

Dentin-Dentinogenesis

Dentin

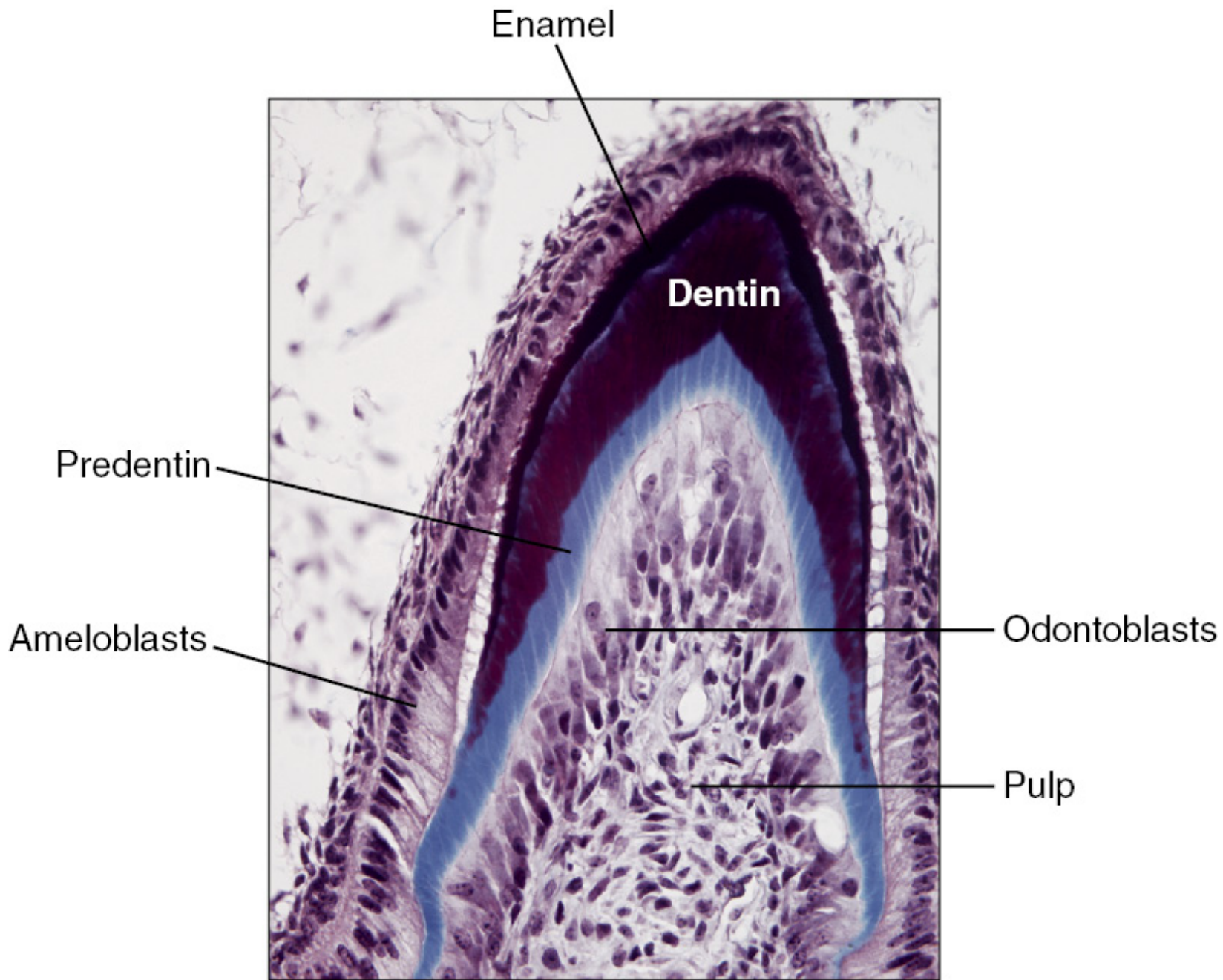
- Forms the bulk of the tooth, elasticity
- Protected tissue (by enamel and cementum)
- Predentin (dentin) ~ Osteoid (bone)
- Dentinal tubules
- Odontoblasts (present in the pulp)
- Mature dentin: 70% inorganic, 20% organic, 10% water
- Primarily type I (~56%), small amounts of III & V
- Other dentin proteins
 - DPP, DSP, DGP, DMP1, osteocalcin, osteopontin etc, **amelogenin**
 - Promoters and inhibitors of mineralization

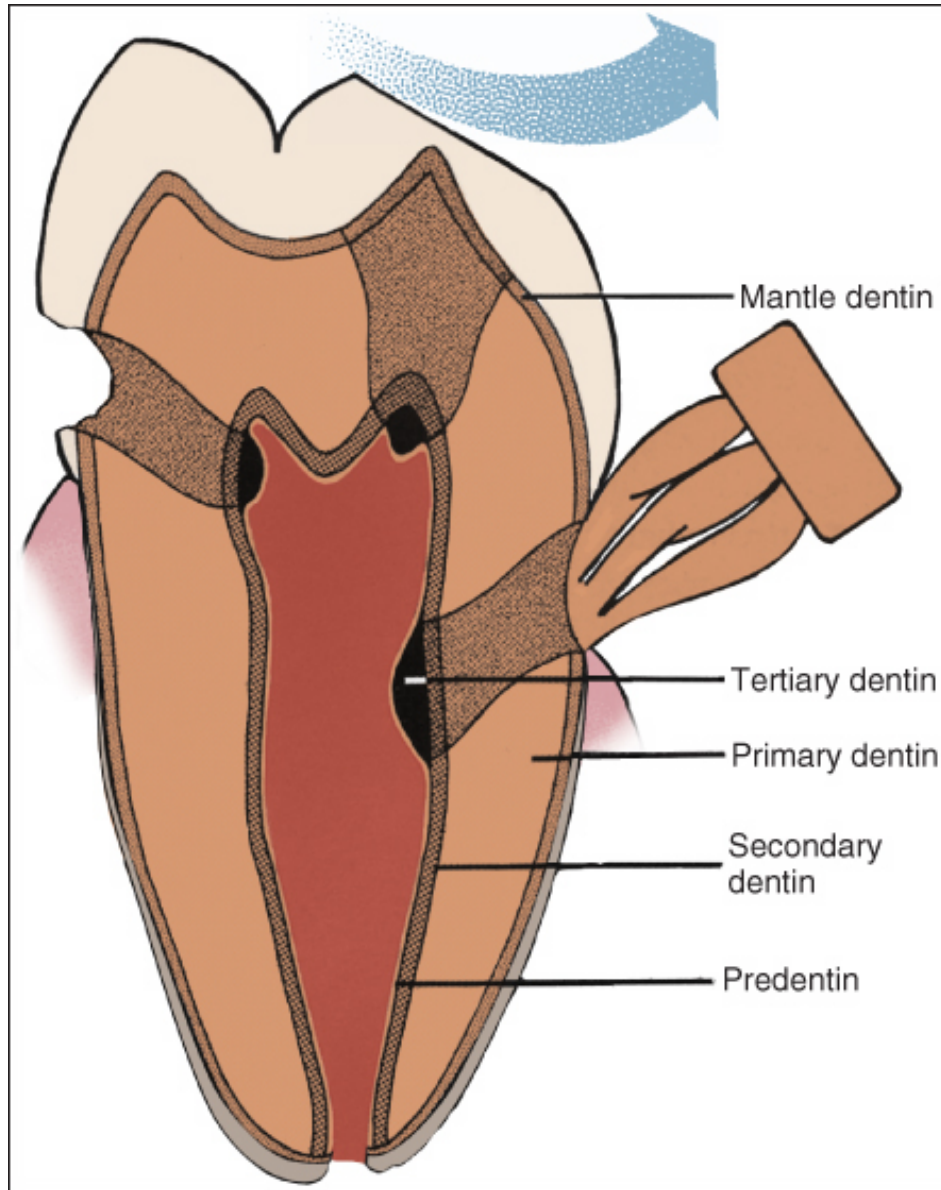
Non-collagenous proteins

- DPP dentin phosphoprotein/phosphophorin
- DSP dentin sialoprotein
- DGP dentin glycoprotein
- DMP1
- Osteonectin (SPARC)
- Osteocalcin
- Bone sialoprotein
- Osteoprotein

Dentin Sialophosphoprotein

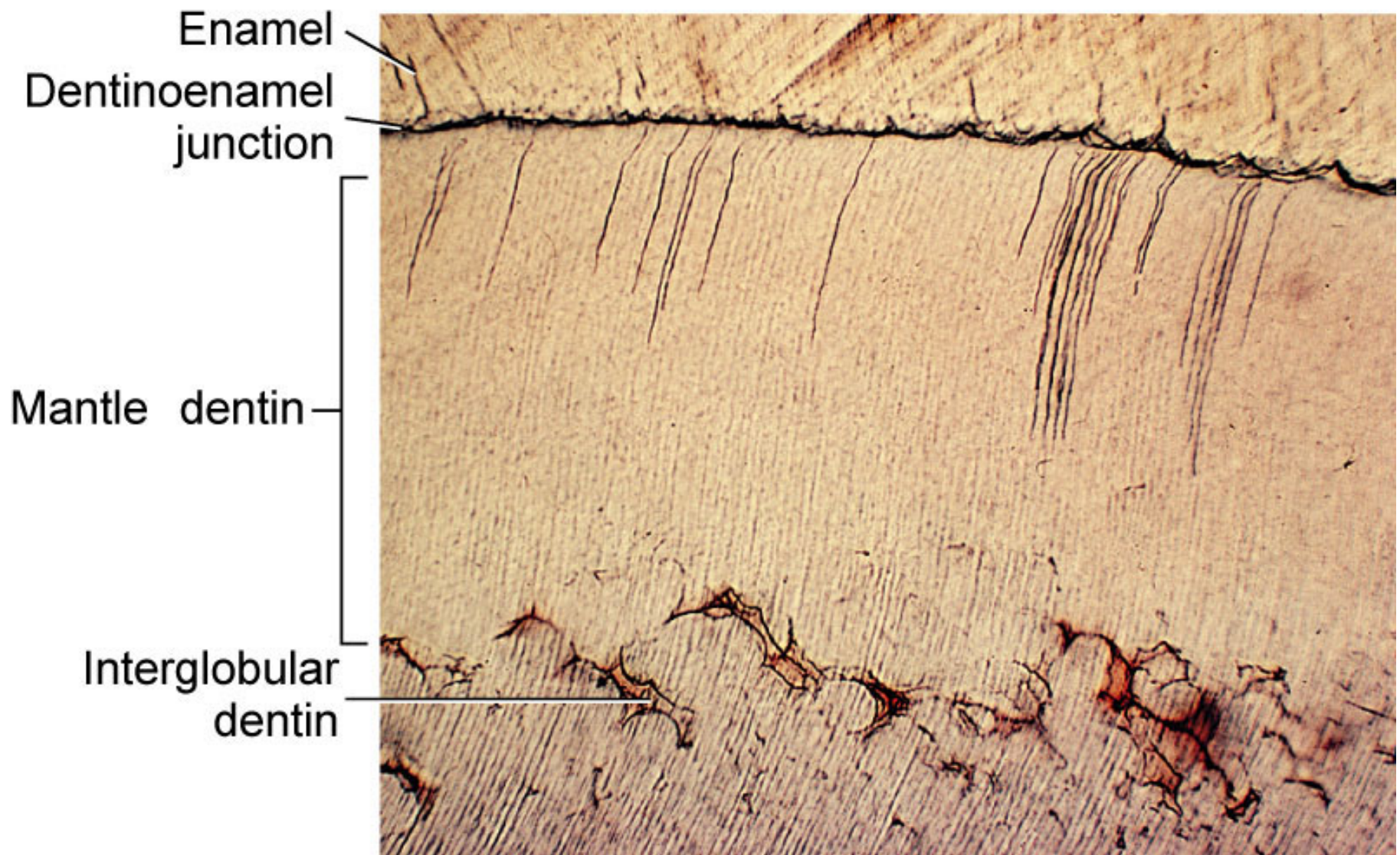
- Composed of
 - DPP binds calcium; collagen, initiates hydroxyapatite formation
 - DSP peritubular dentin; prevent occlusion of tubules
 - DGP





Dentin

- Primary (circumpulpal) dentin: Most of the dentin
 - Mantle dentin (FIRST DENTIN): outer layer of coronal dentin.
 - Different properties (collagen distribution and orientation) in the crown compared to the root
- Secondary
 - After root formation
 - By odontoblasts that form primary
 - Demarcation line
 - Continuous but slower odontoblastic activity
 - Reduction of pulpal chamber size (recession)
- Tertiary
 - Reactionary (preexisting odontoblasts) or reparative (newly differentiated cells) dentin
 - Reaction to attrition, caries or restorative procedure
 - Site-specific. Produced only by those cells directly stimulated
 - Tubular or atubular / osteodentin



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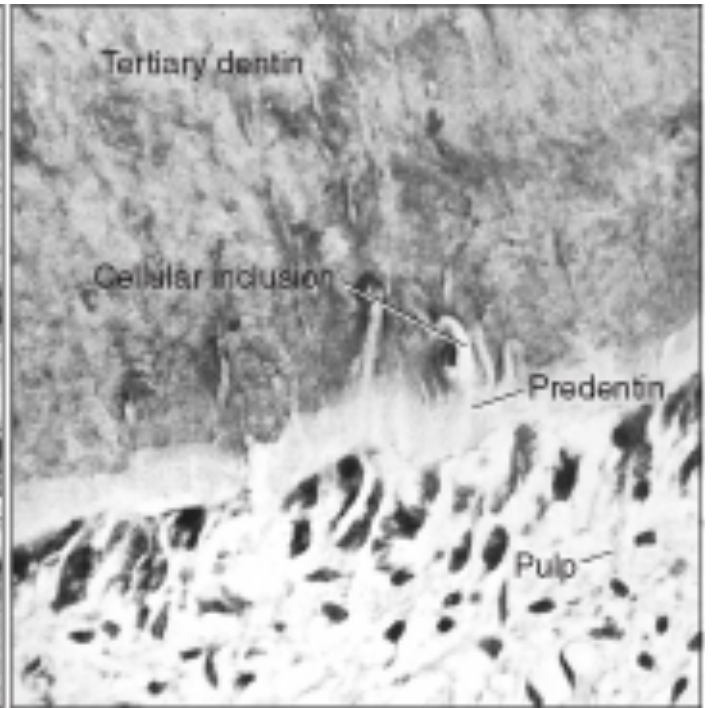
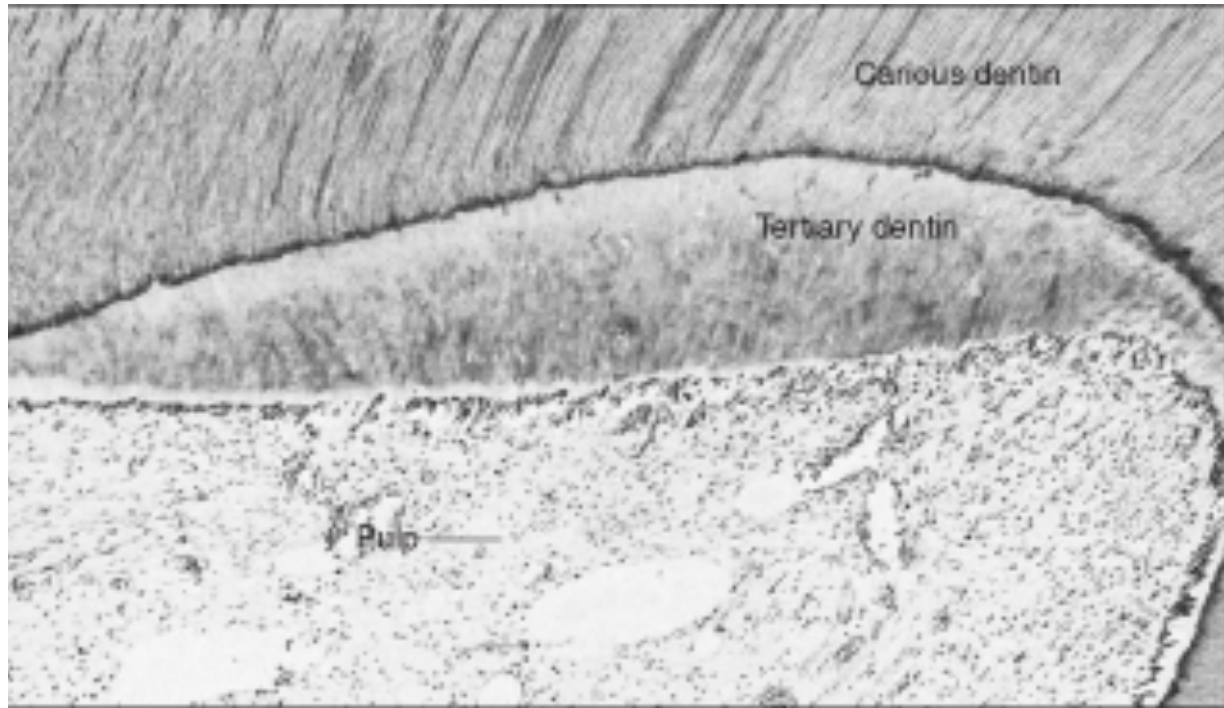
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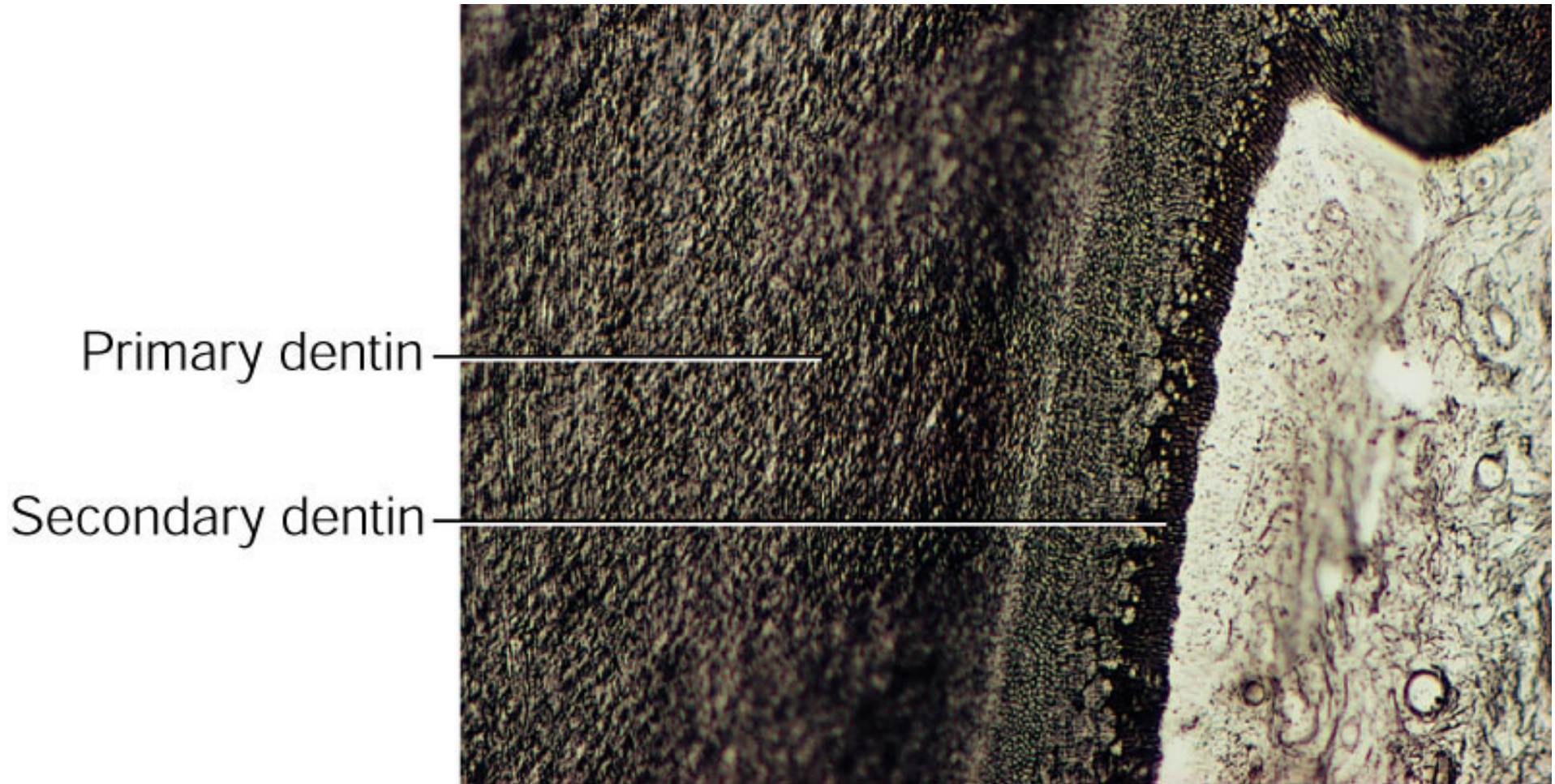
1° Dentin

