DENTIN

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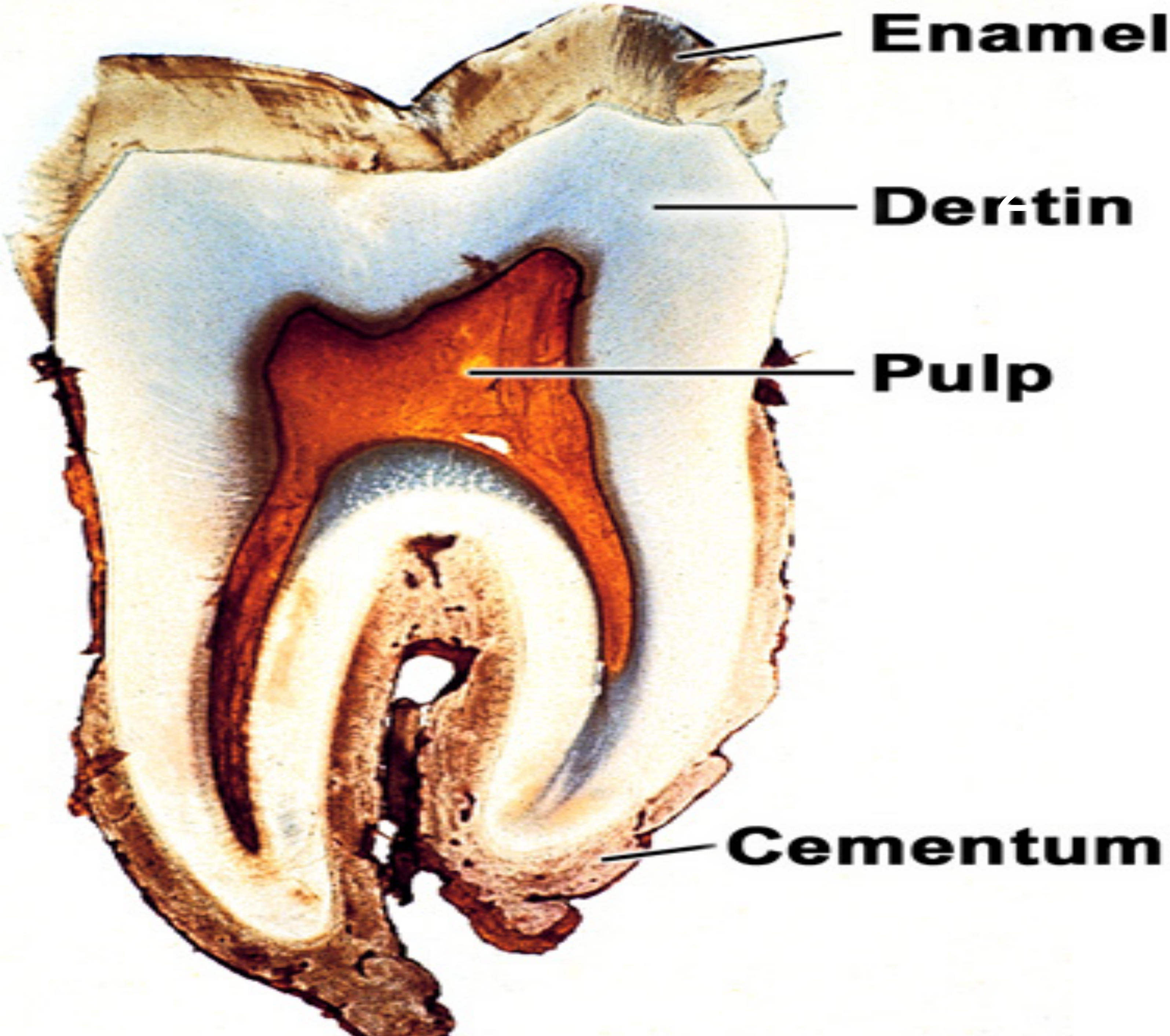
PROF. & HEAD,
IDS, BLY

DENTIN



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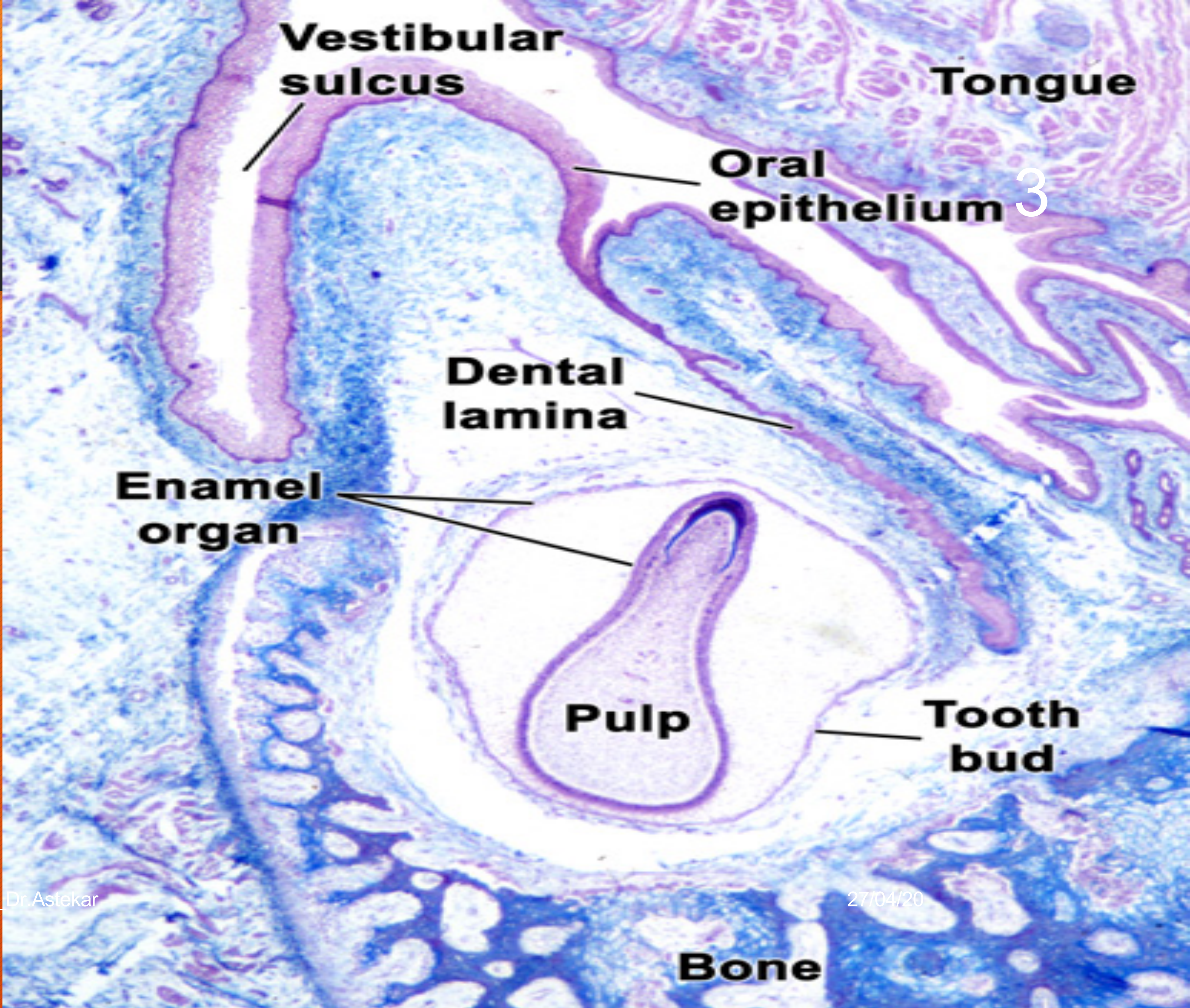
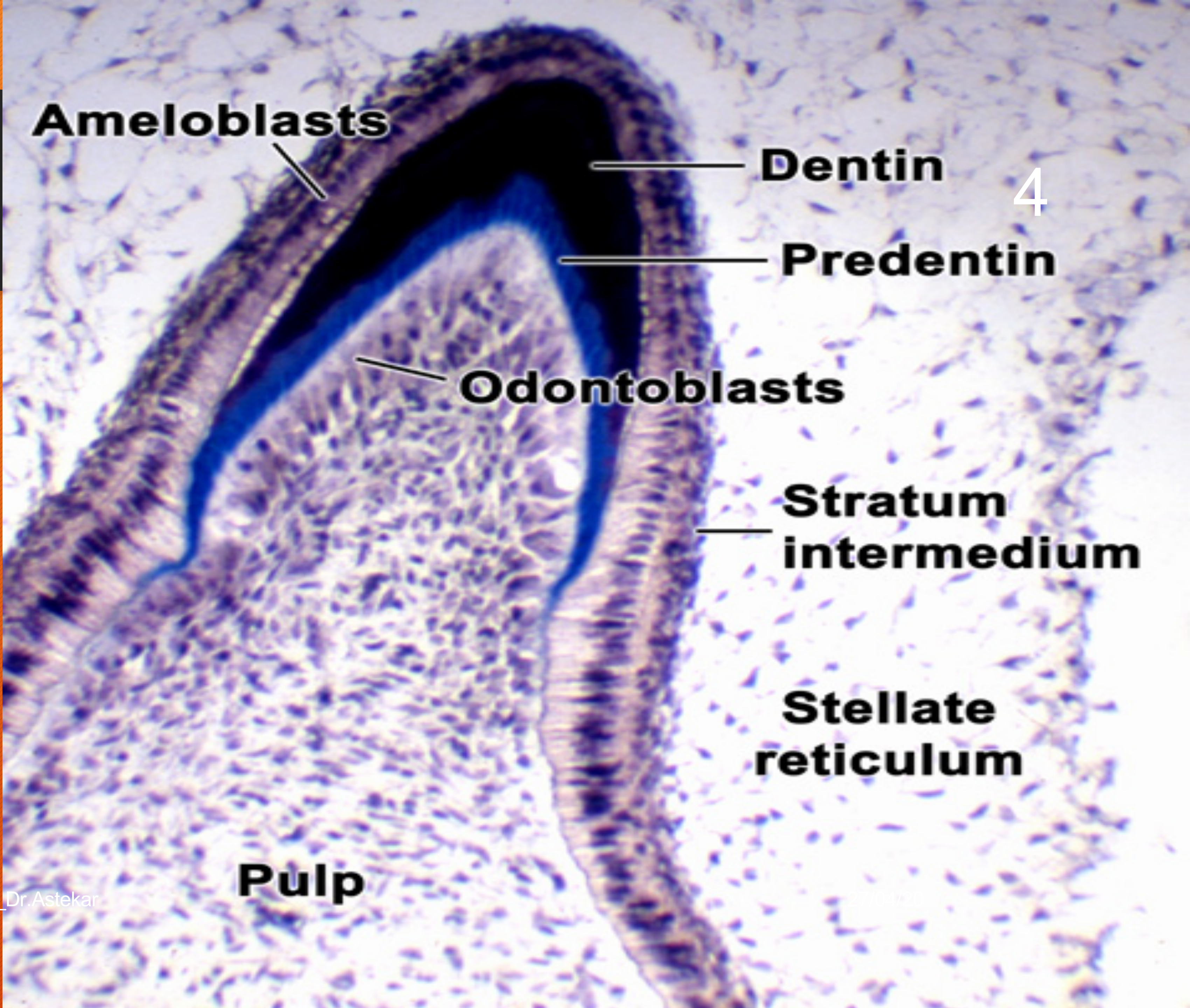

Vestibular sulcus
Tongue
Oral epithelium
Dental lamina
Enamel organ
Pulp
Tooth bud
Bone

D E N T I N


Ameloblasts
Dentin
Predentin
Odontoblasts
Stratum intermedium
Stellate reticulum
Pulp

Introduction

DENTIN

- Hard tissue – body of each tooth
- Protective covering & support
- Vital tissue
- Odontoblasts – matrix & sensory
- Colour
- Bone – contains trapped cells & blood vessels
- Dentin – not continuously remodeled – limited capacity for repair

Composition

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D E N T I N

BY WEIGHT

- Mineral – 70%
- Organic matrix – 20%
- Water – 10%

BY VOLUME

Mineral – 50%

Organic matrix – 30%

Water – 20%

- Does not have uniform composition through out the tooth – due to anatomic location, degree of dental sclerosis or both.

- Resiliency – high organic content & fluid within the dentinal tubules acts as "hydraulic shock absorbers" there by dissipation the forces of mastication.

Table. 10.3 Organic components in dentin and their possible functions

Component	Comments	Function
Collagen	Major organic component (91–92%). Type I predominates with minor amounts of type V; Type III found in the pulp and during early dentinal matrix formation.	May play a role in initiating mineralization. Provides the structural framework for dentin, giving it strength and resilience.
Phosphoproteins	Major noncollagenous proteins; deposited at the mineralization front; not found in predentin. Dentin sialoprotein and dentin phosphoprotein have recently been found to be cleavage products of a larger protein.	May play an important role in mineralization.
Proteoglycans	Dermatan, chondroitin, and keratin sulfates; decorin and biglycan are present.	Some inhibit mineralization and others bind calcium nonspecifically. Presence may thus control the mineralization process. Those that associate with collagen may control fibrillogenesis.
γ-carboxyglutamate-containing proteins, Matrix Gla and bone Gla (osteocalcin) proteins	Carboxylation reaction is vitamin K dependent.	Role in mineralized tissues is uncertain but they can bind calcium suggesting that they may initiate or control the mineralization process in some way by regulating local calcium levels.
Acidic glycoproteins	Osteopontin, 65 and 90 kDa glycoproteins.	Osteopontin may be associated with the odontoblastic process serving as a link between matrix and cell membrane. Roles of other proteins are unknown.
Growth factors	Transforming growth factor β, cartilage-inducing factors, insulin-like growth factors, and platelet-derived growth factors.	May control the proliferation and differentiation of new odontoblasts following injury or a pathologic process. Stimulate repair.
Lipids	No unique lipids are found in dentin.	Phospholipids may be involved in initiation of mineralization.

Inorganic matrix

D E N T I N

- Hydroxyapatite is the principal inorganic component
- Trace amount of calcium carbonate, fluoride, magnesium, zinc, and other minerals
- Ca:Po4 = 1:2.14 (peritubular), 1:2.10 (intertubular) and 1:2.13 (average)
- Knoop hardness number
  - Enamel – 343
  - Dentin – 68
  - Sclerotic dentin – 80
  - Carious dentin - 25

Mineralisation pattern:
1. Matrics Vesicles

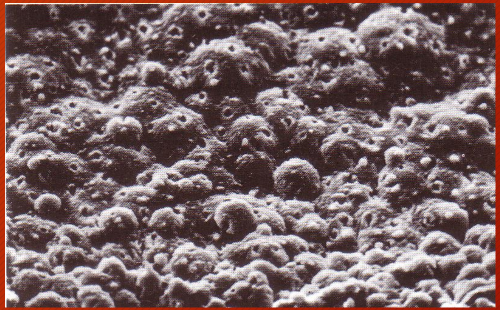
DENTIN

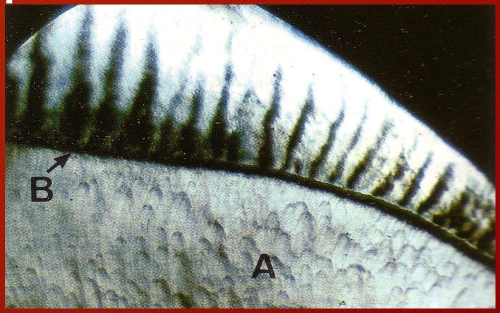
- Matrics vesicles bud off from the odontoblast process with in the dentin
- Collagen fibers is seen within the predentin
- Arrow: The frist crystallites are formed within the M vesicle, later the walls are lost and more crystals develop around the original ones.
- Matrics vesicles are seen at the onset of the mineralisation, none are seen in the later stages.

