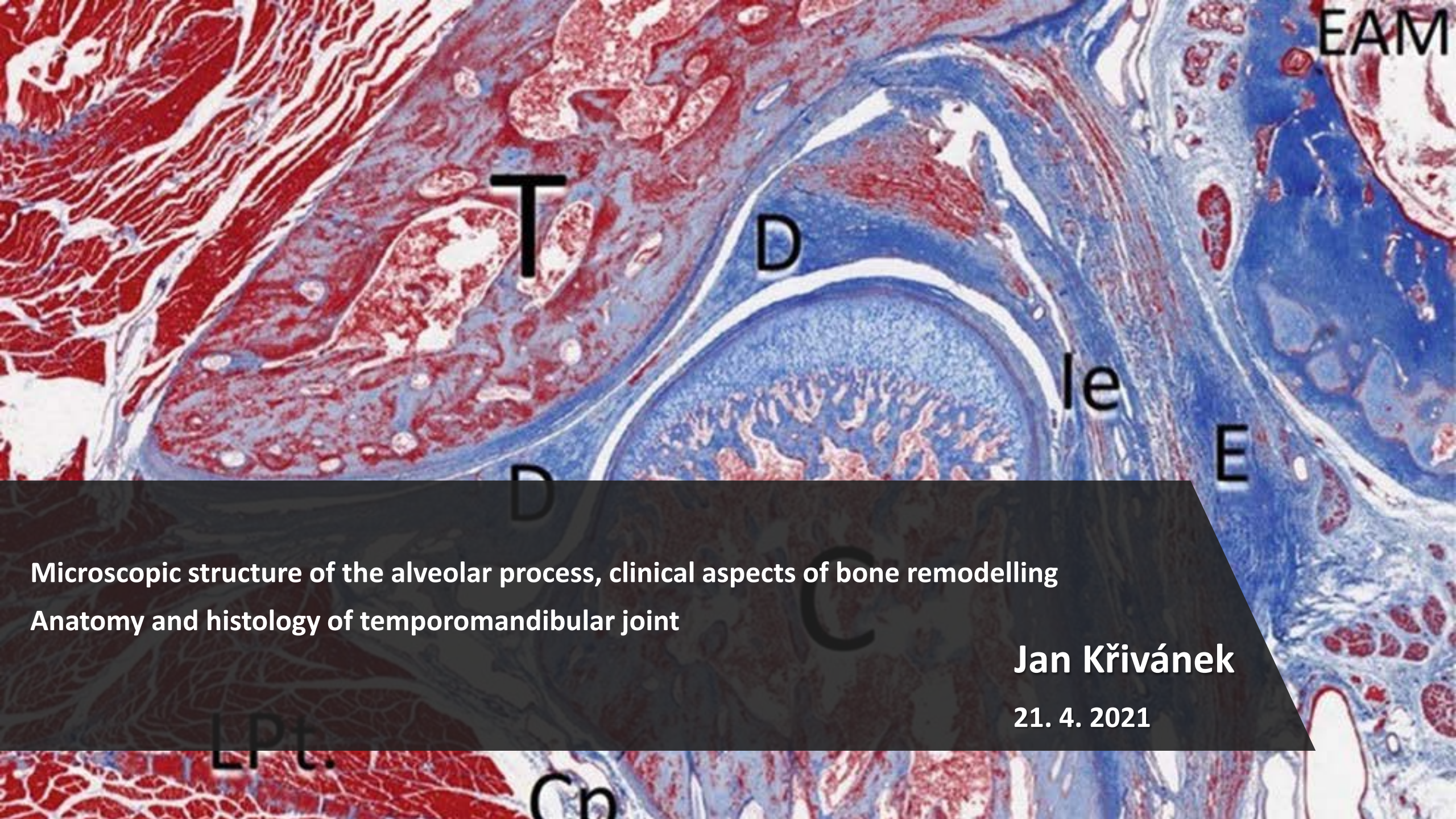


Microscopic structure of the alveolar process, clinical aspects of bone remodelling

Anatomy and histology of temporomandibular joint

Jan Křivánek

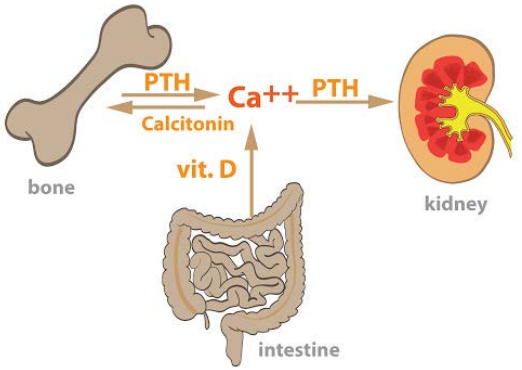
21. 4. 2021

Overview of bone microstructure, and bone plasticity

Two main functions:

Structural – forming skeleton

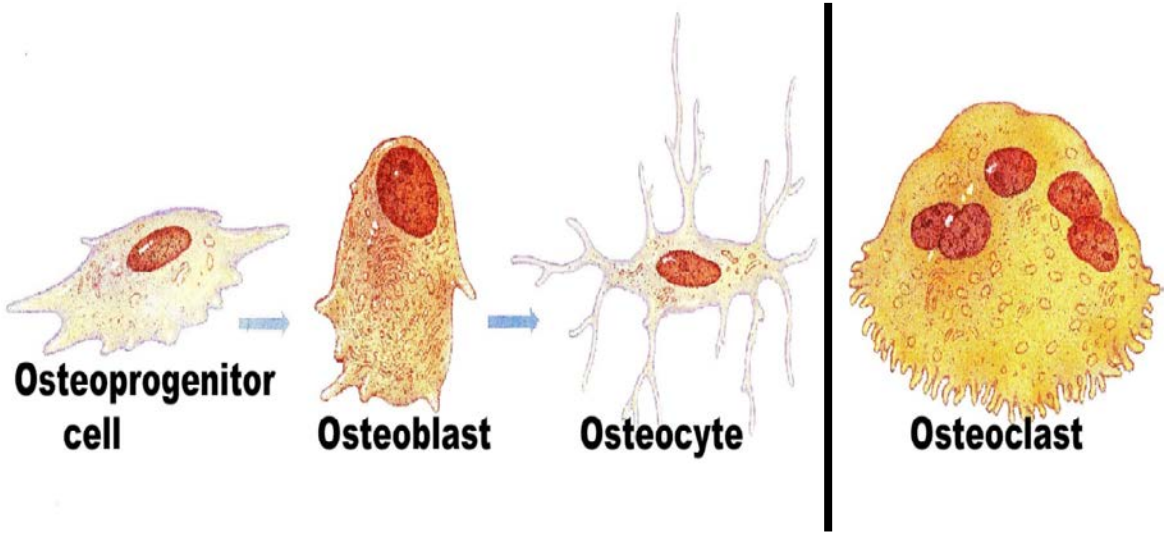
Storage of Ca^{2+} in our bodies (99 %) - releasing calcium from bone into blood and vice versa



Compostion:

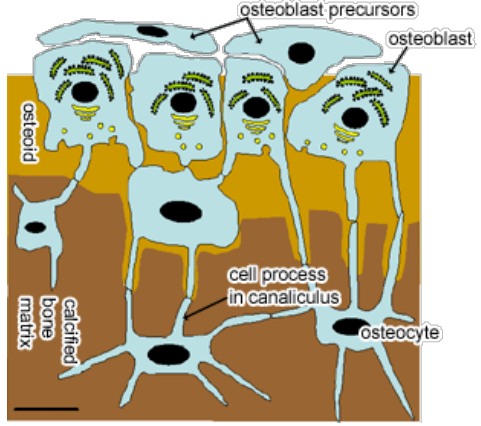
Cells

Extracelullar matrix (ECM) - **bone matrix**



Cells in bone

osteoblasts a osteocytes; osteoclasts

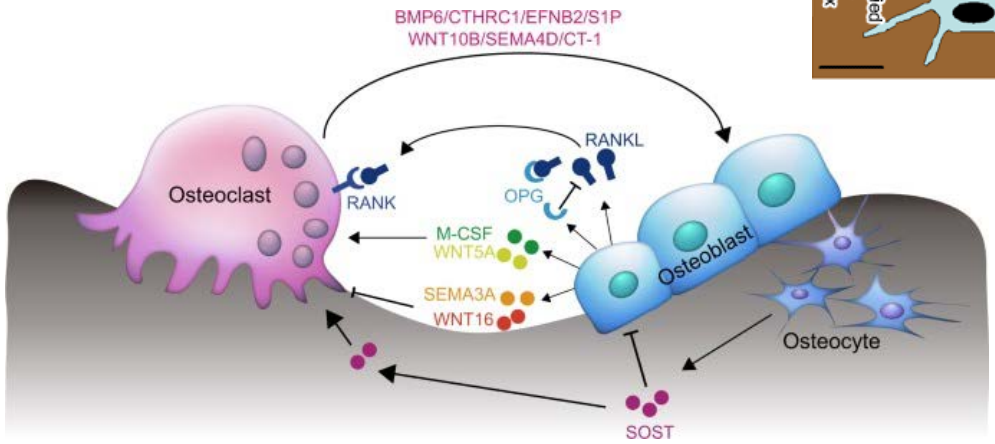


Osteoblasts

Synthesize organic component of extracelullar bone matrix: Collagen I, proteoglycans, glycoproteins

Deposit inorganic salts in matrix

During development forms one layer of cells on the surface



Osteocytes

„Resting“ forms of osteoblasts, have small oval bodies with thin cytoplasmic processes

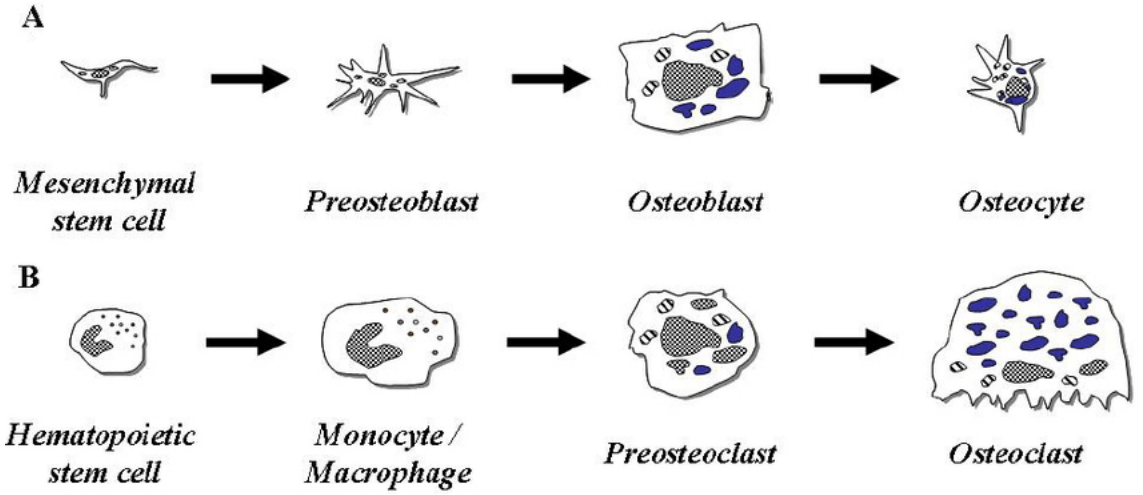
Inhabit bone lacunea and its processess are in **canaliculi ossium**

Osteoclasts

Large cells (diameter around 100 um), with multiple iregular processess

Multinuclear – number of nuclei may be 50 or more, originate by the fusion of monocytes/macrophages

Digest/decompose bone matrix. Essential for bone remodelling



Extracellular matric (ECM) – Bone matrix

Inorganic (+- 45 %) and **Organic** (+- 30 %), rest is Water

Inorganic components are responsible for bone hardness while collagenous fibres determine the resilience and flexibility of bone

The ration bewteen inorganic and organic component is essential for the right mechanical behaviour

Inorganic component

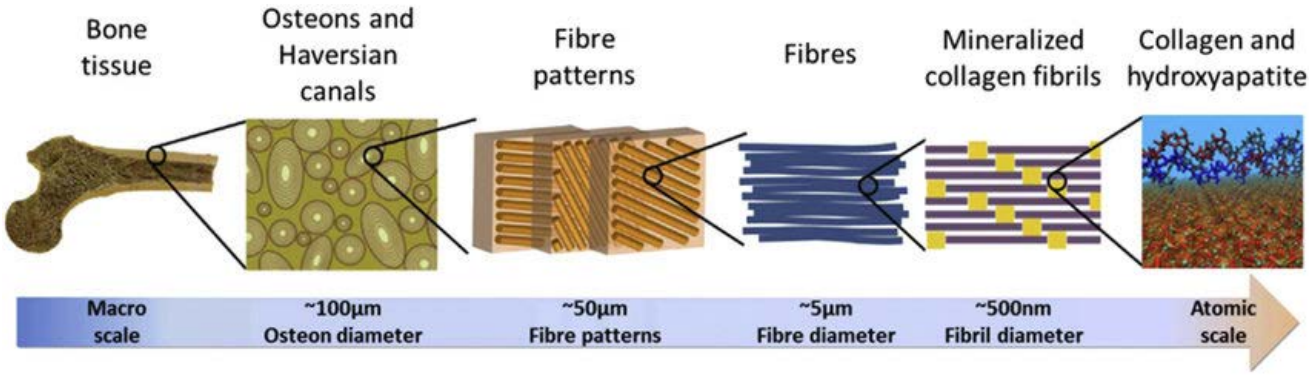
Responsible for hardness and stiffness of bones

Formed by hydroxyapatite crystals – have shape of flat plates of hexagonal profile measuring 40 x 25 x 3 nm, deposited parallel to collagen fibrils

Organic component

Mainly **Collagen I**, then **proteoglycans** (glycosaminoglycans associated with proteins) and **adhesive proteins** – sialoprotein, osteocalcin, osteopontin, osteonectin

Important role in calcium deposition during bone growth and remodelling



Histologically we divide 2 types of bone tissue

Woven bone (primary)

Primitive structure

Resembles calcified fibrous connective tissue

Firstly developer (during growth and remodelling)

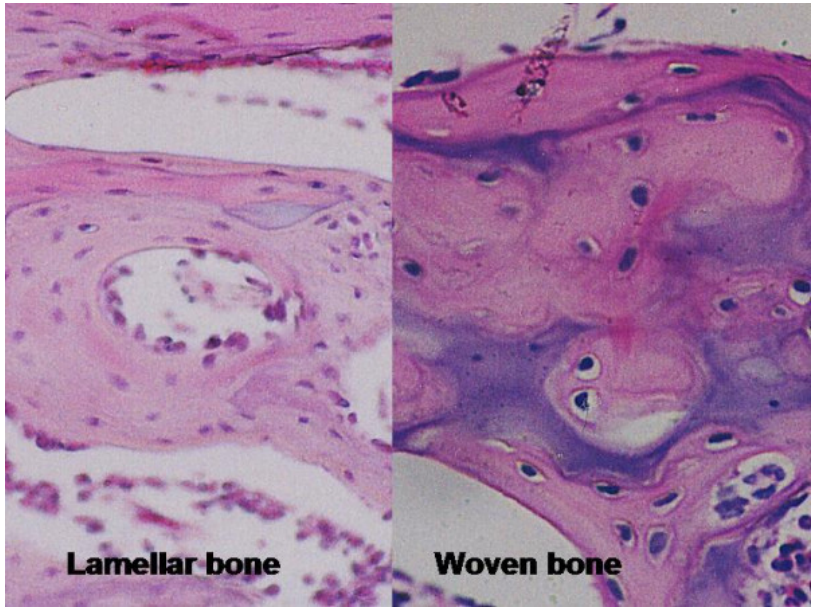
Lamellar bone (secondary)

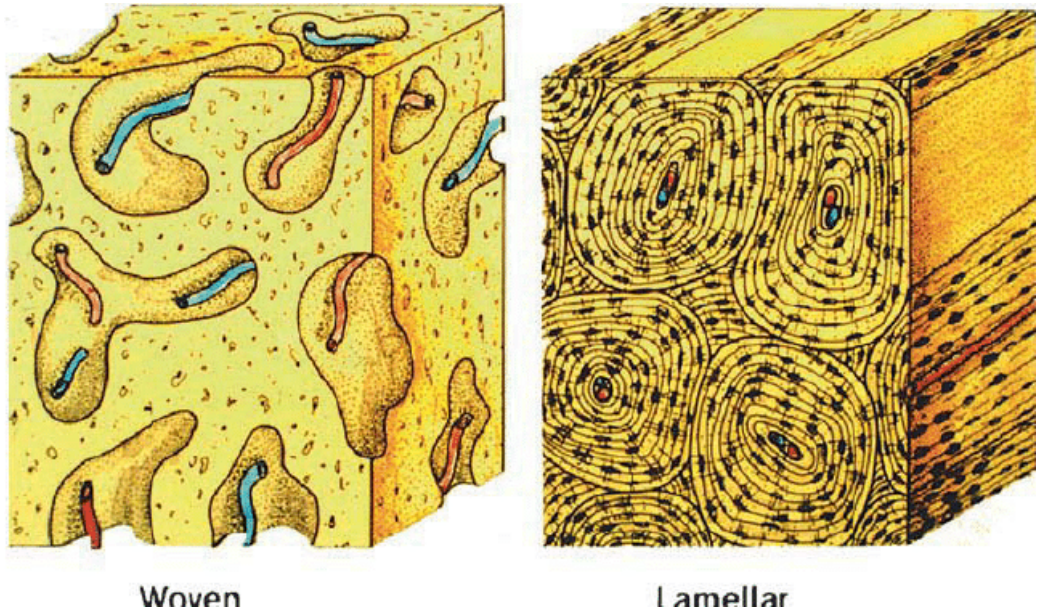
Developmentally and functionaly better developed

Bone lamellae = 3-7 µm

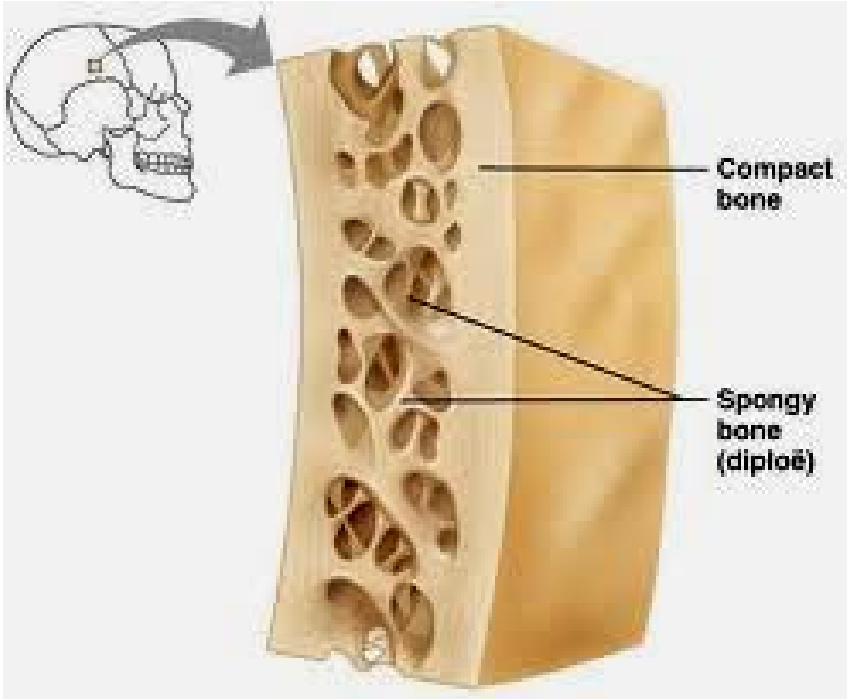
Collagenous fibres in lamellae always in the same direction

