

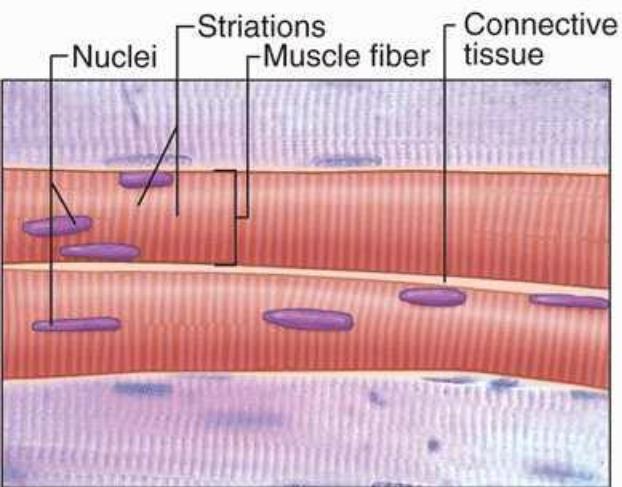
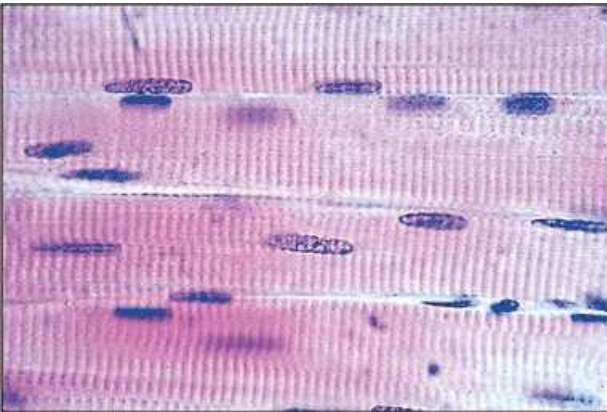
A fluorescence micrograph of skeletal muscle tissue. The image shows multiple muscle fibers with a distinct striated pattern. Nuclei are stained blue and are located along the periphery of the fibers. Mitochondria are stained green and are scattered throughout the muscle fibers. The overall color palette is dominated by red and orange, with blue and green highlights from the staining.

TKANKA MIĘŚNIOWA

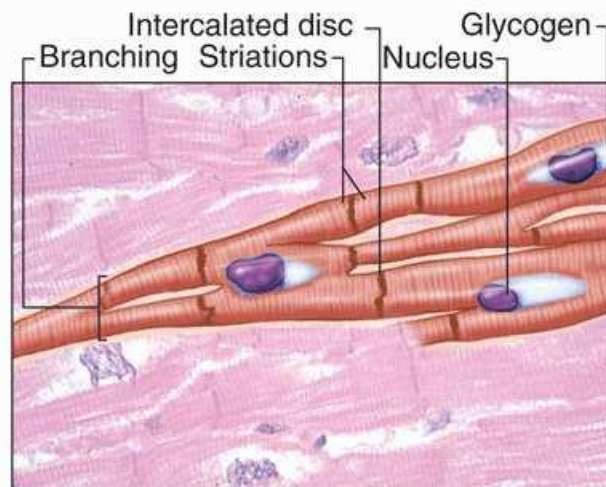
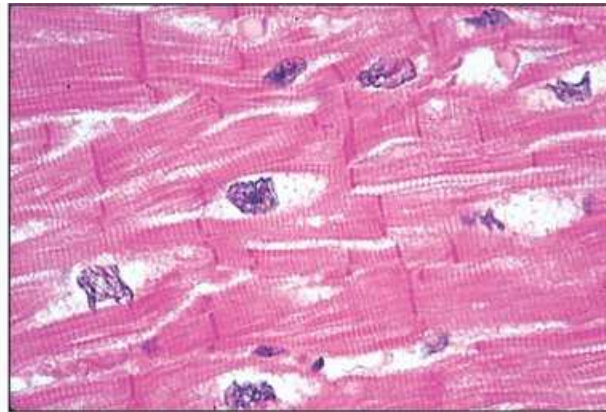
Ewa Jankowska-Steifer

SEMINARIUM

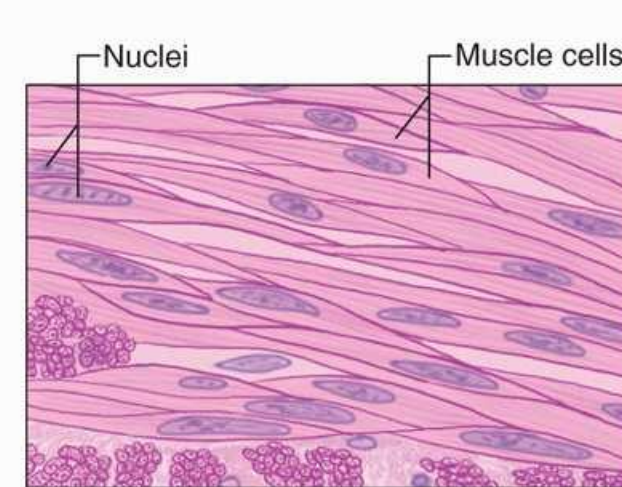
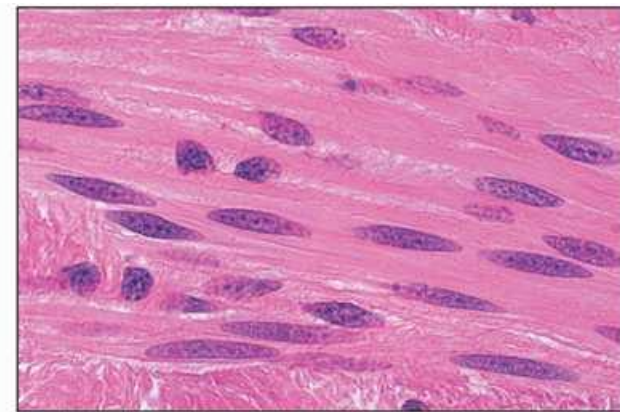
Typy tkanki mięśniowej



a Skeletal muscle

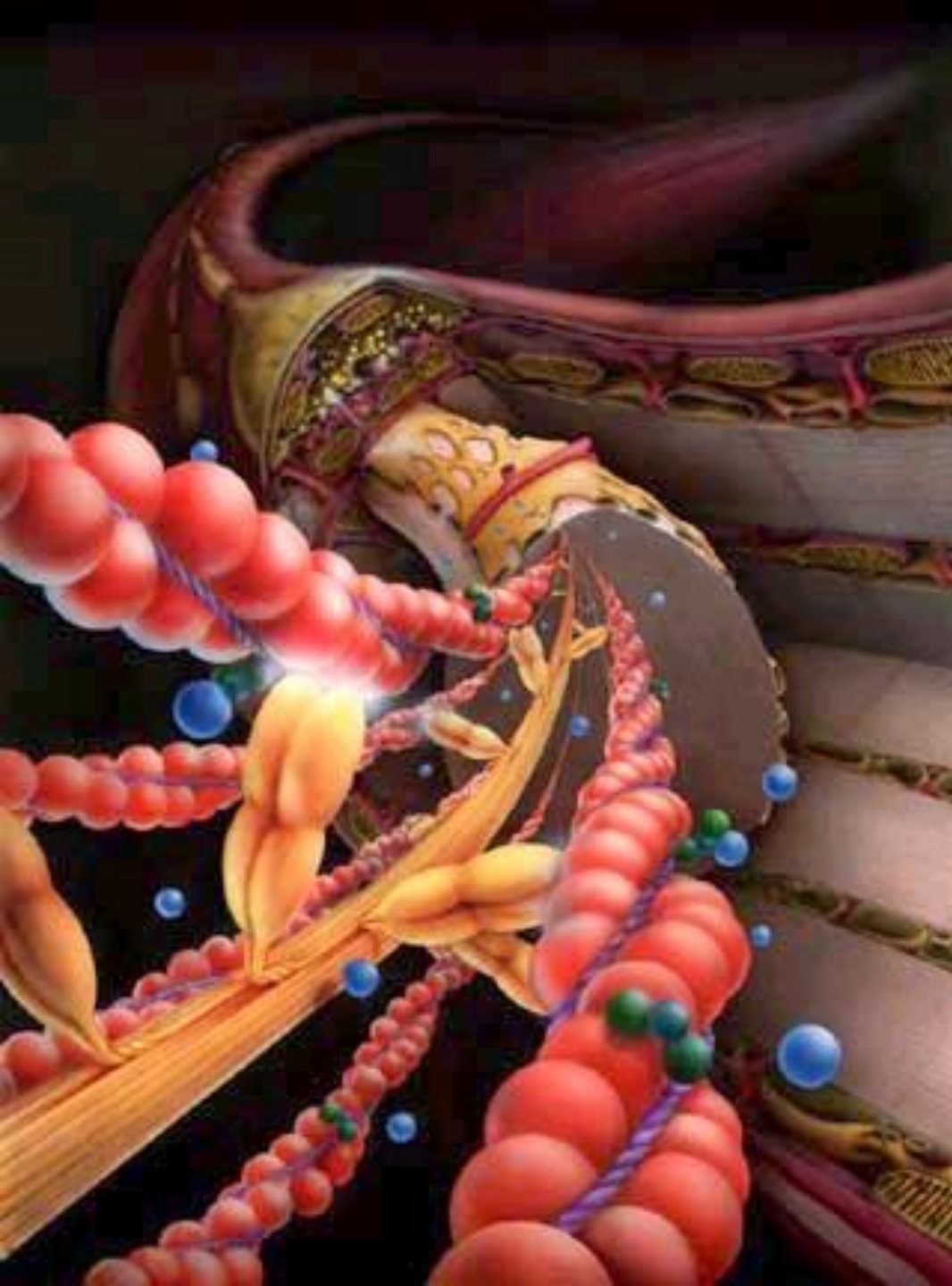


b Cardiac muscle



c Smooth muscle

TKANKA
MIĘŚNIOWA
SZKIELETOWA



Sarkoplazma

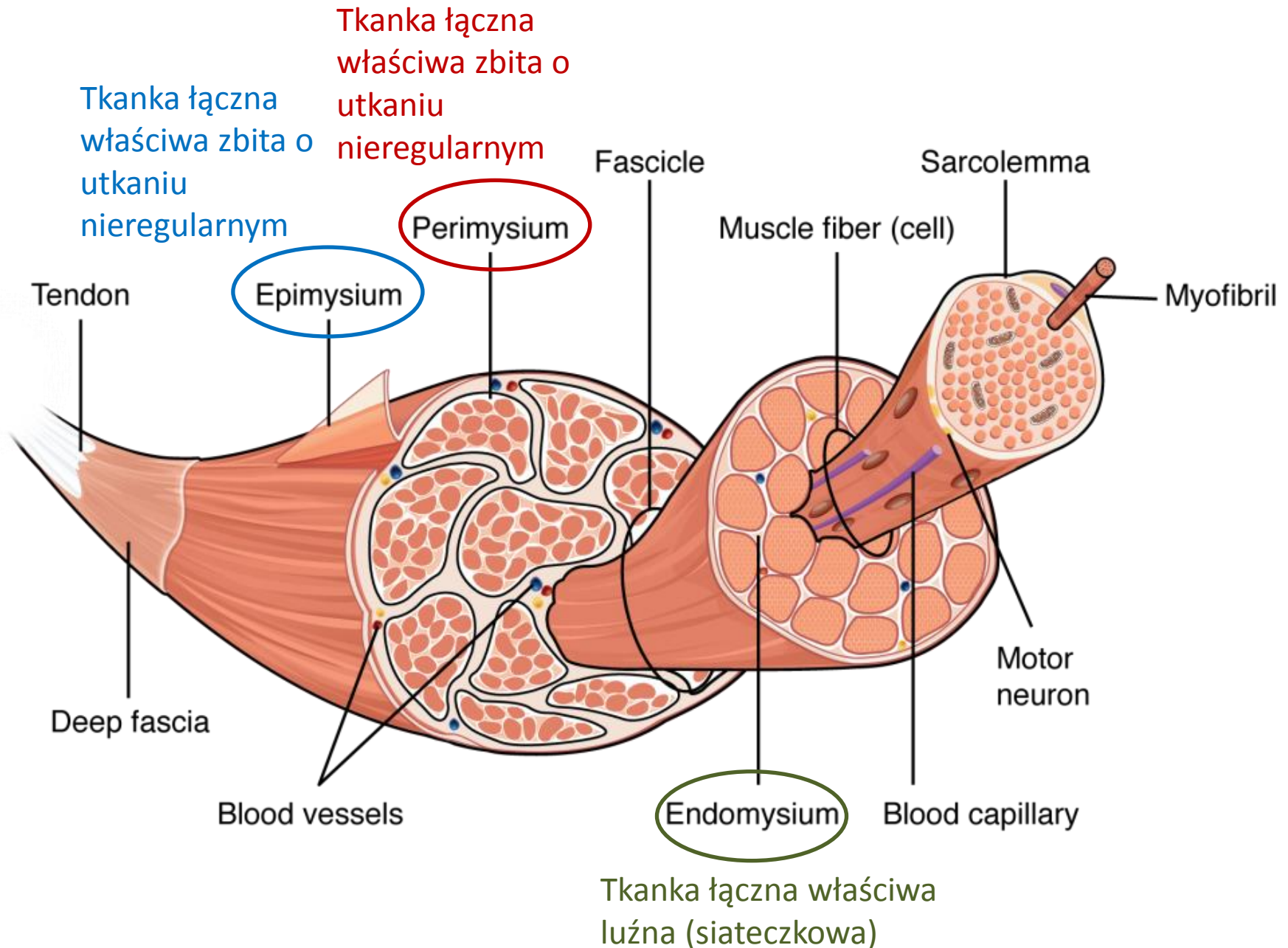
Sarkolema

Siateczka
sarkoplazmatyczna

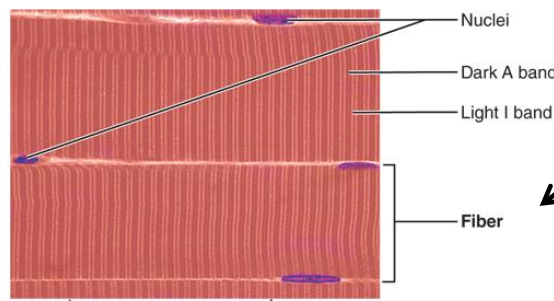
Sarkosomy

Sarkomery

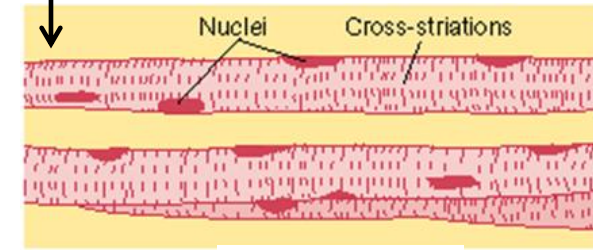
Mięsień i tkanki łączne



(a) Photomicrograph of portions of two isolated muscle fibers (700×). Notice the obvious striations (alternating dark and light bands).

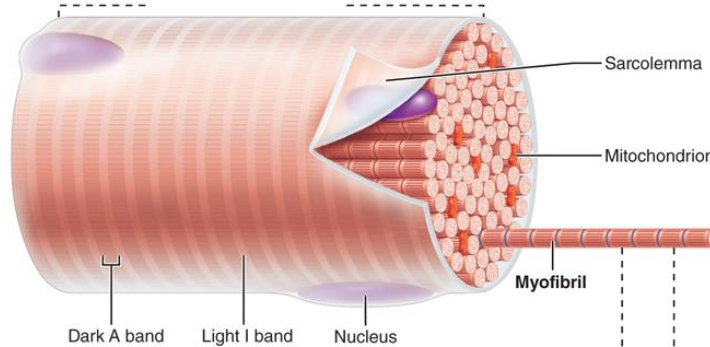


MIOWŁÓKNO = WŁÓKNO MIĘŚNIOWE
= KOMÓRKA MIĘŚNIA
SZKIELETOWEGO



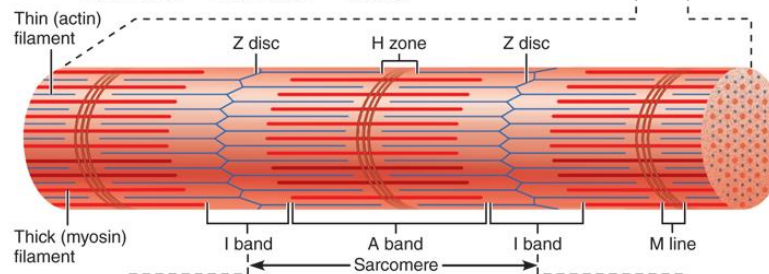
POLIKARIOCYTY

(b) Diagram of part of a muscle fiber showing the myofibrils. One myofibril extends from the cut end of the fiber.

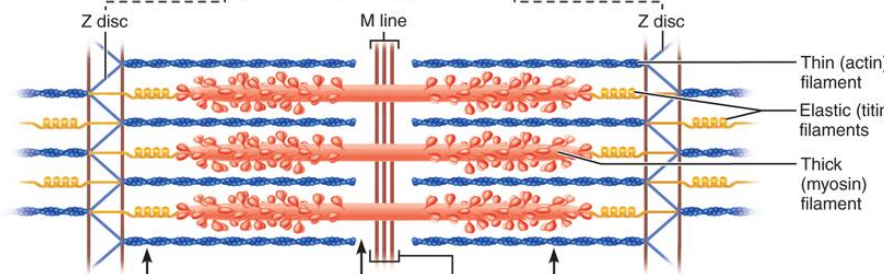


Miofibryla – szereg sarkomerów

(c) Small part of one myofibril enlarged to show the myofilaments responsible for the banding pattern. Each sarcomere extends from one Z disc to the next.

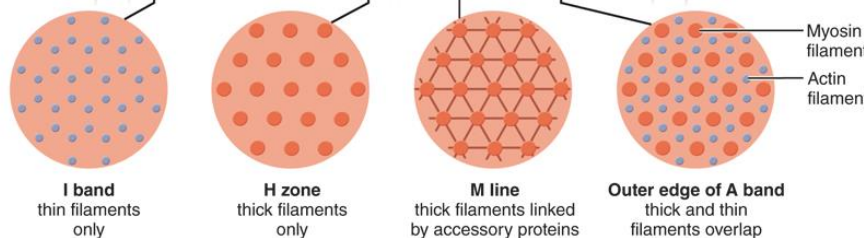


(d) Enlargement of one sarcomere (sectioned lengthwise). Notice the myosin heads on the thick filaments.



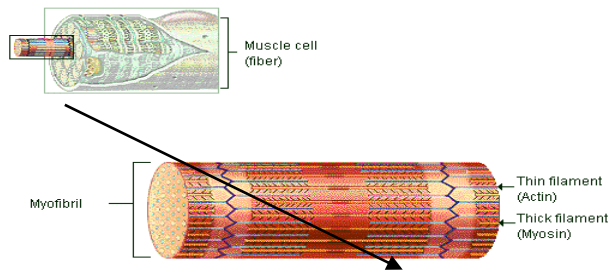
SARKOMER – PODSTAWOWA
JEDNOSTKA SKURCZOWA

(e) Cross-sectional view of a sarcomere cut through in different locations.



MIOFILAMENTY – CIENKIE (aktyna)
GRUBE (miozyna)

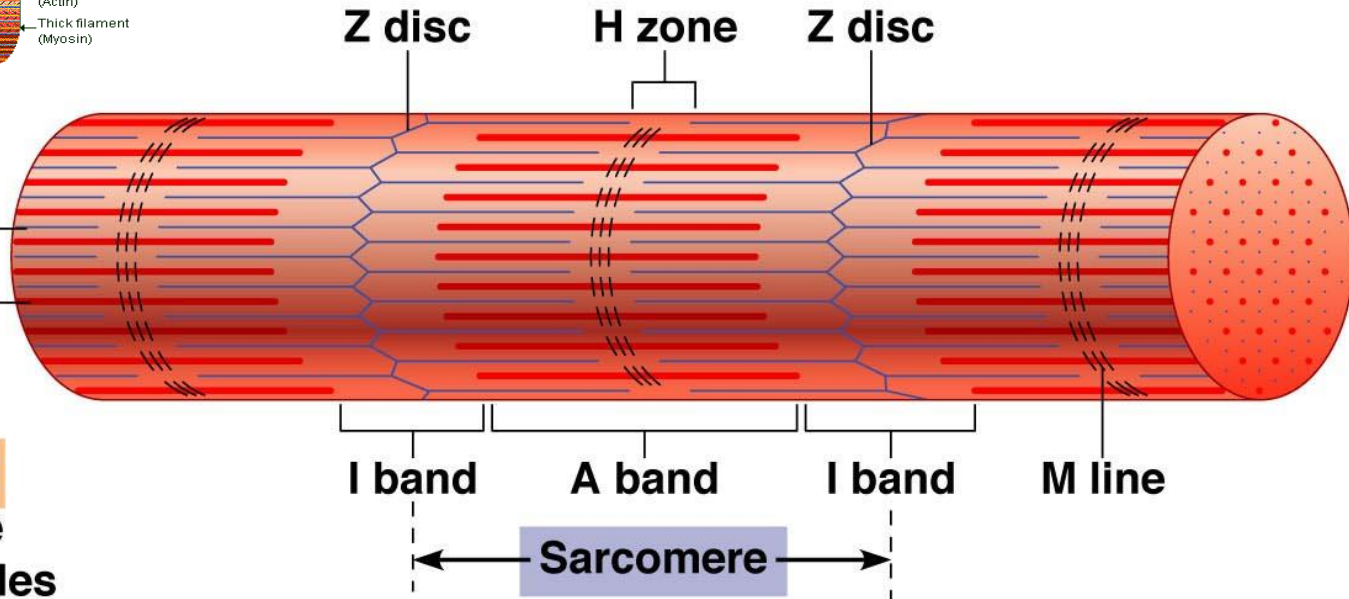
Budowa włókienka mięśniowego i sarkomerów



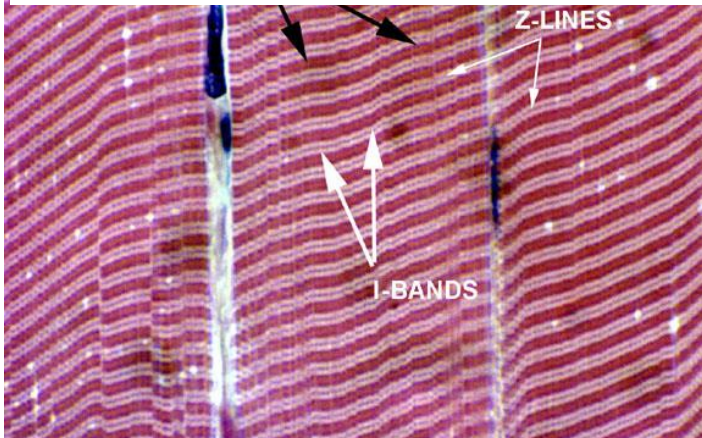
Thin (actin) filament

Thick (myosin) filament

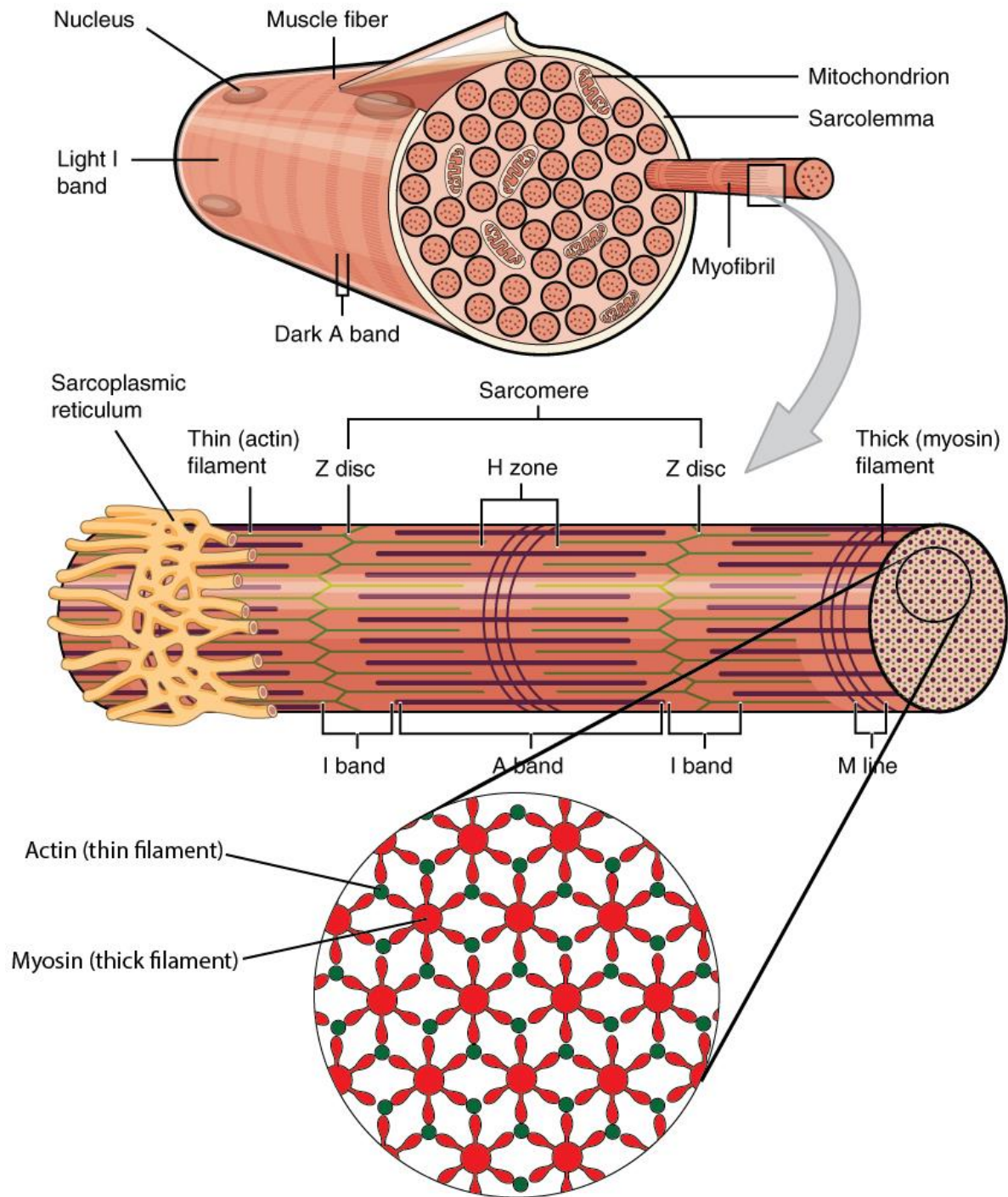
(b) **Myofibril or fibril**
(complex organelle
composed of bundles
of myofilaments)

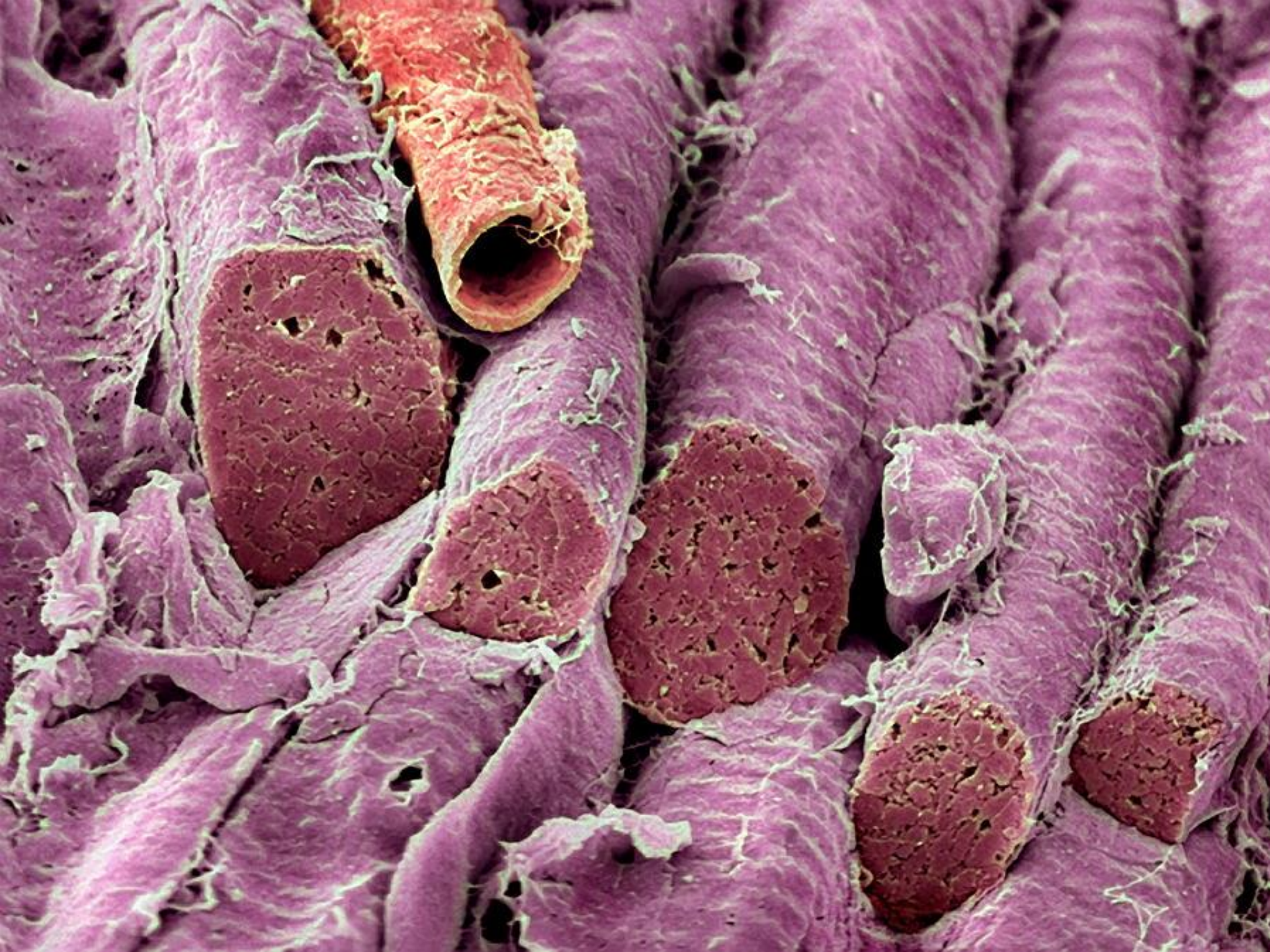


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Miofibryle i sarkomery



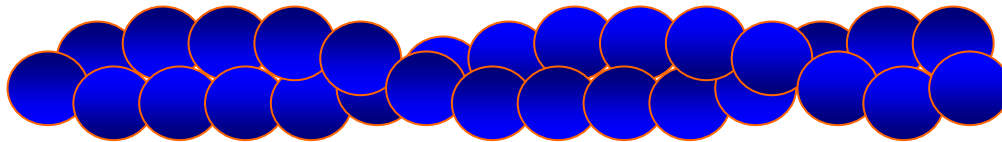


THIN - actin filaments

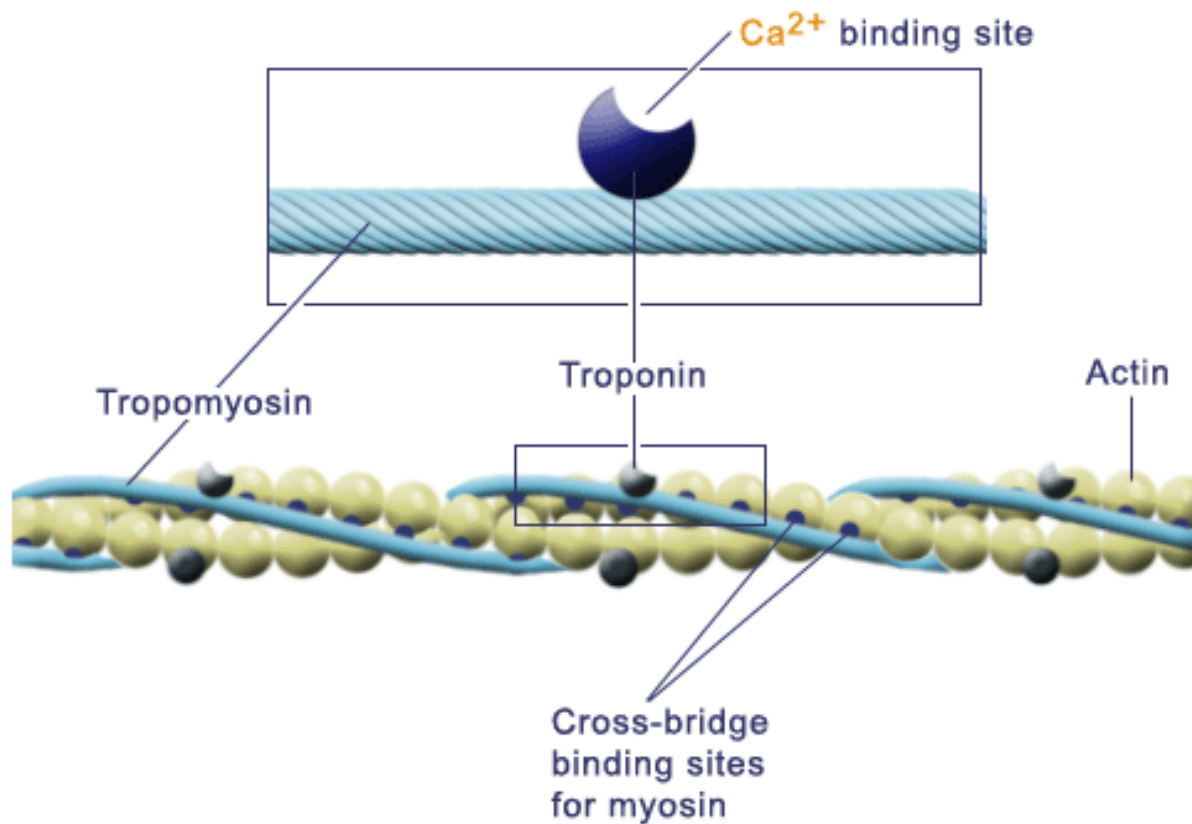


G actin

F-aktyna jest polimerem globularnych G aktyn



F actin

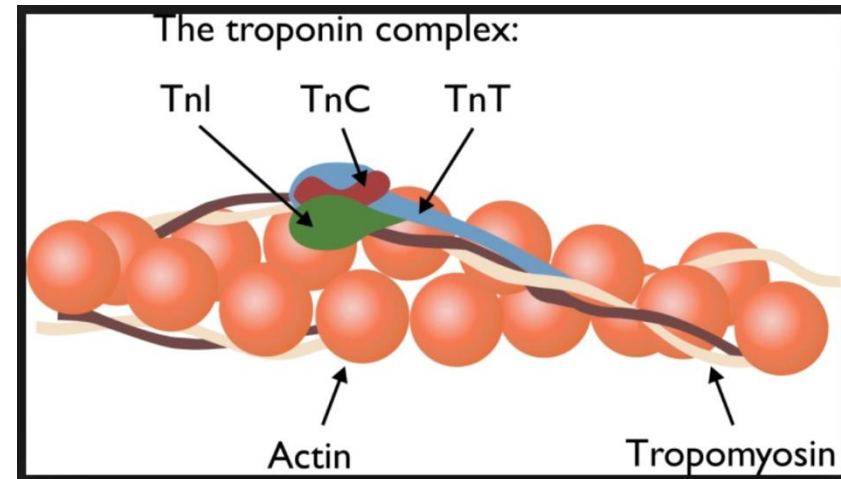
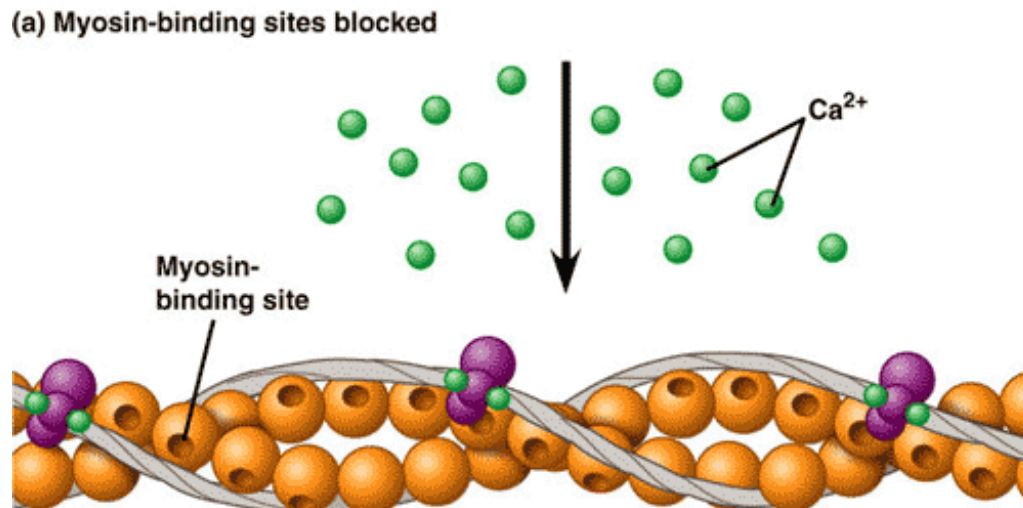
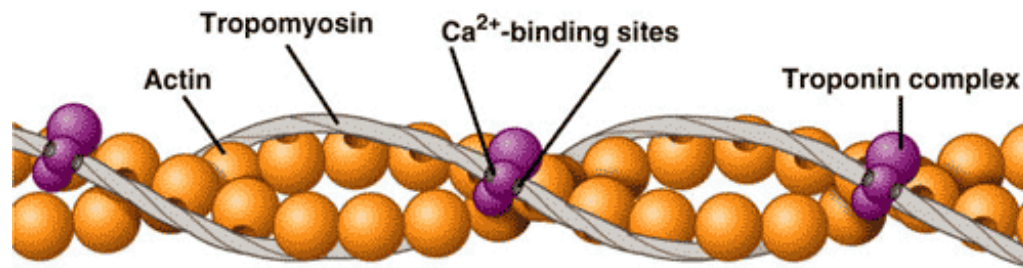


TROPONIN - function

Troponina T (TnT) – wiąże się z tropomiozyną

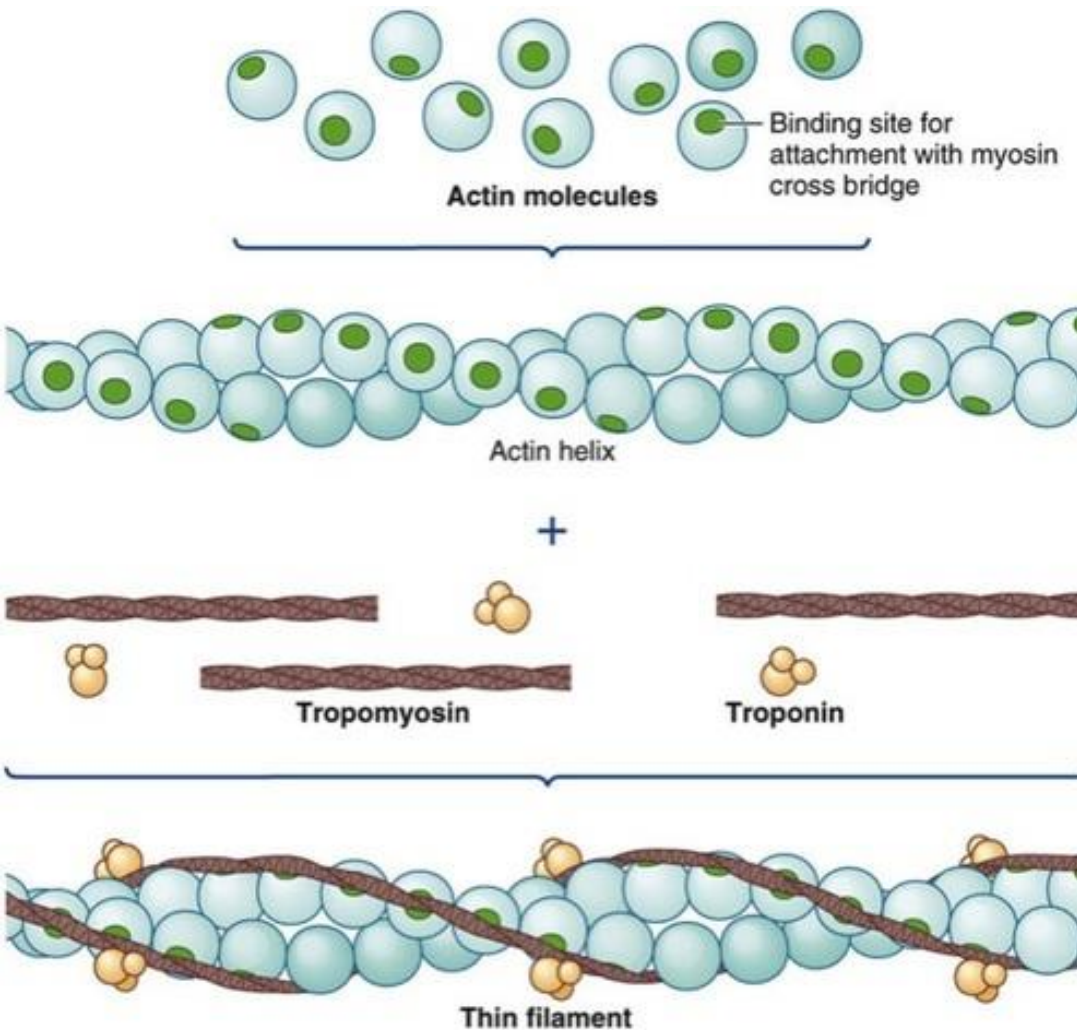
Troponina C (TnC) – ma powinowactwo do jonów wapnia

