

MSK block

Bone fracture and healing

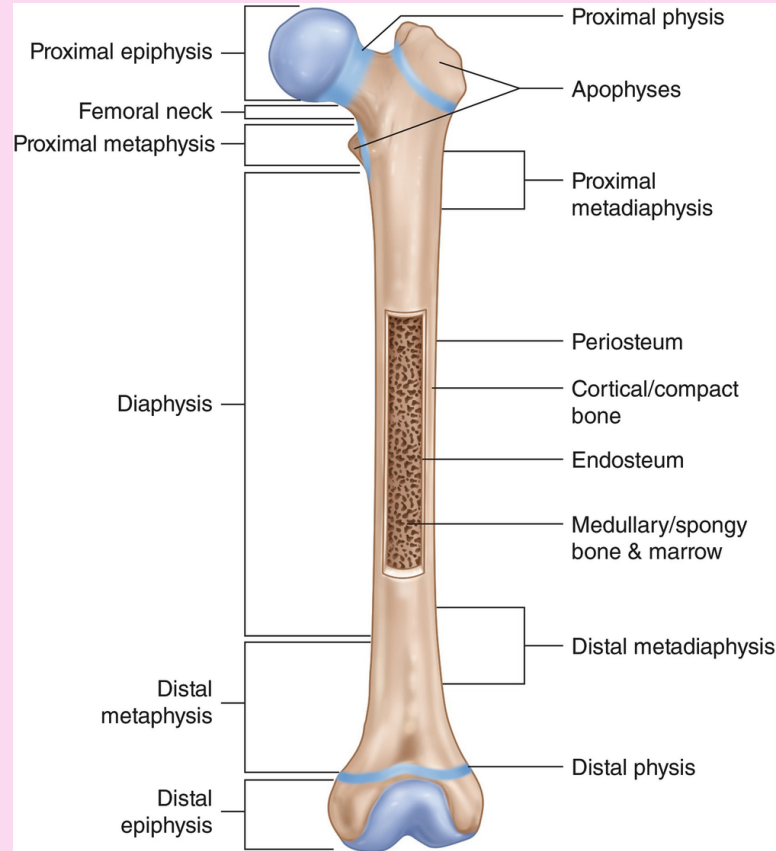
Afaf AlSolami

Bone and Soft tissue pathologist

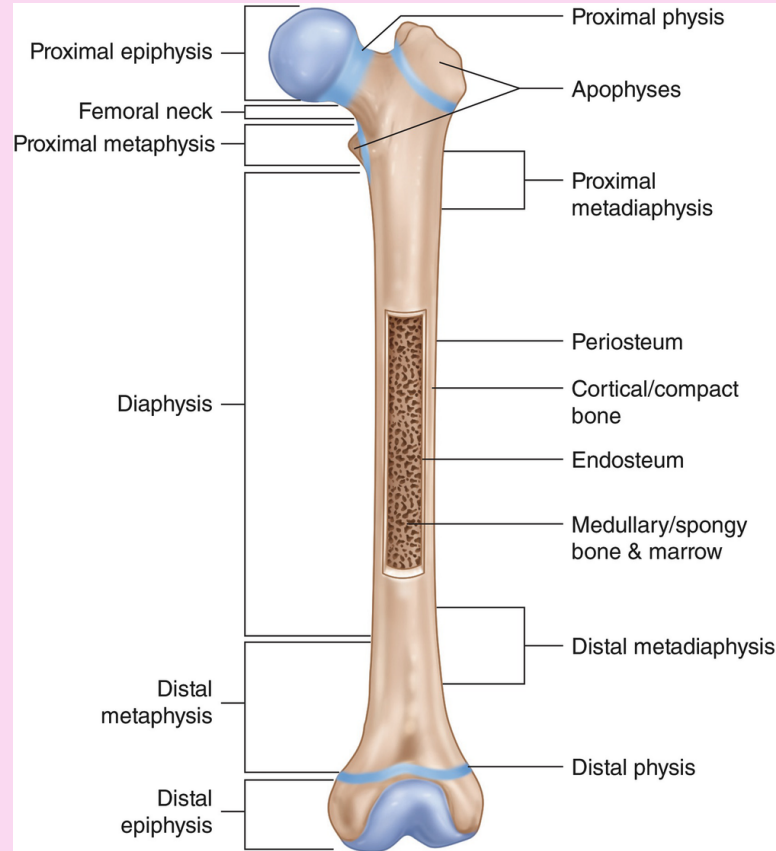
aalsolami1@ksu.edu.sa

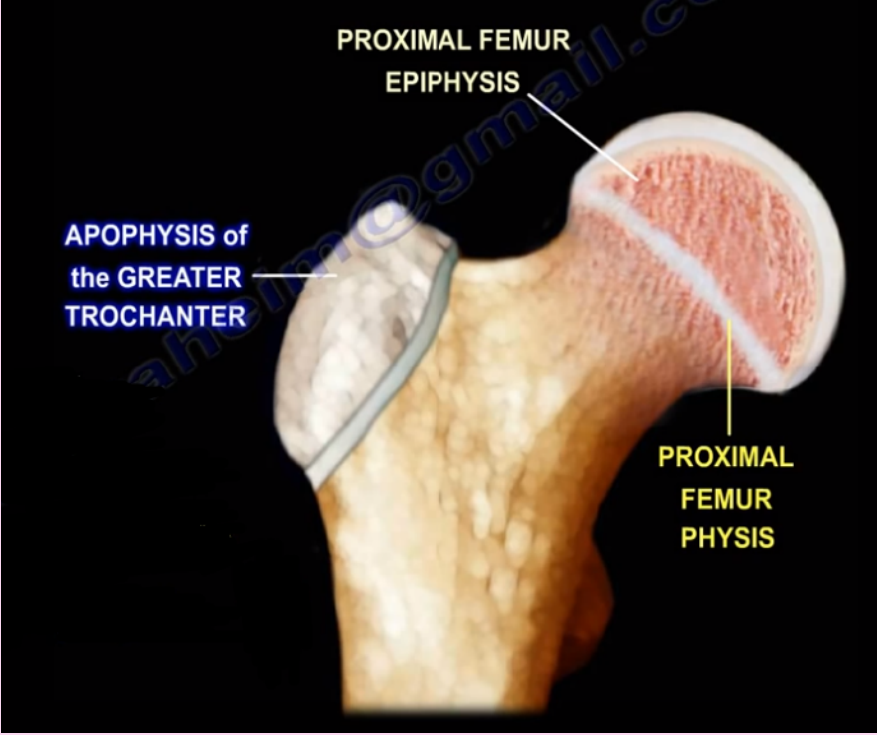
- Objectives of this lecture:
 - Know the different **types** of fractures
 - Be aware of the **mechanism and stages** of fracture healing process
 - Know **the factors affecting healing** process and the possible **complications** of healing process
 - Understands the difference between trauma induced and pathological fractures
 - Appreciate the importance of Motor Vehicle Accidents (MVA) as a major cause of disability in Saudi Arabia

