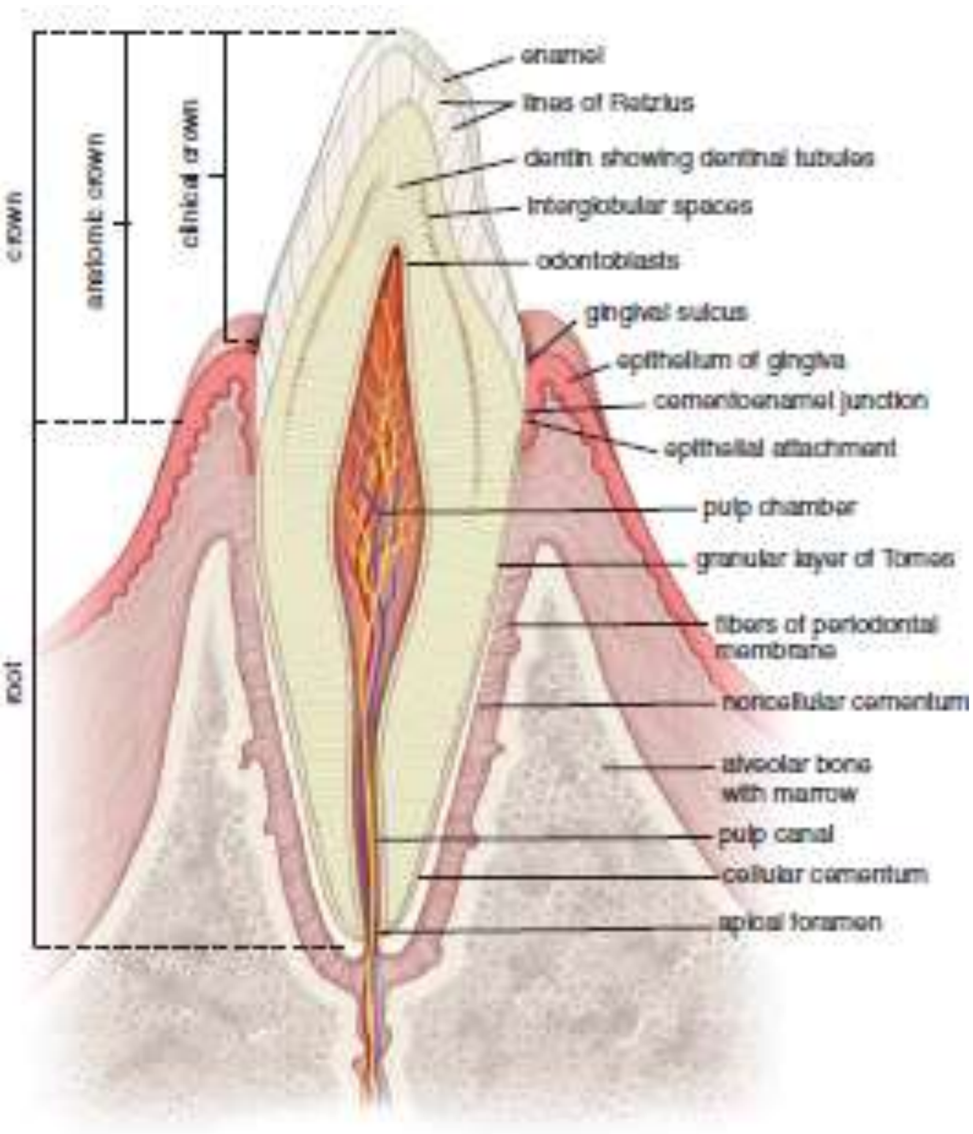
TOOHT STRUCTURE

Department of Histology, Embryology and Cytology of General Medical faculty



TOOTH STRUCTURE

Teeth are made up of three specialized tissues:

- **Enamel**
- **Dentin**
- **Cementum**

• **Enamel**, a hard, thin, translucent layer of acellular mineralized tissue that covers the crown of the tooth.

• **Dentin**, the most abundant dental tissue; its unique tubular structure and biochemical composition support the more rigid enamel and cementum.

• **Cementum**, a thin, pale-yellowish layer of bone-like calcified tissue. It is softer and more permeable than dentin

ENAMEL

is the hardest substance in the body

it consists of 96 to 98% of calcium hydroxyapatite

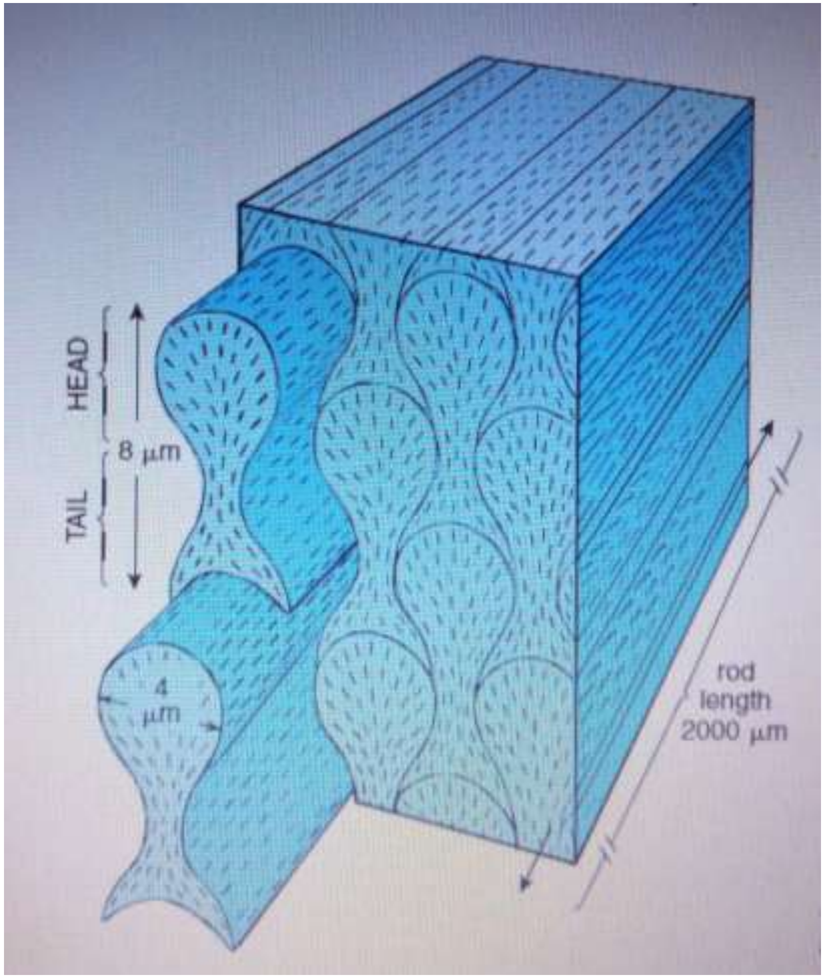
Main characteristics of enamel:

