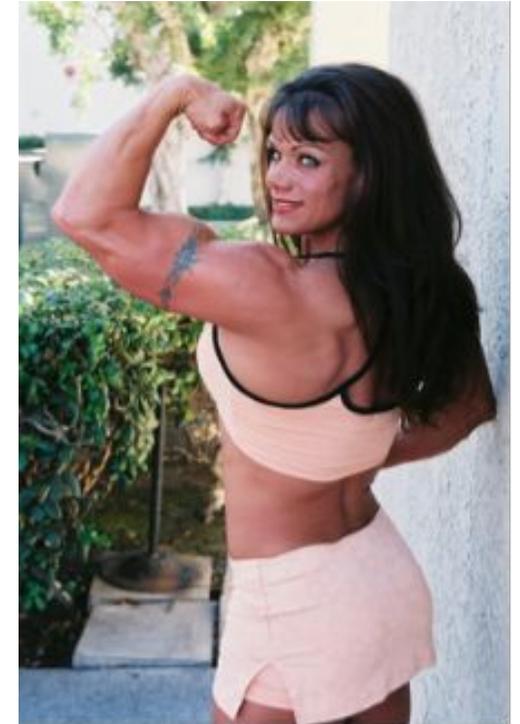


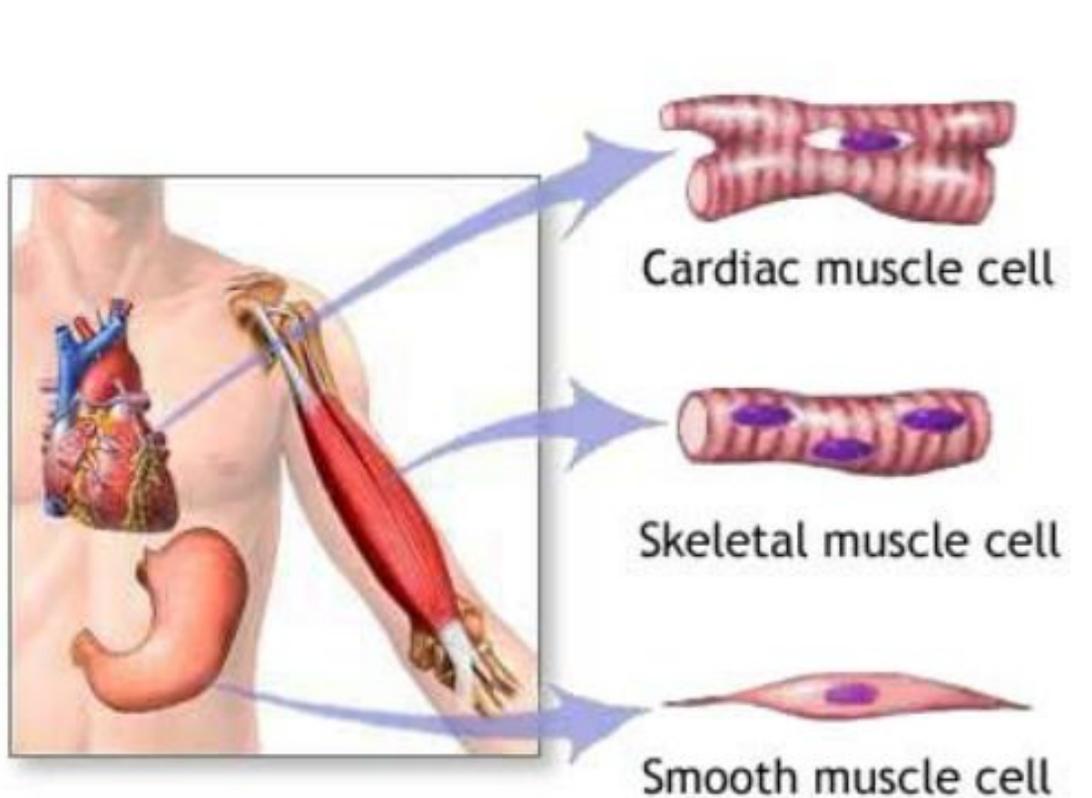


# Muscular System



# Types of Muscle

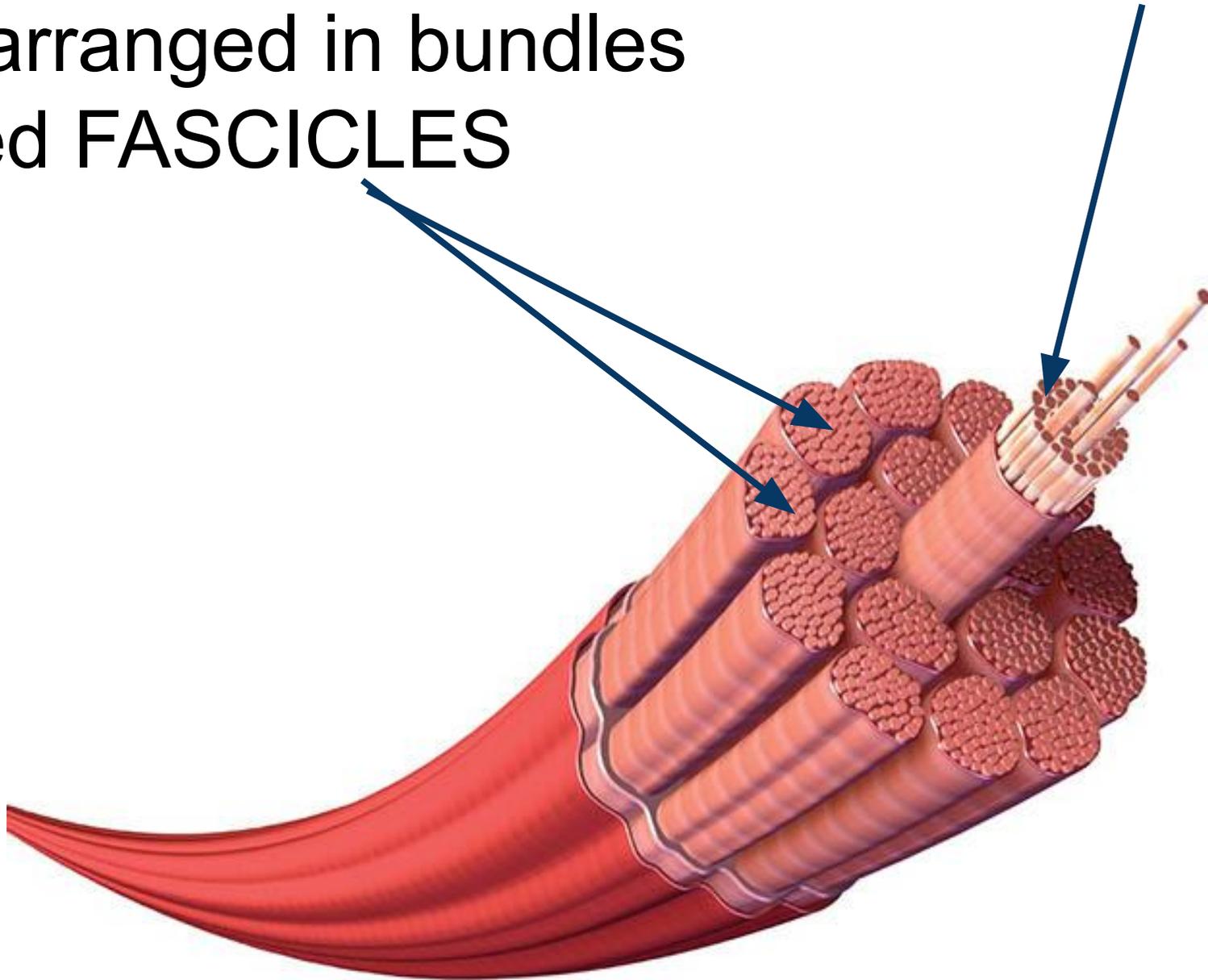
- Skeletal – striated & voluntary
- Smooth – involuntary
- Cardiac - heart



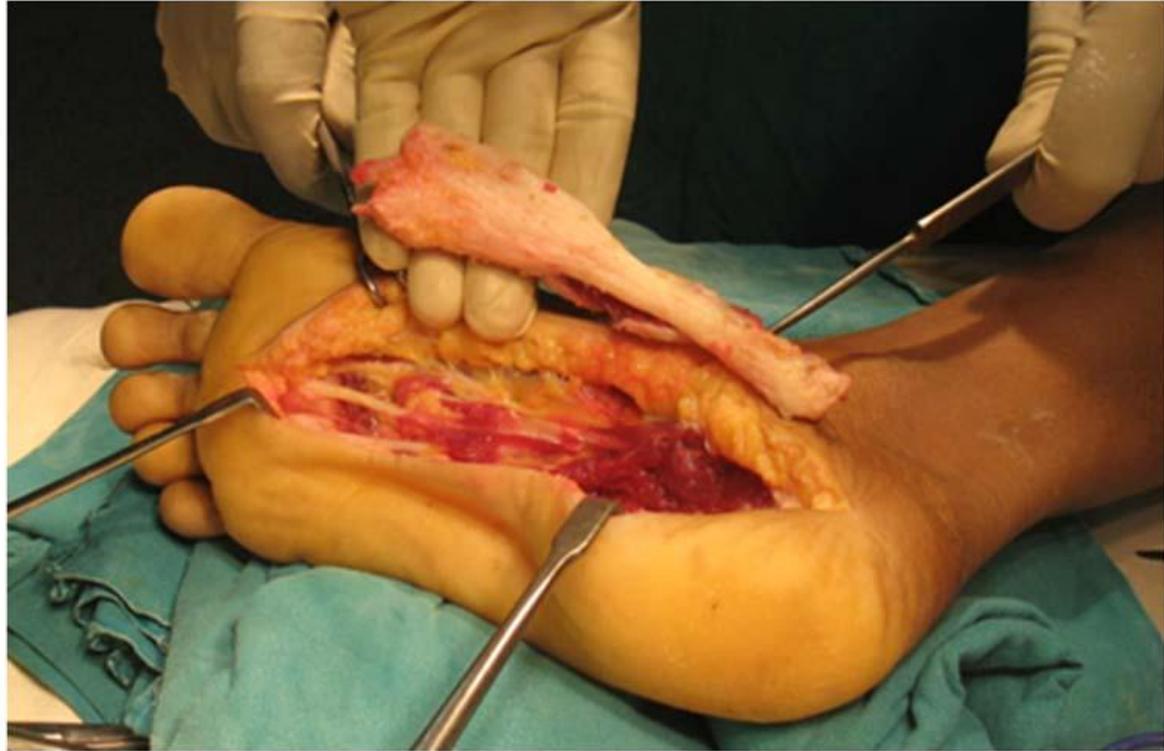
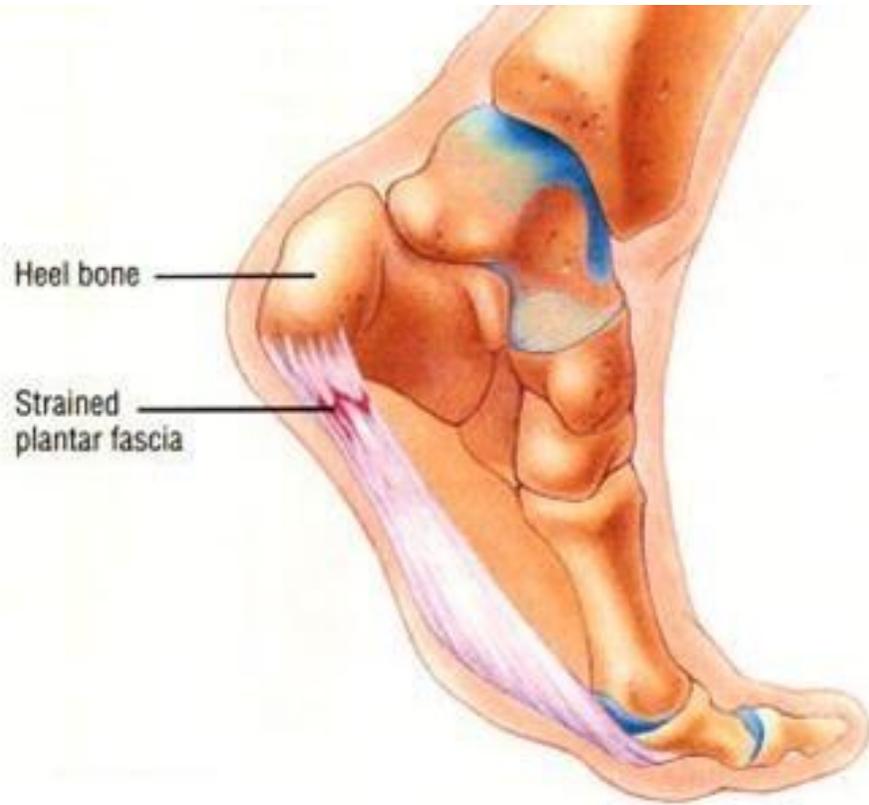
*The word “striated” means striped. Skeletal muscle appears striped under a microscope.*

# Muscles and Muscle Fiber Structure

Muscles are composed of many FIBERS that are arranged in bundles called FASCICLES



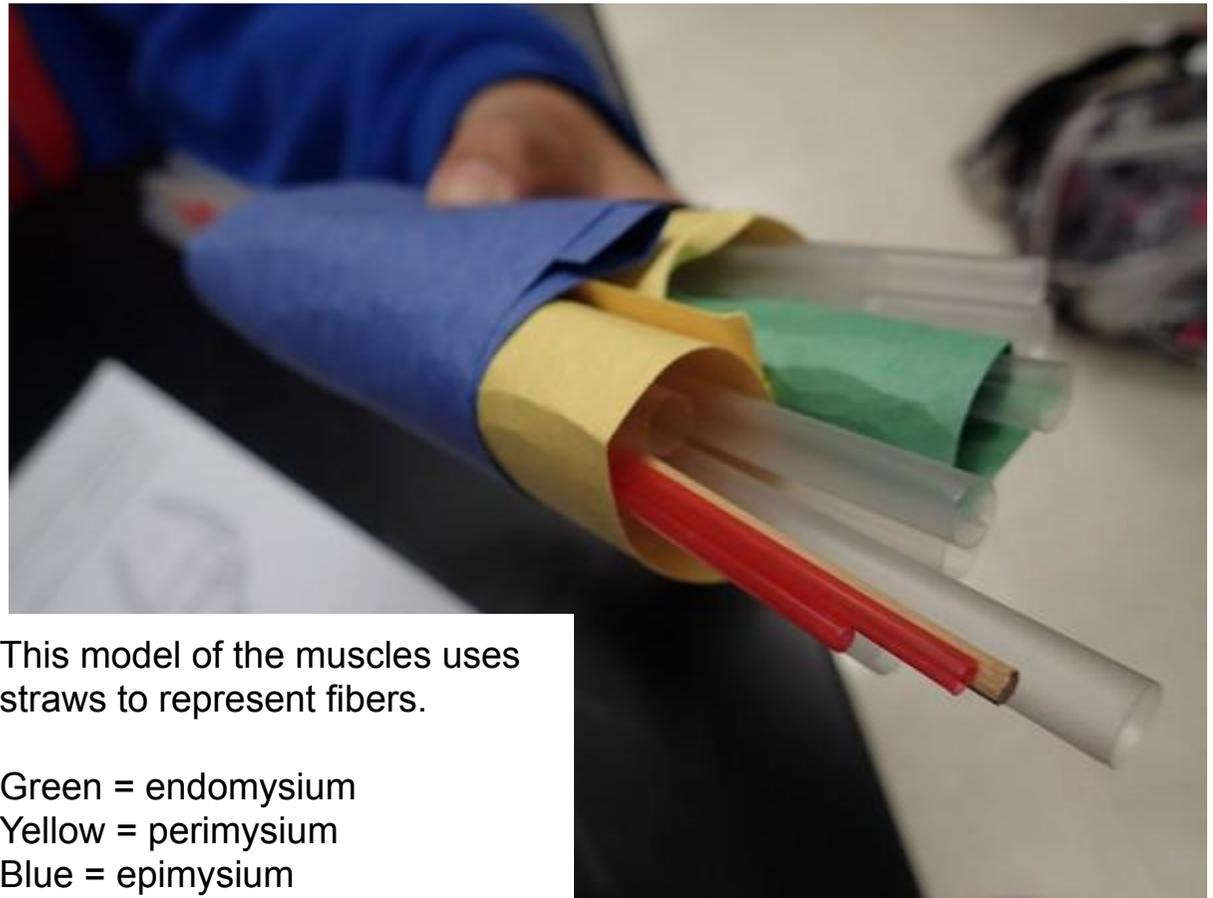
Individual muscles are separated by FASCIA, which also forms tendons



EPIMYSIUM = outermost layer, surrounds entire muscle.