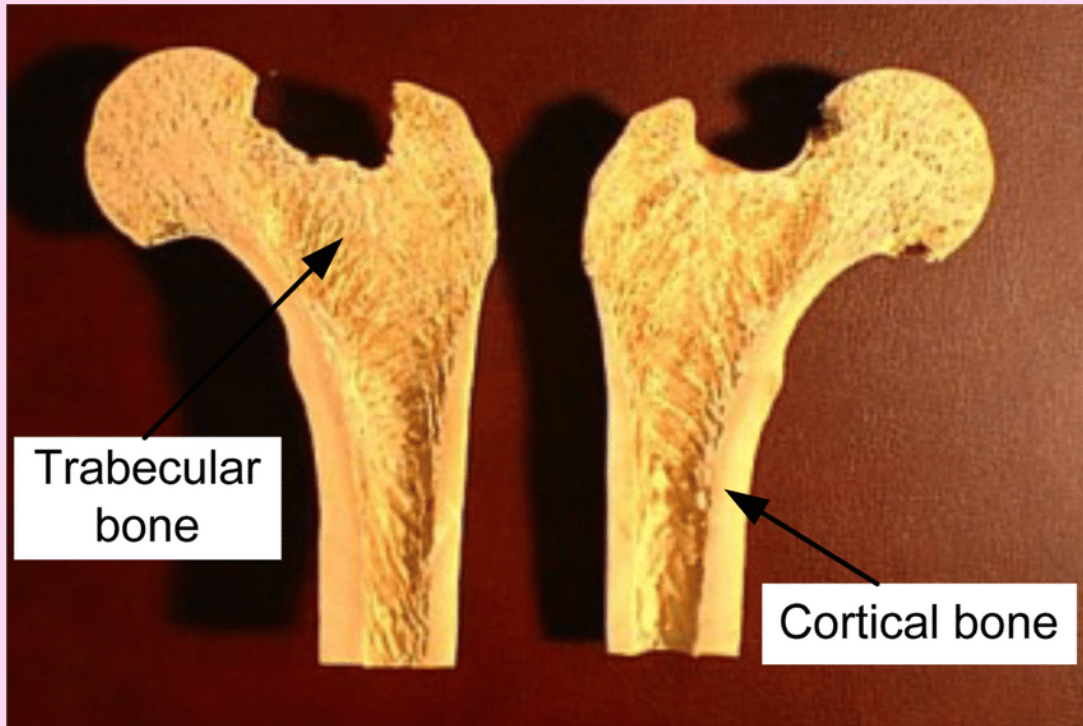
- 1- Epiphysis: ends of bone, partially covered by articular cartilage.
- 2- Physis: the growth plate.
- 3- Metaphysis: junction of diaphysis and epiphysis.
- 4- Diaphysis: the shaft.



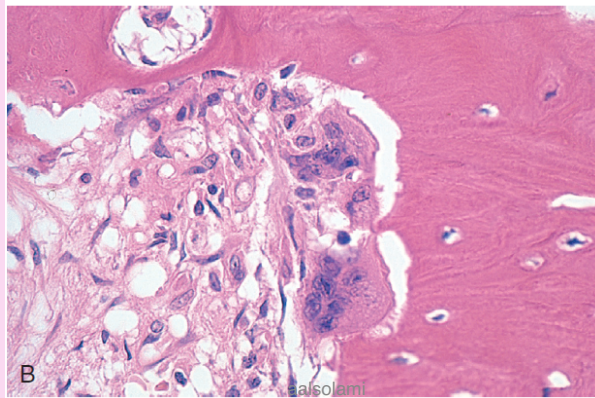
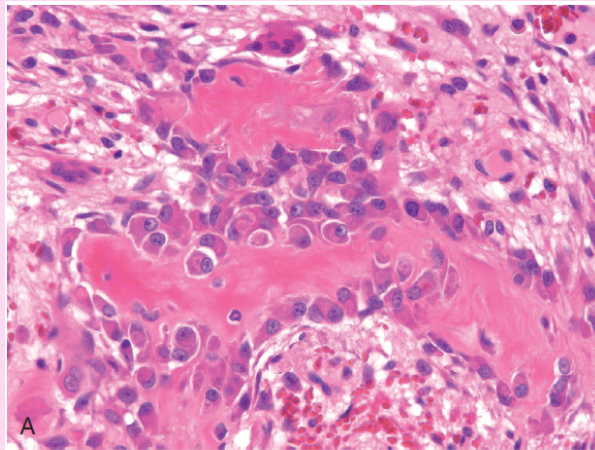
- 1- Periosteum.
- 2- Cortex: Cortical/ Compact bone.
- 3- Endosteum.
- 4- Medullary space: Cancellous/ Spongy bone.

