Terminology, Muscle Structure, and Muscle Function

Terminology

International anatomic terminology

- Terminologia Anatomica (TA): international standard on human anatomic terminology
- Latin is basis for creating terms, but English terms are commonly used.

Anatomic terminology for muscle names and attachments is sometimes confusing and is not always consistent.

Muscle Attachment Terminology

Based on physiology or function

- Origin/Insertion

Based on anatomy or structure

- Proximal/Distal
- Arises from/Attaches to
- From/To

Presented in text as:

- Origin, proximal attachment, arises from
- Insertion, distal attachment, attaches to

The origin of a muscle is the attachment that does not move when the muscle contracts; the origin is usually the proximal attachment or the attachment closer to the midline or center of the body.

The insertion is the attachment that does move when the muscle contracts; the insertion is usually the distal attachment or the attachment farther from the midline or center of the body.

Origins and insertions of a muscle often switch—that is, the insertion could stay fixed while the origin moves. When this situation occurs, the movement is called a reverse action.

Muscle Structure and Function

Muscles and force

- Muscle can change chemical energy (from ATP) into mechanical energy.
- Energy: the capacity to do work
- Dynamic force: creates movement and change
- Static force: expends energy, but creates no movement or noticeable change, like pushing against a wall

Massage professionals often seek to transform static force into dynamic force, thereby releasing the energy to achieve therapeutic goals.

Function of Skeletal Muscle

Movement production

Joint stabilization

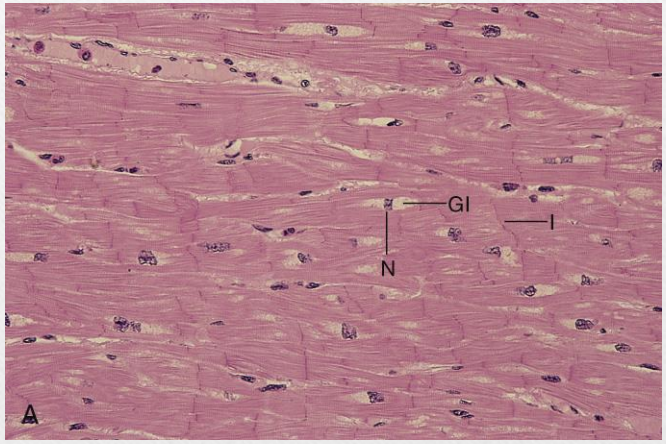
Posture maintenance

Heat generation

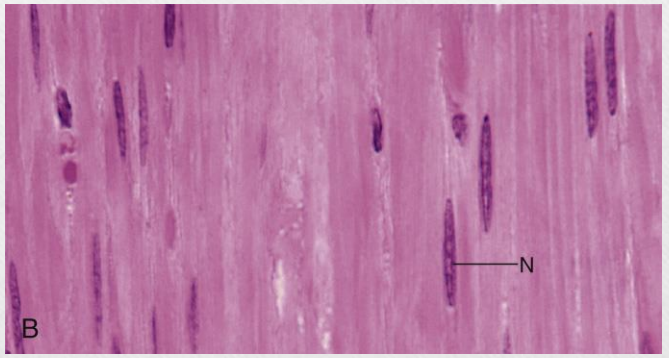
Because the shoulder has so many movements, it can develop rotator cuff impingement or become dislocated relatively easily.

Function of Cardiac and Smooth Muscle Tissue

Cardiac muscle



Smooth muscle



Another name for cardiac muscle is Striated involuntary muscle.

Cardiac muscle is found in only one organ of the body: the heart. The functional anatomy of cardiac muscle tissue resembles that of skeletal muscle but has specialized features related to the role of pumping blood continuously.

Smooth muscle comprises small, tapered cells with single nuclei. The two types of smooth muscle tissue are visceral muscle and multiunit muscle. Visceral smooth muscle usually has a rhythmic self-excitation, or self-rhythm, that spreads across the entire tissue.

Functional Characteristics of Muscle

Excitability: the ability to receive and respond to a stimulus

Contractility: the ability to shorten forcibly with adequate stimulation

Extensibility: the ability to be stretched or extended

Elasticity: the ability to recoil and resume the original resting length after being stretched

A stimulus is a change in the internal or external environment. Massage therapy often applies specific stimuli to achieve specific goals.

