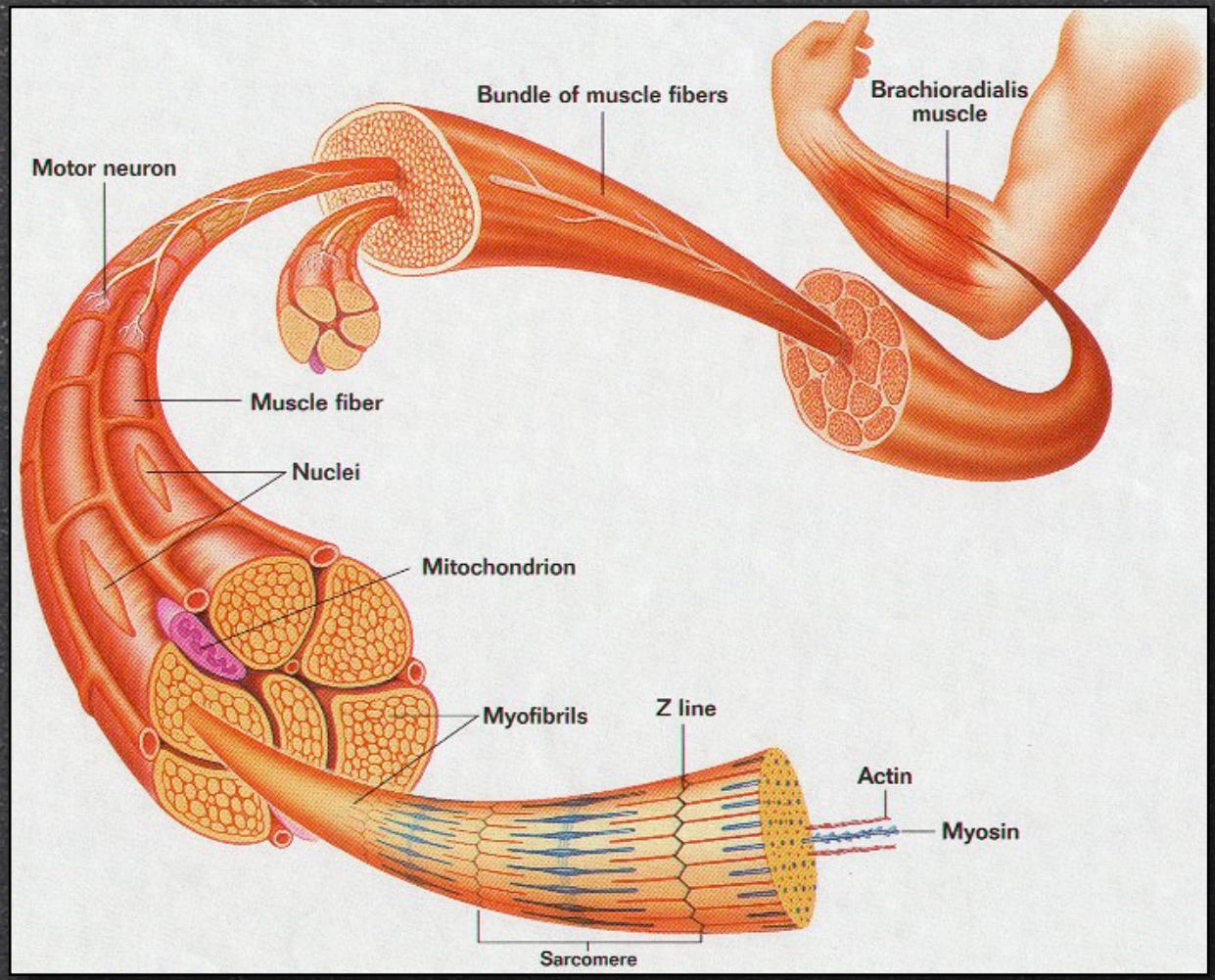
Physiology of the Musculoskeletal System

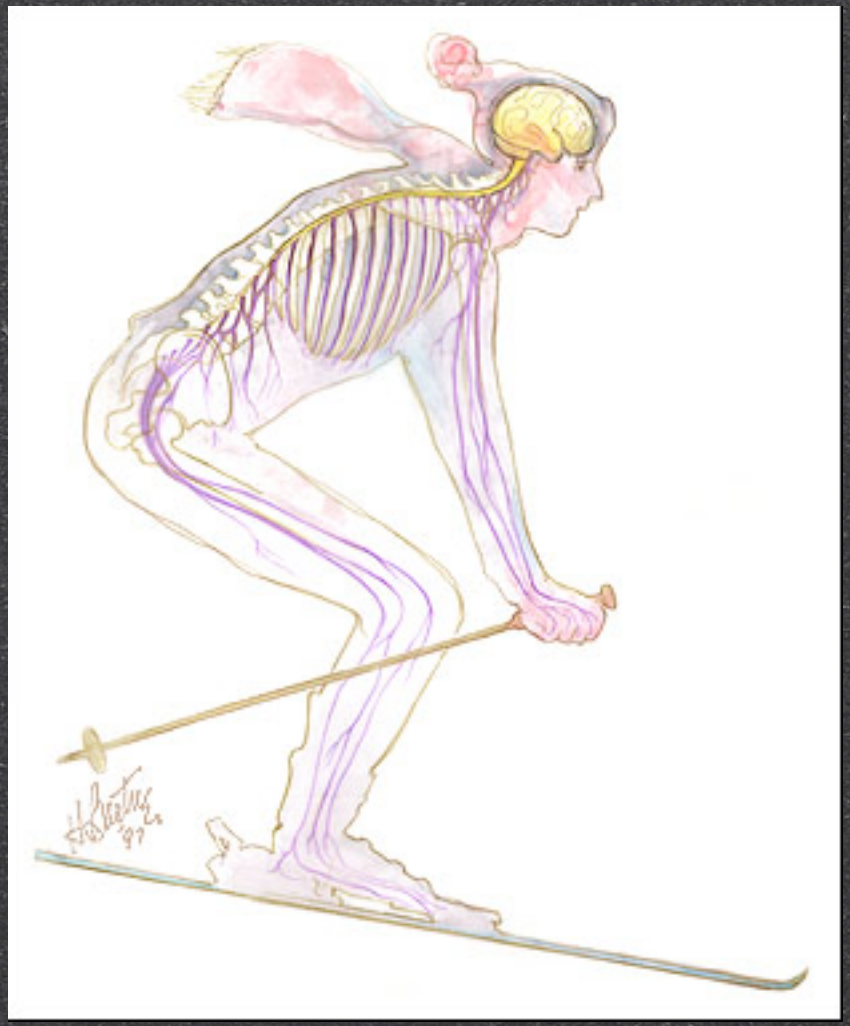
Chapters 7 & 8

1. Neuromuscular Anatomy



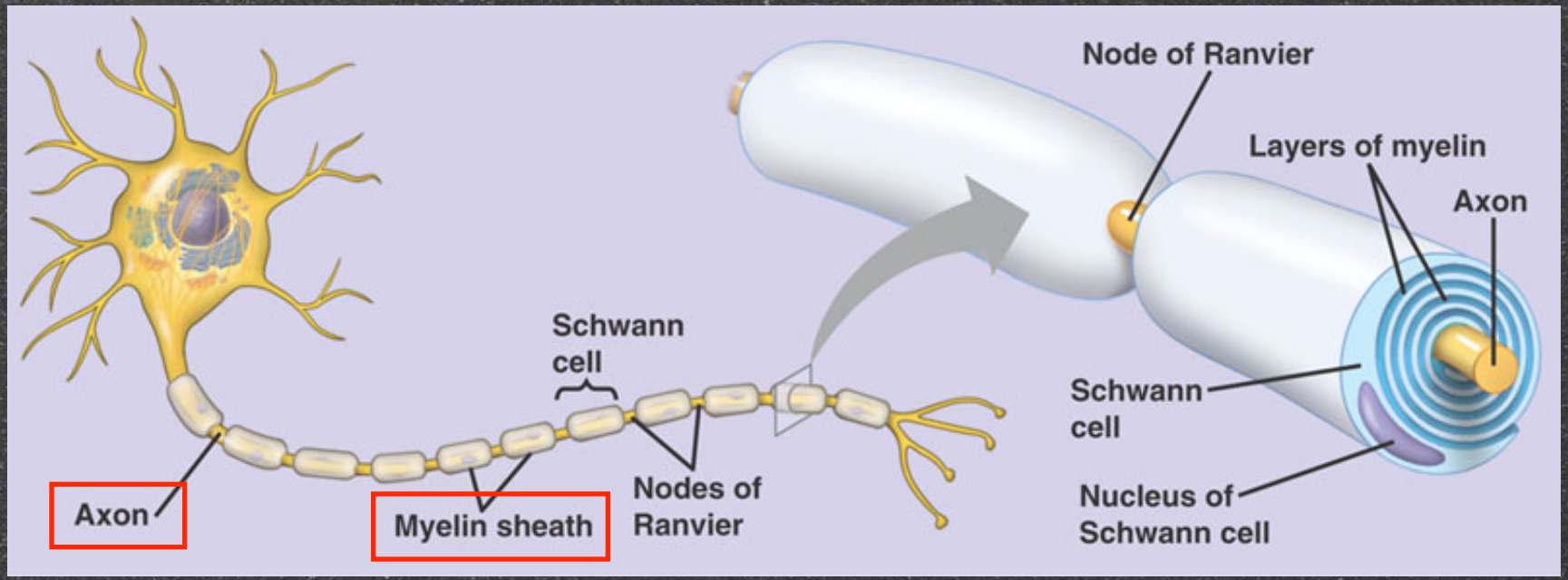
Neuromotor System

Central Nervous System

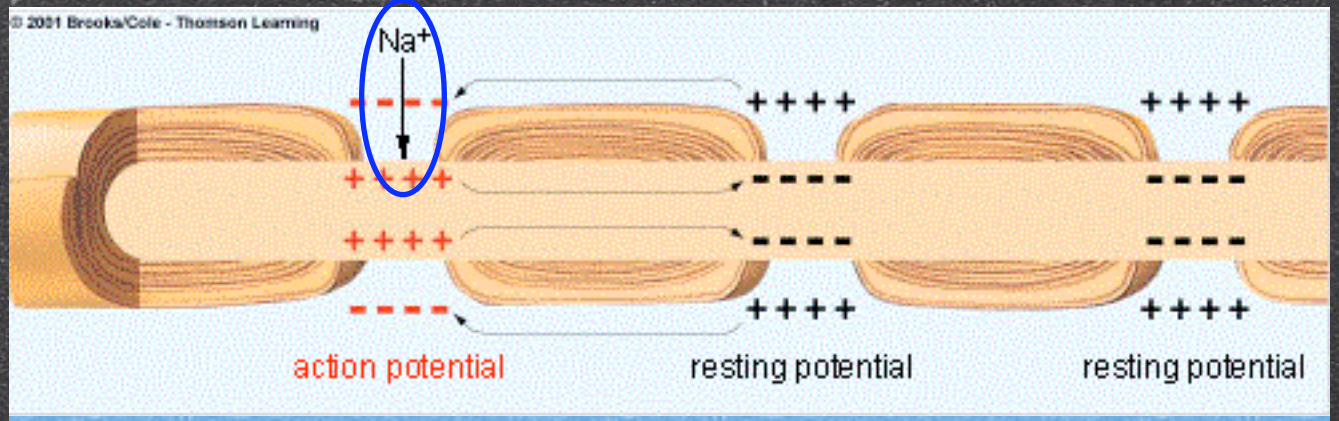


Peripheral Nervous System

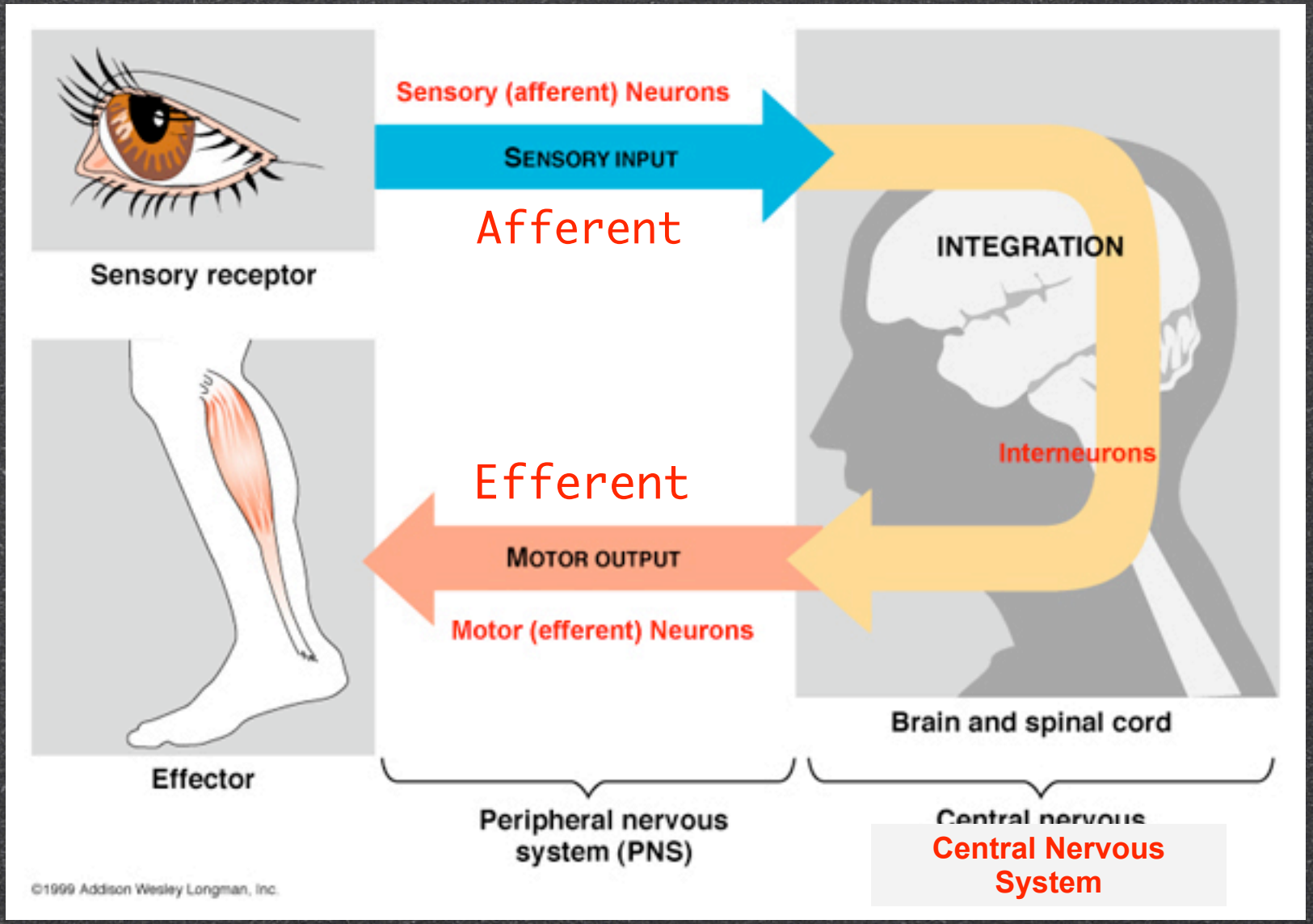
Neuron

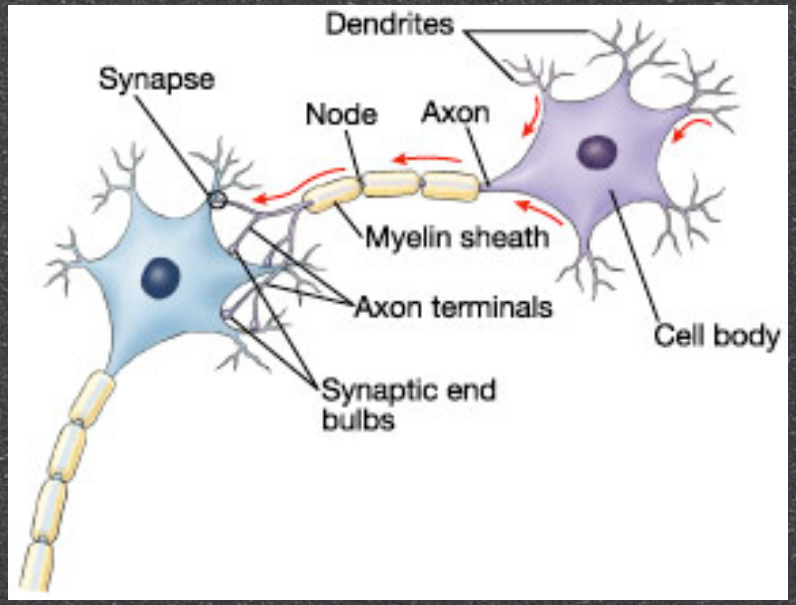

Node of Ranvier
Layers of myelin
Axon
Schwann cell
Schwann cell
Nodes of Ranvier
Axon
Myelin sheath
Nucleus of Schwann cell

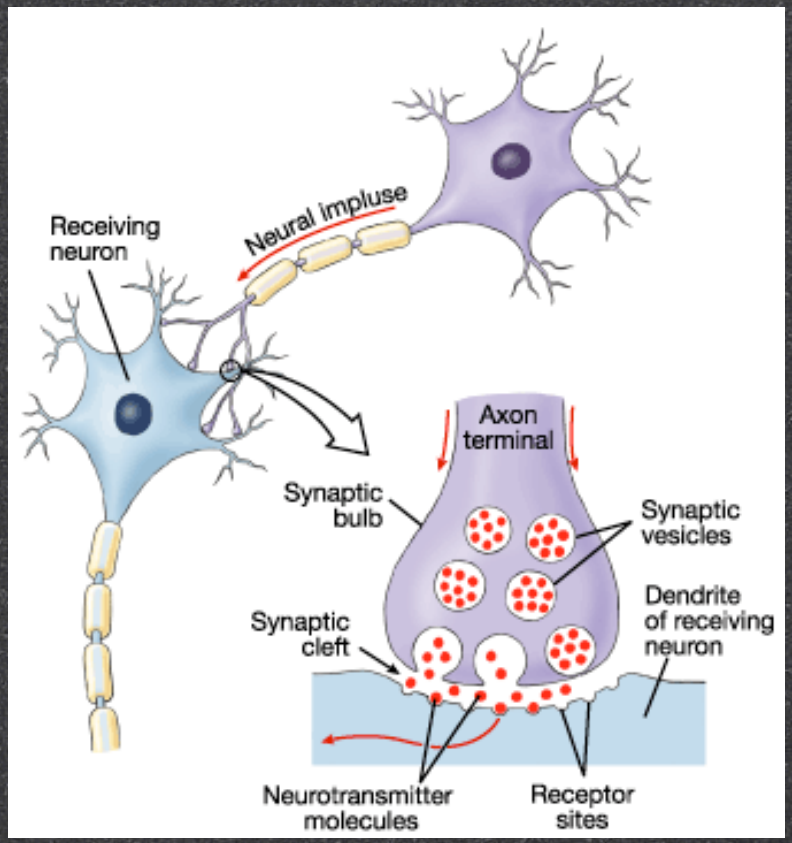
Action Potential



Afferent & Efferent

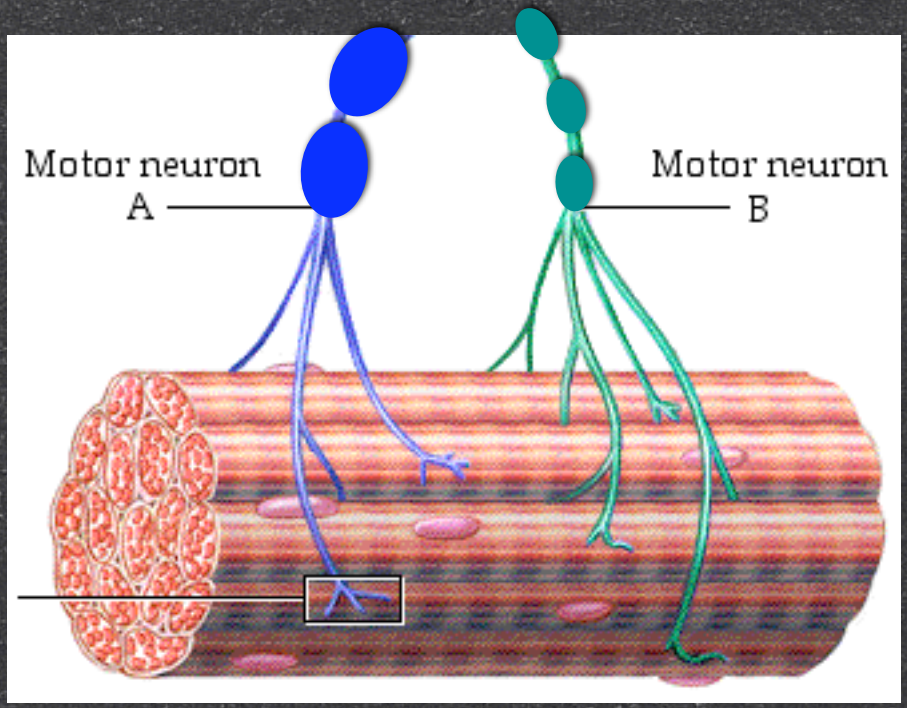



Dendrites
Synapse
Node
Axon
Myelin sheath
Axon terminals
Cell body
Synaptic end bulbs

