



Intro to Anatomy:

Muscles

What are we going to learn?

- Identify three types of muscle tissue
- Describe the sliding filament hypothesis of muscle contraction
- Explain the role of calcium and adenosine triphosphate in muscle contraction
- Describe the events that occur at the neuromuscular junction
- Trace the sequence of events from nerve stimulation to muscle contraction
- Introduction to primary muscles of the body

Three Muscle Types:

- **Skeletal muscle**

- generally attached to bone
- voluntary control
- cells appear striated

- **Smooth muscle**

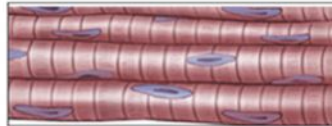
- generally found in the walls of viscera
- involuntary control
- nonstriated

- **Cardiac muscle**

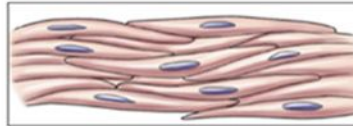
- only found in the heart
- cells are long and branch to fit closely together at junctions called intercalated discs
- involuntary control
- cells appear striated

Muscle Types Pictured

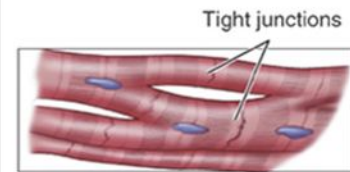
Cellular appearance:



Skeletal muscle

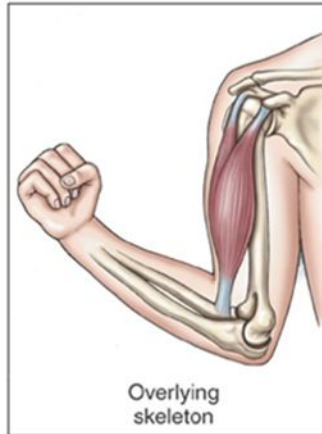


Smooth muscle

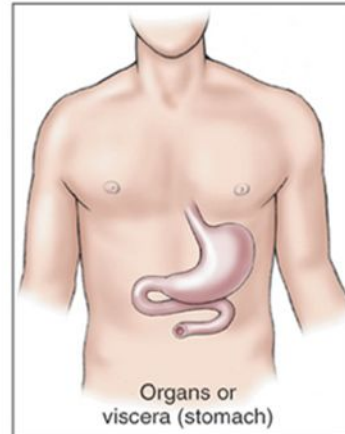


Cardiac muscle

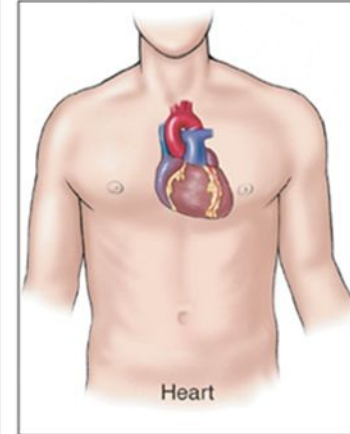
Location:



**Overlying
skeleton**



**Organs or
viscera (stomach)**



Heart

Description:

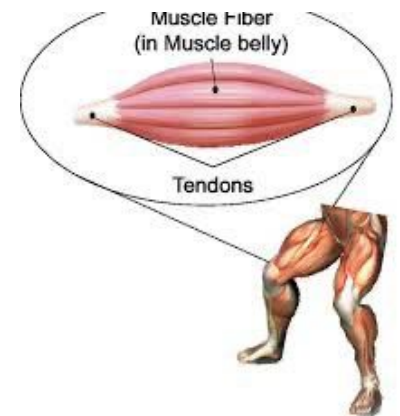
**Striated
voluntary**

**Nonstriated
involuntary**

**Striated
involuntary**

Skeletal Muscle Structure

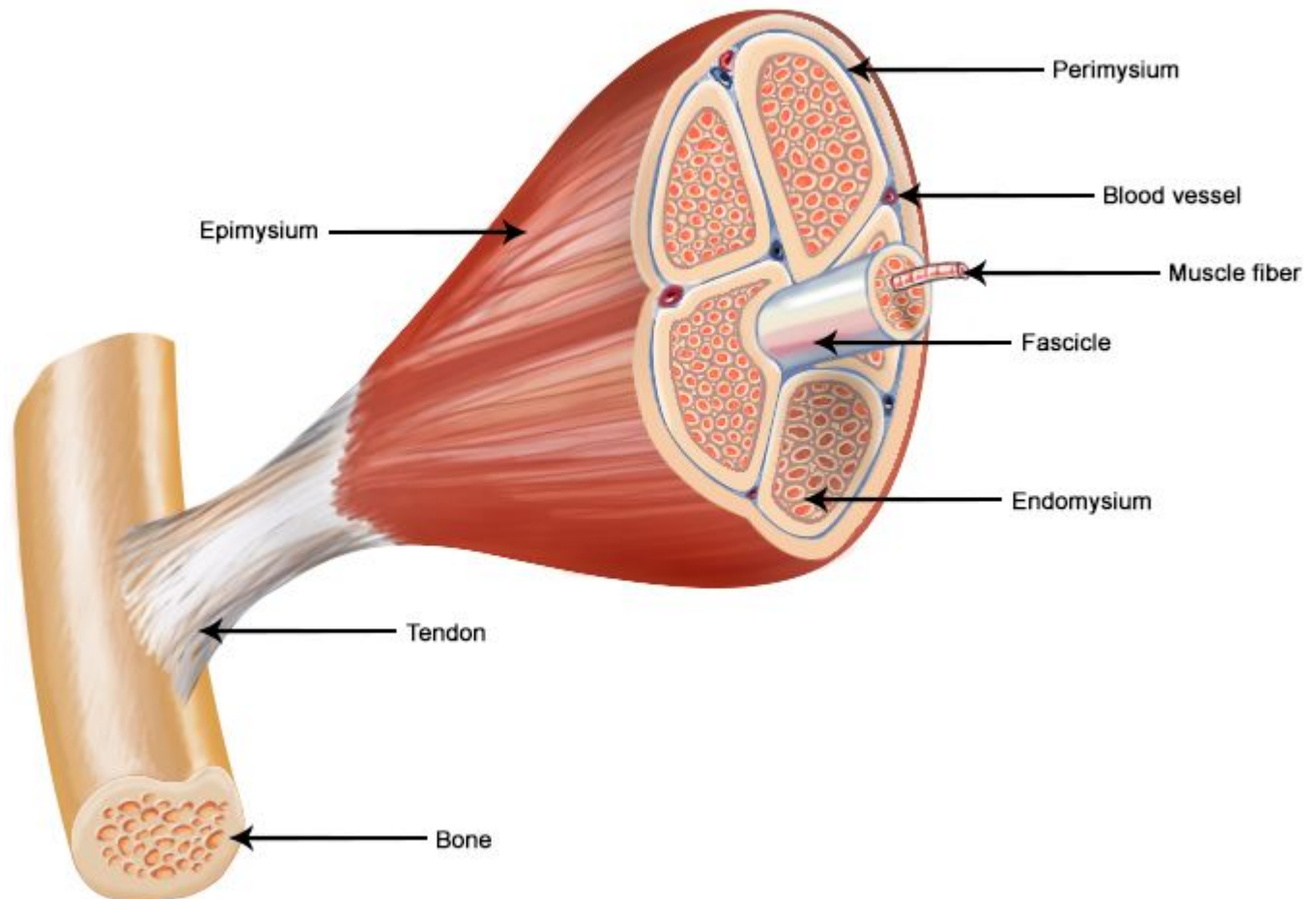
- Skeletal muscle attaches to a **bone** via **tendons** - strong, cordlike fascia that extend at both proximal and distal end of bones
- The largest/fleshiery part of a muscle is called the **muscle belly**
- **Fascia is a deep connective tissue** that surrounds a muscle, functioning to keep things together and to allow movement between structures



