Intro to Anatomy:

Muscles

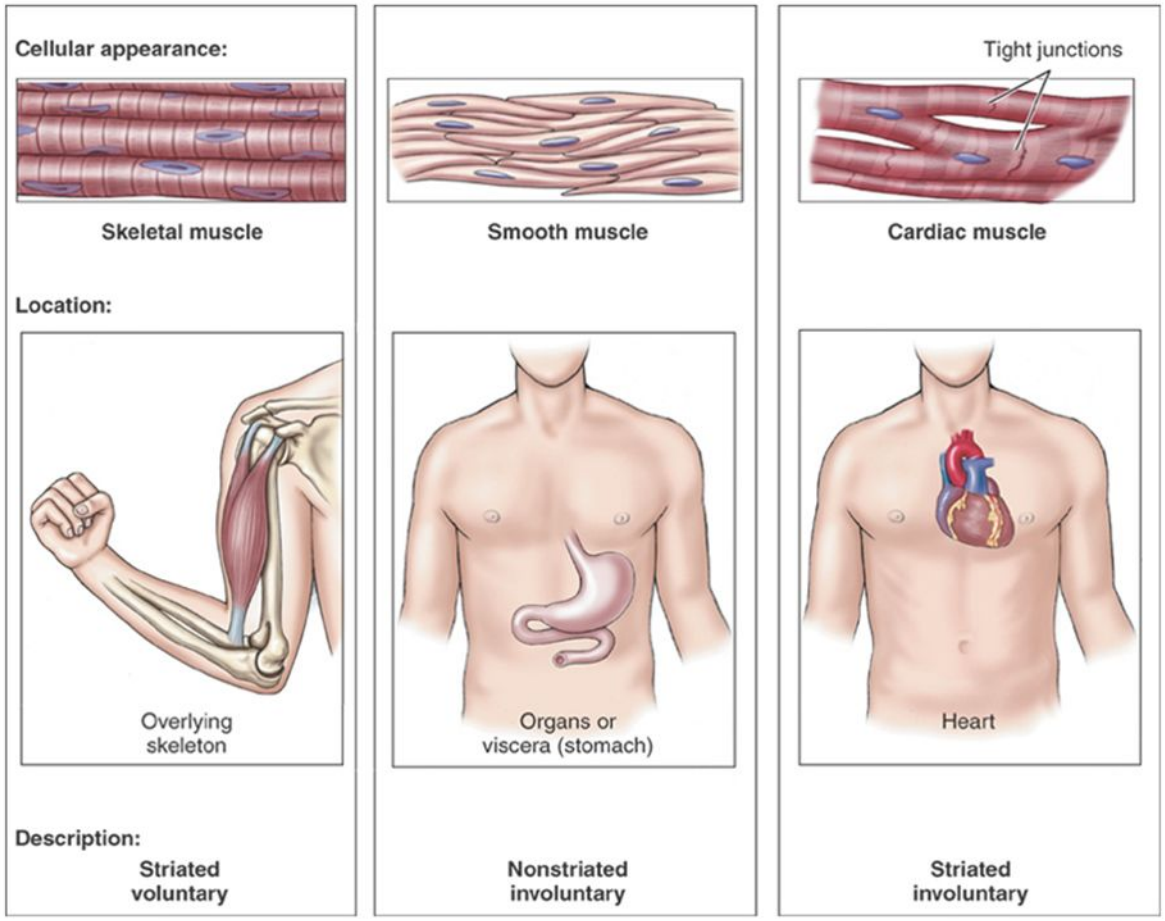
What are we going to learn?

- 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:

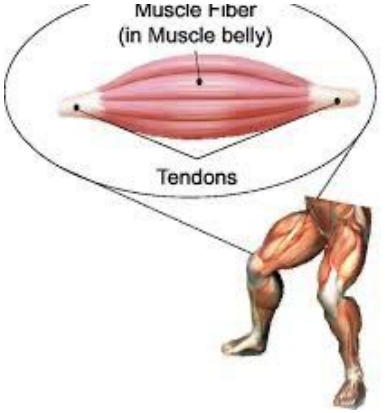
- Skeletal muscle
  - generally attached to bone
  - voluntary control
  - cells appear striated
- Smooth muscle
  - generally found in the walls of viscera
  - involuntary control
  - nonstriated
- Cardiac muscle
  - only found in the heart
  - cells are long and branch to fit closely together at junctions called intercalated discs
  - involuntary control
  - cells appear striated

Muscle Types Pictured



Skeletal Muscle Structure

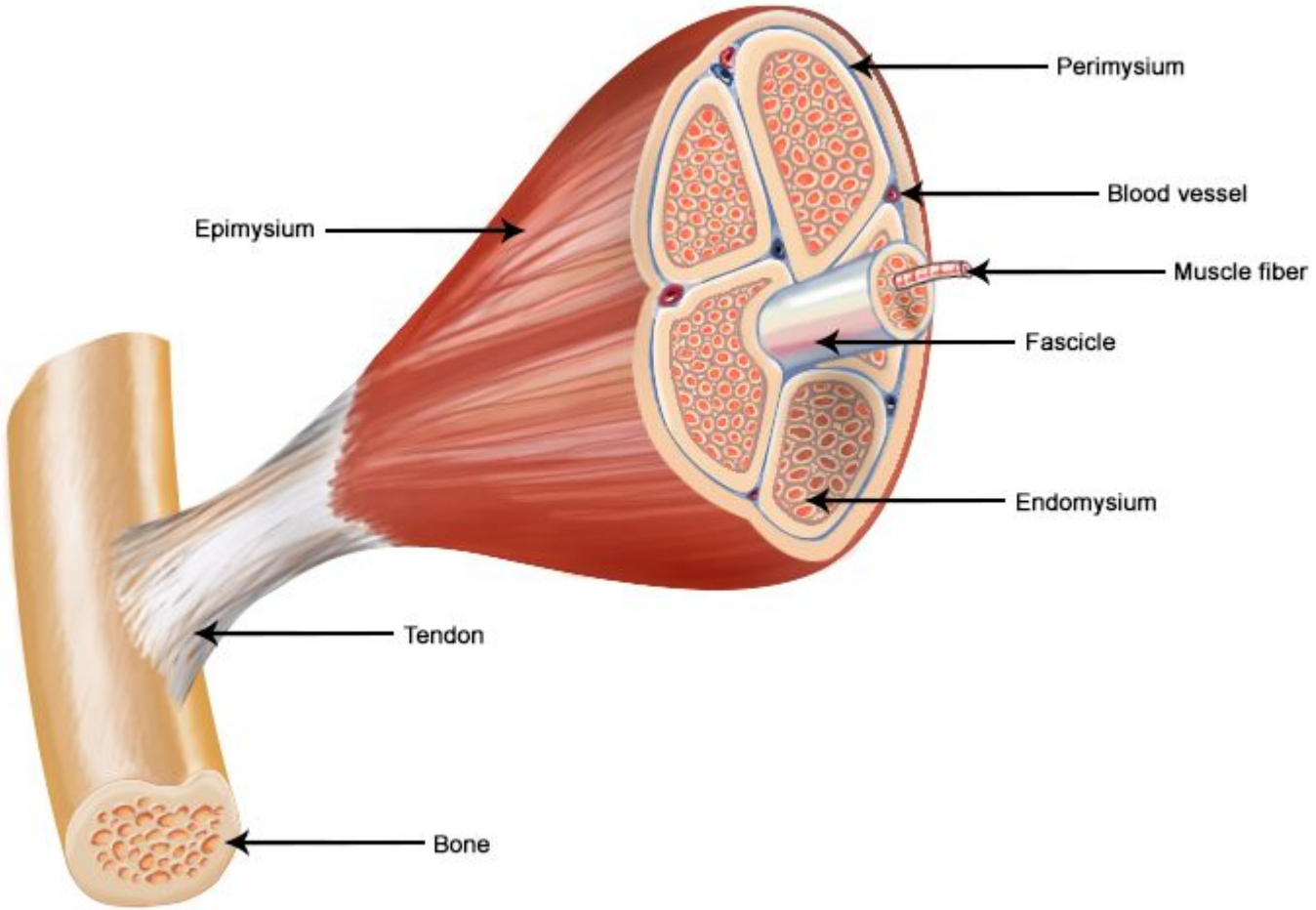
- Skeletal muscle attaches to a **bone** via **tendons -** strong, cordlike fascia that extend at both proximal and distal end of bones
- The largest/fleshiest part of a muscle is called the **muscle belly**
- **Fascia is a deep connective tissue** that surrounds a muscle, functioning to keep things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