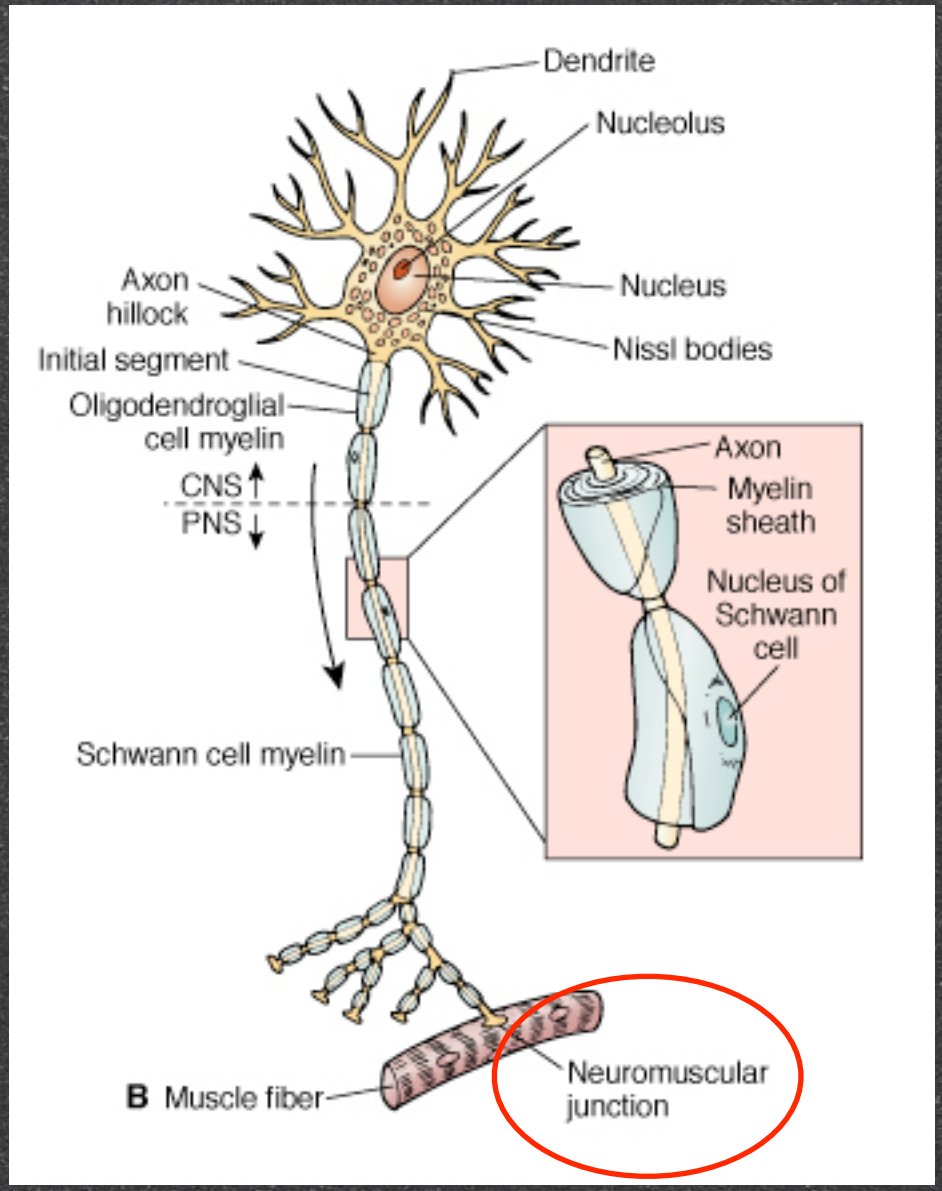

Receiving neuron
Neural impluse
Axon terminal
Synaptic bulb
Synaptic vesicles
Dendrite of receiving neuron
Synaptic cleft
Neurotransmitter molecules
Receptor sites

Motor Neurons

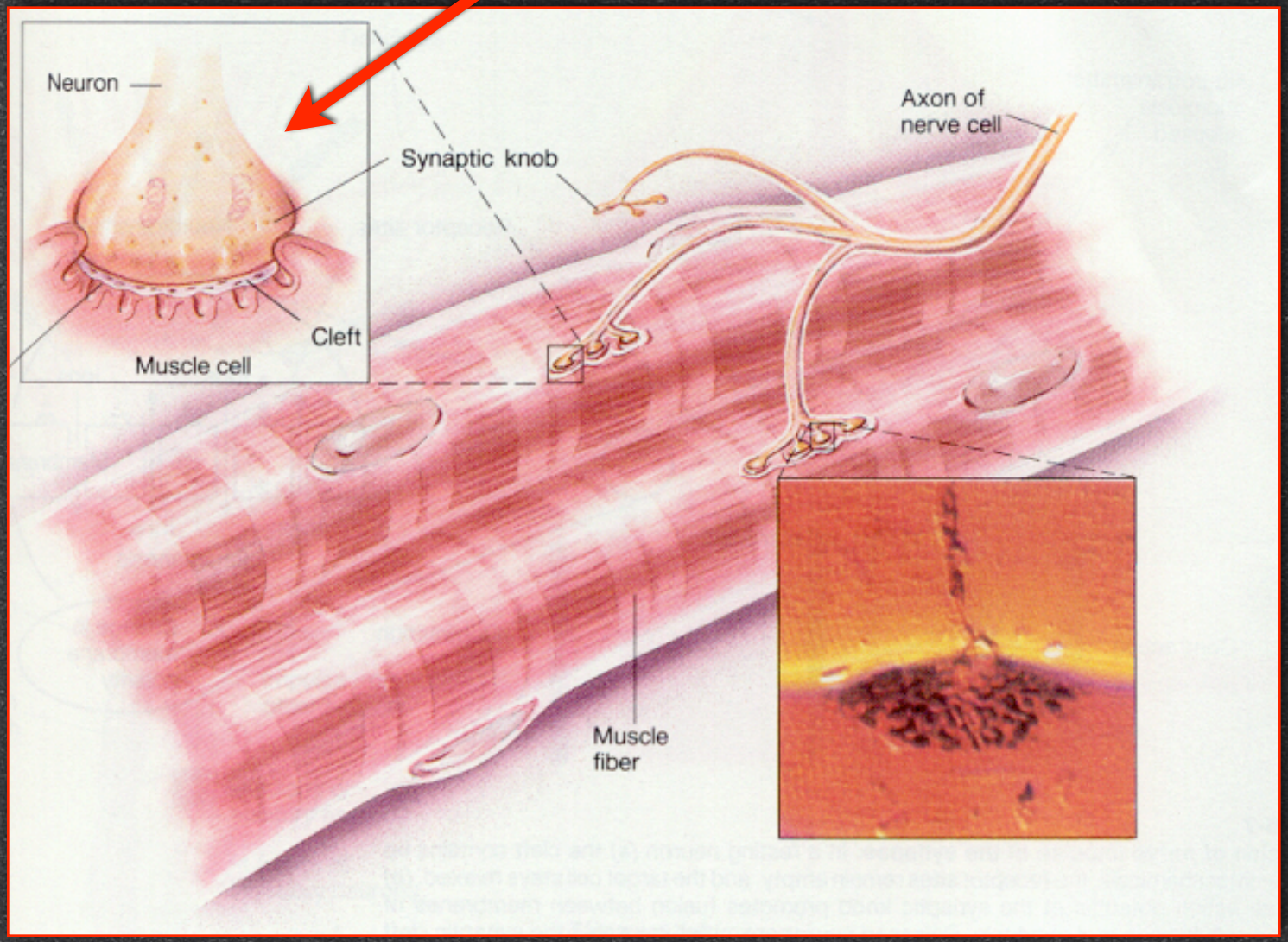
Fast Slow



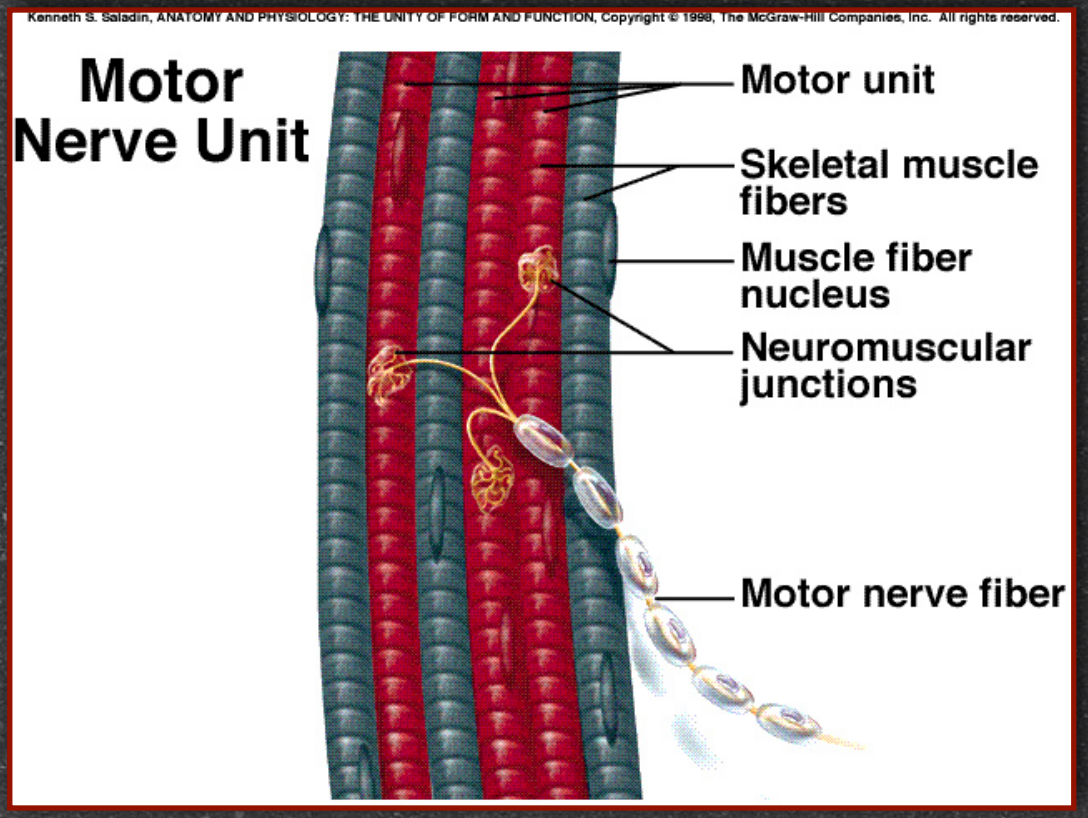
Neuromuscular Junction



Neuromuscular Junction

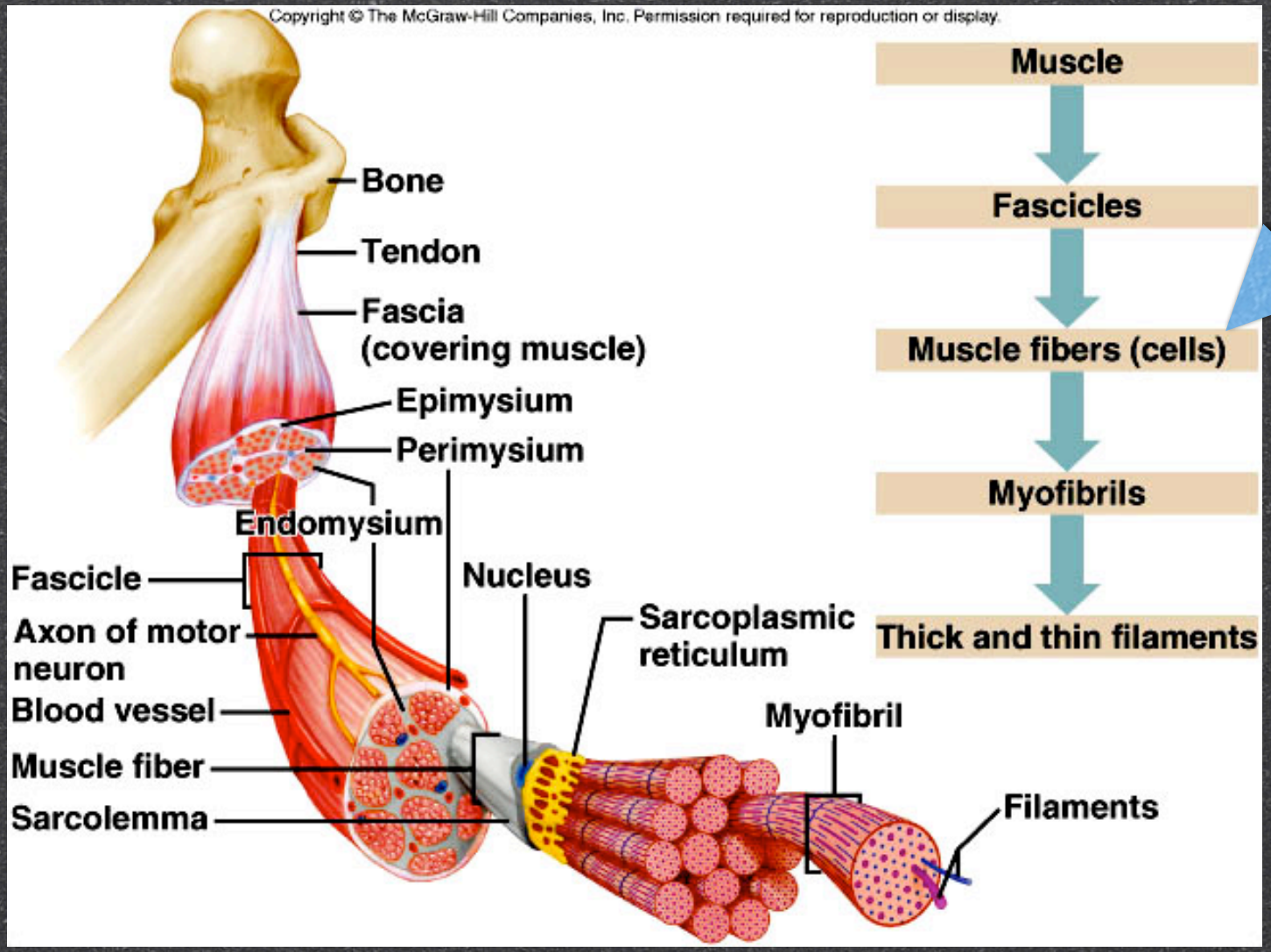


Motor Unit

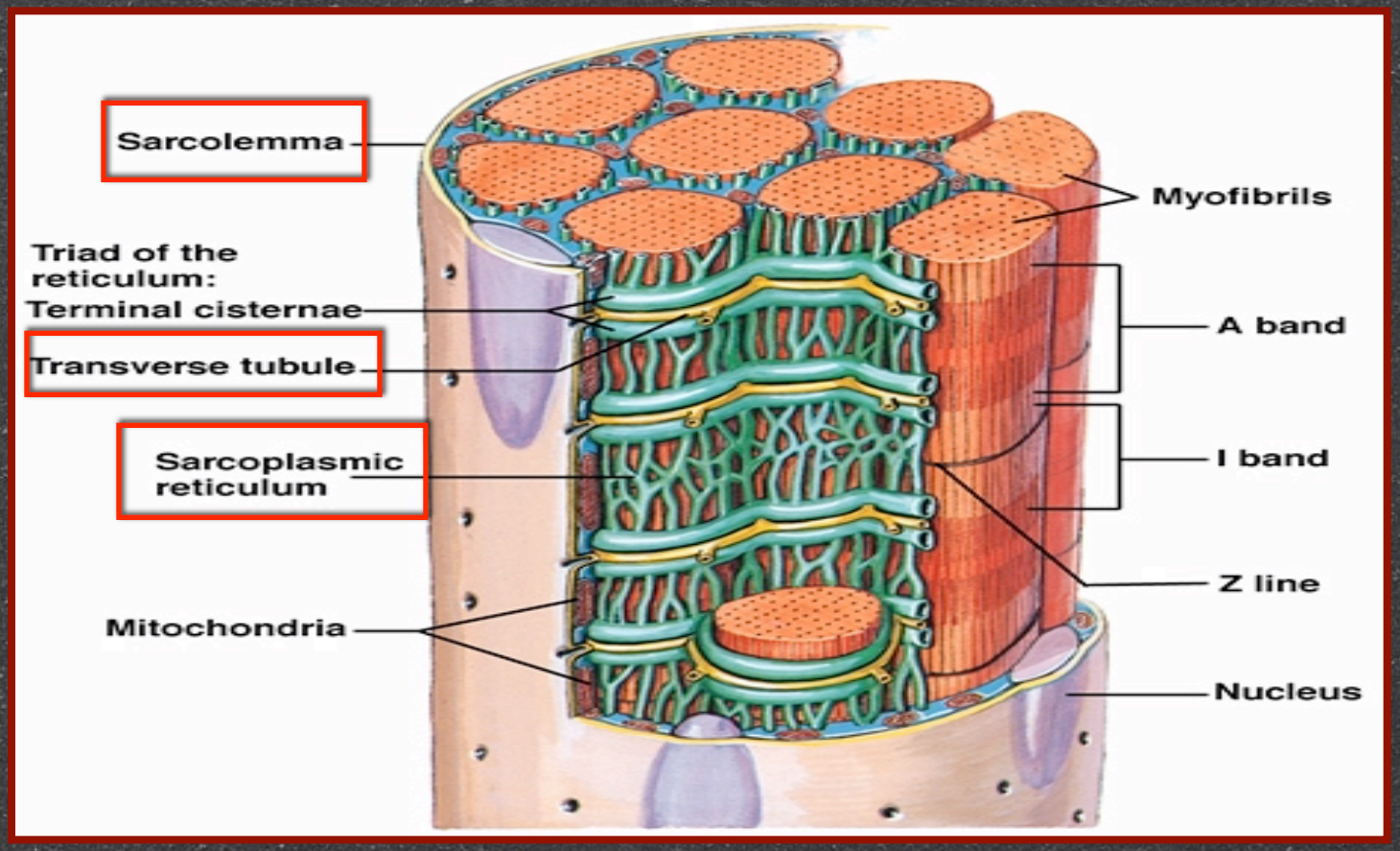


Note: This motor unit has a 3:1 ratio
Actual motor units range from 20:1 to 2,000:1

