Muscular System - Anatomy & Physiology

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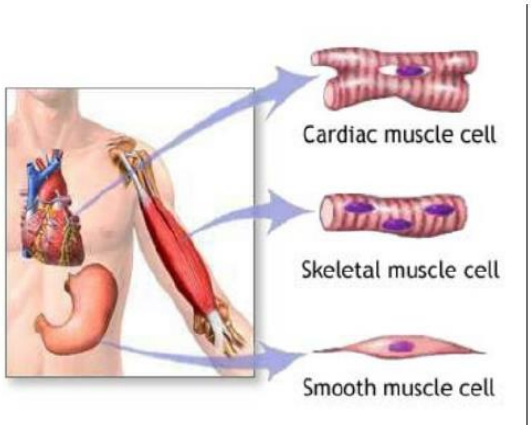
Muscle
Is animal tissue consisting predominantly of contractile cells

Muscle cells - Are specialized contractile cells (fibres)
All muscles share some terminology

- Prefix *myo* refers to muscle
- Prefix *mys* refers to muscle
- Prefix *sarco* refers to flesh

Types of Muscle

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



Skeletal Muscles:

- They are also known as striped, striated, somatic and voluntary muscles
- They are the most abundant type and are found **attached to the skeleton**. For this reason they are called skeletal muscles.
- They are under voluntary control. (They obey the will of human beings.)
- They respond quickly to stimuli and are capable of rapid contractions. They get fatigued easily because of their rapidity in action.
- Each muscle fiber is multinucleated cylindrical cell containing groups of **myofibrils**. The myofibrils are in turn made up of **myofilaments** of four types namely **actin, myosin, troponin and tropomyosin**.
- Thus the skeletal muscles have **three structural levels** namely:
    - *Muscle fibers,*
    - *Myofibrils and*
    - *Myofilaments.*

- **Smooth muscles:**

Smooth Muscles

- They are also known as non-striated, visceral and involuntary muscles.
- Unlike skeletal muscles, they do not exhibit cross striations under the microscope and thus they got the name “smooth”.
- They are supplied by autonomic nervous system and therefore they are involuntary in their action. (They do not obey the will of human being.)
- They respond slowly to stimuli but are capable of long time sustained contractions.
- They do not get fatigued easily because of their slowness of response.
- They provide motor power for regulating internal environment related to digestion, circulation, secretion and excretion.
- Each smooth muscle fiber is an **elongated spindle shaped cell** with a single nucleus placed at the center. They also possess actin and myosin filaments but the structural arrangement of these filaments is very different as compared to the skeletal muscles.
- Examples of smooth muscles include muscles of blood vessels, and muscles of the gut etc.

