# Neuromuscular Function

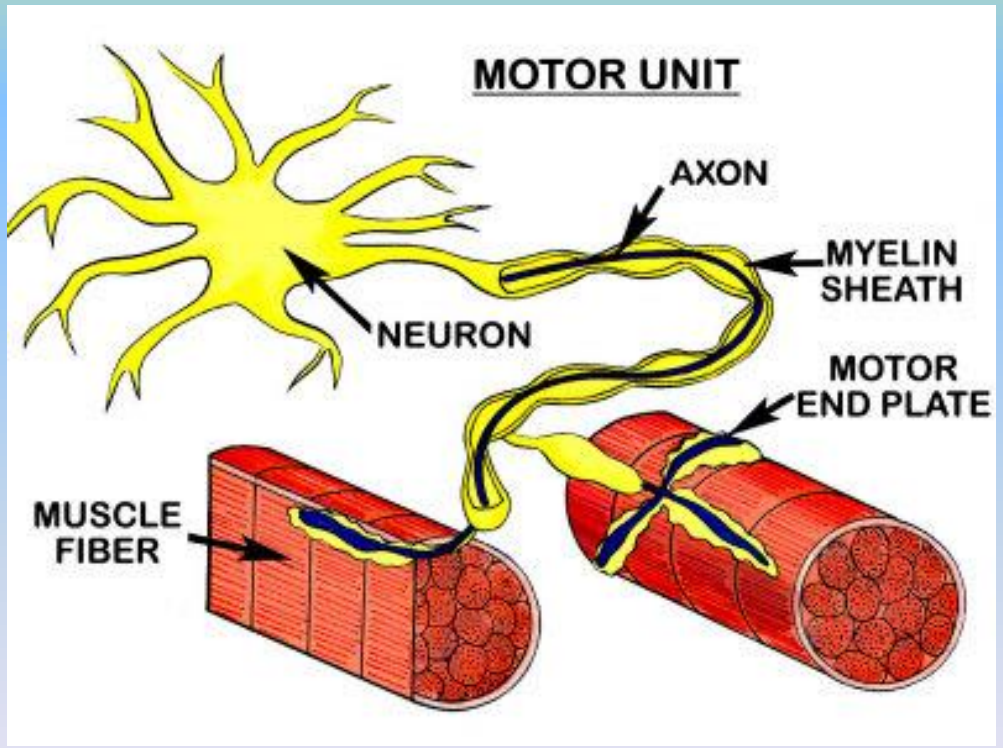
Draw and label a diagram of a motor unit.

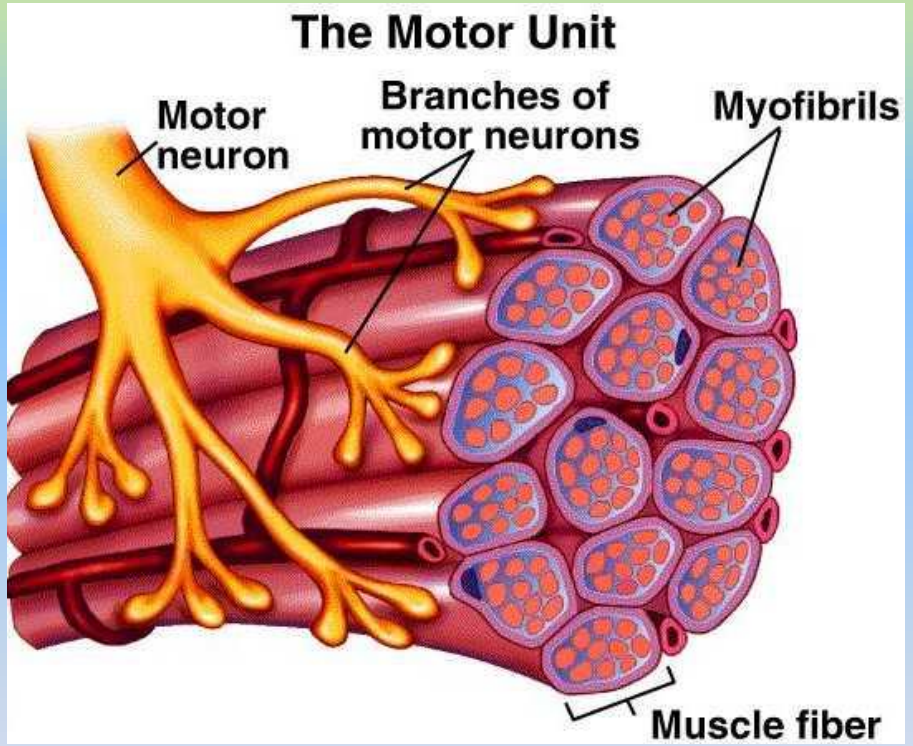
Terms to know:

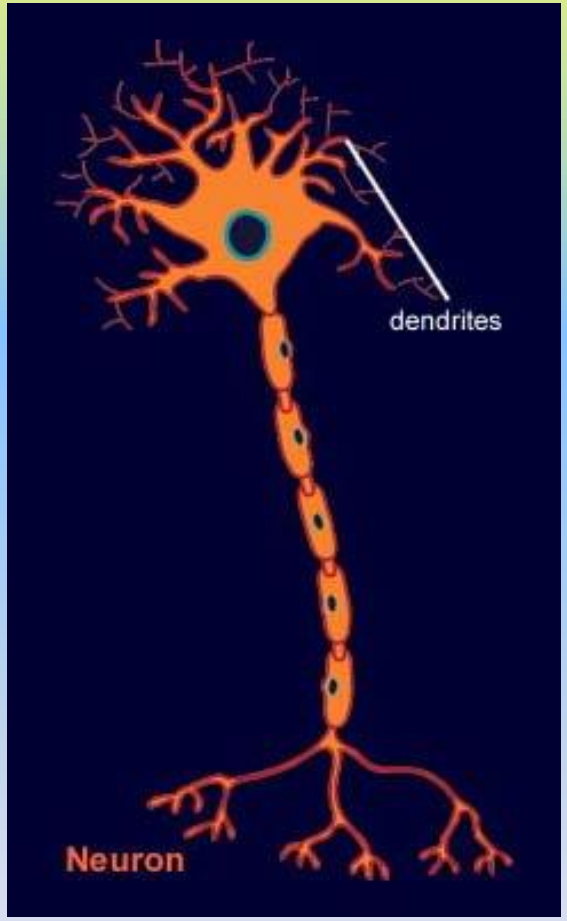
- dendrite
- cell body (soma)
- nucleus
- axon
- motor end plate
- synapse

# Neuromuscular Function

Draw and label a diagram of a motor unit.

