

# TYPE OF MUSCLES TISSUE:

Skeletal muscle

### Cardiac muscles

### Smooth muscles.







(a) Skeletal muscle

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(b) Cardiac muscle





(c) Smooth muscle



## TYPPES

### Skeletal muscle:

bundles of very long, multinucleated cells with cross-striations. Their contraction is quick, forceful, and usually under voluntary control.

- Cardiac muscle: cross-striated and is composed of elongated (often branched) cells bound to one another at structures called intercalated discs (unique).
   Contraction is involuntary, vigorous, and rhythmic.
- Smooth muscle: consists of collections of fusiform cells that lack striations and have slow, involuntary contractions.



## SKELETAL MUSCLE

Skeletal (or striated) muscle:

- long, cylindrical multinucleated cells (10-100  $\mu$ m diameter).
- Mesenchymal myoblasts--<u>fuse</u>--Myotube--<u>differentiate--</u> Striated muscle fibers.
- Satellite cells: A small population of reserve progenitor cells



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## ORGANIZATION OF SKELETAL MUSCLE

Muscle tissue are organized by connective tissue:

### Epimysium

External sheath of dense irregular connective tissue. Carries vessels, nerves, and lymphatics

### Perimysium

Thin connective tissue layer that immediately surrounds each

bundle of muscle fibers (fascicle)

### Endomysium

Very thin and delicate layer of reticular fibers/scattered fibroblasts. fibers, capillaries form a rich network



## ORGANIZATION WITHIN MUSCLE FIBERS

- Longitudinally, skeletal muscle fibers show striations of alternating light and dark bands
- Contains cylindrical filament bundles called myofibrils that run parallel to the long axis of the fiber
- Dark bands are called A
- The I band is bisected by
- Sarcomere is the repetiti
  Z-discs). 2.5 um in restine



## SKELETAL MUSCLE FIBER

- Myofibrils: consist of an end-to-end repetitive arrangement of sarcomeres.
- The A and I banding in sarcomeres is due to regular arrangement of thick and thin myofilaments (myosin and F-actin).

- Sarcoplasm--- cytoplasm
- Sarcolemma---plasma membrane.



Structure and striation



A: A Band I: I Band N: Nucleus of muscle fik F: Nucleus of fibroblast Z: Z disc H: H zone M: Mitochondria.





- Myosin is a large complex with two identical heavy chains and two pairs of light chains.
- Globular projections containing the four myosin light chains form a head at one end of each heavy chain.
- The myosin heads bind both actin, forming transient crossbridge between the thick and thin filaments, and ATP, catalyzing energy release (actomyosin ATPase activity).
- Several hundred myosin molecules are arranged within each thick filament with overlapping rodlike portions and the globular heads directed toward either end.
- The thin, helical actin filaments are each 1.0-µm long and 8nm wide and run between the thick filaments.
- Each G-actin monomer contains a binding site for myosin.

## Structure





b Thin filament







### SARCOPLASMIC RETICULUM & TRANSVERSE TUBULE SYSTEM

- Sarcoplasmic reticulum contains pumps and other proteins for ca<sup>2+</sup> sequestration and surrounds the myofibrils
- Calcium release--- voltage-gated ca<sup>2+</sup> --- membrane depolarization---motor nerve.
- Ca<sup>2+</sup> release throughout the muscle fiber simultaneously and produce uniform contraction of all myofibrils----sarcolemma has tubular infoldings called transverse or **t-tubules** (fingerlike).
- Penetrate deeply into the sarcoplasm and encircle each myofibril near the aligned A- and I-band boundaries of sarcomeres.
- Adjacent to each t-tubule are expanded terminal cisternae of sarcoplasmic reticulum.
- Complex of a t-tubule with two terminal cisternae is called a **triad**.



## INNERVATION/CONTRACTION

- Myelinated motor nerves branch out within the perimysium, where each nerve gives rise to several unmyelinated terminal twigs that pass through endomysium and form synapses with individual muscle fibers.
- Schwann cells enclose the small axon branches.



- The axon terminal contains mitochondria and numerous synaptic vesicles----neurotransmitter acetylcholine.
- Between the axon and the muscle is the synaptic cleft.
- Adjacent to the synaptic cleft---the sarcolemma---- deep junctional folds--- greater postsynaptic surface area and more acetylcholine receptors.

# INNERVATION/CONTRACTION



- Acetylcholine + receptor-----depolarizing the sarcolemma---muscle action potential.
- muscle action potential moves along the sarcolemma and along T-tubules.
- At triads the depolarization signal triggers the release of Ca<sup>2+</sup> from terminal cisterns of the sarcoplasmic reticulum--- contraction cycle.
- An axon can form MEPs with one or many muscle fibers.
- Innervation of single muscle fibers by single motor neurons--- precise control of muscle activity--extraocular muscles (eye movements).
- Larger muscles---motor axons branch profusely---innervate 100 or more muscle fibers (motor unit).



## INNERVATION/CONTRACTION

- Striated muscle fibers do not show graded contraction---all or none.
- To vary the force of contraction--- fibers within a muscle fascicle do not all contract at the same time.
- large muscles with many motor units---firing of a single motor axon -----tension proportional to the number of muscle fibers it innervates.



**RELAXATION VERSUS CONTRACTION** 





## MUSCLE SPINDLES & TENDON ORGANS

Self study!!!



# TYPES OF MUSCLE FIBERS

### Slow oxidative: Type I

Slow contractions over long periods without fatigue, having many mitochondria, many surrounding capillaries, and much myoglobin

#### Fast oxidative-glycolytic: Type IIa

Rapid, short-term contraction, few mitochondria/capillaries and depending on Oxidative phosphorylation (mainly) and anaerobic metabolism, fibers appear white. Rapid contractions – rapid fatigue due to lactic acid production.

#### Fast glycolytic: Type IIb

Physiological and histological features intermediate between those of the other two types.



	Slow, Oxidative Fibers (Type I)	Fast, Oxidative-Glycolytic Fibers (Type IIa)	Fast, Glycolytic Fibers (Type 11b)
Mitochondria	Numerous	Numerous	Sparse
Capillaries	Numerous	Numerous	Sparse
Fiber diameter	Small	Intermediate	Large
Size of motor unit	Small	Intermediate	Large
Myoglobin content	High (red fibers)	High (red fibers)	Low (white fibers)
Glycogen content	Low	Intermediate	High
Major source of ATP	Oxidative phosphorylation	Oxidative phosphorylation	Anaerobic glycolysis
Glycolytic enzyme activity	Low	Intermediate	High
Rate of fatigue	Slow	Intermediate	Fast
Myosin-ATPase activity	Low	High	High
Speed of contraction	Slow	Fast	Fast
Typical major locations	Postural muscles of back	Major muscles of legs	Extraocular muscles

Myoglobin: globular sarcoplasmic protein similar to hemoglobin which contains iron atoms and allows for  $O_2$ 

