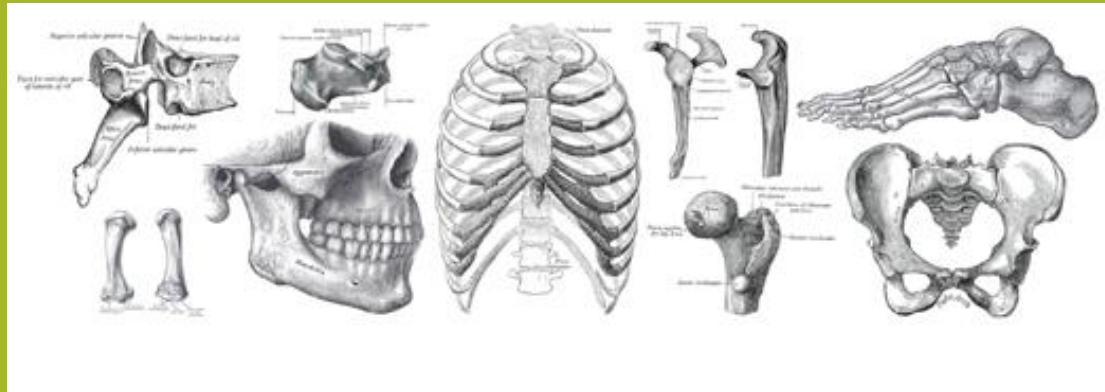


**KAZAN FEDERAL (VOLGA REGION) UNIVERSITY  
INSTITUTE OF FUNDAMENTAL MEDICINE AND BIOLOGY  
DEPARTMENT OF MORPHOLOGY AND GENERAL PATHOLOGY**

Lecture 2

# Osteology



**Zaikina Elvira Ildarovna,**  
*MD, PhD, Senior lecturer*

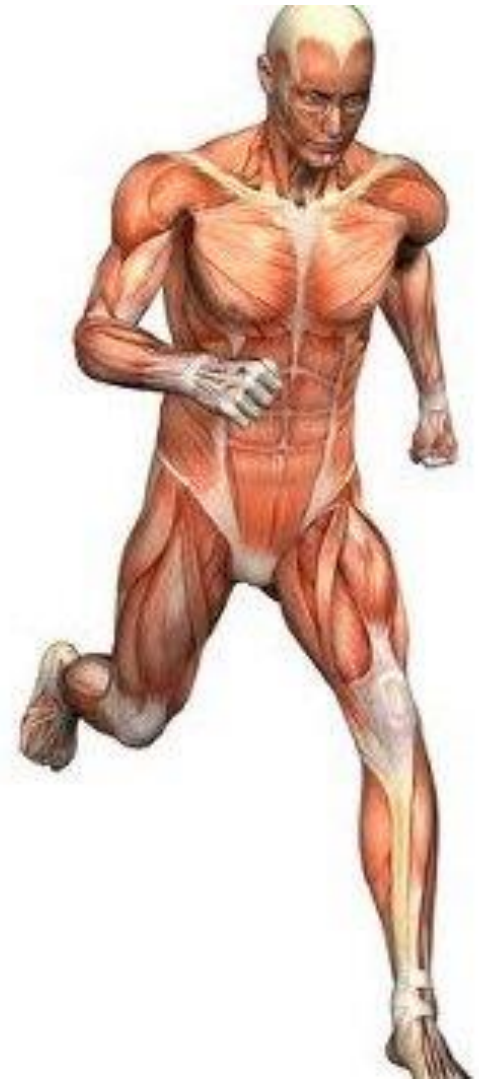
# The Muscular-Skeletal System



Osteology



Articular System



Myology

# Osteology – a study of the skeleton

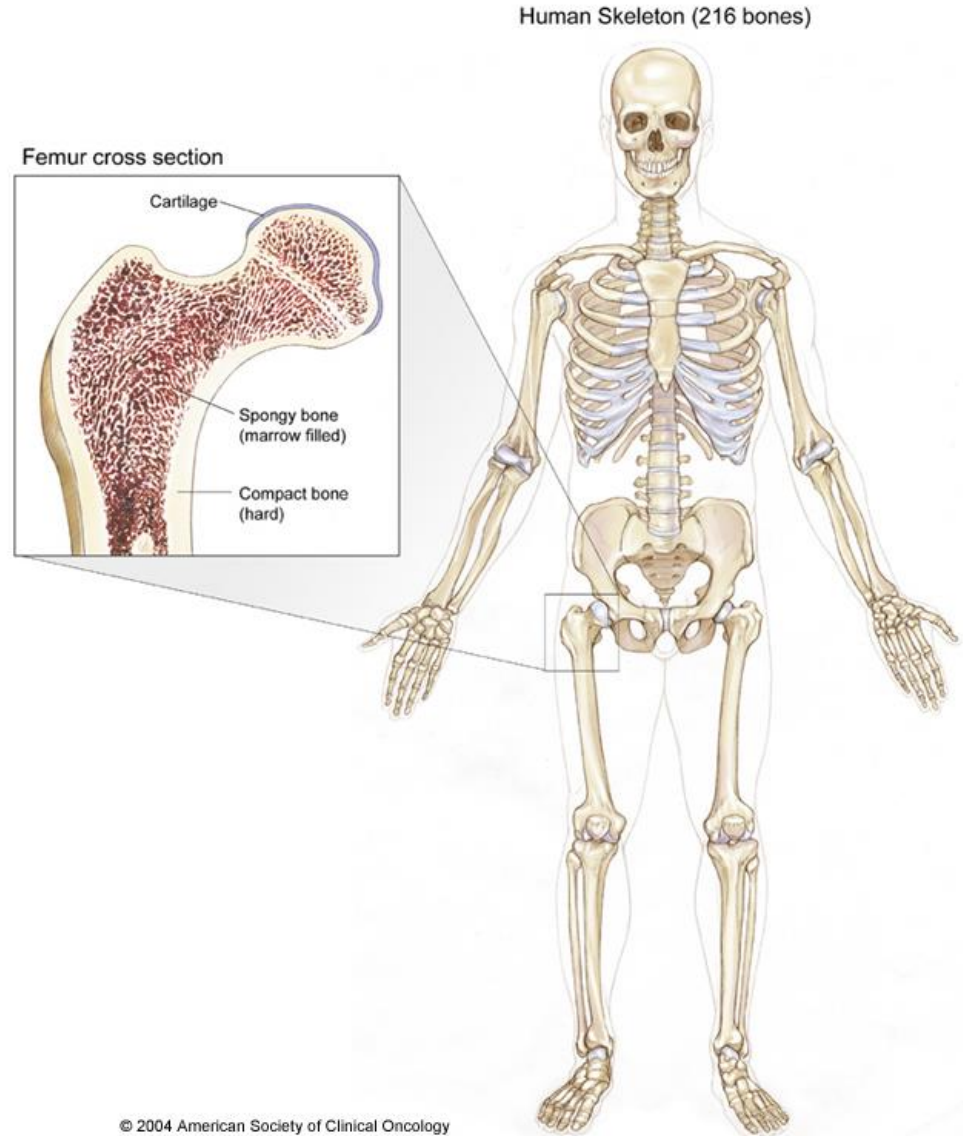
## Definition:

