Oral Embryology and Histology

Chapter 8
Learning Objectives
Lesson 8.1: Oral Embryology

1. Pronounce, define, and spell the key terms.
2. Define embryology and discuss this important phase of development, including the following:
   • Describe the three periods of prenatal development.
   • Discuss prenatal influences on dental development.
   • Describe the stages of development of the hard and soft palates.
   • Describe the stages in the development of a tooth.
   • Name the genetic and environmental factors that can affect dental development.
   • Describe the functions of osteoclasts and osteoblasts.
Introduction

- Embryology is the study of prenatal development in the stages before birth.
- Learning about the development of the oral structures is the foundation for understanding developmental problems that can occur in these structures.
Introduction (Cont.)

- Histology is the study of the structure and function of the tissues on a microscopic level
  - This includes the tissues and structures of the oral mucosa, which surrounds the teeth and lines the mouth
  - By understanding the histology of the oral tissues, the dental assistant can understand the disease processes that occur in the oral cavity
Oral Embryology

- Pregnancy begins with conception, also known as fertilization
  - This occurs when the sperm penetrates and fertilizes the ovum
- Birth occurs, on average, 38 weeks after conception, or 40 weeks after the beginning of the last menstrual period (LMP)
  - For general descriptive purposes, this is divided into three trimesters of 3 months each
- In embryology, developmental age is based on the date of conception, which is assumed to have occurred 2 weeks after the LMP
Periods and Structures in Prenatal Development

- Zygote
- Blastocyst
- Blastocyst to Disc
- Disc to Embryo
- Embryo
- Embryo
- Fetus

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Fertilization to Form Zygote
Prenatal Development

- The preimplantation period is the first week
- The embryonic period extends from the beginning of the second week to the end of the eighth week; at this time the developing life is known as an *embryo*
- The embryonic period is the most critical time in development
- The fetal phase begins with the ninth week and lasts until birth
Fetus at Various Weeks of Development

Eleventh Week to Full Term

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Embryonic Development of the Face and Oral Cavity

- The face and its related tissues begin to form during the fourth week of prenatal development within the embryonic period.
- During this time, the rapidly growing brain of the embryo bulges over the oropharyngeal membrane, beating heart, and stomodeum.
Primary Embryonic Layers

- During the third week of development, the cells of the embryo form the three primary embryonic layers:
  - Ectoderm
  - Mesoderm
  - Endoderm
Head and Neck of an Embryo at 4 Weeks
Human Embryo during the Fifth Week of Development

Endoderm
Developing digestive system:
- Oropharyngeal membrane
- Pharynx
- Foregut

Ectoderm
- Developing brain
- Developing spinal cord

Mesoderm
- Developing heart

Developing brain
Developing heart

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Early Development of the Mouth

● Fourth week
  - The stomodeum, or primitive mouth, and primitive pharynx merge, and the stomodeum develops into part of the mouth

● Fifth week
  - The embryo is approximately 5 mm long
  - The heart is prominent and bulging
Branchial Arches

- By the end of the fourth week, six pairs of branchial arches have formed.
- The first branchial arch forms the lower lip, the muscles of mastication, and the anterior portion of the alveolar process of the mandible.
- The second branchial arch forms the styloid process, stapes of the ear, stylohyoid ligament, part of the hyoid bone, and more.
- Other branchial arches form the body of the hyoid, the posterior tongue, and structures of the lower throat.
Development of the Hard and Soft Palates

- The formation of the palate in the embryo, and later in the fetus, takes several weeks.
- The palate is formed from two separate embryonic structures:
  - Primary palate
  - Secondary palate
- Any disruption in the process may result in a cleft lip or cleft palate.
Adult Palate and Developmental Divisions

Primary palate with four incisor teeth

Secondary palate formed from fused palatal shelves with canines and posterior teeth

Hard palate

Area of median palatine suture

Soft palate

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Prenatal Facial Development

The development of the human face occurs chiefly between the fifth and eighth weeks:

- At 1 month, the forehead is the dominant feature.
- At 4 months, the face looks human, the hard and soft palates are beginning to form, and the primary dentition has begun.
- During the last trimester, fat is laid down in the cheeks in what is known as “sucking pads.”
  - These give a healthy full-term fetus the characteristic round facial contours.
Prenatal Tooth Development

- The earliest signs of tooth development are found in the anterior mandibular region when the embryo is 5 to 6 weeks old
  - By the 17th week, development of the permanent teeth has begun
  - At birth, there are normally 44 teeth in various stages of development
  - Enamel formation is well under way on all primary dentition and the beginnings of the permanent first molars
Developmental Disturbances

- Disturbances at any stage of dental development may cause a wide variety of anomalies
- These can be caused by:
  - Genetic factors
    - In prenatal tooth development, the genetic factor that is most often a concern is tooth and jaw size
  - Environmental factors
    - Adverse environmental influences called *teratogens* include infections, drugs, and exposure to radiation
Infant with a Left Unilateral Complete Cleft Lip and Palate

The Infant After Corrective Surgeries

Facial Development After Birth

- There is considerable change in the shape of the face from that of the newborn to that of an adult.
- Bones grow and are reshaped to achieve normal growth and development of the face.
- This process involves the laying down of new bone in some areas and the removal of existing bone from others.
Changes in Facial Contours from Birth to Adulthood

Newborn 2 years 8 years Adult

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Mandible Grows by Displacement, Resorption, and Deposition
Tooth Movement

- Remodeling occurs in response to forces placed on the tooth within its socket
- When force is applied to a tooth and the tooth moves, the bone in front will be resorbed
- Bone will be deposited in back of the tooth to fill the space
Process of Orthodontic Tooth Movement
Learning Objectives
Lesson 8.2: Teeth and Oral Histology

3. Describe the life cycle of a tooth.
4. Define histology and discuss its importance, including the following:
   - Explain the difference between clinical and anatomical crowns.
   - Name and describe the tissues of the teeth.
   - Name and describe the three types of dentin.
   - Describe the structure and location of dental pulp.
   - Name and describe the components of the periodontium, including the functions of periodontal ligaments.
   - Describe the various types of oral mucosa and give an example of each.
Life Cycle of a Tooth

- The process of tooth formation, called *odontogenesis*, is divided into three primary periods:
  - Growth
  - Calcification
  - Eruption
Growth Period

- The growth period is divided into three stages:
  - The bud stage, also known as *initiation*, in which the formation of the tooth begins
  - The cap stage, also known as *proliferation*, in which the cells of the developing tooth increase
  - The bell stage, also known as *histodifferentiation* and *morphodifferentiation*, in which the different tissues of the tooth form and its shape are established
### Stages of Tooth Development

**Table 8.2 Stages of Tooth Development**

<table>
<thead>
<tr>
<th>Stage/Time Span*</th>
<th>Microscopic Appearance</th>
<th>Main Processes Involved</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiation stage/sixth to seventh week</td>
<td>Induction</td>
<td>Ectoderm lining stomodeum gives rise to oral epithelium and then to dental lamina, adjacent to deeper mesenchyme and neural crest cells and separated by a basement membrane.</td>
<td></td>
</tr>
<tr>
<td>Bud stage/eighth week</td>
<td>Proliferation</td>
<td>Growth of dental lamina into bud that penetrates growing mesenchyme.</td>
<td></td>
</tr>
<tr>
<td>Cap stage/ninth to tenth week</td>
<td>Proliferation, differentiation, morphogenesis</td>
<td>Enamel organ forms into cap, surrounding mass of dental papilla from the mesenchyme and surrounded by mass of dental sac also from the mesenchyme; formation of the tooth germ.</td>
<td></td>
</tr>
<tr>
<td>Bell stage/eleventh to twelfth week</td>
<td>Proliferation, differentiation, morphogenesis</td>
<td>Differentiation of enamel organ into bell with four cell types and dental papilla into two cell types.</td>
<td></td>
</tr>
</tbody>
</table>

