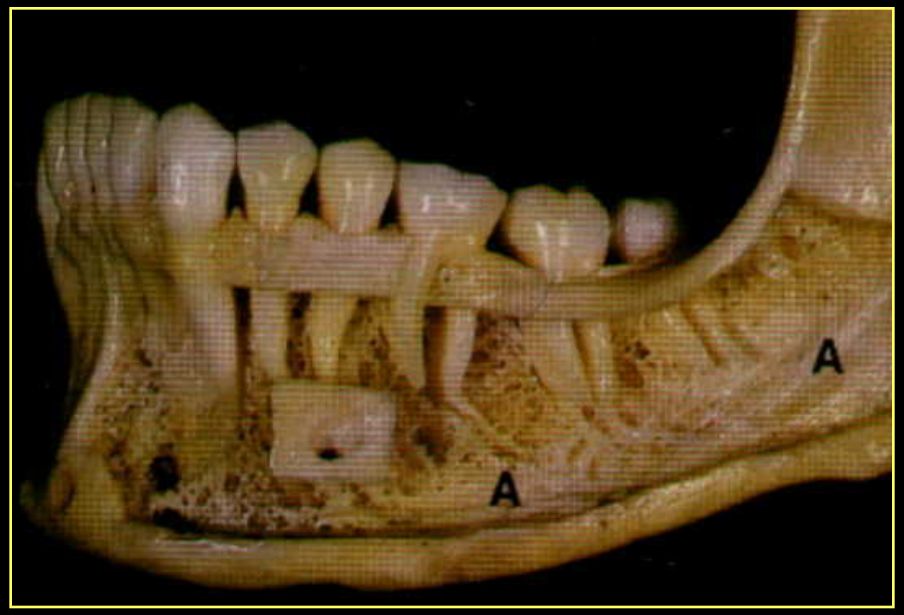
HISTOMORPHOLOGY OF ALVEOLAR BONE



Evolution

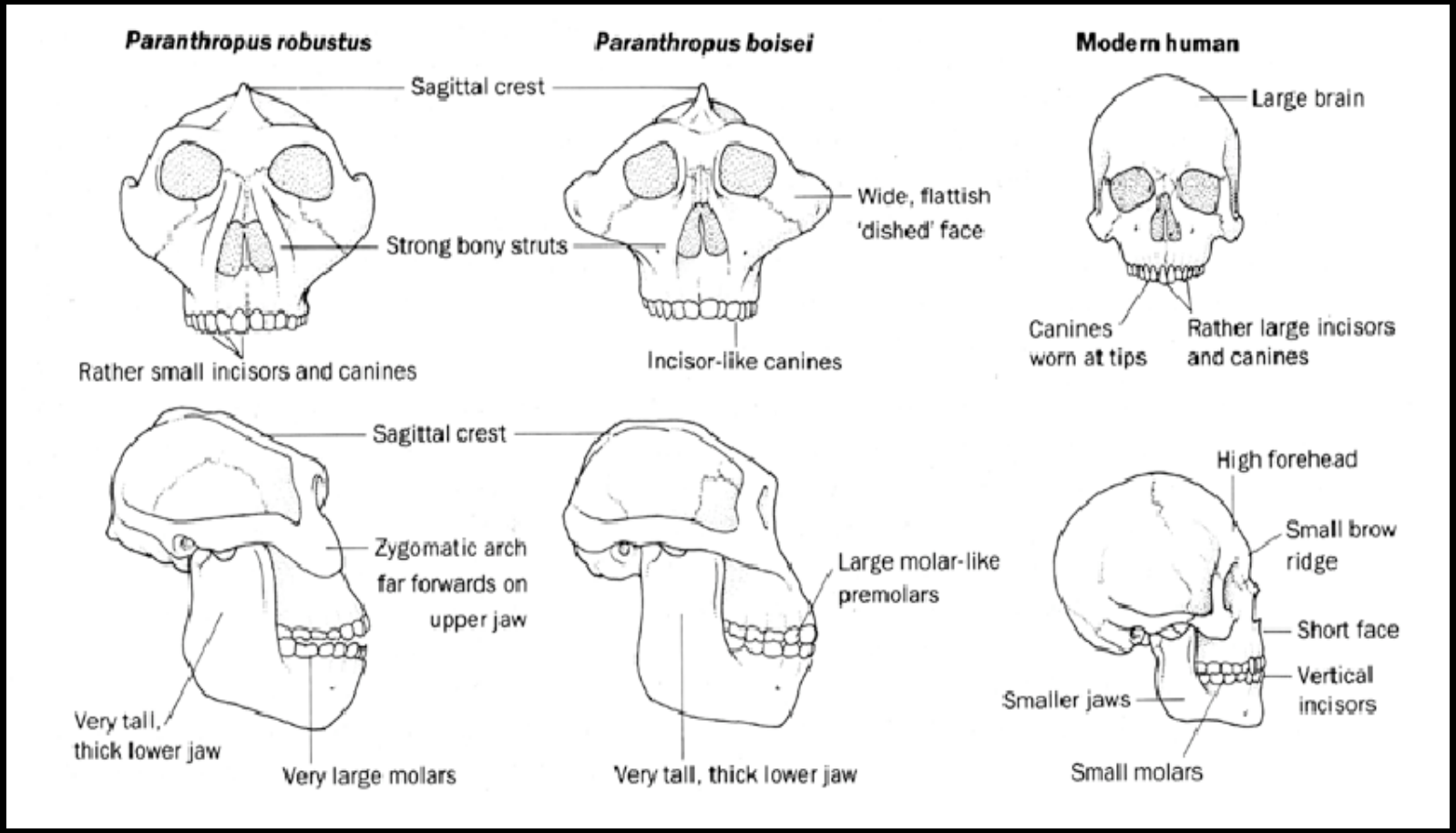
The human skull evolved, like all other primates, from the basic mammalian skull starting millions of years ago.

Why did we evolve ?

- Functional Adaptation
  - Binocular / Stereoscopic vision
  - Olfaction
  - Mastication
  - Increased mental capability
- Survival of the fittest

Increased size of Brain Cavity

Re-arrangement of jaw musculature



Absence of 3rd molars

- Diet

- Small size of jaws

Osteology

It is defined as the detailed study of the structure of bones, skeletal element, morphology, function, disease, pathology, the process of ossification & the study of resistance and hardness of bones.

Development

- As with the cartilage, bone also develops from the mesenchyme.

- It is a type of connective tissue.

Classification

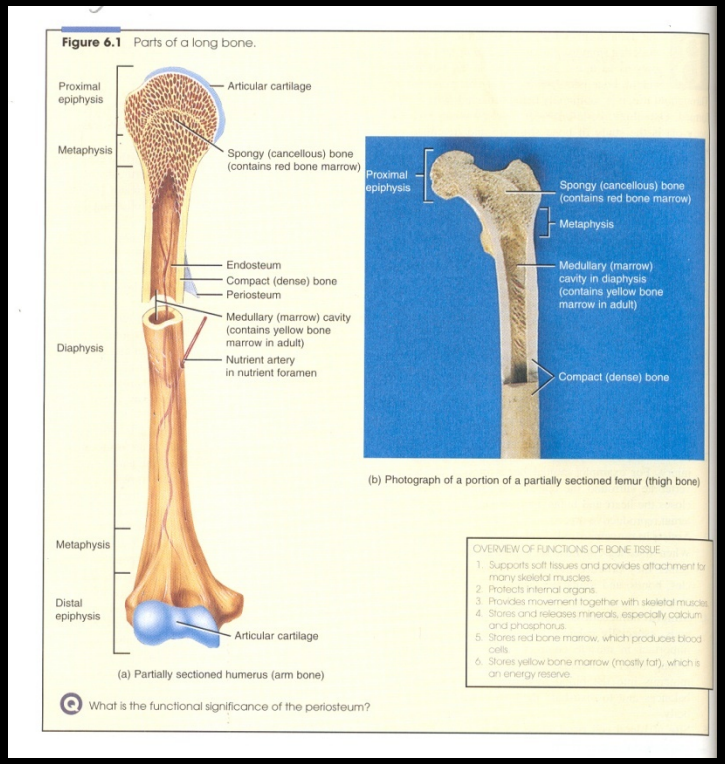
Shape

i. Long Bones
ii. Short Bones
iii. Flat Bones
iv. Irregular Bones

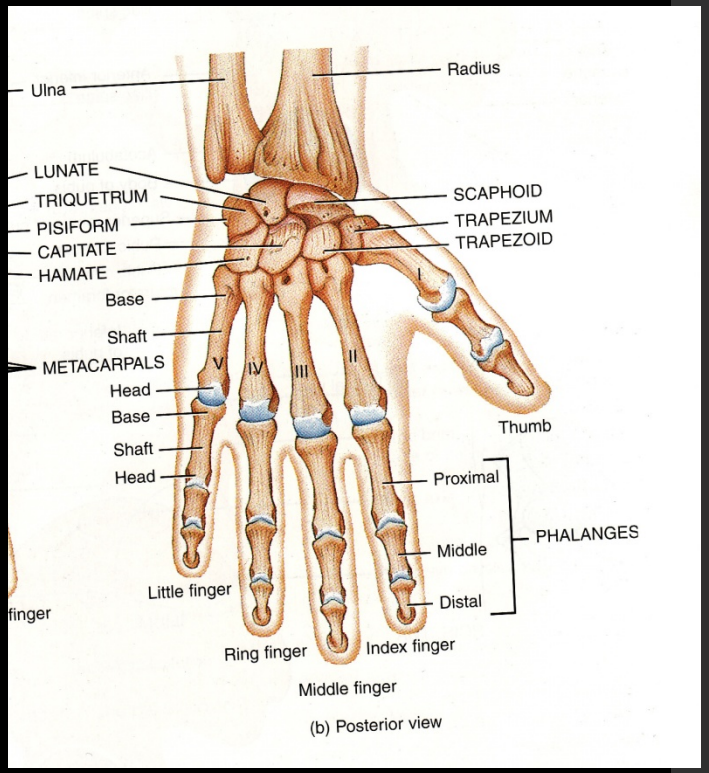
Location

i. Sutural
ii. Seasmoid

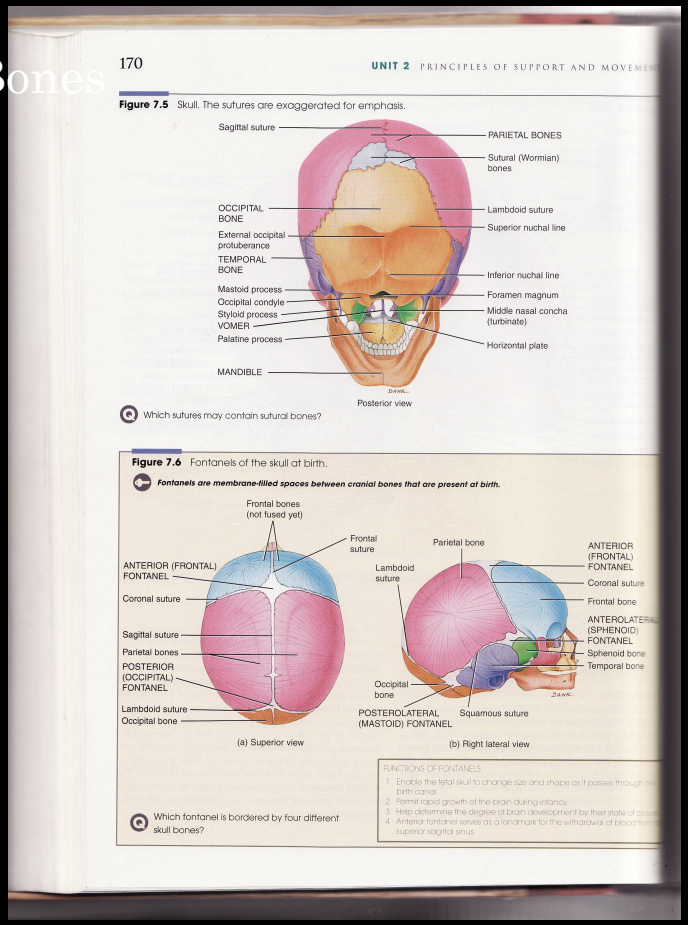
- Long Bones



- Short Bones



- Flat Bones



170 UNIT 2 PRINCIPLES OF SUPPORT AND MOVEMENT

Figure 7.5 Skull. The sutures are exaggerated for emphasis.

Sagittal suture
PARIETAL BONES
Sutural (Wormian) bones
OCCIPITAL BONE
Lambdoid suture
External occipital protuberance
Superior nuchal line
TEMPORAL BONE
Inferior nuchal line
Mastoid process
Foramen magnum
Occipital condyle
Styloid process
Middle nasal concha (turbinate)
VOMER
Palatine process
Horizontal plate
MANDIBLE

Posterior view

Which sutures may contain sutural bones?

Figure 7.6 Fontanels of the skull at birth.

Fontanels are membrane-filled spaces between cranial bones that are present at birth.

Frontal bones (not fused yet)
Frontal suture
ANTERIOR (FRONTAL) FONTANEL
Coronal suture
Sagittal suture
Parietal bones
POSTERIOR (OCCIPITAL) FONTANEL
Lambdoid suture
Occipital bone

(a) Superior view

Parietal bone
Lambdoid suture
ANTERIOR (FRONTAL) FONTANEL
Coronal suture
Frontal bone
ANTEROLATERAL (SPHENOID) FONTANEL
Sphenoid bone
Temporal bone
Occipital bone
POSTEROLATERAL (MASTOID) FONTANEL
Squamous suture

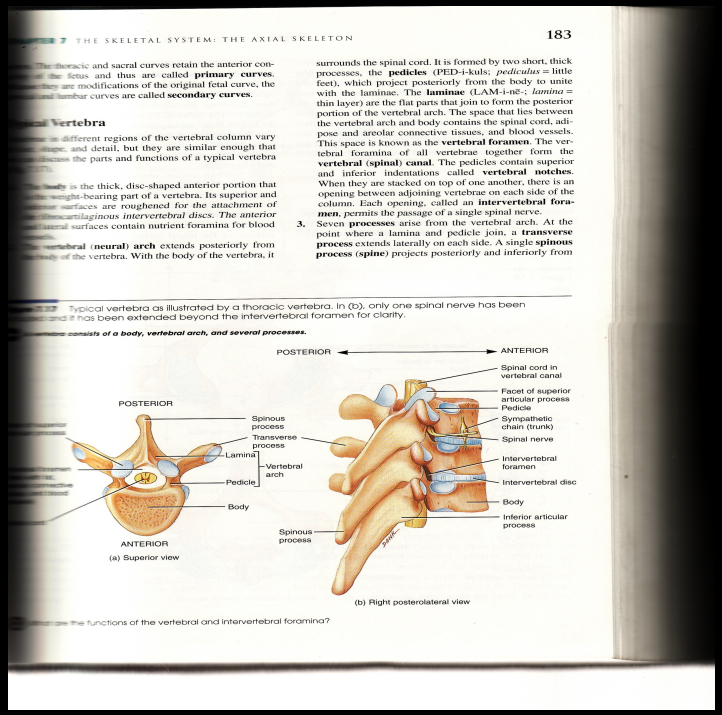
(b) Right lateral view

Which fontanel is bordered by four different skull bones?