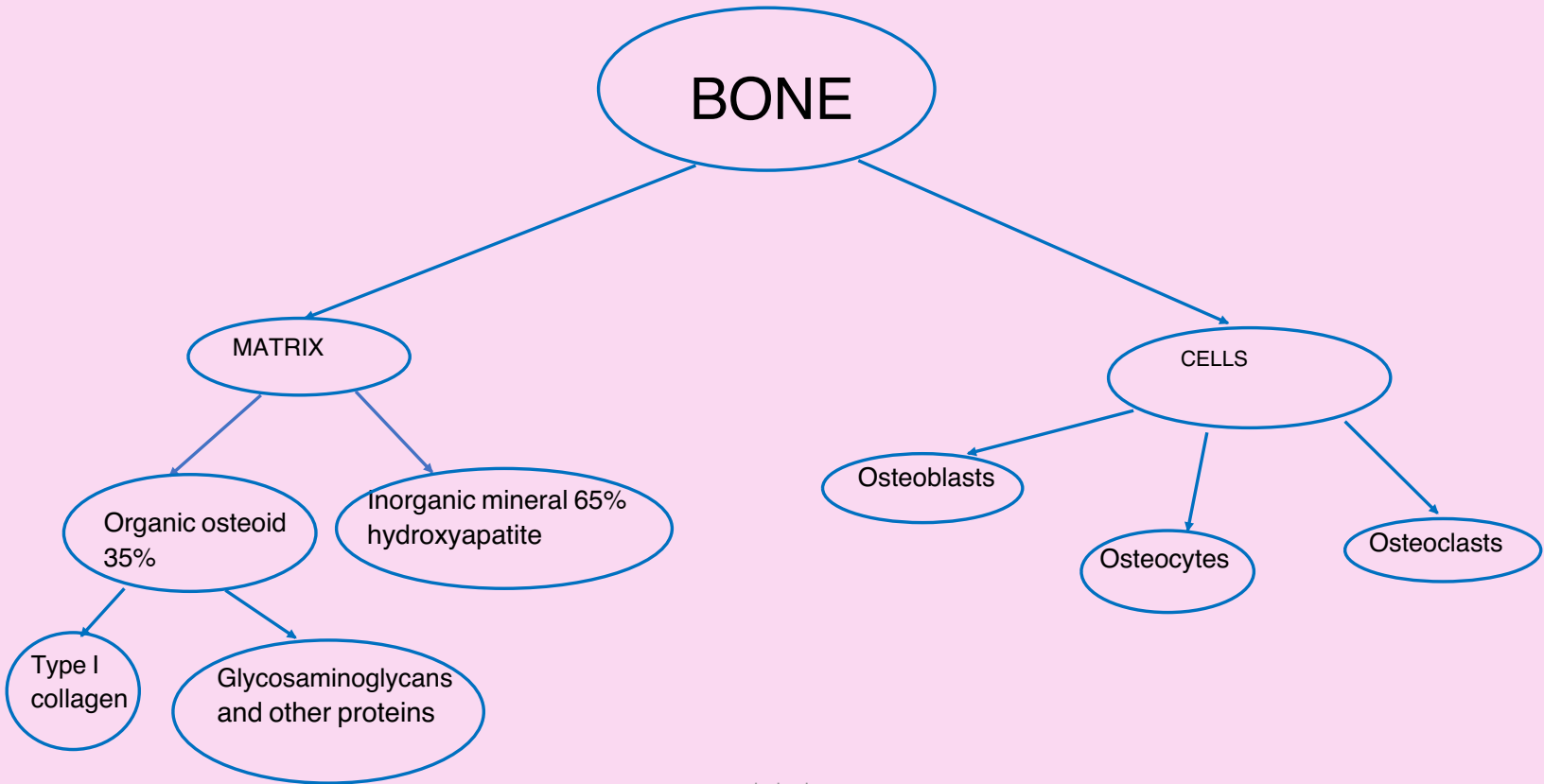


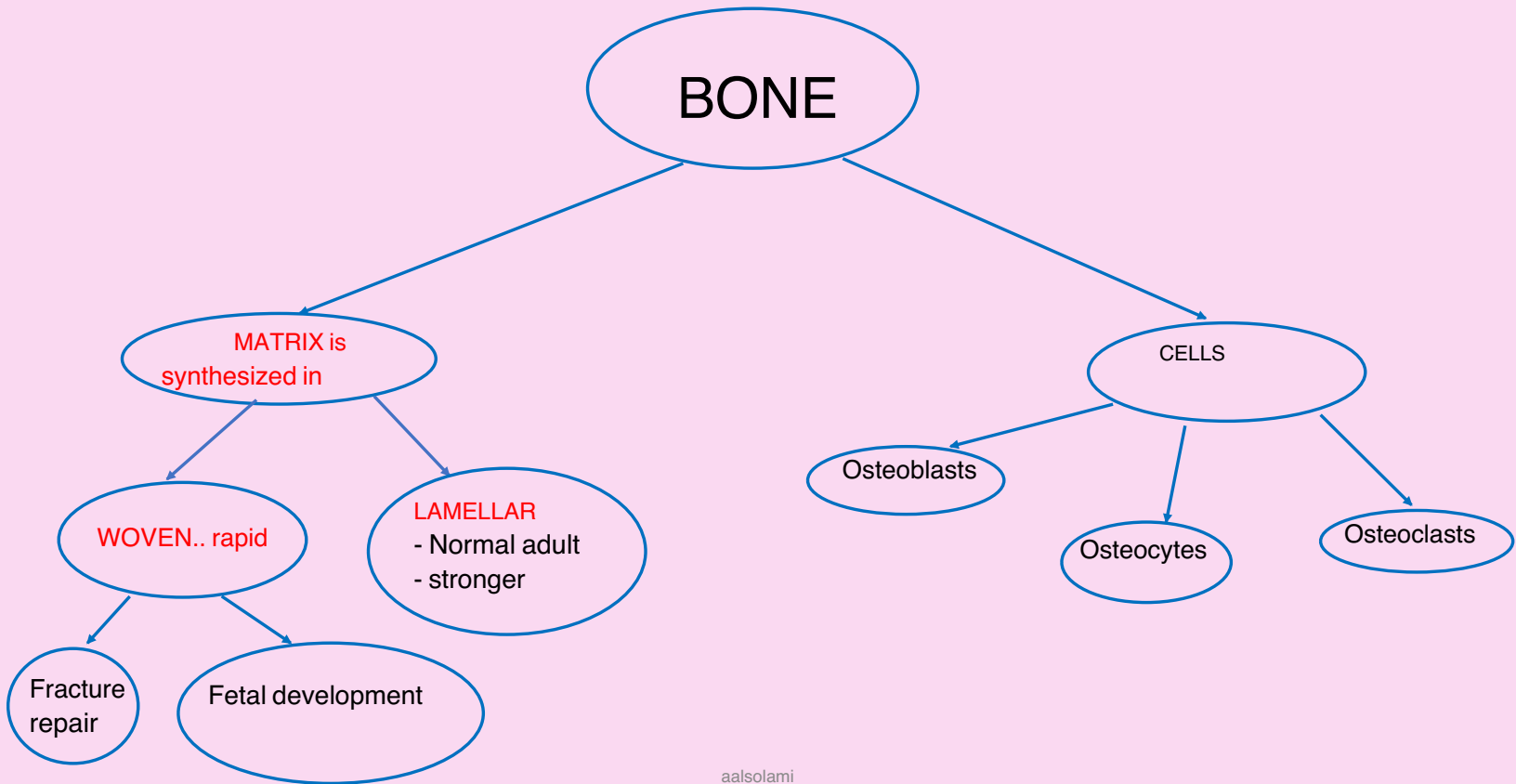


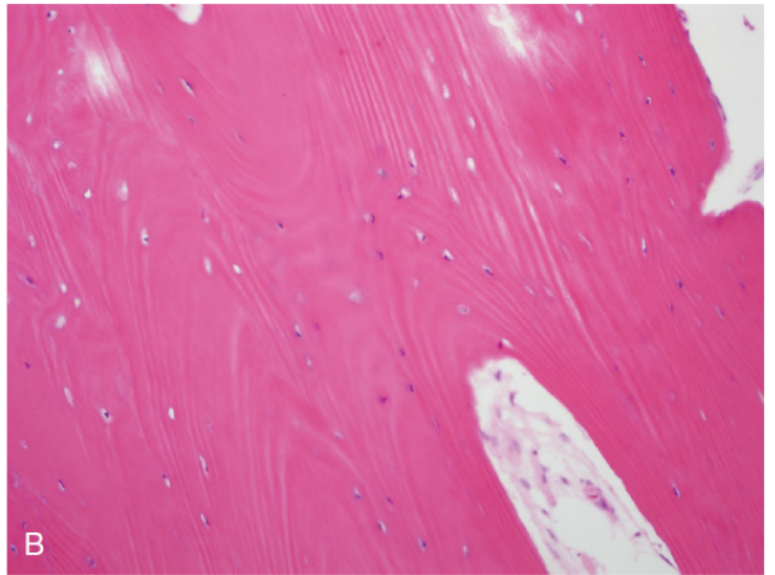
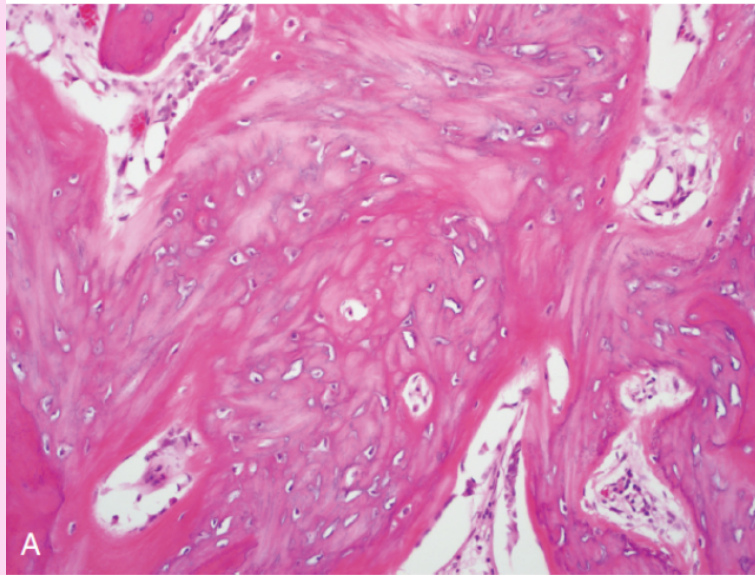












BONE

```
graph TD; BONE --> CELLS; CELLS --> Osteoblasts; CELLS --> Osteocytes; CELLS --> Osteoclasts;
```

