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Structure of the tooth: Sylabus for foreign students – Dental medicine

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Function: to chew the food = MASTICATION, biggining of the digestive process

speech-sound

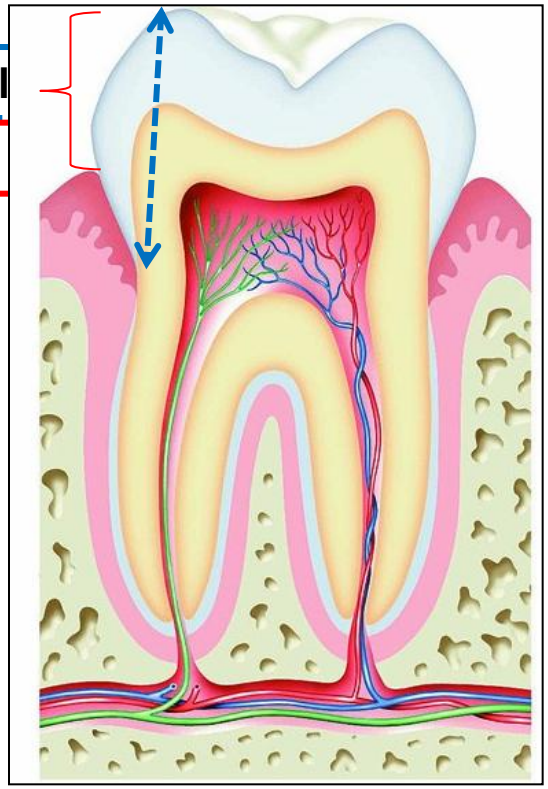
Anatomic structures:

- **in humans <u>two sets of teeth:</u>**
  1. **deciduous – milk teeth (20)**
  2. **permanent – adult teeth (32)**

- **<u>anatomical parts:</u> crown (*corona dentis*)**
  neck (*cervix*)
  root (*radix*)
  pulp cavity, root canal, apical foramen

anatomical

clinical



Teeth are situated in the bone sockets (alveolus) in jaws:

(maxillar & mandibular bones)

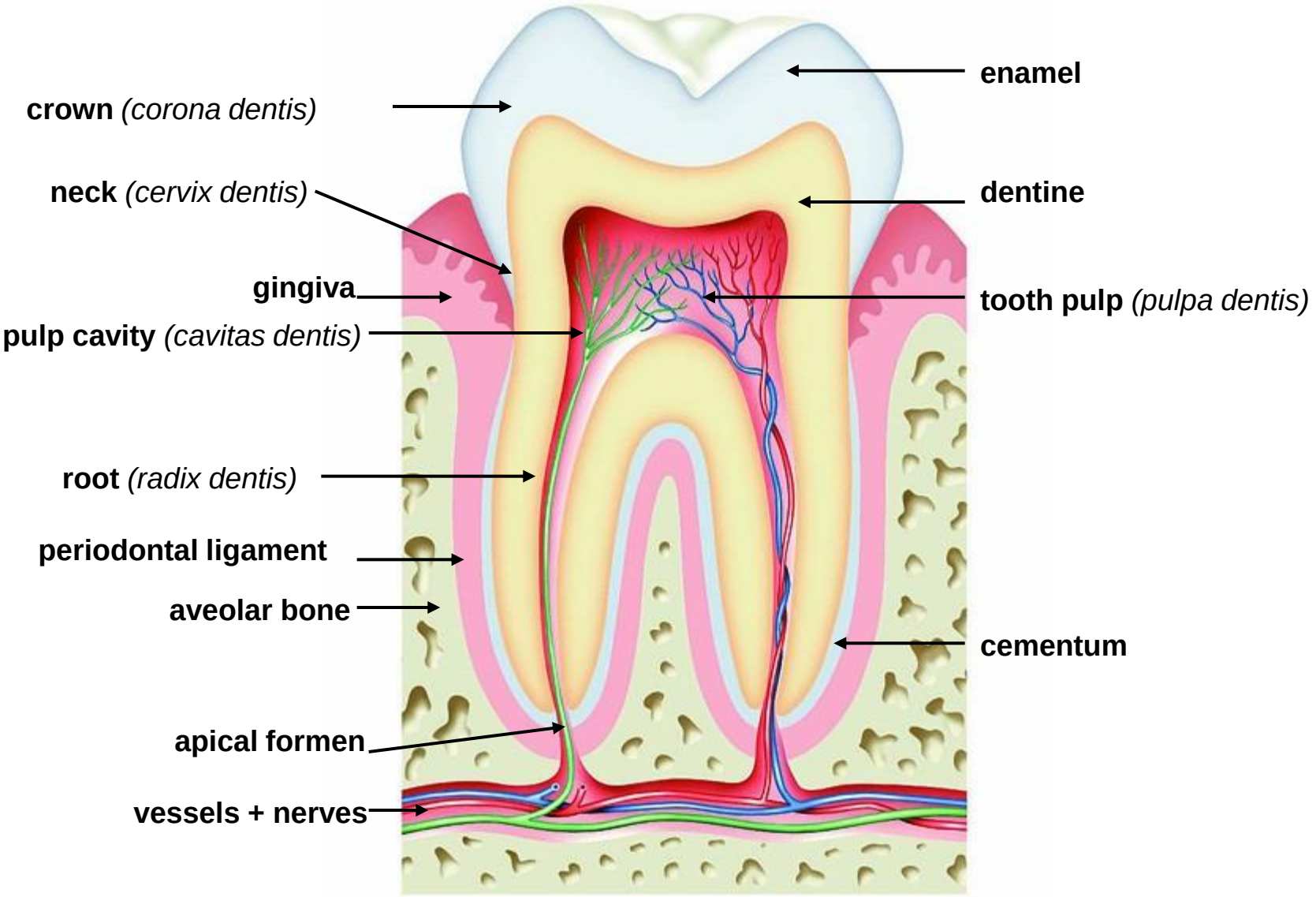
BASIC STRUCTURES:

a. **<u>hard tissues</u> – *enamel*, *dentin*, cementum**
   higly mineralized tissues

b. **<u>soft tissue</u> – tooth pulp**

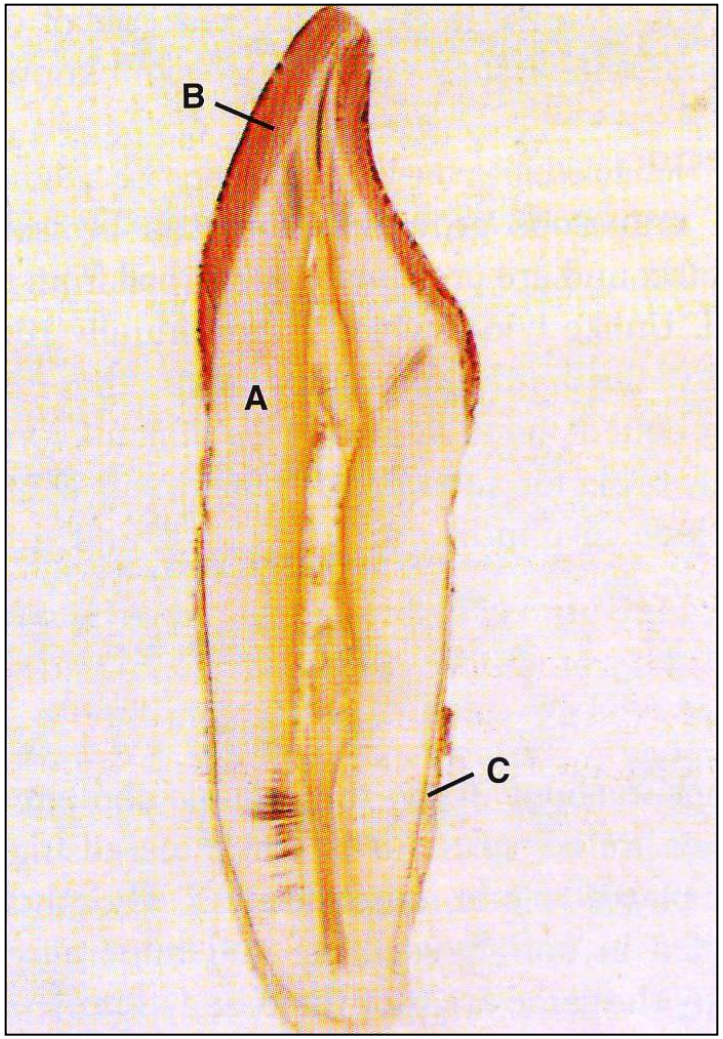
c. **<u>supporting tissues</u>: periodontal ligaments, gingiva, alveolar bone**