Muscle Structure - Breakdown

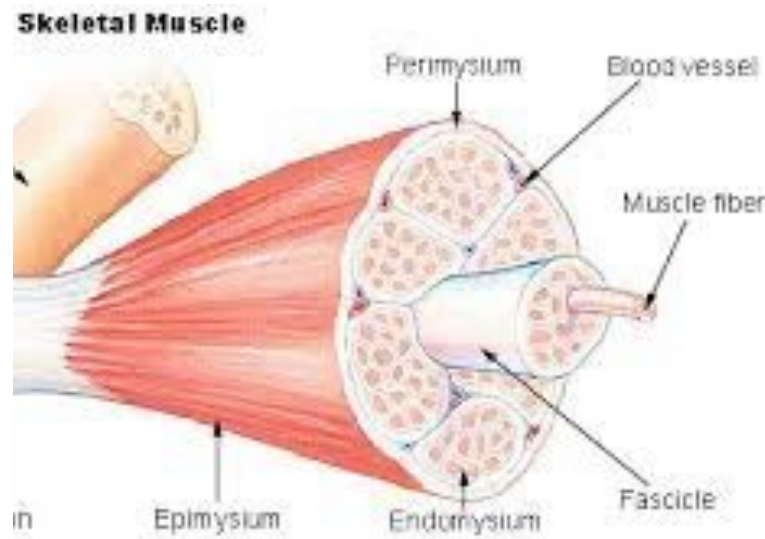
- Epimysium
 - outermost layer of fascia - it surrounds the entire muscle
- Perimysium
 - surrounds groups of individual muscle cells
- Endomysium
 - surrounds individual muscle cells

Structure of a Skeletal Muscle



Muscle Structure - Breakdown

- Muscle fascicle
 - a group of single muscle cells
- Muscle fiber
 - a single muscle cell



Muscle Structure - Breakdown

- Sarcolemma
 - cell membrane of a single muscle fiber
- Sarcoplasmic reticulum
 - specialized endoplasmic reticulum
 - main function is to store calcium ions
- Myofibrils
 - long, cylindrical structures in each muscle fiber
 - run parallel to each other
 - contain sarcomeres

Muscle Structure

- T-tubules

- transverse tubules
- penetrate from the superficial sarcoplasm deep into the muscle fiber

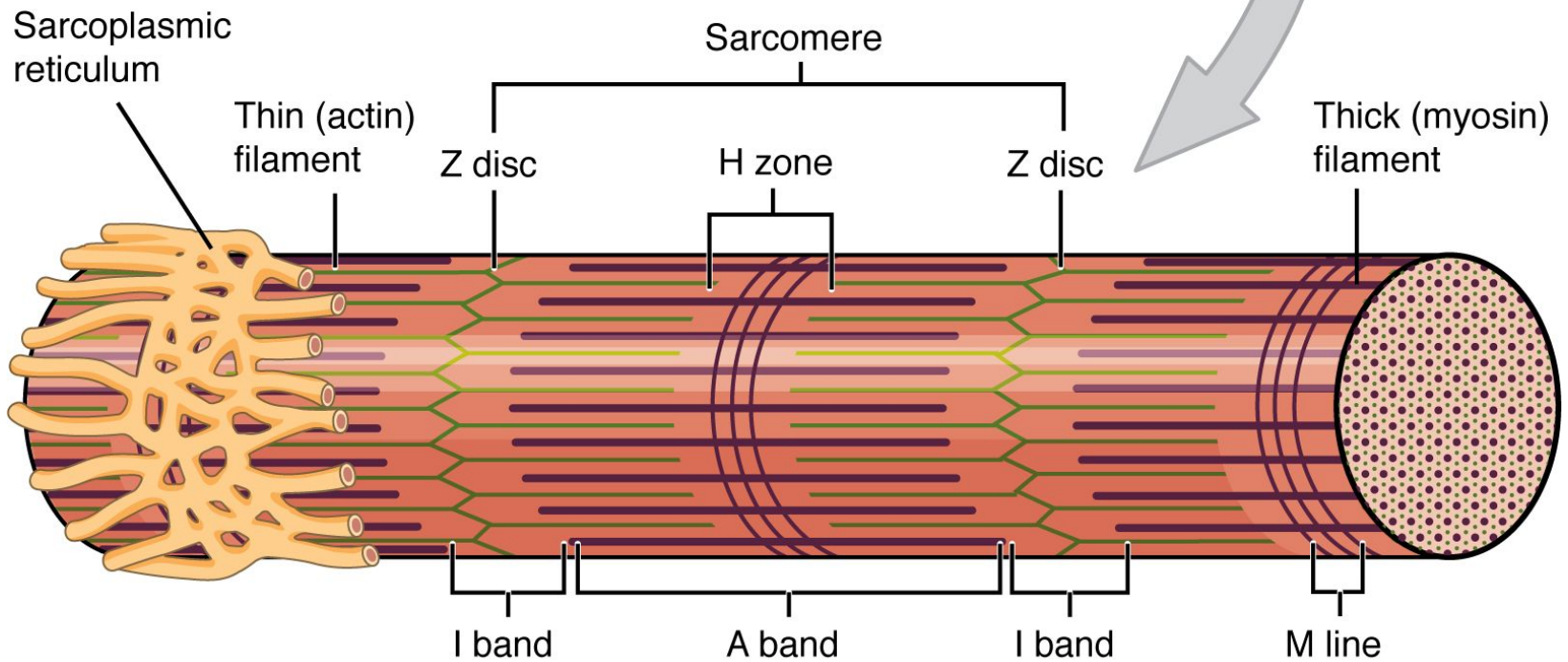
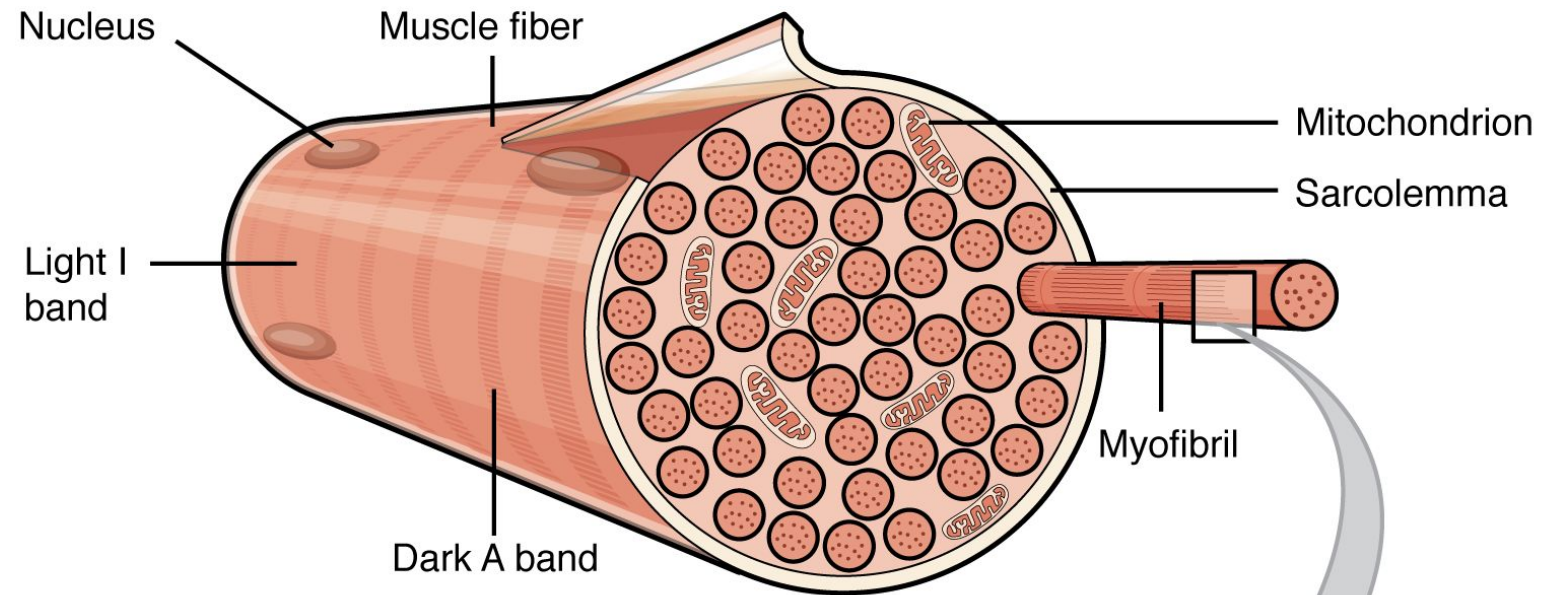
- Sarcomeres

