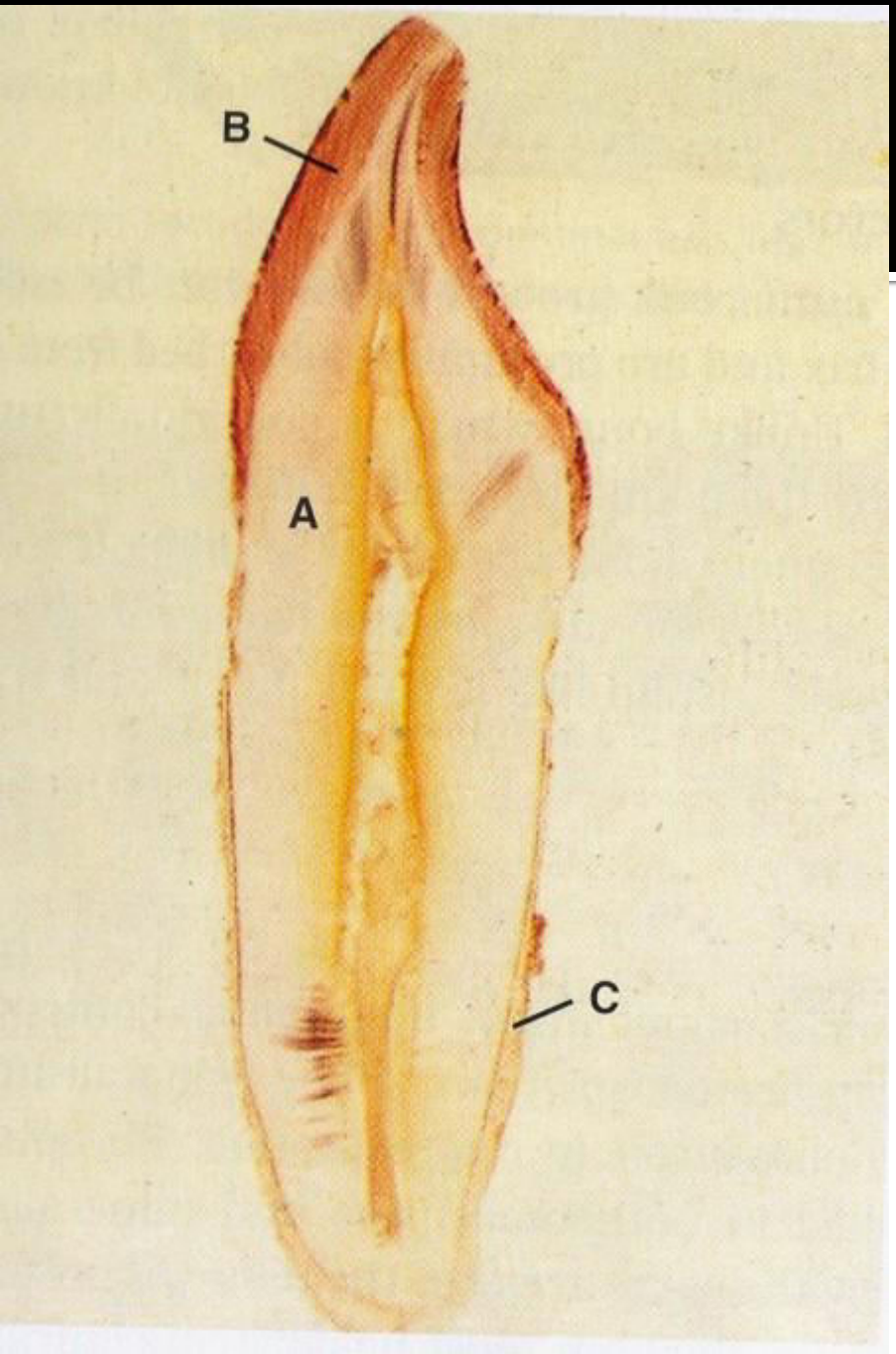
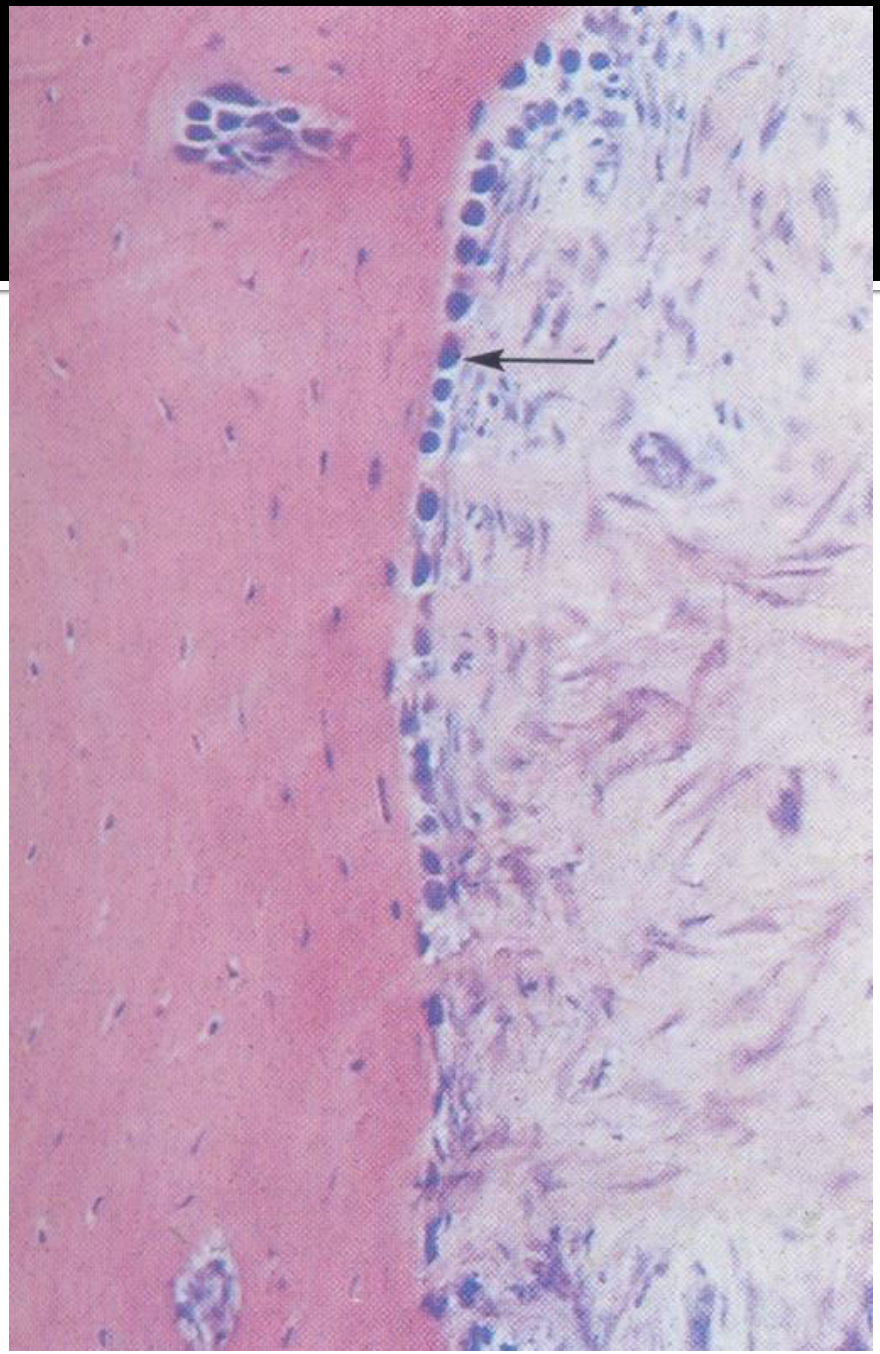
DENTINE


B
A
C

INTRODUCTION

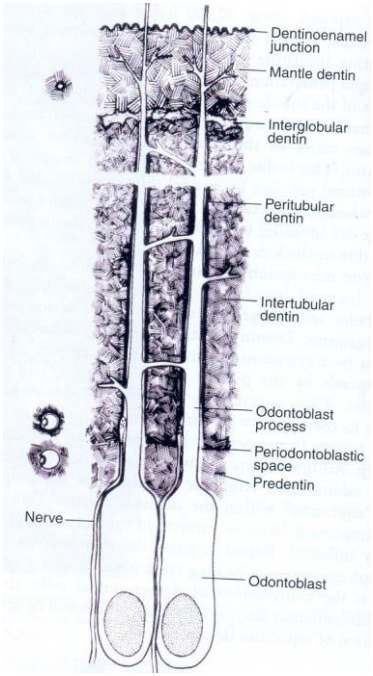
- Dentin is the mineralized tissue with tubules throughout its thickness that forms the bulk of the tooth & provides general form to the tooth.
- In the crown it is covered by enamel & in the root by cementum.
- As it begins to form slightly before enamel ,it determines the shape of the enamel.

- Two major properties distinguish dentin from enamel
- Dentin is sensitive.
- Is formed throughout life.
- Living tissue : contains the processes of specialised cells ,the **odontoblasts** within its tubules.



- Physically & chemically ,closely resembles bone (both are vital) but differs:
- Some of the **osteoblasts** exist on the surface of the bone ,some may enclosed within matrix ,
  an **osteocyte**.

- The odontoblast's cell bodies remain external to dentin ,but processes exist within tubules in dentin.



PHYSICAL PROPERTIES

- Light yellowish in color: light can readily pass through thin highly mineralised enamel & be reflected by underlying dentin.
- Resilient (viscoelastic)
- Subject to slight deformation.
- Harder than bone but considerably softer than enamel.

- Hardness varies :
  - Harder in central part than near pulp or periphery.
  - Slightly less hard in primary teeth.
- More radiolucent than enamel *(because of decreased mineral content)*
- Compressive strength 40,000 psi.

CHEMICAL PROPERTIES

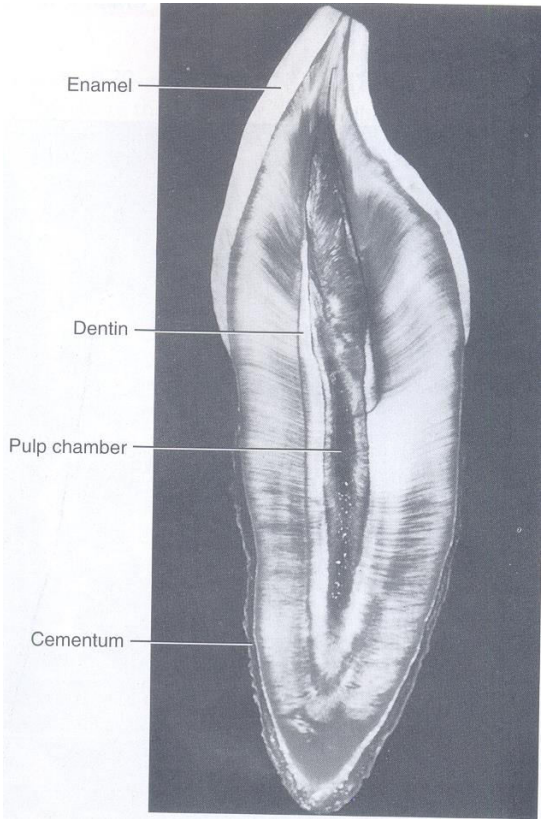
- 65-70% inorganic (mainly hydroxyapatite crystals :3Ca 3(PO4)2.Ca (OH)2)
- Crystals are plate shaped & much smaller than crystals in enamel.
- Crystals are poor in calcium but rich in carbon compared to enamel
- 20-25% organic (Type I collagen & fractions of glycoproteins & proteoglycans)
- 5-10% H2O

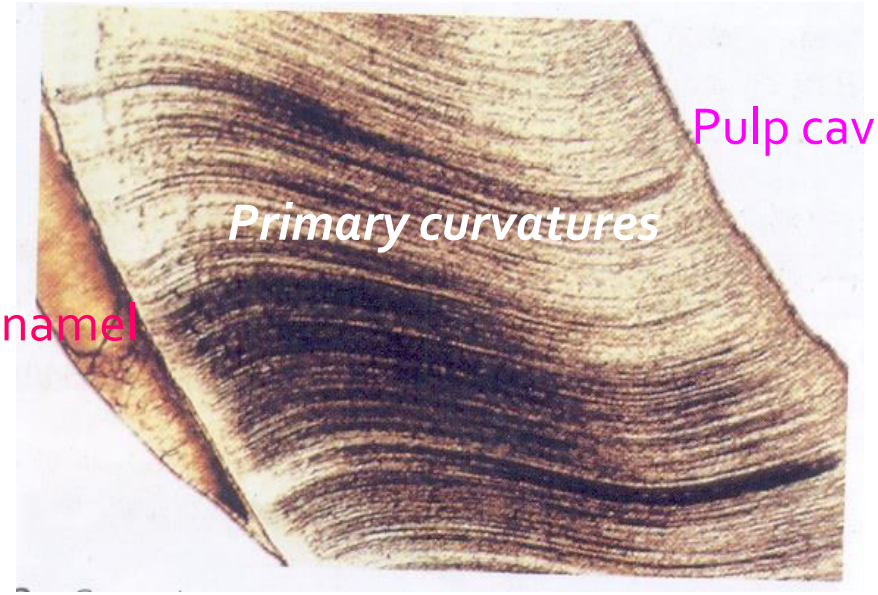
FUNCTIONS

- Protects the soft connective tissue of pulp.
- Forms the main bulk of tooth.
- Induces differentiation of ameloblasts.
- Healing (Tertiary dentin formation).
- Sensory (contains myelinated nerves).

DENTINAL TUBULES

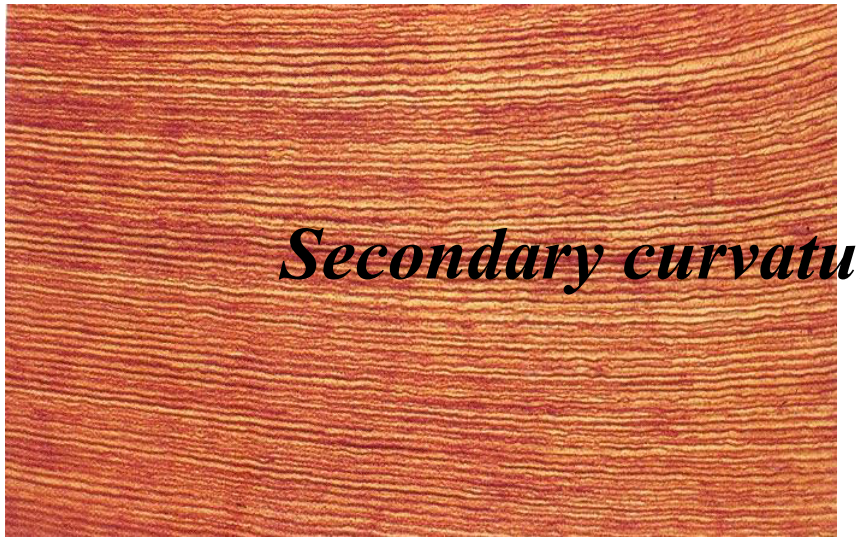
- **Dentinal tubules:** extend through entire thickness of the dentin from DEJ to the pulp.