Troponina I (TnI) – zapobiega wiązaniu się aktyny z miozyną



Jony wapnia po związaniu z TnC inicjują zmiany konformacyjne w tropomiozynie

THIN - actin filaments



F aktyna – dwa łańcuchy skręcone spiralnie

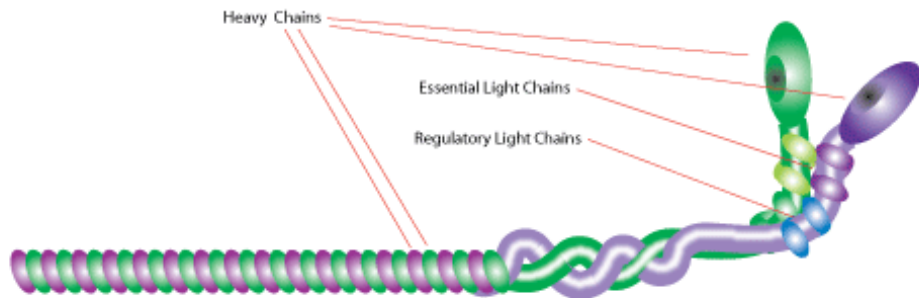
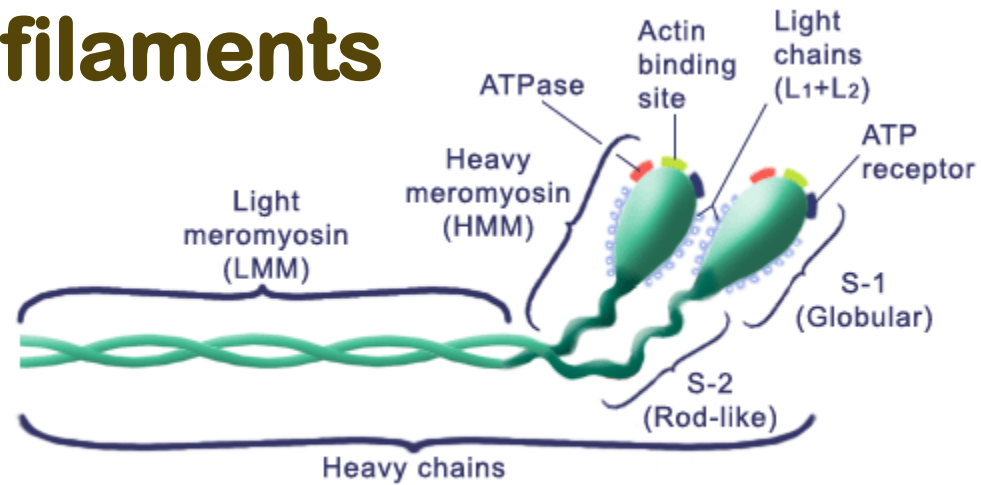
Troponiny – trzy globularne białka

Tropomiozyna w rozkurczu leży powyżej spiralnego rowka filamentu aktynowego – maskowanie miejsc wiązania z miozyną

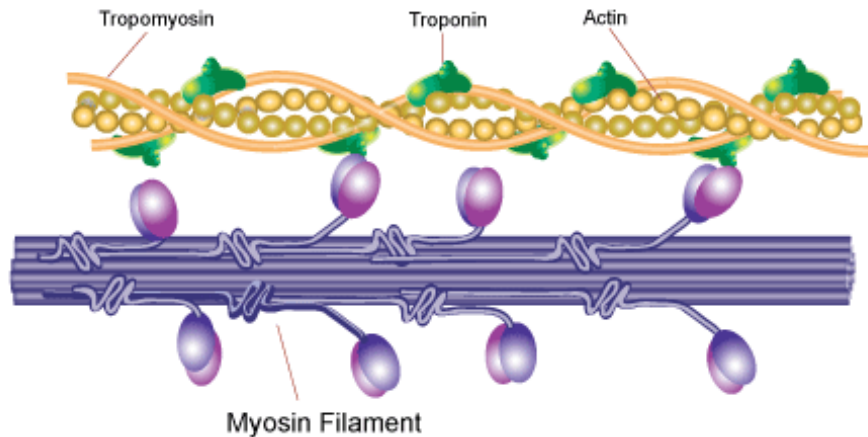
THICK - myosin filaments

2 łańcuchy ciężkie

2 łańcuchy lekkie



Łańcuch lekki właściwy

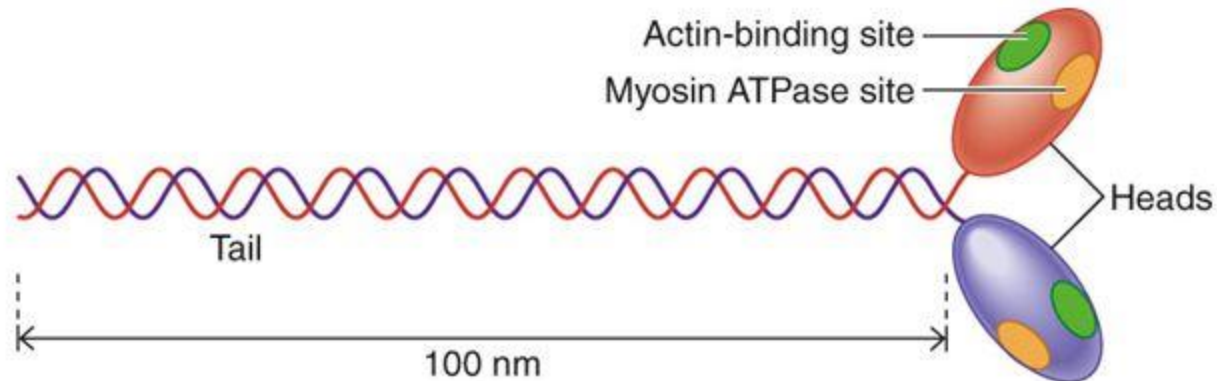


Łańcuch lekki regulatorowy

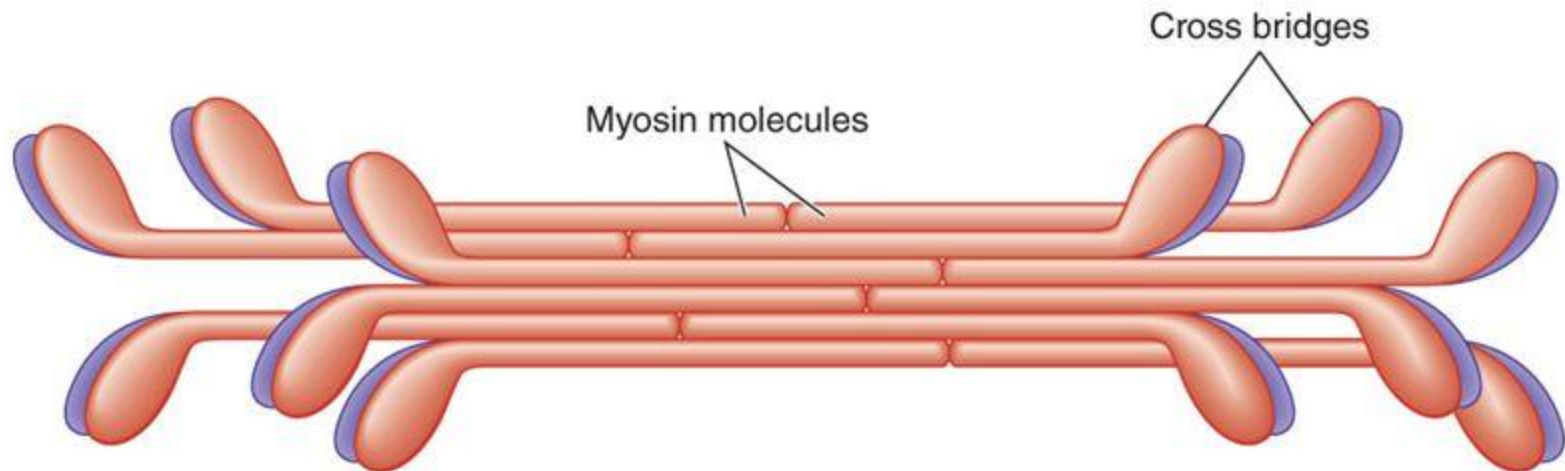


Kinaza lekkich łańcuchów miozyny

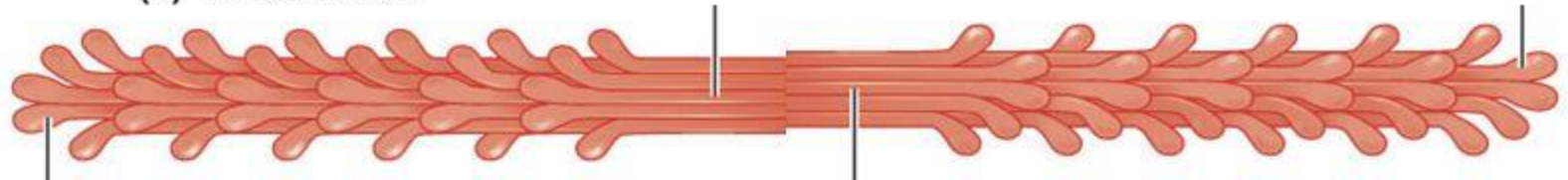
Structure and Arrangement of Myosin Molecules Within Thick Filament

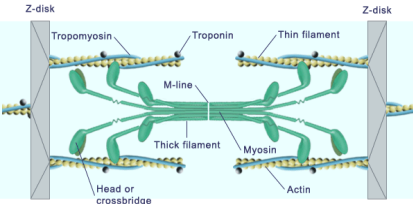


(a) Myosin molecule

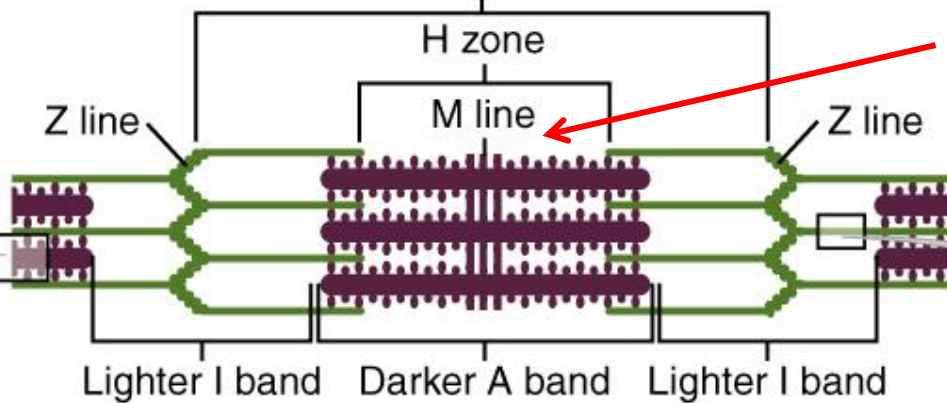


(b) Thick filament



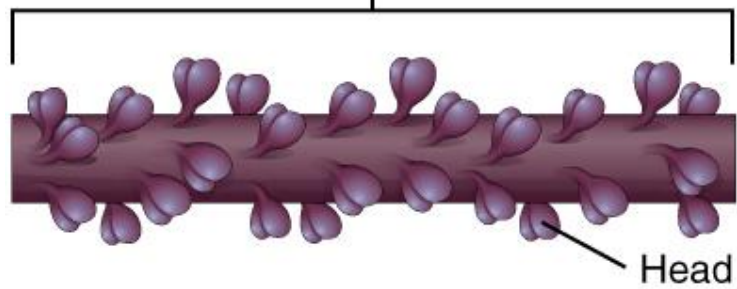


Sarcomere



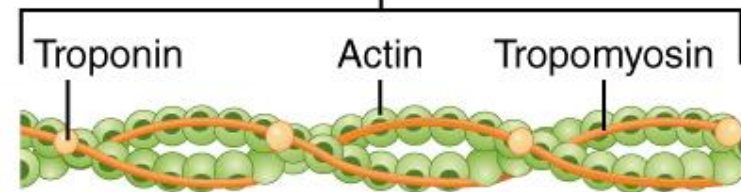
Myomesin
C-protein
Creatine kinase

Portion of a
thick filament



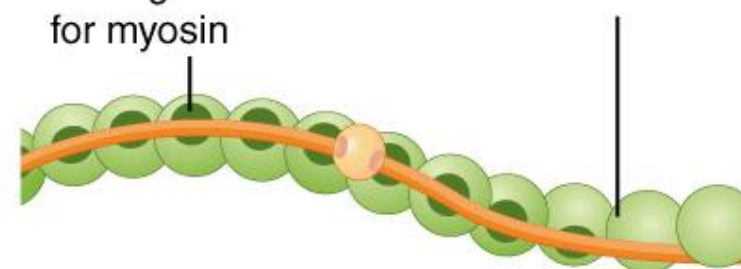
Head

Portion of a
thin filament



Binding site
for myosin

Actin subunits

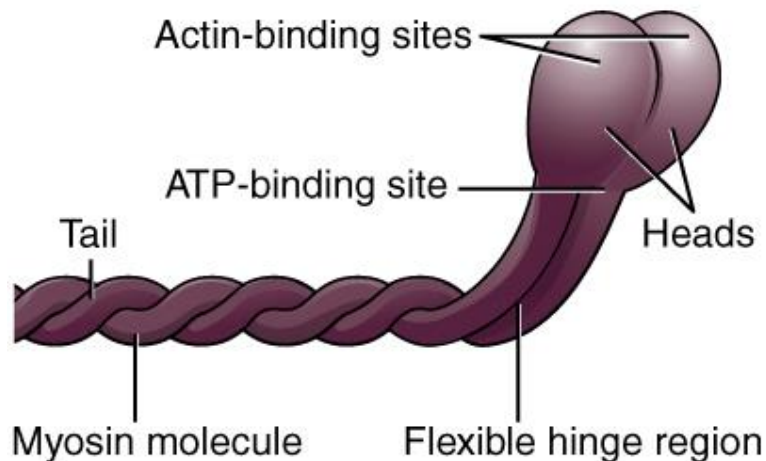


Actin-binding sites

ATP-binding site

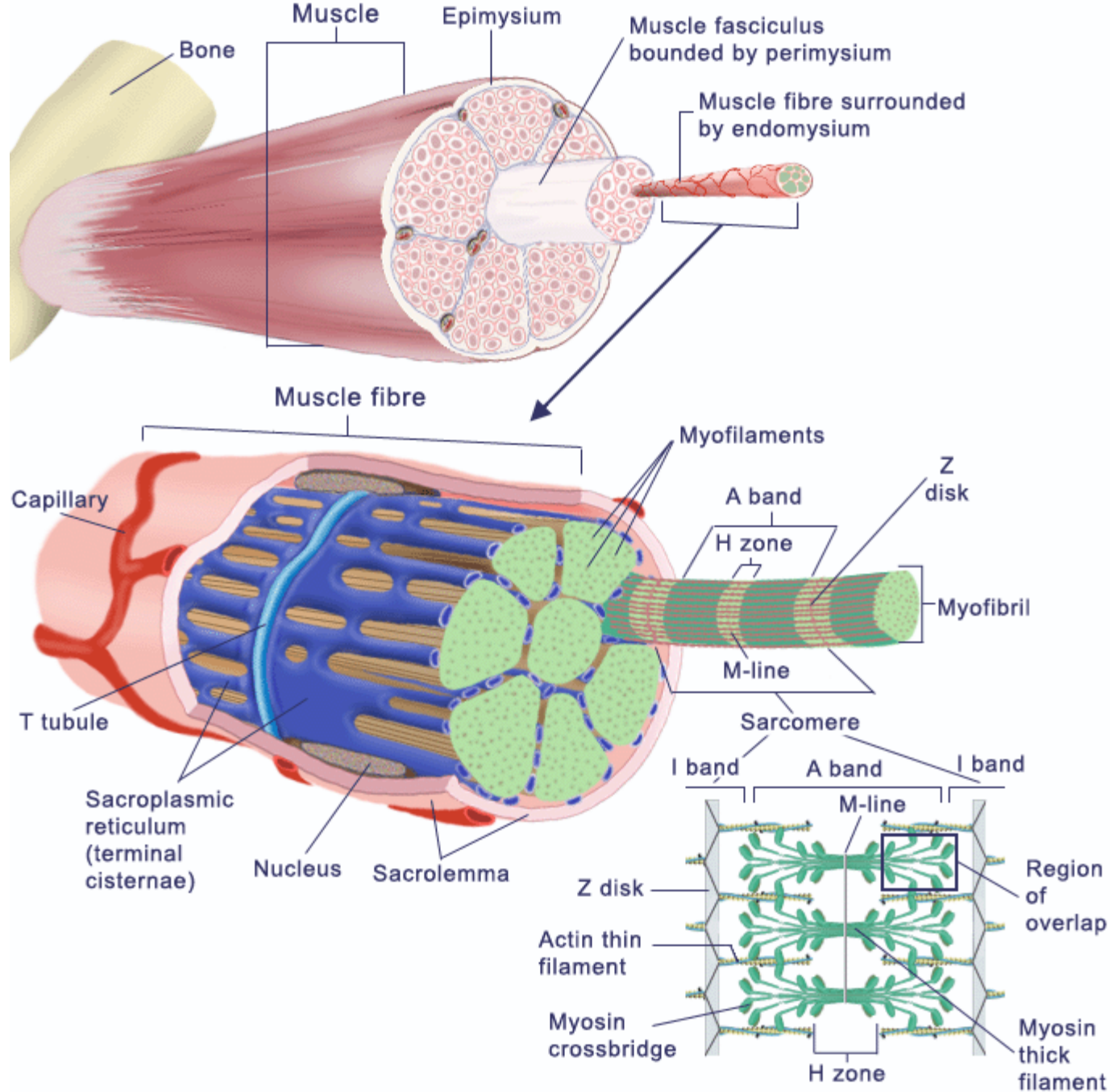
Tail

Heads



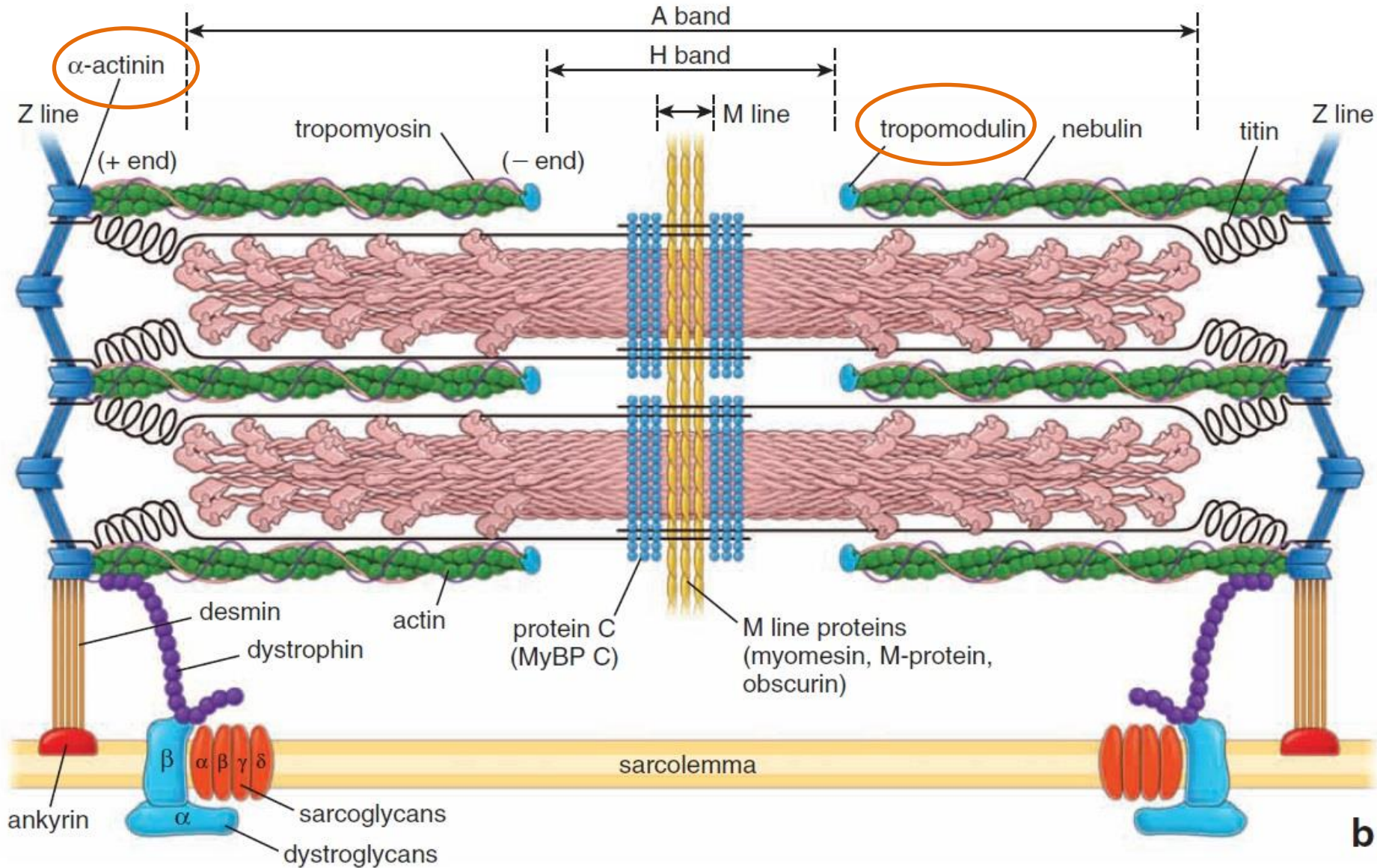
Myosin molecule

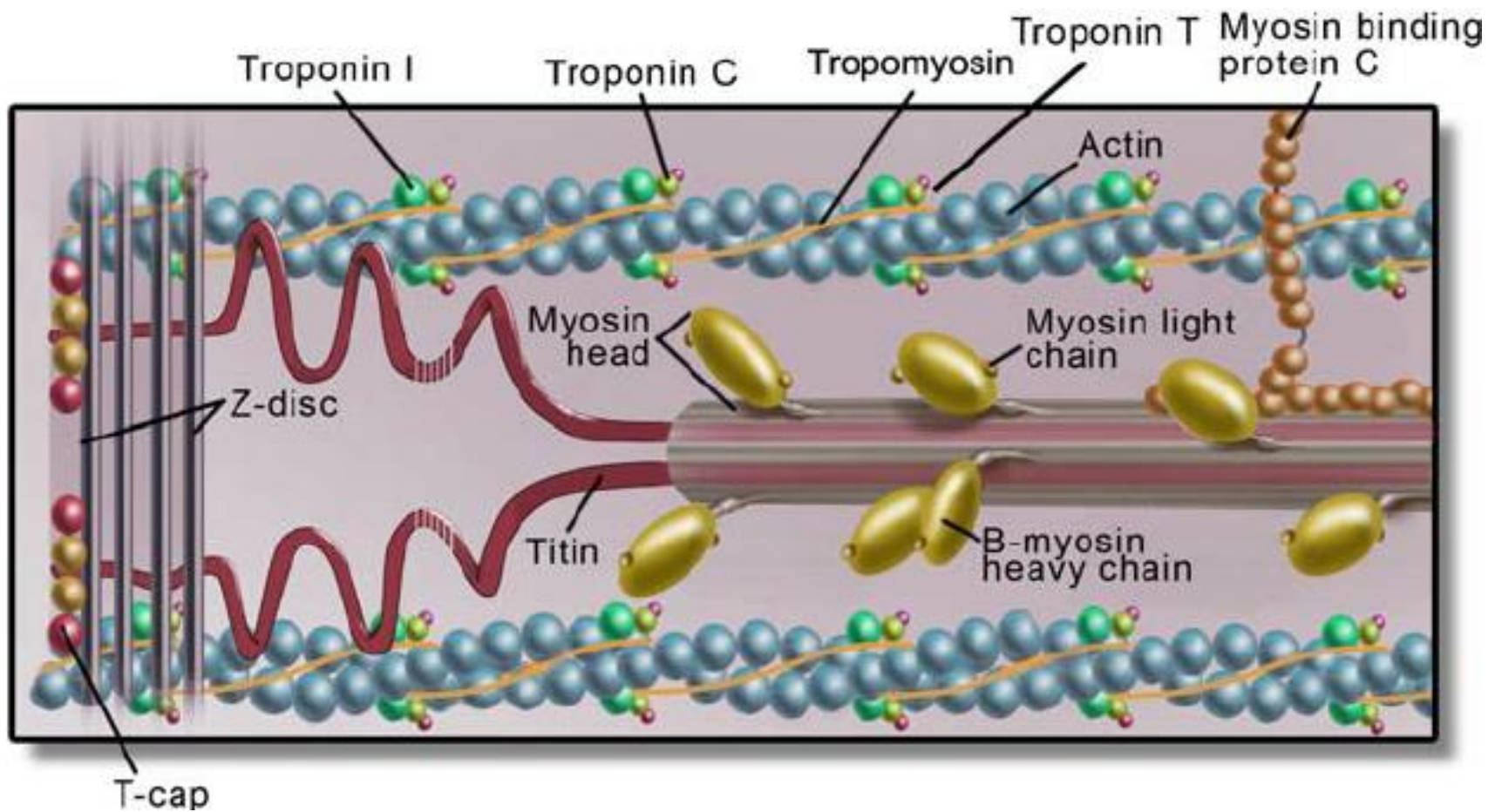
Flexible hinge region

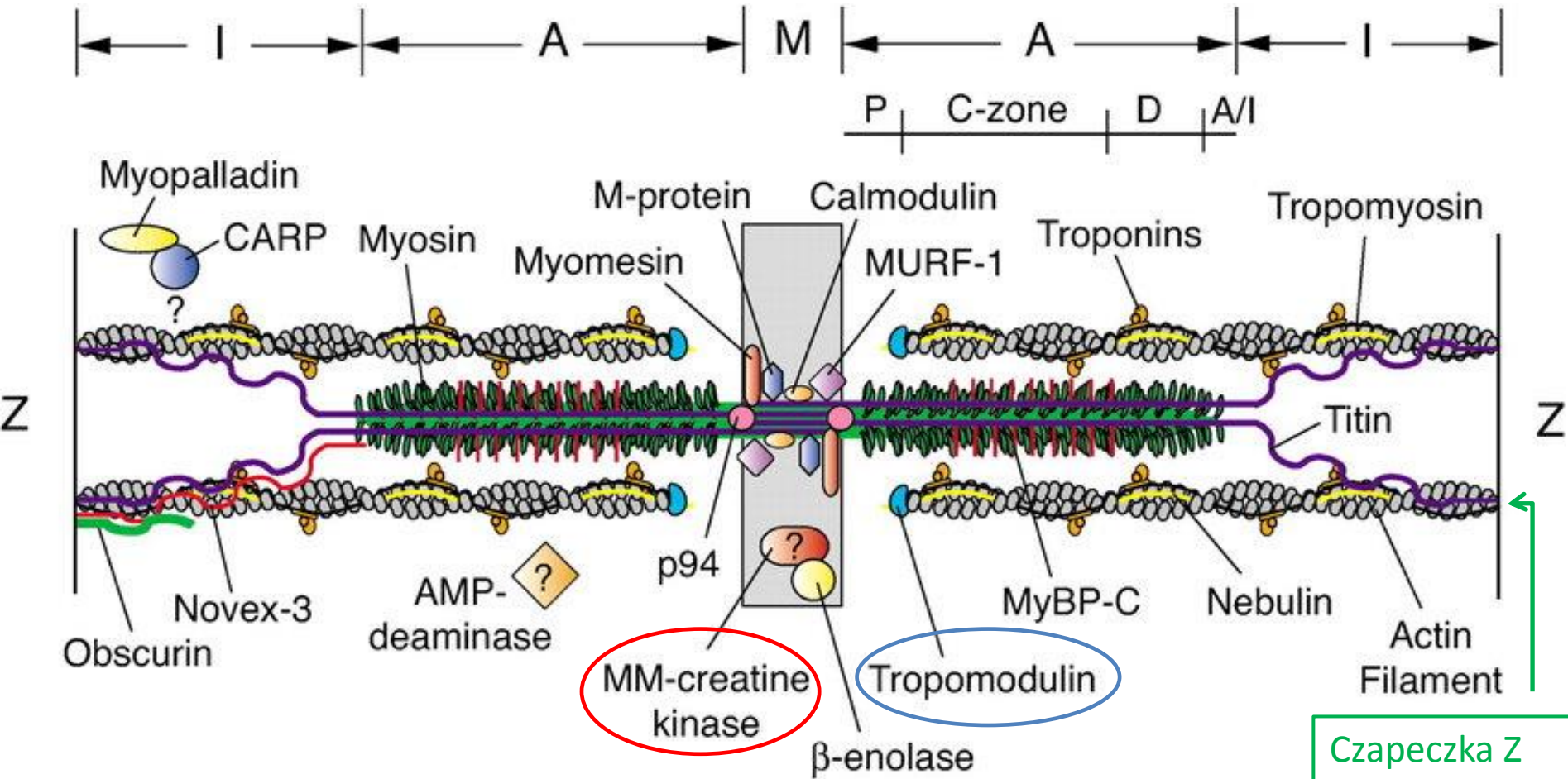


około 10 000 sarkomerów tworzy miofibrylę

Sarkomer







Kinaza kreatynowa (fosfokreatynowa) – przemiany energetyczne komórki

Fosforylacja kreatyny (*kwas β-metyloguanidynoowy*) = kreatyna + ATP

Czapeczka Z

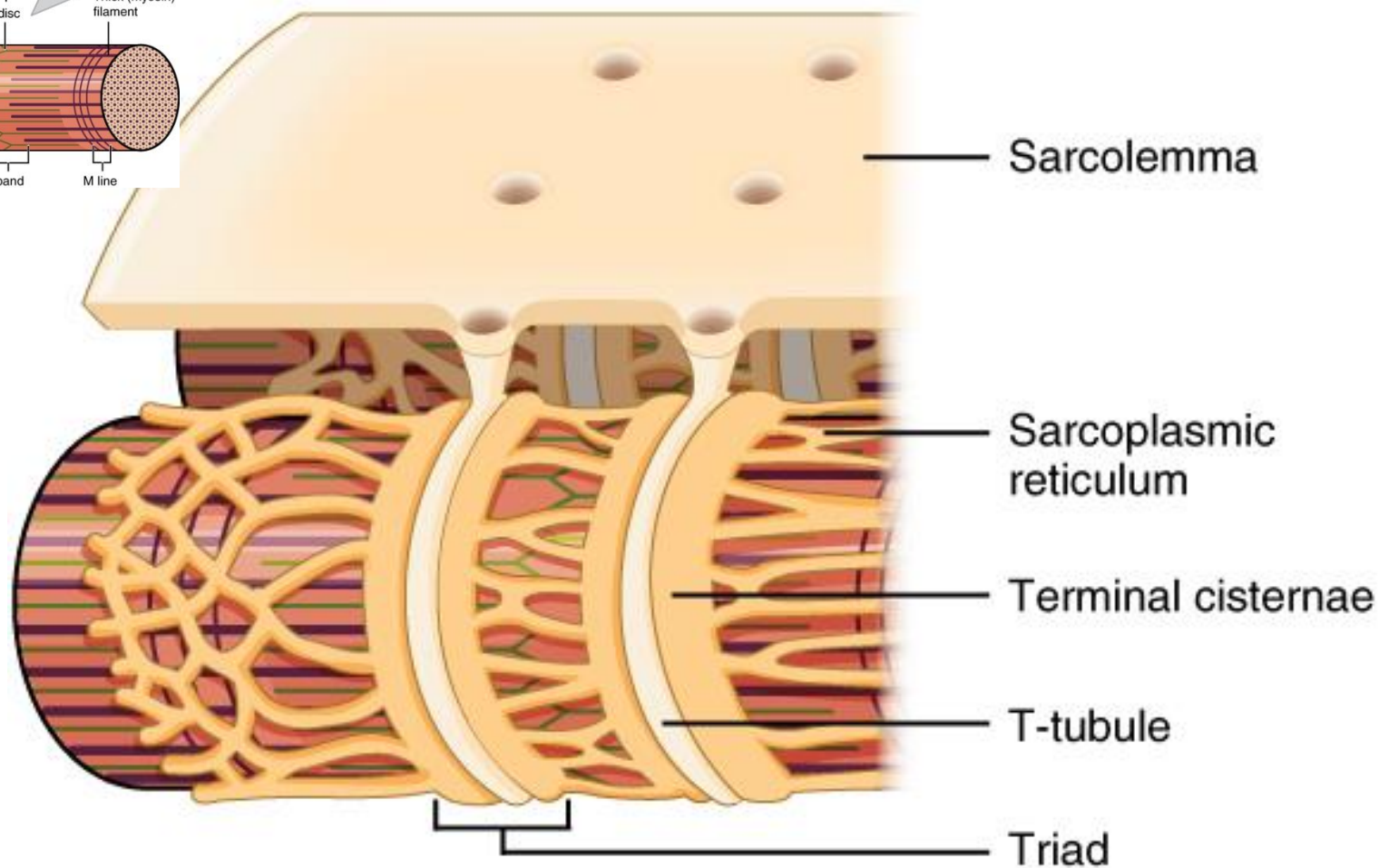
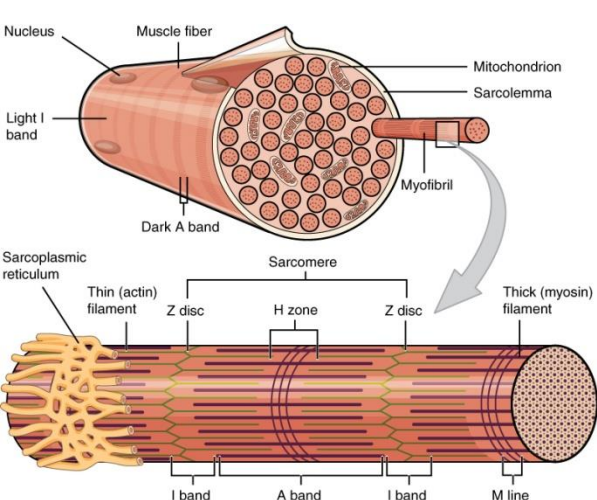
Końce plus

Regulacja wzrostu

filamentów

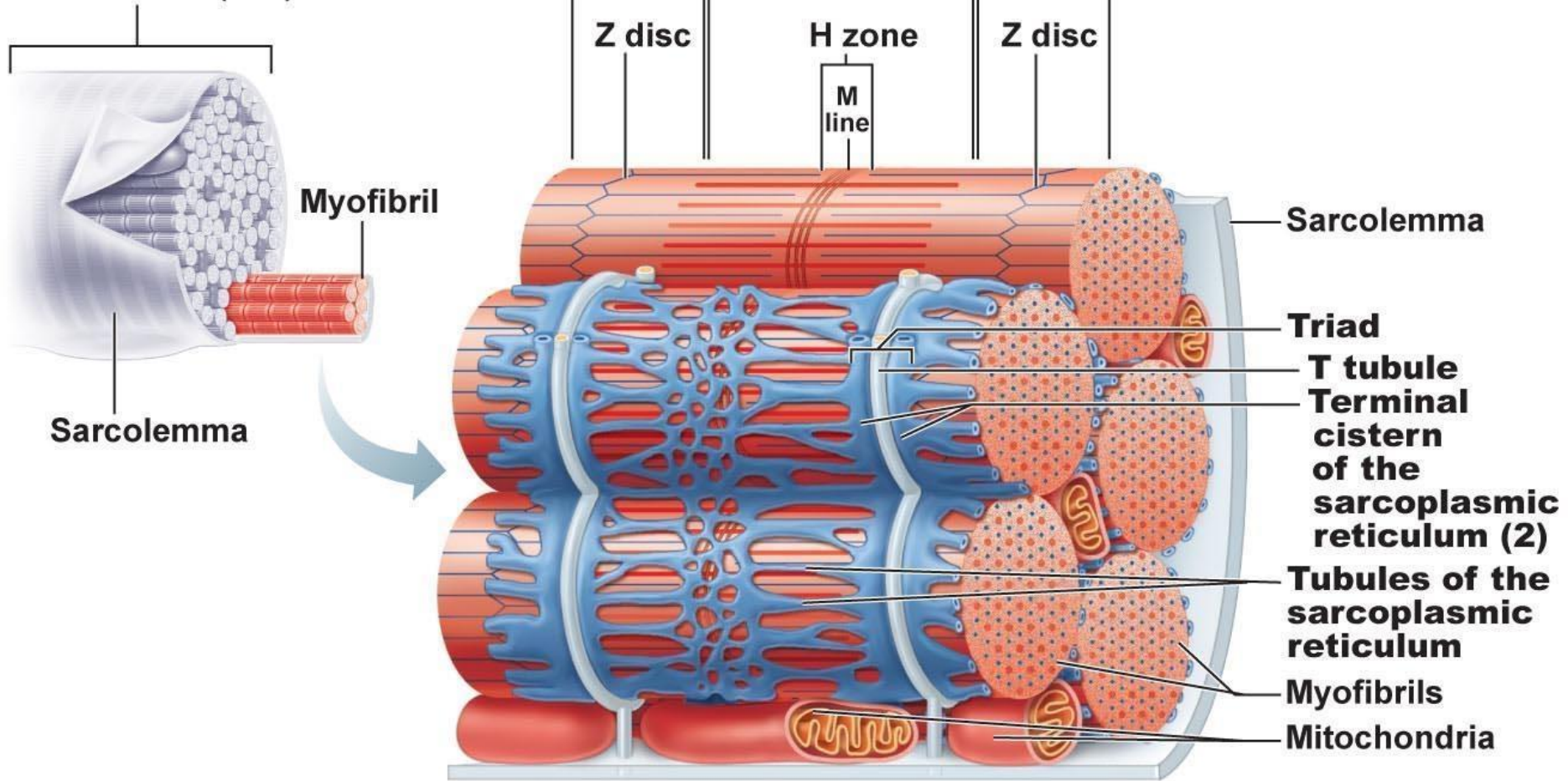
aktynowych

Koniec +



Kanalik T i dwa zbiorniki siateczki śródplazmatycznej – przeniesienie potencjału czynnościowego. Otwarcie kanałów dla jonów wapnia.