Osteocytes between lamellae

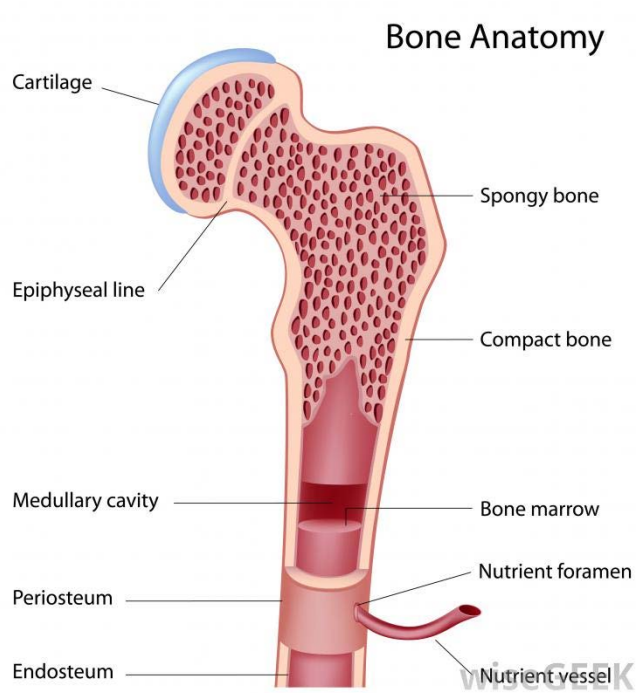




All bones of skeleton (long, short, flat, irregular) **– are composed only by lamellar type**
Lamellae are present in both forms: **Compact (dense) bone and Spongy (cancellous, trabecular)**



Flat bone



Long bone

External and internal surfaces are covered by a connective tissue coats – the periosteum (well developed) and the endosteum (less obvious)

Compact bone consists of **three types** of lamellae

Concentrically arranged lamellae around longitudinal haversian canals, number: 4 to 20

Form cylindrical units called **osteons** that run parallel to longitudinal axis of bone

In cross sections, osteons appear as concentric rings around circular opening (Haversian canal),

In longitudinal sections lamellae resemble closely spaced bands

Interstitial lamellae

Are lamellae without relations to blood vessels

Supposed to be rests of old non-fuctional Haversian systems

which are just being resorbed

Circumferential lamellae

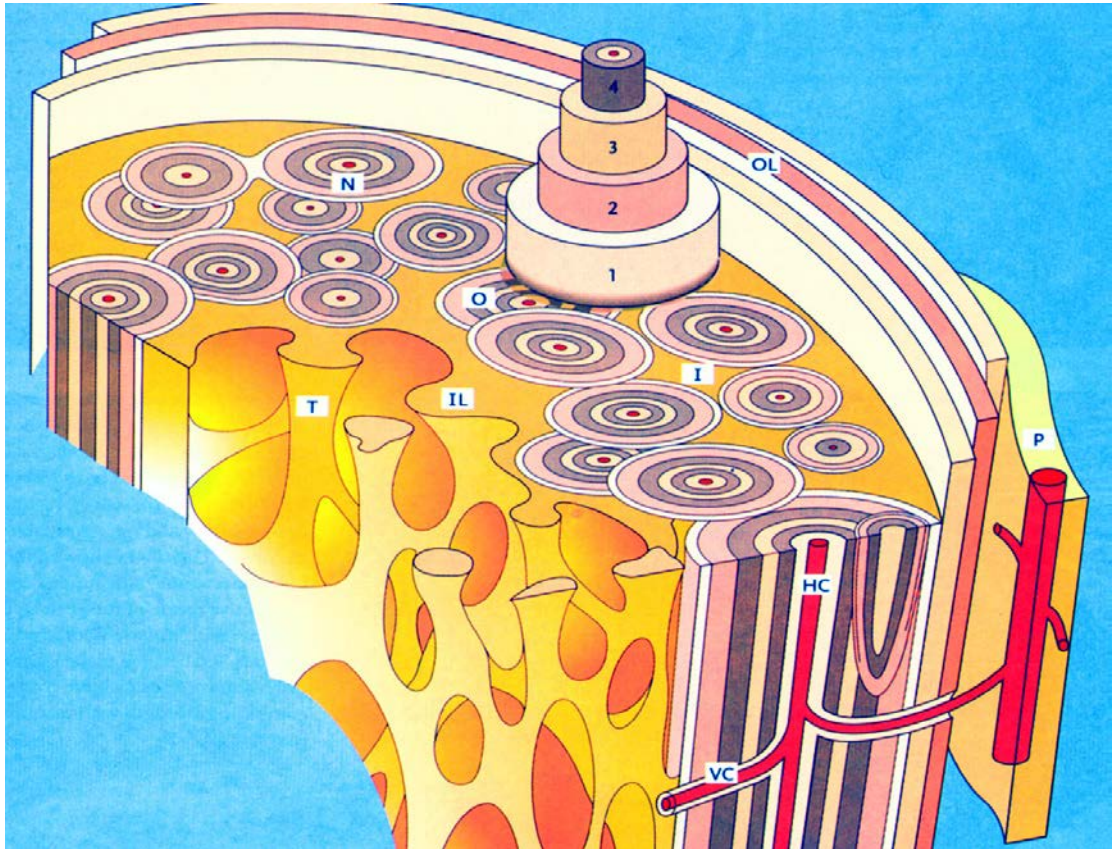
Located at outer and at inner surface of bone

Run in parallel to the periosteum or parallel to endosteum

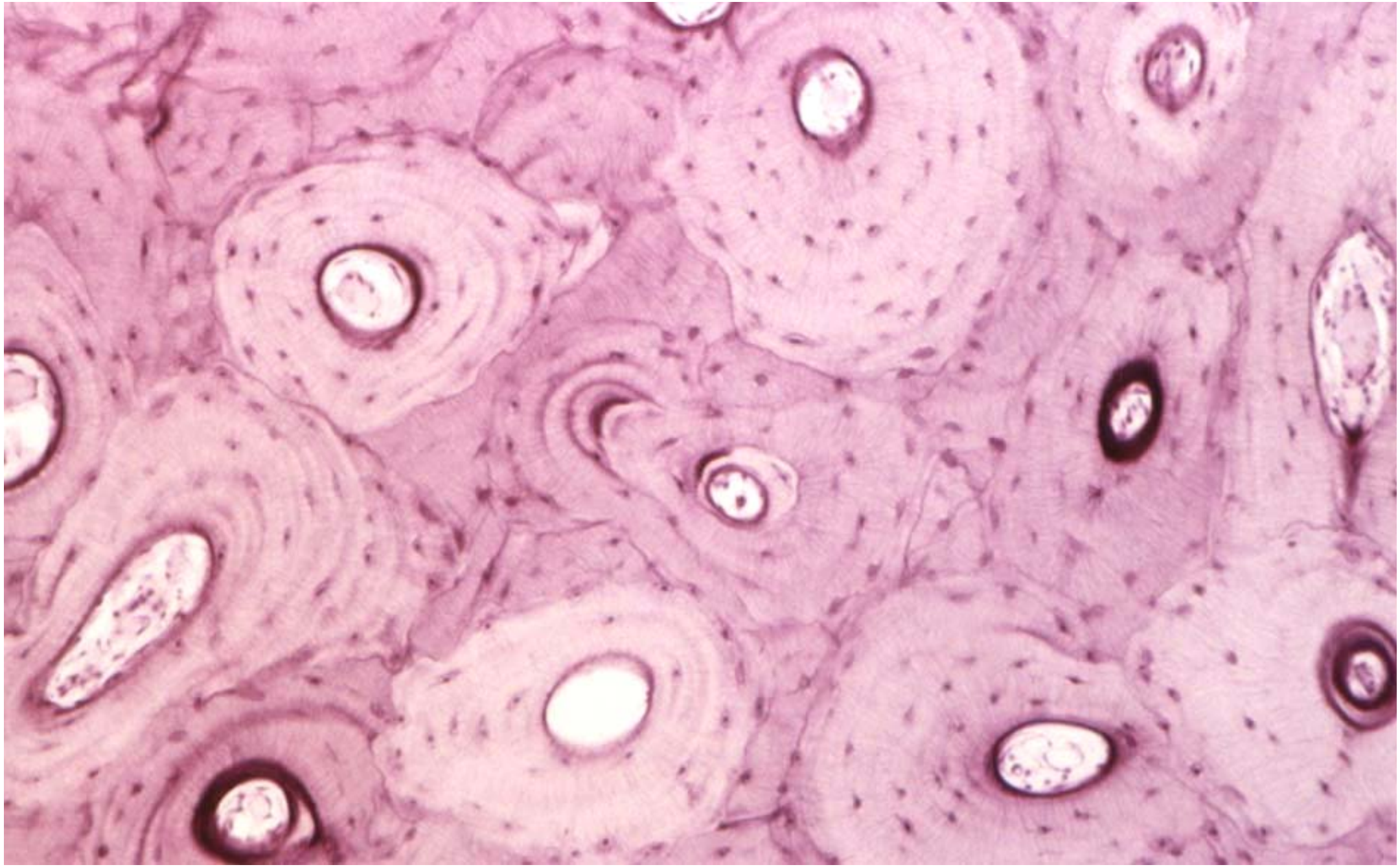
(around the central cavity)

Outer circumferential lamellae

Inner circumferential lamellae



Diaphysis transversally (HE)



2 types of vascular channels in the compact bone

Haversian canals

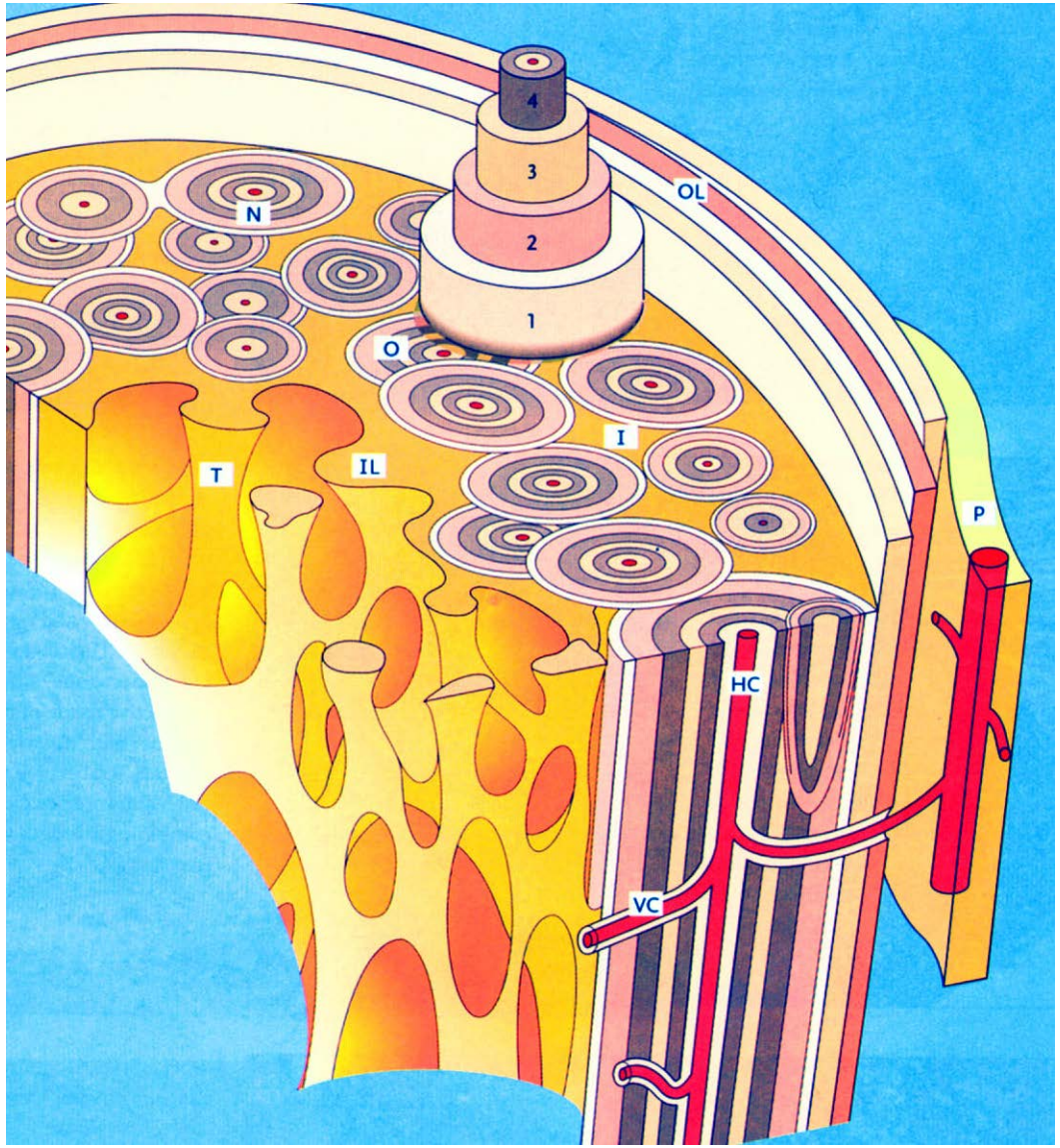
In the centers of Haversian systems

Contain one or two blood vessels

Volkmann's canals

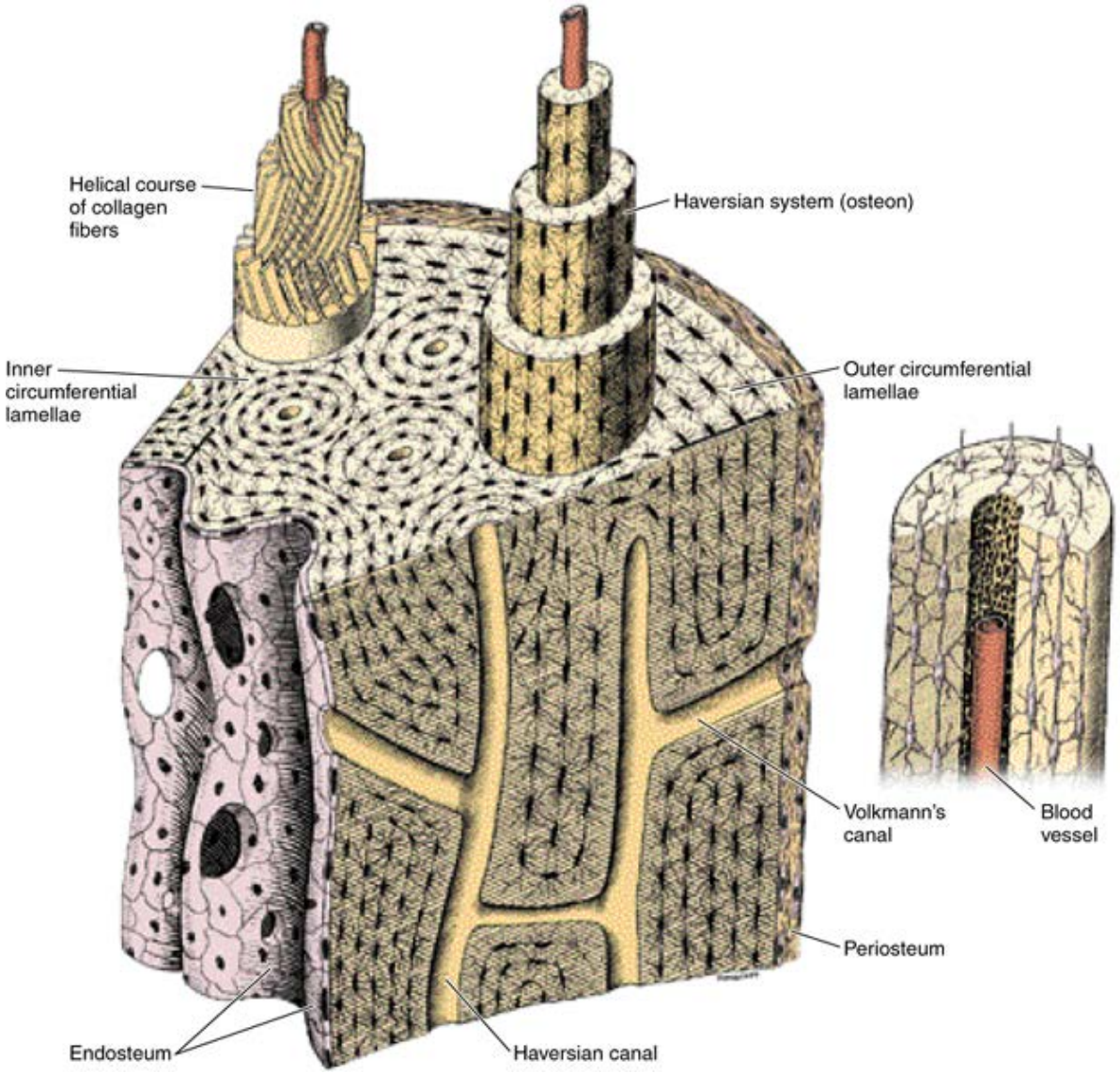
Are not surrounded by lamellae and traverse the bone in perpendicular or oblique direction to the Haversian canals

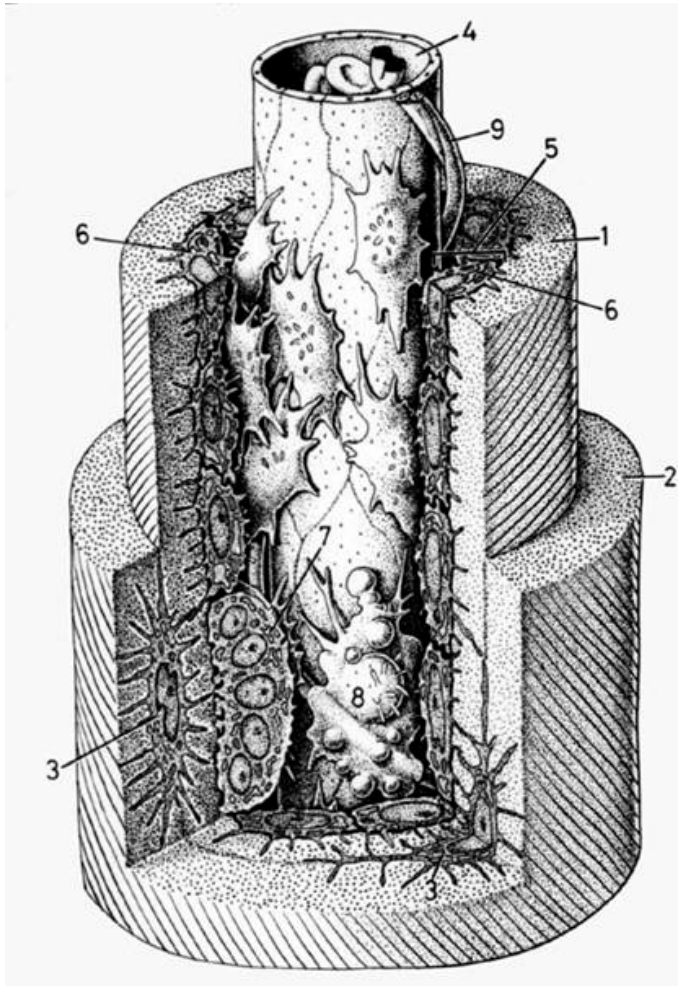
Function: connect Haversian canals with one other and serve for vessels entering the compact from the periosteum or the marrow cavity