Mineralisation pattern:
2. Calcospherite

DENTIN

- Surface is irregular due to presence of numerous calcospherites.
- They form around, as well as b/w the odontoblastic process.
- Under polarised microscopy appears as spherical junctional regions outlining the original positions of calcospherites.
- Variations in both crystal and collagen fiber orientation produce this appearance.





Globular mineralization

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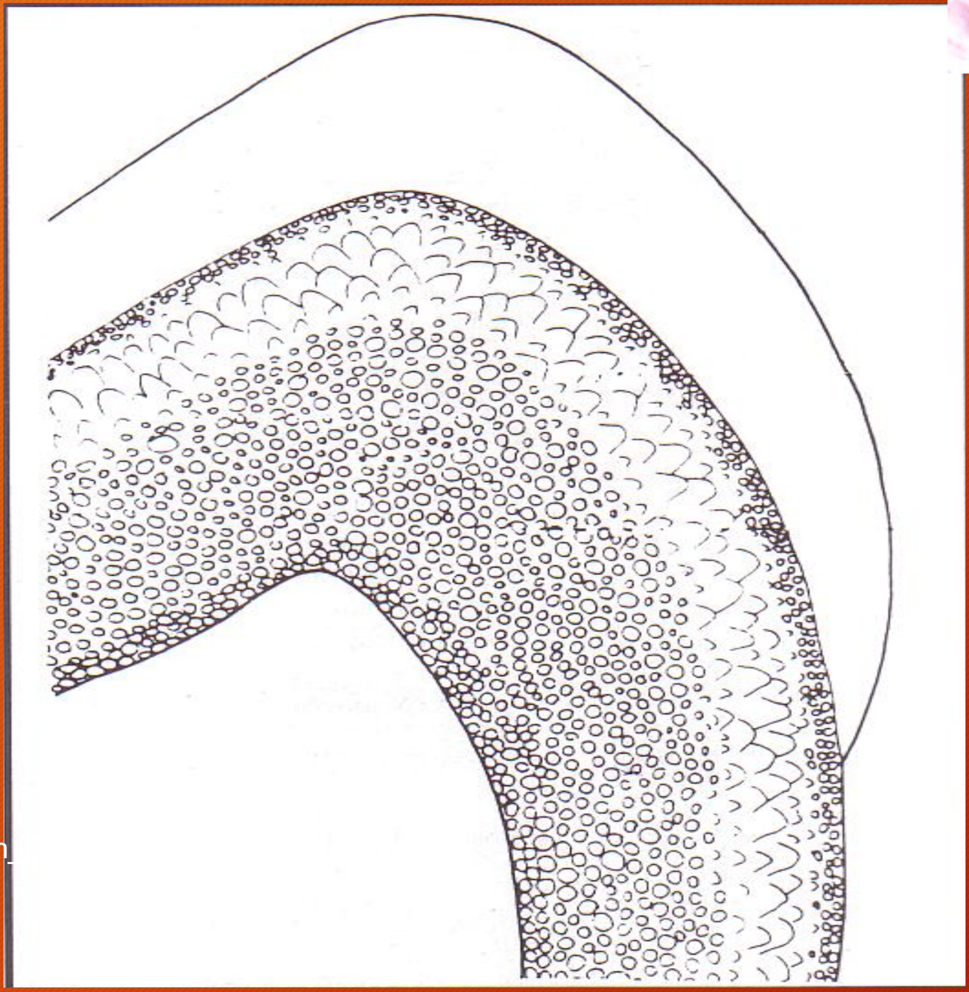

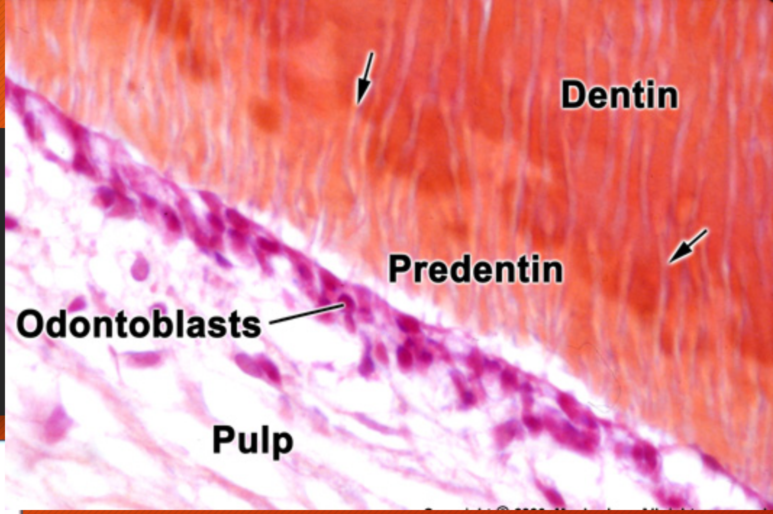

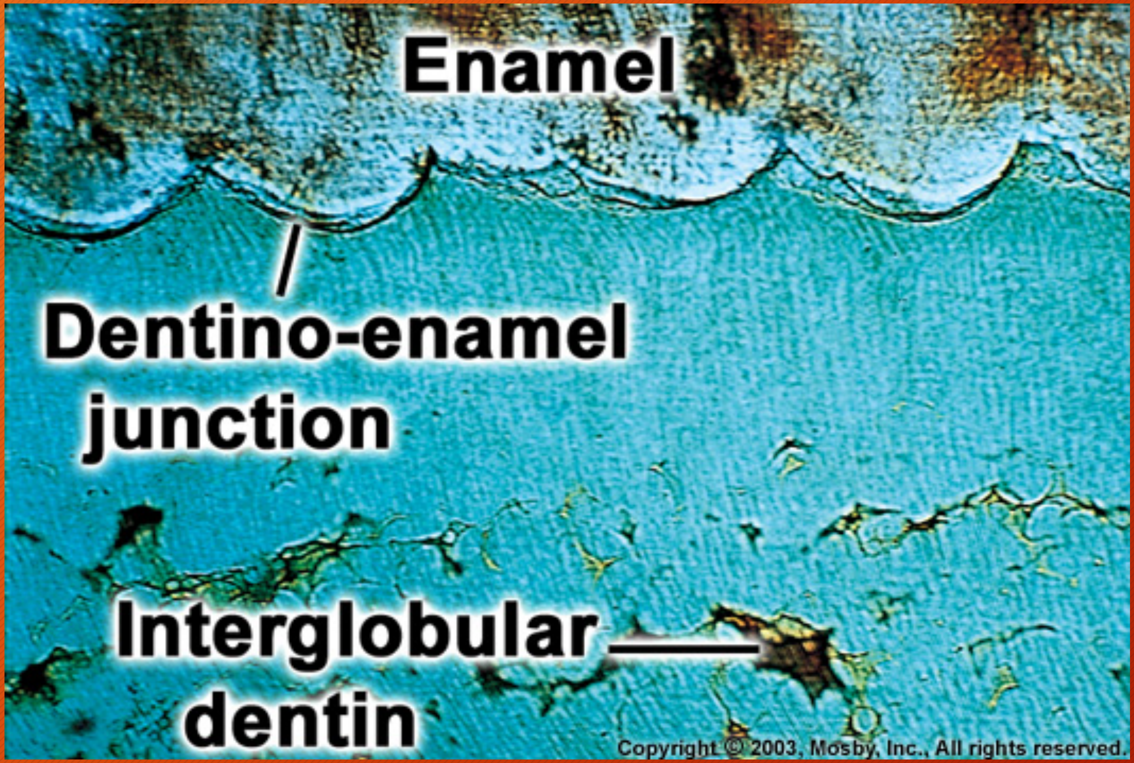
Enamel
Dentino-enamel junction
Interglobular dentin
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Dentinal structure

- Orthodentin – true dentin with out cells, contains tubules and organized by odontoblasts.
- Odontoblastic process are tapered and branched more near the DEJ.
- Tubules are more numerous and closer nearer the pulp(40,000/mm2) than in the outer mantle dentin(20,000/mm2).
- Prominent feature is dentinal tubules having “S” shape with two curvature extending from DEJ towards Pulp.

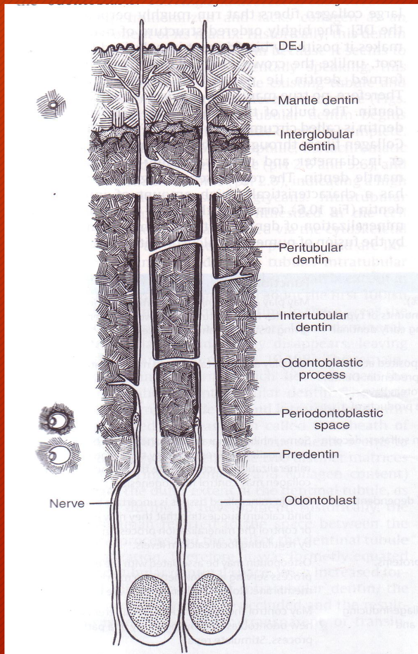


Fig. 10.3 Relationship between the odontoblastic process and dentinal tubule.

Primary curvatures

- First curve bends towards occlusal / incisal surface
- Second curve towards apex
- Becomes less pronounced in cervical region
- Rather straight in root portion
- Represent the path taken during the inward migration of the odontoblasts.

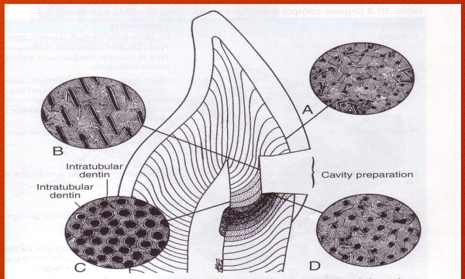
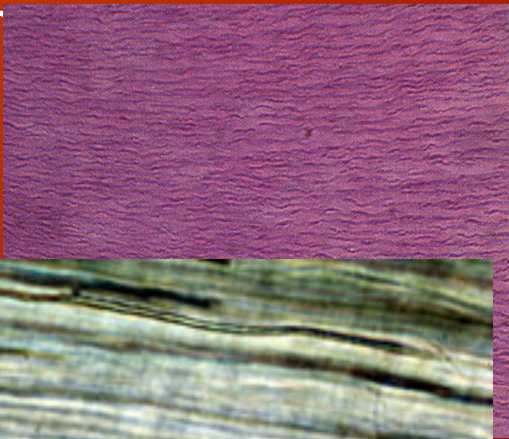


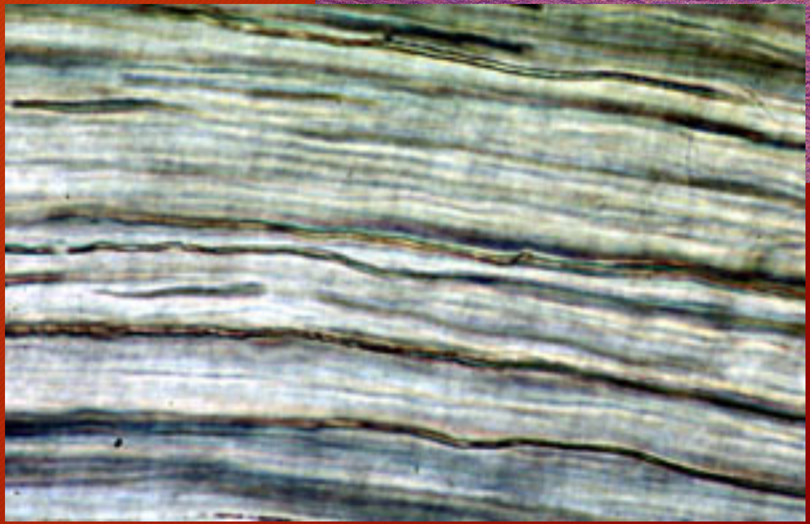
Fig. 10.5 Location and size of dentinal tubules at the DEJ **(A)** and the pulp **(C)**. Relationship between tubules in the cavity floor (**B** and **D**) and pathway of caries through dentin.

secondary curvatures

DENTIN

- May be the result of small spiraling undulations of the odontoblastic process during matrix formation and mineralization
- Smaller secondary curvatures are visible microscopically.





Classification of Dentin

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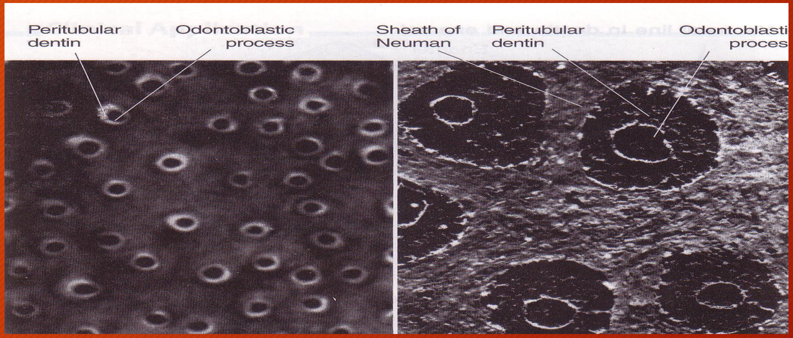
- According to location
  - Intertubular dentin: found around and between dentinal tubules
  - Intrarubular dentin: found and formed within dentinal tubules; also called peritubular dentin.
  - Mantle dentin: formed initially in the crown; outer coronal dentin
  - Circumpulpal dentin: nearest to the pulp; formed in crown after mantle dentin has been deposited.



