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Bone: Structure, function, and healing

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3 main functions

- Calcium Reservoir
- Haematopoietic marrow
- Mechanical

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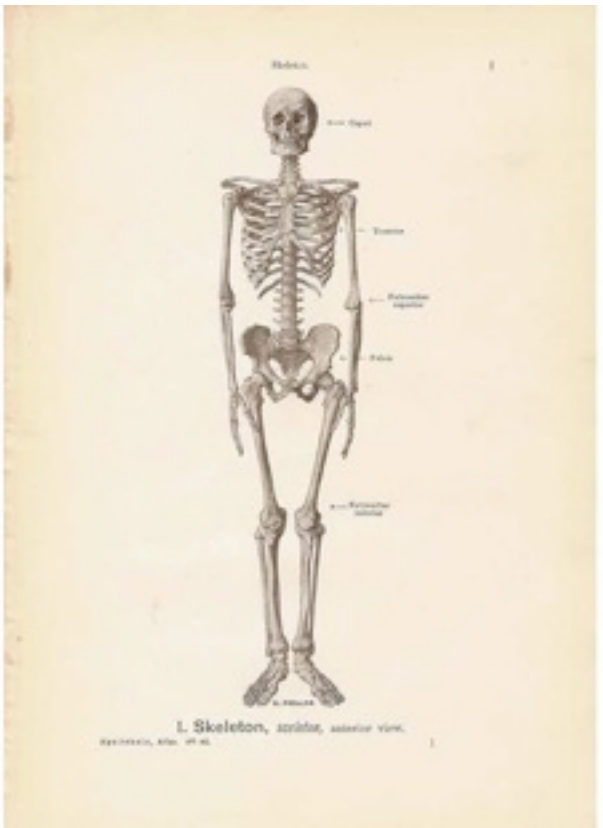
Skeleton

- 206 bones in the skeleton
- Weighs 2kg



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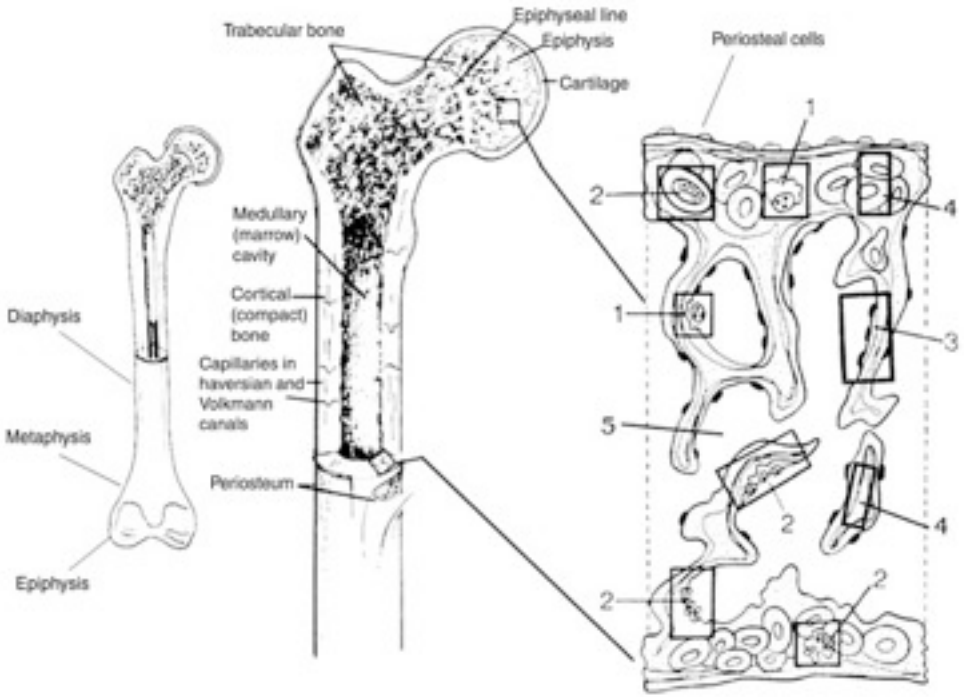
Long Bone



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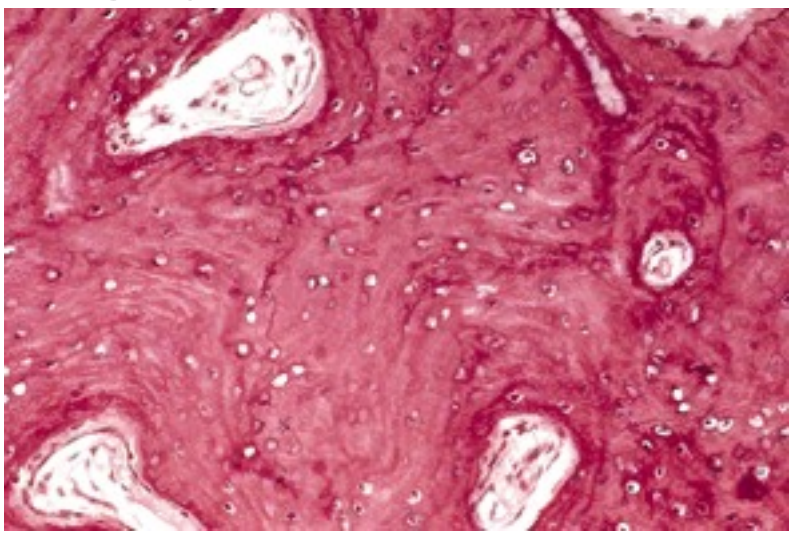
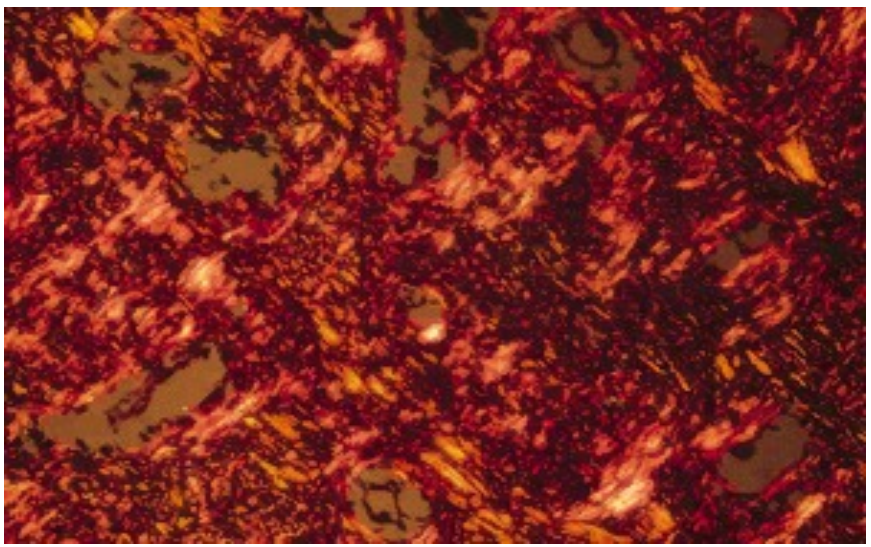
Woven /Immature Bone

- 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

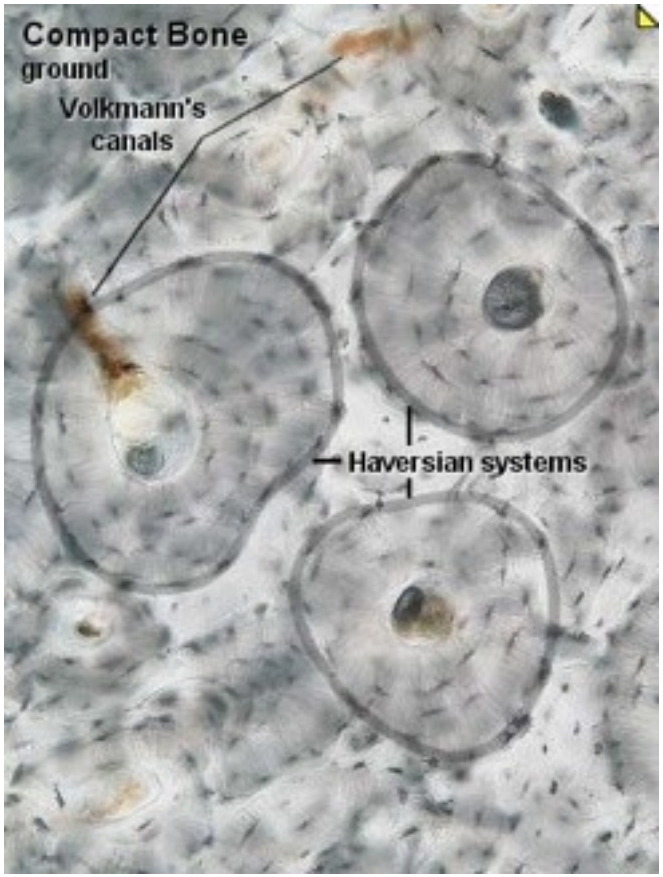
- Stress-orientated collagen
- Lamellae

Cortical bone (compact bone)