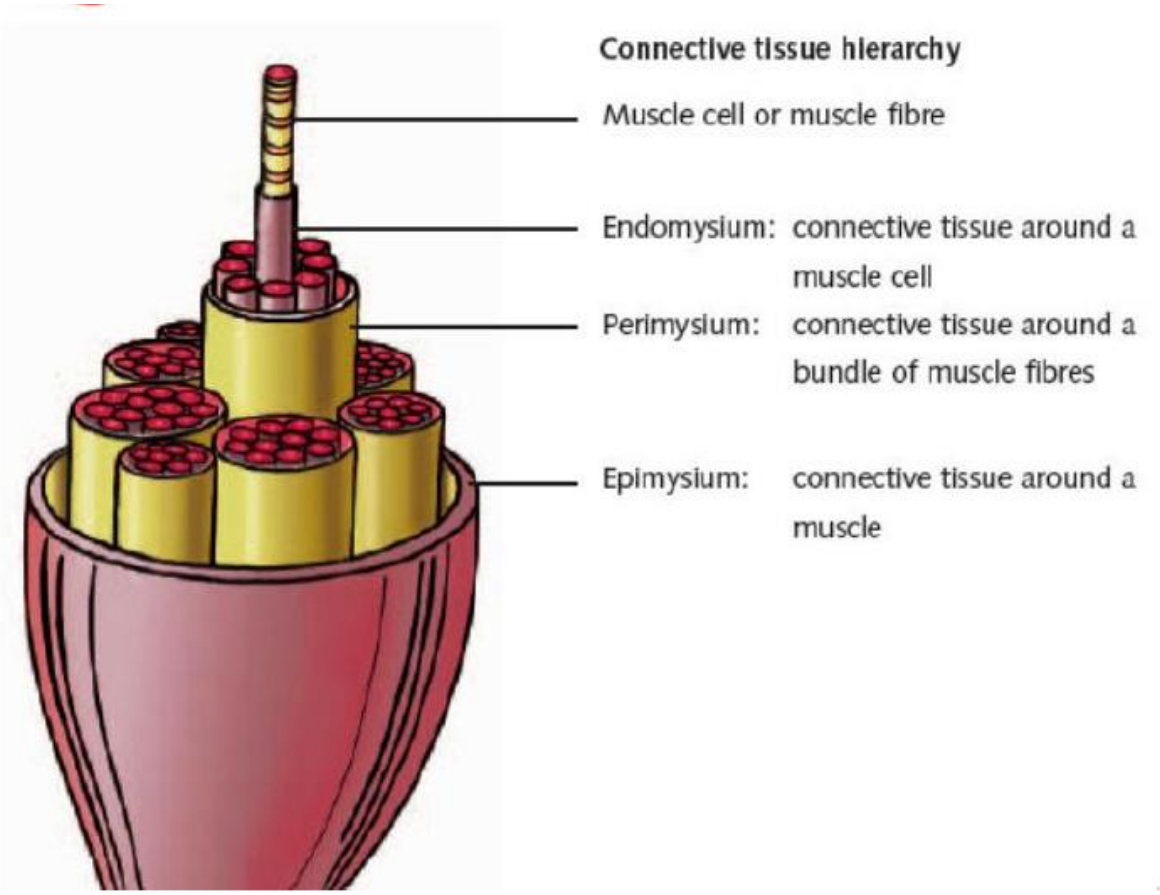
Cardiac muscles:

- They form the **myocardium** of human heart.
- They are striated like skeletal muscles but at the same time they are involuntary and have uninuclear cells like smooth muscles.
- They are meant for automatic rhythmic contractions for long period of time.
- Each muscle fiber has a single centrally placed nucleus.
- Neighboring cells are joined by intercalated discs which provide conductive pathways from one cell to another

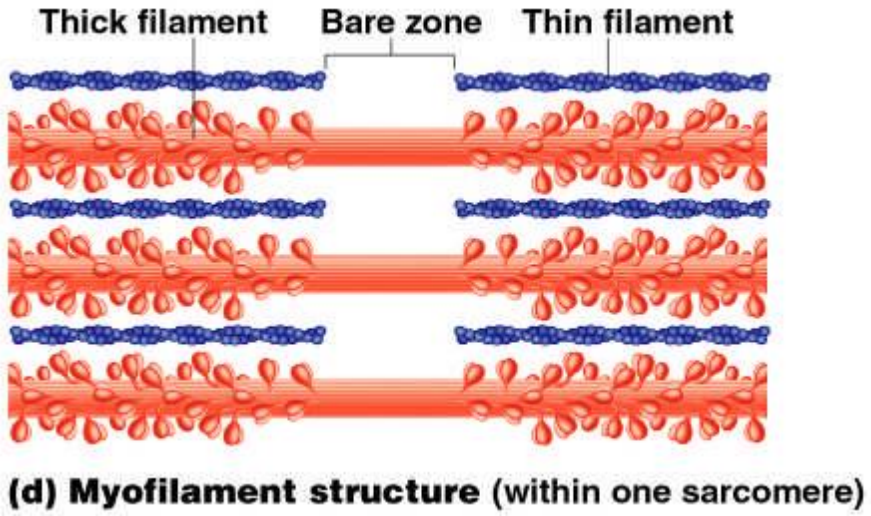
ORGANISATION OF SKELETAL MUSCLE

Skeletal muscle cells are multinucleate.