*Note that these are approximate prenatal time spans for development of the primary dentition.*

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<td>Apposition stage/variou per tooth</td>
<td></td>
<td>Induction, proliferation</td>
<td>Dental tissues secreted as matrix in successive layers.</td>
</tr>
<tr>
<td>Maturation stage/variou per tooth</td>
<td></td>
<td>Maturation</td>
<td>Dental tissues fully mineralize to their mature levels.</td>
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*Note that these are approximate prenatal time spans for development of the primary dentition.*

Calcification

● The process by which the structural outline of the tooth is formed during the growth stage and hardened by the deposit of calcium or other mineral salts

● The enamel is built layer by layer by the ameloblasts working outward from the dentinoenamel junction, starting at the top of the crown of each tooth and spreading downward over its sides
Pits and Fissures

- If the tooth has several cusps, a cap of enamel forms over each cusp.
- A fissure is a fault along a developmental groove on the occlusal surface caused by incomplete or imperfect joining of the lobes during the formation of the tooth.
- A pit results when two developmental grooves cross each other, forming a deep area that is too small for the bristle of a toothbrush to clean.
Eruption of Primary Teeth

- Eruption is the movement of the tooth into its functional position in the oral cavity.
- Eruption of the primary dentition takes place in chronologic order, as does the permanent dentition later.
- Active eruption of a primary tooth has many stages in the movement of the tooth.
- Shedding, or exfoliation, is the normal process by which the primary teeth are lost.
Stages in the Process of Tooth Eruption
Stages in the Process of Tooth Eruption (Cont.)
Shedding of Primary Teeth

- Shedding, or exfoliation, is the normal process by which primary teeth are lost as succedaneous (permanent) teeth develop.
- When it is time for a primary tooth to be lost, osteoclasts cause resorption of the root, beginning at the apex and continuing in the direction of the crown.
- Eventually, the crown of the tooth is lost because of lack of support.
Normal Resorption of Roots of a Mandibular Primary Molar
Eruption of Permanent Teeth

- The process of eruption for a succedaneous tooth is the same as for a primary tooth.
- The permanent tooth erupts into the oral cavity in a position lingual to the roots of the shedding primary anterior tooth or between the roots of the shedding primary posterior tooth.
Oral Histology

- Oral histology is the study of the structure and function of the teeth and oral tissues
- It concerns:
  - Anatomical parts and the histology of the teeth
  - The supporting structures
  - The oral mucosa, which surrounds the teeth and lines the mouth
Crown

- Each tooth consists of a crown and one or more roots
- In the crown, dentin is covered by enamel, and in each root, dentin is covered by cementum
- The inner portion of the dentin of both the crown and root also covers the pulp cavity of the tooth close to the cementoenamel junction
  - Anatomical crown: The portion of the tooth that is covered with enamel
  - Clinical crown: The portion of the tooth that is visible in the mouth
Dental Tissues
Anatomical and Clinical Crowns

A. Anatomical crown
B. Clinical crown
The root of the tooth is the portion normally embedded in the alveolar process.

- It is covered with cementum.
- Depending on the type of tooth, it may have one, two, or three roots.
  - *Bifurcation* means division into two roots.
  - *Trifurcation* means division into three roots.
- The tapered end of each root tip is known as the apex.
  - Anything that is situated at the apex is said to be *apical*.
  - Anything surrounding the apex is *periapical*.
Enamel

- Enamel, which makes up the anatomical crown of the tooth, is the hardest material of the tooth body.
- Enamel is translucent and ranges in color from yellow to grayish white.
- Enamel consists of 96% to 99% inorganic matter and only 1% to 4% organic matrix.
- Enamel is composed of millions of calcified enamel prisms, also known as *enamel rods*. 
Enamel Rod, the Basic Unit of Enamel

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From Fehrenbach MJ, Popowics T: Illustrated dental embryology, histology, and anatomy, ed 4, St Louis, 2016, Saunders.
Dentin

