Human Anatomy and Physiology

CLS 224

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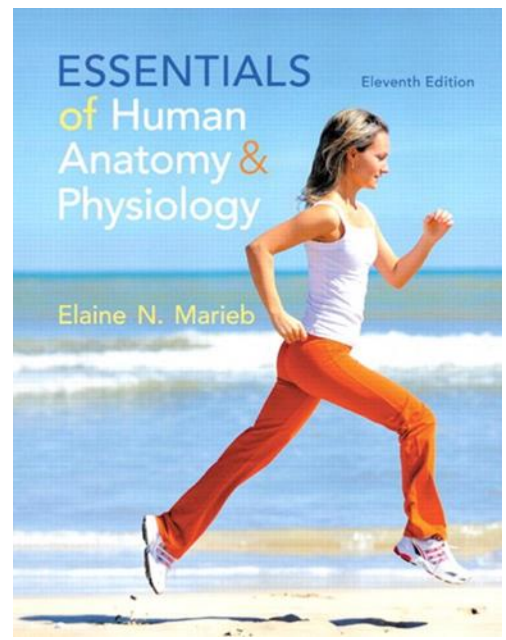


The Muscular & The Skeletal System

(chapters 5 & 6)

The Skeletal System

1. Bones: An overview.

1. Bones: An overview

Objectives:

- Identify the subdivisions of the skeleton as axial or appendicular.
- list the functions of the skeletal system.
- Name the four main classifications of bone.
- Identify the major anatomical areas of a long bone.
- Describe the process of bone formation, growth and remodeling.

1. Bones: An overview

Function:

1. Support.
2. Protection.
3. Movement.
4. Storage.
5. Blood cell formation (hematopoiesis).

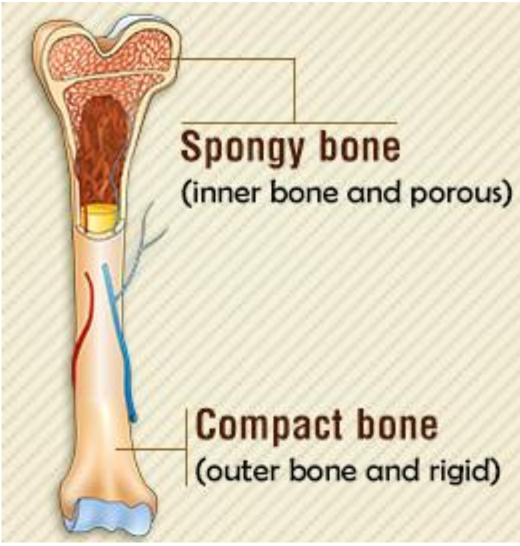
Classification of Bones

206 bones in the human body

There are two basic types of osseous (bone tissue):

- Compact bone (cortical bone)is dense and looks smooth and homogeneous.
- Spongy bone (trabecular bone)is composed of small needlelike pieces of bone and

lots of open space.

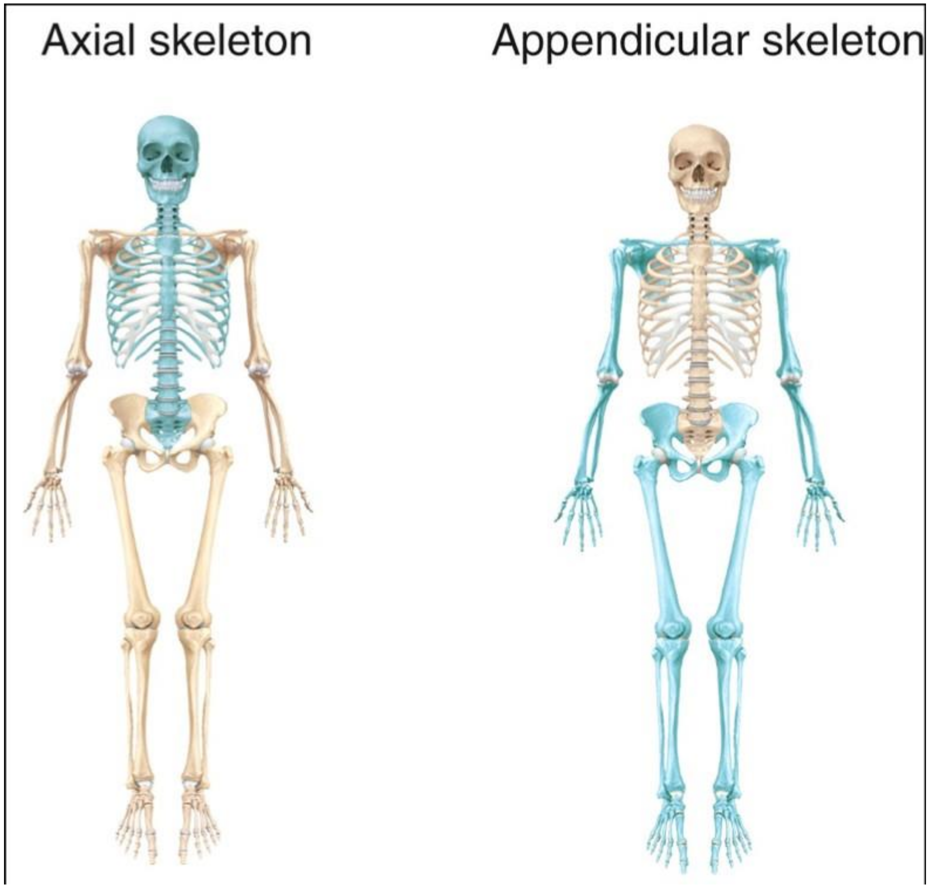


The Skeleton is Subdivided into two divisions

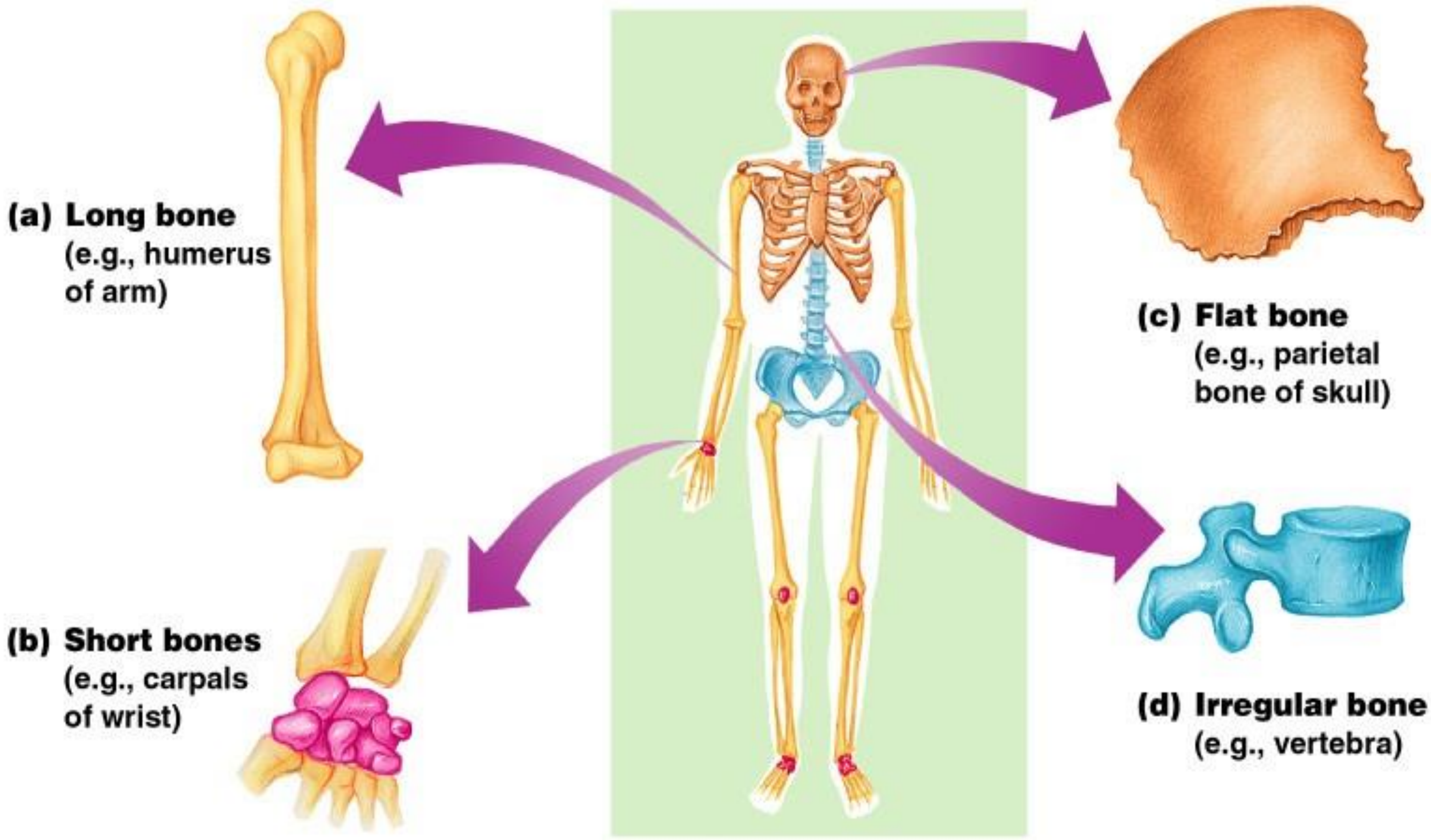
- <u>Axial Skeleton:</u>

Bones that form the longitudinal axis of the body (skull, vertebral column and ribcage).

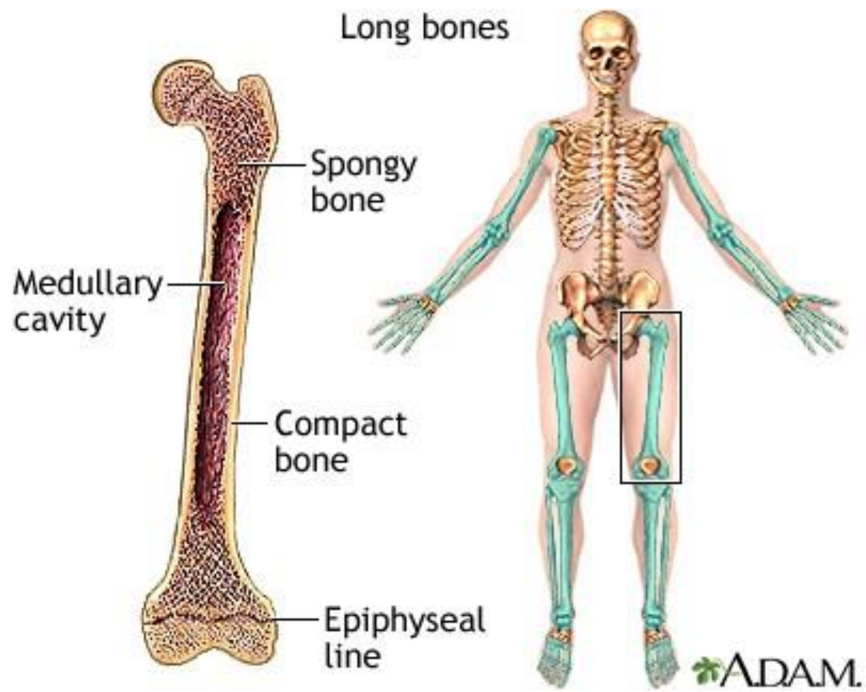
- <u>Appendicular Skeleton:</u> Bones of the upper and lower limbs, shoulders and hips.



