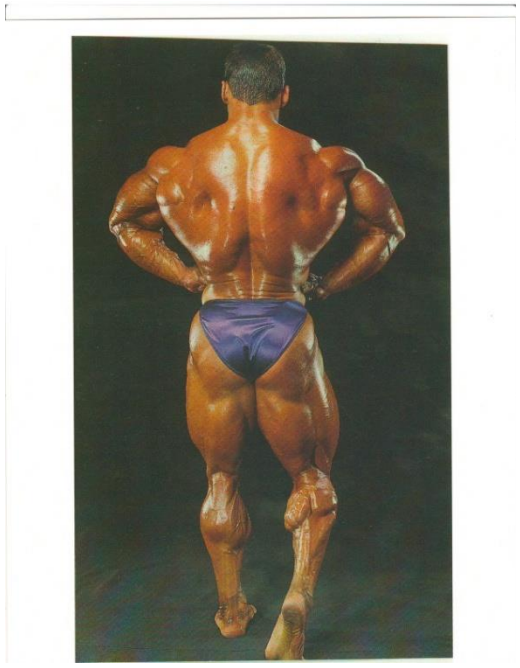

FLEX WHEELER



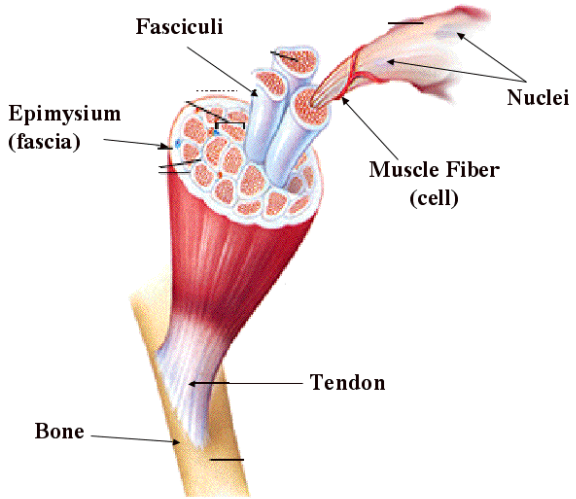
Muscular system 1

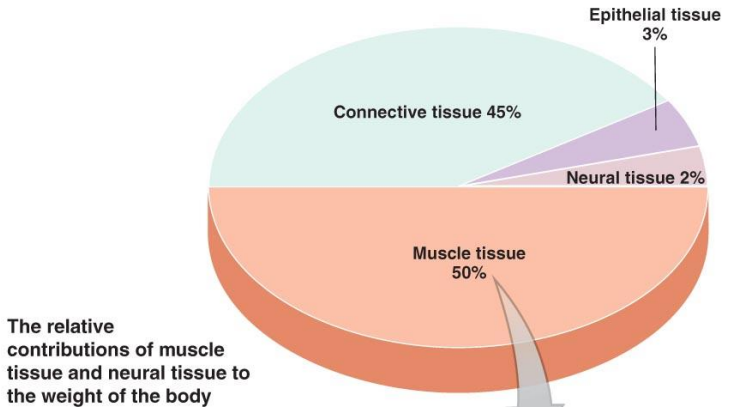
Macroanatomy of muscle

Muscle type and sceletal muscle function

Learning Objectives

- Definition: muscle and its accesory structures
- Muscle parts
- Function of muscle
- Muscle fibers arrangement
- Type of muscle (under light microscope)
- Organization level of muscle
- Type of muscle (mitochondria, twitch)
- Extrafusal and intrafusal muscle fibers
- Type of muscle based on contraction

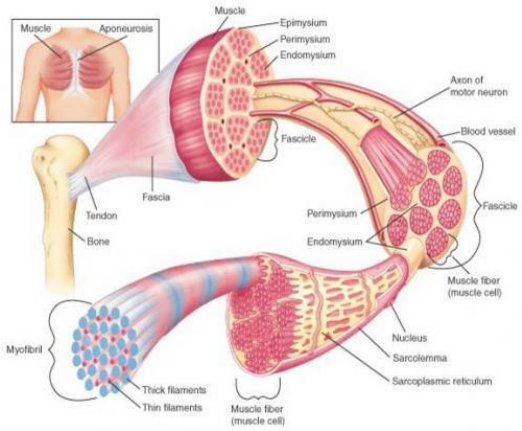




- Gross anatomy, Myology, sarcology (Greek)
- Muscle = musculus (Latin),
- The branch of science concerned with the muscles and their accessory parts: tendons,aponeuroses, bursae, synovial sheath and fasciae
- *musculus*= little mouse(L), from Latin *mūs* mouse,

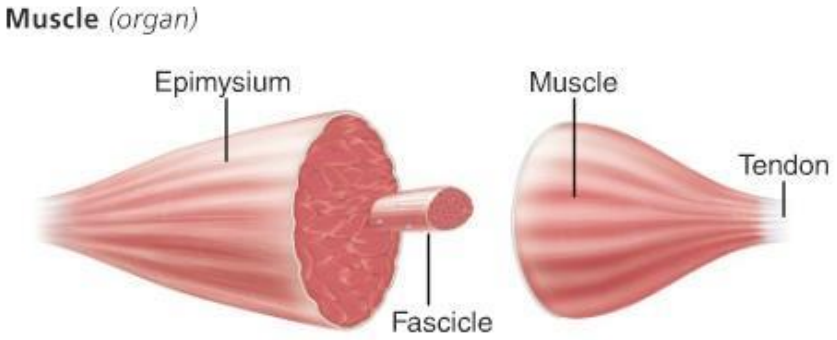
  from the imagined resemblance of some muscles to mice

Mus, musculus



- Mus a genus of rodents containing many kinds of mice
- *Mus* a sub-genus of *Mus* containing the house mouse
- The house mouse (*Mus musculus*) is a small mammal of the order Rodentia
- Musculus
  a bundle of long slender cells (muscle fibers) that have the power to contract and hence to produce movement.

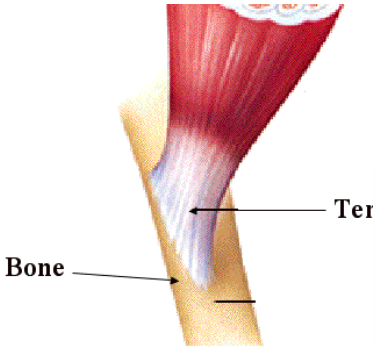
muscle

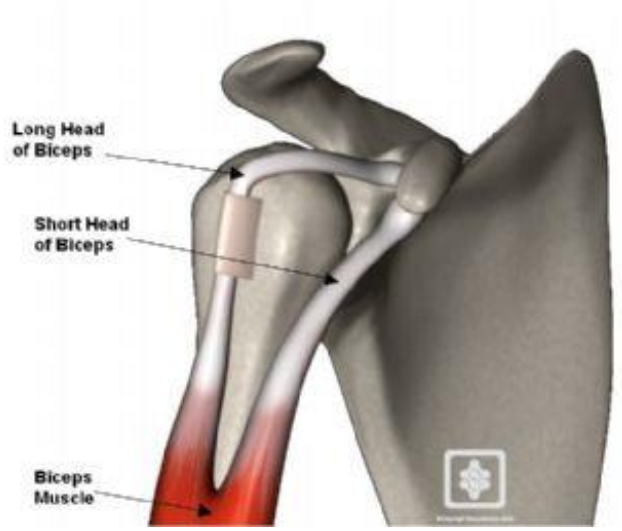


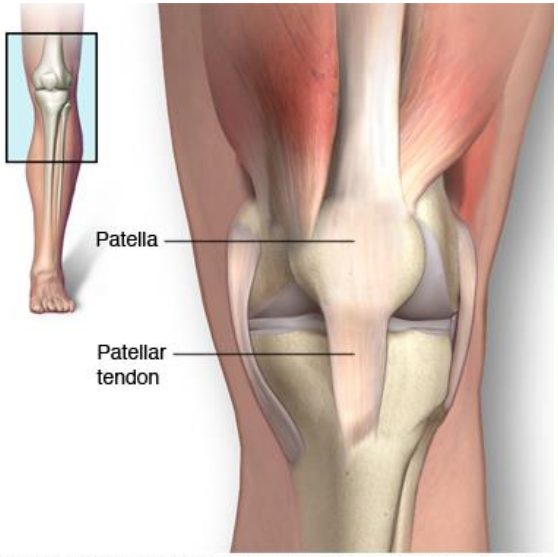
- **A tissue** composed of fibers capable of contracting to effect bodily movement
- a tissue composed of bundles of elongated cells capable of contraction and relaxation **to produce movement** in an organ or part
- A contractile organ consisting of a special bundle of muscle tissue, which moves a particular bone, part, or substance of the body
- an organ composed of muscle tissue (an **organ** / **viscus = internal organ**) is a collection of tissues joined in a structural unit to serve a common function, the main tissue is that which is unique for the specific organ, such as the myocardium, the main tissue of the heart, while sporadic tissues include the nerves,blood vessels, and connective tissues

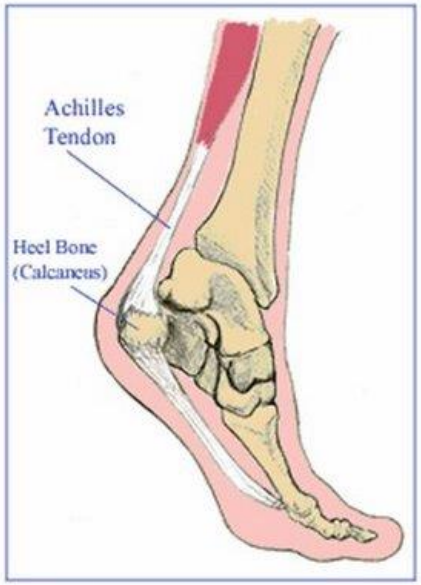
tendon

- a cord or band of white in elastic collagenous tissue that attaches a muscle to a bone or some other part;
- Latin tend, tendn- alteration (influenced by Latin tendere, *to stretch*) of Greek tenn;
- Example:
- Patellar tendon, Achilles tendon

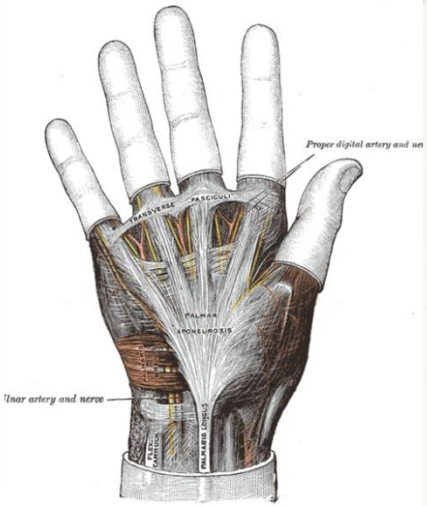


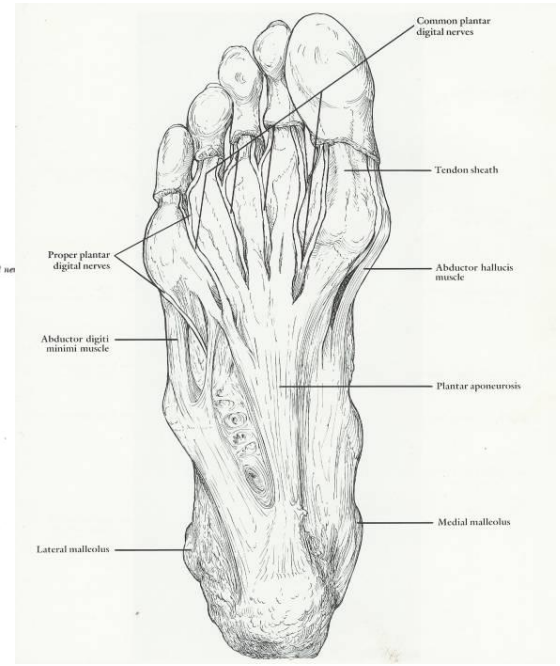






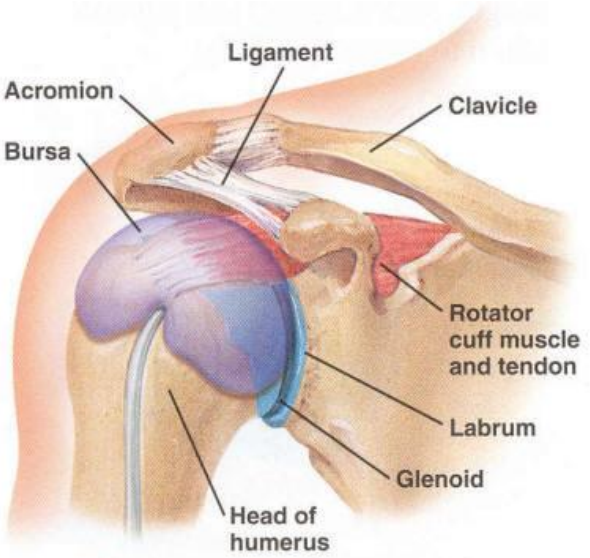
aponeurosis





- a white fibrous sheet of tissue by which certain muscles are attached to bones
- A sheetlike fibrous membrane, resembling a flattened tendon, that serves as afascia to bind muscles together or as a means of connecting muscle to bone
- Example: cranial, palmar, plantaris aponeurosis

