

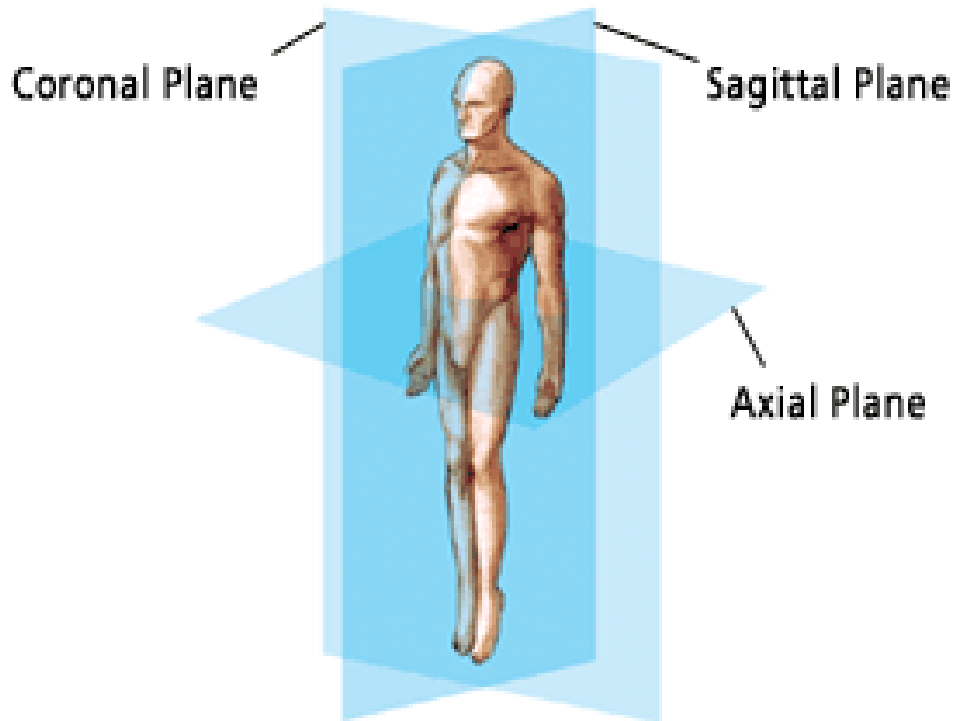
# Premedical Biology

Motor mechanism

**Skeletal system**

**Muscular system**

Axes	Meaning
<b>Frontal or Coronal Plane</b>	Divides the front and back halves of the entire body.
<b>Median or Sagittal Plane</b>	<b>Divides the left and right sides of the entire body.</b>
<b>Transverse or Axial Plane</b>	<b>Divides the body at the waist (top and bottom halves of the body).</b>



- Superior
- Inferior
- Cranialis
- Caudalis
- Anterior
- Posterior
- Ventralis
- Dorsalis
- Medialis
- Lateralis
- Dexter
- Sinister
- Proximalis
- Distalis
- Ulnaris
- Radialis
- Tibialis
- Fibularis

# Function

## Support

The pelvis and associated ligaments and muscles provide a floor for the pelvic organs. Without the ribs, costal cartilages, and the intercostal muscles the lungs would collapse.

## Movement

The joints between bones permit movement.

## Protection

The skull protects **the brain, the eyes, and the middle and inner ears.**

The vertebrae protect the **spinal cord.**

The rib cage, spine, and sternum protect **the lungs, heart and major blood vessels.**

The clavicle and scapula protect **the shoulder.**

The ilium and spine protect **the digestive and urogenital systems** and the hip.

# Function

## Blood cell production

The skeleton is the place for **haematopoiesis**, which takes place in the **red bone marrow**.

## Storage

The bone matrix can store **calcium** and is involved **in the calcium metabolism**, and bone marrow can **store an iron in the ferritin** and it is involved in the iron metabolism.

## Endocrine regulation

A bone cells release a hormone called **osteocalcin**, which contributes to the **mineralization, development of teeth and bones, and increases the adrenalin level** [the regulation of glucose and fat deposition].

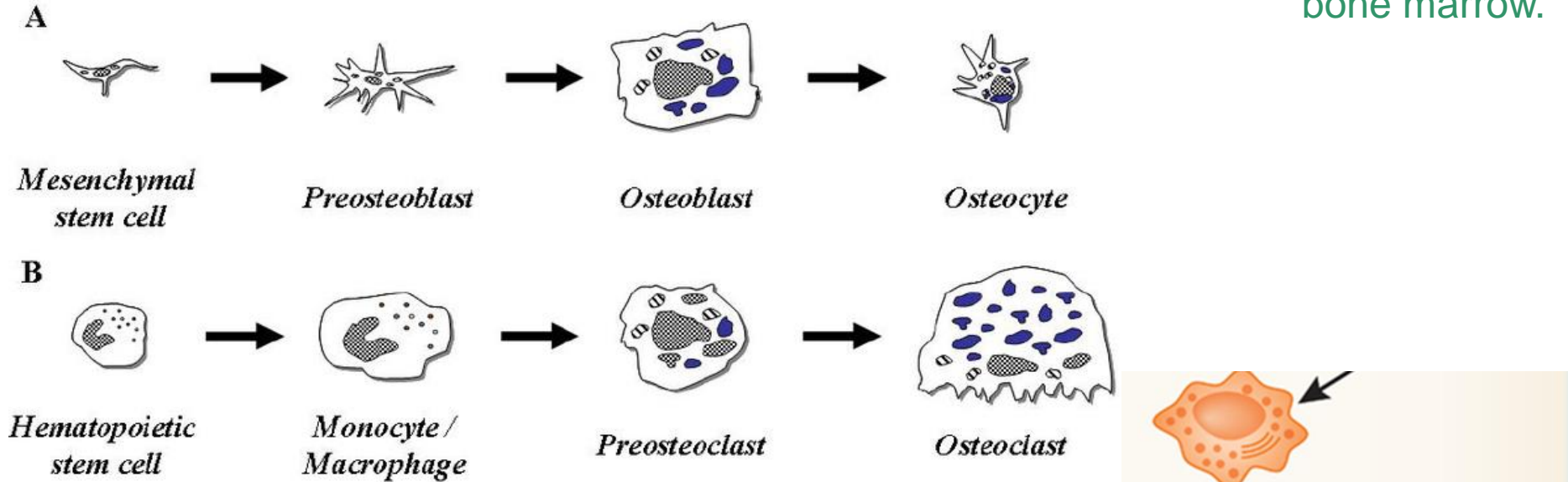
# Endoskeleton

- **Bone matrix: An extracellular matrix** consists of **amorphous and fibrillar components**. The **amorphous** component is formed by **proteoglycans, structural glycoproteins**. The **fibrillary component consists of the type I Collagen**. An **inorganic** constituent is represented by **calcium and phosphorus** ions in the form of the **hydroxyapatite ( $\text{Ca}_5(\text{PO}_4)_3\text{OH}$ )** and the calcium phosphate, carbonate
- **Dynamic structure** - up to **5%** of the bone matter is a **recycling** every week
- **Continuous remodeling** resides primarily in the function of three cells: **osteoblast, osteocyte and osteoclast**.

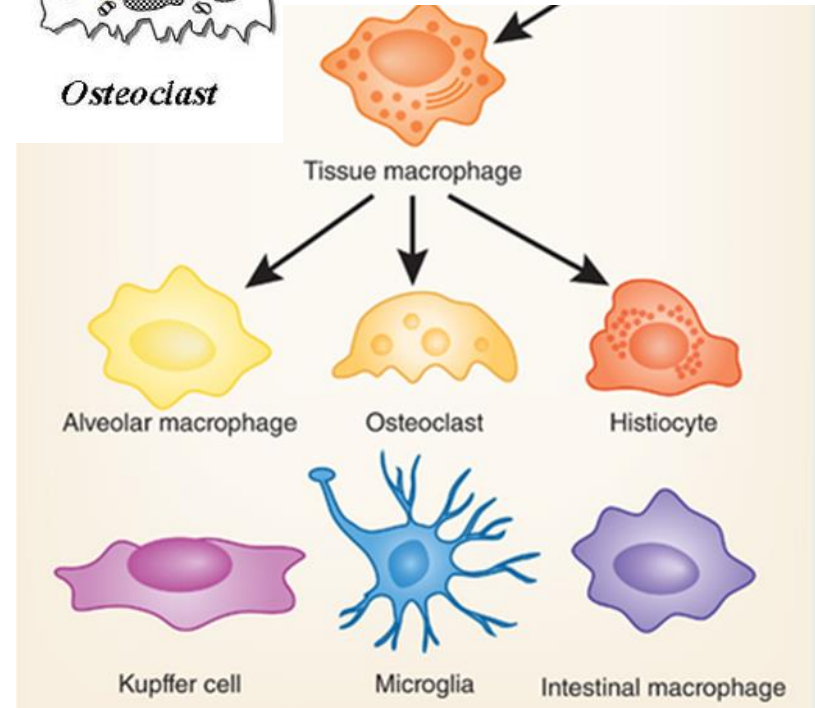
- **Osteoblasts** developed from a mesenchyme synthesize the bone matrix (type I collagen, glycosaminoglycans, proteoglycans, glycoproteins).
- **Osteocytes** are surrounded by bone matrix (which do not synthesize), they occupy empty spaces called lacunae. They affect a function of Osteoblasts and Osteoclasts. Osteocytes do not have mitotic activity.
- **Osteoclasts** are multinucleated cells of hemopoietic origin involved in bone resorption. They contain lysosomes with proteolytic enzymes, their membrane contain proton pump. They belong to **monocyte-macrophage system**.

# Osteoblast, osteocyte (A) and osteoclast (B) differentiation.

Mesenchymal stem cells develop in the bone marrow until they have the location and a phenotype of osteoblasts. Osteoclasts are giant multinucleate cells that differentiate from hematopoietic cells of the monocytes/macrophage lineage in the bone marrow.



## Monocyte-macrophage system



## endochondral ossification

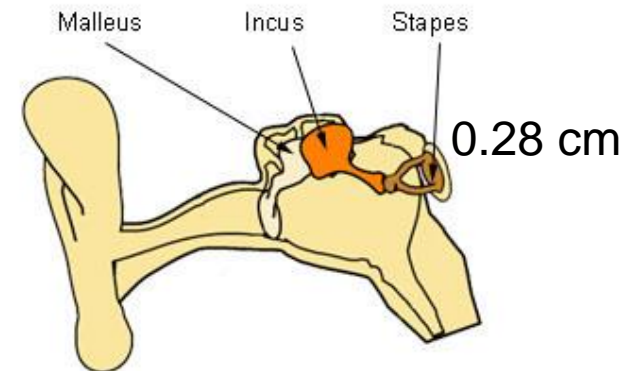
- long bones and most other bones gradually form in the hyaline cartilage model of the future bone

## intramembranous ossification

- flat bones of the skull, the clavicles and mandible are formed from the mesenchymal tissue by a process of ossification and calcification.

