

Academic year 2021-2022
2nd year S3

Musculo-Skeletal System

Session: 2 Lecture: 1 Date: 26/10/2021

Skeletal Muscles

Structure, Morphology and Mechanics

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References: Moore, K.L. and Dalley, A.F. Clinically Oriented Anatomy, 8th Edition. Lipincott Wlliams and Wilkins, 2018.



Objectives **Module LO 6,7**

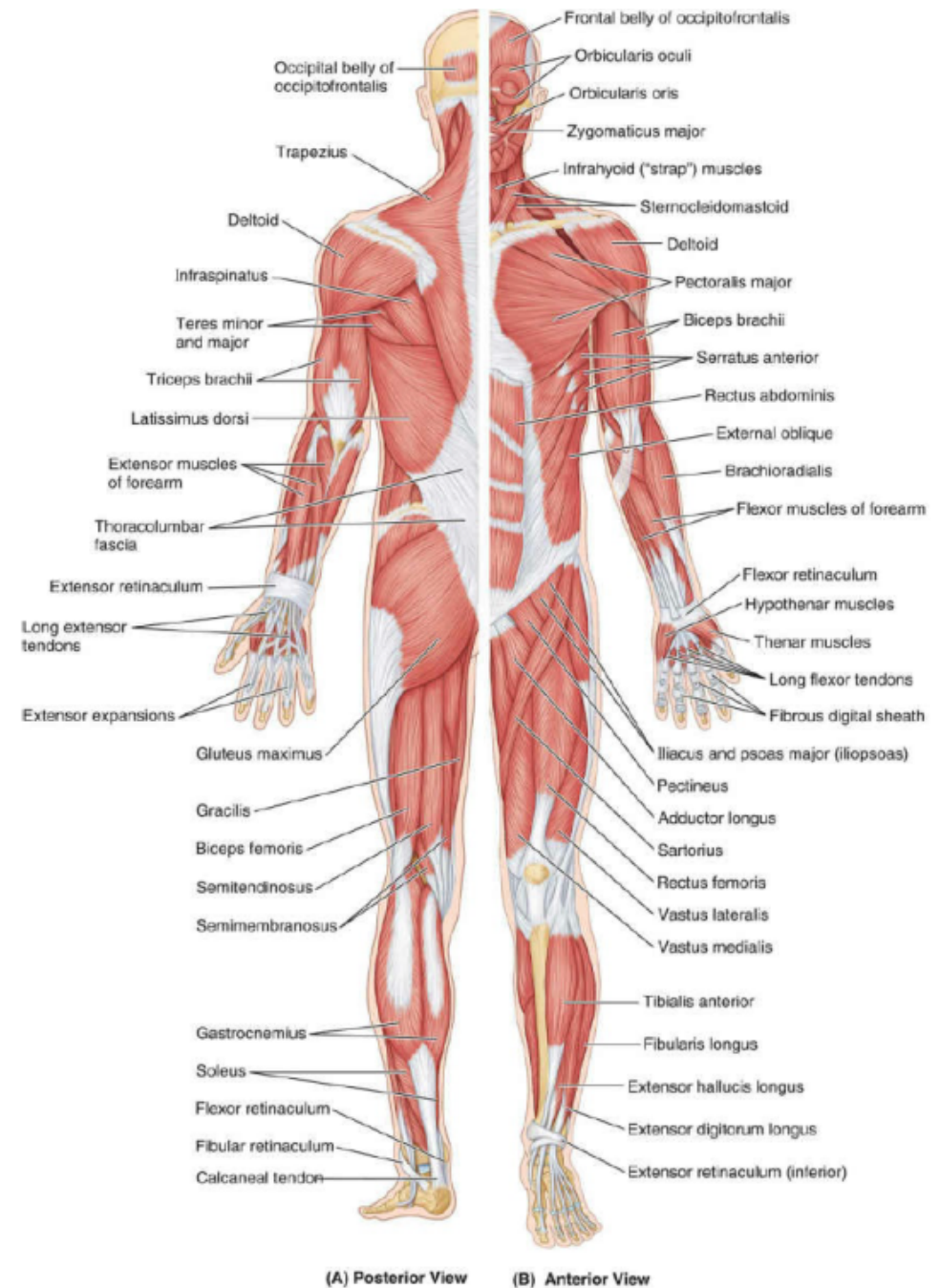
By the end of this lecture the student should be able to:

- Describe the structure and organization of skeletal muscle **(LO1)**
- Explain the mechanism of contraction of skeletal muscles. **(LO2)**
- Define the motor unit and explain the basis of muscle tone in relation to causes of hypotonia. **(LO3)**
- Describe, simply, the physiological mechanisms which underlie variation in the force of contraction of a muscle. **(LO4)**
- Differentiate the sources of energy for muscle contraction and relate these to muscular fatigue and muscle fiber type. **(LO5)**

Skeletal muscles

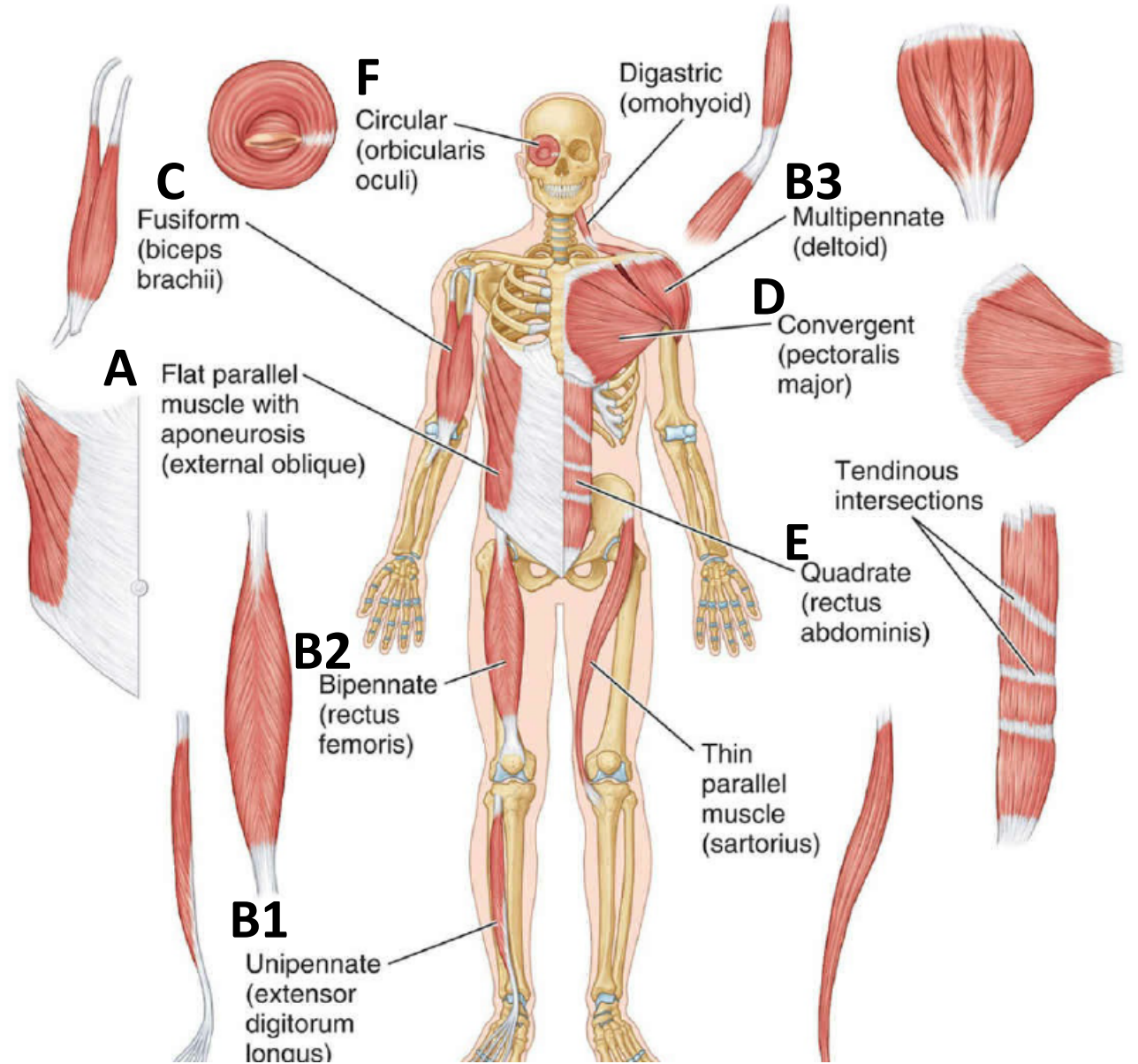
All have fleshy, reddish, contractile portions composed of skeletal striated muscle fibers.

Skeletal muscles function to permit movement and are usually contracted voluntarily and consciously.