- Endomysium – connective tissue around single muscle fiber
- Perimysium – around a fascicle (bundle) of fibers
- Epimysium – covers the entire skeletal muscle
- Fascia – on the outside of the epimysium



- A **muscle fiber** is a multinucleated muscle cell that attaches to connective tissue.
- **Sarcolemma** is the muscle cell membrane.
- **Sarcoplasm** is the cytoplasm containing nuclei, mitochondria, and myofibrils.
- **Myofibrils** are composed of protein filaments, predominantly myosin and actin
- **Thick filaments.** The larger, thick filaments, also called **myosin filaments**, are made mostly of bundled molecules of the protein myosin, but they also contain ATPase enzymes, which split ATP to generate the power for muscle contraction.
- **Thin filaments.** The thin filaments are composed of the contractile protein called **actin**.
- **Myosin:** Thick filament of twisted protein strands with globular ends called cross-bridges.



(d) Myofilament structure (within one sarcomere)

- **At rest, there is a bare zone that lacks actin filaments – the H zone**

- **Sarcoplasmic reticulum.** Is a specialized smooth endoplasmic reticulum; and its major role is to store calcium and to release it on demand.

Types of Muscle Contractions

Isotonic contractions – "same tone" or tension
- Myofilaments are able to slide past each other during contractions
- The muscle shortens

Isometric contractions – "same measurement" or length
- Tension in the muscles increases
- The muscle is unable to shorten

Effects of Exercise on Muscle
- Increase in muscle size
- Increase in muscle strength
- Increase in muscle efficiency
- Muscle becomes more fatigue resistant

Special Movements
- Dorsiflexion – lifting the foot
- Plantar flexion – depressing the foot
- Inversion – turn foot inward
- Eversion – turn foot outward
- Supination – hand facing upward
- Pronation – hand facing downward
- Opposition – touching thumb to other fingers

Naming of Skeletal Muscles

1. Direction of muscle fibers

Example: *rectus* (straight) or *oblique* (slanted)

2. Relative size of the muscle

Examples: *maximus* (largest), *minimus* (smallest), *longus* (long), brevis (short), major (large), minor (small)

3. Location of the muscle

Example: many muscles are named after bones (e.g., *temporalis,* which is near the temporal bone*), tibialis*

4. Number of origins

Example: *biceps, triceps, quadriceps* (two, three, or four origins or heads)

5. Location of the muscle's origin and insertion

Example: *sterno* (on the sternum) *cleido* (clavicle) *mastoid* (on the mastoid process)

6. Shape of the muscle

Example: *deltoid* (triangular), trapezius (trapezoid, 2 parallel sides), serratus (saw-toothed), rhomboideus (rhomboid, 4 parallel sides), orbicularis and sphincters (circular)

7. Action of the muscle

Example: *flexor* and *extensor* (flexes or extends a bone)