Tooth – basic structure

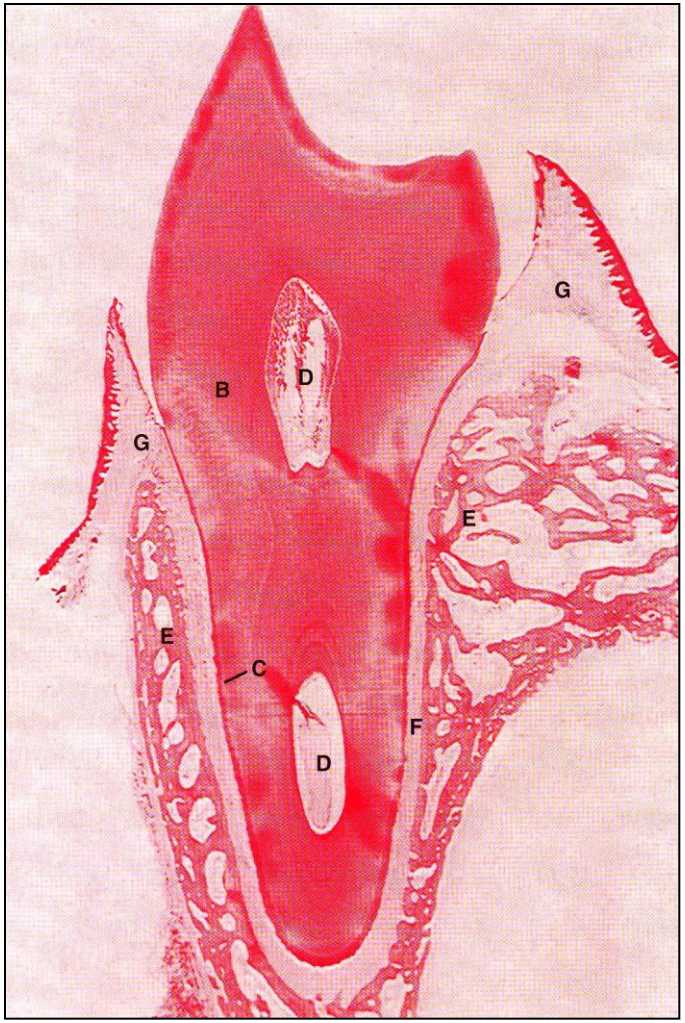


Histological preparation of tooth

1. Thin sections technique: Organic matrix is removed, only inorganic remains, thereafter tooth is cut into a thin slices.



2. Decalcification – calcified matrix is removed, organic component is preserved, than cut & stained



I. Hard tissues of the tooth: enamel, dentine, cementum

ENAMEL

- ECTODERMAL ORIGIN
- covers surface of the crown
- produced by ameloblasts

PHYSICAL PROPERTIES of the ENAMEL

The hardest tissue, resistent to abrasion

Thickness:
- at the edges and cusps - 2,5 mm
- neck region, lateral surfaces of the crown - 1,3 mm

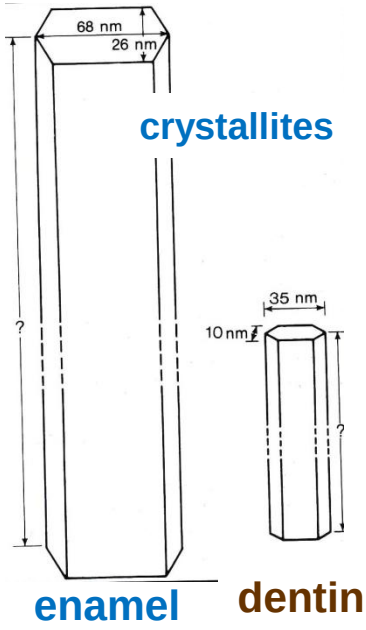
Enamel is synthesized only during development
does not regenerate

Color of enamel:
- young teeth – bluish white
- adult teeth – more transparent enamel,
colour of dentine is visible - yellowish

Superficial enamel undergoes higher mechanical stresses, therefore is:

- harder
- less porous
- contains more of fluorides

CHEMICAL PROPERTIES of the ENAMEL



1. Inorganic component: 95 - 96%

- calcification of enamel matrix only during development of tooth !

MINERAL SALTS – milions of hydroxyapatite crystallites of hexagonal shape form enamel prisms

2. Organic component in matured enamel: 1-2%

- is produced by ameloblasts only during development of tooth !

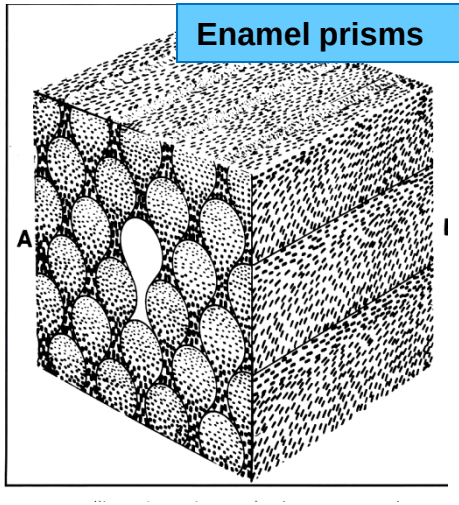
around the prism is non calcified organic matrix

Proteins:

amelogenins and enamelins (tuftelins, ameloblastins)

3. Water: 2%

H_2O is bind to material of crystals and in the organic matrix



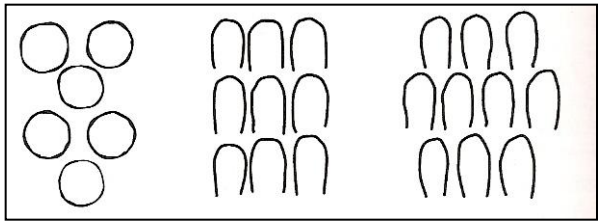
Shape of the prisms and orientation:

Type I. – circular prisms

Type II. - paralel prisms

Type III. – keyhole prisms (head and tail)

more frequent



I. **II.** **III.**

Microscopic structure of enamel prisms

Basic structural units of the enamel are enamel prisms

Prism is composed of millions of hydroxyapatite crystallites (diameter: 70x30 nm)

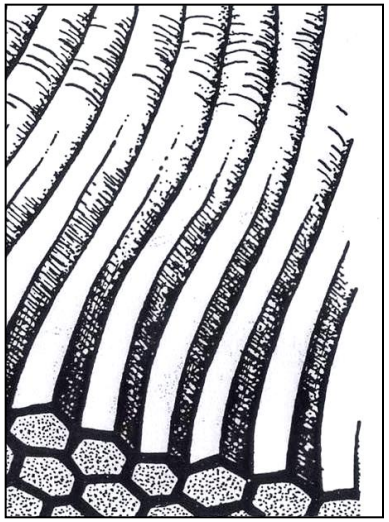
- **crystallites are bigger than in the bone and dentine**
- **oriented paralel with long axis of the prism**

Shape of the prisms

- **polygonal**, **or keyhole**

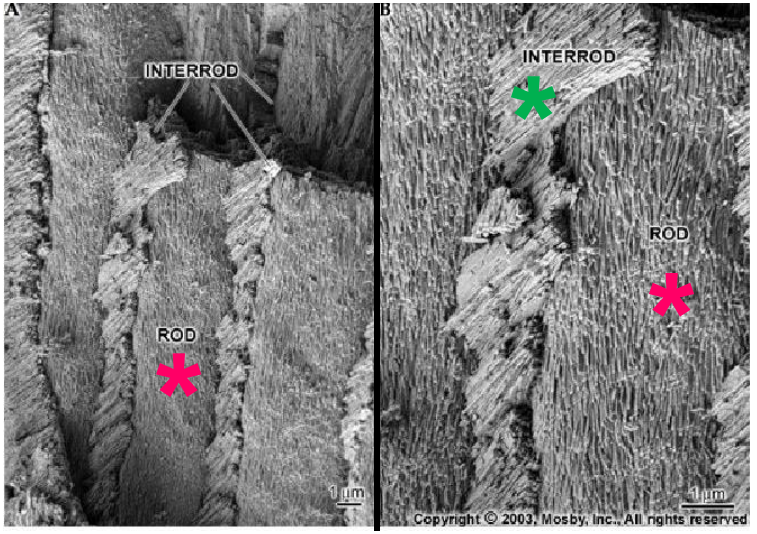
1. **prisms run perpendicular to the enamel surface**
2. **paralel to each other**
3. **are continuous without interuption**

