



# General osteology

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# Plan (objectives):

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- ▶ Classification of bones
- ▶ Functions of bones
- ▶ Structure of bone. **Bone as an organ**
- ▶ Development of bones
- ▶ Anomalies (abnormalities) of bones



# What means?

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- ▶ Os
- ▶ Ossa
- ▶ Osteology
- ▶ Osteogenesis
- ▶ Osteomyelitis



*Os* – bone, *ossa* –bones

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**Osteology** (*os/osteo* = bone, *logos* = science) – science about structure and functions of bones.

**Osteogenesis** (*os/osteo* = bone, *genesis* = birth, formation) – bones forming.

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There are 206 bones in the skeleton of the adult as follows:

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- a) Axial skeleton (74 bones):** skull – 23,  
vertebral column – 26,  
ribs and sternum – 25.
- b) Appendicular skeleton (126 bones):**  
upper extremities – 64,  
lower extremities – 62.
- c) Auditory ossicles – 6 bones.**

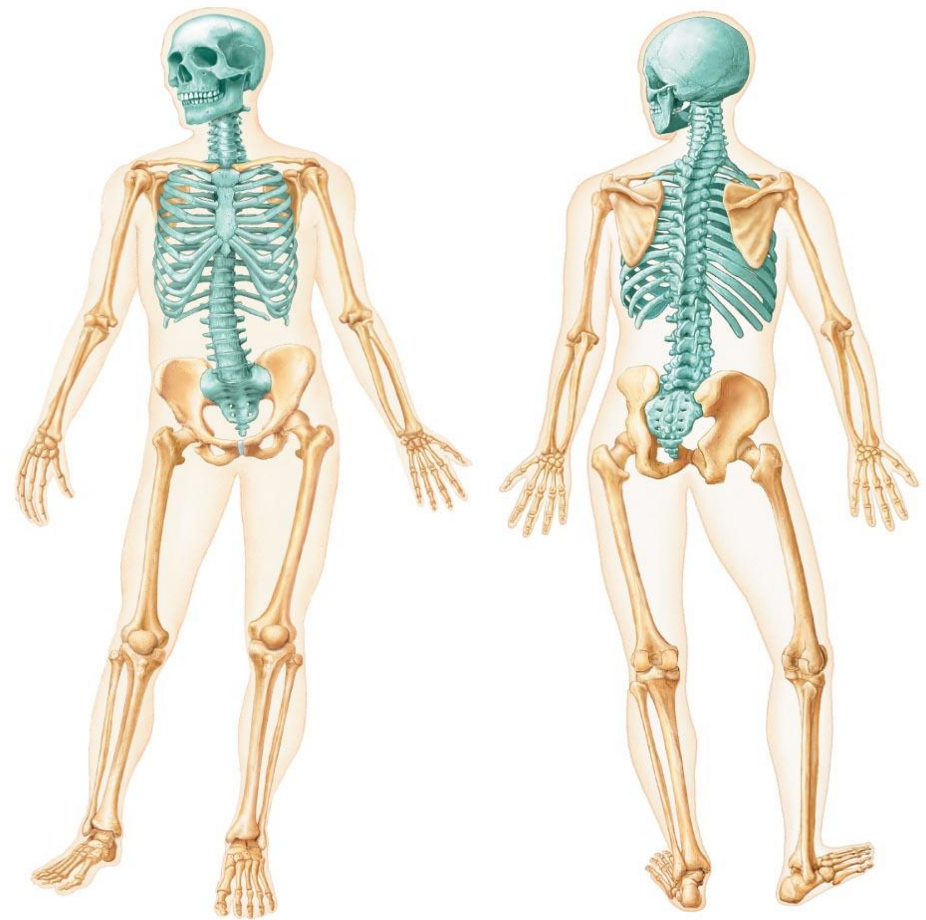


# Classification of bones

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▶ According to their position:

1. ***Axial skeleton*** (blue);
2. ***Appendicular skeleton*** (yellow).



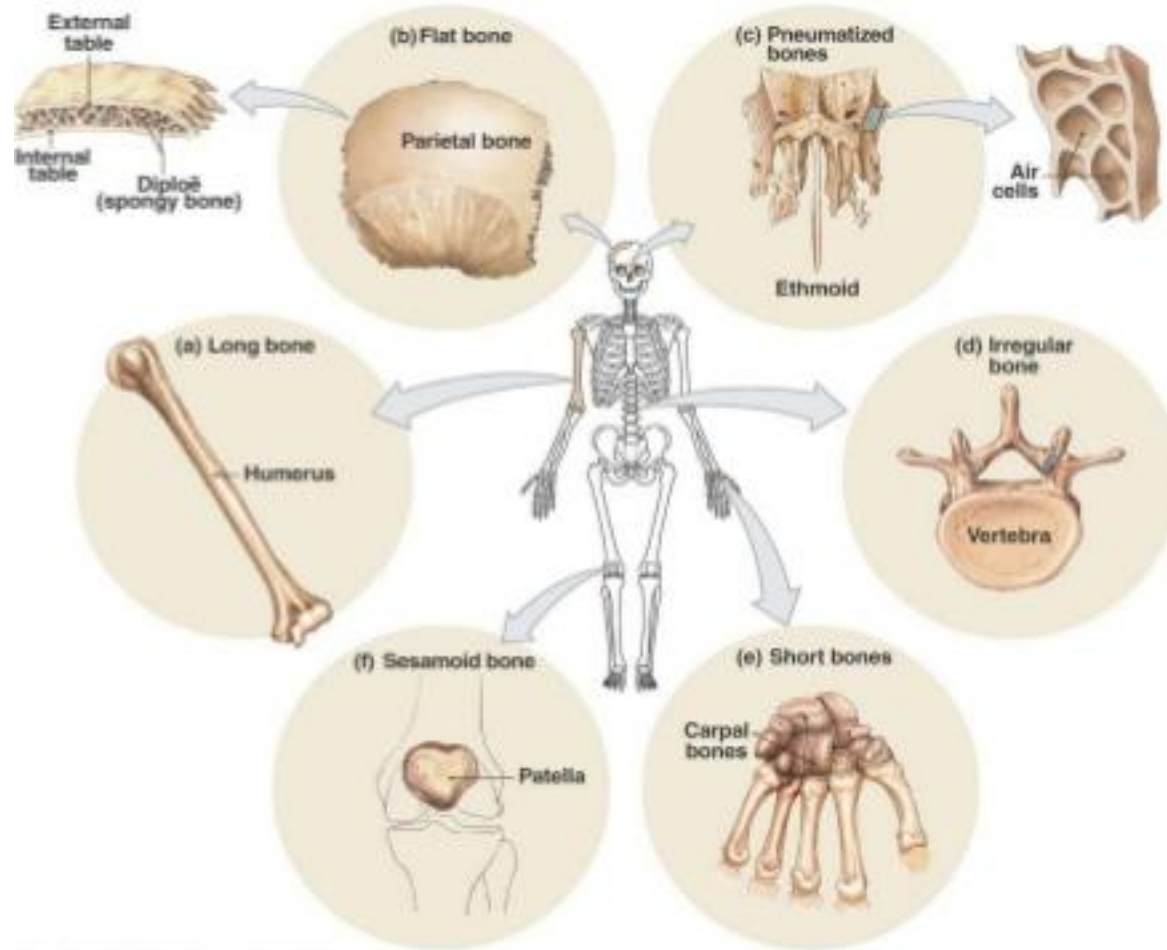
# Classification of bones

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- ▶ According to their shape (According to Terminologia Anatomica, 1998):
    1. **Long bones** are tubular in shape;
    2. **Short bones** are cuboidal in shape;
    3. **Flat bones** serve protective functions;
    4. **Irregular bones** have various shapes other than long, short or flat.
    5. **Pneumatized bones** contain air cavities (or cells).
    6. **Sesamoid bones** develop in some tendons of muscles, close to the joints.
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# Classification of bones