CELLS

Osteoblasts

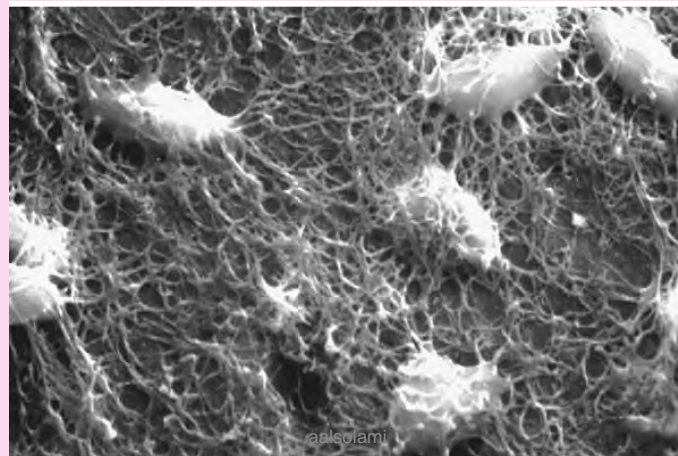
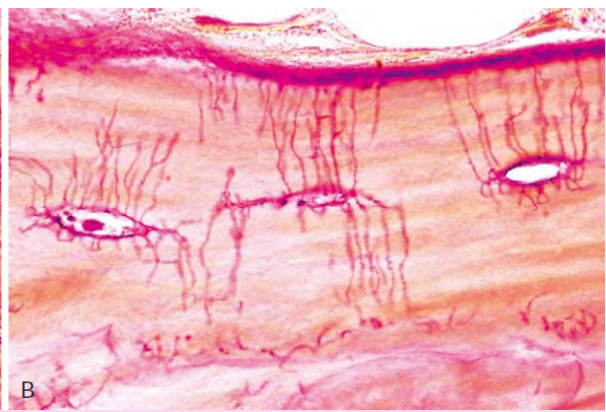
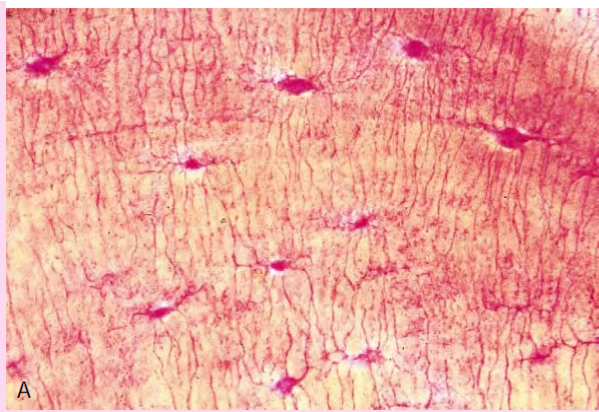
- On surface of bone matrix (synthesize, transport and regulate mineralization).
- From mesenchymal stem cells, under periosteum (early), medullary space (later)

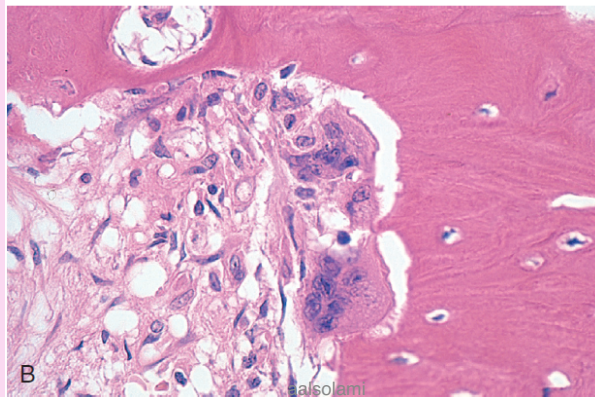
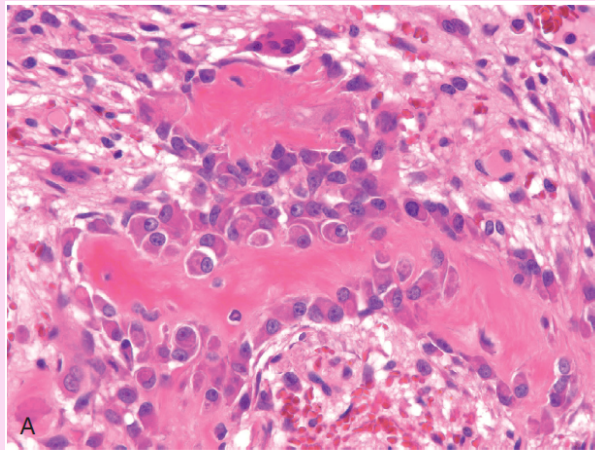
Osteocytes

- Within the bone.
- Interconnected, network of cytoplasmic processes through tunnels (canaliculi).
- Help control Ca and Ph, detect mechanical forces and translate them into biologic activity (mechanotransduction)

Osteoclasts

- On surface of bone.
- Specialized multinucleated macrophages..circulating monocytes.
- Bone resorption.
- Attach to bone matrix, sealed extracellular trench (resorption pit), secrete acid and neutral protease/MMPs, reosorb bone





Fracture..break in continuity of bone

- Loss of bone integrity resulting from mechanical injury and/or diminished bone strength.

Types of fracture

1- **Simple:** the overlying skin is intact

Closed

2- **Compound:** the bone communicates with the skin surface

Open

INFECTION!

3- **Comminuted:** The bone is fragmented.

4- **Displaced:** the ends of the bone at the fracture site are not aligned

5- **Stress (Hairline):** a slowly developing fracture that follows a period of increased physical activity in which the bone is subjected to repetitive loads

6- **Greenstick:** extending only partially through the bone, common in infants when bones are soft

7- **Pathologic:** involving bone weakened by an underlying disease process, such as a tumor