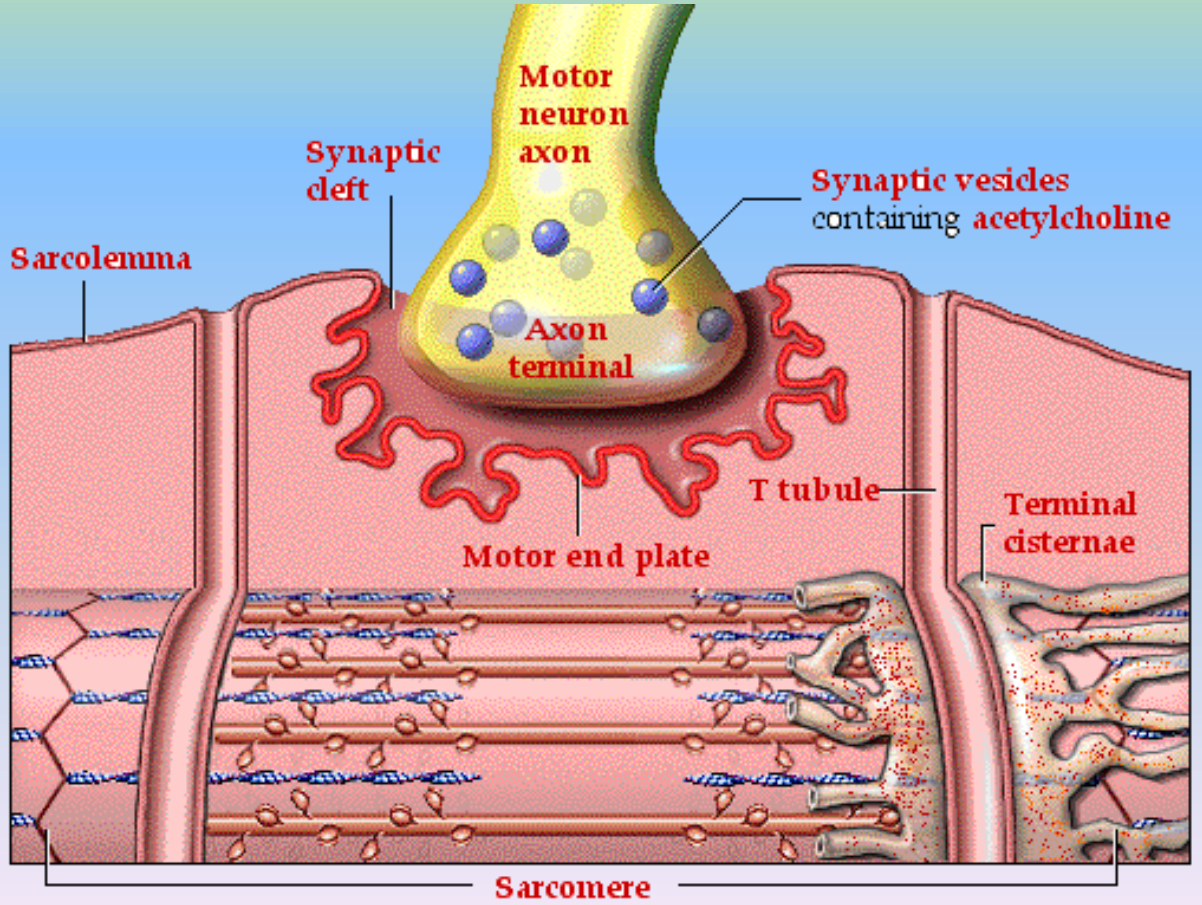



The Motor Unit
Motor neuron
Branches of motor neurons
Myofibrils
Muscle fiber

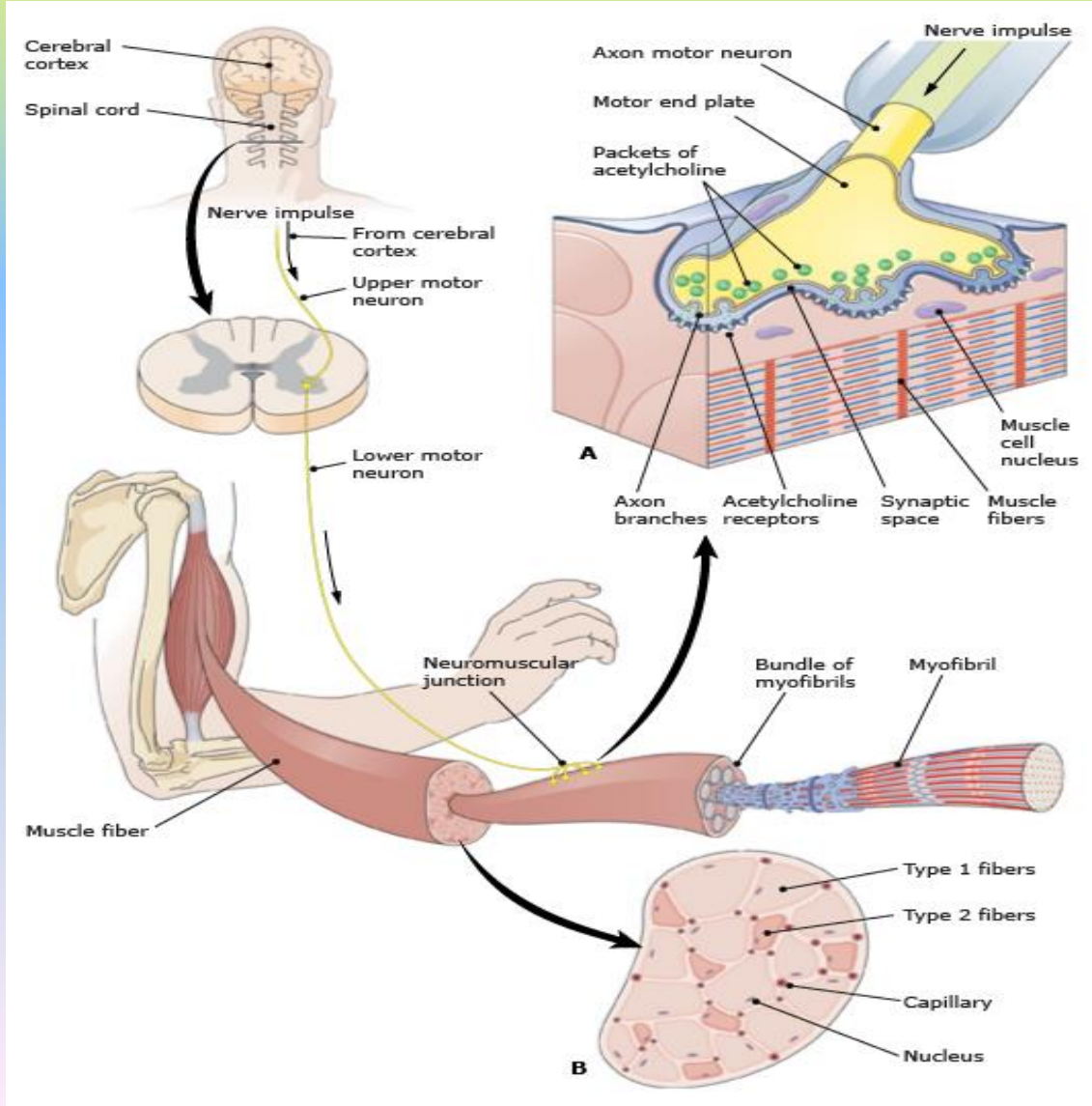

dendrites
Neuron

# Neuromuscular Function

Draw and label a diagram of a motor unit.



# Neuromuscular Function



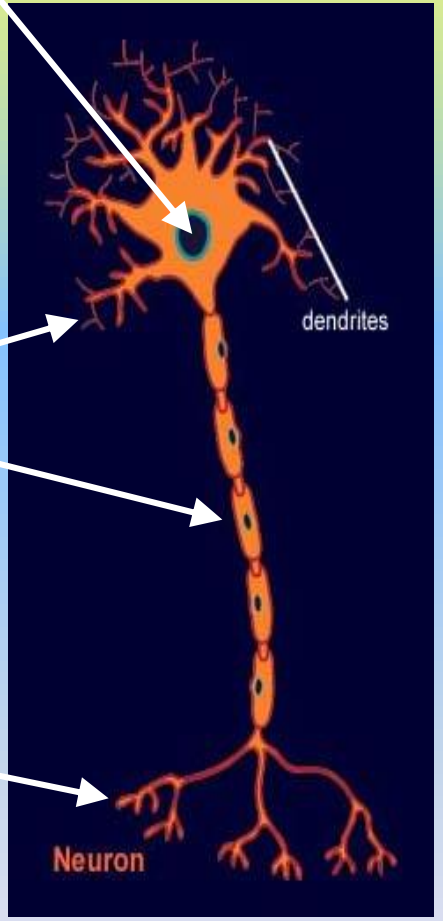
**Nucleus –** a membrane enclosed organelle that contains most of the cells genetic material

**Axon -** A long fibre of a nerve cell (a neuron) that acts somewhat like a fiber-optic cable carrying outgoing (efferent) messages. The neuron sends electrical impulses from its cell body through the axon to target cells. Each nerve cell has one axon. An axon can be over 20 cm (a foot) in length, which for the human body is remarkably long.

**Dendrites** - bring information to the cell body

**Motor end plate** – or A **neuromuscular junction** (**NMJ**) is the synapse or junction of the axon terminal where a neural cell (neuron) communicates with a target cell.

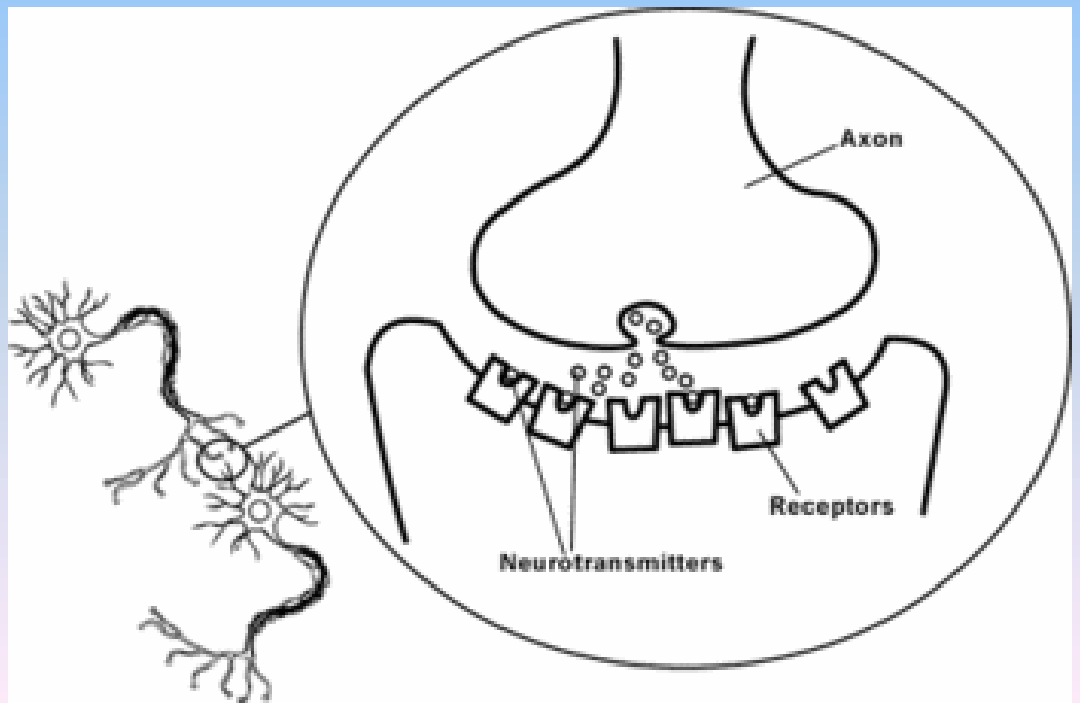
Synapse - The small junction across which a nerve impulse passes from one cell to another



# Neuromuscular Function

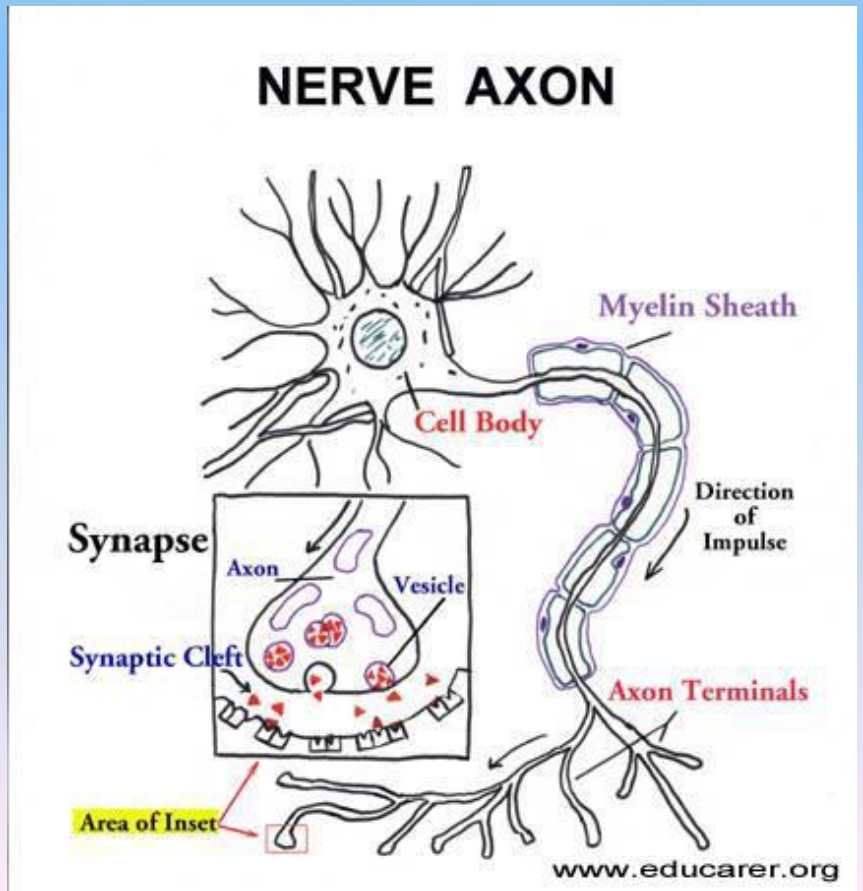
Role of neurotransmitters in stimulating muscle contraction.

- Neurotransmitters are chemicals that are used for communication between a neuron at the synapse and another cell.



# Neuromuscular Function

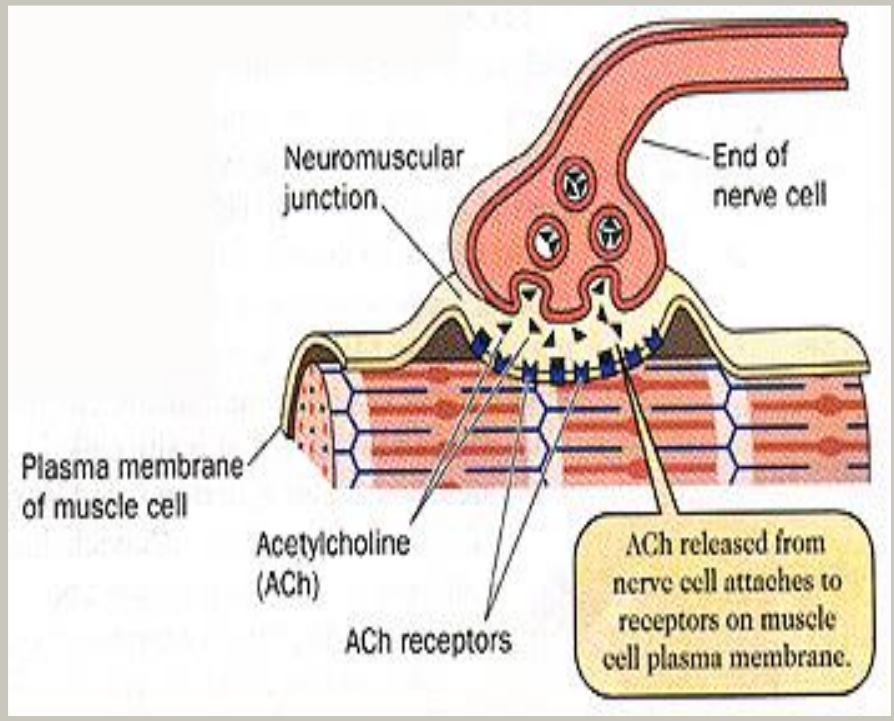
Role of neurotransmitters in stimulating muscle contraction.