PERIMYSIUM = separates and surrounds fascicles (bundles of muscle fibers)

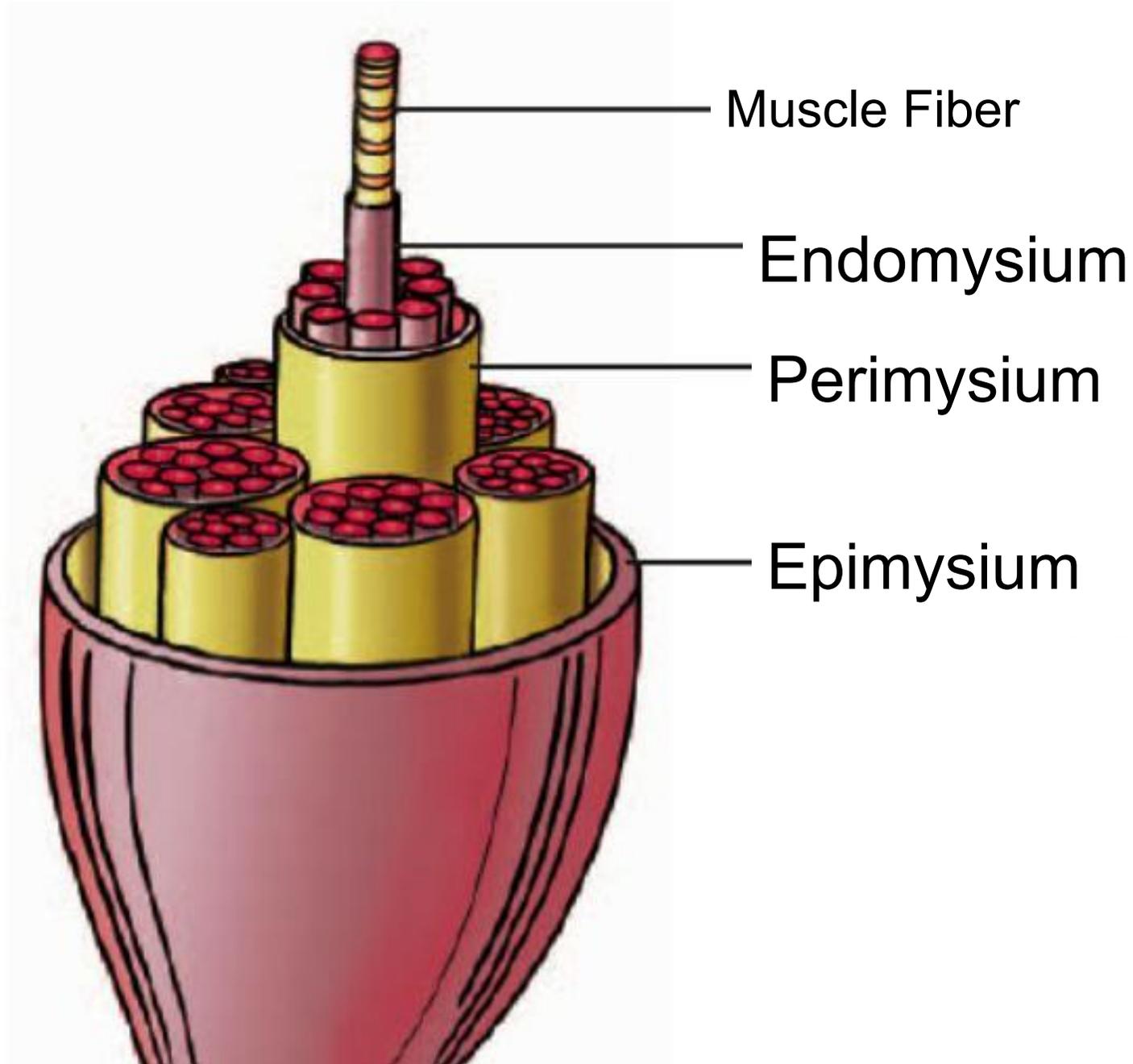
ENDOMYSIUM  
= surrounds each individual muscle fiber

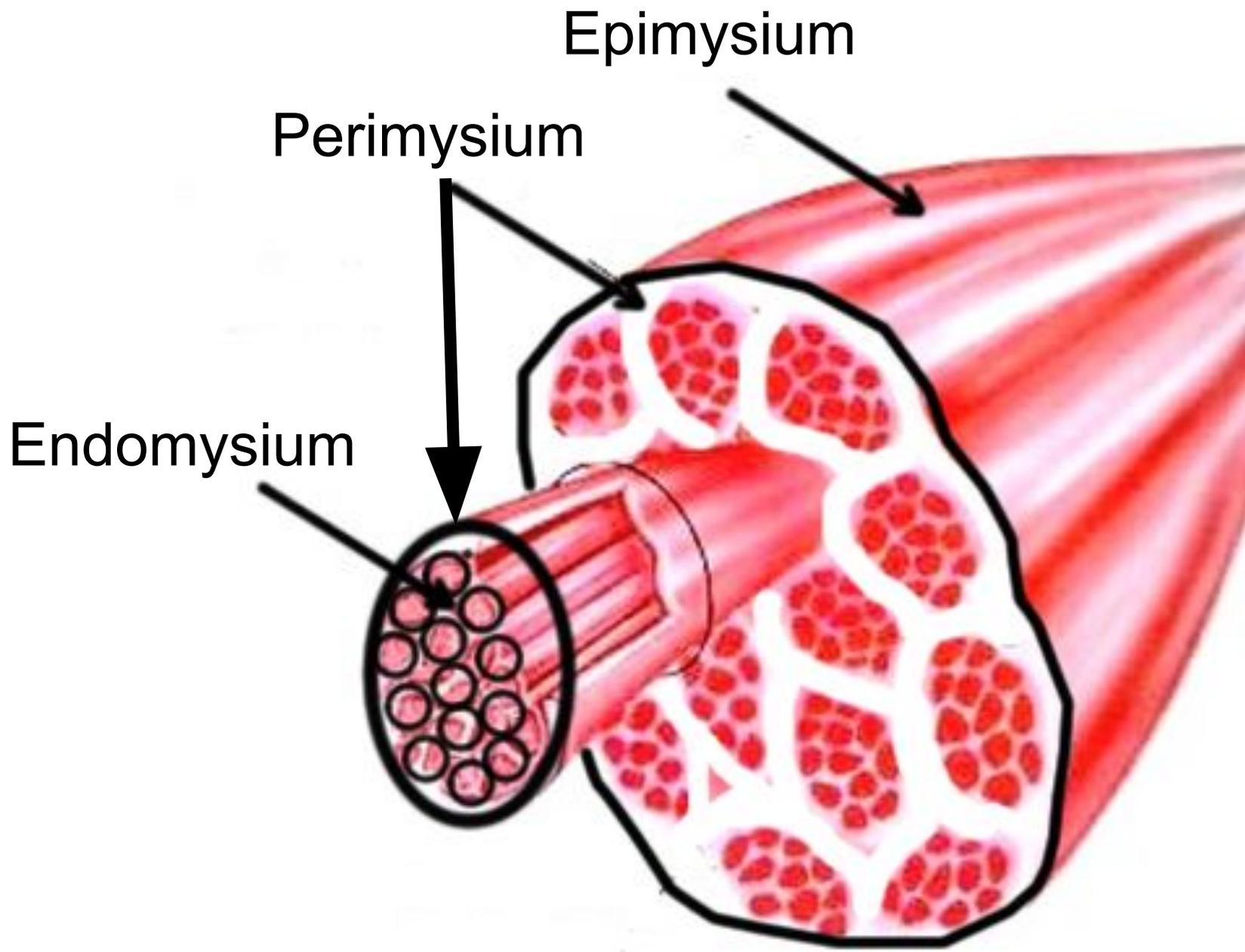


This model of the muscles uses straws to represent fibers.

Green = endomysium  
Yellow = perimysium  
Blue = epimysium

# Muscle Layers





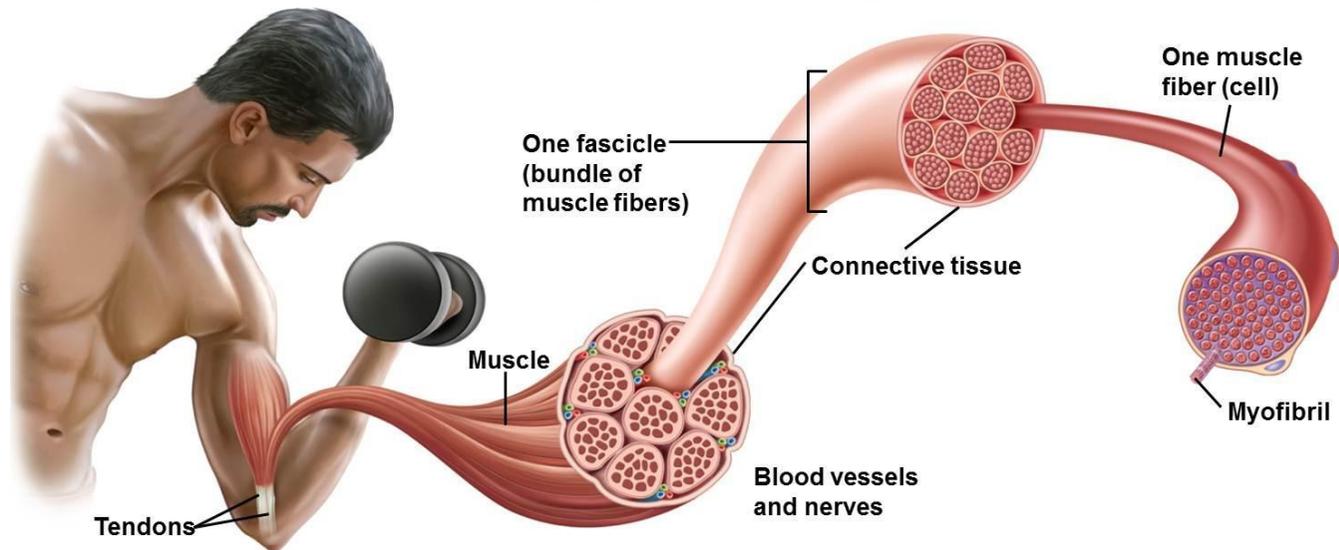
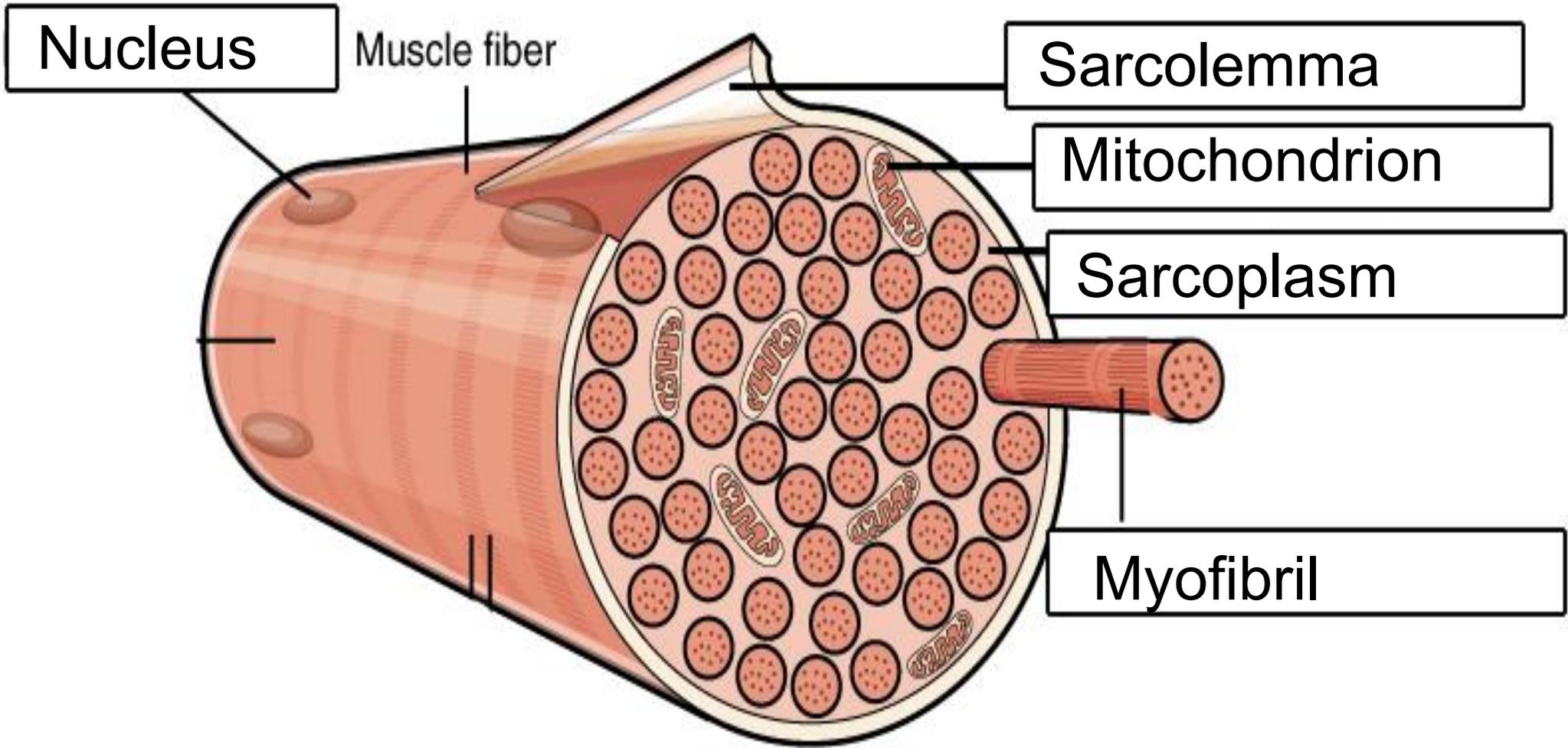
# Muscles / Cells