FUNCTIONS OF FONTANELS

1. Enable the fetal skull to change size and shape as it passes through the birth canal.
2. Permit rapid growth of the brain during infancy.
3. Help determine the degree of brain development by their state of ossification.
4. Anterior fontanel serves as a landmark for the withdrawal of blood from the superior sagittal sinus.

- Irregular Bones



THE SKELETAL SYSTEM: THE AXIAL SKELETON 183

The thoracic and sacral curves retain the anterior concavity of the fetus and thus are called **primary curves**. They are modifications of the original fetal curve, the cervical and lumbar curves are called **secondary curves**.

Vertebra

The different regions of the vertebral column vary in shape and detail, but they are similar enough that we can discuss the parts and functions of a typical vertebra (Fig. 7.7).

The body is the thick, disc-shaped anterior portion that is the weight-bearing part of a vertebra. Its superior and inferior surfaces are roughened for the attachment of intervertebral fibrocartilaginous intervertebral discs. The anterior and lateral surfaces contain nutrient foramina for blood vessels.

The **vertebral (neural) arch** extends posteriorly from the body of the vertebra. With the body of the vertebra, it surrounds the spinal cord. It is formed by two short, thick processes, the **pedicles** (PED-i-kuls; *pediculus* = little feet), which project posteriorly from the body to unite with the laminae. The **laminae** (LAM-i-ne; *lamina* = thin layer) are the flat parts that join to form the posterior portion of the vertebral arch. The space that lies between the vertebral arch and body contains the spinal cord, adipose and areolar connective tissues, and blood vessels. This space is known as the **vertebral foramen**. The vertebral foramina of all vertebrae together form the **vertebral (spinal) canal**. The pedicles contain superior and inferior indentations called **vertebral notches**. When they are stacked on top of one another, there is an opening between adjoining vertebrae on each side of the column. Each opening, called an **intervertebral foramen**, permits the passage of a single spinal nerve.

3. Seven **processes** arise from the vertebral arch. At the point where a lamina and pedicle join, a **transverse process** extends laterally on each side. A single **spinous process** (**spine**) projects posteriorly and inferiorly from

Typical vertebra as illustrated by a thoracic vertebra. In (b), only one spinal nerve has been removed and it has been extended beyond the intervertebral foramen for clarity.

consists of a body, vertebral arch, and several processes.

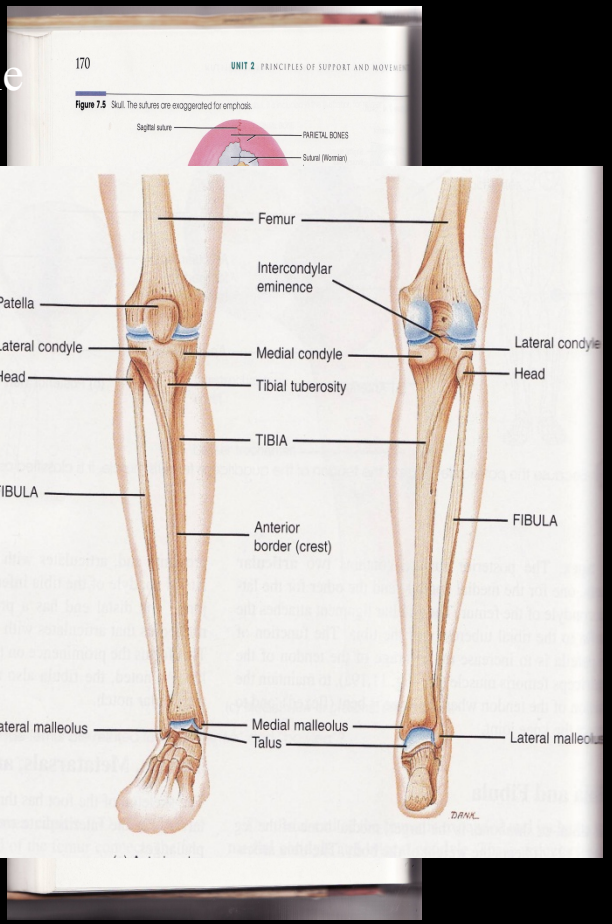
POSTERIOR
ANTERIOR
Spinal cord in vertebral canal
Facet of superior articular process
Pedicle
Sympathetic chain (trunk)
Spinal nerve
Intervertebral foramen
Intervertebral disc
Body
Inferior articular process
Spinous process
Transverse process
Lamina
Vertebral arch
Pedicle
Body

(a) Superior view

(b) Right posterolateral view

the functions of the vertebral and intervertebral foramina?

- Seasmoid Bone



- Sutural Bones

Classification

Trabecular spaces

i. Cancellous

ii. Compact

Immature / Mature

i. Bundle

ii. Woven

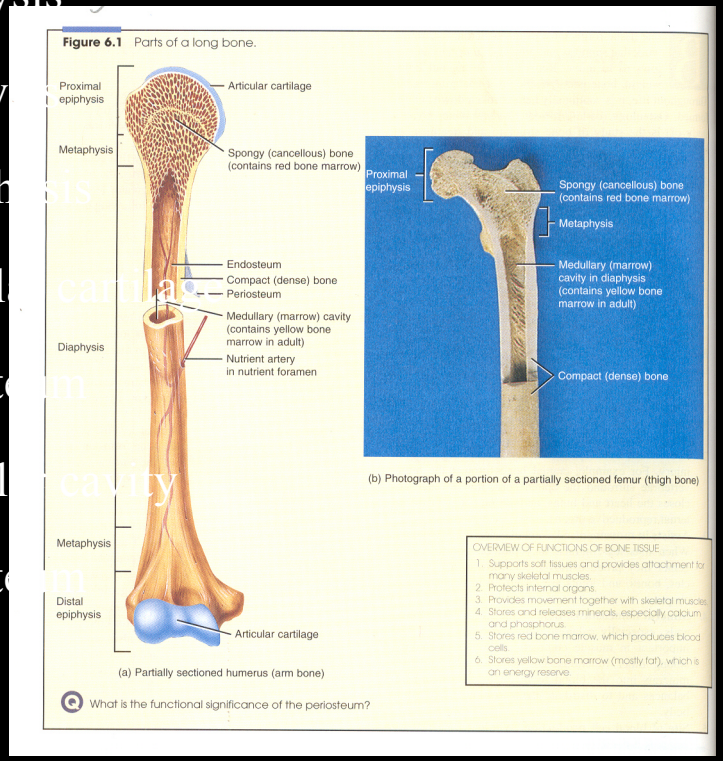
iii. Fine Fibred

Physiology & Function

- Support
- Protection
- Movement
- Mineral Homeostaisis
- Site for blood cell production

Anatomy / Structure

- Diaphysis
- Epiphysis
- Metaphysis
- Articular cartilage
- Periosteum
- Medullary cavity
- Endosteum



Histology

- Type of cells

- Bone matrix

Type of Cells

- Oseteogenic / Osteoprogenitor Cells
- Osteoblasts
- Osteocytes
- Osteoclasts

Bone Matrix

- Extra cellular mineralised material of bone, consisting of ground substance in which collagen fibers are embedded
- In mature bone , the dry weight consists of
    i. 60 – 70 % inorganic minerals
    ii. 30 – 40 % collagen
    iii. 0.5% proteins & carbohydrates

Collagen

- Mechanical strength
- Elasticity
- Synthesized from osteoblasts
- Primary bone – inter woven meshwork
- Partialy mineralised collagen
- Collagen from periosteum
- Terminal collagen from tendons and ligaments

Non Collagenous Components

- Osteonectin
- Osteocalcin
- Osteopontin / thrombospondin

Bone Minerals

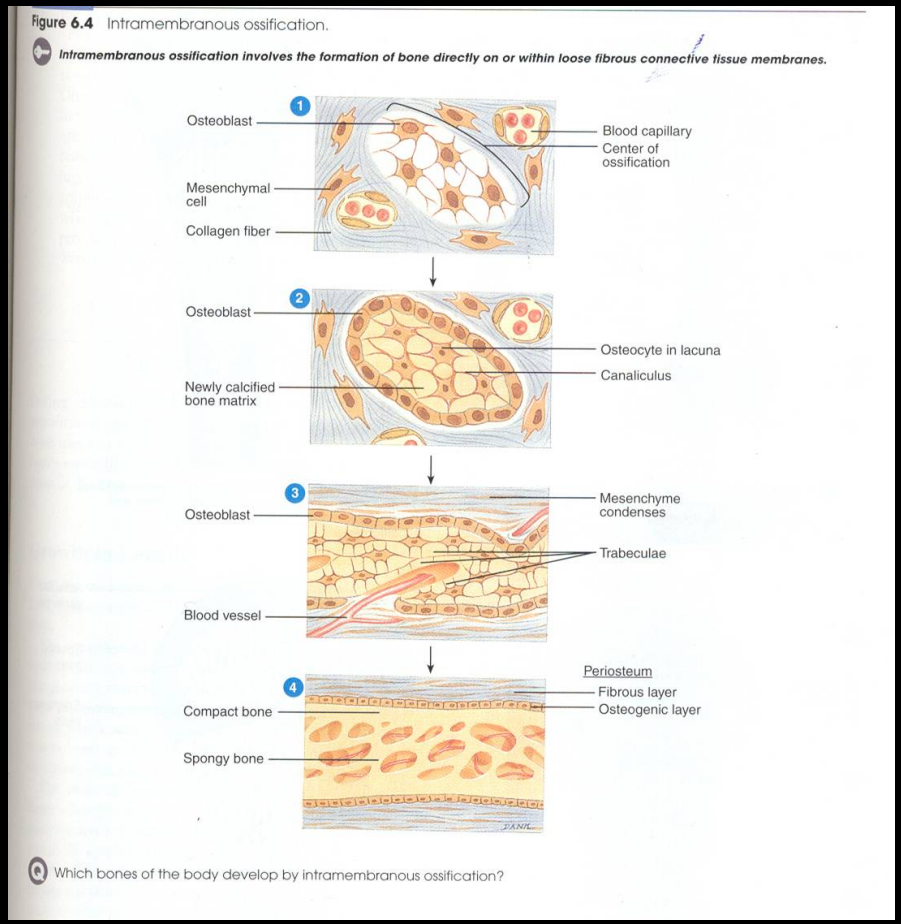
- Inorganic component of bone
- Confers hardness and rigidity
- Hydroxy apatite & calcium phosphate
- Major ions include calcium, phosphate hydroxyl & carbonate

