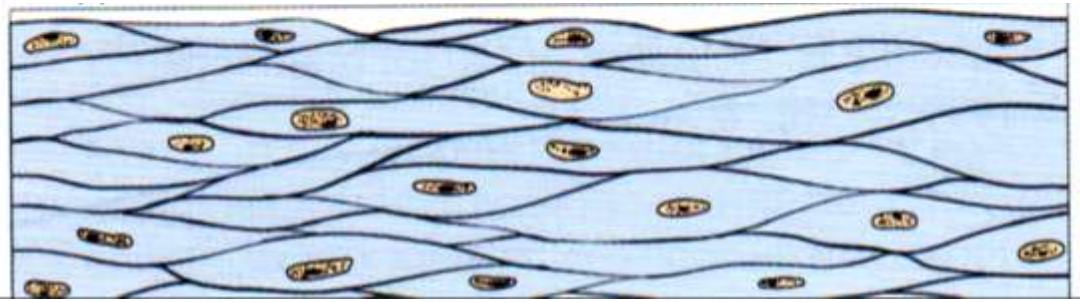
Cardiac muscle

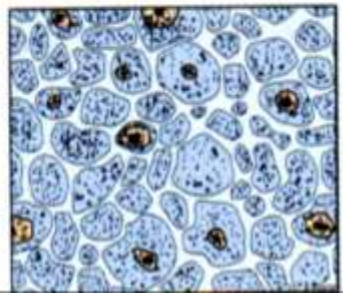




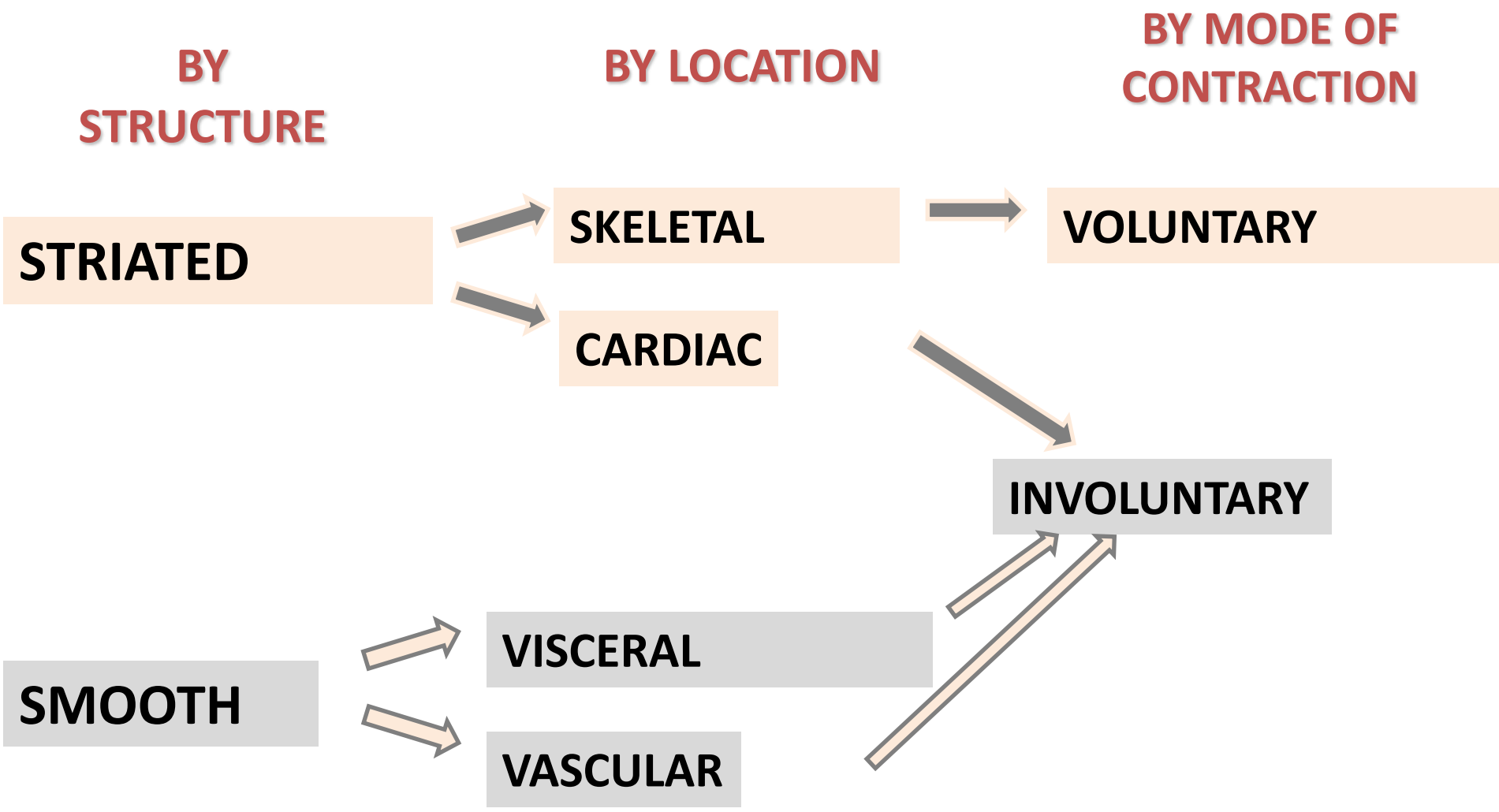
intercalated discs

Smooth muscle



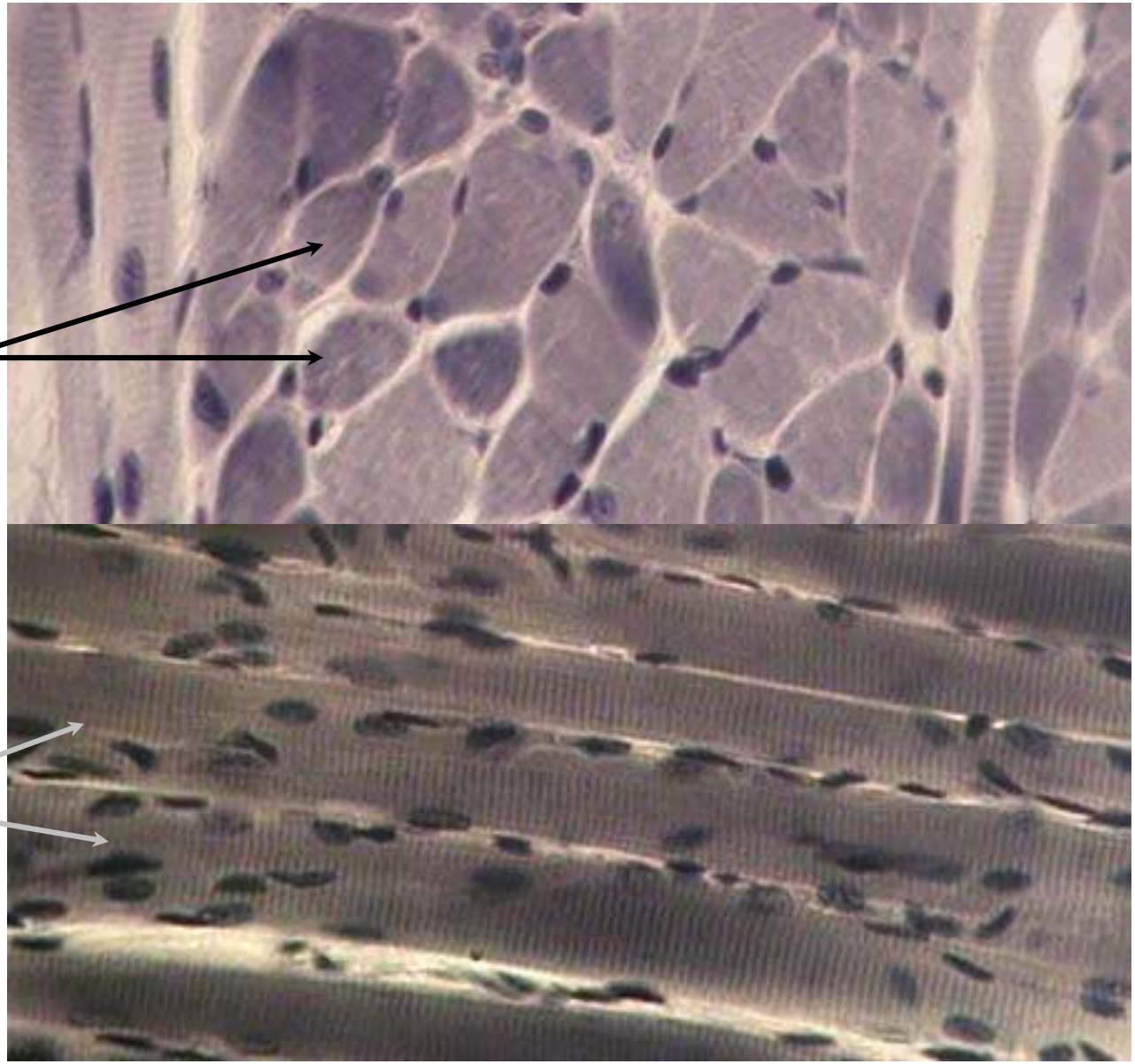


MUSCLE TISSUE TYPES



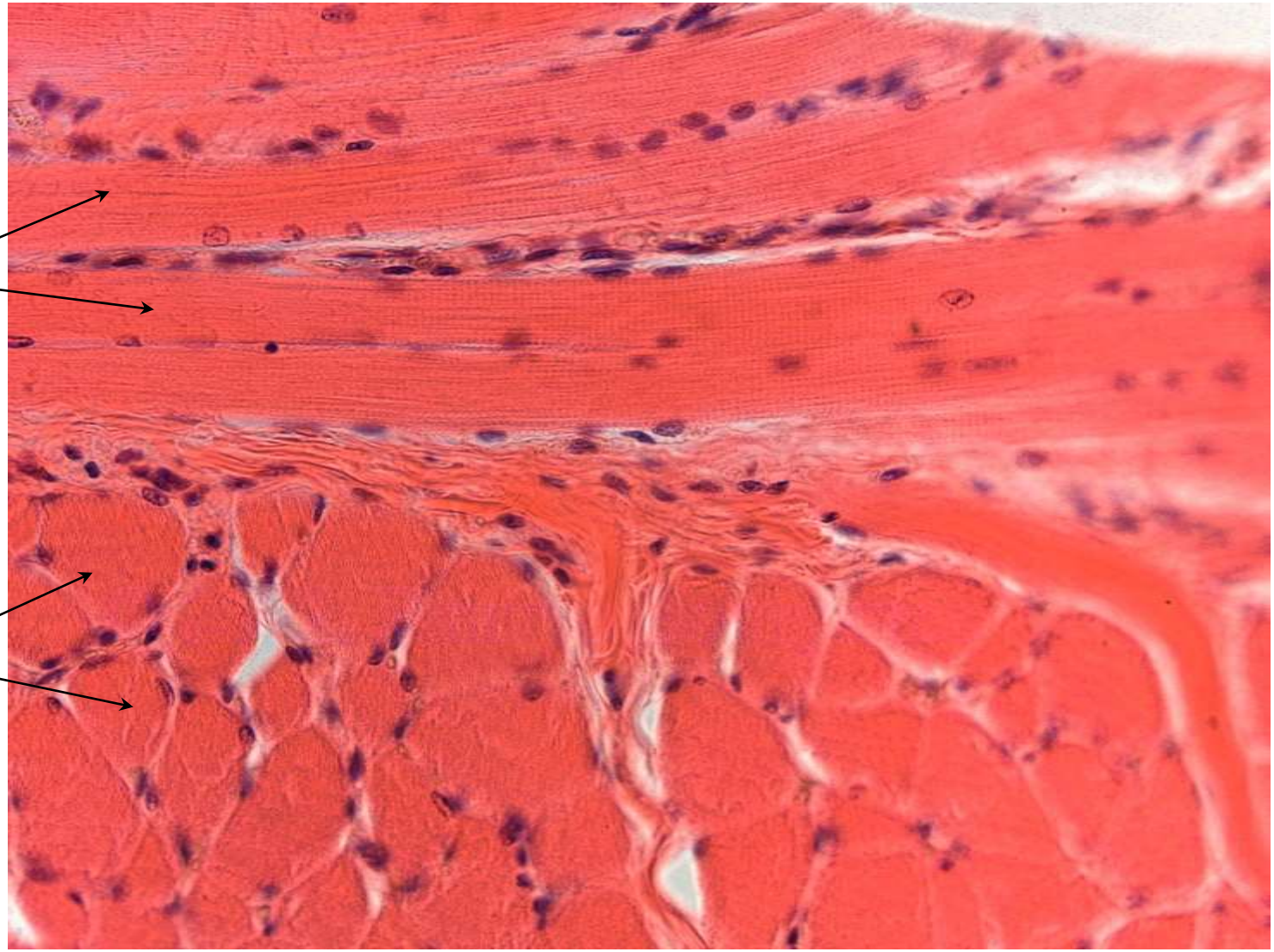
STRIATED SKELETAL MUSCLE TISSUE

Stained with H&E



STRIATED SKELETAL MUSCLE TISSUE

Stained with H&E



EMBRYONIC DEVELOPMENT OF SKELETAL MUSCLE

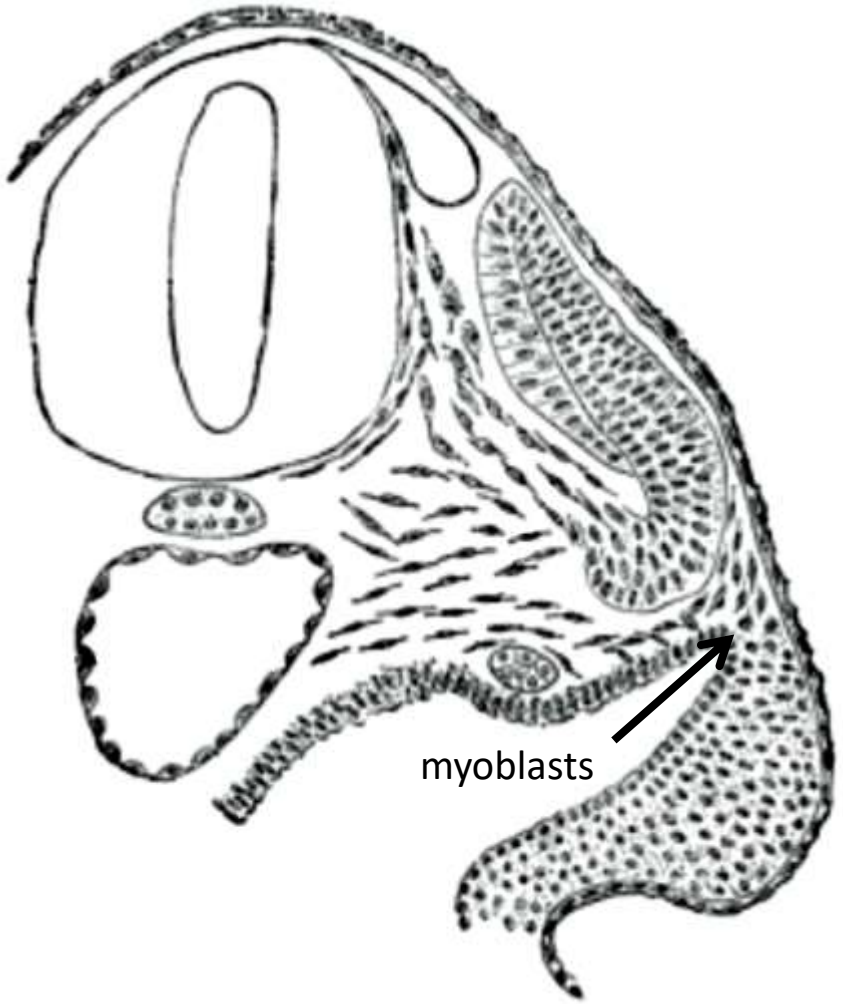
STAGES

1. Myoblasts originate from myotomes, undergo cell divisions and enlarge

2. Several hundreds myoblasts line up and fuse together to form a myotube (syncytium)

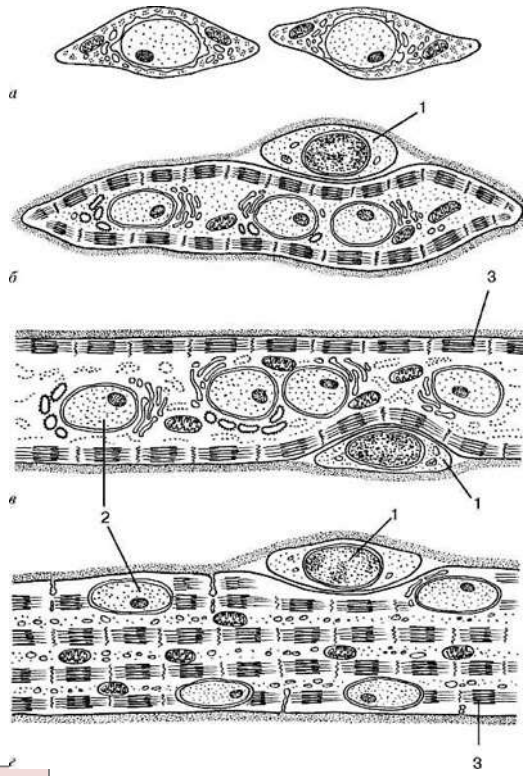
3. Myotubes mature to form skeletal muscle fibers

Addition of loose CT, capillaries and nerves



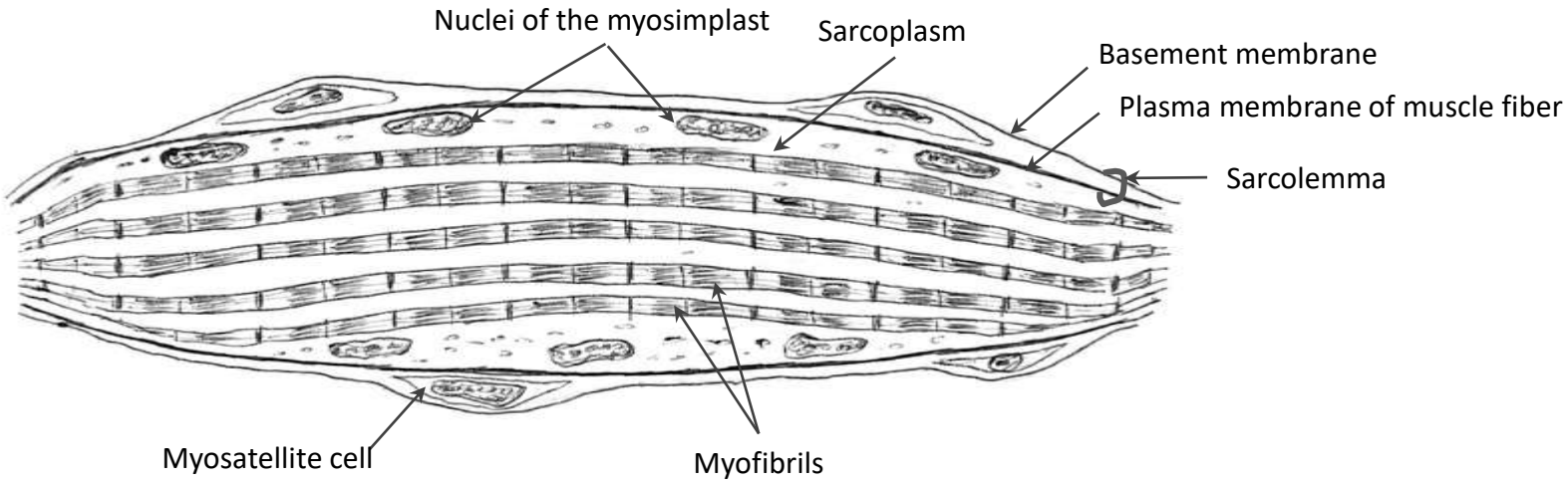
EMBRYONIC DEVELOPMENT of striated skeletal muscle tissue

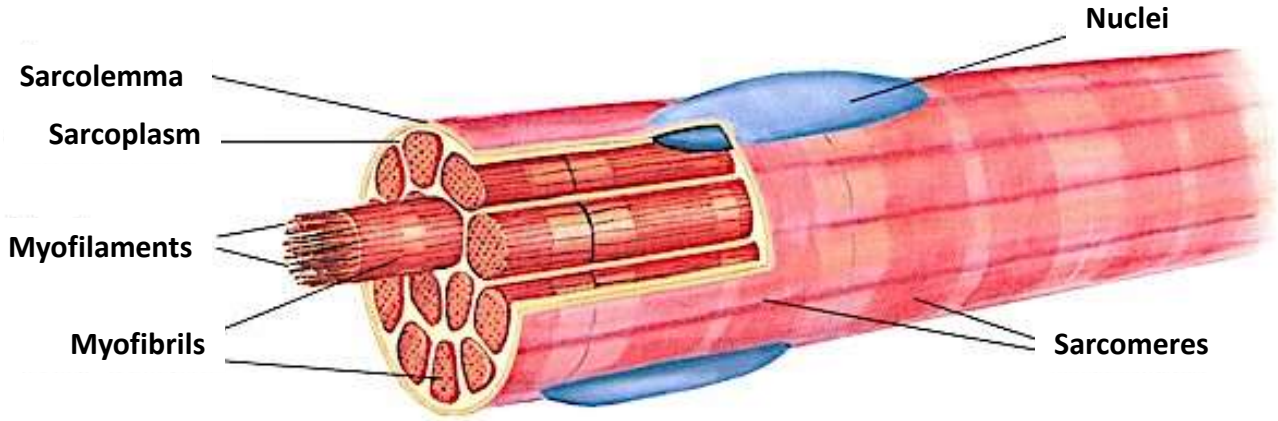
STAGES	CELL PROCESSES
1. Myoblasts	Proliferation
2. Myotubes	Proliferation and differentiation
	Differentiation
3. Muscle fibers	Growth

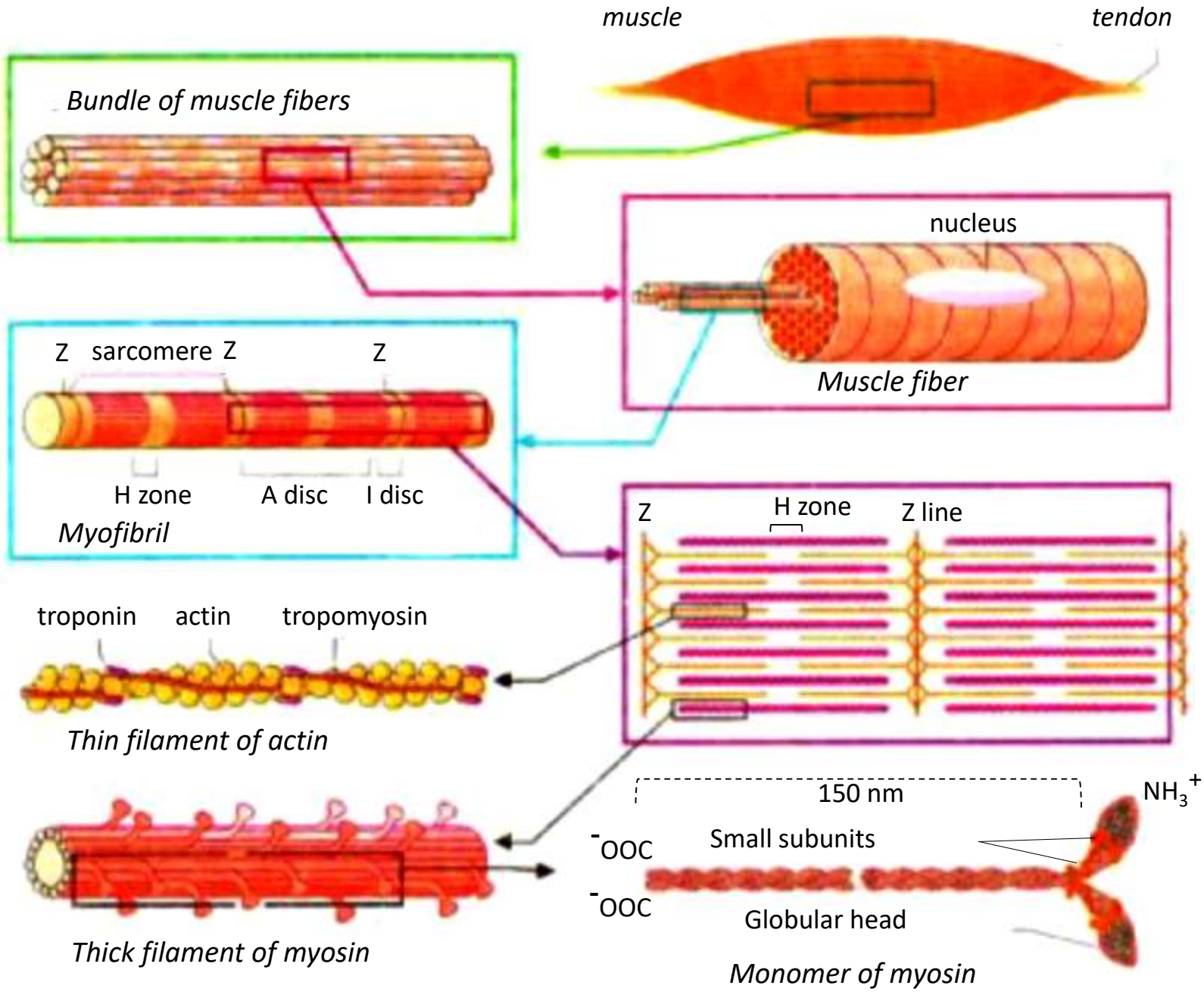


+ loose CT + capillaries+ nerves

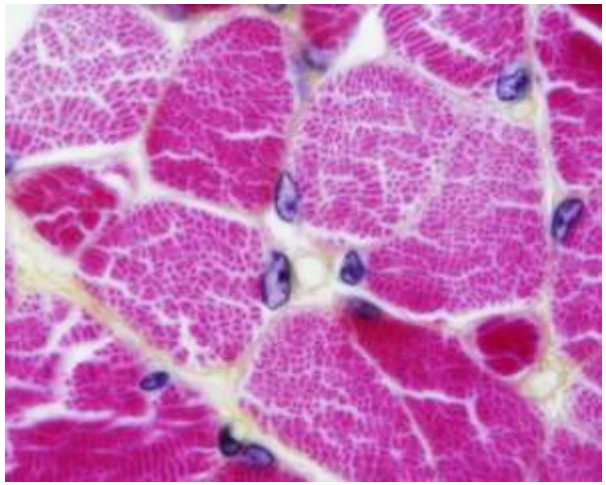
MUSCLE FIBER is structural and functional unit of skeletal muscle

