Lectures of Histology

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Anatomy and Histology Department

By

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Muscle Tissue

It is a highly cellular and vascular tissue specialized, consist of muscle cells (muscle fibers) which are composed of myofibrils that contain long protein myofilaments (actin thin, and myosin thick filaments) via their interaction the contraction occurs. This tissue is responsible for all types of body movement and for changes in the size and shape of internal organs.

Essentially all muscle cells are of mesodermal origin and differentiate by a gradual process of cell lengthening with abundant synthesis of the contractile protein actin and myosin.

* Functions of Muscle Tissue

1. Contractible (can shorten in length).
2. Extensible (can extend or stretch).
3. Elastic (can return to their original shape).
4. Maintain posture.

Because of the high degree specialization of muscle cells, there are special terms used with them, such as:
1. Myocytes (muscle cells) are called muscle fibers.
2. Cytoplasm is called sarcoplasm.
3. Plasma membrane is called sarcolemma.
4. Endoplasmic reticulum is called sarcoplasmic reticulum.

* Classification of Muscle Tissue

Three types of muscle tissue can be distinguished based on their morphological and functional characteristics (Fig.1):
1. Skeletal (voluntary) striated muscles.
2. Cardiac (involuntary) striated muscles.
3. Visceral (involuntary) smooth muscles.

- Skeletal muscle contains bundles of very long, multinucleated cells with transverse striations. Their contraction is forceful, and usually under voluntary control.
- Cardiac muscle also has transverse striations and is composed of elongated, often branched cells bound to one another at structures called intercalated discs that are unique to cardiac muscle. Contraction is involuntary, vigorous, and rhythmic.
- Smooth muscle consists of collections of fusiform cells that lack transverse striations and have slow, involuntary contractions.

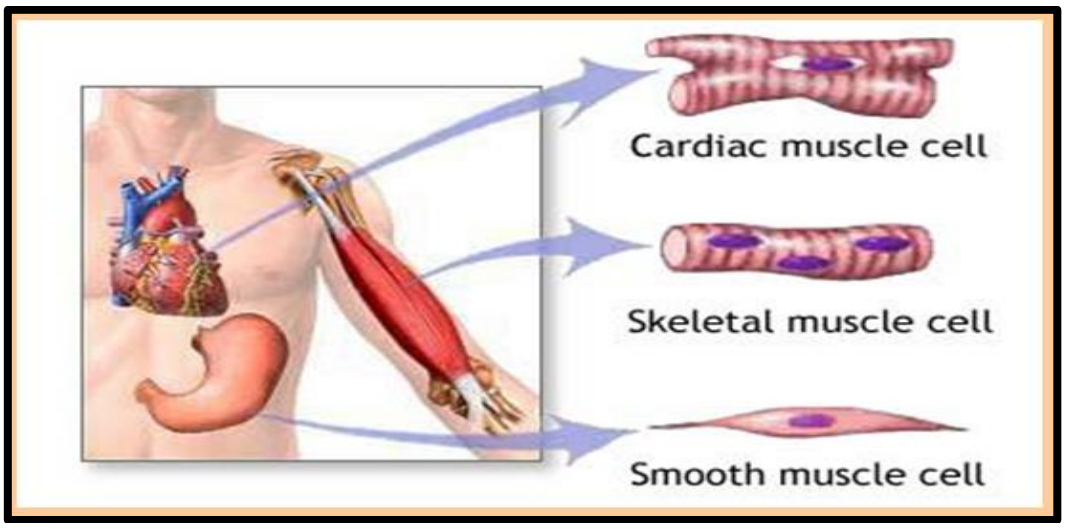


Fig. 1: Types of Muscle Tissue.

Skeletal Muscle

Consists of muscle fibers, which are long, cylindrical multinucleated cells with diameters of (10-100)μm. During embryonic muscle development, mesenchymal myoblasts fuse, forming myotubes which then differentiate to muscle fibers with many nuclei (Fig.2). Elongated nuclei are found peripherally just under the sarcolemma, a characteristic nuclear location unique to skeletal muscle fibers/cells. A small population of reserve progenitor cells called muscle satellite cells remain adjacent to most fibers of differentiated skeletal muscle (Fig.3).