- **hyoid bone** – only bone without connection to skeleton

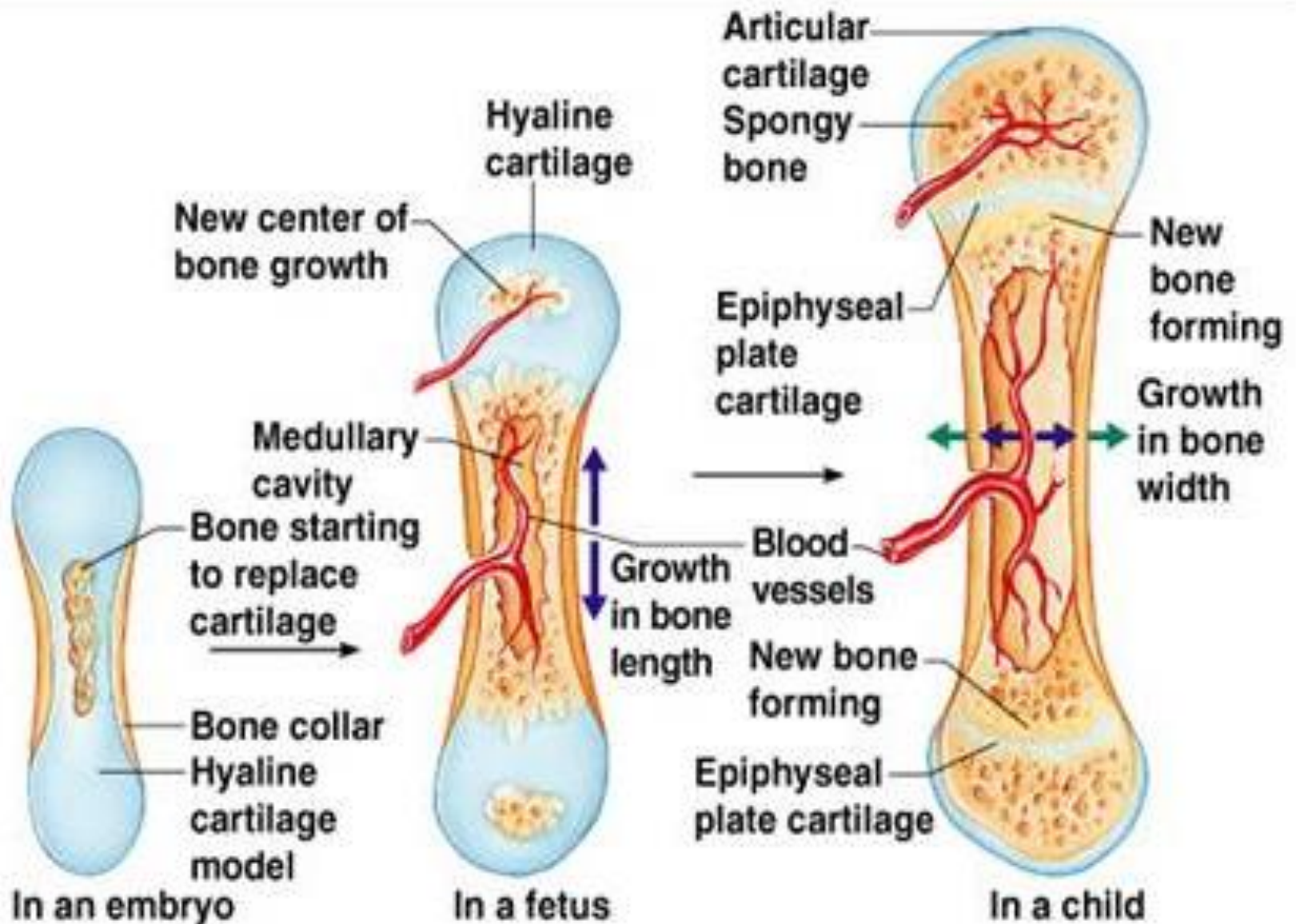
- **three bones in each middle ear – auditory ossicles**, transmit sounds from the air to the fluid-filled labyrinth (cochlea)



**Cranial Bones**



# Endochondral ossification



(a)

# Hormones

**Vitamin D** – an absorption of  $\text{Ca}^{2+}$  and phosphates in the small intestine and a reabsorption of calcium in the kidneys

**Parathormone** is secreted by the parathyroid glands. It stimulates the resorption of bone by increasing the activity of osteoclasts. The result is an increased release of  $\text{Ca}^{2+}$  and phosphates from the bone.

**Calcitonin** a hormone produced by the parafollicular cells (C cells) of the thyroid gland inhibits osteoclast activity, reduces bone resorption and it results in increased deposition of  $\text{Ca}^{2+}$  in bones.

- Osteoporosis
- Fractures
- Osteogenesis imperfecta
- Achondroplasia

**Most well-known diseases**

# Osteoporosis



# Achondroplasia



# Osteogenesis imperfecta



**Enamel** is the hardest tissue of the body, covering part or all of the crown of the tooth in mammals. Enamel, when mature, consists predominantly of apatite crystals. Enamel is not living and contains no nerves.

Therefore, the second hardest tissue in the body which is also living, is the **Dentin**.

**Enamel** is the most mineralized tissue of the body, forming a very hard, thin, translucent layer of calcified tissue

# Human skeleton

Axial skeleton – a backbone, a rib cage and a cranium (skull)

Appendicular sk. – bones of limbs, a pelvis and a shoulder

It consists of both **fused and individual bones** supported and supplemented by ligaments, tendons, anchoring muscles and cartilage.

- The skeleton of **adult** human consists of **206 bones**
- **New-born children** have about **300 bones** [grow together].

Fused bones include those of **the pelvis and the cranium** (skull).

The development of whole skeleton is accomplished in the age of 20-25 years.

# Functional classification

- **fibrous joint - synarthrosis** - connects bones without allowing any movement - bones of our skull and pelvis
- **cartilaginous joint - amphiarthrosis** - These joints allow for only a little movement, such as in the spine (vertebrae) or ribs.
- **synovial joint - diarthrosis** - Cavities between bones in synovial joints are filled with the synovial fluid. This fluid helps lubricate and protect the bones permits a variety of movements (e.g., shoulder, hip, elbow, knee, etc.).



# Joints

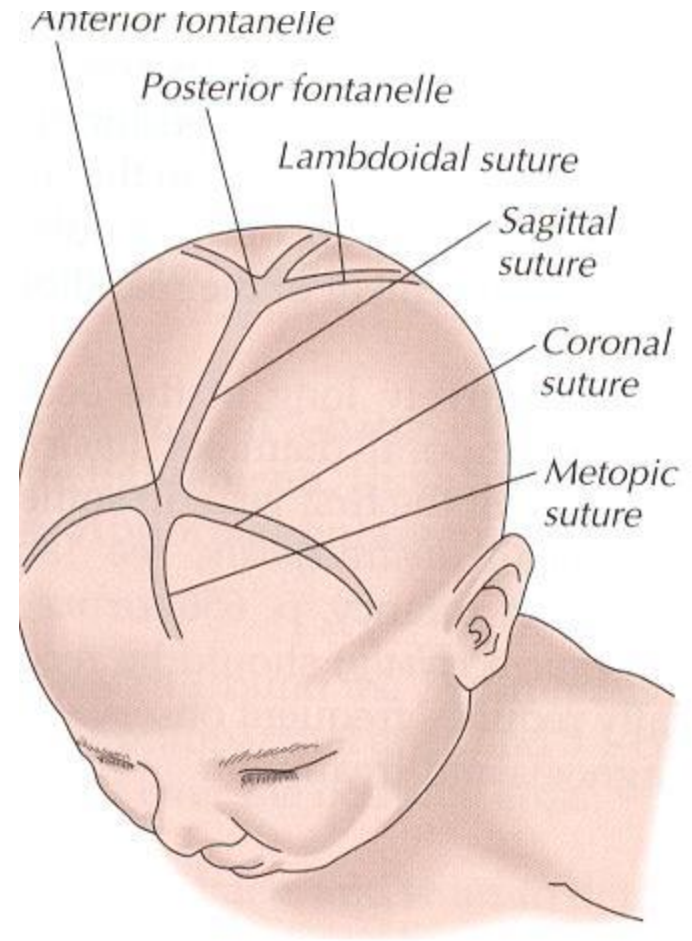
## Joint's types

- **Sutures** – concretion - fibrous joint

only in the skull

The term "**fontanelle**" is used to describe the resulting "soft spots".

- **Articulation** – attachment two or more bones; they make a contact

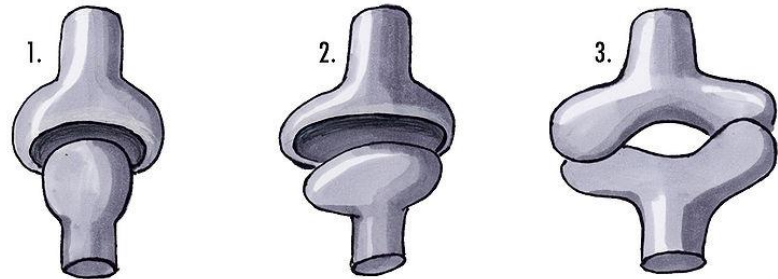


# shapes of joints

## 1. Ball and Socket

the distal bone is capable of motion around an indefinite number of axes, which have one common center. It enables the bone to move in a 360° angle. They are found in **the hips and shoulders.**

## 2. Condyloid joint - the wrist-joint, metacarpophalangeal joints, metatarsophalangeal joints



## 3. Saddle

The movements are the same as in a condyloid joint: flexion, extension, adduction, abduction, and circumduction are allowed; but no axial rotation.

**carpometacarpal joint of the thumb**



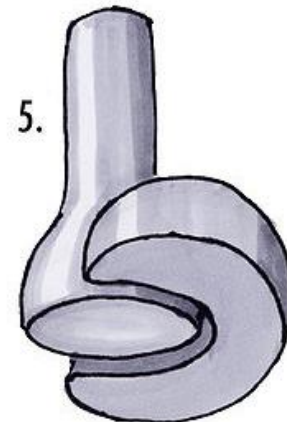
## 4. Hinge

**elbow**, only motion in one plane, backward and forward

## 5. Pivot

Pivot joints are found in humans in the neck, forearms, knees, and other parts of the skeletal system that are able to rotate.

A pivot joint is composed of a bone and ligament ring rotating around another bone.

