Bone and Cartilage

Dental Relevance

Bone and cartilage have very similar properties to teeth. The calvaria, maxilla, and mandible (which make up the skull) are composed of bone. Thus, it is important that we, as dental professionals, know its nature and properties. For example, bone has collagen type 1, along with dentine and cementum, thus all three can be affected by a disease called osteogenesis imperfecta. The metabolic role of bone can also be affected by various diseases that your patient may have or any medication that they take. A good understanding of cartilage is also essential, for example, the connective tissue in the epiglottis is elastic cartilage.

Bone:

Contents:

1) 2 types of bone ossification:
    a) Intramembranous ossification
        i) How is it initiated?
        ii) What is its process?
        iii) What bones form by intramembranous ossification?
    b) Endochondral ossification
        i) How is it initiated?
        ii) What is its process?
        iii) What bones form by endochondral ossification?
2) Types of bone
3) Organisation of bone
4) Repair
5) Joints
6) Metabolic role of bone

Cartilage:

1. Components of cartilage
2. Types of cartilage (type 1 collagen) (articular cartilage)
3. Interstitial growth
4. Appositional growth

Bone:

1) 2 types of bone ossification:
    a. Intramembranous ossification
        i. How is it initiated?

Differentiation of mesenchymal connective tissue cells into osteoblasts

ii. What is its process?

1. **Mesenchymal cells in embryonic skeleton cluster to form ossification centres**
    a. Clustered cells begin to differentiate into specialised cells
        i. Some differentiate into capillaries
        ii. Others become osteogenic cells and then osteoblasts
    b. Early osteoblasts appear in a cluster called an ossification center
    c. Later spread out by the formation of bone tissue
2. **Osteoblasts become trapped by secreted osteoid**
    a. Osteoblasts secrete osteoid (uncalcified matrix)
    b. Osteoid calcified (hardens) mineral salts are deposited
    c. Within a few days, osteoblasts are entrapped
    d. Once entrapped, osteoblasts become osteocytes
    e. As osteoblasts transform into osteocytes, osteogenic cells in surrounding connective tissue differentiate into new osteoblasts
    f. Osteoid secreted around the capillaries results in a trabecular matrix
3. **Trabecular matrix and periosteum form**
    a. Osteoblasts on the surface of spongy bone become the periosteum
4. **Compact bone develops superficial to trabecular bone**
    a. Periosteum creates a superficial protective layer of compact bone (outside the trabecular bone)
    b. Crowded blood vessels condense into bone marrow

Mesenchymal cells→ osteoblasts→ ossification center→ osteoid→ trapped→ osteocytes→ trabecular matrix

New osteoblasts→ periosteum

Crowded blood vessels→ bone marrow

iii. What bones form by intramembranous ossification?

1. Scapula
2. Skull (flat bones)
3. Face (flat bones)
4. Mandible (flat bones) (body of mandible)
5. Clavicle (flat bones)
6. Pelvis
7. Sternum

b. Endochondral ossification

i. How is it initiated?

Formation of hyaline cartilage

ii. What is its process?

1. Mesenchymal progenitor cells condense and differentiate into chondrocytes to form the cartilage model that prefigure future long bones
2. Chondrocytes in the centre become hypertrophic, while cells in the surrounding periodontium differentiate into osteoblasts, forming a bony collar, the provisional cortical bone (compact bone)
3. The hypertrophic cartilage core subsequently is invaded by blood vessels along with osteoprogenitors and osteoclasts, and becomes eroded and is replaced by bone and marrow (primary ossification center)
4. In the metaphysis, hypertrophic cartilage of the growth cartilage is continually replaced by trabecular (spongy) bone, a process that relies on metaphyseal vascularisation and mediates longitudinal bone growth
5. Epiphyseal vessels invade the avascular cartilage at the ends of the bone and initiate the secondary centers of ossification
6. Discrete layers of residual chondrocytes form growth plates between the epiphyseal and metaphyseal bone centres to support further postnatal longitudinal bone growth
   mesenchymal→ chondrocytes→ cartilage→ hypertrophic→ invaded by blood vessels, osteoprogenitors, osteoclasts→ primary ossification centre

   Hypertrophic (@metaphysis) → trabecular bone

   Epiphyseal vessels→ secondary ossification centre

   perichondrium→ osteoblasts → bone collar/cortical bone

   chondrocytes→ growth plates

iii. What bones form by endochondral ossification?