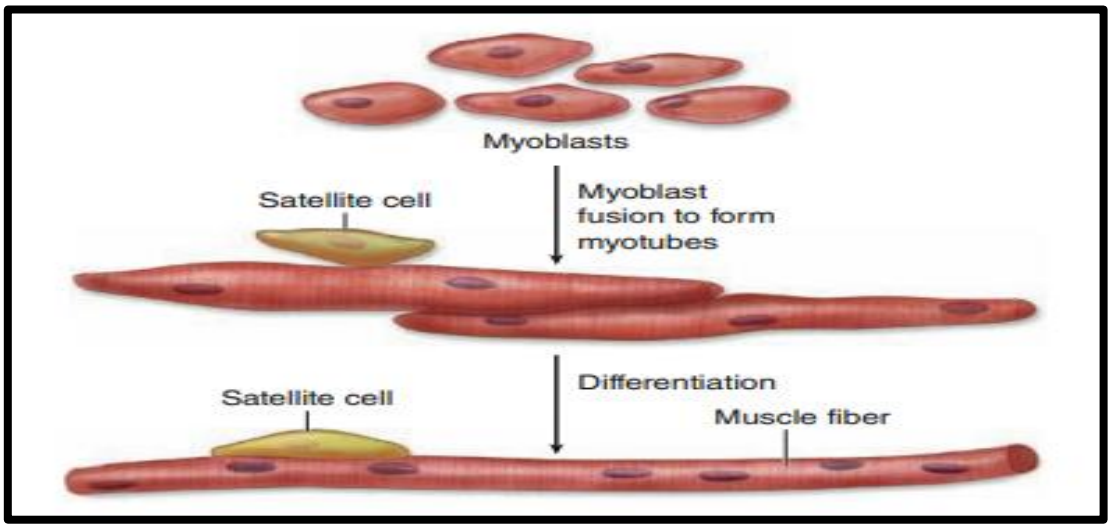


Fig. 2: Development of Skeletal Muscle.

