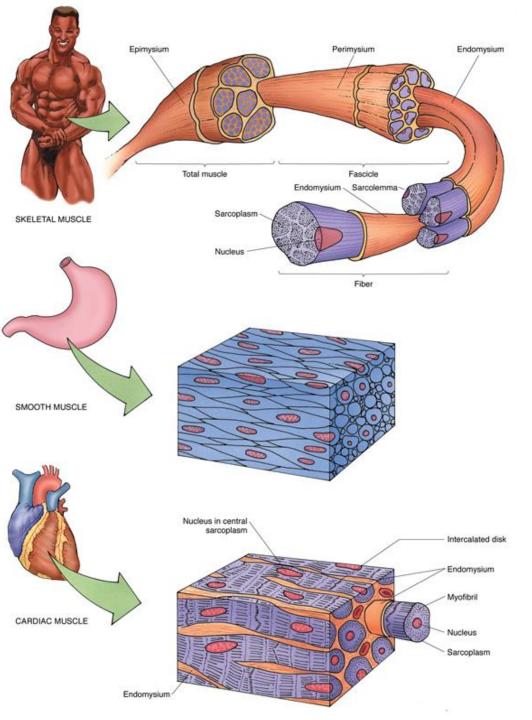
MUSCULAR TISSUE

Contractile abilities



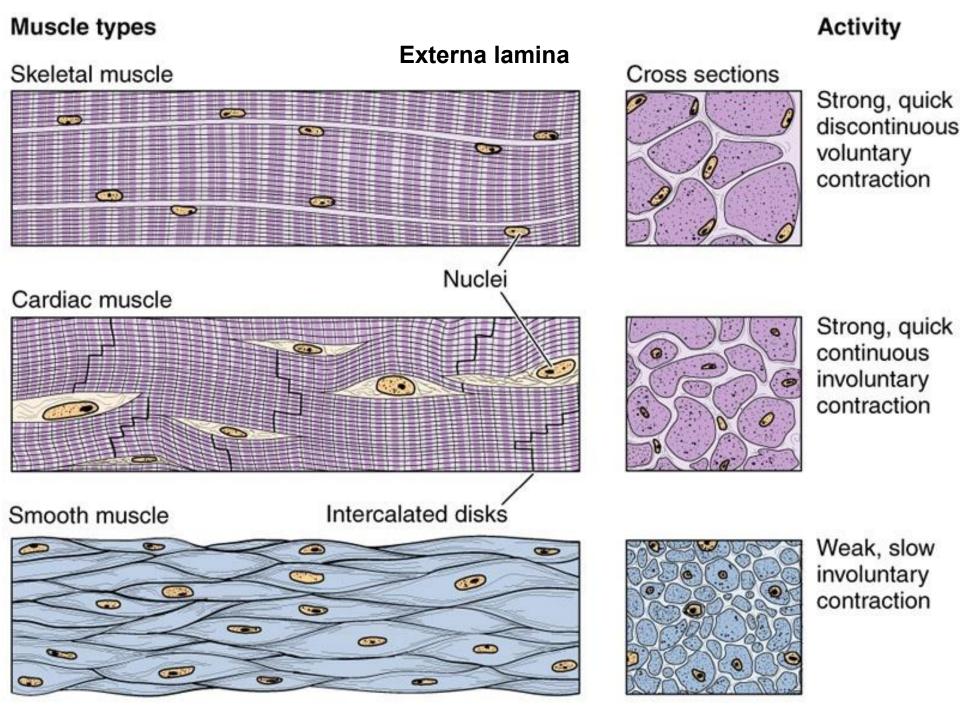
Cells of muscle are elongated and are called **striated** or **smooth** muscle, depending on the respective presence or absence of a regularly repeated arrangement of myofibrillar contractile proteins, the myofilaments.

Striated muscle cells display characteristic alternations of light and dark cross-bands, which are absent in smooth muscle. There are two types of striated muscle: **skeletal**, accounting for most of the voluntary muscle mass of the body, and involuntary **cardiac** muscle, limited almost exclusively to the heart.

Smooth muscle is located in the walls of blood vessels and the viscera as well as in the dermis of the skin.

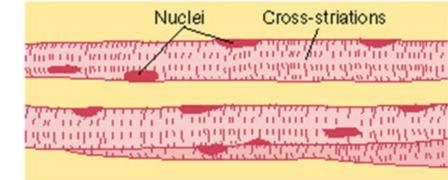
Unique terms are often used to describe the components of muscle cells. Thus, muscle cell membrane is referred to as sarcolemma; the cytoplasm, as sarcoplasm; the smooth endoplasmic reticulum, as sarcoplasmic reticulum; and occasionally, the mitochondria, as sarcosomes. Because they are much longer than they are wide, muscle cells frequently are called muscle fibers; unlike collagen fibers, however, they are living entities.

Three types of muscle. *Top*, Skeletal muscle; *center*, smooth muscle; *bottom*, cardiac muscle.



SKELETAL MUSCLE

BASIC DEFINITIONS



MYOFIBER = MUSCLE FIBER

Skeletal muscle

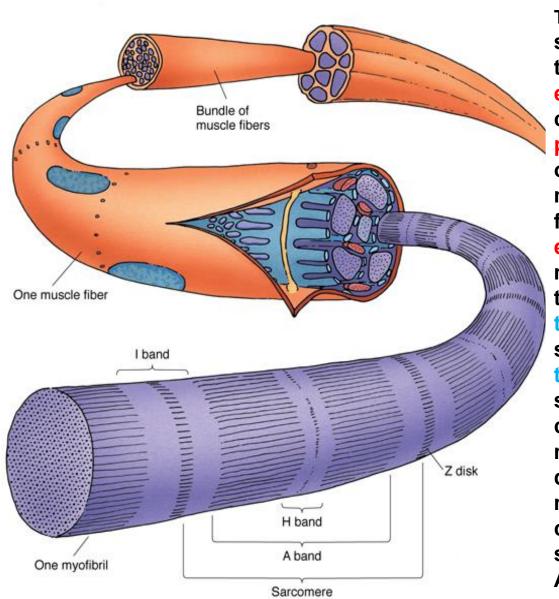
= SKELETAL MUSCLE CELL

MYOFIBRIL – CHAIN OF SARCOMERES

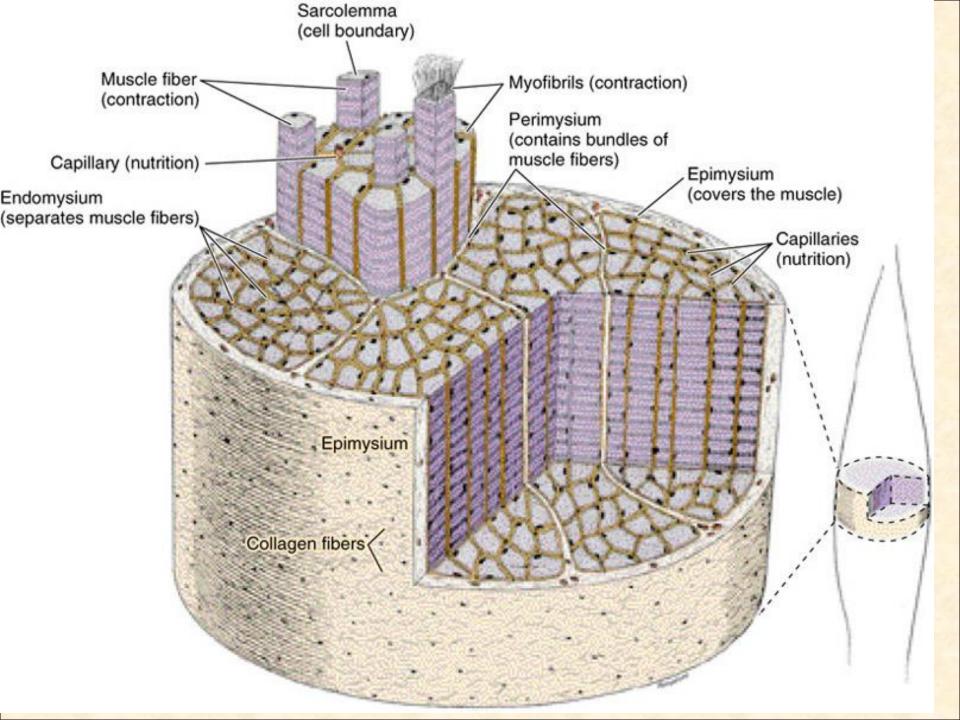
SARCOMERE – BASIC CONTRACTILE UNIT
OF STRIATED MUSCLE

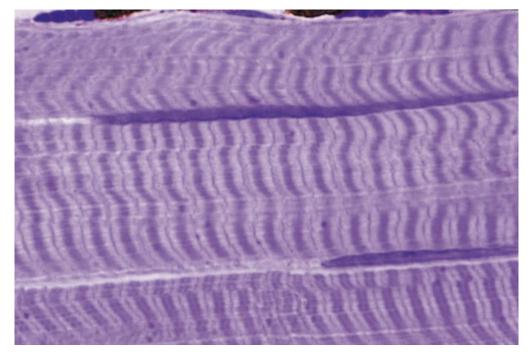
MYO<u>FILAMENTS</u> – THIN (ACTIN); THICK (MYOSIN)

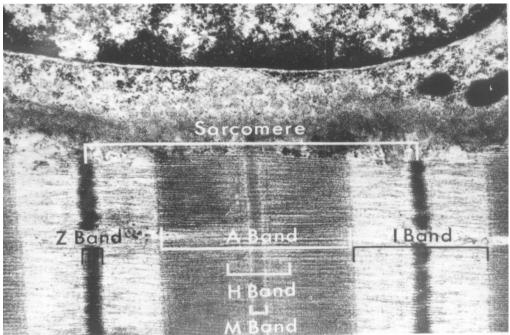
Organization of myofibrils and sarcomeres within a skeletal muscle cell



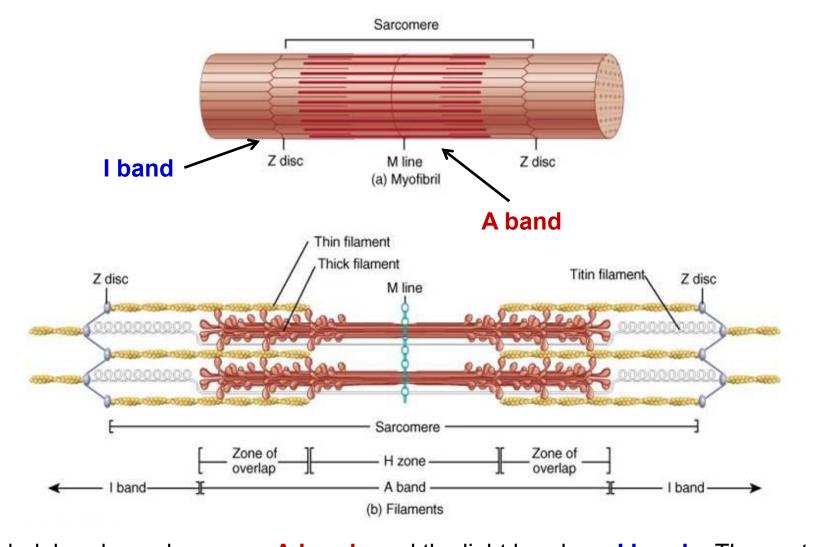
The entire gross muscle is surrounded by a thick connective tissue investment, known as the epimysium, which provides finer connective tissue elements (the perimysium) that surround bundles of skeletal muscle fibers. Individual muscle cells are surrounded by still finer connective tissue elements, the endomysium. Individual skeletal muscle fibers possess a sarcolemma that has tubular invaginations (T tubules) that course through the sarcoplasm and are flanked by terminal cisternae of the sarcoplasmic reticulum. The contractile elements of the skeletal muscle fiber are organized into discrete cylindrical units called myofibrils. Each myofibril is composed of thousands of sarcomeres with their characteristic A, I, and H bands and Z disk.