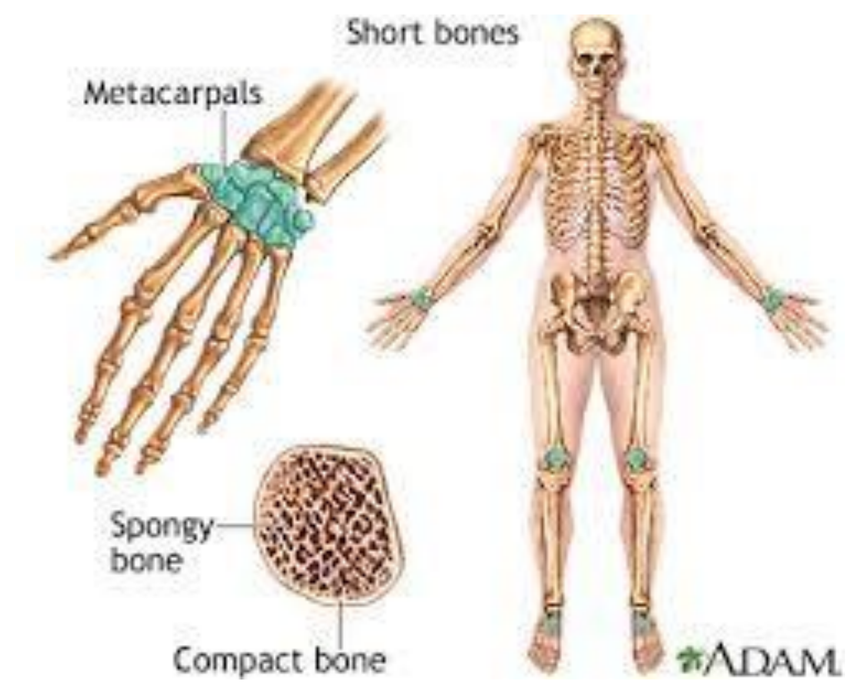
Classification of Bones on the Basis of Shape



- **Long bones**
  - Typically longer than they are wide.
  - Cylindrical with knob--like ends.
  - Are mostly **Compact Bone**.
  - All the bones of the limbs, except the patella (kneecap) and the wrist and ankle bones, are long bones.
    - Examples: Femur, humerus



- **Short bones**
  - Generally cube--shaped
  - Are mostly **Spongy Bone**
    - Examples: Carpals, tarsals



- **Flat bones**
  - Thin and flattened
  - Usually curved
  - Two thin layers of **compact bone** sandwiching a layer of **spongy Bone**.
    - Examples: Skull, ribs, sternum, pelvis.

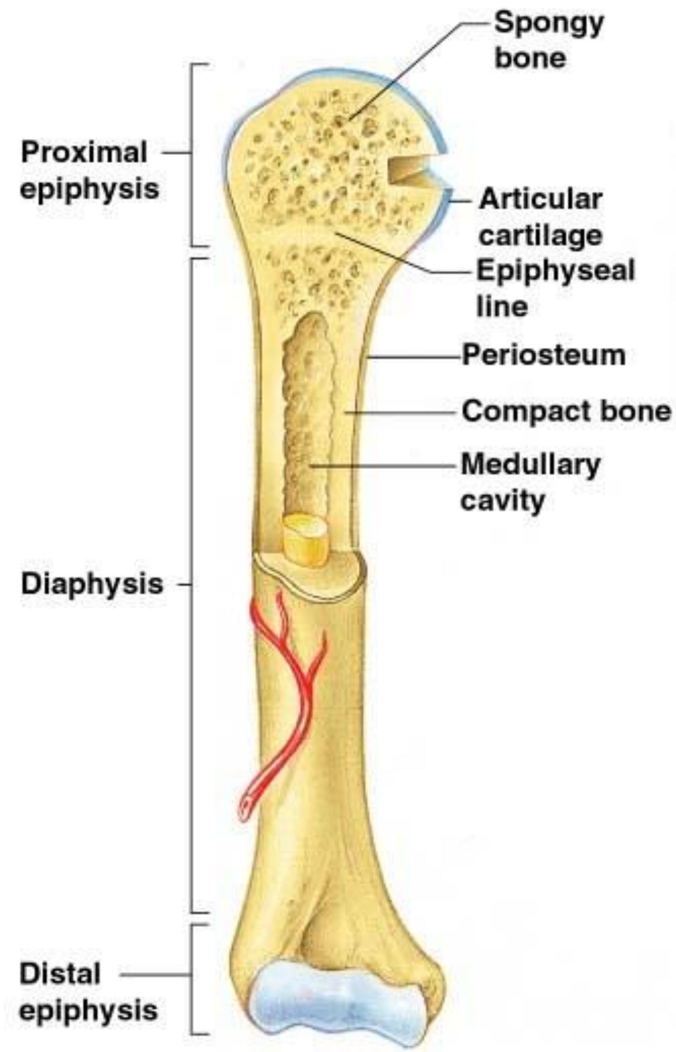
- **Irregular bones**
  - Do not fit into other bone classification categories
    - Example: Vertebrae and hip.

Structure of Bones

Structure of a Long Bone (Gross)

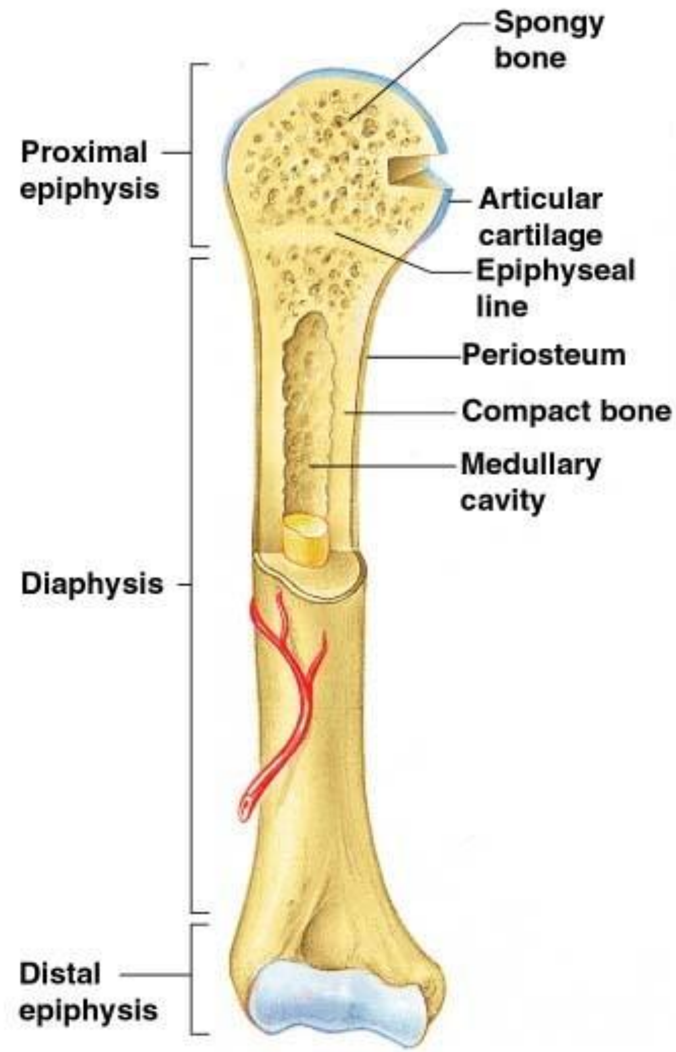
Epiphysis:

- Ends of long bone.
- Composed mostly of **Spongy Bone** covered by a thin layer of **Compact Bone**.
- Covered by glassy **hyaline cartilage** providing a smooth slippery surface that decrease friction.
- The hollow spaces of epiphysial spongy bone are filled with blood making tissue called red bone marrow.



Diaphysis:

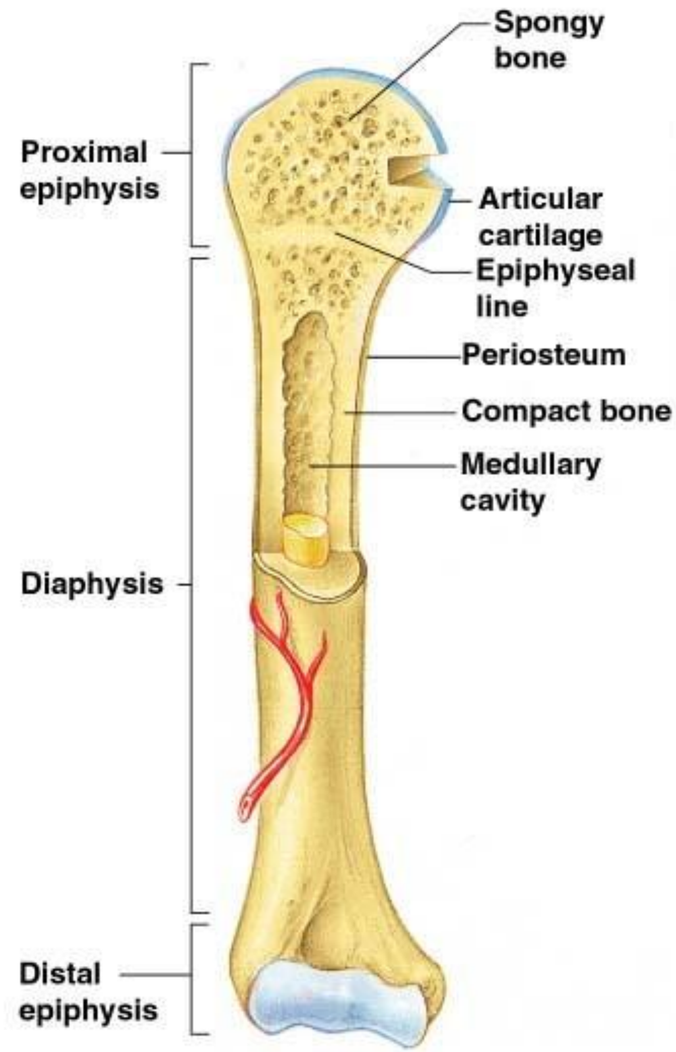
- The long shaft between the epiphysis.
- Most of the bon's length.
- Composed of **Compact Bone**.
- It is hollow.
    - Covered and protected by a fibrous connective tissue membrane called the **Periosteum**.



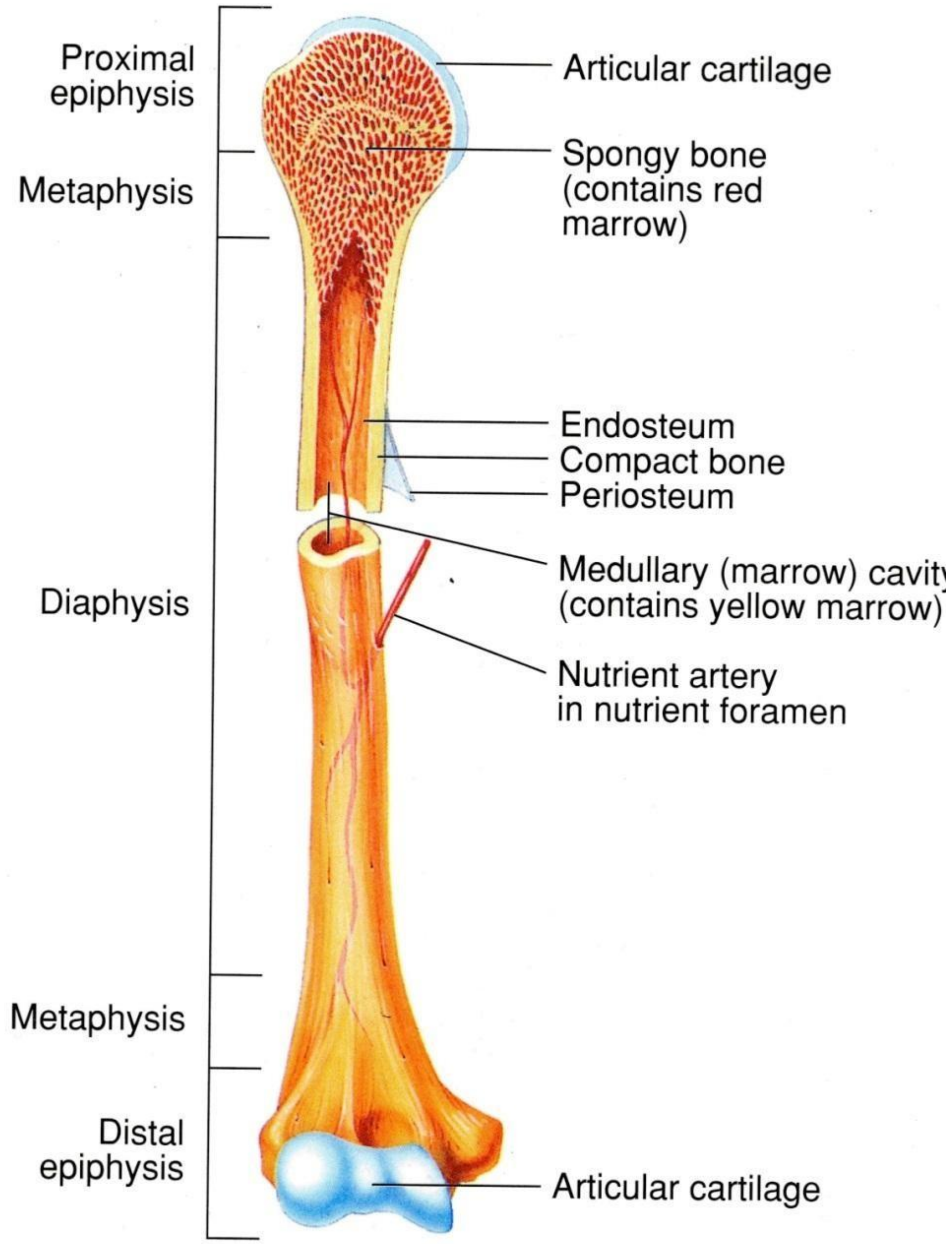
- Medullary cavity:
  - The hollow center of the diaphysis.
  - Lined by a thin layer of connective tissue called Endosteum.
  - In adults, it is filled with adipose tissue called the yellow bone marrow.

