# Muscle Tissue

Descriptive Histology 272

20 Oct 2019

# Objectives

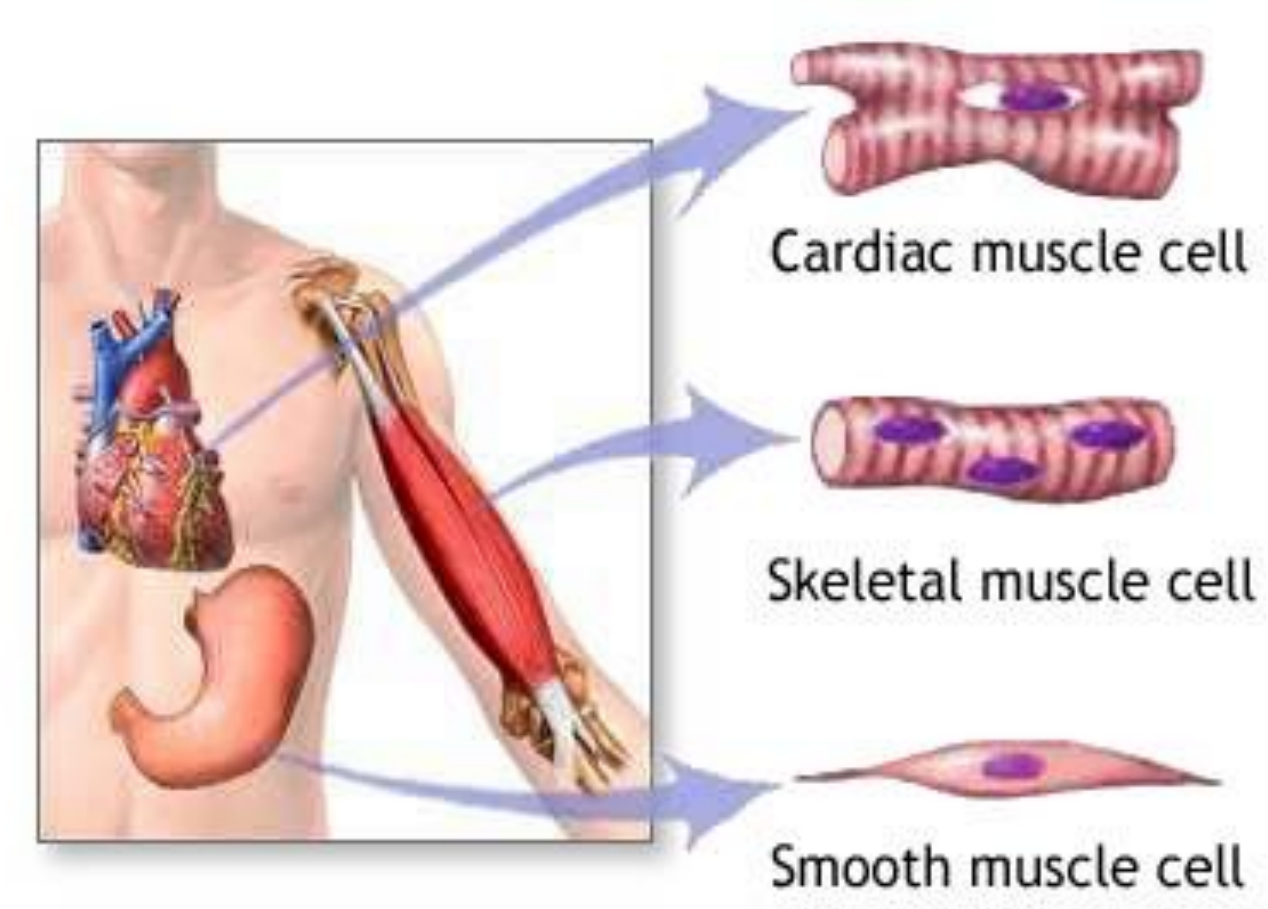
By the end of this lecture you will be able to:

- Understand the different type of muscles in human body.
- Learn the differences on shape, structures, and function of human muscles.
- Learn the histology of muscle tissue.

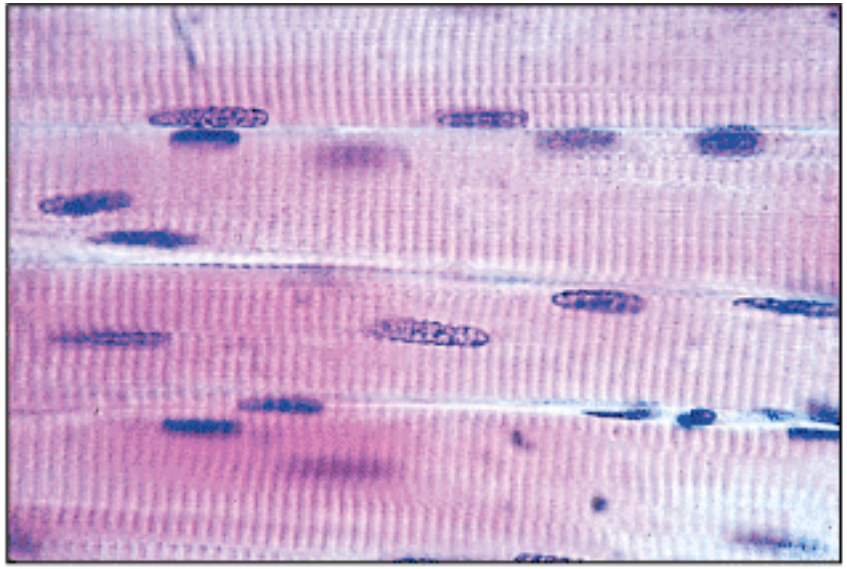
# Muscle Tissue

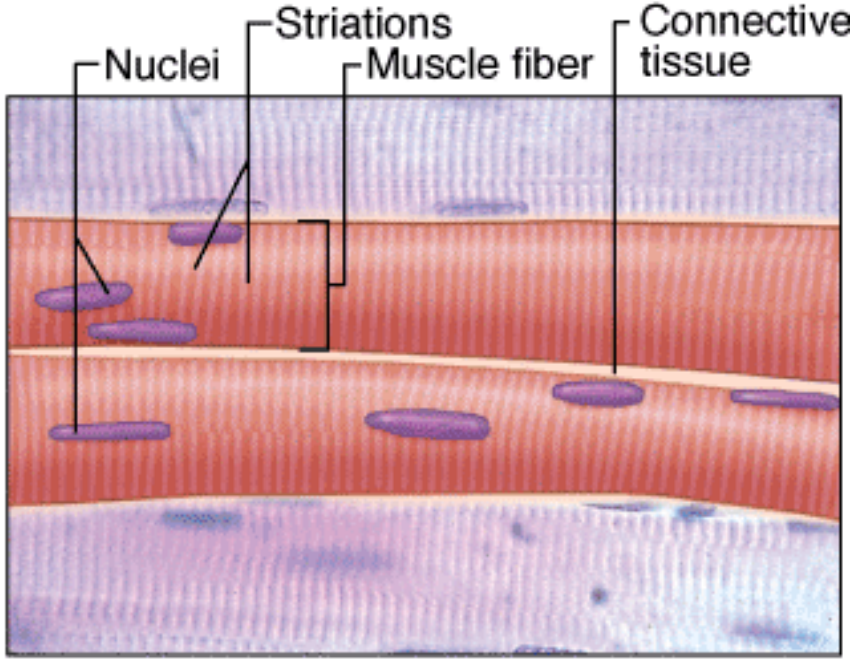
- Muscle tissue is composed of differentiated cells containing contractile proteins.
- Microfilaments and associated proteins together generate the contraction.
  - Originates from Mesenchyme
  - Provided with well developed vascular supply and nerve network.

