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# Fracture and bone healing

Black: original content  
Red: important  
Grey: Explanation  
Blue: Only in the boys slides  
Pink: only in the girls slide  
Green: ALRIKABI's NOTES

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# Healing of bone fractures

## Objectives of this lecture:

- Know the different types of fractures
- Be aware of the mechanism and stages of fracture healing process
- Know the factors affecting healing process and the possible complication of healing process
- Understand the difference between trauma induced and pathological fractures
- Appreciate the importance of road traffic accidents as a major cause of disability in Saudi Arabia

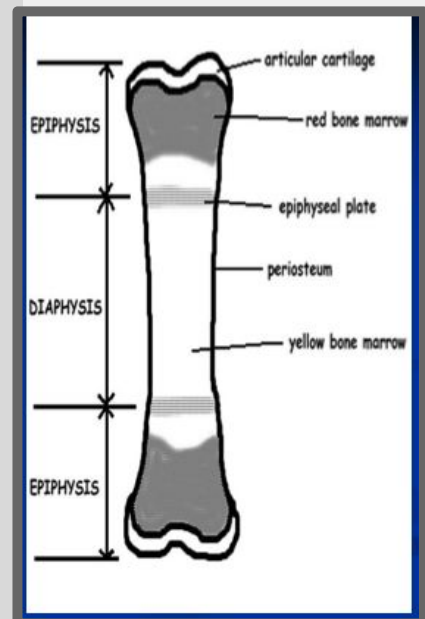
# Normal anatomy

## Parts of long bones:

- 1) **Epiphysis** (ends of bone, partially covered by articular cartilage)
- 2) **Physis** (growth plate) (Epiphyseal plate remains open in childhood and close during or before puberty and when it stops the person stops growing.)
- 3) **Metaphysis** : junction of diaphysis and epiphysis (1/3 of the bone.)  
\*Osteomyelitis (associated with Subperiosteal abscess) and certain tumors (E.g:Chondrosarcoma and osteosarcoma) starts from metaphysis.
- 4) **Diaphysis** : shaft (Two parts forming the diaphysis: cortical or compact (lamellar) and spongy (trabecular) bones (in the medullary).  
\*Spongy bone has spaces which has fat and bone marrow.)

\***Articulate cartilage**:it is important because it is the area where osteoarthritis happen, it is part of joint and where the bone moves.

\***Periosteum**: a membrane cover the bone. In osteomyelitis there will Subperiosteal abscess because the pus and the infection track accumulate in this area. Periosteum is not rigid.



Note 434:the bone is covered with articular cartilage and periosteum

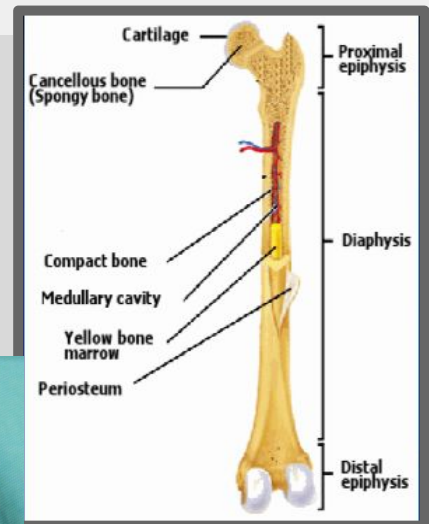
# Normal anatomy

Cross section:

## 1) Periosteum

2) Cortex (composed of cortical bone or compact bone)

3) Medullary space (composed of cancellous or spongy bone)



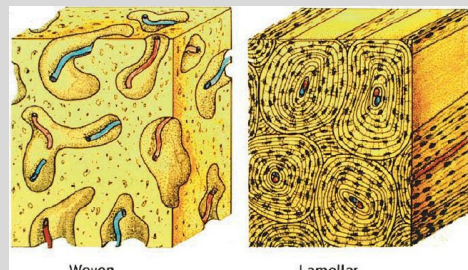
## Three types of bone:

1) **Cortical or compact (lamellar):** it is very hard formed of Haversian canals, it called lamellar because it shows parallel lines in polarizing light micrograph.

2) **Spongy:** irregular bone, found in medulla, inside the cortical bone, contains fats and bone marrow elements (hematopoietic cells). No parallel lines.