,While

  - In infants, this area is filled with red bone marrow.

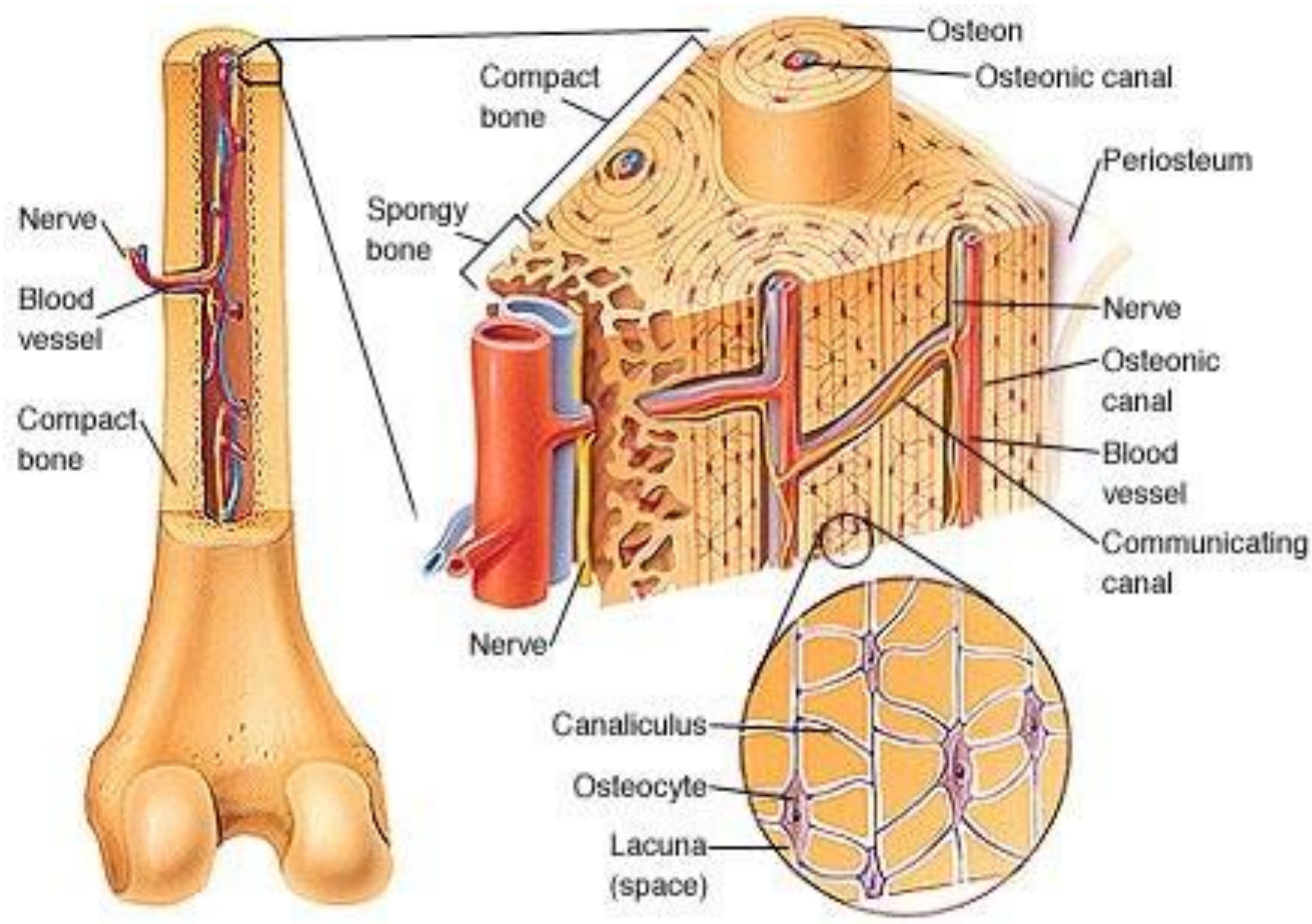


Adult bone

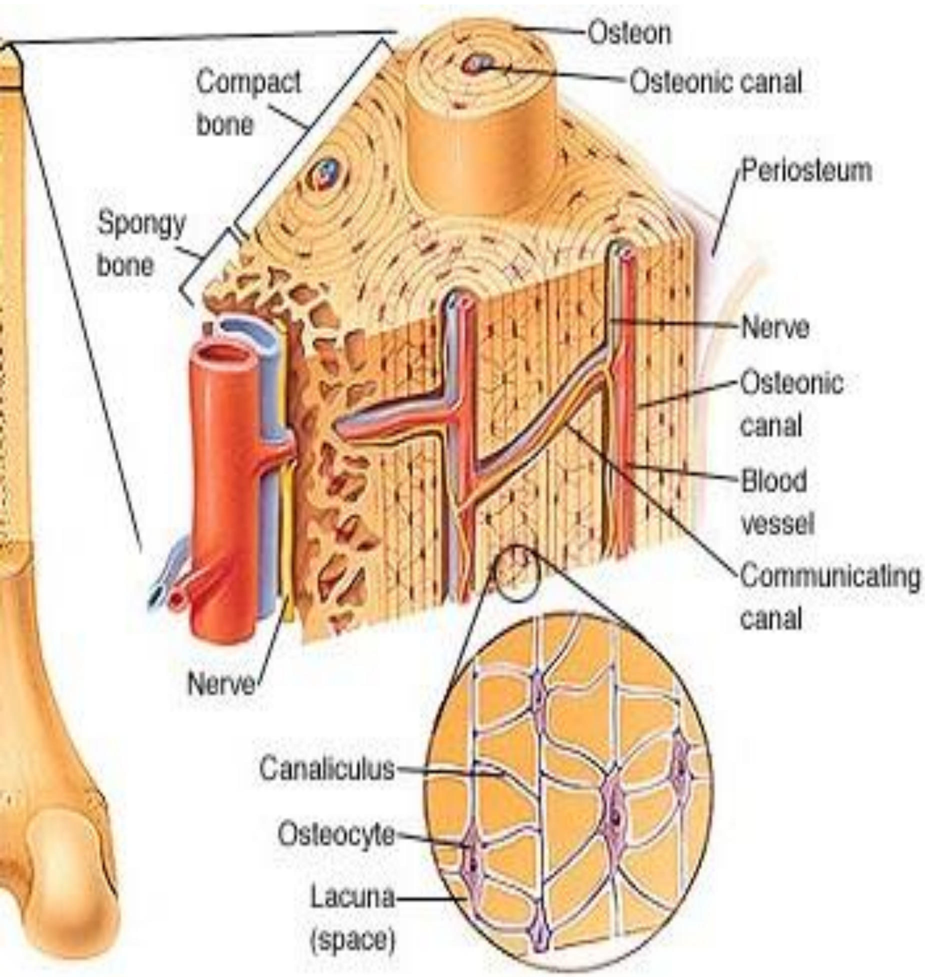


Proximal epiphysis
Metaphysis
Diaphysis
Metaphysis
Distal epiphysis
Articular cartilage
Spongy bone (contains red marrow)
Endosteum
Compact bone
Periosteum
Medullary (marrow) cavity (contains yellow marrow)
Nutrient artery in nutrient foramen
Articular cartilage

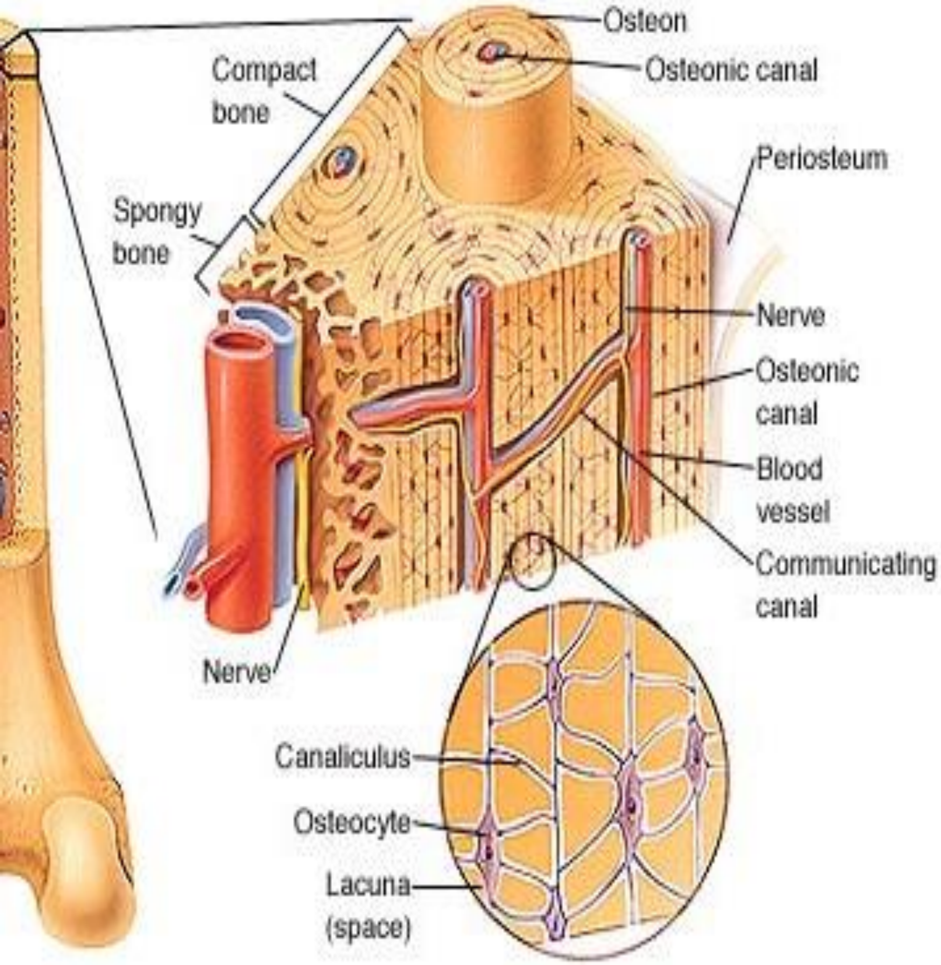
Structure of a Long Bone (microscopic)



Structure of a Long Bone (microscopic)