- Type of lamellar bone
- 80% of adult skeleton
- Diaphyses of long bones

- Dense
- Stiffer
- Resistant to bending

- Haversion systems



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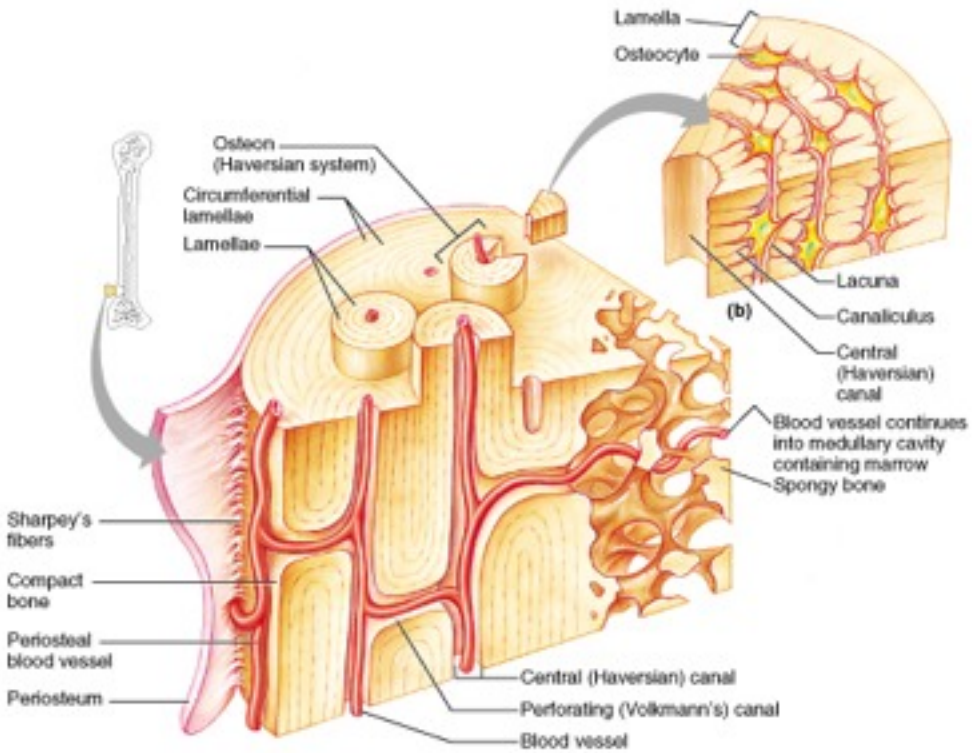
Haversion systems (Osteons)



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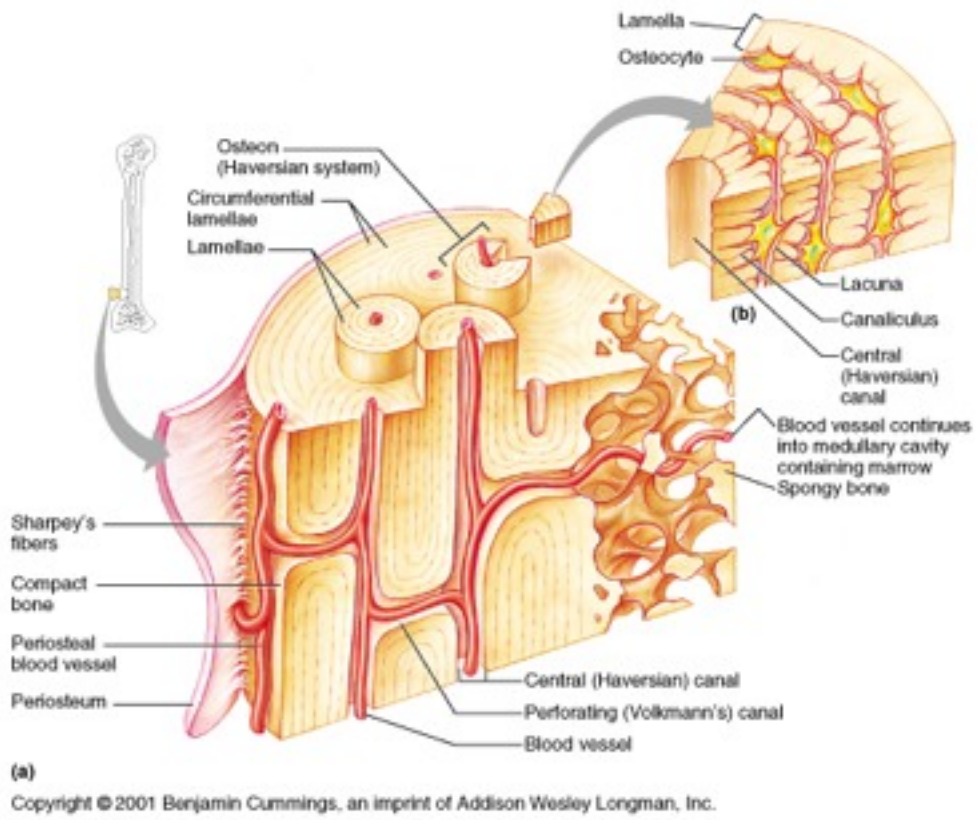
Haversion systems (Osteons)



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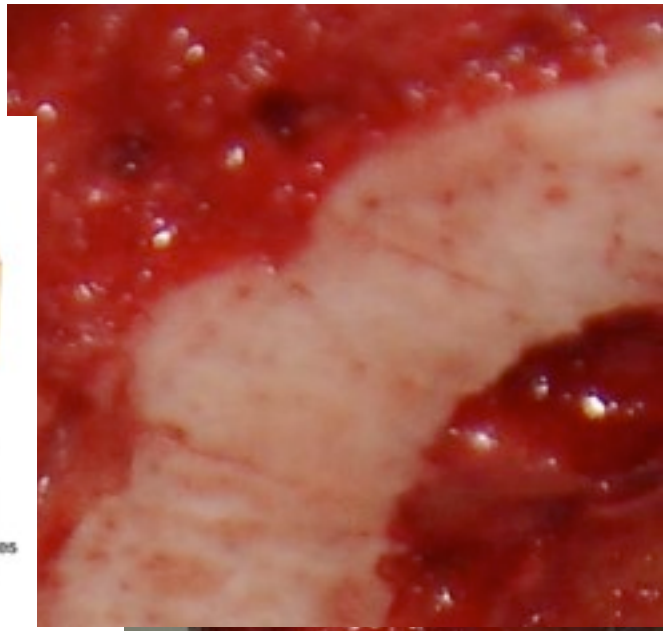

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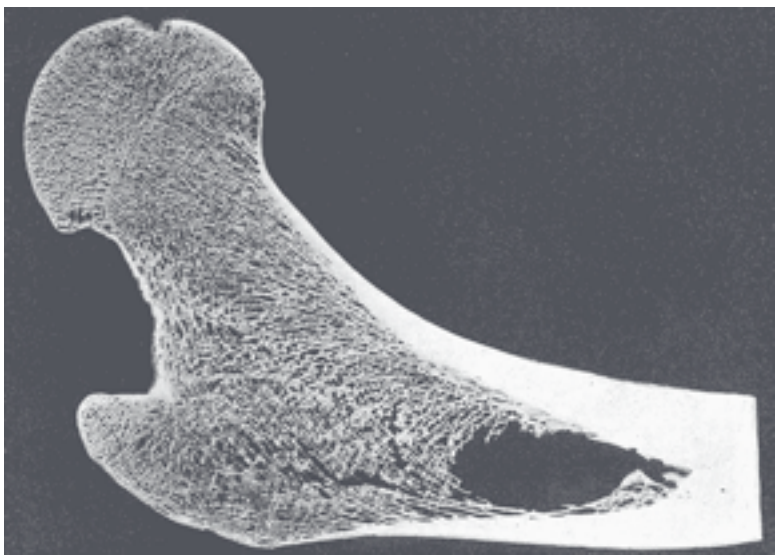
Cancellous (trabecular) bone

- Type of lamellar bone
- Metaphyses and epiphyses
- 3D lattice of trabeculae

- Aligned according to Wolff's Law (stress)