- Dentin, which makes up the main portion of the tooth structure, extends almost the entire length of the tooth
- It is covered by enamel on the crown and by cementum on the root
- There are three major types of dentin:
  - Primary dentin
  - Secondary dentin
  - Tertiary dentin (reparative dentin)
Dentinal Tubules
Cementum

- Bonelike, rigid connective tissue that covers the root of the tooth
- It overlies the dentin and joins the enamel at the cementoenamel junction
- A primary function of cementum is to anchor the tooth to the bony socket with attachment fibers within the periodontium
  - Primary cementum is formed as the root develops
  - Secondary cementum forms after the tooth has reached functional occlusion
Pulp

- Pulp is made up of blood vessels and nerves that enter the pulp chamber through the apical foramen
- The blood supply is derived from branches of the dental arteries and from the periodontal ligament
  - Coronal pulp
  - Radicular pulp
The Dental Pulp

- Pulp horns
- Coronal pulp
- Accessory canal
- Radicular pulp
- Apical foramen
The Periodontium

- The periodontium supports the teeth within the alveolar bone and consists of cementum, alveolar bone, and the periodontal ligaments
- These tissues protect and nourish the teeth
- The periodontium is divided into two major units:
  - Attachment apparatus
  - Gingival unit
Periodontium of the Tooth

Periodontium:
- Cementum
- Alveolar bone
- Periodontal ligament

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The alveolar process supports the teeth in their functional positions in the jaws

- The cortical plate is the dense outer covering of the spongy bone that makes up the central part of the alveolar process
- The alveolar crest is the highest point of the alveolar ridge
- The alveolar socket is the cavity within the alveolar process that surrounds the root of a tooth
- The lamina dura is the thin layer of compact bone lining the alveolar socket
Anatomy of the Alveolar Bone

From Fehrenbach MJ, Popowics T: Illustrated dental embryology, histology, and anatomy, ed 4, St Louis, 2016, Saunders.
Anatomy of the Alveolar Bone (Cont.)
Anatomy of the Alveolar Bone (Cont.)

From Fehrenbach MJ, Popowics T: Illustrated dental embryology, histology, and anatomy, ed 4, St Louis, 2016, Saunders.
The Alveolar Crest

Periodontal Ligament

- Dense connective tissue organized into fiber groups that connect the cementum covering the root of the tooth with the alveolar bone of the socket wall
  - The fibers are designed to support the tooth in its socket and hold it firmly in normal relationship to the surrounding soft and hard tissues
  - The fibers also act as the sensory receptors necessary for the proper positioning of the jaws during normal functioning
Periodontal Ligament (Cont.)

- **Supportive and protective functions**
  - Allows the tooth to withstand the pressures and forces of mastication

- **Sensory function**
  - Nerve fibers in the surrounding bone provide the tooth with the protective “sense of touch”

- **Nutritive function**
  - Ligaments receive their nutrition from the blood vessels that also supply the tooth and its alveolar bone

- **Formative and resorptive function**
  - Fibroblasts of the periodontal ligament permit the continuous and rapid remodeling that is required for these fiber groups
Periodontal Ligament Fiber Groups

- **Periodontal fiber groups**
  - Support the tooth in its socket

- **Transseptal fiber groups**
  - Support the tooth in relation to the adjacent teeth

- **Gingival fiber groups**
  - Support the gingiva that surrounds the tooth
Periodontal Fiber Groups

Sharpey’s fibers within alveolar bone

Alveolar crest
Alveolar bone
Interradicular septum
Interdental bone
Cementum

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Fiber Subgroups of the Gingival Fiber Group

- Dentogingival ligament
- Circular ligament
- Alveologingival ligament
- Dentoperiosteal ligament

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Gingival Unit

- Oral mucosa almost continuously lines the oral cavity
- The oral mucosa is perforated in various regions of the oral cavity by the ducts of salivary glands
- There are three main types of oral mucosa in the oral cavity:
  - Lining mucosa
  - Masticatory mucosa
  - Specialized mucosa
Mucosa
Questions?