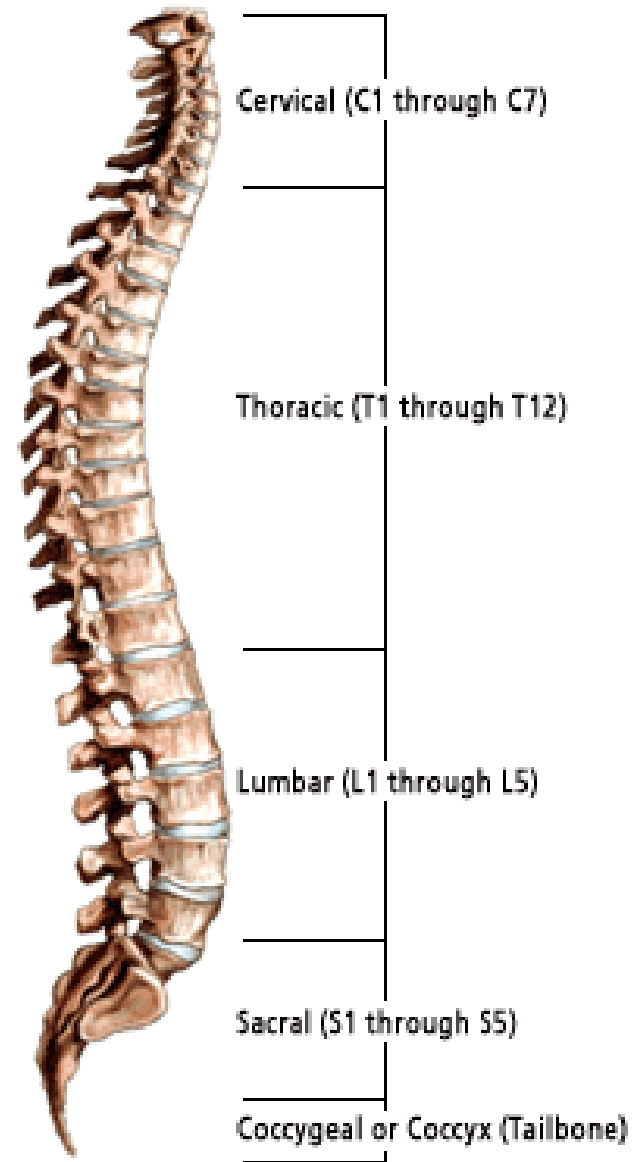


# Fuselage framework

Backbone (*columna vertebralis*)

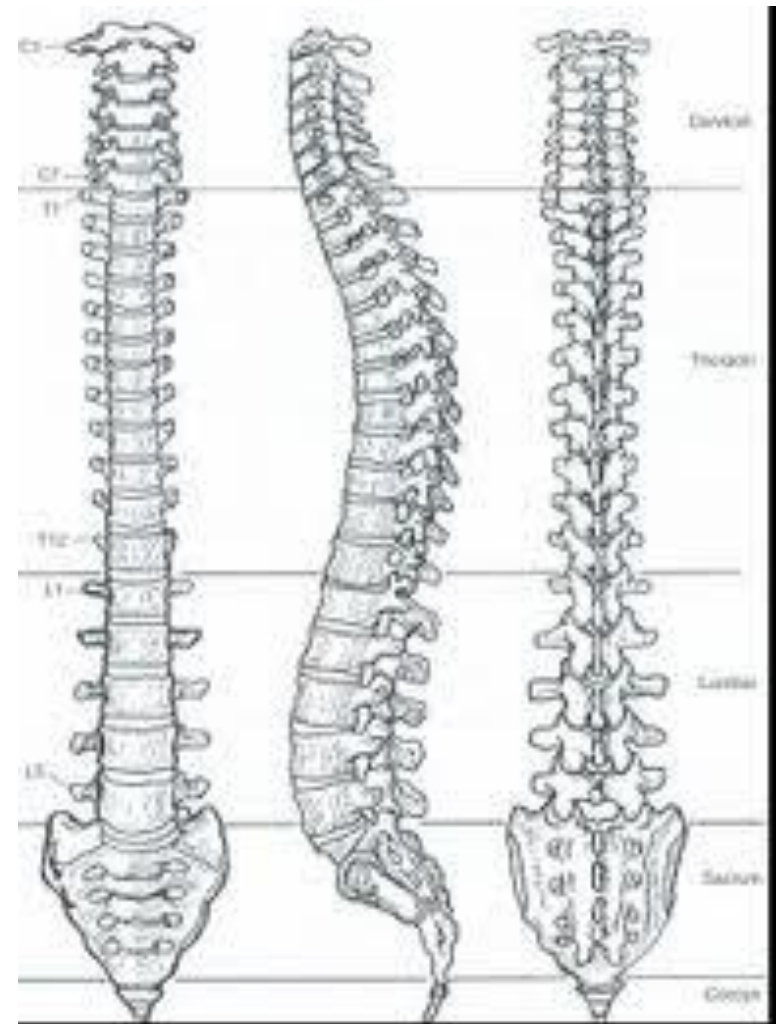
Rib cage: 33-34 vertebrae, ribs, sternum

- 7 cervical (*vv. cervicales*) C1- C7  
(*atlas, axis*)
- 12 thoracic (*vv. thoracicae*)  
Th1-Th12
- 5 lumbar (*vv. lumbales*) L1-5
- os sacrum (*vv. sacrales*) S1 -5
- coccyx (*vv. coccygae*) Co1- 4-5



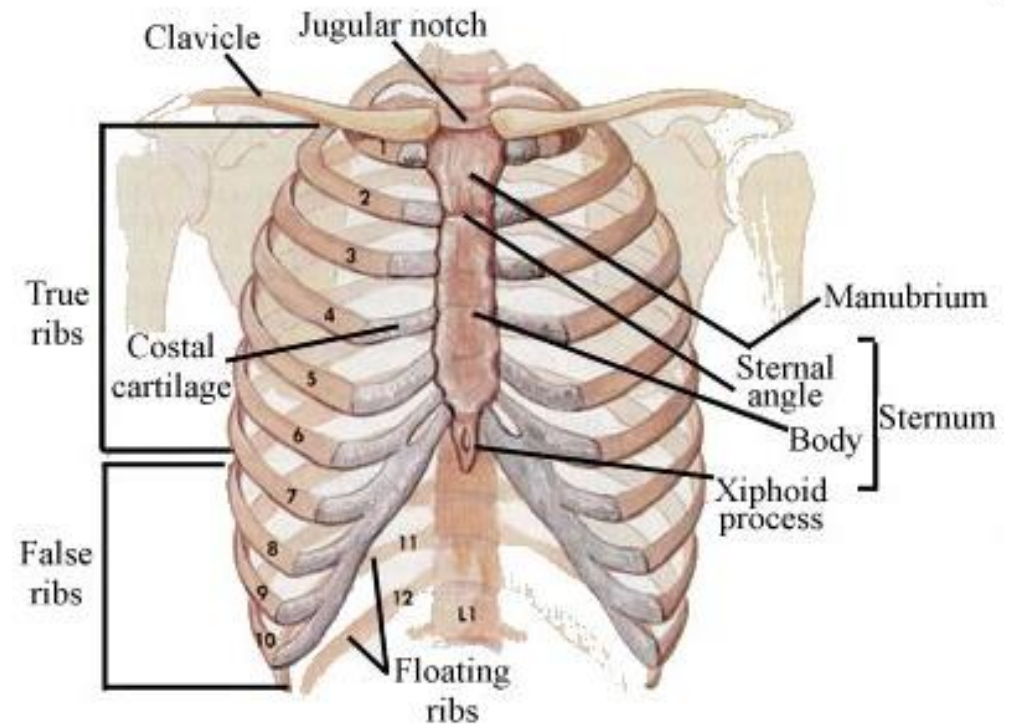
- **lordosis** – an inward curvature of a part of the vertebral column - **cervical and lumbar** segments, are *normally* lordotic

- **kyphosis** – also called **hunchback**, is a common condition of a curvature of the upper spine thoracic and coccygeal

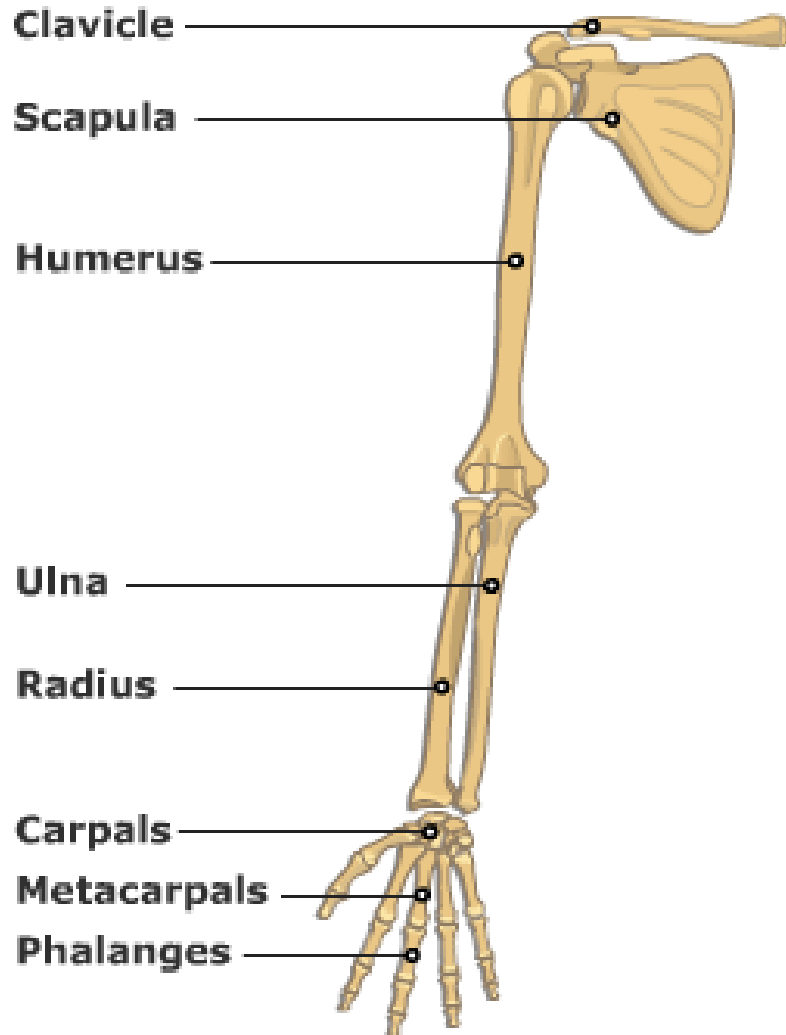


# Ribcage Th 1-12

- **7 pairs** „true ribs“ attached to the sternum
- „false ribs“: **3 pairs** attached to common cartilaginous connection to the sternum
- **2 pairs free - floating**



# Upper limb, Arm



- Clavicle
- Scapula
- Humerus
- Radius
- Ulna
- Carpal bones
- Metacarpals
- Phalanges