Muscle Structure - Breakdown

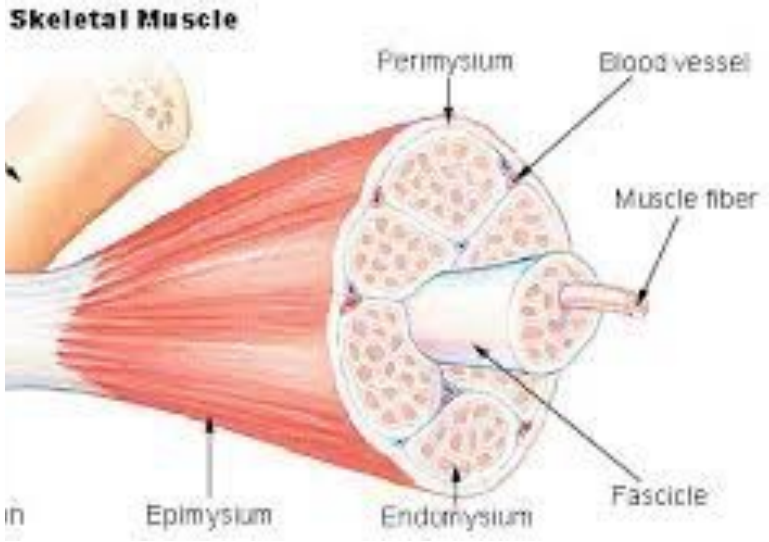
- Epimysium
  - outermost layer of fascia - it surrounds the entire muscle
- Perimysium
  - surrounds groups of individual muscle cells
- Endomysium
  - surrounds individual muscle cells

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

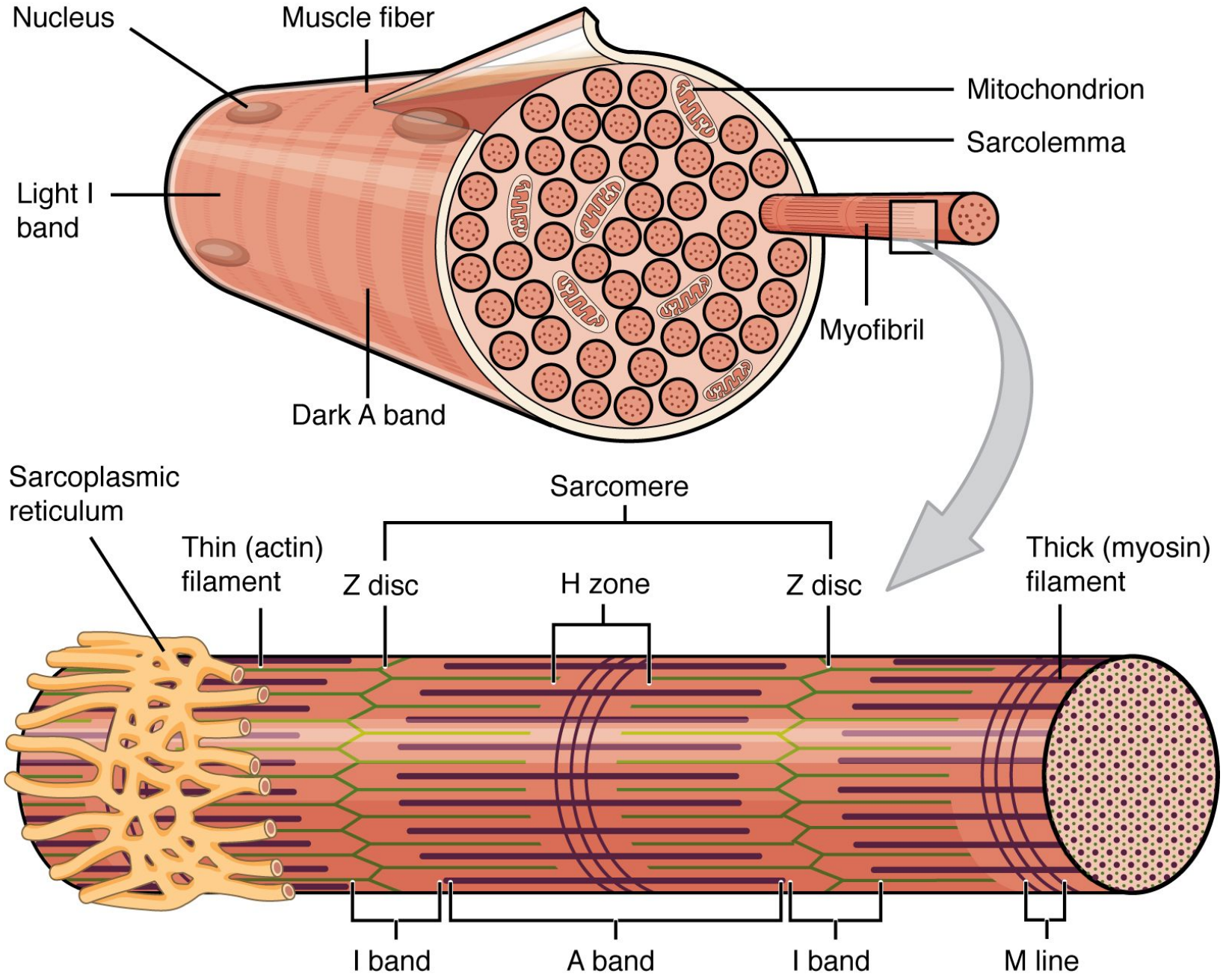
- T-tubules
  - transverse tubules
  - penetrate from the superficial sarcoplasm deep into the muscle fiber

