# Dentinogenesis

**Dentin formation (Dentinogenesis):**

Begins at the **bell stage** development in the papillary tissue adjacent to the concave tip of the folded **inner enamel epithelium** the site where cuspal development begins. From that point, dentin formation spreads down the cusp slope as far as the cervical loop of the enamel organ, and the dentin thickens until all the **coronal dentin** is formed.

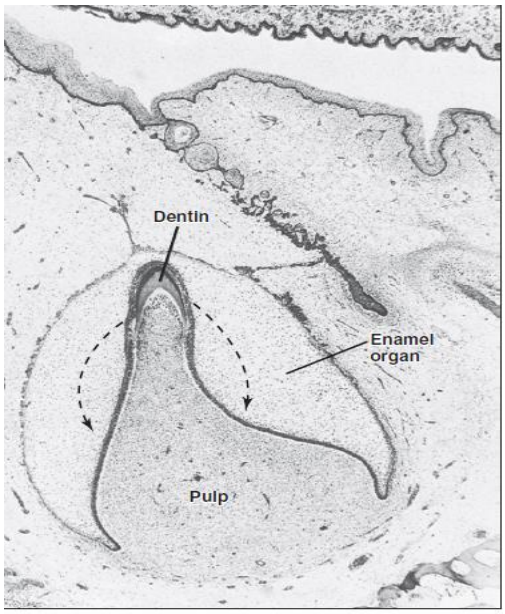
In multicusped teeth, dentin formation begins independently at the sites of each **future cusp tip** and again spreads down the flanks of the cusp slopes until fusion with adjacent formative centers occurs. Dentin thus formed constitutes the dentin of the crown of the tooth, or coronal dentin.

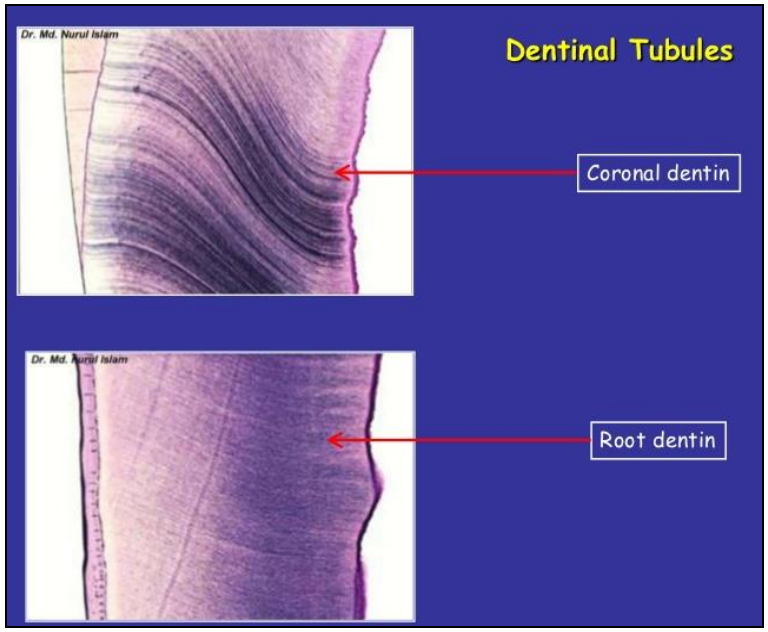
**Odontoblasts Differentiation**:- The differentiation odontoblasts from the dental papilla in normal development is brought about by the expression of **signaling molecules and growth factors** in the cells of the inner enamel epithelium illustrate the differentiation sequence, The few organelles. At this time they are separated from the inner enamel epithelium by cell free zone that contains some fine collagen fibrils.

Almost immediately after cells of the inner enamel epithelium **reverse polarity**, changes also occur in the adjacent dental papilla. The ectomesenchymal cells adjoining this zone rapidly enlarge and elongate to become preodontoblasts first and then odontoblasts as their cytoplasm increases in volume to contain increasing amounts of protein-synthesizing organelles. Then this zone gradually is eliminated as the odontoblasts **differentiate** and **increase in size** and occupy this zone.