- No Haversion systems

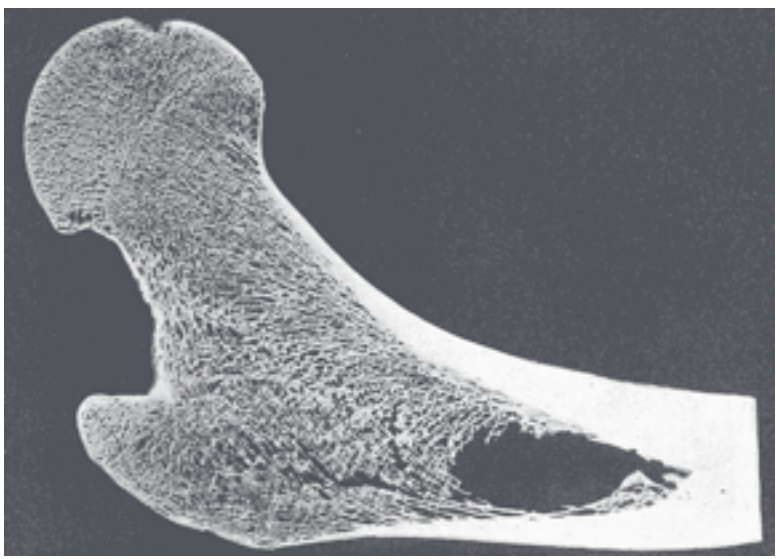
- Parallel sheets of lamellae



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

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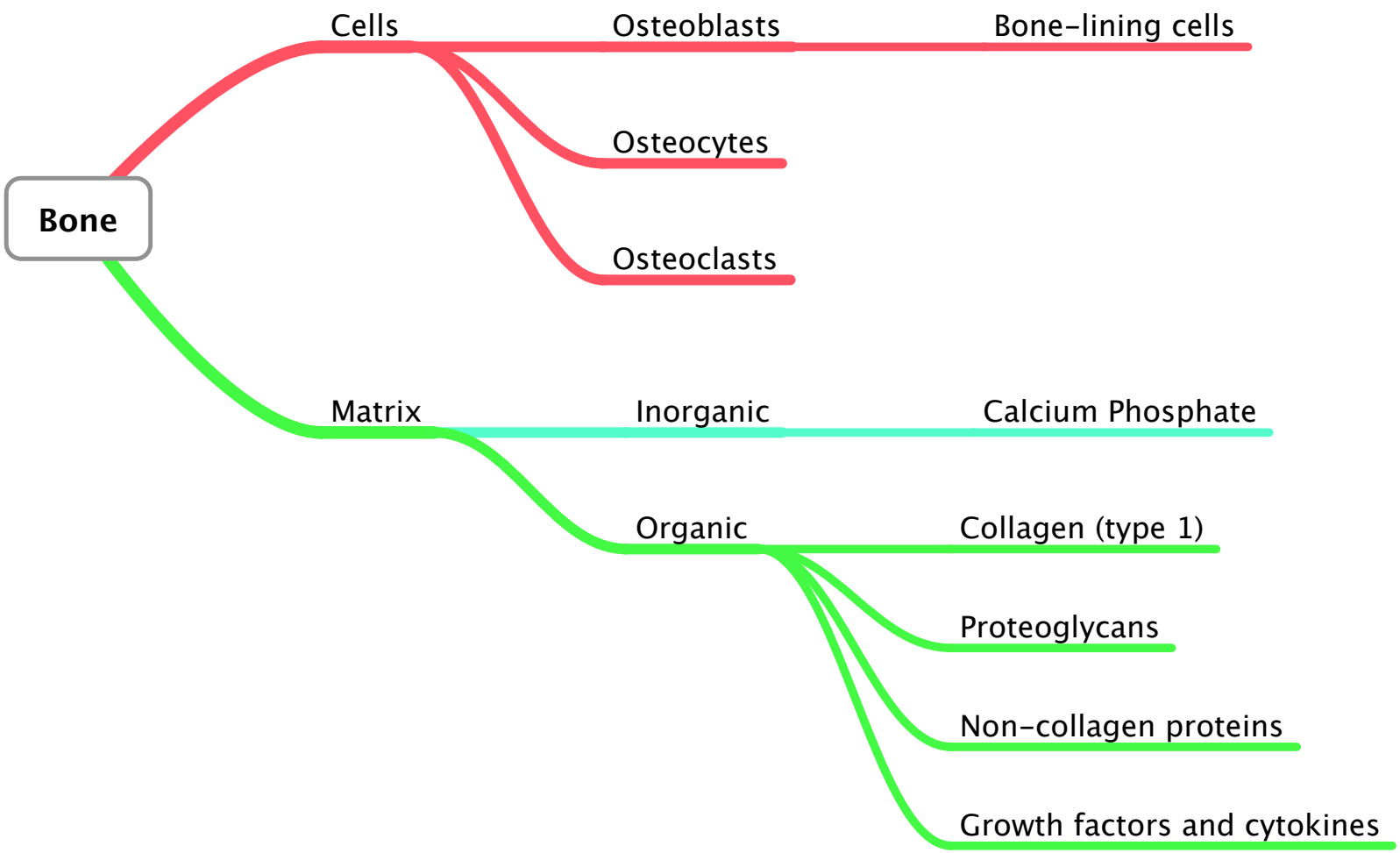
Bone



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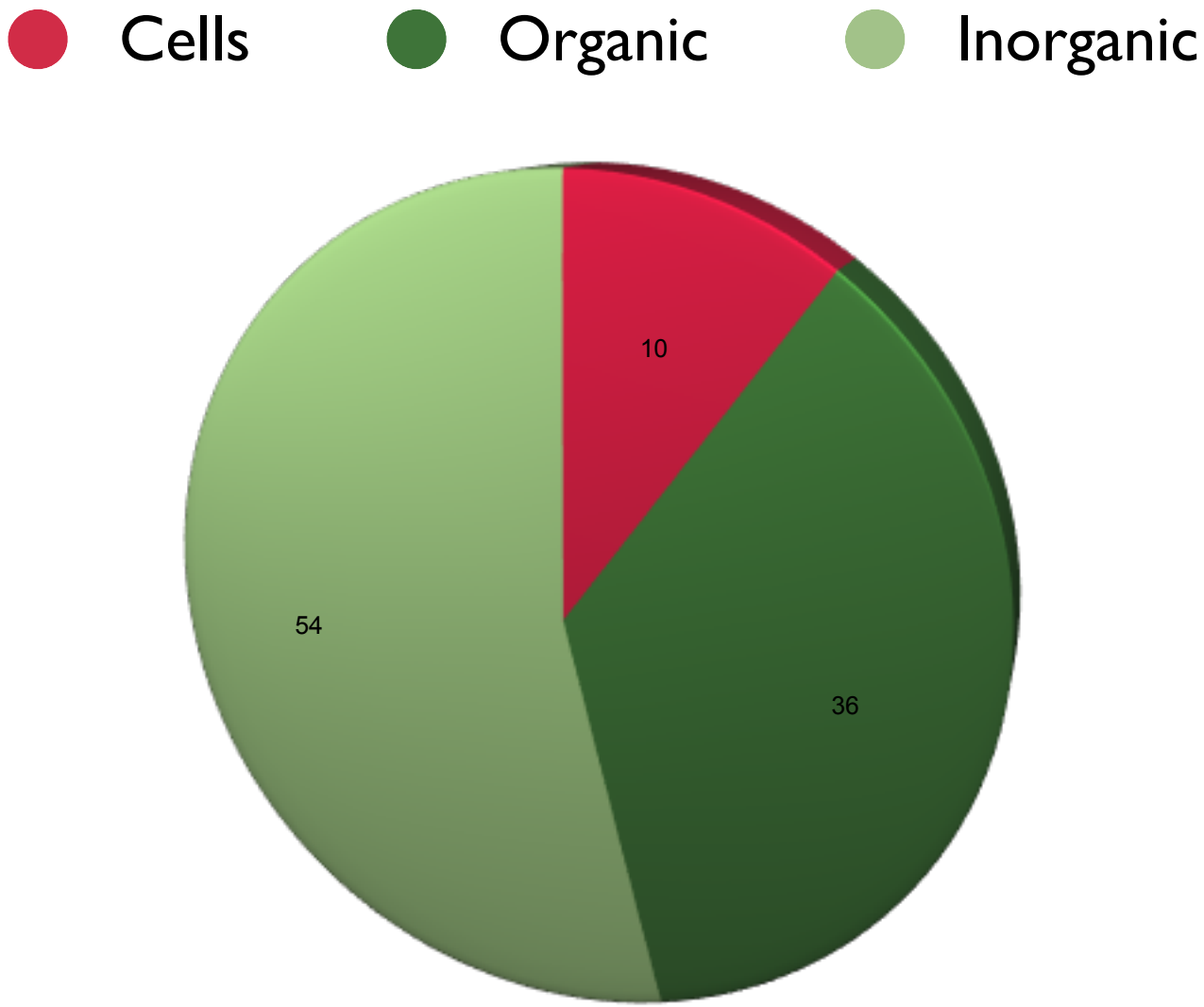
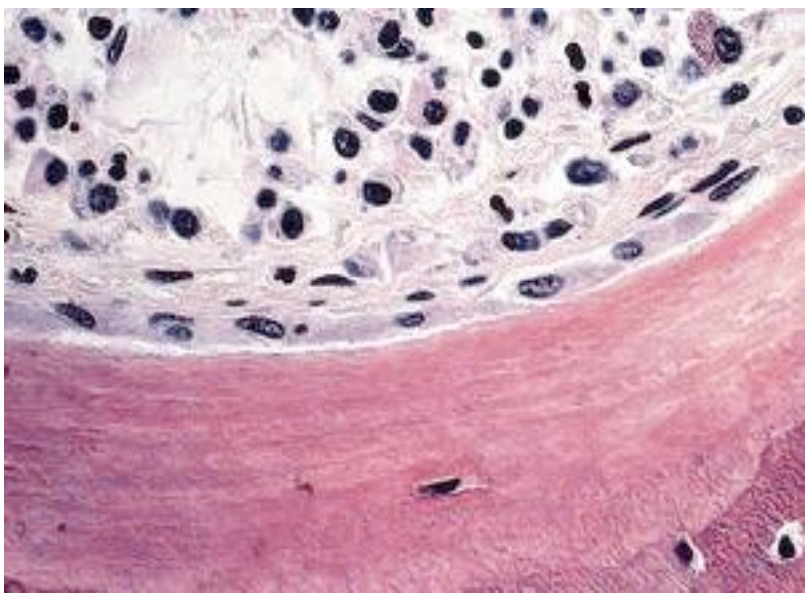
Percentage cells and matrix



