

# Bone: Structure, function, and healing

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Professor JP Cobb

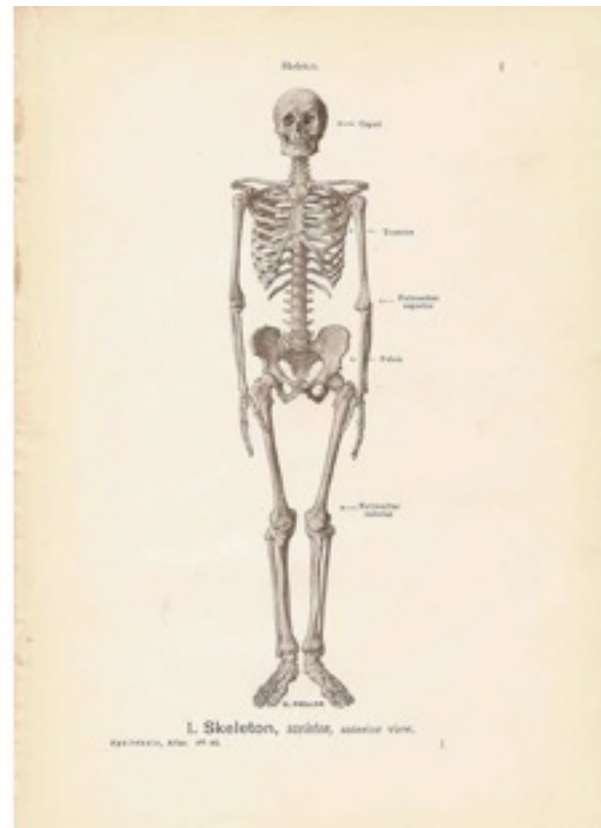


## 3 main functions

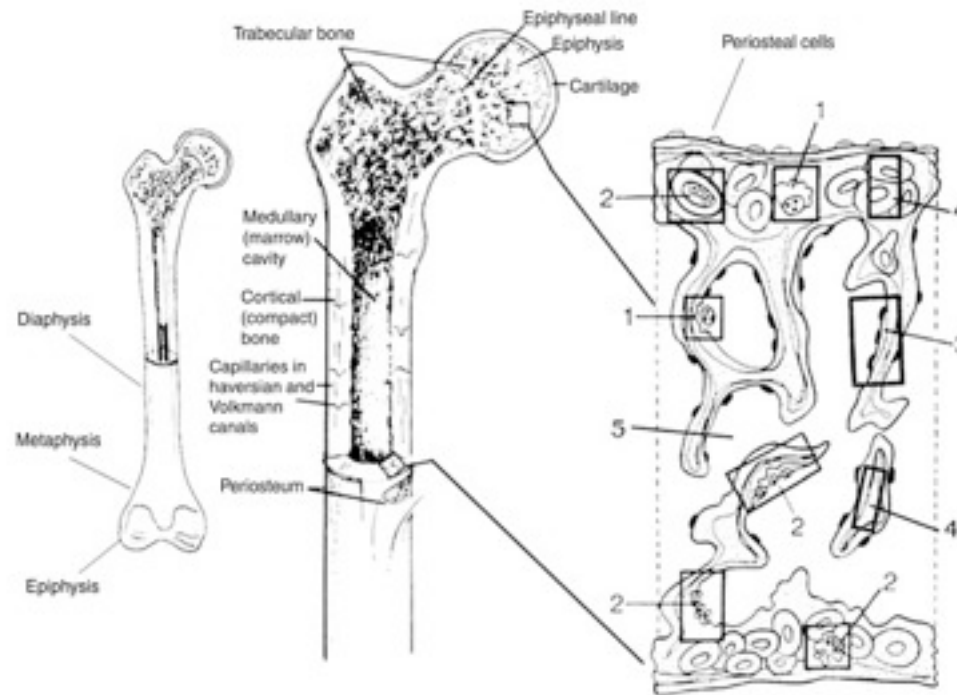
- Calcium Reservoir
- Haematopoietic marrow
- Mechanical

# Skeleton

- 206 bones in the skeleton
- Weighs 2kg

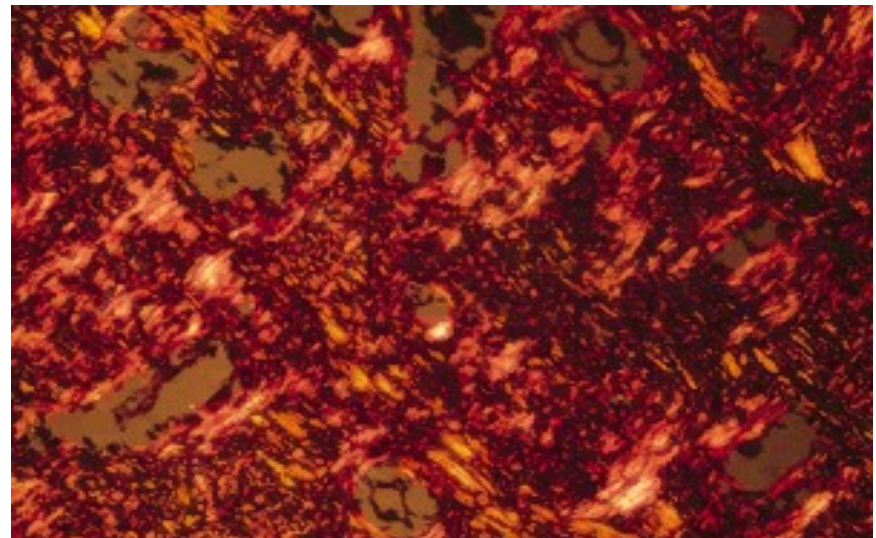
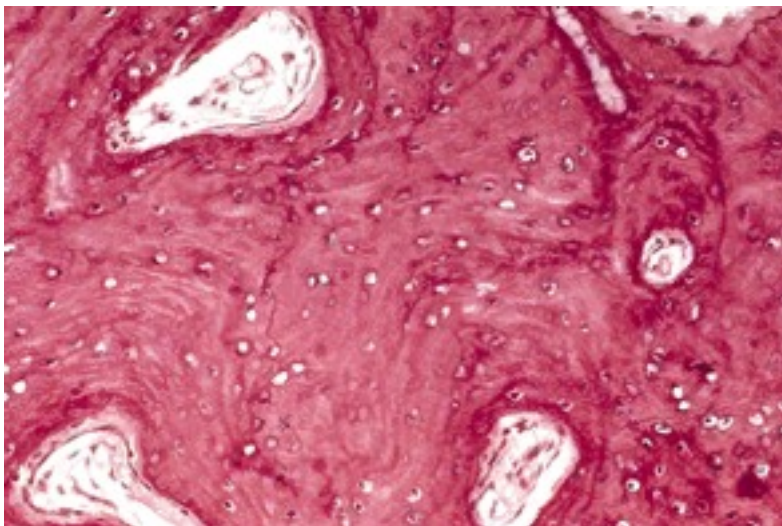


# Long Bone



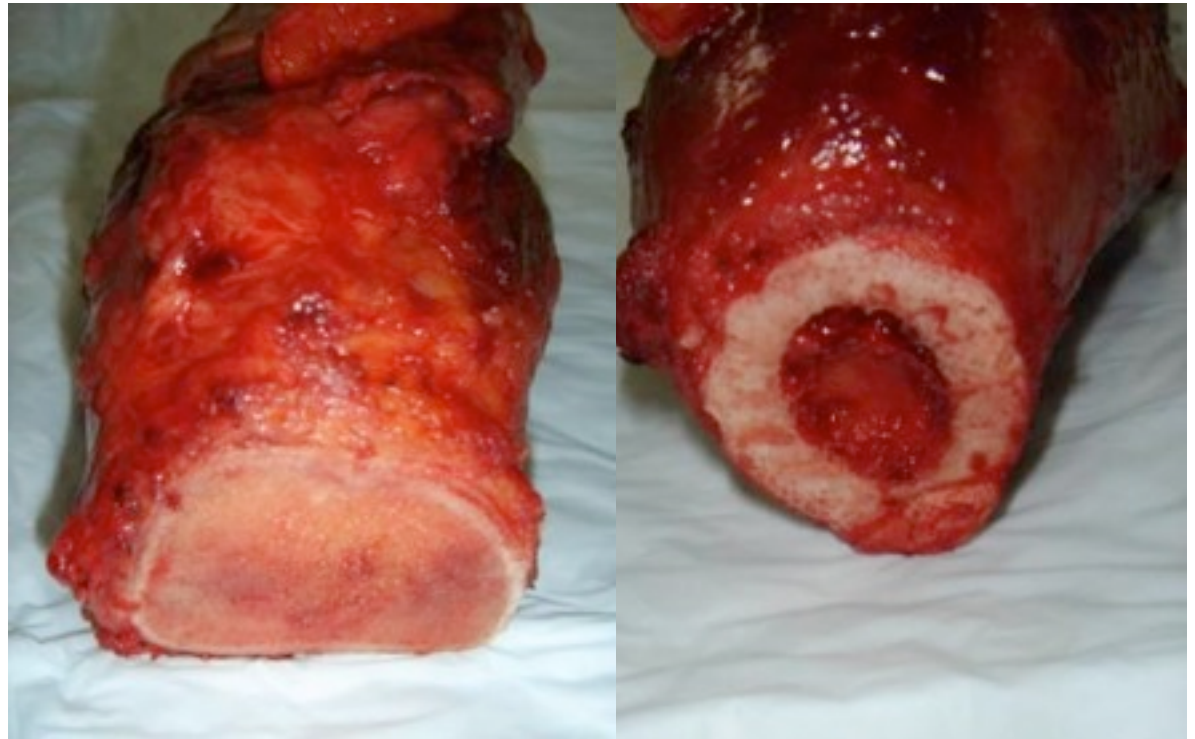
## Woven /Immature Bone

- Embryonic skeleton
- Initial fracture repair tissue (early hard callus)
- Rapid rate of deposition and resorption
- Irregular woven pattern of collagen fibrils
- Weak and flexible
- Highly cellular



