

Skeletal muscles

Histology Of Skeletal Muscle

General Characteristics

- **Type:** Voluntary, striated muscle.
- **Control:** Under the **somatic nervous system**.
- **Location:** Attached to bones; responsible for body movements.
- **Appearance:** Long, cylindrical, multinucleated fibers with visible cross-striations.

Microscopic Structure of Skeletal Muscle Fiber

Muscle Fiber (Cell)

- **Shape:** Long, cylindrical.
- **Size:** Diameter: 10–100 µm; Length: several centimeters.
- **Nuclei:** Multiple, oval, **peripherally located** just under the sarcolemma.
- **Sarcolemma:** Plasma membrane of the muscle fiber.
- **Sarcoplasm:** Cytoplasm containing:
 - **Mitochondria** (abundant for ATP production)
 - **Myoglobin** (oxygen-binding protein)
 - **Glycogen granules** (energy storage)
 - **Myofibrils** (contractile elements)

Myofibrils

- Rod-like structures filling most of the sarcoplasm.
- Composed of repeating units called **sarcomeres**.

Sarcomere: Functional Unit of Contraction

Definition

- The segment between two **Z-lines**.
- Length: ~2.5 µm in resting muscle.

Structural Components (Striations)

Band/Line	Description
Z-line (disc)	Defines boundaries of the sarcomere; anchors thin filaments (actin).
I-band	Light band; contains only thin filaments (actin).

A-band	Dark band; contains thick filaments (myosin), some overlap with actin.
H-zone	Central lighter region within A-band; contains only myosin.
M-line	Middle of H-zone; holds myosin filaments in place.

Filaments

A. Thick Filaments

- **Protein:** Myosin
- **Structure:** Myosin molecules with:
 - Tail region
 - Two globular heads with:
 - **ATPase activity**
 - **Actin-binding sites**

B. Thin Filaments

- **Protein:** Actin + regulatory proteins
- **Components:**
 - **Actin:** Globular (G-actin) monomers polymerize to form filamentous (F-actin) chains.
 - **Tropomyosin:** Rod-shaped protein that covers myosin-binding sites on actin.
 - **Troponin Complex** (three subunits):
 - **TnT:** Binds tropomyosin
 - **TnI:** Inhibits actin-myosin interaction
 - **TnC:** Binds calcium ions (Ca^{2+}) to initiate contraction

Supporting Structures

A. Sarcoplasmic Reticulum (SR)

- Specialized endoplasmic reticulum of muscle fiber.
- **Stores and releases Ca^{2+}** to trigger muscle contraction.

B. T-tubules (Transverse Tubules)

- Invaginations of the sarcolemma.
- Conduct **action potentials** into the muscle fiber's interior.

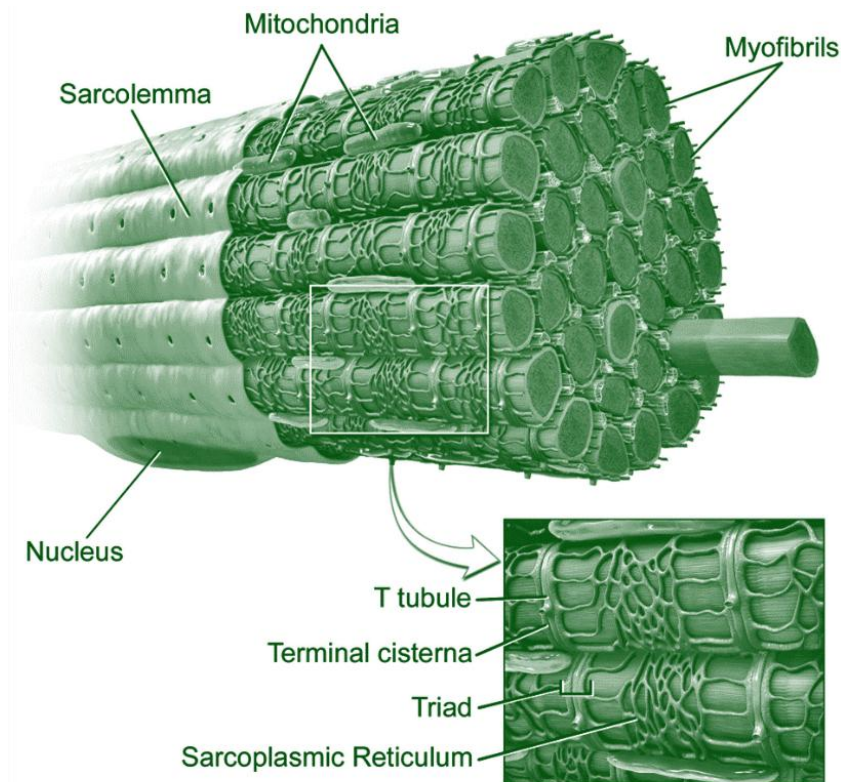
C. Triad

- **Composition:** One T-tubule + Two terminal cisternae of SR.
- **Function:** Key structure in **excitation-contraction coupling**, ensures rapid Ca^{2+} release during contraction.