# Muscle Types

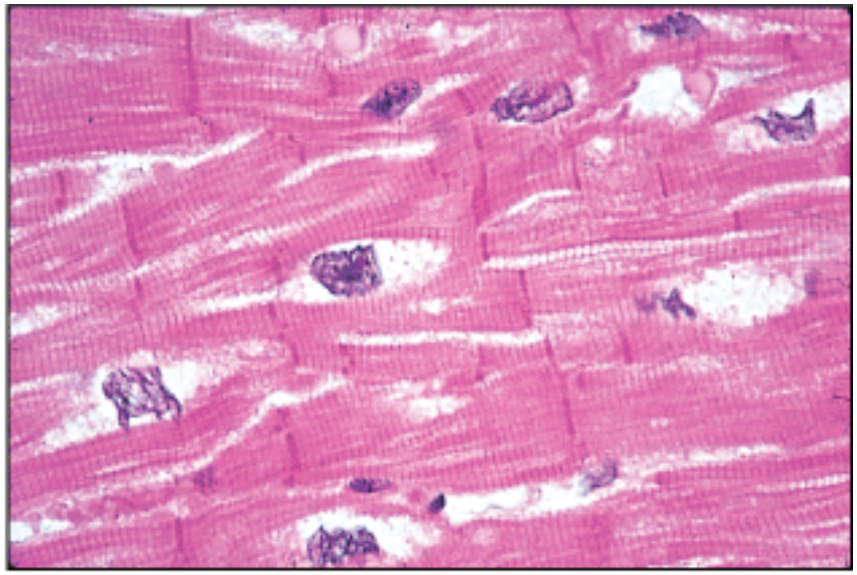


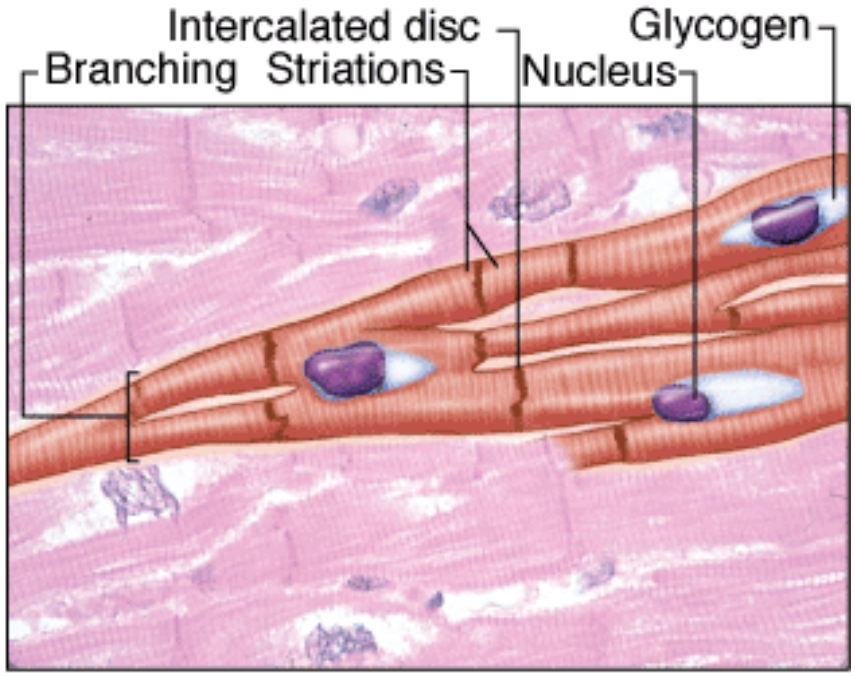

Every human body has:
650
muscles
187
joints
healthsterling.com
Source: The Incredible Human Machine, National Geographic



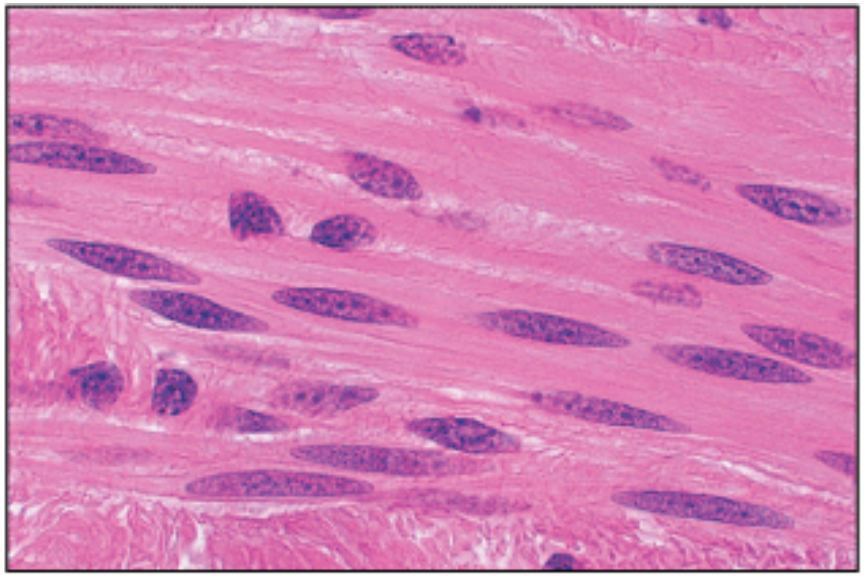


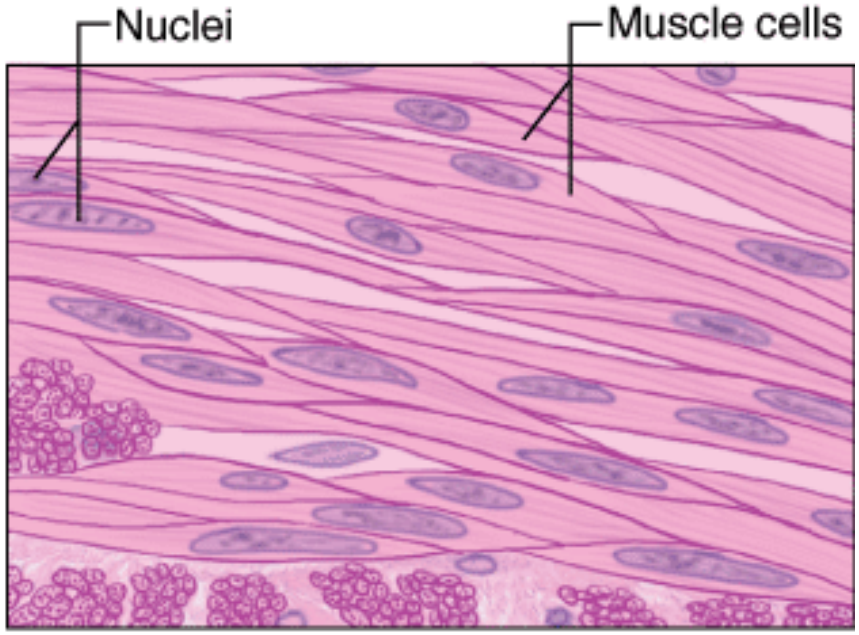

**Skeletal Muscle** is composed of large, elongated, multinucleated fibers that show strong, quick, voluntary contractions






**Cardiac Muscle** is composed of irregular branched cells bound together longitudinally by **intercalated disks** and shows strong, involuntary contractions






**Smooth Muscle**
is composed of grouped, fusiform cells with weak, involuntary contractions. The density of intercellular packing seen reflects the small amount of extracellular connective tissue present

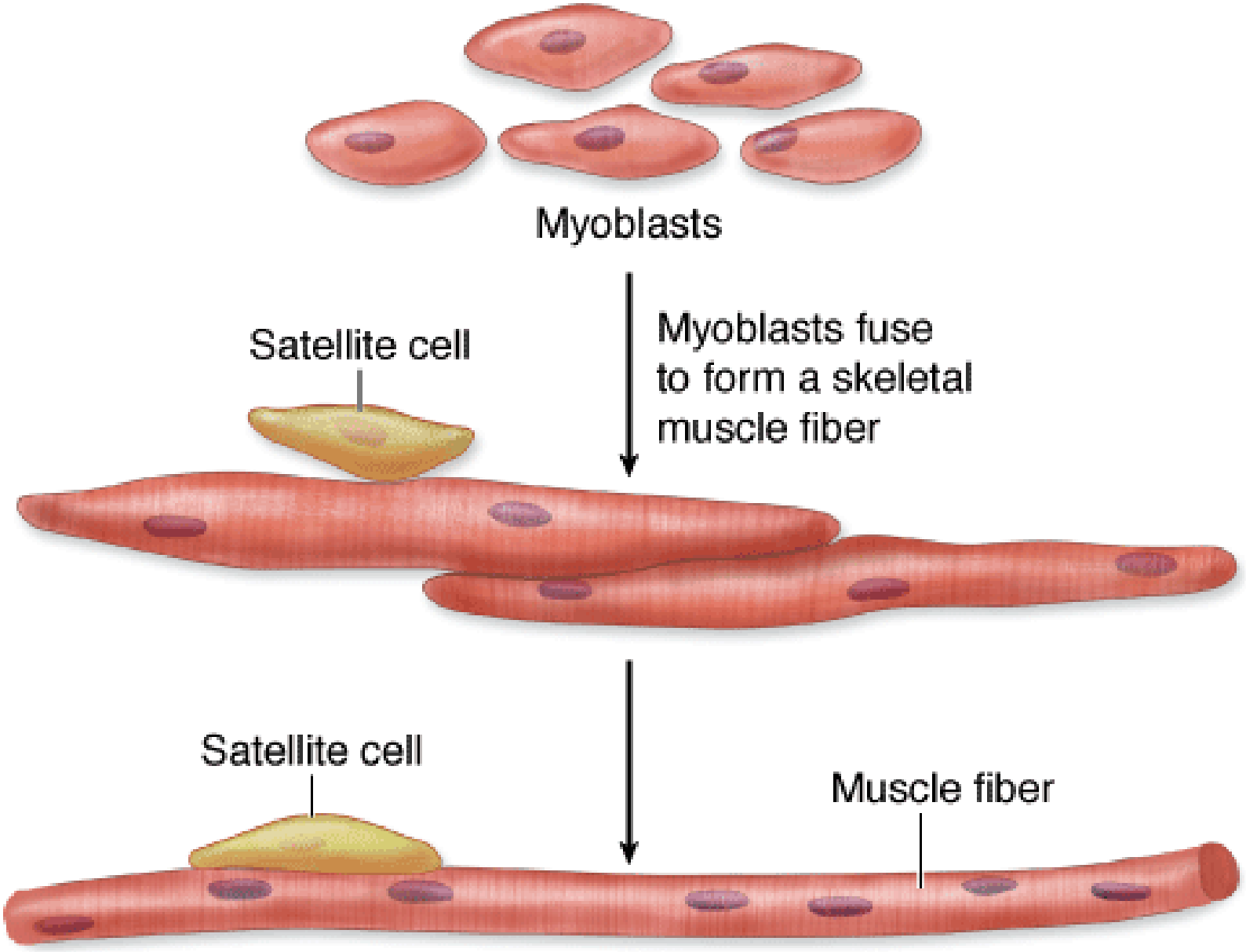
**Fusiform** means having a spindle-like shape that is wide in the middle and tapers at both ends.

# Definitions

- The cytoplasm of muscle cells is called **sarcoplasm** (Gr. *sarkos,* flesh, + *plasma,* thing formed)
- The smooth ER is called **sarcoplasmic reticulum.**
- The **sarcolemma** (*sarkos* + Gr. *lemma,* husk) is the cell membrane, or plasmalemma.