Osteogenesis / Ossification

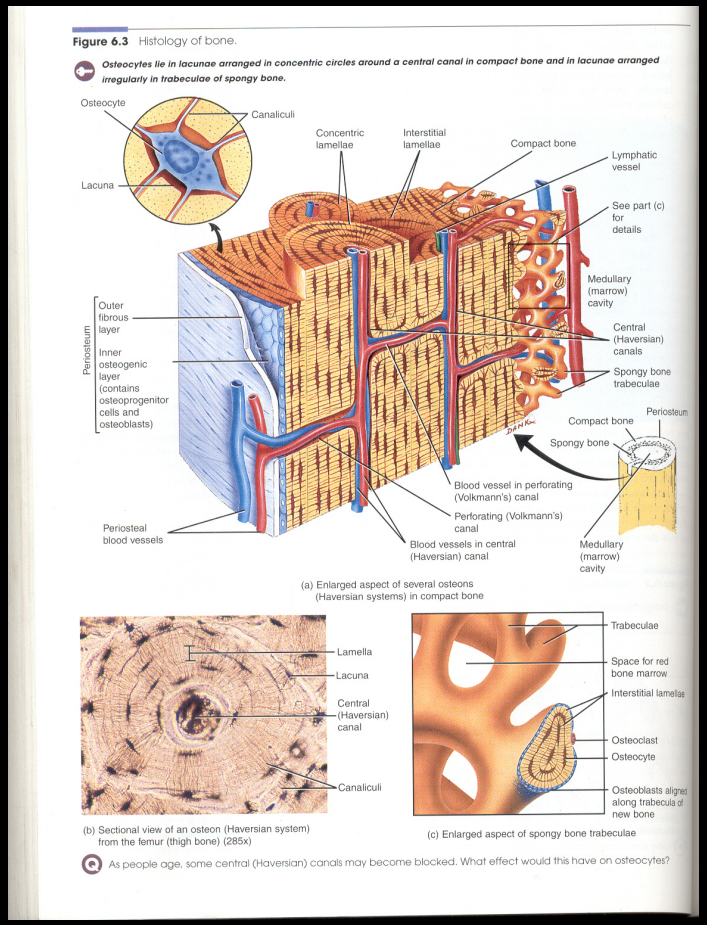
- Intra membranous ossification

- Endochondral ossification

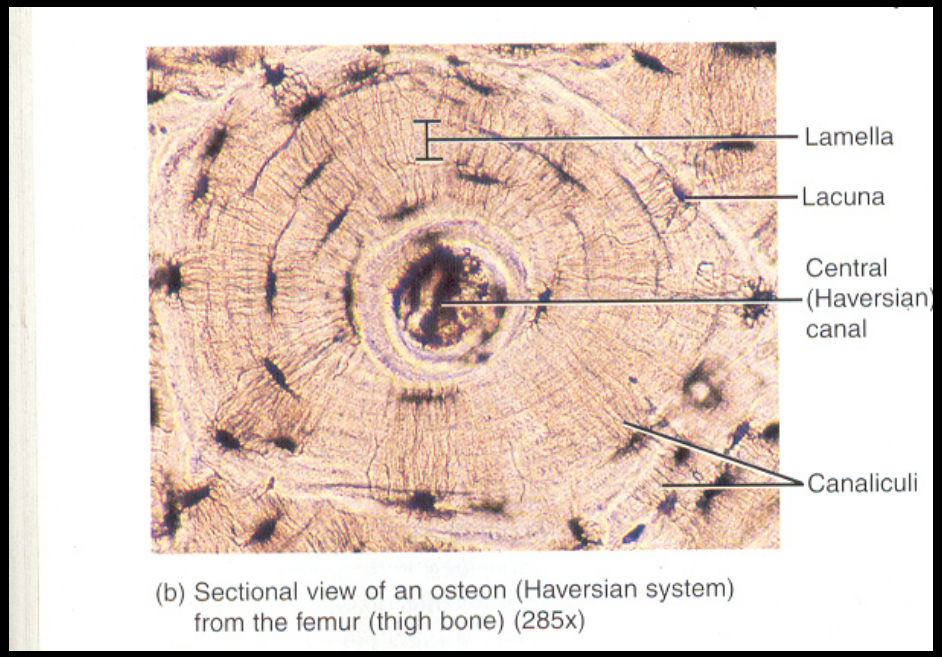
Intra Membranous Ossification



Haversian Canals

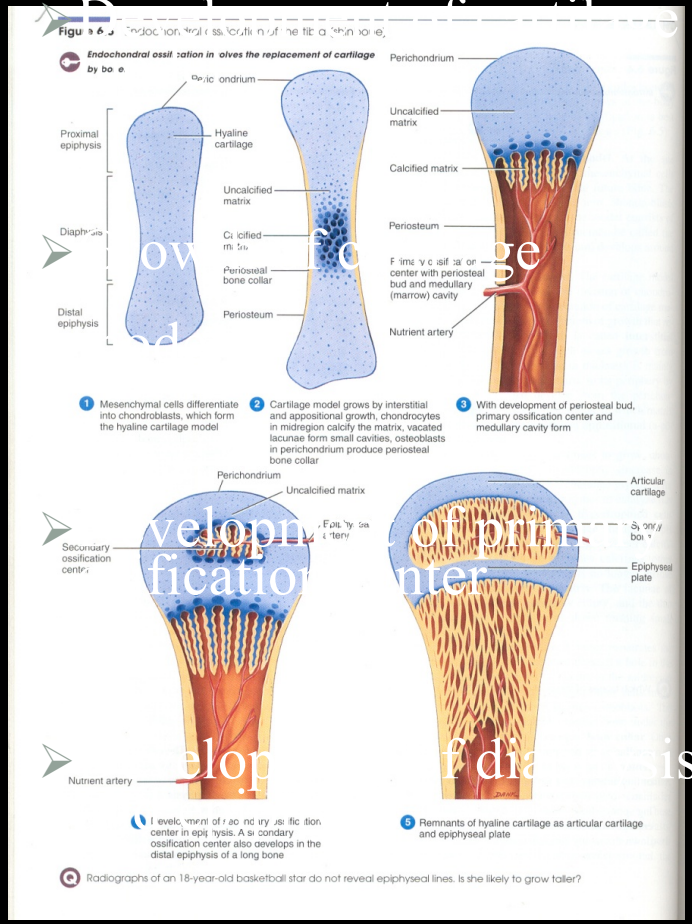


Osteon



(b) Sectional view of an osteon (Haversian system) from the femur (thigh bone) (285x)

Endochodral Ossification



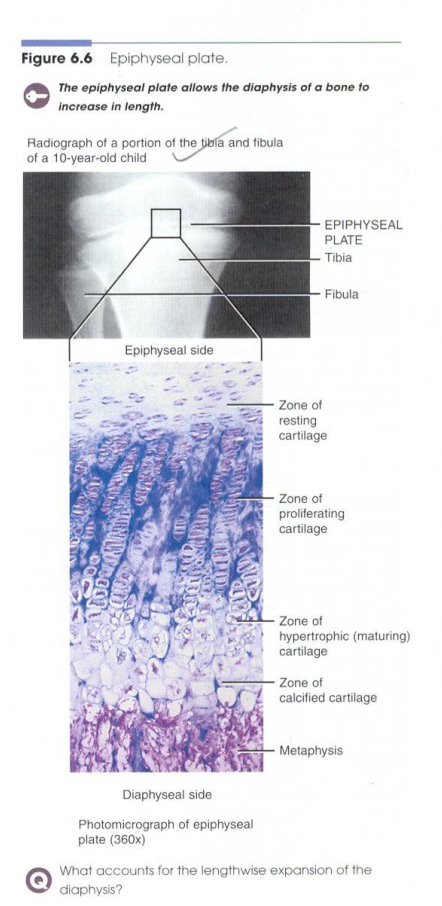
Calcification

- $[Ca^{2++}]$ x [Pi] ion product
- Matrix vesicles
- Macromolecular constituents of bone matrix

Bone Growth

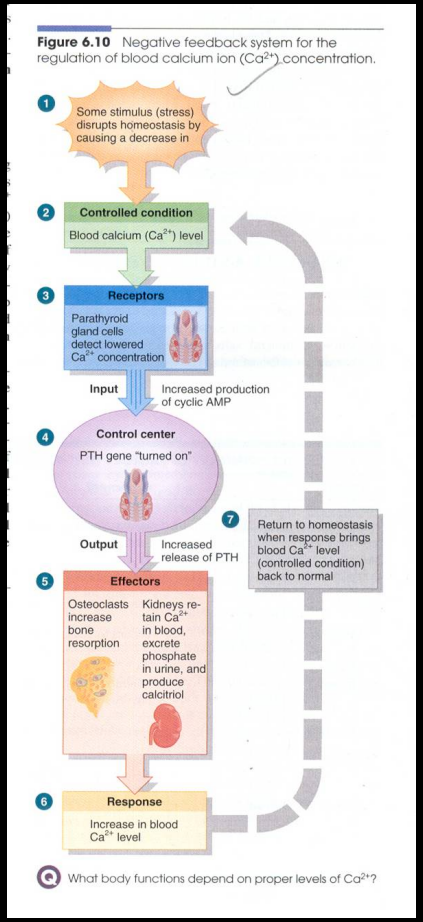
- Length
- Thickness

Growth in length



- Resting cartilage
- Proliferating cartilage
- Hypertrophic cartilage
- Calcified cartilage

Calcium Homeostasis



DEFINITION

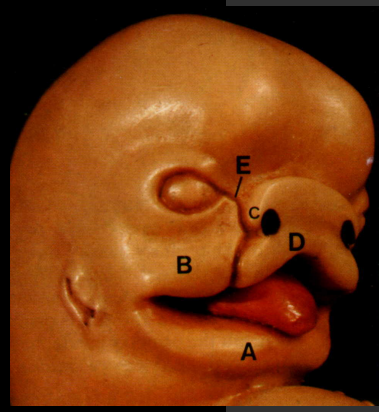
That part of the mandible and the maxilla in which the teeth are located is referred to as the ALVEOLAR PROCESS.

The alveoli that support the teeth are found within the alveolar process, and the bone lining the alveoli is called the ALVEOLAR BONE PROPER or BUNDLE BONE.

THE FACE OF A SIX-WEEK-OLD EMBRYO

- The two mandibular processes (A) fuse in the midline to form the tissues of the lower jaw. The mandibular and maxillary (B) processes meet at the angles of the mouth, thus defining its outline.

- From the corners of the mouth, the maxillary processes grow inwards beneath the lateral nasal processes (C) towards the medial nasal processes (D) of the upper lip. Between the merging maxillary and the lateral nasal processes lie the naso-optic furrows (E).



THE APPEARANCE OF THE DEVELOPING JAWS OF A HUMAN FOETUS

(14 weeks intra-uterine)

A: Body of mandible

B: Ramus of the mandible

C: Secondary condylar cartilage

D: Secondary coronoid cartilage

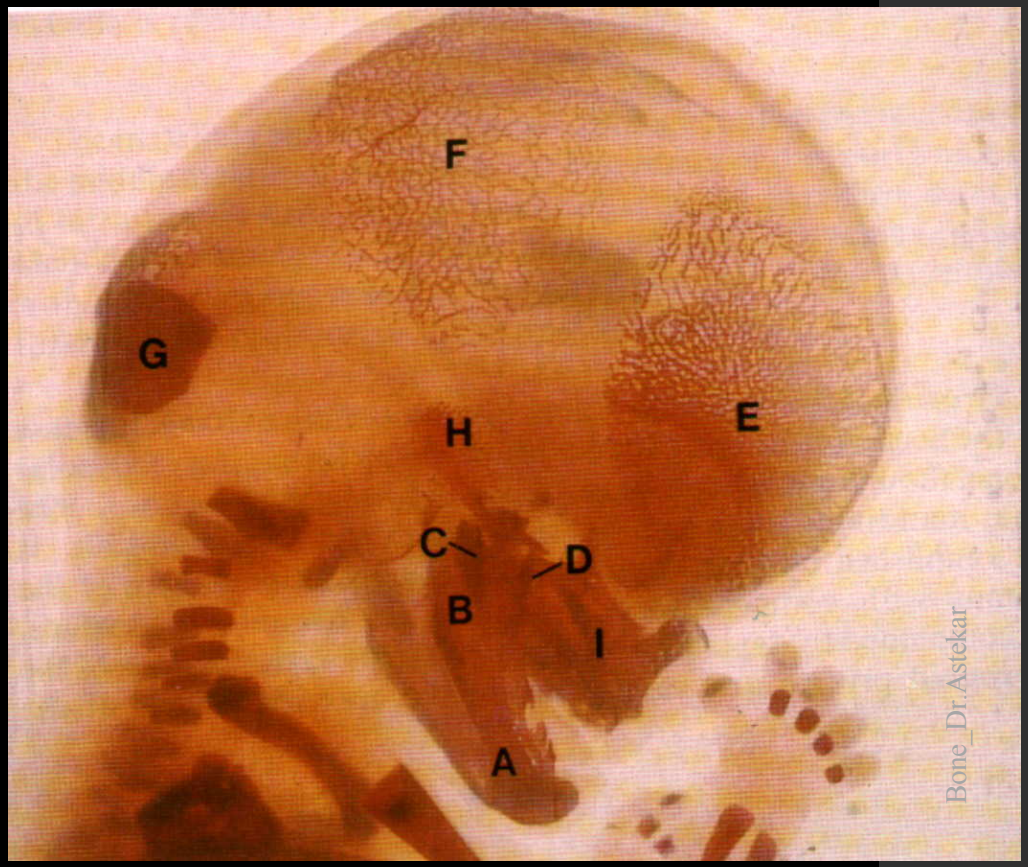
E: Frontal bone

F: Parietal bone

G: Occipital bone

H: Squamous portion of temporal bone

I: Maxilla.



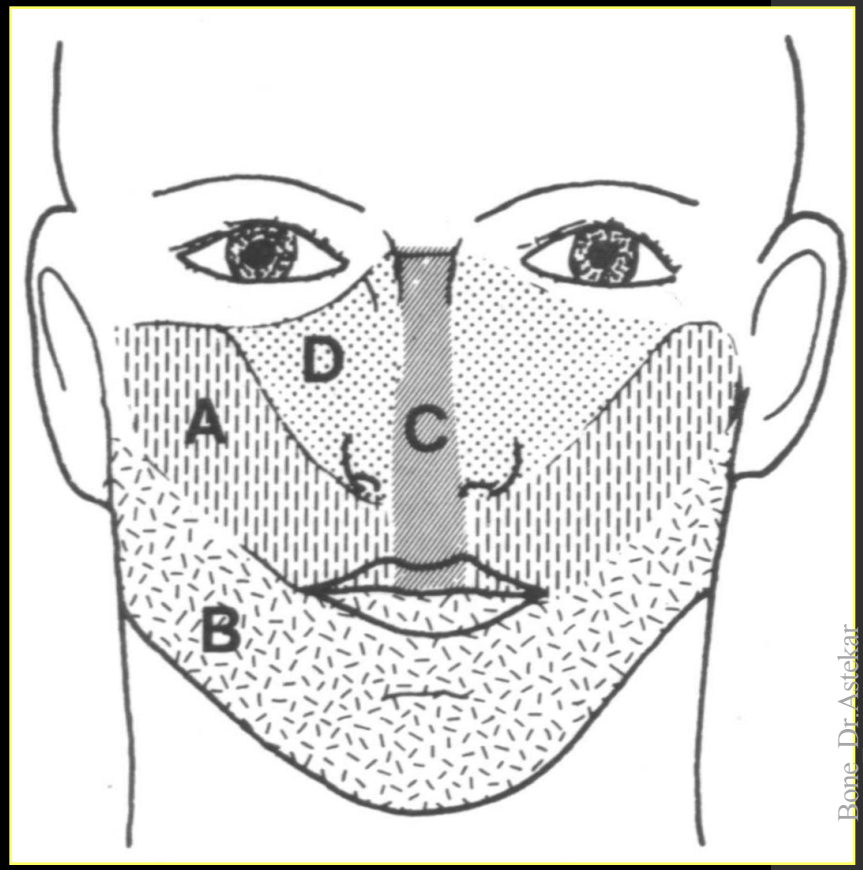
CONTRIBUTIONS TO THE ADULT FACE FROM THE EMBRYONIC FACIAL PROCESSES.

A: Maxillary process.

B: Mandibular process.

C: Medial nasal process.