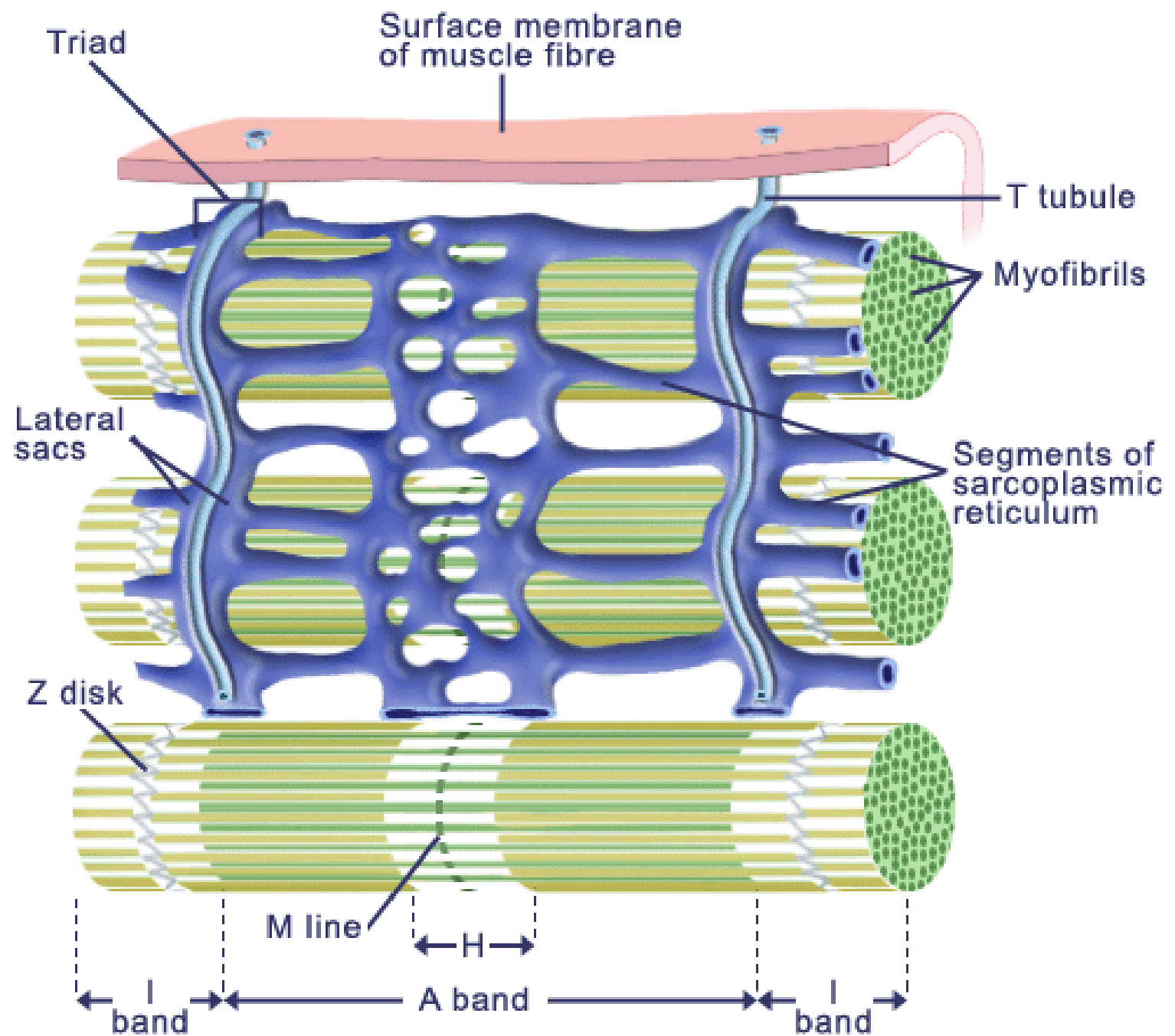
Part of a skeletal muscle fiber (cell)



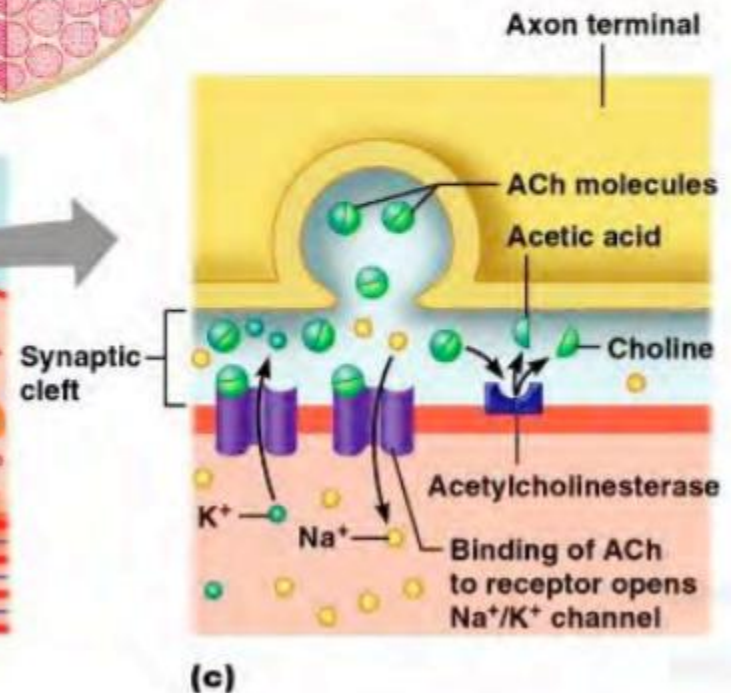
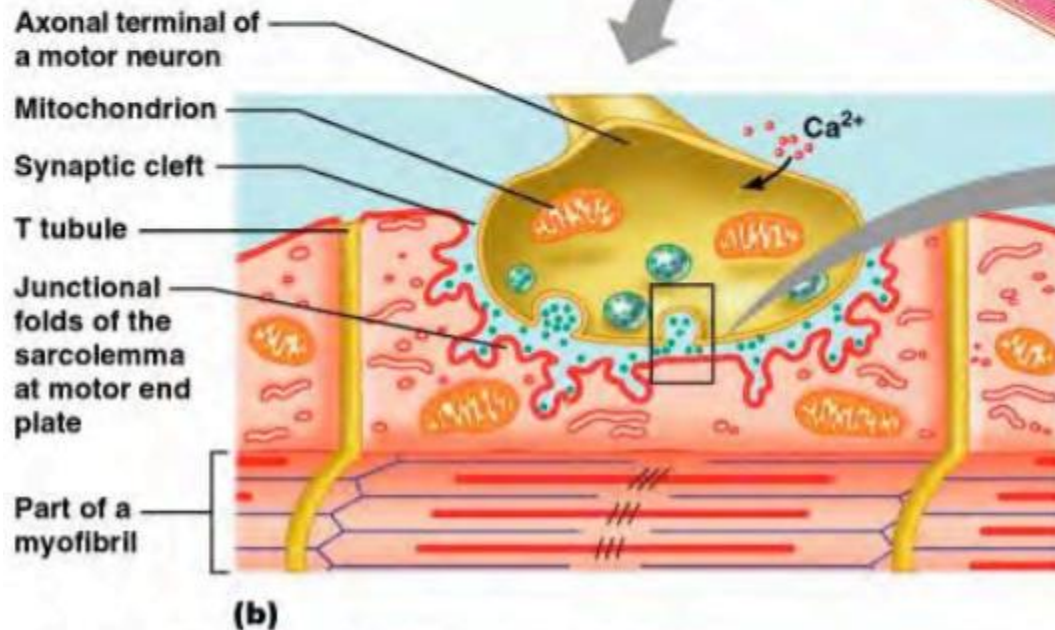
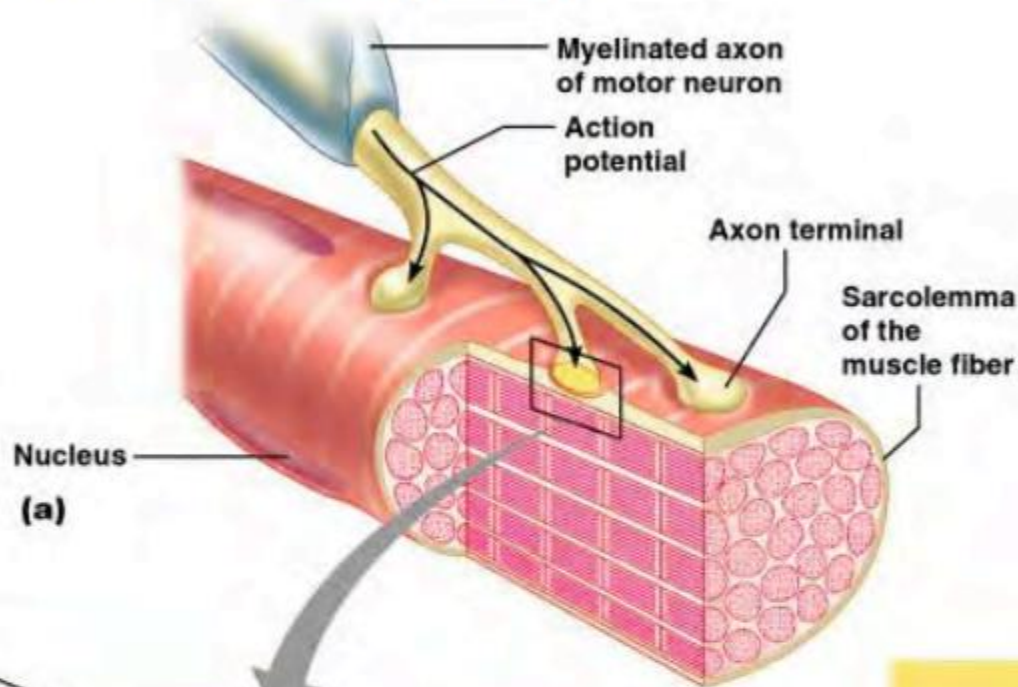
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TRIADA

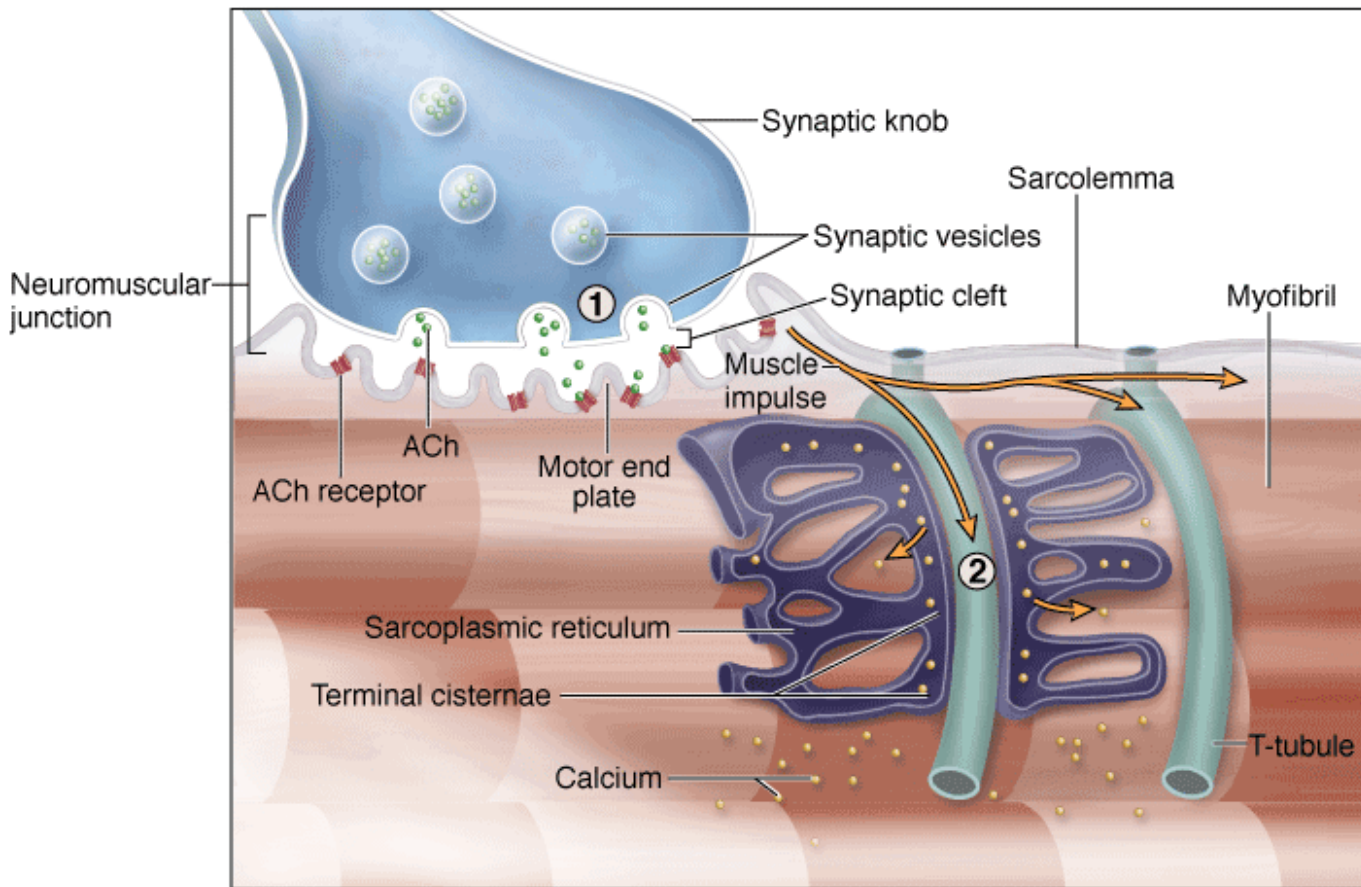
- Umożliwia rozprzestrzenianie się fali depolaryzacji do wnętrza komórki mięśniowej



The Neuromuscular Junction

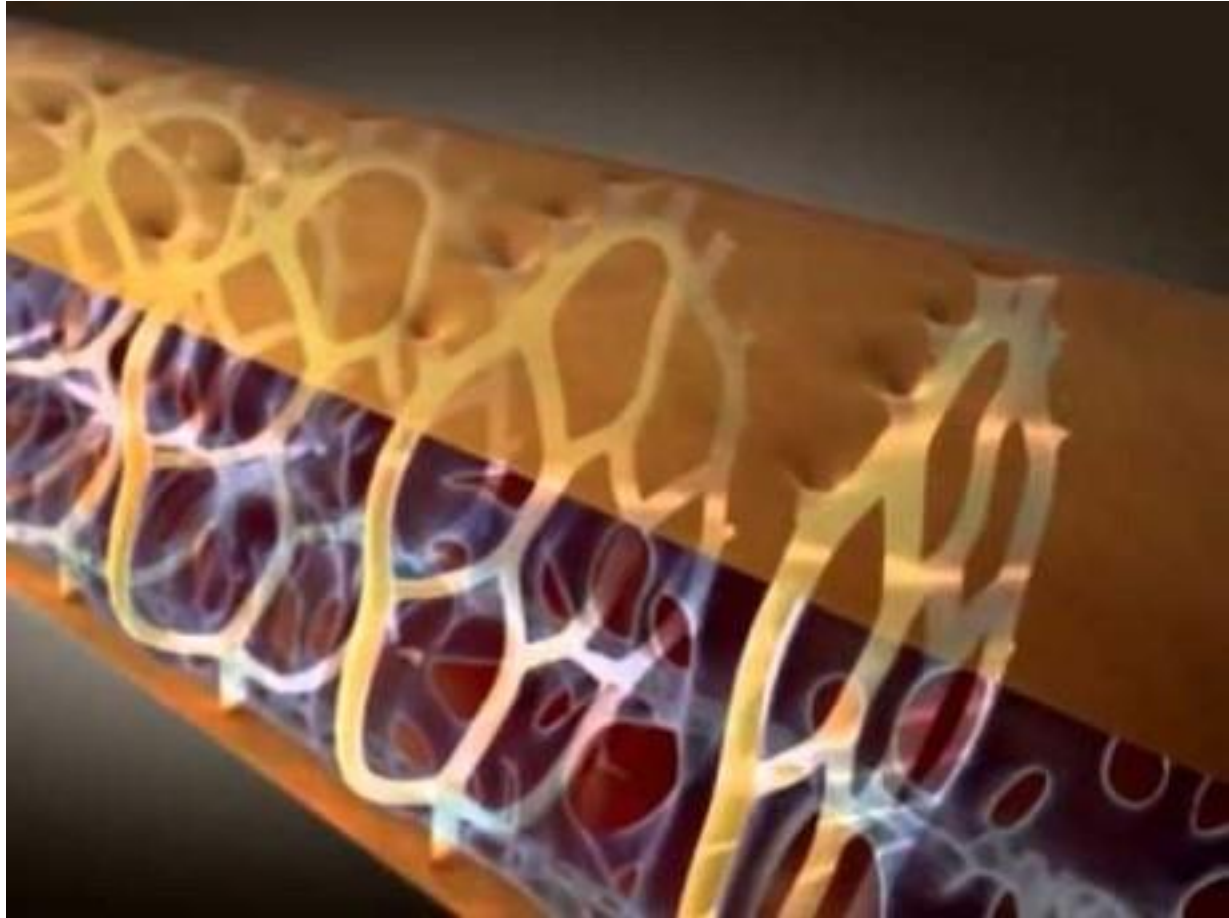




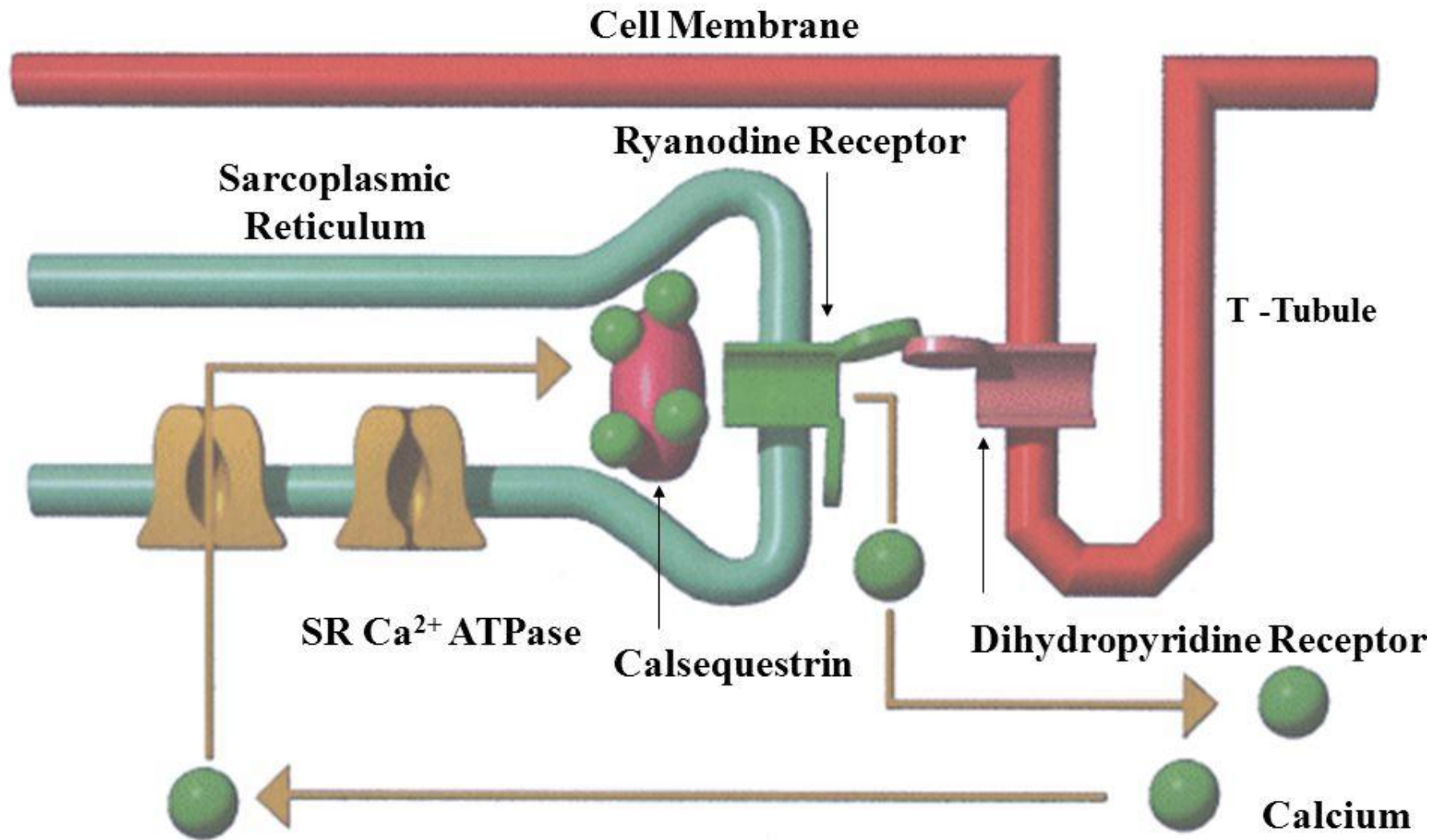


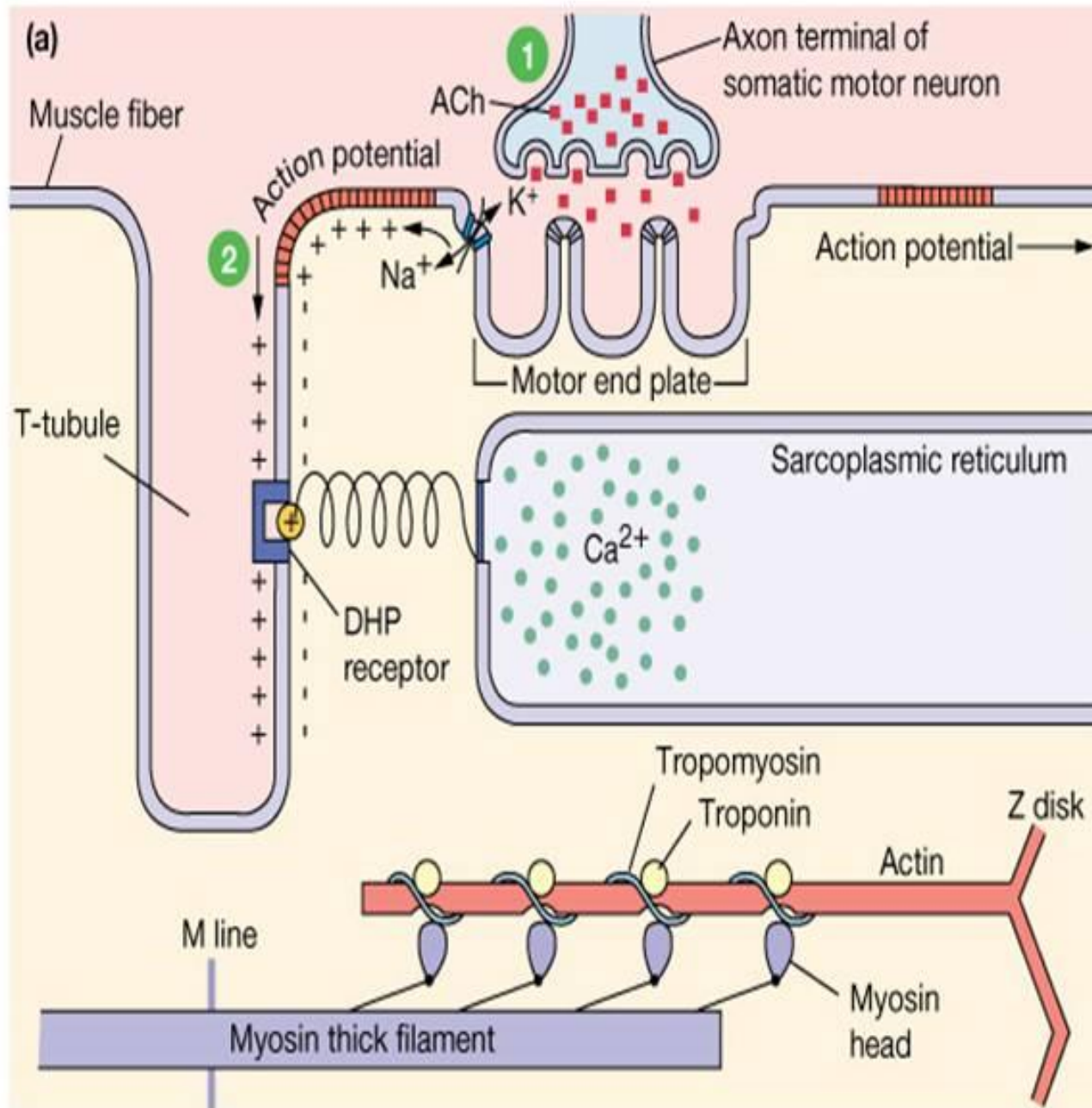
① A nerve impulse triggers release of ACh from the synaptic knob into the synaptic cleft. ACh binds to ACh receptors in the motor end plate of the neuromuscular junction, initiating a muscle impulse in the sarcolemma of the muscle fiber.

② As the muscle impulse spreads quickly from the sarcolemma along T-tubules, calcium ions are released from terminal cisternae into the sarcoplasm.



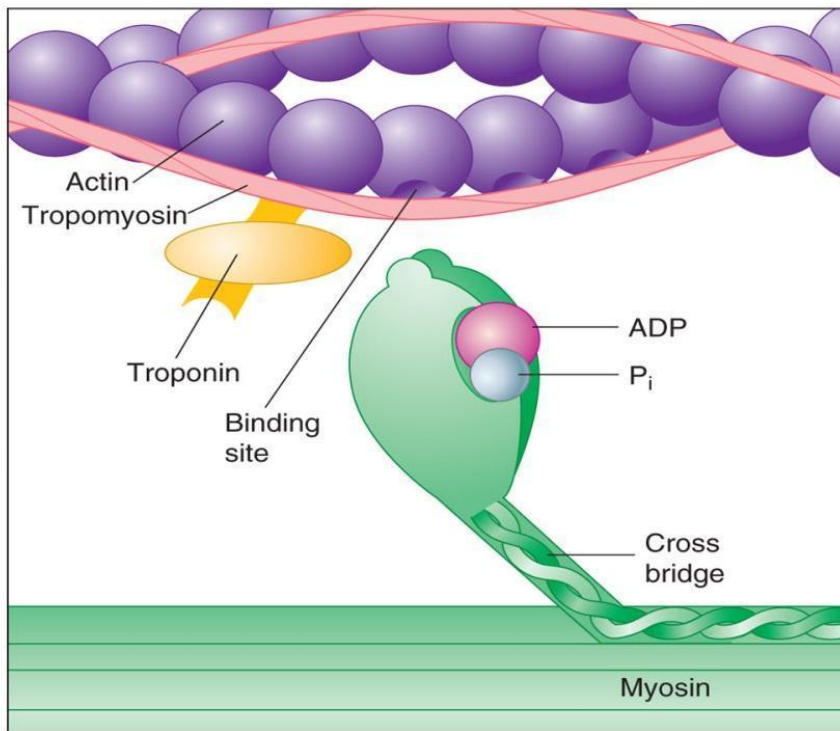
ACTION POTENTIAL CAUSES RELEASE OF CALCIUM FROM SR





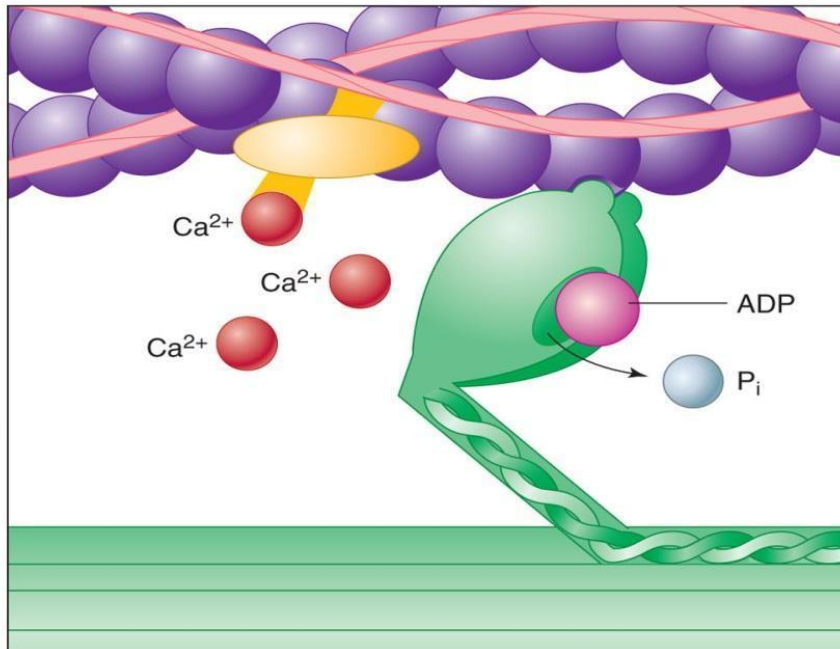
1 Somatic motor neuron releases ACh at neuromuscular junction.

2 Net entry of Na⁺ through ACh receptor-channel initiates a muscle action potential.



Relaxed muscle:
tropomyosin
blocks the
binding site

- Tropomiozyna maskuje miejsca
wiązania miozyny na cząsteczce G
aktyny



Contracting muscle:
myosin
head binds
to actin

- Związanie jonów wapnia przez
troponinę C indukuje przesunięcie
tropomiozyny – odsłonięcie miejsc
wiązania i wiązanie miozyny z
aktyną

Key:

● = Ca^{2+}

Główka miozyny
hydrolizuje ATP do
ADP i Pi.

ADP i Pi pozostają związane z
główką miozyny.

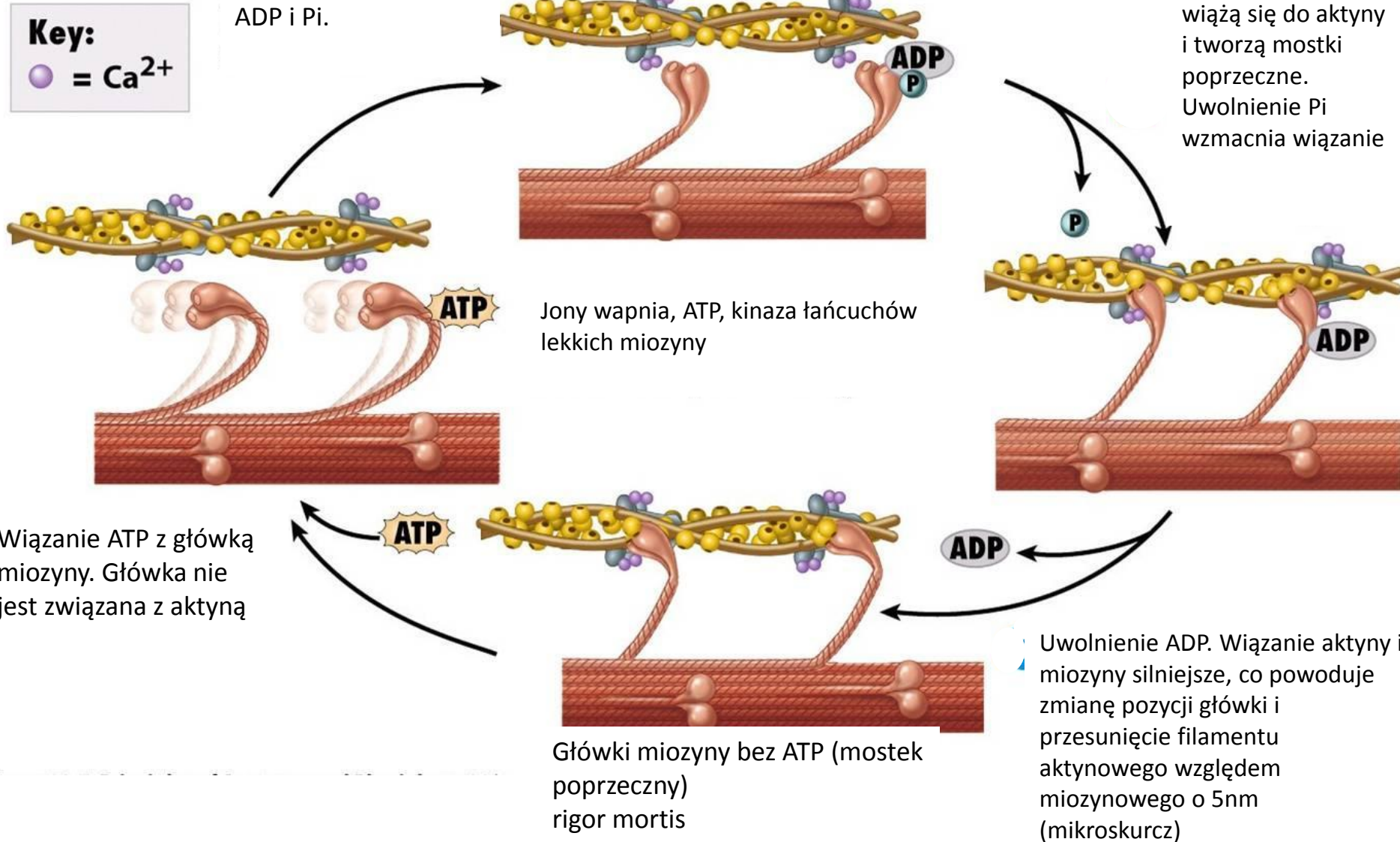
Główki miozyny
wiążą się do aktyny
i tworzą mostki
poprzeczne.
Uwolnienie Pi
wzmacnia wiązanie

Jony wapnia, ATP, kinaza łańcuchów
lekkich miozyny

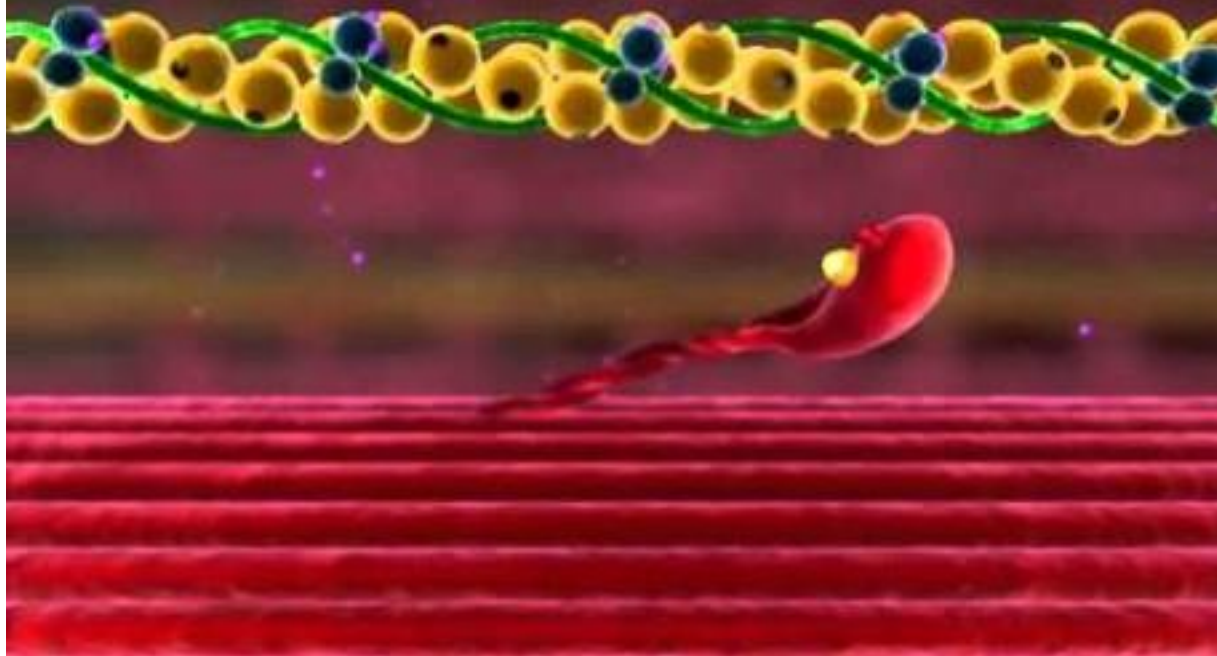
Uwolnienie ADP. Wiązanie aktyny i
miozyny silniejsze, co powoduje
zmianę pozycji główki i
przesunięcie filamentu
aktynowego względem
miozynowego o 5nm
(mikroskurcz)

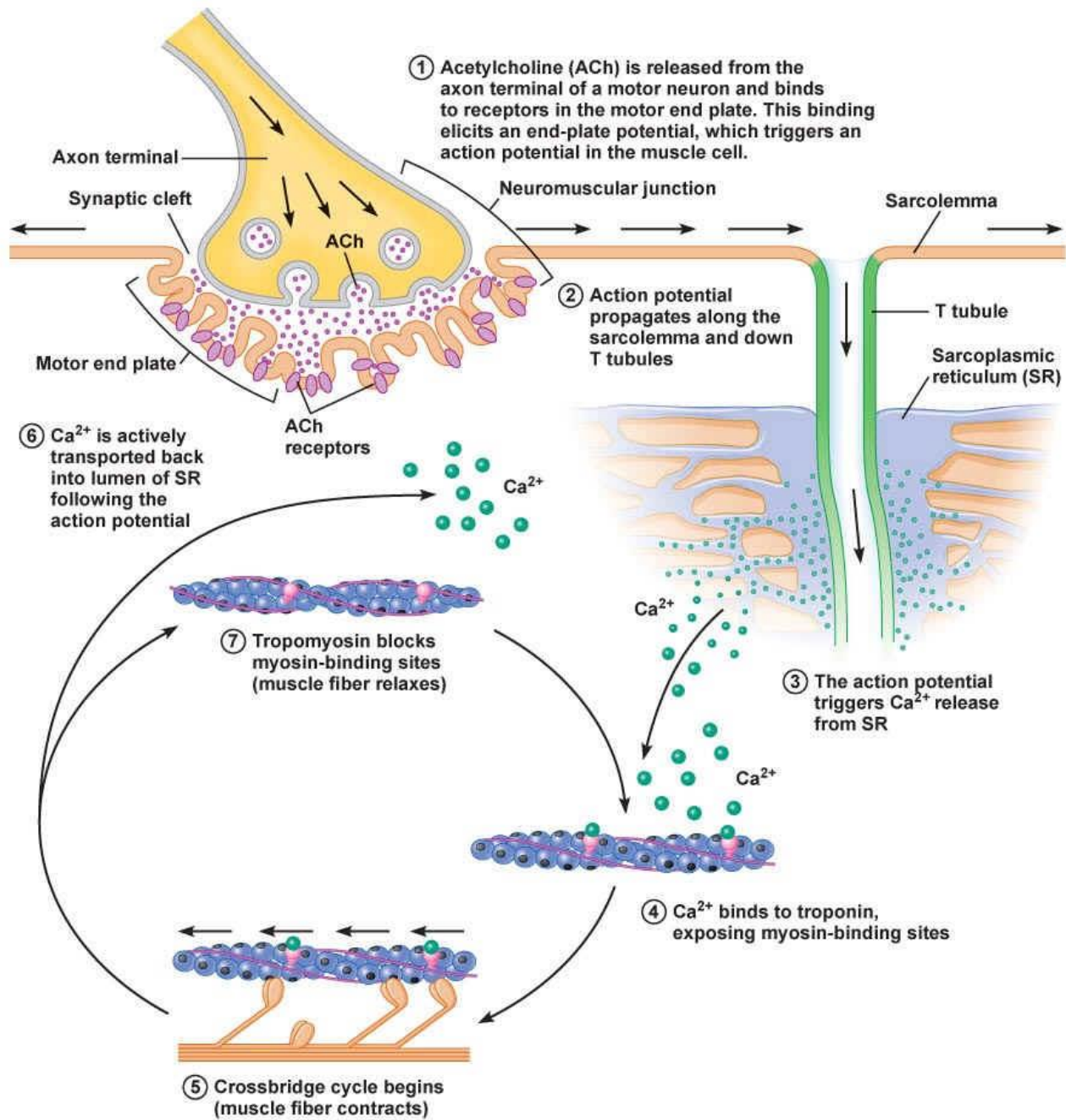
Główki miozyny bez ATP (mostek
poprzeczny)
rigor mortis

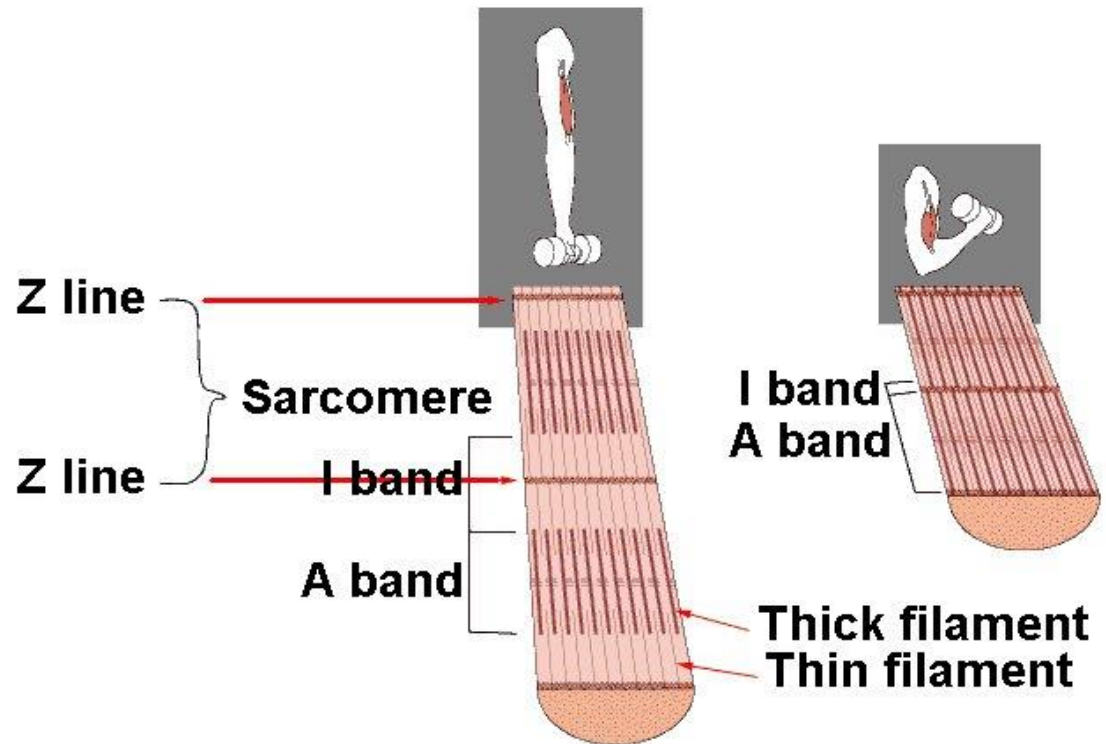
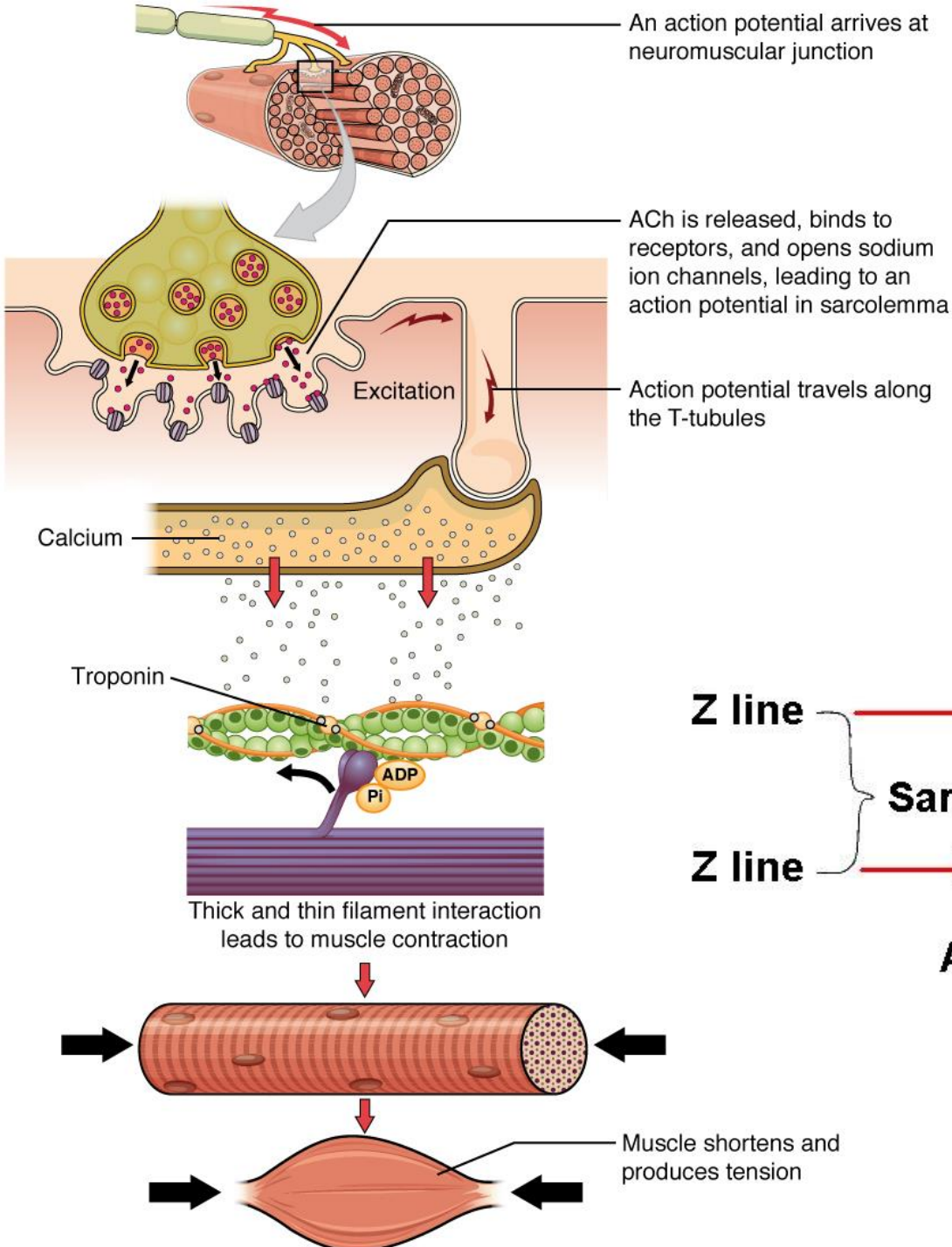
Wiązanie ATP z główką
miozyny. Główka nie
jest związana z aktyną

