Eruption and Shedding of Teeth
Mixed Dentition: Presence of both dentitions
Tooth eruption is the process by which developing teeth emerge through the soft tissue of the jaws and the overlying mucosa to enter the oral cavity, contact the teeth of the opposing arch, and function in mastication – **therefore it is a continuous process**

**Phases of tooth eruption**

**Preeruptive phase:** All movements of primary and permanent tooth germs (crowns) from time of their early initiation and formation to the time of crown completion (ends with early initiation of root formation)

**Eruptive phase:** Starts with initiation of root formation and made by teeth to move from its position within bone of the jaw to its functional position in occlusion. Has an intraosseous and extraosseous compartments. 4 stages: root formation, movement, penetration and occlusal contact

**Posteruptive phase:** Takes place after the teeth are functioning to maintain the position of the erupted tooth in occlusion while the jaws are continuing to grow and compensate for occlusal and proximal tooth wear
Remember that during all these 3 stages is the progression that happens from primary to permanent dentition which involves the shedding (exfoliation) of primary teeth

**Dentition:**
Diphodont: two sets of dentition in humans
Primary vs Secondary dentition
Deciduous vs Permanent dentition
Mixed dentition: presence of two dentition

Teeth in primary dentition are smaller and fewer in number than permanent dentition to conform to the smaller jaw size

Primary dentition: ~ 2 to 6 years of age
Mixed dentition: ~ 6 to 12 years
Permanent dentition: > 12 years
Pre-eruptive tooth movement: Why do developing crowns move constantly in the jaws during the preeruptive phase?

To place teeth in position for eruptive tooth movement

1. To alleviate the problems of jaw growth which allows second molar to move backward and anterior teeth to move forward

2. Developing crown move constantly during the preeruptive phase as they respond to positional changes of the neighboring crowns and to changes in the mandible and maxilla

3. Permanent teeth develop lingual to the incisal level of the primary anterior teeth and later as primary teeth erupt, the permanent crowns are lingual to the apical 3rd of primary roots

4. Permanent premolars move from occlusal level of primary molars to a position enclosed within the primary tooth roots

5. All movements in the preruptive phase occur within the crypts of the developing crowns
Two types of tooth movement in pre-eruptive phase:

1. Total bodily movement

2. Movement where one part remains fixed while the rest continues to grow leading to change in the center of the tooth germ
**FIG. 6-1** Relative position of primary and permanent incisor teeth in, **A**, preeruptive and, **B**, prefunctional eruptive periods.

**FIG. 6-2** Relative position of primary molar and permanent teeth in, **A**, preeruptive and, **B**, prefunctional eruptive periods.
Figure from Ten Cate’s Oral Histology, Ed., Antonio Nanci, 6th edition
Eruptive Tooth Movement

4 major events occur:
1. Root formation. Space is required for root formation
   Proliferation of epithelial root sheath
   Initiation of root dentin and pulp
   Increase in fibrous tissue of the follicle

2. Movement. Occurs incisally or occlusally
   The main reason for movement is so that the roots can form normally
   Reduced enamel epithelium fuses and contacts the oral epithelium

3. Penetration of the tooth’s crown tip through the fused epithelial layers allowing entrance of the crown into the oral cavity

4. Intraoral incisal or occlusal movement of the erupting tooth continues until clinical contact with the opposing crown occurs
Figure 13-7. Diagrammatic illustration of the process of root formation, tooth eruption, the rootward migration of the attachment epithelium, cementum exposure, and cervical abrasion. A. The reduced enamel epithelium covers the tooth crown and is separated from the oral epithelium by connective tissue. The root has not yet begun to form. B. Root formation has begun, and the crown has moved incisally. The reduced enamel and oral epithelium are in contact. C. The root is longer, and the incisal edge of the crown is exposed in the oral cavity. The reduced enamel epithelium, which is the remains of the enamel organ, is now continuous with the oral epithelium and is called the junctional epithelium. D. The length of the root dentin is complete, and the crown has moved farther into the oral cavity. The junctional epithelium is still entirely on the enamel. The apical foramen is narrower. E-G. The junctional epithelium grows onto the cementum at its apical border and separates from the tooth surface at its cervical border. Cementum becomes exposed. H, I. Increased cementum exposure and improper use of an abrasive dentifrice have resulted in abrasion of cementum and dentin in the cervical area. OE, oral epithelium; CT, connective tissue; REE, reduced enamel epithelium; HS, Hertwig's sheath; AE, attachment (junctional) epithelium; RM, rests of Malassez; C, cementum; and AB, abrasion.
FIG. 6-5  Histology of erupting cuspid tooth. Crown tip is contacting oral epithelium.

