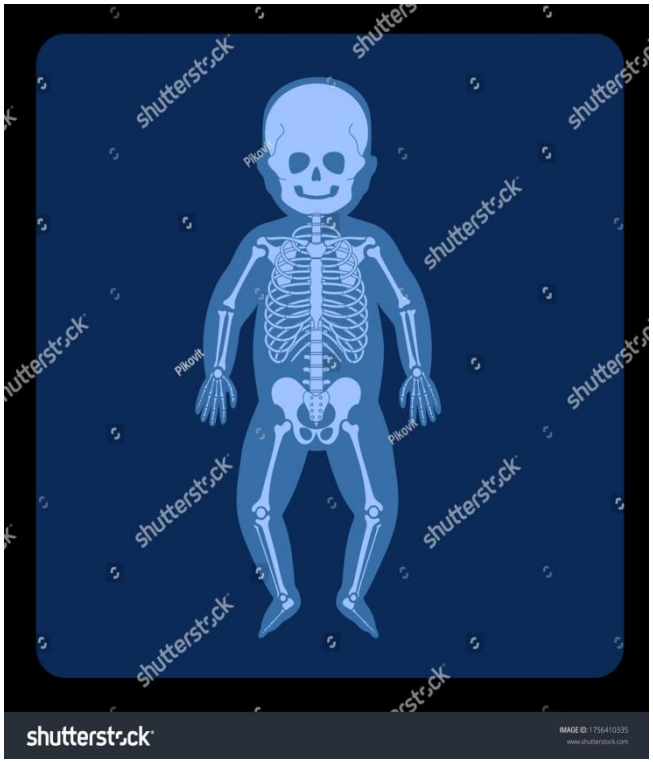
Bone formation



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ILOs

1. Recognize the two types of bone development.
2. Know the two ways of **bone growth.**
3. Recognize the main events in the process of bone repair
4. Identify the different types of bone marrow.

Bone formation

When??:

- Formation of bone in an **embryo (development)**
- **Growth** of bones until adulthood
- **Repair** of fractures
- **Remodelin**g of bone

Bone development (osteogenesis) (Ossification)

There are two types of bone development

- Bone may develop (**directly**) from mesenchyme *or* by the replacement of cartilage (**indirectly**).

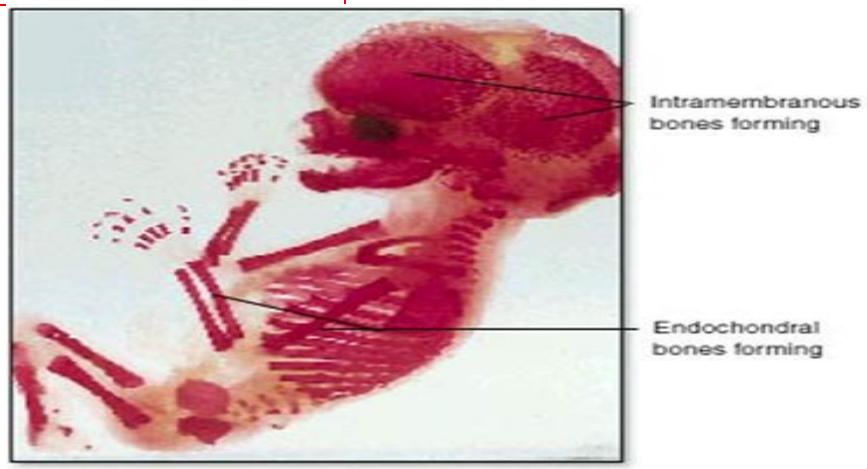
Bone development

Intramembranous ossification:

- The mesenchymal cells within the embryonic mesenchymal membrane differentiate into osteoblasts which begin secreting **osteoid** tissue (organic matrix).
- Forms: Flat bones

Endochondral (Intracartilagenous) ossification:

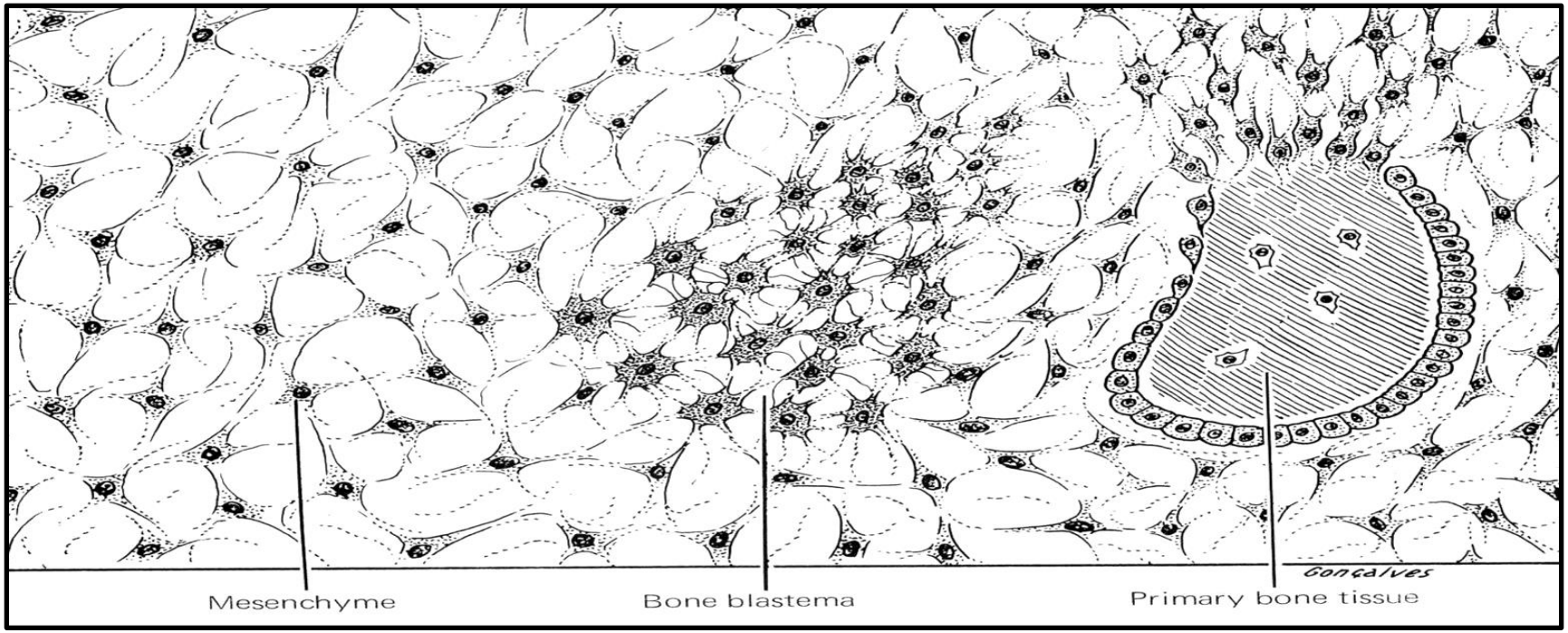
- Deposition of bone matrix on the surface of pre-existing cartilage matrix followed by resorption of the cartilage.
- Forms: Most bones of the body (short,long)