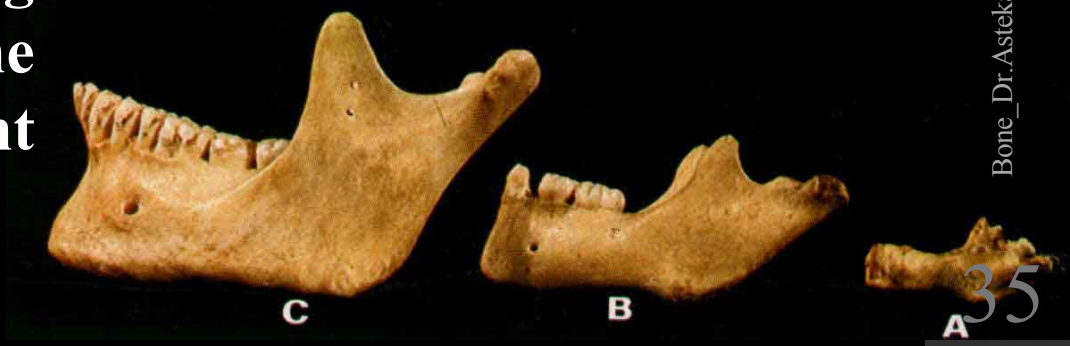
D: Lateral nasal process.



POST NATAL DEVELOPMENT OF THE MANDIBLE

Mandible at birth (A), at six years (B), and in an adult (C). The ratio of body to ramus is greater at birth than in the adult, indicating a proportional increase with time in the development of the ramus. At birth, there is no distinct chin and two halves of the mandible are separated at the mandibular symphysis. Ossification of symphysis is complete during the second year and the two

halves of the mandible uniting to form a single bone. The chin becomes most prominent after puberty.



COMPOSITION OF BONE

CELLS OF BONE

- Osteoprogenitor cells
- Osteoblast cells.
- Osteocytes
- Osteoclast cells.

ORGANIC PART – 33% - 35%

- Collagen – 88% - 90% (Type – I)
- Non collagen – 10% - 11%.
- Glycoproteins – 6% - 9% (Mono, Di, Poly and Oligosaccharides).
- Proteoglycanes – 0.8% (sulfated and Non sulfated)
- Sialoproteins – 0.35%
- Lipids – 0.4%

INORGANIC PART – 65% - 67%

- **Calcium & Phosphates – 95%**

  (Hydroxyapatite Crystals – $Ca_{10}(PO_4)_6(OH)_2$)

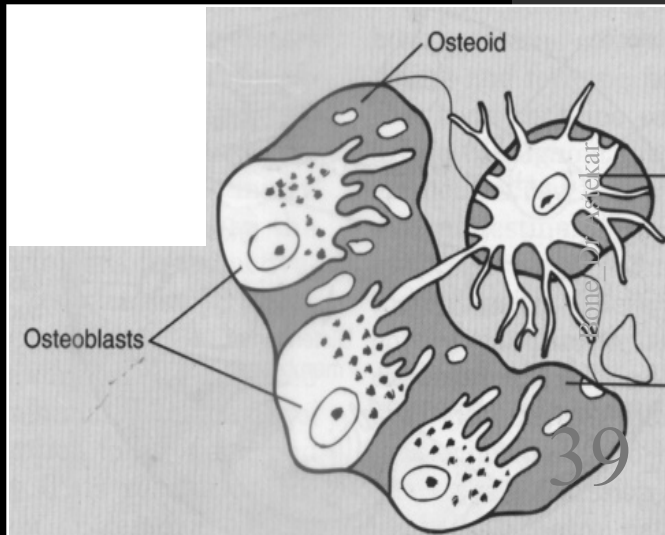
- **Magnesium**

- **Trace elements – Nickel, Iron, Fluoride, Cadmium, Magnesium, Zinc and Molybdenum.**

OSTEOBLASTS

Osteoblasts are uninucleated cells that synthesize both collagenous and noncollagenous bone protein. They are responsible for mineralization and are derived from a multipotent mesenchymal cell. They constitute a cellular layer over the forming bone surface. When bone is no longer forming, the surface osteoblasts become inactive and are termed lining cells(bone maintenance).

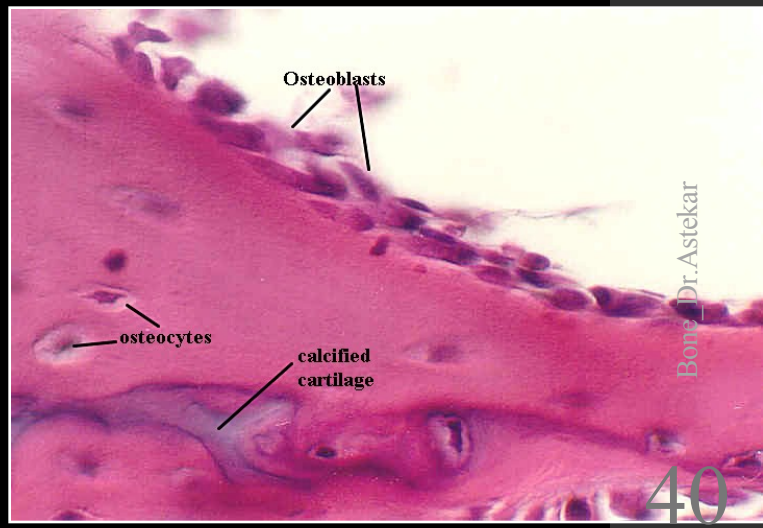
Osteoblasts exhibit high levels of alkaline phosphate on the outer surface of their plasma membranes.



Other enzymes that participate in there activity are ATPase and pyrophosphates. Osteoblasts secrete, in addition to type I and type V collagen and small amounts of several noncollagenous proteins, a variety of cytokines.

Osteoblasts under the stimulation of interleukin 6 also produce their own hydrolytic enzymes that aid in destroying or modifying the unmineralized matrix. Thus freeing the osteoblast from its own secreted matrix.

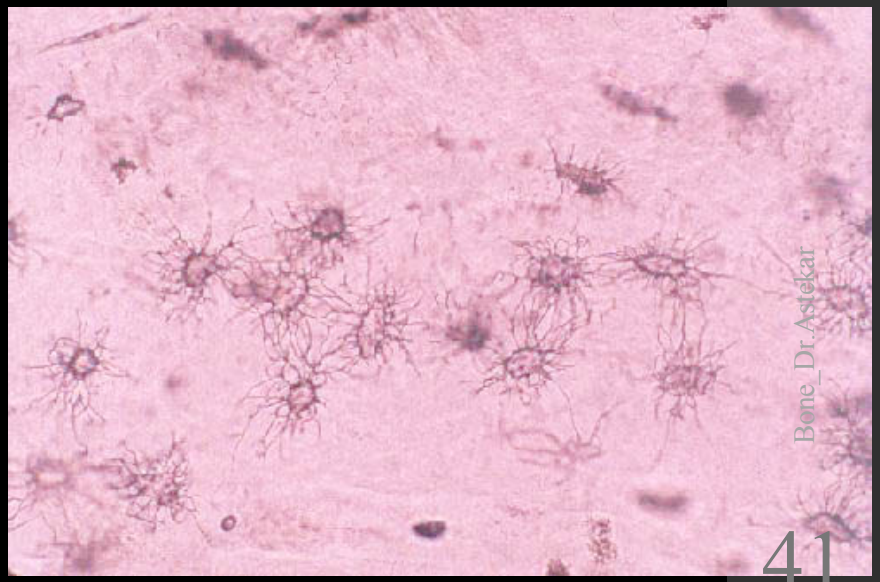
The hormones most important in bone metabolism are parathyroid hormone. 1,25 dihydroxyvitamin D, calcitonin, estrogen, and the glucocorticoids,which have a influence on osteoblasts.



OSTEOCYTE

As osteoblasts secrete bone matrix, some of them become entrapped in lacunae and are then called osteocytes. The number of osteoblasts that become osteocytes varies depending on the rapidity of bone formation. The more rapid the formation, a more osteocytes are present per unit volume.

As a general rule, embryonic bone and repair bone have more osteocytes than does lamellar bone.



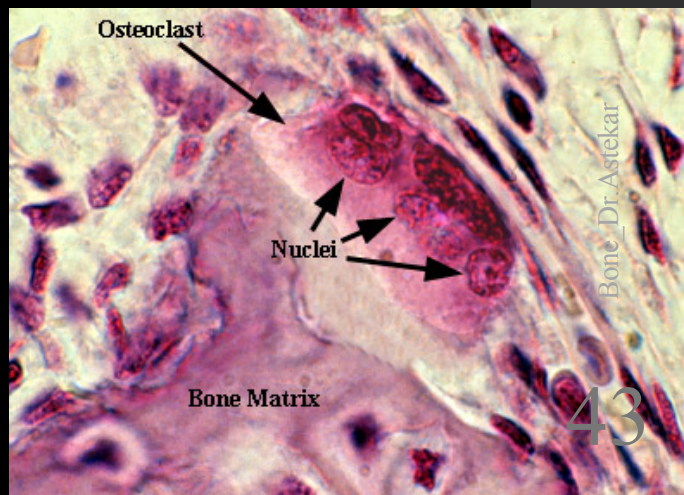
Osteocytes gradually lose most of their matrix synthesizing machinery and become reduced in size. The space in the matrix occupied by an osteocyte is called the osteocytic lacuna. Narrow extensions of these or canaliculi, that form radiating osteocytic processes maintain contact with adjacent osteocytes and osteoblasts the endosteum, periosteum, and Haversian canals.

Failure of any part of this inter connecting system result in hyper mineralization (sclerosis) and death of the bone.

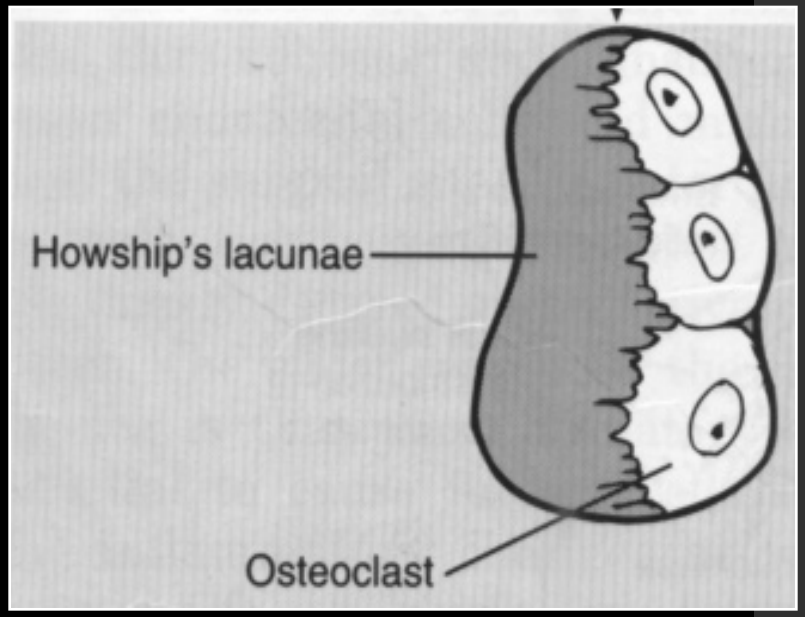
OSTEOCLAST

Compared to all other bone cells and their precursors, the multinucleated osteoclast is a much larger cell. Because of their size, it can be identified under the light microscopy, generally seen in a cluster rather than singly. The osteoclast is characterized by acid phosphatase within its cytoplasmic vesicles and vacuoles, which distinguishes it from other giant cells and macrophages.

Typically osteoclasts are found against the bone surface occupying shallow, hollowed out depressions, called Howship's lacunae.



Adjacent to the tissue surface, their cell membrane is thrown into a myriad of deep folds that form a brush border. This clear or “sealing” zone attached the cells to the mineralized surface.



Isolates a micro environment between them and the bone surface. The cell organelles consist of many nuclei, each surrounded by multiple Golgi complexes, an array of mitochondria and free polysomes, a rough endoplasmic reticulum, many coated transport vesicles, and numerous vacuolar structures. Osteoclast are also rich in lysosomal enzymes.

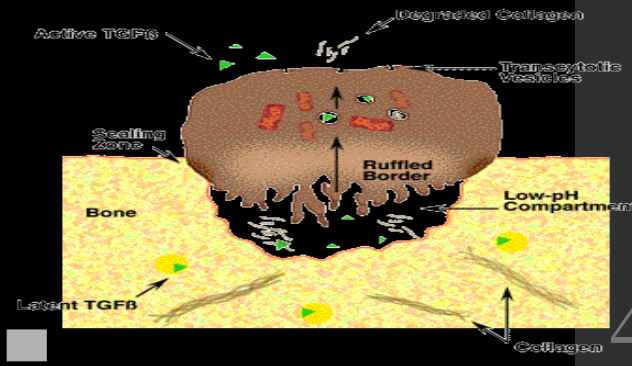
Thus the sequence of resorptive events is considered to be

11. Attachment of osteoclasts to the mineralized surface of bone.

C2. Creation of a sealed acidic environment through action of the proton pump, which demineralizes bone and exposes the organic matrix.

D3. Degradation of this exposed organic matrix to its constituent amino acids by the action of released enzymes.

4. Uptake of mineral ions and amino acids by the cell.



CLASSIFICATION OF BONE

Bones are organs because they are functionally related groups of tissues and each bone has a unique form and function. Macroscopically, osseous structure is classified according to density as ***Compact*** or ***Trabecular*** bone. But practically, bone mass is actually a combination of ***Fine Trabeculae, Coarse Trabeculae, Porous Compacta*** and **Dense Compacta.** Microscopically bones are composed of ***Woven bone, Lamellar bone, Bundle bone*** and ***Composite bone.***

Woven bone

- Highly cellular.
- Formed rapidly (30-50 μm/ day or more) in response to growth or injury.
- Low mineral content.
- Random fiber orientation and minimal strength.
- Stabilize unloaded Endosseous implants during initial healing.

Lamellar bone

- Principle load bearing tissue of adult skeleton.
- Predominant component of mature cortical and trabecular bone.
- Formed relatively slowly (<1 μm/ day).
- Densely mineralized and highly organized matrix.

