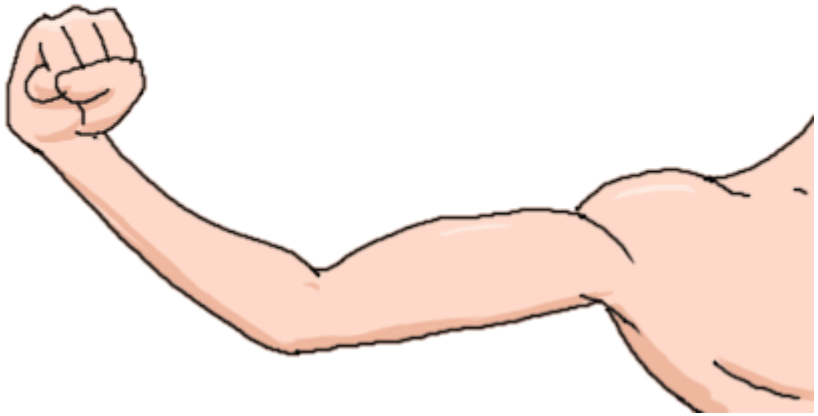
# MUSCLE



# The Three Types of Muscle

**Skeletal**; Attached to the bones, controls body movement
**Cardiac**; Only in heart and moves blood through the circulatory system.
**Smooth**; is the primary muscle of the internal organs and tubes. It affects the movement of material into, out of and within the body.

# SKELETAL MUSCLE

Attached to bones
-Movement
-Breathing
-Posture
-Heat Production

Striated

Voluntary
-under conscious control

## Antagonistic muscles

Usually attached to bones by
tendons made of collagen

Contraction of the muscle moves the skeleton

If the connected bones are brought
closer → flexion

If bones move away → extension

A skeletal muscle is a  collection of muscle cells, muscle fibers.
A muscle fiber is a cylindrical cell with many nuclei.

# Ultrastructure of Muscle

SR concentrates and secretes $Ca^{++}$.

The cytosol also contains many glycogen granules and mitochondria. Glycogen is the storage form of glucose. Mitochondria produce ATP for muscle contraction.

T-tubules brings Aps into interior of muscle fiber.

Cell membrane of a muscle  is sarcolemma.

The cytoplasm is called sarcoplasm.

A muscle fiber contains many myofibrils. Each is composed of several types of proteins organized into repeating contractile structure called **sarcomeres**.

Myosin are motor proteins. Which create movement.  250 myosins join to form the thick filaments.

Actin makes up the thin filament with tropomyosin and troponin attached.

Titin and  nebulin anchor and stabilize.

Actin and myosin form crossbridges

Each sarcomere has;

**Z disks**: 2 Z disks have filaments between them. They are zigzag proteins and attachment sites for thin filaments. ‘zwischen’

**I bands**: lightest band and represent a region with thin elements. ‘isotropic’

**A band**: darkest band, the entire length of thick filament ‘anisotropic’

**H zone**: central region of A band, thick filaments only ‘helles’

**M line**: attachement site for thick filament (Z disk for thin filaments) ‘mittel’

# Summary of Muscle Contraction

**Muscle tension:** force created by muscle
**Load:** weight that opposes contraction
**Contraction:** creation of tension in muscle, active process, needs energy input from ATP
**Relaxation:** release of tension

Contraction of muscles enables us to create force to move or to resist a load.

1. Ach signal from a somatic neuron into an electrical signal in the msucle fiber.
2. Is the process in which Aps initiate Ca signals.
3. Sliding filament theory of contraction.

# Anatomy of the Neuromuscular Junction

The neuromuscular junction consists of axon termials, motor end plates on the muscle membrane, and Schwann cell sheats.
Motor end Plate is a region of muscle membrane that contains high concentrations of Ach receptors.