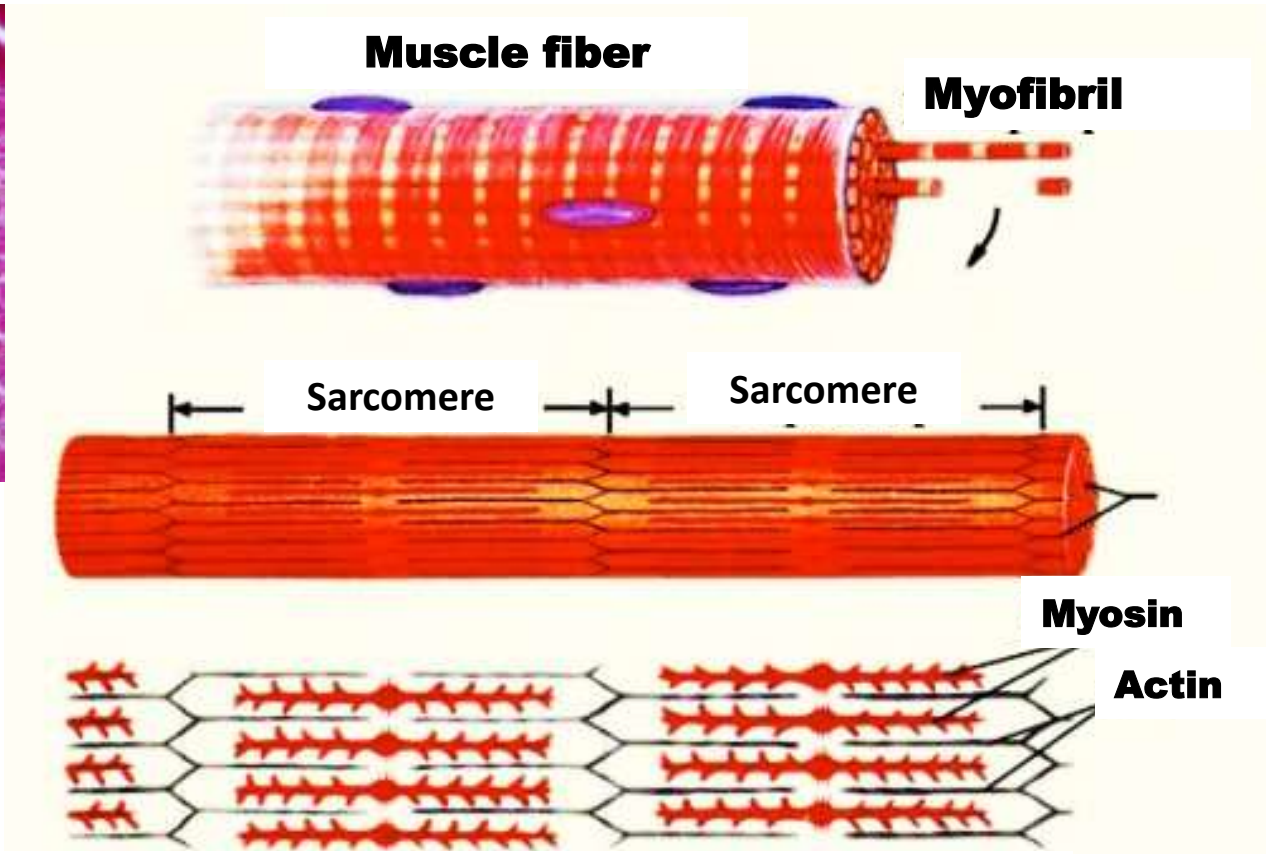


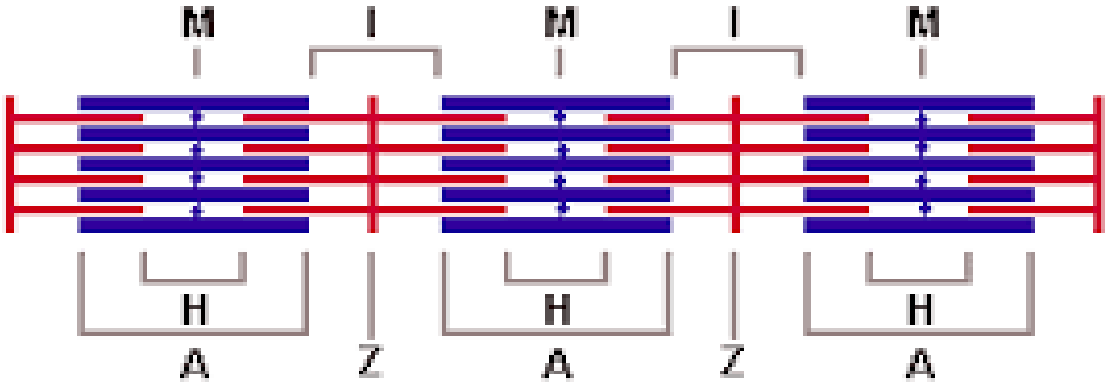



muscle
tendon
Bundle of muscle fibers
nucleus
Muscle fiber
Z
sarcomere
Z
Z
H zone
A disc
I disc
Myofibril
Z
H zone
Z line
troponin
actin
tropomyosin
Thin filament of actin
150 nm
NH_3^+
^-OOC
Small subunits
^-OOC
Globular head
Thick filament of myosin
Monomer of myosin

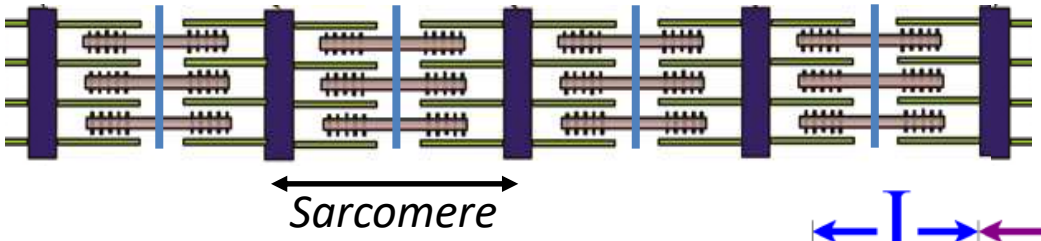
CONTRACTILE APPARATUS OF MUSCLE FIBER
MYOFIBRIL







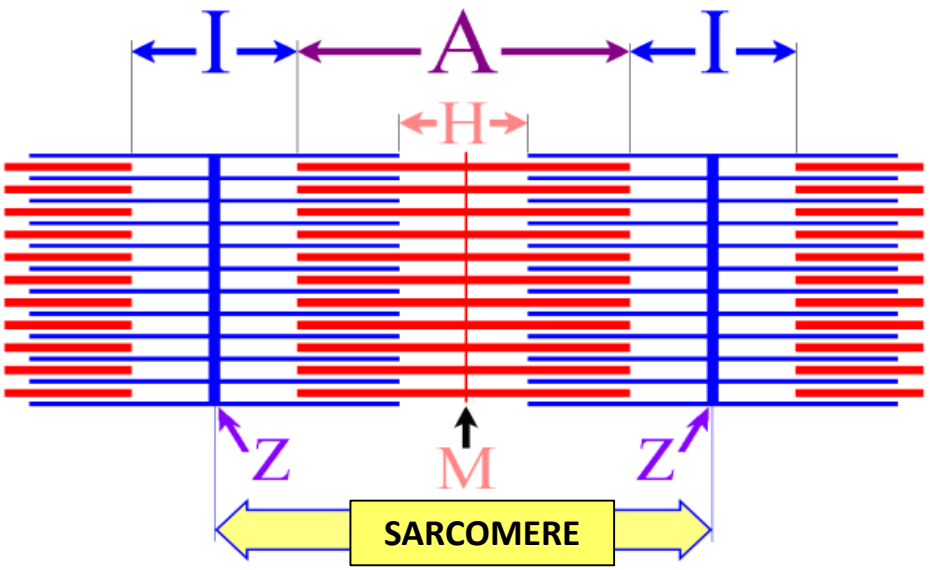
MYOFIBRIL

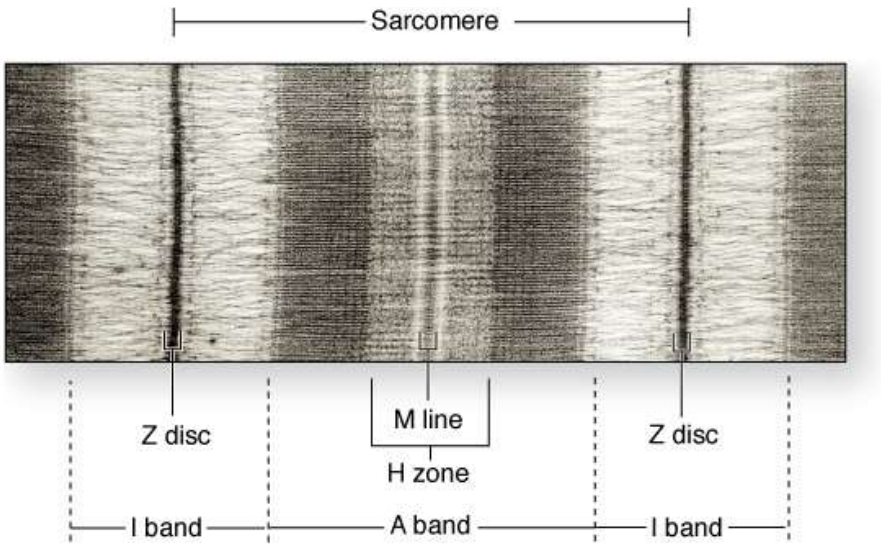


MYOFIBRIL STRUCTURE
SARCOMERE STRUCTURE

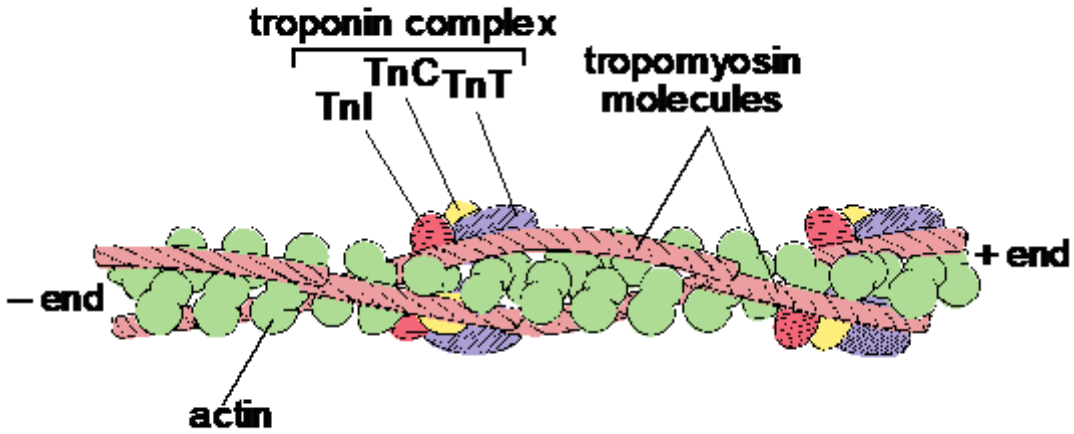
Z line = telophragm

M line = mesophragm





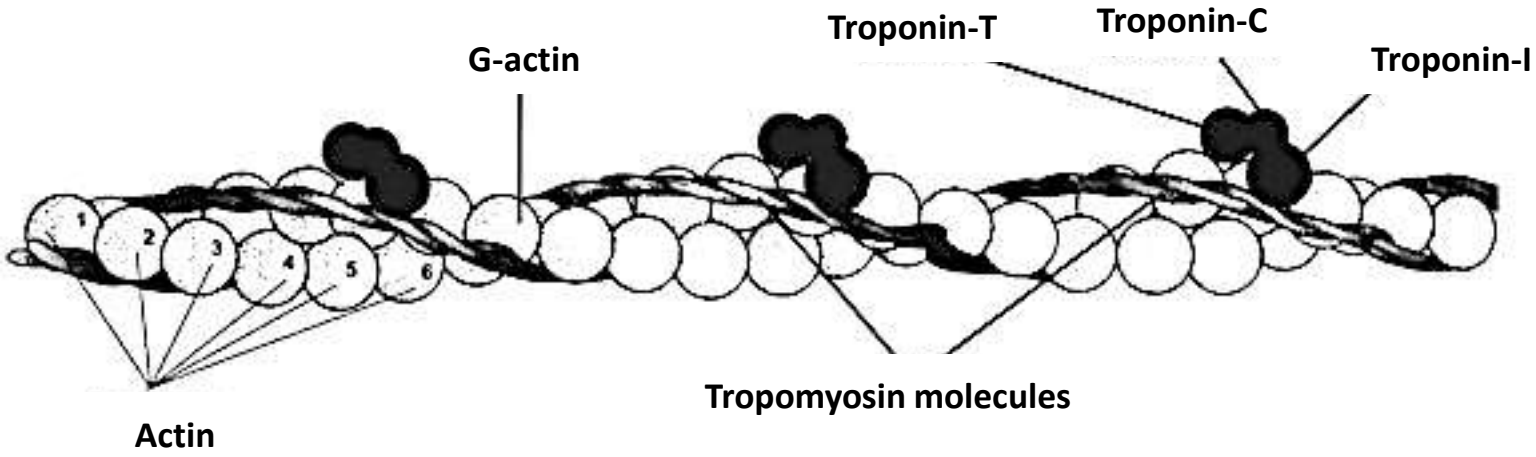
MYOFILAMENTS STRUCTURE



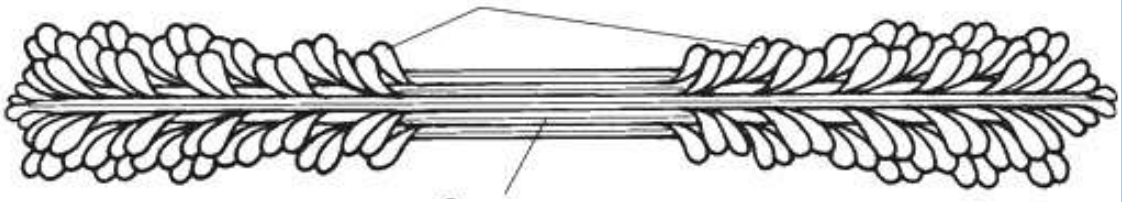
Binds to trohomyosin

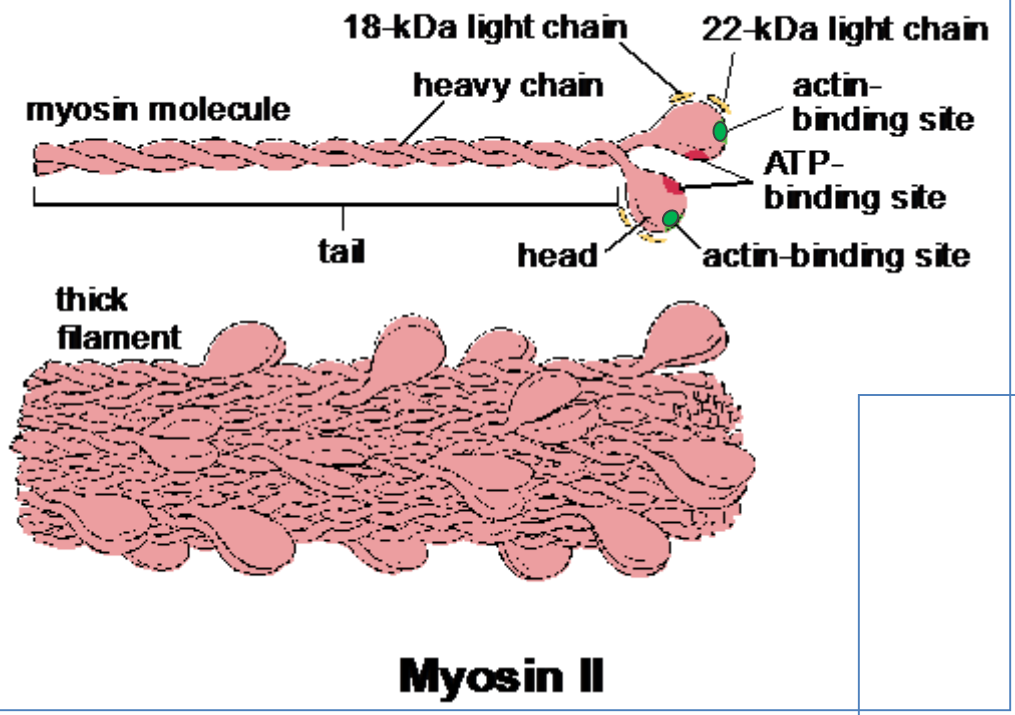
Binds to Ca^{2+}

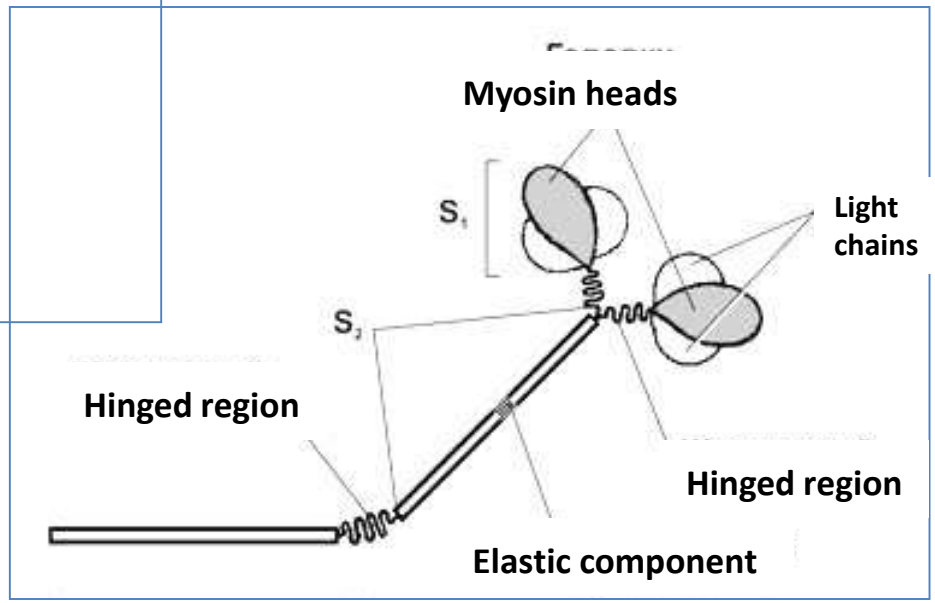
Inhibits actin-myosin interaction

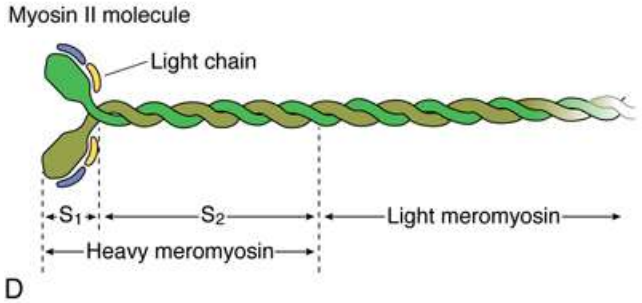


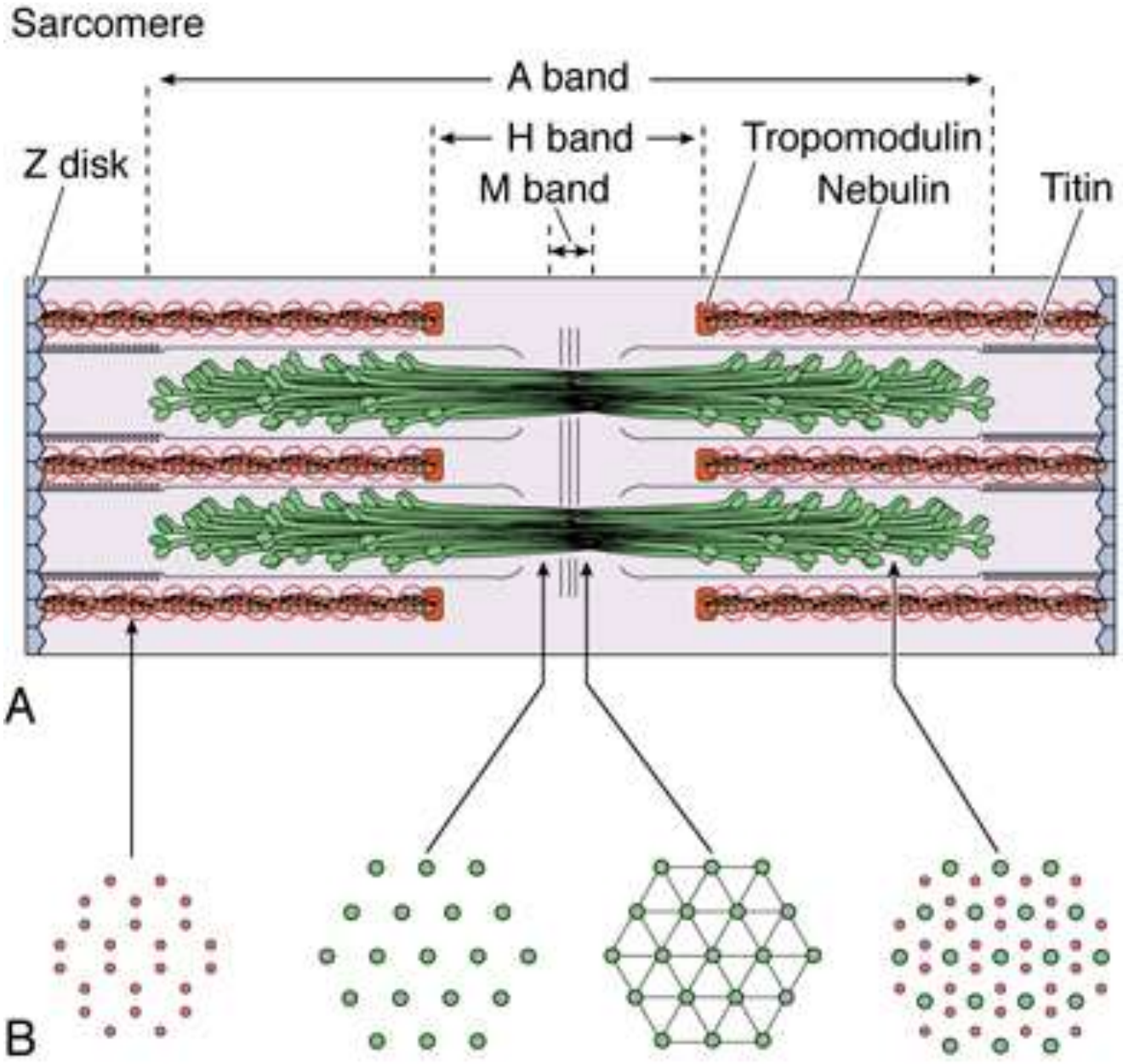
MYOFILAMENTS STRUCTURE



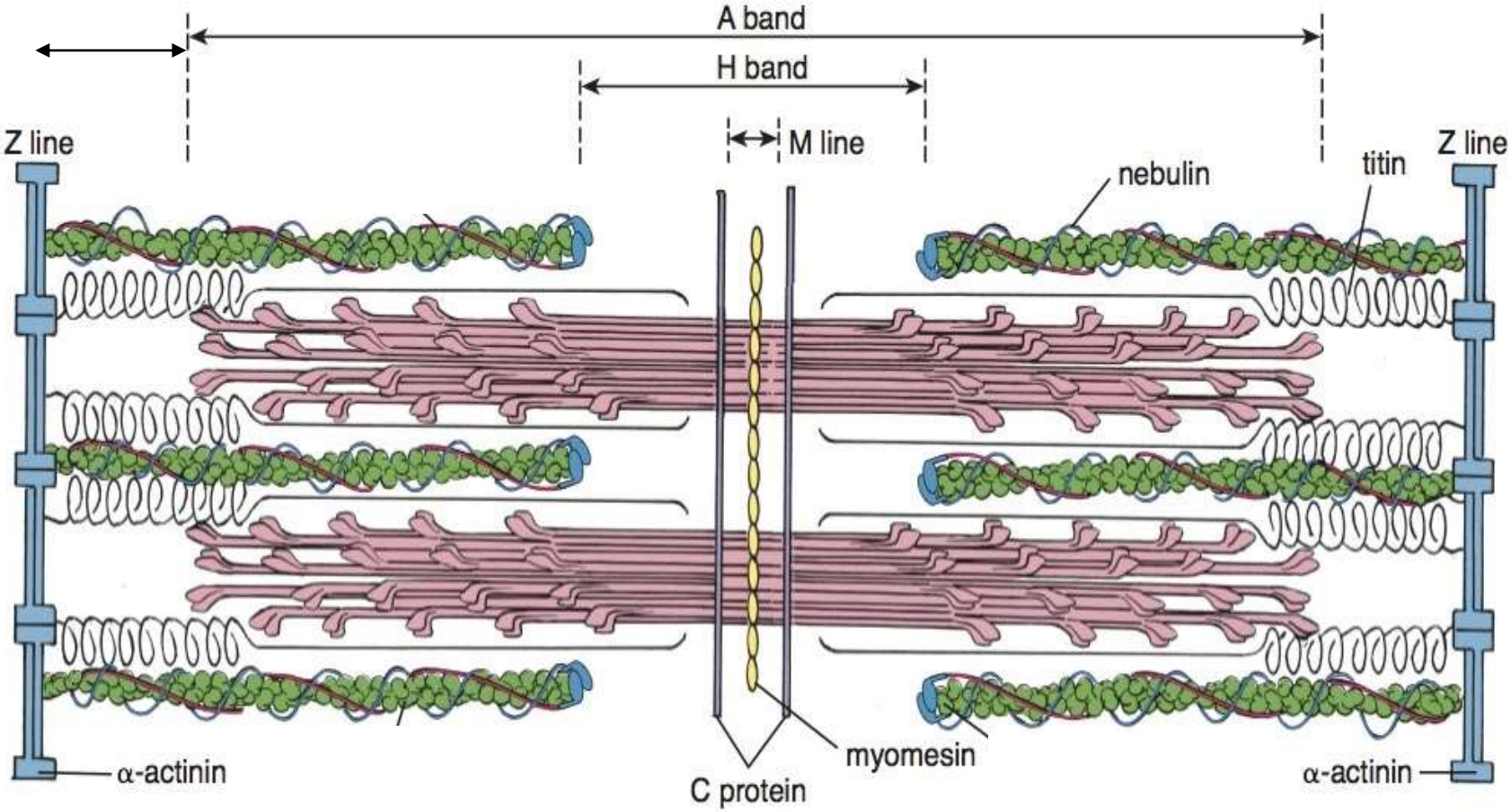




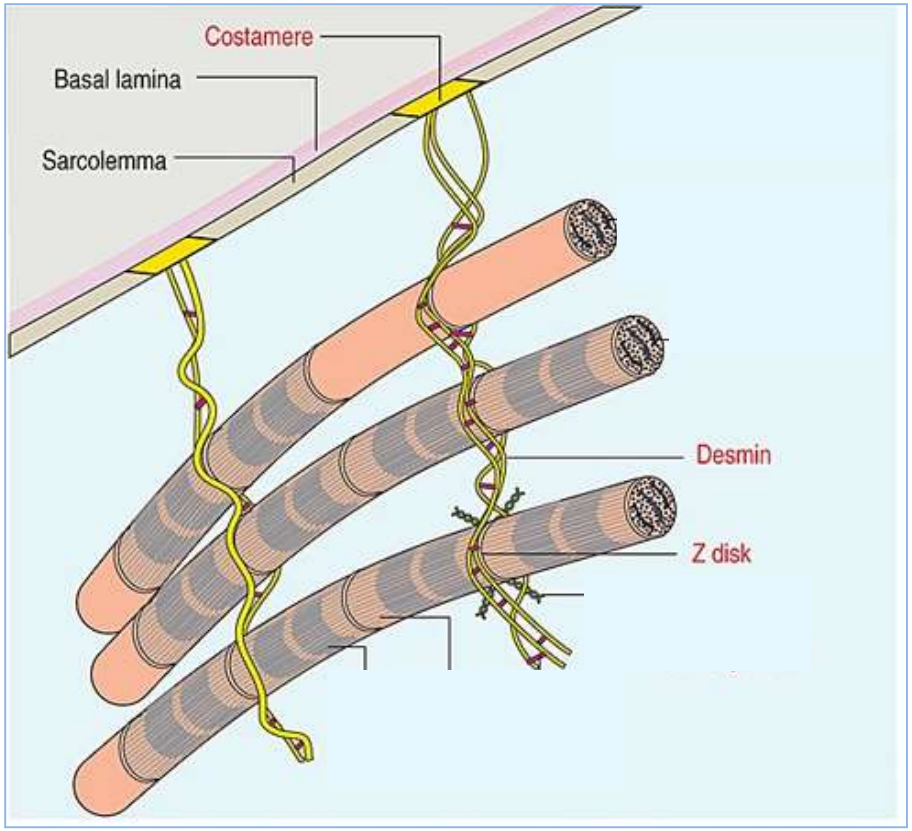


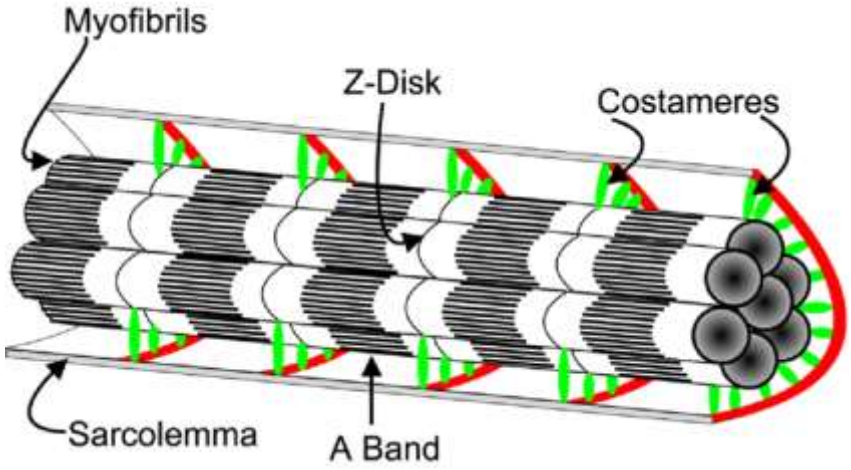

Sarcomere
A band
H band
M band
Z disk
Tropomodulin
Nebulin
Titin
A
B

MYOFIBRIL STRUCTURE



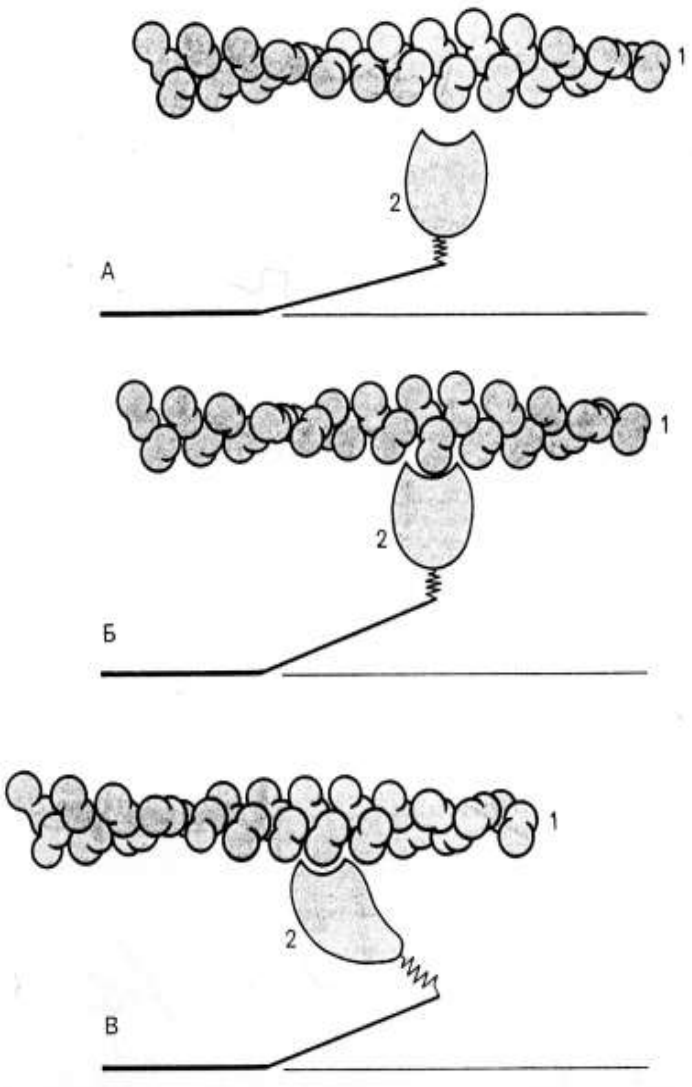
SIMPLAST CYTOSKELETON





CONTRACTILE MECHANISM
according to SLIDING FILAMENT MODEL (HUXLEY, 1954)

shortening of the sarcomere is caused by an increase in the overlap of the thick and thin filaments



