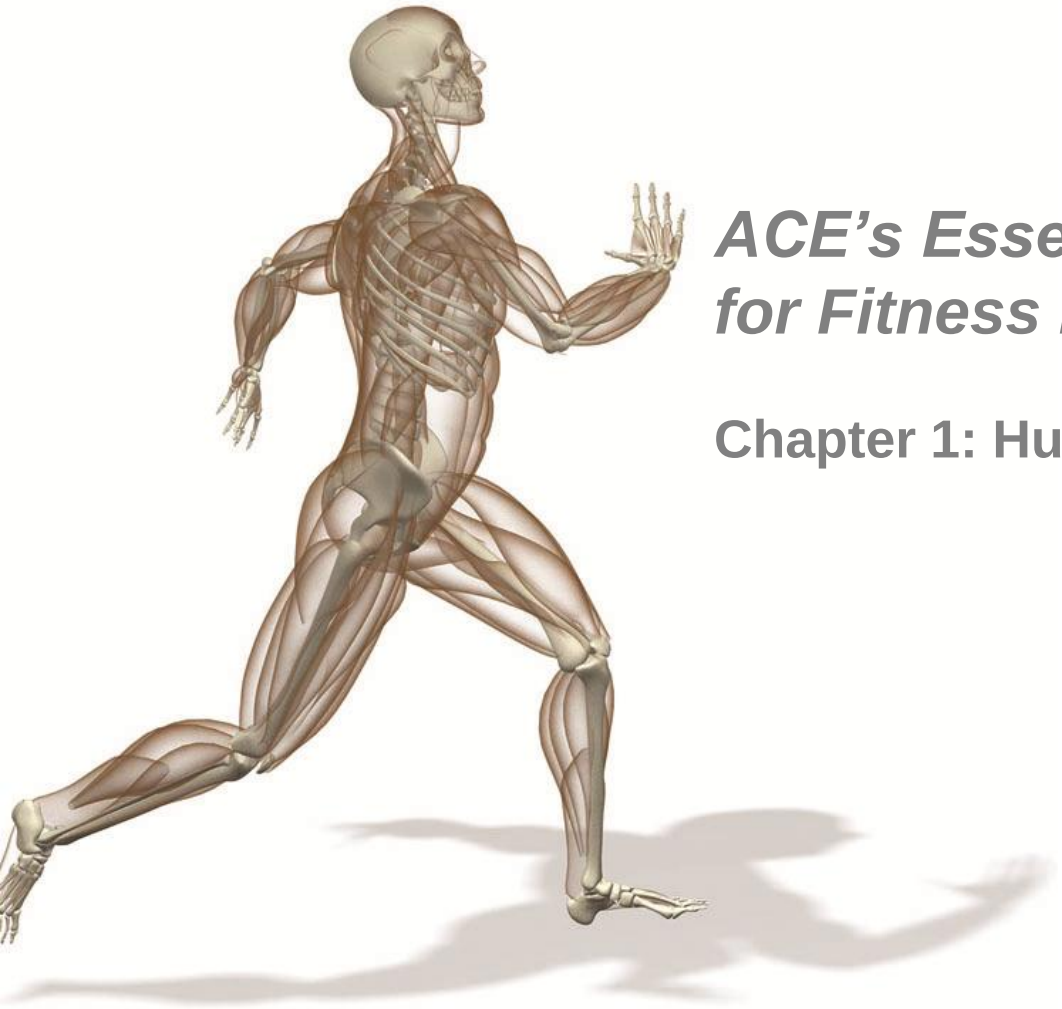


ACE's Essentials of Exercise Science for Fitness Professionals

Chapter 1: Human Anatomy

AMERICAN COUNCIL ON EXERCISE

Learning Objectives

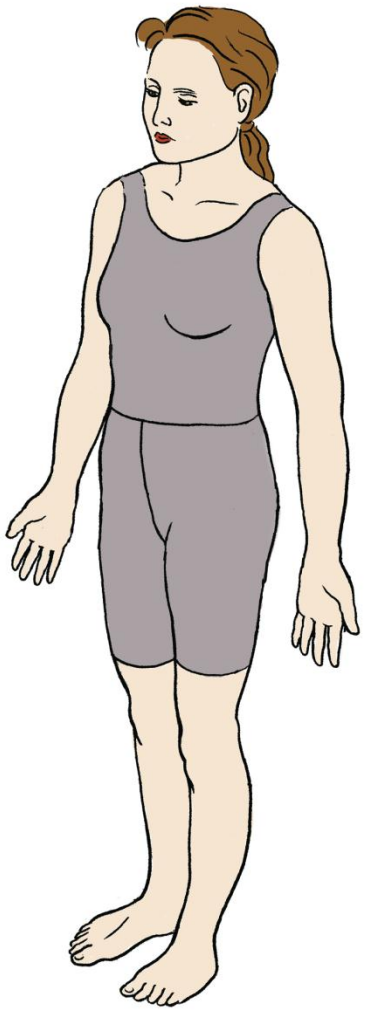
- This chapter covers the seven physiological systems of the human body that all fitness professionals must understand: the cardiovascular, respiratory, digestive, skeletal, neuromuscular, muscular, and endocrine systems.
- Upon completion of this chapter, you will be able to:
  - Understand basic anatomical terminology
  - Describe the functional anatomy of the heart and blood flow through the heart
  - List the components of the respiratory system
  - Describe the function of the skeletal system
  - Explain the structure of, and type of movements allowed by, joints
  - Describe the role of the nervous system in muscular actions
  - List the fundamental movements of the human body
  - Explain muscle names and locations
  - List the principal endocrine glands

Introduction

- A working knowledge of human anatomy requires an understanding of the body's structures.
- It also requires knowledge of how these structures operate in various systems.
- Knowledge of the important directional and regional terms associated with the structures of the body help in learning the names of anatomical structures.

Anatomical Position

- Anatomical position is the reference point for describing structures of the body in relation to each other.
  - Anatomical position refers to a person standing erect with the head, eyes, and palms facing forward.



Anatomical, Directional, and Regional Terms

Anatomical, Directional, and Regional Terms	
Anterior (ventral)	Toward the front
Posterior (dorsal)	Toward the back
Superior	Toward the head
Inferior	Away from the head
Medial	Toward the midline of the body
Lateral	Away from the midline of the body
Proximal	Toward the attached end of the limb, origin of the structure, or midline of the body
Distal	Away from the attached end of the limb, origin of the structure, or midline of the body
Superficial	External; located close to or on the body surface
Deep	Internal; located further beneath the body surface than the superficial structures
Cervical	Regional term referring to the neck
Thoracic	Regional term referring to the portion of the body between the neck and the abdomen; also known as the chest (thorax)
Lumbar	Regional term referring to the portion of the back between the abdomen and the pelvis
Plantar	The sole or bottom of the feet
Dorsal	The top surface of the feet and hands
Palmar	The anterior or ventral surface of the hands
Sagittal plane	A longitudinal (imaginary) line that divides the body or any of its parts into right and left sections
Frontal plane	A longitudinal (imaginary) section that divides the body into anterior and posterior parts; lies at a right angle to the sagittal plane
Transverse plane	Also known as the horizontal plane; an imaginary line that divides the body or any of its parts into superior and inferior sections

Anatomical Terminology

- Knowing the meaning of common root words will help in understanding the structures and terminology.

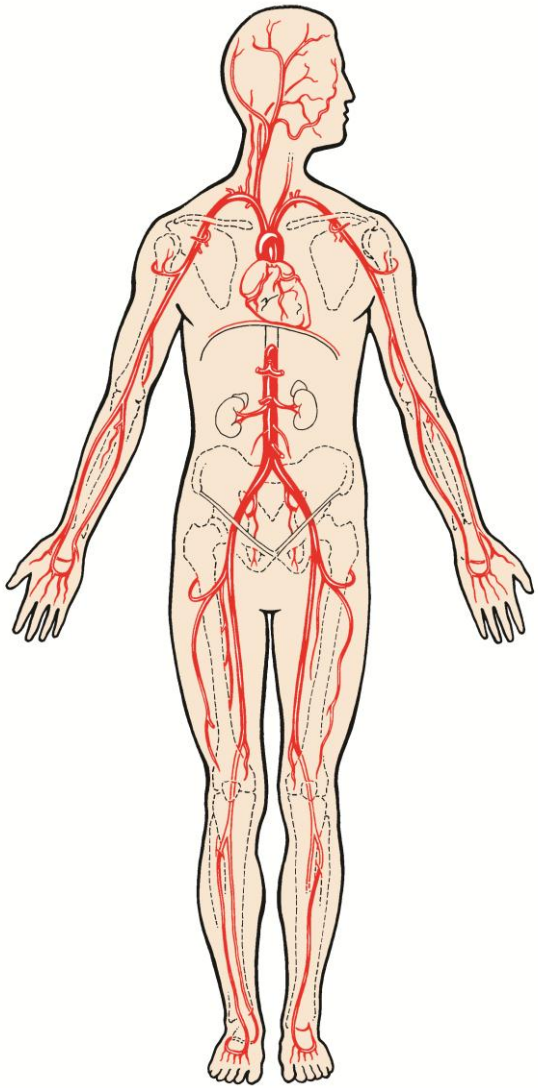
Common Anatomical (Medical) Terminology			
Root	**Meaning**	**Term**	**Definition**
arthro	joint	arthritis	inflammation in a joint
bi	two	biceps	two-headed muscle
brachium	arm	brachialis	muscle of the arm
cardio	heart	cardiology	the study of the heart
cephalo	head	cephalic	pertaining to the head
chondro	cartilage	chondroectomy	excision of a cartilage
costo	rib	costochondral	pertaining to a rib and its cartilage
dermo	skin	dermatitis	inflammation of the skin
hemo, hemat	blood	hemorrhage	internal or external bleeding
ilio	ilium	ilium	the wide, upper part of the pelvic bone
myo	muscle	myositis	inflammation of a muscle
os, osteo	bone	osteomalacia	softening of the bone
pulmo	lung	pulmonary artery	vessel that brings blood to the lungs
thoraco	chest	thorax	chest
tri	three	triceps	three-headed muscle

Structural Levels of the Body

- There are four structural levels of the body: cells, tissues, organs, and systems.
  - Cells are the most basic structure and combine to form tissue.
  - Two or more tissues make up an organ.
  - Organs that function together make up a system.
  - The fitness professional must understand the cardiovascular, respiratory, digestive, skeletal, nervous, muscular, and endocrine systems.

Cardiovascular System

- The cardiovascular system, also called the circulatory system, is composed of the heart, blood vessels, and blood.
- Blood is the fluid component that transports necessary substances throughout the body.
  - Blood is composed of plasma and formed elements: red blood cells, white blood cells, and platelets.
  - Blood is transported via blood vessels: arteries, veins, and capillaries.

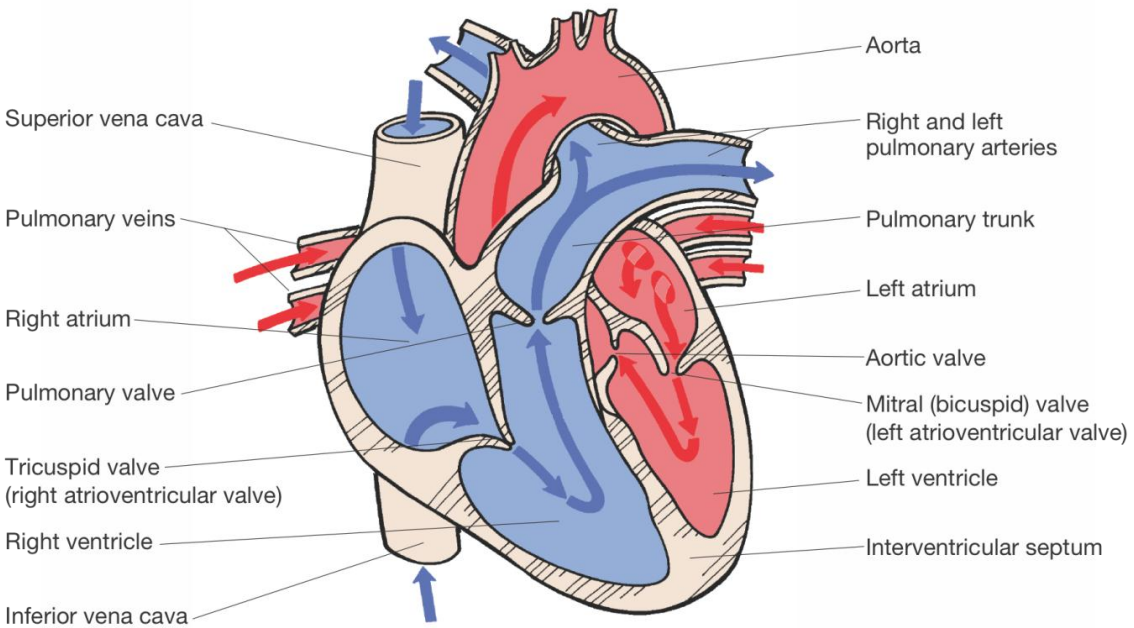


The Heart

- Blood travels continuously through the heart into the arteries, then to the capillaries and into the veins, and then back to the heart.
- The heart, which is about the size of an adult fist, pumps blood throughout the body.
  - It is divided into four chambers: right atrium, right ventricle, left atrium, and left ventricle.
  - The atria are the receiving chambers and the ventricles are the propulsion chambers.
  - Valves are necessary to prevent backflow between the atria and ventricles, and between the ventricles and the pulmonary arteries and aorta.