- 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


Nucleus
Muscle fiber
Mitochondrion
Sarcolemma
Light I band
Myofibril
Dark A band
Sarcoplasmic reticulum
Sarcomere
Thin (actin) filament
Z disc
H zone
Z disc
Thick (myosin) filament
I band
A band
I band
M line

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

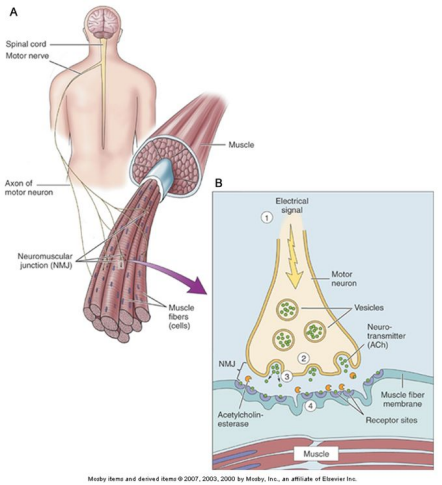
Important players in a muscle contraction

- 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 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 Ca2+ ions bind to troponin located on actin
- this coupling forces tropomyosin to unbind from actin resulting in free binding sites for myosin

Actin → Mysoin (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?

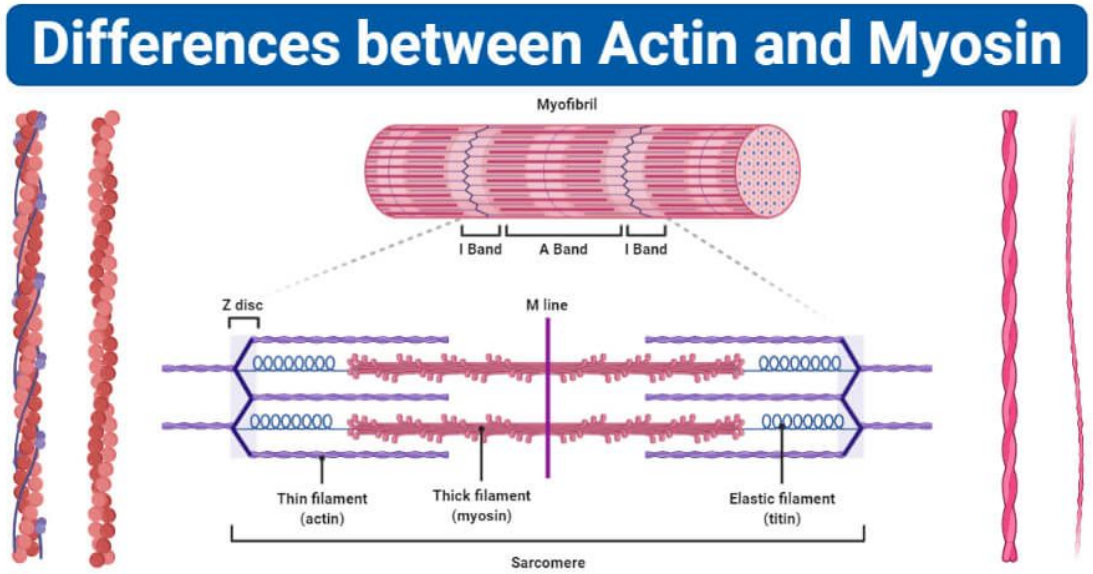
Step 3: Relaxation

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 Ca2+ stores
- thus, the process will start again and continue until Ca2+ stores are depleted

Video

[Muscles, Part 1 - Muscle Cells: Crash Course Anatomy & Physiology #21]

