MUSCULOSKELETAL BLOCK

Pathology

Fracture and bone healing

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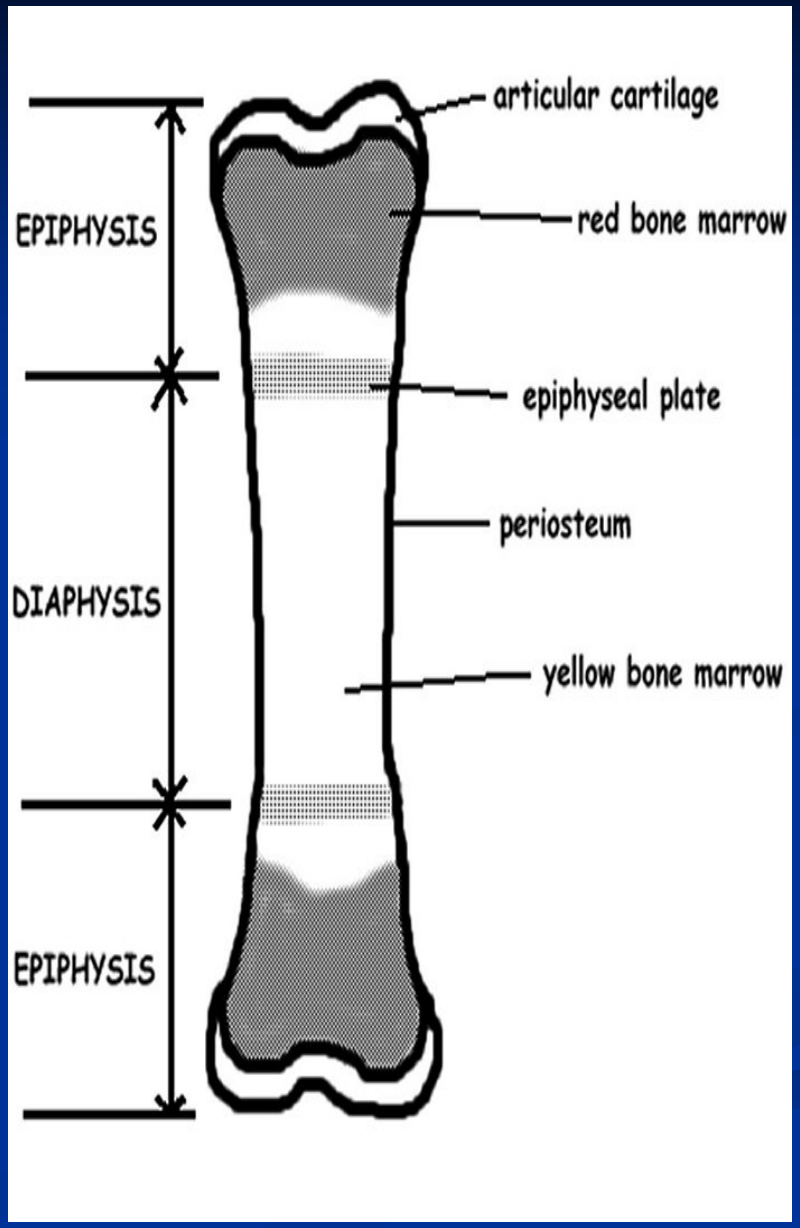
Healing of bone fractures

- 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 **complications** of healing process
  - Understands the difference between trauma induced and pathological fractures
  - Appreciate the importance of road traffic accidents as a major cause of disability in Saudi Arabia