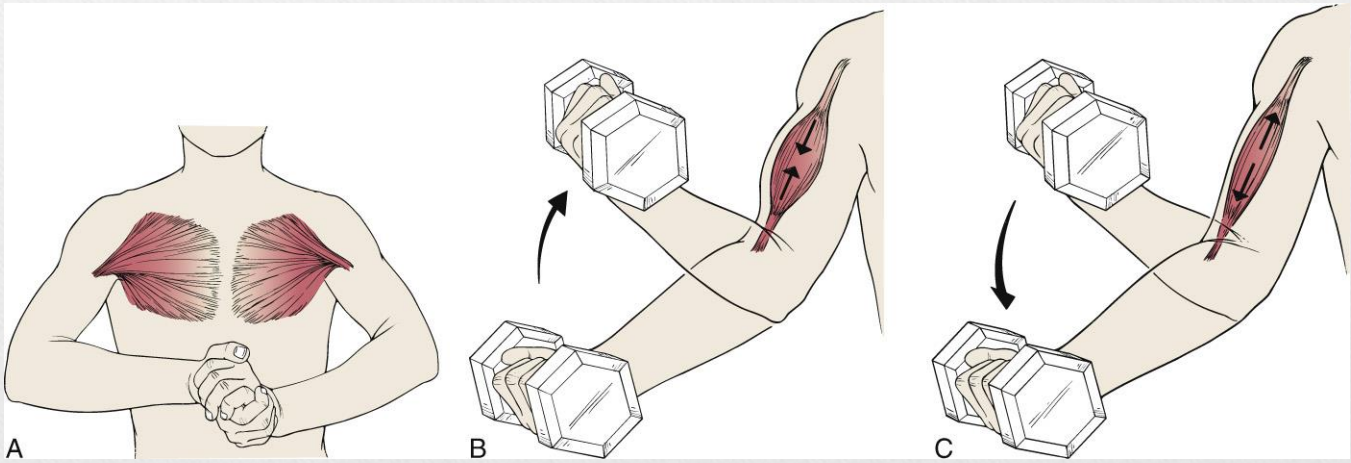
Types of Muscle Actions

Isometric

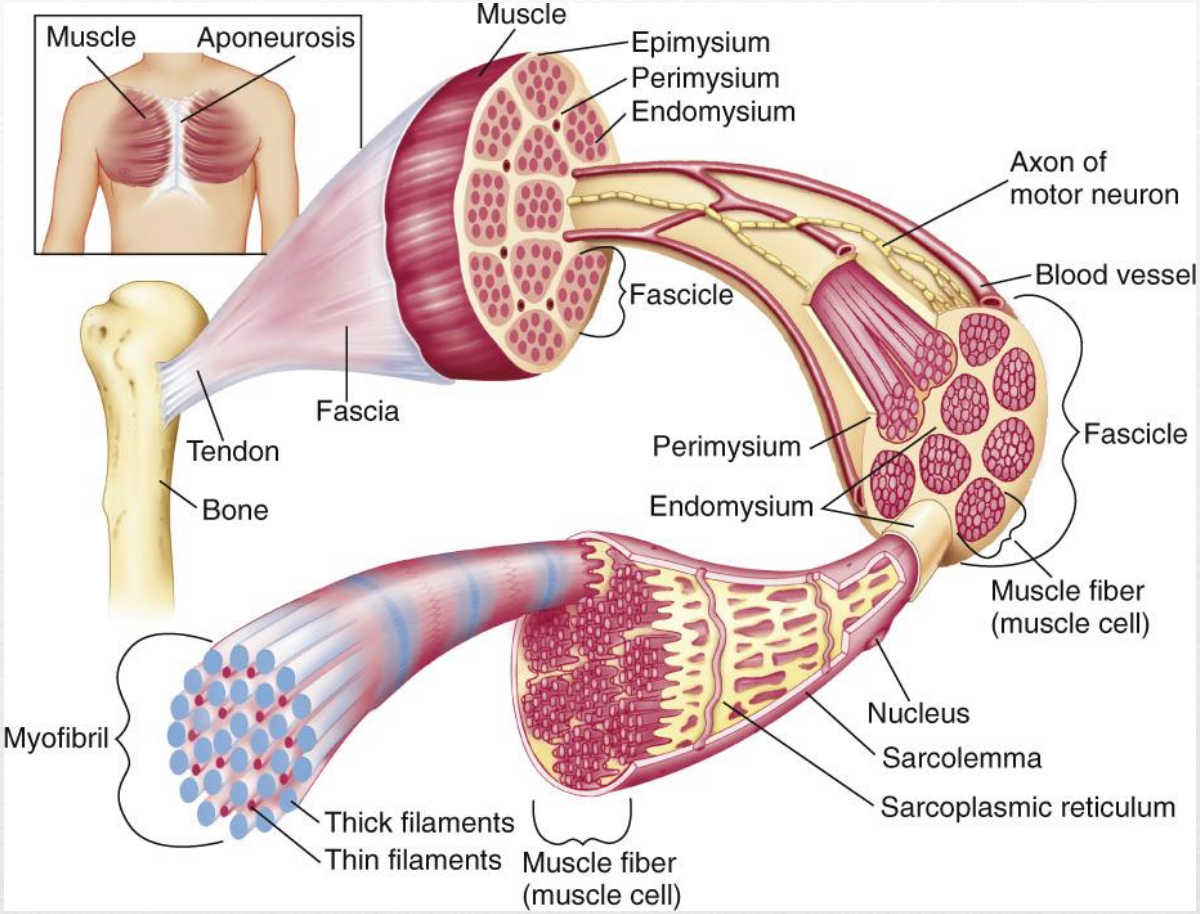
Isotonic

- Concentric
- Eccentric

Isotonic action occurs when tension develops as muscle shortens or lengthens. Concentric describes shortening; eccentric refers to lengthening.



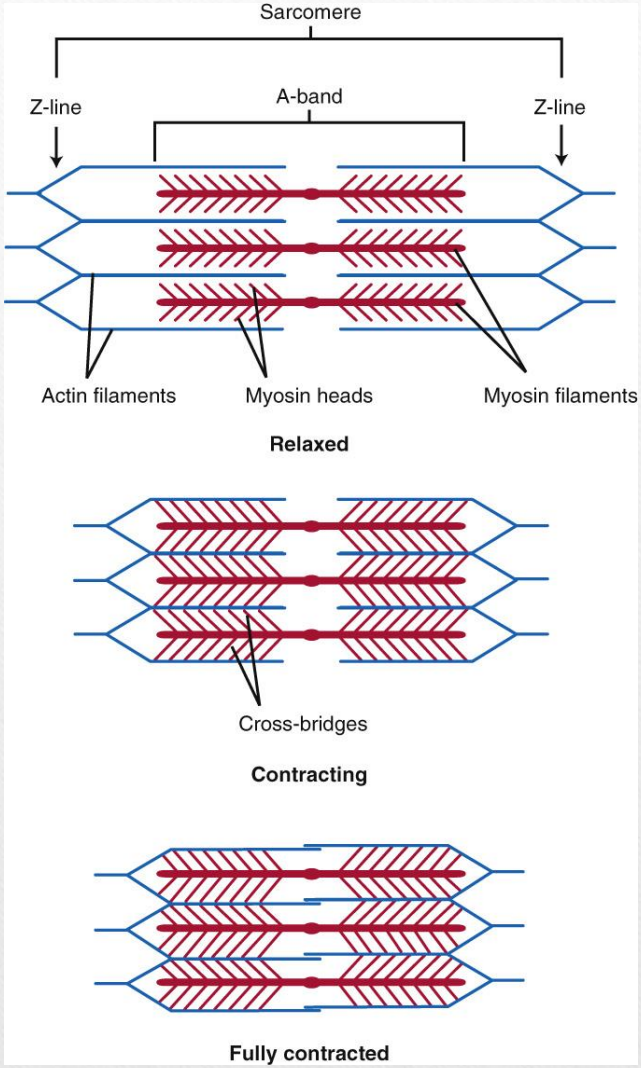
Structure of a Muscle Organ



What types of tissues make up a skeletal muscle?

Muscle fibers (muscle cells), large amounts of connective tissue and nerve fibers, and many blood vessels.

Relaxed/Contracted Muscle



Sarcomeres are the structural units of contraction in skeletal muscle fibers.