Osteoblasts

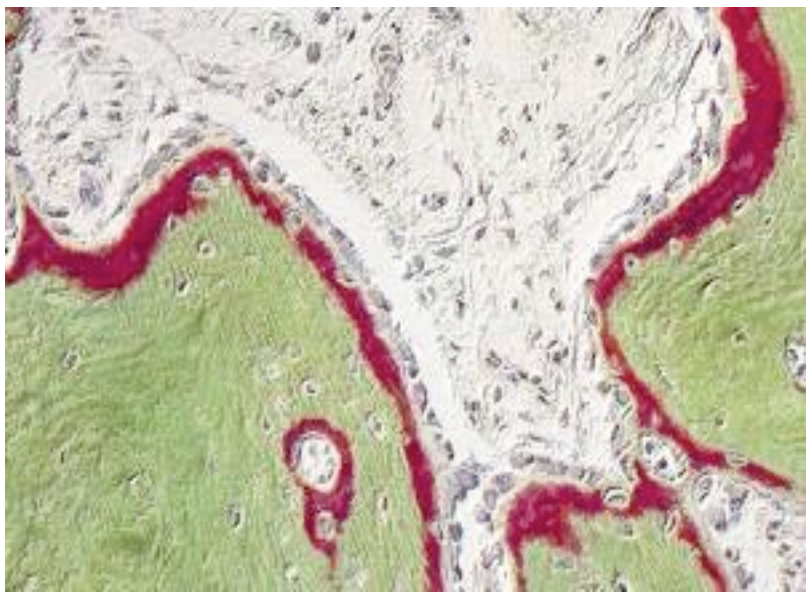
- Bone-forming cells
- Generate the organic, non-mineralized matrix
- Line the surface of the bone
- May become osteoclasts or bone lining cells



Osteoblasts

Intense basophilic stain,

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



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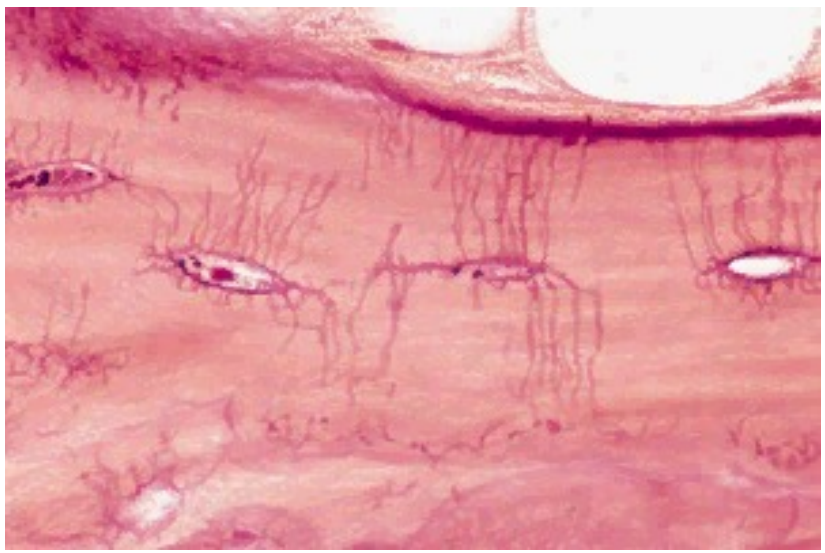
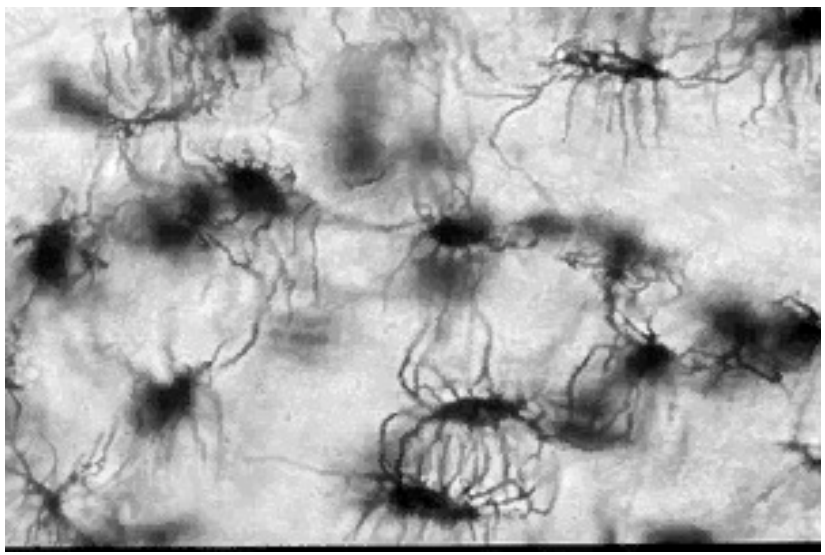
Osteocytes