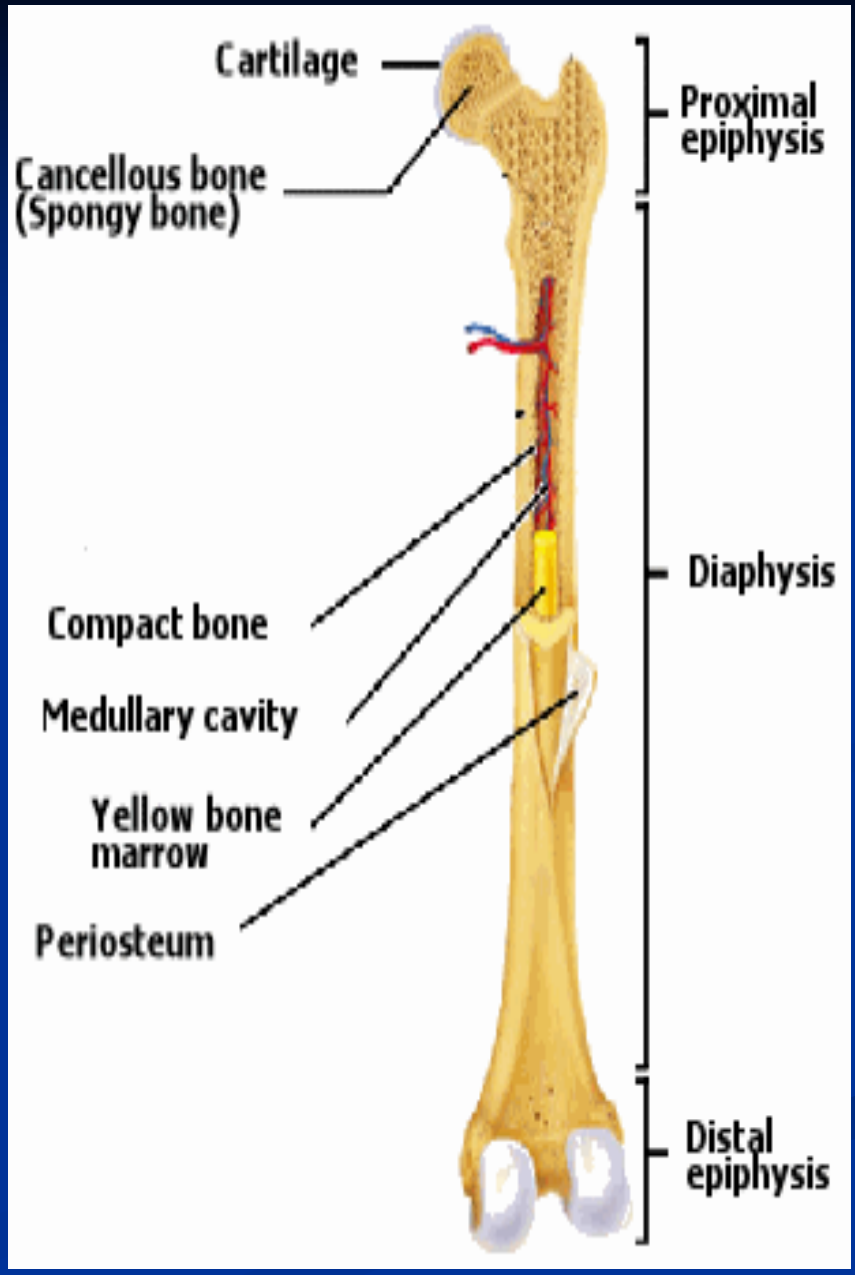
Normal anatomy

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



Normal anatomy

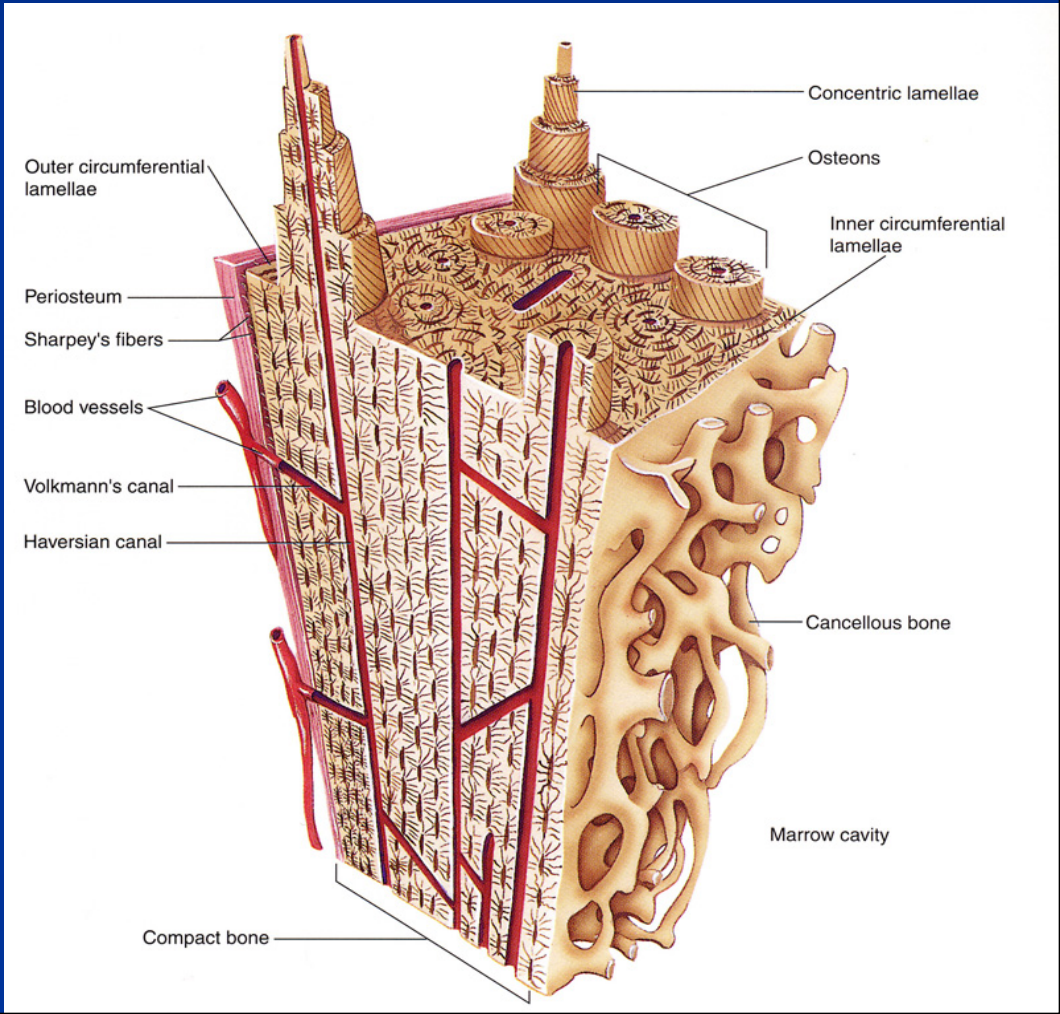
- **Cross section:**
  - Periosteum
  - cortex (composed of cortical bone or compact bone)
  - medullary space (composed of cancellous or spongy bone)



Normal histology

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

- **Lamellar bone:**
  - layered bone with concentric parallel lamellae
  - normal type of bone found in adult skeleton
  - 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

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** 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** .
- 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.
- In normal lamellar bone the osteoid collage is deposited in a mechanically strong, parallel stratified pattern.
- In woven bone, the osteoblasts deposit osteoid collagen in a haphazard pattern. With its random arrangement of osteoid collagen