# Neuromuscular Function

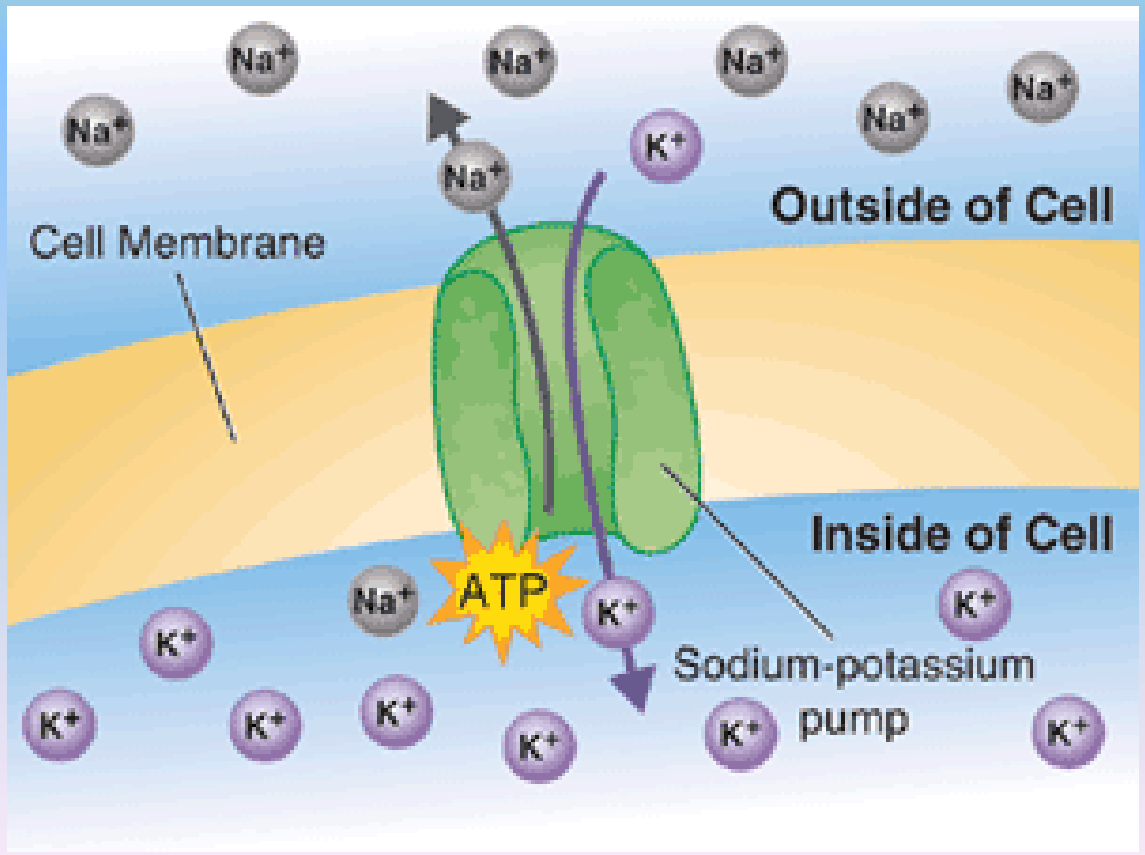
Role of neurotransmitters in stimulating muscle contraction.

Acetylcholine (Ach): Acetylcholine is the primary neurotransmitter for the motor neurons that innervate skeletal muscle and for most parasympathetic neurons. It is generally an excitatory neurotransmitter, but it can have inhibitory effects at some parasympathetic nerve endings, such as the heart.



# Neuromuscular Function

Role of neurotransmitters in stimulating muscle contraction.

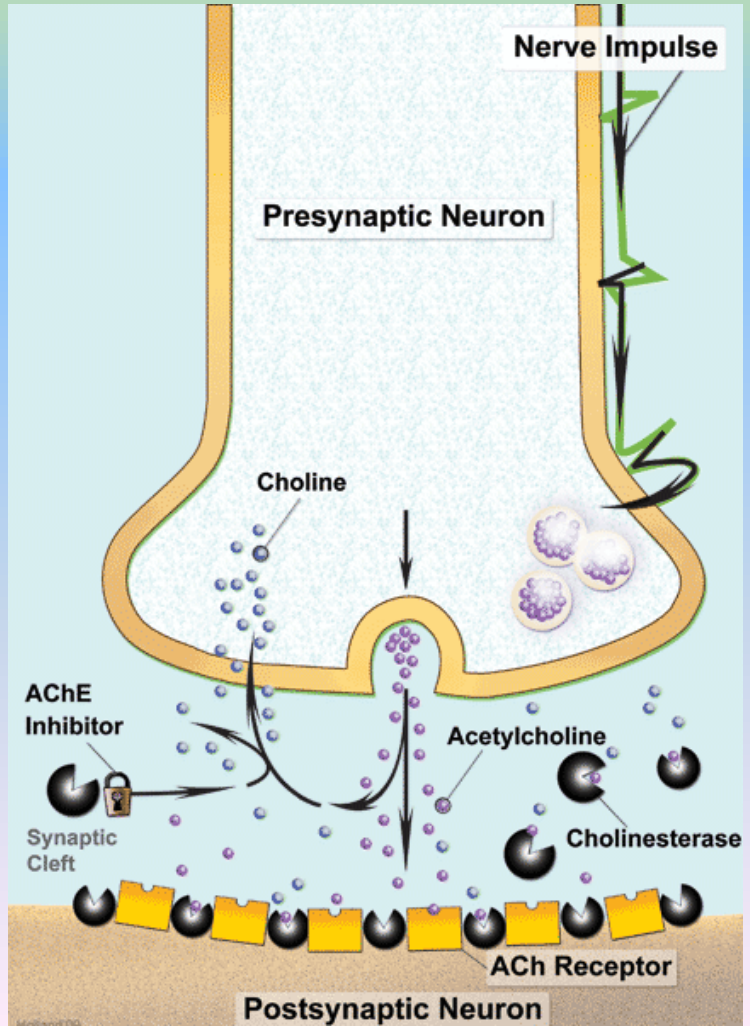


# Neuromuscular Function

Role of neurotransmitters in stimulating muscle contraction.

**Cholinesterase** is an enzyme that catalyzes the hydrolysis of the neurotransmitter acetylcholine into choline and acetic acid, a reaction necessary to allow a neuron to return

to its resting state after activation.



# Neuromuscular Function

## Sliding Filament Theory

**Terms to know:**

myofibril
myofilament
sarcomere
actin/myosin
H zone
A band
Z line
tropomyosin
troponin
sarcoplasmic reticulum
sarcoplasm
sarcolemma
calcium ions
ATP

# Neuromuscular Function

## Sliding Filament Theory

**Tropomyosin** is an actin-binding protein that regulates actin mechanics. (found on the actin protein)

**Troponin** (a protein)is attached to the protein tropomyosin and lies within the groove between actin filaments in muscle tissue. In a relaxed muscle, tropomyosin blocks the attachment site for the myosin crossbridge, thus preventing contraction.

# Neuromuscular Function

## Sliding Filament Theory

- When the muscle cell is stimulated to contract by a nerve, calcium channels open in the sarcoplasmic reticulum and release calcium into the sarcoplasm (cytoplasm) of a striated muscle cell. Some of this calcium attaches to troponin, causing a physical change that moves tropomyosin out of the way so that the cross bridges can attach to actin and produce muscle contraction.
- Difference between Smooth ER and sarcoplasmic ER is the smooth ER synthesizes molecules and the sarcoplasmic reticulum stores and pumps calcium ions. The sarcoplasmic reticulum contains large stores of calcium, which it stores and then releases when the muscle is innervated. This has the effect of triggering muscle contraction.

# Neuromuscular Function

## Sliding Filament Theory

- Explains how muscle fibers shorten during a contraction.
- When the myosin cross-bridges are activated, they bind with actin, resulting in a conformational change in the cross-bridge, which causes the myosin to tilt and to drag the thin filament toward the center of the sarcomere.