# Classification of bones

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▶ According to their shape and structure

1. ***Tubular bones*** (long and short)
2. ***Spongy bones*** (long, short and sesamoid)
3. ***Flat bones*** (skull and girdle bones)
4. ***Mixed bones***
5. ***Pneumatized bones***



# 1. Tubular bones

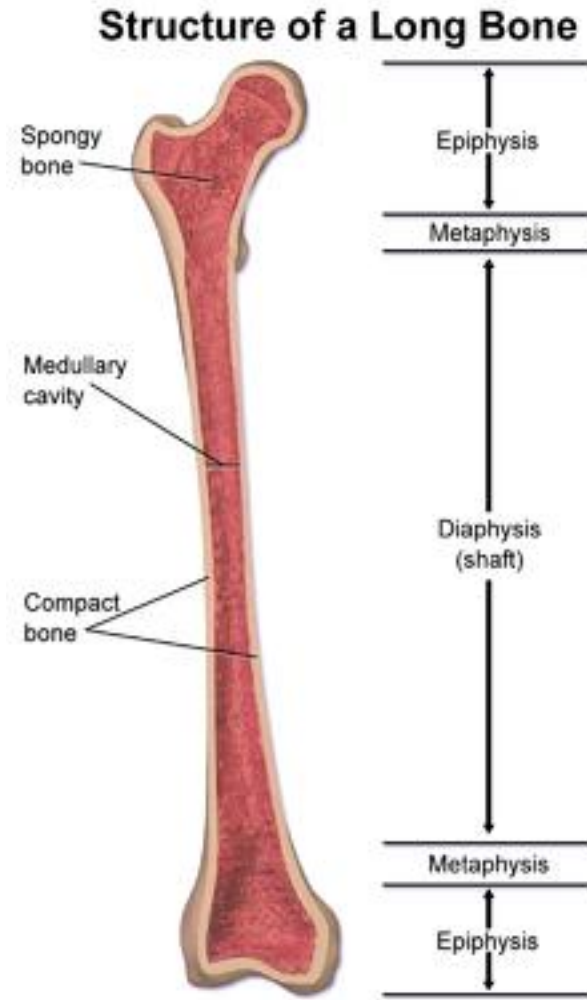
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- a) **Long tubular bones** (*biepiphyseal bones*):
- *humerus, ulna and radius,*
  - *femur, tibia and fibula;*
- b) **Short tubular bones** (*monoepiphyseal bones*):
- *metacarpals (I-V);*
  - *metatarsals (I-V),*
  - *phalanges.*



# Parts of a long tubular bone

1. **Body (shaft) or *diaphysis*** (composed of compact bone);
2. **Two ends or *epiphyses*** (composed mostly of spongy bone);
3. ***Metaphysis*** the portion between epiphysis and diaphysis.



## 2. *Spongy bones*

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### a) **Long spongy bones:**

- *ribs;*
- *sternum;*

### b) **Short spongy bones:**

- *carpal bones;*
- *tarsal bones;*

### c) **Sesamoid bones** (resemble sesame seed):

- *patella;*
- *pisiform bone;*
- *sesamoid bones of the fingers and toes.*



### 3. Flat bones

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- a) **Flat bones of the skull**  
(frontal, parietal, nasal and lacrimal bones, vomer);
  
- b) **Flat bones of the girdles**  
(scapula and hip bone).



## 4. *Mixed bones*

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**Mixed bones** are formed by the fusion of several parts, which differ in function, structure and development:

- ***bones of the base of the skull*** (*occipital, temporal, sphenoidal and ethmoidal bones*);
- ***vertebrae***;
- ***clavicle***.