Blood Flow Through the Heart

- The pathway of blood through the heart
  - Oxygen-poor blood coming from the body (via the veins) enters the right atrium.
  - From the right atrium, it is pumped to the right ventricle, which sends it to the lungs (via the pulmonary arteries) to give off carbon dioxide and pick up fresh oxygen.
  - Oxygenated blood returns to the heart (via the pulmonary veins) entering the left atrium.
  - It is then pumped to the left ventricle, which pumps it through the aorta to the rest of the body (except the lungs).

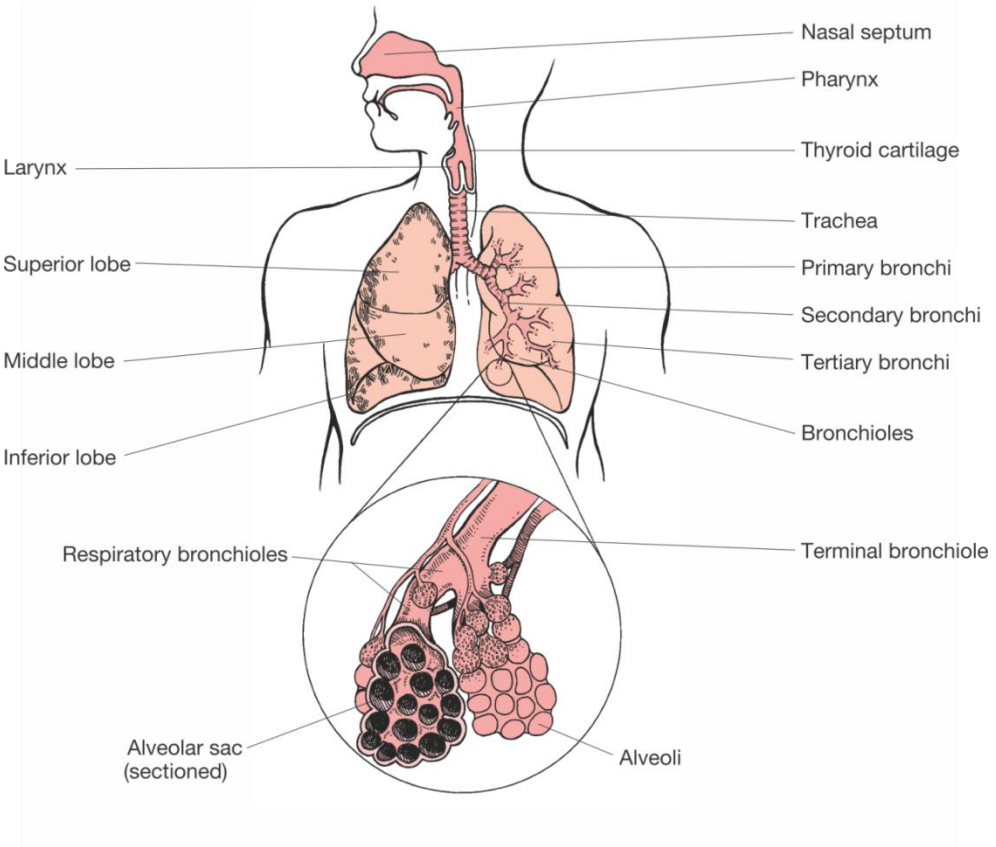


The Cardiac Cycle

- The series of cardiovascular events occurring from the beginning of one heartbeat to the beginning of the next is called the cardiac cycle.
- The left and right sides of the heart work simultaneously.
  - When the heart beats, both atria contract.
  - Approximately 0.1 second after the atria contract, both ventricles contract.
  - The repeated contraction and relaxation is known as systole and diastole.
    - Systole: contraction phase (ventricles contract)
    - Diastole: relaxation phase (ventricles fill)

Respiratory System

- The functions of the respiratory system include:
  - Replacing oxygen and removing carbon dioxide from the blood
  - Vocalization
  - Regulation of the acid-base balance during exercise
- Components of the respiratory system include the nose, nasal cavity, pharynx, larynx, trachea, bronchi, and lungs.
  - They form a passage that filters air and transports it to the lungs.
  - Gas exchange occurs in the lungs in the alveoli.

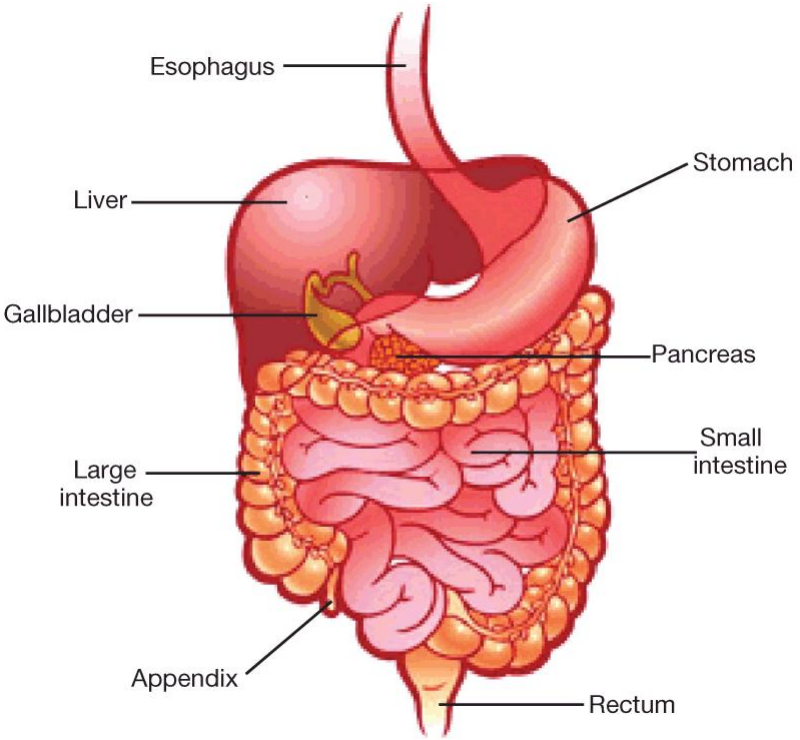


Air Flow Through the Respiratory System

- Air flow
  - Air enters through the mouth and nostrils, where it is warmed and then passed through the pharynx (throat) and the larynx.
  - Air continues through the trachea (windpipe) to the right and left primary bronchi, which divide further into:
    - Secondary bronchi (in each lobe)
    - Tertiary bronchi
    - Tiny bronchioles
    - Terminal bronchioles
    - Smaller respiratory bronchioles
    - Clusters of alveoli (approximately 300 million)
- The breathing rate through the nose increases from 5 to 6 liters of air per minute at rest to 20 to 30 liters per minute during exercise.
- During exercise, additional muscles are recruited to aid in both inspiration and expiration.

Digestive System

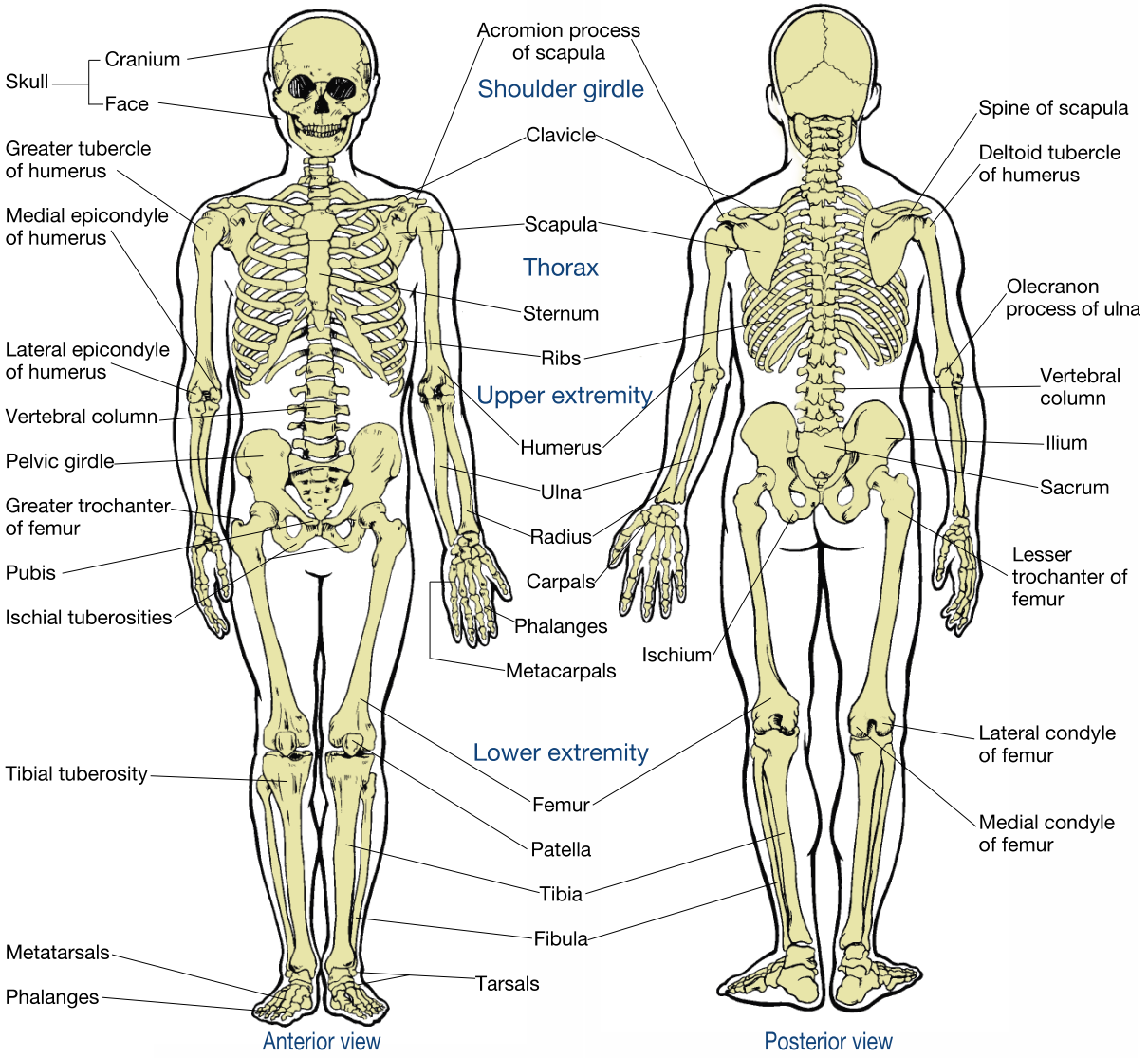
- The digestive system is responsible for:
  - Moving food along the digestive tract
  - Preparing food for digestion
  - Chemically digesting food
  - Absorbing food
  - Eliminating waste products
- Digested food molecules may be reassembled into proteins, carbohydrates, and fats.
  - Also may be used in the production of energy to support body activity