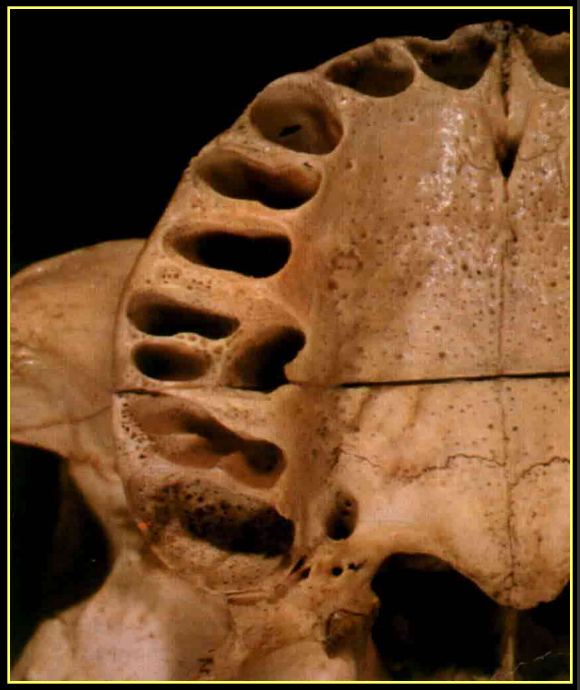
Bundle bone

- Characteristic of ligament and tendon attachments along bone-forming surfaces.
- Sharpey's fibers from adjacent connective tissue insert directly into bone.
- Bundle bone is formed adjacent to the periodontal ligament of natural teeth.

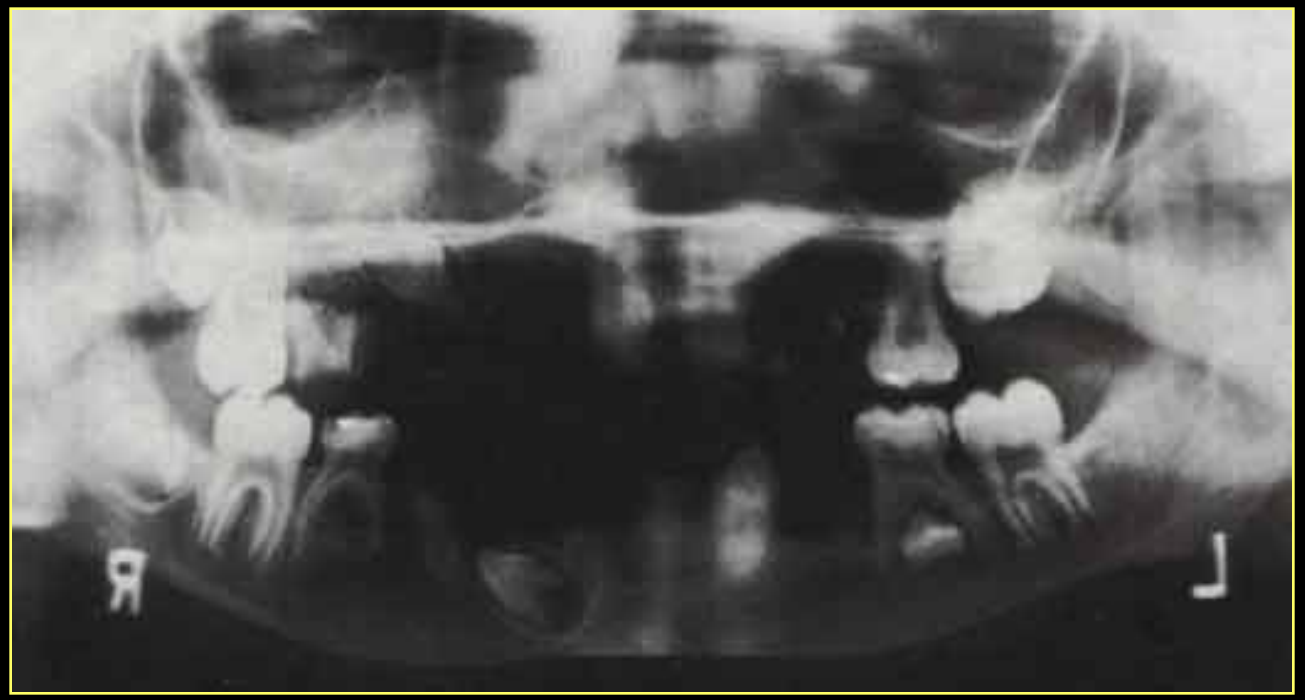
Composite bone

- High quality lamellar bone deposited on a woven bone matrix.
- Got adequate strength for load bearing.
- Important in achieving stabilization of an implant during the rigid integration process.

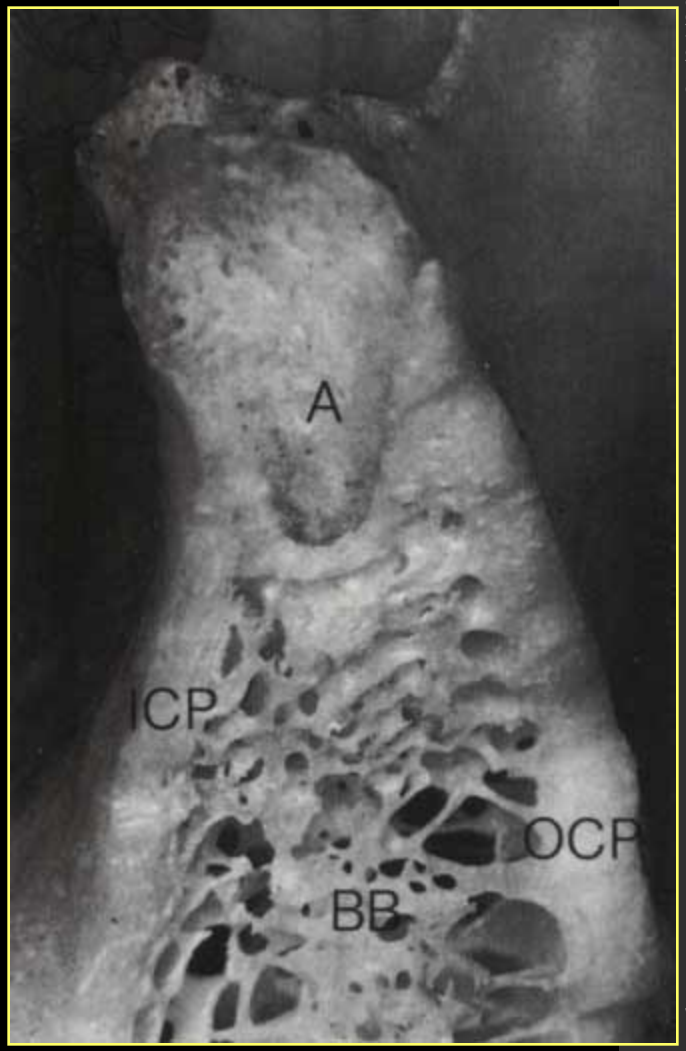
Alveolar Bone forms the bony sockets of the jaw bones in which the roots of the natural teeth are suspended by the attachment of the periodontal ligament fibers (**"Gomphosis"** - Greek "Bolting together). Some alveolar bone is formed during tooth development, but ***the majority of alveolar bone formation occurs during tooth eruption.***



The presence of alveolar bone in the jaw bones is totally dependent on the roots of the natural teeth; without the teeth the alveolar bone need not exist.



Several morphologic features can be distinguished within the alveolar bone. The **cortex** of the basal bone of either mandible or maxilla continues around the alveolar process as either the outer (OCP) or the inner (ICP) cortical plate. The alveolar bone of these outer and inner plates is composed of hard, lamellar (arranged in thin plates) bone.

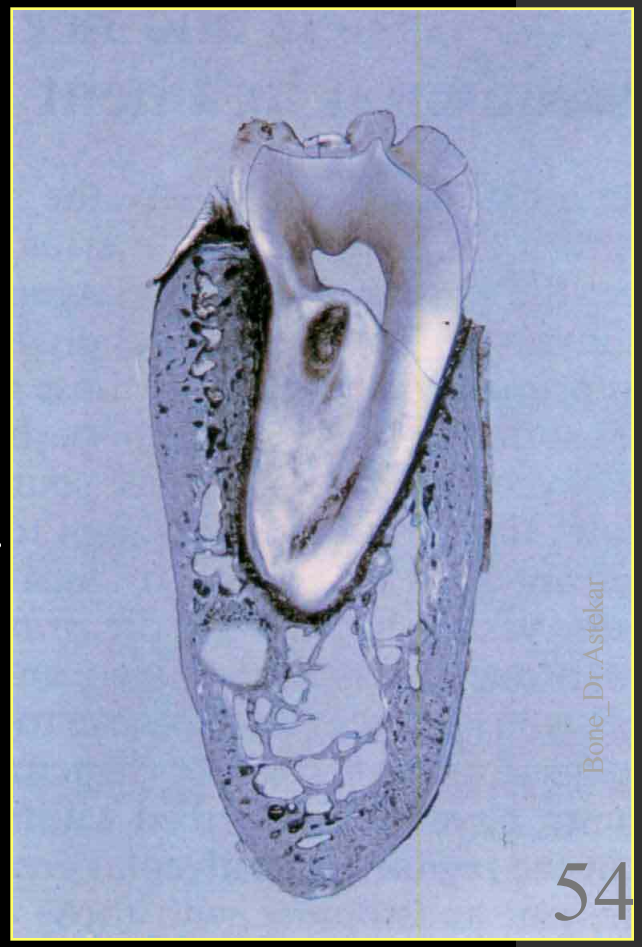


A - Alveolus

B B - Basal Bone

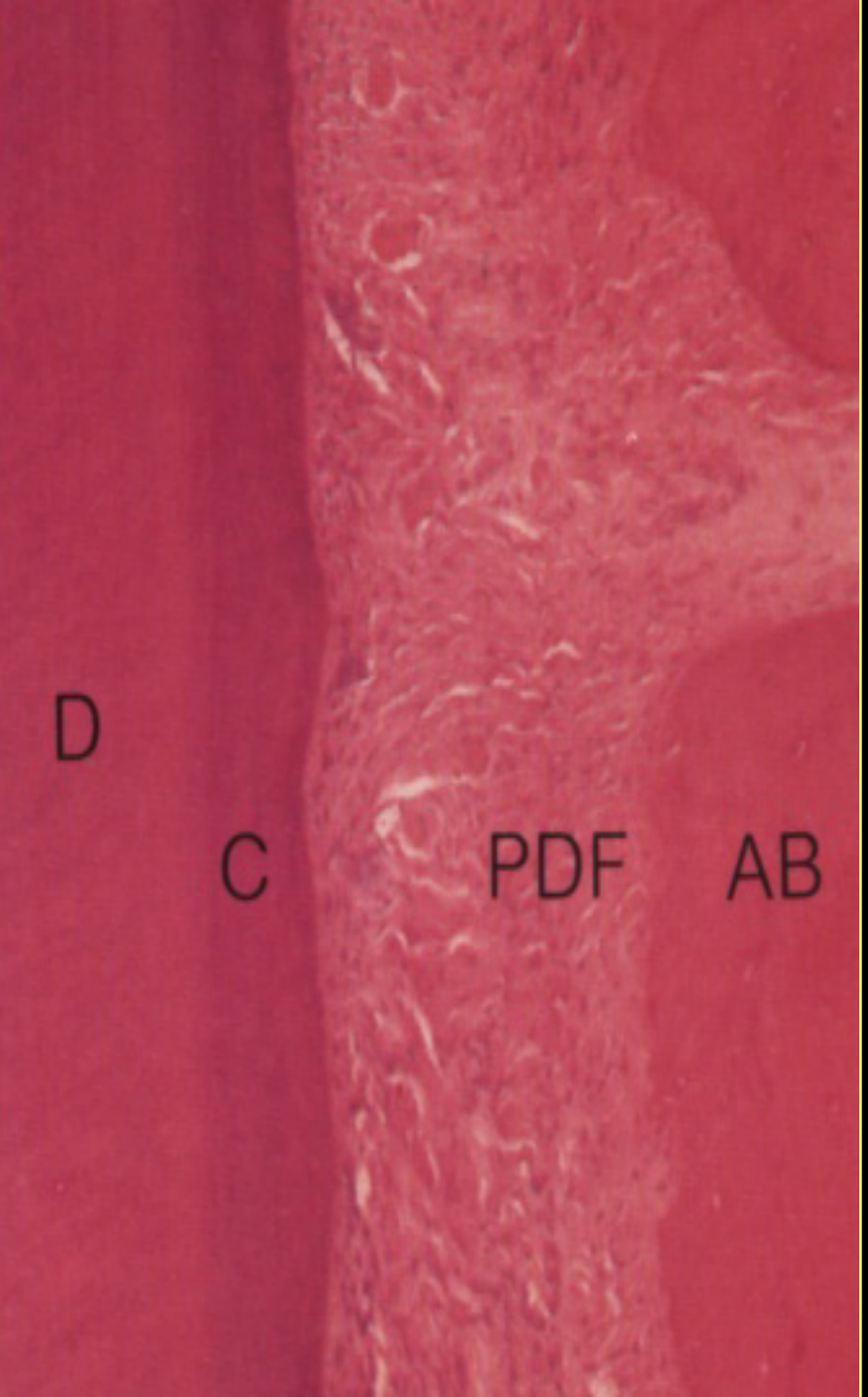
The **actual tooth socket**, is composed of a slightly different type of hard bone called the **"cribriform (sieve like) plate".**

Numerous blood vessels and nerve fibers pass through the cribriform plate, providing unlimited access between the alveolar bone and tissues of the periodontal ligament.



The cribriform plate itself is made up of two types of bony layers:

- The Hard, lamellar type.
- Bundle Bone oriented toward the periodontal ligament and thick enough to anchor the periodontal fibers within it.



The periodontal fibers visible in the bundle bone are termed **"Sharpey's Fibers".** The fibers of the periodontal ligament function like a miniature shock absorber system that acts to dissipate the forces of occlusion through the trabecular pattern of the alveolar bone.