2. Muscle Anatomy Overview

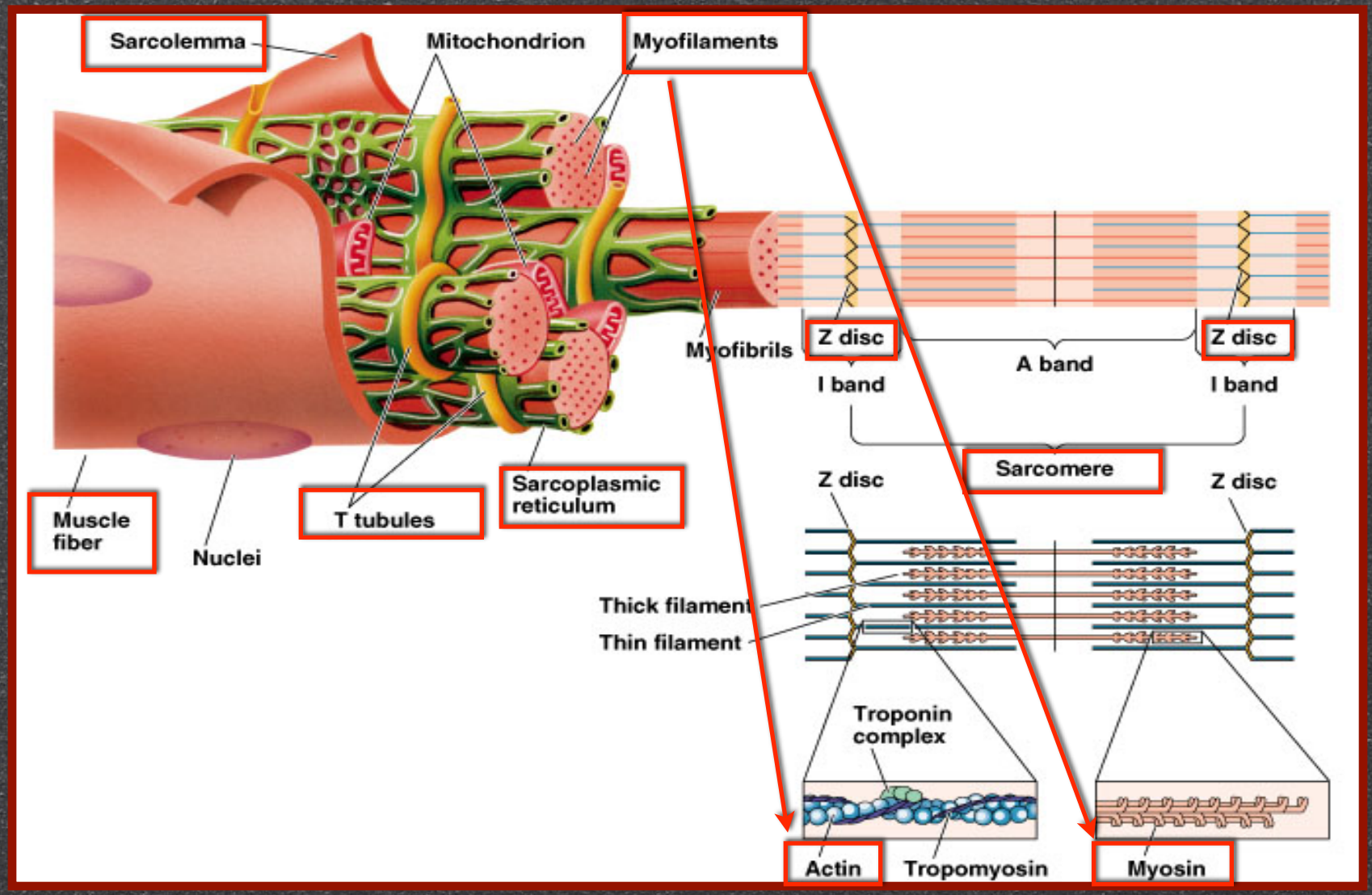


Muscle Fiber Anatomy

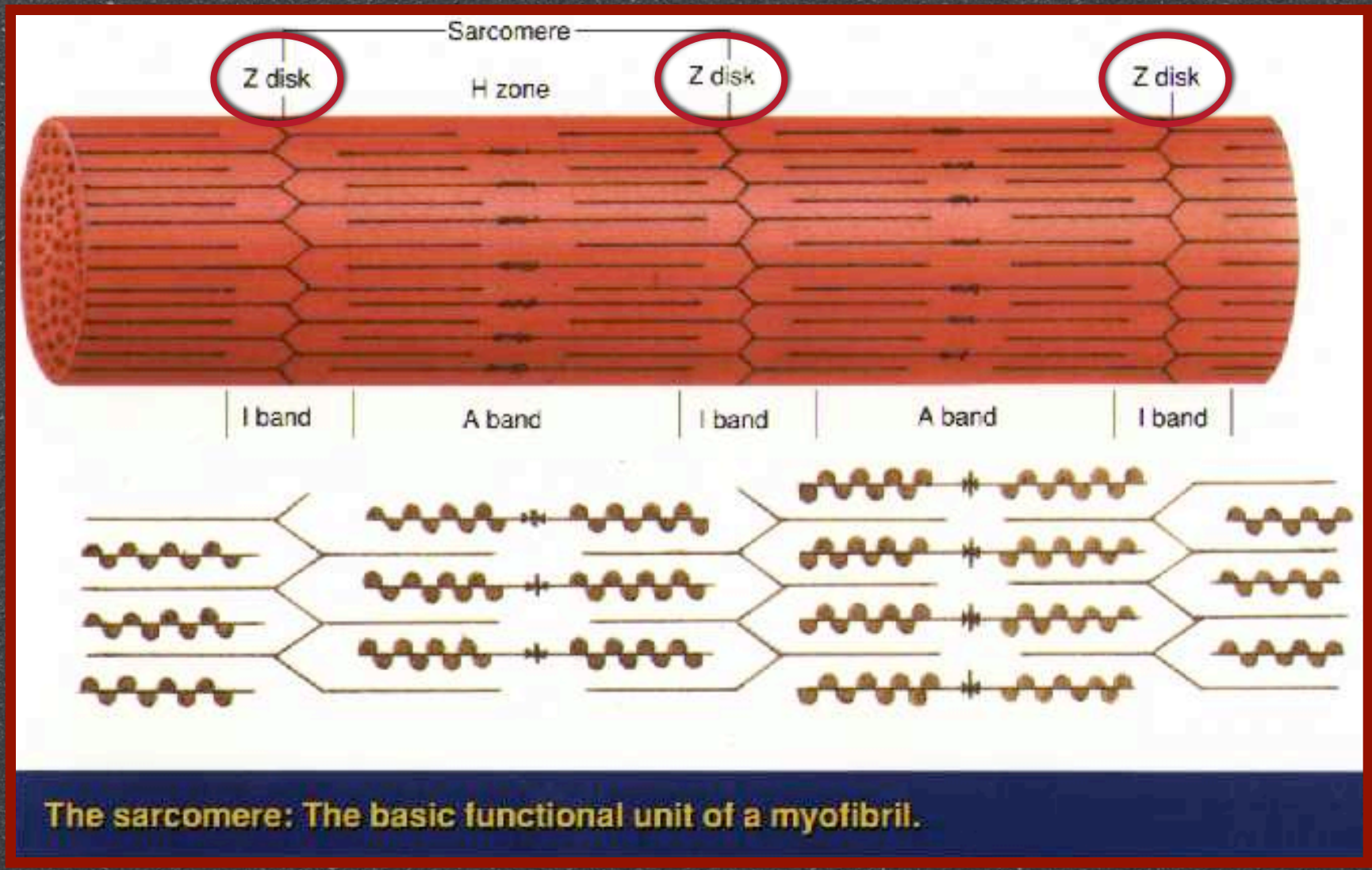


Note: muscle fiber = muscle cell

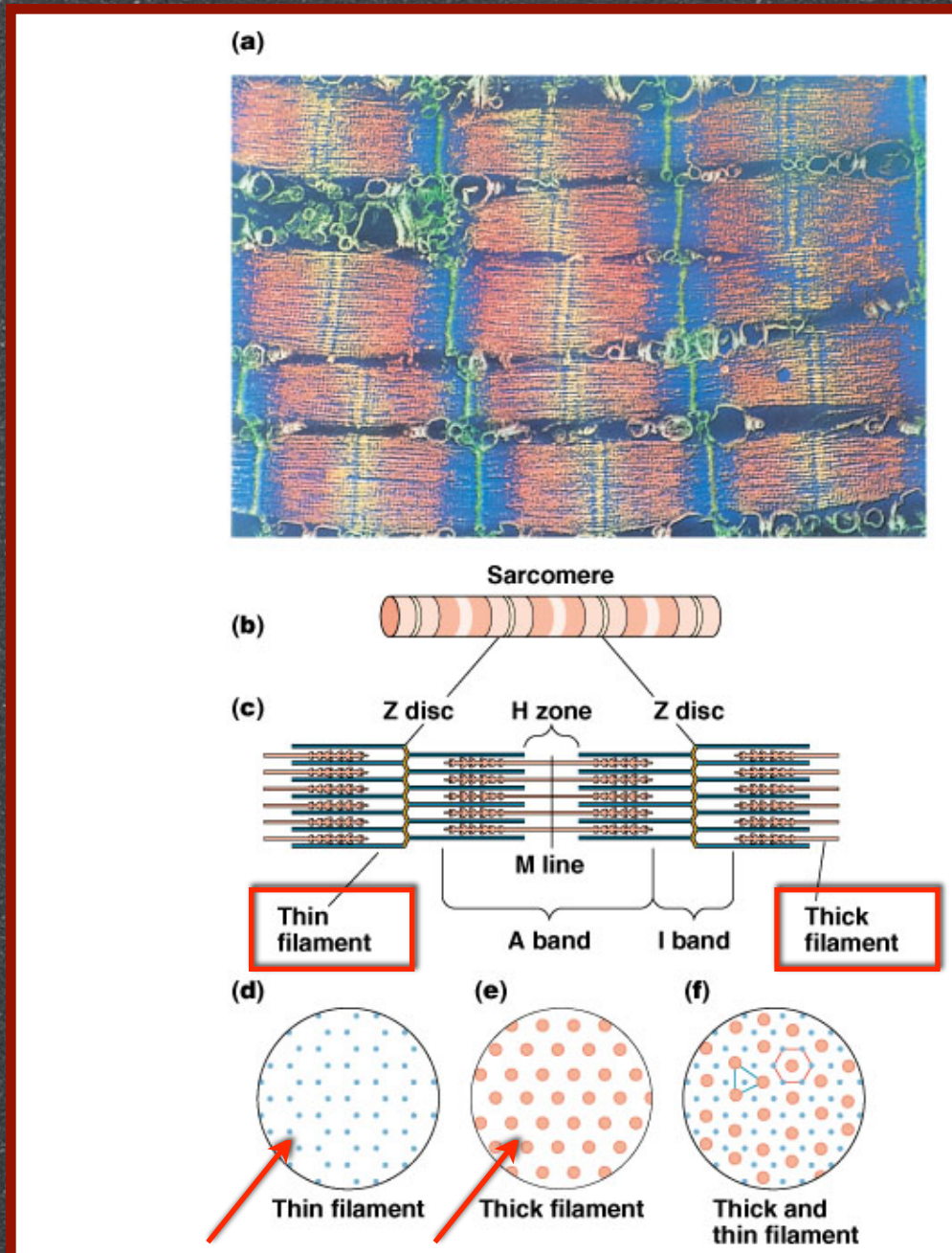
Muscle Fiber Anatomy

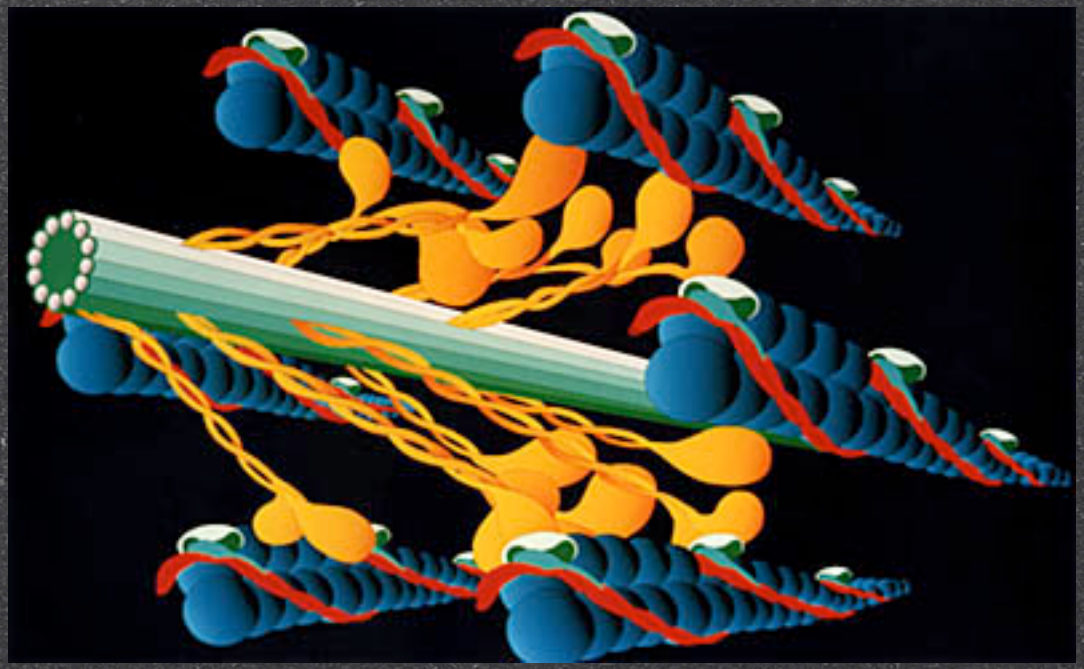


Sarcomere

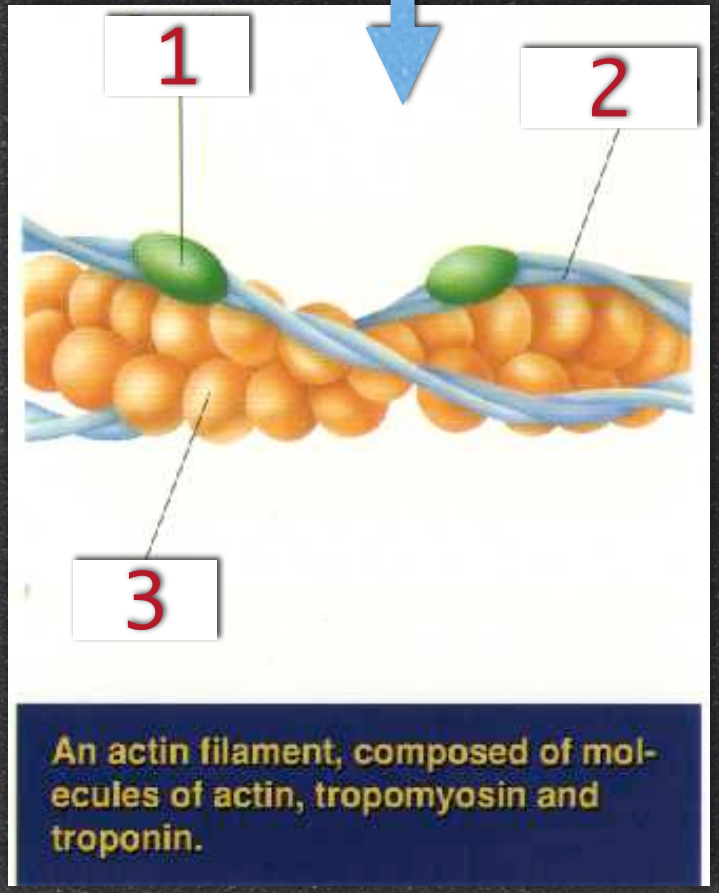


The sarcomere: The basic functional unit of a myofibril.

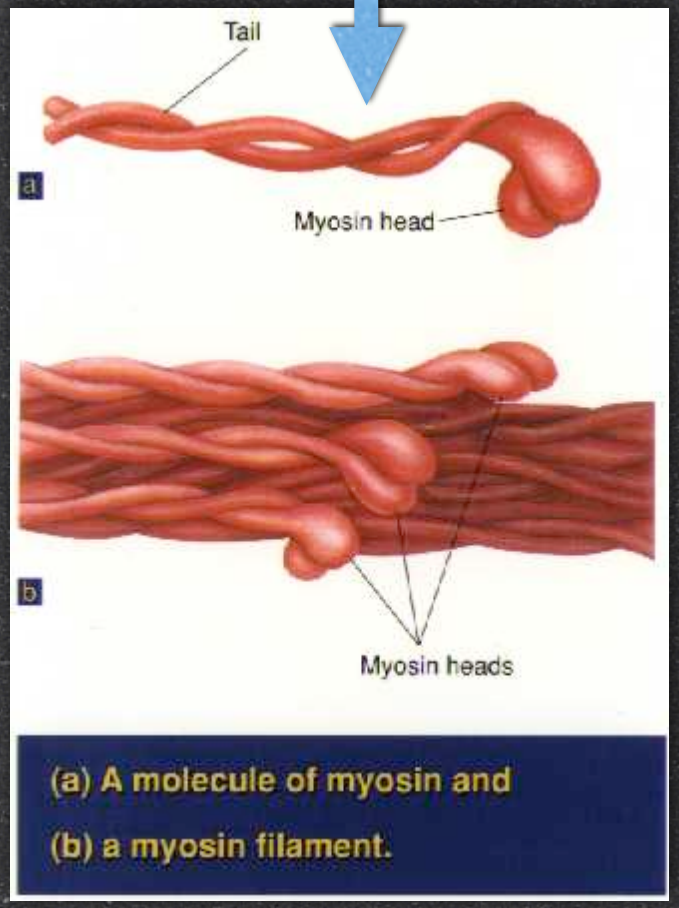

(a)
Sarcomere
(b)
(c)
Z disc
H zone
Z disc
M line
Thin filament
A band
I band
Thick filament
(d)
(e)
(f)
Thin filament
Thick filament
Thick and thin filament



Actin & Myosin



An actin filament, composed of molecules of actin, tropomyosin and troponin.

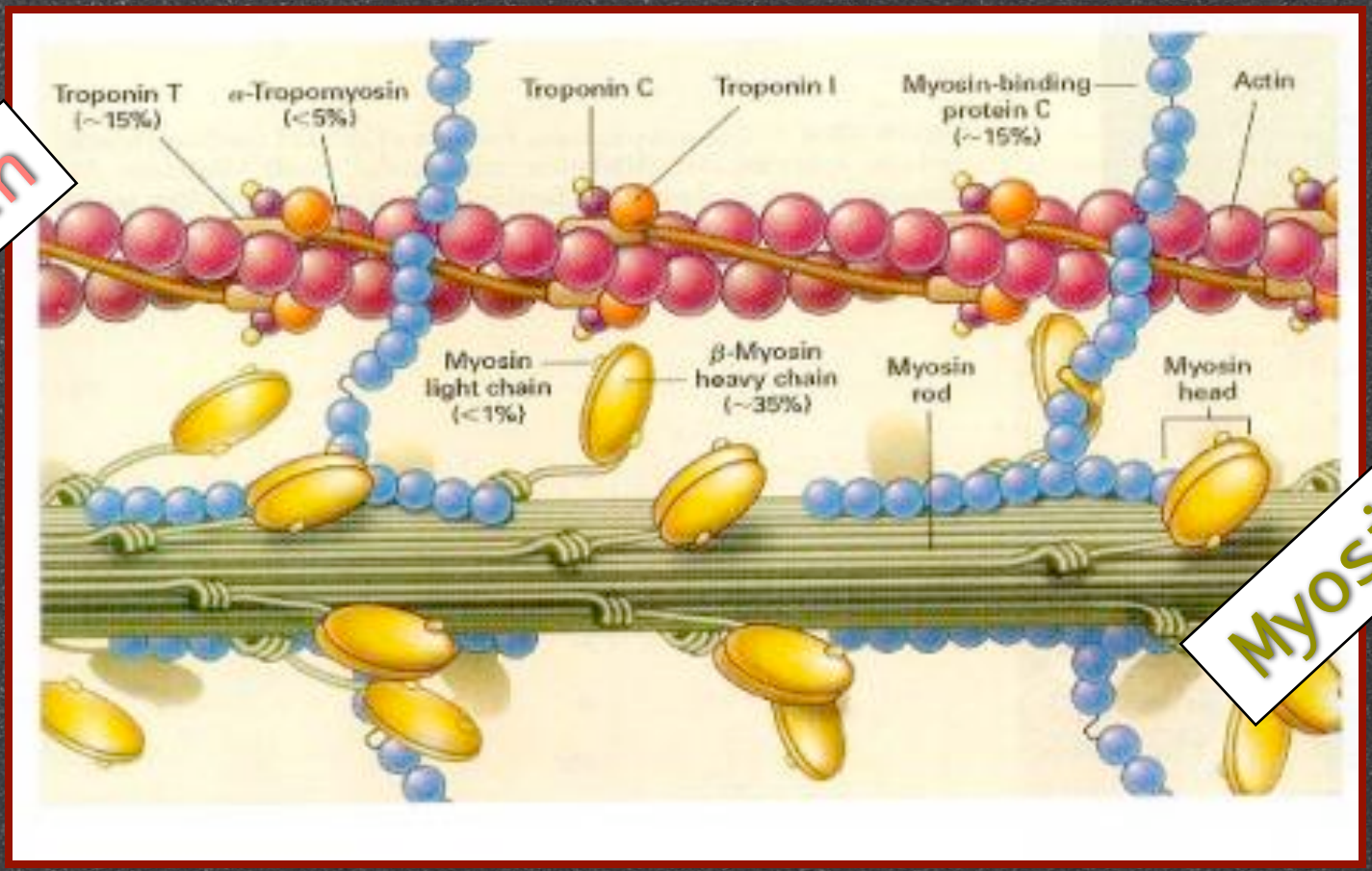


(a) A molecule of myosin and

(b) a myosin filament.