## Lamellar (Mature) Bone

- Cortical
- Cancellous



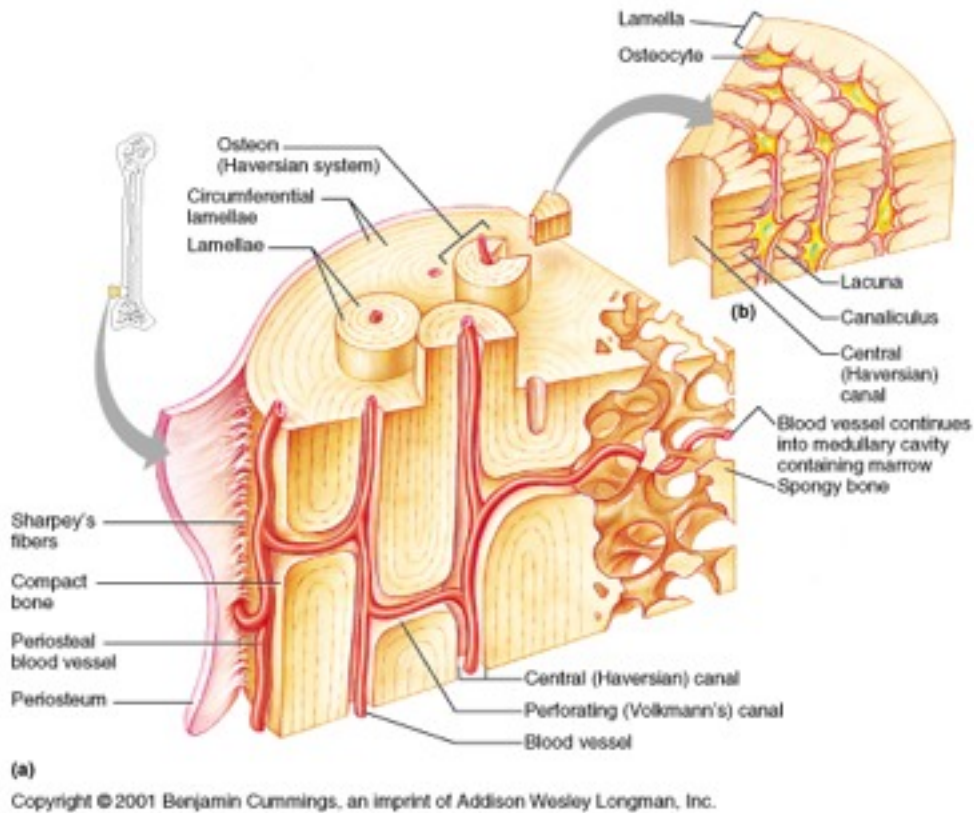
- Stress-orientated collagen
- Lamellae

## Cortical bone (compact bone)

- Type of lamellar bone
- 80% of adult skeleton
- Diaphyses of long bones
  
- Dense
- Stiffer
- Resistant to bending
  
- Haversian systems

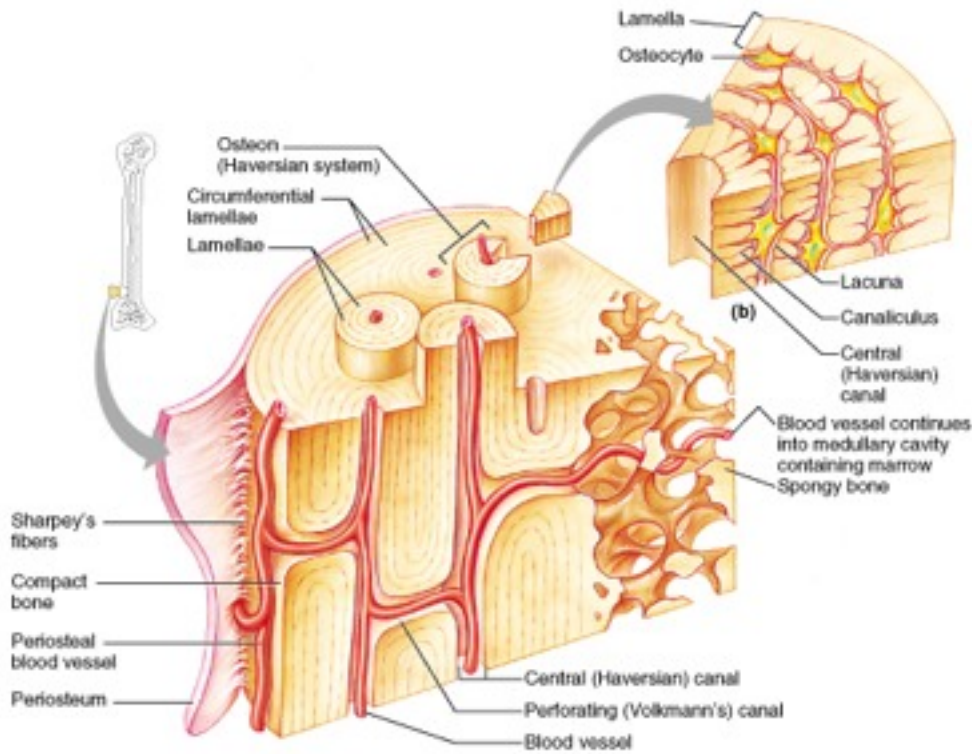


# Haversian systems (Osteons)





# Haversian systems (Osteons)

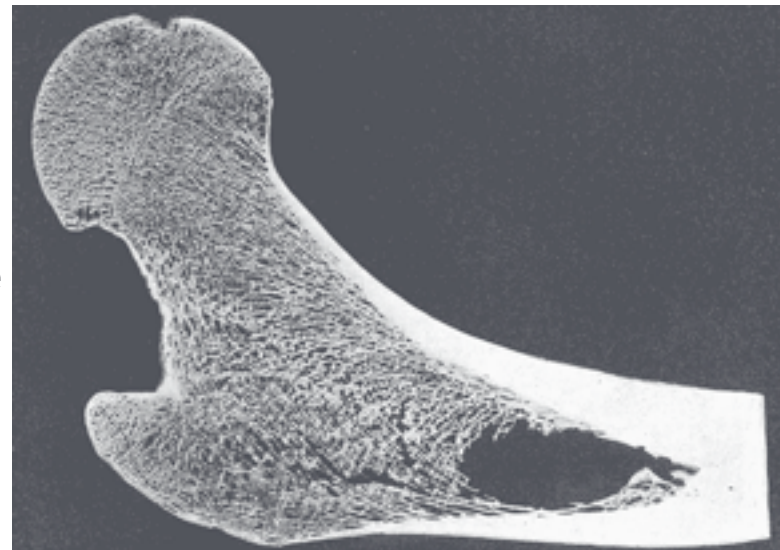


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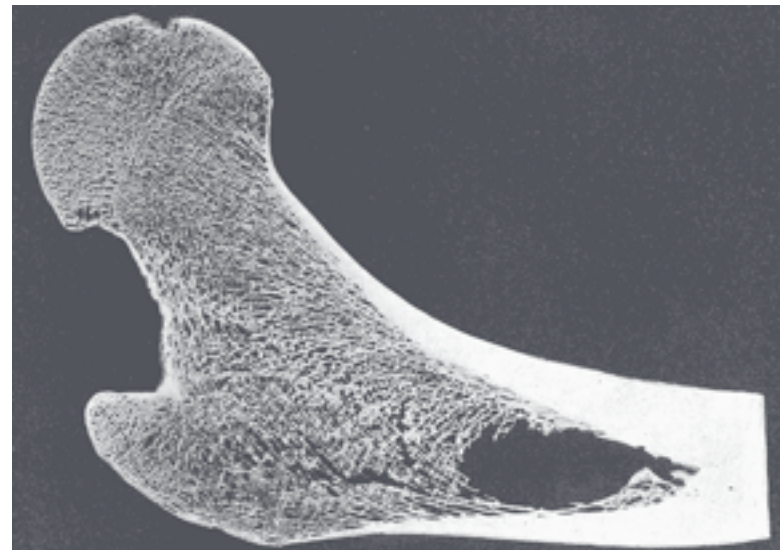
# Cancellous (trabecular) bone

- Type of lamellar bone
- Metaphyses and epiphyses
- 3D lattice of trabeculae
- Aligned according to Wolff's Law (stress)
- No Haversian systems
- Parallel sheets of lamellae



# Cancellous (trabecular) bone

- Large surface area
- High turnover and metabolic rate
- Less dense
- Less elastic (more brittle)
- Less strong

