LEC-10

Dentin Formation (Dentinogenesis)

Dentinogenesis starts at the late bell stage, and occurs in the crown as well as root regions. Differentiated odontoblasts are secretory cells with characteristic apical cytoplasmic structures called **Tomes fibers** (odontoblastic process) which connect the cells with the surface of dentin. Tomes fibers elongate as dentin matrix formation (predentin) continues.

Dentinogenesis occurs *prenatally* as well as *postnatally*, and can be seen during the whole life when secondary and tertiary dentin is formed. 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.

Odontoblasts

Odontoblasts differentiate from the peripheral cells of the dental papilla by signaling molecules and growth factors of the inner enamel epithelium (IEE) . Odontoblasts first appear at sites of tooth development at *17–18 weeks* in utero and remain present until death unless killed by bacterial or chemical attack, or indirectly through heat or trauma (e.g. during dental procedures).
Histologically odontoblasts are large columnar cells in the crown to flatter cells near the apex of root, whose cell bodies are arranged along the interface between dentin and pulp. The cell is rich in endoplasmic reticulum and Golgi complex, especially during primary dentin formation, which allows it to have a high secretory capacity. As more dentine matrix is deposited, the odontoblast cells retreat in the direction of the pulp leaving an elongated process known as the *odontoblastic process or Tomes fibers*.
During secretion , its nucleus is aligned away from the newly formed dentin (toward the pulp side), with its Golgi complex and endoplasmic reticulum towards the dentin. Shape of the odontoblasts also reflect the functional activity of the cell. During active phase or ***secretory phase***, cells show increase in length about 40µm and 7µm in width with increase endoplasmic reticulum, Golgi apparatus and secretory vesicles. While during resting phase cells or ***Quiescent phase*** are flattened with little cytoplasm condensed chromatin and decrease number of

endoplasmic reticulum.
Numerous junctions such as gap junctions, tight junction and desmosomes are found between odontoblasts indicating exchange of ions and small molecules and also promote cell to cell adhesion

Dentinogenesis occur in two stages:

1-Secretion of dentin matrix (predentin):
The first unmineralized organic matrix secreted by odontoblasts. A narrow layer of predentin is always present on the surface of the pulp adjacent to odontoblasts. Odontoblasts form approximately *4 μm* of predentin daily during tooth development. The odontoblasts form the main components of the dentin matrix, the collagen fibers and non-collagenous protein which forms the ground substance.
The main non-collagenous proteins in the predentin are:
1. Bone morphogenic proteis (BMP 2,4 ,7)
2. Dentin phosphoprotein /phosphoryn (DPP)
3. Osteocalcin, Osteonectin and Osteopontin
4. Dentin sialoproteins (DSP)
The first indication of forming predentin is the development of the ***vonKorff's fibers***
which are bundles of type III collagen fibers secreted by odontoblasts and they are perpendicular to the basement membrane. This fibers is is present in *Mantle dentin*(first type mineralized primary dentin).Then smaller collagen fibril (type I) form a network in the dentin adjacent to the mantle dentin, which is called *Circumpulpal dentin*(second type mineralized primary dentin).

2-Mineralization of dentin:
It occurs parallel to predentin formation and it begins at the tip of the crown and it proceeds in a rhythmic pattern to gradually complete cervically.
The first layer of predentin begins its mineralization in a globular pattern, where small centers of calcification(crystals) which come from *matrix vesicle*(electrone microscopic vesicle attached to cell membrane of odontoblast which contain first Hydroxyapatite crystals and alkaline phosphatase enzyme). When the crystals grow the matrix vesicles rupture and their content spread in predentin until they fuse together and form globules.

Mineralization of predentin or maturation of dentin takes place in two phases: primary and secondary.
Initially, the calcium hydroxyapatite crystals form as *globules*, or *calcospherules*, in the collagen fibers of the predentin, which allows for both the expansion and fusion during the primary mineralization phase.
Later, new areas of mineralization occur as globules form in the partially mineralized predentin during the secondary mineralization phase. These new areas of crystal formation are more or less regularly layered on the initial crystals, allowing them to expand.
In areas where both primary and secondary mineralization have occurred with complete crystalline fusion, these appear as lighter rounded areas on a stained section of dentin and are considered *globular dentin*. In contrast, the darker area like areas in a stained section of dentin are considered *interglobular dentin*. In interglobular area, only primary mineralization has occurred within the predentin, and the globules of dentin do not fuse completely. Thus, interglobular dentin is slightly less mineralized than globular dentin. Interglobular dentin is especially evident in coronal dentin, near the DEJ.