Shapes of skeletal muscles

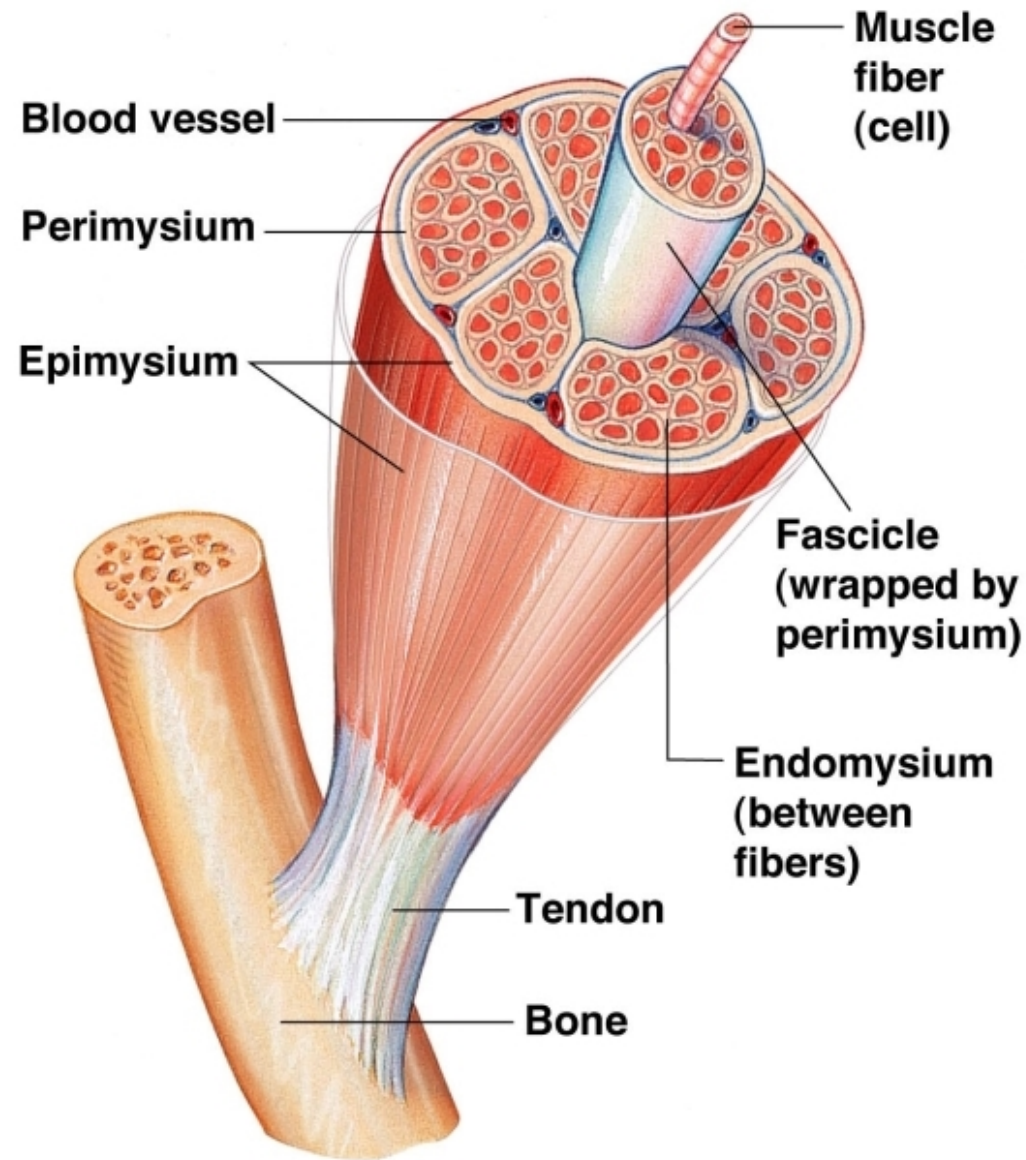
- A. Flat muscles: have parallel fibers
- B. Pennate muscles: feather like
- C. Fusiform muscles: spindle shape
- D. Convergent muscles
- E. Quadrate muscles
- F. Circular muscles



Attachment of skeletal muscles

- ❖ Most skeletal muscles are attached directly or indirectly to bones, cartilages, ligaments, or fascias or to some combination of these structures.
- ❖ Some muscles are attached to organs (e.g., the eyeball), skin (such as facial muscles), and mucous membranes (intrinsic tongue muscles).

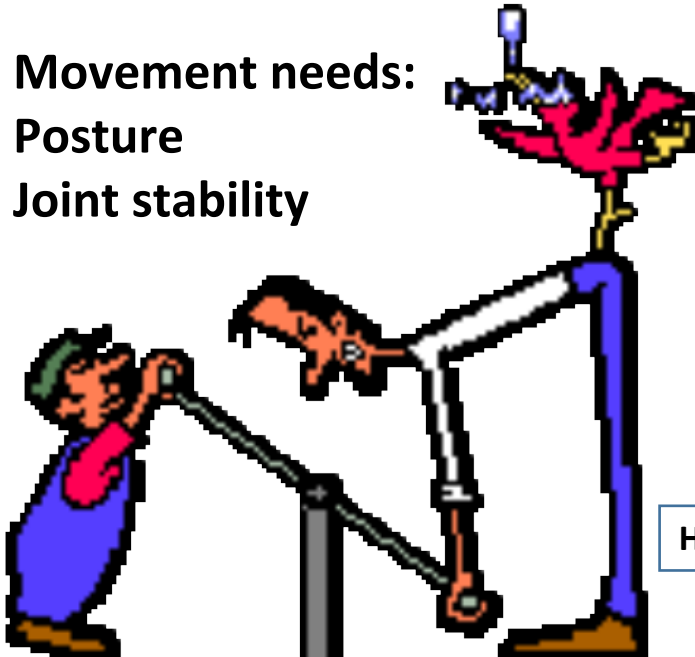
Structure of skeletal muscle



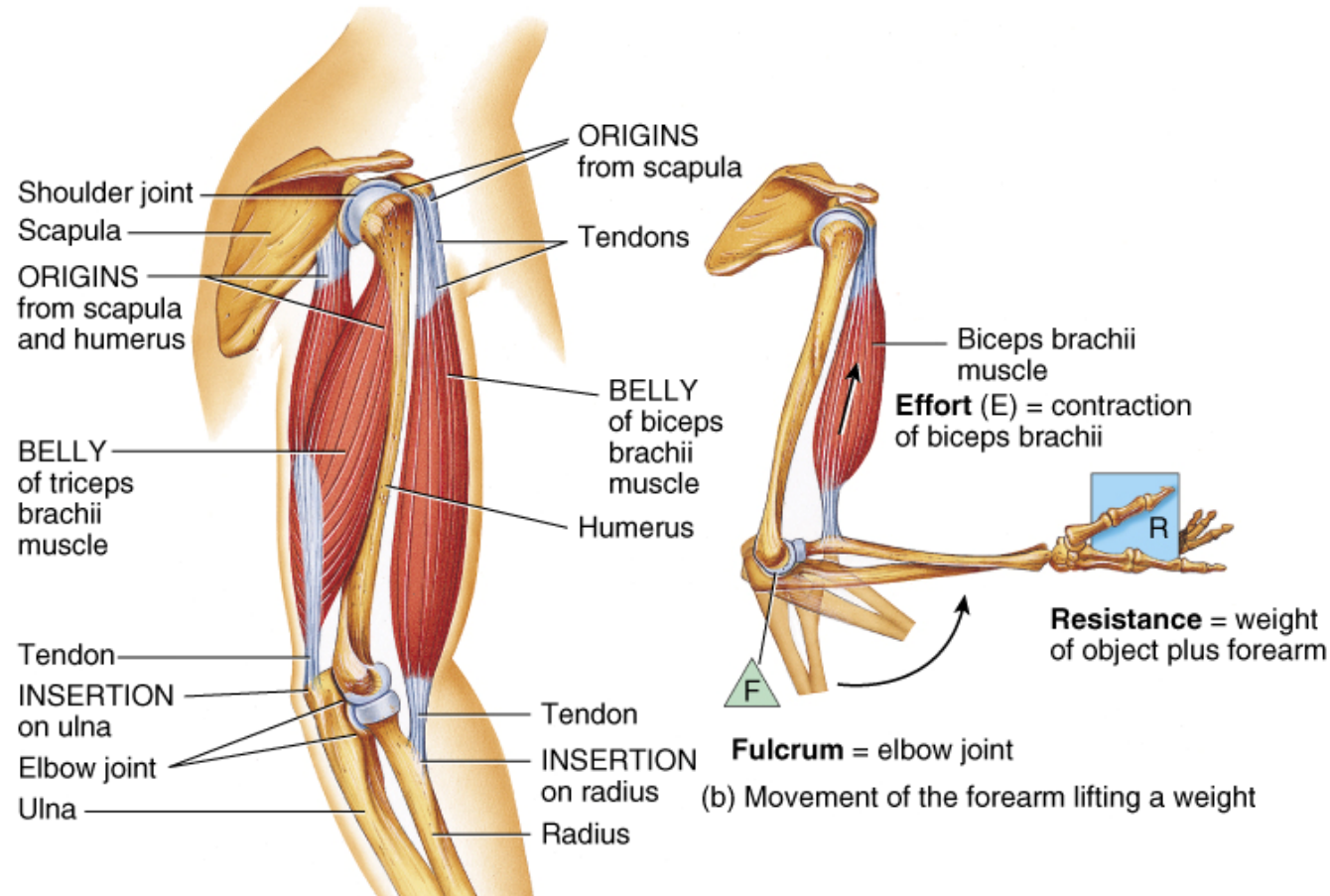
Function of skeletal muscle

1. Muscles are organs of locomotion (movement)
2. Provide static support.
3. Give form to the body.
4. Provide heat.

Movement needs:
Posture
Joint stability



Heat generation →



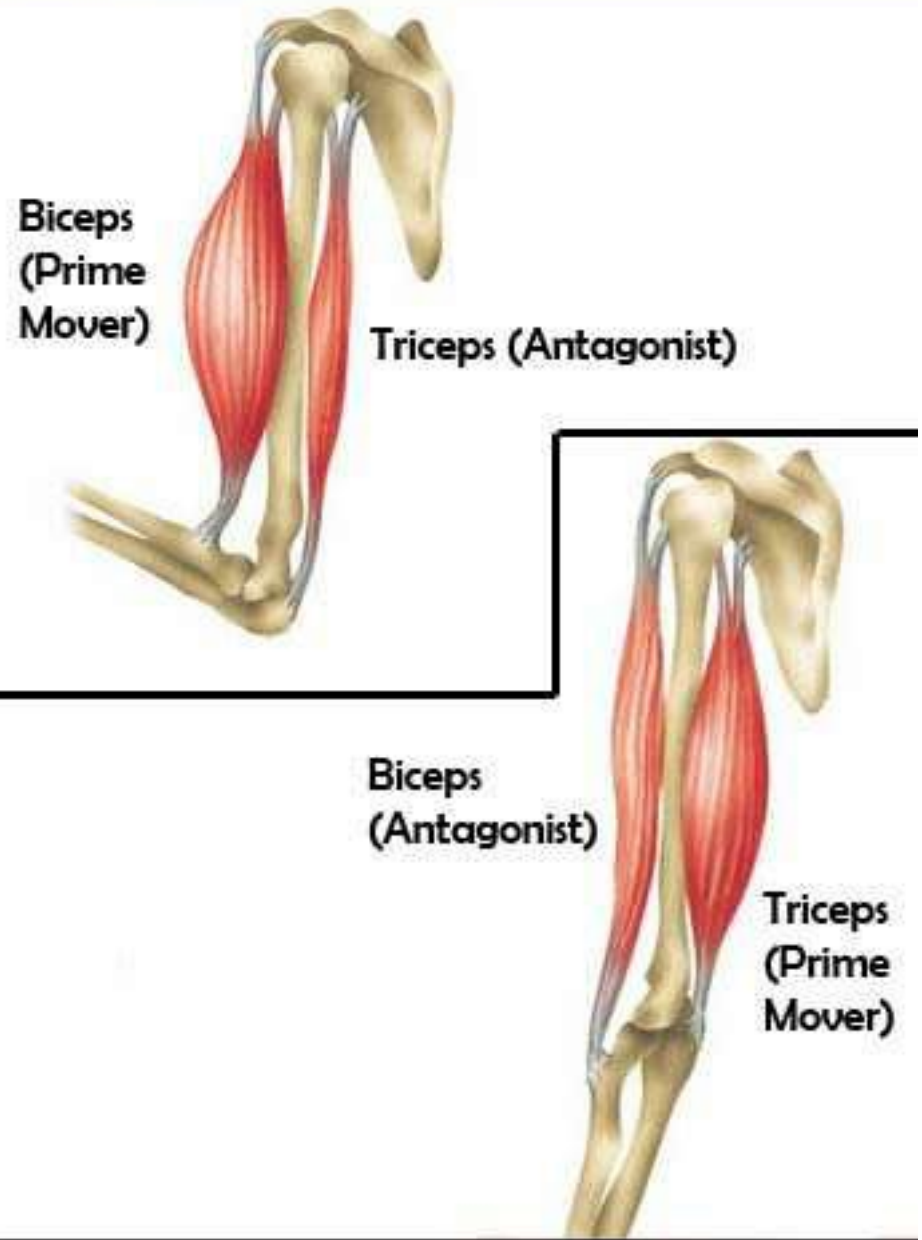
Muscles serve specific functions in moving and positioning the body