Skeletal System

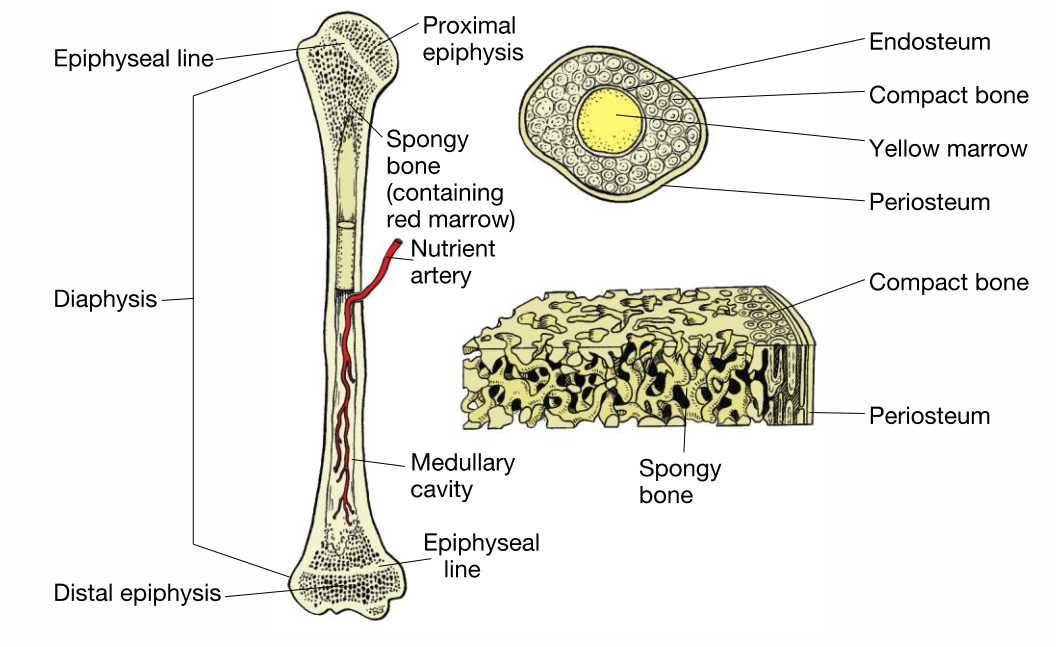
- The human skeleton performs the following functions:
  - Supports soft tissues and provides attachment sites for muscles
  - Movement at joints when muscles are contracted
  - Protects organs (e.g., the skull encases the brain)
  - Stores calcium, phosphorus, fat, sodium, potassium, and other minerals
  - Production of blood cells
- The skeletal system is divided into two parts:
  - The axial skeleton
  - The appendicular skeleton
- An illustration of the skeletal system is presented on the following slide.

Skeletal System Illustration



Bones

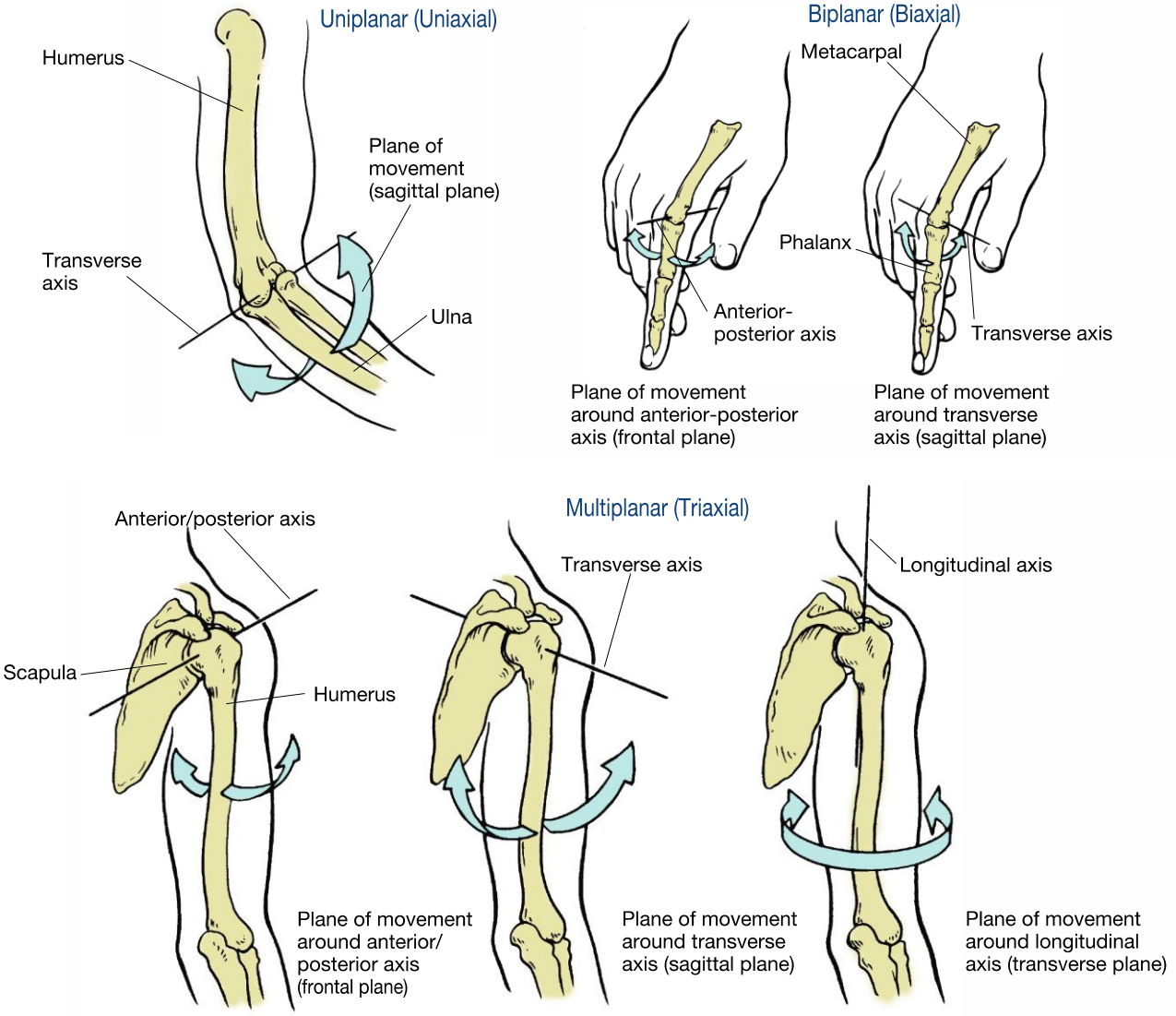
- While bones take on different shapes, the majority of bones are long bones.
- Bone is continuously being “remodeled” via osteoclasts (cells that break down bone) and osteoblasts (cells that build bone).
- Wolff’s law states that changes in bone structure coincide with changes in bone function.
  - “Form follows function”



Movement of the Skeleton

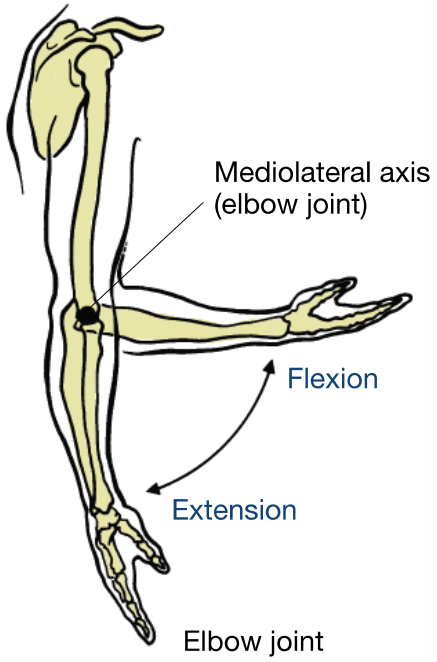
- There are three main types of joints:
  - Fibrous joints
  - Cartilaginous joints
  - Synovial joints
- Synovial joint movement occurs within the three planes of motion: sagittal, frontal, and transverse.
  - Movement occurs along the joint's axis of rotation, where the plane of movement is generally perpendicular to the axis.
  - Uniplanar joints (hinge joints) allow movement in only one plane.
  - Biplanar joints allow movement in two planes that are perpendicular to each other.
  - Multiplanar joints allow movement in all three planes.

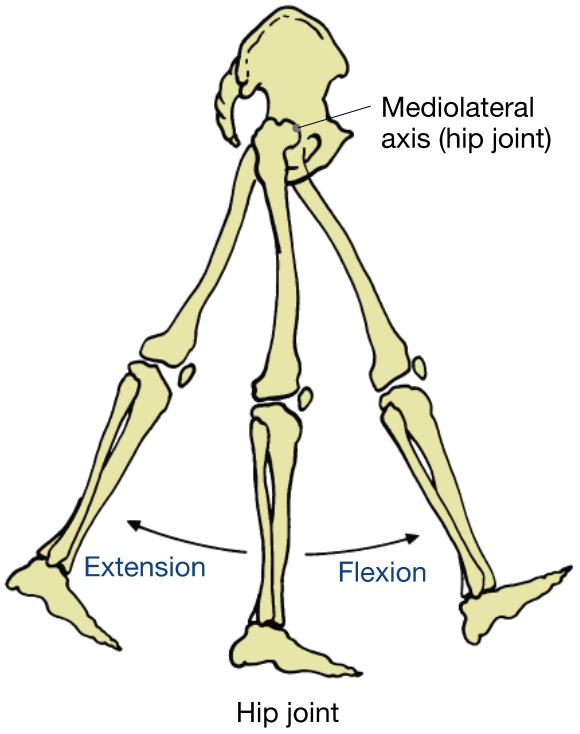
Movement of Synovial Joints



Movement in the Sagittal Plane

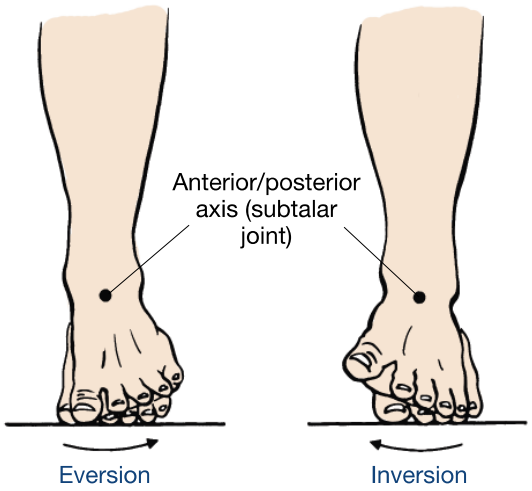
- The sagittal plane runs anterior-posterior, dividing the body into left and right sections.
- Movements that involve rotation about a mediolateral axis occur in the sagittal plane.
- Examples include:
  - Flexion
  - Extension
  - Dorsiflexion
  - Plantarflexion

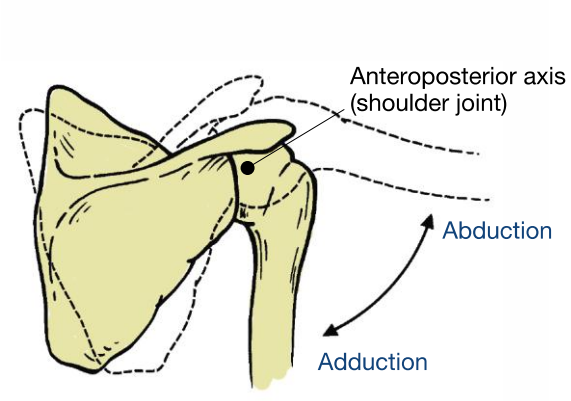




Movement in the Frontal Plane

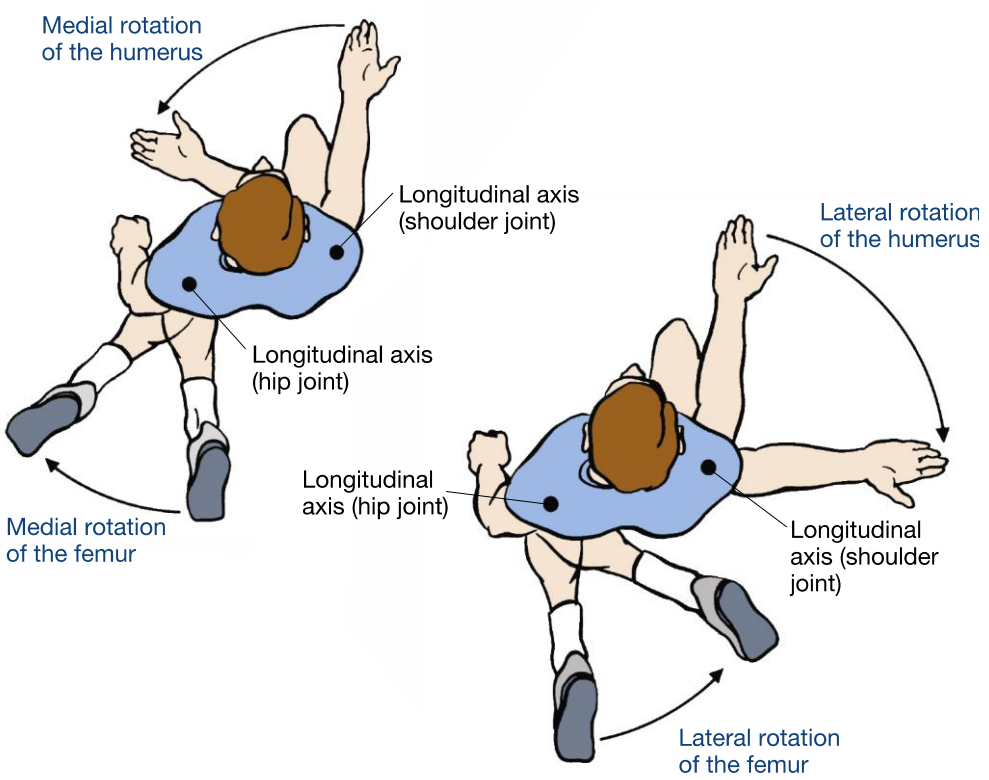
- The frontal plane runs laterally, dividing the body into anterior and posterior sections.
- Movements that involve rotation about an anteroposterior axis occur in the frontal plane.
- Examples include:
  - Abduction
  - Adduction
  - Elevation
  - Depression
  - Inversion
  - Eversion