## 3) Woven:

- in: **1.** Embryogenic life. **2.** Rapid healing. **3.** Fractures. **4.** Malignancy.
- It develops to cortical or spongy, irregular bone matrix. No parallel lines. Weaker, less efficient and faster to make than lamellar bone.



# Normal histology

Bone: mineralized osteoid; either lamellar bone or woven bone.

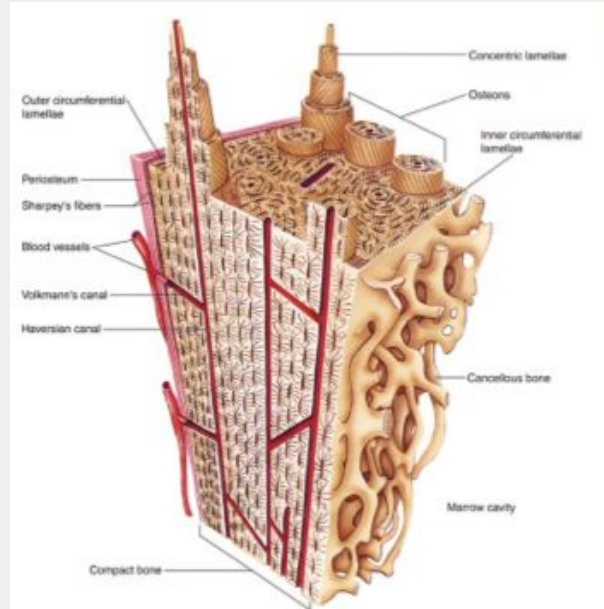
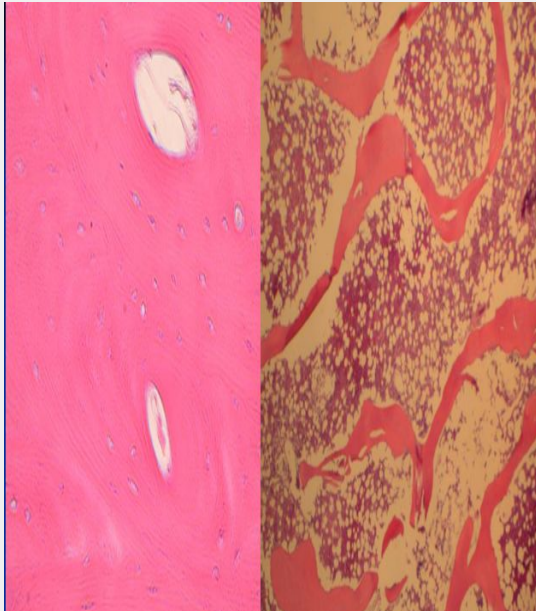
**\*Lamellar bone:**

-layered bone with concentric parallel lamellae normal type of bone found in -adult skeletons stronger than woven bone

**\*Bone is composed of specialized collagen (osteoid), which is mineralized by the deposition of hydroxyapatite**

\*Bone is composed of a collagen-containing extracellular matrix (osteoid) synthesized by osteoblasts, which is mineralized by calcium-containing salts

**\*Osteoprogenitor cells:** they set in the connective tissue, adjacent to the bone, those cell can be spindle and stellate (irregular), they used when they are needed (if there is tumor or ossification.)



Note 434: The bone marrow has progenitor stem cells (red bone marrow) and fat (yellow bone marrow).

- Bone marrow biopsy is an important diagnostic tool.

# Bone cells

## 1)Osteoblasts:

- arise from marrow mesenchymal cells
- when active, are plump and present on bone surface
- are encased within the collagen they produce

## 2)Osteoclasts:

- large multinucleated cells found attached to the bone surface at sites of active bone resorption. (they lyse the bone, they have the capability to transform to giant cells.)

## 3)osteoid: (basic connective tissue in the bone.)

- is the unmineralized, organic portion of the bone matrix that forms prior to the maturation of bone tissue.
- Osteoblasts begin the process of forming bone tissue by secreting the osteoid .

\***Osteocytes:** inert (inactive) they set inside Lacunae (space or cavity). Do nothing. Lacunae without nuclei help to identify dead bone.