Greek,

*osteon=bone,*  
*logos=science*

The branch of anatomy that deals with the structure and function of bones

Robert Morreale/Visual Explanations, LLC

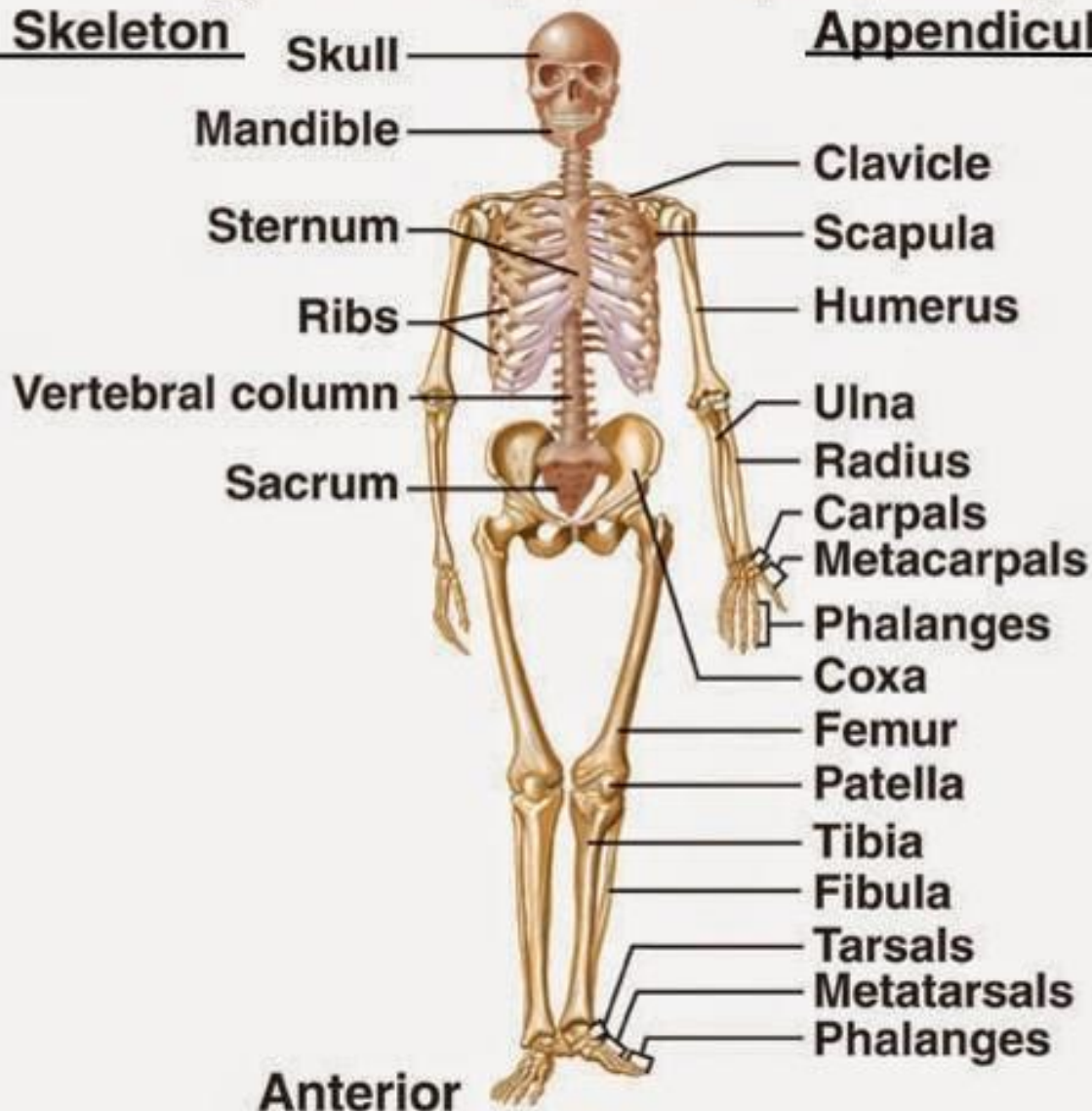


# The human skeleton

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## Axial Skeleton

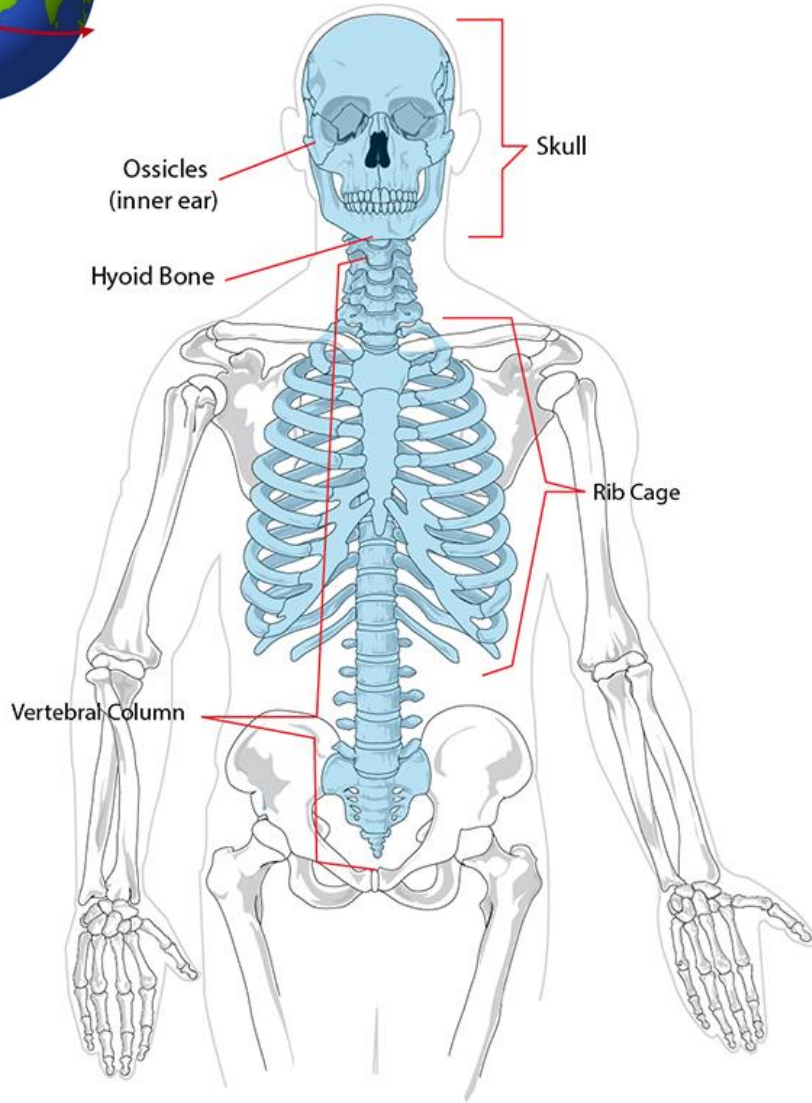
## Appendicular Skeleton



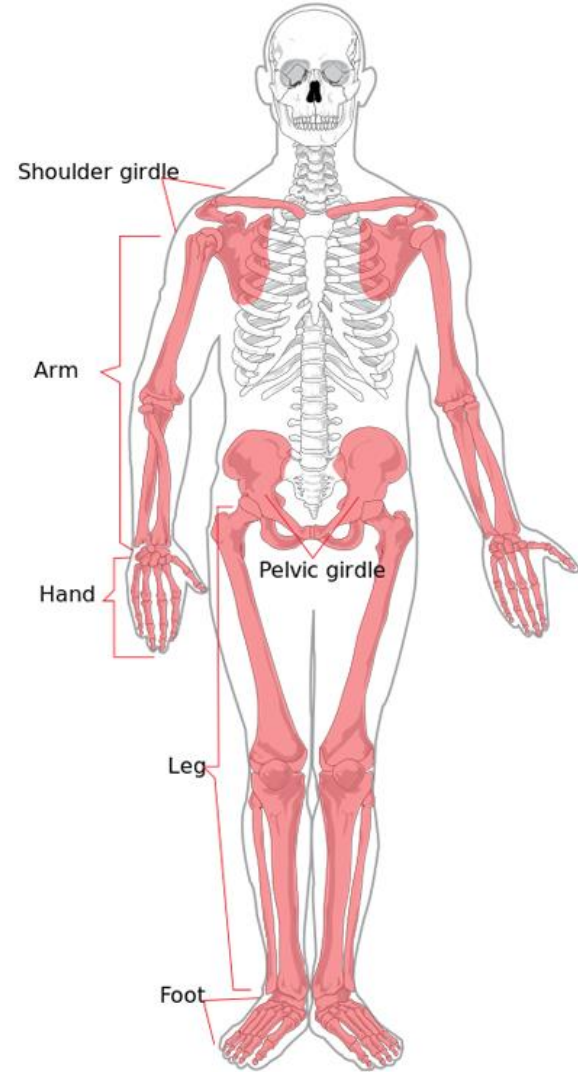




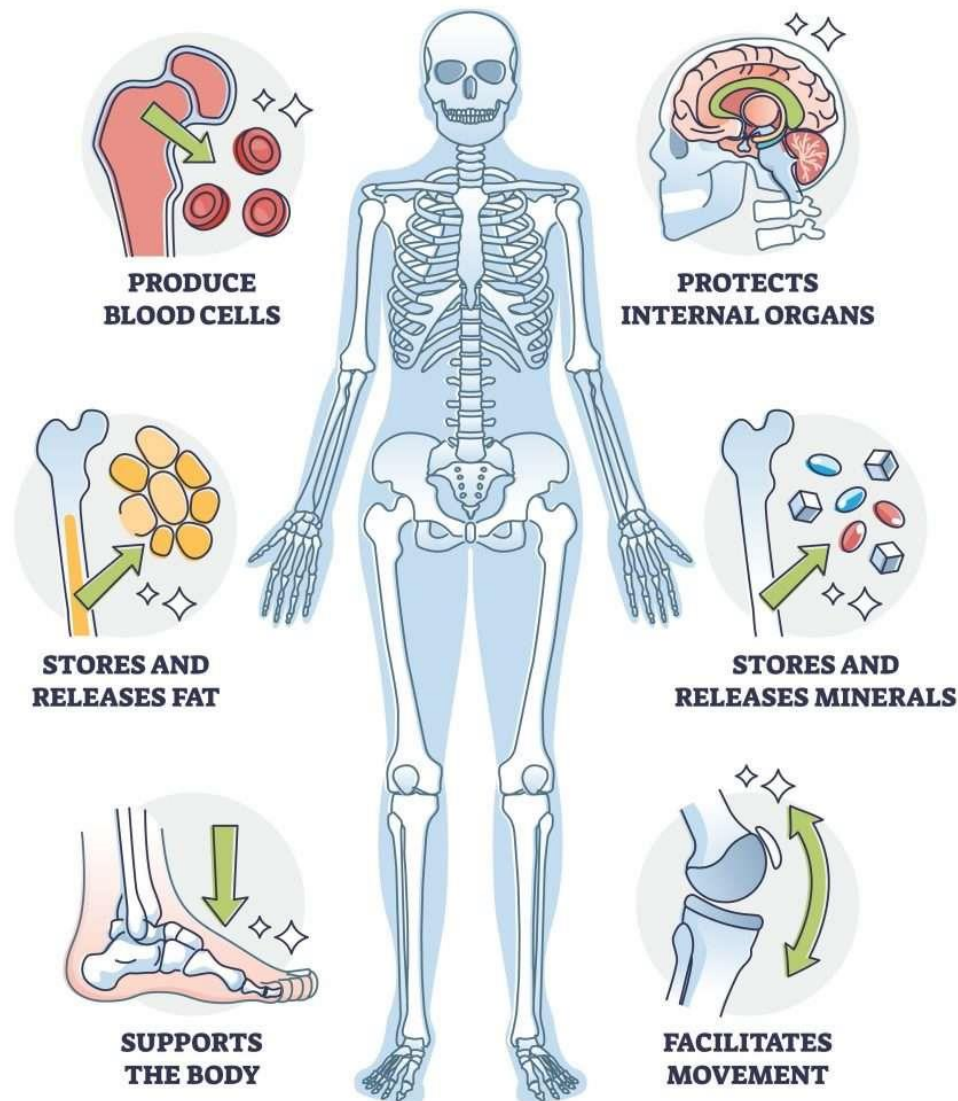
## AXIAL SKELETON DIAGRAM



## APPENDICULAR SKELETON DIAGRAM



# Functions of the Skeletal System

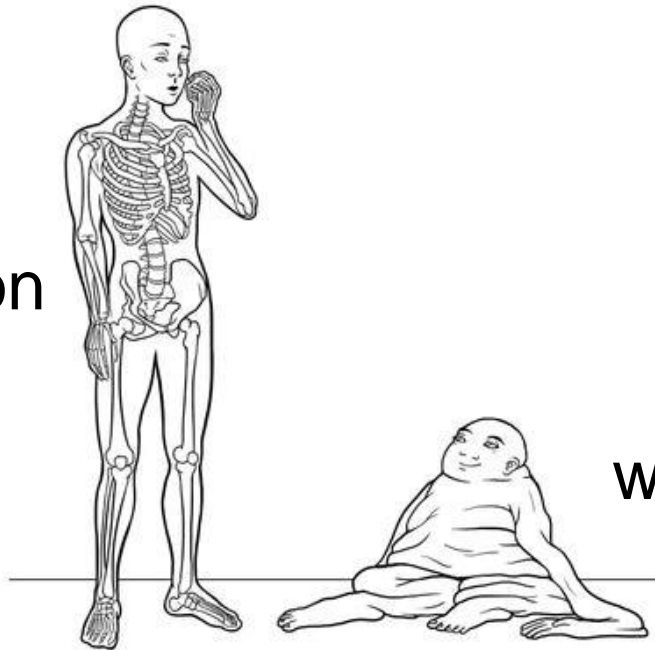


# Functions of the Skeletal System

## A. Support

- a framework and structural support for the whole body

with skeleton

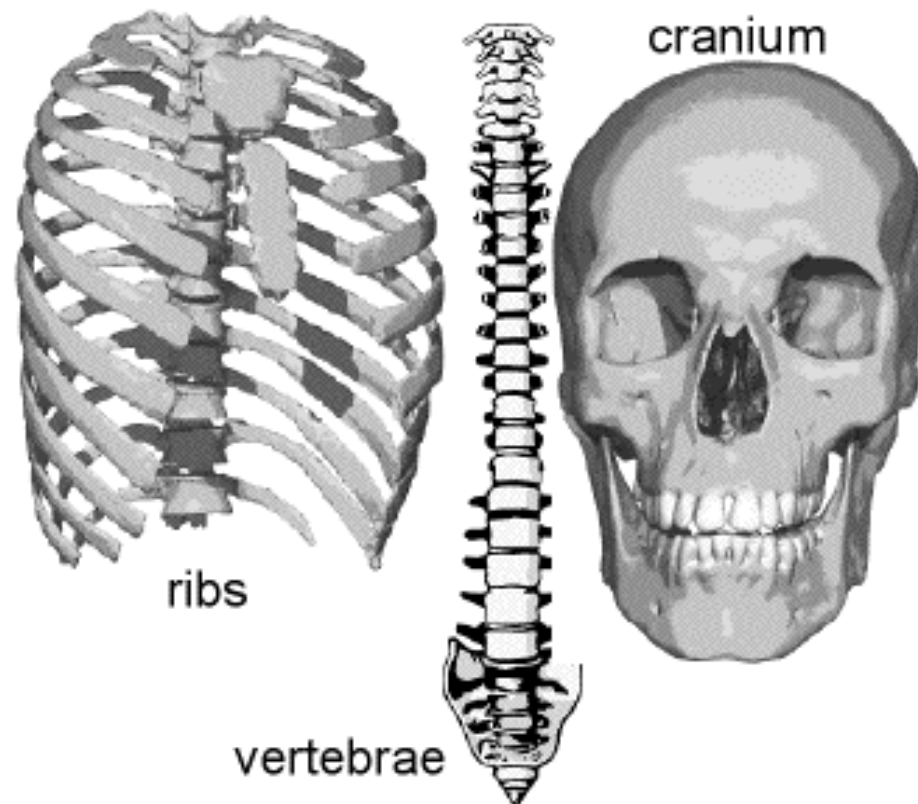


without skeleton

# Functions of the Skeletal System

## B. Protection

- Cover or surround vital organs

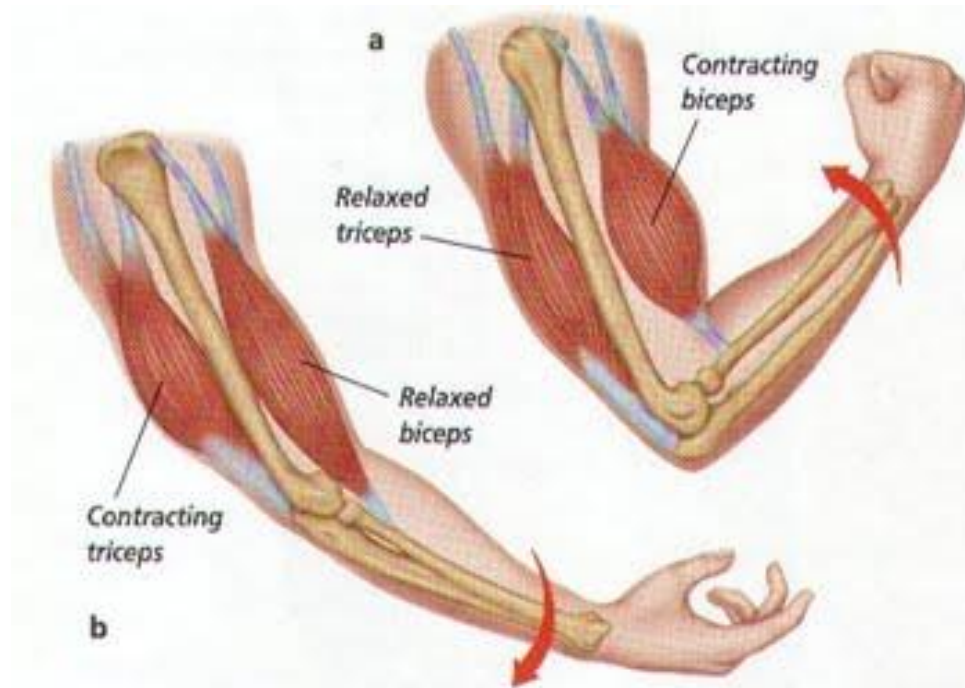




# Functions of the Skeletal System

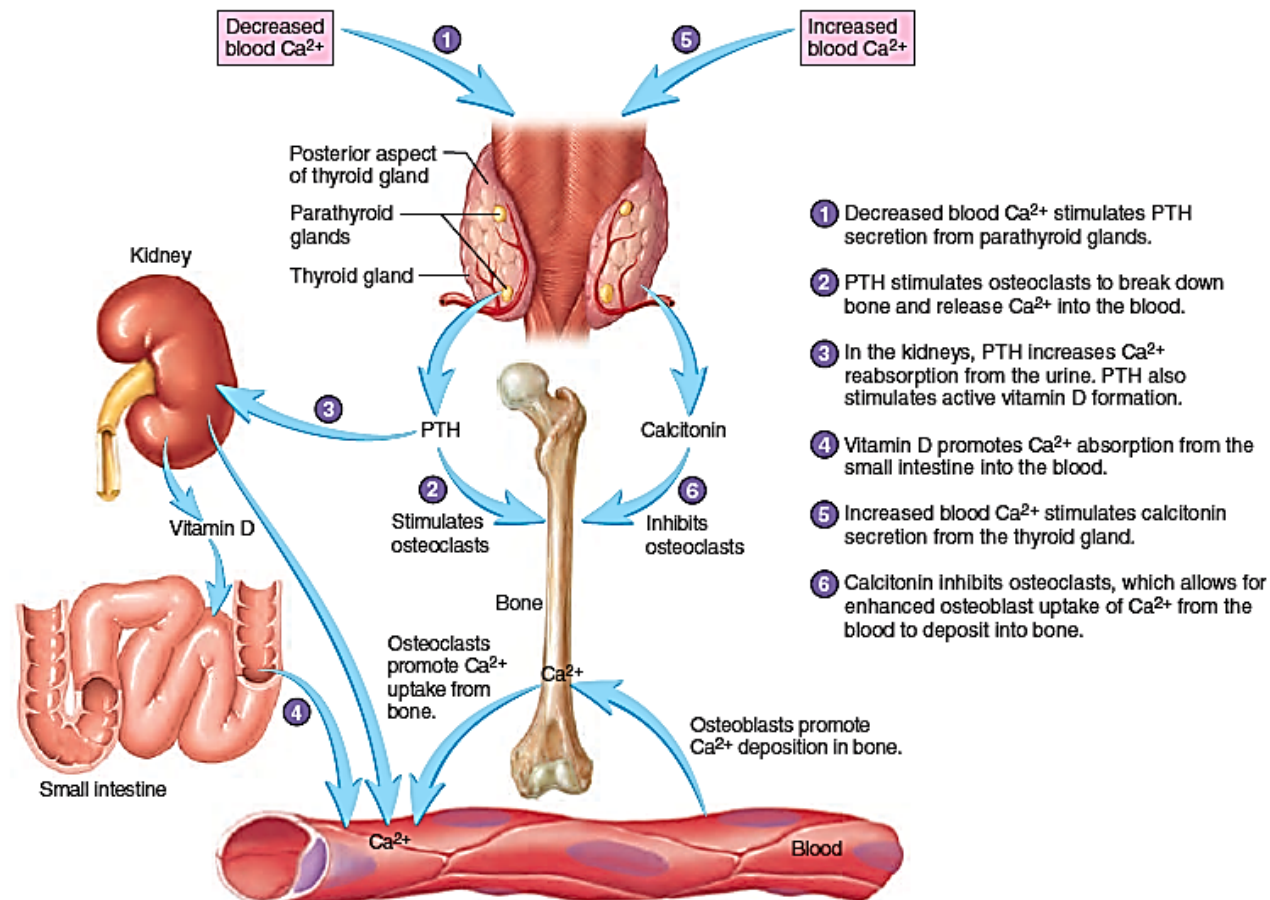
## C. Movement

1. Muscles are attached to bones
2. Muscles pull bones to produce movement



# Functions of the Skeletal System

- D. Storage and homeostasis of  $\text{Ca}^{++}$



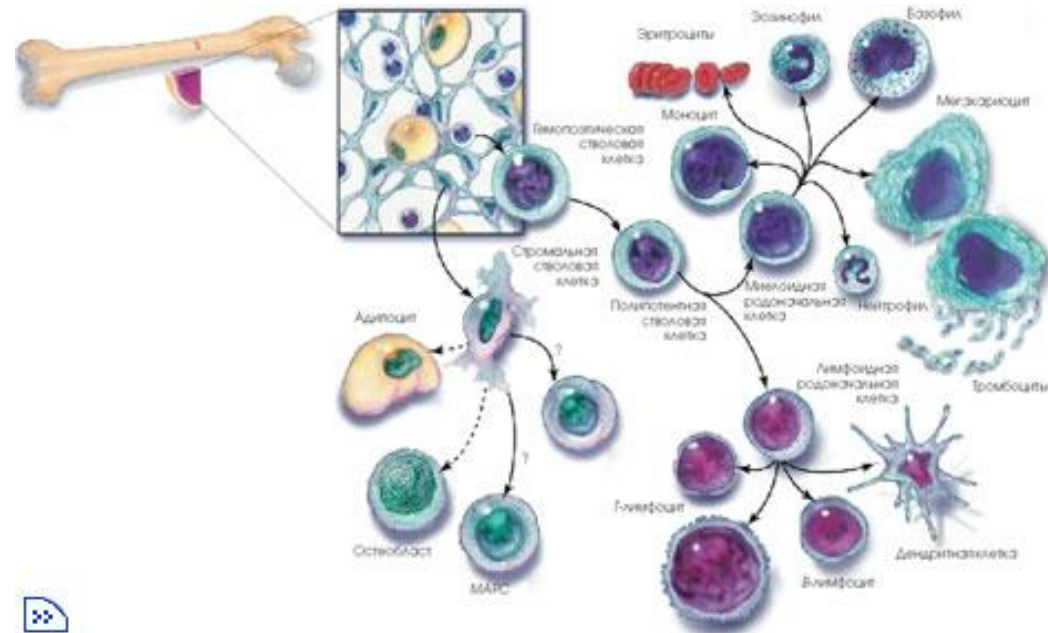
PROCESS Figure 6.9 Calcium Homeostasis

# Functions of the Skeletal System

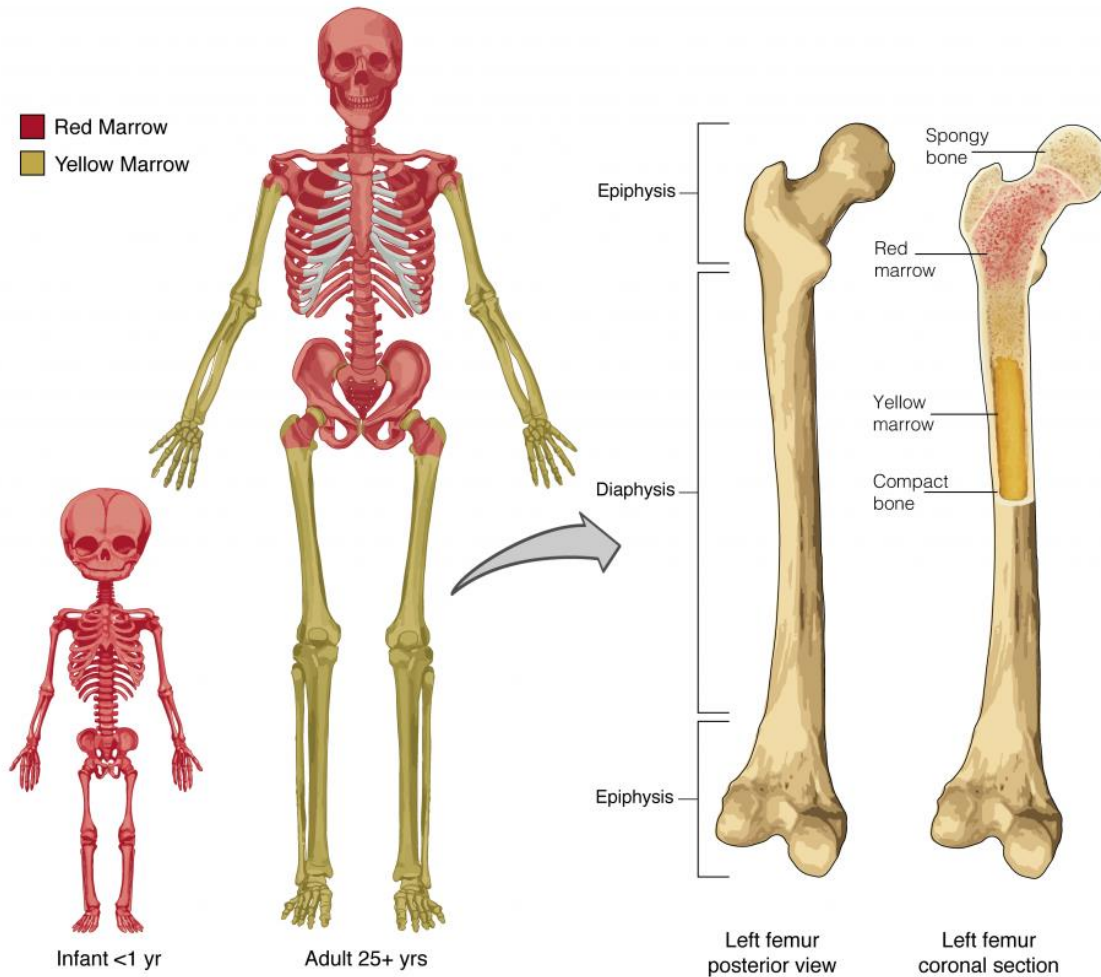
- **E. Hematopoiesis**

1. Definition: The process of blood cell formation.

2. Occurs in red bone marrow



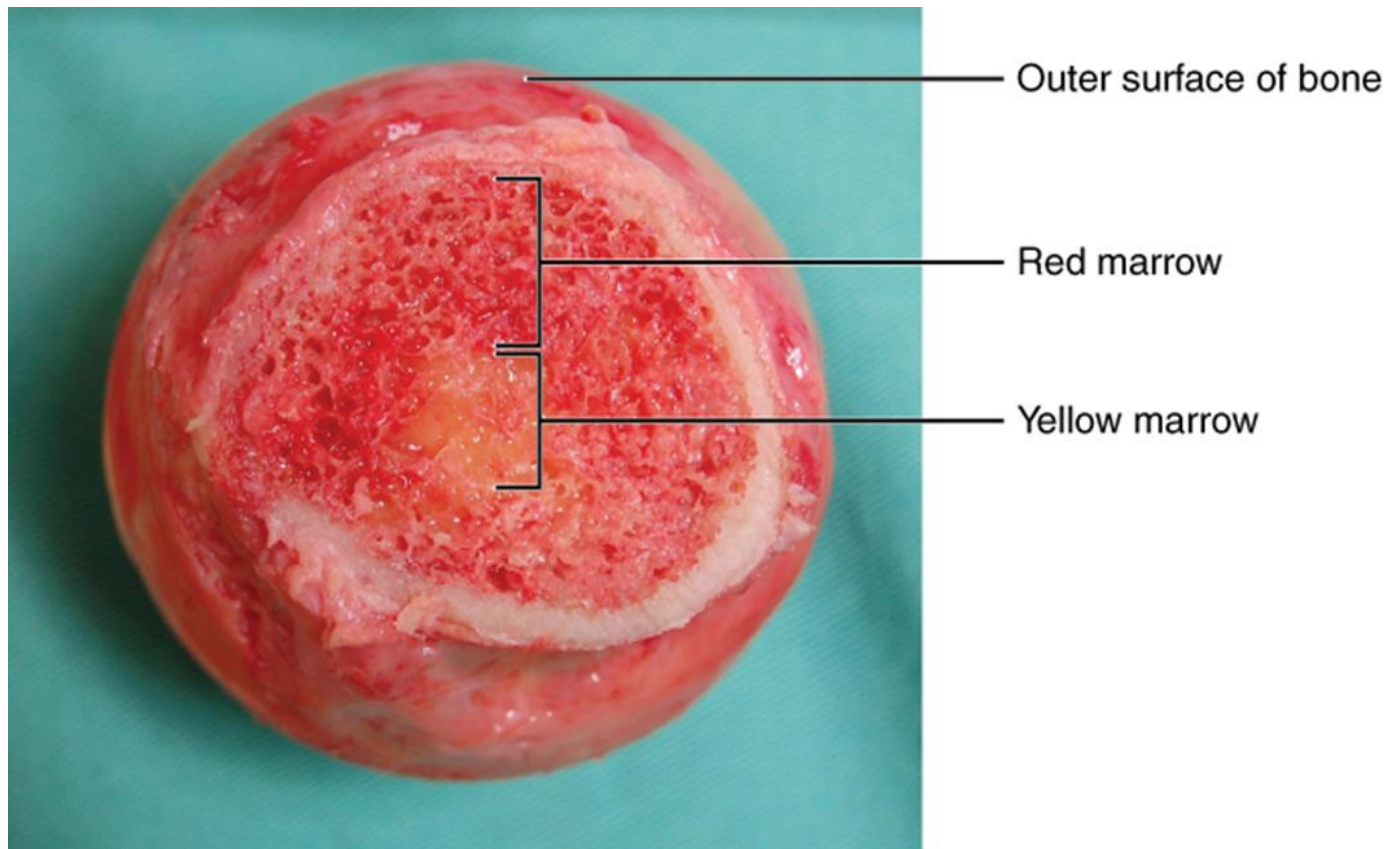
# Red and Yellow bone marrow



# Functions of the Skeletal System

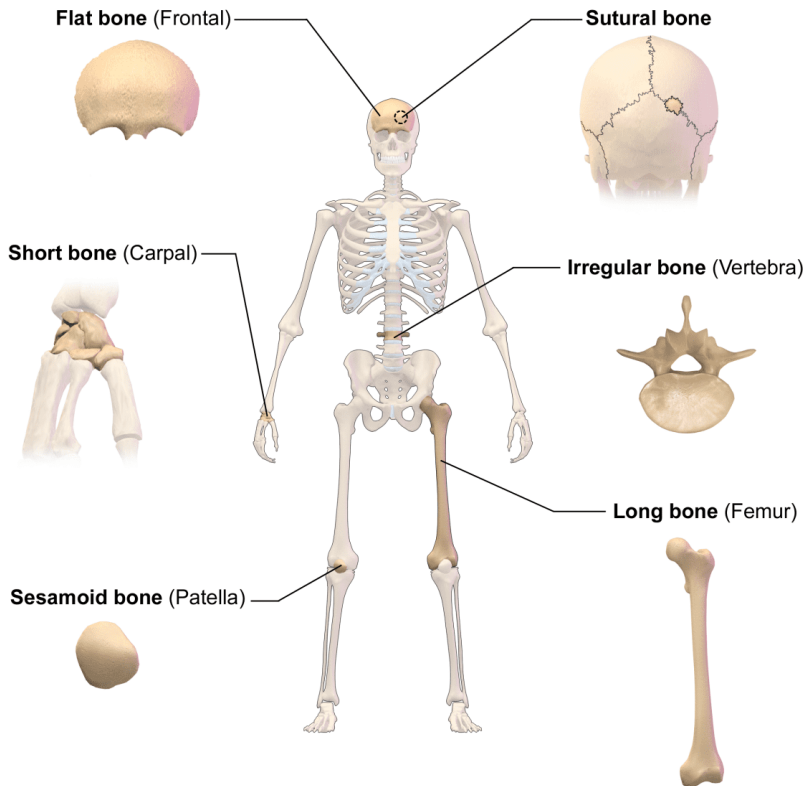
- **E. Stores and releases fat**

Occurs in yellow bone marrow

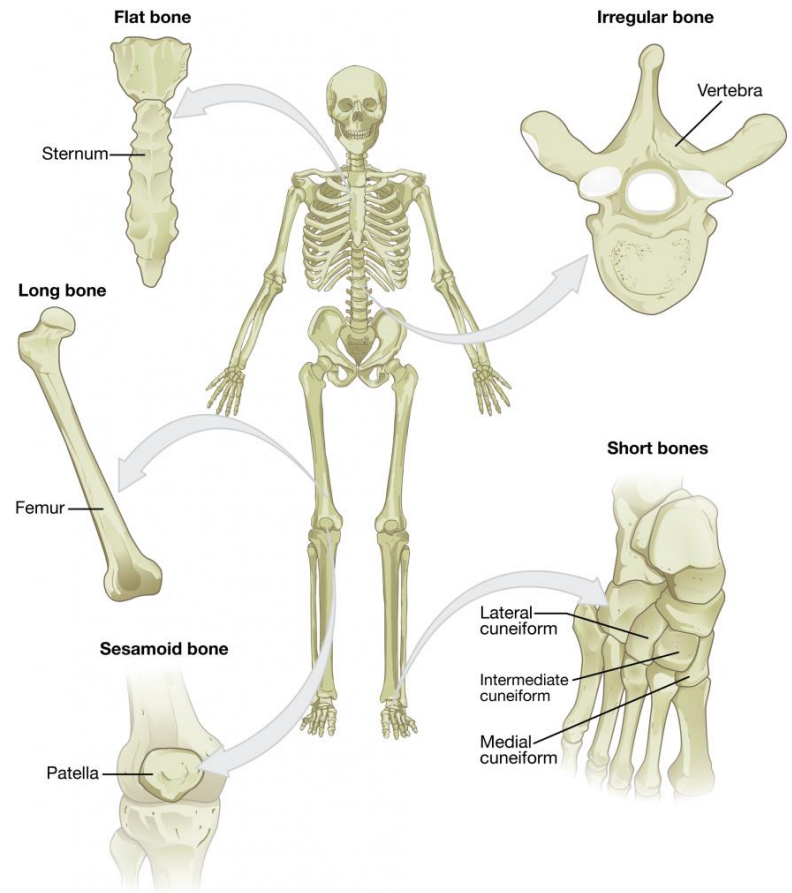




# Types of Bones



**Classification of Bones by Shape**



# Types of Bones

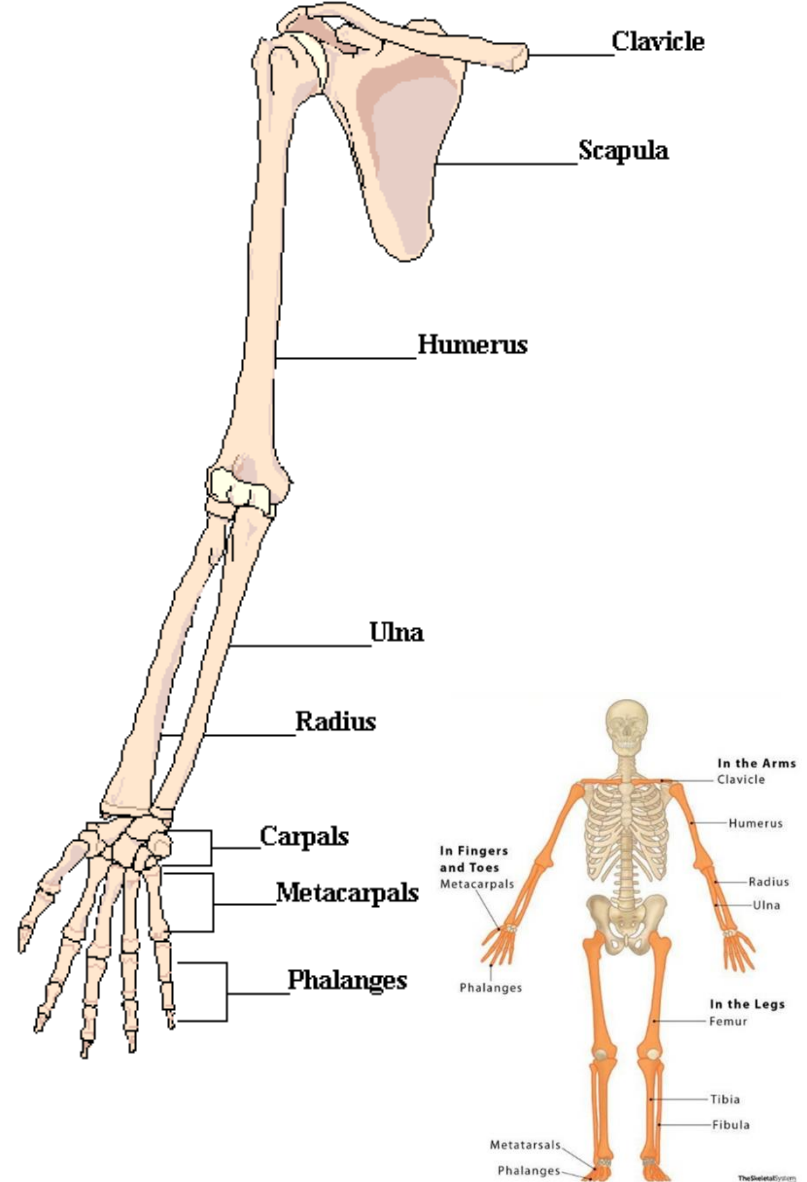
## A. Long tubular (hollow, cylindrical) bones

1. Femur
2. Humerus
3. Forearm bones
4. Leg bones
5. Clavicle

## B. Short tubular (hollow, cylindrical) bones

1. Tarsals
2. Carpals
3. Phalanges

- provide levers for movement
- develop by replacement of **hyaline cartilage**
- have structurally distinct regions (epiphysis, diaphysis, metaphysis)



# Types of Bones

## C. Flat bones (squamous)

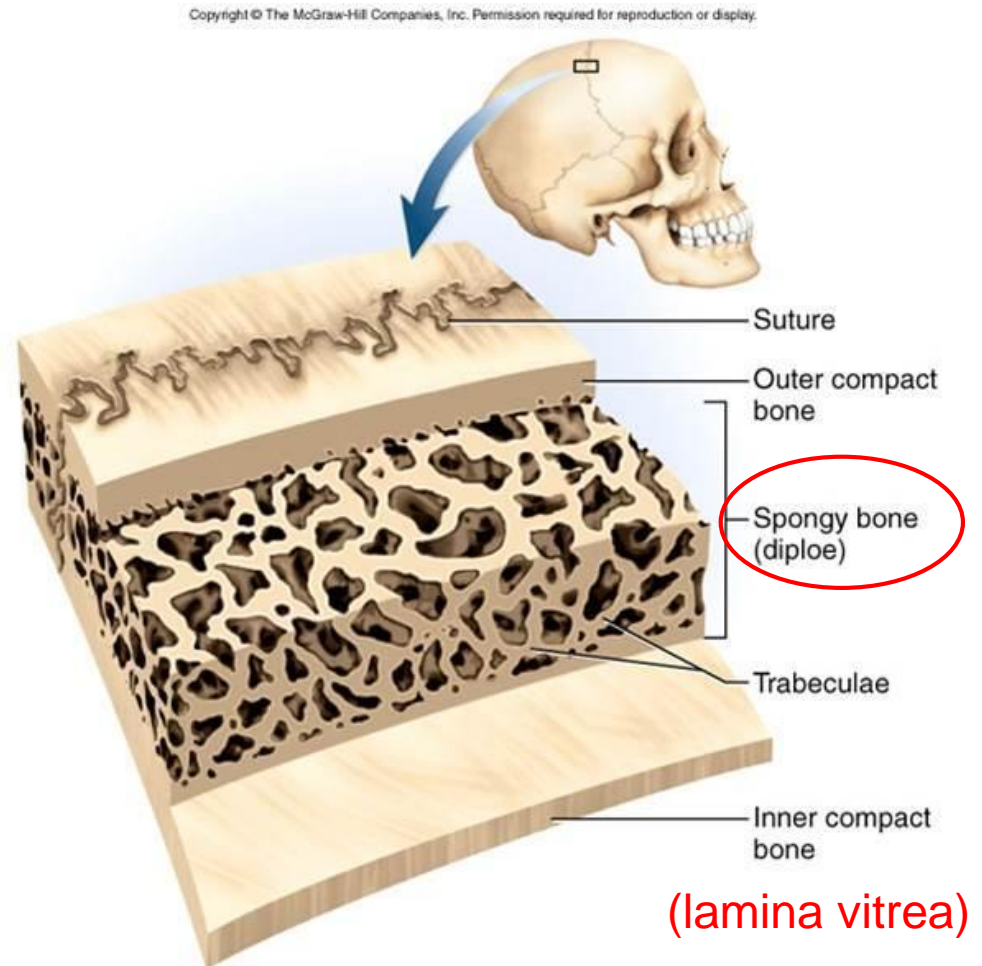
1. Frontal
2. Scapula

- mainly consist of homogenous mass of spongy bone covered outside with a thin layer of compact bone