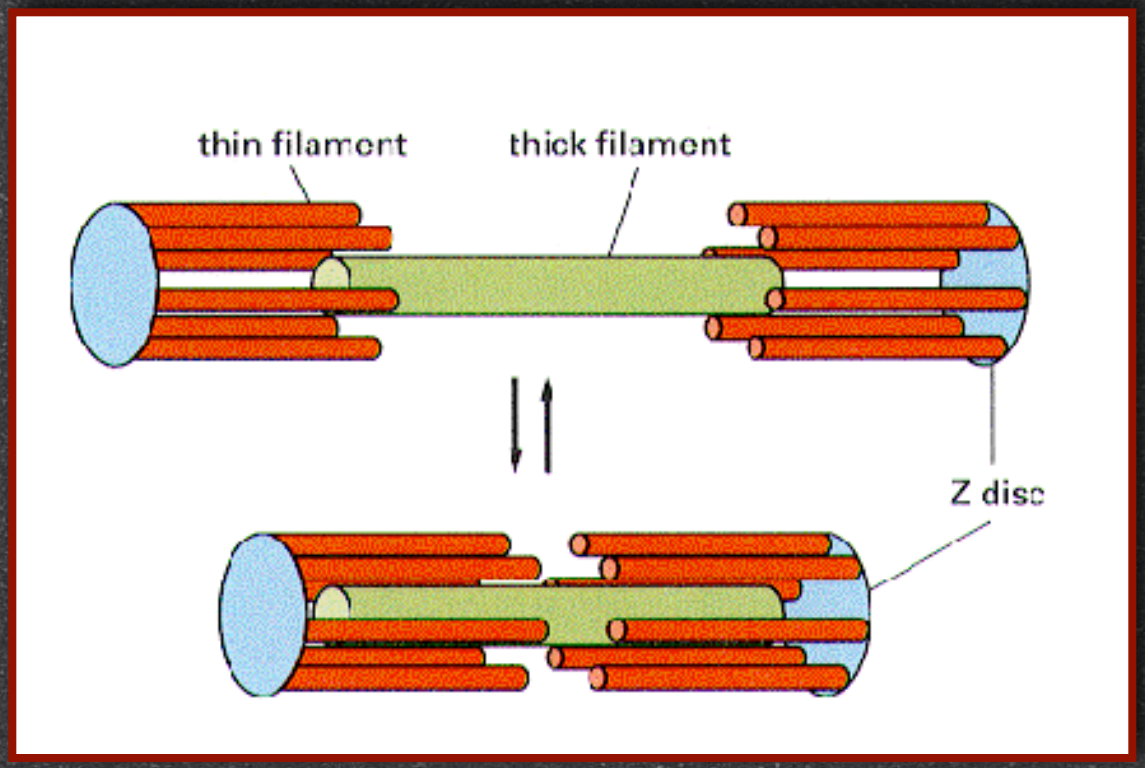
1. Troponin
2. Tropomyosin
3. Actin

Actin & Myosin



3. The Sliding Filament Theory

Excitation-Contraction Coupling



Step-by-Step Summary of Excitation-Contraction Coupling p. 145

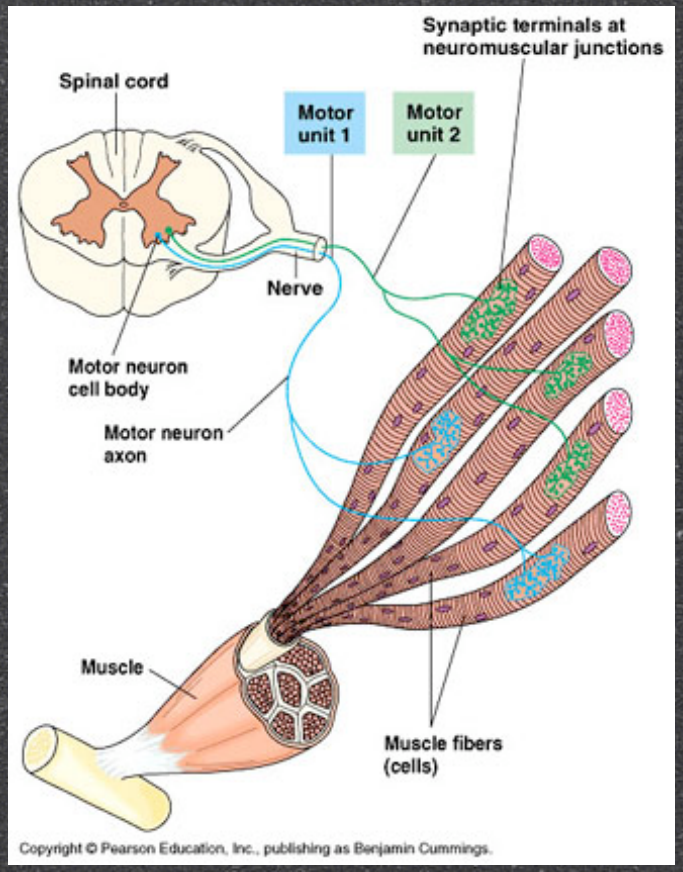
Web site on sliding filament theory

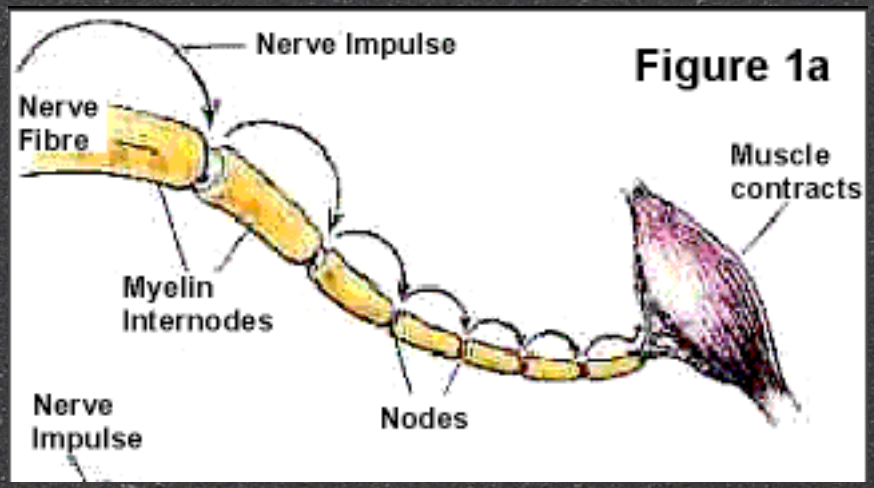
http://www.blackwellpublishing.com/matthews/myosin.html

http://muscle.biomol.uci.edu/mus1011.htm

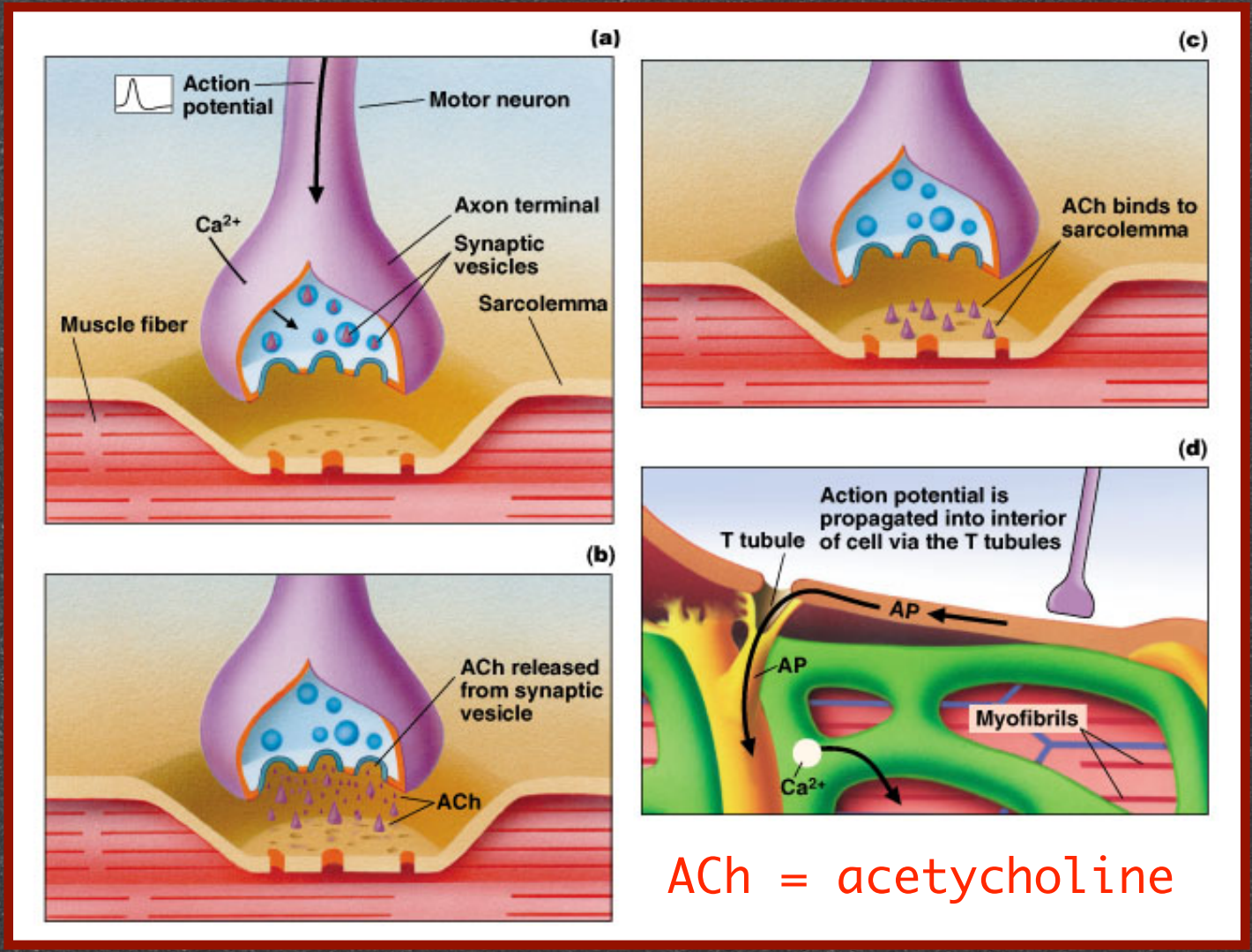
http://muscle.ucsd.edu/more_html/overview.shtml

Neural Stimulation



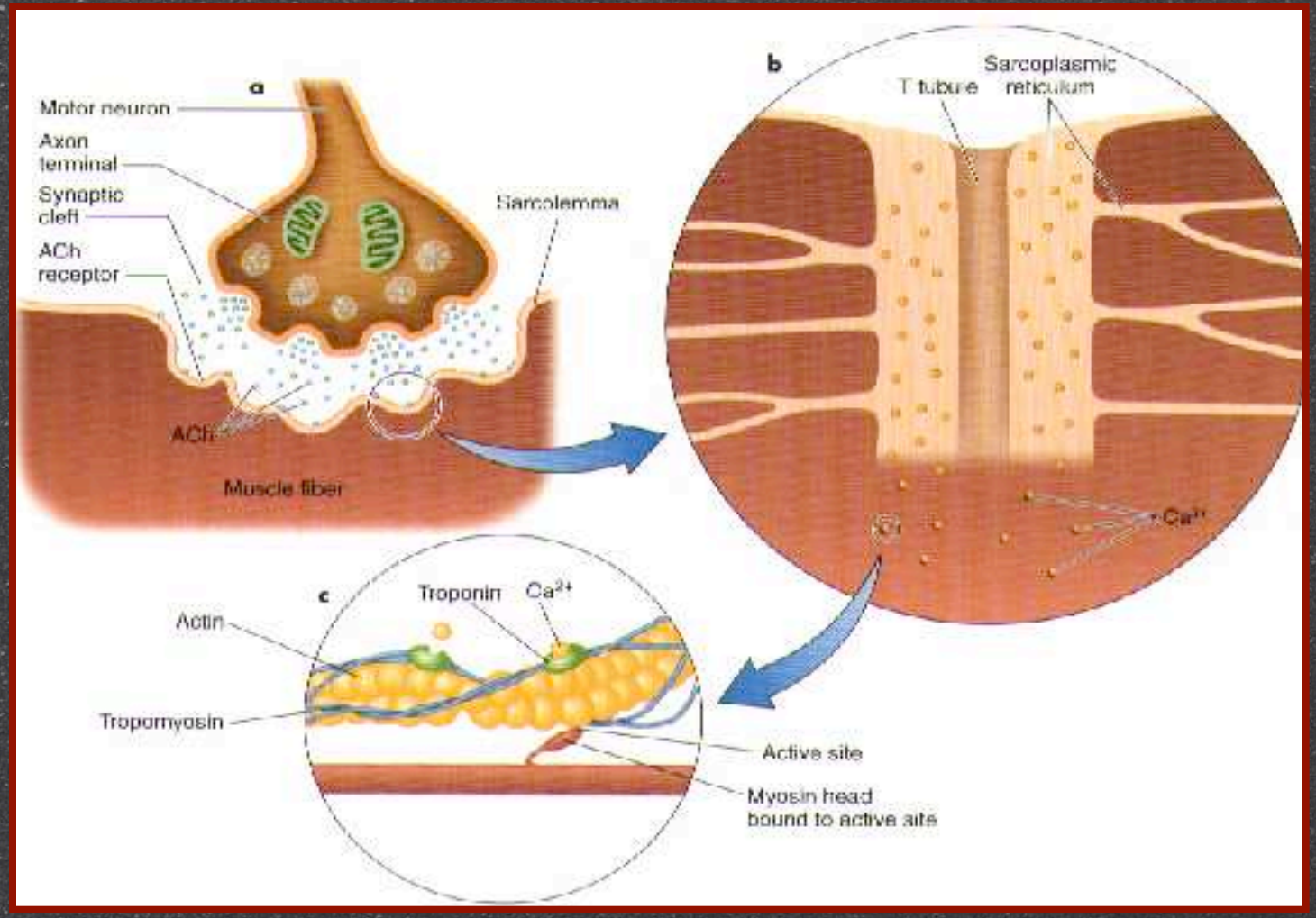


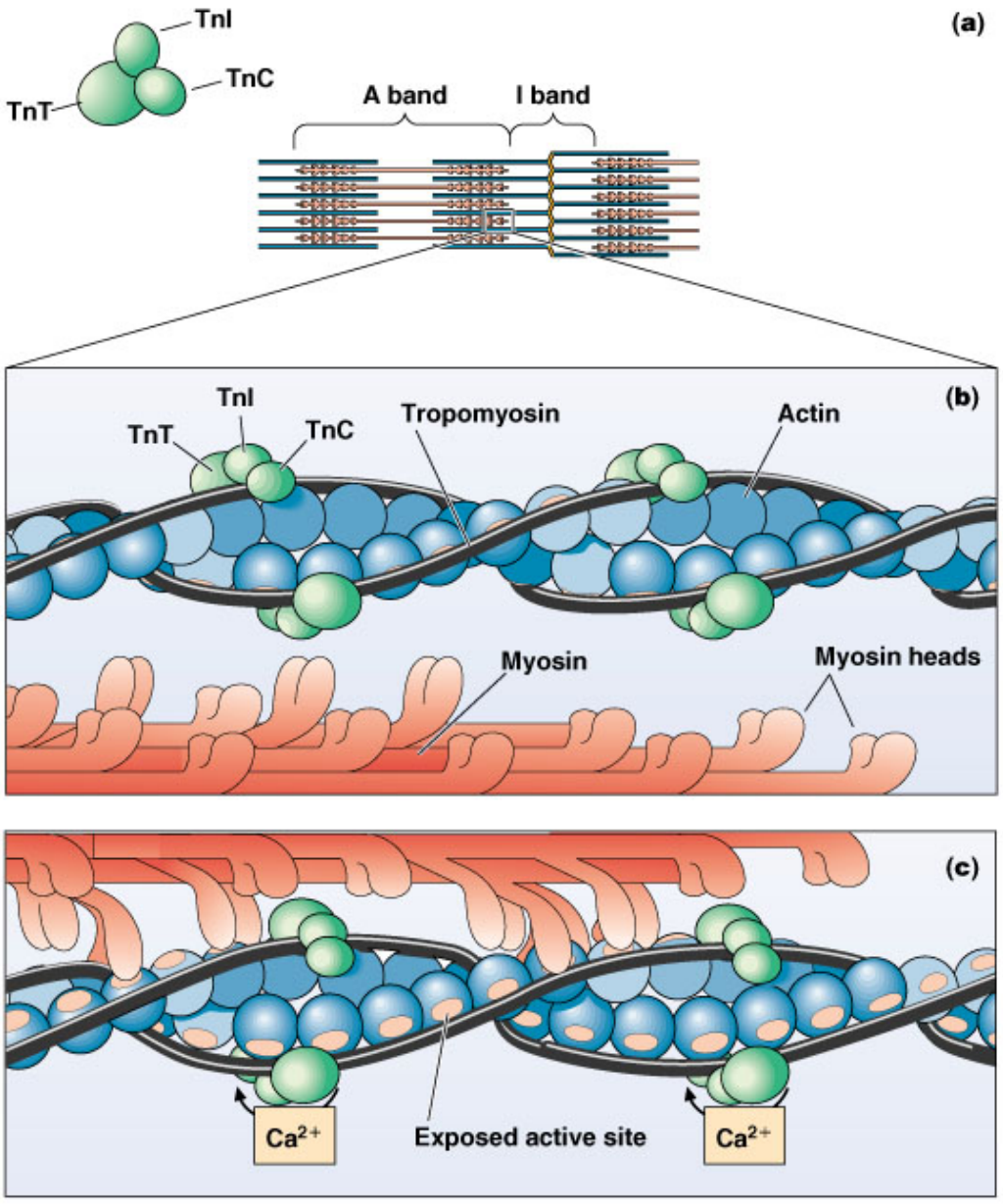
Depolarization



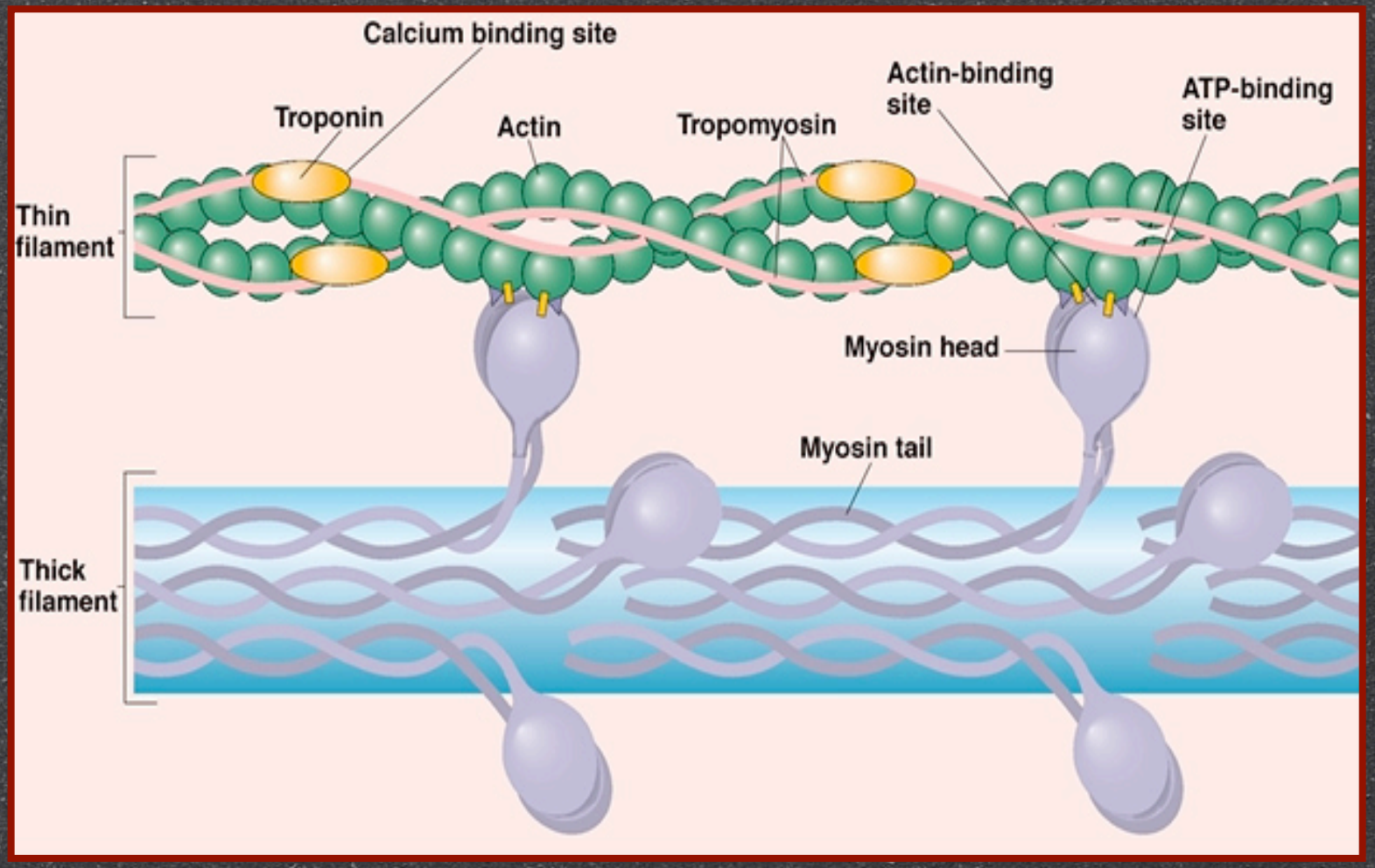
ACh = acetycholine

Calcium

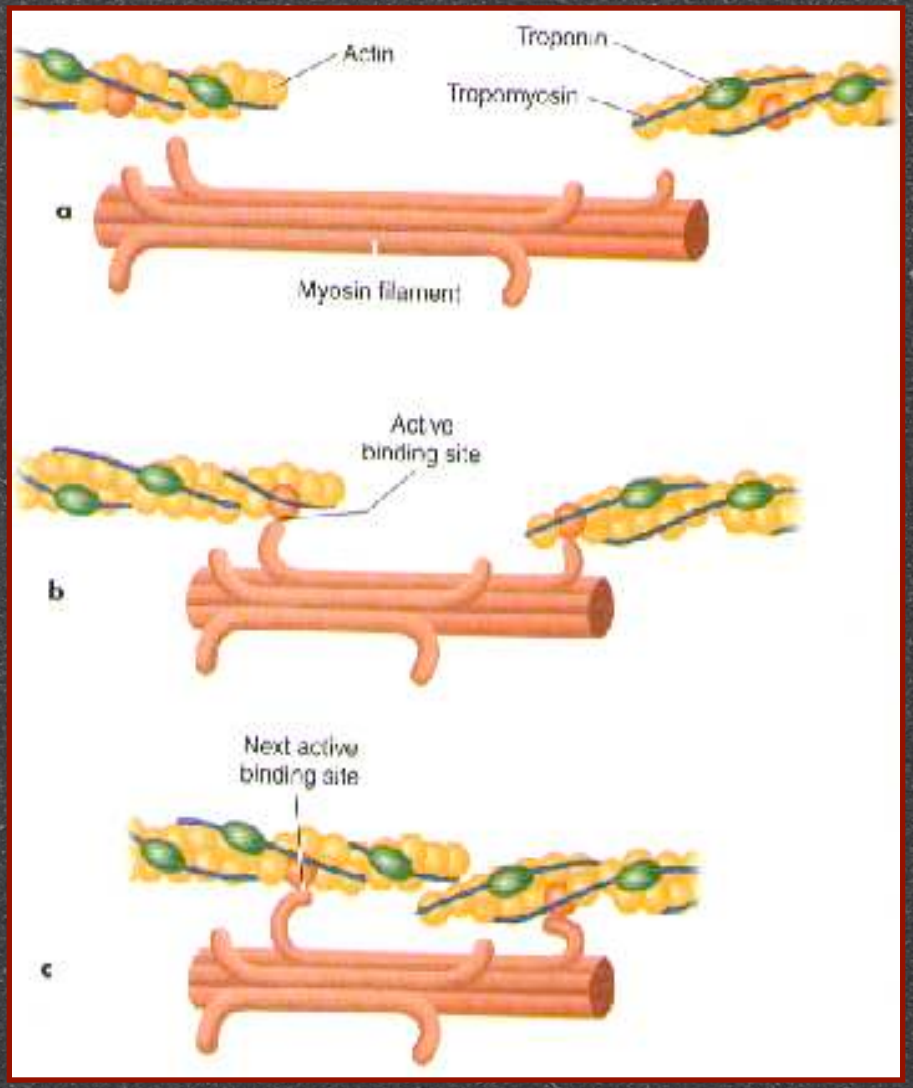

a
Motor neuron
Axon terminal
Synaptic cleft
ACh receptor
Sarcolemma
ACh
Muscle fiber
b
Sarcoplasmic reticulum
T tubule
Ca2+
c
Troponin
Ca2+
Actin
Tropomyosin
Active site
Myosin head bound to active site