## Bone resorption

Bone resorption is resorption of bone tissue, that is, the process by which osteoclasts break down the tissue in bones

### There are two main patterns of bone deposition.

1)In normal lamellar bone the osteoid collage is deposited in a *mechanically strong, parallel stratified pattern.*

2)In woven bone, the osteoblasts deposit osteoid collagen in a *haphazard pattern. With its random arrangement of osteoid collagen fibers*

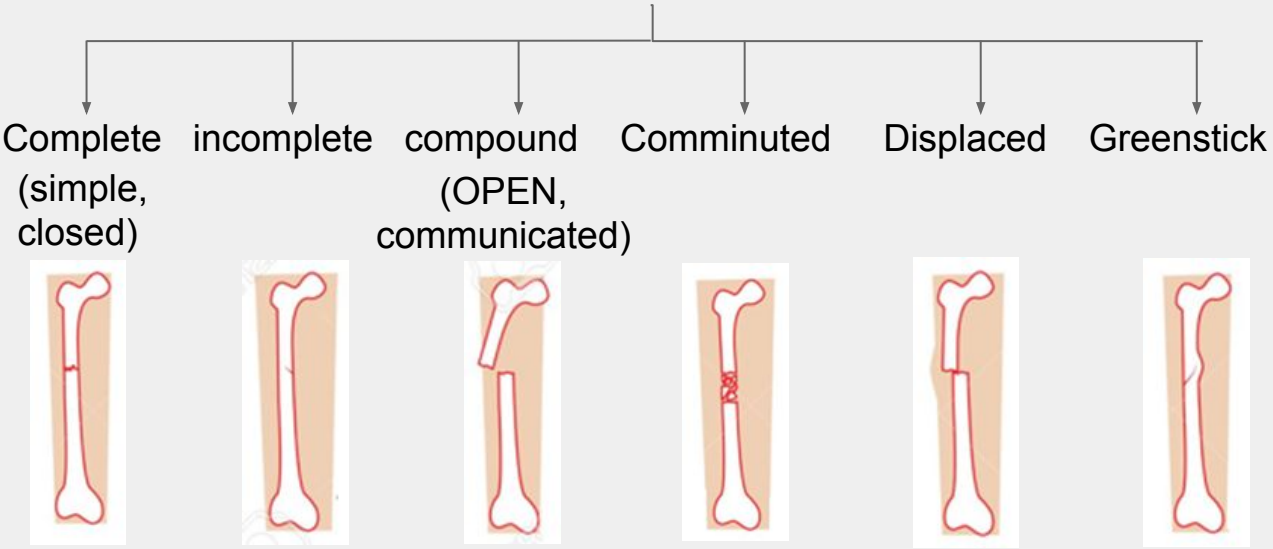
***\*woven pattern is far less efficient and much weaker than lamellar bone with a greater tendency to fracture under stress.***

ALRAKABI: **Colles fracture** occurs in the lower third of the radius

# Fracture

## Fracture

loss of integrity of the bone (disruption), the most common cause of this type of fracture is mechanical or physical trauma.



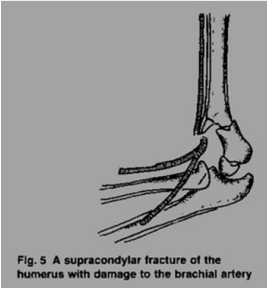
\*The overlying Tissue is intact.  
\*Does **NOT** communicate with external environment.

- The fracture extends into the overlying skin.  
-Communicate with external environment.  
- **High risk of infection.** leads to **osteomyelitis**  
-treated by surgery or cast with Wight.  
-E.g: Window side fracture

-More than two fragments  
-Happens in major trauma

both part of the bone are not opposed.

-Mostly found in **children** (because of their soft bone, we can see the **epiphyseal plate** in the x.ray). fracture is not complete.  
Healing of this fracture is excellent for two reasons:  
-Does not need splint, it will heal perfectly even if displaced .  
-children have a lot of progenitor cells, so healing will be very quick.



\***Complicated Fracture:** Associated with damage to nerves, vessels, or internal organs  
\*complicated is not necessarily open fracture

# Causes of fracture

## Causes of fractures

### Traumatic fracture

- Severe trauma e.g. MVA.
- Trauma due to motor vehicle accidents is of major cause of bone fracture.

### Pathological fracture

- Fracture occur with **minimal trauma**.
- The underlying bone is **abnormal**
- caused by disease affecting the bone.  
**Examples:**
  - Osteoporosis & Osteosarcoma (**Most common causes**)
  - Osteomalacia
  - Paget's disease of bone
  - Primary Or Metastatic tumor.
  - Congenital bone disorders e.g. osteogenesis imperfecta (**abnormality in collagen I**)



### Stress fracture

- A stress fracture **develops slowly** over time as a collection of microfractures **associated with increased physical activity**, especially with new repetitive mechanical loads on bone.
- Stress fractures are most common in the weight bearing bones of the lower leg ankle (metatarsal) and foot.  
**Who is susceptible to stress fractures?**
  - Track and field athletes
  - military recruits who carry heavy packs over long distances>.