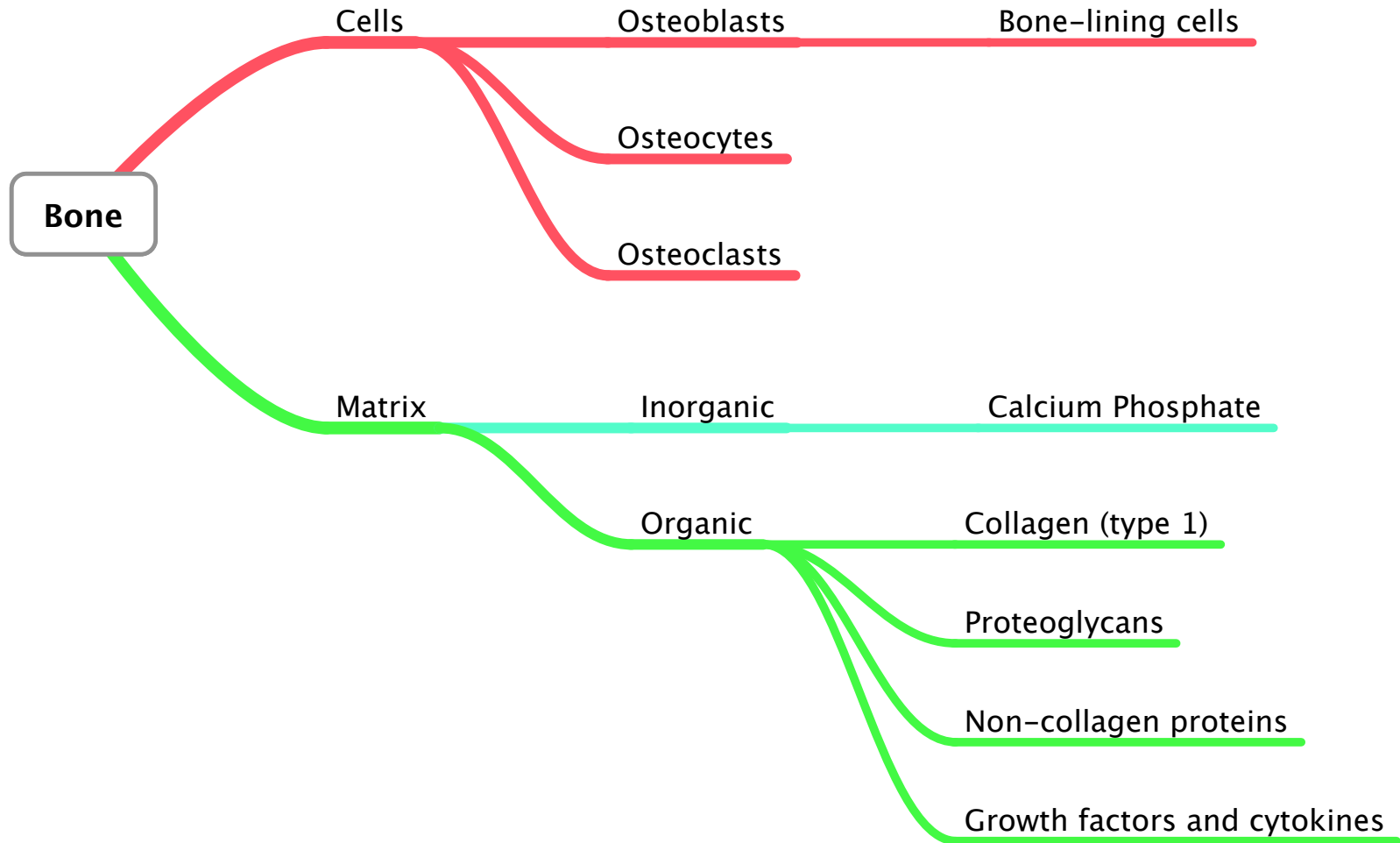


# Periosteum

- Circumferential connective tissue
- Responsible for growth in diameter
- Cambial layer
- Fibrous layer

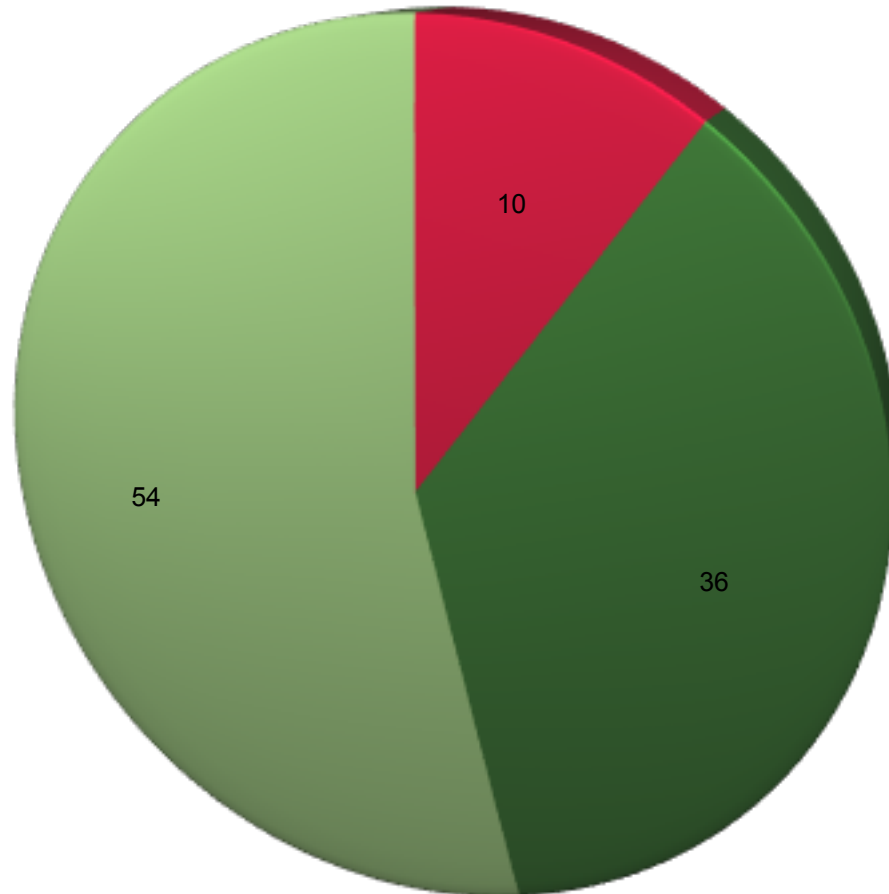


# Bone



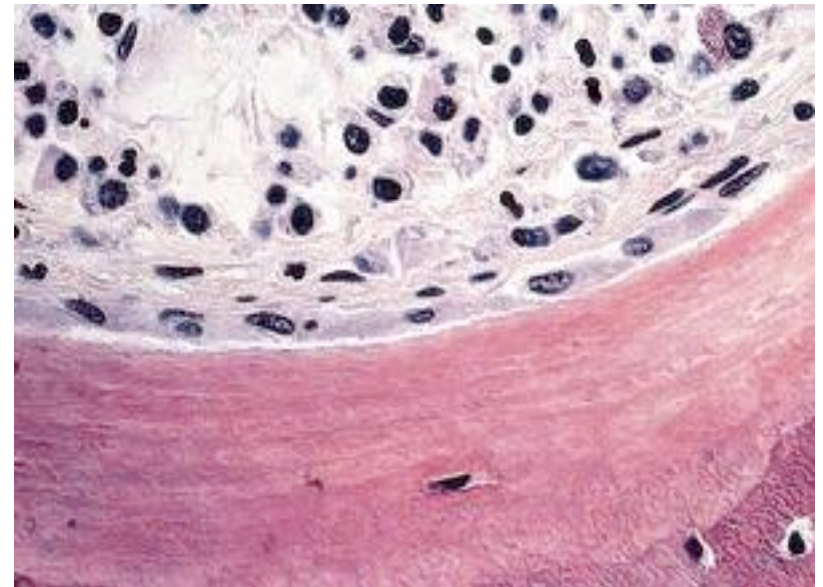
## Percentage cells and matrix

● Cells    ● Organic    ● Inorganic



## Osteoblasts

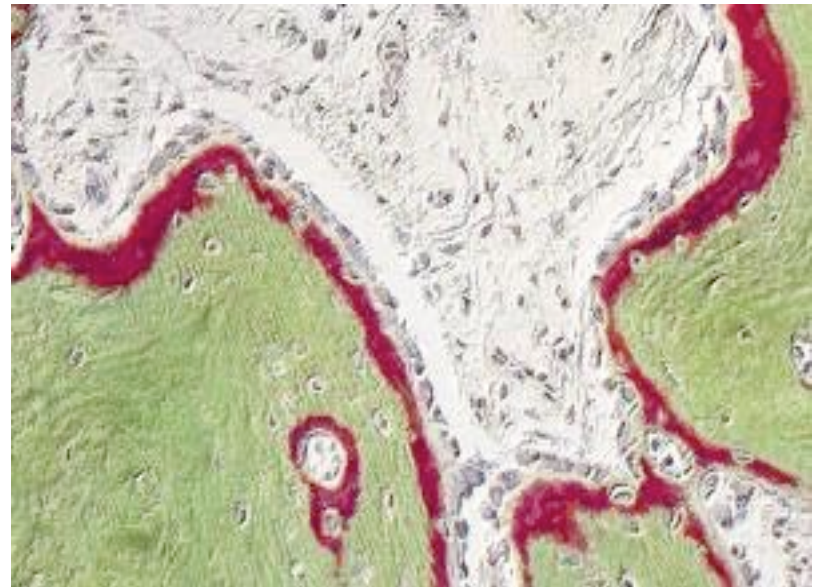
- Bone-forming cells
- Generate the organic, non-mineralized matrix
- Line the surface of the bone
- May become osteoclasts or bone lining cells