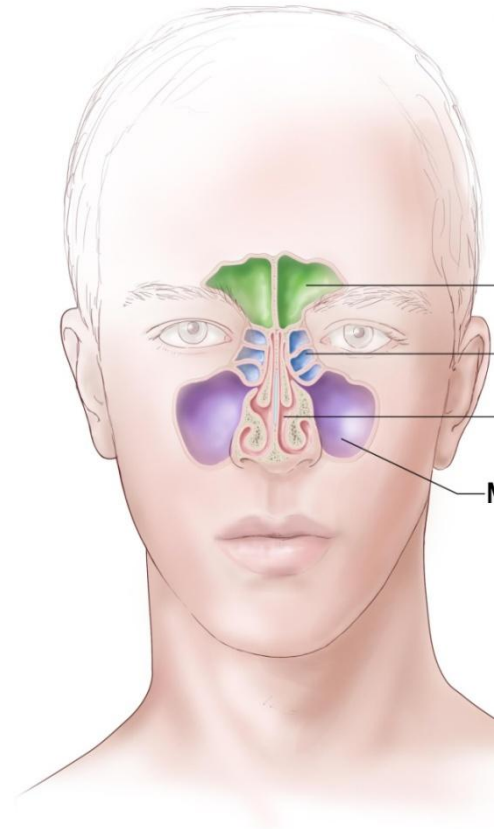


## 5. *Pneumatized bones*

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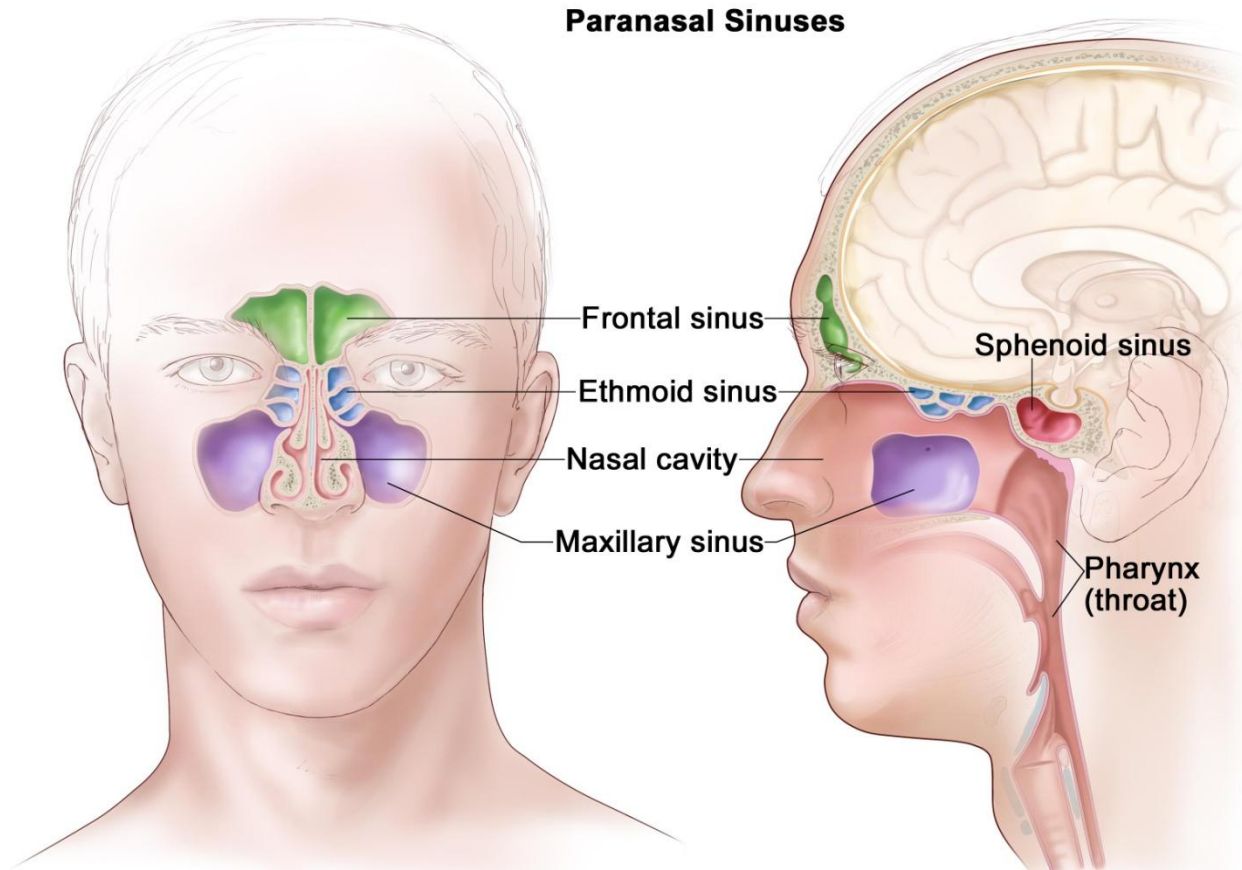
**Pneumatized** are **bones** which are hollow or contain many air cells or a cavity filled with air:

- ✓ **frontal bone** (*frontal sinus*);
- ✓ **sphenoidal bone** (*sphenoidal sinus*);
- ✓ **ethmoidal bone** (*ethmoidal sinus*);
- ✓ **maxilla** (*maxillary sinus*);
- ✓ **temporal bone** (*mastoid cells*).



Paranasal sinuses are filled with air and these bones are pneumatized.

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# *The significance of the skeleton*

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## ▶ **Mechanical functions:**

1. **Protection.** Bones such as skull, vertebral column, thoracic cage and pelvis protect the CNS and internal organs.
2. **Support.** Bones provide the framework for the attachment of muscles and other soft tissues.
3. **Movement** is possible because the bones have the structure of long and short levers connected by mobile articulations.



# *The significance of the skeleton*

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## ▶ **Biological functions:**

1. **Mineral storage** (the skeleton is a reservoir of mineral salts: calcium, phosphorus, iron etc.).
2. Function of **hematopoiesis** (blood cells production) since the bone marrow is located within the bones.
3. **Energy storage** (lipids stored in adipose cells of the yellow bone marrow serve as an energy reservoir).



# *The chemical composition of bone*

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Bone matter consists of two types of chemical material:

1. **organic**, mainly **ossein**, which determines the **elasticity** of bone;
2. **inorganic**, mainly **calcium salts** (calcium phosphate, in particular) which determines the strength (**hardness**) of bone.



## *The age changes in bone*

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- ▶ ***The bones of children*** contain comparatively **greater** amounts of **ossein**, are marked by greater pliability, and their **fractures are** consequently **rare**.
- ▶ ***In old age***, when the proportion of the organic and inorganic materials changes in favour of the latter, bones become less elastic and more fragile. As a result, bone **fractures are** encountered most **frequently** in person of old age.

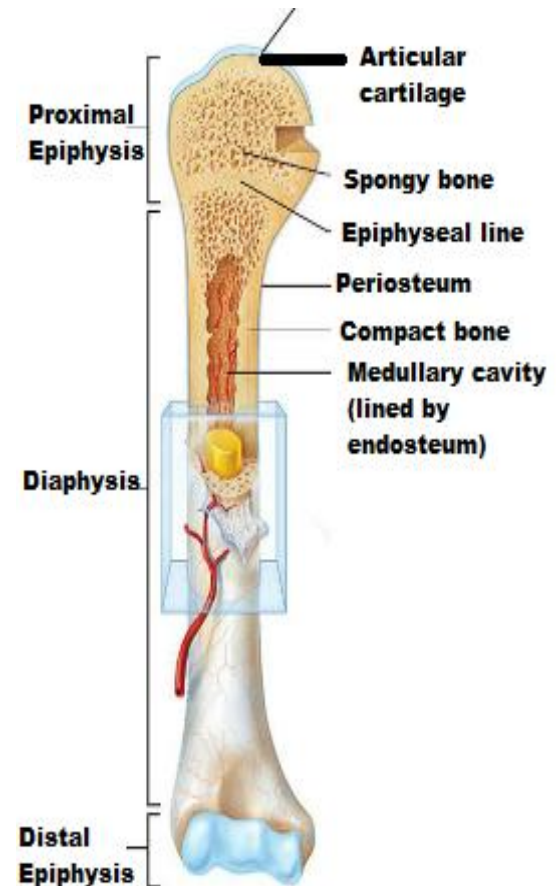


# *The structure of bone*

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**Bone as an organ** consists of  
**(several tissues):**

1. the ***bone tissue*** forming the main mass of the bone;
2. the ***periosteum***;
3. the ***articular cartilage***;
4. the ***bone marrow***;
5. the ***nerves and vessels***.

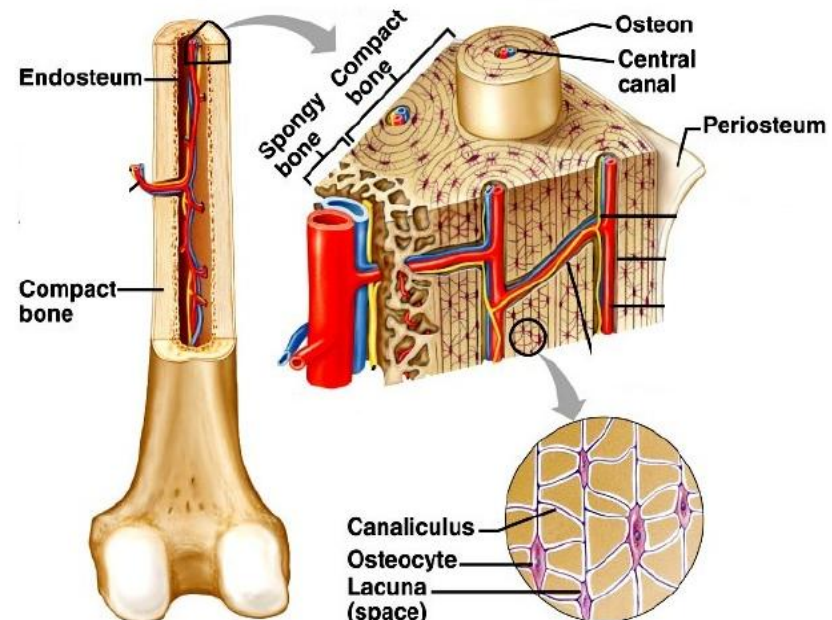


# The macroscopic structure of bone

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Two types of bone substance  
(tissue):