Movement in the Transverse Plane

- The transverse plane runs horizontally, dividing the body into superior and inferior sections.
- Movements that involve rotation about a longitudinal axis occur in the transverse plane.
- Examples include:
  - Rotation
  - Pronation
  - Supination
  - Horizontal flexion
  - Horizontal extension

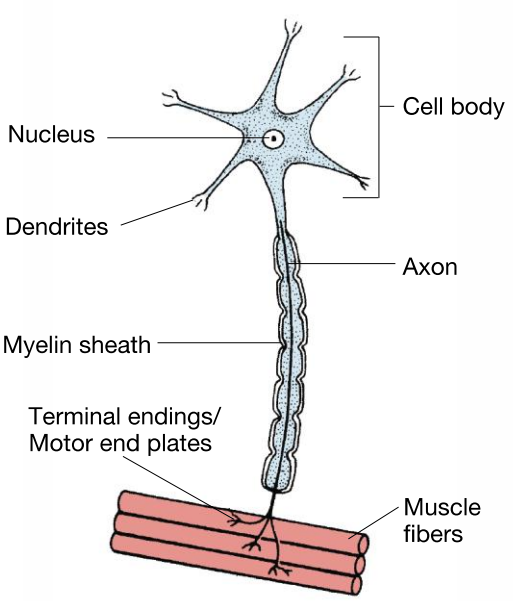


Multiplanar Movement

- Circumduction and opposition are two specific actions that occur in multiple planes.
  - Circumduction: “cone” motion; combines flexion, extension, abduction, and adduction in sequence
  - Opposition: thumb movement specific to humans and primates

Nervous System

- The nervous system connects the muscles to the brain and spinal cord through a network of nerve circuits.
- Structurally, it is divided into the central nervous system (CNS) and peripheral nervous system (PNS).
  - The CNS consists of the brain and spinal cord, while the PNS consists of all the nerve structures outside the brain and spinal cord.
- Nerves are made up of multiple nerve cells called neurons.
- Sensory nerves carry impulses to the CNS, while motor nerves carry impulses from the CNS to the PNS.

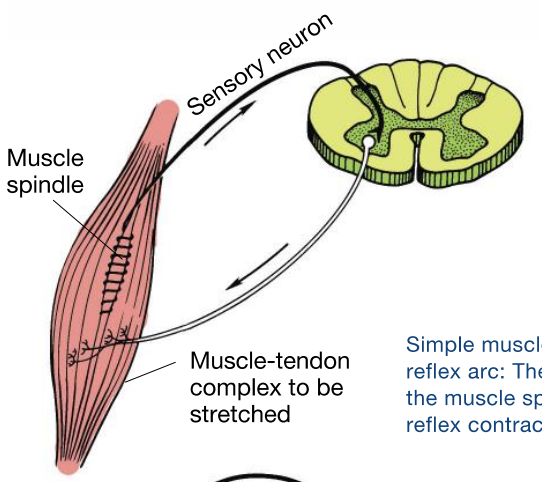


Proprioception

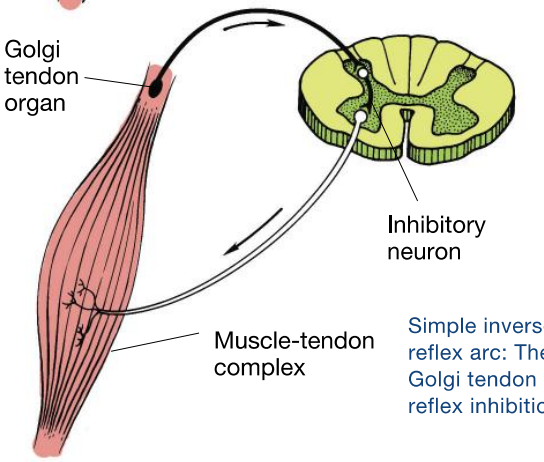
- Proprioception is the sense of knowing where the body is in relation to its various segments and the external environment.
  - Receptors in the skin, in and around the joints and muscles, and in the inner ear transmit the information.
  - The primary receptors involved in muscular control and coordination are the Golgi tendon organs (GTO) and muscle spindles.

Musculotendinous Receptors

- Muscle spindle
  - Located in the muscle belly lying parallel to the fibers
  - Causes a reflexive contraction (stretch reflex) in the muscle when the muscle senses a stretch force.
  - Simultaneously causes the antagonist to relax (reciprocal inhibition).
- GTO
  - Located between the muscle belly and its tendon
  - Causes muscle inhibition (autogenic inhibition) when it senses tension.



Simple muscle stretch reflex arc: The stretch of the muscle spindle causes reflex contraction.



Simple inverse stretch reflex arc: The stretch of Golgi tendon organ causes reflex inhibition (relaxation).

Muscular System

- Three types of muscle:
  - Skeletal
    - Attaches to the skeleton via tendons, contracts to move bones
    - Voluntary
    - Striated appearance
  - Smooth
    - Found on the walls of hollow organs and tubes (e.g., stomach and blood vessels)
    - Involuntary
    - Smooth appearance
  - Cardiac
    - Forms the walls of the heart
    - Involuntary
    - Smooth appearance

Skeletal Muscle Fiber Types

- Skeletal fibers can be divided into two general categories based on how quickly they contract.
  - Slow-twitch muscle fibers contain relatively large amounts of mitochondria and are surrounded by more capillaries than fast-twitch fibers.
    - Slow-twitch fibers contract more slowly than fast-twitch fibers.
    - They have lower force outputs, but are more efficient and fatigue-resistant than fast-twitch fibers.
  - Fast-twitch muscle fibers are further subdivided into fast-glycolytic and fast-oxidative glycolytic fibers.
    - Type IIx muscle fibers contain a relatively small amount of mitochondria, have a limited capacity for aerobic metabolism, and fatigue more easily than slow-twitch fibers.
    - Type IIx have considerable anaerobic capacity, and are the largest and fastest, and are capable of producing the most force, of all the skeletal muscle fibers.
    - Type IIa muscle fibers possess speed, fatigue, and force-production capabilities somewhere between type I and type IIx fibers.
    - Type IIa fibers are also called intermediate fibers.

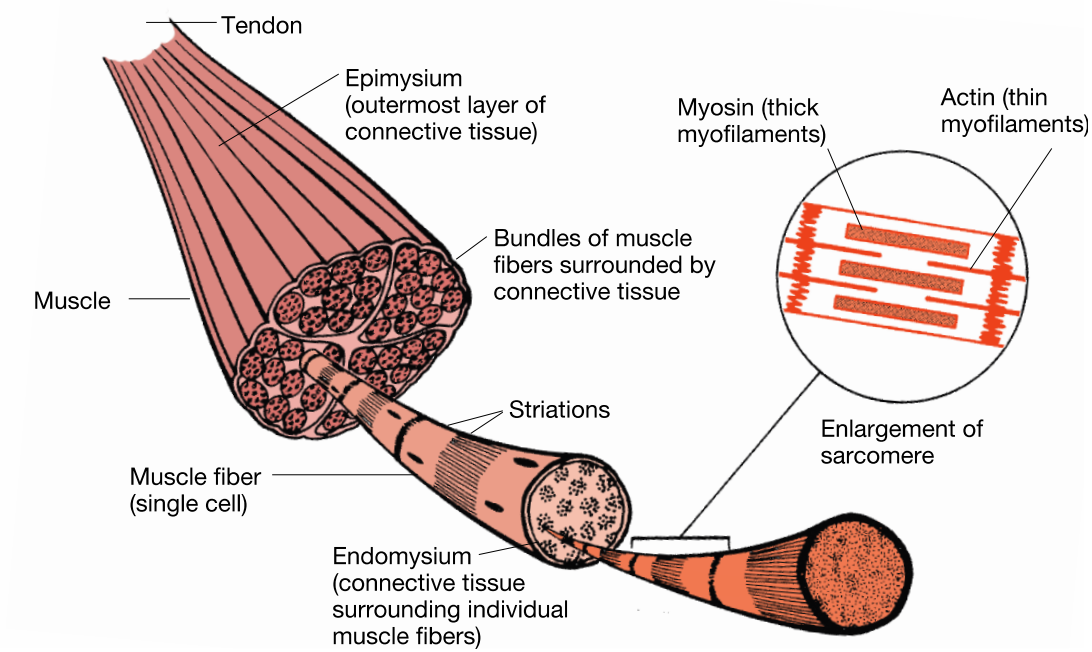
Comparison of Muscle Fiber Types

- The following table compares the three types of muscle fiber using the relative terms low, medium, and high.

	Type I	Type IIa	Type IIx
Speed of contraction	Low	Medium	High
Force capacity	Low	Medium	High
Fatigue resistance	High	Medium	Low
Mitochondrial content	High	Medium	Low
Size	Low	Medium	High
Efficiency	High	Medium	Low
Aerobic capacity	High	Medium	Low
Anaerobic capacity	Low	Medium	High

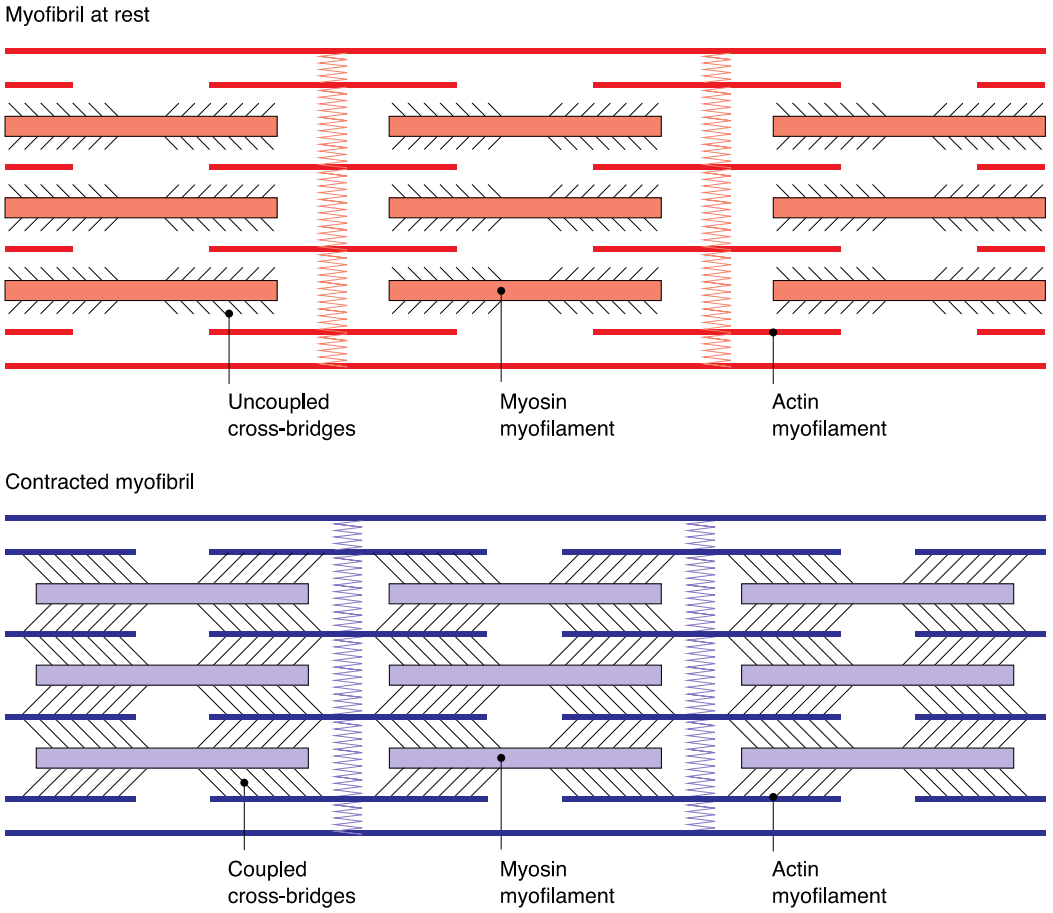
Muscle-fiber Microanatomy

- Skeletal muscles are made up of many muscle fibers held in place by connective tissue (fascia).
- Muscle fibers are made up of myofibrils (protein filaments) composed of a series of repeating segments called sarcomeres.
- Sarcomeres, made up of thick (myosin) and thin (actin) myofilaments, are the functional contracting unit of skeletal muscle.