- acellular mineralized tissue (more highly mineralized and harder than any other mineralized tissue in the body) that covers the crown of the tooth.
- mature enamel contains very little organic material.
- unique tissue because it is a mineralized material derived from epithelium.
- varies in thickness and may be as thick as 2.5 mm on the **cusps** (biting and grinding surfaces) of some teeth
- once formed it cannot be replaced.

ENAMEL

Enamel is composed of **enamel rods** that span the full thickness of the enamel layer from the dentinoenamel junction to the enamel surface.

Enamel rods consist of the carbonated calcium **hydroxyapatite crystals** (4 μm wide and 8 μm high)



Enamel rods reveal a keyhole shape ; the *head* is oriented superiorly, and the *tail* is directed inferiorly toward the root of the tooth.

Crystals are primarily oriented parallel to the long axis of the rod within the head, and in the tail they are oriented more obliquely.

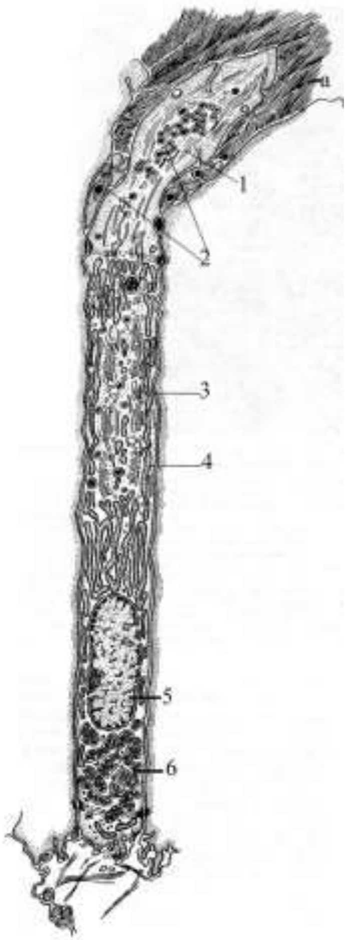
The limited spaces between the rods are also filled with enamel crystals.

Lines of Retzius is striations observed on enamel rods may represent evidence of rhythmic growth of the enamel in the developing tooth.

Enamel of an erupted tooth lacks cells and cell processes, but it is not a static tissue.

ENAMAL FORMATION (AMELOGENESIS)

Enamel is produced by ameloblasts with cooperation of other enamel organ cells.



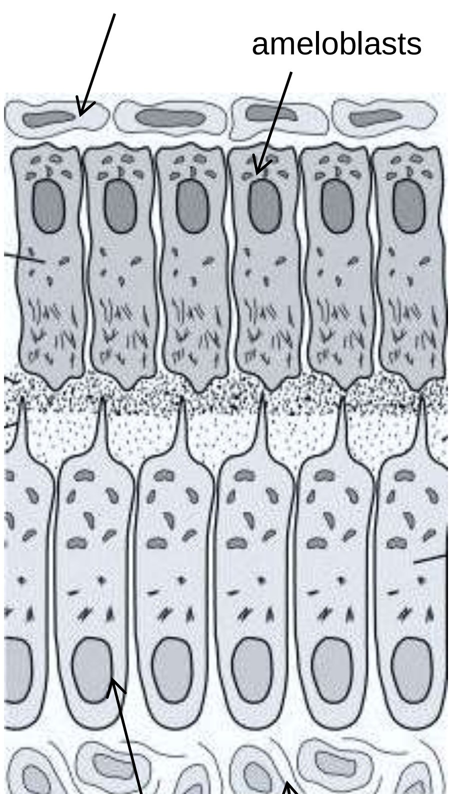
MAJOR STAGES OF AMELOGENESIS:

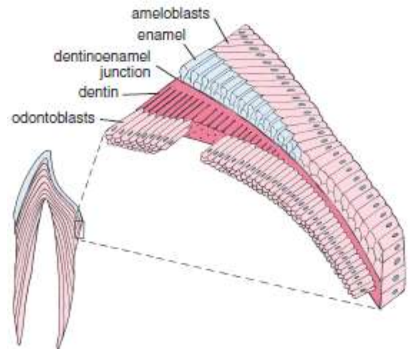
- **Matrix production**, or **secretory stage**.
  Production partially mineralized organic matrix by cells called **secretory-stage ameloblasts**.

- **Matrix maturation**.
  Maturation of the partially mineralized enamel matrix, that involves cells called **maturation-stage ameloblasts.**
  Maturation:
  - the removal of organic material
  - continued influx of calcium and phosphate into the maturing enamel.

Matrix production, or **secretory stage**.

ENAMAL FORMATION (AMELOGENESIS)





Young enamel is deposited by secretory-stage ameloblasts onto the previously formed dentin.

