# DEVELOPMENT OF TOOTH

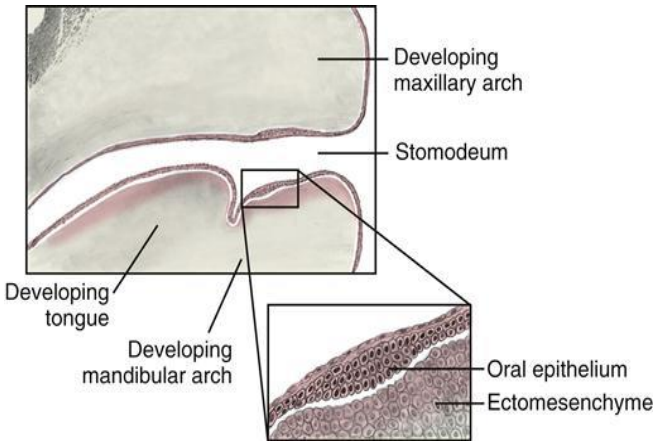
Development of tooth is a complex process initiates, mediated and controlled by the interaction between ectoderm and supporting ectomesenchyme.

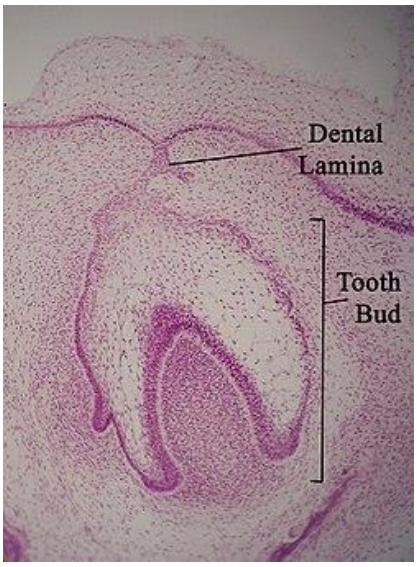
Tooth development begins at 3rd week of intrauterine life.

**Dental lamina (INITIATION)**

The **dental lamina** is a band of epithelial tissue seen in histological sections of a developing tooth. The dental lamina is first evidence of tooth development and begins at the sixth week of intrauterine life.

The dental lamina proliferates into the underlying ectomesenchyme and forms a U-shaped band along the future dental arches in each jaw.




**Stages of tooth development**

The tooth germ is an aggregation of cells that eventually forms a tooth.

These cells are derived from the ectoderm of the first pharyngeal arch and the ectomesenchyme of the neural crest.

The tooth germ is organized into three parts:

- Enamel organ
- Dental papilla
- Dental sac or follicle

The ***enamel organ*** is composed of the **outer enamel epithelium, inner enamel epithelium**, **stellate reticulum** and **stratum intermedium**.

These cells give rise to **ameloblasts**, which produce enamel and become a part of the reduced enamel epithelium (REE) after maturation of the enamel.

The location where the outer enamel epithelium and inner enamel epithelium join is called **the cervical loop**.

The growth of cervical loop cells into the deeper tissues forms **Hertwig Epithelial Root Sheath**, which determines the root shape of the tooth.

The ***dental papilla*** contains cells that develop into **odontoblasts,** which are dentin-forming cells.

The junction between the dental papilla and inner enamel epithelium determines the crown shape of a tooth.

**Mesenchymal cells** within the dental papilla are responsible for formation of tooth pulp.

The ***dental sac or follicle*** gives rise to three important entities: **cementoblasts, osteoblasts,** and **fibroblasts**.

Cementoblasts form the cementum of a tooth.

Osteoblasts give rise to the alveolar bone around the roots of teeth.

Fibroblasts are involved developing the periodontal ligament which connect teeth to the alveolar bone through cementum.

**PHYSIOLOGICAL PHASES**

1. Initiation
2. Proliferation
3. Morphodifferentiation
4. Histodifferentiation
5. Apposition

**MORPHOLOGICAL STAGES**

1. Bud stage
2. Cap stage
3. Bell stage : Early bell stage
   Advanced bell stage

**<u>BUD STAGE (PROLIFERATION)</u>**

Enamel organ resembles a small bud.