Muscle Contraction

- Sliding filament model
  - When acetylcholine is released from the CNS and detected, calcium is released.
  - Calcium exposes binding sites along the actin for the myosin to attach.
  - If sufficient ATP is present, cross-bridges are formed and the myosin pulls the actin toward the center, thereby shortening the sarcomere.



Connective Tissue

- There are two types of connective tissue directly related to joint movement:
  - Collagen
    - Made up of proteins that provide tensile strength and relative inextensibility, thereby limiting motion and resisting stretch
    - Found in tendons and ligaments
  - Elastic fibers
    - Made up of amino acids and allow for extensibility
    - Surround the sarcomere and are found in other organs
- Tendons are tough, cord-like tissues that transmit force from the muscle to the bone, causing movement.
- Ligaments contain a greater mixture of collagen and elastic fibers, taking on various shapes that support a joint by attaching bone to bone.

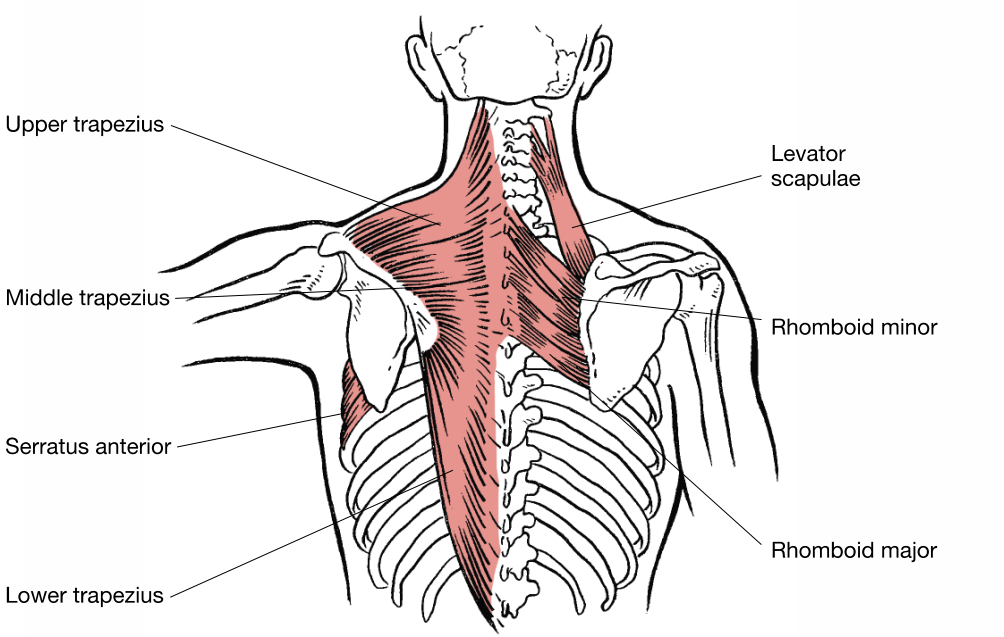
Factors That Impact Flexibility

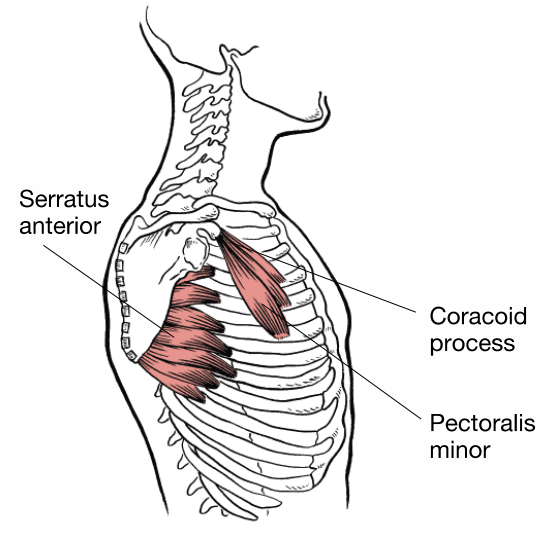
- Soft tissues contribute to the total resistance to joint movement as follows:
  - Joint capsule: 47%
  - Muscle (fasciae): 41%
  - Tendons: 10%
  - Skin: 2%

- Other factors that impact flexibility include:
  - Age
    - Muscle strength, endurance, flexibility, and agility naturally decrease with age due to muscle atrophy that coincides with increased collagen.
  - Gender
    - In general, females are more flexible than males due to anatomical and physiological differences.
  - Joint structure and past injury
    - The rebuilding of broken bones and the build-up of scar tissue can limit joint movement.

The Shoulder Girdle

- The muscles of the shoulder girdle act on the scapula, primarily to stabilize it.
- There are six major muscles that anchor the scapula.
  - Four posterior muscles
  - Two anterior muscles



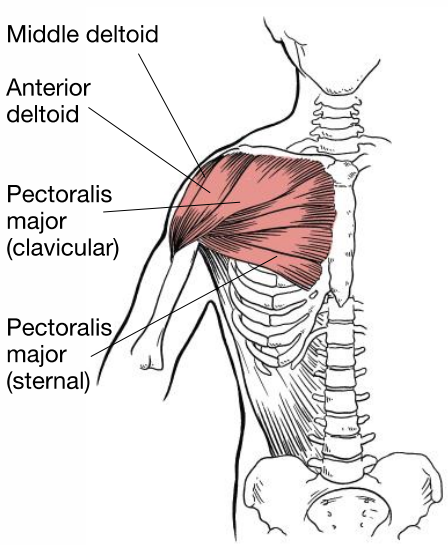


Major Muscles That Act at the Shoulder Girdle

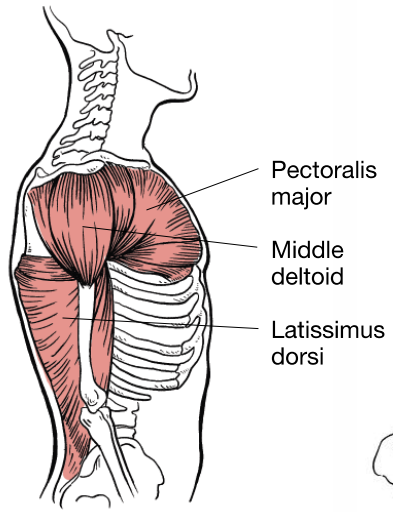
Major Muscles That Act at the Shoulder Girdle				
Muscle	**Origin**	**Insertion**	**Primary Function(s)**	**Selected Exercises**
Trapezius	Occipital bone, spines of 7th cervical and thoracic vertebrae	Lateral third of clavicle, acromion process, and spine of scapula	Upper: upward rotation and elevation of scapula Middle: upward rotation and adduction of scapula Lower: depression of scapula	Upright rows, shoulder shrugs
Levator scapulae	Transverse processes of first four cervical vertebrae	Upper vertebral border of scapula	Elevation of scapula	Shoulder shrugs
Rhomboid major and minor	Spines of 7th cervical through 5th thoracic vertebrae	Middle to lower vertebral border of scapula	Adduction, downward rotation, and elevation of scapula	Chin-ups, supported dumbbell bent-over rows
Pectoralis minor	Anterior surface of ribs 3 through 5	Coracoid process of scapula	Stabilization, depression, downward rotation, and abduction of the scapula	Push-ups, incline bench press, regular bench press, cable crossover chest flys
Serratus anterior	Lateral, anterior surface of ribs 1 through 9	Ventral surface of vertebral border of scapula	Stabilization, abduction, and upward rotation of the scapula	Push-ups, incline bench press, pull-overs

The Shoulder

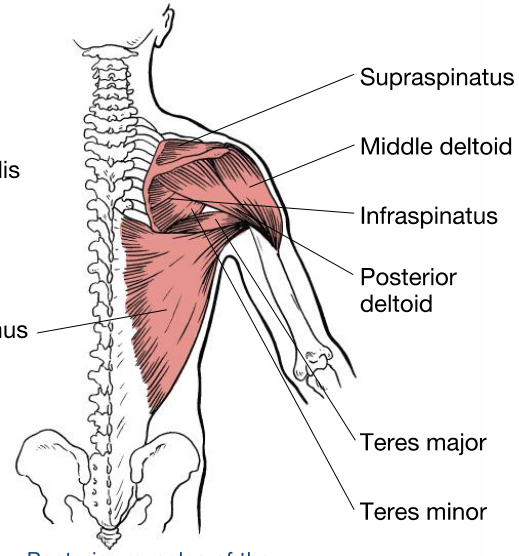
- The shoulder joint is the most mobile joint in the body.
- There are a total of nine muscles that cross the shoulder joint (inserting on the humerus).
  - Seven muscles originate from each scapula.
  - Two muscles originate from the axial skeleton (no attachment on the scapula).



Anterior deltoid and pectoralis major



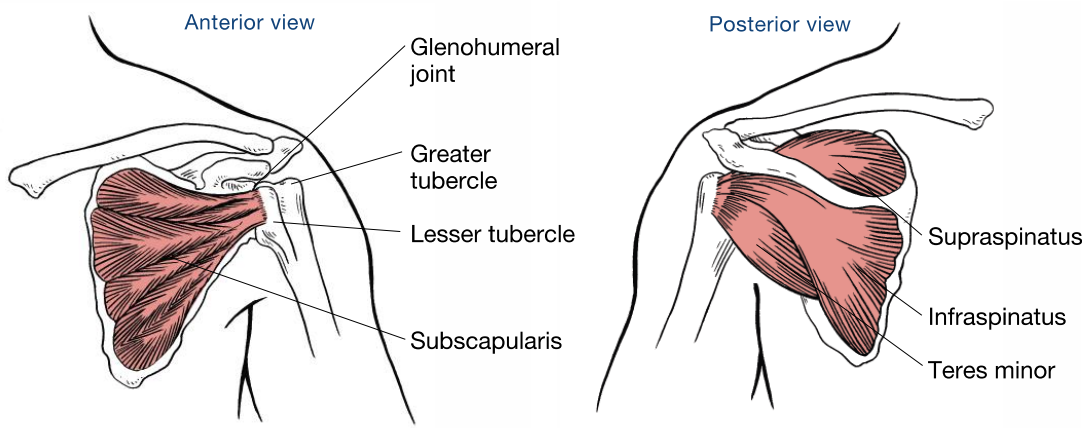
Latissimus dorsi, pectoralis, and deltoid, lateral view



Posterior muscles of the shoulder (glenohumeral) joint

The Rotator Cuff

- Four of the muscles that act at the shoulder are commonly called the rotator cuff.
- The rotator cuff's primary stabilizing function is to hold the humeral head in the glenoid fossa to prevent subluxation (dislocation).
- The muscles of the rotator cuff can be remembered using the acronym SITS:
  - **S**upraspinatus
  - **I**nfraspinatus
  - **T**eres minor
  - **S**ubscapularis