Coordinated movement

- **Prime Mover (Agonists):** main muscle (s) responsible for a particular movement
- **Antagonist:** opposes prime mover
- **Synergist:**
 - (i) assists prime mover
 - (ii) Stabilizes action of prime mover, (fixator), e.g, fixes non-moving joint when prime mover acting over two joints

Flexion of elbow

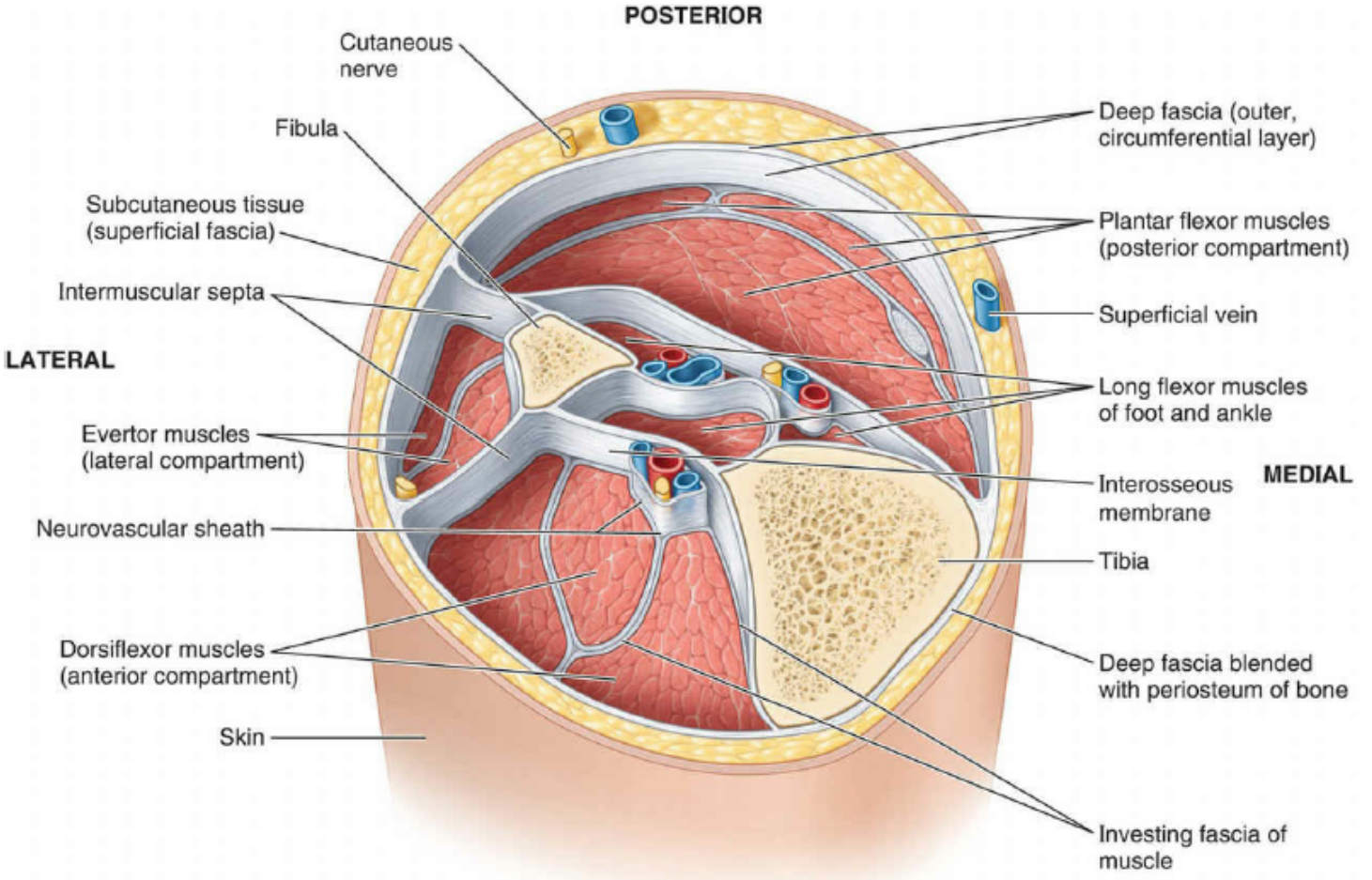
LO 1



Extension of elbow

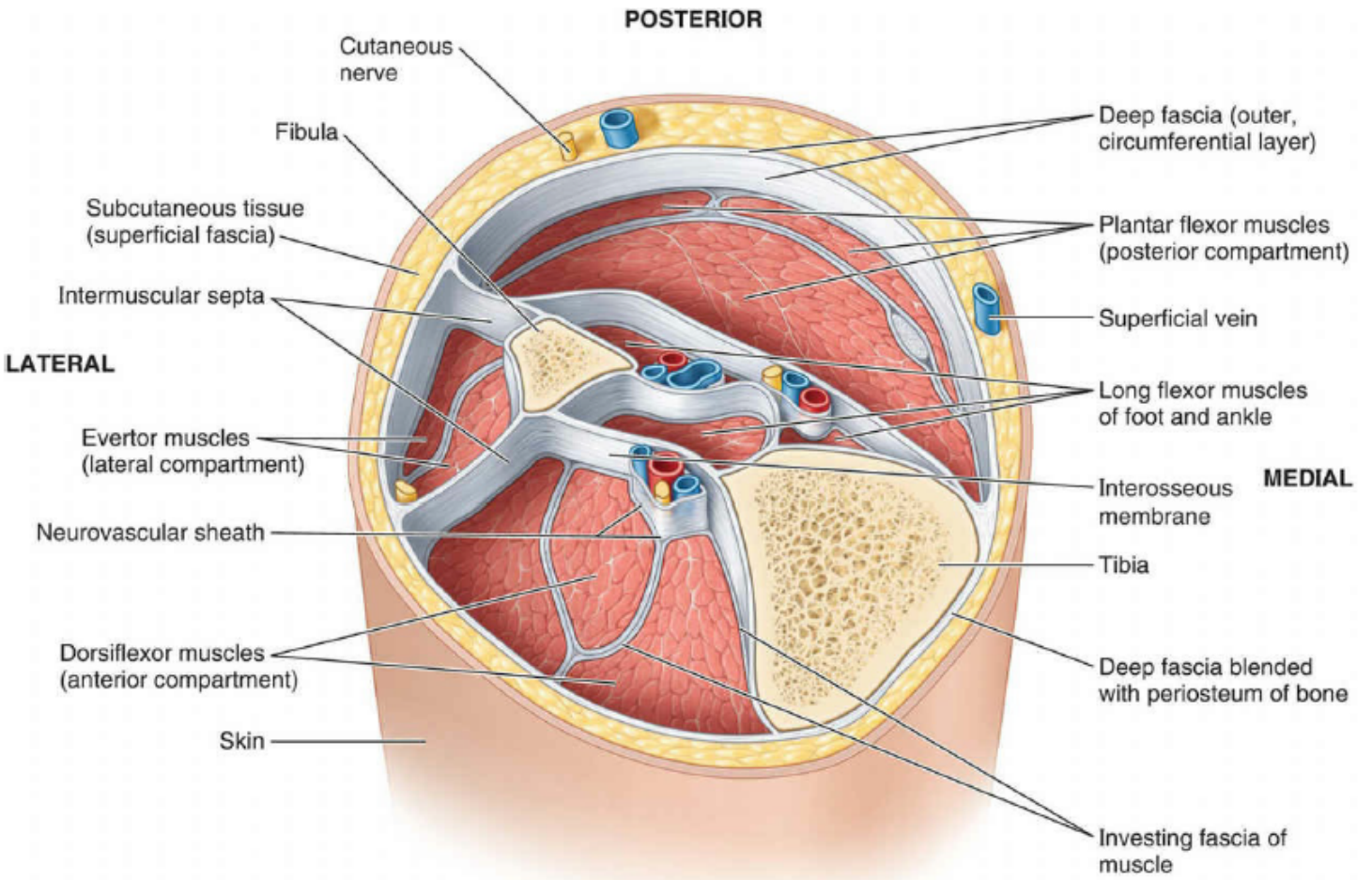
Nerve supply of muscles

In the limb, muscles of similar actions are generally contained within a common fascial compartment and share innervation by the same nerves.