on the cusps & ridges: lenght: 2,5 mm; width: 5 µm



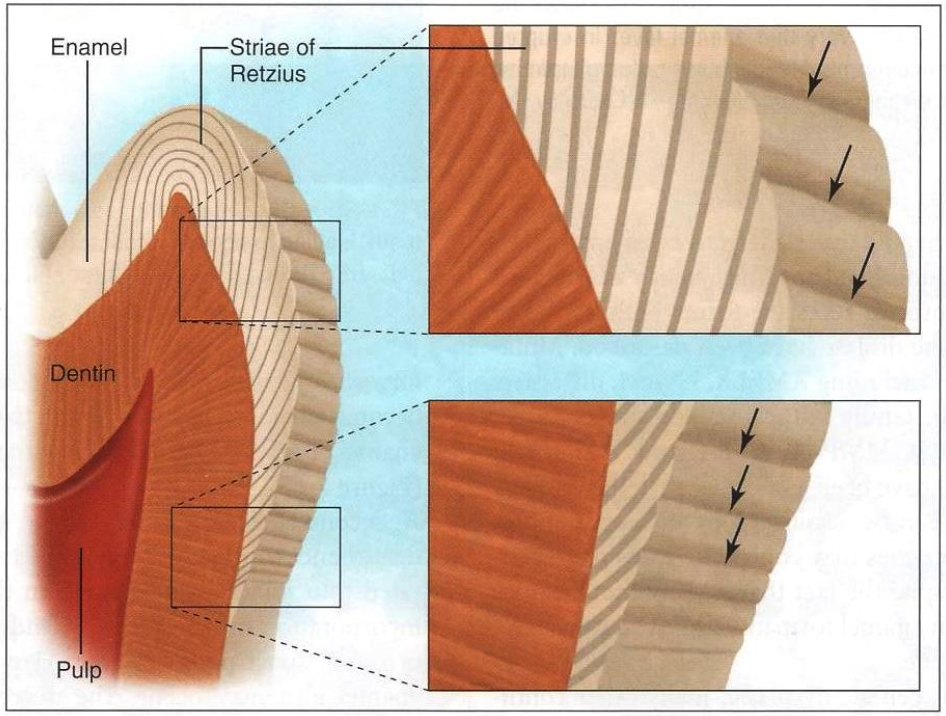
- **surface of the prism** is covered by **prismatic membrane = nonmineralized enamel matrix**

- **<u>prisms</u> (rods*) are connected by <u>interprismatic substance</u> (interrod *) – orientation of crystallites has different angle**



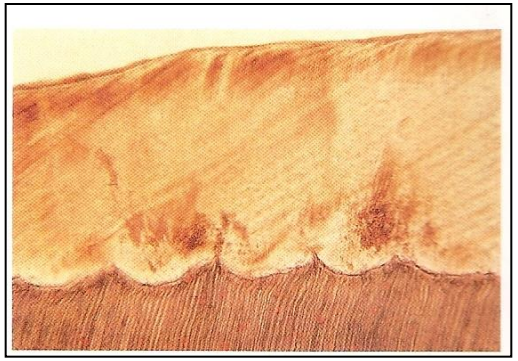
Formation of enamel prisms is periodic (active – non active period of formation) visible in the enamel like <u>growing lines</u> = incremental lines (Retzius lines; RL)

- traverse obliquely from dentine-enamel junction
- showed periods of enamel formation



Connection of ENAMEL – DENTIN

- **<u>Arcuate connection</u> in the places with high mechanical stress (ridges and cusps)**
- **<u>Straight connection</u> on lateral surfaces of the crown**



AMELOBLASTS

Function:

- produce enamel only during development of tooth
- synthesis and secretion of enamel components

Microscopic structure:

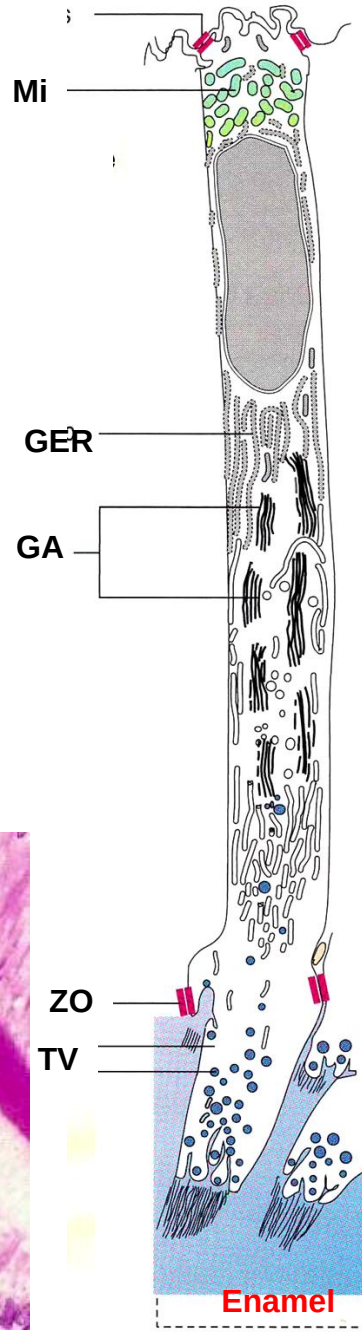
tall columnar cells, connected by zonulla occludens

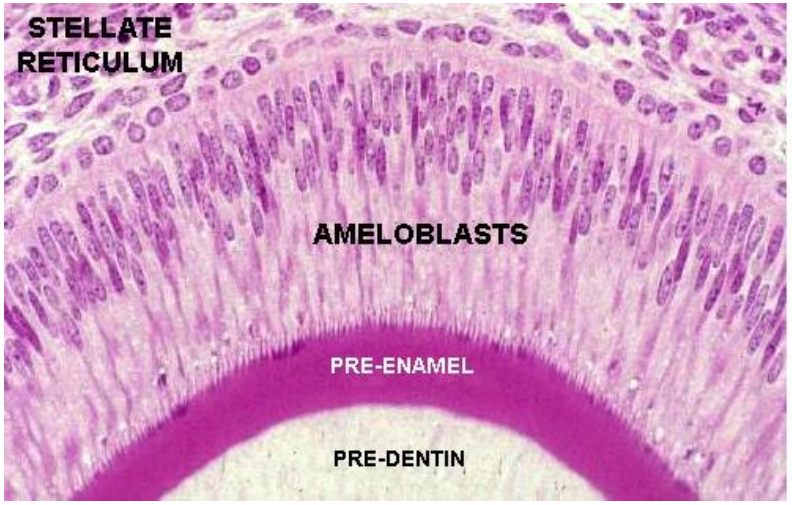
<u>basal part of cell</u>: mitochondria (Mi),

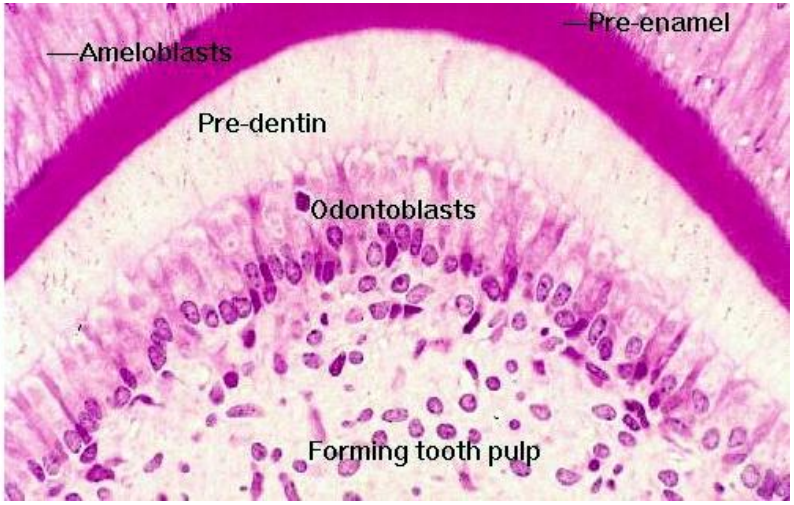
near the nucleus: rER, GA

<u>apical surface:</u>

- shorter Tomes´ process contains secretory granules
- cytoskeleton

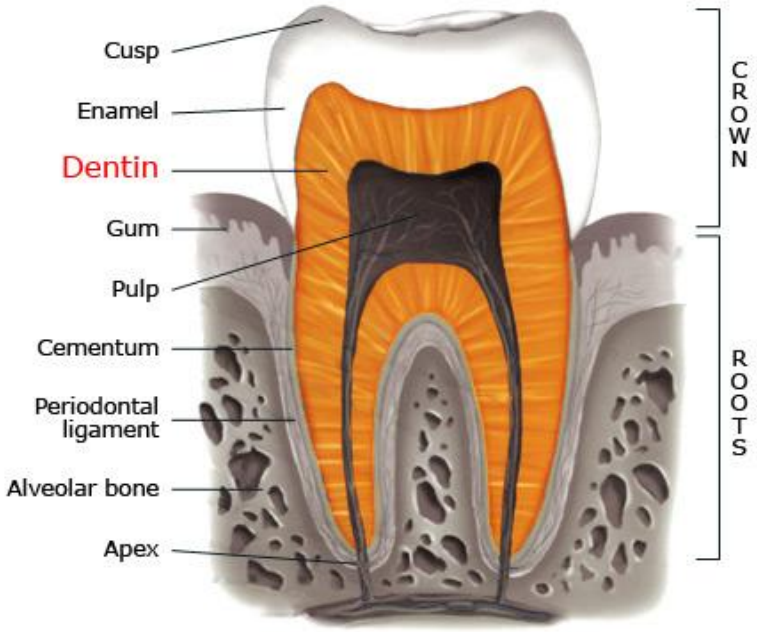






Dentine

- hard calcified tissue
- formes crown and root
- surrounds tooth cavity (pulp cavity)
- is produced by odontoblasts
- origin: ectomesenchymal