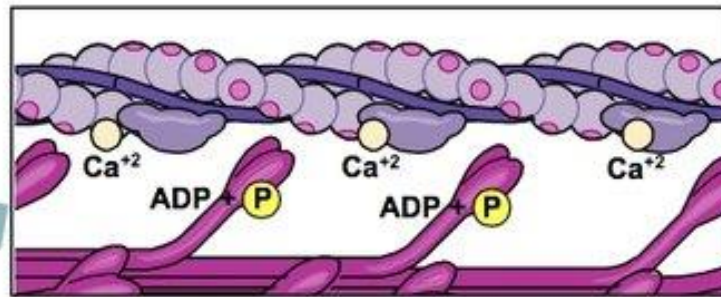


STEP 1: Cross Bridge Formation



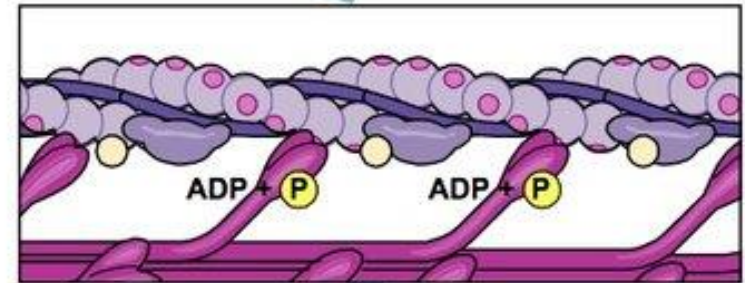




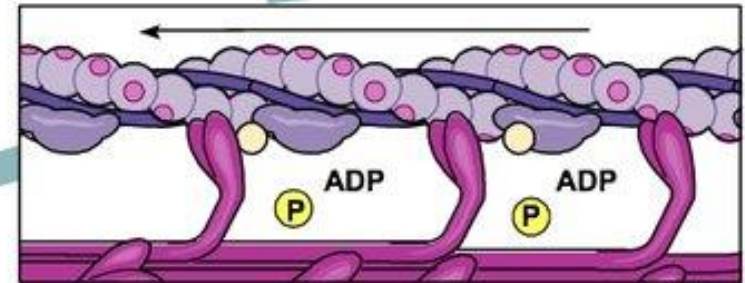


1 Exposed binding sites on actin allow the muscle contraction cycle to occur

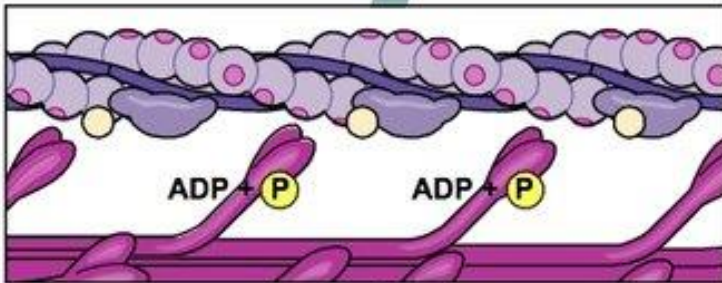
Contraction cycle



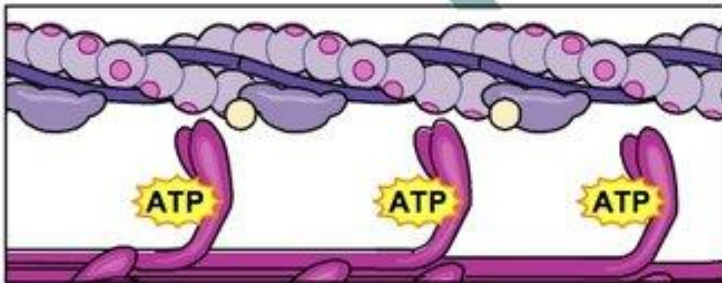
2 Cross-bridge binds actin to myosin



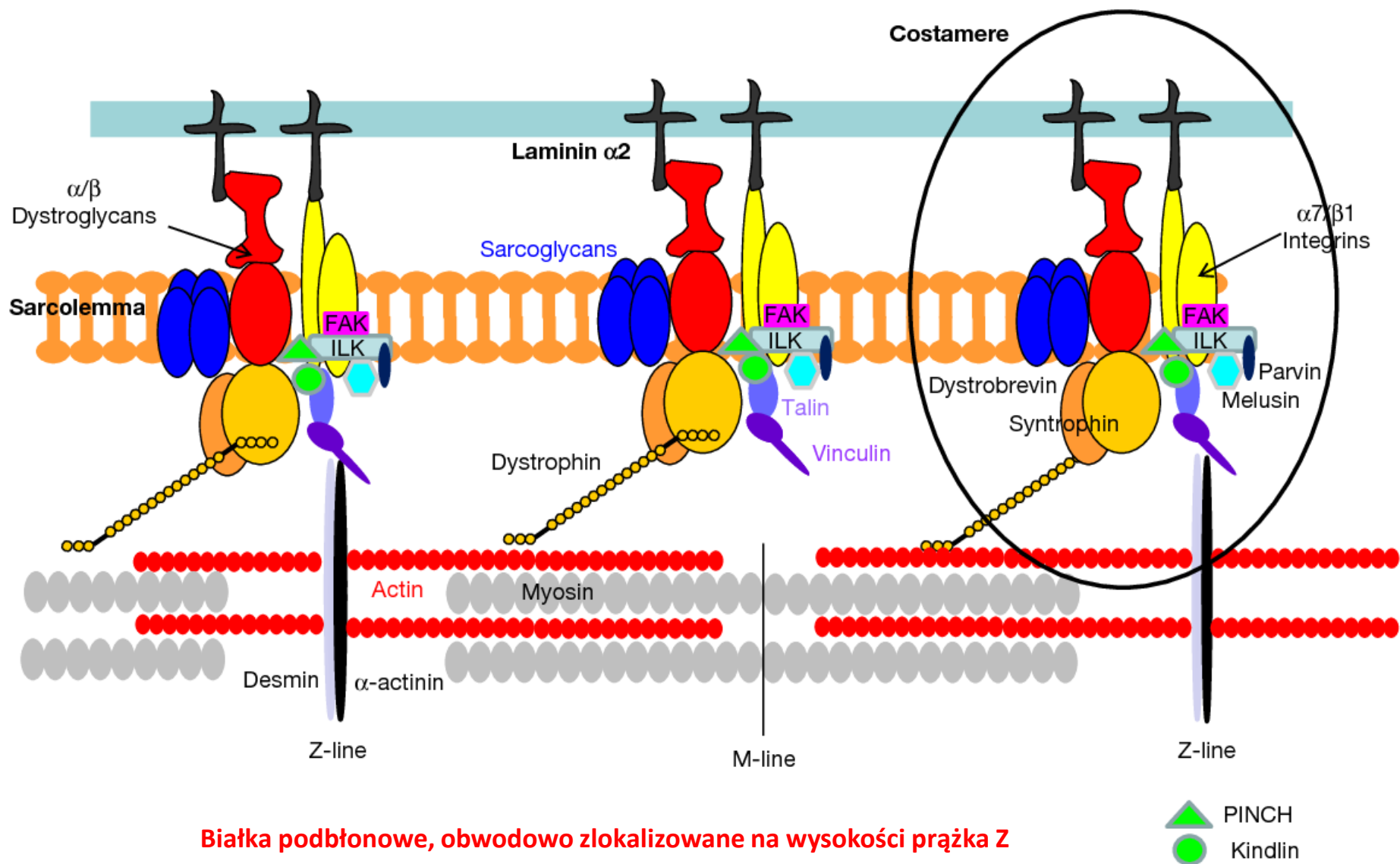
3 Cross-bridge pulls actin filament (power stroke), ADP and P released from myosin



5 ATP splits, which provides power to "cock" the myosin cross-bridge



4 New ATP binds to myosin, causing linkage to release



Schematic representation of proteins forming costamere in skeletal muscle

The Dystrophin-Associated Protein Complex

Jeffrey Ehmsen, Ellen Poon and Kay Davies

Disorders associated with mutations in various members of the DAPC

Dystrophin

- Duchenne muscular dystrophy
- Becker muscular dystrophy
- mdx (mouse)

Dystroglycans

- no known human mutations
- embryonic lethal in mouse

Sarcoglycans

- α -SG: LGMD2D
- β -SG: LGMD2E
- γ -SG: LGMD2C
- δ -SG: LGMD2F
- ϵ -SG: myoclonus-dystonia
- dystrophy for all SG knockouts (mouse)

Sarcospan

- no known human mutations
- no apparent dystrophy in mouse knockout

Dystrobrevins

- dystrophy in mouse knockout despite maintenance of DAPC

Syntrophins

- no known human mutations
- no apparent dystrophy in α 1-syntrophin-knockout mice, though postsynaptic membrane is abnormal

Syncoilin

- upregulated in a number of muscular dystrophies

nNOS

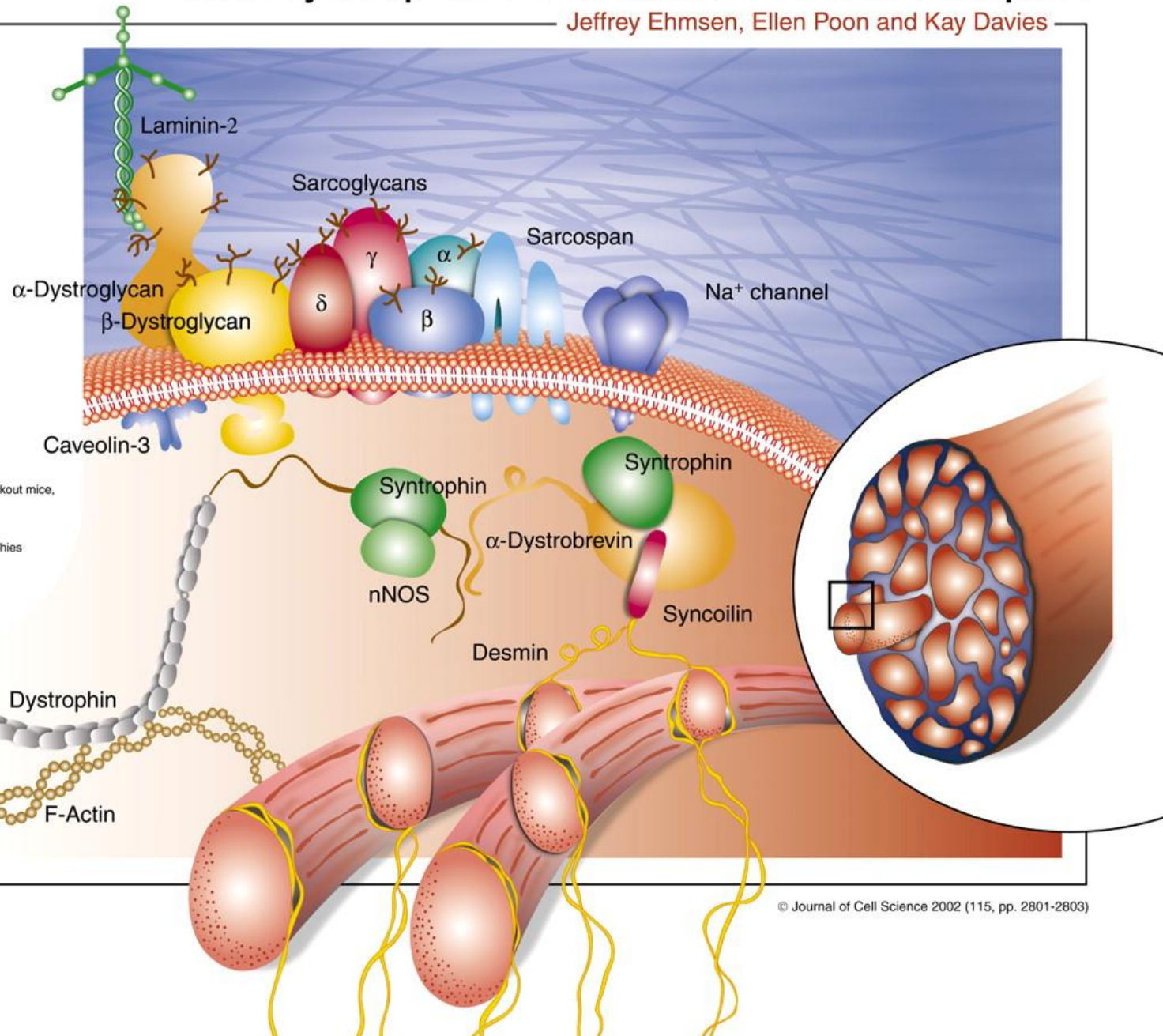
- no apparent dystrophy in mouse knockout

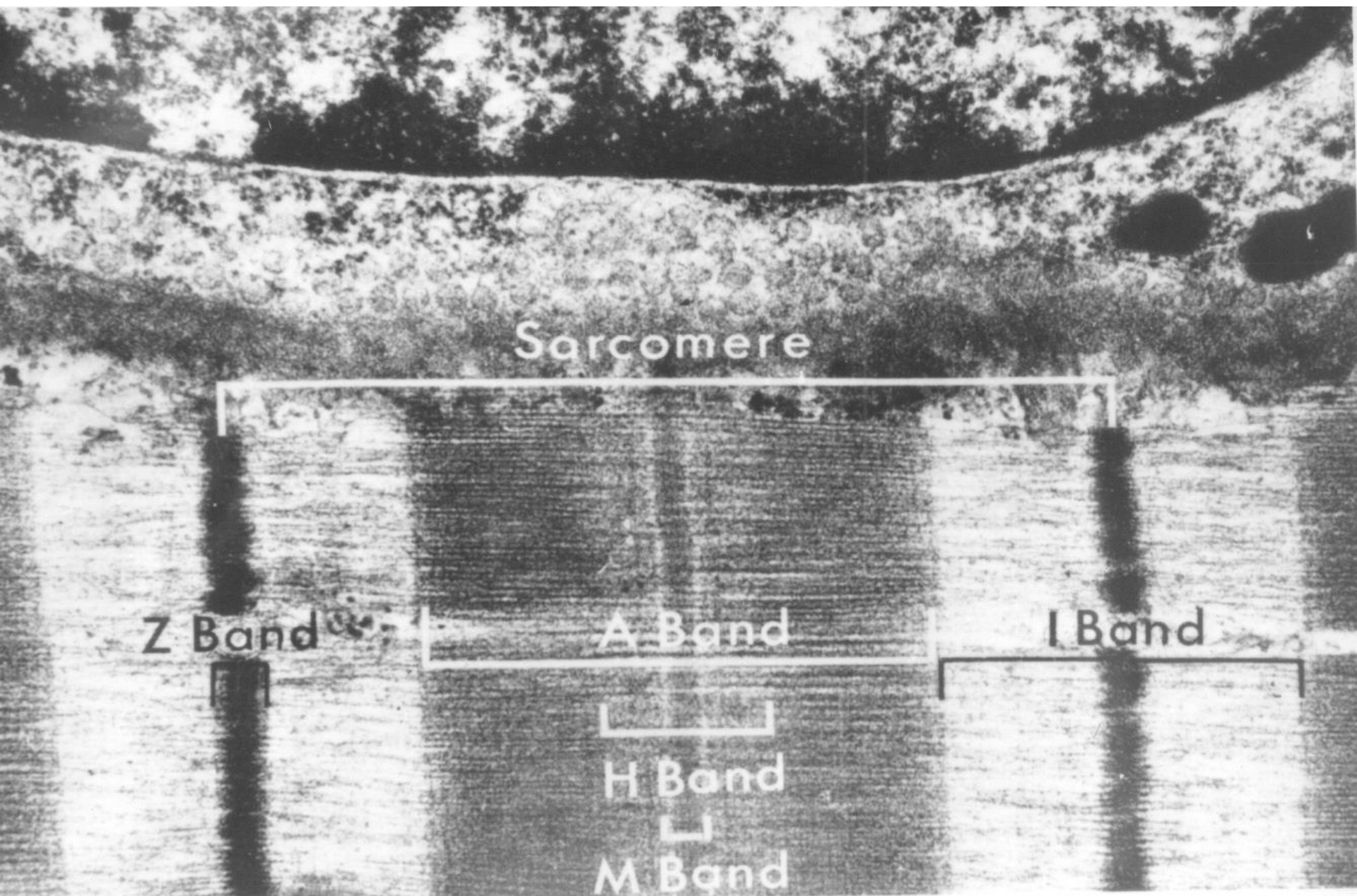
Laminin-2

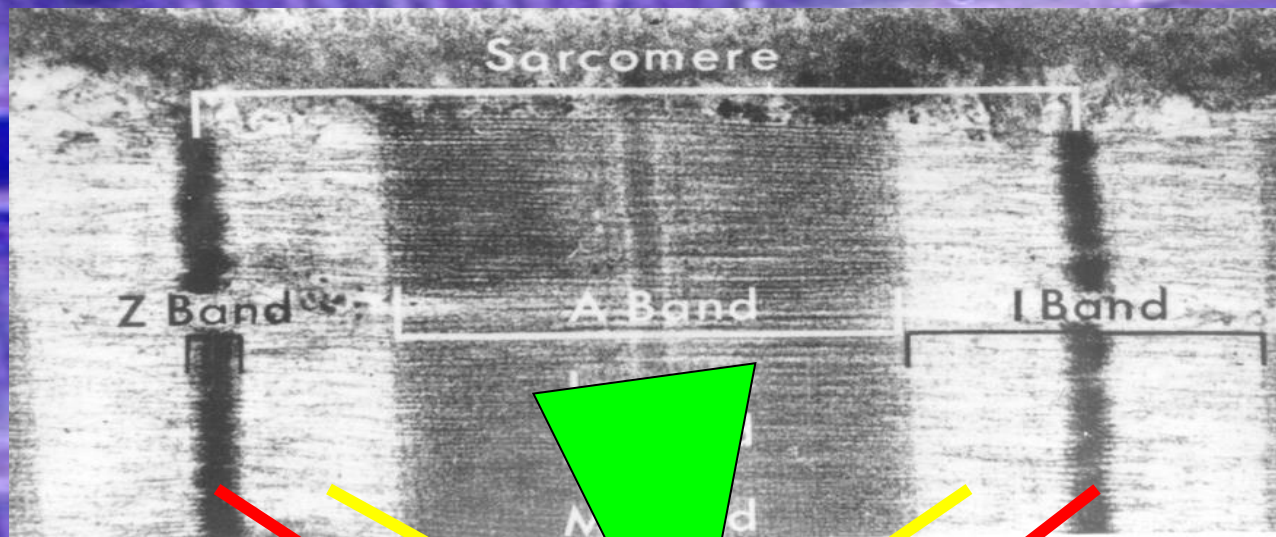
- α chain: MDC1A (human)
- α chain: dy (mouse)

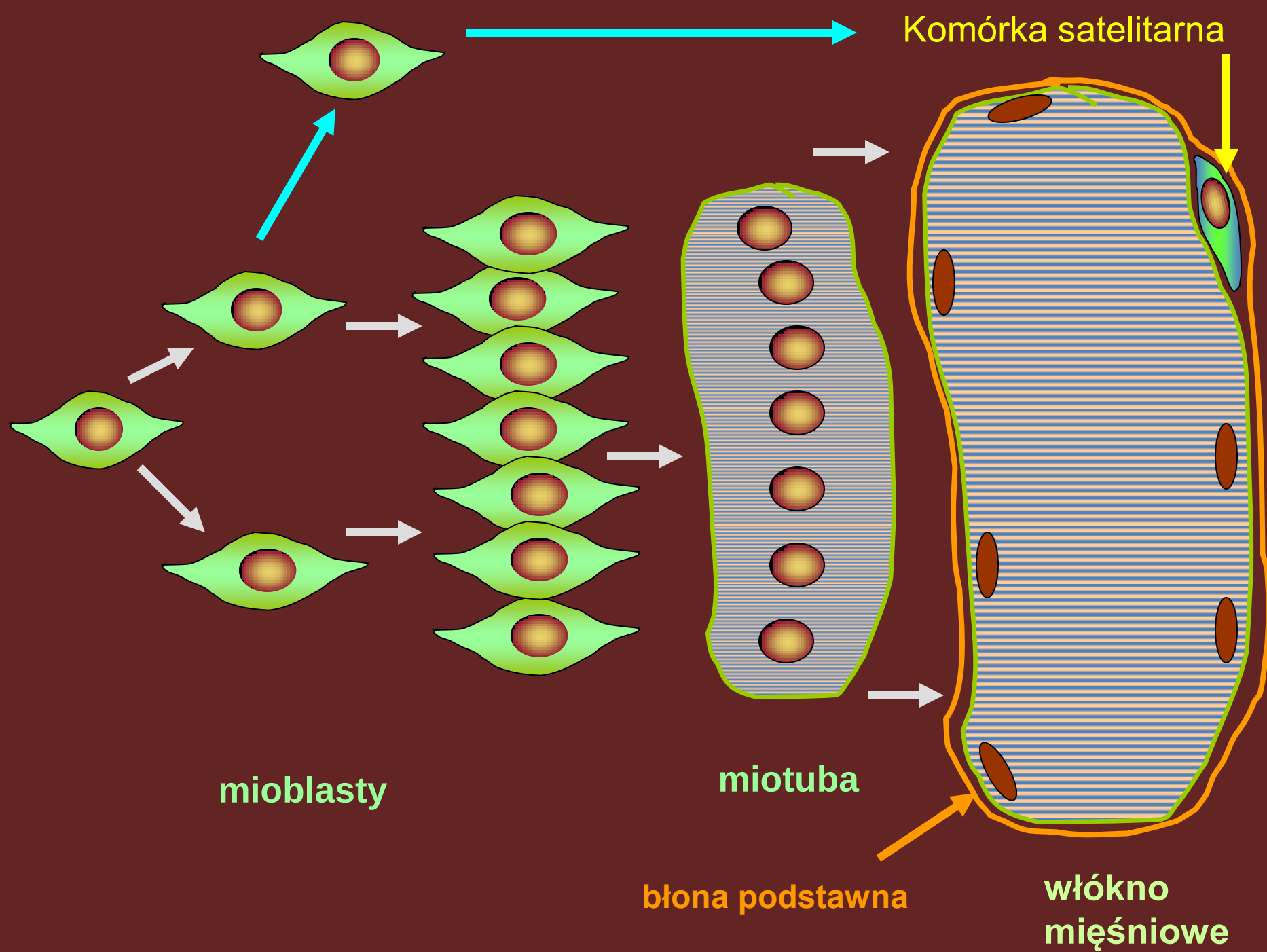
Caveolin-3

- LGMD-1C (human)
- myopathy (mouse knockout)