## Osteoblasts

Intense basophilic stain,

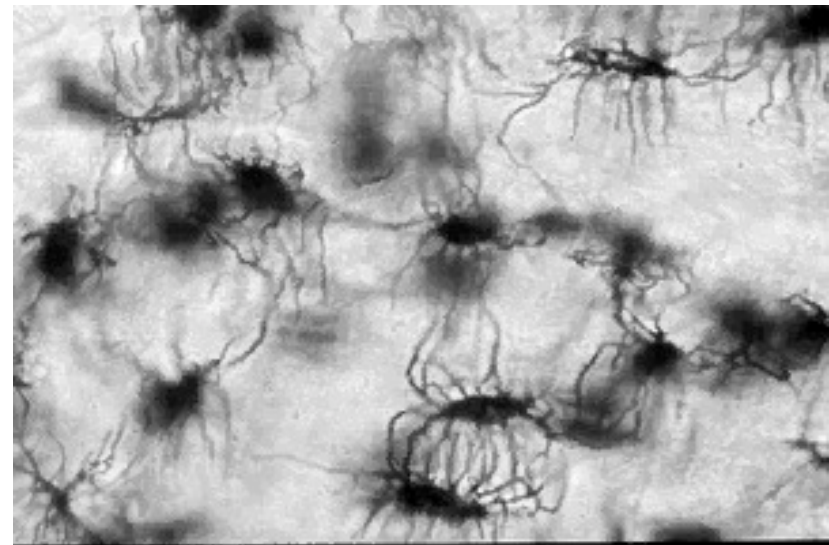
- Produce alkaline phosphatase
- Respond to Parathyroid hormone (PTH)
  - » 1,25 Vit D
  - » Glucocorticoids
  - » Oestrogen
  - » Prostaglandins





## Osteocytes

- **Maintain bone**
- Are osteoblasts trapped by matrix
- 90% of cell population
- Canaliculi
- Calcium homeostasis
- Wolff's Law



# Osteoclasts

- Resorb bone

Large size

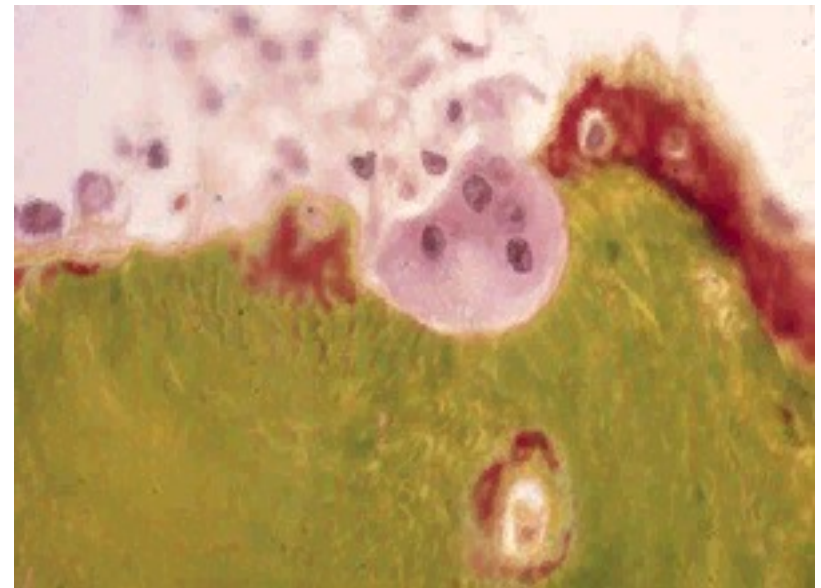
- 100 microns

Lie in pits

- Howship's Lacunae

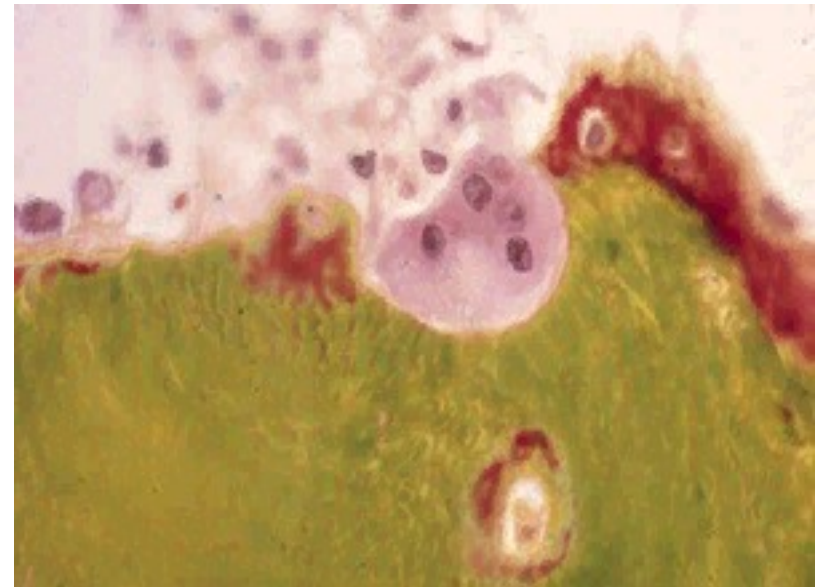
May be

- Inactive
- Active
  - » show brush border



## Osteoclasts in disease

- Multiple myeloma
- Metastases
- Pagets
- Osteopetrosis
  
- ?Implant loosening
  
- Stopped by bisphosphonates



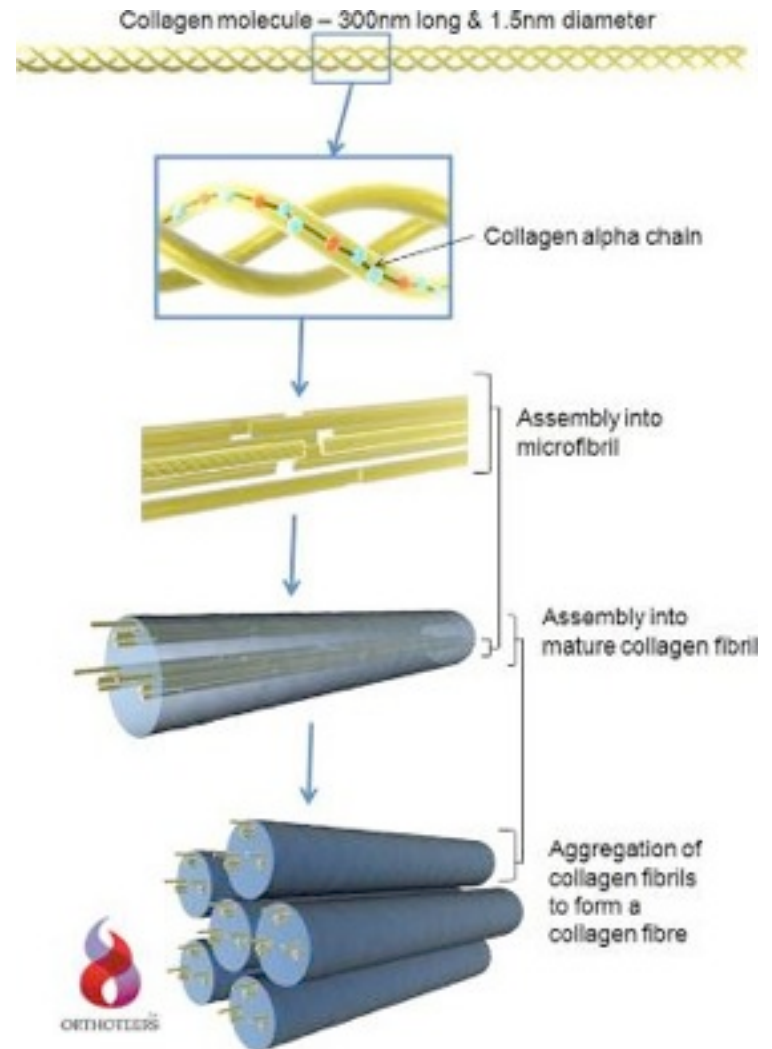
## Bone matrix

- 60% inorganic - compressive
- 40% organic - tensile strength
- Inorganic
  - Calcium hydroxyapatite  
[Ca<sub>10</sub>(PO<sub>4</sub>)<sub>6</sub>(OH)<sub>2</sub>]
  - Osteocalcium phosphate  
(brushite)
  - Mineralization of organic  
matrix
  - 99% total body calcium
  - 85% phosphorous