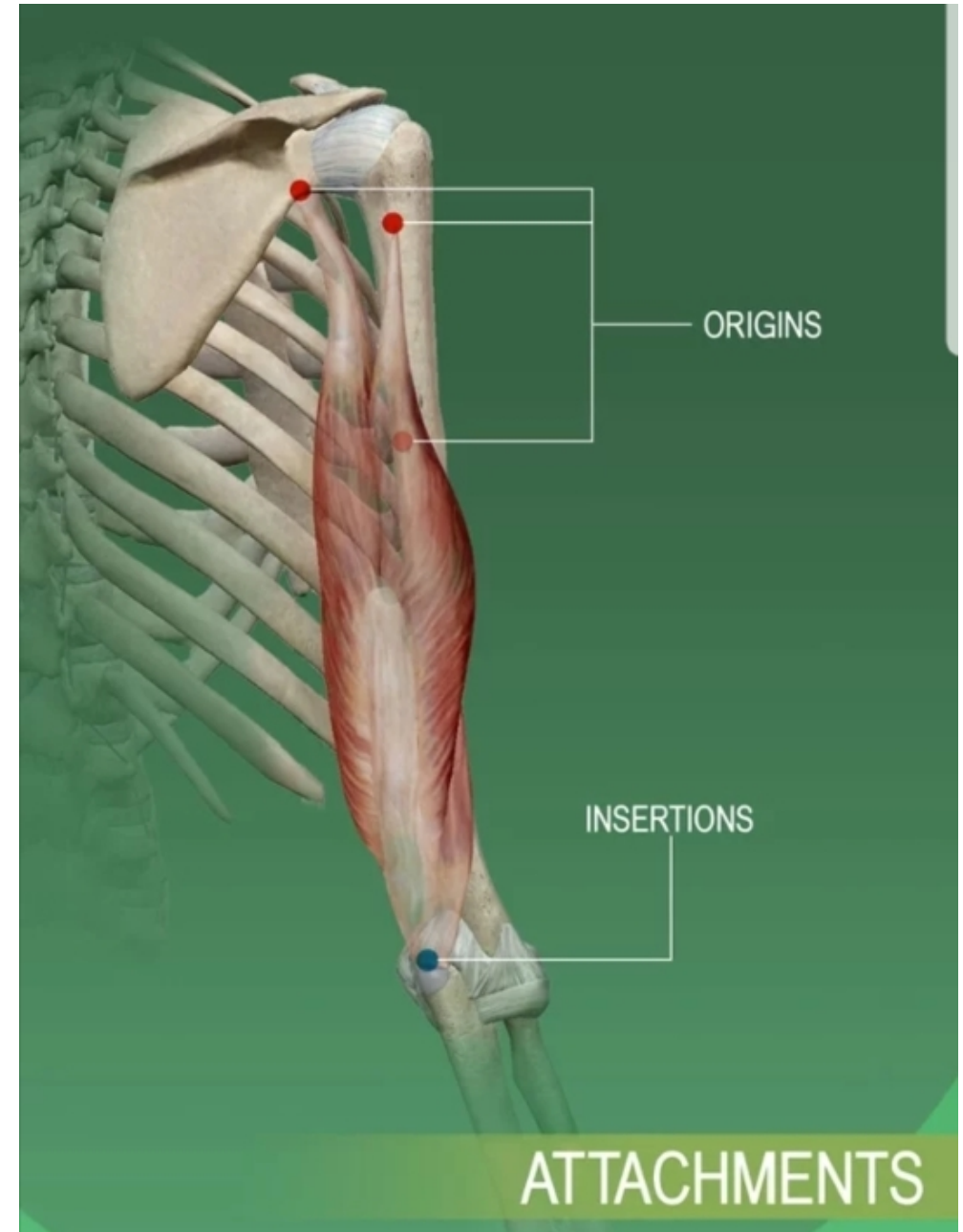
Blood supply of muscles

The blood supply of muscles usually multiple. Arteries generally supply the structures they contact.



CONTRACTION OF MUSCLES

- ❖ Skeletal muscles function by contraction; they pull and never push.
- ❖ When a muscle contracts usually shortens.
- ❖ They have 2 attachments(usually bony) commonly described as the **origin** (usually proximal & us. remain fixed) and **insertion**(usually distal & us. mobile) during muscular contraction.



CONTRACTION OF MUSCLES

- 1. Phasic (active) Contraction**
- 2. Reflexive Contraction.**
- 3. Tonic Contraction.**

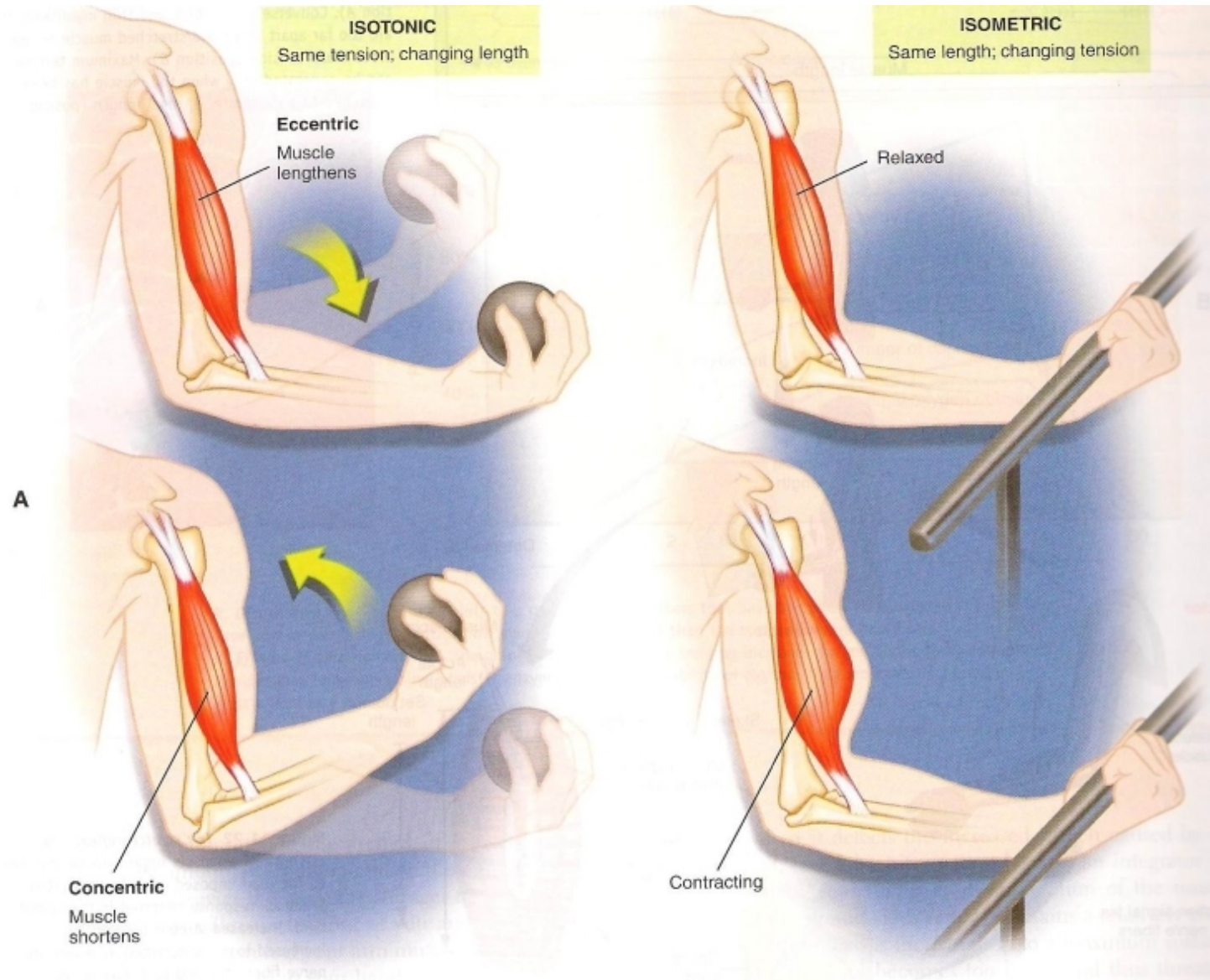
CONTRACTION OF MUSCLES

Phasic (active) Contraction:

Two main types:

- (1) Isotonic contractions: the muscle changes length (production of movement):
 - i. Concentric contraction: shortening
 - ii. Eccentric contractions: actively controlled lengthening (relaxation).
- (2) Isometric contractions: muscle length remains the same—no movement occurs (maintaining upright posture).

Type of muscle contraction



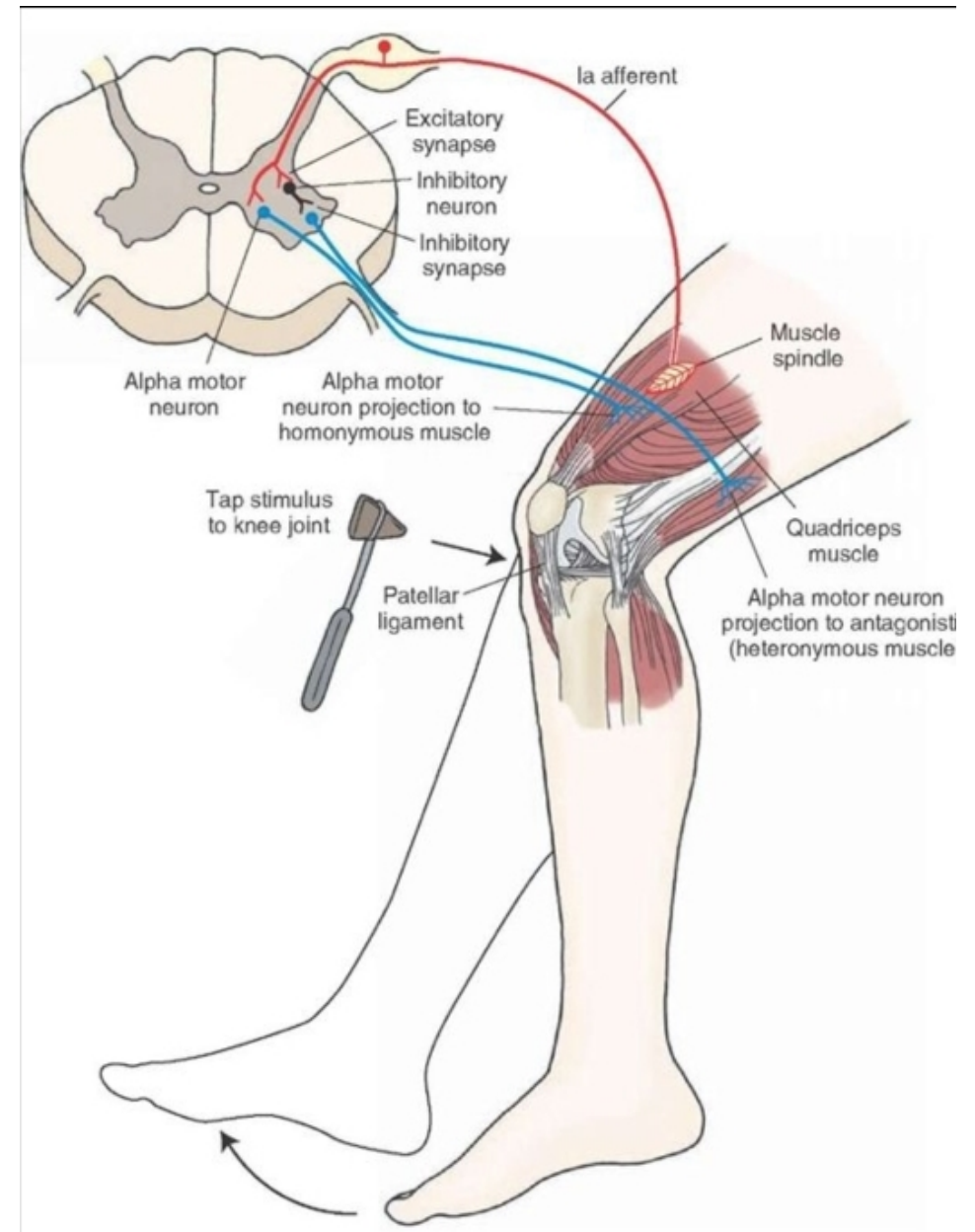
CONTRACTION OF MUSCLES

Reflexive Contraction:

- ❖ Although skeletal muscles are voluntary.
- ❖ In certain situations, are automatic (reflexive) and not voluntarily controlled.

