Periodontium (forms a specialized fibrous joint called Gomphosis)

- Cementum
- Periodontal Ligament
- Alveolar bone
- Gingiva facing the tooth
Cementum

The other bone (not so simple)
It is a hard avascular connective tissue that covers the roots of teeth

Role of Cementum

1) It covers and protects the root dentin (covers the opening of dentinal tubules)
2) It provides attachment to the periodontal fibers
3) It compensates for tooth resorption

Cementum simulates bone

- Organic fibrous framework, ground substance, crystal type, development
- Lacunae
- Canaliculi
- Cellular component
  - Osteoblast-specific membrane protein Bril
- Incremental lines (also known as “resting” lines; they are produced by continuous but phasic, deposition of cementum)
**Differences between cementum and bone**

- Not vascularized – a reason for it being resistant to resorption
- Minor ability to remodel
- More resistant to resorption compared to bone
- Lacks neural component – so no pain
- 70% of bone is made by inorganic salts (cementum only 45-50%)
- 2 unique cementum molecules: Cementum attachment protein (CAP) and Insulin-like Growth Factor

**Clinical Correlation**

Cementum is more resistant to resorption: Important in permitting orthodontic tooth movement

**Development of Cementum**

Cementum formation occurs along the entire tooth

- Hertwig's epithelial root sheath (HERS) – Extension of the inner and outer dental epithelium
- HERS sends inductive signal to ectomesenchymal pulp cells to secrete predentin by differentiating into odontoblasts
- HERS becomes interrupted
- Ectomesenchymal cells from the inner portion of the dental follicle come in contact with predentin by differentiating into cementoblasts
- Cementoblasts lay down cementum

**How cementoblasts get activated to lay down cementum is not known**

3 theories:

1. Infiltrating dental follicle cells receive reciprocal signal from the dentin or the surrounding HERS cells and differentiate into cementoblasts
2. HERS cells directly differentiate into cementoblasts
3. What are the function of epithelial cell rests of Malassez?
Cementoblasts

- Derive from dental follicle
- Transformation of epithelial cells
  - Epithelial-mesenchymal transition

Proteins associated with Cementogenesis

- Growth factors
  - TGF: cementoblast differentiation and cementogenesis
  - PDGF: cementum formation
  - FGF: PDL formation
- Adhesion molecules
  - Osteopontin: mineralization
  - Epithelial/enamel proteins
  - Collagens
    - I, III, XII (maintenance of PDL vs. continuous formation of cementum)

Proteins associated with Cementogenesis

- Gla proteins, i.e. osteocalcin
  - Cell maturation-regulation of mineralization
  - Matrix Gla → inhibition of mineralization (PDL maintenance)
- Transcription factors
  - Cbfa 1 (Runx2) and osterix
- Signaling molecules
  - Osteoprotegerin: PDL maintenance
  - Sclerostin: promotion of cementum formation
  - Wnt: differentiation of cementoblasts
- Other
  - Alkaline phosphatase
    - hypophosphatasia

Hyaline layer of Hopewell-Smith (Intermediate Cementum)

First layer of cementum is actually formed by the inner cells of the HERS and is deposited on the root's surface is called intermediate cementum or Hyaline layer of Hopewell-Smith. Deposition occurs before the HERS disintegrates. Seals of the dentinal tubules. Intermediate cementum is situated between the granular dentin layer of Tomes and the acellular cementum; Approximately 10 µm thick and mineralizes greater than the adjacent dentin or the secondary cementum.
Properties of Cementum

Physical
Cementum is pale yellow with a dull surface
Cementum is more permeable than other dental tissues
Relative softness and the thinness at the cervical portion means that cementum is readily removed by the abrasion when gingival recession exposes the root surface to the oral environment

Chemical Composition of Cementum
Similar to bone
45% to 50% hydroxyapatite (inorganic)
50% to 55% collagenous and noncollagenous matrix proteins (organic)

Classification of Cementum

• Presence or absence of cells
• Origin of collagenous fibers of the matrix
• Prefunctional and functional

Cellular and Acellular Cementum

Acellular cementum: covers the root adjacent to dentin
Cellular: apical area and overlying acellular cementum. Also common in inter-radicular areas
Cementum is more cellular as the thickness increases in order to maintain viability
The thin cervical layer requires no cells to maintain viability as the fluids bathe its surface

A: Acellular cementum (primary cementum)
B: Cellular Cementum (secondary cementum)
Cellular: Has cells
Acellular: No cells and has no structure

Cellular cementum usually overlies acellular cementum

Variations also noted where acellular and cellular reverse in position and also alternate
Are acellular and cellular cementum formed from two different sources?

One theory is that the structural differences between acellular and cellular cementum is related to the faster rate of matrix formation for cellular cementum. Cementoblasts gets incorporated and embedded in the tissue as cementocytes.