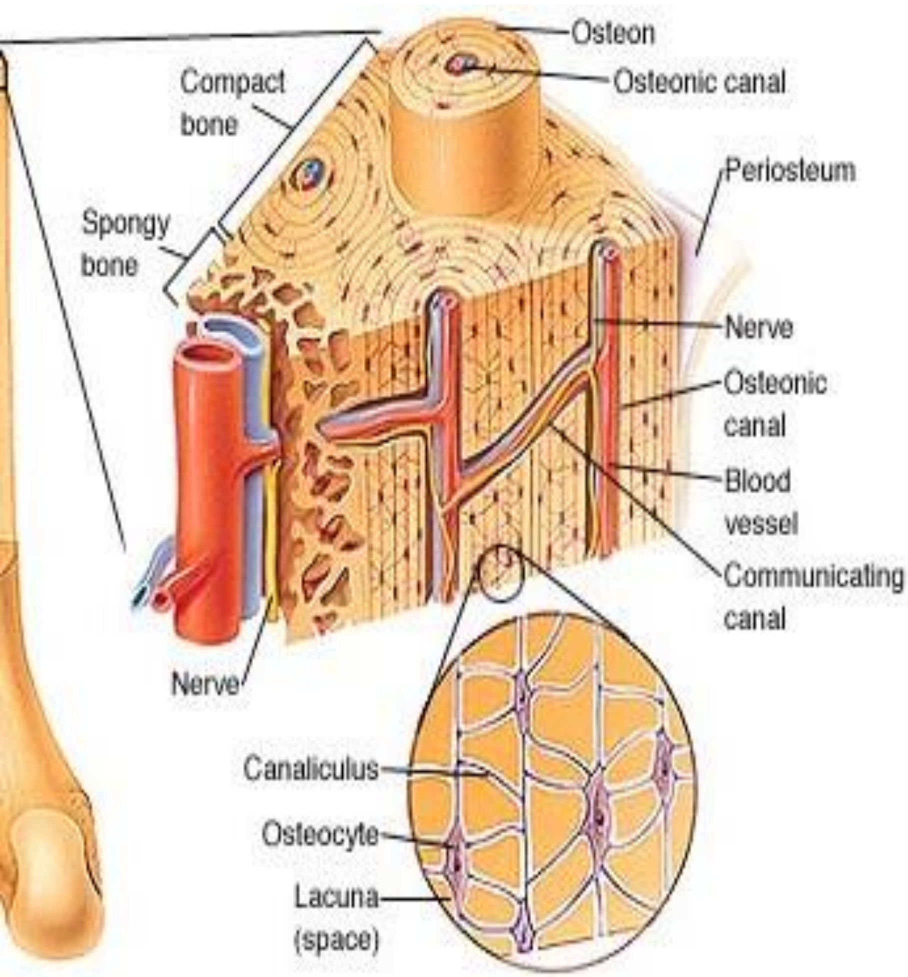
- Compact bone has a complex structure filled with nerves, blood vessels which provide bone cells with nutrients and a route for waste disposal.
- Mature bone cells “osteocytes” are found in cavities within the matrix called lacunae.



- Lacunae are arranged in concentric circles called lamellae around central (haversian) canals. Each complex consisting of central canal and lamellae is called an osteon or harvasian system.

- Central canals run lengthwise through the bony matrix carrying blood vessels and nerves to all areas of the bone.

- Tiny canals “canaliculi”, radiate outwards from the central canals to all lacunae acting as a transportation system connecting neighboring bone cells to the main nutrient supply.

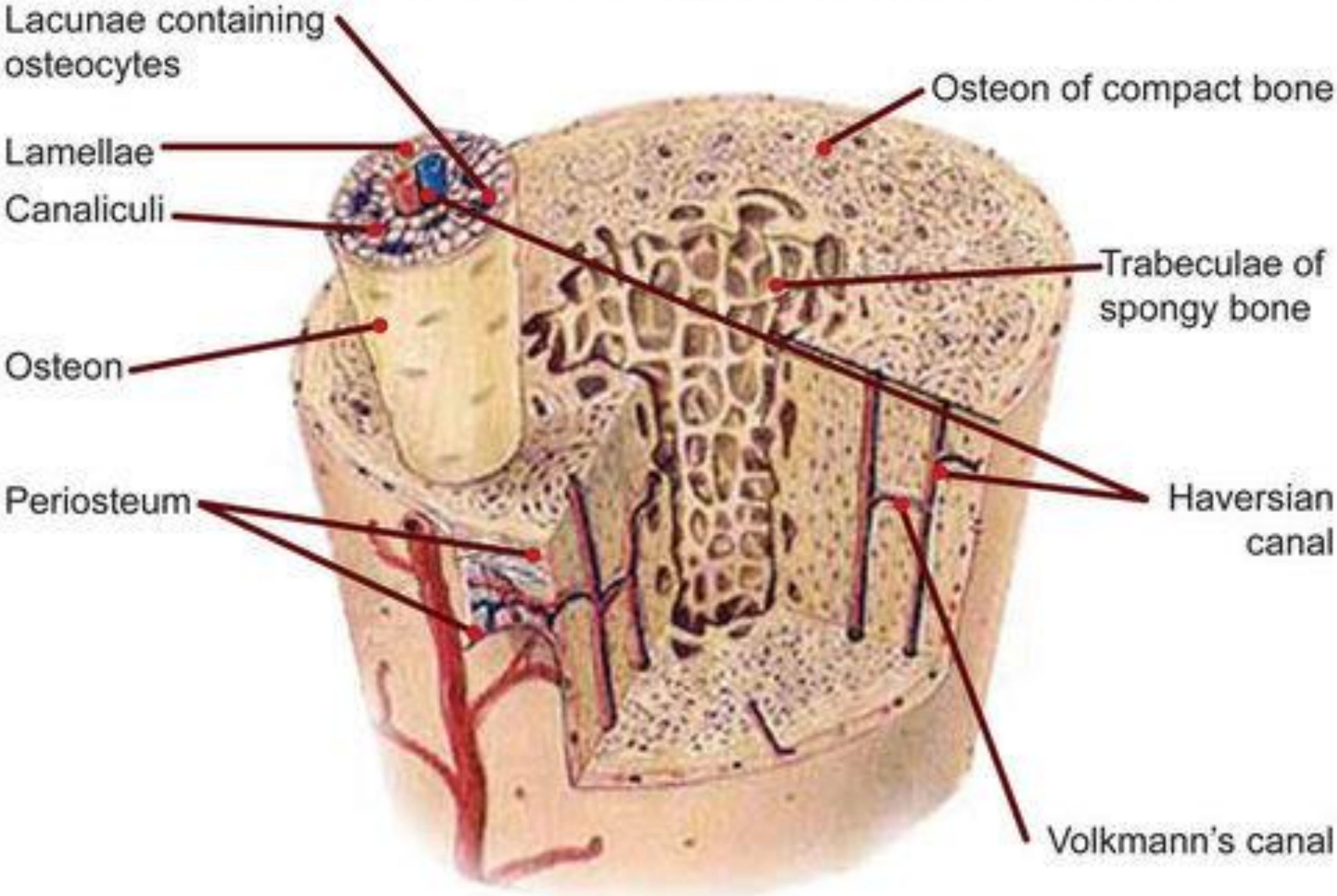


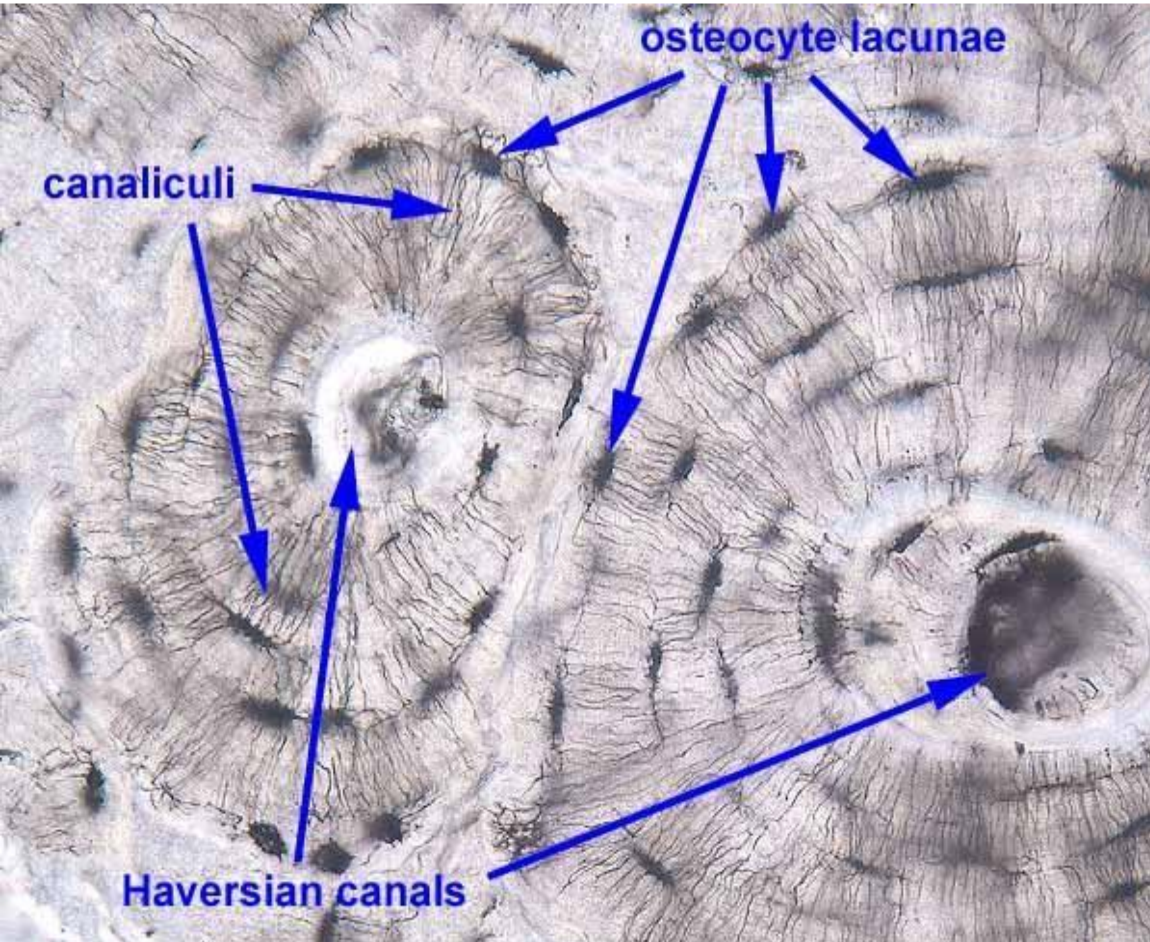
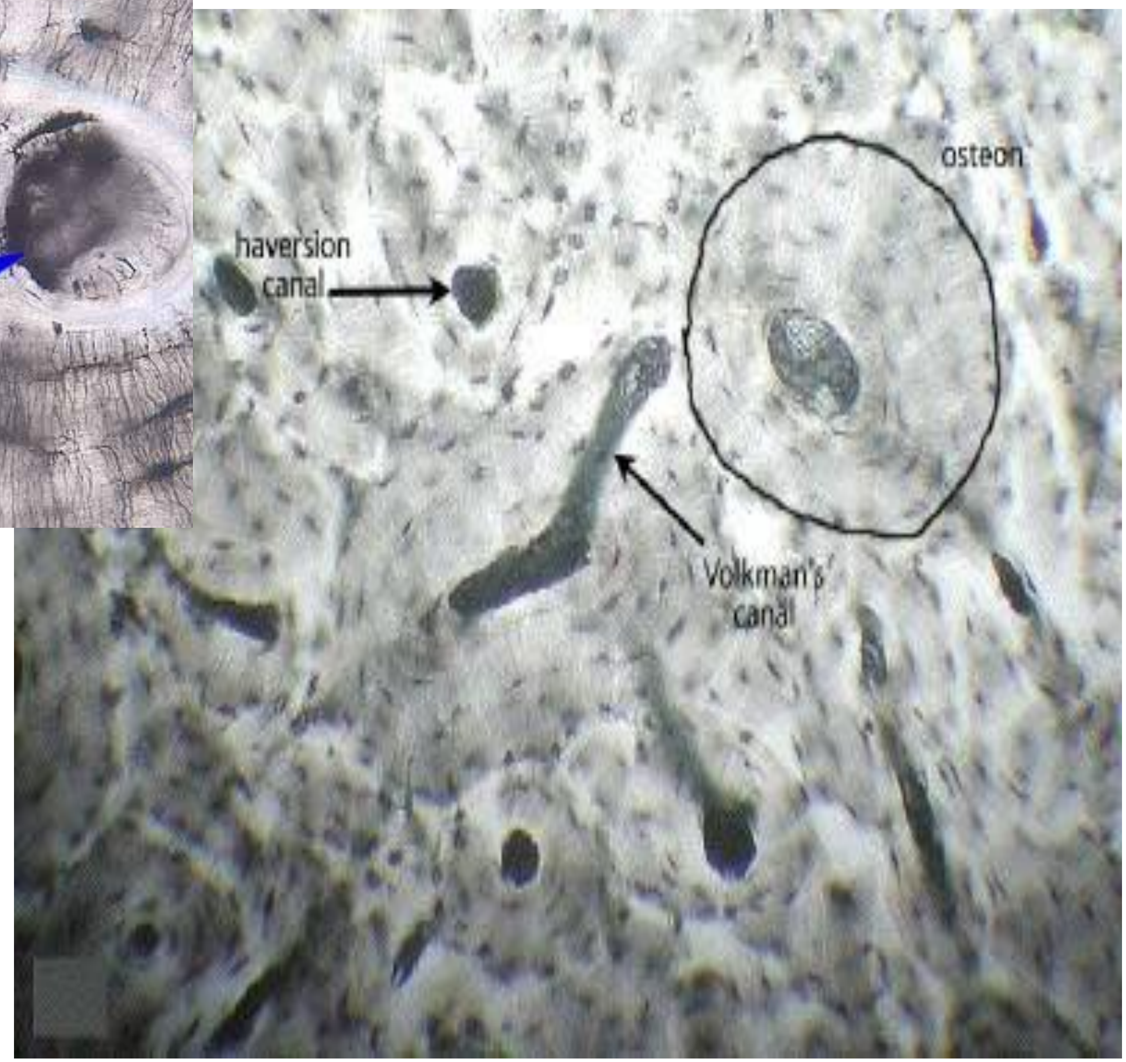
- The communication pathway from from the outside of the bone to its interior (the central canals) is completed by <u>performating (volkman's) canals</u>, which run into the compact bone at right angles to the shaft.