Examples:

- Respiratory movements of the diaphragm (levels of oxygen and carbon dioxide in the blood).
- Myotatic reflex (Stretch by tapping a tendon with a reflex hammer).



Muscle tone

- Present in muscles **at rest**, due to
 - (1) motor neuron activity
 - (2) muscle elasticity

- **Control of muscle tone**
 - (1) via motor control centers in the brain
 - (2) afferent fiber signals originating in the muscle themselves

CONTRACTION OF MUSCLES

Tonic Contraction

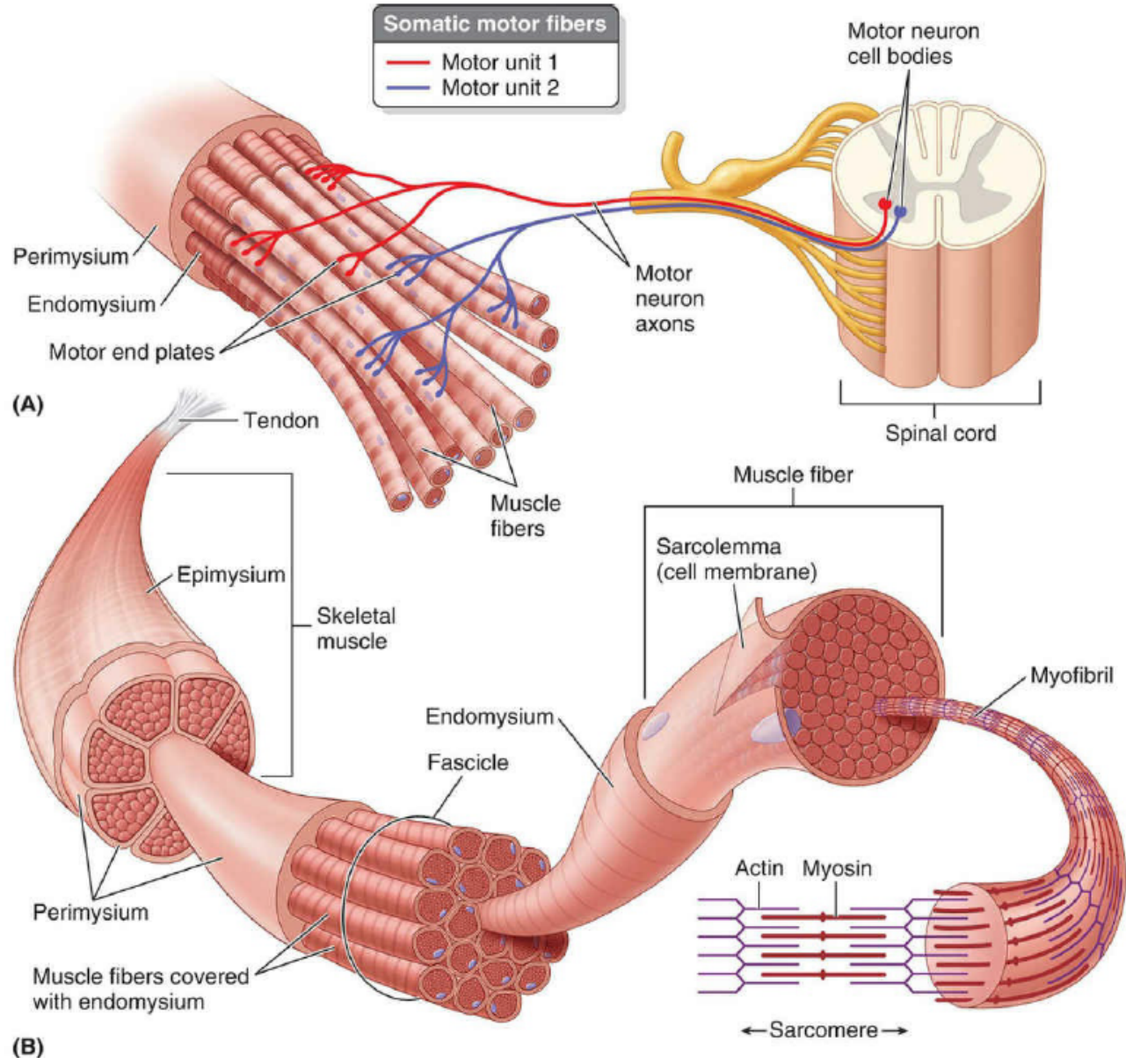
Even when “relaxed,” the muscles of a conscious individual are almost always slightly contracted (tonic contraction). Does not produce movement:

- i. Assisting the stability of joints.
- ii. Maintenance of posture.
- iii. Keeping the muscle ready to respond to stimuli.

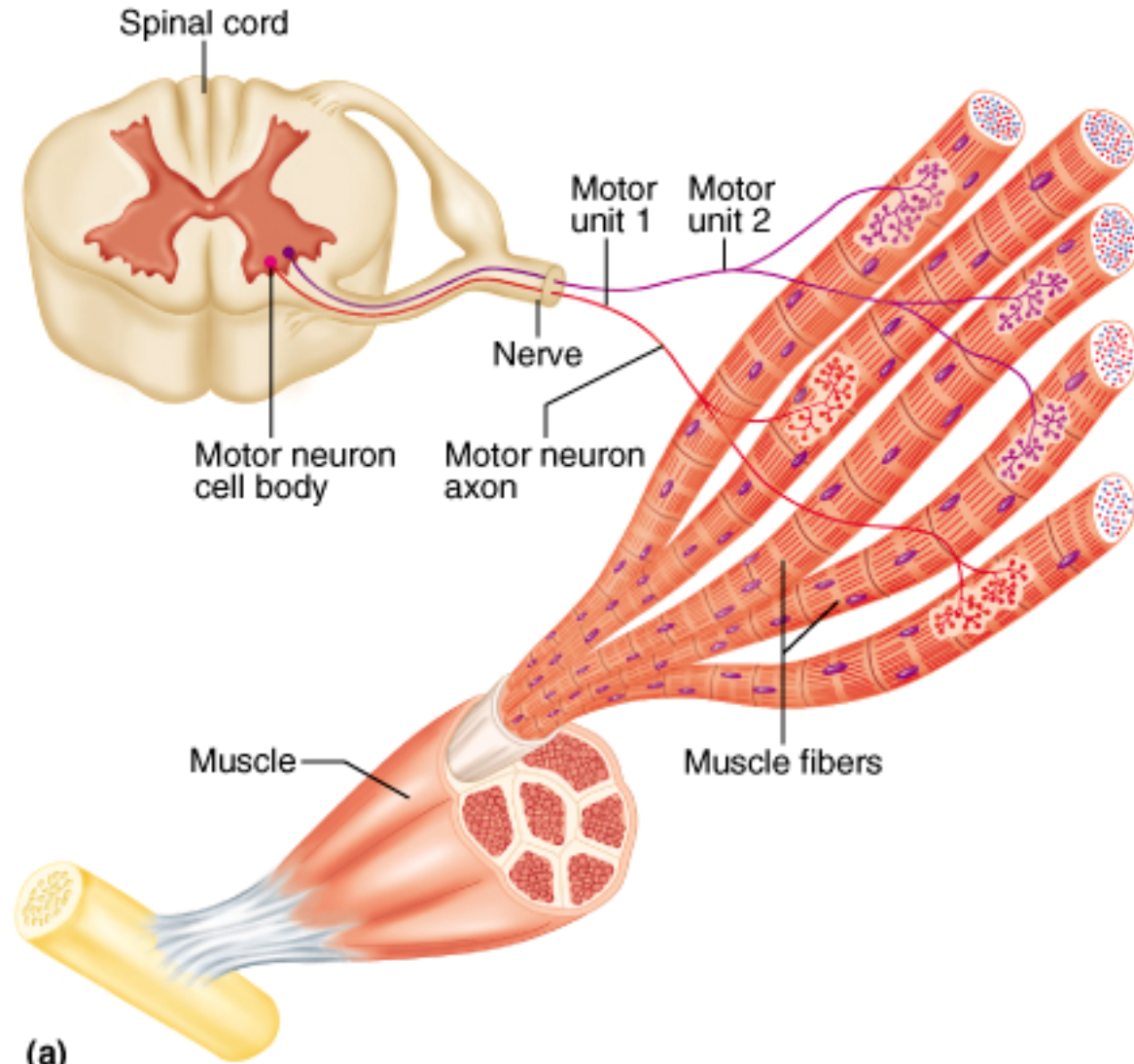
CONTRACTION OF MUSCLES: need integrity and coordination of :

- Structural unit: **skeletal striated muscle fiber.**
- Functional unit: **motor unit**, consisting of a motor neuron and the muscle fibers it controls