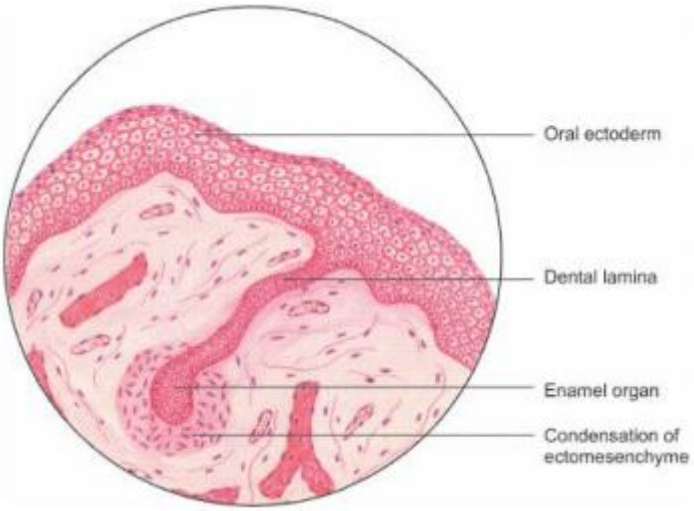
Enamel organ consists of peripherally located low columnar cells and centrally located polygonal cells.

The surrounding mesenchymal cells proliferate, which results in their condensation in two areas.

The area of condensation immediately below the enamel organ is the dental papilla.

The ectomesenchymal condensation that surrounds the tooth bud & the dental papilla is the tooth sac.

*Bud stage*



**CAP STAGE (PROLIFERATION)**

The tooth bud grows around the ectomesenchymal aggregation, taking on the appearance of a cap, and becomes the enamel organ.

A condensation of ectomesenchymal cells called the dental follicle surrounds the enamel organ and limits the dental papilla.

Eventually, the enamel organ will produce enamel, the dental papilla will produce dentin and pulp, and the dental follicle will produce all the supporting structures of a tooth.

*Histology of cap stage*

Enamel organ shows three different types of cells:

Inner enamel epithelium: The inner enamel epithelium, also known as the internal enamel epithelium, is a layer of columnar cells located on the rim nearest the dental papilla of the enamel organ in a developing tooth.

Outer enamel epithelium: The outer enamel epithelium, also known as the external enamel epithelium, is a layer of cuboidal cells located on the periphery of the enamel organ in a developing tooth.

Stellate reticulum: The stellate reticulum is a group of cells located in the center of the enamel organ of a developing tooth. These cells are star-shaped and synthesize glycosaminoglycans.

*Structures of enamel organ*

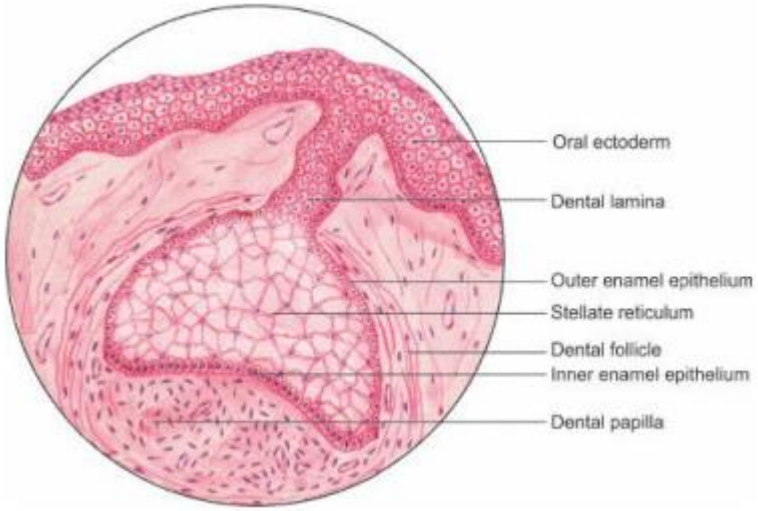
Enamel knot: It is a transitory cluster of non dividing ectodermal cells present as knob like projection at the deepest part of invagination of enamel organ which partly project into the dental papilla.

Enamel cord: The enamel cord is a localization of cells on an enamel organ that appear from the outer enamel epithelium to an enamel knot.

Enamel septum: sometimes enamel cord becomes thick in a bucco-lingual direction forming a septum partly dividing the enamel organ.

Enamel niche: small invagination seen in the area where the enamel cord joins the outer enamel epithelium.

*Cap stage*




**BELL STAGE (HISTODIFFERENTITION)**

The dental organ is bell-shaped during this stage, and the majority of its cells are called stellate reticulum because of their star-shaped appearance.