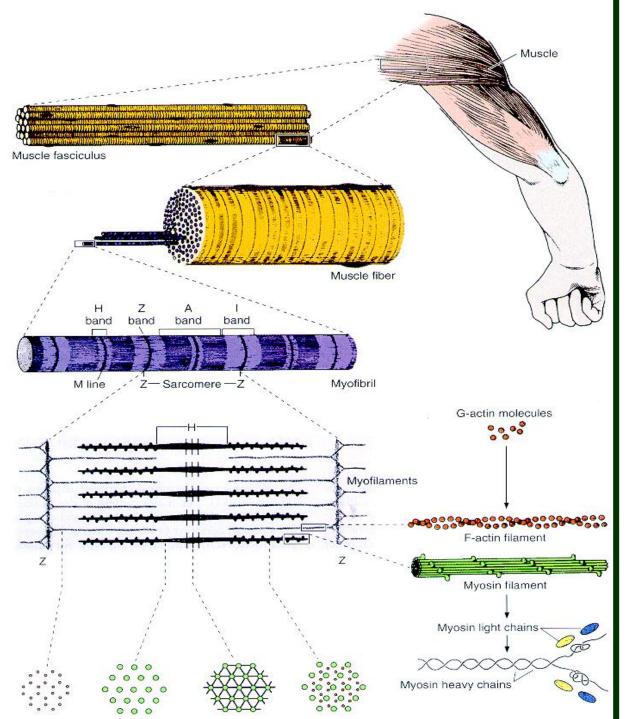




Much of the skeletal muscle cell is composed of longitudinal arrays of cylindrical myofibrils. They extend the entire length of the cell and are aligned precisely with their neighbors. This strictly ordered parallel arrangement of the myofibrils is responsible for the crossstriations of light and dark banding that are characteristic of skeletal muscle viewed in longitudinal section.



The dark bands are known as **A bands** and the light bands as **I bands**. The center of each A band is occupied by a pale area, the **H band**, which is bisected by a thin **M line**. Each I band is bisected by a thin dark line, the **Z disk (Z line)**. The region of the myofibril between two successive Z disks, known as a **sarcomere**.



I-bands contain thin myofilaments. Are attached to Z line.

A-bands contain both thin and thick myofilaments. One thick filament is surrounded by 6 thin filaments.

H-band contains only thick filaments.

M-line – lateral connections between thick myofilaments.

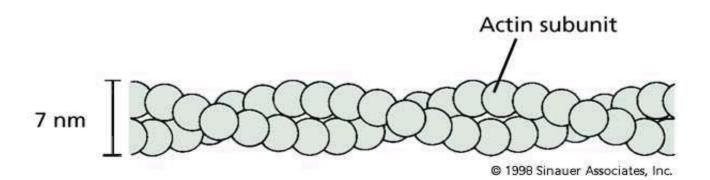
Junqueira LC., Carneiro J. Basic histology. McGraw-Hilll Companies, 2003

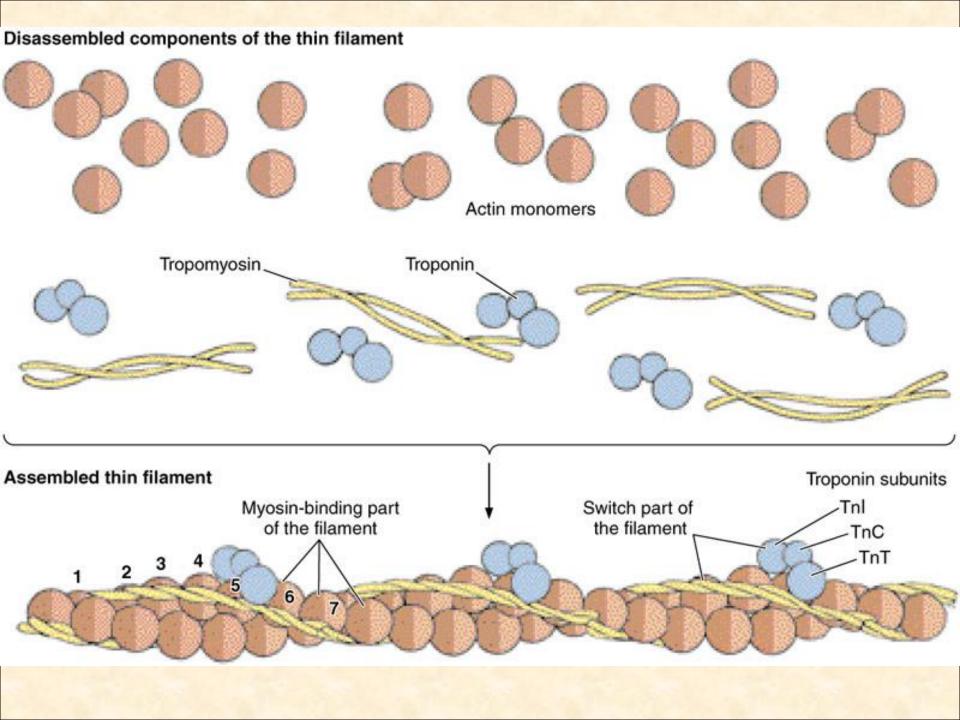
Microfilaments - actin filaments tread-like protein fibers

G-actin = 43 kD globular monomer, 375 amino acids long, binding ATP

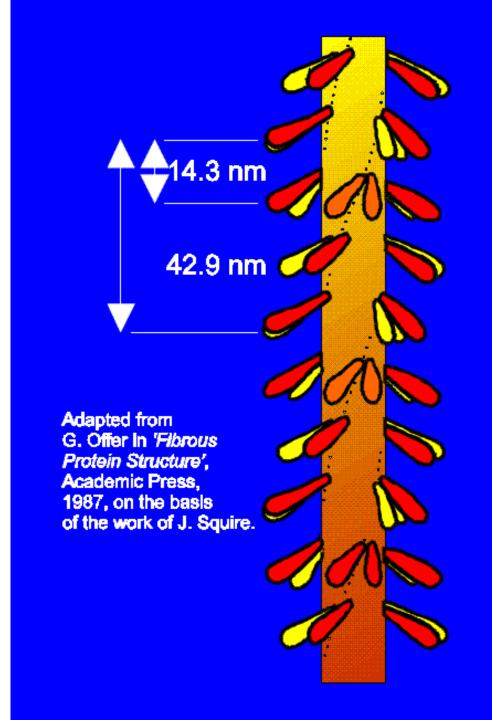
F-actin = G-actin polymers assembled into long filaments

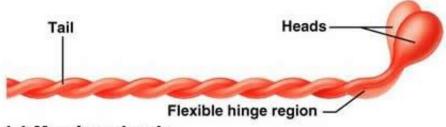
Actin filaments are rode-like double helical polymers, which appear in the EM as threads about 7 nm wide



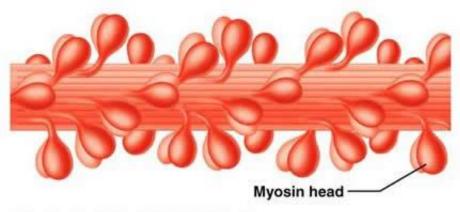


Here is a cartoon of a thick filament showing the regular arrangement of myosin protruding from the backbone every 14.5 nm. There are 294 myosin molecules per thick filament (588 ATPase sites).

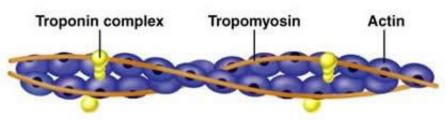




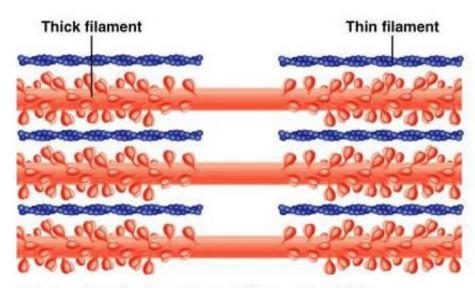
(a) Myosin molecule



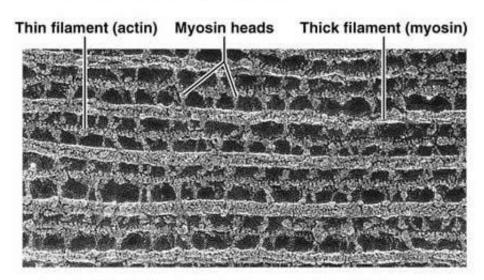
(b) Portion of a thick filament



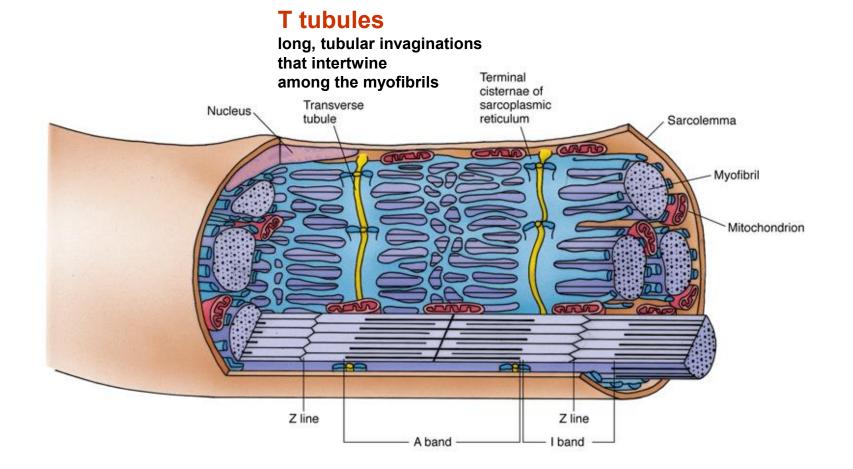
(c) Portion of a thin filament



(d) Longitudinal section of filaments within one sarcomere of a myofibril



(e) Transmission electron micrograph of part of a sarcomere

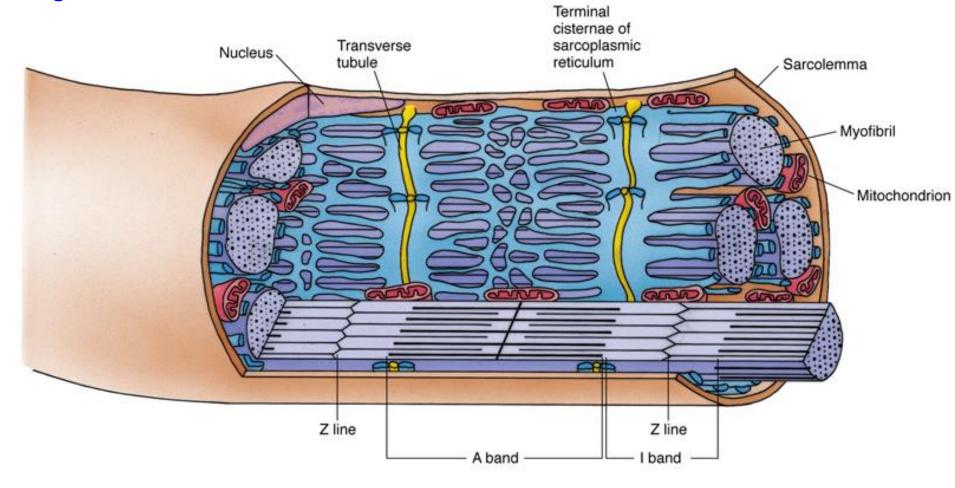


T tubules pass transversely across the fiber and each sarcomere possesses two sets of T tubules, one at each interface of the A and I bands. Thus, T tubules extend deep into the interior of the fiber and facilitate the conduction of waves of depolarization along the sarcolemma.