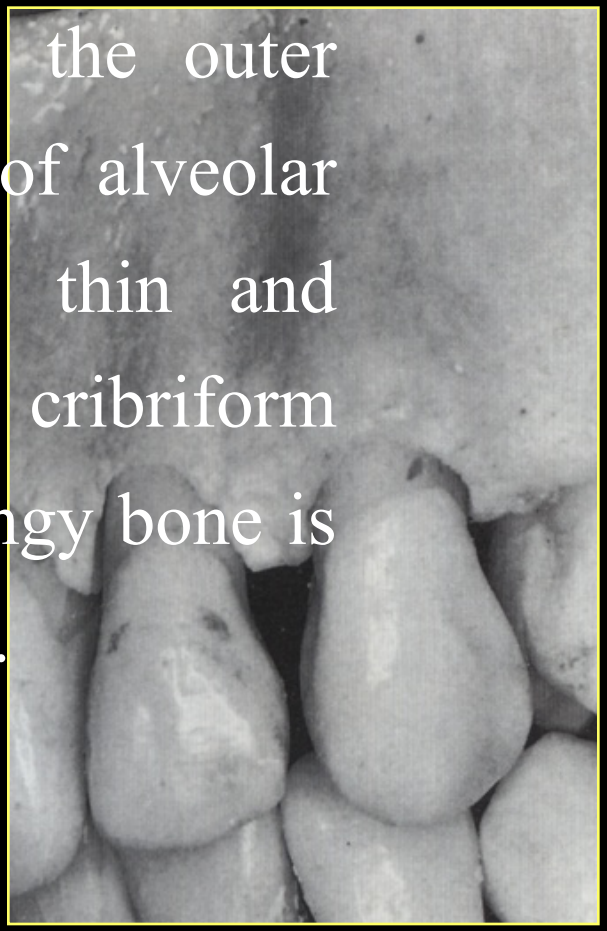
The **cribriform plate** (alveolar bone proper) forms the sockets, or alveoli, around each single- or multiple- rooted tooth and follows the configuration of the root(s) with precision, leaving only a small space of less than 0.2 mm between the root and bone occupied by the suspensory periodontal ligament. Between the alveoli of adjacent teeth, the alveolar bone forms an interdental septum composed of adjacent cribriform plates and at times interposed spongy bone. The roots of multirooted teeth are separated from one another by interradicular septum, and are composed of adjacent cribriform plates and spongy bone between them.

When viewed with a dental radiograph (IOPA), the cribriform plate surrounding each tooth root appears as a dense white line called the **"Lamina dura".** We might assume that the alveolar bone surrounding the tooth is denser or more highly calcified than the other bone.

But this is not clearly the case and is a radiographic artifact based on the geometry of the cribriform plate.

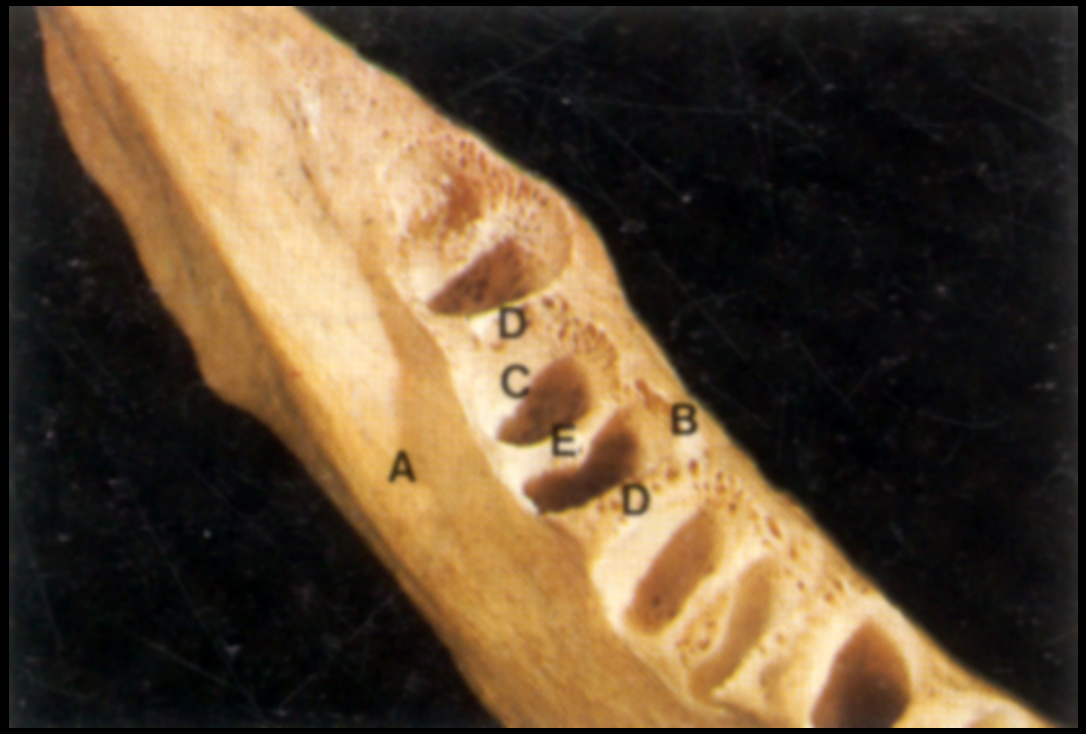
Between the cortical and cribriform plates of the alveolar bone, another type of bone termed "Spongy Bone" may be present. This spongy bone contains small amounts of bony trabeculae (supporting beams) surrounded by bone marrow that is of either the RED (forming blood - in young adults) or YELLOW (fatty - in older individuals). The response of the alveolar bone to occlusal forces transmitted by the tension of the periodontal fiber bundles is to form a trabecular pattern that is both parallel and perpendicular to the functional forces applied.

On the labial surfaces of anterior teeth, the outer cortical plate of alveolar bone is very thin and fused to the cribriform plate, and spongy bone is notably absent.

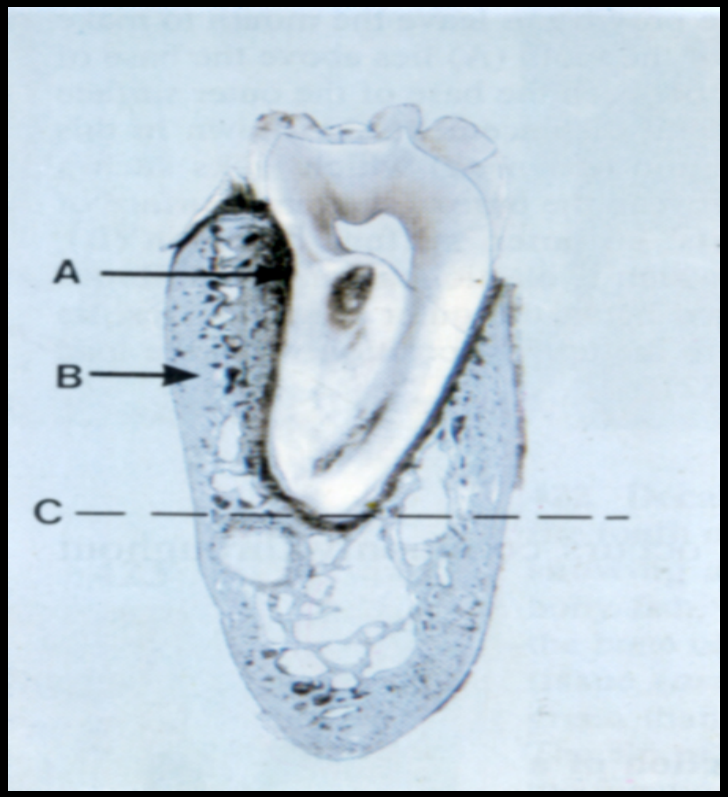


Alveolar bone is a plastic tissue, able to respond and adapt to both functional occlusal forces and changes in tooth position. E.g. “mesial drift”, which is a nonpathologic, slow mesial tooth migration due to enamel wear between the contact areas of some or all adjacent natural teeth. For this changes to occur in each alveoli of the teeth, both Osteoblasts and Osteoclasts must be active.

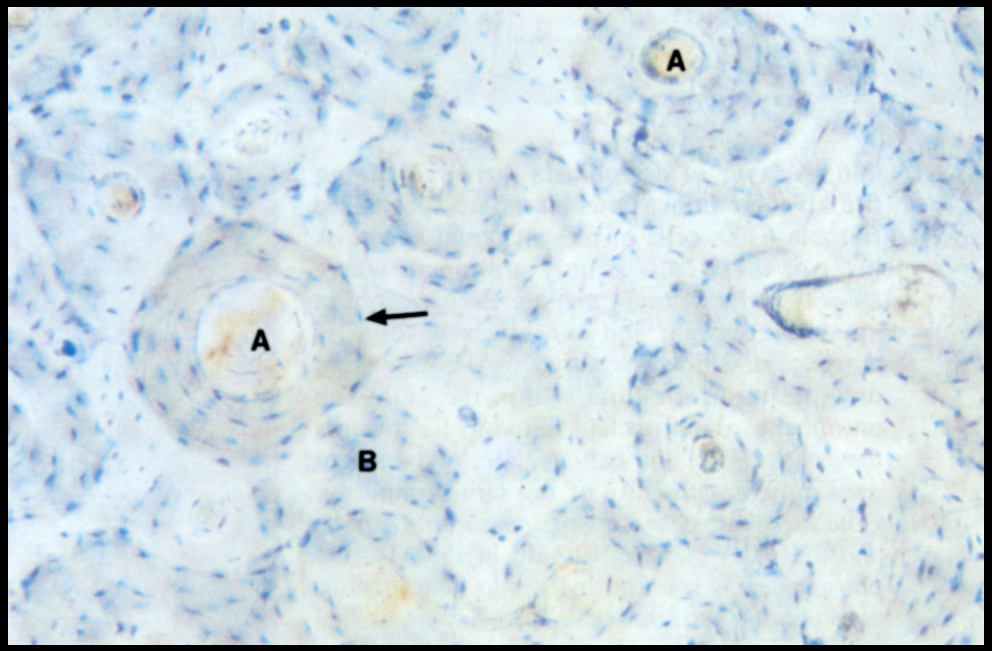
Throughout the life of the individual, age-related tooth wear, changes in occlusal loading and pathologic changes in the teeth and supporting tissues keep the trabecular pattern of alveolar bone in a constant state of remodeling activity.



- Morphology of the bony socket showing
  - (A) Outer alveolar plate
  - (B) Inner alveolar plate.
  - (c) Cribriform plate lining the sockets.
  - (D) Interdental bone.
  - (E) Interadicular Septa



- A Tooth along with supporting alveolar bone.
  - (A) Internally thin layer of compact bone – lines the socket and gives attachment to the periodontal ligament.
  - (B) Externally thick layer of compact bone form the external and internal alveolar bone plates.
  - (C) Broken Line- Boundary between the alveolar bone and the body of jaw.

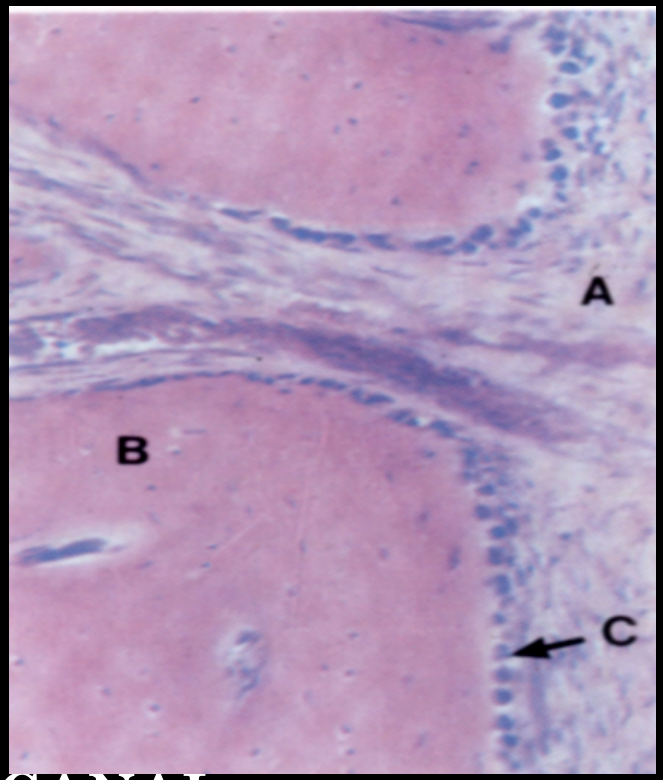


COMPACT BONE.

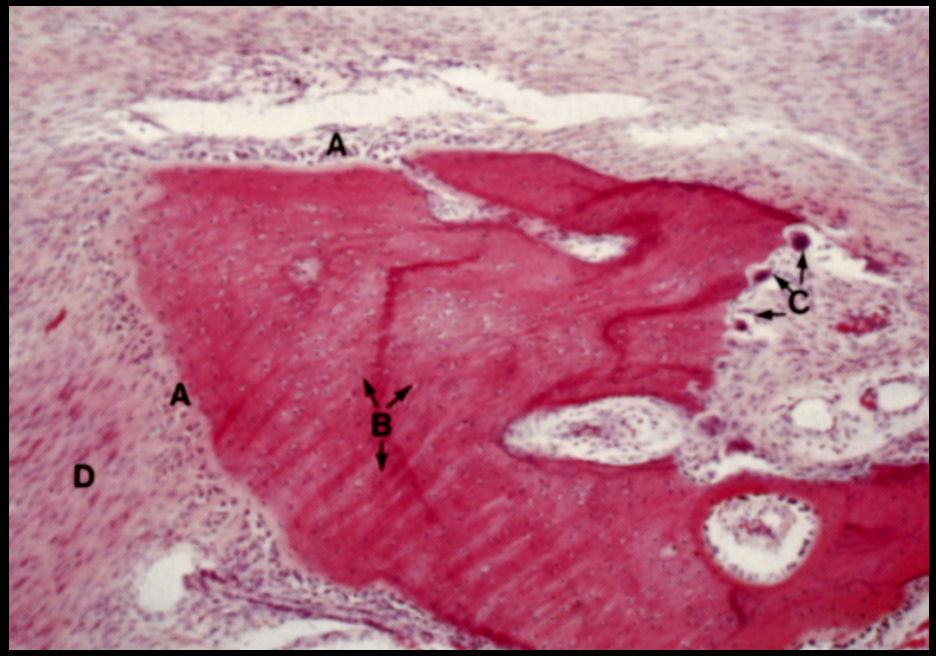
(A) Haversian system- Haversian canal together with concentric lamellae

(B) Interstitial lamellae representing fragments of concentric lamellae.