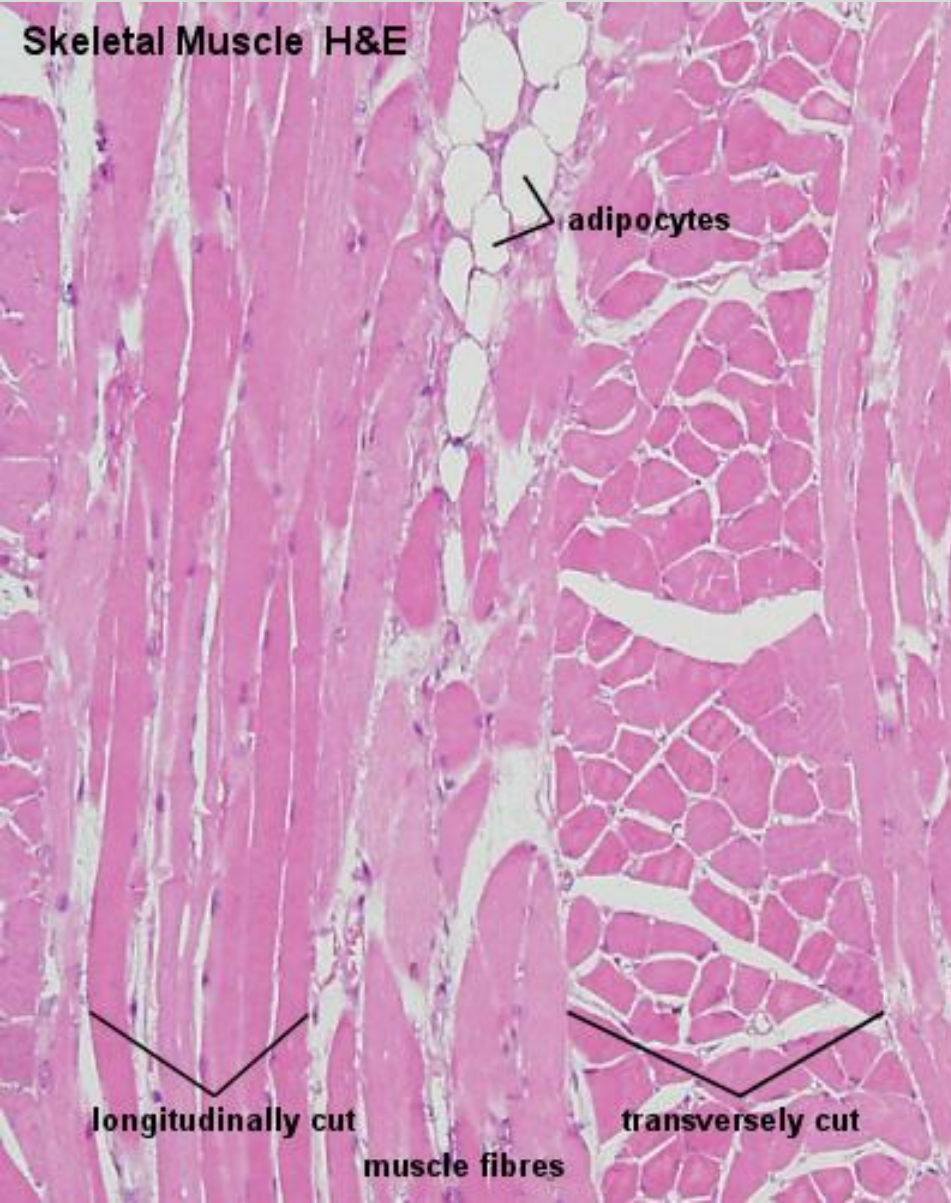




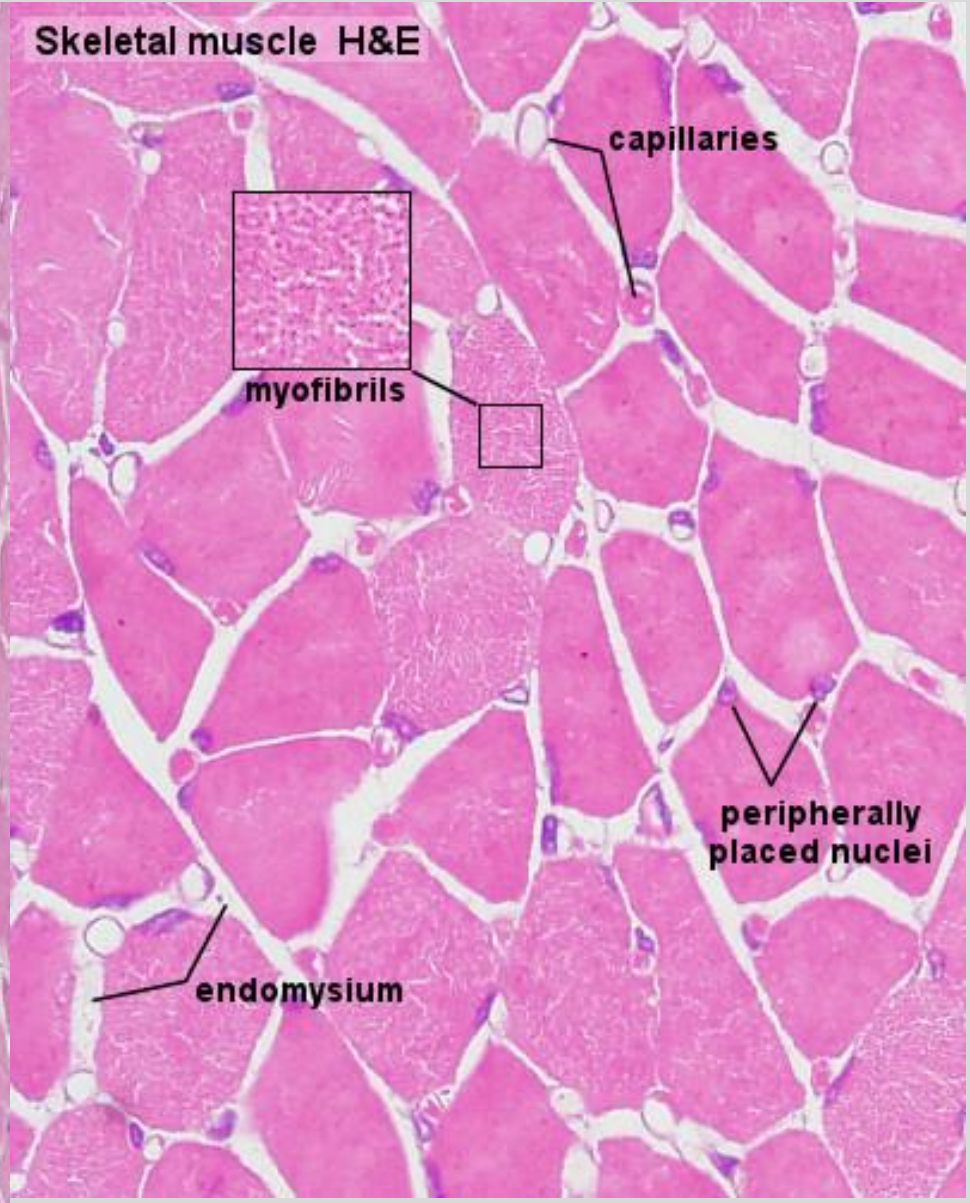




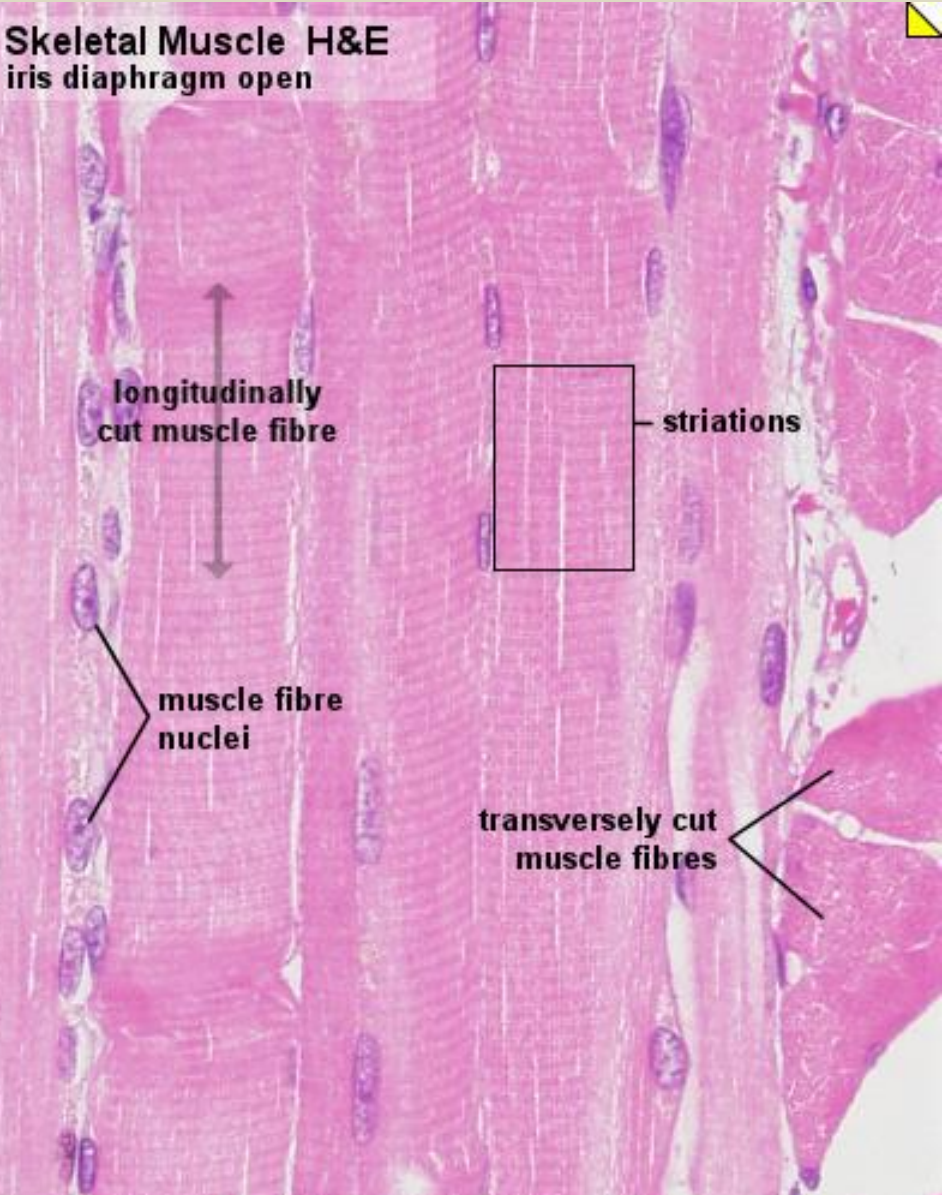
Skeletal Muscle H&E



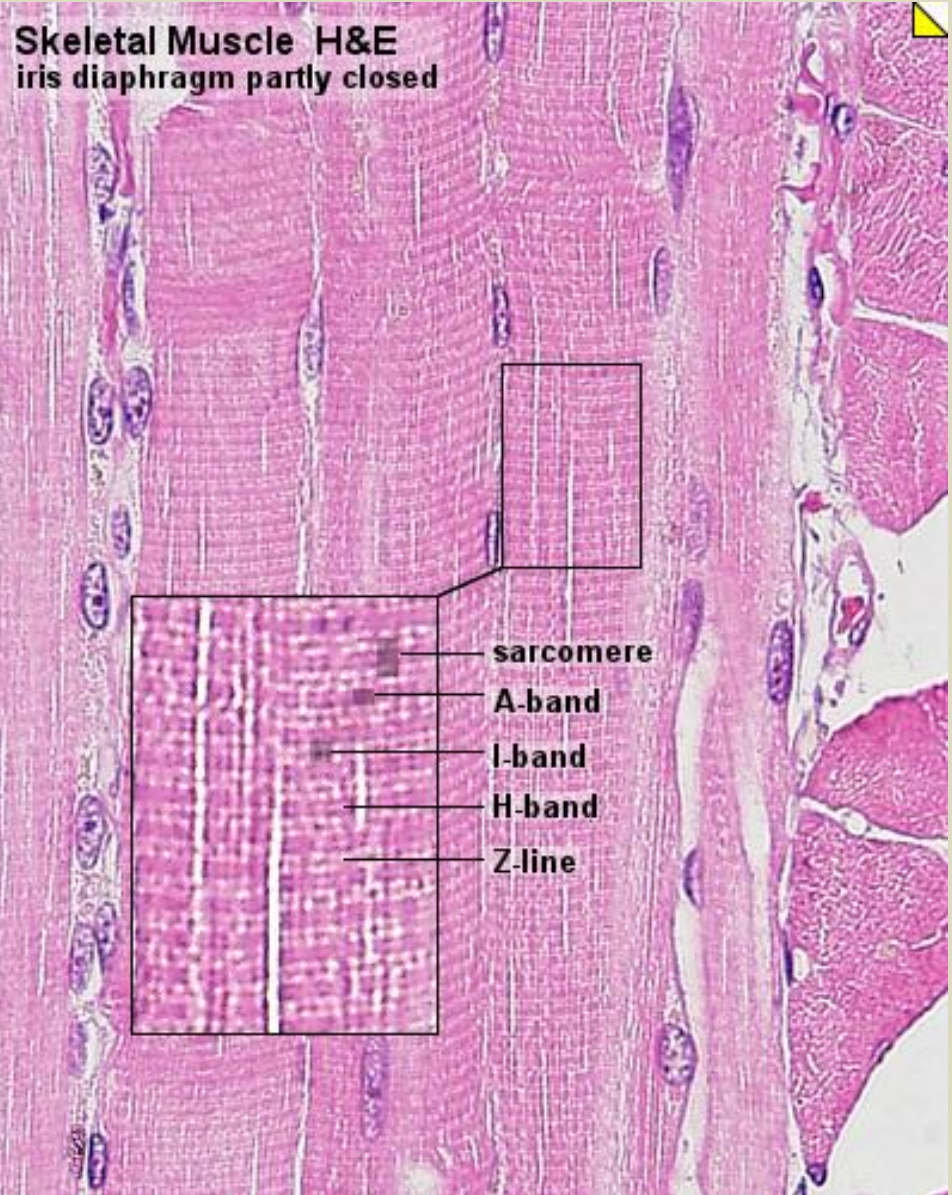
Skeletal muscle H&E

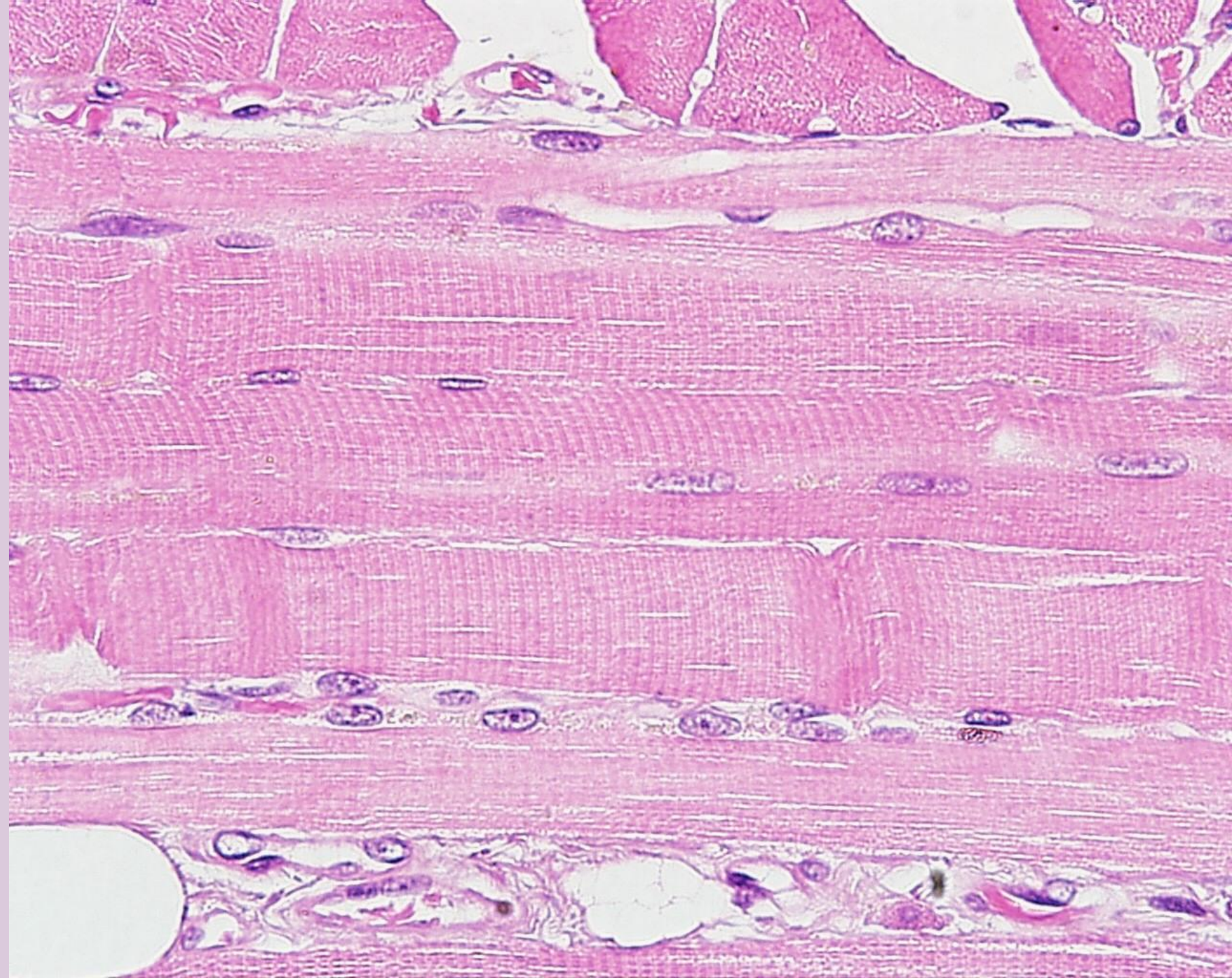


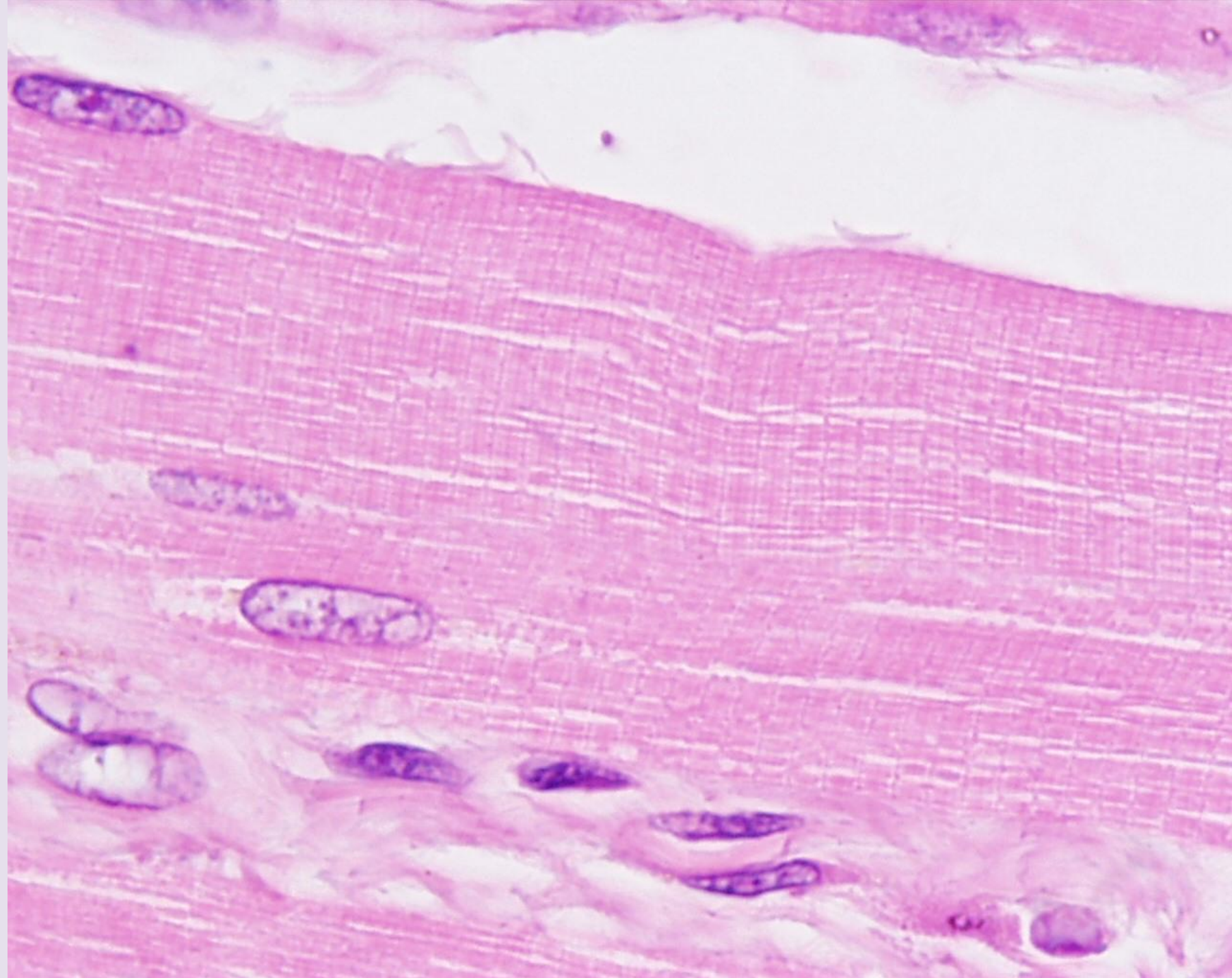
Skeletal Muscle H&E
iris diaphragm open

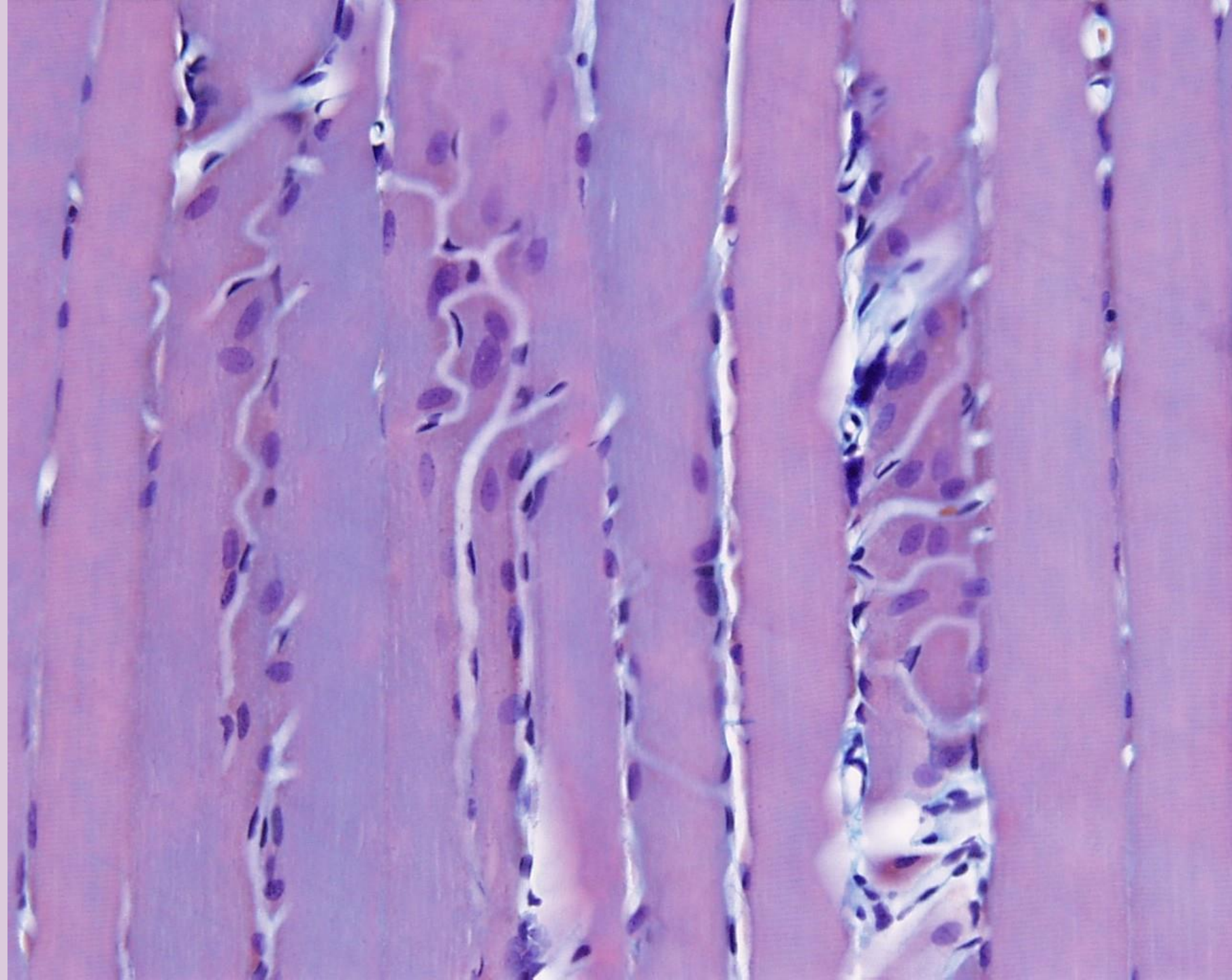


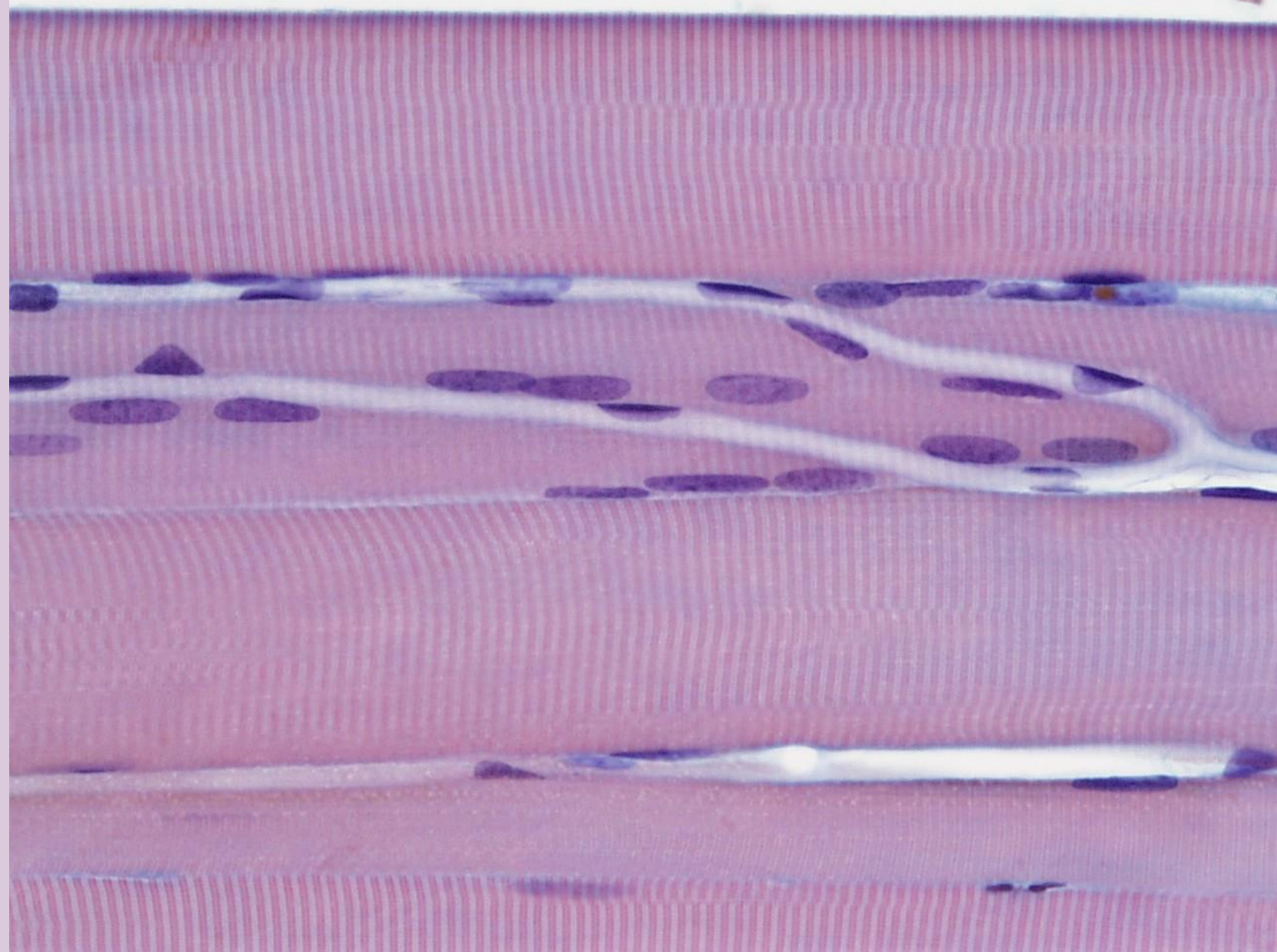
Skeletal Muscle H&E
iris diaphragm partly closed

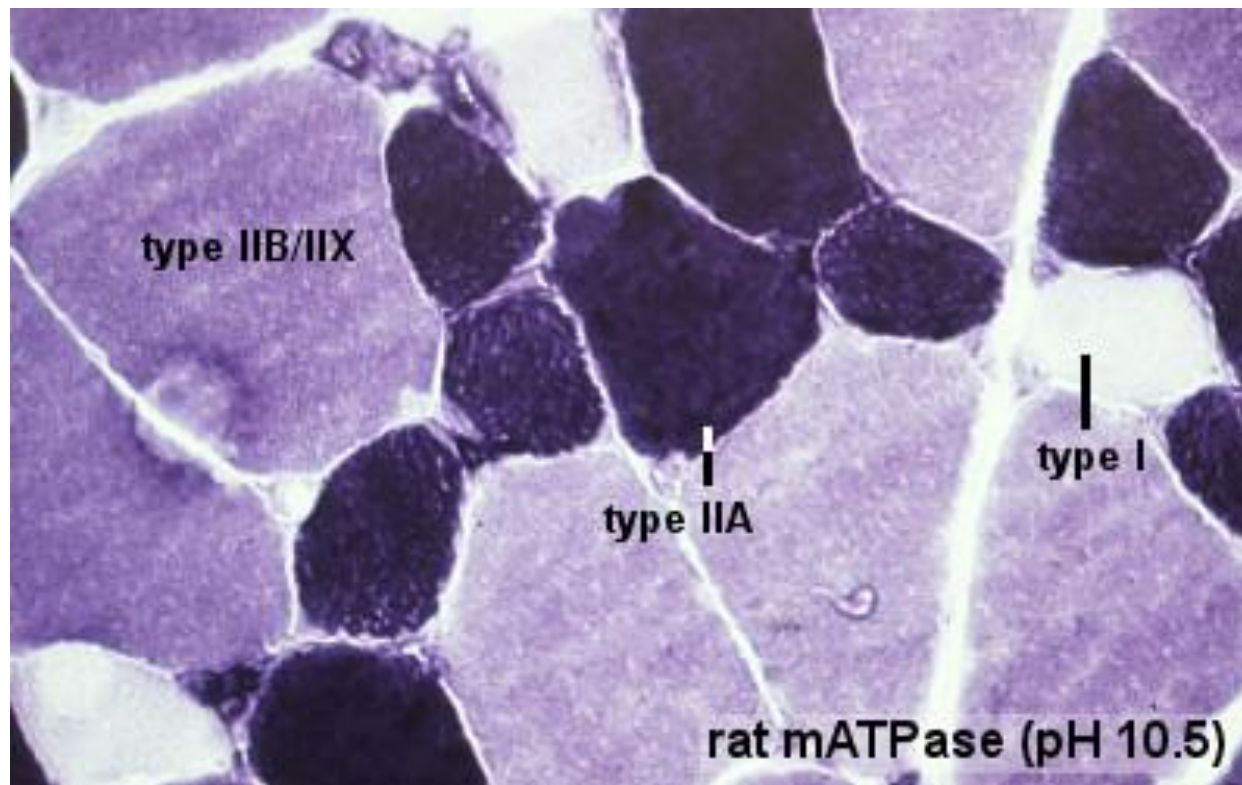












Muscle Fibre Types



Long Distance

Type 1

Slow twitch



400m / 800m

Type 2A

Fast twitch oxydative



Short Sprints

Type 2B

Fast twitch glycolytic

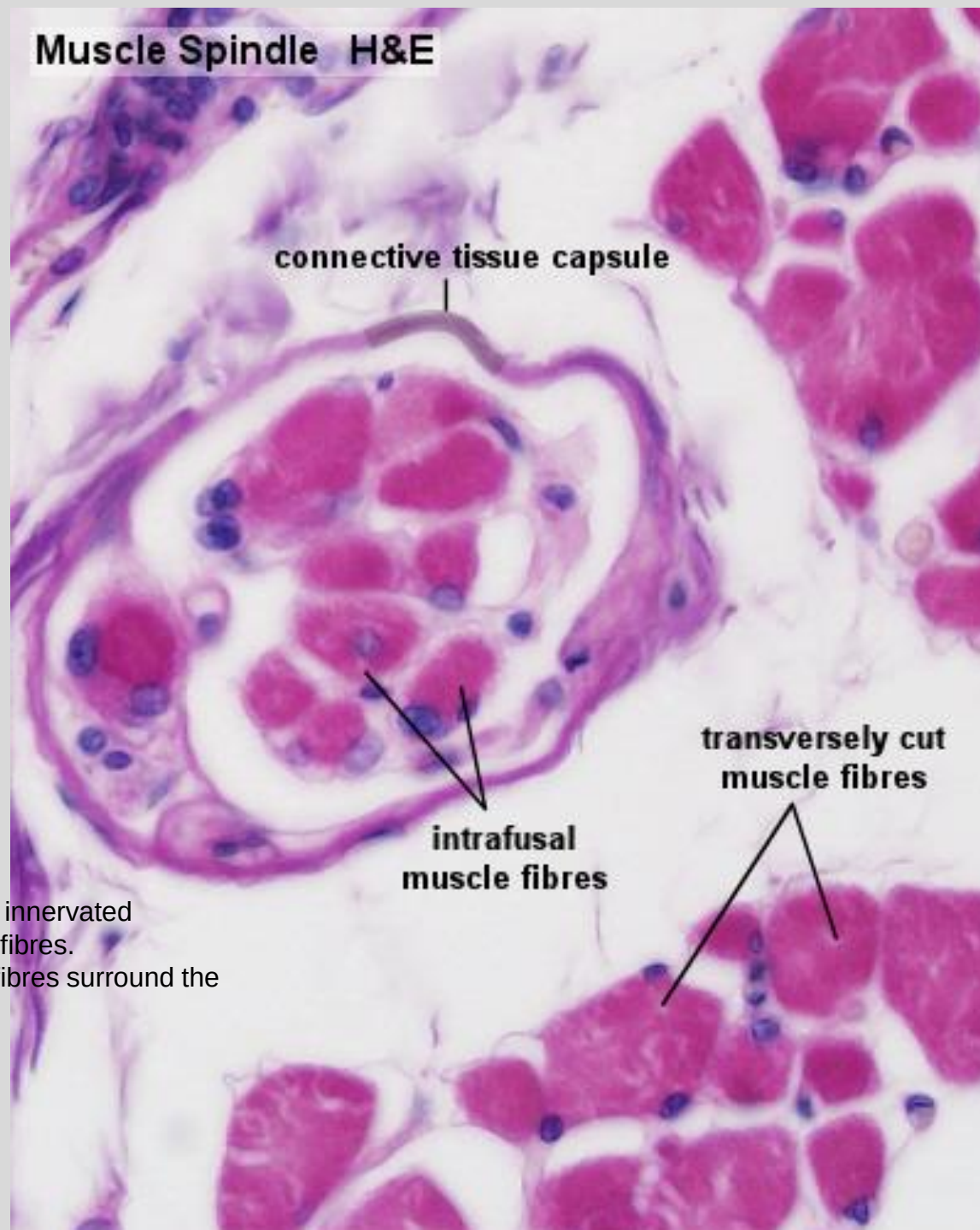
Low



High

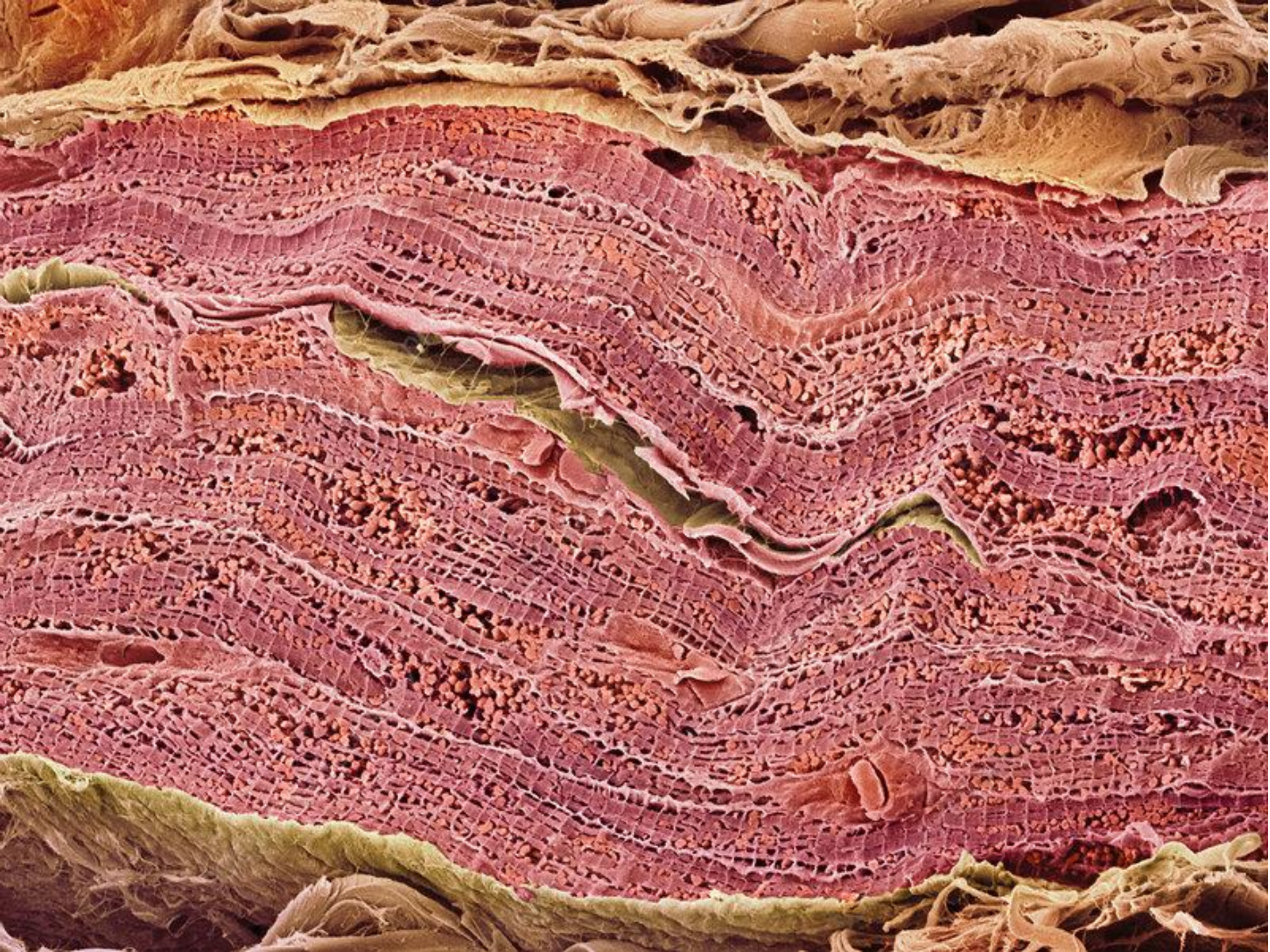
Fatigue rate

Muscle Spindle H&E



The intrafusal fibres are innervated by efferent motor nerve fibres. Afferent sensory nerve fibres surround the intrafusal muscle fibres.

**TKANKA
MIĘŚNIOWA
SERCA**

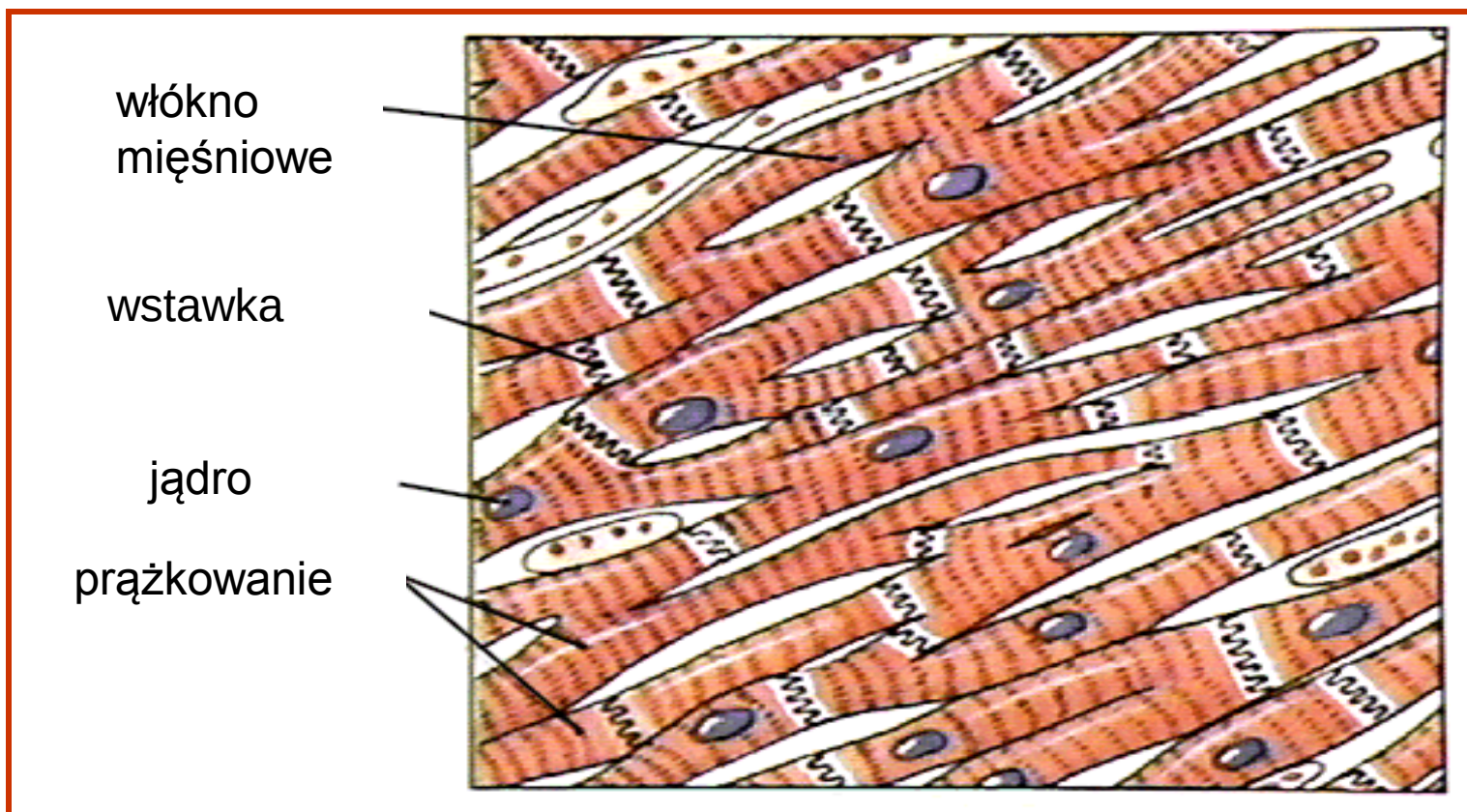


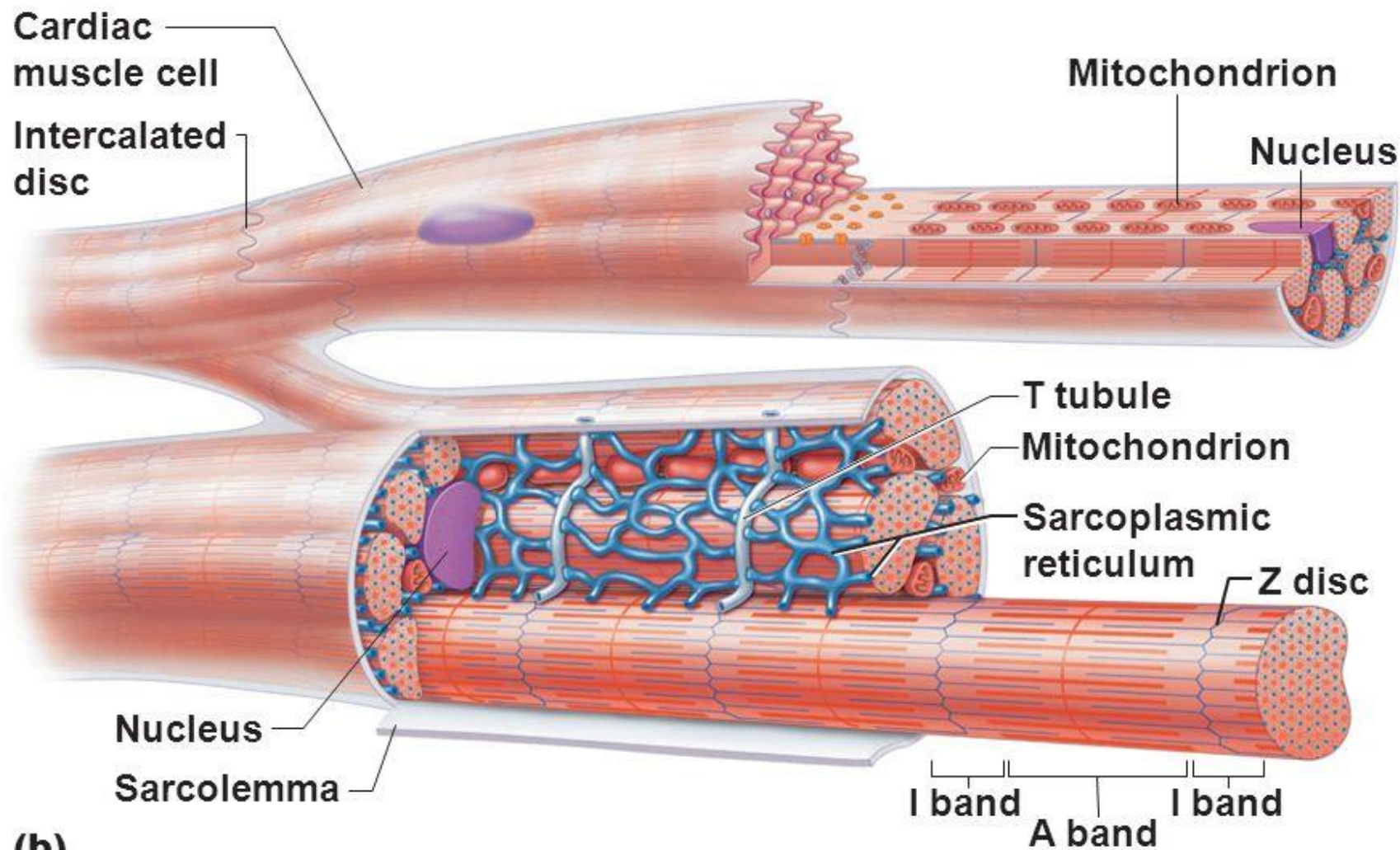
TKANKA MIĘŚNIOWA POPRZECZNIE PRAŻKOWANA SERCA

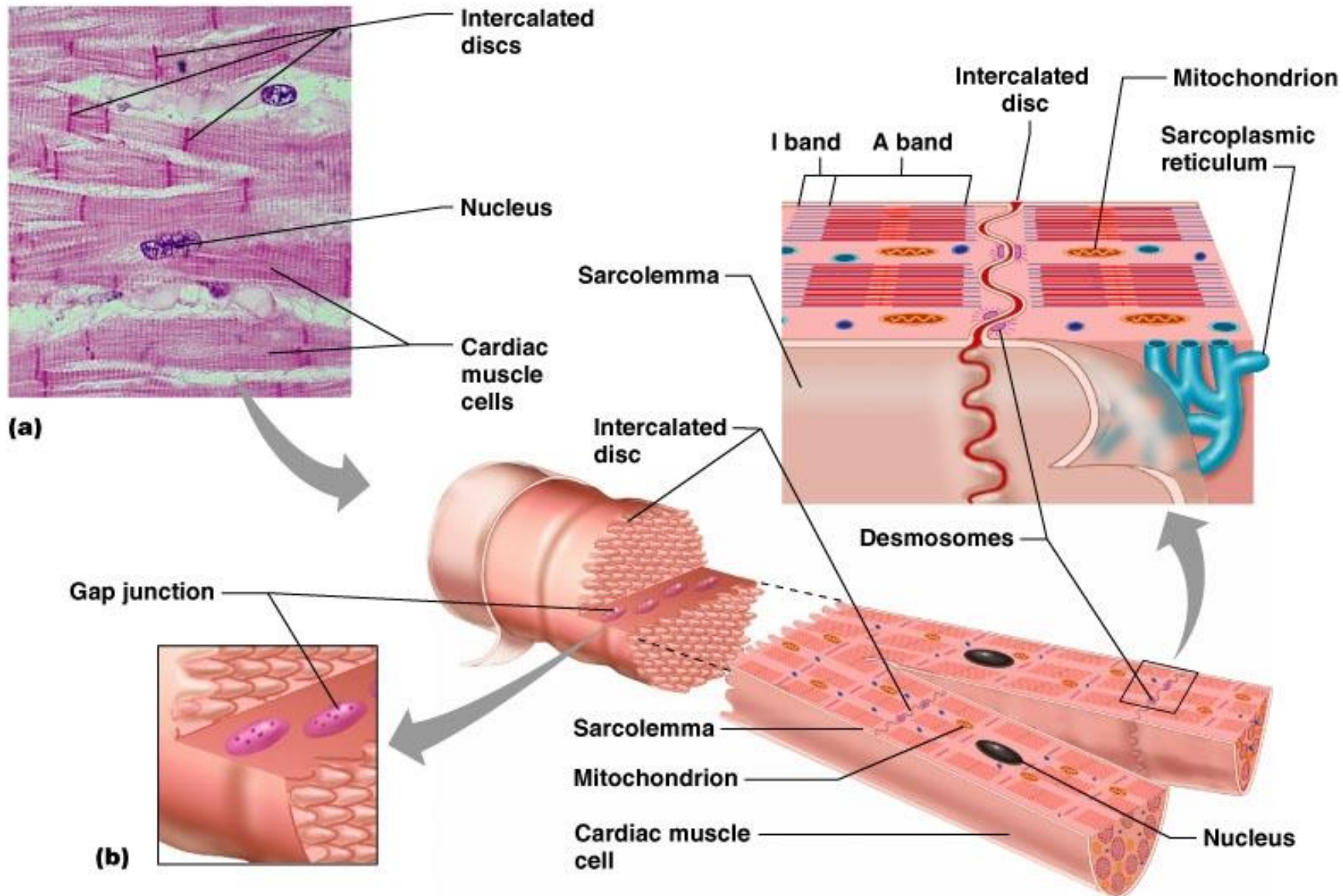
komórka mięśnia poprzecznie prążkowanego serca = kardiomiocyt

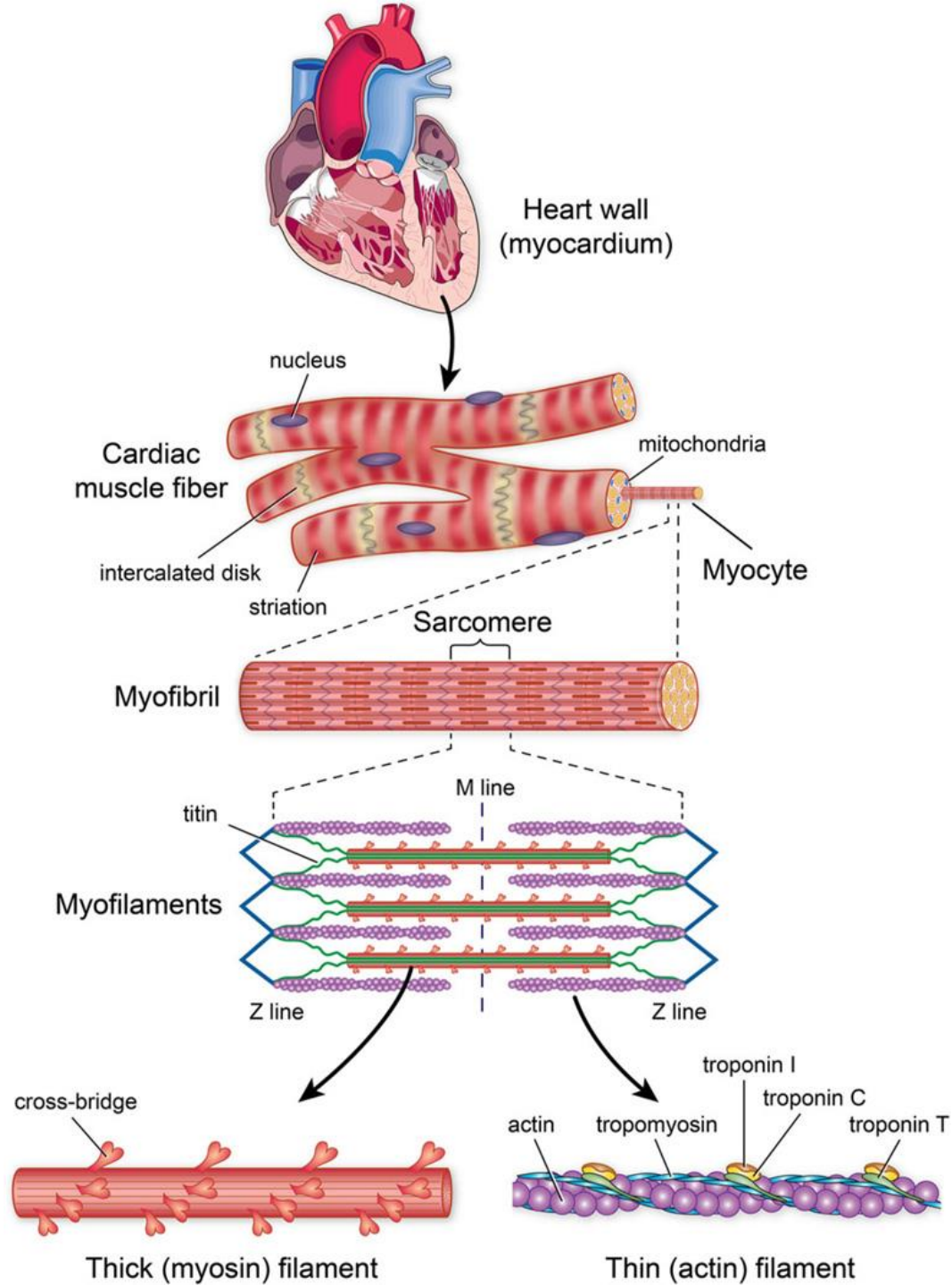
- otoczona błoną podstawną
- jedno do 2 jąder, rozmieszczenie centralne
- poprzeczne prążkowanie
- diady