Secretory-stage ameloblasts are polarized columnar cells.
At the apical pole – **Tomes's process**,
which is surrounded by the developing enamel.
At the base – a layer of **stratum intermedium** cells**.**

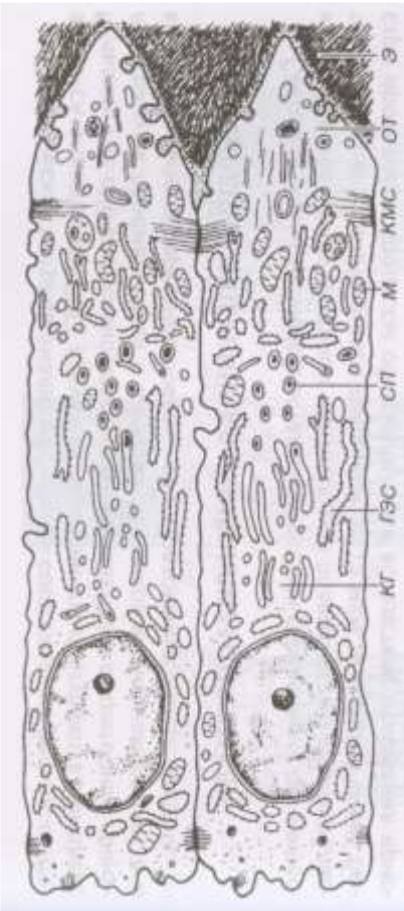
Junctional complexes are present at both apical and basal parts of the cell. They maintain the integrity and orientation of the ameloblasts as they move away from the dentoenamel junction.

Actin filaments joined to these junctional complexes are involved in moving the secretory-stage ameloblast over the developing enamel.

The rod produced by the ameloblast follows in the wake of the cell. Thus, in mature enamel, the direction of the enamel rod is a record of the path taken earlier by the secretory-stage ameloblast.

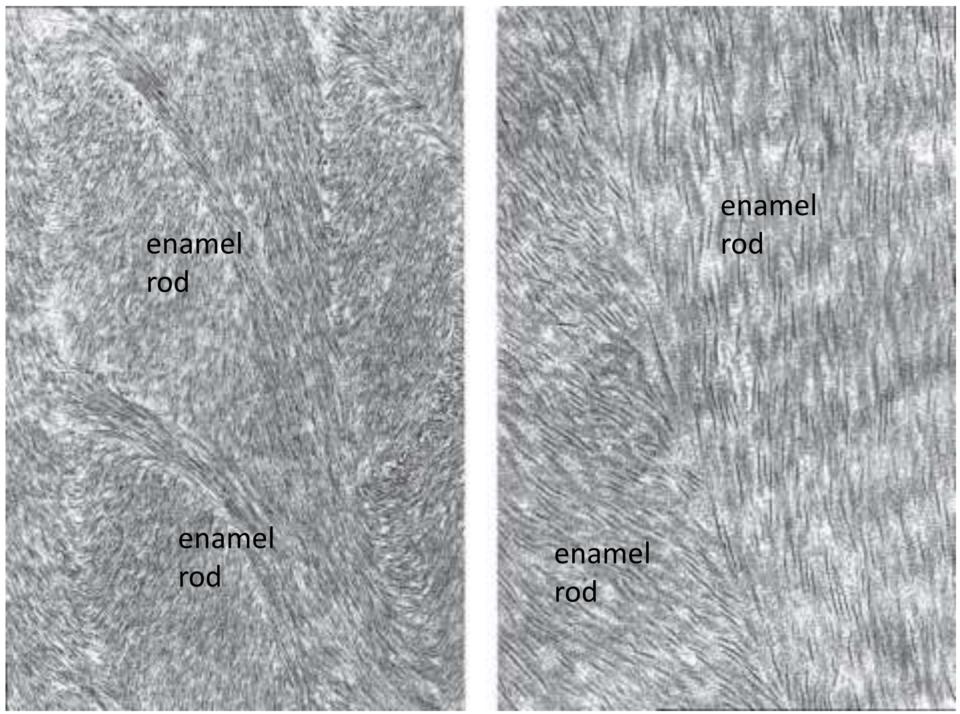
Matrix production, or **secretory stage**.

ENAMAL FORMATION (AMELOGENESIS)



Secretory-stage ameloblasts
produce an *organic proteinaceous matrix* by
- rough endoplasmic reticulum (rER),
- Golgi apparatus, and
- secretory granules.

Structure of young enamel



the boundary between the two rods. The dark needlelike objects are young hydroxyapatite crystals; the substance between the hydroxyapatite crystals is the organic matrix of the developing enamel.
As the enamel matures, the hydroxyapatite crystals grow, and the bulk of the organic matrix is removed.

The secretory-stage ameloblasts continue to produce enamel matrix until *the full thickness of the future enamel is achieved*.

Enamel matrix is highly heterogeneous.

ENAMAL FORMATION (AMELOGENESIS)

PRINCIPAL PROTEINS in the extracellular matrix of the developing enamel:

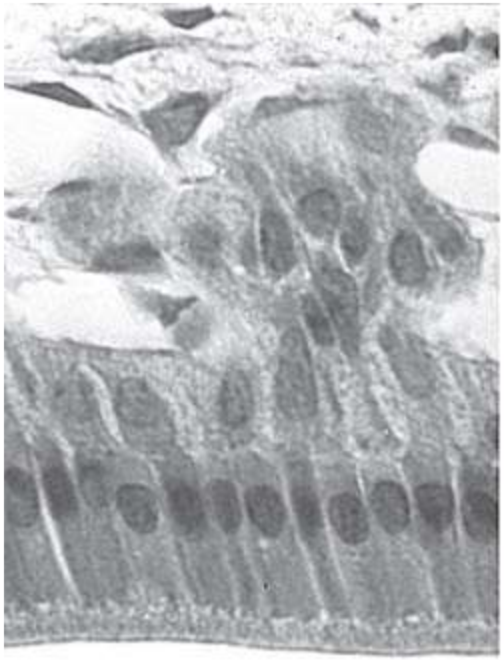
- **Amelogenins**, important proteins in establishing and maintaining the spacing between enamel rods in early stages of enamel development.
- **Ameloblastins**, signaling proteins produced by ameloblasts from the early secretory to late maturation stages. Ameloblastins are believed to guide the enamel mineralization process by controlling elongation of the enamel crystals and to form junctional complexes between individual enamel crystals.
- **Enamelins**, proteins distributed throughout the enamel layer. These proteins undergo proteolytic cleavage as the enamel matures.
- **Tuftelins**, the earliest detected proteins located near the dentinoenamel junction. Their acidic and insoluble nature aids in the nucleation of enamel crystals. Tuftelins are present in **enamel tufts** and account for hypomineralization, i.e., enamel tufts have a higher percentage of organic material than the remainder of the mature enamel.