FIG. 6-6  Histology of erupting tooth. Fused enamel and oral epithelium are stretched over enamel of crown. (Enamel space occurs as enamel is dissolved in preparation of slide.)
FIG. 6-7  Histology of erupting primary tooth and appearance of clinical crown in mouth. Permanent tooth’s position is shown on left. Dotted line indicates cuticle overlying enamel surface of erupting tooth.
Clinical crown: During eruption, the exposed crown extending from the cusp tip to the area of the gingival attachment

Anatomic crown: Entire crown, extending from cusp tip to the cementoenamel (CE) junction
Histology – changes that occur in tissues overlying erupting teeth

Degeneration of connective tissue (decrease in blood vessels and degeneration of nerves) immediately overlying the erupting teeth

Eruption pathway – altered tissue area overlying the teeth

Macrophages destroy cells and fibers by secreting hydrolytic enzymes

**Gubernacular cord:** The connective tissue overlying a successional tooth that connects with the lamina propria of the oral mucosa by means of a strand of fibrous connective tissue that contains remnants of dental lamina

**Gubernacular canal:** Holes noted in a dry skull noted lingual to primary teeth in jaws that represent openings of gubernacular cord

As the successional teeth erupt, gubernacular canal widens enabling tooth to erupt
Figure from Ten Cate’s Oral Histology, Ed., Antonio Nanci, 6th edition
Stages of tooth eruption

**FIG. 6-19** Tooth eruption  
A, Crown penetrating bone and connective tissue.  
B, Contact of crown with oral epithelium.  
C, Fusion of epithelia.  
D, Thinning of epithelia.  
E, Rupture of epithelium.  
F, Crown emergence.  
G, Occlusal contact.
Histology – Surrounding tissues

The surrounding fibers change from being parallel to the tooth surface to bundles that are attached to the tooth surface and extending towards the periodontium (bone)

The periodontal ligament have contractile properties and changes drastically during eruption

During eruption, collagen fiber formation and turnover are rapid enabling fibers to attach and release and attach in rapid succession. Some fibers may attach and reattach later while the tooth moves occlusally as new bone forms around it and the fibers will organize and increase in number and density as the tooth erupts
FIG. 6-20  Principal fiber development during tooth eruption.  

A, Origin of fibers at the cervical area.  B, Fiber development with root growth.  C, Change in orientation of the fibers with occlusal function.  a, Initial fiber formation.  b, Development of secondary fibers.  c, Further fiber development.  Initial fiber groups change direction.  Observe the changes in direction of these initial fiber groups.
Histology – Underlying tissues

As the tooth moves occlusally it creates space underneath the tooth to accommodate root formation.

Fibroblasts around the root apex form collagen that attach to the newly formed cementum.

Bone trabeculae fill in the space left behind as the tooth erupts in the pattern of a ladder which gets denser as the tooth erupts.

After tooth reaches functional occlusion periodontal fibers attach to the apical cementum and extend into the adjacent alveolar bone.
The rate of tooth eruption depends on the phase of movement

Intraosseous phase: 1 to 10 \( \mu \text{m/day} \)

Extraosseous phase: 75 \( \mu \text{m/day} \)

Environmental factors affecting the final position of the tooth:
Muscular forces
Thumb-sucking
Mechanisms of Eruptive Tooth Movement

Eruption is a multifactorial process

The accepted theories of tooth eruption are:

1. **Root Formation.** Should be an obvious cause of tooth eruption. But studies have not provided evidence for this. If a tooth that is continuously erupting (rodent incisor and guinea pig molar) is prevented the root still forms by causing bone resorption. Rootless tooth still erupt, some teeth erupt more than the total length of the roots and the teeth still erupt after completion of root formation. Therefore root formation is accommodated during eruption and may not be the cause of tooth eruption.