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

Fracture:-

Break in the continuity of bone

Fig. 1 Complete fracture

Fig. 2 Incomplete fracture

A fracture is defined as breakage in a bone

The fracture can be

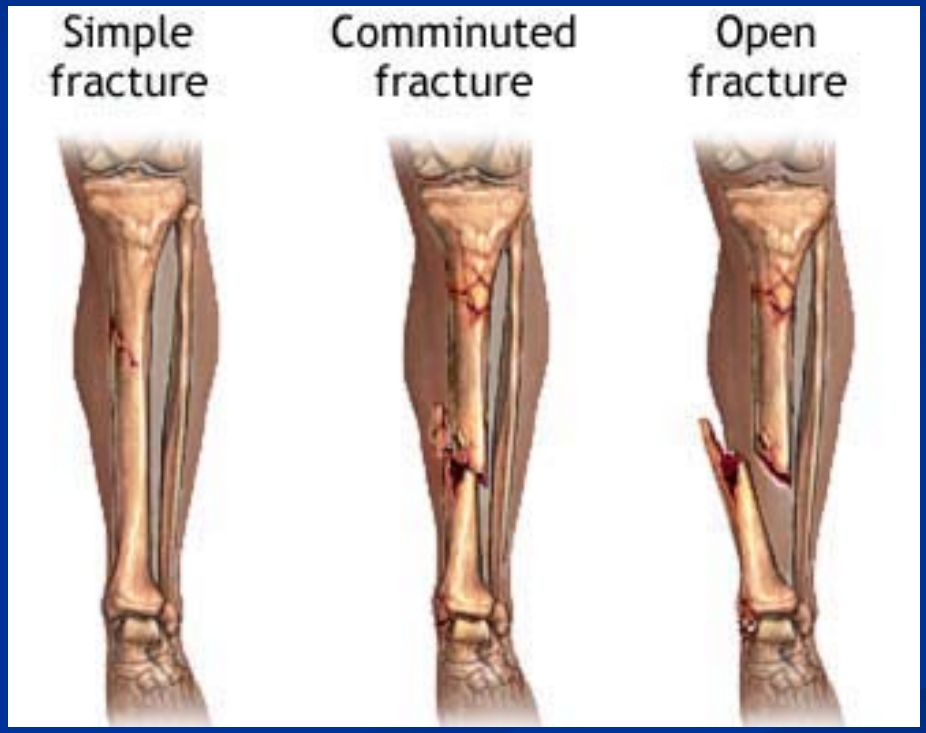
Complete

or

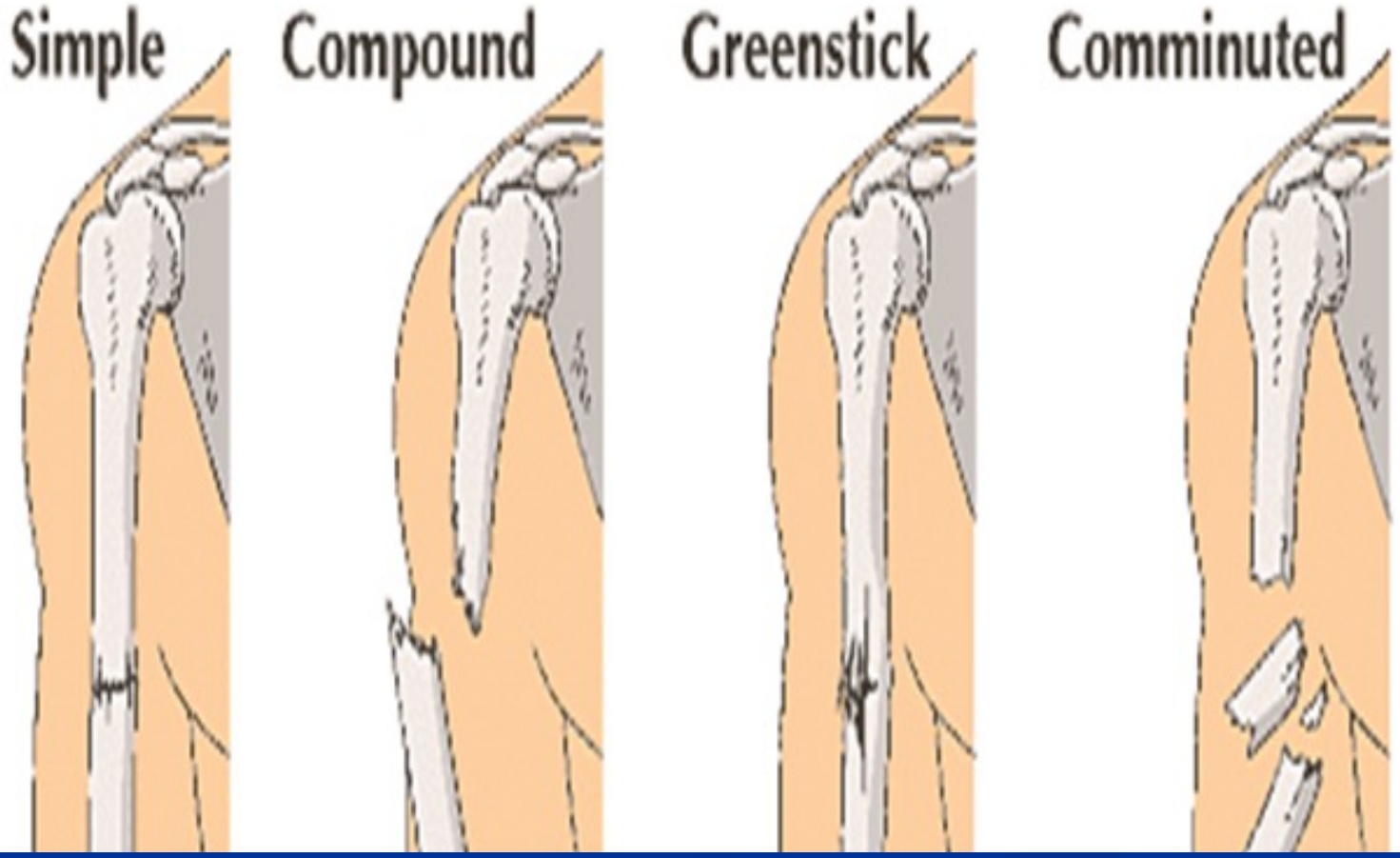
Incomplete

Classification of fractures

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



Types of Fractures



Closed Fracture (simple):-

The overlying Tissue is intact

Does NOT communicate with external environment

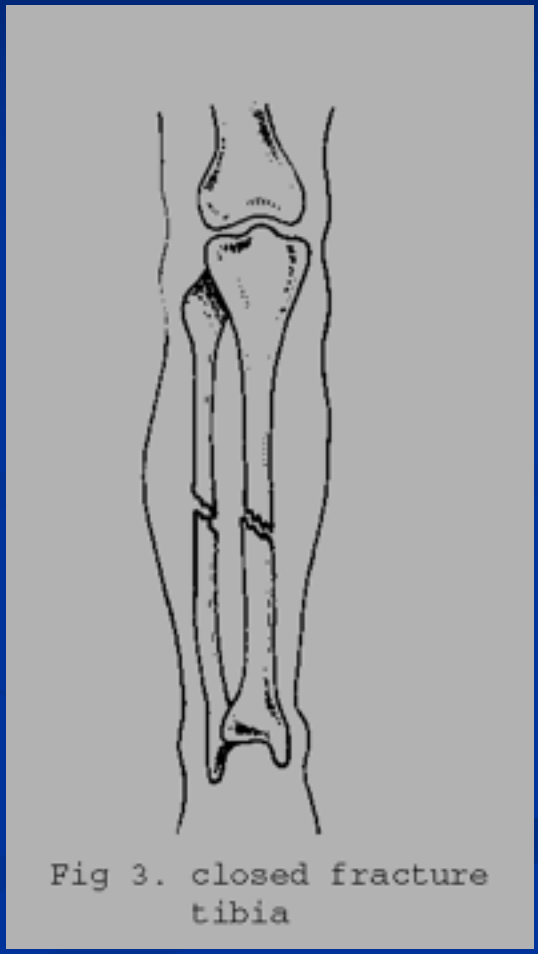


Fig 3. closed fracture tibia

- **Open Fracture (compound):-**
- The fracture extends into the overlying skin

Communicate with external environment

Infection !!