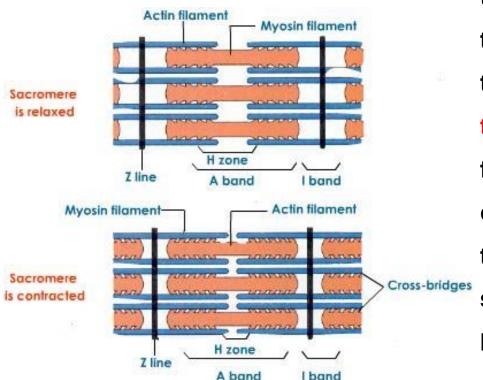
Associated with this system of T tubules is the **sarcoplasmic reticulum**, which is maintained in close register with the A and I bands as well as with the T tubules. The sarcoplasmic reticulum forms a meshwork around each myofibril and displays dilated **terminal cisternae** at each A-I junction. Thus, two of these cisternae are always in close apposition to a T tubule, forming a **triad** in which a **T tubule** is **flanked by two terminal cisternae**.

Myofibrils are held in register with one another by the intermediate filaments **desmin** and **vimentin**.

Organization of triads and sarcomeres of skeletal muscle

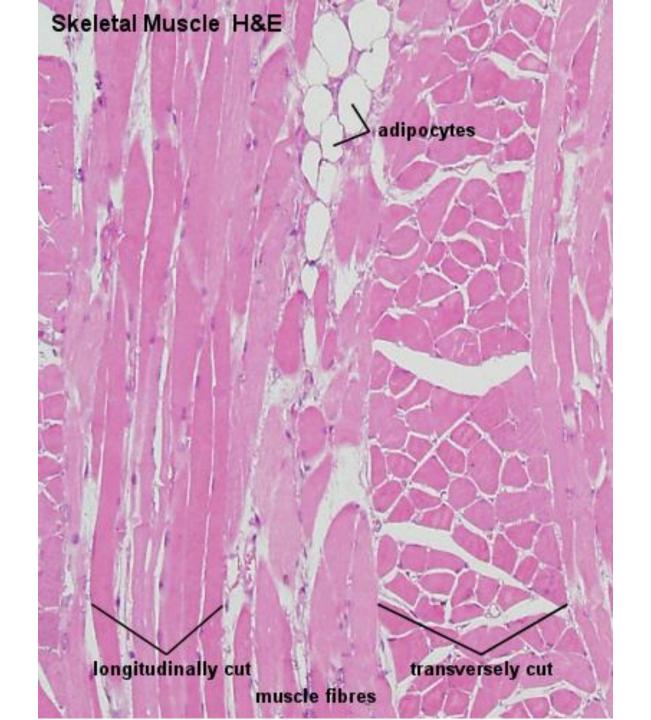


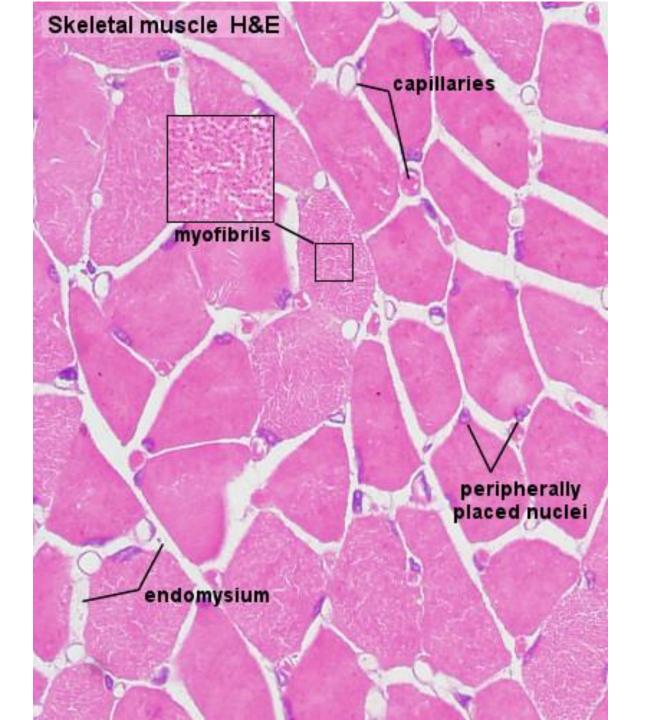
In skeletal muscle the triad is always located at the junction of the A and I bands, permitting the quick release of calcium ions from the terminal cisternae of the sarcoplasmic reticulum just in the region where the interaction of the thick and thin filaments can produce efficient sarcomere shortening. Observe the presence of mitochondria around the periphery of the myofibrils.

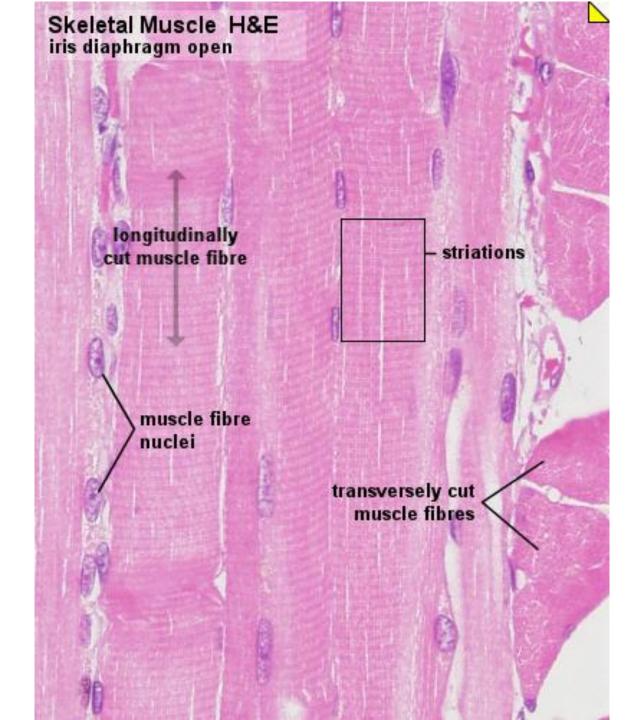


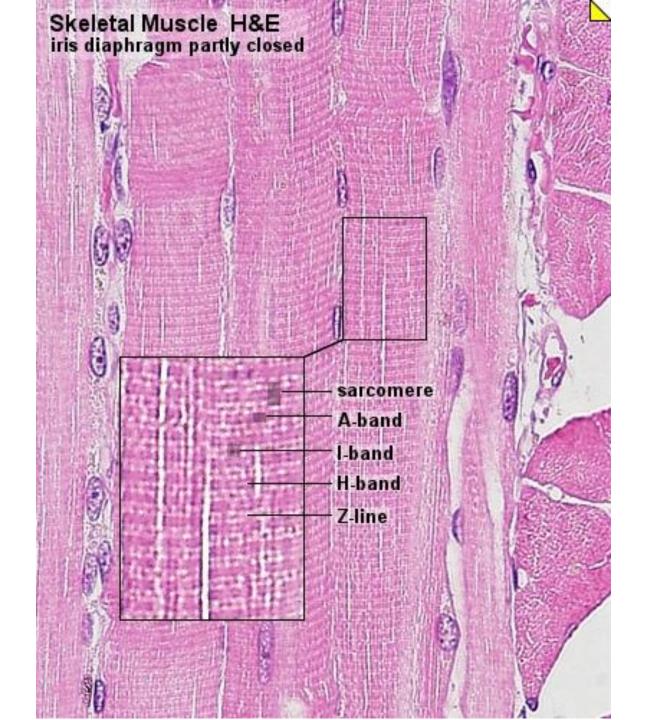
During contraction, individual thick and thin filaments do not shorten; instead, the two Z disks are brought closer together as the thin filaments slide past the thick filaments (Huxley's sliding filament theory). Thus, when contraction occurs, the motion of the thin filaments toward the center of the sarcomere creates a greater overlap between the two groups of filaments, effectively reducing the widths of the I and H bands without influencing the width of the A band.

