Ans 1: There are three theories as proposed for pain transmission through dentin:

1. Direct innervation/neural theory
2. Transduction theory
3. Hydrodynamic theory

• **Direct conduction theory**

  • According to this theory stimuli directly effect the nerve endings in the tubules.
  
  • This concept advocates that thermal, or mechanical stimuli, directly affect nerve endings within the dentinal tubules through direct communication with pulpal nerve fibres.
  
  • While this theory has been supported by the observation of the presence of unmyelinated nerve fibres in the outer layer of root dentine and the presence of putative neurogenic polypeptides, this theory is still considered theoretical with little solid evidence to support it.

• **Transduction theory**

  • This states that the membrane of the odontoblast process conducts an impulse to the nerve endings in the predentin, odontoblast zone, and pulp.
  
  • Odontoblastic processes are exposed on the dentine surface and can be excited by a variety of chemical and mechanical stimuli.
  
  • As a result of such stimulation neurotransmitters are released and impulses are transmitted towards the nerve endings.
  
  • To date no neurotransmitters have been found to be produced or released by odontoblastic processes
**Fluid or hydrodynamic theory**

1. By far the most widely accepted theory for dentinal hypersensitivity is the hydrodynamic theory proposed by Brannstrom and co-workers.

2. This theory postulates that fluids within the dentinal tubules are disturbed either by temperature, physical or osmotic changes and that these fluid changes or movements stimulate a baroreceptor which leads to neural discharge.

3. The basis of this theory is that the fluid filled dentinal tubules are open to the oral cavity at the dentine surface as well as within the pulp. Stimuli cause an inward or outward movement of fluid in the tubule, which in turn produces movement of the odontoblast and its processes.

4. In general, the excitation of nerve fibres by different kinds of stimuli can be explained by the hydrodynamic theory. For example, dehydration associated with desiccation following air movement over the exposed dentine surface results in outward movement of dentinal fluid towards the dehydrated surface, which triggers nerve fibres and results in a painful sensation.

5. In a similar manner thermal changes can result in expansion or contraction of the dentinal tubules resulting in changes in dentinal fluid flow and associated excitation of nerve fibres causing pain. High osmotic stimuli such as sugar, acid and salt can also result in fluid flow within the dentinal tubules and induce nerve stimulation and painful sensations.

6. Physical stimulation is more difficult to explain through this theory although it is possible that mechanical abrasion of the exposed dentine surface may be sufficient to induce unwanted fluid flow within the dentinal tubules with resulting pain from the stimulated nerve fibres.
SHORT ESSAYS

1. Hypocalcified structures of enamel

1. Striae of Retzius
2. Neonatal line
3. Enamel lamellae
4. Enamel tufts
5. Enamel spindles
6. Enamel crack

ENAMEL TUFTS

- These are hypocalcified enamel rods and interprismatic substance that originates at the dentinoenamel junction
- It extends into enamel for about 1/3 to 1/5 of its total thickness in the direction of long axis of the crown and may play a role in the spread of dental caries
- They appear branched and contain greater concentrations of enamel protein than the rest of the enamel
- They are known as enamel tufts because they look like tufts of grass projecting into the enamel
- It is a narrow ribbon-like structure, inner end of which occasionally may very slightly project into dentin
- Developmentally, they are formed due to the abrupt change in the direction of enamel rod, which leads to the different ratio of inter-rod and rod enamel, creating less mineralized and weakened planes.
They are best seen in transverse ground section of enamel

Enamel lamellae are very thin, leaf-like structures, sometimes visible to naked eye. They extend from the enamel surface towards the dentinoenamel junction, rarely extending into dentin. The enamel lamellae contain mostly organic material and represent improperly mineralized enamel. Lamellae may develop in planes of tension. Enamel lamellae can be differentiated into three types:

- **TYPES A** – lamellae composed of poorly calcified rod segment.
- **TYPE B** – lamellae composed of degenerated cells.
- **TYPE C** – lamellae arising in erupted teeth where the cracks are filled with organic matter and debris from saliva.

**INCREMENTAL LINES OF RETZIUS**
THE INCREMENTAL LINES OF RETZIUS Illustrate the rhythmic successive apposition of layers of enamel during formation of the crown. 

When a ground section of a tooth is seen under microscope, concentric brown lines are seen in the enamel and these are known as incremental lines of retzius. 

In transverse section of tooth the incremental line of retzius appears as concentric rings. 

In longitudinal sections the lines traverse the cusp and incisor area in a symmetrical arc pattern descending obliquely to the DEJ.