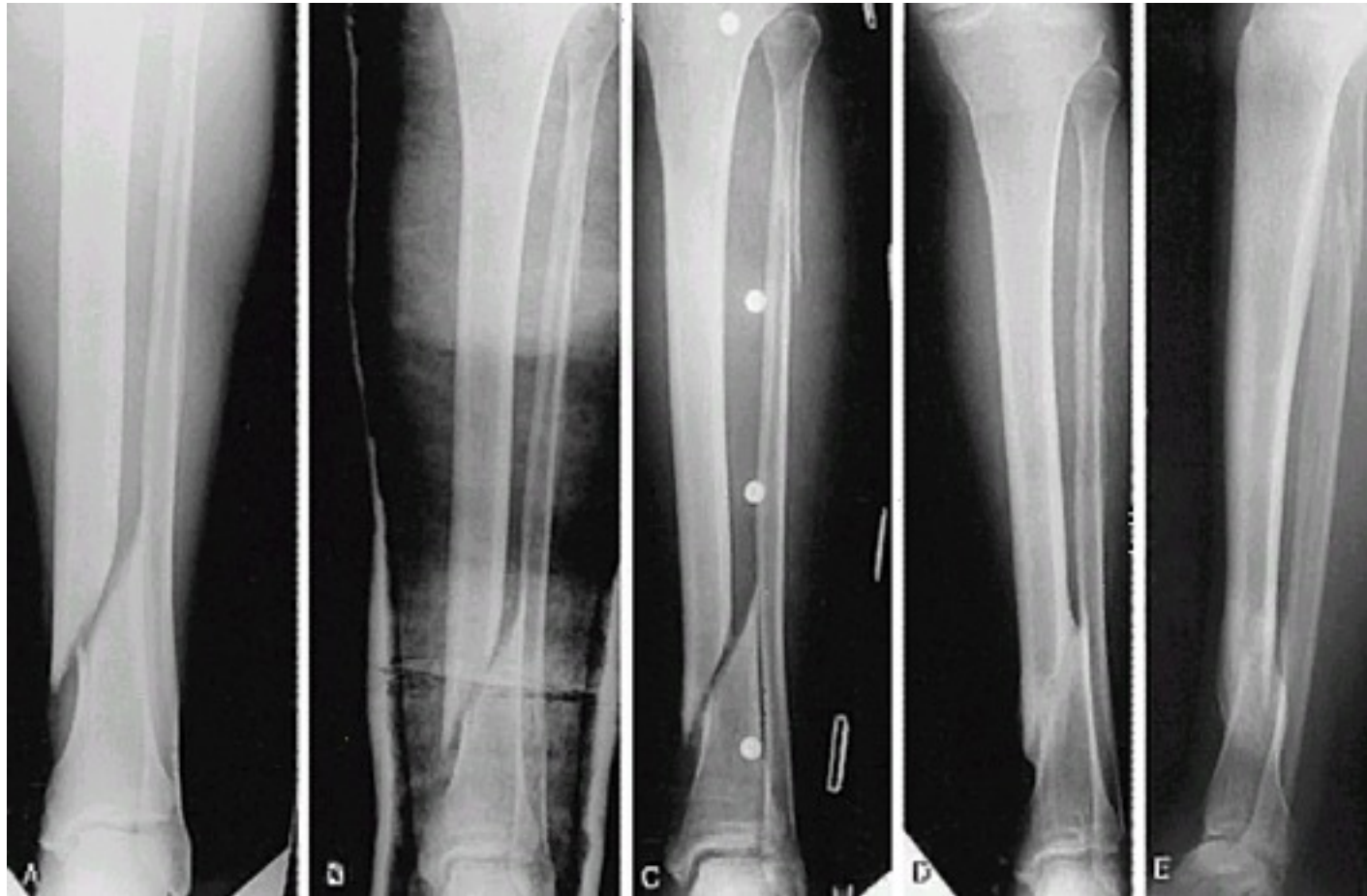


## Bone matrix

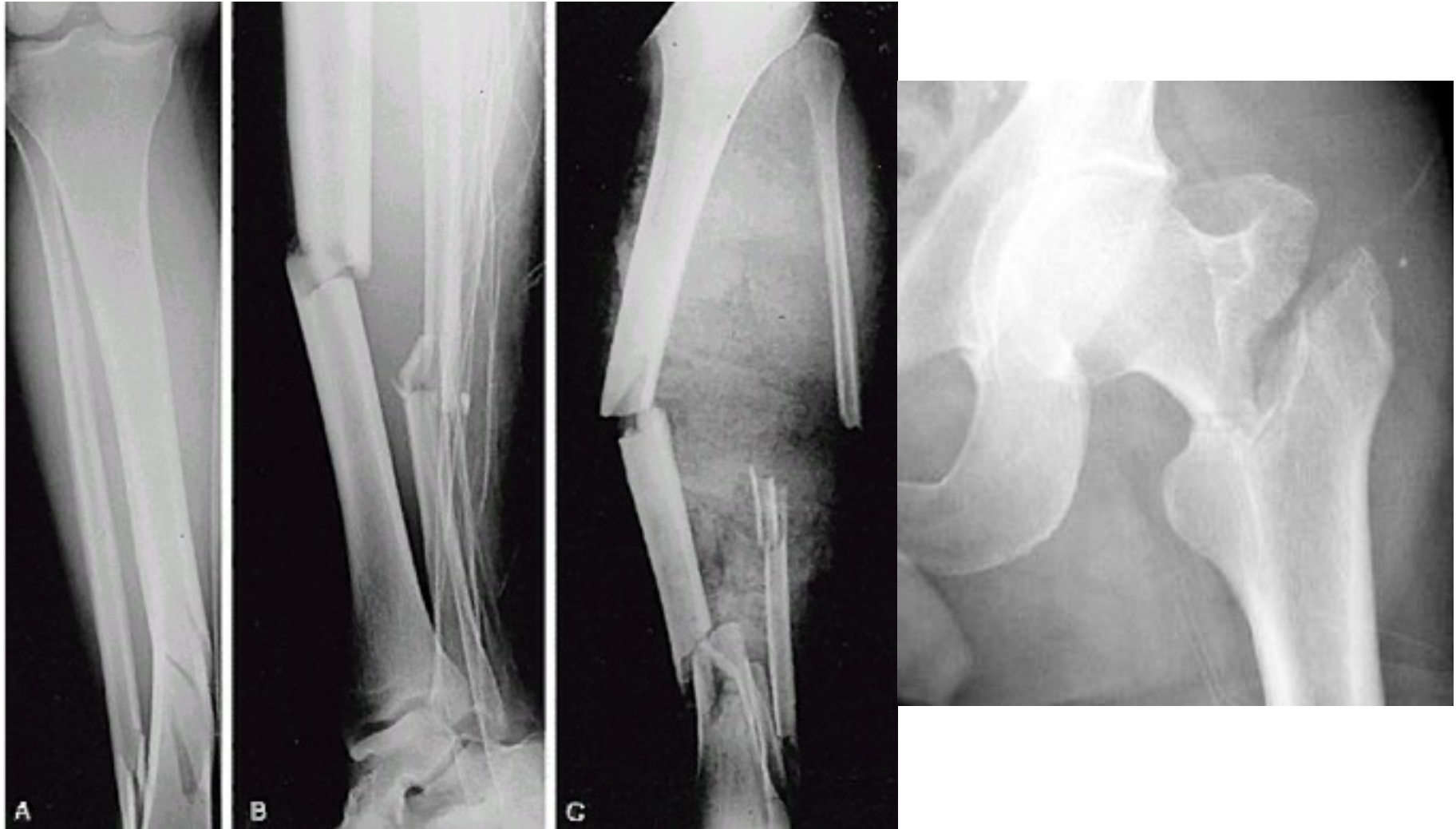
- Organic matrix
  - 90% Type 1 collagen
  - Proteoglycans
  - Non-collagenous matrix proteins
  - Growth factors
  - Cytokines



