Anatomy & Physiology

Muscular System

9

Unit Two

Chapter 9

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Muscular System URLs

Frog Dissection

http://curry.edschool.virginia.edu/go/frog/home.html

Cat Dissection

http://www.mhhe.com/biosci/ap/cat_dissect/index.htm

List of Muscles

http://www.meddean.luc.edu/lumen/MedEd/GrossAnatomy/dissector/mml/mmlregn.htm

Origin and Insertion

http://www.gpc.edu/~jaliff/anahumus.htm

Structure of a Skeletal Muscle

CONNECTIVE TISSUE COVERINGS

****600 muscles in the human body****

A. The three types of muscle in the body are skeletal, smooth, and cardiac muscle. (look at chapter 5 to review these)

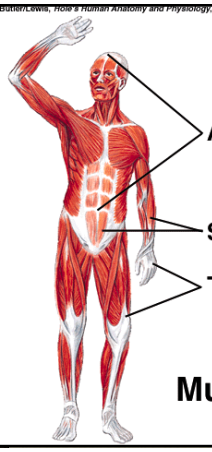
B. This chapter focuses on skeletal muscle.

*are attached to bones & under conscious control

*a skeletal muscle is an organ

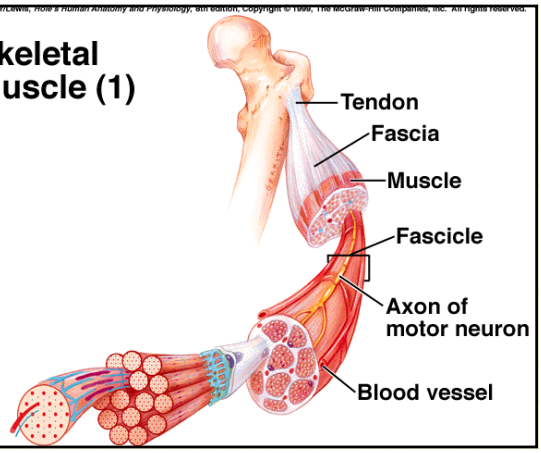
*fascia – layers of dense connective tissue that separate adjacent muscles & hold them in position; fascia surrounds each muscle and projects to form the cordlike tendon that attaches muscles to bone; tendon fibers intertwine with the periosteum

*aponeuroses – broad fibrous sheets of connective tissue that attach muscles in other parts; they are tendons

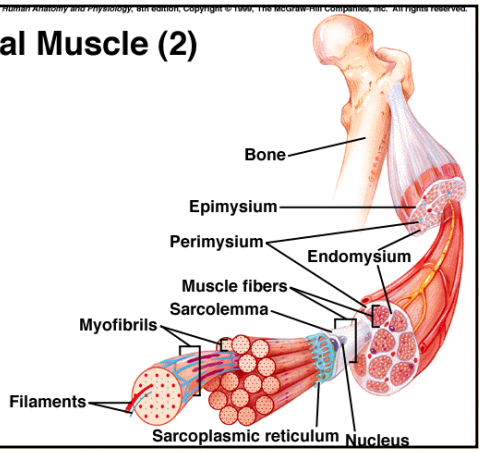


Muscle Attachments

Skeletal Muscle (1)



Skeletal Muscle (2)



C. Each muscle is an organ, comprised of skeletal muscle tissue, connective tissues, nervous tissue, and blood.

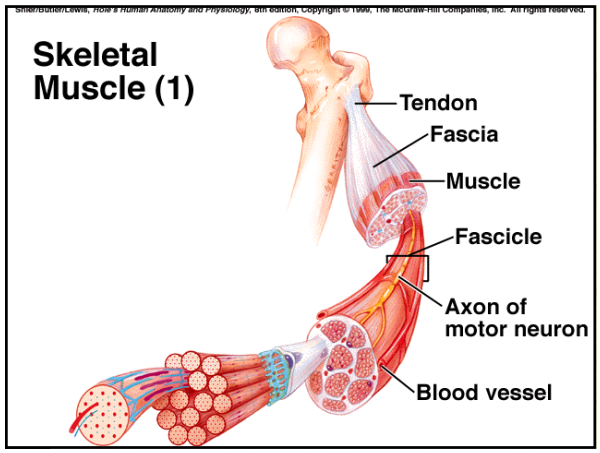
D. Skeletal muscles, as organs, make up the muscular system.

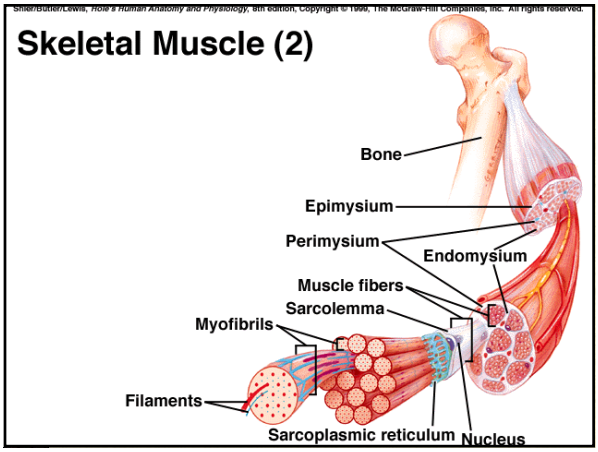
CONNECTIVE TISSUE COVERINGS

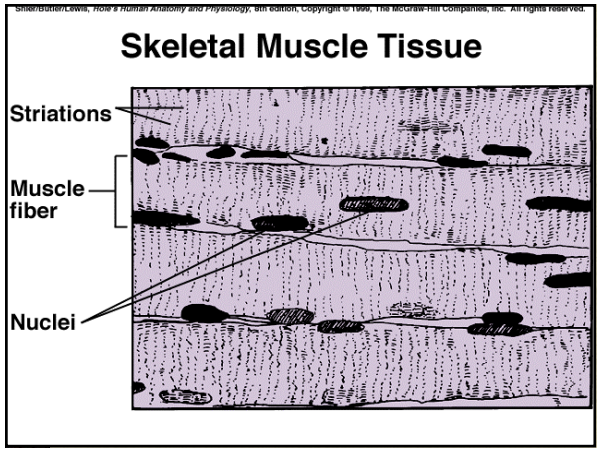
*epimysium – layer of connective tissue that surrounds the muscle

*perimysium – this layer extends inward from the epimysium & separates the muscle tissue into small sections called *fascicles – bundles of skeletal muscle fibers in each section

*endomysium – the sheath of connective tissue surrounding each skeletal muscle fiber







SKELETAL MUSCLE FIBERS

*a skeletal muscle fiber is a single muscle cell; it is the unit of contraction; muscle cells are cylindrical with many nuclei; have rounded ends that attach to the connective tissues associated with muscle

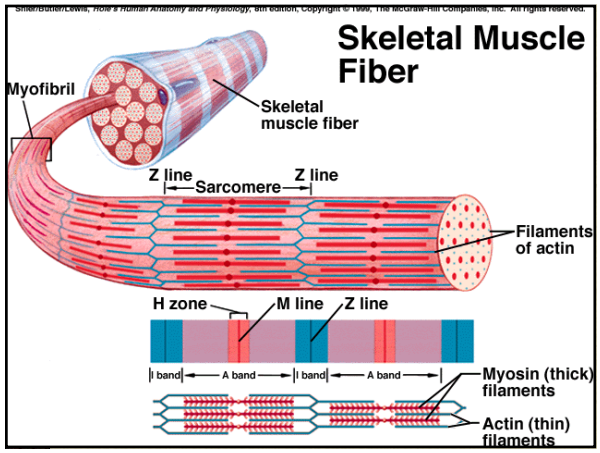
*the sarcolemma (cell membrane), sarcoplasm (cytoplasm) contains mitochondria, sarcoplasmic reticulum, & myofibrils parallel structures of actin & myosin

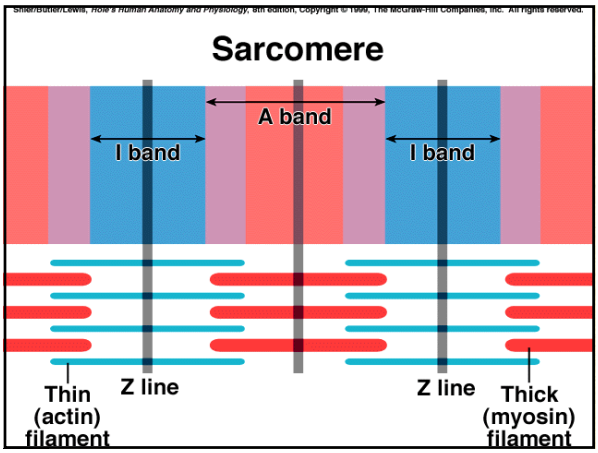
*myofibrils – threadlike & play a role in muscle contraction

-have 2 kinds of protein filaments: thick filaments – myosin & thin filaments – actin; organization of these filaments gives striations to skeletal muscle

-I bands (light bands) are actin & are held by Z lines

-A bands (dark bands) are myosin & are held by Z lines & attached by titin = a large protein





*myosin – two twisted thick protein strands with globular parts called cross-bridges

*actin – two twisted thin protein strands with binding sites for attachment of myosin cross-bridges

*troponin & tropomyosin – 2 proteins that associate with actin

-troponin molecules – 3 protein subunits & are attached to actin

-tropomyosin molecules – rod-shaped & occupy the longitudinal grooves of the actin helix

Each tropomyosin is held in place by a troponin molecule, forming a troponin & tropomyosin complex

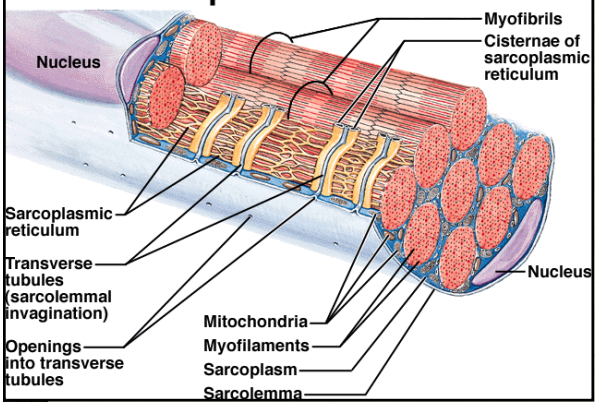
*sarcomere – segment of a myofibril that extends from one Z line to the next Z line

*sarcoplasmic reticulum – network of channels that surround & parallel each myofibril (= endoplasmic reticulum)

*transverse tubules – channels that extend through the myofibril that transmit muscle impulses into the cell interior

*cisternae - each transverse tubule lies between 2 enlarged portions of the sarcoplasmic reticulum called the cisternae near the region where the actin & myosin filaments overlap

*triad – network of membranous channels that includes the sarcoplasmic reticulum, transverse tubules, & cisternae



Muscle contraction involves several components that result in the shortening of sarcomeres (segment of a myofibril that extends from one Z line to the next) & the pulling of the muscle against its attachments.