The post-synaptic membrane is **folded**. This is to increase the surface area and therefore the number of receptors (*in the synaps the post-synaptic membrane is not folded*)

The post-synaptic membrane always **depolarizes** and never hyperpolarizes (*in the synaps it can also hyperpolarize*)

There is only **one type** of transmitter: Acetycholine (*in synapses in the brain, there are many types of transmitters*)

Transmission from nerve to muscle is **always** successful (*in the chemical synaps, successful transmission depends on the number of EPSP's and IPSP's generated*).

# Mechanism of Signal Conduction

- Axon terminal *(of presynaptic cell)*
- Motor end plate – *series of folds in the plasma membrane of the postsynaptic cell*
- Stimulates fiber contraction as a result in increased intracellular calcium concentration

At its resting length, within each sarcomere, ends of thick and thin filaments overlap slightly. In the relaxed state, a sarcomere has a large I band and an A band whose length is the length of thick filament.

When the muscle contracts, thick and thin filaments slide past each other.
Z disks move closer together as the sarcomere shortens.
I bans and H zone almost disappear.
The length of A band remains constant.
Sliding of thin actin filaments along the thick myosin filaments as the actin filaments move toward M line in the center of the sarcomere.
It is why this process is called **sliding filament theory**.

# The Molecular Basis of Contraction

Tight binding in the rigor state. The crossbridge is at a 45° angle relative to the filaments.

ATP binds to its binding site on the myosin. Myosin then dissociates from actin.

The ATPase activity of myosin hydrolyzes the ATP. ADP and $P_i$ remain bound to myosin.

The myosin head swings over and binds weakly to a new actin molecule.

The crossbridge is now at 90º relative to the filaments.

Release of $P_i$ initiates the power stroke. The myosin head rotates on its hinge, pushing the actin filament past it.

At the end of the power stroke, the myosin head releases ADP and resumes the tightly bound rigor state.

# Excitation-Contraction Coupling

Somatic motor neuron releases ACh at neuromuscular junction.

Net entry of $Na^+$ through Ach receptor-channel initiates a muscle action potential.

Action potential in t-tubule alters conformation of DHP receptor.

DHP receptor opens $Ca^{2+}$ release channels in sarcoplasmic reticulum and $Ca^{2+}$ enters cytoplasm

$Ca^{2+}$ binds to troponin, allowing strong actin-myosin binding.

Myosin heads execute power stroke.

Actin filament slides toward center of sarcomere.