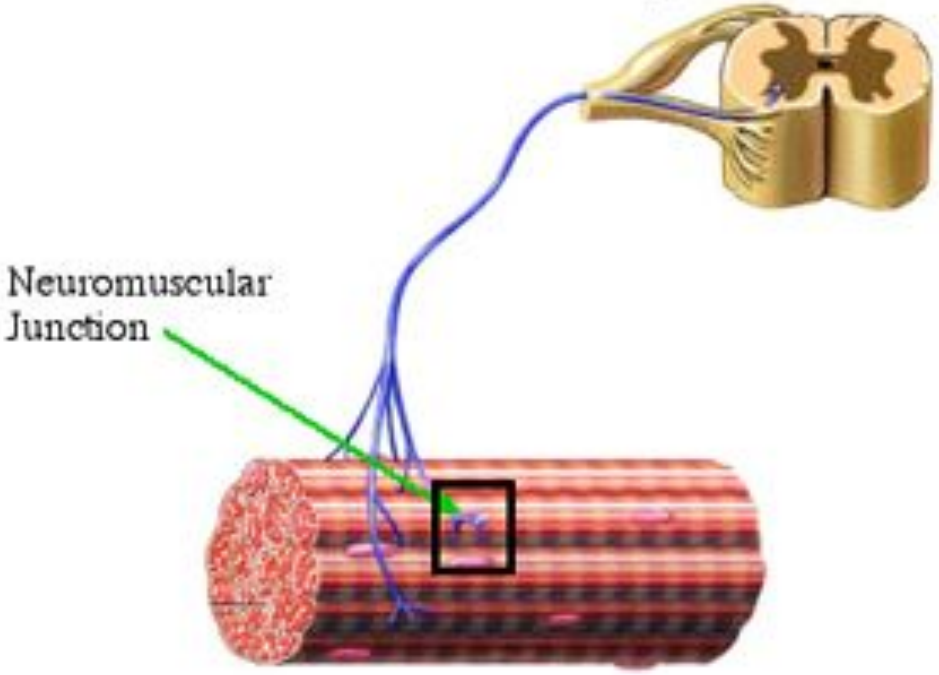


Muscle Recruitment

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

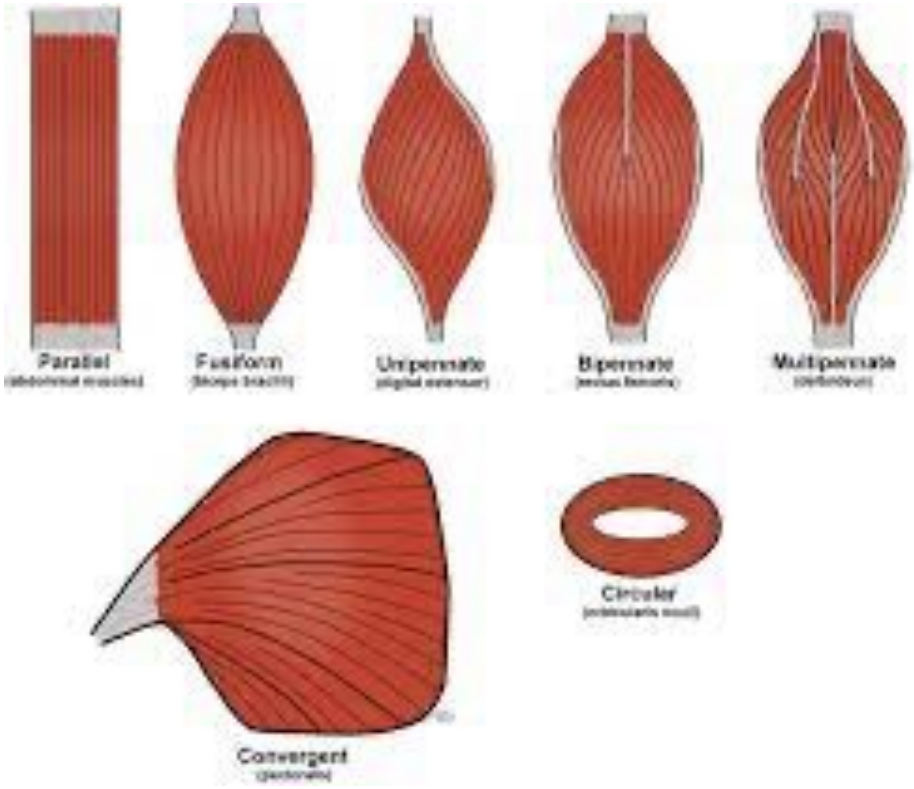
- Isometric Contraction
  - muscle tension will increase but the length of the muscle stays the same

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

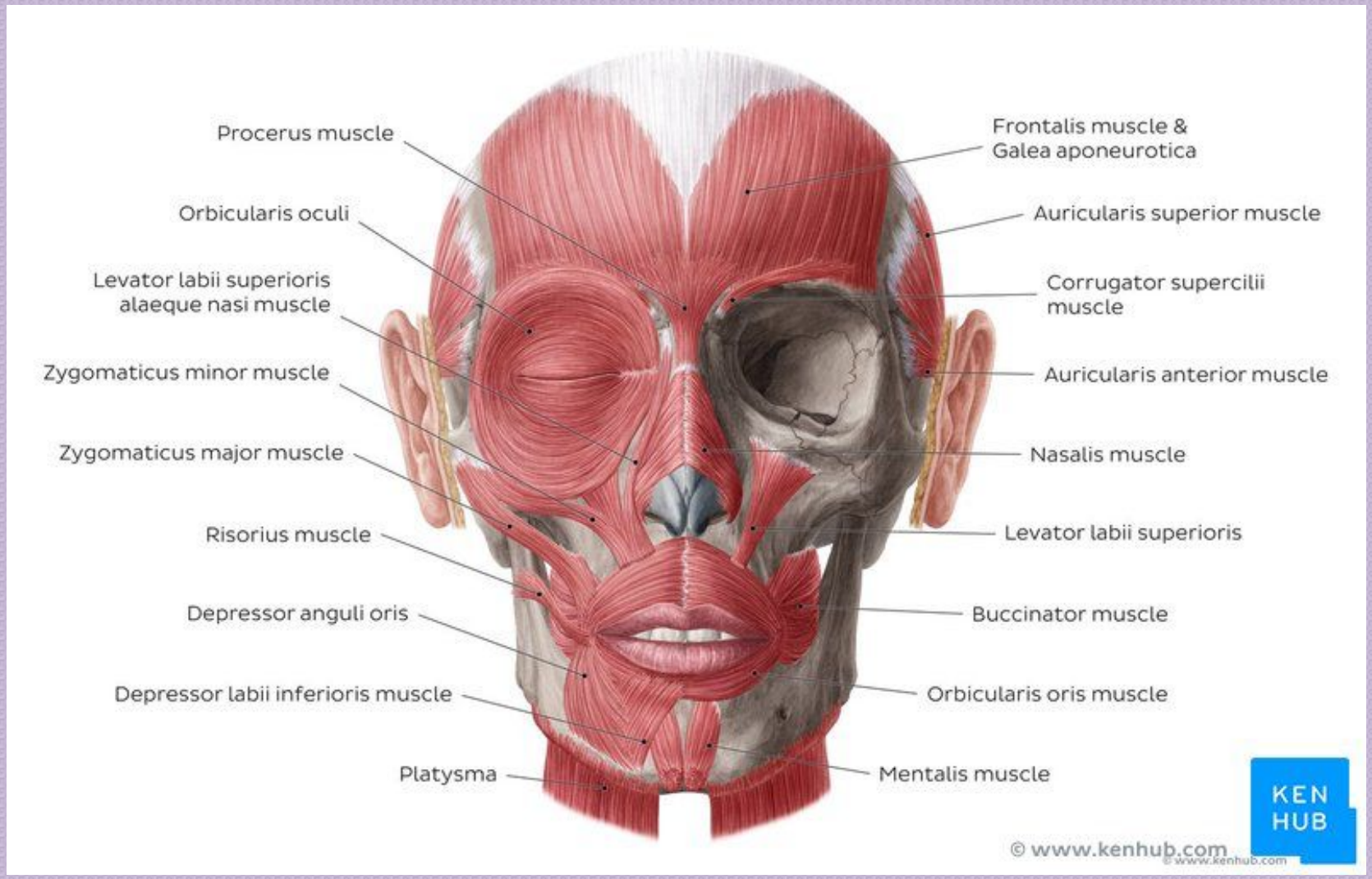


Circular Muscles

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

examples:

- obicularis oris
- obicularis oculi


Procerus muscle
Orbicularis oculi
Levator labii superioris alaeque nasi muscle
Zygomaticus minor muscle
Zygomaticus major muscle
Risorius muscle
Depressor anguli oris
Depressor labii inferioris muscle
Platysma
Frontalis muscle & Galea aponeurotica
Auricularis superior muscle
Corrugator supercilii muscle
Auricularis anterior muscle
Nasalis muscle
Levator labii superioris
Buccinator muscle
Orbicularis oris muscle
Mentalis muscle
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Pennate Muscles

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

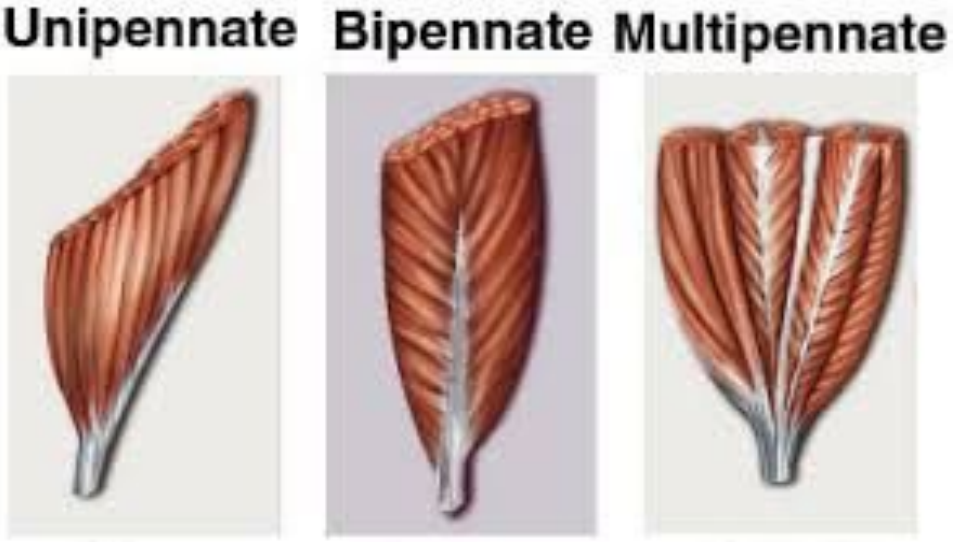
Divisions:

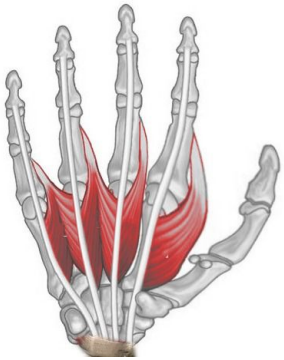
- Unipennate:
  - these muscles have their fibres arranged to insert in a diagonal direction onto the tendon
  - this orientation allows for great strength
  - examples include the
    - lumbricals (deep hand muscles)

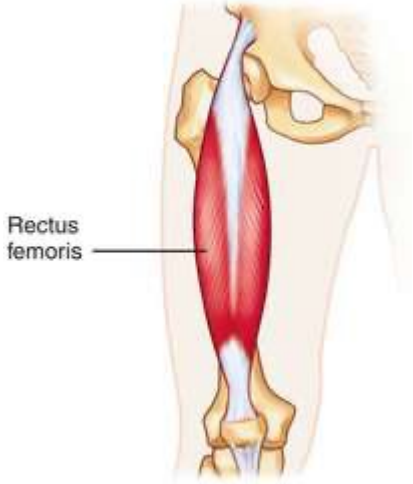
Pennate Muscles ct'd

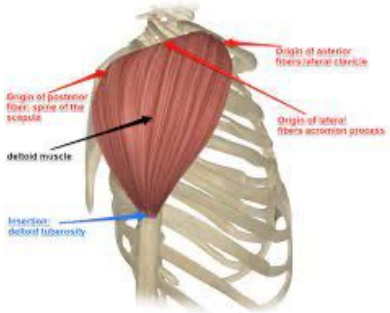
- Bipennate
  - bipennate muscles have two rows of muscle fibres, facing in opposite diagonal directions from a central tendon
  - looks similar to a feather
  - this orientation allows for even greater power but less range of motion
  - example:
    - rectus femoris
- Multipennate:
  - multipennate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









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

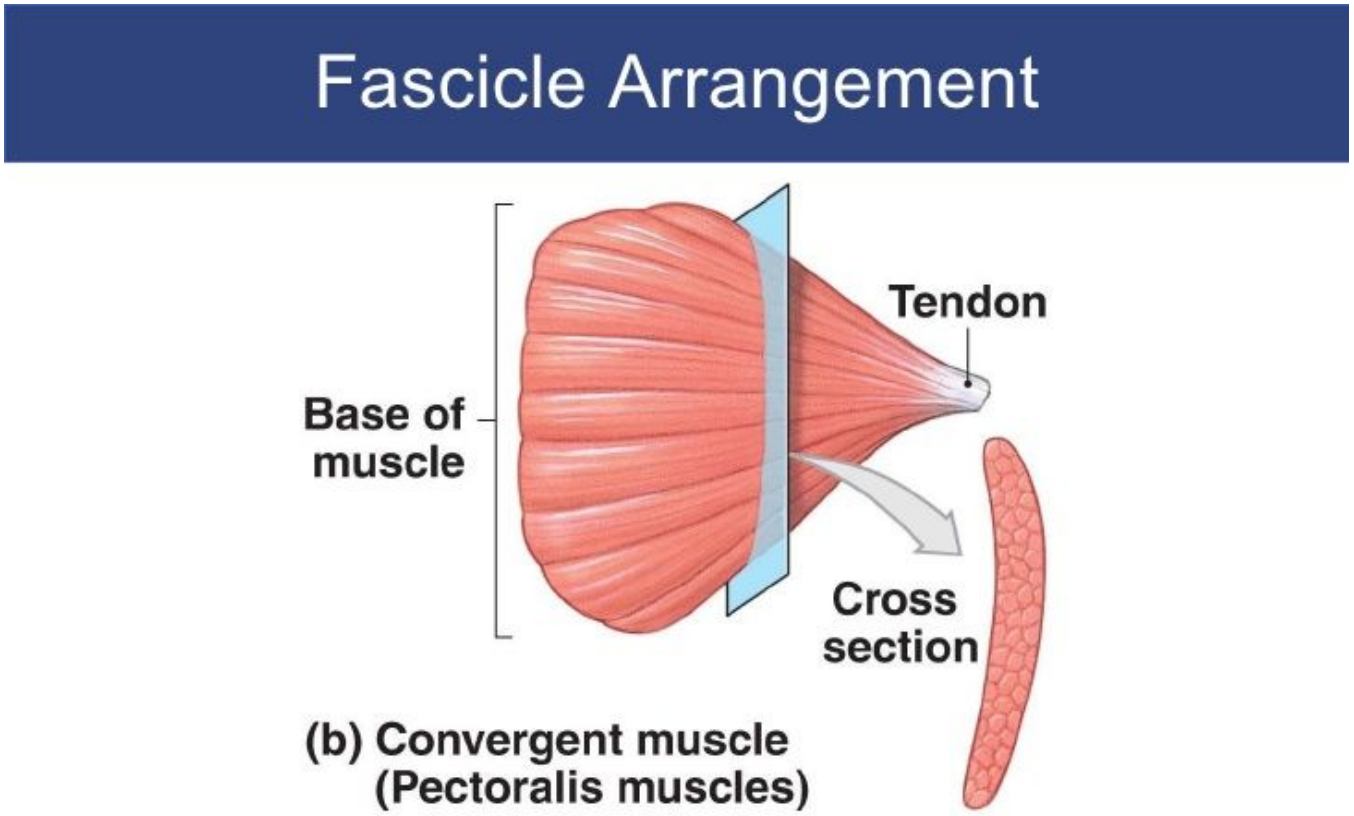


Figure 11–1b Muscle Types Based on Pattern of Fascicle Organization.