2° Dentin

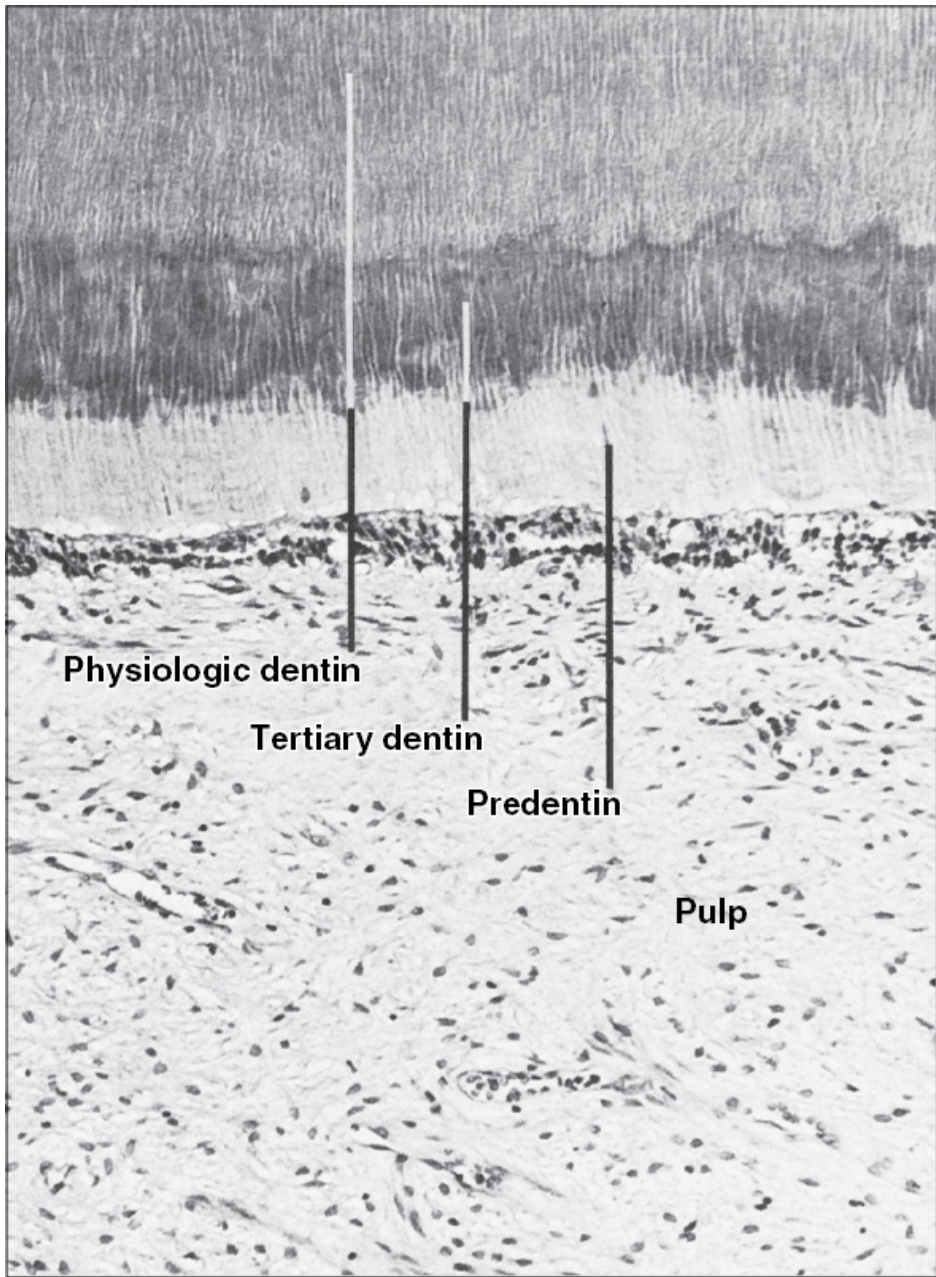
Pulp



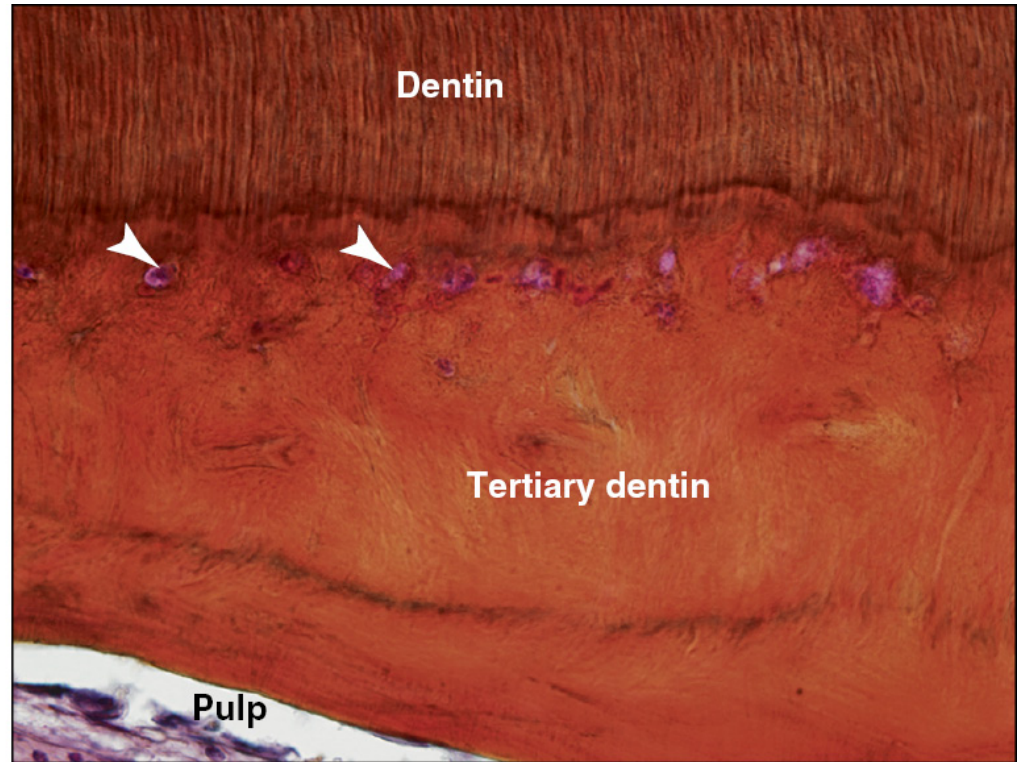




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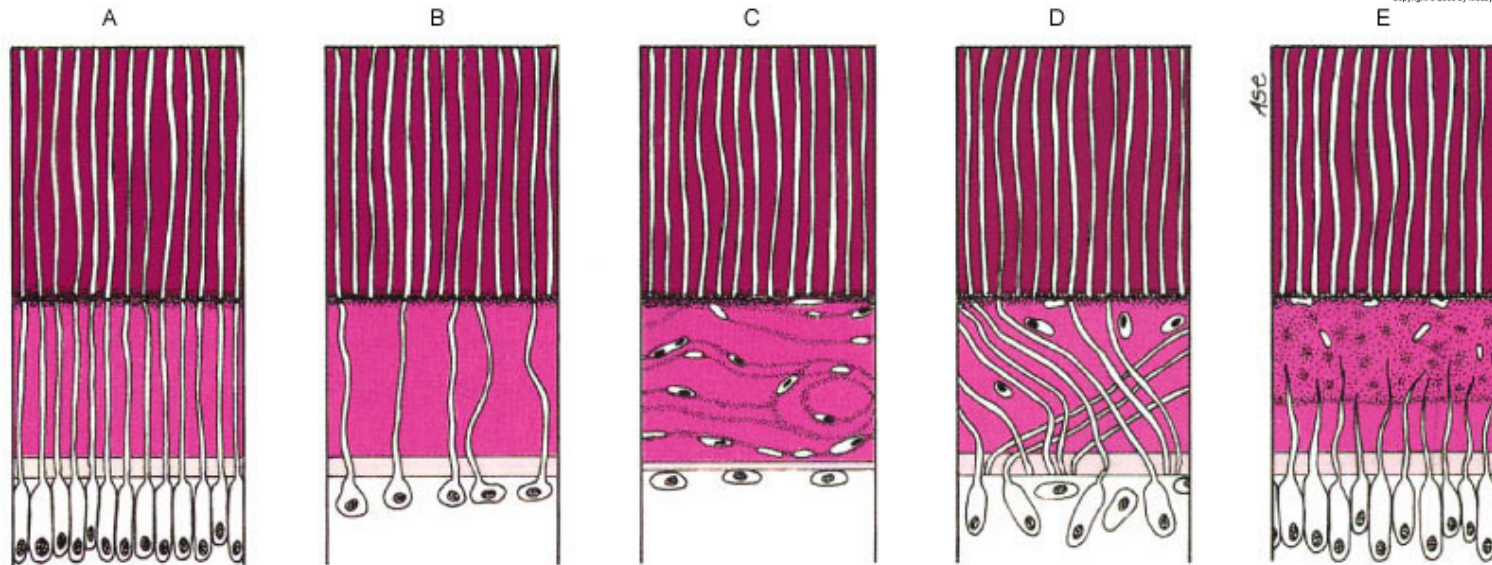
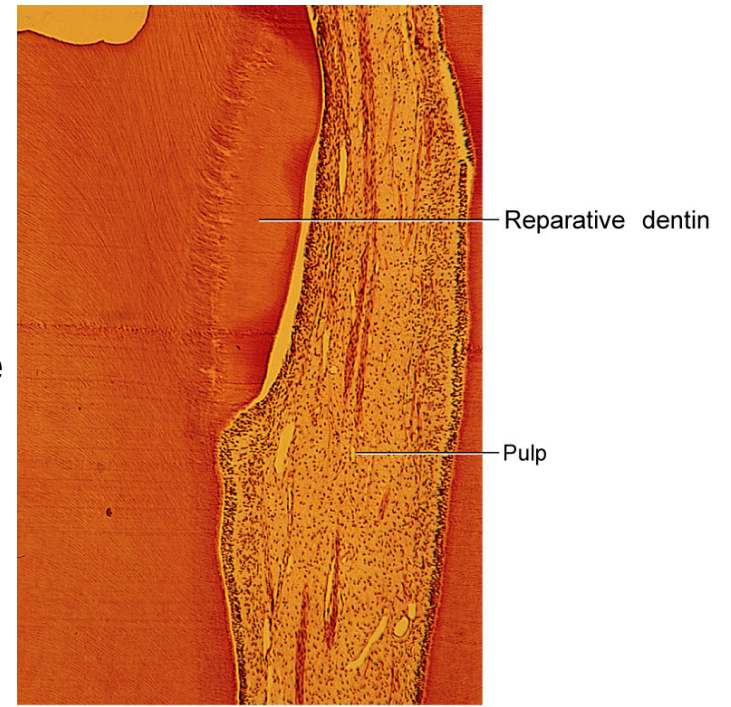


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Tertiary Dentin

Rate of deposition depends on the degree of injury
 More severe injury: more rapid rate of dentin deposition

Due to rapid rate of deposition cells get entrapped in the newly formed matrix and tubular pattern becomes grossly distorted



Normal

Few tubules

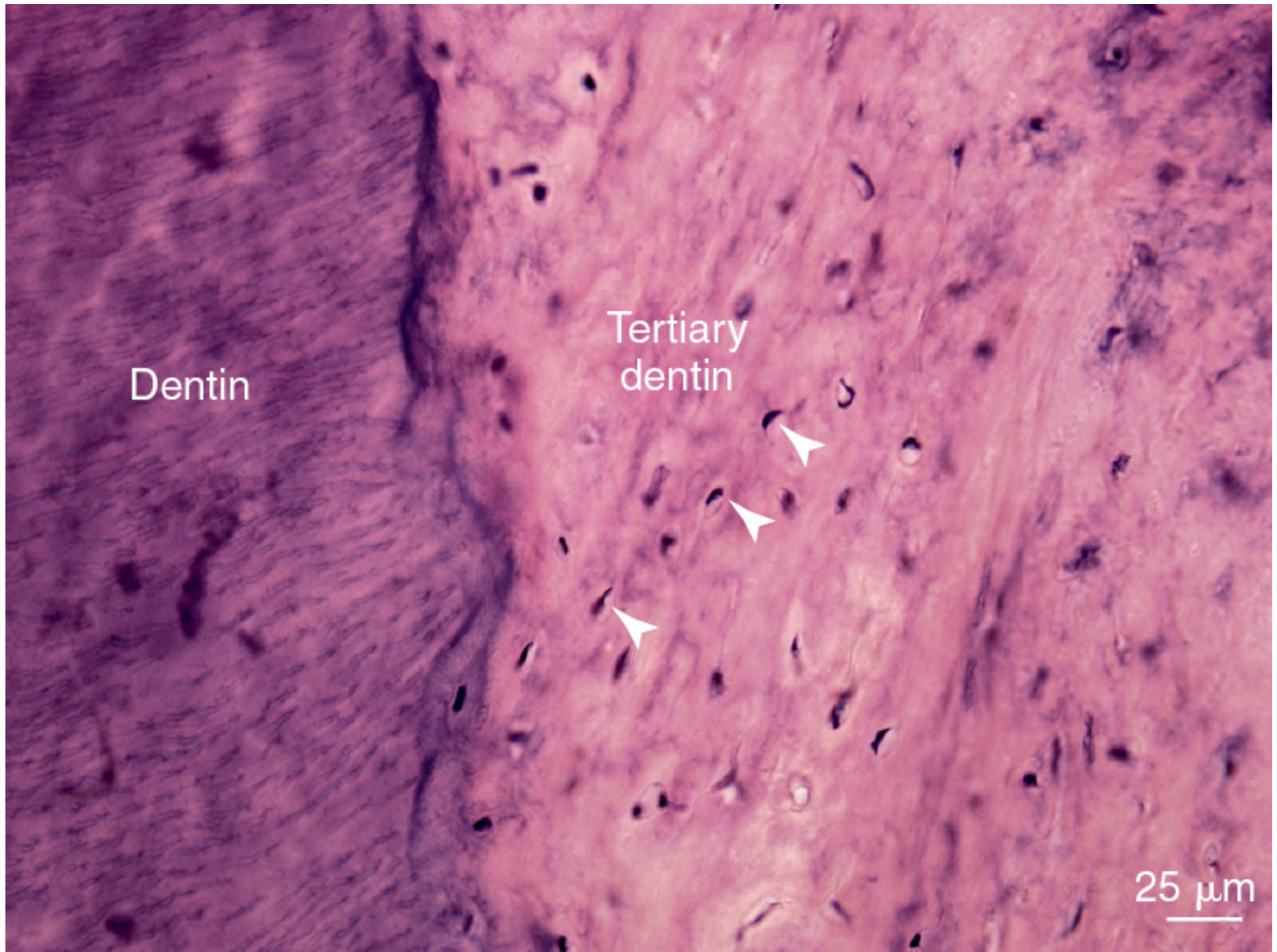
Osteodentin

Irregular

Combination

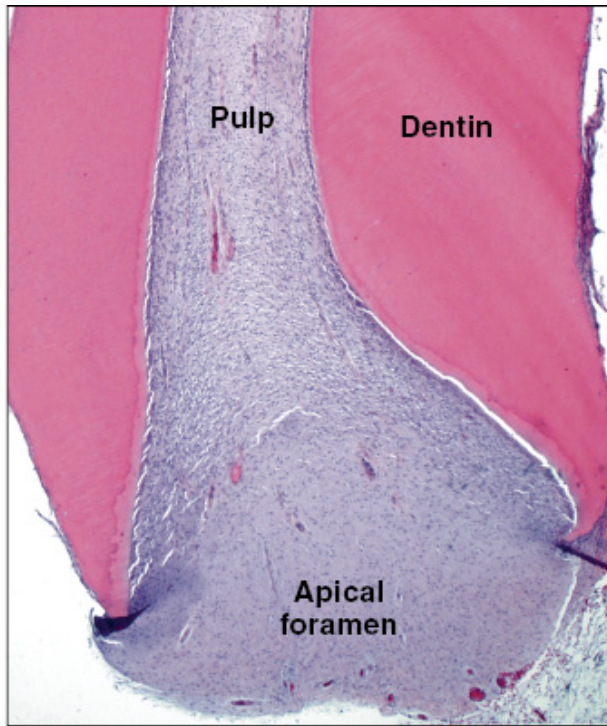
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Dentin formation