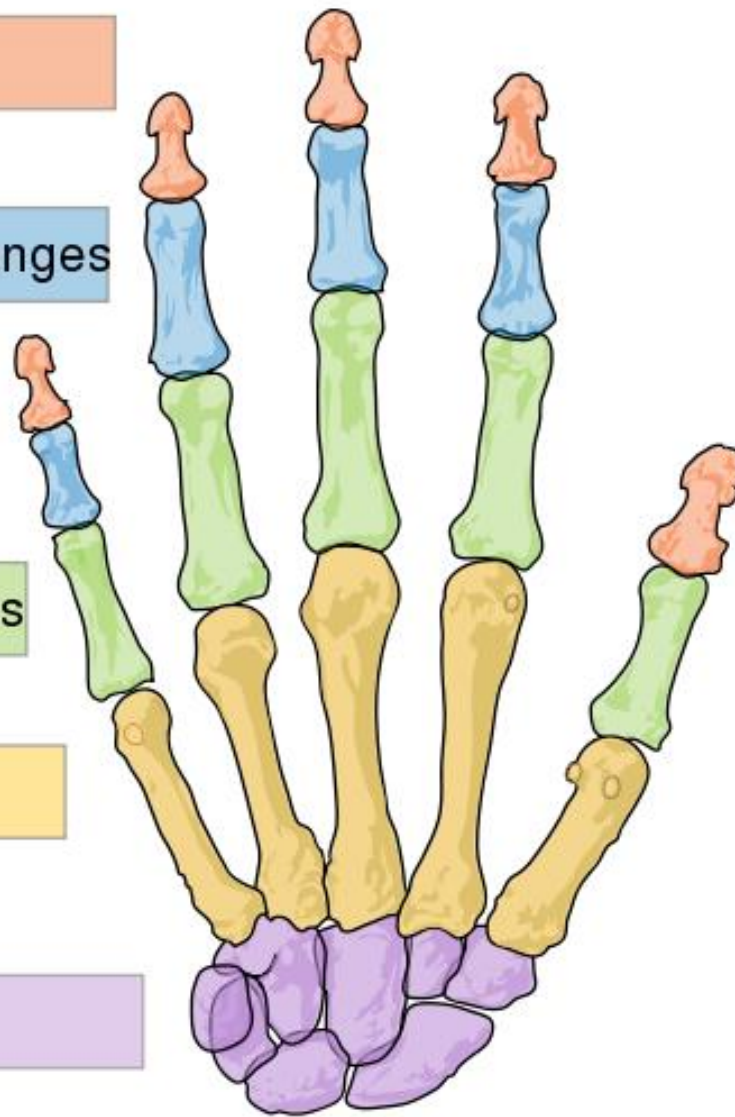
Distal phalanges

Intermediate phalanges

Proximal phalanges

Metacarpals

Carpals

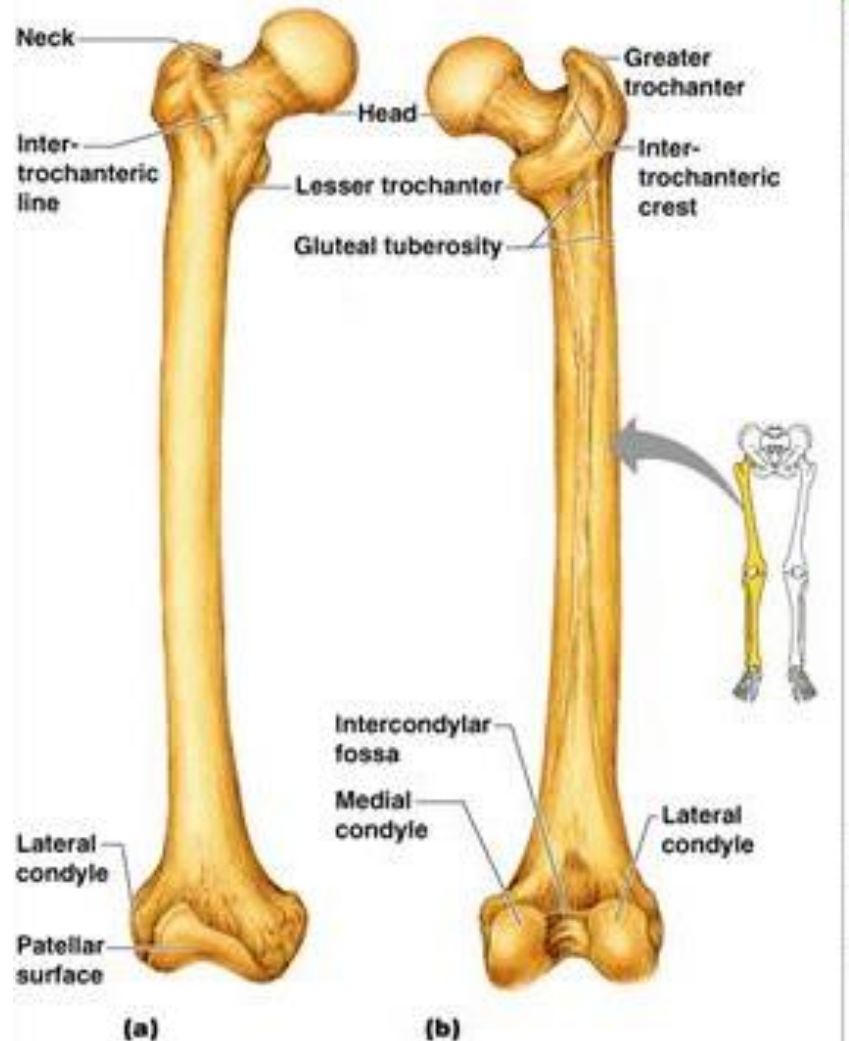


# Lower limb, Leg

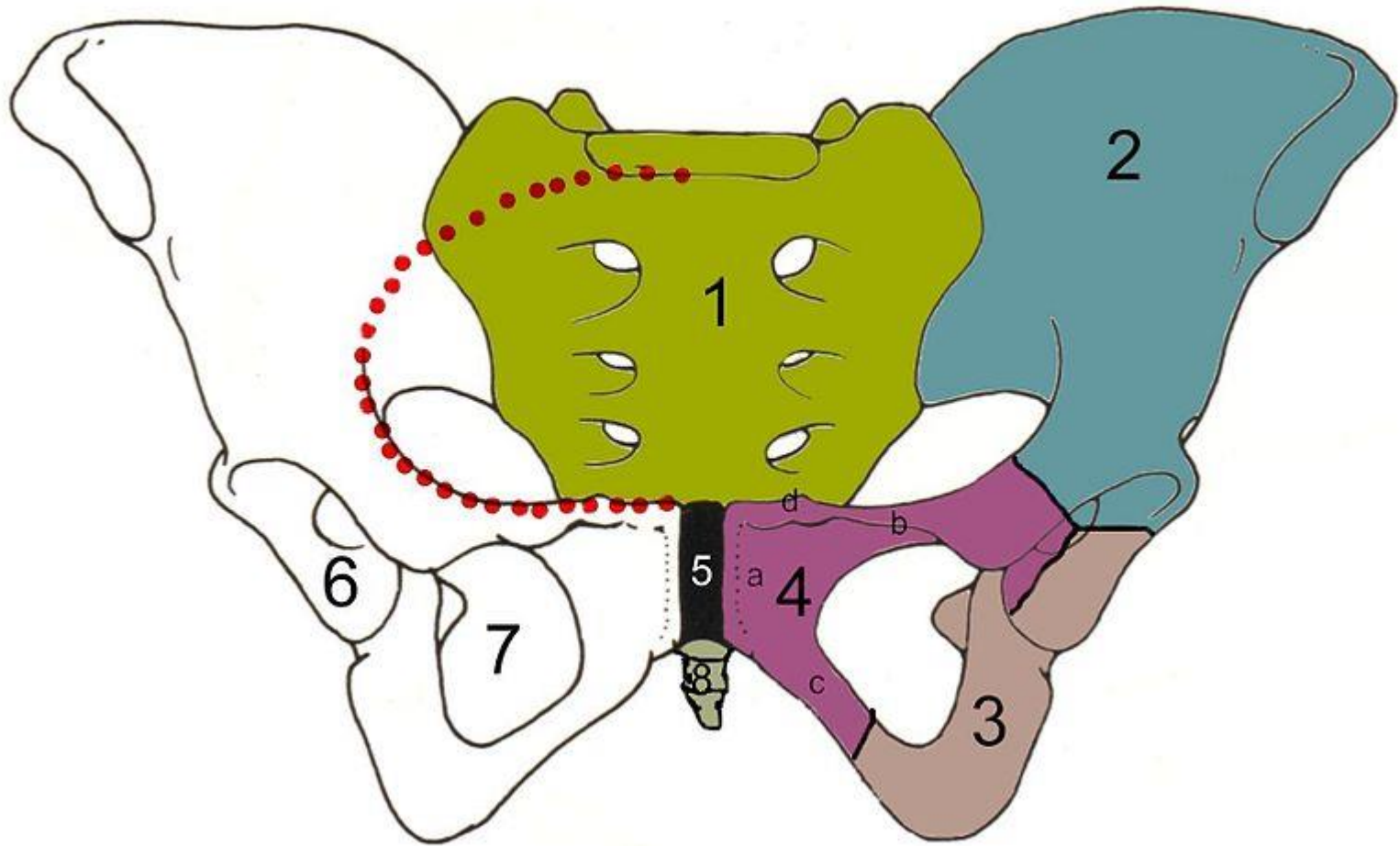
## Pelvis

1. Sacrum
2. Ilium
3. Ischium
4. Pubic bone
5. Pubic symphysis
6. Acetabulum
7. Foramen obturator
8. Coccyx

**Thigh femur** (thighbone)  
the longest, largest, and  
strongest bone







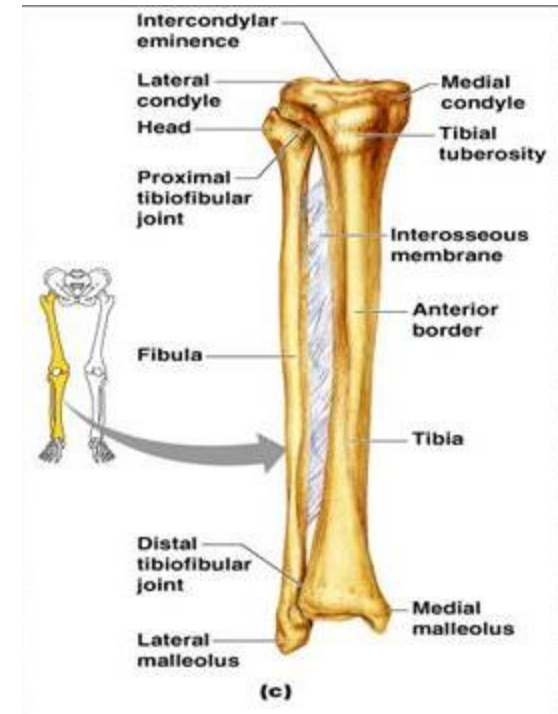
: (1) sacrum, (2) ilium, (3) ischium, (4) pubis, (5) pubic symphysis, (6) acetabulum, (7) obturator foramen, (8) coccyx,



# Leg

1. **Tibia** (shinbone) connected to the femur form the knee joint and allow the ankle to flex and extend

2. **Fibula** serves as an area for muscle attachment



**Patella** (kneecap) is a large, triangular sesamoid bone, it is formed in the response to the strain in the tendon

# Foot

contains 26 bones of the ankle, instep, and the five toes

- the ankle is composed of the 7 tarsal bones
- the 5 metatarsal bones
- the 14 phalanges of the foot, are arranged in a proximal row, a middle row, and a distal row, with the big toe, or hallux