Haversian and Volkmans canals

Osteon


Helical course of collagen fibers
Haversian system (osteon)
Inner circumferential lamellae
Outer circumferential lamellae
Volkmann's canal
Blood vessel
Periosteum
Endosteum
Haversian canal


4
9
5
6
1
6
2
7
8
3
3

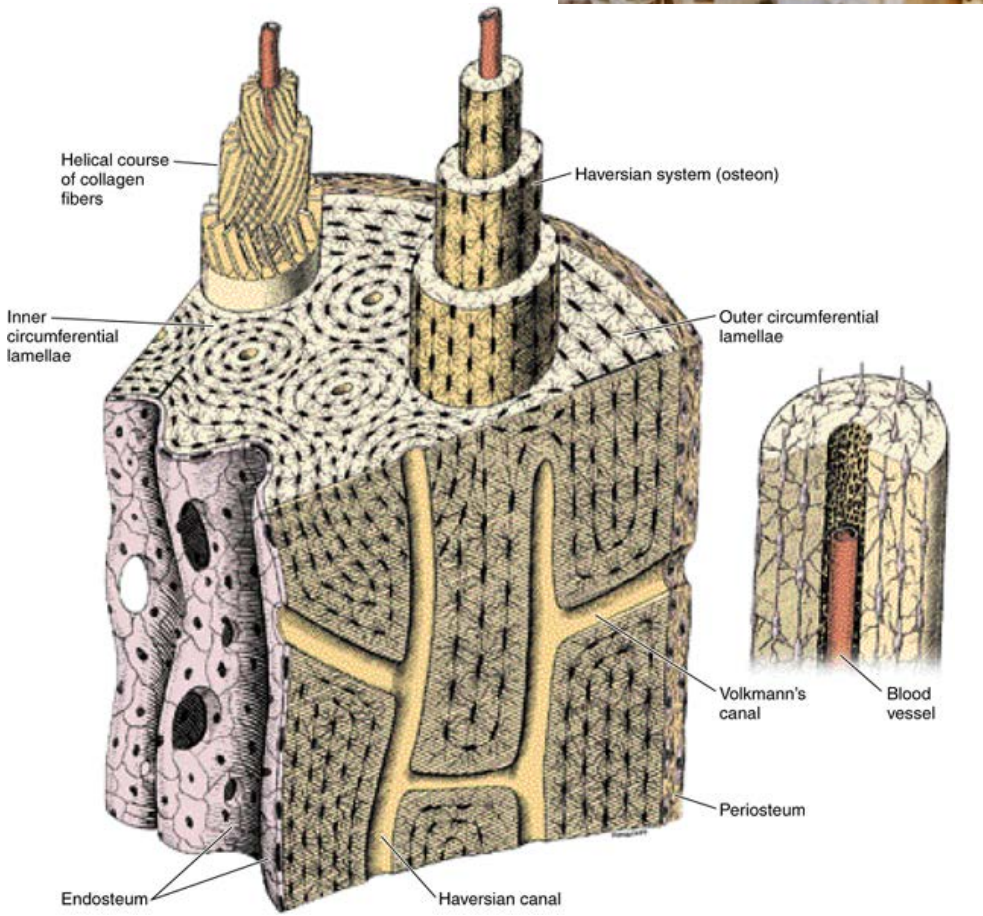
Cancellous/Trabecular bone

composed by trabeculated bone tissue
The course of depends of forces from outer environment

Periostem

Around the bone – from outside
Highly innervated (pain)

2 layers:
Stratum fibrosum, Sharpey‘s fibres
Stratum osteogenicum – osteoprogenitor cells



Endosteum

On the inner surface
Same structure as the periosteum, but thinner

Bone plasticity

Bones as organs can remodel the internal structure to match the actual mechanical load

Remodelling: interaction/equilibrium between osteoblasts and osteoclasts activity

Remodeling is rapid in childhood - it is reported that about 10% of skeletal bones are rebuilt each year

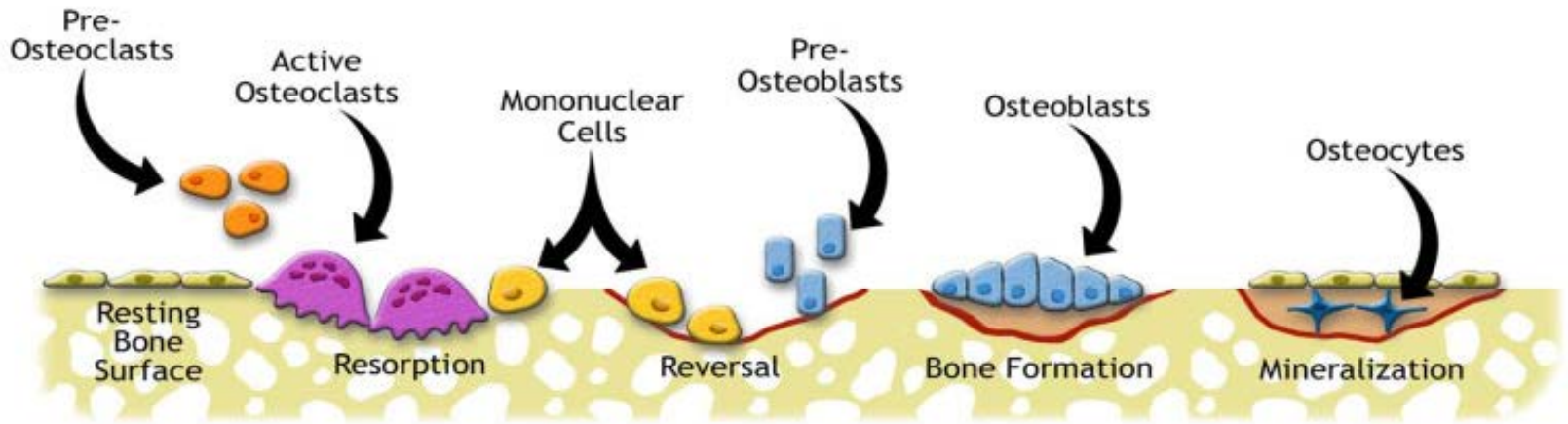
Bone remodeling can be induced by artificial stimuli: by the action of tension or pressure

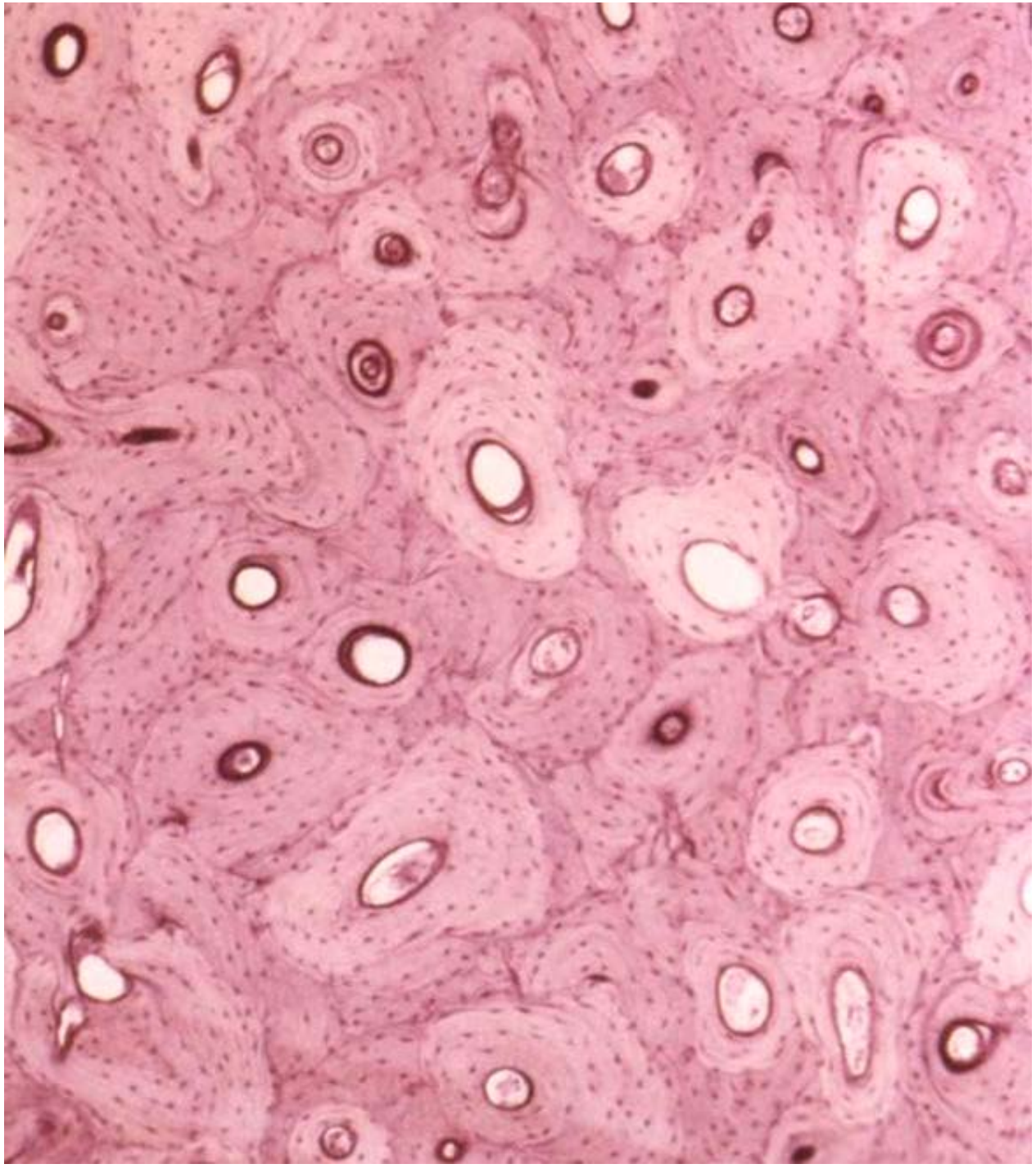
The action of tension creates new bone tissue,

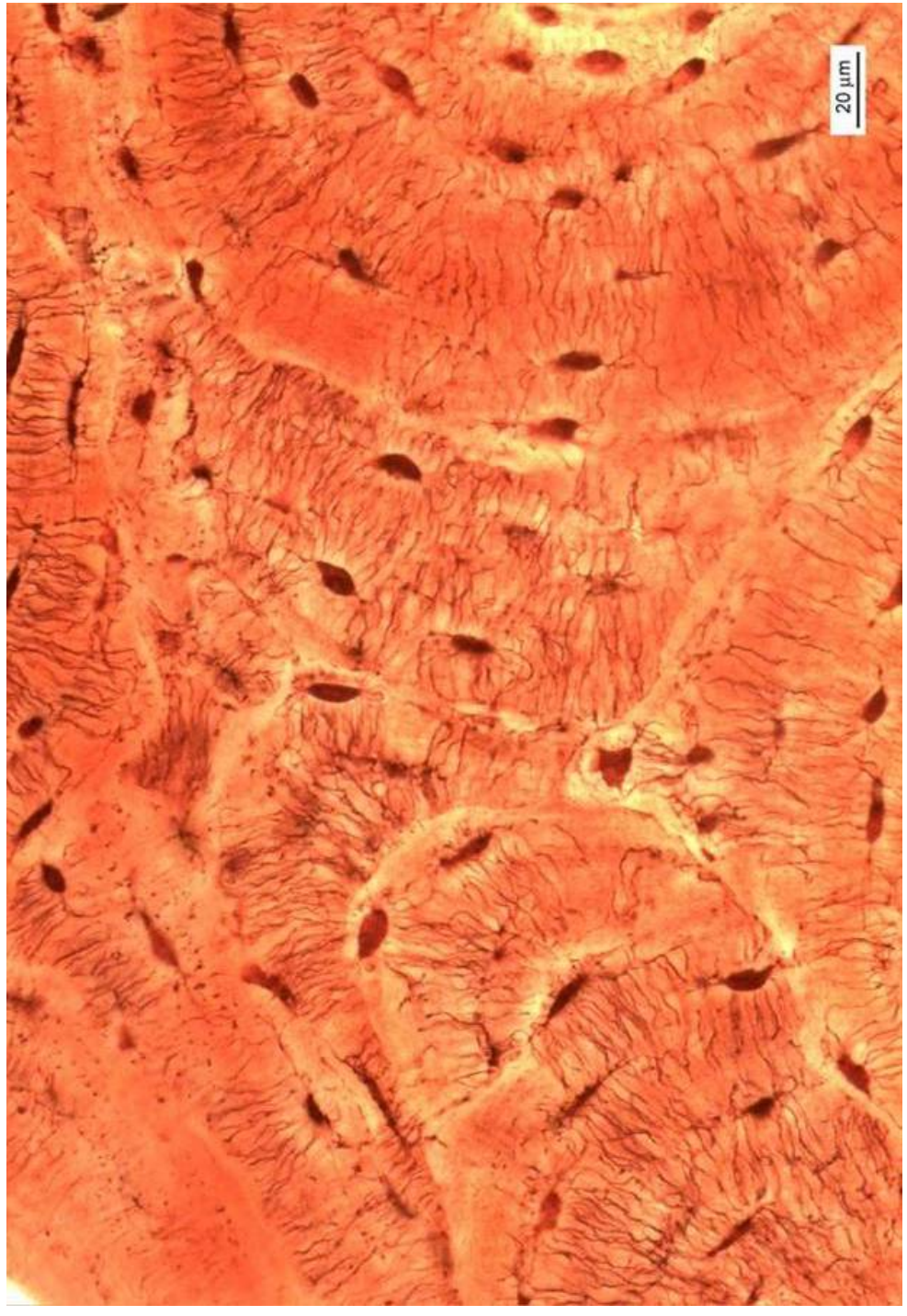
Opposite, it is resorbed under the action of pressure

The role of osteocytes - they act as mechanosensors, they transmit a signal to osteoblasts in the endost or periosteum, and they transmit it to osteoclasts

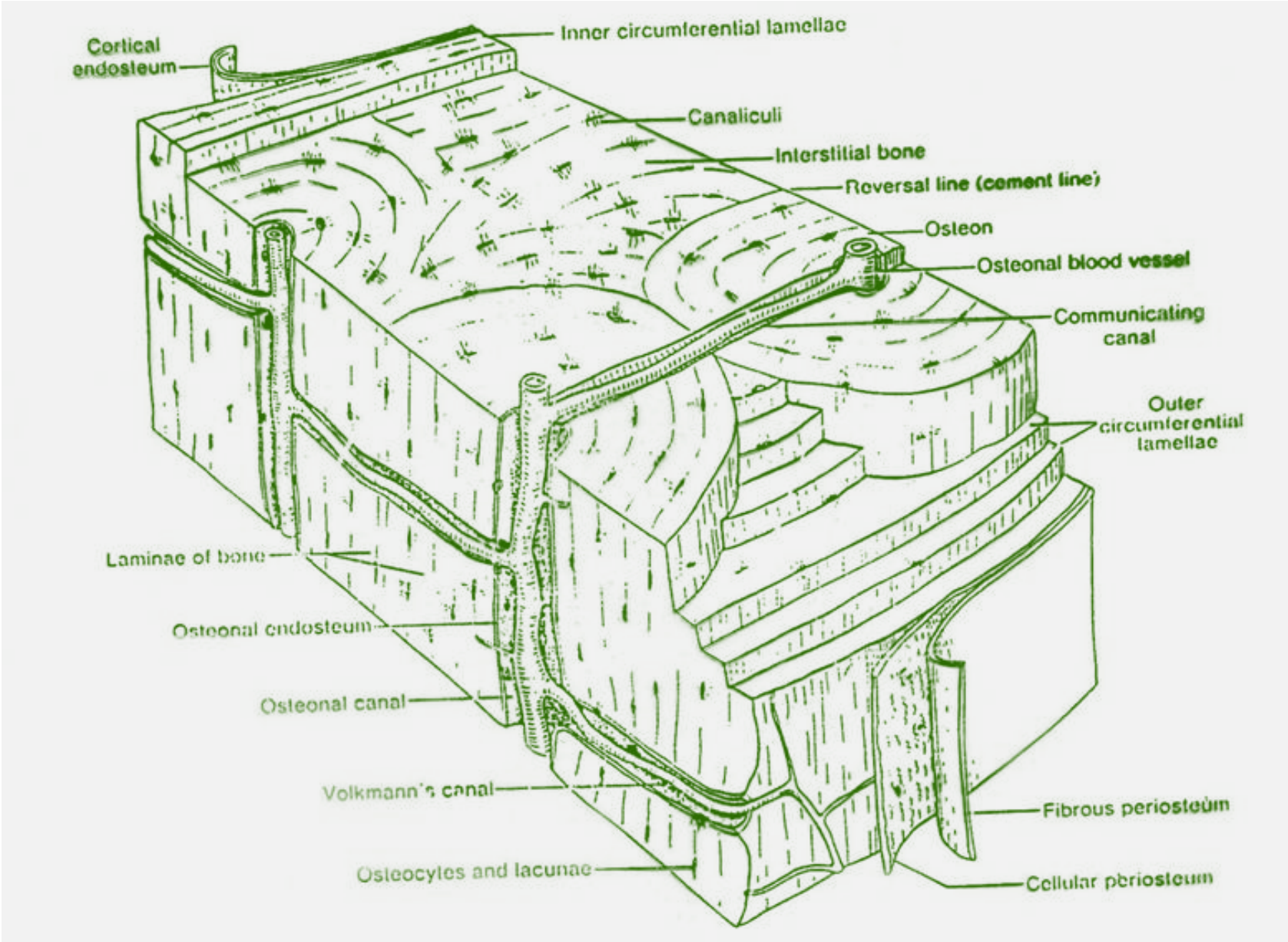
Cycle of bone remodelling






20 µm

Summary

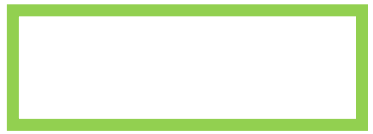

Cortical endosteum
Inner circumferential lamellae
Canaliculi
Interstitial bone
Reversal line (cement line)
Osteon
Osteonal blood vessel
Communicating canal
Outer circumferential lamellae
Laminae of bone
Osteonal endosteum
Osteonal canal
Volkmann's canal
Osteocytes and lacunae
Fibrous periosteum
Cellular periosteum