- generally serve protective or reinforcement functions

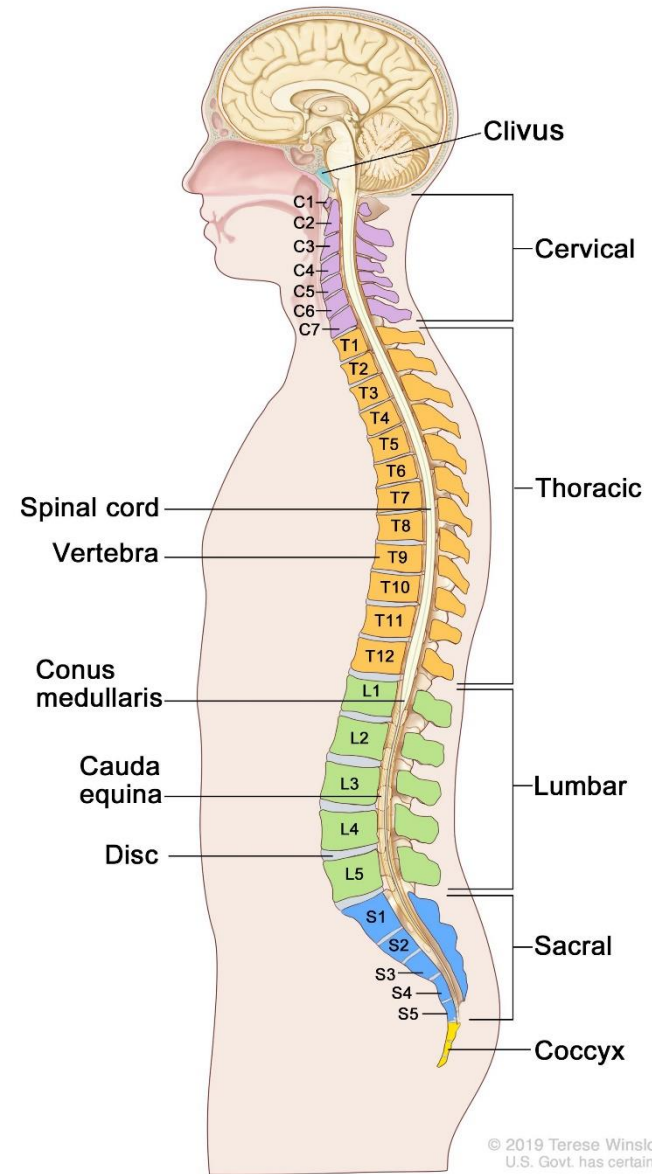
- develop by replacement of **connective tissue**

- **Diploe** – spongy bone structure between two plates of compact bone



# Types of Bones

- **D. Irregular bones**
  - Vertebrae (26 bones)



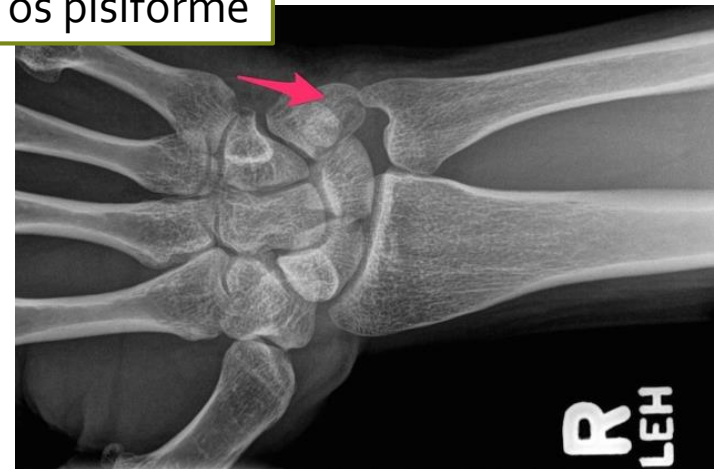
# Types of Bones

- **E. Sesamoid bones**
  - Patella
  - Pisiform bone

- develop within tendon  
- change the attrition of the tendon  
- increase the volume of the movement



os pisiforme

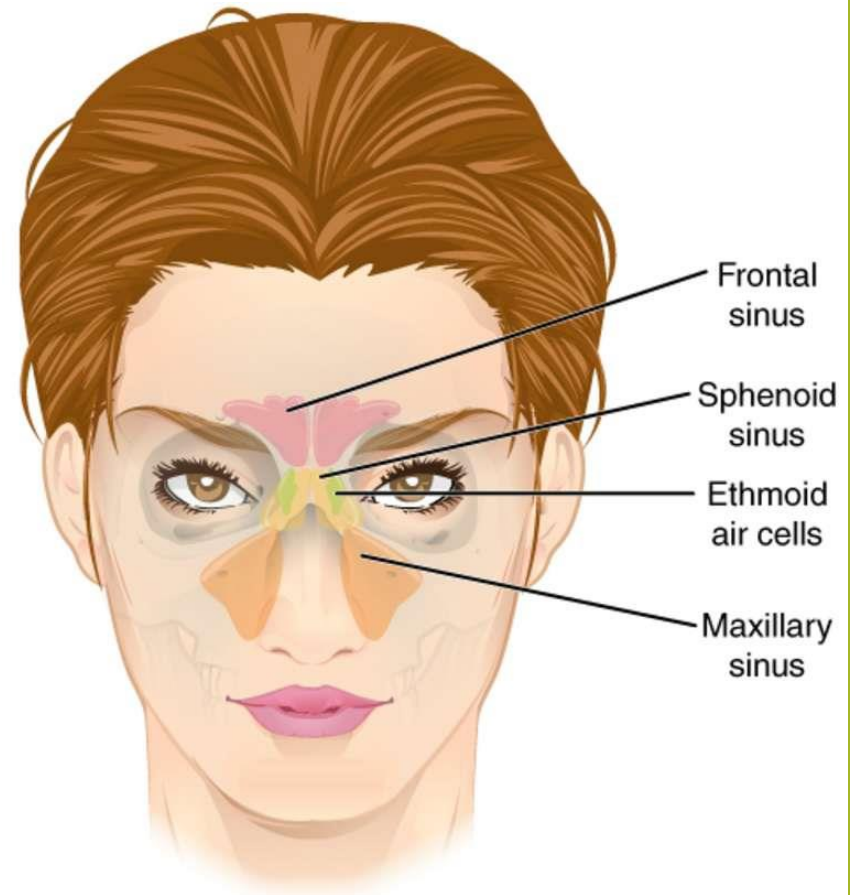




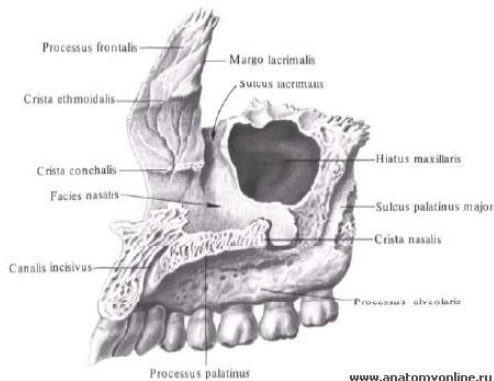
# Types of Bones

## ● F. Pneumatic bones

- bones which contain air spaces lined with mucous membrane
- typically skull bones
- make the skull light
- impart resonance to voice
- act as conditioning chambers for inspired air



Anterior



# Chemical Composition of the Bones

- Depends on the age and individual characteristics



## In a grown-up:

- Water – 50%;
- Fat – 16%;
- Other organic substances – 12%
- Inorganic substances – 22%



# Chemical Composition of the Bones

## Inorganic matter

- 65%
- Mostly Calcium and inorganic orthophosphate deposited between collagen
- **Function** – hardness of the bones



## Organic matter

- 35% (28-30% collagen and 5-7% non-collagenous proteins)
- Osteocalcin
- Bone sialoprotein
- Osteonectin
- Bone morphogenic protein
- **Function** – elasticity of the bones



# Osteogenesis imperfecta (OI)

(brittle bone disease, Lobstein syndrome)

- deficiency of type I collagen - defective connective tissue (or without the ability to make it)



# Long Bone Structure

## • 1. Diaphysis

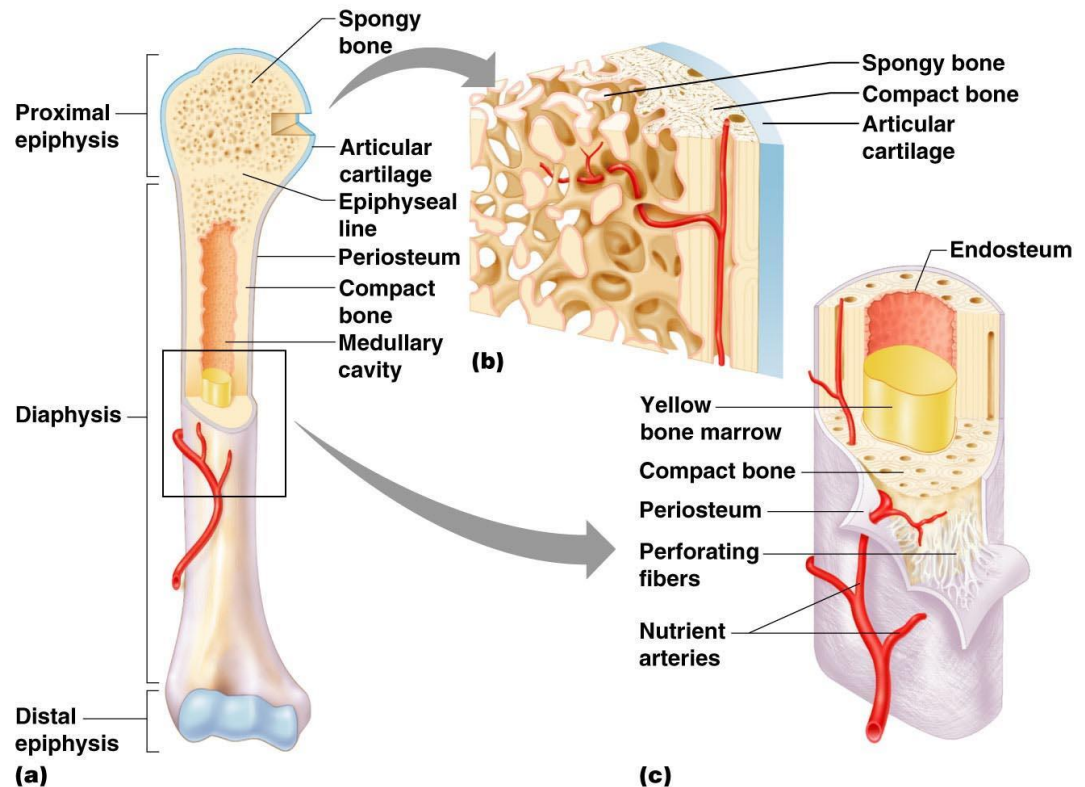
- a. Shaft: made of hard compact bone

## • 2. Medullary cavity

- a. Hollow area inside diaphysis
- b. Contains yellow bone marrow (inactive, fatty marrow)

## • 3. Epiphyses

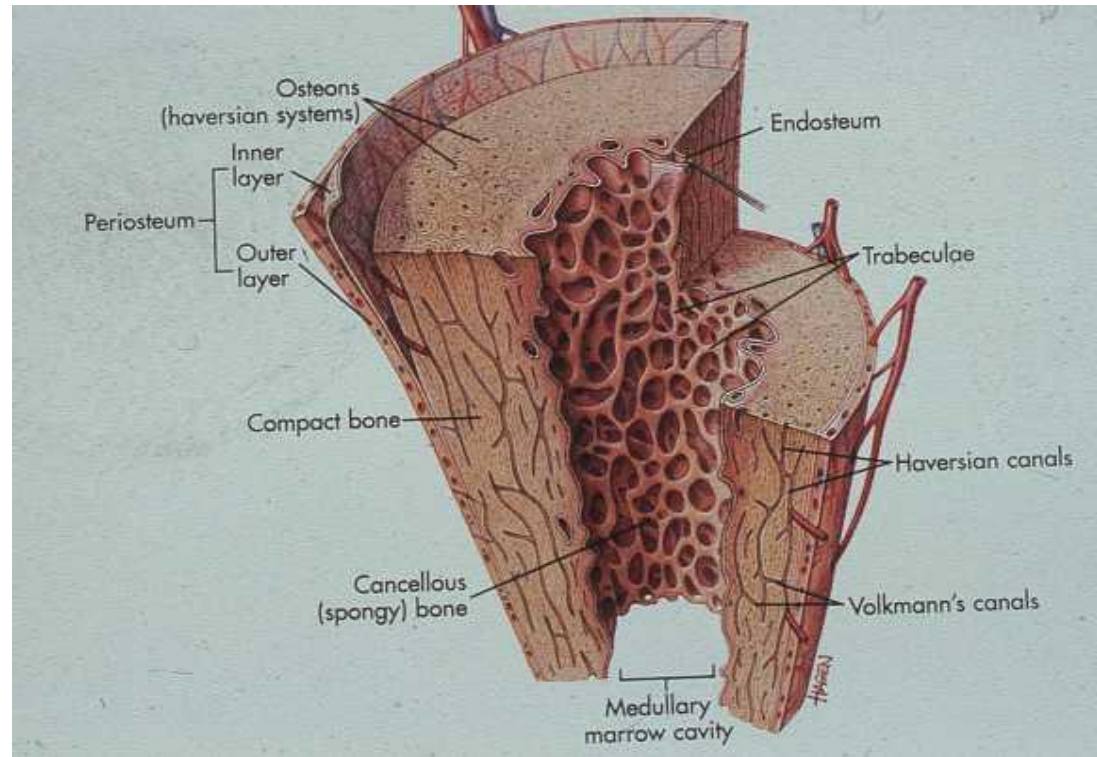
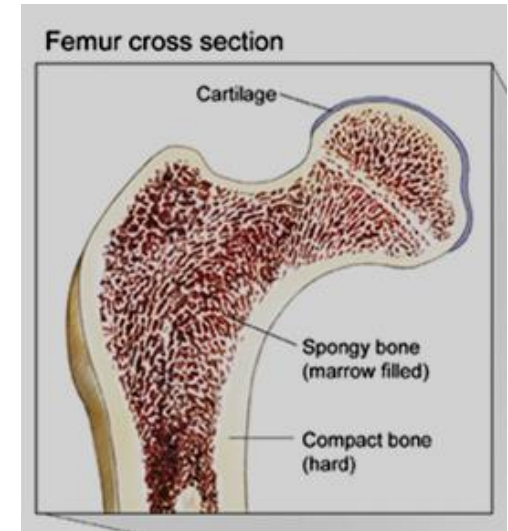
- a. Ends of long bone
- b. Inside contains red, spongy bone marrow





# Long Bone Structure

- **4. Articular Cartilage**
  - a. Thin layer of cartilage cover each epiphyses (bone ends)
  - b. Act as a cushion at the joint
- **5. Periosteum**
  - a. Fibrous membrane covering a long bone (except the ends)
- **6. Endosteum**
  - a. Fibrous membrane lining medullary cavity