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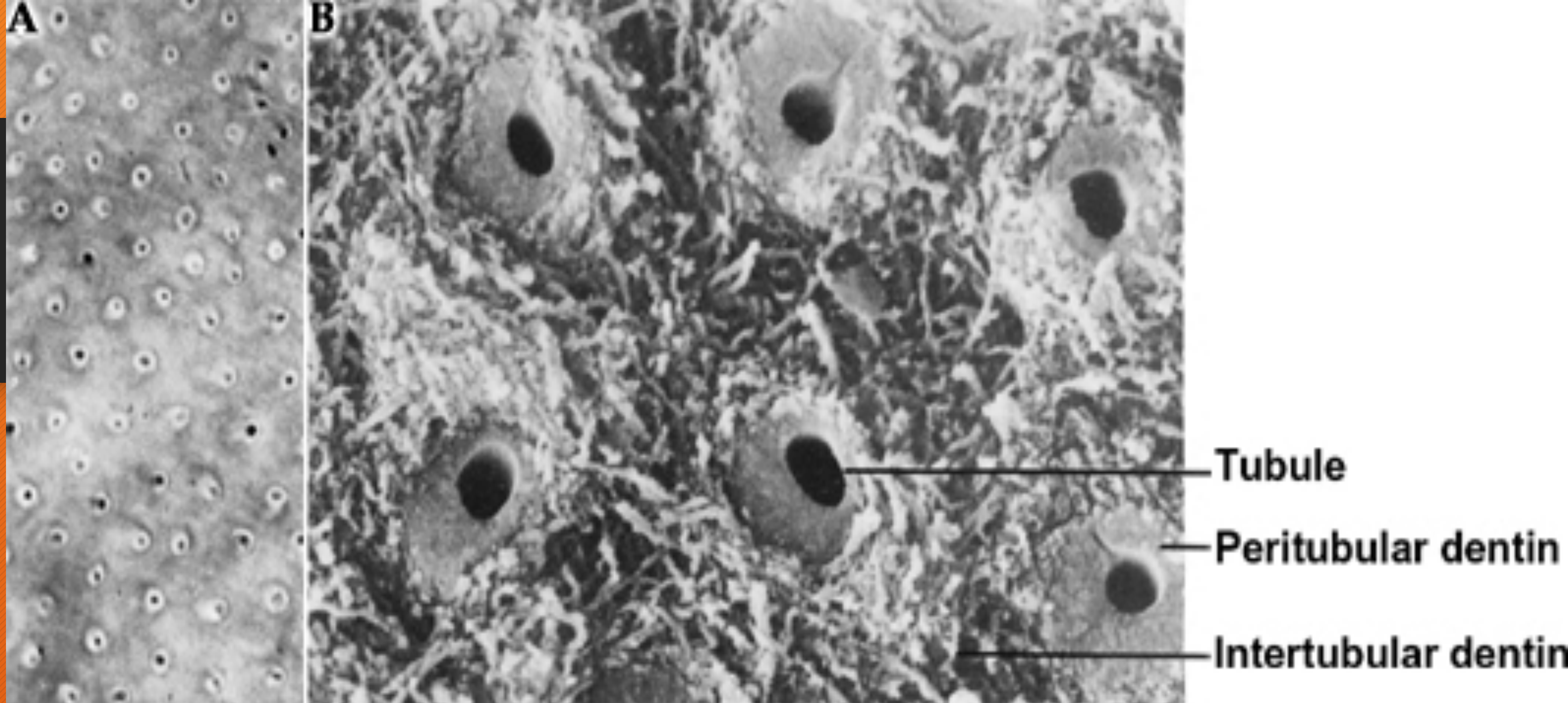
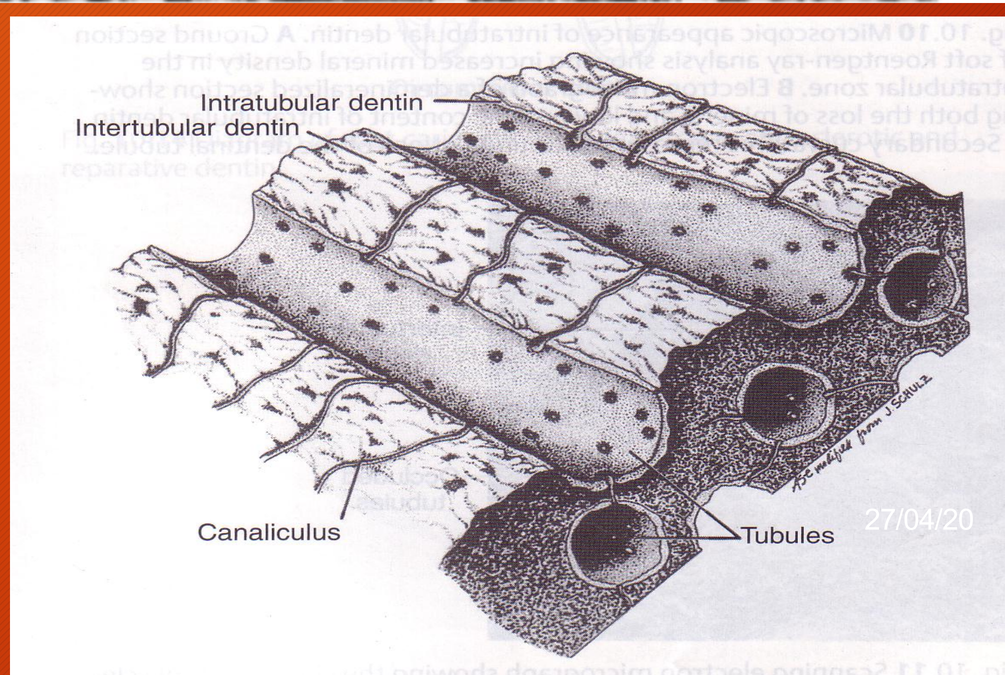

A
B
Tubule
Peritubular dentin
Intertubular dentin


Intratubular dentin
Intertubular dentin
Canaliculus
Tubules

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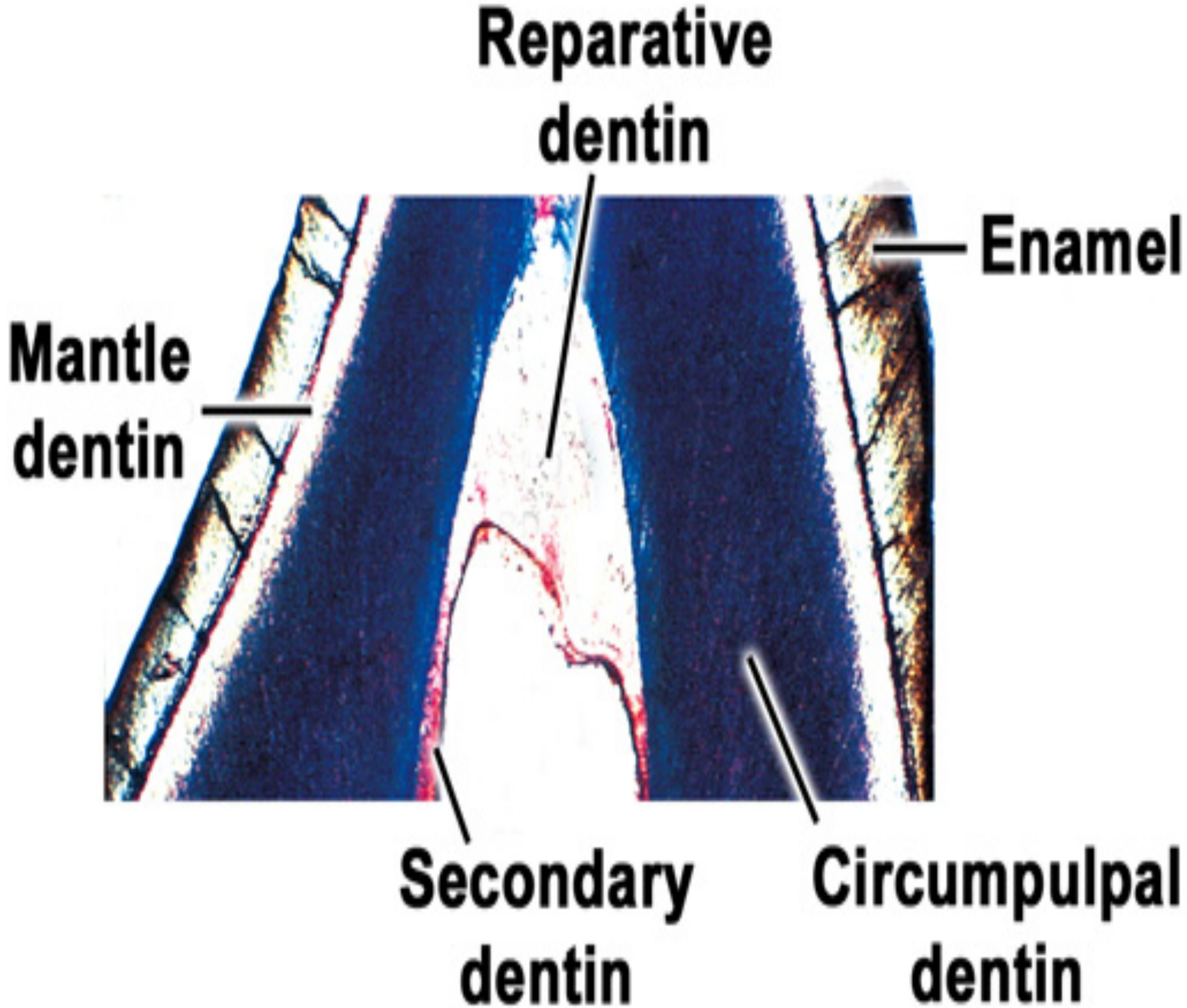
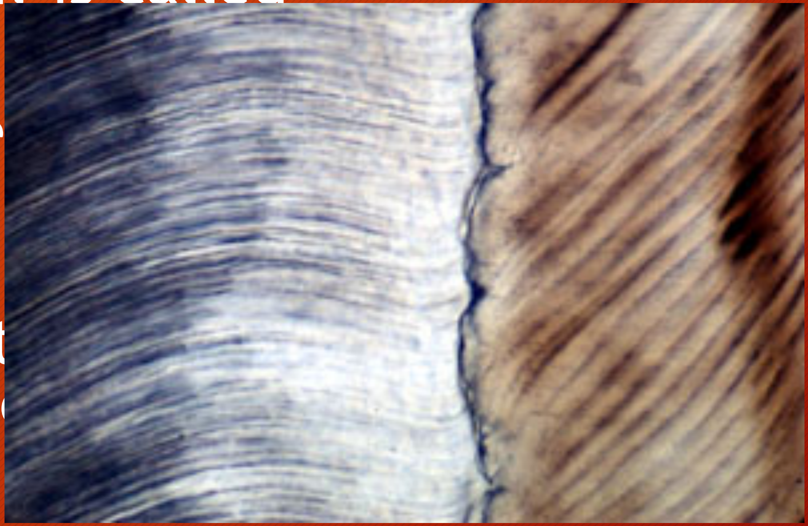

Reparative
dentin
Enamel
Mantle
dentin
Secondary
dentin
Circumpulpal
dentin

Mantle Dentin

DENTIN

- The peripheral layer of dentin, which is the first layer of dentin deposited, is called mantle dentin.
- It is located adjacent to the e crowns of teeth and adjacent cementum in the roots.
- Notice the lines of Retzius in t are oriented at an angle to th junction.
- Unstained, 100x



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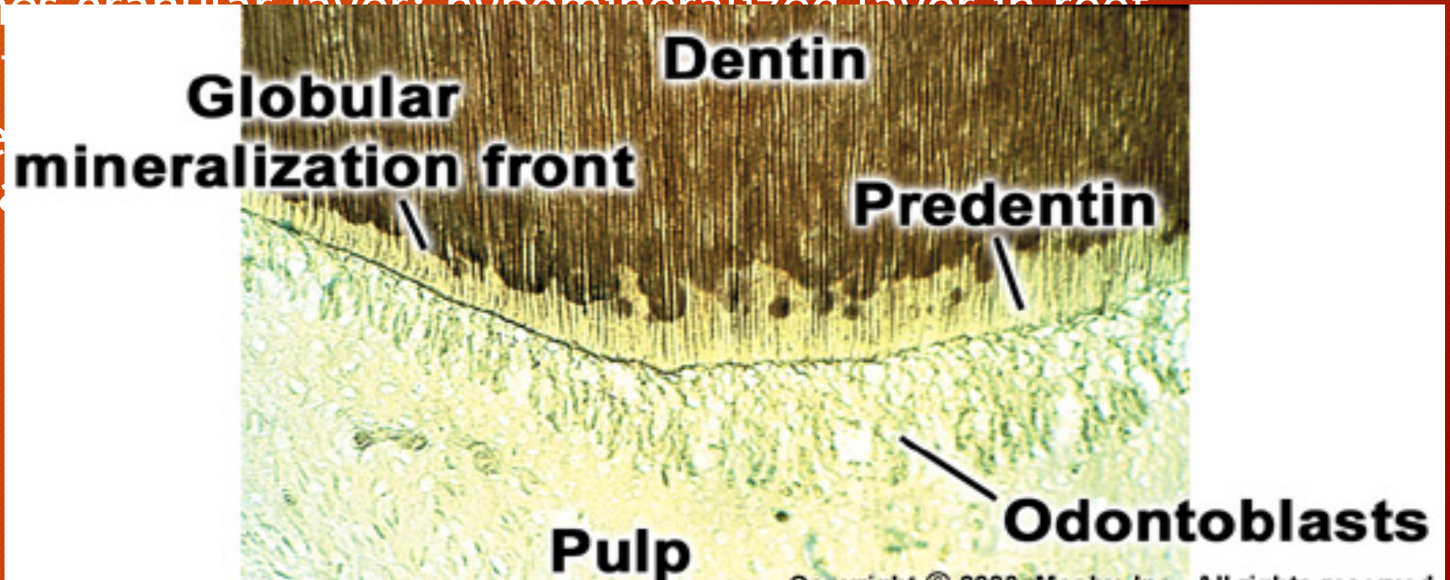
- II. According to mineralization
  - Globular dentin: formed from calcospherites
  - Interglobular dentin: hypomineralized dentin between mantle and circumpulpal dentin; normally only found in the coronal dentin.
  - Tomes granular layer: hypomineralized layer in root den
  - Scle intr



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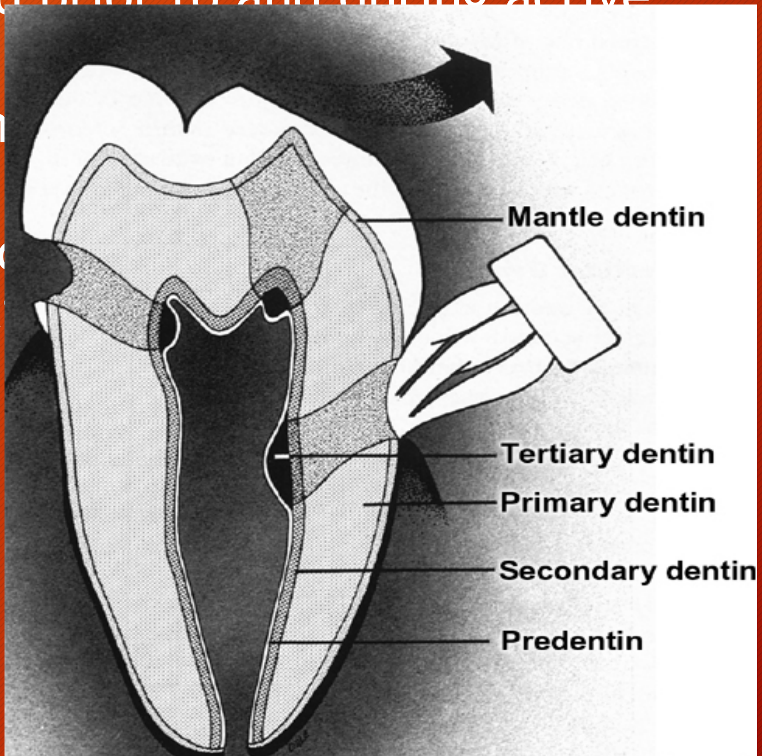
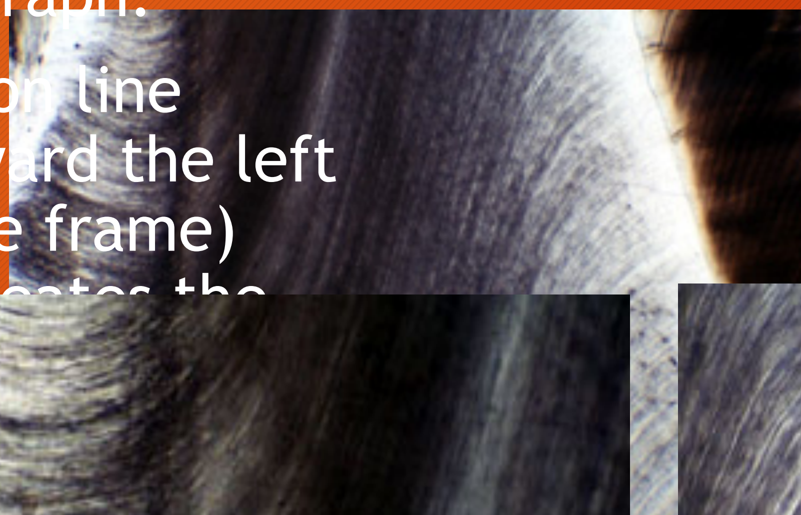
- III. According to developmental pattern
  - Primary dentin: formed prior to and during active eruption
  - Secondary dentin: form comes into occlusion
  - Tertiary dentin: formed response; may be reac