Actin - Myosin Crossbridge Video

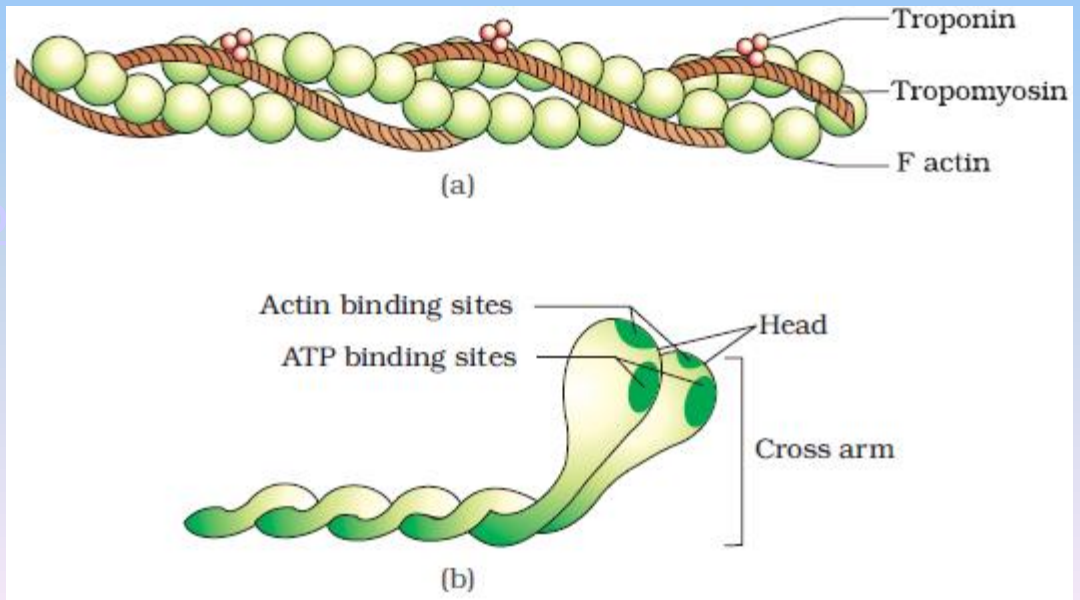



**Figure 20.3** (a) An actin (thin) filament (b) Myosin monomer (Meromyosin)

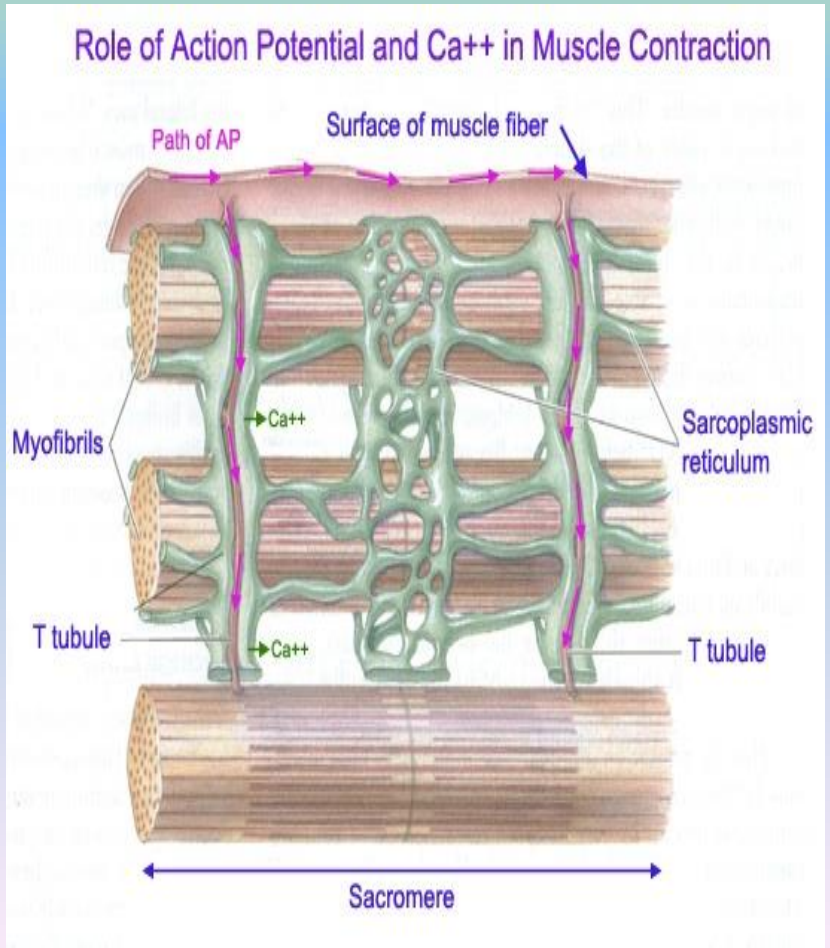
# Neuromuscular Function

## Sliding Filament Theory

Steps of a muscle contraction:

*$Ca^{++}$ are released by the sarcoplasmic reticulum.

*$Ca^{++}$ binds to troponin preventing the blocking action of tropomyosin.



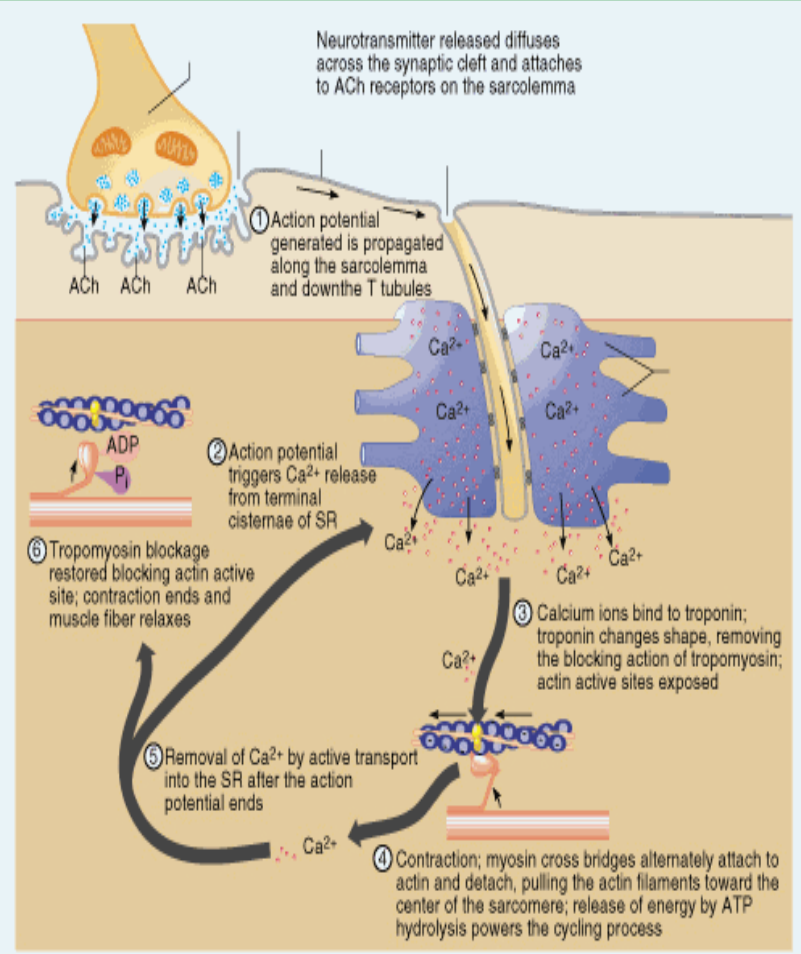
# Neuromuscular Function

## Sliding Filament Theory

*myosin heads can now attach to active sites on the actin filament.

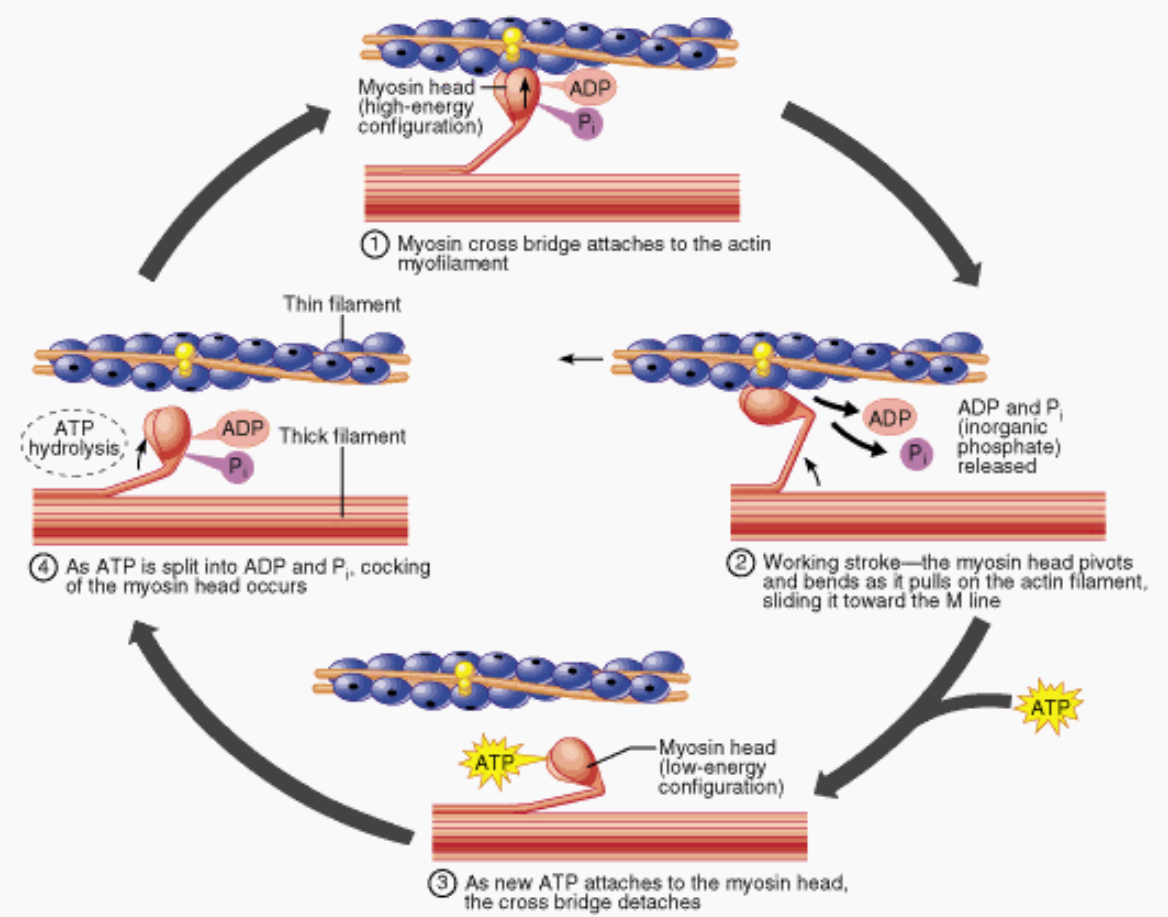
*using ATP, the myosin heads pulls on the actin filament.

*myosin head releases the actin when a new ATP is formed.



