MUSCULOSKELETAL BLOCK

Pathology

Lecture 1: Fracture and bone healing

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MUSCULOSKELETAL BLOCK

Pathology: 5 lectures

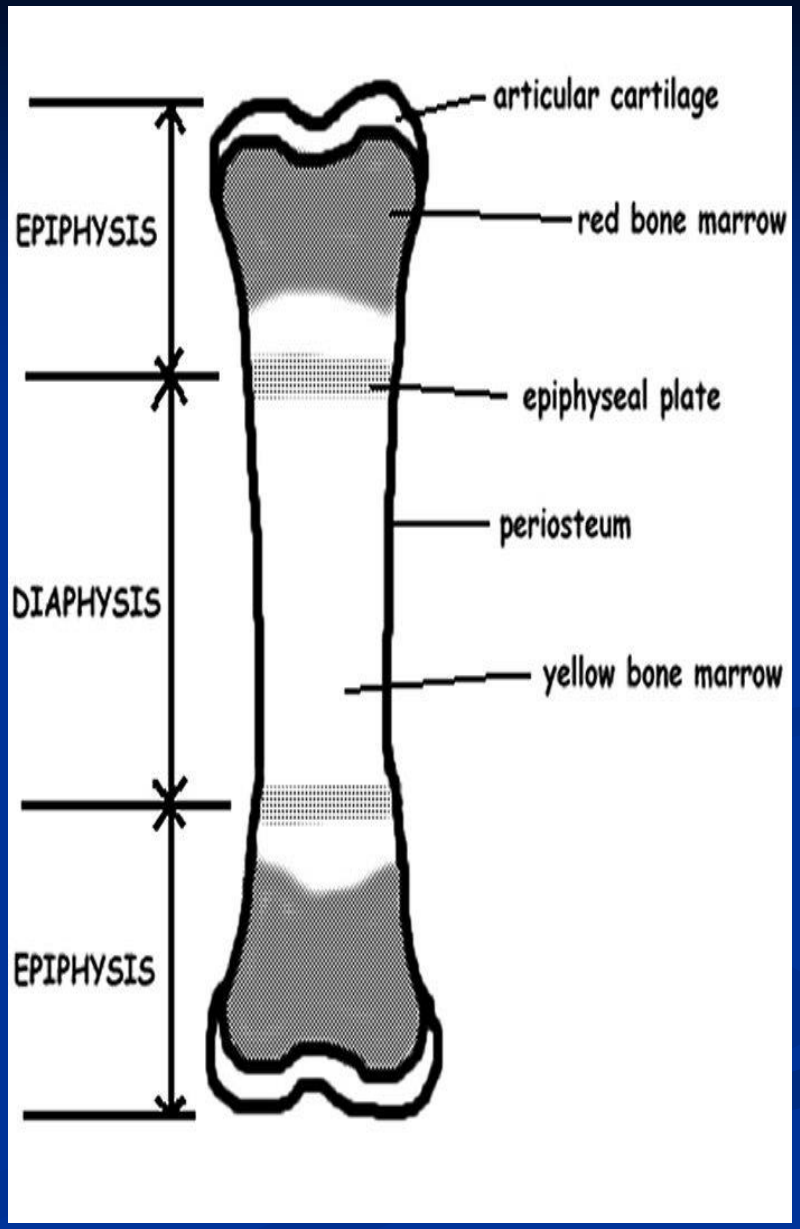
1. Fracture and bone healing
2. Congenital and developmental bone diseases
3. Introduction to myopathies and muscular dystrophy
4. Non-infectious arthritis
5. Osteomyelitis and septic arthritis

Healing of bone fractures

- At the end of this lecture you should :
  - 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
  - Appreciate the importance of road traffic accidents as a major cause of disability in Saudi Arabia

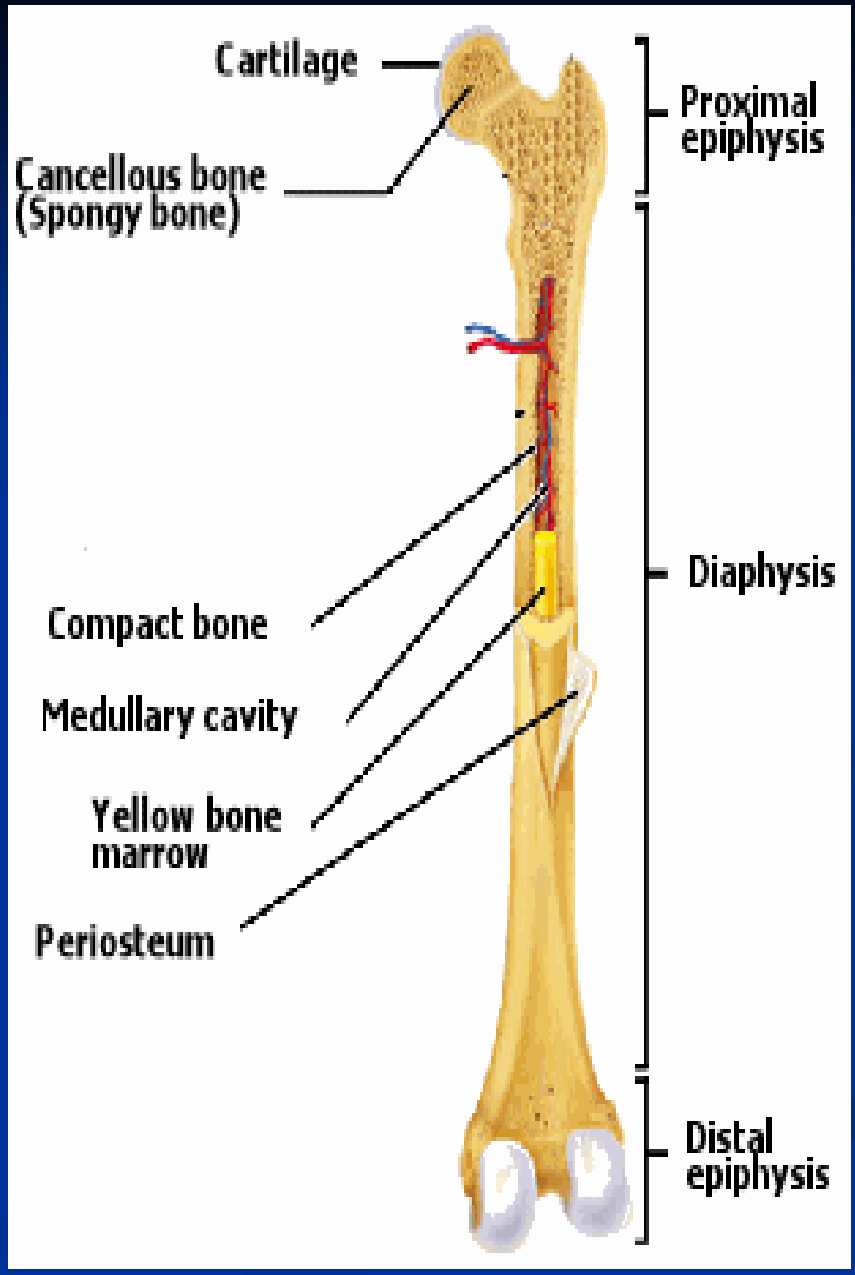
Normal anatomy

- **Parts of a long bones:**
  - epiphysis (ends of bone, partially covered by articular cartilage)
  - physis (growth plate)
  - metaphysis (junction of diaphysis and epiphysis, most common site of primary bone tumors)
  - diaphysis (shaft)