- This elaborate network of canals causes the bones to be well nourished despite the hardness of the matrix.

- Calcium salts deposited in the matrix give bone its hardness. The organic parts especially collagen fibers, provide the bone with flexibility.

Compact Bone & Spongy (Cancellous Bone)




osteocyte lacunae
canaliculi
Haversian canals

osteon
haversion canal
Volkman's canal

Formation of the Human Skeleton

- The Skeleton is formed from the most supportive tissues in the body: cartilage and bone..
- In embryos, the skeleton is primarily made of hyaline cartilage.
- During development, much of this cartilage is replaced by bone.
- Cartilage remains in isolated areas:
  - bridge of the nose
  - Parts of ribs
  - joints.

Bone Development, <u>Ossification</u>, <u>Osteogenesis</u>

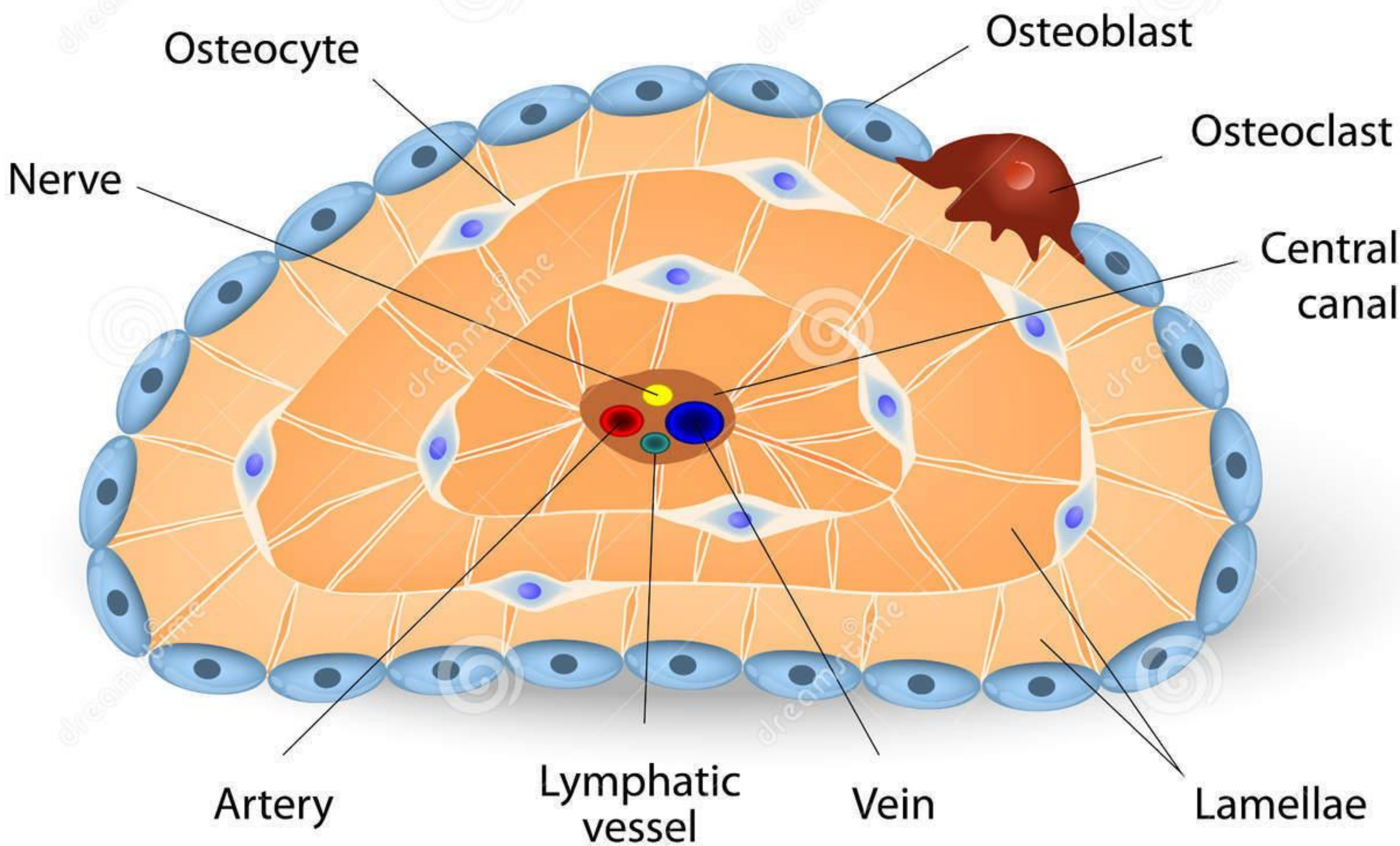
- For most bones, hyaline cartilage is used as the "model" in the process of ossification.
- An <u>exception is flat bones</u> which use fibrous connective tissue as a model for forming bones.

  - <u>osteoblasts</u> (bone--forming cells), They can be stimulated to proliferate and differentiate as osteocytes.

  - <u>Osteocytes</u> (mature bone cells): Osteocytes manufacture substances that make up the bone extracellular matrix. Osteocytes are found enclosed in bone matrix.

  - <u>Osteoclasts</u> (bone--resorbing cells): "clast" means to break; osteoclasts break down bone.

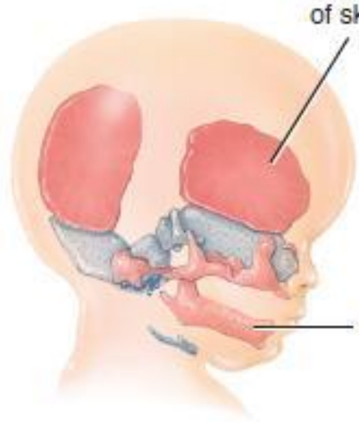
OSTEON

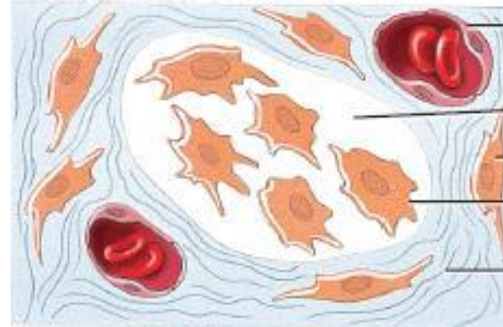

Osteocyte
Osteoblast
Osteoclast
Nerve
Central canal
Artery
Lymphatic vessel
Vein
Lamellae

Two Ossification types depending on the type of bone;

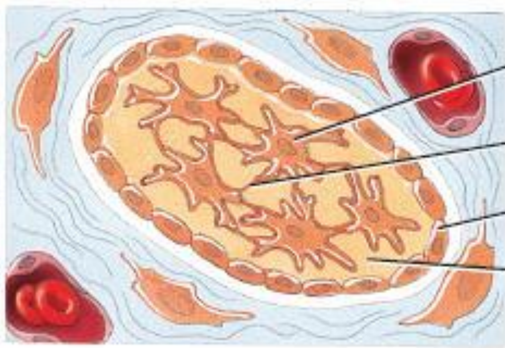
1- Intramembranous ossification :

- Occurs in Flat bones e.g.: ribs, pelvis and skull.
- Starts by mesenchymal stem cell within the embryonic fibrous C.T. > develops into Osteoblast > Ossification centre is initiated > organic portion of the bone matrix (Osteoid).
- Some Osteoblasts incorporates within osteoid to form Osteocytes > osteoid becomes mineralized > forming spiky needles (Spicule) that aggregates forming the supporting structure or Trabecular.
- periosteum is formed and bone growth continues at the surface of trabeculae.

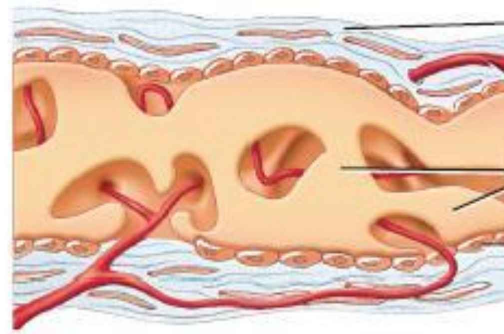




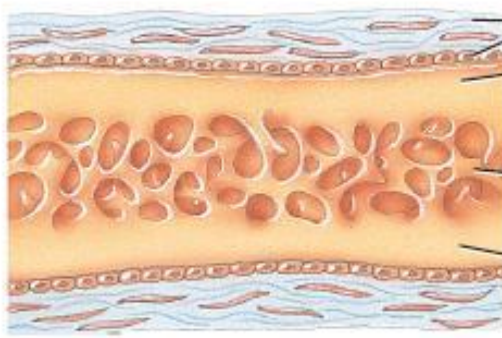
1 Development of ossification center: osteoblasts secrete organic extracellular matrix



2 Calcification: calcium and other mineral salts are deposited and extracellular matrix calcifies (hardens)



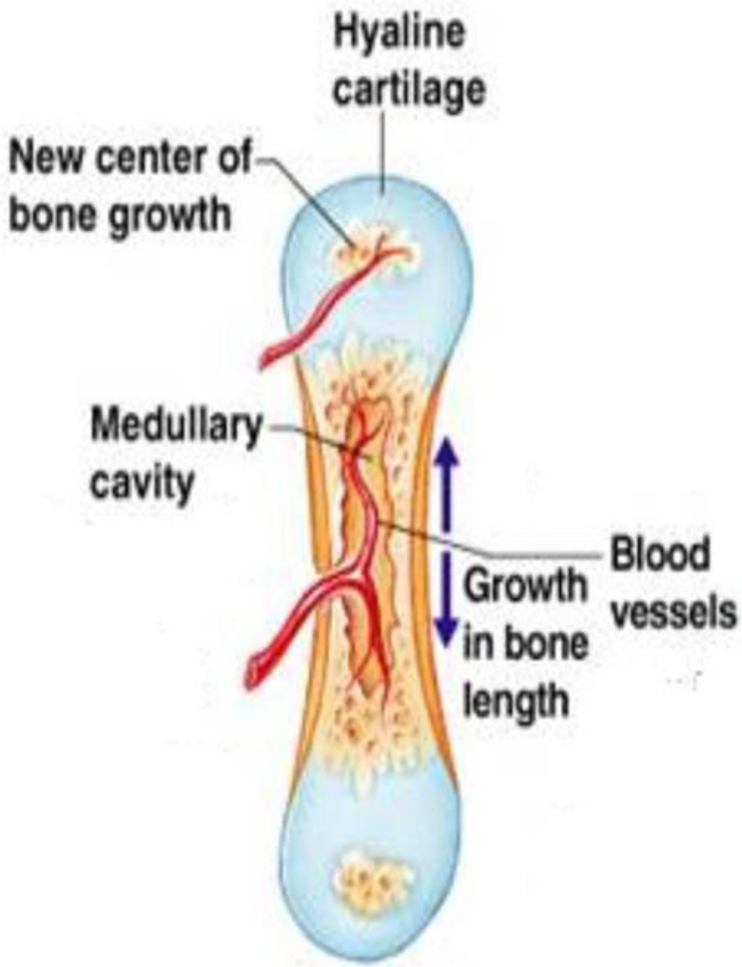
3 Formation of trabeculae: extracellular matrix develops into trabeculae that fuse to form spongy bone