- contractile units within a myofibril formed of smaller contractile proteins: actin and myosin
- actin & myosin are responsible for muscular contraction & give skeletal muscle its striated appearance

Muscle Structure: Sarcomeres

Bands, lines, discs & zones

- A band
 - darker in colour
 - where thin (actin) & thick (myosin) filaments overlap
- I band
 - lighter coloured bands
 - no thick filaments
 - ONLY thin (actin) filaments
- H zone
 - area in the center of the A band
 - ONLY thick (myosin) filaments
 - runs vertically
- M line
 - disc in the middle of the H zone
 - myosin is anchored to the M line
- Z disc
 - where actin filaments are anchored to
 - creates the borders of adjacent sarcomeres



Muscle Contraction: Components

Important players in a muscle contraction:

- Actin & myosin
 - actin - thin filament
 - myosin - thick filament
- Troponin & tropomyosin
 - troponin
 - responsible for muscle contraction
 - tropomyosin
 - responsible for muscle relaxation as it prevents actin & myosin from interacting

Muscle Contraction: Components

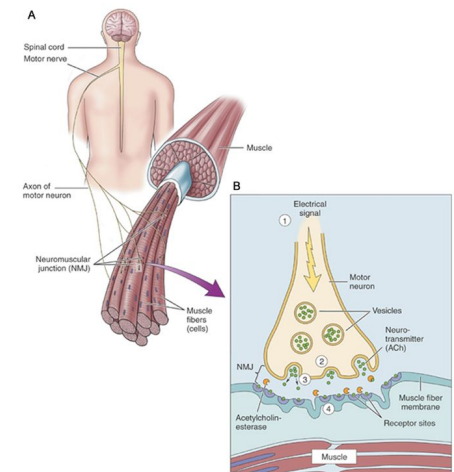
Important players in a muscle contraction

- Calcium
 - required in order for a muscle to contract
- ADP + ATP
 - energy components used during muscle contraction & relaxation
- Acetylcholine (neurotransmitter)
 - important to start the electrical impulse in the skeletal muscle cell

Muscle Contraction: Components

Important players in a muscle contraction

- **Motor nerve:**
 - type of nerve that supplies skeletal muscle with stimulation
- **Neuromuscular junction (NMJ):**
 - area where motor nerve meets muscle fibers



Sliding Filament Theory: What?

Sliding Filament Theory

aka: skeletal muscle contraction

What happens?

- actin & myosin (contractile proteins) slide past one another, causing the sarcomere to shorten = muscular contraction

Sliding Filament Theory: How?

Step 1: Muscle Stimulation

Motor neuron → Neuromuscular junction → Skeletal muscle

Process:

- the brain sends a message to fire an action potential (AP)
- the AP travels down the motor neuron until it reaches the axon terminal
- the electrical energy at the axon terminal allows for acetylcholine (ACh) to be released into the neuromuscular junction (NMJ)
- ACh travels across the NMJ and attaches to receptor sites on the skeletal muscle

Sliding Filament Theory: How?

Step 2: Muscle Contraction

Skeletal muscle → Sarcolemma → T-tubules → Calcium channels

- ACh binds to the skeletal muscle, allowing the action potential (AP) to continue on the surface of the skeletal muscle
- the AP travels down the muscle cell membrane (sarcolemma) & continues to travel deep within the skeletal muscle via T-tubule
- the AP opens calcium ion channels; allowing calcium to release from the sarcoplasmic reticulum

Calcium channels → Calcium → Actin (troponin & tropomyosin)

- the free Ca^{2+} ions bind to troponin located on actin
- this coupling forces tropomyosin to unbind from actin resulting in free binding sites for myosin

Actin → Myosin (ATP/ADP + P) → Cross bridge → Power stroke

- myosin binds with ATP to break it down to ADP + P and can now interact with actin; forming a cross bridge
- a power stroke occurs - actin and myosin slide past each other and shorten the sarcomere = muscle contraction

Sliding Filament Theory: How?

Step 3: Relaxation

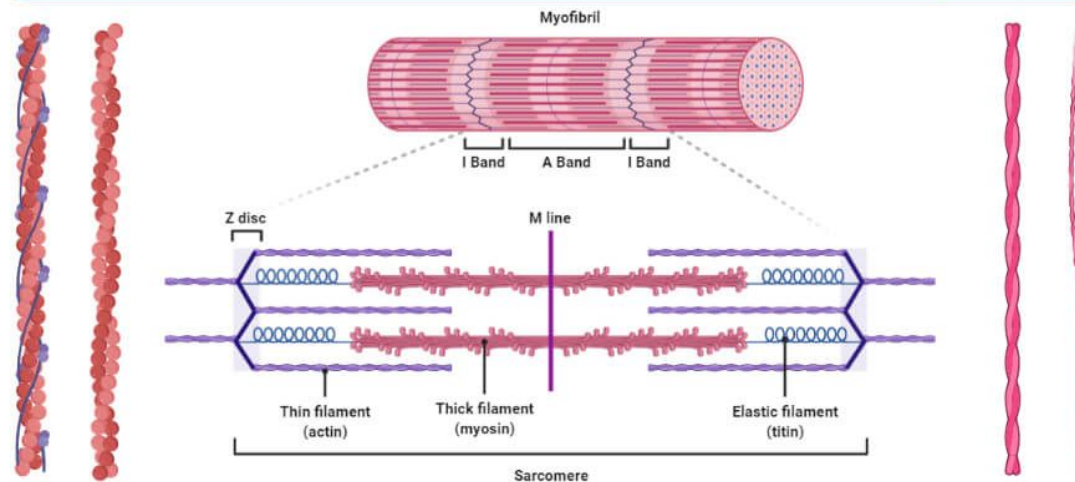
ATP → Myosin → process starts again

- once the contraction is over ADP + P release from the myosin head
- a new molecule of ATP comes to remove the myosin head from actin = breaking the cross bridge
- the new molecule of ATP will break down to ADP + P while simultaneously the sarcoplasmic reticulum is generating more Ca^{2+} stores
- thus, the process will start again and continue until Ca^{2+} stores are depleted