Types of Fractures

Simple



Compound



Greenstick

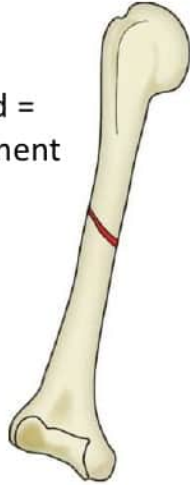


Comminuted



Displaced and Non displaced

Non displaced =
normal alignment



Displaced = pulled out
of normal alignment

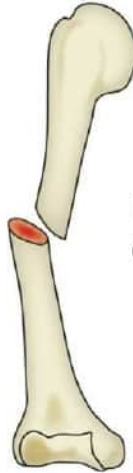




Fig. 1 Complete fracture



Fig. 2 Incomplete fracture

- **Complicated fracture:**

Associated with damage to nerves, vessels or internal organs

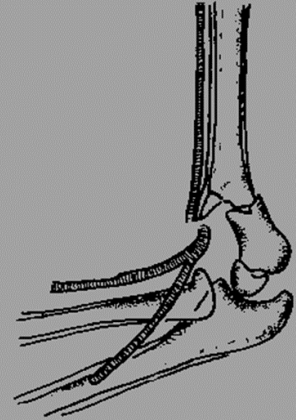
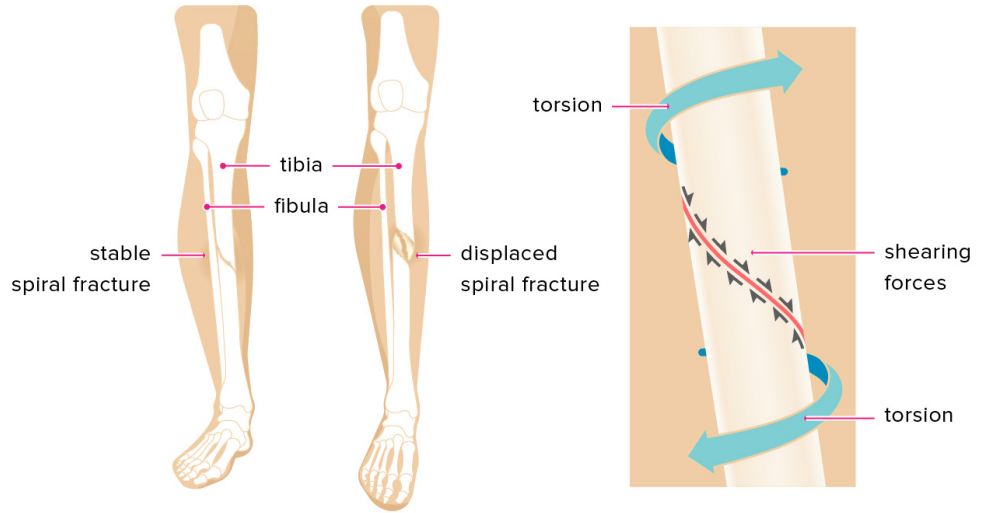
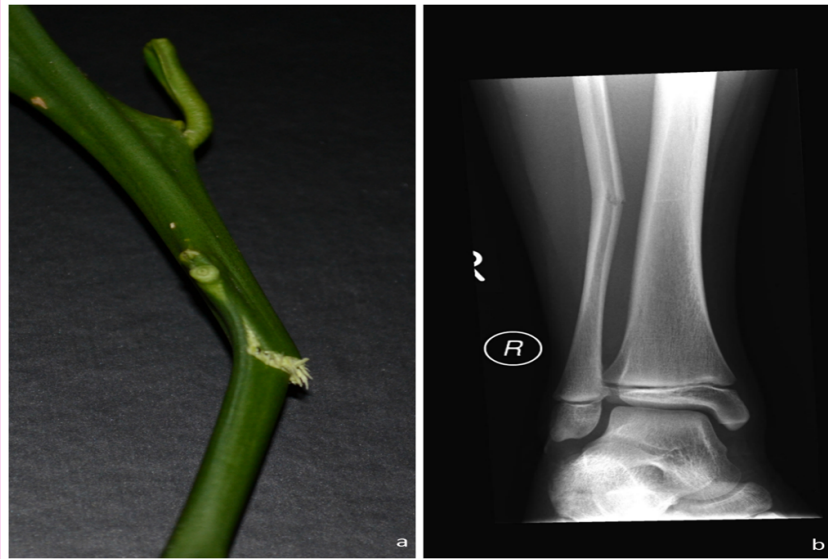


Fig. 5 A supracondylar fracture of the humerus with damage to the brachial artery

- Spiral fracture:
Twisting force





Causes of fracture

1-

TRAUMATIC:

Severe trauma e.g. MVA

2-

PATHOLOGIC:

3-

STRESS:

Causes of fracture

2-

PATHOLOGIC:

- Minimal trauma.
- The underlying bone is abnormal..

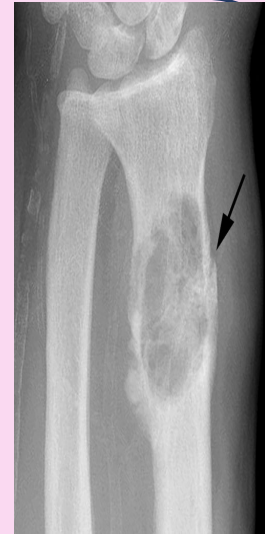
e.g. Osteoporosis

Osteomalacia

Paget's disease of bone

Tumor (primary or metastasis)

Congenital bone diseases (e.g. Osteogenesis Imperfecta).



Causes of fracture

3-

STRESS:

- Slowly over time.
- Collection of microfractures associated with increased physical activity (new repetitive mechanical loads on bone).
- most common in the weight-bearing bones of the lower leg and foot.
- athletes and military recruits who carry heavy packs over long distances are particularly susceptible

Healing of fracture

1- Reactive phase:

- a) Hematoma and inflammatory phase.
- b) Granulation tissue formation.

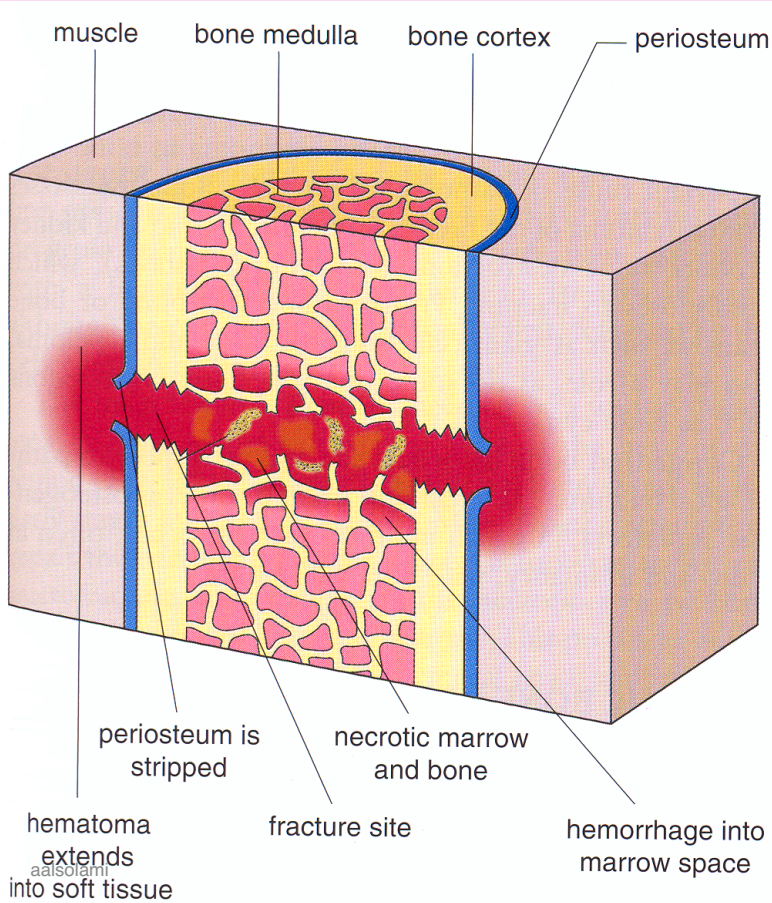
2- Reparative phase:

Callus formation (soft and bony).

3- Remodeling phase:

Remodeling to original bone contour

1- Reactive phase

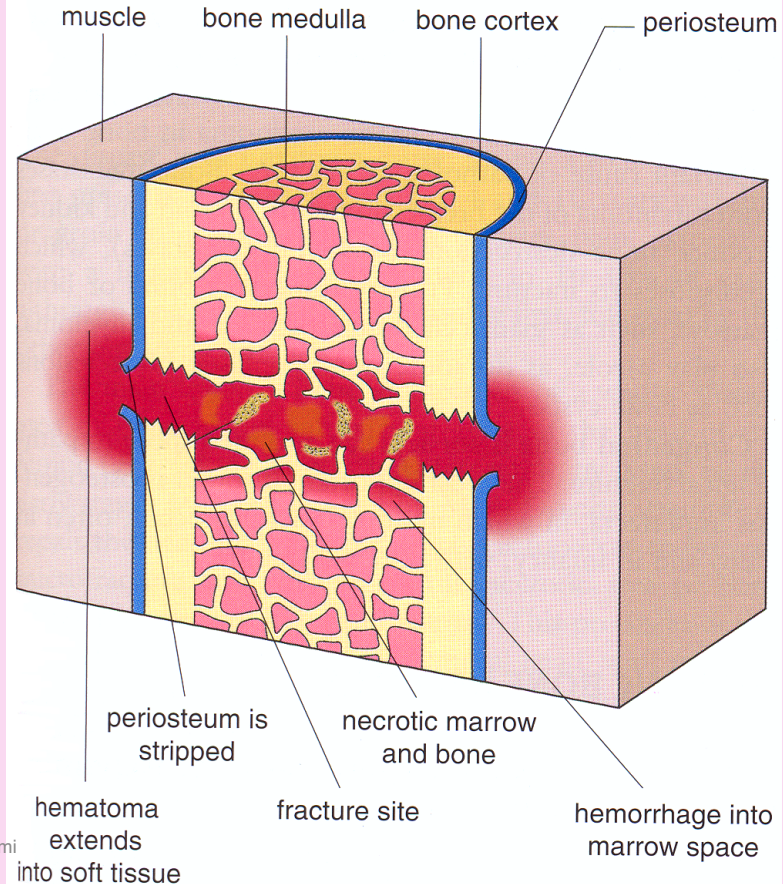


1- Reactive phase:

- Bleeding causes swelling due to inflammation induced by chemical mediators produced from macrophages and other inflammatory cells with granulation tissue formation.

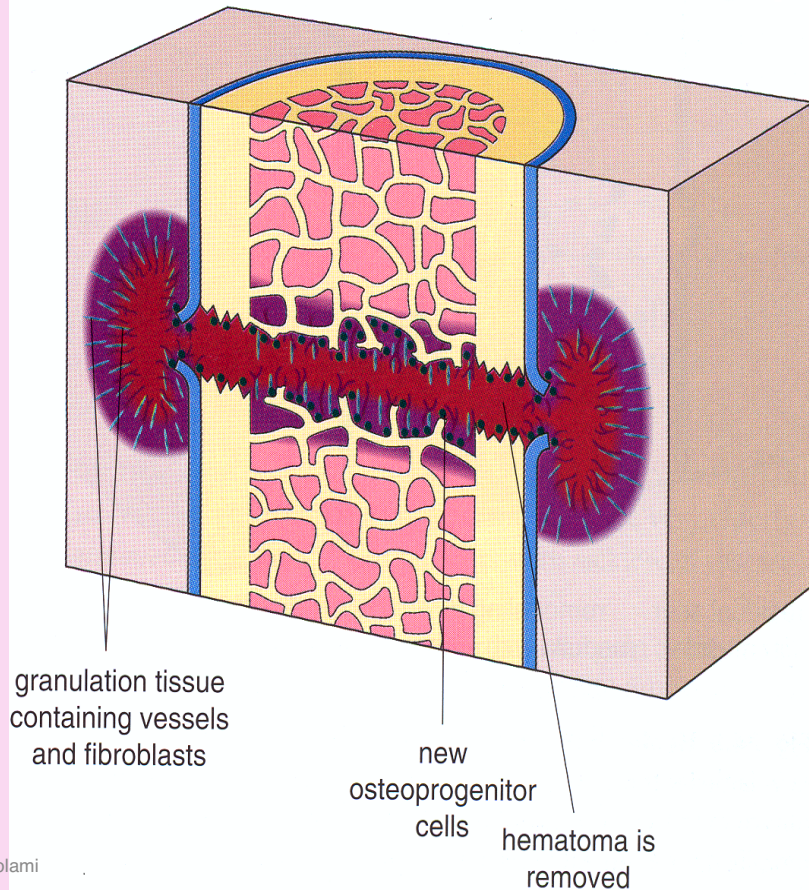
1- reactive phase

- A. Due to tearing of blood vessels in the medullary cavity, cortex and periosteum, a hematoma forms at the site of fracture. The periosteum is stripped from the surface.

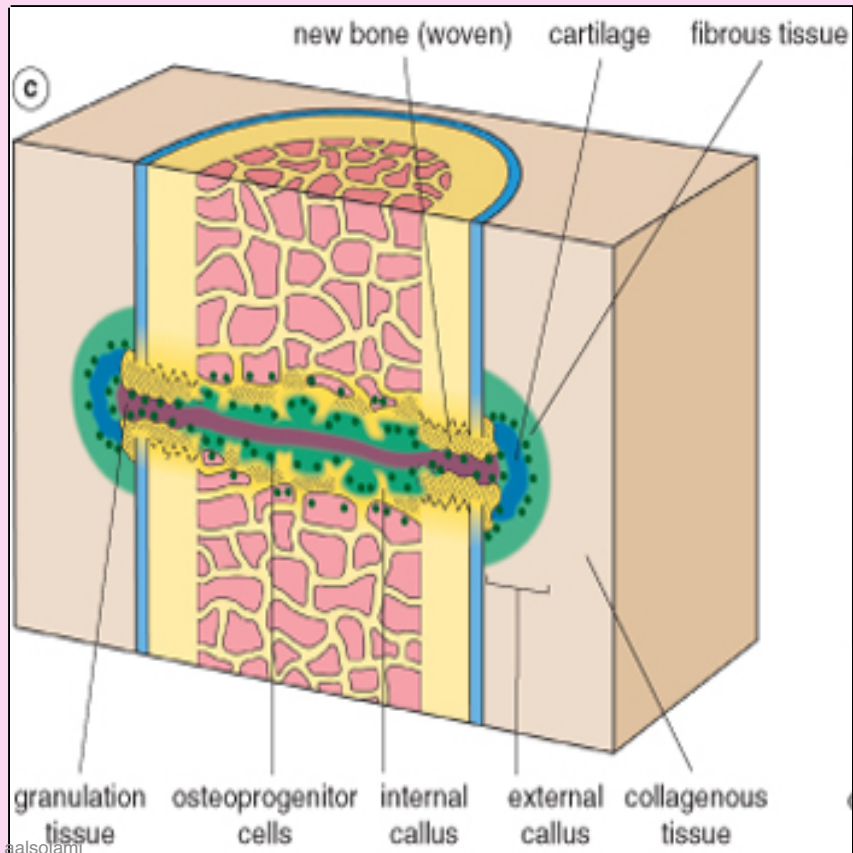


1- reactive phase

- B. Organization of the hematoma is associated with the migration of neutrophils and macrophages into the fracture hematoma; these cells phagocytose the hematoma and necrotic debris.



2- Reparative phase



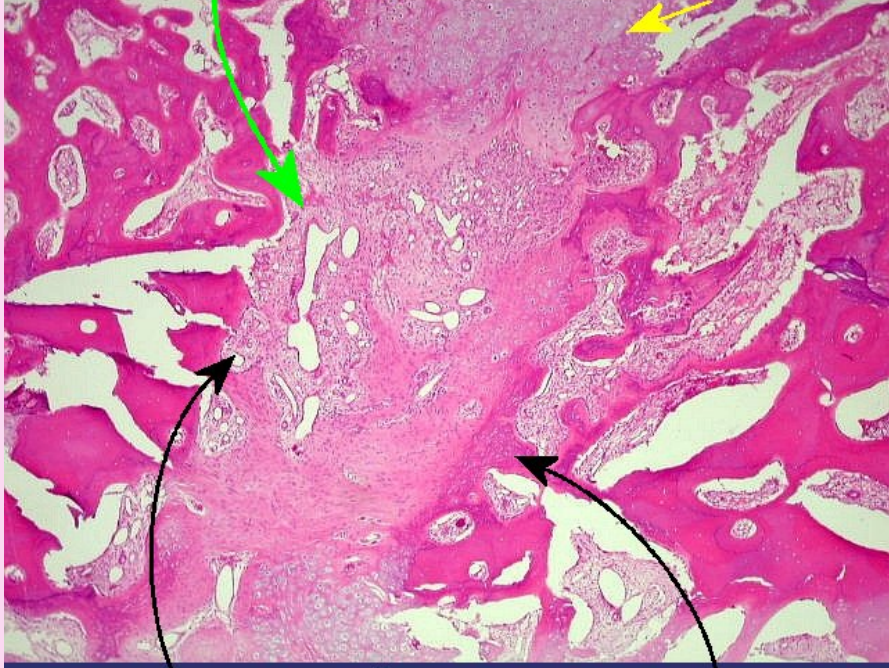
2- Reparative phase:

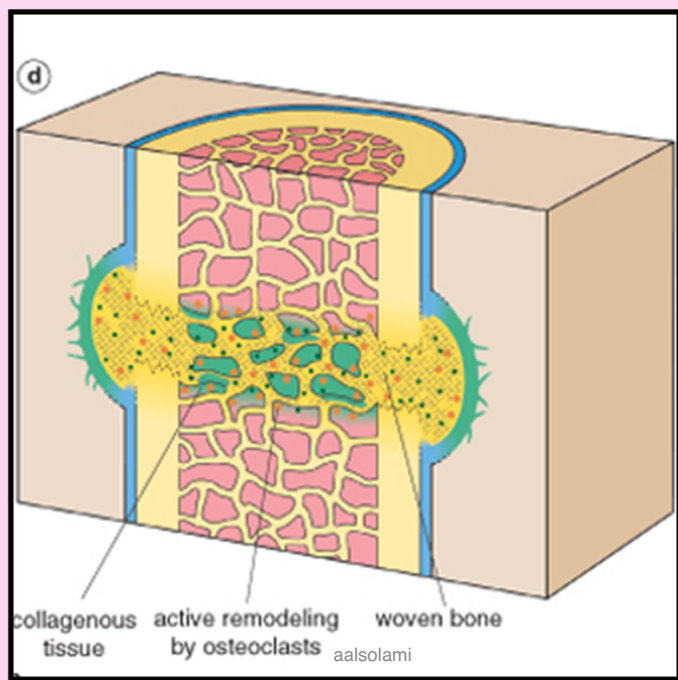
- Degranulated platelets and marauding inflammatory cells subsequently release a host of cytokines (e.g., platelet-derived growth factor, fibroblast growth factor, TGF- β)
- PDGF, FGF, and TGF- β .. activate bone progenitor cells, and within a week, the involved tissue is primed for new matrix synthesis.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

2- Reparative phase: after 2 weeks

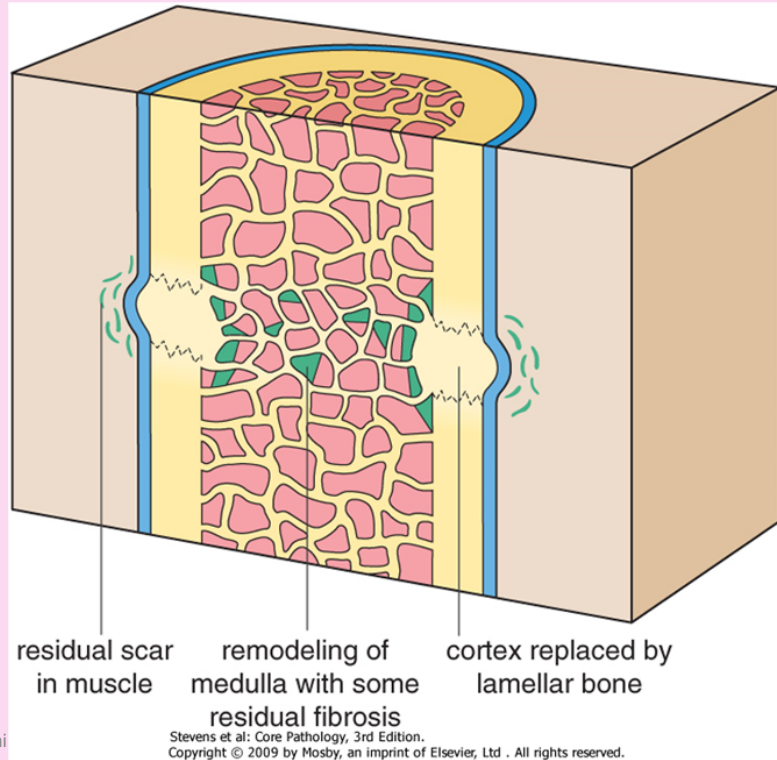
- **HARD CALLUS:**

- Activated osteoprogenitor cells deposit *woven bone*.
- In some cases, the activated mesenchymal cells in the soft tissues and bone surrounding the fracture line also differentiate into chondrocytes that make fibrocartilage and hyaline cartilage.
- In uncomplicated fractures, this early repair process peaks within 2 to 3 weeks.
- The 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.





3- Remodeling phase:

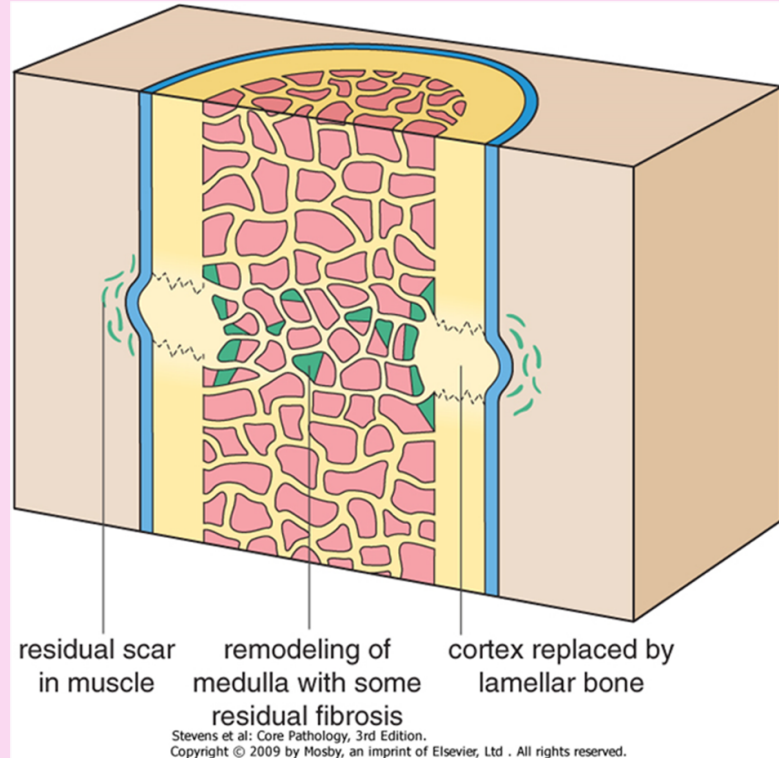


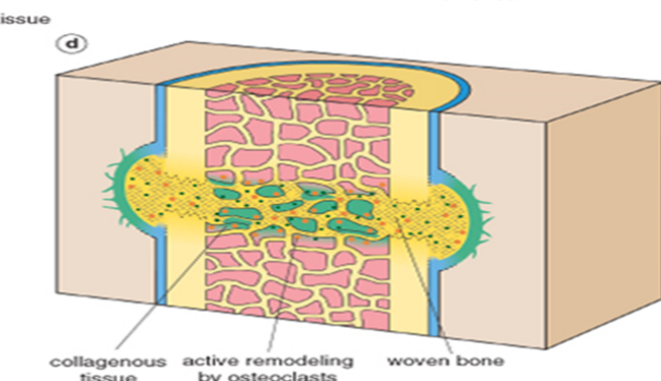
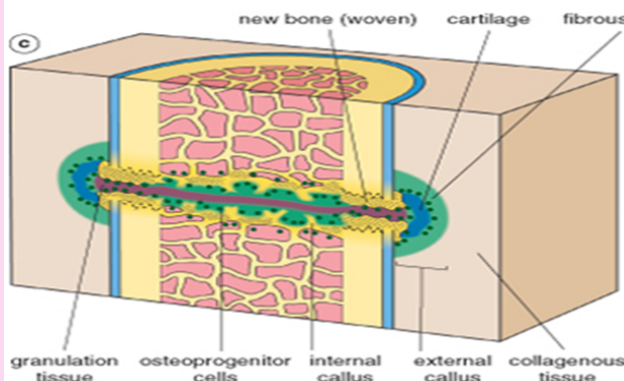
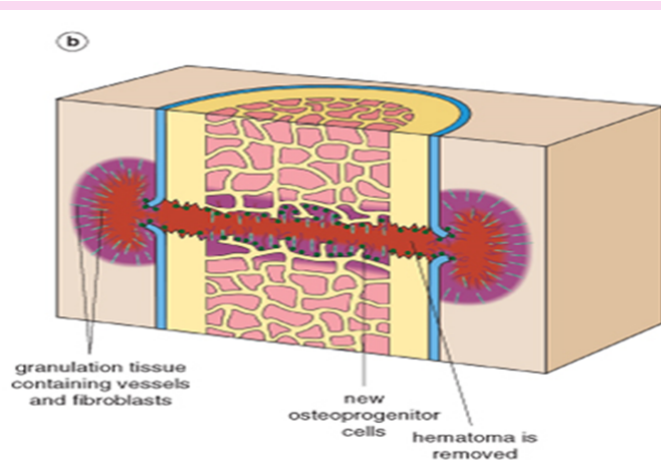
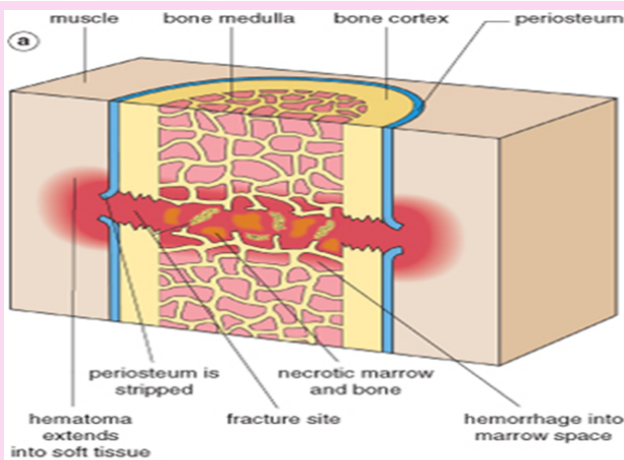
3- remodeling phase:

- 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.
- Although excess fibrous tissue, cartilage, and bone are produced in the early callus, subsequent weight bearing leads to remodeling of the callus... lamellar bone and restoration of medullary cavity.

3-remodeling phase

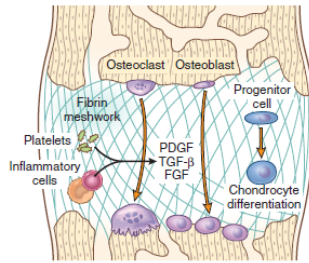
- The rate of healing and the ability to remodel a fractured bone vary tremendously for each person and depend on
 - age
 - health
 - the kind of fracture
 - the bone involved.



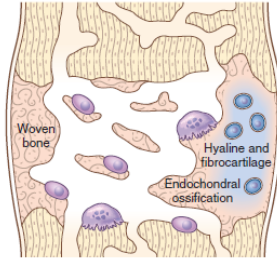




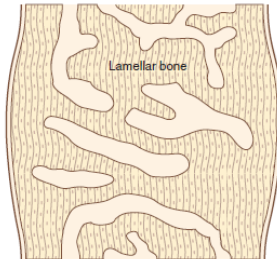
0-1 day
Organizing
hematoma



0-2 weeks - Soft callus



2-3 weeks - Bony callus



3 weeks-months - Bony callus

Factors disrupting healing process:

1- Displaced and comminuted fractures

2- Infection

3- 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** of fracture fragments.

4- Inadequate minerals and vitamins

5- Inadequate immobilization (movement of the callus and prevents its normal maturation, resulting in *delayed union* or *Nonunion*)

Complications

- 1- Delayed **union**
- 2- Non**union**
- 3- Mal**union**
- 4- Neurovascular injury
- 5- Infection (Open fractures can become infected)
- 6- Post-traumatic arthritis (Fractures that extend into the joints (intra-articular fractures))
- 7- Growth abnormalities (A fracture in the open physis, or growth plate, in a child, can cause many problems)

....UNION

1- Delayed...:

A fracture that takes longer to heal than expected is a delayed union.

2- Non...:

A fracture that fails to heal in a reasonable amount of time is called a nonunion (pseudarthrosis)..

3- Mal...:

A fracture that does not heal in a normal alignment is called a malunion

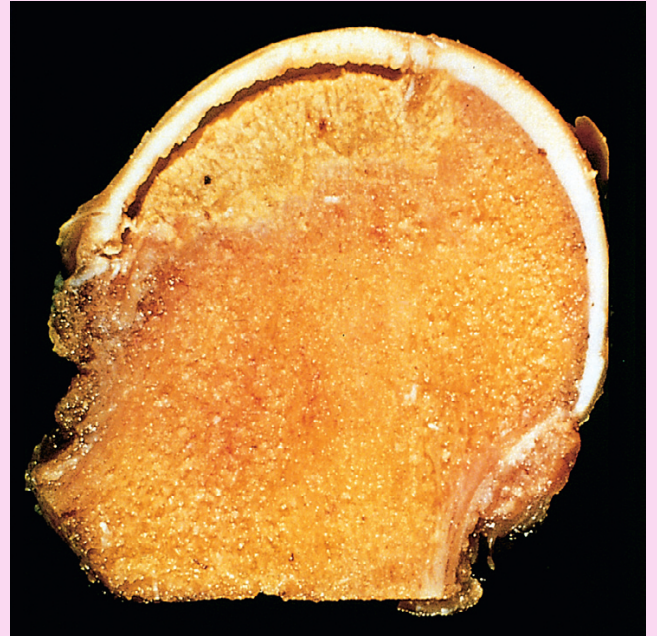


aalsolami

Osteonecrosis (avascular necrosis)

- Infarction (ischemic necrosis) of bone and marrow cells, peak 30-50, 10% hip replacement.
- Causes:
 - 1) Vascular injury (trauma, vasculitis)
 - 2) Drugs (corticosteroids)
 - 3) Systemic disease (sickle cell disease)
 - 4) Radiation
 - 5) Unknown (25%)
- Mechanism:
 - 1) Mechanical disruption of vessel
 - 2) Thrombotic occlusion
 - 3) Extravascular compression

- Cortex not affected .. Collateral blood flow.
- Overlying cartilage is viable.. Synovial fluid
- Dead bone.. Empty lacunae
- Can lead to secondary osteoarthritis



Homework

- Avulsion fracture.
- Buckled fracture.
- Colles fracture.

Reference

- Kumar V, Abbas AK, Aster JC. Robbins Basic Pathology. 10th ed. Elsevier; 2017. Philadelphia, PA.

p. 797-798

805-806

aalsolami1@ksu.edu.sa