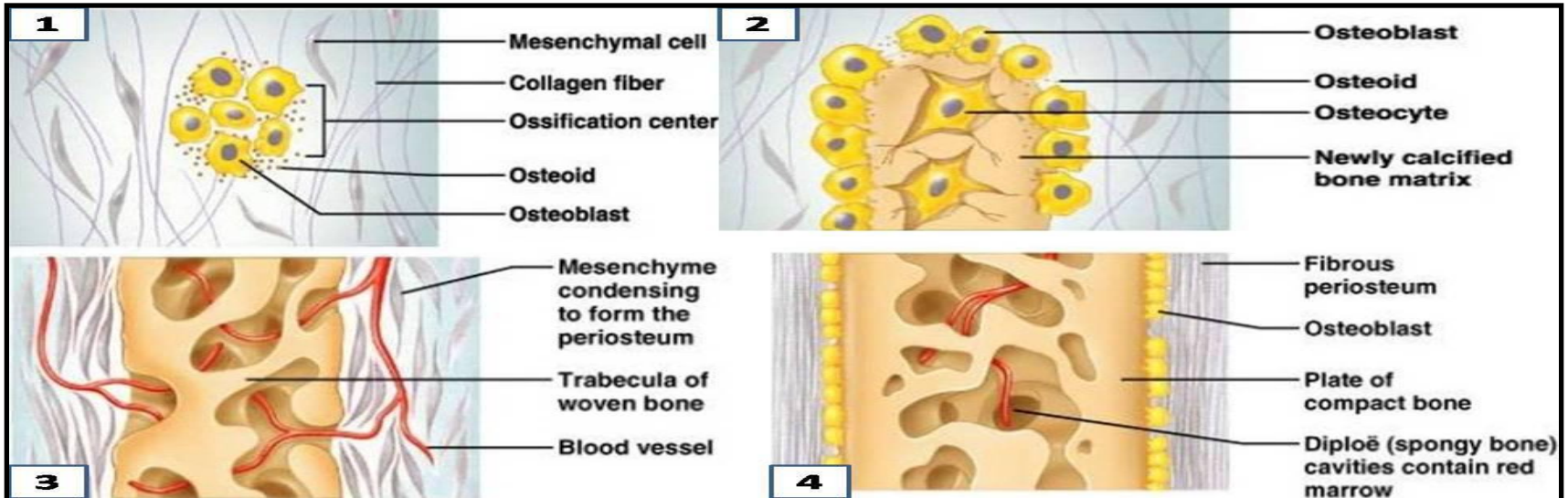


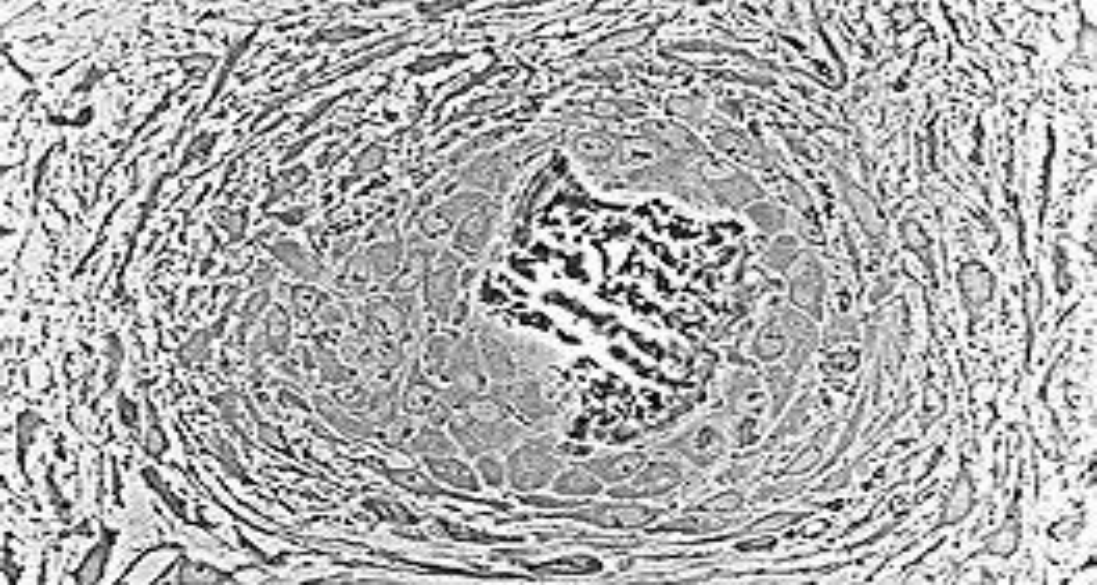
Intramembranous ossification

- Within **mesenchymal tissue**, the **mesenchymal cells** begin to differentiate into **osteoblast** forming **ossification center**.
- **Osteoblasts** begin to secrete **osteoid (organic matrix) .**
- Osteoblasts trapped themselves with bone matrix, forming **osteocytes.**
- **Accumulating osteoid** between embryonic blood vessels forming a random **network.** The result is a network of **trabeculae.**
- **Vascularized** mesenchyme condenses on the external face of the bone and becomes **the periosteum**.
- **Trabeculae** just deep to the periosteum **thicken** forming a woven bone that is later replaced with **mature lamellar bone** (compact bone) ex*ternally*.
- **Spongy bone** consisting of **distinct trabeculae** persists *internally* and its vascular tissue becomes **red bone marrow.**

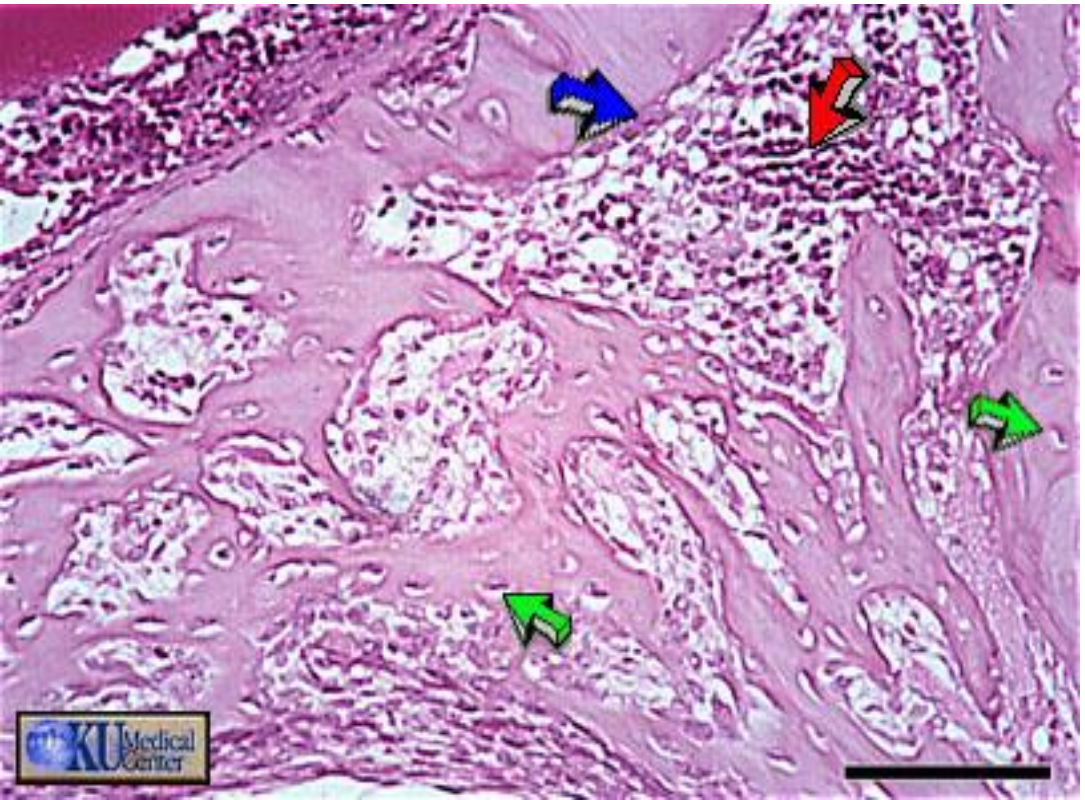
Intramembranous ossification







Ossification center within the mesenchyme



-Blue arrow: osteoblasts
-Green arrows:Primary bone
-Red arrow: bone marrow cavity

Endochondral (Intracartilagenous) ossification

1. It takes place within a **piece of hyaline cartilage** that resembles a small embryonic model of the bone to be formed.
2. A **bone collar** develops beneath the perichondrium around the middle of the long bones' cartilage models, causing degeneration of the underlying cartilage. perichondrium become periosteum.

3. Hypertrophy and **destruction of chondrocytes** **leaving lacunae** separated by **septa of calcified cartilage matrix.**

4. **Invasion of osteogenic cells** and **blood capillaries** (come from periosteum) the lacunar spaces to form **primary ossification center** in the diaphysis.

5. The osteogenic cells give rise to **osteoblasts** which form **bone matrix** over the remnants of the calcified cartilage.
6. Here **bone matrix** is deposited by the new osteoblasts, undergoes calcification into woven bone, and is remodeled as compact bone

7.Around the time of birth **secondary ossification centers** begin to develop by a similar process in the epiphyses.