# Cranial and Facial bones

**8 plate-like bones** form the human cranium by fitting together at joints, which are called **sutures**.

The human skull also includes **14 facial bones**

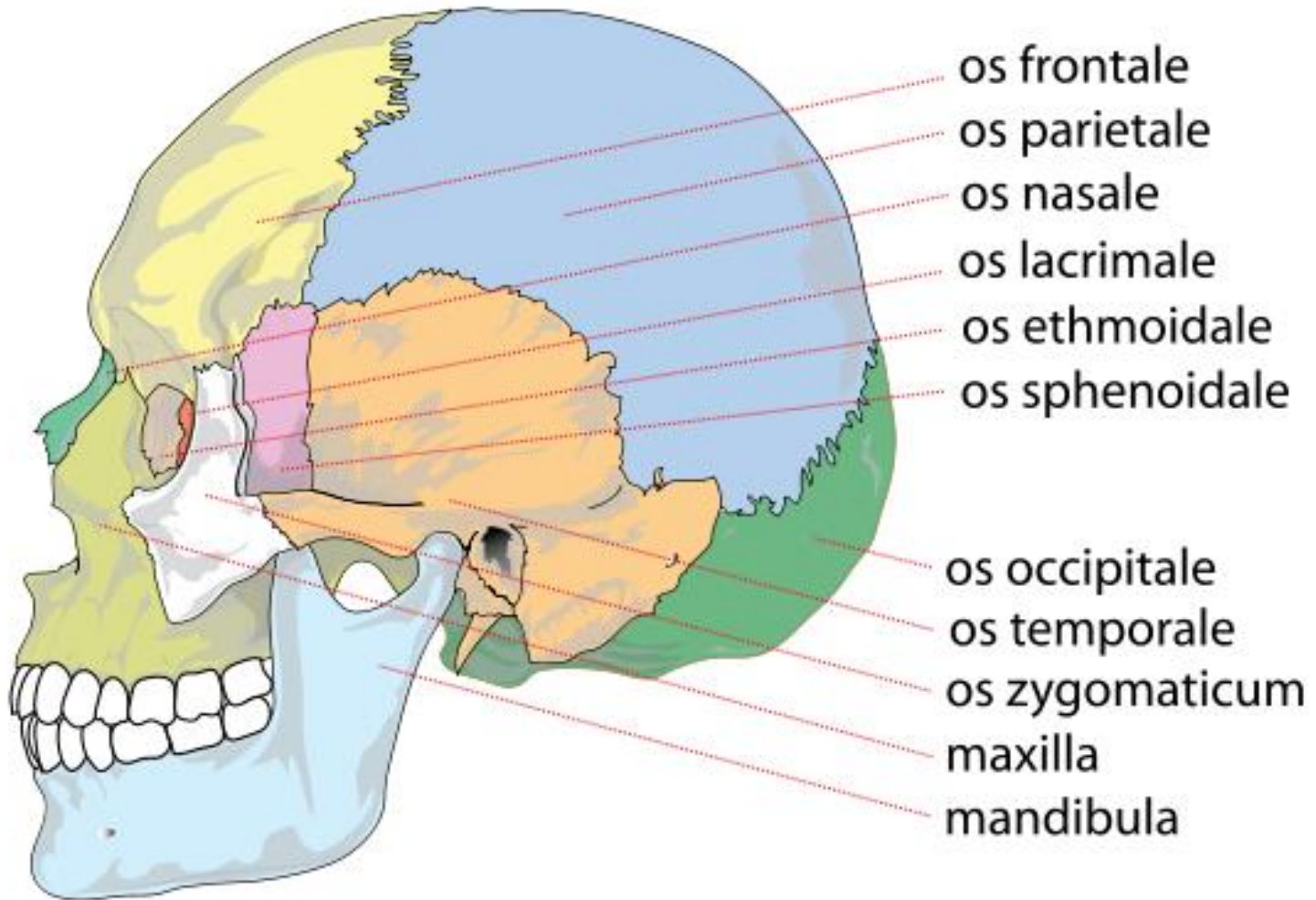
The important facial bones include

the **jaw bone or mandible**,

the **maxilla or upper jaw**,

the **zygomatic or cheek bone**, and the **nasal bone**.

# Cranial and Facial bones



# Cranial and Facial bones

zygomatic bone - cheek

nasal bone - nose

lacrimal bone - inner corner of eye socket

maxilla - upper part of jaw

mandible or jaw bone - lower part of jaw

vomeronasal bone - nasal cavity

ethmoid bone - eye cavity

frontal bone - top of face (forehead) and front top of head

parietal bone - the lower rear of the head

occipital bone - top and side of head

sphenoid bone - temple and eye orbit area

temporal bone - side of the head, above the ear

# **Muscular system**

## Functions of Skeletal Muscle

Movement: muscle pulls tendons to move the skeleton

Control swallowing, defecation and urination

**Maintain posture**

Stabilize joints

**Generate Heat**

## Properties of Muscle

**Irritability** – ability to receive and respond to a stimulus

**Contractibility** – ability to shorten

**Extensibility** – ability to stretch

**Elasticity** – ability to return to normal shape

Muscle Fibers are connected to bone by

Tendon - cord-like structure,

Aponeurosis - sheet-like structure

# Skeletal muscle

Muscle with fascia

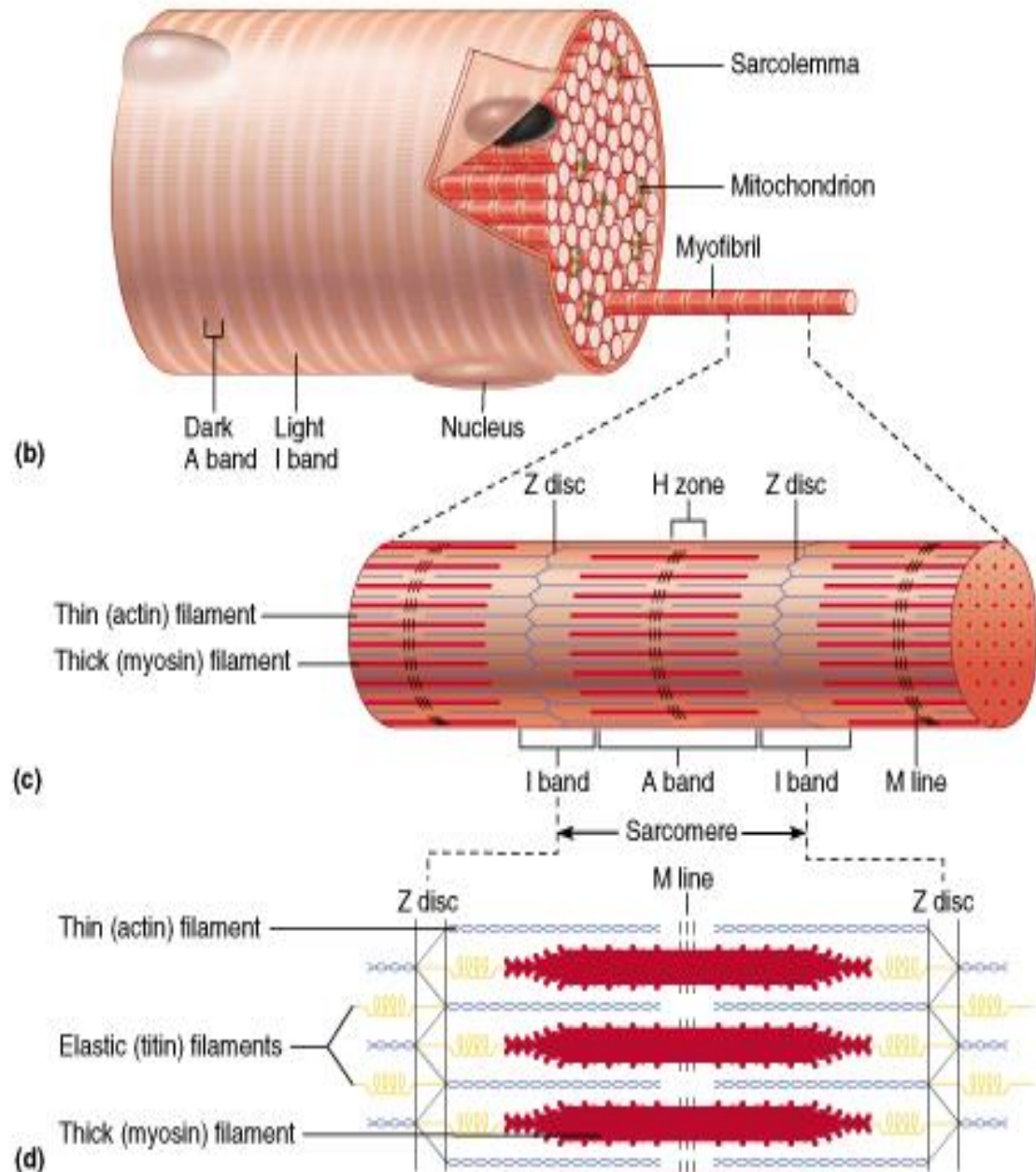
Tendon

b) bundle of fibers

c) Fiber = Myofibril –  
= one multinucleated fiber  
sarcomeres - units

Actin, Myosin

- **actin (thin)** and **myosin (thick)** filaments, associated proteins into **myofibrils**
- regular repeating segments = **sarcomeres** transverse striations - **skeletal and cardiac**





# Skeletal muscle

Sarcolemma, Sarcoplasm, Sarcomers, Sarcoplasmic reticulum

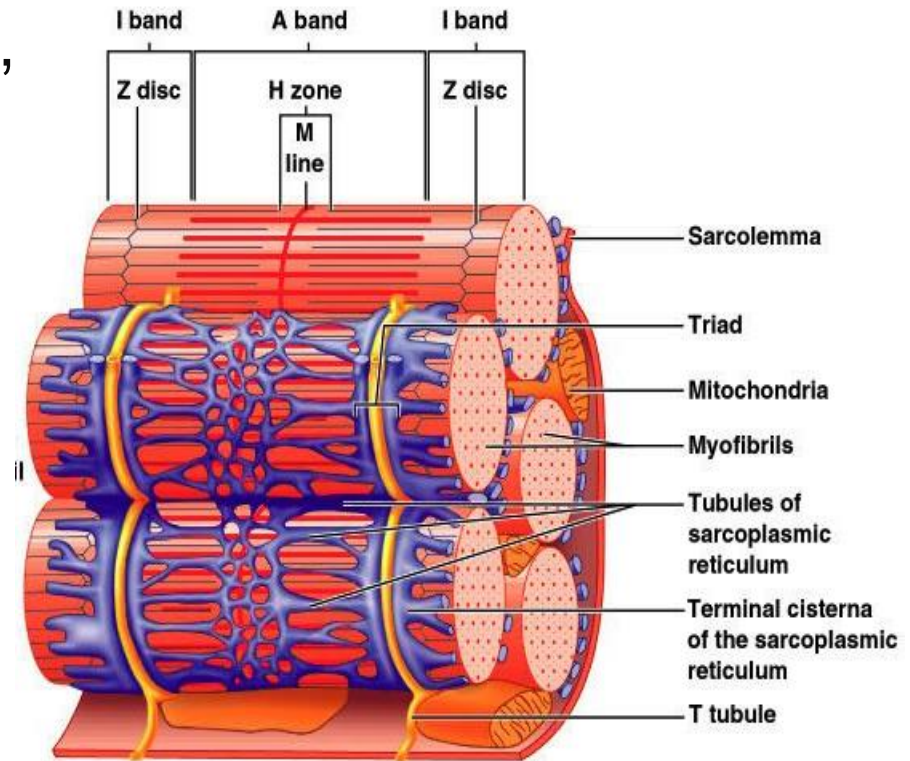
Mitochondria, Myoglobin

## Sarcoplasmic Reticulum =

specialized form of ER, cisternae,  
expanded

chambers - store calcium

T – tubules are extensions  
of a cell membrane for extension  
of depolarization



Benjamin Cummings.