CONTRACTION OF MUSCLE



Motor unit



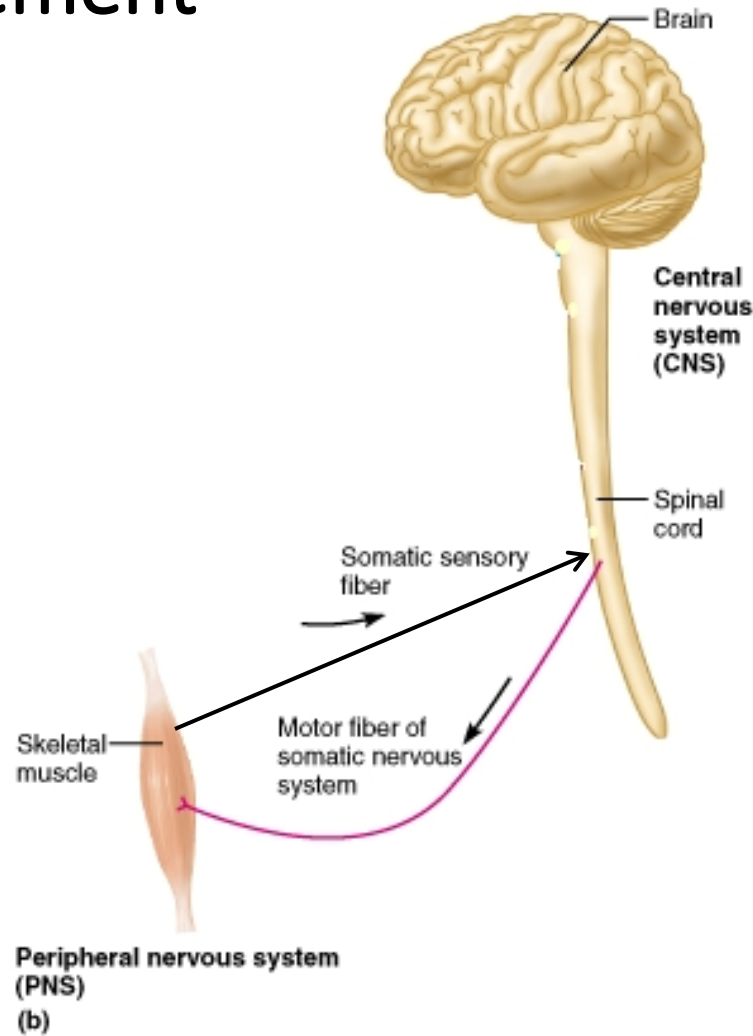
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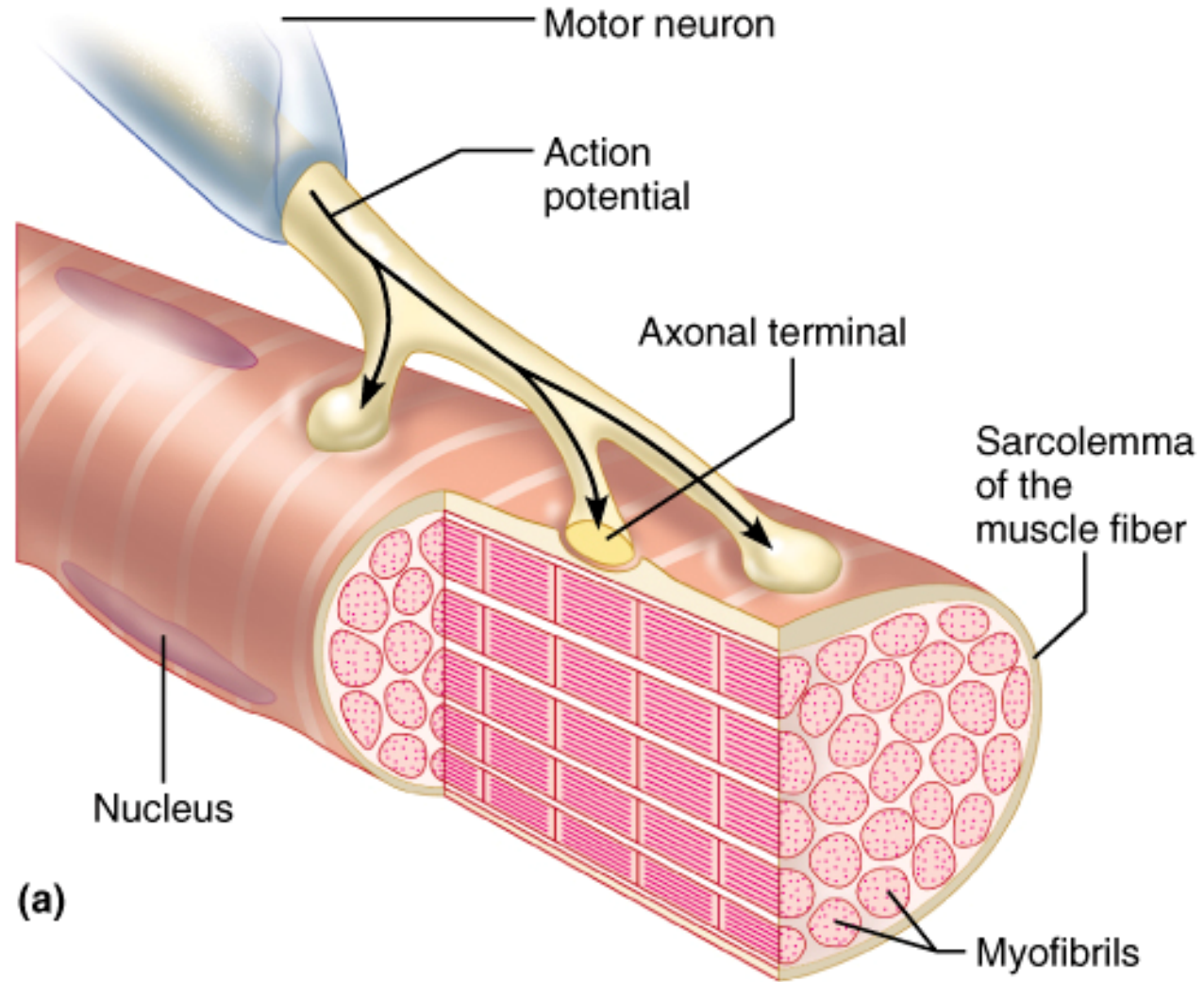
Steps for motor movement