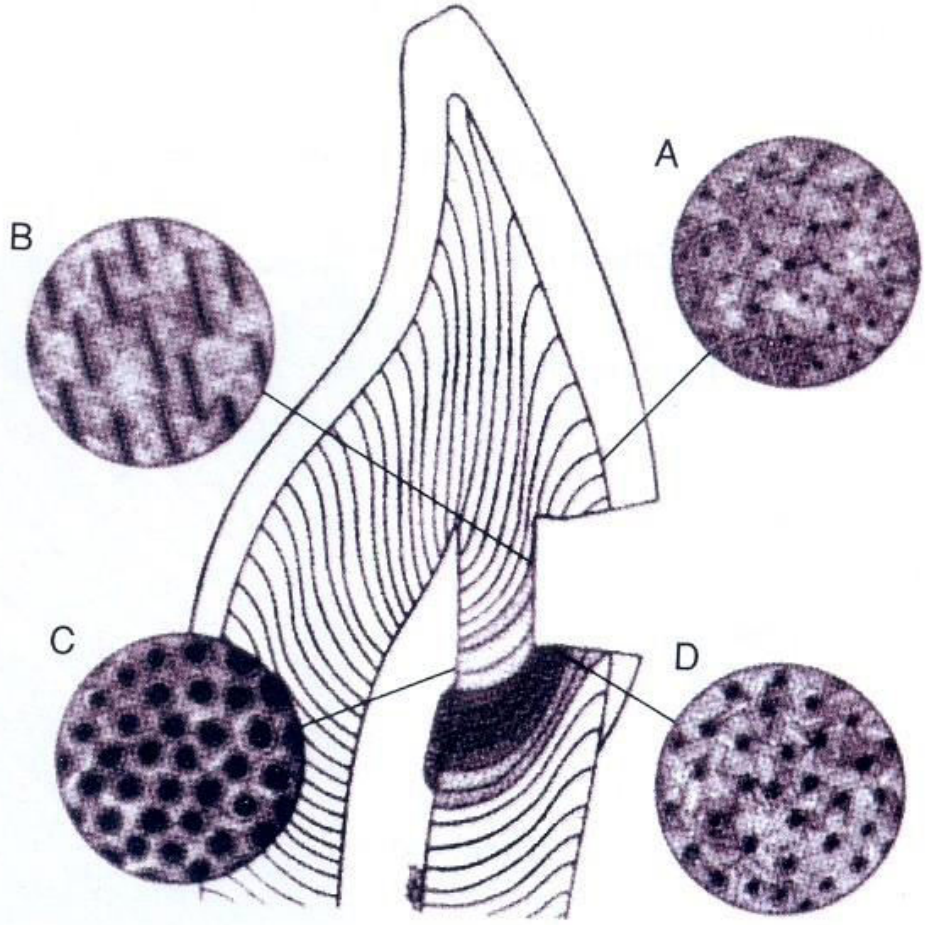
- They follow a gentle '**S**'(sigmoid course) shaped curve – ***Primary curvature.***
- Starting at right angles from pulpal surface first convexity is directed towards the apex of the tooth.

- This ‘S’ is less pronounced in root dentin, beneath incisal edges & cusps.
- Caused by crowding of odontoblasts.
- There are also secondary oscillations called as ***Secondary curvatures*** **.**



Secondary curvatures

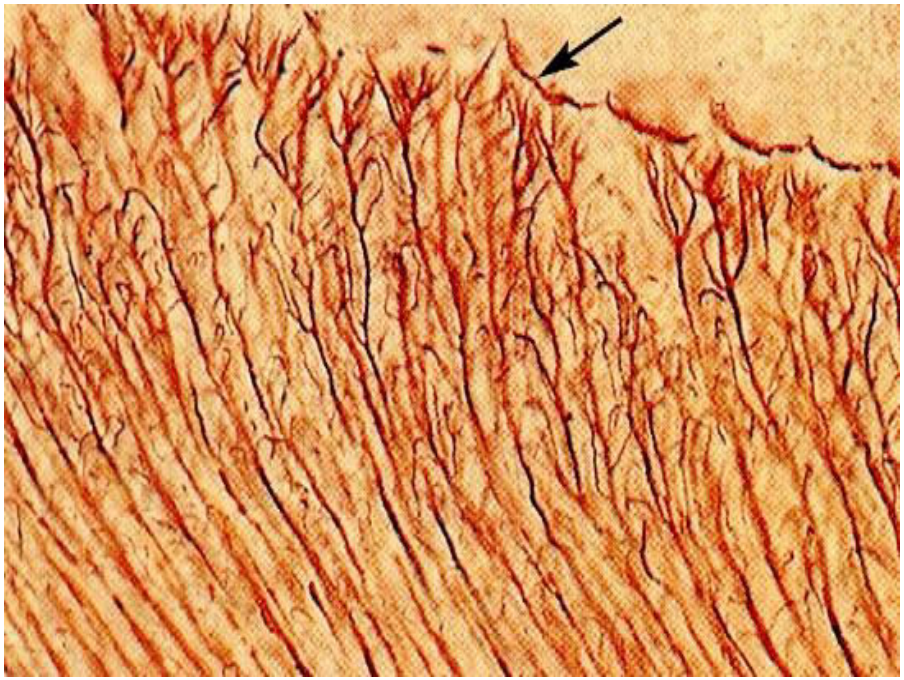
- Dentinal tubules :longer than the thickness of the dentin. (curved)
- Thickness of the dentin:3-10 mm approx.
- Dentinal tubules are tapered structures measuring approx. diameter.



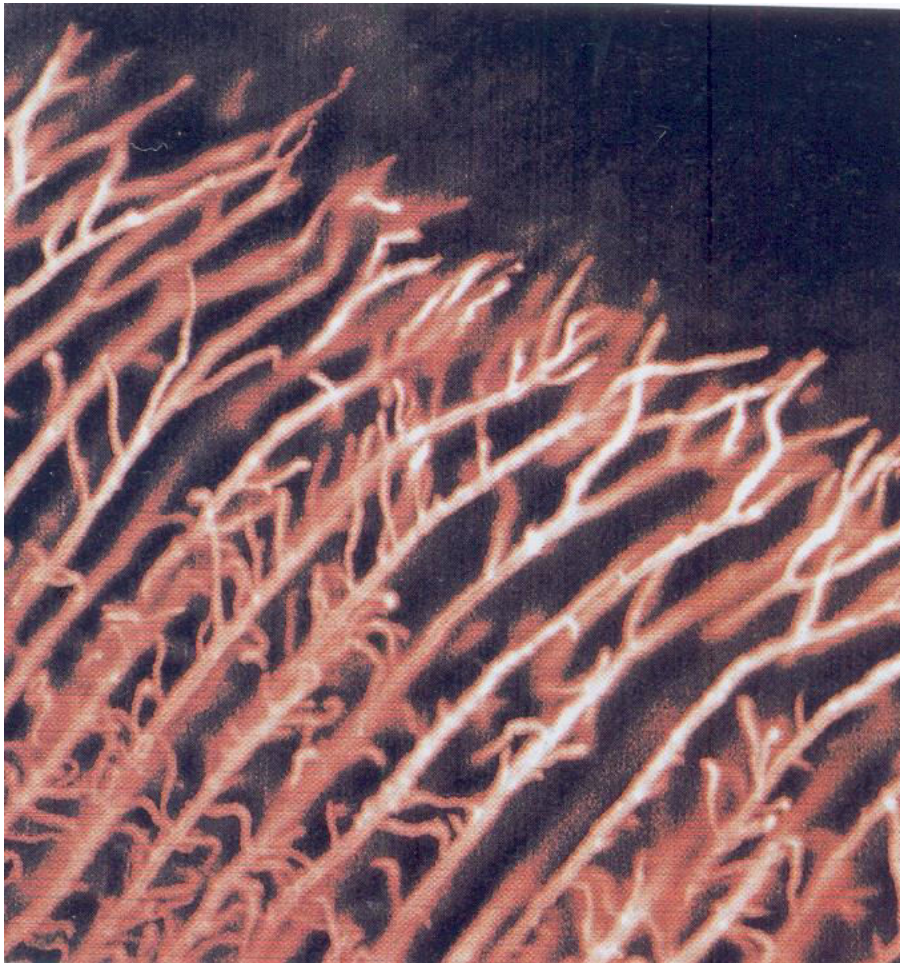
- A- 1 µm at DEJ (10,000 to 15000 / sq.mm)
- B- 1.5-2 µm at mid portion
- C- 1.5- 3µm near Pulp (55,000 to 75000 / sq.mm)

- Number of tubules in premolar and molar at pulpal surface: 55,000 to 75,000 / sq.mm ,almost half in no. at DEJ .
- Associated with crowding of the odontoblasts as the pulp space becomes smaller.
- Ratio of no. of tubules per unit area on the pulpal & outer surfaces of dentin - 4:1
- More tubules per unit area in the crown than in the root.

Y-SHAPED TERMINAL BRANCHING OF TUBULES

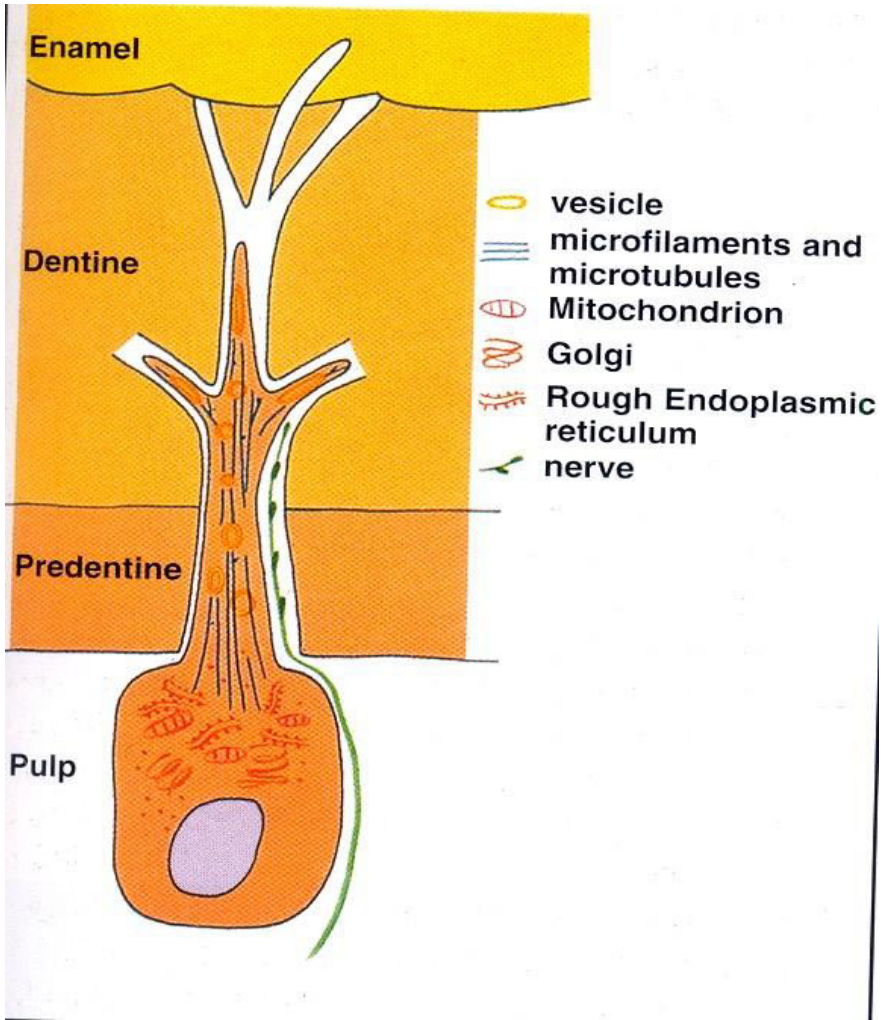


- The terminal parts of the tubules branch ,resulting in an increased no. of tubules per unit length of the dentin.
- It is more profuse in root dentin & in the periphery near the D-E junction.



- **Canaliculi/microtubules:** lateral extensions, branch at intervals of 1-2 μm along its length.

CONTENTS OF THE DENTINAL TUBULE

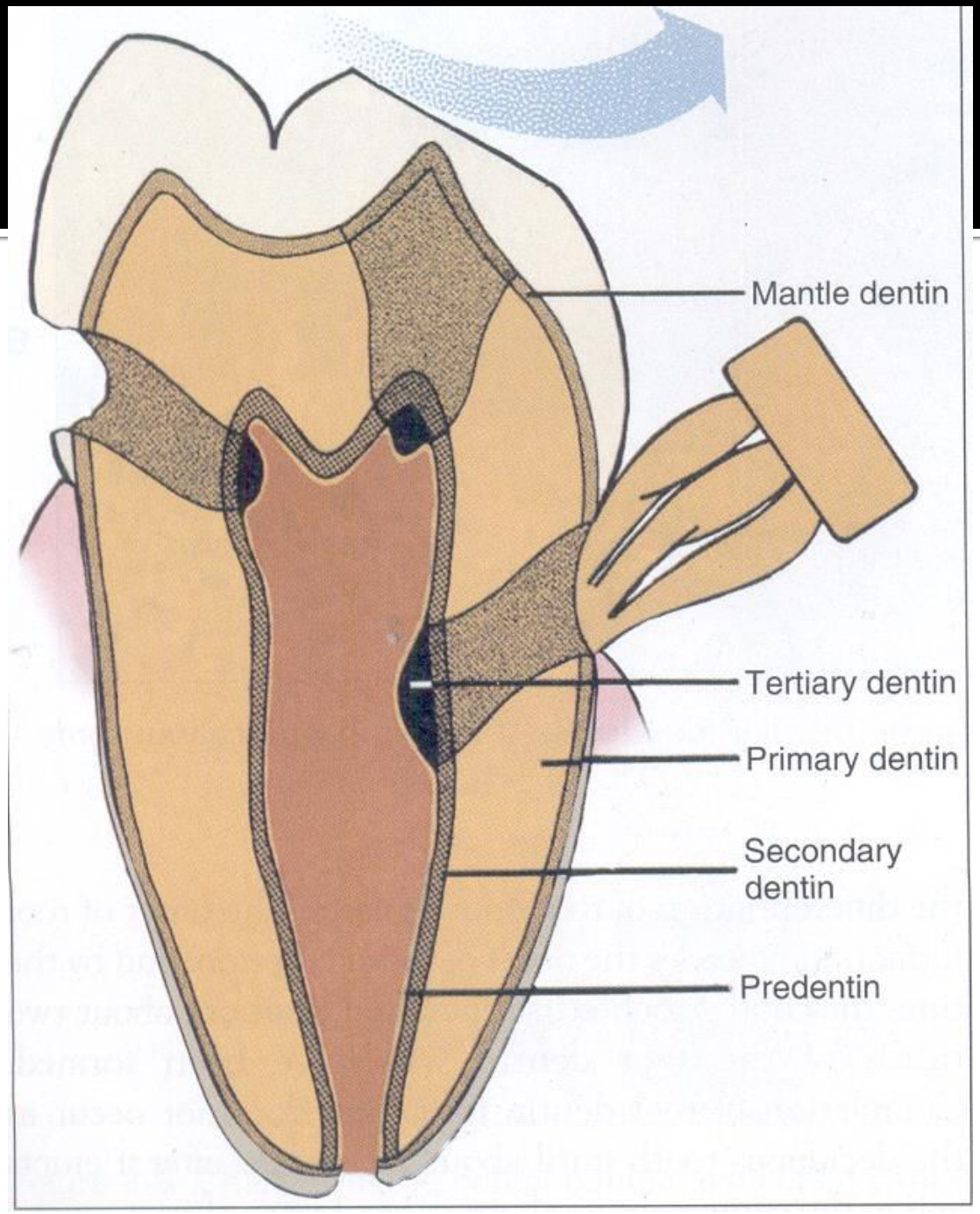


- Odontoblastic process
- Dentinal fluid
- Nerve fibers
- Collagen I
- Plasma proteins (albumin, transferrin)
- Glycoproteins (Tenascin)
- Proteoglycans (Decorin)

ODONTOBLAST PROCESS

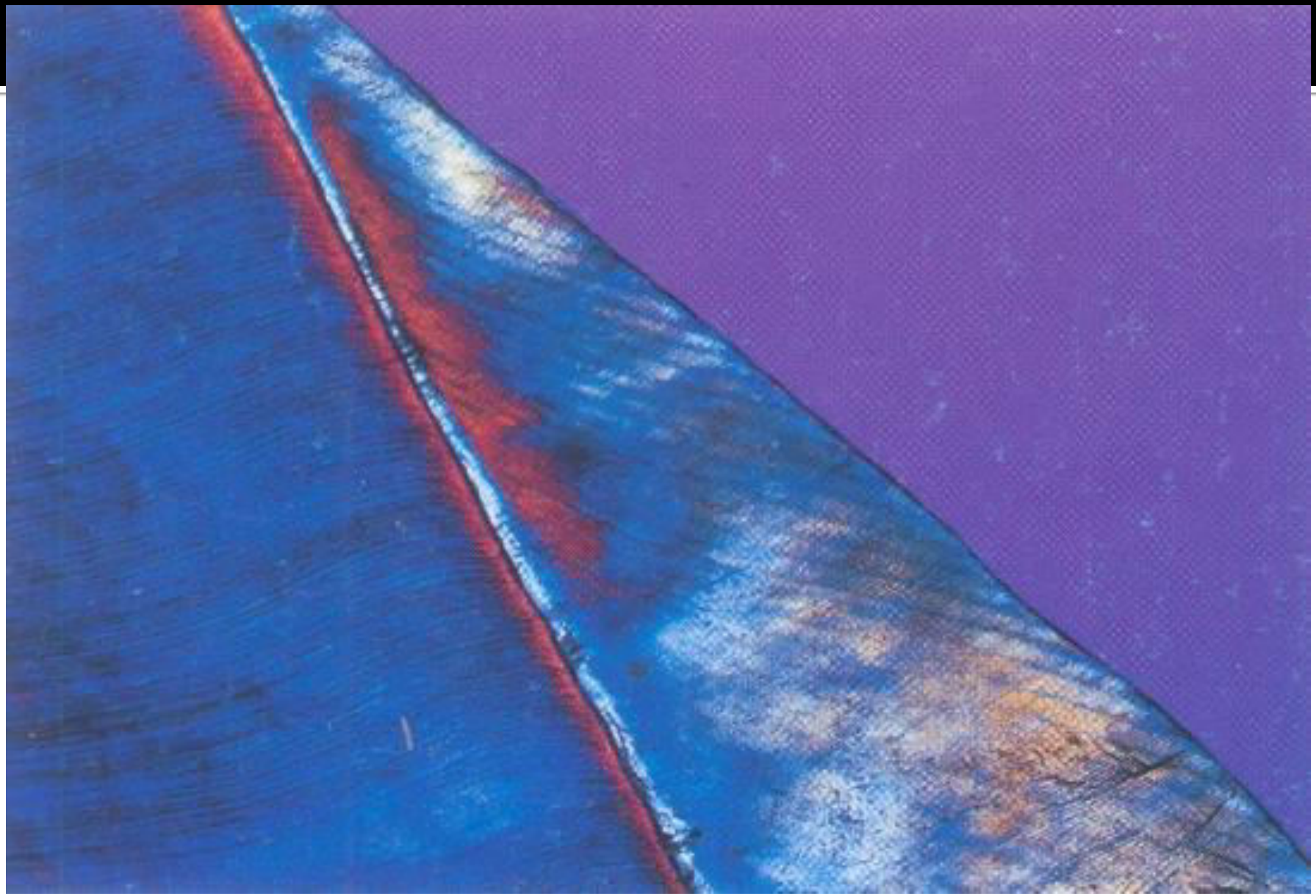
- Cytoplasmic extensions of odontoblast.
- Odontoblast cells reside in the peripheral pulp at the pulp –predentin border & their processes extend into dentinal tubules.
- Diameter : 3-4 μm near pulp & taper approx. 1μm into dentin.
- Structure varies: organelles most numerous in the predentin ,whereas very few in mineralised dentin.