Sarcolemma = muscle fiber membrane

Sarcoplasm = inner material surrounding fibers (like cytoplasm)

Sarcoplasmic Reticulum - transport

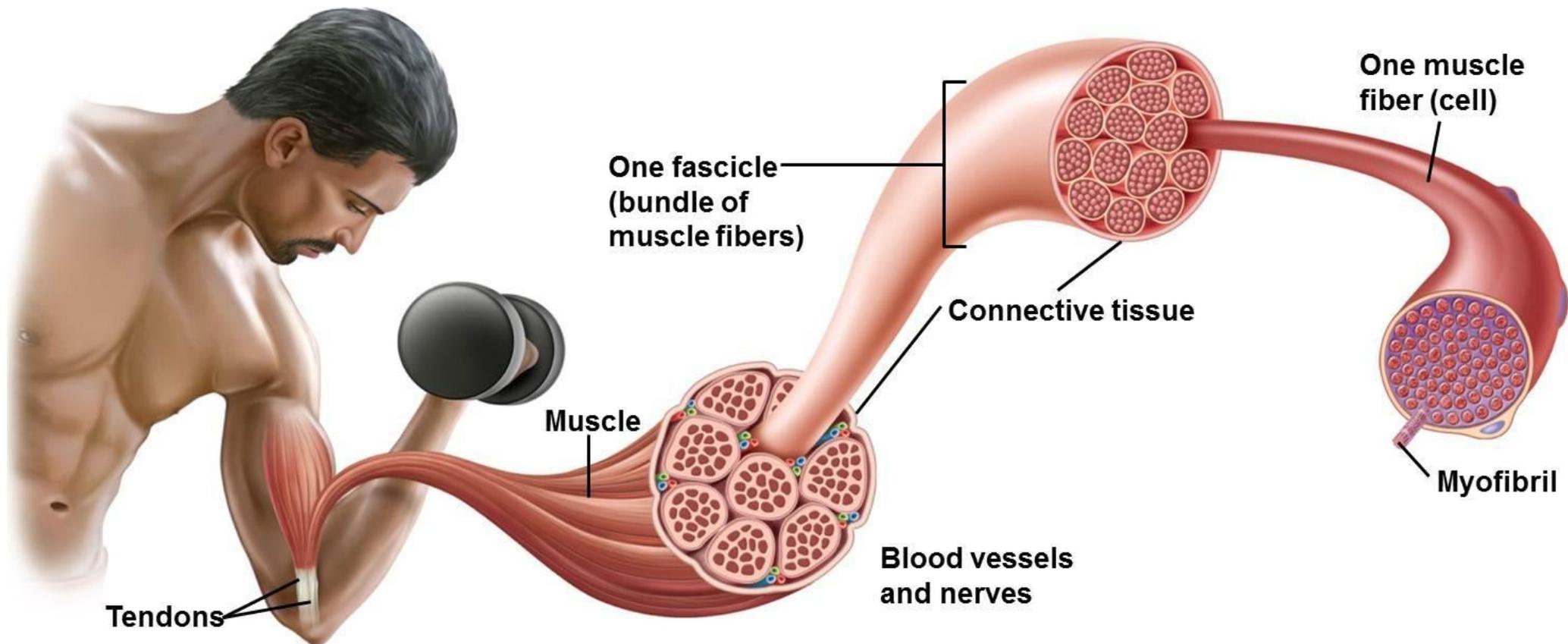
Myofibrils = individual parallel muscle fibers, within sarcoplasm



# Myofibrils are made of

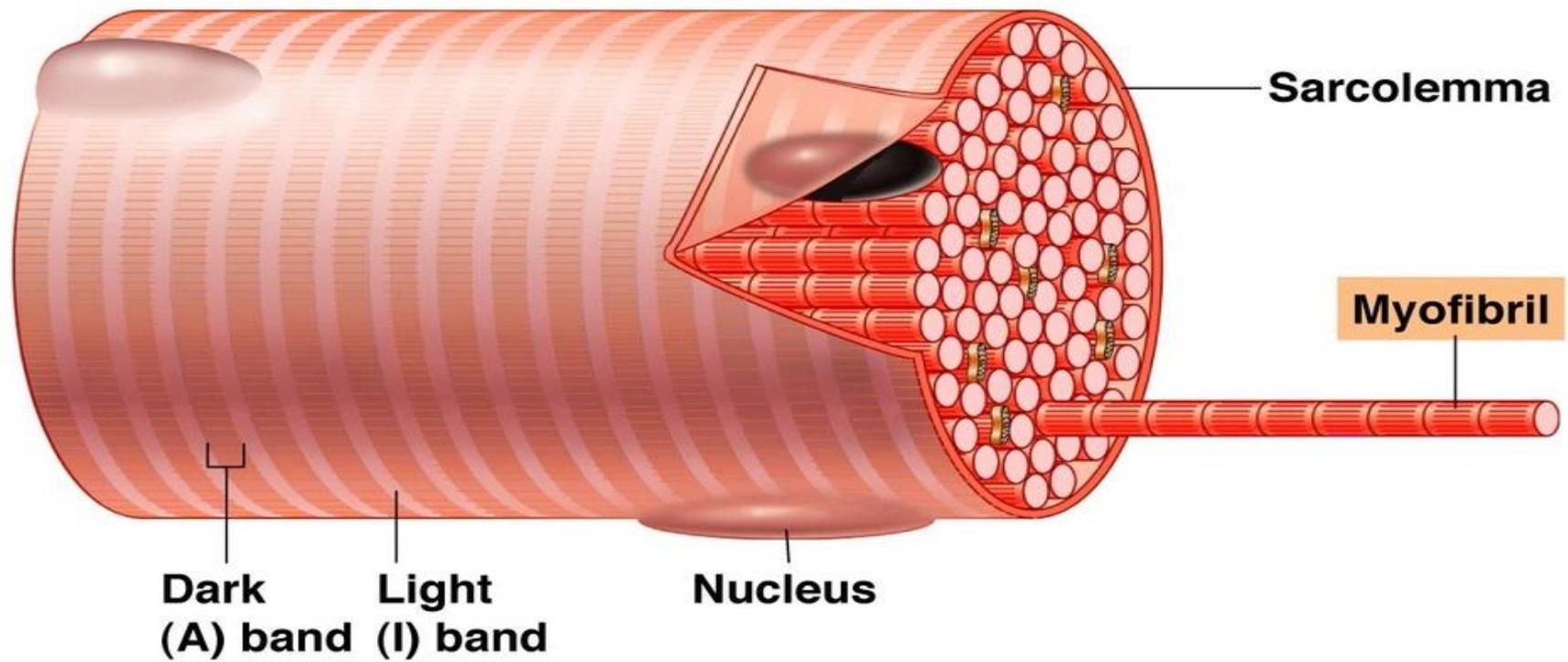
ACTIN = thin filaments

MYOSIN = thick filaments

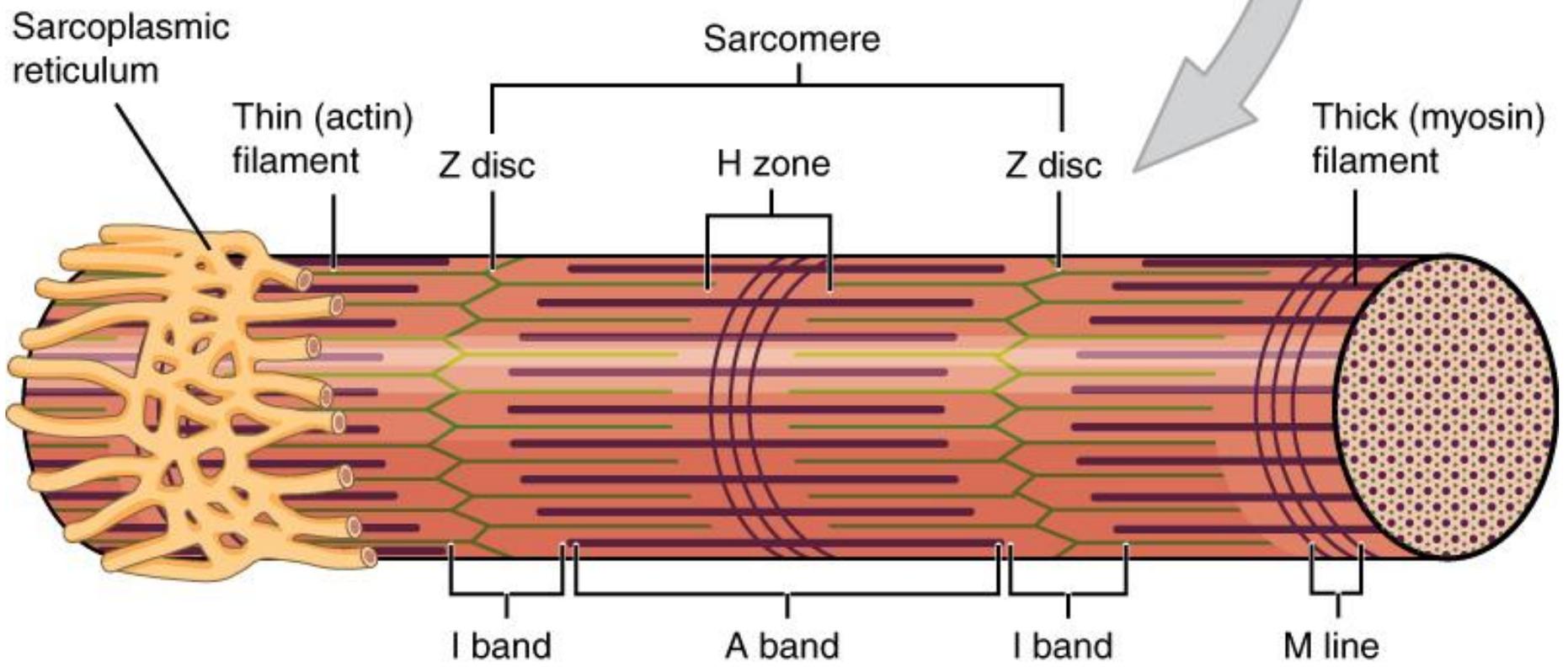
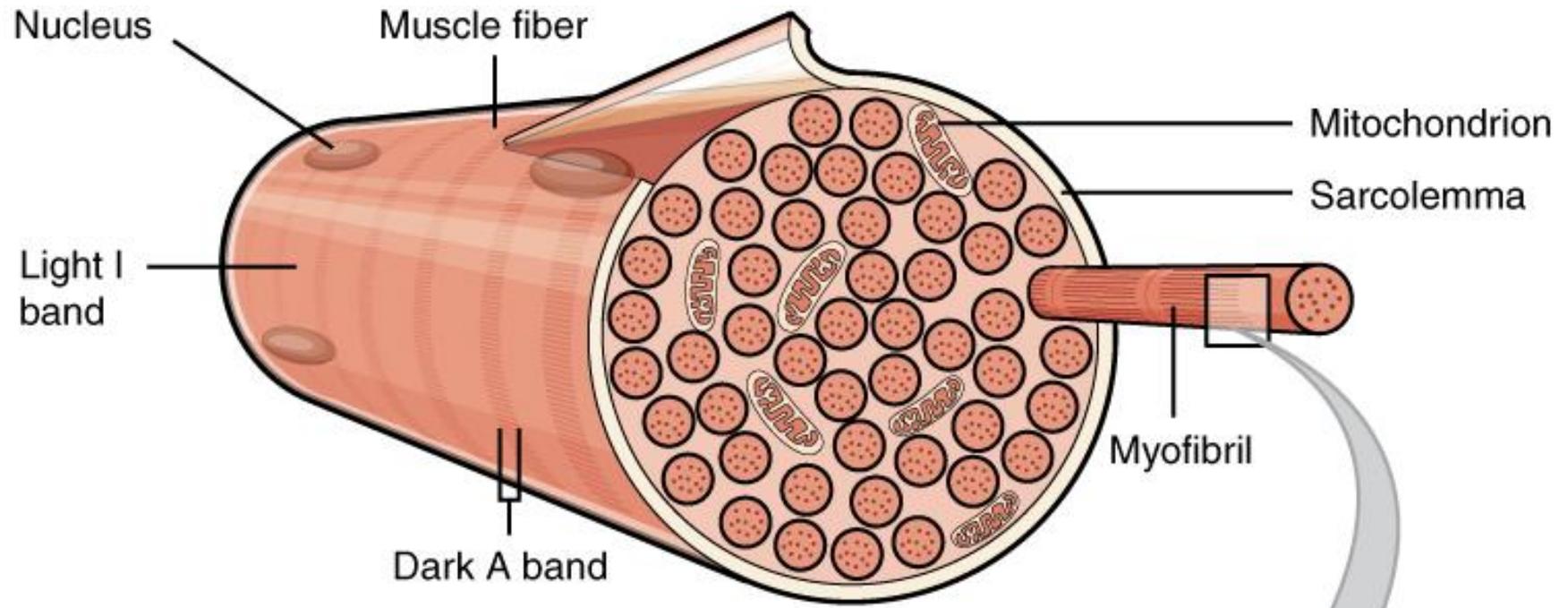


# Myofilaments    ACTIN (thin) and MYOSIN (thick)

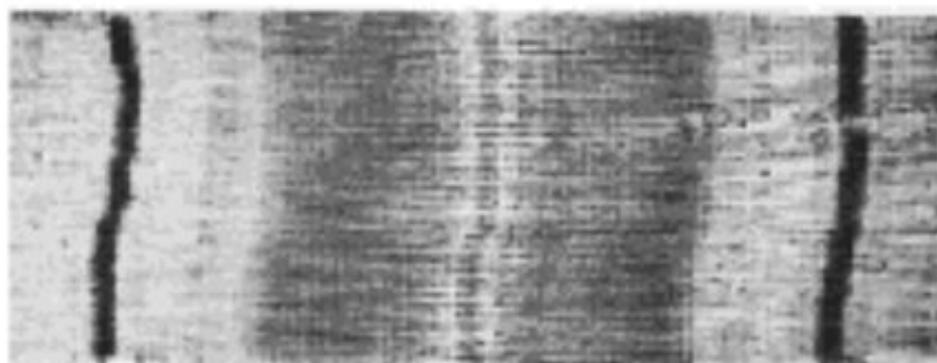
- form dark and light bands
  - A band = dArk • thick (myosin)
  - I band = lIght • thIn (actin)



(a) Segment of a **muscle fiber** (cell)