Video

Muscles, Part I - Muscle Cells: Crash Course Anatomy & Physiology #21

Differences between Actin and Myosin



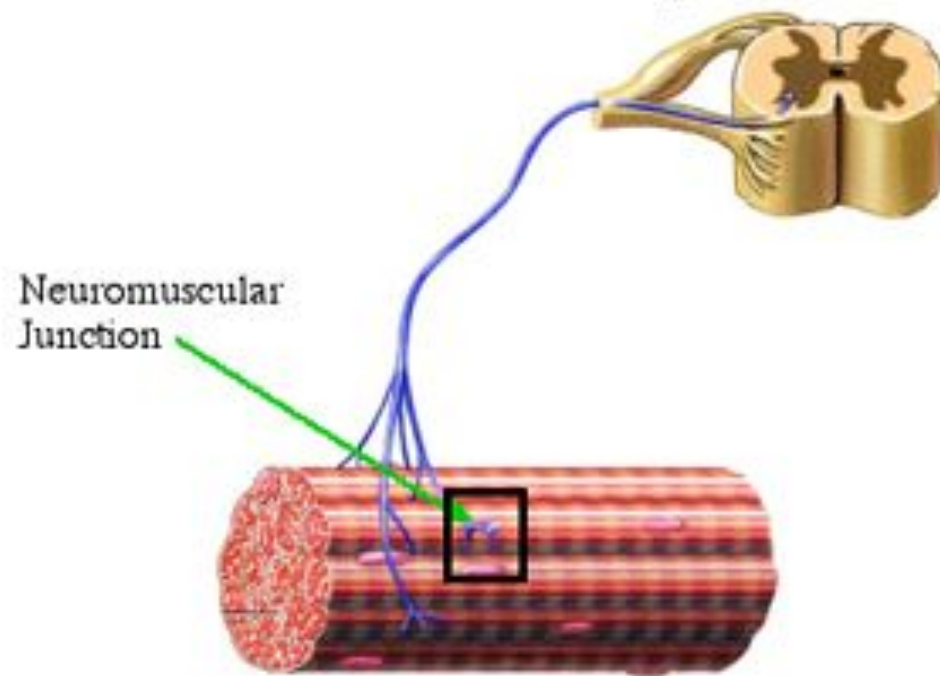
Muscle Recruitment

Recruitment

- process of using additional muscle fibers to achieve greater muscle force
- when a neuron impulse fires all of the muscle fibers innervated by the nerve will contract = all-or-none response
- note: one motor nerve can innervate many muscle fibers

○

- ◆ One motor nerve innervates many muscle fibers



Muscle Recruitment ct'd

- **Twitch**
 - single muscle response in which a muscle contracts and then fully relaxes
 - APs are delivered slow enough that the muscle will relax during successive twitches
- **Tetanus**
 - sustained muscle contraction caused by repeated stimulation
 - when a motor unit is maximally stimulated, causing APs to be delivered at a high frequency causing a twitch to overlap
 - ex: holding a heavy box
- **Tonus**
 - normal, continuous state of partial muscle contraction
 - this creates normal muscle tone - so a muscle is never completely relaxed

Muscle Terms

- Muscle attachments

- Origin: attaches to the stationary bone
- Insertion: attaches to the more movable bone

- Muscle groups and cooperation

- Agonist
 - muscle responsible for most of the movement of a action (prime mover)
- Synergists
 - assist the prime mover
- Antagonists
 - muscles that oppose the action of another muscle

Muscle Terms

- **Hypertrophy**
 - growth in response to overuse
- **Atrophy**
 - muscle wasting in response to disuse
- **Contracture**
 - abnormal fibrous formation in muscle that “freezes” muscle in flexed position
 - typically caused by injury, scarring, or nerve damage

Muscle Terms

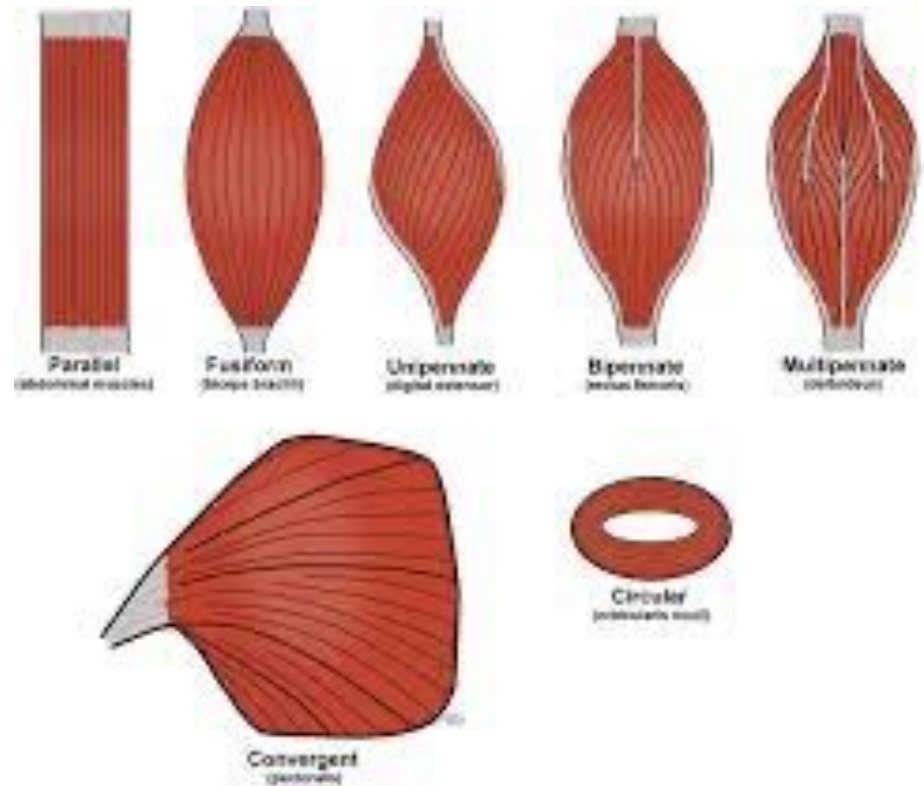
- **Isotonic contraction:**
 - fiber length changes while tension stays the same
 - concentric contraction
 - muscle length shortens
 - eccentric contraction
 - muscle length increases
- **Isometric Contraction**
 - muscle tension will increase but the length of the muscle stays the same

How are muscles named?