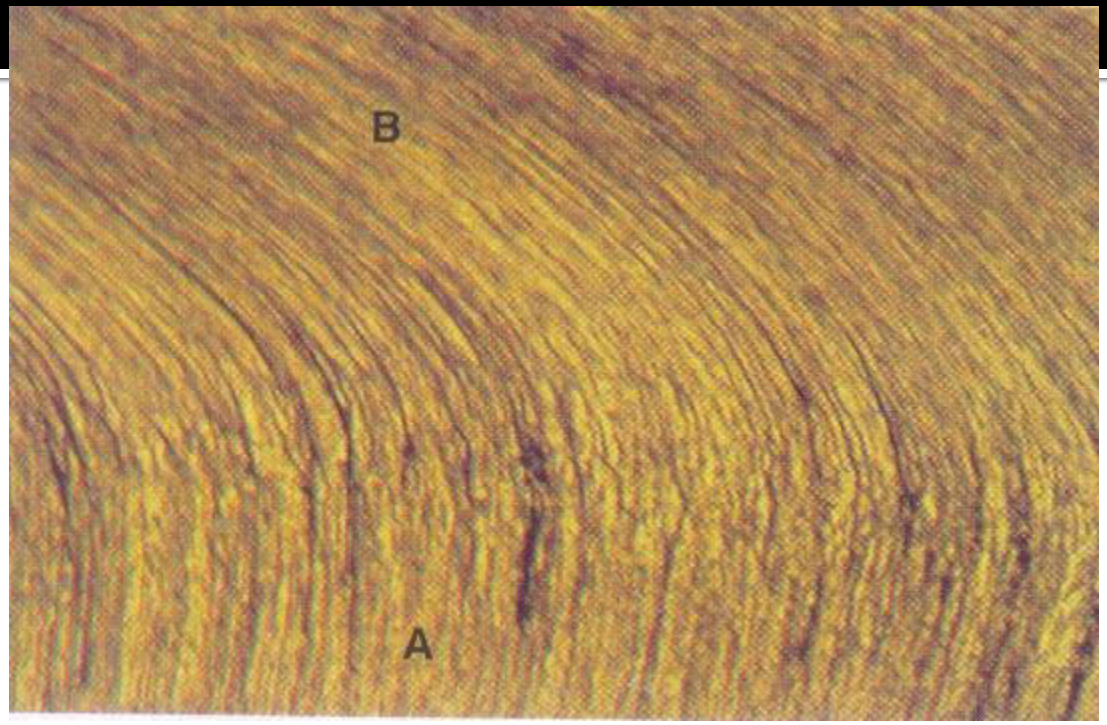
- Whether the processes extend through the thickness of mature dentin ?
- T.E.M. :-Dentinal tubules 200-300 μm from pulp contain processes.
- S.E.M. :-Processes upto the DEJ.
- Lamina limitans :-proteinaceous membrane lining the wall of the tubule.

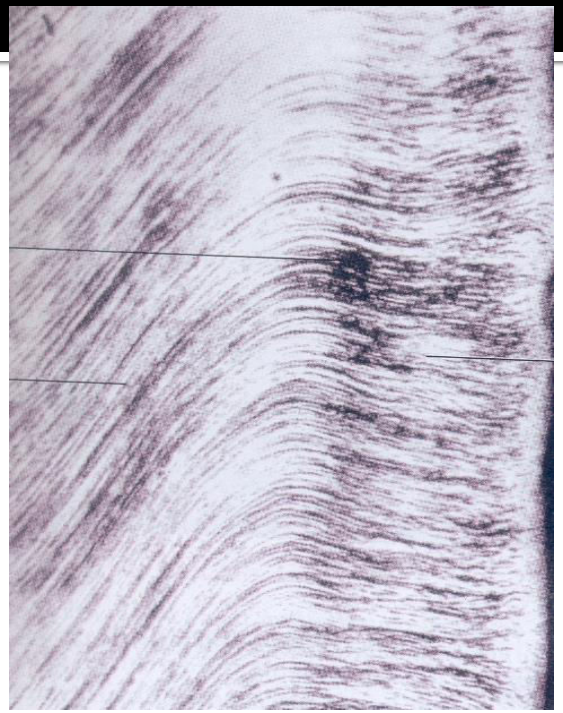

Mantle dentin
Tertiary dentin
Primary dentin
Secondary dentin
Predentin

PRIMARY DENTIN

- Most of the tooth is formed by primary dentin.
- **Mantle dentin**
- **Circumpulpal dentin**
- Outermost layer of primary dentin is called as **Mantle dentin** (150-200 μm) which is the first formed dentin.
- Rest of the primary dentin is called **Circumpulpal dentin.**

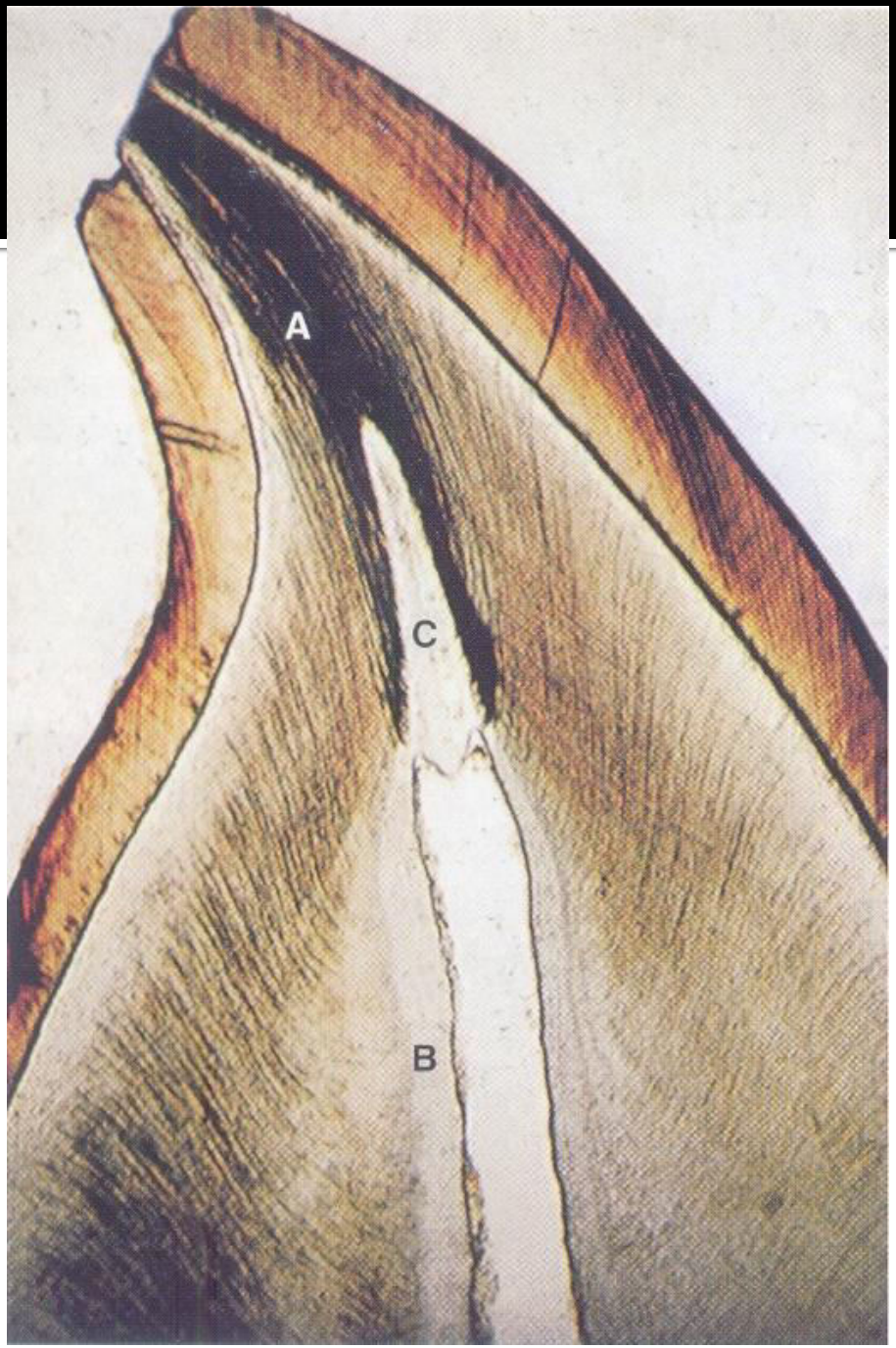



B
A



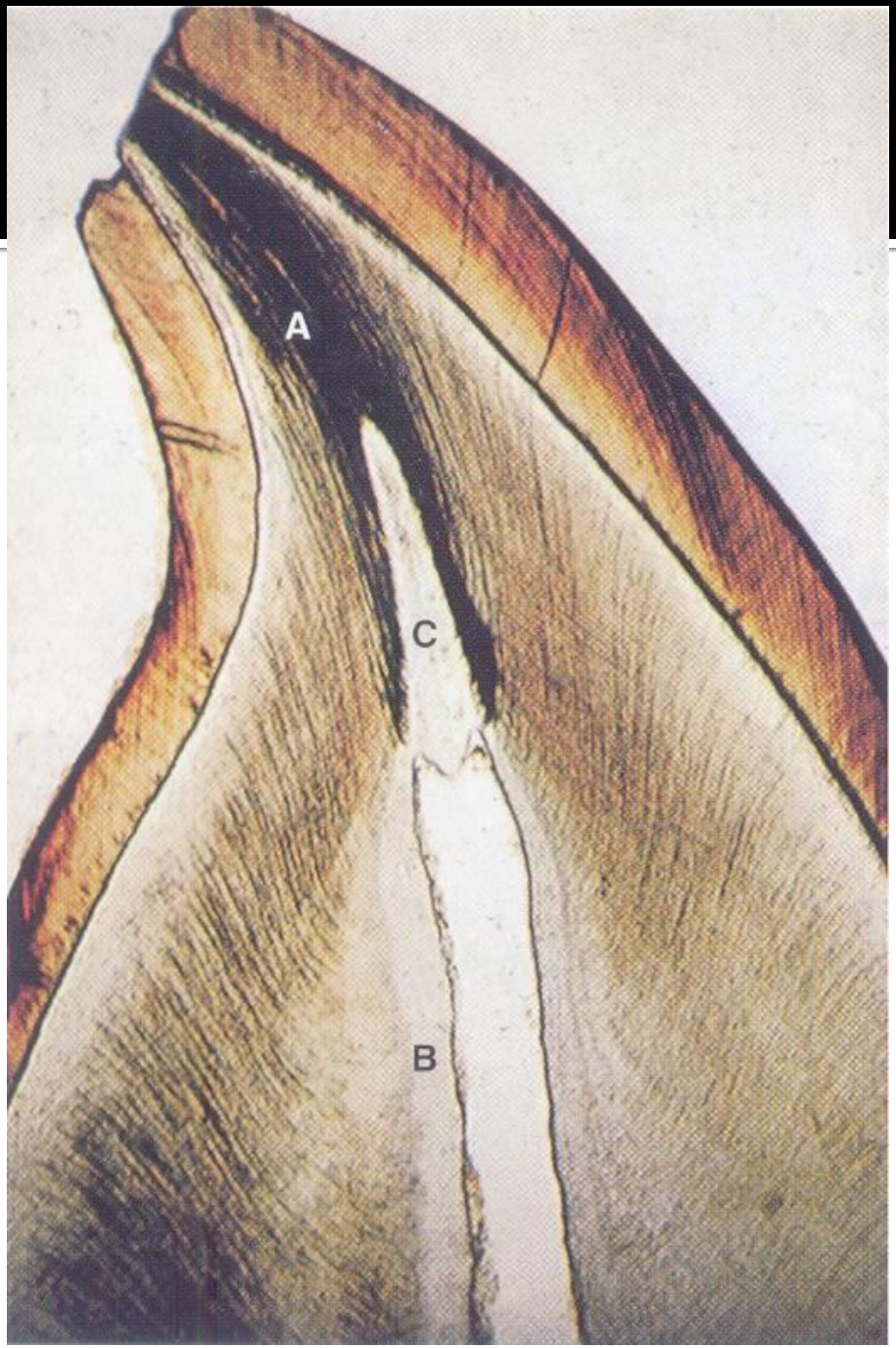
SECONDARY DENTIN

- Develops after root completion.
- Deposition is at much slower rate.
- Structure is same as primary dentin, but contains fewer tubules than primary dentin
- Does not formed uniformly. In greater amounts on the roof & floor of the coronal pulp chamber.

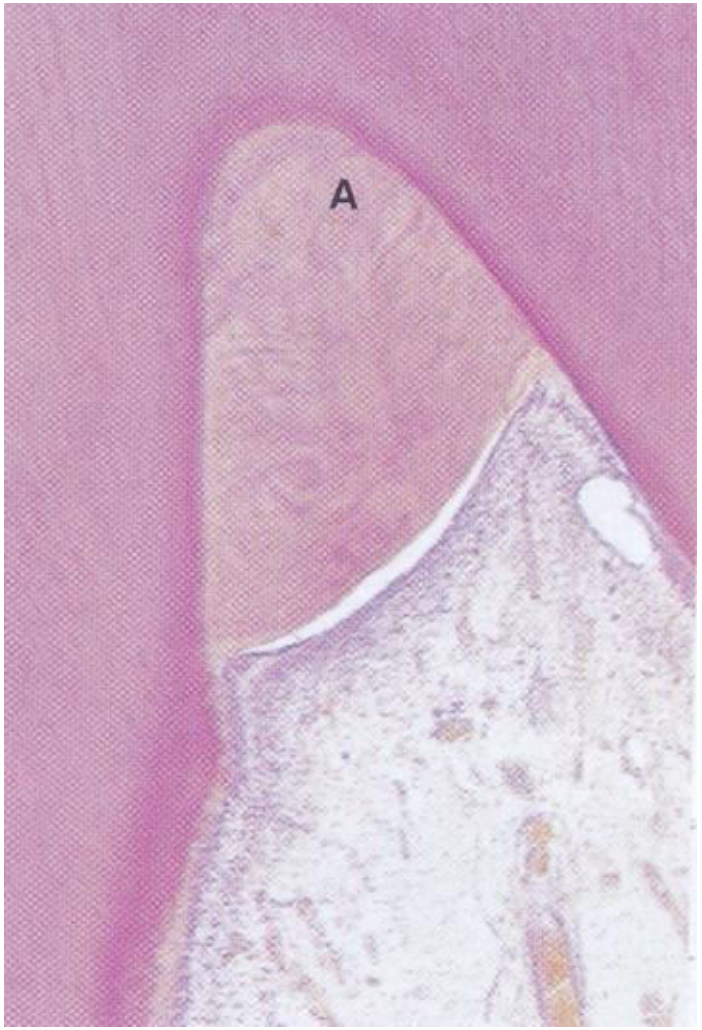

A
C
B

TERTIARY / REPARATIVE / RESPONSE / REACTIVE DENTIN

- Produced in reaction to various stimuli, such as attrition, abrasion, erosion, caries or restorative procedures.
- Bacteria ,their toxic products, chemical substances from restorative materials, migrate down the tubules to the pulp & stimulate pulpal response **--Reparative dentin**

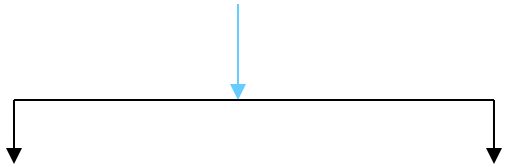

A
C
B

- Healing: formation of reparative dentin is an action to seal off the zone of injury which occurs as a healing process initiated by the pulp.