In Cervical Part Of Crown, They Run Obliquely.

They deviate occlusally from DEJ to the surface.

When these circles are incomplete at the enamel surface, a series of alternative grooves which are called the imbrications lines of pickerill, are formed.

NEONATAL LINE

1. The neonatal line is a particular band of incremental growth lines seen in histologic sections of a deciduous tooth.

2. It belongs to a series of a growth lines in tooth enamel known as the Striae of Retzius. The neonatal line is darker and larger than the rest of the striae of Retzius.

3. It is caused by the different physiologic changes at birth and is used to identify enamel formation before and after birth.

4. In forensic dentistry, the neonatal line can be used to distinguish matters such as if a child died before or after birth and approximately how long a child lived after birth.

5. These lines are formed in Enamel and dentine at the point of birth. Therefore, only teeth that are developing at birth can exhibit neonatal lines. All the primary teeth are forming at birth.

6. The first permanent molar is just beginning calcification at or near birth.

ENAMEL SPINDLE

1. Enamel spindles originate from the DEJ

2. Before enamel forms, some developing odontoblasts process extend into the ameloblast layer, and when enamel formation begins become trapped to form enamel spindles

3. It is an odontoblastic process which extends in between the cells of inner dental epithelium before the formation of enamel.
Ans 2 Chronology of human dentition:

### Maxillary (upper) teeth:

<table>
<thead>
<tr>
<th>Primary teeth</th>
<th>Central incisor</th>
<th>Lateral incisor</th>
<th>Canine</th>
<th>First molar</th>
<th>Second molar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial calcification</td>
<td>14 wk</td>
<td>16 wk</td>
<td>17 wk</td>
<td>15.5 wk</td>
<td>19 wk</td>
</tr>
<tr>
<td>Crown completed</td>
<td>1.5 mo</td>
<td>2.5 mo</td>
<td>2 mo</td>
<td>6 mo</td>
<td>11 mo</td>
</tr>
<tr>
<td>Root completed</td>
<td>1.5 yr</td>
<td>2 yr</td>
<td>3.25 yr</td>
<td>2.5 yr</td>
<td>3 yr</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mandibular (lower) teeth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial calcification</td>
</tr>
<tr>
<td>Crown completed</td>
</tr>
<tr>
<td>Root completed</td>
</tr>
</tbody>
</table>

### Maxillary (upper) teeth:

<table>
<thead>
<tr>
<th>Permanent teeth</th>
<th>Central incisor</th>
<th>Lateral incisor</th>
<th>Canine</th>
<th>First premolar</th>
<th>Second premolar</th>
<th>First molar</th>
<th>Second molar</th>
<th>Third molar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial calcification</td>
<td>3-4 mo</td>
<td>10-12 mo</td>
<td>4-5 mo</td>
<td>1.5-1.75 yr</td>
<td>2-2.25 yr</td>
<td>at birth</td>
<td>2.5-3 yr</td>
<td>7-9 yr</td>
</tr>
<tr>
<td>Crown completed</td>
<td>4-5 yr</td>
<td>4-5 yr</td>
<td>6-7 yr</td>
<td>5-6 yr</td>
<td>6-7 yr</td>
<td>2.5-3 yr</td>
<td>7-8 yr</td>
<td>12-16 yr</td>
</tr>
<tr>
<td>Root completed</td>
<td>10 yr</td>
<td>11 yr</td>
<td>13-15 yr</td>
<td>12-13 yr</td>
<td>12-14 yr</td>
<td>9-10 yr</td>
<td>14-16 yr</td>
<td>18-20 yr</td>
</tr>
</tbody>
</table>

<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Initial calcification</td>
</tr>
<tr>
<td>Crown completed</td>
</tr>
<tr>
<td>Root completed</td>
</tr>
</tbody>
</table>

Ans 3. Life cycle of ameloblasts:
1. Morphogenic stage.
2. Organizing stage.
3. Formative stage
4. Maturative stage
5. Protective stage.
6. Desmolytic stage

**MORPHOGENIC STAGE**

1. Bell Stage of tooth development
2. Inner Enamel Epithelium
   a. Low columnar to cuboidal cells
   b. Centrally placed nucleus
   c. Golgi bodies and centioles placed proximally(towards str. Intermedium)
   d. Mitochondria and other cytoplasmic bodies are scattered.
3. IEE separated from dental papilla by basal lamina
4. Adjacent dental papilla is cell free