- Based on 7 characteristics of skeletal muscles:
 - Size
 - Shape
 - Direction of fibers
 - Location
 - Number of origins
 - Identification of origin and insertion
 - Muscle action

5 Types of Muscles:

- Circular
- Pennate
- Convergent
- Parallel
- Fusiform



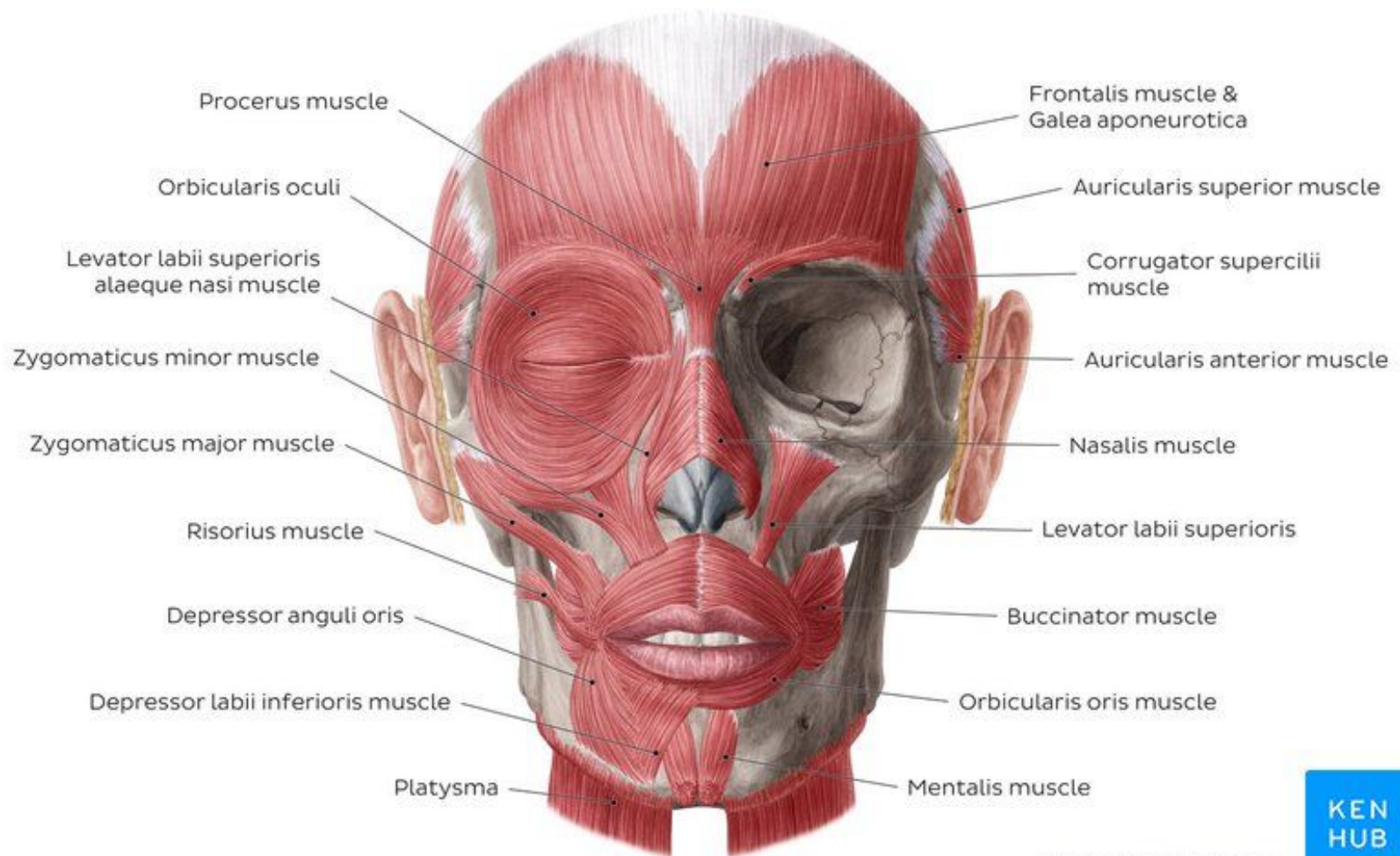
Circular Muscles

- Circular Muscle

- these muscles appear circular in shape
- are normally sphincter muscles which surround an opening

examples:

- obicularis oris
- obicularis oculi



Pennate Muscles

- have a large number of muscle fibres per unit
- are very strong, but tire easily

Divisions:

- Unipennate:
 - these muscles have their fibres arranged to insert in a diagonal direction onto the tendon
 - this orientation allows for great strength
 - examples include the
 - lumbricals (deep hand muscles)

Pennate Muscles ct'd

- **Bipennate**

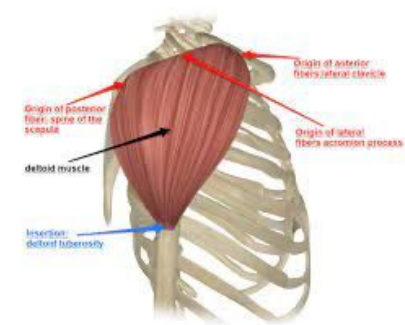
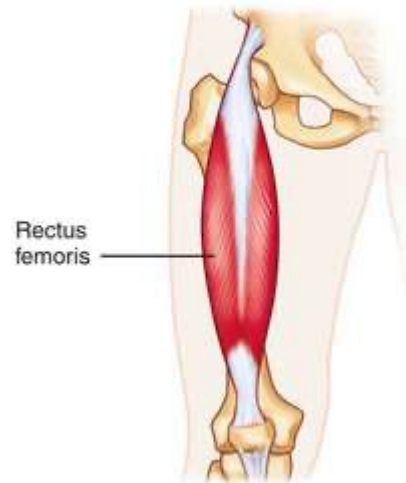
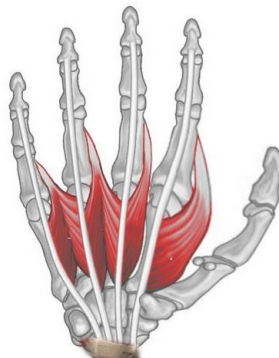
- bipennate muscles have two rows of muscle fibres, facing in opposite diagonal directions from a central tendon
- looks similar to a feather
- this orientation allows for even greater power but less range of motion
- example:
 - rectus femoris

- **Multipennate:**

- multipennate muscles have multiple rows of diagonal fibres which branch from two or more central tendons.
- example:
 - deltoid muscle
 - three sections: anterior, posterior and middle

Pennate muscles

Unipennate Bipennate Multipennate



Convergent Muscles

- sometimes known as triangular muscles
- groups of muscles where the **origin** (the attachment to a fixed bone, usually the proximal attachment) is wider than the point of insertion (moveable part of attachment, usually distal)
- the fiber arrangement allows for maximum force production
- example:
 - pectoralis major

Convergent muscles

Fascicle Arrangement

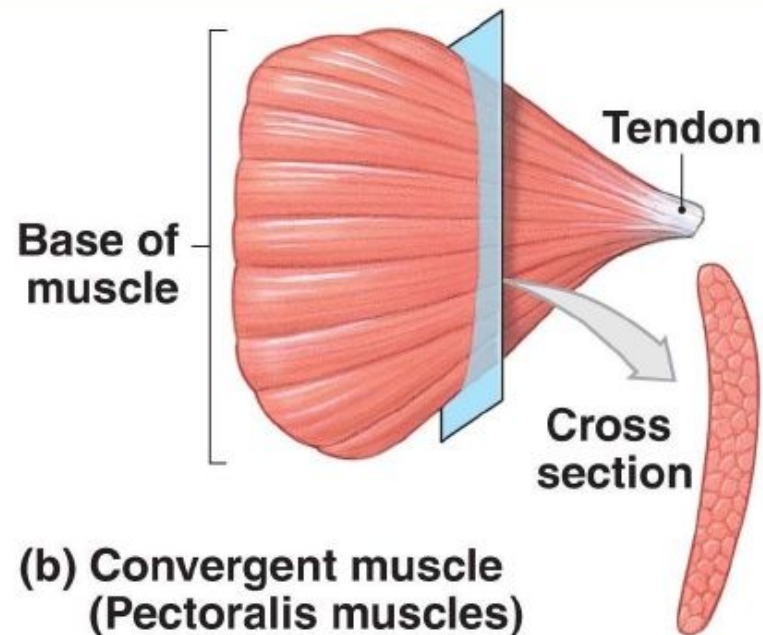


Figure 11–1b Muscle Types Based on Pattern of Fascicle Organization.