What happens when a muscle cell contracts?

Its individual sarcomeres shorten.

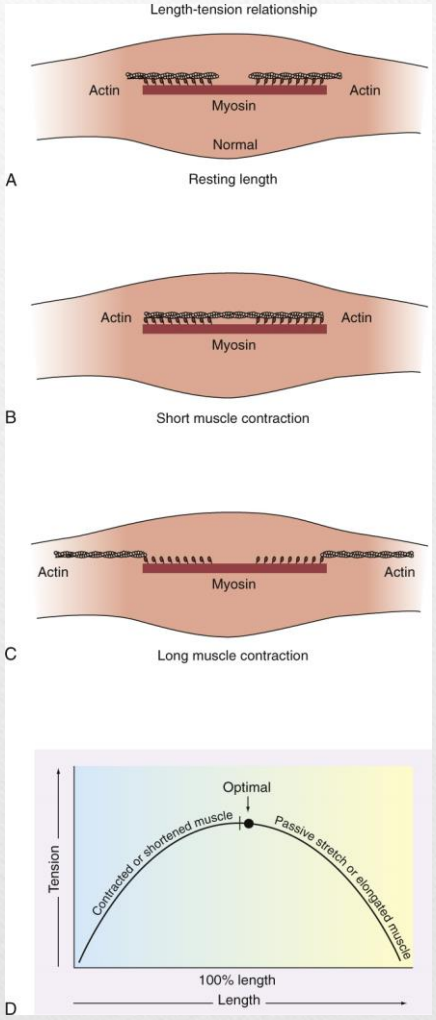
The two types of filaments found within the myofibril are myosin and actin. Cross-bridges from the myosin attach to active sites on the actin subunits of the filaments; then sliding begins. Each cross-bridge attaches and detaches several times during a contraction, which generates tension and pulls the thin actin filaments toward the center of the sarcomere.

Length and Tension

Direct link between tension development and length of the muscle

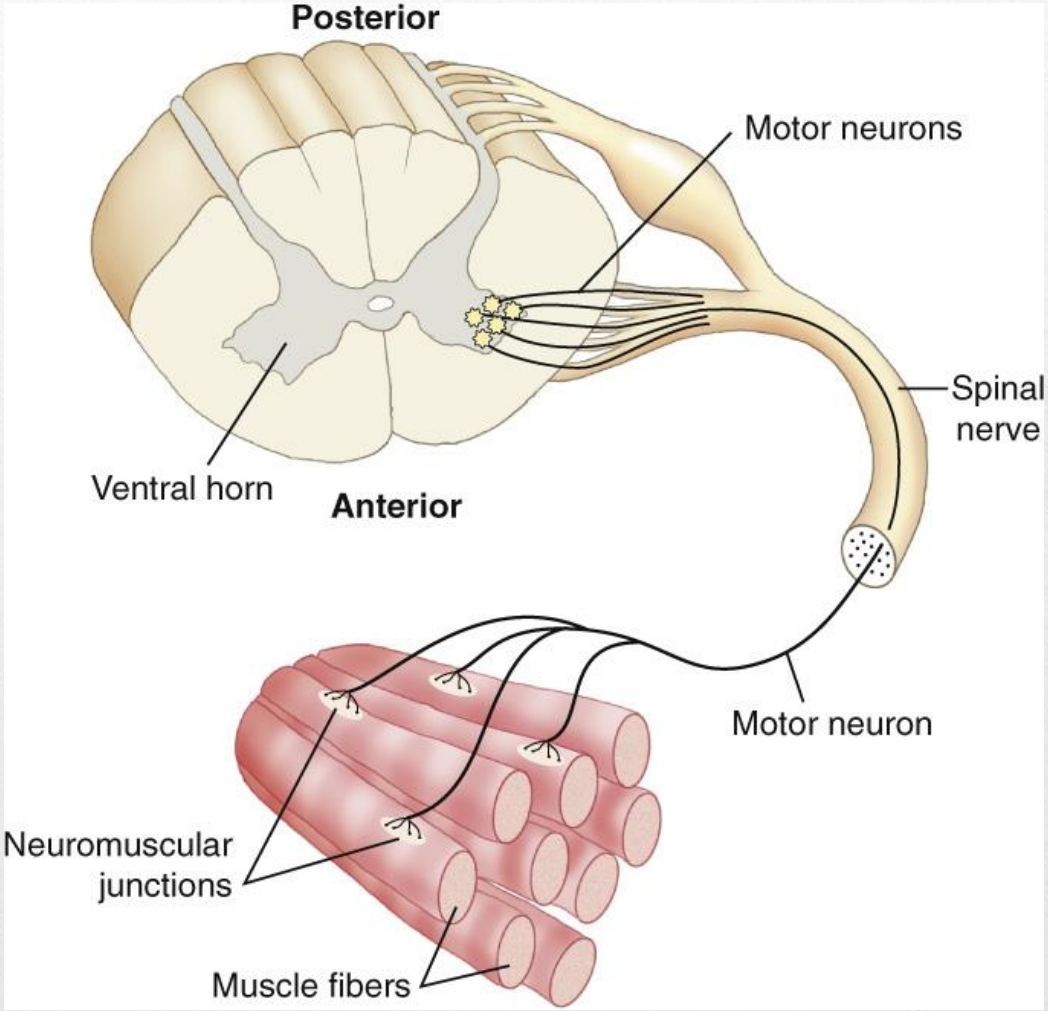
If shortened, or lengthened beyond optimum, tension decreases.

An optimum length exists at which a muscle is capable of developing maximal tension.



Innervation

A motor point is where a motor neuron enters a muscle. Motor points act like pilot lights in gas furnaces.



Acupuncture points correspond to motor point locations and the locations of the Golgi tendon organs. Some agreement has been reached that these points correspond to neurovascular bundles in the muscles. This supports the idea of a neurologic and a vascular component of pathologic conditions of these points and the benefits of acupuncture and trigger point methods.

Resting Muscle Tone

Resting tone: minimal amount of tautness maintained by muscles, even at rest

- Keeps muscles ready to respond
- Maintains the natural firmness of our muscles and their state of ready responsiveness
- Help stabilize our joints and maintain our posture

Resting muscle tone is controlled by small signals from the spinal cord, brain, and spindles of the individual muscles.