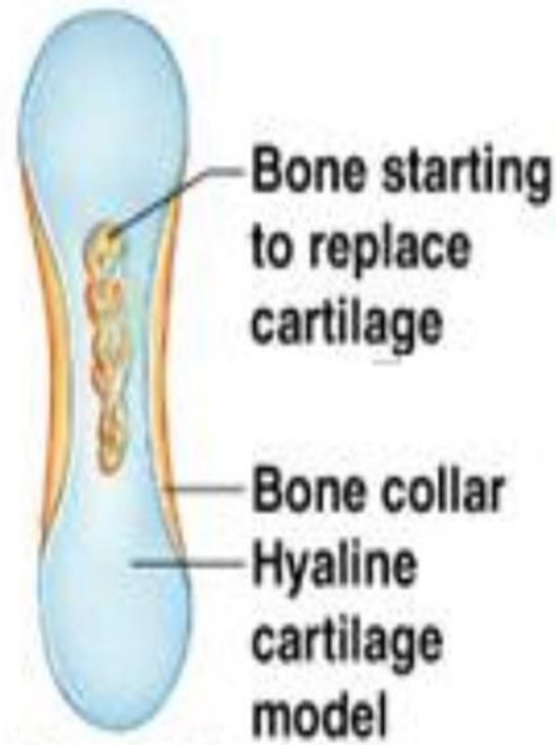
4 Development of the periosteum: mesenchyme at the periphery of the bone develops into the periosteum

2- Endochondral Ossification:

- hyaline cartilage is used as a model that get replaced by bone.
- Starts at embryonic stage.
- 8th week of fetus life, Chondroblast starts building hyaline cartilage by forming Chondrocytes.
- the hyaline cartilage will then serve as a model, and will be completely covered by osteoblasts.
- BV will infiltrate forming a ossification centre.
- Ossification will extended at both ends to reach epiphysis.
- 12th week into development the epiphysis will be replaced by spongy bone.
- Osteoclasts will start eating away the calcified tissue within the centre, creating a hollow medullary space (cavity).



In a fetus



In an embryo

- Shortly after birth, most of its is replaced by bone.

- **Some areas remain cartilaginous:**
  - Articular cartilage over the epiphysis, persist for life reducing friction at the joint surface.
  - The epiphyseal plate between the epiphysis and diaphysis.
    - The epiphyseal plate provide for longitudinal growth of the bone during childhood.
    - This process of long bone growth is controlled during childhood by the growth hormone and during puberty the sex hormones. This ends during adolescence when the epiphyseal plate are completely converted to bone.

Bone Remodelling
(cycles of resorption and formation)

Bones are remodeled continually in response to changes in two factors:
(1) calcium levels in the blood
(2) the pull of gravity and muscles on the skeleton.

When blood calcium levels <u>drop</u> below homeostatic levels, the parathyroid glands are stimulated to release parathyroid hormone (PTH) into the blood. PTH activates osteoclasts, to break down bone matrix and release calcium.
When blood calcium levels are too high (hypercalcemia) calcium is deposited in bone matrix as hard calcium salts.

Terms

OSTEO = bone

Osteocytes =

Osteoblast =

Osteoclast =

Osteon =

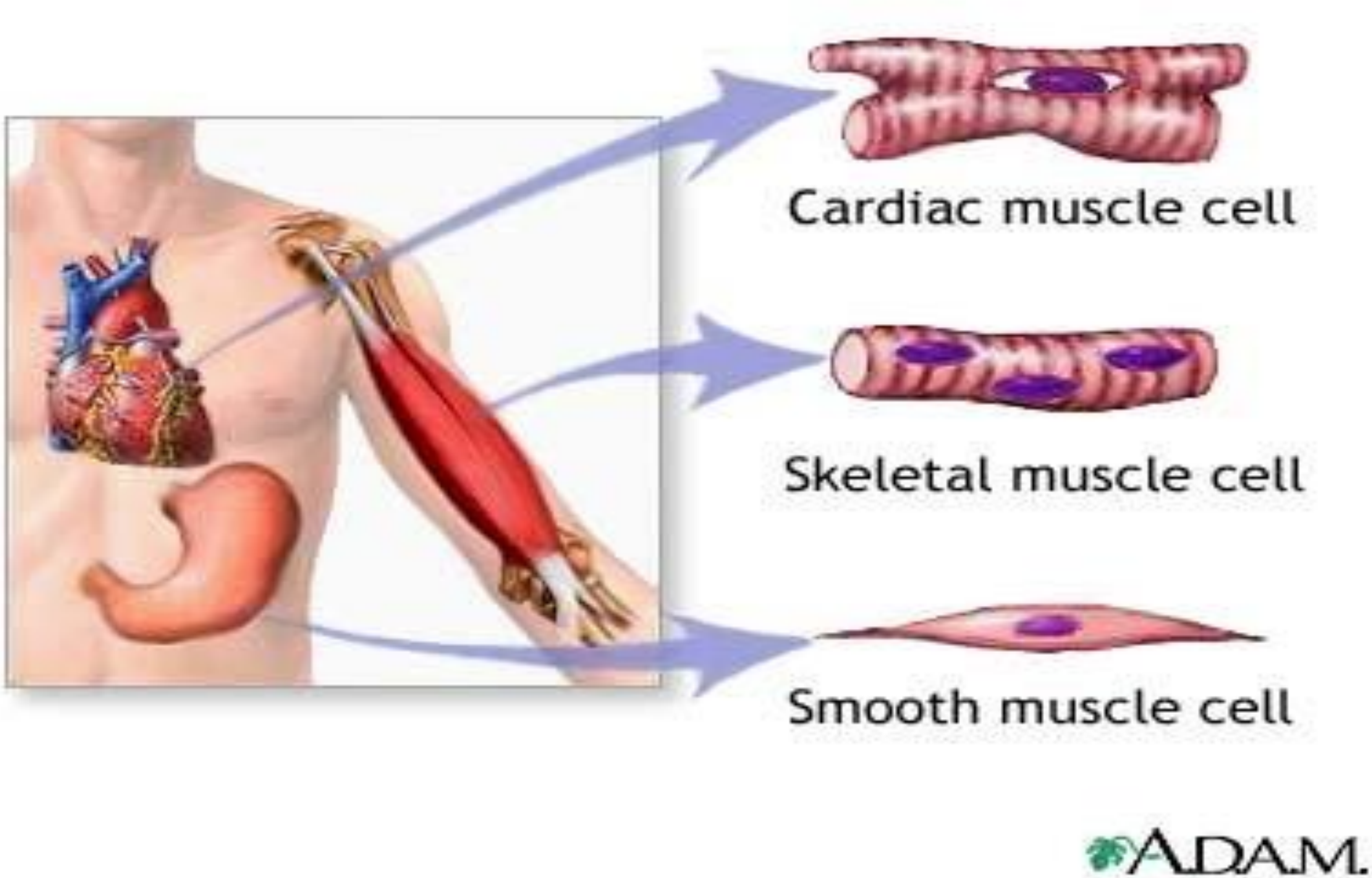
Muscular system

1. Overview of muscle tissue.
2. Microscopic anatomy of the skeletal muscle.
3. Skeletal muscle activity.

1. Overview of muscle tissue

- The only body tissue able to ***contract.*** As a result, muscles are responsible for all body movement.
- "The machine of the body".
- There are three basic types of muscle:
  - ***Skeletal***
  - ***Cardiac***
  - ***Smooth***

3 Types of Muscles

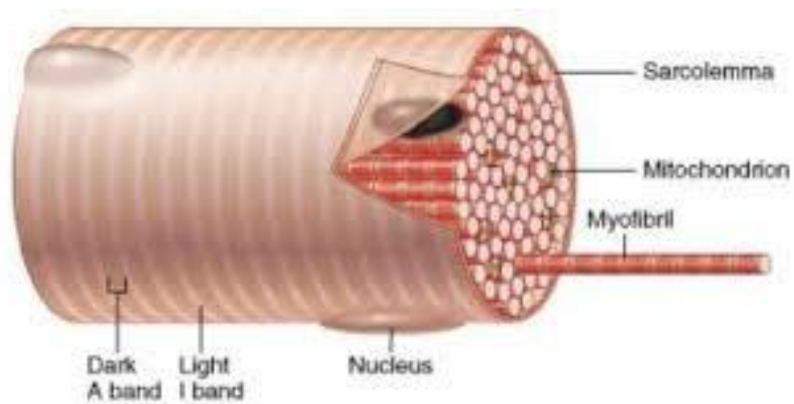


Classification of Muscle

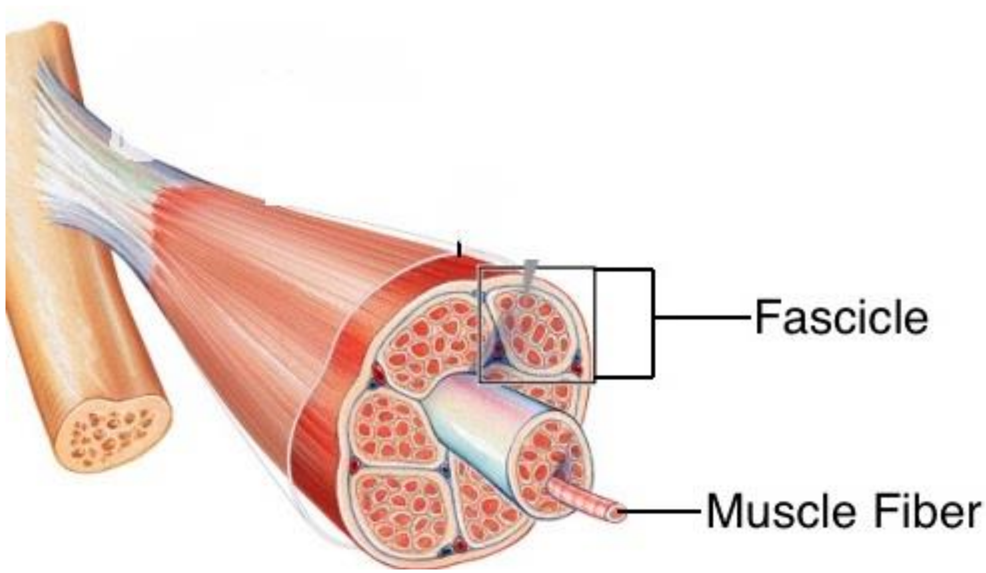
Skeletal-- (muscle fiber)	Cardiac-- (x)	Smooth-- (muscle fiber)
Found attach to the body's Skeleton	Found in heart	Found in viscera (stomach, urinary bladder, large arteries..)
Striated, multi– nucleated	Striated, 1nucleus	Not striated, 1 nucleus
Controlled by SoNS	Regulated by ANS	Controlled by ANS
Voluntary	Involuntary	Involuntary
Movement, maintain posture, generate heat & facial expressions	Heart beating	Peristalsis
Slow to fast	slow	Very slow

2.Microscopic anatomy of skeletal muscle

- Bundles of fibers that are bond together.
- Threads of **myofibrils** aggregate to form individual muscle cell is called a **muscle fiber.**
- A muscle fiber is enclosed by a plasma membrane called the **sarcolemma**.
- The cytoplasm of a muscle fiber is called a **sarcoplasm**.
- Nuclei pushed aside by the **myofibrils** that fill the cytoplasm.