8. During childhood the primary and secondary ossification centers gradually come to be separated only by the epiphyseal plate that provides for continued bone elongation.

9.The two ossification centers do not merge until the epiphyseal plate disappears when full stature is achieved.

Endochondral (Intracartilagenous) ossification

Stages of Endochondral Ossification

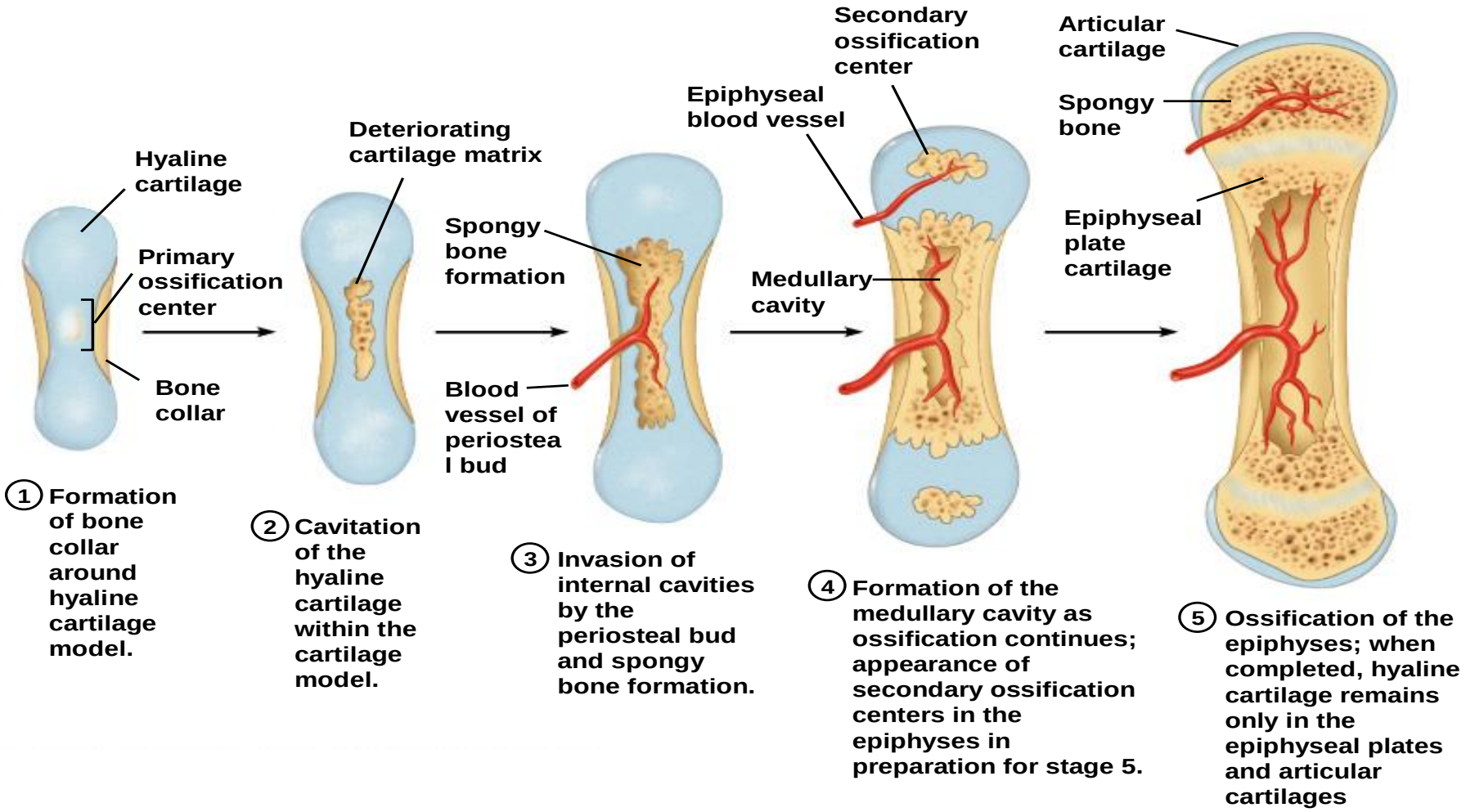


Figure 6.8

Bone growth

- Increase in length = **interstitial growth** of **epiphyseal plate**

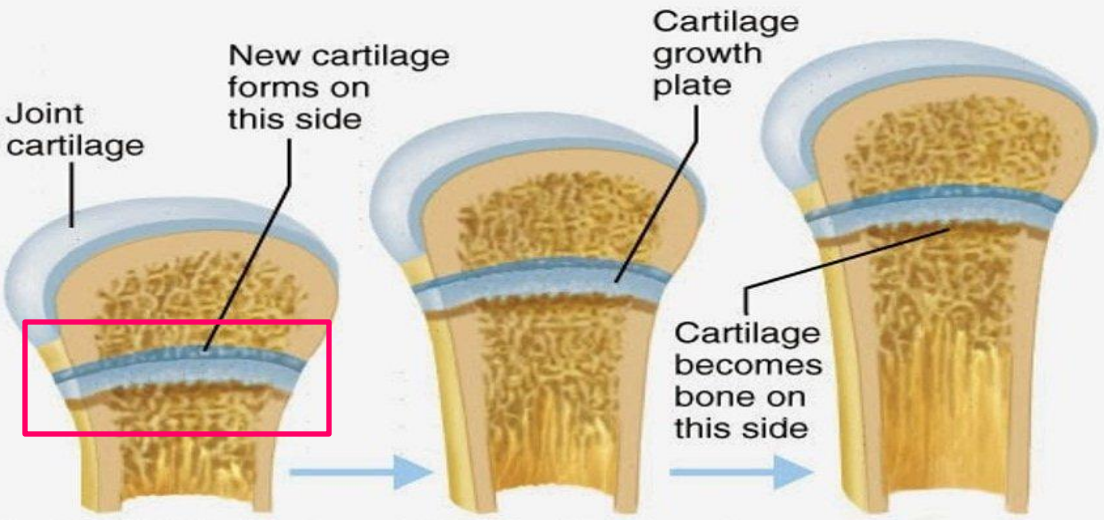
- Increase in width = **appositional growth**