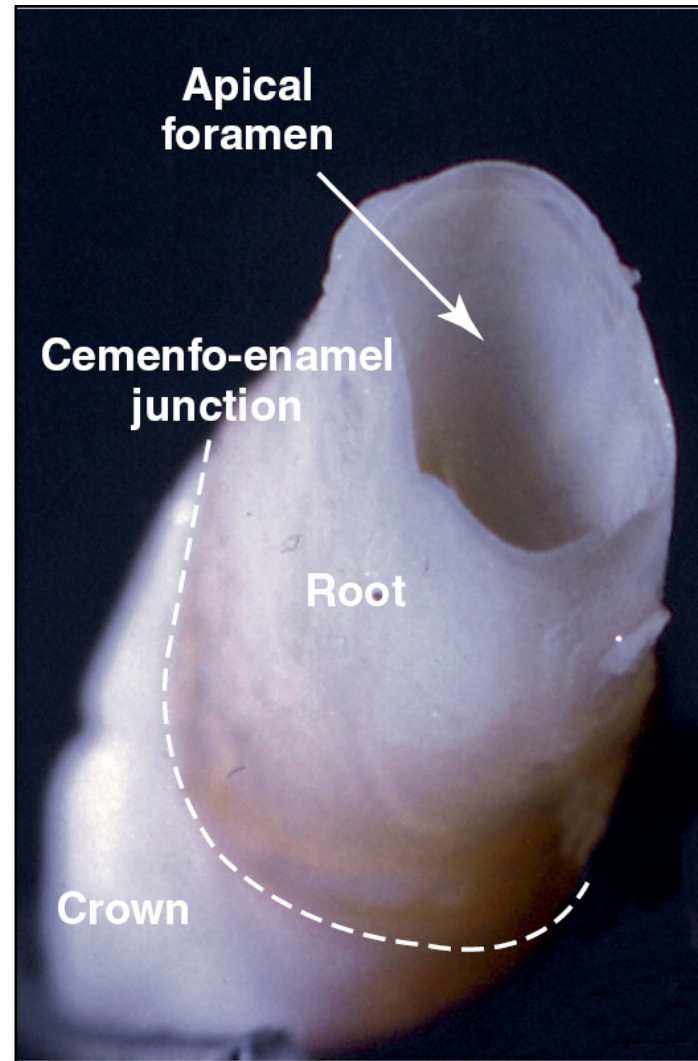
- Begins at bell stage
- From cusp tips and down the slope
- Coronal and radicular dentin
- Completion of root dentin occurs after tooth eruption (open apex)
- Completion of root dentin formation does not occur in the primary tooth until 18 months after eruption; and 2-3 years for permanent teeth after eruption (during this period the tooth is said to have an open apex)



A

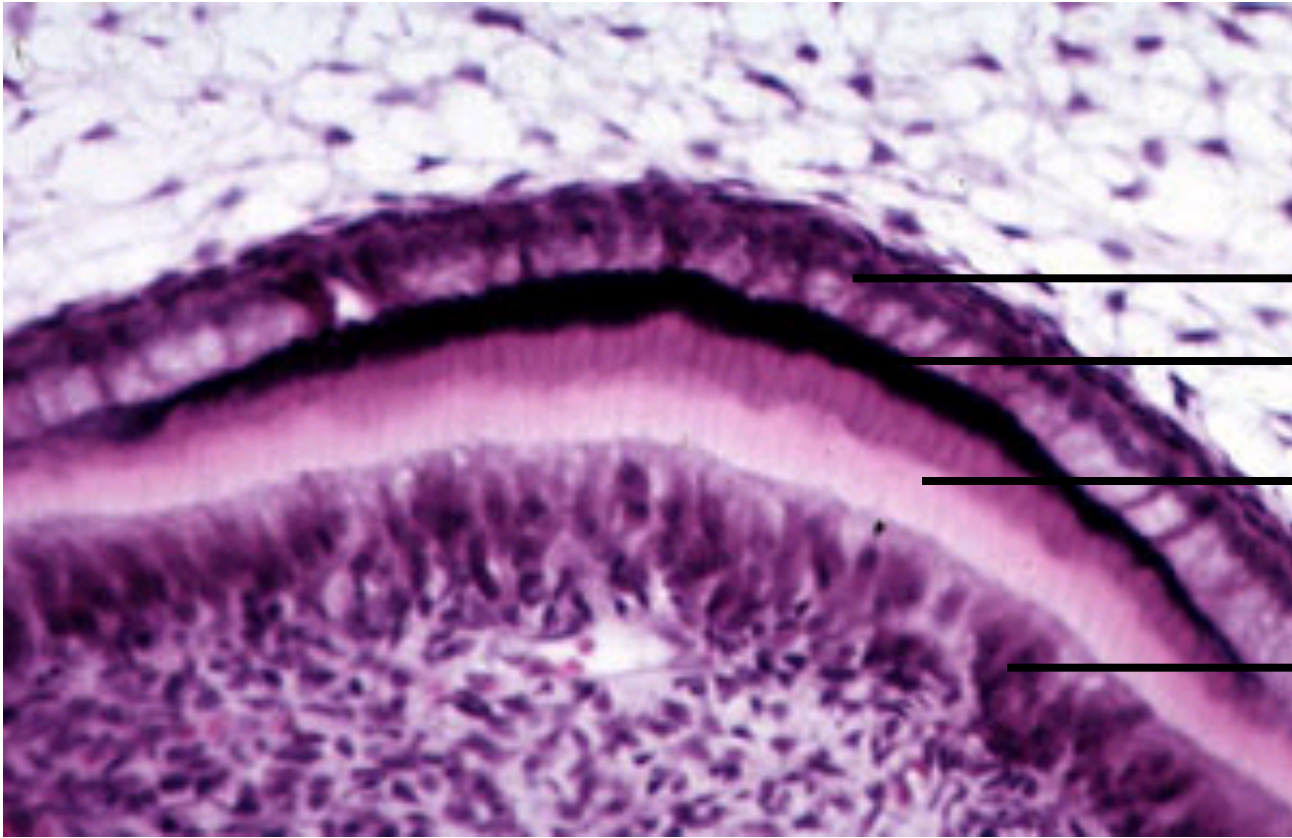
FIGURE 8-2A The apical foramen in developing teeth is widely open.

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B

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Ameloblasts

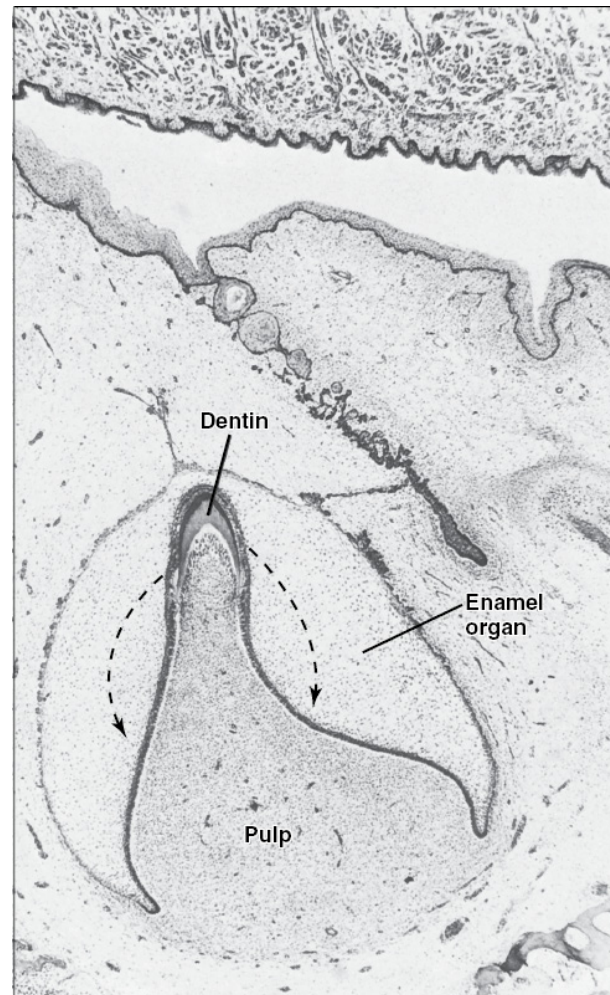
First layer of enamel

Dentin

Odontoblasts

Rates of dentin deposition varies both within various regions of a tooth and also among different teeth

Dentin formation continues throughout the life of the tooth resulting in a gradual and progressive reduction in the size of the pulp cavity



Dentinogenesis

- Odontoblasts (preodontoblasts)
- Role of inner enamel epithelium
- Acellular zone (collagen fibrils)
- First product: type III collagen fibrils with fibronectin (von Korff's fibers)
- Then type I collagen parallel to DE junction
- Enamel spindles
- Odontoblastic processes

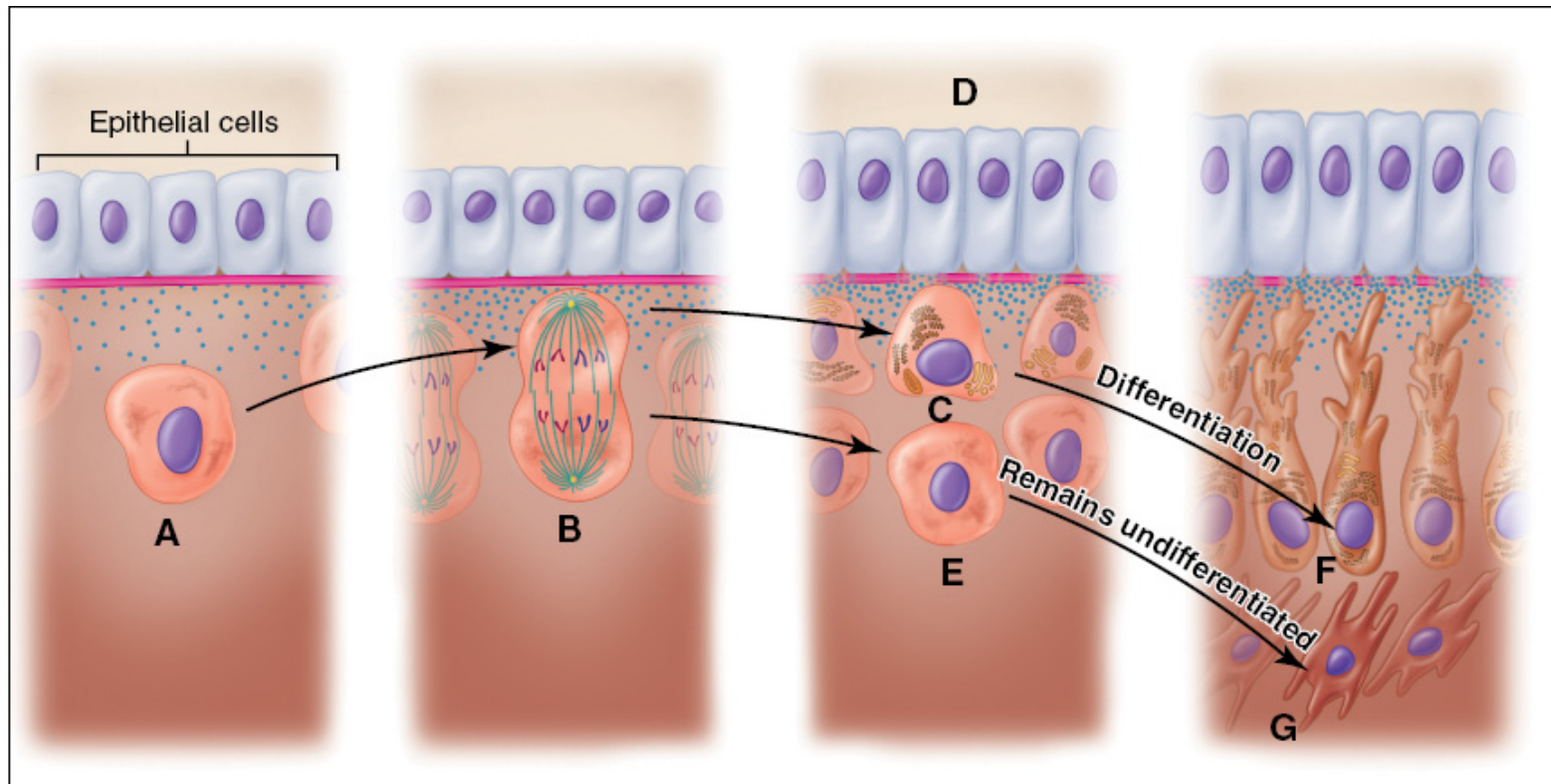
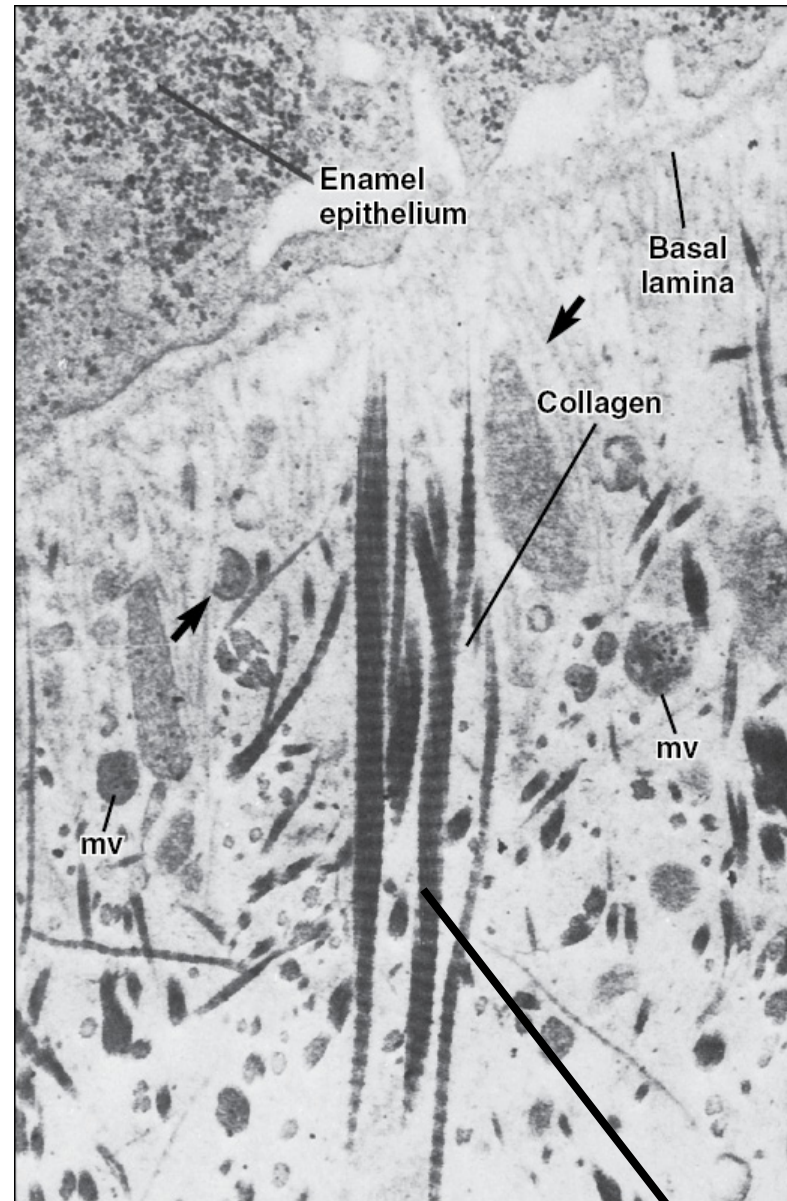
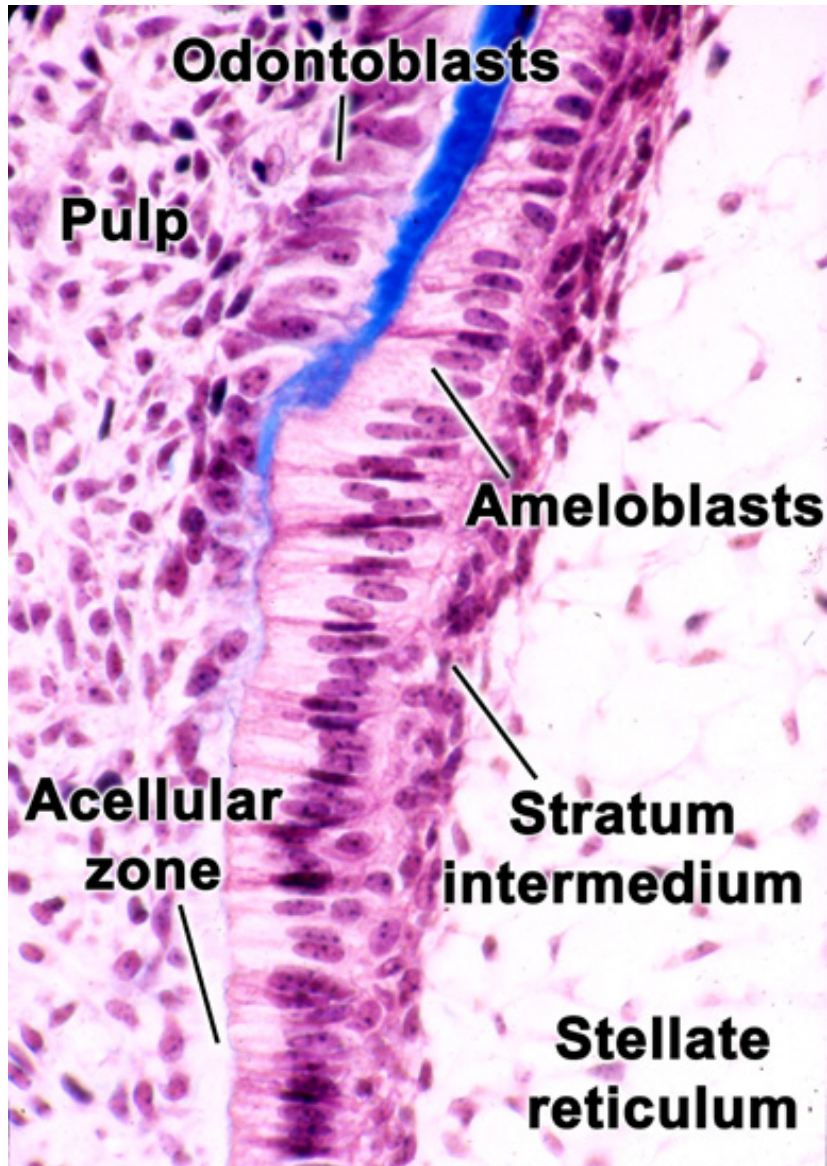