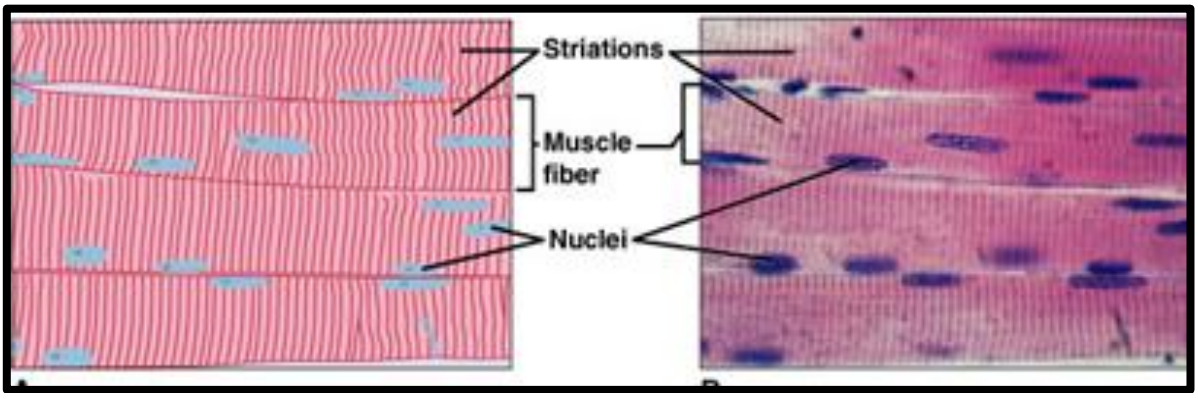
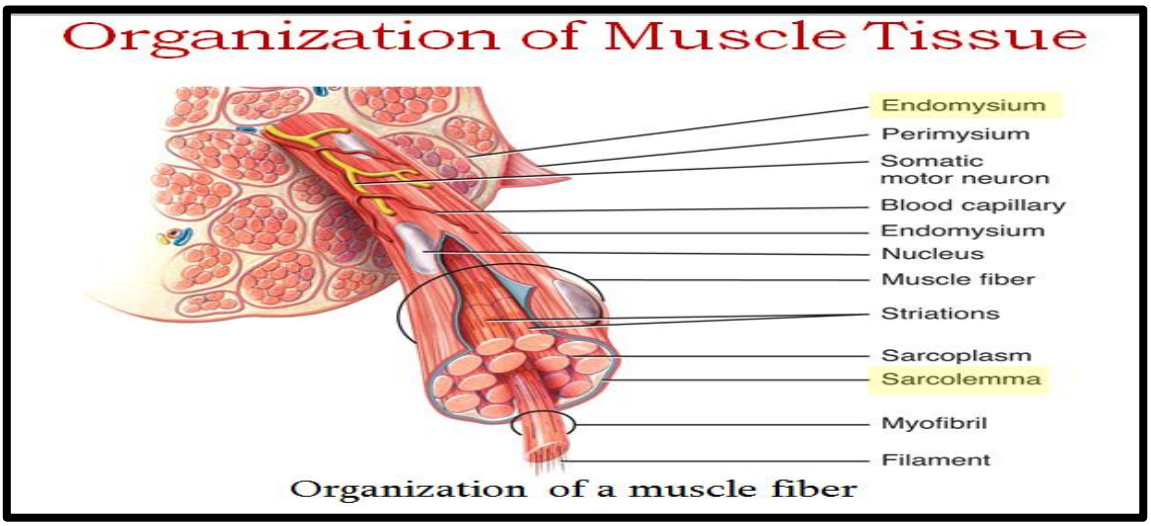


Fig. 3: Skeletal Muscle.

* Organization of Skeletal Muscle

- **Epimysium** an external sheath of dense irregular connective tissue, surrounds the entire muscle. Septa of this tissue extend inward, carrying the larger nerves, blood vessels, and lymphatics of the muscle.
- **Perimysium** is a thin connective tissue layer that immediately surrounds each bundle of muscle fibers termed a fascicle. Each fascicle of muscle fibers makes up a functional unit in which the fibers work together. Nerves, blood vessels, and lymphatics penetrate the perimysium to supply each fascicle.
- **Endomysium** (within fascicles) a very thin, delicate layer of reticular fibers and scattered fibroblasts surrounds individual muscle fibers. In addition to nerve fibers, capillaries form a rich network in the endomysium (Fig.4).