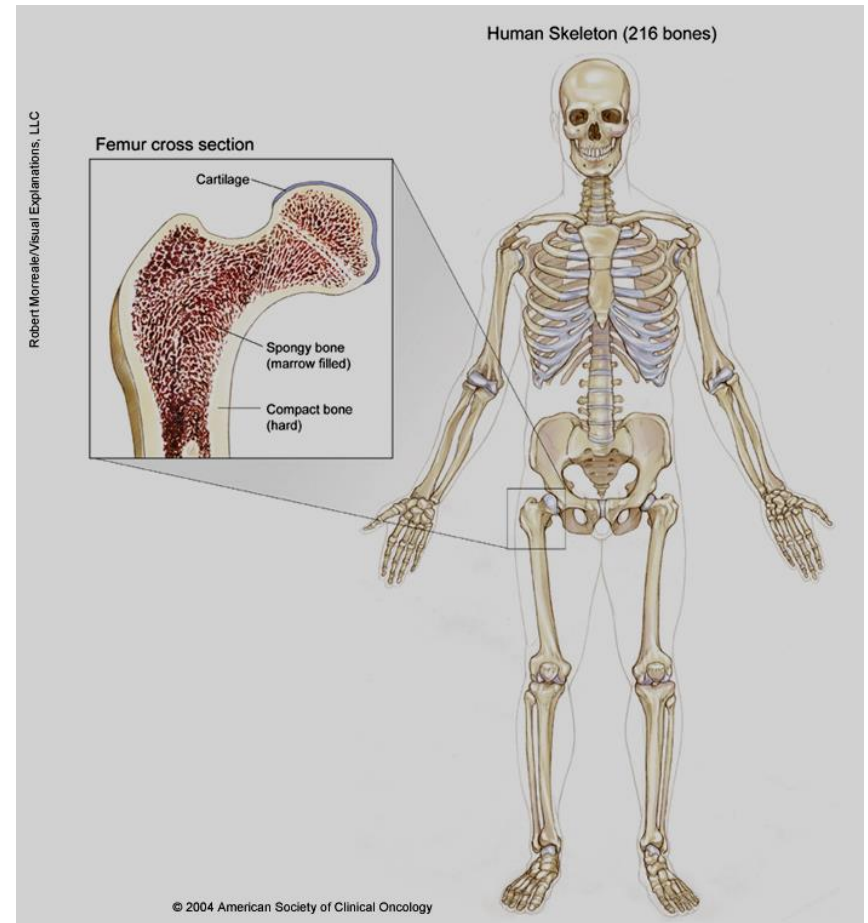
# Microscopic Structures

## 1. Compact bone

outer layer of bone that is hard and dense

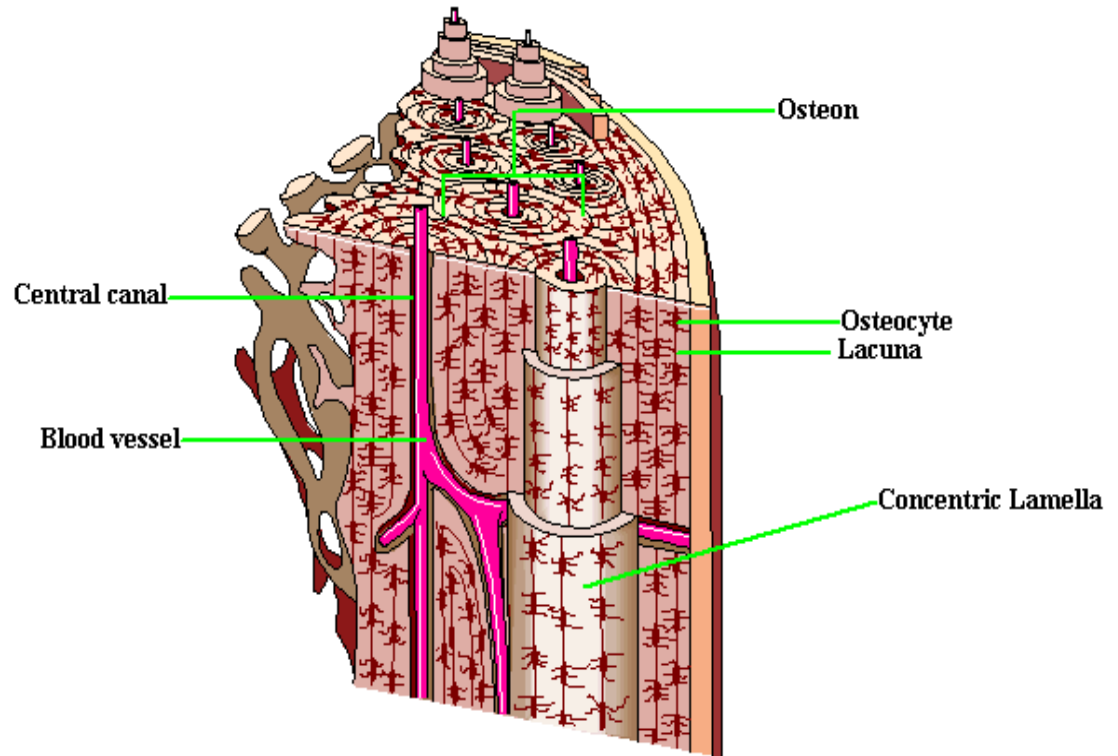
## 2. Spongy (trabecular) bone

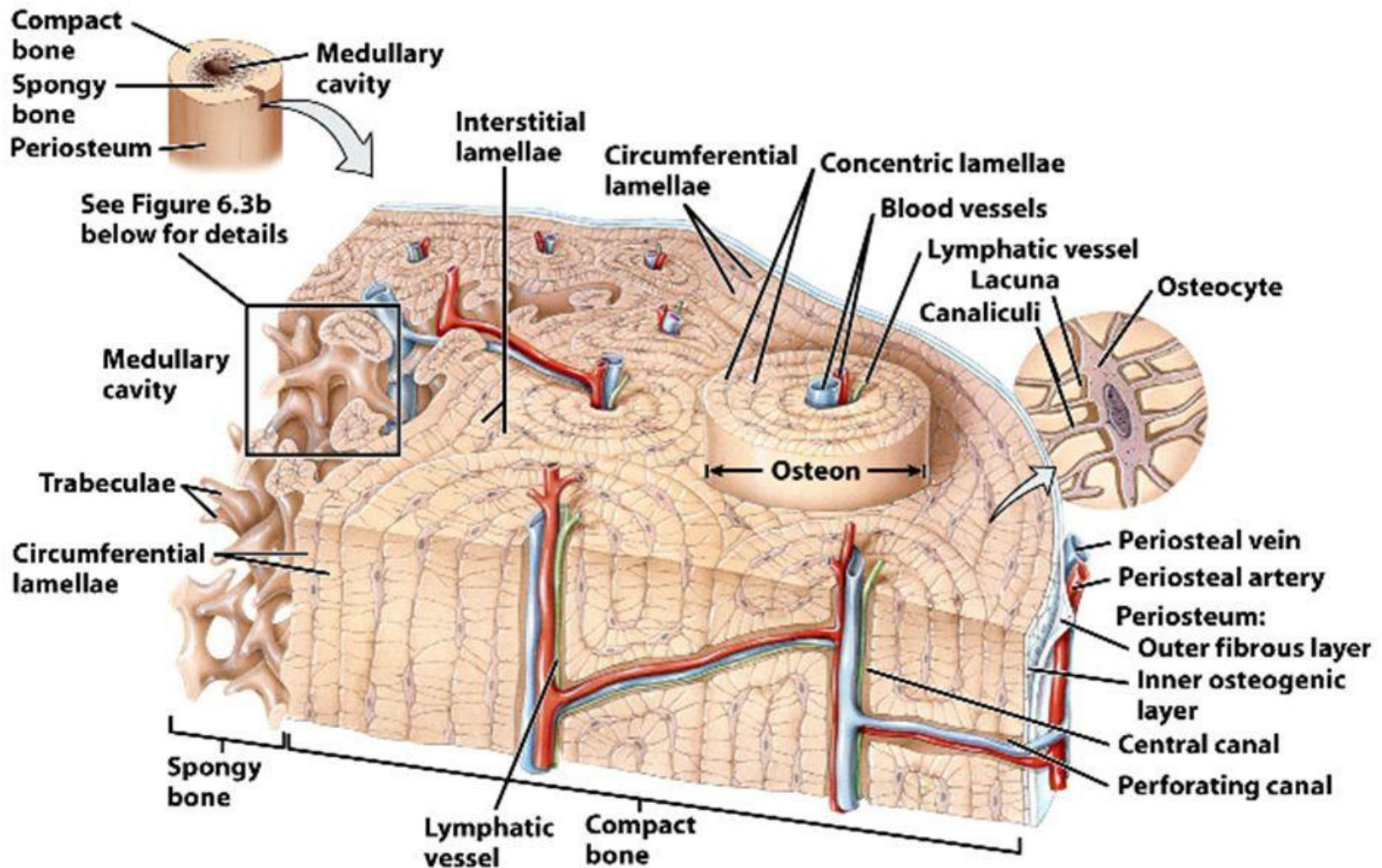
porous bone in the end of a long bone



# Compact bone

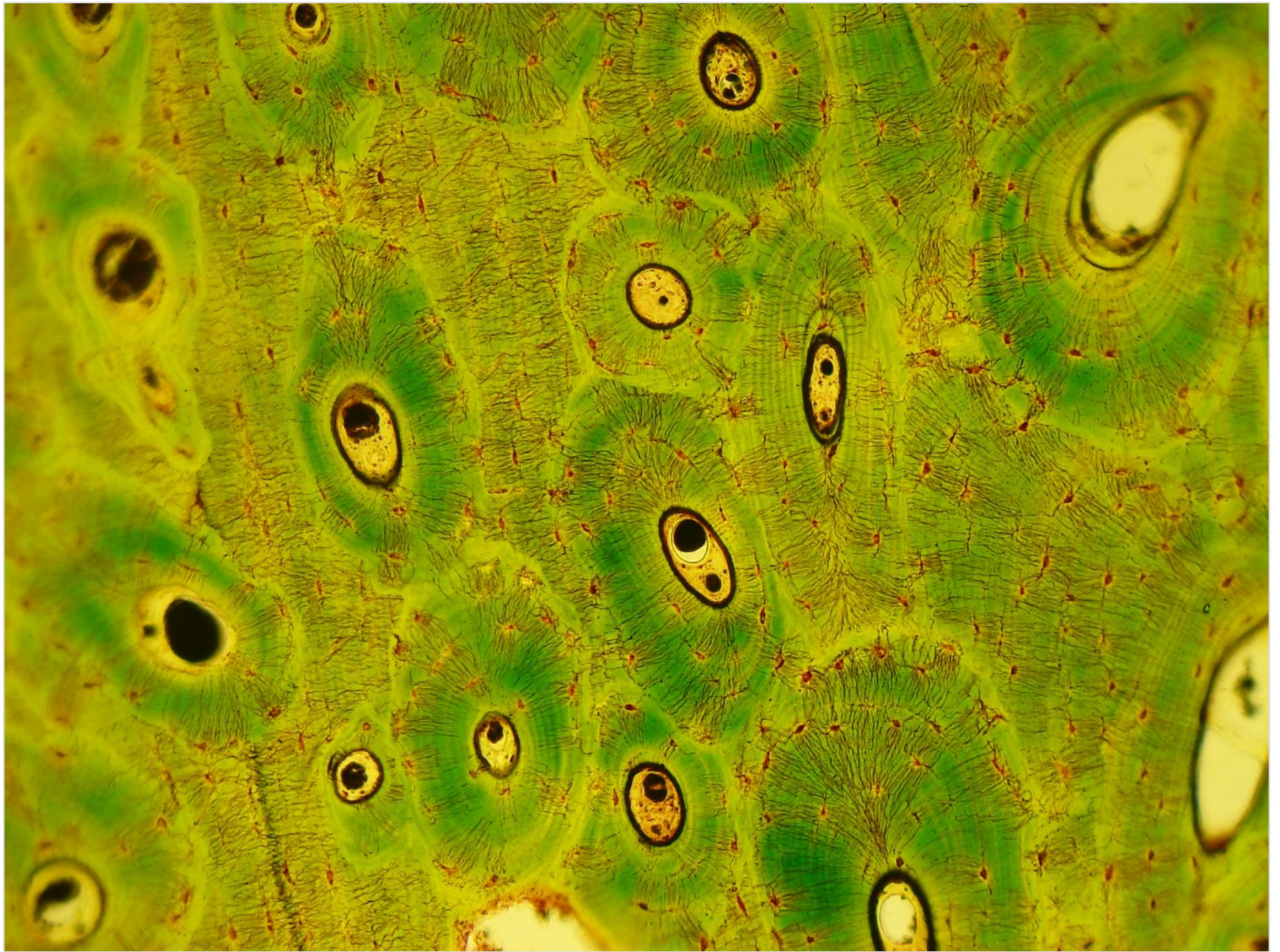
- Matrix composed of Osteons or Haversian systems – morphological and functional unit of bone
- Calcium matrix arranged in rings
- Each ring = concentric lamella
- Central canal contain blood vessels





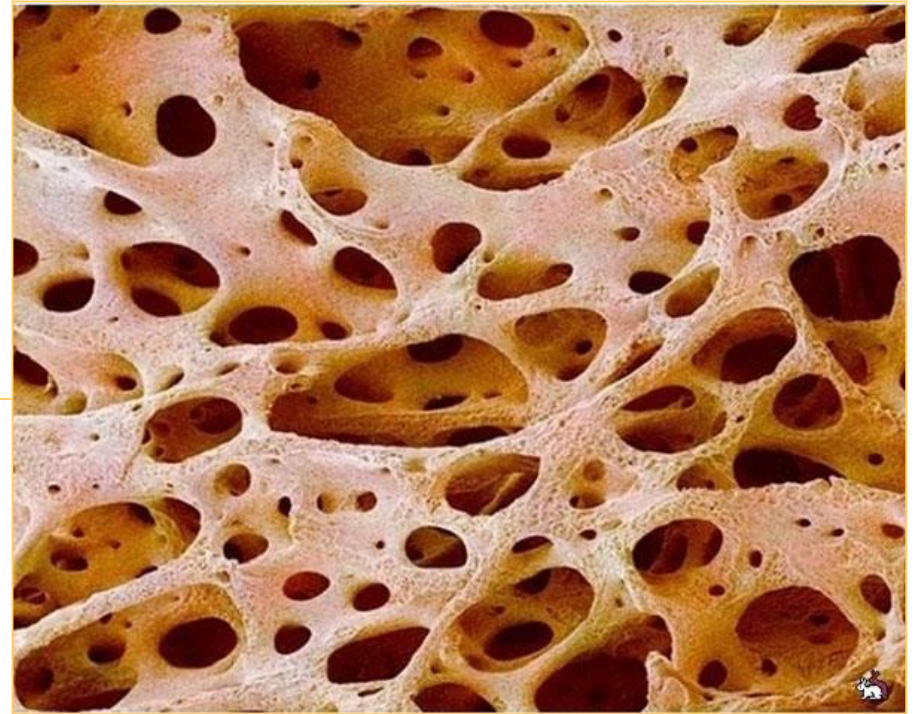
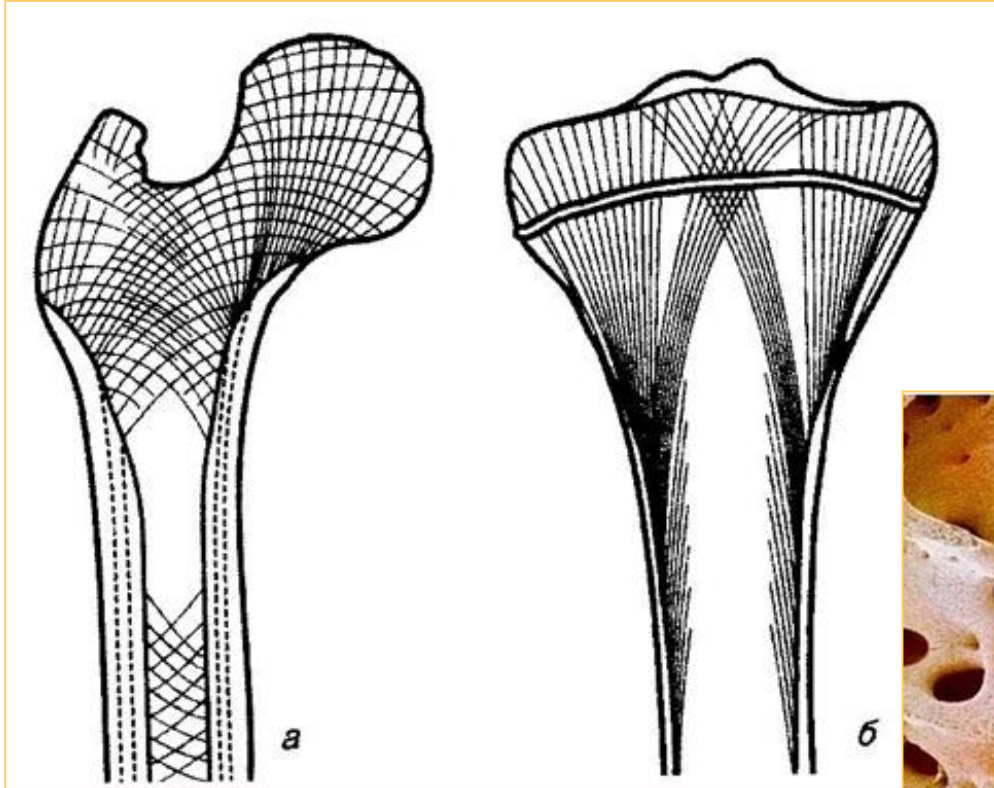
## Osteons (haversian systems) in compact bone and trabeculae in spongy bone

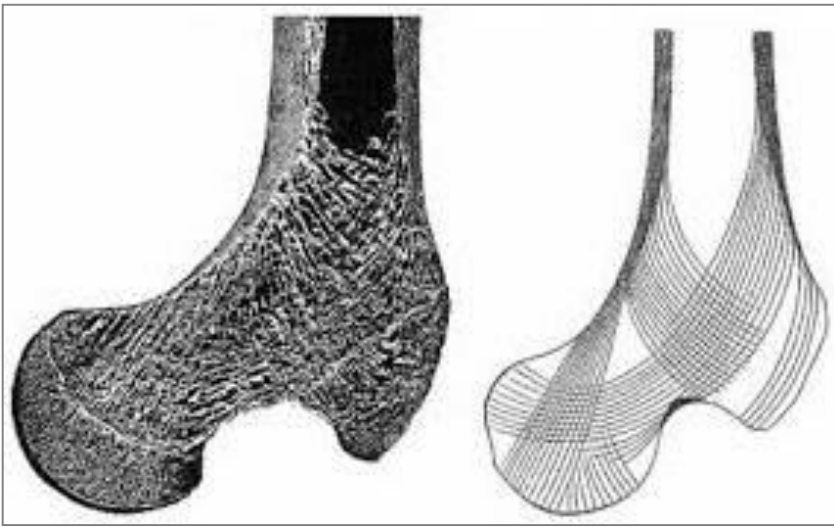






# Bone trabeculae





1840 – Herman von Meier  
(Switzerland, Professor of Anatomy)  
- Studied the bones (patent)

1866 – Carl Kulmann  
(Switzerland, engineer)  
- Theoretic explanation

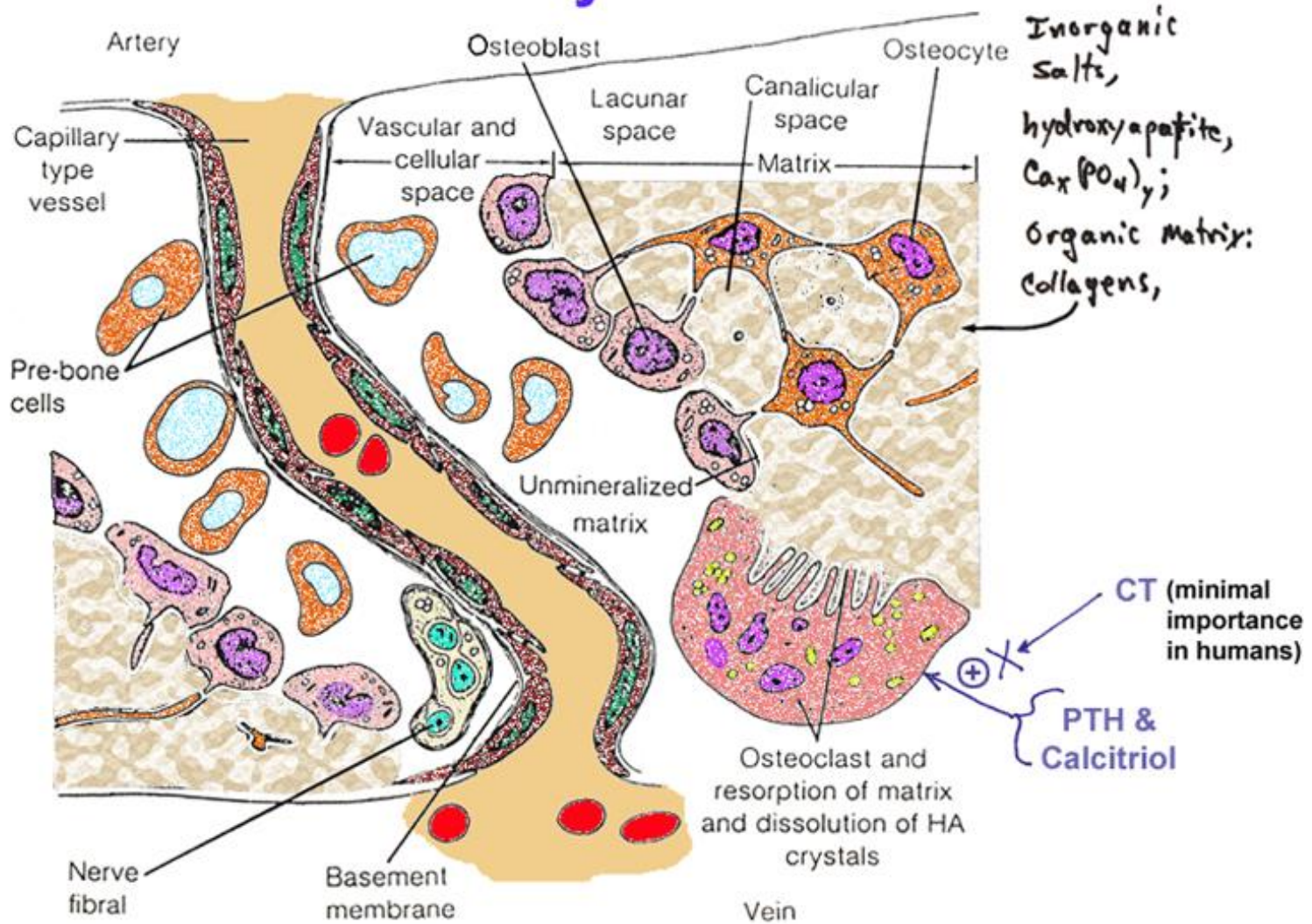


1889 – Gustave Eiffel (France)  
- Construction of the Eiffel Tower





# Cellular Anatomy of Bone



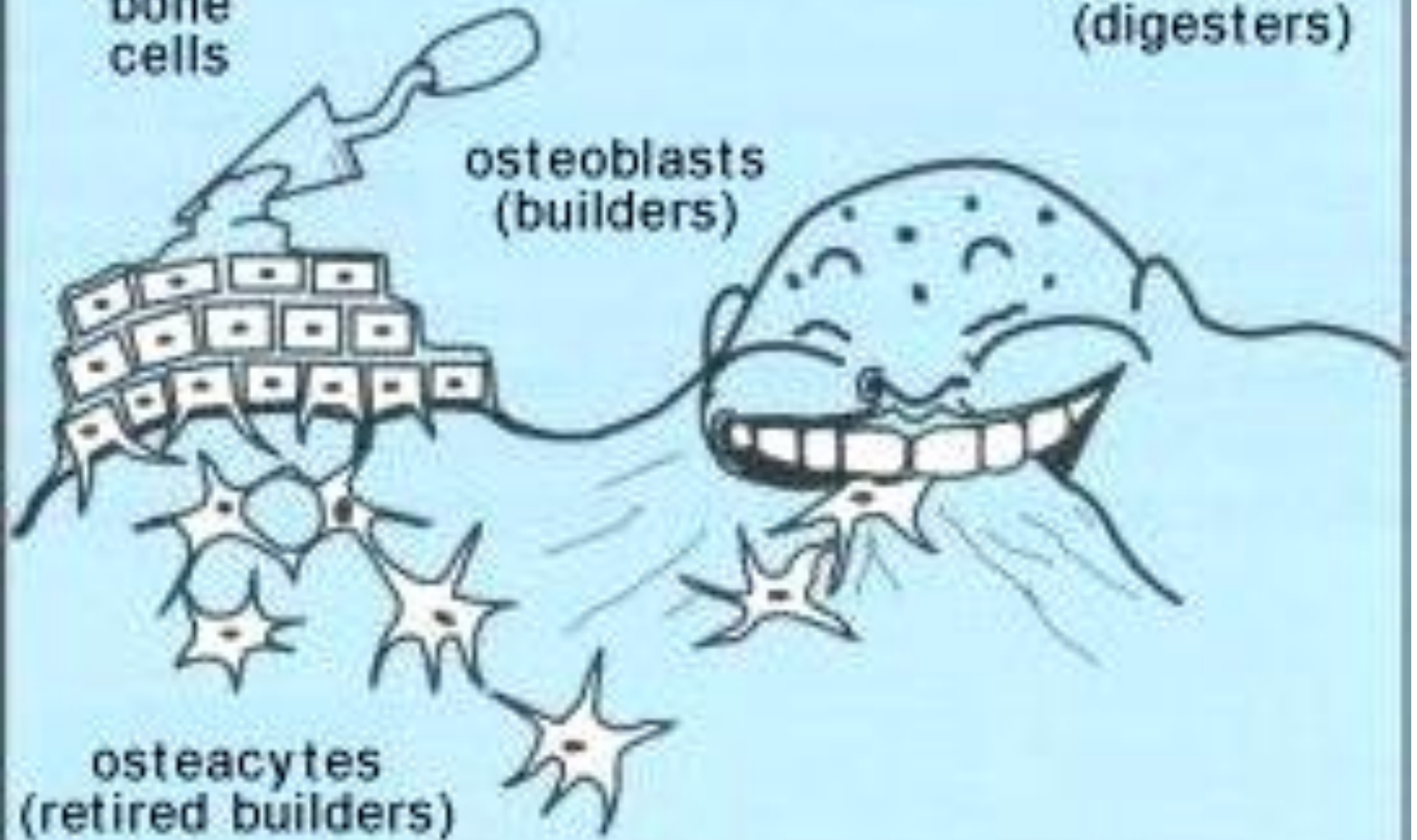
Modified from Paxton, *Endocrinology: Biological and Medical Perspectives*, W.C. Brown Publishers: Dubuque, IA, 1986.

bone  
cells

osteoclasts  
(digesters)

osteoblasts  
(builders)

osteocytes  
(retired builders)

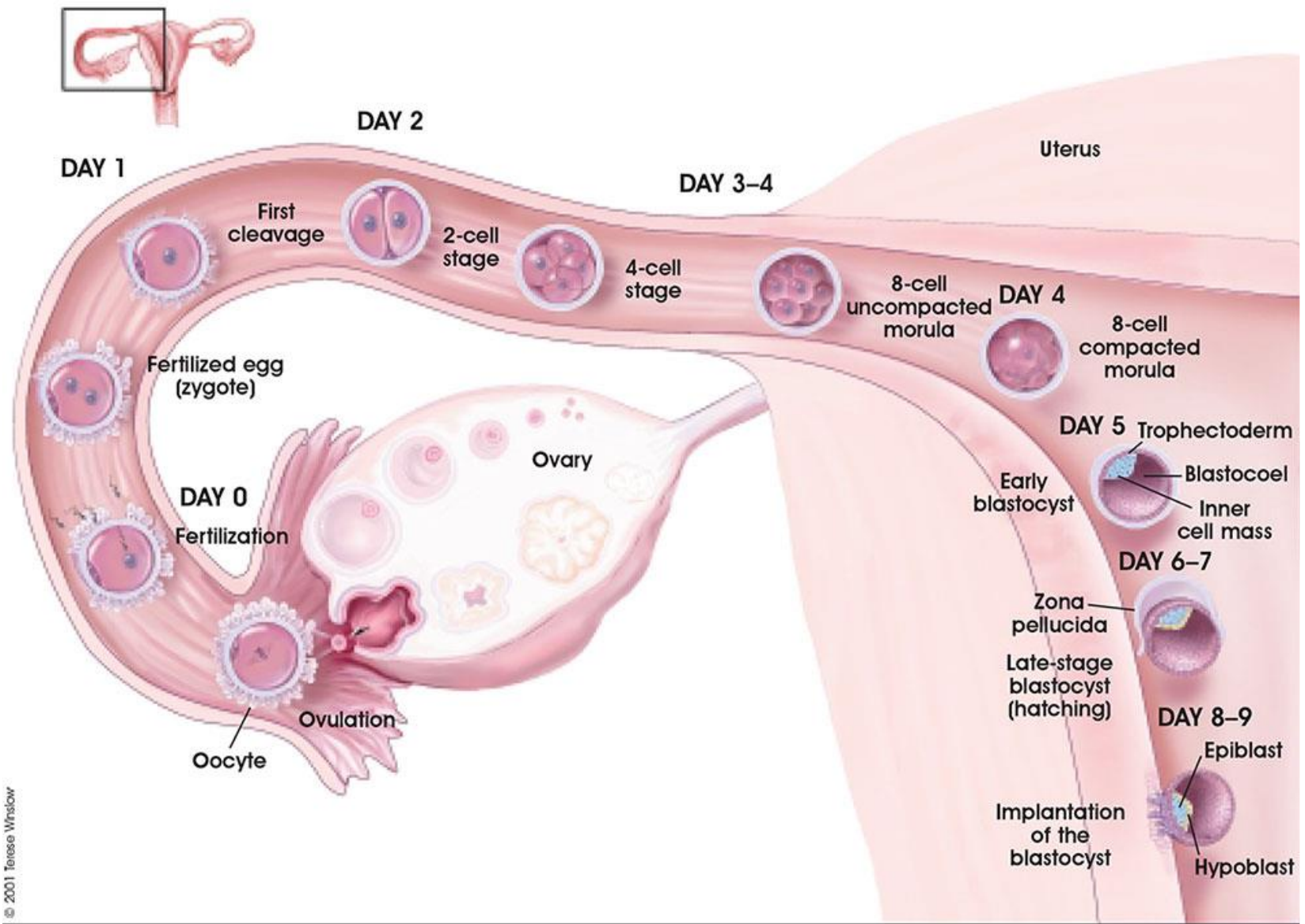


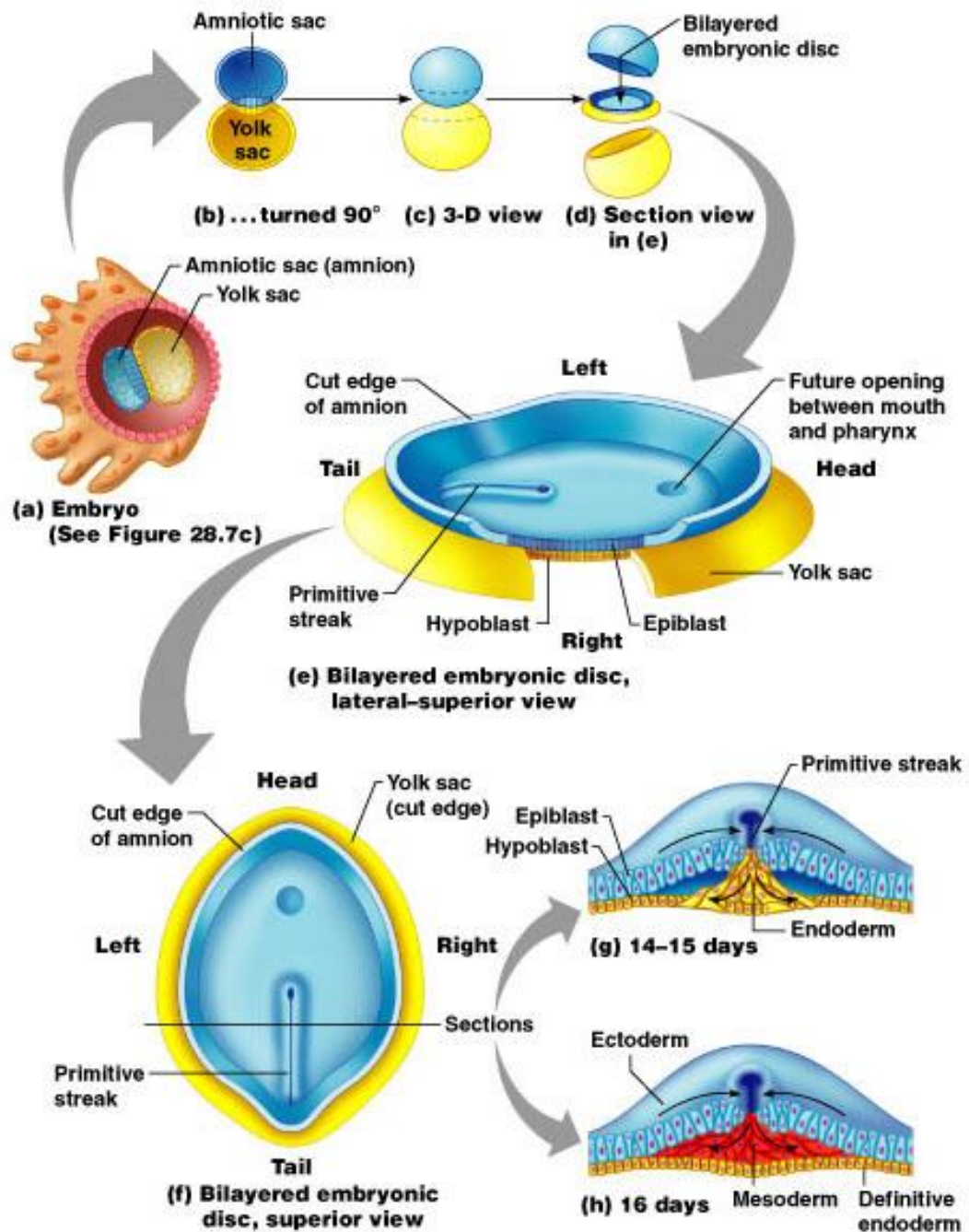
# Bone growth and development (osteogenesis)

Bone begins as cartilage and fibrous structures in the fetus.