Alveolar process (processus alveolaris)

Part of the jaw which form the bony support for teeth (*alveoli dentales*)
The protrusion, like other anatomical sections of the jaws, is composed of **lamellar-type bone tissue - dense and spongy**

<u>Compact bone</u> structure
2 plates:

- **Cortical (external alveolar)** - forms the vestibular or oral side of the alveoli
- **Cribriform (internal alveolar, os alveolaris, lamina dura)** - forms the wall of alveoli

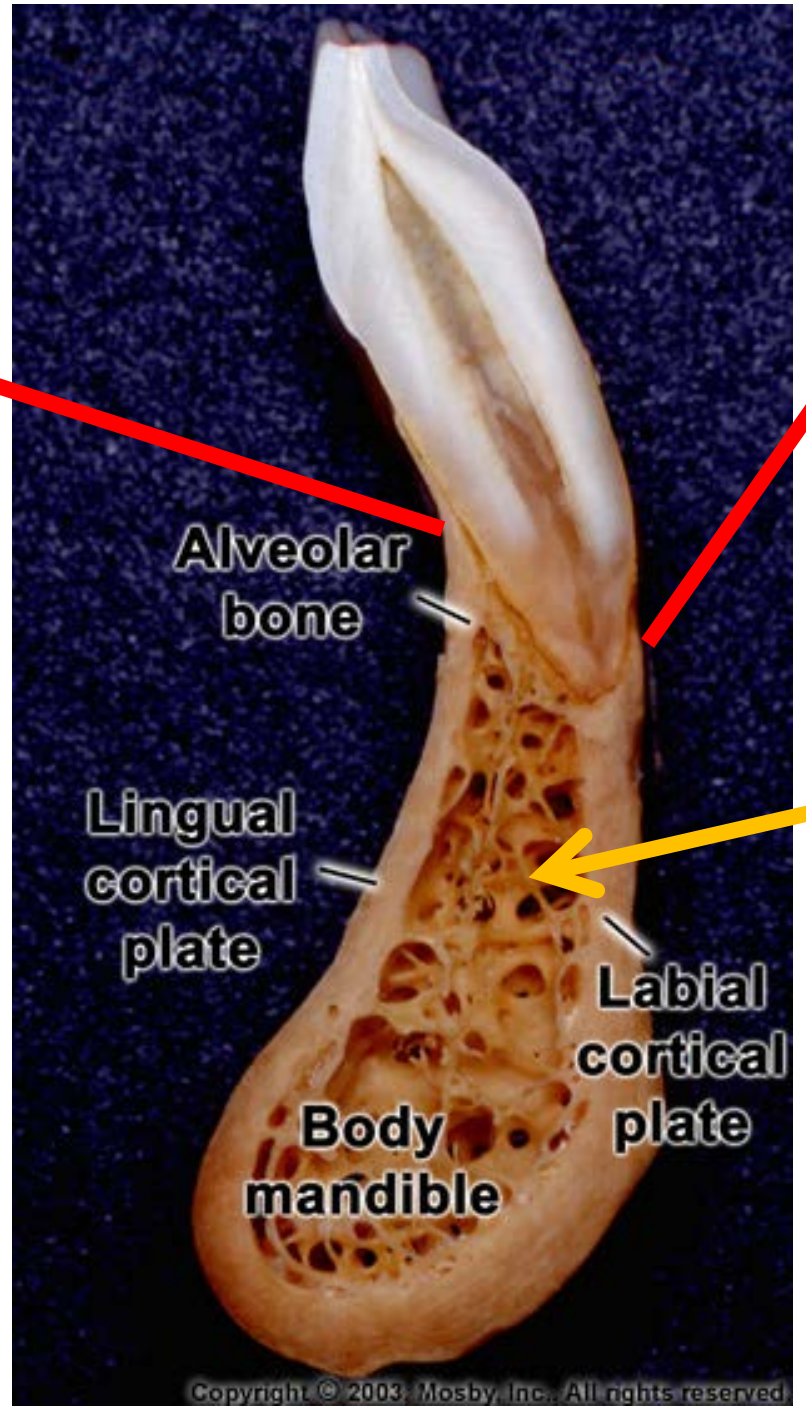


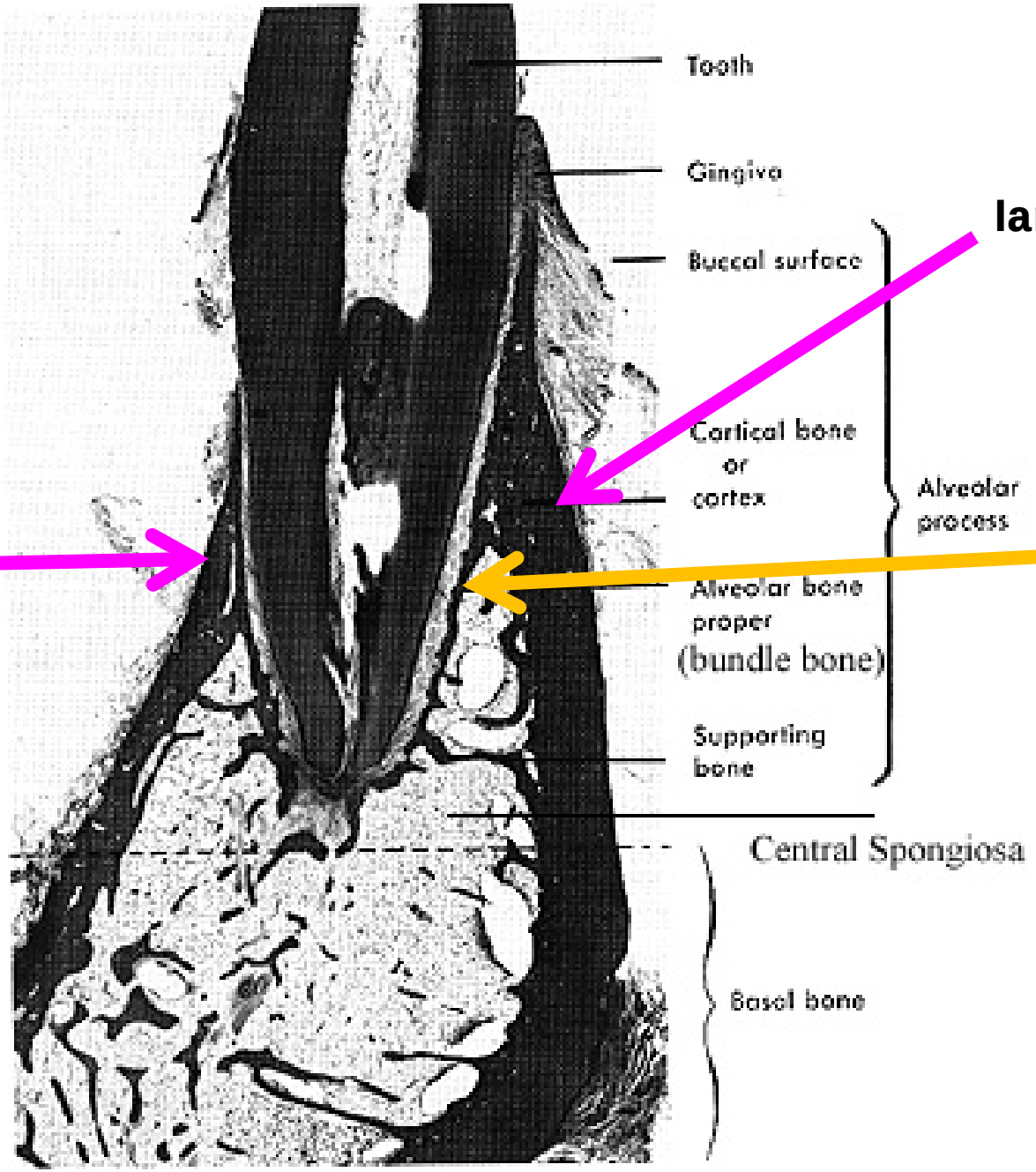
Cortical (outer alveolar) plate
Thicknes: **1,5 - 3,0 mm**

Divided into:
- **Lamina vestibularis**
- **Lamina oralis**

Both are covered by periosteum
Osteons in different directions

In the area of mandibular molars is lamina oralis usually thickened





Cortiaal lamina vestibularis

Cortical lamina oralis

Cribriform os alveolare

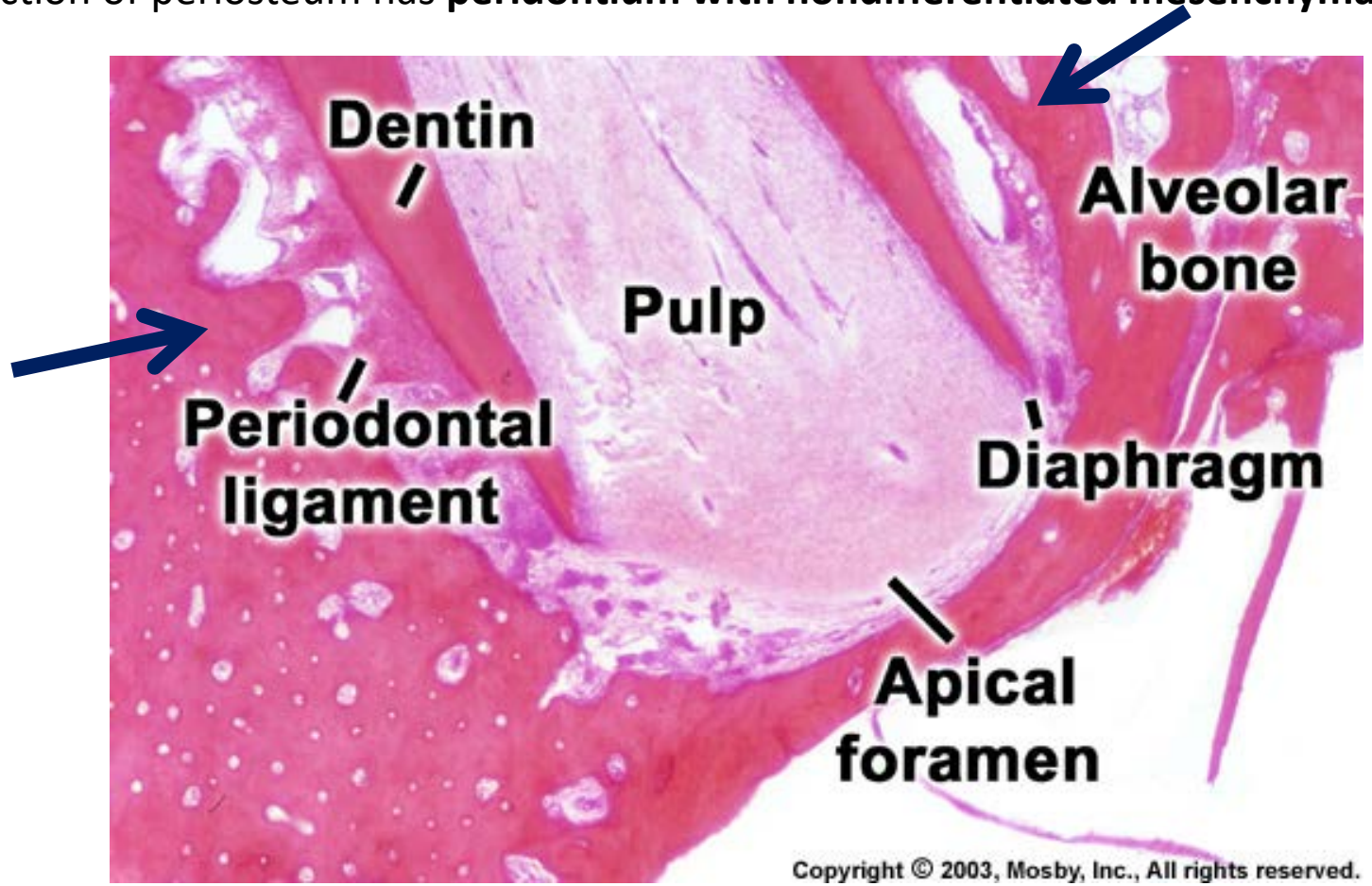
Cribriform plate (inner alveolar plate = os alveolare)

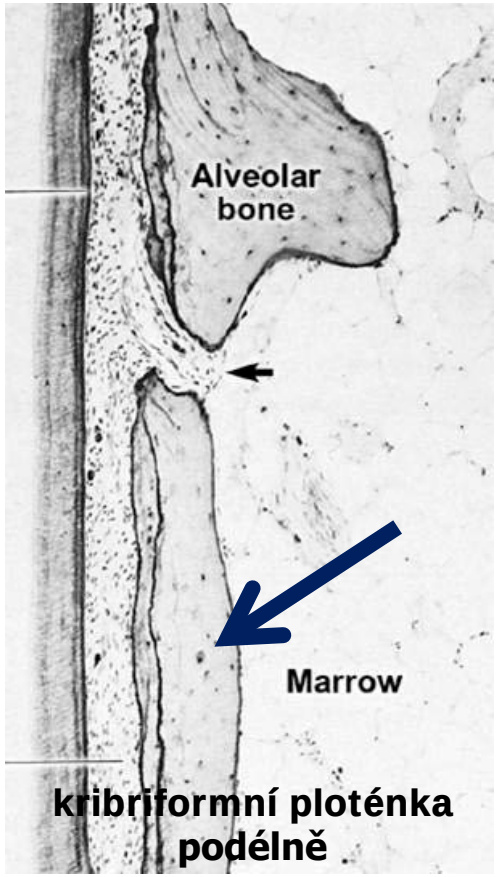
Forms the wall of alveolus, is thinner – **0,5 - 1,0 mm**

Perforated by Volmanns channels (for interalveolar vessels and nerves)

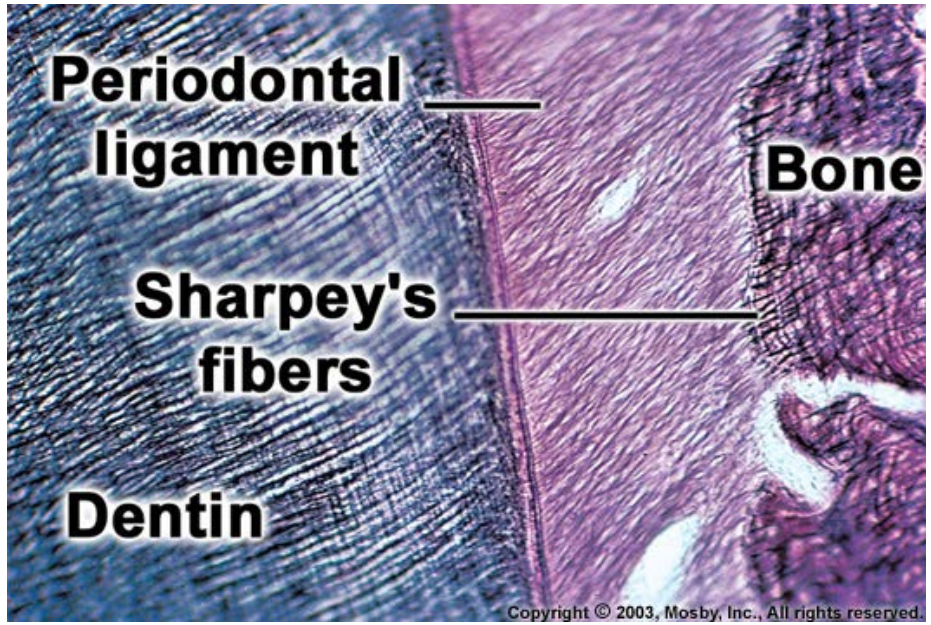
Structure similar as in cortical plate, but no periosteum

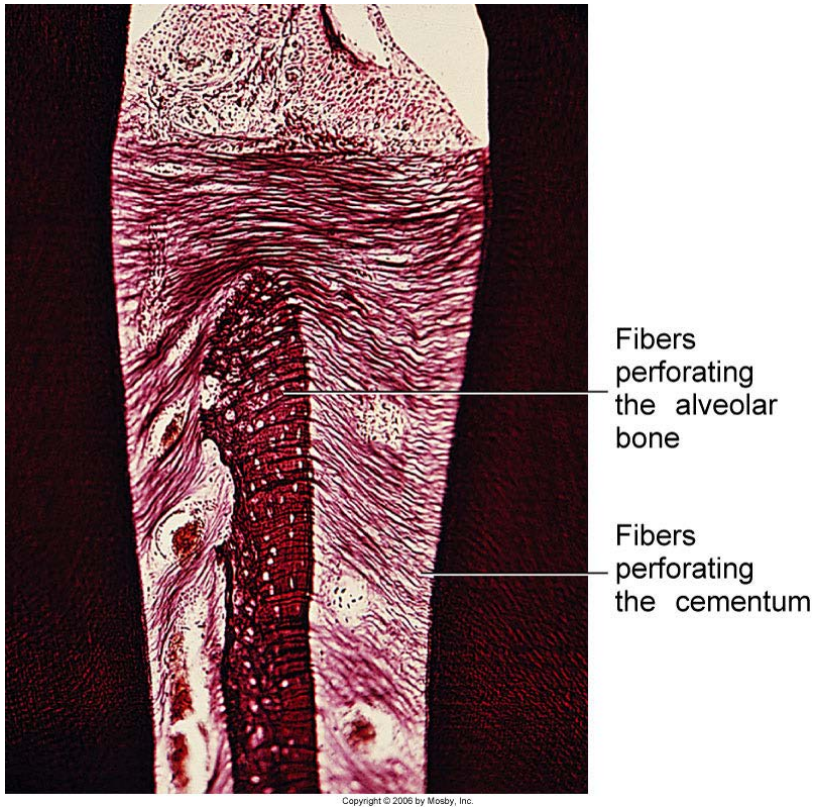
The function of periosteum has **peridontium with nondifferentiated mesenchymal cells** (diferentiate into different -blasts)





