

# **OSSIFICATION:**

## **ENDOCHONDRAL OSSIFICATION:**

1. Growth of cartilage model:
  - Cartilage model will grow in length by continuous cell division of chondrocytes – accompanied by further secretion of extracellular matrix = this is called interstitial growth.
  - Appositional growth occurs when the cartilage model also grows in thickness due to the addition of more extracellular matrix on the peripheral cartilage surface – accompanied by new chondroblasts that develop from the perichondrium.
  
2. Primary center of ossification:
  - First site of ossification (middle of bone shaft).
  - Formation of periosteum from perichondrium – periosteum contains layer of osteoprogenitor cells which later become osteoblasts.
  - Formation of bone collar – osteoblasts secrete osteoid against shaft of cartilage model (appositional growth), which serves as a support for new bone.
  - Calcification of matrix – chondrocytes begin to grow (hypertrophy) stopping their production of collagen, and other proteoglycans, and beginning their secretion of alkaline phosphatase (enzyme essential for mineral deposition). Calcification occurs and osteoprogenitor cells use calcified matrix as scaffold and begin to secrete osteoid (forms bone trabecular).
  - Osteoclasts, formed from macrophages, break down spongy one to form medullary cavity (bone marrow).
  
3. Secondary center of ossification:
  - Time of birth – secondary ossification center appears in each epiphysis of long bones.
  - Periosteal bud carries mesenchyme and blood vessels in and the process is similar to that which occurs at the primary center.
  - Cartilage between primary and secondary centers = epiphyseal plate – it continues to form new cartilage which is replaced by bone (increasing bone length).
  - Growth continues until the age of 20 or so, or until the epiphyseal plate is completed replaced by bone creating the epiphyseal line.
  
4. Appositional bone growth:
  - Growth in diameter of bones around the diaphysis occurs by deposition of bone beneath periosteum.
  - Osteoclasts in interior cavity continue to degrade bone until its ultimate thickness is achieved – at which rate of formation on outside and degradation of inside is constant.

## **INTRAMEMBRANOUS OSSIFICATION:**

### 1. Overview:

- Formation of bone spicules - which eventually fuse with each other and become trabeculae.
- Periosteum formed and growth continues at surface of trabeculae.
- Increasing growth of trabeculae results in interconnection = woven bone.
- Woven bone replaced by lamellar bone.

### 2. Bone spicules:

- Embryologic mesenchymal cells (MSC) condense into layers of vascularized primitive connective tissue.
- Certain mesenchymal cells group together, usually near/around blood vessels, and differentiate into osteogenic cells which deposit bone matrix.
- Aggregates of bone matrix = bone spicules
- Separate mesenchymal cells differentiate into osteoblasts, which line up along surface of spicule and secrete more osteoid, increasing size of spicule.

### 3. Woven bone:

- As spicules continue to grow, they fuse with adjacent spicules – results in trabeculae formation.
- When osteoblasts become trapped in matrix they secrete, they differentiate into osteocytes.
- Osteoblasts continue to line up on surface – increasing size.
- As growth continues, trabeculae become interconnected = more woven bone.
- Primary spongiosa = initial trabecular network.

### 4. Primary center of ossification:

- Periosteum formed around trabeculae by differentiating mesenchymal cells.
- Primary center is area where bone growth occurs between bone and periosteum.
- Osteogenic cells which originate from periosteum increase appositional growth and a bone collar is formed.
- Bone collar eventually mineralized and lamellar bone formed.

### 5. Osteon formation:

- Osteons = units of compact bone.
- During formation of spicules, cytoplasmic processes from osteoblast interconnect – becomes canaliculi of osteons.
- Since bone spicules tend to form around blood vessels, the perivascular space is greatly reduced as bone continues to grow.
- When replacement to compact bone occurs, this blood vessel becomes the central canal of the osteon.