osteoblasts lay down matrix in layers on outer surface and osteoclasts dissolve bone on inner surface

Growth at the epiphyseal plate:

- After the long bone is formed, its further longitudinal growth depends on the presence of the epiphyseal plate of cartilage.

- **Epiphyseal plate** is present at the junction of the epiphysis with the diaphysis of the long bones.



The zones in the epiphyseal growth plate

1-Resting zone: thin layer of small, randomly oriented *chondrocytes.*

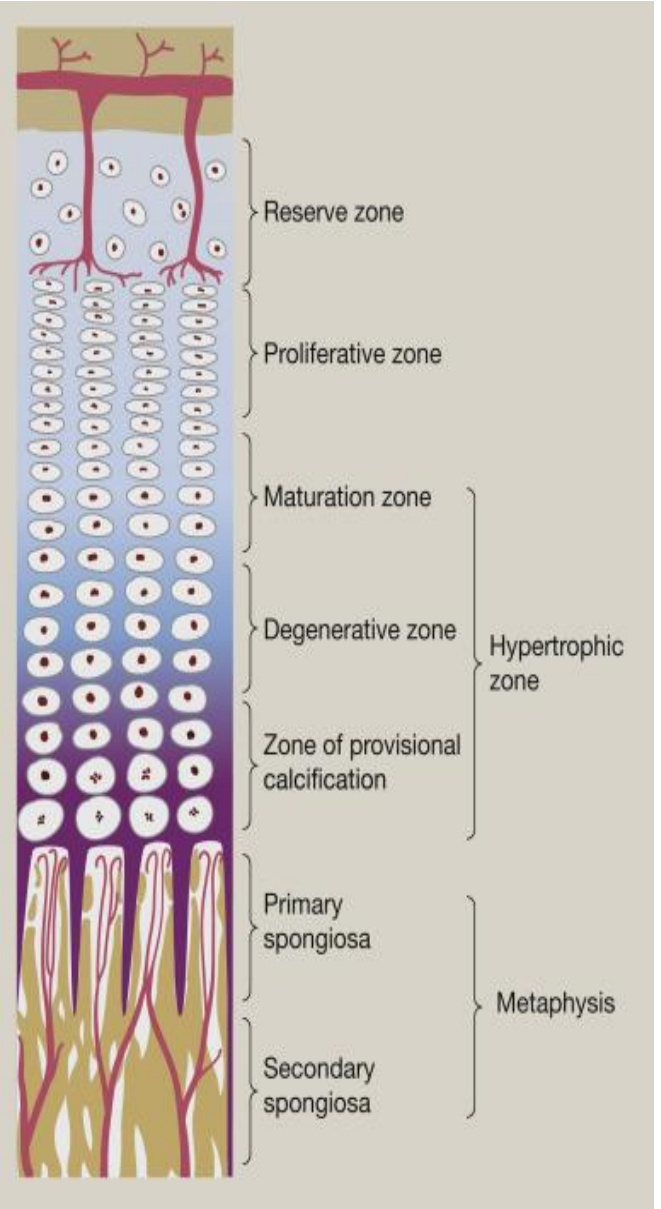
2-Proliferative zone: Chondrocytes proliferate by mitosis and form columns parallel to the long axis of the bone.

3. *Hypertrophic zone:* Chondrocytes increase in size, accumulate glycogen and lipids and become separated by thin matrix septa.

-They start production of alkaline phosphatase enzyme which helps in precipitation of Ca salts in the matrix of the deeper layer.