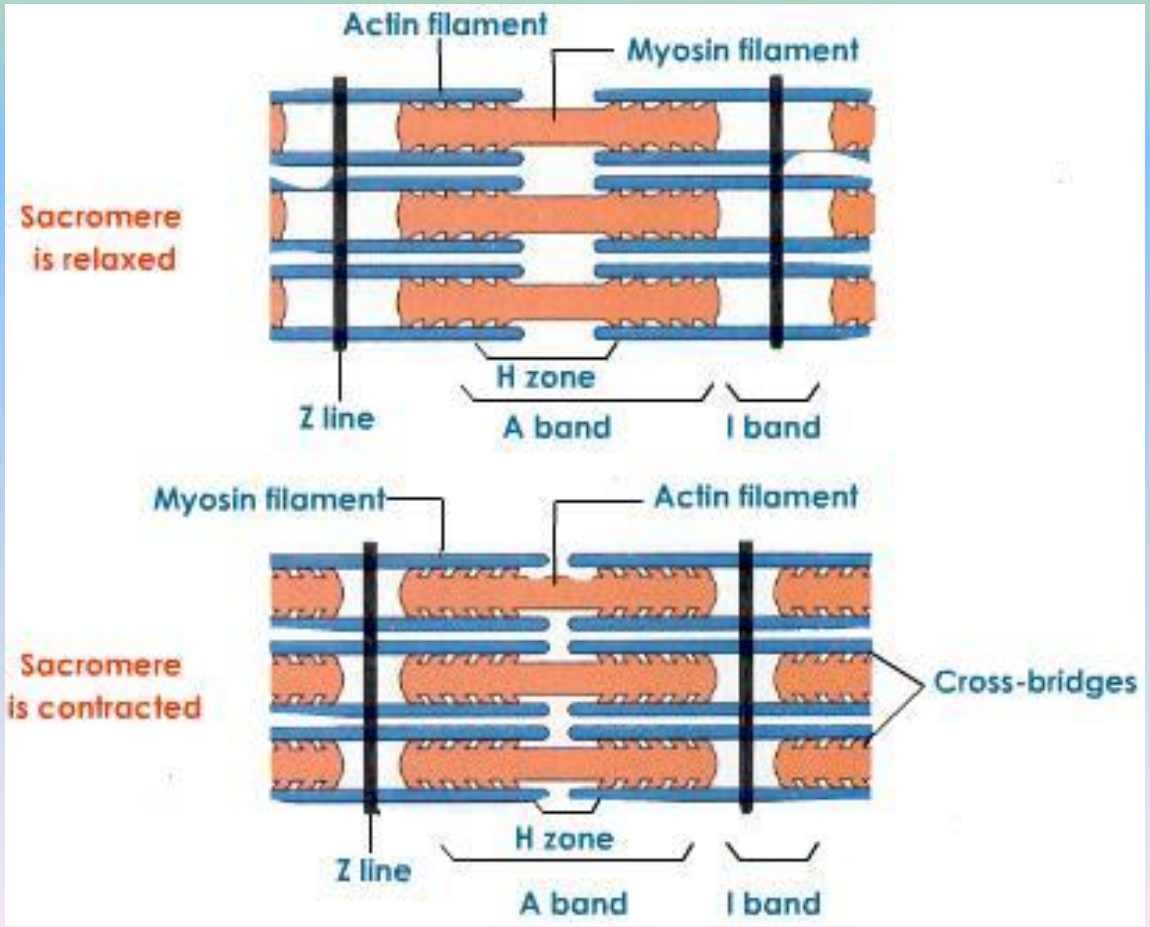
# Neuromuscular Function

## Sliding Filament Theory



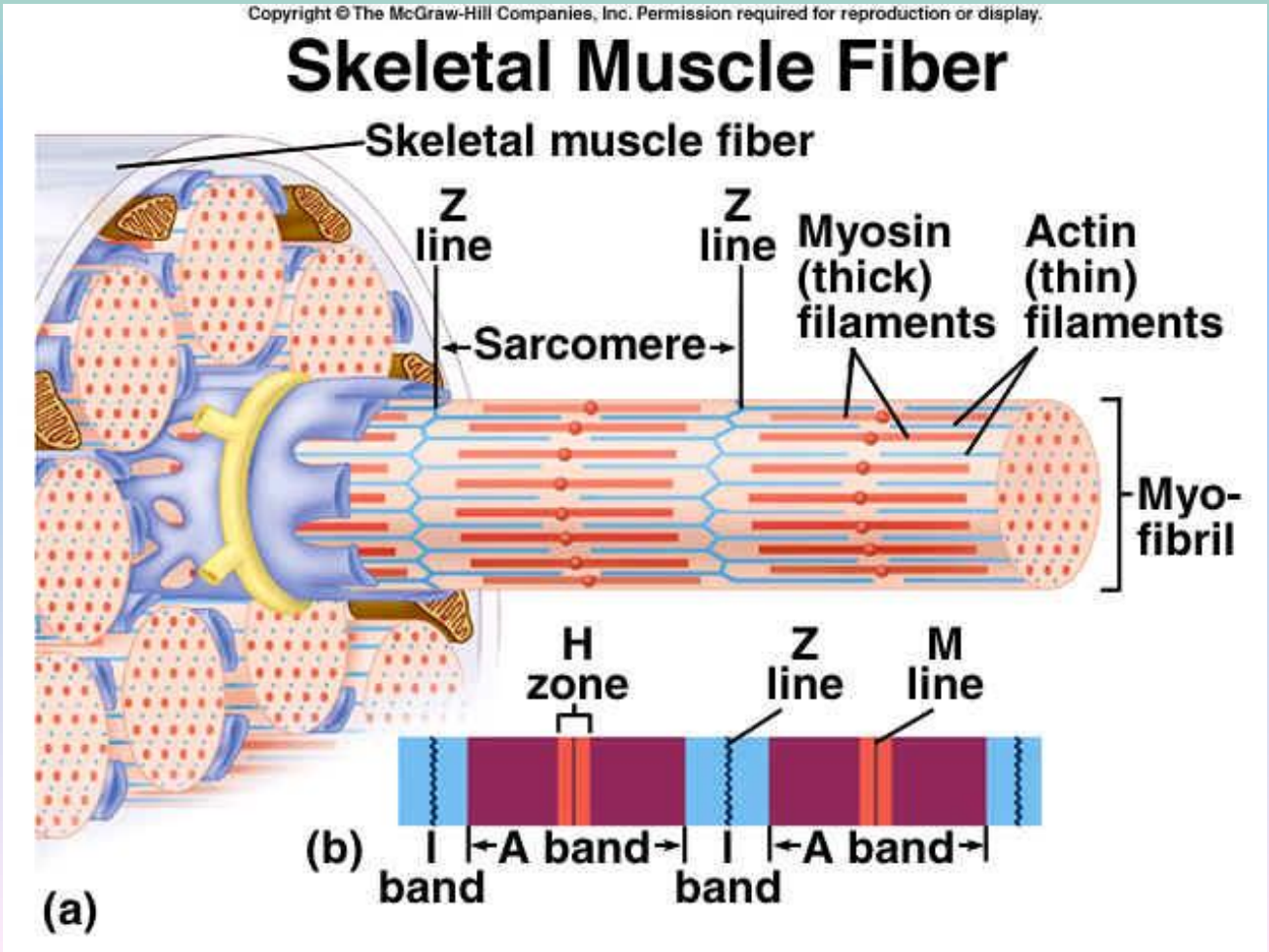
# Neuromuscular Function

## Sliding Filament Theory



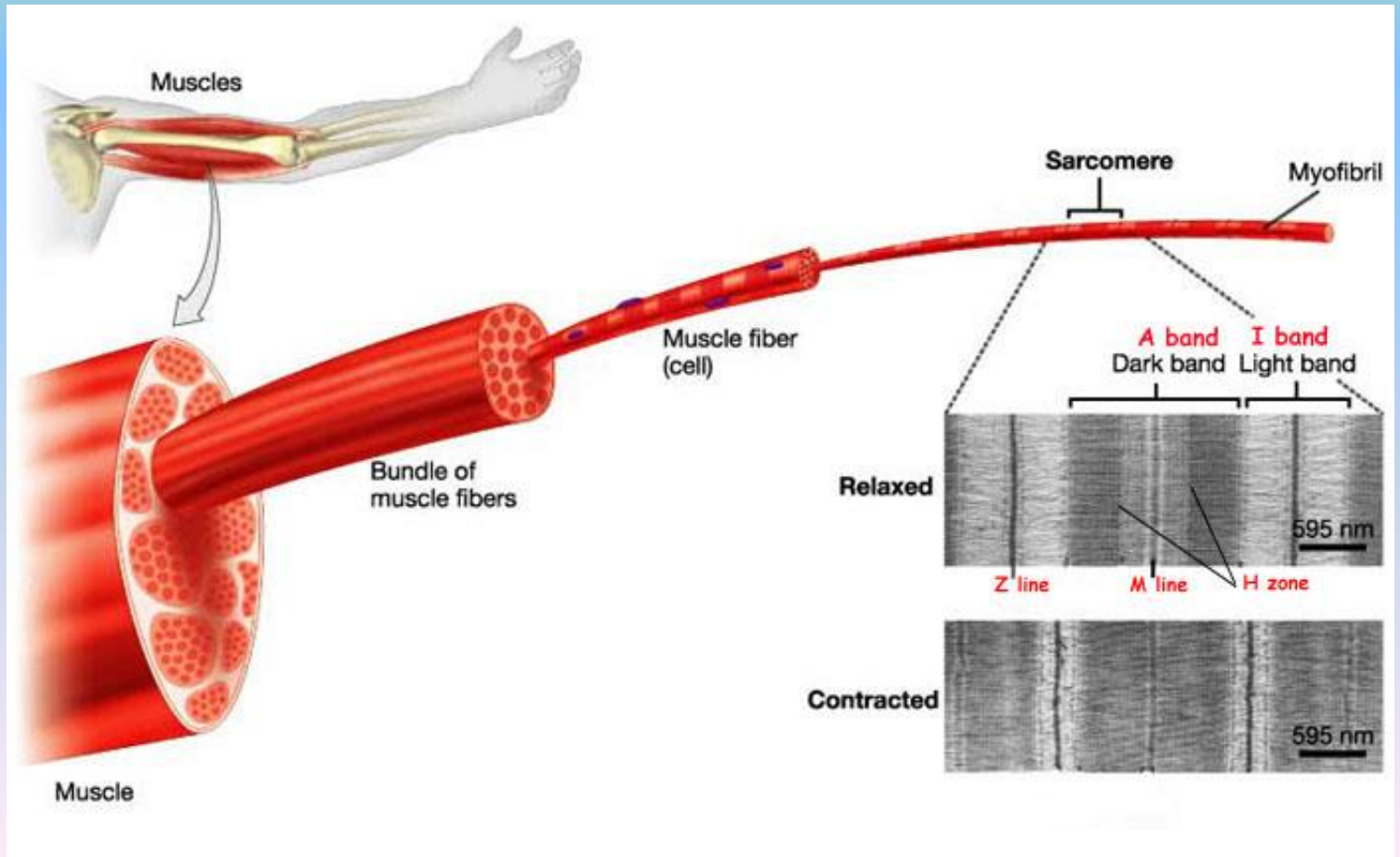
# Neuromuscular Function

## Sliding Filament Theory



# Neuromuscular Function

## Sliding Filament Theory



# Neuromuscular Function

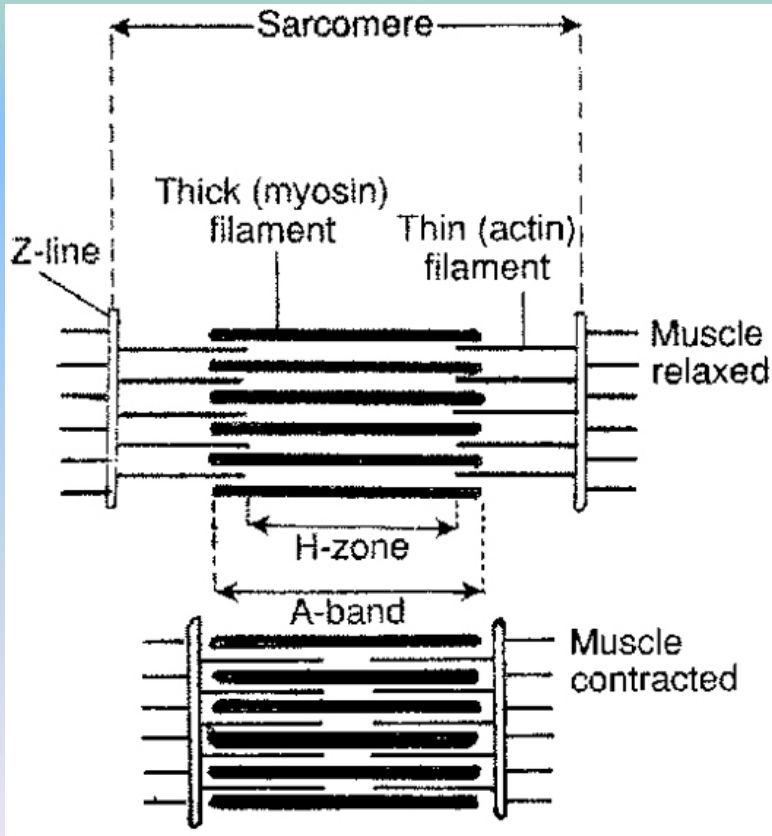
## Sliding Filament Theory

- Immediately after the myosin head tilts, it breaks away from the active site, rotates back to its original position, and attaches to a new active site farther along the actin filament. Repeated attachments and power strokes cause the filaments to slide past one another, giving rise to the term *sliding filament theory*. This process continues until the ends of the myosin filaments reaches the Z-disks, or until the Calcium is pumped back into the sarcoplasmic reticulum.