Because the stimulation occurs alternately to different sets of motor units within the muscle itself, some parts of the muscle contract while others relax. This keeps the muscle, especially postural muscles, from fatiguing.

Threshold Stimulus and Treppe

Threshold stimulus

The stimulus at which the first noticeable muscle contraction occurs

Treppe

First contraction of a muscle unit may be as little as one half the strength of those that occur in succession after it.

Maximal stimulus is the stimulus intensity beyond which the muscle fails to increase in strength or the point at which all the motor units of the muscle have been recruited.

Energy Source for Muscle Contraction

ATP

Glucose

Oxygen: aerobic respiration

Anaerobic respiration: no immediate oxygen use

- Produces lactic acid
- Leads to oxygen debt

The body tries to make up for oxygen debt by breathing more heavily.

This helps convert lactic acid.

Muscle Fatigue

State of exhaustion produced by strenuous muscular activity

Low levels of ATP

Physiologic or psychologic?

Psychologic muscle fatigue produces an exhausted feeling that keeps us from continuing a muscular activity, thereby reducing the chance of serious injury

Types of Muscle Fiber

Fast-twitch (white) fiber

- Contract most rapidly, forcefully

Slow-twitch (red) fiber

- Contract more slowly, less intensely

Intermediate-twitch fibers

- Combine red and white qualities

Fast-twitch fibers fatigue more quickly than slow-twitch fibers

Repair of Muscles

Within hours of an injury, enzymes in the body begin to digest the damaged cell portion.

Satellite cells, which are inactive during normal muscle activity, begin to form the new fibers by creating myotubes, which combine to form myofibrils.

These new cells take on the characteristics of muscle fibers.

Cardiac muscle has no satellite cells, and its damaged cells are replaced with fibrous connective tissue.

Smooth muscle is able to regenerate itself throughout life.

Myotatic Units

Muscles rarely act independently.

Muscles are part of larger movement patterns.

It might help to think of the muscles in a myotatic unit as actors. In one production, one actor might be the star, while in another he might take a supporting role.

Names of Muscles by Function

Mover (agonist)

Antagonist

Fixator (stabilizer)

Neutralizer

Support muscle

Synergist

The antagonist usually has the opposite action of the mover, or agonist. It's usually on the opposite side of the joint from the mover.

Box 9-2 Names of Muscles by Function

Mover (agonist) A muscle or muscles using concentric contractions that are the main force causing a joint motion through a specified plane of motion; the mover or movers most responsible for the action can be called the *prime mover(s).*

Antagonist A muscle that has the opposite action to the mover and usually is located on the opposite side of the joint and eccentrically contracts and lengthens, restraining and controlling an opposite force (usually a force external to the body such as gravity).

Fixator (stabilizer) A muscle that surrounds the joint or body segment and isometrically contracts to support or stabilize one attachment of the mover (or antagonist), enabling the other attachment of the mover (or antagonist) to work effectively. Usually, the fixator establishes a firm base for the more distal attachment to carry out movements.

Neutralizer A muscle that stops an unwanted action of the mover (or antagonist) at the attachment of the mover (or antagonist) that is moving. Like fixators, neutralizers work by way of isometric contractions.

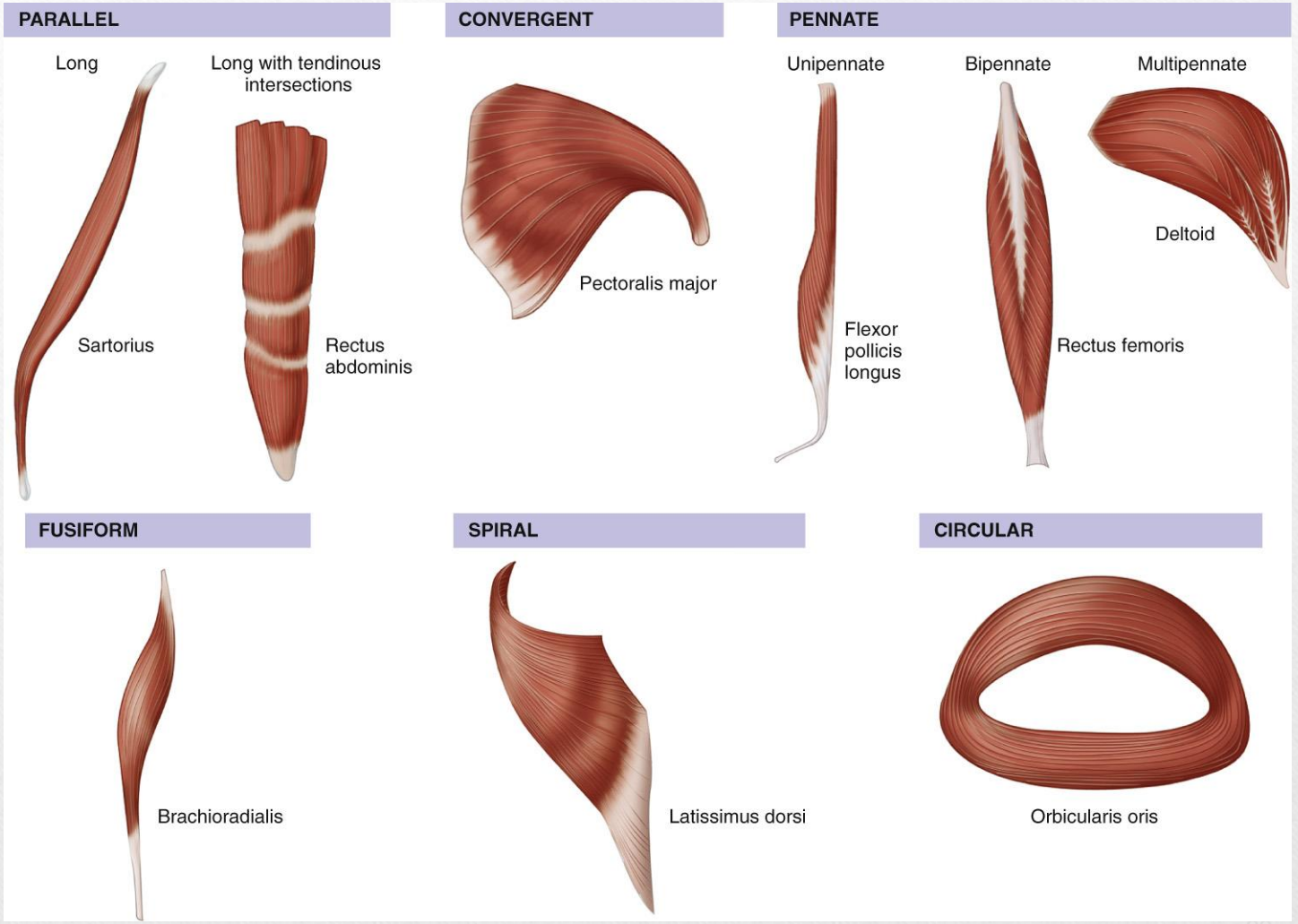
Support muscle A muscle that acts at a joint other than where the action in question is occurring to hold a body part in position while the action in question is occurring. Support muscles generally work by way of isometric contractions.