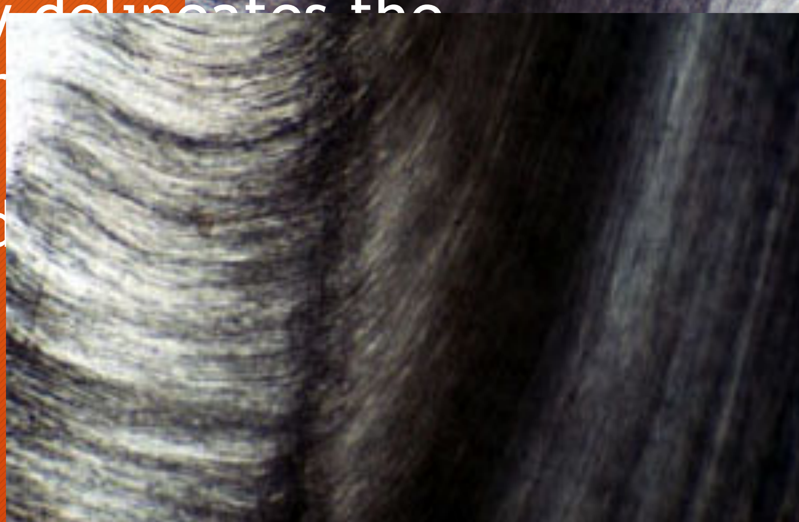


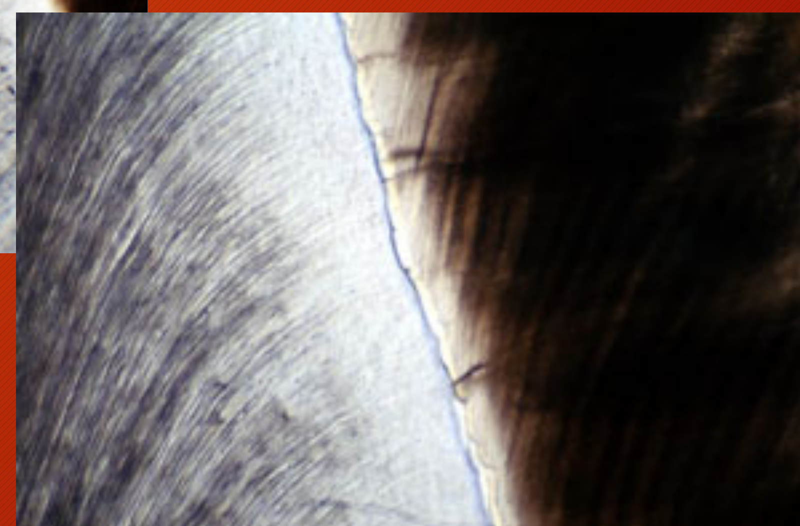
Primary & Secondary Dentin

D E N T I N

- Primary dentin occupies the major area of the photomicrograph.
- A demarcation line (located toward the left border of the frame) clearly delineates the primar… more i… second…







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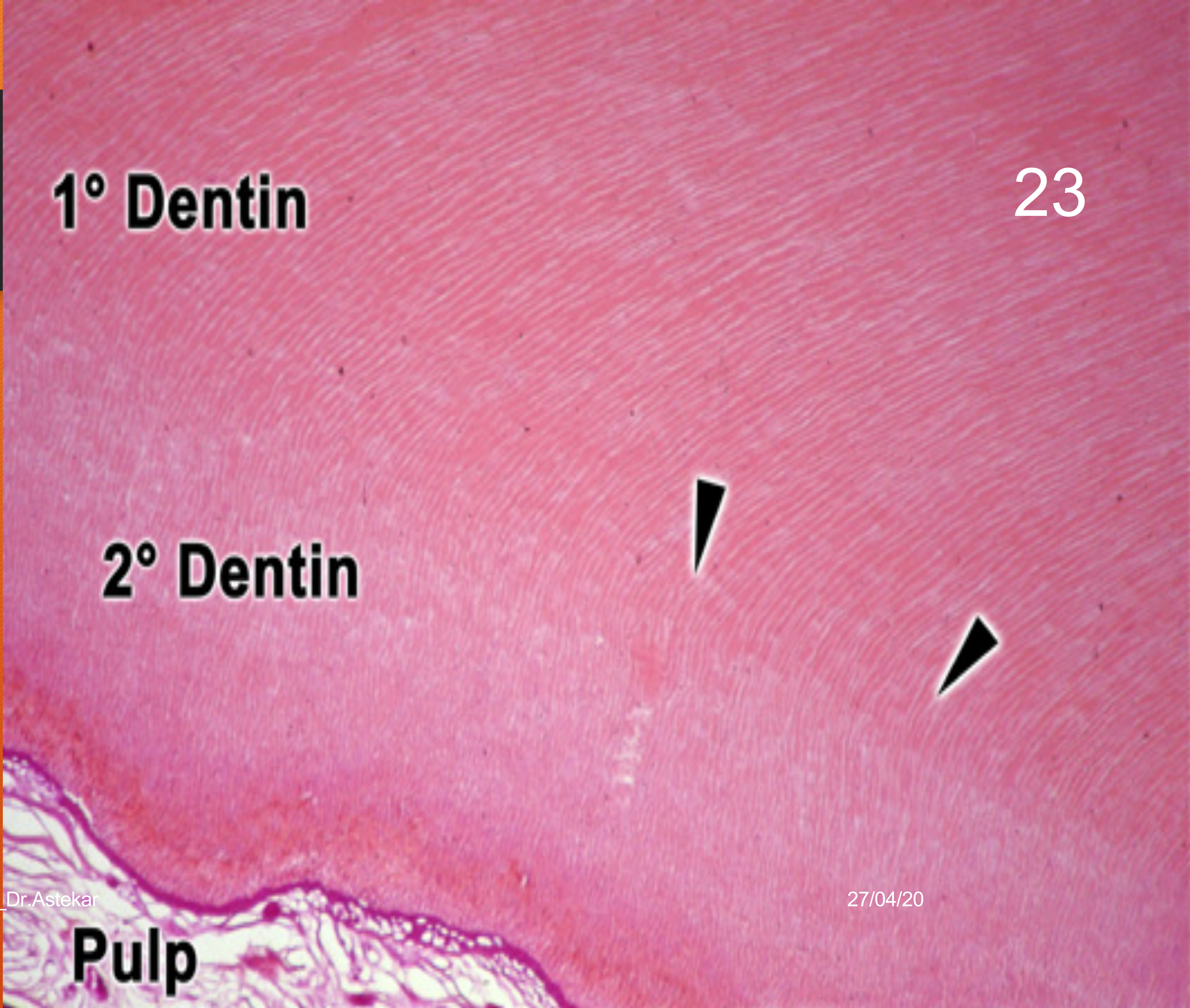

Reactionary & Reparative Dentin

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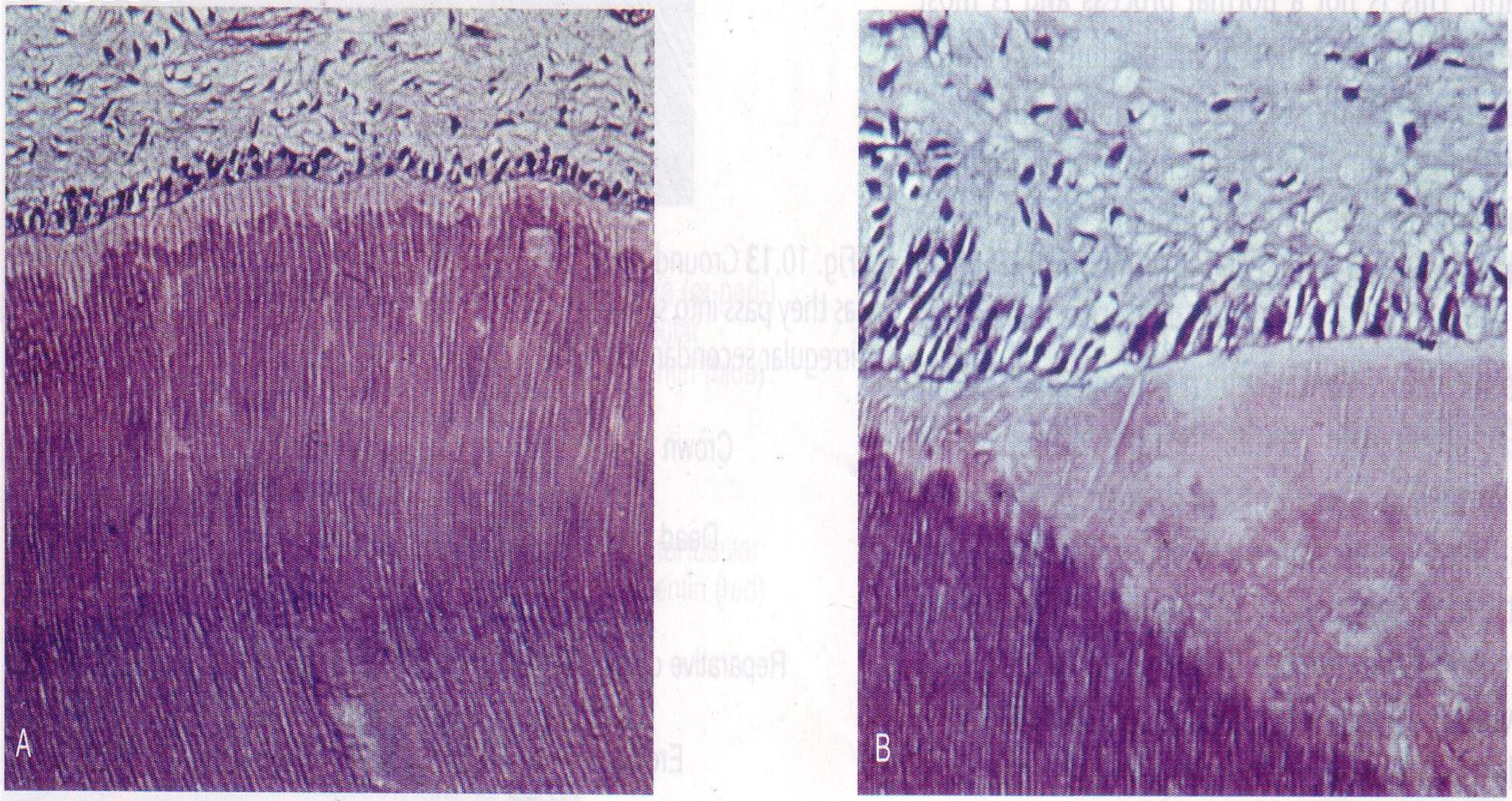

Fig. 10.**16 A** Reactionary dentin. Note a large zone of dentinal matrix deposited by surviving original postmitotic odontoblasts that had been stimulated by a relatively mild stimulus. This tubular reactionary dentinal matrix was deposited immediately beneath the area of dentin submitted to the stimulus. appears to exhibit cellular inclusions. A strong stimulus

B Reparative dentin. Note the dystrophic and atubular dentinal matrix that appears to exhibit cellular inclusions (osteodentin). Consequently, the reparative dentinal matrix was deposited by a new generation of odontoblast–like cells which have differentiated from precursor cells as a mechanism for tissue repair.

Reactionary & Reparative Dentin

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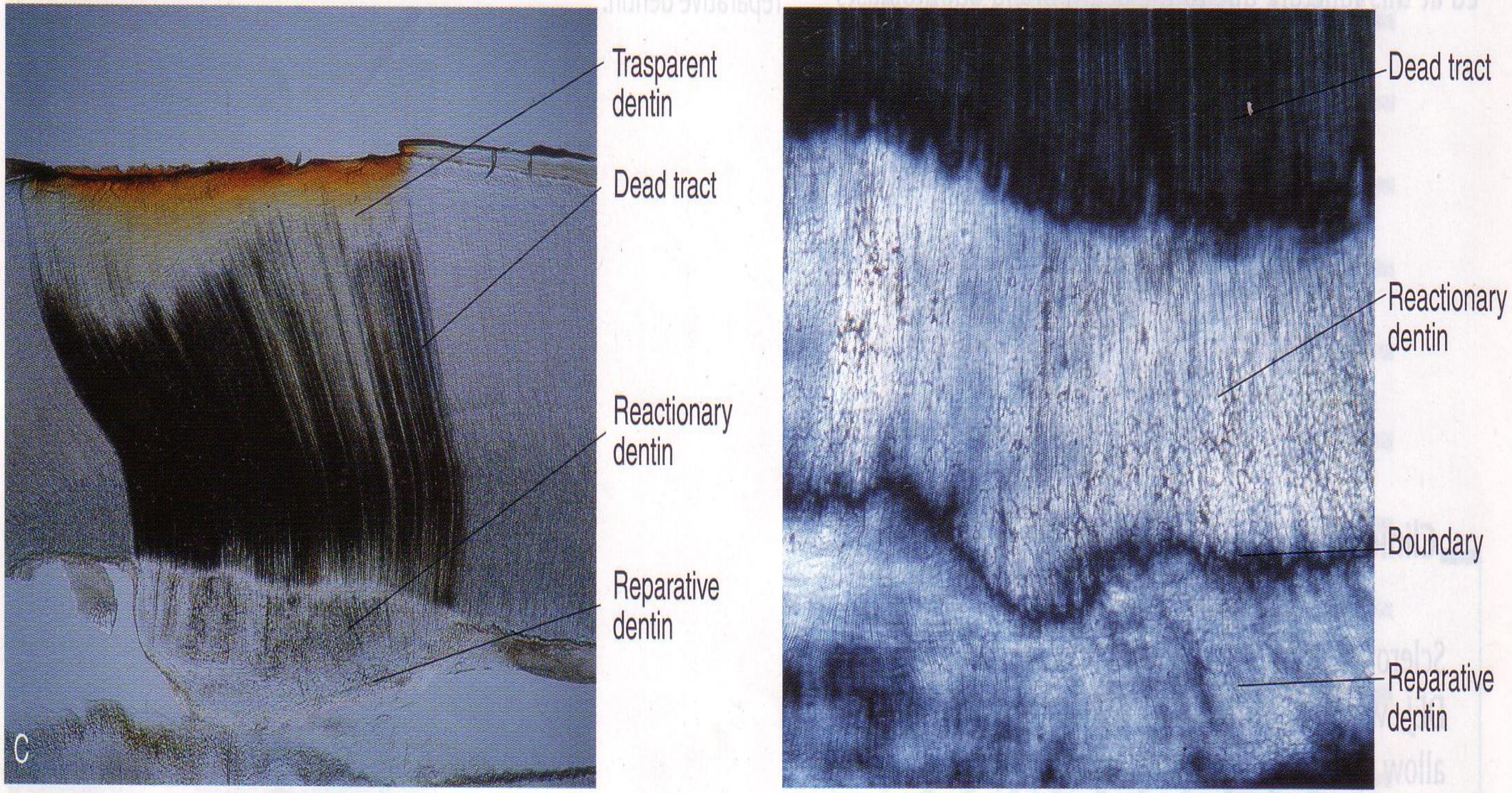
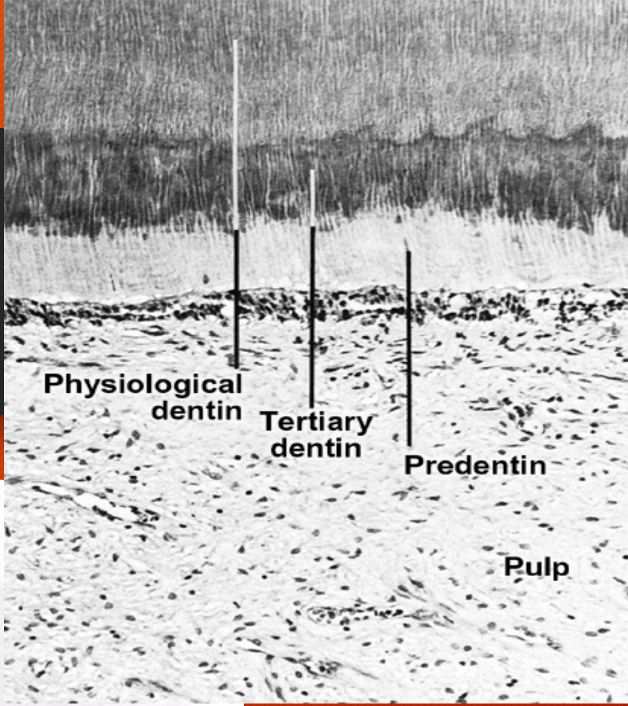


C Ground section showing cervical caries. Note the transparent dentin underlying the dead tract. Inset area showing reactionary dentin with sparse tubules overlying atubular reactionary dentin by polarized microscopy. Note the dark border between reactionary and reparative dentin.