Roles of Myosin and Actin

*myosin accounts for about 2/3rds of the protein in skeletal muscles; is composed of 2 twisted protein strands with globular parts called cross-bridges that project outward; when Ca is present the myosin cross-bridges react with actin filaments and form linkages with them; this is the actin-myosin interaction that is responsible for the contraction in all 3 types of muscle

*actin accounts for 1/4th of the protein in skeletal muscle; has a binding site to which the cross-bridges of myosin can attach; can form a helix called an actin filament

Skeletal Muscle Contraction: a complex interaction of cellular & chemical constituents

NEUROMUSCULAR JUNCTION

*motor neurons stimulate muscle fibers to contract

*neuromuscular junction – site where nerve fiber & muscle fiber meet

*motor end plate – area of muscle fiber where nuclei & mitochondria are abundant & sarcolemma (cell membrane of a muscle cell) is folded

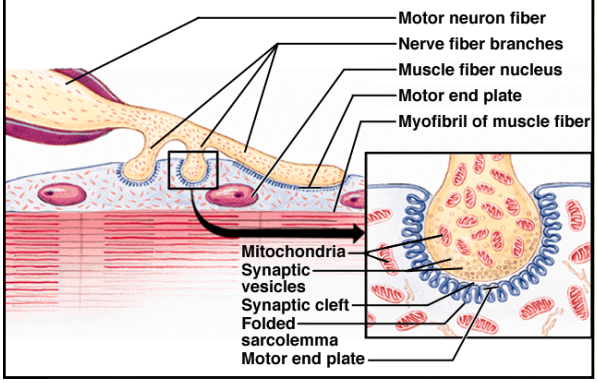
*motor unit – a motor neuron & the muscle fibers it controls

*synaptic cleft – a small gap between the membrane of the nerve fiber & the membrane of the muscle fiber

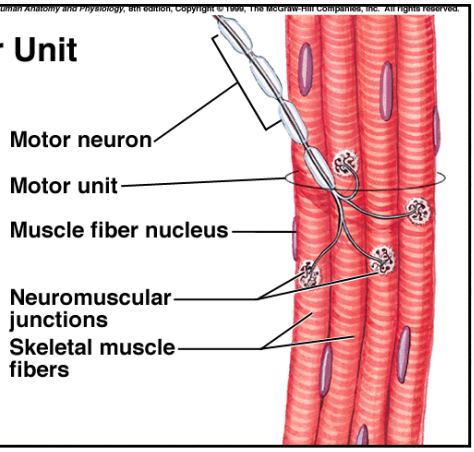
*neurotransmitter – a chemical that is released when nerve impulses from brain or spinal cord causes muscle fibers to contract (synaptic vesicles store neurotransmitter)

*dystrophin – another protein vital to muscle function; .002% of muscle protein; absence causes muscular dystrophy

Neuromuscular Junction



Motor Unit



STIMULUS for CONTRACTION

*skeletal muscle contracts when a neurotransmitter stimulates it (normally)

*acetylcholine - (ACh) neurotransmitter,is synthesized in cytoplasm of motor neurons, stored in synaptic vesicles near the distal end of nerve fiber (axon); when nerve impulse (action potential) reaches the end of axon, acetylcholine is released in synaptic cleft (gap) between the nerve fiber & the motor end plate; ACh diffuses rapidly across synaptic cleft & stimulates the muscle fiber; the response is a muscle impulse (electrical signal) which changes the muscle cell membrane & transmits the impulse in all directions around the muscle cell into the transverse tubules > sarcoplasm > sarcoplasmic reticulum > cisternae

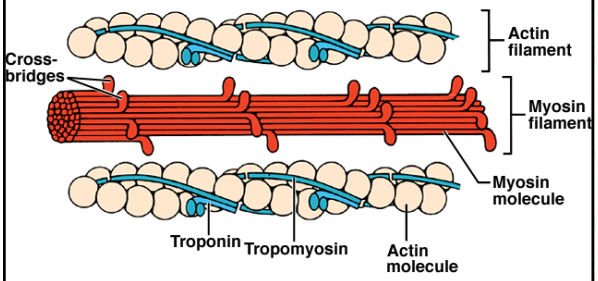
EXCITATION CONTRACTION COUPLING

- sarcoplasmic reticulum has high concentration of Ca ions due to active transport of Ca ions (Ca pump) in the membrane of sarcoplasmic reticulum; after muscle impulse, membranes of the cisternae become more permeable to the Ca & the Ca moves to the cytosol of the muscle fiber

Muscle fiber is at rest when troponin-tropomyosin complexes block actin binding sites & myosin cross-bridges

As Ca moves into the muscle fiber's cytosol it binds to troponin changing its conformation & alters the position of the tropomyosin. The movement of the tropomyosin molecules exposes the binding sites on the actin filaments, allowing linkages to form between myosin (cross-bridges) & actin

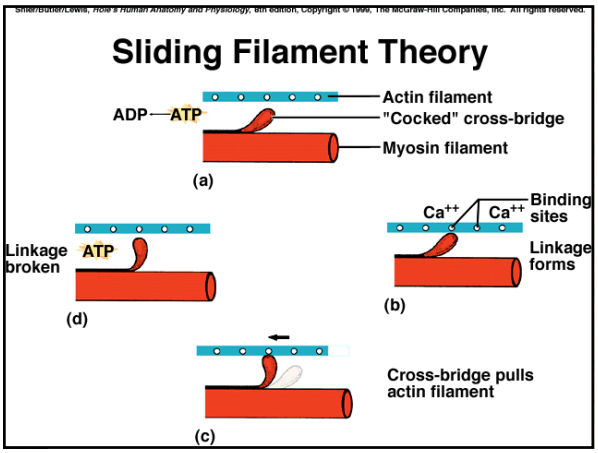
Myosin and Actin

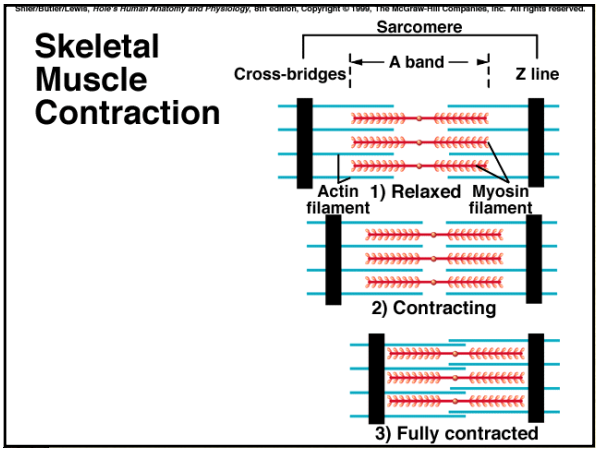


THE SLIDING FILAMENT THEORY

sarcomere – functional unit of skeletal muscles; when sarcomere shortens a skeletal muscle contracts

sliding filament theory – when sarcomeres shorten, the thick & thin filaments (myosin & actin) slide past one another; the z lines move closer together, shortening the sarcomere





CROSS-BRIDGE CYCLING

- The cross-bridges pulling on the thin filaments shortens the sarcomeres; then the head of the cross-bridge can release & combine with another binding site further down the actin filament & pull again.

-Cross-bridges contain ATPase (enzyme) which catalyzes breakdown of ATP to ADP+P = Energy is released. This is the force for muscle contraction.

-Breakdown of ATP puts cross-bridges in "cocked" position to attach to actin binding sites. When P+ADP = ATP cross-bridges release actin filament until ATP >ADP again & cross-bridges are cocked again; this cycle may repeat many times as long as ATP is available & nerve impulses cause release of ACh

RELAXATION (of muscle fiber)

*When nerve impulses cease 2 events relax the muscle fiber.

1. Acetylcholinesterase (enzyme) in the synapse & on the membranes of the motor end plate decomposes the ACh & prevents a single nerve impulse from continuously stimulating the muscle fiber.