One point of importance is that, the tissue beneath the growing root resists the apical movement of the developing root. This resistance results in the occlusal movement of the tooth crown as the root lengthens.
Mechanisms of Eruptive Tooth Movement

2. **Bone Remodeling.** Major proof is when a mand PM is removed without disturbing its follicle or you wire down the tooth germ, an eruptive pathway still forms within bone as osteoclasts widen the gubernacular canal. If the dental follicle is also removed no eruption path develops. So not sure if bone remodeling plays a significant role but is involved.

One point to remember: Bone formation also occurs apical to the developing tooth

- **Dental Follicle.** Studies have shown that the reduced dental epithelium initiates a cascade of intercellular signals that recruit osteoclasts to the follicle. By providing a signal and chemoattractant for osteoclasts, it is possible that the dental follicle can initiate bone remodeling which goes with tooth eruption. Teeth eruption is delayed or absent in animal models and human diseases that cause a defect in osteoclast differentiation.
Mechanisms of Eruptive Tooth Movement

4. **Periodontal ligament.** Formation and renewal of PDL can be a factor in tooth eruption because of the traction power of the fibroblasts. However, presence of PDL does not always correlate with tooth eruption. Other factors involved are vascular pressures within the PDL. Examples of PDL being present but tooth not erupting and rootless teeth erupting have been reported.
Post Eruptive Tooth Movement

1. Movements to accommodate the growing jaws. Mostly occurs between 14 and 18 years by formation of new bone at the alveolar crest and base of socket to keep pace with increasing height of jaws.

2. Movements to compensate for continued occlusal wear. Compensation primarily occurs by continuous deposition of cementum around the apex of the tooth. However, this deposition occurs only after tooth moves. Similar to eruptive tooth movement.

3. Movements to accommodate interproximal wear. Compensated by mesial or approximal drift. **Mesial drift is the lateral bodily movement of teeth on both sides of the mouth.** Very important in orthodontics.
Several factors control mesial drift:
(a) Contraction of the transseptal fibers: As the proximal tooth surfaces of adjacent teeth become worn from functional tooth movement, the transseptal fibers of the periodontal ligament become shorter (due to contraction) and thereby maintain tooth contact

(b) Adaptability of bone tissue: The side of pressure on PDL fibers causes bone resorption, whereas pull on the fibers causes bone apposition (formation). Therefore, as the contact areas of the crowns wear, the teeth tend to move mesially, thereby maintaining contact

(c) Anterior compartment of occlusal force: An anteriorly directed force is generated when teeth are clenched, due to the mesial inclination of most teeth and the forward-directed force generated from inter-cuspal forces. Eliminating opposing teeth results in elimination of biting forces, causing a slowing down of the mesial migration

(d) Pressure from soft tissues: Buccal mucosa and tongue push teeth mesially
Active eruption: to compensate incisal and occlusal wear

Passive eruption: gradual recession of the gingiva and the underlying alveolar bone

Both active and passive eruption leads to lengthening of clinical crown
Shedding of Teeth

1. Osteoclast/bone remodeling
2. Odontoclast (cementoclast; dentinoclast)
3. Resorption of soft tissues

Pressure from successional teeth

Figure Source: Dr. Sandra Meyers
Osteoclasts are bone resorbing cells derived form monocyte-macrophage lineage

Giant multinuclear cells with 4-20 nuclei

Osteoclasts resorb hard tissue by separating mineral from the collagen matrix through the action of hydrolytic enzymes

Resorption occurs at the ruffled border which greatly increases the surface area of the osteoclast in contact with bone

Hard Tissue resorption:
  1. Extracellular phase
  2. Intracellular phase
Shedding of mandibular incisor

5 months

At birth

1 year

2 years

3.5 years

4.5 years

Figure Source: Dr. Sandra Meyers
Deciduous 1st molar

Figure from Ten Cate’s Oral Histology, Ed., Antonio Nanci, 6th edition
Shed element following “shedding of primary incisor”

Complete resorption of roots

Resorption lacunae seen (arrow)