These newly differentiated cells are characterized by being highly polarized (**40 µm in length and 7 µm in width**), with their nuclei positioned away from the inner enamel epithelium.

Thus the dental papilla is the formative organ of dentin and eventually becomes the pulp of the tooth, a change in terminology generally associated with the moment dentin formation begins.




## Life cycle of odontoblasts :

**1- <u>Differentiating stage</u>:**

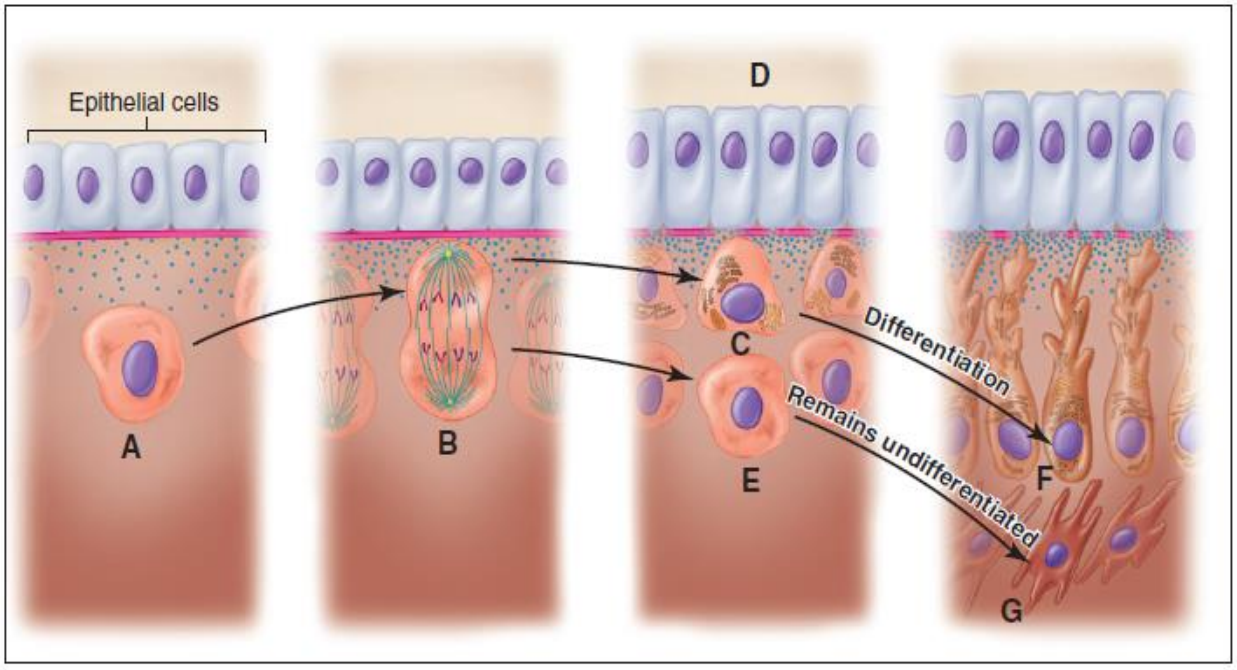
- Before Differentiation the inner dental epithelium is separated from dental papilla by the thin basement membrane.
- The undifferentiated peripheral cells are spindle and separated by great amount of ground substance.
- In the early bell stage, under the inductive influence of the inner dental epithelium, the peripheral ectomesenchymal cells differentiate into preodontoblasts.
- They assume to a columnar shape and aligned as a single row along the basement membrane.
- Several projections (odontoblast process) arise from the upper part of the cells.
- The nuclei become basally oriented toward the pulp. The cells grow in length to become columnar (40µm)
- Now the fully differentiated odontoblasts begin their work.

**2- Formative stage**:

- ❖ Concentration of the cell organelles, granular components and globular elements
- ❖ Production of the first amount of dentin (dentin matrix)
- ❖ The odontoblasts retreat from the basement membrane
- ❖ Leaving a single odontoblastic process which become enclosed in the dentinal tubule (Tome´s fiber).
- ❖ With successive deposition of dentin, tubule and odontoplastic process (Tome´s fiber) grow in length.