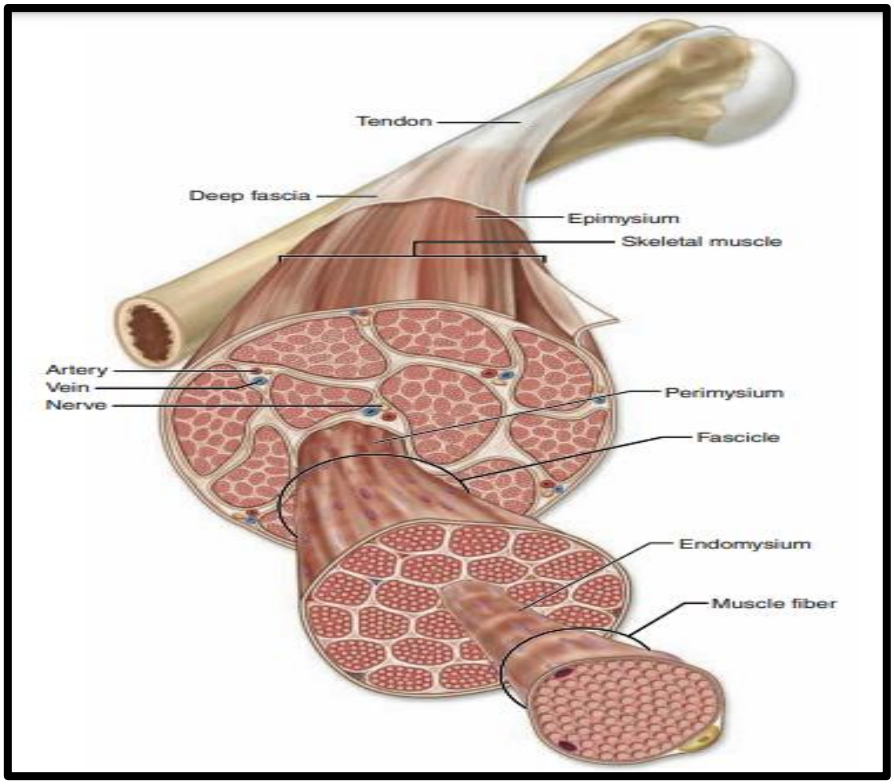


Fig. 4: Epimysium, Perimysium, Endomysium.

* Organization within muscle fibers

Sarcoplasm is highly organized, containing primarily long cylindrical filament bundles called myofibrils that run parallel to the long axis of the fiber. Longitudinally sectioned skeletal muscle fibers show striations of alternating light bands (called I bands: isotropic in polarized light microscopy) and dark bands (called A bands: anisotropic) on the myofibrils (Fig.5). A and I banding patterns are due mainly to regular arrangement of thick (myosin) and thin (actin) myofilaments.

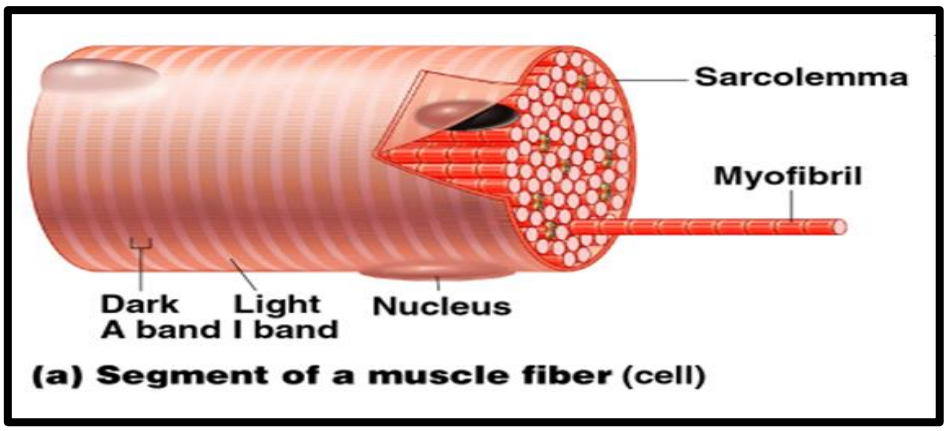


Fig. 5: Dark and light bands.

Cardiac Muscle

Cardiac muscle cells form complex junctions between interdigitating processes (Fig.6). Consequently, the heart consists of tightly knit bundles of cells, interwoven in spiraling layers that provide for a characteristic wave of contraction. Each cardiac muscle cell usually has only one nucleus and is centrally located. Surrounding the muscle cells is a delicate sheath of endomysium with a rich capillary network. A thicker perimysium separates bundles and layers of muscle fibers and in specific areas forms larger masses of fibrous connective tissue comprising the "cardiac skeleton".