miejsce styku dwóch komórek = wstawka



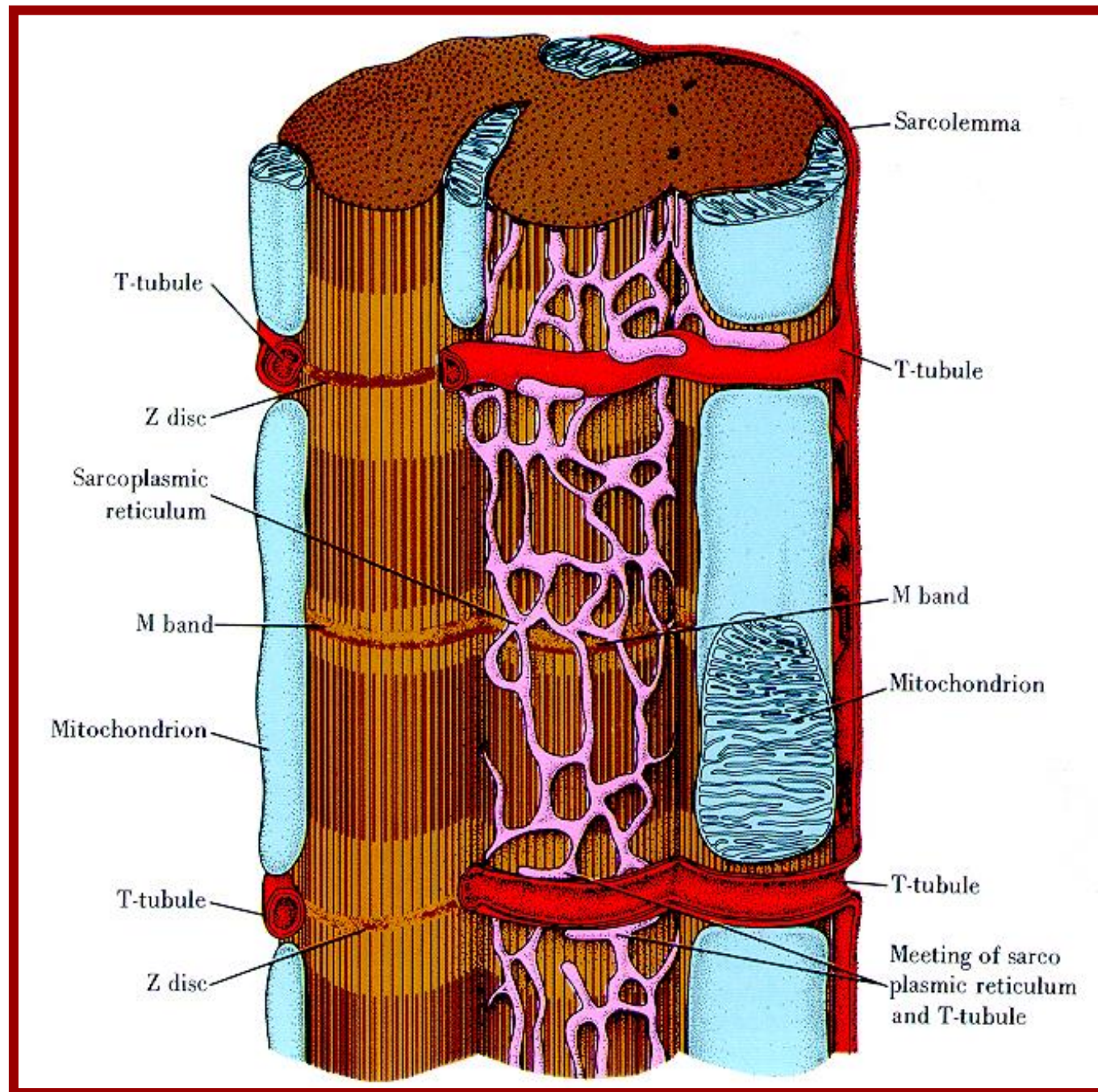


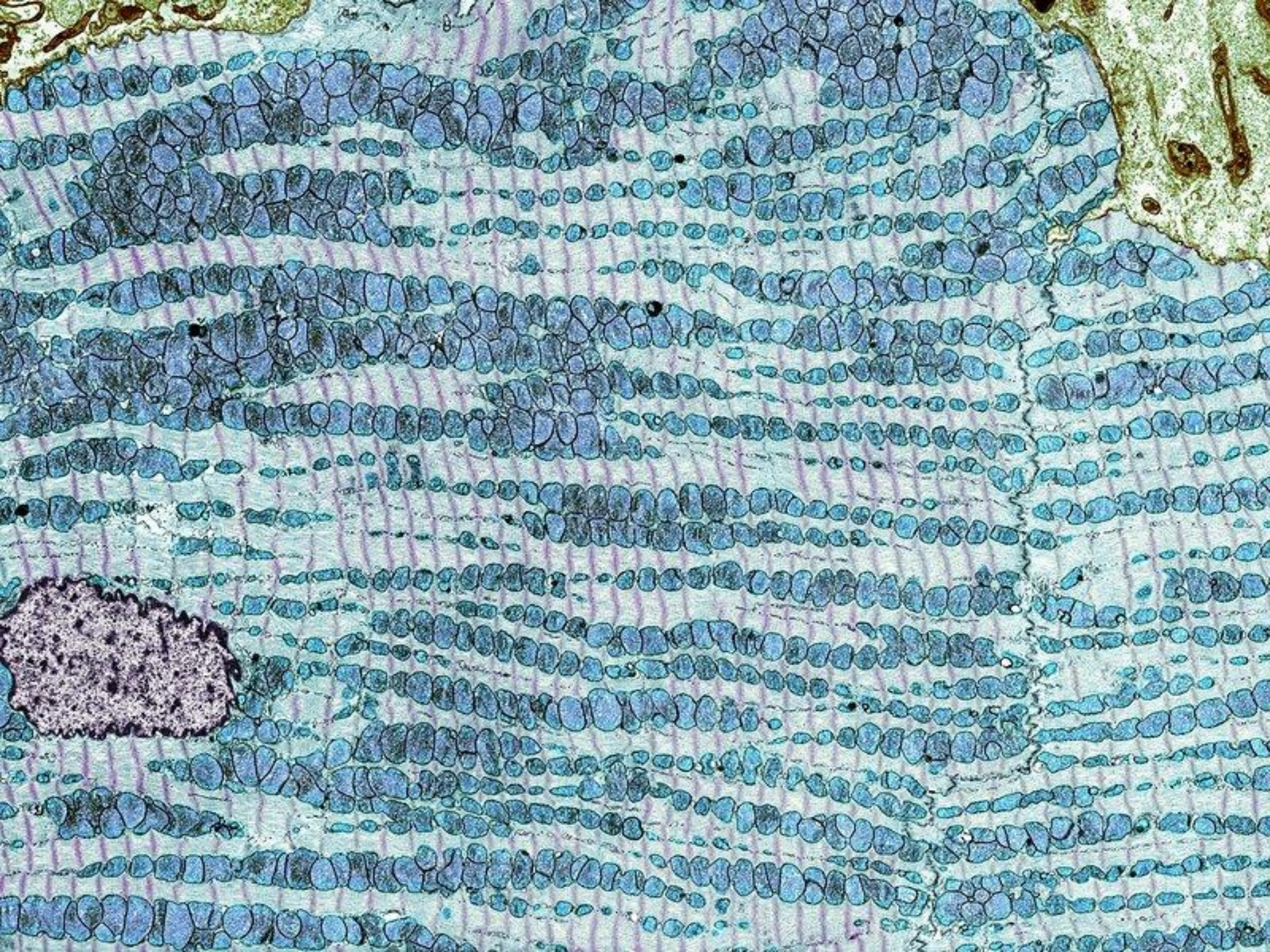




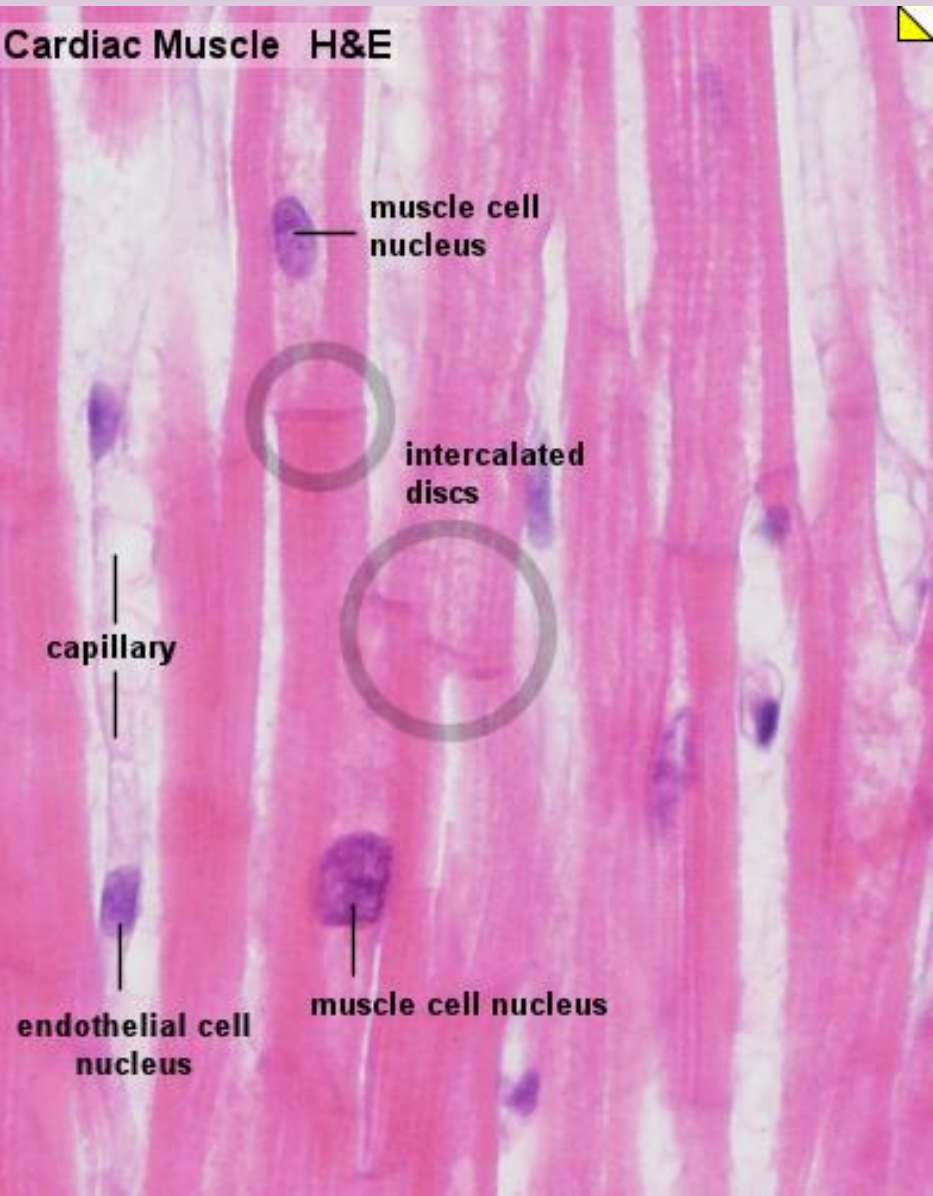
Cardiac muscle forms dyads instead of the triads formed between the T-tubules and the sarcoplasmic reticulum in skeletal muscle

Dyads in cardiac muscle are located in the vicinity of the Z line

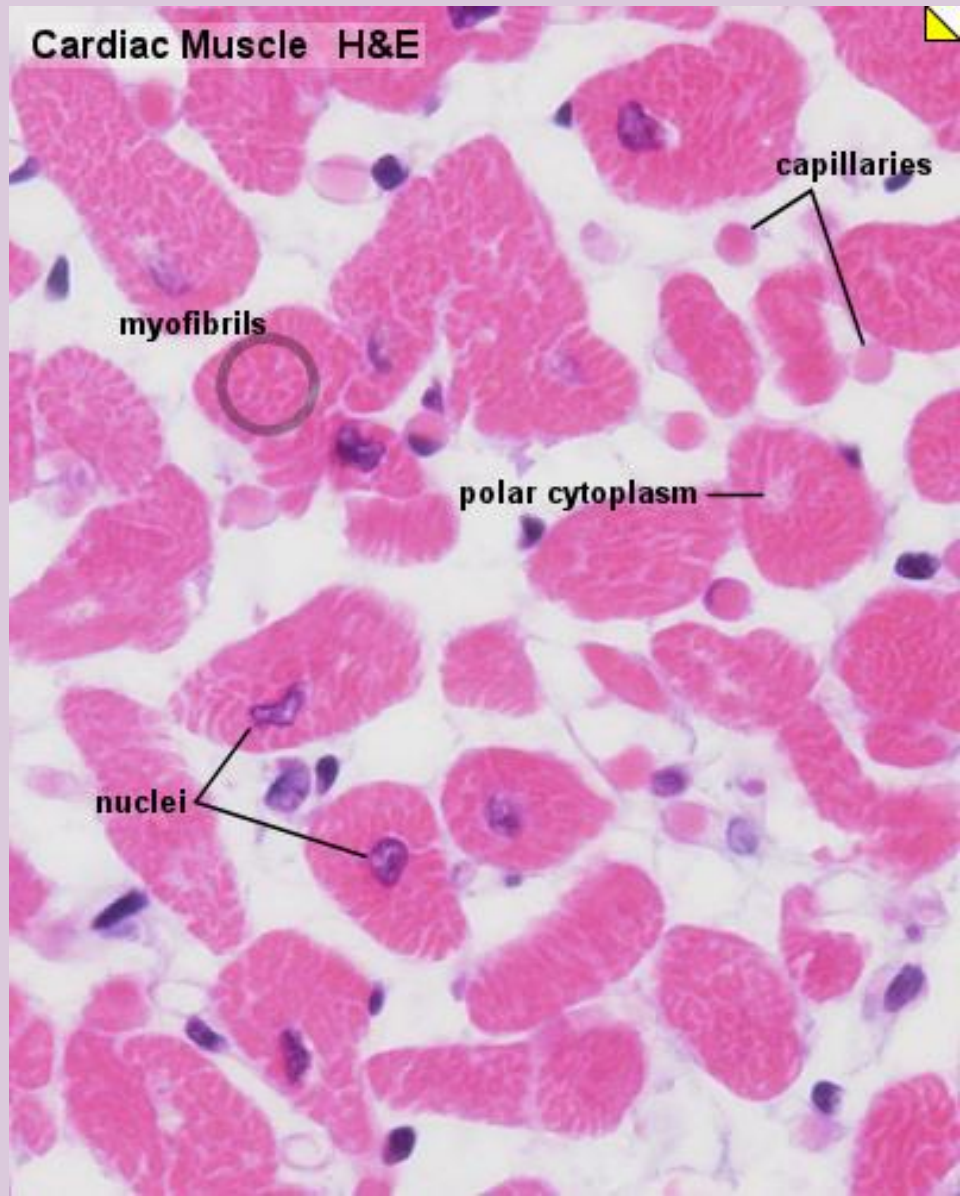


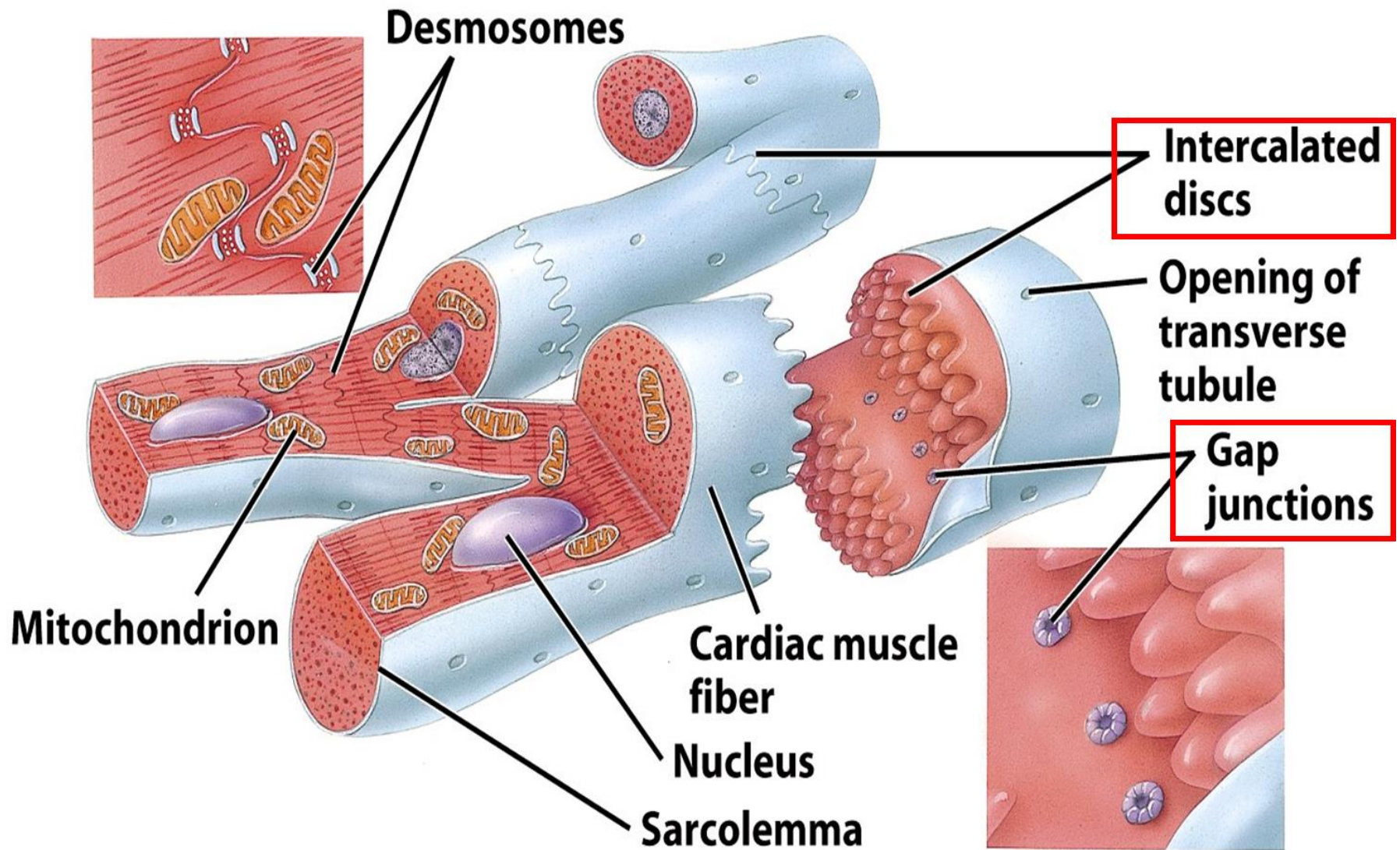


Cardiac Muscle H&E

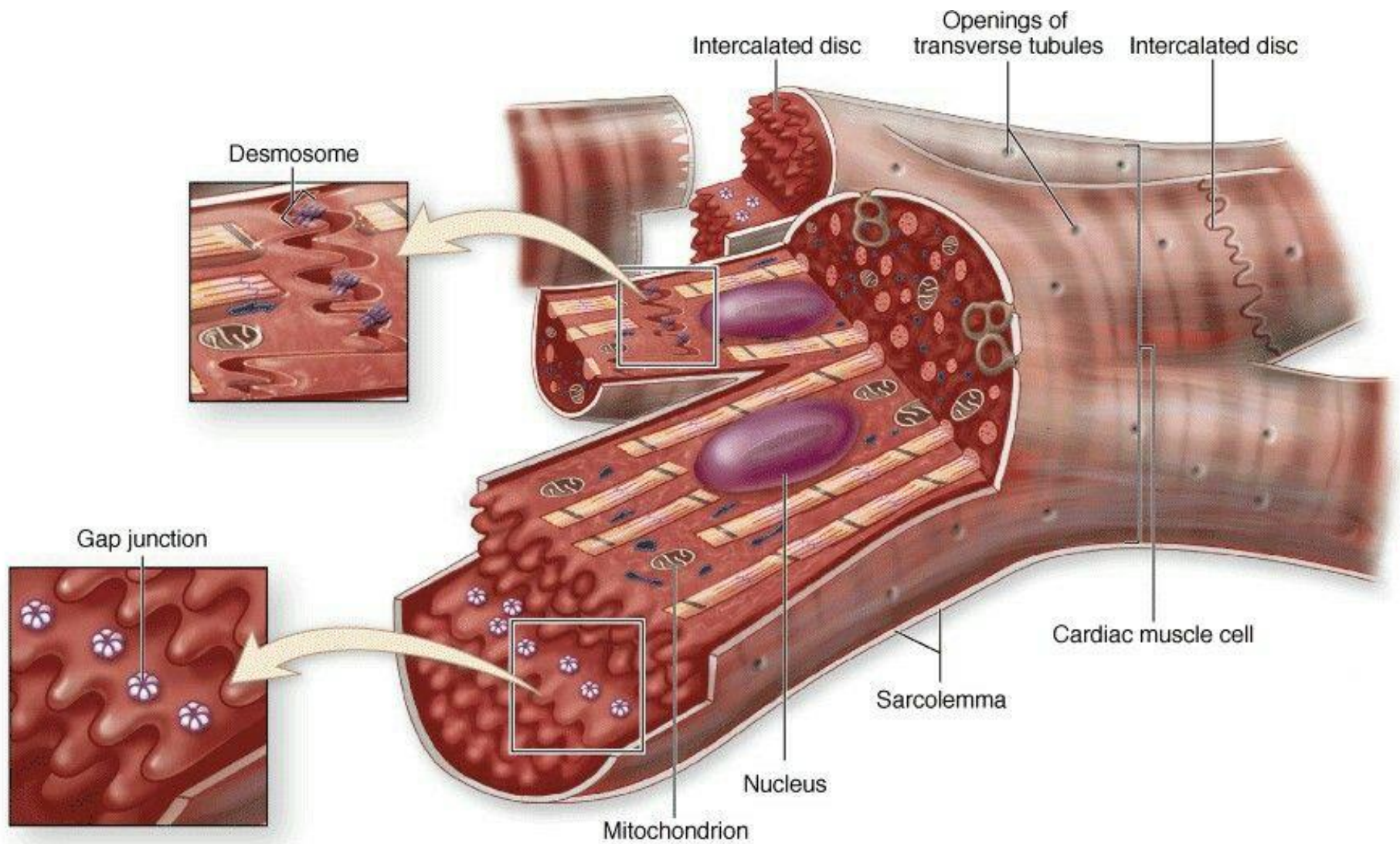


Cardiac Muscle H&E

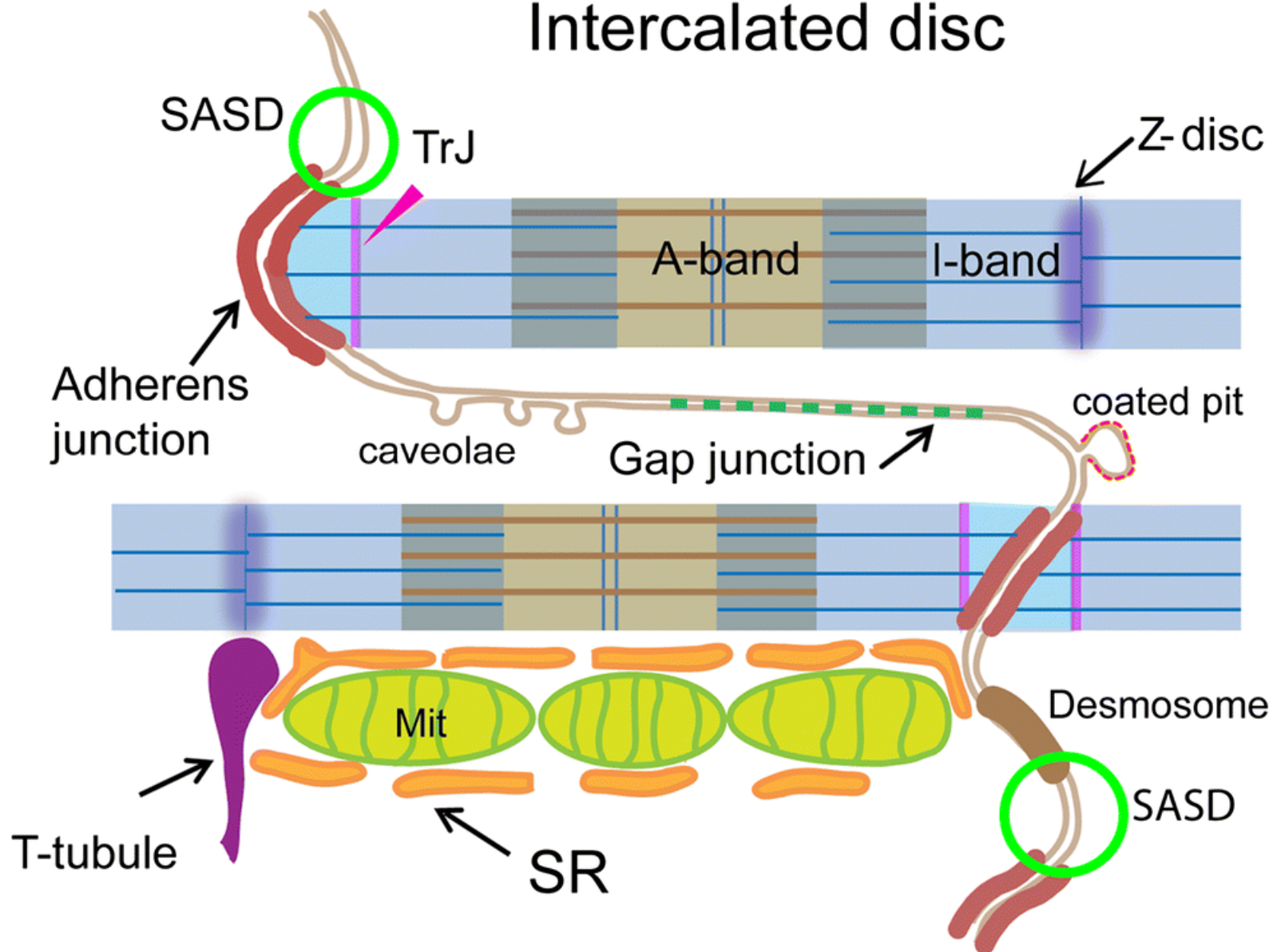




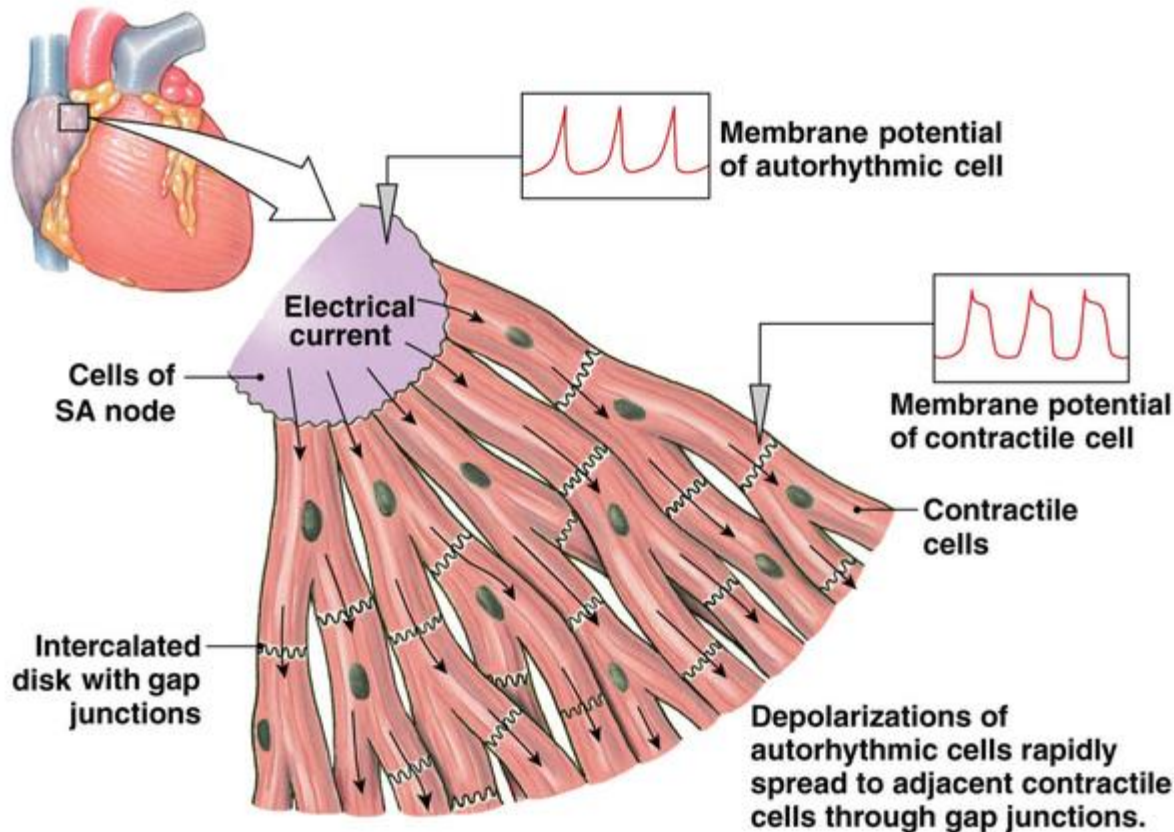
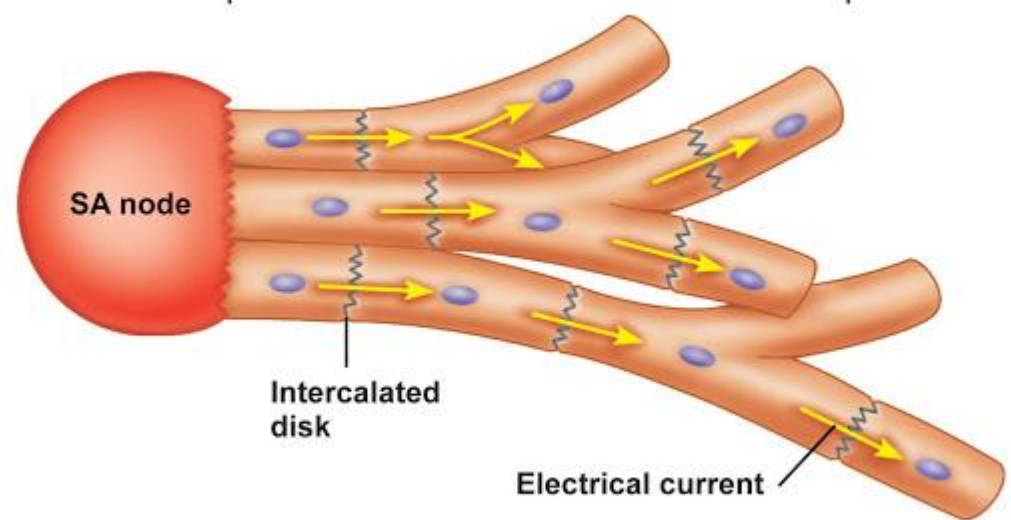
Cardiac muscle fibers



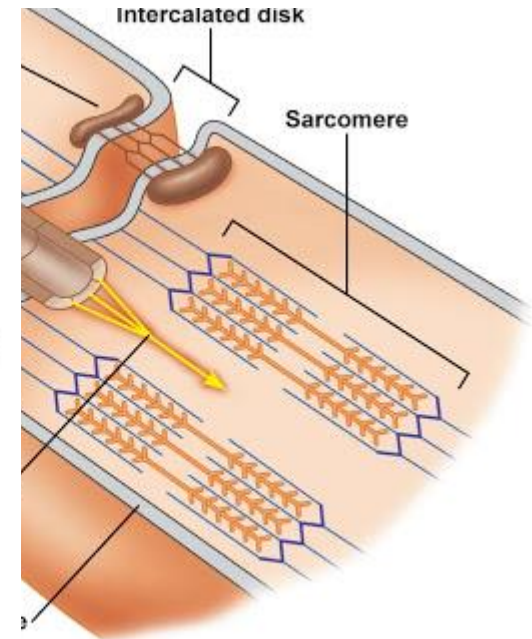
Intercalated disc



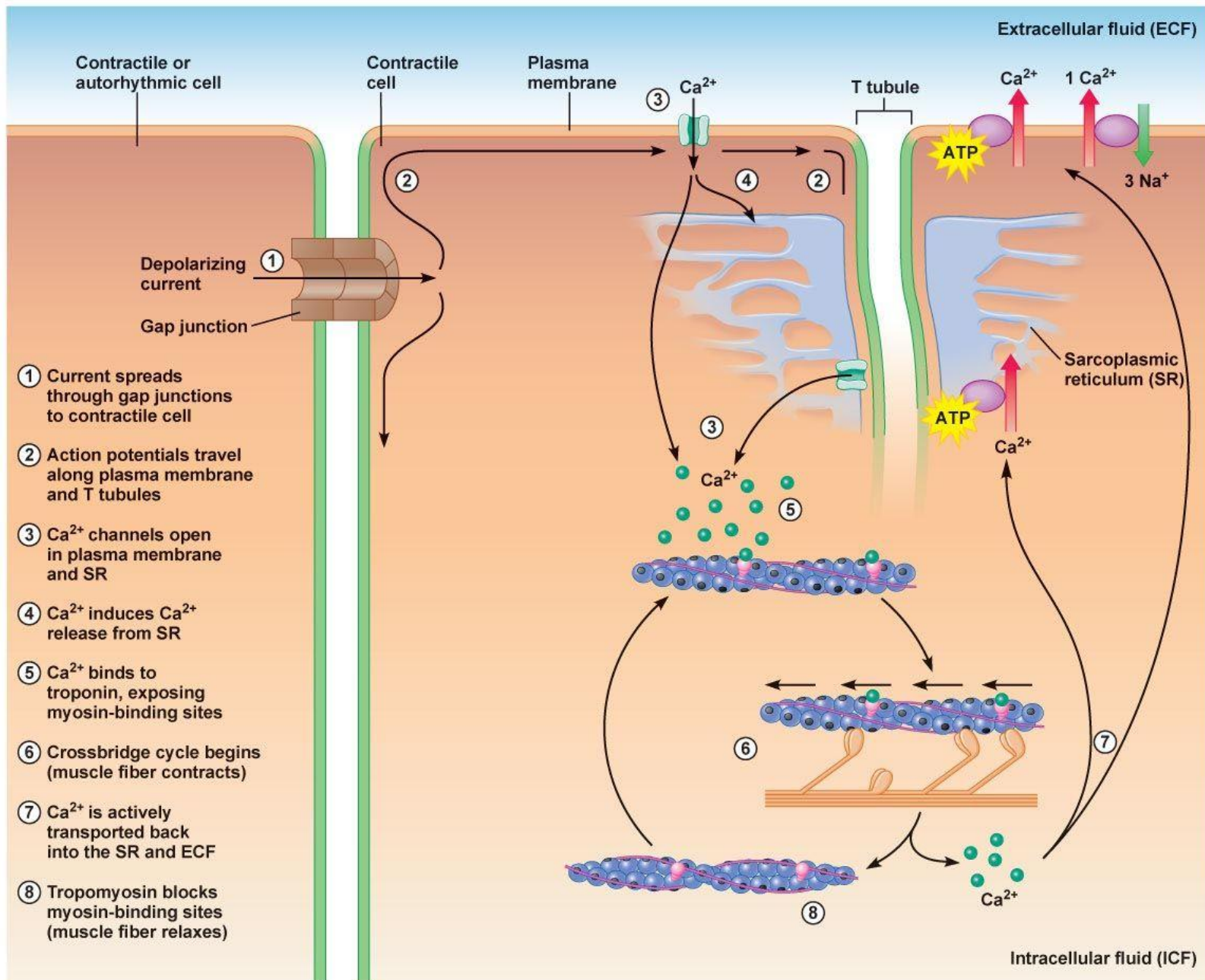
ACTION POTENTIALS in PACEMAKER CELLS

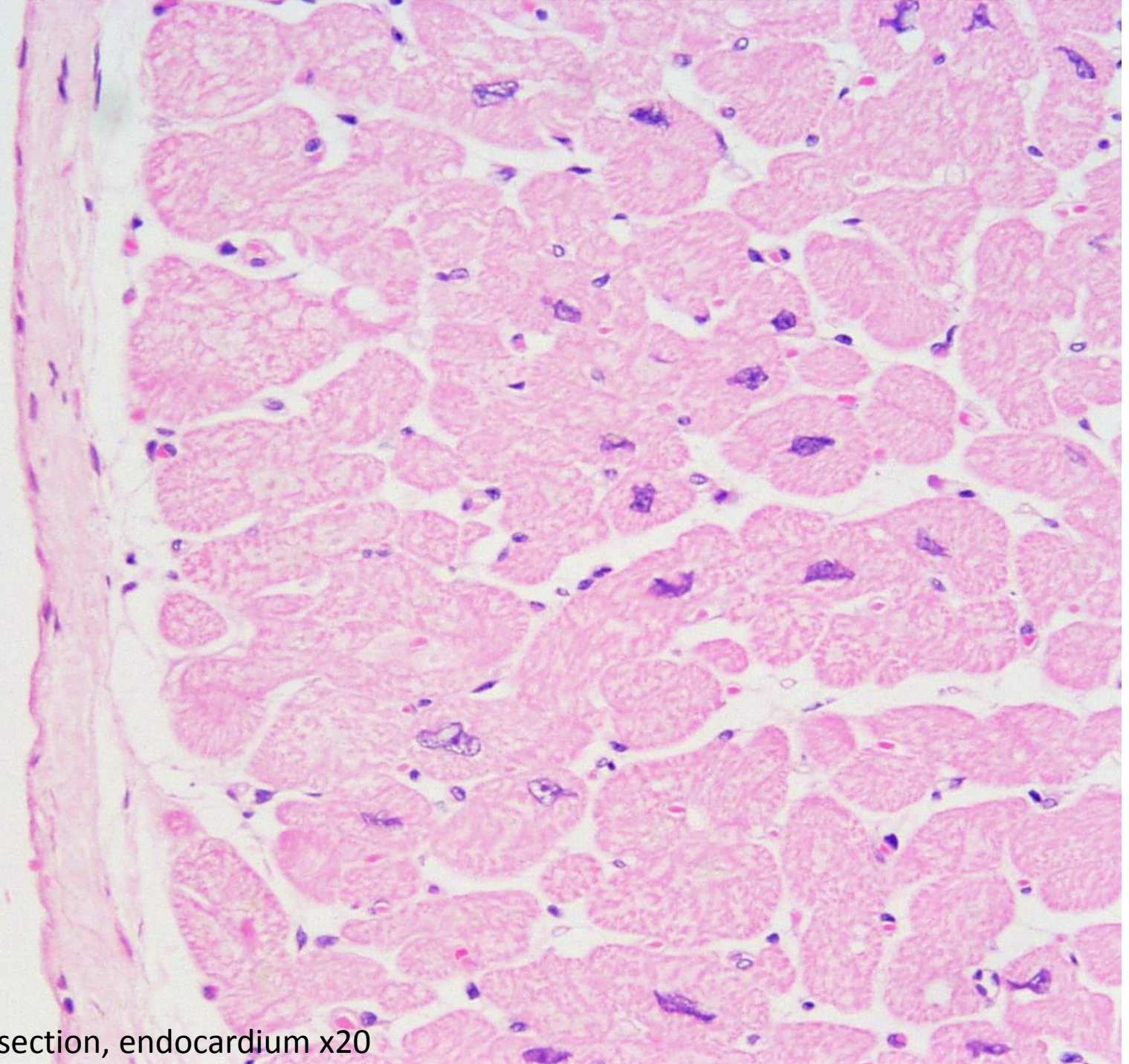


2011 Pearson Education, Inc.

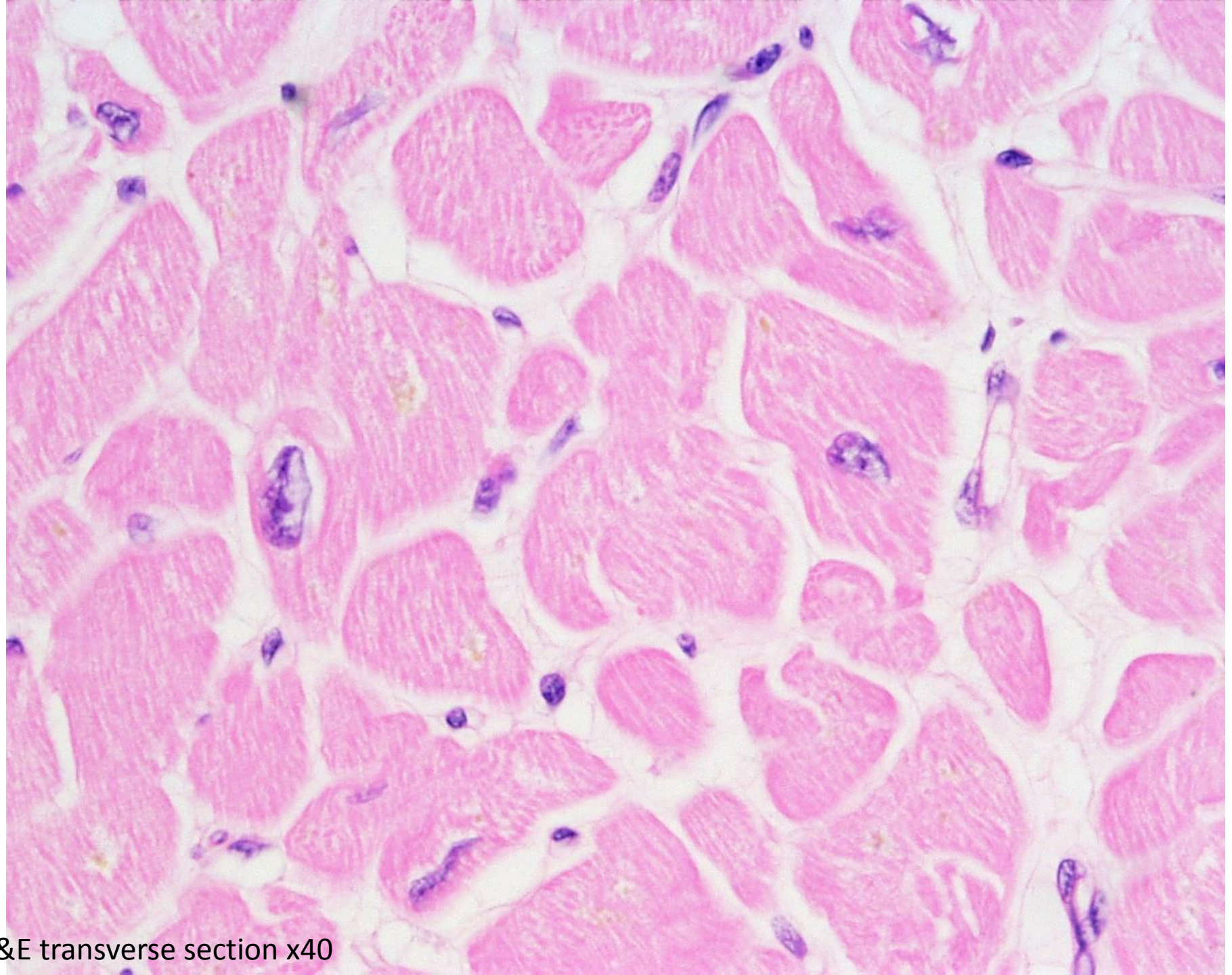


son Education, Inc.