In cribriform plate are anchored PDL endings – Sharpey‘s fibres





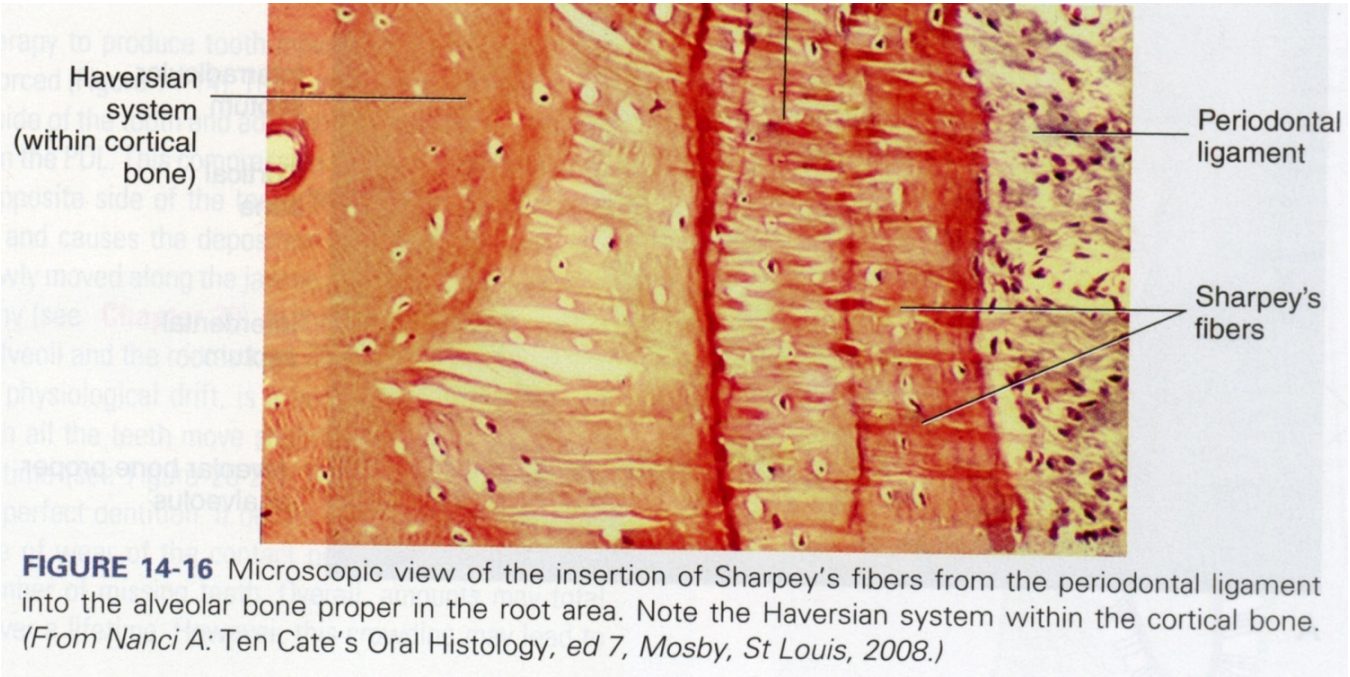
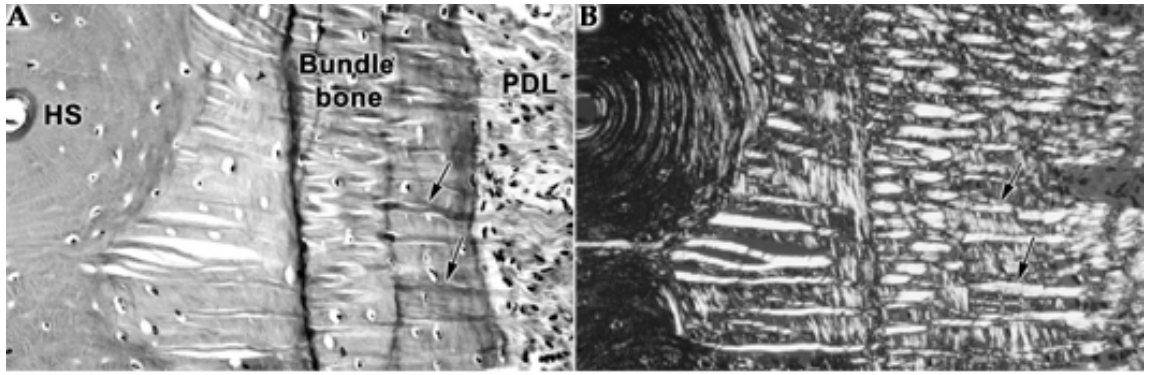


FIGURE 14-16 Microscopic view of the insertion of Sharpey's fibers from the periodontal ligament into the alveolar bone proper in the root area. Note the Haversian system within the cortical bone. *(From Nanci A:* Ten Cate's Oral Histology*, ed 7, Mosby, St Louis, 2008.)*



Cribriform plate is more mineralized – on X-ray has higher density – **lamina dura**

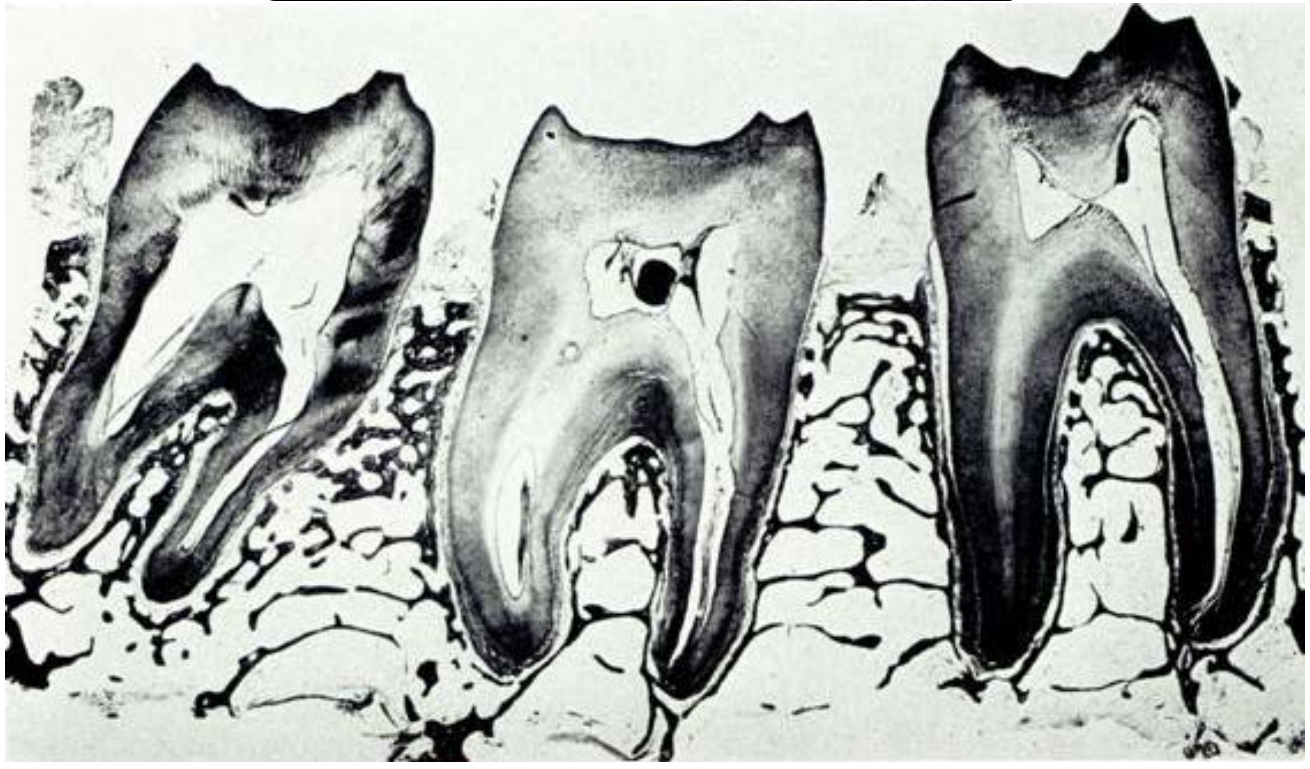
In teeth of primary dentition and young secondary the **lamina dura** is flat, later has wavy structure

Cancellous / Spongy bone

Trabeculae - filling between the plates, high variability in the arrangement of the trabeculae (mostly horizontal direction)

Located between plates and in interdental and interradicular septae

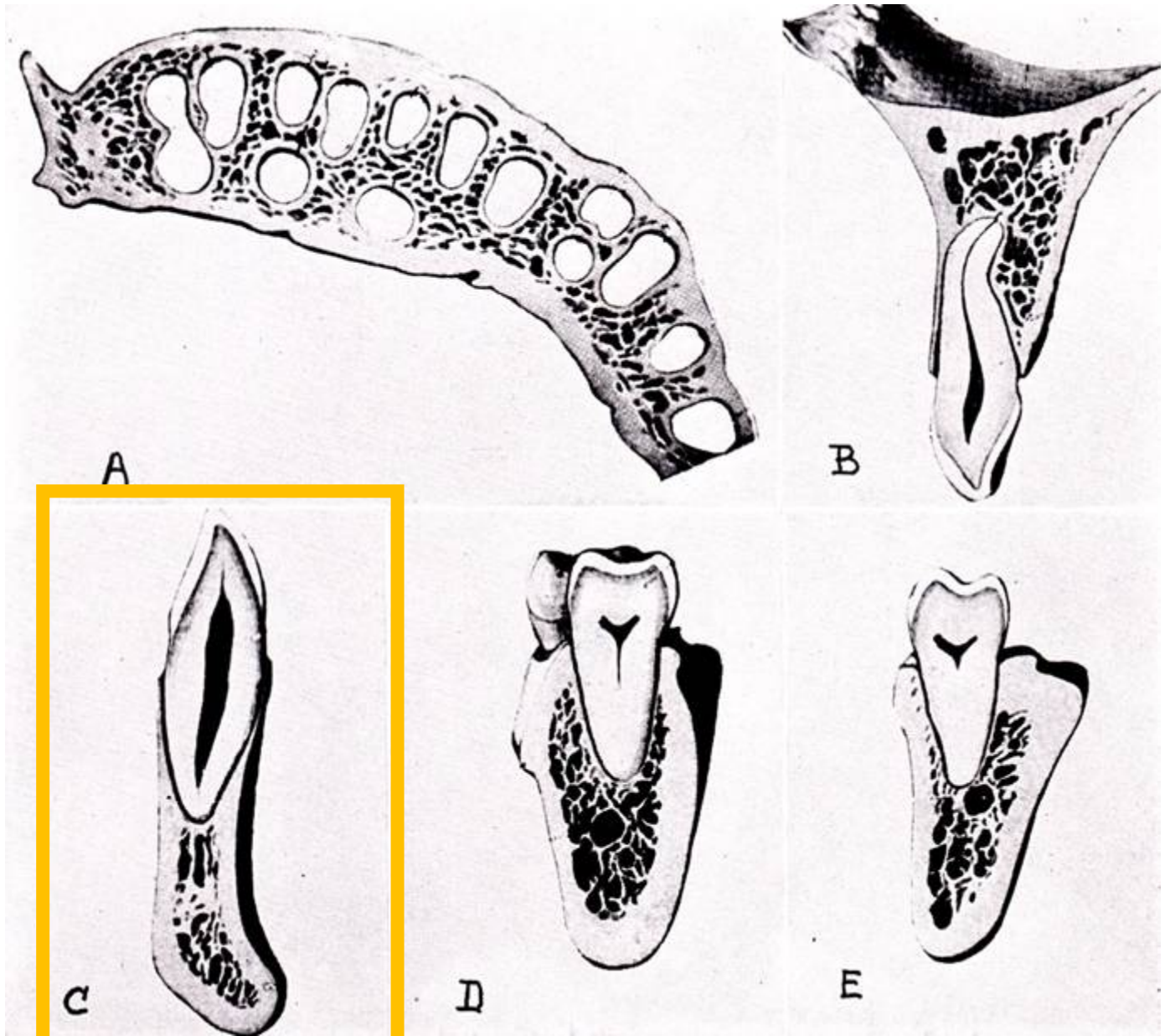
High variability in the arrangement of trabeculae

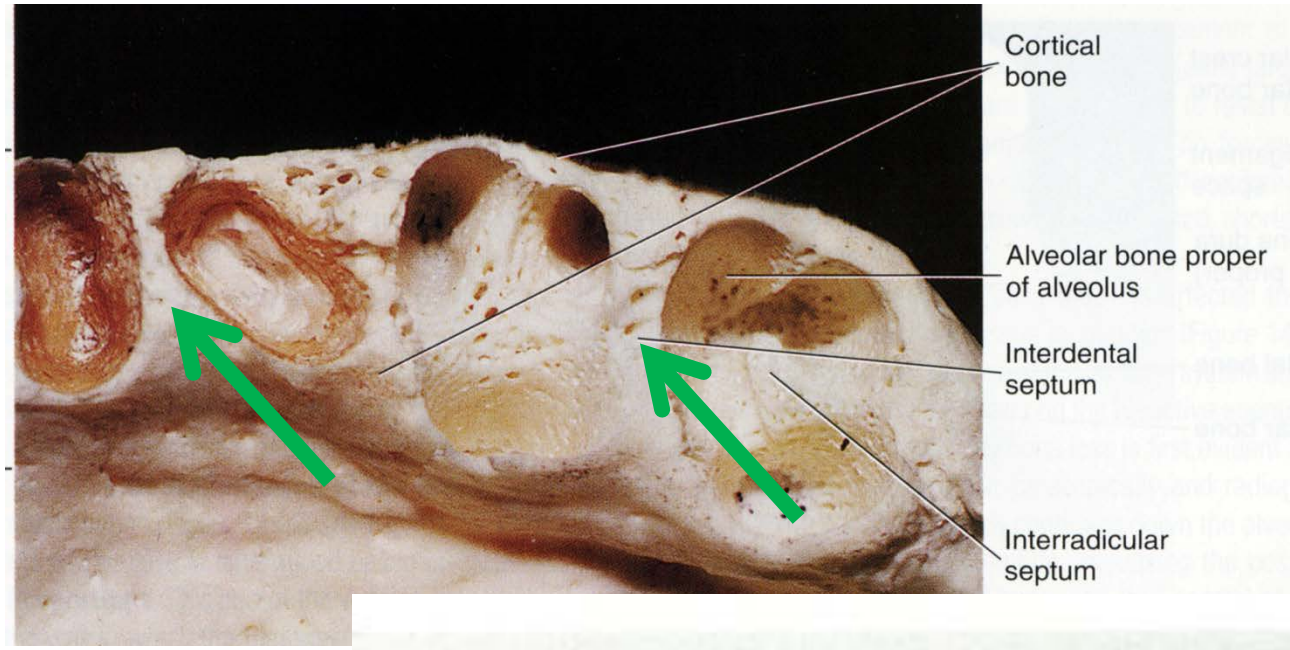


Horizontal course

Between the trabeculae is a hematopoietic bone marrow

In the area of maxillary and mandibular incisors: both lamina oralis and vestibularis fuse with the cribriform plate



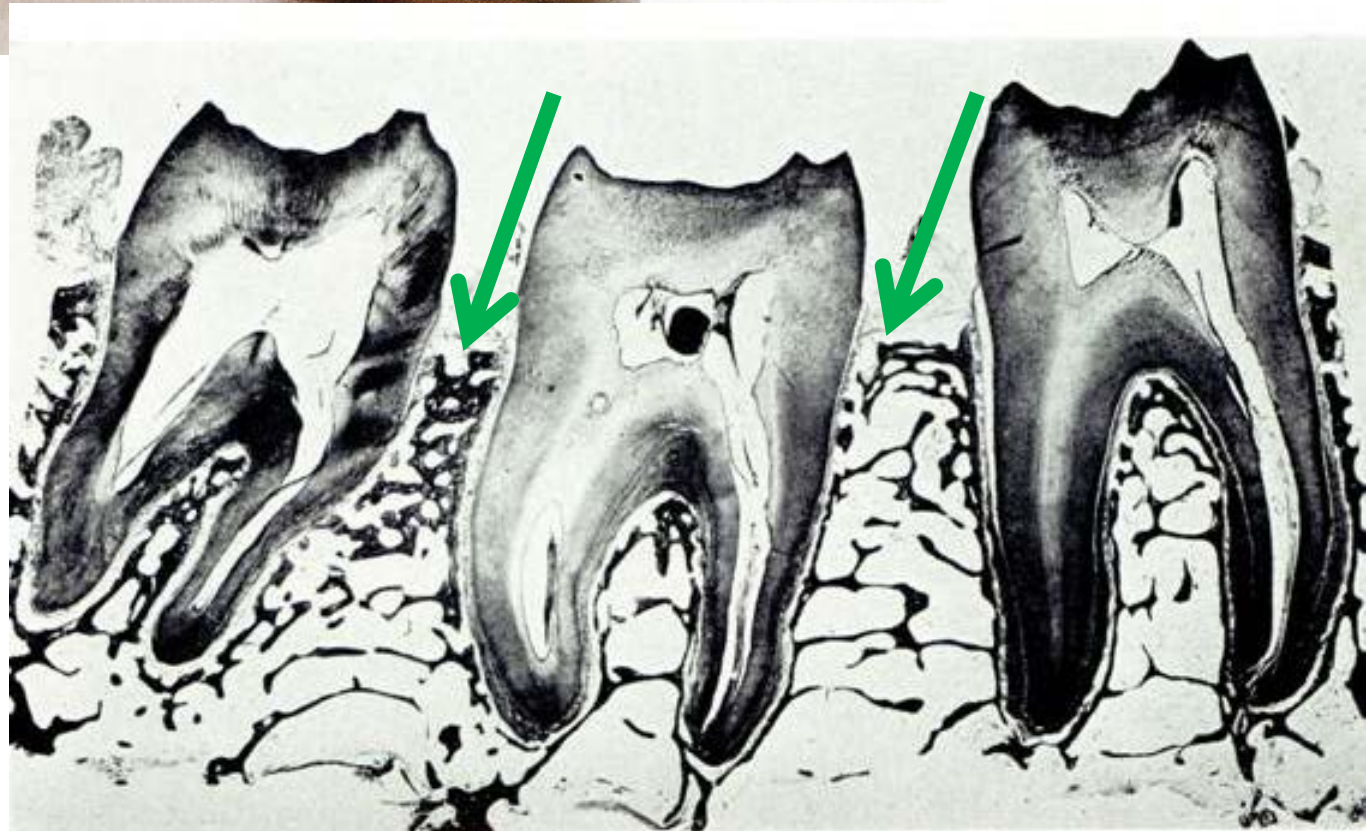


Different alveoli separates:

Interalveolar septae = **septae interdentalia**

Perpendicularly oriented partitions formed by the fusion of mesial and distal parts of cribriform plates of adjacent alveoli