Muscle terminology

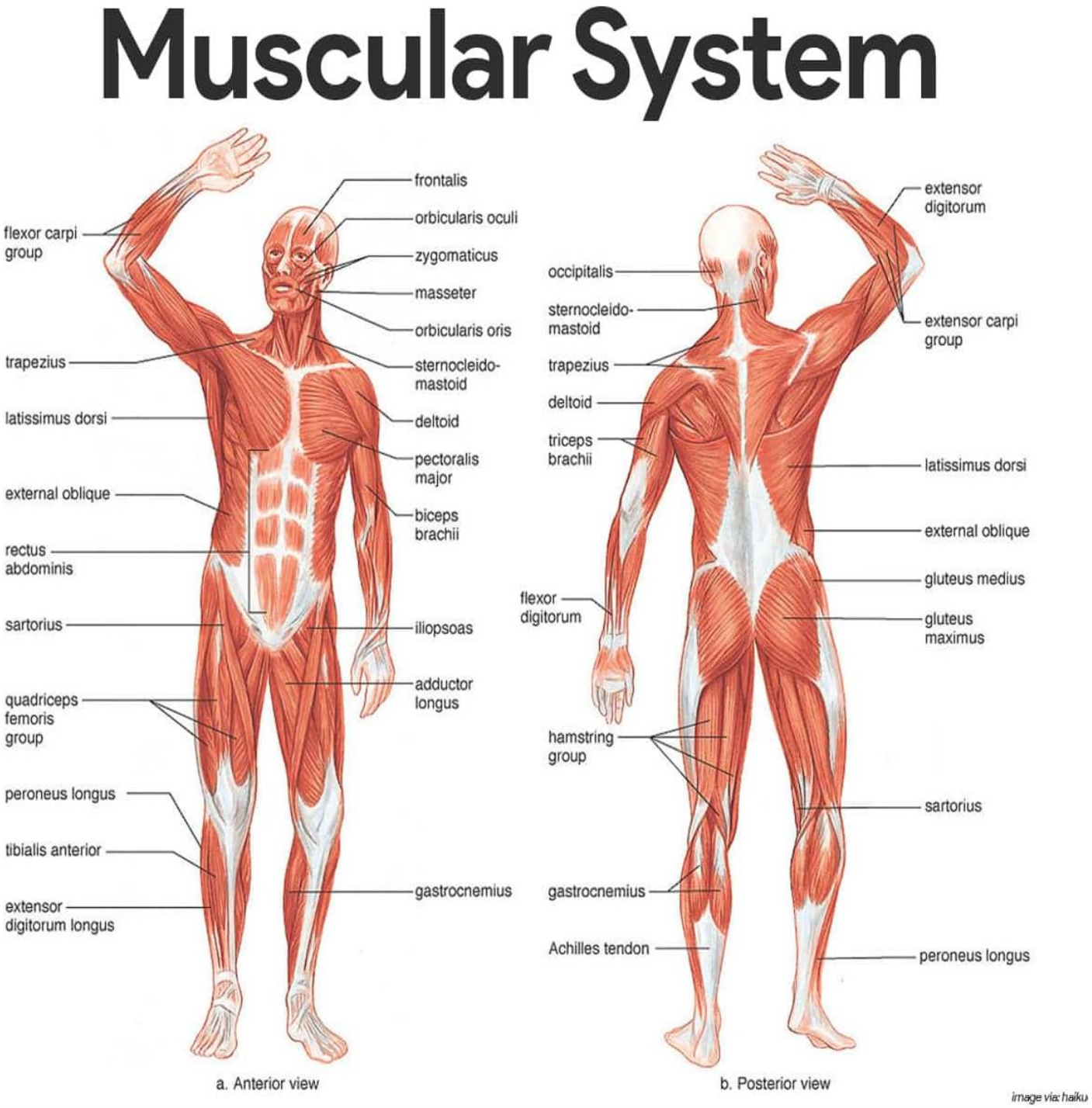
i) **Muscle origin –** usually its proximal attachment. Is generally at the bone that remains still when the muscle contracts, giving it an anchor to pull against.

ii) **Muscle insertion –** usually the distal attachment site, on the bone that is moved when the muscle contracts

Functions of the Muscular System

1. **Producing movement.** Mobility of the body as a whole reflects the activity of the skeletal muscles, which are responsible for all locomotion; they enable us to respond quickly to changes in the external environment.
2. **Maintaining posture.** We are rarely aware of the skeletal muscles that maintain body posture, yet they function almost continuously, making one tiny adjustment after another so that we can maintain an erect or seated posture despite the never-ending downward pull of gravity.
3. **Stabilizing joints.** As the skeletal muscles pull on bones to cause movements, they also stabilize the joints of the skeleton; muscle tendons are extremely important in reinforcing and stabilizing joints that have poorly fitting articulating surfaces.

4. **Generating heat.** The fourth function of muscle, generation of body heat, is a by-product of muscle activity; as ATP is used to power muscle contraction, nearly three-quarters of its energy escape as heat and this heat is vital in maintaining normal body temperature.