# Skeletal Muscle Development

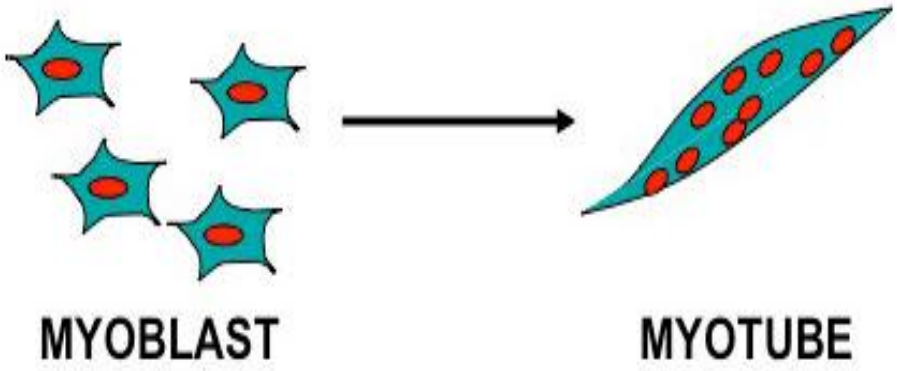
- Skeletal Muscle - forms "flesh" or "meat" of body
- 40% of total body weight.
- Cells form long fibers up to 100 mm (4 inch)
- Cells are unique - formed from a syncytium (multinucleate), many cells fused together for more efficient function;
- Multinucleate, 3-5 nuclei/mm length; nuclei always at periphery of cell.
- very well organized; ensheathed by Proper CT (endomysium; perimysium; epimysium).




Source: Mescher AL: *Junqueira's Basic Histology: Text and Atlas, 12th Edition:* http://www.accessmedicine.com

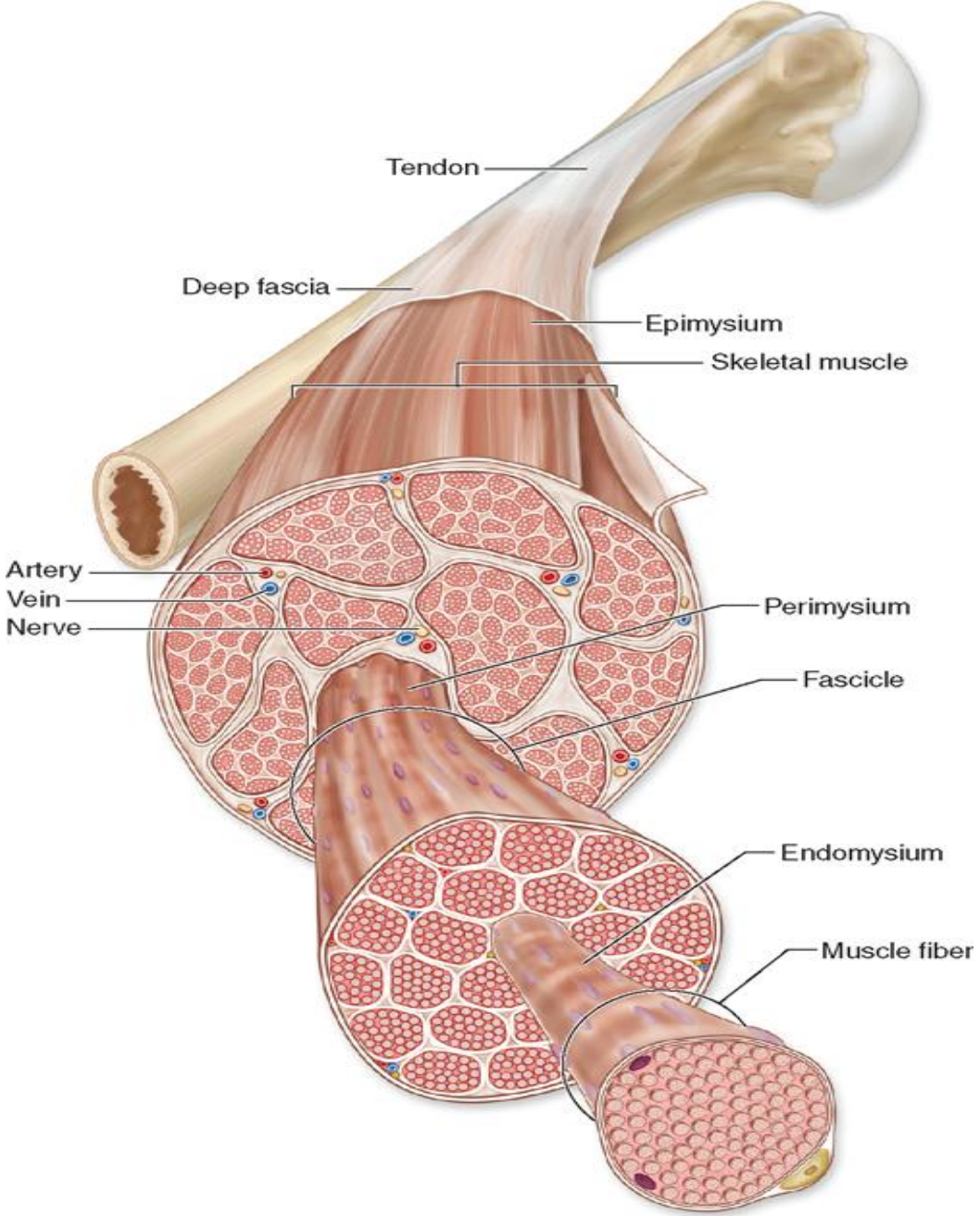
# Skeletal Muscle Development con.

- Skeletal muscle begins to differentiate when mesenchymal cells called myoblasts align and fuse together to make longer, multinucleated tubes called myotubes.
- Myotubes synthesize the proteins to make up myofilaments and gradually begin to show cross striations by light microscopy.
- Myotubes continue differentiating to form functional myofilaments and the nuclei are displaced against the sarcolemma.


MYOBLAST
MYOTUBE

# Skeletal Muscle Development con.

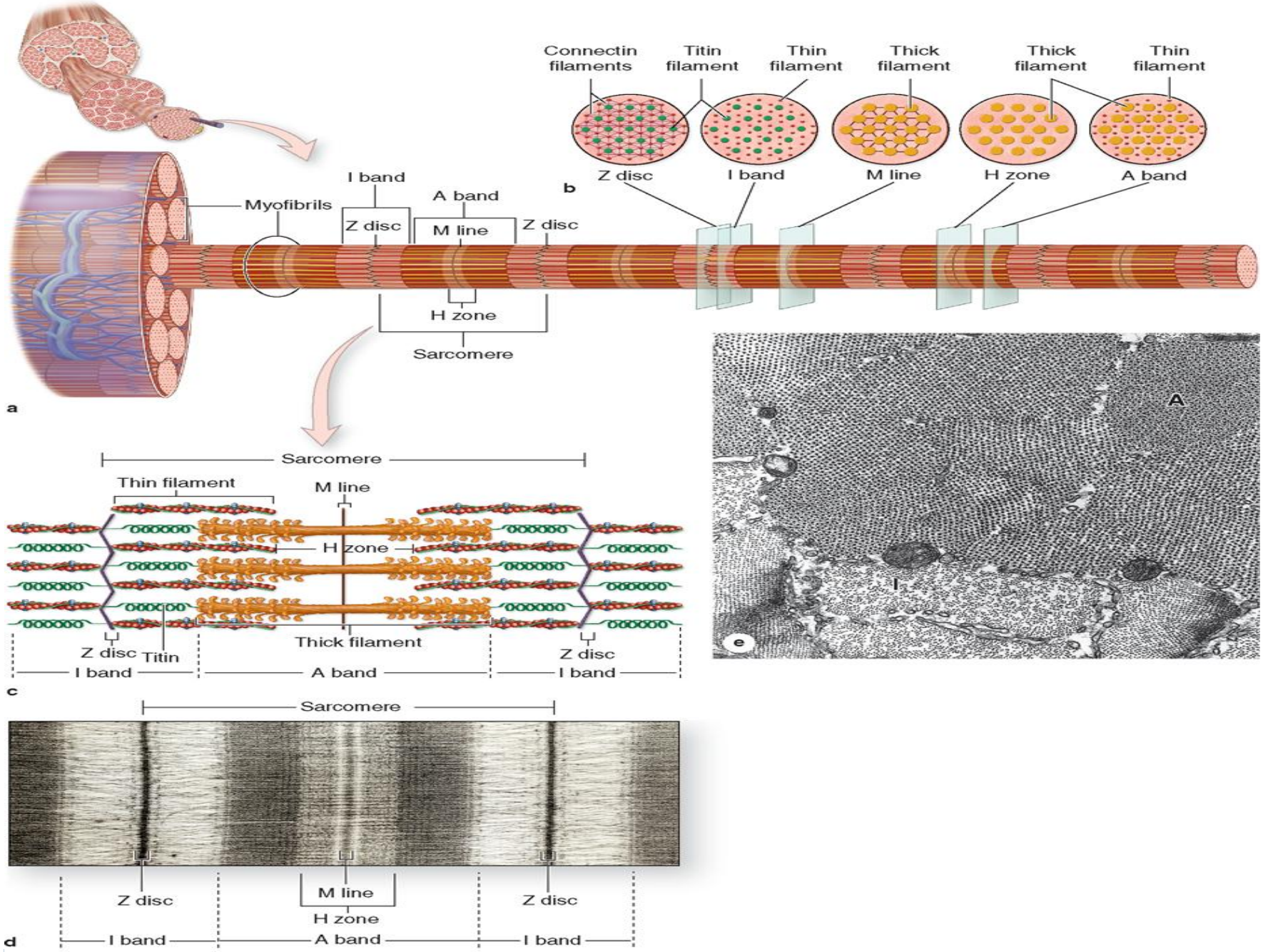
- Part of the myoblast population does not fuse and differentiate, but remains as a group of mesenchymal cells called muscle satellite cells located on the external surface of muscle fibers inside the developing external lamina.
- Satellite cells proliferate and produce new muscle fibers following muscle injury.



