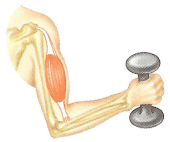
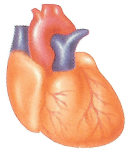
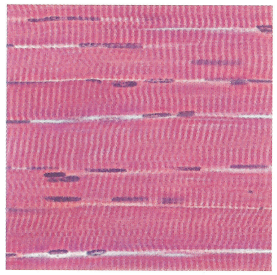
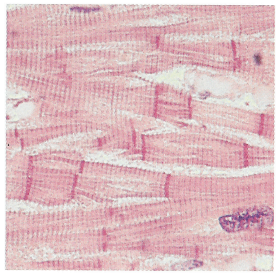
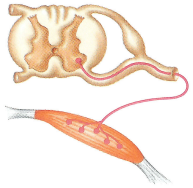
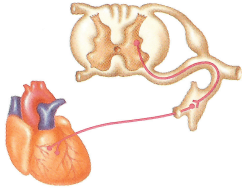
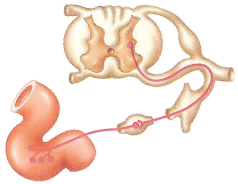
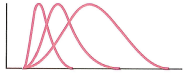
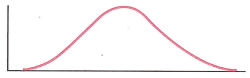
Muscular System

Function of the Muscular System

- Provides movement for the body and its parts, maintains posture, generates heat and stabilizes joints.
- Essential function is to shorten.

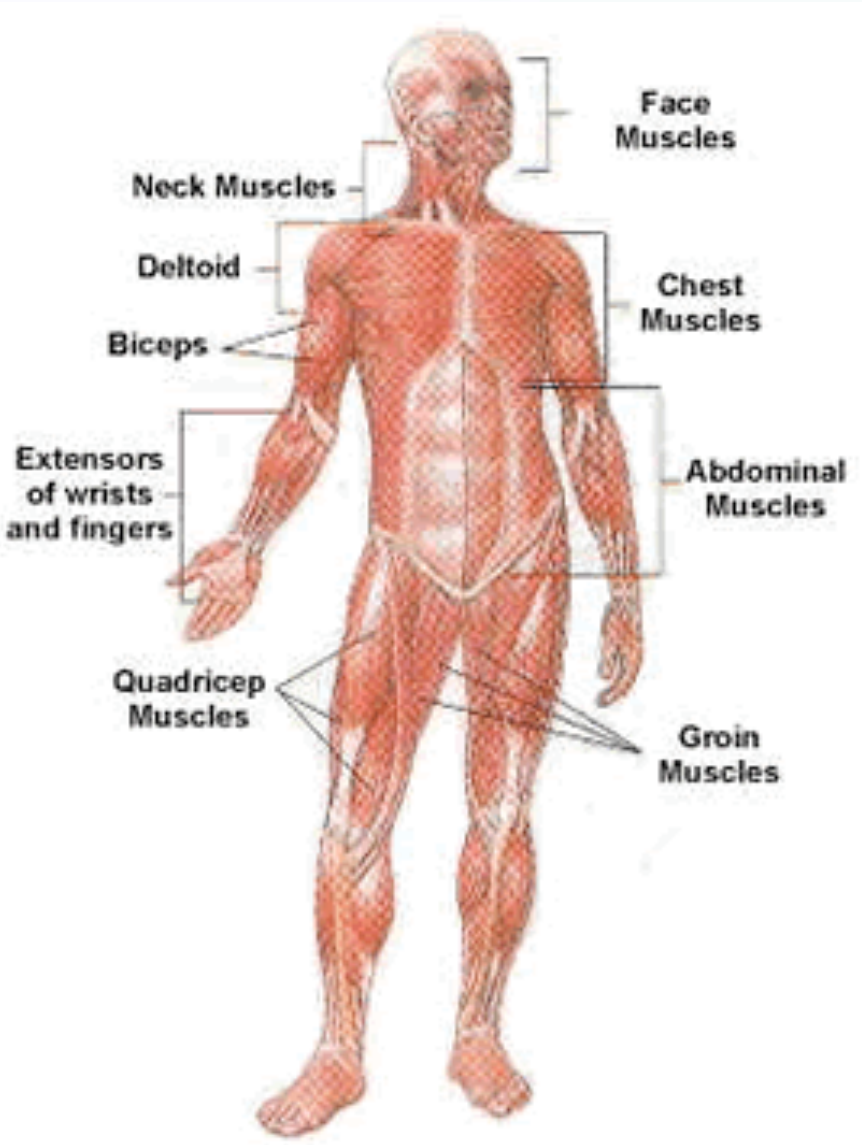
Types of Muscles

- Skeletal
- Smooth
- Cardiac

Characteristic	Skeletal	Cardiac	Smooth
Body location	 Attached to bones or, for some facial muscles, to skin	 Walls of the heart	 Mostly in walls of hollow visceral organs (other than the heart)
Cell shape and appearance	  Single, very long, cylindrical, multinucleate cells with very obvious striations	  Branching chains of cells; uninucleate, striations; intercalated discs	  Single, fusiform, uninucleate; no striations
Regulation of contraction	 Voluntary; via nervous system controls	 Involuntary; the heart has a pacemaker; also nervous system controls; hormones	 Involuntary; nervous system controls; hormones, chemicals, stretch
Speed of contraction	 Slow to fast	 Slow	 Very slow
Rhythmic contraction	No	Yes	Yes, in some

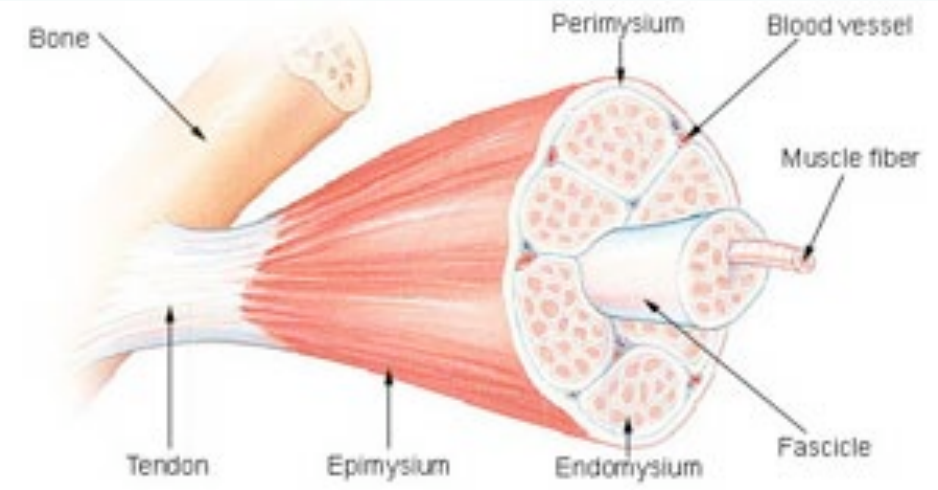
Skeletal Muscle

- Attached to the body's skeleton.
- Multinucleated cells reaching 1 foot in length.
- Striated muscle
- Voluntary