2. When ACh is broken down, the stimulus to the sarcolemma & membranes within the muscle fiber ceases; Ca pump has no ATP to continue & moves Ca ions back into sarcoplasmic reticulum, decreasing the Ca ion concentration of the cytosol; cross-bridge linkages break & troponin & tropomyosin inhibit the interaction between the filaments. As a result the muscle fiber relaxes

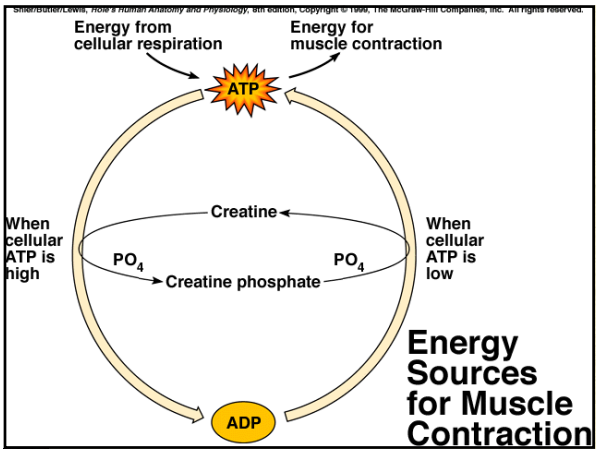
NOTE Table: "Major Events of Muscle Contraction & Relaxation"

ENERGY SOURCES FOR CONTRACTION

*ATP supplies the energy for the interaction between actin & myosin filaments during muscle fiber contraction

*creatine phosphate –source of energy that can be used to synthesize ATP as it is decomposed into ADP

*active muscles depend upon cellular respiration for energy



OXYGEN SUPPLY & CELLULAR RESPIRATION

*anaerobic respiration yields few ATP molecules & aerobic respiration produces many ATP molecules

*hemoglobin in red blood cells carries O2 from the lungs to body cells

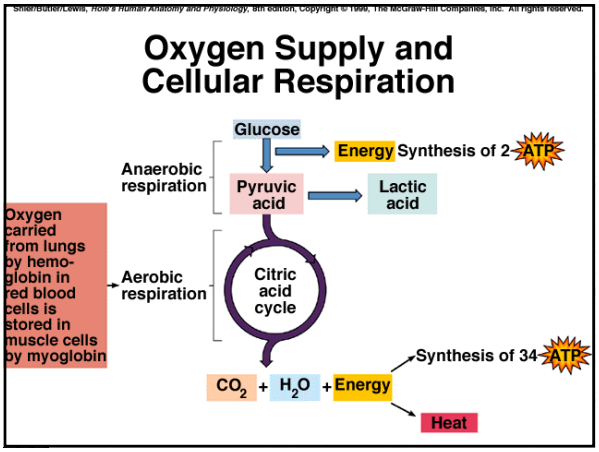
*myoglobin – protein pigment in muscle cells gives skeletal muscle reddish-brown color; it has a stronger attraction for O2 than does hemoglobin

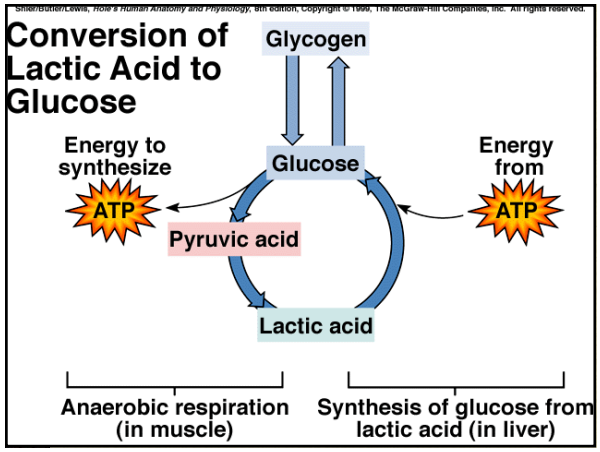
OXYGEN DEBT

*O2 supply is sufficient to support aerobic respiration during rest or moderate exercise

*lactic acid accumulates during anaerobic respiration when O2 deficiency occurs

*oxygen debt - O2 has to be present to convert lactic acid to to glucose & to restore supplies of ATP & creatine phosphate





MUSCLE FATIGUE

*fatigued muscles cannot contract; due to accumulation of lactic acid; athletes have better ability to produce less lactic acid because of their conditioning which increases the ability to supply O2 and nutrients to muscles

HEAT PRODUCTION

*muscles are an important source of body heat

*heat produced in cellular respiration is lost

*heat is transported by blood vessels

Muscular Responses

One method of studying muscle function is to remove a single fiber and connect it to a device that records its responses to electrical stimulation.

THRESHOLD STIMULUS

*a minimal stimulus needed to elicit a muscular contraction; an impulse in a motor neuron normally releases enough ACh to bring the muscle fibers in its motor unit to threshold

RECORDING A MUSCULAR CONTRACTION

*myogram – a recording of an electrically stimulated isolated muscle pulling a lever

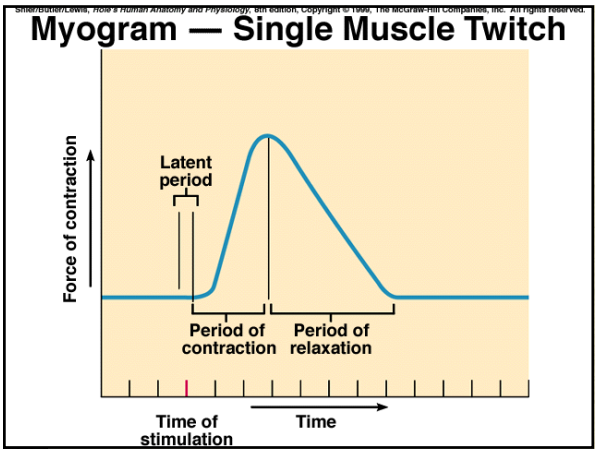
*twitch – a single contraction reflecting stimulation of some motor units in a muscle

*latent period – time between stimulus & responding muscle contraction

*refractory period – the very brief moment after muscle contraction that a muscle remains unresponsive (rests)

*all-or-none response - muscle fibers contract completely (they may not shorten completely)

*motor units respond in an all-or-none manner



SUMMATION

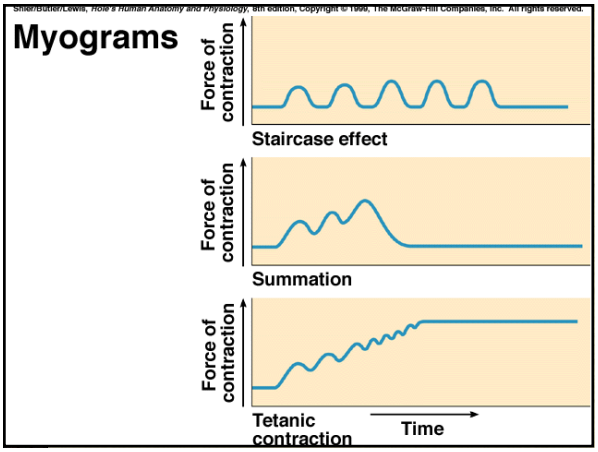
*a rapid series of stimuli summation of twitches & sustained contraction

*tetanic contraction – forceful, sustained contraction without relaxation (eye-twitching)

RECRUITMENT of MOTOR UNITS

*the # of muscle fibers in a motor unit varies considerably; the fewer muscle fibers in the motor units, the finer the movements that can be produced in a particular muscle; the motor units of the muscles that move the eyes can have fewer than 10 muscle fibers per motor unit; the motor units of the muscles of the back may have a 100+ muscle fibers = coarse vs. fine movements of the eyes

*small #s of motor units contract at low intensity of stimulation *at increasing intensities of stimulation, other motor units are recruited until the muscle contracts with maximal tension



SUSTAINED CONTRACTION

*strength of contraction increases when contractions fuse due to recruitment of fibers *when muscles are at rest they still maintain tone – partial contraction

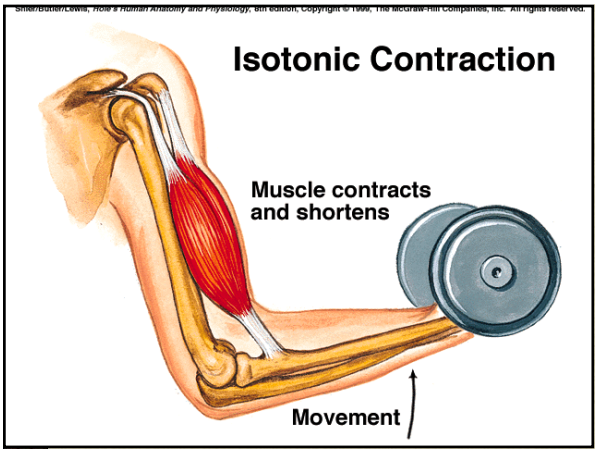
TYPES OF CONTRACTION

*isotonic – when muscle contracts & ends pulled closer together (ie. lifting an object) – is concentric contraction because the muscle is shortened

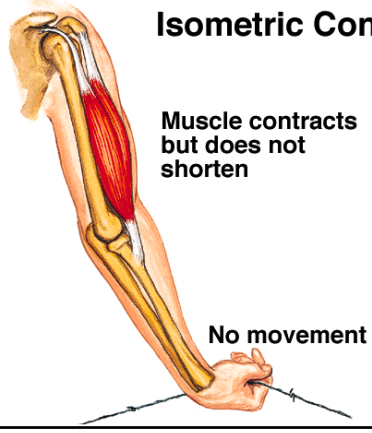
*isometric – when muscle contracts & its attachments do not move (ie. pushing against a wall)

*eccentric contraction – when muscle doesn't generate enough force to lift or move an object

*most body movements involve both isometric & isotonic



Isometric Contraction



Muscle contracts but does not shorten

No movement

FAST & SLOW TWITCH MUSCLE FIBERS

*muscle contraction speed =‘s a muscle’s specific function

*slow-contracting (red) muscles can generate ATP fast enough to keep up contractions for long periods of time (have more myoglobin so have more O_2) (long muscles in the back); & have more mitochondria than white muscles

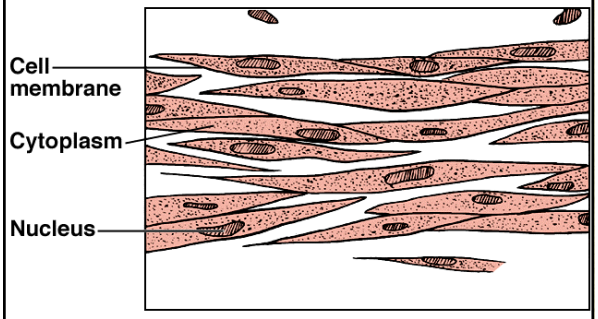
*fast-contracting (white) muscles have reduced abilities for aerobic respiration & fatigue easily. (have less myoglobin so have less O_2) (hand & eye muscles)

Smooth Muscles

A. Smooth Muscle Fibers
- *cells are shorter than fibers of skeletal muscle
- *contain actin & myosin filaments
- *lack transverse tubules & sarcoplasmic reticula are not well-developed
- *2 types of smooth muscle fiber: multiunit & visceral smooth muscle
- *visceral smooth muscle displays rhythmicity – a pattern of spontaneous repeated contraction
- *peristalsis aids movement of material through hollow organs

B. Smooth Muscle Contraction
- *ACh & norepinephrine are neurotransmitters for smooth muscles
- *hormones & stretching affect smooth muscle contractions
- *can maintain a contraction longer than skeletal muscle
- *can change length without changing tautness

Smooth Muscle Tissue



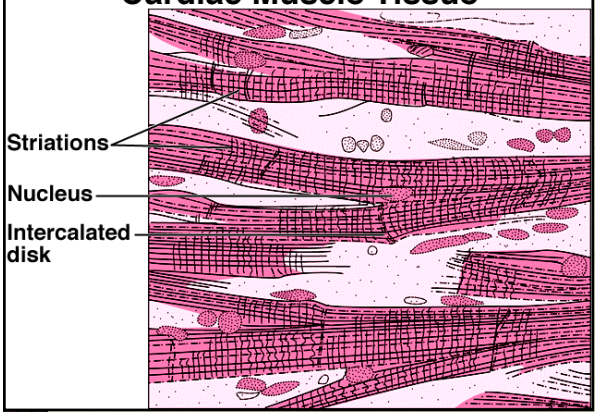
Cardiac Muscle

A. Cardiac muscle has transverse tubules that supply extra calcium, and can thus contract for longer periods.

B. Complex membrane junction, called intercalated disks, join cells and transmit the force of contraction from one cell to the next, as well as aid in the rapid transmission of impulses throughout the heart.