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

Fusiform

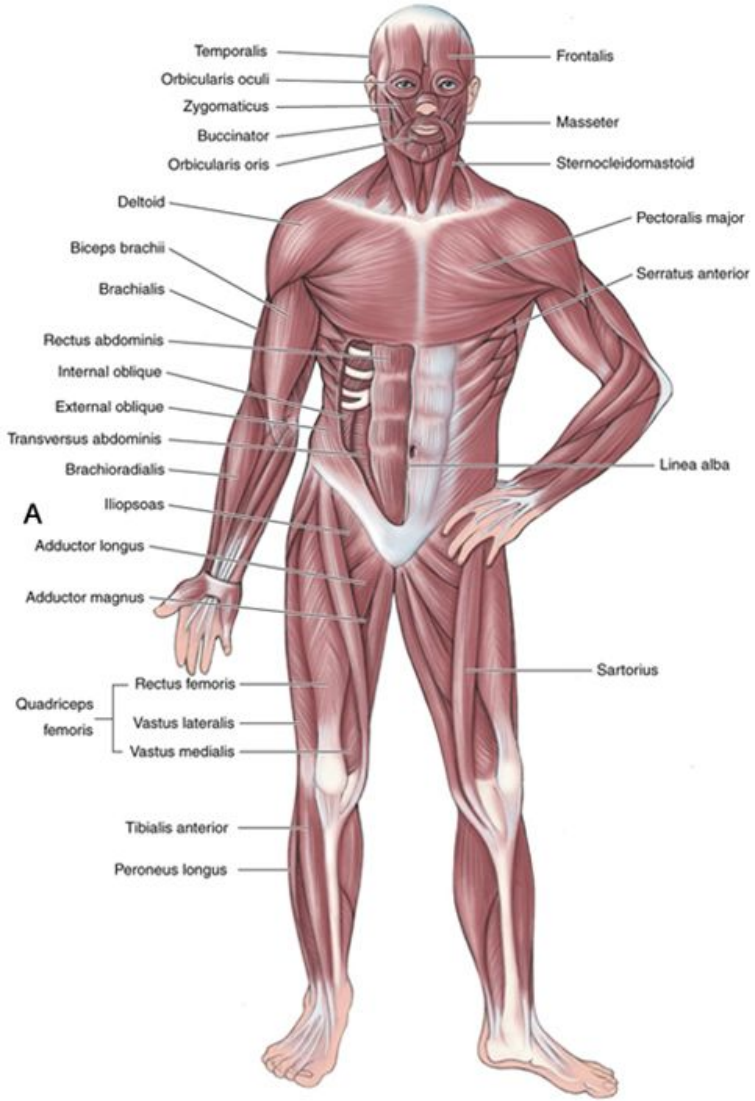
- sometimes included in the parallel muscle group
- these muscles are more spindle shaped, with the muscle belly being wider than the origin and insertion
- examples:
  - Biceps Brachii
  - Psoas major

Fusiform

(f) Fusiform
(biceps brachii)