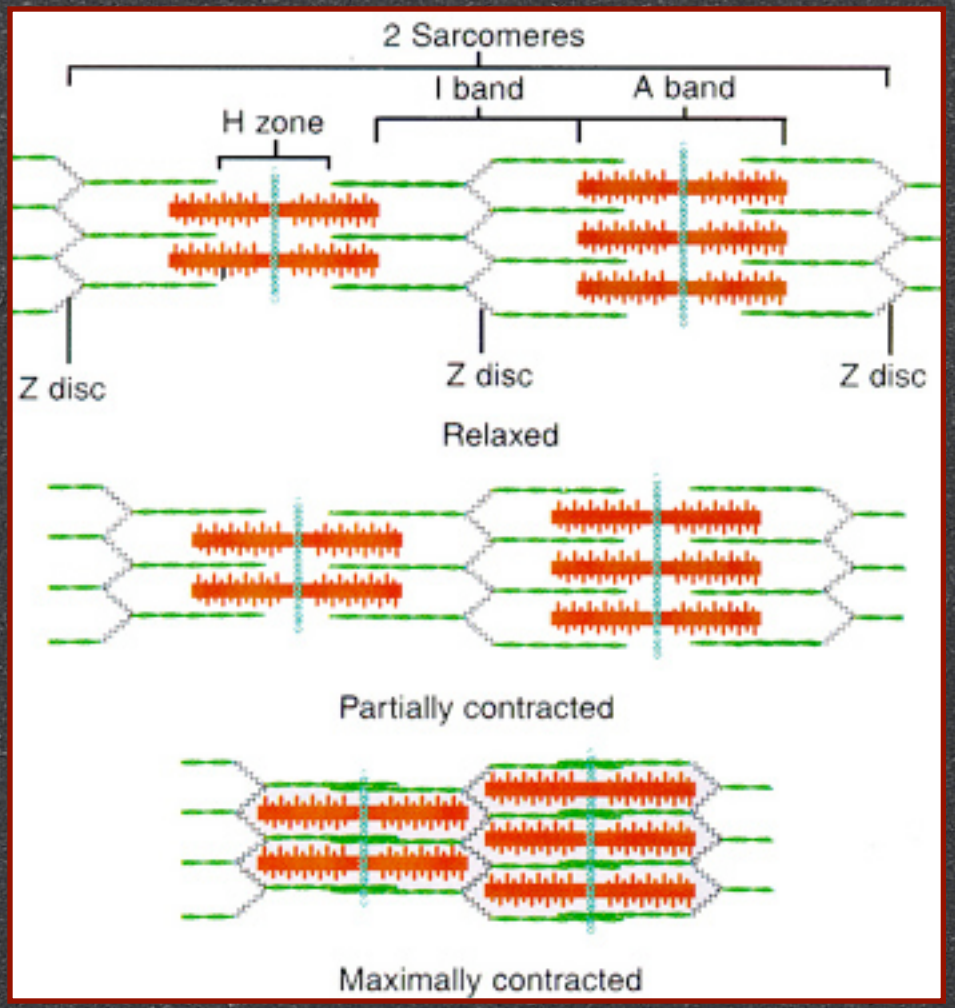

(a)
TnI
TnC
TnT
A band
I band
(b)
TnI
TnT
TnC
Tropomyosin
Actin
Myosin
Myosin heads
(c)
Ca2+
Exposed active site
Ca2+

Cross-Bridges & Power Strokes



Sliding


Actin
Tropomyosin
a
Myosin filament
Active binding site
b
Next active binding site
c

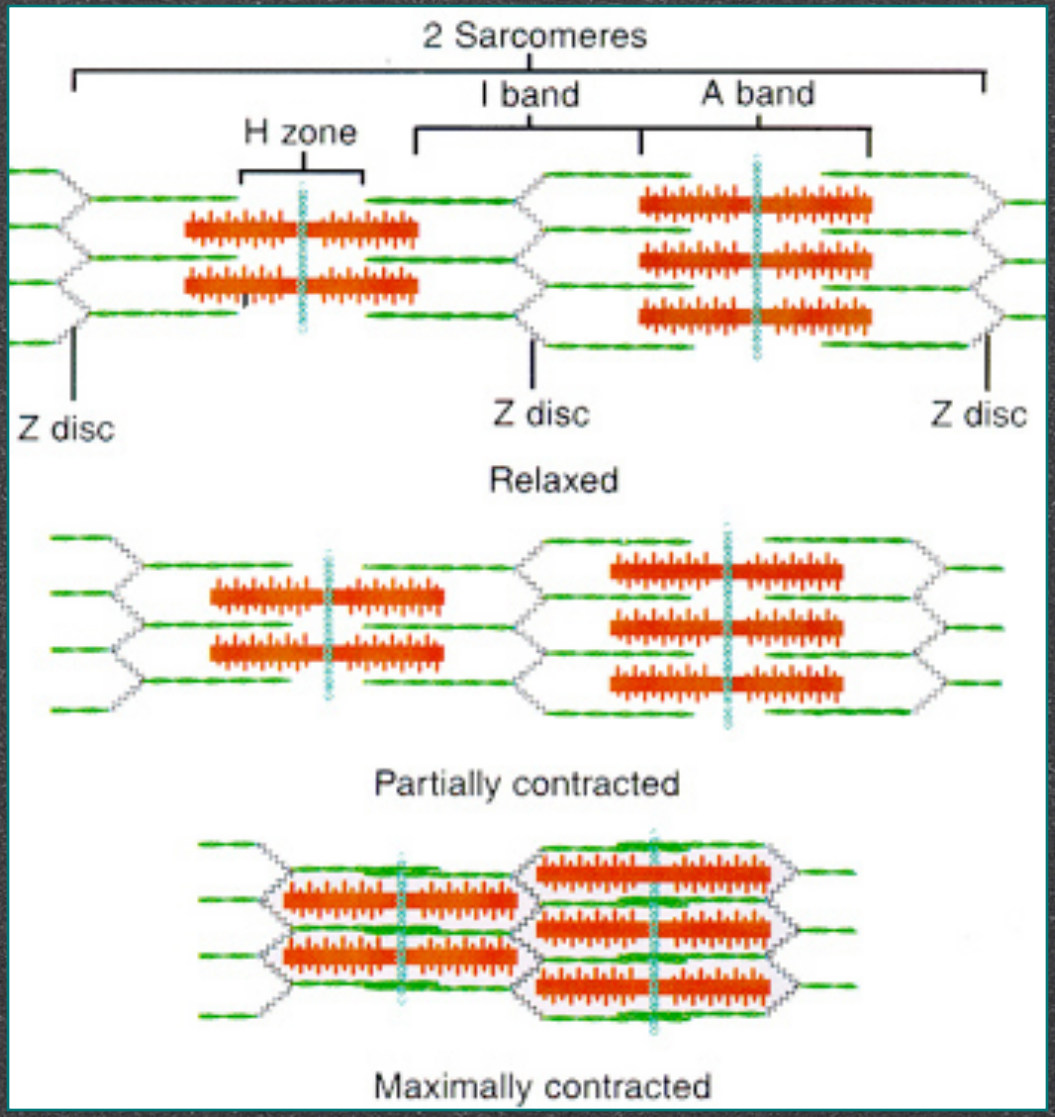

2 Sarcomeres
I band
A band
H zone
Z disc
Z disc
Z disc
Relaxed
Partially contracted
Maximally contracted

Sliding

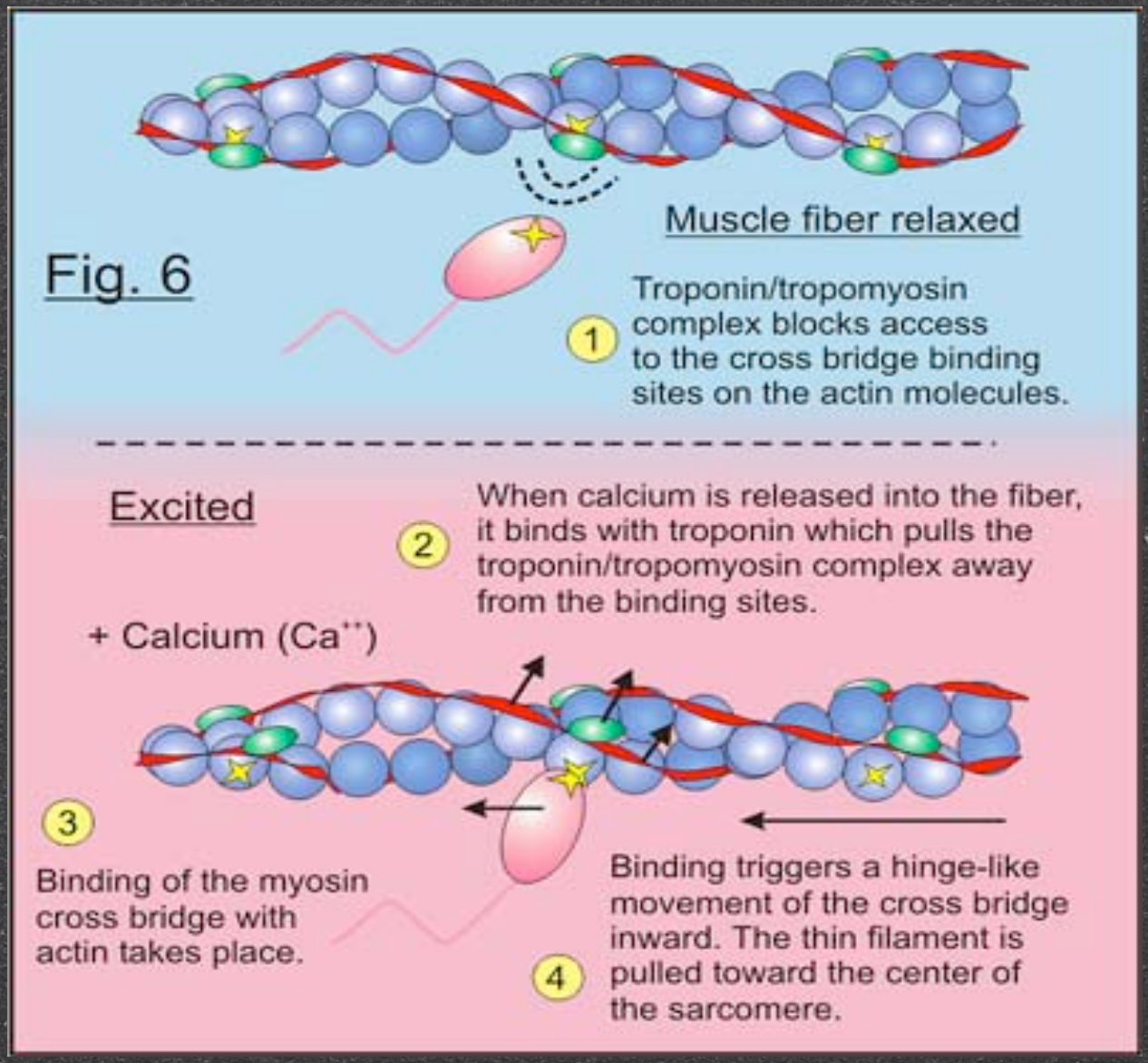
Relaxed →

Partial →

Maximal →



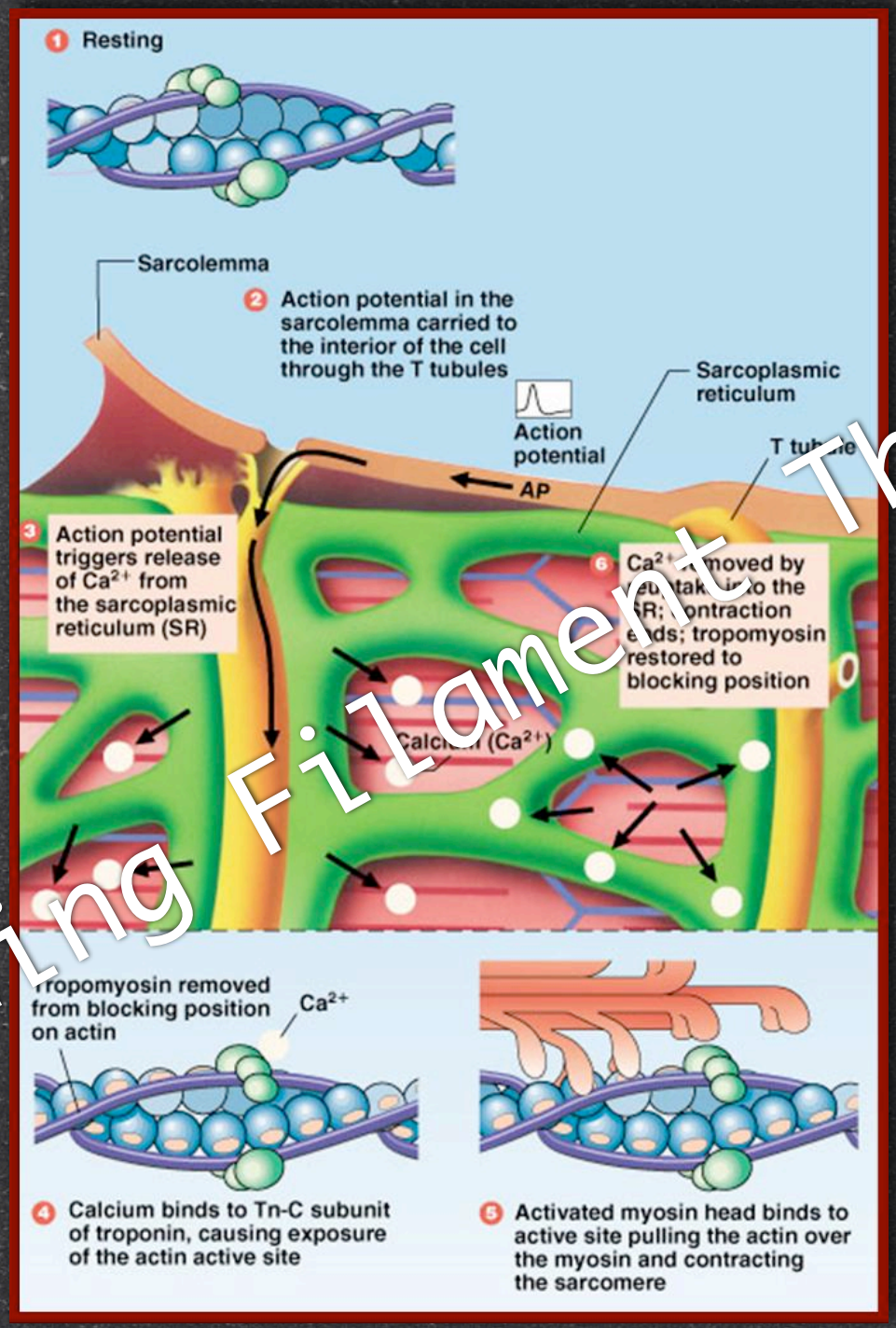
ATP and Muscle Contraction



I.

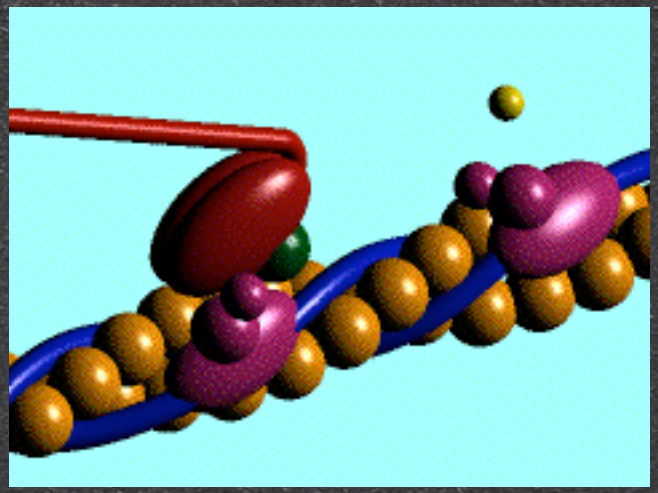
II.

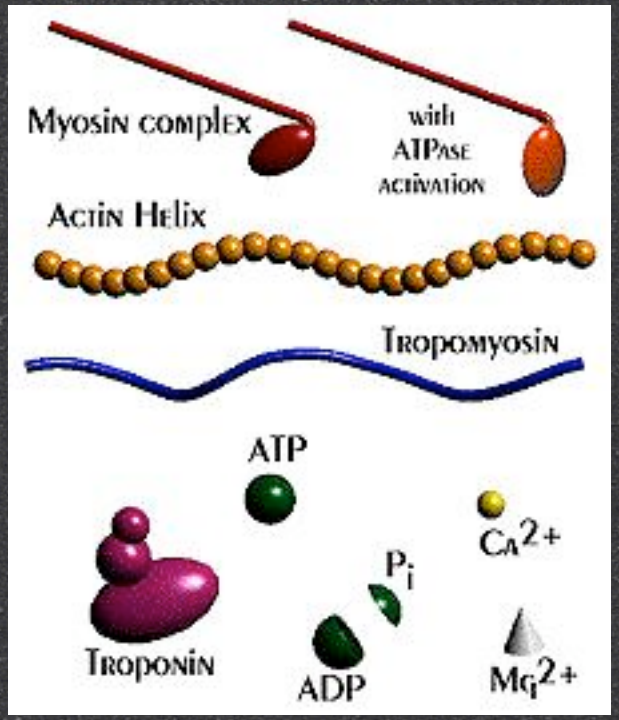
Sliding Filament Theory



Quick Time Movie

- This Quick Time Movie of the contraction process can be downloaded at the class web page.