# How does a fracture heal ?

When a fracture occur: There will be a formation of hematoma (formation of a big mass of clotted blood), there will be inflammation caused by mechanical trauma, after that there will be organization (inflammatory vascular granulation tissue), stimulations of osteoprogenitor cells into chondrocytes, and that helps in the formation of callus

## Healing of fractures

### 1. Reactive Phase

- i. Hematoma and inflammatory phase
- ii. Granulation tissue formation

### 2. Reparative Phase

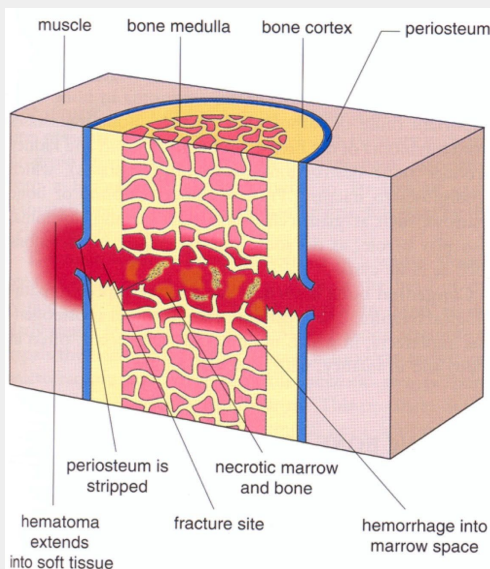
- iii. Callus formation

### 3. Remodeling Phase

- v. Remodeling to original bone contour

## 1- Reactive phase :

Bleeding from the fractured bone and surrounding tissue causes the fractured area to swell due to inflammation induced by chemical mediator produced from macrophages and other inflammatory cells with granulation tissue formation.



- i. Tearing of blood vessels in the medullary cavity, cortex and periosteum Lead to **hematoma** at the site of fracture.

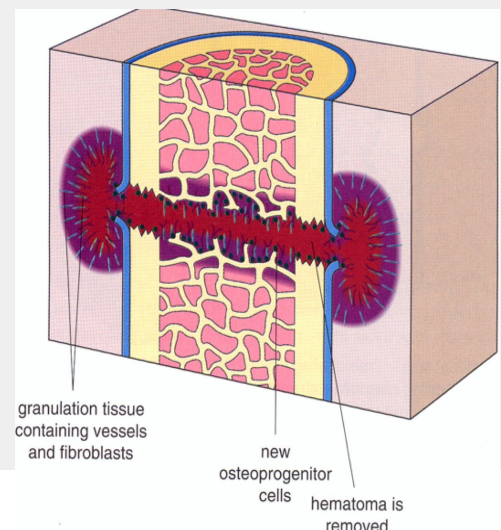
The periosteum is stripped from the surface.

(when we have a fracture usually we have immediately Hematoma because the bone is highly vascular if we didn't treat it after one hour we will see erythema)

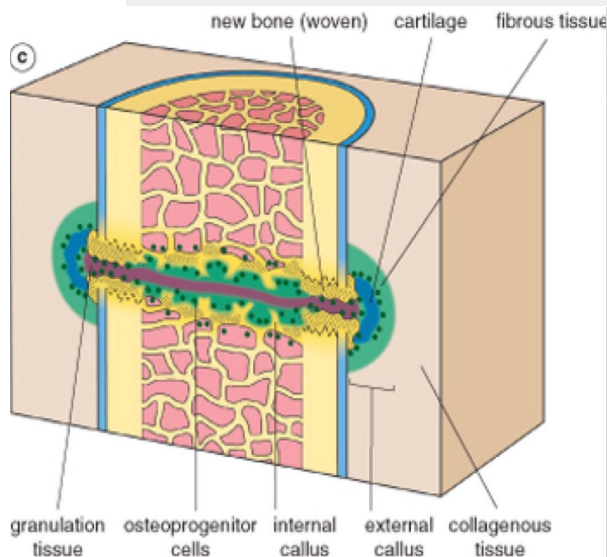
- ii. Organization of the hematoma:

\*Margination of **neutrophils** and **macrophages** into the fracture hematoma.