1. Mandible (some) (ramus of mandible)
2. Sphenoid
3. Malleus
4. Incus
5. Stapes

2. *Types of bone*
   - immature/woven bone
   - mature/lamellar bone
     - cortical/compact bone
     - cancellous/spongy/trabecular bone
3. *Organisation of bone*

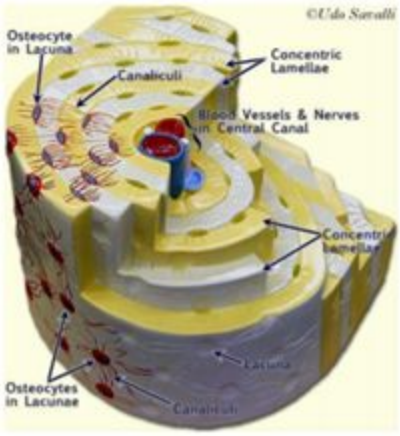
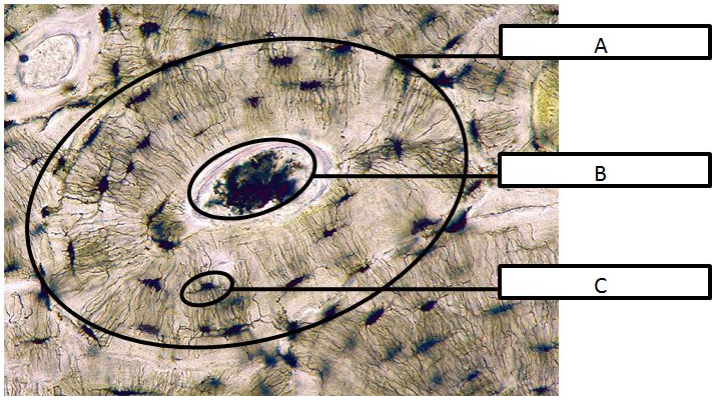
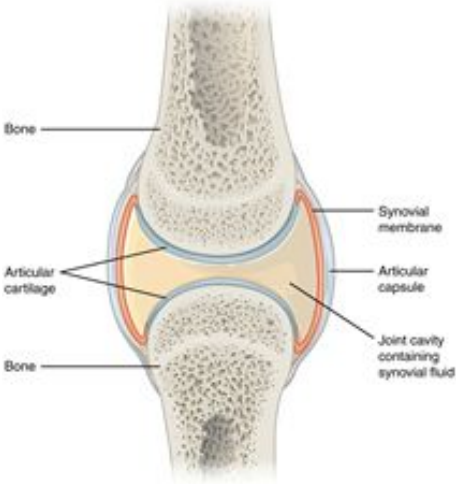


Figure1



4. *Repair*
    1) Activation of periosteal fibroblasts to produce initial soft, fibrocartilage-like callus
    2) Soft callus is replaced by hard callus of woven bone which is soon remodelled to produce stronger lamellar bone
5. *Joints*

(Below diagram, but periosteum also included)



6. *Metabolic role of bone*
    - Ca2+:
        - Stored in bone when dietary calcium is adequate
        - Mobilised from bone when dietary calcium is deficient
    - Osteoclast activity stimulated by:
        - rankL
        - Parathyroid hormone
        - Calcitriol
    - Osteoclast activity inhibited by
        - Calcitonin
        - Osteoprotegerin