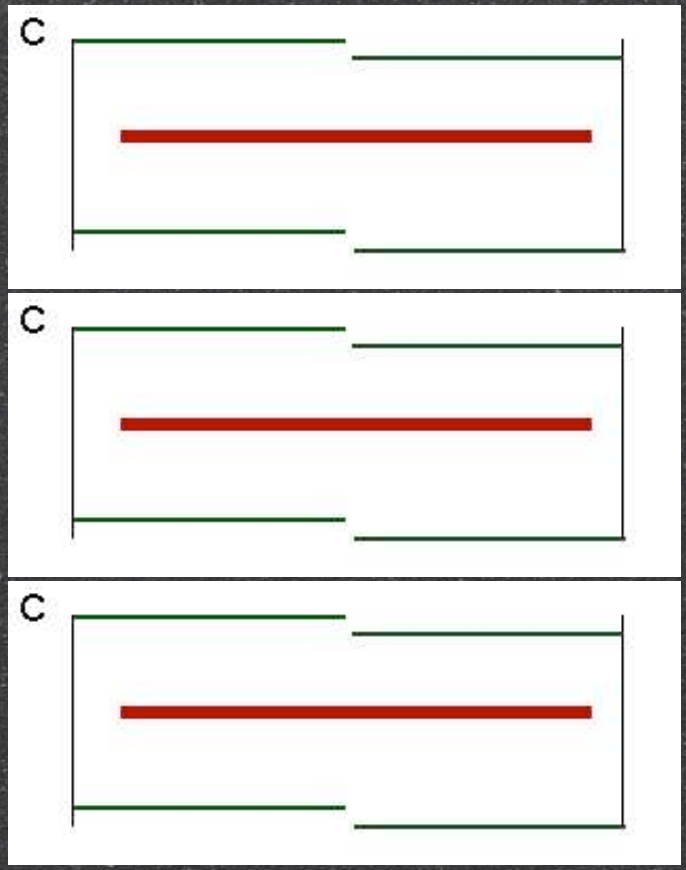




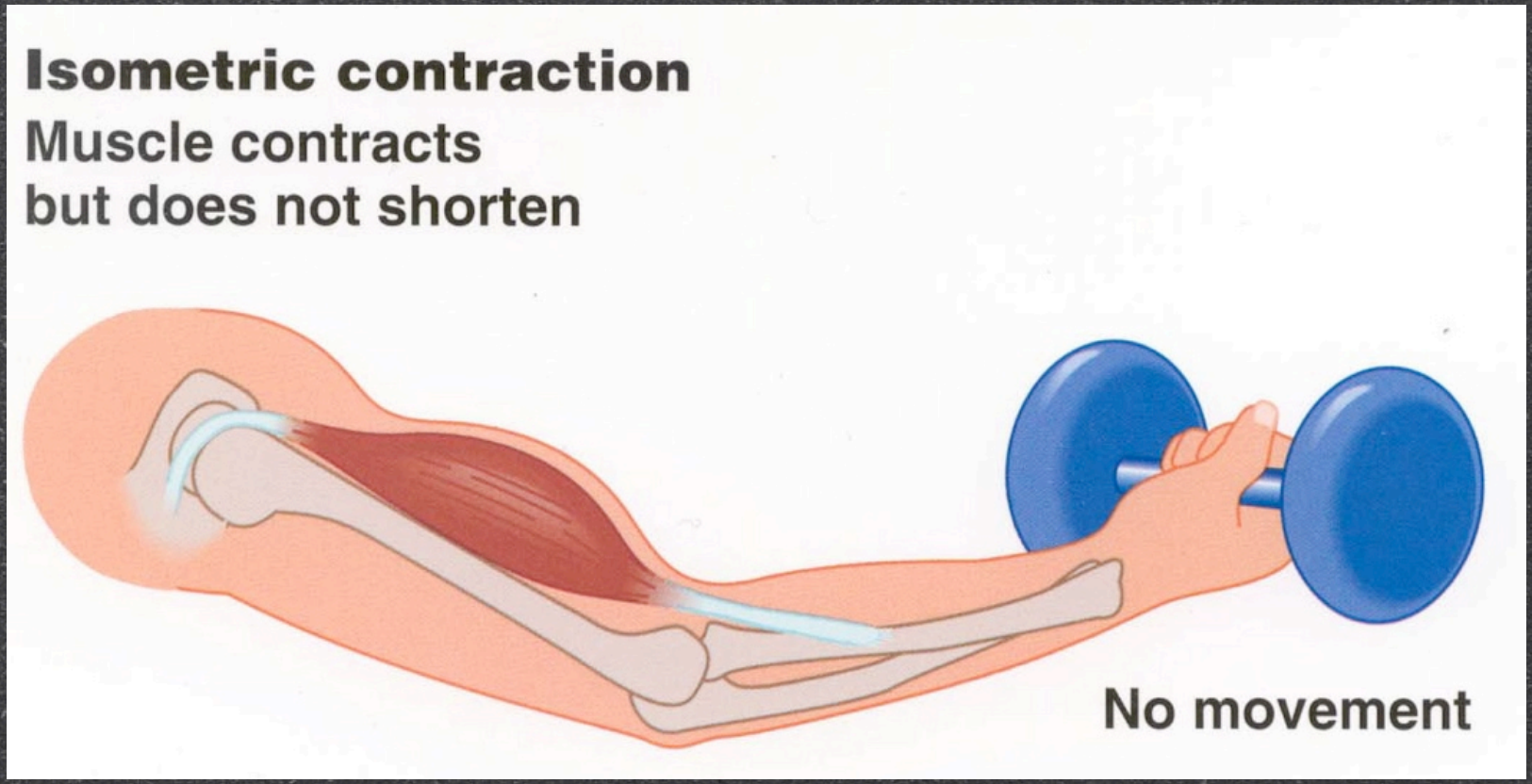
4. Types of Muscle Contraction

- Static contraction
  - Isometric
- Dynamic contraction
  - Concentric
  - Eccentric