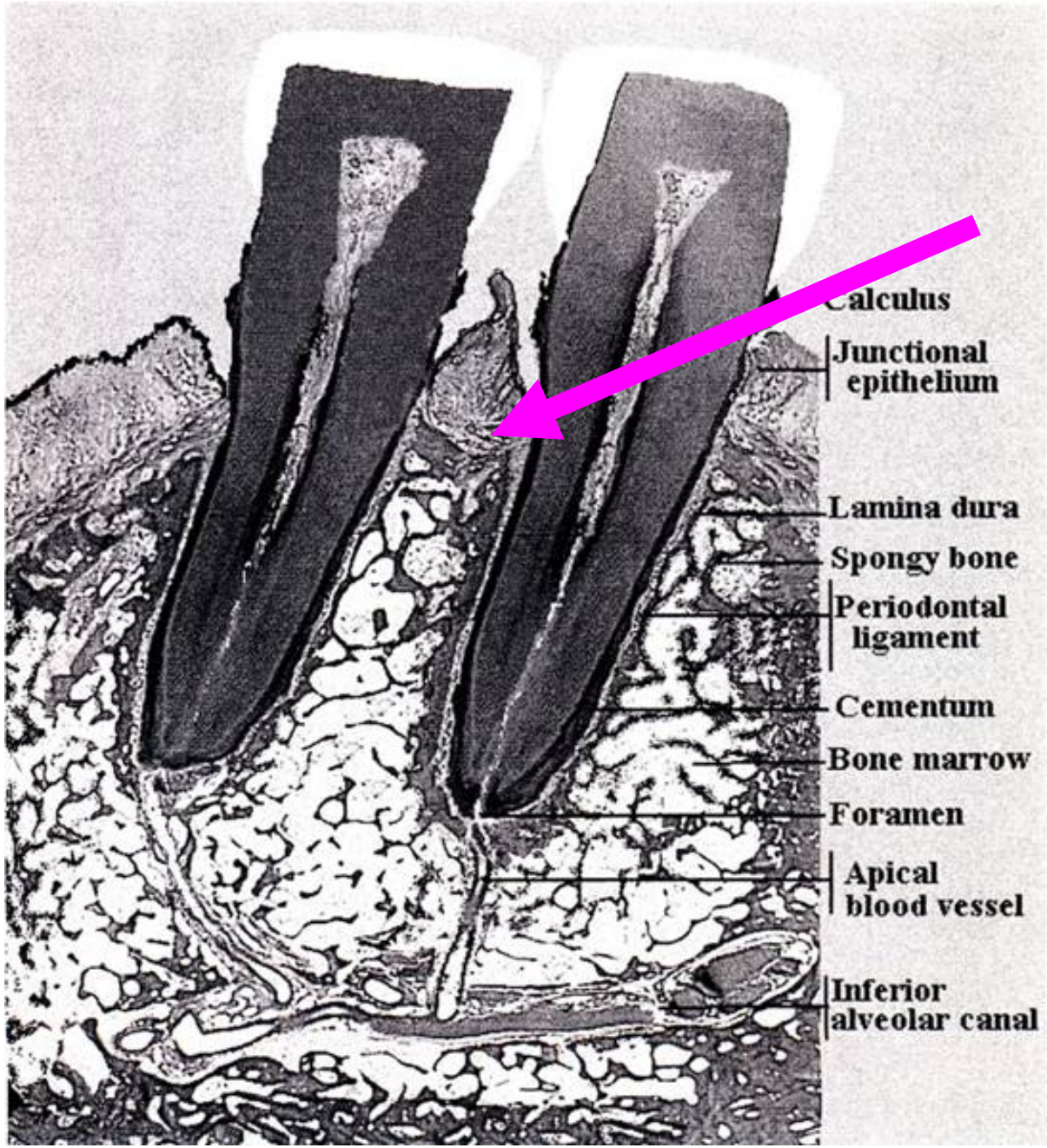
The ridges of the interdental septae are usually rounded and reach the CEJ level



Transseptal fibres

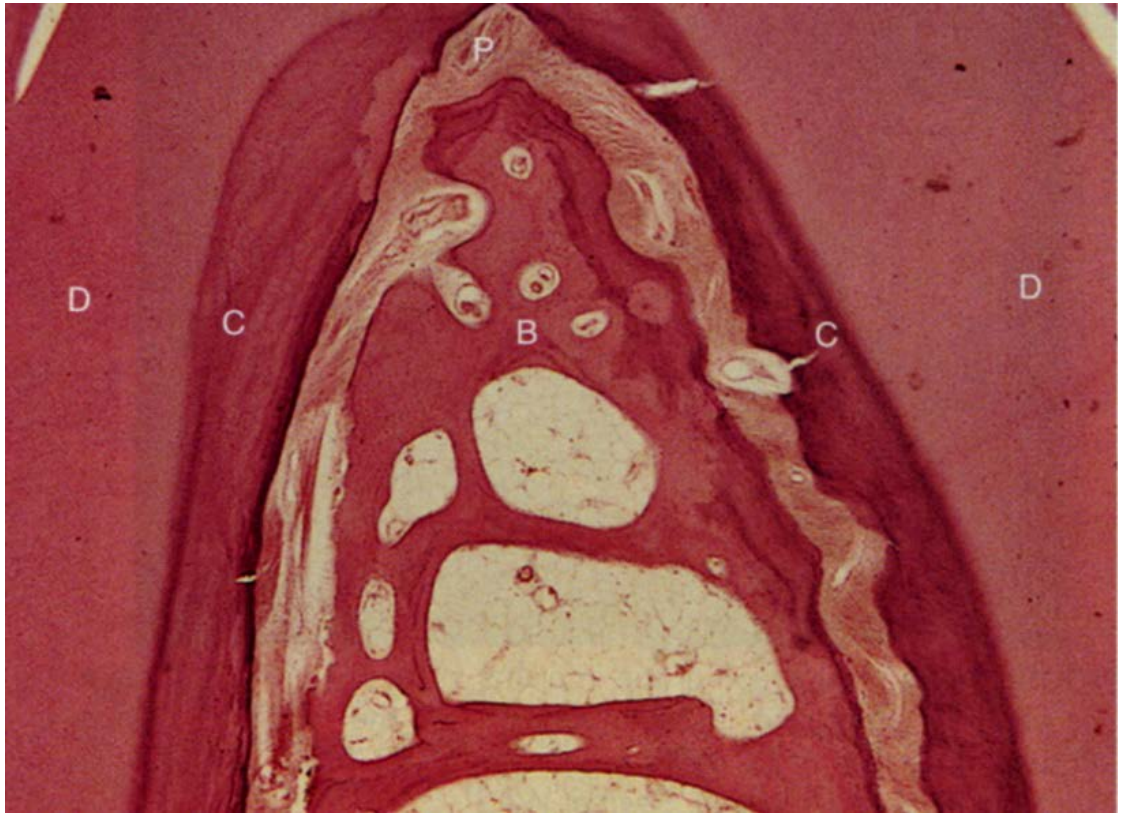
Above interdental septae are **transseptal fibres vlákna** (lig. interdentalia) – forms the shape of crests

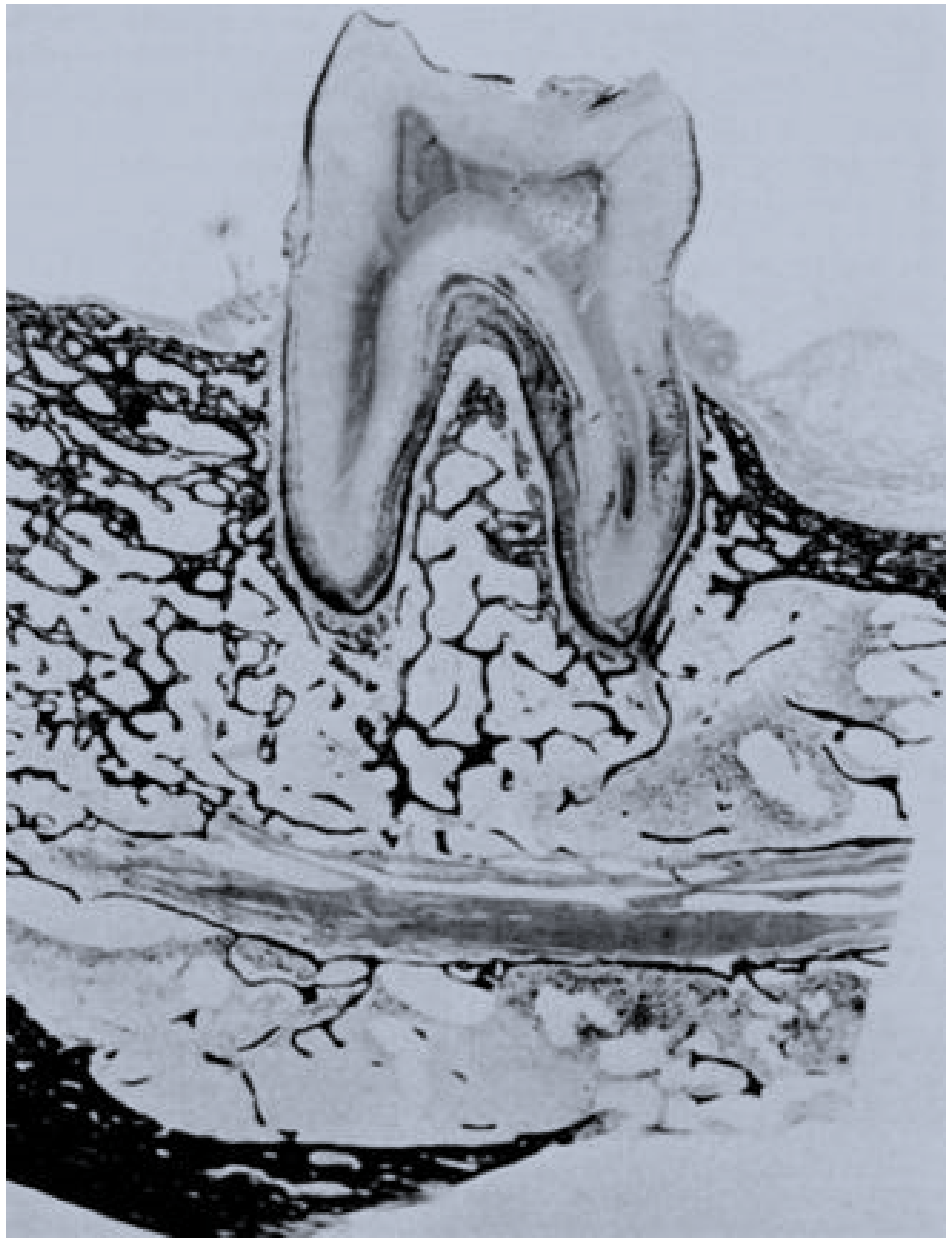
When teeth are inclined the pressure of fibres causes the tilt of crest in the direction of inclination (secondarily, the septum may be shortened)



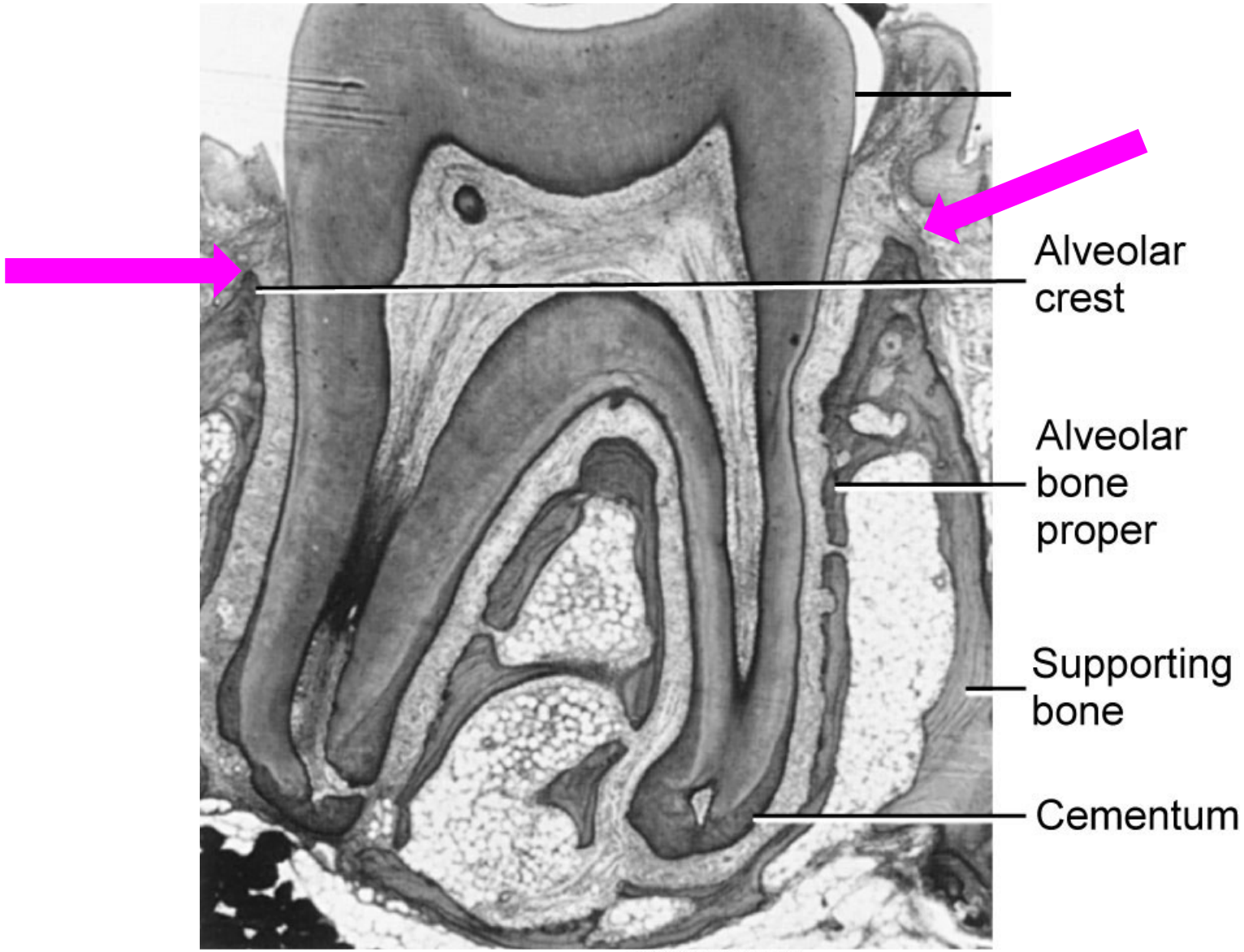
Septa interradicularia

Present only in teeth with more roots
Cribriformn plate together with trabecules of cancellous bone forms interradicular septs - **septa interradicularia**





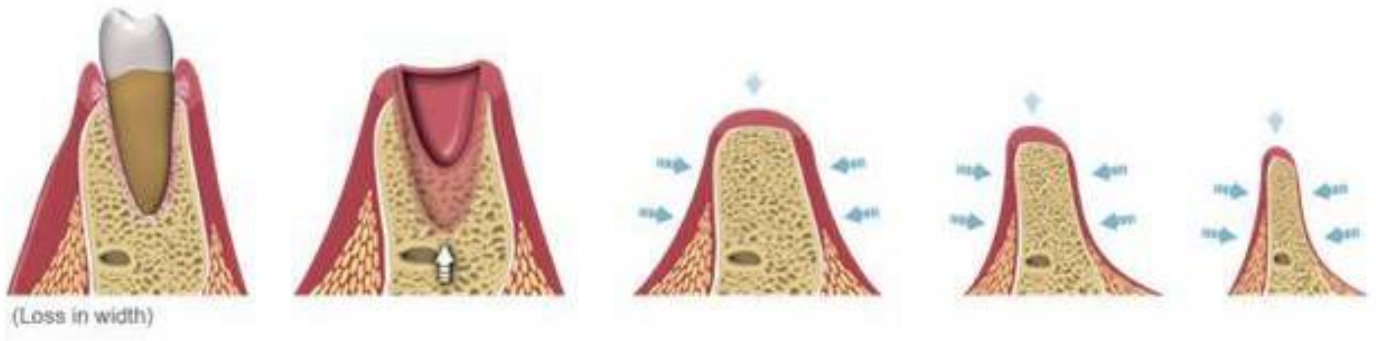
Edge of tooth alveolus – Alveolar crest – is the plase where the coronal end of cribriform plate meets lamina vestibularis or lamina oralis

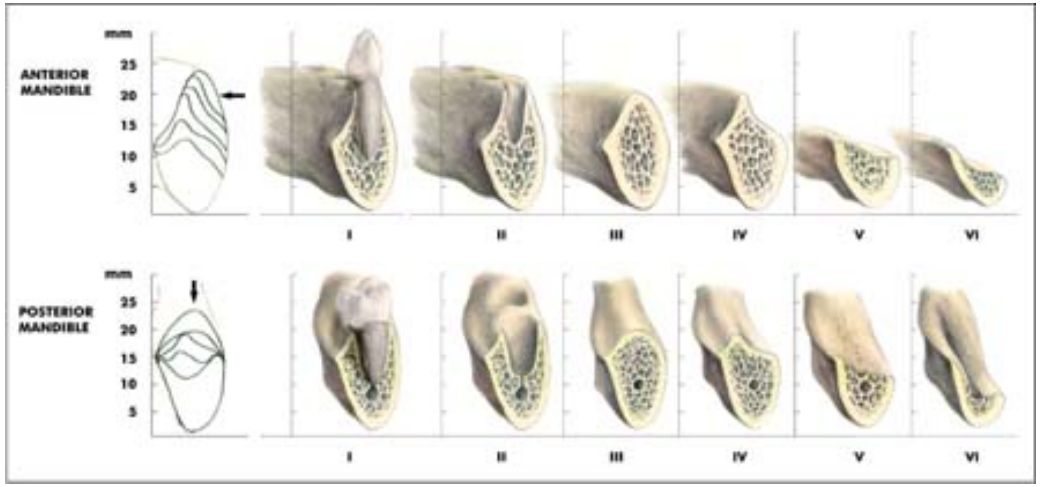


Clinical relevance of alveoli plasticity

The structure and arrangement of the alveolar ridge is affected by a number of factors such as:

- **Overall nutritional status**
- **Hormones (hyper-, hypo- production)**
- **Masticatory forces during food processing**
- **Growth of dental roots and tooth eruption**
- **Infection**
- **Tooth extraction**





Clinical relevance of alveoli plasticity

1. Because of different effect of long-lasting tension and pressure on the bone remodeling the bone structure can be achieved

Long-lasting tension – tooth formation **(tension zone)**

Long-lasting pressure – tooth resorbtion **(pressure zone)**

This is widely used in orthodontics

2. When the bone is not adequately loaded for a long time, structural changes occur

Applies for both the upper and lower jaw

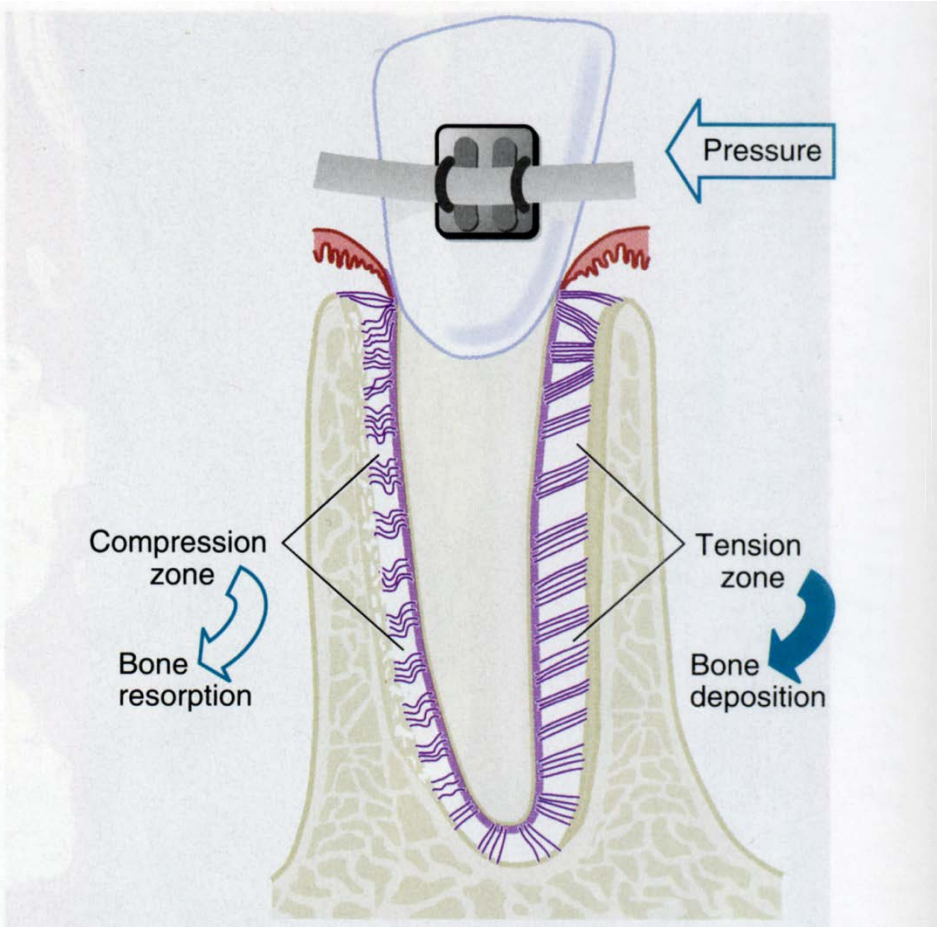
REMEMBER:

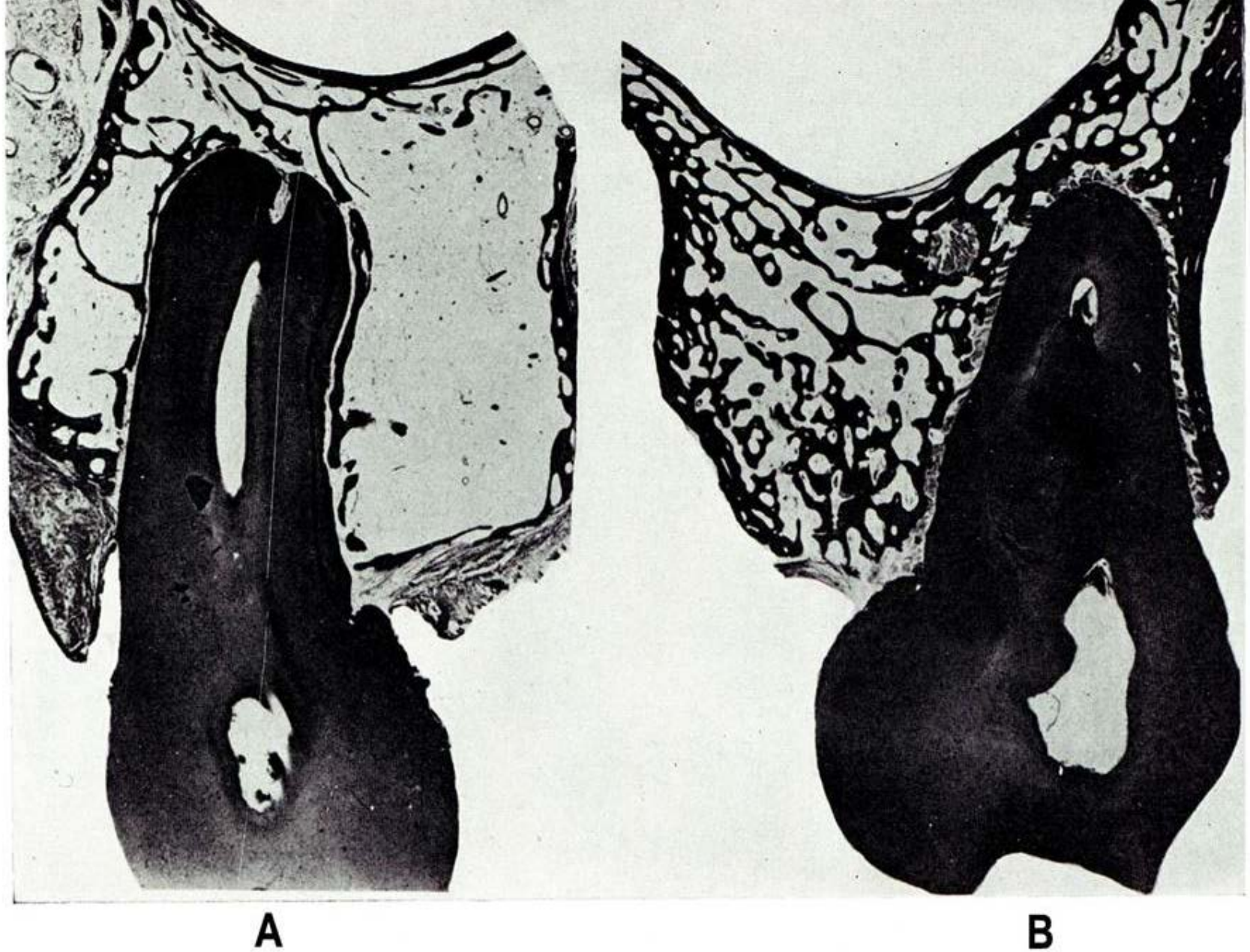
When antagonists are lost – if this condition last for a longer period of time (in the order of months) - there are changes in the alveolus and periodontal ligaments

2 conclusions:

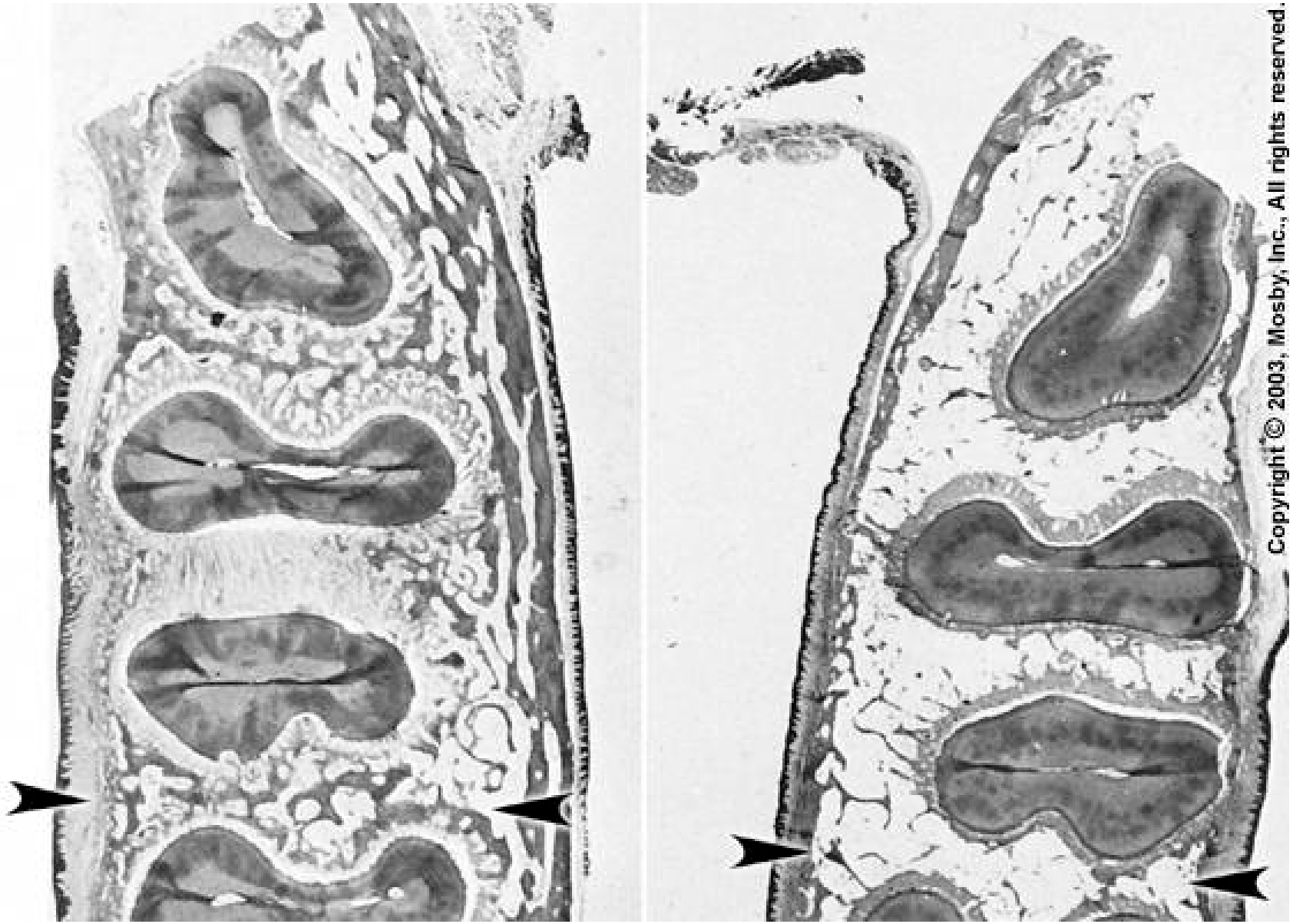
- Carefully indicate teeth extractions

- Fill missing or extracted teeth





A – changes after removal of antogonizing teeth
B – control



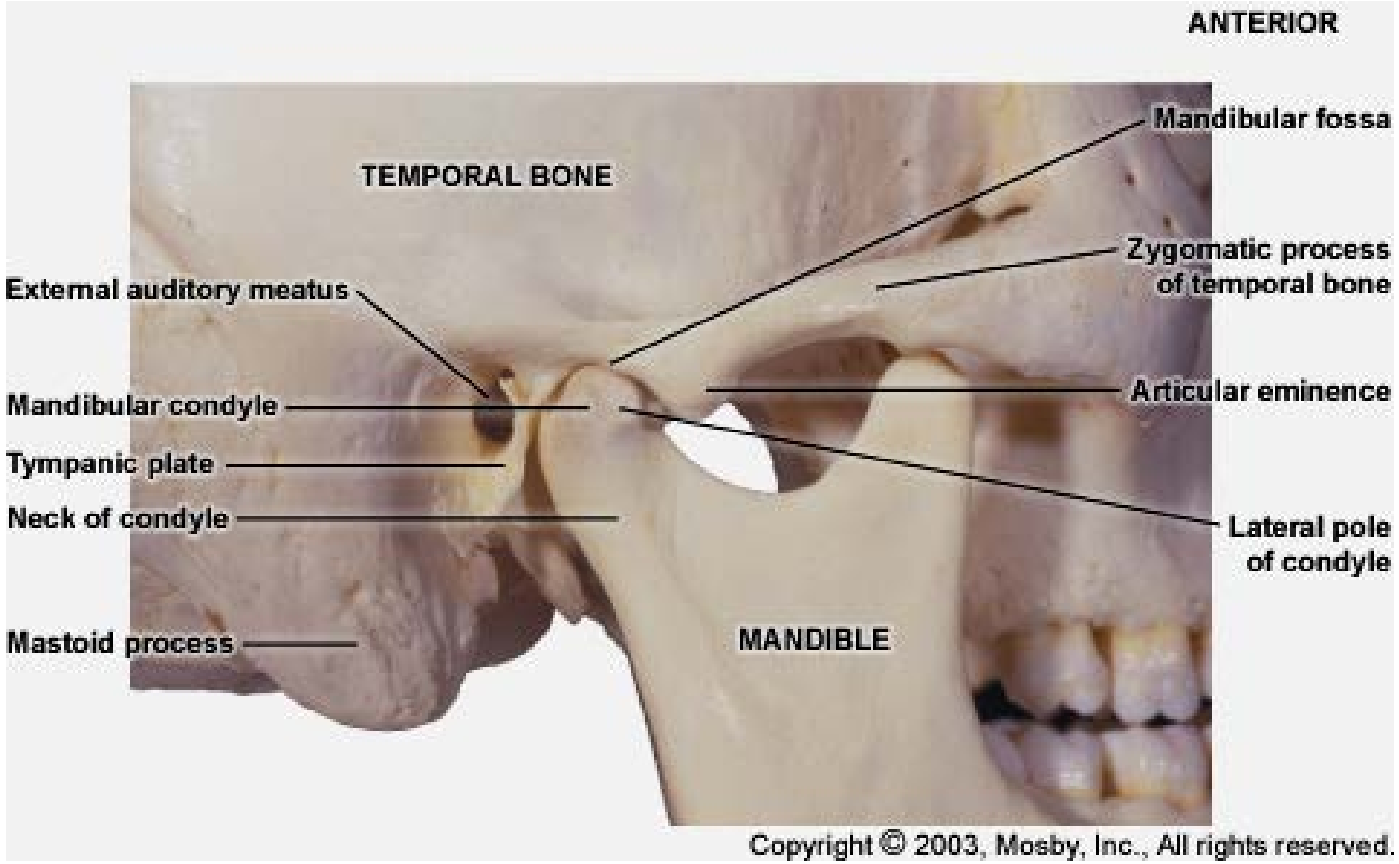
normal loading

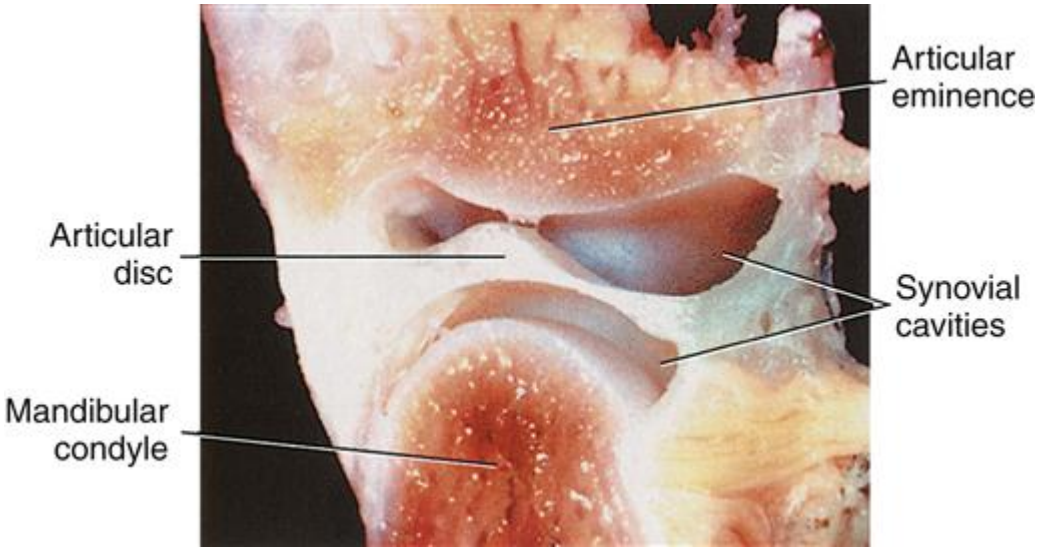
changes from inactivity

Temporomandibular joing (art. temporomandibularis, TMJ)

The connection between the mandible and the fixed temporal bone of the cranial base

Fossa mandibularis + **Tuberculum art**. of temporal bone
Caput mandibulae (condylus mandibulae)
Discus articularis – cartilage plate



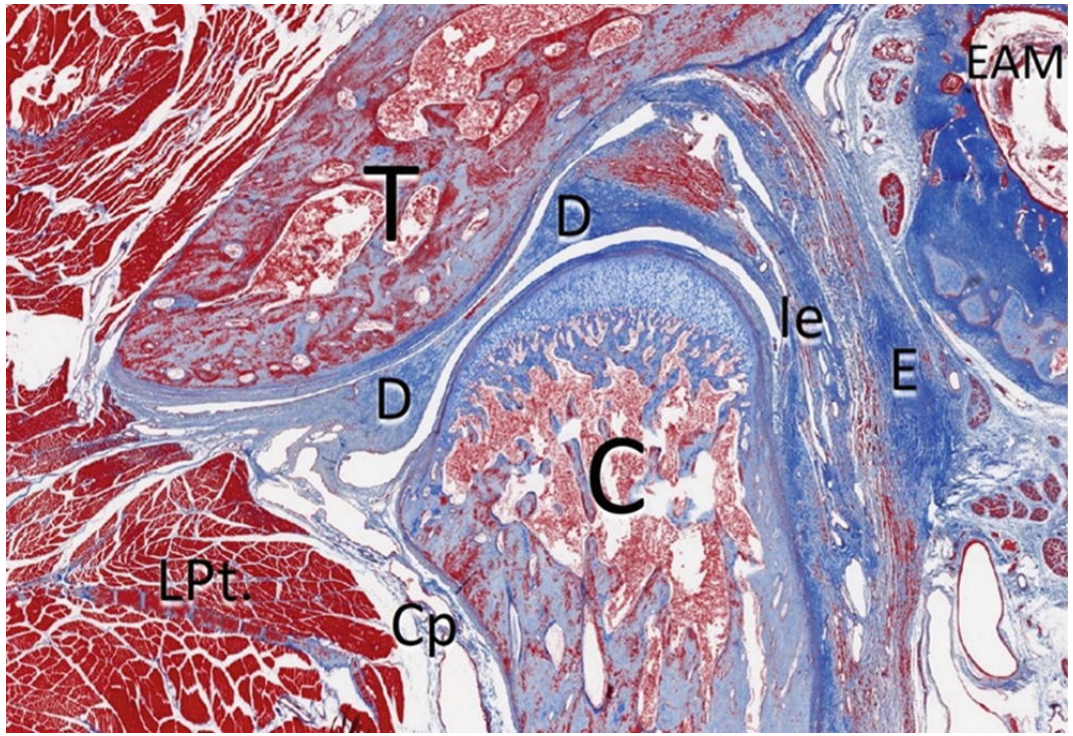


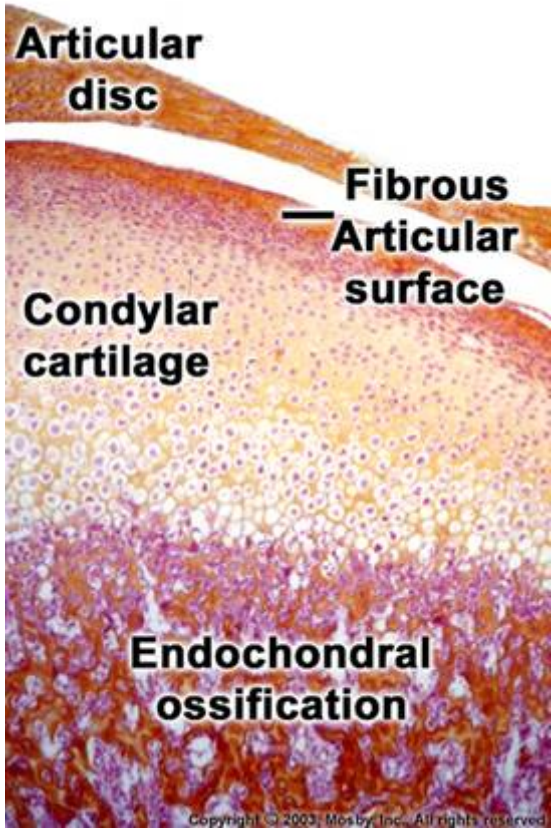
Microscopic structure of TMJ

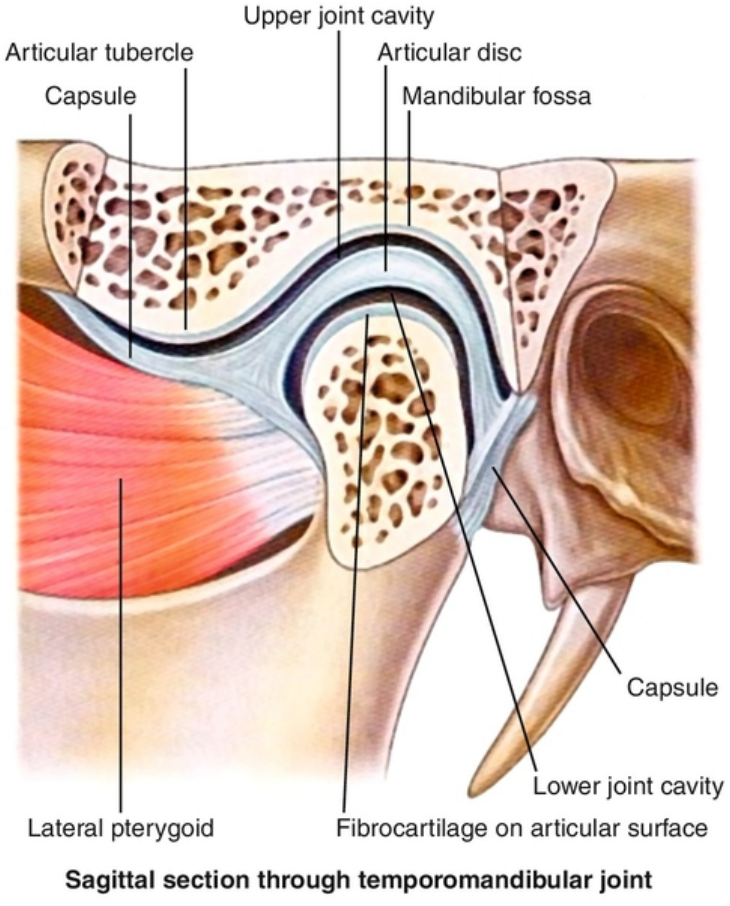
Caput mandibulae (condylus mandibulae) – elongated ellipsoidal shape, elongated axis oriented horizontally on the condyle surface - thin plate of compact