Motor neuron

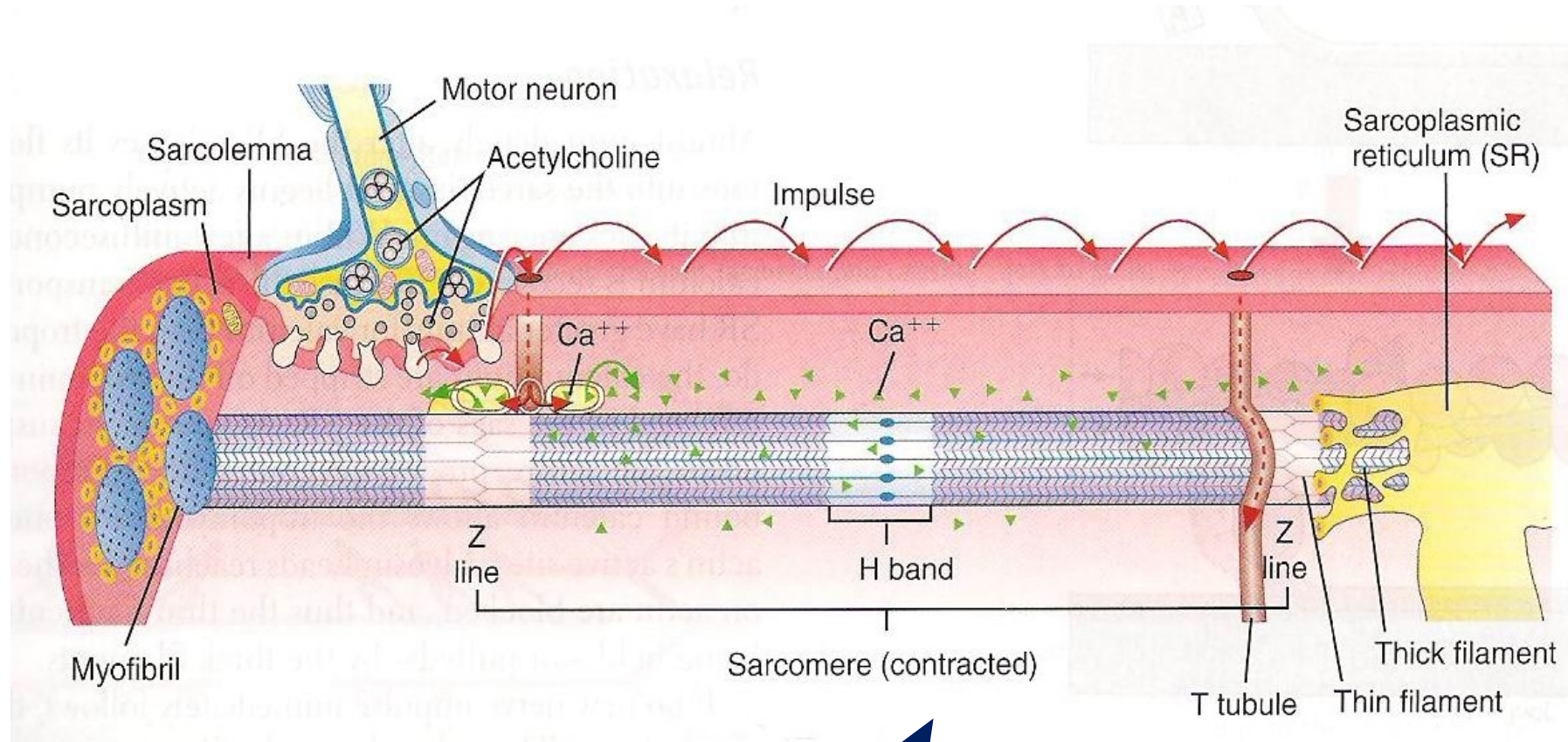
Sensory feedback



Neuromuscular junction



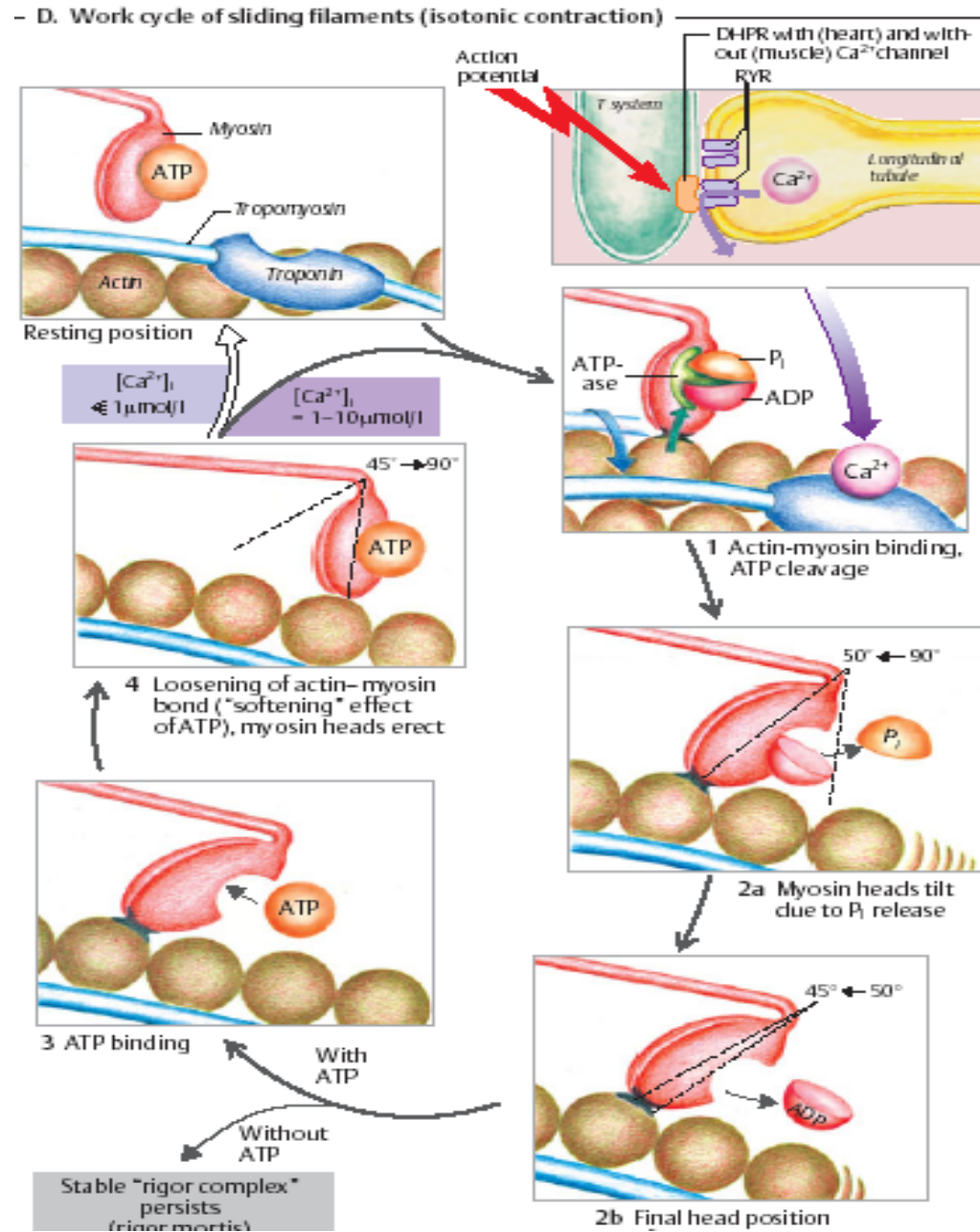
Starting muscle contraction



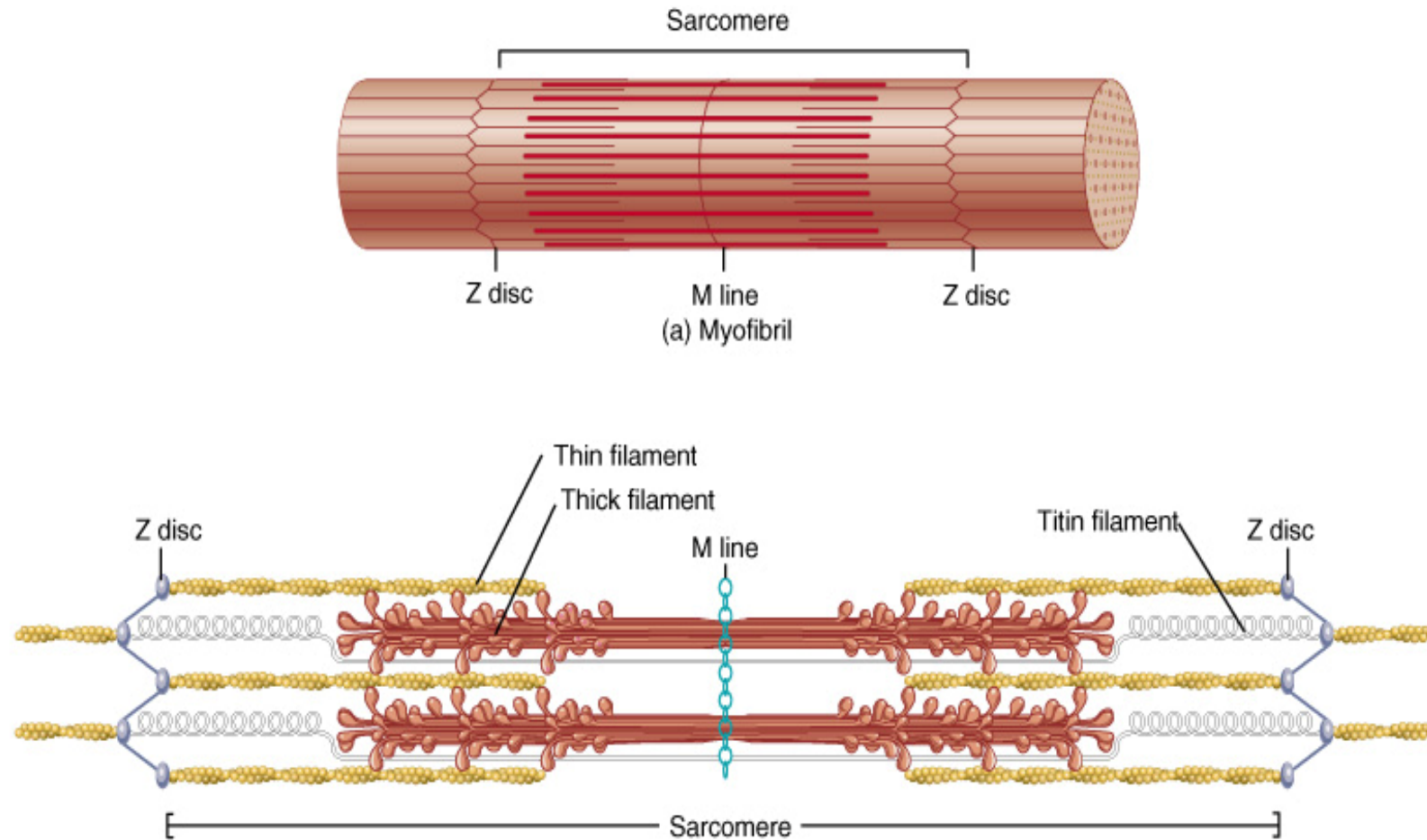
Ca^{++} ion

Excitation-contraction coupling

During excitation: myofibrils in the cells generate tension (via the cross-bridge cycle) and may shorten the muscle fiber. The collective shortening of these fibers contract the muscle and so cause movement



The cross bridge (Swiveling, walk along, power stroke) mechanism



Muscle relaxation

Calcium ion is
actively pumped
into the
sarcoplasmic reticulum



Muscle contracture

- A state of continuous muscle contraction
- Occurs when ATP is depleted
- Resulted in failure of detachment of the actin filaments from myosin heads

Writers cramps ?

Compartment syndrome ?

Rigor mortis ?

Think about diseases that may affect the muscle tone and contractility



Hypotonea



Hypertonea



Increase power



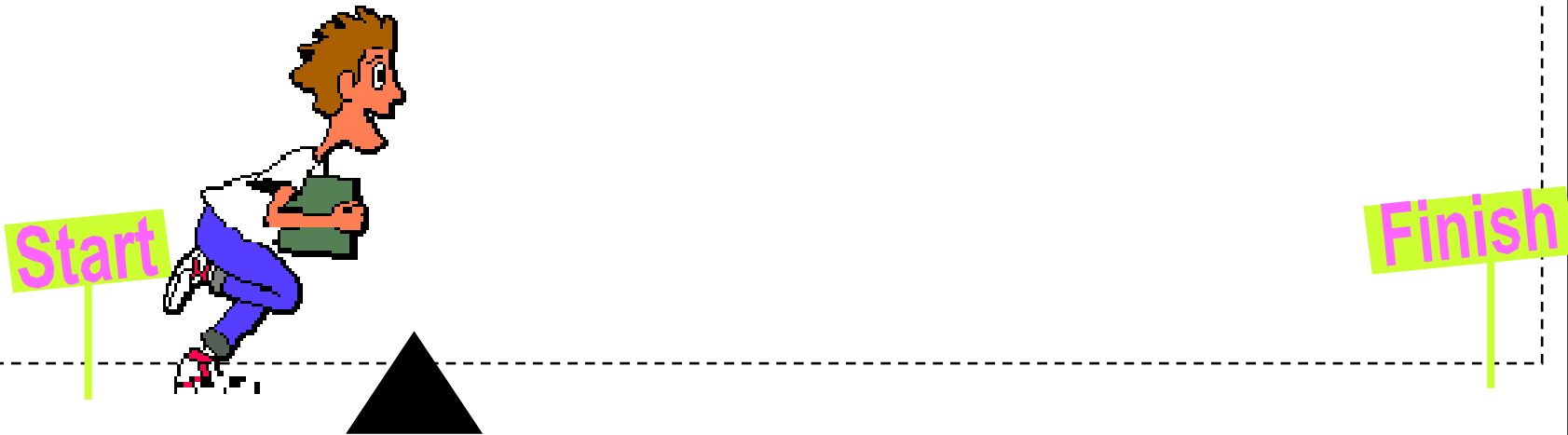
Decrease power

What is the **fuel** for the muscle?