Types of Body Movements

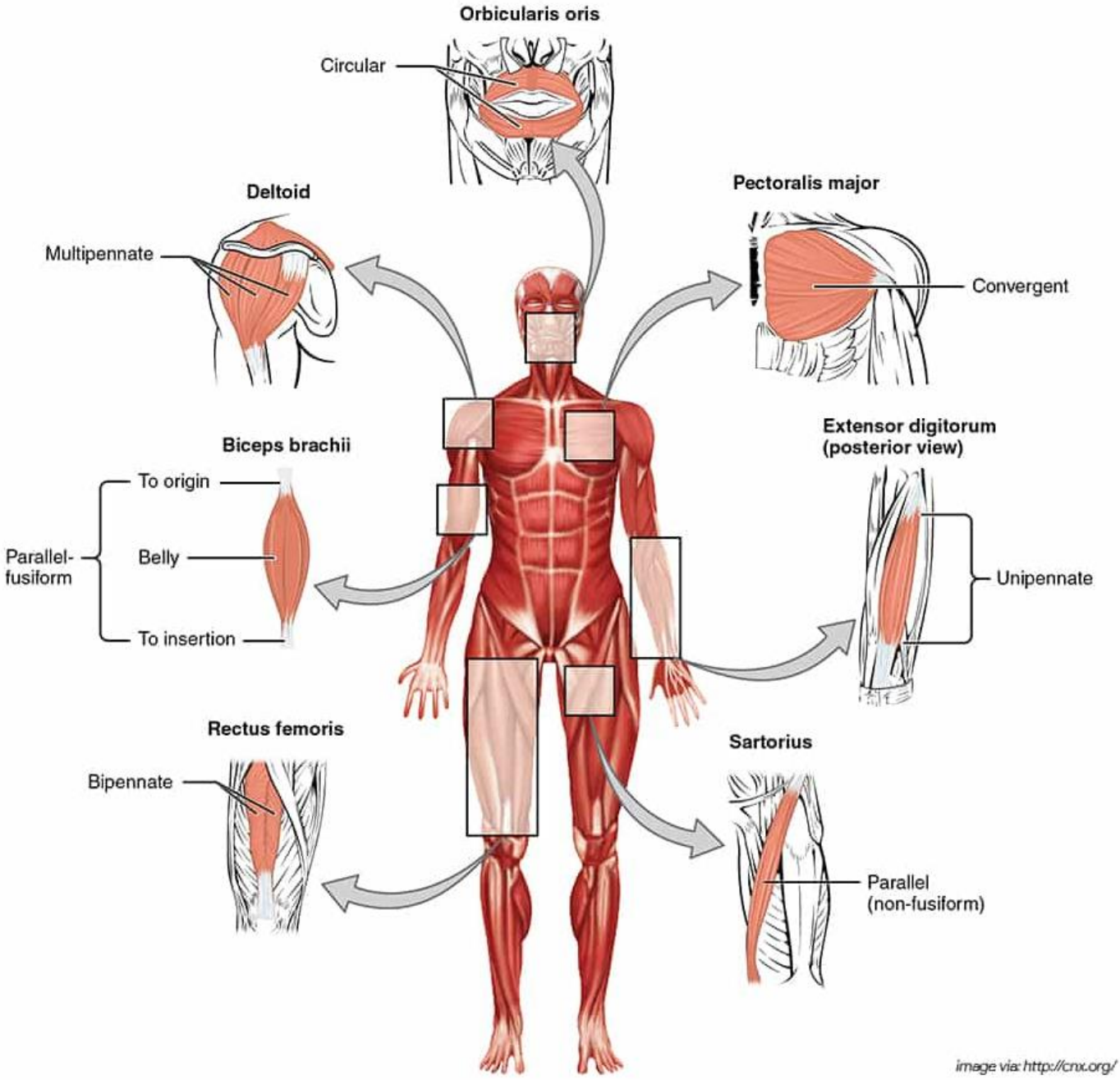
- **Origin.** One of these points, the origin, is attached to the immovable or less movable bone.
- **Insertion.** The insertion is attached to the movable bone, and when the muscle contracts, the insertion moves toward the origin.
- **Flexion.** Flexion is a movement, generally in the sagittal plane, that decrease the angle of the joint and brings two bones closer together; it is a type of hinge joints, but it is also common at ball-and-socket joints.
- **Extension.** Extension is the opposite of flexion, so it is a movement that increases the angle, or the distance, between two bones or parts of the body.
- **Rotation.** Rotation is movement of a bone around a longitudinal axis; it is a common movement of ball-and-socket joints.
- **Abduction.** Abduction is moving the limb away from the midline, or median plane, of the body.
- **Adduction.** Adduction is the opposite of abduction, so it is the movement of a limb toward the body midline.
- **Circumduction.** Circumduction is a combination of flexion, extension, abduction, and adduction commonly seen in ball-and-socket joints; the proximal end is stationary, and its distal end moves in a circle.