Synergist A helper mover (assistant mover or emergency mover) of the action that is occurring, more broadly defined as any muscle that helps an action occur. Synergists are sometimes known as *guiding muscles.*

Mover and antagonist muscles can contract at the same time in what is called a *co-contraction.* The result is no movement because the forces generated resist each other. Isometric contraction occurs, providing stability.

Muscle Shapes, Reflexes, Firing Patterns, and Actions

Muscle Shapes



The bundles of muscle fibers known as fascicles form different patterns in muscles, resulting in the different shapes of muscles.

These fascicle forms affect function, primarily the strength and direction of movement.

Proprioceptors and Reflexes

Receptors provide information to central nervous system.

Muscle spindles: respond to sudden, prolonged stretch

Tendon organs: respond to tension in muscle relayed to tendon

Joint kinesthetic receptors: respond to pressure, changes in joint movement

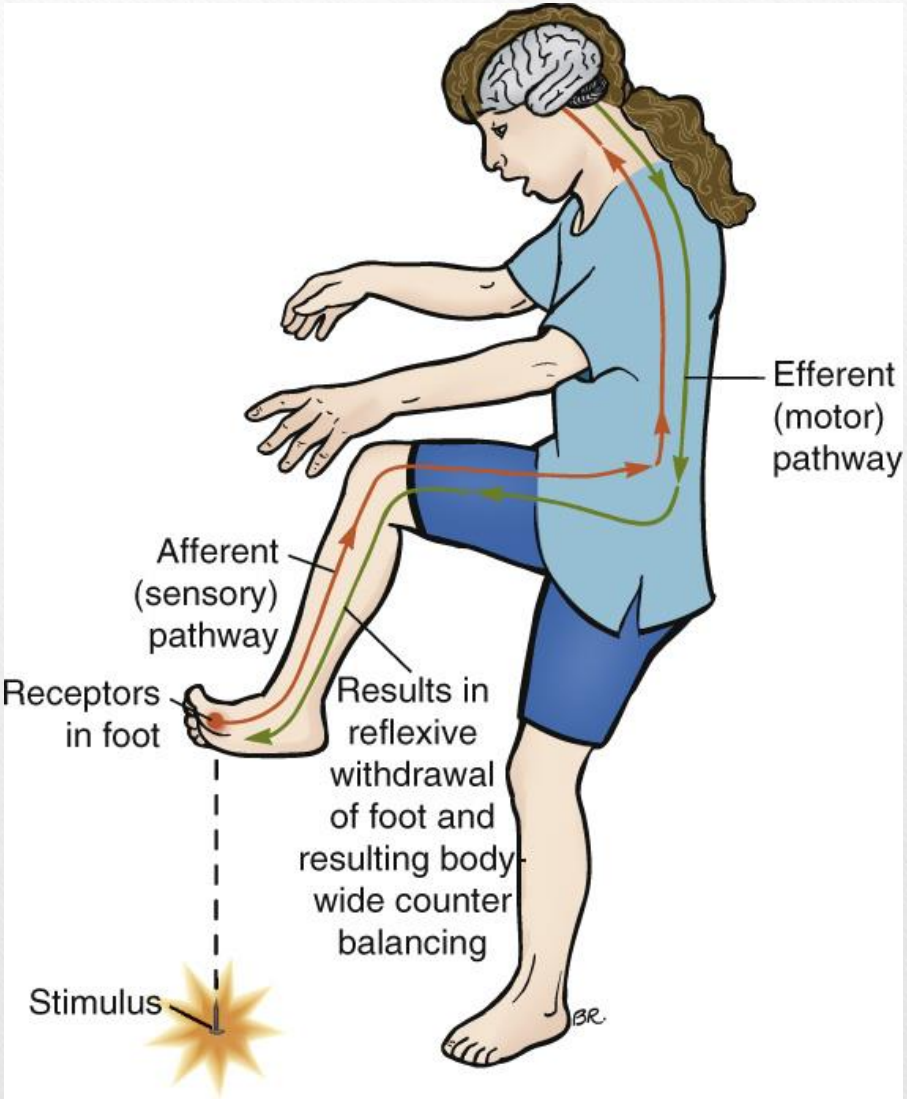
The stretch reflex, tendon reflex, flexor reflex, and crossed extensor reflex are reflex responses most often stimulated.

Stretch reflex

Tendon reflex

Flexor and crossed extensor reflex

Postural reflexes



Reflexes are automatic responses triggered by changes in the environment. They quickly and predictably restore homeostasis.

The stretch reflex is a protective contraction when a muscle is stretched suddenly or intensely.

The flexor reflex causes all the right muscles in an endangered limb to contract in order to withdraw the limb.

The purpose of posture reflexes is to maintain posture, as well as to keep the eyes in the horizontal plane and oriented forward.

Muscle Firing Patterns
Muscle Activation Sequences

Prime movers contract.

Stabilization occurs in order for fixators or co-contractors to contract.