Sarcomere



Z line

Z line

Thin filaments

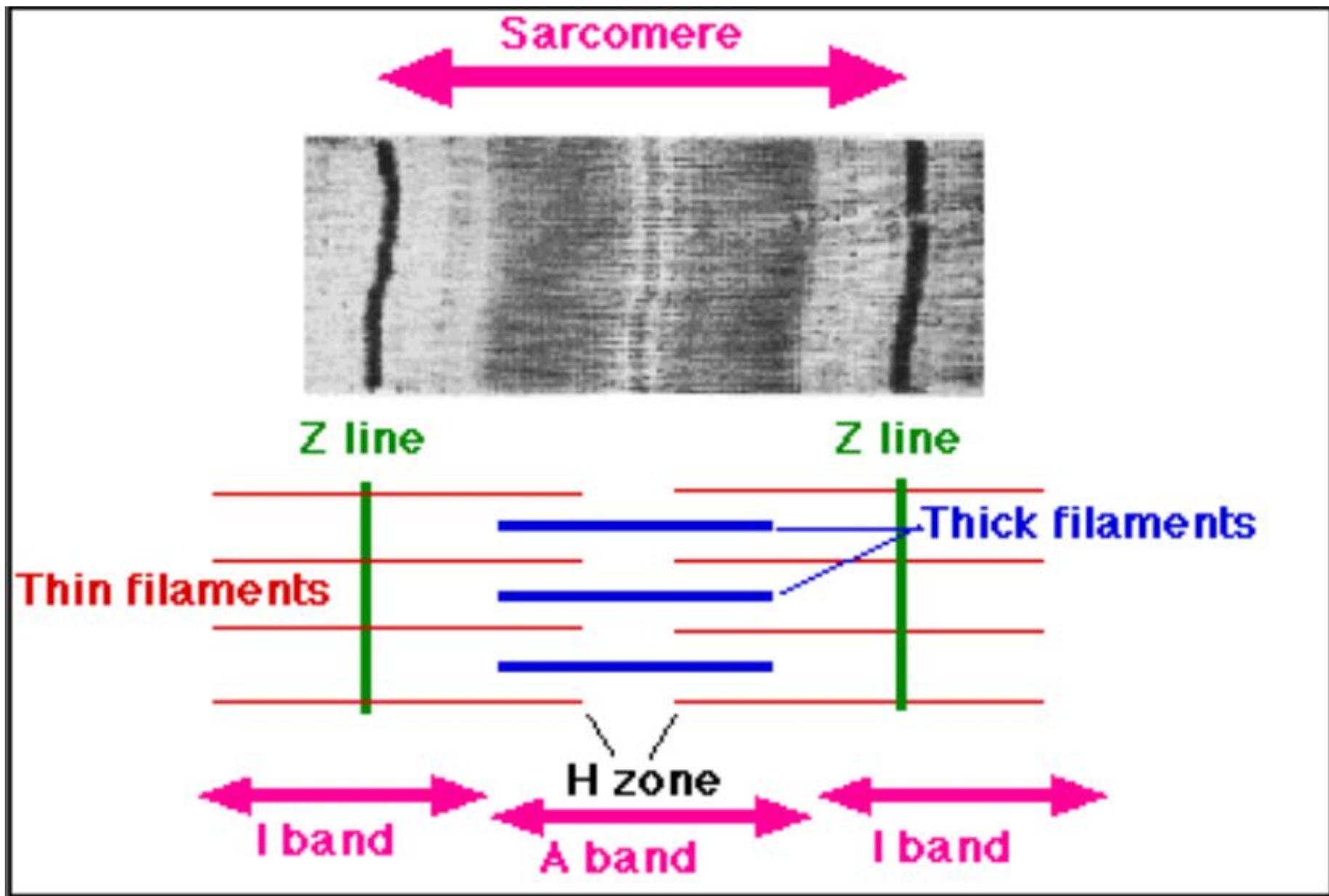
Thick filaments

H zone

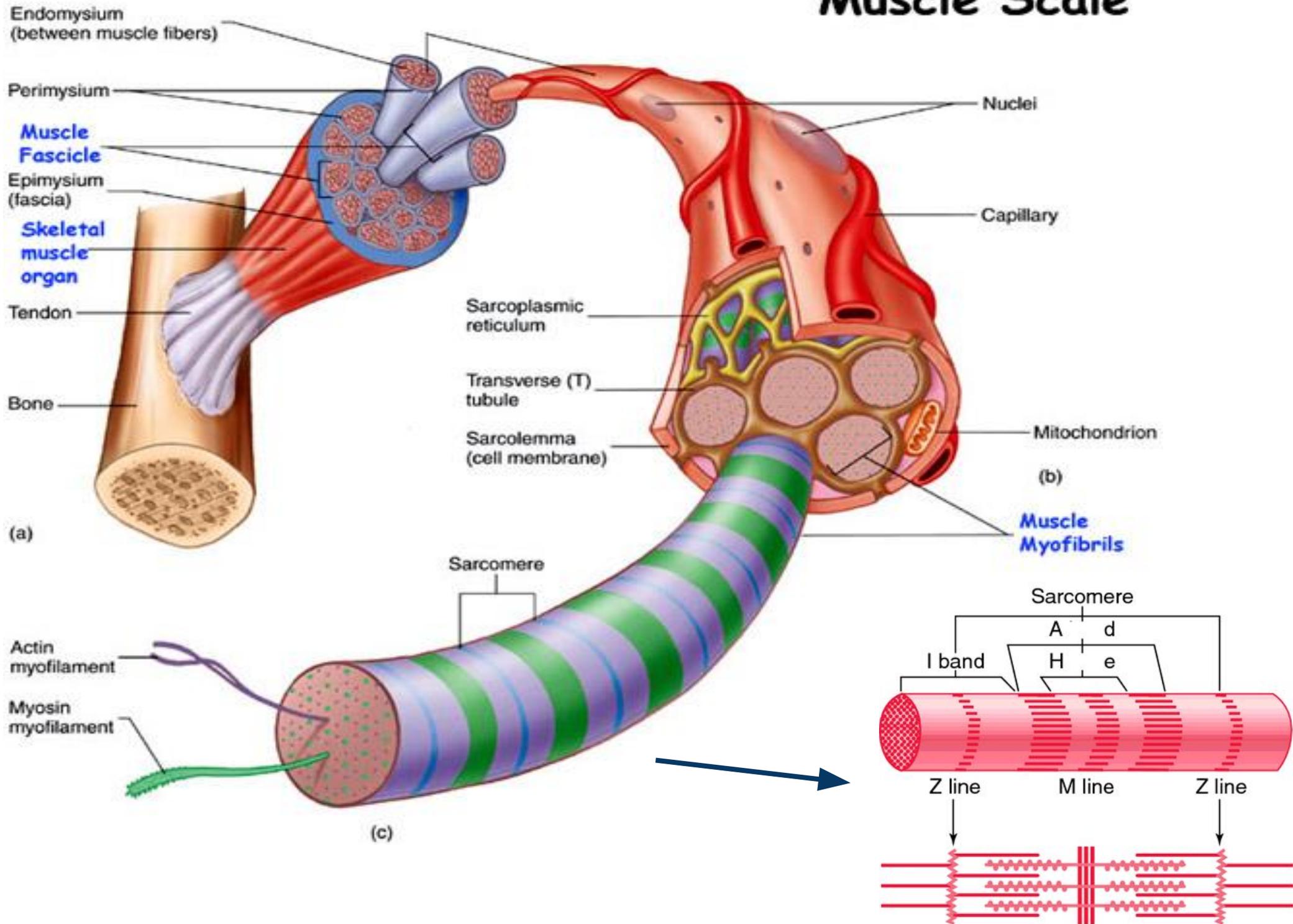
I band

A band

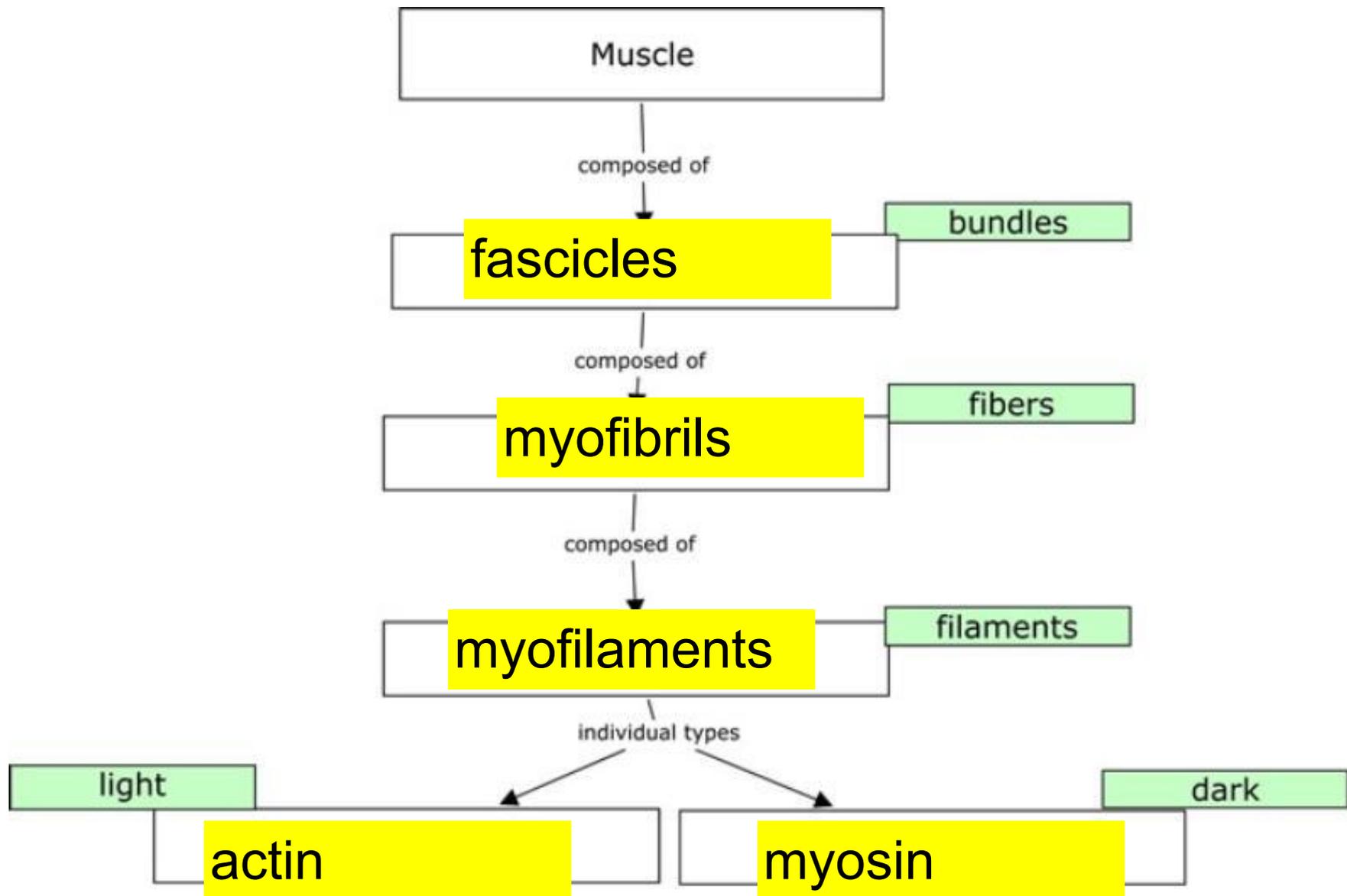
I band



# Muscle Scale

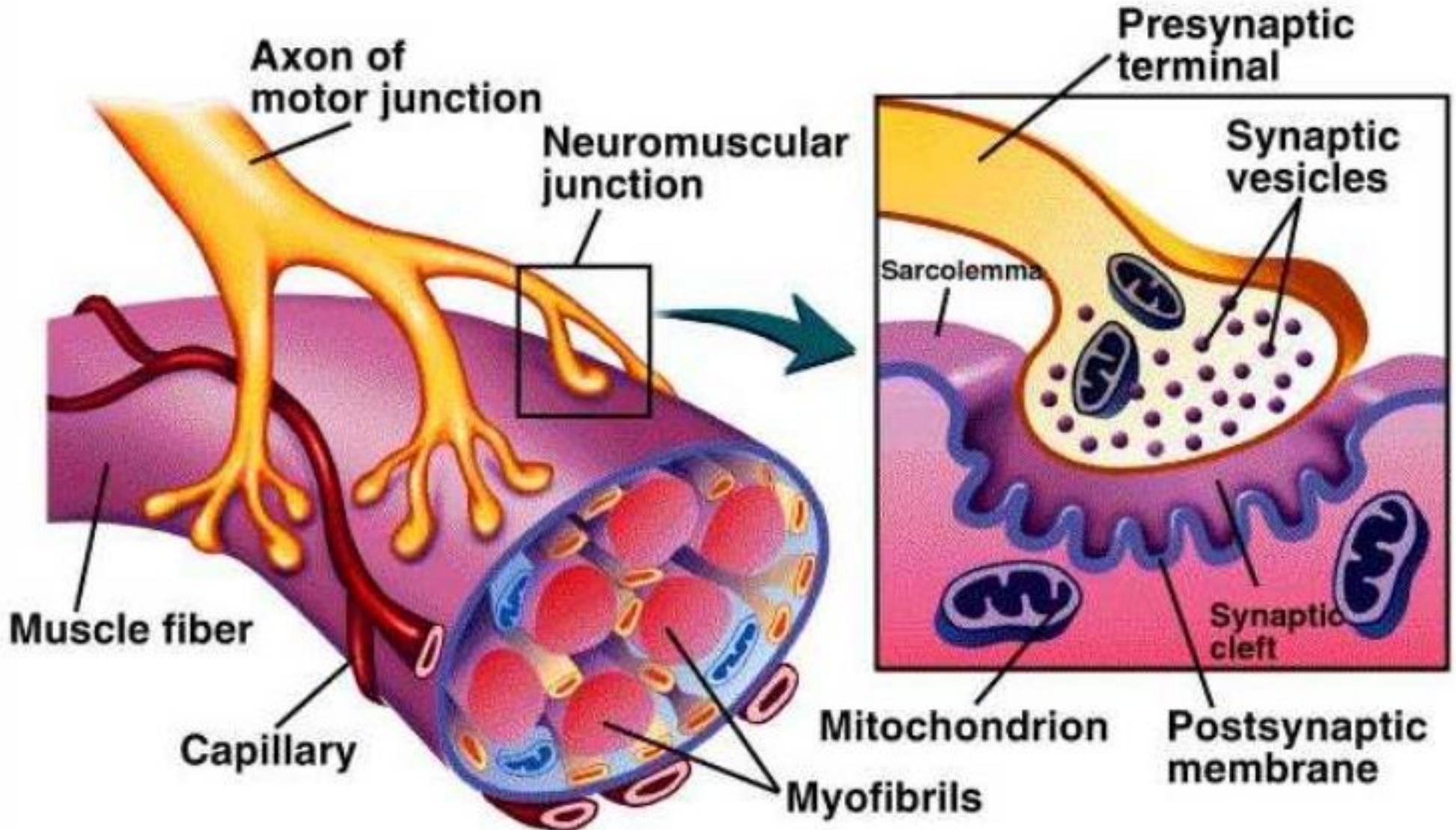


It is important to remember the hierarchy



# How Muscles Work with the Nervous System

## Neuromuscular Junction



**NEUROMUSCULAR JUNCTION** - where a nerve and muscle fiber come together

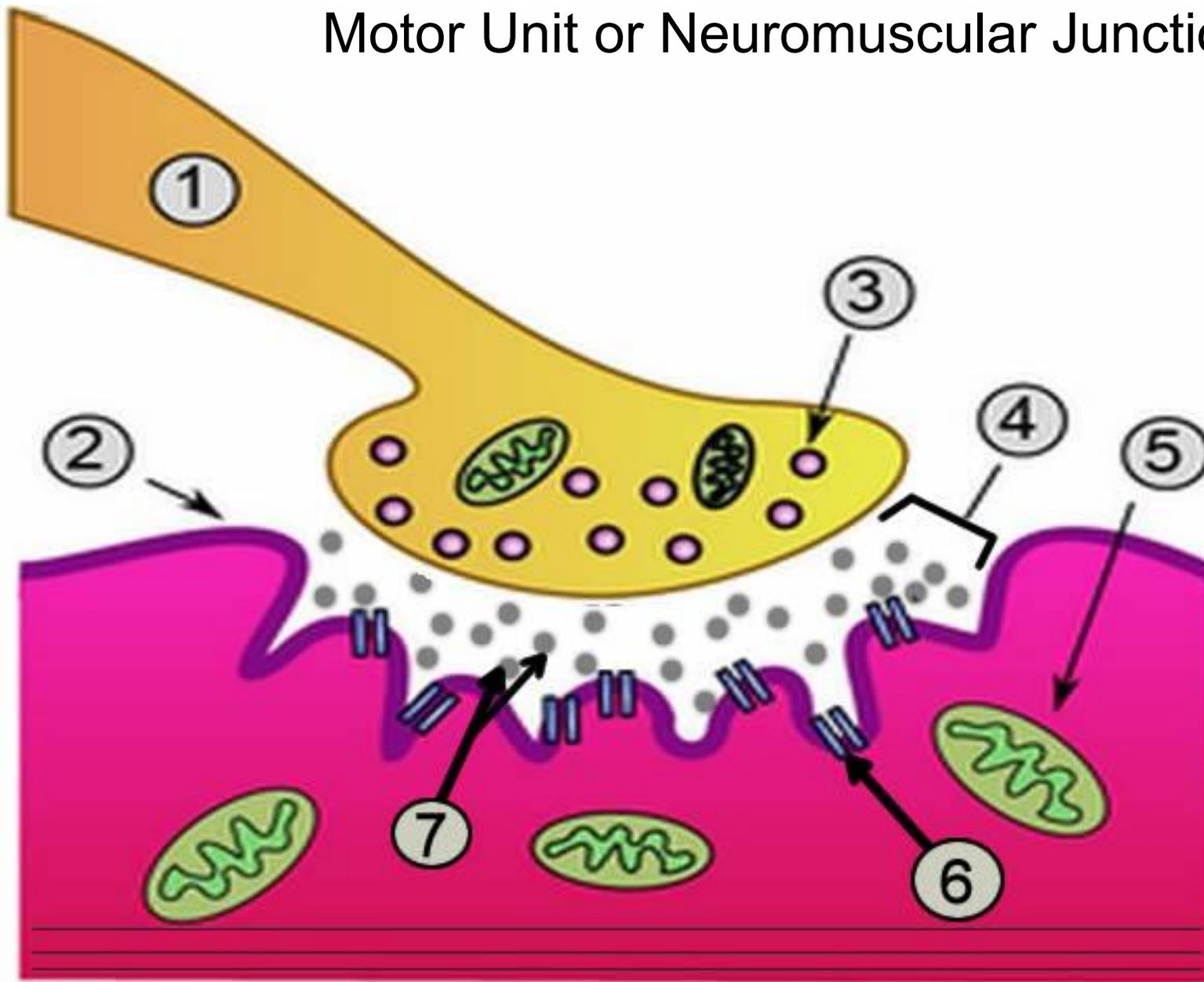
**MOTOR END PLATE** - folded area where muscle and neuron communicate

**SYNAPSE** - gap between the neuron and motor end plate (*synaptic cleft*)

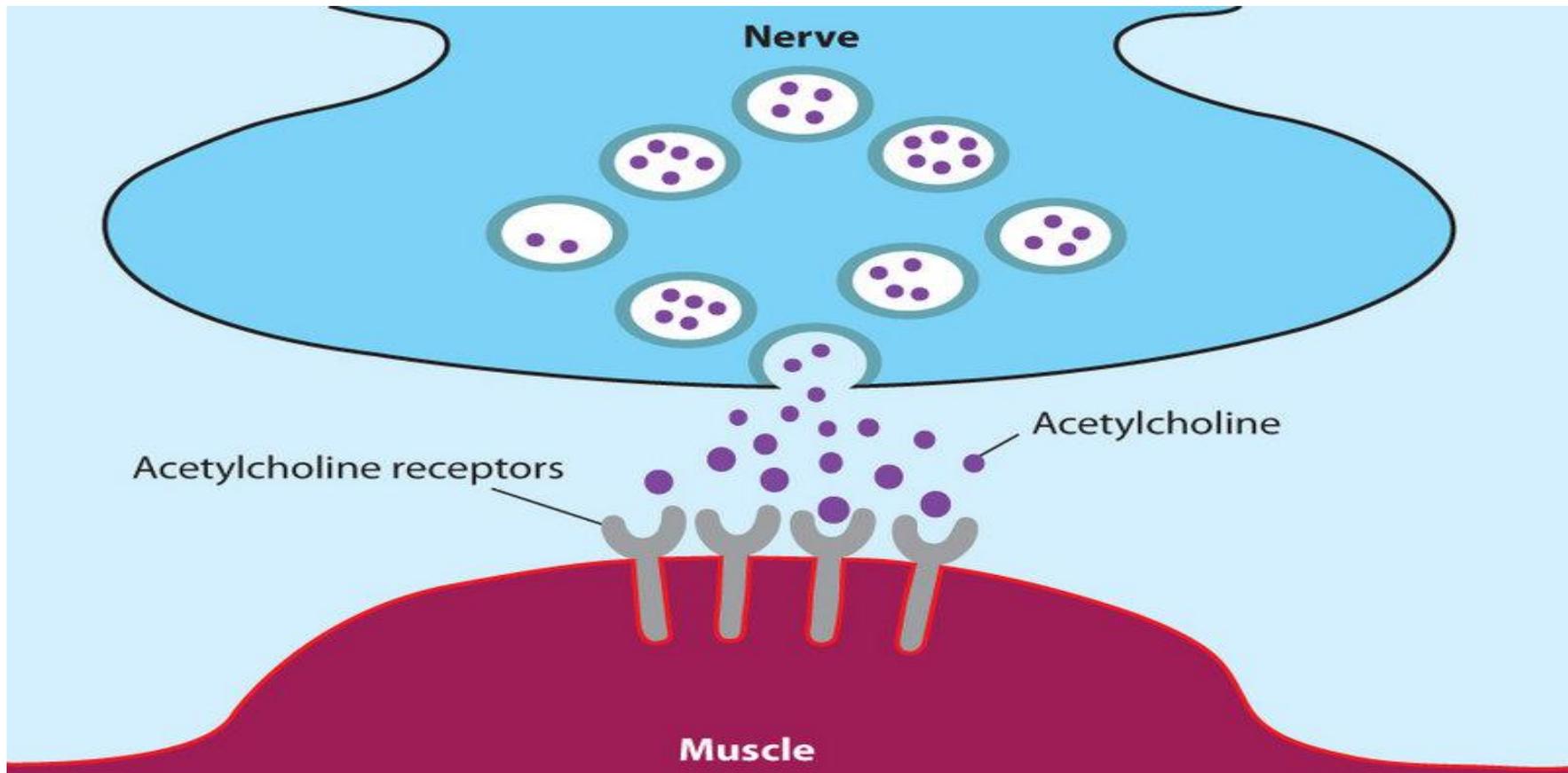
