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

Anatomic structures:
- **in humans two sets of teeth:**
  1. **deciduous** – milk teeth (20)
  2. **permanent** – adult teeth (32)
- **anatomical parts:** crown (*corona dentis*)
  - neck (*cervix*)
  - root (*radix*)
  - pulp cavity, root canal, apical foramen

Teeth are situated in the bone sockets (*alveolus*) in jaws:
  - (maxillar & mandibular bones)

**BASIC STRUCTURES:**
- **hard tissues** – *enamel, dentin, cementum*
  - highly mineralized tissues
- **soft tissue** – tooth pulp
- **supporting tissues**: periodontal ligaments, gingiva, alveolar bone
Tooth – basic structure

crown (*corona dentis*)
neck (*cervix dentis*)
pulp cavity (*cavitas dentis*)
root (*radix dentis*)
periodontal ligament

enamel
dentine
tooth pulp (*pulpa dentis*)
cementum

gingiva

vessels + nerves
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 – millions 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 enamelin (tuftelins, ameloblastins)

3. Water: 2%
   H₂O 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
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 parallel with long axis of the prism

**Shape of the prisms**

- polygonal, or keyhole
  1. prisms run perpendicular to the enamel surface
  2. parallel to each other
  3. are continuous without interruption
     - on the cusps & ridges: length: 2,5 mm; width: 5 μm

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

- **prisms (rods*)** are connected by **interprismatic substance (interrod *)** – orientation of crystallites has different angle
Formation of enamel prisms is periodic (active – non active period of formation) visible in the enamel like growing lines = incremental lines (Retzius lines; RL)

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

Connection of ENAMEL – DENTIN

- Arcuate connection in the places with high mechanical stress (ridges and cusps)
- Straight connection 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 zonula occludens
basal part of cell: mitochondria (Mi),
near the nucleus: rER, GA
apical surface:
  - shorter Tomes´ process contains secretory granules
  - cytoskeleton

STEMMA RETICULUM
AMELOBLASTS
PRE-ENAMEL
PRE-DENTIN

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GER
Mi
GA
ZO
TV

Enamel
Dentine

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

70% inorganic matrix (hydroxyapatite)
- dentinal crystallites of hydroxyapatite are flattened, and smaller than in enamel

20% organic matrix
- collagen type I (90%)
- amorphous ground substance (10%)

10% $\text{H}_2\text{O}$

ORIGIN of odontoblasts: ectomesenchymal
Odontoblasts produce dentine – synthesis 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
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**
   - rhythmic 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
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

**Thickness:**
- 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 between them is exposed
**Chemical properties of cementum:**
65% inorganic matrix (hydroxyapatite, small, flattened crystallites: 8x55 nm)
23% organic matrix (collagen type I, sialoprotein)
12% H\(_2\)O

Histologically can be distinguished 2 types of cementum:

(A) Acellular (primary) cementum (10 - 200 \(\mu\)m)
(B) Cellular (secondary) cementum (500 \(\mu\)m)

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
- Odontoblasts
- Blood vessels
Tooth pulp

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

**Cells of tooth pulp:**
- **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

**Extracellular matrix:**
- **a)** collagen type I and III
- **b)** amorphous ground substance
  
  **GAG** (hyaluronic acid, dermatan sulphate, chondroitin sulphate), **structural glycoproteins** (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: **Parodontium** 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
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)

- **Sharpey's fibers** originating in the periodontal ligament