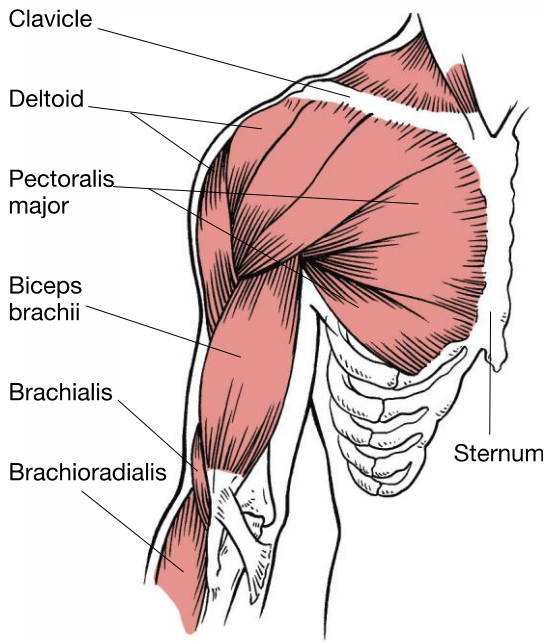


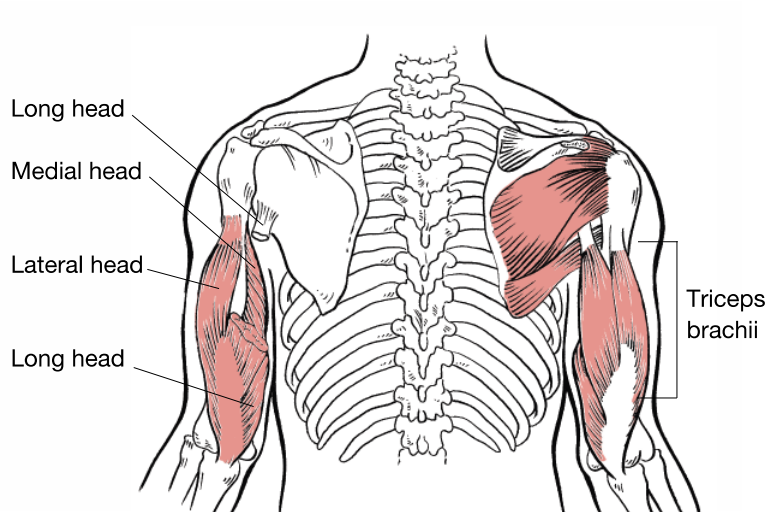
Major Muscles That Act at the Shoulder

Major Muscles That Act at the Shoulder				
Muscle	**Origin**	**Insertion**	**Primary Function(s)**	**Selected Exercises**
Pectoralis major	Clavicle, sternum, and first six costal cartilages	Greater tubercle of humerus	Flexion, extension, adduction, internal rotation, and horizontal adduction	Push-ups, pull-ups, incline bench press, regular bench press, climbing a rope, all types of throwing, tennis serve
Deltoid	Anterior, lateral clavicle, border of the acromion, and lower edge of spine of the scapula	Deltoid tubercle of humerus on mid-lateral surface	Entire muscle: abduction Anterior fibers: flexion, internal rotation, and horizontal adduction Posterior fibers: external rotation and horizontal abduction	Lateral "butterfly" (abduction) exercises; anterior deltoid has similar functions to the pectoralis major
Latissimus dorsi	Spines of lower six thoracic vertebrae and all lumbar vertebrae, crests of ilium and sacrum, lower four ribs, and interior angle of scapulae	Medial side of intertubercular groove of humerus	Extension, adduction, horizontal abduction, and internal rotation	Chin-ups, rope climbing, dips on parallel bars, rowing, any exercise that involves pulling the arms downward against resistance (e.g.,"lat" pull-downs on exercise machine)
Rotator cuff	Various aspects of scapula	All insert on greater tubercle of humerus except for the subscapularis, which inserts on the lesser tubercle of the humerus	Infraspinatus and teres minor: external rotation Subscapularis: internal rotation Supraspinatus: abduction All contribute to the stability of the humeral head	Exercises that involve internal and external rotation (e.g., tennis serve, throwing a baseball), internal and external rotation exercises
Teres major	Posterior inferior lateral border of scapula, just superior to inferior angle	Intertubercular groove of the humerus	Extension, adduction, and internal rotation	Chin-ups, seated rows, "lat" pull-downs, rope climbing

The Elbow

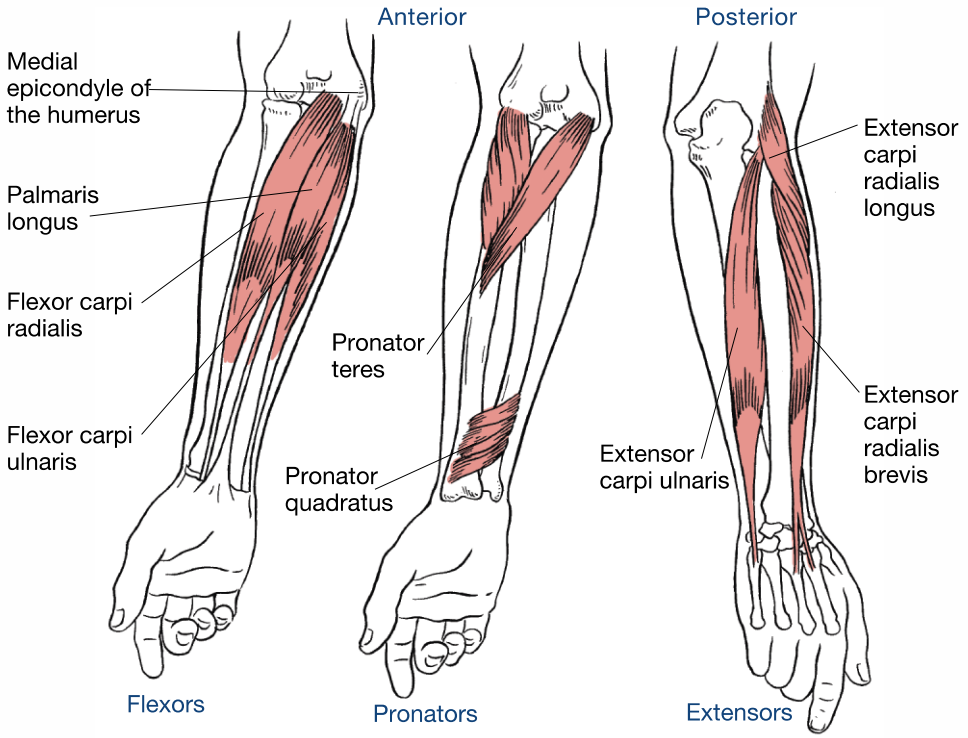
- Flexion and extension of the elbow are controlled by muscles in the upper arm.
- Pronation and supination of the forearm are controlled by muscles in the upper arm, as well as several muscles in the forearm.





The Wrist

- The majority of the muscles that act at the wrist cross the elbow and are responsible for flexion and extension of the wrist and pronation and supination of the forearm.
  - Flexion muscles originate primarily from or near the medial epicondyle.
  - Extension muscles originate primarily from or near the lateral epicondyle.



Major Muscles That Act at the Elbow and Forearm

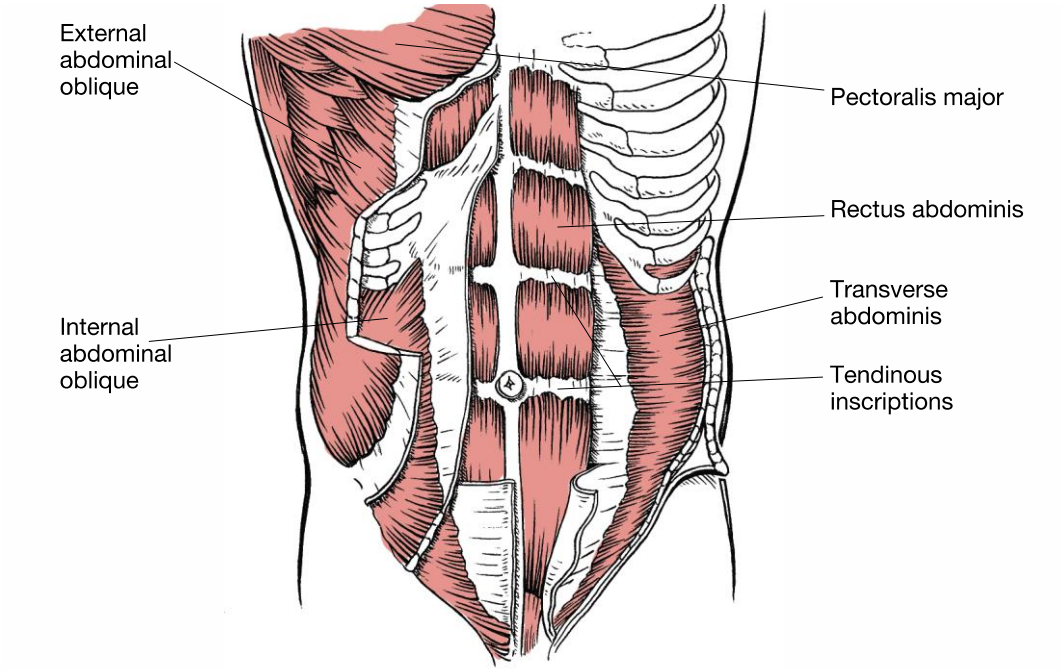
Major Muscles That Act at the Elbow and Forearm				
Muscle	**Origin**	**Insertion**	**Primary Function(s)**	**Selected Exercises**
Biceps brachii	Long head: tubercle above glenoid cavity; Short head: coracoid process of scapula	Radial tuberosity	Flexion at elbow; supination at forearm	Arm curls, chin-ups, rock climbing, upright rowing
Brachialis	Anterior humerus	Ulnar tuberosity and coronoid process of ulna	Flexion at elbow	Same as for biceps brachii
Brachioradialis	Distal ⅔ of lateral condyloid ridge of humerus	Styloid process of radius	Flexion at elbow; supination at forearm	Same as for biceps brachii
Triceps brachii	Long head: lower edge of glenoid cavity of scapula; Lateral head: posterior humerus; Short head: distal ⅔ of posterior humerus	Olecranon process of ulna	Extension at elbow; arm extension (long head)	Push-ups, dips, bench press, shoulder press
Pronator teres	Epicondyle of medial humerus	Middle ⅓ of lateral radius	Flexion at elbow and pronation at forearm	Pronation of forearm with dumbbell
Pronator quadratus	Distal anterior surface of ulna	Distal anterior surface of radius	Pronation at forearm	Resisted pronation
Supinator	Lateral, posterior epicondyle of humerus and supinator crest of ulna	Proximal, lateral surface of radius	Supination at forearm	Resisted supination

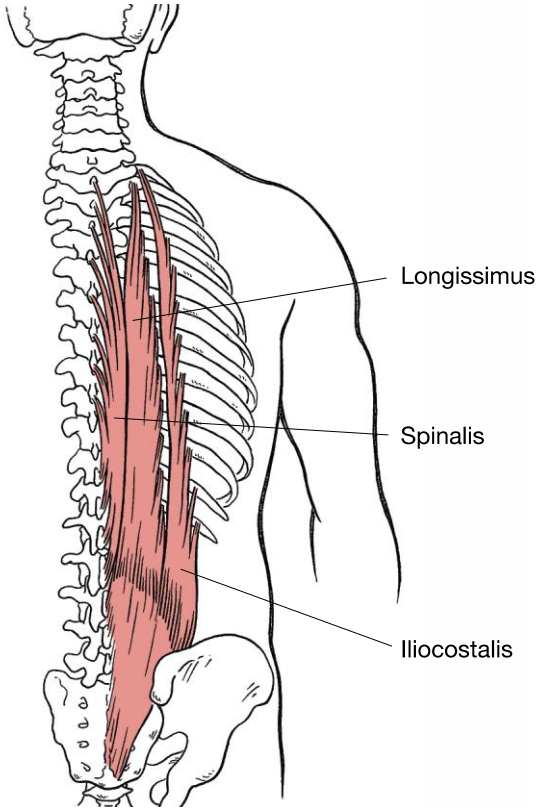
Major Muscles That Act at the Wrist

Major Muscles That Act at the Wrist				
Muscle	**Origin**	**Insertion**	**Primary Function(s)**	**Selected Exercises**
Flexor carpi radialis	Medial epicondyle of humerus	Anterior base of 2nd and 3rd metacarpals	Flexion	Wrist curls; grip-strengthening exercises for racquet sports
Flexor carpi ulnaris	Medial epicondyle of humerus, medial olecranon process, and upper, posterior ulna	5th metacarpal	Flexion	Same as flexor carpi radialis
Extensor carpi radialis longus	Lateral epicondyle of humerus	Posterior base of 2nd metacarpal	Extension	"Reverse" wrist curls; racquet sports, particularly tennis
Extensor carpi ulnaris	Lateral epicondyle of humerus and middle ½ of posterior ulna	Posterior base of 5th metacarpal	Extension	Same as extensor carpi radialis longus
Palmaris longus	Medial epicondyle of humerus	Palmar aponeurosis	Flexion	Wrist curls

The Trunk

- The major muscles of the trunk support, stabilize, and move the spine.
  - The abdominal wall, made up of the rectus abdominis, obliques, and transverse abdominis, has no skeletal support.
  - Its strength comes from the multidirectional layers of muscle.