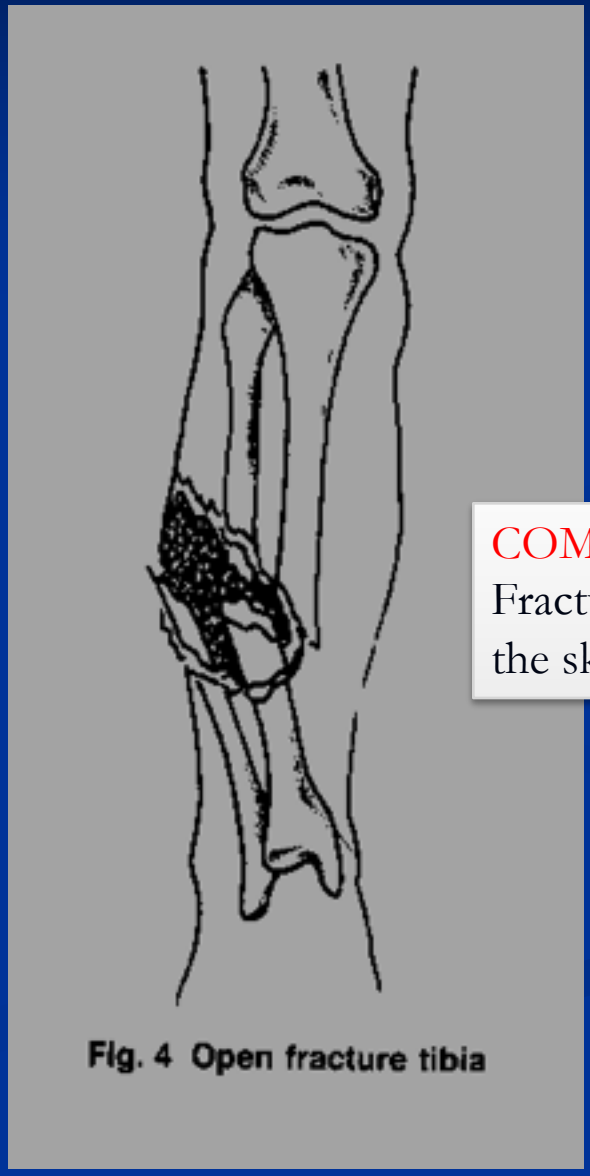


Fig. 4 Open fracture tibia

COMPOUND #
Fracture extend to the skin

- **Complicated Fracture:-**

Associated with damage to nerves, vessels or internal organs

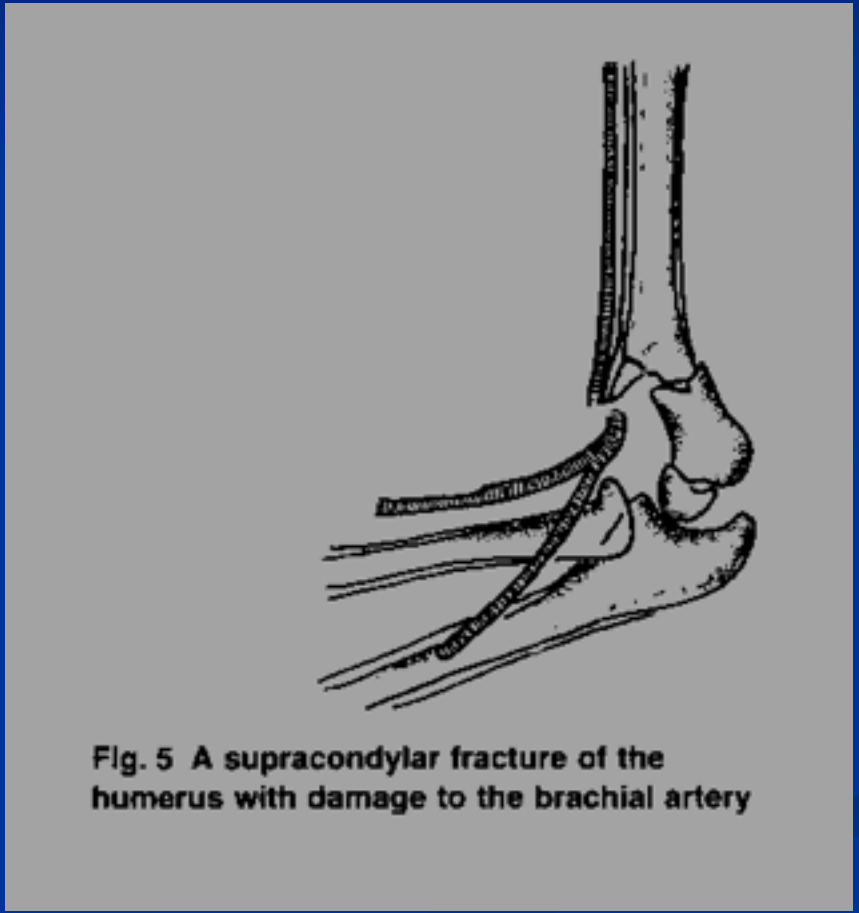
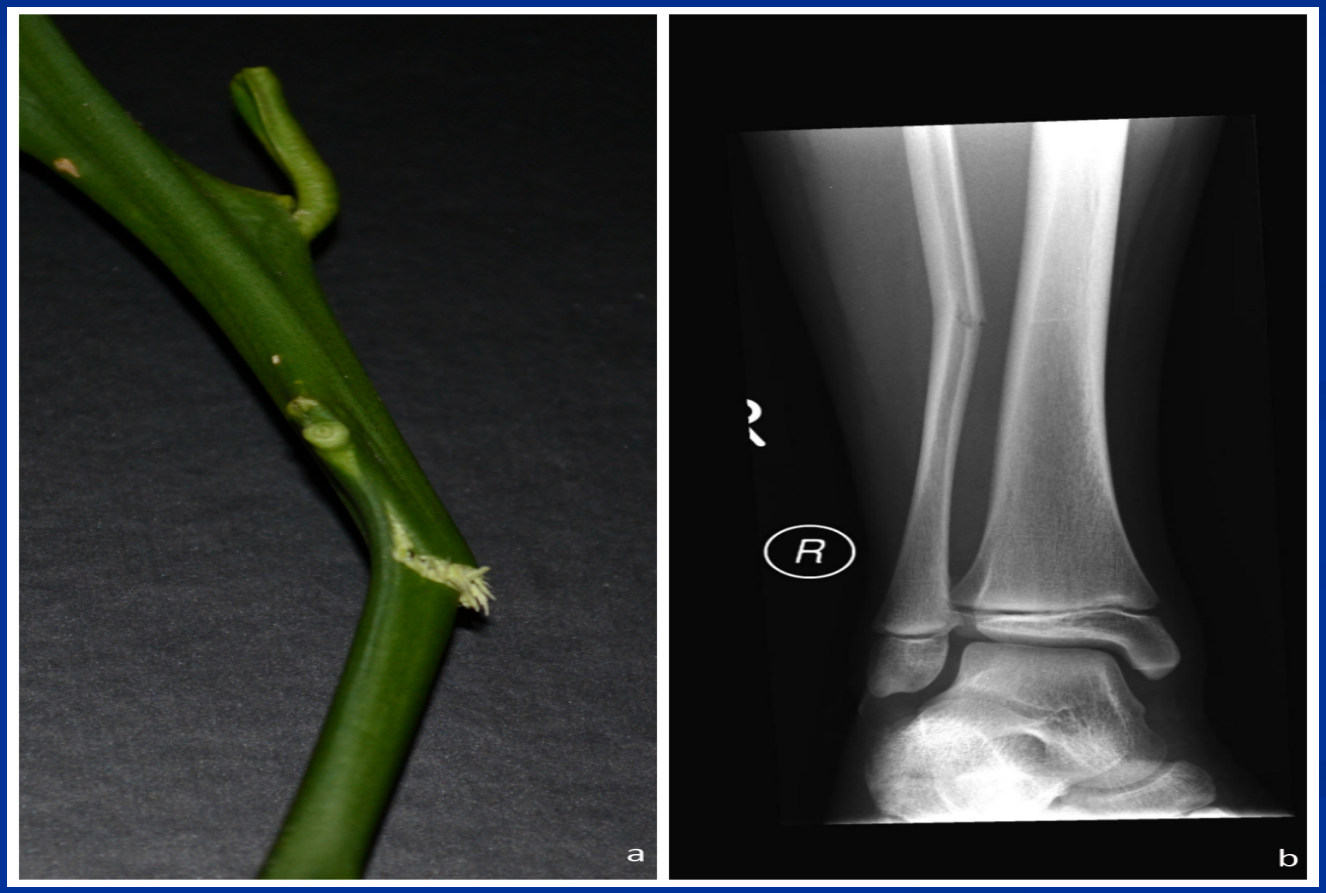


Fig. 5 A supracondylar fracture of the humerus with damage to the brachial artery

Greenstick Fracture

A greenstick fracture is a fracture in a young, soft bone in which the bone bends and breaks.



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

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*** 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 and foot. Track and field athletes and military recruits who carry heavy packs over long distances are particularly susceptible