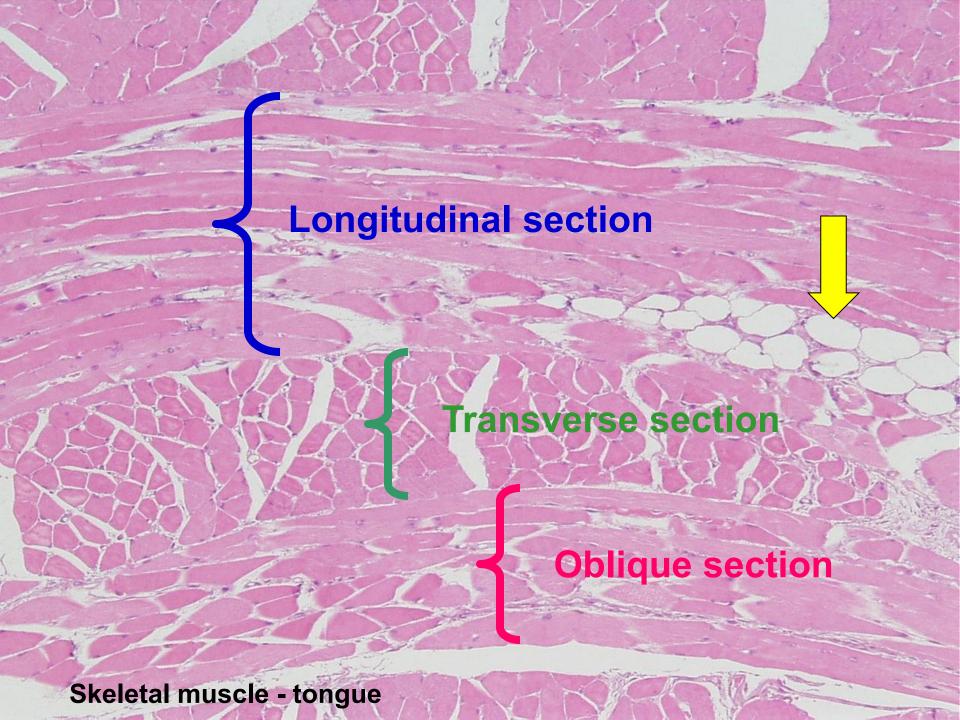


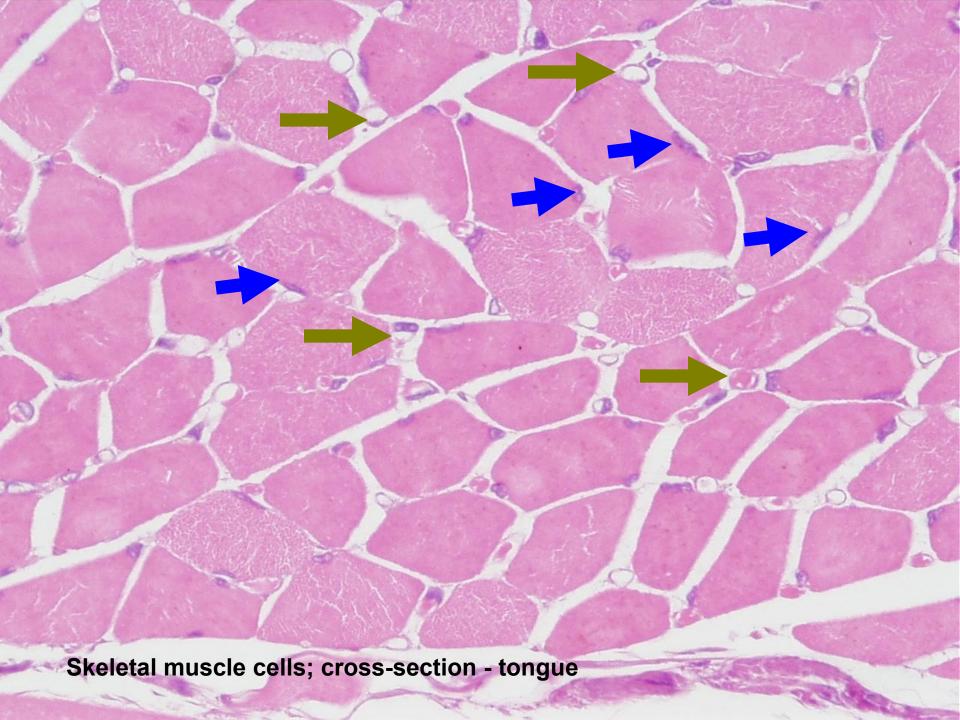


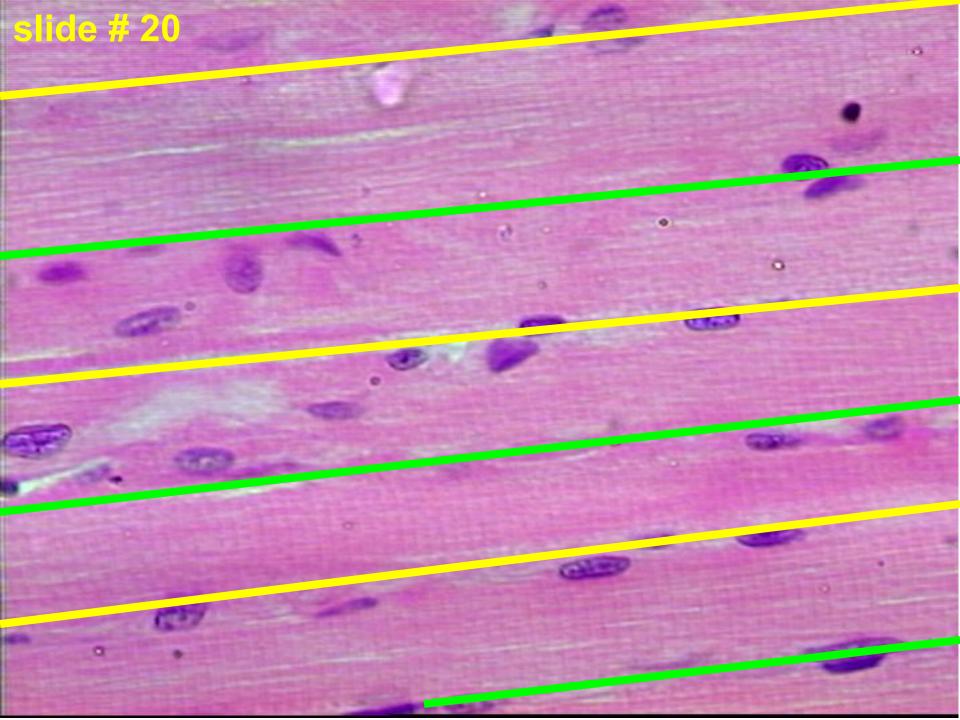


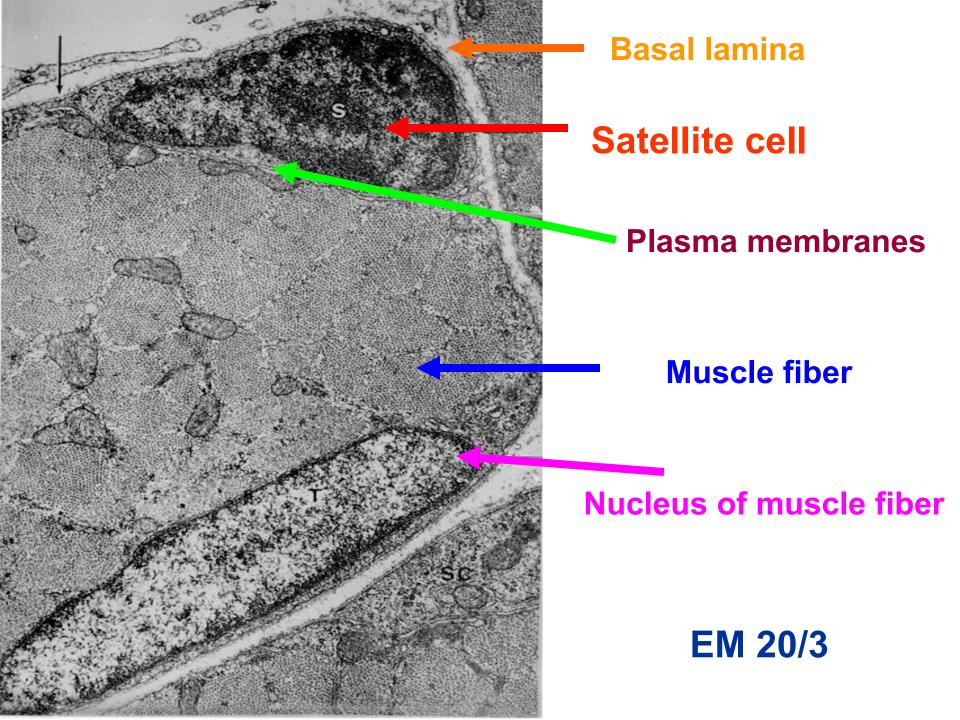


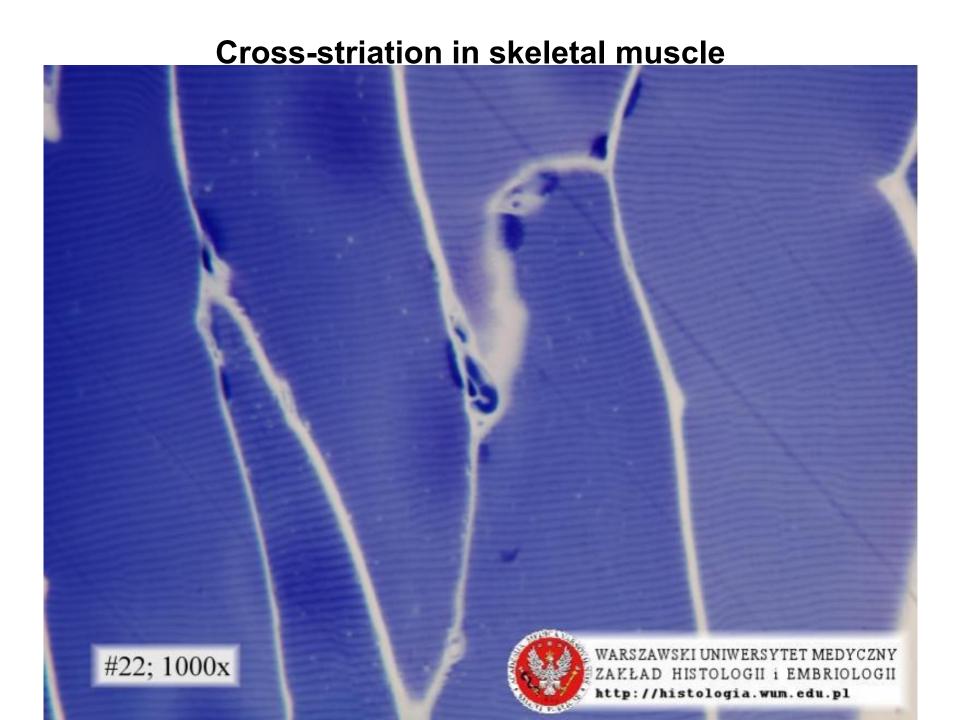




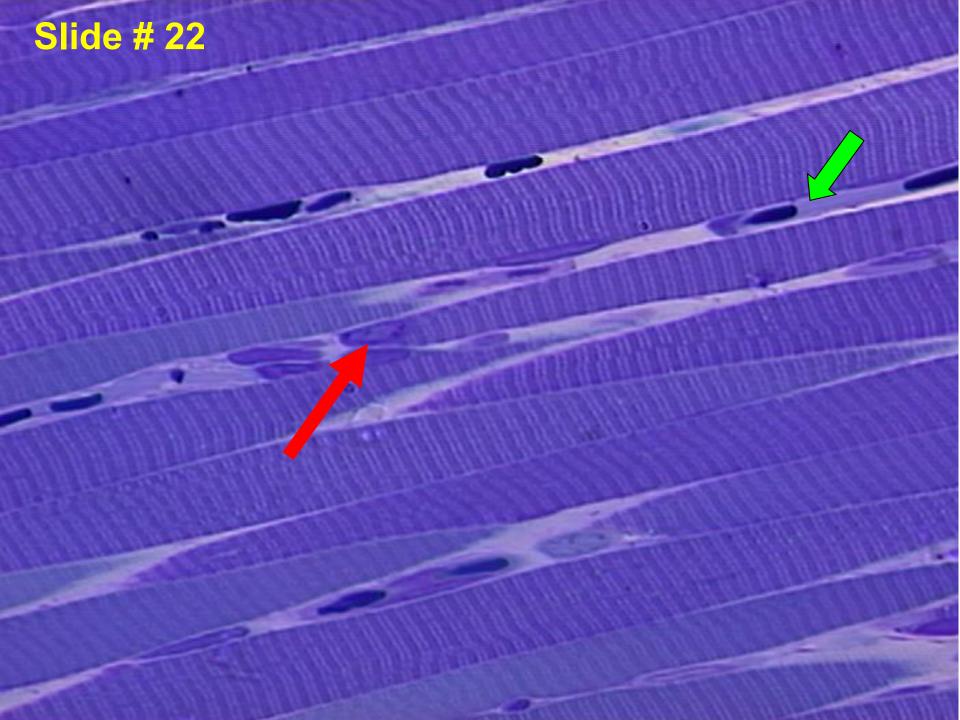


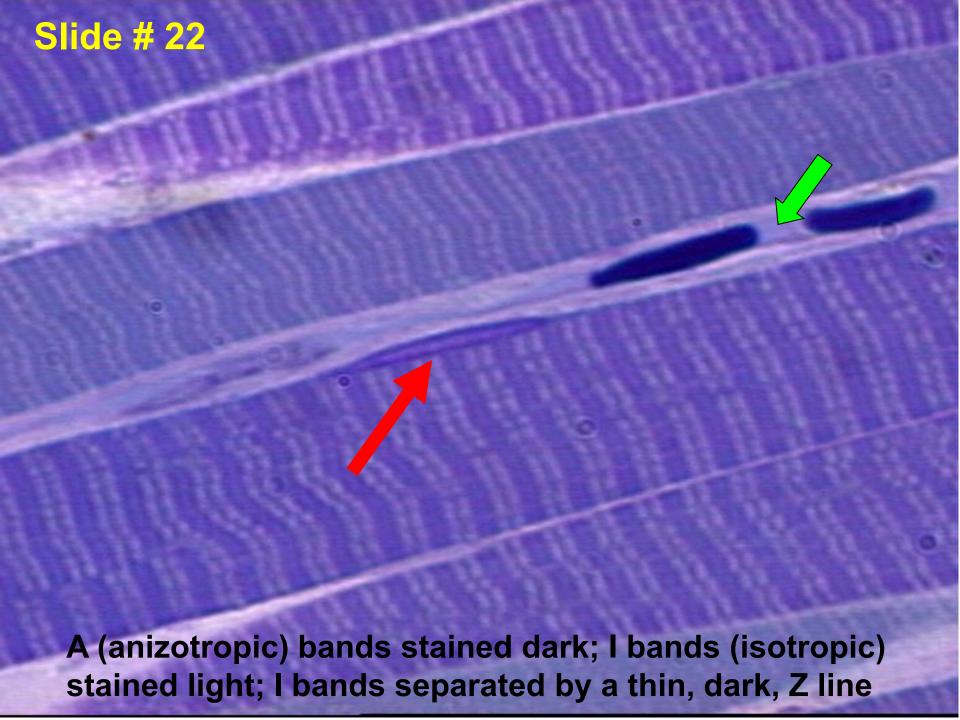




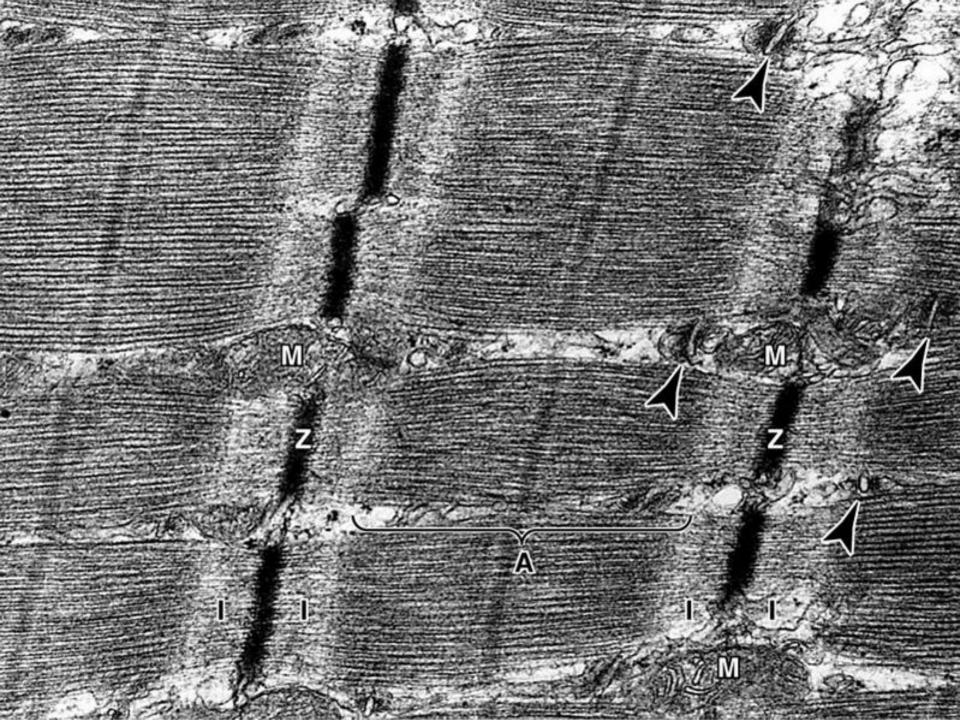


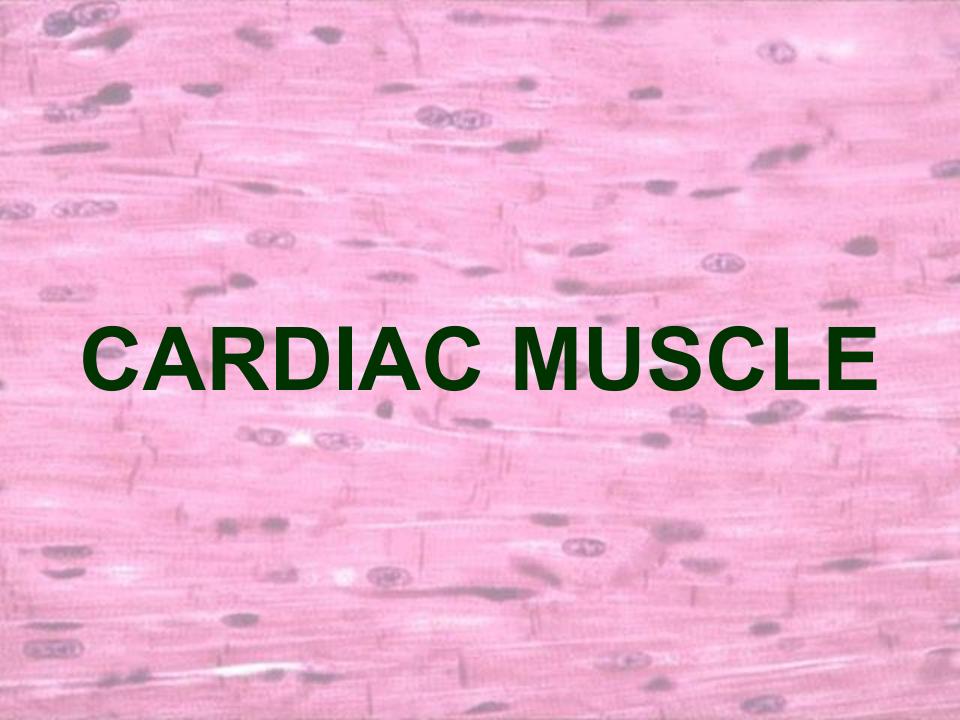




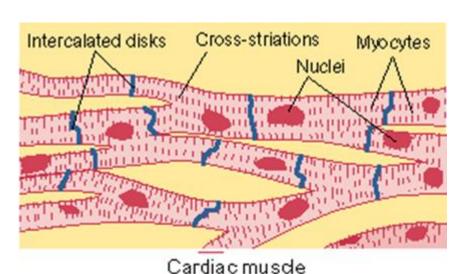


Z Bond A Bond LBand





CARDIAC MUSCLE

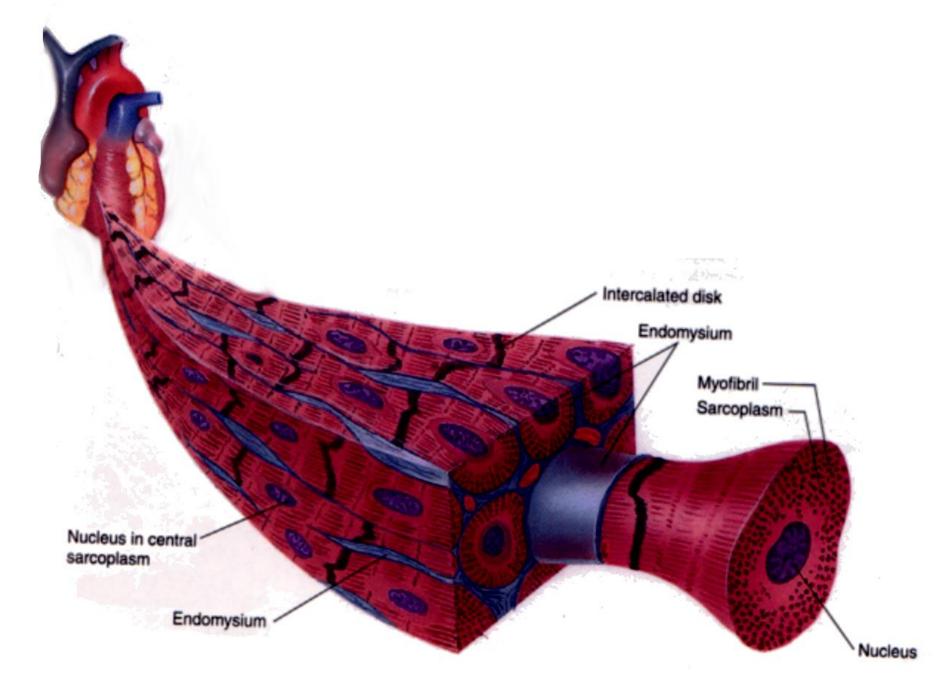


Cardiac muscle differs from skeletal and smooth muscles in that it possesses an inherent rhythmicity as well as the ability to contract spontaneously