PHYSICAL PROPERTIES of the DENTINE

- yelowish color
- dentine is harder than the bone, softer than enamel

CHEMICAL PROPERTIES

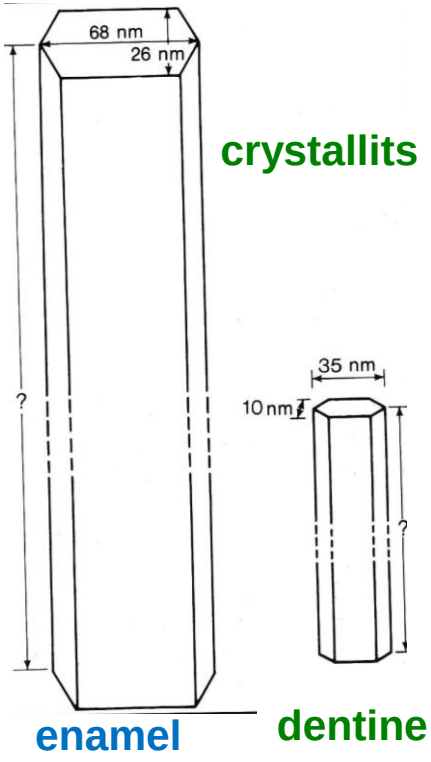
70% inorganic matrix (hydroxyapatite)

- dentinal crystallites of hydroxyapatite are flatenned, and smaller than in enamel

20% organic matrix

- collagen type I (90%)
- amorphous ground substance (10%)

10% H_2O



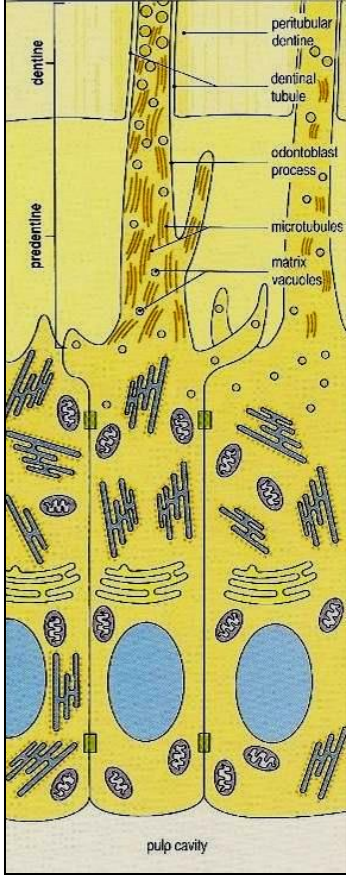
ORIGIN of odontoblasts: ectomesenchymal

Odontoblasts produce dentine – synhesis and secretion of all dentinal components

Dentin: avascular

sensitive (*sensitive nerve fibers* enter the dentinal tubules)

Microscopic structure of the dentin



LM: parallel stripes = dentinal tubules
eosinophilic staining (collagen type I)

ODONTOBLASTS:

Function: the cells forming and maintaining dentine

Location: at the border of dentinal pulp and dentine

active all of the life

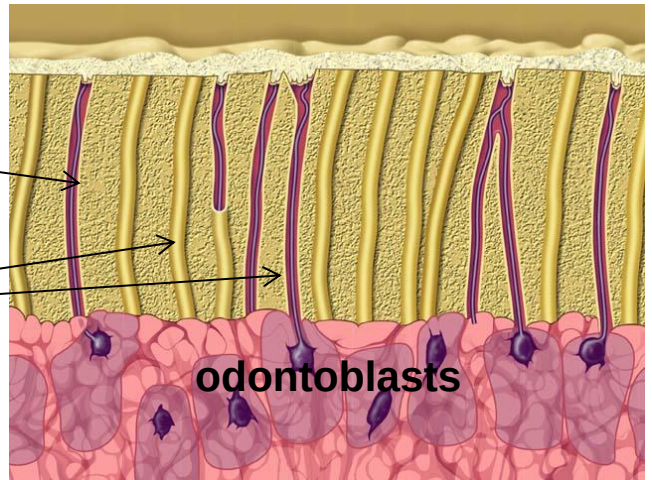
EM: **ultrastructure of odontoblasts**:

- cells are connected by tight junctions
- well developed rER, GA = protein synthesis (collagen type I)
- number of mitochondria
- secretory granules released through apical cytoplasm

Apical surface: odontoblasts have

long cytoplasmic processes **Tomes´fibers,**

that run in the **dentinal tubules** in the entire dentine

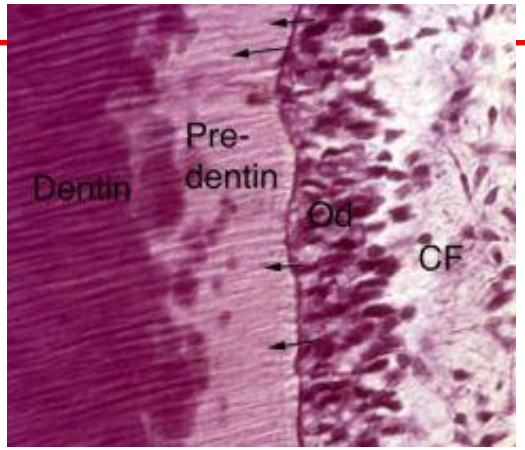


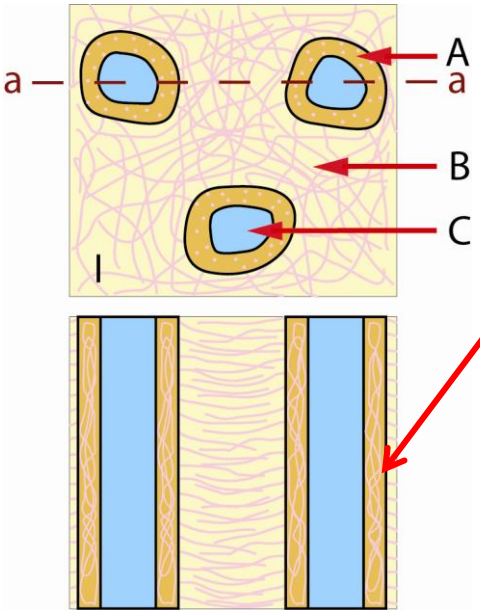
Dentin according the rate of mineralization

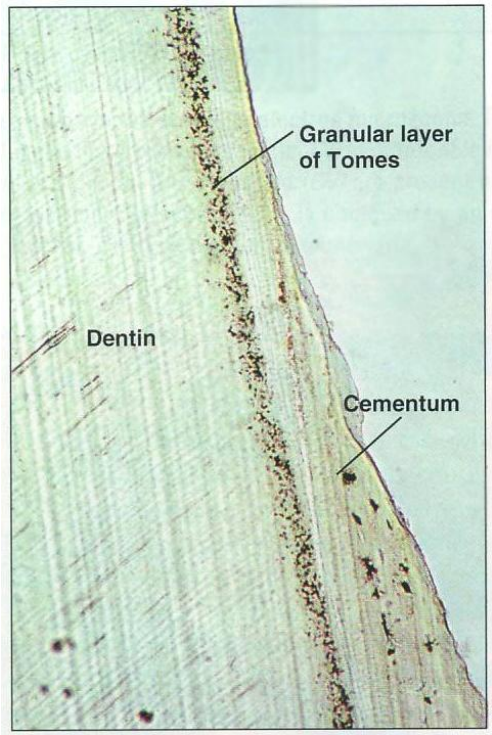
Predentine - non calcified
Dentine - calcified

Peritubular dentine (A) – more calcified

Intertubular dentine (B) – less calcified than peritubular D







- at the border of dentine-cementum = granular Tomes´layer → nonmineralized dentine
- at the border of dentine-enamel (crown) = Czermak´s lacunae → nonmineralized dentine