The maturation of the developing enamel results in its continued mineralization so that it becomes the hardest substancein the body. Amelogenins and ameloblastins are removed during enamel maturation. Thus, mature enamel contains only enamelins and tuftelins.

Matrix maturation.

Maturation:

- the removal of organic material
- continued influx of calcium and phosphate into the maturing enamel.



Maturation-stage ameloblasts differentiate from secretory-stage ameloblasts and function primarily as a transport epithelium, moving substances into and out of the maturing enamel.

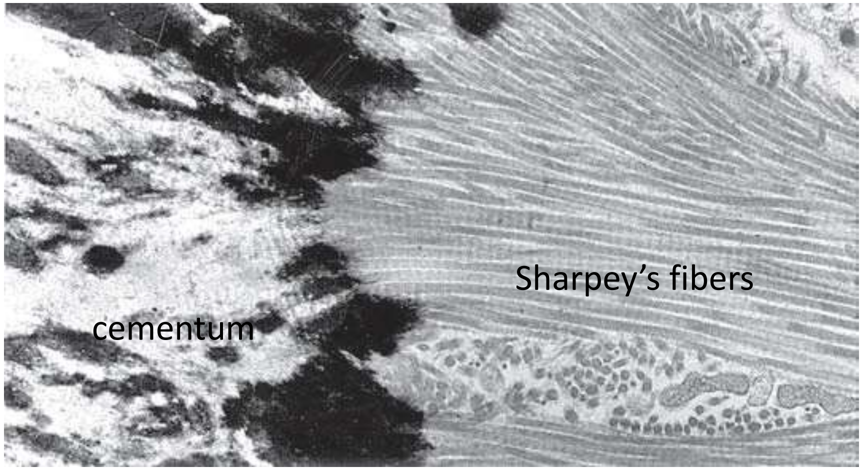
Maturation-stage ameloblasts undergo cyclical alterations in their morphology that correspond to cyclical entry of calcium into the enamel.

The maturation-stage ameloblasts are characterized by numerous mitochondria. Their presence indicates cellular activity that requires large amounts of energy and reflects the function of maturation-stage ameloblasts as a transporting epithelium.

The ameloblasts degenerate after the enamel is fully formed, at about the time of tooth eruption through the gum.

CEMENTUM

Cementum covers the root of the tooth.
The **root** is the part of the tooth that fits into its **alveolus**, or socket in the maxilla or mandible.



Cementum characteristics:
- a thin layer of bonelike material
- is secreted by **cementocytes,** cells that closely resemble osteocytes.
- is 65% mineral, like bone
- unlike bone, cementum is avascular.
- is notresynthesized.

Collagen fibers that project out of the matrix of the cementum and embed in the bony matrix of the socket wall form the bulk of the **periodontal ligament**. These fibers are another example of **Sharpey's fibers.**

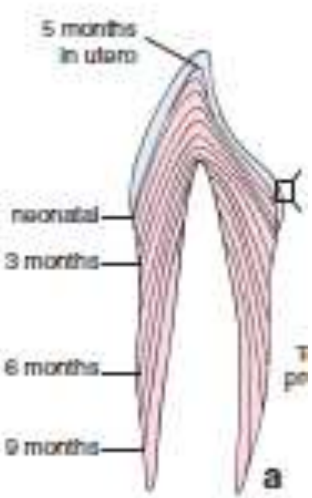
Formation of cementum (cementogenesis) consists of:
1. Secretion of the organic matrix of cementum
2. Mineralization

During mineralization two types of cementum are formed:
- ***acellular*** or *primary cementum*, which is deposited slowly while the tooth is erupting and covers 2/3 of the root surface closer to the crown.
- ***cellular*** or *secondary cementum*, which is formed after the eruption of the tooth more close to apical portion of the root.

DENTIN

Dentin is the first mineralized component of the tooth to be deposited.

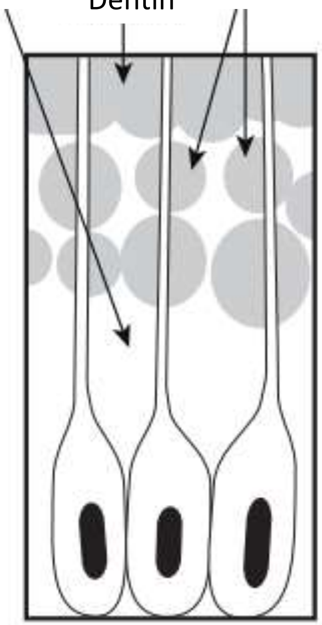
Dentin is secreted by **odontoblasts**



Dentin is a calcified material that forms most of the tooth substance.
Dentin lies deep to the enamel and cementum.
It contains:

- *inorganic substances* - about 70% (less hydroxyapatite than enamel, but more than is found in bone and cementum)
- *organic substances* – about 30% (pre-collagen and collagen fibers, odontoblast processes, dentin-specific non-collagen calcium-binding proteins (phosphophoryn (dentin phosphoprotein), dentin sialoprotein), nonspecific proteins (osteocalcin, osteonectin), and alkaline phosphatase.