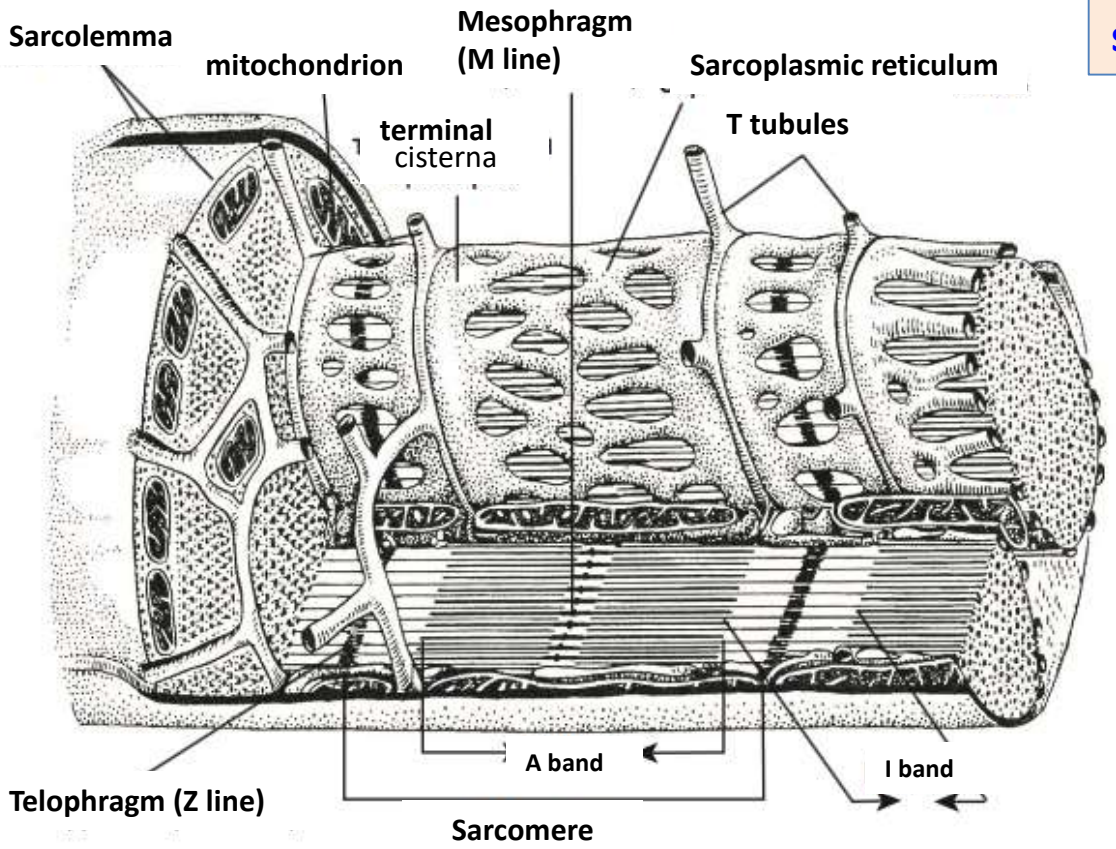
Mechanism of contraction is cyclic process:
In the resting muscle actin and myosin don't interact.
The heads of myosin molecule are free from ATP;
binding sites of actin mask by tropomyosin.

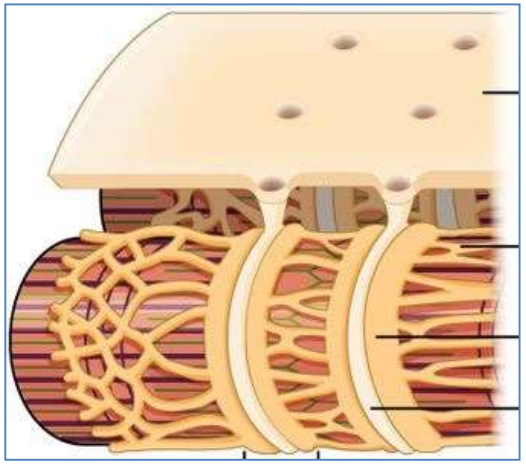
Ca^{2+} iones bind to TnC, changing the configuration of Tn Subunits and driving tropomyosin molecule deeper into the cleft between F-actin chains. This exposes the myosin binding site on G-actin.
ATP binds to the myosin.
Myosin head forms the cross-brige with G-actin

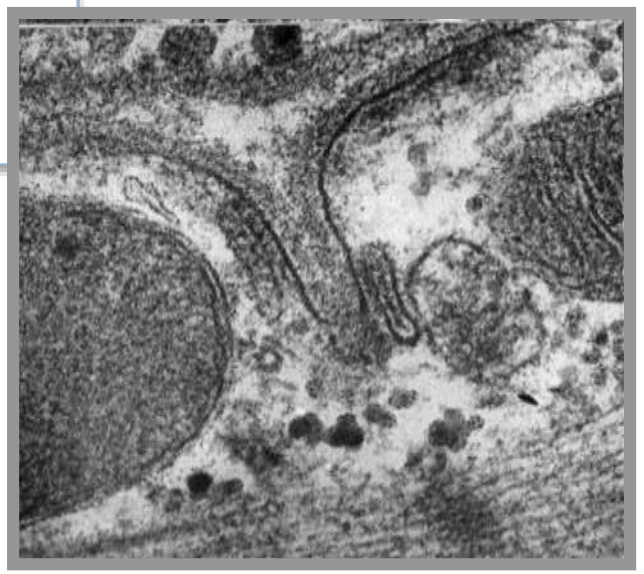
Hydrolysis of ATP. Energy is necessary to change angle between light and heavy meromyosins, it becomes shaper and bends toward H zone. Because myosin is bound to actin, actin filament is drived in the same direction (10 nM)

ADP and phosphate are lost from myosin head.
It courses the releasing myosin head from actin, myosin head resumes its original conformation.
It's recocked for the next stroke

REGULATION OF CONTRACTION: sarcoplasmic reticulum, T system

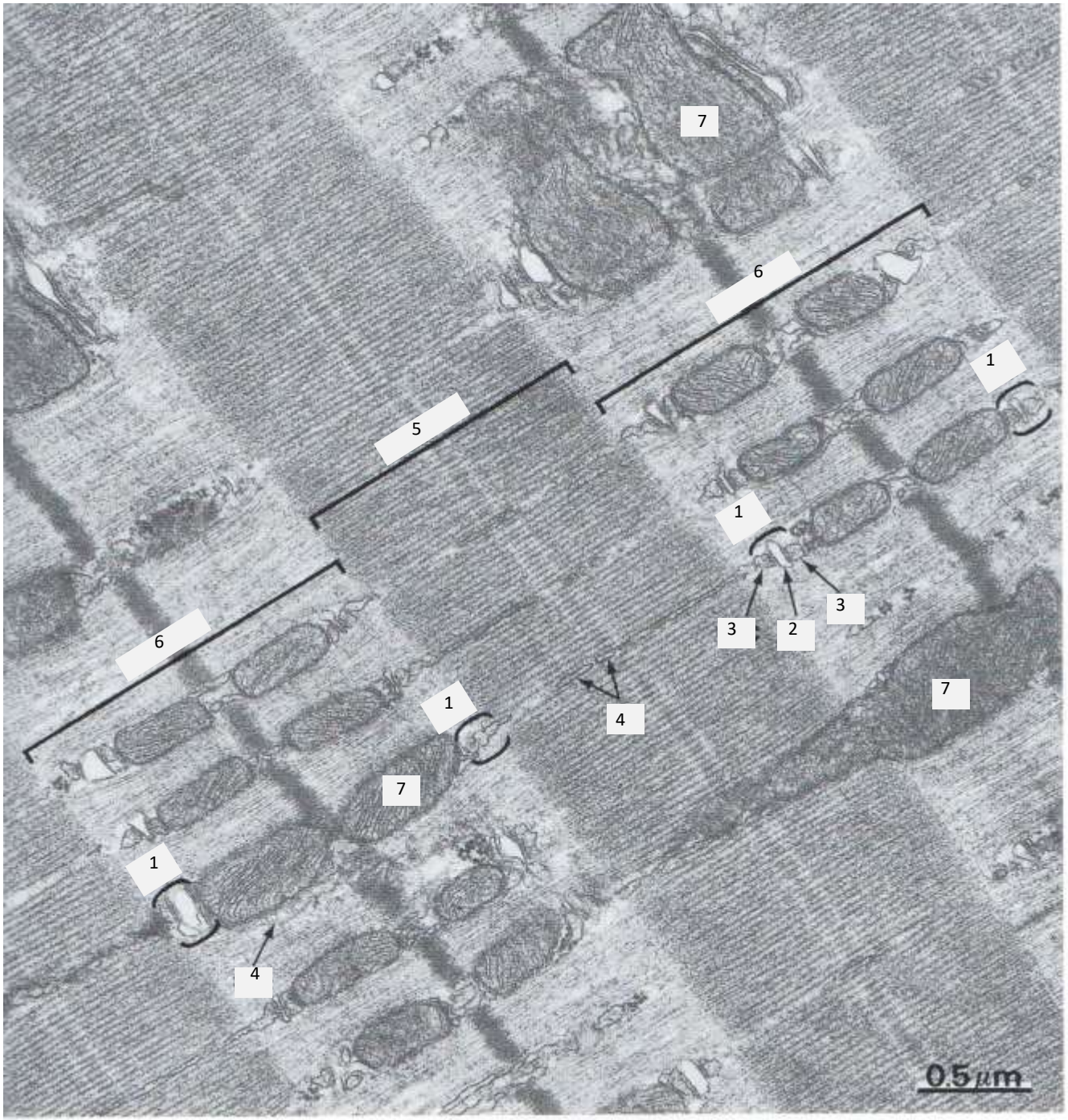




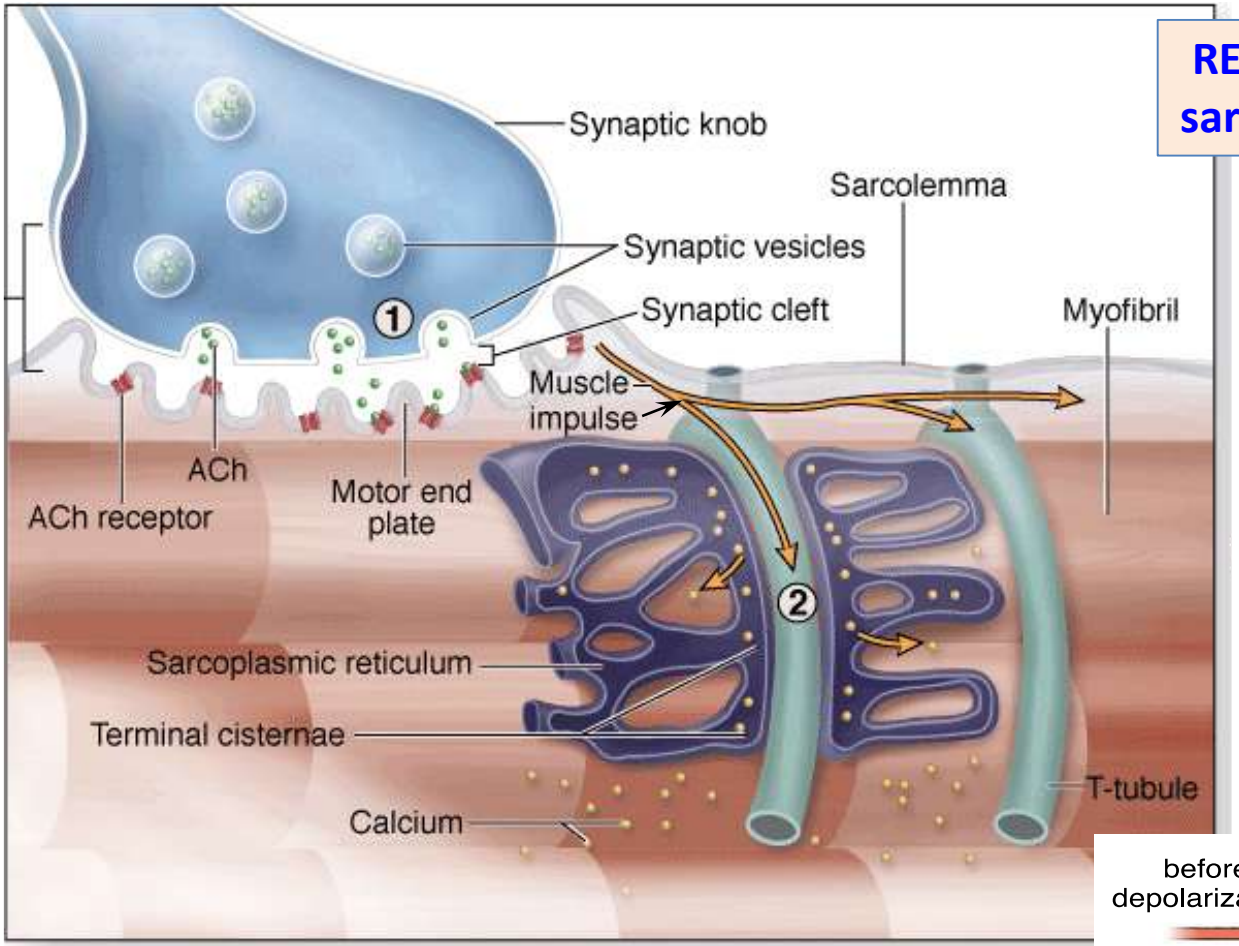


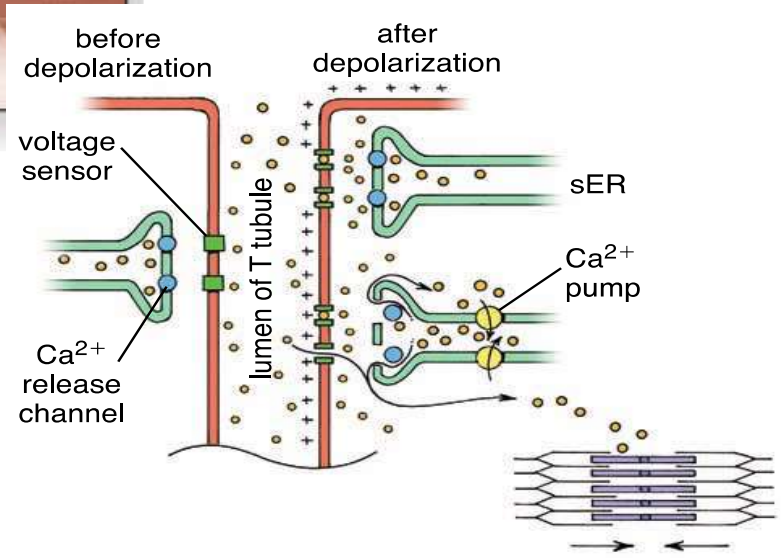
TRIAD:

T-tubule and
2 terminal cisternae

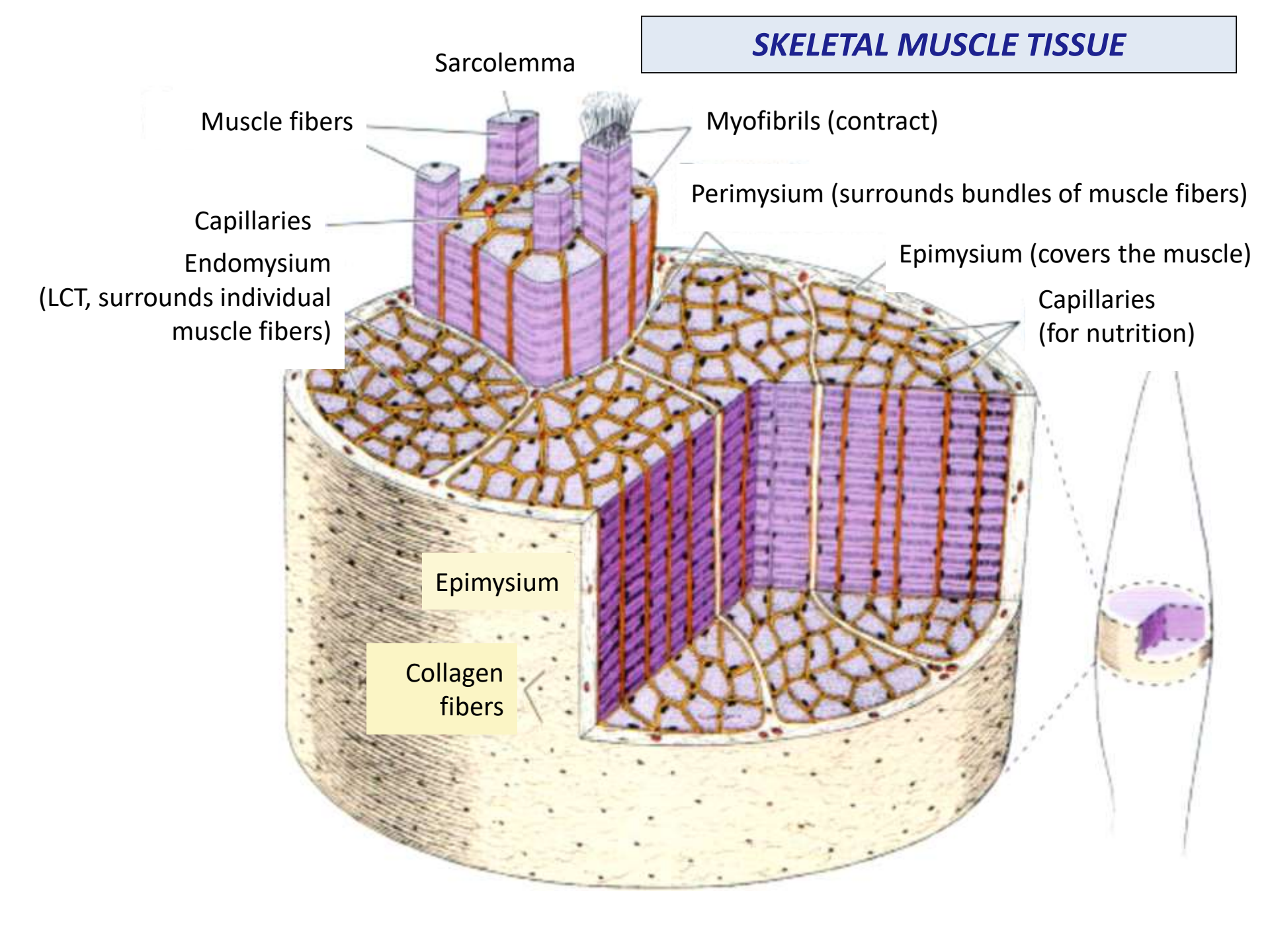

7
6
1
5
1
3
3
2
6
7
1
4
7
1
4
0.5 μm

REGULATION OF CONTRACTION: sarcoplasmic reticulum, T system

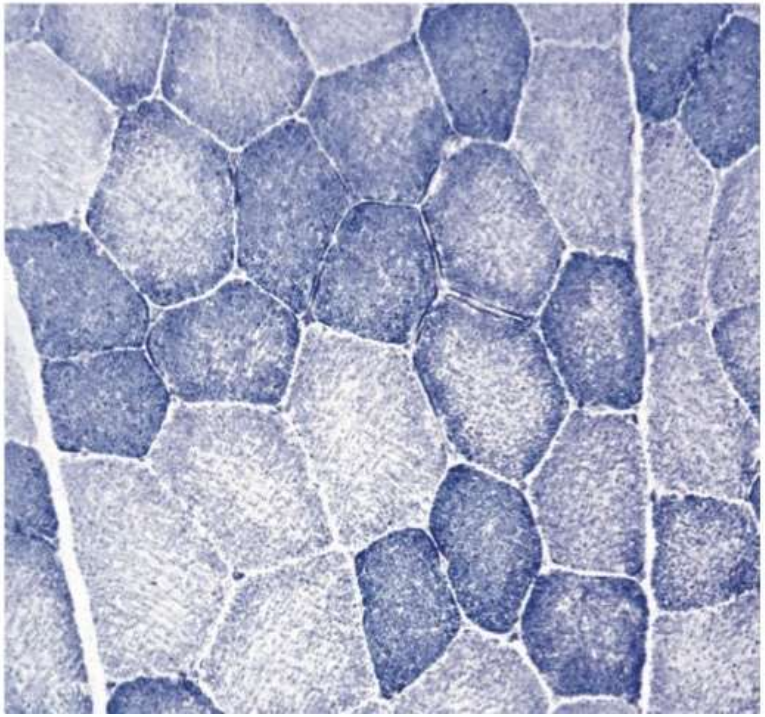




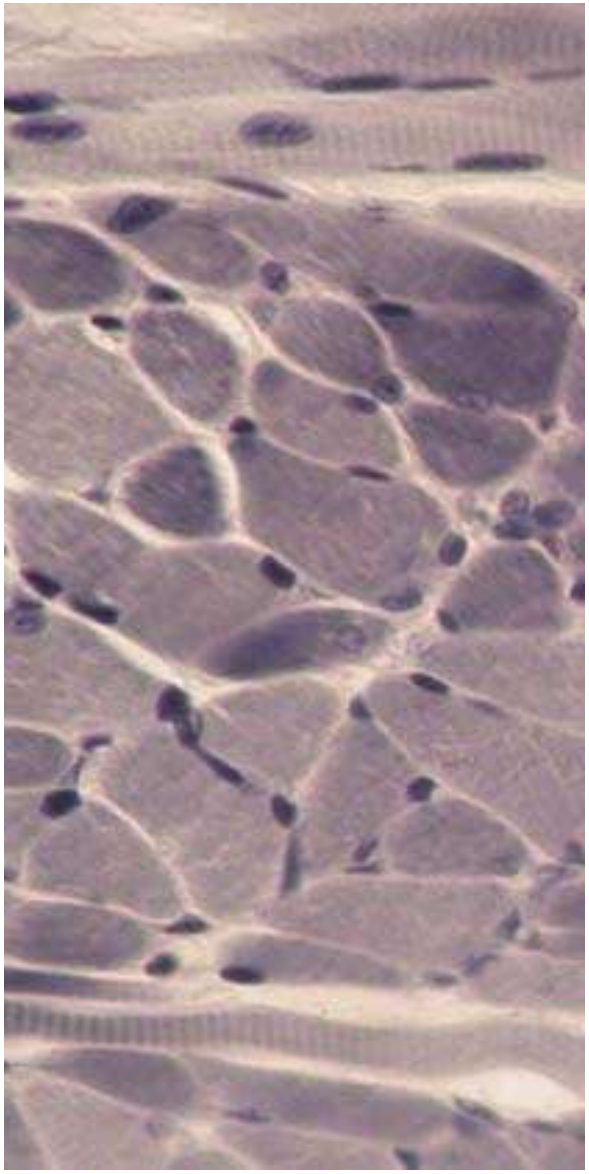
SKELETAL MUSCLE TISSUE



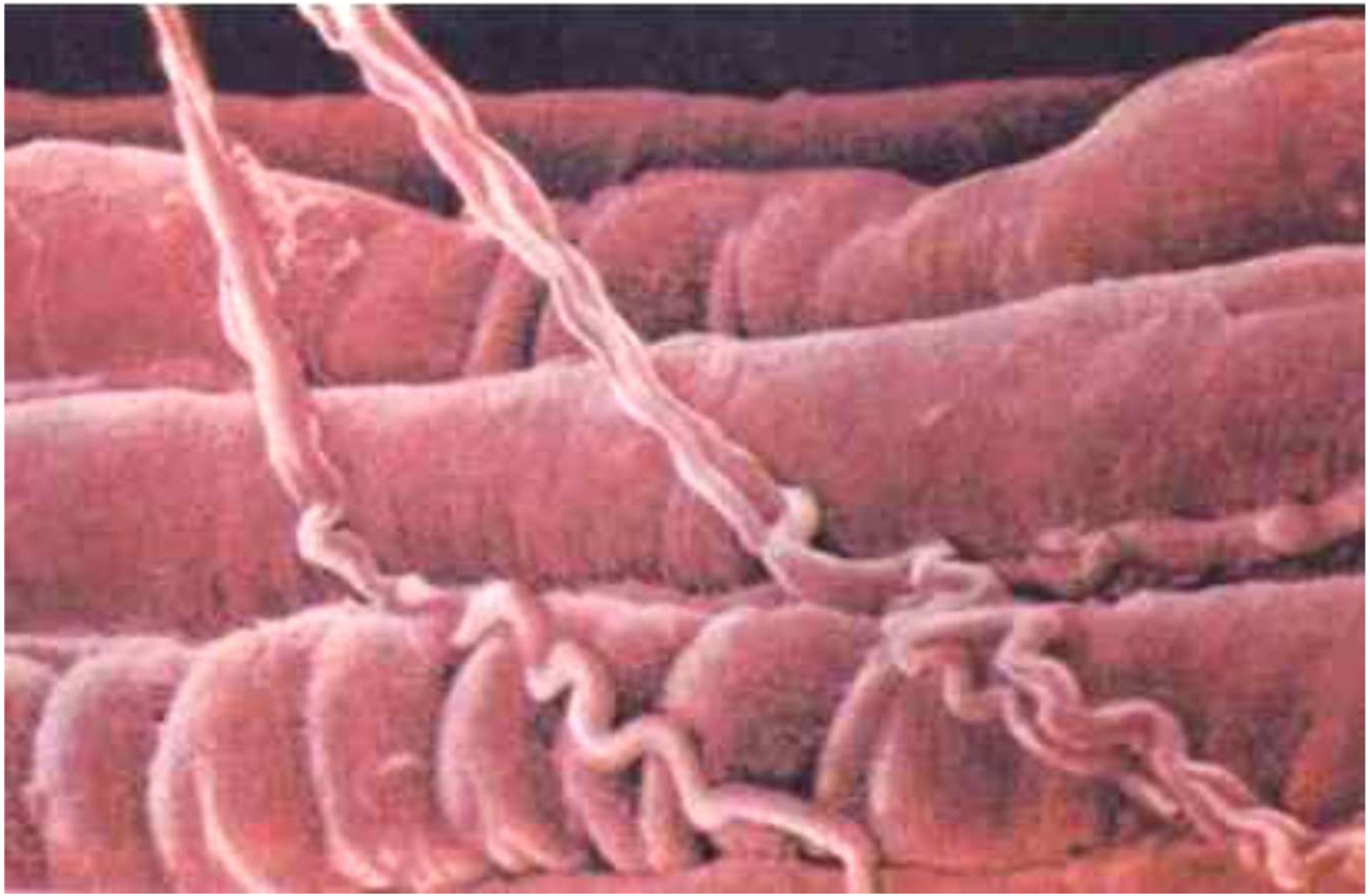
Types of muscle fibers



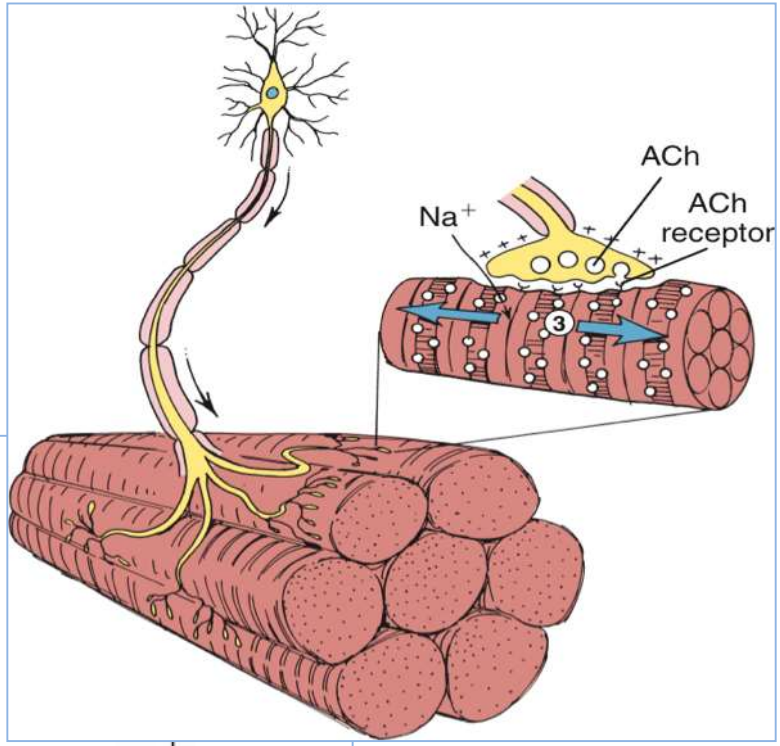
- Red
- White
- Intermediate

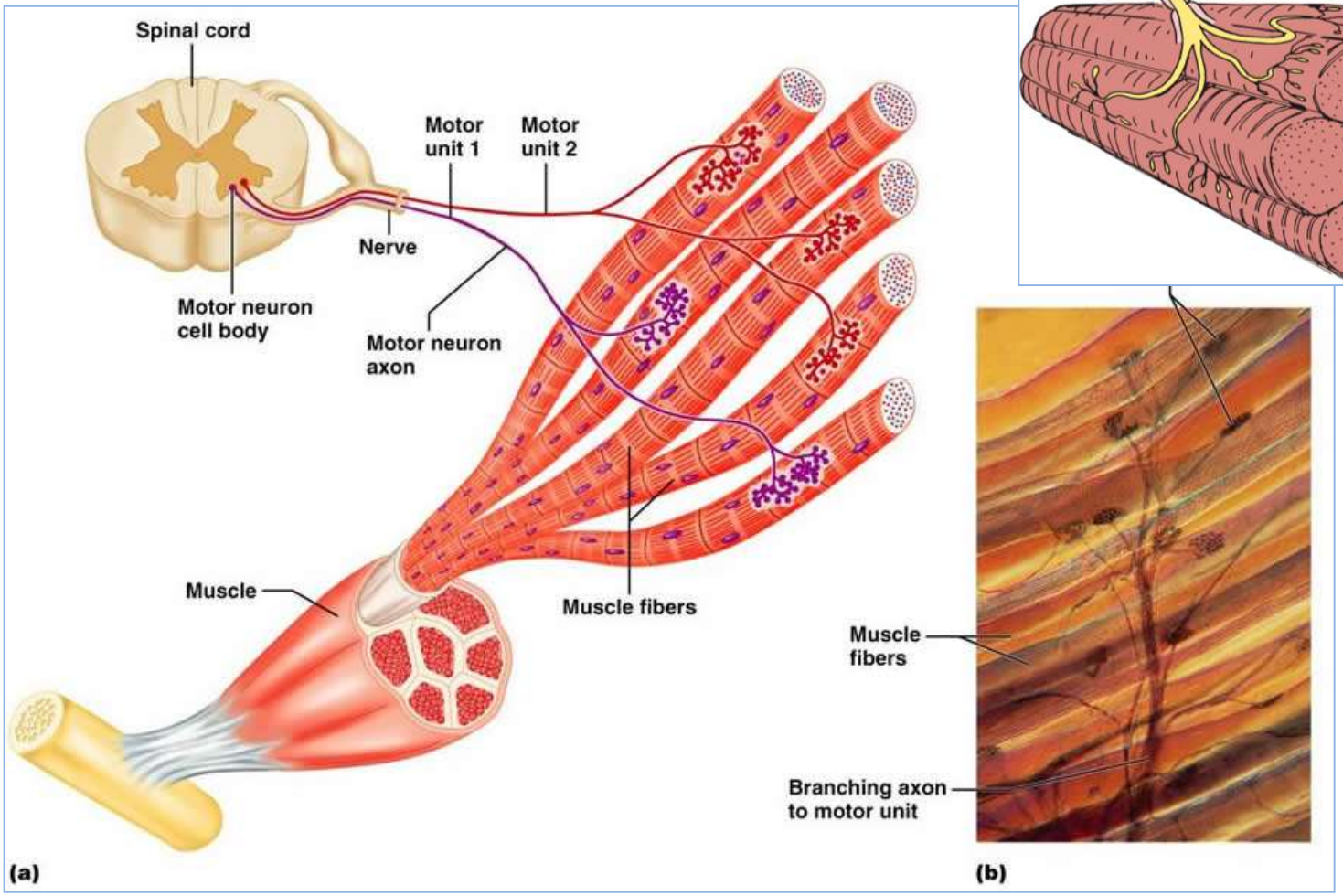


Innervation of Muscle fibers

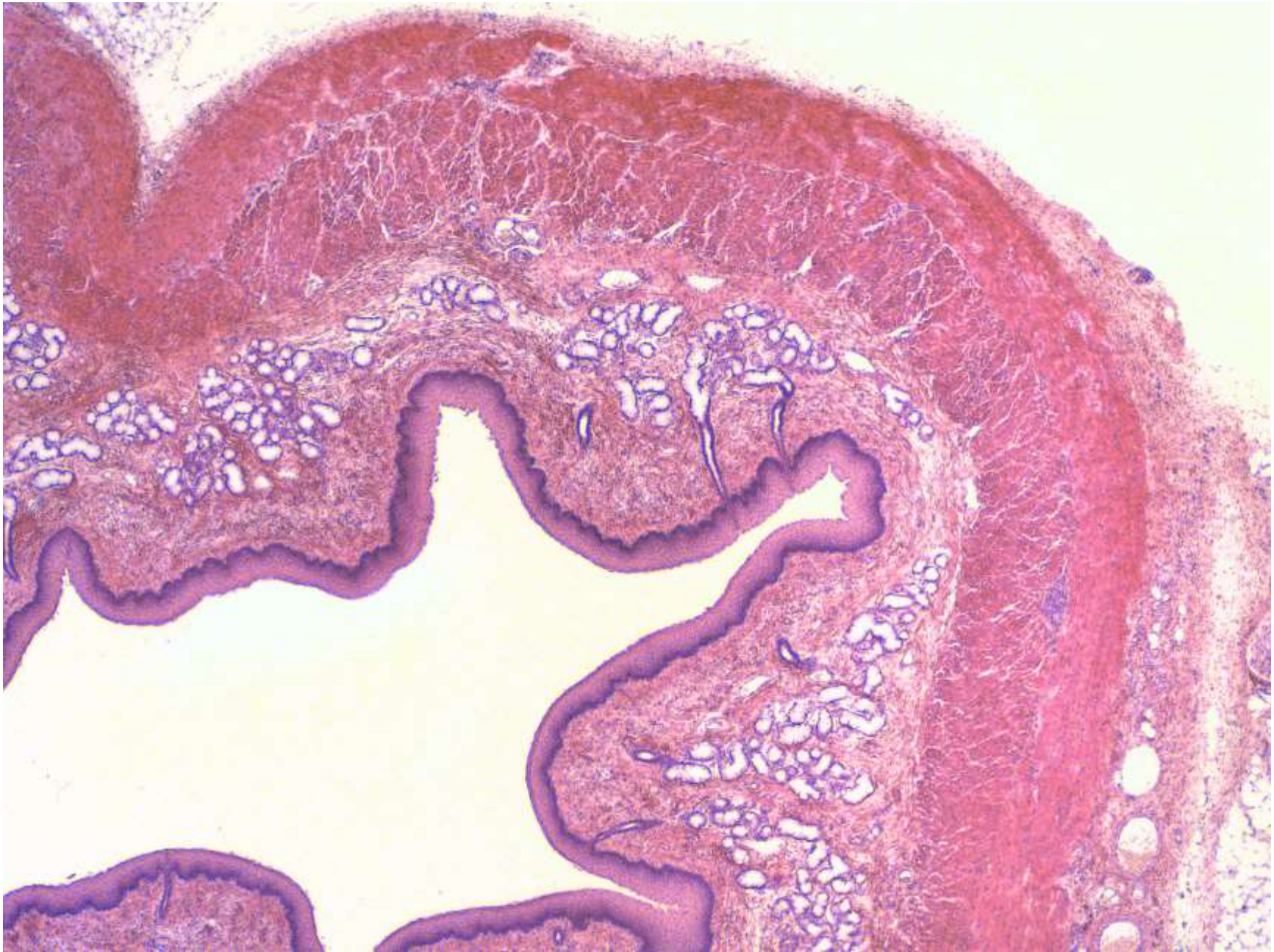


MOTOR UNIT

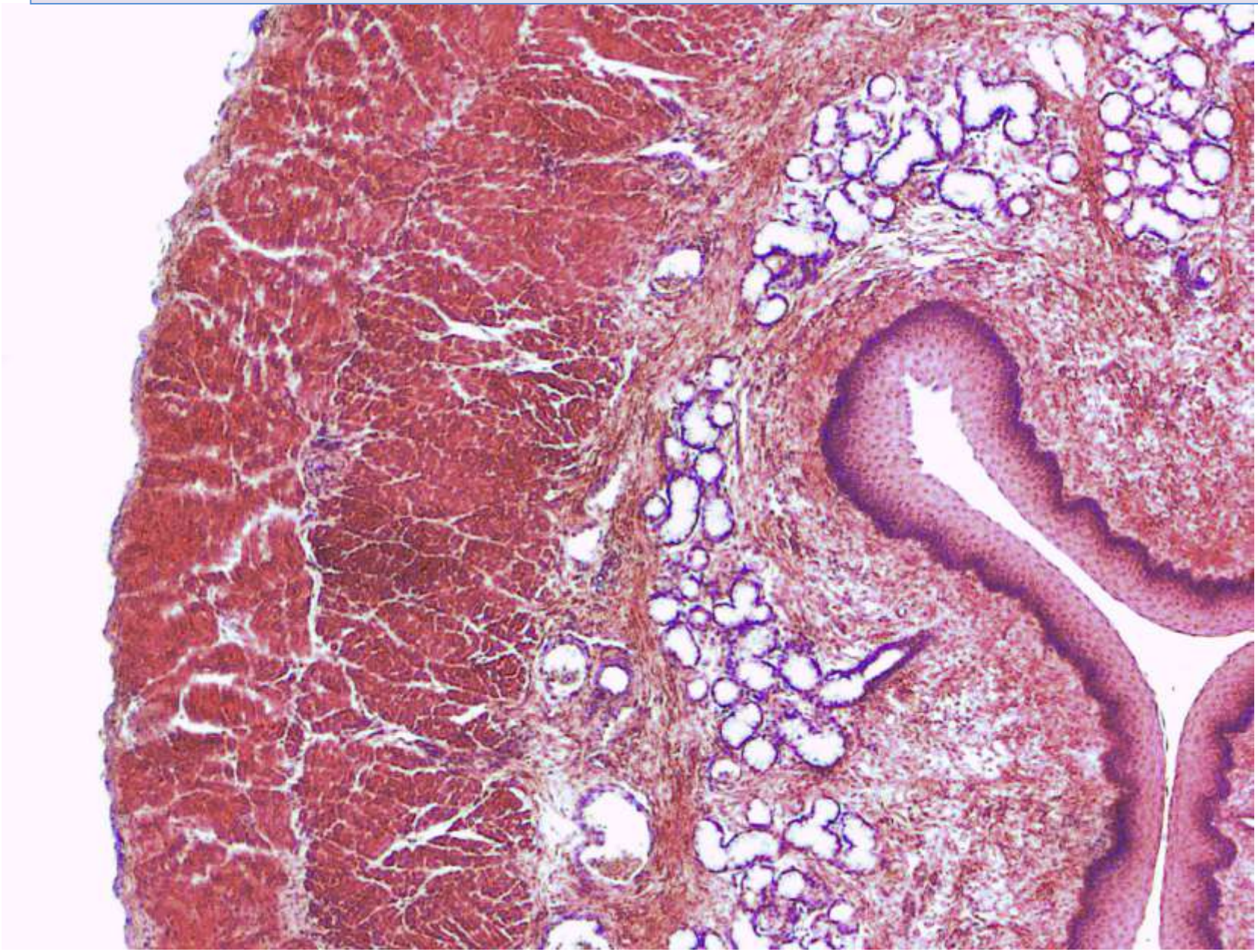

ACh
ACh receptor
Na+
3


Spinal cord
Motor unit 1
Motor unit 2
Nerve
Motor neuron cell body
Motor neuron axon
Muscle
Muscle fibers
(a)
Muscle fibers
Branching axon to motor unit
(b)

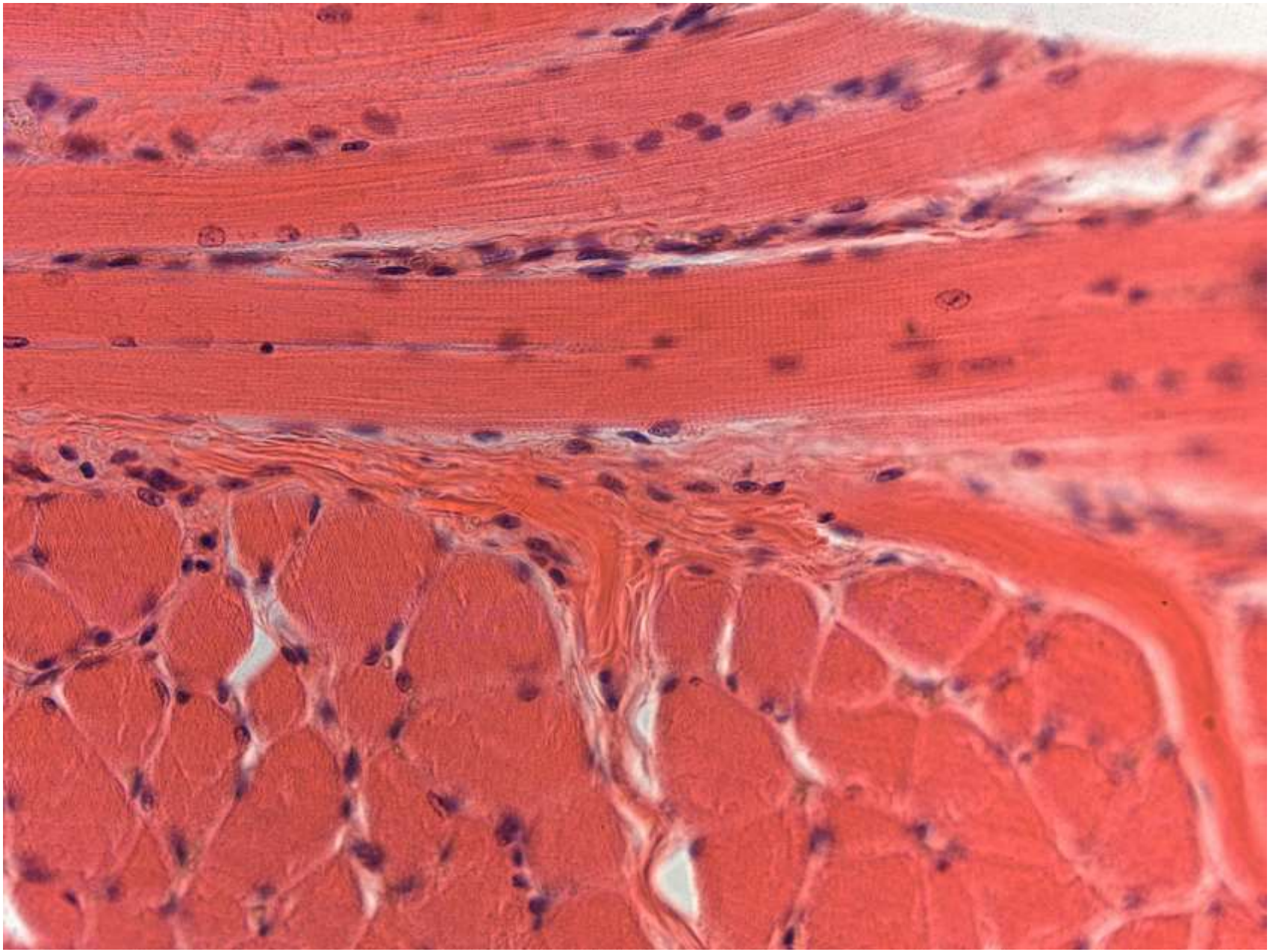
Slide №70 «Striated skeletal muscle tissue. Section of esophagus, H&E»



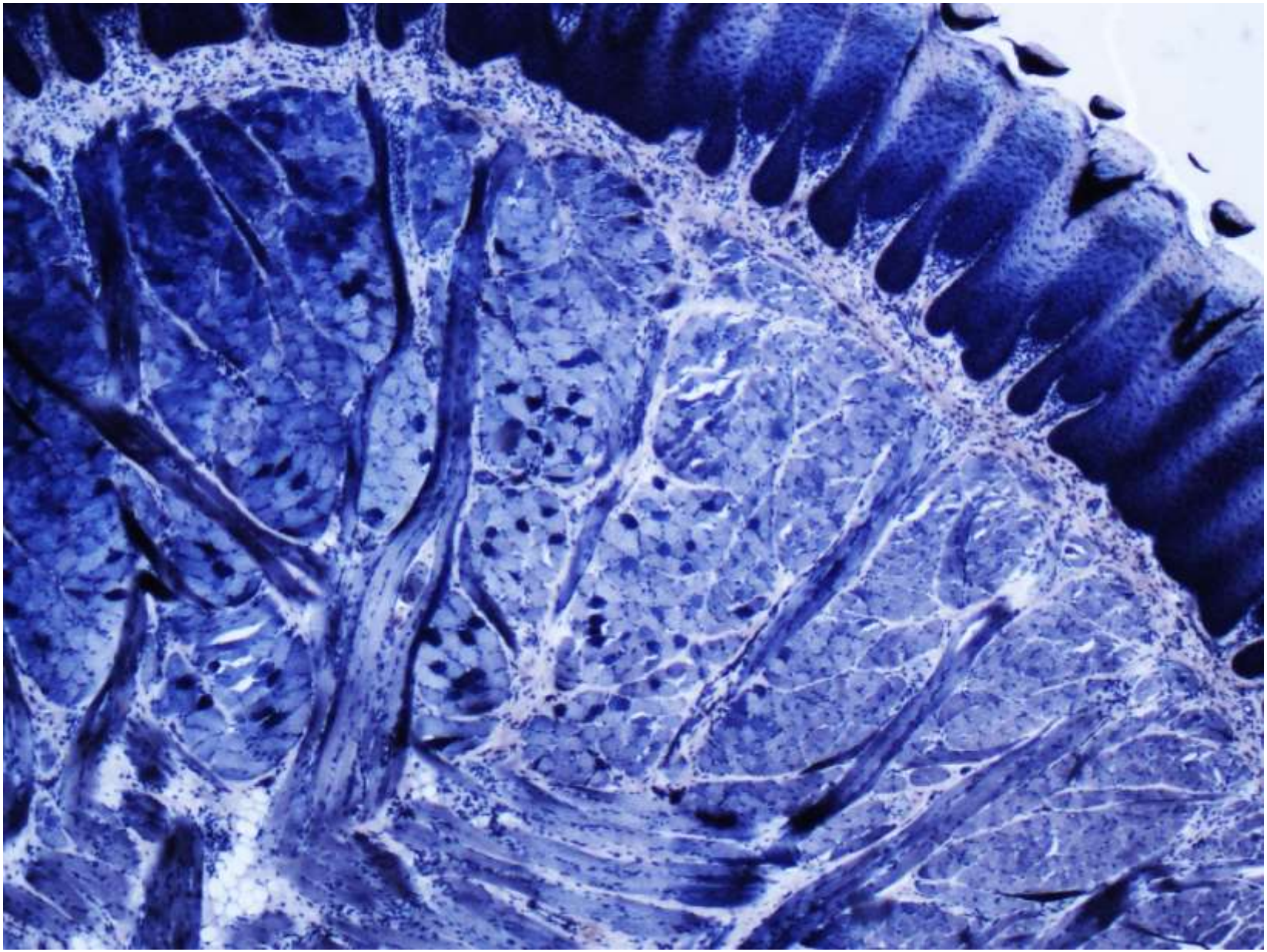
Slide №70 «Striated skeletal muscle tissue. Section of esophagus, H&E»



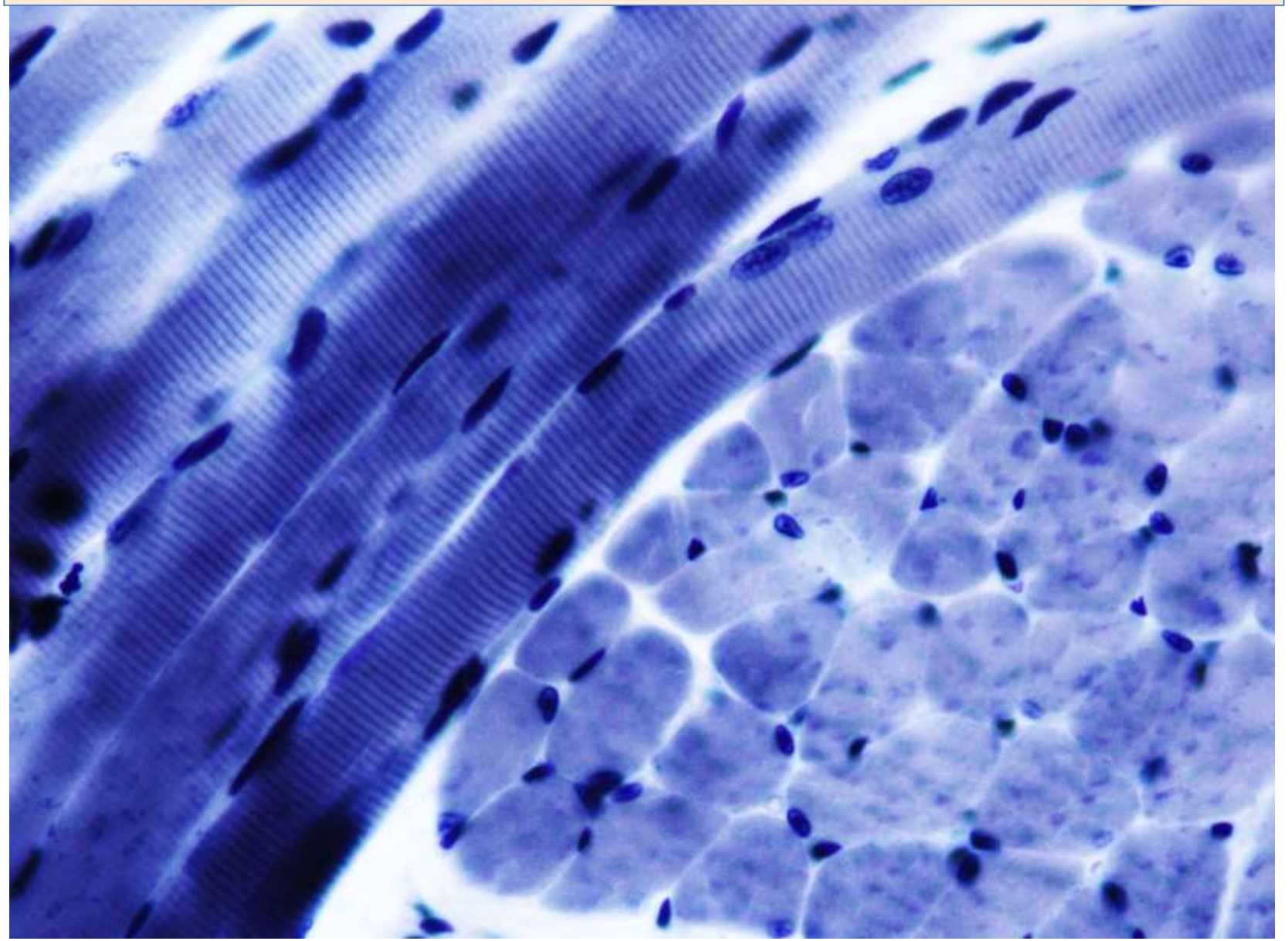
Slide №70 «Striated skeletal muscle tissue. Section of esophagus, H&E»



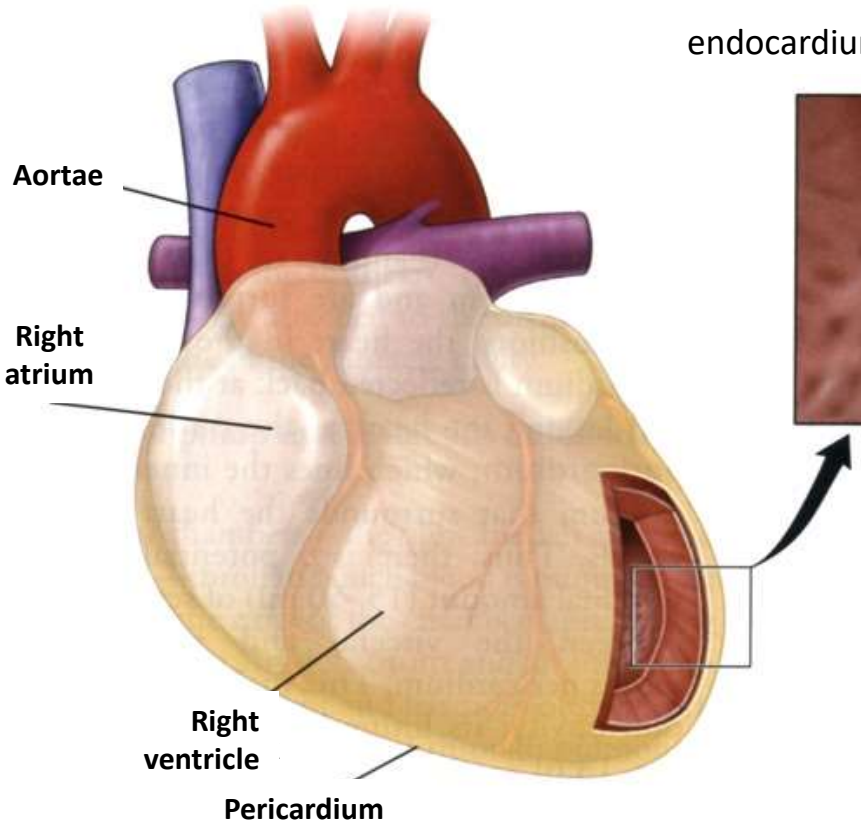
Slide №70a «Striated skeletal muscle tissue. Section of tongue» H&E

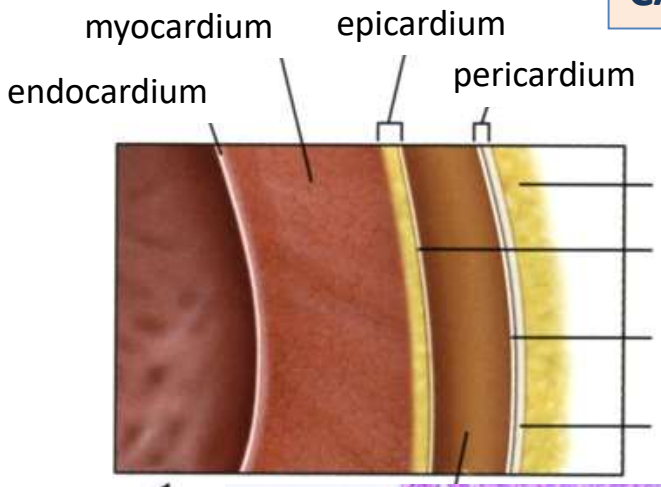


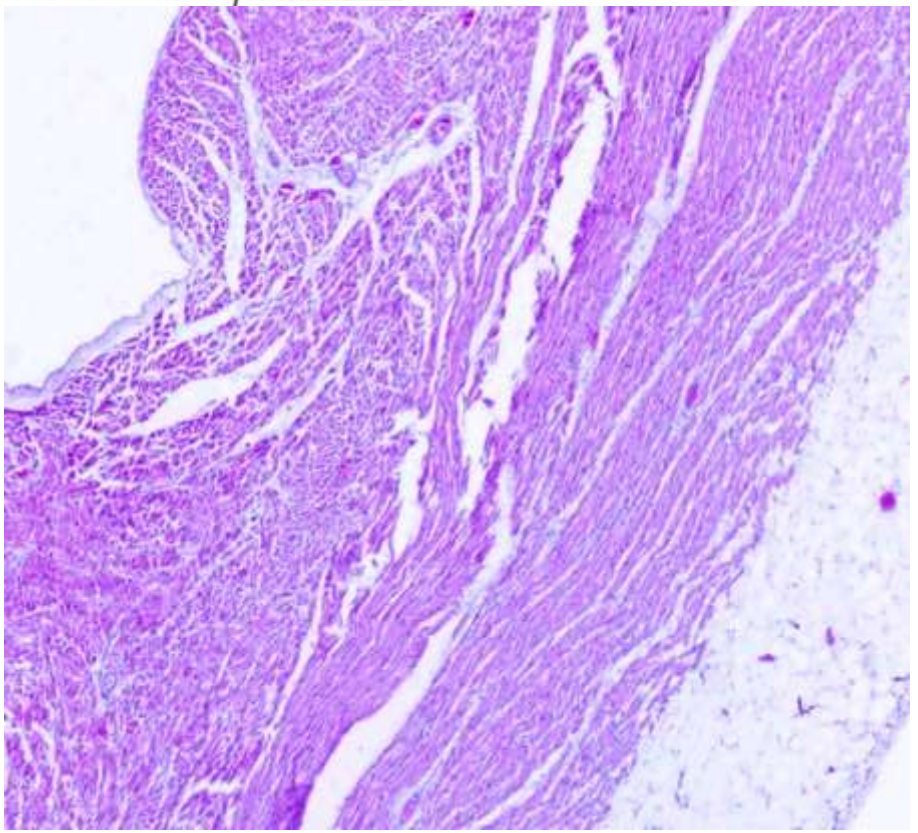
Slide №70a «Striated skeletal muscle tissue. Section of tongue» H&E