Interactions of Skeletal Muscles in the Body

Muscles are arranged in such a way that whatever one muscle can do, other muscles can reverse. Because of this, muscles are able to bring about an immense variety of movements.

- **Prime mover.** The muscle that has the major responsibility for causing a particular movement is called the prime mover.
- **Antagonists.** Muscles that oppose or reverse a movement are antagonists; when a prime mover is active, its antagonist is stretched and relaxed.
- **Synergists.** Synergists help prime movers by producing the same movement or by reducing undesirable movements.

Skeletal Muscle Shapes



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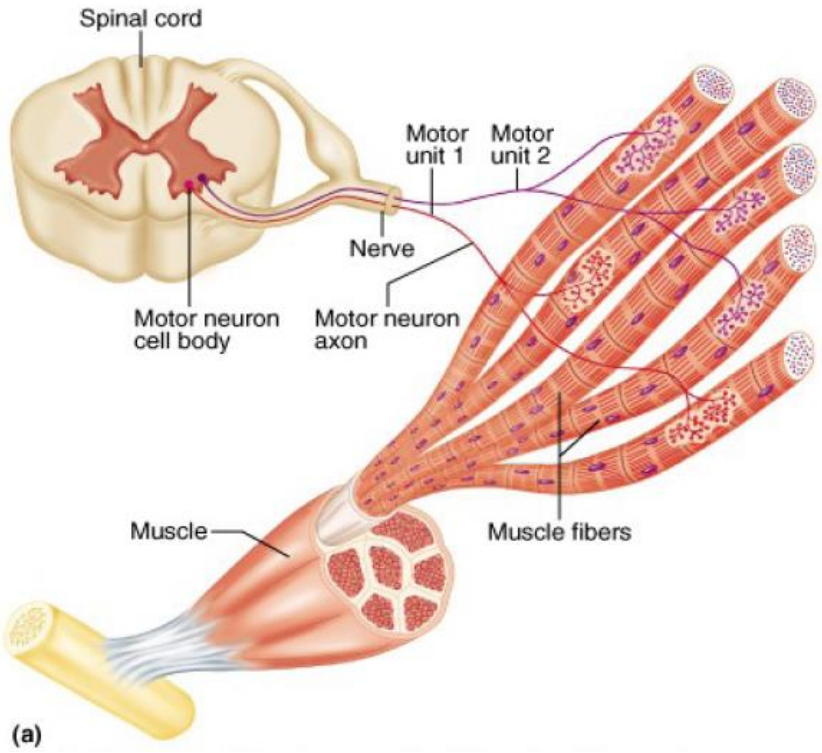
Arrangement of Fascicles

Skeletal muscles consists of fascicles, but fascicle arrangement vary, producing muscles with different structures and functional properties.

- **Circular.** The pattern is circular when the fascicles are arranged in concentric rings; circular muscles are typically found surrounding external body openings which they close by contracting.
- **Convergent.** In convergent muscle, the fascicles converge toward a single insertion tendon; such a muscle is triangular or fan-shaped.
- **Parallel.** In a parallel arrangement, the length of the fascicles run parallel to the long axis of the muscle; these muscles are straplike; a modification of the parallel arrangement, called **fusiform**, results in a spindle-shaped muscle with an expanded belly.
- **Pennate.** In a pennate pattern, short fascicles attach obliquely to a central tendon; in the extensor digitorium muscle of the leg, the fascicles insert into only one side of the tendon and the muscle is **unipennate**; if the fascicles insert into opposite sides of the tendon or from from several different sides, the muscle is **bipennate** or **multipennate**.

Motor Unit

The muscle fiber and the motor neuron



Muscles & Nervous System