Deposition of dentin by odontoblasts continues throughout the life and increases with tooth damage. With age, dentin thickness normally increases, while the volume of tooth cavity decreases

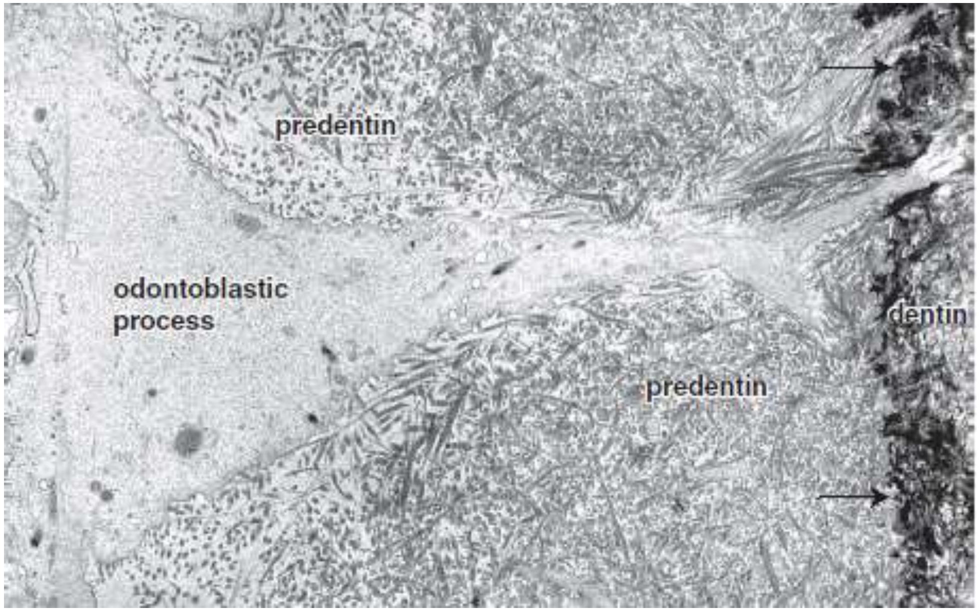


DENTIN and dentinogenesis

TOOTH STRUCTURE

Dentin composition:

- ground substance,
- collagen fibers (organized in bundles and running in two directions — radial and tangential)
- **dentinal tubules** (narrow channels containing embedded in the dentin odontoblast processes).
- calcium hydroxyapatite.



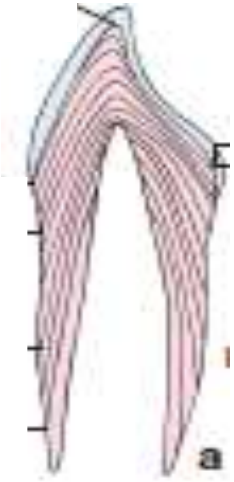
mineralization front

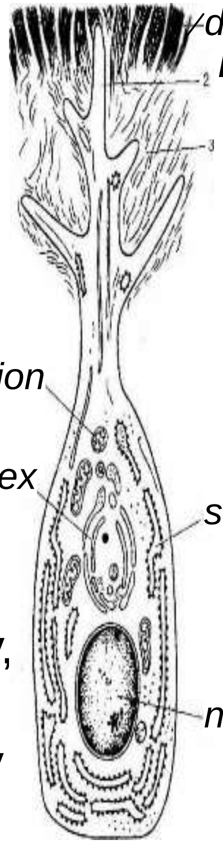
Stages of dentin formation (dentinogenesis):

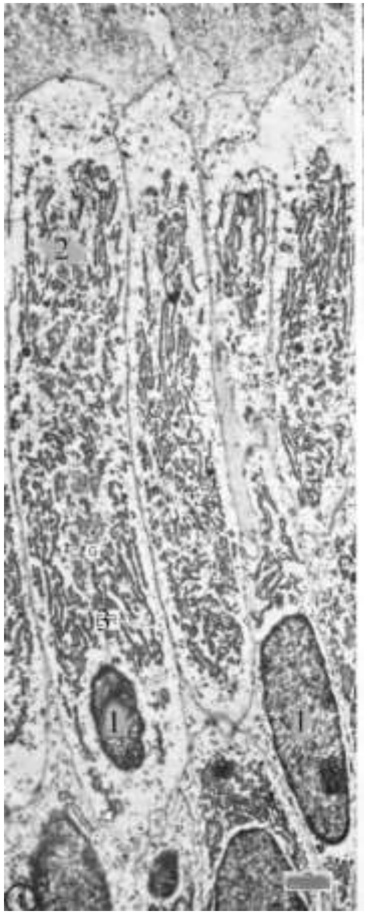
1. Secretion of the organic matrix of dentin, or predentin,
2. Mineralization of organic matrix and formation dentin

DENTIN and dentinogenesis

The cells (odontoblasts) form a layer at the periphery of the dental papilla and then secrete the organic matrix of dentin, or predentin, at their apical end (away from the dental papilla)



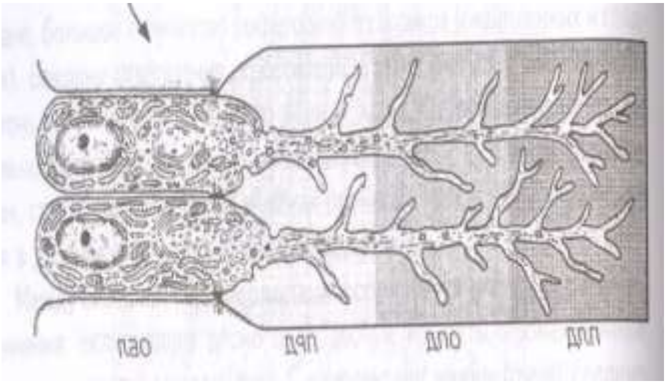




As the predentin thickens, the odontoblasts move or are displaced centrally.