Parallel Muscles

- parallel muscles have fibers that run parallel to each other
 - sometimes called strap muscles
- they are normally long muscles which cause large movements
- are not very strong but have good endurance
- Examples include
 - Sartorius
 - Sternocleidomastoid

Parallel Muscles



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Fusiform

- sometimes included in the parallel muscle group
- these muscles are more spindle shaped, with the muscle belly being wider than the origin and insertion
- examples:
 - Biceps Brachii
 - Psoas major

Fusiform

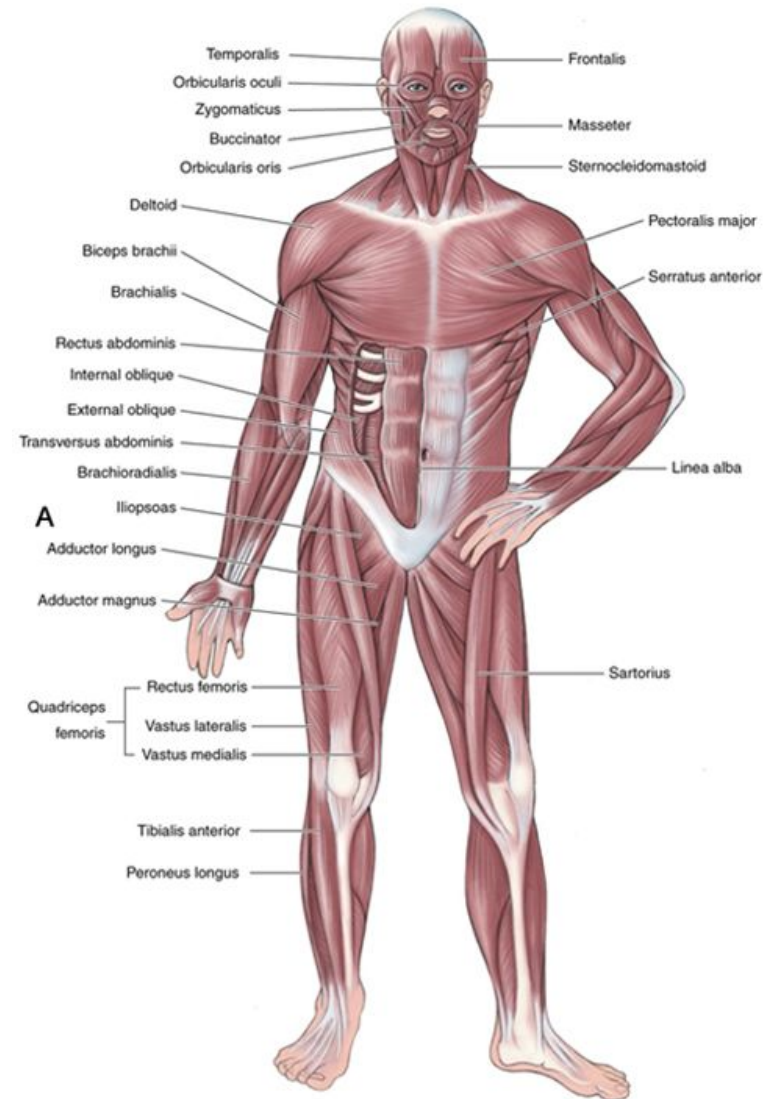


(f) Fusiform
(biceps brachii)