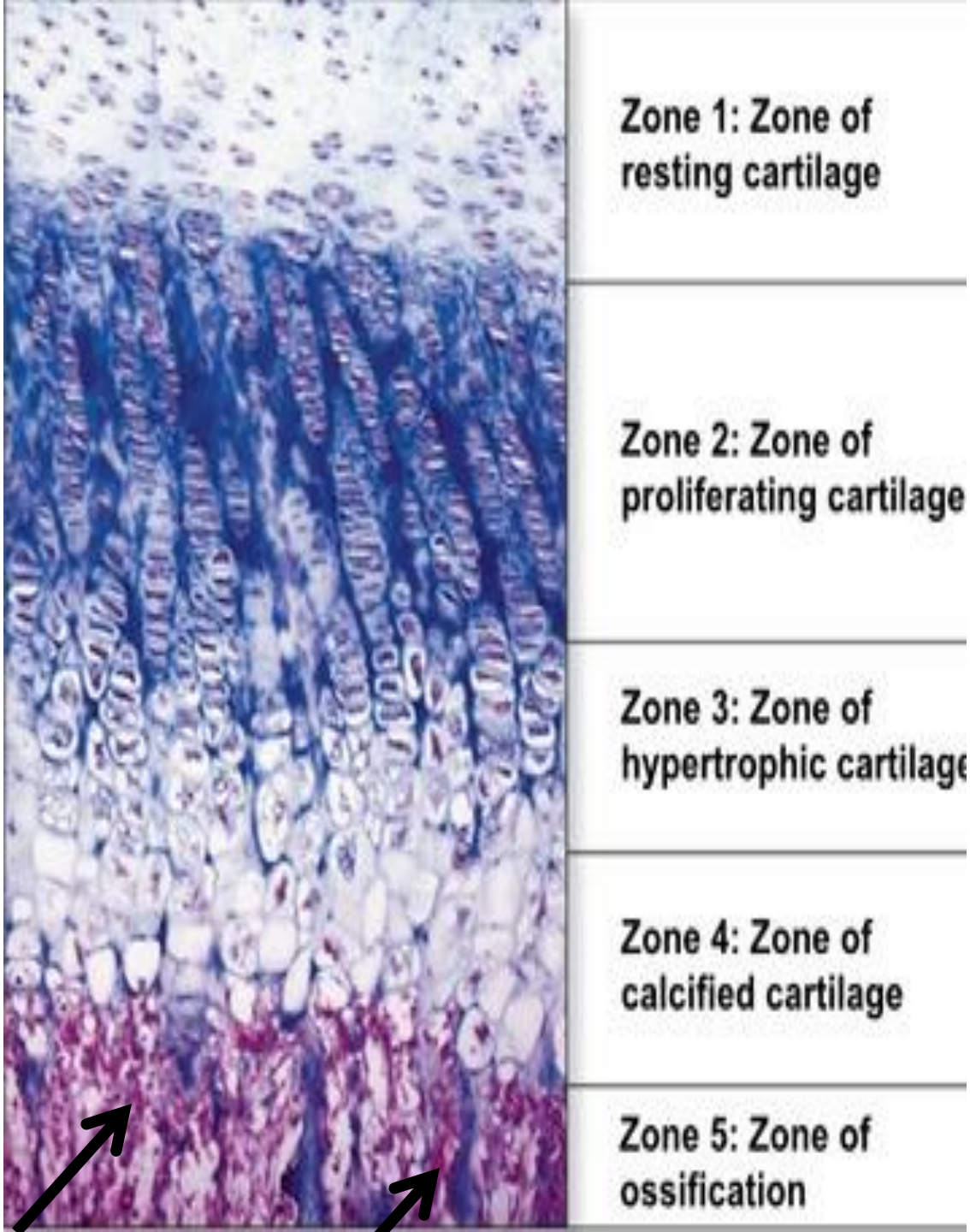
4. *Calcification zone:* Cartilage matrix becomes calcified. that prevents diffusion of nutrients and cause death of chondrocytes. The lacunae of degenerated cells appear as empty spaces.

5. *Ossification zone:* Blood vessels and osteoprogenitor cells (that change to osteoblasts) invade the empty spaces left by the dead chondrocytes. Osteoblasts lay down bone matrix over the septa of calcified cartilage matrix, and the trapped cells are transformed into osteocytes.