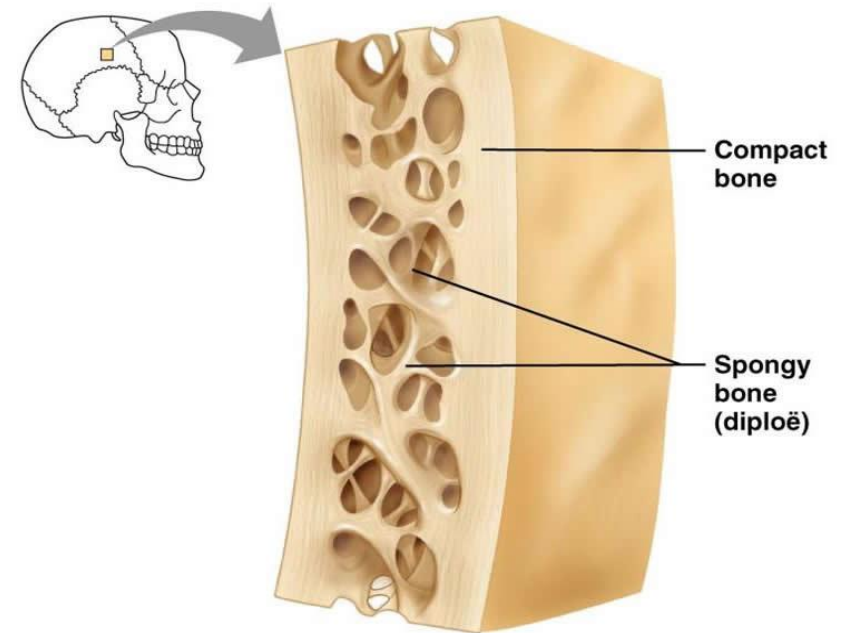
1. **compact substance** (dense like ivory);
2. **spongy** (trabecular, or cancellous) **substance** (honeycombed by large cavities).



# The macroscopic structure of bone

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- ▶ The **flat bones** perform mainly protective functions and consist of **two plates of compact bone** with spongy bone (**diploë**) between them.

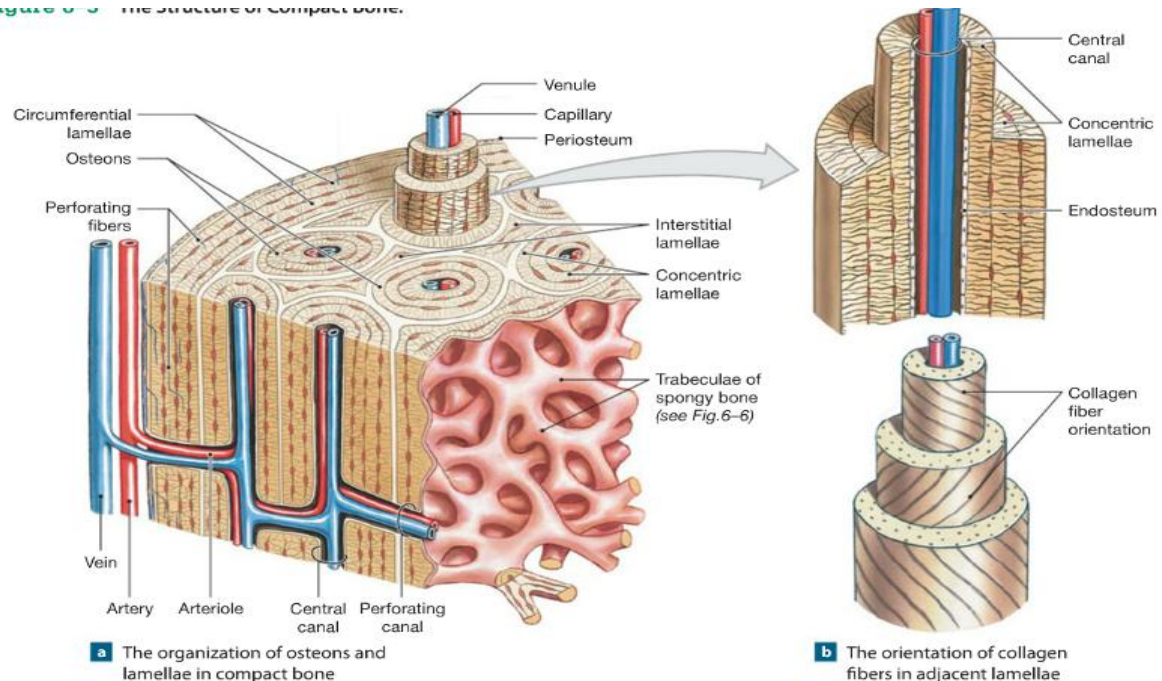


# The microscopic structure of bone

The **structural unit of bone** is the **osteon** or the **Haversian system**:

- bone (concentric) lamellae;
- central or Haversian canal containing vessels and nerves.

Figure 6-5 The structure of compact bone.

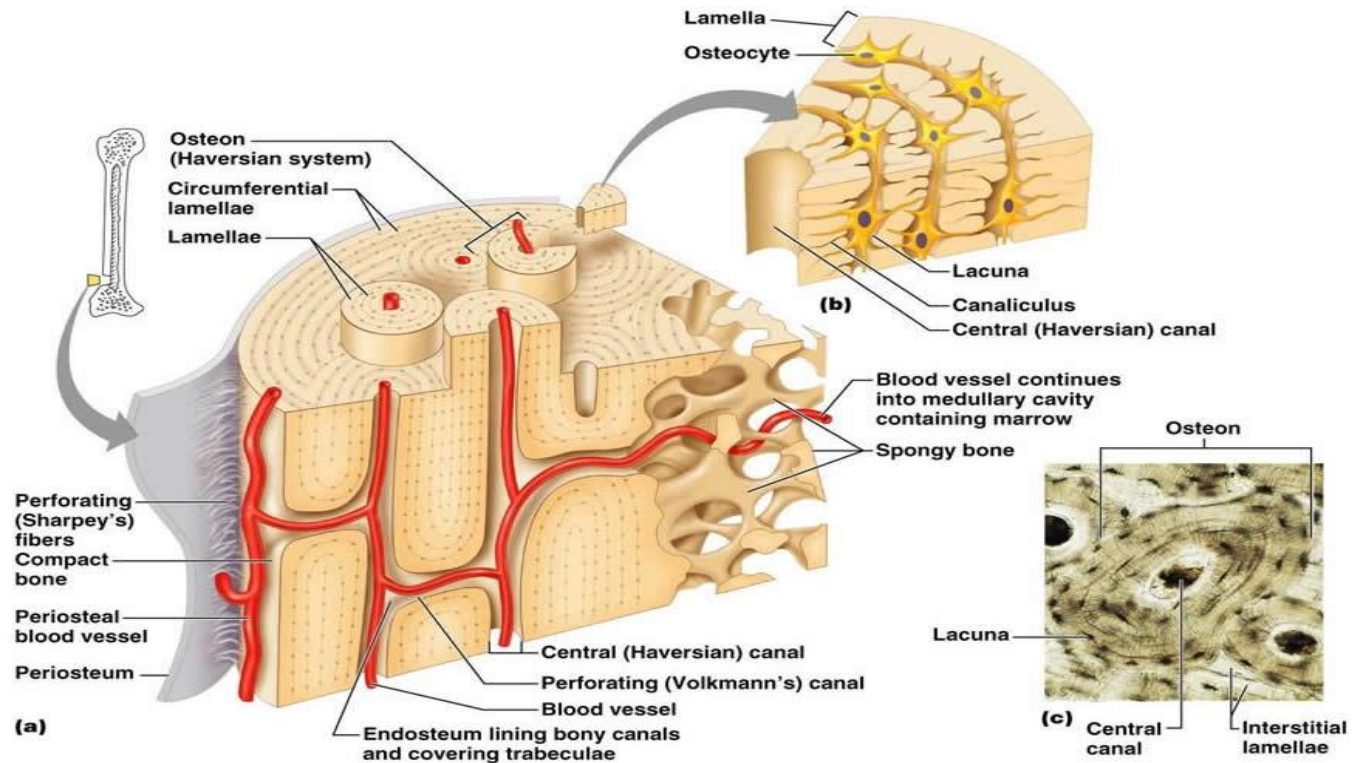




# *The microscopic structure of bone*

There are **21 million osteons** in the adult skeleton.