Healing of fractures

1. **Reactive Phase**

   I Hematoma and inflammatory phase

   ii. Granulation tissue formation

2. **Reparative Phase**

   iii. Callus formation

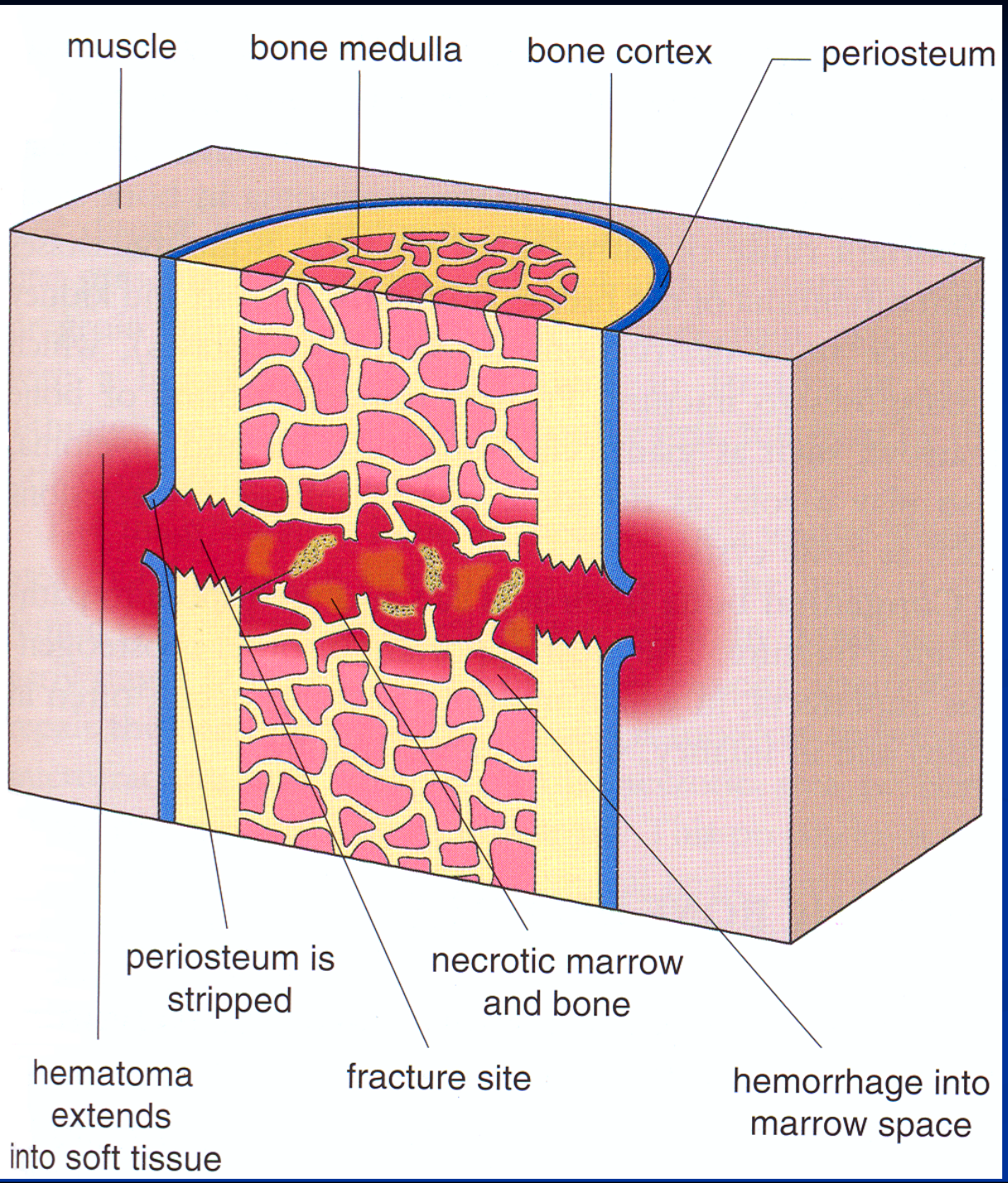
3. **Remodeling Phase**

   v. Remodeling to original bone contour

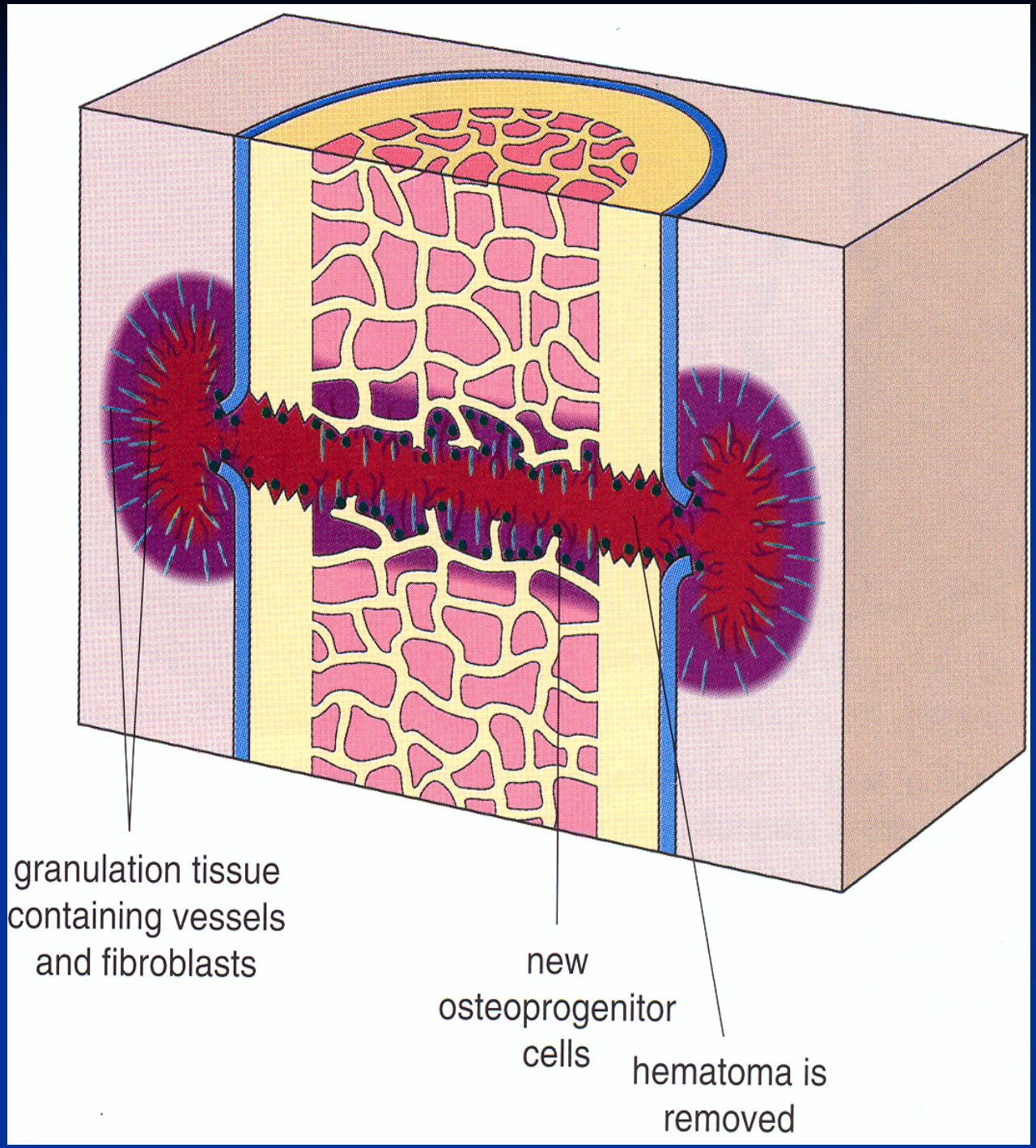
How does a fracture heal?

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.