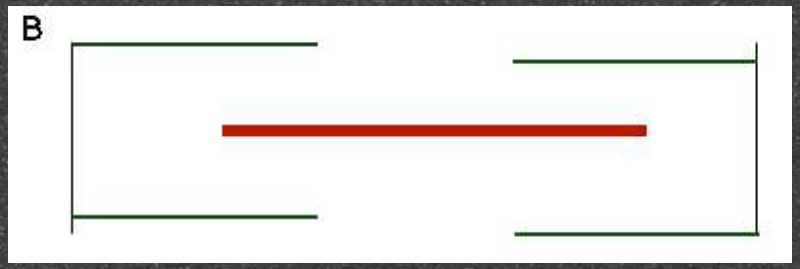
Isometric or Static Contraction

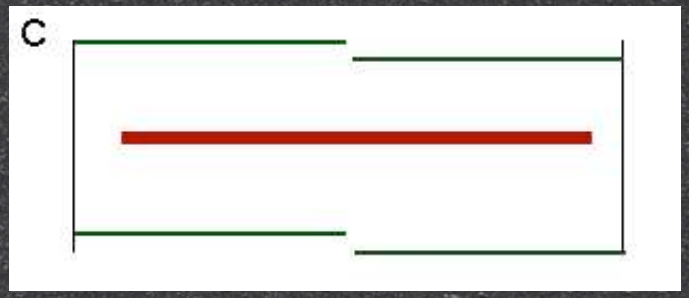


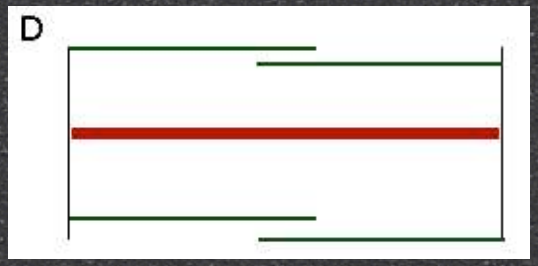
Isometric


Isometric contraction
Muscle contracts
but does not shorten
No movement

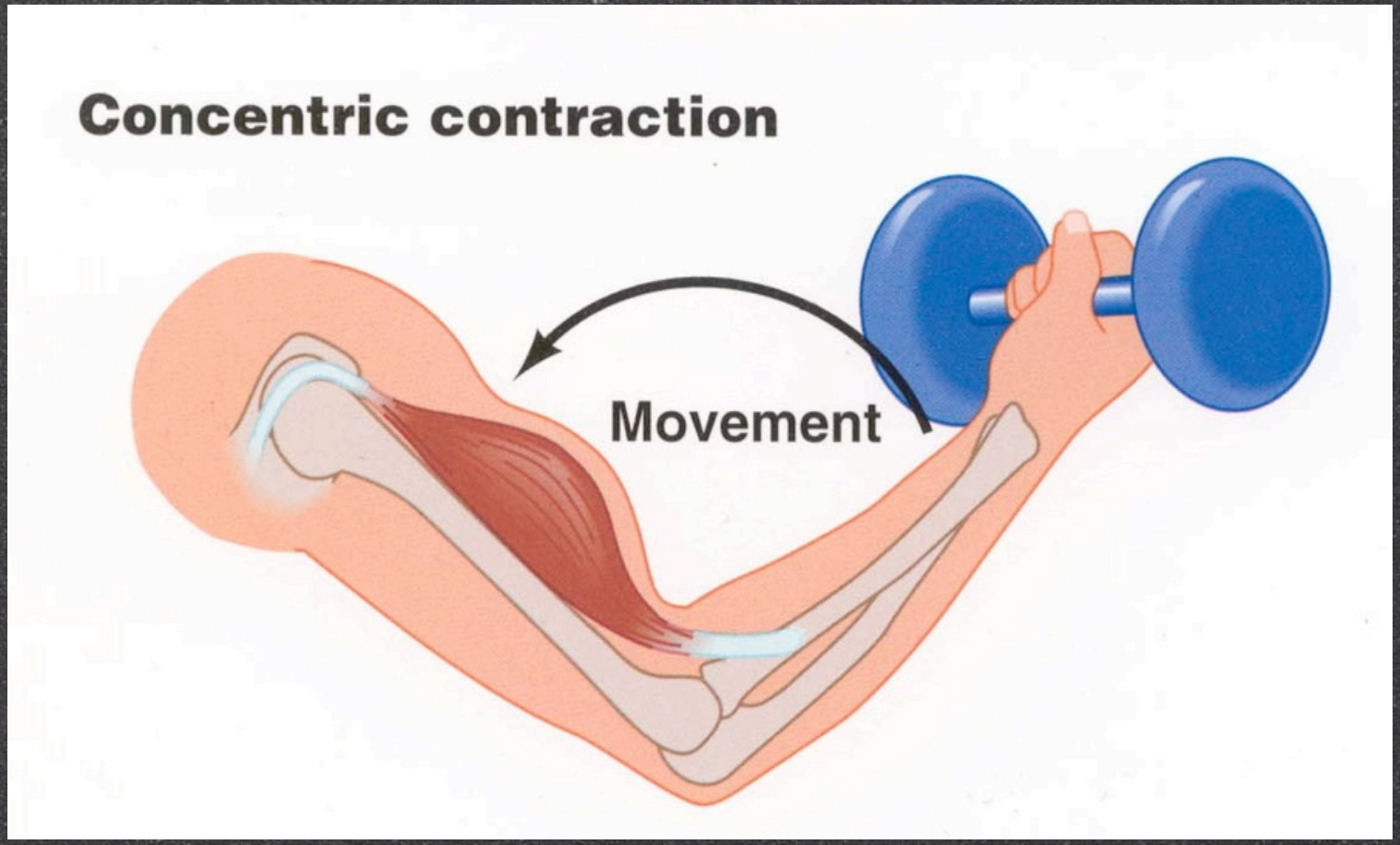
Concentric Contraction



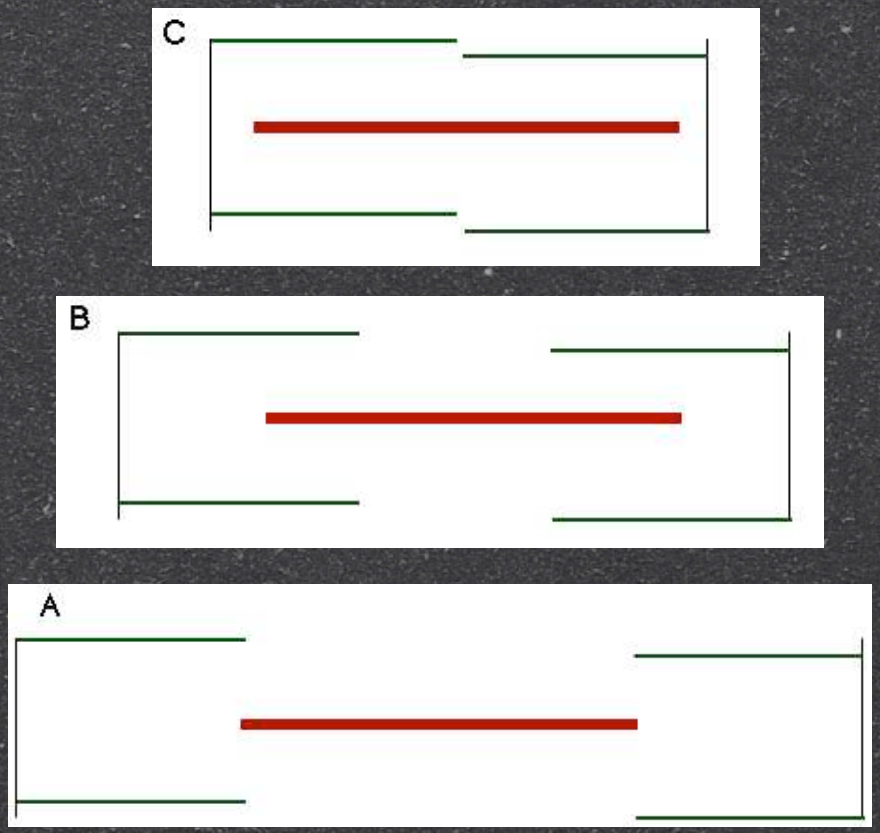




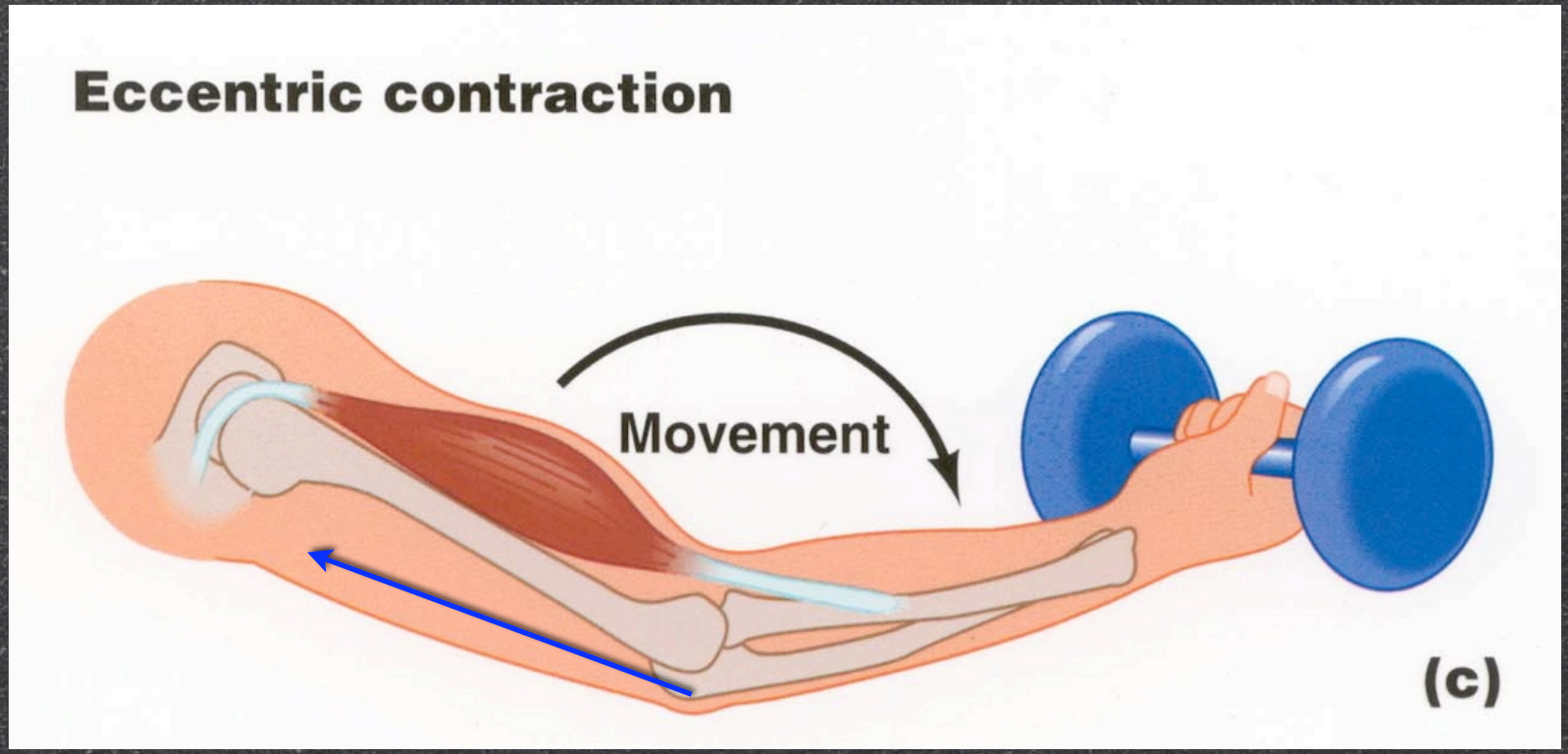
Concentric



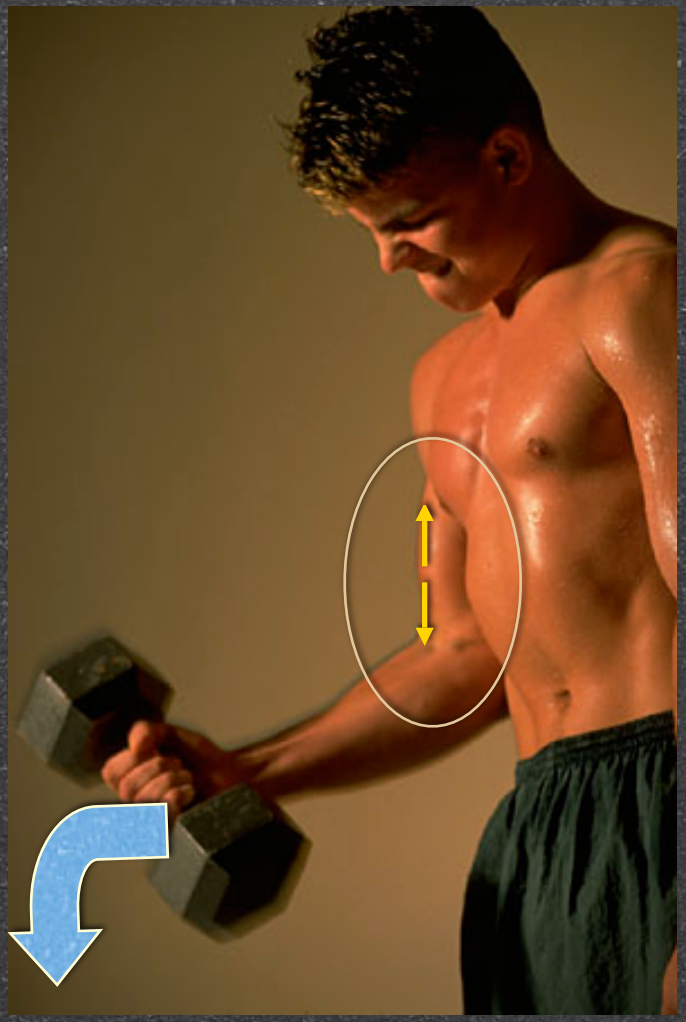
Eccentric Contraction



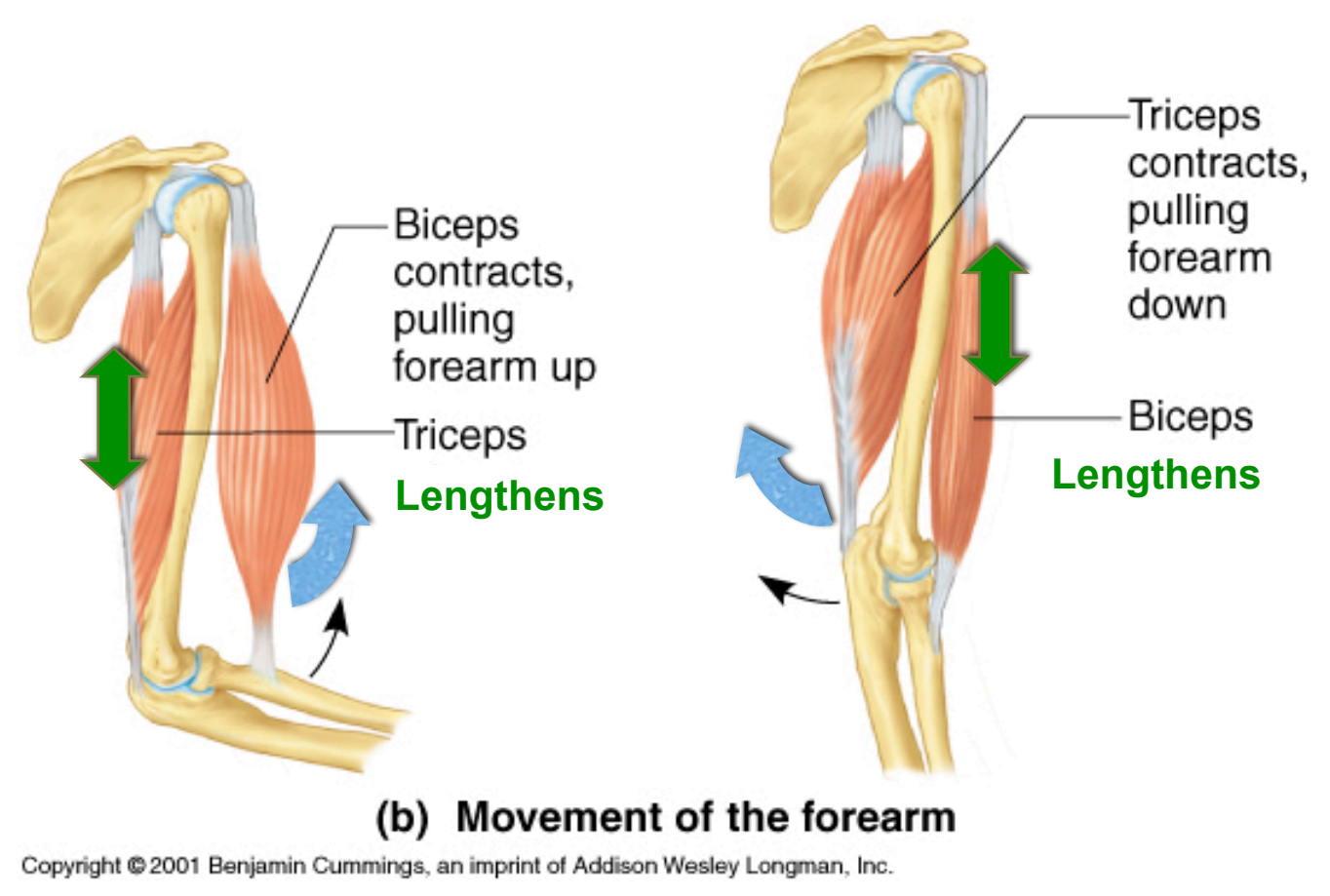
Eccentric



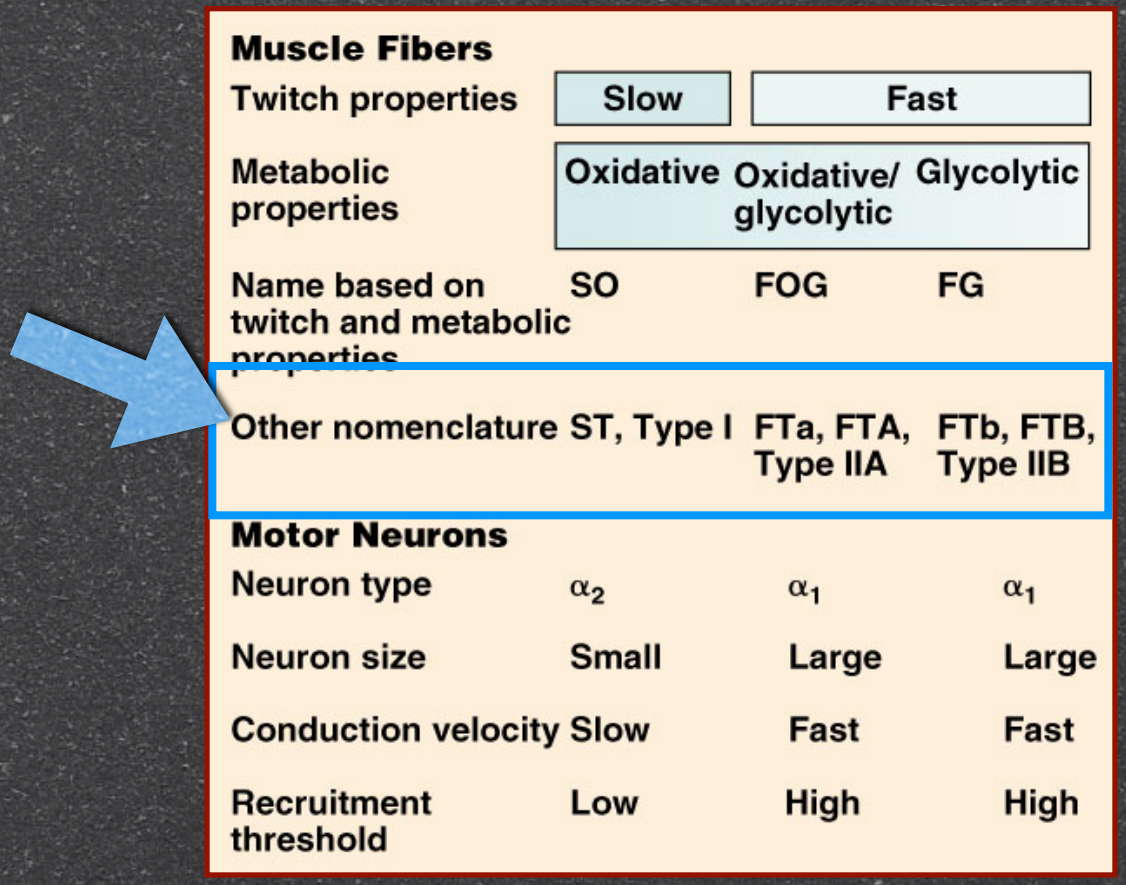
Eccentric Contraction



Eccentric Contraction



5. Muscle Fiber Types



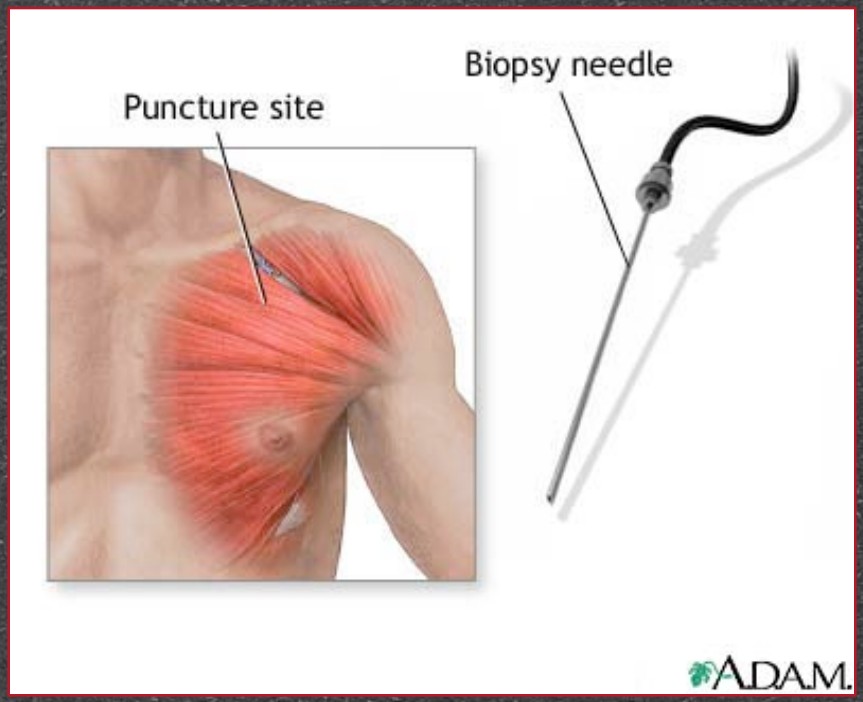
Muscle Fibers			
Twitch properties	Slow	Fast	
Metabolic properties	Oxidative	Oxidative/ glycolytic	Glycolytic
Name based on twitch and metabolic properties	SO	FOG	FG
Other nomenclature	ST, Type I	FTa, FTA, Type IIA	FTb, FTB, Type IIB
Motor Neurons			
Neuron type	α_2	α_1	α_1
Neuron size	Small	Large	Large
Conduction velocity	Slow	Fast	Fast
Recruitment threshold	Low	High	High

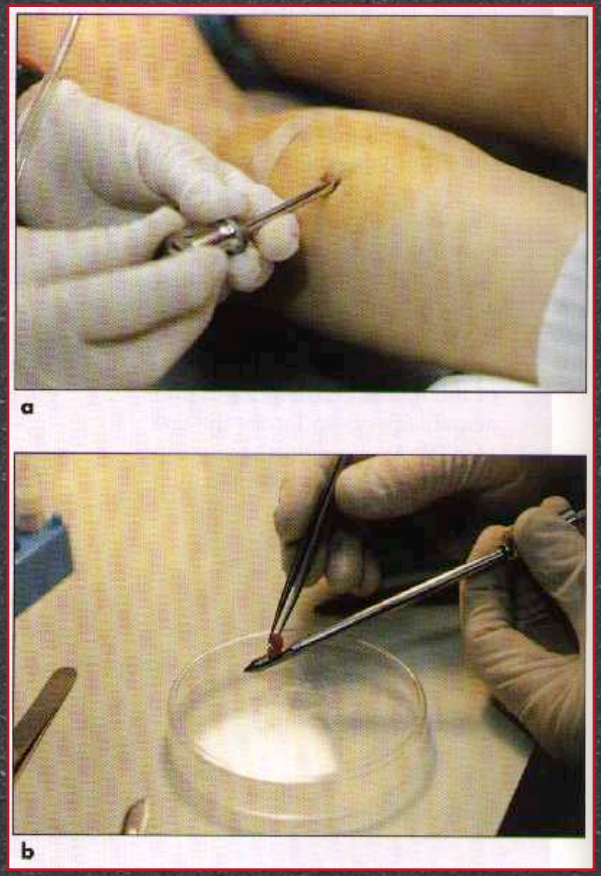
Most Common: Slow twitch/Type I, Fast twitch A/ Type IIa, and Fast twitch B/Type IIb

Fiber Type Characteristics (Table 8.1)

	Fast Fibers		Slow fibers
Characteristic	**Type IIb**	**Type IIa**	**Type I**
Resistance to fatigue	Low	High/mod	High
Predominant energy system	Anaerobic	Combination	Aerobic
Speed of shortening	Fastest	Intermediate	Slowest
Force production	High	High	Moderate
Fiber Diameter	Large	Intermediate	Small
Others			

Fiber Typing FYI





Fiber Typing

FYI

Fiber Typing FYI

Type II

Type I

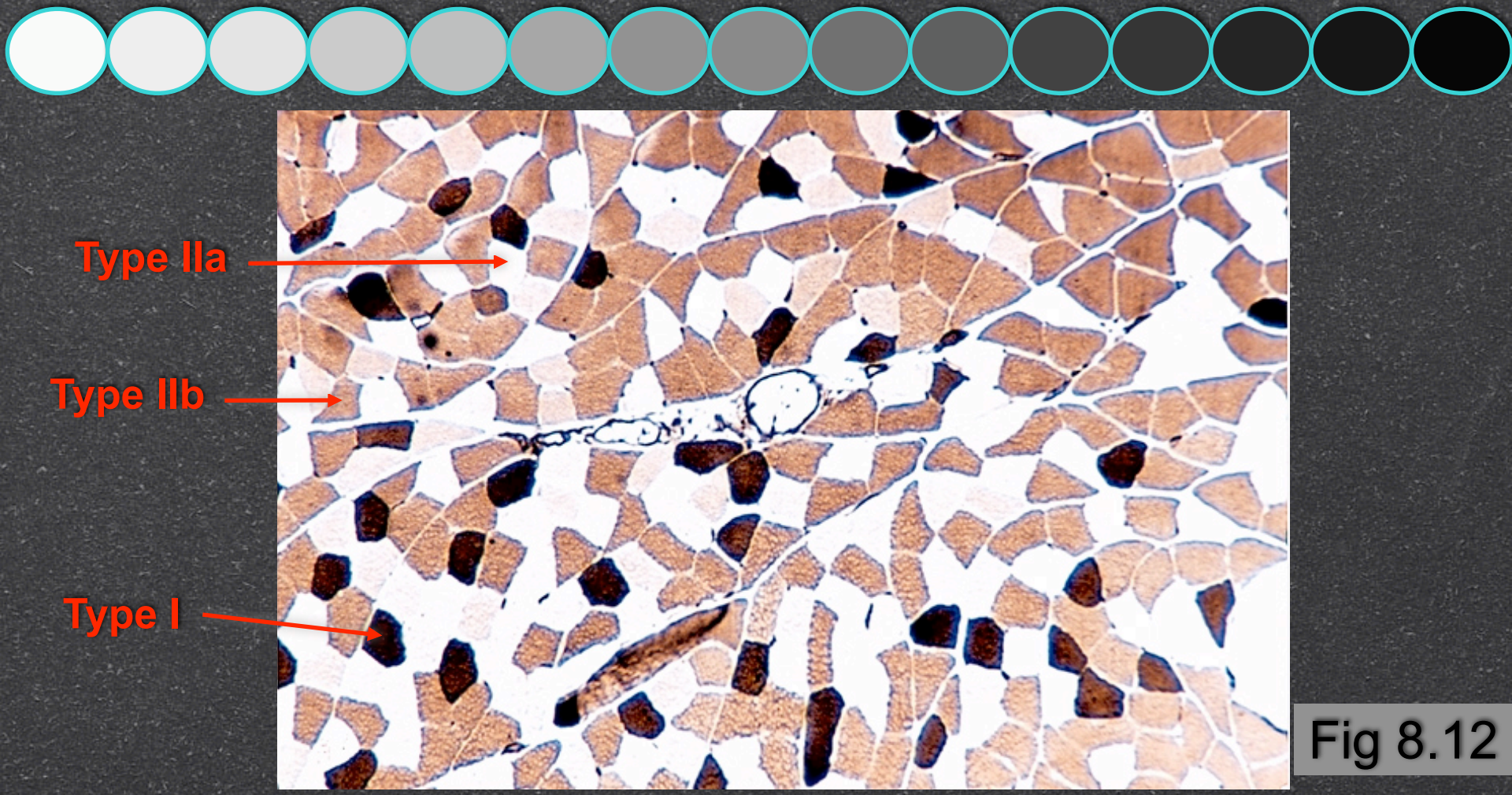


Fig 8.12

Fiber Types and Individual Differences

Western States 100 two weeks later won Badwater Ultramarathon

107.5 kg (237 lbs) at clean & jerk in 1997. Bodyweight was 53.1 kg (117 lbs).

- What are the percentages of fiber types in the average person?

Fiber Type Distribution

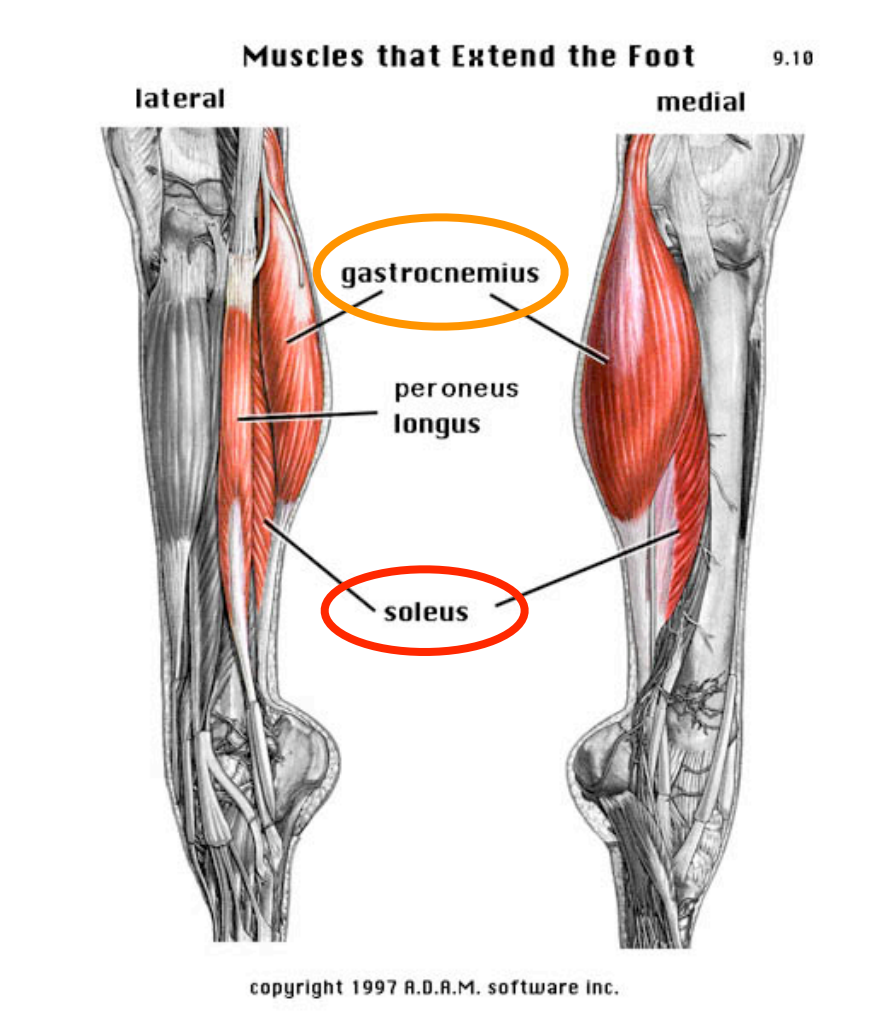
Sport	Type I	Type II
Distance Runner	70-80	20-30
Track Sprinter	25-30	70-75
Non-athlete	47-53	47-53

Table 8.2

Fiber Type Distribution

- Average person; equal mix
- No sex difference
- No age difference

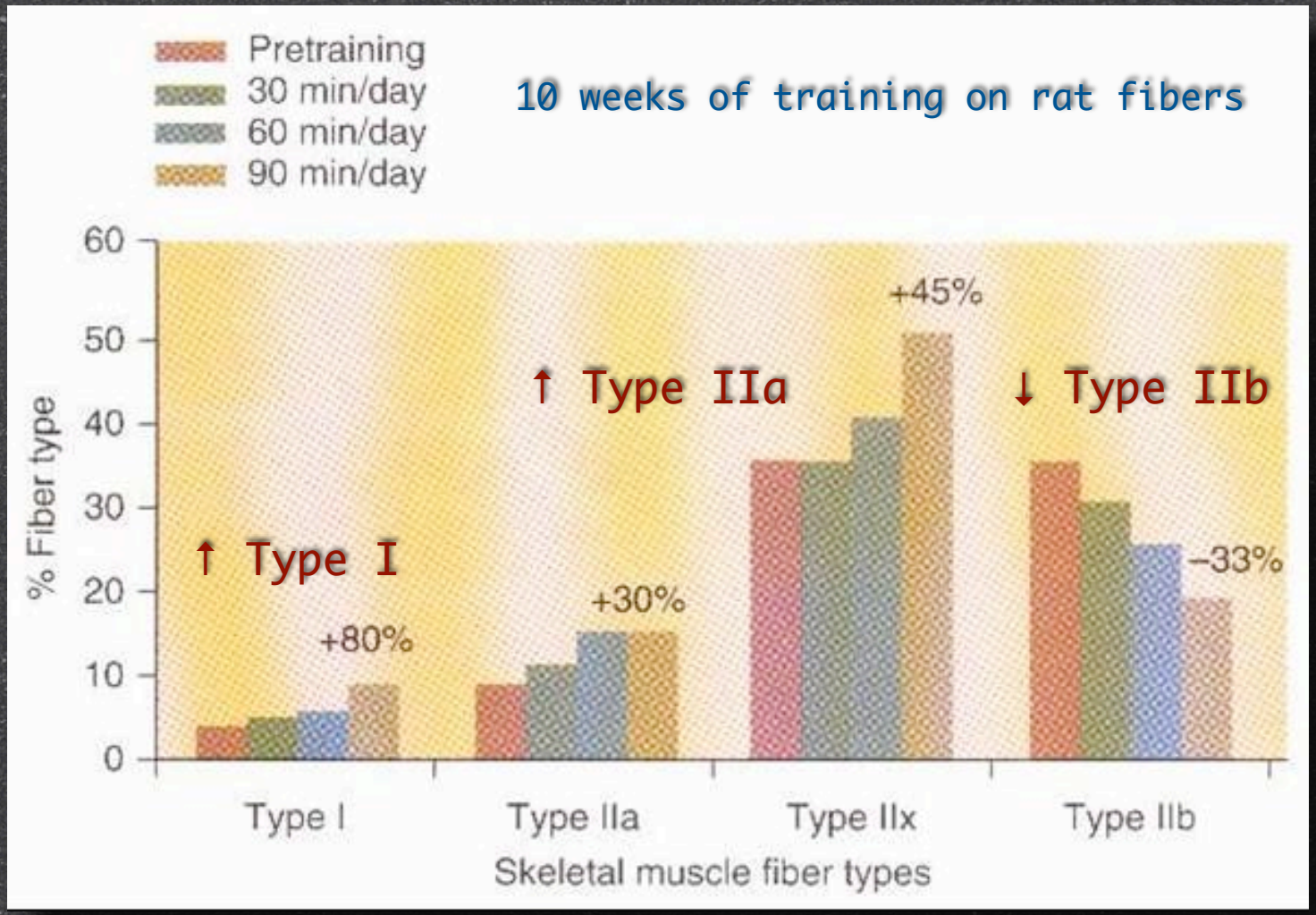
Fiber Type Distribution



Alterations in Fiber Types

- Shift
  - “skeletal muscle is highly plastic”
- Complete change
  - rigorous and regular exercise
  - Fast twitch to Slow twitch

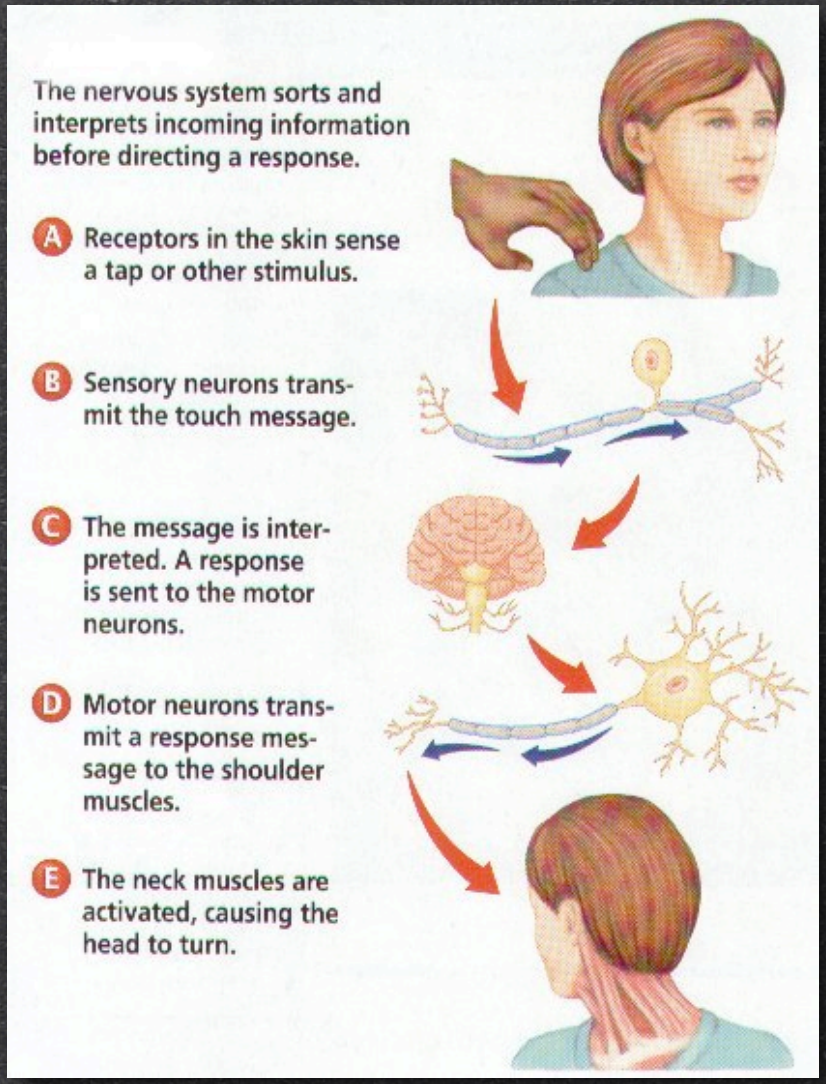
Alteration of Muscle Fiber Type



Terms

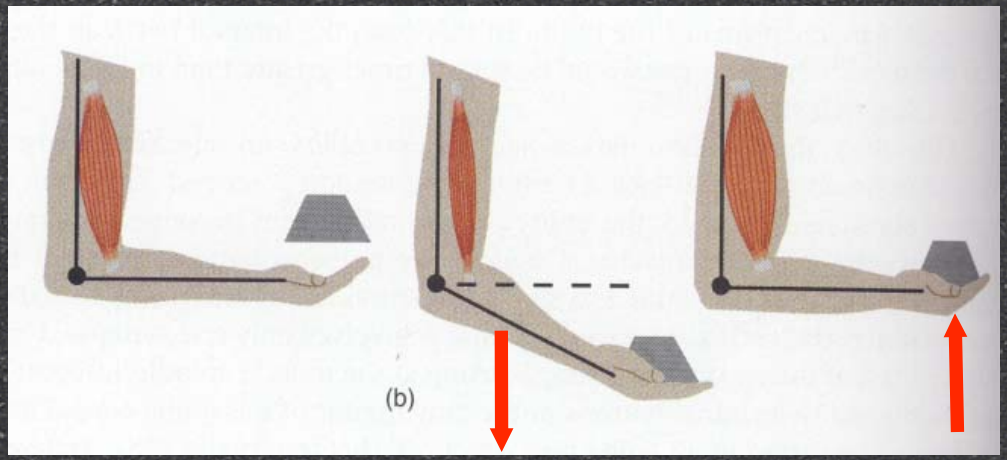
- Atrophy
  - Conditions when atrophy might occur?
- Hypertrophy