## Red muscle

slow-twitch muscle in which small dark "red" muscle fibers predominate; myoglobin is abundant and great numbers of mitochondria occur, characterized by slow, sustained (tonic) contraction

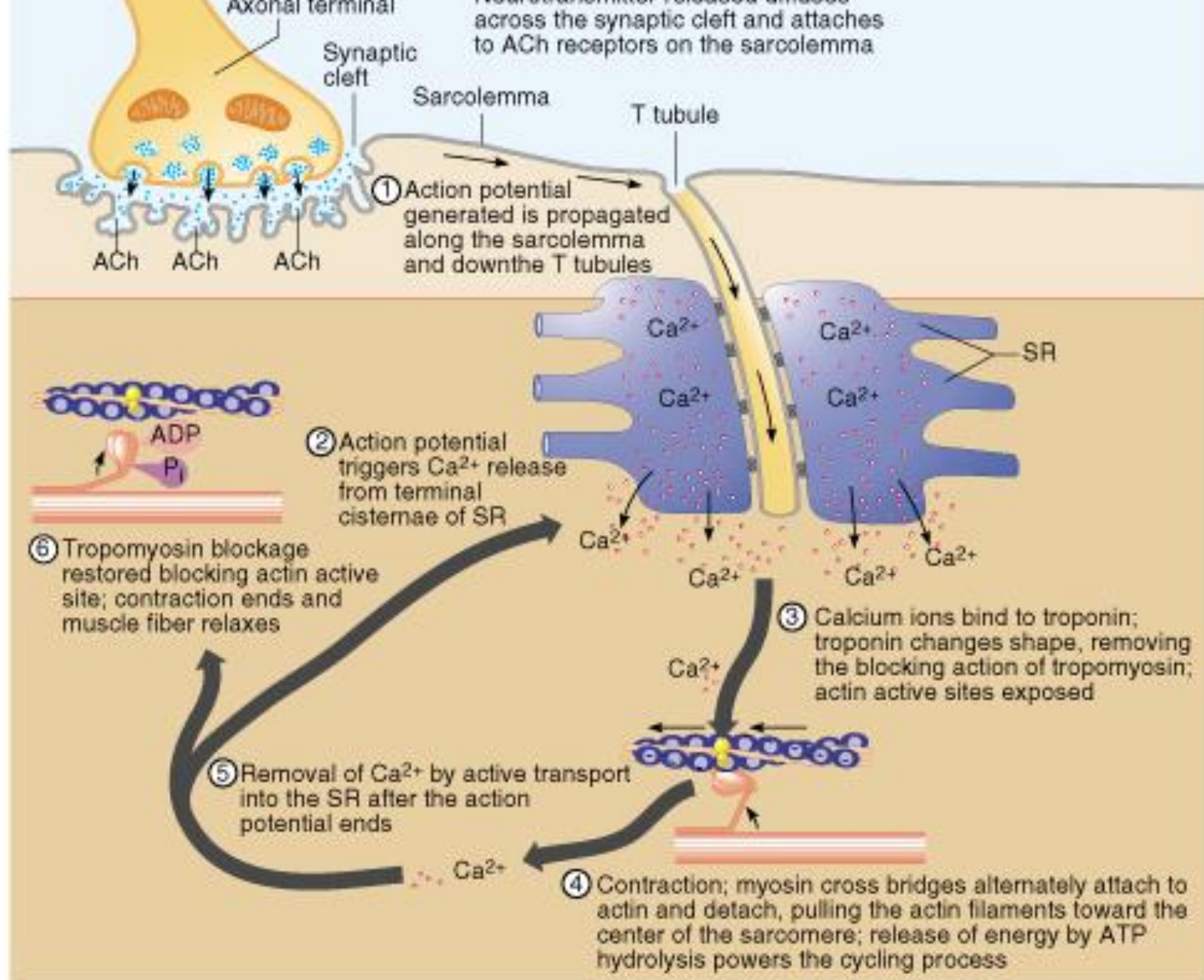
## White muscle

a rapid or fast-twitch muscle in which pale, large "white" fibers predominate; mitochondria and myoglobin are relatively sparse compared with findings in red muscle; involved in phasic contraction.

# *Summary of Muscle Contraction*

1. Brain – spinal cord - motor nerve - neuromuscular junction
  2. Acetylcholine(ACh) released by synaptic vesicles, crosses synaptic cleft
    - Acetylcholinesterase enzyme breaks down ACh, binds to receptors
  3. Sodium ions “leak” into muscle cell initiating action potential which travels T-tubules to sarcoplasmic reticulum (SR)
  4. Calcium ions (high affinity for troponin) released from SR
  5. Calcium binds with troponin
  6. Shift of tropomyosin, make sites available for myosin
  7. With ATP present, ATPase splits ATP to ADP + P + Energy
  8. Myosin combines with actin
  9. Sliding action of actin over myosin (Sliding filament theory)
  10. Impulse stops, calcium or ATP depleted, calcium ions pumped to SR
  11. Tropomyosin returns over active sites on actin, myosin no longer bound
- 
-





# - Classification - relative to the Midline

**RECTUS** = parallel to the midline

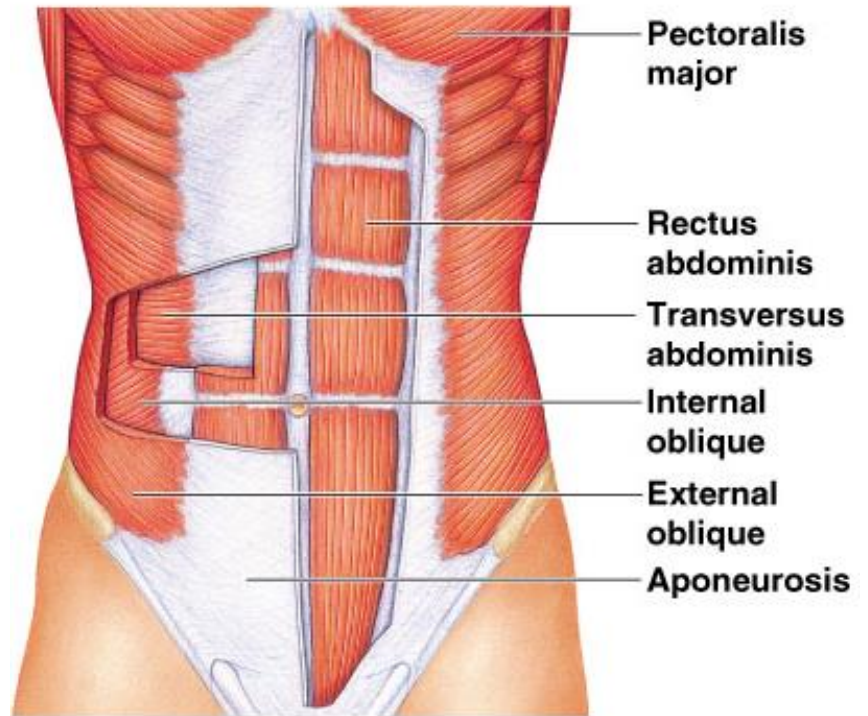
*Rectus Abdominus*

**TRANSVERSE** = perpendicular to midline

*Transverse Abdominus*

**OBLIQUE** = diagonal to midline

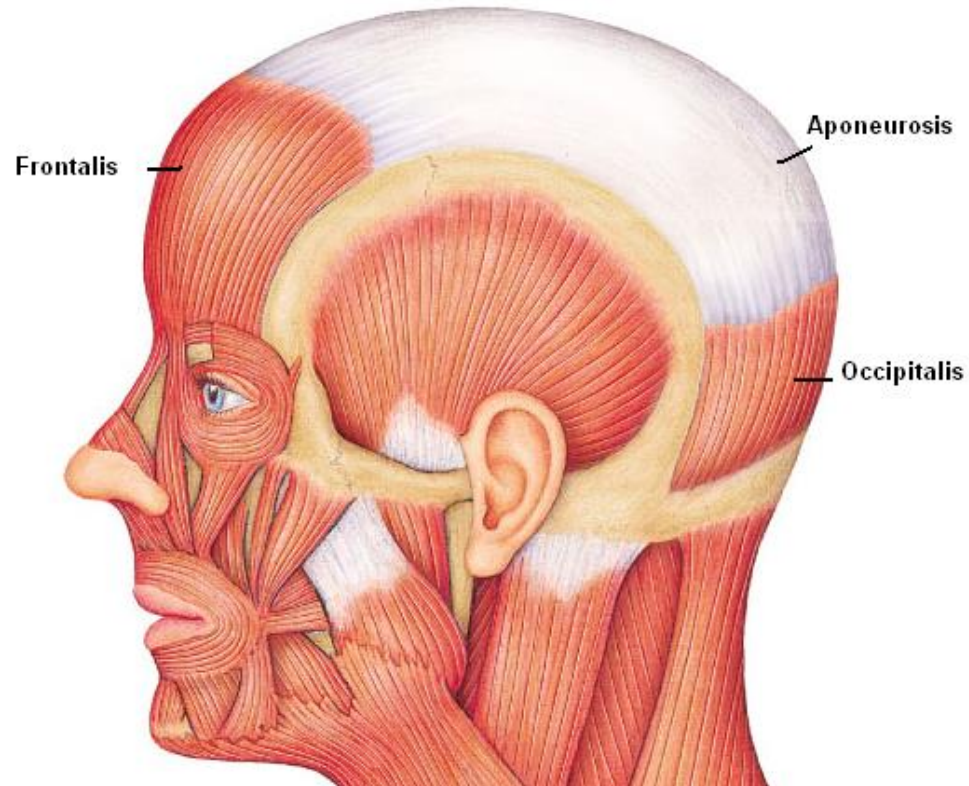
*External Oblique*



# Classification - relative to structure near which muscle is found

**FRONTALIS** = near FRONTAL bone

**OCCIPITALIS** = near OCCIPITAL bone



**Classification - relative  
to  
size of muscle**

**MAXIMUS** = largest  
*Gluteus **Maximus***

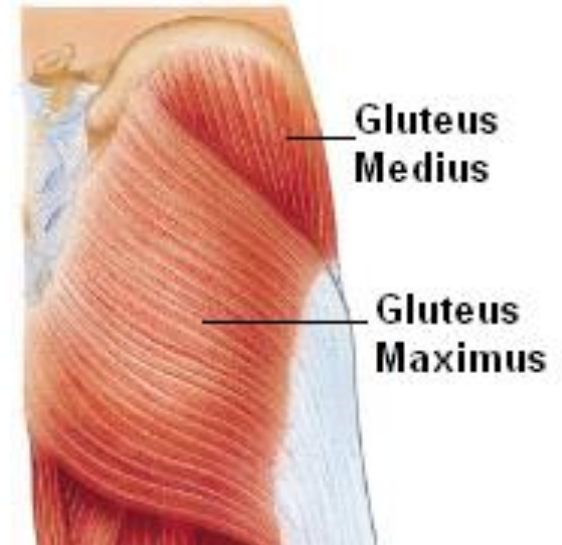
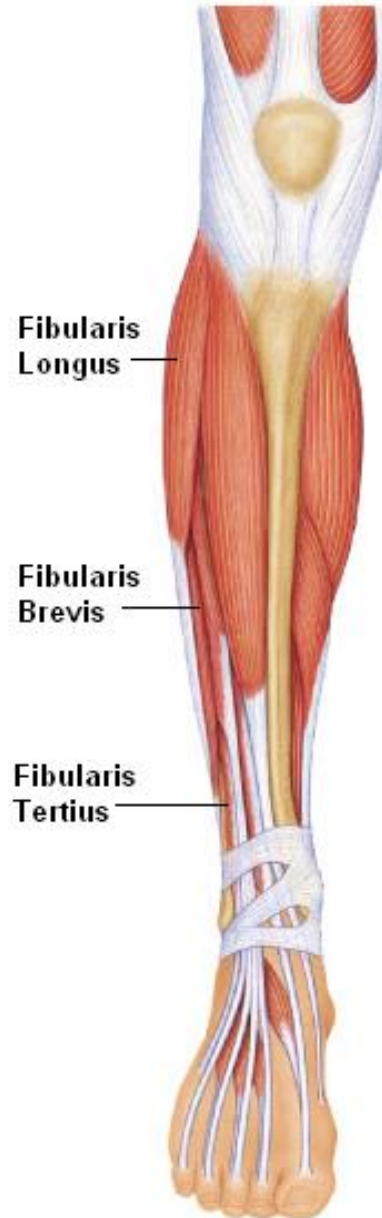
**MEDIUS** = middle  
*Gluteus **Medius***