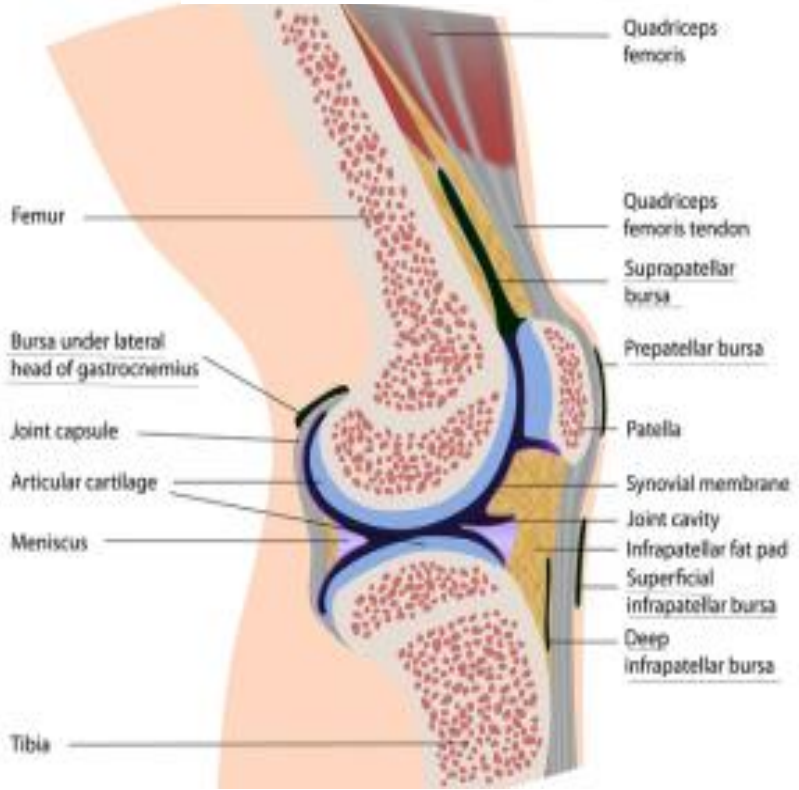
bursae



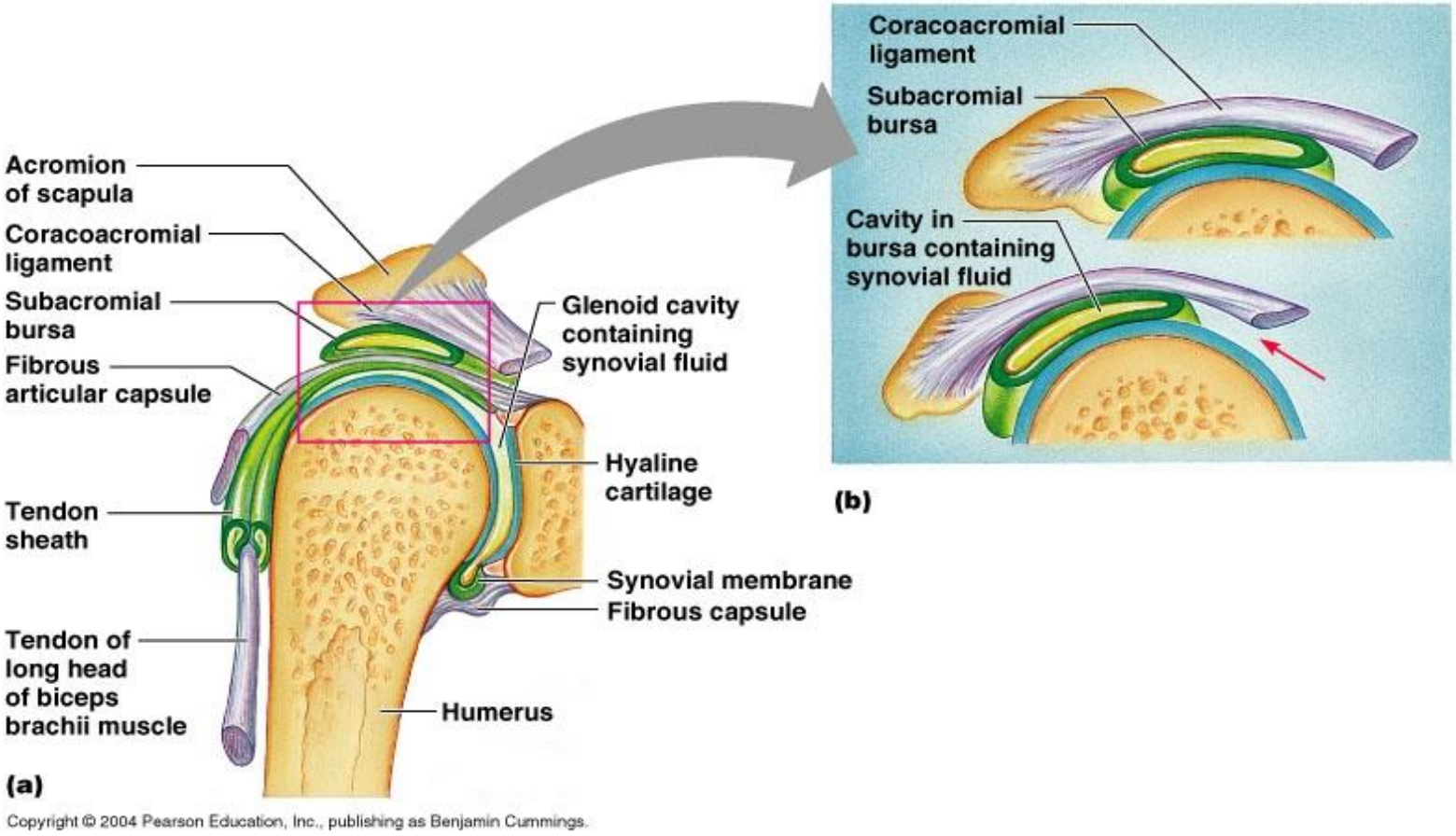
- a small fluid -
  filled sac that reduces friction between mo vable parts of the body, esp. at joints
- a pouch, sac, or vesicle, esp. a sac containi ng synovia, to facilitate motion, as between a tendon and a bone.
- A sac or saclike bodily cavity, especially one containing a viscous

  lubricating
  fluid and located between a tendon and a bone or at

  points of friction between
  moving structures.
- Example: supra, pre, infra infrapatellar bursae

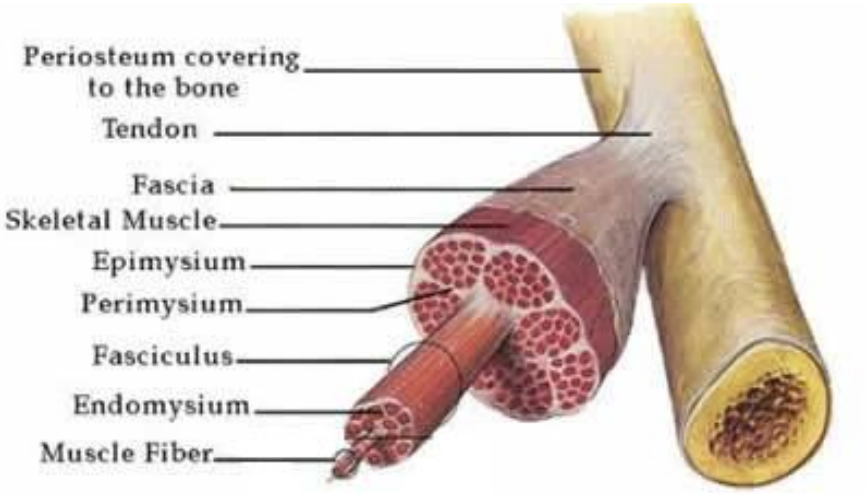


synovia



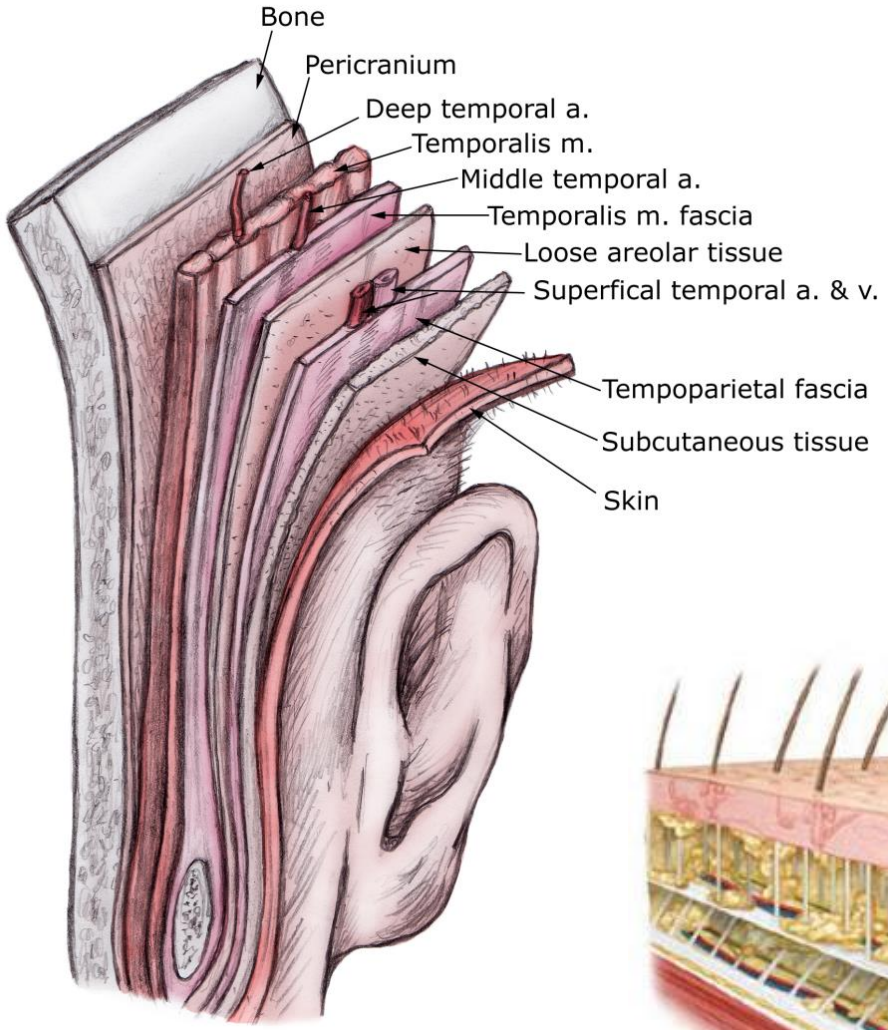
- A clear, viscid lubricating fluid secreted by membranes in joint cavities, sheaths of tendons, and bursae.

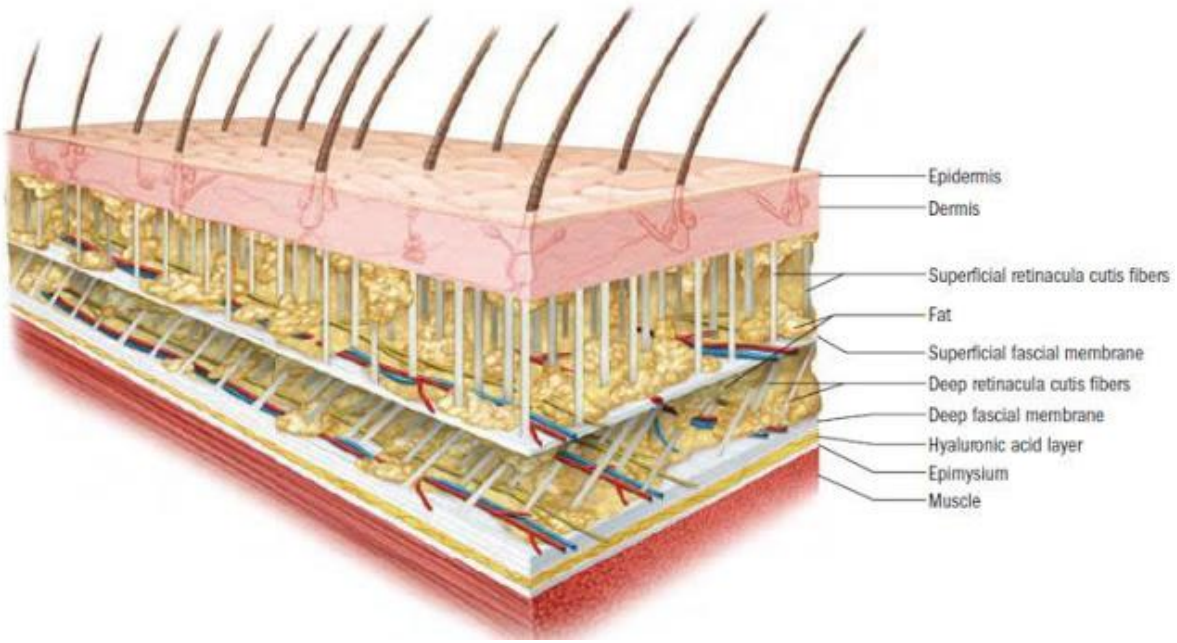
fascia



- A sheet/band of fibrous connective tissue enveloping separating, or binding together muscles, organs, and other soft structures of the body
- a band/sheath of connective tissue covering, supporting/connecting the muscles/ internal organs of the body
- Superficial, deep fascia, visceral, parietal

Superficial and deep fasciae





fascia (fasciae)

- A "band“(L)is a layer of fibrous tissue
- A fascia is a structure of connective tissue that surrounds muscles, groups of muscles, blood vessels, and nerves, binding some structures together, while permitting others to slide smoothly over each other.
- Various kinds of fascia may be distinguished.
- They are classified according to their distinct layers, their functions and their anatomical location:

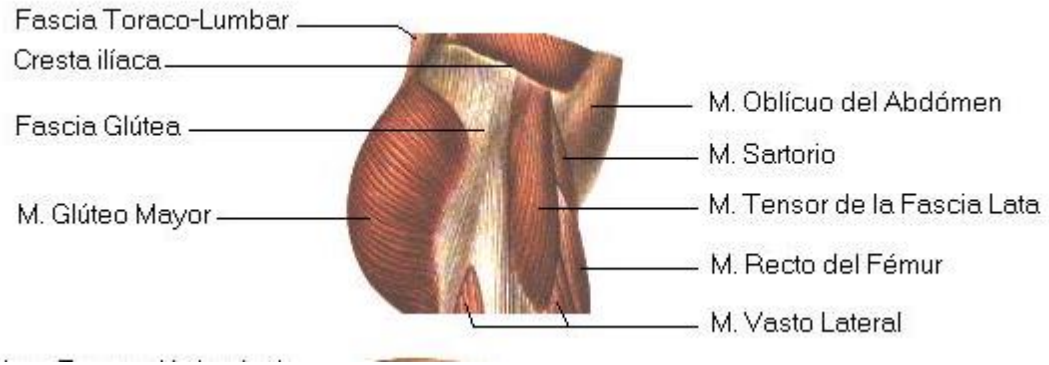
  superficial fascia, deep (or muscle) fascia, and visceral (or parietal) fascia (pericardium)

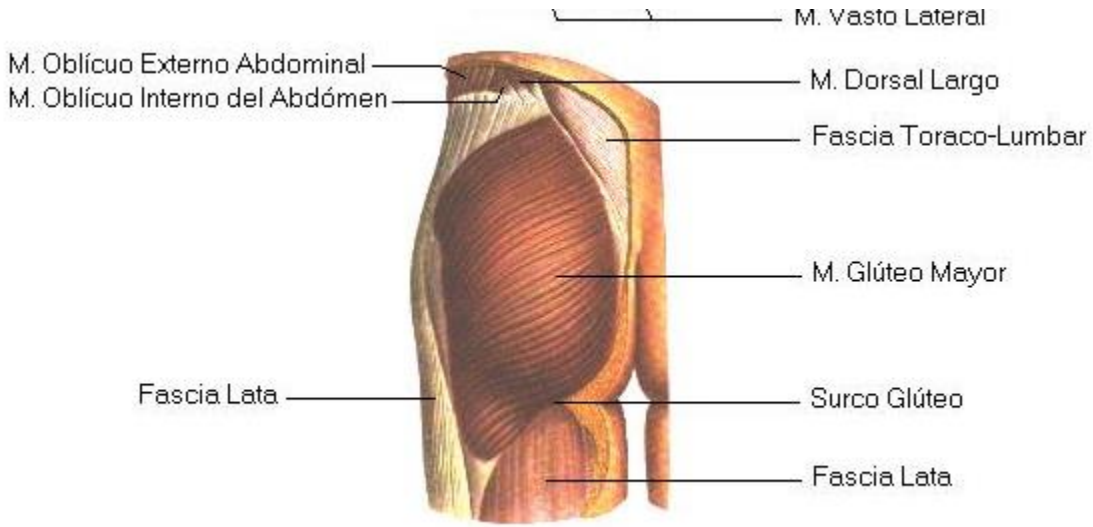
- Superficial fascia:

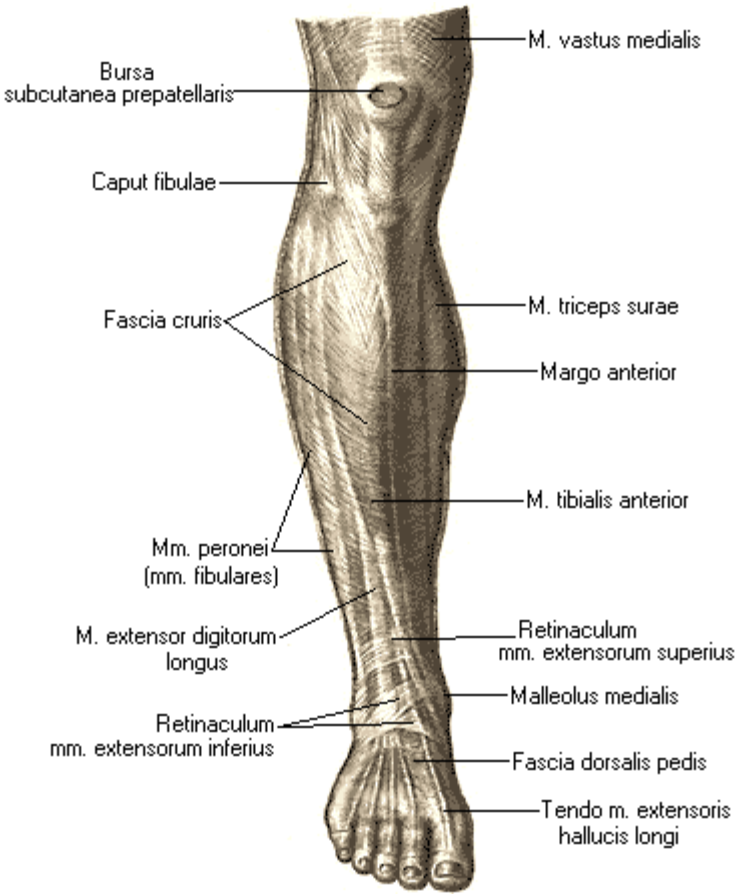
  This is found in the subcutis in most regions of the body, blending with the reticular layer of the dermis (example: camper and Scarpa fascia)
- Deep fascia:

  Muscle fascia: This is the dense fibrous connective tissue that interpenetrates and surrounds the muscles, bones, nerves and blood vessels of the body (example:fascia latae, fascia glutea, fascia cruris)
- Visceral & Parietal fascia:

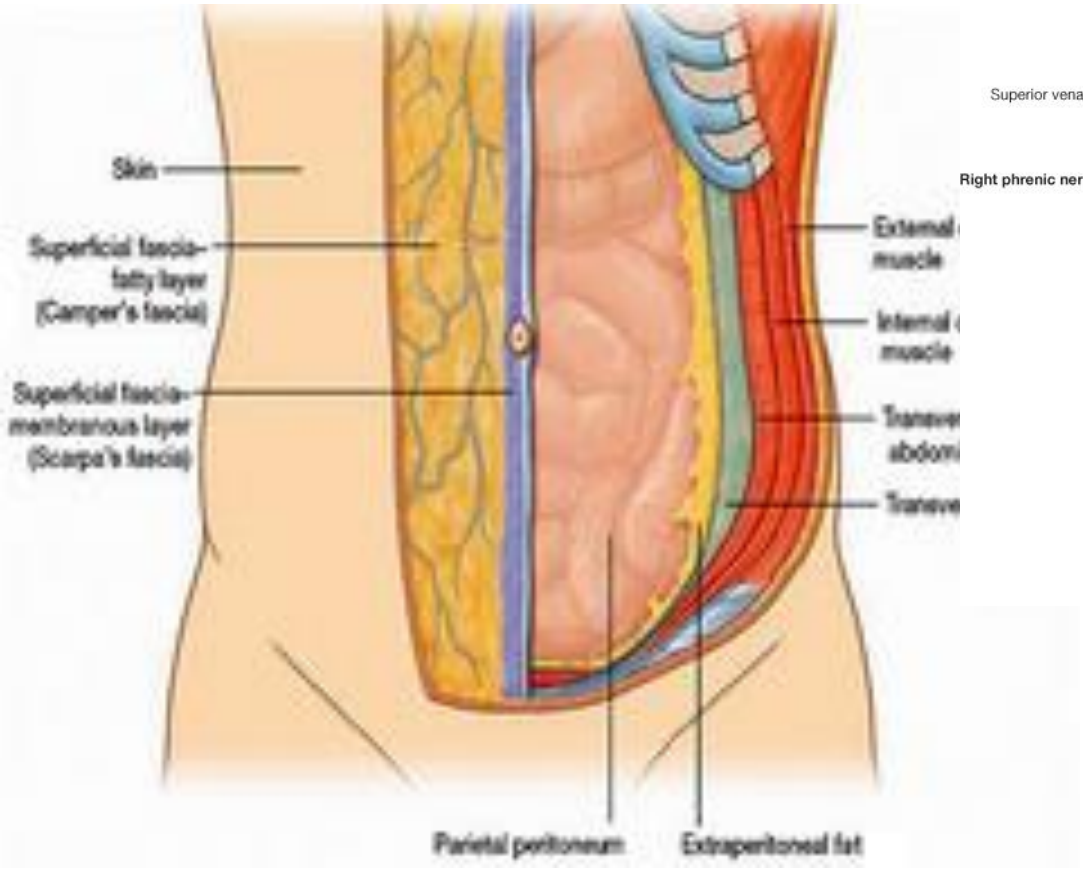
  This suspends the organs within their cavities and wraps them in layers of connective tissue membranes (example:pericardium, peritoneum)


Fascia Toraco-Lumbar
Cresta ilíaca
Fascia Glútea
M. Glúteo Mayor
M. Oblícuo del Abdómen
M. Sartorio
M. Tensor de la Fascia Lata
M. Recto del Fémur
M. Vasto Lateral

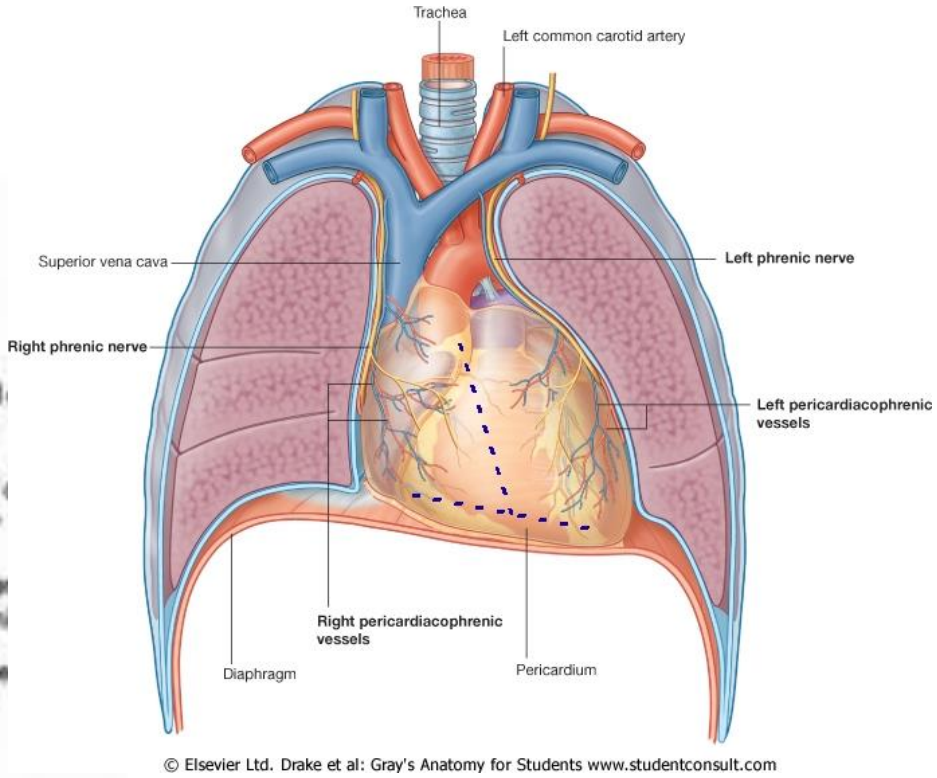

M. Vasto Lateral
M. Oblícuo Externo Abdominal
M. Oblícuo Interno del Abdómen
M. Dorsal Largo
Fascia Toraco-Lumbar
M. Glúteo Mayor
Fascia Lata
Surco Glúteo
Fascia Lata


M. vastus medialis
Bursa
subcutanea prepatellaris
Caput fibulae
Fascia cruris
M. triceps surae
Margo anterior
M. tibialis anterior
Mm. peronei
(mm. fibulares)
M. extensor digitorum
longus
Retinaculum
mm. extensorum superius
Malleolus medialis
Retinaculum
mm. extensorum inferius
Fascia dorsalis pedis
Tendo m. extensoris
hallucis longi

Camper`s fascia (fatty layer), Scarpa`s fascia (membranaceus), peritoneum



Pericardium, pleura



Function of fascia

- Fasciae are normally thought of as passive structures that transmit mechanical tension generated by muscular activities or external forces throughout the body
- The function of muscle fasciae is to reduce friction to minimize the reduction of muscular force.

  In doing so, fasciae:

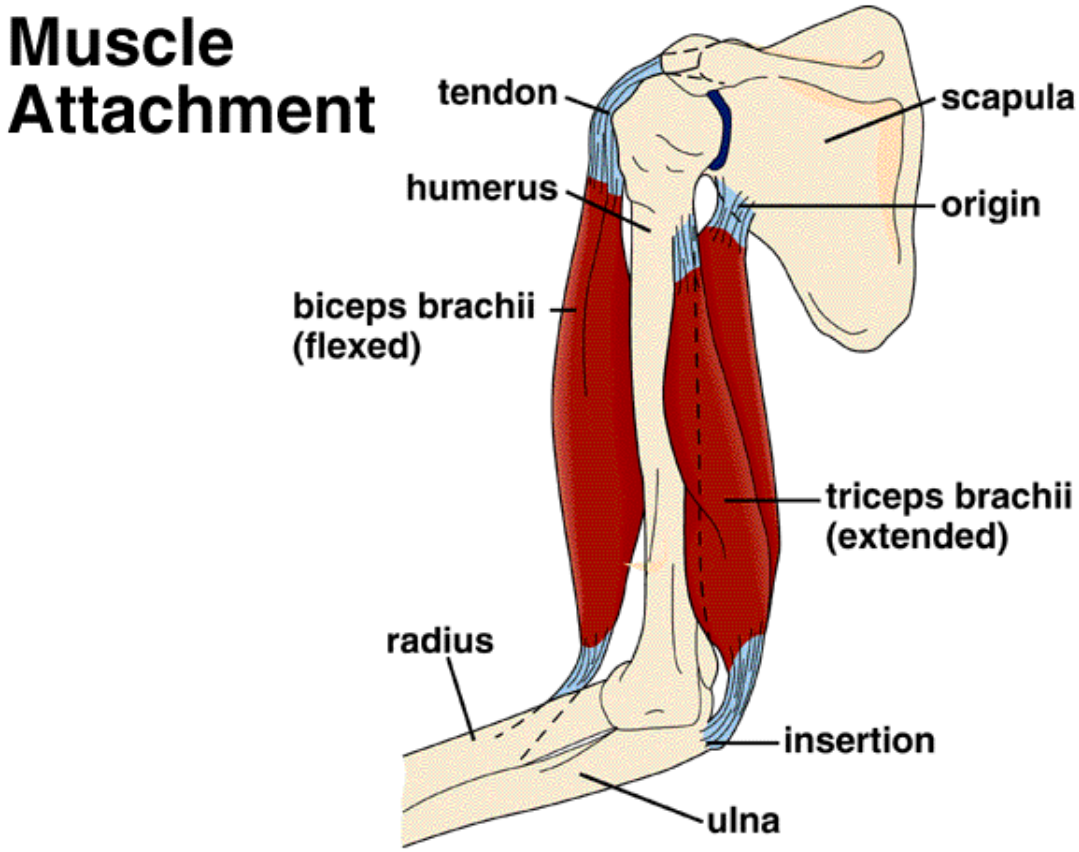
  Provide a sliding and gliding environment for muscles.

  Suspend organs in their proper place.

  Transmit movement from muscles to bones.

  Provide a supportive and movable wrapping for nerves and blood vessels as they pass through and between muscles

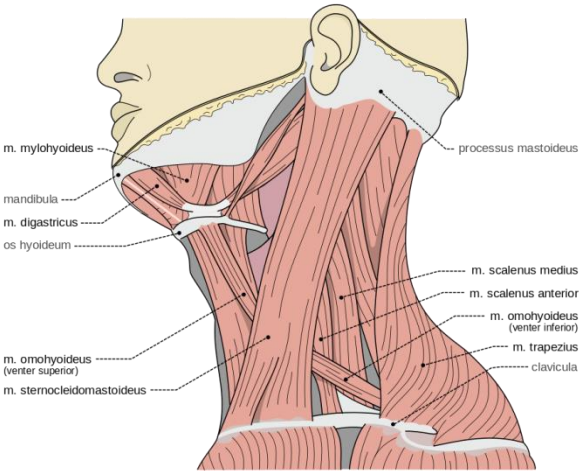
Muscle origin and insertion (proximal & distal parts; fixation & mobile parts)

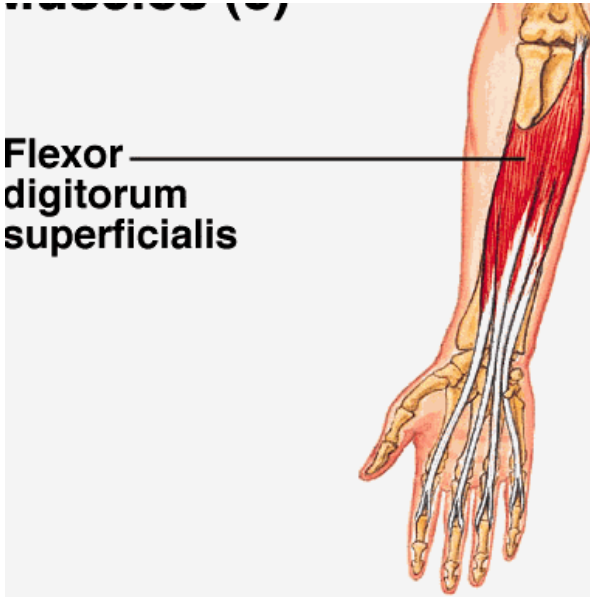


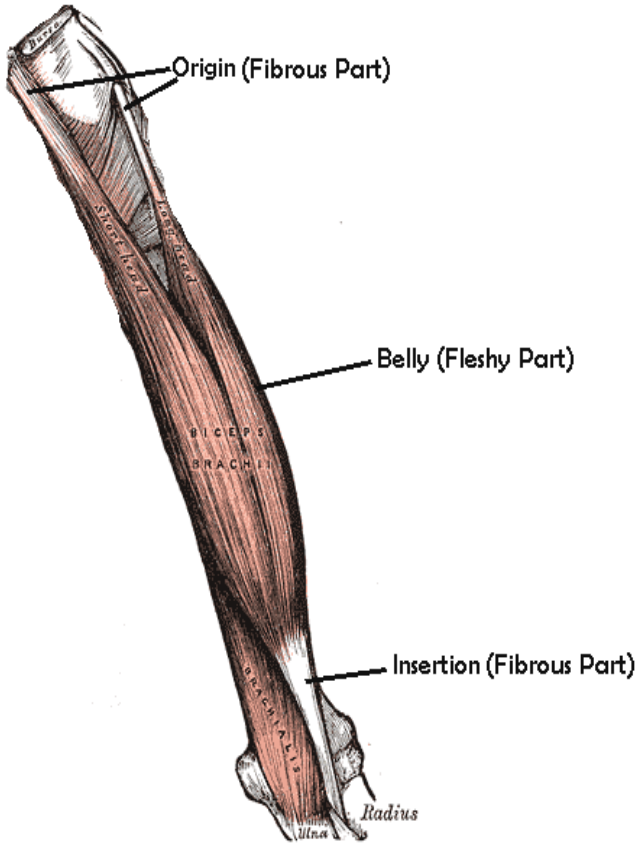
m.biceps brachii: O: caput longum: tuberositas supraglenoidalis, caput breve: proc. Coracoideus, insertion: tuberositas radii

m.triceps brachii: O: caput longum: tuberositas infraglenoidalis, caput mediale: facies posterior humeri, distal sulcus nervi radialis, caput laterale: : facies posterior humeri, distal sulcus nervi radialis, , insertion: olecranon ulnae

Muscle parts: caput (biceps, triceps, quadriceps &venter (biventer), cauda







Body muscle function

- Body movement/motion (skeletal muscle)

  Muscle spread passthrough the joint, bring the part of body close or far away from other

- Body heat (skeletal muscle)

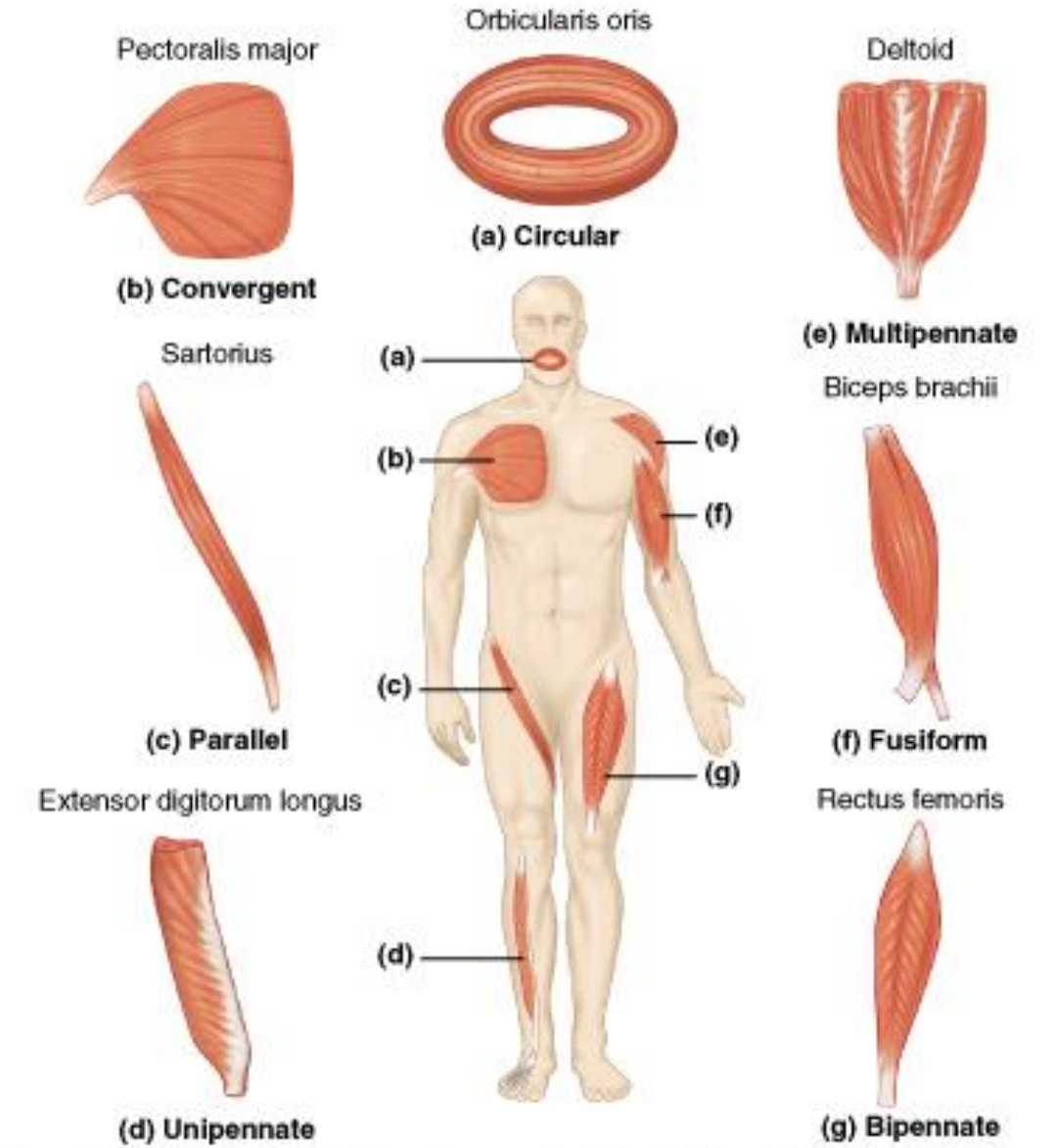
  When our muscles use that power, an exothermic chemical reaction occurs that "burns" ATP, breaking it into two pieces (ADP and phosphate). That reaction releases energy. Some of that energy is used in the actual movement of the muscle, and remains as a heat

