DEVELOPMENT OF TOOTH

DEPARTMENT OF ORAL AND MAXILLOFACIAL PATHOLOGY & ORAL MICROBIOLOGY

DENTAL LAMINA
- Fate of dental lamina
- Vestibular lamina

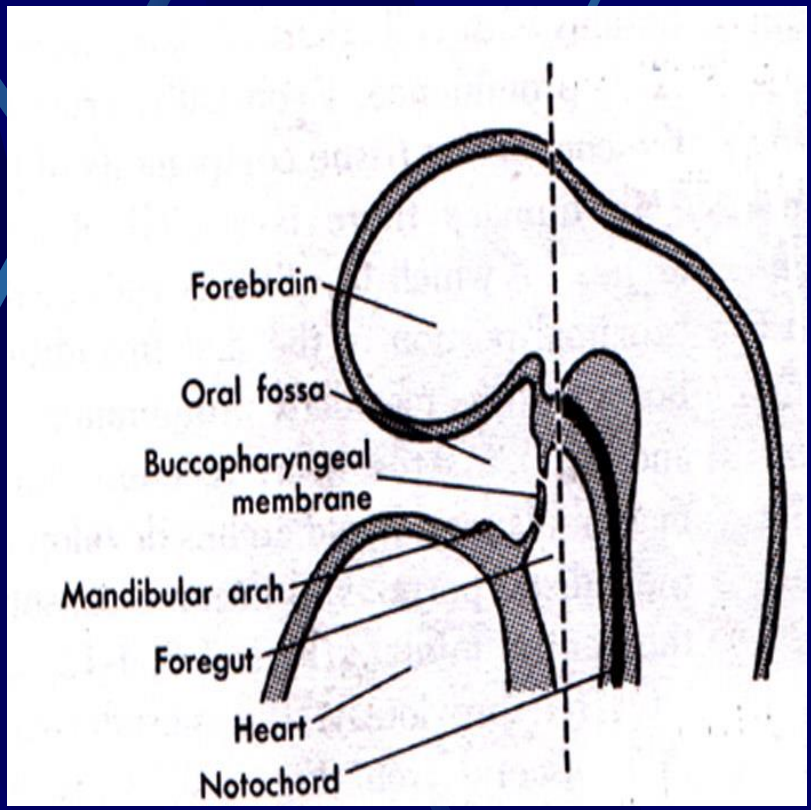
TOOTH DEVELOPMENT

DEVELOPMENTAL STAGES
- Bud stage
- Cap stage
- Bell stage
- Advanced bell stage

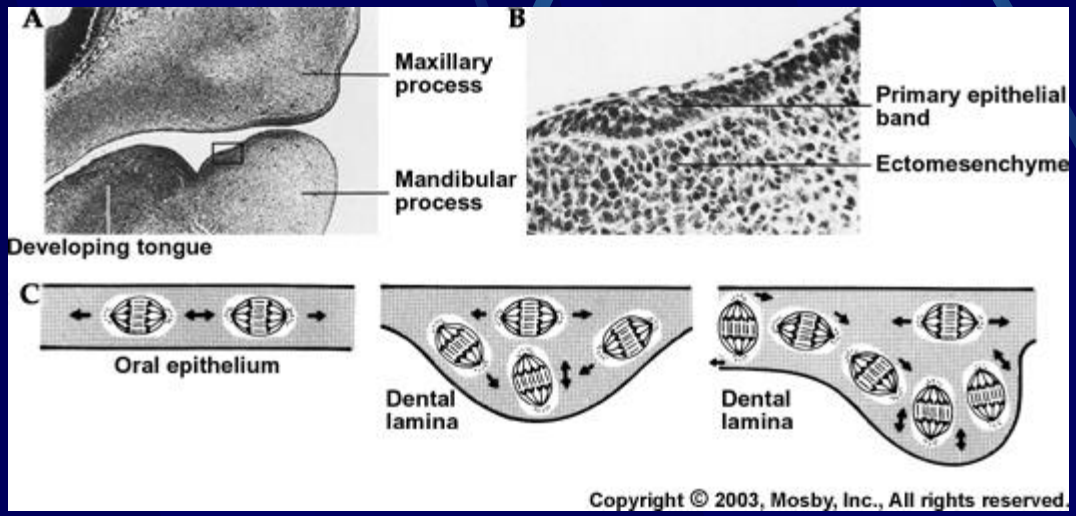
ROOT FORMATION

HISTOPHYSIOLOGY AND CLINICAL CONSIDERATION
- Initiation
- Proliferation
- histodifferentiation
- Morphodifferentiation
- Apposition

The primitive oral cavity or stomatodeum is lined by stratified Squamous epithelium called the oral ectoderm. The oral ectoderm contacts the endoderm of the foregut to form the buccopharyngeal membrane.



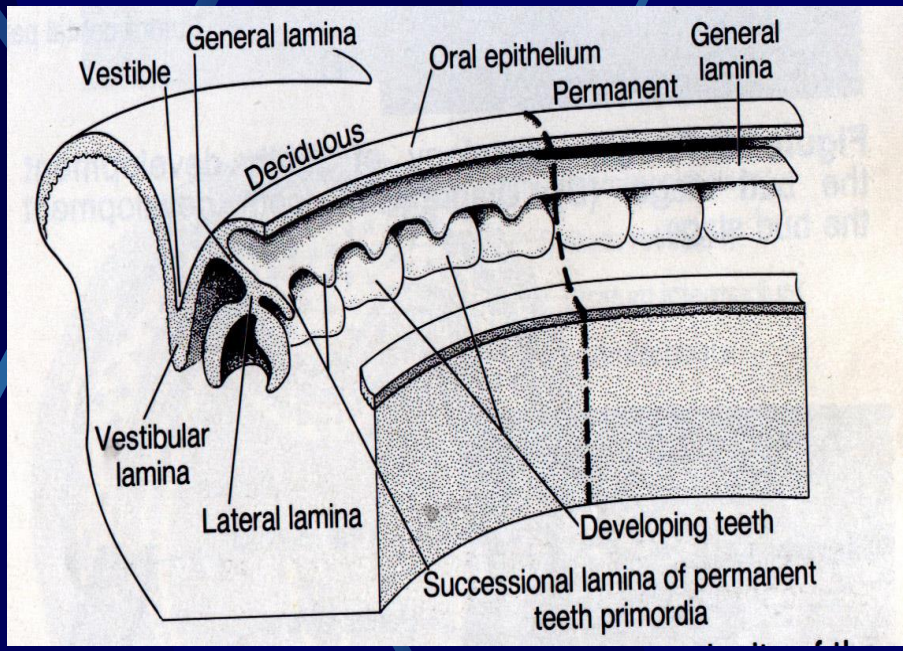
Dental Lamina : Two or three weeks after rupture of the buccopharyngeal membrane, when the embryo about 6 weeks old, certain areas of basal cells of the oral ectoderm proliferate at more rapid rate than do the cells of the adjacent areas leads to the formation of dental lamina.



- D.L. is a band of epithelium that has invaded the underlying ectomesenchyme along each of horseshoe-shaped future dental arches.

- It serve as primordium for the ectodermal portion of deciduous teeth.

- Permanent molar arise directly from a distal extension of dental lamina.
- The successors of deciduous teeth develop from a lingual extension of the free end of dental lamia opposite to the enamel organ of each deciduous tooth.
- Lingual extension of Dental Lamina is named the succesional Lamina



Stylized diagram depicting the continuity of dental lamina system for deciduous and permanent teeth.

Fate of Dental Lamina :

- Total activity of dental lamina extends over atleast 5 yrs.
- The dental lamina may still be active in the third molar region after it has disappeared elsewhere, except for occasional epithelial remnants. This remnants is persists as epithelial pearls or islands within the jaw as well as in the gingiva.

- **Vestibular Lamina :**

- Labial and buccal to the dental lamina in each dental arch, another epithelial thickening develops independently and somewhat later called vestibular lamina or lip furrow band.

- It forms the oral vestibule between the alveolar portion and the lips and cheeks.