(C) Arrow → Osteon, the structural and functional unit of bone.

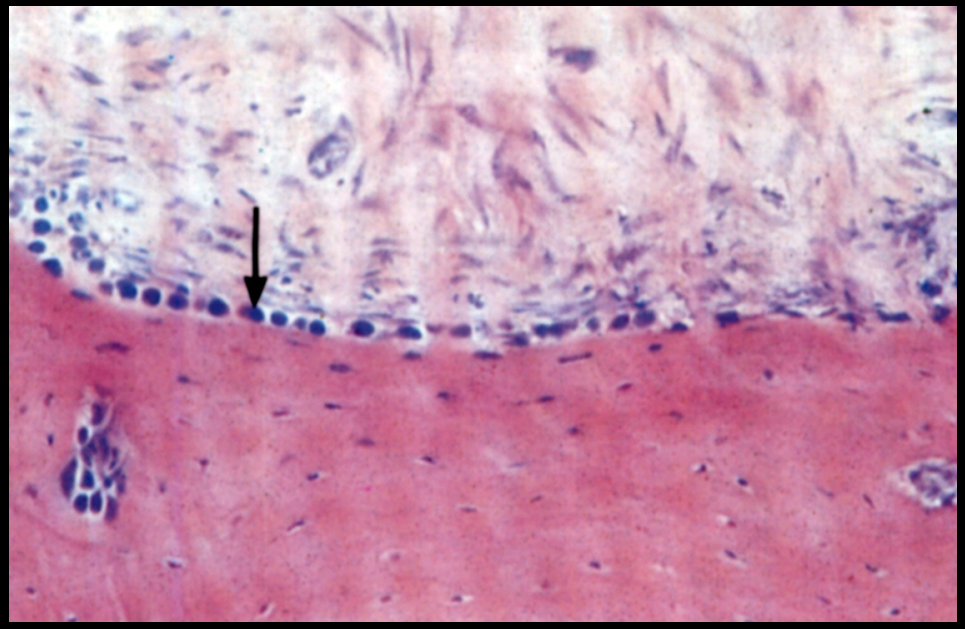


- **VOLKMANN'S CANAL:**
  - Vascular Canal passing from alveolar bone into periodontal ligament.
    - (A) Periodontal Ligament
    - (B) Supporting bone
    - (C) Osteoblastic layer.

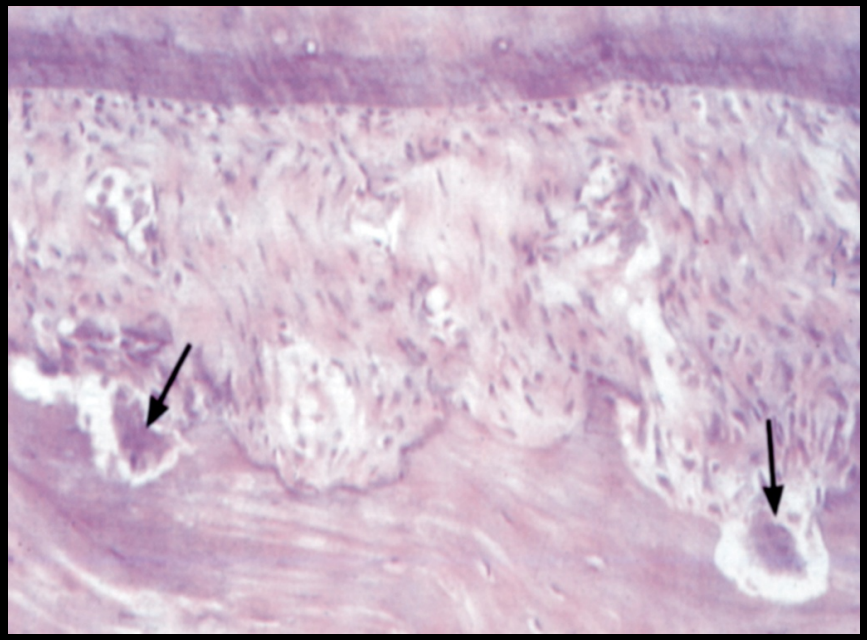


- **BONE CELLS** – 3 Types
  - (A) Osteoblasts
  - (B) Osteocytes
  - (C) Osteoclasts

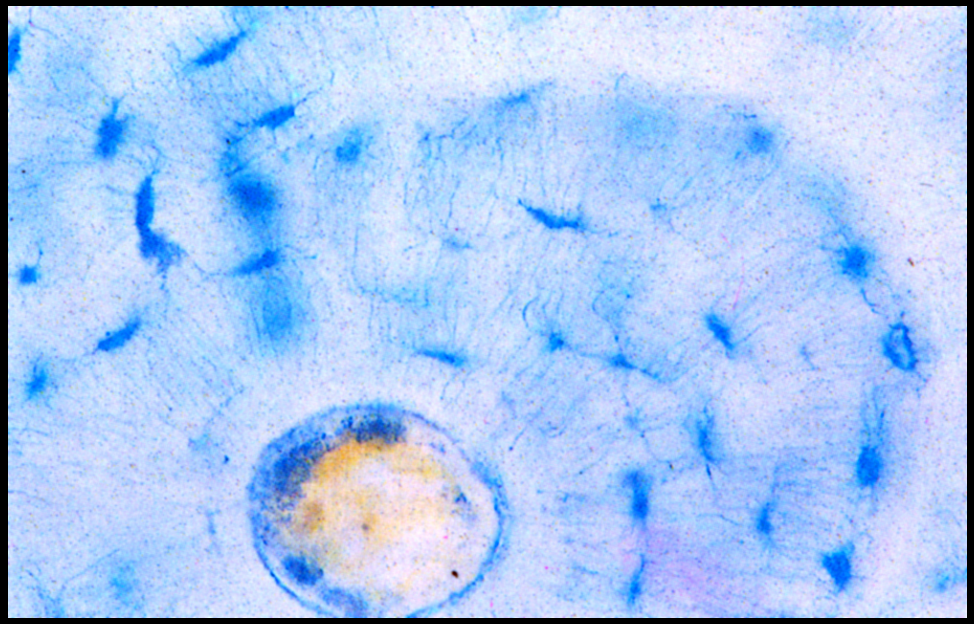
    (D) Periodontal Ligament.



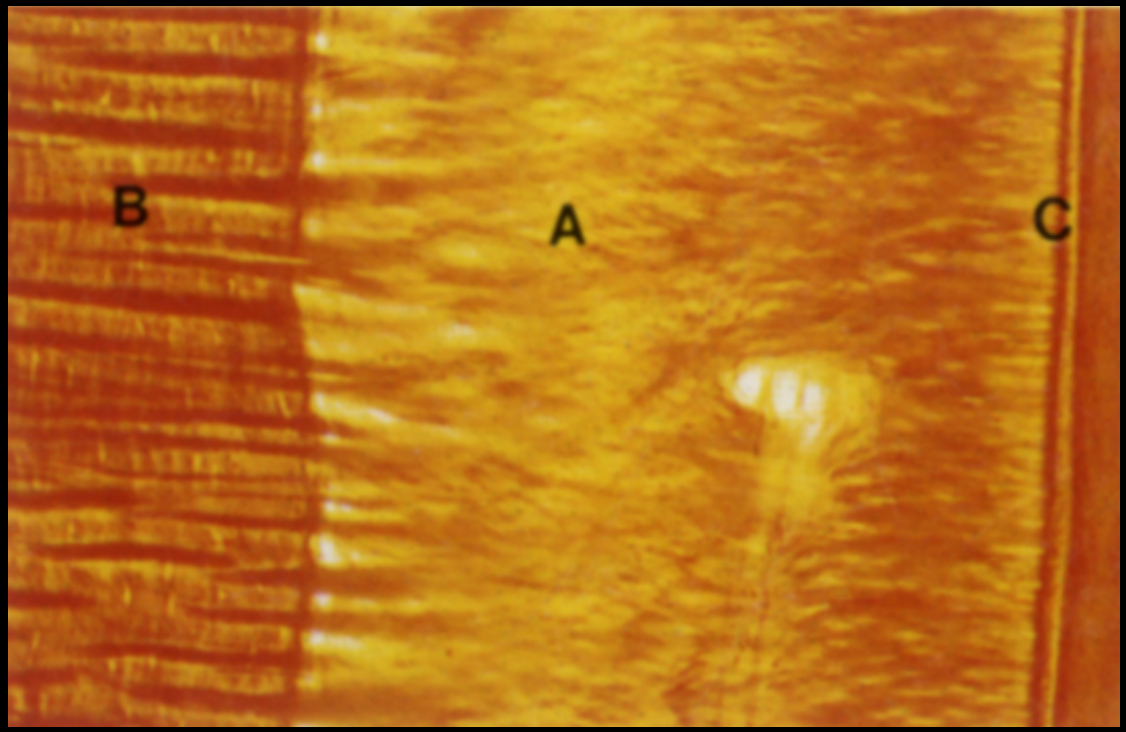
- **OSTEOBLASTS –**
  - Specialized fibroblast like mesenchymal cells.
  - They are cuboidal with basophilic cytoplasm and prominent round nuclei with presence of alkaline phosphatase with in the cytoplasm.
  - They are responsible for bone deposition.



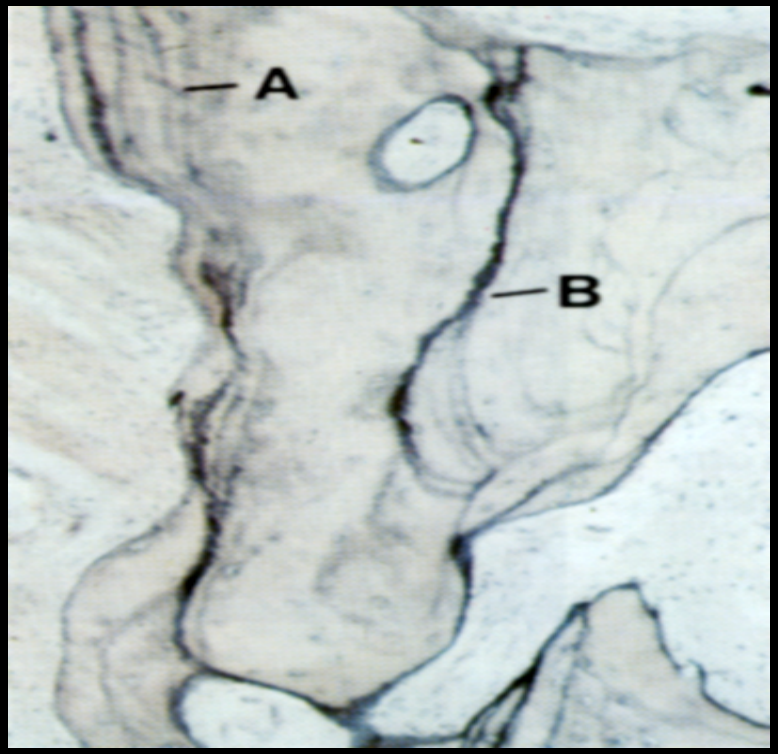
- **OSTEOCLASTS-**
  - They lie in resorption concavities known as HOWSHIPS LACUNAE.
  - They are large multinucleated showing brush border.
  - The presence of tartrate resistant acid phosphatase is a characteristic feature.



- **OSTEOCYTES –**
  - The osteoblasts when entrapped within the matrix surrounded by lacunae space is called Osteocyte.
  - The lacunae are regularly distributed with fine radiating canals called canaliculi which allow diffusion of substances through bone.



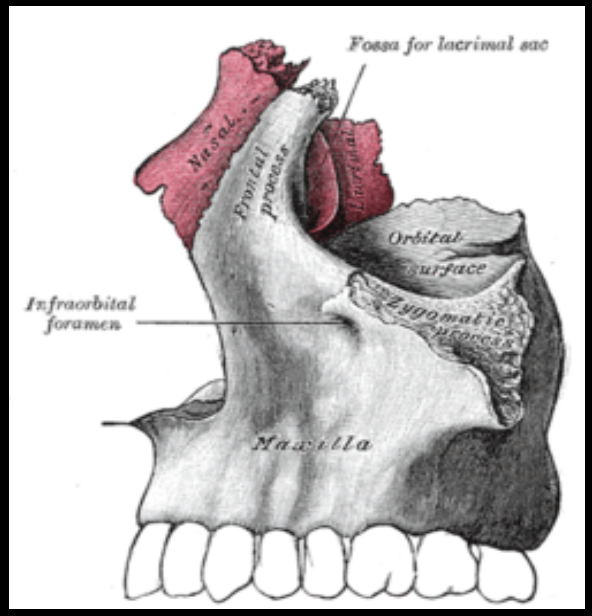
- **SHARPEY'S FIBERS** – The bundles of collagen fibers from the periodontal ligament.
  - (A) Appears to insert both into the Alveolar bone
  - (B) and Cementum
  - (C) giving rise to a firm anchorage.