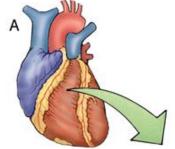
Branching cell
Single nucleus
Centrally located

Sarcomere T tubules Dyed

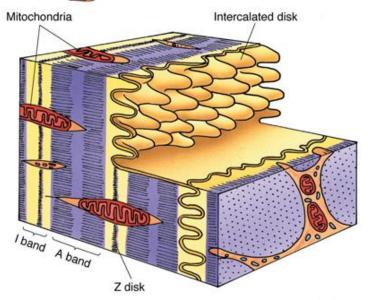
The adult myocardium consists of an anastomosing network of branching cardiac muscle cells arranged in layers (laminae). Laminae are separated from one another by slender connective tissue sheets that convey blood vessels, nerves, and the conducting system of the heart.



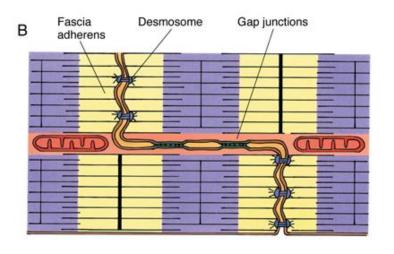
Gartner LP., Hiatt JL. Color atlas of histology. Lippincott Williams & Wilkins, 2000



Intercalated disc (specialized end-to-end junction)