Normal anatomy

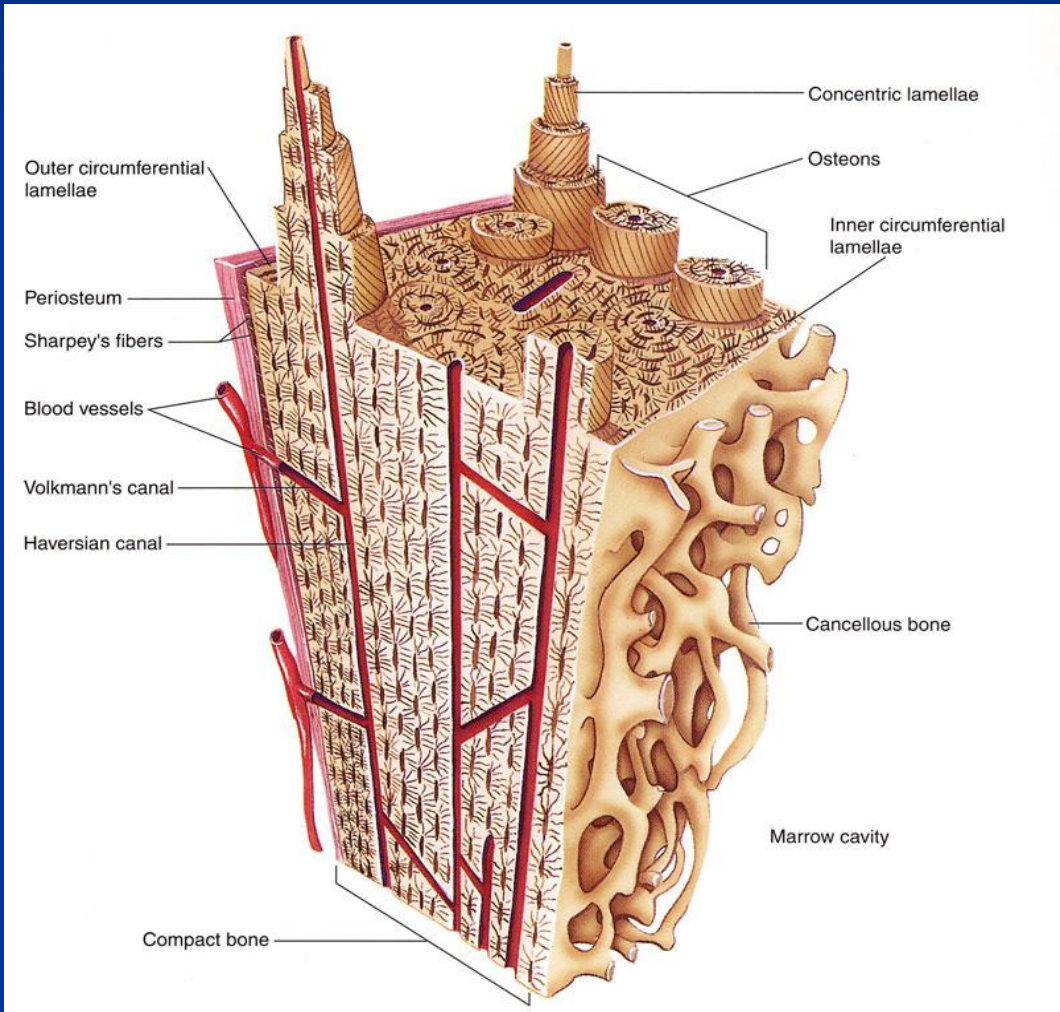
- **Cross section:**
  - Periosteum
  - cortex (composed of cortical bone or compact bone)
  - medullary space (composed of cancellous or spongy bone)