Calciotraumatic line

D E N T I N



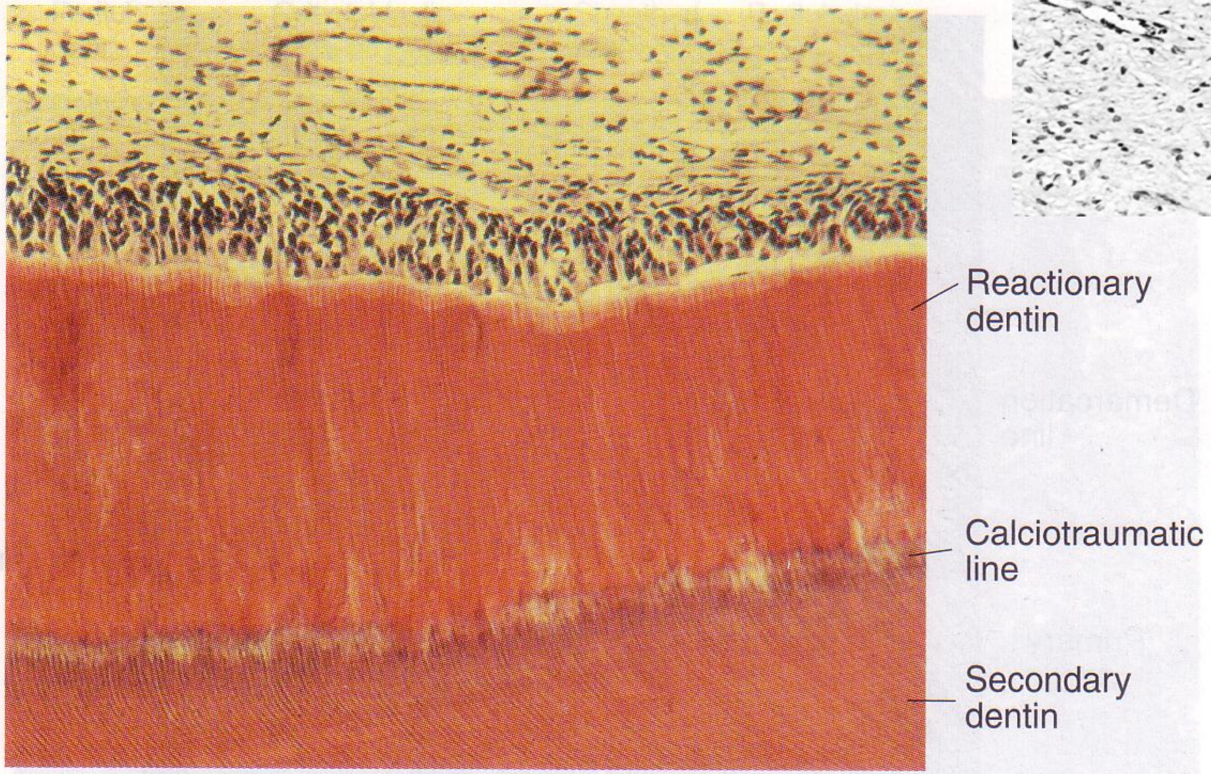


Fig. 10.15 Reparative dentin. Odontoblasts can be seen underlying a thick layer of reactionary dentin. Between the reactionary and secondary dentin there is a pronounced calciotraumatic line.

Reparative Dentin

- Reparative dentin is produced in response to irritation.
- It is a variation of dentin in which the dentinal tubules are more irregular and fewer in number than in primary or secondary dentin.
- Unstained, 40x

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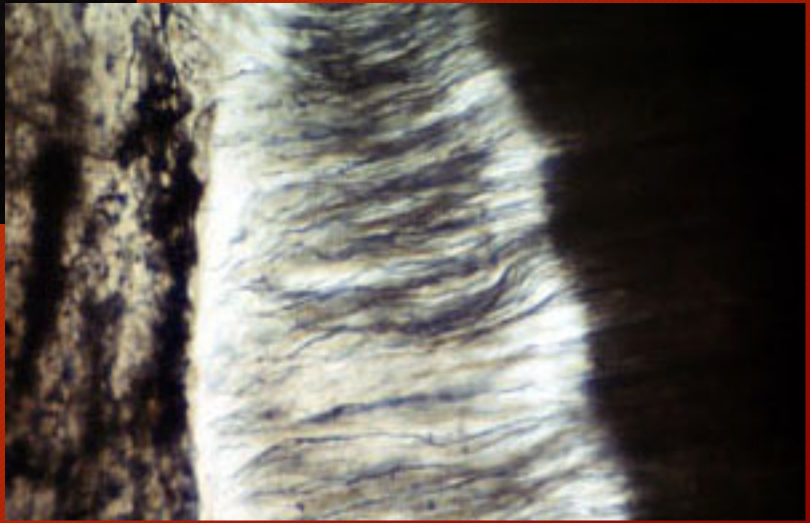

Reparative Dentin at Cusp Tip

- Another view of irregular dentin, this time at a cusp tip. Unstained, 40x

- (Higher magnification) Unstained, 100x

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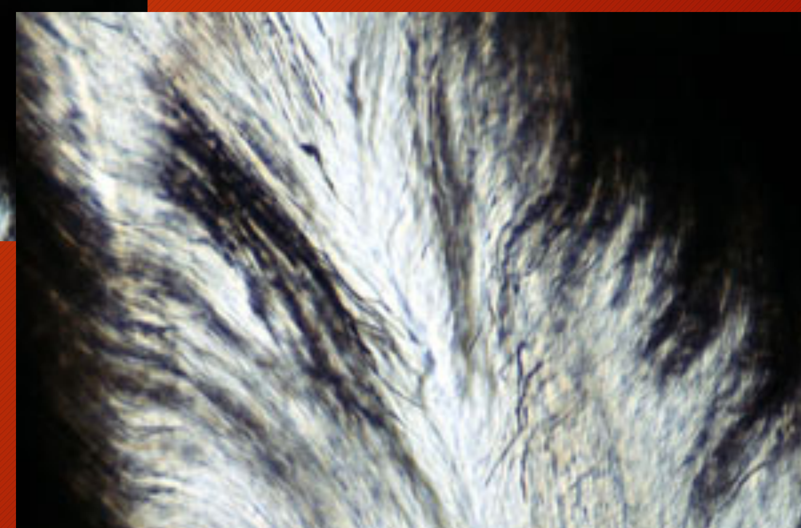
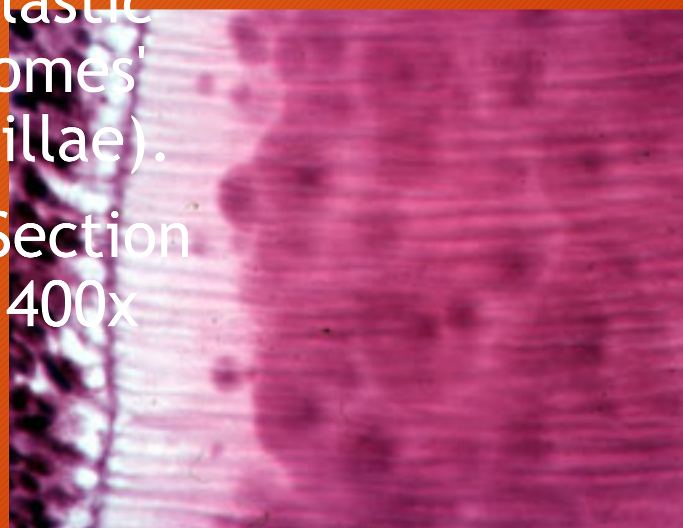
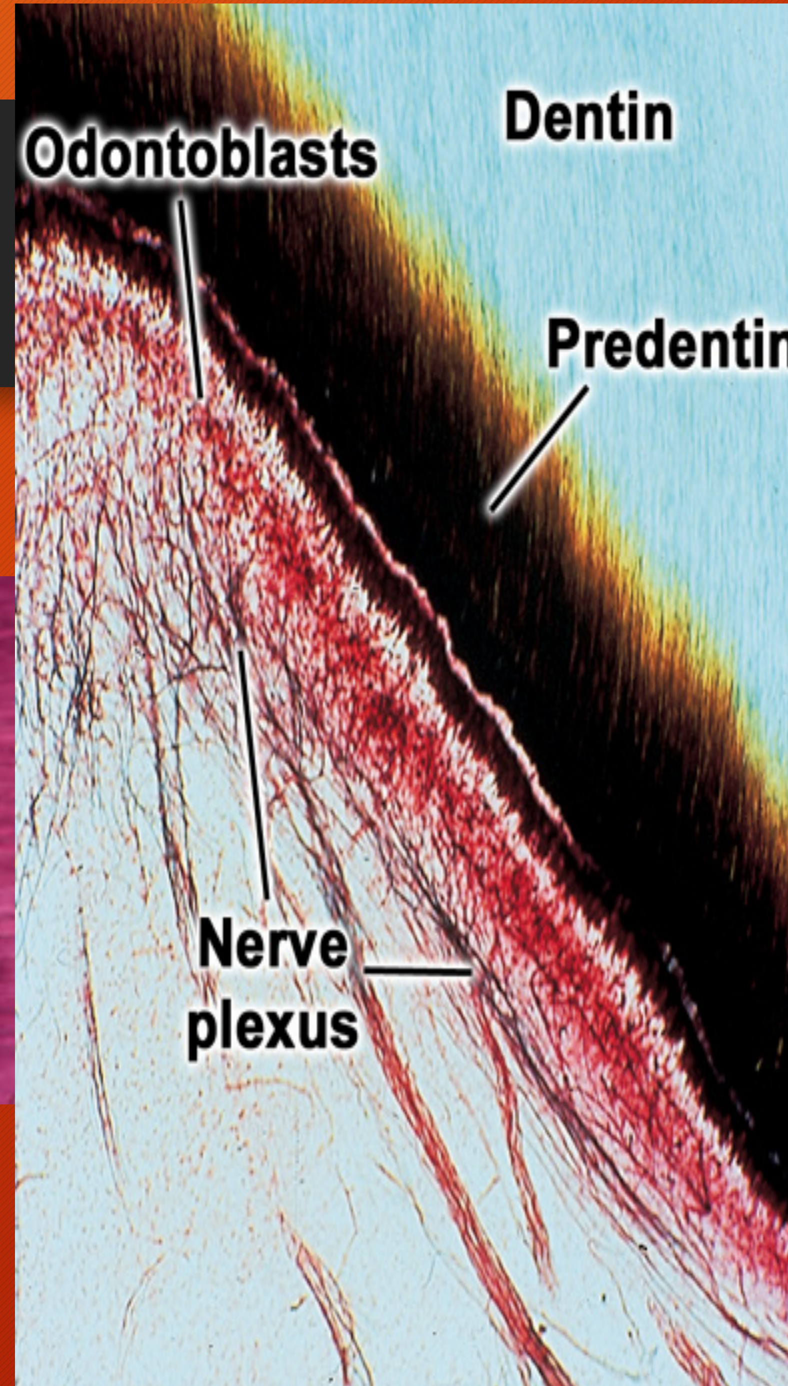


Predentin

- Identify dentin, predentin, odontoblasts and odontoblastic processes (Tomes' dentinal fibrillae).
- Decalcified Section Silver Stain, 400x

DENTIN





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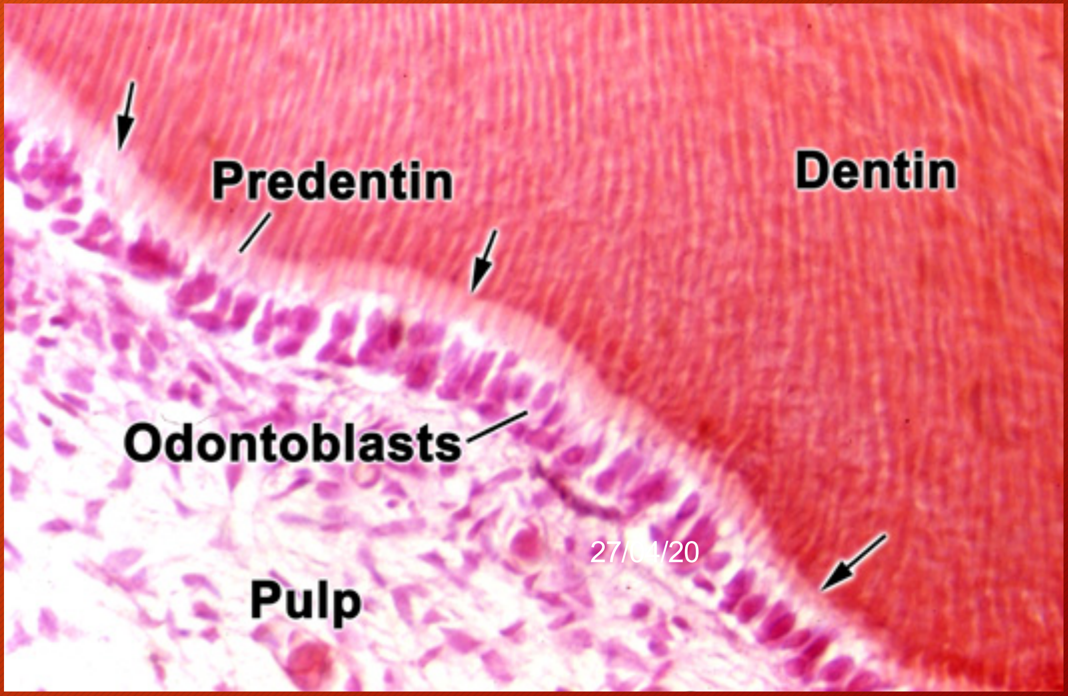

Lateral canaliculi of tubules

- The dentinal tubules have lateral canaliculi which anastomose with those from adjacent tubules. The odontoblastic processes have lateral processes which extend into the canaliculi. Silver Stain, 40x, 200x and 400x.

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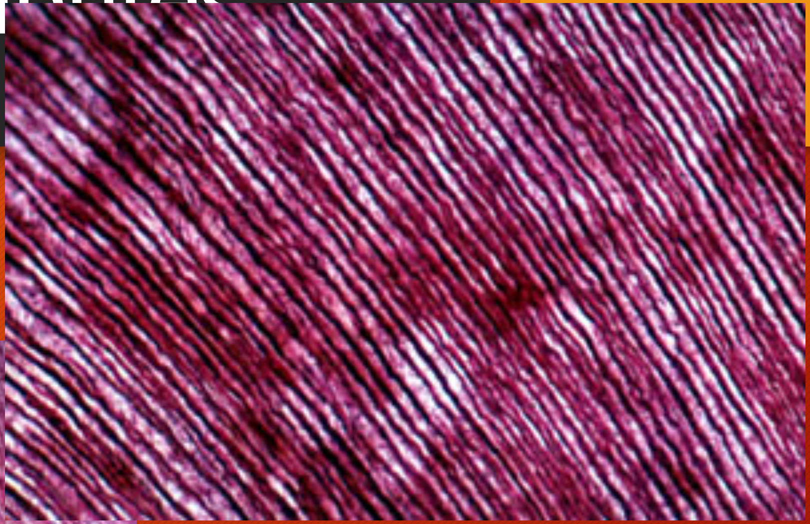

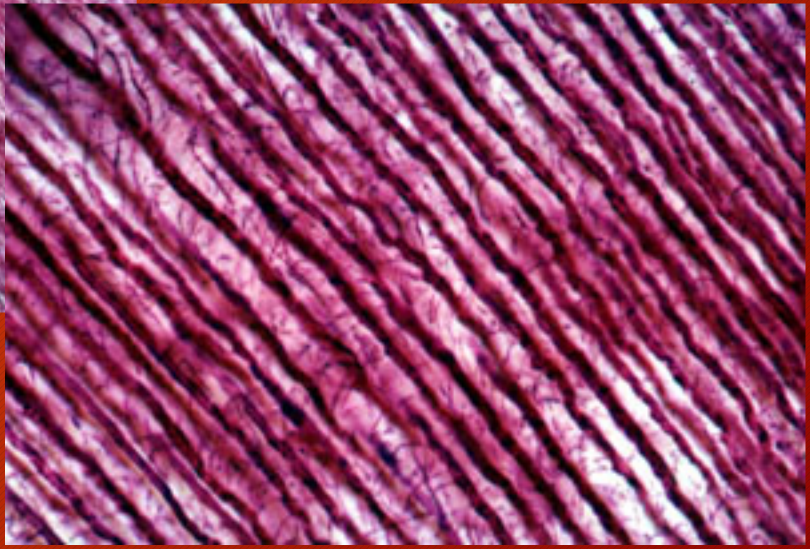

Y shaped branching of Tubules

- The terminal ends of the dentinal tubules branch at the dentinocementum junction.
- Decalcified Section Silver Stain, 400x