Haversian canals communicate with each other via perforating channels called ***Volkman`s canals***.



## *Types of bone cells*

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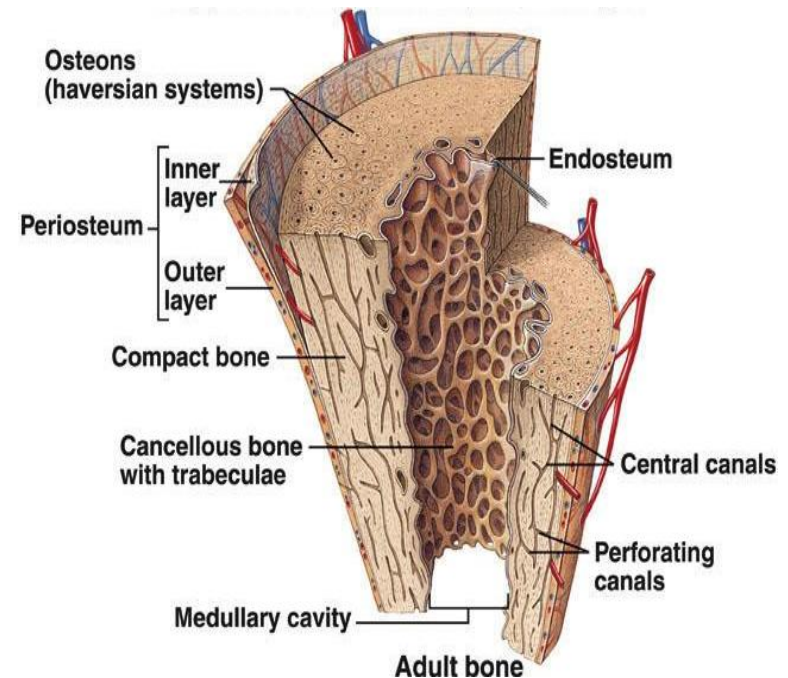
- ▶ **Osteoblasts** – bone-forming cells.
- ▶ **Osteocytes** – mature bone cells (reside inside spaces called *lacunae*).
- ▶ **Osteoclasts** – bone-destroying cells.



# The periosteum

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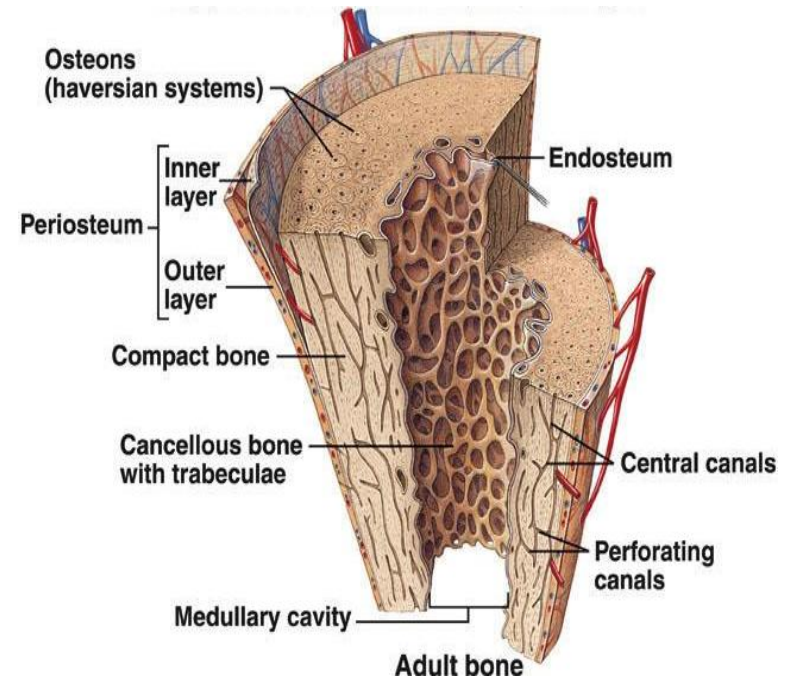
- ▶ The **periosteum** is a thin, strong **connective-tissue membrane**, which surrounds the bone on the outer surface.
- ▶ It consists of two distinct layers:
  1. **outer, fibrous layer;**
  2. **inner, bone-forming (osteogenic or cambium) layer.**



# The endosteum

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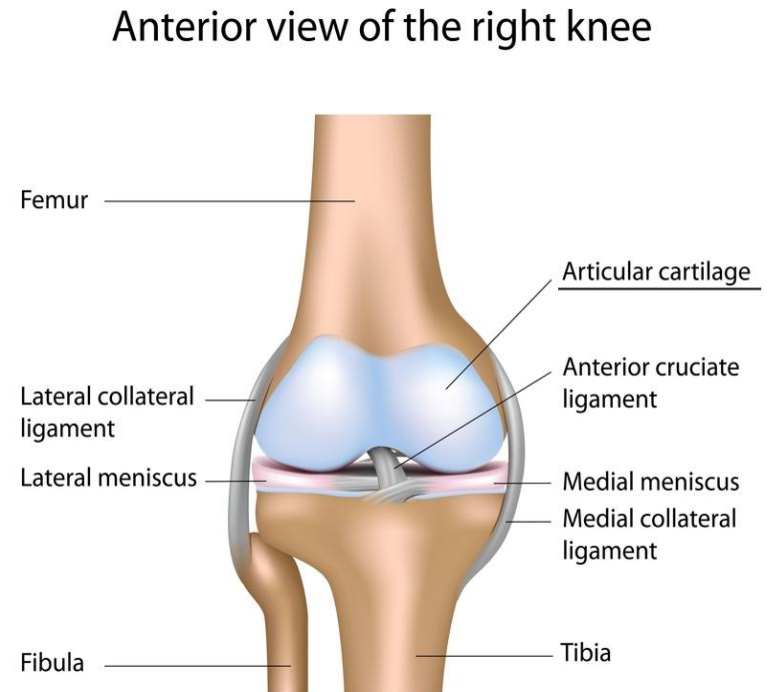
- ▶ The inner surface of bone is lined by endosteum.
- ▶ The **endosteum** is a thin **layer** which lines all the internal (**medullary**) **cavities** of bone including the **Haversian and Volkmann's canals**.



# The articular cartilage

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- ▶ The smooth **articular surfaces** of bone are free of the *periosteum* and are covered by the **articular cartilage**.
- ▶ It is made of hyaline cartilage, which reduces friction on the joint surfaces and have no blood vessels.