**MINIMUS** = smallest  
*Gluteus **Minimus***

**LONGUS** = longest  
*Fibularis **Longus***

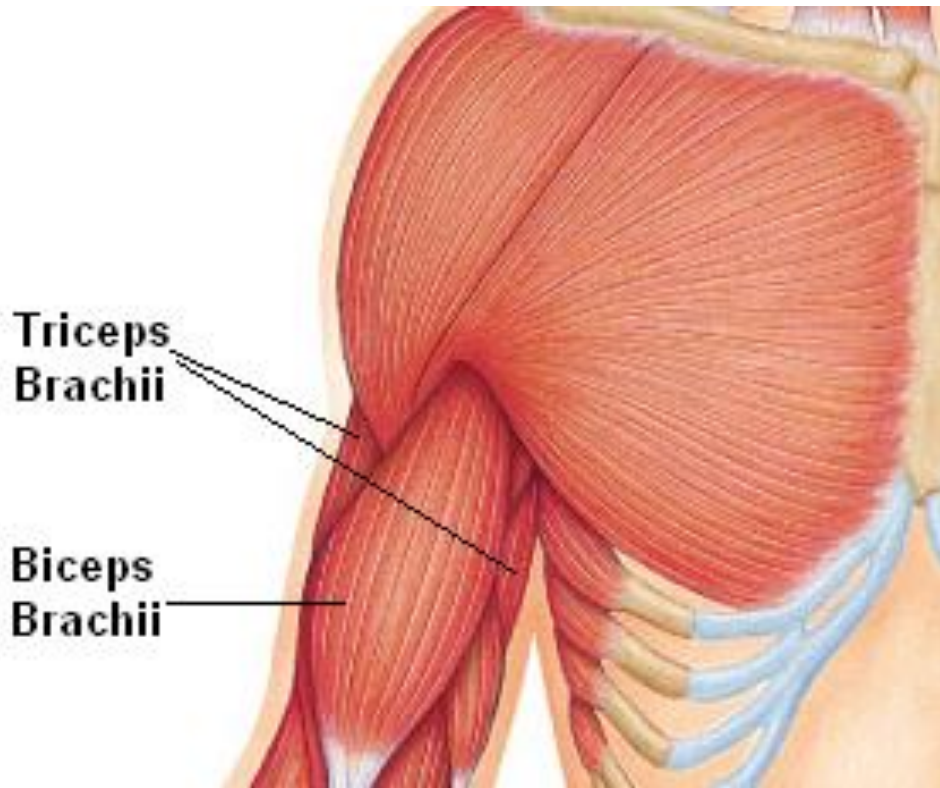
**BREVIS** = short  
*Fibularis **Brevis***

**TERTIUS** = shortest  
*Fibularis **Tertius***





# Classification - relative to number of tendons of origin



**BICEPS = Two**

*Biceps Brachii*

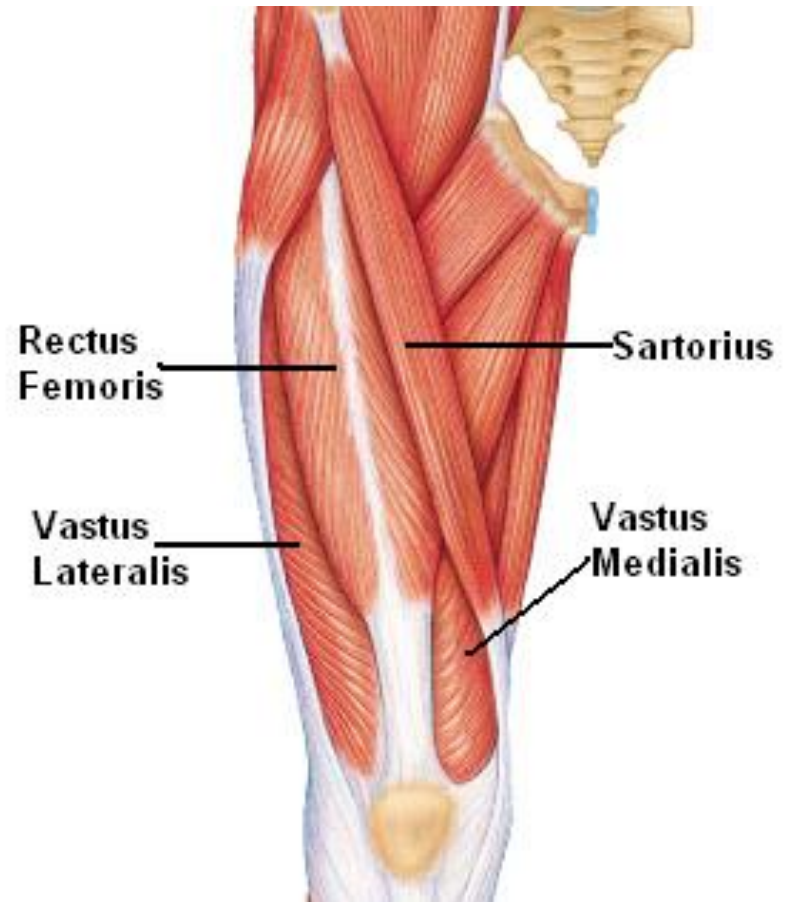
*Biceps Femoris*

**TRICEPS = Three**

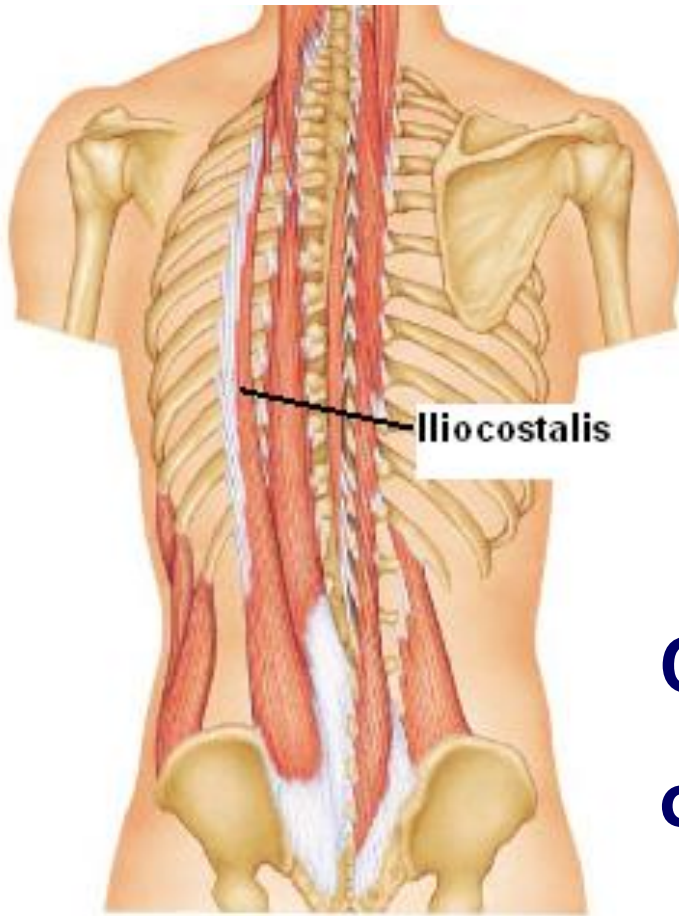
*Triceps Brachii*



- **“Quadriceps”**
  - Rectus Femoris
  - Vastus Lateralis
  - Vastus Medialis
  - Vastus Intermedius
  - Sartorius



\*\*Vastus Intermedius is beneath Rectus Femoris



**Classification - relative to origin**

**ILIO COSTALIS**= attaches to the ilium & ribs (costal = ribs)

# Classification – related to function

<b>NAME</b>	<b>ACTION</b>	<b>EXAMPLE</b>
<b>FLEXOR</b>	Decrease angle at a joint	<i>Flexor Carpi Radialis</i>
<b>EXTENSOR</b>	Increase angle at a joint	<i>Extensor Carpi Ulnaris</i>
<b>ABDUCTOR</b>	Move bone away from midline	<i>Abductor Pollicis Longus</i>
<b>ADDUCTOR</b>	Move bone toward midline	<i>Adductor Longus</i>
<b>LEVATOR</b>	Produce upward movement	<i>Levator Scapulae</i>
<b>DEPRESSOR</b>	Produce downward movement	<i>Depressor Labii Inferioris</i>
<b>SUPINATOR</b>	Turn palm upward/anterior	<i>Supinator</i>
<b>PRONATOR</b>	Turn palm downward/posterior	<i>Pronator Teres</i>

# Classification - relative to shape of the muscle

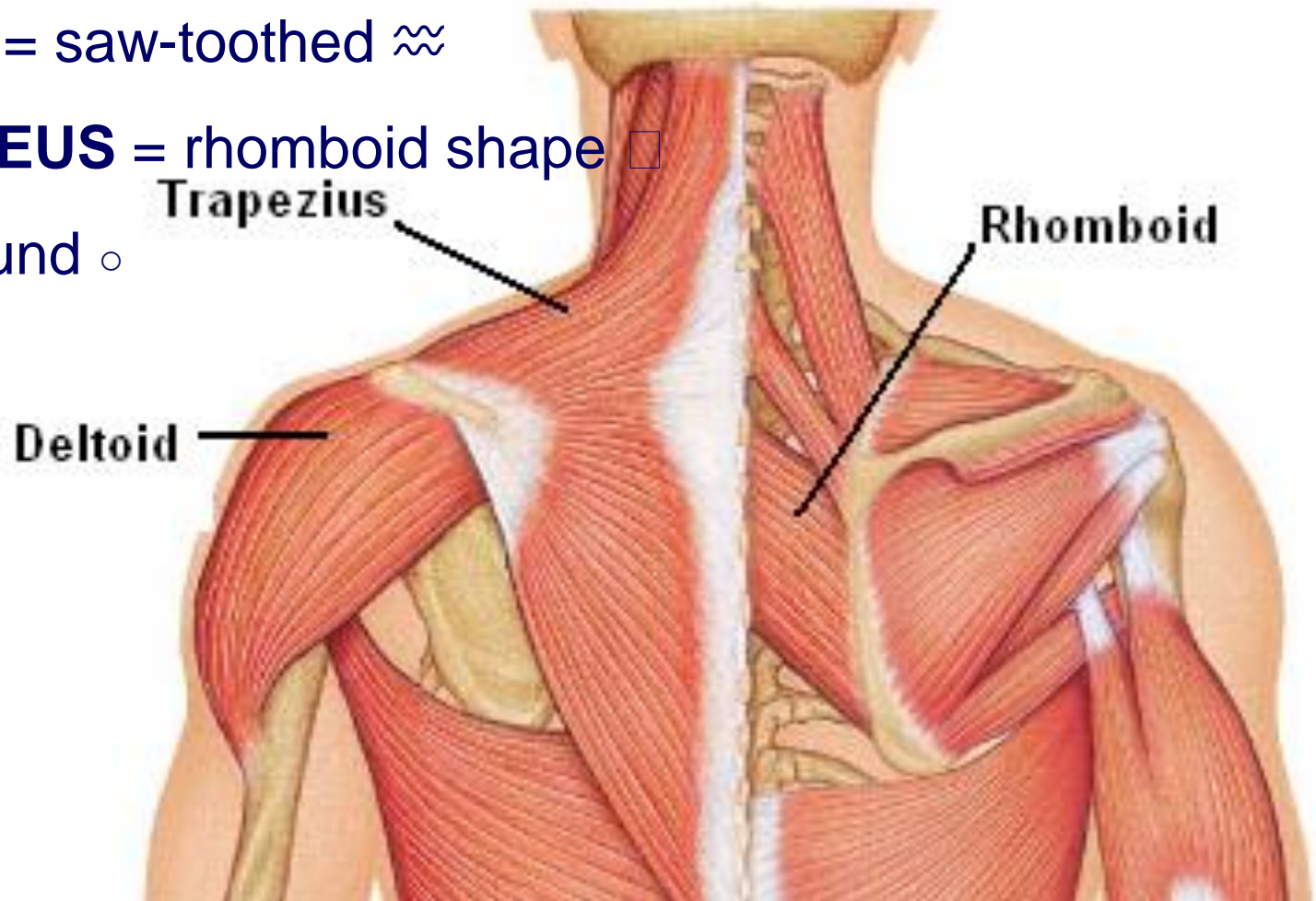
**DELTOID** = triangular shape  $\Delta$