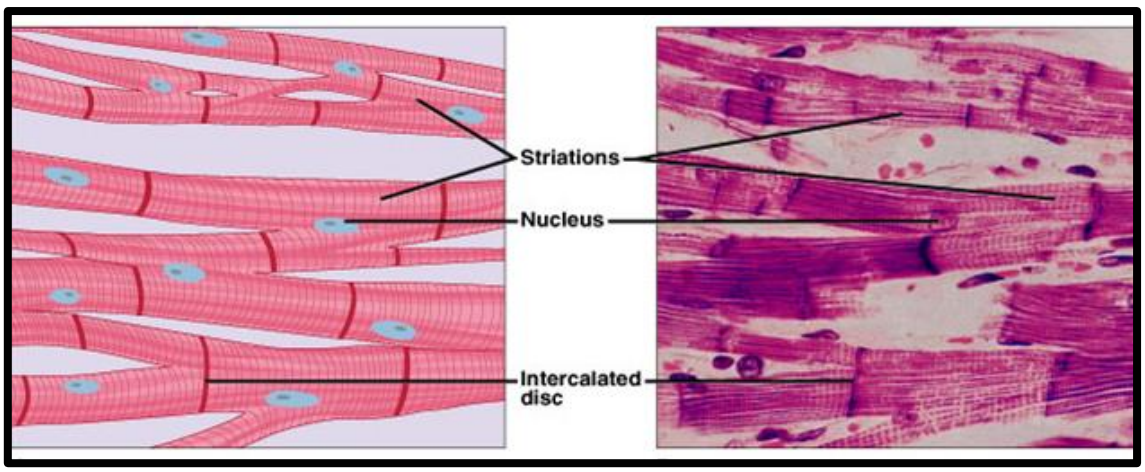
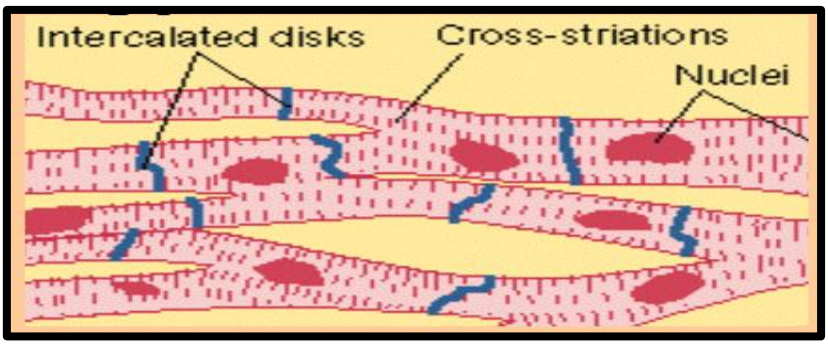


Fig. 6: Cardiac Muscle.

A unique characteristic of cardiac muscle is the presence of transverse lines that cross the fibers at irregular intervals where the myocardial cells join. These intercalated discs represent the interfaces between adjacent cells and consist of many junctional complexes (Fig.7).