C. Cardiac muscle is self-exciting and rhythmic, and the whole structure contracts as a unit (syncytium).
- *responds in all-or-none manner

Cardiac Muscle Tissue

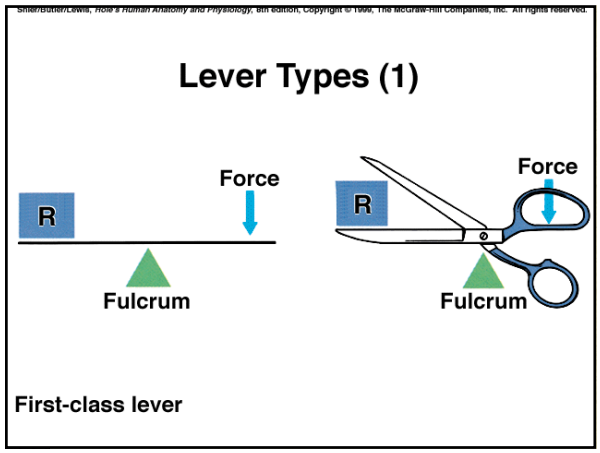


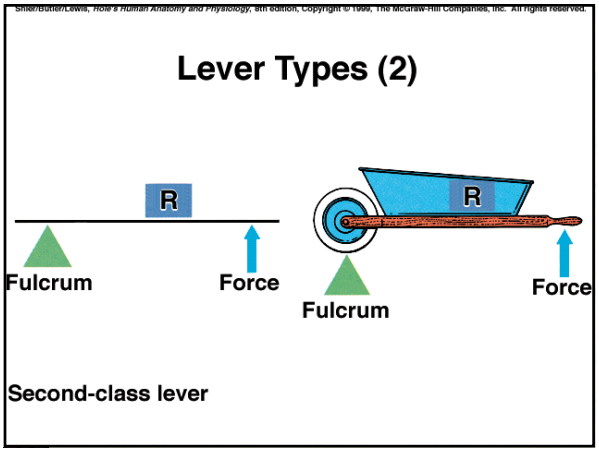
Skeletal Muscle Actions

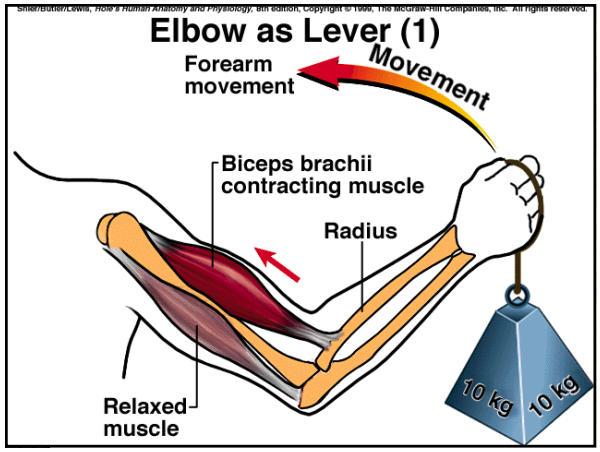
A. Support and Protection
- *shape, support, protect internal organs & tissues, house tissues that produce blood cells, & store inorganic salts

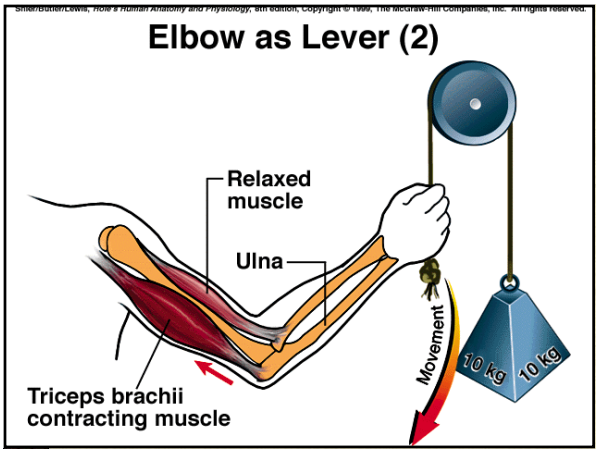
B. Body Movement
- *bones & muscles function as levers for movement
- *4 components of a lever: rod, pivot, resistance, energy
  1) rigid bar or rod
  2) pivot or fulcrum on which the bar turns
  3) object moved against resistance
  4) force that supplies energy for movement of the bar
- 1st class lever – resistance-pivot-force (pivot = fulcrum)
- 2nd class lever – pivot-resistance-force
- 3rd class lever – resistance-force-pivot

Levers provide a range of movements.







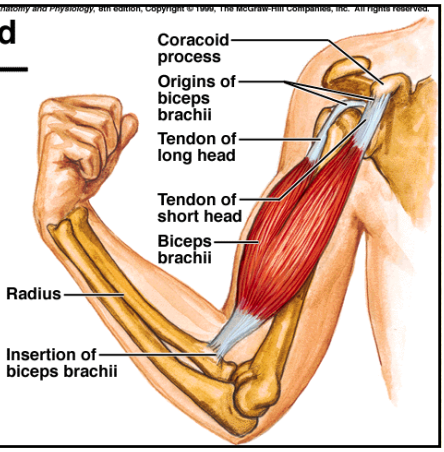


Skeletal Muscle Actions

Origin and Insertion
- *insertion – movable end of a skeletal muscle to a bone
- *origin – immovable end
- *some muscles have more than one origin or insertion; when a muscle contracts its insertion is pulled toward its origin
- *biceps brachii's insertion is on the radius & origin is on the scapula

Interaction of Skeletal Muscles
- *function in groups
- *prime mover – responsible for most of a movement
- *synergists – aid prime movers
- *antagonists – resist the movement of the prime mover
- *smooth movements depend upon antagonists giving away to the actions of prime movers

Origin and Insertion — Biceps Brachii



Major Skeletal Muscles

A. Muscles are named according to any of the following criteria: size, shape, location, action, number of attachments, or direction of its fibers.

B. Muscles of Facial Expression
*lie between skin of face & scalp; communicate feelings

C. Muscles of Mastication
*attached to mandible for chewing

D. Muscles that Move the Head & Vertebral Column
*muscles in the neck & back move the head

Major Skeletal Muscles

E. Muscles that Move the Pectoral Girdle
*muscles connect scapula to bones of arm; move the arm

F. Muscles that Move the Arm
*connect humerus to various regions of the pectoral girdle, ribs, & vertebral column

G. Muscles that Move the Forearm
*connect radius & ulna to humerus & pectoral girdle

H. Muscles that Move the Hand
*arise from the distal end of the humerus & from radius & ulna

I. Muscles of the Abdominal Wall
*connect rib cage & vertebral column to pelvic girdle

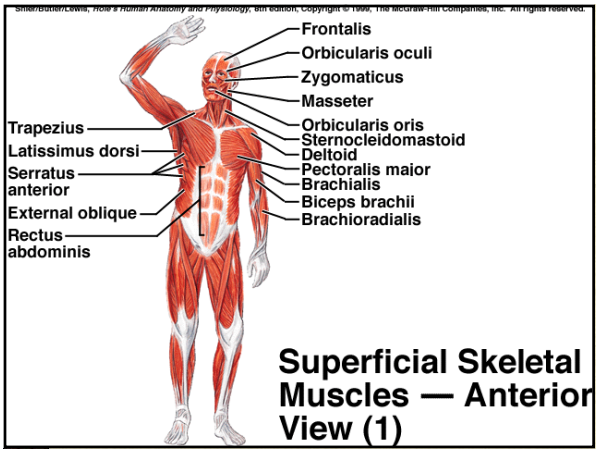
Major Skeletal Muscles

J. Muscles of the Pelvic Outlet
*form the floor of the pelvic cavity & fill the space of the pubic arch

K. Muscles that Move the Thigh
*attached to the femur & some part of the pelvic girdle

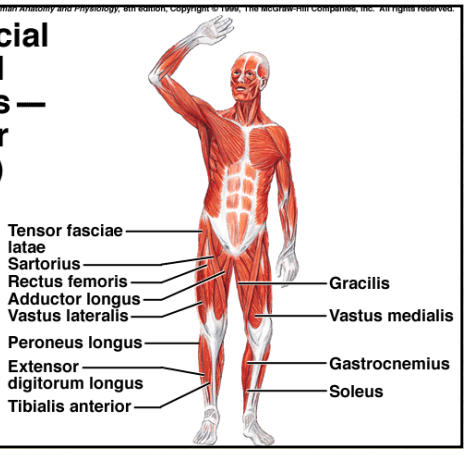
L. Muscles that Move the Leg
*connect the tibia or fibula to the femur or pelvic girdle