**3- Quiescent stage**:

- Odontoblasts decrease in size and function.
- The dentin formation is reduced.
- They produce now secondary and reparative dentin.



**Dentinogenesis occur by odontoblasts in two stages**:-

**1- Formation of dentin matrix ( predentin):**

After the differentiation of odontoblasts, the next step in the production of dentin is formation of its **organic matrix**.

The first sign of dentin formation is the appearance of distinct, large-diameter collagen fibrils (0.1 to 0.2 µm in diameter) called **Von Korff's fibers .** These fibers consist of **collagen type IIl** associated, at least initially, with **fibronectin**. These fibers originate deep among the odontoblasts , extend toward the inner enamel epithelium, and fan out in the structure less ground substance immediately below the IEE cells.

As the odontoblasts continue to increase in size, they also produce smaller **collagen type I fibrils** that orient themselves parallel to the future dentinoenamel junction .

The odontoblasts form the main components of the predentin , the collagen fibers and non-collagenous protein.

**The main non-collagenous proteins in the predentin** are:

1. Bone morphogenic proteis (BMP 2,4 ,7),
2. Dentin phosphoprotein (DPP)
3. Osteocalcin, Osteonectin and Osteopontin,
4. Dentin sialoproteins (DSP).

**DPP and DSP represent the major non-collagenous** protein in D. because they are important for organization and mineralization of predentin. Coincident with this deposition of predentin, the odontoblast develops a cell process, the odontoblast process or Tomes ' fiber, which is left behind in the forming dentin matrix as the odontoblast moves away toward the pulp.

**2- Mineralization of the predentin**

It occurs **parallel** to predentin formation. It begins at the **tip of the crown** and then it proceeds in **a rhythmic pattern** to gradually complete **cervically.**

Mineralization of dentine begins when the predentin is approximately **5 µm thick.**

Spherical zones of hydroxyapatite called **calcospherites** are formed within the predentin. Mineralization of the dentine matrix starts at random points and eventually these calcospherites **fuse together** to form mineralized dentine.

Dentinal tubules will form around each odontoblastic process. The first layer of predentin begins its mineralization called **primary Mantle dentin** is formed in a layer approximately 15 to 20 µm thick onto which then is added the **primary Circumpulpal dentin**.

## PATTERN OF MINERALIZATION

Histologically, two patterns of dentin mineralization can be observed during dentinogenesis 1**- globular , 2- linear mineralization** that seem to depend on the rate of dentin formation**.**

**Globular (or calcospheric) calcification**: involves the deposition of crystals in several discrete areas of predentin. **Mantle dentin** mineralization occurs in a globular pattern, where small centers of calcification spread concentrically until they fuse together as calcospherites . This mineralization occur by buds off small matrix vesicles (an electron microscopical budding) in cell membrane of odontoblasts contain the first hydroxyapatite crystals and alkaline phosphatase enzyme) which lie superficially near the basement membrane. **Mineral phase** first appears within the matrix vesicles **as single** hydroxyapatite crystals. Crystals grow and rupture of matrix vesicle occur and fuse of crystals with adjacent crystals to form a continuous layer of mineralized dentin matrix.

The mineralization goes then in linear or occasionally globular pattern in the remnant or bulk thickness of dentin which is called **circumpulpal dentin.** The mineralization begins by crystal deposition in form **of fine plates of hydroxyapatite crystals** on the surface of the collagen fibrils. The long axes of the crystals are paralleling to the collagen fibrils. If somewhere those globules do not fuse together, areas of uncalcified dentin are known as **interglobular dentin.**

**Root dentin:-** forms at a slightly later stage of development and requires the proliferation of epithelial cells **(Hertwig's epithelial root sheath**) from the **cervical loop** of the enamel organ to initiate the differentiation of root odontoblasts.

Root dentin form similarly to coronal dentin, but some differences have been reported.

The mantle dentin in the root, shows differences in collagen fiber orientation and organization, in part because the collagen fibers from cementum blend with those of dentin. Also it forms **at a slower speed**, and its **degree or mineralization less** than that of coronal dentin. **The onset** of root formation **precedes** the onset of tooth eruption, and when the tooth reaches its functional position, about 2/3 of the root dentin will have been formed. **Completion of root dentin** occur in the deciduous tooth until about **18 months** after it erupts and in the permanent tooth until (2 **to 3) years after it erupts**.