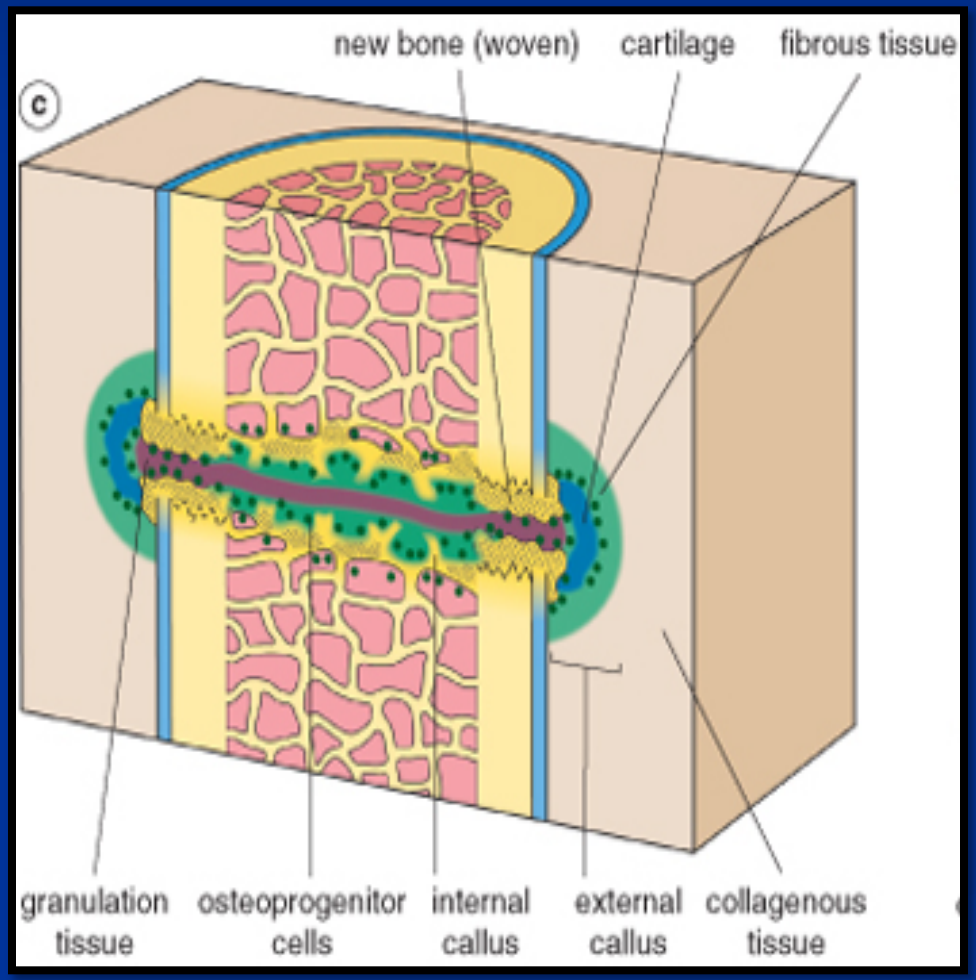


A. Due to tearing of blood vessels in the medullary cavity, cortex and periosteum, a hematoma forms at the site of fracture. The periosteum is stripped from the surface.



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.

Reparative phase



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

Reparative Phase

- Hard callus:

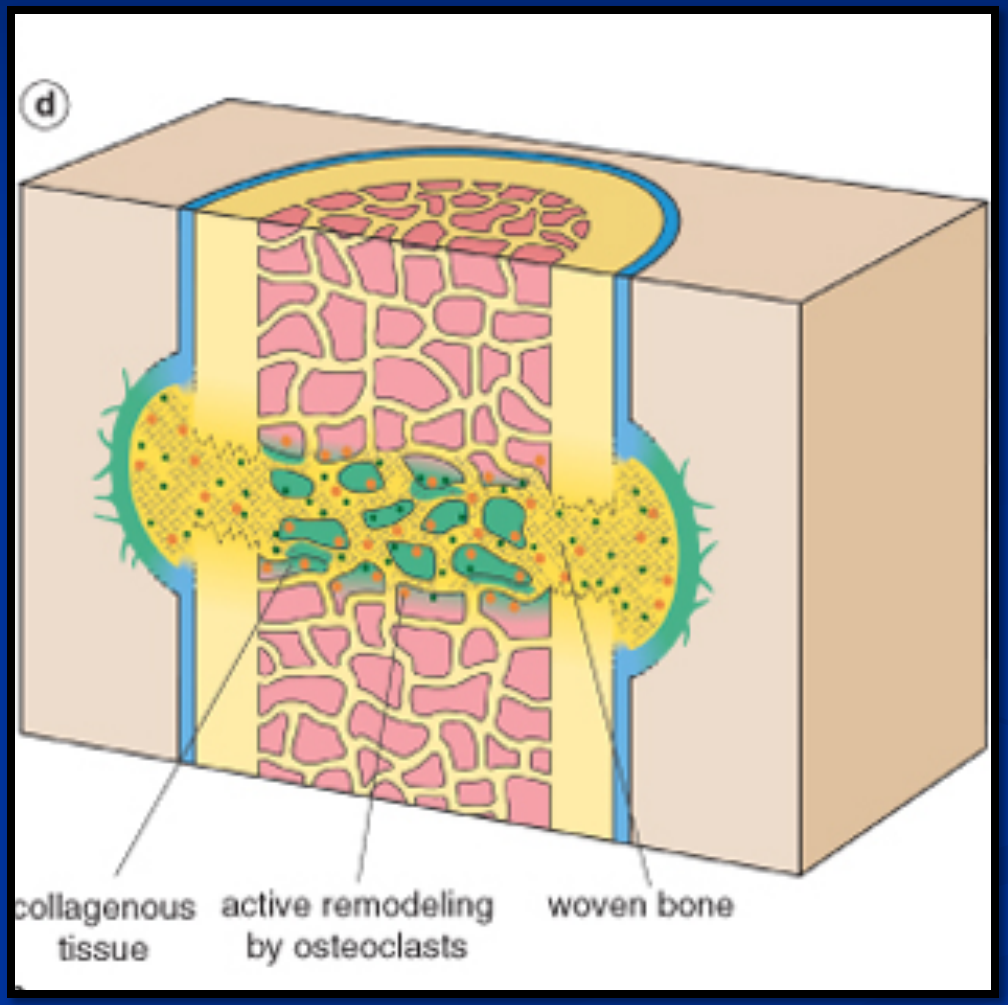
Bone progenitors in the periosteum and medullary cavity deposit new foci of woven bone, and activated mesenchymal cells at the fracture site differentiate into cartilage-synthesizing chondroblasts.

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.