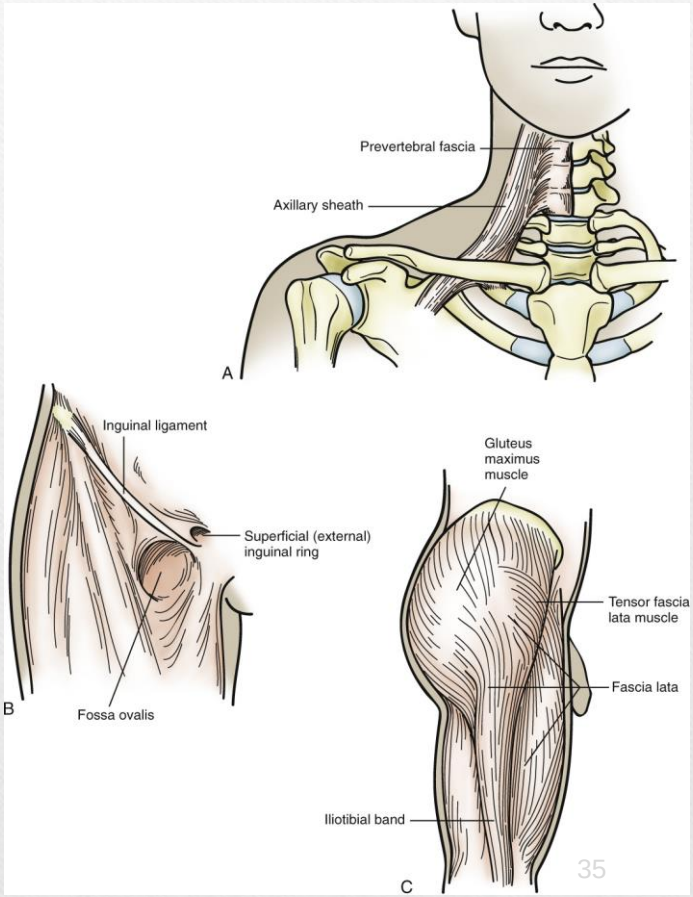
Muscles to guide joint movement contract (synergists).

Disruption of the activation sequence causes labored movement, and muscle fatigue often occurs.

Connective Tissue Component of Muscle

Fascia

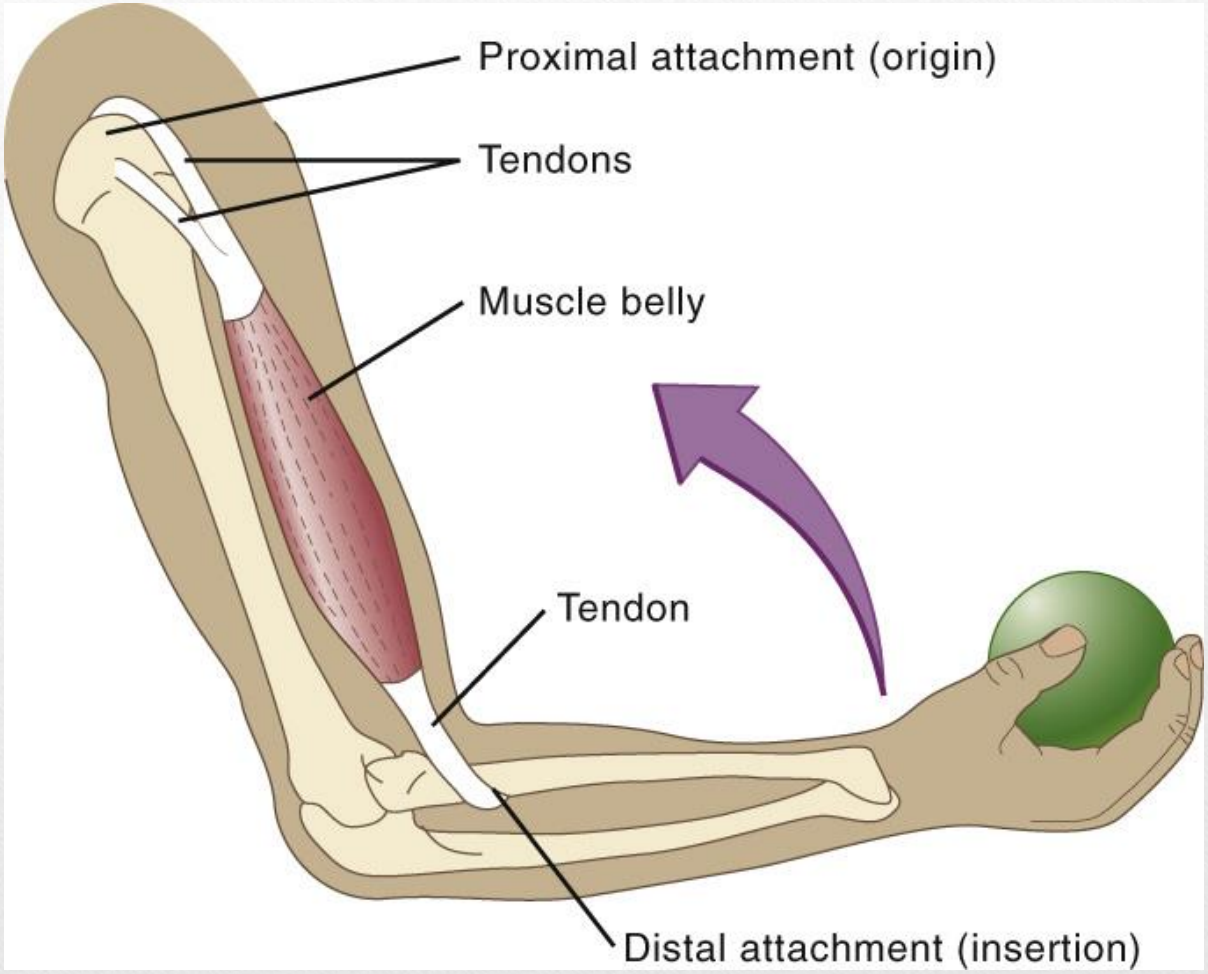
- Involved in nearly all the fundamental processes of the body
- Intimately related to muscle



If any part of a fascial structure becomes deformed or distorted, adverse effects can occur anywhere in its associated network.

Massage affects fascia.

Connective Tissue Component of Muscle



Muscle attachments do not stick on bone but wrap around the bone such that the muscles can lift the bone when they contract.

The middle of the muscle or the area with the largest and broadest concentration of muscle fibers is the belly of the muscle.

When muscle fibers contract, they pull on the connective tissue sheaths, which transmit the force to the bone to be moved.

Role of Fascia in Biochemical Activities

Connective tissue provides supporting matrix.

Superficial fascia allows for storage of fat and aids in body heat conservation.

Deep fascia promotes circulation.

Fascia supplies restraining mechanisms to assist in coordination of movement.

Connective tissue has nutritive function.

Connective tissue aids in injury repair.