M. Muscles that Move the Foot
*attach the femur, tibia, & fibula to various bones of the foot

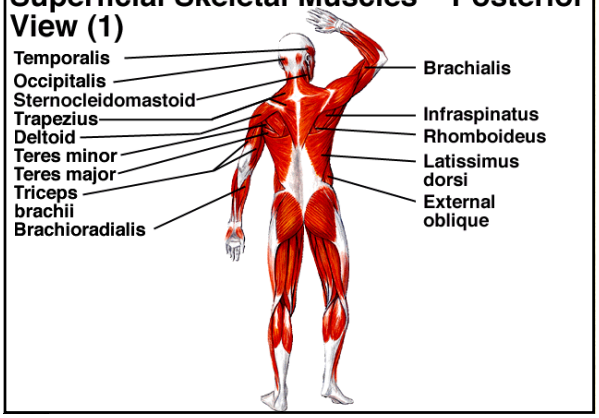


Superficial Skeletal Muscles — Anterior View (1)

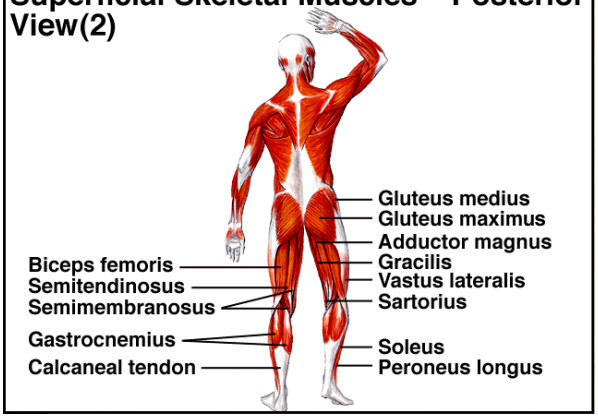
Superficial Skeletal Muscles — Anterior View (2)



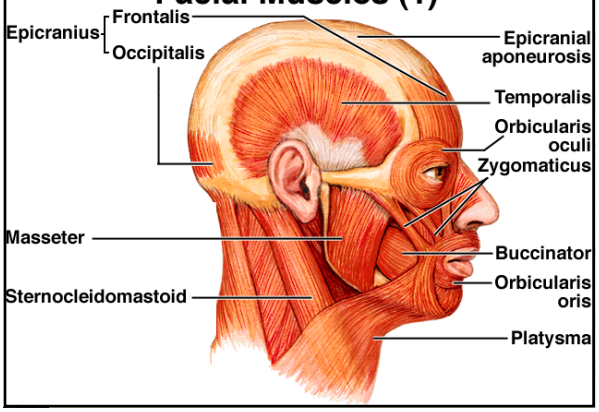
Superficial Skeletal Muscles—Posterior View (1)

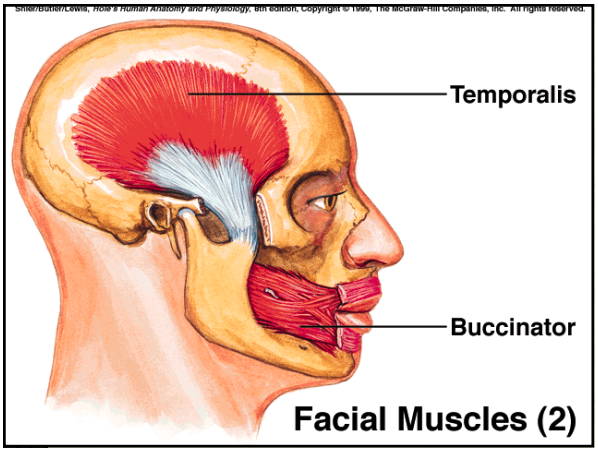


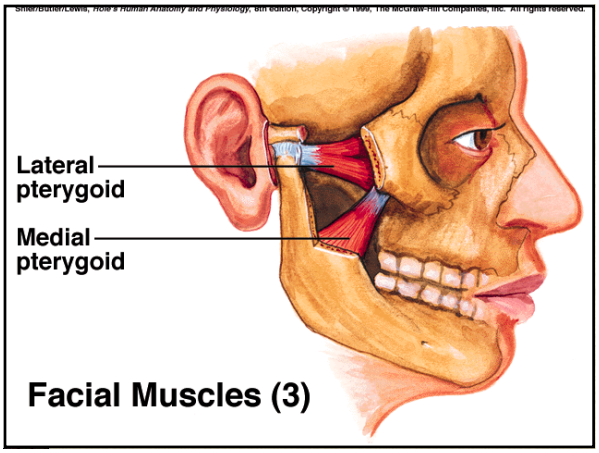
Superficial Skeletal Muscles—Posterior View(2)

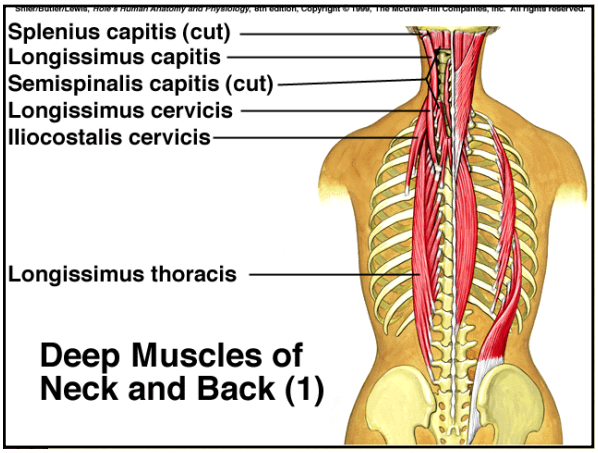


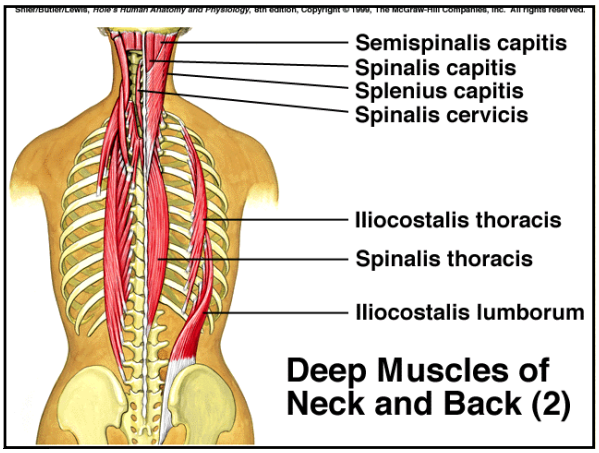
Facial Muscles (1)





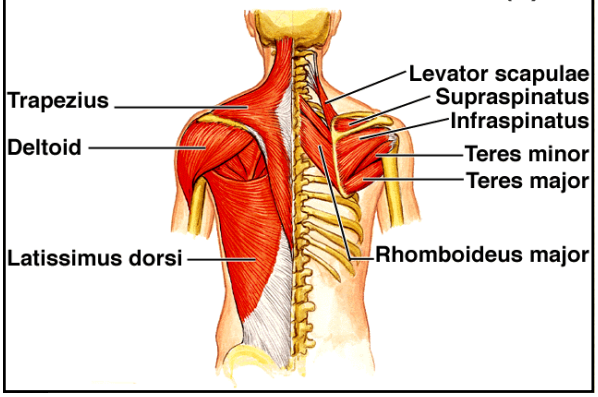




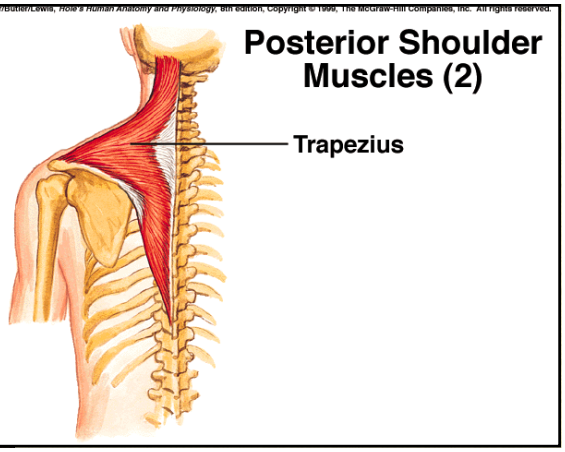


Deep Muscles of Neck and Back (2)

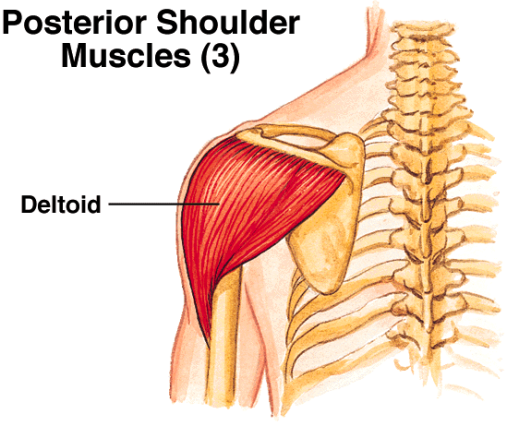
Posterior Shoulder Muscles (1)



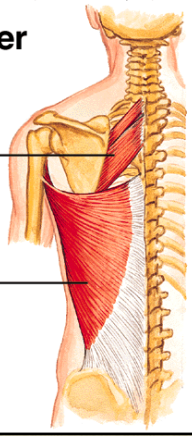
Posterior Shoulder Muscles (2)



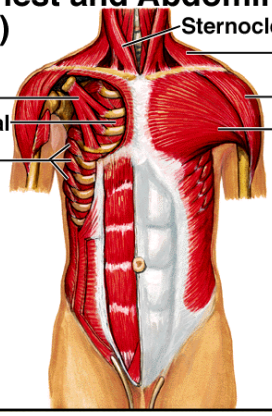
Posterior Shoulder Muscles (3)



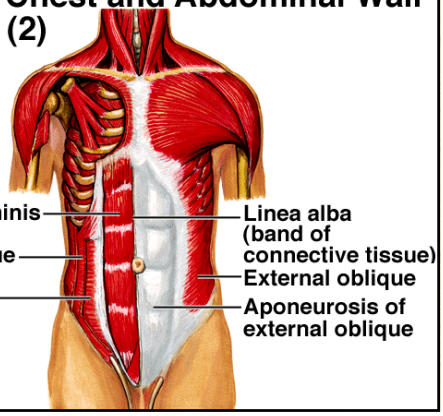
Posterior Shoulder Muscles (4)