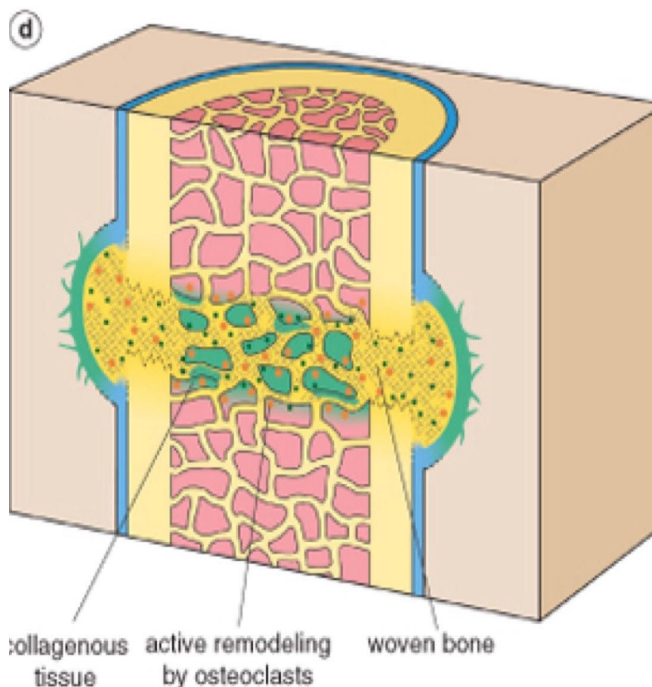
\*They phagocytose the hematoma and necrotic debris



## 2-Reparative phase :



- Degranulated platelets and marauding inflammatory cells → release a host of cytokines (e.g., platelet derived growth factor (PDGF), fibroblast growth factor (FGF), **TNF beta 1**) → activate bone progenitor cells.
- within a week: involved tissue is primed for new matrix synthesis.
- **soft tissue callus**: can hold the ends of the fractured bone in apposition but is noncalcified and cannot support weight bearing.



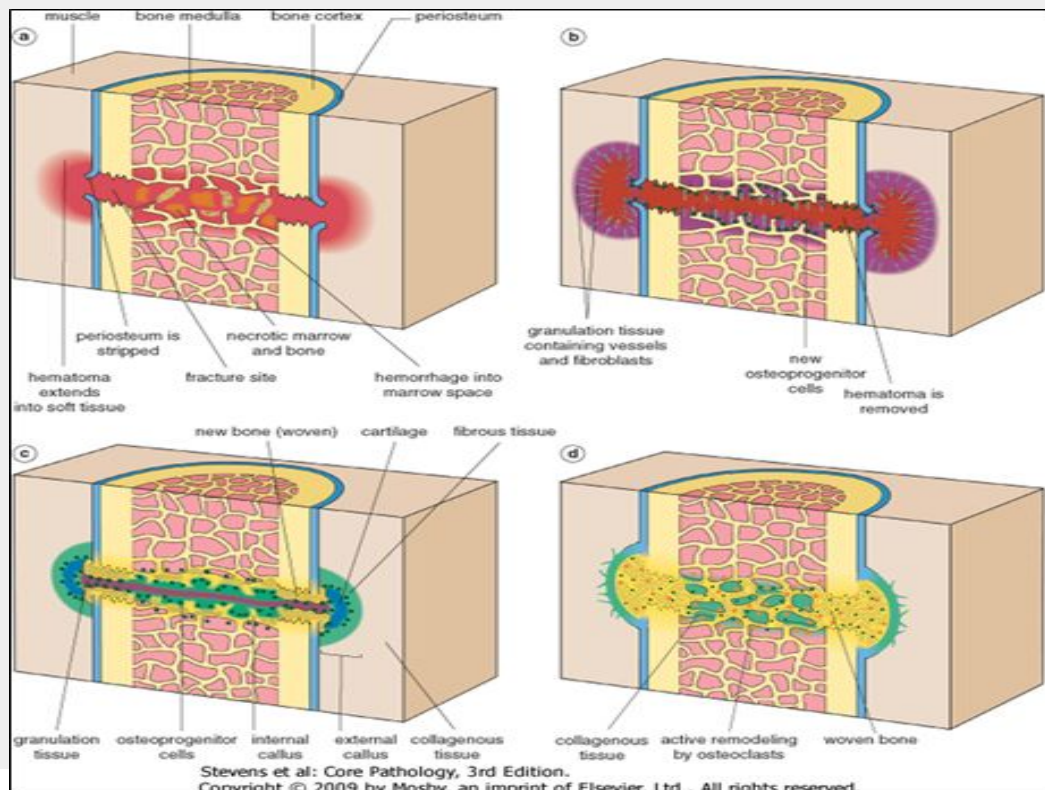
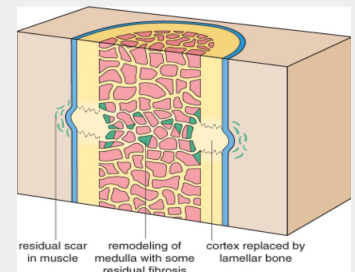
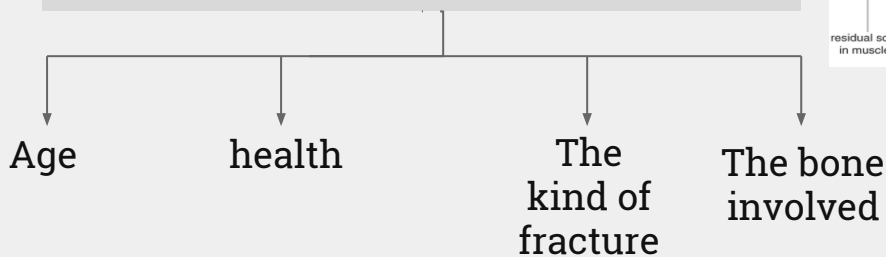
### Hard callus (peak healing step):