- Tertiary dentin is only formed at the areas affected by stimuli **(localized)** (Unlike primary & secondary dentin , which are formed throughout the pulp chamber)

TERTIARY DENTIN

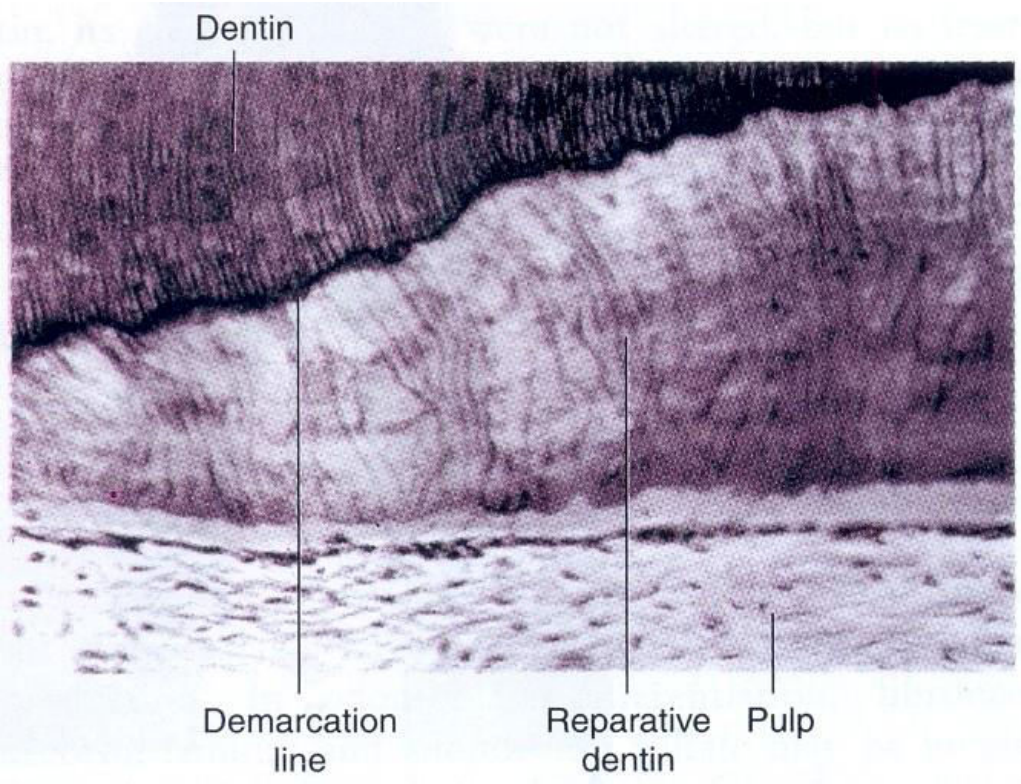


Reactionary dentin

- Deposited by pre-existing odontoblasts

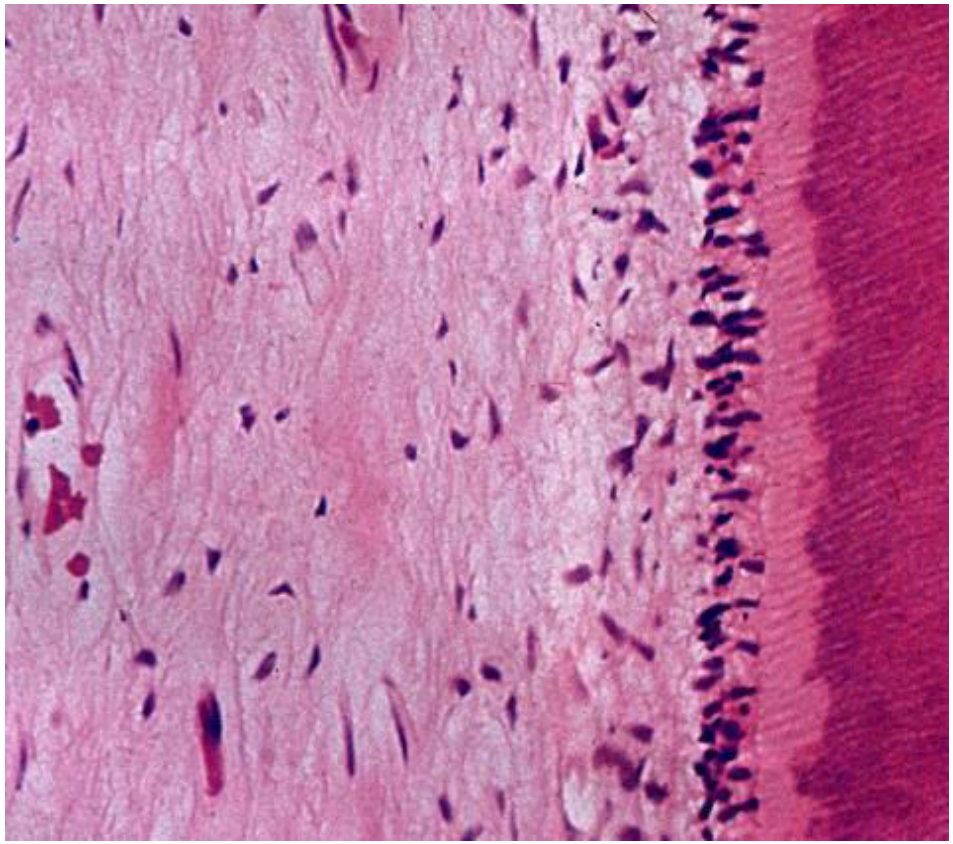
Reparative dentin

- Deposited by newly differentiated odontoblasts

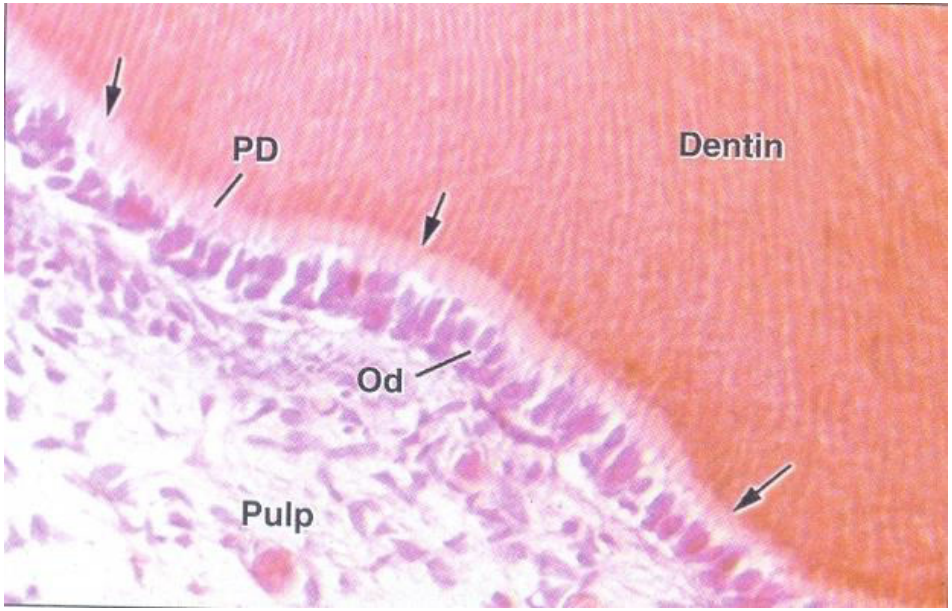


- **Reparative dentin :** Characterised by fewer & more twisted tubules than normal dentin.

PREDENTIN



- Present at the innermost (pulpal) portion (ie mineralizing front) of dentin.
- First formed dentin & is **unmineralized.**
- 2-6 μm in width.



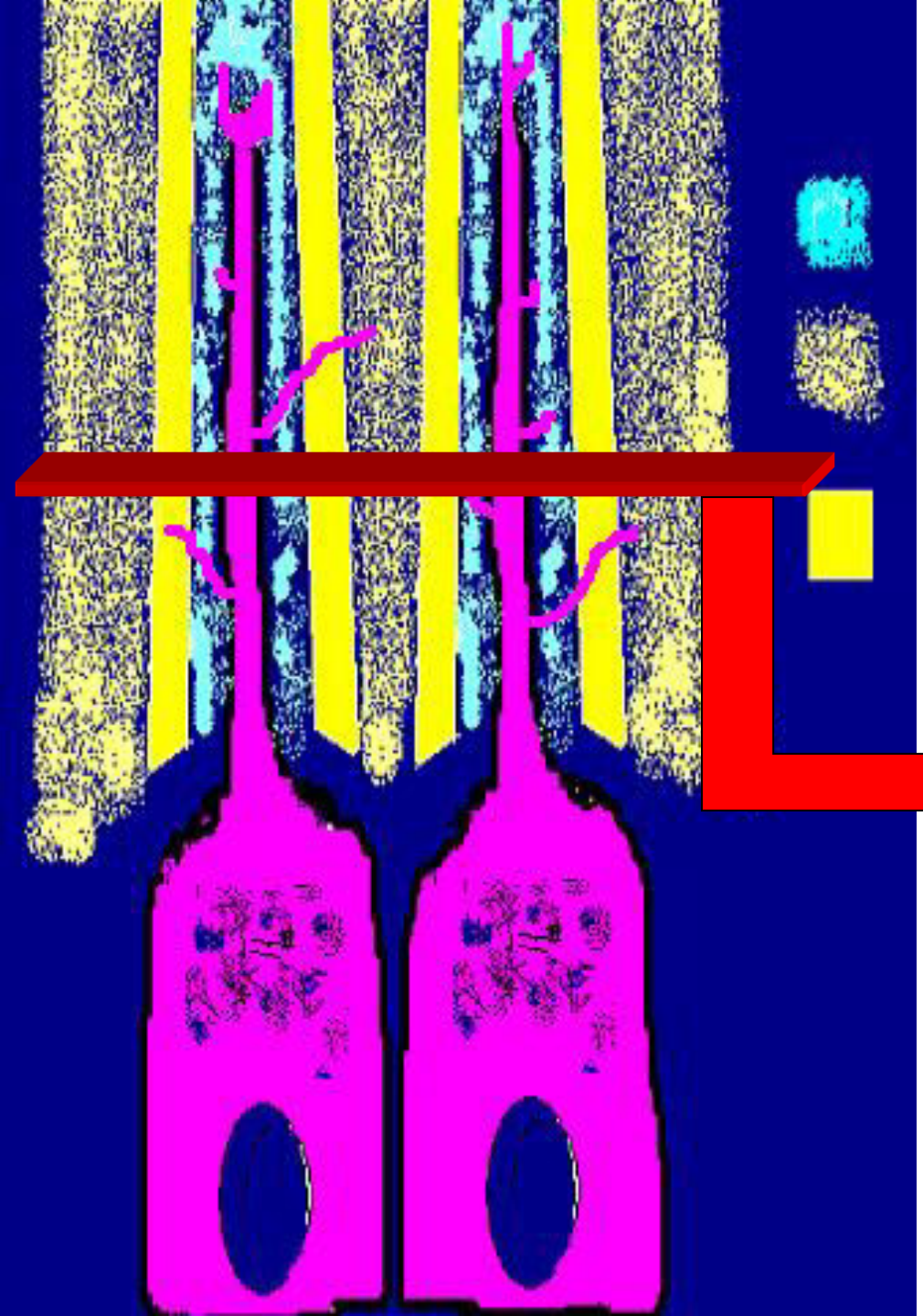
- Consists principally of collagen, glycoprotein & proteoglycans.
- It stains less intensely than mineralized dentin.
- Function: to maintain the integrity of dentin.

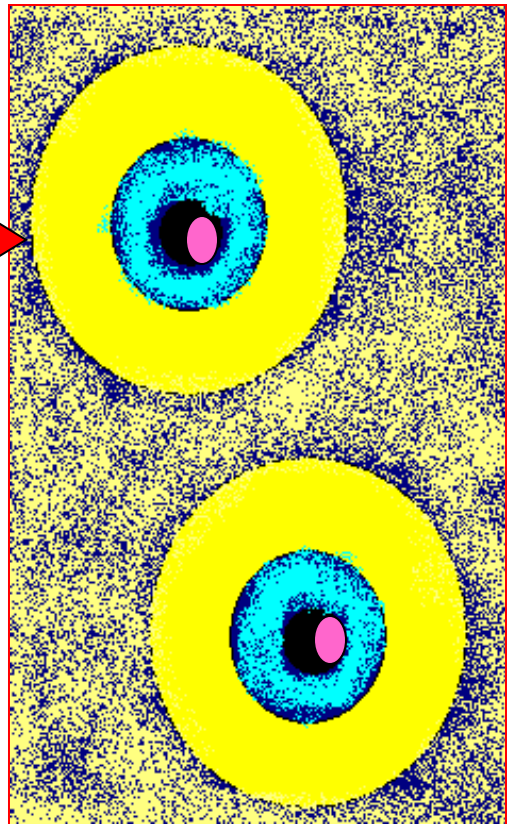
- INTERTUBULAR DENTIN
  &
- PERITUBULAR DENTIN (INTRATUBULAR DENTIN)

Dentinal fluid (Dentinal lymph)