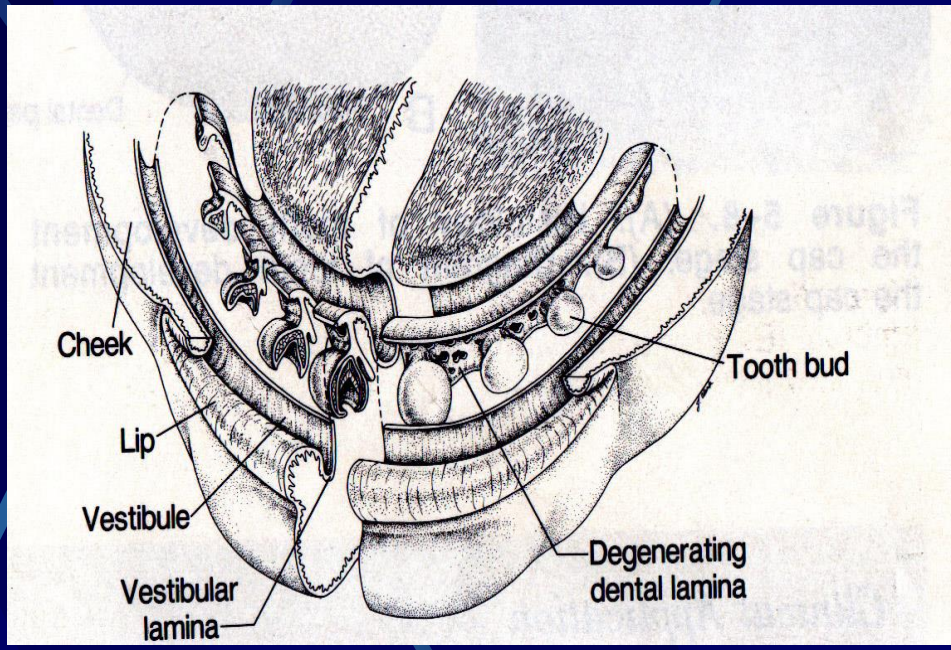


Figure shows vestibular lamina

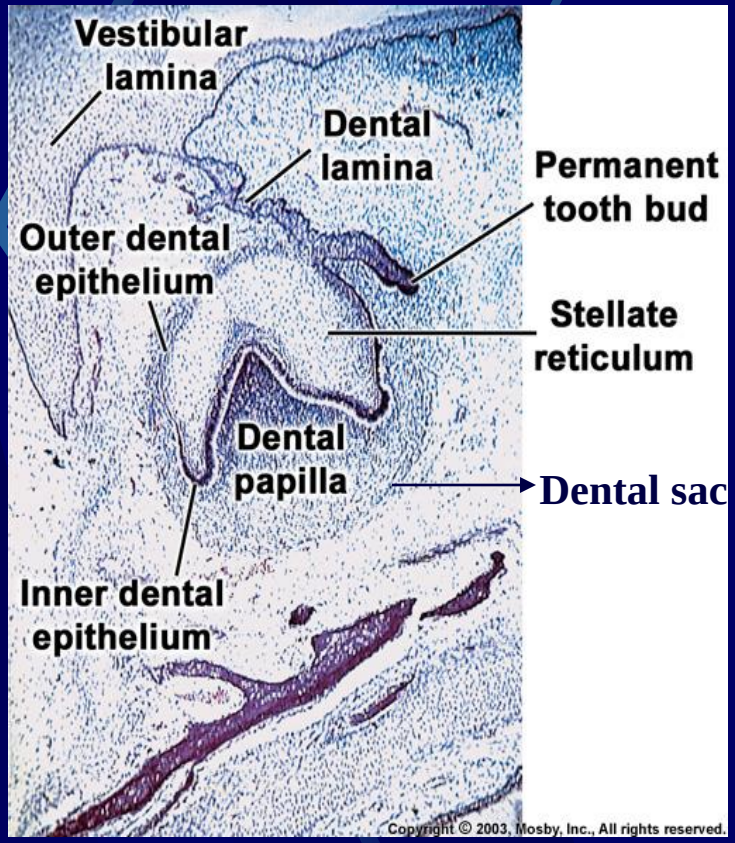
- **Tooth Development :**

- At certain points along the dental lamina the ectodermal cells multiply still more rapidly and form little knobs that grow in to the underlying mesenchyme represents the beginning of enamel organ of the tooth bud of deciduous tooth.

- As cell proliferate, each enamel organ increase in size and change in shape and it takes on a shape that resembles a cap.

- **Inside of the cap, the tissue appear more dense than the surrounding mesenchyme and represents the beginning of the dental papilla.**

- **Surrounding the combined enamel organ and dental papilla, third part of the tooth bud forms, called dental sac.**



Bell stage of tooth development. The primary tooth has acquired its final shape but not its final size

- As development takes place, the dental lamina, which had thus for connected the enamel organ to the oral epithelium, breaks up and the tooth buds loses its connection with the epithelium of the primitive oral cavity.

- **Developmental stages:**

- Although tooth development is a continuous process the development of tooth is divided into several morphologic “stages” for descriptive purposes. They are named after the shape of the epithelial part of the tooth germ and are called the bud, cap and bell stages.

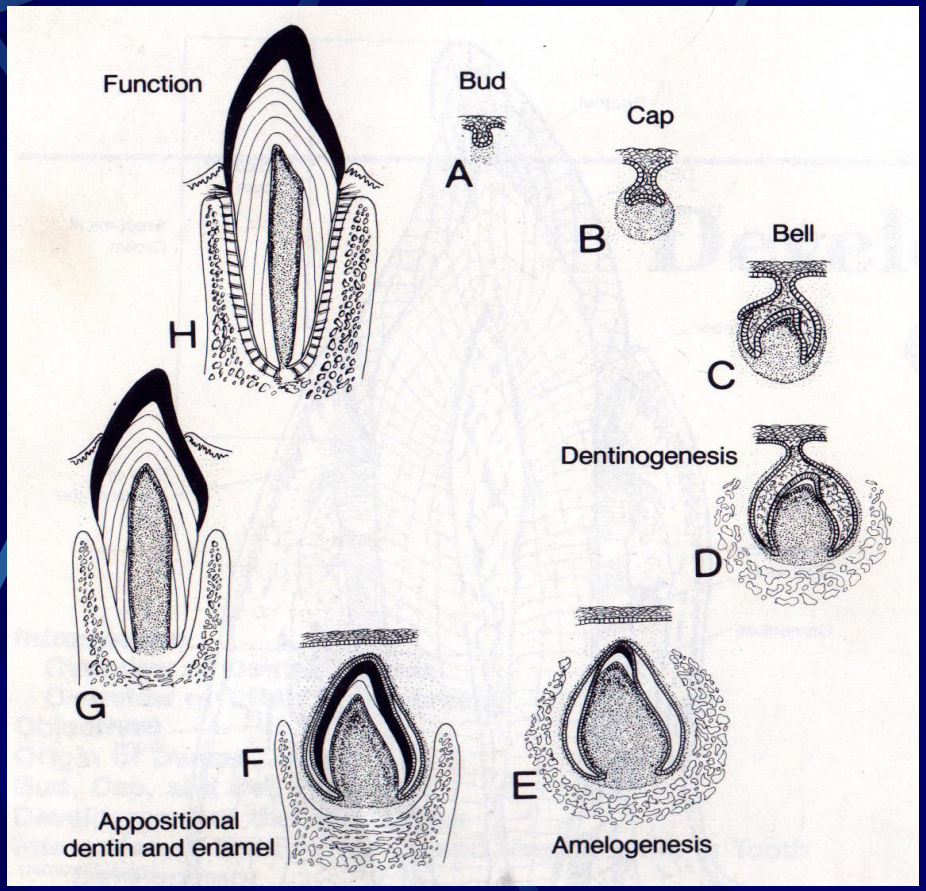
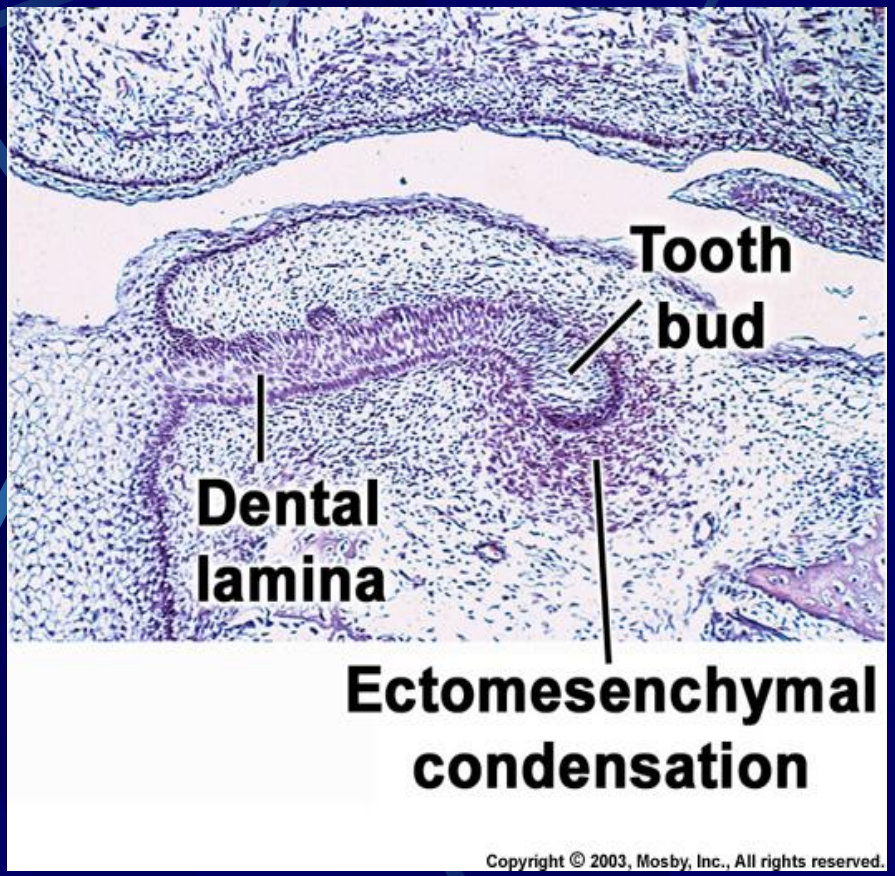


Figure shows developmental stages of tooth development beginning with the bud stage

1. **BUD STAGE :**

The epithelium of the dental laminae is separated from the underlying ectomesenchyme by a basement membrane. Simultaneous with the differentiation of each dental lamina , round or ovoid swelling arise from the basement membrane at 10 different points, corresponding to the future positions of the decidous teeth. These are the primordia of the enamel organ, the tooth buds.