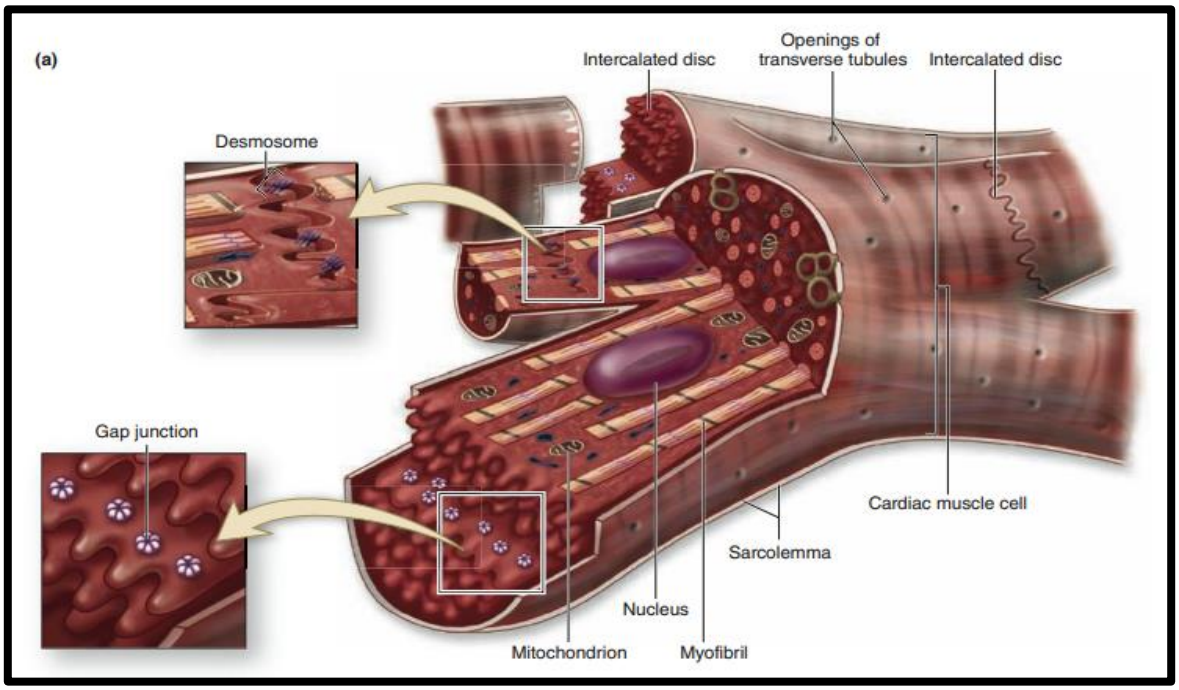


Fig. 7: Intercalated Disc.

Impulses for rhythmic contraction (heartbeat) are initiated and coordinated locally by nodes of myocardial fibers specialized for impulse generation and conduction, in addition to Purkinje fibers (impulse-conducting), which have large sizes and lighter-staining properties compared with the cardiac muscle fibers. Purkinje fibers located at the apex of heart and arranged in small groups (Fig.8).

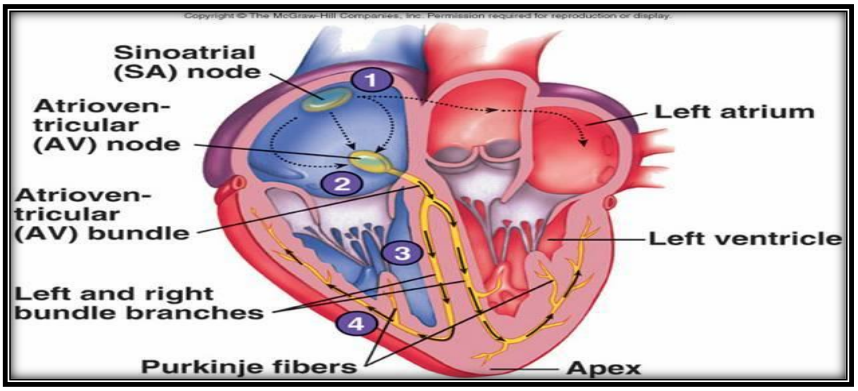


Fig. 8: Impulse generation and conduction.

Smooth Muscle

It specialized for slow, steady contraction under the influence of autonomic nerves and various hormones. This type of muscle is a major component of blood vessels and of the digestive, respiratory, urinary, and reproductive tracts and their associated organs. Fibers of smooth muscle (also called visceral muscle) are elongated, tapering, and non-striated cells, each of which is enclosed by a network of type I and type III collagen fibers comprising the endomysium (Fig.9).