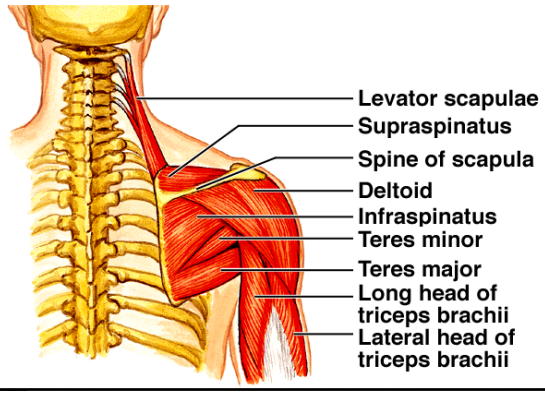
Anterior Chest and Abdominal Wall Muscles (1)



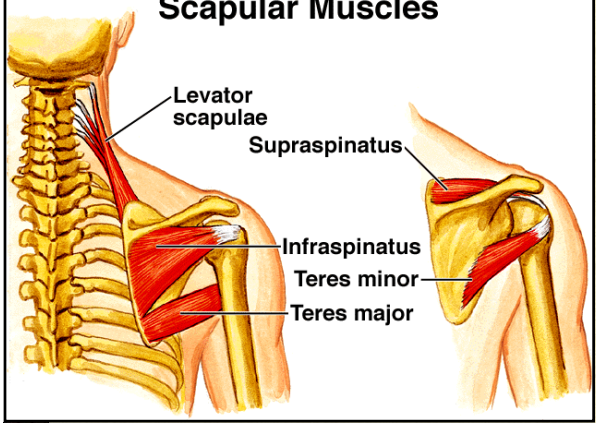
Anterior Chest and Abdominal Wall Muscles (2)



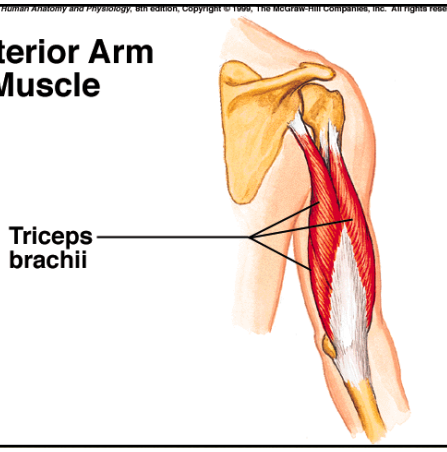
Posterior Scapular and Arm Muscles



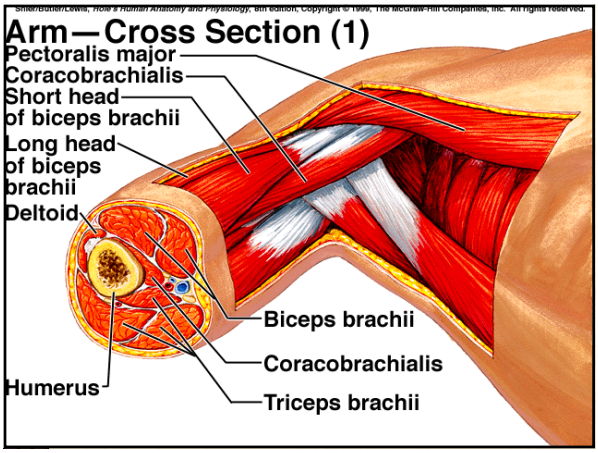
Scapular Muscles



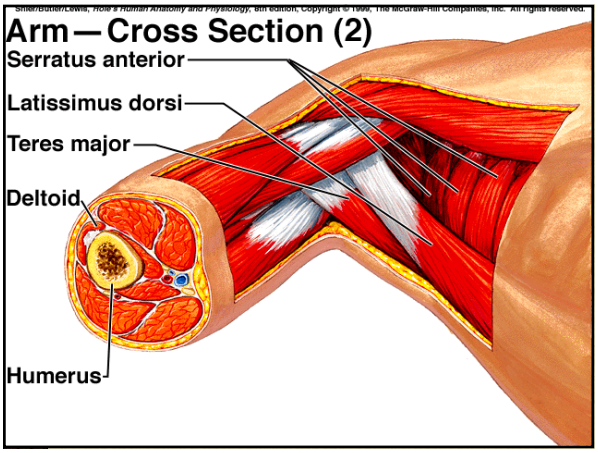
Posterior Arm Muscle



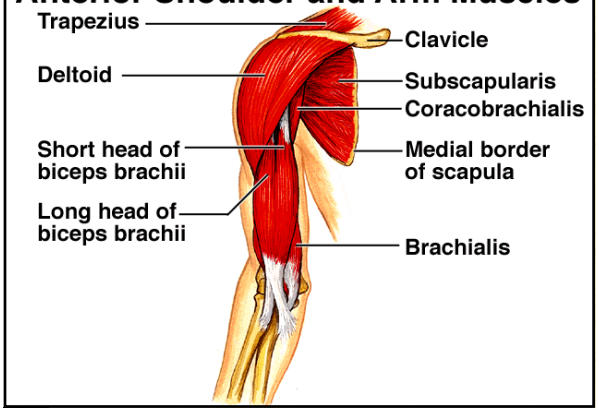
Arm—Cross Section (1)

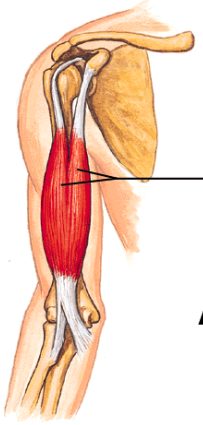


Arm—Cross Section (2)

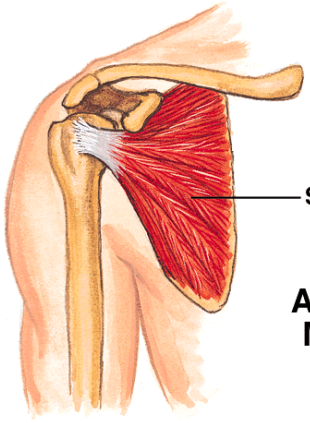


Anterior Shoulder and Arm Muscles

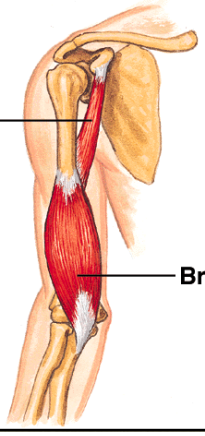




Anterior Arm Muscles (1)

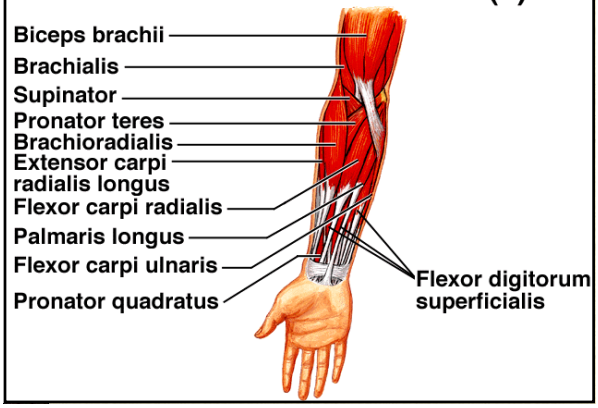


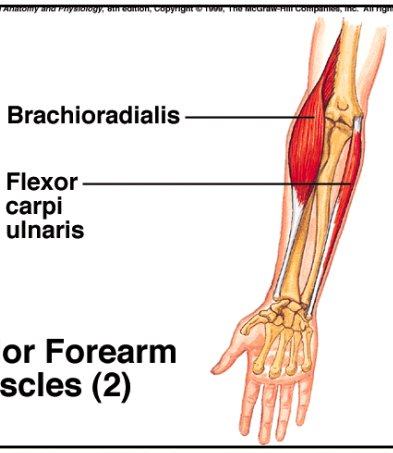
Anterior Arm Muscles (2)



Anterior Arm Muscles (3)

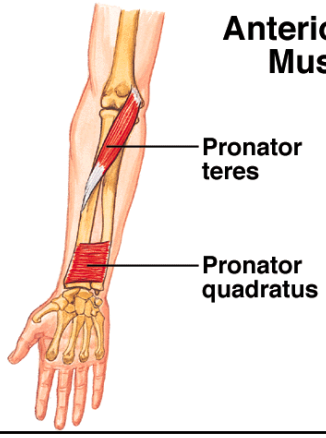
Anterior Forearm Muscles (1)





Anterior Forearm Muscles (2)

Anterior Forearm Muscles (3)



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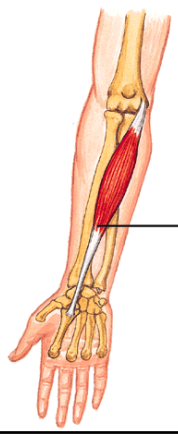
Anterior Forearm Muscles (4)



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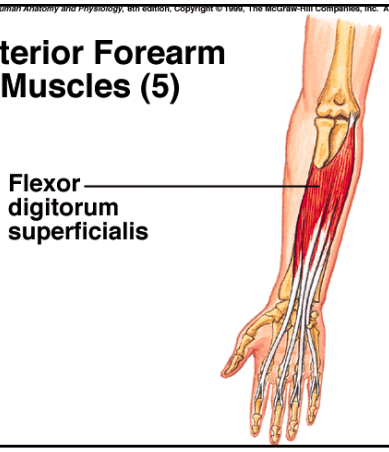
Anterior Forearm Muscles (5)



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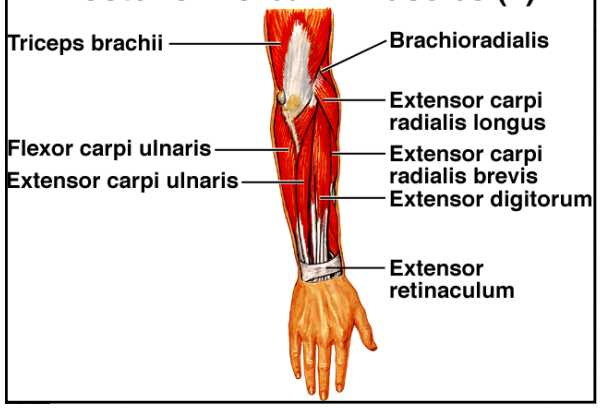
Posterior Forearm Muscles (1)