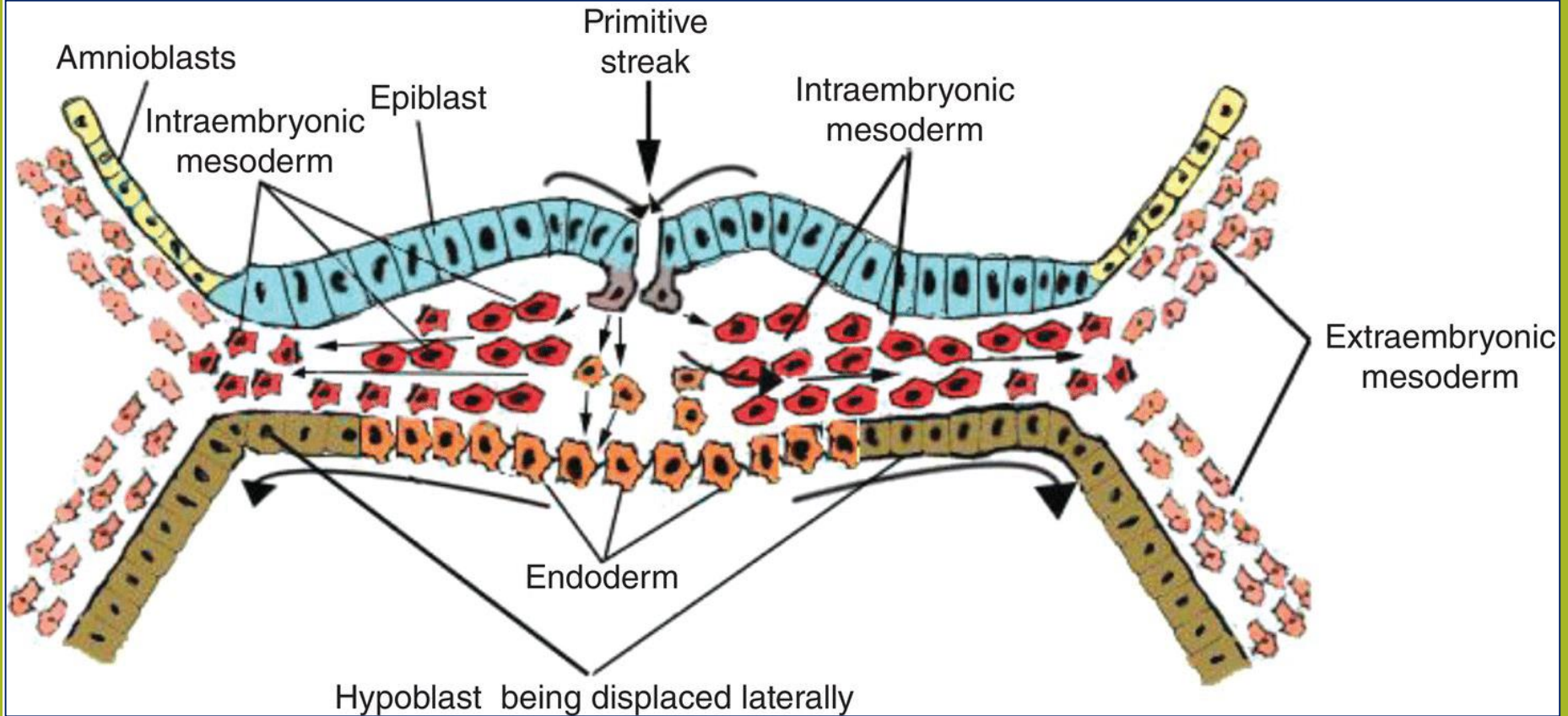








# Gastrulation – formation of germ layers (4<sup>th</sup> week)

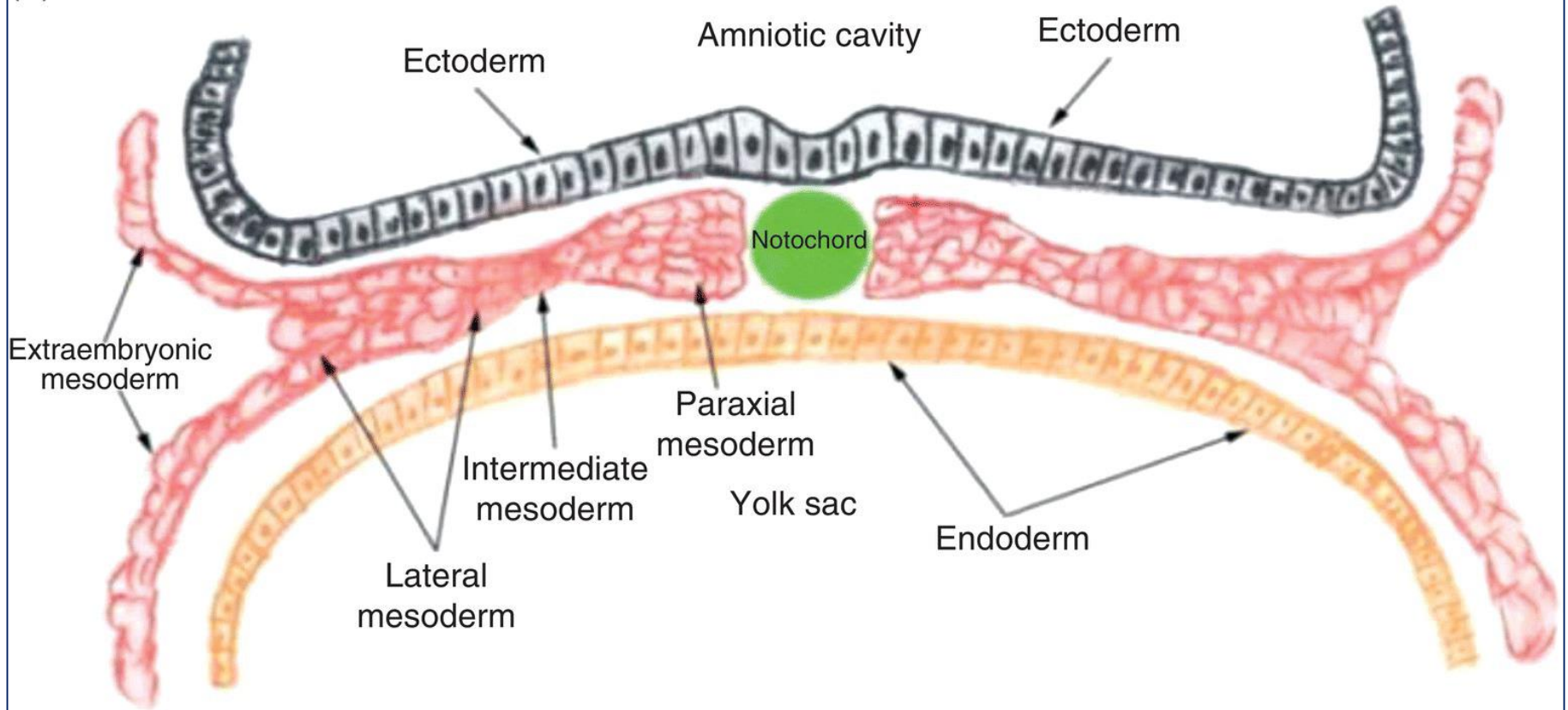


## Embryonic germ layers:

- Ectoderm
- Mesoderm
- Entoderm



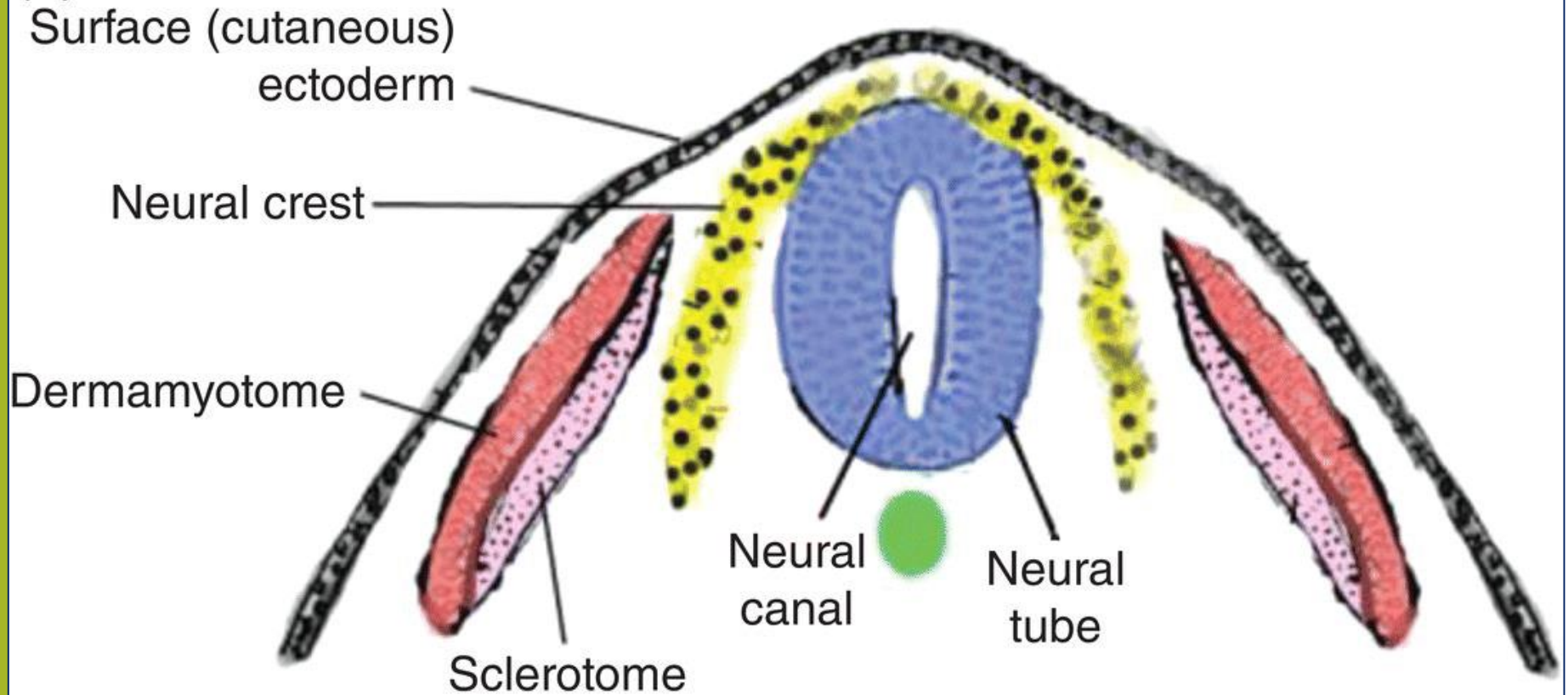
(a)



## Intraembryonic mesoderm plates:

- ***Paraxial (dorsal) mesoderm*** – axial skeleton
- ***Intermediate mesoderm*** – urogenital apparatus
- ***Lateral mesoderm (somatic and splanchnic)*** – appendicular skeleton and internal organs

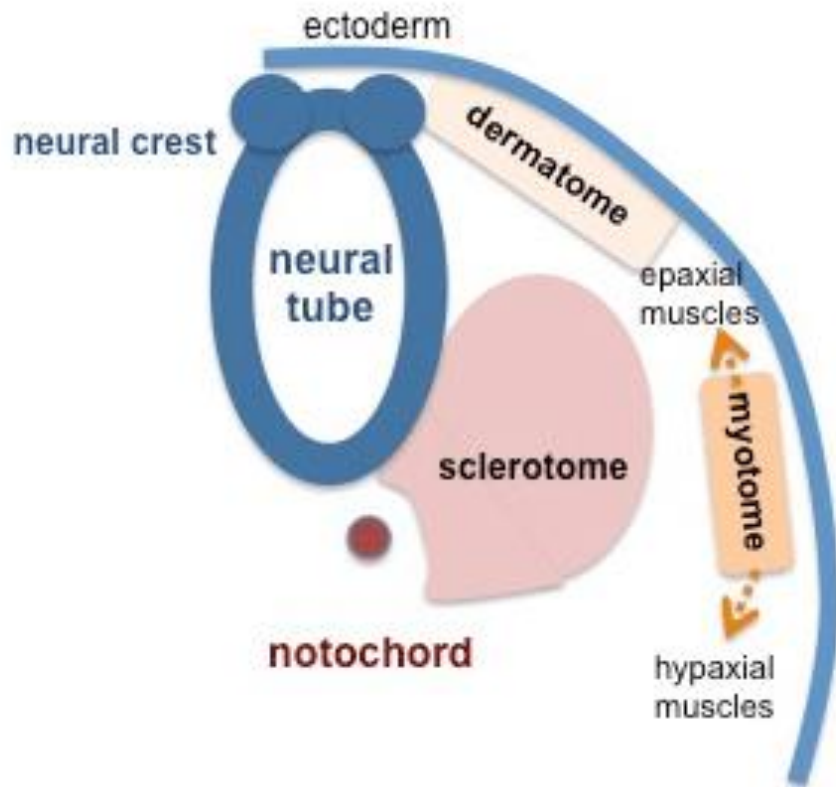
(d)



Each somite displays three subdivisions:

- (1) a *ventromedial sclerotome* which will form the vertebrae and the vertebral column, axial skeleton;
- (2) a *dorsolateral dermatome* which contributes to the dermis of the skin;
- (3) an *intermediate myotome* which forms the skeletal muscles of the trunk and limbs.





**Sclerotome**

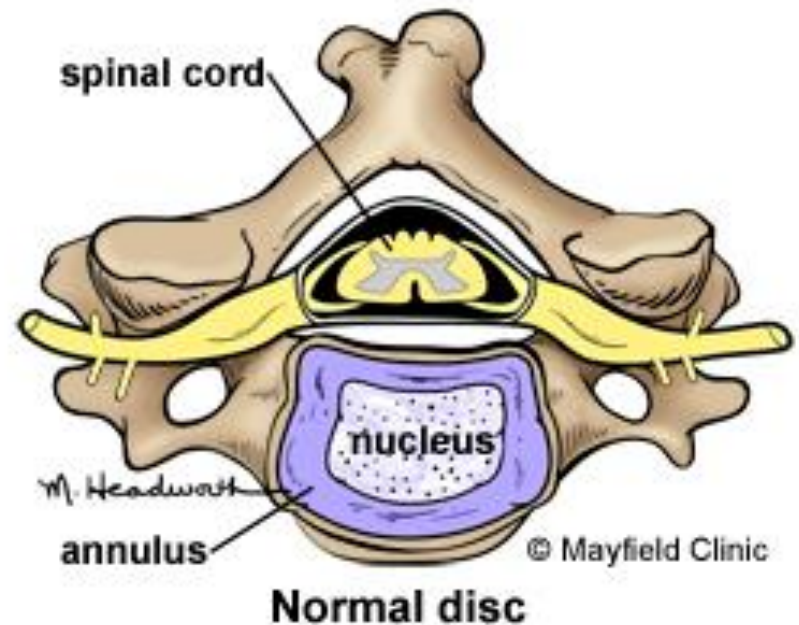
↓

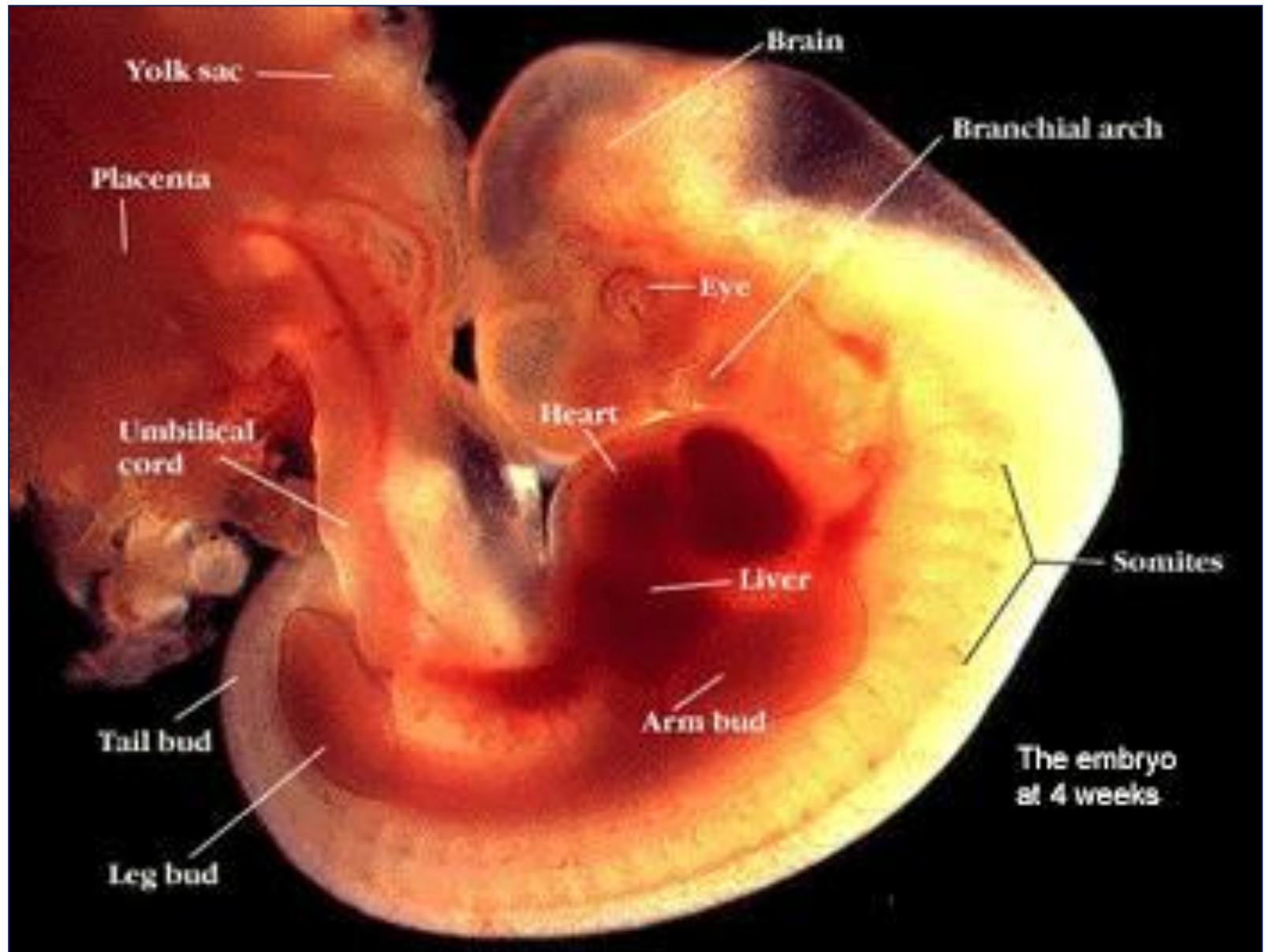
**Vertebrae,  
vertebral column,  
axial skeleton**

**Notochord**

↓

**Nucleus pulposus  
(intervertebral disc)**





# Osteogenesis:

## Direct

(intramembranous primary ossification)

- on the base of embryonic connective tissue (mesenchyme)
- flat bones of the skull, clavicle, and mandible

Mesenchyme



Bone tissue

## Indirect

(endochondral secondary ossification)

- through the cartilage model of the bone
- all other bones of the skeleton

Mesenchyme



Cartilage model of the bone



Bone tissue

# Osteogenic cell:

```
graph TD; A["Osteogenic cell:"] --> B["Plenty of Oxygen  
(presence of blood vessels)"]; A --> C["Lack of Oxygen  
(no blood vessels)"]; B --> D["Osteoblast –  
Bone tissue  
formation"]; C --> E["Chondroblast –  
Cartilage tissue  
formation"];
```

Plenty of Oxygen  
(presence of blood vessels)

**Osteoblast –**  
**Bone tissue**  
**formation**

Lack of Oxygen  
(no blood vessels)

**Chondroblast –**  
**Cartilage tissue**  
**formation**



# Intramembranous bones (dermal bones)

Mesenchyme condensation



Vascularization (blood vessels growth)



Osteogenic islets formation



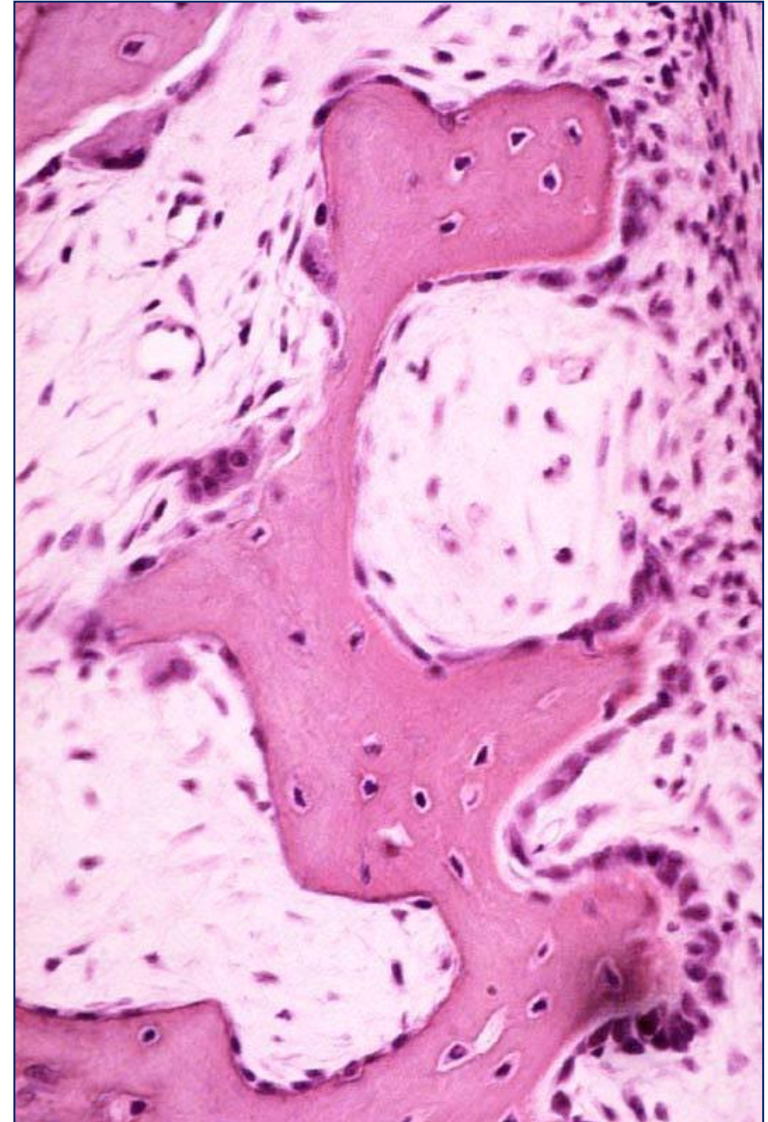
Osteogenic cell differentiate into osteoblast (produce organic matrix)