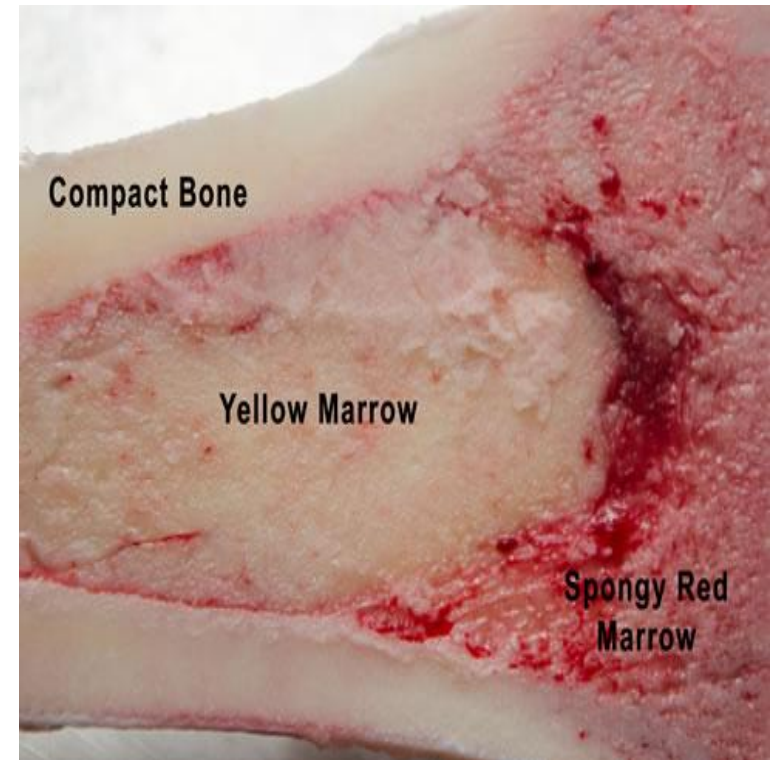
# *The bone marrow*

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All the internal spaces of the bone are filled with **marrow** (*medulla ossium* or *myelos*).

There are two types of bone marrow:

1. **Red bone marrow** concerned with *hematopoiesis* and *bone formation*;
2. **Yellow bone marrow** mainly composed of fat cells.

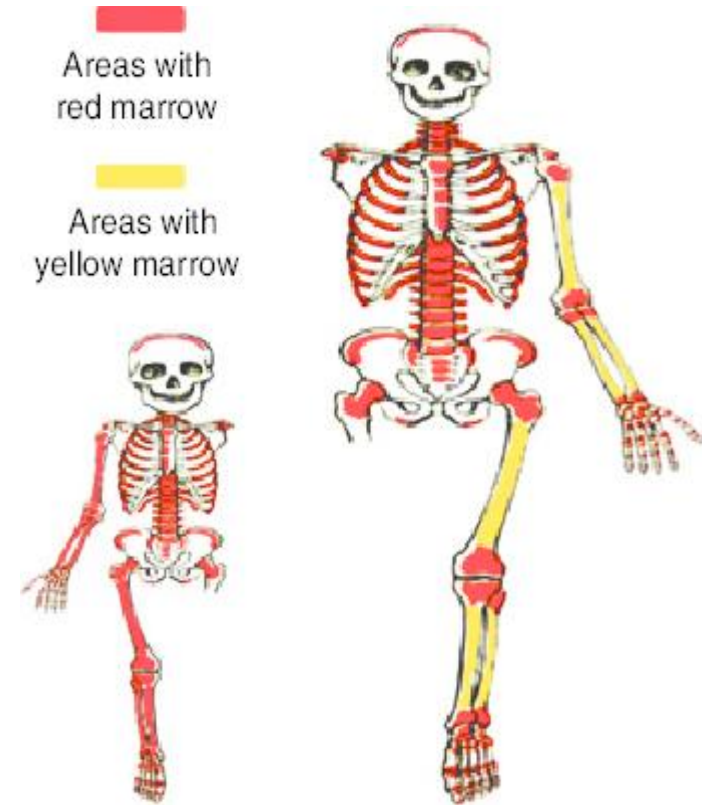


# The bone marrow

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- ▶ **Red bone marrow** is located in the **trabecular cavities of the spongy substance** in the flat bones, spongy bones and in the epiphyses of the tubular bones.
- ▶ **Yellow bone marrow** is located in the **medullary cavities** of the diaphyses of the tubular bones.

PS. The newborns have only the red bone marrow.



# The nerves and vessels

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- ▶ The periosteum is rich in **nerves** and **vessels** which contribute to the nutrition of the bone.
- ▶ Blood vessels penetrate the bone through numerous **nutrient foramina** (*foramina nutricia*).



Figure 4. Shaft of Ulnae showing Nutrient Foramina





## *The development of bones*

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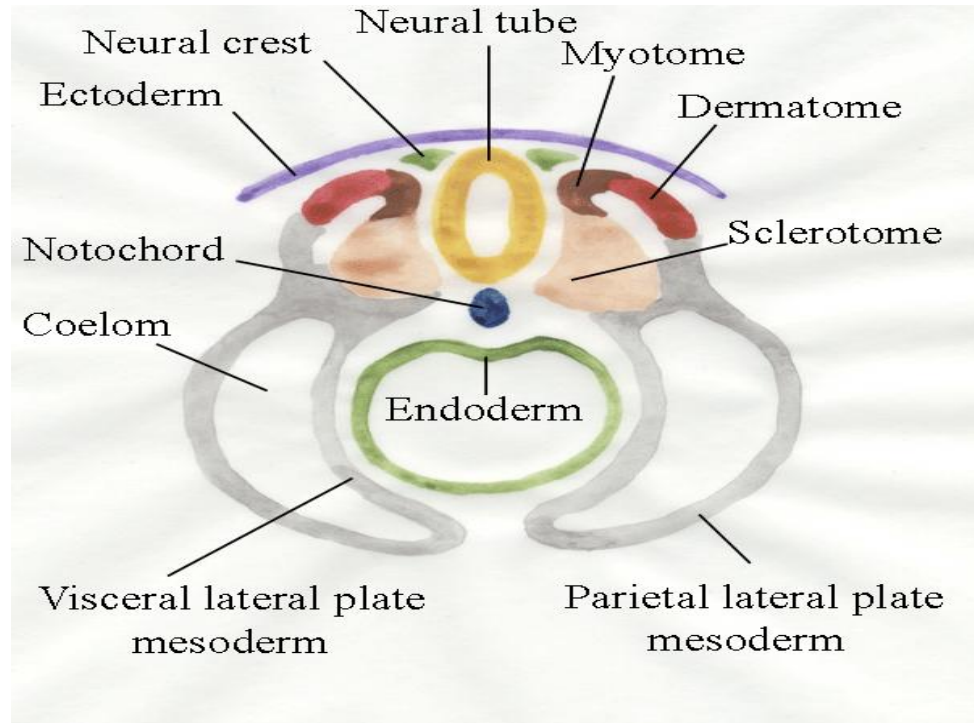
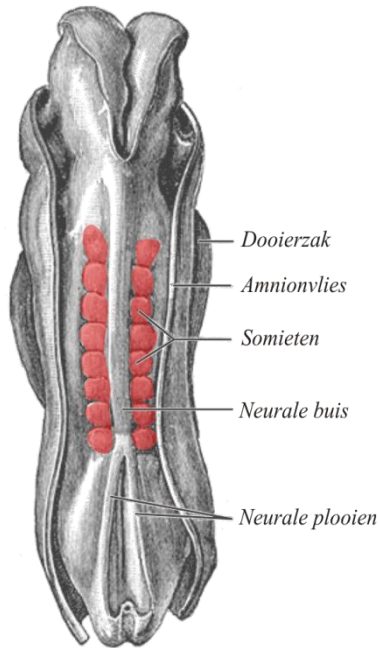
The bones develop from the dorsal part of **mesoderm**. It forms **40-44 pairs of somites**.