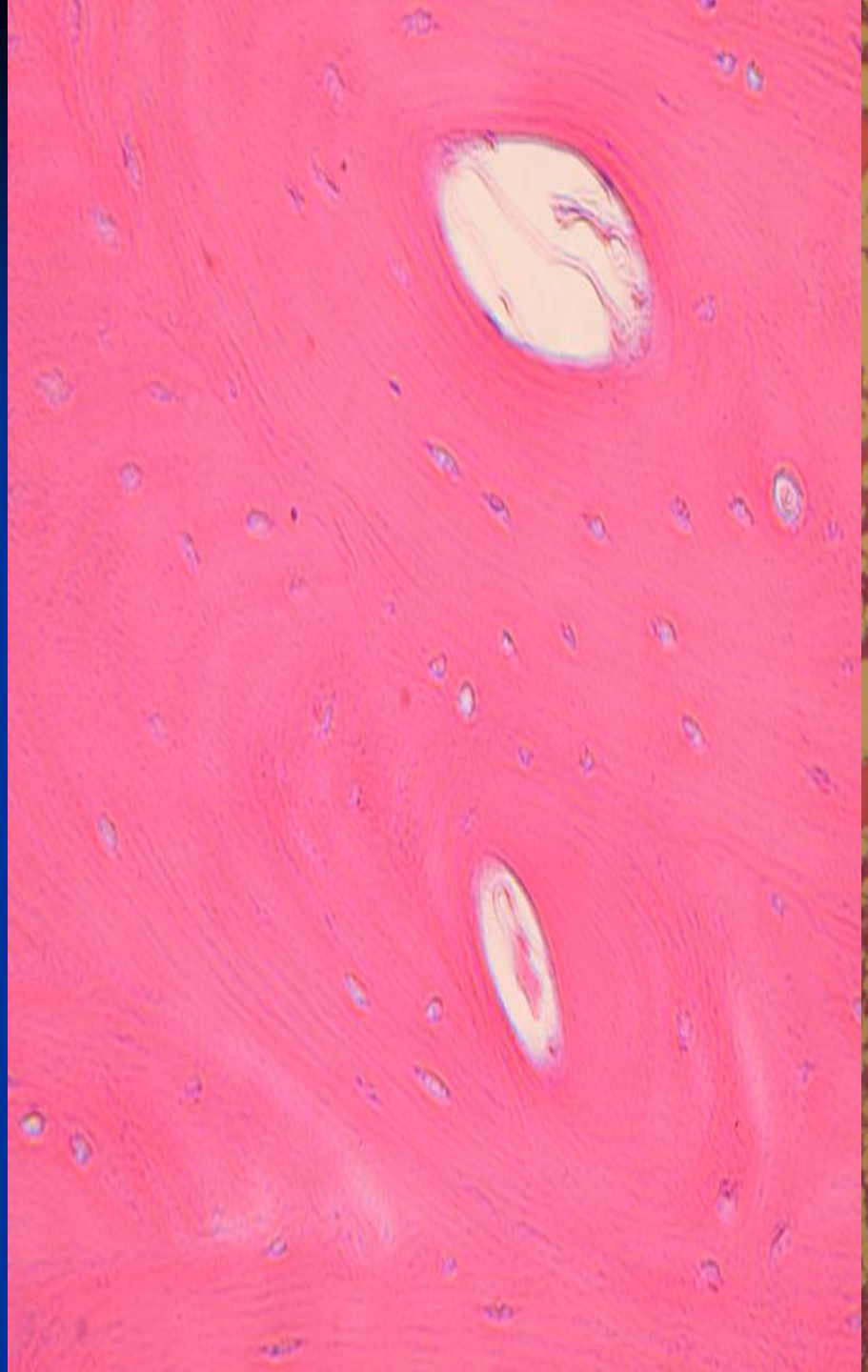


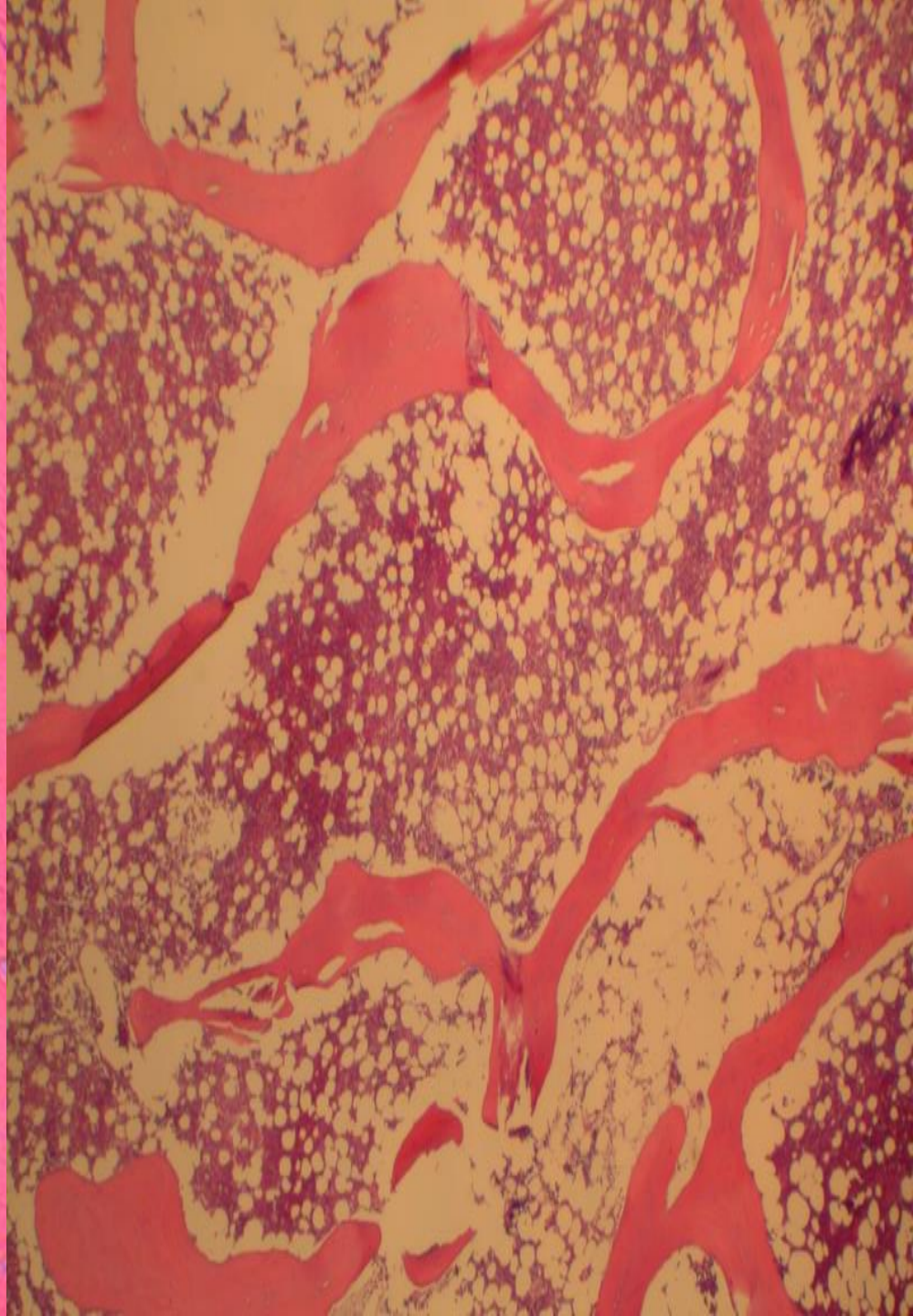
Normal histology

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

- **Lamellar bone:**
  - layered bone with concentric parallel lamellae
  - gradually replaces woven bone
  - normal type of bone found in adult skeleton
  - stronger than woven bone

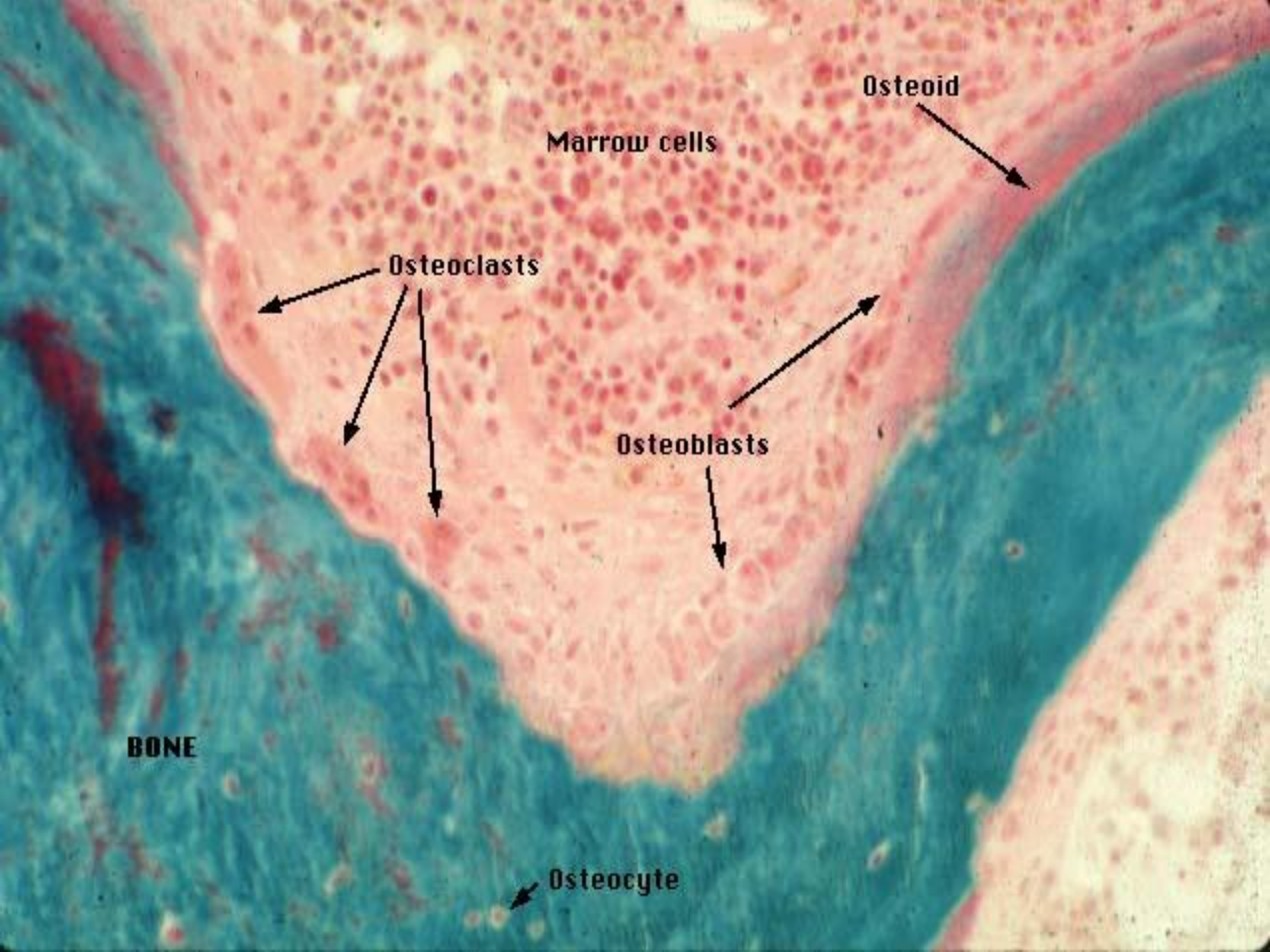






Bone Cells

- **Osteoblasts:** arise from marrow mesenchymal cells; when active, are plump and present on bone surface; eventually are encased within the collagen they produce.
- Osteoclasts: large multinucleated cells found attached to the bone surface at sites of active bone resorption.


Osteoid
Marrow cells
Osteoclasts
Osteoblasts
BONE
Osteocyte

Fracture:-

Break in the continuity of bone

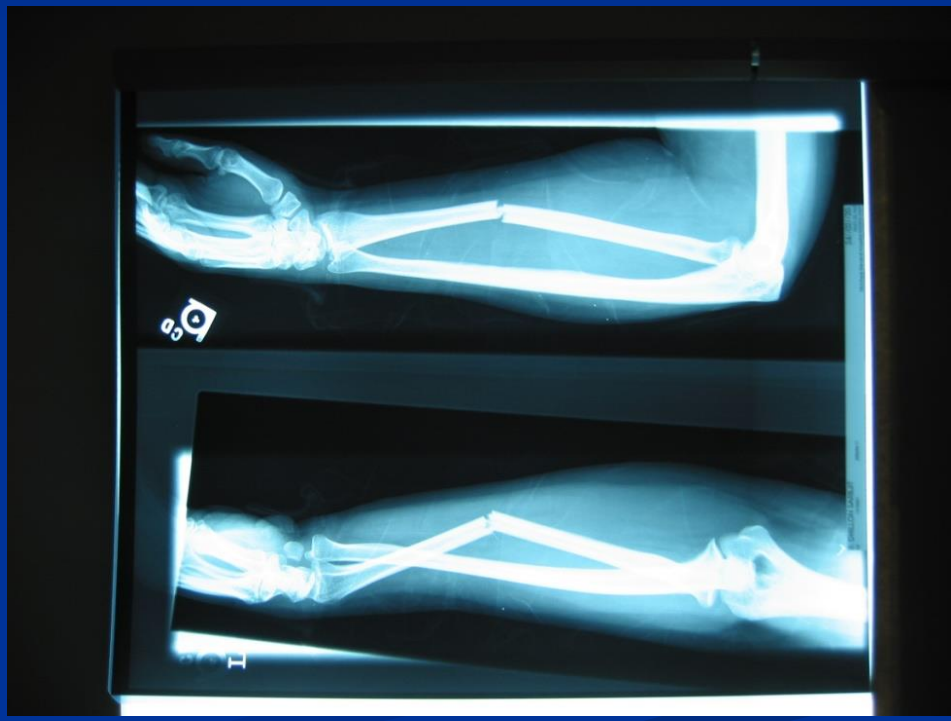
Fig. 1 Complete fracture

Fig. 2 Incomplete fracture

Defintions

Incomplete

Complete



Defintions.

- Closed fracture (simple).
- Open fracture (compound).
- Complicated fracture.

Defintions

- Closed Fracture (simple):-

  Does **NOT** communicate with external environment

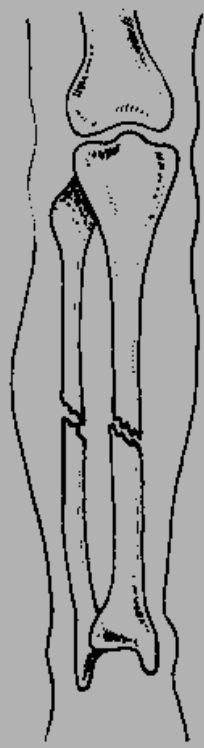


Fig 3. closed fracture tibia

Defintions.

- Open Fracture (compound):-

Communicate with external environment

Infection !!