CARDIAC MUSCLE TISSUE

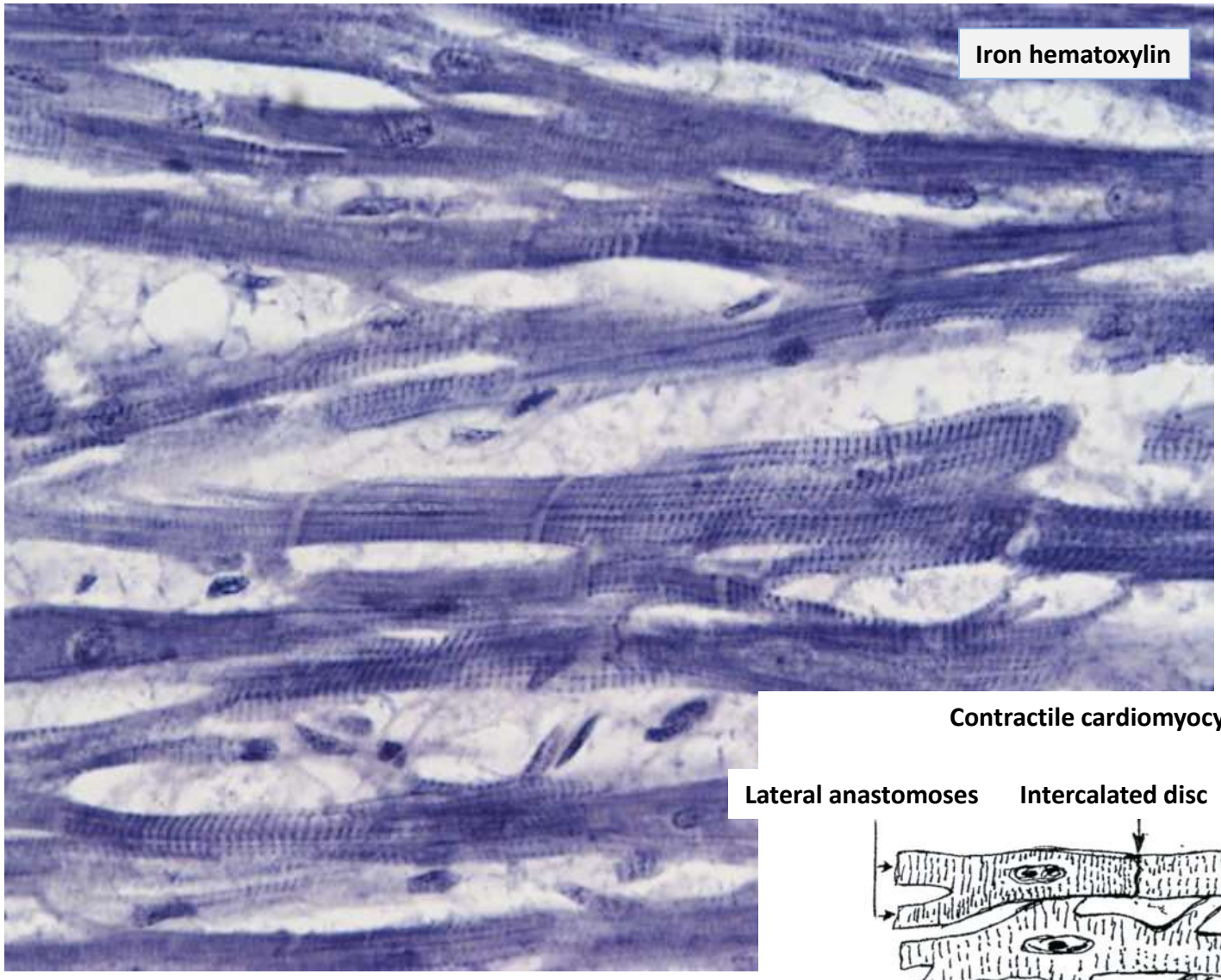


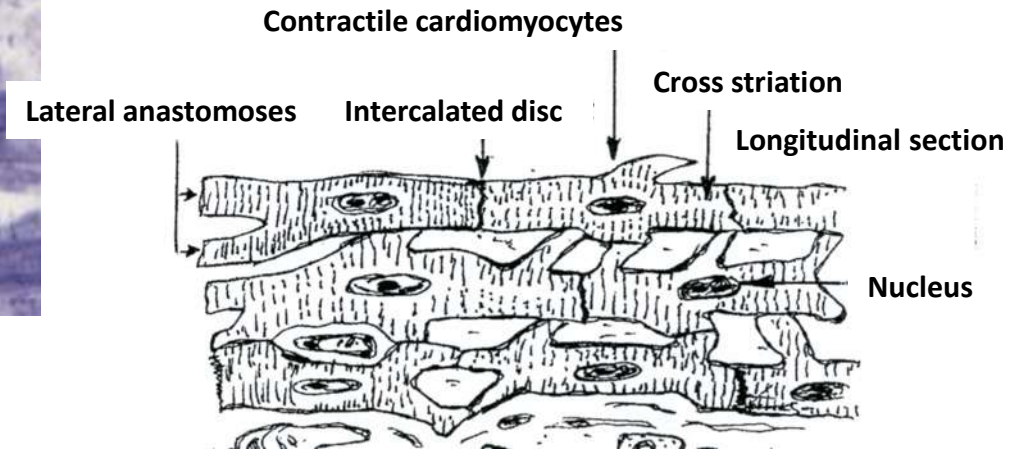




Structural unit –
cardiomyocyte

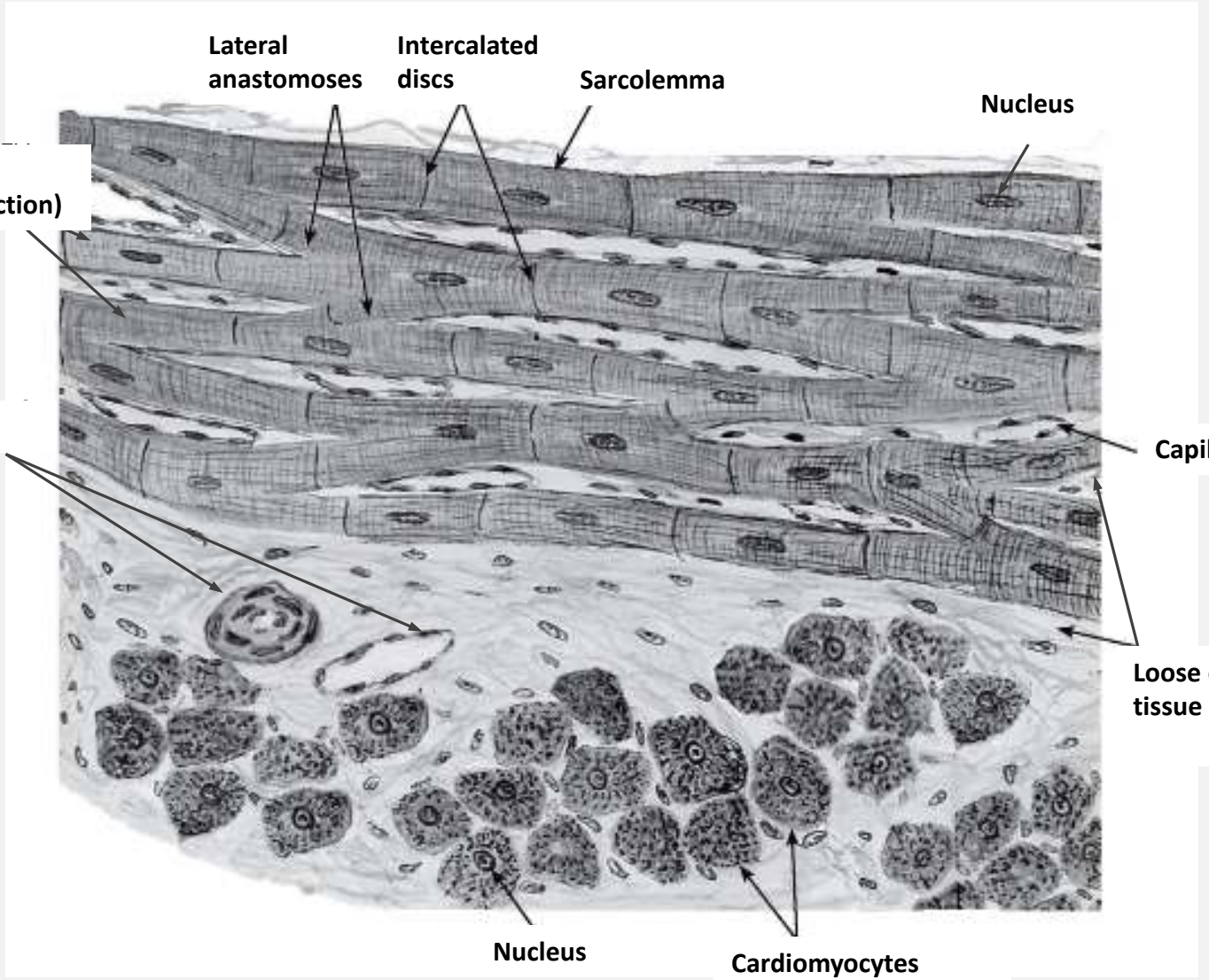
STRIATED CARDIAC MUSCLE TISSUE





Structural and functional unit – ***functional fiber***

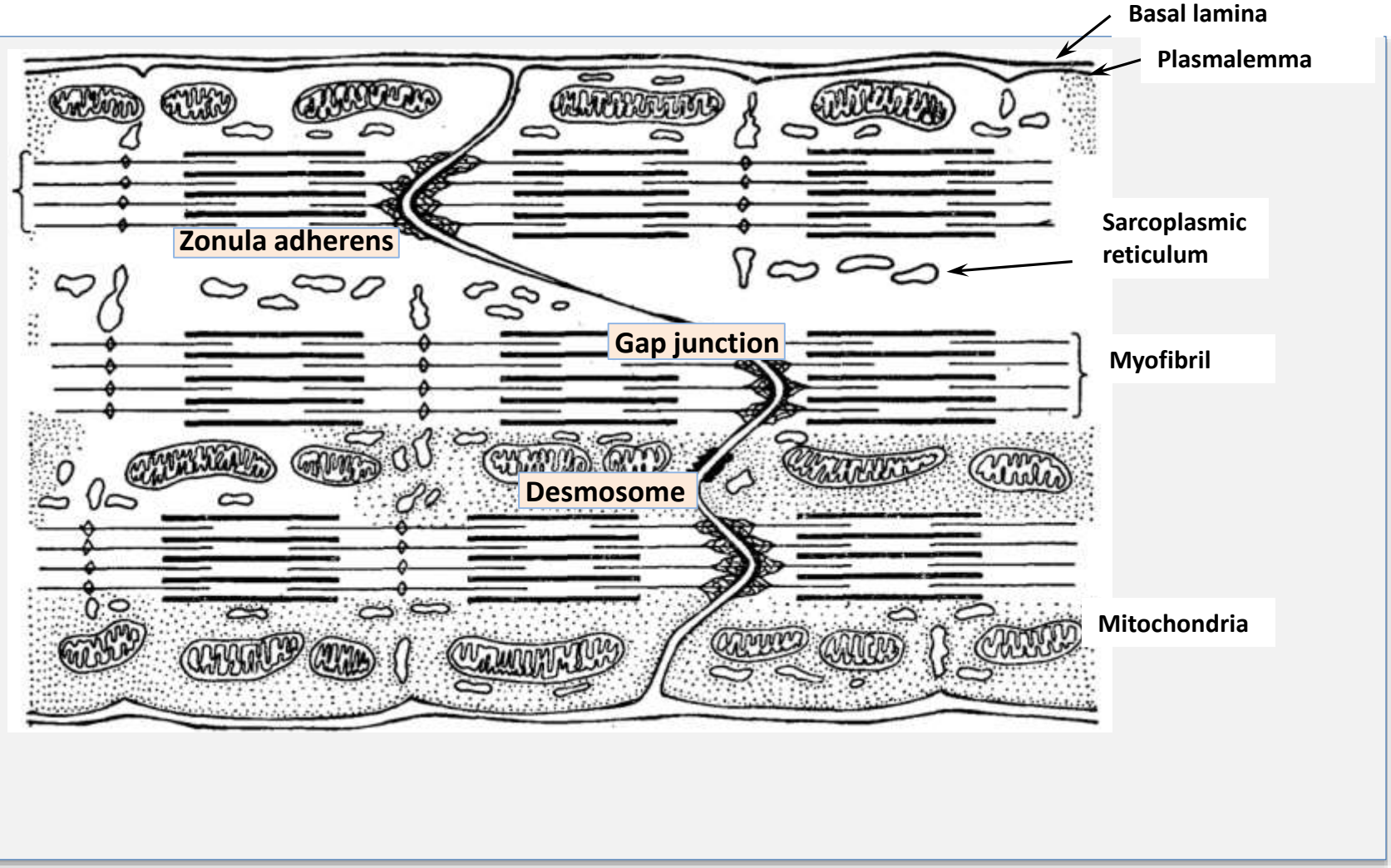
CARDIOMYOCYTES STRUCTURE *(typical cardiomyocyte)*