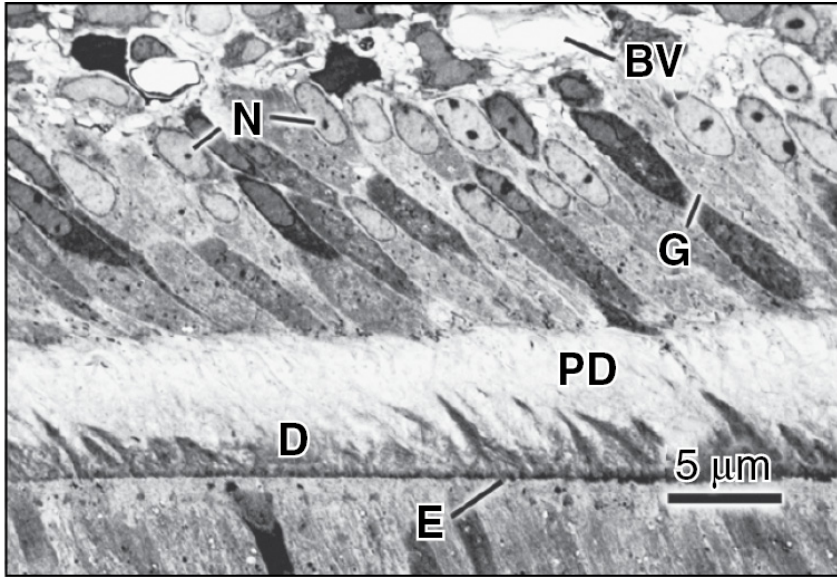
FIGURE 8-11 Odontoblast differentiation. The undifferentiated ectomesenchymal cell (A) of the dental papilla divides (B), with its mitotic spindle perpendicular to the basal lamina (*pink line*). A daughter cell (C), influenced by the epithelial cells and molecules they produce (D), differentiates into an odontoblast (F). Another daughter cell (E), not exposed to this epithelial influence, persists as a subodontoblast cell (G). This cell has been exposed to all the determinants necessary for odontoblast formation except the last.



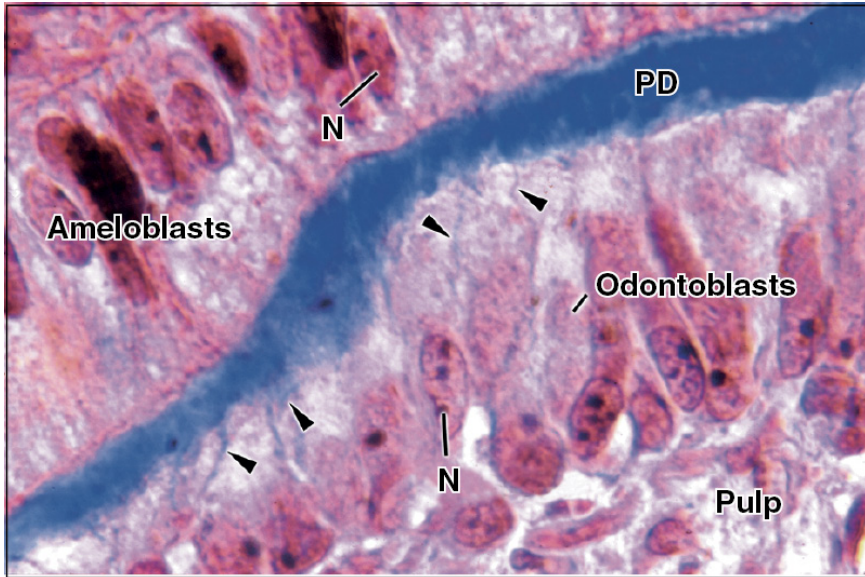
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Von Korff's fibers

C

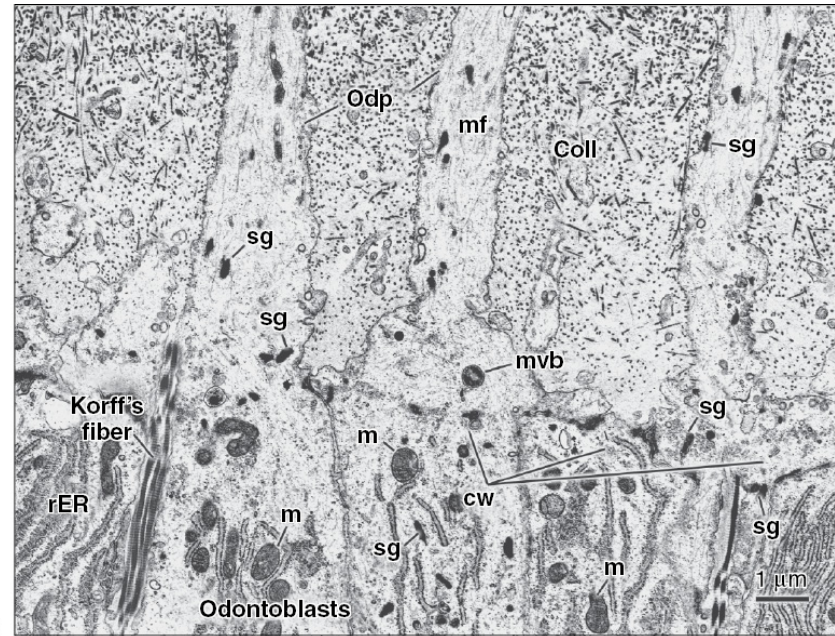


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A

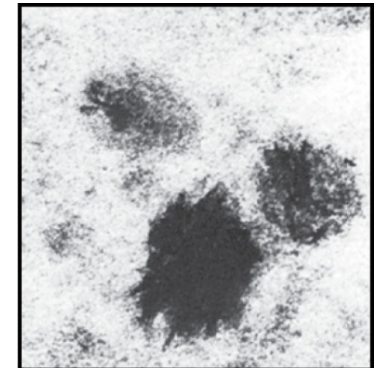
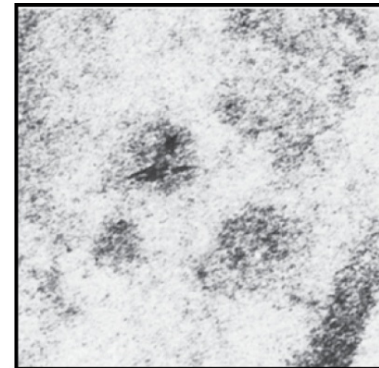
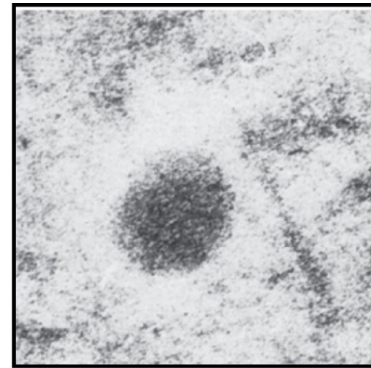
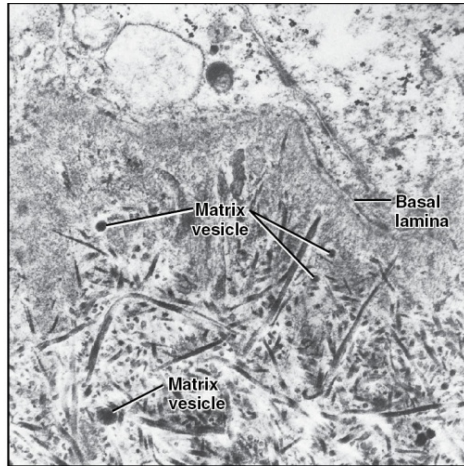


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Von Korff's fibers (arrowheads): Observed deep in between odontoblasts

Mineralization of Dentin

Occurs by formation of matrix vesicles



Mineralization first appears as single crystals seeded by phospholipids in the vesicle membrane

These crystals grow rapidly and rupture from the confines of the vesicle to spread as a cluster of crystallites that fuse with adjacent clusters to form a continuous layer of mineralized matrix

Deposition of mineral lags behind the formation of the organic matrix so that a layer of predentin (organic layer) is always present between odontoblasts and the mineralization front

Following this, noncollagenous protein secreted by odontoblasts will now regulate mineral deposition

Two recognized patterns of dentin mineralization: linear and globular depending on the rate of dentin formation

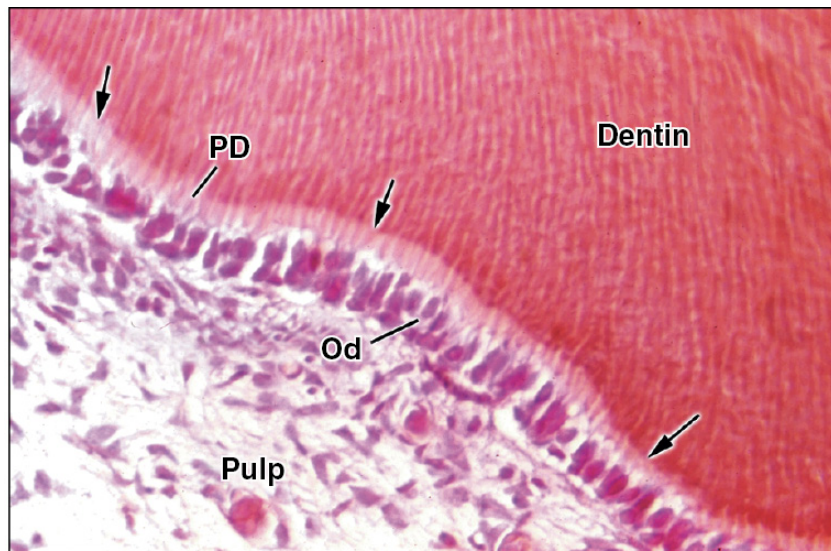
Mantle dentin: predominantly globular

Circumpulpal dentin: both linear and globular

Globular pattern occurs when mineralization is the fastest

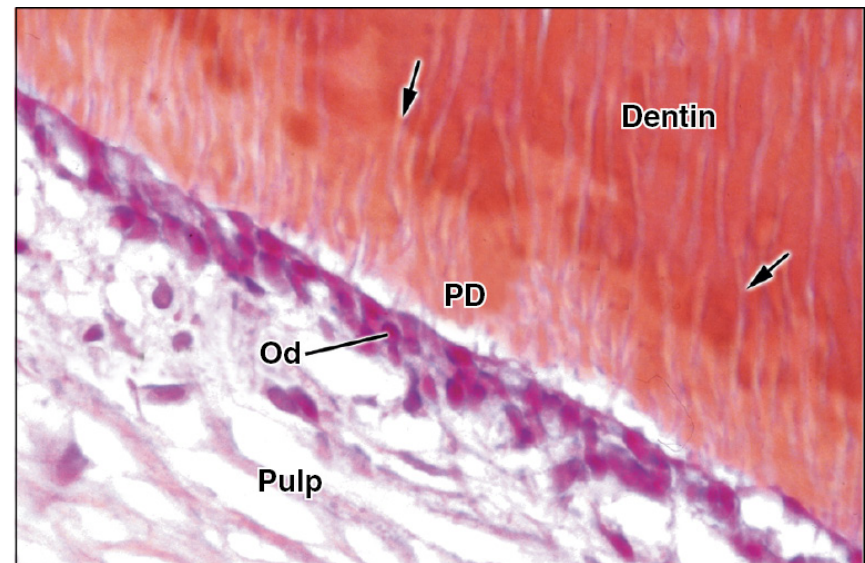
Linear pattern occurs when rate of formation is slow

Linear



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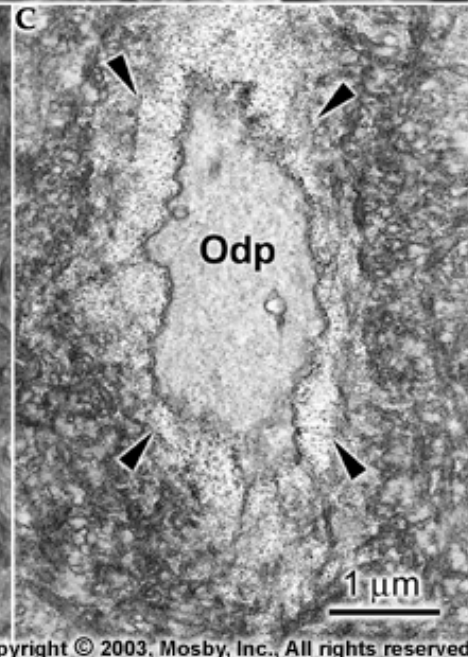
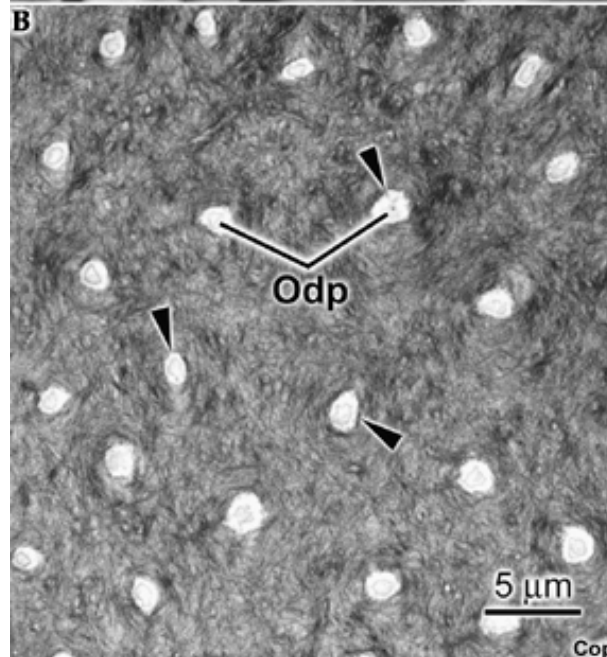
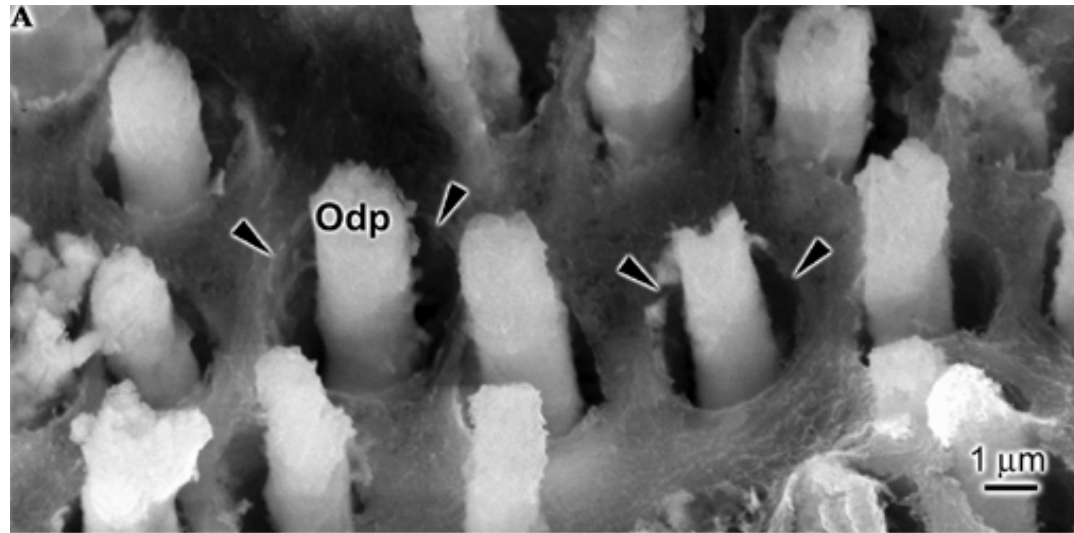
Globular