http://www.youtube.com/watch?v=f_tZne9ON7c

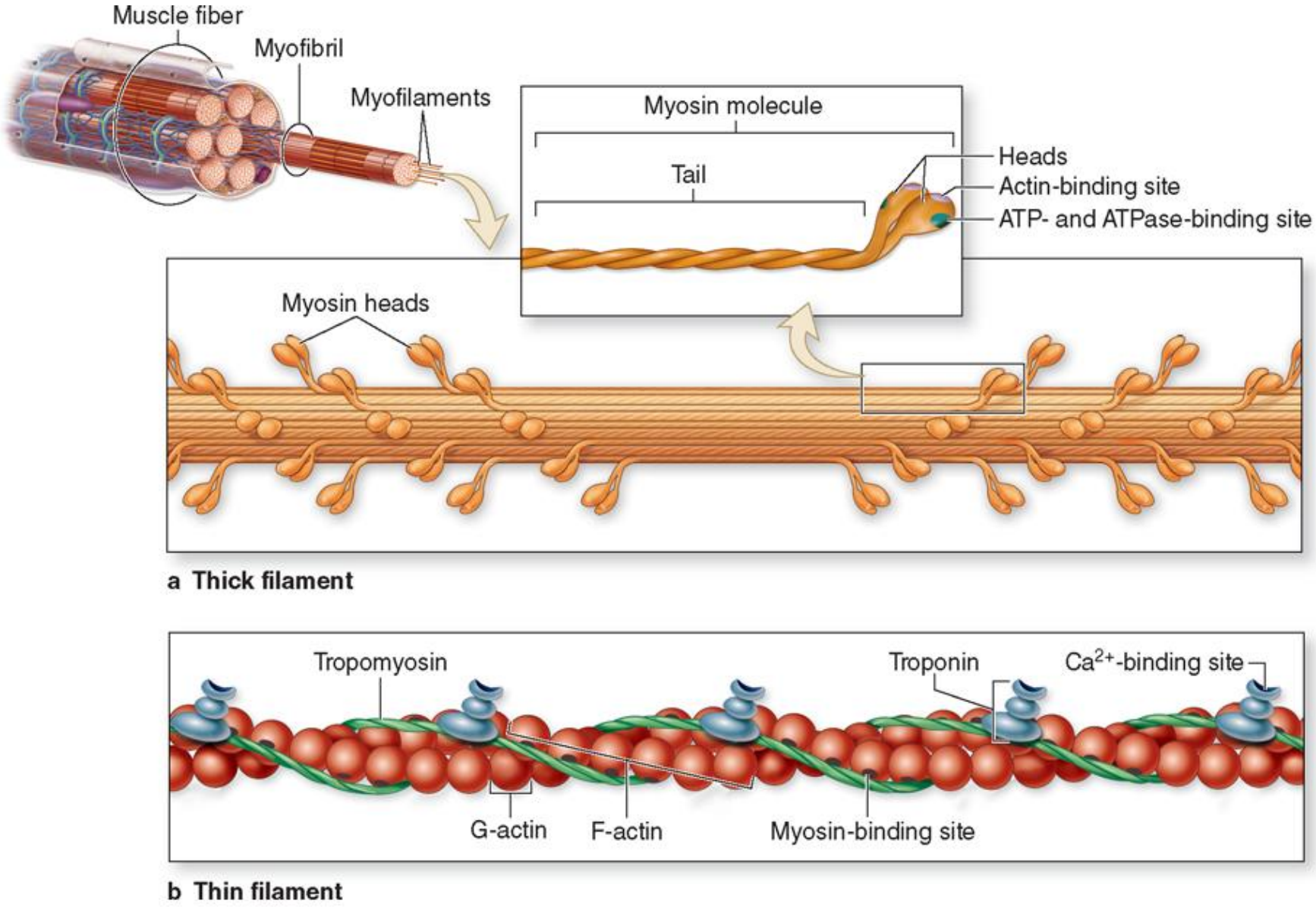
# Organization of skeletal muscle.

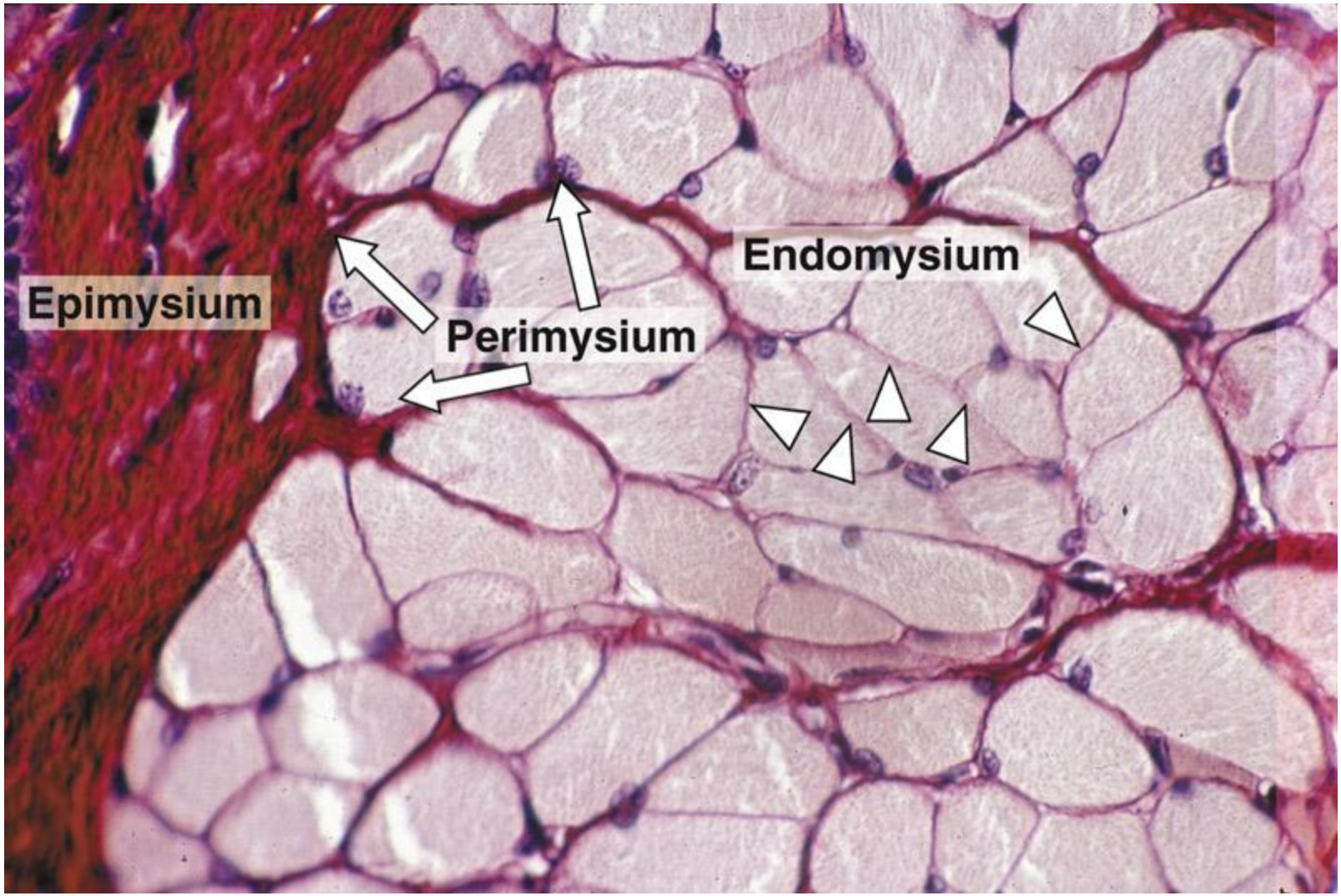
- An entire skeletal muscle is enclosed within a dense connective tissue layer called the epimysium continuous with the tendon binding it to bone (a).
- Each fascicle (bundle) of muscle fibers is wrapped in another connective tissue layer called the perimysium (b).
- Individual muscle fibers (elongated multinuclear cells) is surrounded by a very delicate layer called the endomysium, which includes an external lamina produced by the muscle fiber (and enclosing the satellite cells) and ECM produced by fibroblasts (c).