## Fractures: Loss of function

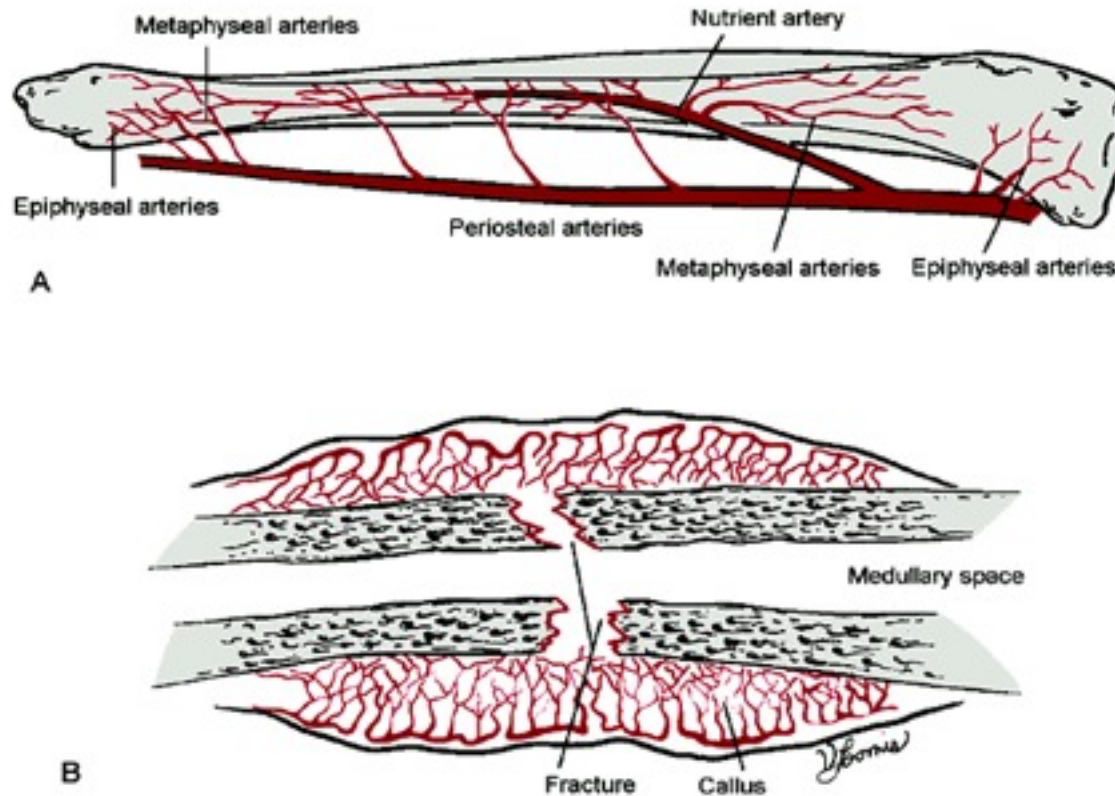


# High vs low energy



# Fracture Healing

Blood Flow is the major factor in healing



**Figure 55-3 A**, The arterial blood supply of the intact human tibia arrives primarily by way of a single nutrient artery, a branch of the posterior tibial artery. It enters through an oblique, fairly long foramen angled distally that is usually located in the upper part of the middle third of the tibia. Where the external surface of the tibia is covered with fibrous periosteum, the arterial surface supplies each the shaft and distal tibia. The arterial surface of the tibia is covered with fibrous periosteum. The arterial surface supplies each the shaft and distal tibia. The arterial surface of the tibia is covered with fibrous periosteum. The arterial surface supplies each the shaft and distal tibia.



# Fracture Healing

- Perren's strain theory
- Secondary (callus) bone healing
- Primary (direct cortical) bone healing
- Examples
- Non-union

## Perren's strain theory

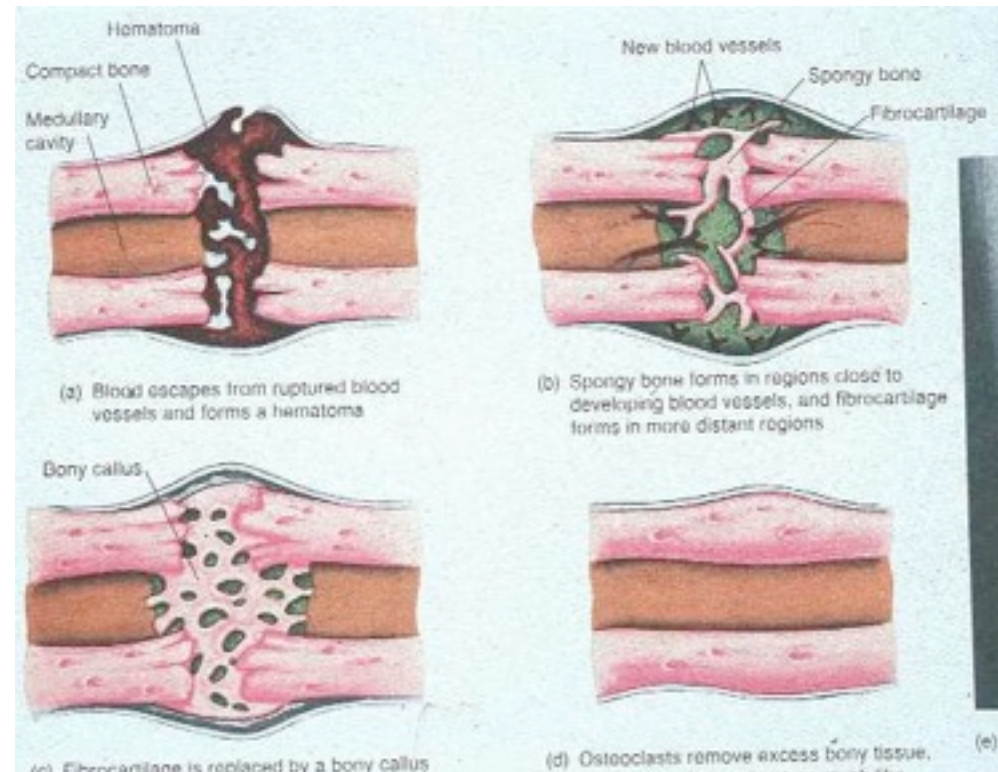
- Amount of movement (strain) = type of healing / tissue formed
- Strain = Change in length / initial length
  - No units
- Large movements = Large strain

## Perren's Strain theory

- Granulation tissue
  - Fibrous tissue
  - Fibrocartilage
  - Lamellar bone
- As fractures heal, they move less, and hence progress down the list.
- Higher strain = callus
  - no/low strain = no callus

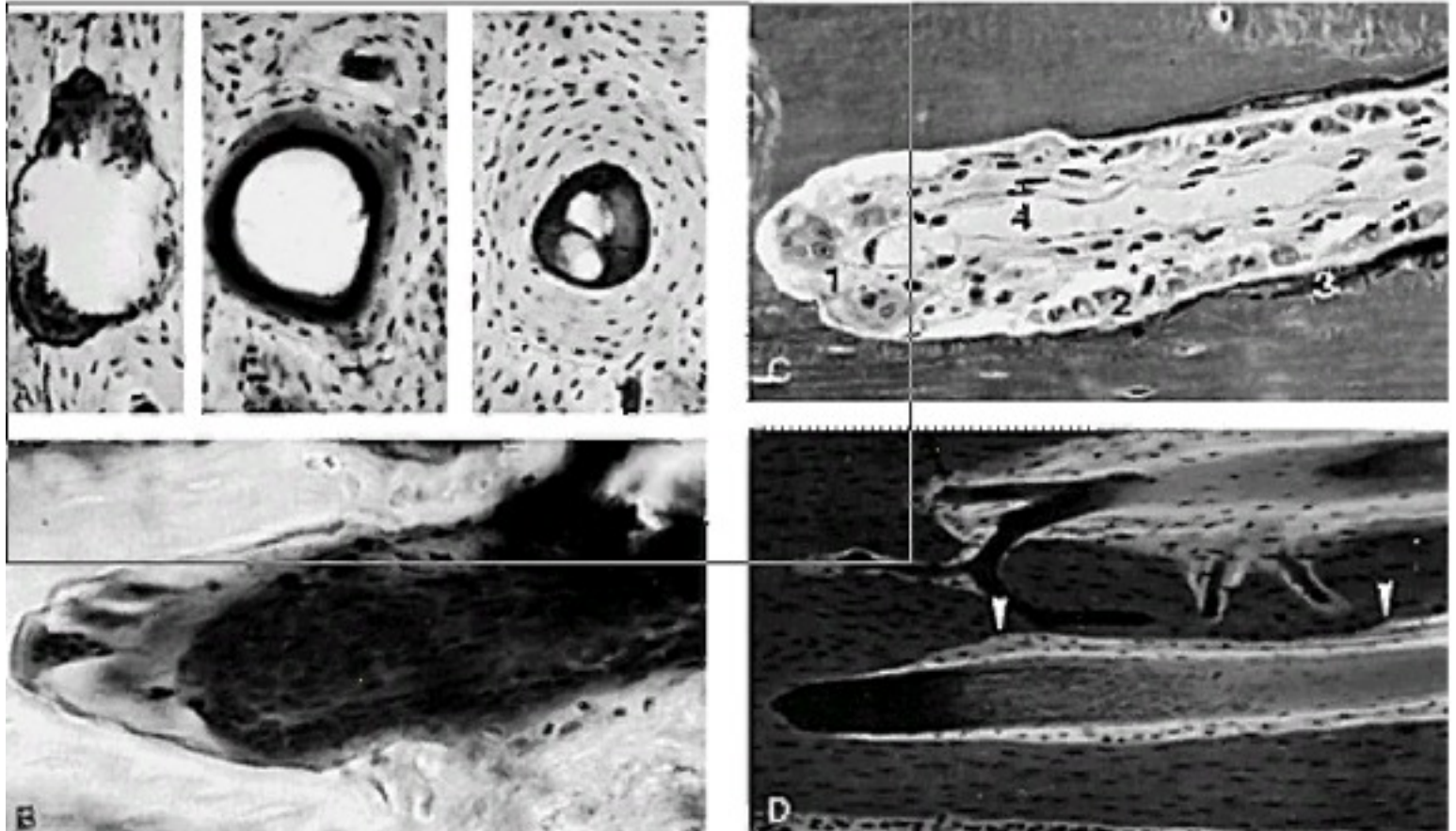
## Secondary (callus) bone healing

- Relative stability
- Higher strain
- Inflammation
- Repair - <2 weeks
  - Soft callus
  - Hard callus - 1-4 months
- Remodelling - Years

