

Al Rasheed College of Dentistry
Oral Histology

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Lecture 6

Enamel formation (Amelogenesis)

Amelogenesis begins shortly after dentinogenesis at the late bell stage. The delicate basement membrane between IEE and odontoblasts will disintegrate after dentinogenesis and before amelogenesis.

Ameloblasts fully differentiate at the cusp tips of the forming crown and this differentiation pattern spreads towards the cervical loop. It should be remembered that once the IEE has fully differentiated into ameloblasts there is no more proliferation as these highly differentiated cells do not divide.

Functions of IEE cells in tooth development and amelogenesis:

1. Establish the crown morphological pattern during the bell stage.
2. Induce adjacent surface cells of the dental papilla to differentiate into coronal odontoblasts.
3. Differentiate into ameloblasts which secrete enamel.
4. Differentiate into maturation ameloblasts which exhibit cyclic modulation between ruffle-ended and smooth-ended ameloblasts.
5. Form with the other layers of the E. organ the reduced enamel epithelium which protects the enamel surface until the tooth erupts.
6. Contribute to the formation of the dentogingival junction of erupted teeth.

Amelogenesis is a complex process, it involves 2 stages: ***E. matrix deposition and mineralization of the E. matrix***

E.matrix deposition:

It means the secretion of the E. matrix by ameloblasts. The freshly secreted E. matrix contain 30% minerals as hydroxyapatite crystals and 70% waters and E. proteins which include 90% amelogenine protein and 10% nonamelogenins protein (enameline and ameloblastin). These E. proteins which are secreted by ameloblasts are responsible for creating and maintaining an extracellular environment favorable to mineral deposition. When the first layer of E. is laid down, the ameloblasts will begins to retreat from DEJ towards E. surface and begins to secrete the next layer of E.

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Enamel matrix appear as a deep staining layer in the H. and E. staining sections. The ameloblasts usually secrete the E. in rods or prisms. The initially secreted E. matrix is described as Rodless or prismless E.

Mineralization of the E.:

when the full thickness of E. matrix has been deposited, mineralization will be started, this process involved additional minerals with the removal of organic material and water to reach 96% mineral content. This mineral makes the initial E. crystals that formed in first stage to grow wider and thicker due to the deposition of large amount of hydroxyapatite crystals.

The source of minerals during maturation are from the:

1. Ameloblast itself and other cells of E. organ like stratum intermedium.
2. Capillaries which are approach to the outer E. epith. and it's very close to the E.

Life cycle of the ameloblasts:

According to their function, the life span of the cells of the IEE can be divided into 5 stages: (1) Presecretory (morphogenic, and differentiation), (2) formative, (3) transitional (4) maturative, (5) protective.

Amelogenesis which is the formation of enamel occurs during formative and maturative stages of the ameloblasts.

1- Presecretory stage:

a. Morphogenetic phase:

During this phase the IEE begins its differentiation first into pre-ameloblasts which induce adjacent dental papilla cells to differentiate into odontoblasts which form dentin. At this stage the IEE cells are cuboidal or low columnar, with large, centrally located nuclei and poorly developed Golgi elements in the proximal portion of the cells (facing the stratum intermedium), where a junctional complex exists. Mitochondria and other cytoplasmic components are scattered throughout the cell.

b. Differentiation phase:

As the cells of the inner enamel epithelium differentiate into ameloblasts, they elongate and their nuclei shift proximally toward the

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stratum intermedium, with more organelles mostly protein synthesizing organelles (Golgi apparatus, RER, and Mitochondria) in their distal end. These cells can no longer divide. During this phase the formation of the dentin by the odontoblasts begins.

2- Secretory (formative) stage:

the ameloblasts enter their formative stage after the first layer of dentin has been. Secretory ameloblasts are polarized tall columnar cells with Tomes' processes (conical shaped processes) at their distal ends.

Tomes' processes interdigitate with the surface of the forming enamel giving it a picket fence appearance. Tomes' processes determine the orientation of the newly formed enamel hydroxyapatite crystals.

The organelle content of secretory ameloblasts is mainly protein synthesizing organelles i.e. Golgi complex and granular endoplasmic reticulum. Numerous mitochondria and secretory granules are also present. Junctional complexes tight junctions and desmosomes are present at the distal and proximal ends of ameloblasts. Also, desmosomes and gap junctions are present along their lateral surfaces. As the secretory stage is ending Tomes' processes are lost and accordingly the last formed layers of enamel are **rodless or prismless E.**

3- Transitional stage:

When enamel reaches its full thickness the ameloblasts enter a brief transitional stage. Their height is decreased and protein synthesizing organelles are drastically reduced. Many lysosomes and autophagic vacuoles are also present. The overall number of ameloblasts is reduced by programmed cell death (apoptosis) and it is estimated that by the end of this stage the ameloblast population is reduced by as much as **50%**.

4- Maturation stage:

During maturation massive influx of calcium and phosphates occurs and at the same time there is selective loss of enamel proteins, mainly amelogenin and water.

The ameloblasts modulate (i.e. change their morphology from one type to the other and back) between two phenotypes depending on the morphology of their distal ends. The ameloblasts either have numerous microvilli forming a ruffled border or their distal ends are even (straight). Thus forming two morphologically different types, namely **Ruffled-ended**

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ameloblasts (Cell spends 80% of its lifetime in this form and they incorporate of inorganic material to E. matrix) and **Smooth-ended ameloblasts** (Cell spends 20% of its life time in this form and they exit of protein fragments & water from E. matrix).

5- Protective stage:

At this stage the ameloblasts lose their differentiation and become short cuboidal cells which together with the remnants of the other layers of the E. organ form a multilayered structure, namely the **reduced enamel epithelium**. This structure remains on the surface of fully formed enamel until the tooth erupts. It separates the enamel from the dental sac cells and thus protect it from being in contact with them. If this contact accidentally happens, either enamel is resorbed resulting in pitting on E. surface, or dental sac cells in the contact area differentiate into cementoblasts and lay down cementum on the enamel surface. Both produce adverse effects on enamel appearance. Later during tooth eruption, the reduced enamel epithelium and the oral epithelium joint together and form the dentogingival junction of the erupting tooth.

Clinical consideration:

Amelogenesis Imperfecta (AI) represents a group of conditions, genomic in origin, which affect the structure and clinical appearance of the enamel of nearly all the teeth (primary and permanent dentitions were affected) and which may be associated with morphologic or biochemical changes elsewhere in the body.

In its mildest form, AI causes discoloration, while in the most severe presentation the enamel is hypo-mineralized causing it to be abraded from the teeth shortly after their emergence into the mouth.