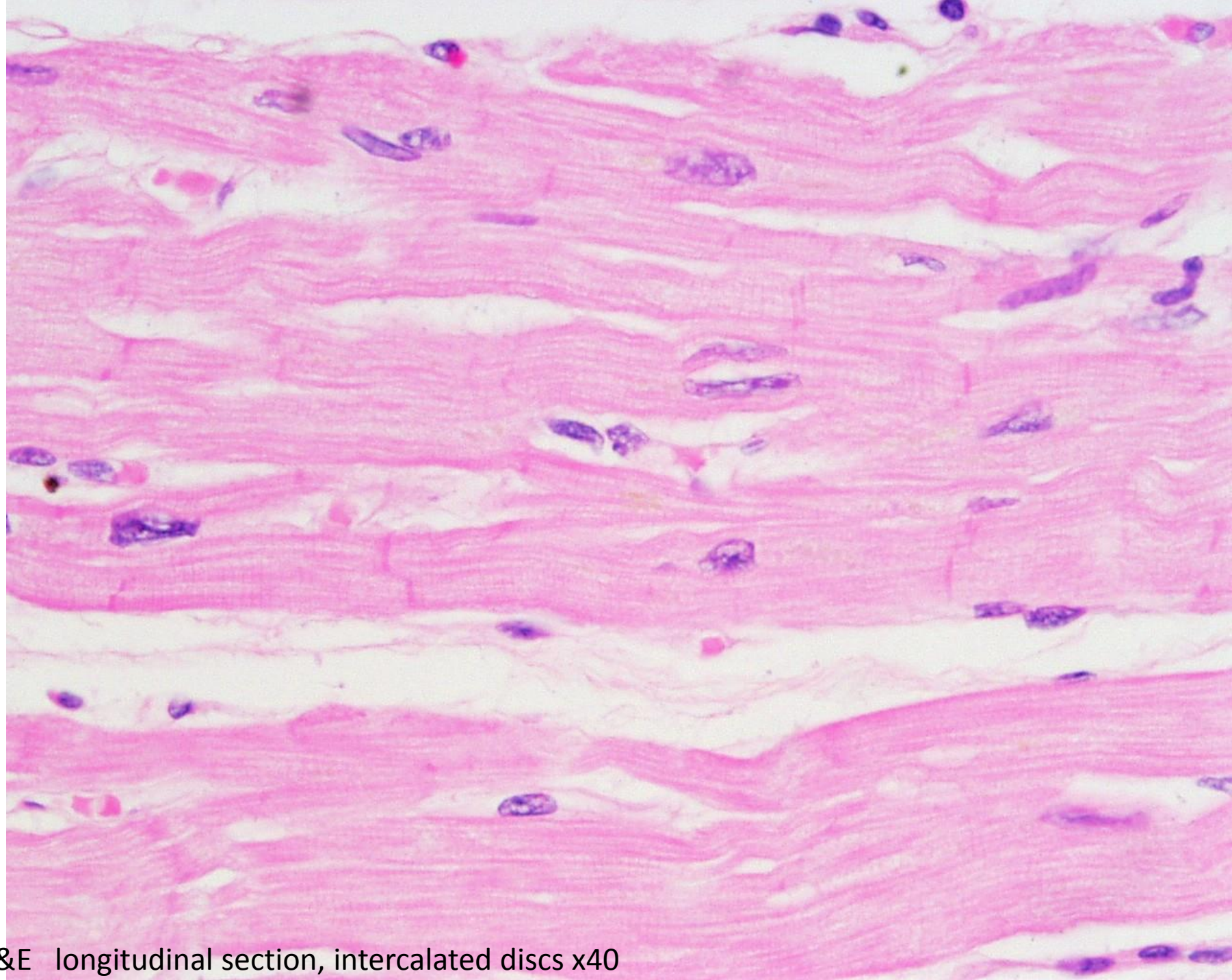




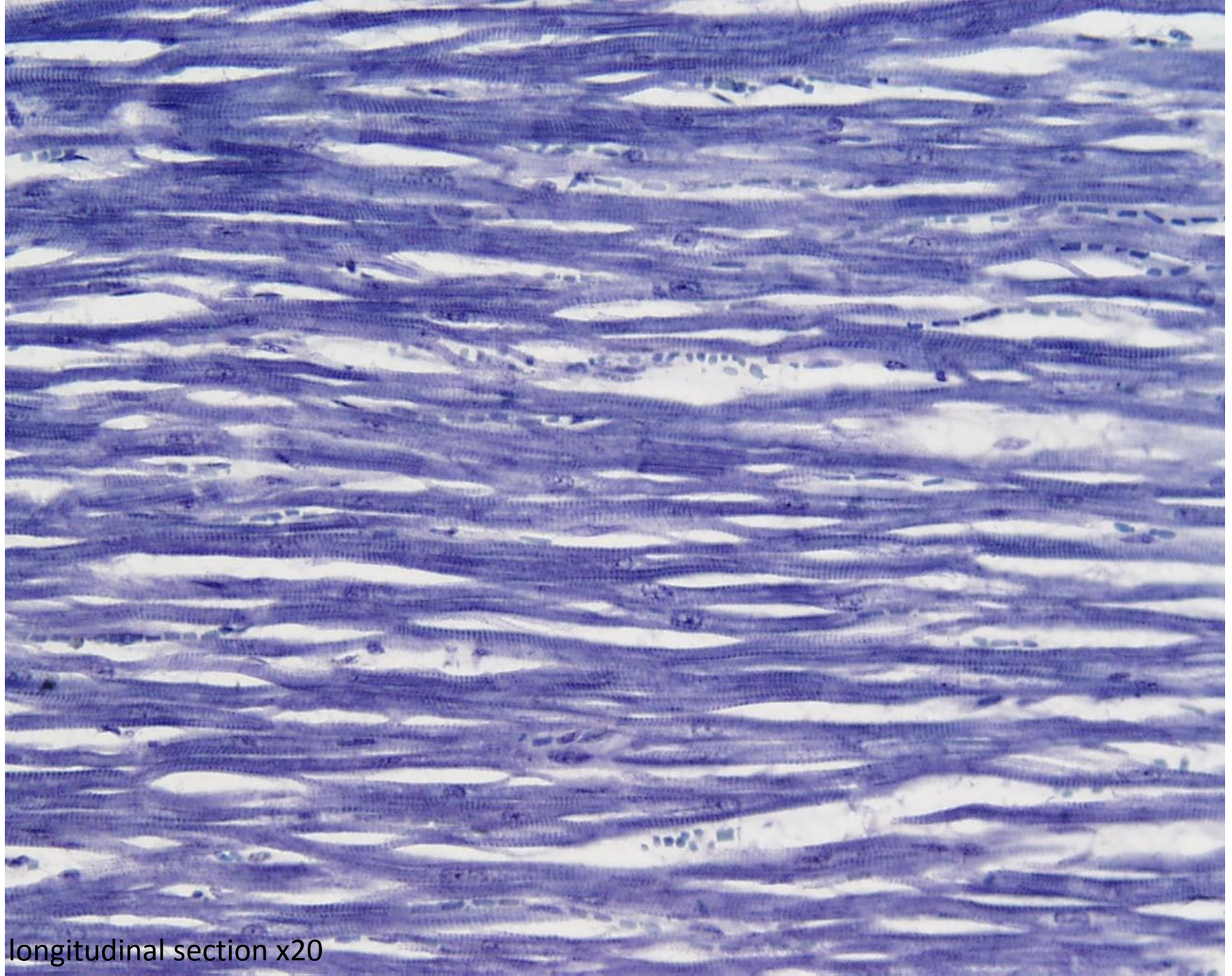
H&E transverse section, endocardium x20



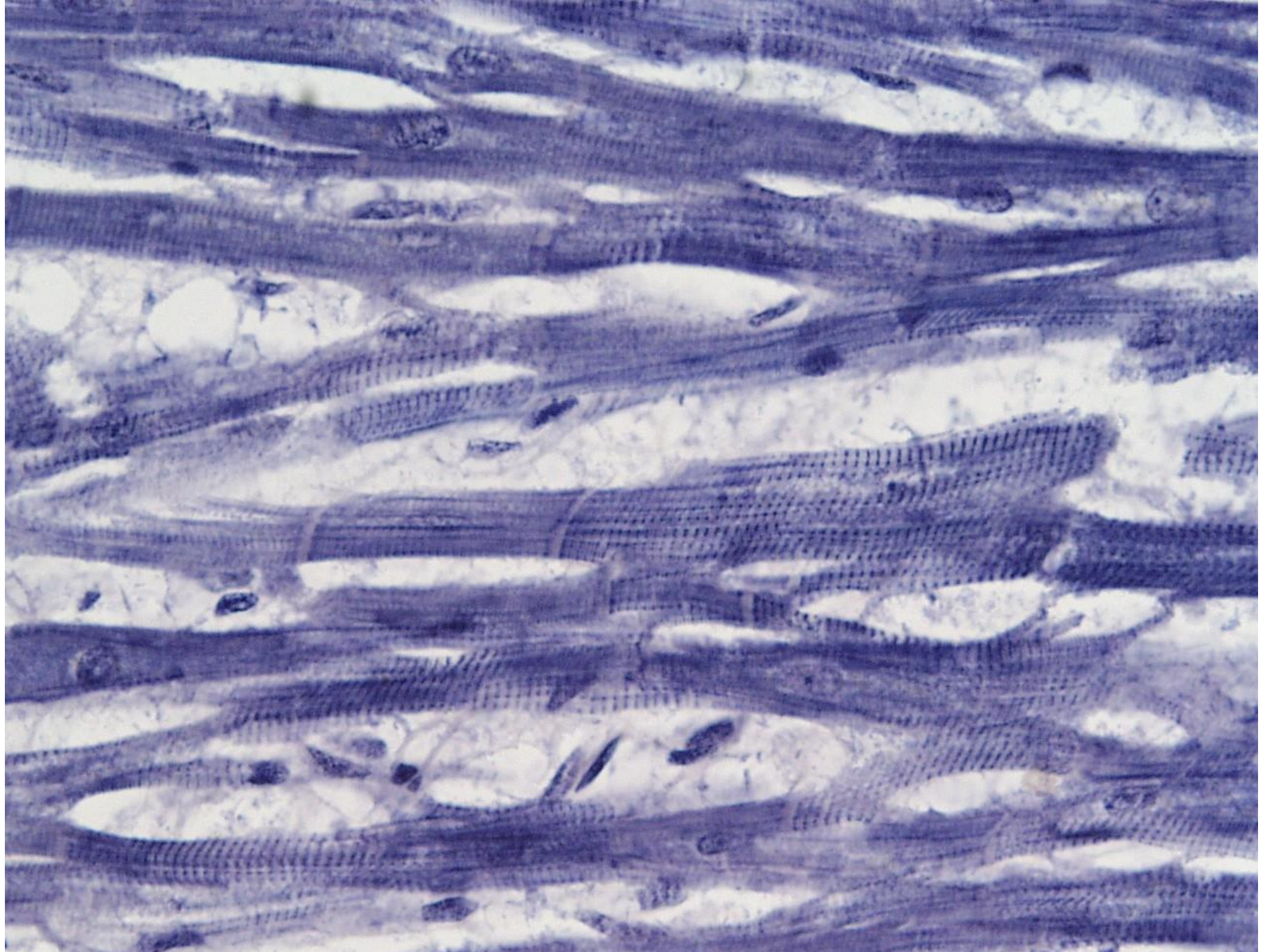
H&E transverse section x40



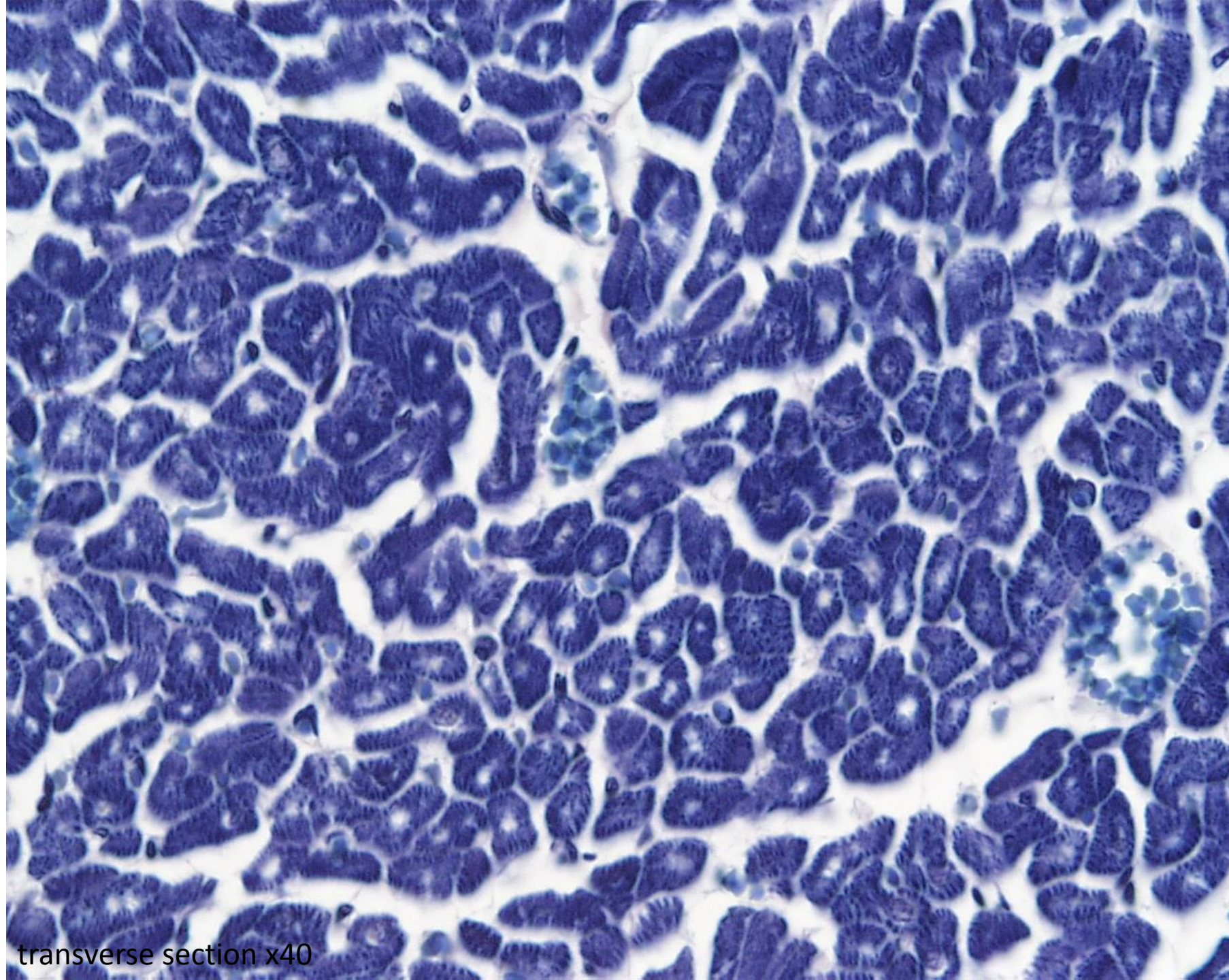
H&E longitudinal section, intercalated discs x40



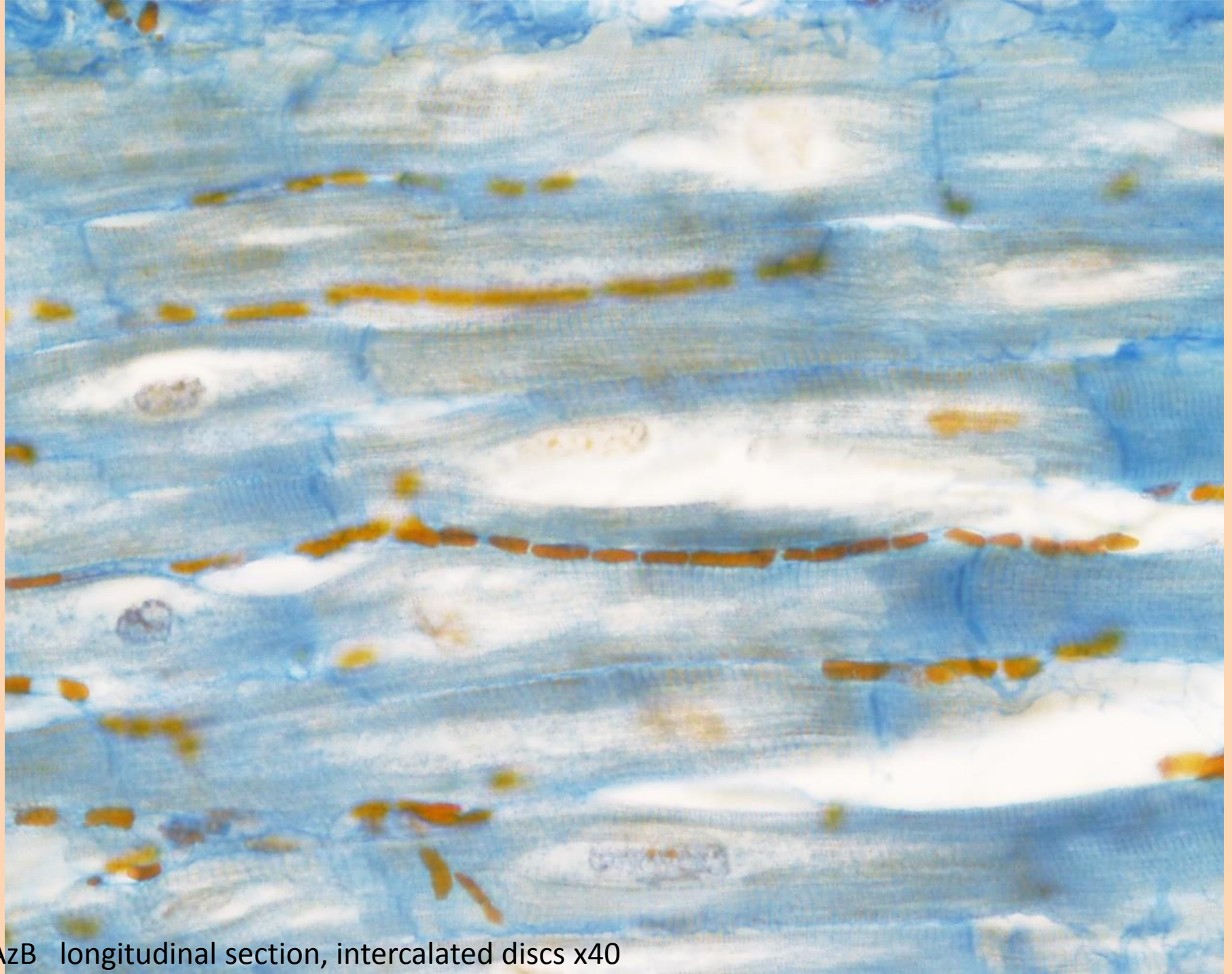
IH longitudinal section x20



IH longitudinal section, intercalated discs x40

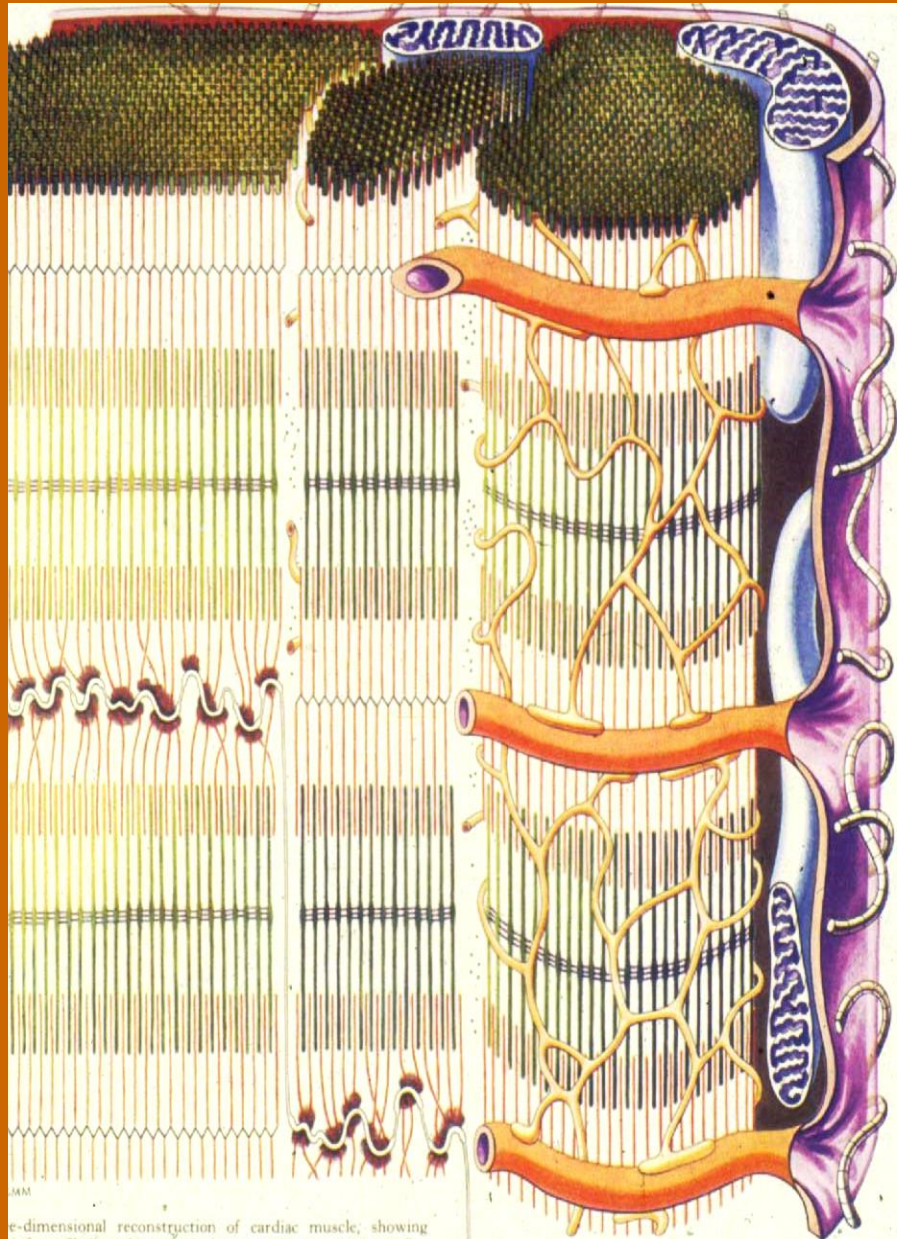


IH transverse section x40

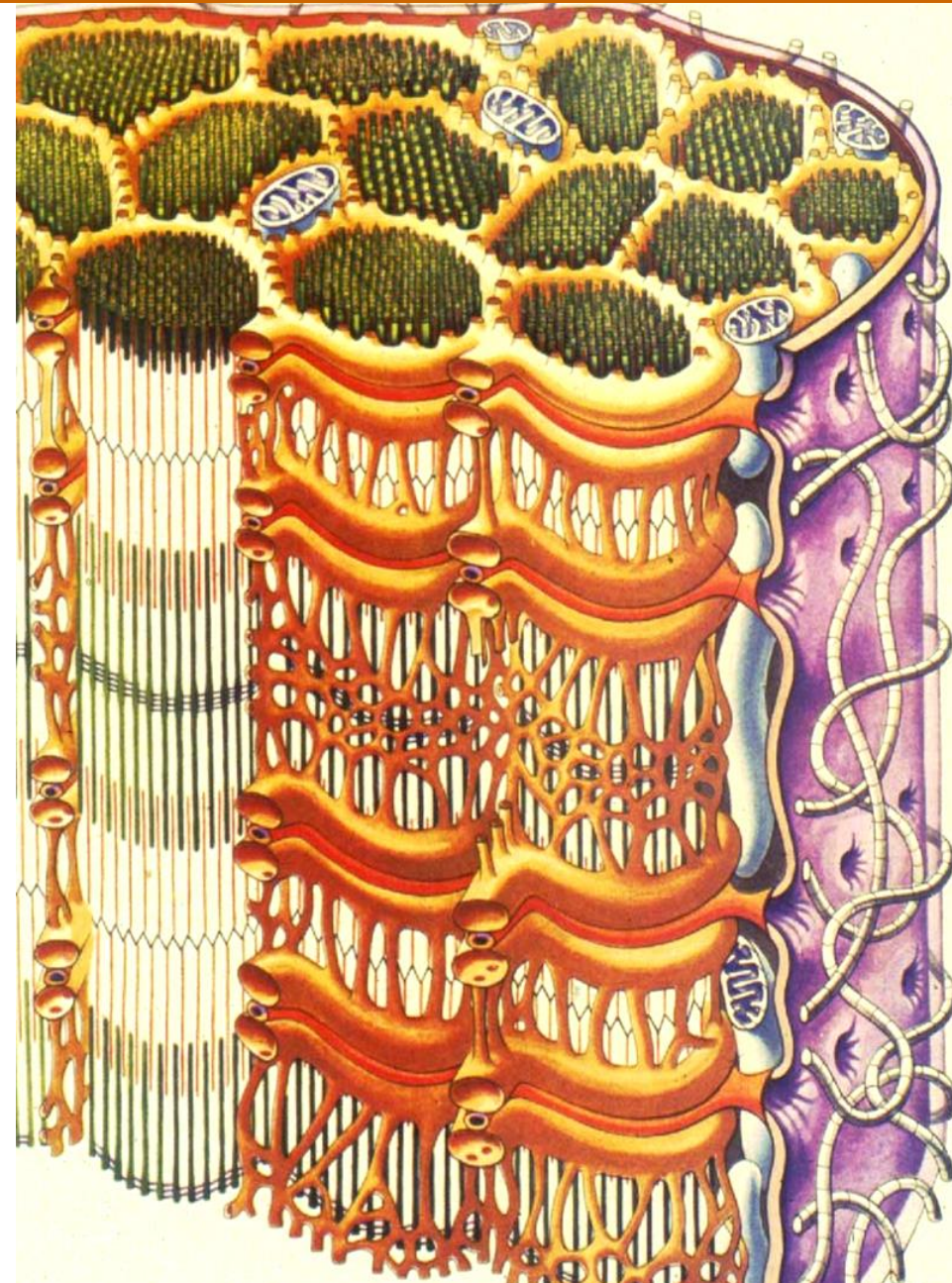


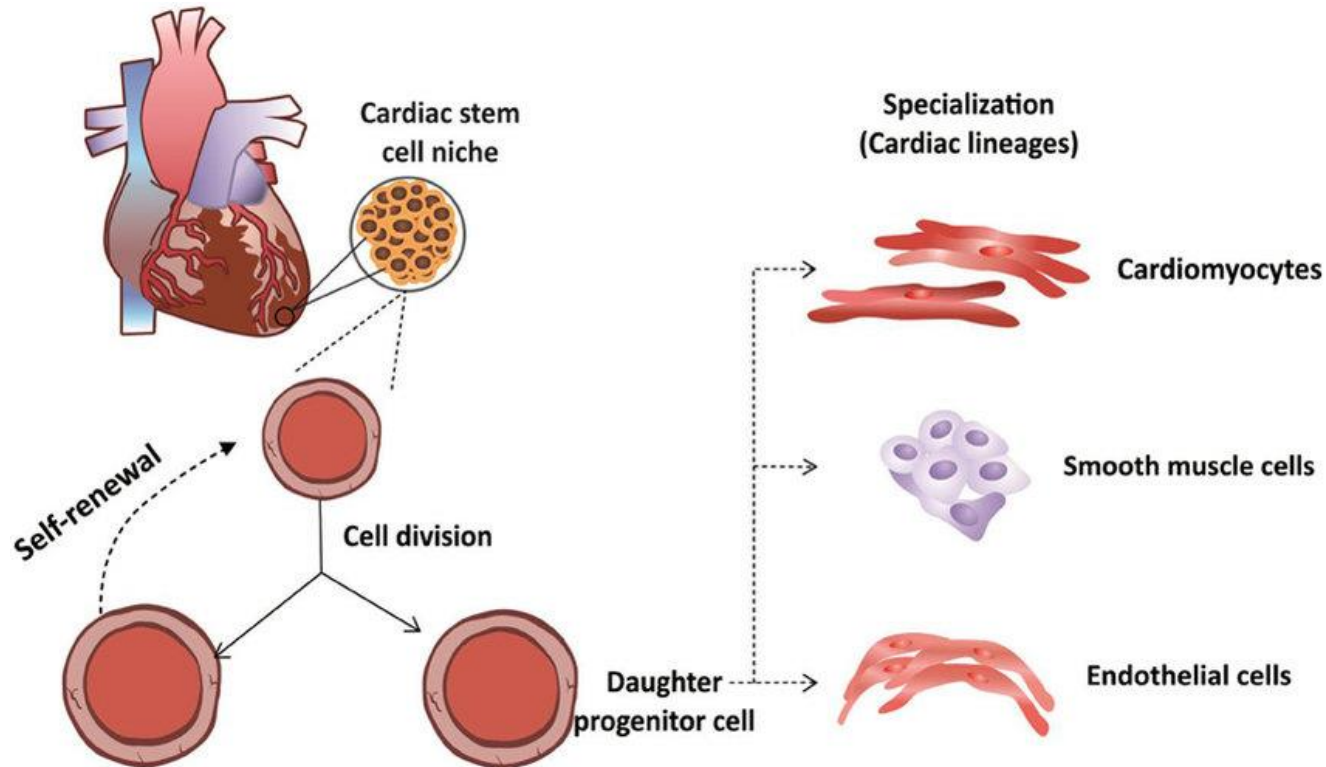
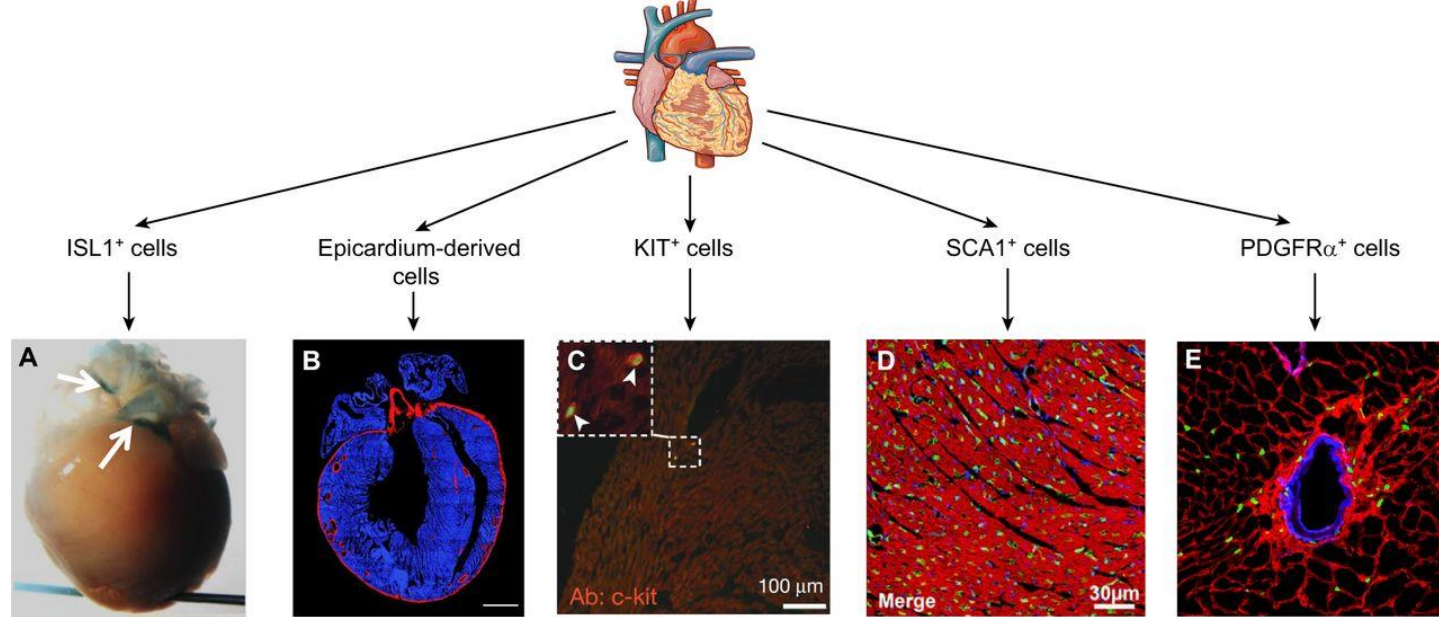
AzB longitudinal section, intercalated discs x40

Porównanie budowy komórek mięśni poprzecznie prążkowanych serca



3-dimensional reconstruction of cardiac muscle; showing arrangement of myofibrils and membrane systems. Compare with 5.6. See other details. (Modified from a diagram by Professor D. Fawcett.)



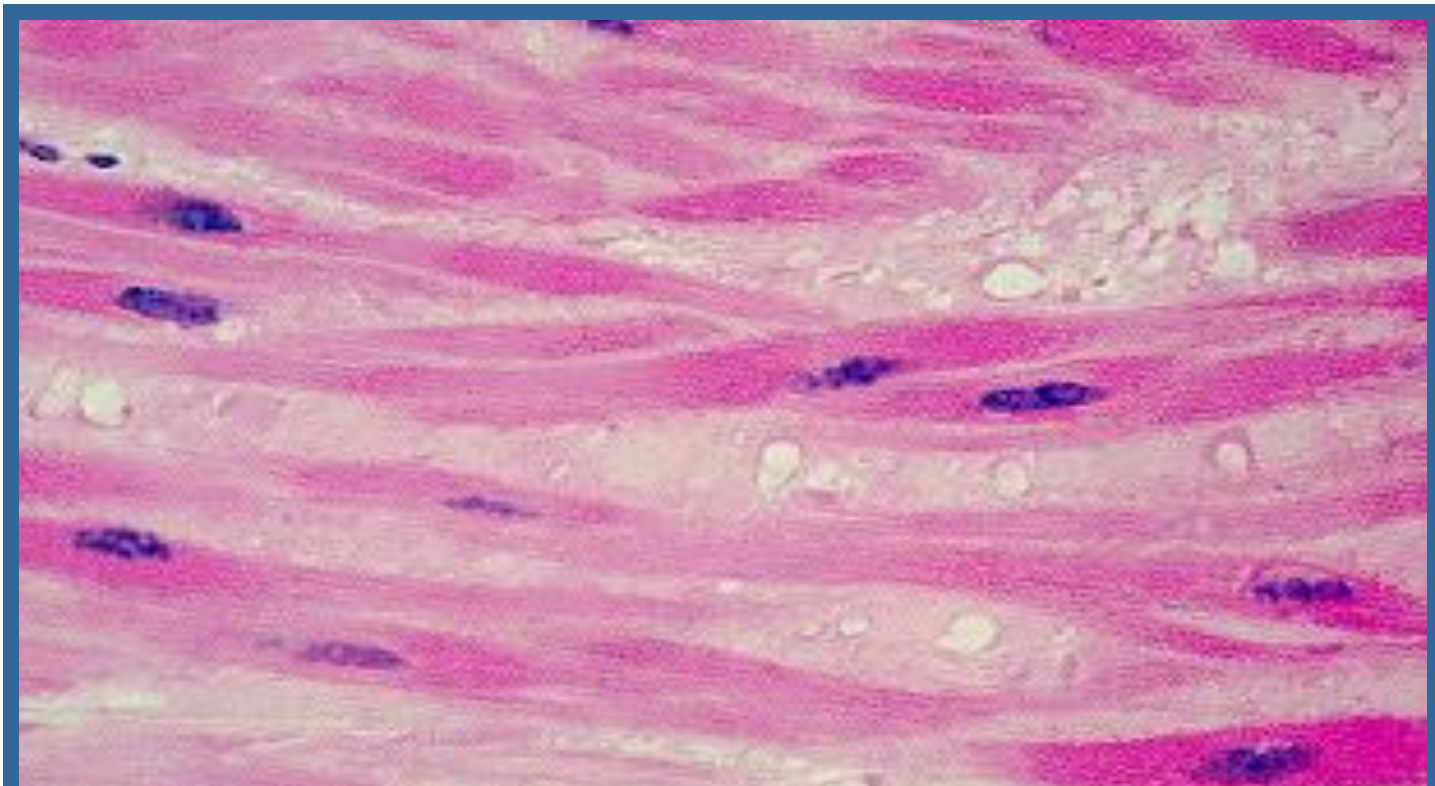


A microscopic image of smooth muscle tissue, showing elongated, spindle-shaped cells with central, dark, oval nuclei. The cells are arranged in a somewhat organized pattern, with some showing cross-striations. The background is a mix of green and brownish-yellow, indicating the presence of various cellular components and extracellular matrix.

TKANKA MIĘŚNIOWA GŁADKA

TKANKA MIĘŚNIOWA GŁADKA

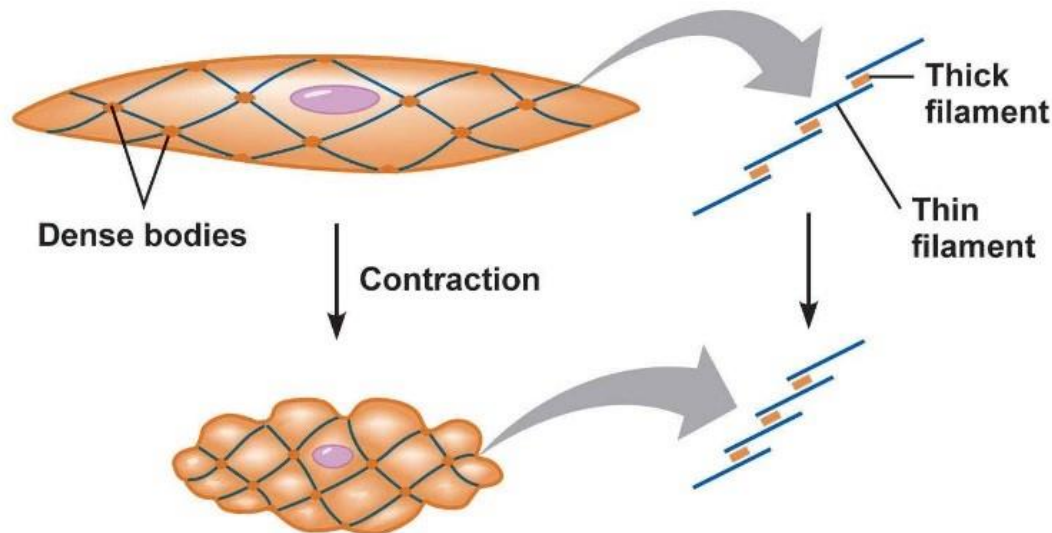
- pojedyncze komórki lub grupy komórek w tkance łącznej narządów (np. gruczoł krokowy, kosmki jelitowe)
 - mięśnie (np. ściana macicy, jelita, żołądka)
 - czynność niezależna od woli
- kontrola poprzez układ nerwowy autonomiczny i hormony



TKANKA MIĘŚNIOWA GŁADKA

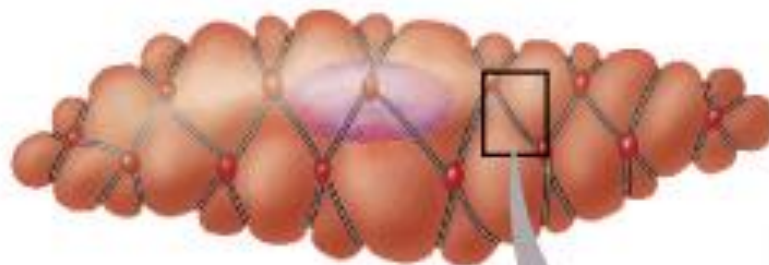
Czynniki wywołujące skurcz lub rozkurcz miocytów gładkich

- spontaniczne wytwarzanie potencjału czynnościowego /komórki rozrusznikowe - miocyty ściany kielichów małych nerek lub jelita/
- impulsy nerwowe - układ autonomiczny współczulny lub przywspółczulny
- hormony: prostaglandyny adrenalina, noradrenalina, angiotensyna 2, leukotrieny
- tlenek azotu /zmniejszenie jonów wapnia w cytosolu - rozkurcz/
 - kininy / krótkie peptydy odcinane od białek surowicy, np. bradykinina/