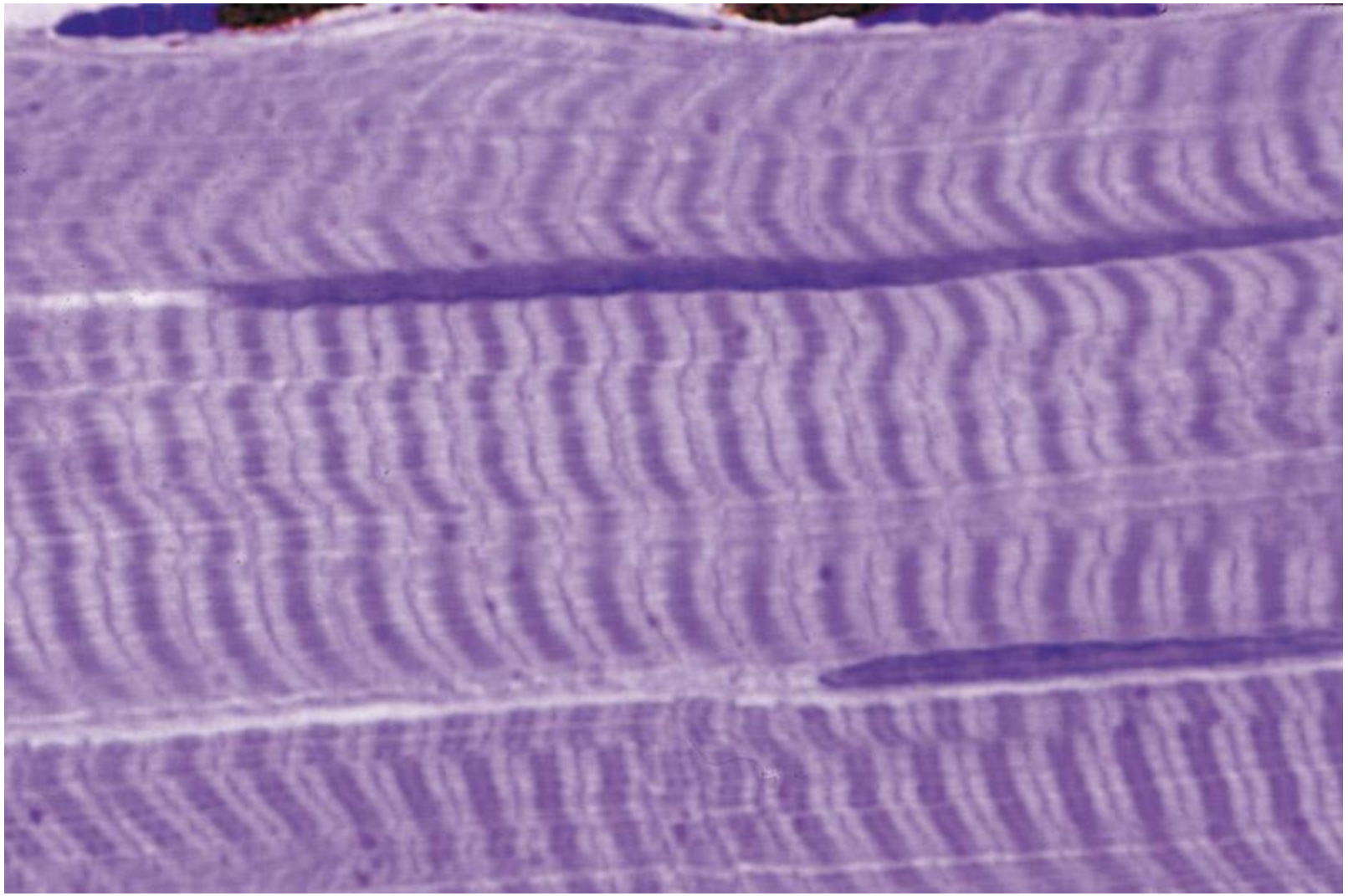


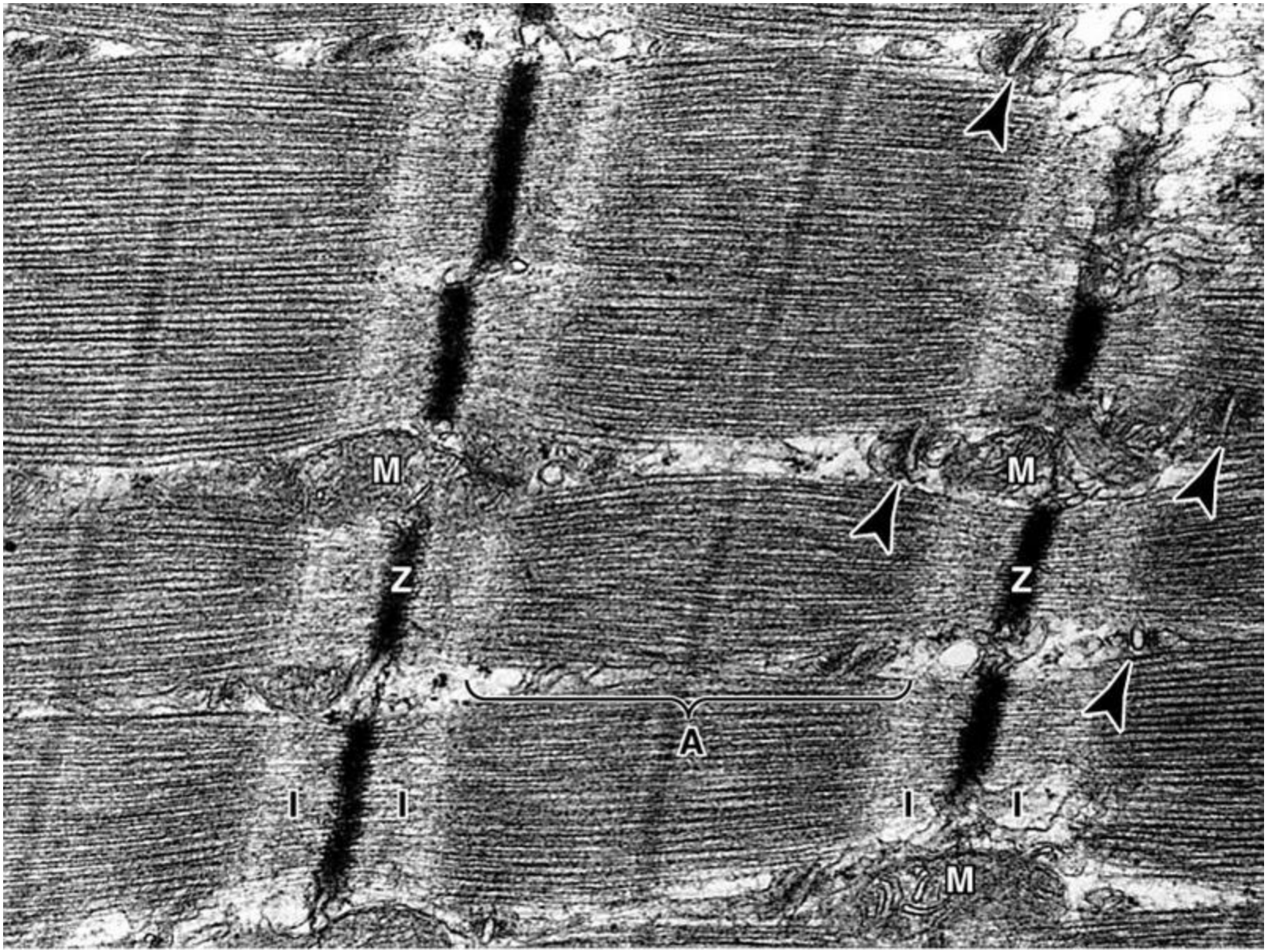
# Skeletal Muscle

- Cells organized into contractile units = Sarcomeres.
- Sarcomeres are connected end to end with Myofibril. Many myofibrils then make up a cell.
- Sarcomere - the basic functional contractile unit;
- Organization of myofilaments, thin (actin) and thick (myosin)
- ER = Sarcoplasmic Reticulum : is a specialized type of smooth ER that regulates the calcium ion concentration in the cytoplasm of striated muscle cells.
- Triads (t-tubule + 2 cisternae) at A-I junction