Most of coronal pulp is intact

Figure Source: Dr. Sandra Meyers
7 years—functional occlusion attained but root apex is still not fully formed

15 years – incisal wear

Figure Source: Dr. Sandra Meyers
# Sequence of Tooth Eruption

### Primary

<table>
<thead>
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<th></th>
<th>CI</th>
<th>LI</th>
<th>1M</th>
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# Sequence and chronology of tooth eruption

## Chronology of the Human Primary Dentition

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<thead>
<tr>
<th>Jaw</th>
<th>Tooth</th>
<th>Calcification begins</th>
<th>Crown completed post-natally</th>
<th>Time of emergence</th>
<th>Root completed (yrs)</th>
<th>Emergence sequence</th>
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<td>7-10</td>
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<td>(upper)</td>
<td>i(^2)</td>
<td>4 months</td>
<td>2-3</td>
<td>8-11</td>
<td>2.5</td>
<td>3</td>
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<tr>
<td></td>
<td>c(^1)</td>
<td>4-5 months</td>
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<td>16-19</td>
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<tr>
<td></td>
<td>m(^1)</td>
<td>4 months</td>
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<td>12-15</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>m(^2)</td>
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<td>25-28</td>
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<td>6-8</td>
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<td>1</td>
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<tr>
<td>(lower)</td>
<td>i(_2)</td>
<td>4 months</td>
<td>3</td>
<td>9-13</td>
<td>2.5</td>
<td>4</td>
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<tr>
<td></td>
<td>c(_1)</td>
<td>4-5 months</td>
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<td>17-20</td>
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<tr>
<td></td>
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<td>4 months</td>
<td>6</td>
<td>12-16</td>
<td>3</td>
<td>6</td>
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<td>20-26</td>
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</table>

(modified from Avery, p.121, Figure 7-1)

The six/four rule for primary tooth emergence
Four teeth emerge for each 6 months of age

1. 6 months: 4 teeth (lower centrals & upper centrals)
2. 12 months: 8 teeth (1. + upper laterals & lower laterals)
3. 18 months: 12 teeth (2. + upper 1st molars & lower 1st molars)
4. 24 months: 16 teeth (3. + upper canines & lower canines)
5. 30 months: 20 teeth (4. + lower 2nd molars & upper 2nd molars)

Summary

1. By 5 months in utero, all crowns started calcification
2. By 1 year old, all crowns completed formation
3. By 2.5 years, all primary teeth erupted
4. By 4 years old, all primary teeth completed root formation

### Chronology of Human Permanent Dentition

<table>
<thead>
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<th>Jaw</th>
<th>Tooth</th>
<th>Calcification begins</th>
<th>Crown completed (yr)</th>
<th>Time of emergence (yrs)</th>
<th>Root completed (yrs)</th>
<th>Emergence sequence</th>
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<td>4-5</td>
<td>7-8</td>
<td>10</td>
<td>4</td>
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<tr>
<td>I2</td>
<td>10-12 months</td>
<td>4-5</td>
<td>8-10</td>
<td>10-11</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>4-5 months</td>
<td>6-7</td>
<td>11-13</td>
<td>14-15</td>
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<td>10-12</td>
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The rules of “Fours” for permanent tooth development (3rd molars not included)

At birth, four 1st molars have initiated calcification
At 4 years of age, all crowns have initiated calcification
At 8 years, all crowns are completed
At 12 years, all crowns emerge
At 16 years, all roots are complete

Rules of “sixes” in dental development

6 weeks old in utero: beginning of dental development
6 months old: emergence of the first primary tooth
6 years old: emergence of first permanent tooth

Problems of Primary Tooth Eruption

Natal and Neonatal Teeth
Retained Primary teeth
Submerged primary teeth

Ankylosed Teeth
Submerged Teeth
Hyper or supra eruption

Submerged 2nd primary molar (potentially ankylosed)
Congenital missing of the 2nd permanent premolar
Ankylosis

Source: Color atlas of clinical oral pathology. Neville, Damm and White. 2nd edition
Congenitally Missing Teeth
Cleidocranial Dysplasia
Osteopetrosis – Defect in Osteoclasts