Hard callus

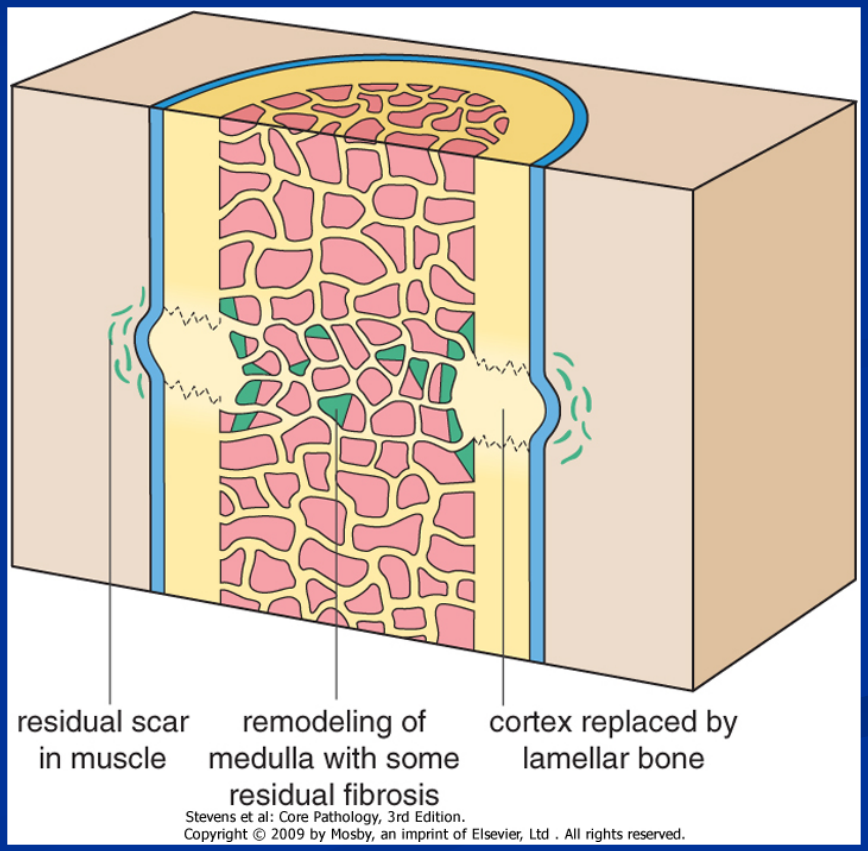

d
collagenous tissue
active remodeling by osteoclasts
woven bone

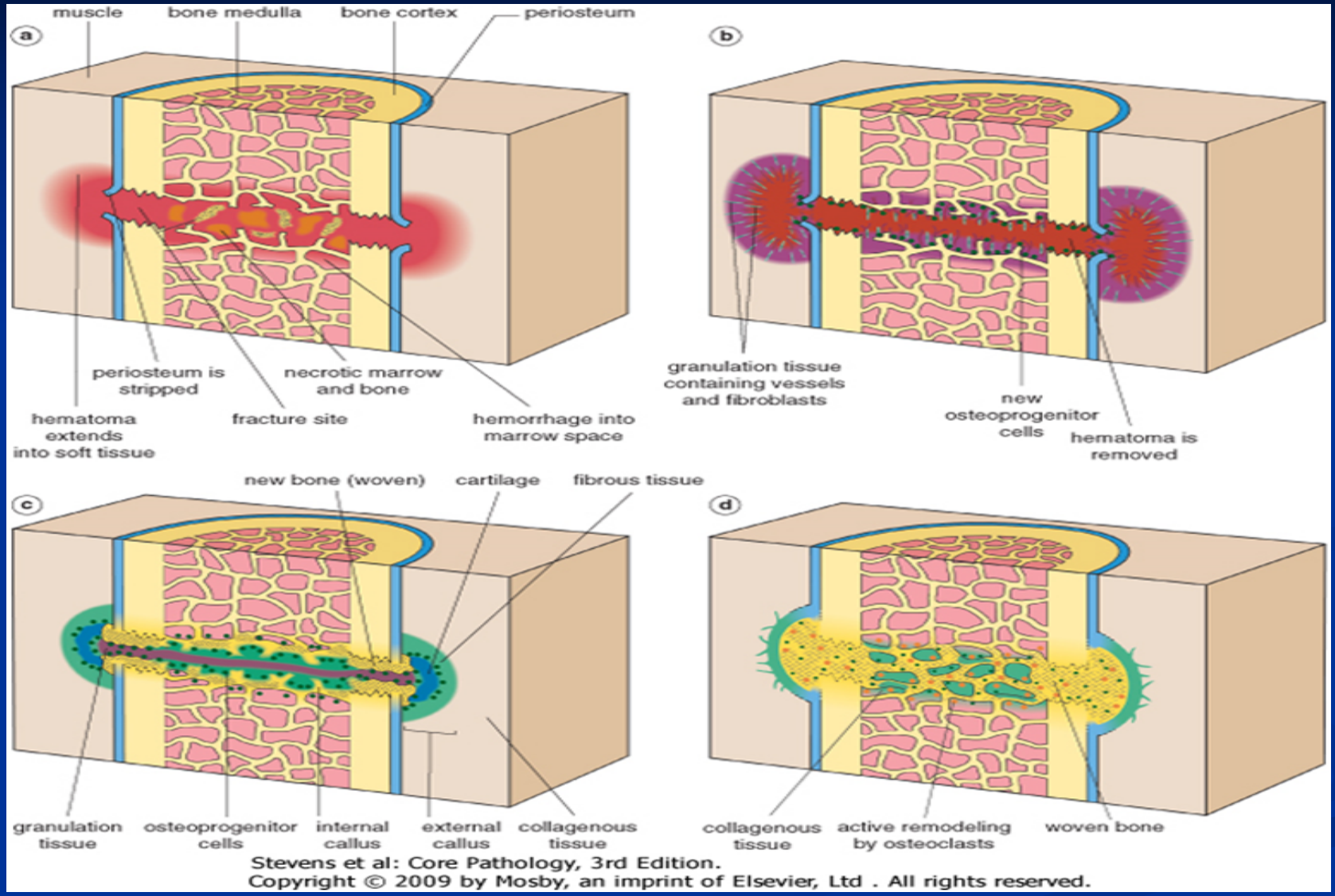
Bone remodeling

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.

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

- 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.





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

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

COMPLICATIONS

- **Neurovascular injury**
- **Infection:** Open fractures can become infected
- **Post-traumatic arthritis:** Fractures that extend into the joints (intra-articular fractures

COMPLICATIONS

- **Growth abnormalities:** A fracture in the open physis, or growth plate, in a child, can cause many problems.