**Dentin formation continues throughout the life** of the tooth, and its formation results in a gradual but progressive reduction in the size of the pulp cavity.

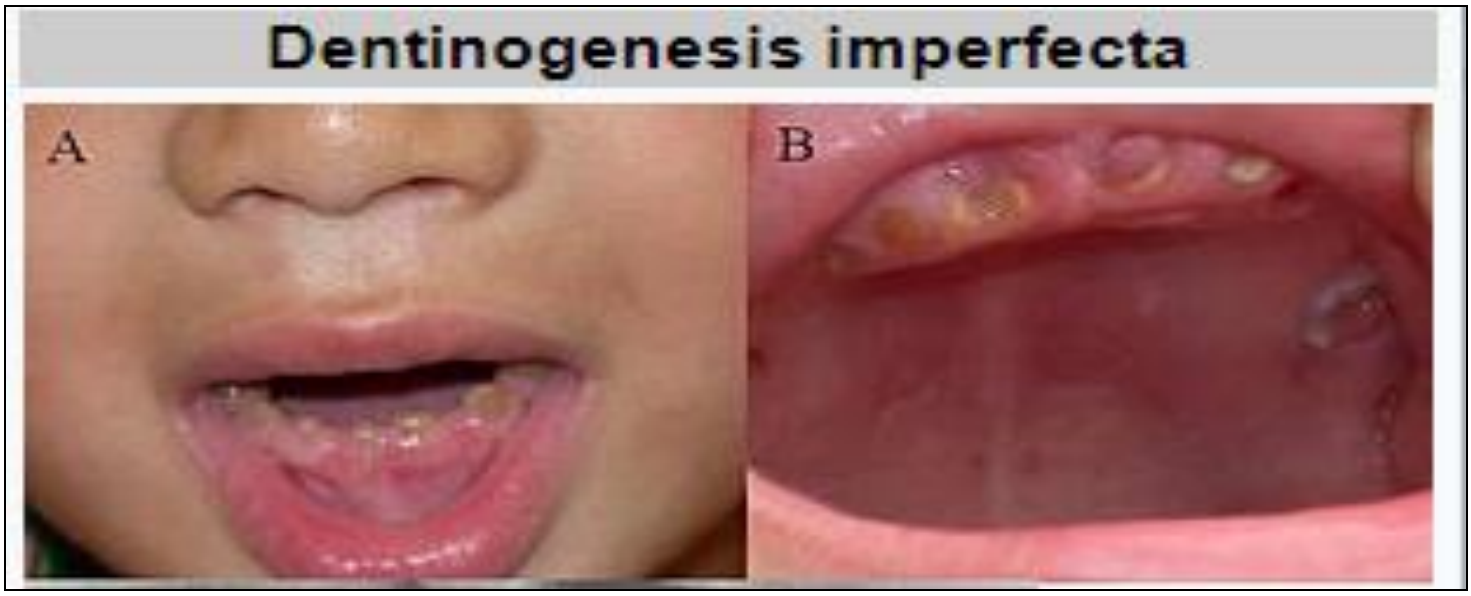
## Clinical considerations:

Disturbances in either the secretion of dentin matrix or maturation of this matrix can lead to defects in dentin structure, and as a consequence to the supportive function of dentin.

Three different types of inherited defects in dentin matrix are classed under the term **dentinogenesis imperfect**. In these individuals, the crowns are found to have a bulbous contour and the pulp chambers become obliterated by poor quality dentin. Clinically, this results in a bluish or brownish cast to the teeth, and shortly after eruption the enamel fractures away leaving the soft inner core of dentin exposed.

**Dentin Sensitivity: three theories**

- Nerve in dentin – the dentin contains nerve endings that respond when it is stimulated.
- Odontoblastic process – the odontoblasts serve as receptors and are coupled to nerves in pulp.
- Fluid movements in the dentinal tubules – the tubular nature of dentin permits fluid movement to occur within the tubule when a stimulus is applied –a movement registered by pulpal free nerve endings close to the dentin.