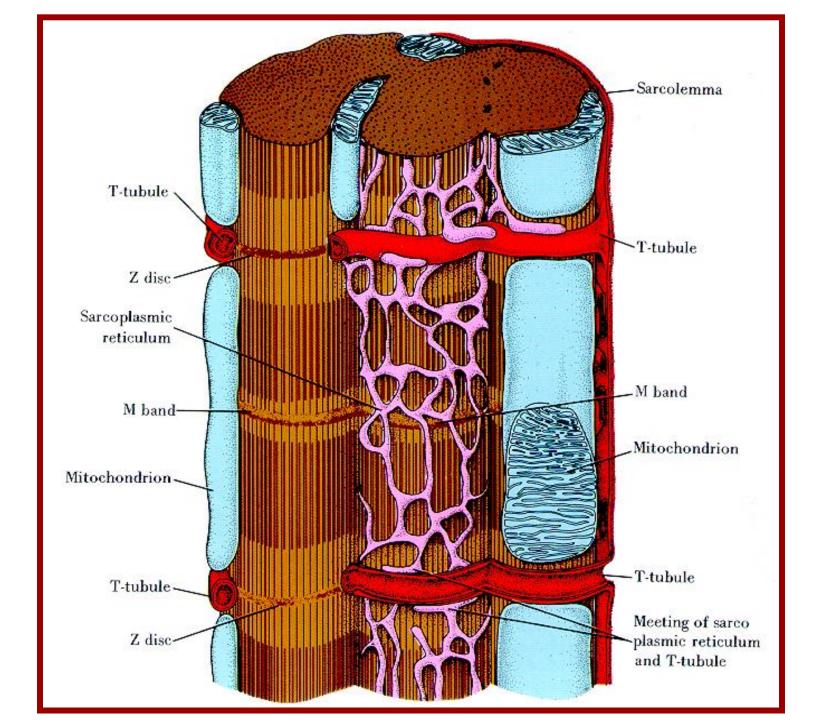


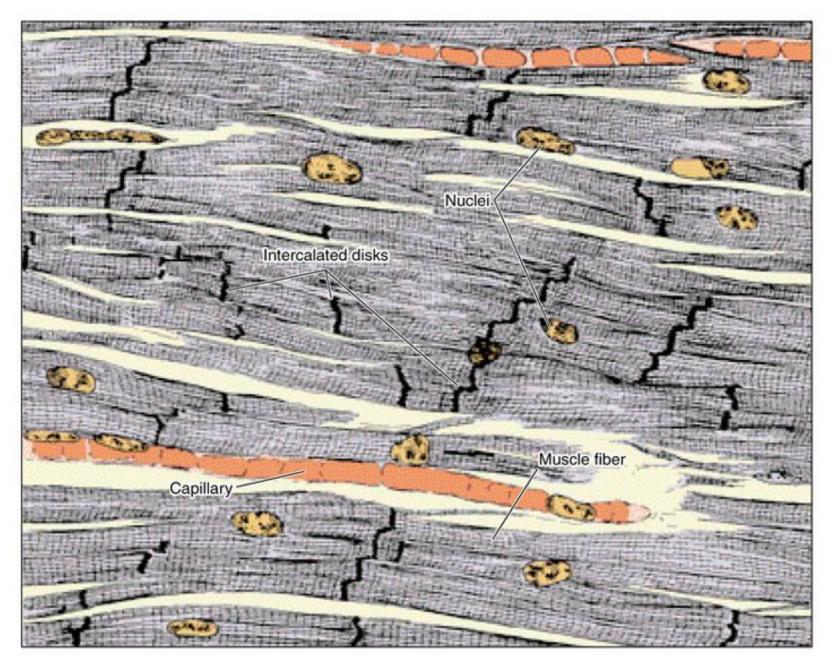
The transverse portions of the intercalated disk act as a Z plate, and thin filaments are embedded in them



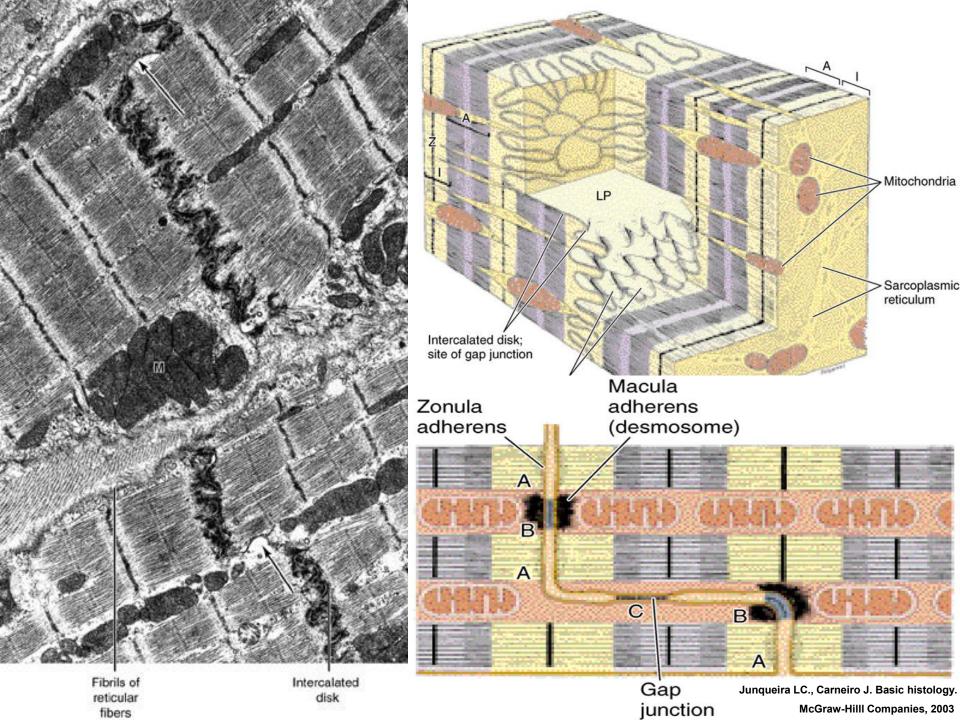
Transverse portions (fasciae adherentes, desmosomes)

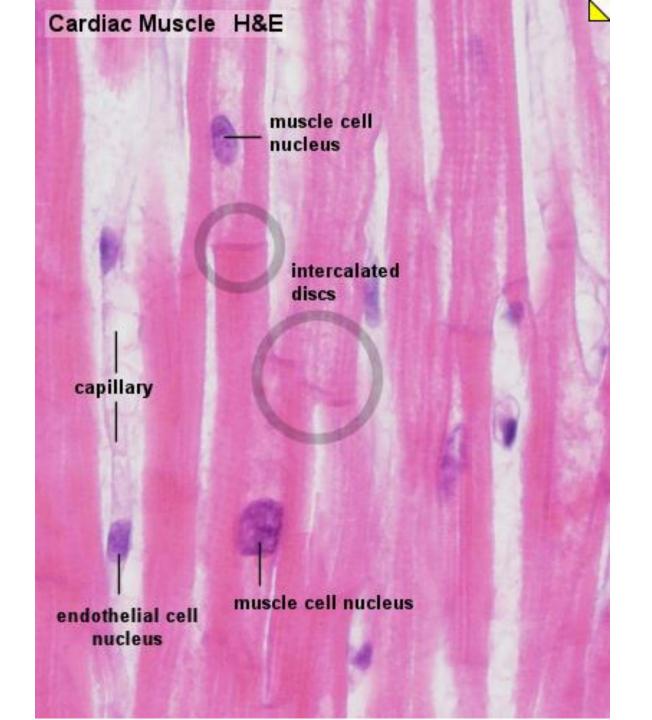
Lateral portions (gap junctions)

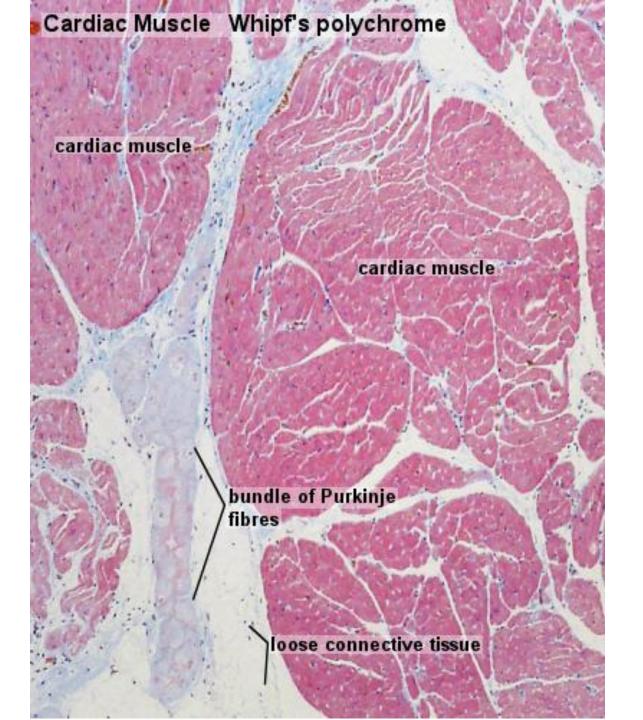


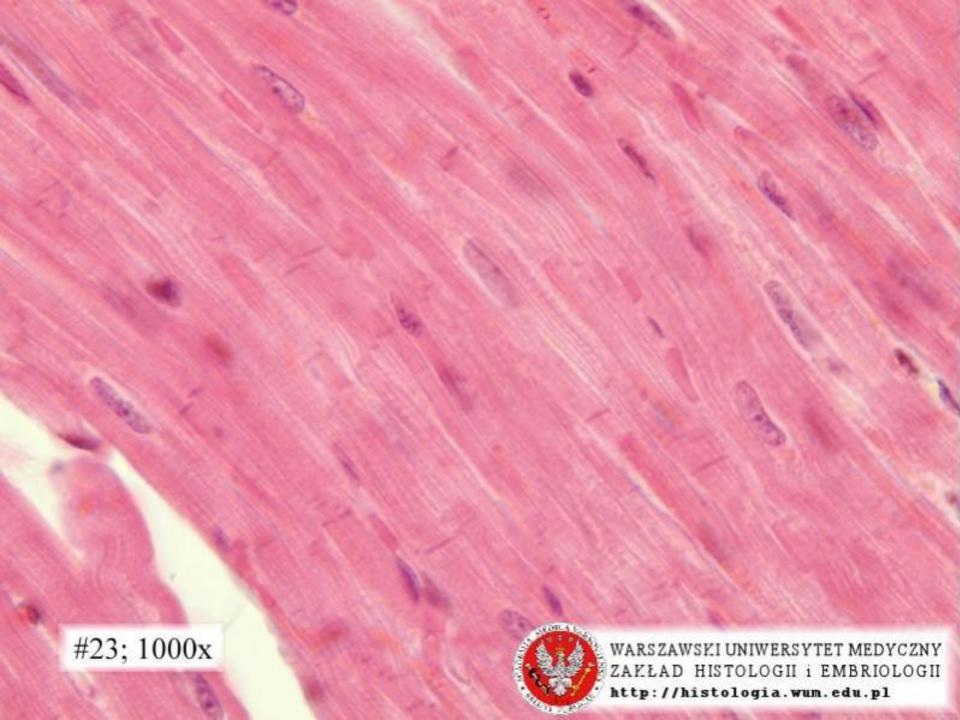


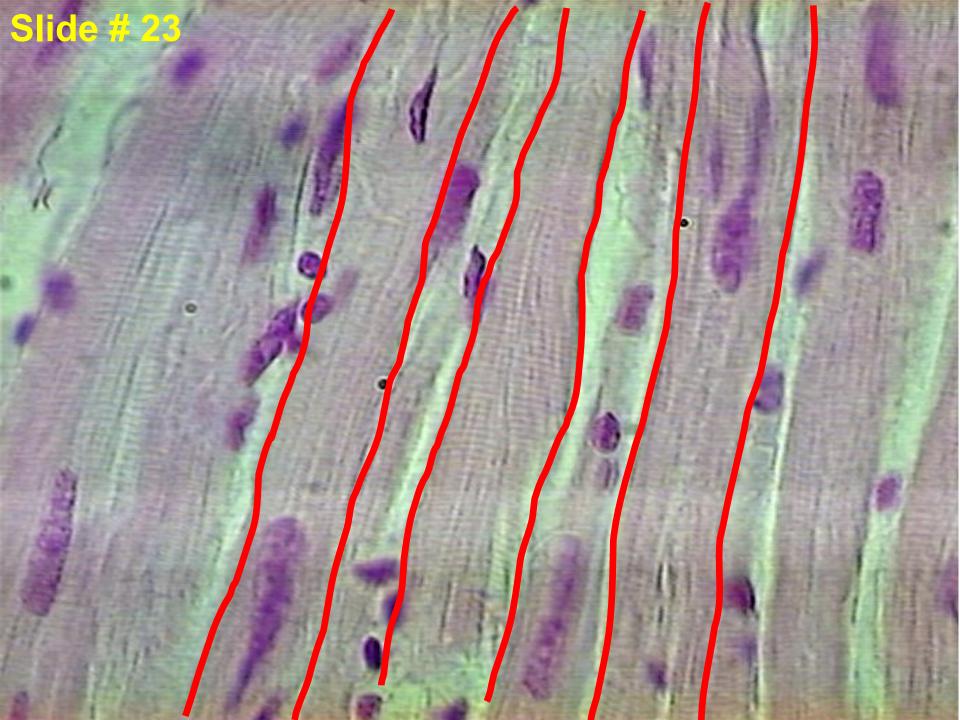
Junqueira LC., Carneiro J. Basic histology. McGraw-Hilll Companies, 2003