Each **somite** differentiates into 3 parts:

- a) **sclerotome**, which gives rise to the bones;
- b) **myotome**, which gives rise to the muscles;
- c) **dermatome**, which gives rise to the derm of skin.



# Embryo with 8 pairs of somites

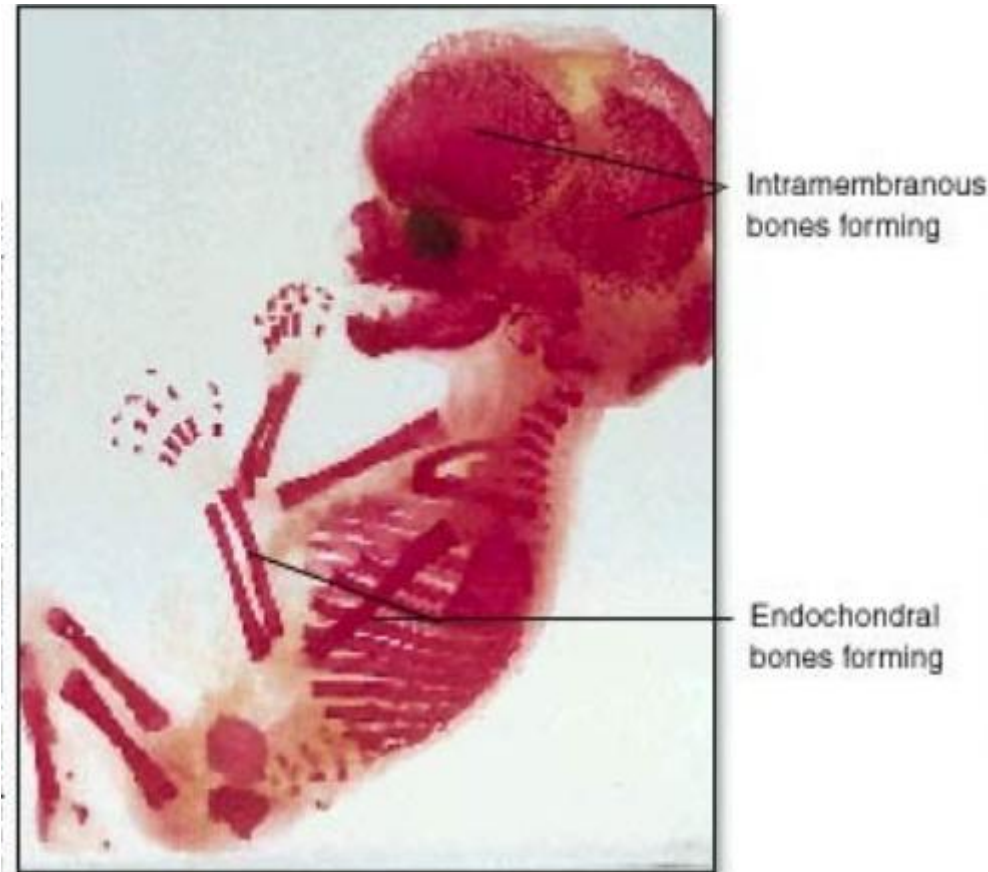


# *The development of bones*

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There are three stages in the development of the skeleton:

1. **connective-tissue (membranous) stage;**
2. **cartilaginous stage;**
3. **bony (osseous) stage.**

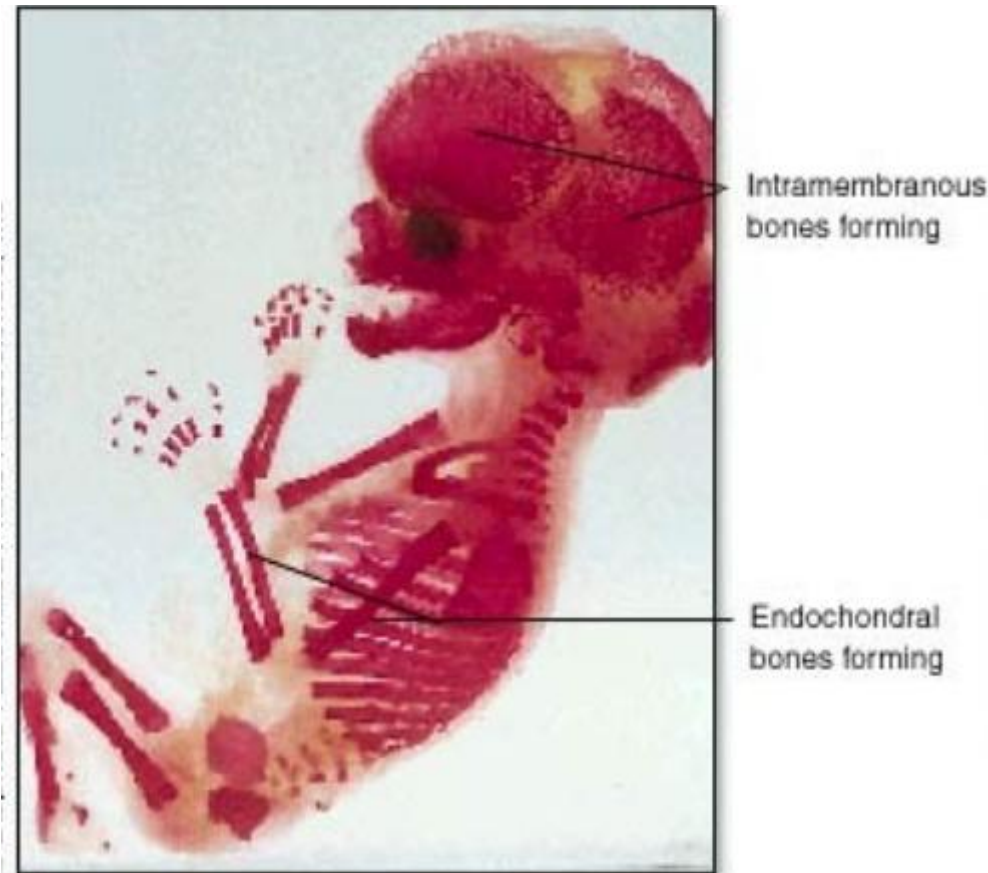


# *The development of bones*

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The following types of ossification (osteogenesis) are distinguished:

1. ***intramembranous***  
(within the membrane)  
or ***endesmal***  
***osteogenesis***;
2. ***intracartilaginous***  
(within the cartilage) or  
***endochondral***  
***osteogenesis***.