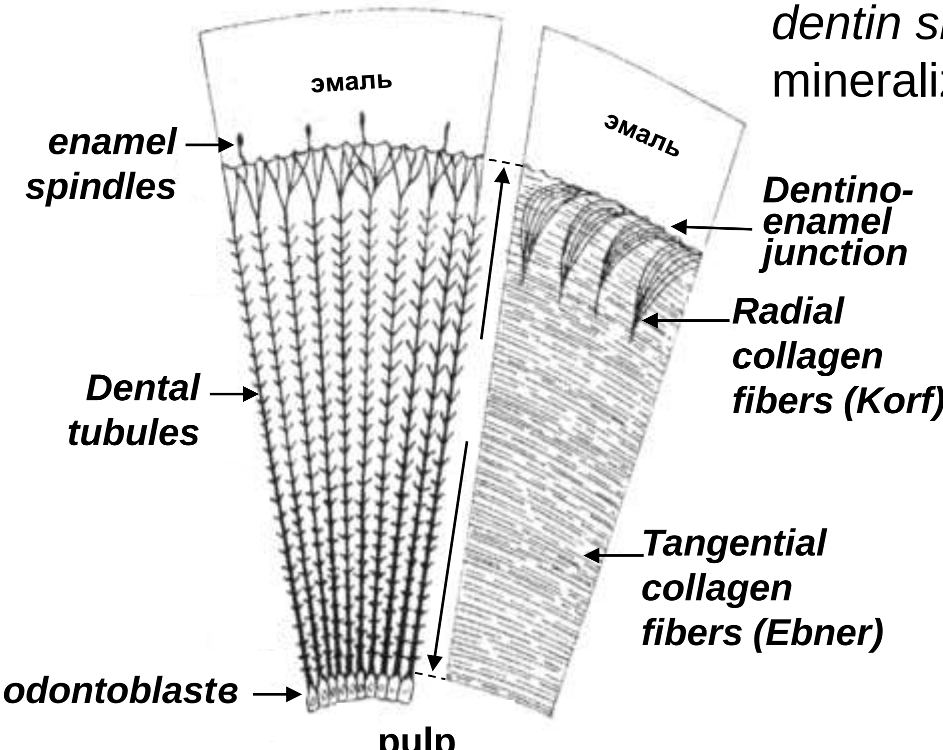
A wave of mineralization of the dentin follows the receding odontoblasts. As the cells move centrally, the odontoblastic processes elongate; the longest are surrounded by the mineralized dentin. In newly formed dentin, the wall of the dentinal tubule is simply the edge of the mineralized dentin. With time, the dentin immediately surrounding the dentinal tubule becomes more highly mineralized; this more mineralized sheath of dentin is referred to as the **peritubular dentin**. The remainder of the dentin is called the **intertubular dentin**.

DENTIN and dentinogenesis



During dentinogenesis three layers of dentin are distinguished:

1) **Predentin** is the newly secreted organic matrix, closest to the cell body of the odontoblast, which has yet to be mineralized, and contains two unique proteins (*dentin phosphoprotein (DPP), dentin sialoprotein (DSP),* involved in the mineralization process)

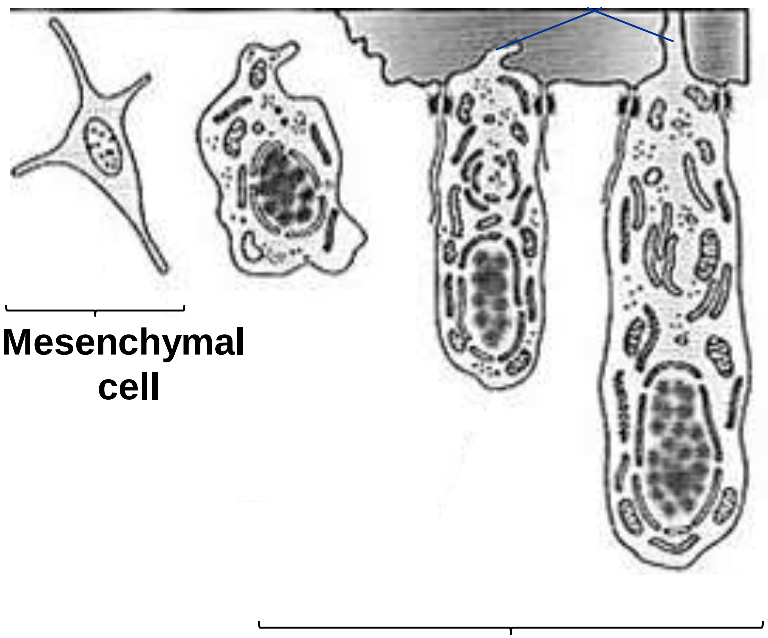


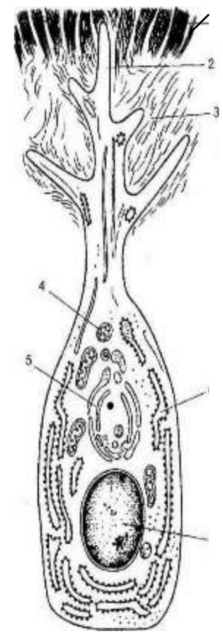
2) **Parapulpar dentin,** which constitutes the main volume of mineralized dentin and contains the tangential von Ebner's fibers.

3) **Mantle dentin** (the outermost), fully mineralized and containing von Korff's fibers.

DENTIN FORMATION (DENTONOGENESIS)

Dentin is produced by odontoblasts, that differentiate from cells at the periphery of the dental papilla.