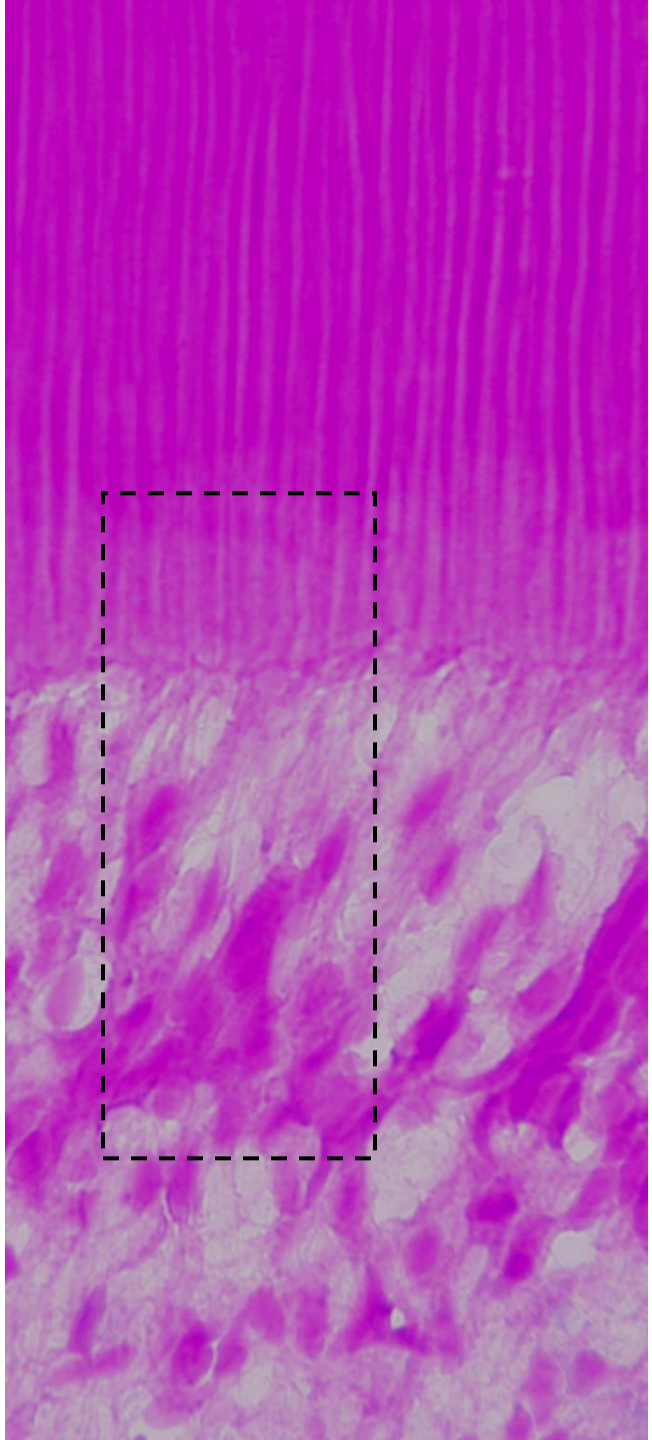
LM

Dentine

Predentine

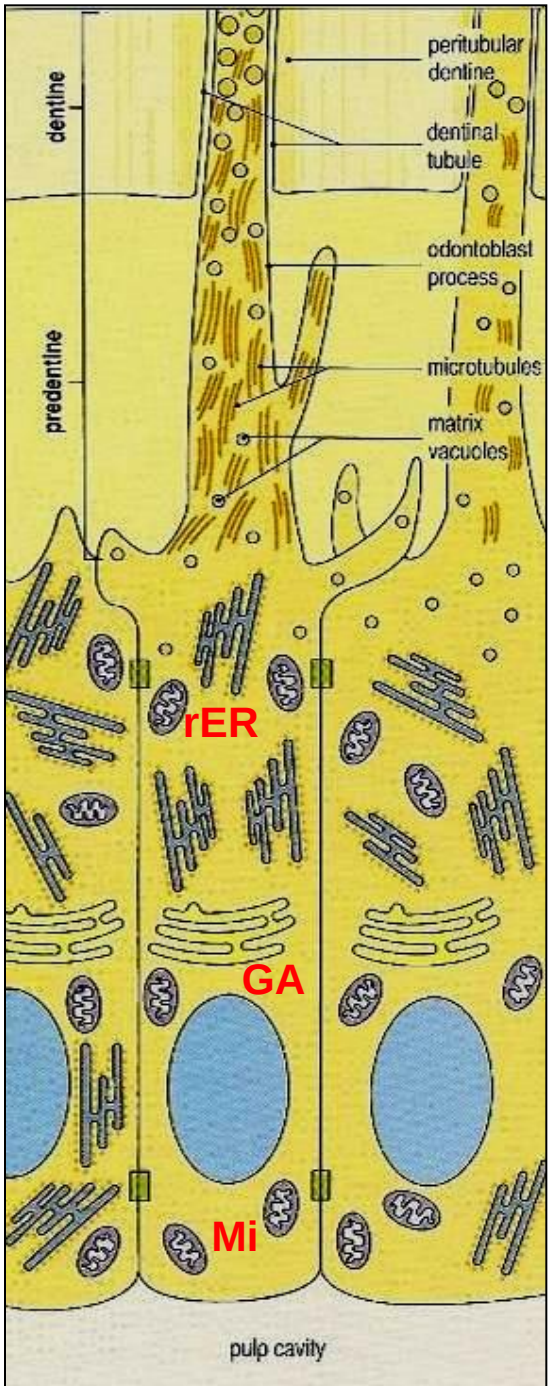
odontoblasts

Tooth pulp



EM

odontoblasts



Dentine according to the structural arrangement:

a) **Mantle dentine -** the outer layer of dentine in the crown

- radial collagen fiber; less mineralized

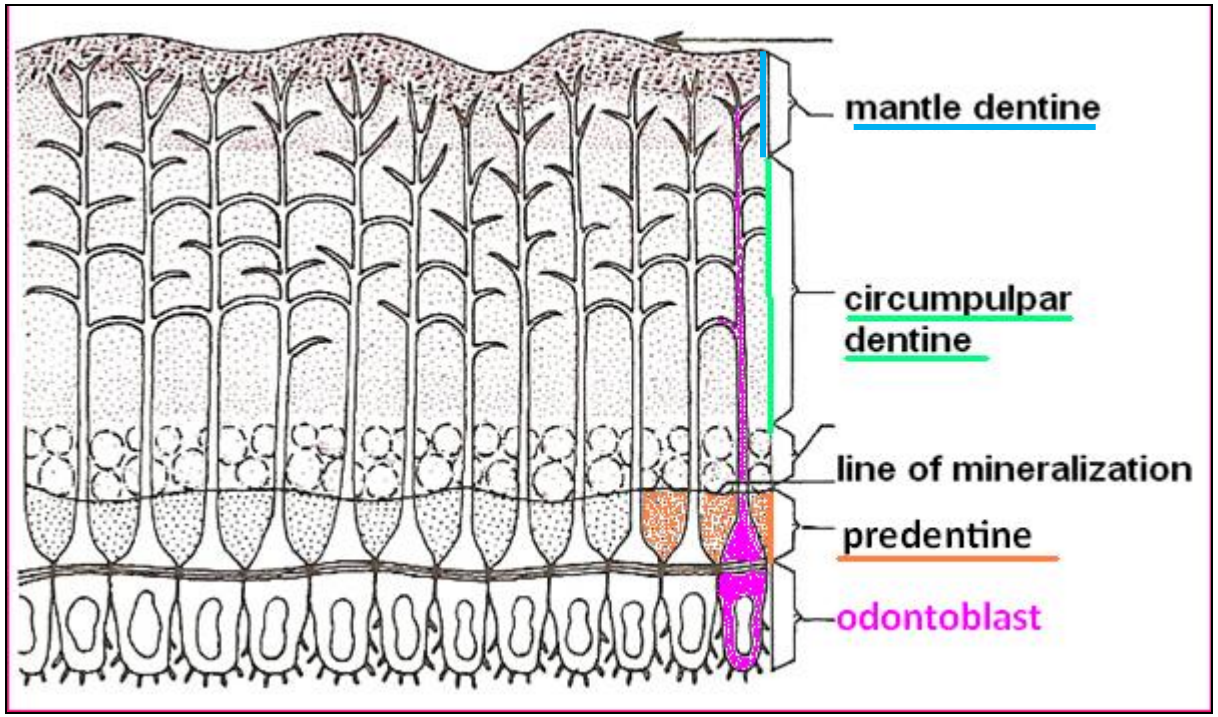
- dentinal tubules are branched

- Tomes´fibers partially engaged in the enamel; contact of crystallites between enamel and dentine

b) **Circumpulpal dentine**

- rythmic secretion and mineralization; typical structure

c) **Predentine** = nonmineralized dentine



Dentine according to the time period of production:

(1) Primary dentine - produced during development of the tooth

(2) Secondary dentine - dentine slowly created throughout the human life

(3) Tertiary dentine - reactive, non typical

- **created by a variety of exogenous stimuli: caries, attrition, pulp cavity preparation, trauma**
- **have irregular dentinal tubules**
- **or no tubules**