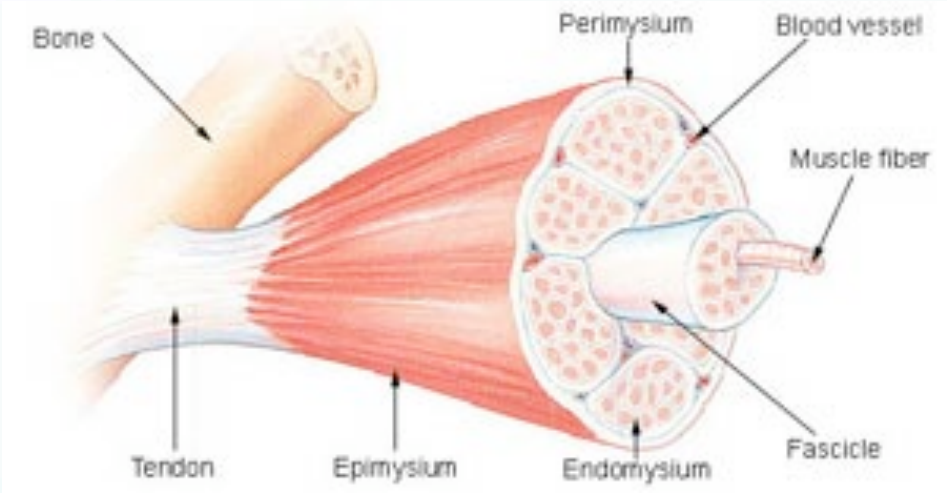
Parts of the Skeletal Muscle

- Endomysium-delicate connective tissue that surrounds the muscle fiber.
- Perimysium-courser fibro membrane that surrounc several muscle fibers cal fascile.
- Tough overcoat that surrounds the fasciles which blend into the tendon.



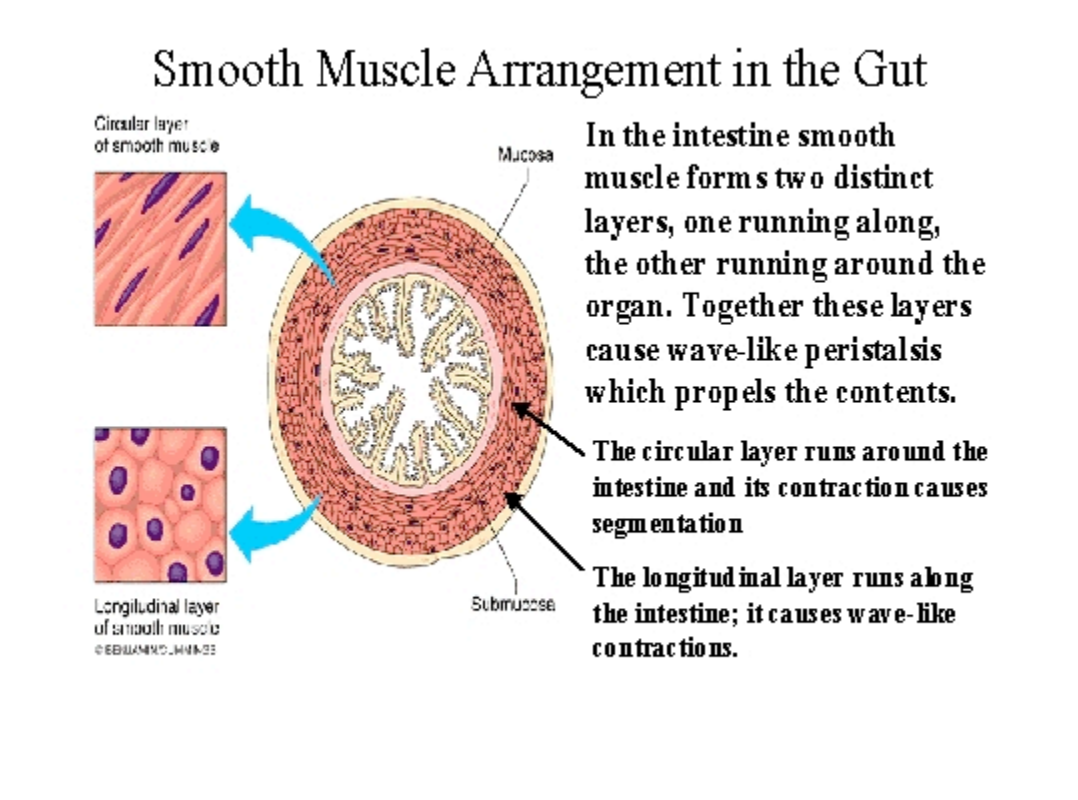
Tendons

- Anchor muscle to bone.
- Tough and durable.
- Conserve space and can move over joints.