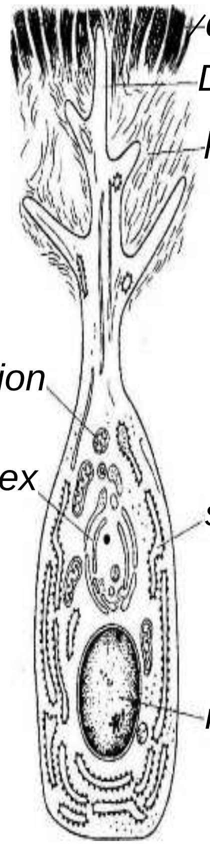




The progenitor cells have the appearance of typical mesenchymal cells, i.e., they contain little cytoplasm. During their differentiation into odontoblasts, the cytoplasmic volume and organelles characteristic of collagen-producing cells increase.

DENTIN FORMATION (DENTONOGENESIS)

TOOTH STRUCTURE



odontoblasts

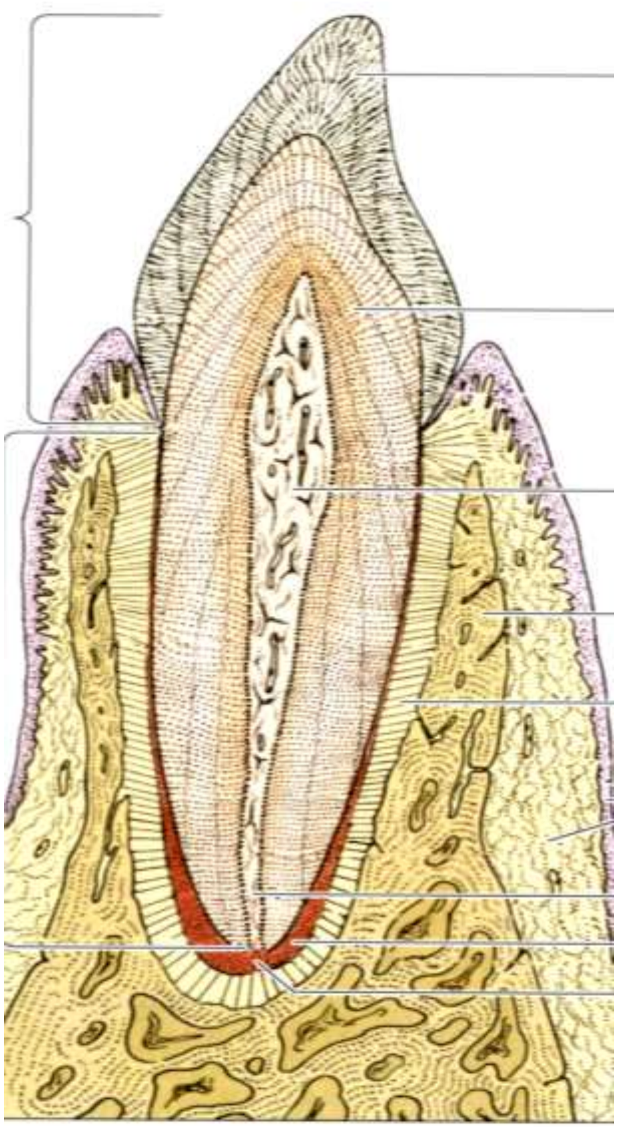
Like ameloblasts, odontoblasts are columnar cells that contain:

- a well-developed rER,
- a large Golgi apparatus,
- and other organelles associated with the synthesis and secretion of large amounts of protein.

The apical surface of the odontoblast is in contact with the forming dentin;

junctional complexes between the odontoblasts at that level separate the dentinal compartment from the pulp compartment.

DENTIN



The layer of odontoblasts retreats as the dentin is laid down, leaving odontoblast processes embedded in the dentin in narrow channels (**dentinal tubules).** The tubules and processes continue to elongate as the dentin continues to thicken by rhythmic growth.

The rhythmic growth of dentin produces certain “growth lines” in the dentin

- incremental lines of von Ebner
- thicker lines of Owen

that mark significant developmental times such as birth (**neonatal line**) and when unusual substances such as lead are incorporated into the growing tooth.

DENTAL PULP (Pulp Chamber)

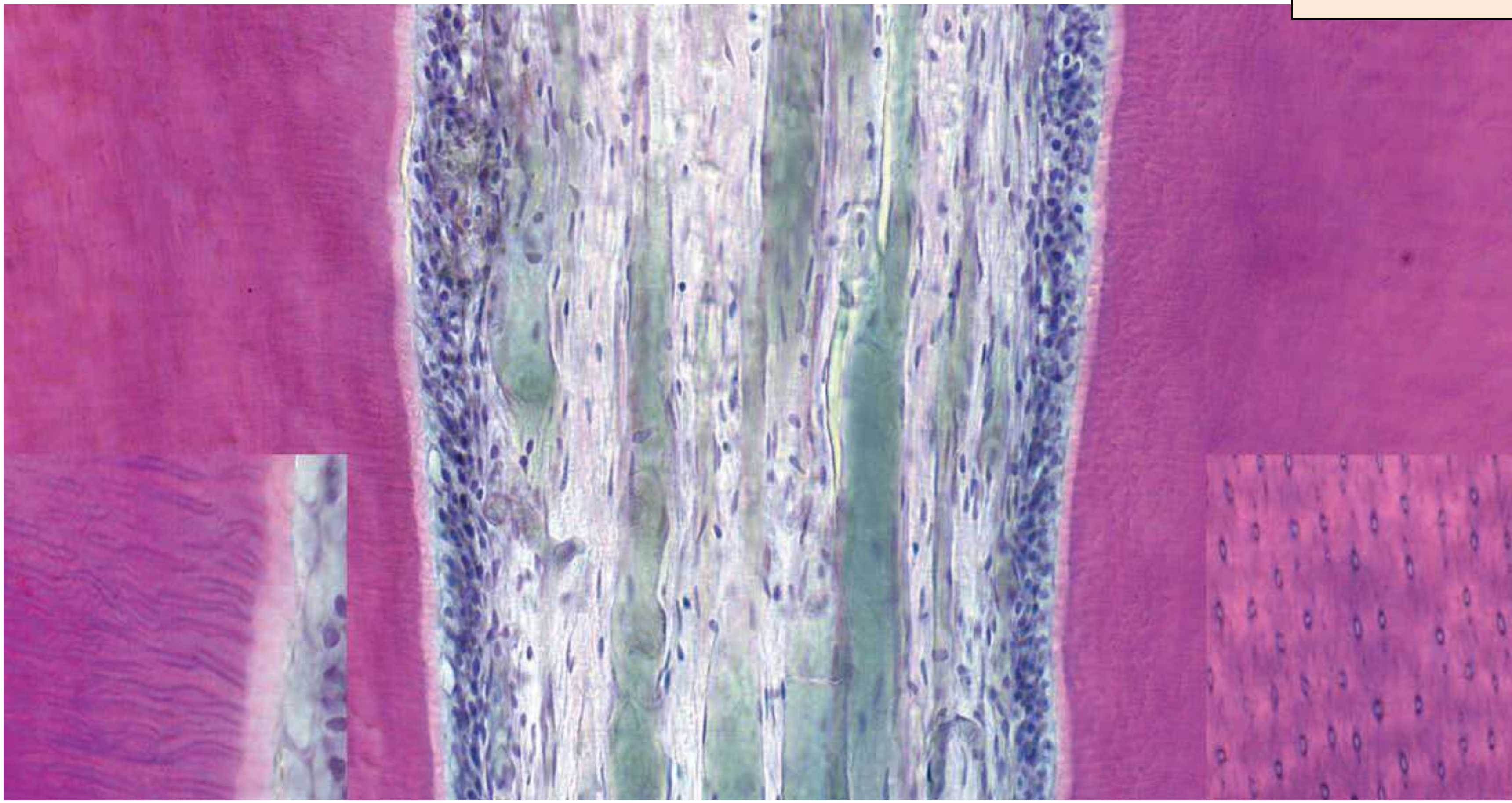
The dental pulp cavity is a connective tissue compartment bounded by the tooth dentin.