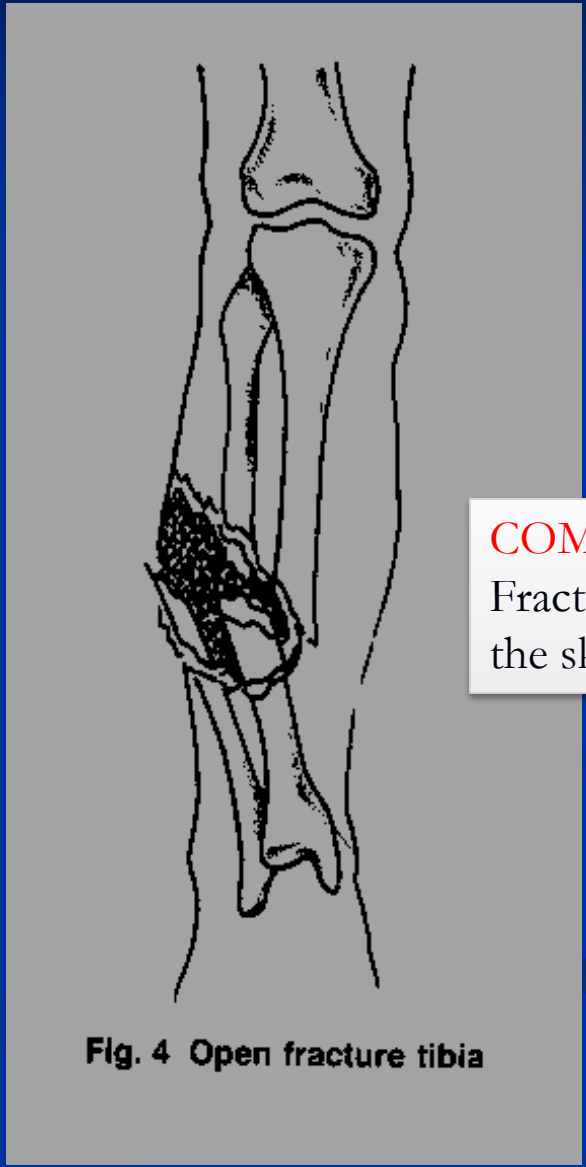


Fig. 4 Open fracture tibia

COMPOUND #
Fracture extend to the skin

Defintions

- Complicated Fracture:-

  Associated with damage to nerves, vessels or internal organs

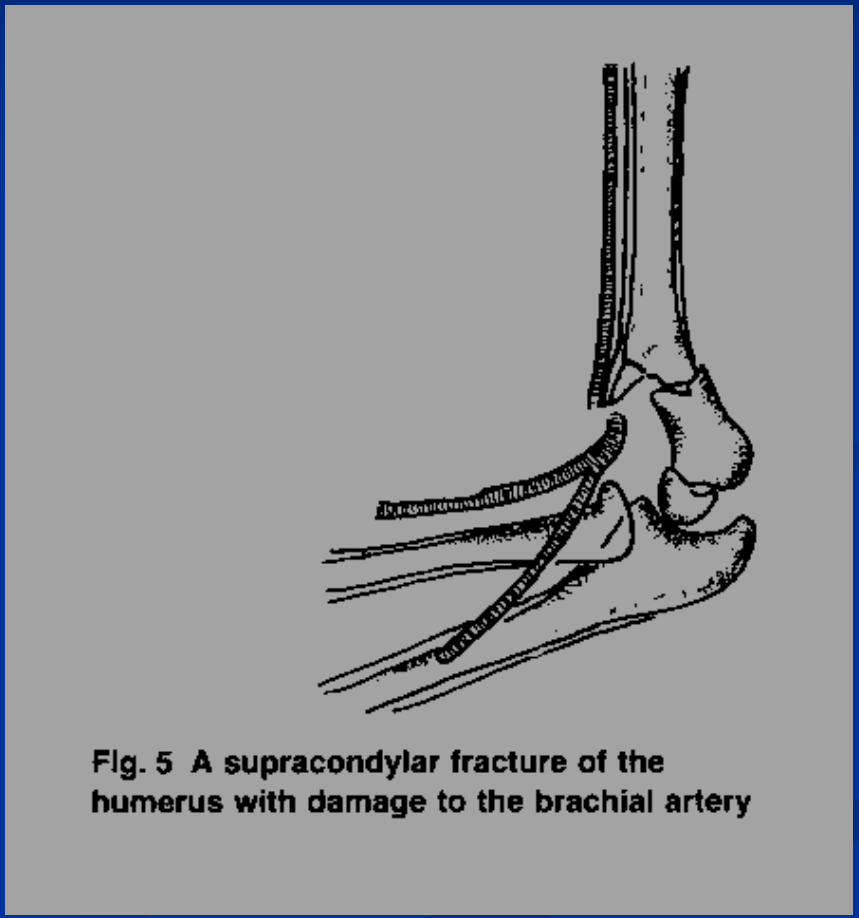
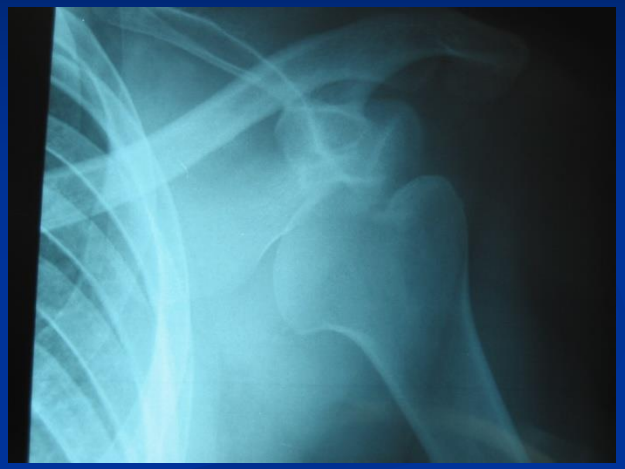


Fig. 5 A supracondylar fracture of the humerus with damage to the brachial artery