- Bone progenitors in the periosteum and medullary cavity deposit new foci of woven bone (WHY? Because it is quick to make).
- Activated mesenchymal cells at the fracture site → cartilage-synthesizing chondroblasts.
- In uncomplicated fractures, this early repair process peaks within **2 to 3 weeks**.
- **Newly formed cartilage** (acts as a nidus for endochondral ossification, recapitulating the process of bone formation in epiphyseal growth plates). This connects the cortices and trabeculae in the juxtaposed bones. With ossification, the fractured ends are bridged by a **bony callus**. (osteoprogenitor cell undergo metaplasia → transform to chondrocytes (Mimicking of endochondral ossification) → transform into osteoblast → osteoid → hard callus)

### 3-Bone remodeling :

- Beginning about **8 to 12 weeks** after the injury, the fracture site remodels itself, correcting any deformities that may remain as a result of the injury. This final stage of fracture healing can last up to several years.
- Weight bearing on callus leads to remodeling → Removal of all excess fibrous tissue, cartilage and bone.

Rate of healing and the ability to remodel a fractured bone depend on :



# Factors disrupting healing process:

**Displaced and comminuted fractures**

**Infection**

**Vascular insufficiency**

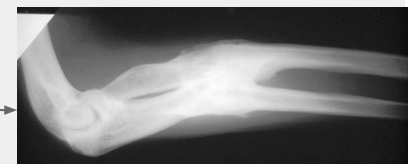
This is particularly important in certain areas such as the scaphoid bone in the wrist and the neck of the femur, both of which can be associated with avascular necrosis (osteonecrosis): It is the death of bone tissue due to a lack of blood supply of fracture fragments.