Pattern of mineralization in dentin:

Histologically, *two patterns* of dentin mineralization can be observed during dentinogenesis *globular and 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 occur in a globular pattern (matrix vesicles)
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.

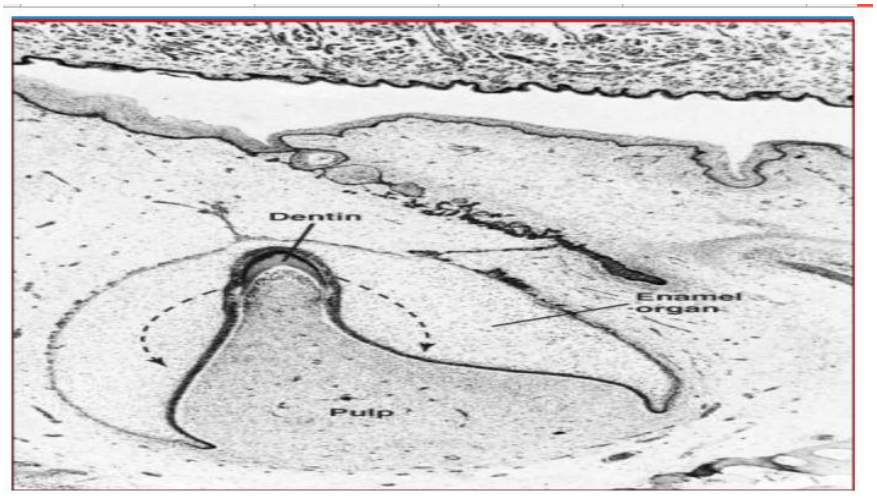
Pattern of Dentin formation

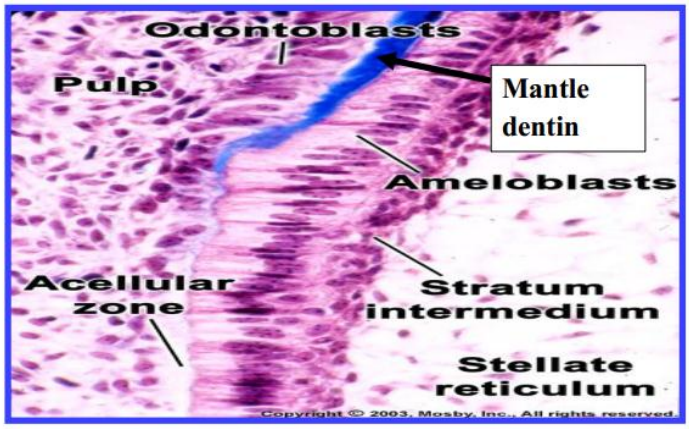
Dentin of the crown(coronal dentin) formation begins at the bell stage of tooth development in the papillary tissue adjacent to the inner enamel epithelium, the site where cuspal development begins. From that point, dentin formation spreads down

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.
Root dentin(Radicular 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 around the growing pulp to initiate the differentiation of root odontoblasts.
Root dentin is considered different from dentin of the crown because of the different orientation of collagen fibers, as well as less mineralization.
The onset of root formation precedes the onset of tooth eruption, and by the time the tooth reaches its functional position, about two thirds of the root dentin will have been formed. Completion of root dentin formation does not 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. During this period the tooth is said to have an open apex.

Dentinogenesis imperfecta(DGI):

Hereditary condition associated with abnormal dentin mineralization and varying degrees of changes in tooth morphology. DGI type I is associated with osteogenesis imperfecta(brittle bone disease), whereas the clinically similar DGI type II is not associated with a syndrome and is caused by mutations in the gene encoding dentin sialophosphoprotein (DSPP). The DGI tooth phenotype is highly variable and is characterized by blue-gray to yellow-brown coloration .