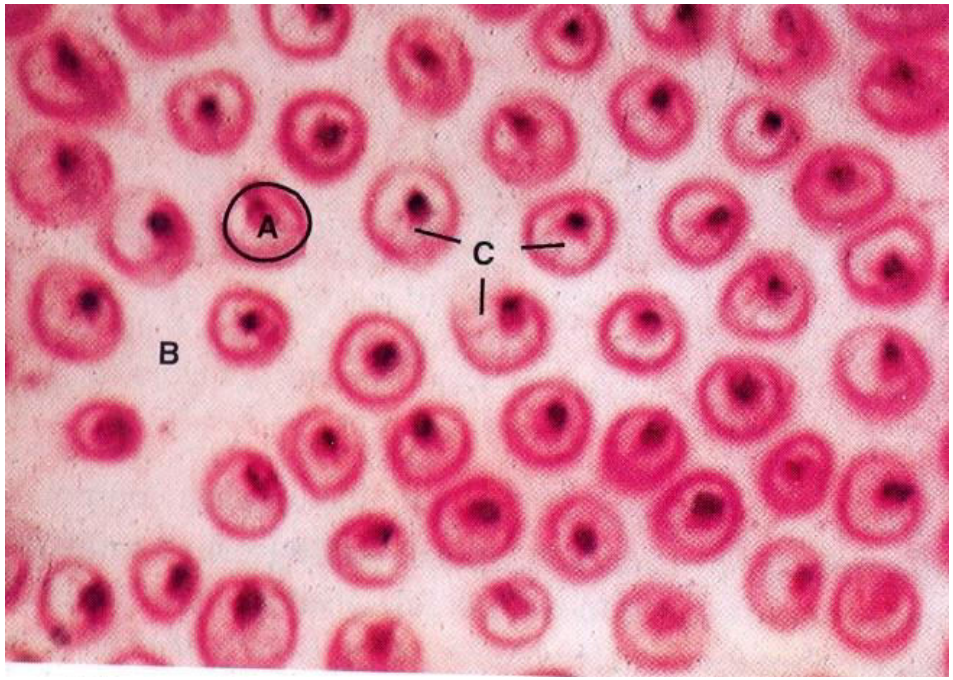
Intertubular Dentin

Peritubular Dentin



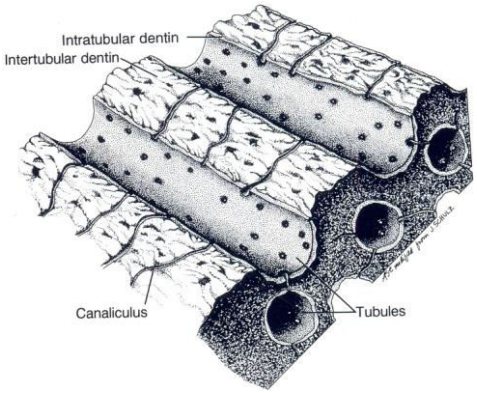


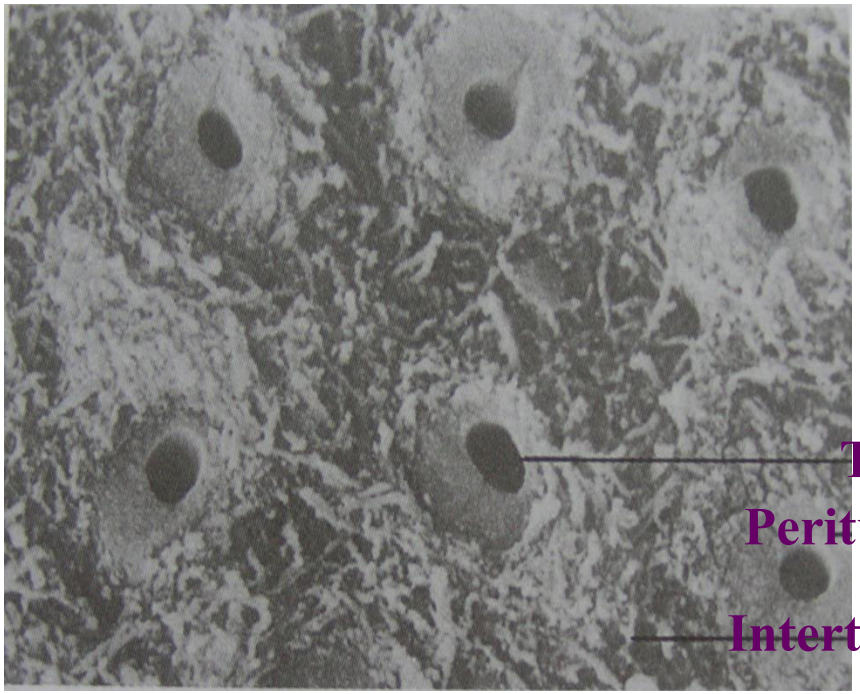
INTERTUBULAR DENTIN



- Dentin located between dentinal tubules.
- It represents primary secretary product of odontoblasts & consists of tightly interwoven network of Type-I collagen fibrils, in which hydroxyapatite crystals are deposited.

Ground substance : proteoglycans, phosphoproteins & glycoproteins.



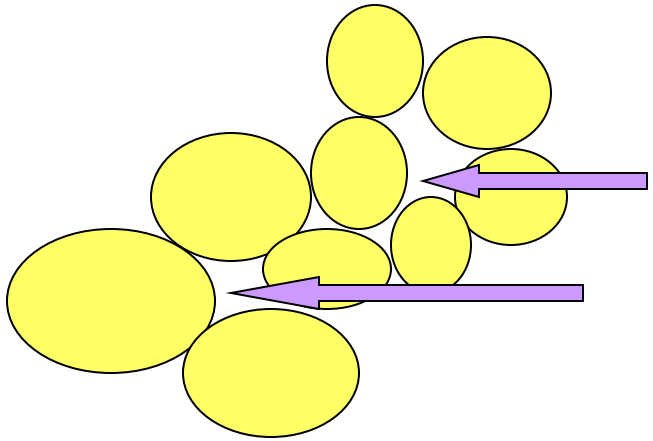


PERITUBULAR DENTIN: (INTRATUBULAR DENTIN)

- Present around the dentinal tubules.
- It is **hypermineralized.** (9 % more than intertubular)
- Lost after demineralization.
- Thicker in outer dentin(0.75 μm) than inner dentin (0.4 μm)
- Peritubular : Old term.
- Intratubular : Anatomically correct term.

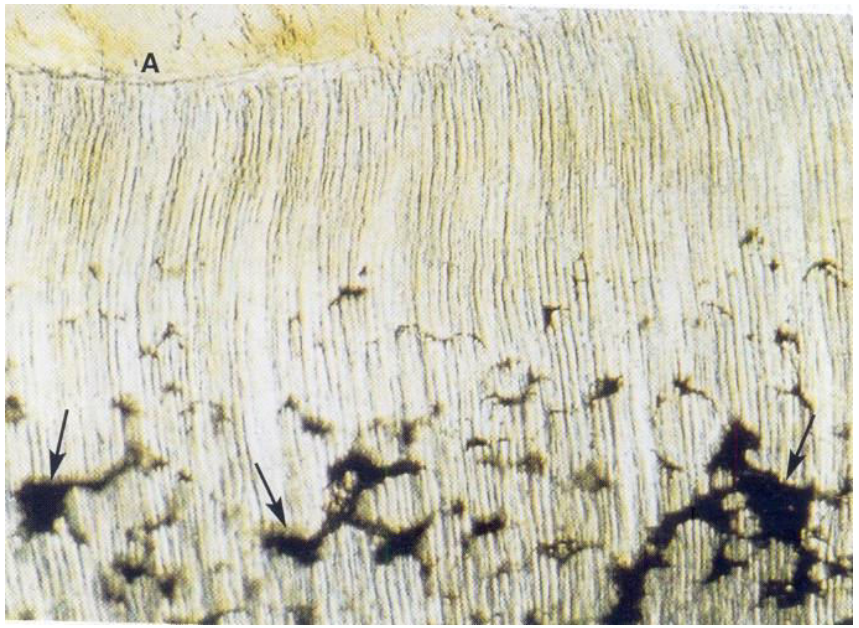
INTERGLOBULAR DENTIN

- Unmineralized or hypomineraized dentin where globular zones of mineralization have ***failed to fuse*** into a homogenous mass within mature dentin.



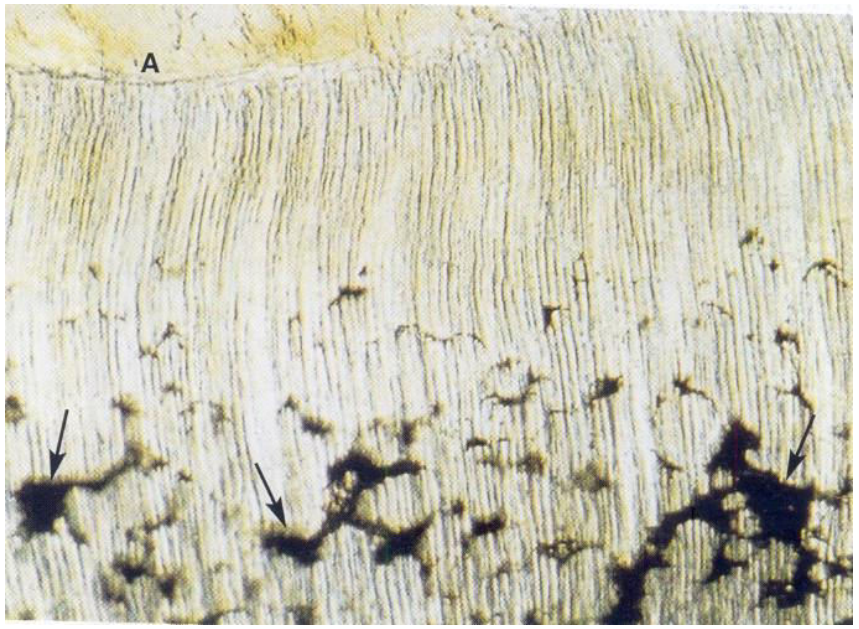
INTERGLOBULAR DENTIN

- It is seen most frequently in circumpulpal dentin just below mantle dentin.



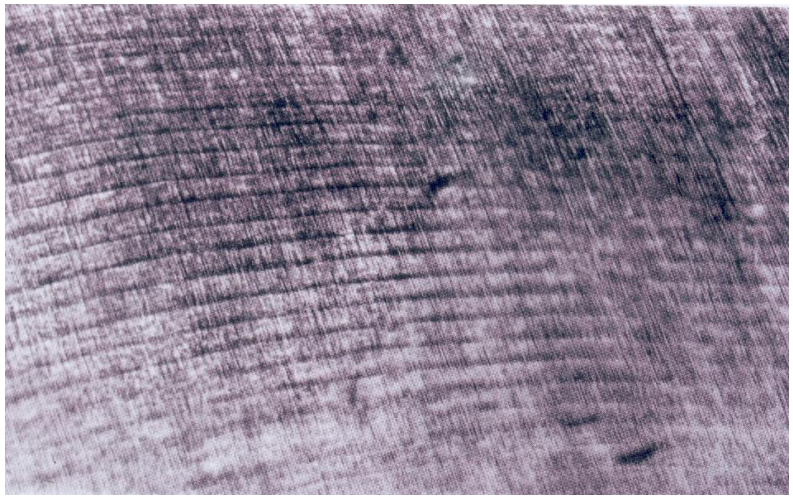
INTERGLOBULAR DENTIN

- It is the defect of mineralization & not of the matrix formation, the normal architectural pattern of the dentinal tubules remains unchanged, & they run uninterruptedly through interglobular dentin.



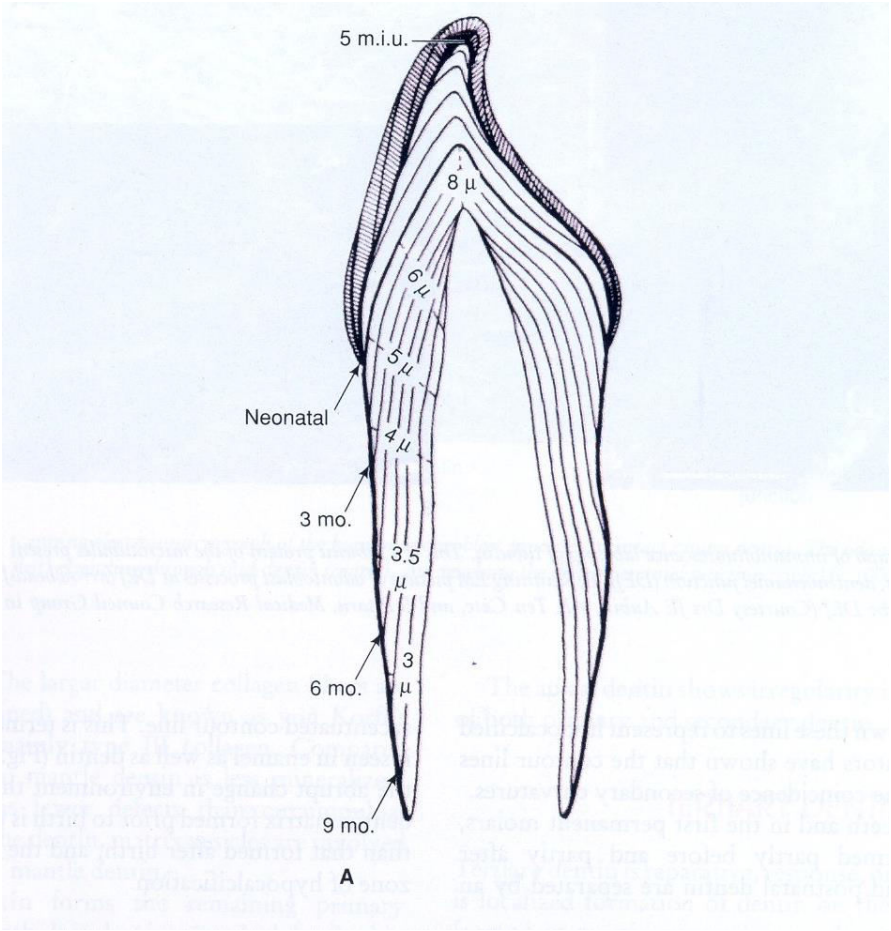
- In dried ground sections some of the interglobular dentin may be lost & a space results ,that appears black in transmitted light.

INCREMENTAL LINES OF DENTIN



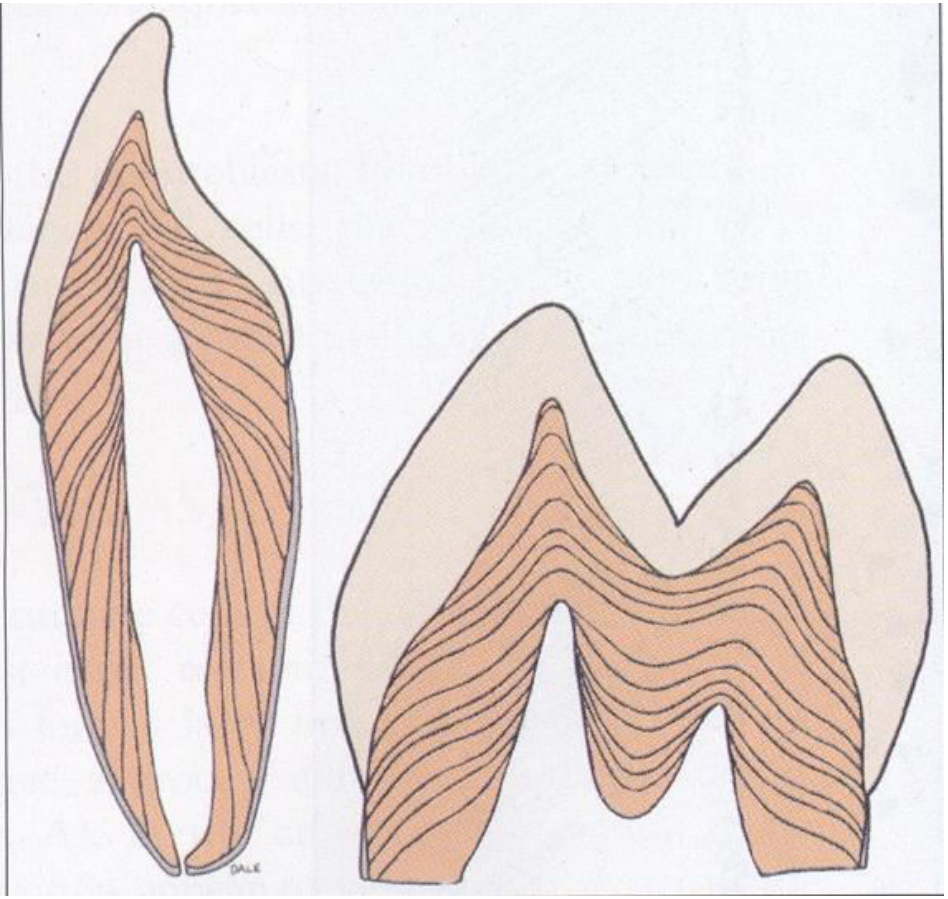
- Dentinogenesis proceeds rhythmically, with alternating phases of activity & quiescence.
- Daily increment is 4-8 μm. So the lines produced by this daily incremental deposition of dentin are called as ***imbrication lines/ Incremental lines of von Ebner.***

INCREMENTAL LINES OF *VON EBNER*



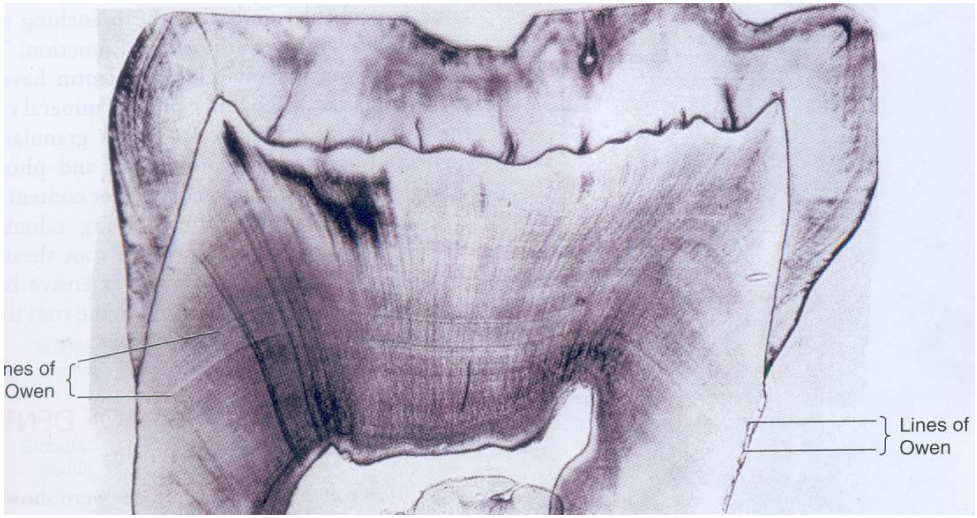
- The distance between lines varies.
- More in the crown than the root.
- Crown :8 μm/day
- Root :3-4 μm/day