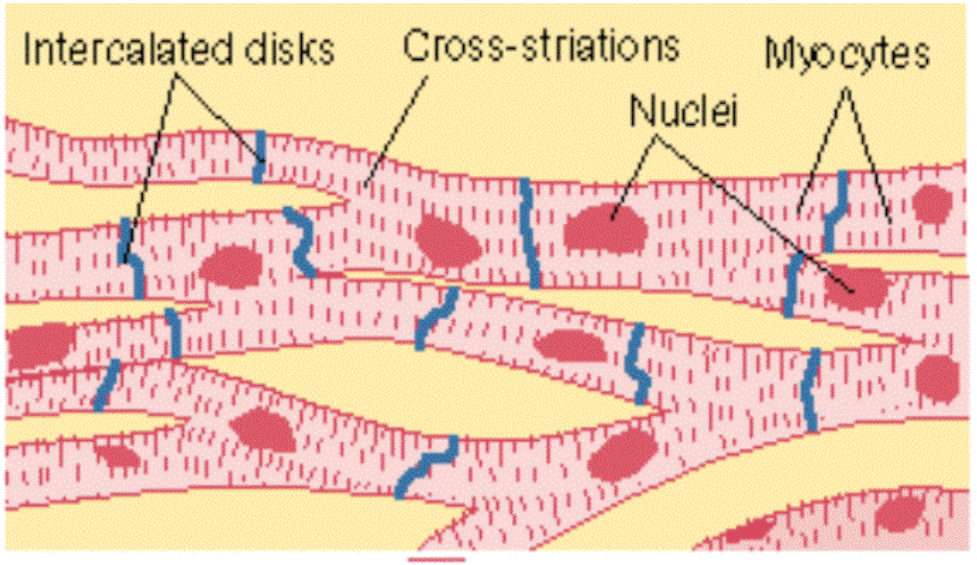
Smooth Muscle

- No striations and involuntary.
- One nucleus and arranged in sheets.



Cardiac Muscle

- Involuntary, striated and branched found only in the heart.



Muscle Functions

Produce Movement

- Controls almost all of the movements of the human body.
- Enable us to respond quickly to external stimuli.

Maintain Posture

- Make one tiny adjustment after another to maintain an erect or seated posture despite the pull of gravity.

Stabilize Joints

- Muscle and tendons keep the joints stable.

Generate Heat

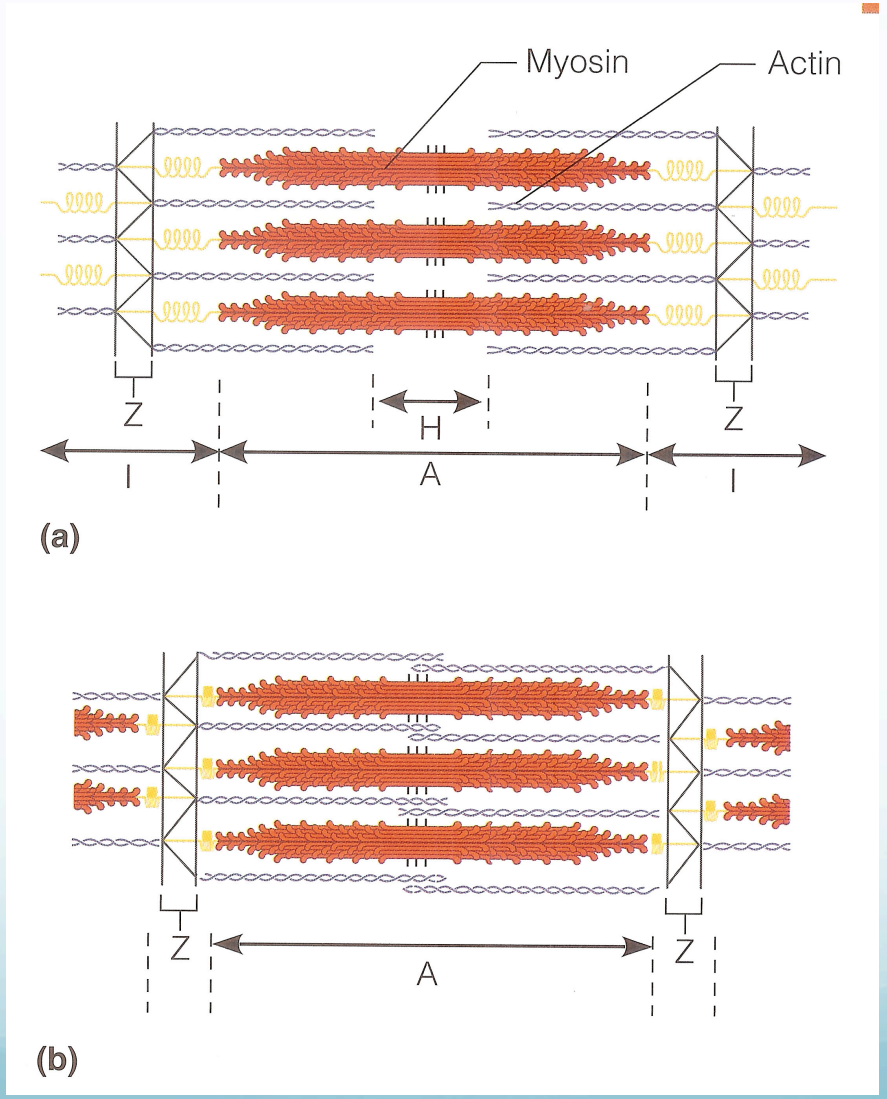
- Heat is the by-product of muscle activity.
- ATP is used to contract the muscle and three quarters of the energy escapes as heat.
- 40% of the body's mass is skeletal muscle that can generate the heat.