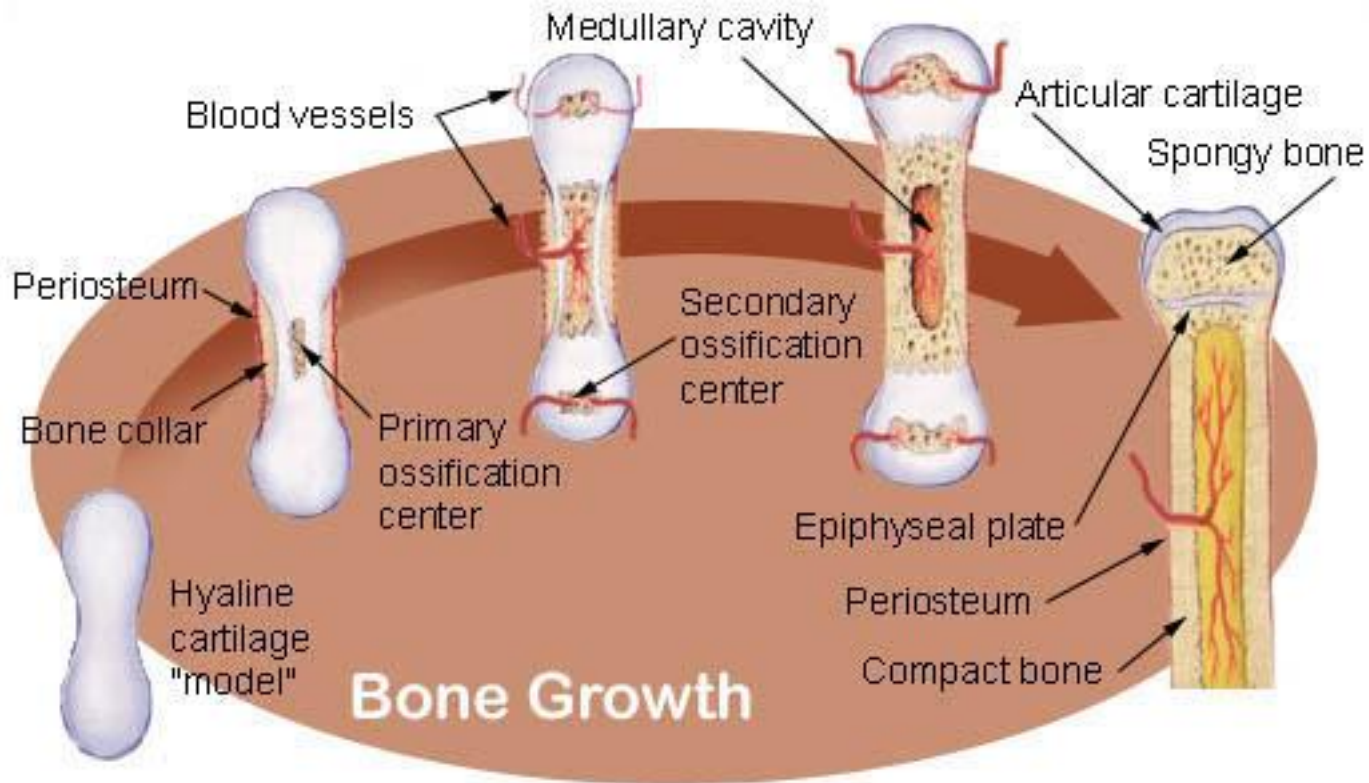
# *The development of bones*

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1. **Intramembranous ossification** forms the *flat bones* of the skull, *clavicle* and *mandible*.
  
2. **Endochondral ossification** is the formation of *long bones* and *other bones*. It requires a **hyaline cartilage precursor**. There are **two centers of ossification** for endochondral osteogenesis:
  - a) **Primary ossification centers** appear, before the birth, in the diaphysis (middle of shaft).
  - b) **Secondary ossification centers** appear, during the first years of postnatal life, at the epiphyses (at the ends of bone).



# The ossification centers of endochondral osteogenesis



# *Classification of bones*

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*According to their development:*

1. **Primary** (*desmal or membrane*) **bones** – bones of skull cap and facial bones;
2. **Secondary** (*chondral*) **bones** – almost all the bones;
3. **Mixed** (*chondro-desmal*) **bones** – clavicle, bones of the base of the skull.



## *Postnatal growth of bone*

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- ▶ **Growth in width** (thickness) via appositional growth due the periosteum.
- ▶ **Growth in length** occurs at the epiphyseal plate (or growth plate). Bone growth stops around age of 23-24 for males, and at 18-19 for females, when the epiphysis and diaphysis fuse (epiphyseal plate closure). Epiphyseal plate activity is stimulated by growth hormone.





# *Osteogenesis imperfecta*

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- ▶ The term “**osteogenesis imperfecta**” means imperfect bones formation.
- It is a heterogeneous group of genetic disorders that affect connective tissue integrity.
- People with this condition have bones that break easily, often from middle trauma or with not apparent cause (**brittle bone disease**).



# *Brittle bone disease*

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## *Short-limb skeletal dysplasia*

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- ▶ **Achondroplasia** (hypoplastic chondrodystrophy)
  - The trunk and head are usually of normal length.
  - The extremities (limbs) are short due a disturbance of endochondral ossification at the epiphyseal plate of long tubular bones.



# *Achondroplasia*

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# *Spondyloepiphyseal dysplasia*

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- ▶ This condition affects the vertebrae of the spine (*spondylo-*) and the ends (*epiphyses*) of long tubular bones of the arms and legs.
  - Short stature (dwarfism) with very short trunk and neck.
  - Abnormal curvature of the spine (kyphoscoliosis and lordosis).
  - Shortened limbs.
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# *Spondyloepiphyseal dysplasia*



# *Arachnodactily* (“spider fingers”)

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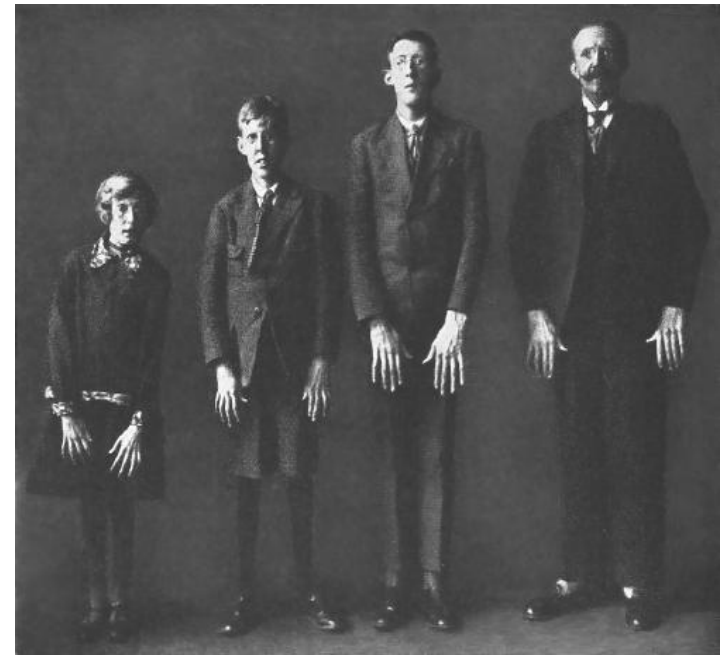
People with this condition have long, slender fingers and toes.

It can be associated with certain medical conditions (e.g. Marfan`s syndrome).



# *Arachnodactily (“spider fingers”)*

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**Thank you!**

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