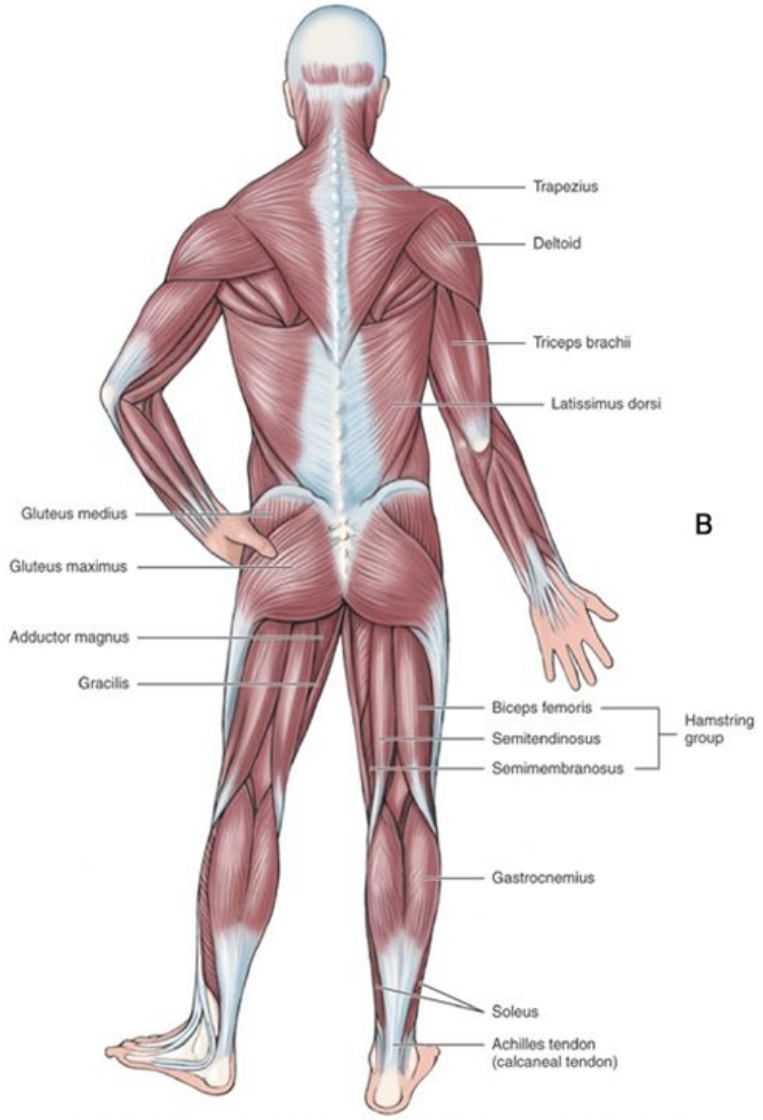
Muscle from Head to Toe

- Anterior view

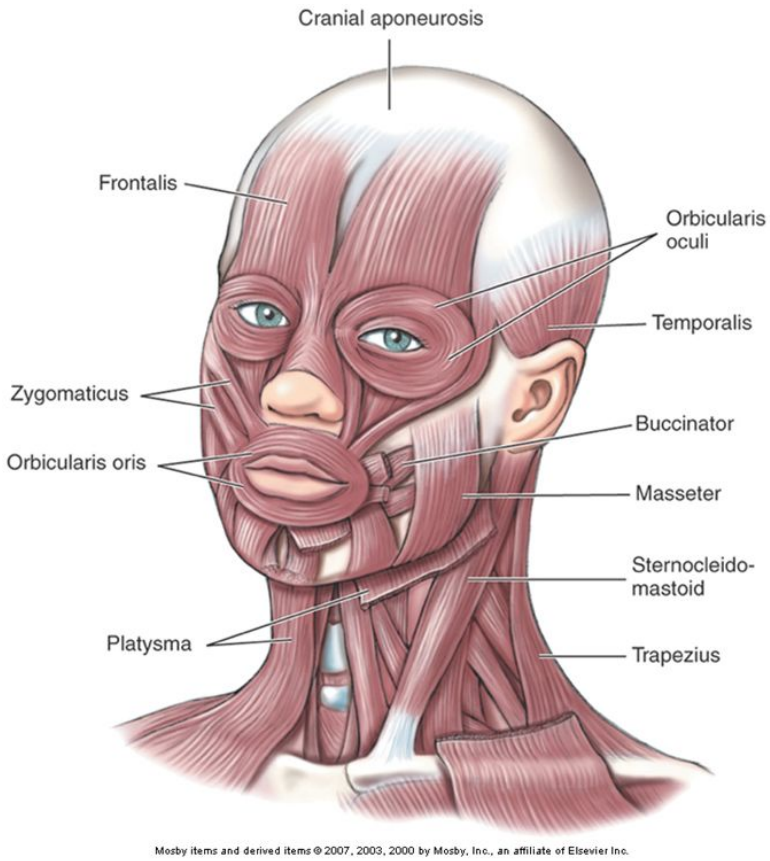


Muscles Head to Toe

- Posterior View



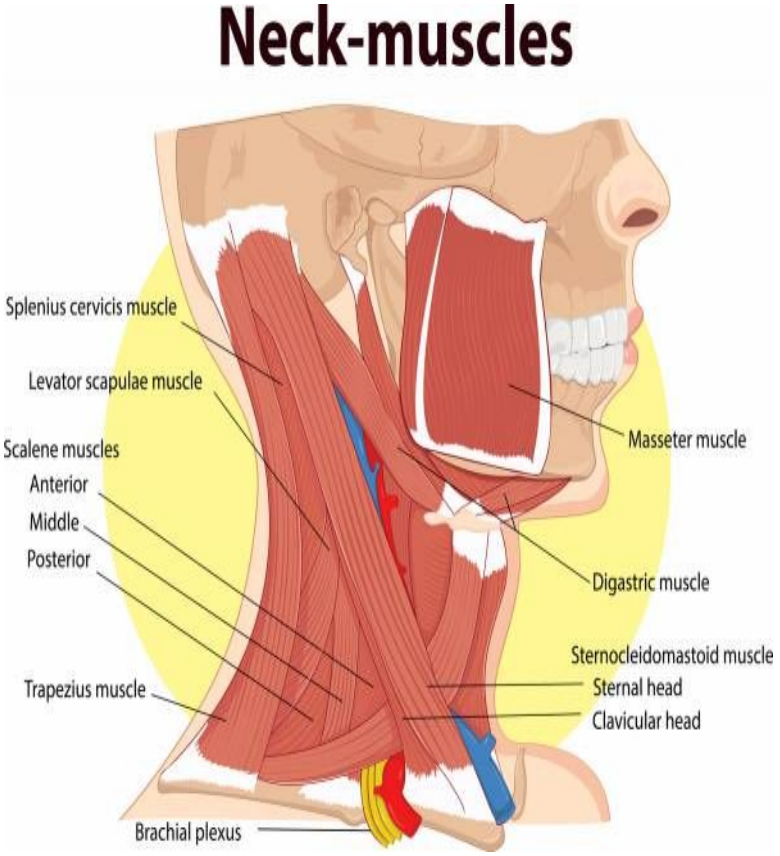
Muscle of the Head



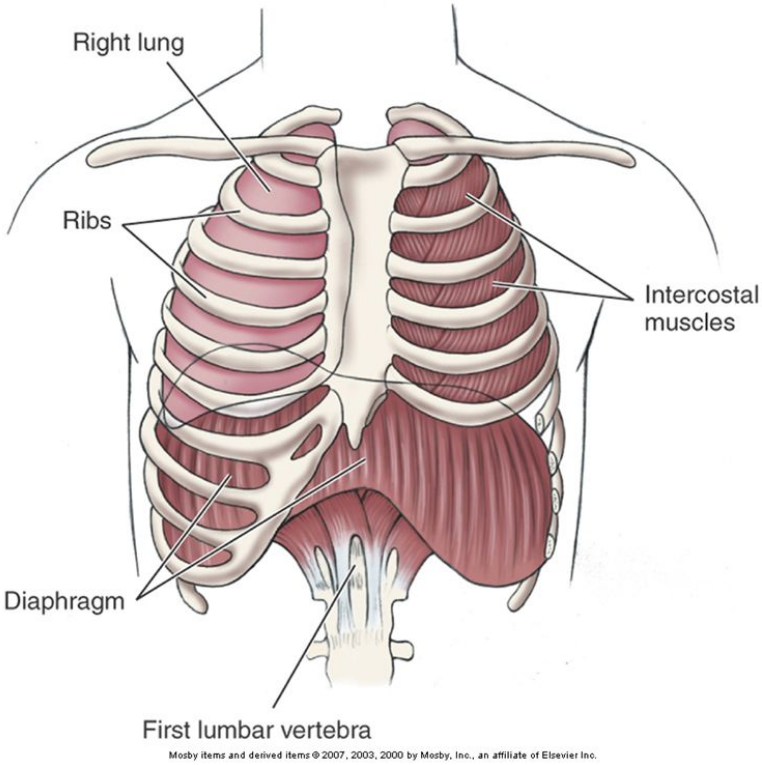
- Facial muscles
  - Frontalis
  - Orbicularis oculi
  - Orbicularis oris
  - Buccinator
  - Zygomaticus
- Chewing muscles
  - Temporalis
  - Masseter