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





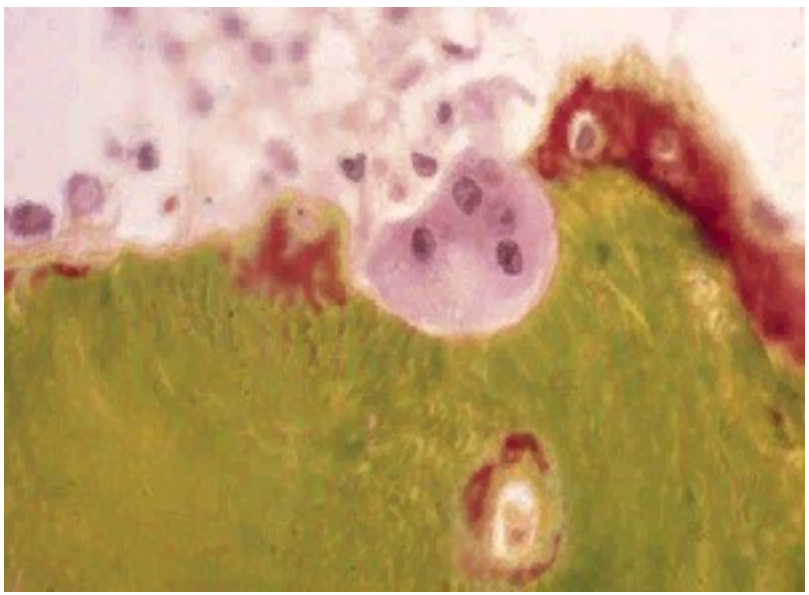
Osteoclasts

- **Resorb bone**

Large size
- 100 microns

Lie in pits
- Howship's Lacunae

May be
- Inactive
- Active
  - »show brush border

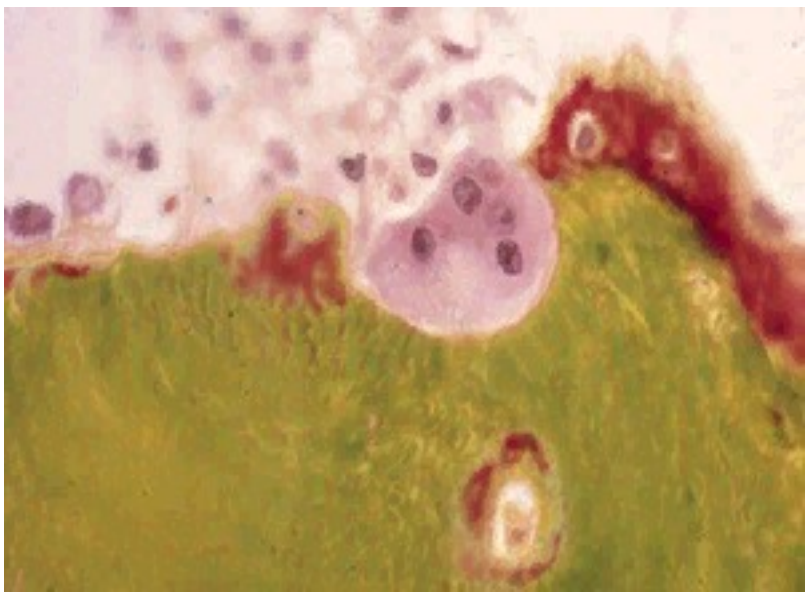


Osteoclasts in disease

- Multiple myeloma
- Metastases
- Pagets
- Osteopetrosis

- ?Implant loosening

- Stopped by bisphosphonates



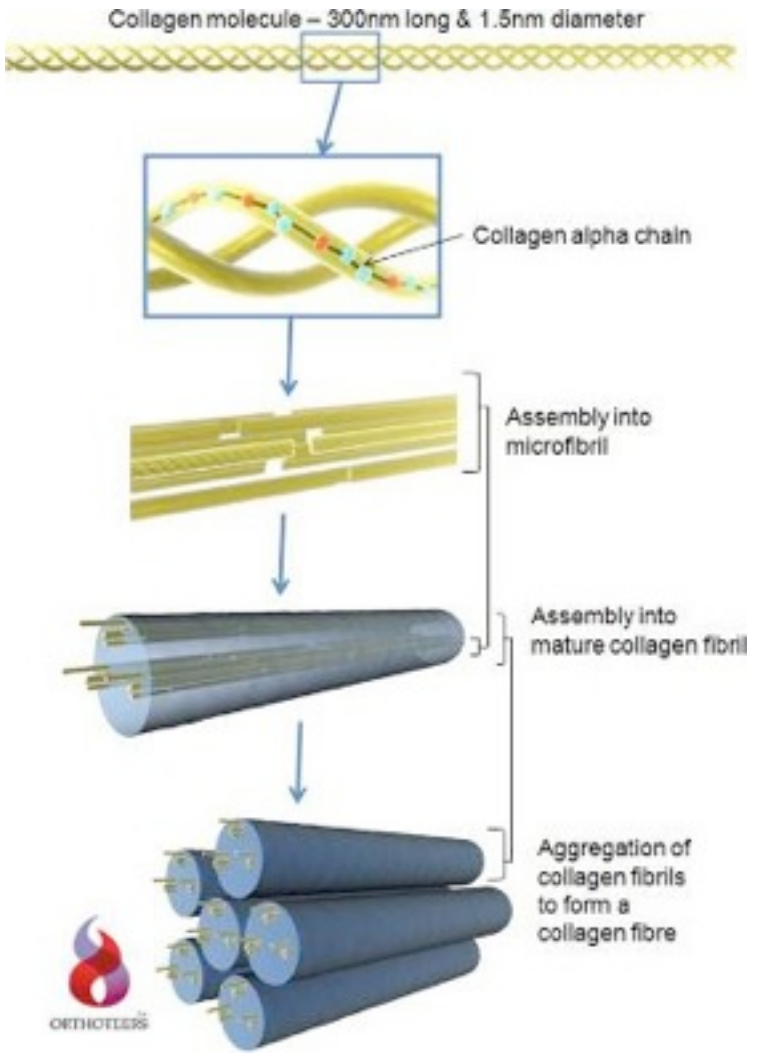
Bone matrix

- 60% inorganic - compressive
- 40% organic - tensile strength

- Inorganic
  - Calcium hydroxyapatite $[Ca_{10}(PO_4)_6(OH)_2]$
  - 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



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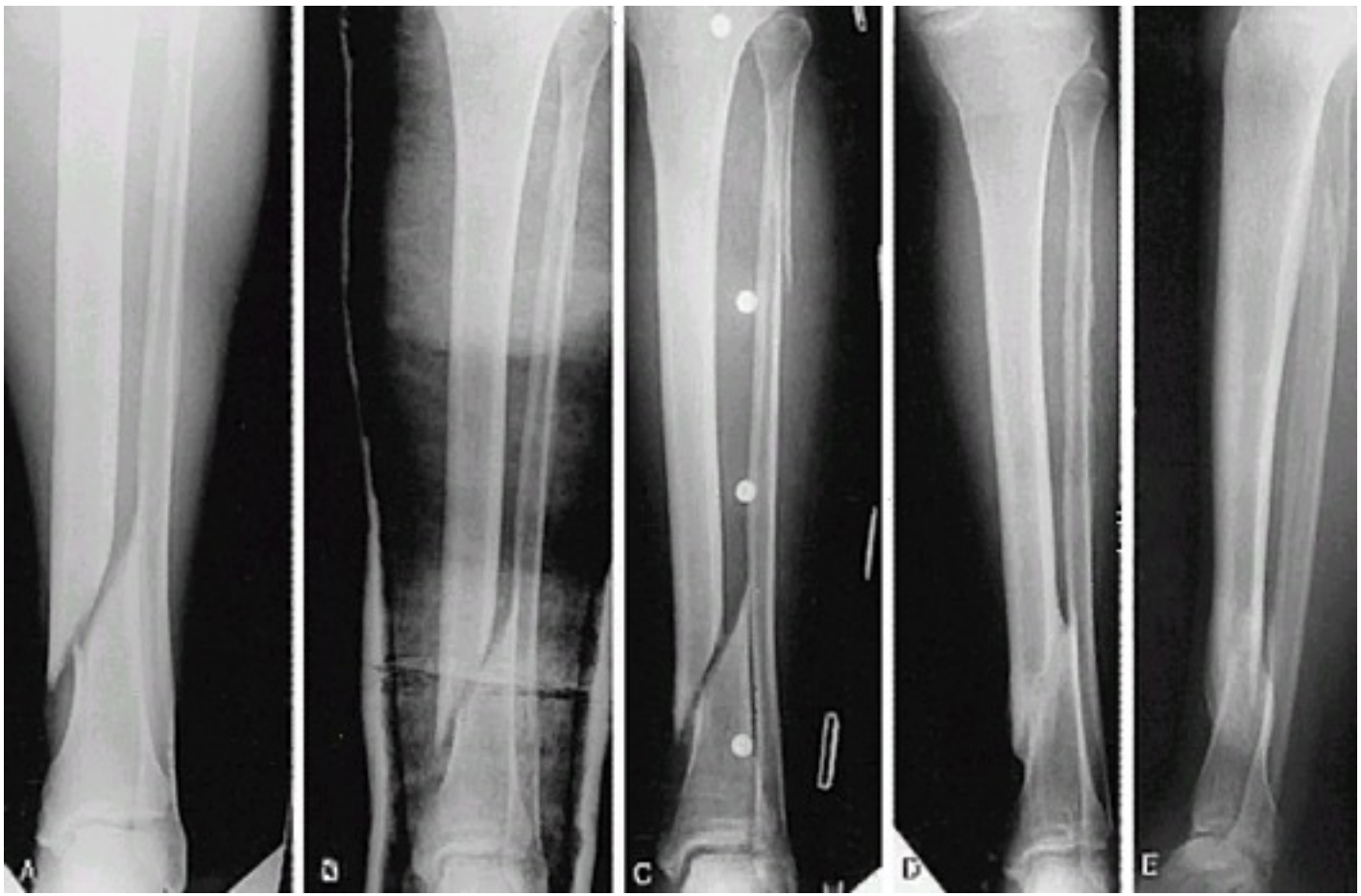
Fractures: Loss of function



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High vs low energy

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Fracture Healing

Blood Flow is the major factor in healing

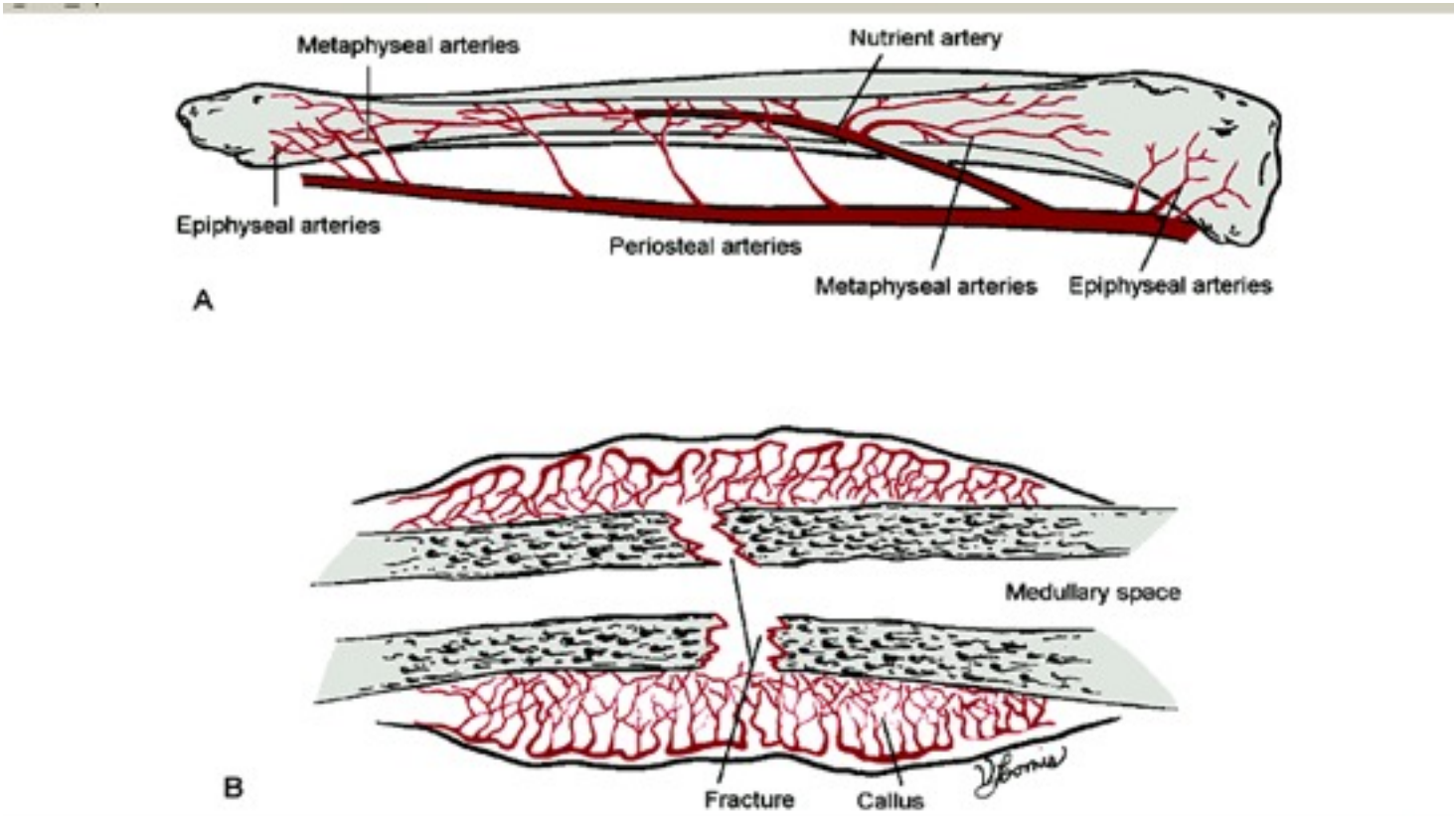

Figure 55-3 *A*, The arterial blood supply of the intact human tibia arrives primarily by way of a single nutrient artery, a branch of the posterior tibial artery. It enters through an oblique, fairly long foramen angled distally that is usually located in the upper part of the middle third of the tibia.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

