HISTOLOGY OF BONE

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LEARNING OBJECTIVES

- Histological Organisation of Bone
- Bone Cells and Matrix
- Formation of Bone
  - Intramembranous Ossification
  - Endochondral Ossification
- Reorganisation and Restoration of Bone
STRUCTURE OF LONG BONE

- Proximal epiphysis
- Spongy bone
- Epiphyseal line
- Periosteum
- Compact bone
- Medullary cavity (lined by endosteum)
- Distal epiphysis
- Articular cartilage
- Compact bone
- Endosteum
- Endosteum – thin layer of loose areolar CT
- Yellow bone marrow
- Compact bone
- Periosteum = dense irreg. CT
- Perforating (Sharpey's) fibers
- Nutrient arteries
BASED ON BONE MATURITY

Lamellar bone  Lamellar bone  Woven bone
WOVEN BONE

- Lamellar appearance - arrangement of collagen fibres
- Woven bone is weak - repair of fracture

LAMELLAR BONE
TYPES OF BONE: macroscopically

**Trabecular bone:**
- Cancellous or spongy bone
- Ends of long bones

**Compact bone:**
- Forms thick-walled tube of the shaft (or diaphysis)
- A thin layer of compact bone also covers the epiphyses of long bones.
COMPACT BONE

- Matrix
- Lamellae*
- Lacunae
- Canaliculi
- Haversian Canals
COMPACT BONE - UNSTAINED

• Haversian system - Osteon
• Interstitial lamellae
• Circumferential lamellae
• Endosteal lamellae
• Volkmann's Canals
COMPACT BONE

Schmorl Stained  Ground section - unstained
TRABECULAR BONE

No Haversian systems

- bone trabeculae
- yellow bone marrow (adipose tissue)

- lamellar bone matrix
- calcified cartilage
- osteocyte in lacuna
- adipocytes
PAGET’S DISEASE

Woven bone and Lamellar bone in disorganised manner
BONE MATRIX

- Collagen fibres (about 90% of the organic substance)
- Ground substance - osteonectin, osteocalcin
- Collagen type I
- Hardness of the matrix - inorganic salts
-Calcification - few days to several months.
BONE CELLS

• Osteoprogenitor cells (stem cells)

• Osteoblasts (or bone forming cells)

• Osteocytes

• Osteoclasts
  (Haematopoietic cells)
OSTEOCLASTS

• Large (up to 100 µm)
• Multi-nucleated (up to 50 nuclei in the actual cell)
• Arise by the fusion of monocytes
• Resorption bays/Howship's lacunae
• Stimulated by parathormone
• Inhibited by calcitonin
FORMATION OF BONE: INTRAMEMBRANOUS

- Osteoprogenitor cells
- Osteoblasts - deposit osteoid
- Woven network - no lamellae
- Osteoid calcifies
- Primitive trabecular bone
- Primitive compact bone
- Subsequent reorganisation
INTRAMEMBRANOUS OSSIFICATION

- Primitive trabecular bone
- Ossification centre
- Mucous connective tissue
- Newly deposited bone matrix
- Osteoblasts
INTRAMEMBRANOUS OSSIFICATION

A. Mesenchymal cell
   - Collagen fiber
   - Ossification center
   - Osteoid
   - Osteoblast

B. Osteoblast
   - Osteoid
   - Osteocyte
   - Newly calcified bone matrix

C. Mesenchyme condensing to form the periosteum
   - Trabeculae of woven bone
   - Blood vessel

D. Fibrous periosseum
   - Osteoblast
   - Plate of compact bone
   - Diploë (spongy bone) cavities contain red marrow
ENDOCHONDRAL OSSIFICATION

• Cartilage bone model
• Calcification of intercellular substance (ALP)
• Periosteal bud invasion
ENDOCHONDRAL OSSIFICATION

• Osteoprogenitor cells - enter hypertrophied and partial calcified cartilage
• Mature into osteoblasts
• Deposition of new bone on calcified cartilage
ENDOCHONDRAL OSSIFICATION

1. Fetal hyaline cartilage model develops.
2. Cartilage calcifies, and a periosteal bone collar forms around diaphysis.
3. Primary ossification center forms in the diaphysis.
4. Secondary ossification centers form in epiphyses.
5. Bone replaces cartilage, except the articular cartilage and epiphyseal plates.
6. Epiphyseal plates ossify and form epiphyseal lines.
ENDOCHONDRAL OSSIFICATION

Diaphysis

Metaphysis

Epiphysis
**EPHYSEAL PLATE**

- **Epiphyseal plate**
  - Zone of resting cartilage
  - Zone of proliferation
  - Zone of hypertrophy
  - Zone of calcification
  - Bone of diaphysis

- **Chondrocytes divide and enlarge.**

- **Length of bone increases.**
- **Thickness of epiphyseal plate remains unchanged.**
- **Bone is added to diaphysis.**

- **Calcified cartilage is replaced by bone.**
EPHYSEAL PLATE

1. Resting zone
2. Proliferation zone
3. Hypertrophic zone
4. Calcification zone
5. Ossification zone
Organization of Cartilage within Epiphyseal Plate of Growing Long Bone

- **Resting zone** - small, inactive cartilage cells

1. **Proliferation zone**
   - Chondroblasts quickly divide and push the epiphysis away from the diaphysis, lengthening the bone.

2. **Hypertrophic zone**
   - Older chondrocytes enlarge and signal the surrounding matrix to calcify.

3. **Calcification zone**
   - Matrix becomes calcified; chondrocytes die, leaving behind trabeculae-shaped calcified cartilage.
   - **THIS IS NOT YET BONE!**

4. **Ossification zone**
   - Osteoclasts digest the calcified cartilage, and osteoblasts replace it with actual bone tissue in the shape of the calcified cartilage – resulting in bone trabeculae.
GROWTH OF BONE

Bone formation and bone resorption go hand in hand during the growth of bone.
REORGANISATION AND RESTORATION

• During growth period and continues
• Changes of tensile and compressive forces.
• Wear and tear occurring in bone
• Osteoclasts and osteoblasts
• Forms new Haversian system within the matrix of compact bone.
• Older Haversian systems - interstitial lamellae
• Capillaries and nerves sprout in
OSTEOPOROSIS

Normal bone

Bone with osteoporosis
WHAT IS COMPACT BONE?

a. Dense bone
b. Woven bone
c. Immature bone
d. Spongy bone
WHAT CELL IS INVOLVED IN BONE RESORPTION?

a. Osteoclast  
b. Osteon  
c. Osteocyte  
d. Osteoid
WHAT TYPE OF BASIC TISSUE TYPE IS BONE?

a. Epithelium  
b. Connective tissue  
c. Muscle  
d. Bone
WHAT IS WOVEN BONE?

a. Cancellous bone
b. Dense bone
c. Immature bone
d. Spongy bone
WHAT ARE THE SPICULES ON SPONGY BONE CALLED?

a. Canaliculi
b. Sharpey's fibers
c. Trabeculae
d. Lacuna
WHAT IS BONE FORMATION CALLED WHEN THE BONE IS FORMED DIRECTLY, WITHOUT USING A CARTILAGE TEMPLATE?

a. Intraosseous
b. Intramembranous
c. Endochondral
d. Endosteum
WHAT FORMS THE EPIPHYSEAL GROWTH PLATE?

a. Fibrocartilage  
b. Hyaline cartilage  
c. Compact bone  
d. Spongy bone