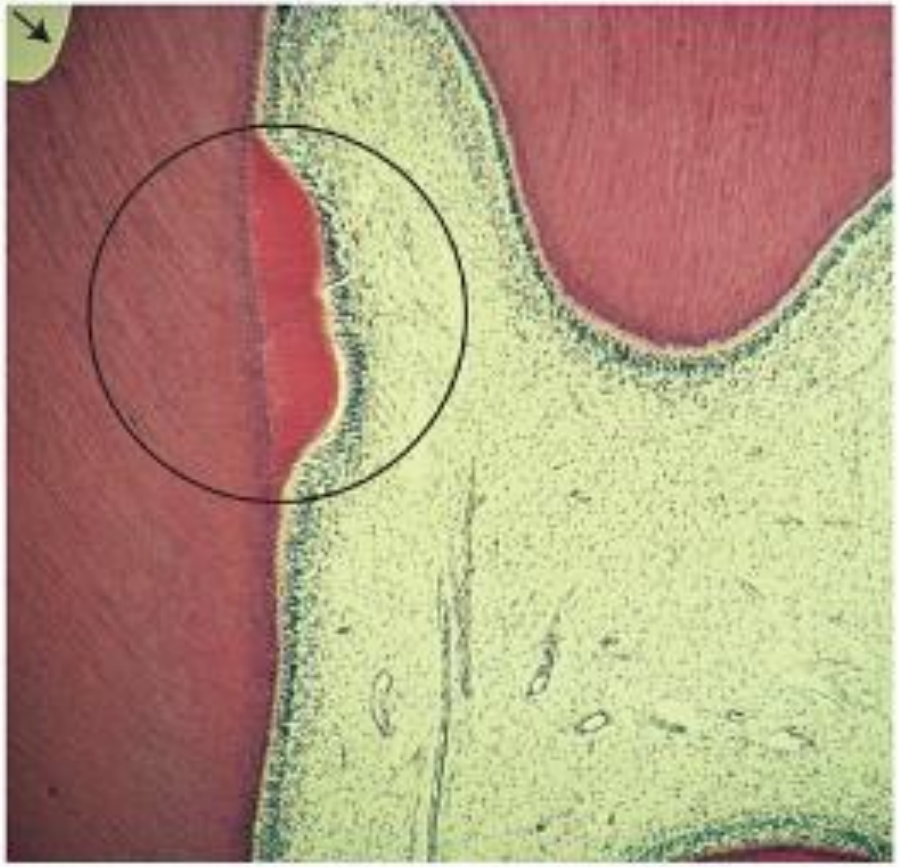


Fig. 2.6 Microphotograph showing hard tissue repair following a cavity preparation (arrow). The circle indicates bulk of new dentin being formed.

Cementum

- thin layer of mineralized tissue on the outer root surface
- covers dentine

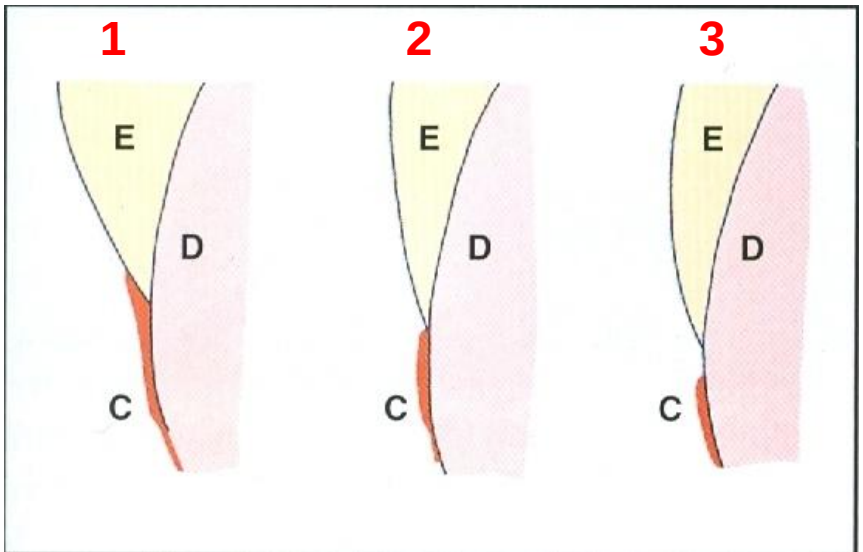
Physical properties: yellowish color, softer than dentine

Function: connection of tooth to the alveolar bone by periodontal ligaments

Thiskness: cervix 10 – 15 µm
apex 50 – 200 µm

Three patterns of the cement - enamel junction:

1. Cementum overlaps enamel
2. Cementum and enamel meet
3. Cementum and enamel fail to meet; dentine betwen them is exposed

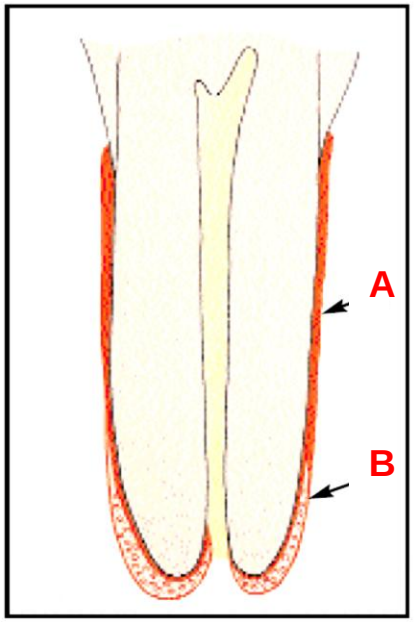


Chemical properties of cementum:

65% inorganic maatrix (hydroxyapatit, small, flattened crystallites: 8x55 nm)

23% organic matrix (collagen type I, sialoprotein)

12% H_2O



Histologically can be distinguished 2 types of cementum:

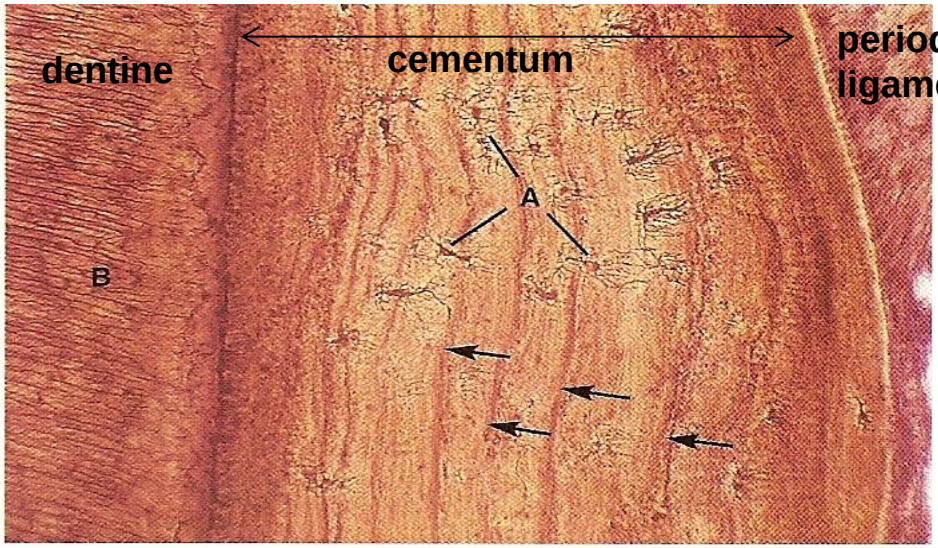
(A) Acellular (primary) cementum (10 - 200 µm)

(B) Cellular (secondary) cementum (500 µm)

Cementum is produced by cementoblasts

Mature cells inside the cementum are cementocytes (lacunae, canaliculi)

- **acellular cementum covers the entire root surface by thin layer attached to the dentine**
- **cellular cementum is found at the apex of the root**