**SYNAPTIC VESICLES** - where neurotransmitters are stored

\*these are released into the cleft and tell the muscle to contract

# Motor Unit or Neuromuscular Junction



- |              |                                    |                 |
|--------------|------------------------------------|-----------------|
| 1. Neuron    | 2. Sarcolemma (or motor end plate) |                 |
| 3. Vesicle   | 4. Synapse                         | 5. Mitochondria |
| 6. Receptors | 7. Acetylcholine                   |                 |



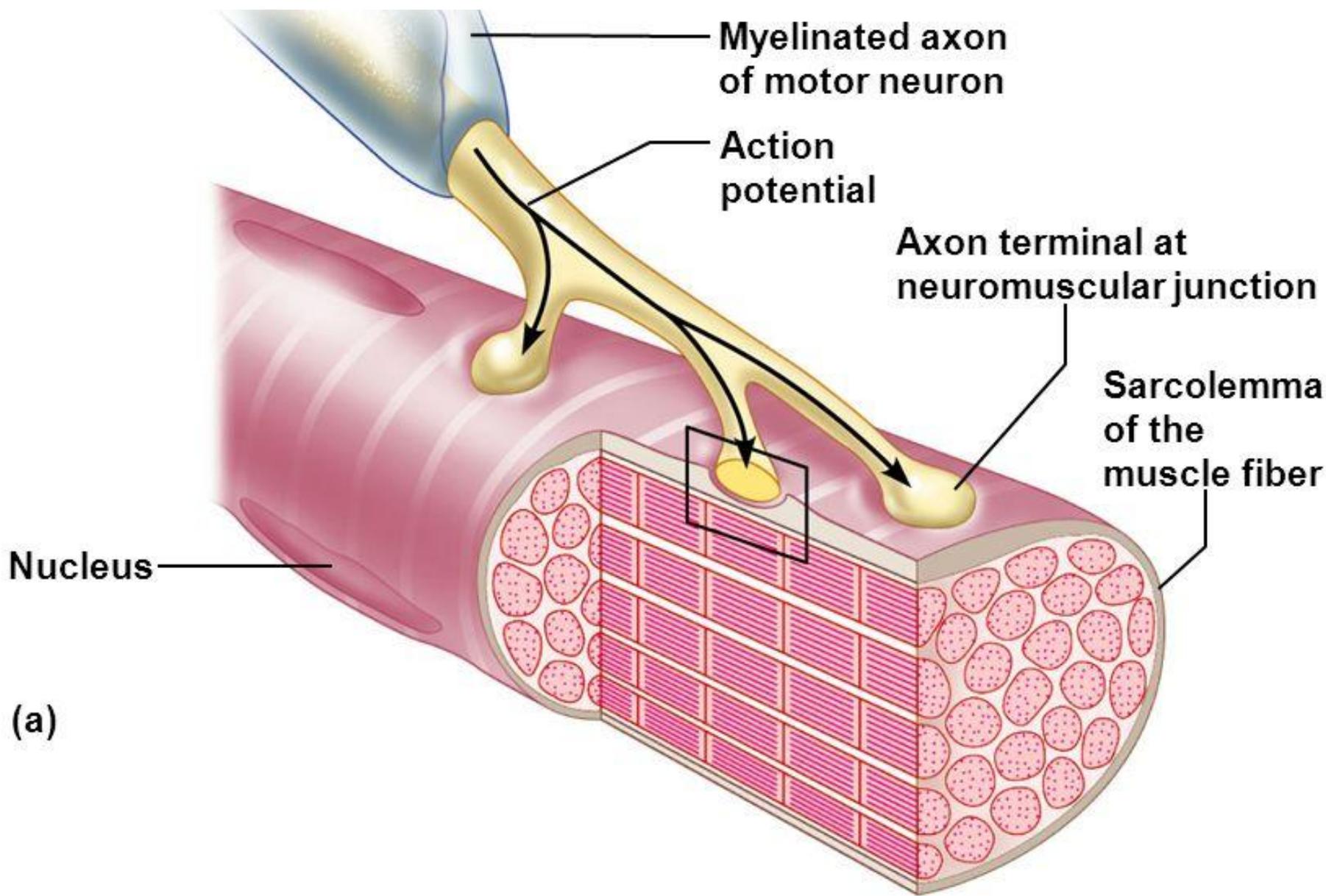
The neurotransmitter that cross the gap is ACETYLCHOLINE

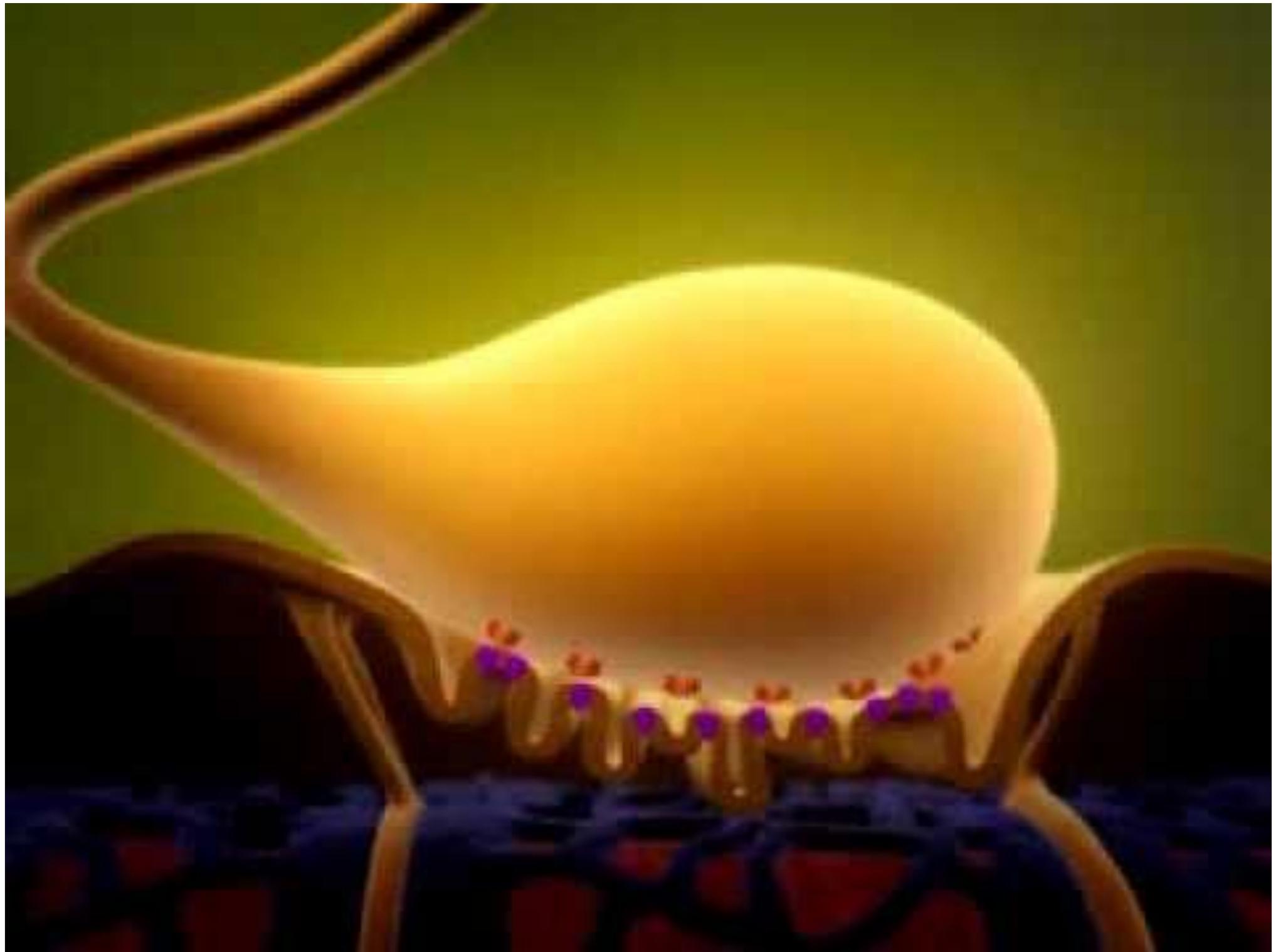
ACH is broken down by CHOLINESTERASE

The neurotransmitter that crosses the gap is **ACETYLCHOLINE**.