**ORGANIZING STAGE**

- IEE interacts with dental papilla
- Peripheral cells get converted to odontoblasts
- Inner enamel epithelium
  i. Cell Elongates
  ii. Nucleus shifts proximally.
  iii. Golgi complex and centrioles migrate from proximal(towards str. Intermedium)to distal(towards dentin) called REVERSAL OF FUNCTIONAL POLARITY
  iv. Mitochondria shift proximally.
  v. Cell free zone disappears in dental papilla
2. Ameloblasts are closely aligned.
3. Development of junctional complexes which encircle complete cell.
4. Proximal terminal web(towards stratum intermedium
5. Distal terminal web(towards dentin)
6. Polarized cell
7. Basal lamina supporting ameloblasts disintegrates after deposition of predentin.
8. Reversal of nutritional support of ameloblasts
FORMATIVE STAGE
1. Begins after first layer of dentin is formed
2. Ameloblasts retain same length
3. Development of blunt cell processes on ameloblasts which enter predentin

MATURATIVE STAGE
1. Ameloblasts reduced in length and closely attached to enamel matrix.
2. Cells of stratum intermedium loose their cuboidal shape and regular arrangement and assume spindle shape.
3. Ameloblasts display microvilli at distal end

PROTECTIVE STAGE
1. Following completion of enamel calcification, ameloblasts de-differentiate.
   a. Ameloblasts secrete material between distal end of cells and enamel surface.
   b. Material appears morphologically similar to basal lamina.
   c. Hemidesmosomes form along distal cell membrane, providing firm attachment for ameloblasts with enamel surface.
   d. Important for establishment of dentogingival junction.
   e. Ameloblasts + SI + SR + OEE together form stratified epithelium – Reduced Enamel Epithelium.
   f. Function – Protect mature enamel till eruption by separation from the connective tissue.

DESMOLYTIC STAGE
1. Epithelium induces atrophy of connective tissue, thus facilitating fusion of oral epithelium and REE.
2. Epithelial cells elaborate enzymes to destroy connective tissue by desmolysis.
3. Premature degeneration may prevent the eruption of tooth.
<table>
<thead>
<tr>
<th>Maxillary central incisor</th>
<th>Mandibular central incisor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LABIAL VIEW</strong></td>
<td></td>
</tr>
<tr>
<td>1. Wider, less symmetrical crown</td>
<td>Long narrow, symmetrical crown</td>
</tr>
<tr>
<td>2. Mesial contacts are more incisally located than distal contacts</td>
<td>Mesial and distal contacts are at the same level</td>
</tr>
<tr>
<td>3. More rounded distoincisal angles</td>
<td>Mesial and distal angles are sharp</td>
</tr>
<tr>
<td>4. Common labial depressions</td>
<td>Less frequent labial depressions</td>
</tr>
<tr>
<td>5. More cervically located contacts</td>
<td>Contacts very near the incisal edge</td>
</tr>
<tr>
<td>6. Level of mesial and distal contacts vary</td>
<td></td>
</tr>
<tr>
<td><strong>LINGUAL VIEW</strong></td>
<td></td>
</tr>
<tr>
<td>1. Pronounced marginal ridges</td>
<td>Lingual smooth, almost no marginal ridges</td>
</tr>
<tr>
<td>2. Deeper lingual fossa</td>
<td>Shallow lingual fossa</td>
</tr>
<tr>
<td>3. Sometimes lingual pits</td>
<td>No pits</td>
</tr>
<tr>
<td>4. Larger cingulum</td>
<td>Smaller cingulum</td>
</tr>
<tr>
<td>5. Cingulum is towards the distal</td>
<td>Almost perfectly symmetrical</td>
</tr>
<tr>
<td><strong>PROXIMAL VIEW</strong></td>
<td></td>
</tr>
<tr>
<td>Incisal edge labial to root axis Wear facets on lingual slopes of incisal edge and in lingual fossa Elevated cingulum. Roots narrower, especially in apical third. Mesial root surfaces are convex</td>
<td>Incisal edge on or lingual to root axis lines. Wear facets slope labially on incisal edge, none on lingual surface Small cingulum Roots noticeable wider faciolingually (with depression on both sides of roots)</td>
</tr>
<tr>
<td><strong>INCISAL VIEW</strong></td>
<td></td>
</tr>
<tr>
<td>Crowns wider mesiodistally than faciolingually incisal edge labial to mid-root axis. Cingulum is to distal. It has more triangular crown outline.</td>
<td>Crowns wider mesiodistally than mesiodistally incisal edge is lingual to or centered on mid-root axis Cingulum is centered. It has crown is oblong faciolingually</td>
</tr>
</tbody>
</table>