The **central pulp cavity** is the space within a tooth that is occupied by **dental pulp**, a loose connective tissue that is richly vascularized and supplied by abundant nerves. The pulp cavity takes the general shape of the tooth.
The blood vessels and nerves enter the pulp cavity at the tip (apex) of the root, called the **apical foramen**.
The blood vessels and nerves extend to the crown of the tooth, where they form vascular and neural networks beneath and within the layer of odontoblasts. Some bare nerve fibers also enter the proximal portions of the **dentinal tubules** and contact odontoblast processes.
In teeth with more than one cusp, **pulpal horns** extend into the cusps and contain large numbers of nerve fibers. More of these fibers extend into the dentinal tubules than at other sites. Because dentin continues to be secreted throughout life, the pulp cavity decreases in volume with age.
There are *peripheral, intermediate* and *central* layers of pulp.
According to location pulp cavity is subdivided into crown part and root parts.

With age, a bodies of calcified substances in the dental pulp — **calcifications** (*petrification areas)* and **denticles** — *can be formed*.

DENTIN and DENTAL PULP

TOOTH STRUCTURE



Dental pulp and structure of dentin. This photomicrograph of a decalcified tooth shows the centrally located dental pulp, surrounded by dentin on both sides. It contains blood vessels and nerves. Dentin contains the cytoplasmic processes of the odontoblasts within dentinal tubules. They extend into the dentinoenamel junction. The cell bodies of the odontoblasts are adjacent to the unmineralized dentin called the predentin. **Left inset.** Longitudinal profiles of the dentinal tubules. **Right inset.** Cross-sectional profiles of dentinal tubules. The dark outline of the dentinal tubules, as seen in both insets, represents the peritubular dentin, which is the more mineralized part of the dentin.

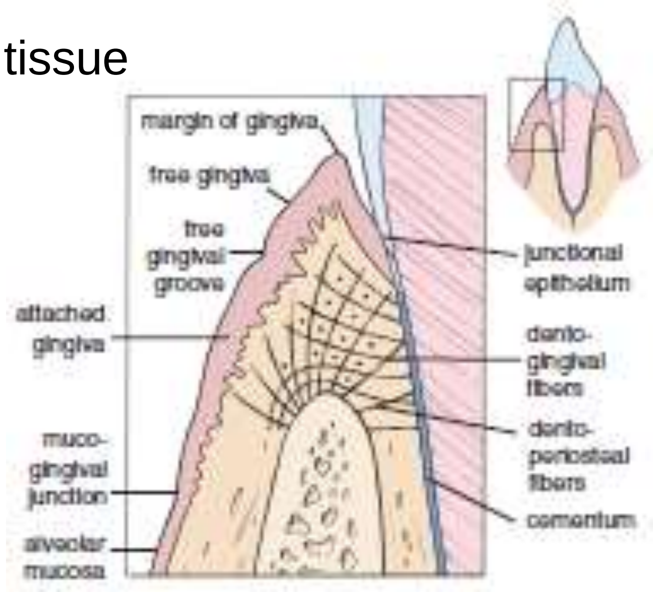
SUPPORTING TISSUES OF THE TEETH

Supporting tissues of the teeth include:
- alveolar bone of the alveolar processes of the maxilla and mandible,
- periodontal ligaments,
- and gingiva.

The **periodontal ligament** is the fibrous connective tissue joining the tooth to its surrounding bone.

The **periodontal ligament** provides for the following:

• Tooth attachment (fixation)
• Tooth support
• Bone remodeling (during movement of a tooth)
• Proprioception
• Tooth eruption



The periodontal ligament contains areas of both dense and loose connective tissue. The dense connective tissue contains collagen fibers and fibroblasts that are orientated in different directions. The loose connective tissue in the periodontal ligament contains blood vessels and nerve endings. In addition to fibroblasts and thin collagenous fibers, the periodontal ligament also contains thin, longitudinally disposed **oxytalan fibers**. They are attached to bone or cementum at each end. Some appear to be associated with the adventitia of blood vessels.