← stored in vesicles

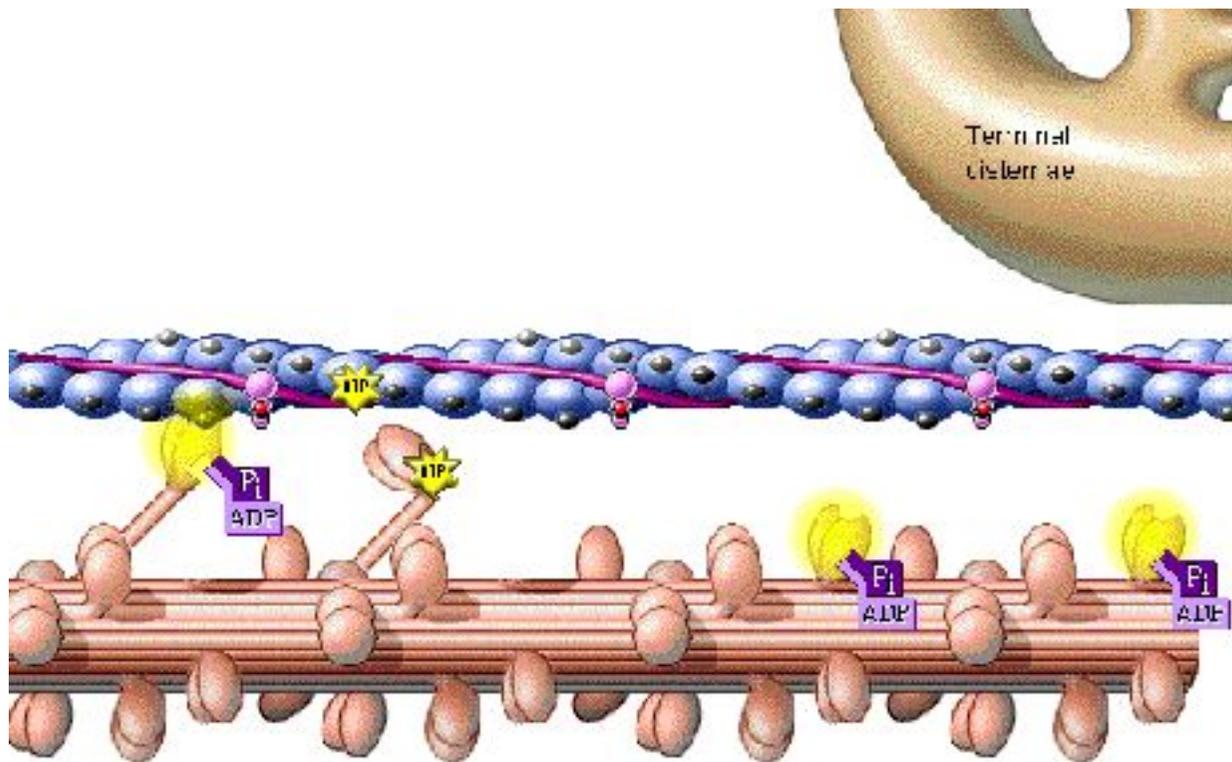
This is what activates the muscle.





# SLIDING FILAMENT THEORY (MODEL)

The theory of how muscle contracts is the sliding filament theory. The contraction of a muscle occurs as the thin filament slide past the thick filaments.



What is needed:

ATP

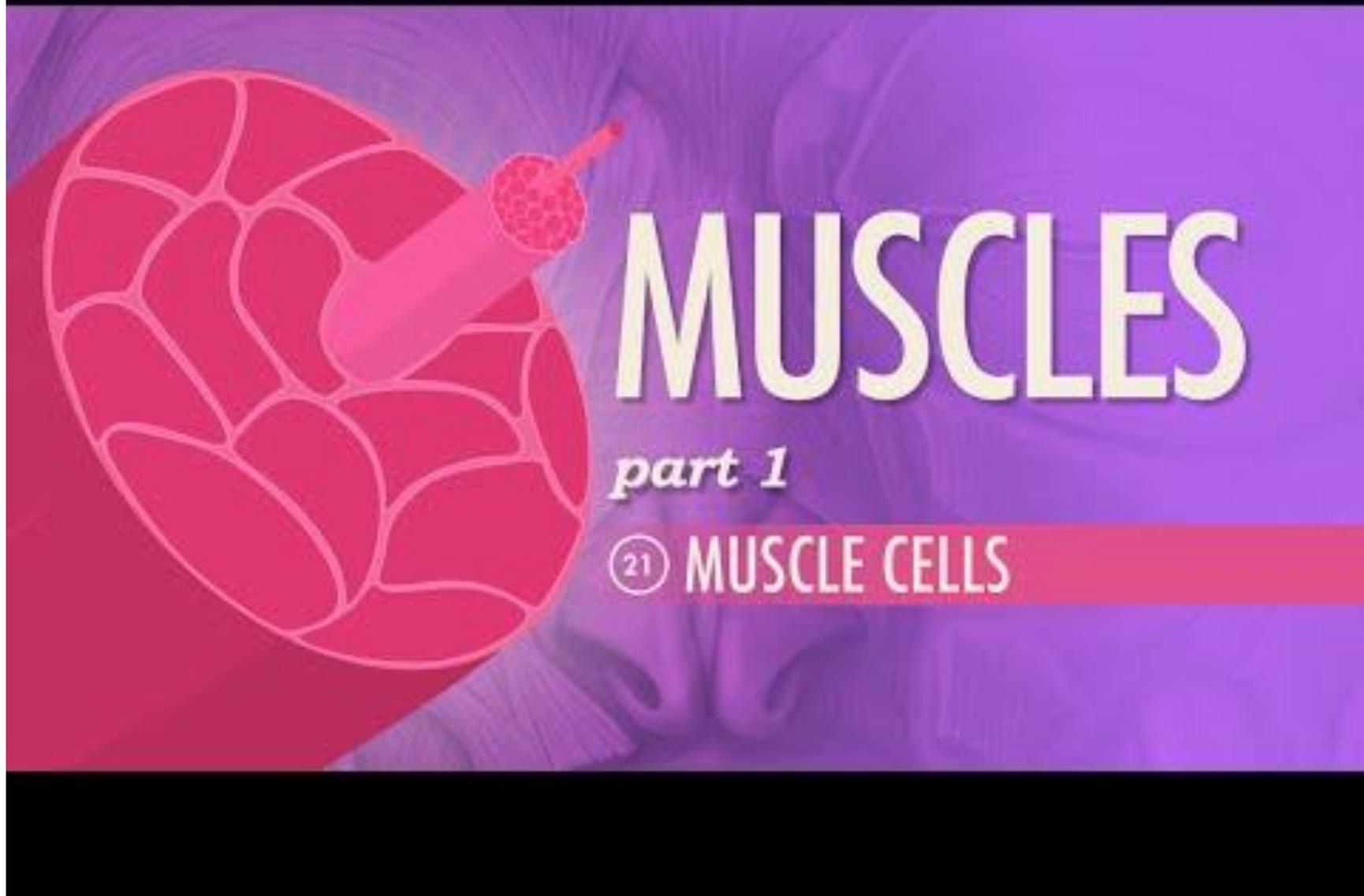
Calcium

Myosin & Actin

Acetylcholine

Cholinesterase

[Sliding Filament Handout](#) (additional)

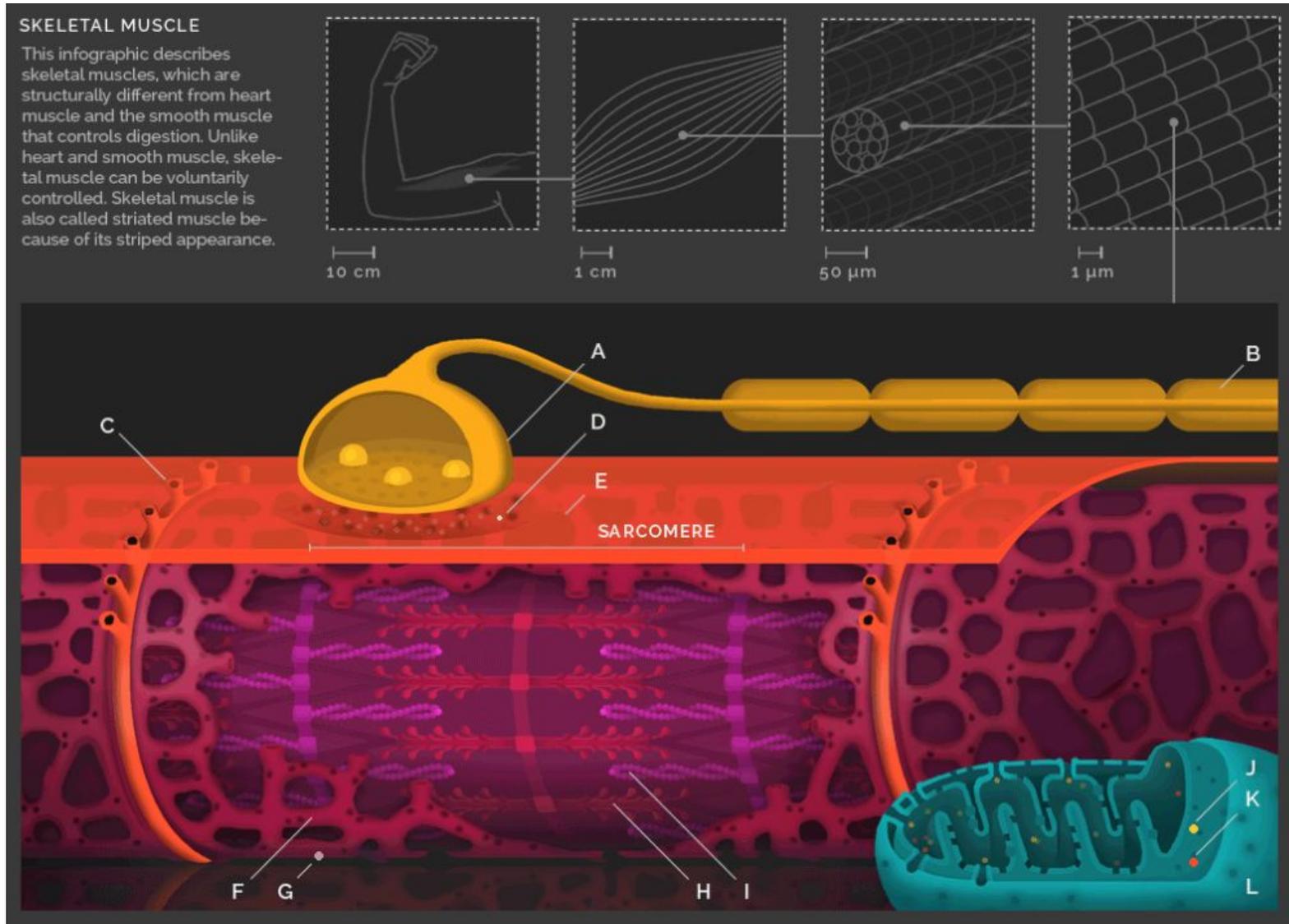


Hank explains muscles and the sliding filament model.

# Sliding Filament (TabletopWhale)

Check out the animation at

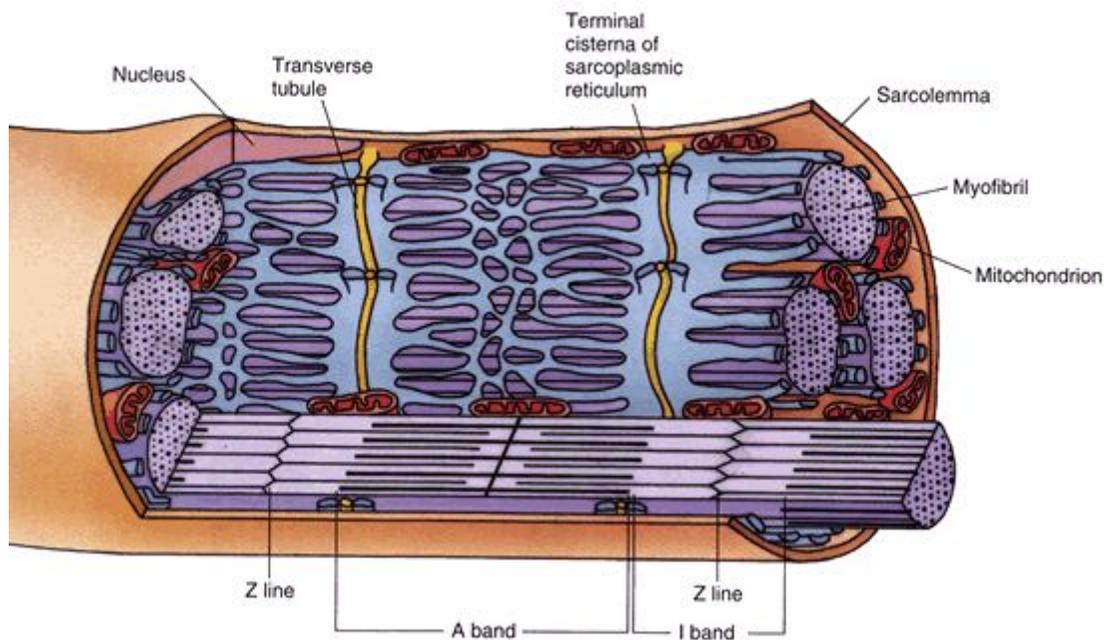
<http://tabletopwhale.com/2014/08/12/a-users-guide-to-muscles.html> -



# Energy Source

-ATP is produced by CELLULAR RESPIRATION which occurs in the mitochondria

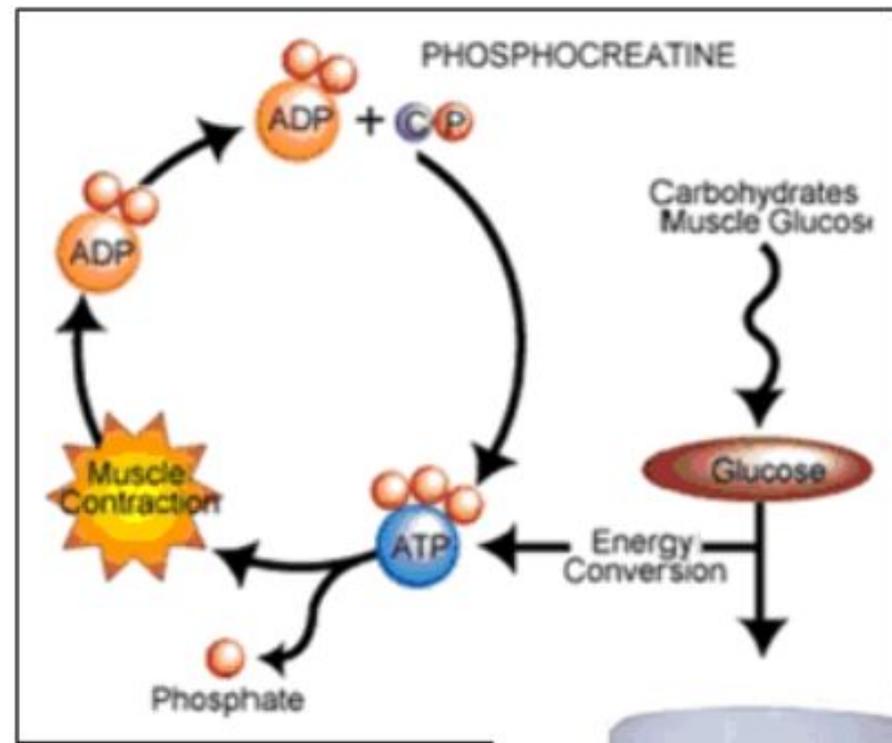
-Creatine phosphate increases regeneration of ATP



\* Only 25% of energy produced during cellular respiration is used in metabolic processes - the rest is in the form of HEAT.