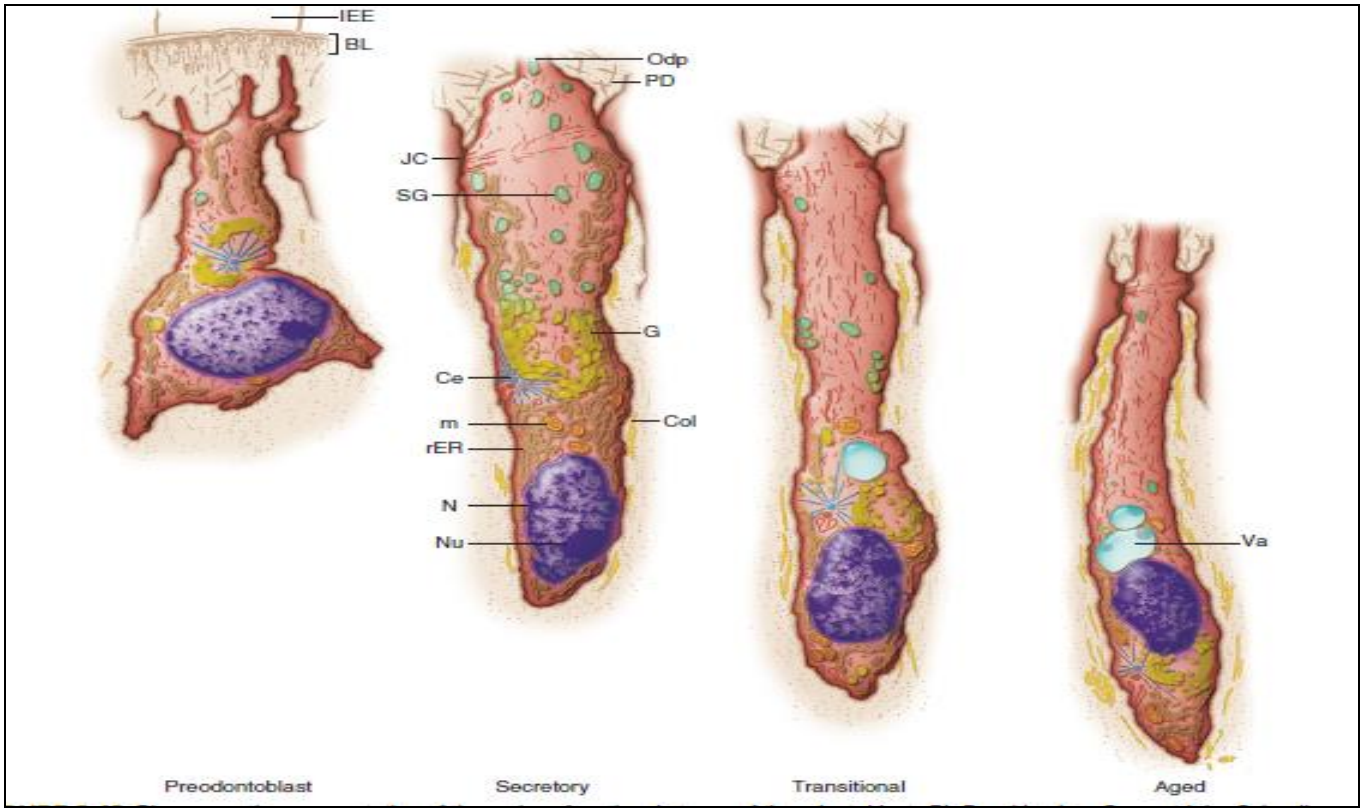




FIGURE 8-42 Diagrammatic representation of the various functional stages of the odontoblast. *BL*, Basal lamina; *Ce*, centriole; *Col*, collagen; *G*, Golgi complex; *IEE*, inner enamel epithelium; *JC*, junctional complex; *m*, mitochondria; *N*, nucleus; *Nu*, nucleolus; *Odp*, odontoblast process; *PD*, predentin; *rER*, rough endoplasmic reticulum; *SG*, secretory granule; *Va*, vacuole. (Adapted from Couve E: *Arch Oral Biol* 31:643, 1986.)