Skeletal Muscle Activity

Stimulate and Contract a Skeletal Muscle Cells

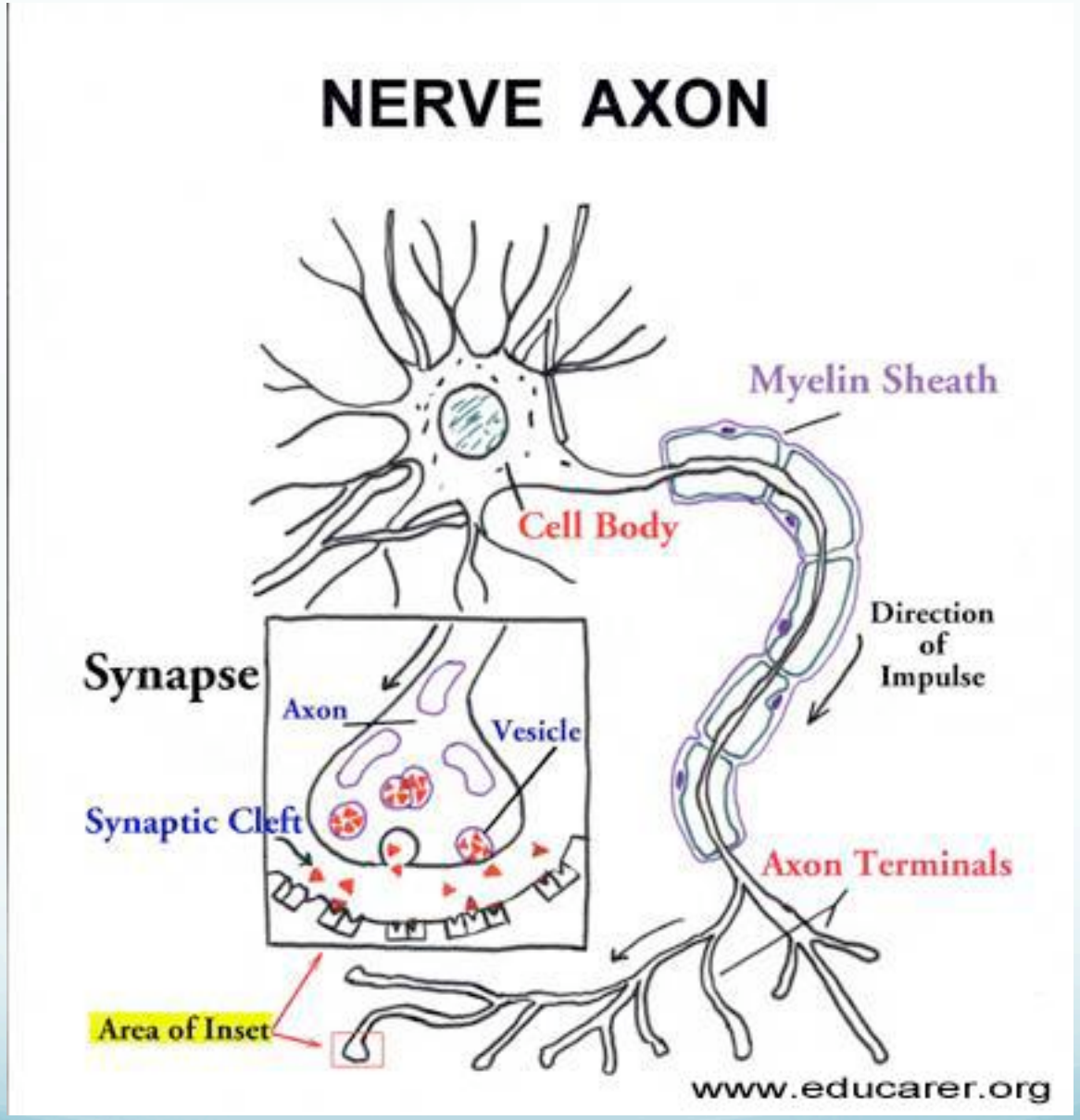
- Irritabiltiy-Ability to receive and respond to a stimulus.
- Contractility-The ability to shorten when an adequate stimuli is received.

Striated Skeletal Muscle



Nerve Stimulus and the Action Potential

- One motor neuron can stimulate a few to over 100 muscle cells.
- This is called a motor unit.
- Happens when the nerve extension called an axon reaches the muscle and branches out. This branching is called the axon terminal.


NERVE AXON
Myelin Sheath
Cell Body
Direction of Impulse
Synapse
Axon
Vesicle
Synaptic Cleft
Axon Terminals
Area of Inset
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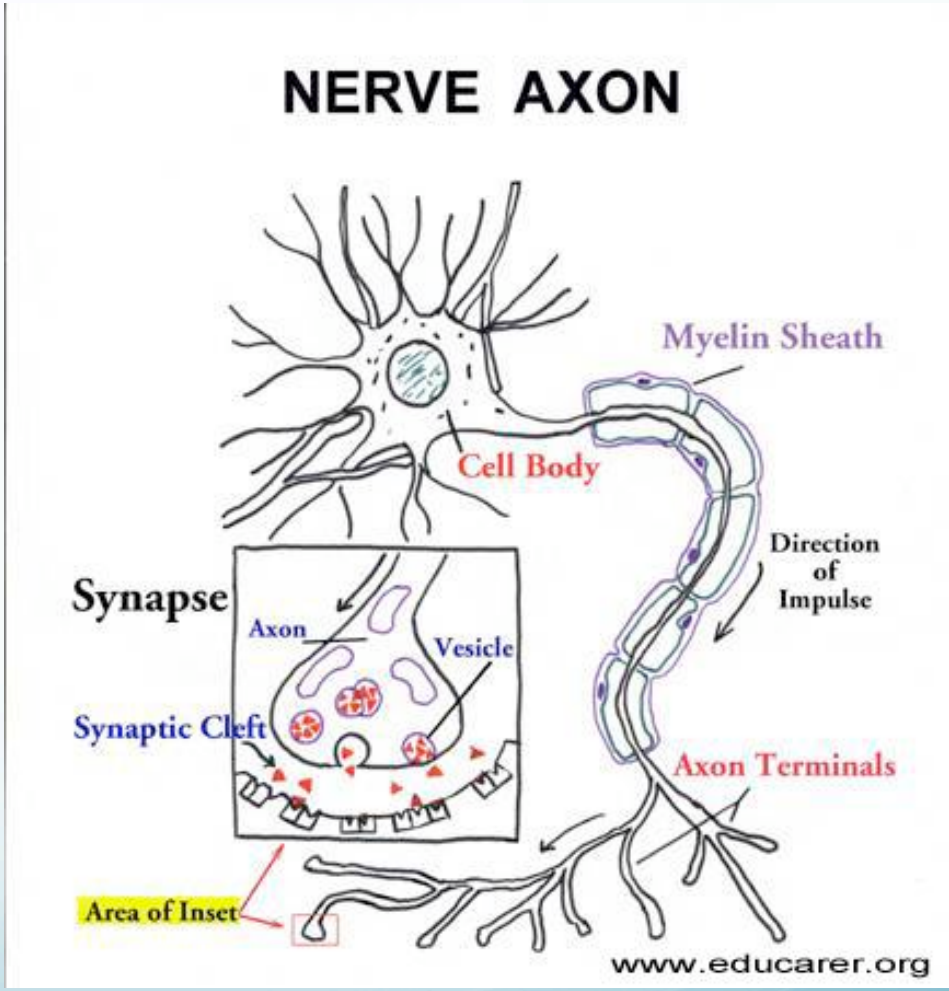
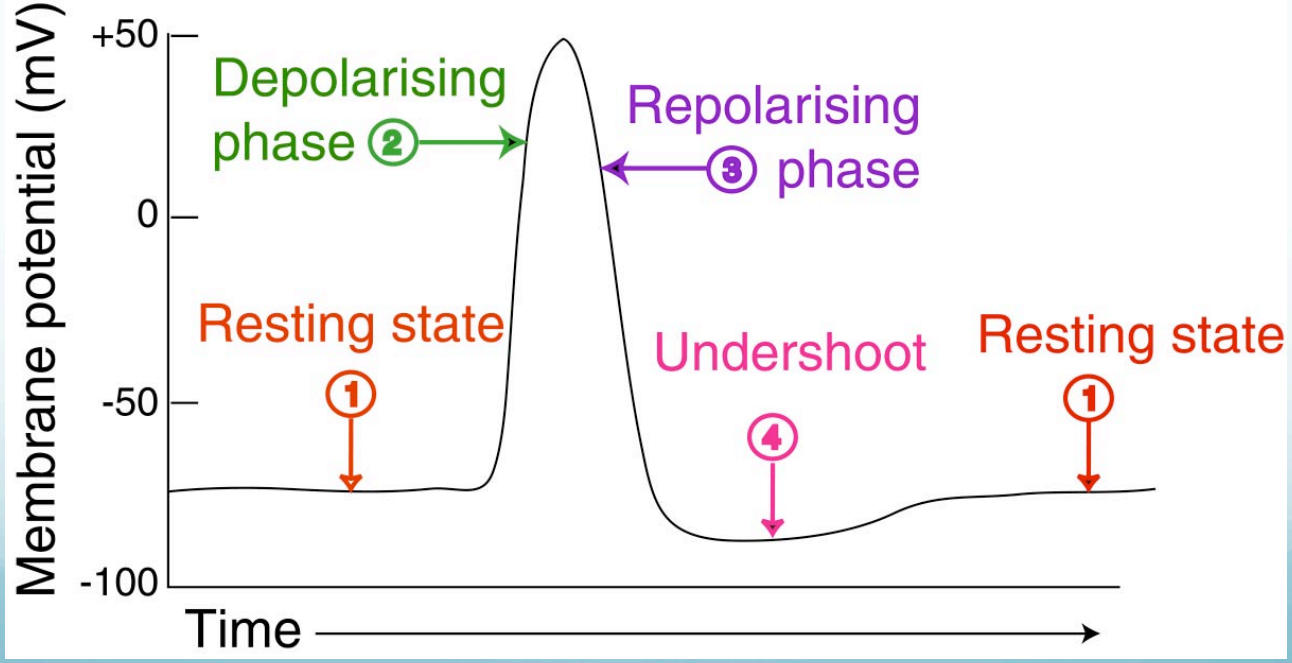
Neurotransmitter