INCREMENTAL LINES OF DENTIN



- The incremental lines run at right angles to dentinal tubules.
- According to some investigators, there is also a 5-day rhythmic pattern associated with dentin deposition, represented as incremental lines separated by 20 µm interval - ***Contour lines of*** **owen**

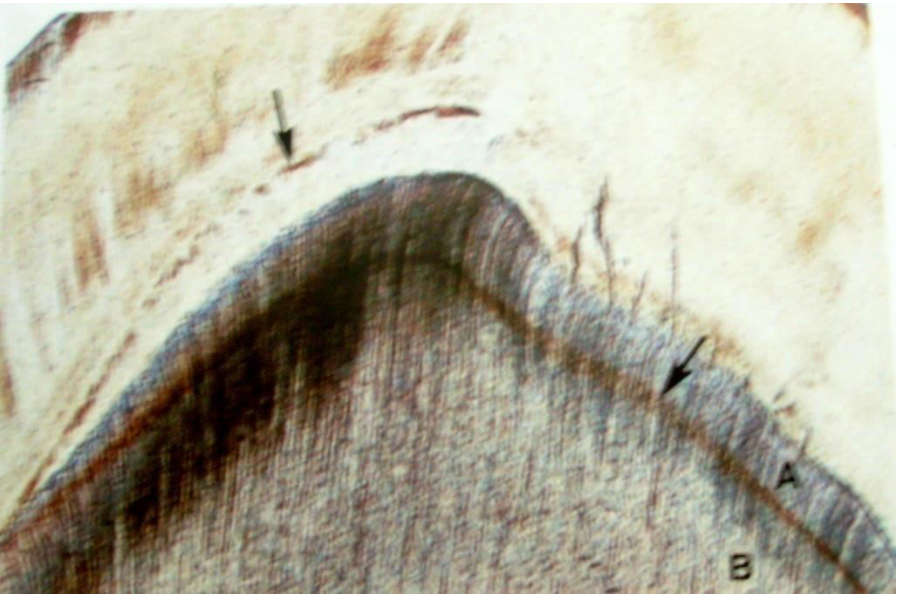
CONTOUR LINES OF OWEN


nes of
Owen
Lines of
Owen

CONTOUR LINES OF OWEN

- It is a optical phenomenon.
- They are produced due to coincident of secondary curvatures between neighboring dentinal tubules.
- Accentuated incremental lines of ***von Ebner***.
- Due to disturbances in matrix & mineralization process.

NEONATAL LINE

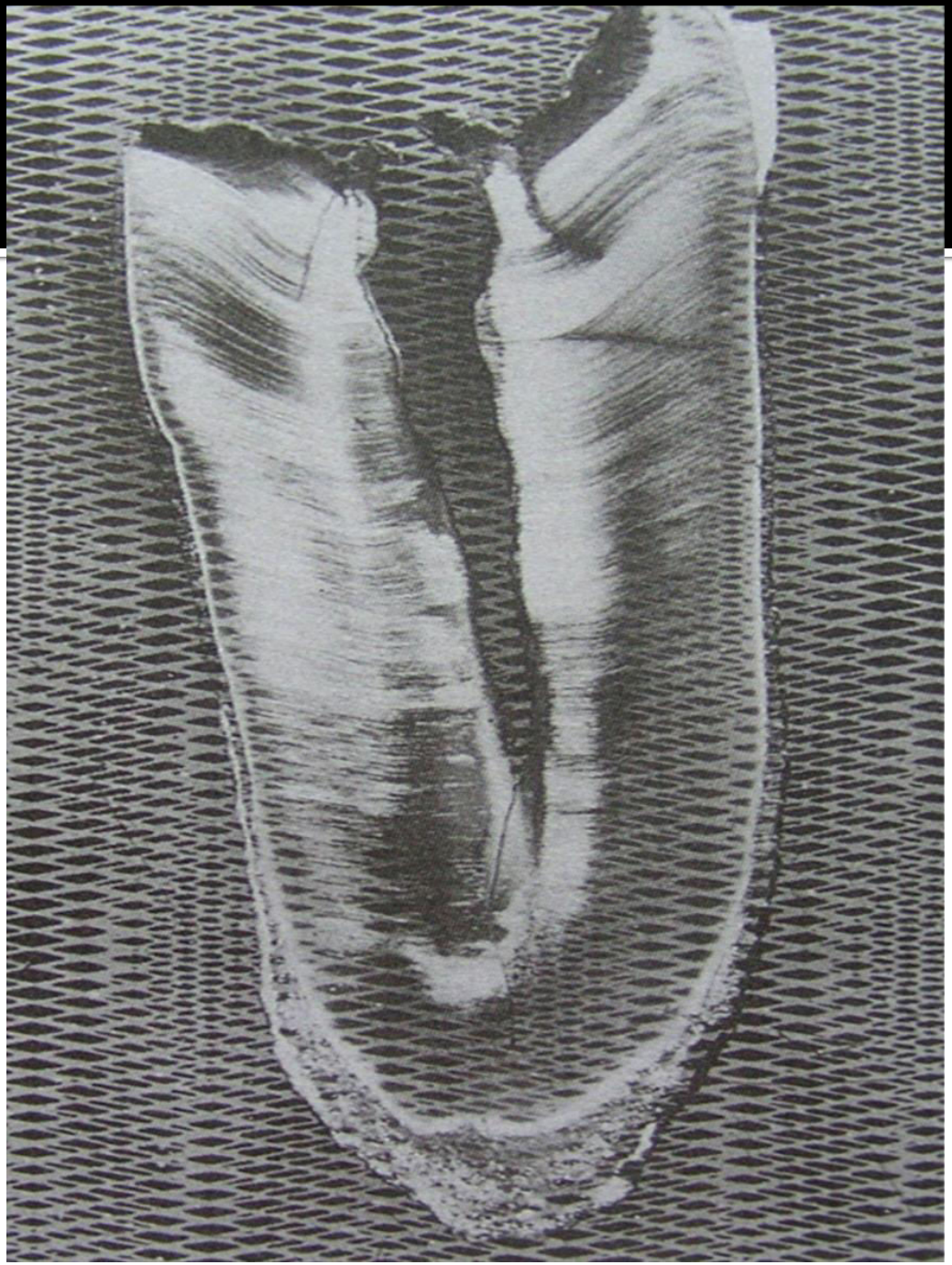


- An accentuated incremental line .
- Deciduous teeth & first permanent molars.
- Reflects the abrupt change in environment at birth.
- Demarcates the prenatal & postnatal dentin.
- Prenatal better than postnatal.
- May be a zone of hypocalcification.

AGE & FUNCTIONAL CHANGES

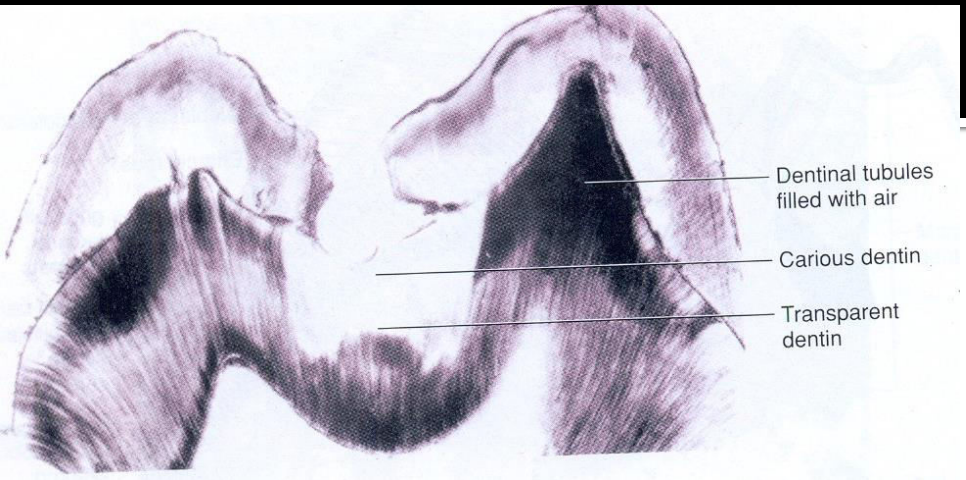
- Reparative dentin.
- Sclerotic dentin /Transparent dentin.
- Dead tracts.

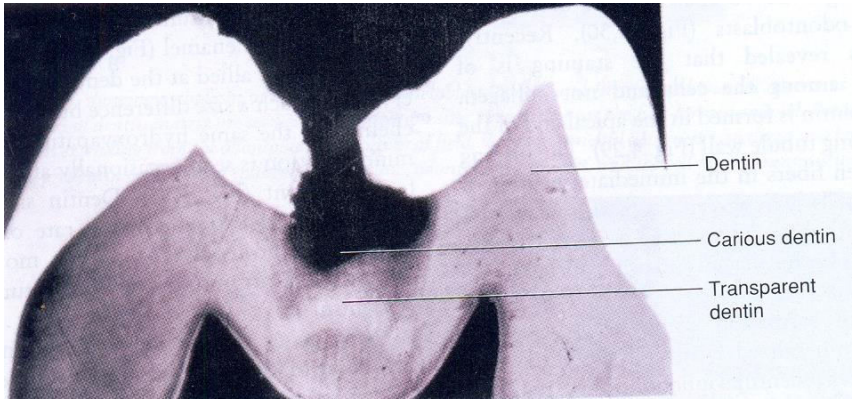
- Various stimuli, such as attrition, abrasion, erosion, caries or restorative procedures:
- Induce formation of reparative dentin.
- Protective changes in the existing dentin.

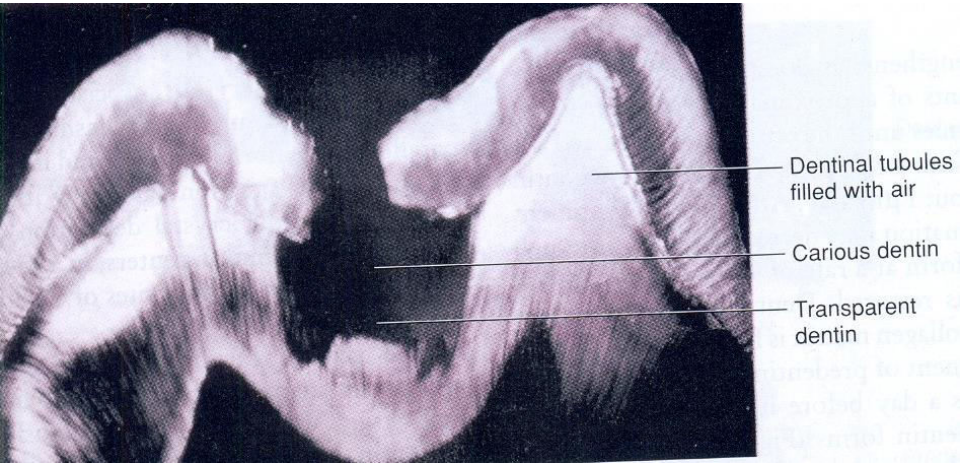


SCLEROTIC DENTIN: (TRANSPARENT DENTIN)

- It is the dentin where the dentinal tubules have become occluded with calcific material.
- When this occurs in several tubules in same area, the dentin assumes a glassy appearance.
- The contents of the tubule acquire the same R.I. as the intertubular dentin & so appear transparent.


Dentinal tubules filled with air
Carious dentin
Transparent dentin


Dentin
Carious dentin
Transparent dentin


Dentinal tubules filled with air
Carious dentin
Transparent dentin

- Amount of sclerotic dentin increases with age & is most common in the apical 3rd of the root.
- Also seen frequently – just below the exposed dentin. (above reparative dentin & near dead tracts)

- It is believed :-
  - Response to stimulus (attrition, caries, fractures)
  - Physiologic response -Age changing process
  - A defensive reaction of the dentin.
- Reduces the permeability of dentin & help to prolong pulp vitality.

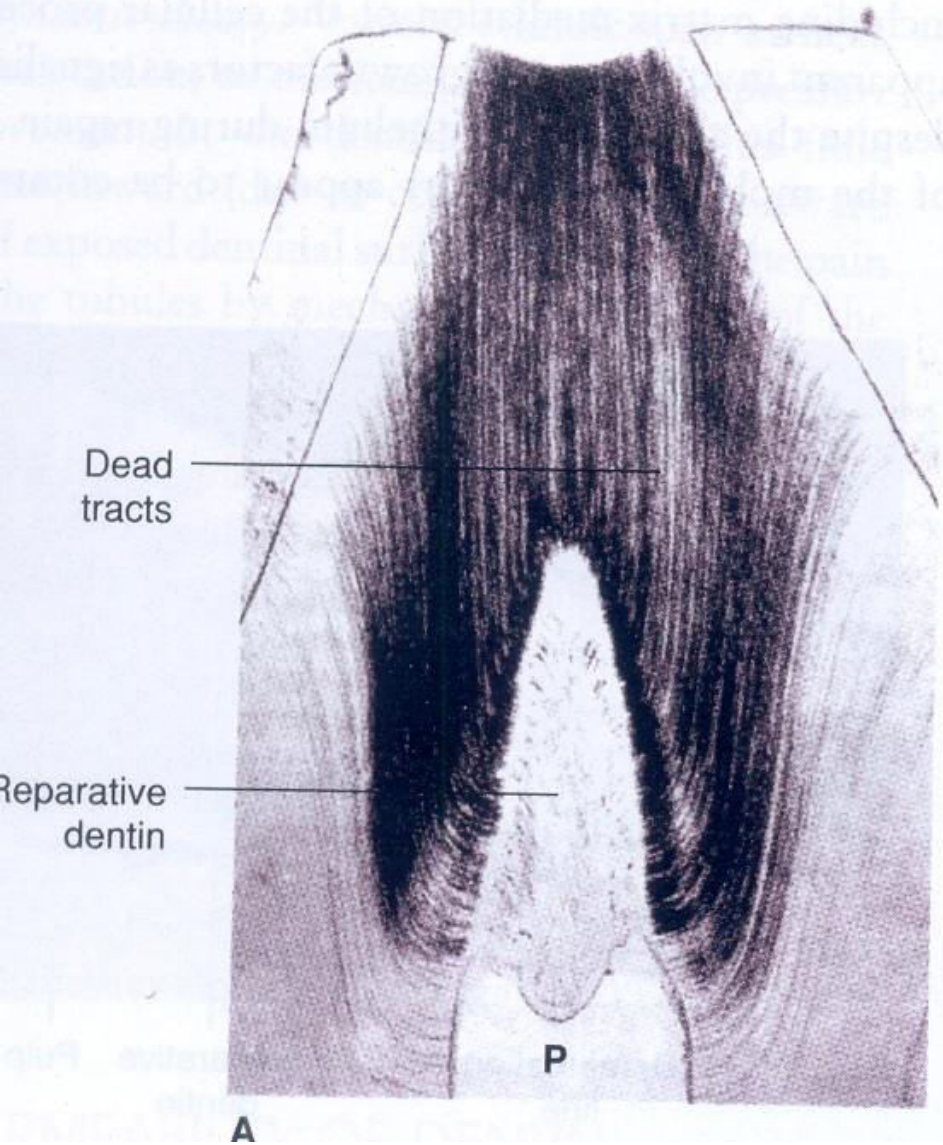
- Assumed that :
- Occlusion of the dentinal tubules is achieved by continued deposition of intratubular dentin.
- Deposition of mineral within the tubule without any intratubular dentin formation.
- A diffuse mineralization occurs with a viable odontoblast process still present.
- Mineralization of both the process & the tubular content.