Muscle of the Neck

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



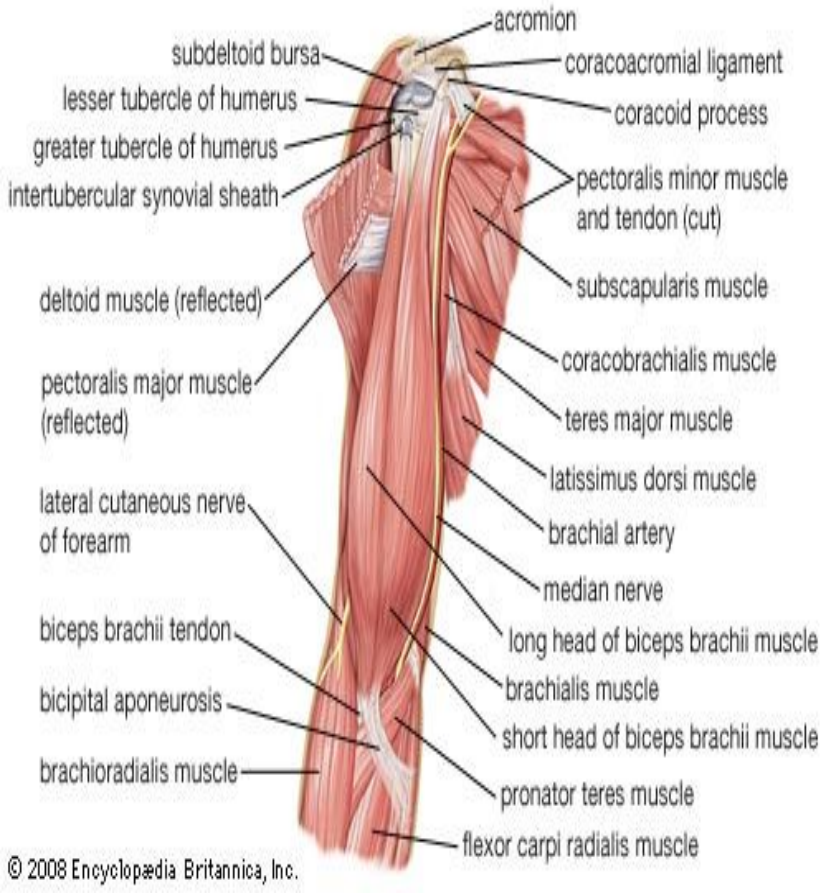
Muscles of the Trunk



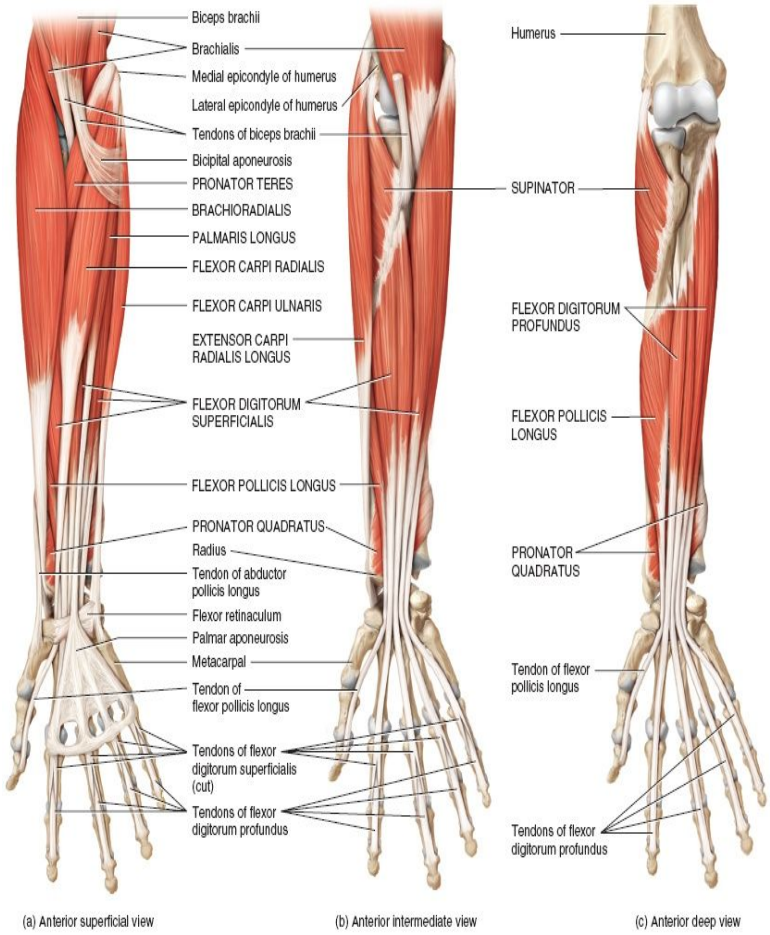
- Muscles involved in breathing
  - Intercostal muscles
  - Diaphragm
- Muscles of the abdominal wall
  - External oblique
  - Internal oblique
  - Transversus abdominis
  - Rectus abdominis
- Muscles of the vertebral column
- Muscles of the pelvic floor

Muscles that move the shoulder and upper arm

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



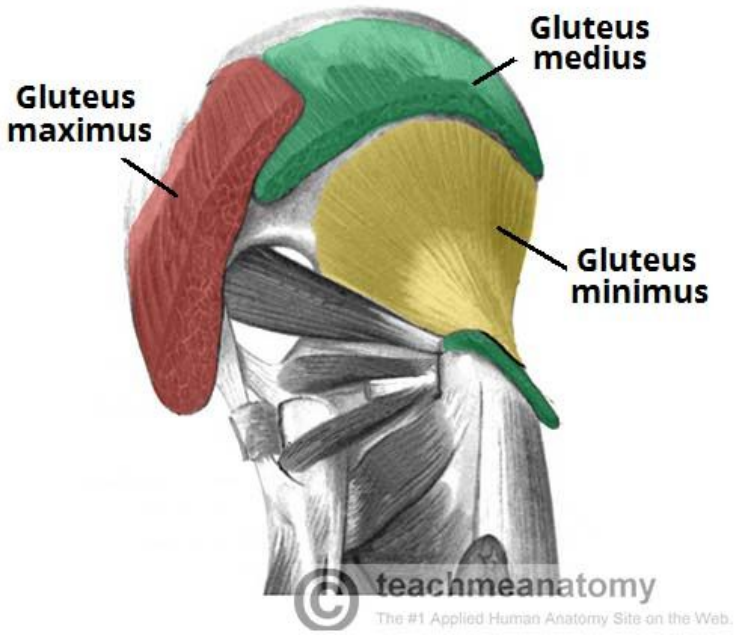
Muscles that move the forearm and hand



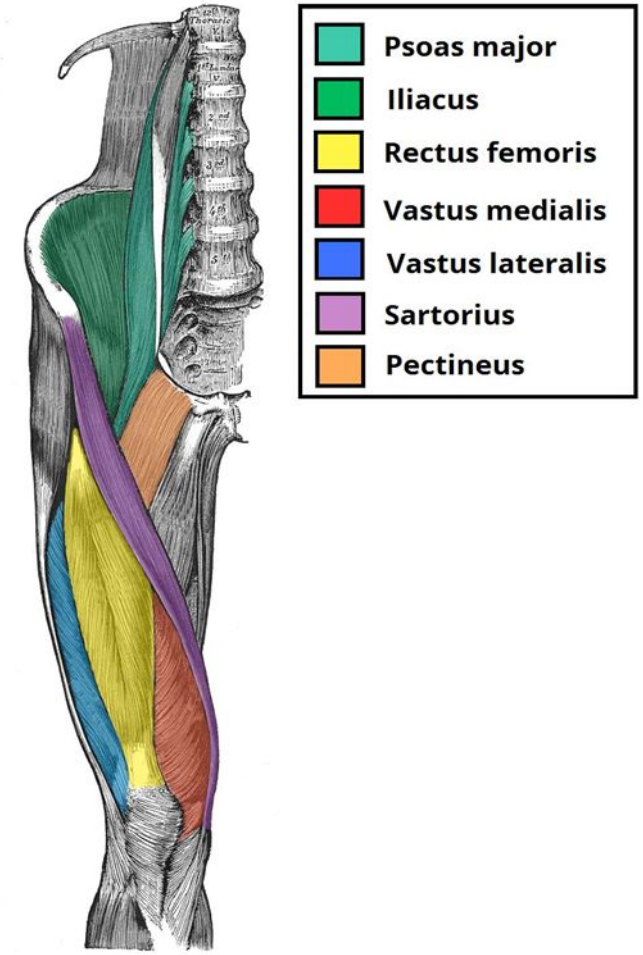
- Biceps brachii
- Triceps brachii
- Brachialis
- Brachioradialis
- Flexor and extensor carpi groups
- Flexor and extensor digitorum groups

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