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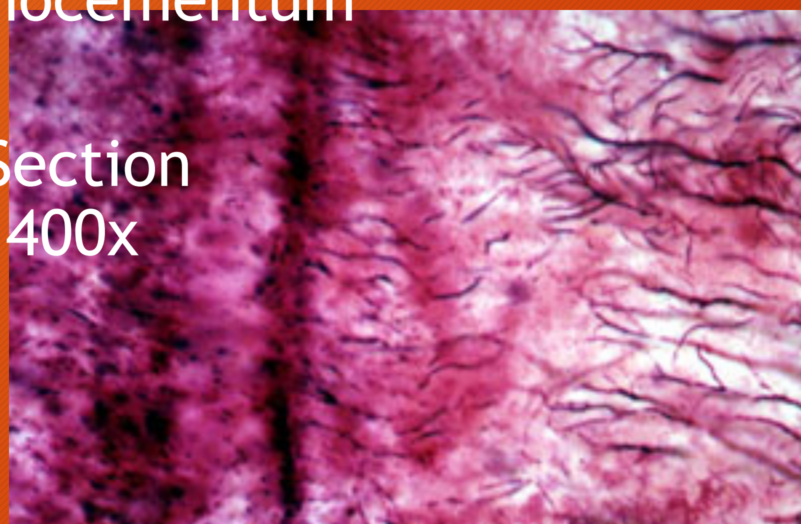
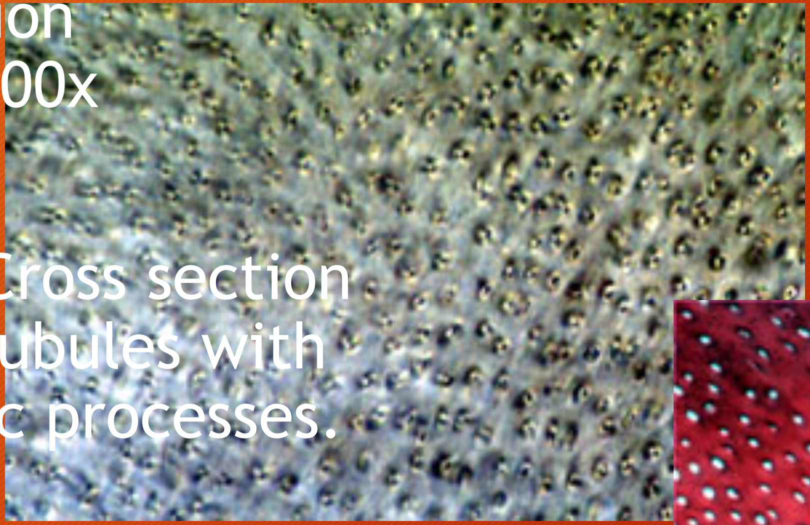


Cross section of dentinal tubules.

- Cross section of dentinal tubules.
- Ground Section Unstained, 400x
- Decalcified Cross section of dentinal tubules with odontoblastic processes. H&E, 400x

D E N T I N



Cross section of dentinal tubules.

- The cut ends of the odontoblastic processes are visible.
- Decalcified Section Silver Stain, 400x

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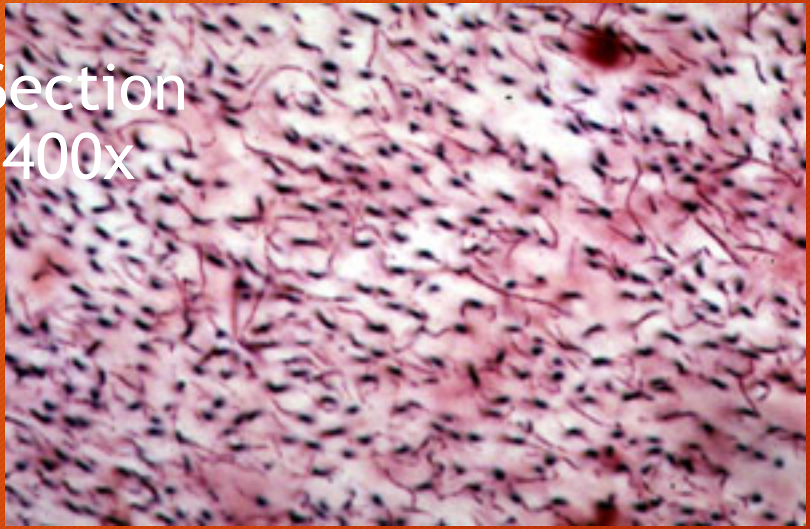
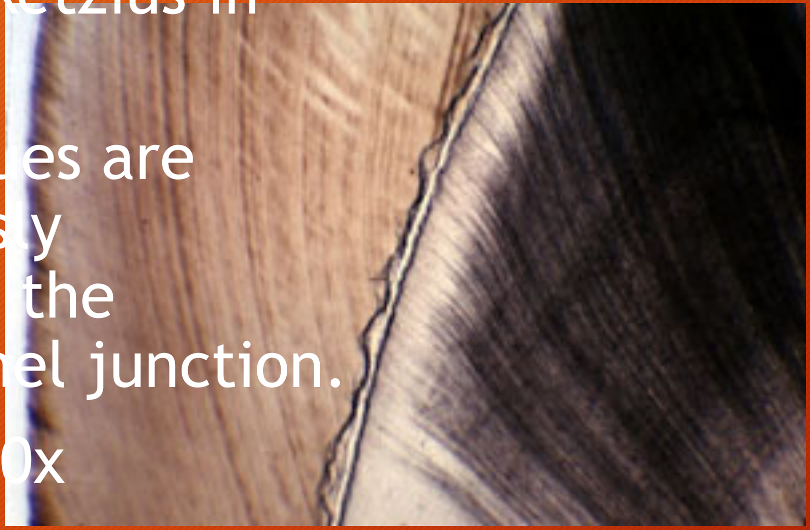


Contour lines of Owen

- Notice the contour lines of Owen in dentin and the lines of Retzius in enamel.
- The two tissues are artifactitiously separated at the dentinoenamel junction.
- Unstained, 40x



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Incremental lines of dentin

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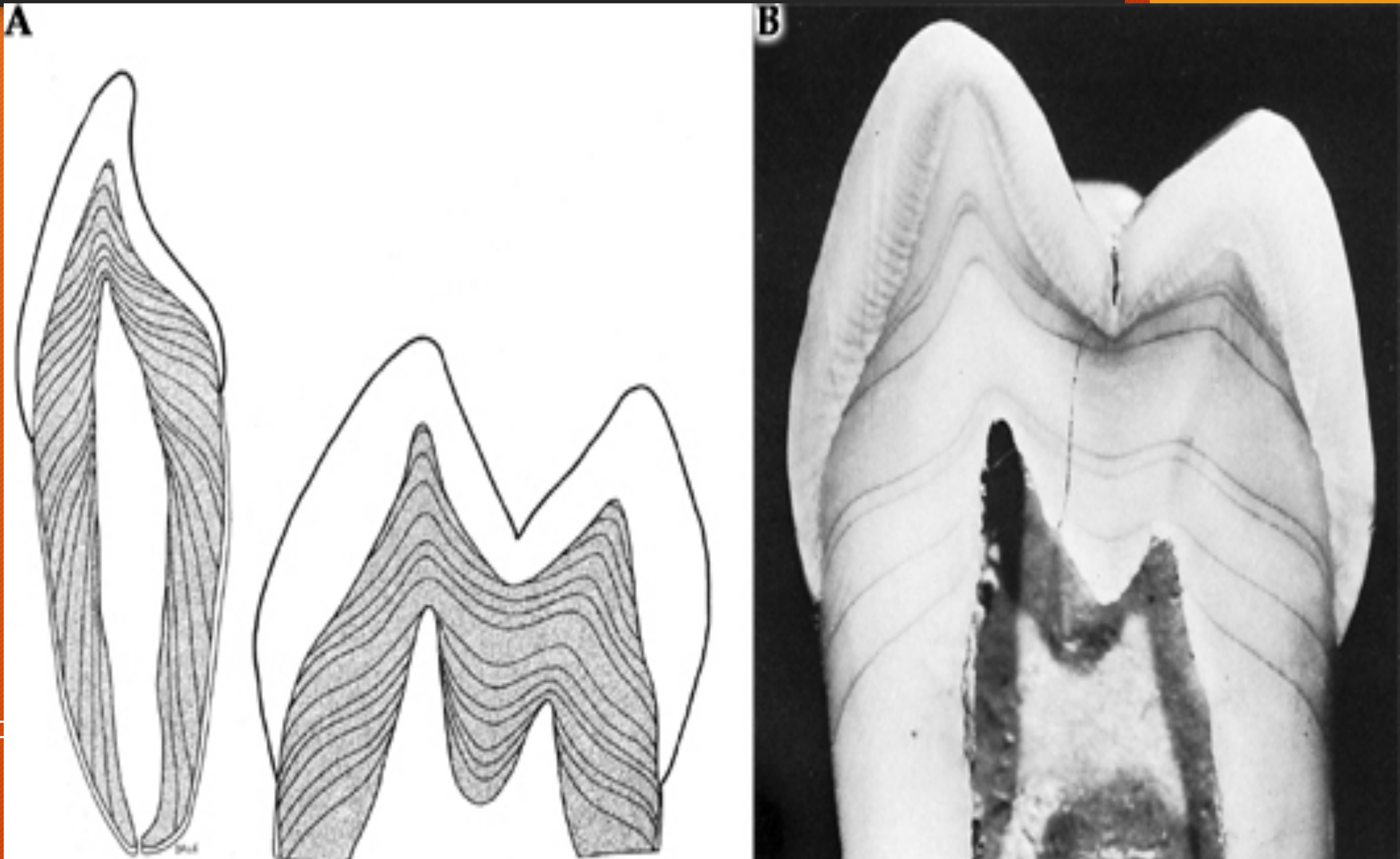
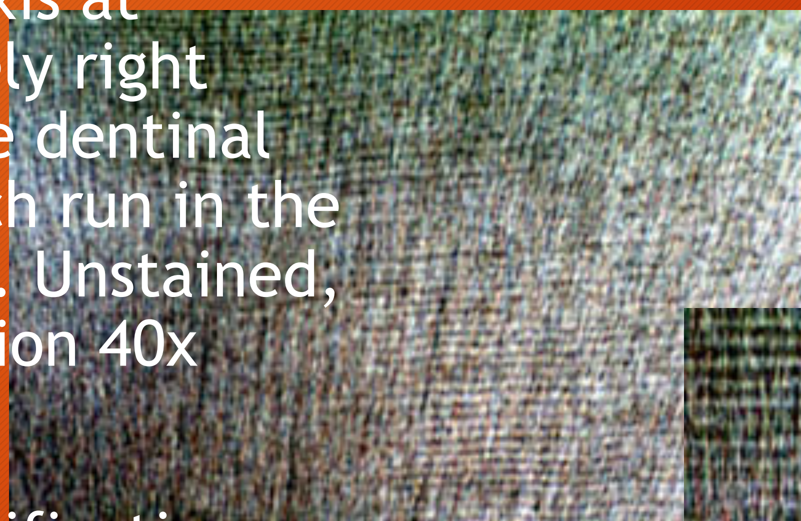


Lines of von Ebner

DENTIN

- The lines of von Ebner are oriented in the horizontal axis at approximately right angles to the dentinal tubules which run in the vertical axis. Unstained, Ground Section 40x



- Higher magnification Unstained, 100x

Lines of von Ebner

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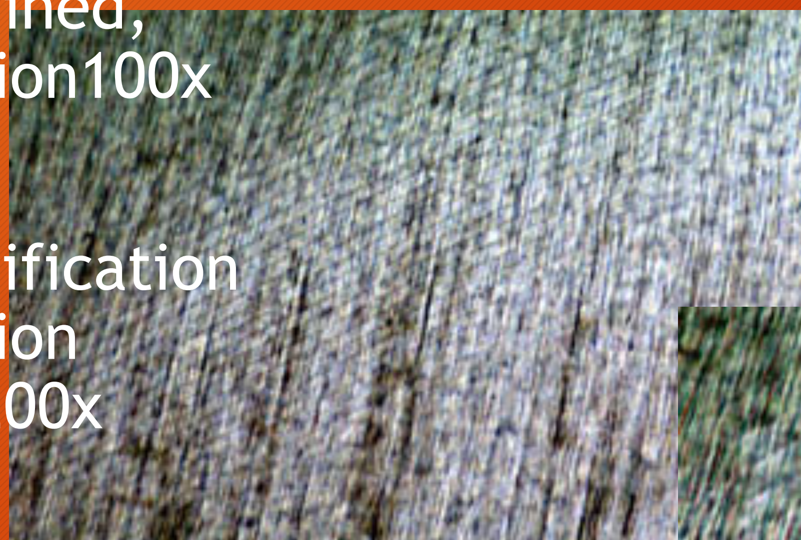
- Another view of the incremental lines of von Ebner. Unstained, Ground Section100x



- Higher magnification Ground Section Unstained, 200x

Neonatal line in enamel & dentin

- Circumpulpal dentin comprises most o dentin of the too

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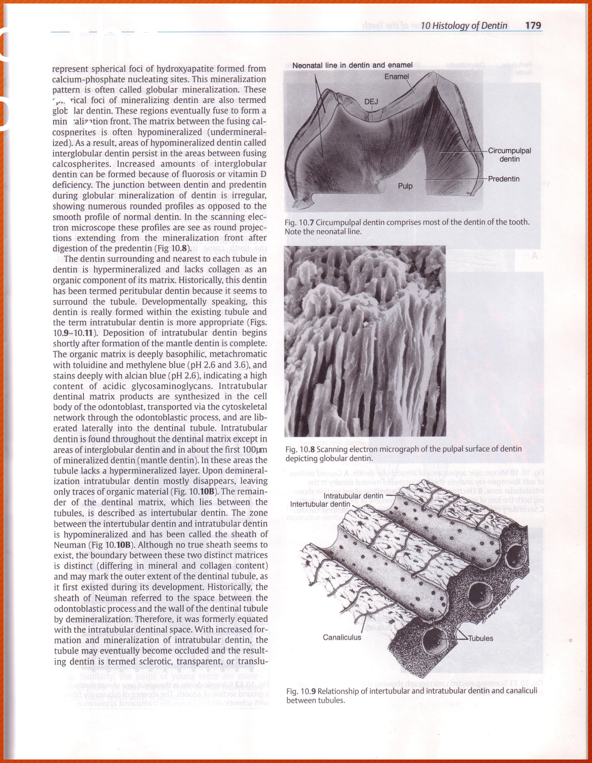


represent spherical foci of hydroxyapatite formed from calcium-phosphate nucleating sites. This mineralization pattern is often called globular mineralization. These spherical foci of mineralizing dentin are also termed globular dentin. These regions eventually fuse to form a mineralization front. The matrix between the fusing calcospherites is often hypomineralized (undermineralized). As a result, areas of hypomineralized dentin called interglobular dentin persist in the areas between fusing calcospherites. Increased amounts of interglobular dentin can be formed because of fluorosis or vitamin D deficiency. The junction between dentin and predentin during globular mineralization of dentin is irregular, showing numerous rounded profiles as opposed to the smooth profile of normal dentin. In the scanning electron microscope these profiles are see as round projections extending from the mineralization front after digestion of the predentin (Fig 10.**8**).