Creates scar tissue

Biomechanical Terms

Fascia is involved in numerous complex biochemical activities.

Box 9-4 Biomechanical Terms Relating to Fascia

Creep Continued deformation (increasing strain) of a viscoelastic material under constant load (traction, compression, twist).

Hysteresis Process of energy loss caused by friction when tissues are loaded and unloaded.

Load The degree of force (stress) applied to an area.

Strain Change in shape as a result of stress.

Stress Force (load) normalized over the area on which it acts (all tissues exhibit stress-strain responses).

Thixotropy A quality of colloids in which the more rapidly force is applied (load), the more rigid is the tissue response.

Viscoelastic The potential to deform elastically when load is applied and to return to the original nondeformed state when load is removed.

Viscoplastic A permanent deformation resulting from the elastic potential having been exceeded or pressure forces sustained.

Adapted from Chaitow L, DeLany J: *Clinical applications of neuromuscular technique,* vol 2, New York, 2008, Churchill Livingstone.

Interconnected Myofascial Structures

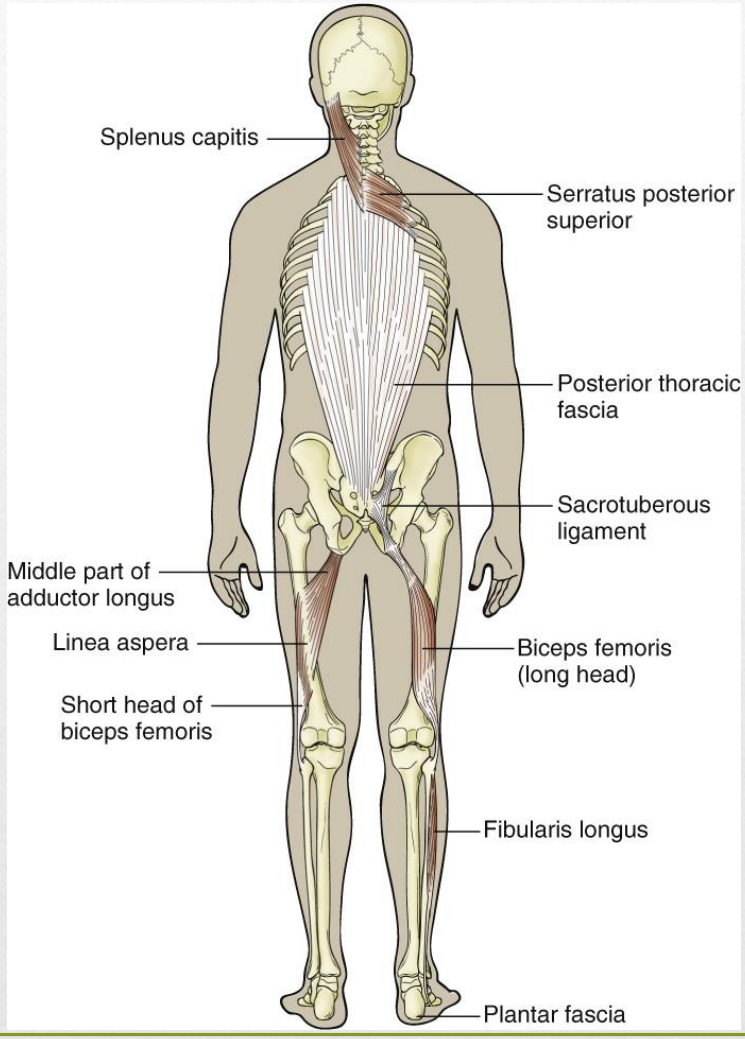
Muscles operate across functionally integrated bodywide continuities within the fascial network.

These sheets and lines follow the network of the connective tissue system, weaving a pattern of interconnected myofascial structures.

Strain, tension, fixation, compensations, and most movement are distributed along these lines.

Myofascial Continuity

As you can see, a muscle cannot be separated from its network of connective tissue.



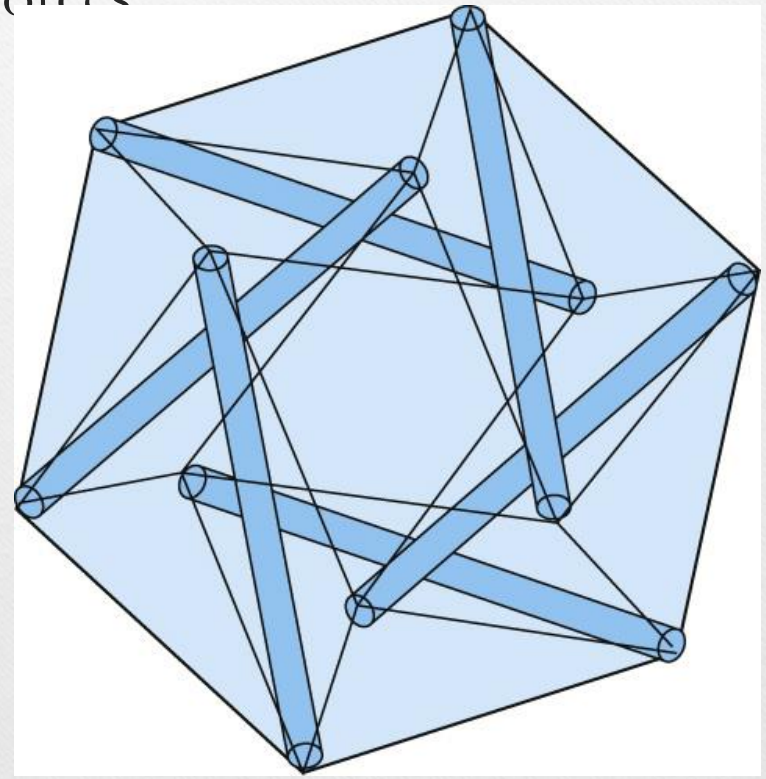
Myofascial Integration: Tensegrity

Sheets and lines of fascia create a whole-body network.

Tensegrity: balance of tensile forces

How did the term "tensegrity" come about?

It was coined by the designer R. *Buckminster Fuller from the phrase "tension integrity." The term can be applied to many natural and man-made structures as well as to the body.*



Specific Properties of Water

Ground substance of fascia consists mainly of water comprised of:

- Glycosaminoglycans (GAGs), proteoglycans, and glycoproteins
- Similar to gelatin
- Demonstrates a tendency to behave in a crystalline manner

Because of the presence of proteins bound to the water, water in our bodies is in more of a gel-like state.