# Neuromuscular Function

## Sliding Filament Theory

- During this sliding (contraction), the thin filaments move toward the centre of the sarcomere and protrude into the H-zone, ultimately overlapping. When this occurs, the H zone is no longer visible.



# Neuromuscular Function

## Slow & Fast Twitch Fibers

Slow Twitch: (type 1)

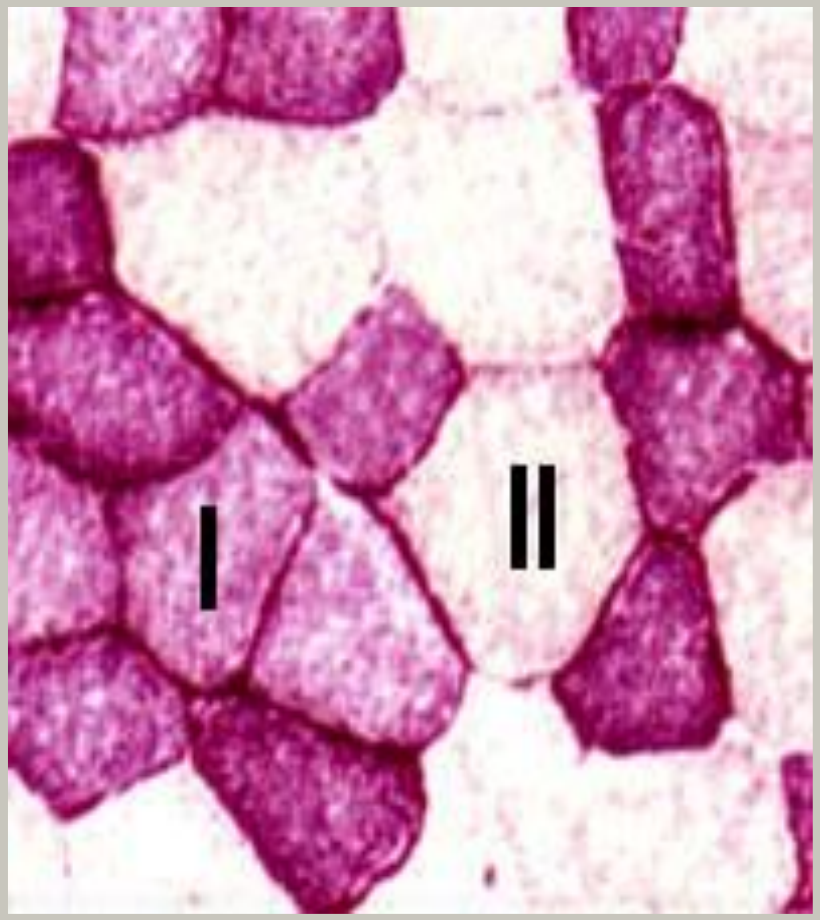
*smaller in diameter

*reddish color

*use aerobic resp. for ATP supply

*contain more mitochondria

*fire slowly, but take long to fatigue.



# Neuromuscular Function

## Slow & Fast Twitch Fibers

**Fast Twitch**: used for short explosive movements, stop and go sports.

Type IIA:

*large diameter

*white in color

*less mitochondria

*uses both anaerobic and aerobic energy transfer

Type IIB:

*similar physical characteristics as Type IIA, but strictly uses the glycolytic anaerobic system.

- less mitochondria

# Neuromuscular Function

## 3 Muscle Fiber Types

| **Fiber type** | **Slow Twitch (Type I)** | **Fast twitch A (Type IIA)** | **Fast twitch B (Type IIB)** |
|---|---|---|---|
| Contraction time | slow | fast | Very fast |
| Fatigue resistance | high | intermediate | Low |
| Used for: | Aerobic activity | Long term anaerobic | Short term anaerobic |
| Capillary density | High | Intermediate | Low |
| Mitochondria density | High | Medium | Low |

# Neuromuscular Function

## Slow & Fast Twitch Fibers

Fast-twitch, or type II, fibers (sometimes referred to as "White") have fewer mitochondria, are capable of more powerful (but shorter) contractions, metabolize ATP more quickly, have a lower capillary to volume ratio, and are more likely to accumulate lactic acid. Weightlifters and sprinters tend to have more type II fibers. Type II fibers are distinguished by their primary sub-types

## Muscle fiber composistion

How do we determine our muscle fiber type?

1. Muscle biopsy (best method)
2. Testing an athletes **muscle groups** for different muscle fiber properties. (chart from question 1)

Example:
establish a 1RM of any exercise.
lift 80% of 1RM as many times as possible.

7 or less reps most likely more than 50%FT fibers
12 or more reps most likely more than 50% ST fibers

## Training specific muscle fiber types

### Training recommendations:

Increase neuromuscular component of maximum strength:
95% of 1RM, 1-3 rep range.

Increasing maximum strength by stimulating muscle hypertrophy:
80% of 1RM, 5-8 rep range.

Increasing muscle size with moderate strength gains:
<80% 1RM will vary, 6-12 rep range.

End of 4.1

- The musculoskeletal system is the arrangement of bones, joints and muscles that permits movement of the human body in sport and exercise

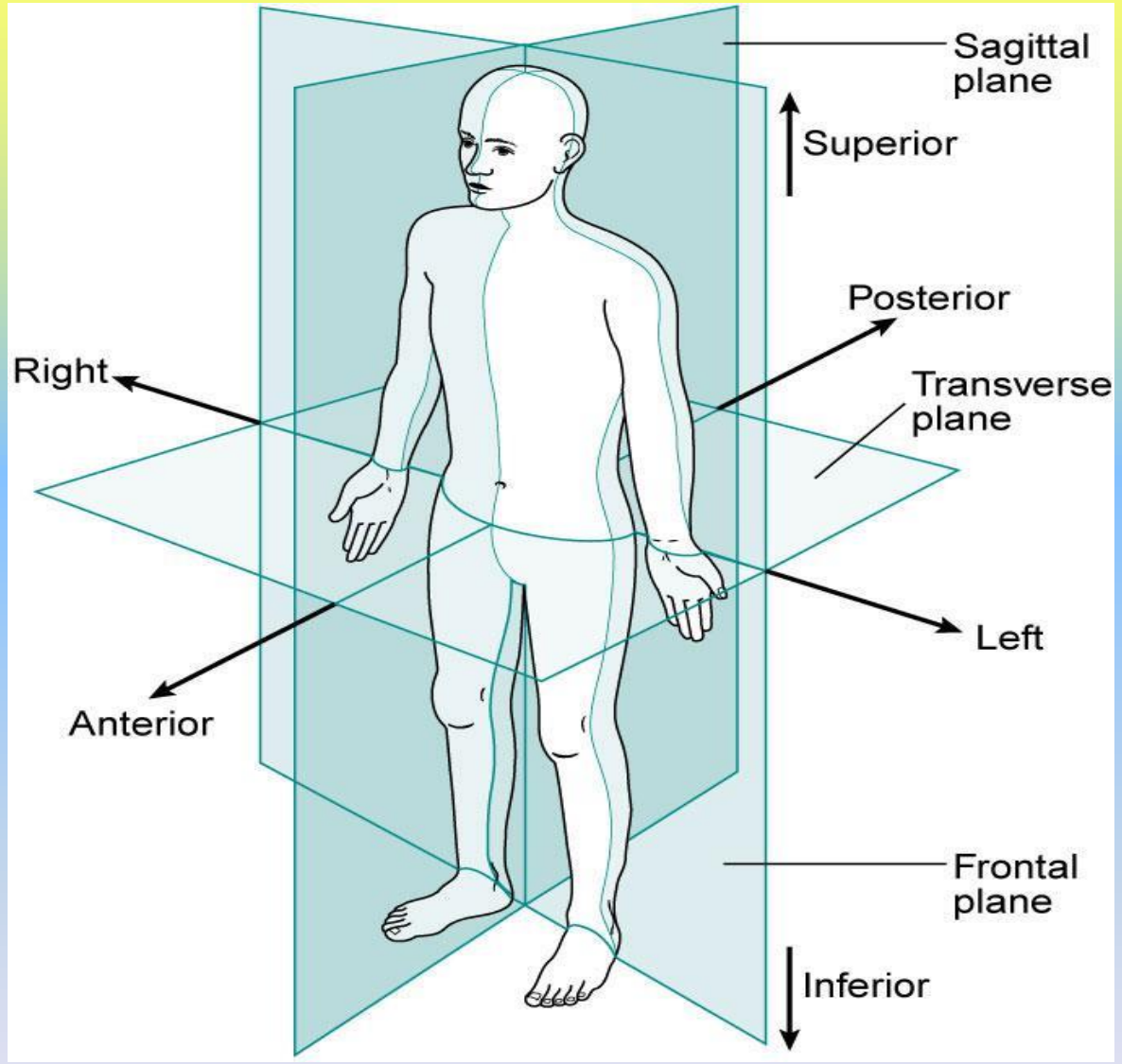
- The body segments are articulated by the **synovial joints** at which two or more bones meet

- Usually movement consists **of rotation of one segment relative to another at the joint**

- The rotation is caused by forces originating from the muscles, other parts of the body or external actors (such as gravity, sporting implements or other people)

- Synovial joints can be classified depending on how many **axes of rotation the bones have**

| TERM | TYPE | EXAMPLE | STRUCTURE |
|---|---|---|---|
| **Non-Axial** | Gliding Joints | Between the carpal bones in the palm of the hand | • The bones slide in relation to each other<br>Therefore, there are no axes of rotation in this type of joint |
| **Uniaxial** | Hinge and Pivot Joints | The elbow and the radio-ulnar joint | • There is only one axis of rotation<br>This means that the structure of the bones at the joint restricts rotation to movement |
| **Biaxial** | Condylar and Saddle Joints | The knee and the base of the thumb | • There are two kinds of axis rotation<br>Therefore, the ones can move in two different ways |
| **Triaxial** | Ball and Socket Joints | The shoulder and the hip | • There are three kinds of axis rotation<br>Therefore, these bones permit the greatest movement, as they allow the limbs attached at them to move through a large volume of space |