Inside is cancellous bone – trabeculles diverge from the center of the condyle radially to the surface

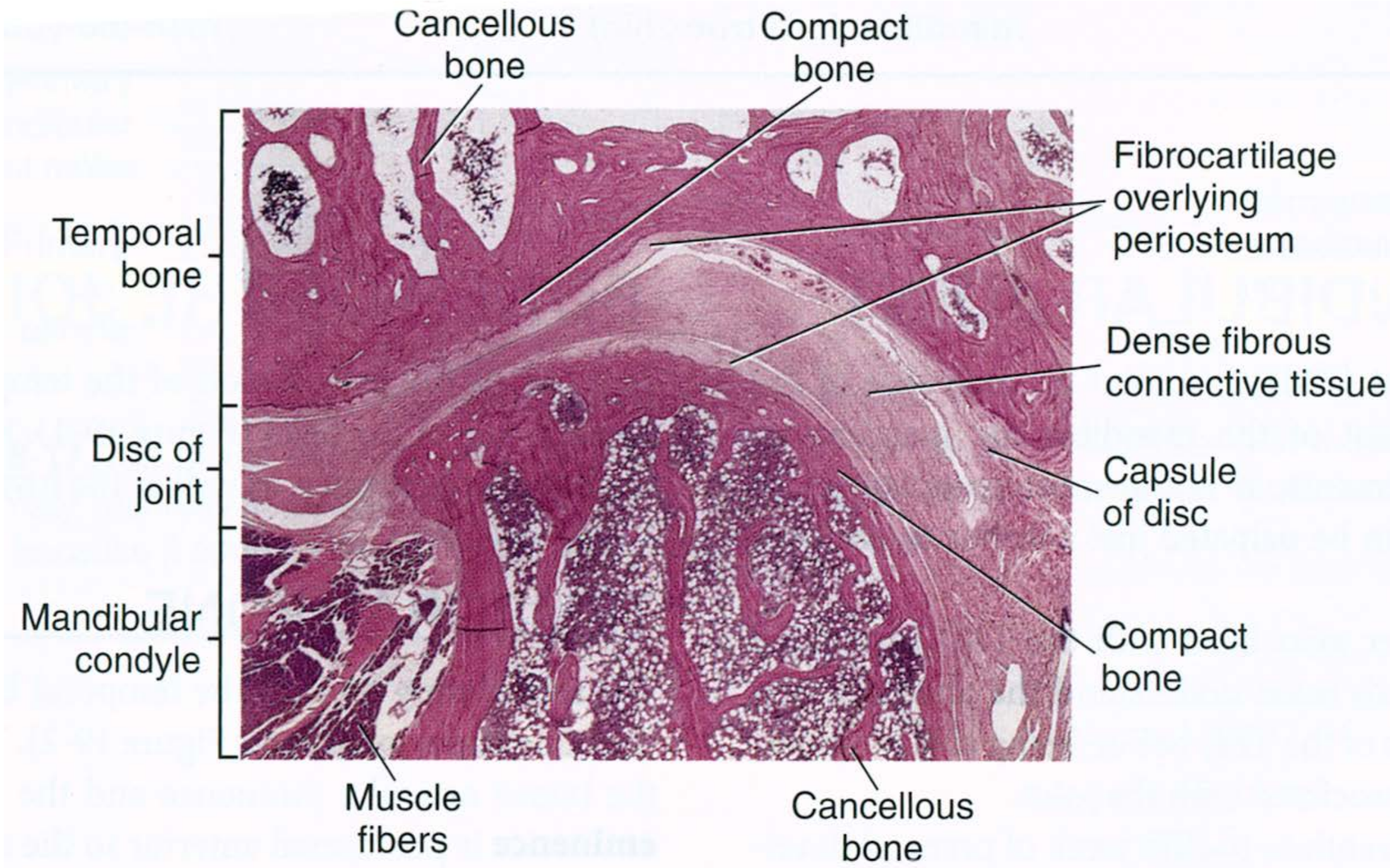
During childhood trabeculles can contain islands of hyaline cartilage







Sagittal section through temporomandibular joint

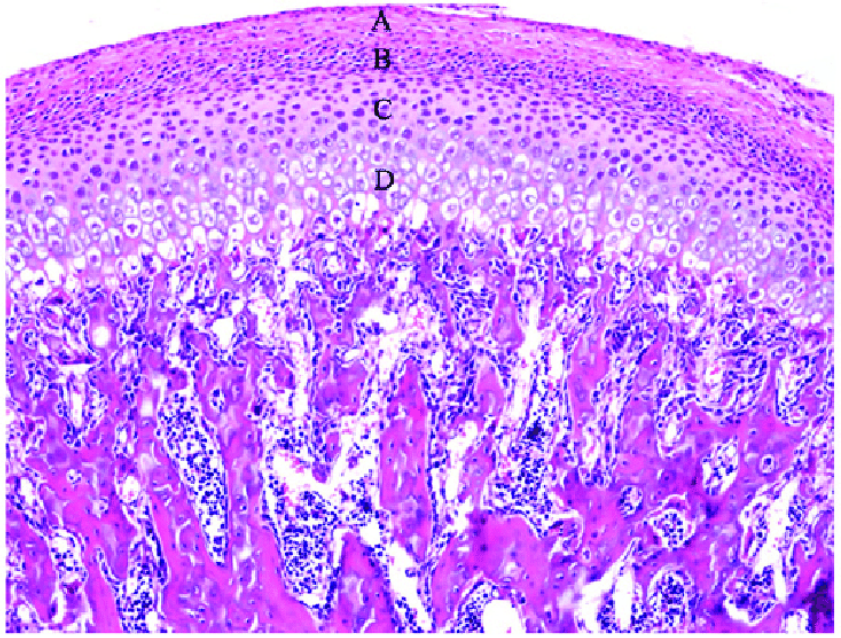

Cancellous bone
Compact bone
Fibrocartilage overlying periosteum
Temporal bone
Dense fibrous connective tissue
Disc of joint
Capsule of disc
Mandibular condyle
Compact bone
Muscle fibers
Cancellous bone

Fossa mandibularis

- Plate of compact bone
- The anterior border of mandibular fossa constitutes the **tuberculum articulare** - it has a similar structure to the caput mandibulae

TMJ surfaces - fibrous cartilage

- It is reinforced on the back of the tuberculum articulare
- Cartilage better resists degeneration and has a good ability to regenerate

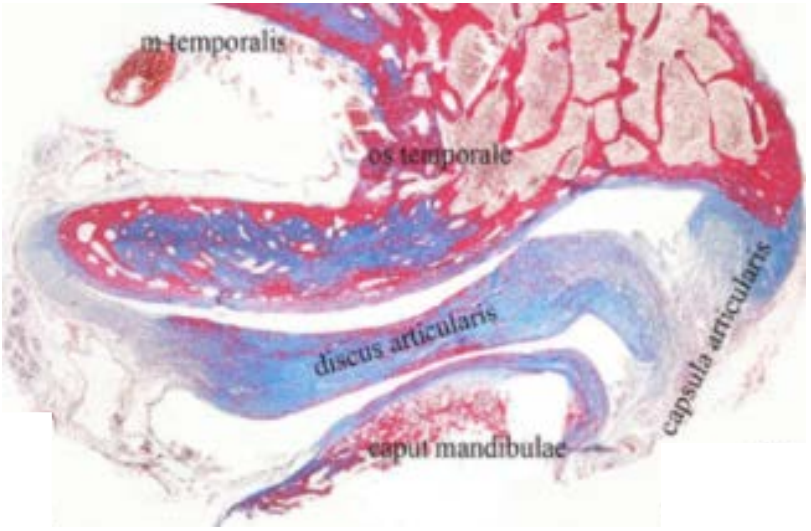


Mandibular condyle

A: Articular layer
B: Proliferative layer
C: Chondrogenic layer
D: Hypertrophic layer

Discus articularis

- Ligament plate 3 - 4 mm thick
- Its edges are fixed in a joint
- Thinner in the middle - intermediate zone (1 - 1.5 mm)
- **Dense collagen tissue of a irregular type**
- In adulthood, it may contain islets of hyaline cartilage
- Function: Stabilization and absorbtion of shocks and vibrations functions



Discus articularis

Complex inner structure

Dorsal section is divided in 2 lamellae:

Superior retrodiscal lamella of elastic fibers, which are inserted to dorsal edge of the fossa

Inferior retrodiscal lamela inserts to the rear edge of condyle

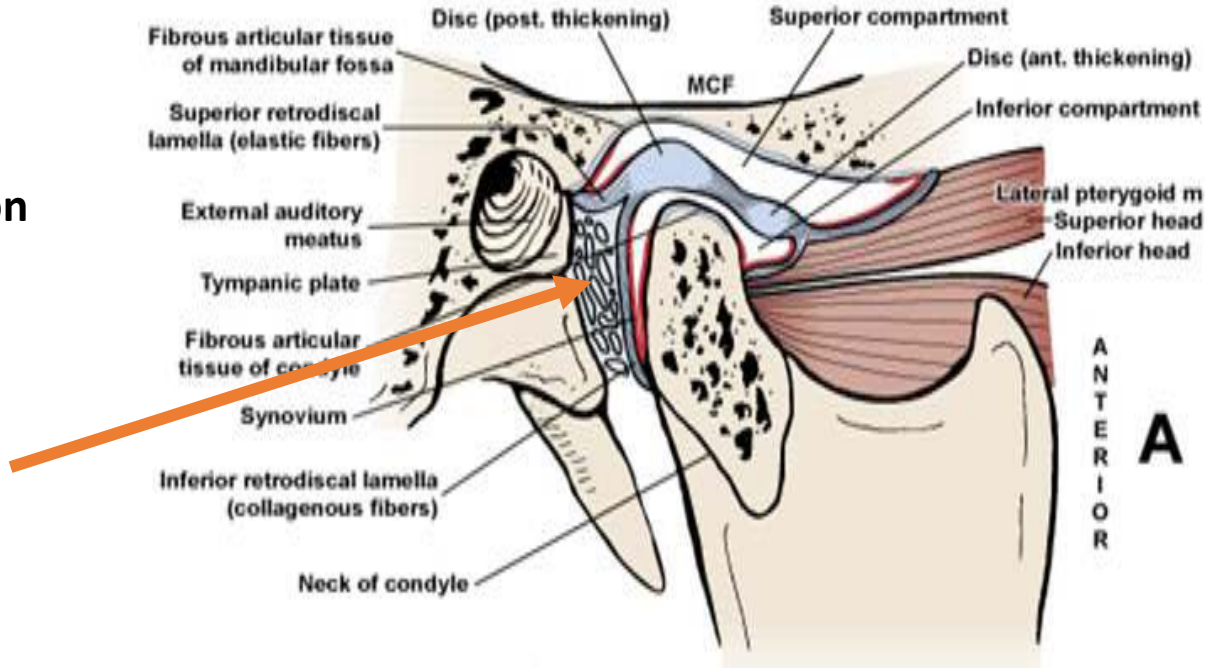
Between lamellae the **retroauricular pillow of Zenker** is present - areolar connective tissue with rich venous plexus (it is continuous by pterygoid plexus - plexus pterygoideus)

Ventral section is thickenned and ends in places of insertion of lateral pterygoid muscle

Thickened compartments act as stabilizing regions (wedges): stabilize condylus in the fossa

Dorsal section

Retroauricular pillow of Zenker



Ventral section

Temporomandibular joing (art. temporomandibularis, TMJ)

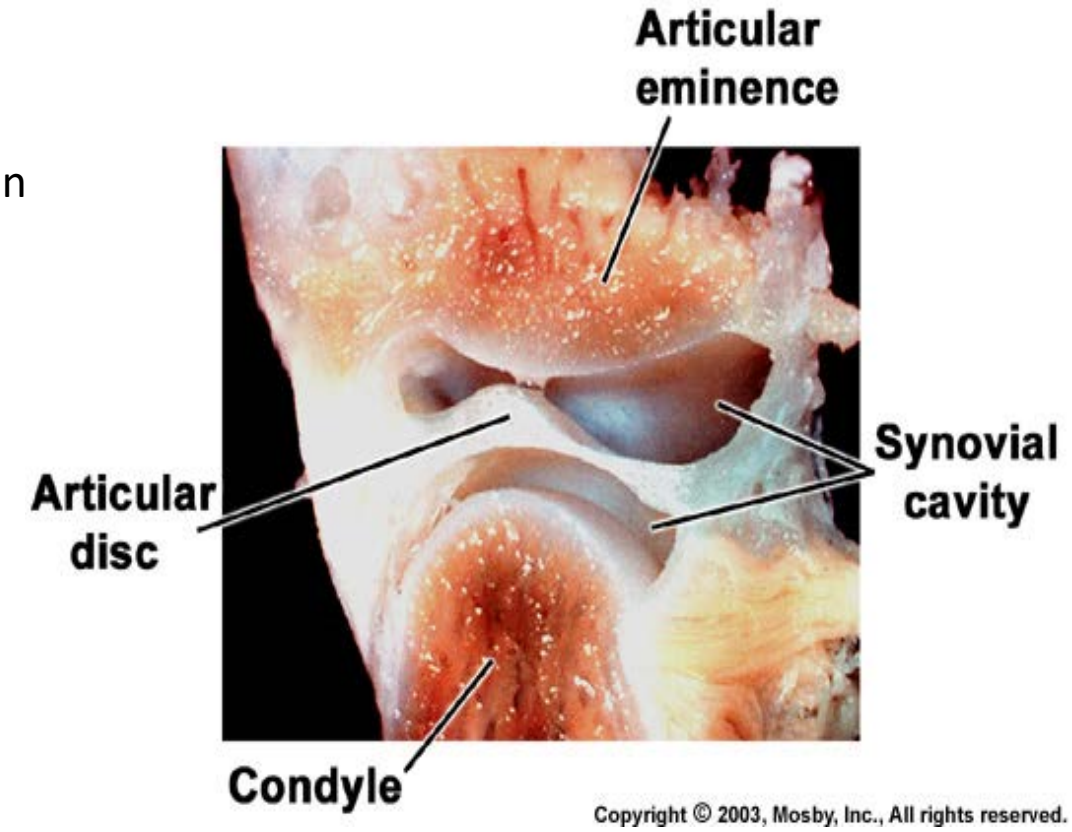
Joint capsule - free, especially on the medial side externally supported by the lateral and medial ligaments

2 layers: stratum fibrosum and stratum synoviale

Articular cavity contains synovial fluid and is divided in two section

upper - **discotemporal**

lower - **discomandibular**



Joint biomechanics:

TMJ (articular disc) movements:
https://www.youtube.com/watch?v=mB468Jh9aAY&ab_channel=AlilaMedicalMedia

MRI:
https://www.youtube.com/watch?v=ZnNgMnSfAws&ab_channel=SpringerVideos

Age changes in TMJ

Final form takes between 20 -25 years of age

Adaptability of TMJ – the ability to adapt to new functional requirements

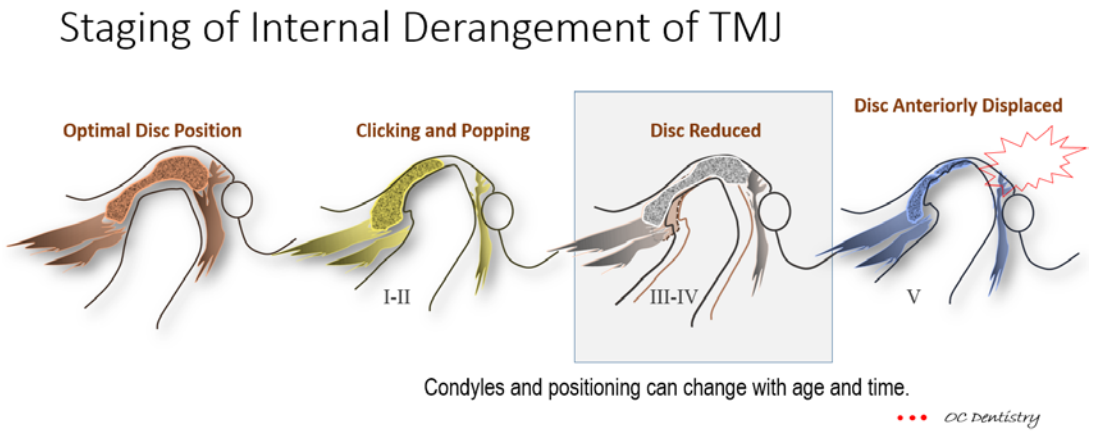
Very good in cartigale

Poor in discur articularis

a) Degenerative changes in the discus articularis, rupture or disintegration

b) After the 5th decade perforation of the central disc part and connection of both sections of the articular cavity can occur

TMJ clicking:
https://www.youtube.com/watch?v=Opgz2EUyI0w&ab_channel=WellingtonVillageOrthodonticsOttawa



https://www.youtube.com/watch?v=bq2mXyHz5uA&ab_channel=HackDentistry