Bud stage of tooth development. Note the accumulation of ectomesenchymal cells aroun the epithelial bud

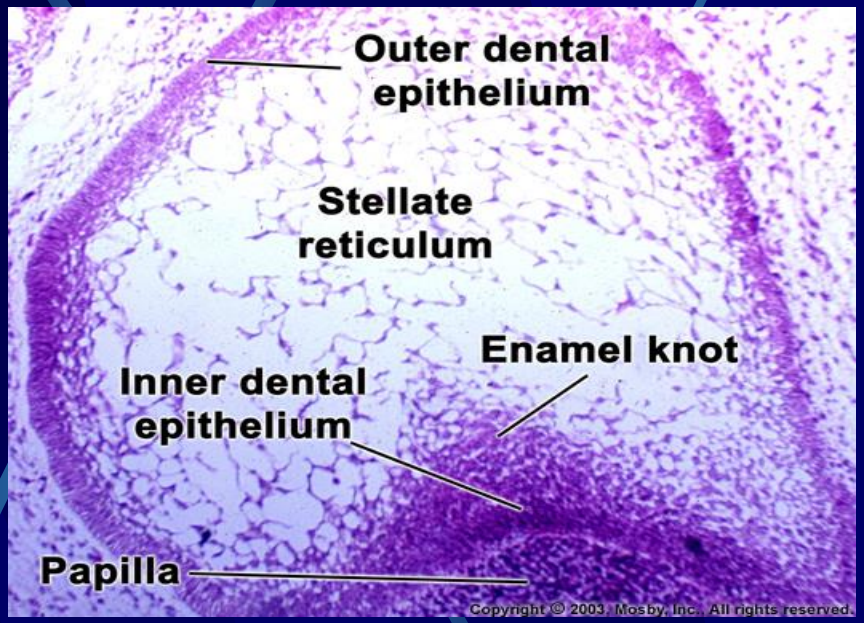
- Thus the development of tooth germs is initiated , and the cells continue to proliferate faster than adjacent cells. In the bud stage , the enamel organs consists of peripherally located low columnar cells and centrally located polygonal cells.

- The area of ectomesenchymal condensation immediately subjacent to the enamel organ is dental papilla. The condensed ectomenchyme that surrounds the tooth bud and the dental papilla is the dental sac.

- The cells of dental papilla will form tooth pulp and dentin. The cells of dental sac will from cementum and the periodontal ligament.

2. CAP STAGE :

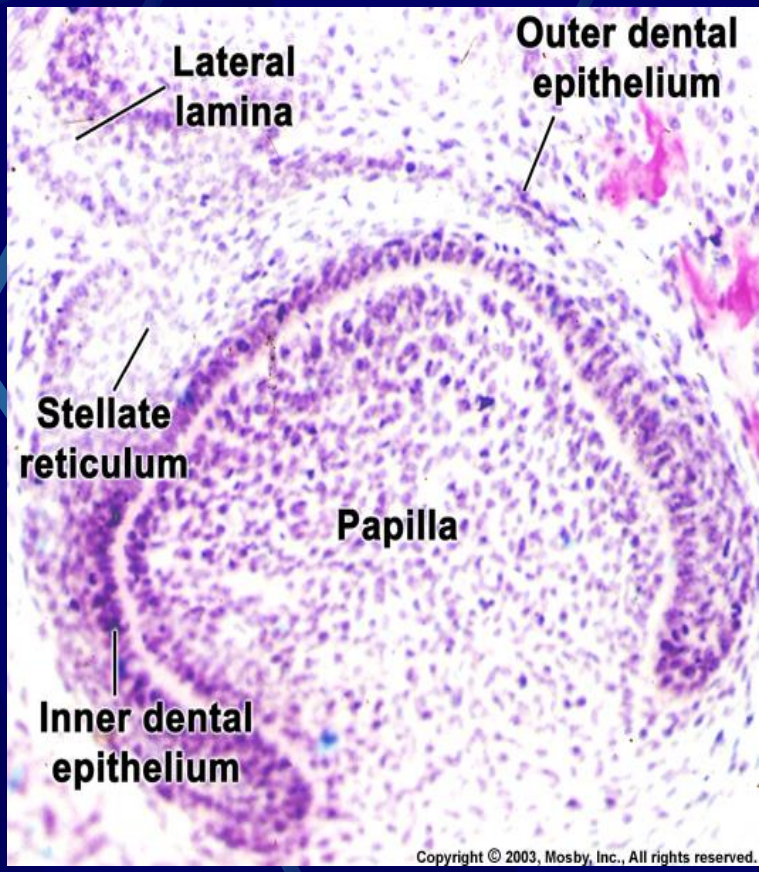
- As cell differentiation continues each enamel organ increase in size and changes its shape.
- Unequal growth in different parts of bud leads to cap stage which is characterized by a shallow invagination on deep surface of the bud.
- Outside of the cap is directed towards oral epithelium. Different layers of enamel organ in cap stage are



Cap stage tooth bud.

a) Outer and Inner enamel Epithelium :-

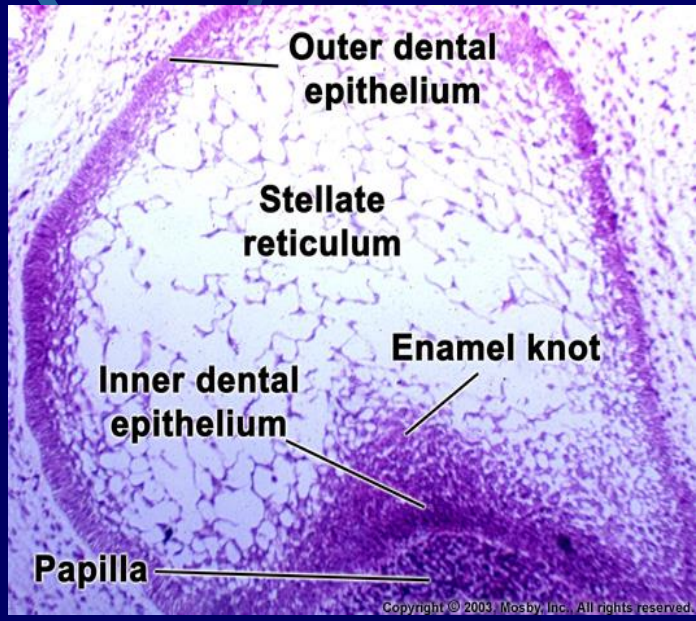
- The peripheral cells of the cap stage are cover the convexity of the “cap” , and are called the outer enamel (dental) Epithelium. The cells in the concavity of the “cap “ become tall, columnar cells and represents the inner enamel (dental) Epithelium. The outer enamel Epithelium is separated from the dental sac, and the inner enamel epithelium from the dental papilla , by a delicate basement membrane.



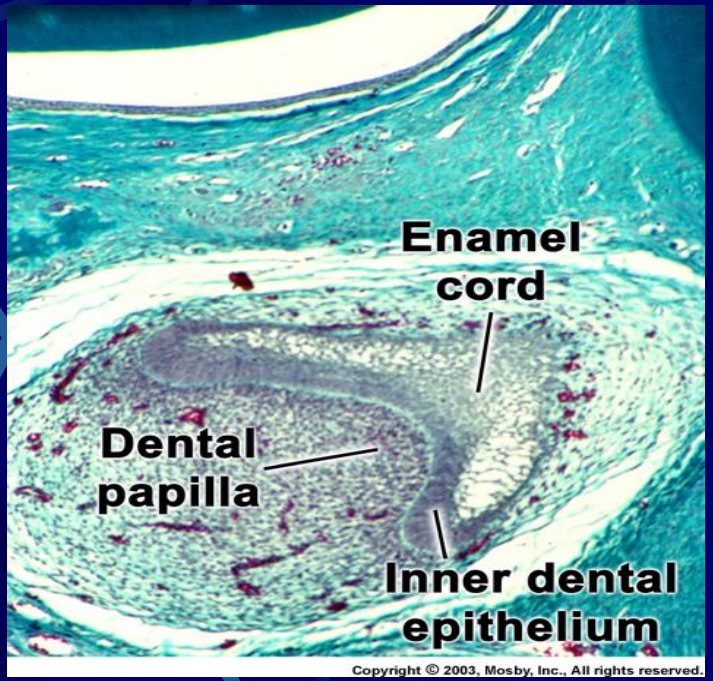
High magnification of a late cap stage tooth organ. Note the difference in structural appearance between the inner and outer dental epithelia and the concentration of ectomesenchymal cells facing the inner dental epithelium.