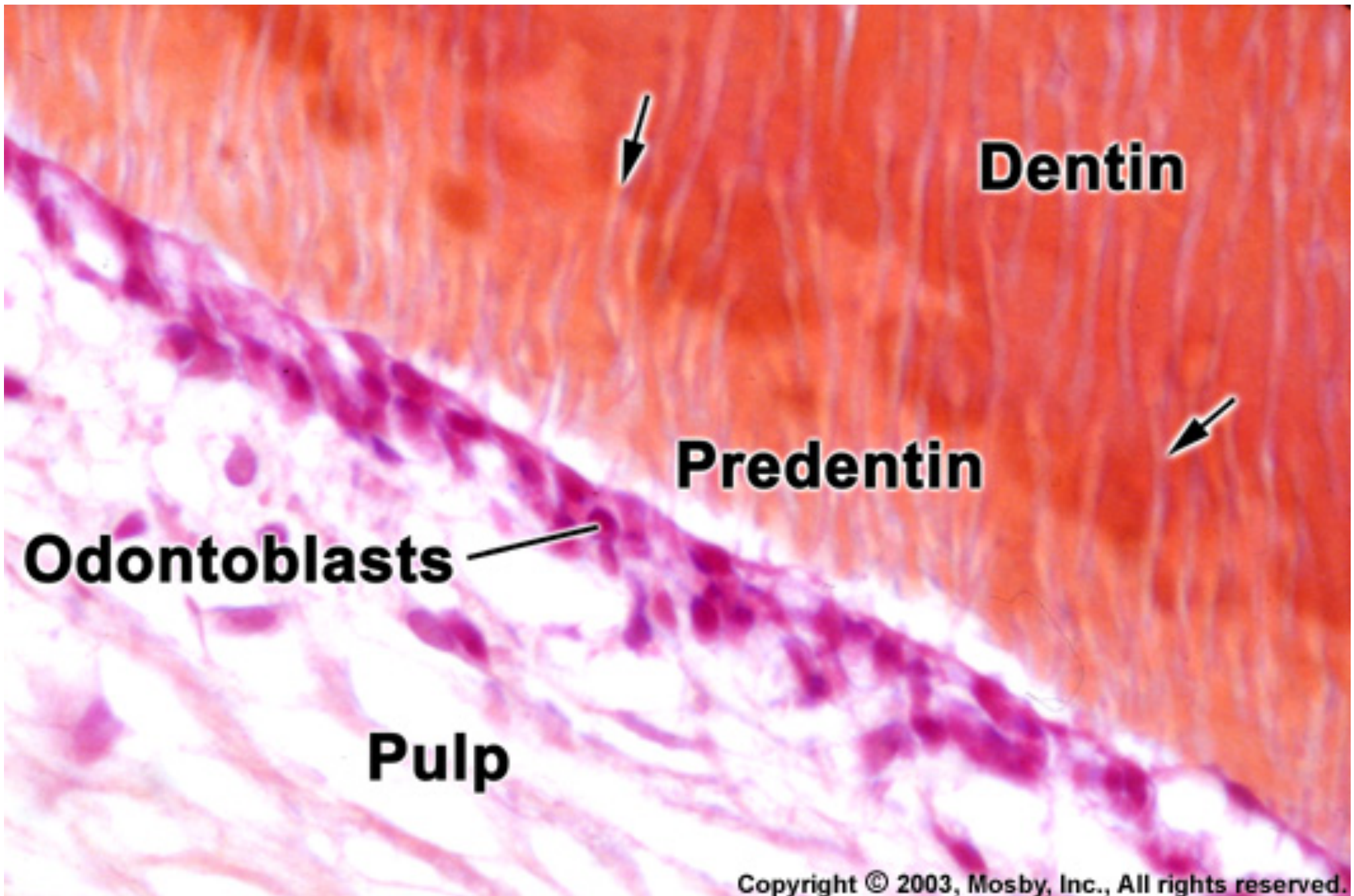


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Dentinal tubules

- Contain cytoplasmic processes
- Extend through the entire thickness
- S-shaped path (curvatures) due to crowding in the crown
 - Secondary curvatures
- Almost straight in the incisal area
- Straight in root dentin
- Tapered (largest diameter near the pulp)
- Branches (more frequent in the root) that derive from branching of the odontoblastic process



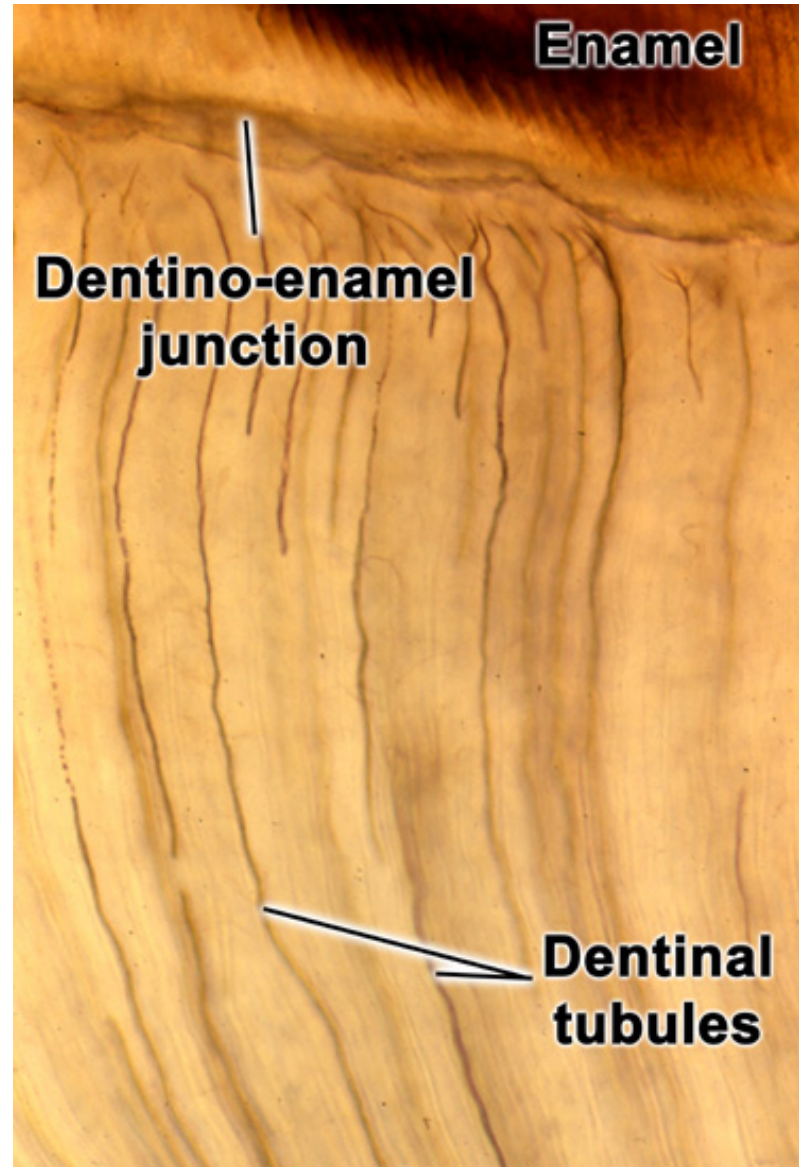


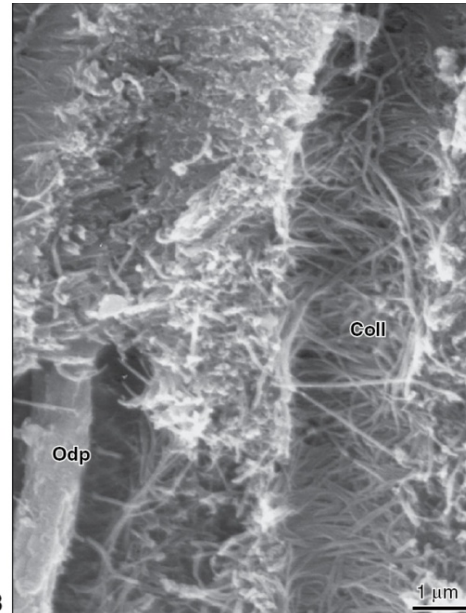
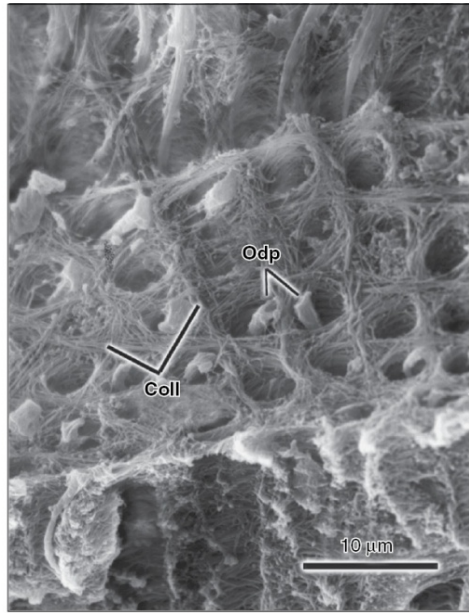
Dentin

Predentin

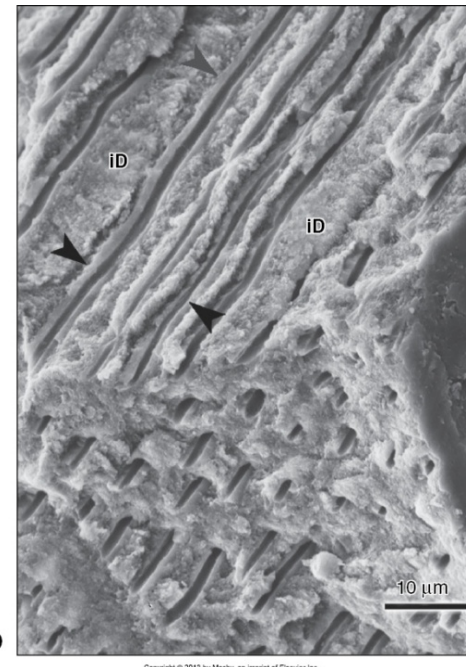
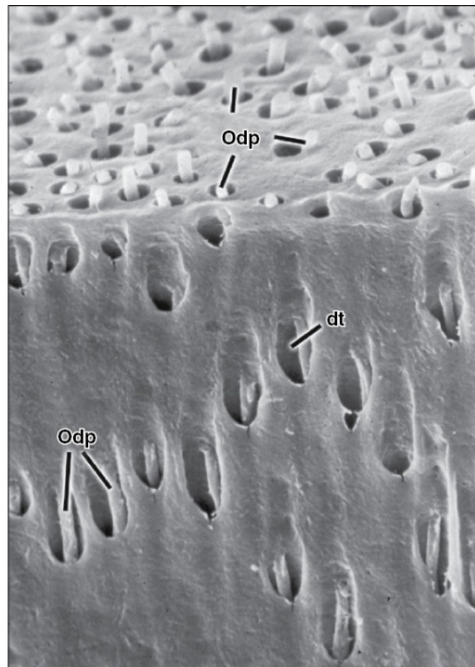
Odontoblasts

Pulp





In predentin, odontoblastic processes are surrounded by meshwork of collagen.



In dentin, the odontoblastic process is within dentinal tubule surrounded by peritubular dentin that is poor in collagen and more mineralized

A

B

C

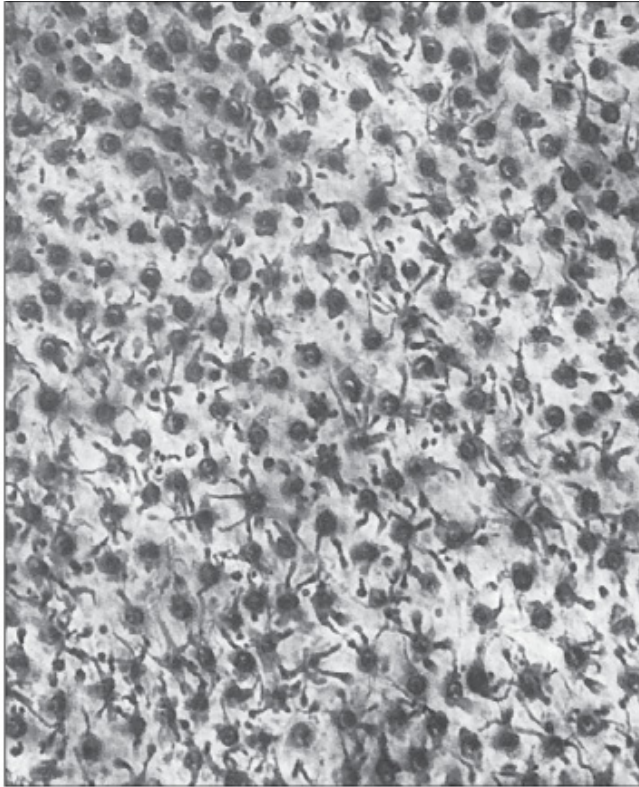
D

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A

FIGURE 8-27A Dentinal tubule branching. **A**, Light microscope cross section of dentin stained with silver nitrate showing the extensive fine branching network of the tubular compartment.

B, Scanning electron micrograph showing microbranch extends from a larger dentinal tubule through the peritubular dentin. A thin layer of peritubular dentin also borders the microbranch.



B

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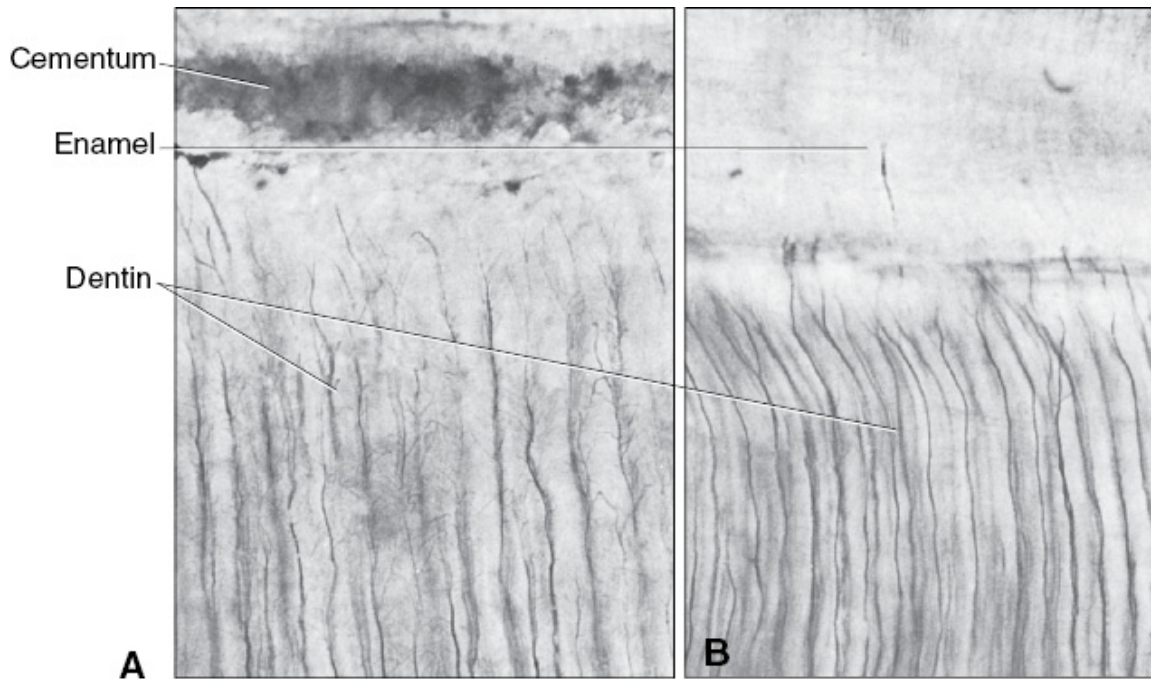
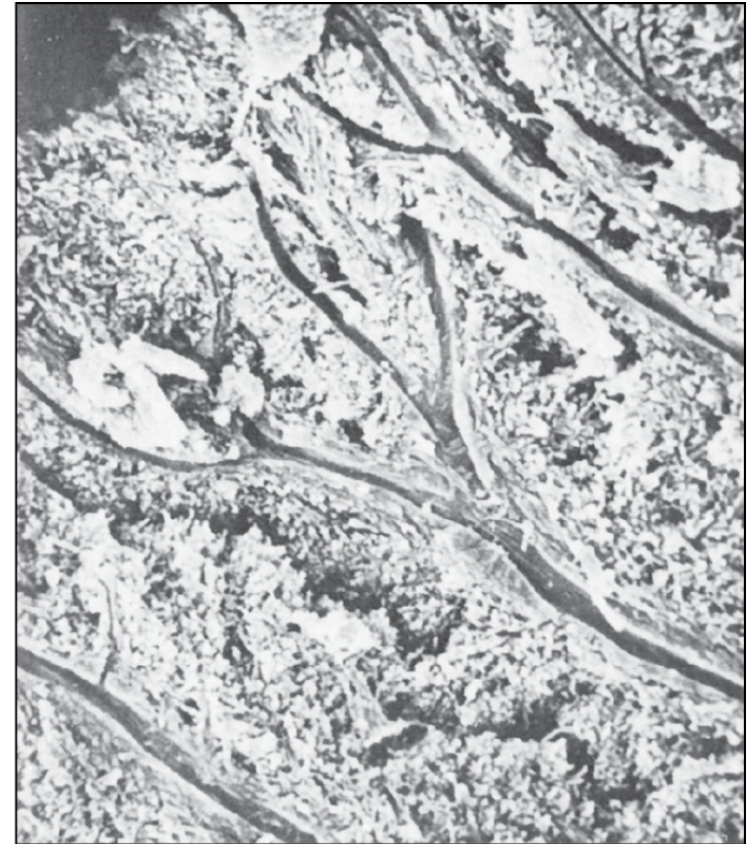