- Body shape (skeletal muscle)

  Bulky muscle such as in the gluteal, brachial, pectoral, shoulder regions

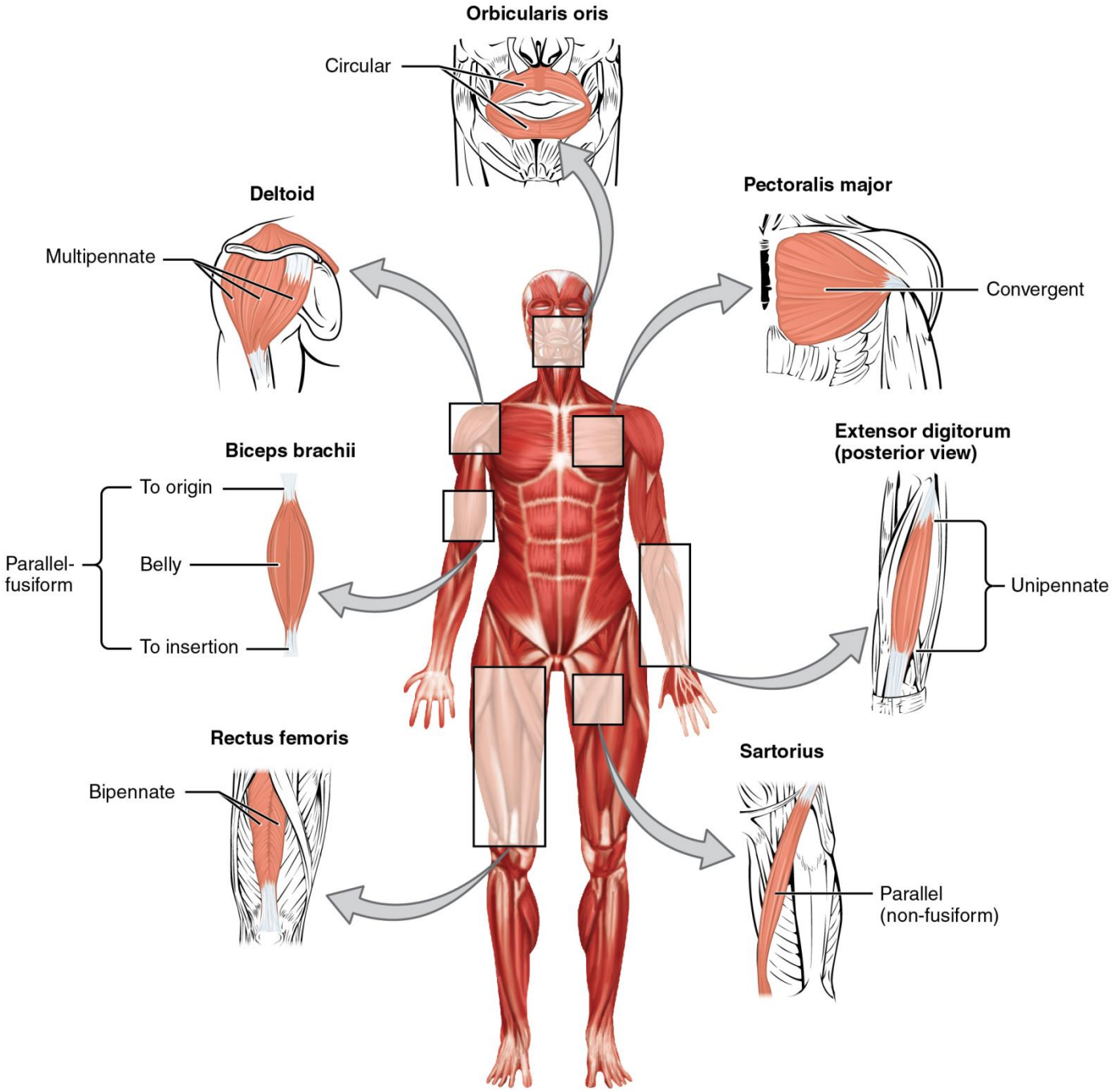
- Blood circulation , lymph circulation (cardiac muscle)
- Food digestion (smooth muscle)
- Storage protein (energy)
- Micturion, defecation, inhalation (smooth and skeletal muscle), etc

Muscle Fibres arrangement

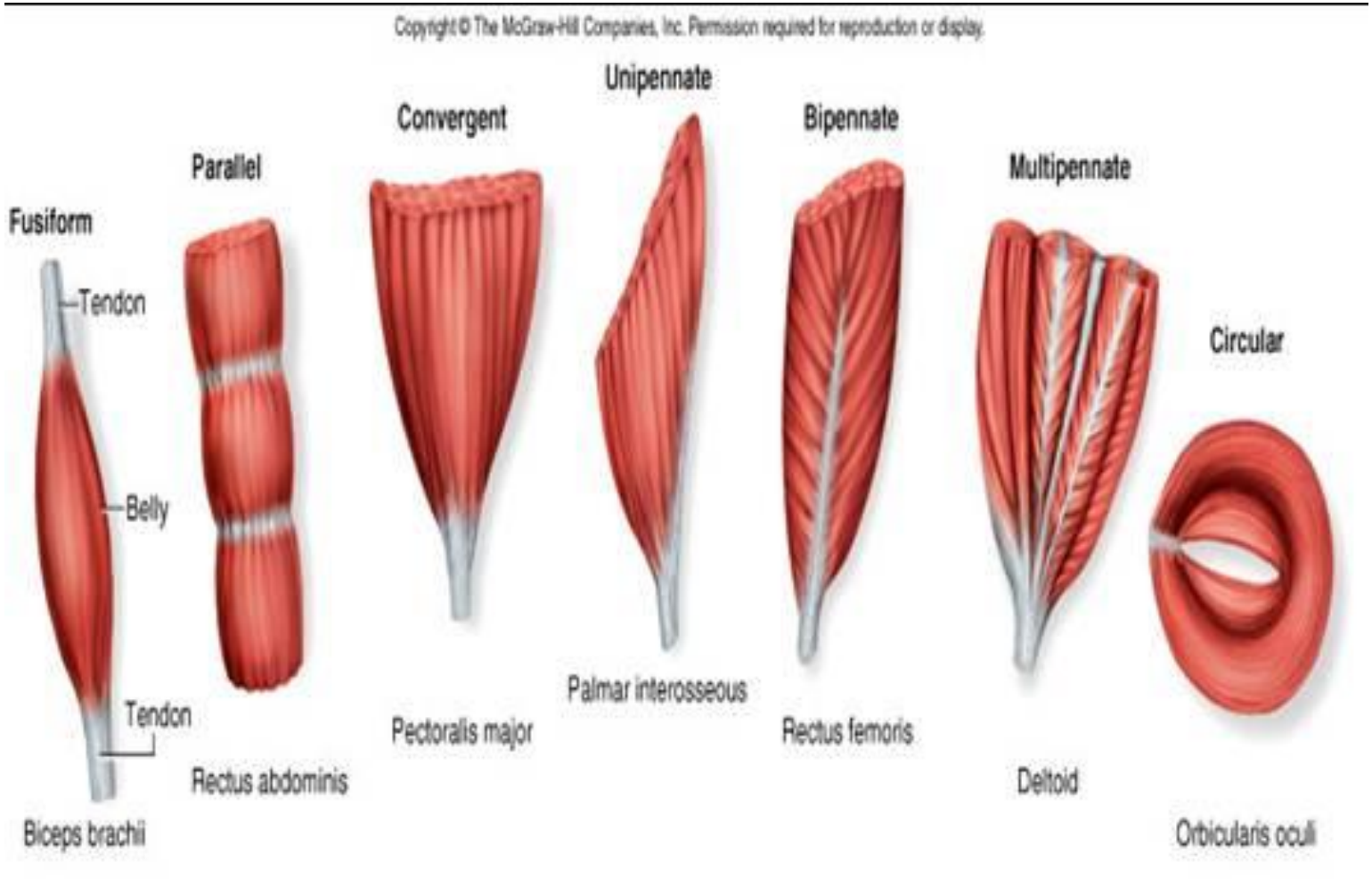


Muscle Shape and Fiber Arrangement

Fiber arrangement	Advantage	Shape	Characteristics / description	Example
Parallel (fibers arranged parallel to the length of the muscle)	Produces greater range of movement than similar-sized pinnate muscles	Flat	Usually thin and broad, fibrous sheetlike aponeurosis that allow them to spread their forces over a broad area.	Rectus abdominus, external oblique
		Fusiform	Spindle-shaped with central belly that tapers to tendons on each end; can focus their power onto small, bony targets.	Brachialis, brachioradialis
		Strap	More uniform in diameter with essentially all of their fibers arranged in a long parallel manner; can focus their power onto small, bony targets	Sartorius
		Radiate (triangular, fan-shaped, or convergent)	Combined arrangement of flat and fusiform muscles, orginate on brad aponeurosis and converge onto a tendon	Pectoralis major, trapezius
		Sphincter (circular)	Technically endless strap muscles, surround openings and function to close them upon contraction	Orbicularis oris, obricularis oculi
Pennate (shorter fibers, arranged obliquely to their tendons)	Produces greater force than similar-sized parallel muscles due to increase cross-sectional area	Unipennate	Run obliquely from a tendon on one side only	Biceps femoris, extensor digitorum longus, tibialis posterior
		Bipennate	Run obliquely on both sides from a central tendon.	Rectus femoris, flexor hallucis longus
		Multipennate	Several tendons with fibers running diagonally between them	Deltoid


Orbicularis oris
Circular
Deltoid
Multipennate
Pectoralis major
Convergent
Biceps brachii
To origin
Parallel-
fusiform
Belly
To insertion
Extensor digitorum
(posterior view)
Unipennate
Rectus femoris
Bipennate
Sartorius
Parallel
(non-fusiform)

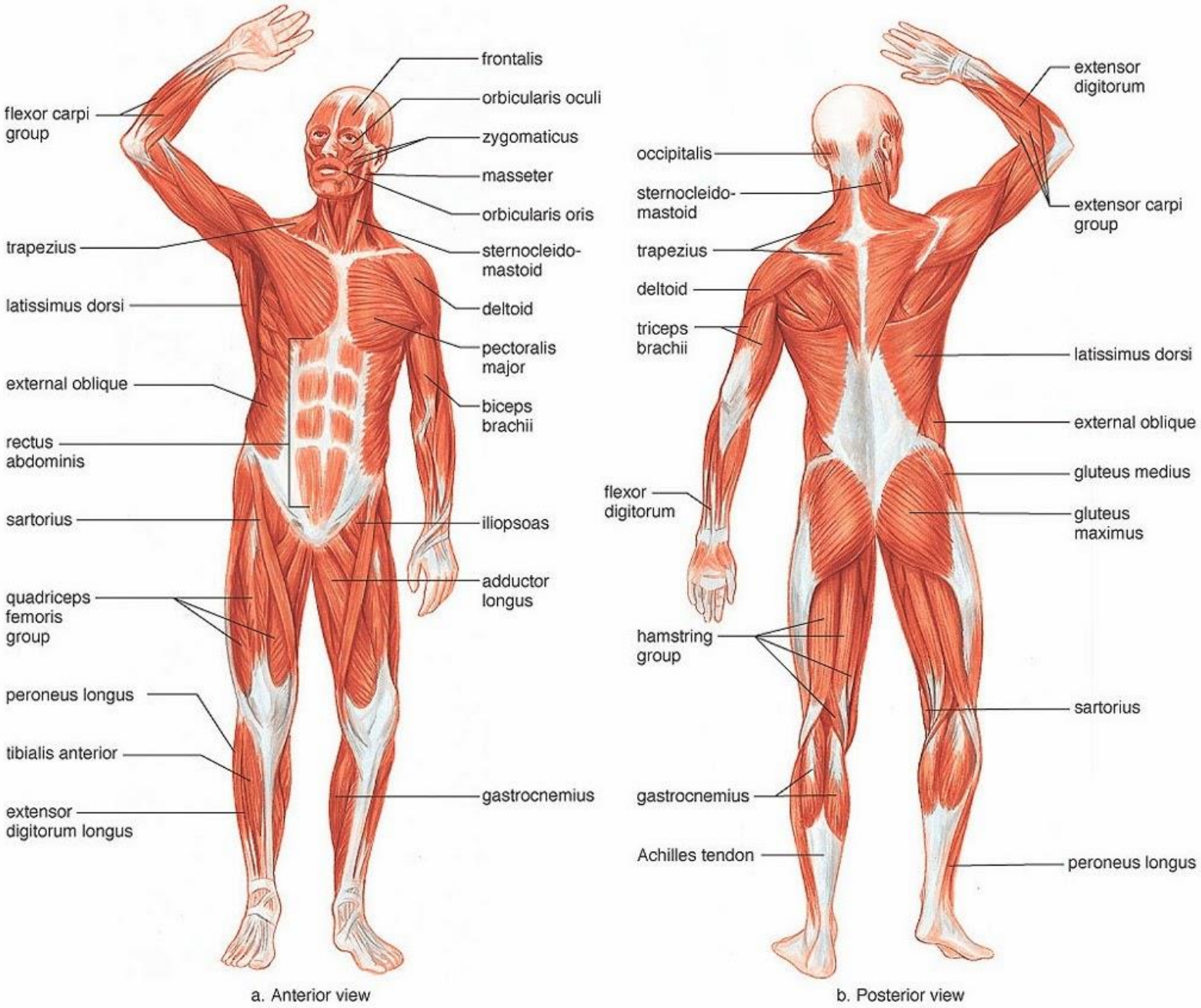
Muscles and its fiber arranggement



Nomenklatur

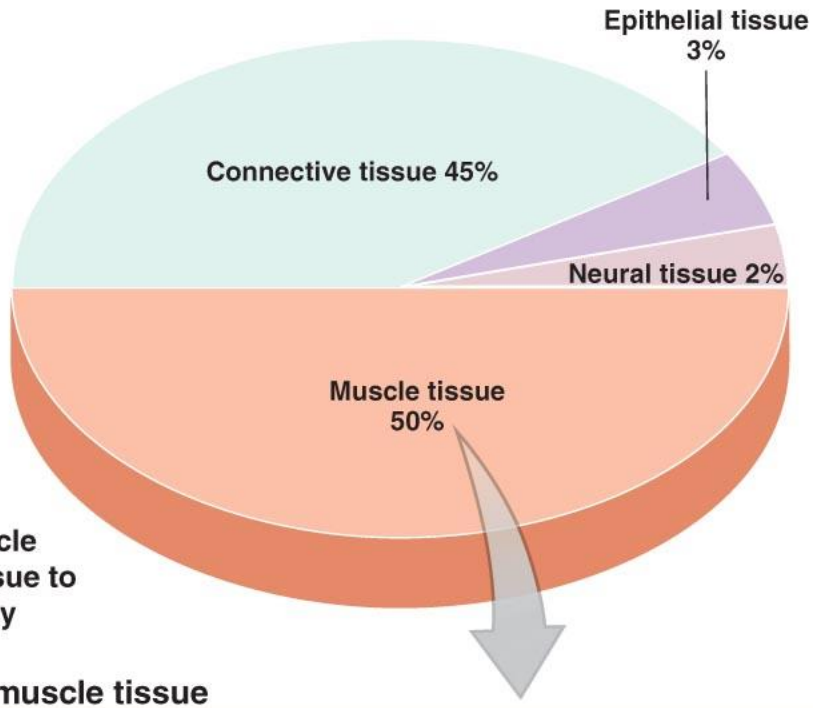
name of individual muscle based on:

- Indicate muscle in Latin, musculus, m.
- Individual muscle shape or size
- Location (appropriate to the body region)
- Anatomical position/direction
- Function of the muscle
- Fibres arrangement
- Origin and insertion location
- Parts of muscle (caput, venter)
- Combination/mixed


flexor carpi group
frontalis
orbicularis oculi
zygomaticus
masseter
orbicularis oris
trapezius
sternocleido-mastoid
latissimus dorsi
deltoid
pectoralis major
external oblique
biceps brachii
rectus abdominis
sartorius
iliopsoas
adductor longus
quadriceps femoris group
peroneus longus
tibialis anterior
extensor digitorum longus
gastrocnemius
a. Anterior view
extensor digitorum
occipitalis
sternocleido-mastoid
extensor carpi group
trapezius
deltoid
triceps brachii
latissimus dorsi
external oblique
gluteus medius
flexor digitorum
gluteus maximus
hamstring group
sartorius
gastrocnemius
Achilles tendon
peroneus longus
b. Posterior view

Examples

- shape : m. trapezius
- location : m. supraspinatus, m. frontalis
- Parts of muscle & region :m. biceps brachii
- Region & direction: m. tibialis anterior
- Region & shape: m. latissimus dorsi
- Location of origin and insertion: m. brachioradialis
- Function of the muscle: m. supinator
- Function, arrengement, region, direction : m. spinchter ani externus
- Function & shape : m. pronator quadratus
- Region & size: m. pectoralis major
- Fibres arrangement and region: m. rectus abdominis
- Shape & size: m. teres major



The relative contributions of muscle tissue and neural tissue to the weight of the body

The three types of muscle tissue

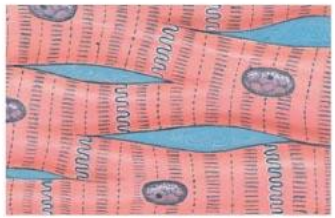
Muscle Tissue

Skeletal Muscle Tissue

Skeletal muscle tissue moves the body by pulling on bones of the skeleton, making it possible for us to walk, dance, bite an apple, or play the ukulele.

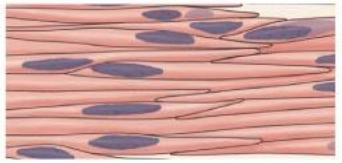
Cardiac Muscle Tissue

Cardiac muscle tissue contractions move blood through the blood vessels.



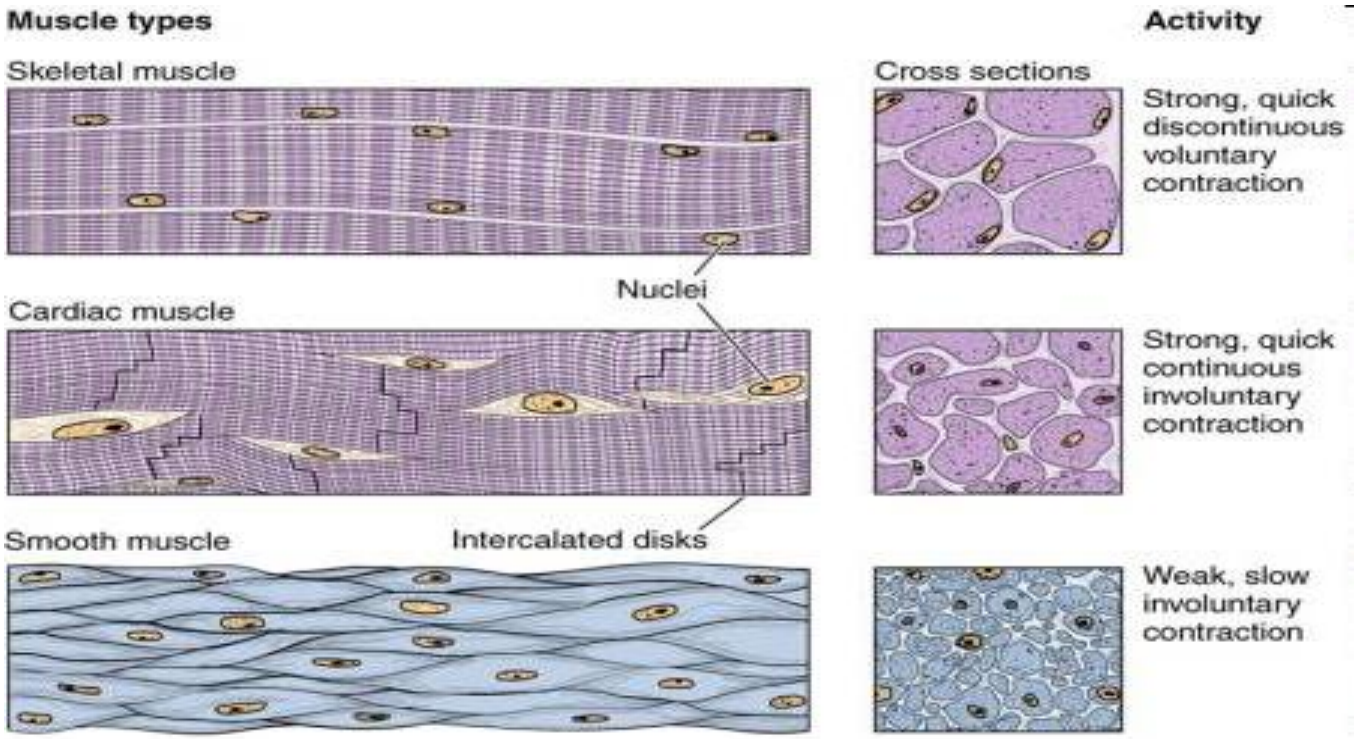
Smooth Muscle Tissue

Smooth muscle tissue contractions move fluids and solids along the digestive tract and regulate the diameters of small arteries, among other functions.

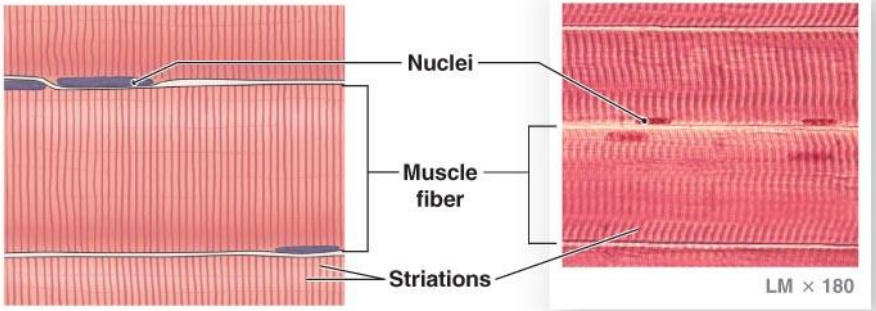


Types muscle

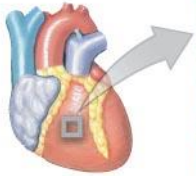
Skeletal	Voluntary	Striated	Multinucleated	Non-branched
Cardiac	Involuntary	Striated	Single nucleus	Branched
Smooth	Involuntary	Nonstriated	Single nucleus	Tapered

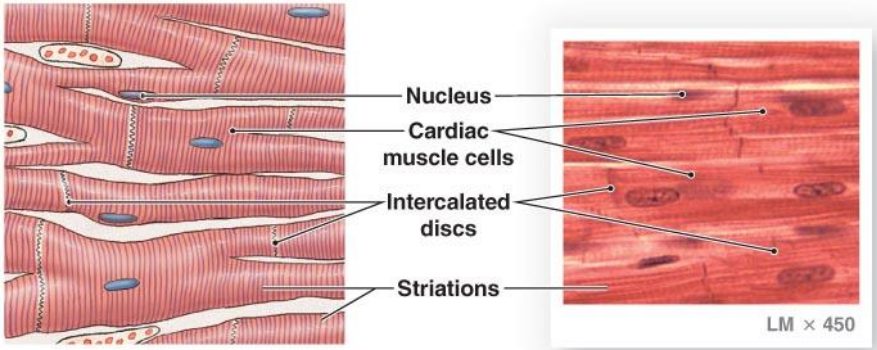


The structure and function of the three types of muscle tissue

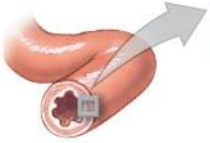


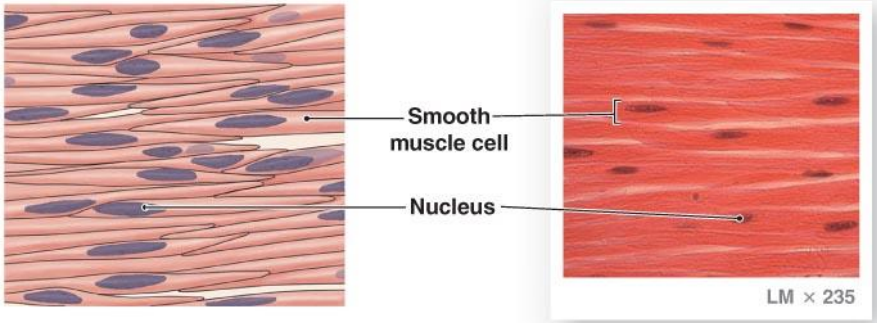
Skeletal muscles move or stabilize the position of the skeleton; guard entrances and exits to the digestive, respiratory, and urinary tracts; generate heat; and protect internal organs.





Cardiac muscle moves blood and maintains blood pressure.





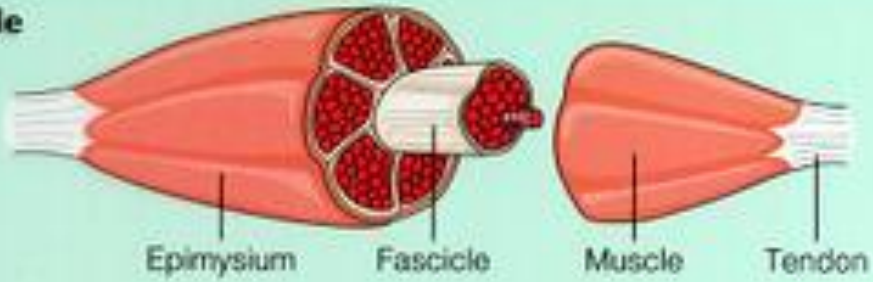
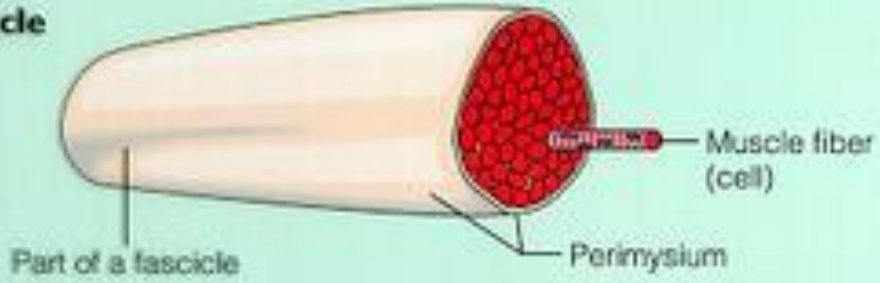
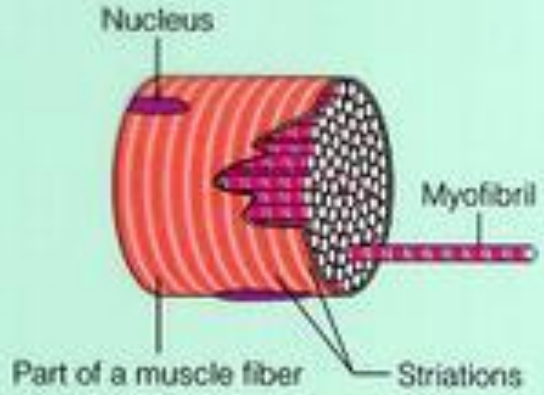
Smooth muscle moves food, urine, and reproductive tract secretions; controls diameter of respiratory passageways and regulates diameter of blood vessels.

Characteristic	Skeletal	Cardiac	Smooth
Body location	 Attached to bones or (some facial muscles) to skin	 Walls of the heart	 Mostly in walls of hollow organs, such as the stomach, respiratory tubes, bladder, blood vessels, and uterus

Microscopic of muscle

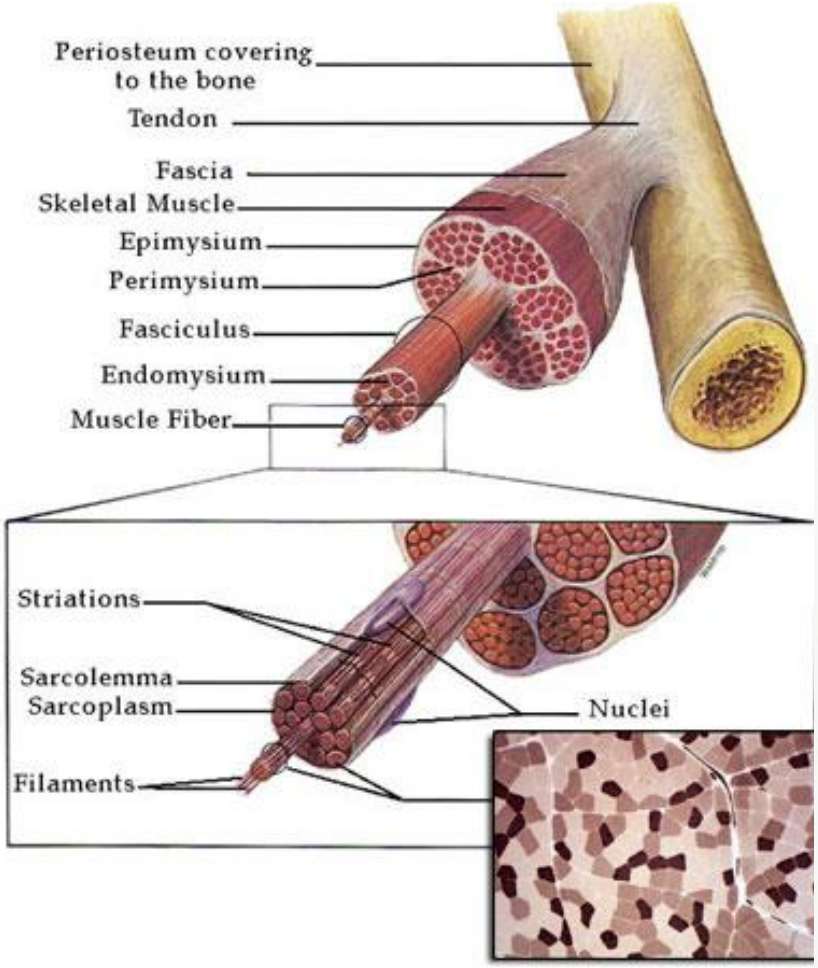
- Skeletal muscle:STRIATED muscle fibers due to regularly arranged ACTIN & MYOSIN filaments, anisotrop and isotrop
  - Voluntary
- Cardiac muscle:STRIATED muscle fibers that occur due to regularly arranged ACTIN & MYOSIM
  -->Contain **Junction** (low resistence bridges for the spread of excitation from one fiber to another), which help it function as a SYNCYTIUM