Muscle fibers form a larger bundle called **fascicle,** which combine to form the largest robe (muscle).

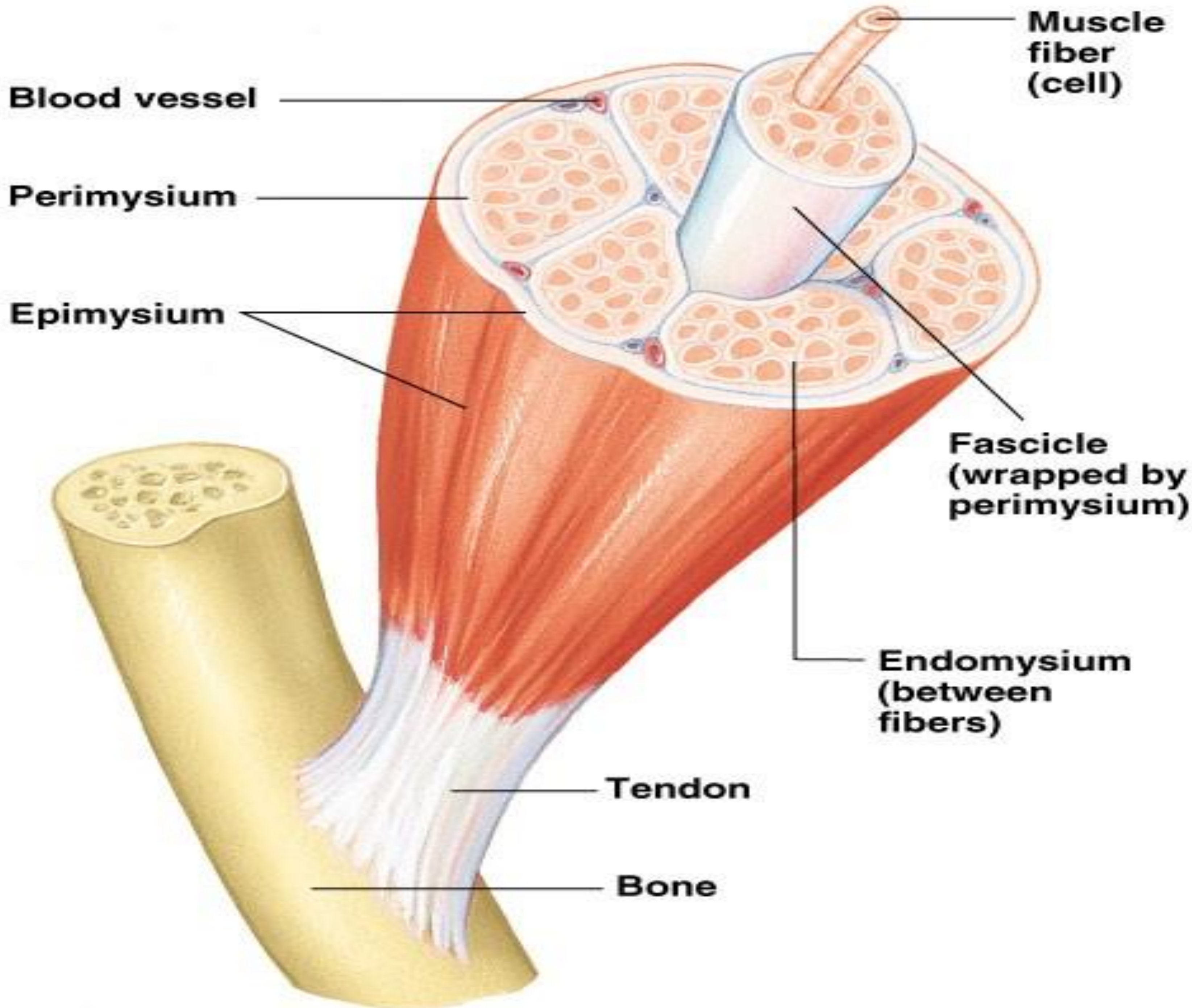


C.T. within skeletal muscle

- Skeletal muscles are sheathed by a tough layer of connective tissue called the **epimysium**. The epimysium joins muscle tissue to tendons at each end, It also protects muscles from friction against other muscles and bones.

- Within the epimysium are multiple bundles of **fascicles**, each of which contains 10 to 100 or more muscle fibers collectively protected by a **perimysium**. The perimysium is a pathway for nerves & the flow of blood within the muscle.

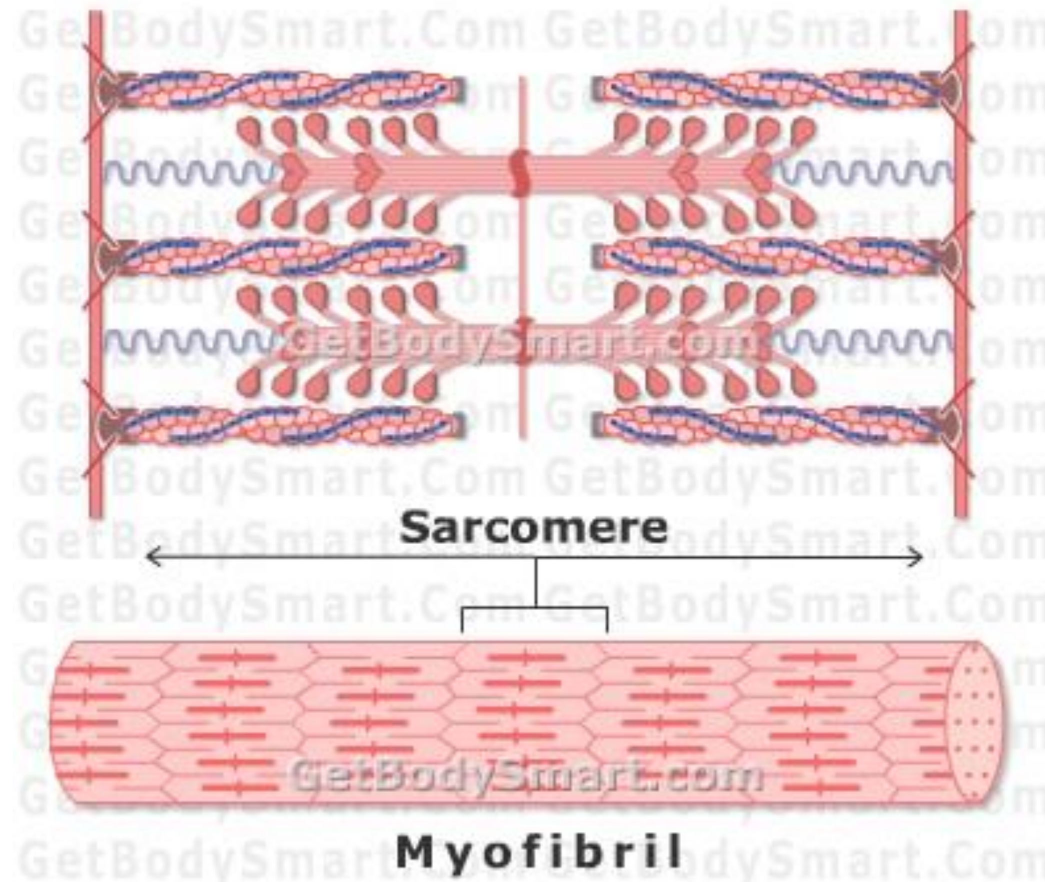
- The thread like muscle fibers (the individual muscle cells), and each cell is encased within its own **endomysium** of delicate connective tissue.


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

- Myofibrils are chains of tiny contractile units called **sarcomeres**.
- Sarcomeres are the smallest functional units of a muscle.

•A sarcomere is composed of <u>two types Of myofilaments</u> :

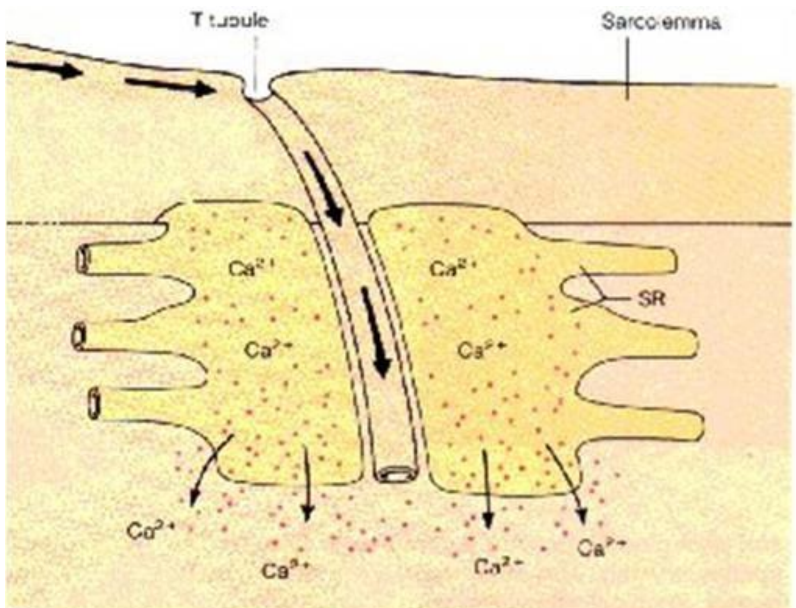
- **Myosin** and **Actin**, which are responsible for muscle contraction.
- Myosin is a thick myofilament, Actin is a Thin myofilament.
- Each Sarcomere is separated by Z-line at each end.
- When muscles contract Z-lines are pulled closer.



Another important muscle fiber organelle

- The **<u>sarcoplasmic reticulum</u>** <u>(SR</u>), is smooth ER.

It releases calcium ions during contraction and absorbs them during relaxation.

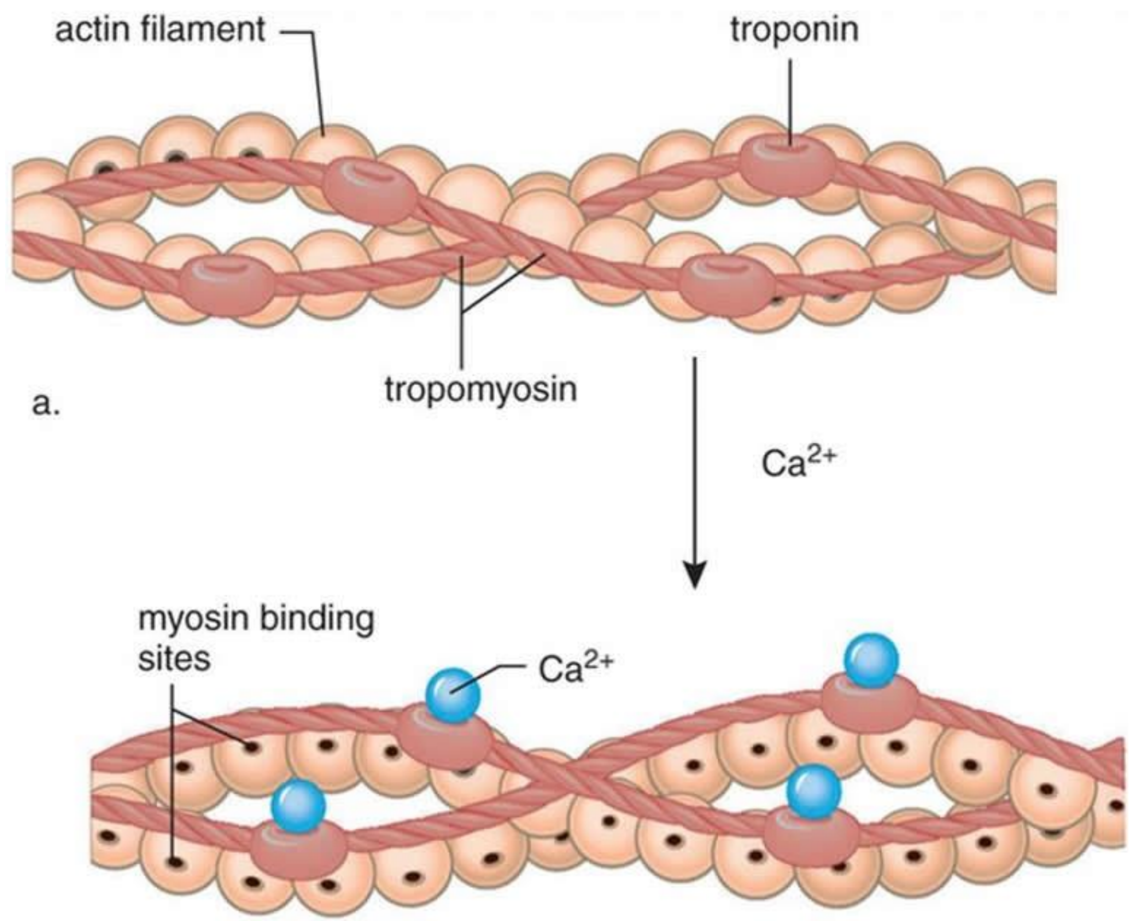


- Within the sarcoplasm, there are **T--tubules** that allow transport of substances throughout the muscle fiber.