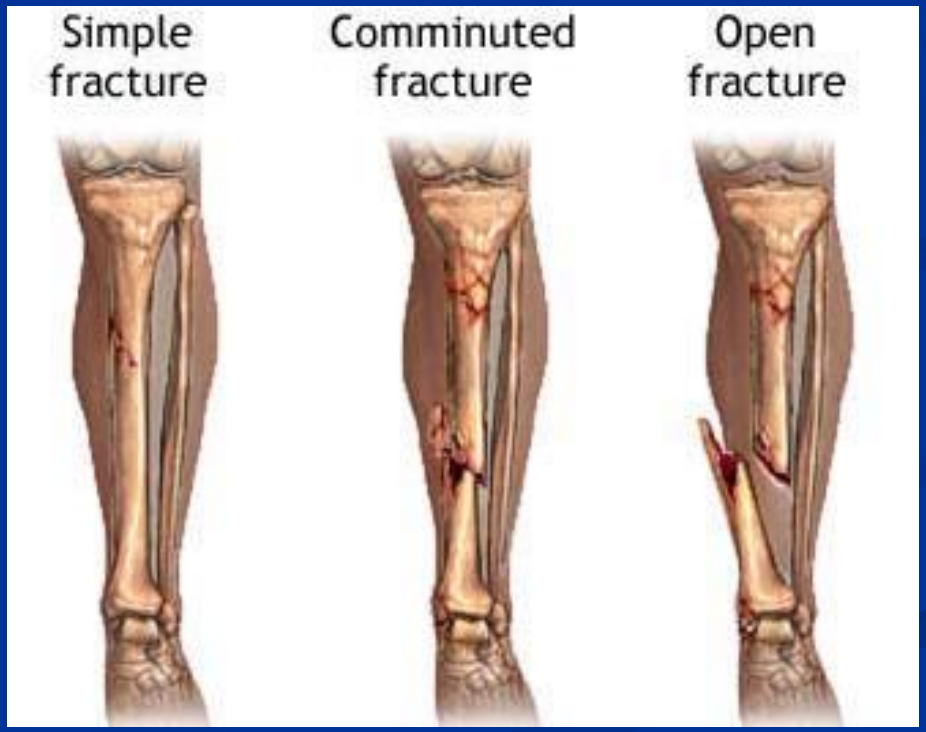
Defintions

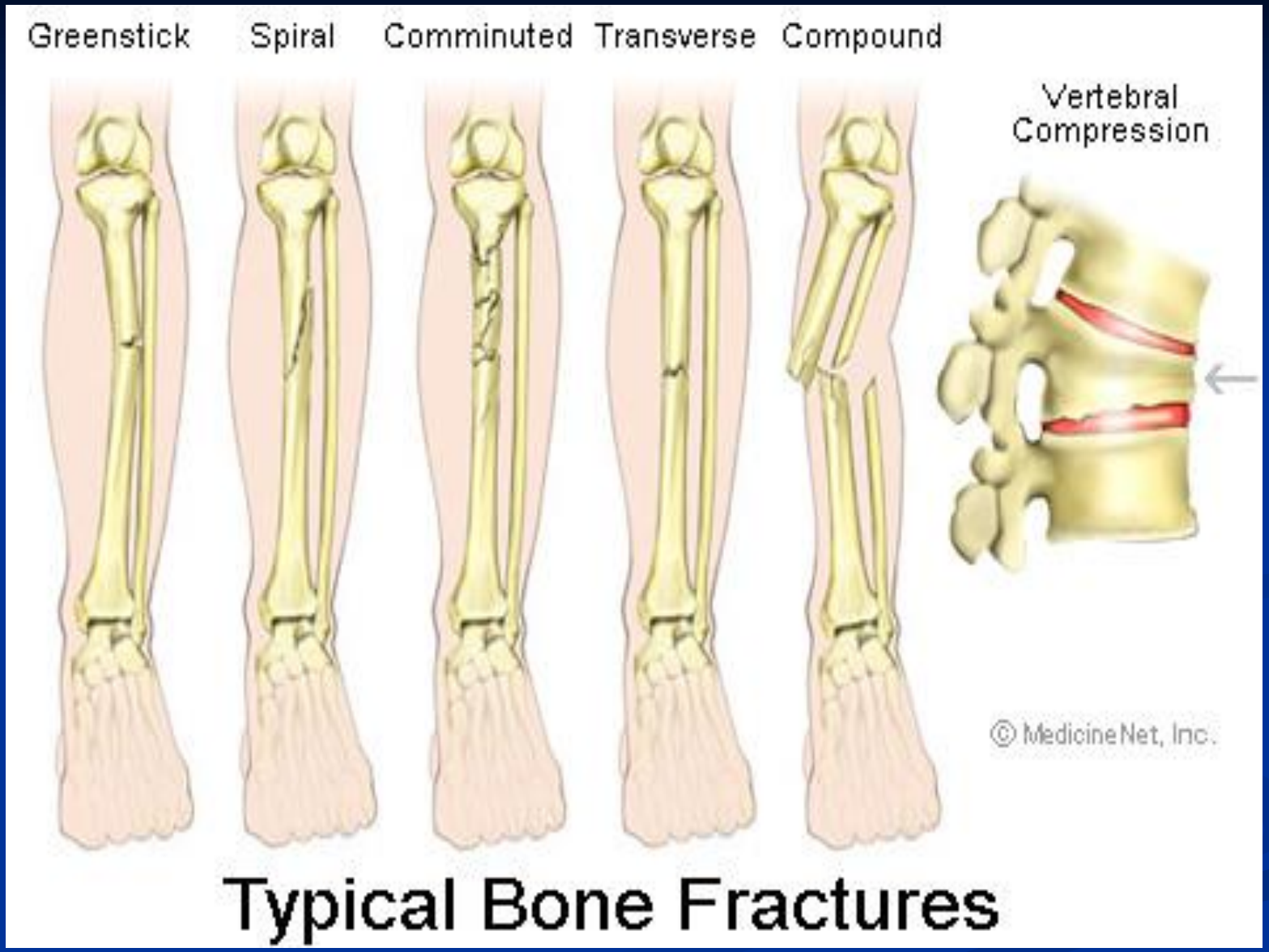
- Fracture Dislocation:-



Classification of fractures

- Complete or incomplete
- Closed or compound
- Comminuted
- Displaced




Greenstick
Spiral
Comminuted
Transverse
Compound
Vertebral Compression
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Typical Bone Fractures

Causes of fractures

- Traumatic fracture: Sever trauma
- Pathological fracture:
- Stress fracture

Causes of fractures

- Traumatic fracture: Sever trauma e.g. MVA
- Trauma due to motor vehicle accidents is of major cause of bone fracture
- Damage inflicted is related to several factors, the most important of which are speed of travel, restraint, and protection from impact.

Causes of fractures

- Pathological fracture:
  - **Fracture occur with minimal trauma**
  - **the underlying bone is abnormal e.g.**
    - **Osteoporosis**
    - **Osteomalacia**
    - **Paget's disease of bone**
    - **Primary** or **metastatic tumor.**
    - **Congenital bone disorders**

      e.g. osteogenesis imperfecta

Stress fracture

A stress fracture is generally an overuse injury. It occurs when muscles become fatigued or overloaded and can not absorb the stress and shock and repeated impact. Fatigued muscles transfer that stress to the nearby bone and the result is a small crack or fracture, in the bone.

Healing of fractures

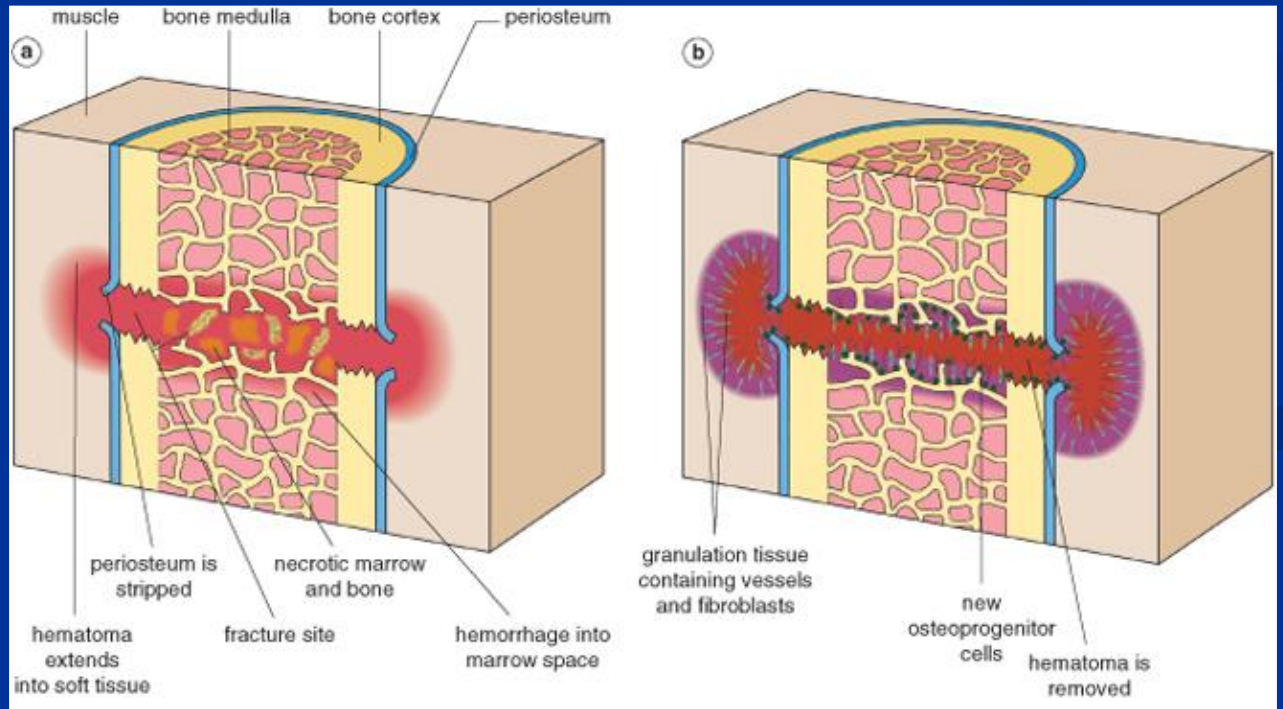
1. **Reactive Phase**
   - i Fracture and inflammatory phase
   - ii. Granulation tissue formation
2. **Reparative Phase**
   - iii. Callus formation
   - iv. Lamellar bone deposition
3. **Remodeling Phase**
   - v. Remodeling to original bone contour