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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

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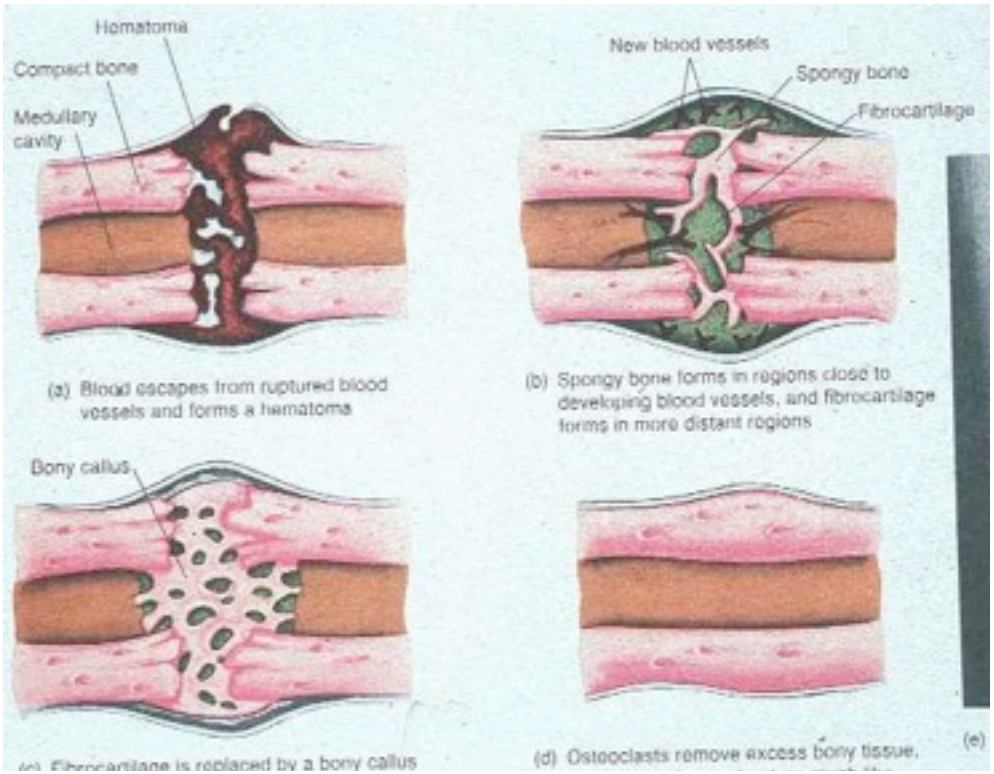
Secondary (callus) bone healing

- Relative stability
- Higher strain

- Inflammation

- Repair - <2 weeks
  - Soft callus
  - Hard callus - 1-4 months

- Remodelling - Years



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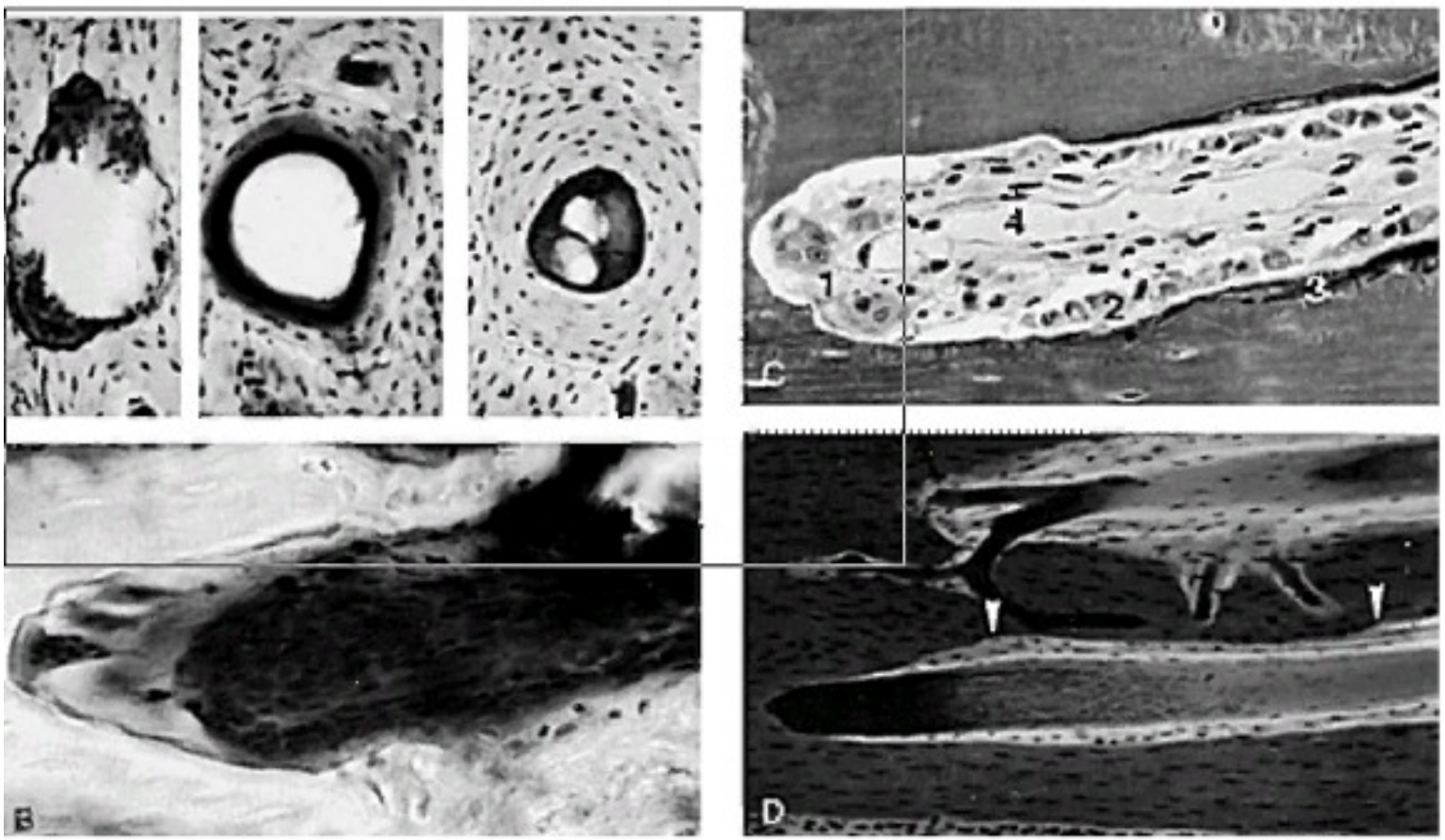
Remodelling & Cutting Cones