- Chemical messengers called neurotransmitters.
- The gap between the axon and the muscle is called the synaptic cleft.
- Acetycholine (Ach) creates an action potential and the muscle contracts.



Action Potential

- Acetyl choline is used up after the action potential and converted into acetic acid and choline.
- This prevents continuous contractions without another nerve impulse.



Contraction of a Skeletal Muscle

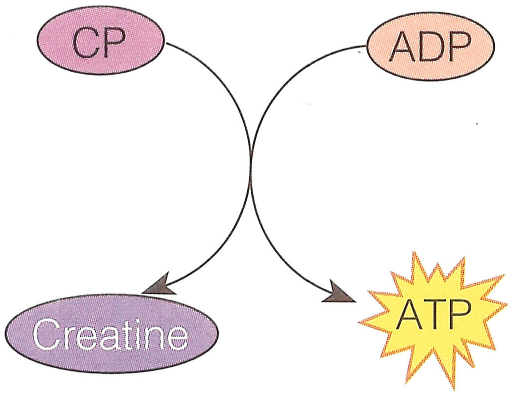
- When a muscle cell contracts its ALL OR NONE.
- The muscle itself is an organ with thousands of muscle cells and can contract gradually with a various degree of shortening. This is a graded response.
- Muscle twitches are an exception to this.

Energy for Muscle Contraction

- ATP is hydrolyzed to release energy needed.
- A muscle has 4-6 seconds worth of stored ATP.
- Three pathways to ATP regeneration are needed to sustain movement.

1. Direct Phosphorylation of ADP by Creatine Phosphate (CP)

- CP is stored in the muscle cell and converts ADP back to ATP in a fraction of a second.
- Muscles store 5X more CP than ATP.
- CP supplies are exhausted in about 20 seconds.



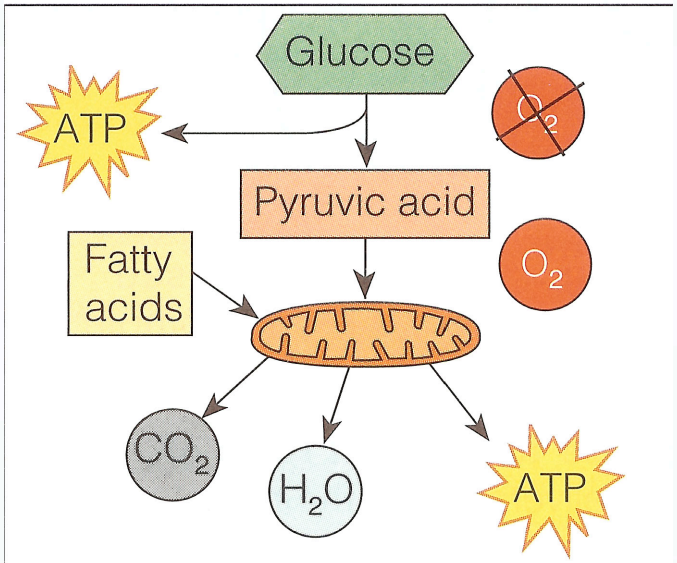
(a) Direct phosphorylation of ADP by reaction with creatine phosphate (CP)

Energy source: CP

Oxygen use: None
Products: 1 ATP per CP, creatine
Duration of energy provision: 15 sec

2. Aerobic Respiration

- Normally through oxidative phosphorylation, the mitochondria use a series of metabolic pathways to convert the ADP back into ATP.
- This will happen nicely in normal muscle activity or even light exercise.
- Glucose is needed (yields 36 ATP's) but is slow and requires oxygen and releases carbon dioxide and water.