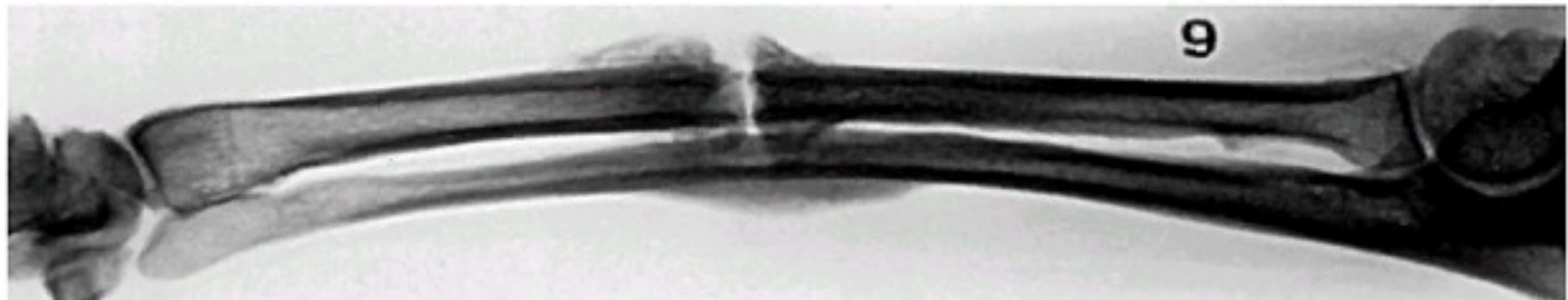
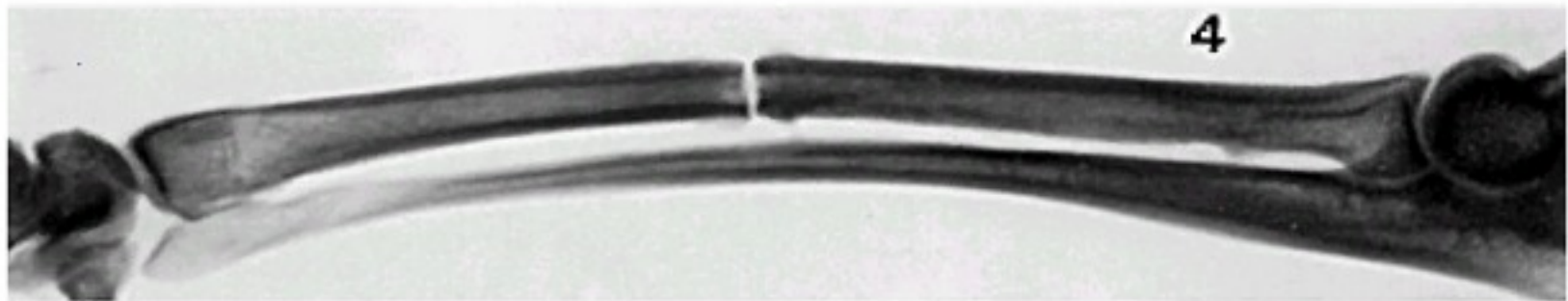
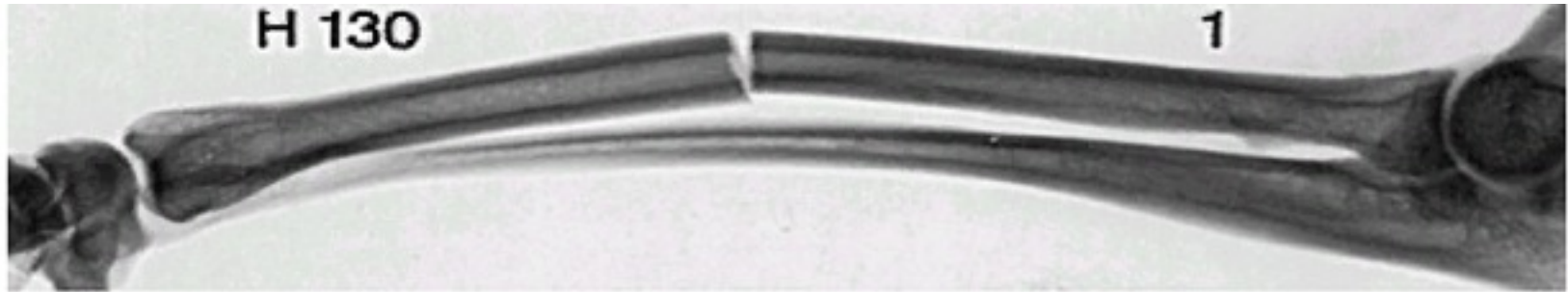


# Remodelling & Cutting Cones

Stopped by bisphosphonates

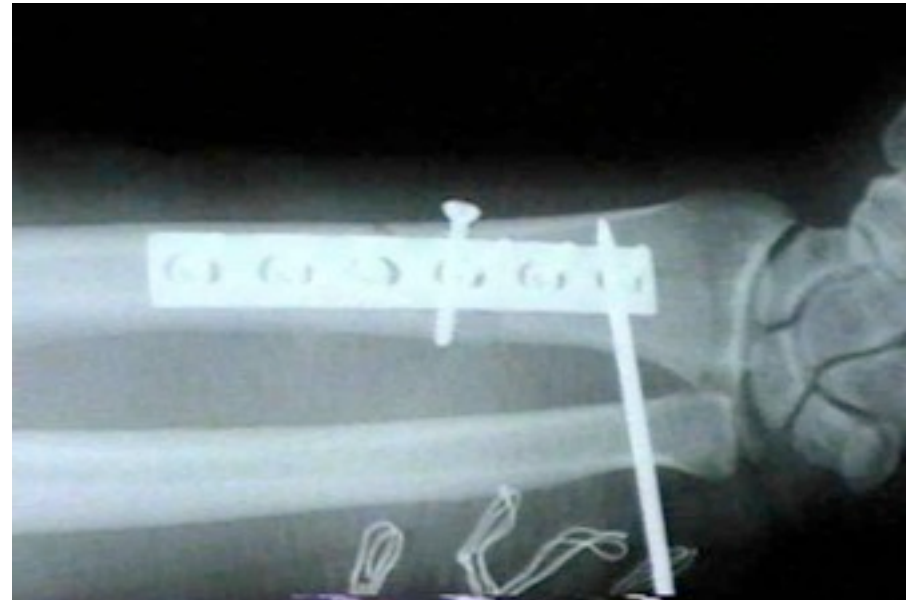


## Secondary Healing Model in Rat's Tibia



## Primary (direct healing)

- Same as remodelling stage of secondary healing
- Cutting cones
- No callus
- Only when:
  - Anatomical reduction
  - Compression
  - Very low strain



## Factors detrimental to bone healing

- Soft-tissue trauma
  - Loss of blood supply
  - Smoking - affects osteoblast function
  - Nutrition
  - Age
- 
- Head injury accelerates healing!



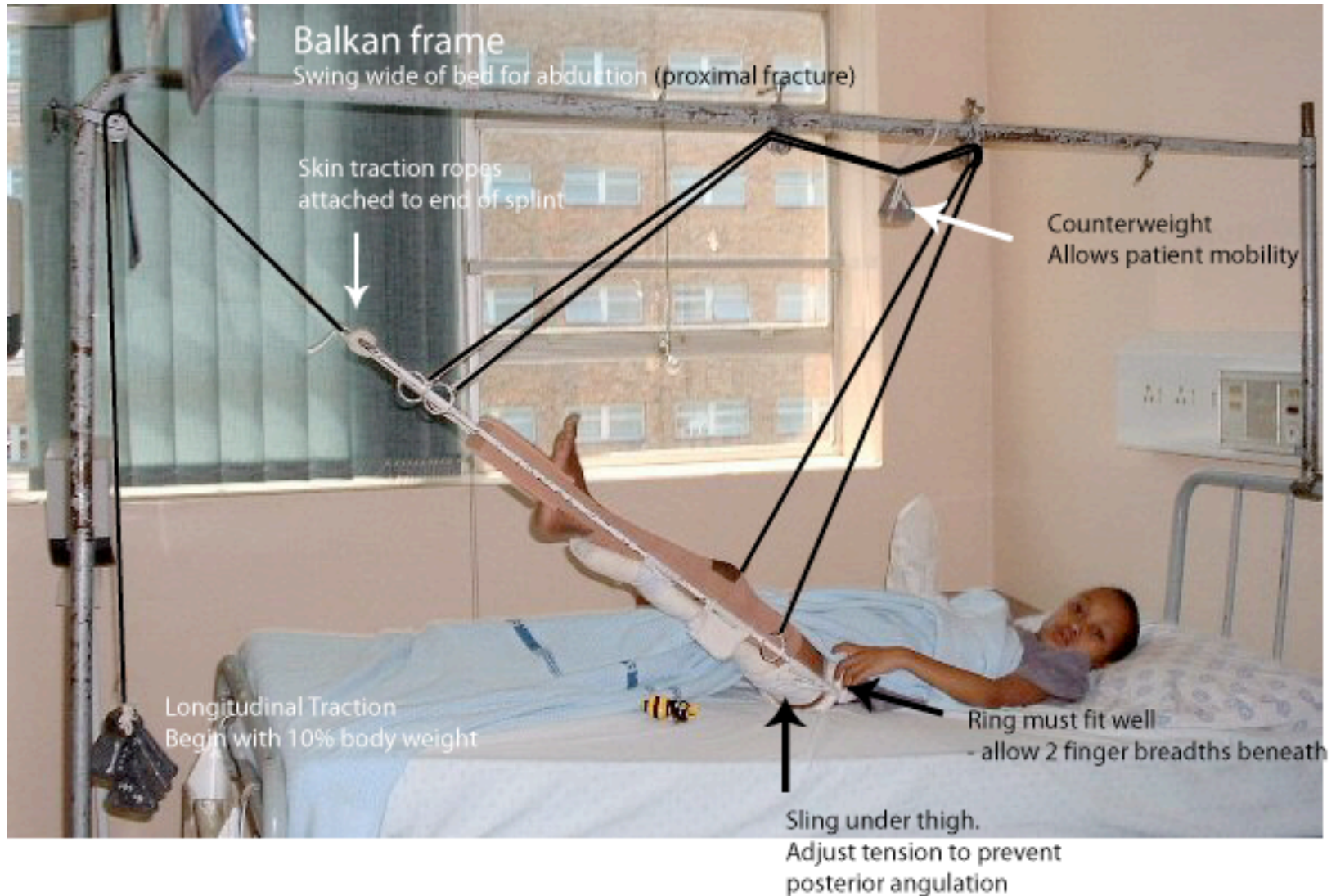
## Type of Fracture Healing Based on Type of