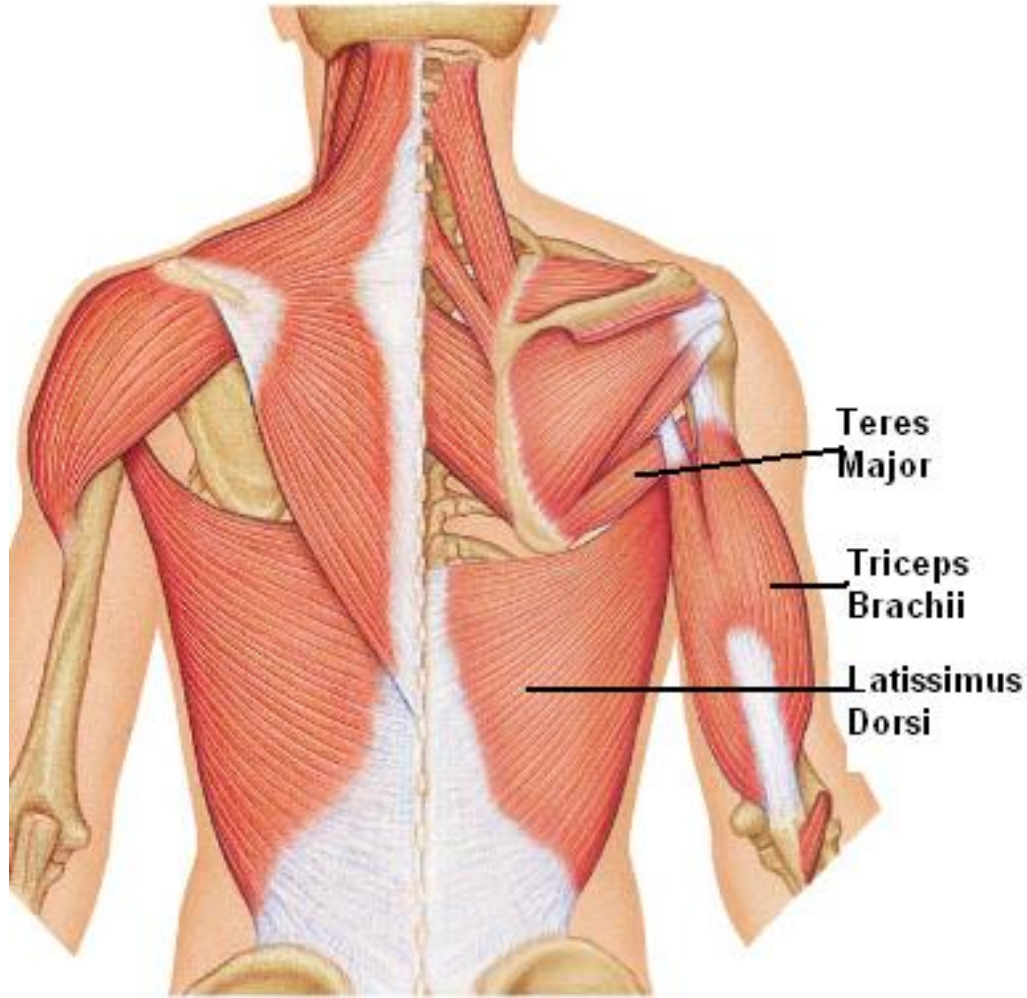
**TRAPEZIUS** = trapezoid shape  $\diamond$

**SERRATUS** = saw-toothed  $\approx$

**RHOMBOIDEUS** = rhomboid shape  $\square$

**TERES** = round  $\circ$





Teres  
Major

Triceps  
Brachii

Latissimus  
Dorsi

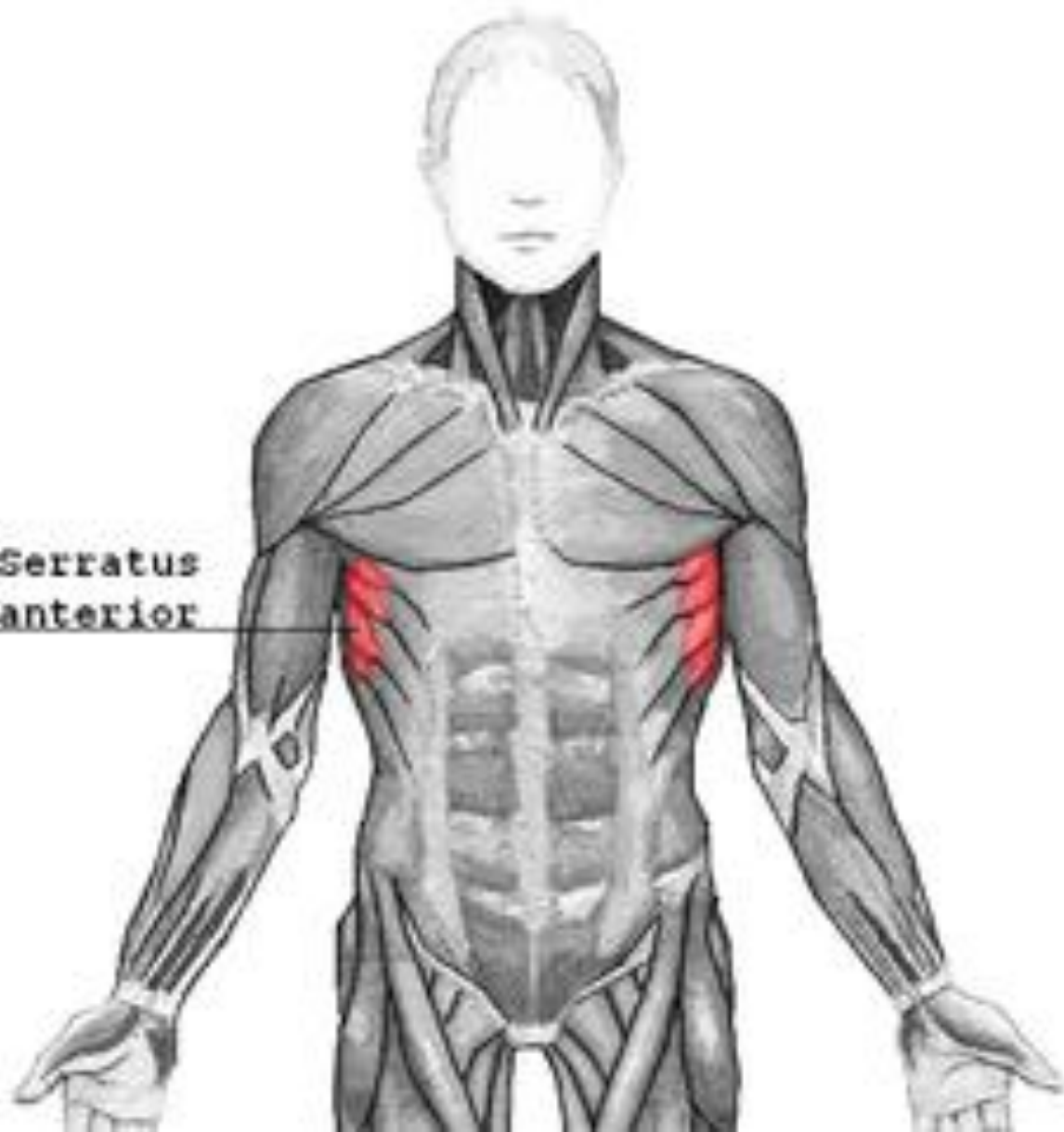
Teres Major

**Latissimus Dorsi**

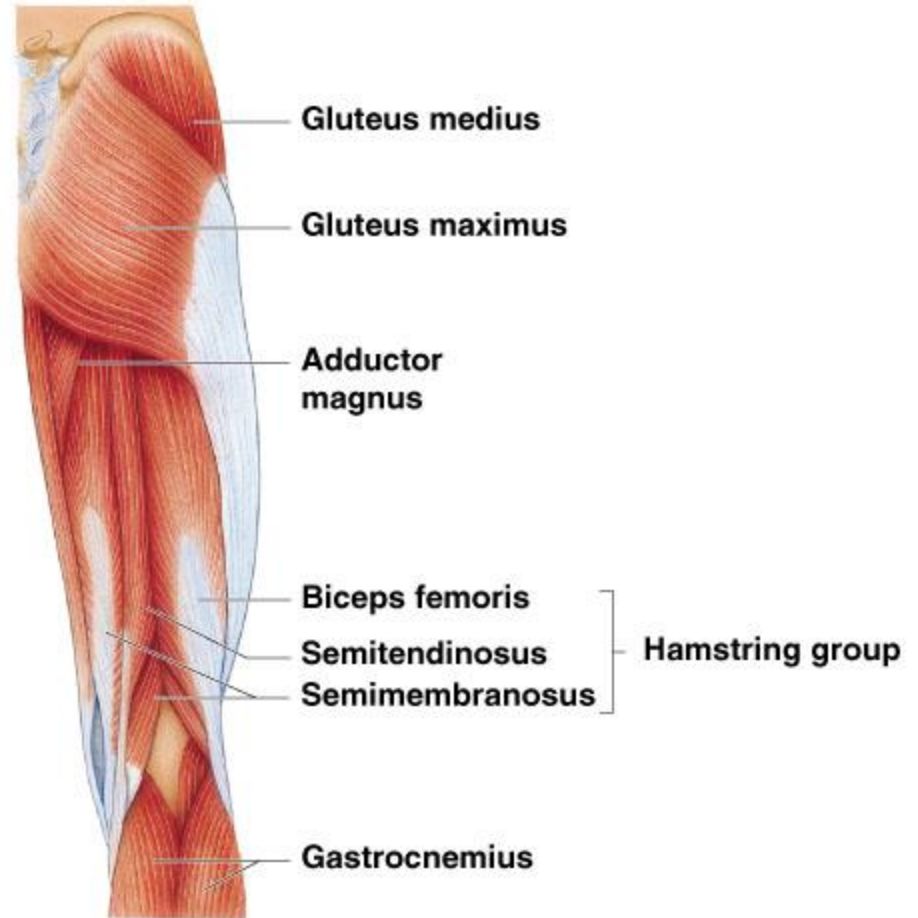
**Triceps Brachii**



Serratus  
anterior



- **“Hamstrings”**
  - **Semimembranosus**
  - **Semitendinosus**
  - **Biceps Femoris**
- **Gastrocnemius - Triceps surae**



# Thank you for your attention

Campbell, Neil A., Reece, Jane  
B., Cain Michael L., Jackson,  
Robert B., Minorsky, Peter V.,  
**Biology**, Benjamin-Cummings  
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