Osteoblasts become osteocytes



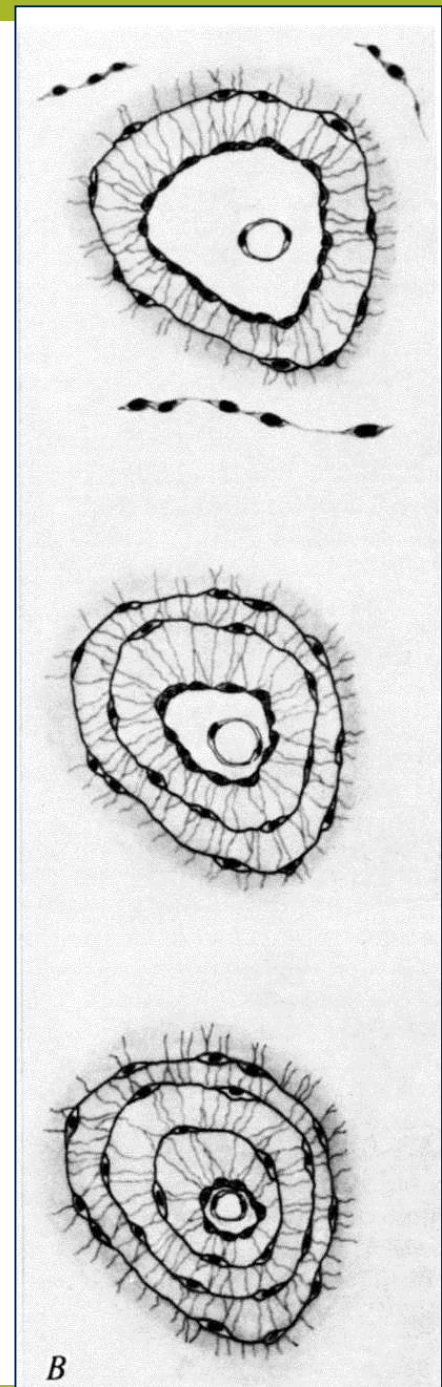
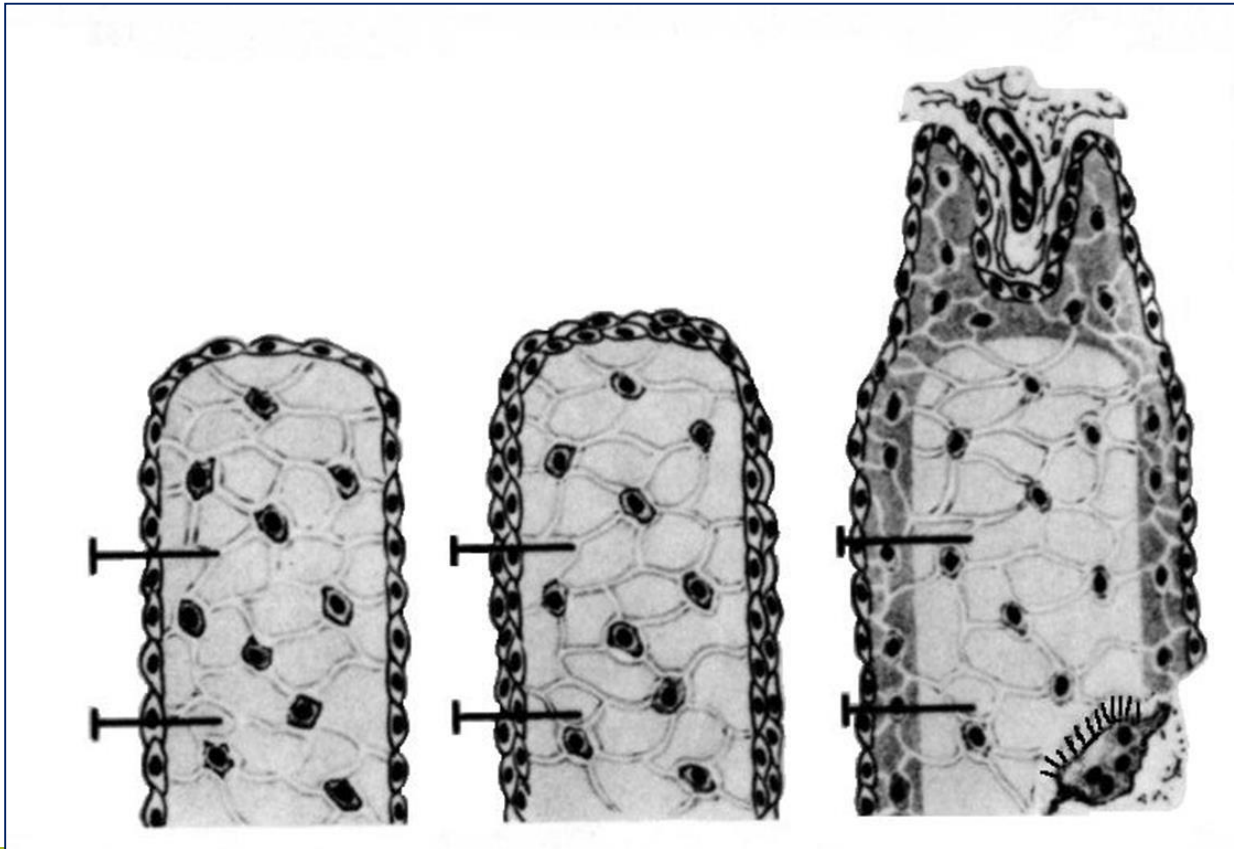
Calcification of matrix (calcium phosphate deposition, osteocytes are trapped inside the matrix)





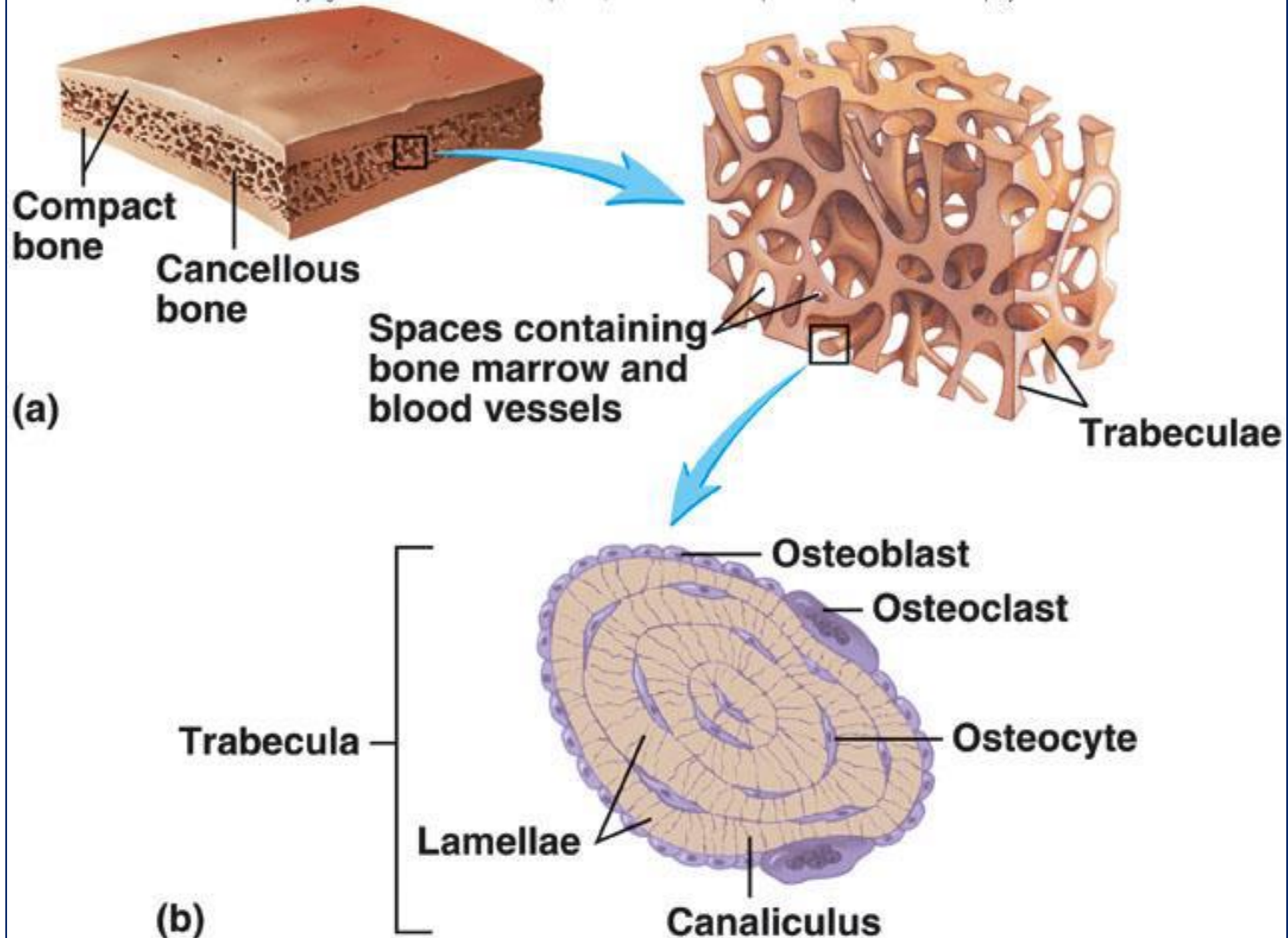
# Transformation of cancellous bone into compact bone

- Thickening of trabecules
- **Osteon** (Haversian system) formation around blood vessels



# Intramembranous bones (dermal bones)

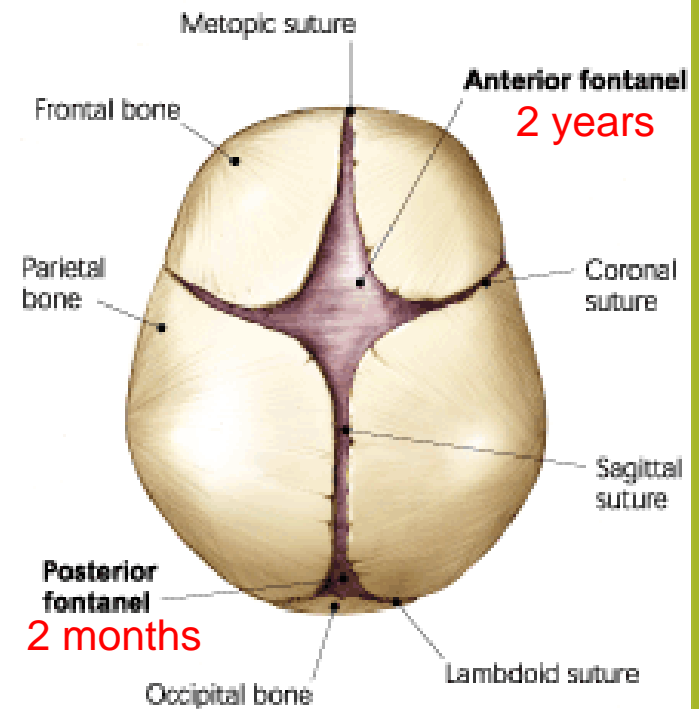
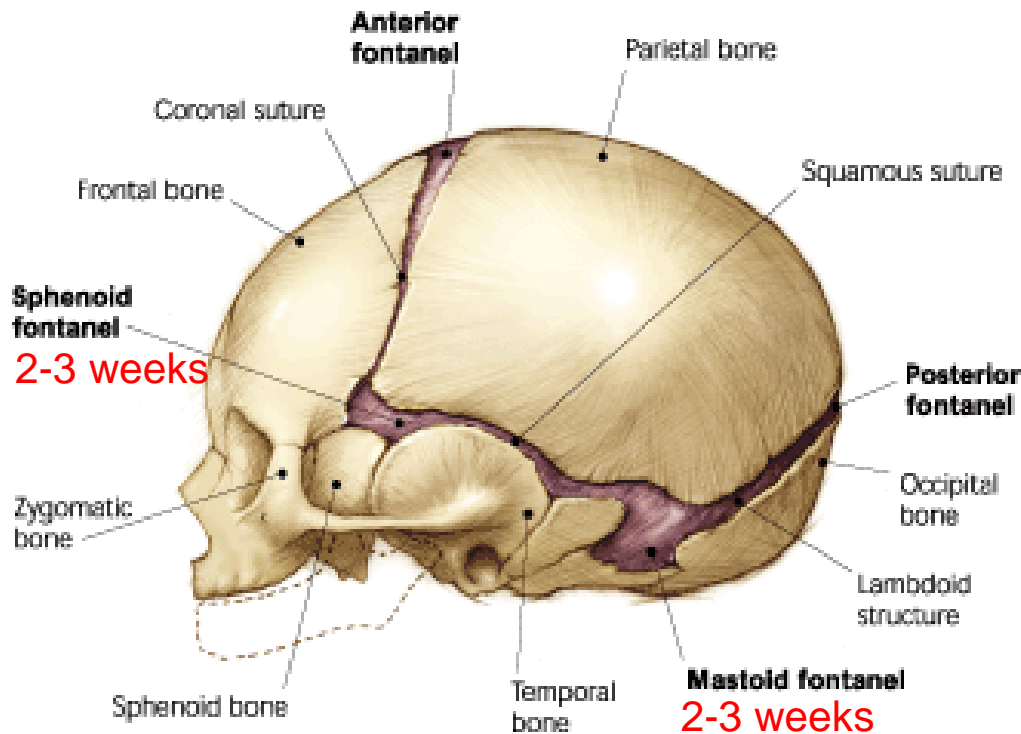
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# Fontanelle

(*Fonticuli cranii*)

- Common only for calvaria of the neurocranium
- Sign of **primary intramembranous osteogenesis**
- Syndesmosis



# Osteogenic cell:

```
graph TD; A["Osteogenic cell:"] --> B["Plenty of Oxygen  
(presence of blood vessels)"]; A --> C["Lack of Oxygen  
(no blood vessels)"]; B --> D["Osteoblast –  
Bone tissue  
formation"]; C --> E["Chondroblast –  
Cartilage tissue  
formation"];
```

Plenty of Oxygen  
(presence of blood vessels)

Osteoblast –  
Bone tissue  
formation

Lack of Oxygen  
(no blood vessels)

Chondroblast –  
Cartilage tissue  
formation



# Endochondrial bones formation

Mesenchyme condensation



Osteogenic cells differentiate into chondroblasts (lack of Oxygen!)



Formation of cartilage (hyaline!) model of future bone (no vessels!)



Growth of cartilage germ



Mature chondrocytes inside the germ die

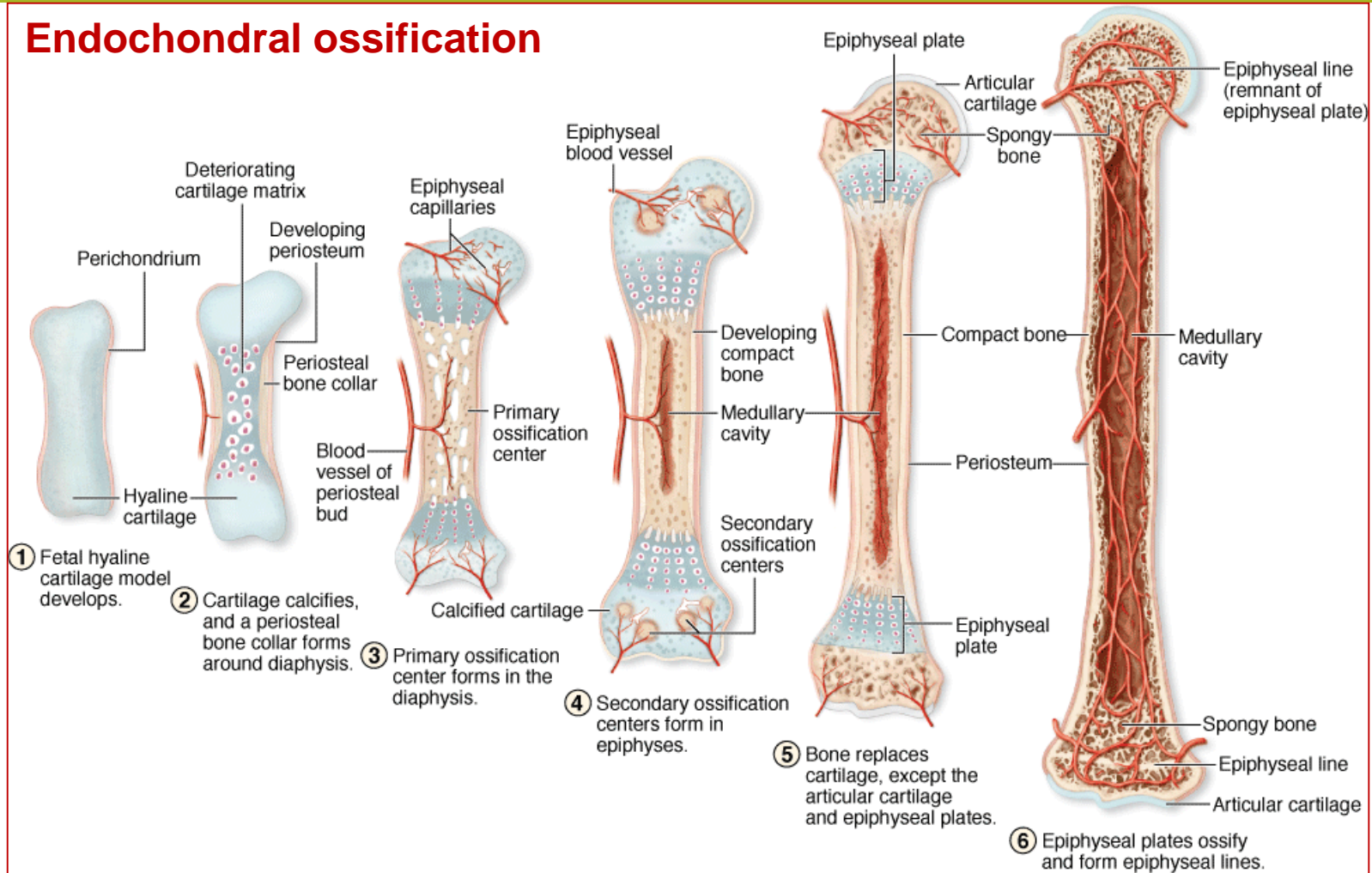


Formation of primary ossification center  
(*punctum ossificatum primum*) - diaphysis



Formation of secondary ossification center  
(*punctum ossificatum secundum*) - epiphysis

# Endochondral ossification

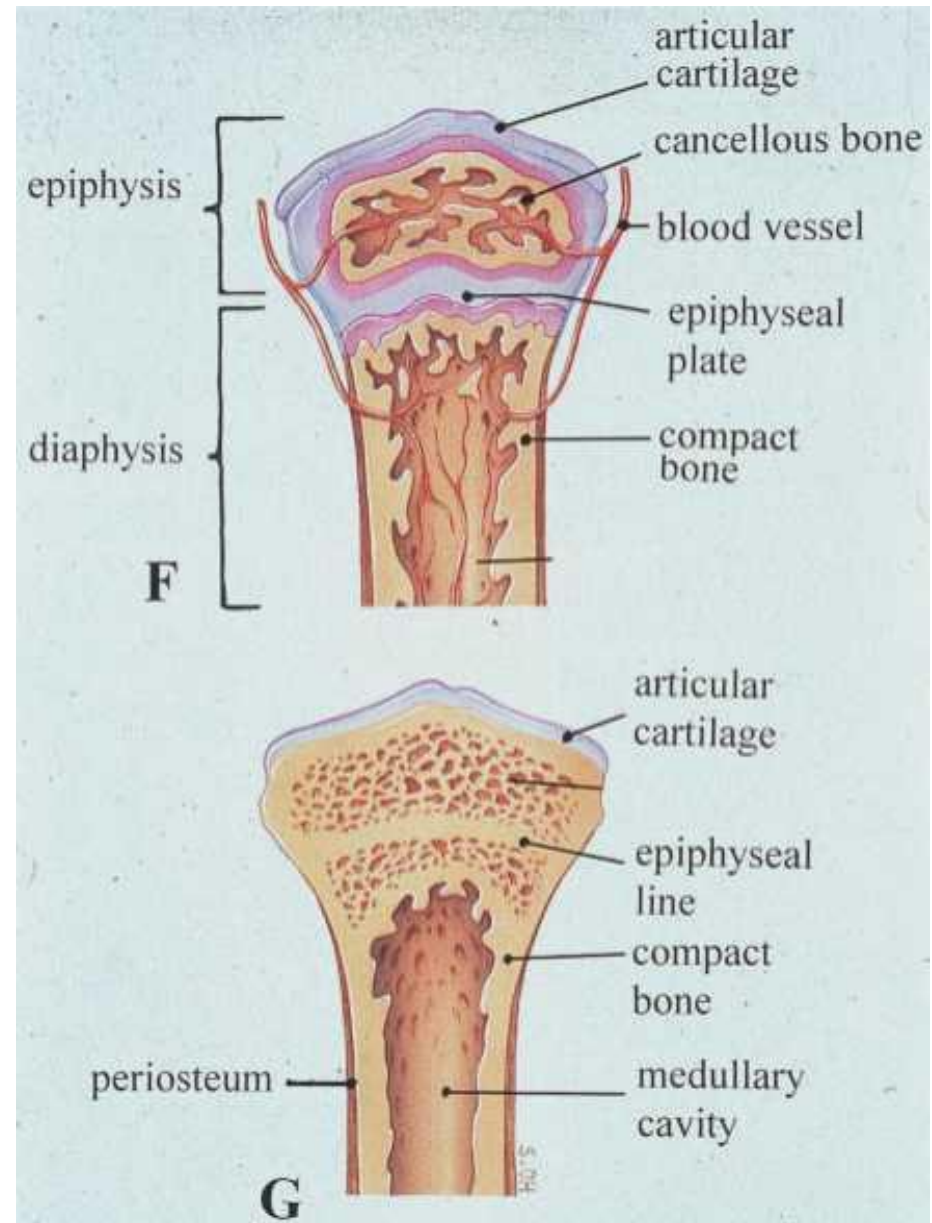


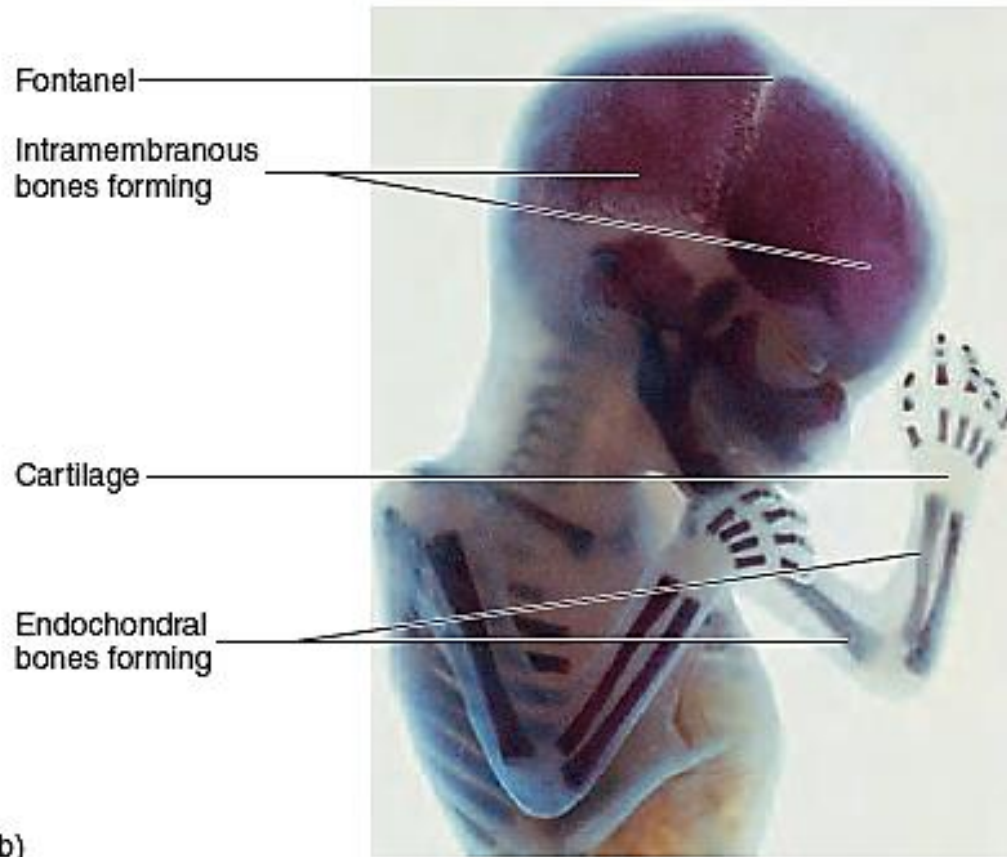
Source: Mescher AL: *Junqueira's Basic Histology: Text and Atlas, 12th Edition*: <http://www.accessmedicine.com>  
 Copyright © The McGraw-Hill Companies, Inc. All rights reserved.