# Axes of Rotation

Anteroposterior axis – going from front to back

Transverse axis – going from left to right

Vertical axis – going from top to bottom

## Alternate Names for planes

Sagittal Plane = median

Frontal Plane = coronal

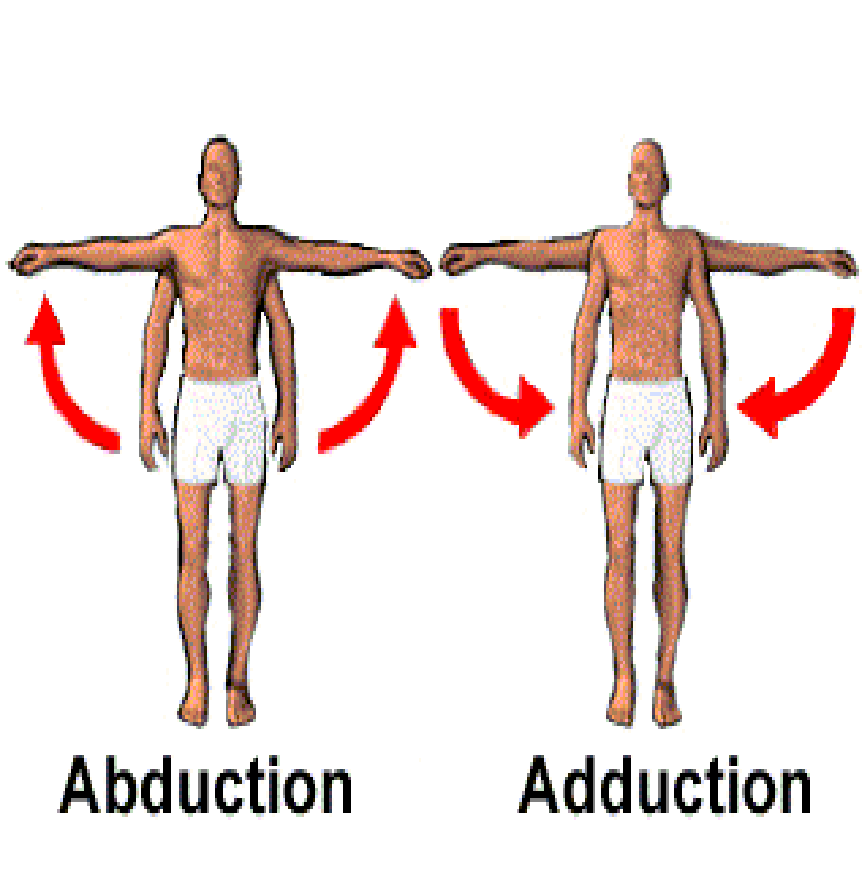
# Neuromuscular Function

## Synovial Joint Movements

Types of Joint Movement:

Abduction: movement away from the body's center.

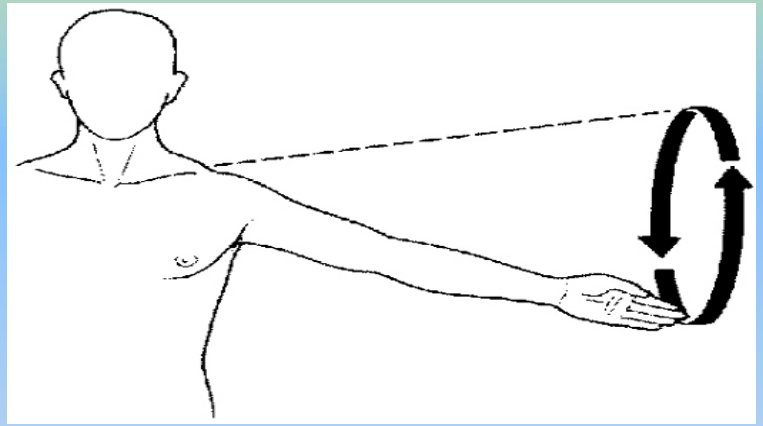
Adduction: movement towards the body's center.



# Neuromuscular Function

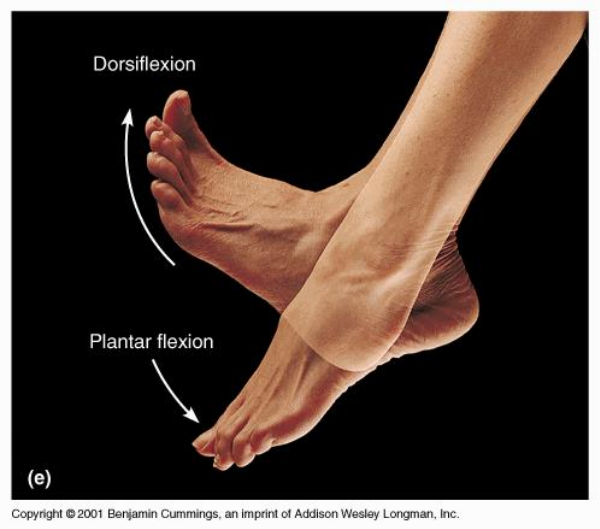
## Synovial Joint Movements

Circumduction: making circular movements.



Dorsiflexion: movement of the ankle elevating the sole. (digging in the heel)

Plantar flexion: extending the ankle and elevating the heel. (standing on tiptoes)

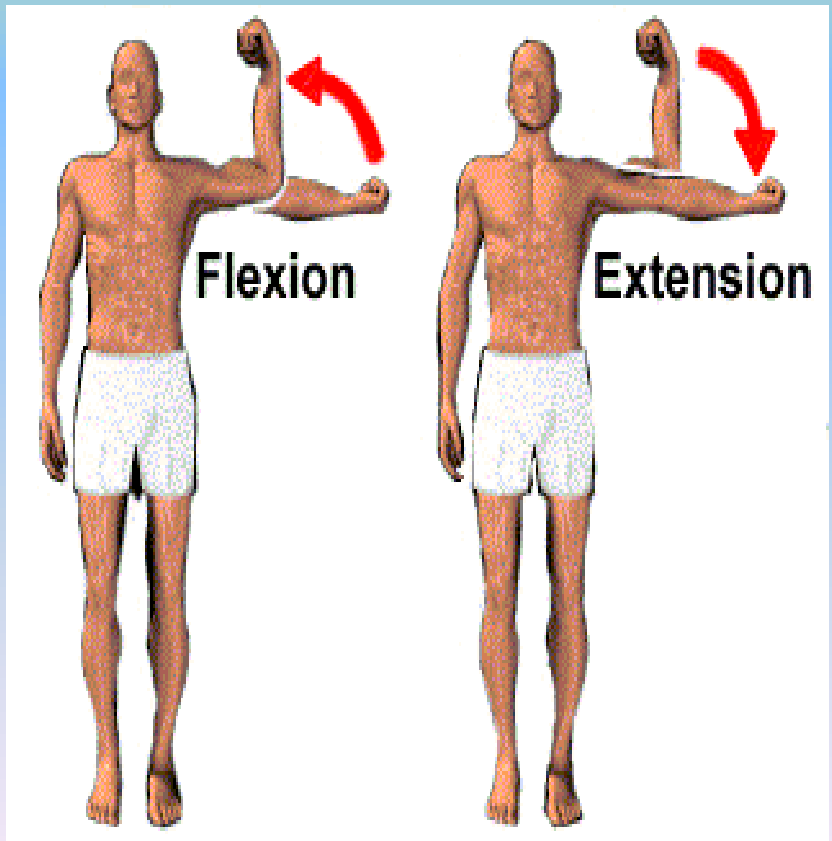


# Neuromuscular Function

## Synovial Joint Movements

Extension: movement that increases the angle between articulating elements opening the joint.

Flexion: decreases the angle between articulating elements and closes the joint.



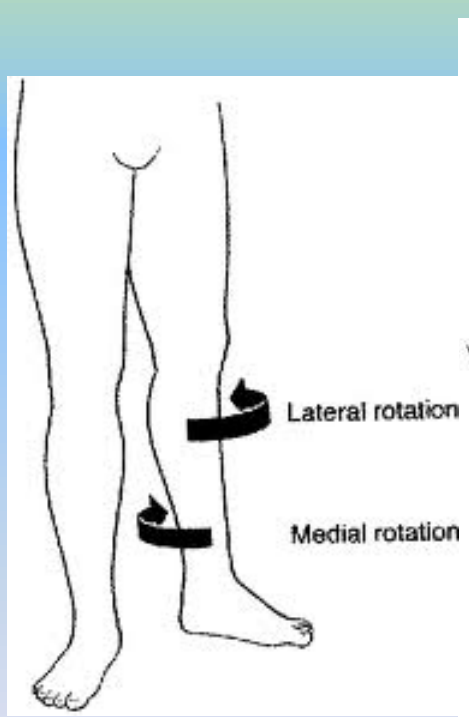
# Neuromuscular Function

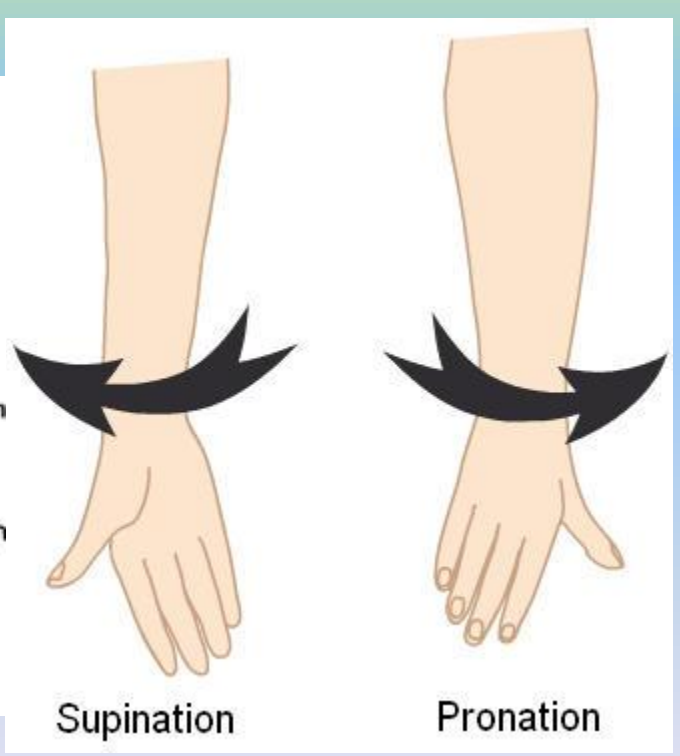
## Synovial Joint Movements

Pronation: rotating the palm down (medially).

Supination: rotating the palm up (laterally).

Rotation: turning the body around a longitudinal axis.