6.Muscle Receptors

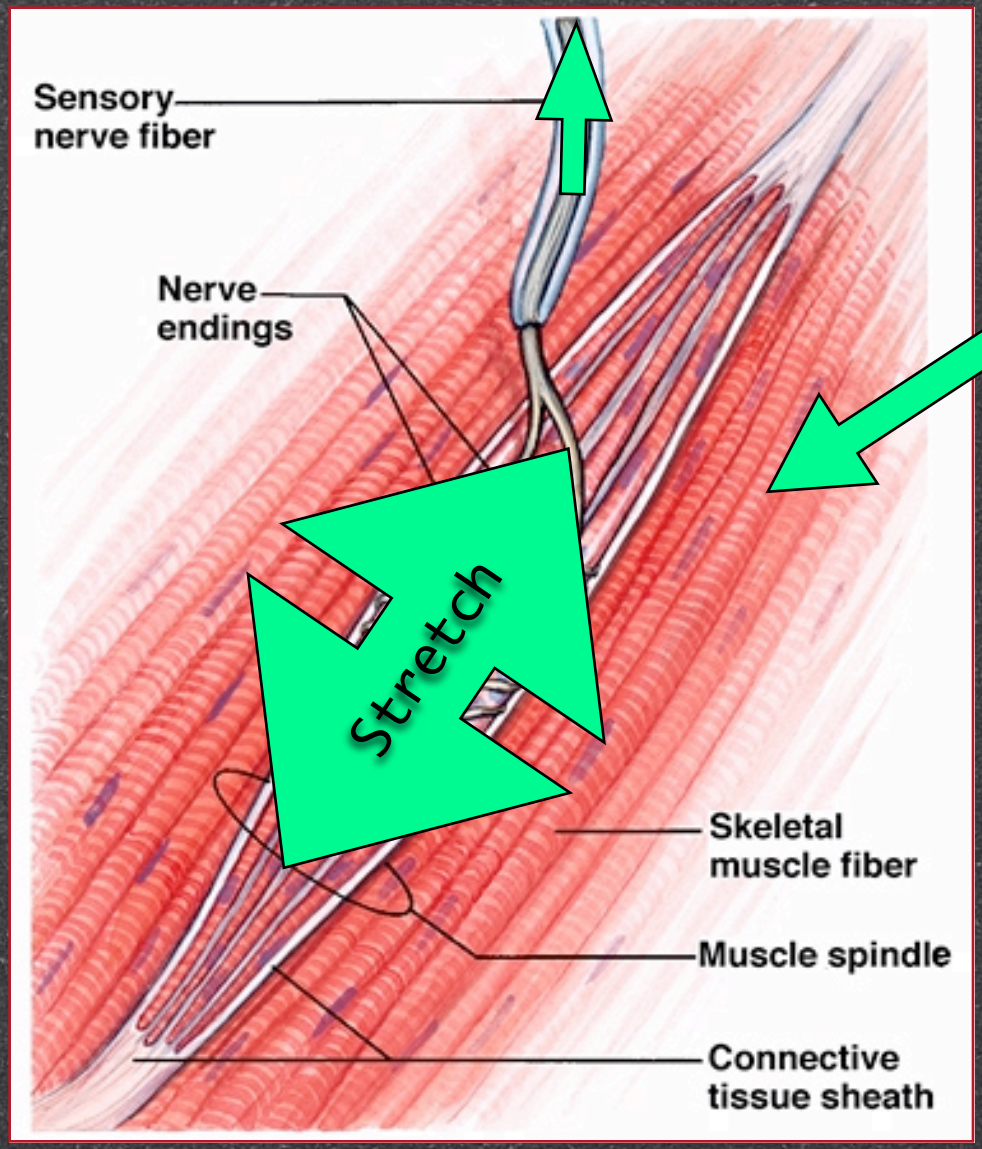


Muscle Spindle

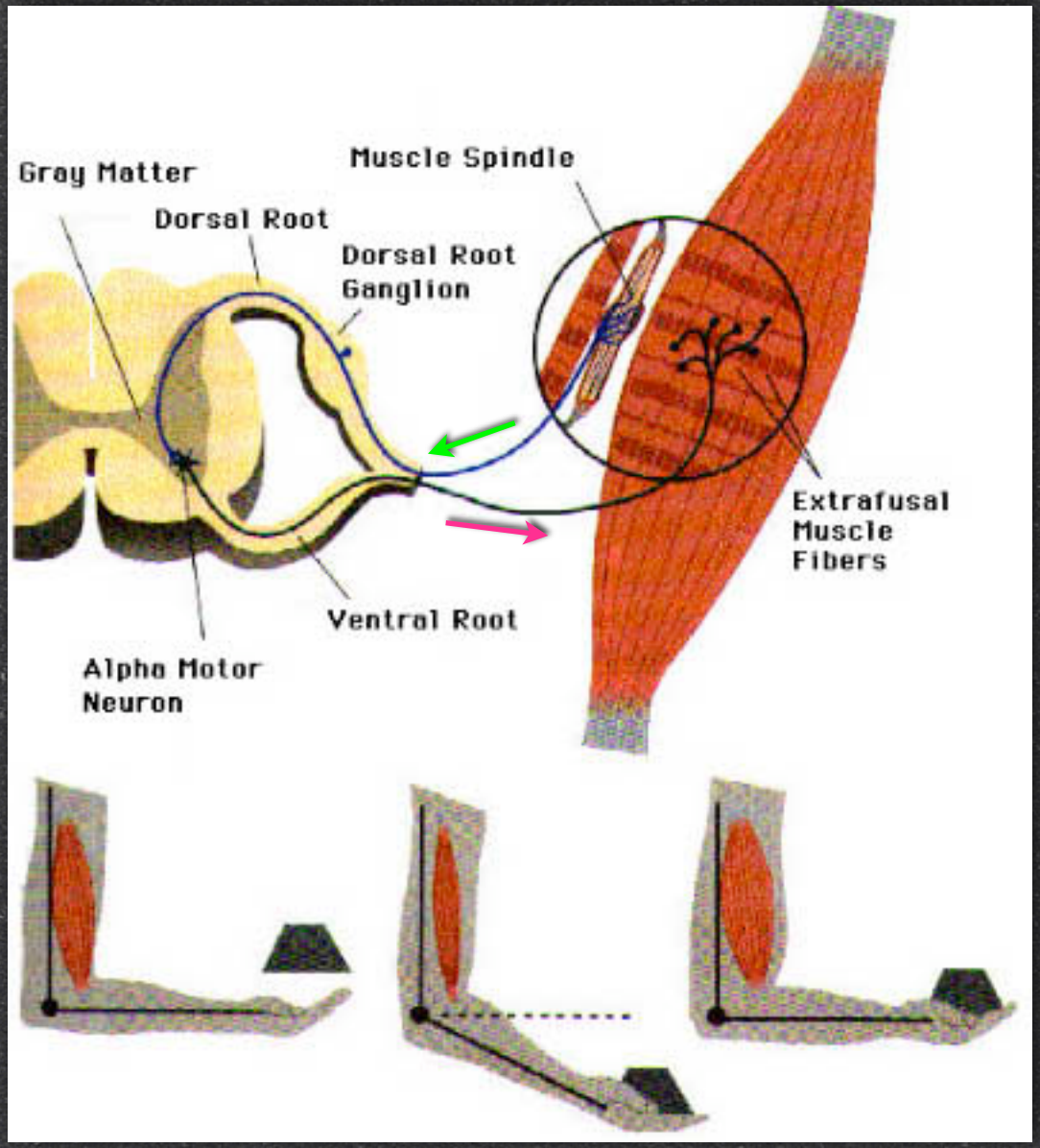
- Stretch reflex
  - stretch or increase length of the muscle...
  - ...muscle contraction



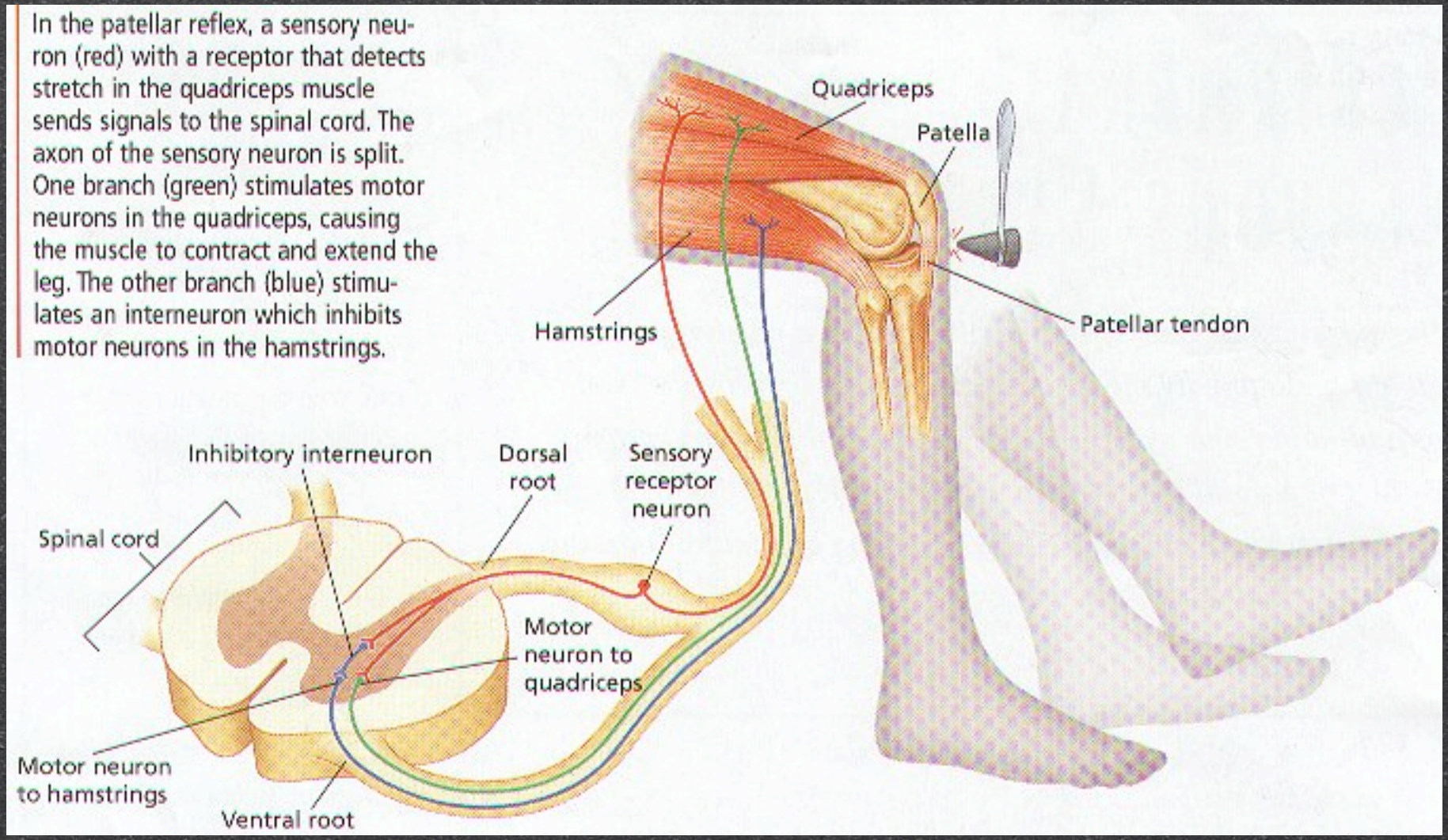
Muscle Spindle



Contraction


Gray Matter
Muscle Spindle
Dorsal Root
Dorsal Root Ganglion
Extrafusal Muscle Fibers
Ventral Root
Alpha Motor Neuron

Muscle Spindle



Golgi Tendon Organ

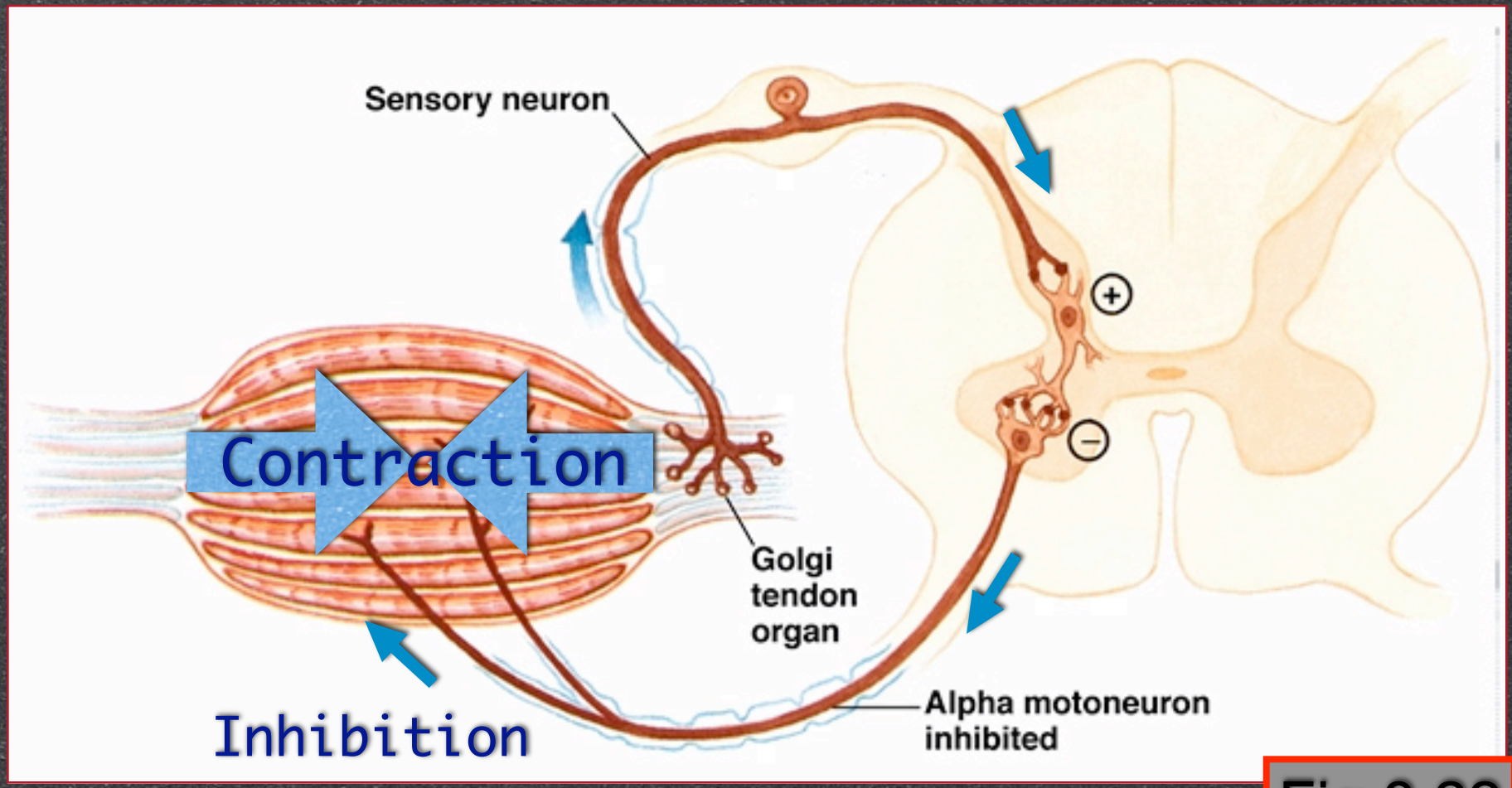
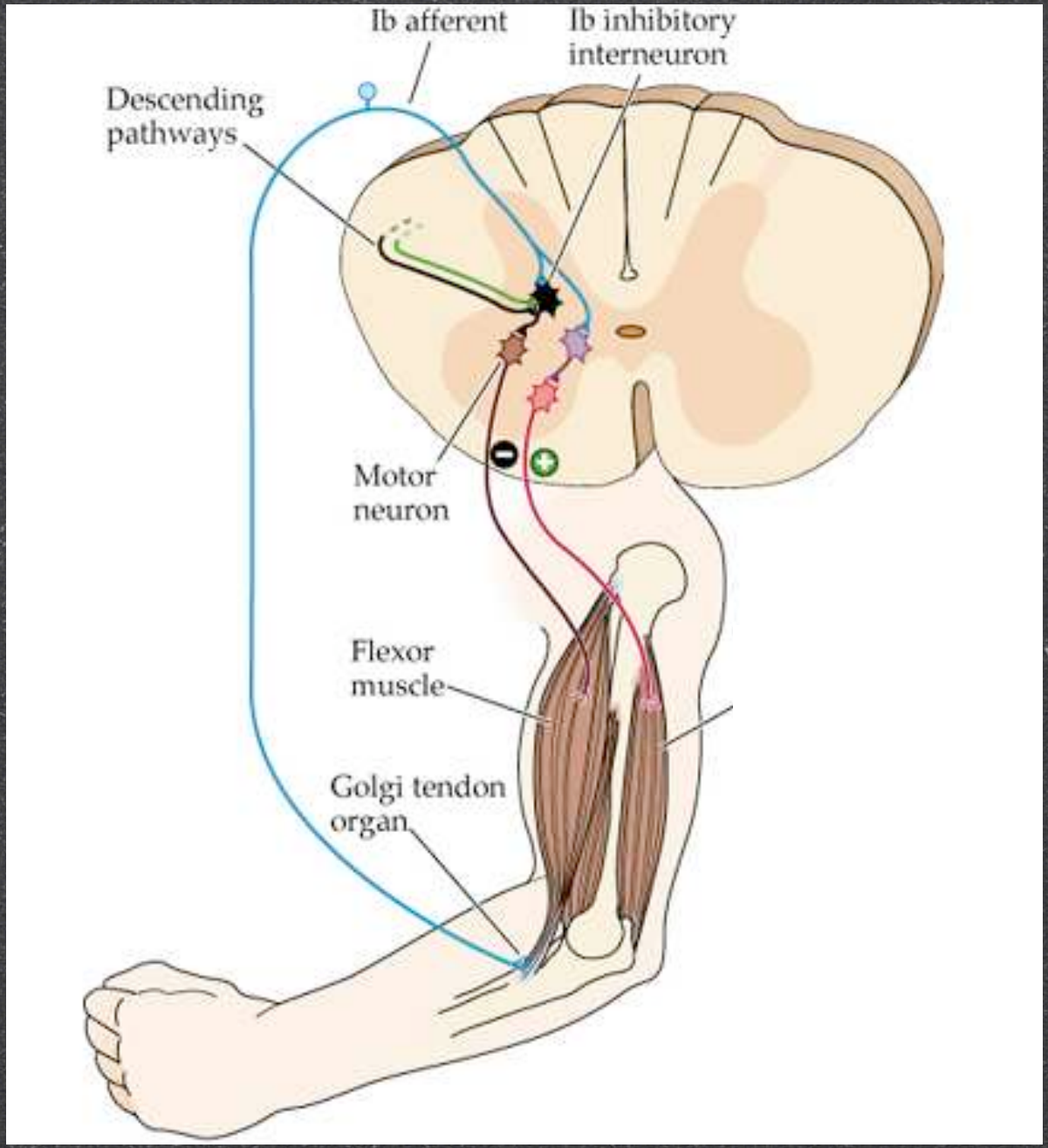


Fig 8.22


Ib afferent
Ib inhibitory interneuron
Descending pathways
Motor neuron
Flexor muscle
Golgi tendon organ