Epimysium
Perimysium
Endomysium




M
M
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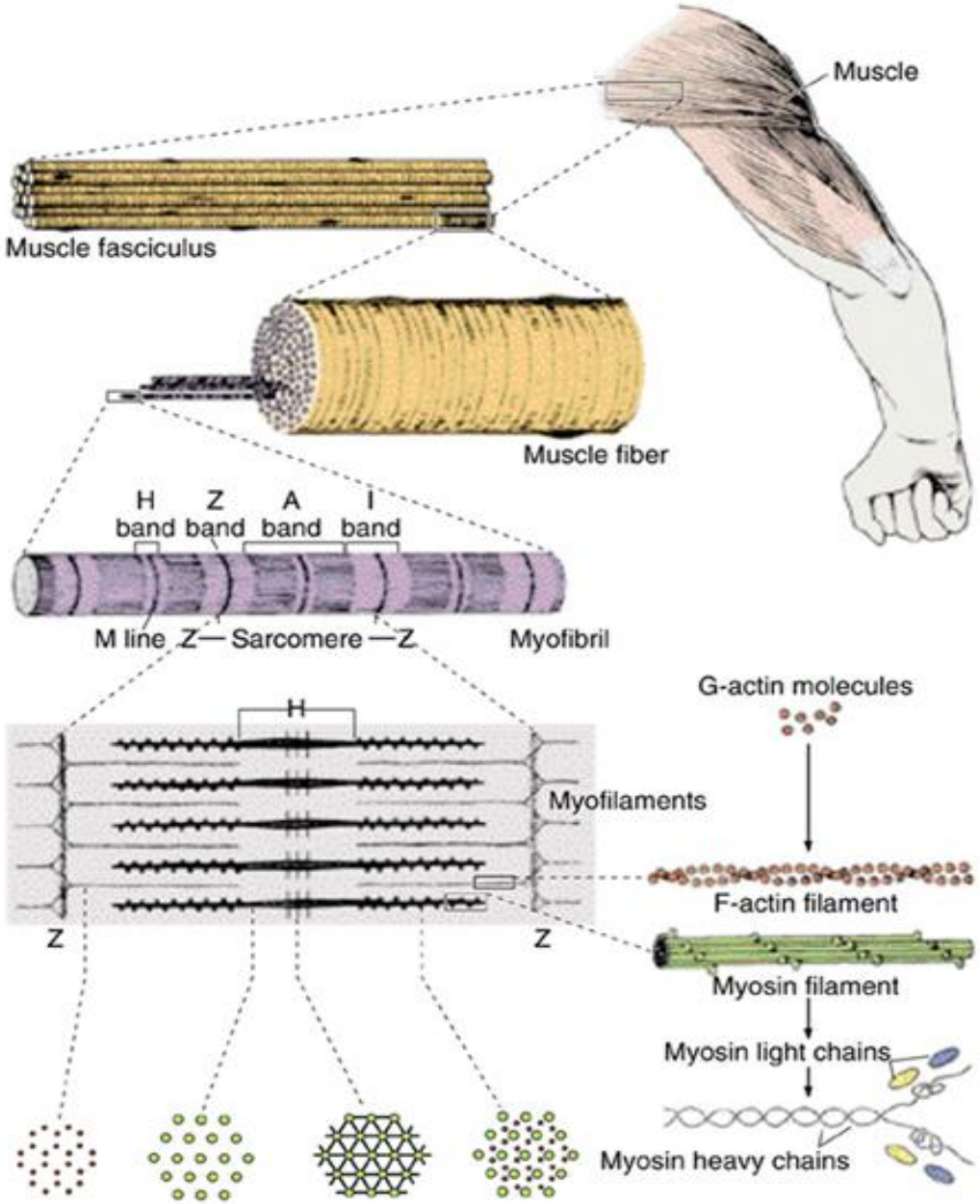
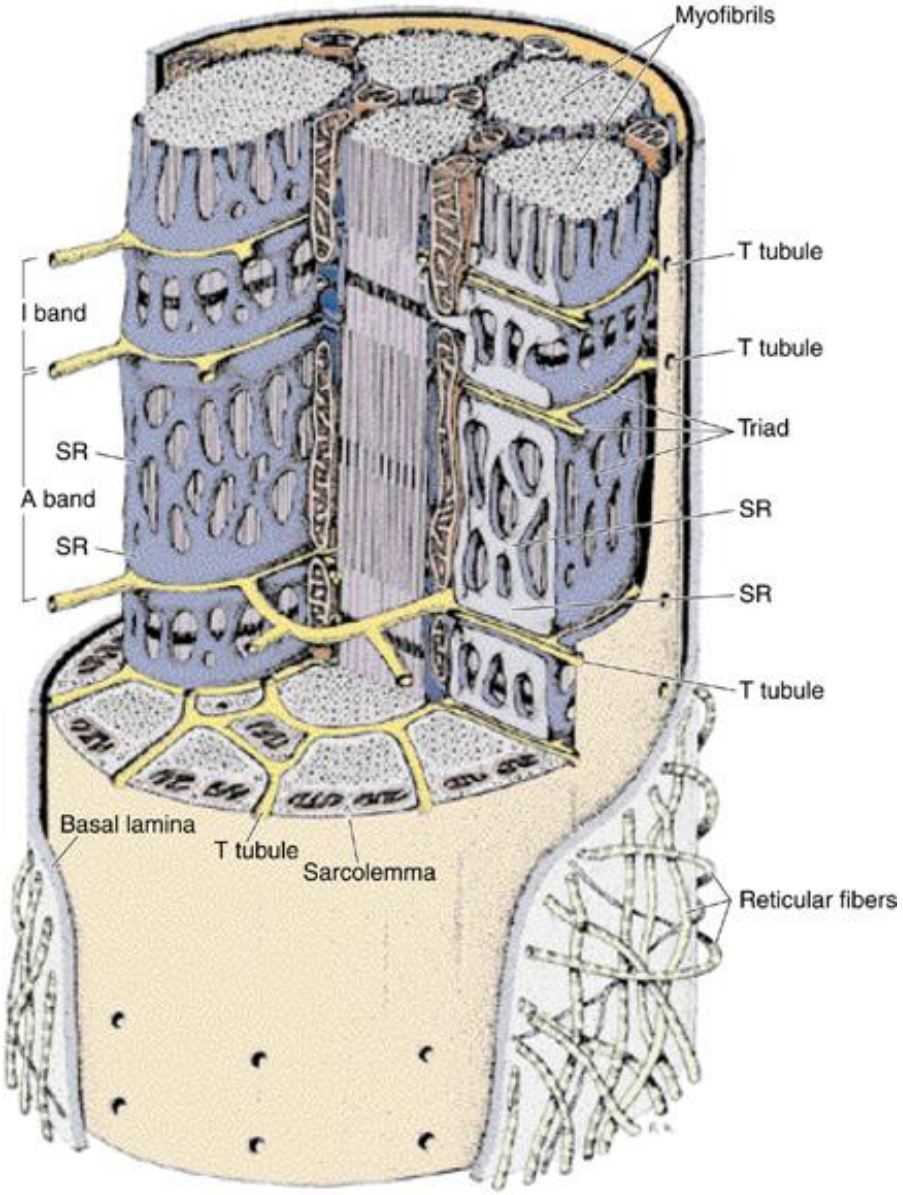
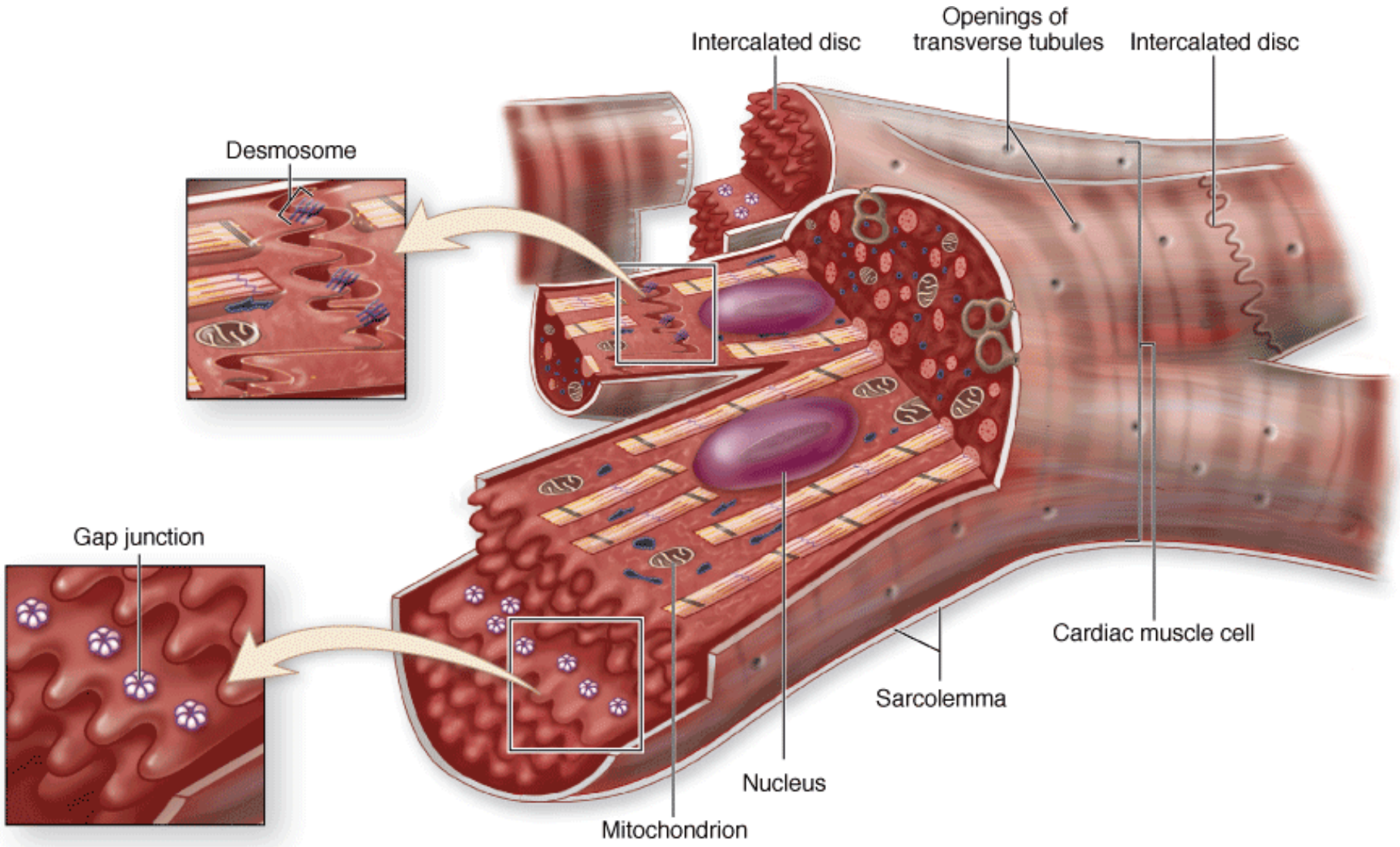

Muscle
Muscle fasciculus
Muscle fiber
H band
Z band
A band
I band
M line
Z
Sarcomere
Z
Myofibril
G-actin molecules
H
Myofilaments
F-actin filament
Z
Z
Myosin filament
Myosin light chains
Myosin heavy chains