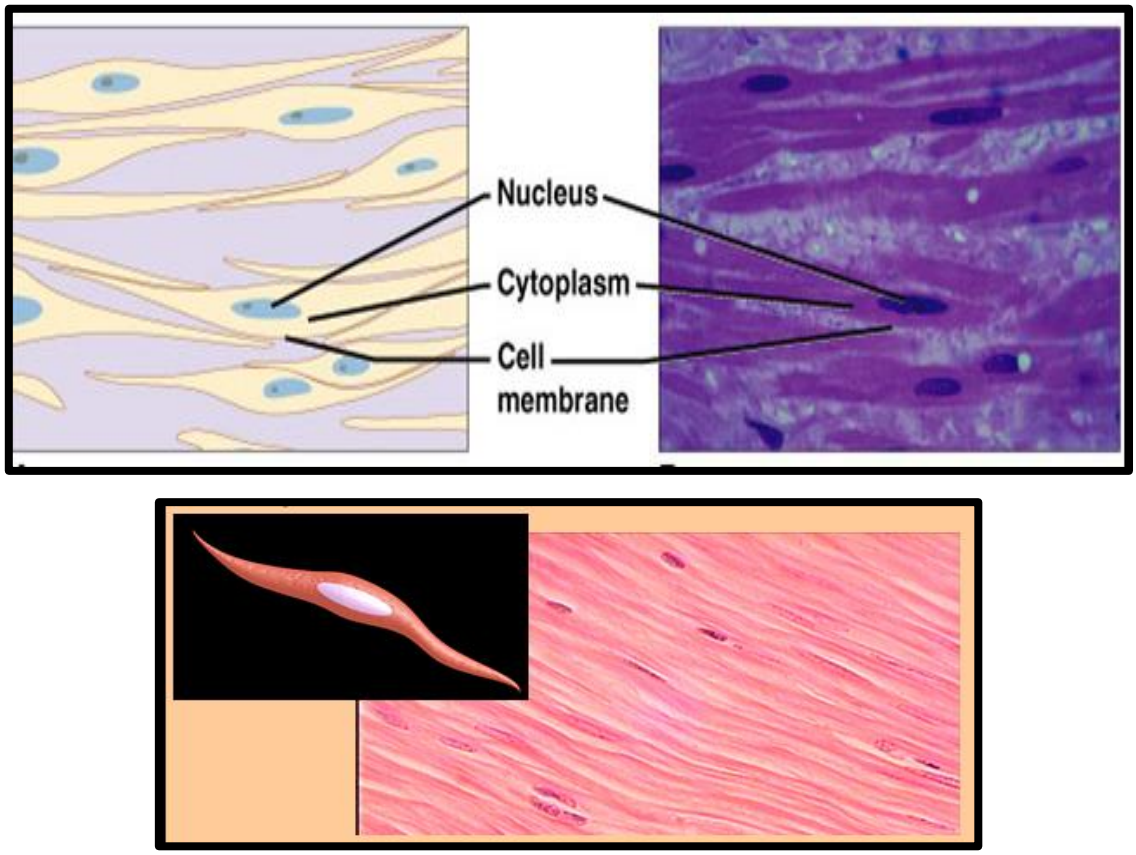


Fig. 9: Smooth Muscle.

Smooth muscle cells range in length from 20μm in small blood vessels to 500μm in the pregnant uterus. At each cell's central, the broadest part is a single elongated nucleus. Close packing is achieved with the narrow ends of each cell adjacent to the broad parts of neighboring cells. Concentrating near the nucleus are mitochondria, polyribosomes, RER, and vesicles of a Golgi apparatus. The characteristic contractile activity of smooth muscle is generated by myofibrillar arrays of actin and myosin organized somewhat differently from those of striated muscle, but the contraction mechanism is basically like that in striated muscle.

* Summary

No.	Feature	Skeletal Muscle	Cardiac Muscle	Smooth Muscle
1	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
2	Striations	Present	Present	Absent
3	Location of nuclei	Peripheral, adjacent to sarcolemma	Central	Central, at widest part of cell
4	Major locations	Skeletal muscles, tongue, diaphragm, eyes, and upper esophagus	Heart	Blood vessels, digestive and respiratory tracts, uterus, bladder, and other organs
5	Key function	Voluntary movements	Automatic (involuntary) pumping of blood	Involuntary movements
6	Efferent innervation	Motor	Autonomic	Autonomic
7	Cell response to increased load	Hypertrophy (increase in fiber size)	Hypertrophy	Hypertrophy and hyperplasia (increase in cell/fiber number)
8	Capacity for regeneration	Limited, involving satellite cells mainly	Very poor	Good, involving mitotic activity of muscle cells