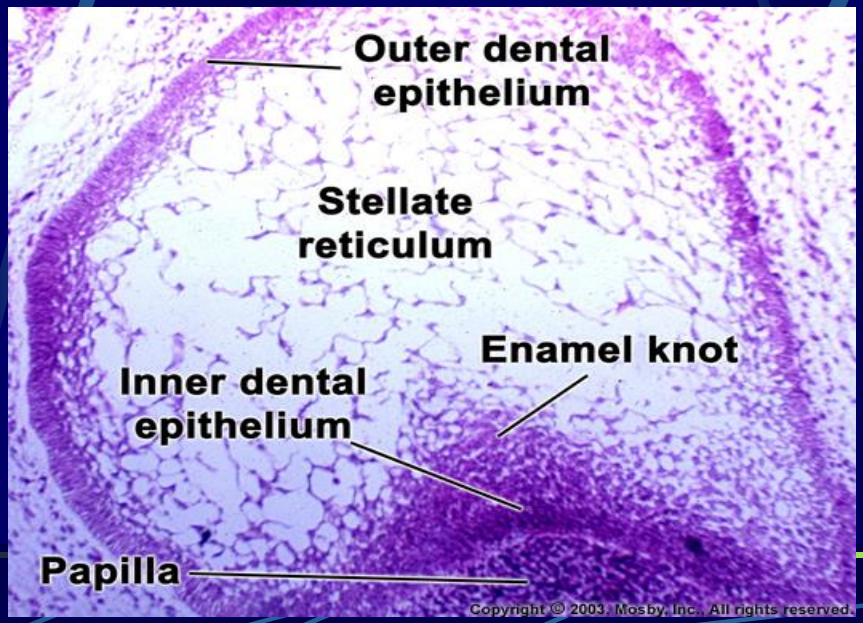
b) Stellate reticulum :

- The cells in the centre of epithelial enamel organ are separated by increased intercellular fluids and they arrange in a network with spaces filled by mucoidal rich fluid. This layer will support and protect the enamel forming cells (ameloblasts) .



The cells in the centre of enamel organ are sometimes densely packed called “enamel knot ‘ and sometimes there is a vertical extension called ‘enamel cord”





The enamel cord is a condensation of epithelial cells that extends from the inner to the outer dental epithelium.

c) Dental Papilla :

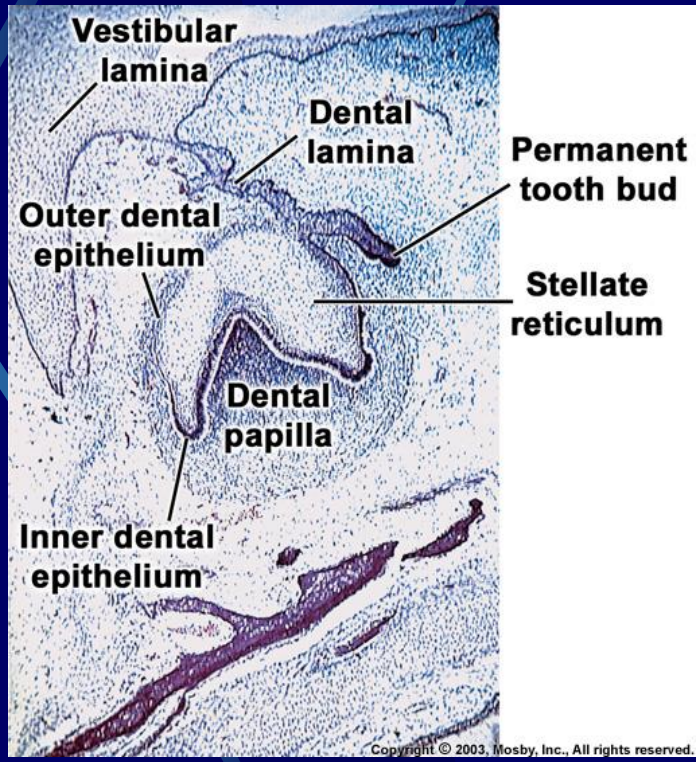
- Under the organising influence of proliferating epithelium of enamel organ, ectomesenchyme which is partially enclosed by the invaginated portion of inner enamel epithelium proliferates. It condenses to form the dental papilla which is formative organ of dentin and pulp.

d) Dental sac :-

- Along with the development of the enamel organ and the dental papilla , there is a marginal condensation of the ectomesenchyme. Gradually it becomes denser and more fibrous , layer develops, which is the primitive dental sac. The cells of this layer are important for the formation of cementum and periodontal ligament.

3. BELL STAGE

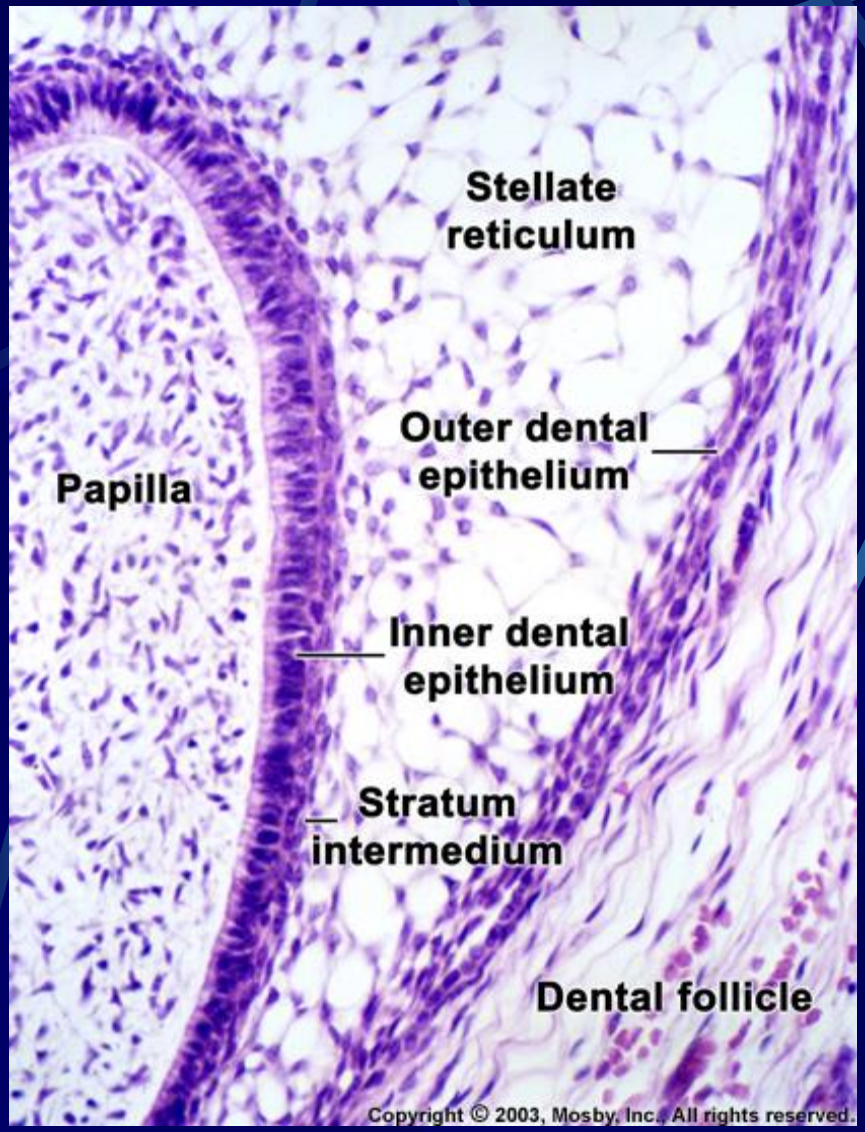
- As the invagination of the epithelium deepens and its margins continue to grow, the enamel organ assumes a bell shape.
- Inner enamel epithelium. Consists of a single layer of cells that differentiate prior to amelogenesis into tall columnar cells called ameloblasts. These cells are 4 to 5 μm in diameter and about 40 μ m hight.



Bell stage of tooth development. The primary tooth has acquired its final shape but not its final size.

Stratum intermedium.

- A few layers of Squamous cells form the stratum intermedium, between the inner enamel epithelium and the stellate reticulum. The well-developed cytoplasmic organelles, acid Mucopolysaccharides, and glycogen deposits indicate a high degree of metabolic activity.