The bell stage is divided into the *early bell stage* and the *late bell stage*.

Cells on the periphery of the enamel organ separate into four important layers.

Cuboidal cells on the periphery of the dental organ are known as outer enamel epithelium (OEE).

The columnar cells of the enamel organ adjacent to the enamel papilla are known as inner enamel epithelium (IEE).

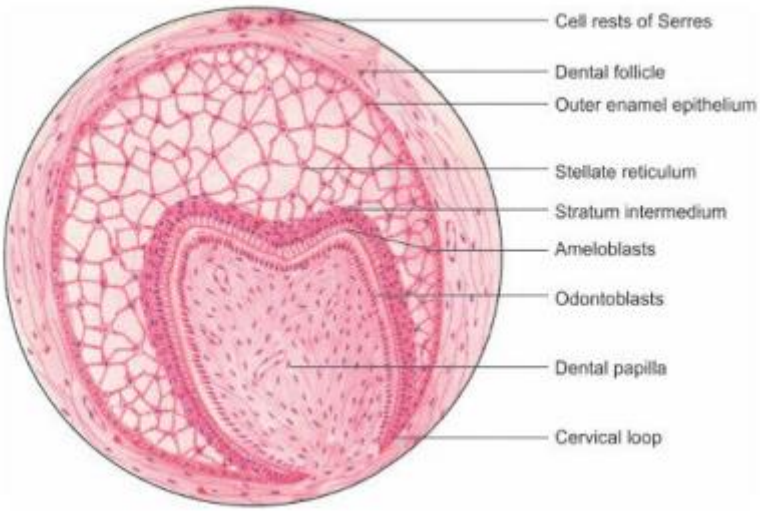
The cells between the IEE and the stellate reticulum form a layer known as the stratum intermedium.

The rim of the enamel organ where the outer and inner enamel epithelium join is called the *cervical loop*.

The dental lamina disintegrates, leaving the developing teeth completely separated from the epithelium of the oral cavity.

The remnants of this dental lamina may persist which are called ‘cell rests of serres’

*Early bell stage*




**ADVANCED BELL STAGE (MORPHODIFFERENTIATION)**

This stage is called the crown, or maturation stage.

Important cellular changes occur at this time. In prior stages, all of the IEE cells were dividing to increase the overall size of the tooth bud, but rapid dividing, called mitosis, stops during the crown stage at the location where the cusps of the teeth form.

The first mineralized hard tissues form at this location.

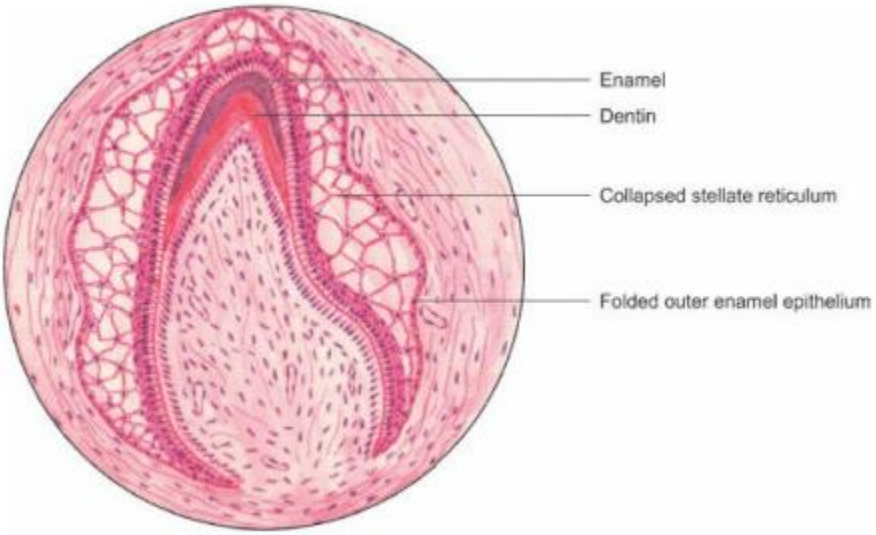
The adjacent layer of cells in the dental papilla suddenly increases in size and differentiates into odontoblasts, which are the cells that form dentin.

After dentin formation begins, the cells of the IEE secrete an organic matrix against the dentin.

This matrix immediately mineralizes and becomes the initial layer of the tooth's enamel.