Troponin and Tropomyosin

- Troponin and tropomyosin are regulatory proteins complexs involved in muscle contraction.

Lies within the actin filaments.

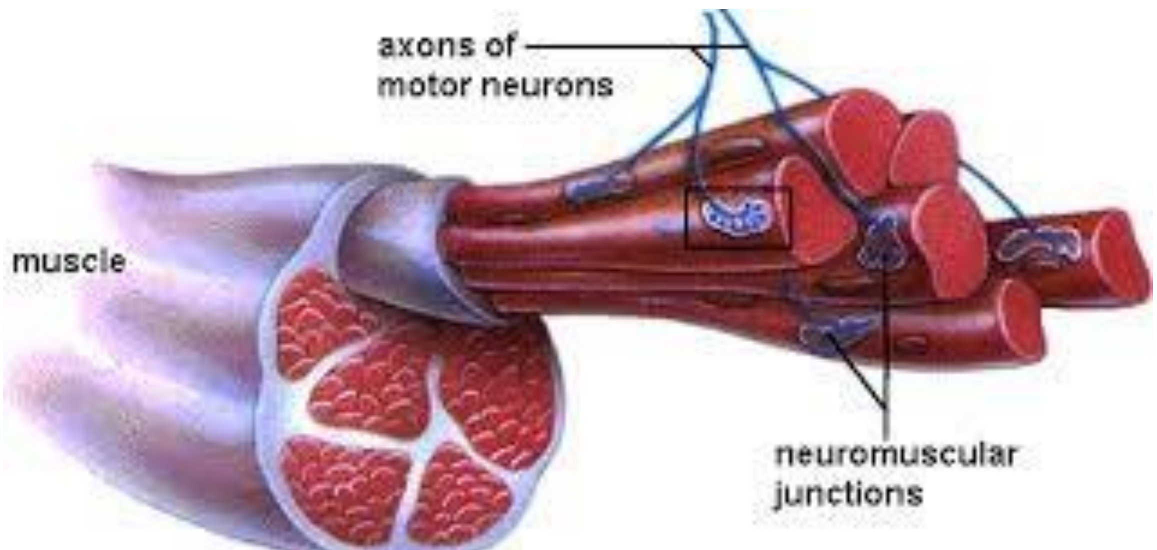


Troponin-Ca^{2+} complex pulls tropomyosin away, exposing myosin binding sites.

Neuromuscular junction

- Every skeletal muscle fiber is connected to a motor neuron ending. This connection is called **neuromuscular junction**.

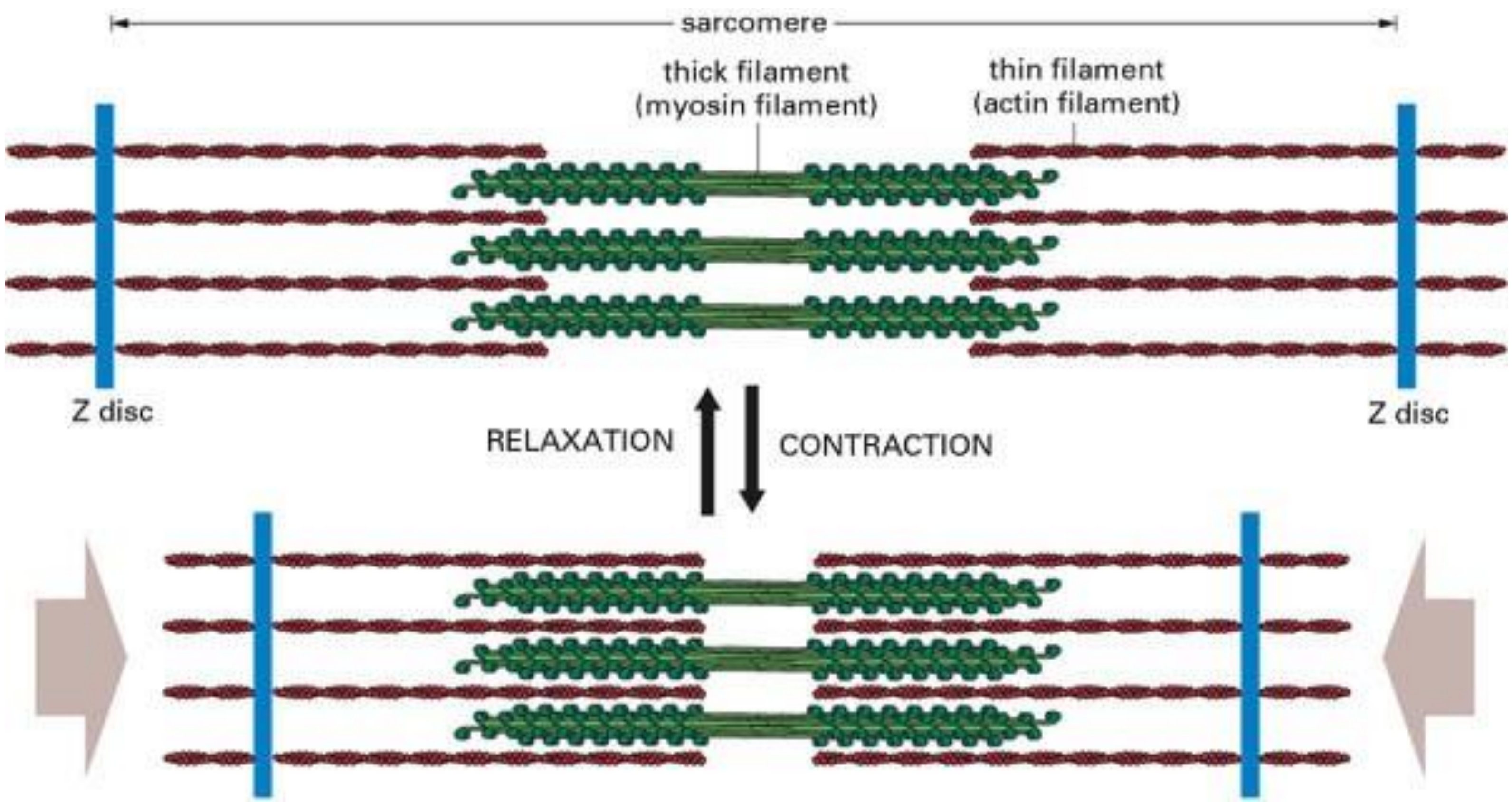
- Between the end of the motor nerve and the muscle fiber is a narrow space called **synaptic cleft.**



Skeletal muscle contraction steps:

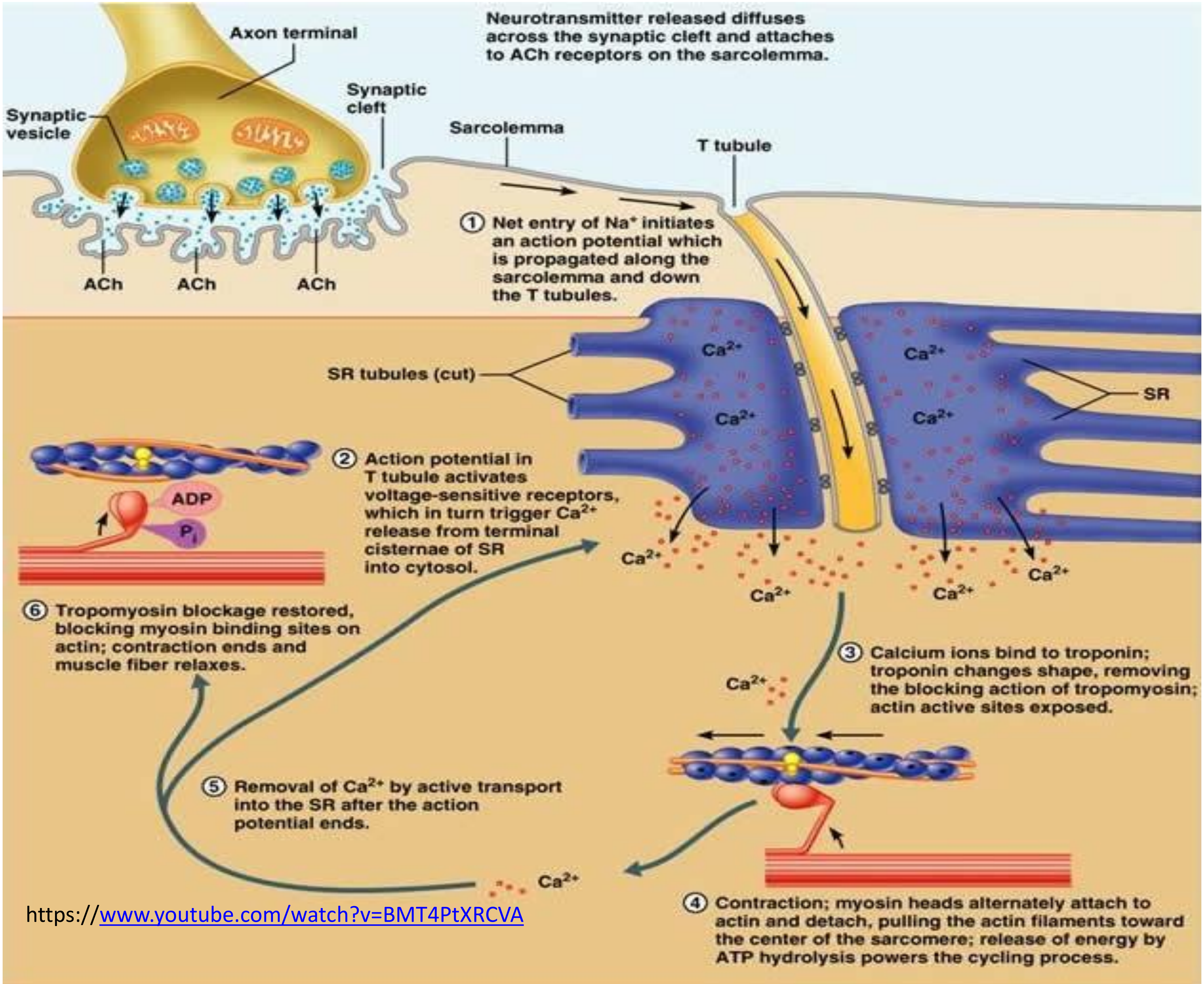
- A skeletal muscle must be stimulated by a motor neuron to contract.
- When an impulse reaches the end of a motor neuron, it causes small vesicles to release a neurotransmitter called acetylcholine (ACh) into the synaptic cleft.
- ACh binds to receptors on the sarcolemma.
- The permeability of the sarcolemma changes allowing sodium ions to enter the muscle cell generating an action potential (electrical impulse) over the sarcolemma & flows inward along the T tubules.
- Calcium ions are released from SR. Calcium ions are the final trigger for muscle fiber contraction.

- The Ca2 binds to troponin on the actin filament, pulling away tropomyosin exposing myosin binding sites. myosin heads on the thick filament can now attach to the actin filament.
- ATP provides the energy for the sliding filament mechanism.
- Contraction occurs.



- Muscle contraction ends when nerve impulses stop arriving at the neuromuscular junction.

3. Skeletal muscle activity



https://www.youtube.com/watch?v=BMT4PtXRCVA