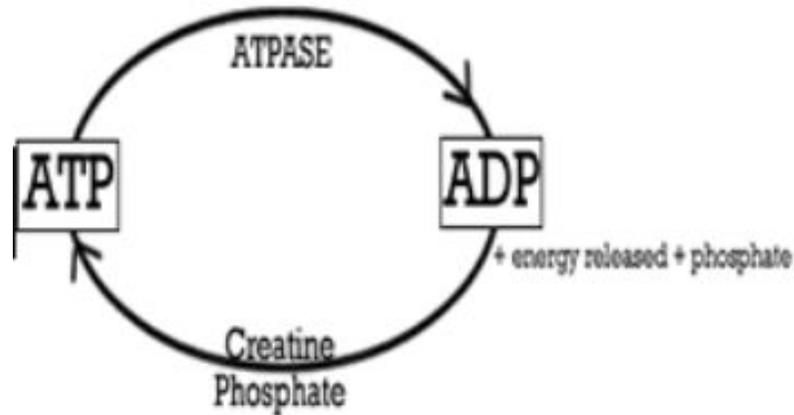
- maintains body temperature.

Why might products like pro-creatine claim to increase energy?



ATP = adenosine triphosphate

ADP = adenosine diphosphate



# Other Terms

- 1. Threshold Stimulus
- 2. All-or-None Response
- 3. Motor Unit
- 5. Recruitment
- 6. Muscle Tone
- 7. Muscular Hypertrophy
- 8. Muscular Atrophy
- 9. Muscle Fatigue
- 10. Muscle Cramp
- 11. Oxygen Debt



# 1. Threshold Stimulus

Minimal strength required to cause a contraction

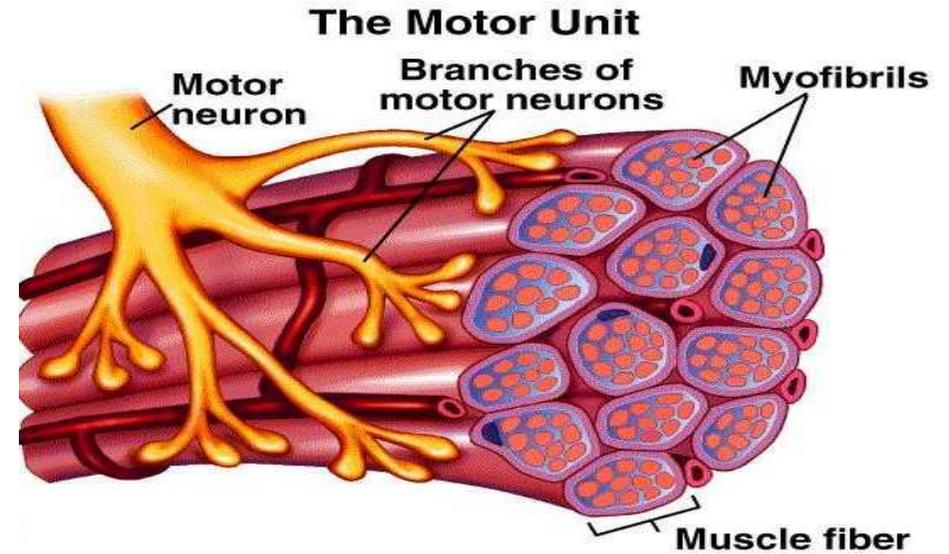
Motor neuron releases enough acetylcholine to reach threshold

# 2. All-or-None Response

Fibers do not contract partially, they either do or don't

### 3. Motor Unit

The muscle fiber + the motor neuron



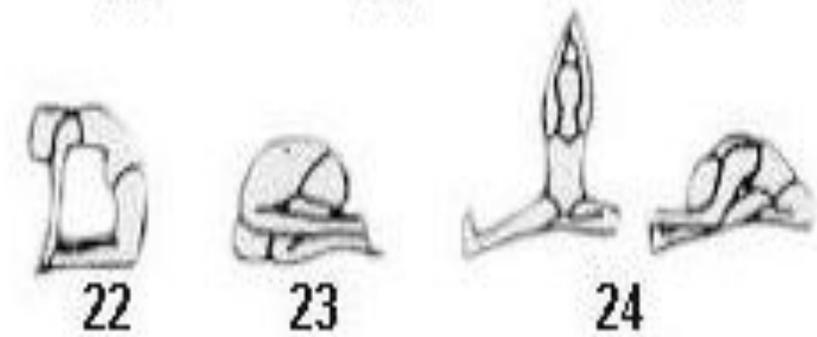
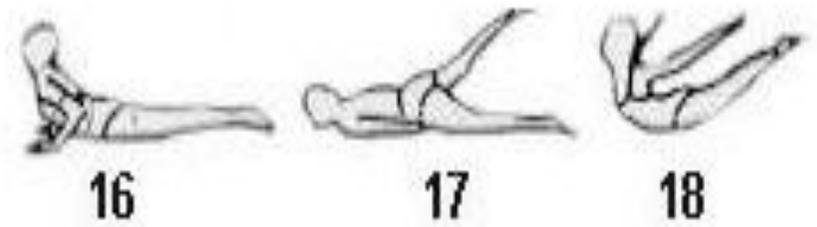
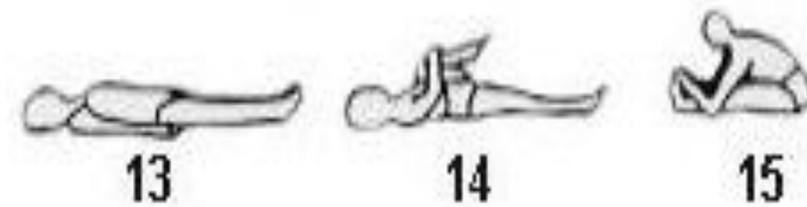
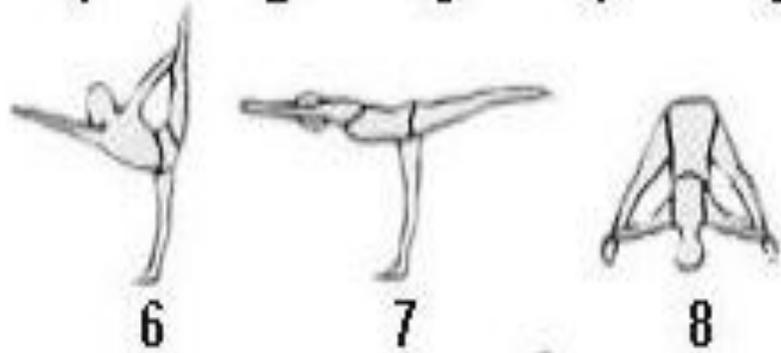
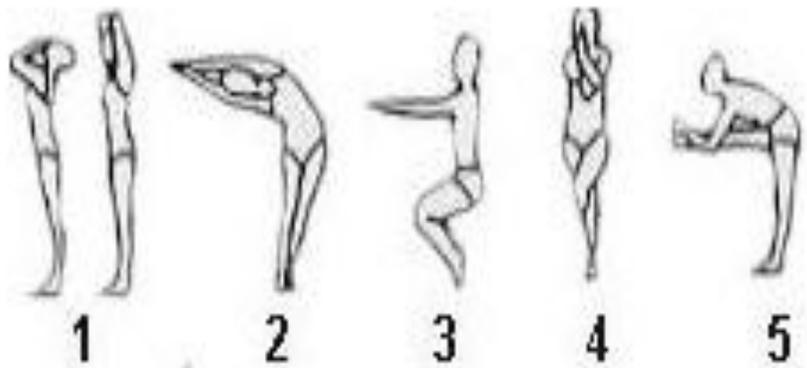
### 4. Recruitment

more and more fibers contract as the intensity of the stimulus increases

### 5. Muscle Tone

Sustained contraction of individual fibers, even when muscle is at rest





6. **Hypertrophy** - muscles enlarge (working out or certain disorders)

7. **Atrophy** - muscles become small and weak due to disuse



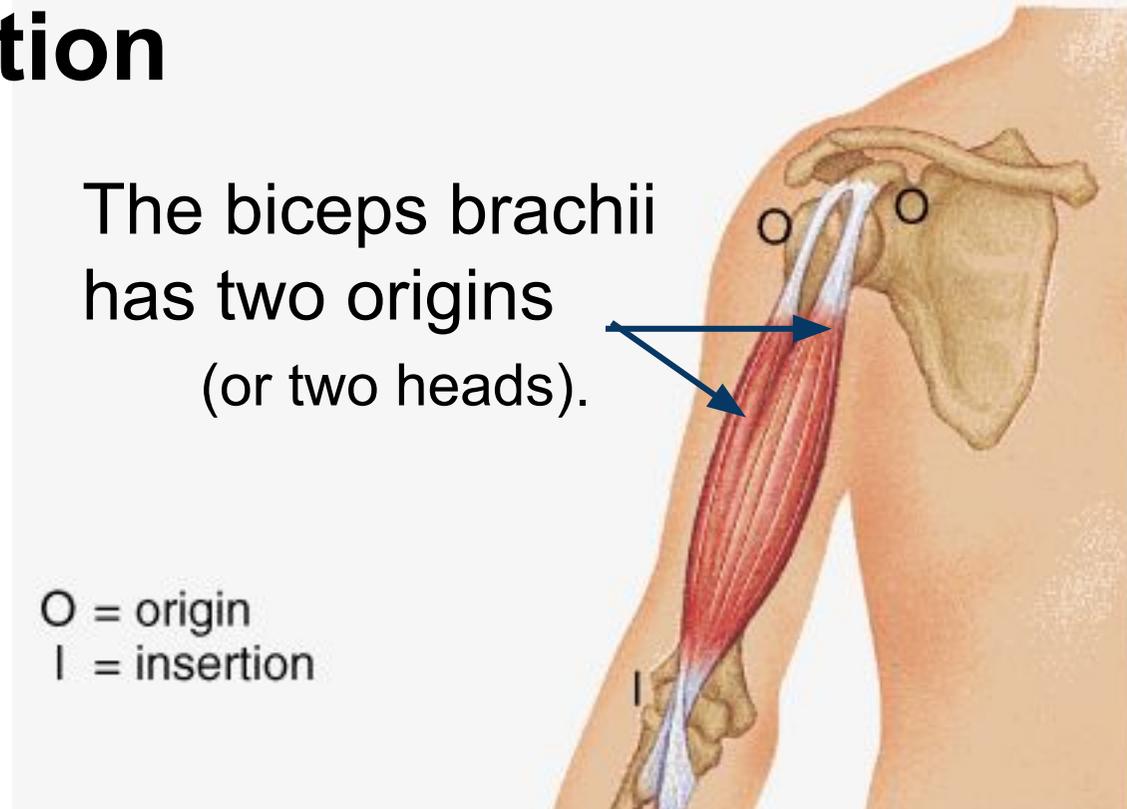
8. **Muscle Fatigue** - muscle loses ability to contract after prolonged exercise or strain
9. **Muscle Cramp** - a sustained involuntary contraction
10. **Oxygen Debt** - oxygen is used to create ATP,  
-- not have enough oxygen causes Lactic Acid to accumulate in the muscles → Soreness

**\*See Magic School Bus**

# 11. Origin and Insertion

--Origin = the immovable end of the muscle

--Insertion = the movable end of the muscle



# 12. Action Potential

the change in electrical potential, passage of an impulse along the membrane (sarcolemma) of the muscle cell

# What is rigor mortis?

A few hours after a person or animal dies, the joints of the body stiffen and become locked in place. This stiffening is called *rigor mortis*. Depending on temperature and other conditions, rigor mortis lasts approximately 72 hours.



Crime Scene Investigation

# Disorders of the Muscular System

## What is tetanus?

Tetanus causes cholinesterase to not break down the acetylcholine in the synapse. This results in a person's muscles contracting and not relaxing.



A tetanus shot must be administered shortly after exposure to the bacteria.

Once you develop tetanus, there is no cure.

# What is Myotonia?

delayed relaxation of the skeletal muscles after voluntary contraction, electrical stimulation, or even being startled.