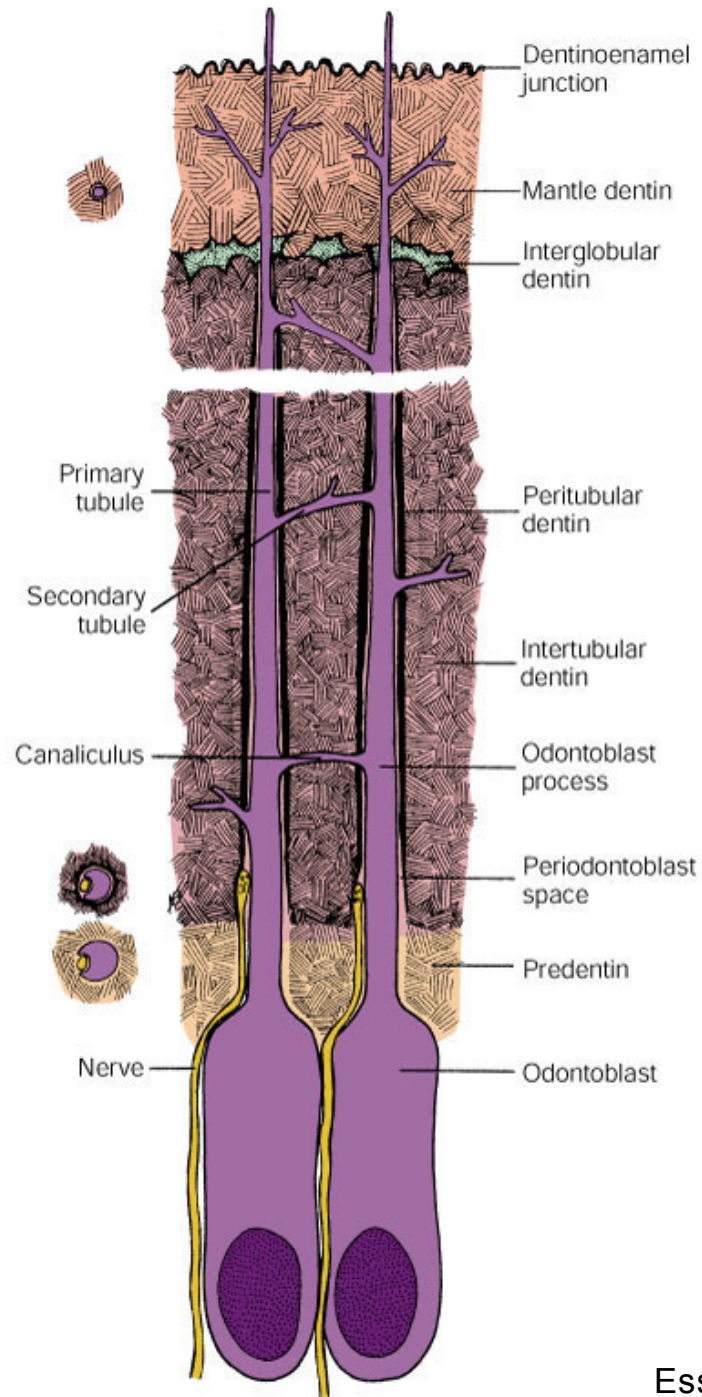
FIGURE 8-28A&B Terminal branching of dentinal tubules is more profuse in root dentin (**A**) than in coronal dentin (**B**). **C**, Scanning electron micrograph showing branching.

C



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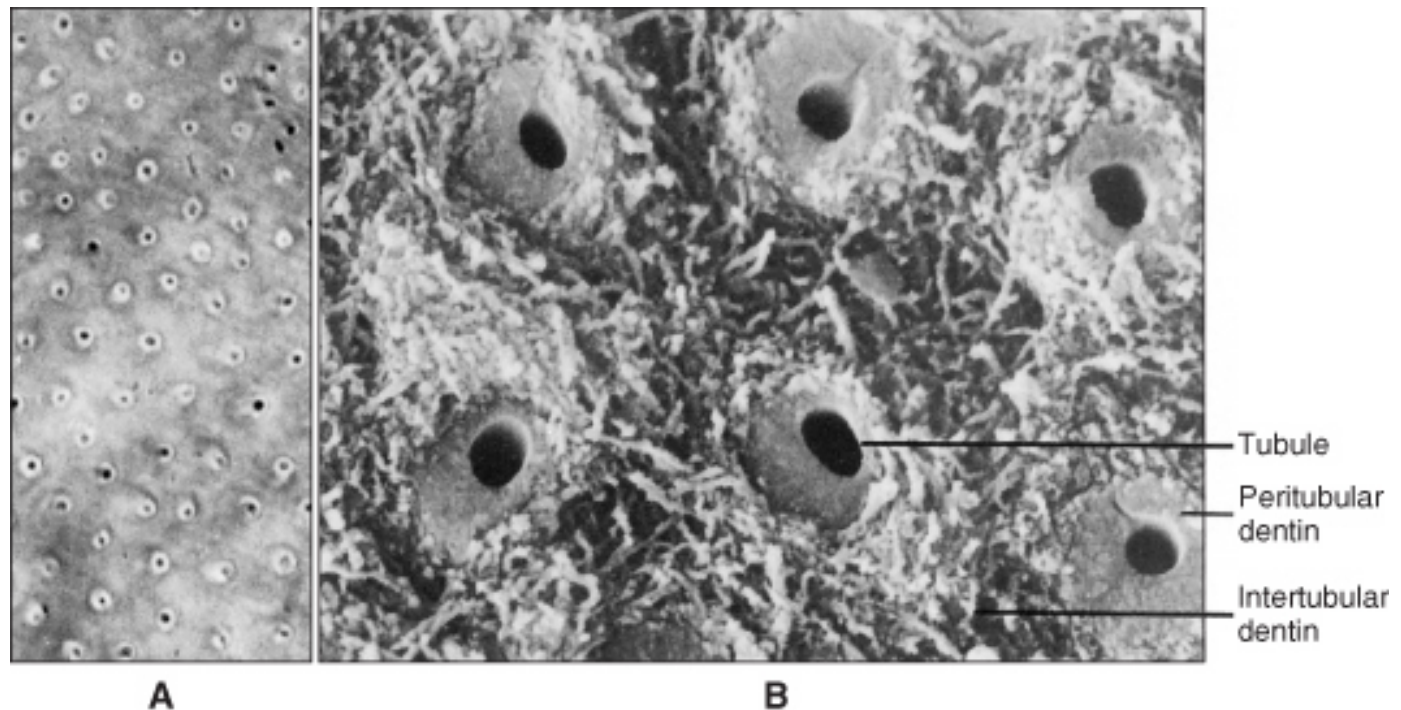


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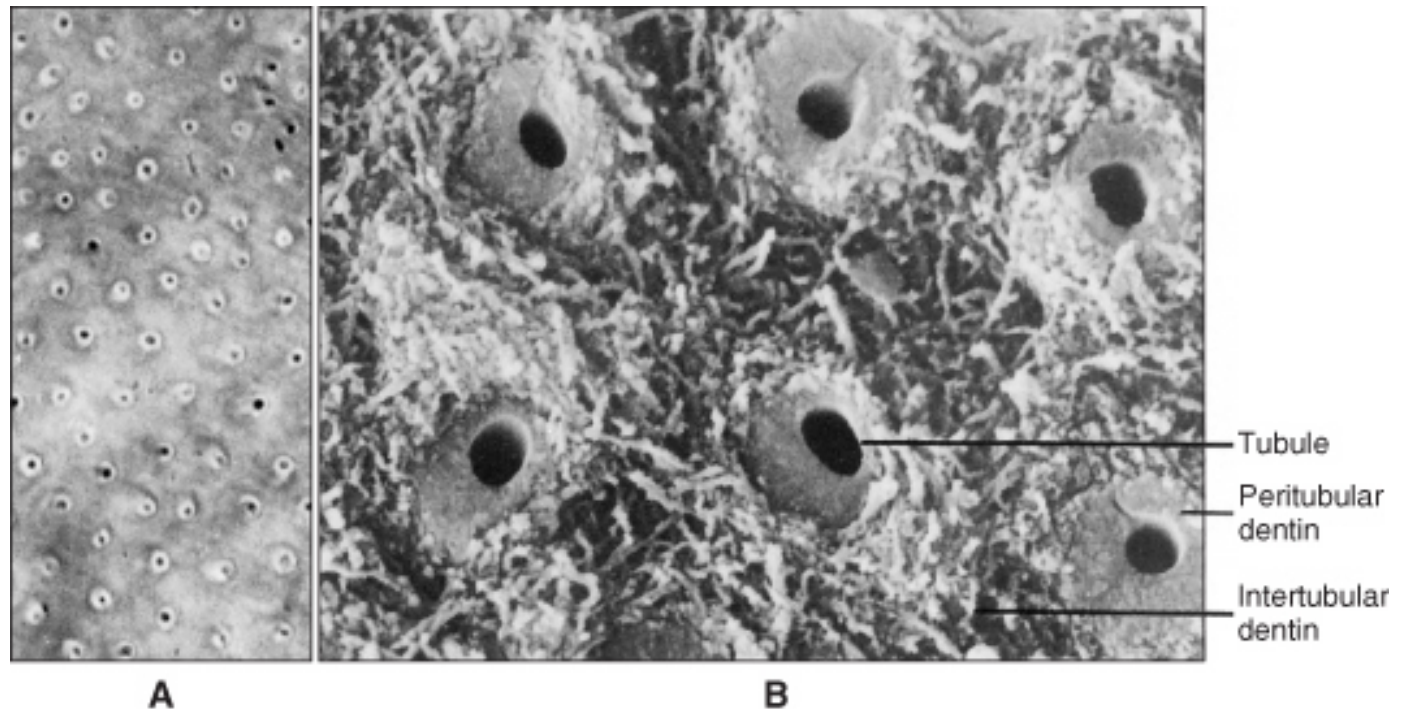
Peritubular dentin

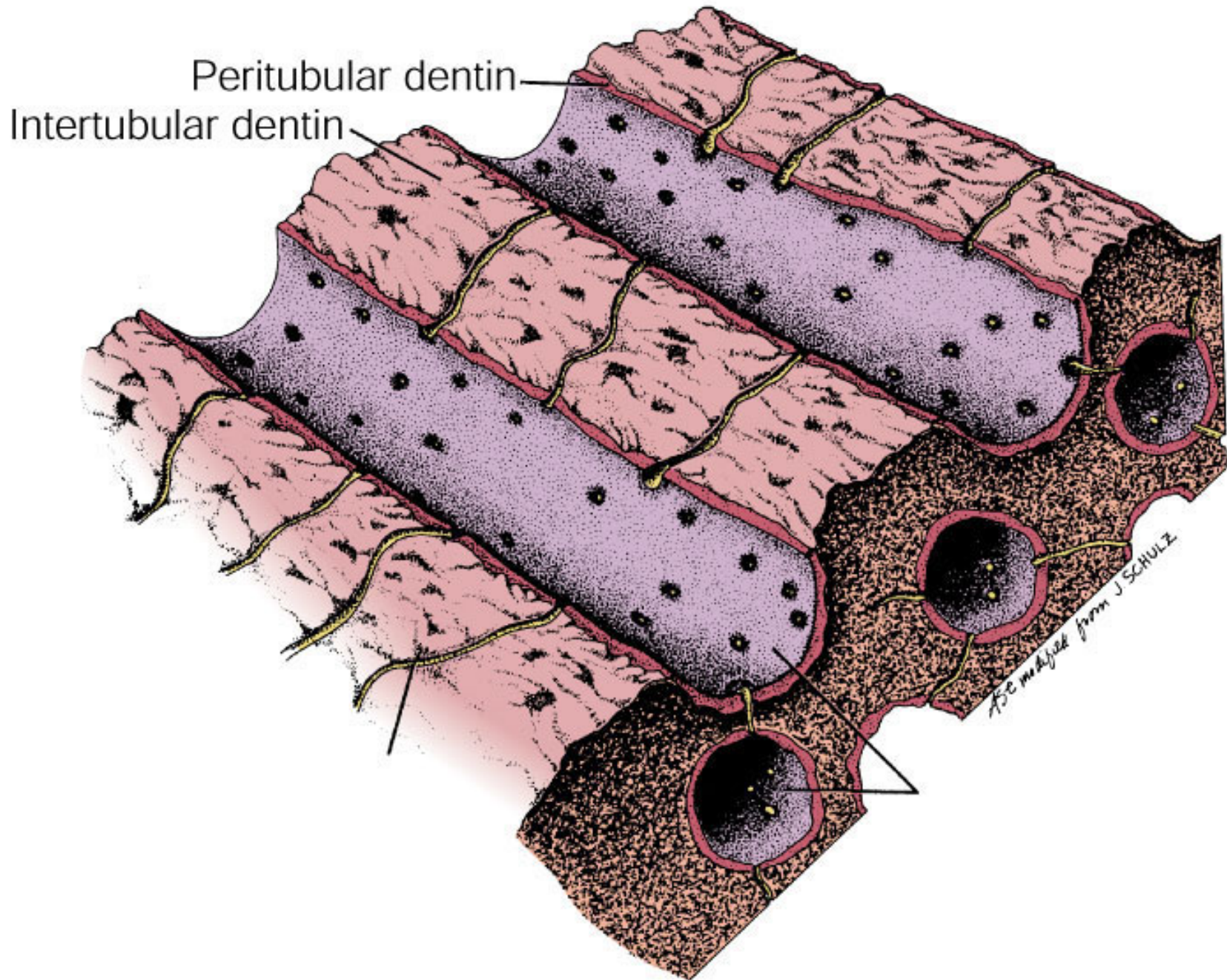
- Intratubular dentin (old **wrong** term)
- Collar of hypermineralized dentin
- Little collagen but \uparrow DSP, DMP1



Intertubular dentin

- Between tubules
- Primary secretory product of odontoblasts



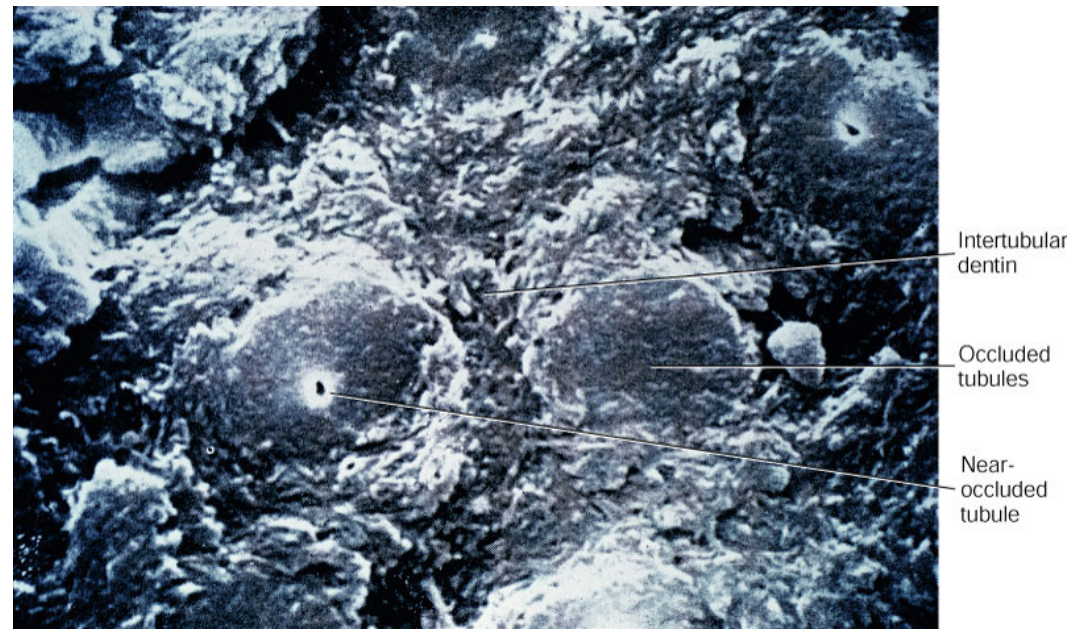


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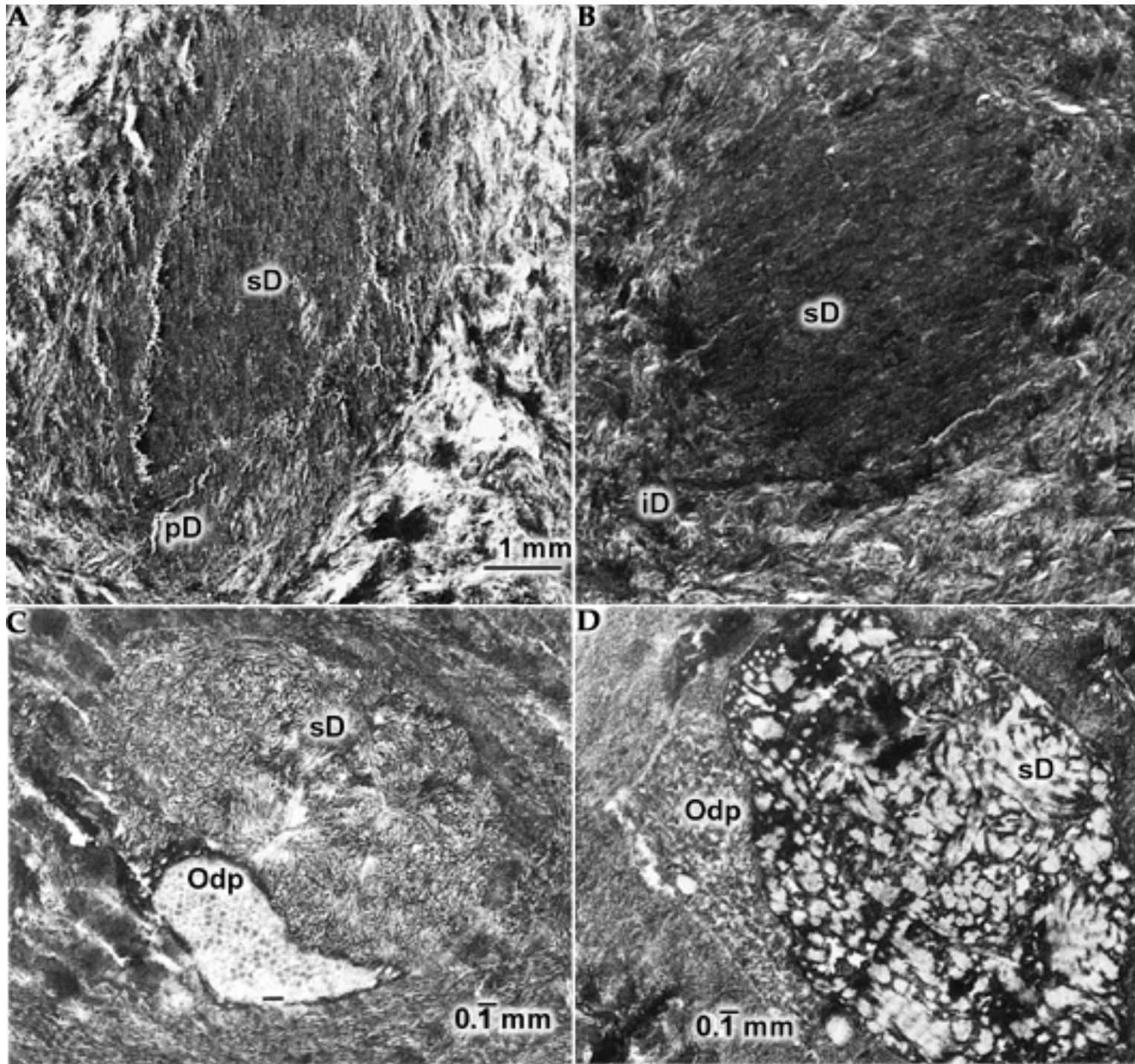
Sclerotic dentin