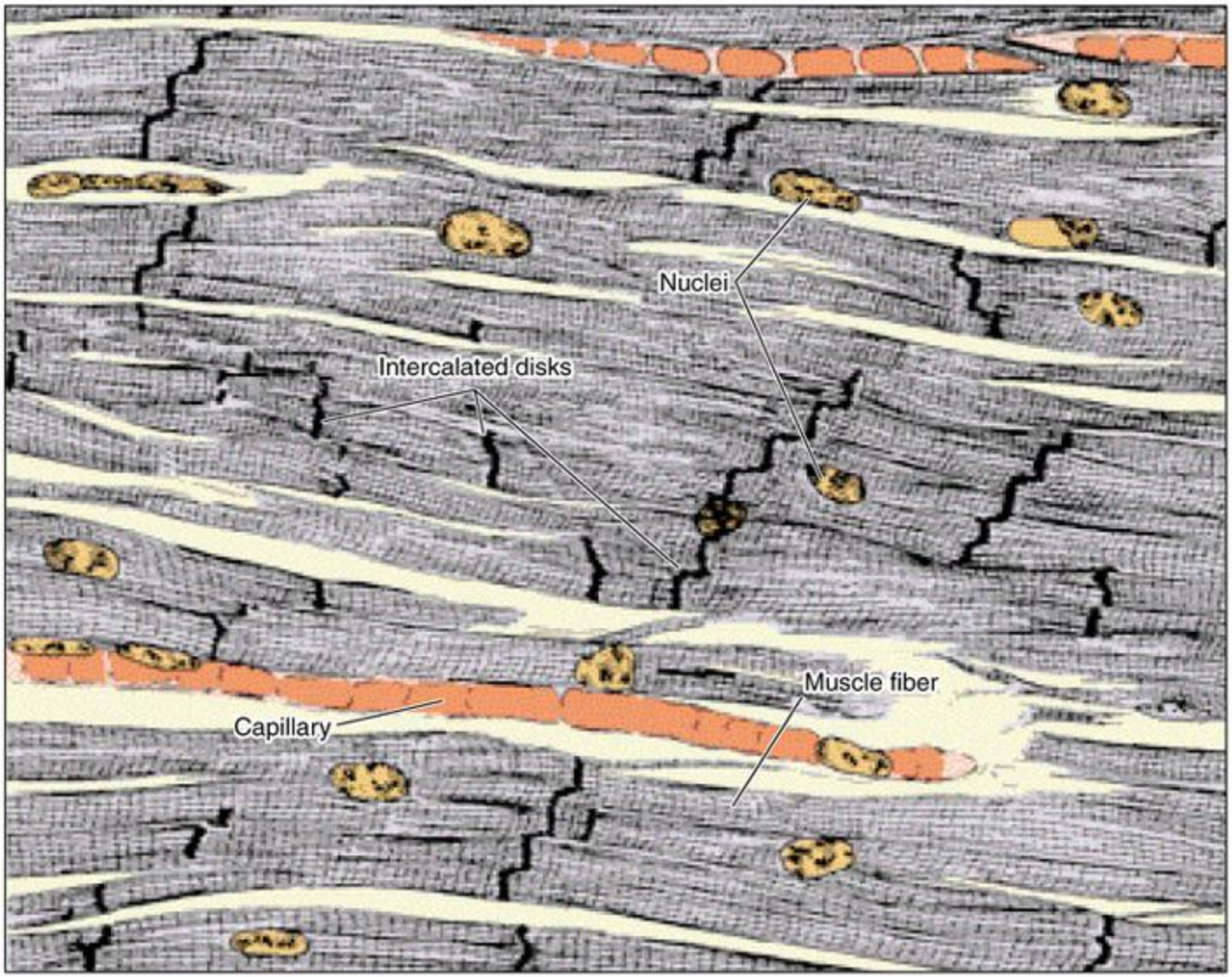

Myofibrils
T tubule
I band
T tubule
Triad
SR
A band
SR
SR
SR
T tubule
Basal lamina
T tubule
Sarcolemma
Reticular fibers

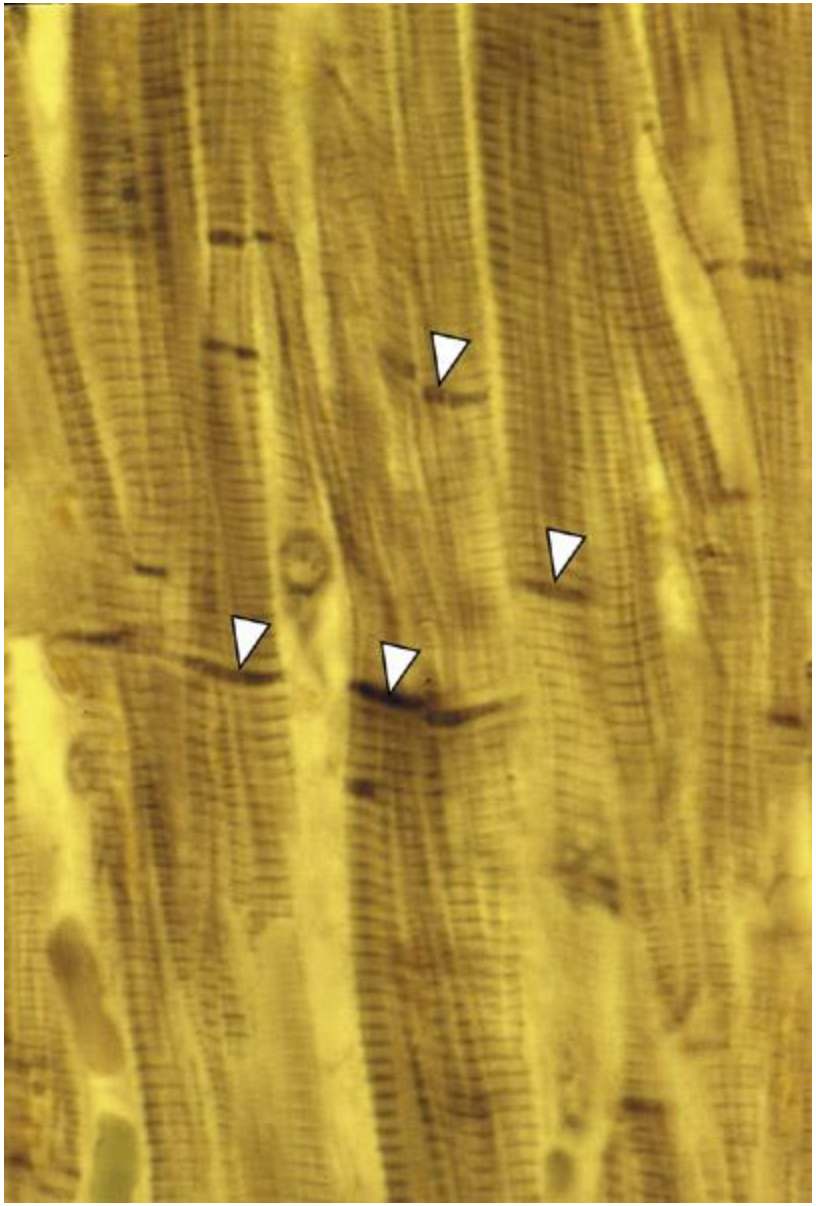
# Cardiac Muscle

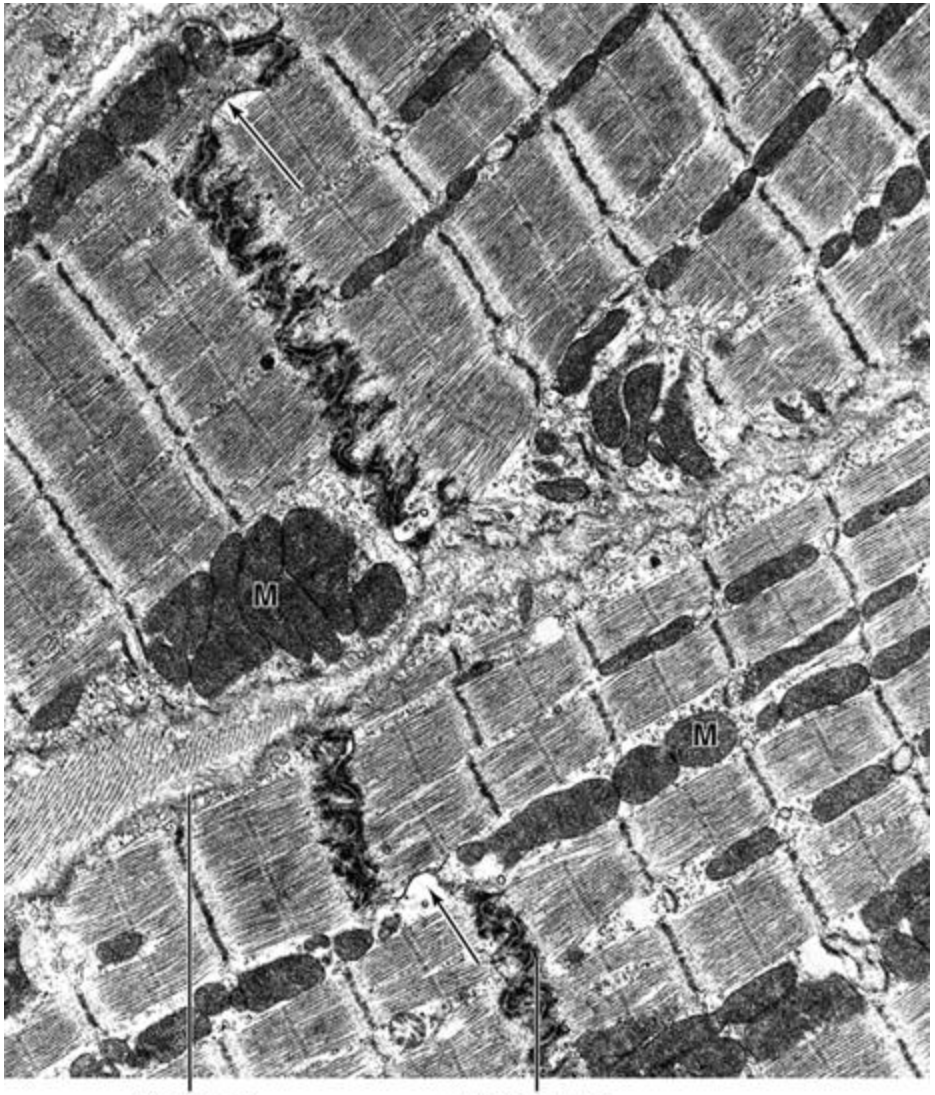
- Mature cardiac muscle cells are approximately 15 μm in diameter and from 85 to 100 μm in length
- They exhibit a cross-striated banding pattern comparable to that of skeletal muscle
- Centrally located (1 or 2 ) nuclei per cell
- Cell membranes interdigitate with each other = intercalated discs
- Surrounding the muscle cells is a delicate sheath of endomysium with a rich capillary network.
- Rich with mitochondria (up to 40% of volume)




Source: Mescher AL: *Junqueira's Basic Histology: Text and Atlas, 12th Edition:* http://www.accessmedicine.com