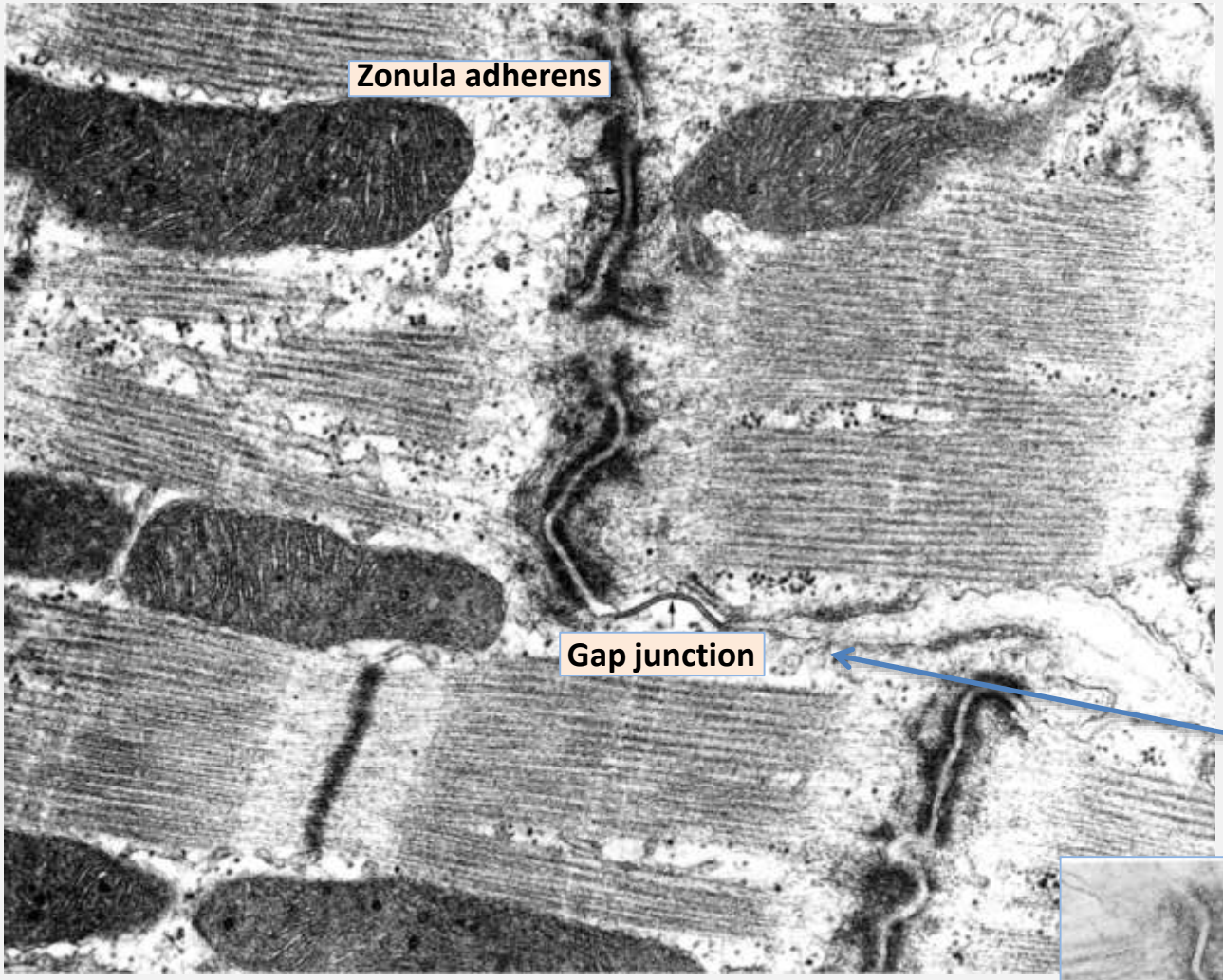
INTERCALATED DISC

Lateral component:
Gap junction

Transverse component
Zonula adherens
Desmosome

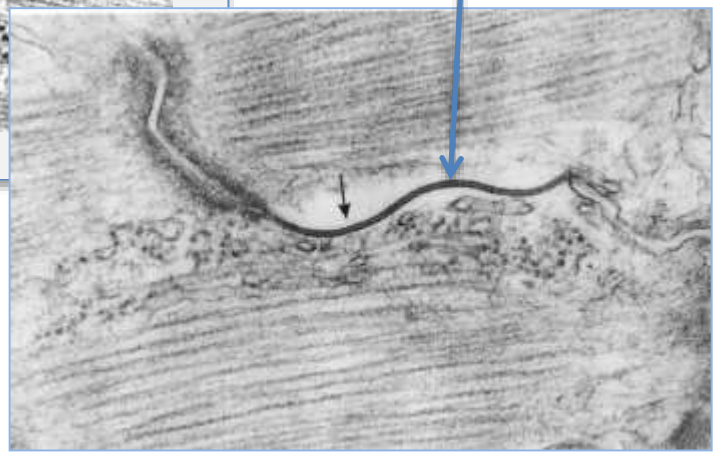


INTERCALATED DISC

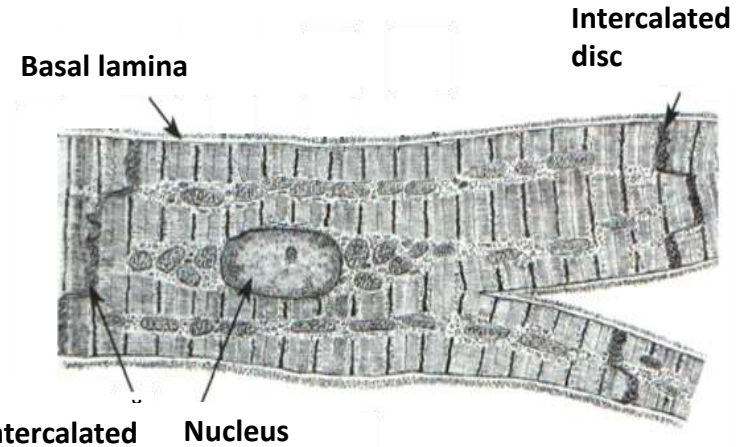


Transverse component

Lateral component

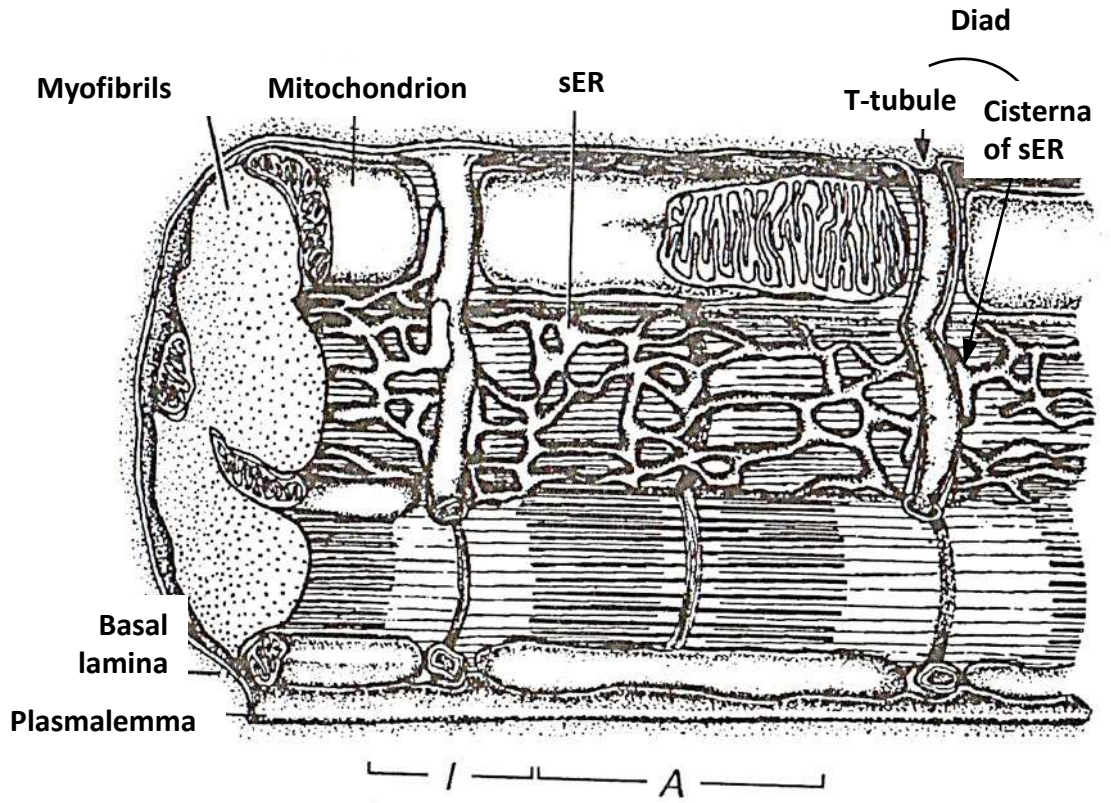


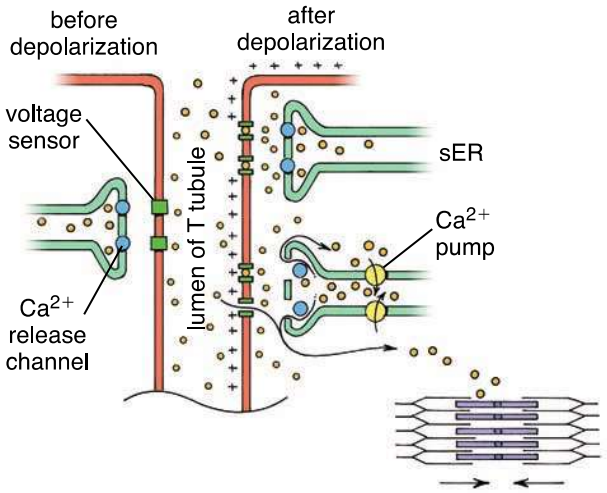
CARDIOMYOCYTE STRUCTURE *(typical)*

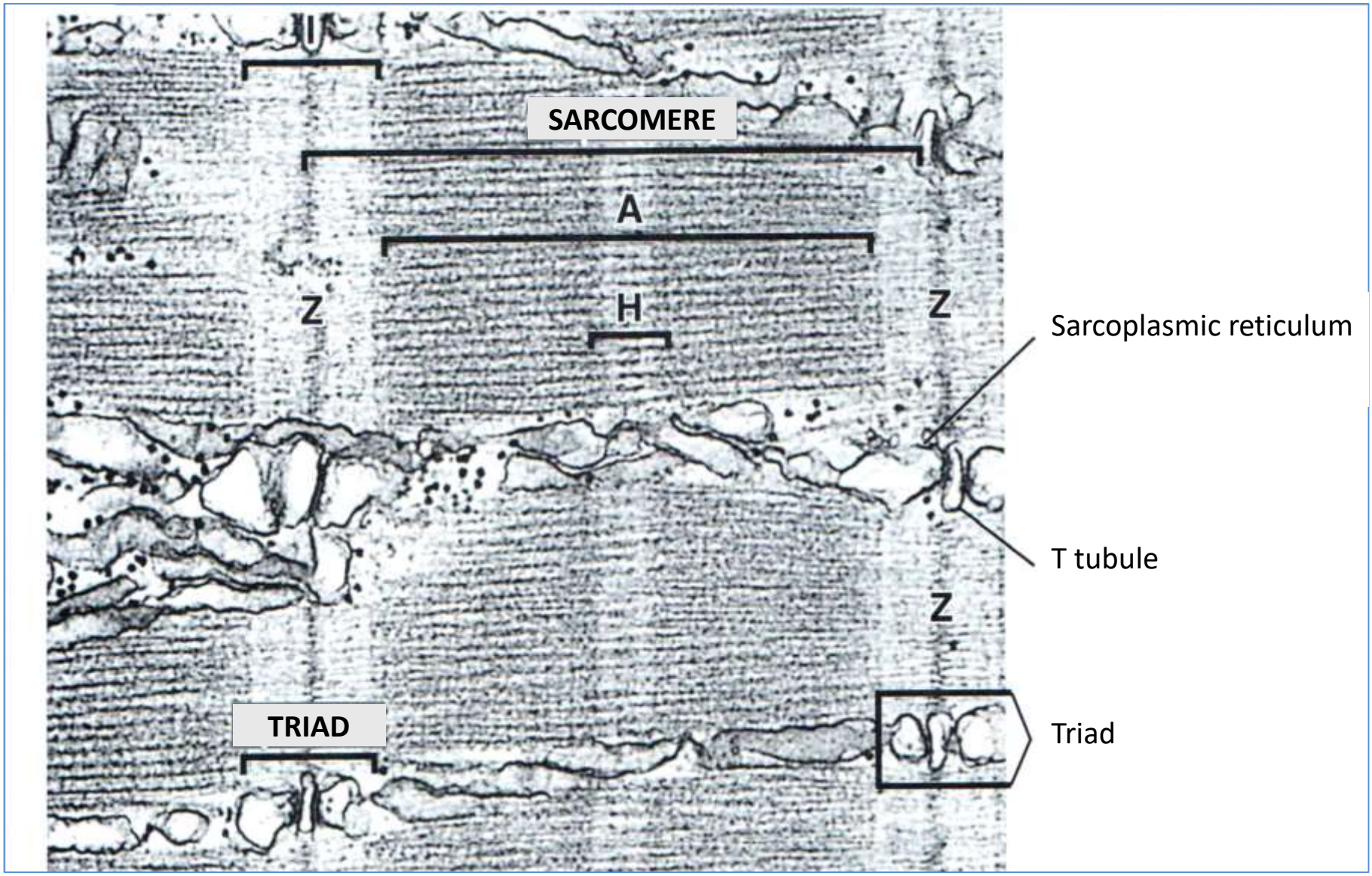


DIADS:
T-tubule
terminal cisterna
at the Z-disc level

Ca^{2+} ions are released from sER and intercellular environment



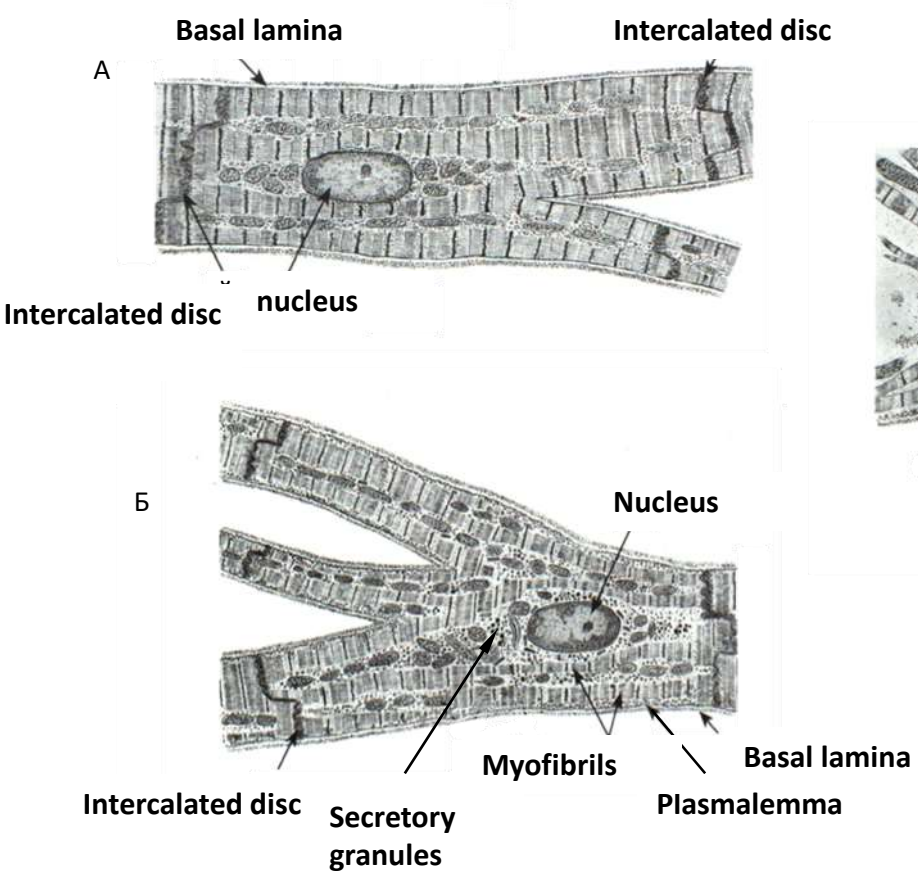



SARCOMERE
A
Z
H
Z
Z
TRIAD
Sarcoplasmic reticulum
T tubule
Triad

TYPES OF CARDIOMYOCYTES

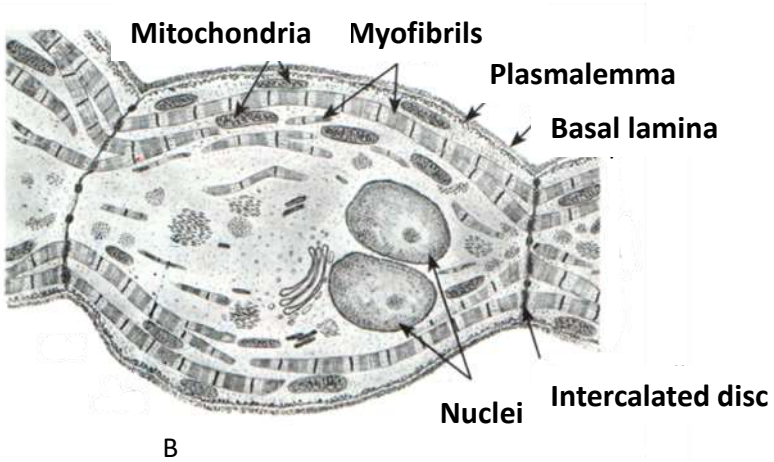
Typical

contractile cardiomyocytes



Secretory

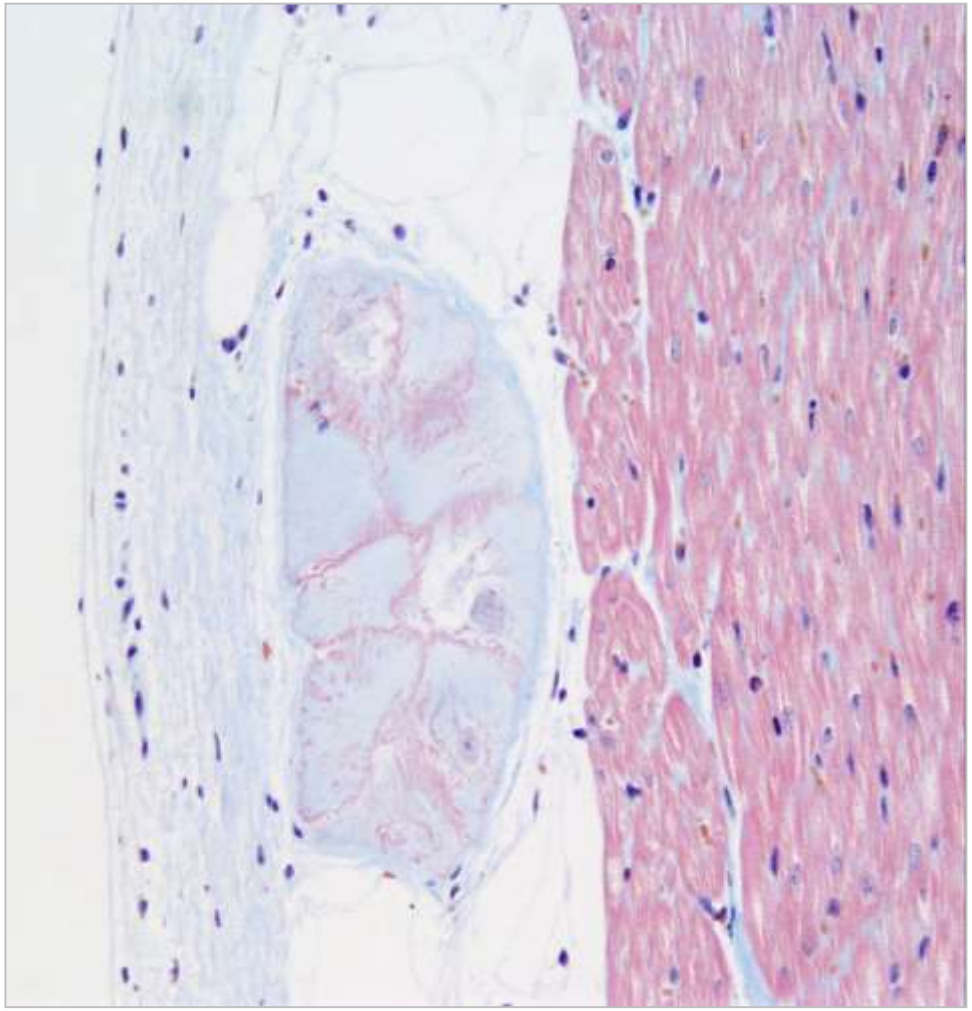
Production of natriuretic factor

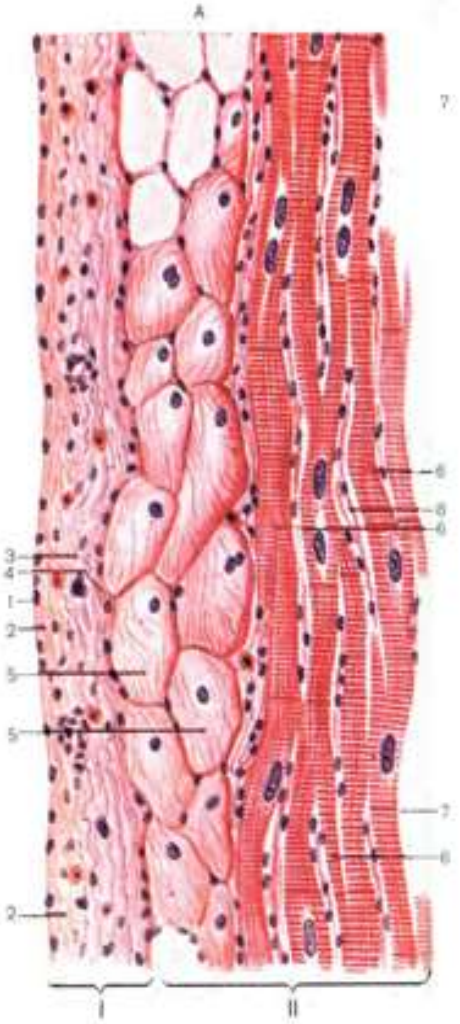


Atypical

Pacemaker or nodes;
Cardiac conducting cells;
Purkinje cells

CARDIAC CONDUCTING CELLS





I – endocardium

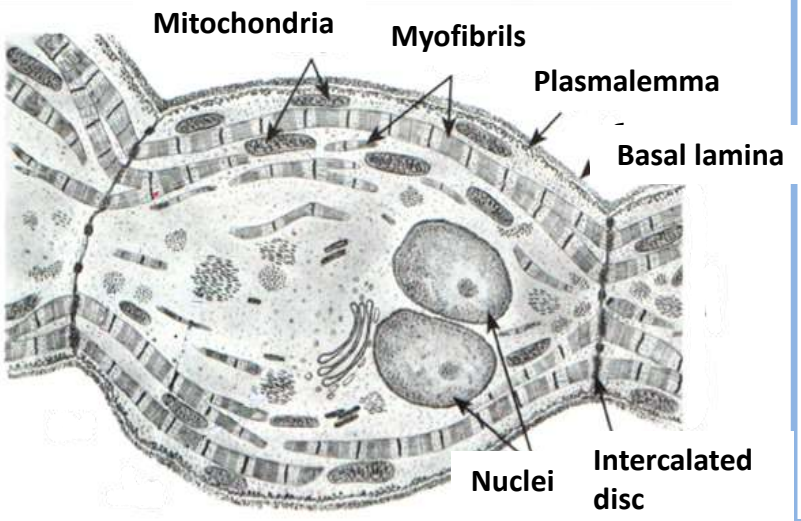
1 – endothelium and subendothelial layer (2) with elastic fibers (3)

II – myocardium

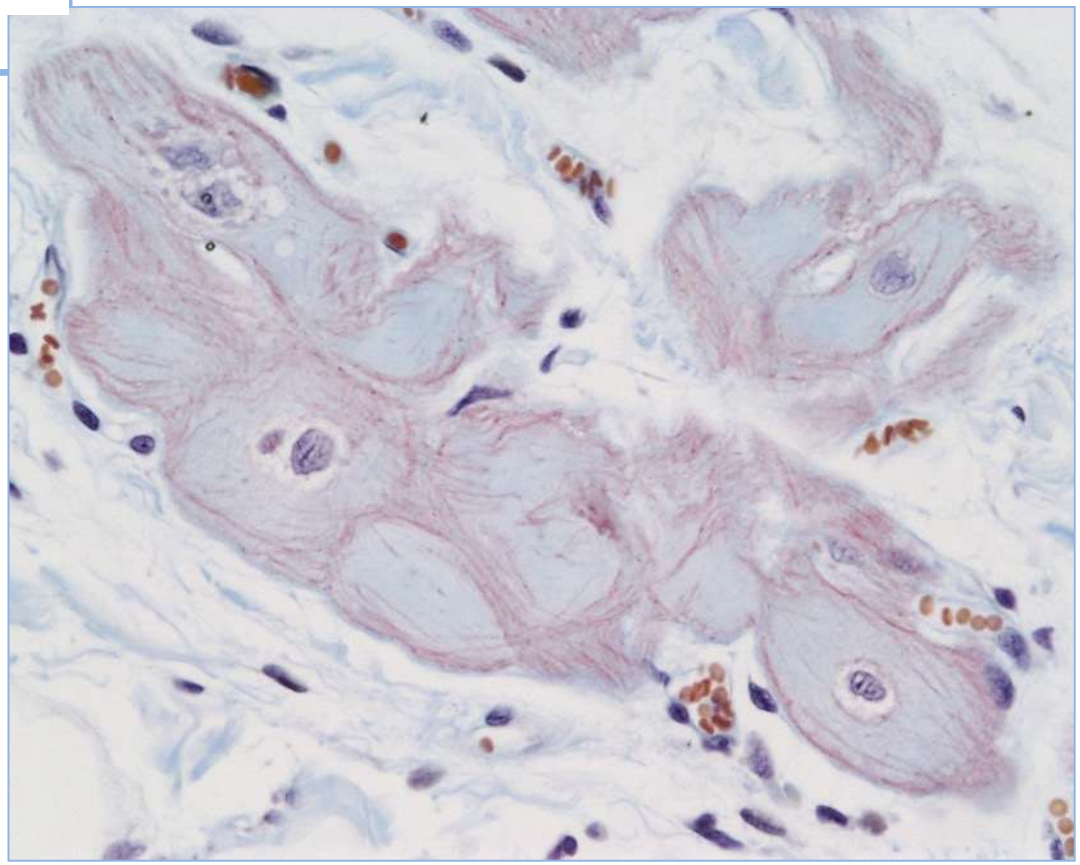
5 – atypical cardiomyocytes (Purkinje fibers)

6 – typical (contractile) cardiomyocytes

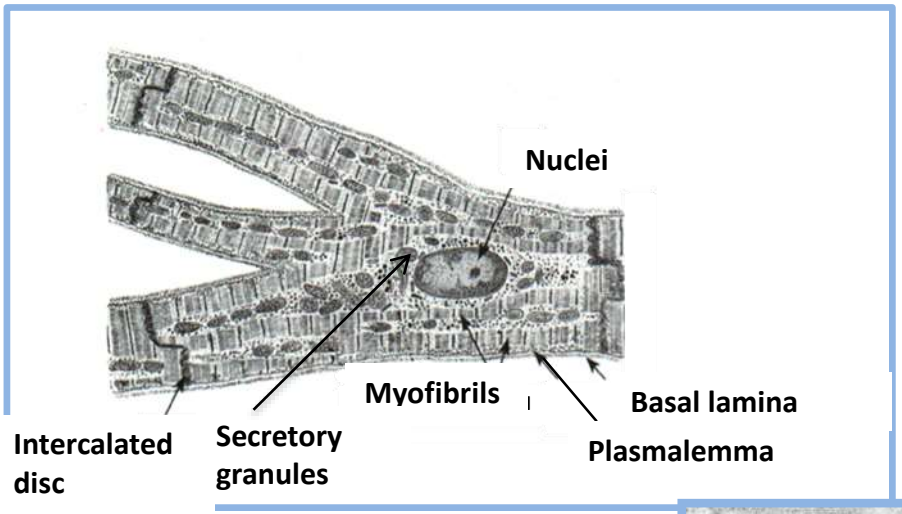
CARDIAC CONDUCTING CELLS



cardiac muscle tissue has an **AUTOMATISM** – ***the ability to generate an action potential self-sufficiently and contract***



SECRETORY CARDIOMYOCYTES



Increase BP ↑

↓

Atrial natriuretic factor

↓

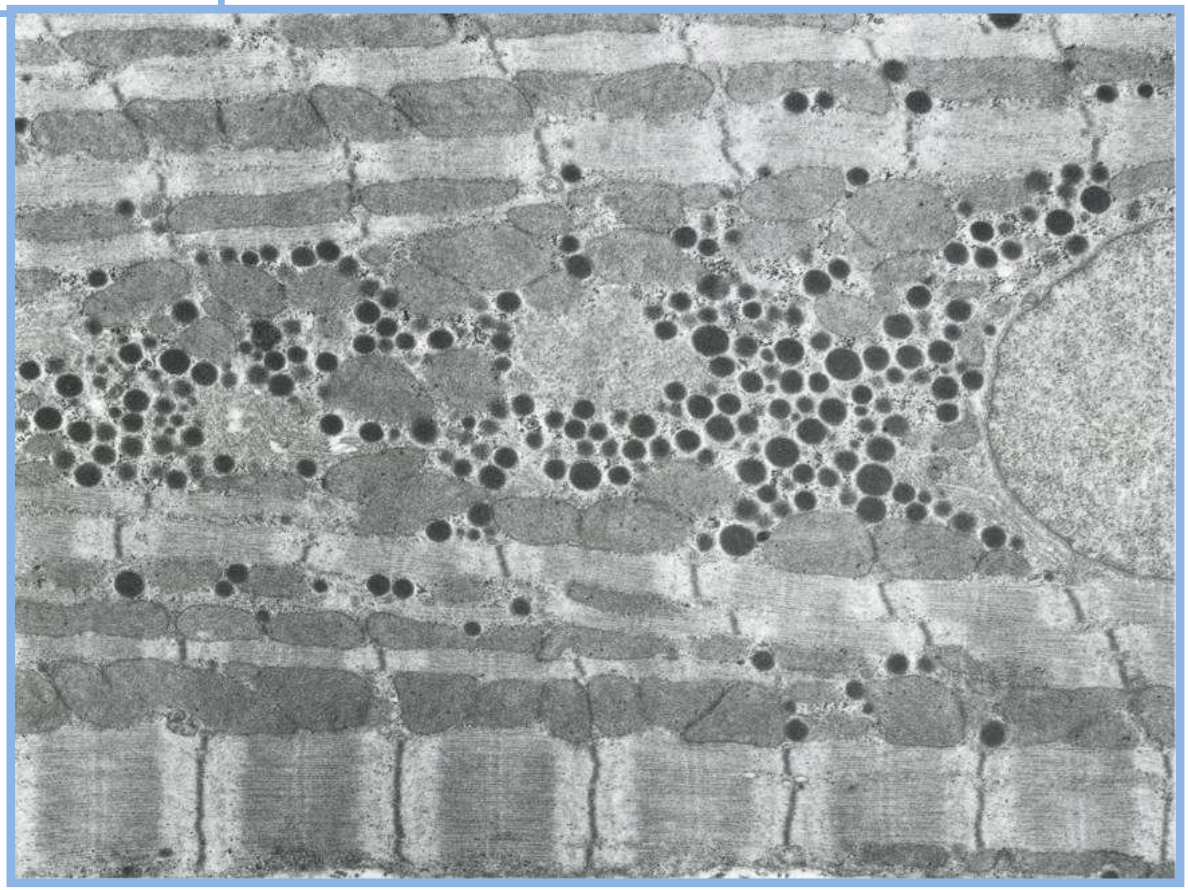
Tubules of nephrons

↓

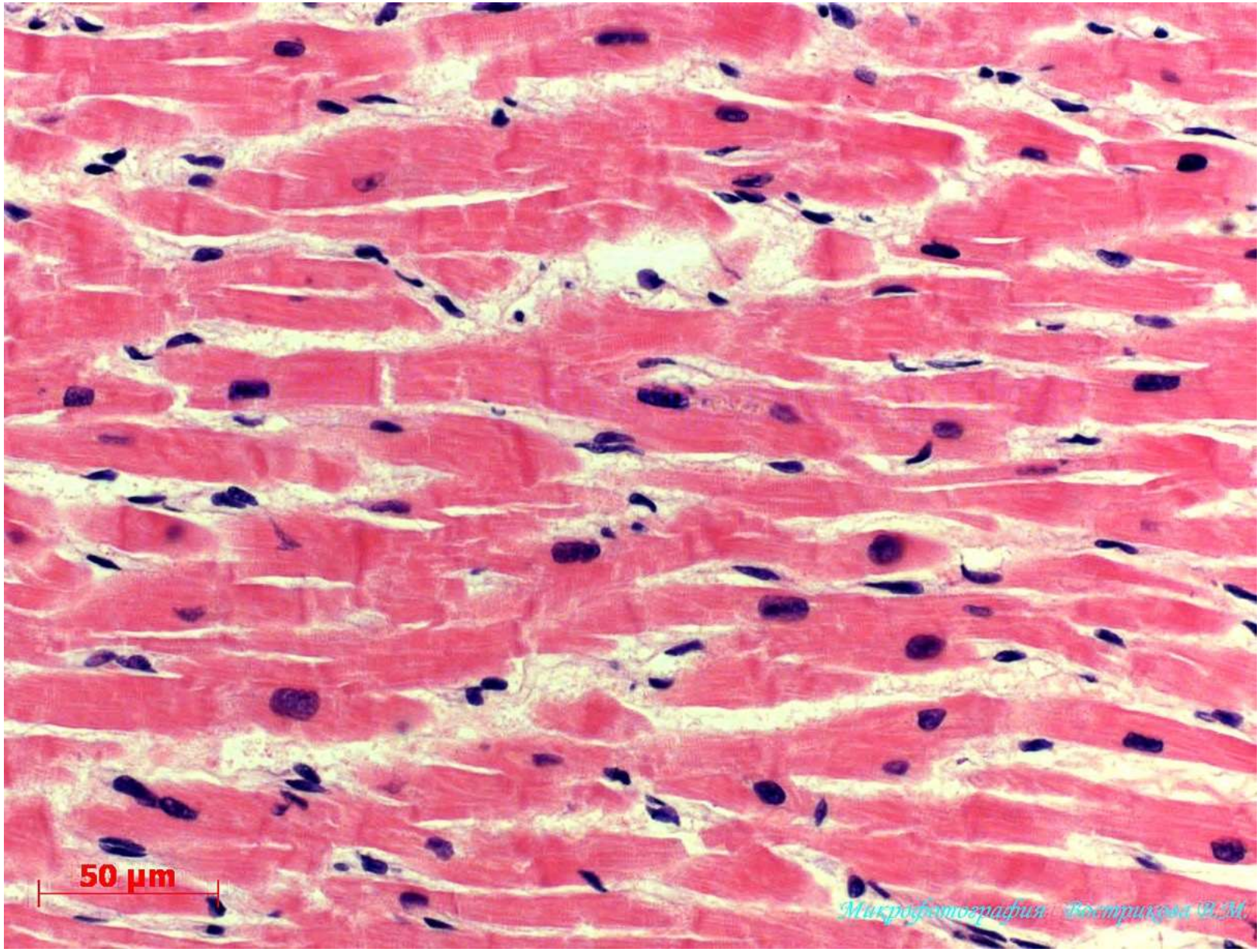
Release Na^+ and H_2O

↓

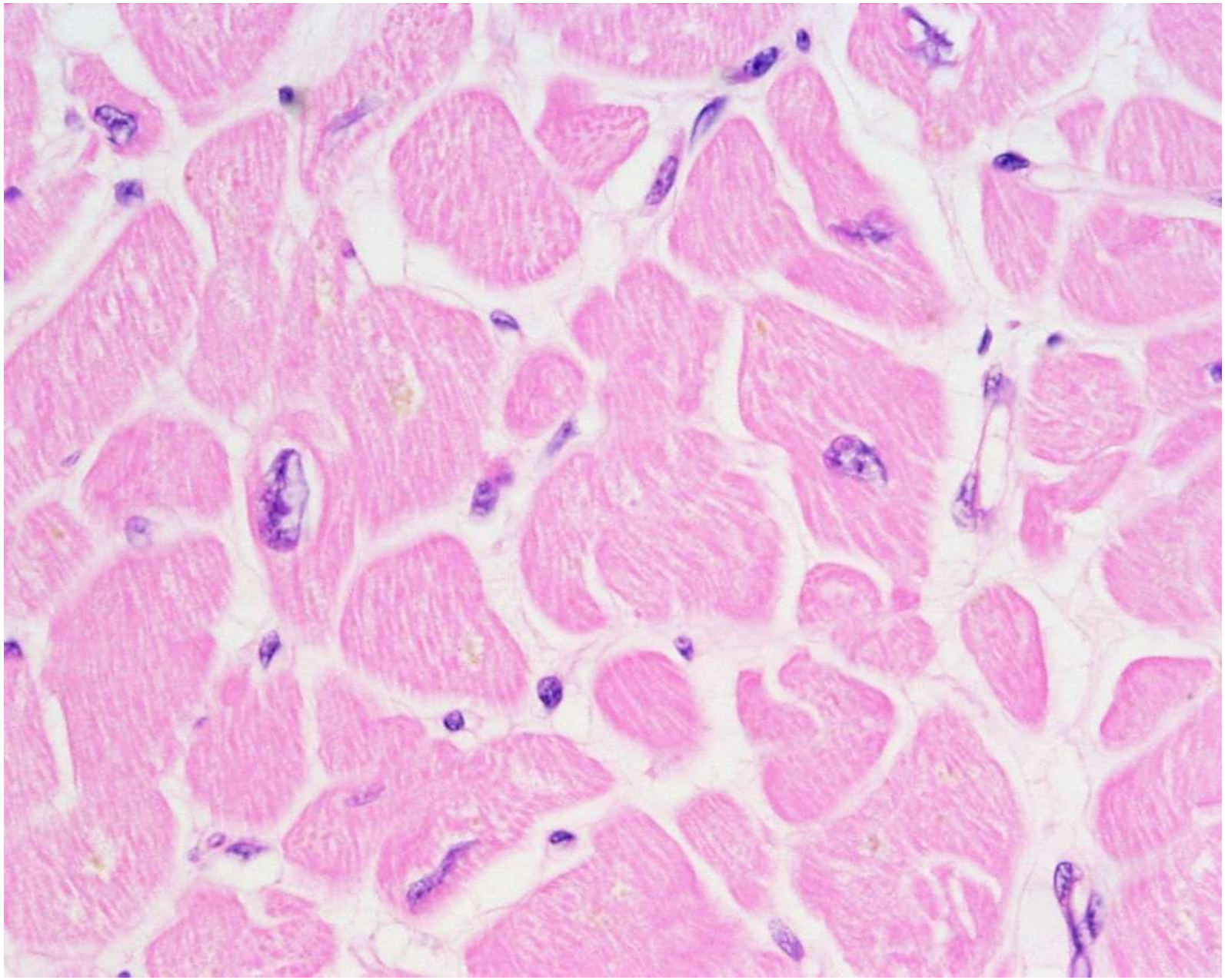
Decrease BP ↓



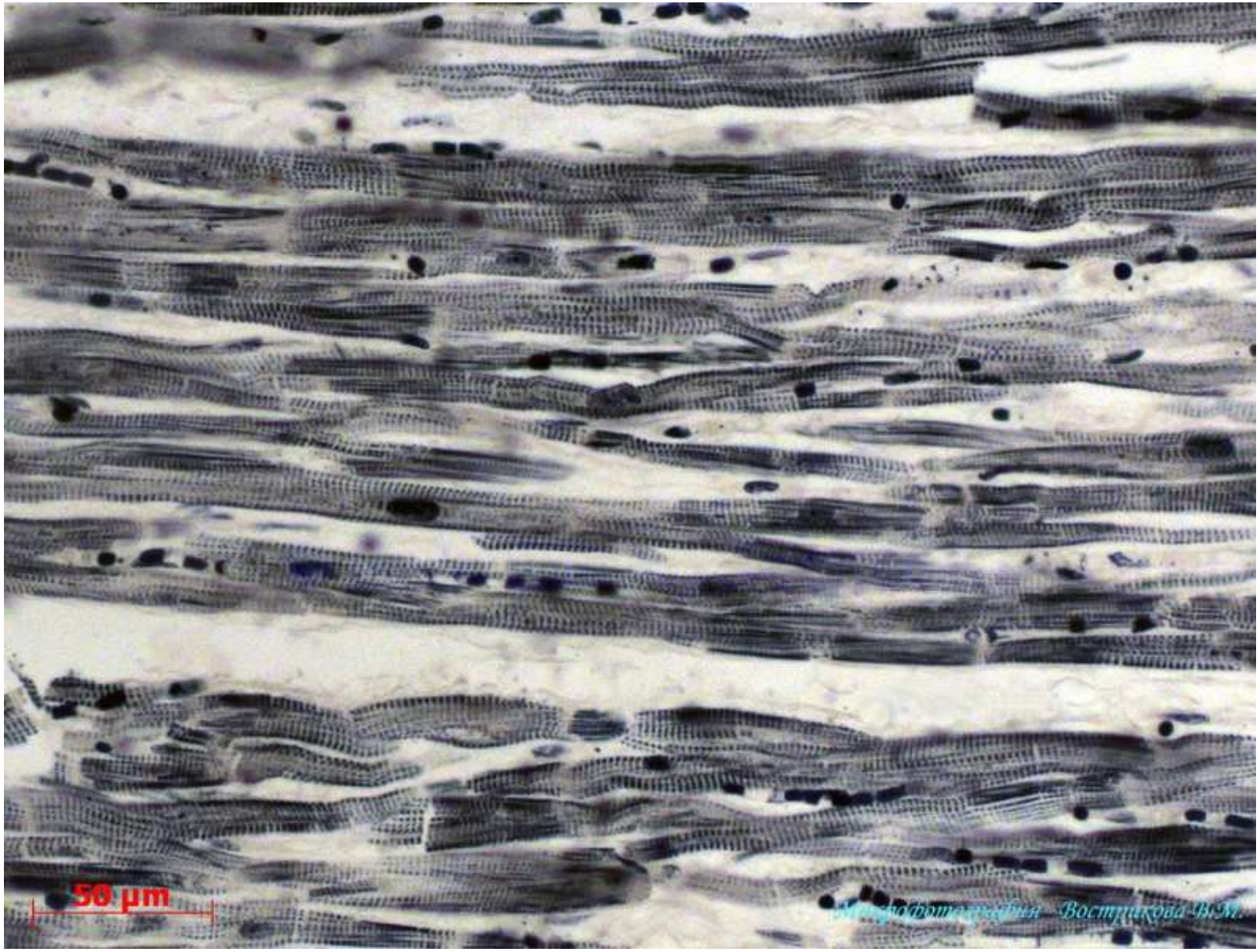
Slide № 71 «**STRIATED CARDIAC MUSCLE TISSUE**» **H&E**