**Inadequate minerals and vitamins**

**Inadequate immobilization**

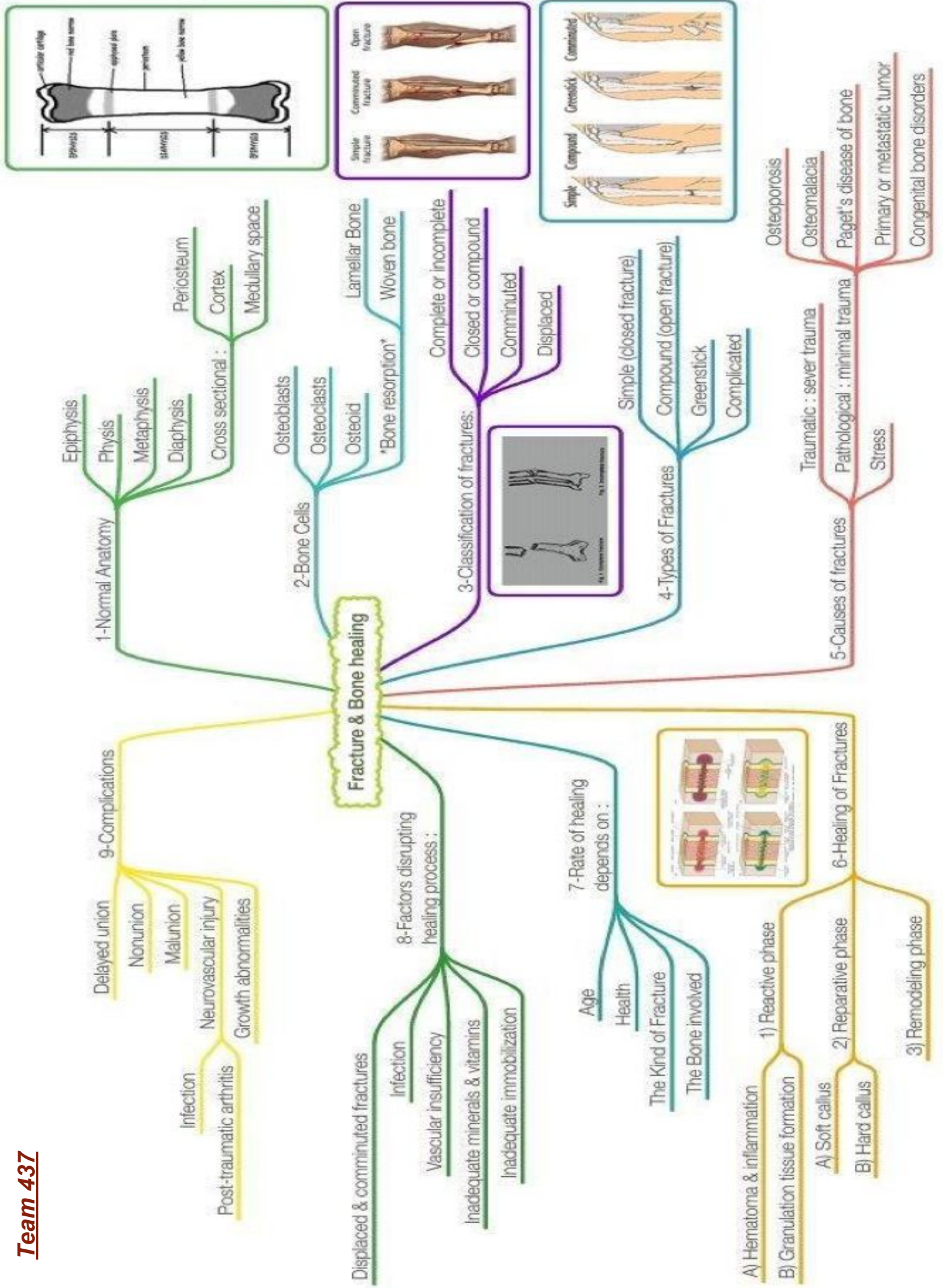
## Complications:

- **Delayed union:** A fracture that takes longer to heal than expected is a delayed union.
- **Nonunion:** A fracture that fails to heal in a reasonable amount of time is called a nonunion (pseudarthrosis). Sometimes caused by overgrowth or foreign bodies
- **Malunion:** A fracture that does not heal in a normal alignment is called a malunion
- **Neurovascular injury**
- **Infection:** Open fractures can become infected
- **Post-traumatic arthritis:** Fractures that extend into the joints (intra-articular fractures)
- **Growth abnormalities:** A fracture in the open physis, or growth plate, in a child, can cause many problems.



\*One of the complications that occur in fracture is bone necrosis or avascular necrosis of the bone, caused by disruption in the artery that feeds the bone, most common sites: head and neck of femur and in navicular bone

# Summary



# AlRakabi's notes

## **The long bone consist of:**

Epiphysis, Epiphyseal plate (line).

\*Epiphyseal plate remains open in childhood and close during or before puberty and when it stops the person stops growing.

## **Diseases:**

Osteomyelitis and certain tumors starts from metaphysis.

**Metaphysis:** 1/3 of the bone.

**Diaphysis:** Shaft of the bone. Two parts forming the diaphysis: cortical or compact (lamellar) and spongy (trabecular) bones (in the medullary).

\***Spongy bone** has spaces which has fat and bone marrow.

Articulate cartilage: it is important because it is the area where osteoarthritis happen, it is part of joint and where the bone moves.