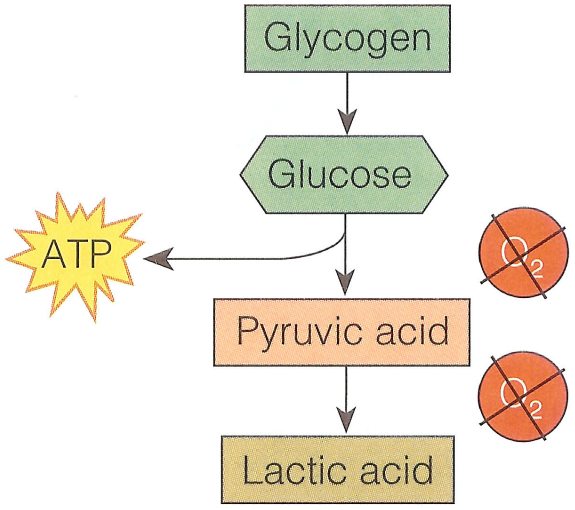
(b) Aerobic respiration (oxidative phosphorylation)

Energy sources: glucose; pyruvic acid; free fatty acids from adipose tissue; amino acids from protein catabolism

Oxygen use: Required
Products: 36 ATP per glucose, CO_2, H_2O
Duration of energy provision: Hours

3. Anaerobic Glycolysis and Lactic Acid Formation 28

- The breakdown of glucose without oxygen yielding only 2 ATP's.
- Pyruvic acid is formed.
- If enough oxygen is present, the pyruvic acid enters the aerobic pathway and things continue.
- If there is an inadequate amount of oxygen, pyruvic acid is converted into lactic acid. This causes muscle fatigue and soreness.



(c) Anaerobic glycolysis and lactic acid formation

Energy source: glucose

Oxygen use: None
Products: 2 ATP per glucose, lactic acid
Duration of energy provision: 30–60 sec

Muscle Fatigue

- The muscle is unable to contract even though a stimulus is being sent.
- Results from oxygen debt.
- Occurs in marathon runners with simply collapse.
- Effects can start to reverse with rest and proper breathing.

Muscle Contractions

- Isotonic Contraction-Muscles shorten when the myofilaments slide past each other.
- Ex. Bending your knee or elbow
- Isometric Contraction-Contraction when the muscles do not shorten.
- Ex. Trying to pick up 400 pounds.

Muscle Tone

- Not consciously controlled.
- Some filaments are contracted while others are relaxed.

Effects of Exercise on Muscles

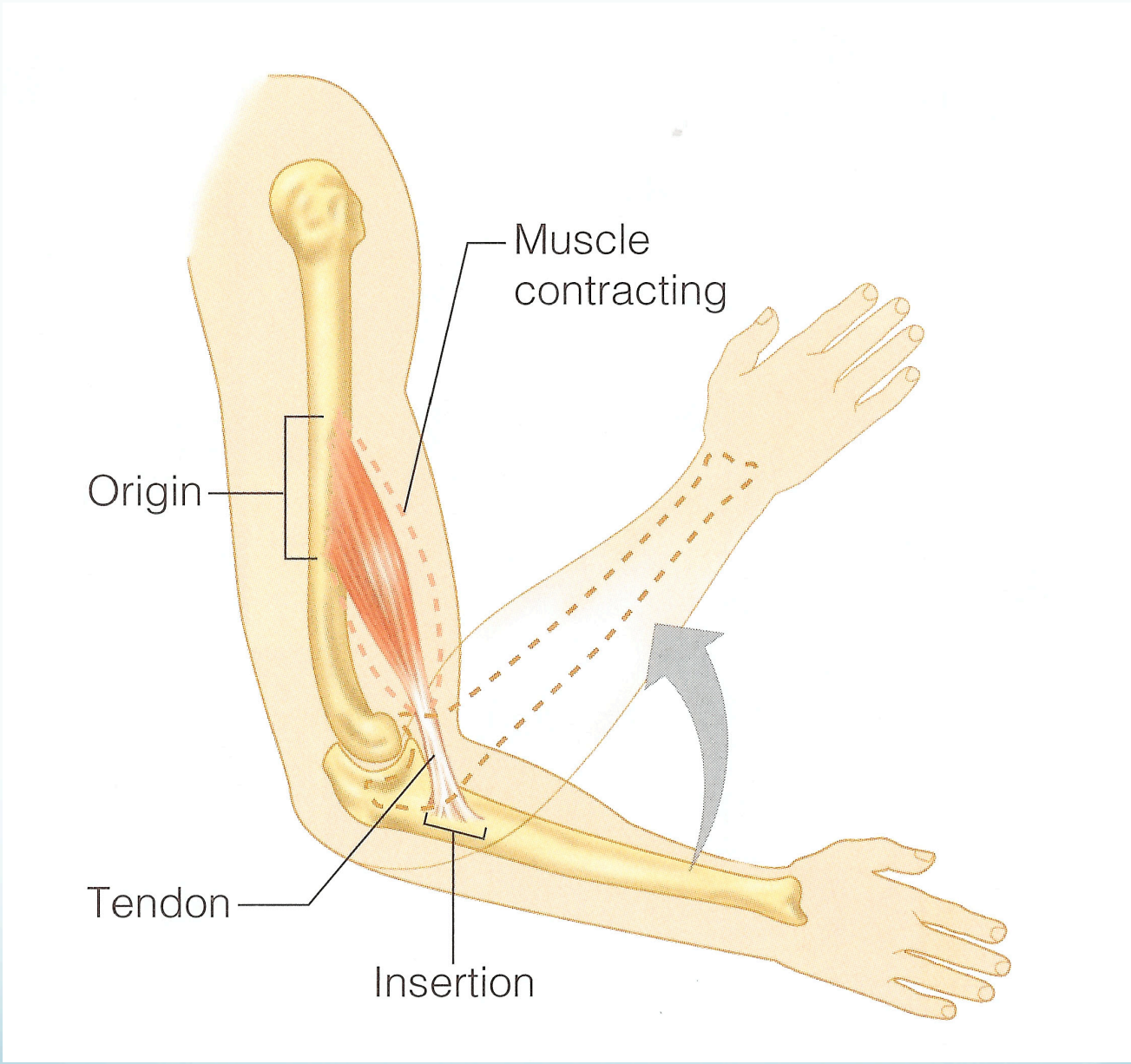
- Use it or lose it. Failure to move muscles will cause an inactivity of the muscle.
- Regular exercise increases a muscles strength and endurance.
- Examples include aerobics, jogging or biking.
- Endurance occurs because more blood reaches the muscles and causes more mitochondria to form.