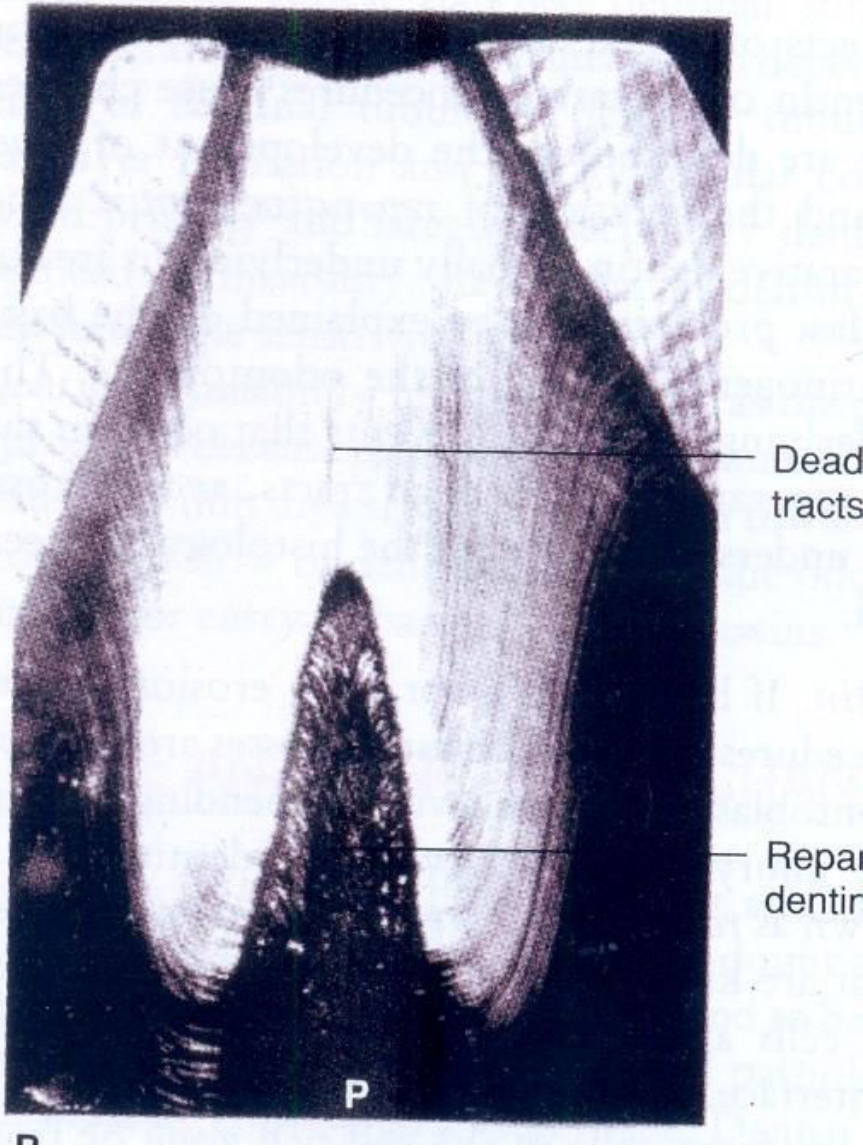
DEAD TRACTS

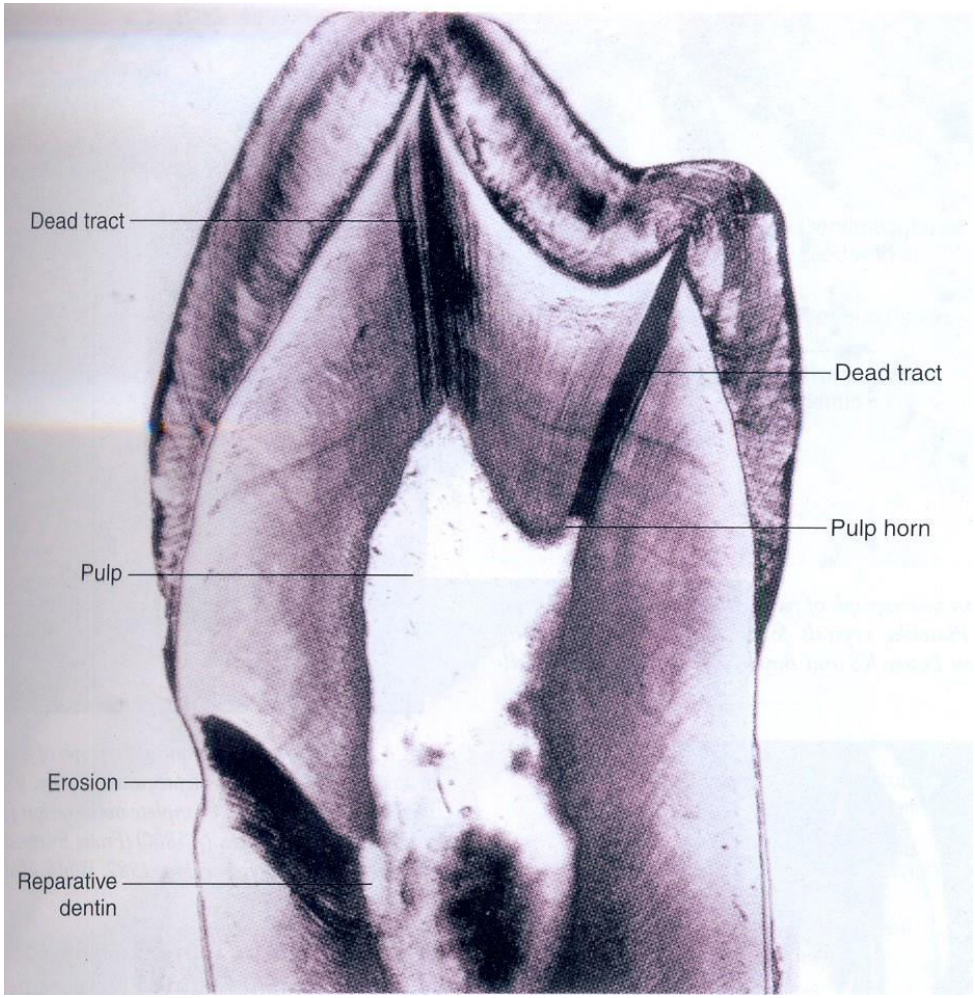
- Due to an external stimulus, dentinal tubules are emptied either by complete retraction of the odontoblastic process from the tubule or through death of odontoblast cell.
- In ground section the empty dentinal tubules are filled with air & hence appear:

Transmitted light

Reflected light

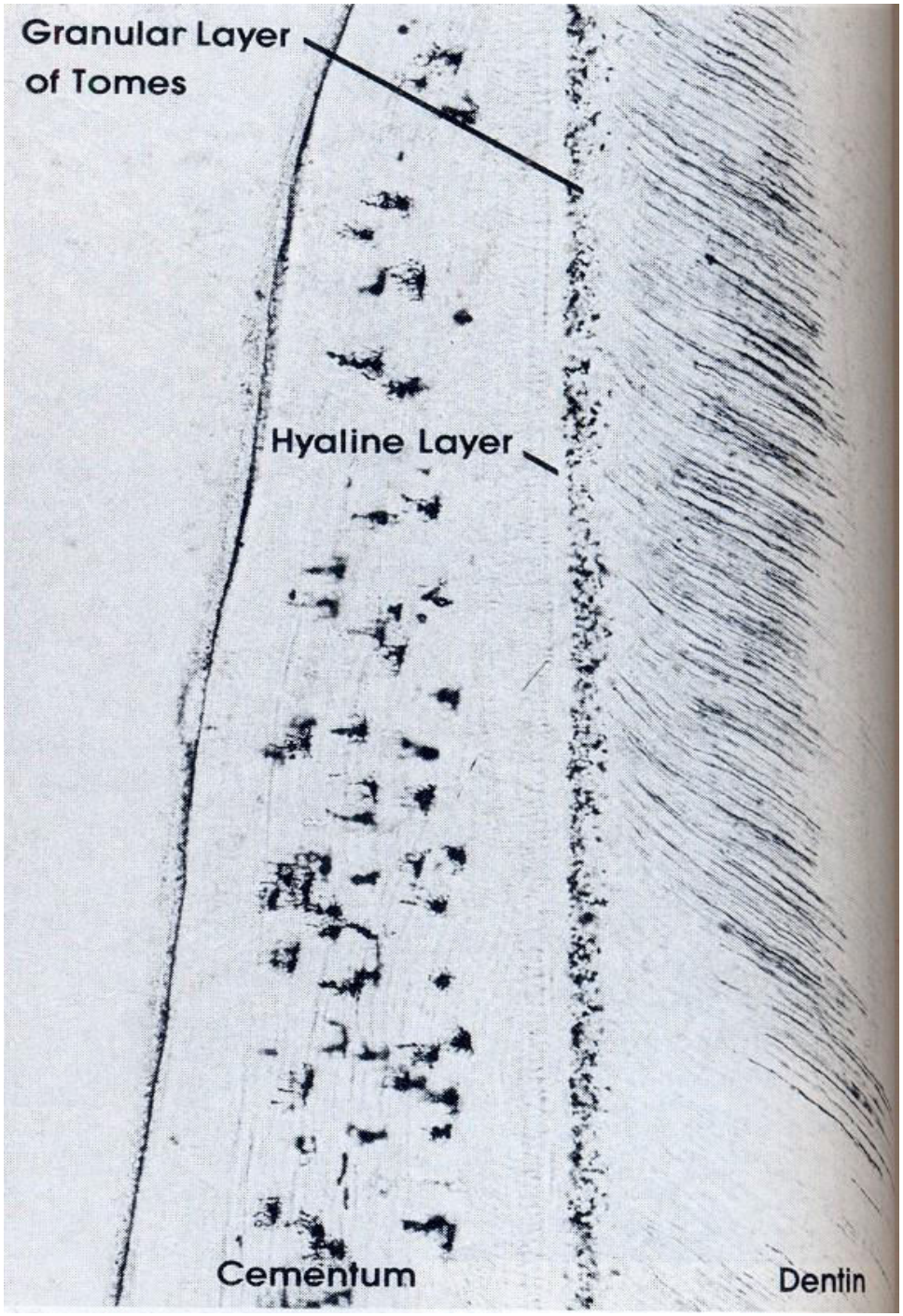






- It is believed : --
  - Response to stimulus
  - Age changing process
- Dead tracts occur most often in coronal dentin & are bound by sclerotic dentin.

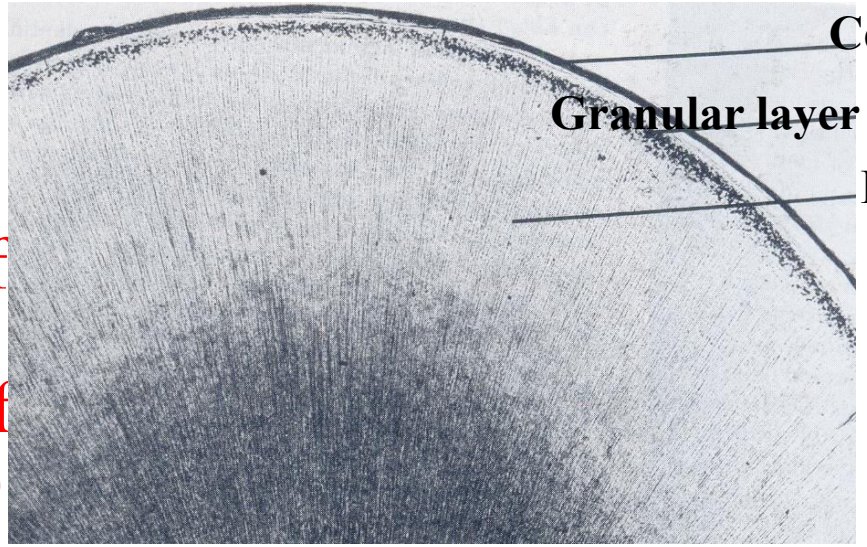
- .

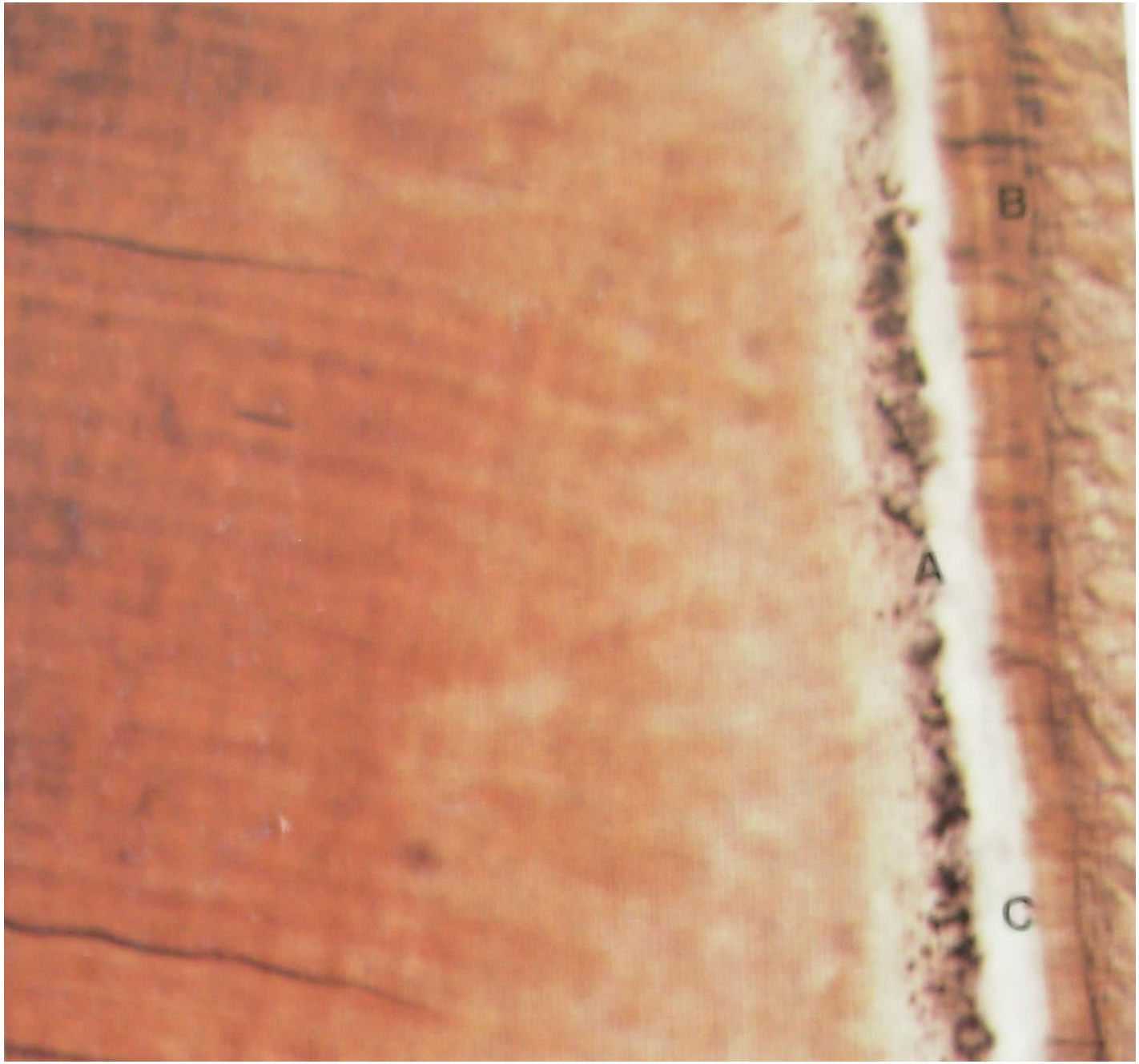

Granular Layer
of Tomes
Hyaline Layer
Cementum
Dentin

GRANULAR LAYER OF TOMES

- In dry ground section of root dentin, a zone adjacent to the cementum appears granular in transmitted light ,known as –***granular layer of Tomes*** .
- Increases slightly in amount from the CEJ to the root apex.
- Hypominaralised as compared to circumpulpal dentin

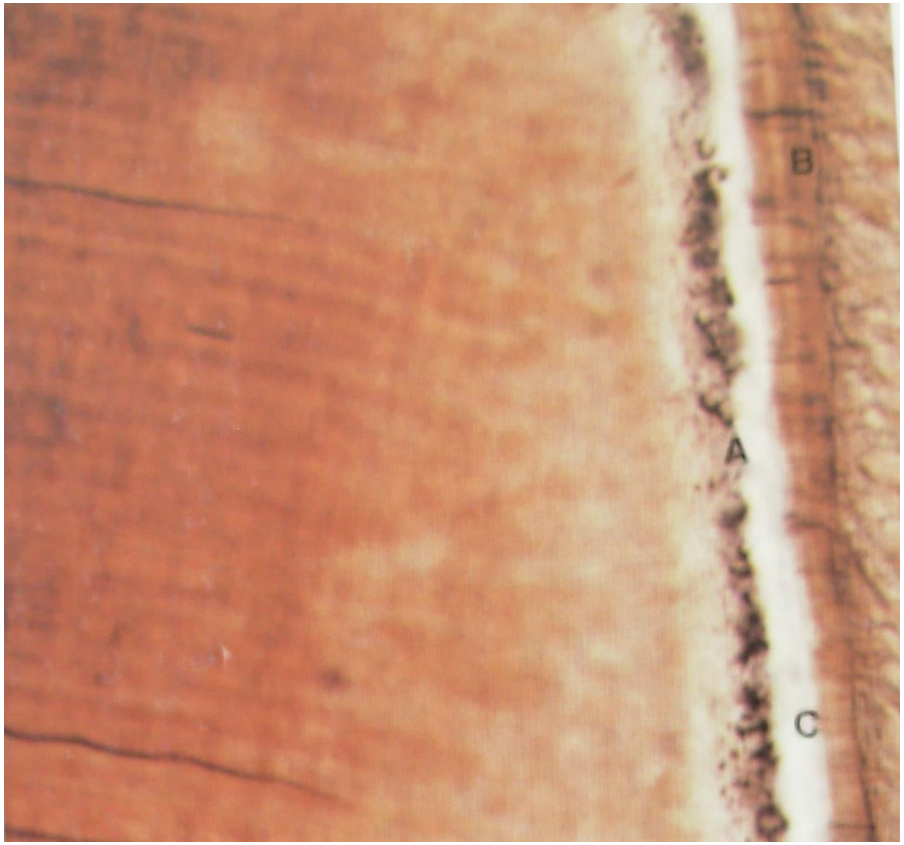
- Believed to be caused by:
- Coalescing & looping of the terminal portions of the dentinal tubules.
- Profuse branching of dentinal tubules.
- Differences in the rate of formation of coronal & root dentin (lower rate of dentin formation in root)