The water content of fascia partially determines its stiffness, and stretching or compression of fascia causes water to be extruded (like a sponge), making the tissues more pliable.

As water in the fascia is squeezed out during tissue compression and stretching, tissues can be mobilized and stretched more effectively and comfortably than if they were still densely packed with water.

Pathologic Connective Tissue Changes

Over time, connective tissue

- Thickens
- Shortens
- Calcifies
- Erodes

Changes can come from sudden or sustained forces.

Pathologic and therapeutic viscoplastic changes are not absolutely permanent, since collagen has a limited half-life (300 to 500 days).

Individual Muscles: Overview

Arranged in layers

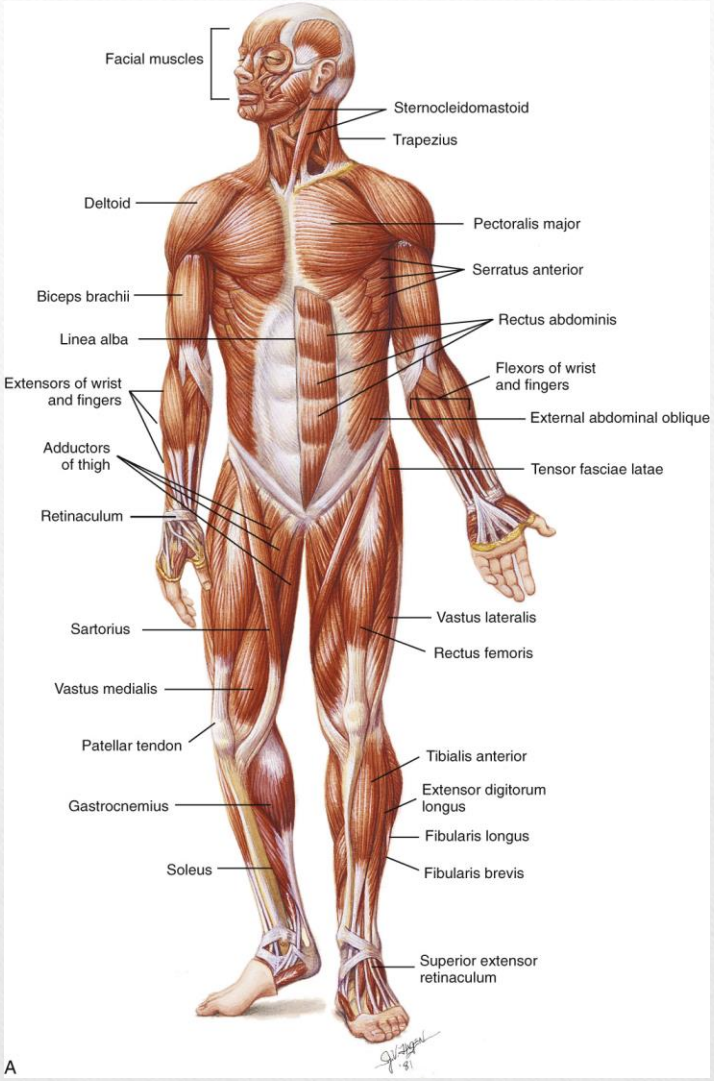
Most areas of body: three to five layers

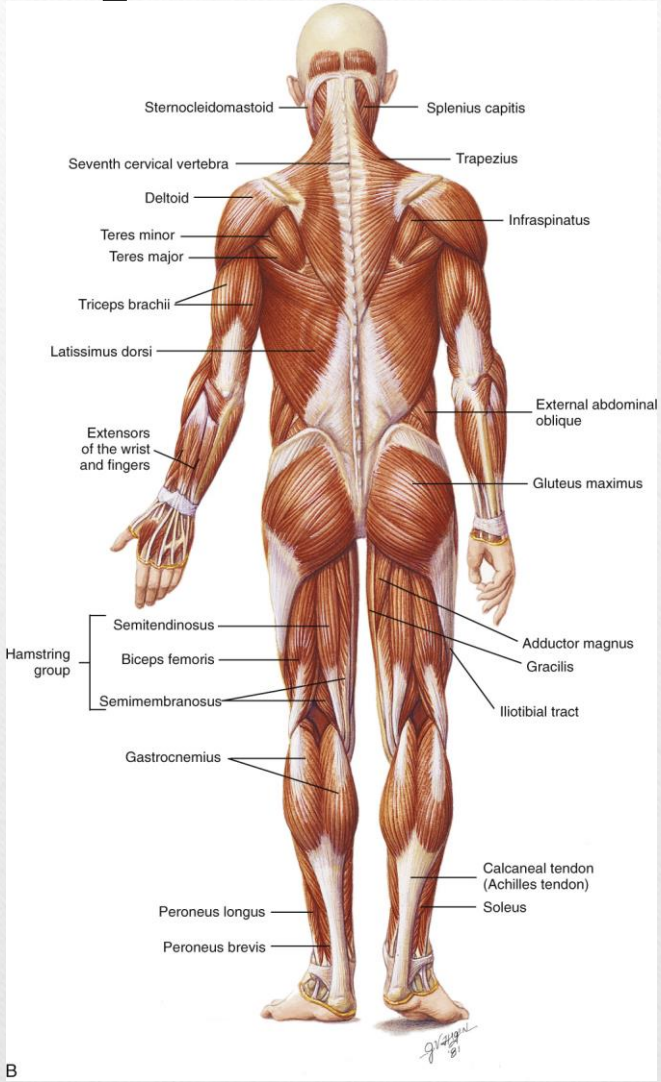
Deep muscle: closest to bone

Superficial muscle: closest to skin

When studying each muscle, pay special attention to referred pain patterns; knowledge of these symptoms can increase the efficacy of massage therapy.

Surface and Deep Muscles





Muscle Actions

Concentric action

Eccentric action

Isometric action

When a muscle is functioning during concentric action, it is called the prime mover or agonist. The muscle is producing acceleration (increase of motion or action).

When a muscle is functioning eccentrically, it is usually called the antagonist. The muscle is producing deceleration (decrease of motion or action).

In isometric action, the tissue stiffens and becomes contracted when the muscle is acting as stabilizers (fixators) and neutralizers.

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