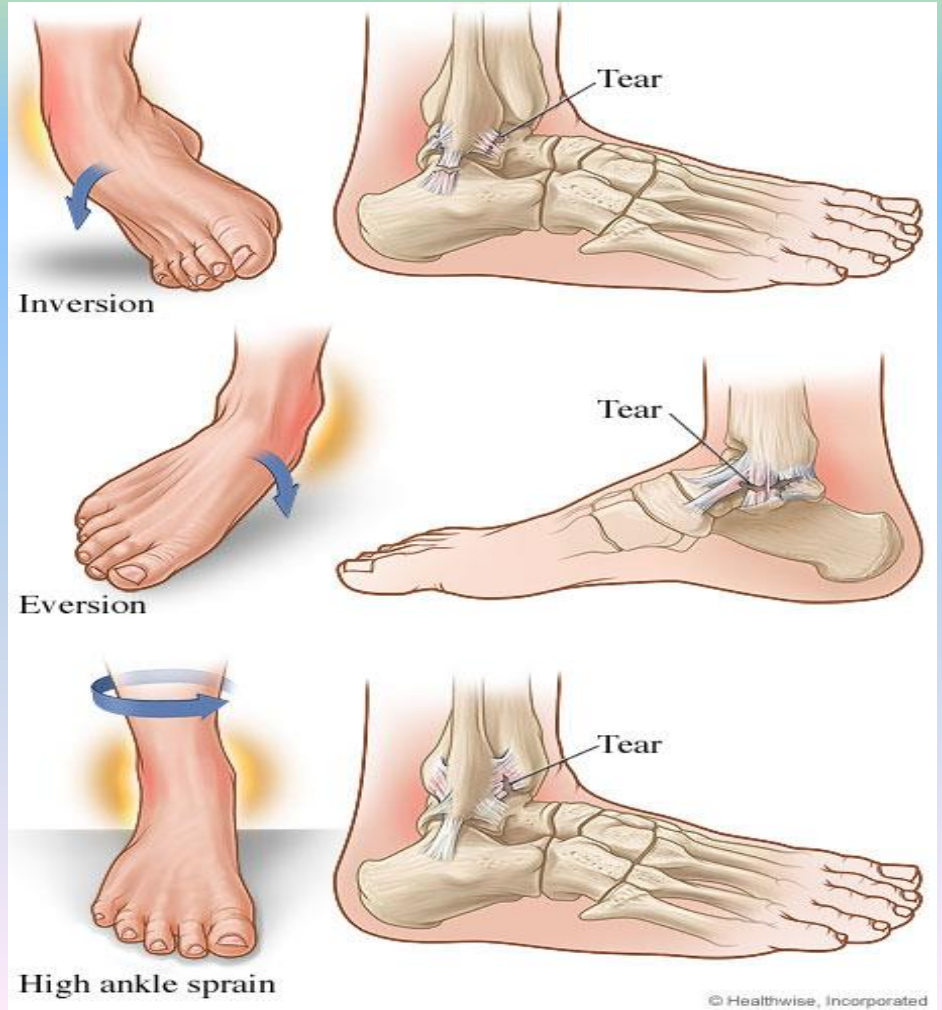



# Neuromuscular Function

## Synovial Joint Movements

Inversion: when the ankle rolls outward (laterally.

Eversion: ankle roles inward (medially).

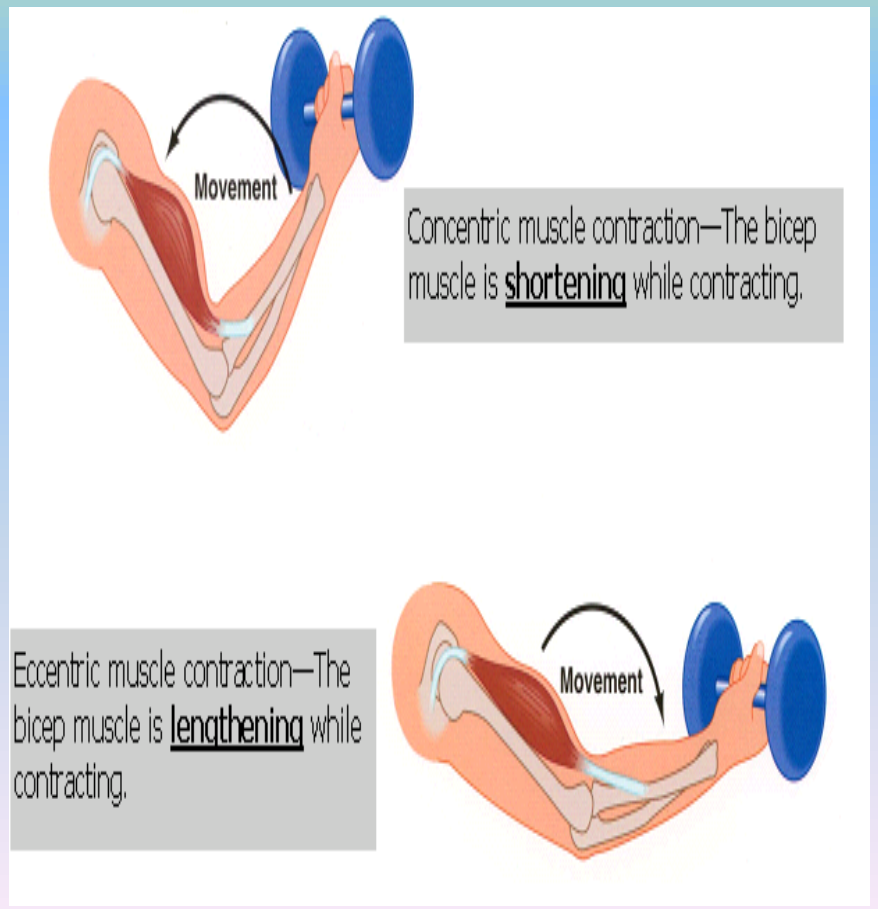
# Neuromuscular Function

## Types of muscle contraction

Isotonic: Increase in loads on muscles. (concentric and eccentric muscle actions.) (resistance fixed, speed varies)

Concentric: muscle is shortened during contraction.

Eccentric: muscle is contracting while lengthening.



# Neuromuscular Function

## Types of muscle contraction

Isometric: muscle generates force without changing length. Ex. Hand grip, plank position & carrying a bag.

Isokinetic: the speed of movement is fixed and the resistance varies with the force exerted.

*requires special equipment!

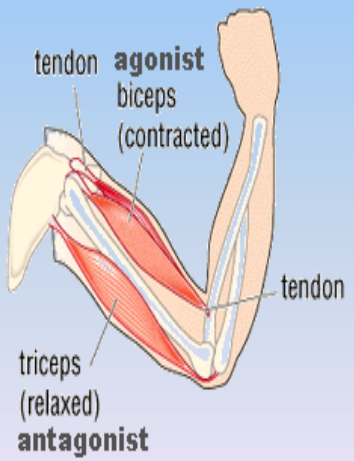
# Neuromuscular Function

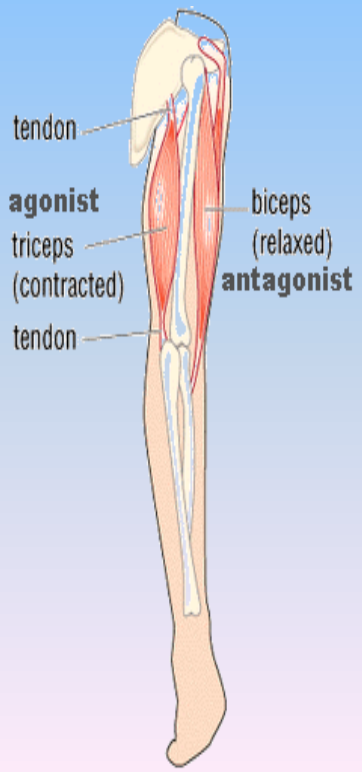
## Reciprocal Inhibition

Describes muscles on one side of a joint relaxing while the other side is contracting. (antagonistic pairs)

Agonist: muscle that causes the movement.

Antagonist: muscle that works opposite the agonist to return the joint to its initial position.



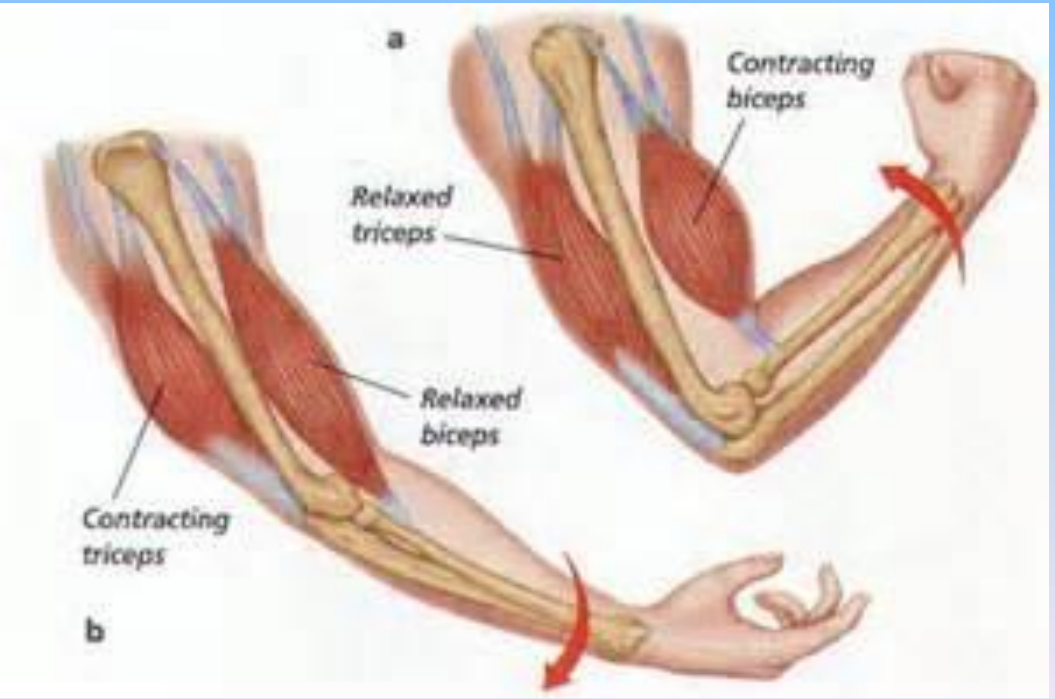



# Reciprocal Inhibition (RI)

- Is exercise attempts to achieve the simultaneous relaxation of one muscle by the contraction of its **antagonist** muscle

- In reality other muscles are involved both in the **contraction and the ensuing relaxation**

- When an **agonist** contracts to move a body segment, it is usual for the **antagonist** (the muscle with the opposite concentric contraction action) to relax
- When the agonist motor neuron is stimulated, the motor neuron to the antagonist is inhibited, preventing it from contracting strongly
- **Example: During the upward phase of bicep curls, the biceps brachii muscle contracts concentrically and the triceps brachii is still relaxed**



## FIXATOR (stabilizer)

- When muscles contract, both ends are drawn towards the middle of the muscle
- However if only one end of the muscle is required to move a body segment, then the body segment to which the other end of the muscle is attached (usually the other segment of the joint) must be kept stationary
- Therefore, this will require **at least one other muscle to contract** (usually isometrically) to prevent this segment from moving so that the agonist may move the desired segment

## SYNERGISTS (neutralizer)

Most muscles have more than one action at a joint

Example:

- When the biceps brachii contracts
- It flexes the elbow joint
- It supinates the radio-ulnar joint

- Synergists contract (usually isometrically) to **prevent unwanted actions** of the agonists or antagonists when undergoing movement

# Neuromuscular Function

## Movement Analysis

Describe movement considering the following terms:

Abduction
Adduction
Circumduction
Dorsiflexion
Plantar flexion
Elevation
Depression
Extension
Flexion
Pronation
Supination
Rotation
Inversion
Eversion

Isotonic
Concentric
Eccentric
Isometric
Isokinetic

muscle & exercise directory

# Neuromuscular Function

## Delayed onset muscle soreness (DOMS)

The pain and stiffness felt in muscles several hours to days after unaccustomed or strenuous exercise.

*brought on by eccentric contractions of the muscle causing pressure at the nerve endings.

Read the article and summarize

http://sportsmedicine.about.com/cs/injuries/a/doms.htm