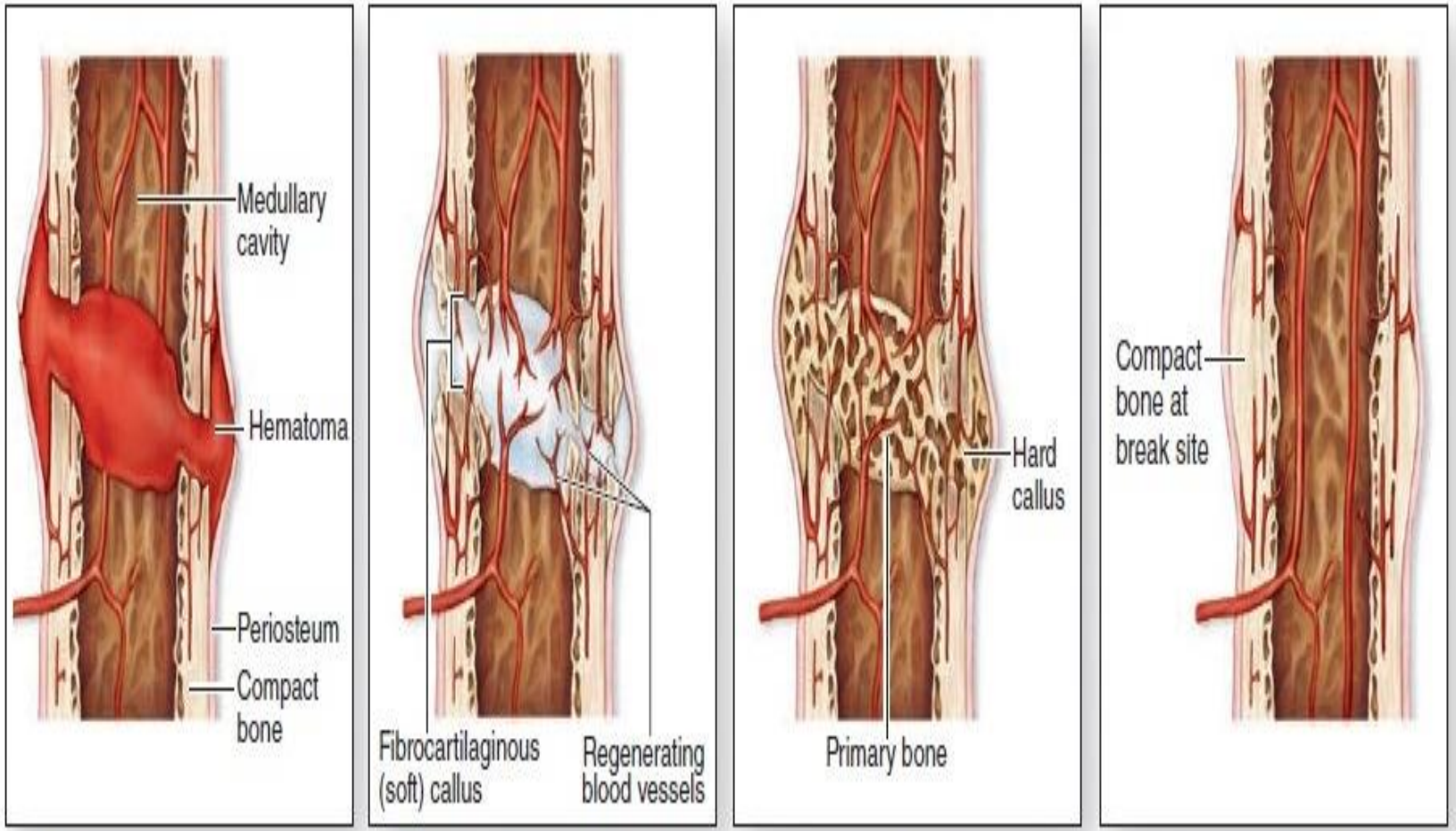


Bone spicules (arrows) are formed

-**<u>In histological sections,</u>** the calcified cartilage appears basophilic while bone tissue is acidophilic.



Fracture and repair



(a) A fracture hematoma forms.

(b) A fibrocartilaginous (soft) callus forms.

(c) A hard (bony) callus forms.

(d) The bone is remodeled.

Repair of a fractured bone occurs through several stages

(a) Blood vessels torn within the fracture release blood that clots to produce a large fracture hematoma.

(b) This is gradually removed by macrophages and replaced by a soft fibrocartilage-like mass of procallus tissue rich in collagen and fibroblasts. periosteum reestablishes continuity over this tissue.

(c) This soft procallus is invaded by regrowing blood vessels and osteoblasts. In the next few weeks the fibrocartilage is gradually replaced by trabeculae of woven bone, forming a **hard callus** throughout the original area of fracture.

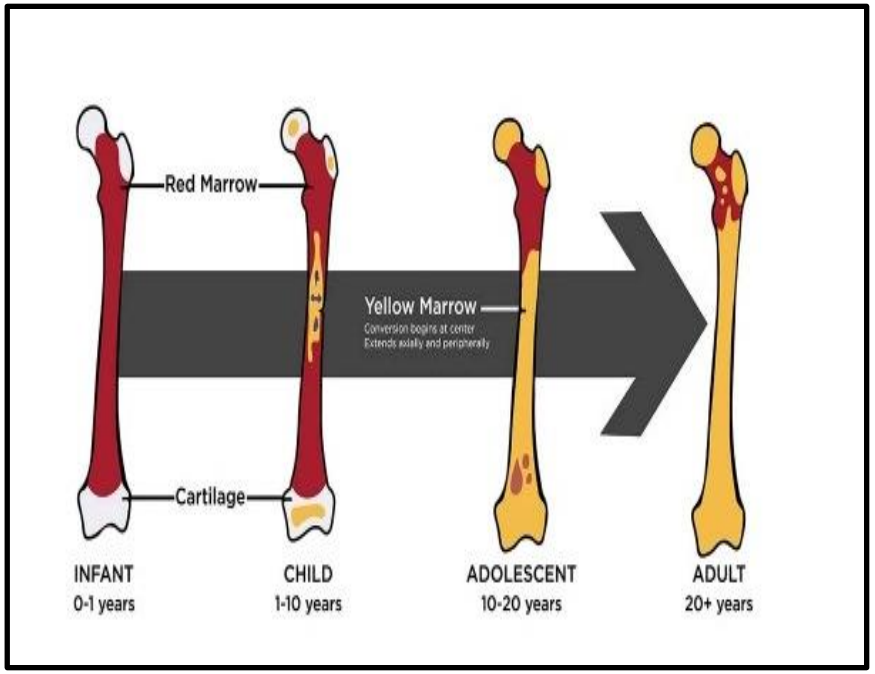
Bone remodeling

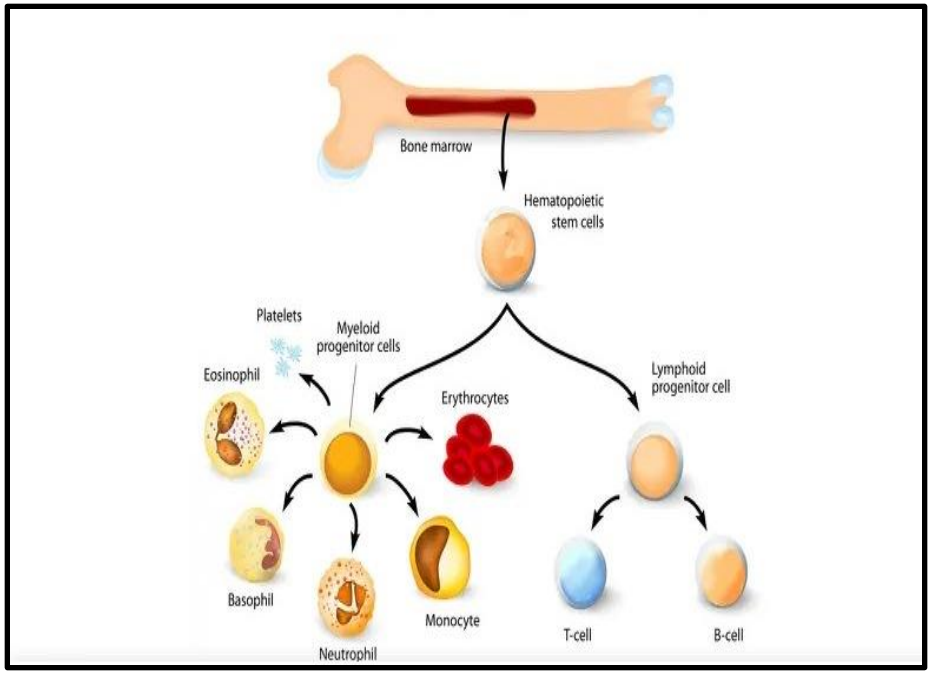
Primary bone is resorbed and replaced by secondary bone