Stopped by bisphosphonates



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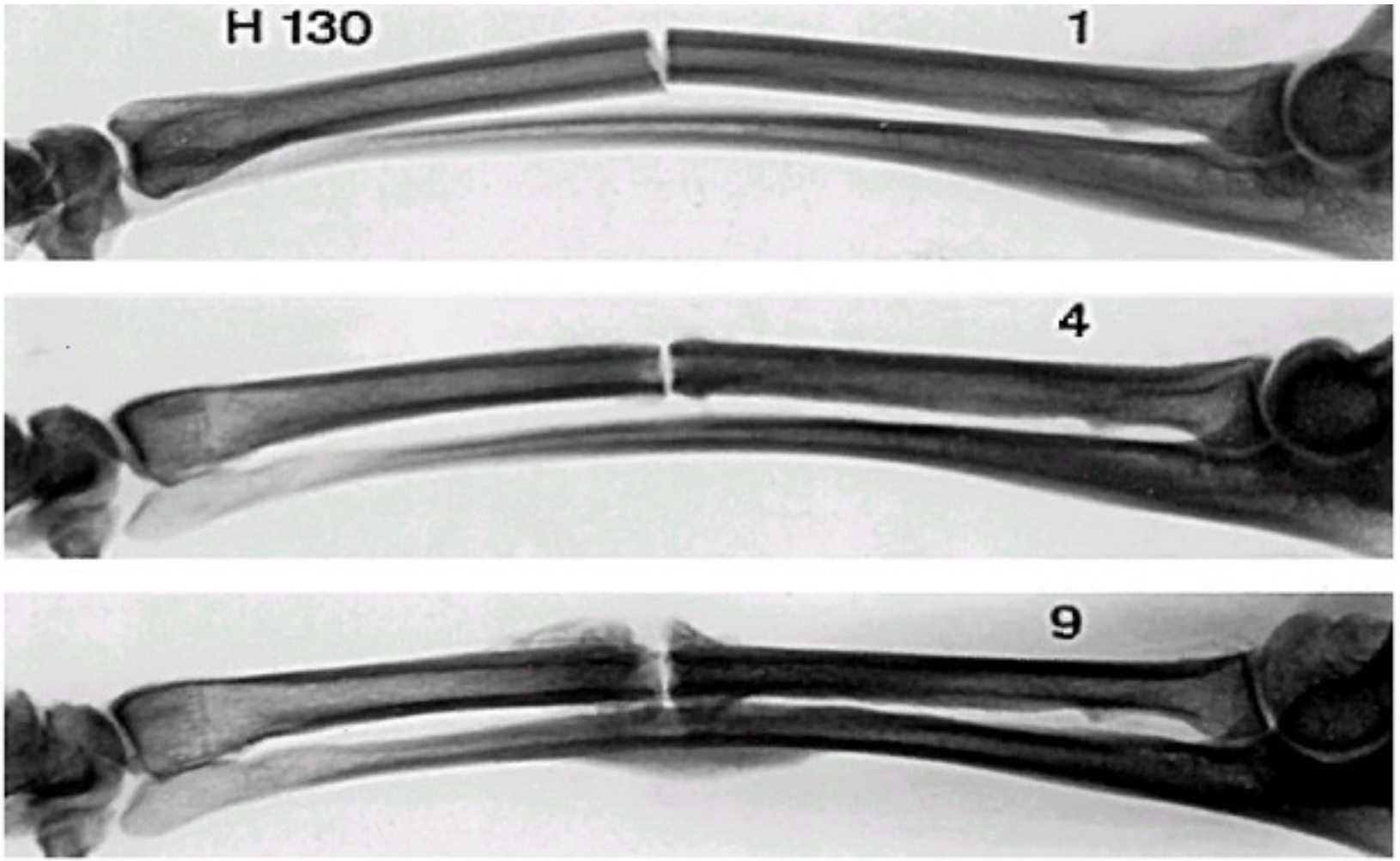
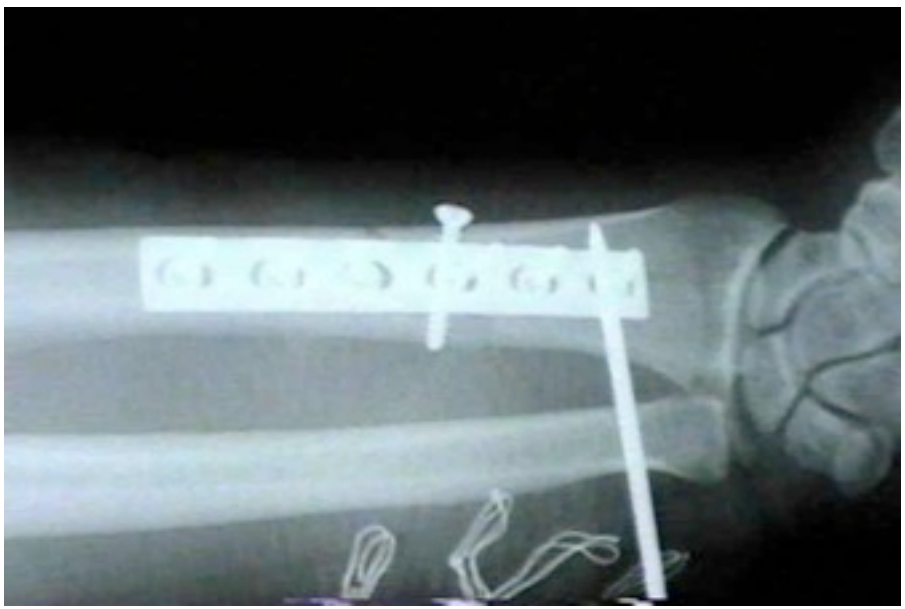
Secondary Healing Model in Rat's Tibia



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

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Plaster Cast Fixation needs skills

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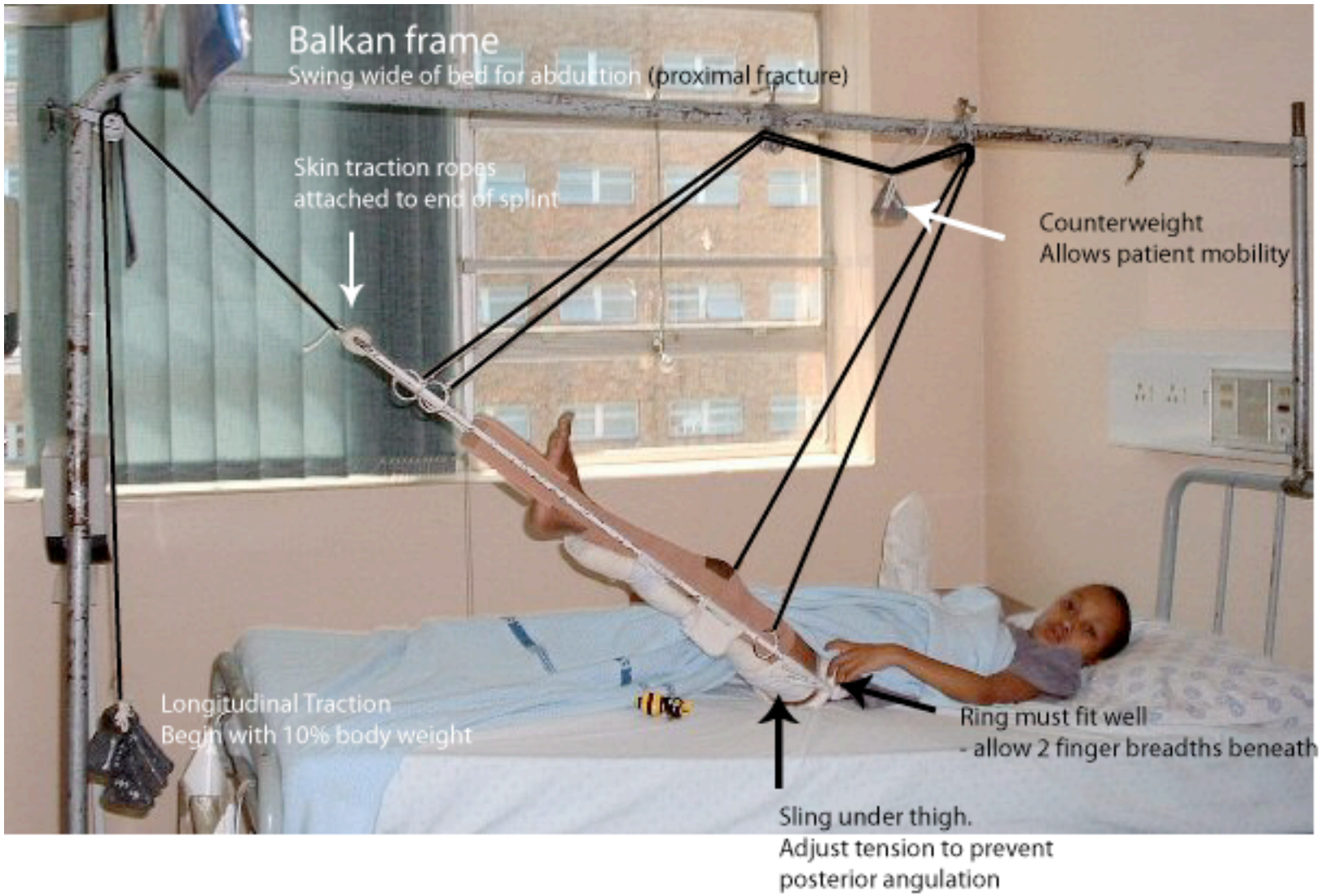
Traction is gentle and safe



