

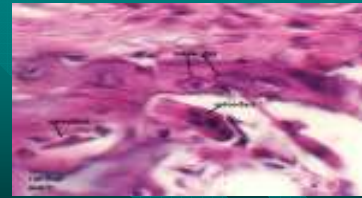
III. Different types of cells involved in bone growth and repair:

- **Osteoprogenitor cells:** unspecialized cells present in the bone, which undergo cell division and transform into osteoblasts.



- **Osteoblasts:** bone-forming cells derived from osteoprogenitor cells; responsible for secreting the matrix.

- **Osteocytes:** mature bone cells derived from osteoblasts (once osteoblasts are surrounded by matrix, they become osteocytes in bone).



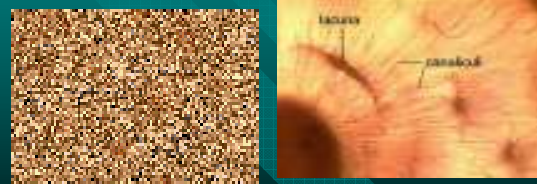
- **Osteoclasts:** most likely derived from monocytes (a type of white blood cell); break down bone and deposit calcium and phosphate into the blood).

IV. Microscopic Structure

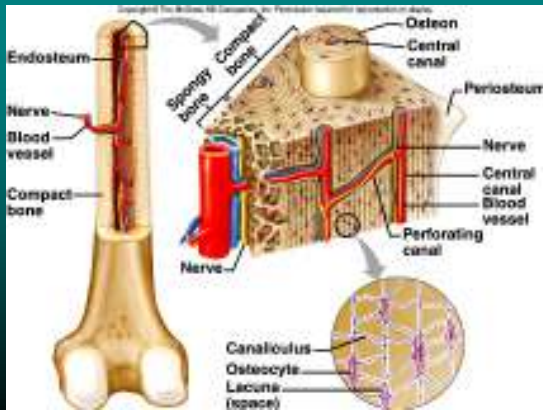
1. Mature bone cells, **osteocytes**, are located within **lacunae** (tiny chambers) that lie in concentric circles around **central canal** forming **osteons**.



2. Osteocytes pass nutrients and gasses in the matrix through by means of cellular processes through **canaliculi** (extensions of osteocytes that serve as passageways of nutrients and wastes)



3. Intercellular material consists of **collagen** and **inorganic salts**.



Study Analogy:

Think of it as a sort of apartment complex or prison system. The osteocytes are "trapped" in the hard matrix. So everything has to be brought in and out for them. The food and oxygen are sent up by "dumb waiters" called osteons. The wastes and carbon dioxide go down the same way. But each cell is in its own apartment or jail cell (lacunae) and so the canaliculi are the way they can pass things back and forth from cell to cell. But they'd better get along! If the first ones "eat up" all the food and oxygen the osteocytes farther out can retaliate with their carbon dioxide and wastes by "flushing their toilets."

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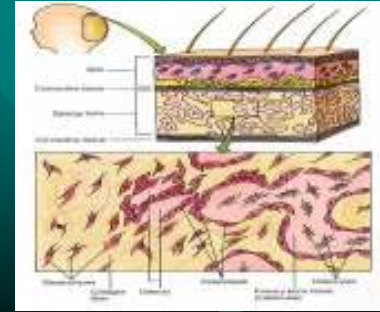
V. Bone Development and Growth

A. Ossification: formation of bone

- B. Bones form by replacing connective tissue in the fetus in two distinct ways:
1. **Intramembranous ossification:** bone develops between sheets of fibrous connective tissue (formed from condensed mesenchyme cells); used to make flat bones.
 2. **Endochondral ossification:** bone develops as it replaces cartilage and is associated with fetal bone development and day-to-day bone growth; used to make most bones of the skeleton.

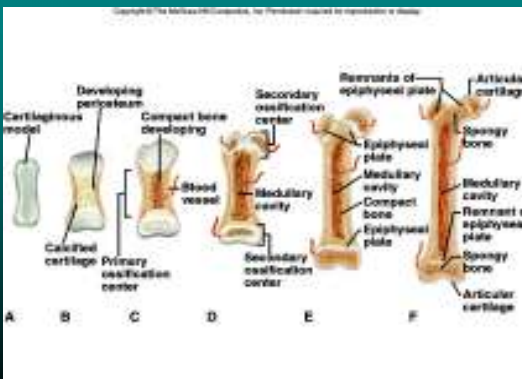
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Intramembranous Ossification



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Endochondral Ossification



A

B

C

D

E

F

C. Intramembranous Ossification:

1. **Formation of ossification center:** mesenchyme cells transform into osteogenic cells, then into **osteoblasts** that begin to secrete bone matrix.
2. **Calcification:** calcium and mineral salts deposited by osteoblasts harden the bone matrix; osteoblasts become **osteocytes** surrounded by lacunae.
3. **Trabeculae formation:** bone matrix develops into trabeculae that fuse together to form spongy bone.
4. **Periosteum formation:** periosteum forms from surface mesenchyme cells and superficial layers of spongy bone are replaced with compact bone.

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Intramembranous Ossification

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D. Endochondral Bones

1. **Development of cartilage model:** in an embryo, mesenchyme cells differentiate into chondrocytes, which then form a model out of hyaline cartilage.
2. **Growth of cartilage model:** the model grows in length and in diameter due to reproduction of chondrocytes that secrete more matrix
3. **Medullary cavity formation:** many chondrocytes die due to inability to get nutrients; osteogenic cells differentiate into osteoblasts that lay down compact bone around outer margin of the bone model.

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4. **Formation of primary ossification center:** blood vessels grow into the shaft and stimulate the formation of primary ossification center where cartilage is replaced by bone tissue as osteoblasts deposit spongy bone trabeculae and osteoclasts digest newly formed spongy bone to enlarge medullary cavity.
 5. **Formation of secondary ossification center:** about the time of birth, secondary ossification centers develop in the ends of bones as osteoblasts form spongy bone in the center.

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6. **Formation of articular cartilage:** hyaline cartilage covering epiphyses differentiates into articular cartilage.
7. **Formation of epiphyseal plate:** hyaline cartilage in the region between two ossification centers forms epiphyseal plate, where layers of chondrocytes undergo mitosis and form matrix; as matrix calcifies, the bone increases in length; bone growth stops between ages 18 and 25.

Endochondral ossification

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E. Bone Growth

9. **Epiphyseal plates** are responsible for **lengthening** bones while increases in **thickness** are due to **intramembranous ossification** underneath the periosteum.

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VI. Remodeling of Bones

1. In the adult, bone is continually being broken down and built up again
 - **Osteoclasts** **break down** bone, remove worn cells, and assist in **depositing calcium** in the blood; they disappear after about 3 weeks.
 - **Osteoblasts** **repair** bone by **removing calcium** from the blood; become osteocytes as they get caught in the mineralized matrix.

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Bone Remodeling