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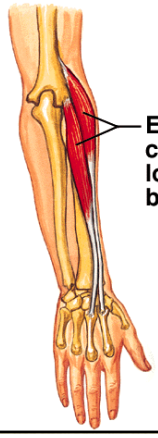

Posterior Forearm Muscles (2)

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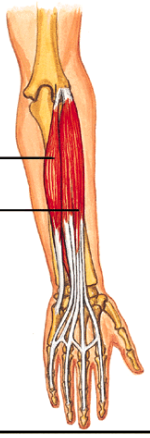
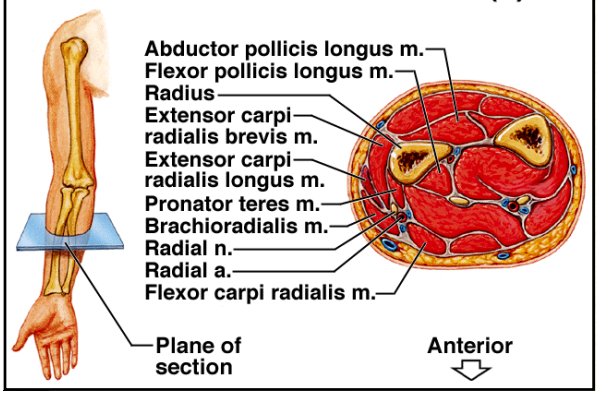
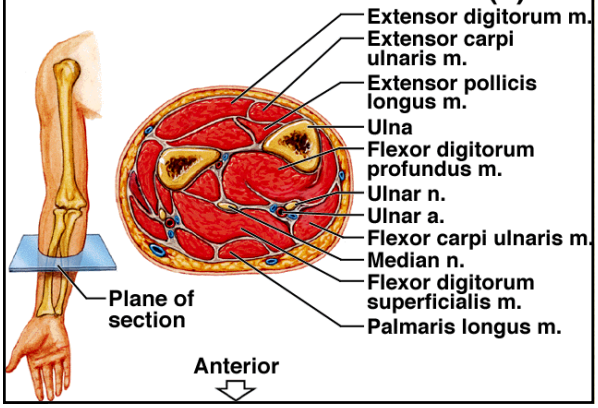


Posterior Forearm Muscles (3)

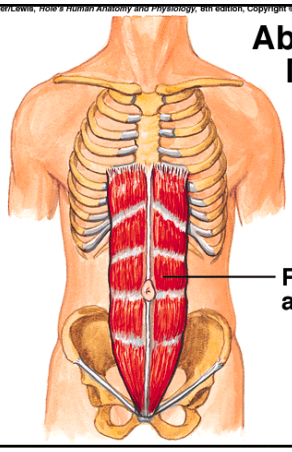
Forearm — Cross Section (1)



Forearm — Cross Section (2)



Abdominal Wall Muscles (1)



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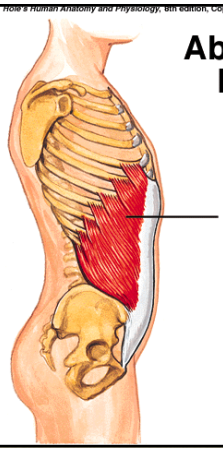
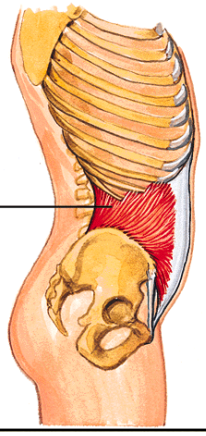
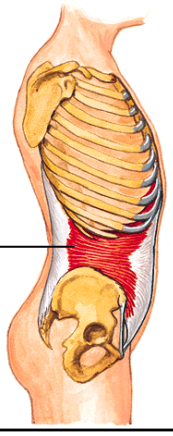


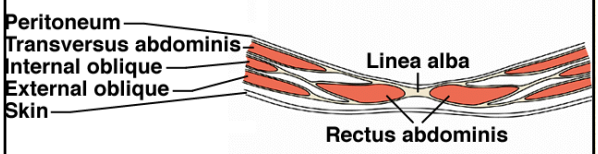
Abdominal Wall Muscles (3)



Abdominal Wall Muscles (4)



Abdominal Muscles — Transverse Section



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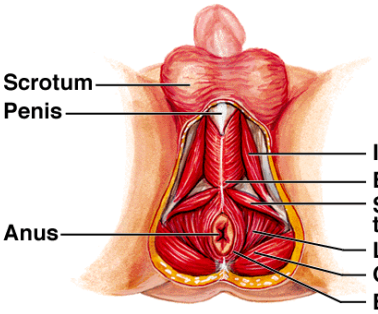
Pelvic Outlet Muscles — Male



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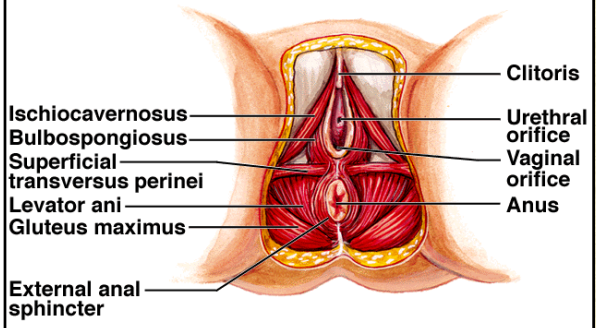
Pelvic Outlet Muscles — Female



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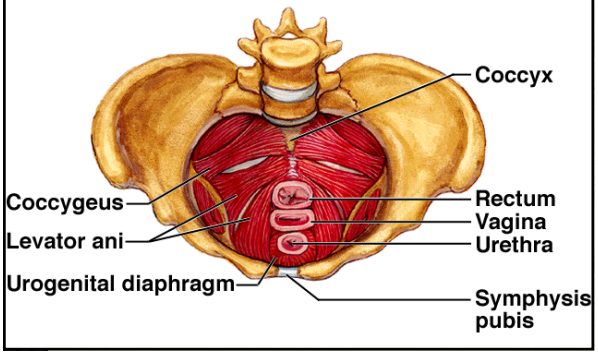
Pelvic and Urogenital Diaphragms — Female



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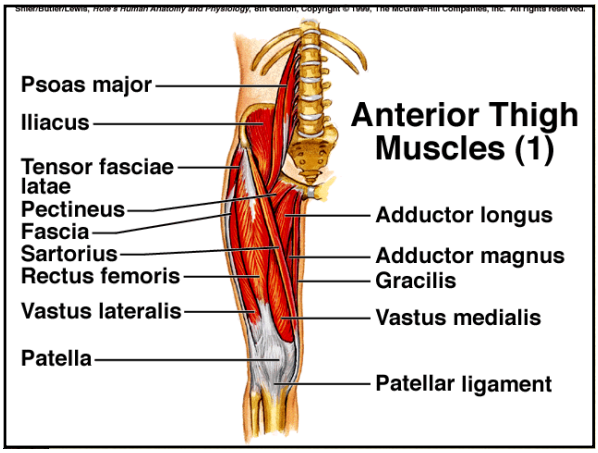
Anterior Thigh Muscles (1)



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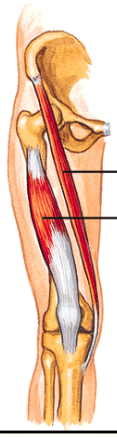
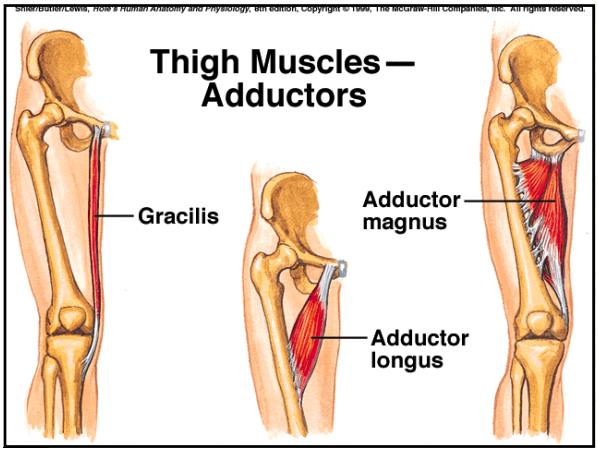
Anterior Thigh Muscles (2)



Thigh Muscles — Adductors



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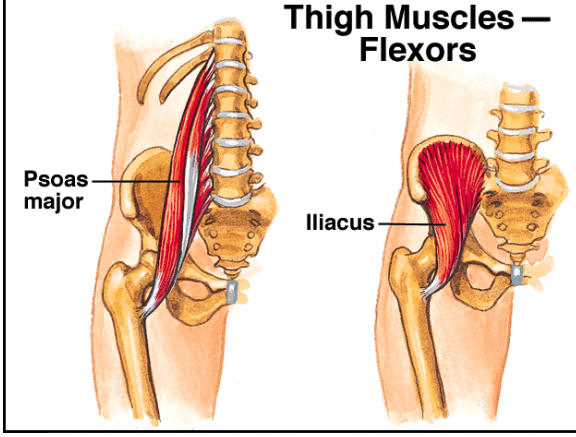
Thigh Muscles — Flexors



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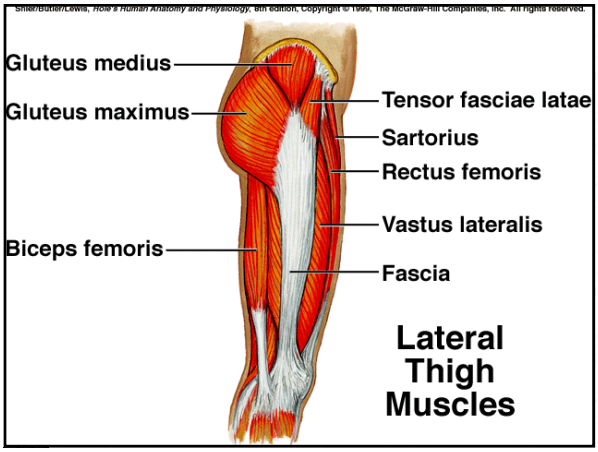