High-power view of the four layers of the enamel organ.

Stellate reticulum.

- The stellate reticulum expands further, mainly by an increase in the amount of intercellular fluid. The cells are star shaped, with long processes that anastomose with those of adjacent cells. Before enamel formation begins, the stellate reticulum collapses, reducing the distance between the centrally situated ameloblasts and the nutrient capillaries near the outer enamel epithelium.

Outer enamel epithelium

- The cells of the outer enamel epithelium flatten to a low cuboidal form. In all of the teeth , except the permanent molars, the dental lamina proliferates at its deep end to give rise to the enamel organs of the permanent tooth.

dental papilla

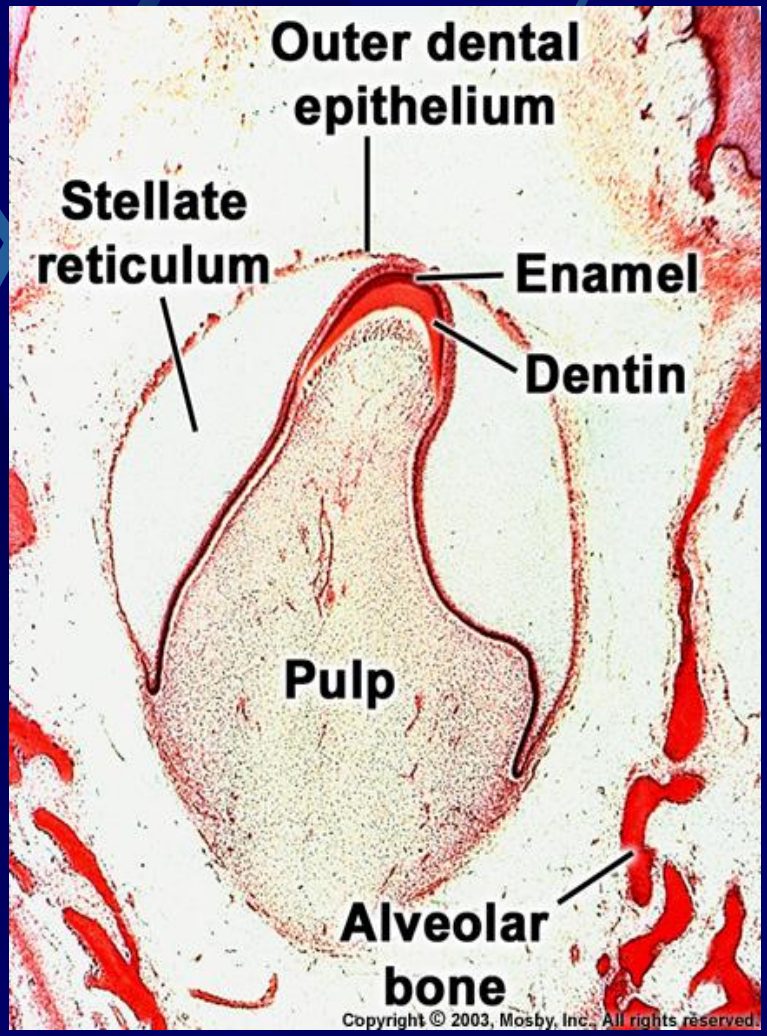
- The dental papilla is enclosed in the invaginated portion of the enamel organ. The basement membrane that separates the enamel organ and the dental papilla just prior to dentin formation is called the membrana preformativa.

dental sac

- With the development of the root, the fibers of the dental sac differentiate into the periodontal fibers that become embedded in the developing cementum and alveolar bone.

4. Advanced bell stage

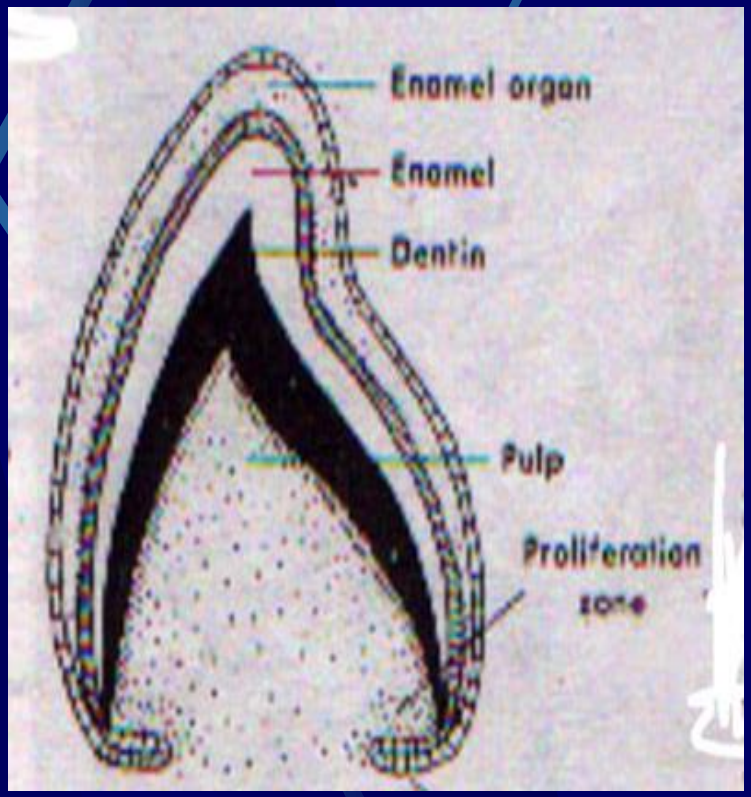
- During the advanced bell stage, the boundary between inner enamel epithelium and odontoblasts outlines the future dentioenamel junction. In addition, the cervical portion of the enamel organ gives rise to the epithelial root sheath of hertwig.