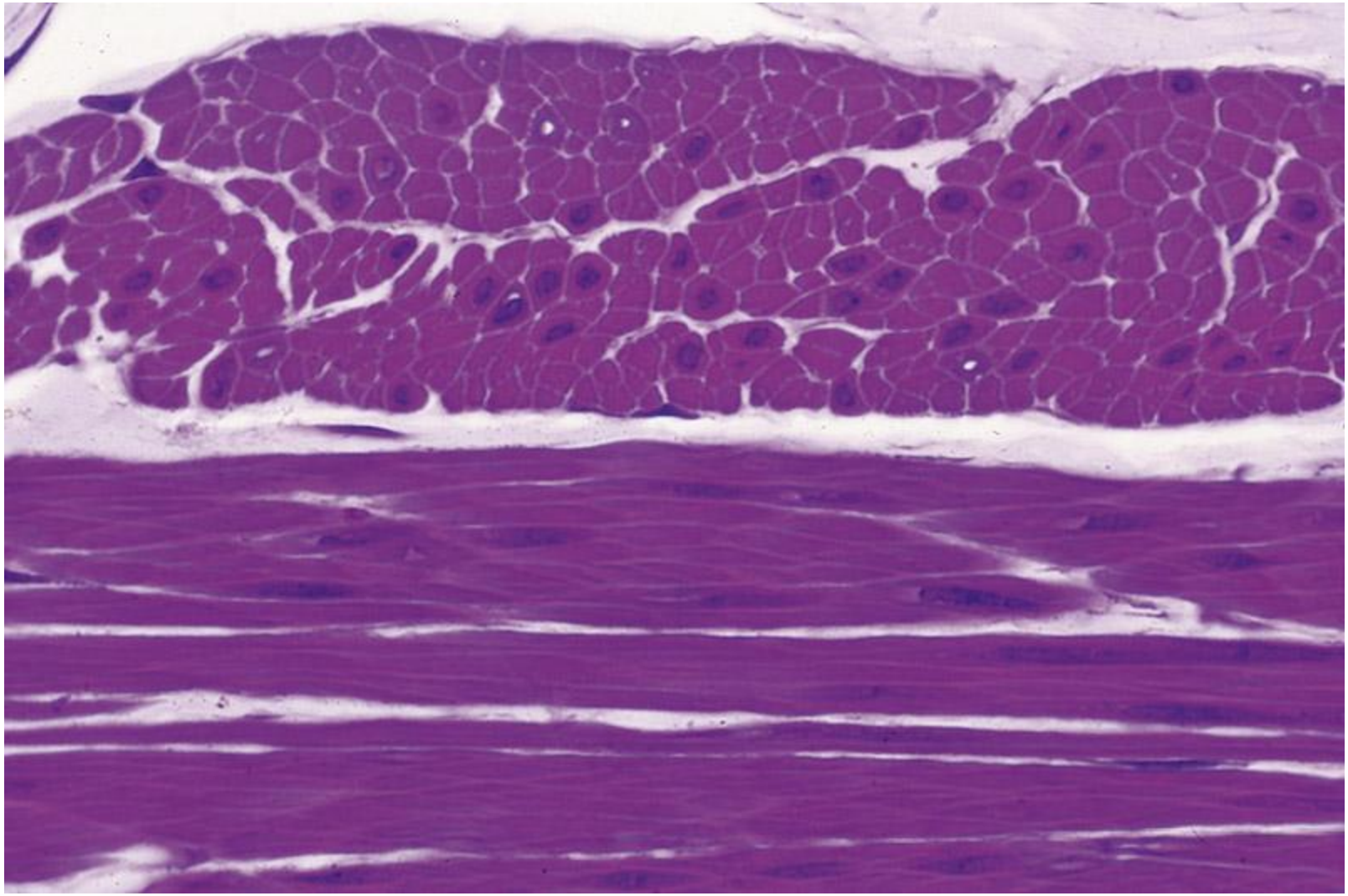

Nuclei
Intercalated disks
Muscle fiber
Capillary

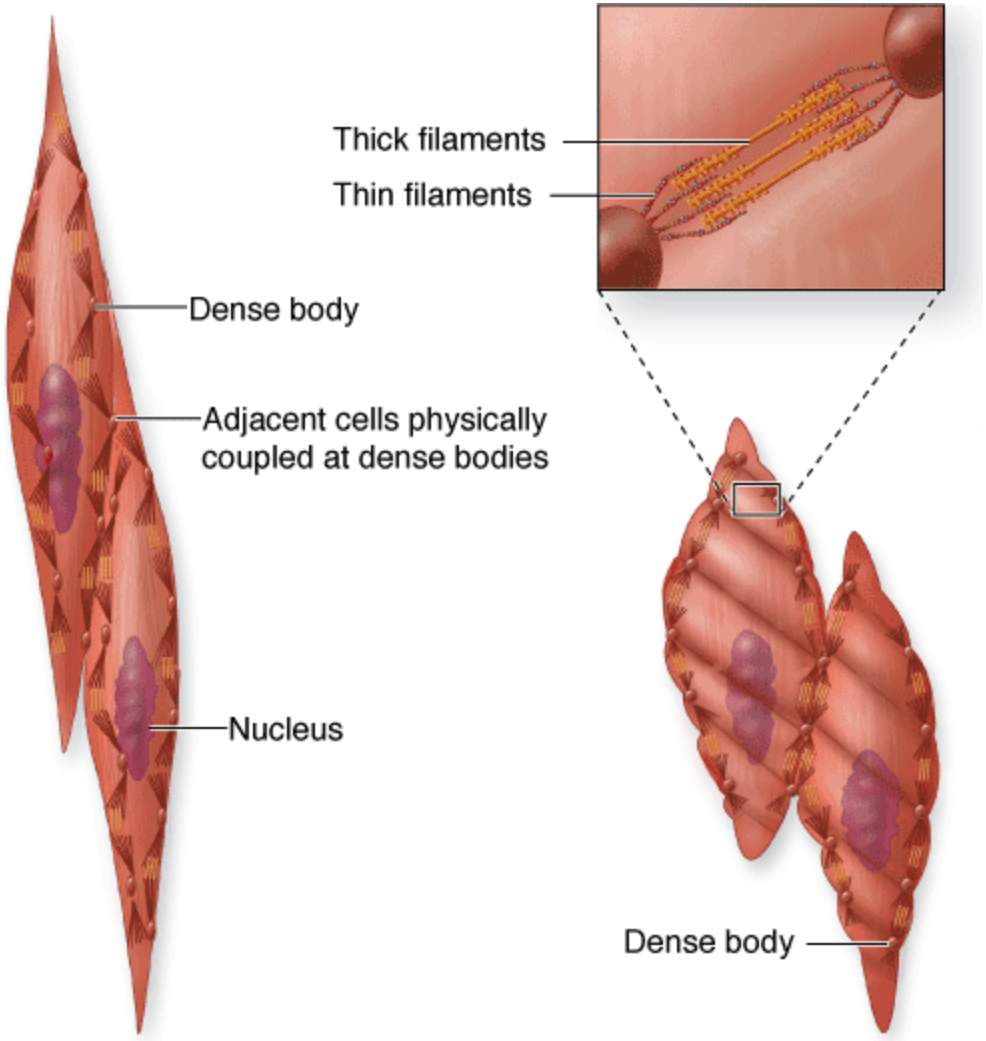



M
M
Fibrils of reticular fibers
Intercalated disk

# Smooth Muscle

- Forms broad, thin sheets of muscle in layers around organs; e.g. GI tract.
- Individual spindle (fusiform) shaped cells are small (20 - 500 μm) loosely packed, have one cigar shaped nucleus in the center of the cell;
- Actin and myosin myofilaments are unorganized; there are no striations or sarcomeres.
- Capable of hyperplasia (e.g. uterus in pregnancy)
- The tissue is poorly innervated



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Source: Mescher AL: *Junqueira's Basic Histology: Text and Atlas, 12th Edition:* http://www.accessmedicine.com

| Table 10–1 Important Comparisons of the Three Types of Muscle. | | | |
|---|---|---|---|
| | Skeletal Muscle | Cardiac Muscle | Smooth Muscle |
| Fibers | Single multinucleated cells | Aligned cells in branching arrangement | Single small, closely packed fusiform cells |
| Cell/fiber shape and size | Cylindrical, 10-100 μm diameter, many cm long | Cylindrical, 10-20 μm diameter, 50-100 μm long | Fusiform, diameter 0.2-10 μm, length 50-200 μm |
| Striations | Present | Present | Absent |
| Location of nuclei | Peripheral, adjacent to sarcolemma | Central | Central, at widest part of cell |
| T tubules | Center of triads at A-I junctions | In diads at Z discs | Absent; caveolae may be functionally similar |
| Sarcoplasmic reticulum (SR) | Well-developed, with two terminal cisterns per sarcomere in triads with T tubule | Less well-developed, one small terminal cistern per sarcomere in diad with T tubule | Irregular smooth ER without distinctive organization |
| Special structural features | Very well-organized sarcomeres, SR, and transverse tubule system | Intercalated discs joining cell, with many adherent and gap junctions | Gap junctions, caveolae, dense bodies |
| Control of contraction | Troponin C binds $Ca^{2+}$, moving tropomyosin and exposing actin for myosin binding | Similar to that of skeletal muscle | Actin-myosin binding occurs with myosin phosphorylation by MLCK triggered when calmodulin binds $Ca^{2+}$ |
| Connective tissue organization | Endomysium, perimysium, and epimysium | Endomysium; subendocardial and subpericardial CT layers | Endomysium and less-organized CT sheaths |
| Major locations | Skeletal muscles, tongue, diaphragm, eyes, and upper esophagus | Heart | Blood vessels, digestive and respiratory tracts, uterus, bladder, and other organs |
| Key function | Voluntary movements | Automatic (involuntary) pumping of blood | Involuntary movements |
| Efferent innervation | Motor | Autonomic | Autonomic |
| Contractions | All-or-none, triggered at motor end plates | All-or-none, intrinsic (beginning at nodes of conducting fibers) | Partial, slow, often spontaneous, wavelike and rhythmic |
| Cell response to increased load | Hypertrophy (increase in fiber size) | Hypertrophy | Hypertrophy and hyperplasia (increase in cell/fiber number) |
| Capacity for regeneration | Limited, involving satellite cells mainly | Very poor | Good, involving mitotic activity of muscle cells |

https://www.youtube.com/watch?v=0_ihc26yxN4

https://www.youtube.com/watch?v=jdYRtQWnpr0