- a. **Primary center (Punctum ossificatum primum)** - middle of long bone (diaphysis)
- b. **Secondary centers (Punctum ossificatum secundum)** - in both epiphyses at ends of long bone
- c. **Epiphyseal plate** - cartilage between epiphysis and diaphysis

# Bone growth plate – growth of bone in length

- Growth will continue to occur as long as any cartilage in epiphyseal plate remains. An x-ray will show if any remains.
- **Epiphyseal line** is all that is left after growth ceases and the epiphyseal plate disappears.





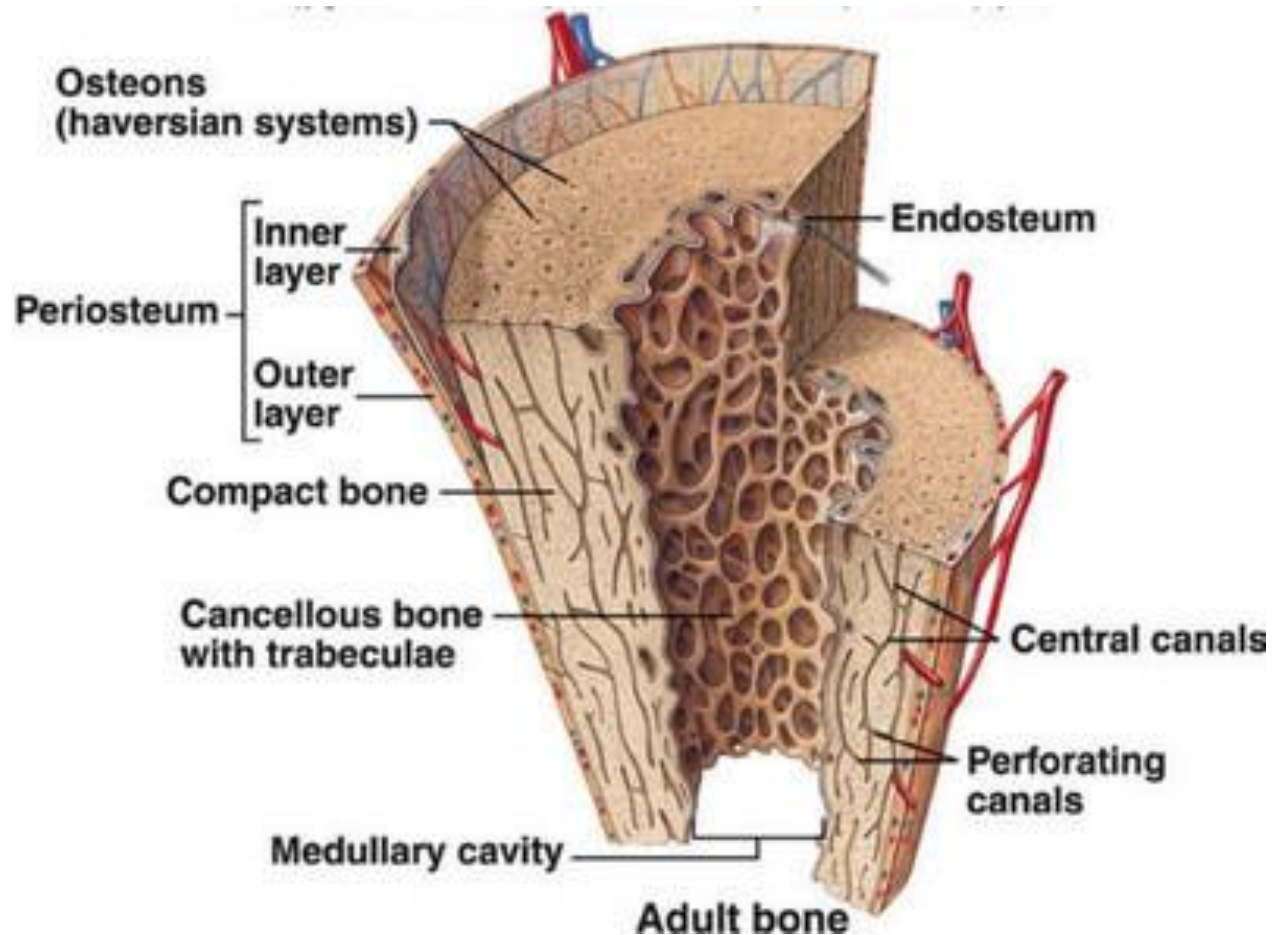
Radiograph of an 18-week-old fetus, showing intramembranous and endochondral ossification. Intramembranous ossification occurs at ossification centers in the flat bones of the skull. Endochondral ossification has formed bones in the diaphyses of long bones. The epiphyses are still cartilage at this stage of development.



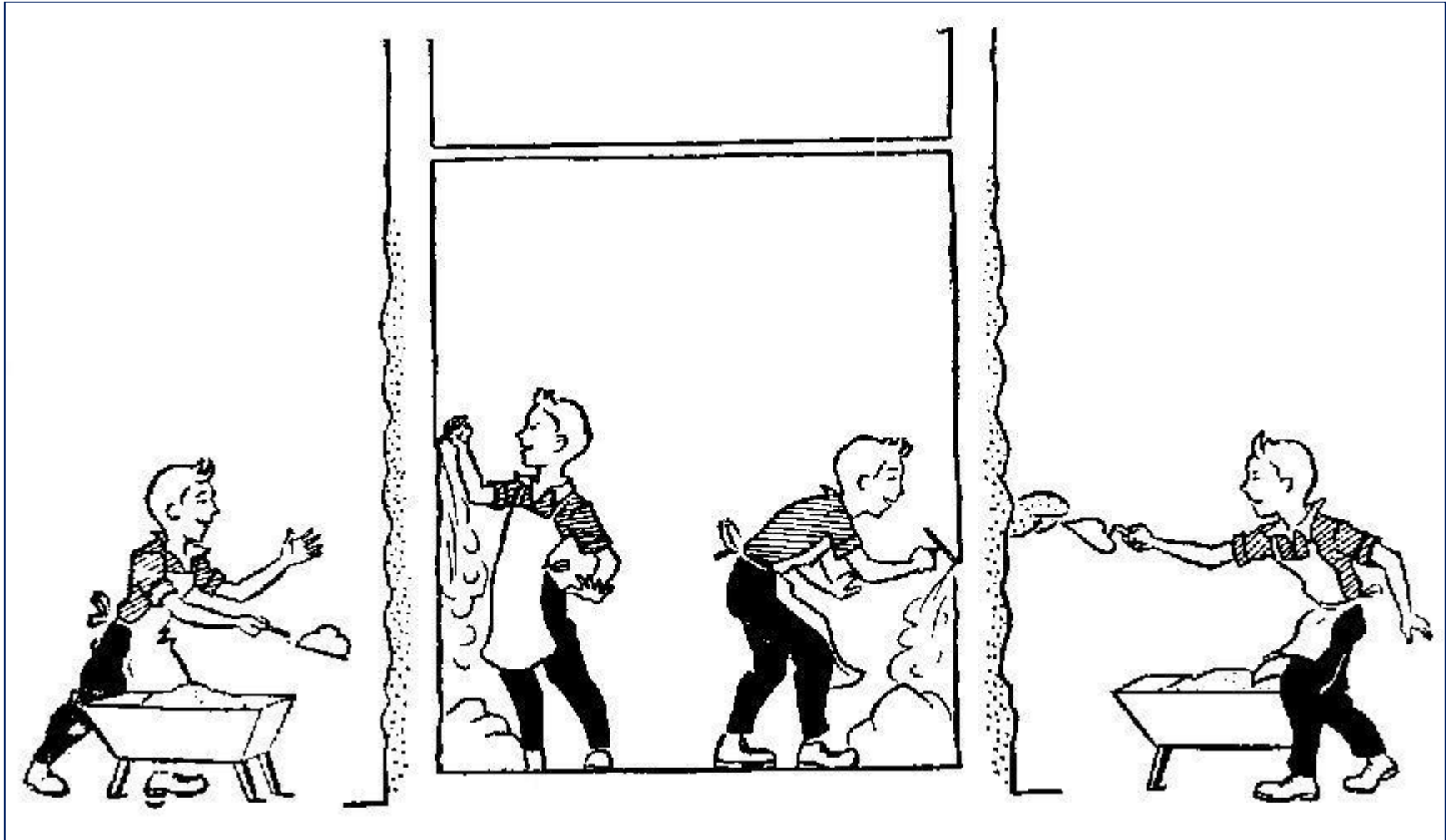
# Periosteum

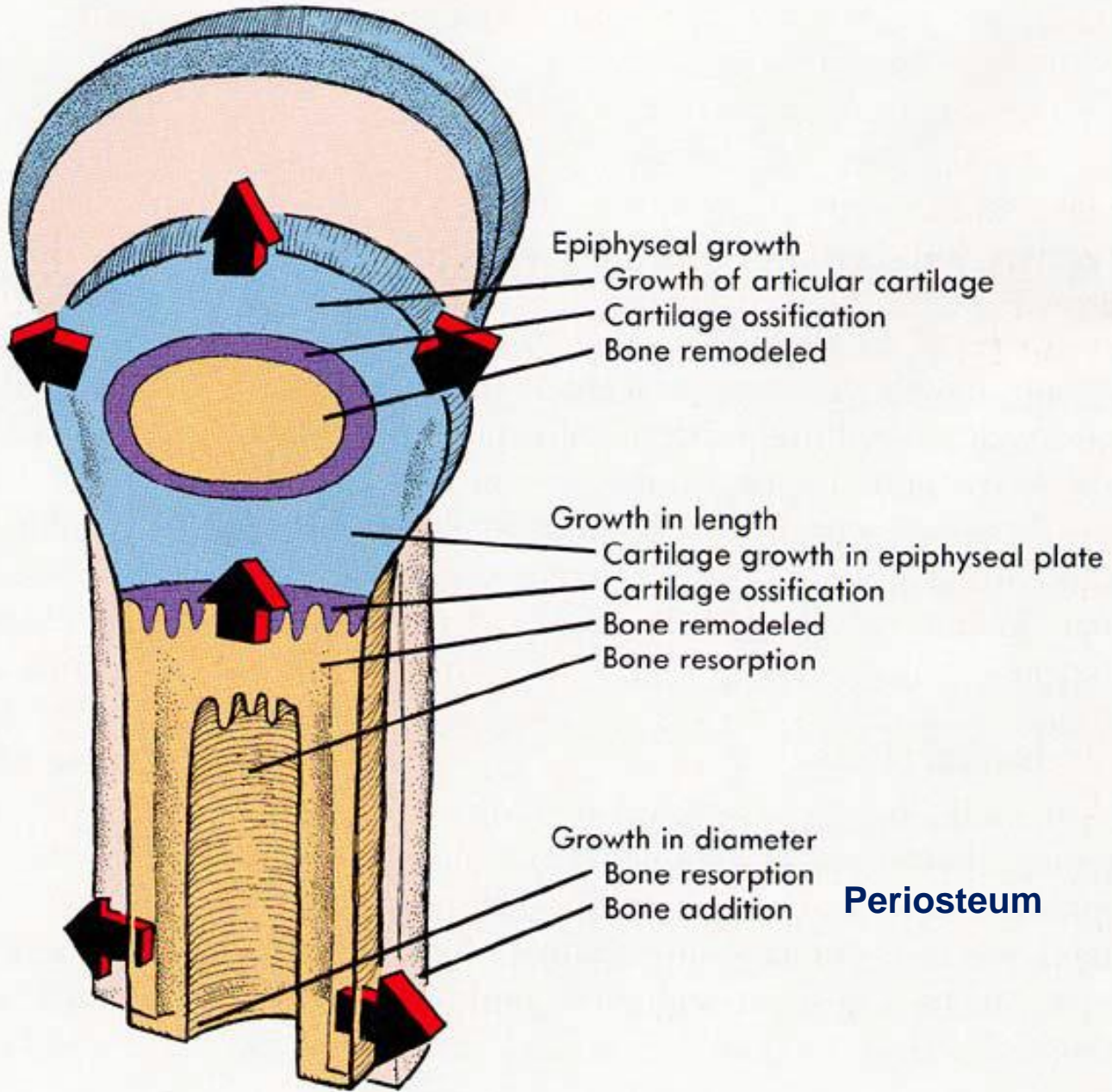
**Inner layer** –  
osteogenic cells  
(growth of bones  
in width)

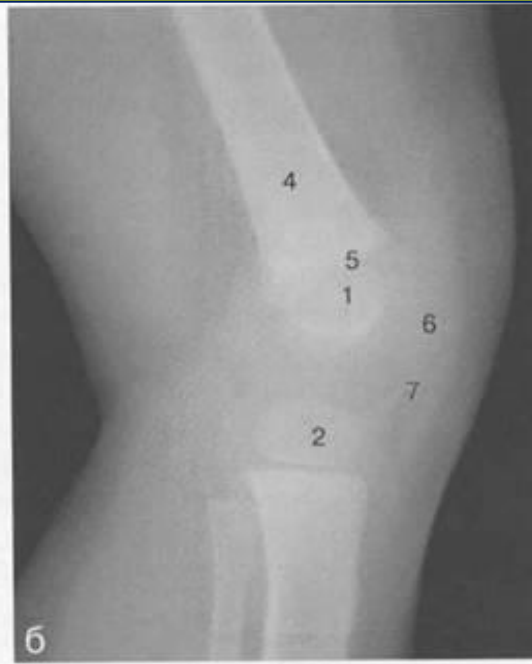
**Outer layer** –  
connective  
fibrous tissue



# Inside the bone – resorption of the bone – formation of the bone marrow cavity

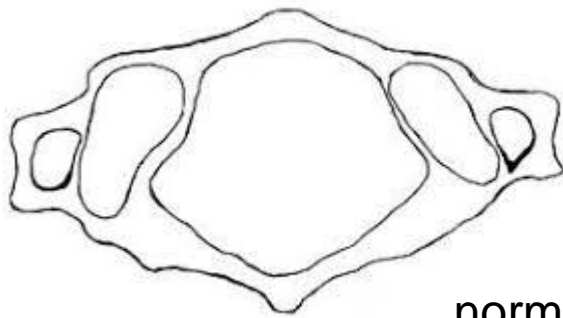




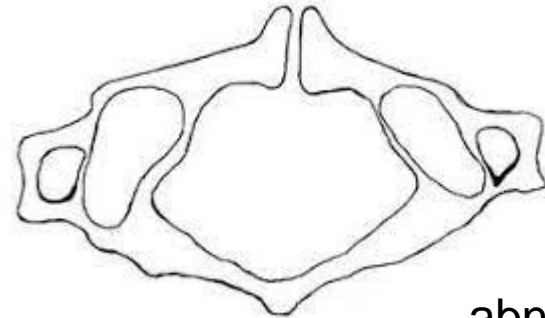




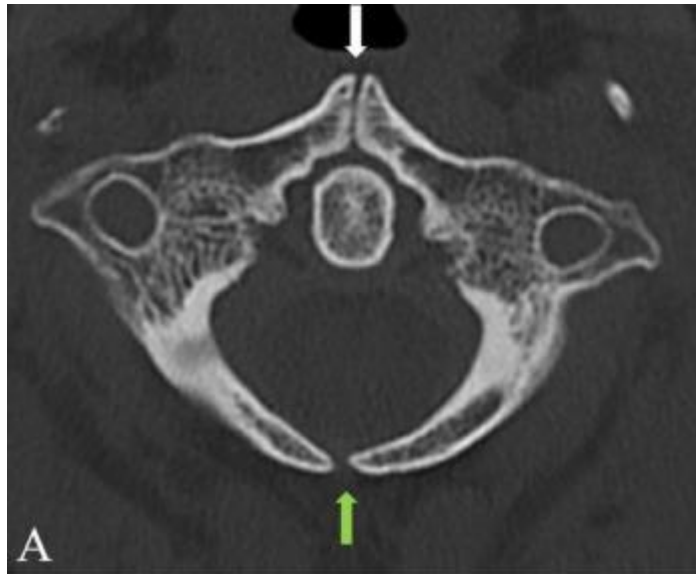
# "Split Atlas"



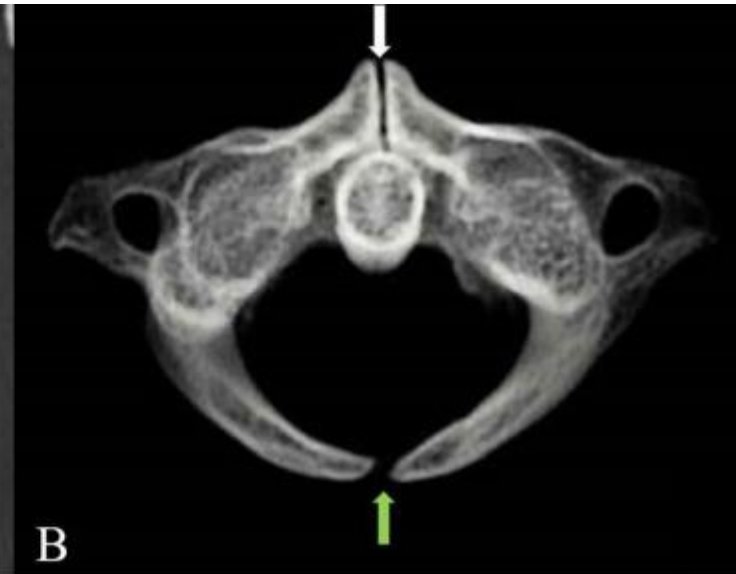
normal



abnormal



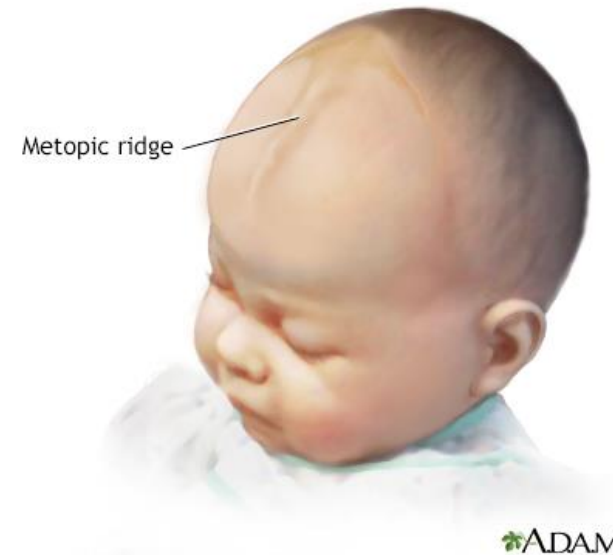
A



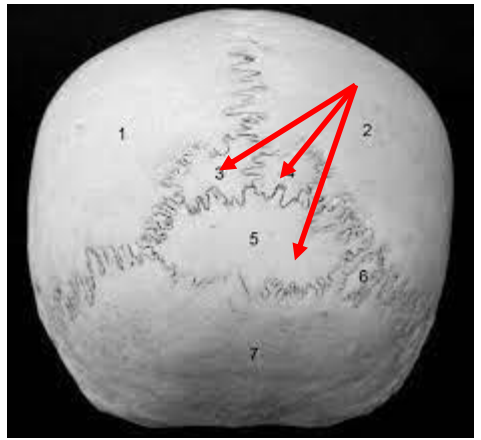
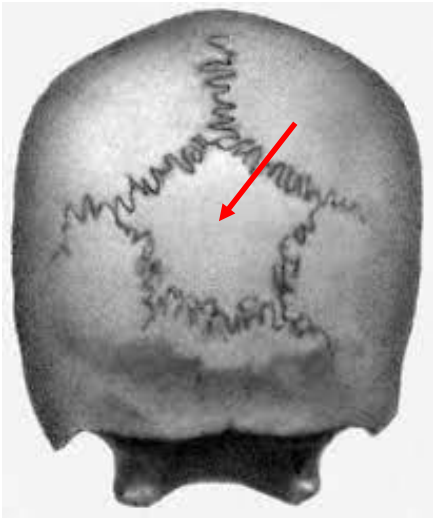
B

Rachischisis in both anterior (white arrow) and posterior (green arrow) arches

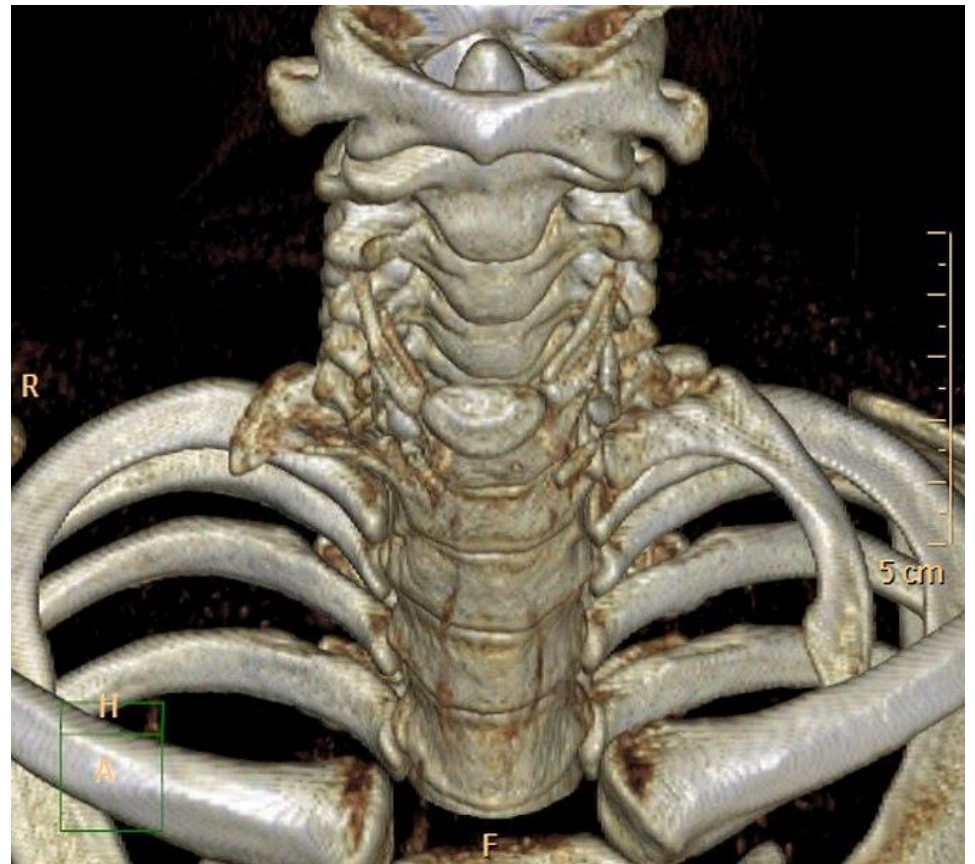
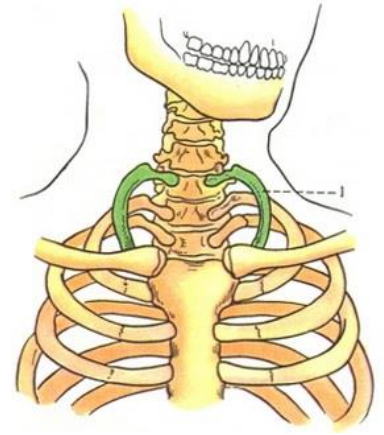
# Frontal bone – metopic suture