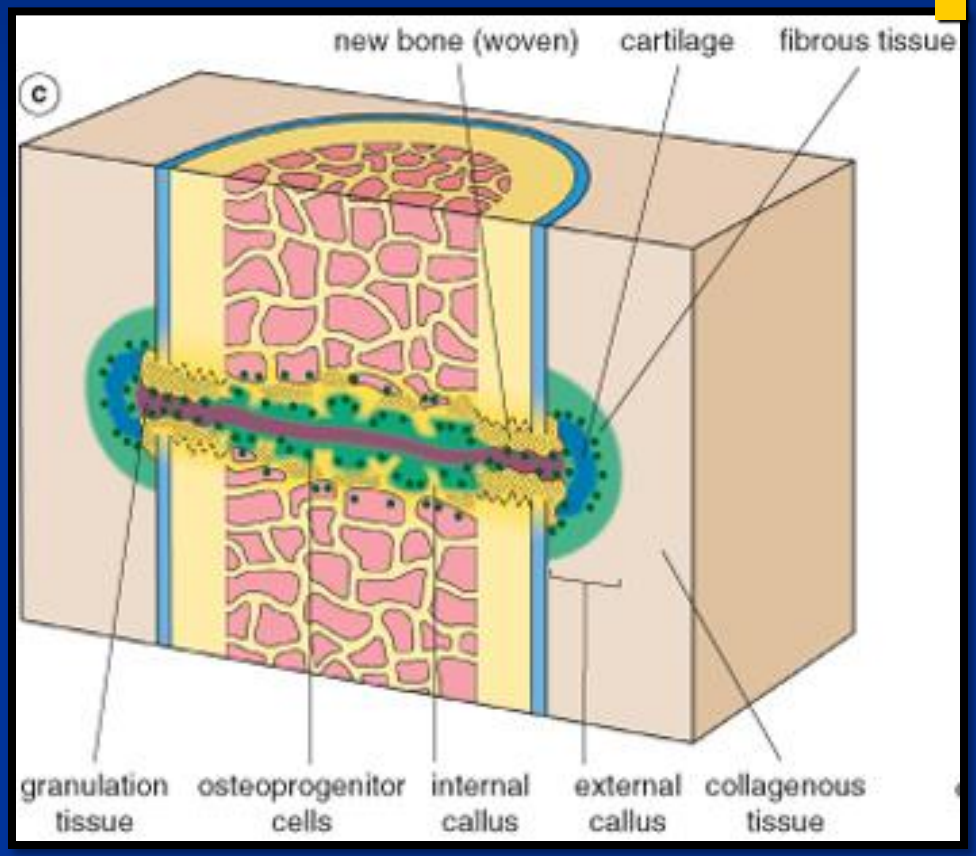
How does a fracture heal?

Reactive Phase

- Stage 1: Inflammation
  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.

This stage begins day one of bone fracture and lasts about 2 to 3 weeks.





degranulated platelets and migrating inflammatory cells release PDGF, TGF-β, FGF, and other factors, activate osteoprogenitor cells in the periosteum, medullary cavity, and surrounding soft tissues and stimulate osteoclastic and osteoblastic activity.

Reparative Phase

- Soft callus

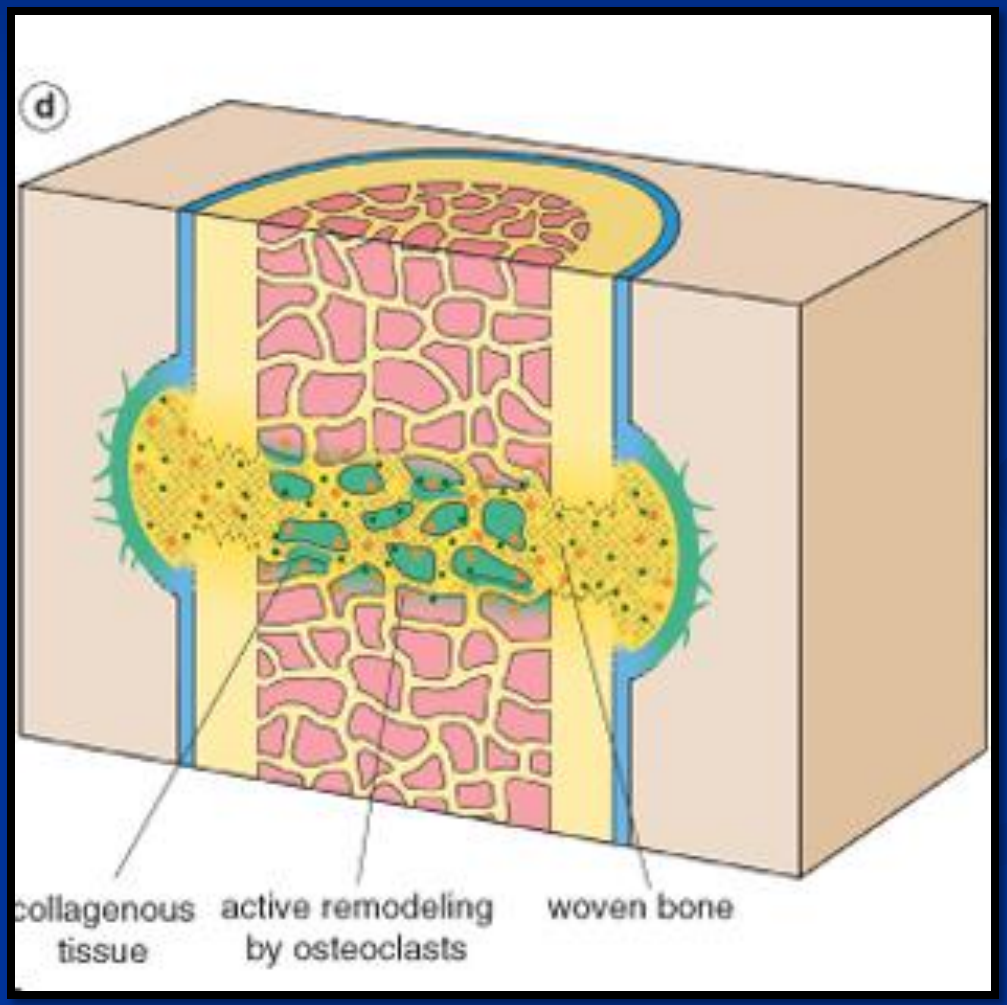
  Between 2 and 3 weeks after the injury, the pain and swelling will decrease. At this point, the site of the fracture stiffens and new bone begins to form. The new bone cannot be seen on x-rays. This stage usually lasts until 4 to 8 weeks after the injury.

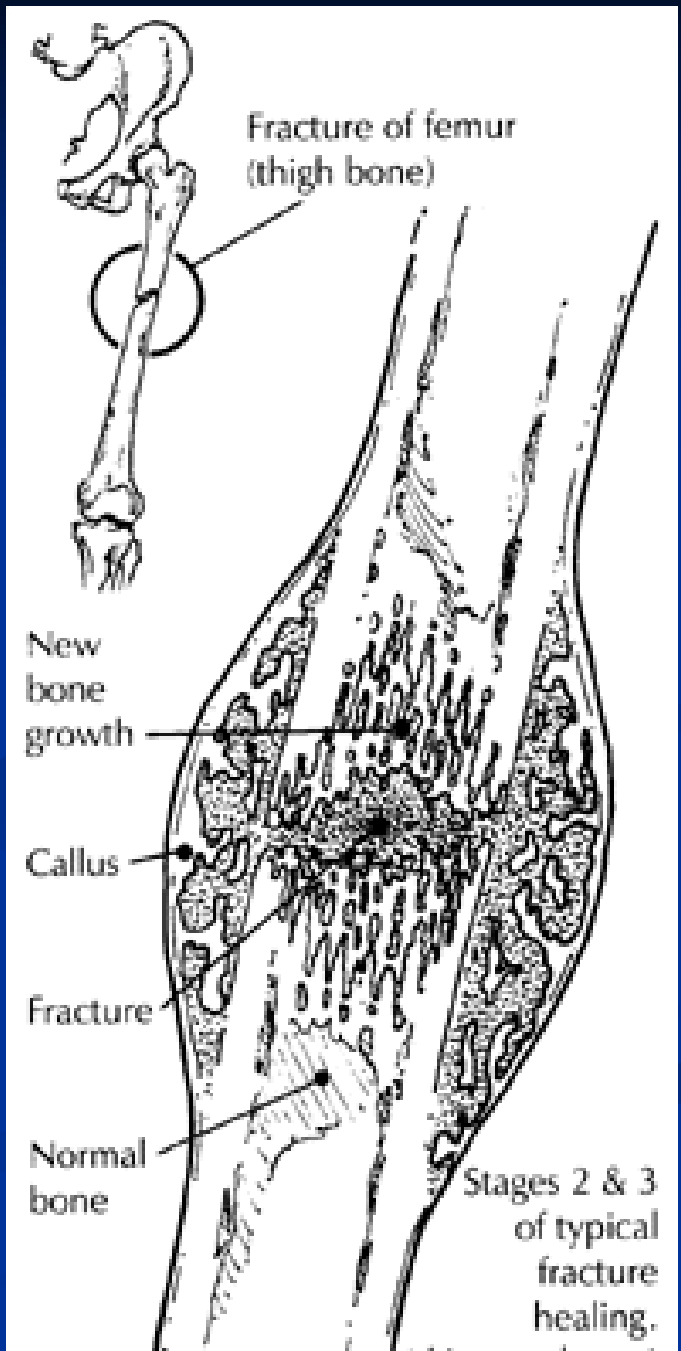
- Hard callus

  Between 4 and 8 weeks, the new bone begins to bridge the fracture. This bony bridge can be seen on X-rays. By 8 to 12 weeks after the injury, new bone has filled the fracture.