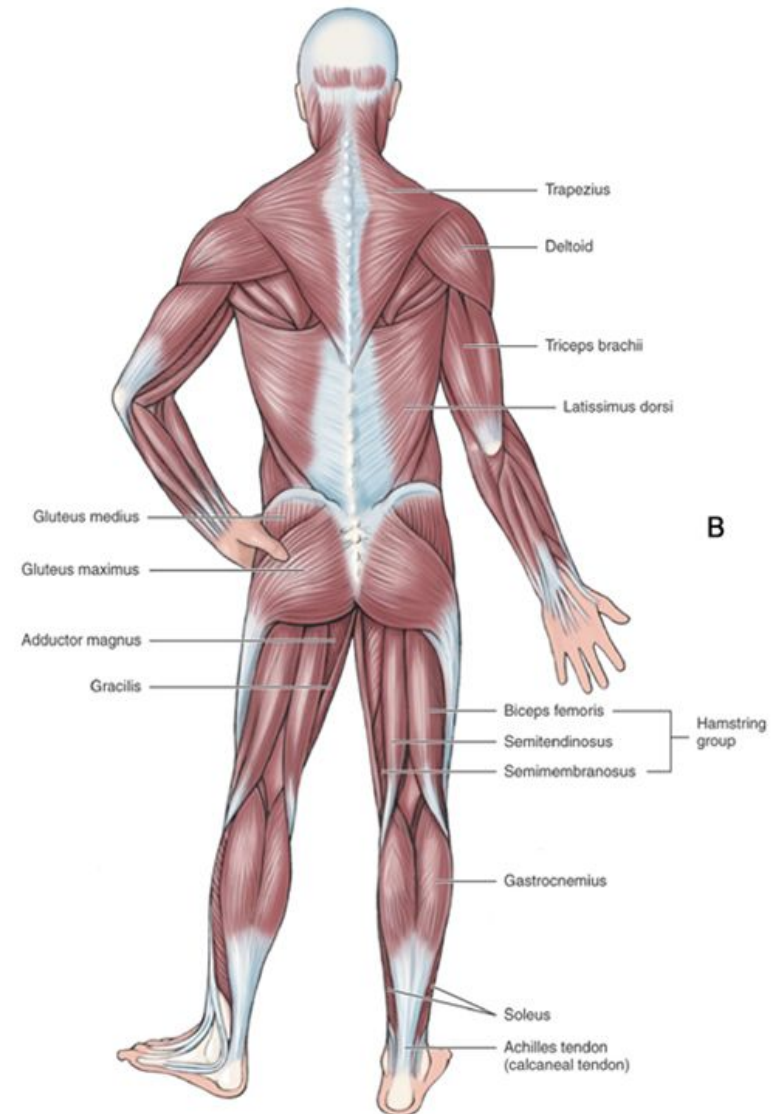
Muscle from Head to Toe

● Anterior view

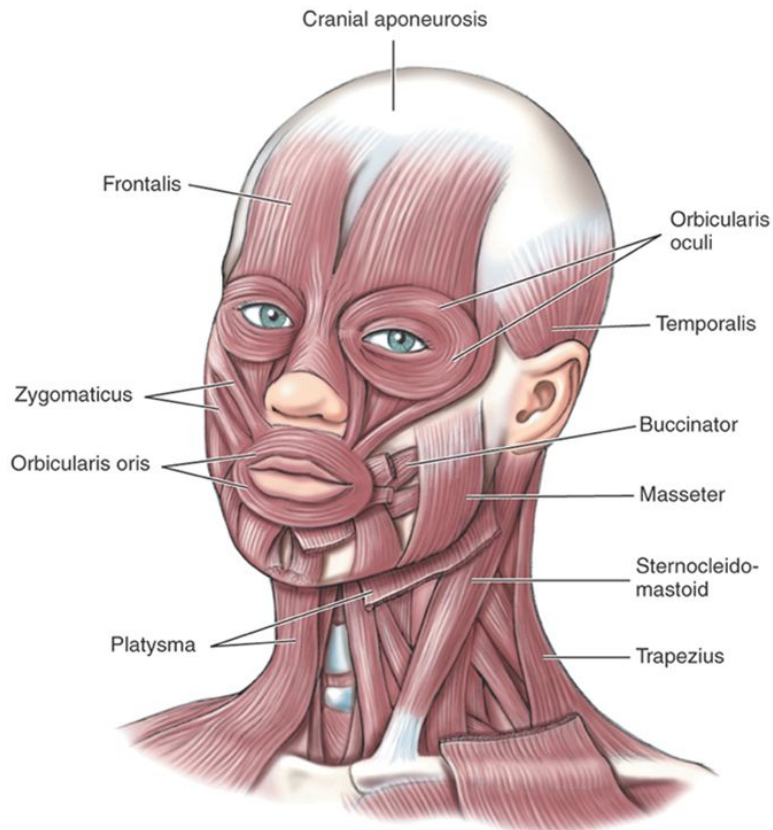


Muscles Head to Toe

● Posterior View



Muscle of the Head



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● Facial muscles

- Frontalis
- Orbicularis oculi
- Orbicularis oris
- Buccinator
- Zygomaticus

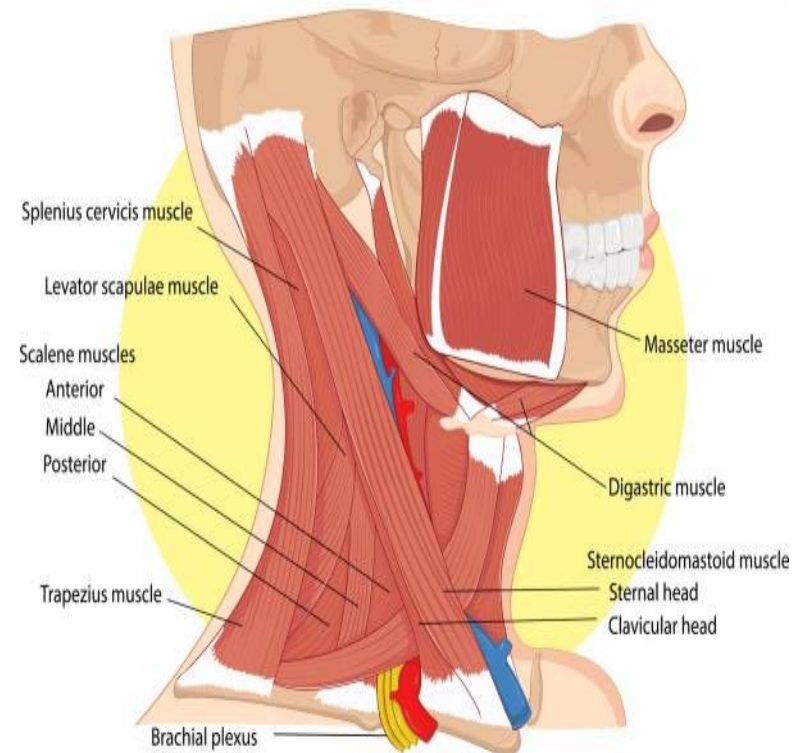
● Chewing muscles

- Temporalis
- Masseter

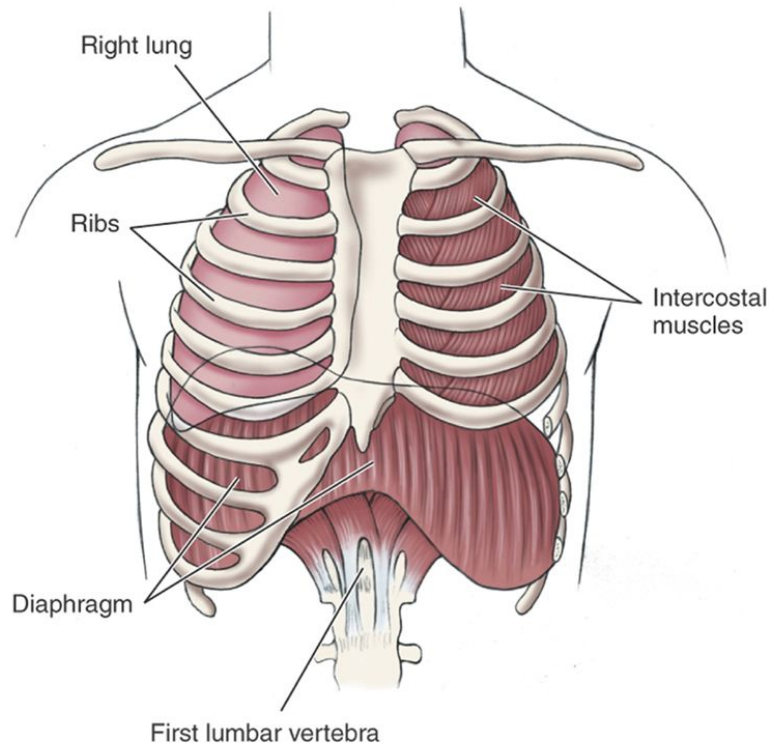
Muscle of the Neck

- Sternocleidomastoid
- Trapezius
- Scalenes
 - Anterior
 - Posterior
 - Middle

Neck-muscles



Muscles of the Trunk

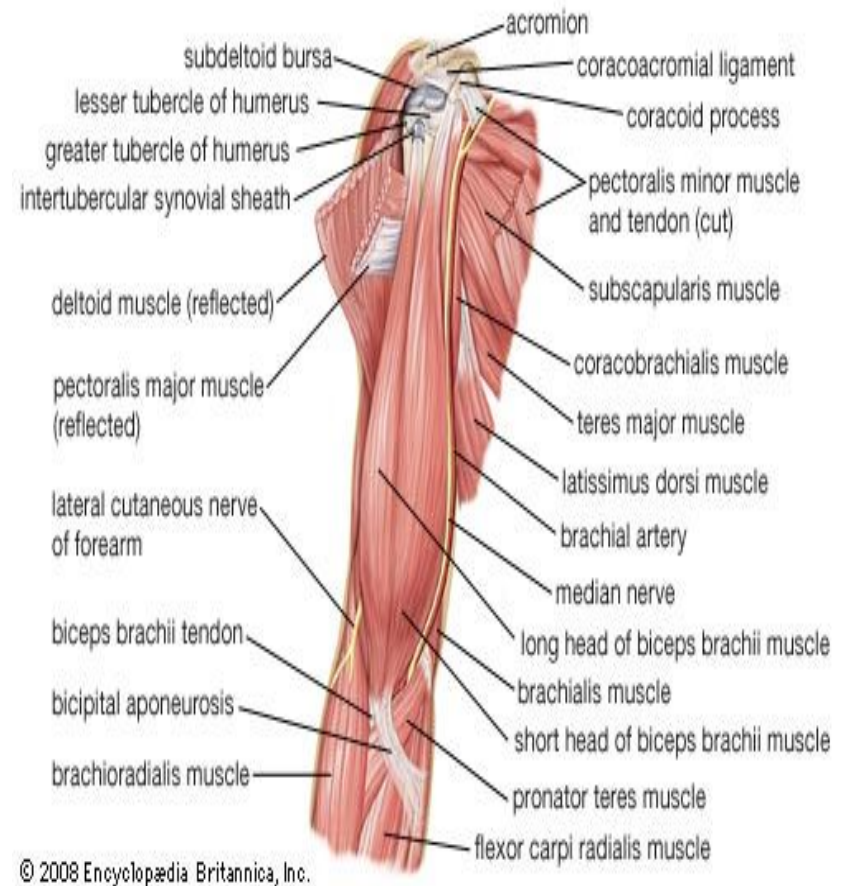


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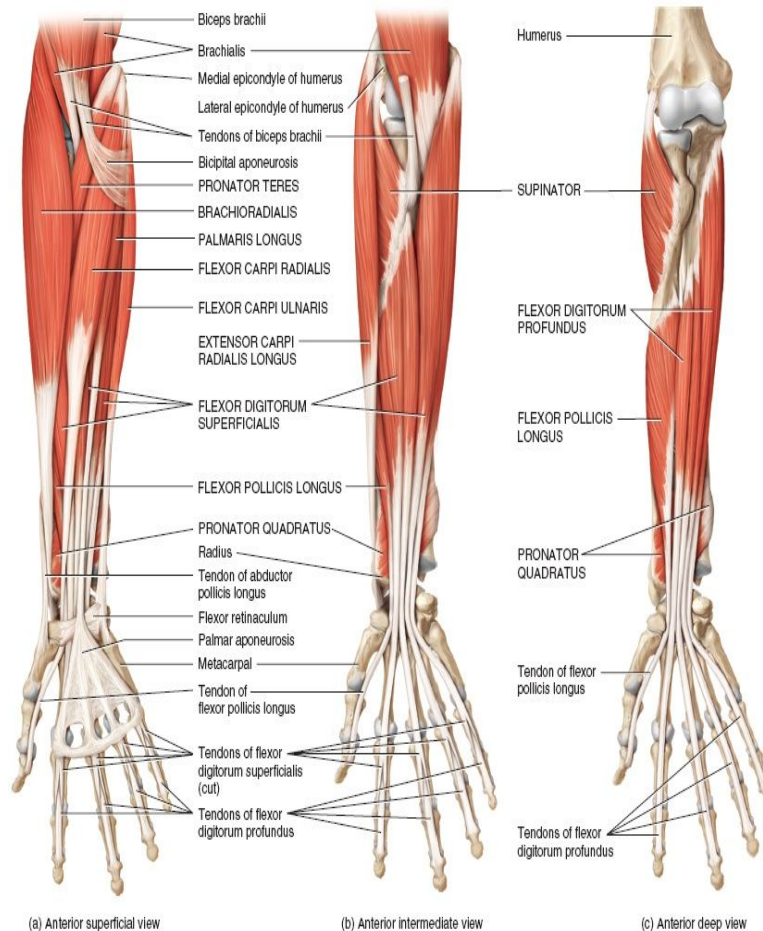
- Muscles involved in breathing
 - Intercostal muscles
 - Diaphragm
- Muscles of the abdominal wall
 - External oblique
 - Internal oblique
 - Transversus abdominis
 - Rectus abdominis
- Muscles of the vertebral column
- Muscles of the pelvic floor