Lateral Thigh Muscles

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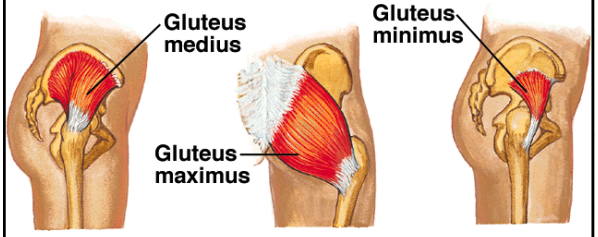
Gluteal Muscles



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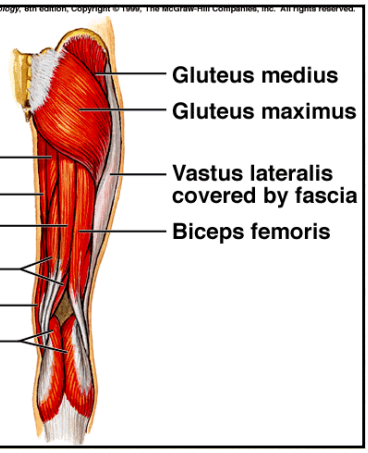
Posterior Thigh Muscles



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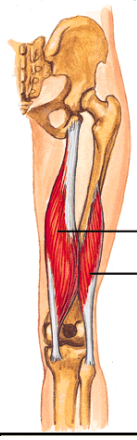
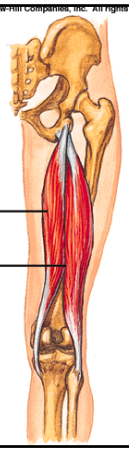
Posterior Thigh Muscles — Flexors (1)



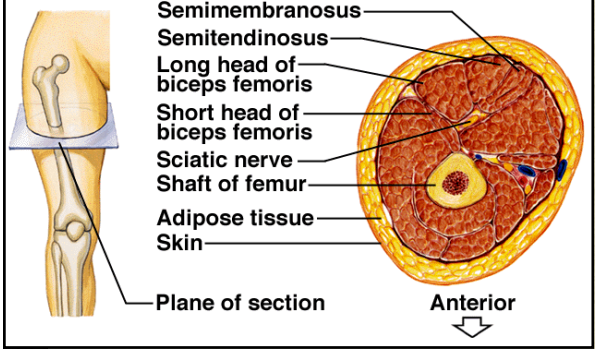
Posterior Thigh Muscles—Flexors (2)



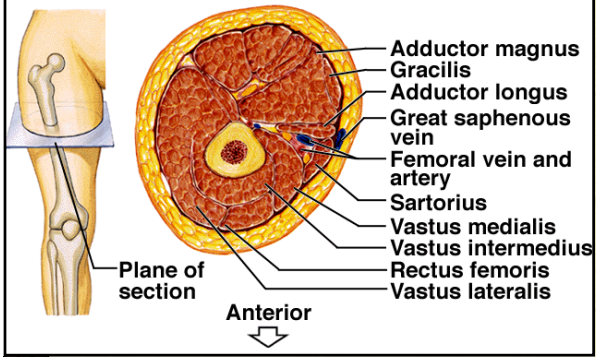
Semitendinosus

Biceps femoris (long head)

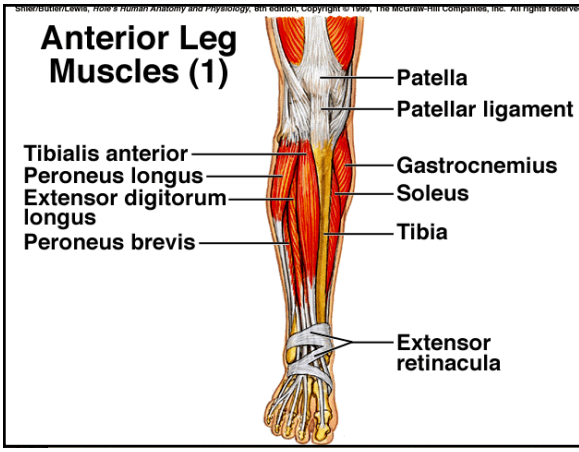
Thigh — Cross Section (1)



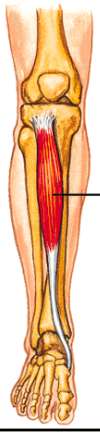
Thigh — Cross Section (2)



Anterior Leg Muscles (1)

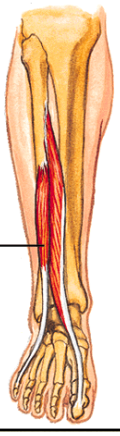


Anterior Leg Muscles (2)



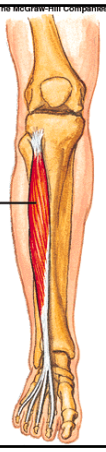
Tibialis anterior

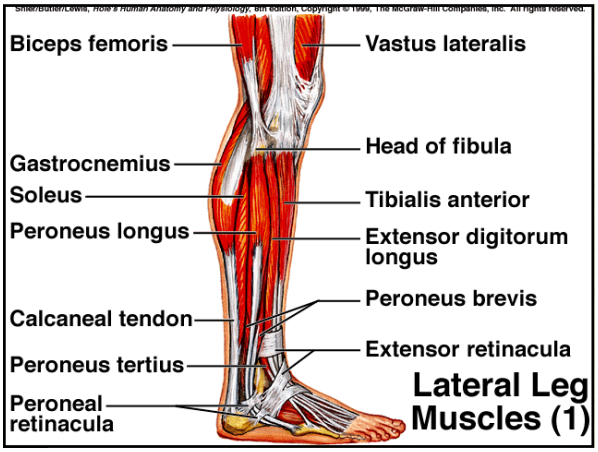
Anterior Leg Muscles (3)



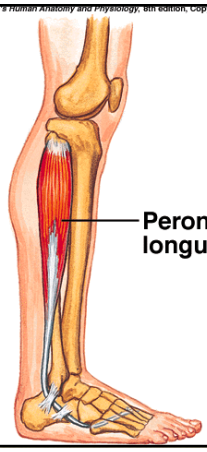
Peroneus tertius

Anterior Leg Muscles (4)





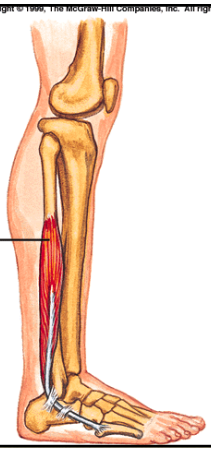
Lateral Leg Muscles (1)

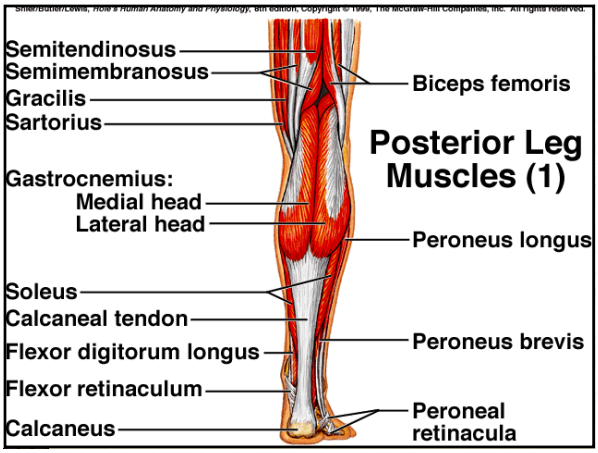


Lateral Leg Muscles (2)

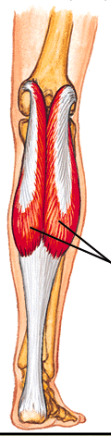
Peroneus longus

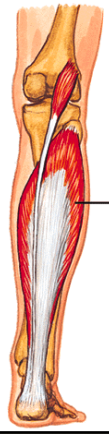
Lateral Leg Muscles (3)



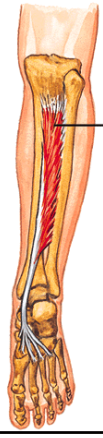


Posterior Leg Muscles (2)



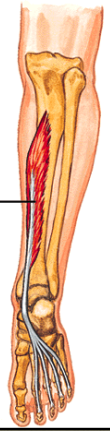


Posterior Leg Muscles (3)

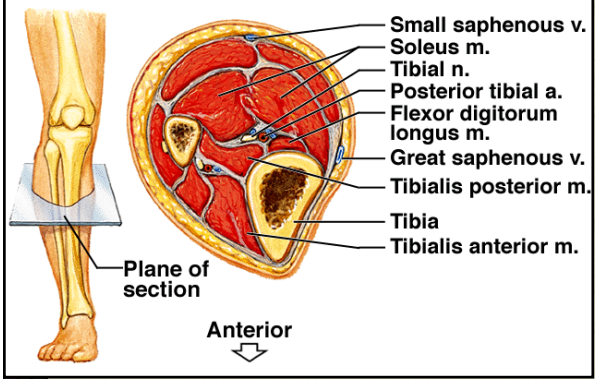


Posterior Leg Muscles (4)

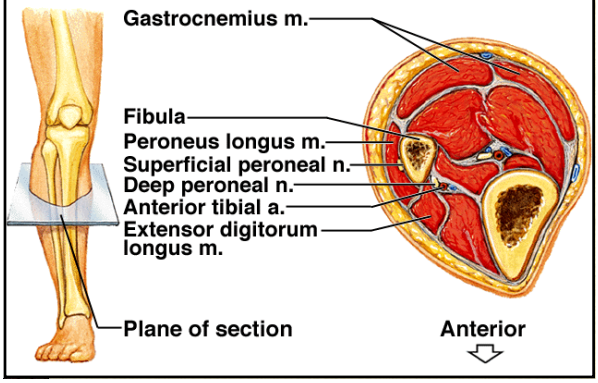
Posterior Leg Muscles (5)



Leg — Cross Section (1)



Leg — Cross Section (2)



Remember – At the end of the chapter is a Chapter Summary that is your Study Guide for the Chapter 9 test.