# “Inka bone” – preinterparietal bone



# Cervical rib





# Bone regeneration after fracture

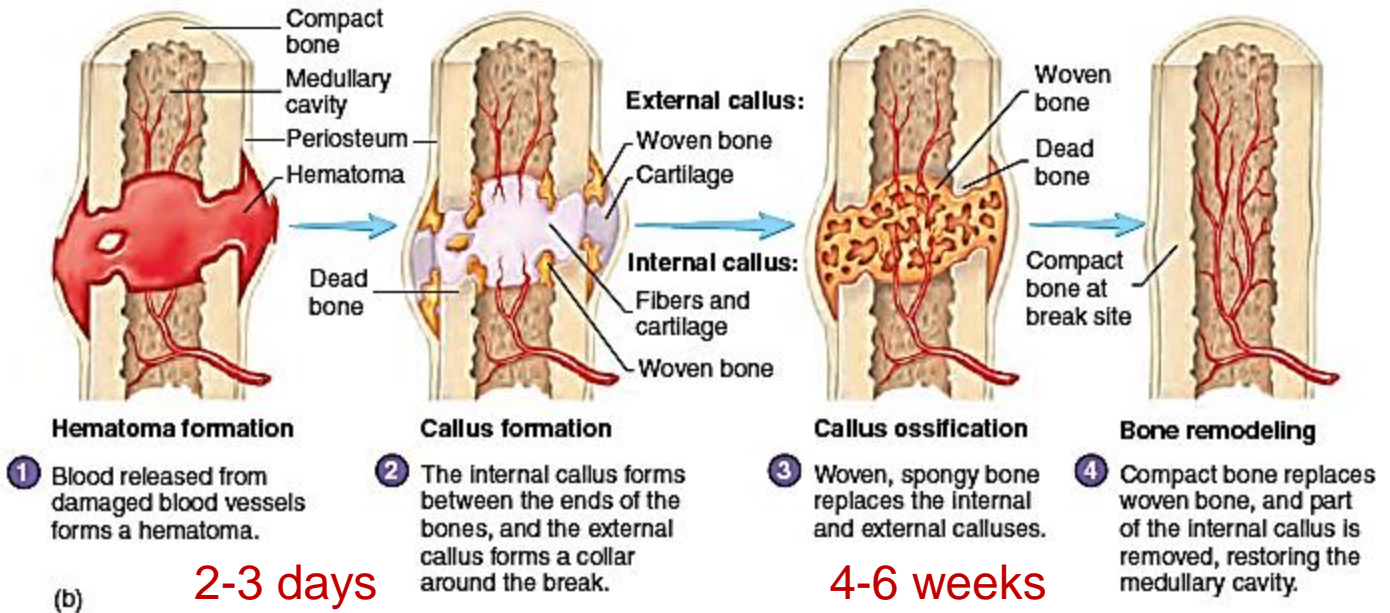


Broken humerus



Callus around broken humerus (at arrow)

(a)



PROCESS Figure 6.8 Bone Repair



Every year 10% of bone is renovated

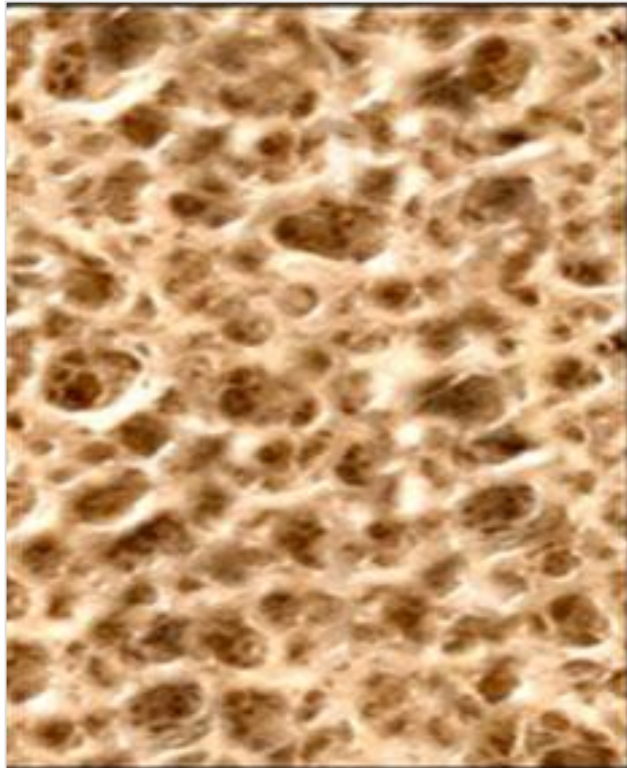










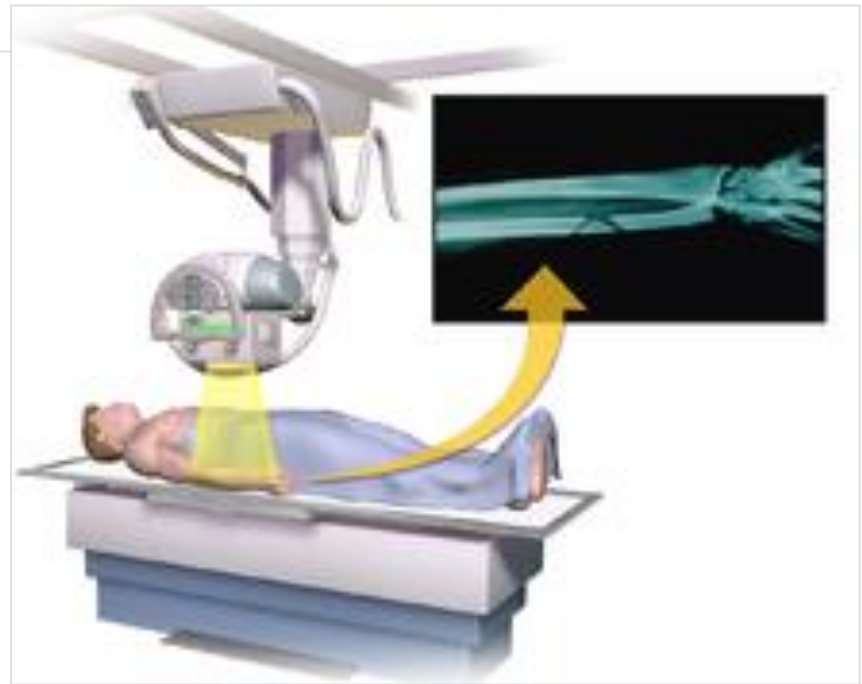


*Normal Bone*



*Osteoporosis*





## Wilhelm Conrad Röntgen

1895 – discovery of X-rays  
1901 – Nobel prize  
(first in physics)





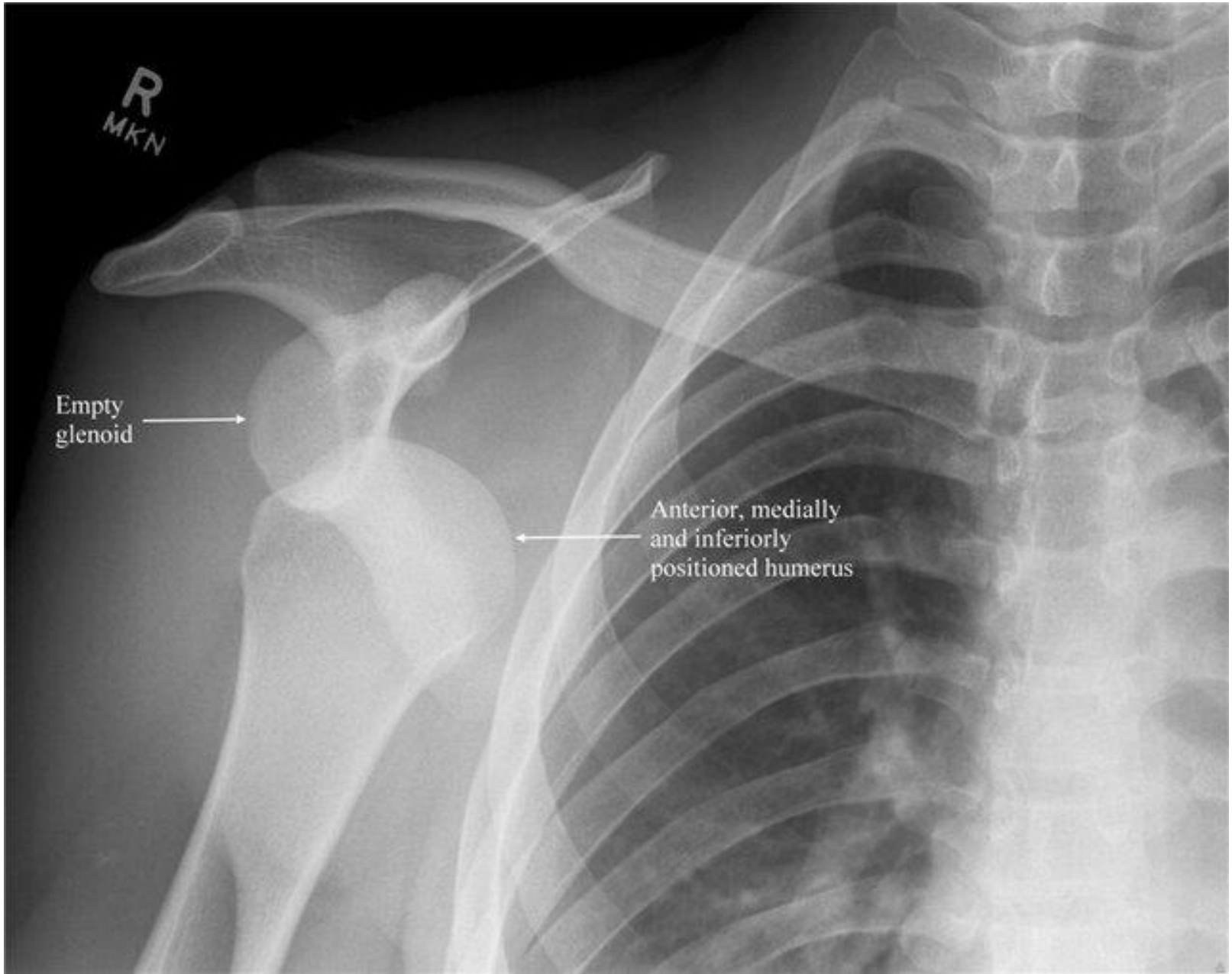




R  
MKN

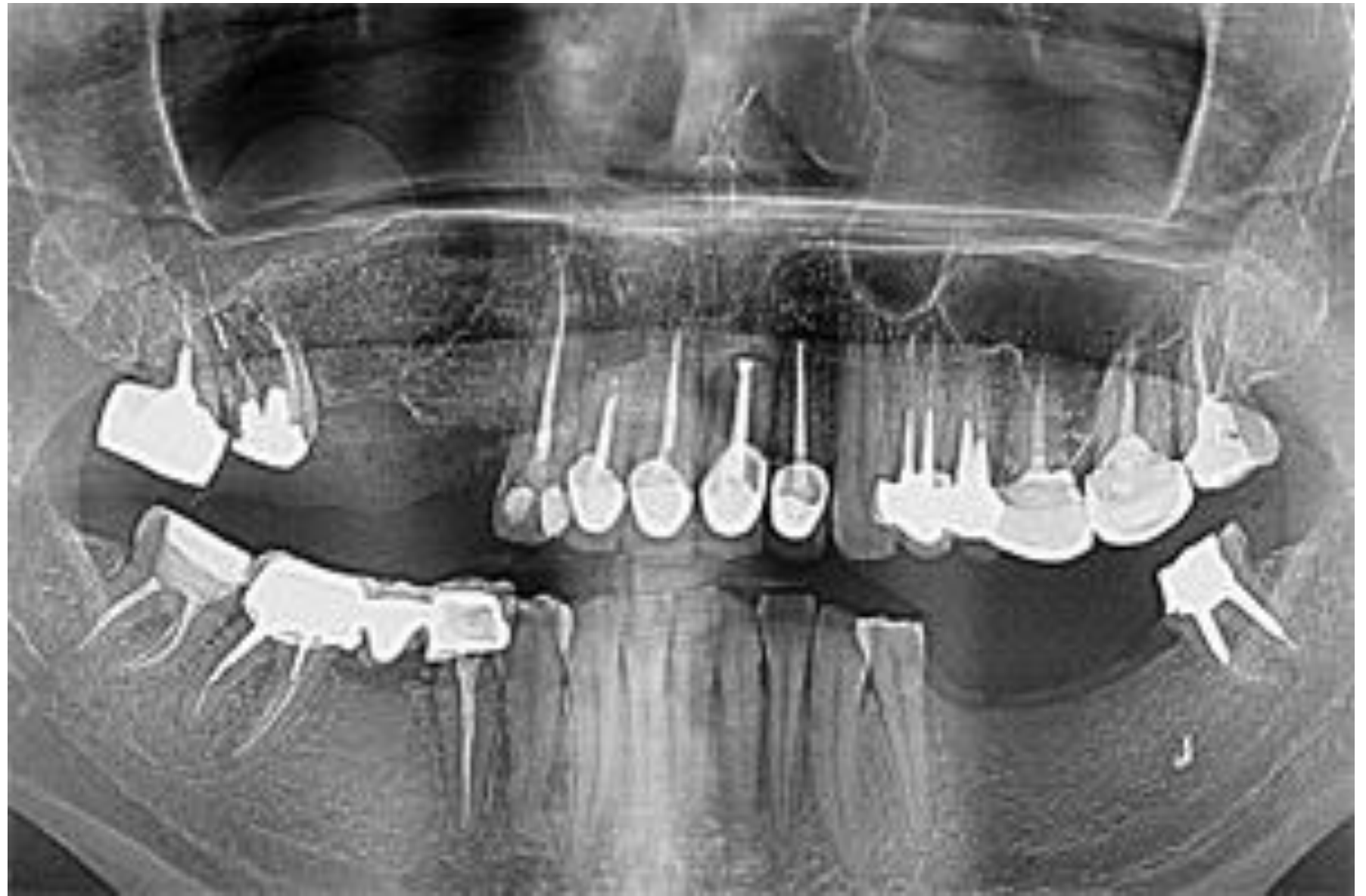
Empty  
glenoid

Anterior, medially  
and inferiorly  
positioned humerus



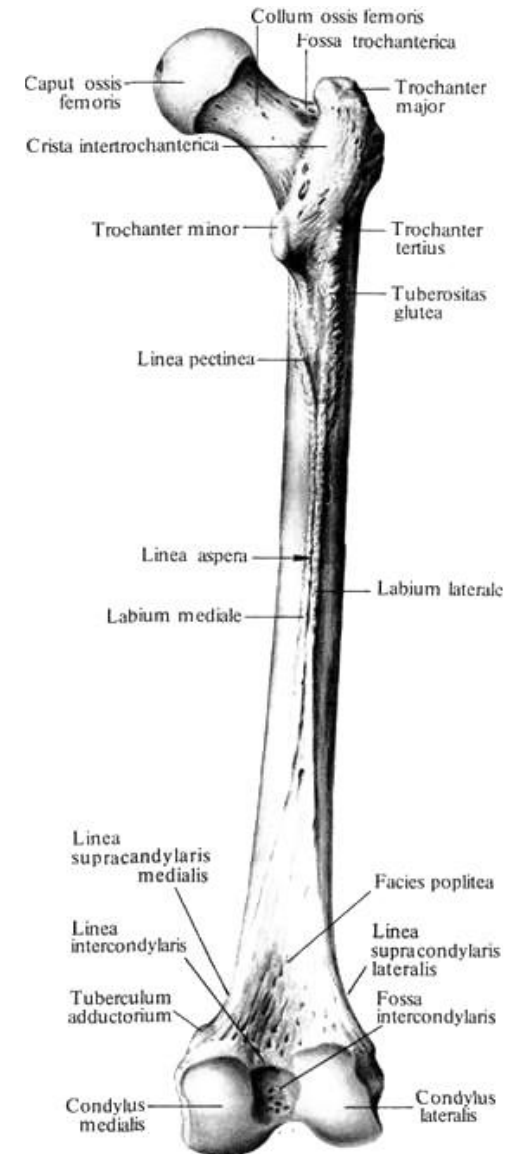




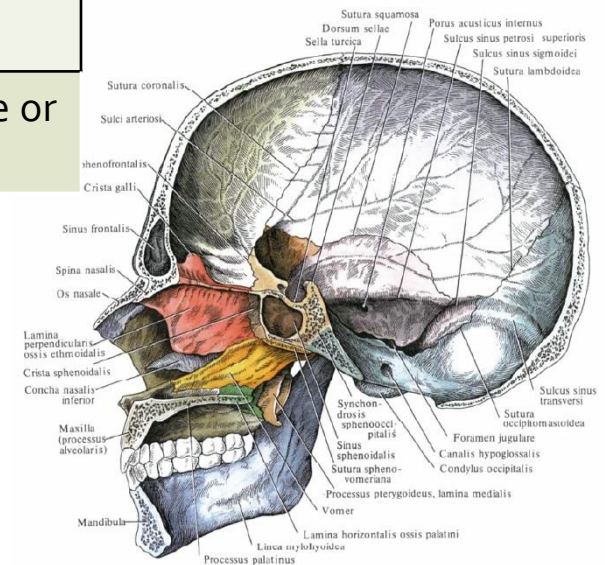
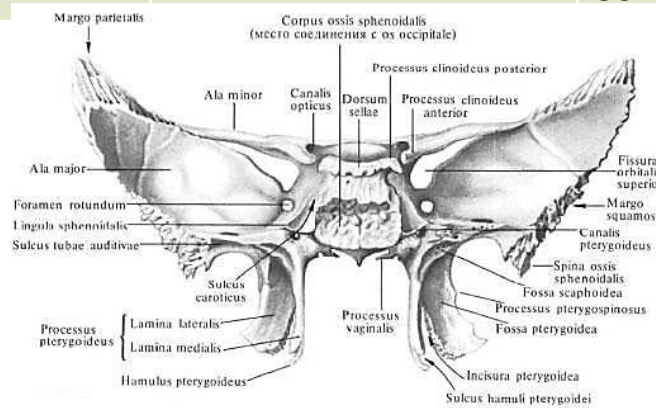
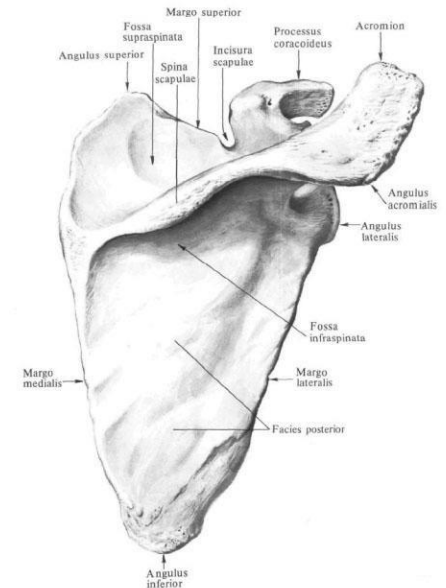


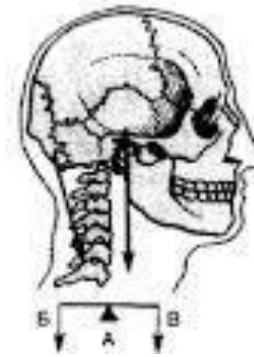
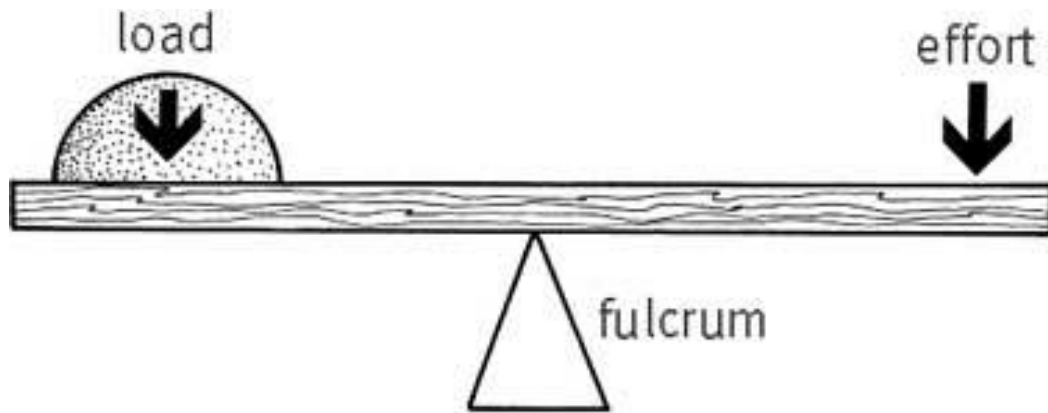


Latin	English	Meaning
<b>Corpus</b>	Body, shaft	Main portion
<b>Caput</b>	Head	Enlarged (often rounded) end
<b>Capitulum</b>	Head (small)	Small (often rounded) end
<b>Collum</b>	Neck	Constricted area between head and body
<b>Condylus</b>	Condyle	Smooth, rounded articular surface
<b>Facies</b>	Facet	Small, flattened articular surface
<b>Crista</b>	Crest	Prominent ridge
<b>Processus</b>	Process	Prominent projection
<b>Tuberculum</b>	Tubercle	Knob
<b>Tuberositas</b>	Tuberosity	Numerous tubercles
<b>Trochanter</b>	Trochanter	Large tuberosity found only on proximal femur
<b>Epicondylus</b>	Epicondyle	Enlargement near or above a condyle

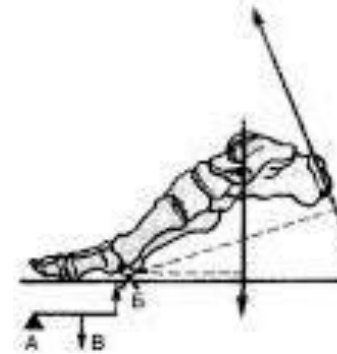
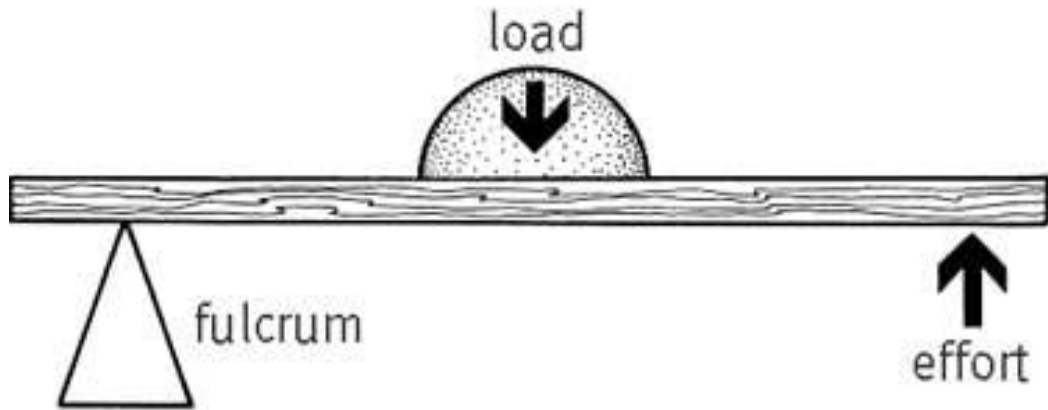


Latin	English	Meaning
Foramen	Foramen	Hole
Canalis, meatus	Canal, meatus	Tunnel
Fissura	Fissure	Cleft
Sinus	Sinus	Cavity
Fossa	Fossa	Depression (round shape)
Fovea	Fovea	Depression (oval shape)
Margo	Margin	Border
Angulus	Angle	Angle
Incisura	Notch	Incision on an edge or surface

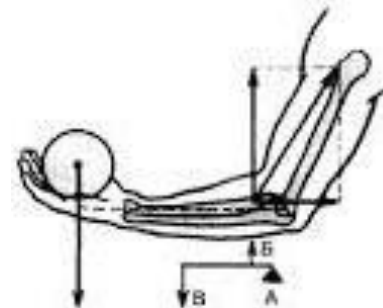
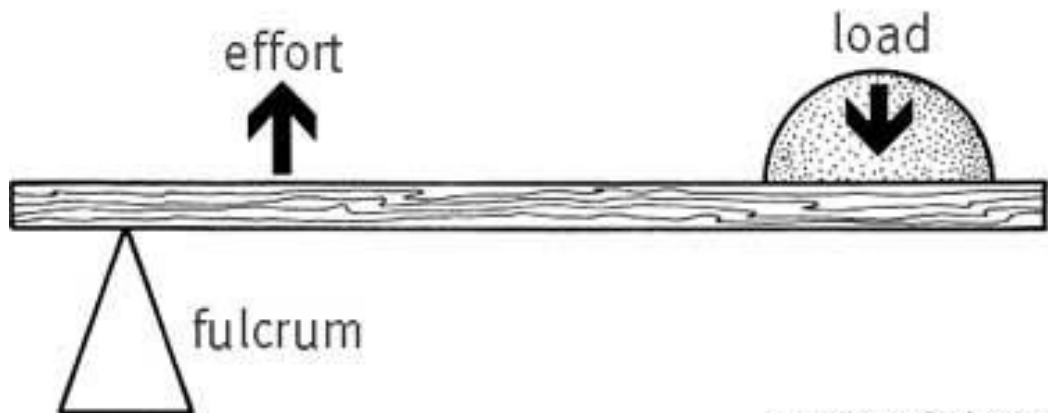




Equilibrium lever  
(First Class)



Power lever  
(Second Class)



Speed lever  
(Third Class)