Size of the Muscle

- Jogging or aerobics will not increase the size of the muscle only the endurance.
- To increase size, isometric exercises are necessary.

Muscle Attachment

- All skeletal muscles (around 600) are attached to bone or other connective tissue in no less than 2 places.
- The origin is attached to the immovable or less movable bone.
- Insertion is attached to the movable bone.
- With few exceptions, all muscles cross at least one joint.


Muscle
contracting
Origin
Tendon
Insertion

Muscles in the Front of the Body

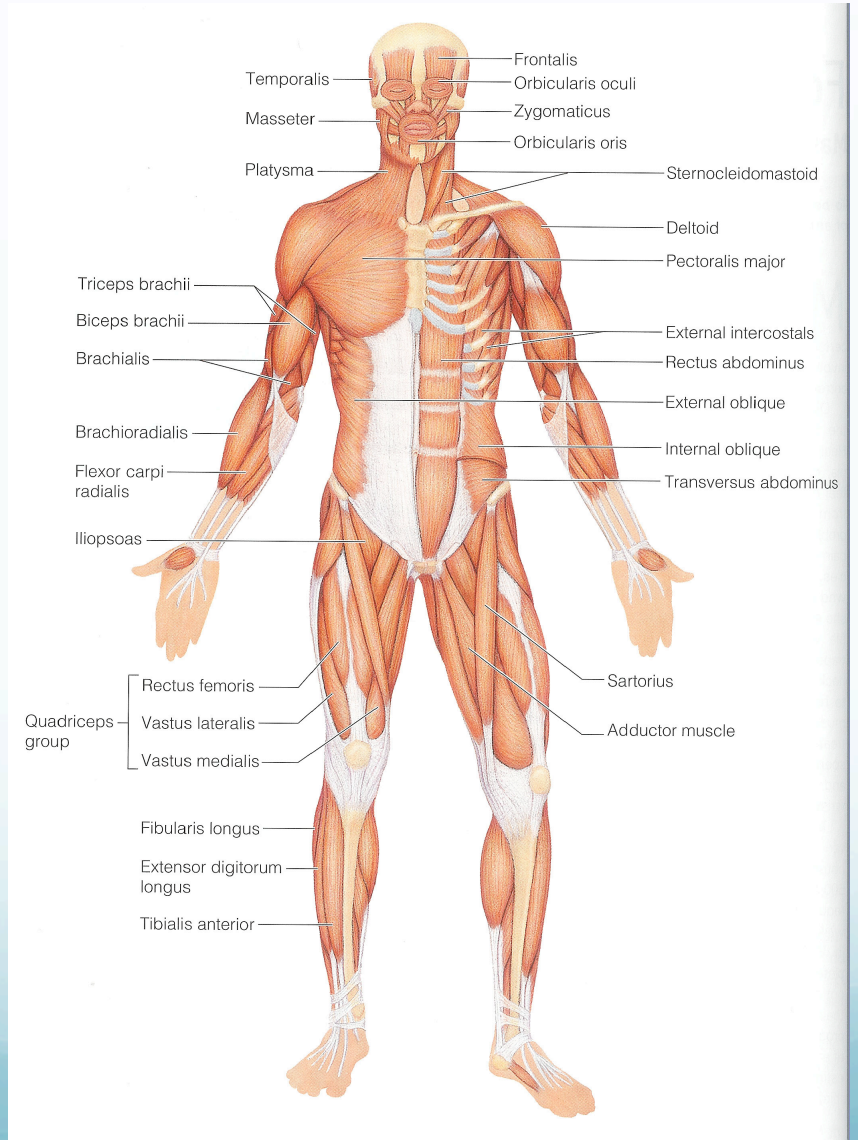


TABLE 6.3 Superficial Anterior Muscles of the Body (See Figure 6.21)

Name	Origin	Insertion	Primary Action(s)
Head/Neck Muscles			
Frontalis	Cranial aponeurosis	Skin of eyebrows	Raises eyebrows
Orbicularis oculi	Frontal bone and maxilla	Tissue around eyes	Blinks and closes eyes
Orbicularis oris	Mandible and maxilla	Skin and muscle around mouth	Closes and protrudes lips
Temporalis	Temporal bone	Mandible	Closes jaw
Zygomaticus	Zygomatic bone	Skin and muscle at corner of lips	Raises corner of mouth
Masseter	Temporal bone	Mandible	Closes jaw
Buccinator	Maxilla and mandible near molars	Orbicularis oris	Compresses cheek as in whistling and sucking; holds food between teeth during chewing
Sternocleidomastoid	Sternum and clavicle	Temporal bone (mastoid process)	Flexes neck; rotates head
Platysma	Connective tissue covering of superior chest muscles	Tissue around mouth	Pulls corners of mouth inferiorly
Trunk Muscles			
Pectoralis major	Sternum, clavicle, and first to sixth ribs	Proximal humerus	Adducts and flexes humerus
Rectus abdominis	Pubis	Sternum and fifth to seventh ribs	Flexes vertebral column
External oblique	Lower eight ribs	Iliac crest	Flexes and rotates vertebral column
Arm/Shoulder Muscles			
Biceps brachii	Scapula of shoulder girdle	Proximal radius	Flexes elbow and supinates forearm
Brachialis	Distal humerus	Proximal ulna	Flexes elbow
Deltoid	See Table 6.4		Abducts arm
Hip/Thigh/Leg Muscles			
Iliopsoas	Ilium and lumbar vertebrae	Femur (lesser trochanter)	Flexes hip
Adductor muscles	Pelvis	Proximal femur	Adduct thigh
Sartorius	Ilium	Proximal tibia	Flexes thigh on hip
Quadriceps group (vastus medialis, intermedius, and lateralis; and the rectus femoris)	Vasti: Femur	Tibial tuberosity via patellar ligament	All extend knee; rectus femoris also flexes hip on thigh
	Rectus femoris: Pelvis	Tibial tuberosity via patellar ligament	
Tibialis anterior	Proximal tibia	First cuneiform (tarsal) and first metatarsal of foot	Dorsiflexes and inverts foot
Extensor digitorum longus	Proximal tibia and radius	Distal toes 2–5	Extends toes and dorsiflexes foot
Fibularis muscles	Fibula	Metatarsals of foot	Plantar flex and evert foot