Type of Immobilization	Predominant Type of Healing
Cast (closed treatment)	Periosteal bridging callus
Compression plate	Primary cortical healing (remodeling)
Intramedullary nail	Early—periosteal bridging callus Late—medullary callus
External fixator	Dependent on extent of rigidity Less rigid—periosteal bridging callus More rigid—primary cortical healing
Inadequate	Hypertrophic nonunion

## Plaster Cast Fixation needs skills



## Traction is gentle and safe



## External Fixation

For open fractures

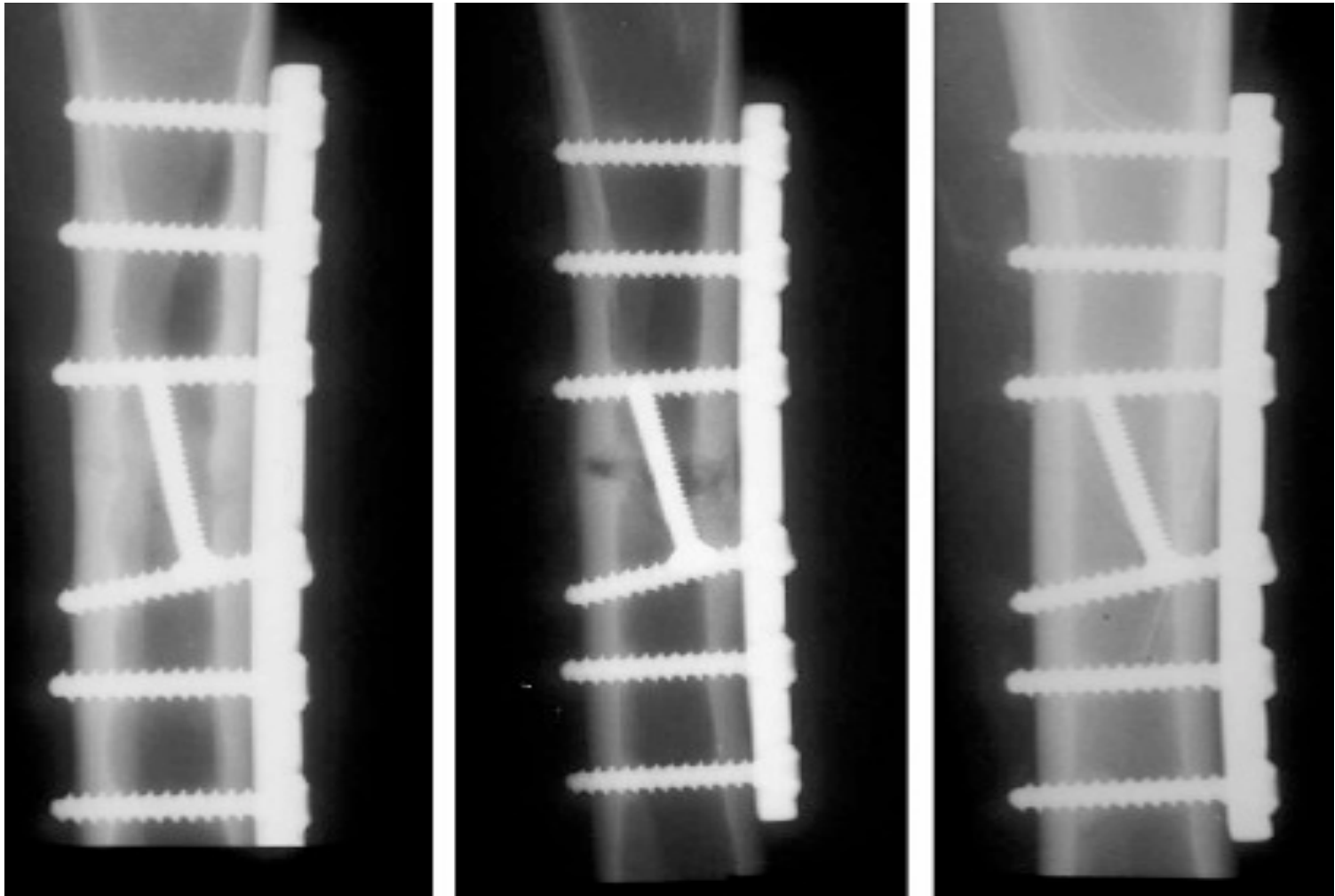


# Internal Fixation

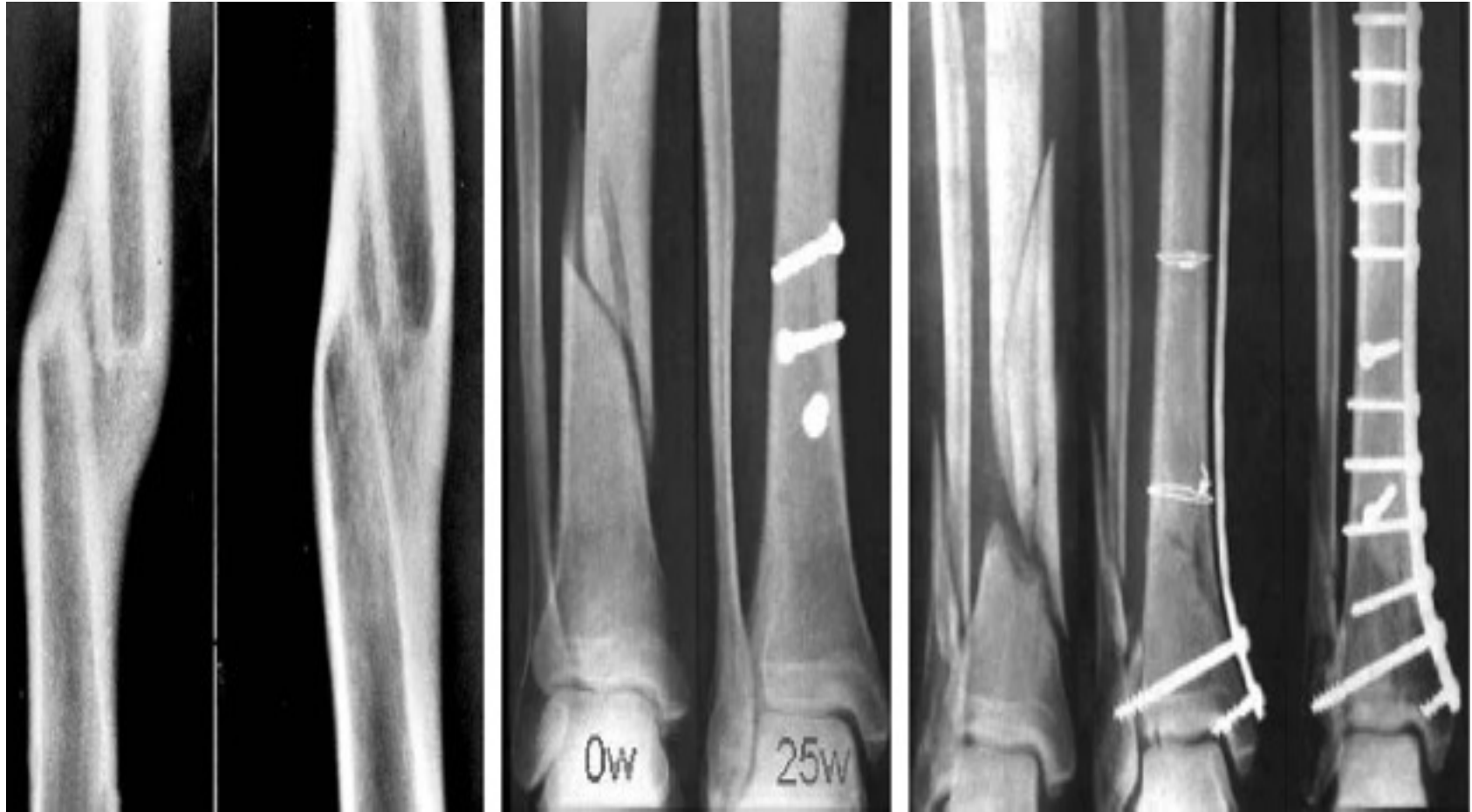
For closed injury



## Internal Fixation/ Primary Healing



## Direct Versus Indirect Healing



## Biological Plates and Callus





## SUMMARY

- Function
- Types of bone
- Cells and matrix
- Periosteum
- Perren's strain theory
- Fracture healing
- Orthopaedic methods