L-type Ca channels, also called dihydropyridine receptors

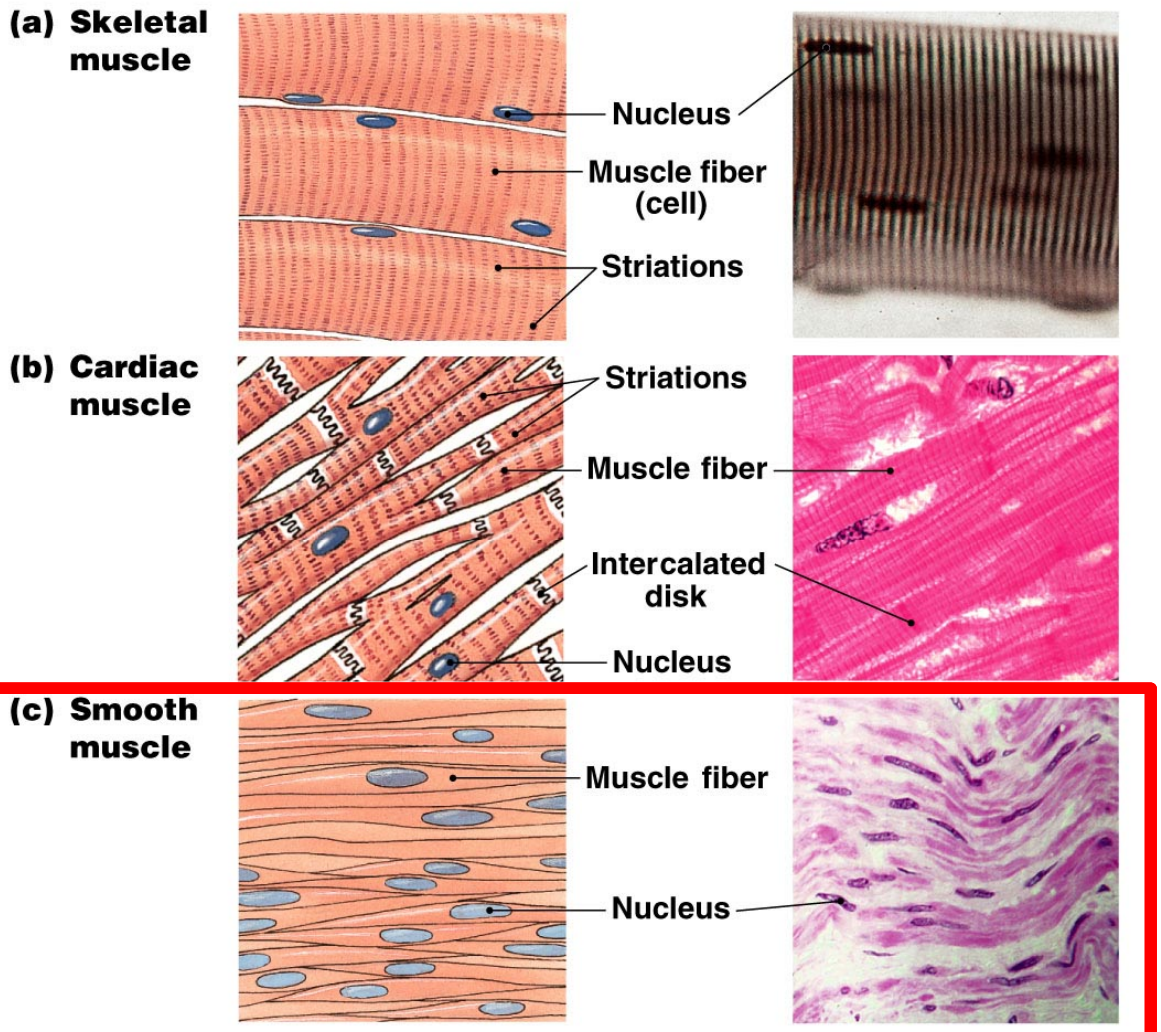
SR Ca release channels are also known as ryanodin receptors.

## Motor Units: Fine motor movements have more innervations

- A group of muscle fibers and somatic motor neuron that controls them compose a motor unit.
- When somatic neuron fires an AP, all muscle fibers in the motor unit contract.
- One somatic neuron innervates multiple fibers, each muscle fiber is innervated by only a single neuron.

# Mechanics of Body Movement

- **Isotonic** contractions creates force and moves a load.
  - Concentric action is a shortening action- *contraction that flexes the joint while working against a load*
  - Eccentric action is a lengthening action- *contraction that extends the joint while resisting a load*
- **Isometric** contractions create force without moving a load- *the muscle produces tension and contracts but does not move the joint.*

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# Smooth Muscle Locations

- Vascular
- Gastrointestinal
- Urinary
- Respiratory
- Reproductive
- Ocular

- Contract and relax much more slowly
- Uses less energy- *has fewer mitochondria, can maintain maximum tension while using only a small percentage of the total maximum cross bridge*
- Maintain force for long periods without fatiguing- allows organs to be tonically contracted and maintain tension for a long time (sphincter muscles)
- Have small, spindle-shaped cells with a nucleus
- Are not arranged in sarcomeres
- May be initiated by electrical or chemical signals or both
- Is controlled by the ANS
- Lacks specialized receptor regions
- $Ca^{2+}$ comes from the extracellular fluid as well as from SR.
- $Ca^{2+}$ signal initiates a cascade that ends with phosphorylation of myosin light chains and activation of myosin ATPase.