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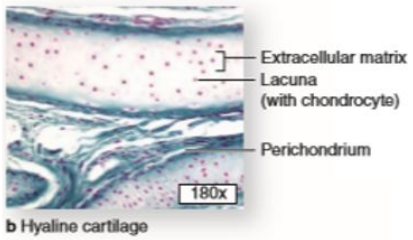
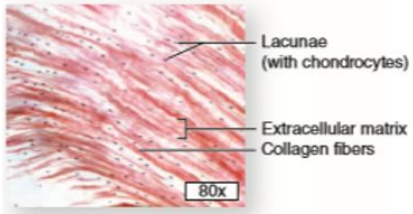
1) *Components of cartilage*
    a) Cellular component: chondrocytes (NOTE: cartilage always lacks blood vessels, lymphatics, and nerves, surrounded by perichondrium that is vascularised)

b) Non-cellular components:
   i) Fibres (collagen)
   ii) Glycoproteins
   iii) Proteoglycans
   iv) GAGs
   v) Water

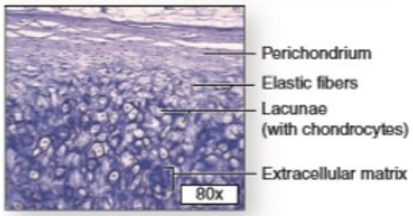
2) *Types of cartilage*



b Hyaline cartilage

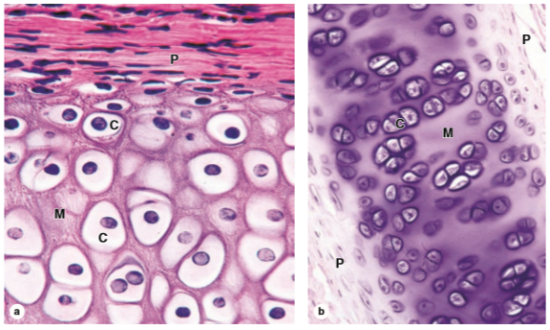


c Fibrocartilage



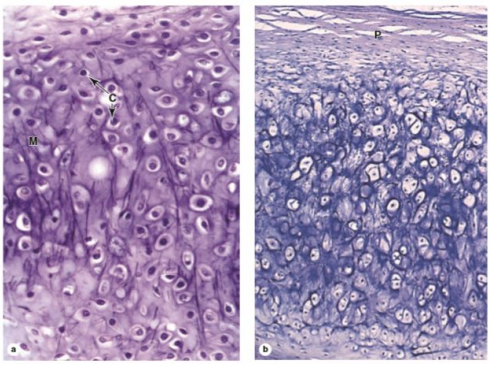
d Elastic cartilage

a) Hyaline cartilage

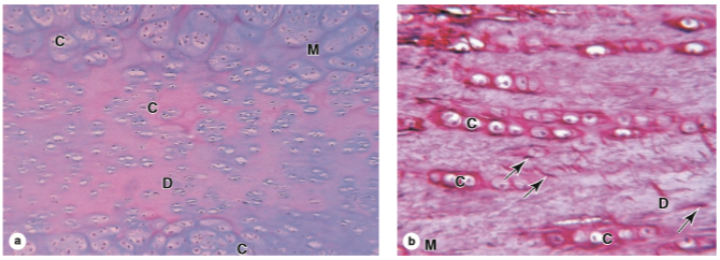


   i) Articular cartilage
   ii) Has type 2 collagen

b) Elastic cartilage



c) Fibrocartilage



i) Has type 1 and type 2 collagen

3) *Interstitial growth*
   a) Chondrocyte undergoes division within a lacuna surrounded by cartilage matrix
   b) As daughter cells secrete additional matrix, they move apart, expanding the cartilage from within
4) *Appositional growth*
   a) Fibroblasts in cellular layer of the perichondrium differentiate into chondrocytes
   b) Chondrocytes secrete new matrix
   c) As matrix enlarges, more fibroblasts are incorporated; they are replaced by divisions of cells in the perichondrium

a. Connective tissue in the epiglottis: elastic cartilage

b. Epiphyseal plate: hyaline cartilage