Odontoblasts
Pulp
Mantle dentin
Ameloblasts
Acellular zone
Stratum intermedium
Stellate reticulum
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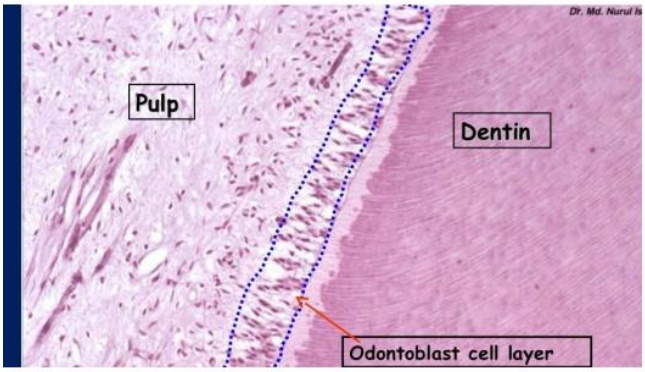
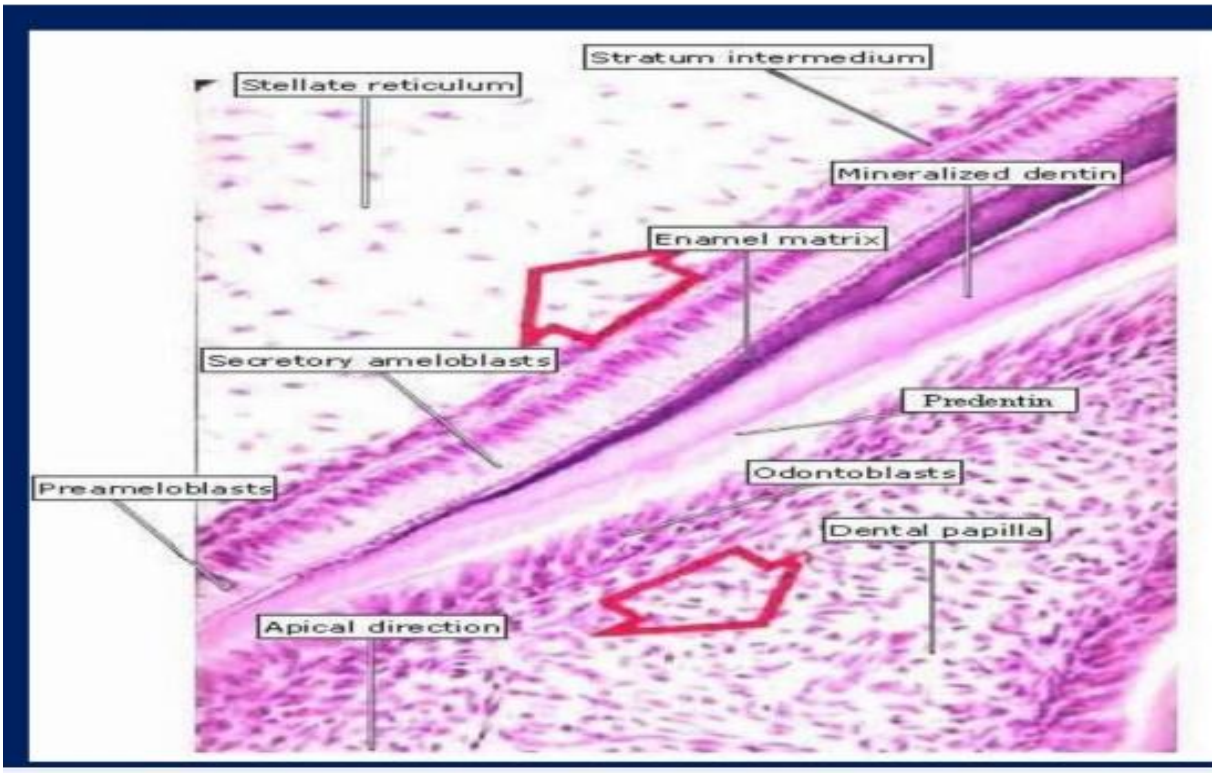

Pulp
Dentin
Odontoblast cell layer


Stratum intermedium
Stellate reticulum
Mineralized dentin
Enamel matrix
Secretory ameloblasts
Predentin
Odontoblasts
Preameloblasts
Dental papilla
Apical direction