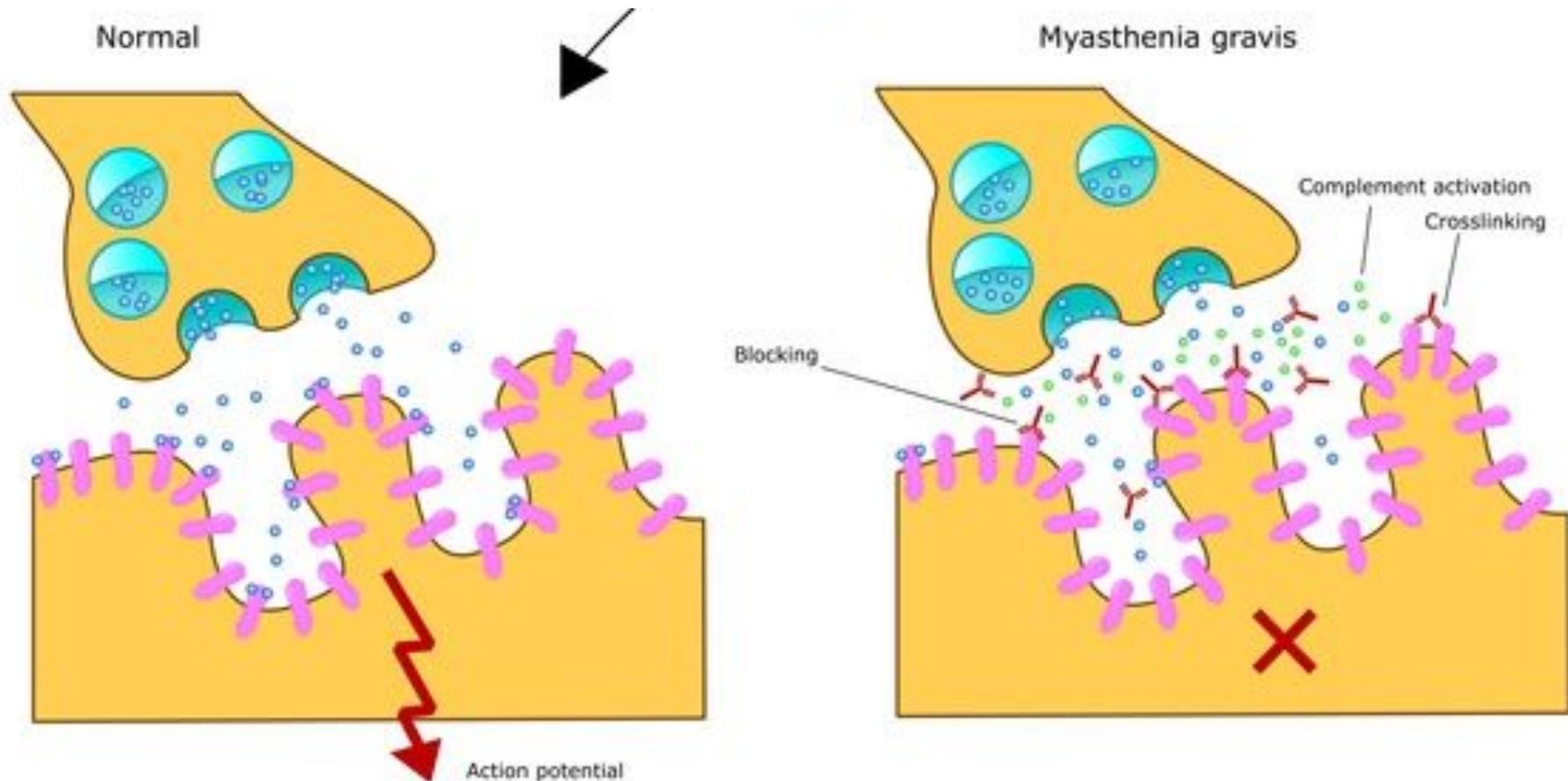
These  
“fainting”  
goats  
have  
*myotonia  
congenita*

# What is Myasthenia Gravis?

- Means "grave muscular weakness."
- Autoimmune disease
- Acetylcholine receptors are damaged

## Symptoms

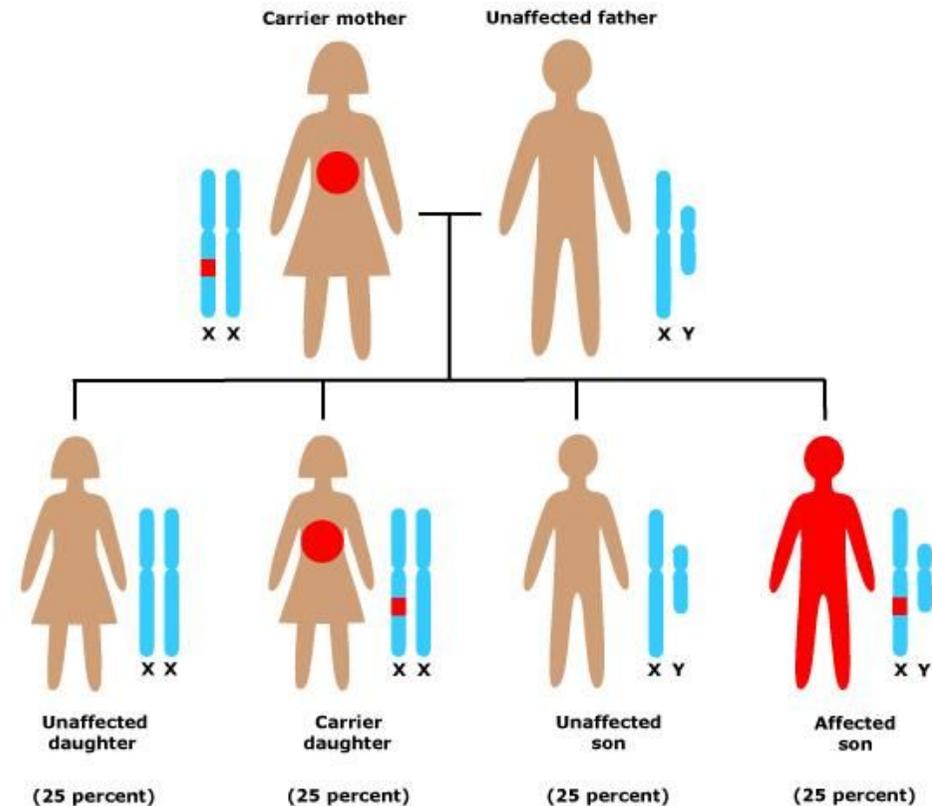
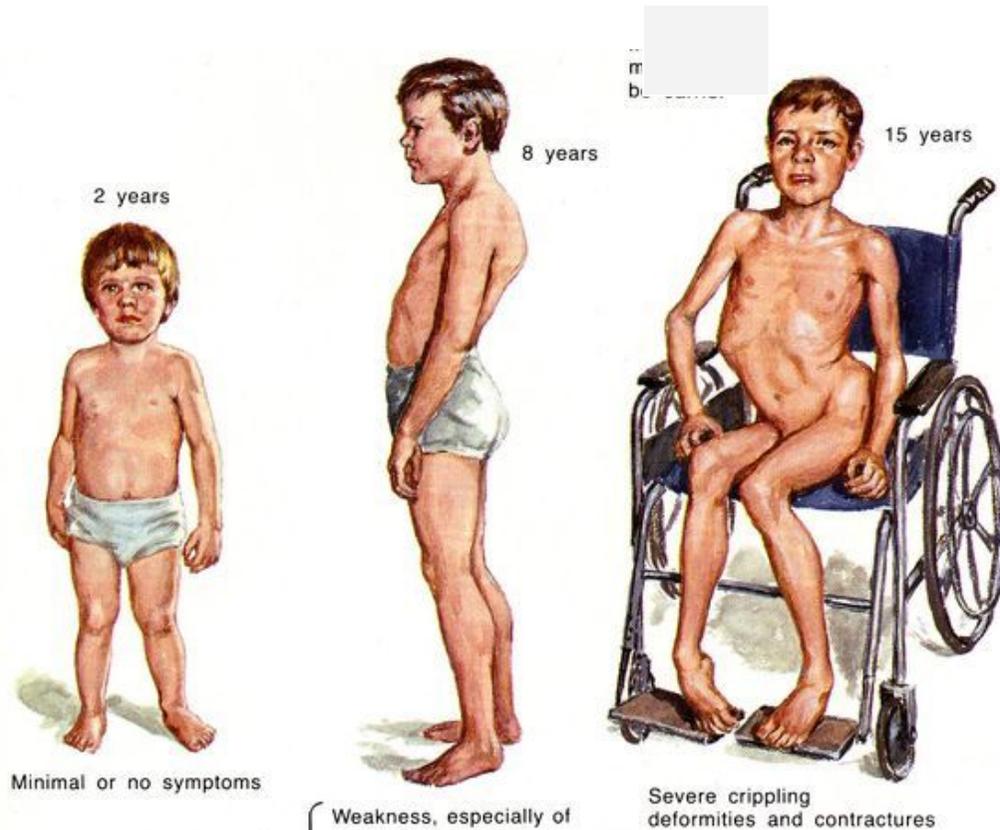
- A drooping eyelid
- Blurred vision
- Slurred speech
- Difficulty swallowing
- Weakness / Fatigue



# What is muscular dystrophy?

Muscles progressively get weaker, often resulting in inability to walk, talk or breathe.

Duchenne MD occurs in boys (sex-linked inheritance pattern)



[Video: Gower's Sign](#)

# ALS

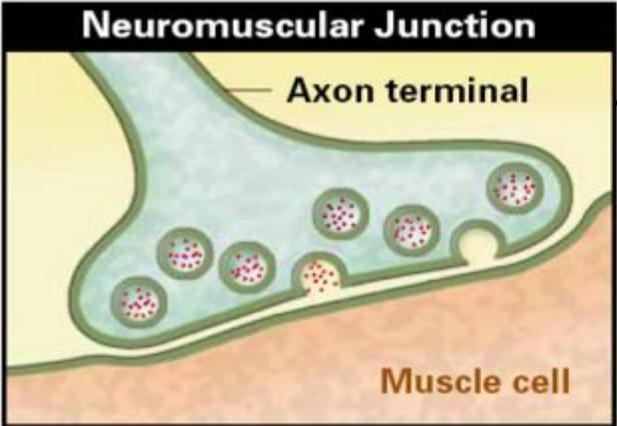
ALS, or amyotrophic lateral sclerosis, is a progressive neurodegenerative disease.

The motor nerves that are affected are the motor neurons (motor unit) that provide voluntary movements and muscle control.



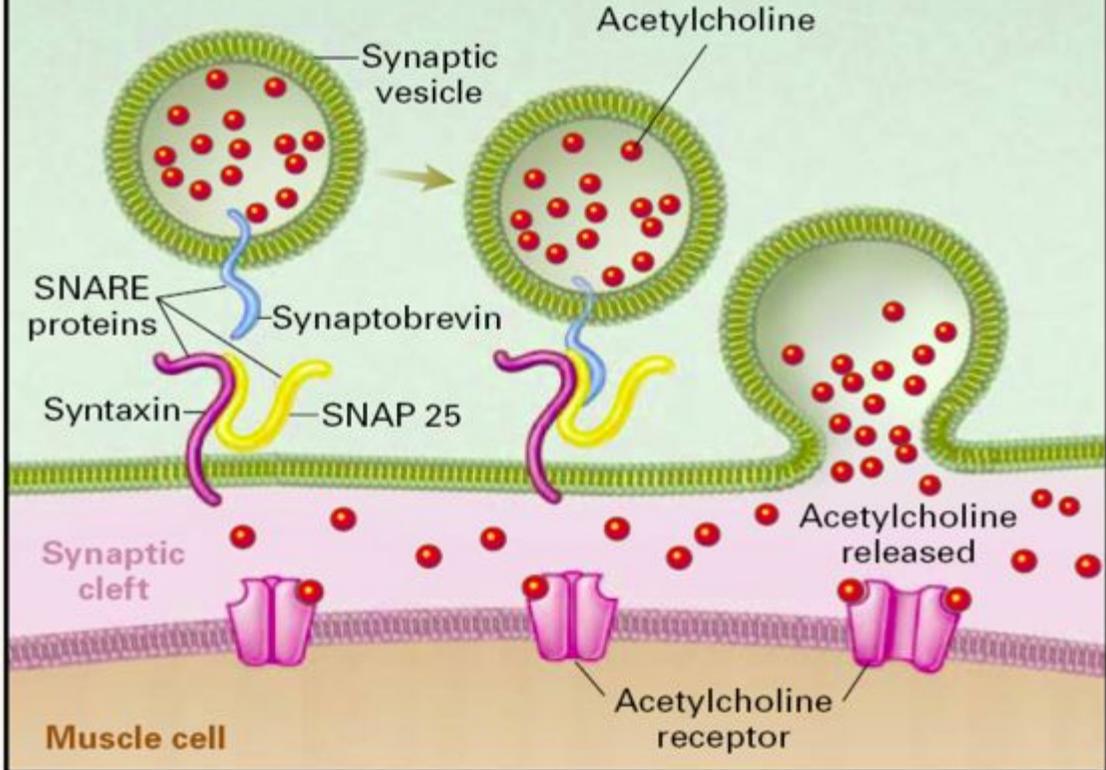
A-myo-trophic comes from the Greek language. "A" means no. "Myo" refers to muscle, and "Trophic" means nourishment – "No muscle nourishment." When a muscle has no nourishment, it "atrophies" or wastes away.

# Poisons that Affect the Neuromuscular Junction



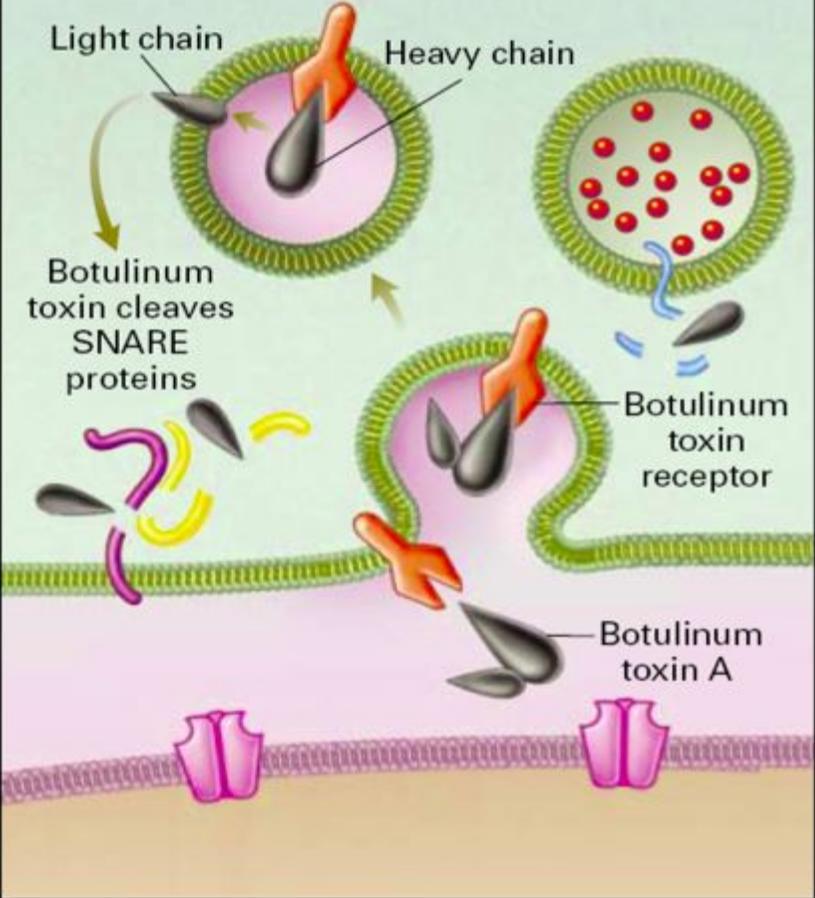
## Normal Transmitter Release

Neuron



## BOTULISM

### Action of Botulinum Toxin A



# Botox?

## HOW MUCH BOTOX DO I NEED?

45 units of Botox is FDA approved. If you purchase 44+ units your Botox is just \$9.50/unit.

**SMILE LIFT** (corners of mouth)  
3-6 units

**DIMPLED CHIN**  
2-6 units

**NECK/PLATYSMAL LINES**  
25-50 units

**PALMS FOR SWEATING**  
50 units

**FOREHEAD LINES**  
8-20 units

**FROWN LINES**  
10-25 units

**EYEBROW LIFT**  
2-5 units

**CROW'S FEET**  
10-15 units (each side)

**BUNNY/NASALIS LINES**  
5-10 units

**UNDERARMS**  
100 units



# Strychnine

Lowers the threshold level for an action potential, making it more likely the muscles will contract

Death occurs from convulsions and asphyxia



# Curare

classified as a neuromuscular blocking agent—it produces flaccidity in skeletal muscle by competing with the neurotransmitter acetylcholine at the neuromuscular junction