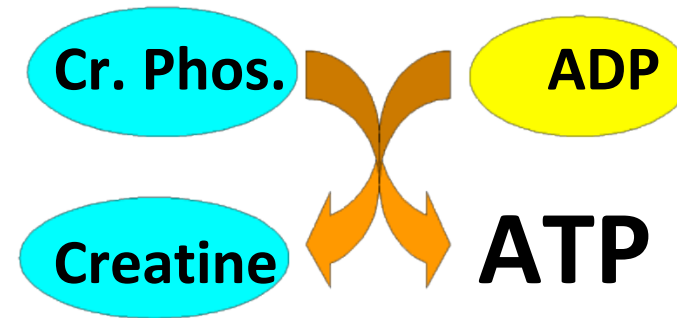
ATP stored in the muscle

Last for few seconds

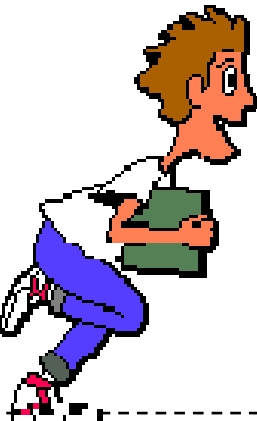


Phosphorylation of ADP by Creatine Phosphate

Last for about 15 seconds

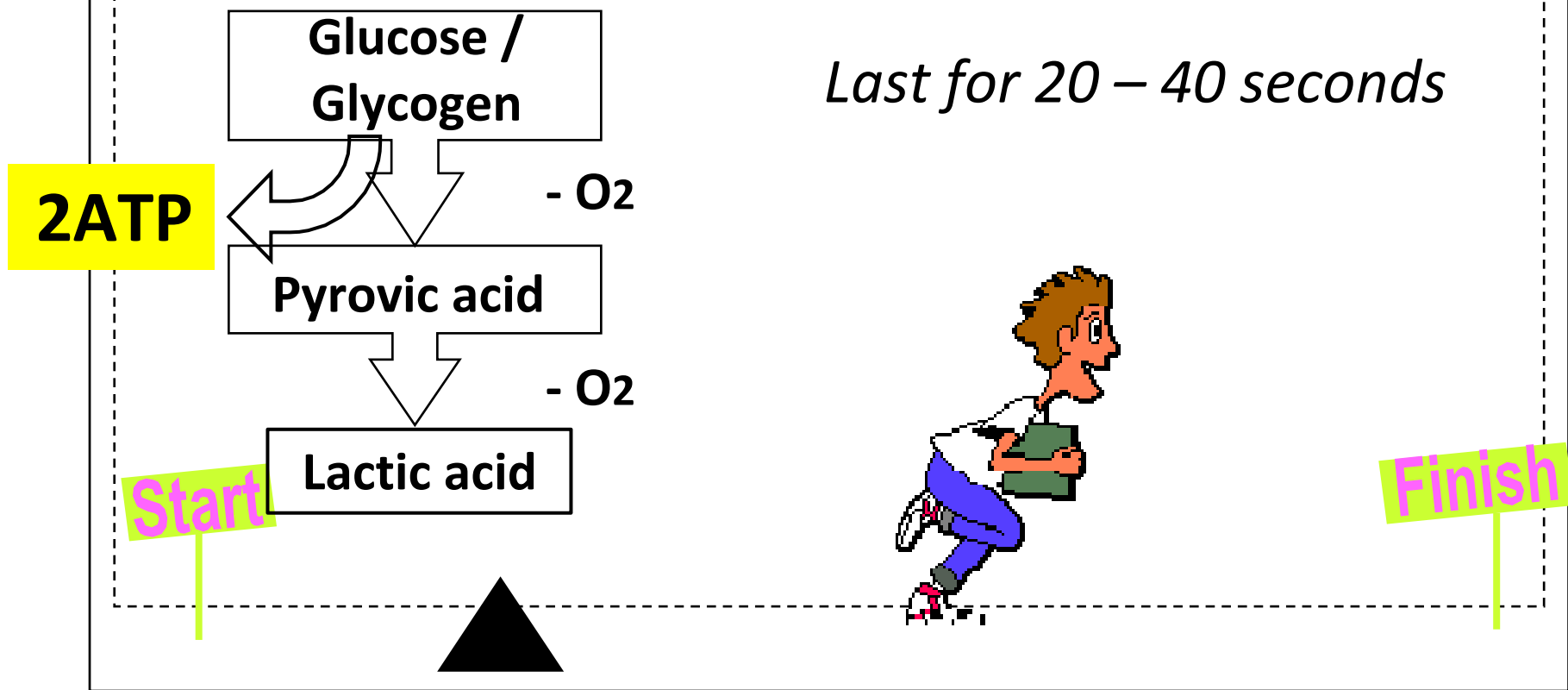


Start

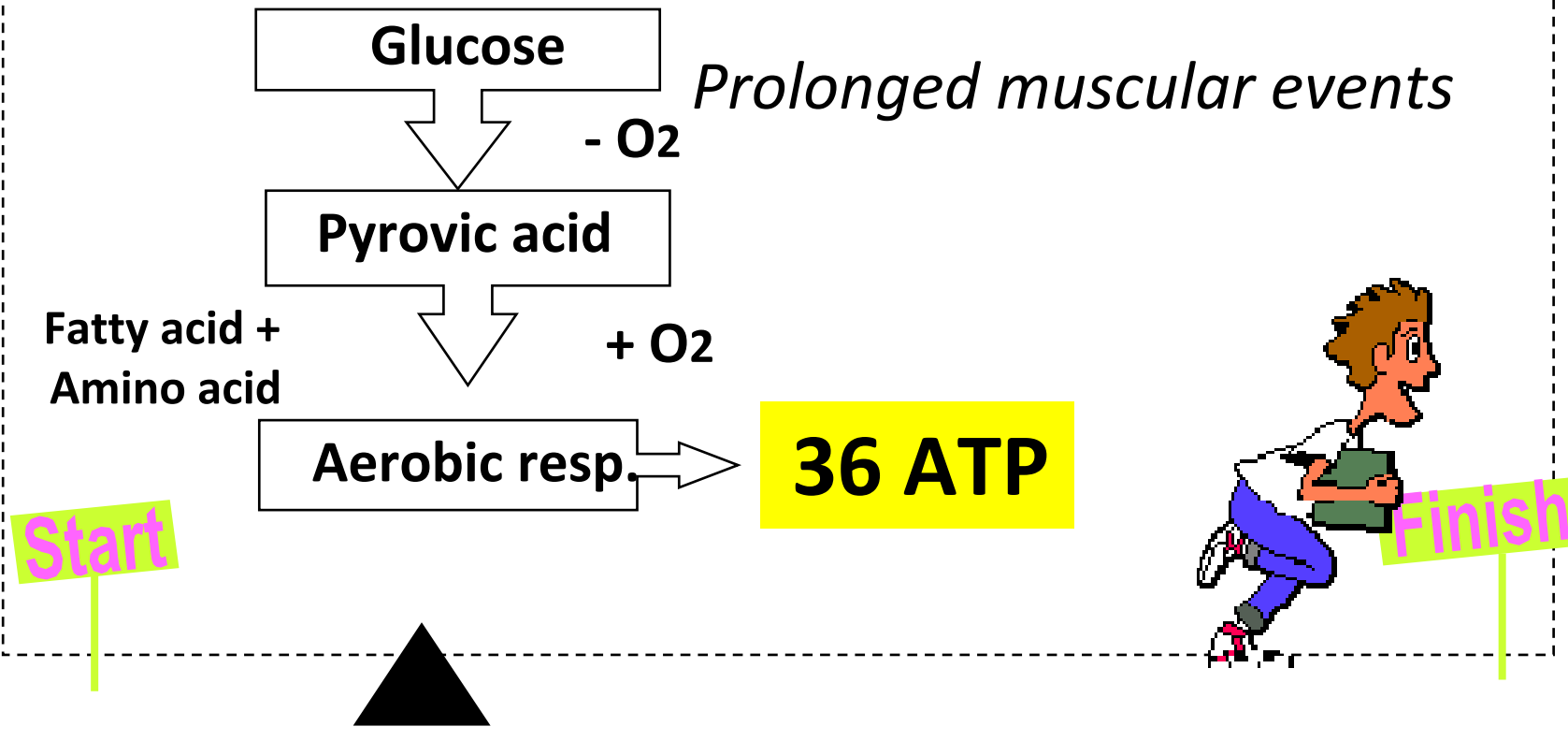


Finish

Anaerobic glycolysis and lactic acid formation



Aerobic respiration (Oxidative phosphorylation)



Where do muscle spend this fuel?

- 1. Physical activity (contraction)**
- 2. Regeneration of ATP molecules**
- 3. Removal of lactic acid (Oxygen debt?)**
- 4. Heat production**

Muscle fatigue

- Depletion of muscle glycogen
- Fatigue of NMJ
- Blood interruption
(intermittent claudication)



How we can do different muscle activities ?

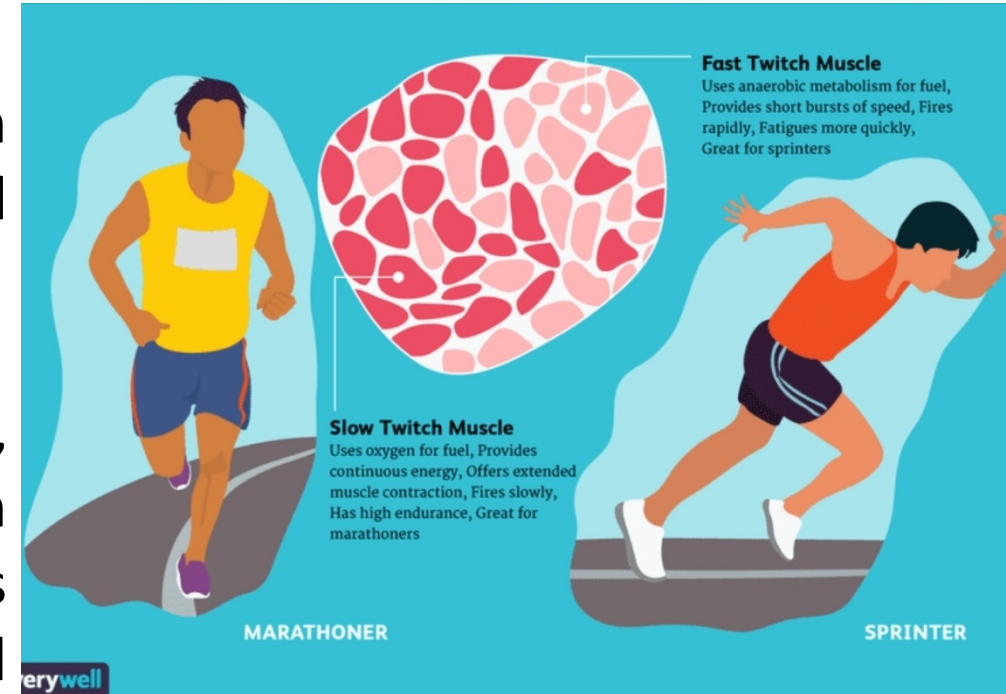
LO 5

Because we have different types of skeletal muscle fibers:

Type I (back muscles): red, small fibers that are rich in mitochondria. These are capable of prolonged powerful muscular contraction (slow-twitch muscle fibers).

Type II b (finger muscles): lighter color (white fibers), have large amount of glycolytic enzymes and are rich in sarcoplasmic reticulum with less mitochondria and less blood vessels and are responsible for rapid, precise and short duration type of contraction (fast-twitch muscle fibers).

Type II a: in between type I and II b.



Summary

- **Skeletal muscle types, action & structure**
- **Function of these muscles** (contraction & relaxation)
- **Requirements for their action**
- **Types of muscle contraction**
- **Their Force, Tone, Fatigue and Contracture**
- **Energy source and its expenditure** (use)
- **Types of muscle fibers and their benefit**
- **Clinical problems related**



Thank You