**Periosteum:** a membrane cover the bone. In osteomyelitis there will Subperiosteal abscess because the pus and the infection track accumulate in this area. Periosteum is not rigid.

## **Histology of the bone:**

- **Osteoprogenitor cells:** they set in the connective tissue, adjacent to the bone, those cell can be spindle and stellate (irregular), they used when they are needed (if there is tumor or ossification.)
- **Osteoblasts:** bone forming cells, they set outside and migrate inside, they are difficult
- **Osteoid:** basic connective tissue in the bone.
- **Osteocytes:** inert (inactive) they set inside Lacunae (space or cavity). Do nothing. Lacunae without nuclei help to identify dead bone.
- **Osteoclast:** they lyse the bone, they have the capability to transform to giant cells.

## **Three types of bone:**

**Cortical or compact (lamellar):** it is very hard formed of Haversian canals, it called lamellar because it shows parallel lines in polarizing light micrograph.

**Spongy:** irregular bone, found in medulla, inside the cortical bone, contains fats and bone marrow elements (hematopoietic cells). No parallel lines.

**Woven:** in embryonic life, it develops to cortical or spongy, irregular bone matrix. No parallel lines.

## **Function of parathyroid hormone:**

Increase calcium in the blood, help calcium migrate from the bone to the blood circulation. Hyperparathyroidism → hypercalcemia

## **Calcitonin:**

Secreted from the thyroid gland, decrease calcium in the blood.

Increase calcitonin → hypocalcemia

Local Signs of fracture: swelling, loss of function, pain.

Fractures: casting hematoma.

# AlRakabi's notes

**Fracture:** loss of integrity of the bone ( disruption), the most common cause of this type of fracture is mechanical or physical trauma.

## **Types of fracture:**

**1-Simple:** linear, closed fracture that has no bleeding or open wound.

**2- opens fracture (compound):** could be infected and this leads to osteomyelitis. Very important.

**3-Colles fracture:** fracture in the lower third of the radius. Called fork like deformity. it is usually happened when falling in the hand when the hand is stretched. Very common.

**4-Greenstick fracture:** occur in children, the fracture is not complete. The healing of this fracture is excellent for two reasons:

- Does not need splint, it will heal perfectly even if displaced.
- Children have a lot of progenitor cells, so the healing will be very quickly.

**5- displaced fracture:** both part of the bone are not opposed.

**6- Comminuted fracture:** fragments of bone

**7- Stress fracture:** it occur us small bones of the ankle (metatarsal) and foot, in people who their jobs require long march (soldiers).

**8- Pathological fracture:** caused by disease affecting the bone, like osteoporosis, tumors (Malignant), and there will be lytic bone lesion.

## **Congenital disease of bone:**

Osteogenesis imperfecta:

Inherited, usually autosomal dominant (homozygous usually dies, heterozygous lives but with bone abnormality) , it is caused in abnormality of collagen type I, rare.

## **When a fracture occur:**

There will be a formation of **hematoma (formation of a big mass of clotted blood)**, there will be inflammation caused by mechanical trauma, after that there will be **organization** (inflammatory vascular granulation tissue), stimulations of **ostero progenitor cells into chondrocytes, and that helps in the formation of callus**

**If there is foreign bodies or overgrowth in the fibers tissue especially when the fracture is displaced there will pseudoarthrosis.**

**Osteonecrosis (avascular necrosis):** dead bone, happens in fracture of the neck and head of femur, and navicular bone.

# AlRakabi's notes

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Inherited, usually autosomal dominant (homozygous usually dies, heterozygous lives but with bone abnormality) , it is caused in abnormality of collagen type I, rare.

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**Osteonecrosis (avascular necrosis):** dead bone, happens in fracture of the neck and head of femur, and navicular bone.



# MCQ

**1-The first step of fracture healing is :**

- A. callus formation
- B. hematoma formation
- C. Remodeling

**2-A fracture that does not heal in a normal alignment is called :**

- A. delayed union
- B. nonunion
- C. malunion

**3-the shaft of the bone is called :**

- A. metaphysis
- B. diaphysis
- C. epiphysis

**4-osteomyelitis and certain tumors start from the :**

- A. metaphysis
- B. diaphysis
- C. physis

**5-help to identify dead bone :**

- A. osteoblast
- B. osteoclast
- C. osteocyte

**6-osteoid is synthesized by :**

- A. osteoblast
- B. osteocyte
- C. osteoclast

## Team leaders

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