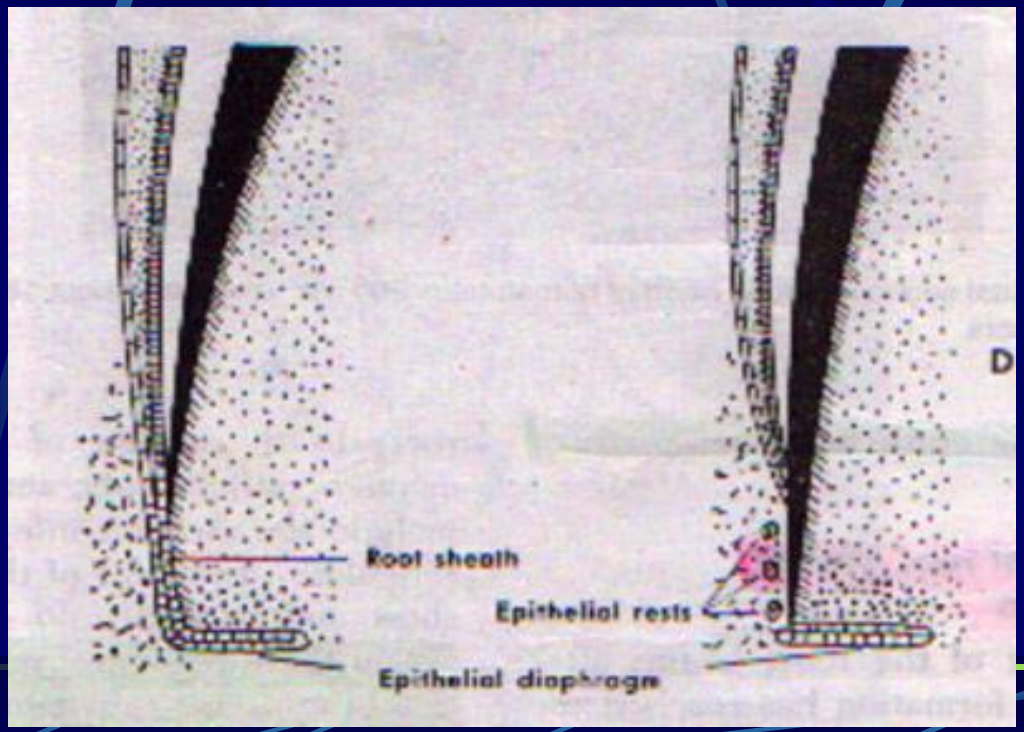
Advanced bell stage

ROOT FORMATION

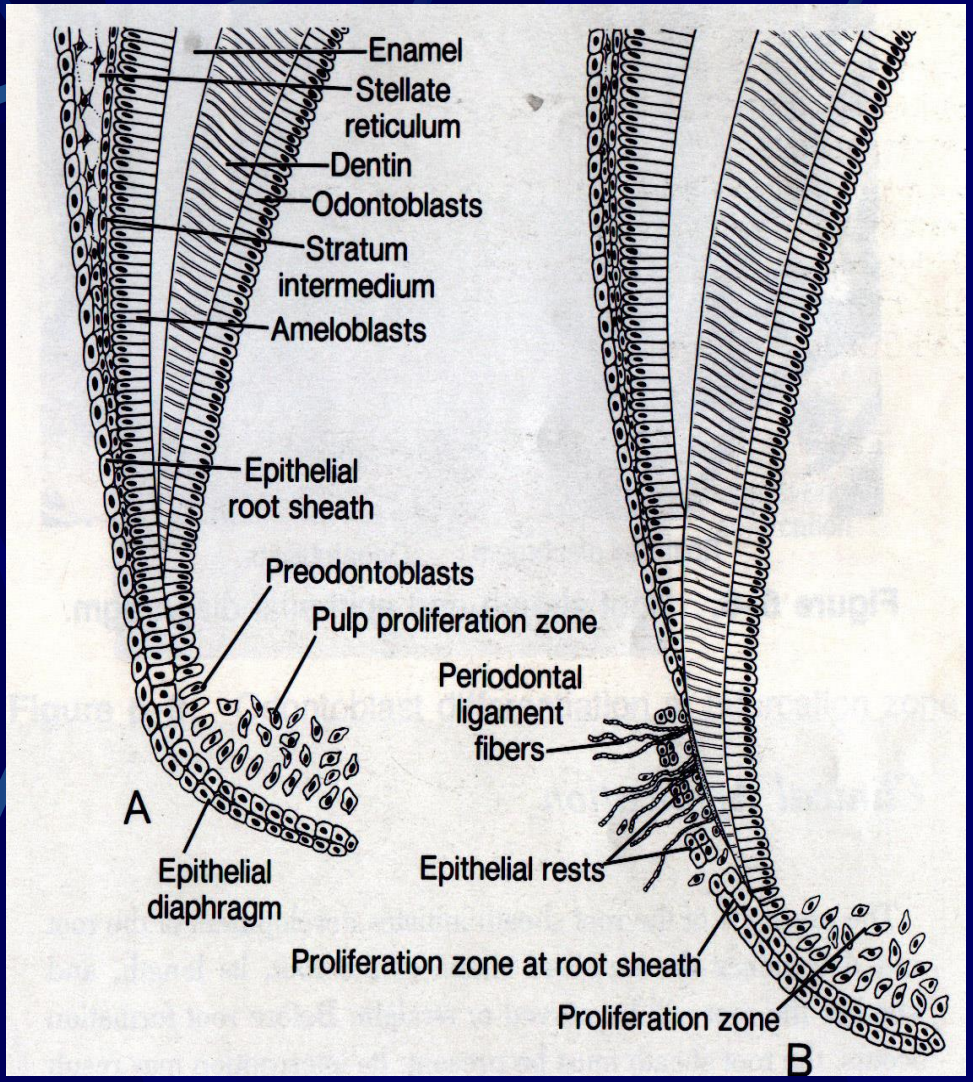
- Once the enamel and dentin formation reaches the future cemento-enamel junction, the formation of the root begins . The outer and the inner enamel epithelium proliferate from the cervical loop of the enamel organ to form a double layered cell sheath called Hertwig's Epithelial Root Sheath.



- This sheath of epithelial cells grows around the dental papilla to enclose the major portion of the dental papilla. The inner enamel epithelial cells initiate differentiation of odontoblasts from cells of the dental papilla. These differentiated odontoblasts form the root dentin or radicular dentin. As soon as root dentin formation starts, the epithelial root sheath loses its structural continuity and forms a strand of cells called Rests of Malassez.



- **The root sheath prior to elongation in an apical direction, forms an epithelial diaphragm which is a horizontal extension of the epithelial cells at the future cemento–enamel junction.**



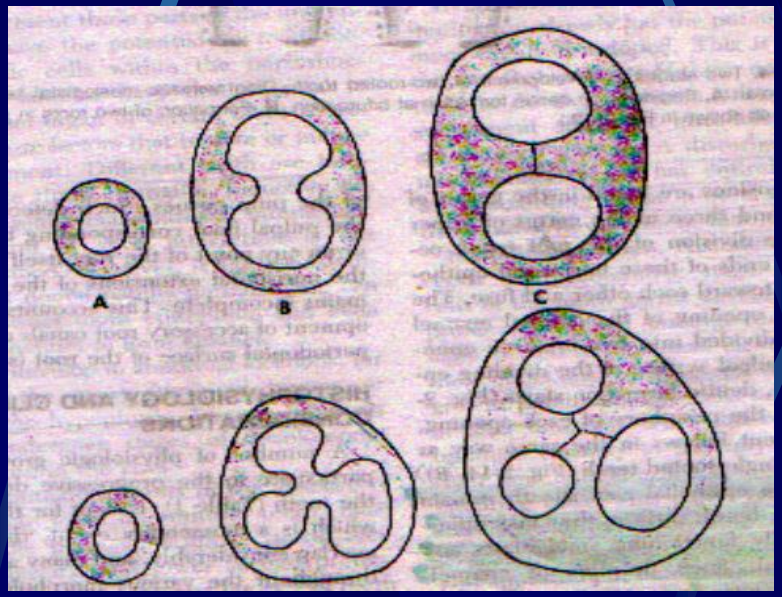
Formation of epithelial diaphragm [A] initial root formation [B] Later root formation

- As the root sheath elongates linearly, differentiation of odontoblasts and formation of dentin occurs.

- Subsequently the epithelial cells disintegrate and move away from the surface of dentin, thereby exposing it to the connective tissue cells of the dental sac which differentiate into cementoblasts and deposit a layer of cementum over the dentin.

- The wide open apical foramen is gradually reduced by apposition of dentin and cementum at the root apex.

- In case of multi rooted teeth the epithelial diaphragm develops tongue like extensions which grow inwards and divides the root trunk into two or three hollow tubes which forms as many roots.



Three Stages in development of tooth with two roots and three roots

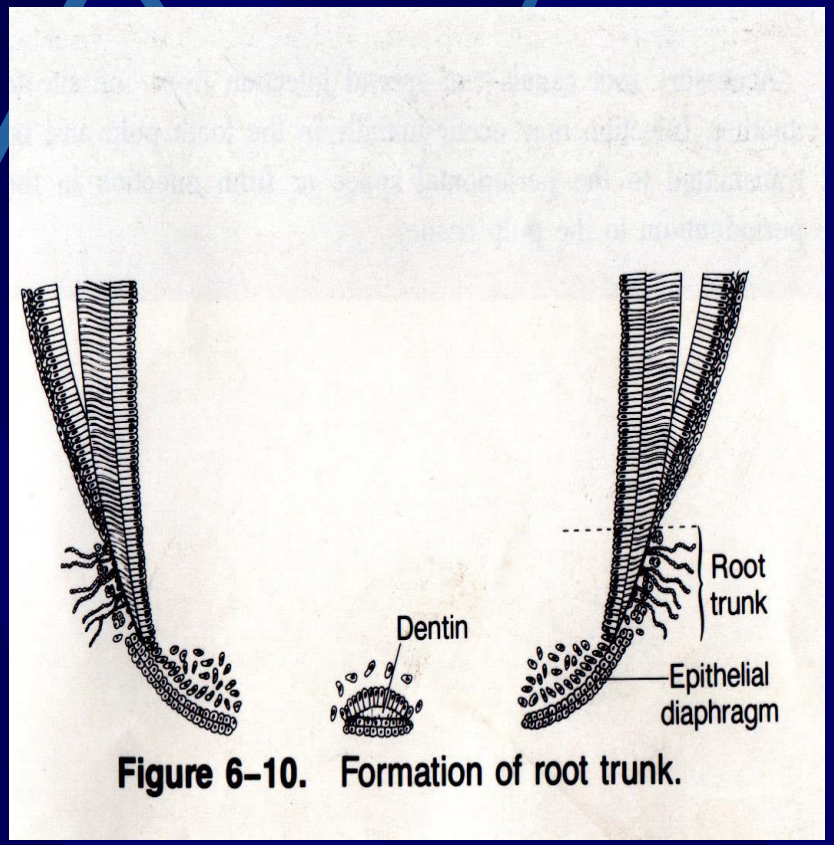


Figure 6–10. Formation of root trunk.