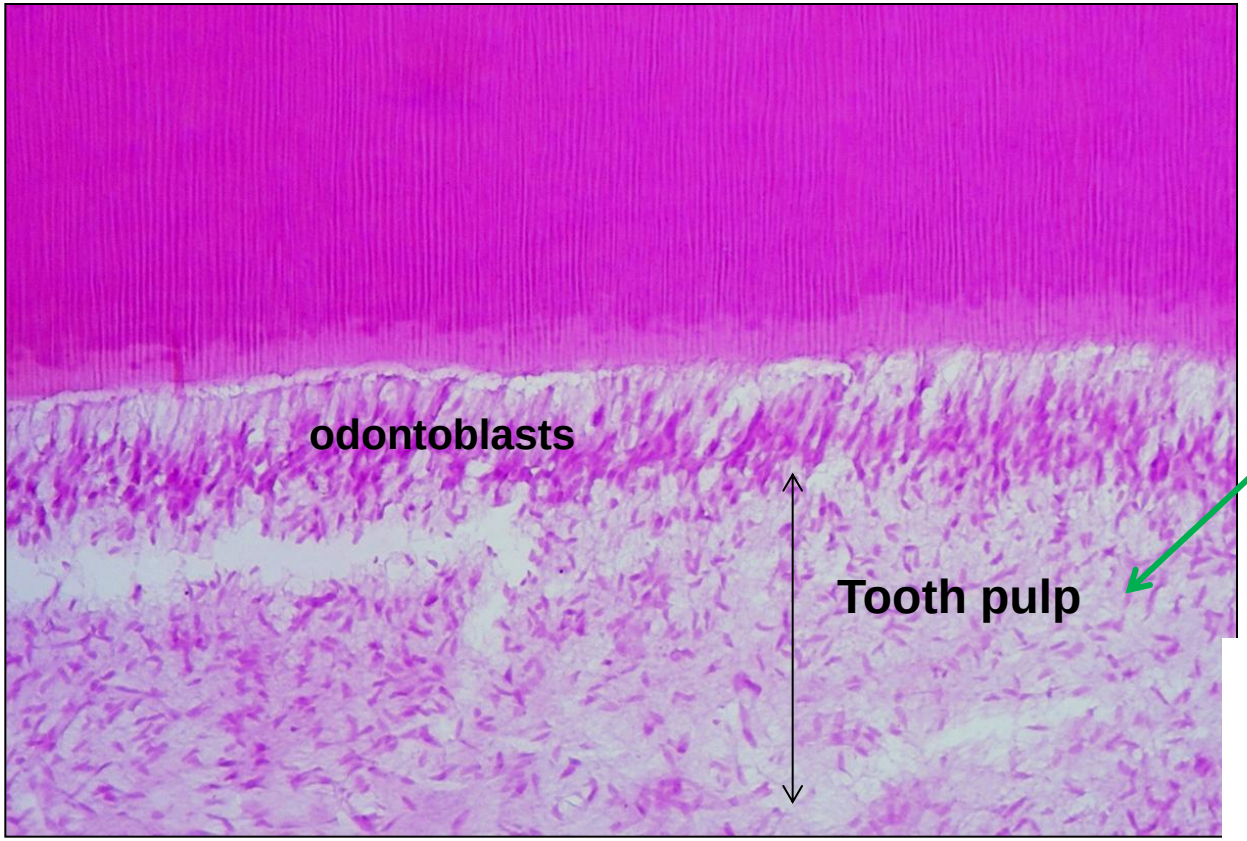


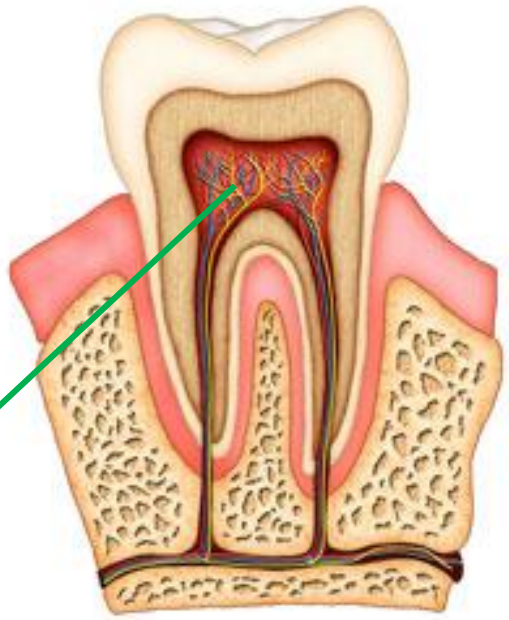
Cementum has no nerves → is non-sensitive to pain !!!

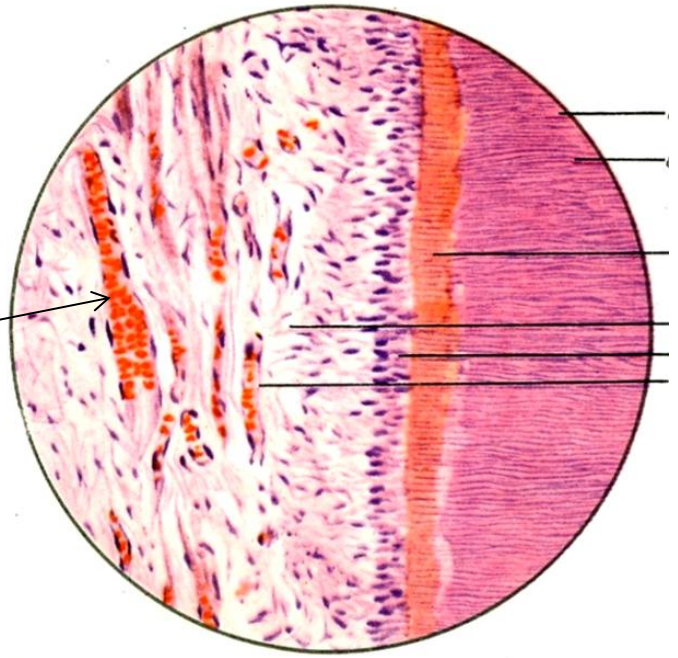
Cellular/Secondary cementum:

- **cementocytes with processes (A)**
- **border with dentine clearly demarcated**
- **incremental = growing lines (arrows)**

II. SOFT TISSUES







Tooth pulp

75% water + 25% organic matrix

- **fills dental cavity**
- **very loose connective tissue important for dentine production**

<u>Cells of tooth pulp</u>:

- **Fixed pulpar fibroblasts**
- **Free cells: histiocytes, plasma cells, antigen-presenting cells, leukocytes**

Border of the pulp cavity and dentine:

- odontoblasts

- subodontoblastic layer: capillaries + nerve plexus

<u>Extracellular matrix</u>:

a) collagen type I and III

b) amorphous ground substance

<u>GAG</u> (hyaluronic acid, dermatan sulphate, chondroitin sulphate), <u>structural gycoproteins</u> (fibronectin, laminin)

FUNCTION OF TOOTH PULP

(1) Nutritive (blood vessels) and supporting function for tooth

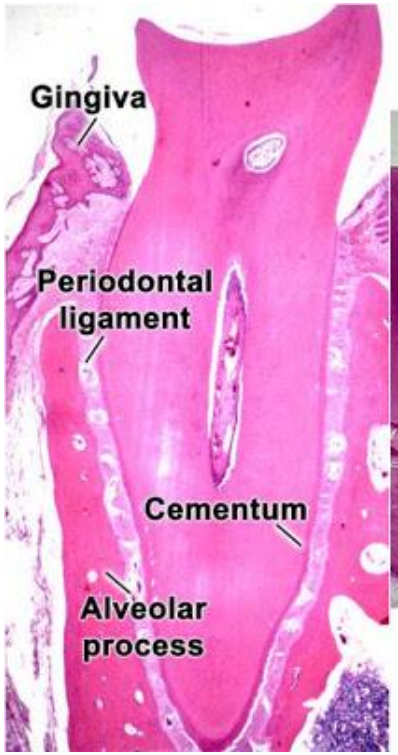
(2) Dentine production – by odontoblasts

(3) Innervation

(4) Defens reactions – macrophages, plasma cells, lymphocytes

III. Supporting tissues of the tooth

1. **Periodontium – periodontal ligaments**
2. **Gingiva - gum**
3. **Alveolar bone – tooth alveolus, tooth socket**



Clinical terminology: Paradontium all the supporting tissues of tooth

Periodontium – periodontal ligaments

Function: strong and flexible connection of bone and tooth

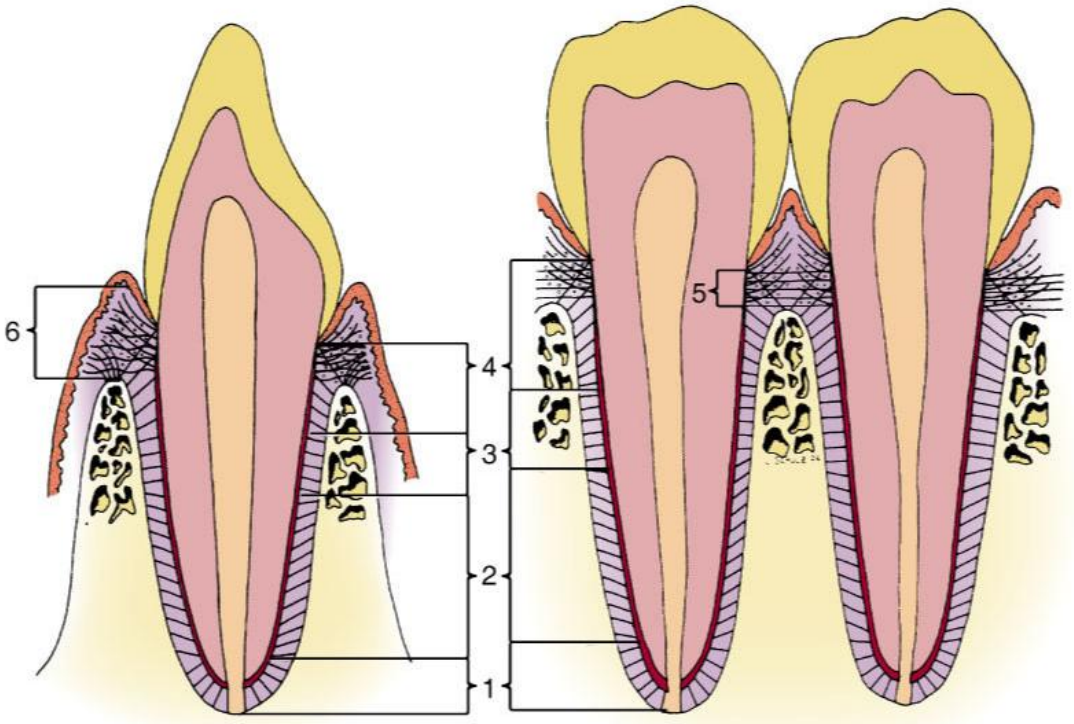
- **dense connective tissue** situated between cementum and alveolar bone