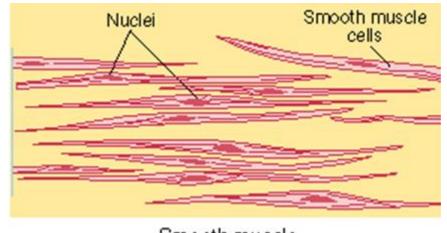








SMOOTH MUSCLE

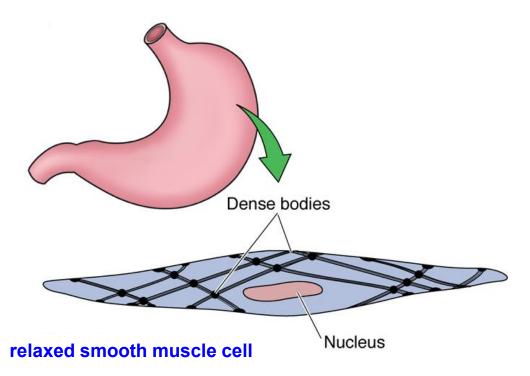


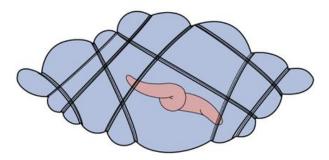
Smooth musde

Single nucleus centrally located no striations

Fusiform, elongated taper at the end

Smooth muscle cells do not possess a system of T tubules. Smooth muscle is not under voluntary control; it is regulated by the autonomic nervous system and local physiological conditions. Hence, smooth muscle is also referred to as involuntary muscle.



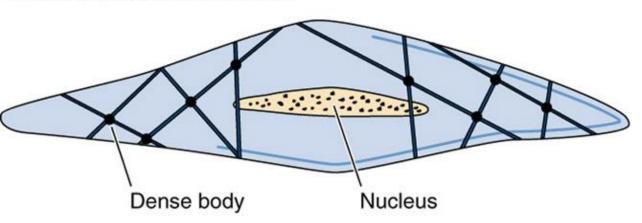


contracted smooth muscle cell, the nucleus appears corkscrew-shaped.

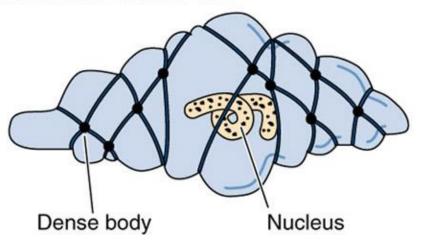
Two types of smooth muscle:

- 1. Cells of multiunit smooth muscle can contract independently of one another, because each muscle cell has its own nerve supply.
- 2. Cell membranes of unitary (single-unit, vascular) smooth muscle form gap junctions with those of contiguous smooth muscle cells, and nerve fibers form synapses with only a few of the muscle fibers. Thus, cells of unitary smooth muscle cannot contract independently of one another.

Relaxed smooth muscle cell

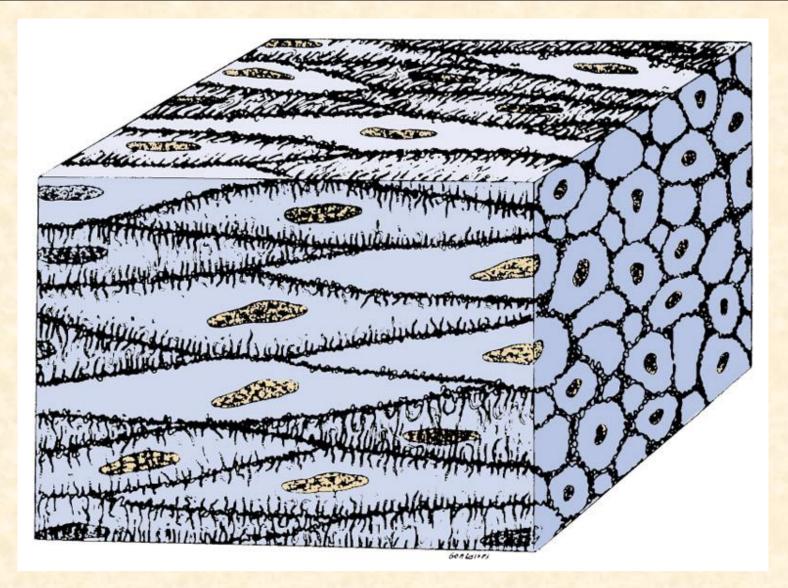


Contracted smooth muscle cell



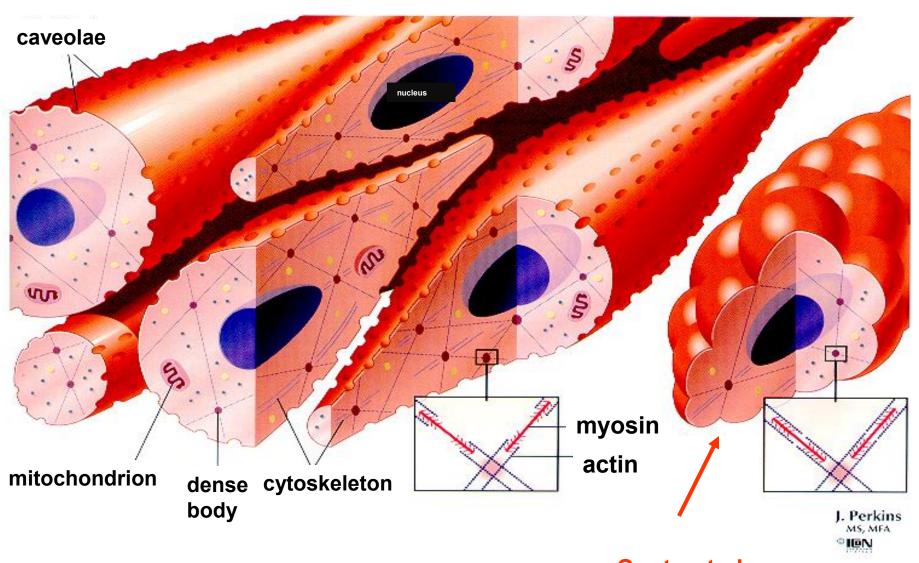
Dense bodies

correspond to Z line in skeletal muscle. Myosin in smooth muscle interacts with actin only after its light chain is fosforylated. In smooth muscle troponin is absent. Calcium complexes with calmodulin what activates myosin light chain kinase and phosphorylation takes place.

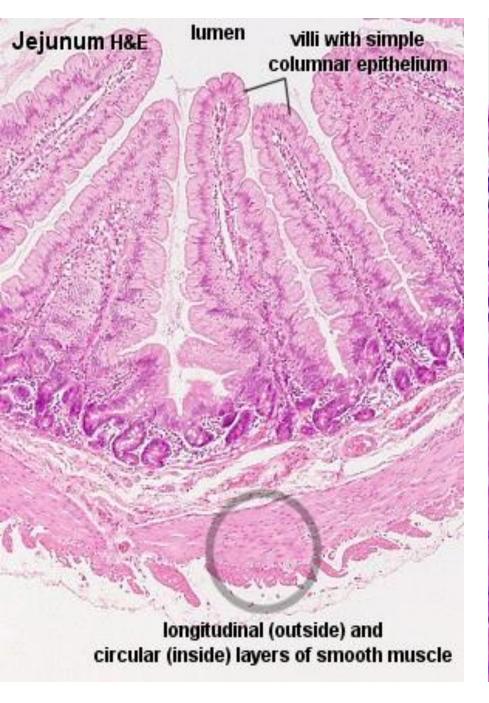


Arrangement of smooth muscle cells surrounded by a net of reticular fibers (embedded in external lamina)