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External Fixation

For open fractures

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Internal Fixation

For closed injury

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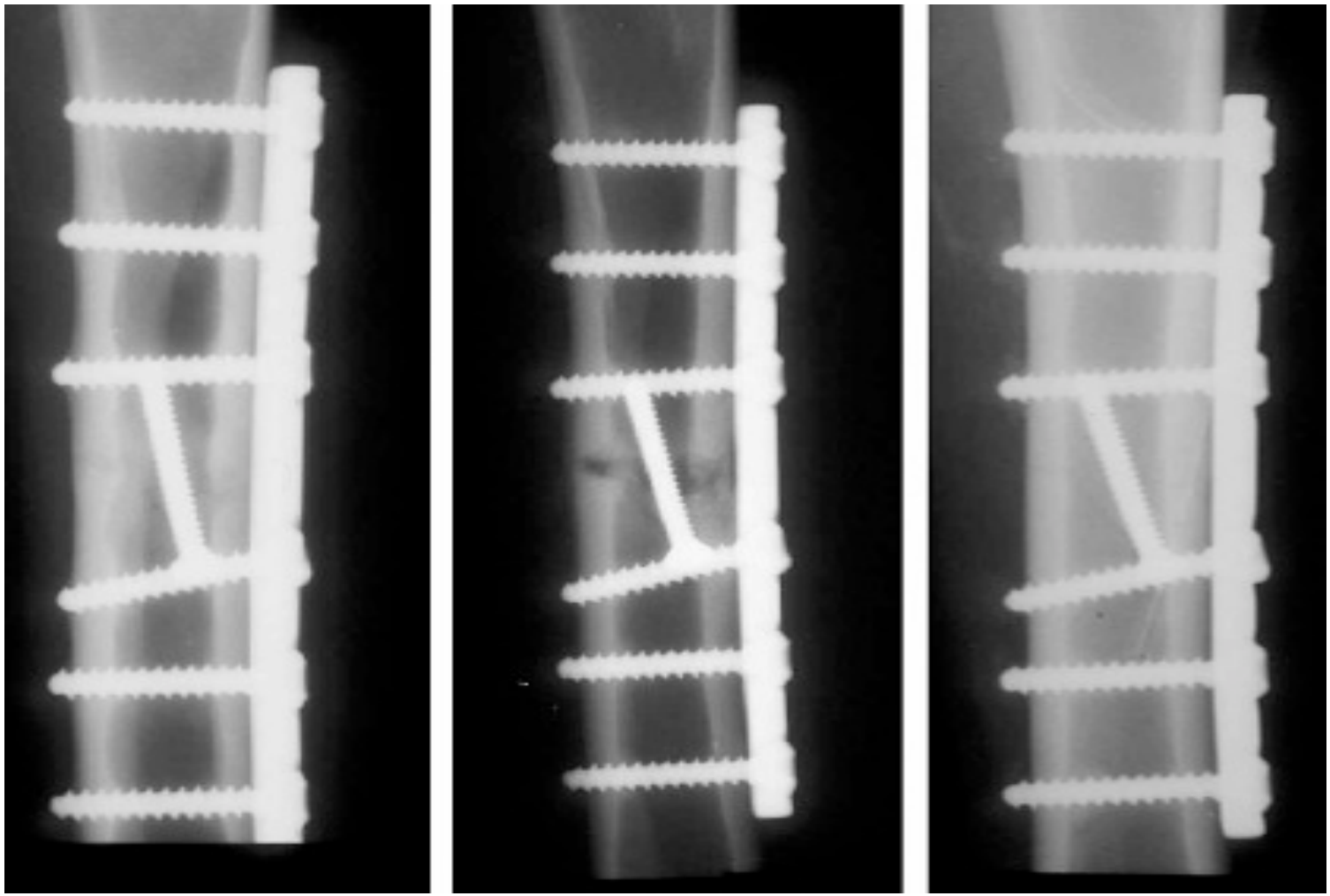
Internal Fixation/ Primary Healing



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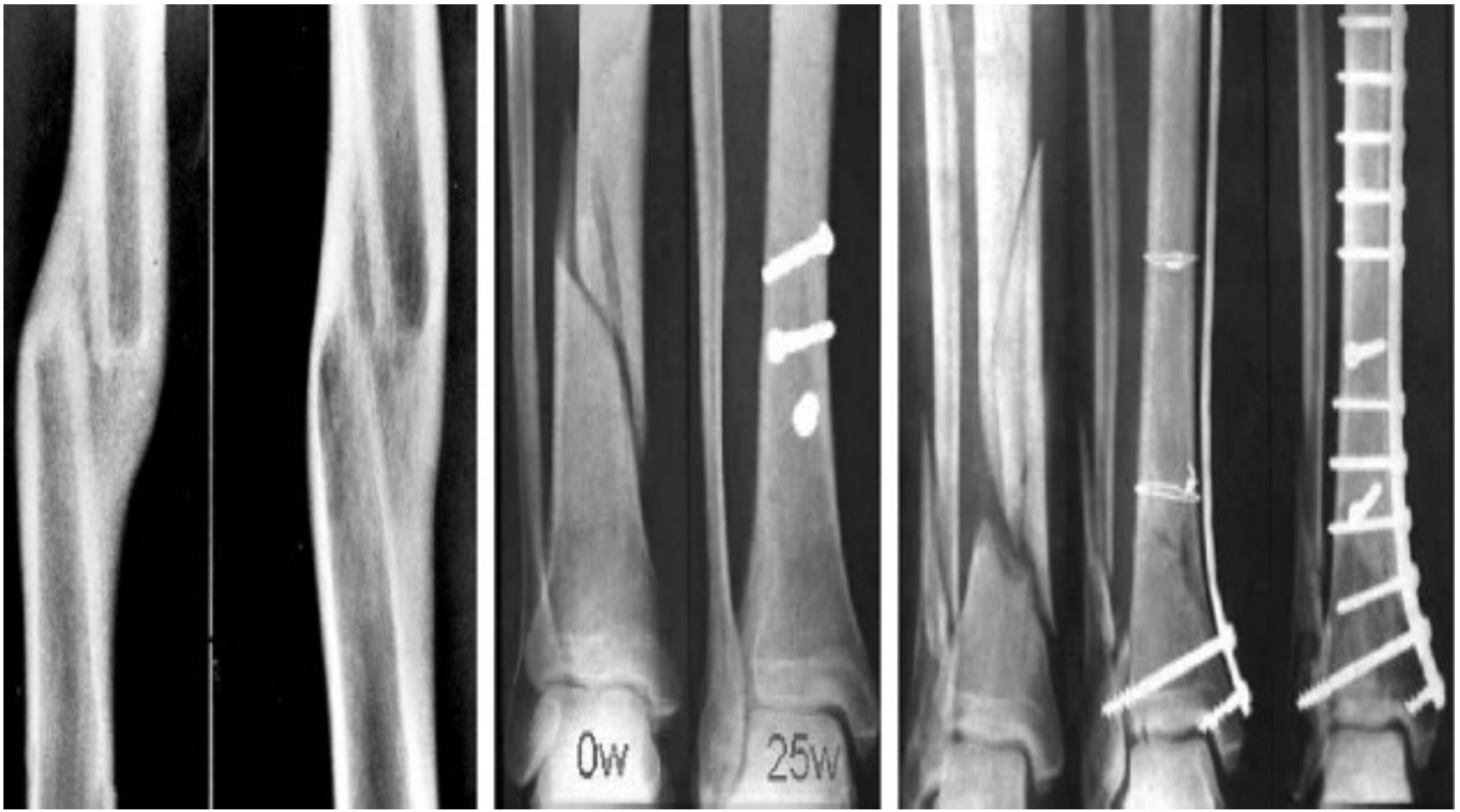
Direct Versus Indirect Healing



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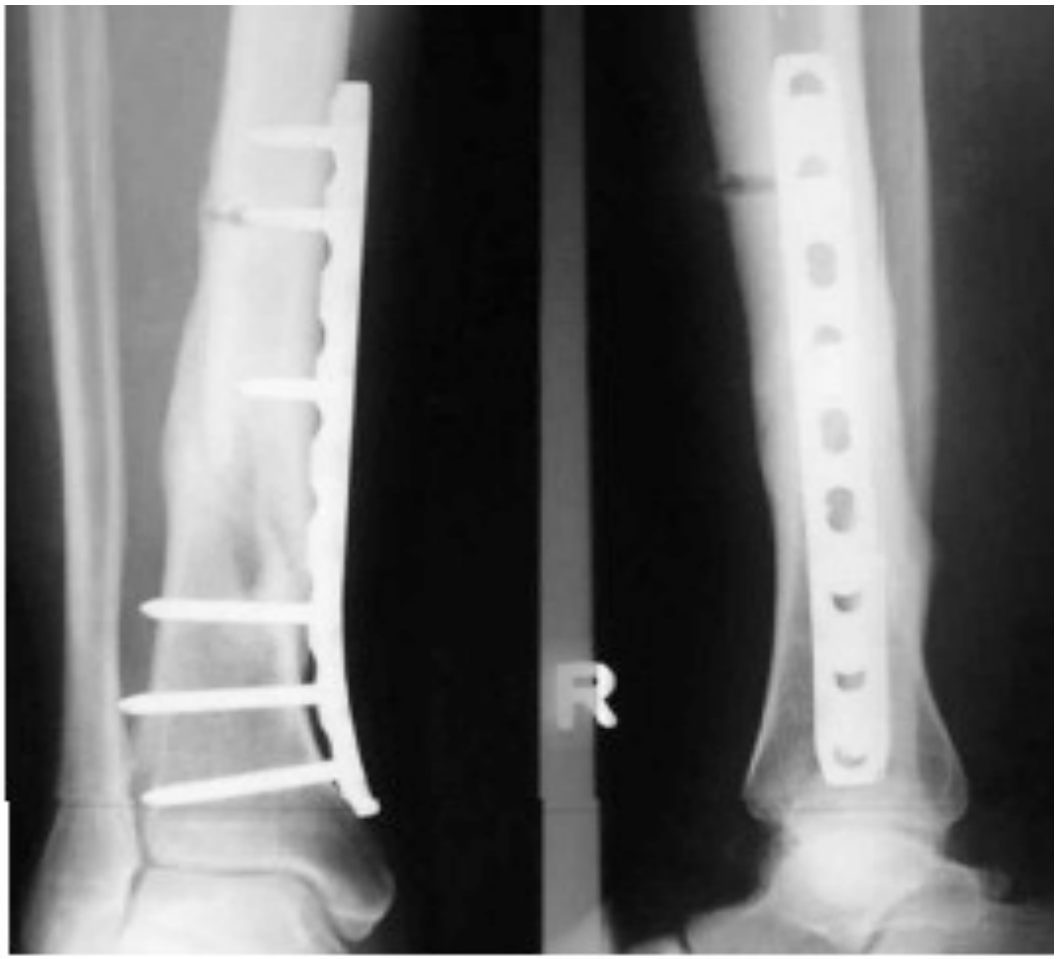
Biological Plates and Callus



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SUMMARY

- Function
- Types of bone

- Cells and matrix
- Periosteum

- Perren's strain theory

- Fracture healing

- Orthopaedic methods