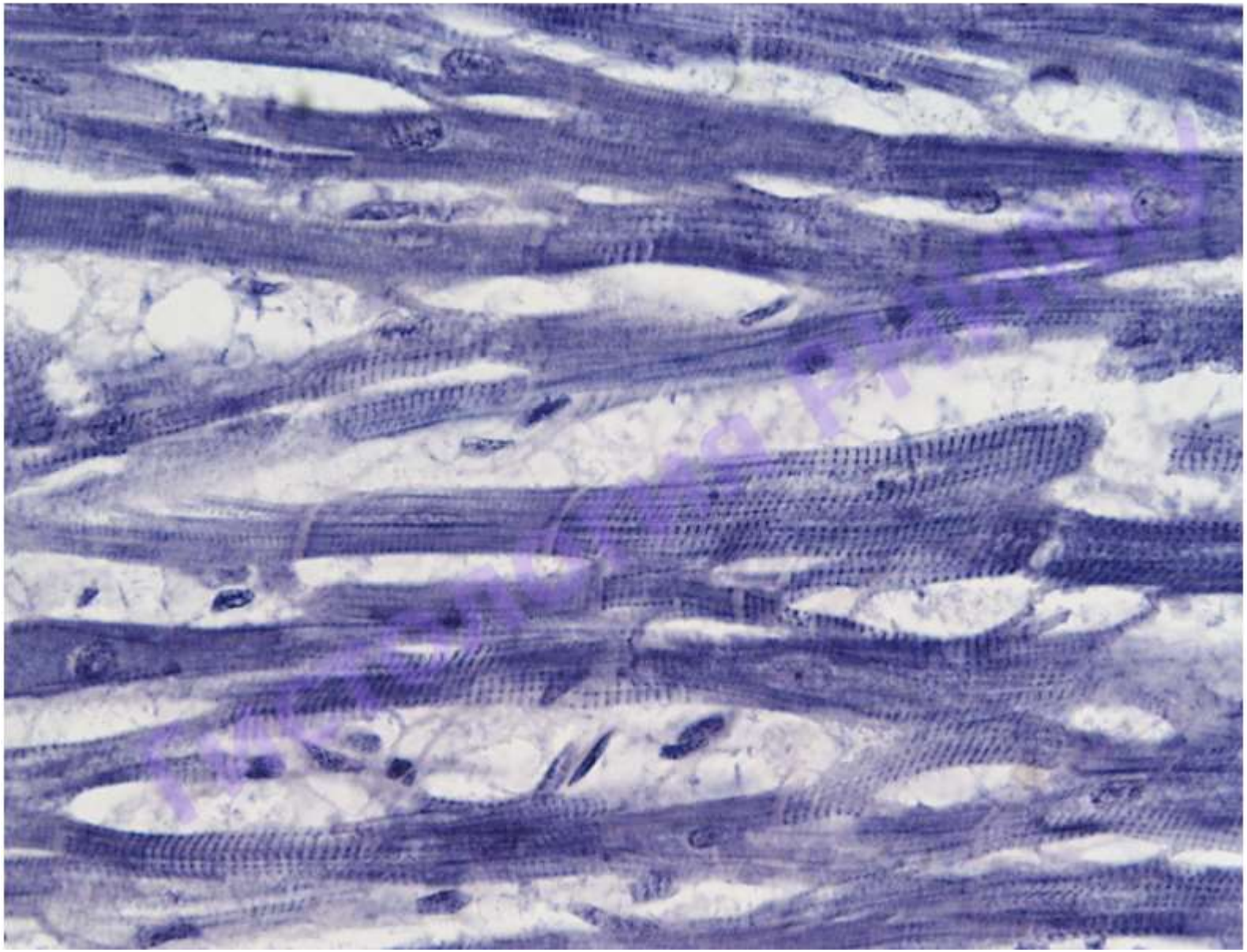
Slide № 71 «**STRIATED CARDIAC MUSCLE TISSUE**» **H&E**



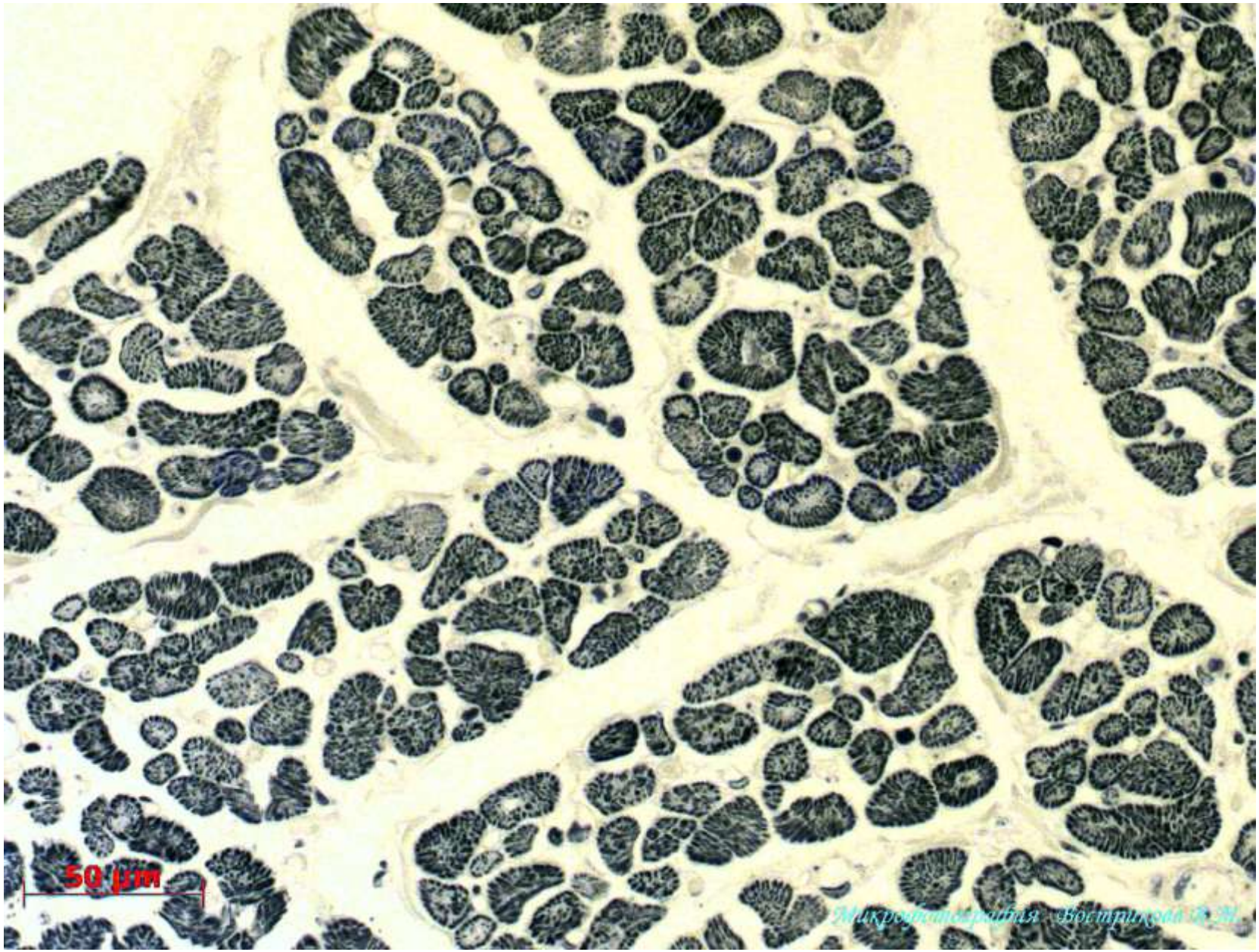
Slide № 71a «**STRIATED CARDIAC MUSCLE TISSUE**» ***Iron hematoxylin***



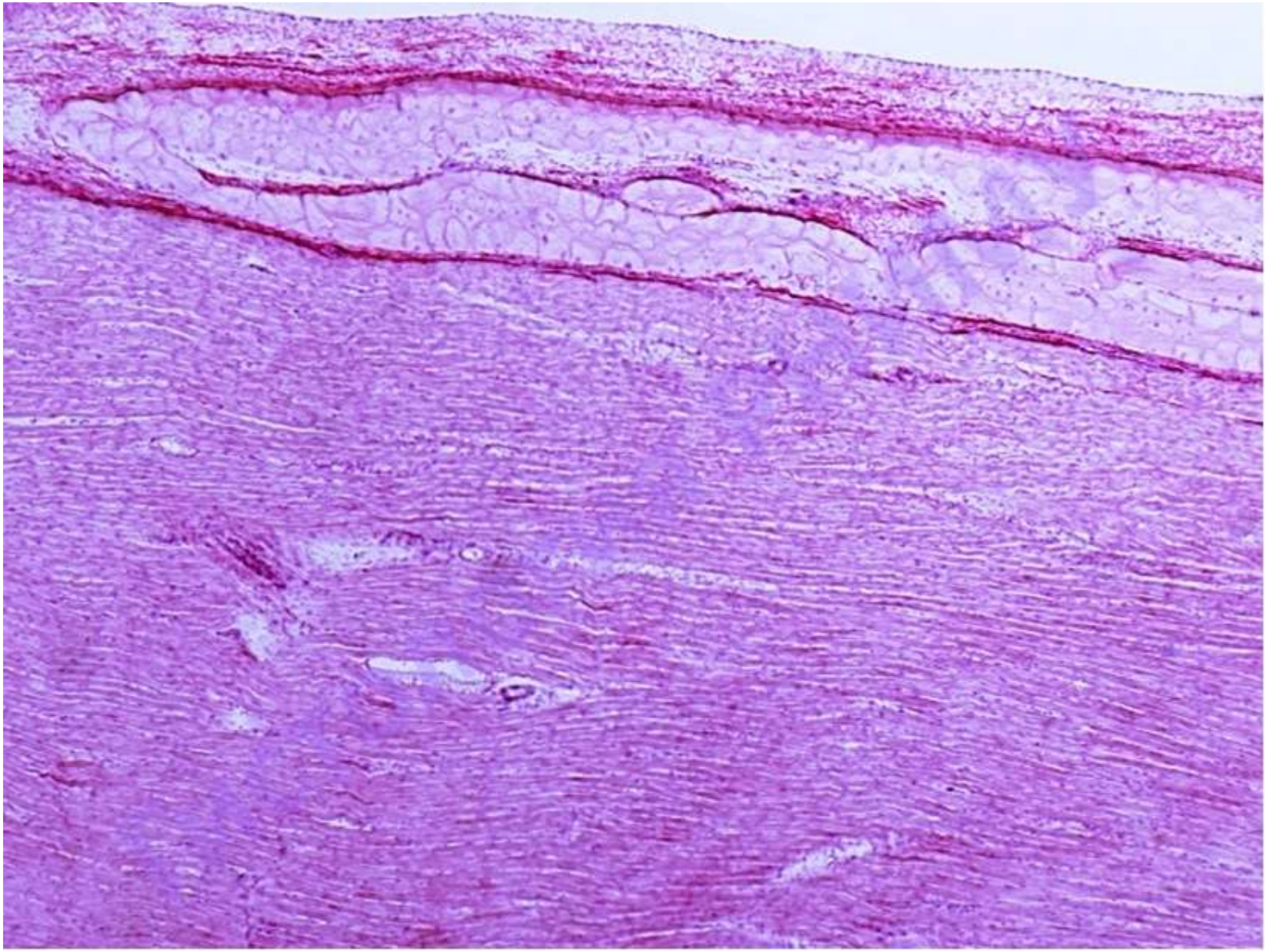
Slide № 71a «**STRIATED CARDIAC MUSCLE TISSUE**» ***Iron hematoxylin***



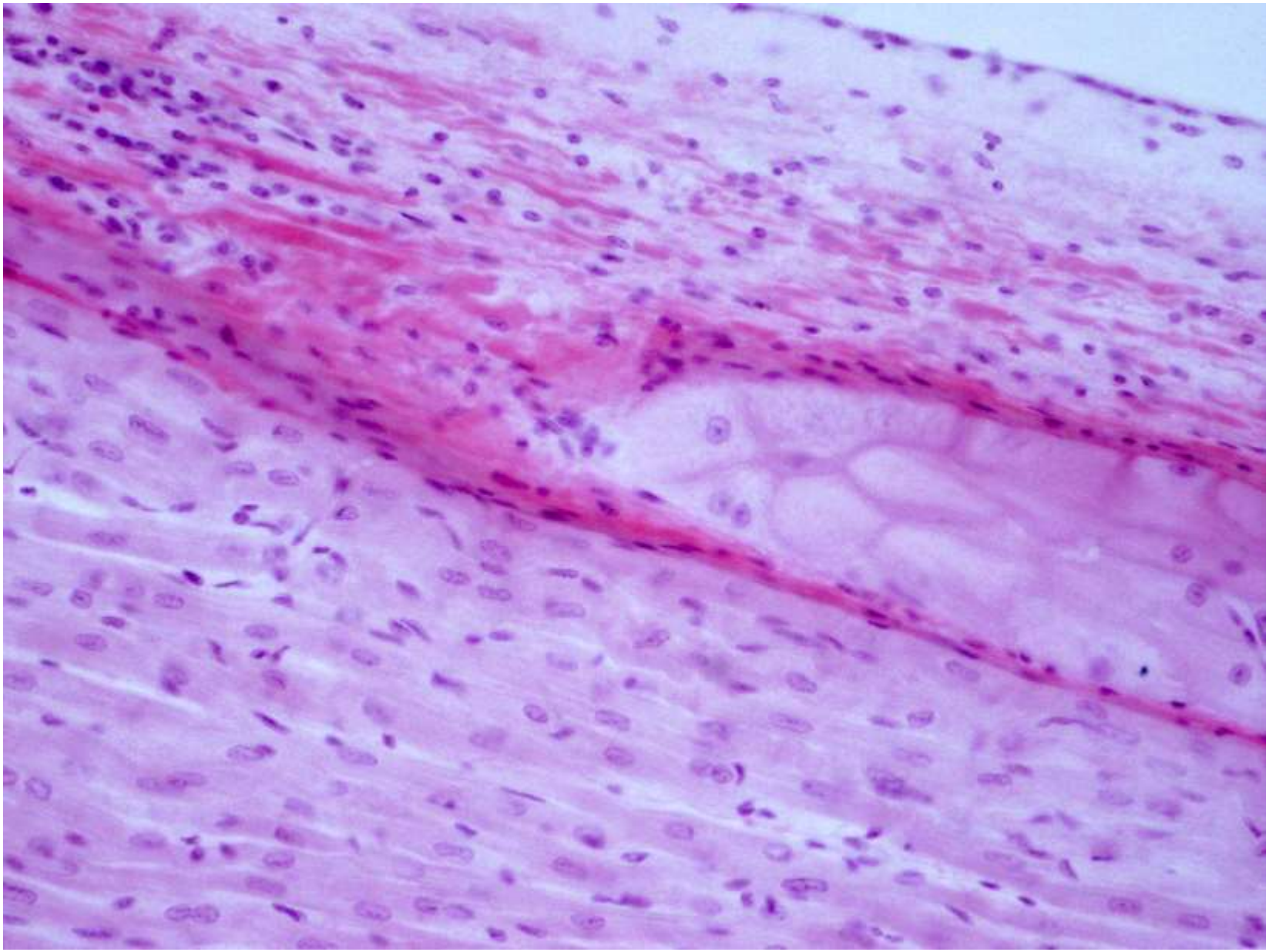
Slide № 71a «**STRIATED CARDIAC MUSCLE TISSUE**» ***Iron hematoxylin***



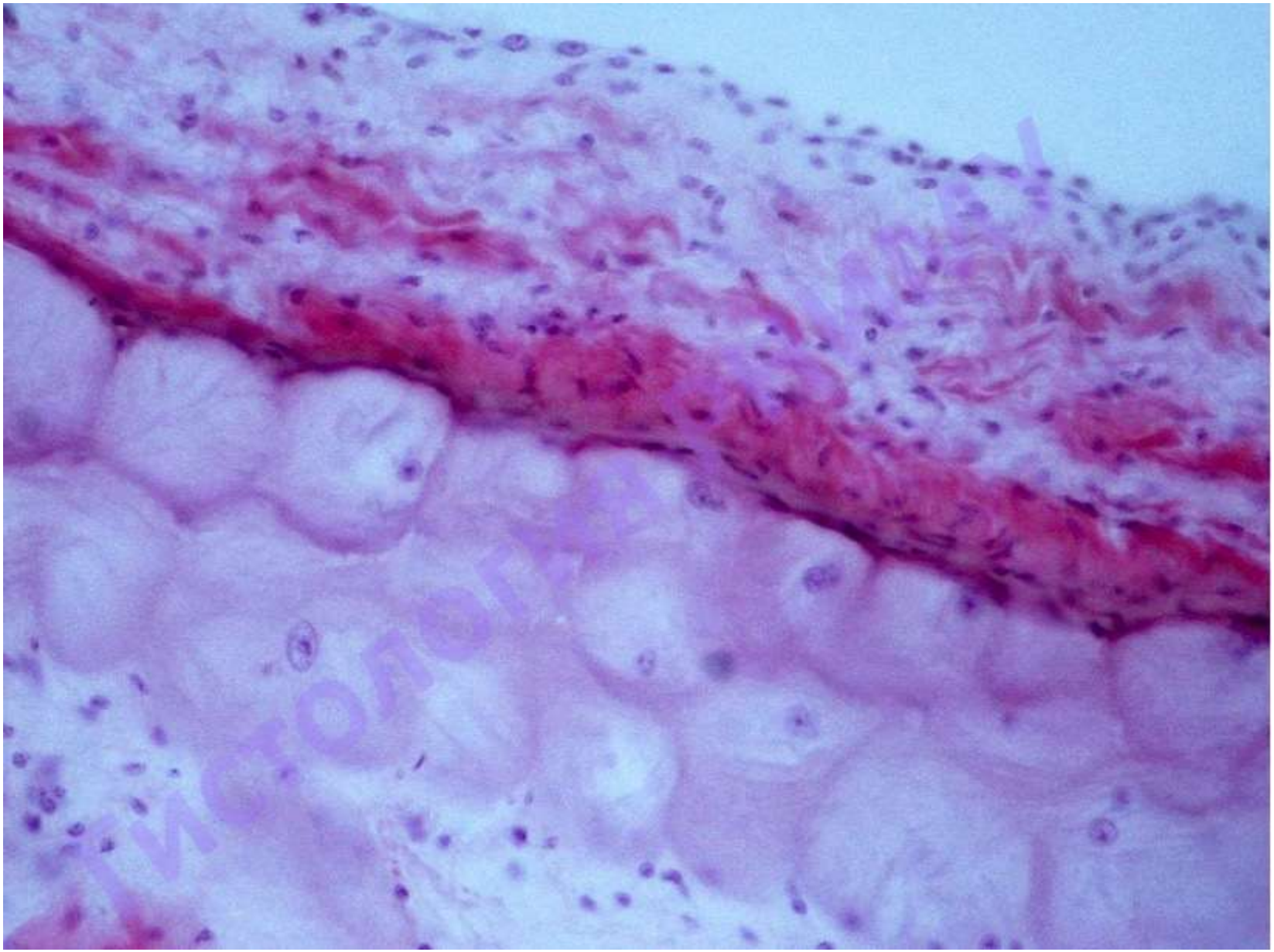
*Slide № 107*a «**WALL OF THE HEART. CARDIAC CONDUCTING CELLS »** **H&E**



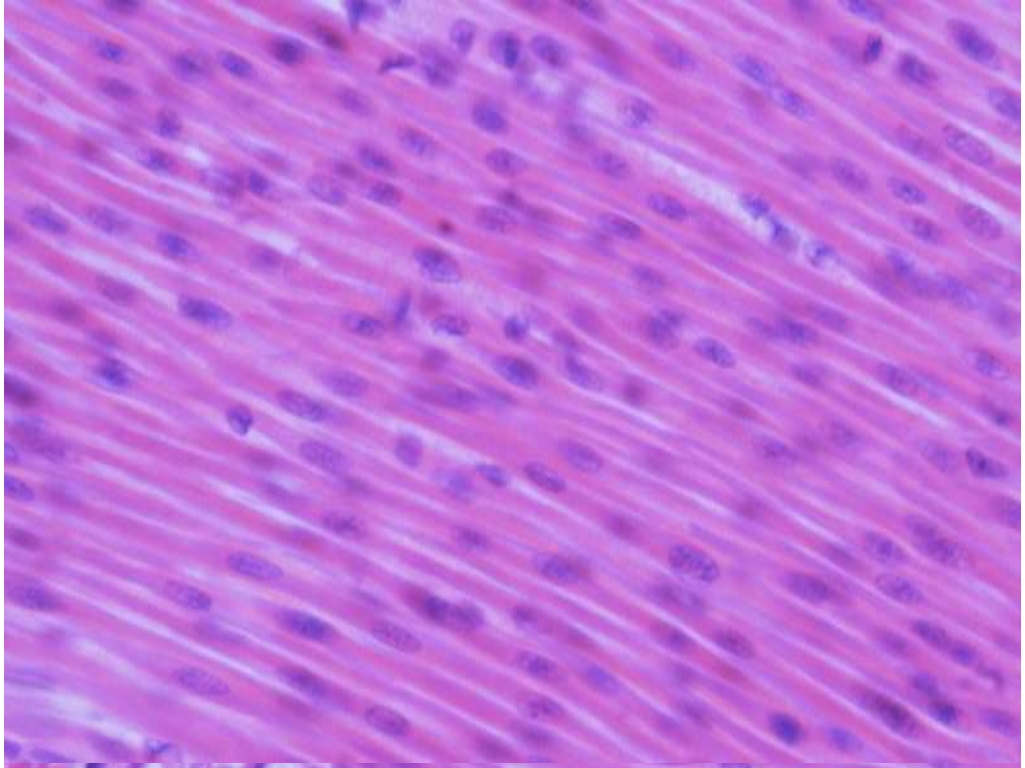
*Slide № 107*а «**WALL OF THE HEART. CARDIAC CONDUCTING CELLS »** **H&E**

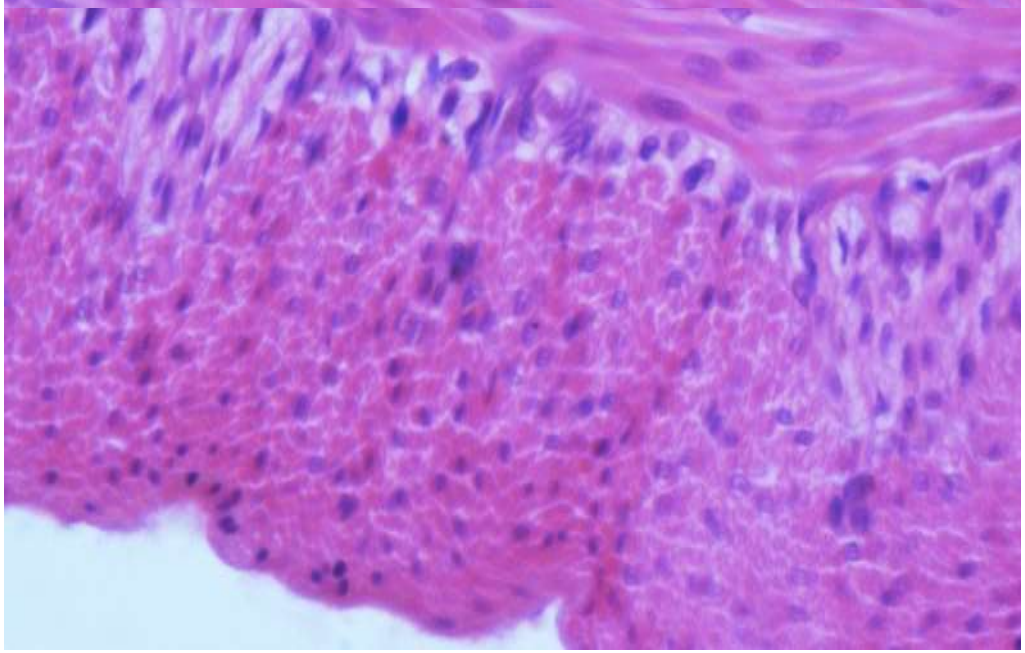


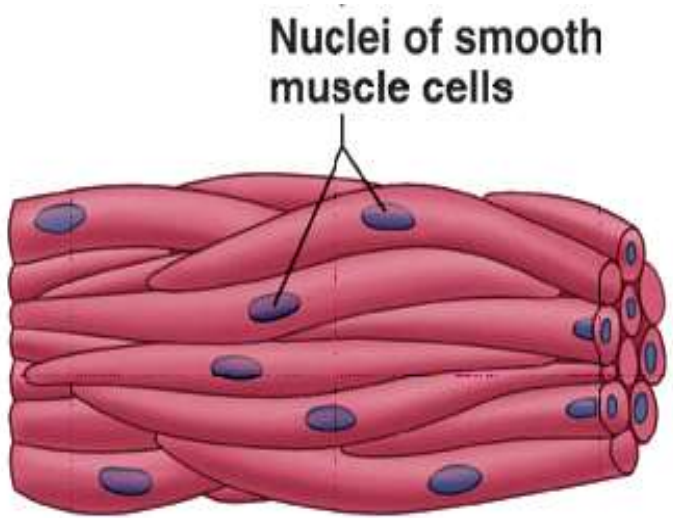
*Slide № 107*a «**WALL OF THE HEART. CARDIAC CONDUCTING CELLS »** **H&E**



SMOOTH MUSCLE TISSUE

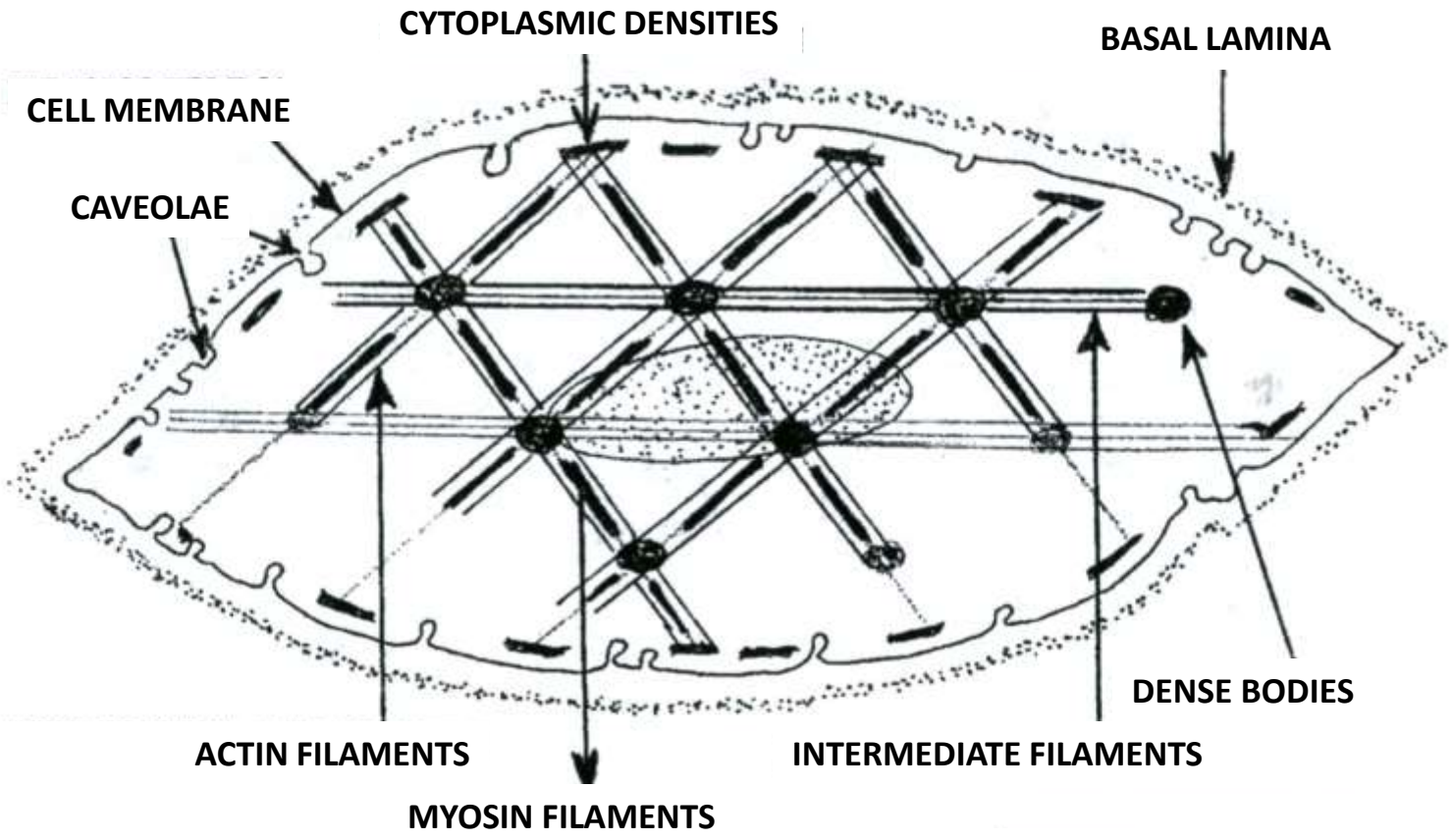




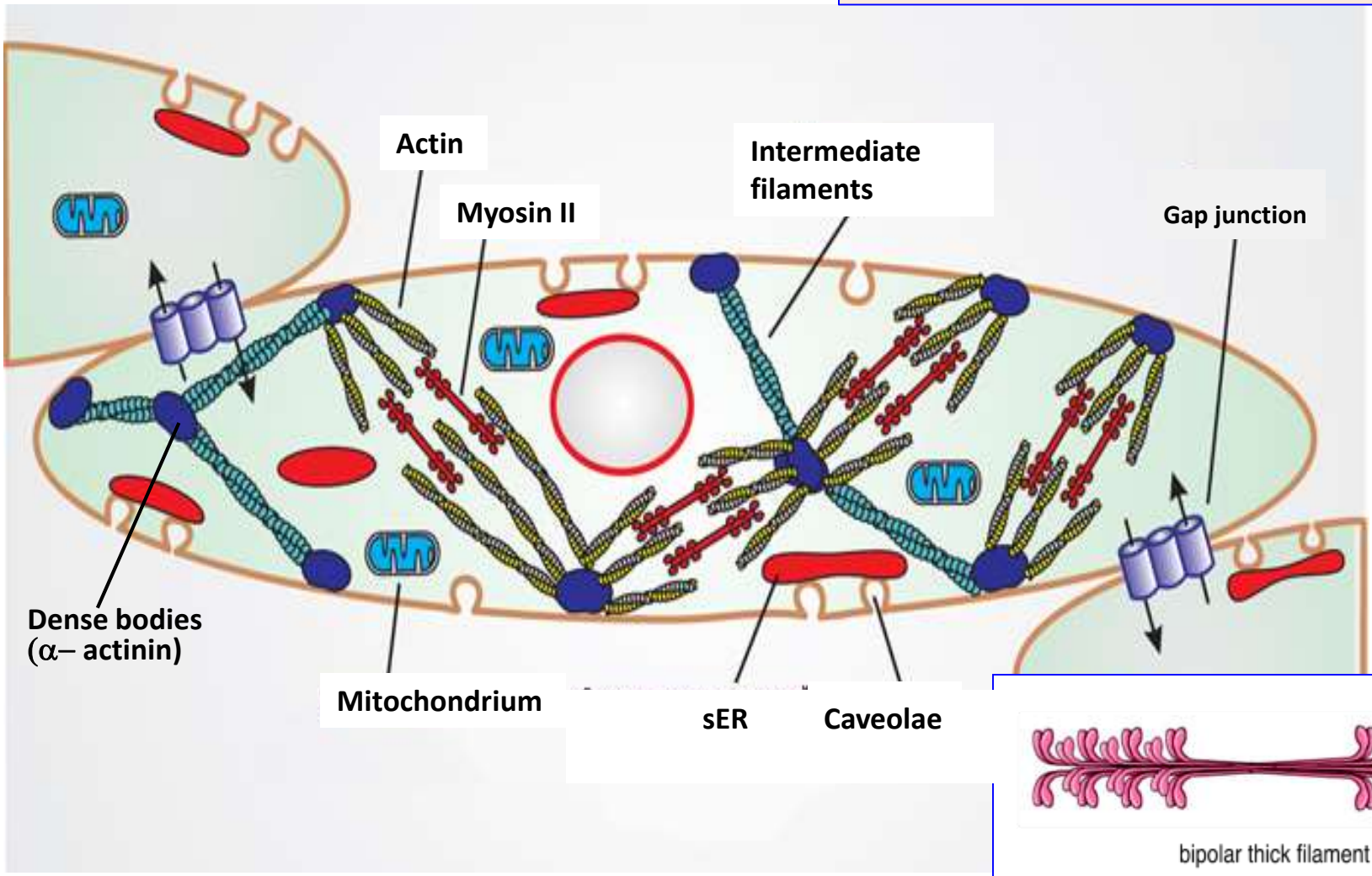


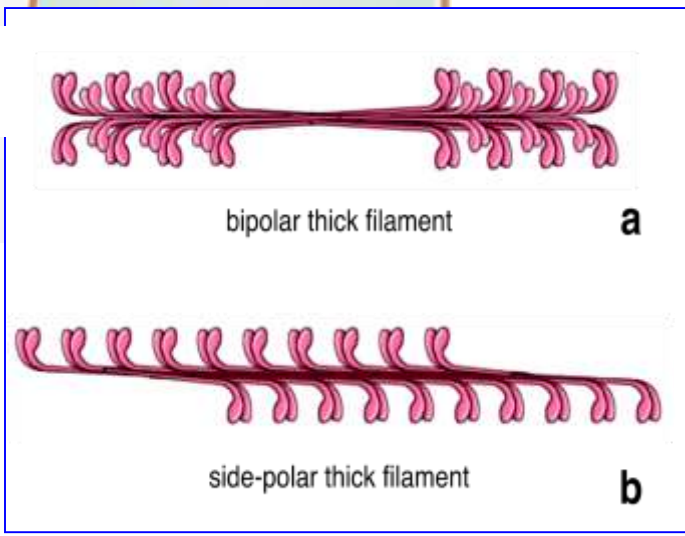
Structural and functional unit – ***smooth muscle cell***