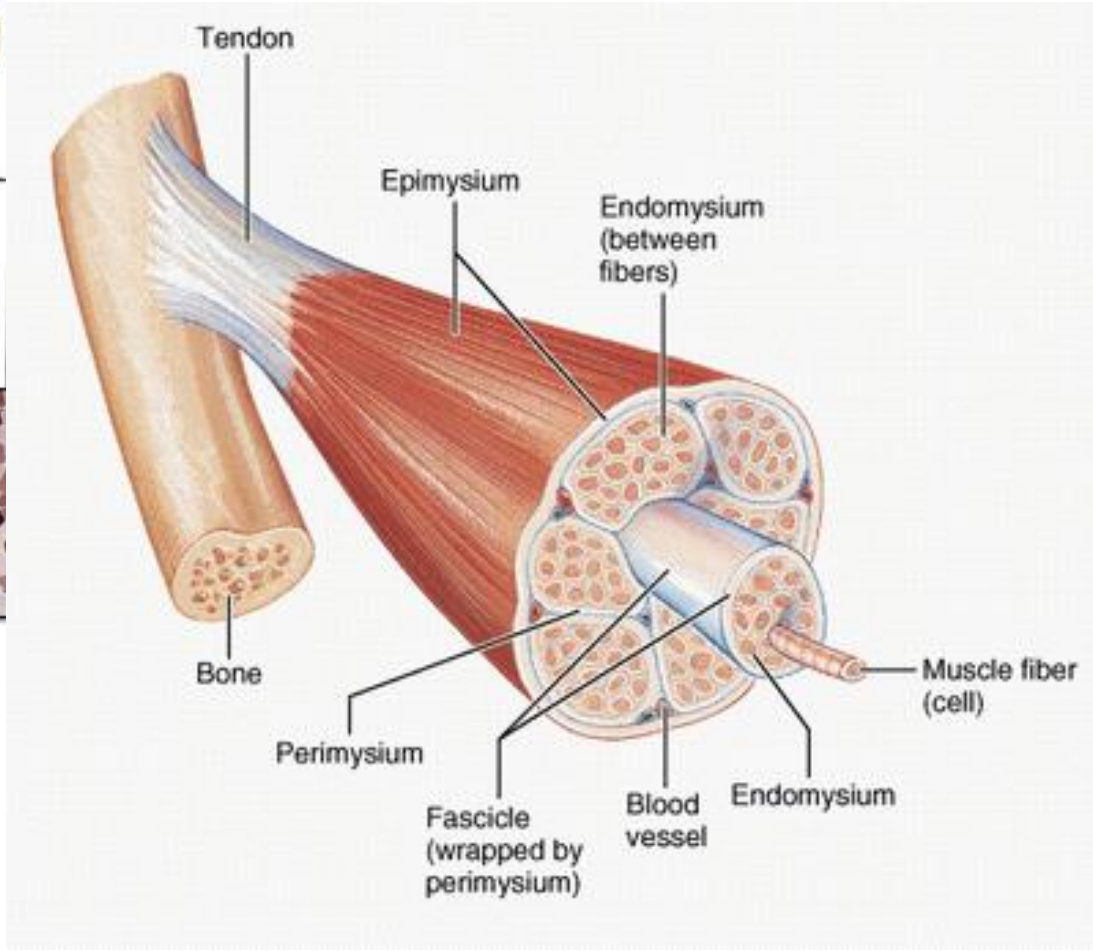
- Smooth muscle: NON-STRIATED muscle fibers due to irregularly arranged ACTIN & MYOSIN filaments
  →INVOLUNTARY type of muscle (Innervated by autonomic NS)

Structure and organizational level	Description	Connective tissue wrappings
Muscle 	Consists of hundreds to thousands of muscle cells, plus connective tissue wrappings, blood vessels, and nerve fibers	Covered externally by the epimysium
Fascicle 	Discrete bundle of muscle cells, segregated from the rest of the muscle by a connective tissue sheath	Surrounded by a perimysium
Muscle fiber 	Elongated multinucleate cell; has a banded (striated) appearance	Surrounded by the endomysium

ORGANIZATION OF MUSCLE

- A MUSCLE is made of bundles of FASCILE -->
- ONE FASCICULUS is made of muslce FIBERS -->
- ONE MUSCLE FIBER (MYOFIBER) is is a MUSCLE CELL, that contains MYOFIBRILS -->
- A MYOFIBRIL is composed of bundles of MYOFILAMENTS -->
- ONE MYOFILAMENT contains contracile proteins (actin & myosin); (Seen only on Electron Microscope)

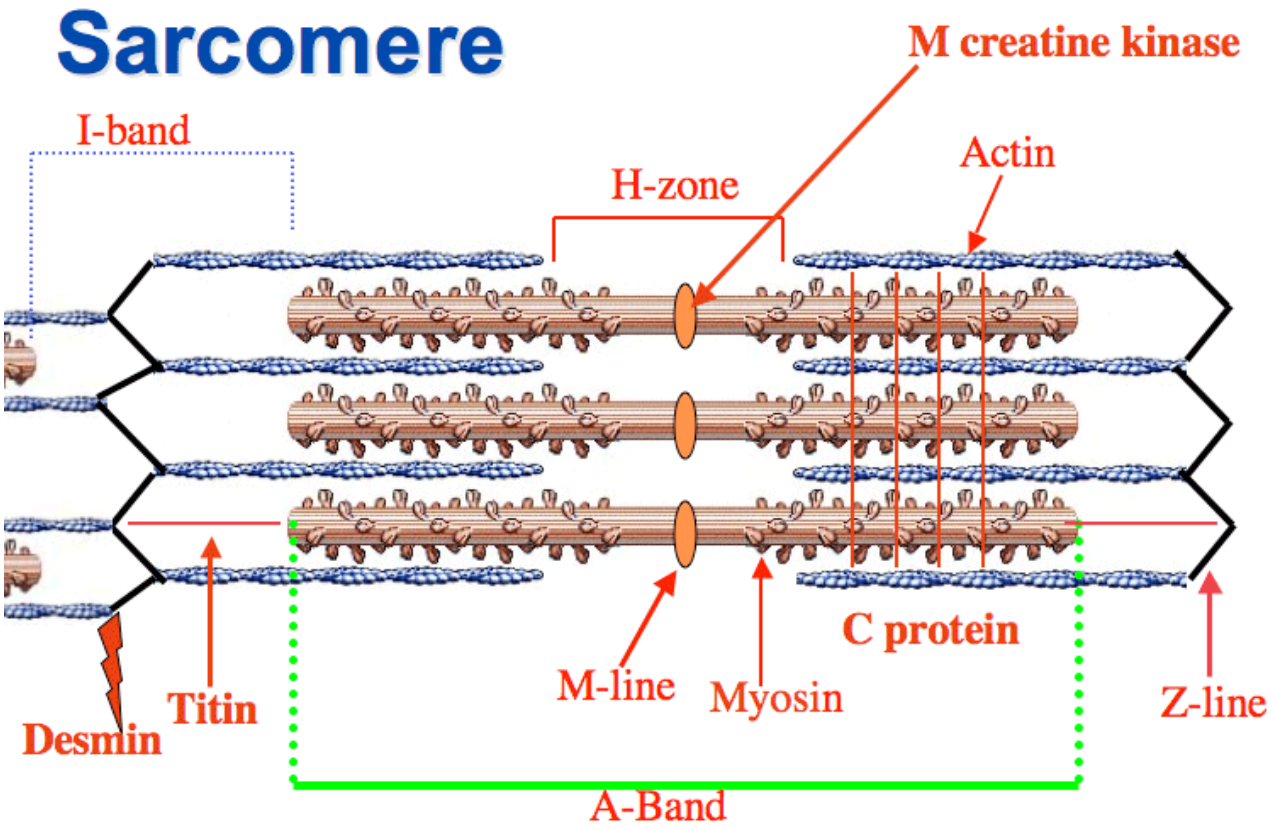

Periosteum covering to the bone
Tendon
Fascia
Skeletal Muscle
Epimysium
Perimysium
Fasciculus
Endomysium
Muscle Fiber
Striations
Sarcolemma
Sarcoplasm
Nuclei
Filaments


Tendon
Epimysium
Endomysium (between fibers)
Bone
Muscle fiber (cell)
Perimysium
Fascicle (wrapped by perimysium)
Blood vessel
Endomysium

Sarcomere: structural unit

- Each myofibril contains myofilaments consisting of thick & thin filaments arranged regularly as **SARCOMERE** (structural unit)

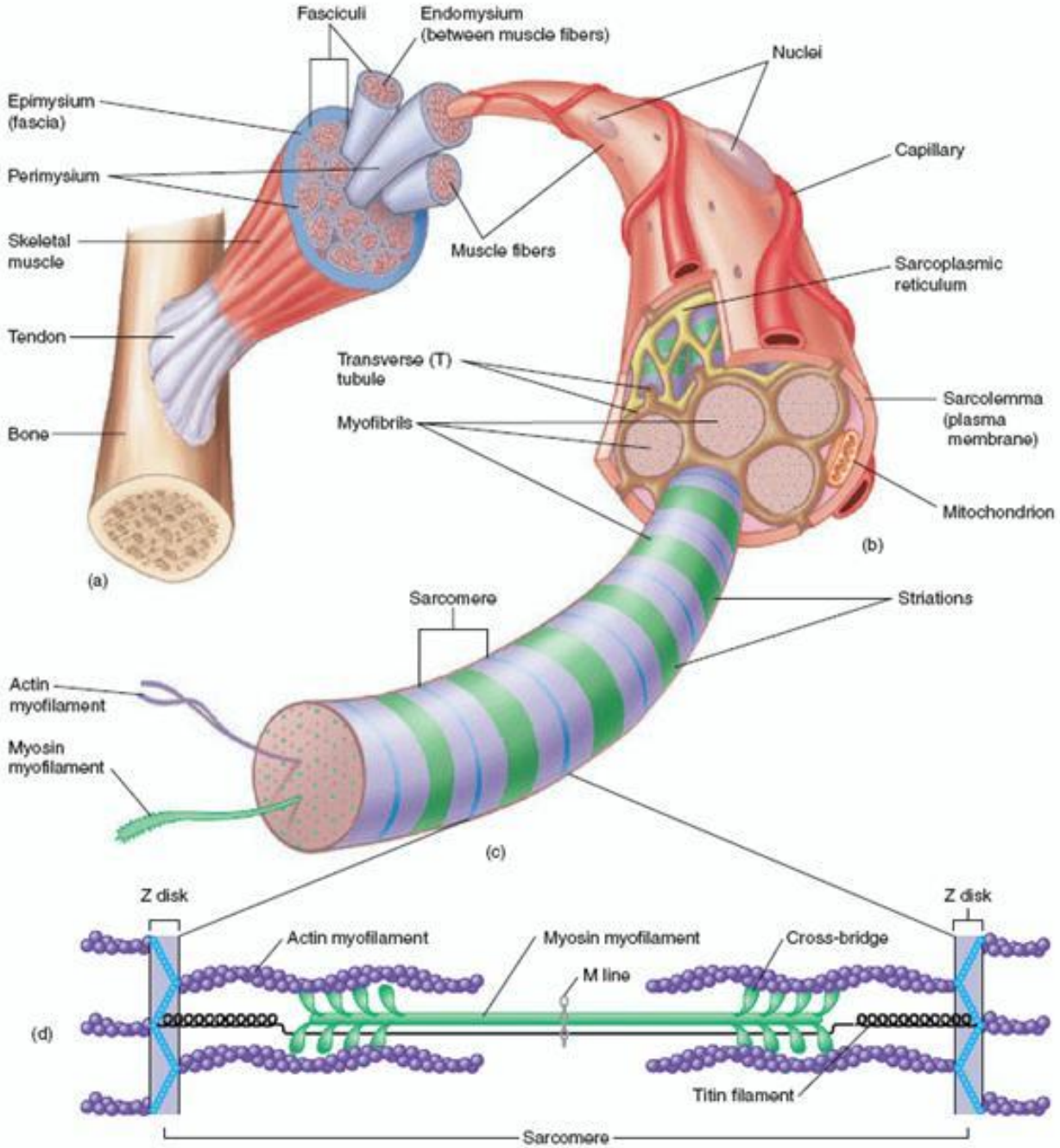
  -->The arrangement of the sarcomere explains the UNIQUE banding pattern seen on Electron Microscope level (i.e. "Striations")



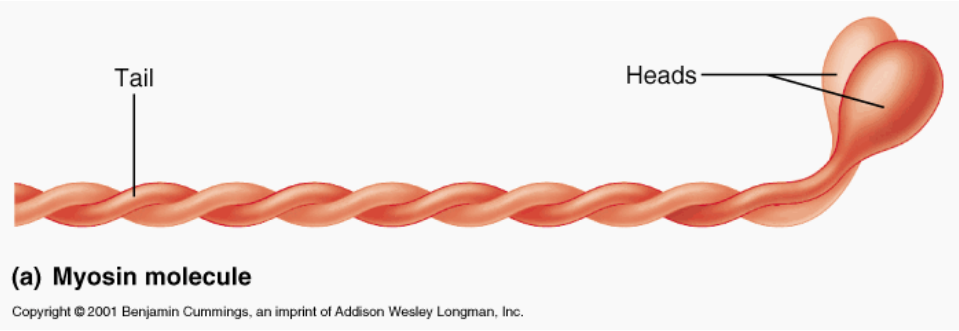
A anisotropic, I isotropic

Anisotropic an isotropic band

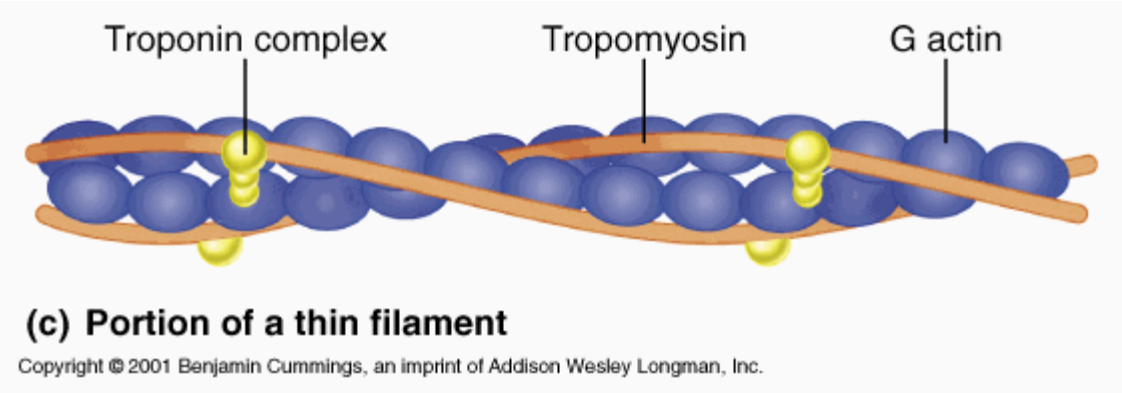
- - **A-Band** in skeletal muscle fibres is so named because it is *anisotropic* in its refractive index which is a characteristic of orderly crystalline structure.
- the **I-Band** is so named because of its *isotropic* nature, as far as its refractive index is considered, which is characteristic of Amorphous substances or substances which lack long-range order.