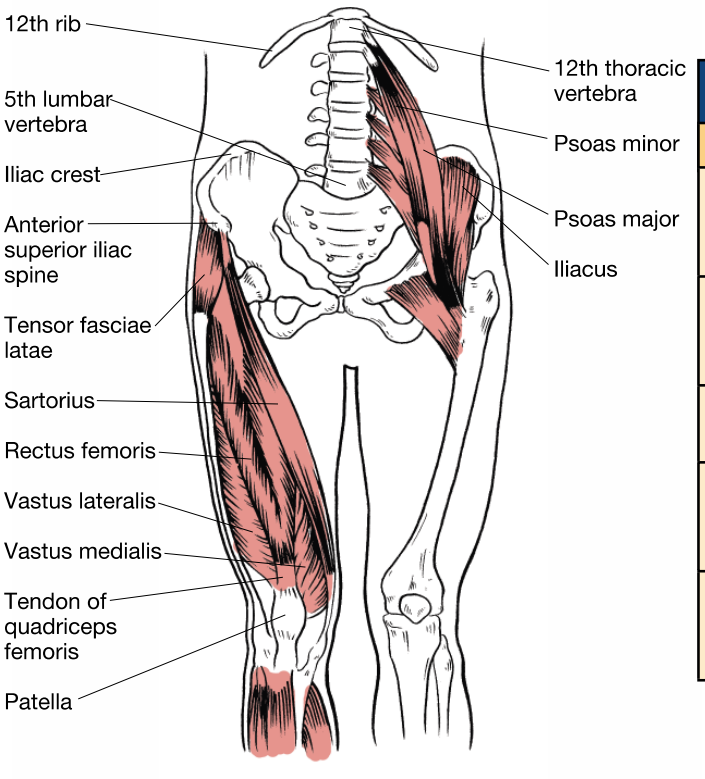


Major Muscles That Act at the Trunk

Major Muscles That Act at the Trunk				
Muscle	**Origin**	**Insertion**	**Primary Function(s)**	**Selected Exercises**
Rectus abdominis	Pubic crest	Cartilage of 5th through 7th ribs	Flexion and lateral flexion of the trunk	Bent-knee sit-ups, partial curl-ups, pelvic tilts
External oblique	Anterior, lateral borders of lower 8 ribs	Anterior half of ilium, pubic crest, and anterior fascia	Contralateral rotation, lateral flexion, and forward flexion (both sides)	Twisting bent-knee curl-ups (rotation opposite) and curl-ups
Internal oblique	Lumbodorsal fascia, iliac crest, and anterior fascia	Cartilage of last 3 to 4 ribs, linea alba, and superior ramis of pubis	Ipsilateral rotation, lateral flexion, and forward flexion (both sides)	Twisting bent-knee curl-ups (rotation same side) and curl-ups
Transverse abdominis	Iliac crest, lumbar fascia, cartilages of last 6 ribs, and anterior fascia	Xiphoid process of sternum, anterior fascia, and pubis	Compresses abdomen	Prone plank and "drawing in" maneuver
Erector spinae	Posterior iliac crest, sacrum, ribs, and vertebrae	Angles of ribs, transverse processes of all ribs	Extension (both sides) and lateral flexion	Squat, dead lift, prone back extension exercises
Multifidi	Posterior surface of the sacrum, articular processes of the lumbar vertebrae, transverse processes of the thoracic vertebrae, articular processes of C3-7	The spinous processes spanning 1 to 4 vertebrae above the origin	Contributes to spinal stability during trunk extension, rotation, and side-bending	Birddog

Hip Flexors

- There are 21 major muscles involved in the actions of the hip joint.
  - Actions of the hip joint include flexion, extension, internal rotation, external rotation, adduction, and abduction.
  - More than half of these muscles are involved in multiple actions.

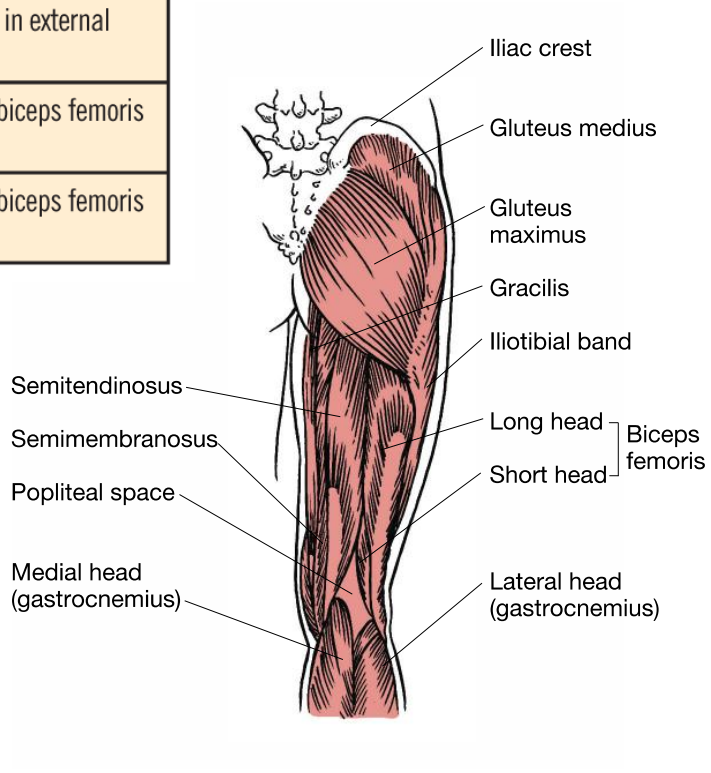


Major Muscles That Act at the Hip Joint

Muscle	Origin	Insertion	Primary Function(s)	Selected Exercises
Iliopsoas: Iliacus and psoas major and minor	Transverse processes of T12 and L1 through L5; iliac crest and fossa	Lesser trochanter of femur	Flexion and external rotation	Straight-leg sit-ups, running with knees lifted up high, leg raises, hanging knee raises
Rectus femoris	Anterior-inferior spine of ilium and upper lift of acetabulum	Superior aspect of patella and patellar tendon	Flexion	Running, leg press, squat, jumping rope
Tensor fasciae latae	Anterior iliac crest and ilium just below crest	Iliotibial band	Flexion, abduction, and internal rotation	Hanging knee raises, side-lying leg raises, running
Sartorius	Anterior superior iliac spine	Proximal anterior medial tibia just below the tuberosity	Flexion and external rotation of the hip; flexion of the knee	Knee lift with hip external rotation, wide stance onto bench
Pectineus	Superior pubic ramus	Lesser trochanter and linea aspera of femur	Flexion, adduction, and external rotation	Hanging knee raises, side-lying bottom-leg raises, resisted external rotation of the thigh

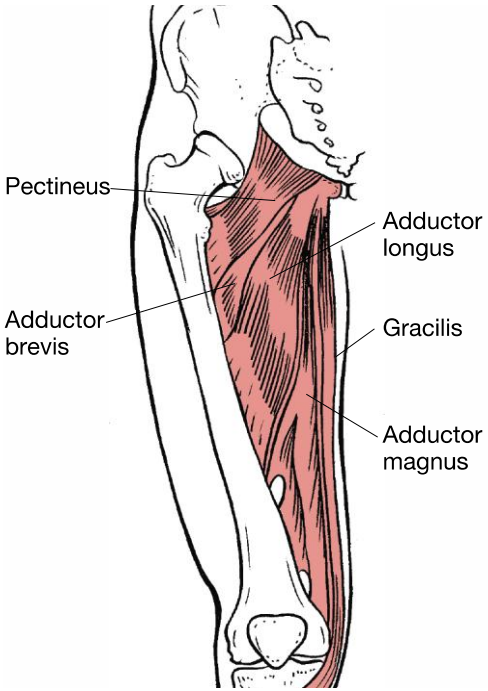
Hip Extensors

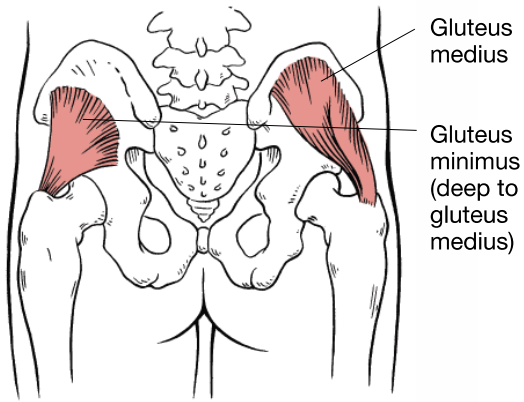
Major Muscles That Act at the Hip Joint				
Muscle	**Origin**	**Insertion**	**Primary Function(s)**	**Selected Exercises**
Gluteus maximus	Posterior 1/4 of iliac crest and sacrum	Gluteal line of femur and iliotibial band	Extension and external rotation; Superior fibers: abduction	Cycling, plyometrics, jumping rope, squats, stair-climbing machine
Biceps femoris	Long head: ischial tuberosity; Short head: lower, lateral linea aspera	Lateral condyle of tibia and head of fibula	Extension, abduction, and slight external rotation	Cycling, hamstring curls with knee in external rotation
Semitendinosus	Ischial tuberosity	Proximal anterior-medial aspect of tibia	Extension, abduction, and slight external rotation	Same as biceps femoris
Semimembranosus	Ischial tuberosity	Posterior aspect of medial tibial condyle	Extension, adduction, and slight internal rotation	Same as biceps femoris



Hip Internal and External Rotators

- The hip internal rotators include the tensor fasciae latae, semitendinosus (slight), and semimembranosus (slight).
- The hip external rotators include the iliopsoas, gluteus maximus, biceps femoris (slight), gluteus medius and minimus (posterior fibers), sartorius, pectineus, and the six deep external rotators.