- Occluded dentinal tubule
 - In ground sections dentin look translucent
 - Starts in the teens
 - Can be just minerals without well formed dentin
- Increases with age
- Root and middle of crown
- Reduces dentin permeability → prolonged pulp vitality



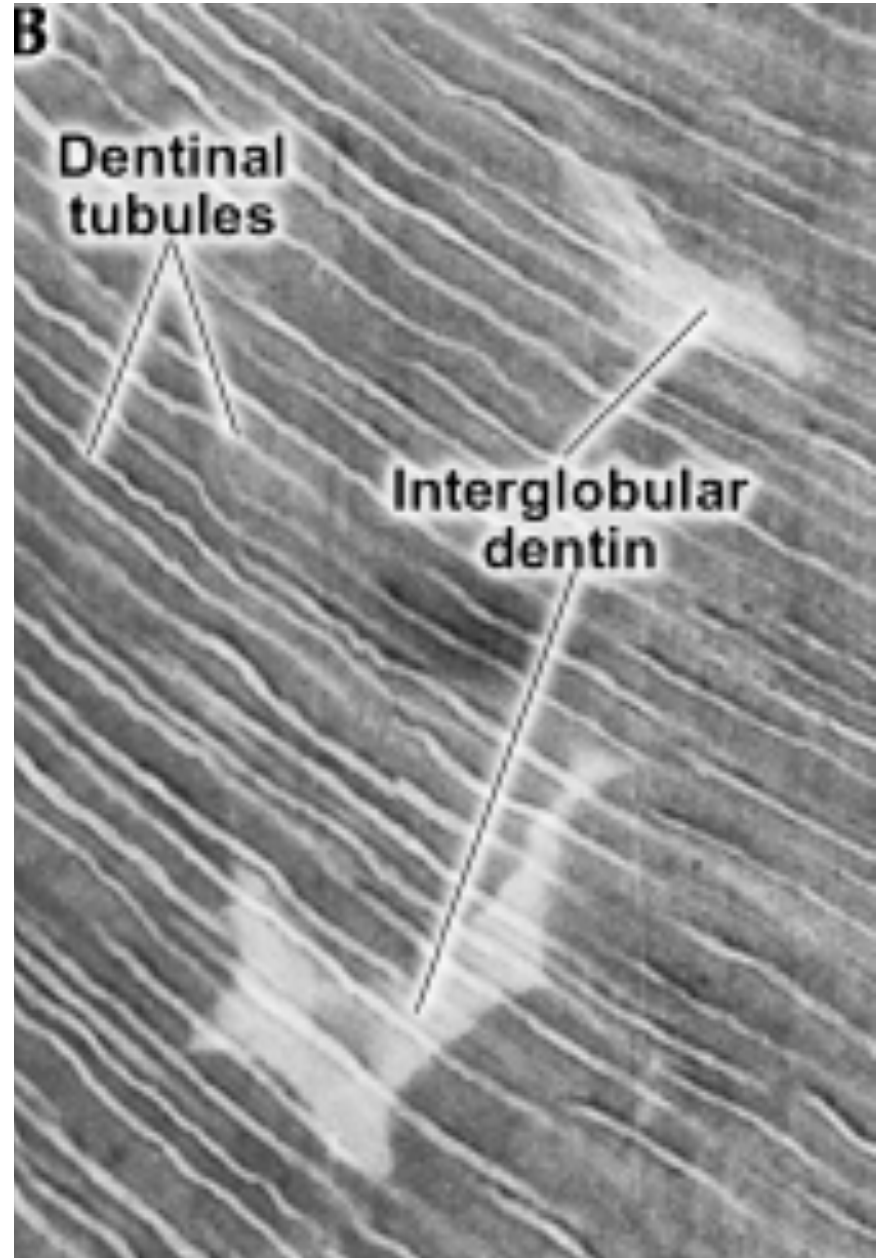
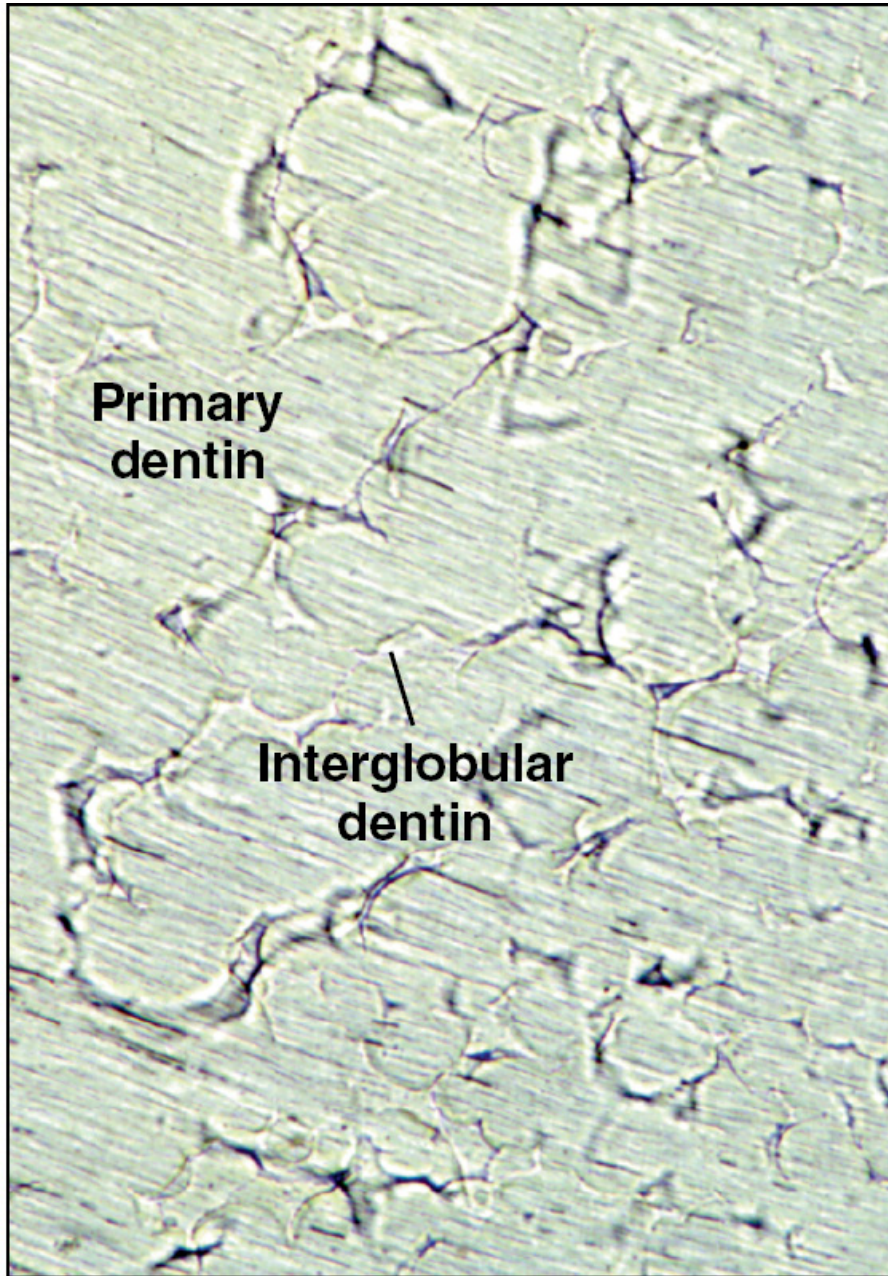
(From Avery JK: Oral development and histology, ed 3, Stuttgart, 2002, Thieme)

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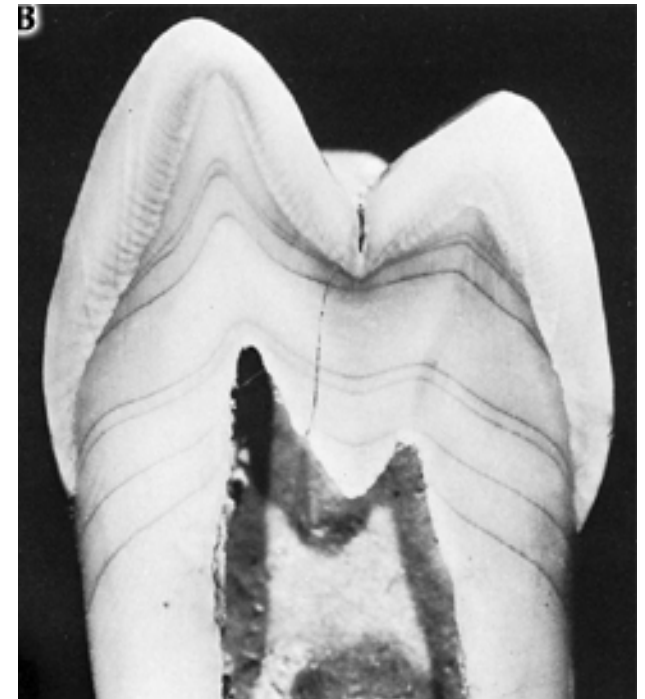
Interglobular dentin

- Areas of undermineralized or hypomineralized dentin – defect in mineralization
- Primary teeth
- Just below the mantle dentin in the circumpulpal area
- Especially prevalent in patients with Vitamin D deficiency or exposed to high levels of fluoride at the time of dentin formation
- No defect in matrix formation. So the architecture of tubules is normal as they run uninterrupted through the interglobular areas.
- However, there is lack of peritubular dentin



Incremental growth lines

- **Organic matrix** deposited as a rate of $4\mu\text{m}$ per day
- Changes in the orientation from day to day
- At the 5th day there is more exaggerated change in orientation (Lines of von Ebner) - $\sim 20\mu\text{m}$ apart.
- At right angle to tubules and generally mark the rhythmic, linear pattern of dentin deposition in an inward and rootward direction
- **Rate of mineralization** is $2\mu\text{m}$ every 12 hours. So the organic matrix of dentin is deposited rhythmically at a daily rate of about $4\mu\text{m/day}$ and is mineralized in a 12-hour cycle



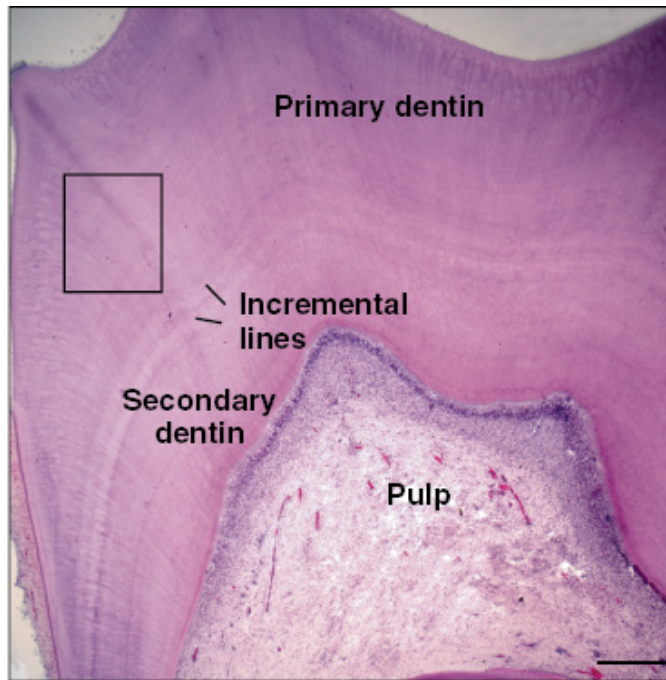
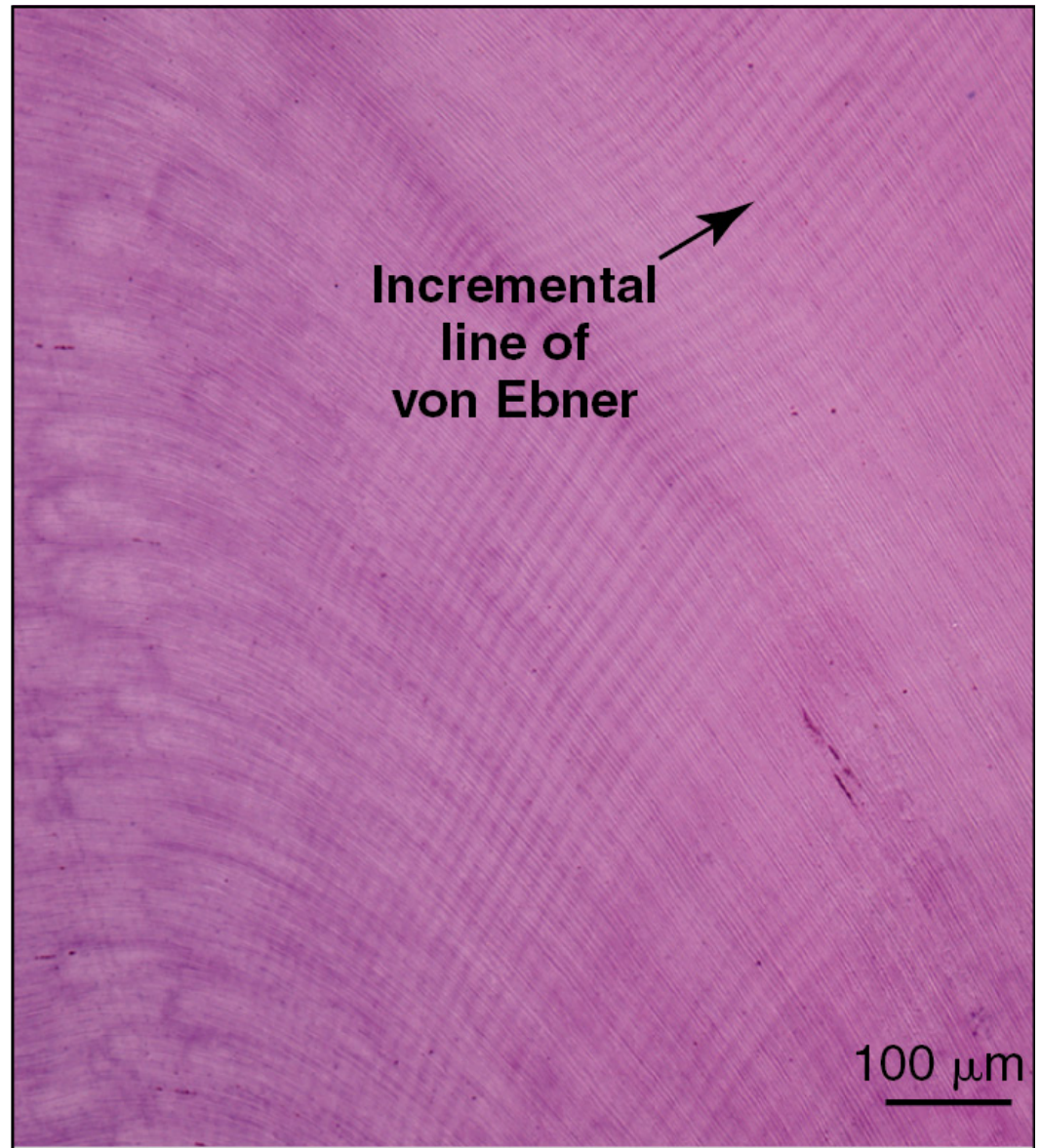


FIGURE 8-36A **A**, Histological section showing fine incremental deposition von Ebner lines in dentin. **B** is a higher magnification of the boxed area in **A**. **C**, Tooth section of a person who received tetracycline intermittently. The drug has been incorporated at successive dentin-forming fronts, mimicking incremental line patterns.