Fasciculi
Endomysium
(between muscle fibers)
Nuclei
Epimysium
(fascia)
Capillary
Perimysium
Skeletal
muscle
Muscle fibers
Sarcoplasmic
reticulum
Tendon
Transverse (T)
tubule
Sarcolemma
(plasma
membrane)
Myofibrils
Bone
Mitochondrion
(a)
(b)
Sarcomere
Striations
Actin
myofilament
Myosin
myofilament
(c)
Z disk
Z disk
Actin myofilament
Myosin myofilament
Cross-bridge
M line
(d)
Titin filament
Sarcomere

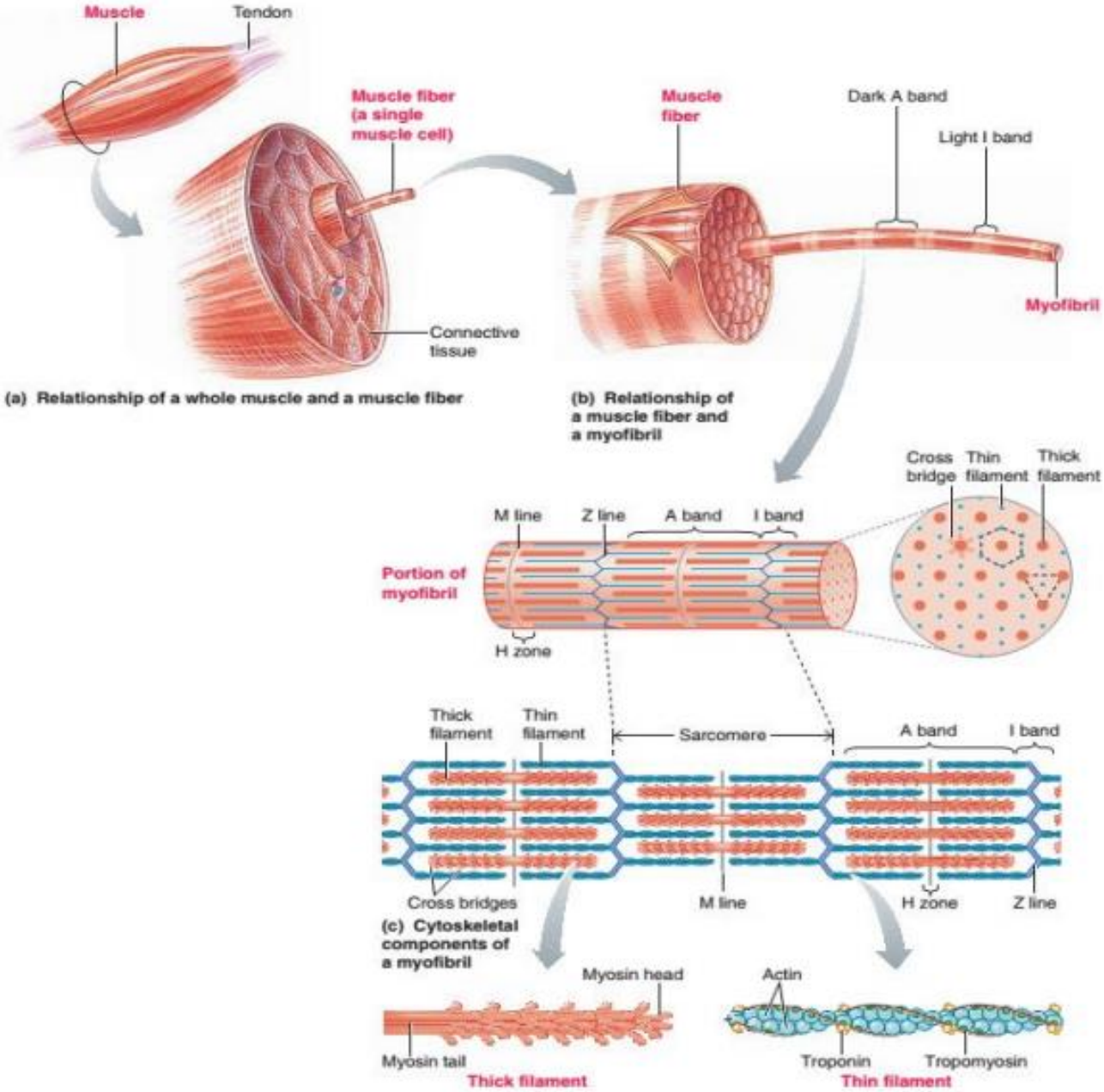
Thick filament (MYOSIN)
Thin Filament (Actin)



(a) Myosin molecule



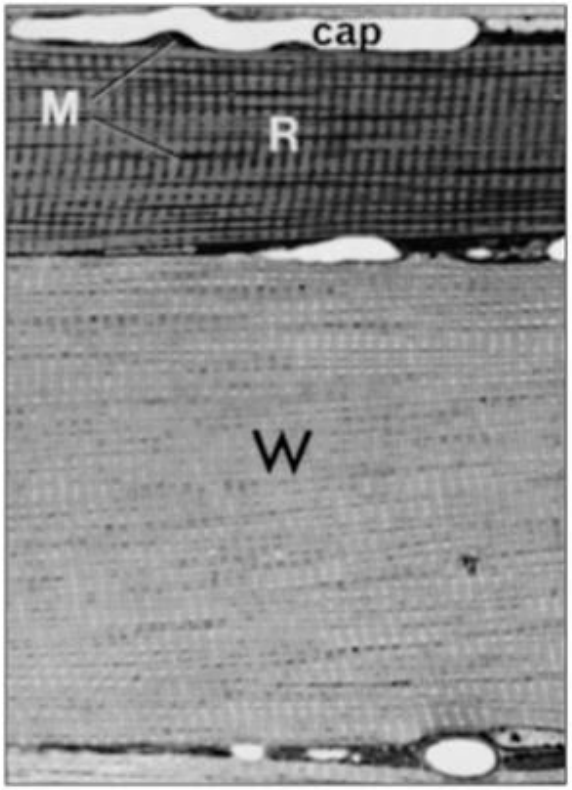
(c) Portion of a thin filament



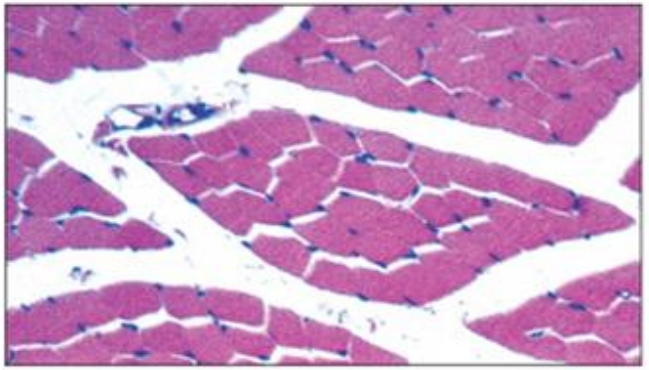
Sumber: Sherwood, 2012


FLORA
PAULA
adidas
PaulaRadcliffe.com

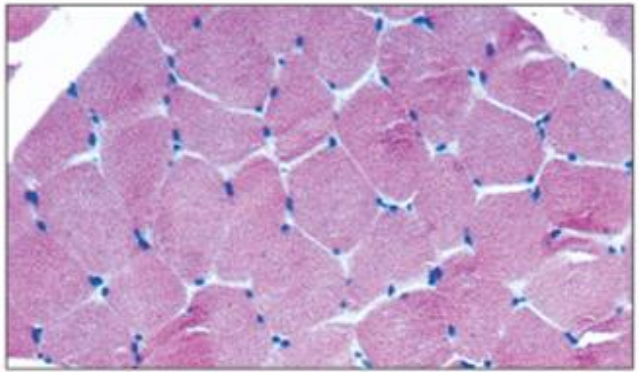

396



Slow-twitch oxidative muscle fibers
Note smaller diameter, darker color due to myoglobin. Fatigue-resistant.



Fast-twitch glycolytic muscle fibers
Larger diameter, pale color. Easily fatigued.



RED MUSCLE
high mitochondrial content

MIXED MUSCLE
medium mitochondrial content

WHITE MUSCLE
low mitochondrial content

Muscle fibers

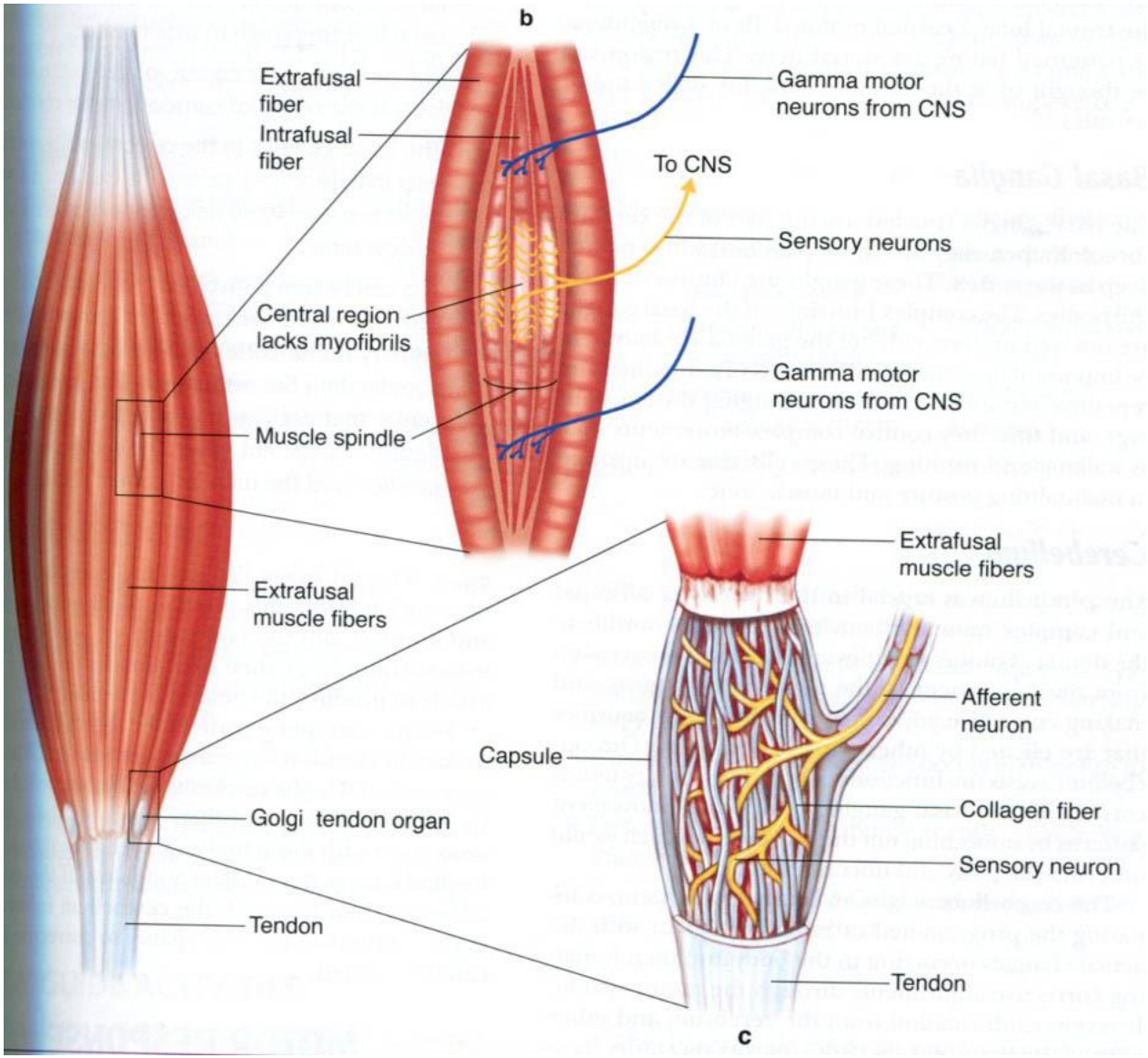
Feature	Slow Oxidative/Red (Type I)	Fast Oxidative/White (Type II A)	Fast Glycolytic/White Type II B)
Diameter	Small	Intermediate	Large
Z-line thickness	Wide	Intermediate	Narrow
Glycogen content	Low	Intermediate	High
Resistance to fatigue	High	Intermediate	Low
Capillaries	Many	Many	Few
Myoglobin content	High	High	Low
Respiration	Aerobic	Aerobic	Anaerobic
Oxidative capacity	High	High	Low
Glycolytic ability	Low	High	High
Twitch rate	Slow	Fast	Fast
Myosin ATPase content	Low	High	High

	red muscle fibers	**white muscle fibers**
alternate names	slow-twitch fibers	fast-twitch fibers
relative size	thin	thick
movement type	prolonged, deliberate	short, high-powered bursts
fueled by	fat + oxygen	glycogen
Requires oxygen?	absolutely	yes, but can run anaerobically
taste/nutrtion	fattier, more flavorful	higher in protein, relatively bland
appearance	dark/red	white

Type of muscle fibers

	Slow Oxidative	Fast Oxidative	Fast Glycolytic
Contraction speed	Slow	Fast	Fast
Myosin ATPase activity	Slow	Fast	Fast
Major pathway for ATP synthesis	Aerobic respiration	Aerobic respiration	Glycolysis
Rate of fatigue	Slow	Intermediate	Fast
Fiber diameter	Small	Intermediate	Large
Mitochondria	Many	Many	Few
Capillaries	Many	Many	Few
Myoglobin content	High	High	Low
Color	Red	Red to pink	White

Extrafusal & intrafusal mucle fiber



Extrafusal muscle fibers

- are the **skeletal standard muscle** fibers that are innervated by alpha motor neurons and generate tension by contracting, thereby allowing for skeletal movement.
- They make up large mass of skeletal (striated) muscle and are attached to bone by fibrous tissue extensions (tendons

- **Each alpha motor neuron** and the extrafusal muscle fibers innvervated by it make up a motor unit
- The connection between the alpha motor neuron and the extrafusal muscle fiber is a neuromuscular junction, where the neuron's signal, the action potential, is transduced to the muscle fiber by the neurotransmitter acetylcholine

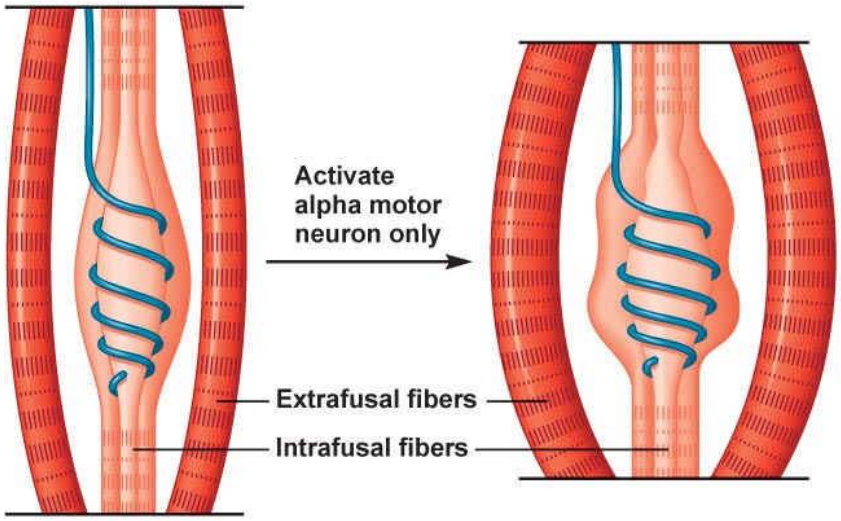
Intrafusal muscle fibers

- are skeletal muscle fibers that serve as **specialized sensory organs** (proprioceptors, **that detect the amount and rate of change in length of a muscle.**

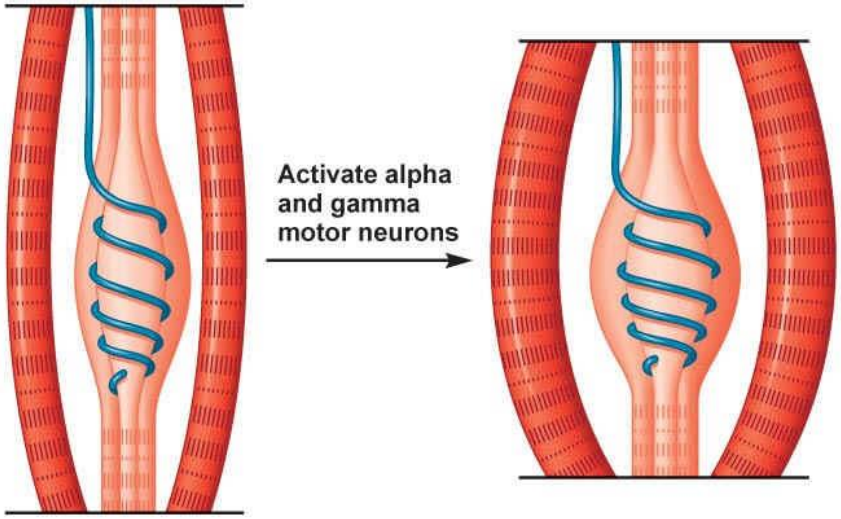
- They constitute the muscle spindle and are innervated by two axons, one sensory and one motor. Intrafusal muscle fibers are walled off from the rest of the muscle by a collagen sheath.
- **This sheath has a spindle or "fusiform" shape**, hence the name "**intrafusal.**"

- There are **two types of intrafusal muscle fibers**: **nuclear bag** and **nuclear chain fibers.**
- They bear two types of sensory ending, known as **annulospiral** and **flower-spray** endings. both **the ends of these fibers contract** but **the central** region only **stretches** and does not contract.

- They are innervated by **gamma motor neurons**. It is by the sensory information from these two intrafusal fiber types that one is able to judge **the position of one's muscle, and the rate at which it is changi**ng.