Further remodeling restore the original bone structure & contour

Bone marrow (Myeloid Tissue)

- The myeloid tissue is a specialized vascular connective tissue rich in cells that are responsible for formation of blood cells.



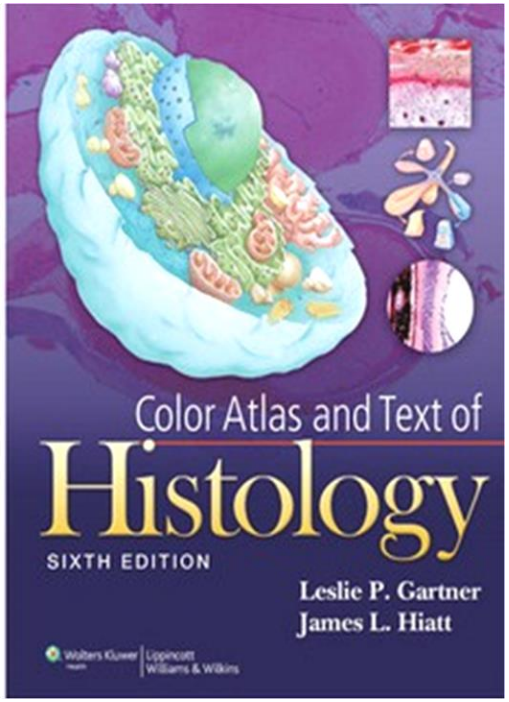


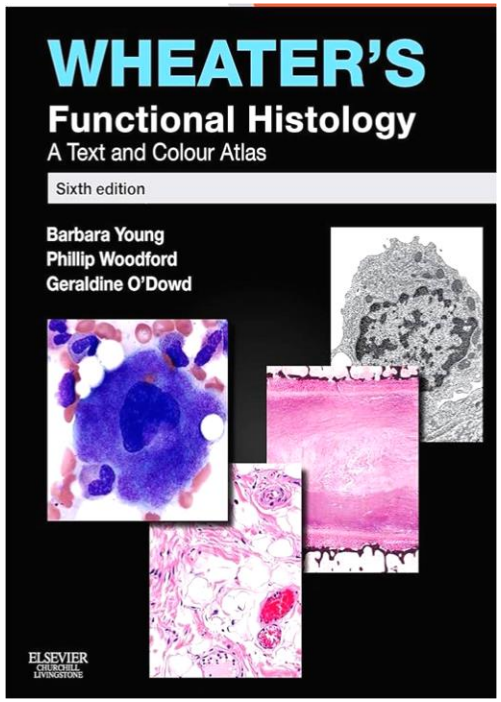
Types of bone marrow

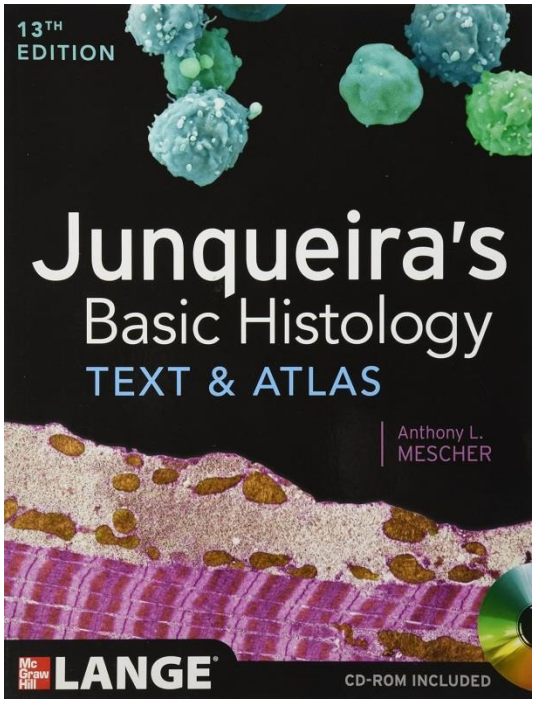
	Red	Yellow
Activity	Active	Inactive
Site	**In fetus present in all bones.** **In adult present in spongy bone.**	**Adult long bones**
structure	• ***Stroma:*** **A delicate network formed of reticular CT. containing developing blood cells (*Hematopoietic cords)* in its meshes.** • ***Sinusoidal capillaries***	**Yellow in color due to great number of adipose(fat) cells.**
function	**Formation of blood cells**	• **Stores fat.** • **Under certain conditions, such as severe hemorrhage,**

References

Text books







Thank you