Different rates of cementum formation also reflected in more widely spaced incremental lines in cellular cementum

<table>
<thead>
<tr>
<th>Table 11.1</th>
<th>Summary of differences between acellular and cellular cementum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acellular cementum</td>
<td>Cellular cementum</td>
</tr>
<tr>
<td>Location in root</td>
<td>Location and川部川 ation containing cementocytes and fibre processes</td>
</tr>
<tr>
<td>Cellar wall clearly demarcated</td>
<td>Border with dentine clearly demarcated</td>
</tr>
<tr>
<td>Rate of development relatively fast</td>
<td>Rate of development relatively slow</td>
</tr>
<tr>
<td>Incremental lines closely together</td>
<td>Incremental lines distinctly separate</td>
</tr>
<tr>
<td>Preparietal layer present</td>
<td>Preparietal layer absent</td>
</tr>
</tbody>
</table>

Classification Based on the Nature and Origin of Collagen Fibers

Organic matrix derived from 2 sources:
1. Periodontal ligament (Sharpey's fibers)
2. Cementoblasts

**Extrinsic fibers** derived from PDL. These are in the same direction of the PDL principal fibers i.e. perpendicular or oblique to the root surface

**Intrinsic fibers** derived from cementoblasts. Run parallel to the root surface and at right angles to the extrinsic fibers

The area where both extrinsic and intrinsic fibers is called **mixed fiber cementum**

Combined classification

**Acellular Extrinsic Fiber Cementum (AEFC-Primary Cementum)**
- Located in cervical half of the root and constitutes the bulk of cementum
- The collagen fibers derived from Sharpey’s fibers and ground substance from cementoblasts
- Covers 2/3rd of root corresponding with the distribution of primary acellular cementum
- Principal tissue of attachment
- Function in anchoring of tooth
- Fibers are well mineralized
Cellular intrinsic fiber cementum (CIFC - Secondary Cementum)

- Starts forming after the tooth is in occlusion
- Incorporated cells with majority of fibers organized parallel to the root surface
- Cells have phenotype of bone forming cells
- Very minor role in attachment (virtually absent in incisors and canine teeth)
- Corresponds to cellular cementum and is seen in middle to apical third and inter-radicular
- Adaptation
- Repair
Secondary cellular mixed fiber cementum

- Both intrinsic and extrinsic fibers
  [Extrinsic (5 – 7 µm) and Intrinsic (1 – 2 µm)]
- Bulk of secondary cementum
- Cementocytes
- Laminated structure
- Cementoid on the surface
- Apical portion and intraradicular
- Adaptation

Intrinsic fibers are uniformly mineralized but the extrinsic fibers are variably mineralized with some central unmineralized cores

Acellular afibrillar cementum

- Limited to enamel surface
- Close to the CE junction
- Lacks collagen so plays no role in attachment
- Developmental anomaly vs. true product of epithelial cells
Distribution of Cementum on the Root

- Acellular afibrillar: cervical enamel
- Acellular extrinsic: Cervix to practically the whole root (incisors, canines) increasing in thickness towards the apical portion 50→200µm
- Cellular: Apical third, furcations

CE junction
The "OMG" rule

<table>
<thead>
<tr>
<th>Description</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cementum overlaps enamel</td>
<td>60%</td>
</tr>
<tr>
<td>Cementum just meets enamel</td>
<td>30%</td>
</tr>
<tr>
<td>Small gap between cementum and enamel</td>
<td>10%</td>
</tr>
</tbody>
</table>

(Not to scale)
Aging of Cementum

1. Smooth surface becomes irregular due to calcification of ligament fiber bundles where they are attached to cementum
2. Continues deposition of cementum occurs with age in the apical area. [Good: maintains tooth length; bad: obstructs the foramen]
3. Cementum resorption. Active for a period of time and then stops for cementum deposition creating reversal lines
4. Resorption of root dentin occurs with aging which is covered by cemental repair

Cementicles

- Calcified ovoid or round nodule found in the PDL
- Single or multiple near the cemental surface
- Free in ligament; attached or embedded in cementum
- Aging and at sites of trauma

Origin: Nidus of epithelial cell that are composed of calcium phosphate and collagen to the same amount as cementum (45% to 50% inorganic and 50% to 55% organic)

Cemental Repair

Protective function of cementoblasts after resorption of root dentin or cementum
Resorption of dentin and cementum due to trauma (traumatic occlusion, tooth movement, hypereruption)
Loss of cementum accompanied by loss of attachment
Following reparative cementum deposition attachment is restored

Clinical Correlation

Cellular cementum is similar to bone but has no nerves. Therefore it is non-sensitive to pain. Scaling produces no pain, but if cementum is removed, dentin is exposed causes sensitivity

Cementum is resistant to resorption especially in younger patients. Thus, orthodontic tooth movement causes alveolar one resorption and not tooth root loss