STRUCTURE OF SMOOTH MUSCLE CELL

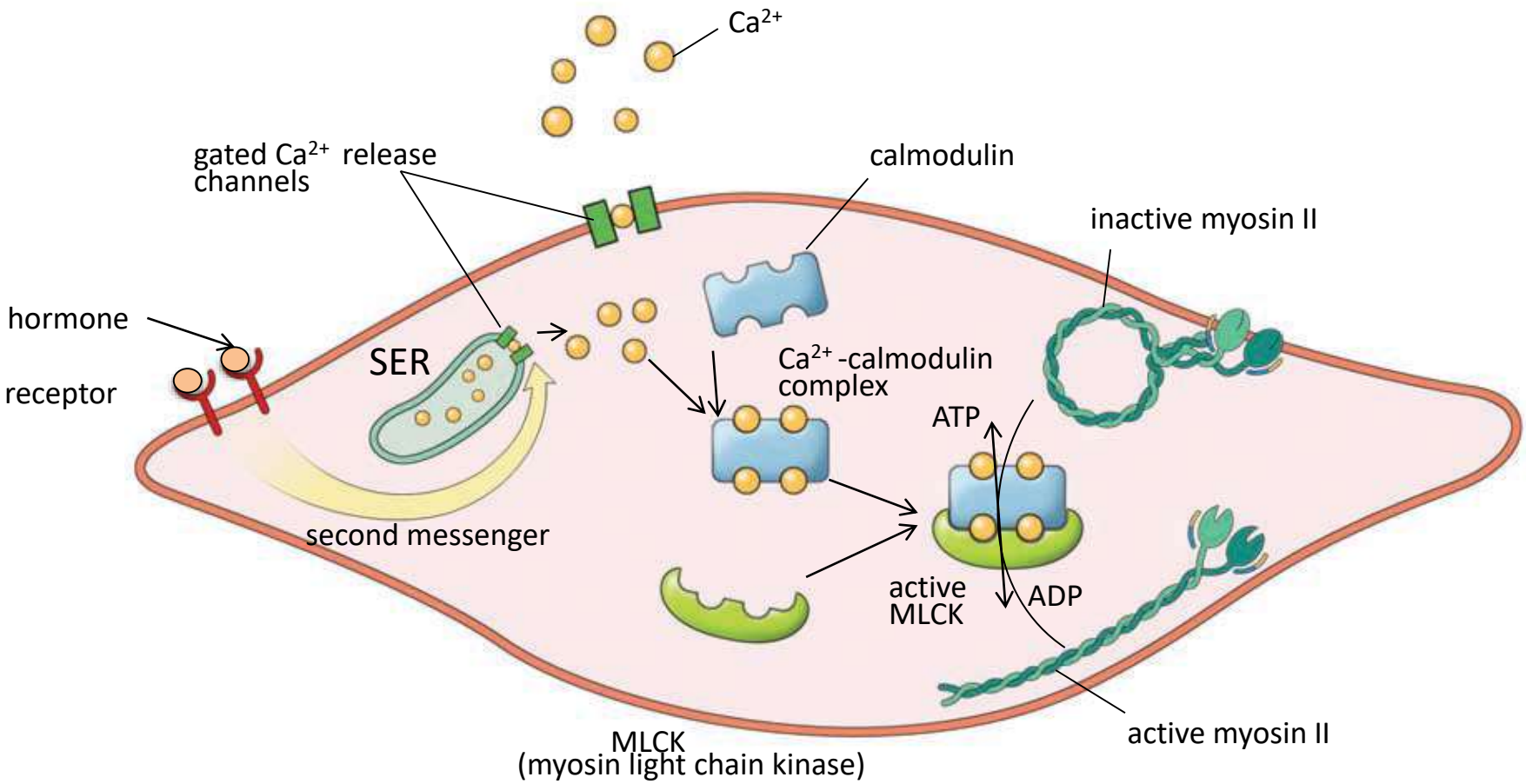


STRUCTURE OF SMOOTH MUSCLE CELL





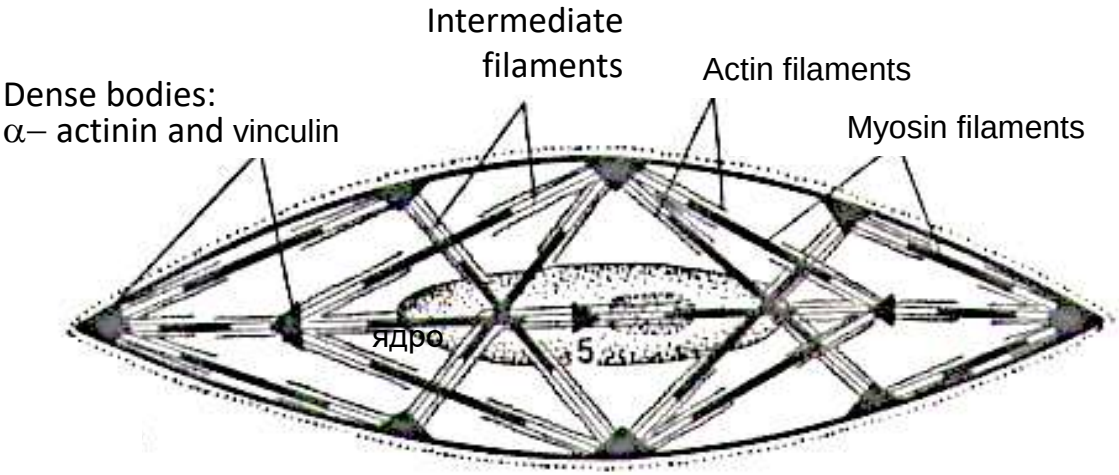
MECHANISM of SMOOTH MUSCLE CELL CONTRACTION



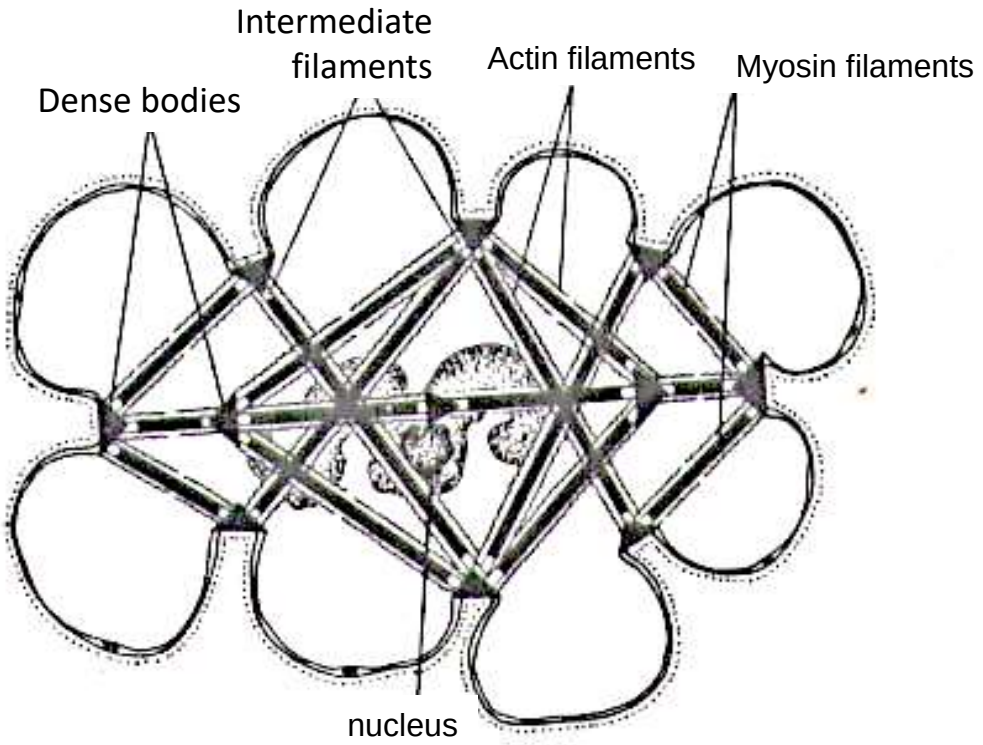
1. An increase in the Ca^{2+} level concentration within the cytosol is necessary to initiate smooth muscle contraction.
2. The intracellular Ca^{2+} binds to calmodulin to form the Ca^{2+}–calmodulin complex.
3. This complex then binds to myosin light chain kinase (*MLCK*) to phosphorylate one of the two regulatory light chains of the myosin molecule.
4. When phosphorylated, the myosin changes its conformation and the actin-binding site on the myosin head is activated, allowing it to attach to actin.
5. In the presence of ATP, the myosin head bends, producing contraction.

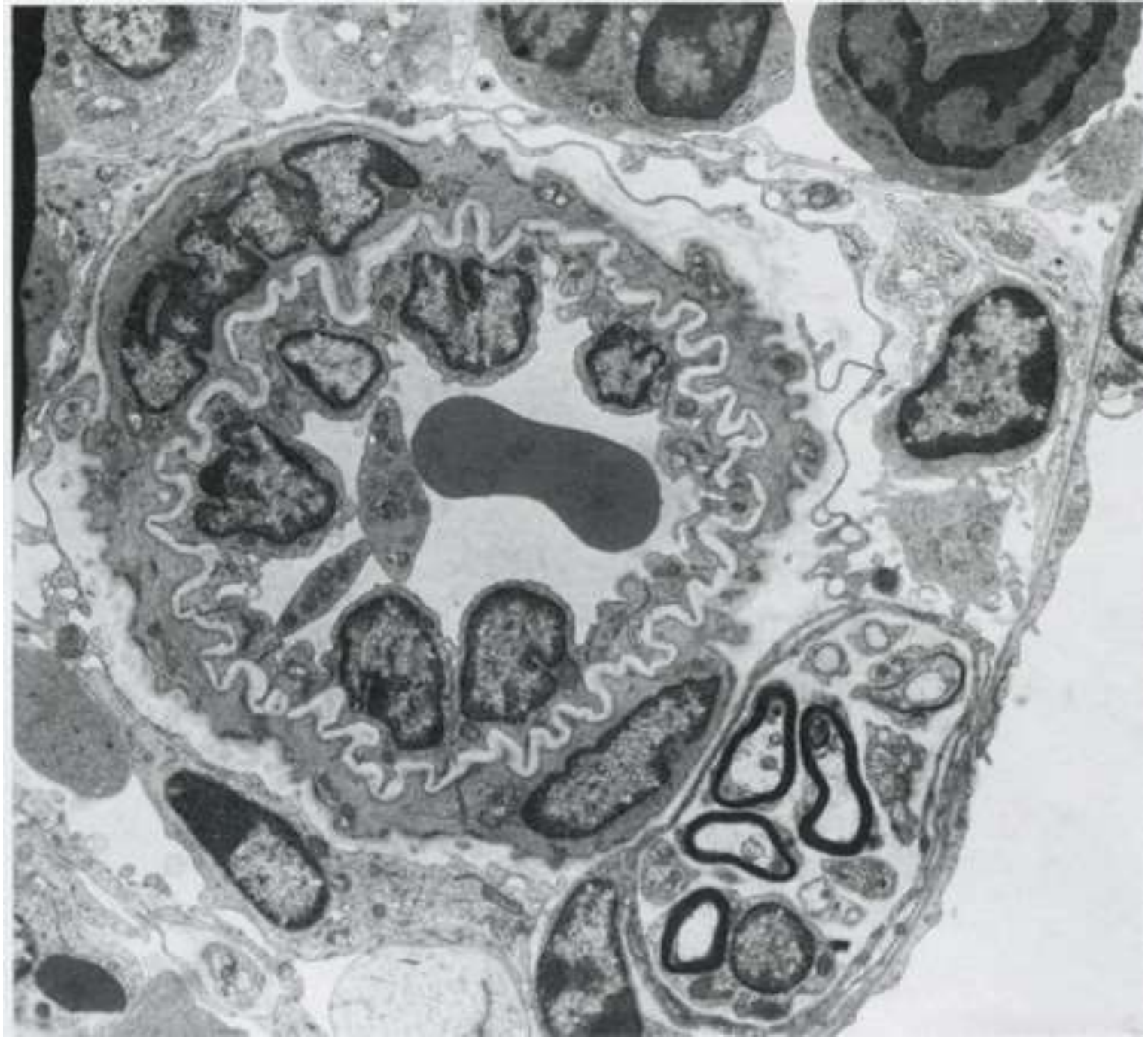
MODEL for SMOOTH MUSCLE CELL CONTRACTION

relaxed

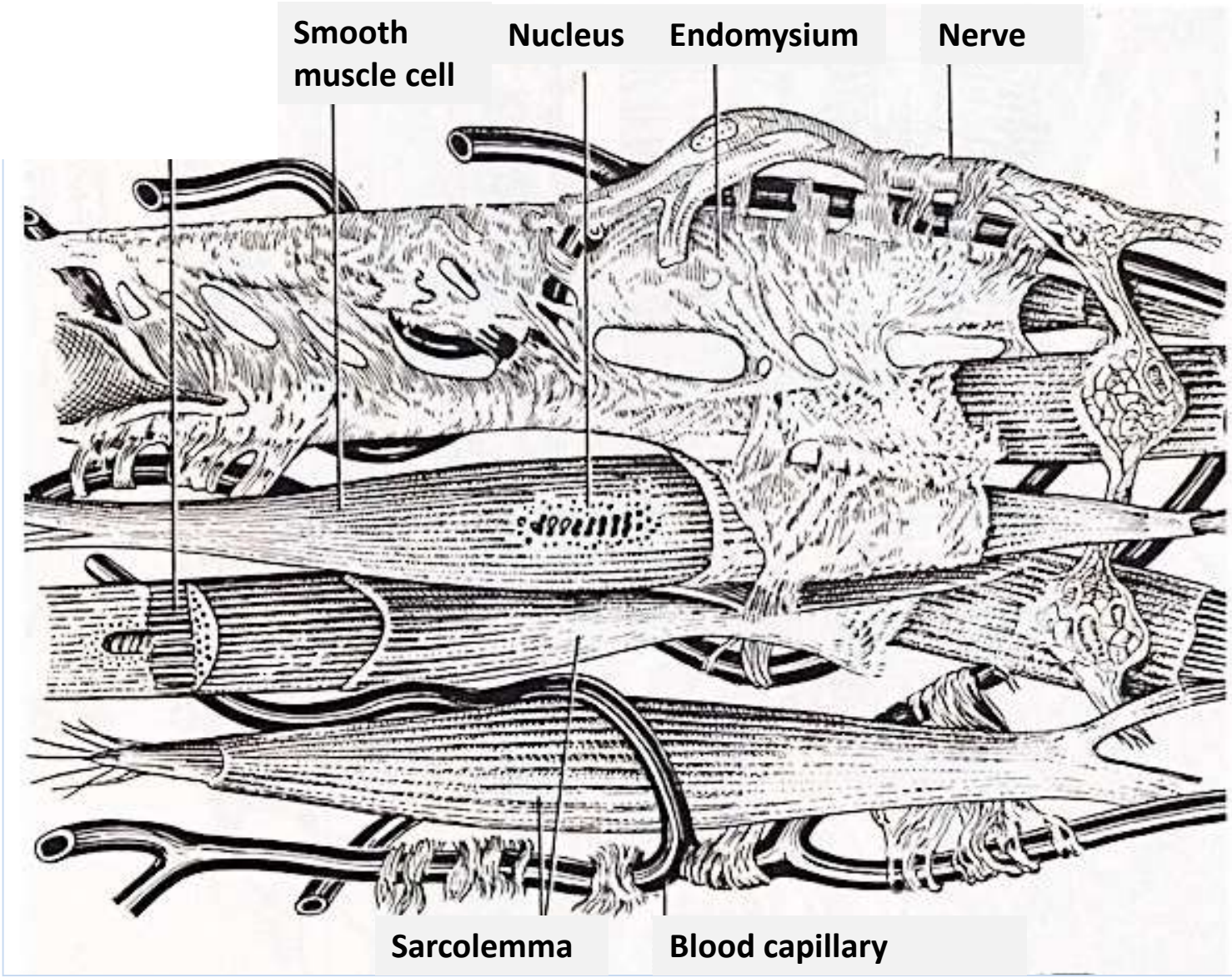


contracted

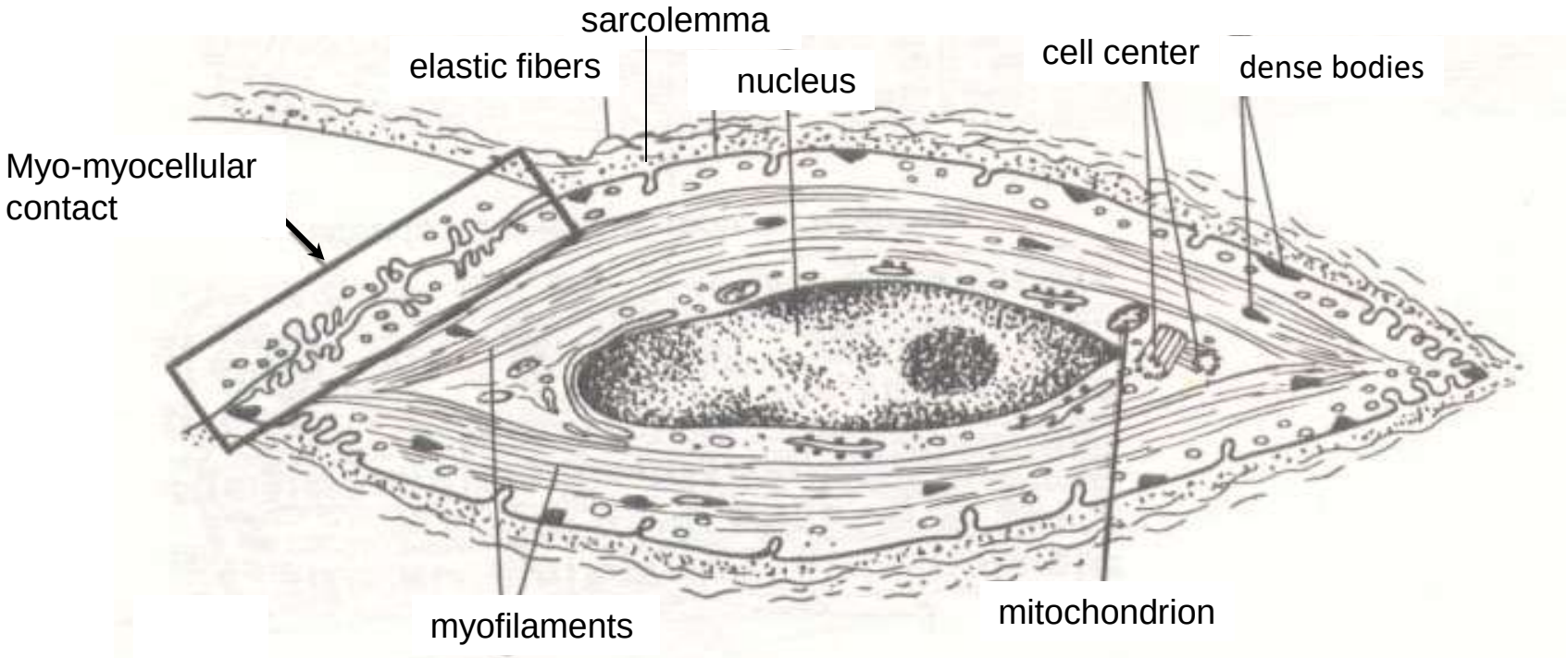




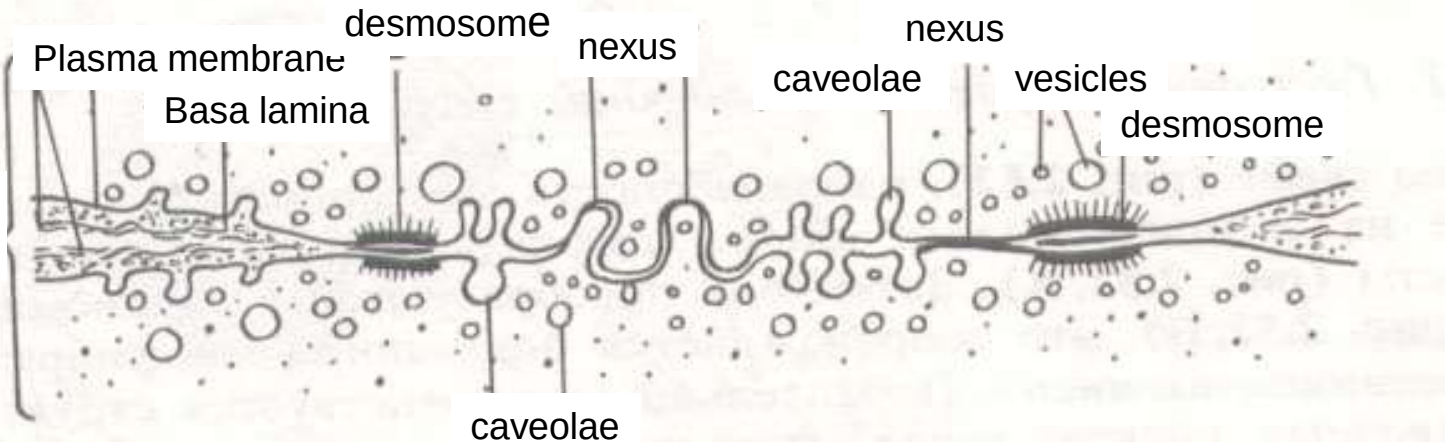
SMOOTH MUSCLE CELLS INTERACTION



SMOOTH MUSCLE CELLS INTERACTION



Myo-myocellular contact



INNERVATION OF SMOOTH MUSCLE

Multiple innervated smooth muscles

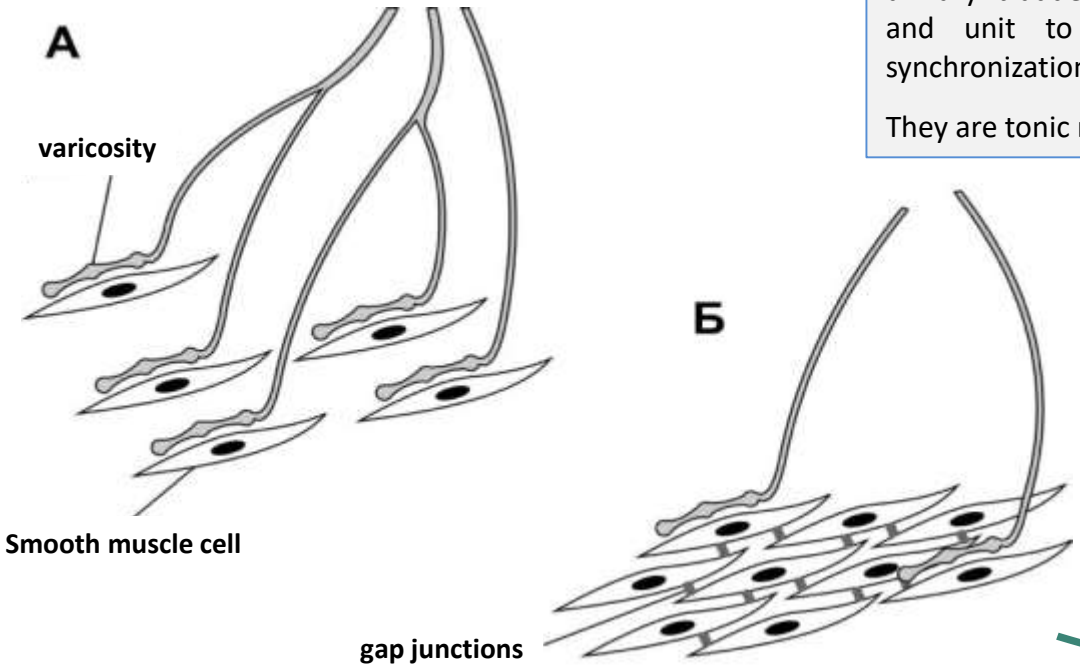
Smooth muscle cells of iris and vas deferens have individual motor innervations. This allows fine regulation of muscle contraction.

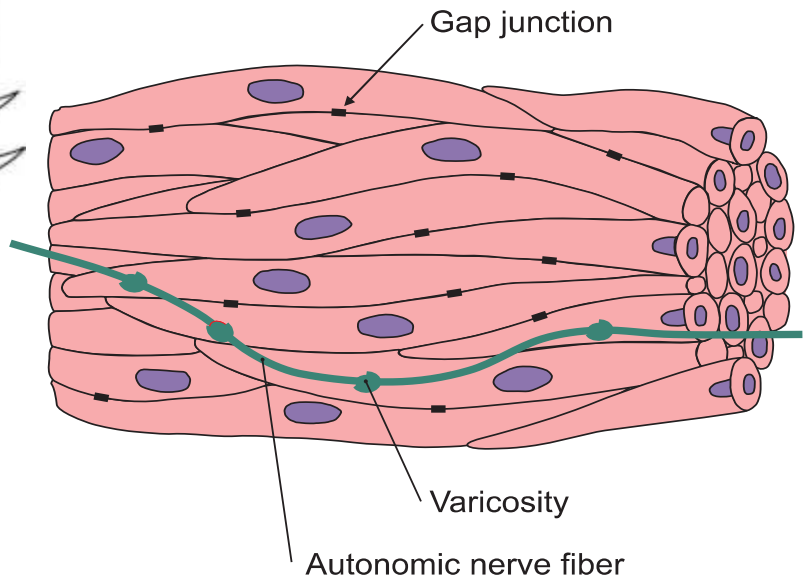
They belong to phasic muscles and have relatively high speed characteristics.

Singly innervated smooth muscles

Smooth muscle cells of digestive tract, uterus, ureter, urinary bladder have numerous gap junctions (nexuses) and unit to large functional cellular complex for synchronization of contraction.

They are tonic muscles.





Slide №72 «**Smooth muscle. Section of small intestine**» **H&E**