Muscles that move the shoulder and upper arm

- Trapezius
- Serratus anterior
- Pectoralis major
- Latissimus dorsi
- Deltoid
- Rotator cuff muscles
 - Supraspinatus
 - Subscapularis
 - Infraspinatus
 - Teres minor



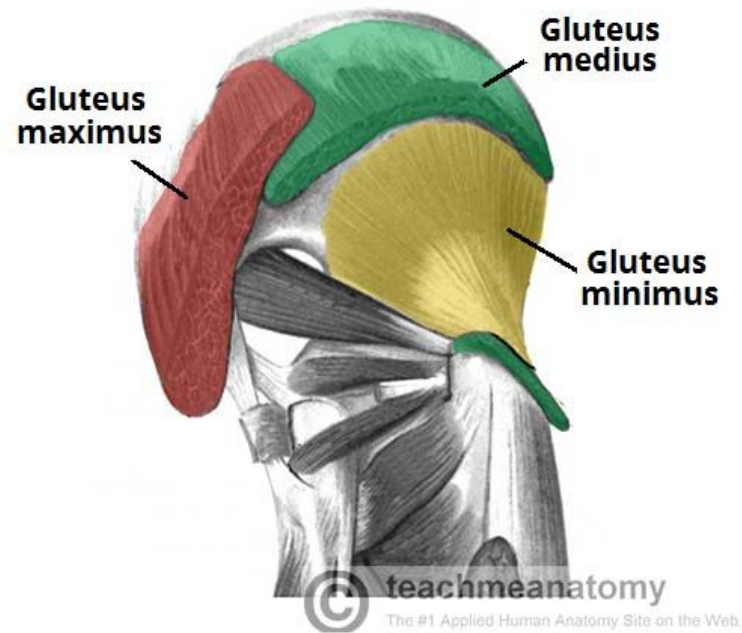
Muscles that move the forearm and hand



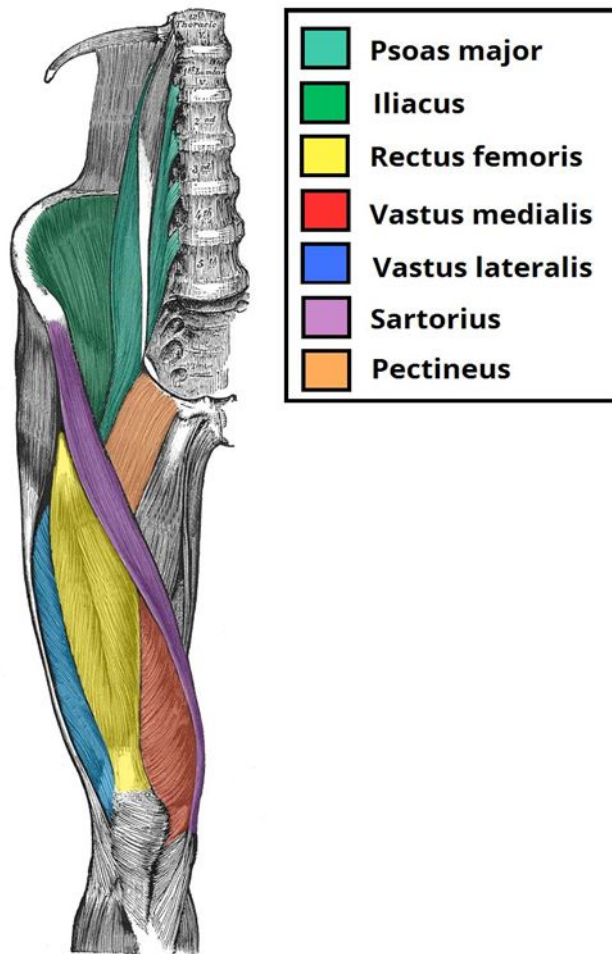
- Biceps brachii
- Triceps brachii
- Brachialis
- Brachioradialis
- Flexor and extensor carpi groups
- Flexor and extensor digitorum groups

Muscles that move the leg

- Gluteus maximus
- Gluteus medius
- Gluteus minimus
- Iliopsoas
- Adductor group
 - Adductor longus
 - Adductor brevis
 - Adductor magnus
- Gracilis



Muscles that move the leg



- Quadriceps femoris
 - Rectus femoris
 - Vastus lateralis
 - Vastus medialis
 - Vastus intermedius
- Sartorius
- Hamstrings
 - Biceps femoris
 - Semitendinosus
 - Semimembranosus

Muscles that move the foot and lower limb

- Tibialis anterior
- Peroneus longus
- Gastrocnemius
- Soleus