STRUCTURE:

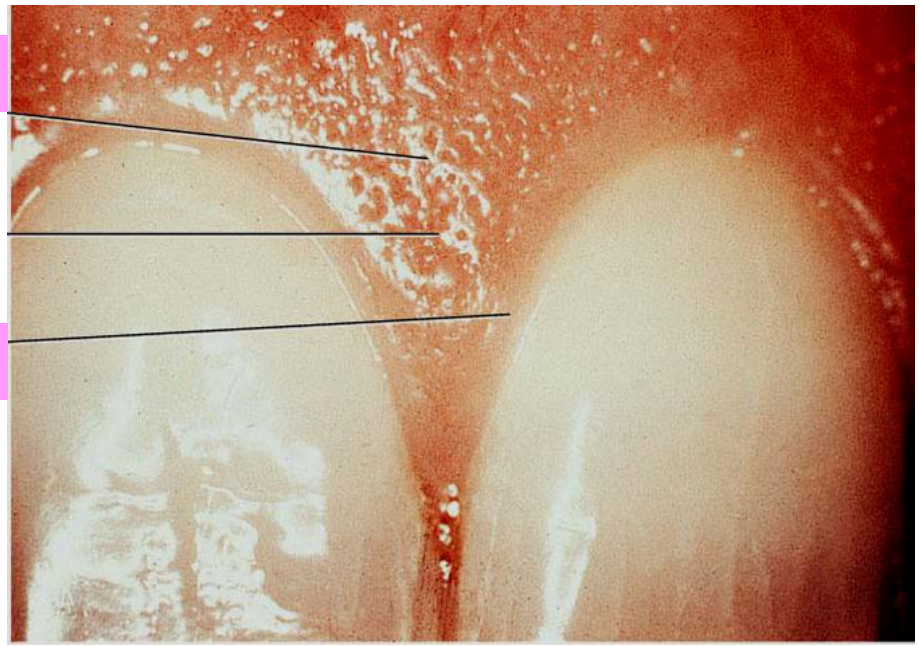
- **collagen type I fibers** (over **90%**), small amount of **elastic fibers**
- **small amount of amorphous ground substance**
- **cells** : **fibroblasts, macrophages**
- **blood vessels, nerves**

Orientation of collagen fibers in different regions of the periodontal ligaments:

1. **Apical fibres**
2. **Oblique fibers**
3. **Horizontal fibers**
4. **Alveologingival fibres**
5. **Transseptal fibers**
6. **Transgingival fibers**



GINGIVA - gum



Microscopic structure:

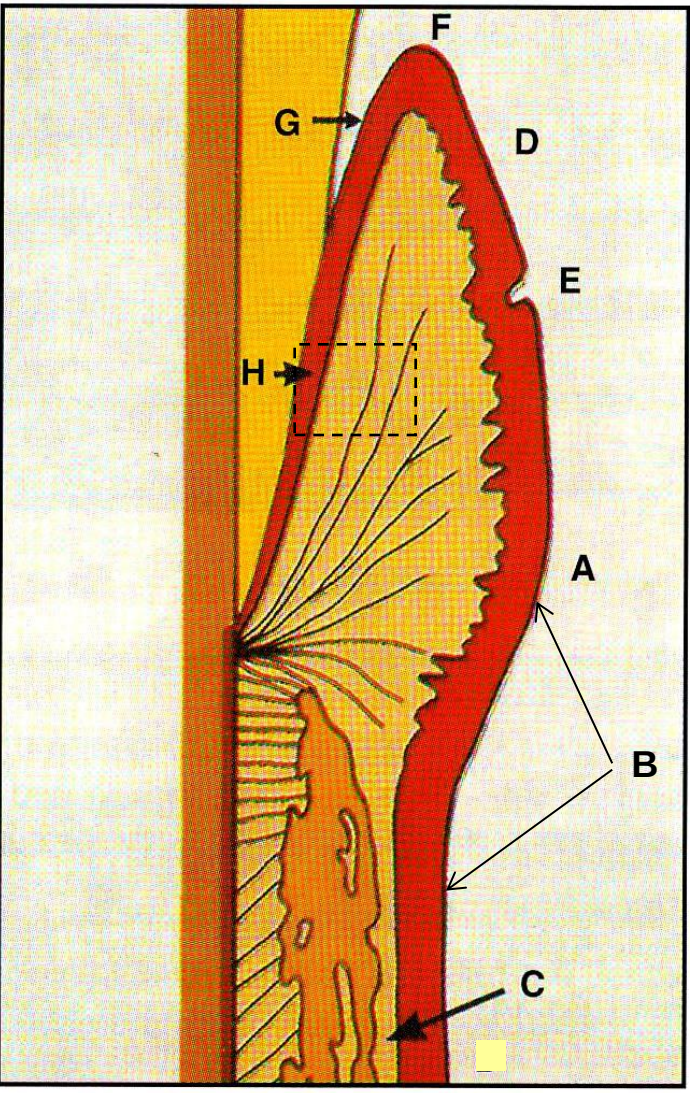
1- lamina epithelialis = **stratified squamous epithelium**

2- lamina propria = dense C.T.

(a) **free gingiva** (unattached) – bound the inner margin by **gingival sulcus (groove)**, which separates it from the tooth, bound on its outer margin by the oral cavity, and apically by the free gingival groove

(b) **attached gingiva –**, separated from alveolar mucosa by the **mucogingival junction (groove)**, attached to the tooth **junctional epithelium**

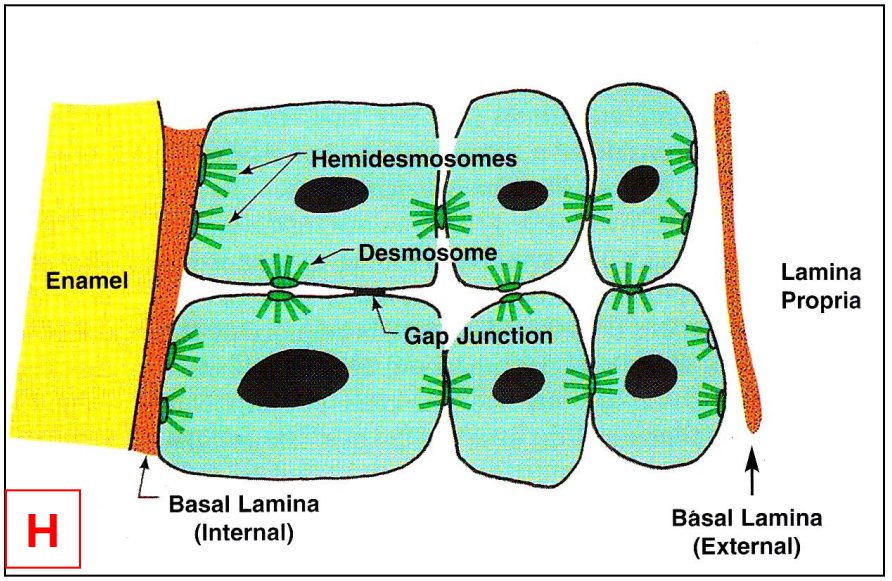
No submucosa



Junctional epithelium

- is attached to enamel by **internal basal lamina (BL)** and to the connective tissue by **external basal lamina**

- epithelial cells are attached to BL by **hemidesmosomes**



Gingiva - detail

A- attached gingiva, B- alveolar mucosa, C- submucosa associated alveolar mucosa, D- free gingiva, E- free gingival groove, F- gingival margin, G- gingival sulcus, H - junctional epithelium

Tooth alveolus (socket)

- the **part of the maxilla** or **manible** that **supports** and **protects** the teeth

- **compact lamellar bone (lamina dura*)**
- **spongy bone** between compact alveolar bone
- the compact layer of bone has numerous **vascular canals** (Volkmann's canals)
- **Sharpye's fibers** originating in the periodontal ligament

*Lamina dura