Hip Adductors

Major Muscles That Act at the Hip Joint				
Muscle	**Origin**	**Insertion**	**Primary Function(s)**	**Selected Exercises**
Semitendinosus	Ischial tuberosity	Proximal anterior-medial aspect of tibia	Extension, adduction, and slight internal rotation	Same as biceps femoris
Semimembranosus	Ischial tuberosity	Posterior aspect of medial tibial condyle	Extension, adduction, and slight internal rotation	Same as biceps femoris
Adductor magnus	Pubic ramus and ischial tuberosity	Medial aspects of femur	Adduction	Side-lying bottom-leg raises, resisted adduction
Adductor brevis and longus	Pubic ramus and ischial tuberosity	Linea aspera of femur	Adduction	Side-lying bottom-leg raises, resisted adduction
Pectineus	Superior pubic ramus	Lesser trochanter and linea aspera of femur	Flexion, adduction, and external rotation	Hanging knee raises, side-lying bottom-leg raises, resisted external rotation of the thigh
Gracilis	Pubic symphysis and arch	Medial tibia just below the condyle	Adduction	Side-lying bottom-leg raises, resisted adduction

Hip Abductors

Major Muscles That Act at the Hip Joint				
Muscle	**Origin**	**Insertion**	**Primary Function(s)**	**Selected Exercises**
Gluteus maximus	Posterior 1/4 of iliac crest and sacrum	Gluteal line of femur and iliotibial band	Extension and external rotation; Superior fibers: abduction	Cycling, plyometrics, jumping rope, squats, stair-climbing machine
Biceps femoris	Long head: ischial tuberosity; Short head: lower, lateral linea aspera	Lateral condyle of tibia and head of fibula	Extension, abduction, and slight external rotation	Cycling, hamstring curls with knee in external rotation
Gluteus medius and minimus	Lateral surface of ilium	Greater trochanter of femur	Abduction (all fibers); Anterior fibers: internal rotation; Posterior fibers: external rotation	Side-lying leg raises, walking, running
Tensor fasciae latae	Anterior iliac crest and ilium just below crest	Iliotibial band	Flexion, abduction, and internal rotation	Hanging knee raises, side-lying leg raises, running

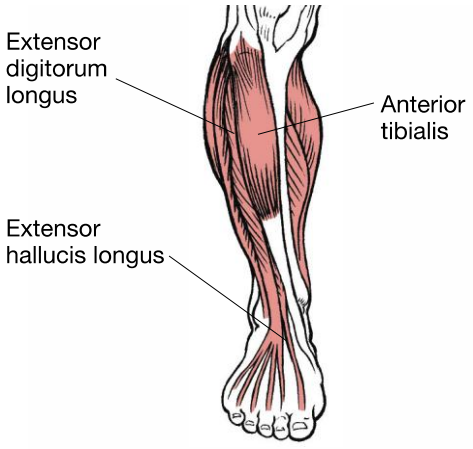
The Knee Joint

- The muscles of the upper thigh are responsible for movement at the knee.

Major Muscles That Act at the Knee Joint				
Muscle	**Origin**	**Insertion**	**Primary Function(s)**	**Selected Exercises**
Rectus femoris	Anterior-inferior spine of ilium and upper lip of acetabulum	Superior aspect of patella and patellar tendon	Extension (most effective when the hip is extended)	Cycling, leg press machine, squats, vertical jumping, stair climbing, jumping rope, plyometrics
Vastus lateralis, intermedius, and medialis	Along the surfaces of the lateral, anterior, and medial femur	Patella and tibial tuberosity via the patellar tendon	Extension	Same as for rectus femoris, resisted knee extension
Biceps femoris	Long head: ischial tuberosity; Short head: lower, lateral linea aspera	Lateral condyle of tibia and head of fibula	Flexion and external rotation	Cycling, lunging, hamstring curls
Semitendinosus	Ischial tuberosity	Proximal anterior medial aspect of tibia	Flexion and internal rotation	Same as biceps femoris
Semimem-branosus	Ischial tuberosity	Posterior aspect of medial tibial condyle	Flexion and internal rotation	Same as biceps femoris
Gracilis	Pubic symphysis and pubic arch	Medial tibia just below the condyle	Flexion	Side-lying bottom-leg raises, resisted adduction
Sartorius	Anterior superior iliac spine	Proximal anterior medial tibia just below the tuberosity	Flexion and external rotation of the hip; flexion of the knee	Knee lift with hip external rotation, wide stance onto bench
Popliteus	Lateral condyle of the femur	Proximal tibia	Knee flexion; internal rotation of the lower leg to “unlock the knee”	Same as biceps femoris

The Anterior Compartment of the Lower Leg

- The ankle joint allows dorsiflexion and plantarflexion.
- The subtalar joint allows inversion and eversion of the foot.
- The muscles of the lower leg control movements of the ankle and foot.
- The lower leg is divided into three primary compartments: anterior, posterior, and lateral.

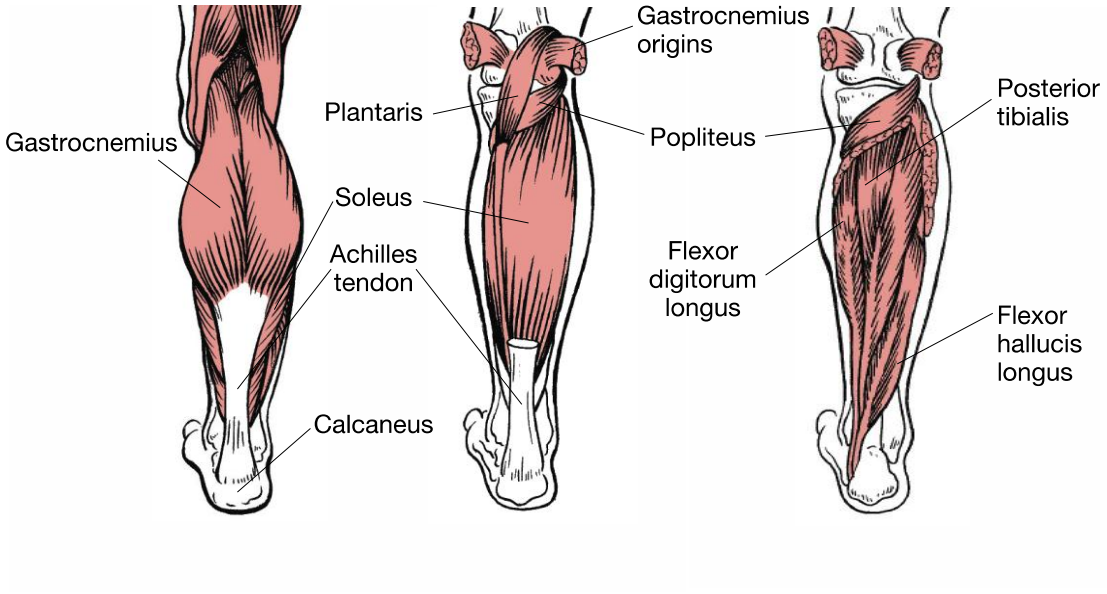


Major Muscles That Act at the Ankle and Foot

Muscle	Origin	Insertion	Primary Function(s)	Selected Exercises
Anterior tibialis	Proximal ⅔ of lateral tibia	Medial aspect of 1st cuneiform and base of 1st metatarsal	Dorsiflexion at ankle; inversion at foot	Cycling with toe clips, resisted inversion (with dorsiflexion)
Extensor hallucis longus	Anterior middle fibula	Dorsal surface of the distal phalanx of the great toe	Dorsiflexion and inversion of the foot; extension of the great toe	Resisted inversion with dorsiflexion
Extensor digitorum	Lateral condyle of tibia, proximal ¾ of the fibula	Dorsal surface of the phalanges of toes 2 through 5	Dorsiflexion and eversion of foot; extension of toes 2 through 5	Resisted eversion with dorsiflexion longus
Peroneus tertius	Distal ⅓ of the anterior/lateral fibula	Dorsal surface of the base of the 5th metatarsal	Dorsiflexion and eversion of the foot	Resisted eversion with dorsiflexion

The Posterior Compartment of the Lower Leg

- The posterior compartment is made up of muscles that plantarflex the foot and/or flex the toes and is divided further into the superficial posterior and deep posterior compartments:
  - Superficial posterior compartment: gastrocnemius, soleus, and plantaris
  - Deep posterior compartment: flexor hallucis longus, flexor digitorum longus, posterior tibialis, and popliteus

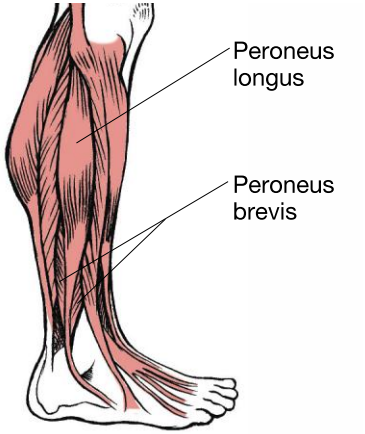


The Posterior Compartment of the Lower Leg (cont.)

Major Muscles That Act at the Ankle and Foot				
Muscle	**Origin**	**Insertion**	**Primary Function(s)**	**Selected Exercises**
Gastrocnemius	Posterior surfaces of femoral condyles	Posterior surface of calcaneus via Achilles tendon	Plantarflexion at ankle; flexion at knee	Hill running, jumping rope, calf raises, cycling, stair climbing
Soleus	Proximal ⅔ of posterior surfaces of tibia and fibula and popliteal line	Posterior surface of calcaneus via Achilles tendon	Plantarflexion at ankle	Virtually the same as for gastrocnemius; bent-knee toe raises with resistance
Posterior tibialis	Posterior surface of the lateral tibia and medial fibula	Lower medial surfaces of medial tarsals and metatarsals	Plantarflexion at ankle; inversion at foot	Resisted inversion of foot with plantarflexion
Plantaris	Posterior surface of the femur above the lateral condyle	Posterior surface of calcaneus via Achilles tendon	Flexion of the knee; plantarflexion of the foot	Same as gastrocnemius
Flexor hallucis longus	Distal ⅔ of the fibula	Plantar surface of distal phalanx of great toe	Flexion of the great toe; plantarflexion and inversion of the foot	Resisted inversion with plantarflexion
Flexor digitorum longus	Posterior middle ⅓ of tibia	Plantar surfaces of distal phalanges of toes 2 through 5	Flexion of toes 2 through 5; plantarflexion and inversion of the foot	Resisted inversion with plantarflexion

The Lateral Compartment of the Lower Leg

- The lateral compartment is made up of muscles that plantarflex and evert the foot, including the peroneus longus and peroneus brevis.



Major Muscles That Act at the Ankle and Foot

Muscle	Origin	Insertion	Primary Function(s)	Selected Exercises
Peroneus longus	Lateral surface of head of tibia, head of fibula, and proximal ⅔ of lateral fibula	Inferior aspects of medial tarsal (1st cuneiform) and base of 1st metatarsal	Plantarflexion at ankle; eversion at foot	Resisted eversion of foot
Peroneus brevis	Distal ⅔ of lateral fibula	Base of the 5th metatarsal	Plantarflexion at ankle; eversion at foot	Resisted eversion of foot

The Endocrine System

- The endocrine system, which is made up of various glands throughout the body, is responsible for regulating bodily activities through the production of hormones.
- The principal glands are as follows:
  - Pituitary
  - Thyroid
  - Parathyroids
  - Adrenals
  - Paradrenals
  - Gonads

Major Endocrine Glands and Their Hormones

Major Endocrine Glands and Their Hormones		
Gland	**Hormones**	**Selected Effects**
Pituitary	Antidiuretic hormone	Reduces urinary excretion of water
	Oxytocin	Stimulates the contraction of the smooth muscle of the uterus and intestines
	Follicle stimulating hormone (FSH) and luteinizing hormone (LH)	Stimulate gonads to secrete sex hormones
	Thyroid stimulating hormone (TSH)	Stimulates thyroid gland to secrete thyroid hormones
	Adrenocorticotropin hormone (ACTH)	Stimulates adrenal glands to secrete glucocorticoids
	Growth hormone (GH)	Stimulates general growth and skeletal growth, and promotes metabolic functions
	Prolactin	Initiates and maintains breast-milk secretion in females
Thyroid	Thyroxine and triiodothyronine	Increases oxygen consumption and heat production, and affects many metabolic functions
	Calcitonin	Decreases blood calcium and phosphate levels
Parathyroids	Parathyroid hormone (PTH)	Raises plasma calcium levels and lowers plasma phosphate levels
Adrenals	Epinephrine	Affects carbohydrate metabolism, generally promoting hyperglycemia. Constricts vessels in the skin, mucous membranes, and kidneys, but dilates vessels in skeletal muscle
	Norepinephrine	Increases heart rate and force of contraction of the myocardium, and constricts blood vessels in most areas of the body
	Mineralocorticoids (e.g., aldosterone)	Promote reabsorption of sodium and excretion of potassium in the kidneys
	Glucocorticoids (e.g., cortisol)	Promote protein and triglyceride breakdown
Pancreas	Insulin	Causes liver and muscle cells to take up glucose and store it in the form of glycogen; encourages fat cells to take on blood lipids and turn them into triglycerides; also has several other anabolic effects throughout the body
	Glucagon	Causes the liver to convert stored glycogen into glucose and release it into the bloodstream

Summary

- To design safe and effective exercise programs and group fitness classes, fitness professionals must have working knowledge of human anatomy.
- This session covered:
  - Anatomical terminology
  - Structural levels of the body
  - The cardiovascular, respiratory, digestive, skeletal, neuromuscular, muscular, and endocrine systems
  - Planes of motion
  - Upper- and lower-extremity and trunk muscles
  - Muscle-fiber types