(a) No gamma activity

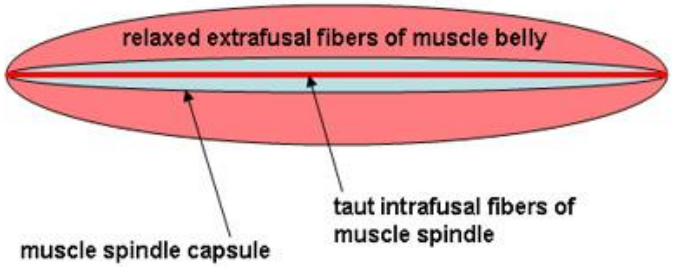


(b) Coactivation of alpha and gamma motor neurons

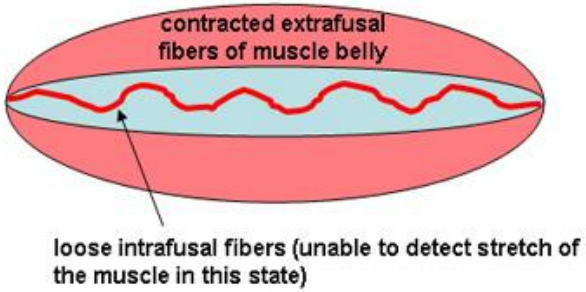
Muscle spindles

- **are sensory receptors** within the belly of a muscle that primarily detect changes in the length of this muscle.
- They convey length information to the central nervous system via sensory neurons.
- This information can be processed by the brain to determine the position of body parts.
- The responses of muscle spindles to changes in length also play an important role in regulating the contraction of muscles, by activating motoneurons via the stretch reflex to resist muscle stretch.
- Muscle spindles are found within the belly ofmuscles, embedded in extrafusal muscle fibers, Note that **"fusus" is the Latin word for spindle**.

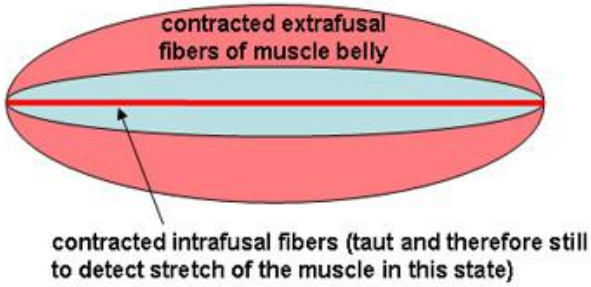
When the extrafusal fibers are relaxed, the muscle spindle fibers are taut and able to detect stretch:



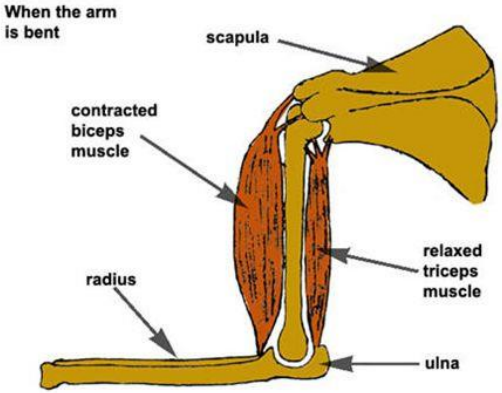
When the extrafusal fibers contract, the overall length of the muscle changes. If the muscle spindle fibers do NOT also contract, they would become loose and unable to detect stretch:



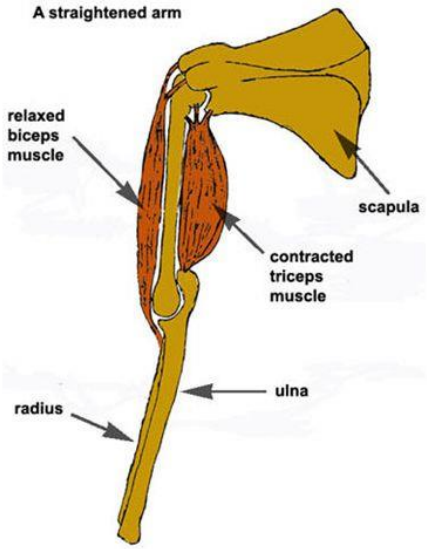
If instead the muscle spindle fibers contract IN CONCERT with the contraction of the extrafusal fibers, the spindle fibers remain taut and able to detect stretch:



How do muscles move?



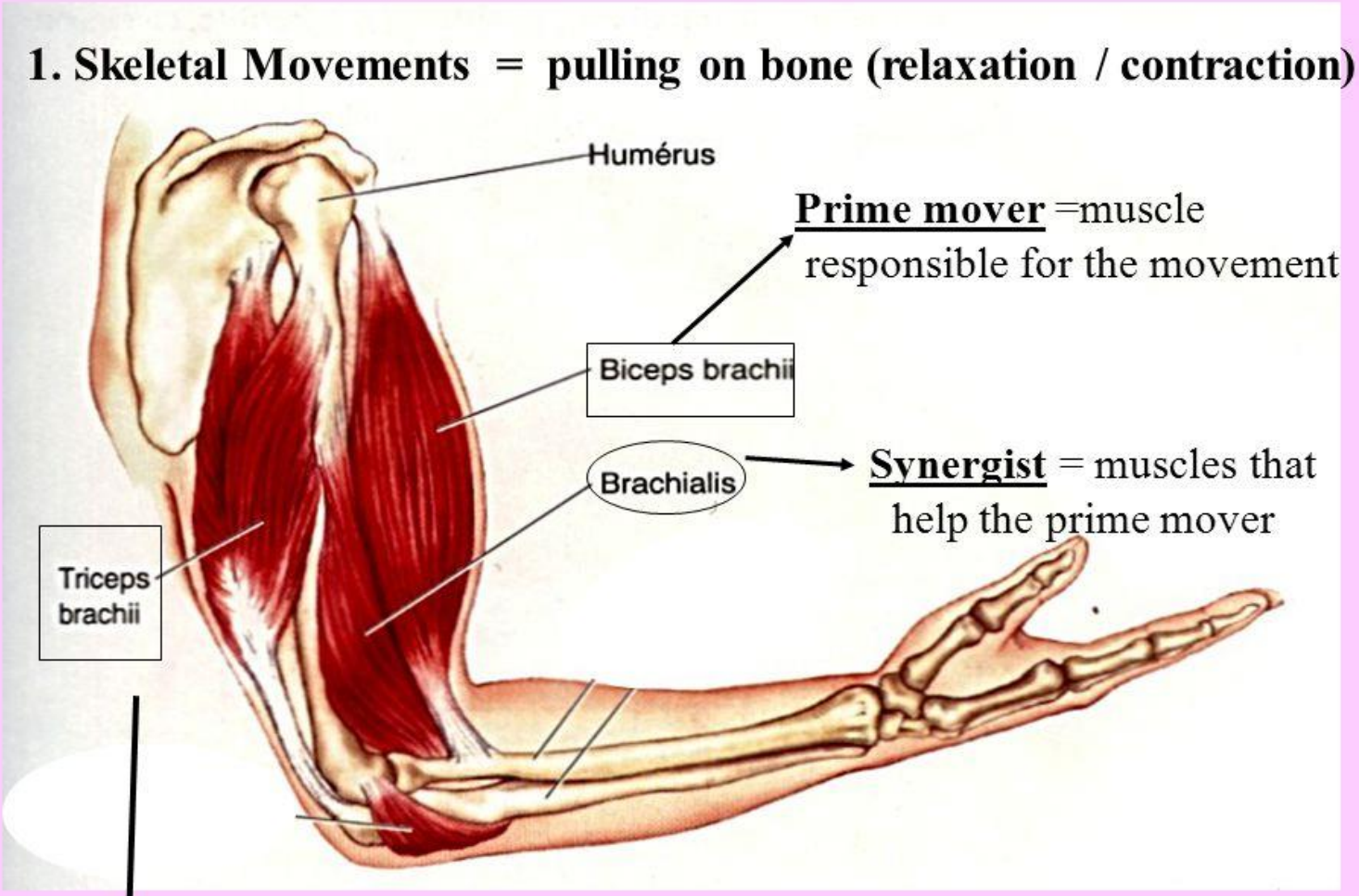
Muscles that move your bones work in pairs. When one contracts, the other must relax. For example, your bicep must relax and lengthen when your triceps contract and shorten.



Movement	Agonist	Antagonist
Knee Flexion	**Hamstrings**	**Quadriceps**
Medial Shoulder Rotation	Pectoralis Major	Infraspinatus
Shoulder Rotation & Elevation	Trapezius	Lattissimus Dorsi
Hip Extension	Gluteus Maximus	Iliopsoas
Trunk Extension	Erector Spinae	Rectus Abdominus
Plantar Flexion	Gastrocnemius	Tibialis Anterior
Wrist Flexion	Wrist Flexors	Wrist Extensors
Forearm Supination	Supinator	Pronator (teres/quadratus)
Dorsi Flexion	Tibialis Anterior	Gastrocnemius
Shoulder Abduction	Anterior Deltoid	Latissimus Dorsi
Shoulder Adduction/Rotation	Latissimus Dorsi	Deltoid/Trapezius
Thigh Flexion	Iliacus	Gluteus Maximus
Hip Extension & Adduction	Adductor Magnus	Gluetus Medius & Psoas
Trunk Rotation	External Obliques	Rectus Abdominus
Adducts/Lateral Rotation of Arm	**Infraspinatus**	**Supraspinatus**
Retracts Scapula	Rhomboids	Serratus Anterior
Neck Flexion	Sternocleidomastoid	Trapezius

Skeletal Muscle Function

1. Skeletal Movements = pulling on bone (relaxation / contraction)



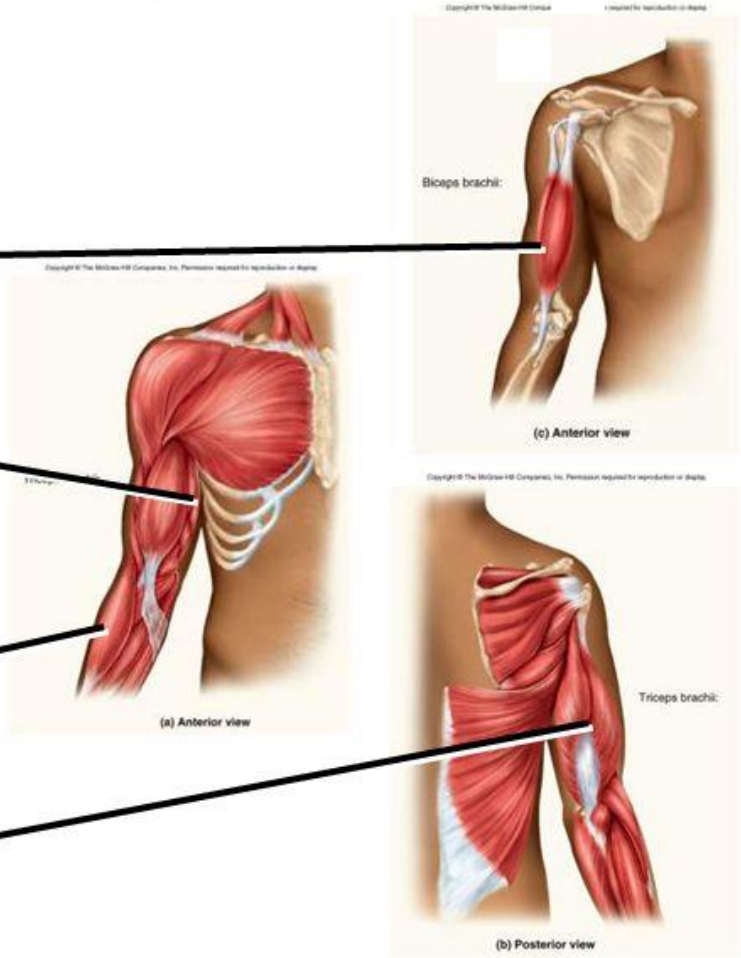
Prime mover =muscle responsible for the movement

Synergist = muscles that help the prime mover

Antagonist = muscle that produces the opposite movement as prime mover

Muscles Acting on Elbow

- **Principal flexors**
  - **biceps brachii**
    - inserts on radius
  - **brachialis**
    - inserts on ulna
- **Synergistic flexor**
  - **brachioradialis**
- **Prime extensor**
  - **triceps brachii**
    - inserts onto ulna



Functional Groups of Muscles

Figure 10.4

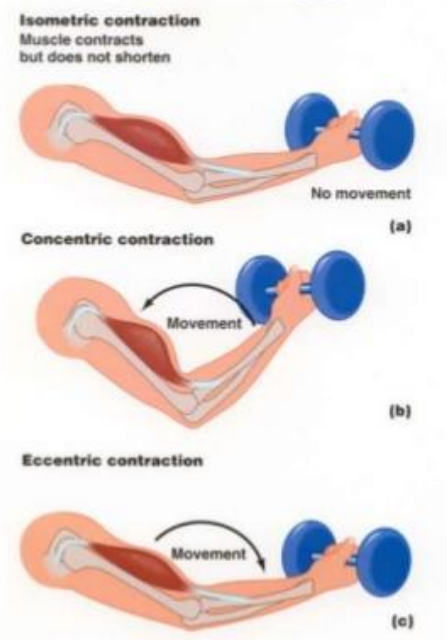
- Prime mover—brachialis
- Synergist—biceps brachii
- Antagonist—triceps brachii
- Fixator—muscle that holds scapula firmly in place
  - Rhomboids

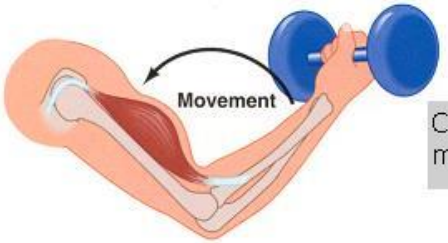
Isotonic & isometric muscle contraction

- **Muscle contraction** is the activation of tension-generating sites within muscle fibers
- Muscle contractions can be described based on two variables: force and length.
- Force itself can be differentiated as either tension or load. Muscle tension is the force exerted by the muscle on an object whereas a load is the force exerted by an object on the muscle. When muscle tension changes without any corresponding changes in muscle length, the muscle contraction is described **as isometric (example: handgrip action)**
- In an **isotonic contraction**, tension remains the same, whilst the muscle's length changes. This occurs when a muscle's force of contraction matches the total load on the muscle.
- There are two types of isotonic contractions: **(1) concentric and (2) eccentric**. In a concentric contraction, the muscle tension rises to meet the resistance, then remains the same as the muscle shortens.
- In eccentric, the muscle lengthens due to the resistance being greater than the force the muscle is producing.

Types of Muscle Contraction

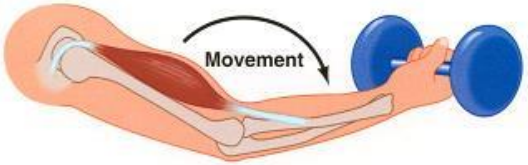
- Isometric
- Concentric
- Eccentric

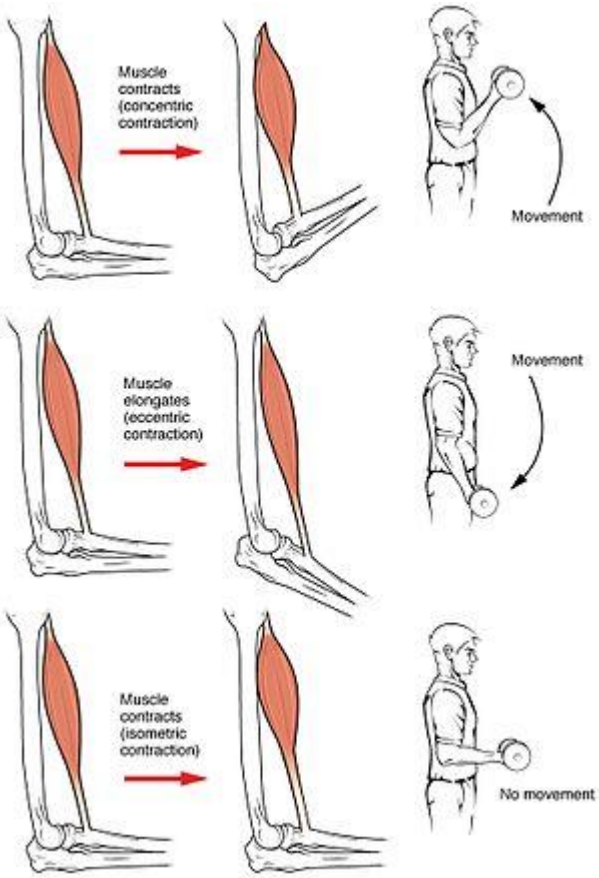




Concentric muscle contraction—The bicep muscle is **shortening** while contracting.

Eccentric muscle contraction—The bicep muscle is **lengthening** while contracting.





Thanks you