Outside the dentin are the newly formed ameloblasts in response to the formation of dentin, which are cells that continue the process of enamel formation; therefore, enamel formation moves outwards, adding new material to the outer surface of the developing tooth.

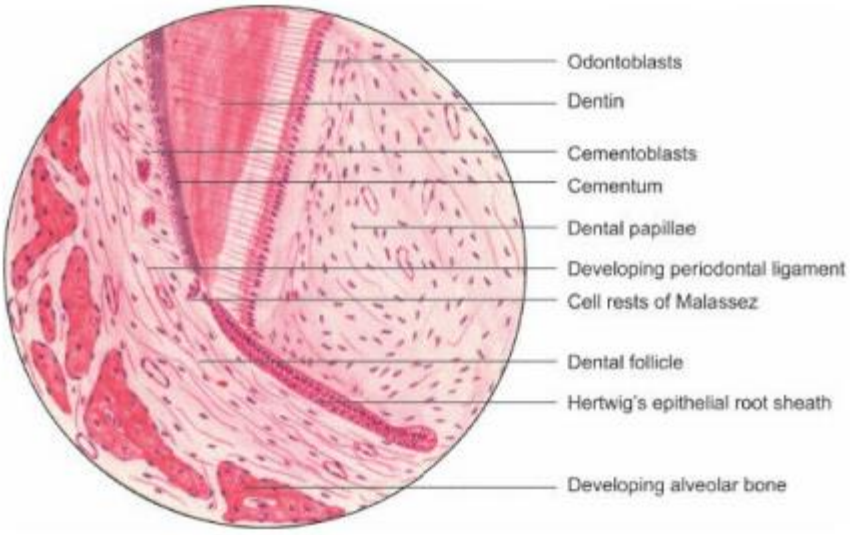
*Advanced bell stage*




**ROOT FORMATION**

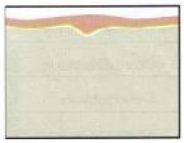
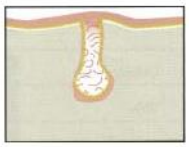
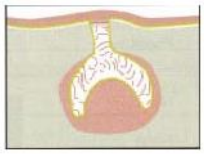
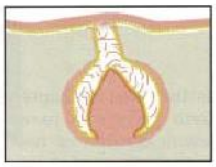
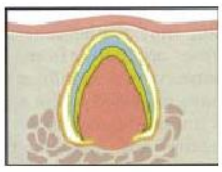
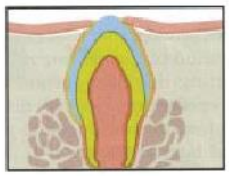
At this stage the enamel organ at the cervical loop proliferates giving rise to a structure called ***Hertwig's epithelial root sheath*** (HERS)

Hertwig epithelial root sheath is derived from the inner and outer enamel epithelium of the enamel organ.




*Root formation*

## *SUMMARY OF TOOTH DEVELOPMENT*

| Stage/Time span* | Microscopic appearance | Main processes involved | Description |
|---|---|---|---|
| Initiation stage/6th to 7th weeks |  | Induction | Ectoderm lining stomodeum gives rise to oral epithelium and then to dental lamina, adjacent to deeper ectomesenchyme, which is influenced by the neural crest cells. These tissues are separated by a basement membrane. |
| Bud stage/8th week |  | Proliferation | Growth of dental lamina into bud that penetrates growing ectomesenchyme. |
| Cap stage/ 9th to 10th weeks |  | Proliferation, differentiation, morphogenesis | Enamel organ forms into cap, surrounding mass of dental papilla from the ectomesenchyme and surrounded by mass of dental sac also from the ectomesenchyme. Formation of the tooth germ. |
| Bell stage/ 11th to 12th weeks |  | Proliferation, differentiation, morphogenesis | Differentiation of enamel organ into bell with four cell types and dental papilla into two cell types. |
| Apposition stage/ varies per tooth |  | Induction, proliferation | Dental tissues secreted as matrix in successive layers. |
| Maturation stage/varies per tooth |  | Maturation | Dental tissues fully mineralized to their mature levels. |

*These are ~ prenatal time spans for development of the primary dentition.

(Adapted from Bath-Balogh, M and Fehrenbach, MJ, In Dental Embryology, Histology, and Anatomy. Philadelphia, PA: WB Saunders, 2006.