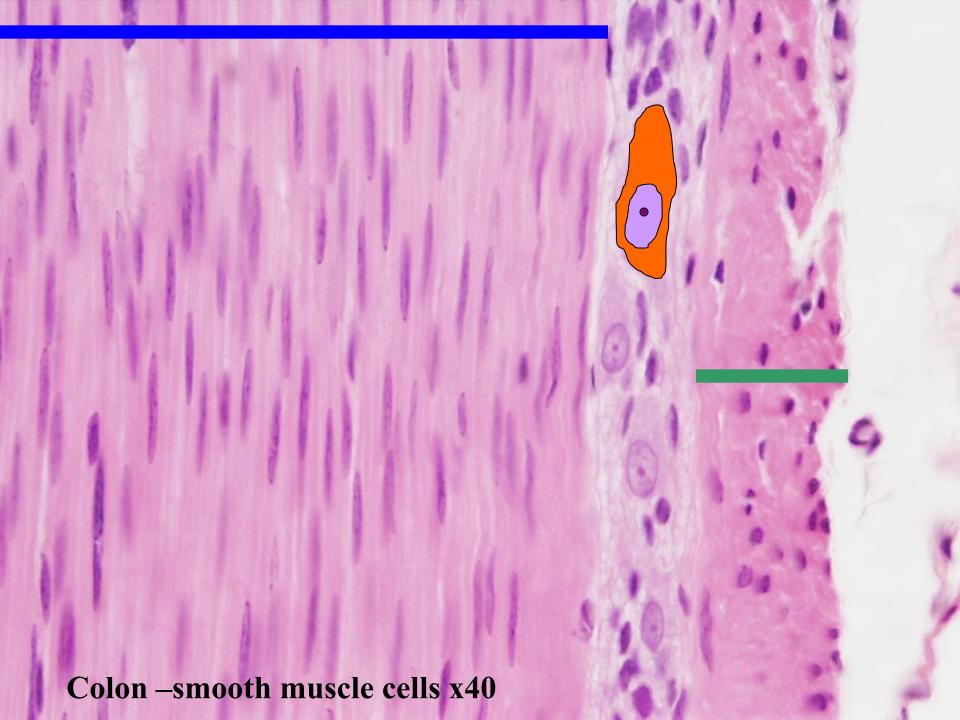
Smooth muscle cells

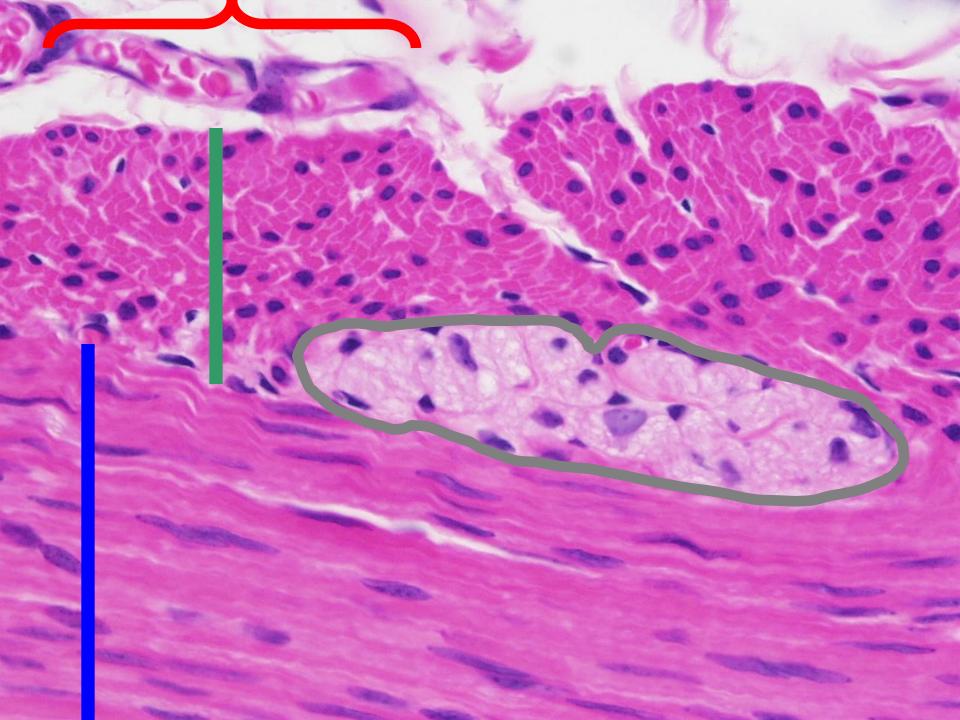


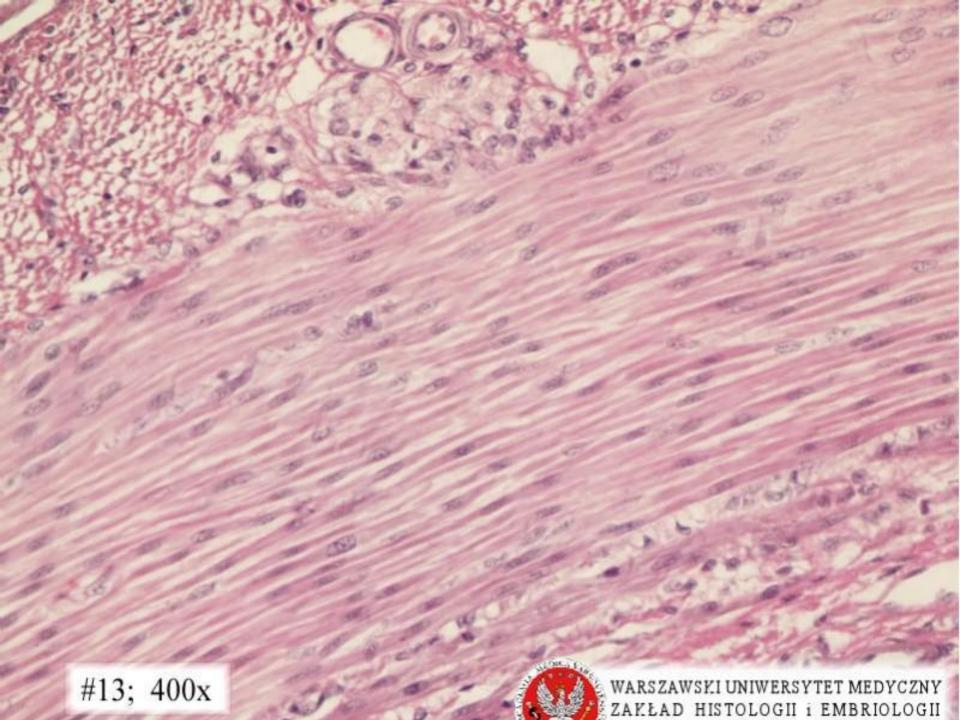
Contracted smooth muscle cell

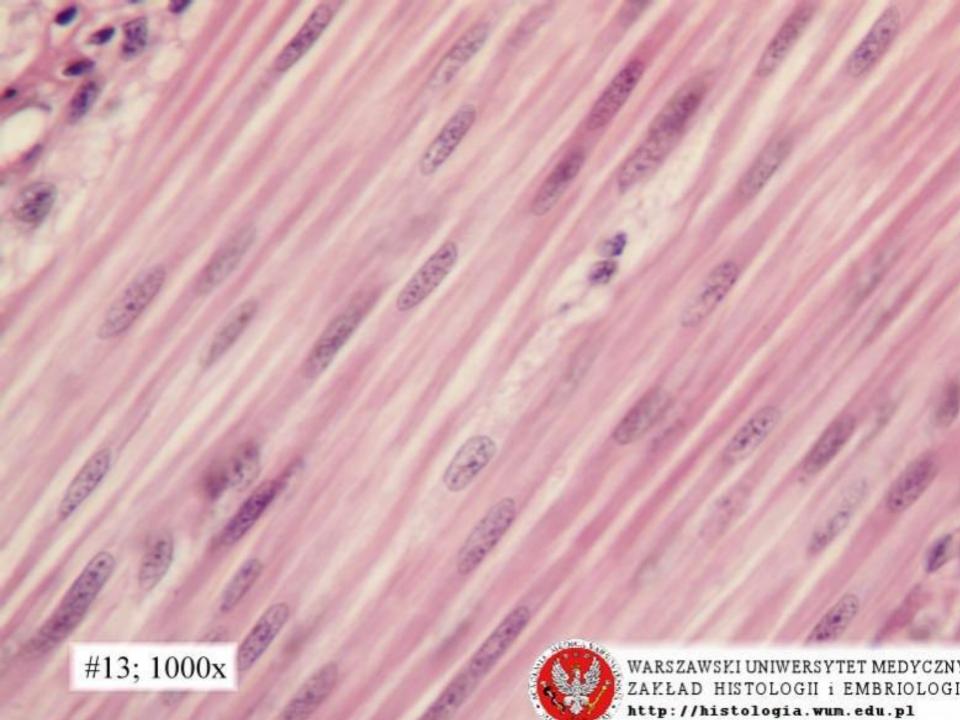


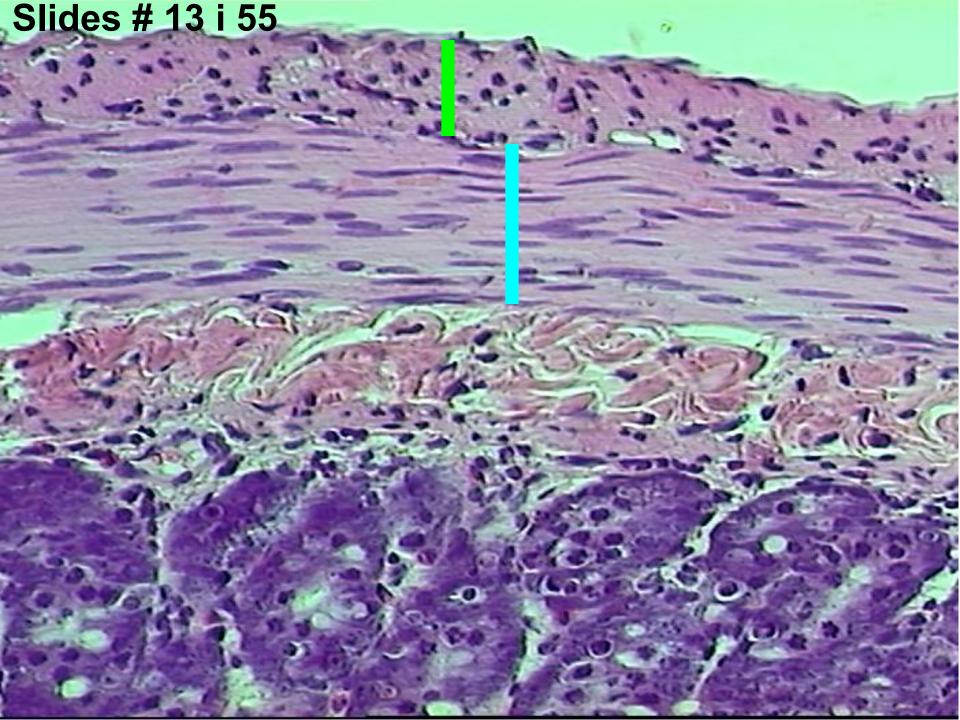












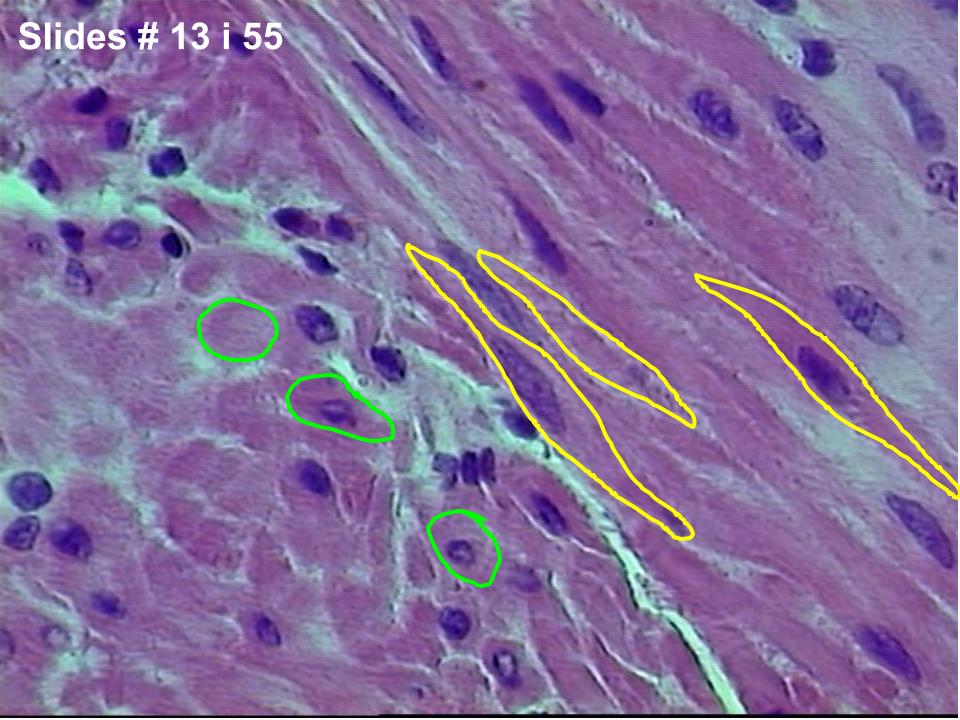


Table. Comparison of Muscle Types

		Muscle Type	
Characteristic	Skeletal	Cardiac	Smooth
Nuclei	Multinucleated; peripherally located	Single nucleus; centrally located	Single nucleus; centrally located
Banding	Actin and myosin form distinctive bands	Actin and myosin form distinctive bands	Actin and myosin; no distinctive bands
Z disks	Present	Present	Z disks not present; cytoplasmic dense bodies are present
T tubules	T tubules at A-I junction; triads present	T tubules at Z disk; diads present	No T tubules; no triads or diads; caveolae are present
Cellular junctions	No junctional complexes	Intercalated disks	Gap junctions
Neuromuscular junctions	Present	Not present; contraction is intrinsic	Not present; contraction is intrinsic, neural, or hormonal
Ca 2+-binding	Troponin	Troponin	Calmodulin
Regeneration	Limited; satellite cells	None	High