Histophysiology and clinical consideration

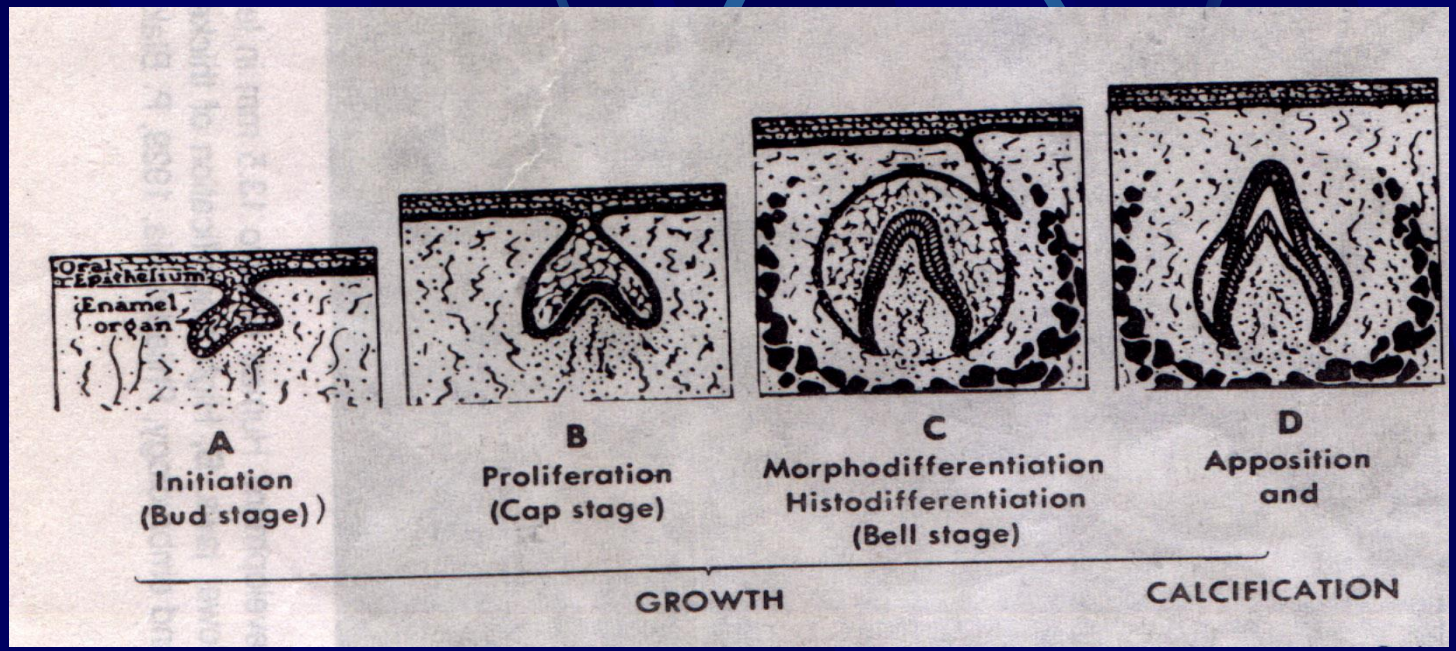
[1] Initiation

[2] Proliferation

[3] Histodifferentiation

[4] Morphodifferentiation

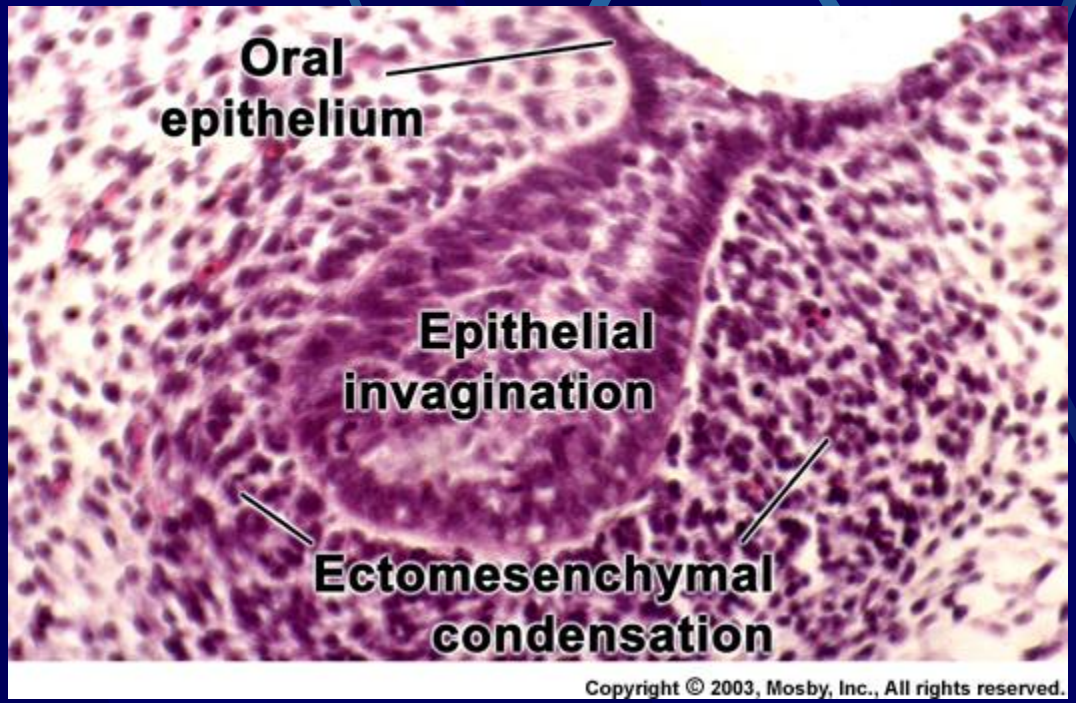
[5] Apposition



Histophysiological stages of tooth development

1. Initiation :

- The dental lamina and associated tooth bud have oral epithelium that have potential for tooth formation.



BUD STAGE

- Dental lamina have specific cells that have potential to form the enamel organ of certain teeth by responding to those factors that initiate or induce tooth development..Different teeth are initiated at definite times. Initiation induction require ectomesenchymal epithelial interaction. The mechanism is not clearly understood.

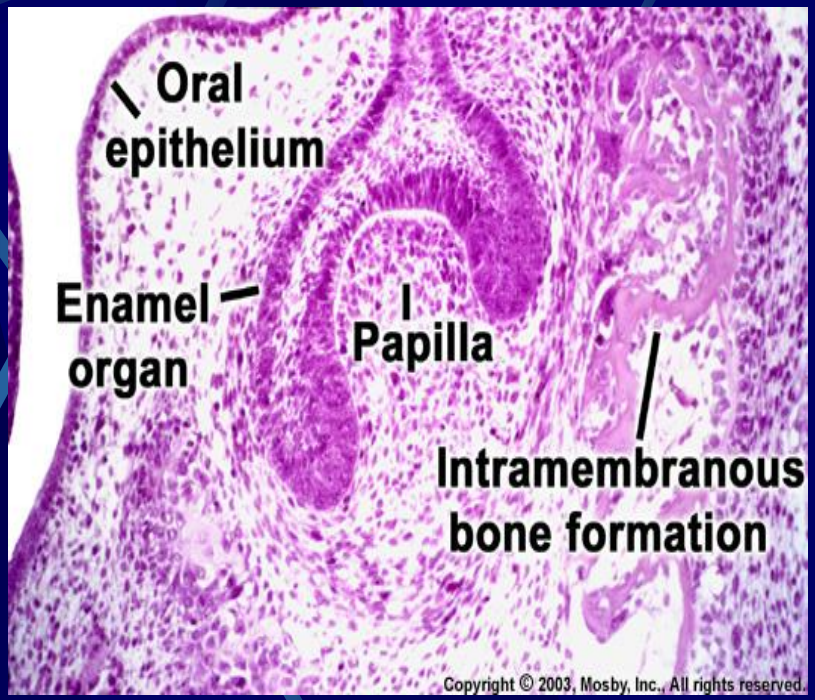
Teeth may develop in abnormal location e.g. in ovary .

A lack of initiation results in the absence of either a single tooth or multiple teeth. There may be a complete lack of teeth (Anodontia). On the other hand, abnormal initiation may result in the development of single or multiple supernumerary teeth.

2. Proliferation :

- **Enhanced proliferative activity ensues at the points of initiation and results successively in the bud, cap and bell stage of the odontogenic organ.**

- **Proliferative growth causes regular changes in the size and proportion of the growing tooth germ.**

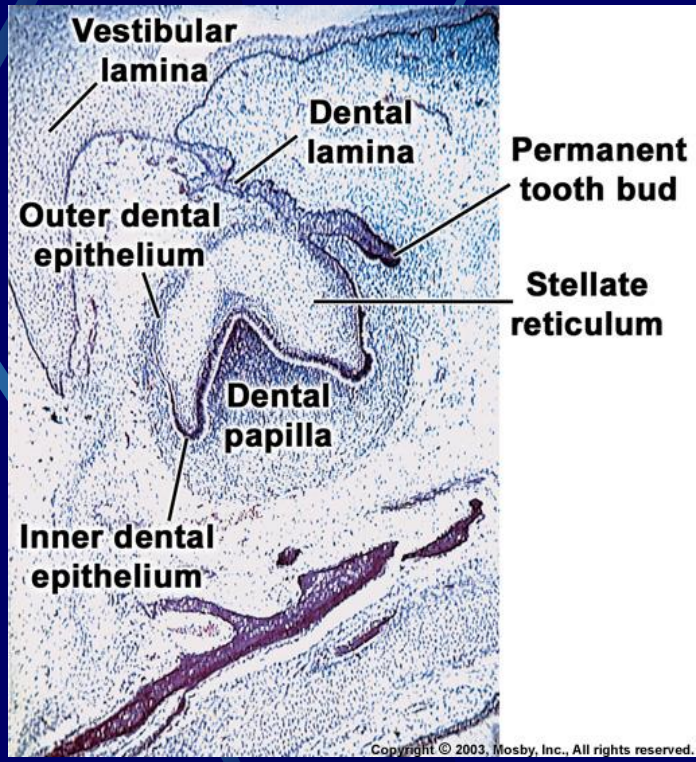


CAP STAGE

- A disturbance or experimental interferences has entirely different effects, according to the time of occurrence and the stage of development that it affects.