The dentin surrounding and nearest to each tubule in dentin is hypermineralized and lacks collagen as an organic component of its matrix. Historically, this dentin has been termed peritubular dentin because it seems to surround the tubule. Developmentally speaking, this dentin is really formed within the existing tubule and the term intratubular dentin is more appropriate (Figs. 10.**9**–10.**11**). Deposition of intratubular dentin begins shortly after formation of the mantle dentin is complete. The organic matrix is deeply basophilic, metachromatic with toluidine and methylene blue (pH 2.6 and 3.6), and stains deeply with alcian blue (pH 2.6), indicating a high content of acidic glycosaminoglycans. Intratubular dentinal matrix products are synthesized in the cell body of the odontoblast, transported via the cytoskeletal network through the odontoblastic process, and are liberated laterally into the dentinal tubule. Intratubular dentin is found throughout the dentinal matrix except in areas of interglobular dentin and in about the first 100µm of mineralized dentin (mantle dentin). In these areas the tubule lacks a hypermineralized layer. Upon demineralization intratubular dentin mostly disappears, leaving only traces of organic material (Fig. 10.**10B**). The remainder of the dentinal matrix, which lies between the tubules, is described as intertubular dentin. The zone between the intertubular dentin and intratubular dentin is hypomineralized and has been called the sheath of Neuman (Fig 10.**10B**). Although no true sheath seems to exist, the boundary between these two distinct matrices is distinct (differing in mineral and collagen content) and may mark the outer extent of the dentinal tubule, as it first existed during its development. Historically, the sheath of Neuman referred to the space between the odontoblastic process and the wall of the dentinal tubule by demineralization. Therefore, it was formerly equated with the intratubular dentinal space. With increased formation and mineralization of intratubular dentin, the tubule may eventually become occluded and the resulting dentin is termed sclerotic, transparent, or translu-

Fig. 10.**7** Circumpulpal dentin comprises most of the dentin of the tooth. Note the neonatal line.

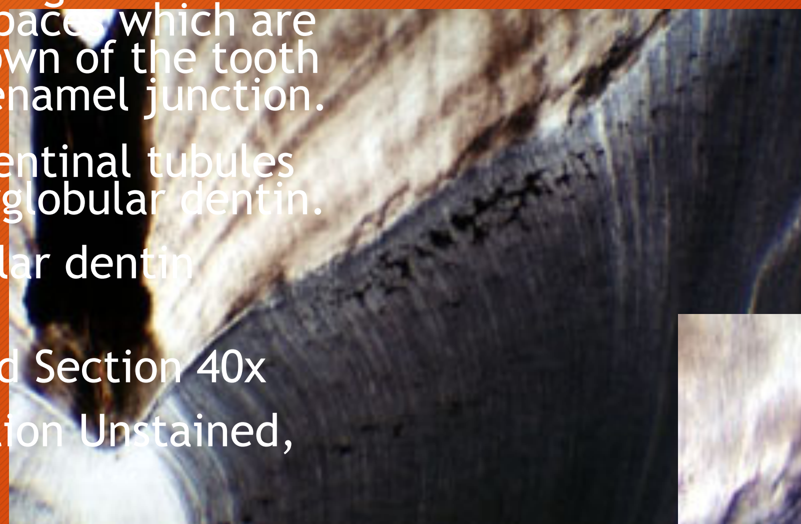
Fig. 10.**8** Scanning electron micrograph of the pulpal surface of dentin depicting globular dentin.

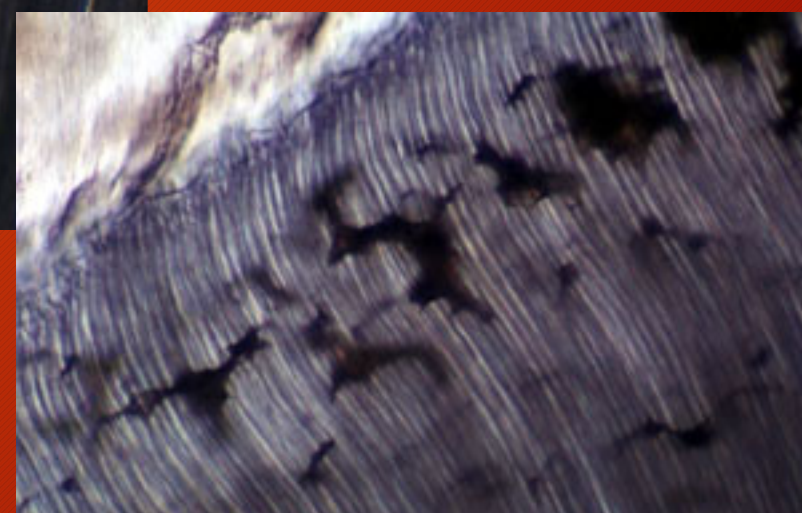
Fig. 10.**9** Relationship of intertubular and intratubular dentin and canaliculi between tubules.

Interglobular Dentin

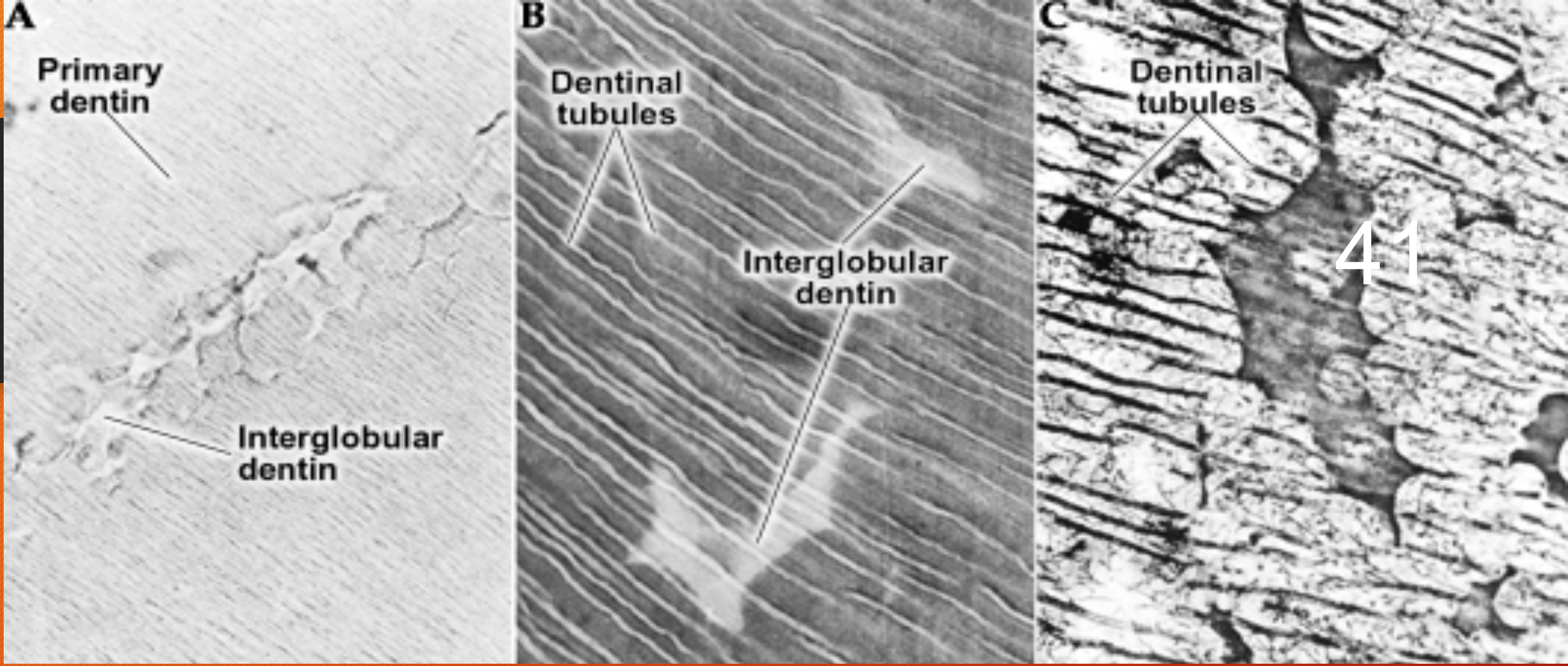
- The photomicrographs depict an occlusal area of a tooth with a brown central pit visible.
- The regions of interglobular dentin appear as black spaces which are located in the crown of the tooth near the dentinoenamel junction.
- Notice that the dentinal tubules traverse the interglobular dentin.
- How is interglobular dentin formed?
- Unstained, Ground Section 40x
- Higher magnification Unstained, 200x

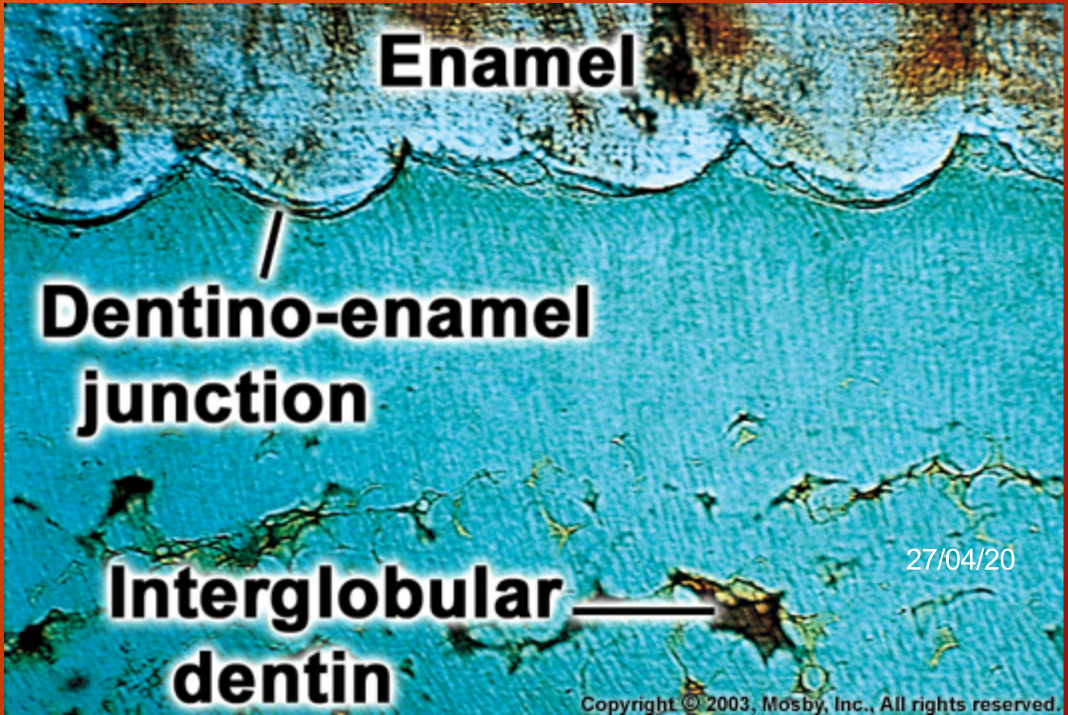
DENTIN





D E N T I N


A
Primary dentin
Interglobular dentin
B
Dentinal tubules
Interglobular dentin
C
Dentinal tubules


Enamel
Dentino-enamel junction
Interglobular dentin
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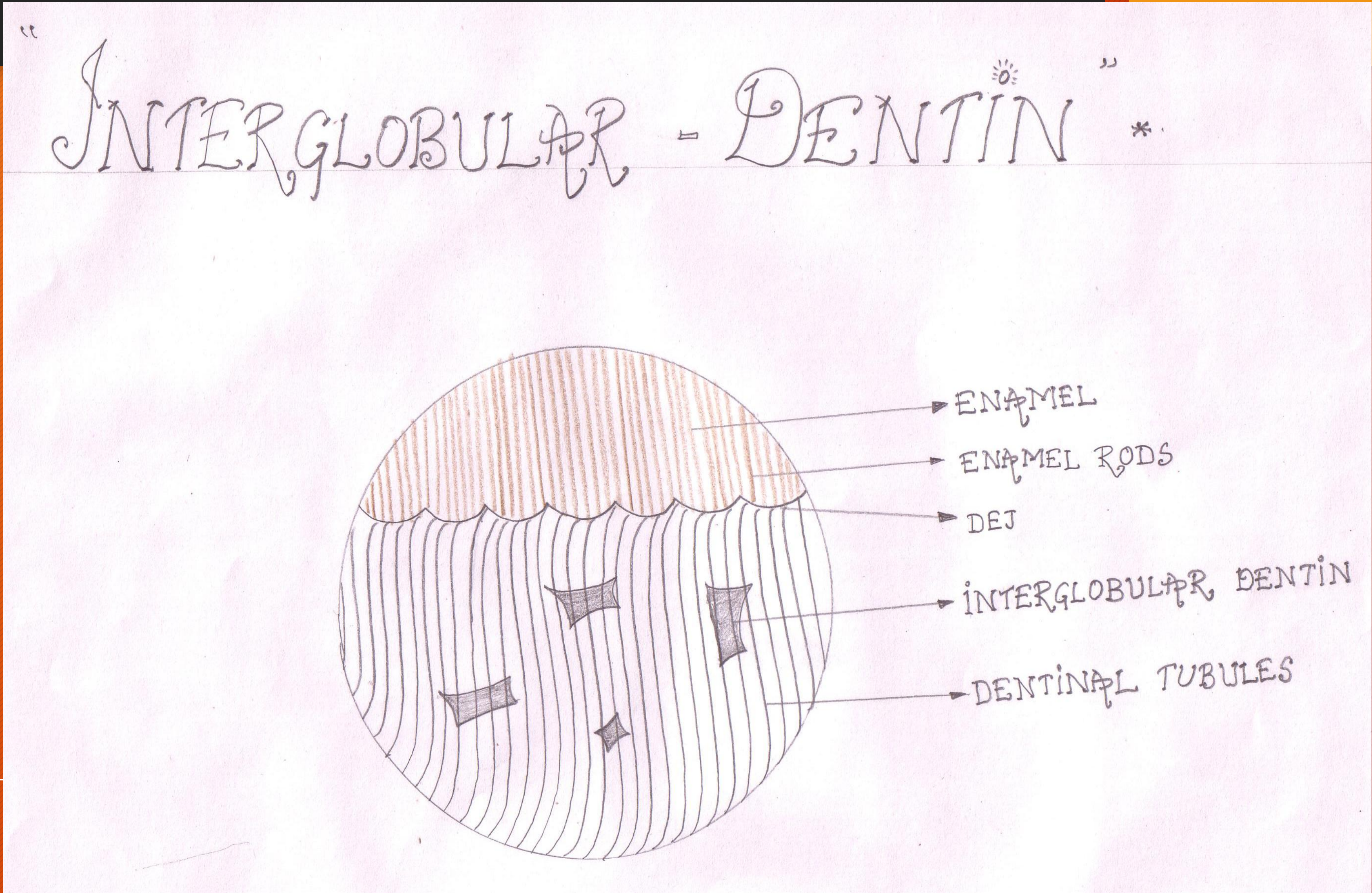
D E N T I N


"INTERGLOBULAR - DENTIN" *
ENAMEL
ENAMEL RODS
DEJ
INTERGLOBULAR DENTIN
DENTINAL TUBULES

Tomes' Granular Layer

- Located in the root dentin along the cemento-dentinal junction.

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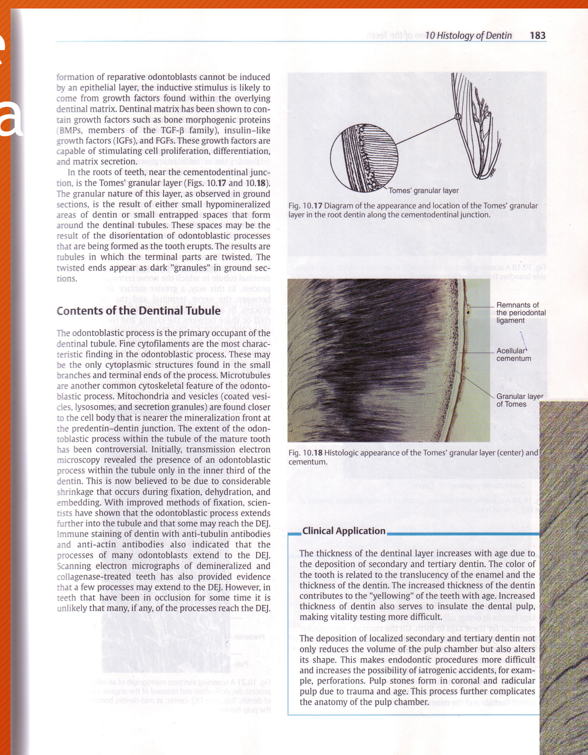


formation of reparative odontoblasts cannot be induced by an epithelial layer, the inductive stimulus is likely to come from growth factors found within the overlying dentinal matrix. Dentinal matrix has been shown to contain growth factors such as bone morphogenic proteins (BMPs, members of the TGF-β family), insulin–like growth factors (IGFs), and FGFs. These growth factors are capable of stimulating cell proliferation, differentiation, and matrix secretion.