  - Osteoblasts arise from pluripotent progenitor cells in the periosteum and granulation tissue. They produce woven bone, resulting in a bony callus that stabilizes the fracture site.

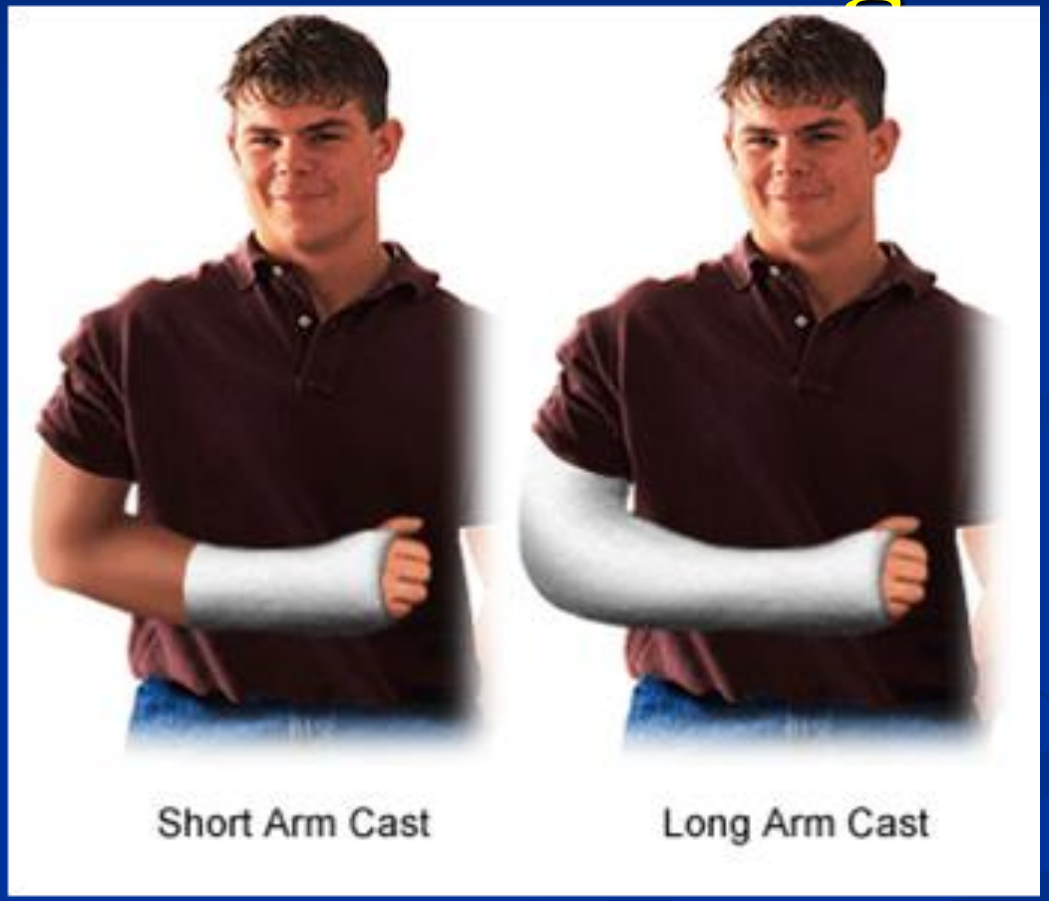
Hard callus

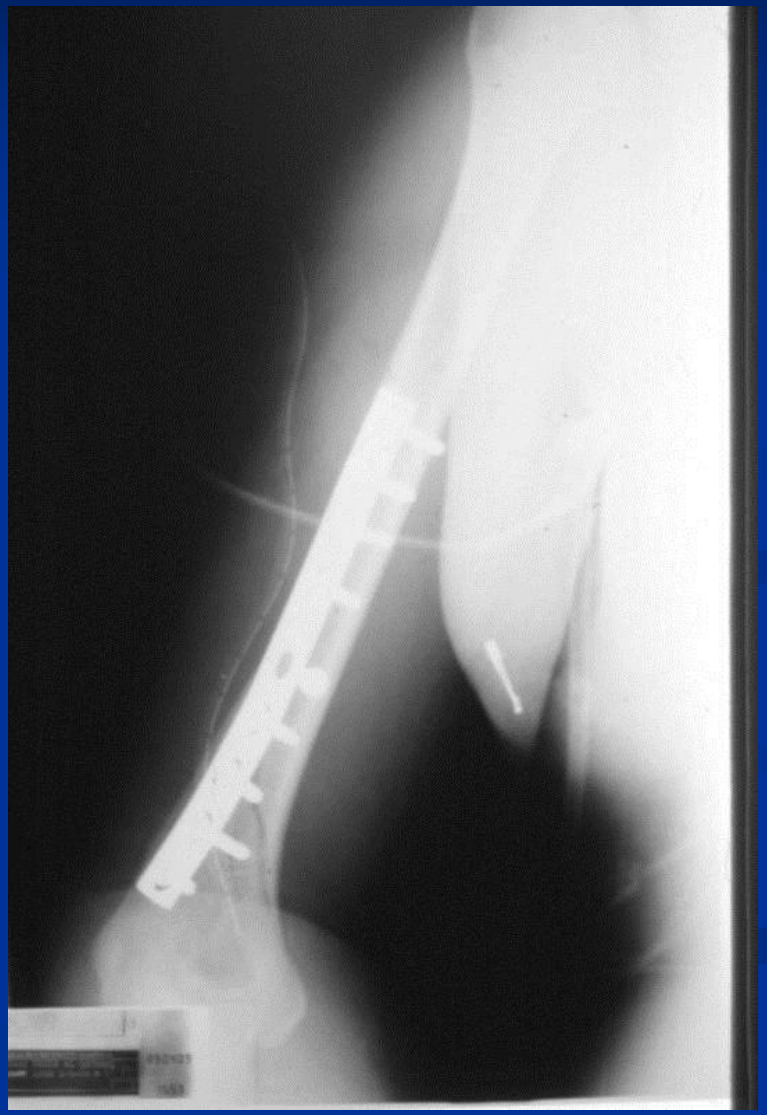

d
collagenous tissue
active remodeling by osteoclasts
woven bone


Fracture of femur (thigh bone)
New bone growth
Callus
Fracture
Normal bone
Stages 2 & 3 of typical fracture healing.

Excellent Reduction with Well Molded Cast

Immobilization promotes bone fracture healing





Bone remodeling

Beginning about 8 to 1 2 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.