3. Histodifferentiation :

- **Histodifferentiation succeeds the proliferative stage. The formative cells of the tooth germs developing during the proliferative stage undergo definite morphologic as well as functional changes and acquire their functional assignment.**



Bell stage of tooth development.

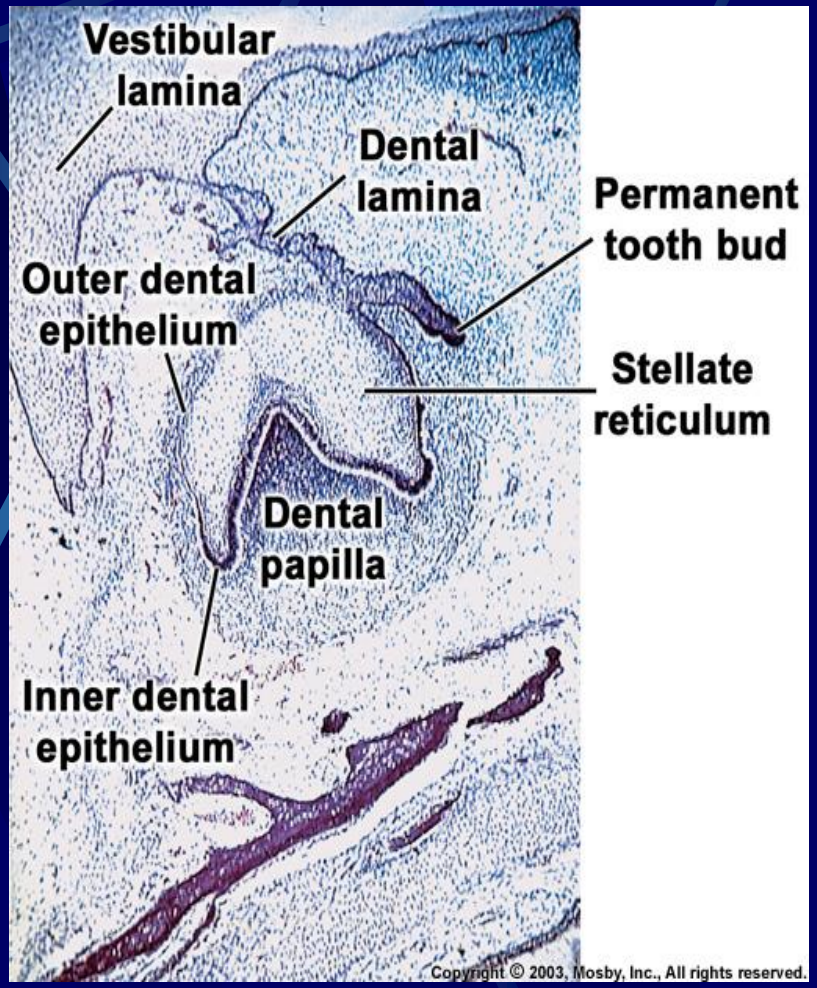
- This phase reaches its highest development on the bell stage of the enamel organ, just preceding the beginning of formation and apposition of dentin and enamel.
- The organizing influence of the inner enamel epithelium on the mesenchyme is evident in the bell stage and causes the differentiation of the adjacent cells of the dental papilla in to odontoblast.
- With formation of dentin the cells of the inner enamel epithelium differentiate into ameloblasts and enamel matrix is formed opposite the dentin. Enamel does not form in the absence of dentin.

- The differentiation of the epithelial cells precedes and is essential to the differentiation of the odontoblasts and the initiation of dentin formation.

- In vitamin A deficiency the ameloblasts fail to differentiate properly. Consequently, their organizing enfluence on the adjacent mesenchymall cells is disturbed and typical dentin known as osteodentin, is formed.

4. Morphodifferentiation :

- The morphologic pattern or basic form and relative size of the future tooth, is established by morphodifferentiation, that is by differential growth. Morphodifferentiation therefore is impossible without proliferation. The advanced bell stage marks not only active histo-differentiation in the crown, outlining the future dentinoenamel junction.



Bell stage of tooth development. The primary tooth has acquired its final shape but not its final size.

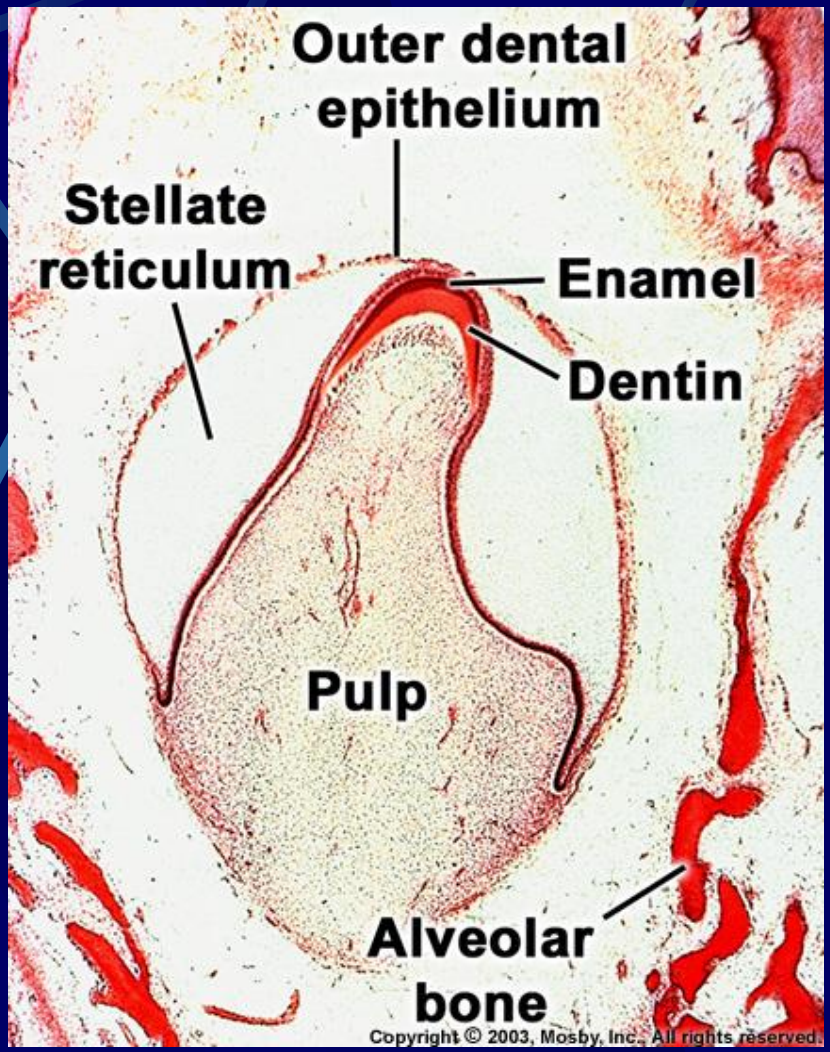
- The dentino-enamel and dentino-cemental junctions, which are different and characteristic for each type of tooth, act as a blue print patern. In conformity with this pattern the ameloblasts, odontoblasts, and cementoblasts deposit enamel,dentin and cementum, respectively and thus give the completed tooth characteristic form and size.

- Disturbances in morphodifferentiation may affect the form and size of the tooth without impairing the function of the ameloblasts or odontoblasts. New parts may be differentiated (supernumerary cusps or roots) twinning may result. A suppression of parts may occur (loss of cusps or roots), or the result may be a peg or malformed tooth (e.g. Hutchinson's incisor) with enamel and dentin that may be normal in structure.

5. Apposition :

- Apposition is the deposition of the matrix of the hard dental structures. Appositional growth of enamel and dentin is a layerlike deposition of an extra cellular matrix.

- It is the fulfillment of the plans outlined at the stage of histodifferentiation and morphodefferentiation. Appositional growth is characterized by regular and rhythmic deposition of the extra cellular matrix.



ADVANCED BELL STAGE

- Genetic and environmental factors may disturb the normal synthesis and secretion of the organic matrix of enamel leading to a condition called enamel hypoplasia.

- It the organic matrix is normal but its mineralization is defective, then the enamel hypocalcified or hypomineralized.

THANK YOU