In the roots of teeth, near the cementodentinal junction, is the Tomes' granular layer (Figs. 10.**17** and 10.**18**). The granular nature of this layer, as observed in ground sections, is the result of either small hypomineralized areas of dentin or small entrapped spaces that form around the dentinal tubules. These spaces may be the result of the disorientation of odontoblastic processes that are being formed as the tooth erupts. The results are tubules in which the terminal parts are twisted. The twisted ends appear as dark "granules" in ground sections.

Contents of the Dentinal Tubule

The odontoblastic process is the primary occupant of the dentinal tubule. Fine cytofilaments are the most characteristic finding in the odontoblastic process. These may be the only cytoplasmic structures found in the small branches and terminal ends of the process. Microtubules are another common cytoskeletal feature of the odontoblastic process. Mitochondria and vesicles (coated vesicles, lysosomes, and secretion granules) are found closer to the cell body that is nearer the mineralization front at the predentin–dentin junction. The extent of the odontoblastic process within the tubule of the mature tooth has been controversial. Initially, transmission electron microscopy revealed the presence of an odontoblastic process within the tubule only in the inner third of the dentin. This is now believed to be due to considerable shrinkage that occurs during fixation, dehydration, and embedding. With improved methods of fixation, scientists have shown that the odontoblastic process extends further into the tubule and that some may reach the DEJ. Immune staining of dentin with anti-tubulin antibodies and anti-actin antibodies also indicated that the processes of many odontoblasts extend to the DEJ. Scanning electron micrographs of demineralized and collagenase-treated teeth has also provided evidence that a few processes may extend to the DEJ. However, in teeth that have been in occlusion for some time it is unlikely that many, if any, of the processes reach the DEJ.

Tomes' granular layer

Fig. 10.**17** Diagram of the appearance and location of the Tomes' granular layer in the root dentin along the cementodentinal junction.

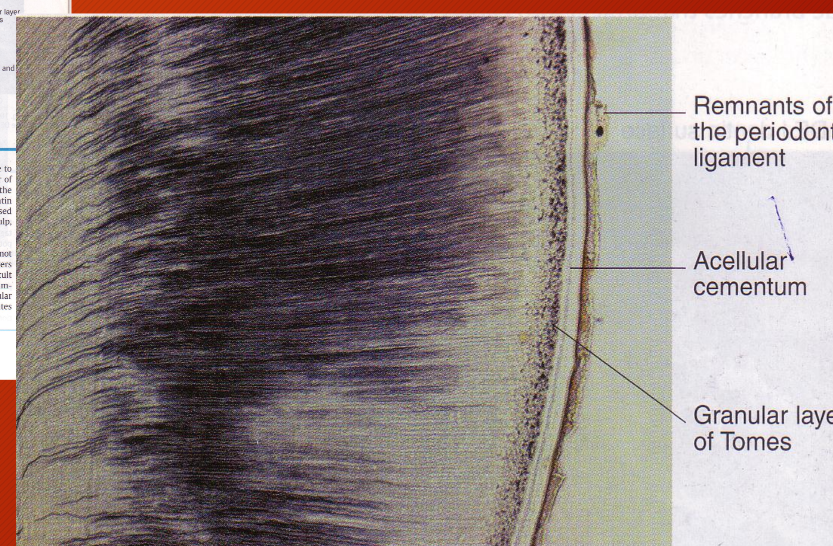
Remnants of the periodontal ligament
Acellular cementum
Granular layer of Tomes

Fig. 10.**18** Histologic appearance of the Tomes' granular layer (center) and cementum.

Clinical Application

The thickness of the dentinal layer increases with age due to the deposition of secondary and tertiary dentin. The color of the tooth is related to the translucency of the enamel and the thickness of the dentin. The increased thickness of the dentin contributes to the "yellowing" of the teeth with age. Increased thickness of dentin also serves to insulate the dental pulp, making vitality testing more difficult.

The deposition of localized secondary and tertiary dentin not only reduces the volume of the pulp chamber but also alters its shape. This makes endodontic procedures more difficult and increases the possibility of iatrogenic accidents, for example, perforations. Pulp stones form in coronal and radicular pulp due to trauma and age. This process further complicates the anatomy of the pulp chamber.



Tomes' Granular Layer

- Tomes' granular layer appears as a black layer of granular structures which are located in the peripheral zone of root dentin adjacent to the cementum.
- Unstained, Ground Section 100x
- Higher power stained, 200x

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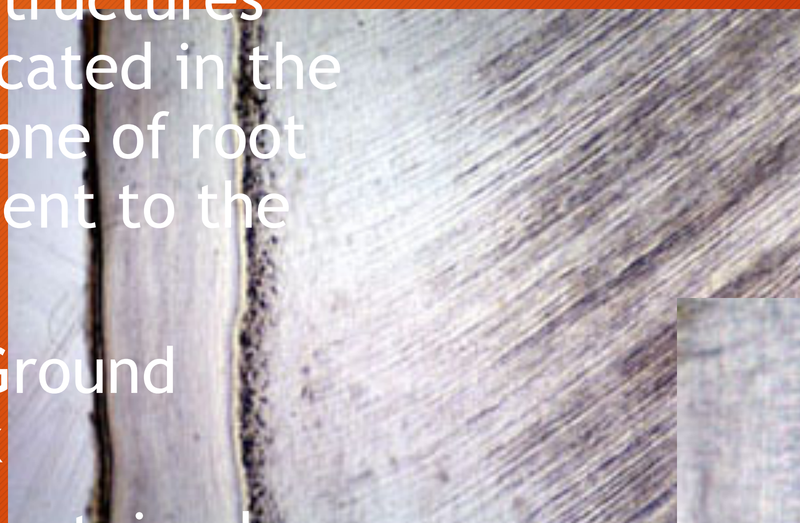

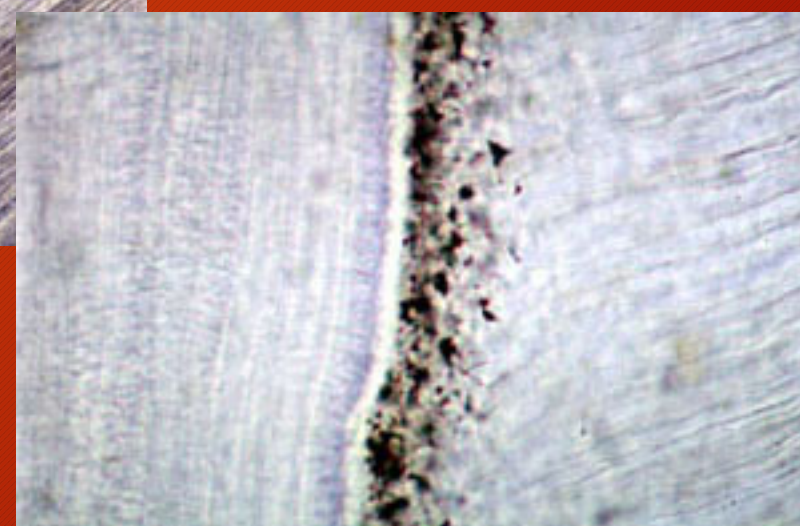

Dead Tracts

- Groups of dentinal tubules which are filled with air appear black in ground sections of dentin when viewed with transmitted light.
- How are dead tracts formed?
- Unstained, Ground Section 40x

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Dentin_

Sclerotic dentin

D E N

- Also called Transperent denin

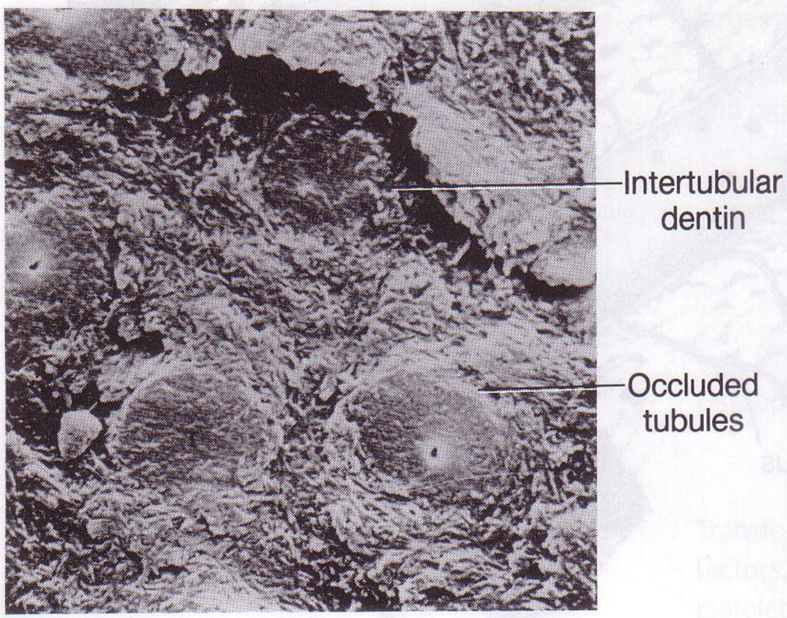
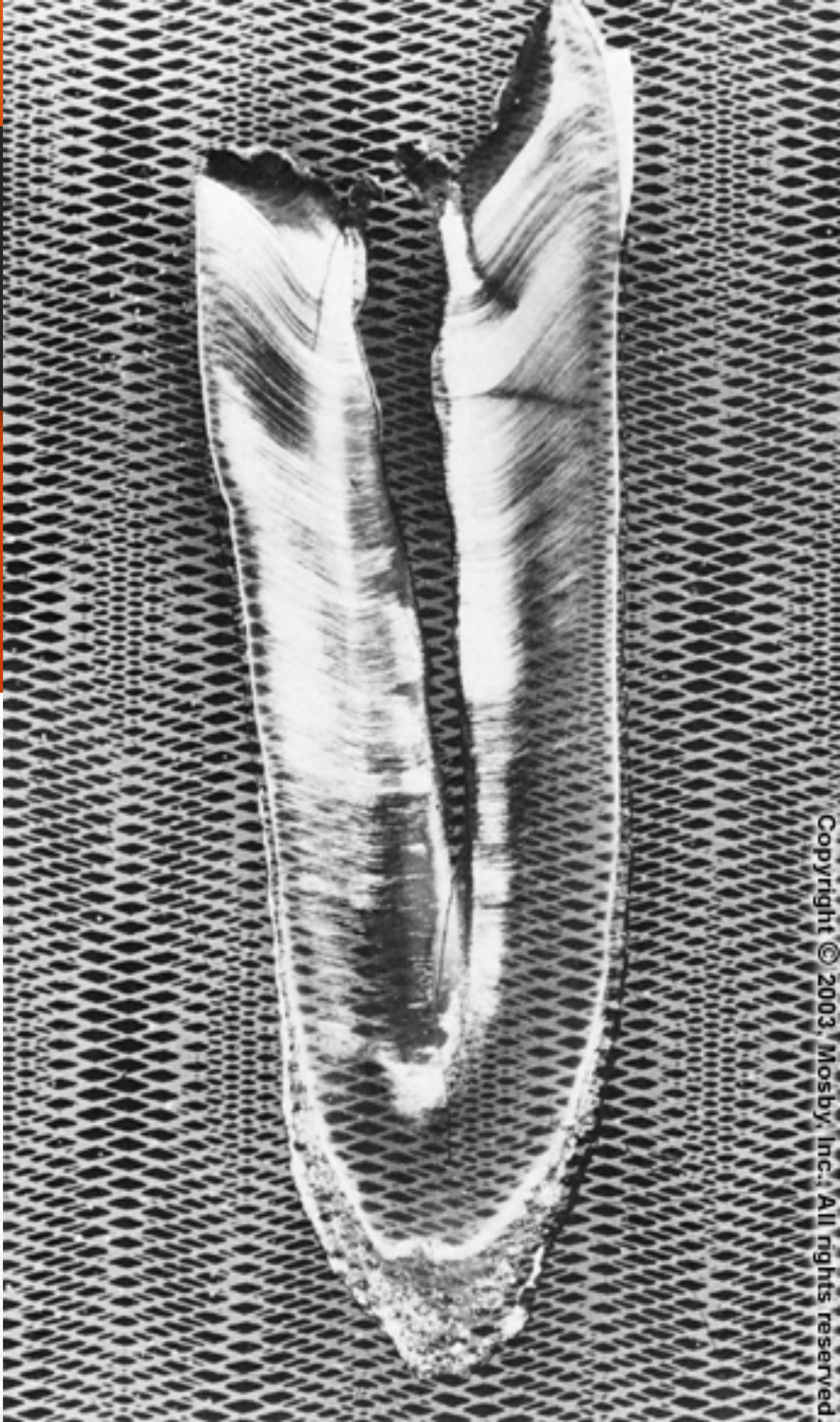


Fig. 10.**11** Scanning electron micrograph showing the closed ends of sclerosed dentinal tubules.



Dentin sensitivity

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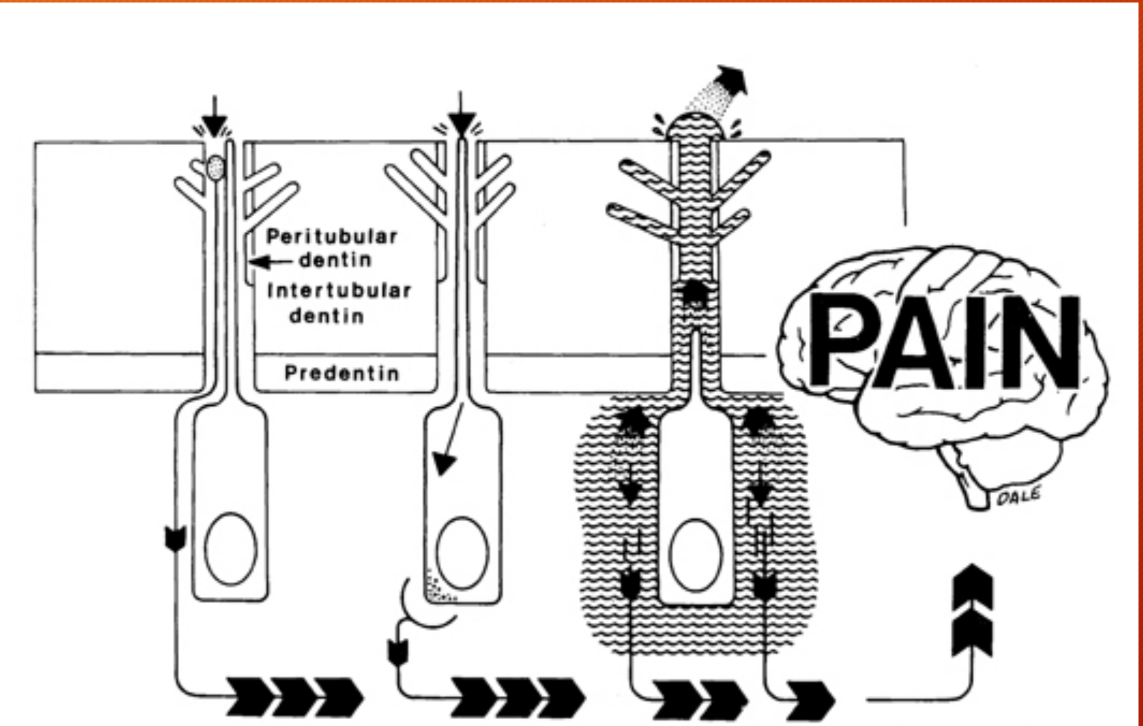

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