www.bonefixator.com

Stage 1 : Impact

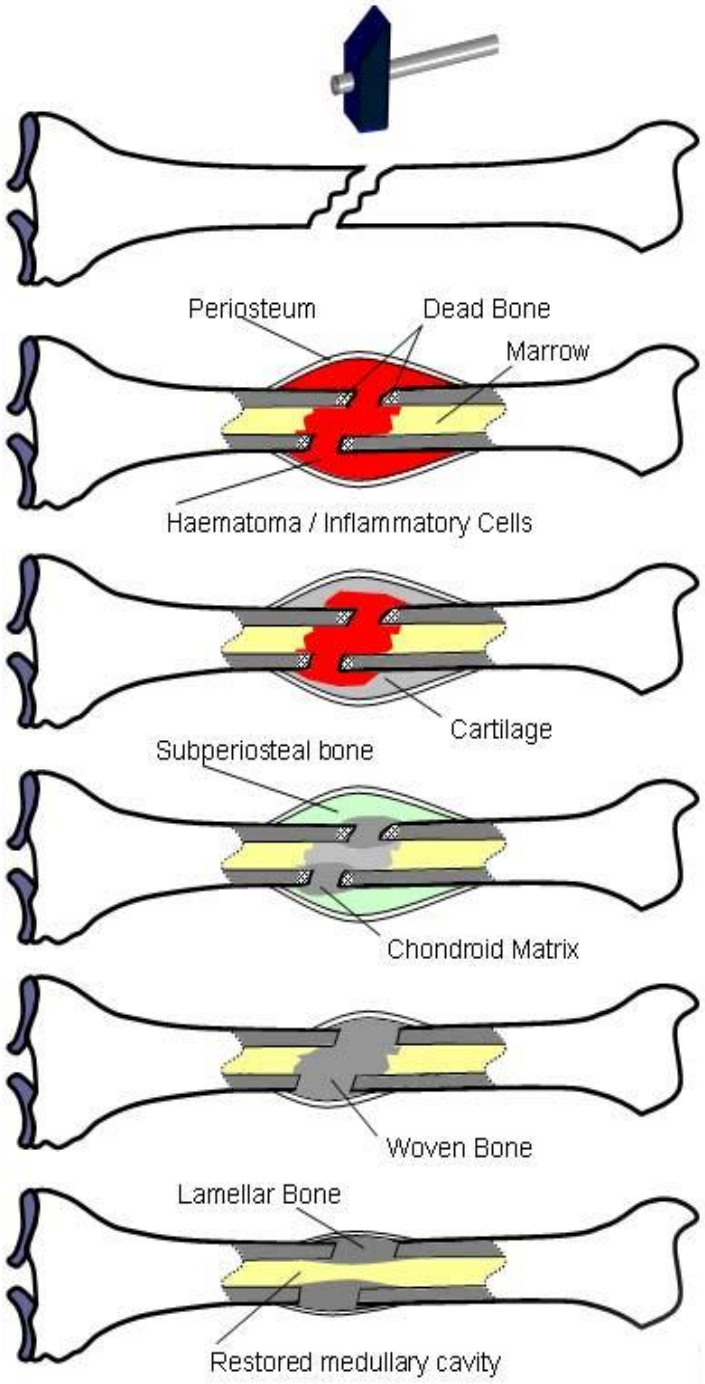
Stage 2 : Induction

Stage 3 : Inflammation

Stage 4 : Soft Callus

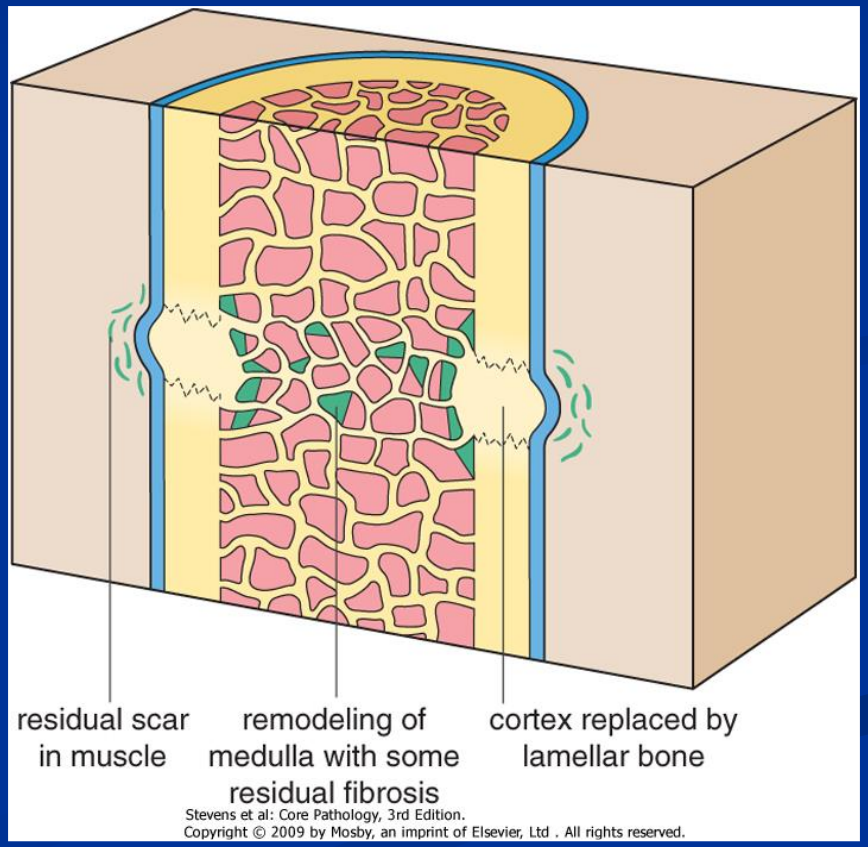
Stage 5 : Ossification

Stage 6 : Remodelling



Fracture Healed

- 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.



Stevens et al: Core Pathology, 3rd Edition.
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Time Factor- Perkin's formula

	Union	Consolidation
Upper limb	Spiral 3 Transverse 6	6 weeks 12 =
Lower Limb	Spiral 6 Transverse 12	12 = 24 =

Children Half this time is needed

Healing of fractures

- 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** 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)

COMPLICATIONS

Delayed Union & Non Union

- Causes:-

1. Nutrition
2. Bone Disease
3. Old Age
4. Infection
5. Soft tissue interposition
6. Position of reduction
7. Poor blood supply

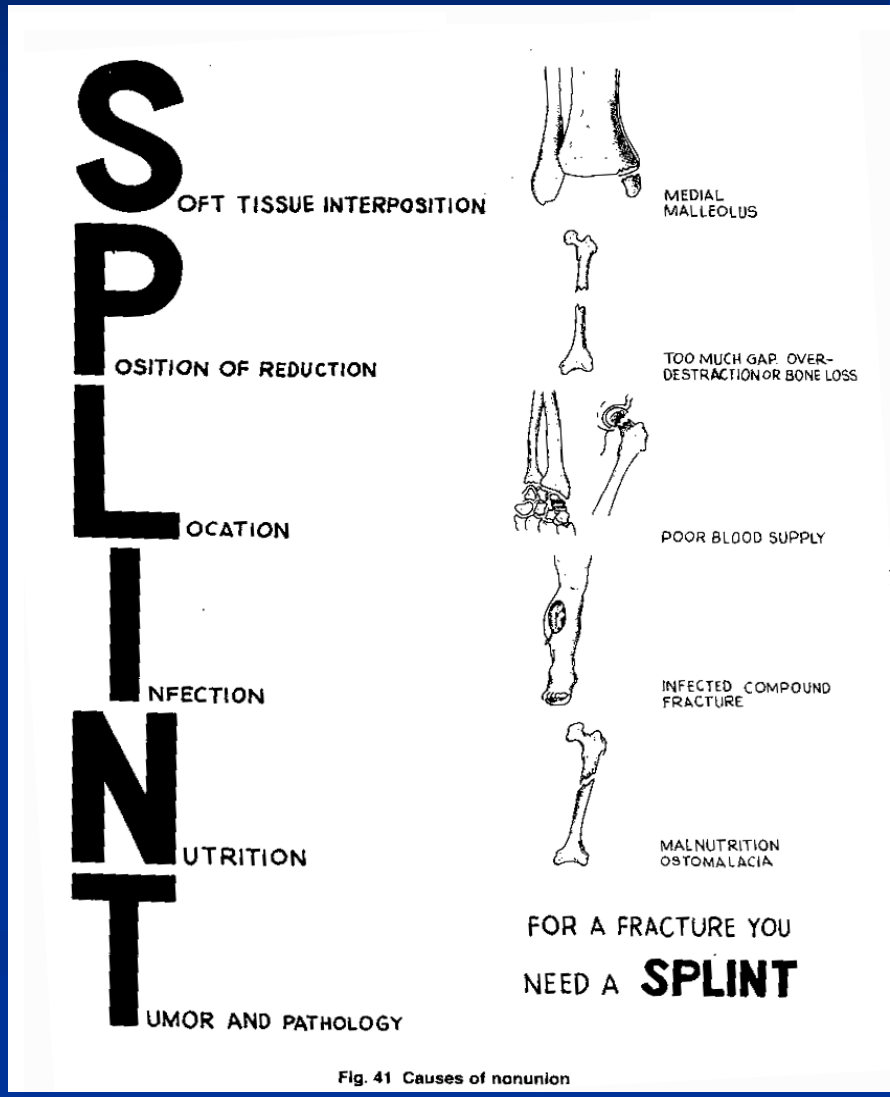

Fig. 41 Causes of nonunion

COMPLICATIONS

- **Malunion:-**
- **Malunion:** A fracture that does not heal in a normal alignment is called a malunion
- **1- Primary Neglected #**

- **2- After Reduction! Watch**

  X-Ray After 10 Days

COMPLICATIONS

Compartment syndrome:

- Severe swelling after a fracture can put so much pressure on the blood vessels that not enough blood can get to the muscles around the fracture.
- The decreased blood supply can cause the muscles around the fracture to die, which can lead to long-term disability.
- Compartment syndrome usually occurs only after a severe injury.

COMPLICATIONS

- **Neurovascular injury**
- **Infection:** Open fractures can become infected
- **Post-traumatic arthritis:** Fractures that extend into the joints (intra-articular fractures) or fractures that cause the bones to meet at an abnormal angle in the joint can cause premature arthritis of a joint.

COMPLICATIONS

- **Growth abnormalities:** A fracture in the open physis, or growth plate, in a child, can cause many problems.
- e.g.
  - premature partial or complete closure of the physis. This means that one side of a bone or the whole bone stops growing before it naturally would.

Summary

Fracture types:

- **Simple:** the overlying skin is intact.
- **Compound:** the bone communicates with the skin surface.
- **Comminuted:** the bone is fragmented.
- **Displaced:** the ends of the bone at the fracture site are not aligned.
- **Stress:** a slowly developing fracture that follows a period of increased physical activity in which the bone is subjected to repetitive loads
- "**Greenstick**": extending only partially through the bone, common in infants when bones are soft
- **Pathologic**: involving bone weakened by an underlying disease process, such as a tumor