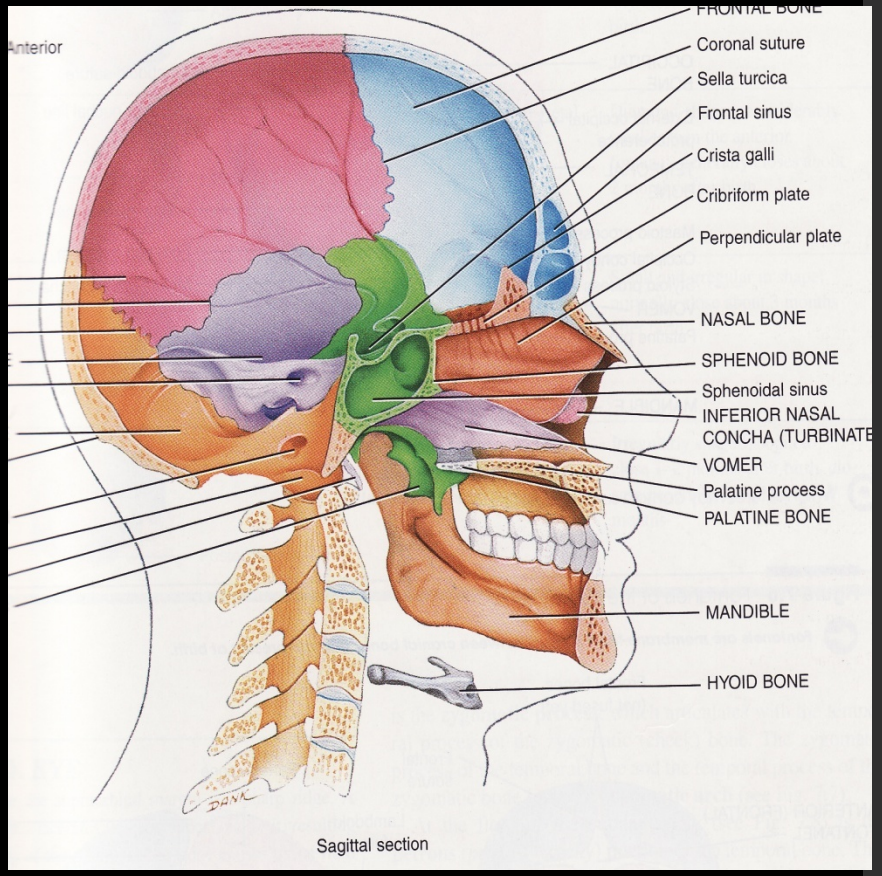


- **THE RESTING AND THE REVERSAL LINES**
  - (A) The resting lines are the one which are formed in the periods of relative quiescence running parallel to each other
  - (B) The Reversal lines and the one which shows the change in the activity from deposition to resorption characterized by the presence of irregular resorptive Howship's lacunae.

Anesthesia

- Anatomical landmarks





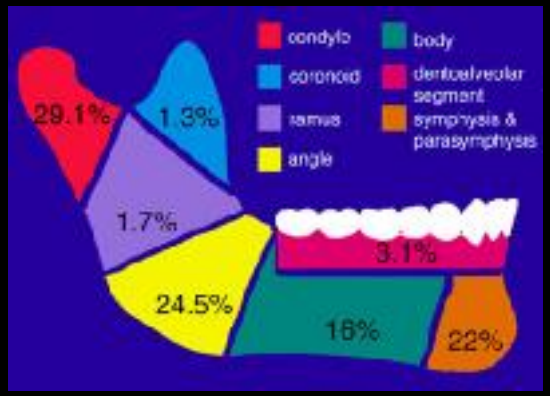
PATHOLOGICAL

FATE OF ALVEOLAR BONE

Fractures involving maxilla



Fractures of Mandible



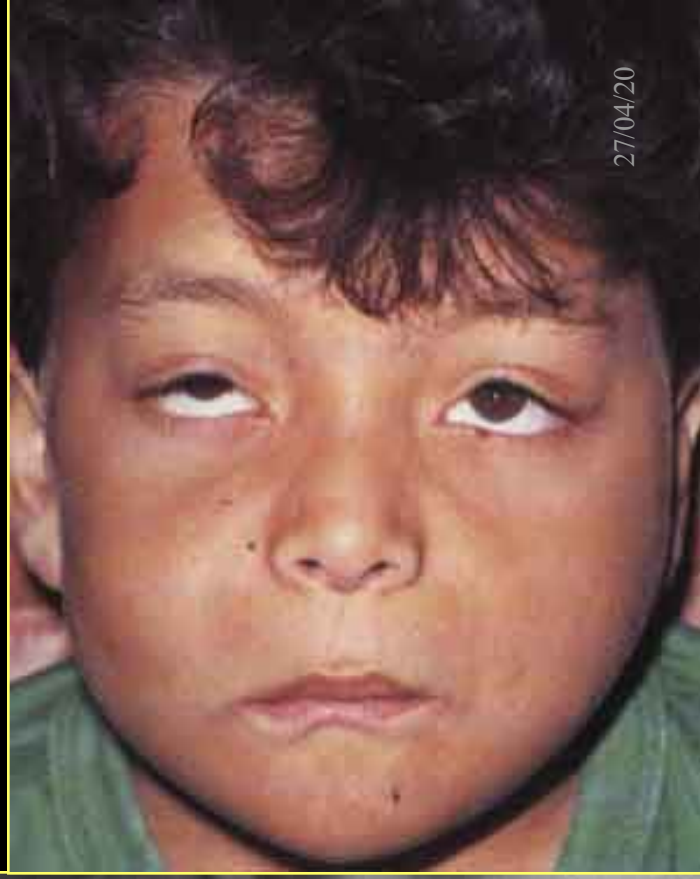
HISTIOCYTOSIS X

- Bone lesion appears as sharply "Punched-out" lytic defect, often with irregular margins.
- The posterior mandible is the most common site.
- Mild dull pain is commonly present.
- Alveolar bone involvement leads to severe horizontal bone loss.

HISTIOCYTOSIS X

CHERUBISM

- Extensive maxillary involvement may stretch the skin to expose the sclera.
- Marked enlargement of maxilla and multiple missing teeth



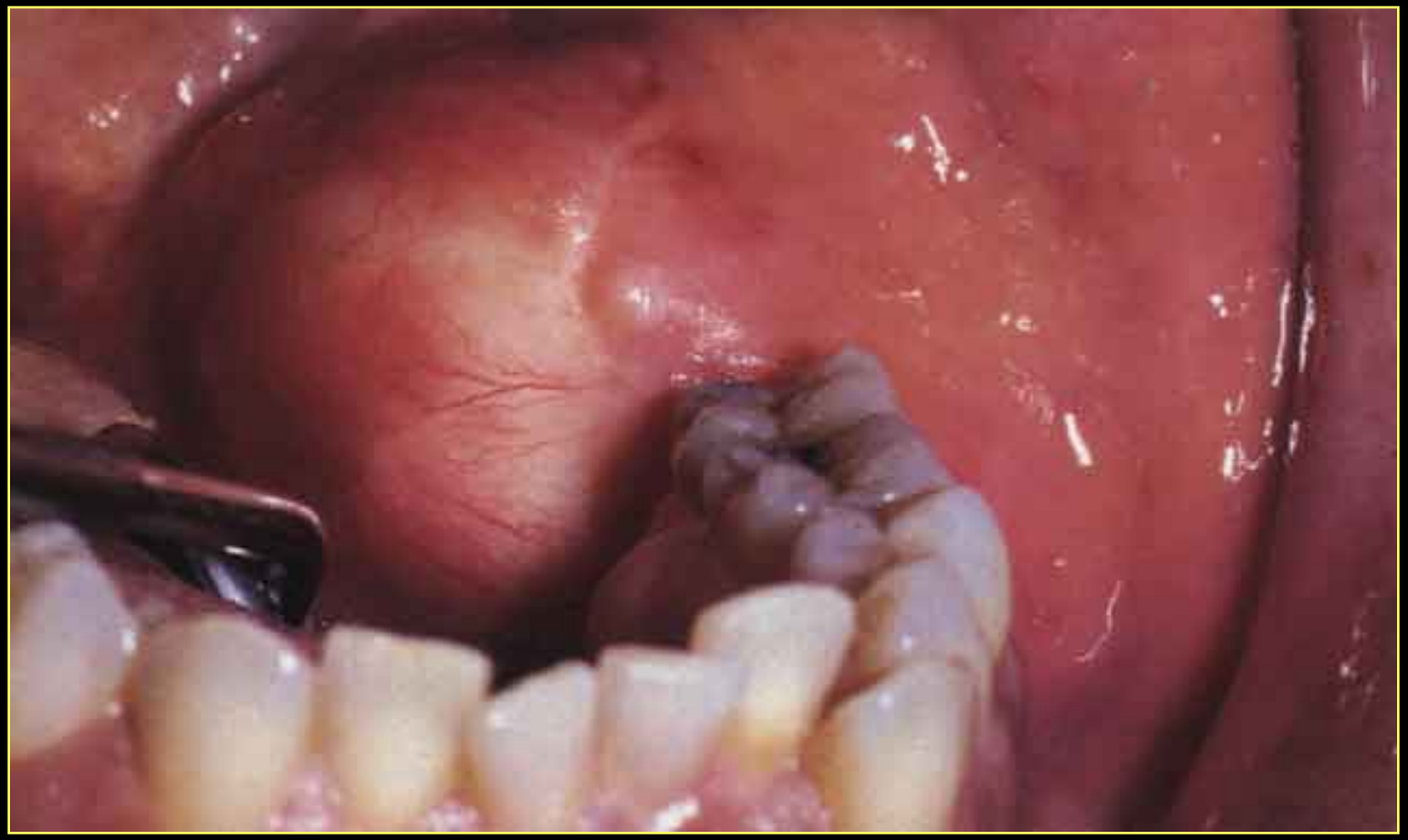
FIBROUS DYSPLASIA

- Painless enlargement of the affected bone.

OSTEOSARCOMA

- Swelling, pain, loosening of teeth, paresthesia are common complaints

CHONDROSARCOMA



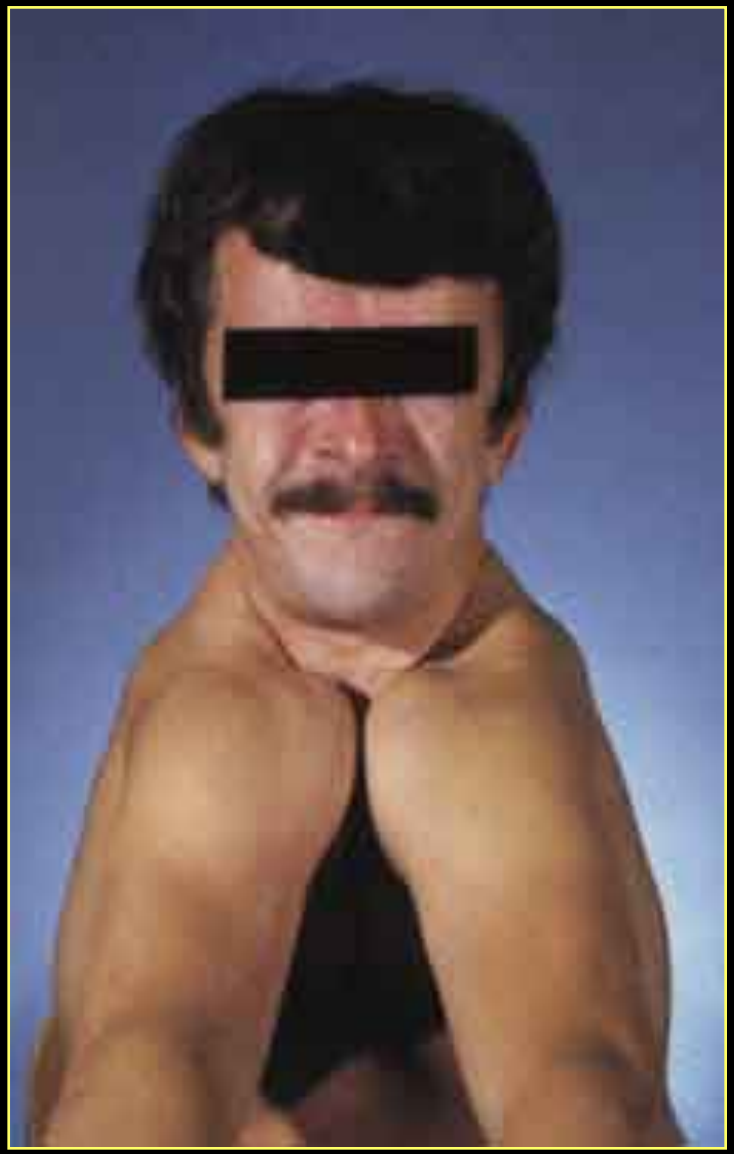
OSTEITIS DEFORMANS (Paget's Disease)

- Progressive, symmetric maxillary enlargement that may reach massive proportions

CLEIDOCRANIAL DYSPLASIA

- Skull and clavicles are chief sites of disorder.
- Large head with bulging of frontal bone.
- Unusual mobility of shoulders.
- Narrow high arched palate, prolonged retention of deciduous teeth and delay or failure of eruption of permanent teeth.

CLEIDOCRANIAL DYSPLASIA



HYPERPARATHYROIDISM

- Increased production of parathyroid hormone results in a generalized disorder of calcium, phosphate and bone metabolism

OSTEOPETROSIS

- Marked increase in bone density
- Bone marrow is replaced by dense bone

OSTEOPOROSIS

Osteoporosis is a systemic disease in the elderly. Osteoporosis shows a decrease in the skeletal mass without alteration in the chemical composition of bone. Loss of the spongy spicules of bone that support the weight bearing parts of the skeleton can be seen in radiographs of regions of the skeleton that bear heavy loads, such as the vertebral column, epiphysis of long bones, the mandible and the fingers.

In edentulous patients, reduction of the residual ridge is one of the most important factors affecting denture support, retention, stability, and masticatory function.

SEVERITY OF OSTEOPOROSIS

JIKEI'S CLASSIFICATION

Class I – Horizontal trabeculae are decreased and vertical trabeculae are prominent.

Class II – Decreasing of horizontal trabeculae is more prominent and vertical trabeculae are sparse.

Class III – Horizontal trabeculae almost disappear and vertical trabeculae are found to be indistinct.

Conclusion

It is important to know the anatomy of maxilla and mandible for

- better and safe placement of implants

- for better internal fixation of fractures

- for effective administration of anesthesia

-for radiographic diagnosis of any bone pathology

Shortcomings of theory of evolution

REFERENCES

1. Human Oral Embryology and Histology.
   I. A. Mjor & O. Fejerskov.
2. A Colour Atlas and Textbook Of Oral Anatomy.
   B.K.B. Berkovitz.
3. An Introduction to Dental Anatomy & Esthetics.
   Robert P. Renner.
4. Sicher & Dubrul's Oral Anatomy (8th Edition)
   E. Lloyd Dubrul.
5. Dental Histology & Embryology.
   Dr. A. N. Radhakrishnan.

THANK YOU