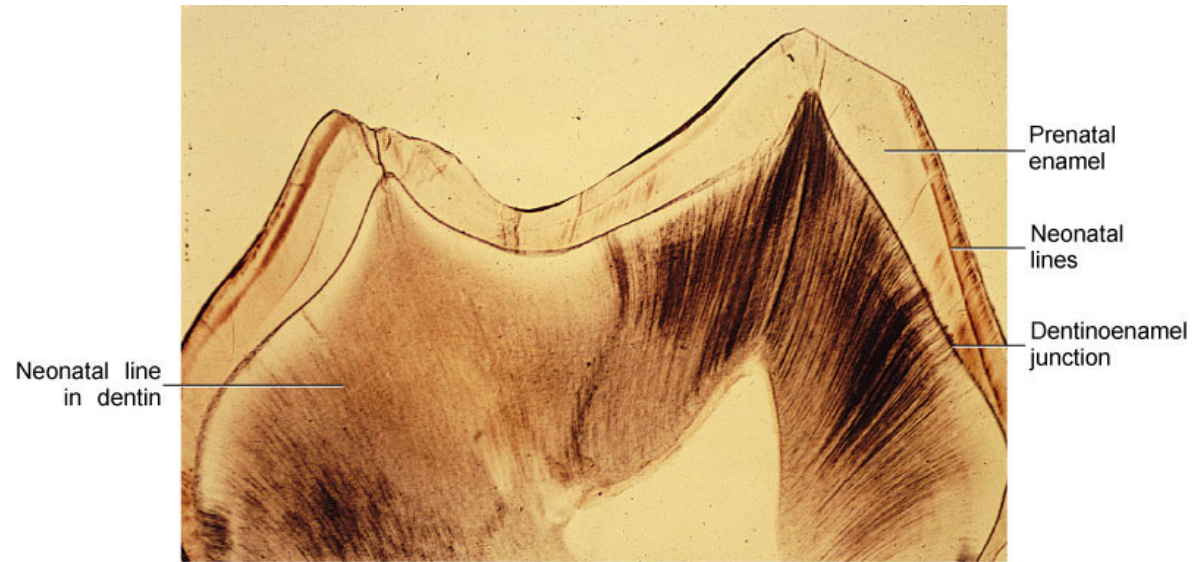
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Contour lines of Owen (Another type of incremental pattern)

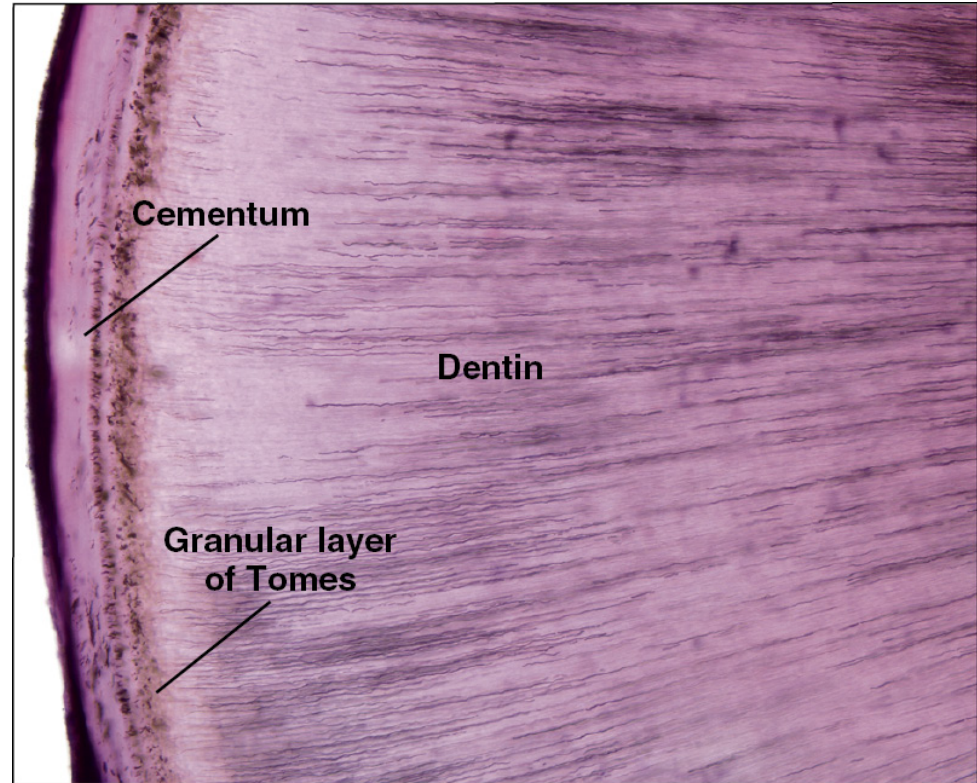
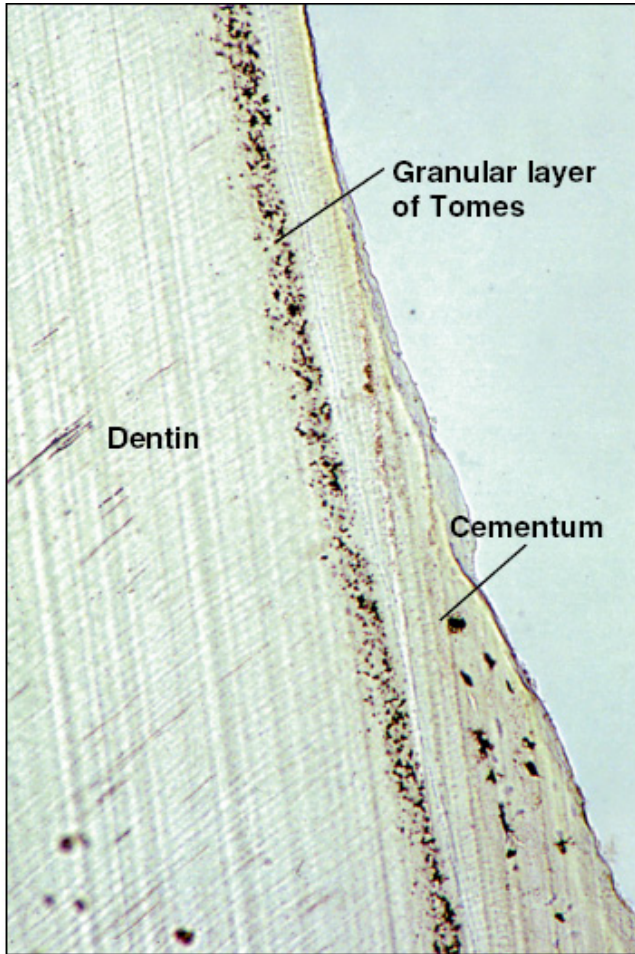
- They characterize areas of deficient mineralization due to trauma
- **Original description by Owen: Lines occurring from the secondary curvature of dentinal tubules**
- Neonatal line: defines the disturbance of mineralization during birth



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Granular layer of Tomes

- Root
- Ground sections
- Progressive increase from the CE junction to the apex of the tooth
- ? Hypomineralization of interglobular dentin
 - Initial theory
- Sections made through loops of dentinal tubules and an optical phenomenon
- Special arrangement of collagen and non-collagen matrix proteins at the interface between dentin and cementum



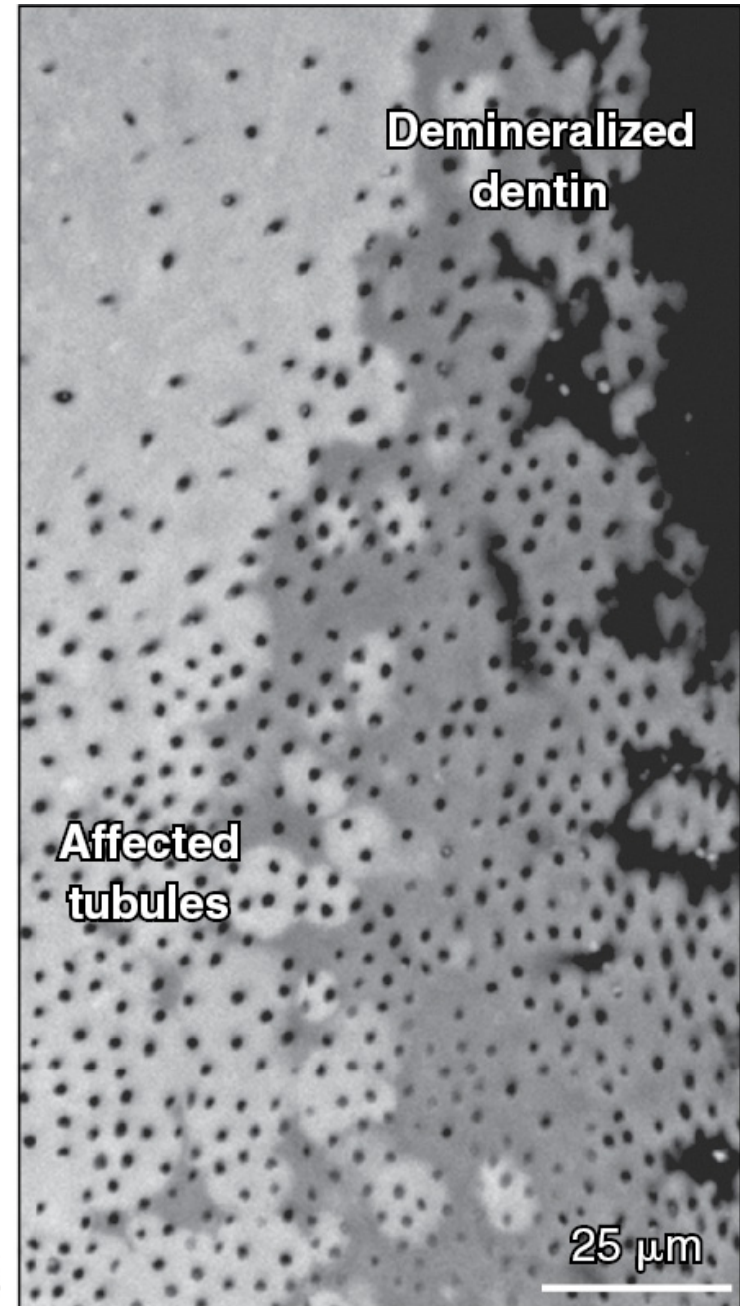
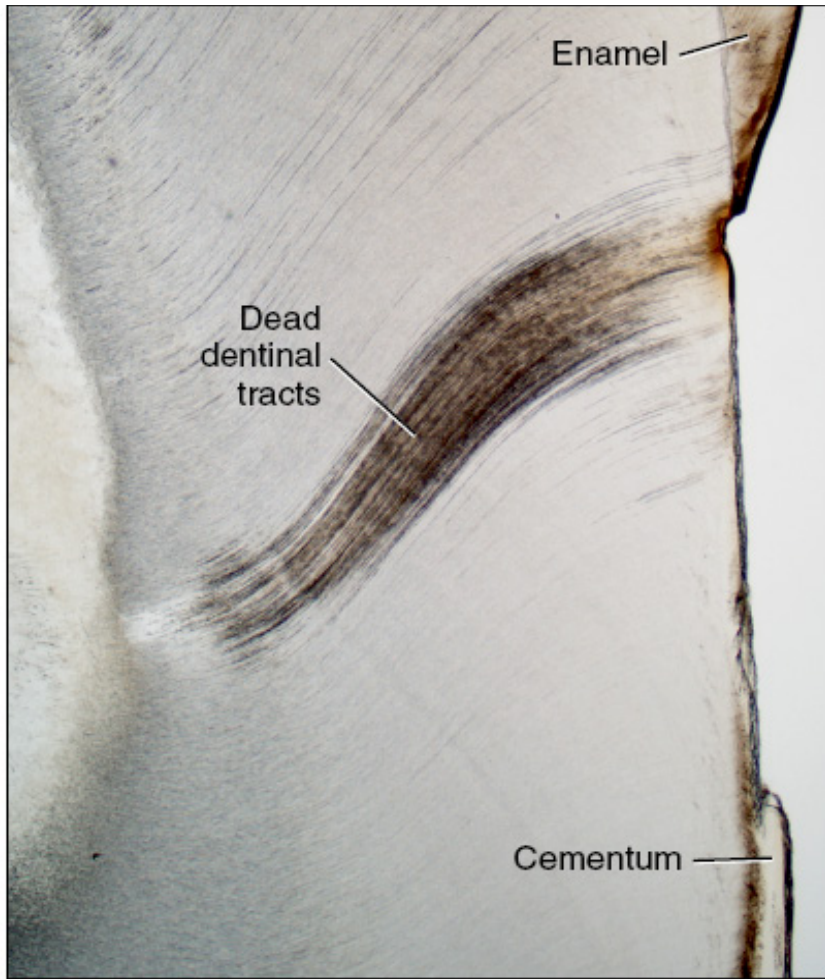
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FIGURE 8-38 Longitudinal ground section of the granular layer of Tomes.

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Age changes

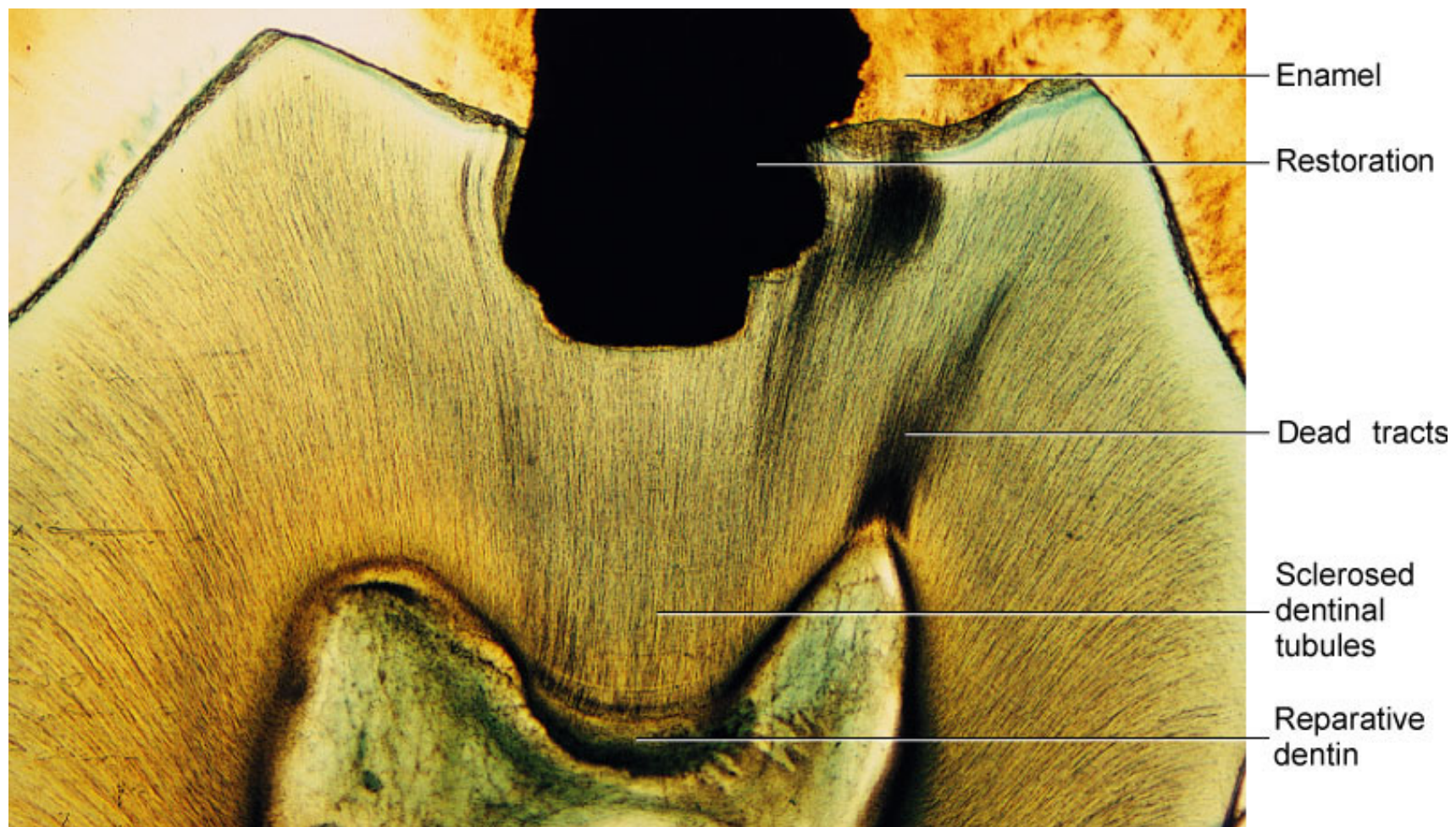
- Dentinal tubule complete closure → Sclerotic dentin
- Dead tracts of dentin
 - Retracted processes from tubules e.g. caries
 - Empty tubules with entrapped air in ground sections
 - Coronal dentin
 - Filled with reparative dentin



A

FIGURE 8-30A A, Light micrograph showing dead tracts on the radicular carious lesion which appear dark under transmitted light. **B**, Scanning electron micrograph showing empty tubules under a carious lesion.

B



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Hereditary Abnormalities of Dentin

- Dentinogenesis imperfecta
- Dentin dysplasia
- Vitamin D resistant rickets

Osteogenesis/Dentinogenesis Imperfecta



Hereditary Opalescent Dentin



Dentin Dysplasia Type II



Dentin Dysplasia Type II



Vitamin D-resistant Rickets