Organization of Skeletal Muscle

- Skeletal muscle is a type of **striated muscle tissue** responsible for voluntary body movements.
- It is composed of long, multinucleated cells called **muscle fibers**.

The Structure of Skeletal Muscle Can Be Understood at Various Levels



Skeletal muscle fiber

A. Whole Muscle:

- A skeletal muscle is an organ made up of muscle tissue, connective tissue, blood vessels, and nerves.
- The entire muscle is encased in a dense connective tissue layer called the **epimysium**.

B. Fascicles:

- Within the muscle, fibers are grouped into bundles called **fascicles**.
- Each fascicle is surrounded by a connective tissue layer called the **perimysium**.

C. Muscle Fibers:

- Fascicles contain multiple **muscle fibers** (muscle cells), which are long, cylindrical, and multinucleated.

- Each muscle fiber is wrapped in a connective tissue layer called the **endomysium**, containing capillaries and nerves.

D. Myofibrils:

- **Myofibrils** are rod-like structures inside each muscle fiber, responsible for muscle contraction.
- They consist of repeating units called **sarcomeres**.

E. Sarcomeres:

- The **sarcomere** is the functional unit of a myofibril, defined by the area between two Z-lines.
- It contains **thick filaments** (myosin) and **thin filaments** (actin, troponin, tropomyosin), giving skeletal muscle its striated appearance.

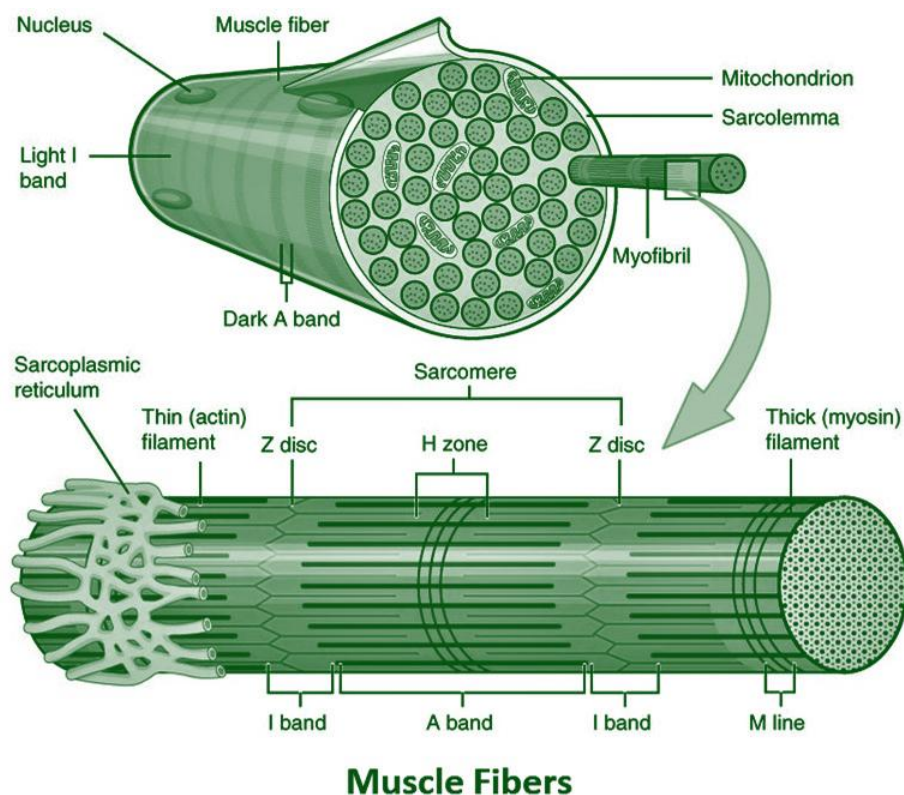
F. Sarcoplasmic Reticulum (SR) and T-Tubules:

- The **sarcoplasmic reticulum (SR)** stores and releases calcium ions, which are crucial for muscle contraction.
- **T-tubules** are extensions of the muscle cell membrane (sarcolemma) that facilitate the rapid

Physiology of muscle contraction

- Muscle contraction is a **complex process** that involves the interaction of **myofilaments (actin and myosin)** within muscle fibers, leading to muscle shortening and force generation.

The Process Can Be Broken Down into Four Key Steps





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