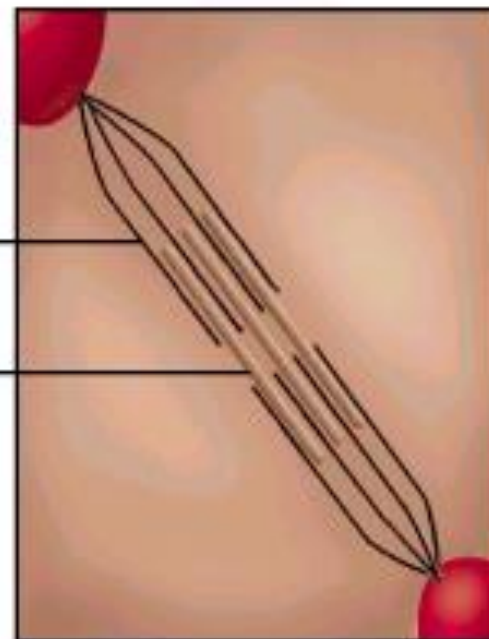
rozkurcz



skurcz

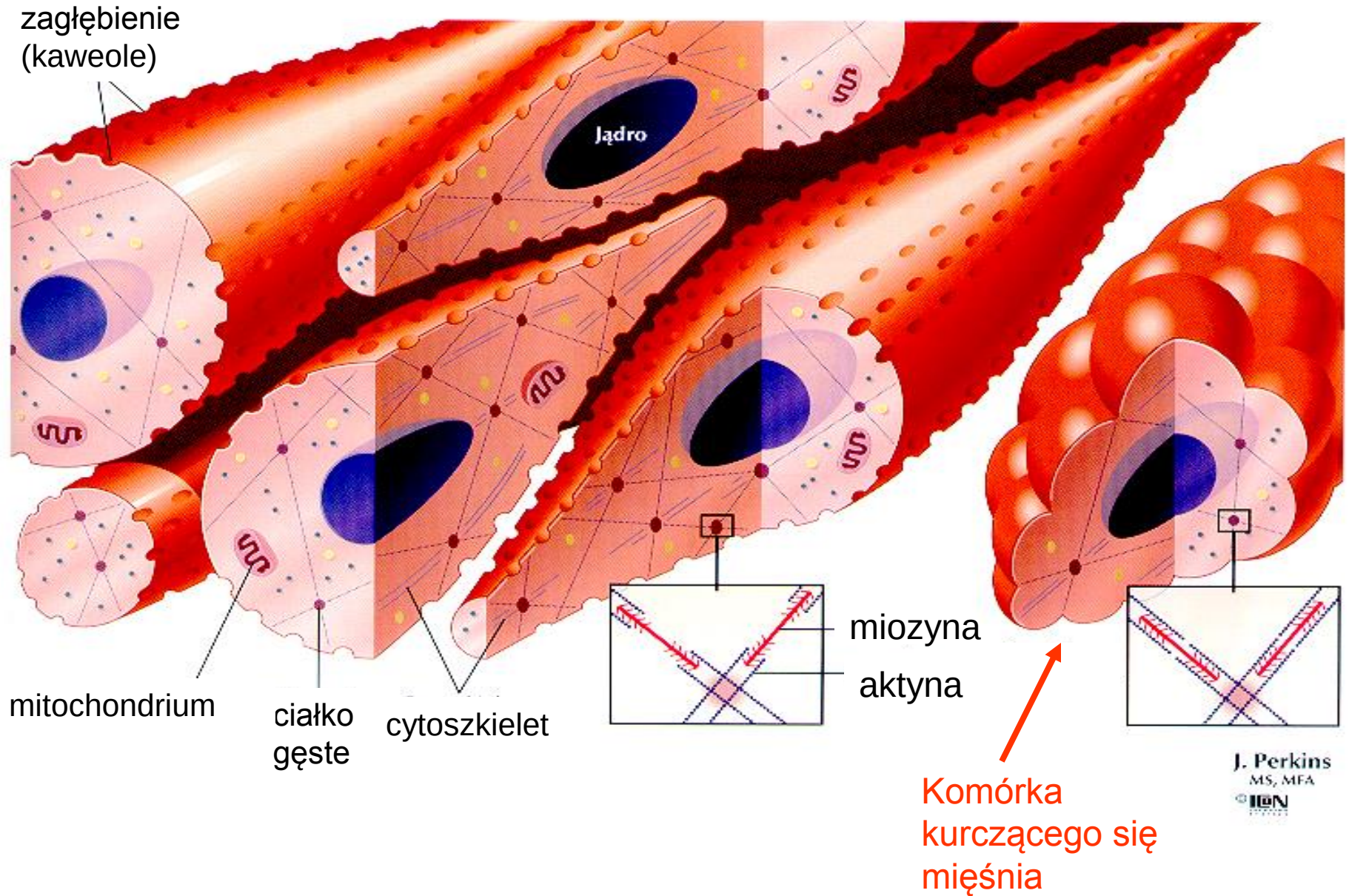
aktyna

miozyna



APARAT KURCZLIWY KOMÓRKI MIĘŚNIA GŁADKIEGO

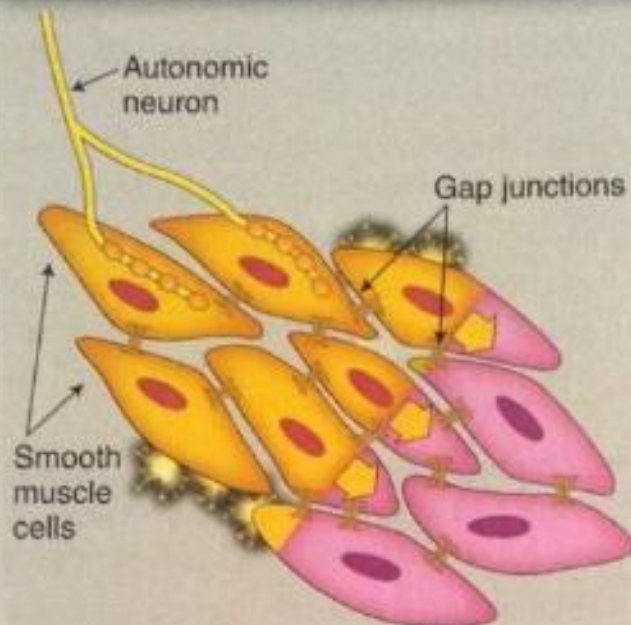
Tkanka mięśniowa gładka



Single Unit vs Multi Unit

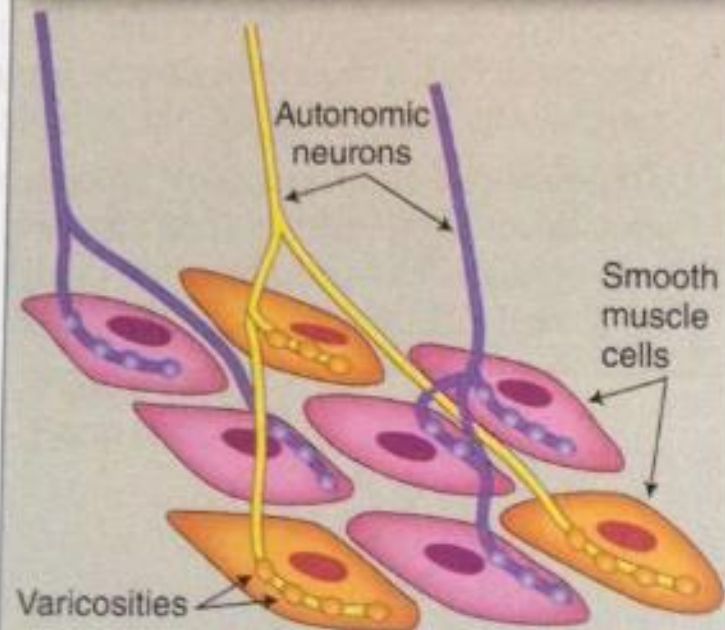
A Phasic smooth muscle

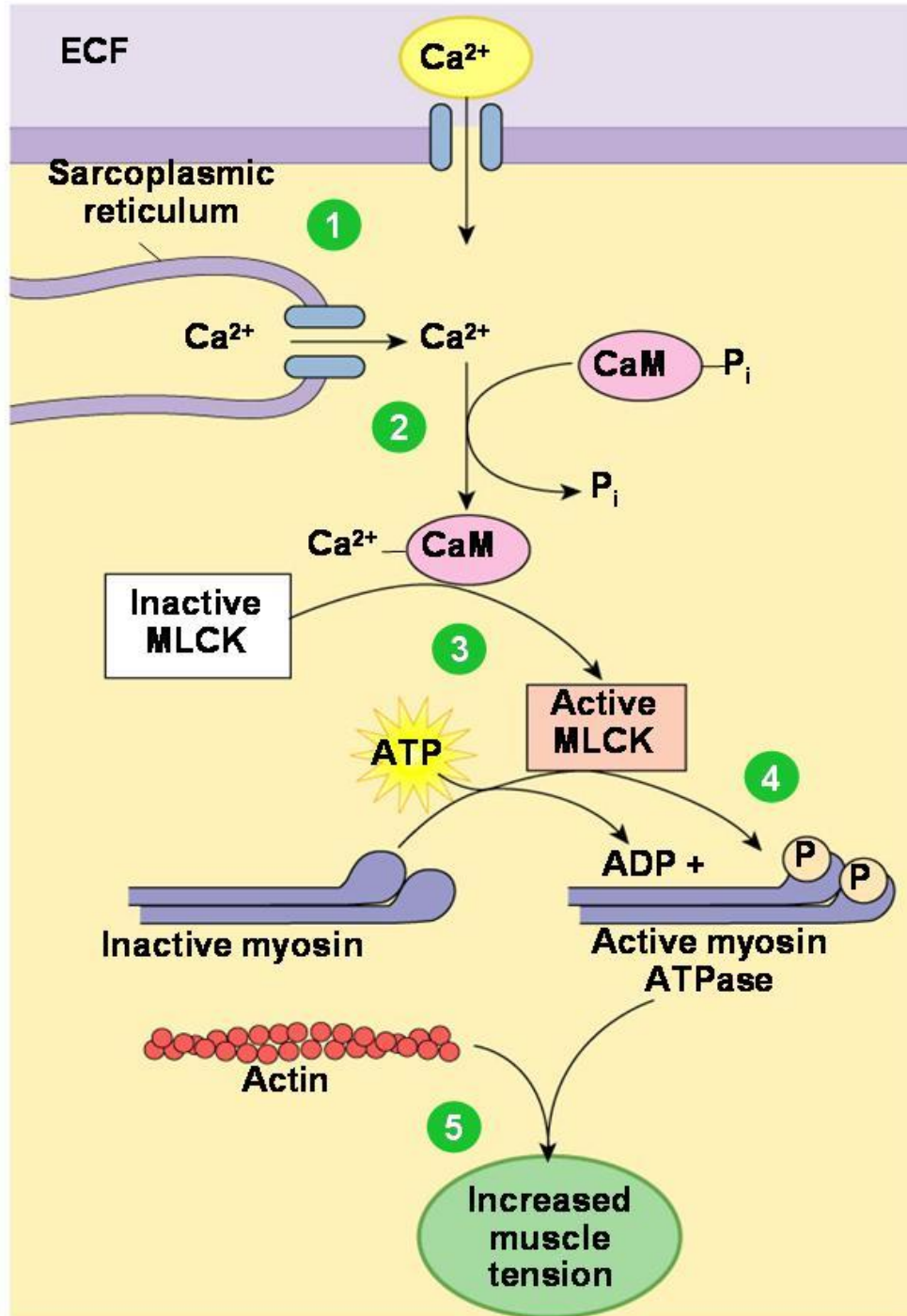
Gap junctions between neighboring cells allow a slow wave of contraction to spread from myocyte to myocyte.



B Tonic smooth muscle

Individual myocytes are isolated from neighboring cells, which allows them to be activated independently for finer control.





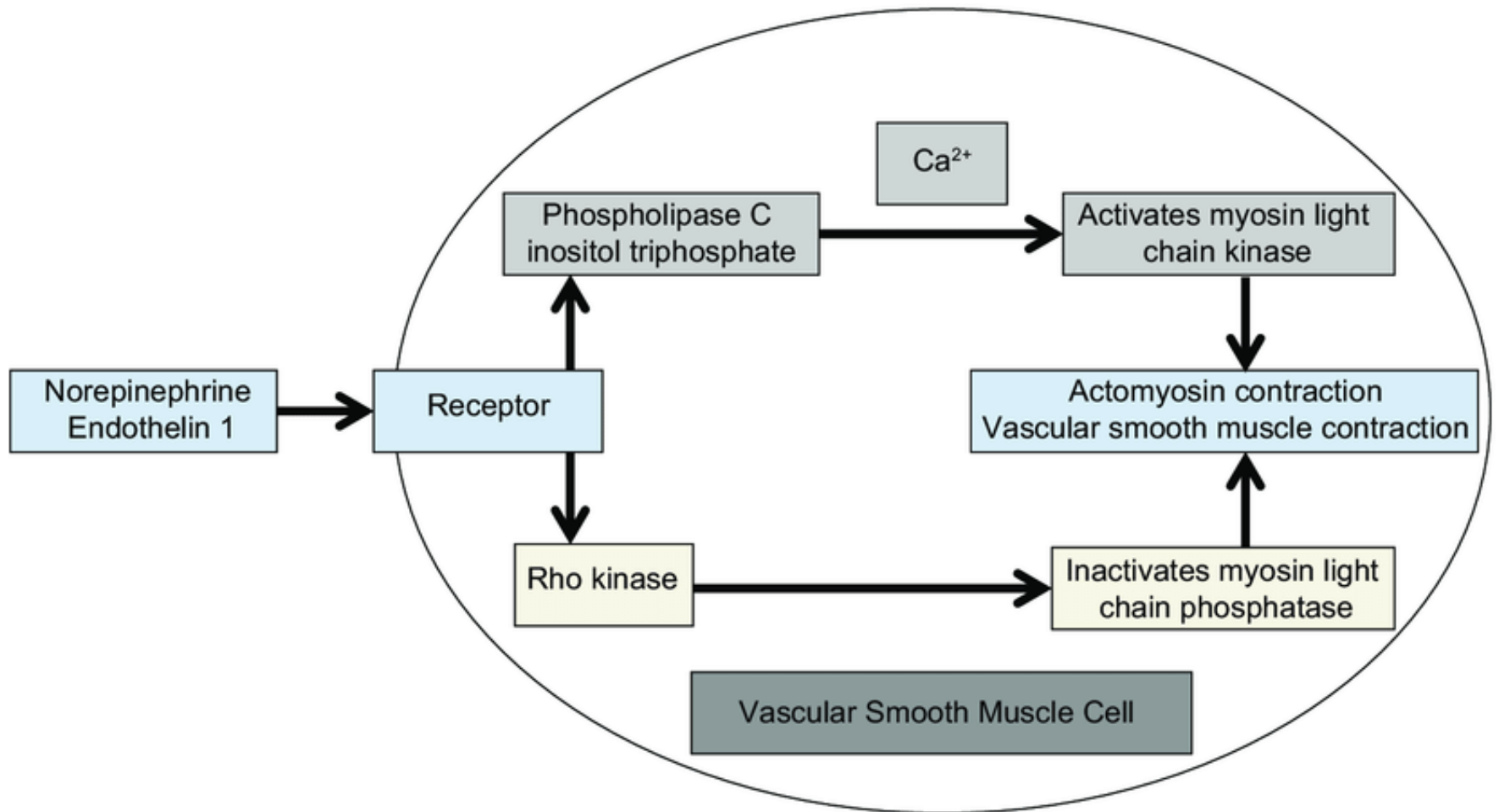
1 Intracellular Ca^{2+} concentrations increase when Ca^{2+} enters cell and is released from sarcoplasmic reticulum.

2 Ca^{2+} binds to calmodulin (CaM).

3 Ca^{2+} -calmodulin activates myosin light chain kinase (MLCK).

4 MLCK phosphorylates light chains in myosin heads and increases myosin ATPase activity.

5 Active myosin crossbridges slide along actin and create muscle tension.



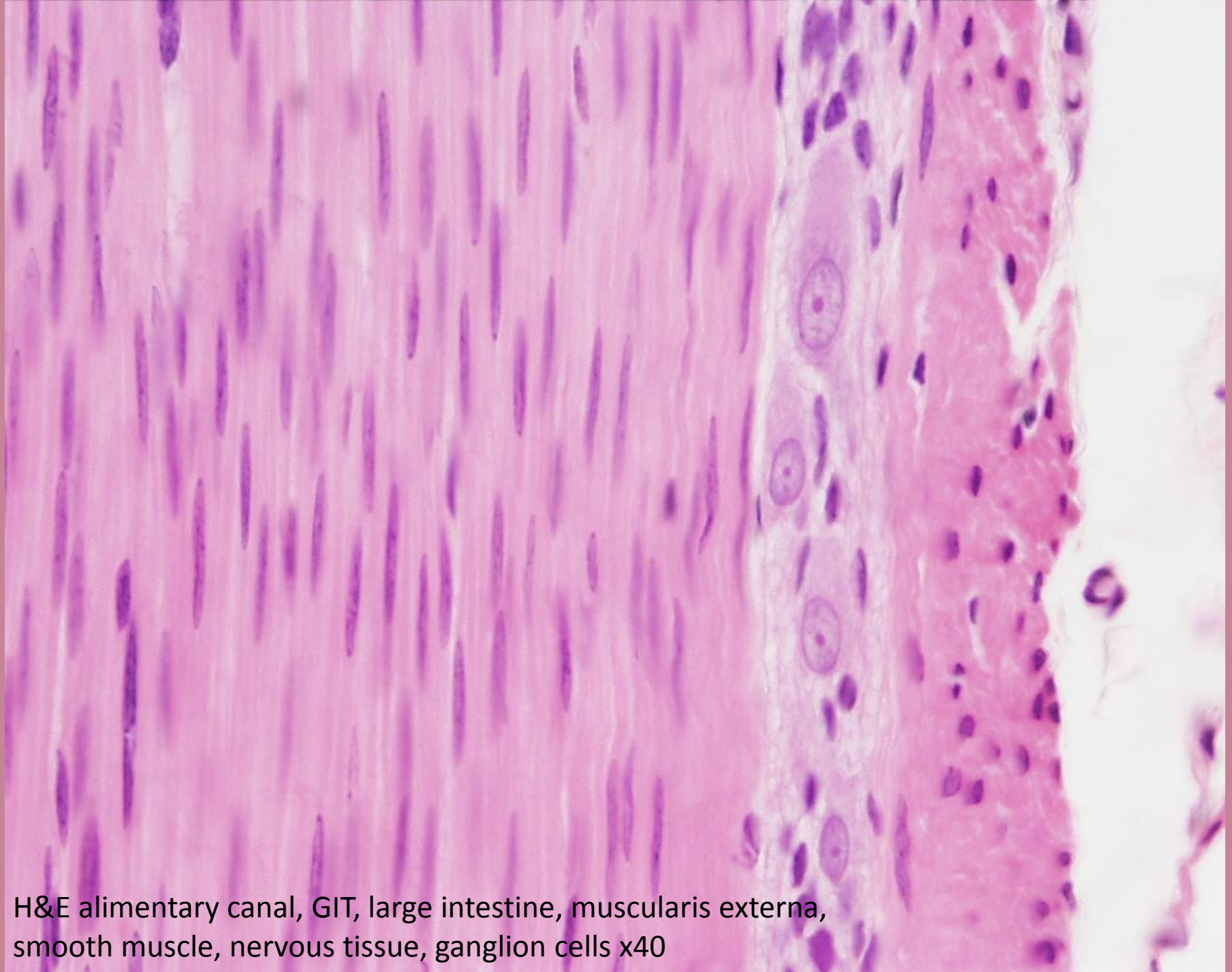
Jejunum H&E

lumen

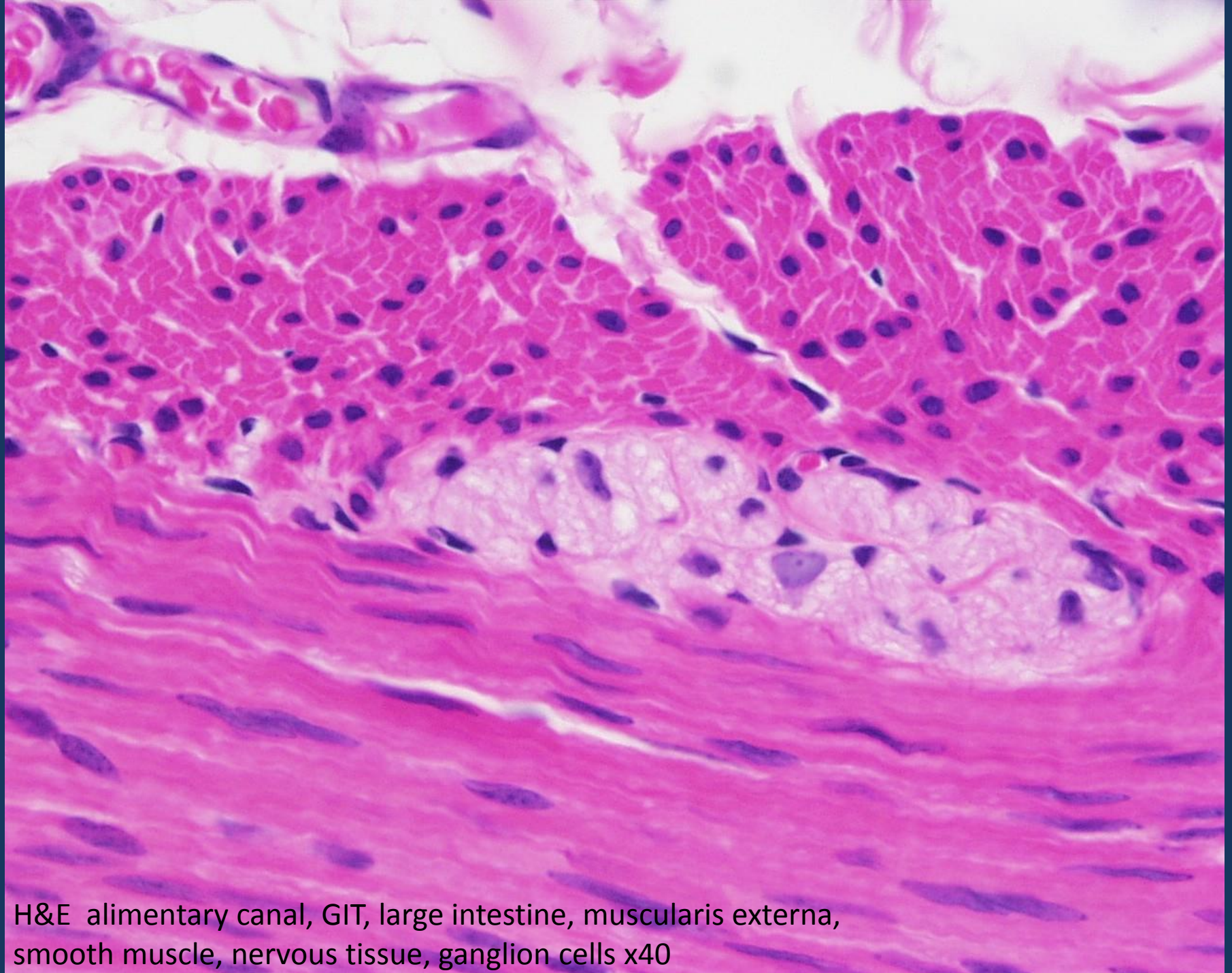
**villi with simple
columnar epithelium**



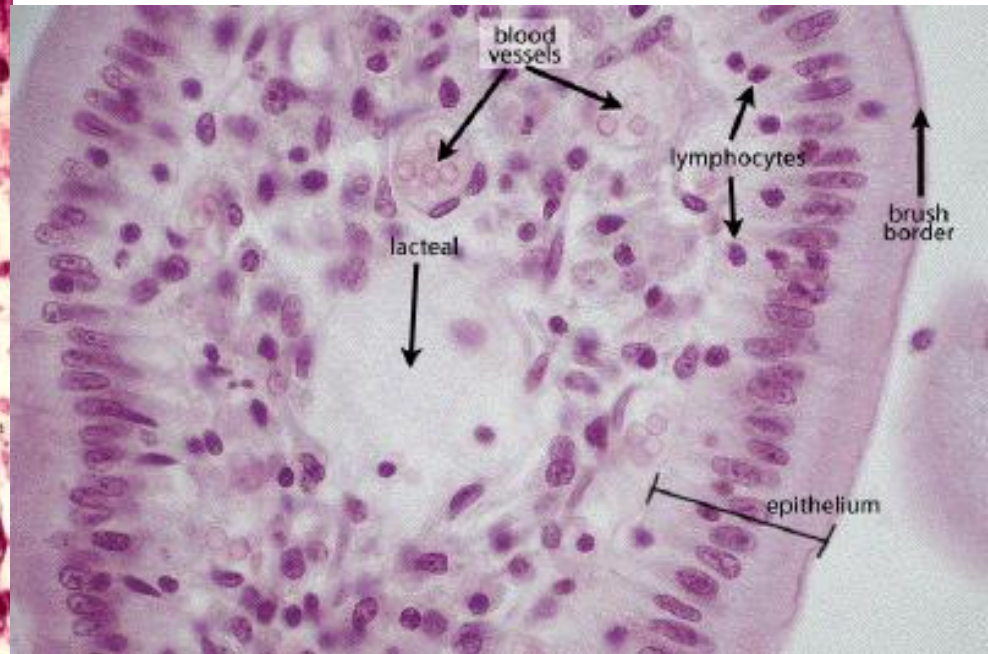
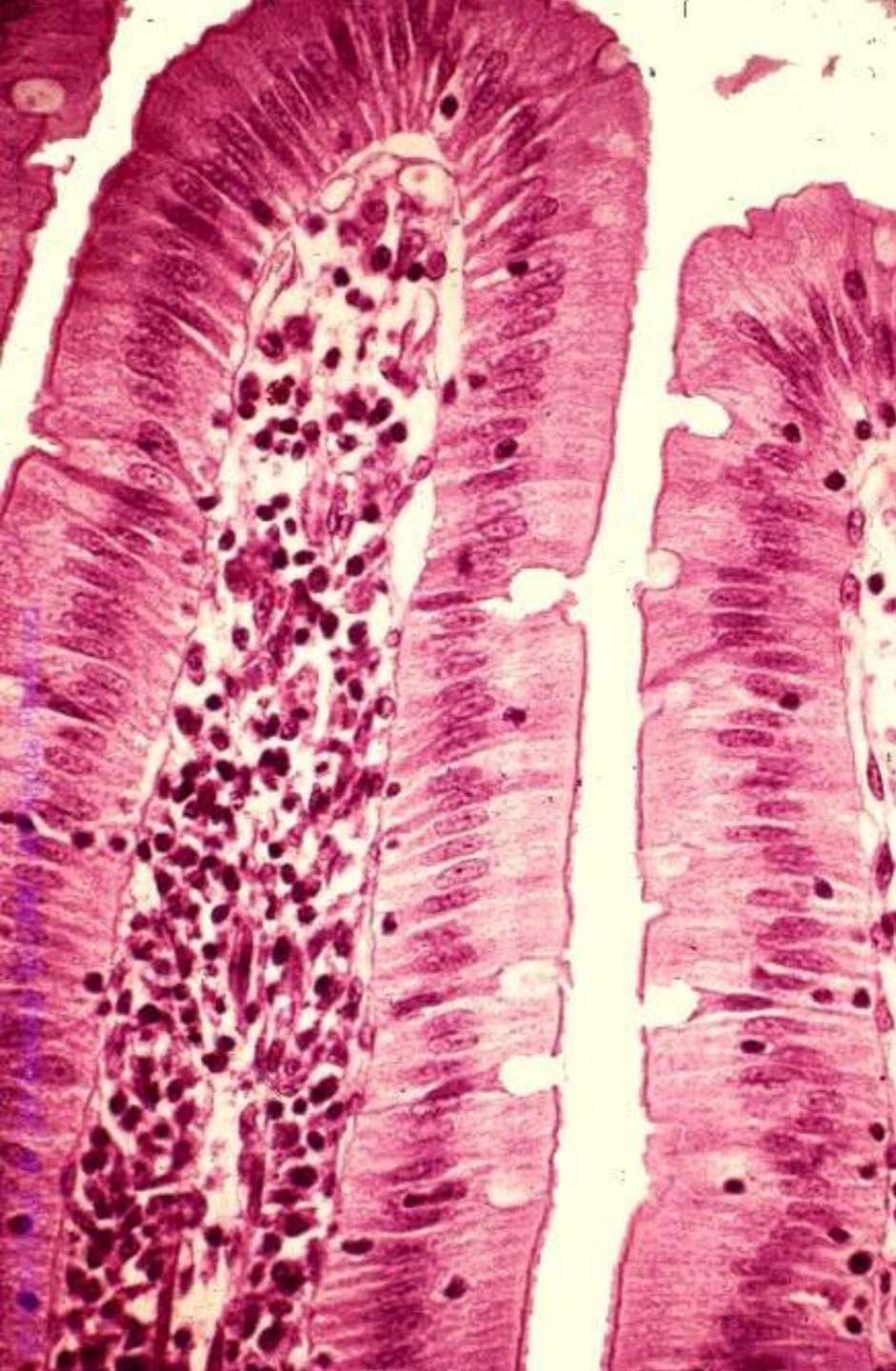
**longitudinally and transversely
cut smooth muscle cells**

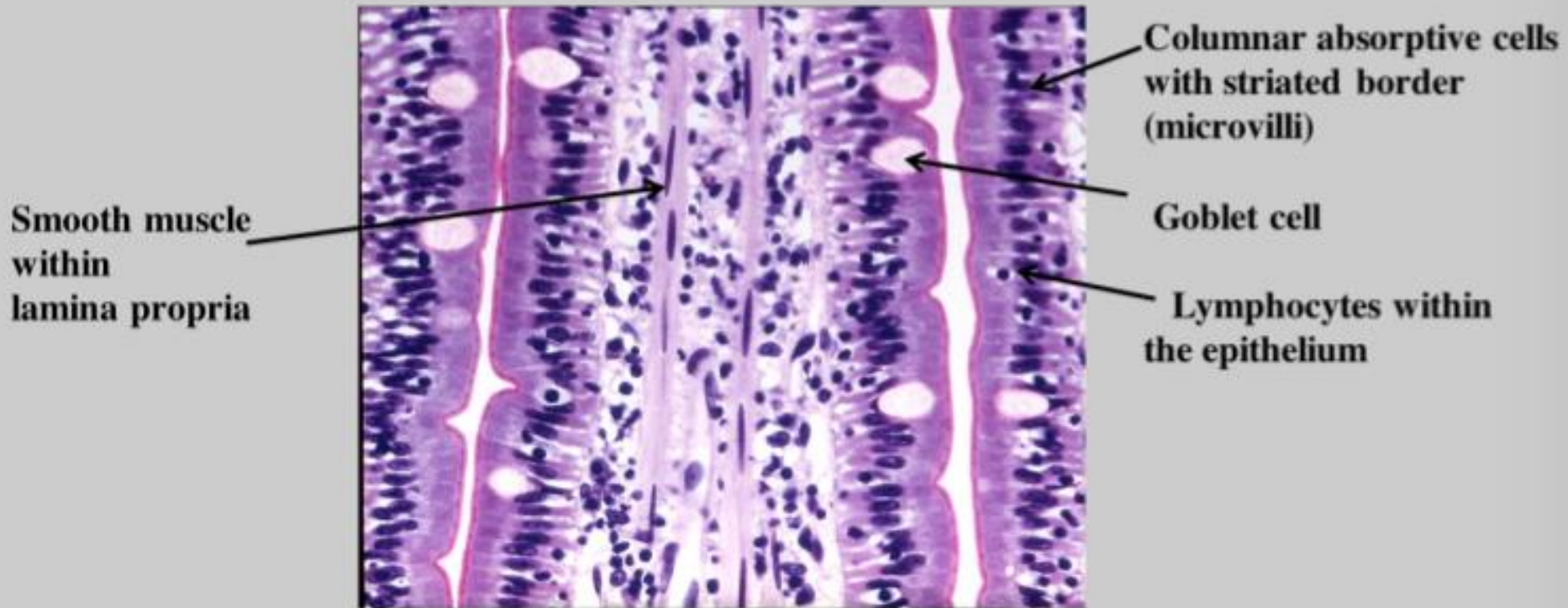


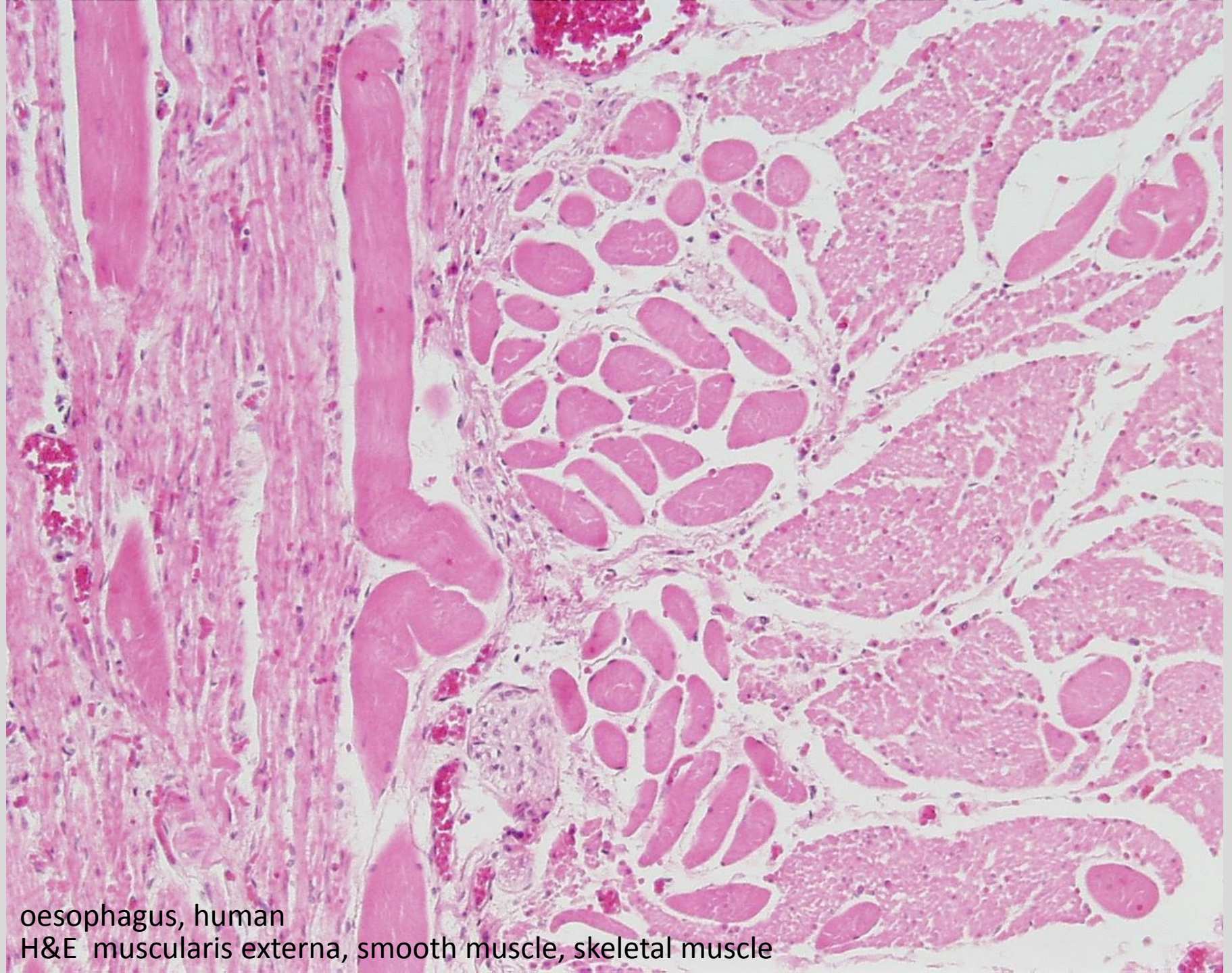
H&E alimentary canal, GIT, large intestine, muscularis externa, smooth muscle, nervous tissue, ganglion cells x40



H&E alimentary canal, GIT, large intestine, muscularis externa, smooth muscle, nervous tissue, ganglion cells x40







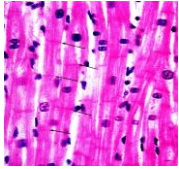
oesophagus, human
H&E muscularis externa, smooth muscle, skeletal muscle



POBUDKA POKAZ PREPARATÓW

SEMINARIUM - Tkanka mięśniowa – typy, funkcja, mechanizm skurczu.

ĆWICZENIE - Budowa histologiczna tkanki mięśniowej gładkiej, poprzecznie prążkowanej szkieletowej i mięśnia serca.



Mięsień sercowy

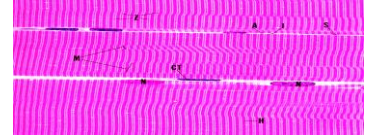
1. Tkanka mięśniowa gładka – jelito (preparat nr 13 okrężny i podłużny układ włókien - p. m.).
2. Mięsień poprzecznie prążkowany szkieletowy - język (preparat nr 20, układ włókien podłużny, poprzeczny i skośny, układ jąder we włóknach poprzecznych i podłużnych, prążkowanie - p. d.).
3. Mięsień poprzecznie prążkowany sercowy (preparat nr 23, układ włókien, pozycja jąder - p. m.).
4. Prążkowanie w mięśniu poprzecznie prążkowanym (preparat nr 22, skrawek półcienki - p.d.).
5. Wstawka mięśnia (EM16 i 39).

6. Komórka satelitarna mięśnia (EM 7).

7. Układ cystern siateczki endoplazmatycznej gładkiej we włóknach mięśnia poprzecznie prążkowanego serca (EM 40).

8. Sarkomer (EM 75).

9. Rozmieszczenie dystrofiny i urofyny w hipotetycznej komórce (schemat 84).



Mięsień szkieletowy mały



EM – 16.

WSTAWKA MIĘŚNIA SERCOWEGO

Is – przestrzeń międzykomórkowa;
2, 3 – fragmenty komórek mięśnia sercowego;
M – miofilamenty;
Mi – mitochondria.



EM – 39 WSTAWKA MIĘŚNIA SERCOWEGO

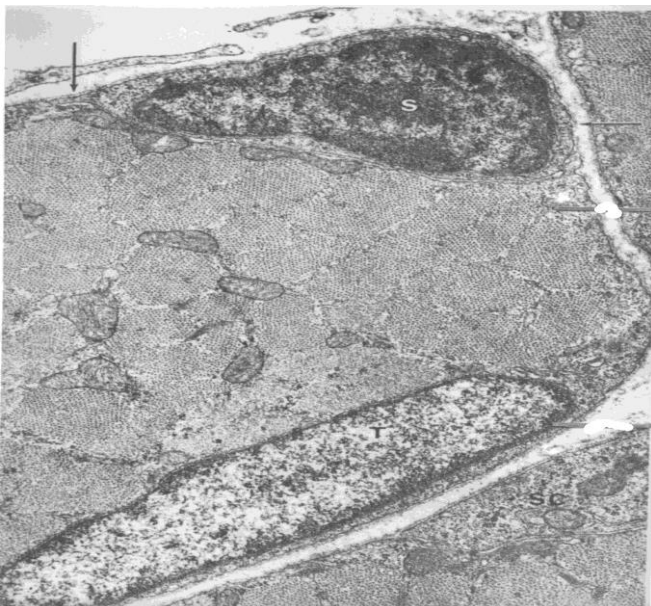
C1, C2, C3 – Fragmenty cytoplazmy trzech komórek mięśnia sercowego;

N1 - połączenie typu nexus we wstawce (materiał

N2 poddany inkubacji z wodorotlenkiem lantanu);

N1 – nexus w przekroju skośnym;

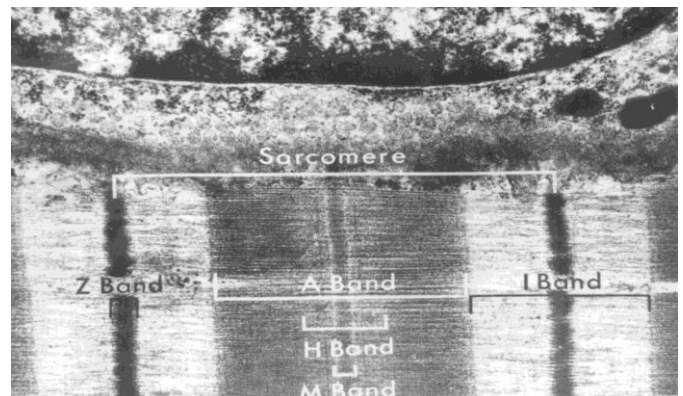
N2 – nexus w przekroju poprzecznym.



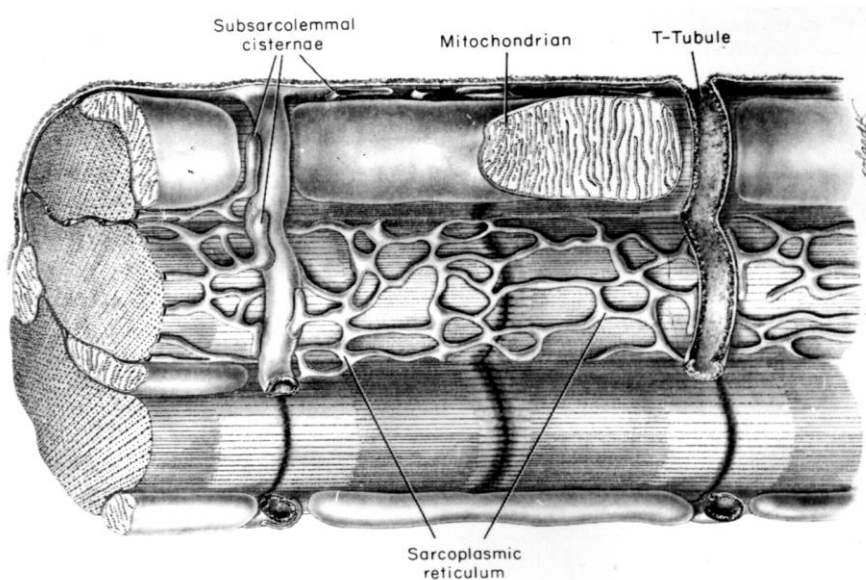
EM - 7

KOMÓRKA SATELITARNA MIĘŚNIA

S – jądro komórki satelitarnej;
T – jądro komórki mięśniowej;
Sc – fragment cytoplazmy komórki Satelitarnej.



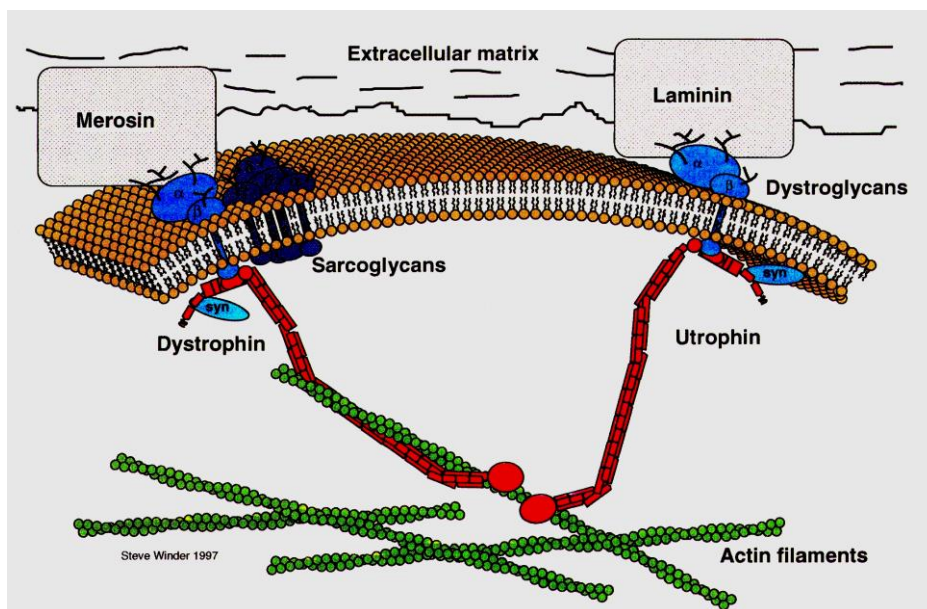
EM - 75
SARKOMER



EM - 40
UKŁAD CYSTERN SIATECZKI
ENDOPLAZMATYCZNEJ
(ŚRÓDPLAZMATYCZNEJ) GŁADKIEJ WE
WŁÓKNACH MIĘŚNIA POPRZECZNIE
PRAŻKOWANEGO SERCA

SUBSARCOLEMMAL CISTERNAE - cysterny siateczki sarkoplazmatycznej leżące pod sarkolemmą (cysterny brzeżne);
MITOCHONDRION - mitochondrium;
T-Tubule - kanalik "T";
SARCOPLASMIC RETICULUM - siateczka sarkoplazmatyczna;

Schemat 84



Schemat przedstawiający rozmieszczenie dystrofiny i utrofiny w hipotetycznej komórce, opracowany na podstawie znanych oddziaływań z innymi białkami. Dystrofina przedstawiona jest po lewej stronie schematu, tak jakby to była komórka mięśniowa, podczas gdy utrofina przedstawiona jest po prawej stronie schematu, tak jakby to była komórka niemięśniowa. Cytoplazmatyczne filamenty aktynowe - zielone, dystroglikany (α , β) i syntrofina (syn) - niebieskie, sarkoglikany (α , β , γ , δ) - fioletowe, hydrofilowe główki fosfolipidów błony komórkowej - żółte, składniki macierzy zewnątrzkomórkowej - czarno/biały.

Oprac. dr C. Wojcik wg. J. Musc. Res. CellMotil. 1997.18: 617