Muscles of the Back of theBody

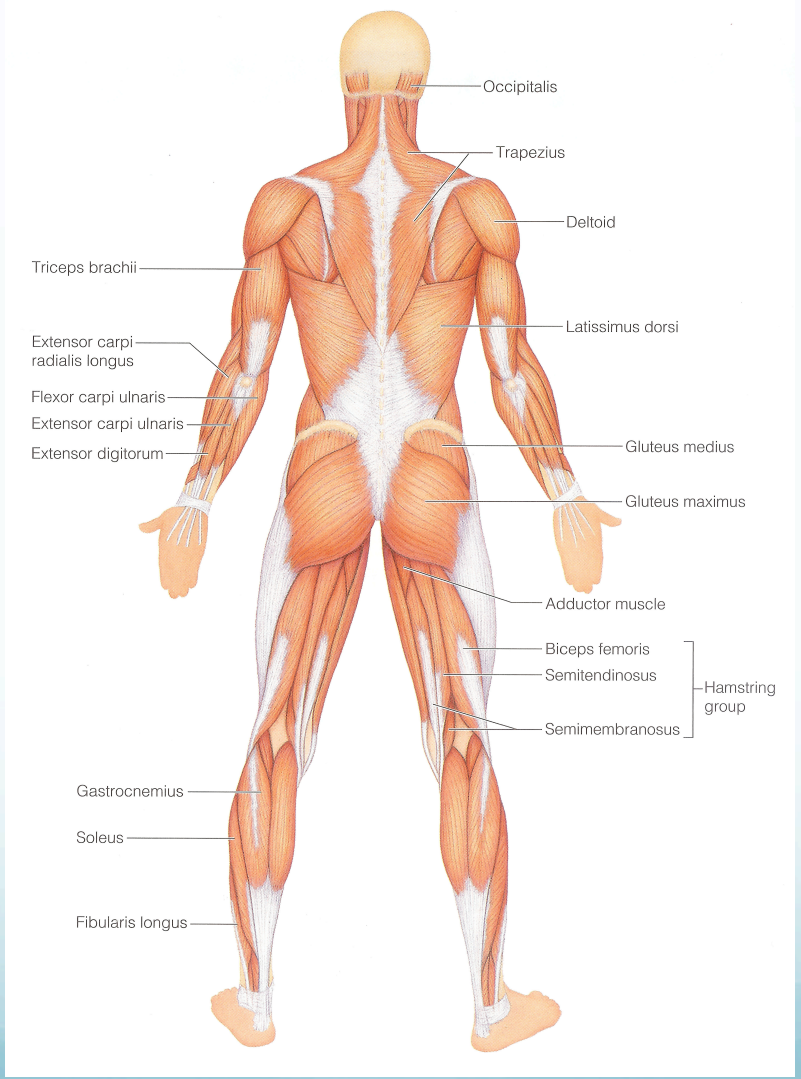


TABLE 6.4 Superficial Posterior Muscles of the Body (Some Forearm Muscles Also Shown) (See Figure 6.22)

Name	Origin	Insertion	Primary Action(s)
Neck/Trunk/Shoulder Muscles			
Trapezius	Occipital bone and all cervical and thoracic vertebrae	Scapular spine and clavicle	Extends neck and adducts scapula
Latissimus dorsi	Lower spine and iliac crest	Proximal humerus	Extends and adducts humerus
Erector spinae*	Iliac crests, ribs 3–12, and vertebrae	Ribs, thoracic and cervical vertebrae	Extends back
Deltoid	Scapular spine and clavicle	Humerus (deltoid tuberosity)	Abducts humerus
Arm/Forearm Muscles			
Triceps brachii	Shoulder girdle and proximal humerus	Olecranon process of ulna	Extends elbow
Flexor carpi radialis	Distal humerus	Second and third metacarpals	Flexes wrist and abducts hand (see Figure 6.21)
Flexor carpi ulnaris	Distal humerus and posterior ulna	Carpals of wrist and fifth metacarpal	Flexes wrist and adducts hand
Flexor digitorum superficialis†	Distal humerus, ulna and radius	Middle phalanges of second to fifth fingers	Flexes wrist and fingers
Extensor carpi radialis	Humerus	Base of second and third metacarpals	Extends wrist and abducts hand
Extensor digitorum	Distal humerus	Distal phalanges of second to fifth fingers	Extends fingers and wrist
Hip/Thigh/Leg Muscles			
Gluteus maximus	Sacrum and ilium	Proximal femur (gluteal tuberosity)	Extends hip (when forceful extension is required)
Gluteus medius	Ilium	Proximal femur	Abducts thigh; steadies pelvis during walking
Hamstring muscles (semitendinosus, semimembranosus, biceps femoris)	Ischial tuberosity	Proximal tibia (head of fibula in the case of biceps femoris)	Flex knee and extend hip
Gastrocnemius	Distal femur	Calcaneus (heel via calcaneal tendon)	Plantar flexes foot and flexes knee
Soleus	Proximal tibia and fibula	Calcaneus	Plantar flexes foot

Developmental Aspects

- Endocrine System-Growth hormones influence muscle growth and mass.
- Lymphatic System-Protects muscles from disease.
- Digestive System-Provides nutrients needed for muscle health, liver metabolizes lactic acid.

Developmental Aspects (cont.)

- Urinary System-Disposes of nitrogenous wastes.
- Nervous System-Stimulates and regulates muscle activity.
- Respiratory System-Provides oxygen and disposes of carbon dioxide.

Developmental Aspects (cont.)

- Integumentary System-Protects muscles by external enclosures.
- Skeletal System-Bones provide levers for muscle activity.
- Cardiovascular System-Delivers oxygen and nutrients and carries away wastes.