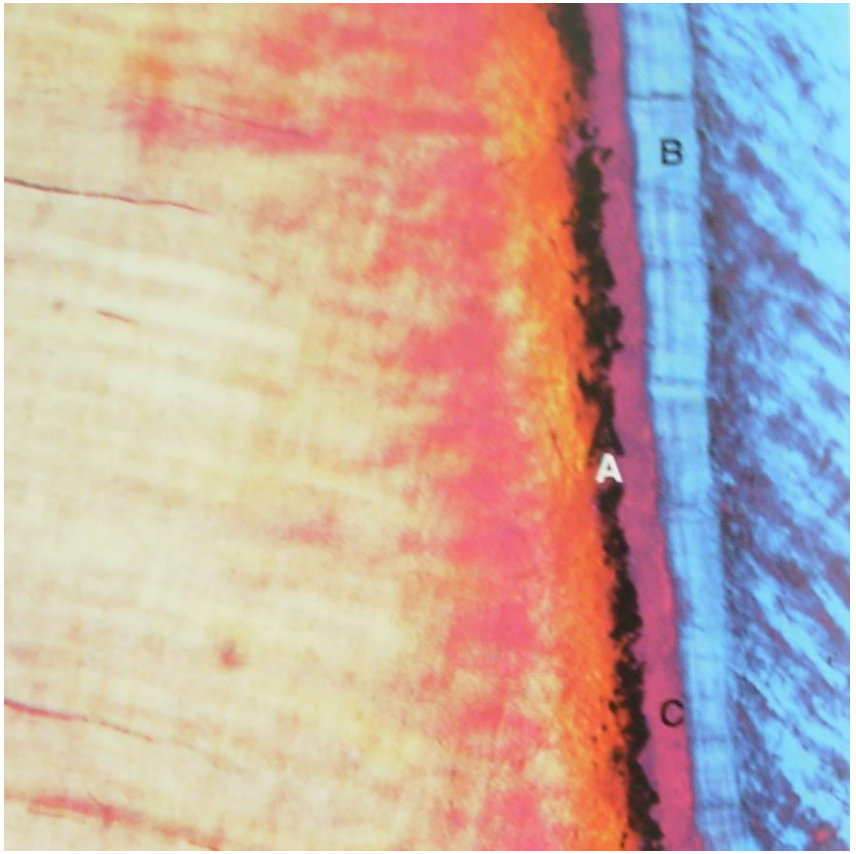



B
A
C

HYALINE LAYER

- Peripheral to the granular layer of Tomes, and separating it from cementum is a thin structureless layer,(20 μm) known as ***Hyaline layer of Hopewell Smith.***
- May serve to bond cementum to dentin.


B
A
C


B
A
C

CONTENTS

- **INNERVATION OF DENTIN**
- **THEORIES OF DENTIN SENSITIVITY**

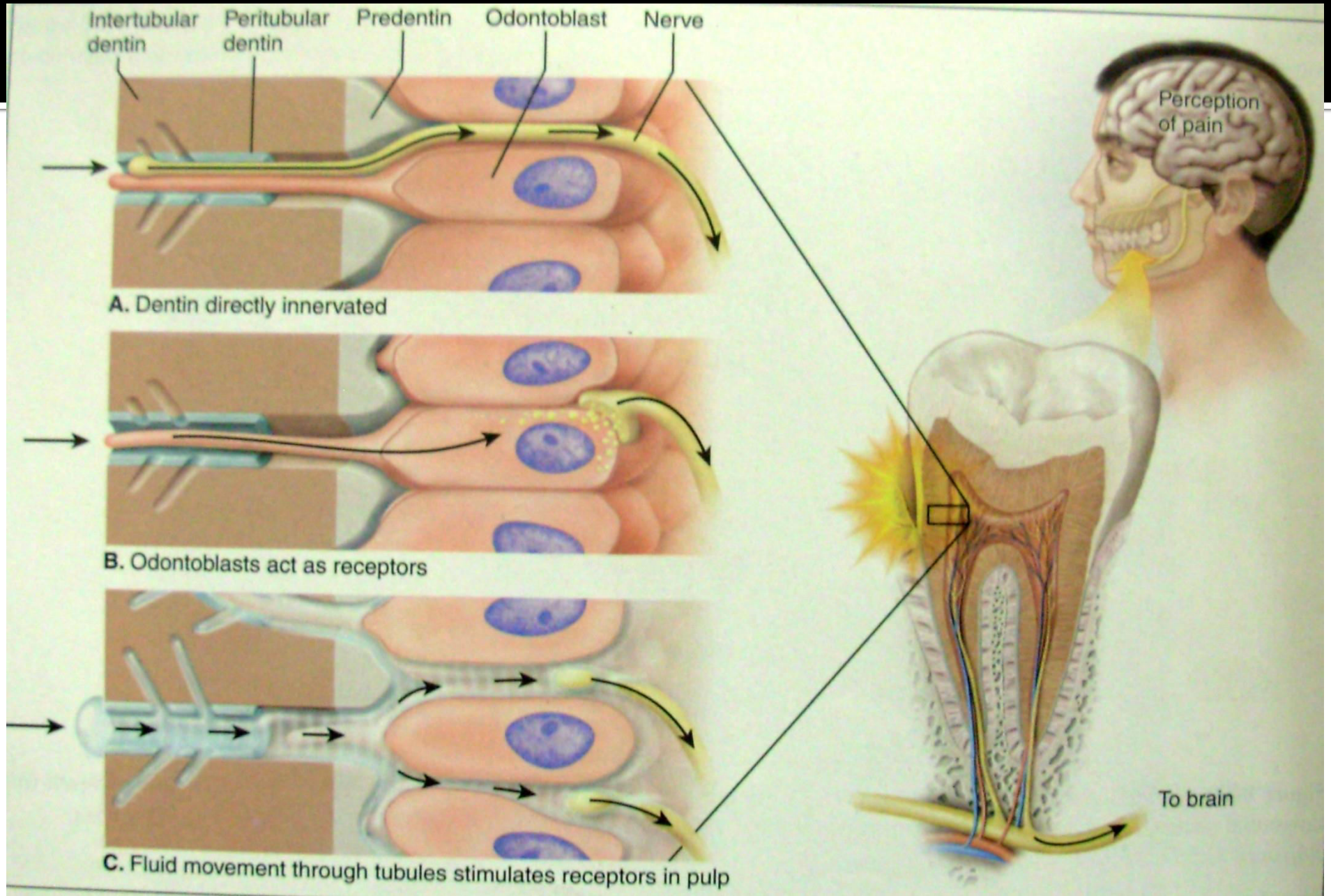
INNERVATION OF DENTIN

- **Intratubular nerves**: nerve fibers accompany 30-70% odontoblastic processes,known as ***Intratubular nerves.***
- Dentinal tubules contain numerous nerve endings in the predentin & inner dentin upto 100 to 150 μm from the pulp.
- Vesiculated endings are located in tubules in the coronal zone, specifically in the pulp horns.

DENTIN SENSITIVITY

- Three theories of dentin sensitivity:
- Dentin contains nerve endings that respond when it is stimulated.
- The odontoblasts serve as receptors & are coupled to nerves in the pulp.
- Tubular nature of dentin permits fluid movement to occur within the tubule when a stimulus is applied.

THEORIES OF DENTIN SENSITIVITY



Direct innervation theory (*Direct neural stimulation*)

- Nerves in the dentin gets stimulated BUT nerves in the dentinal tubules are not commonly seen & & even if present they do not extend beyond inner dentin
- NOT ACCEPTED

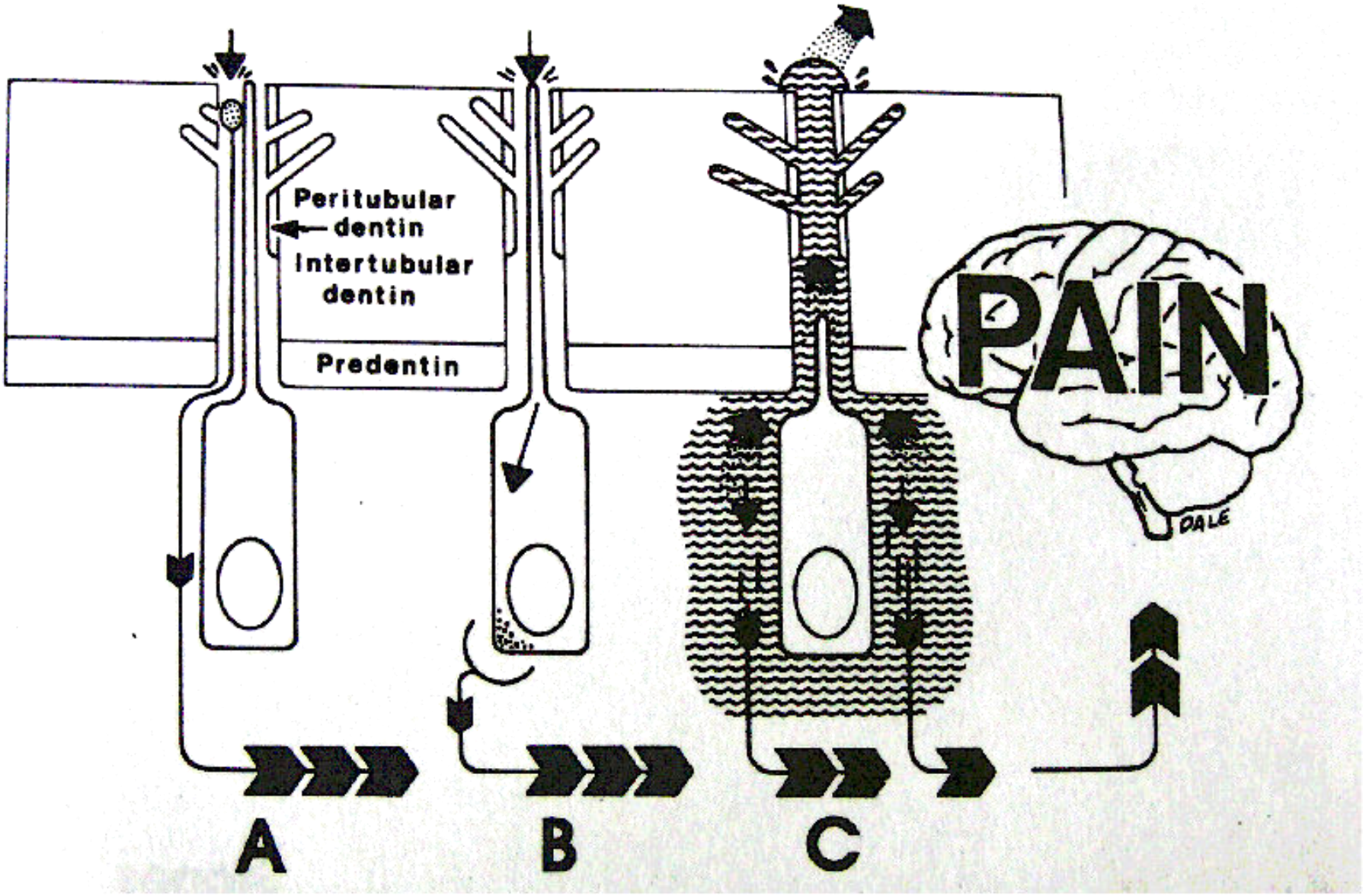
Hydrodynamic theory

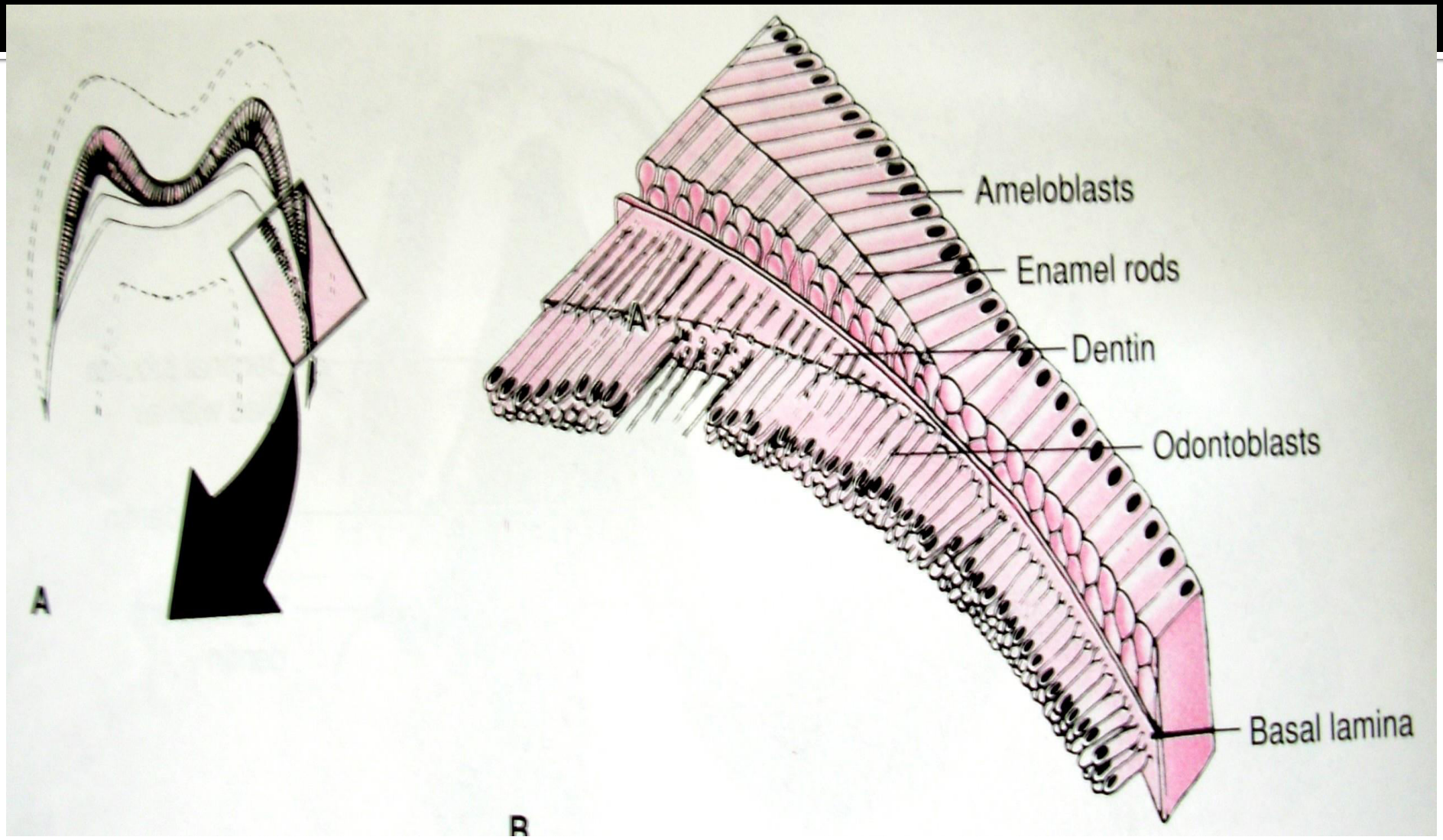
- Various stimuli such as heat ,cold, air blast dessication, mechanical or osmotic pressure affect fluid movement in the dentinal tubules.
- Fluid movement stimulates the pain mechanism in the tubules by mechanical disturbance of the nerves.
- Nerve endings may act as mechanoreceptors

Transduction theory

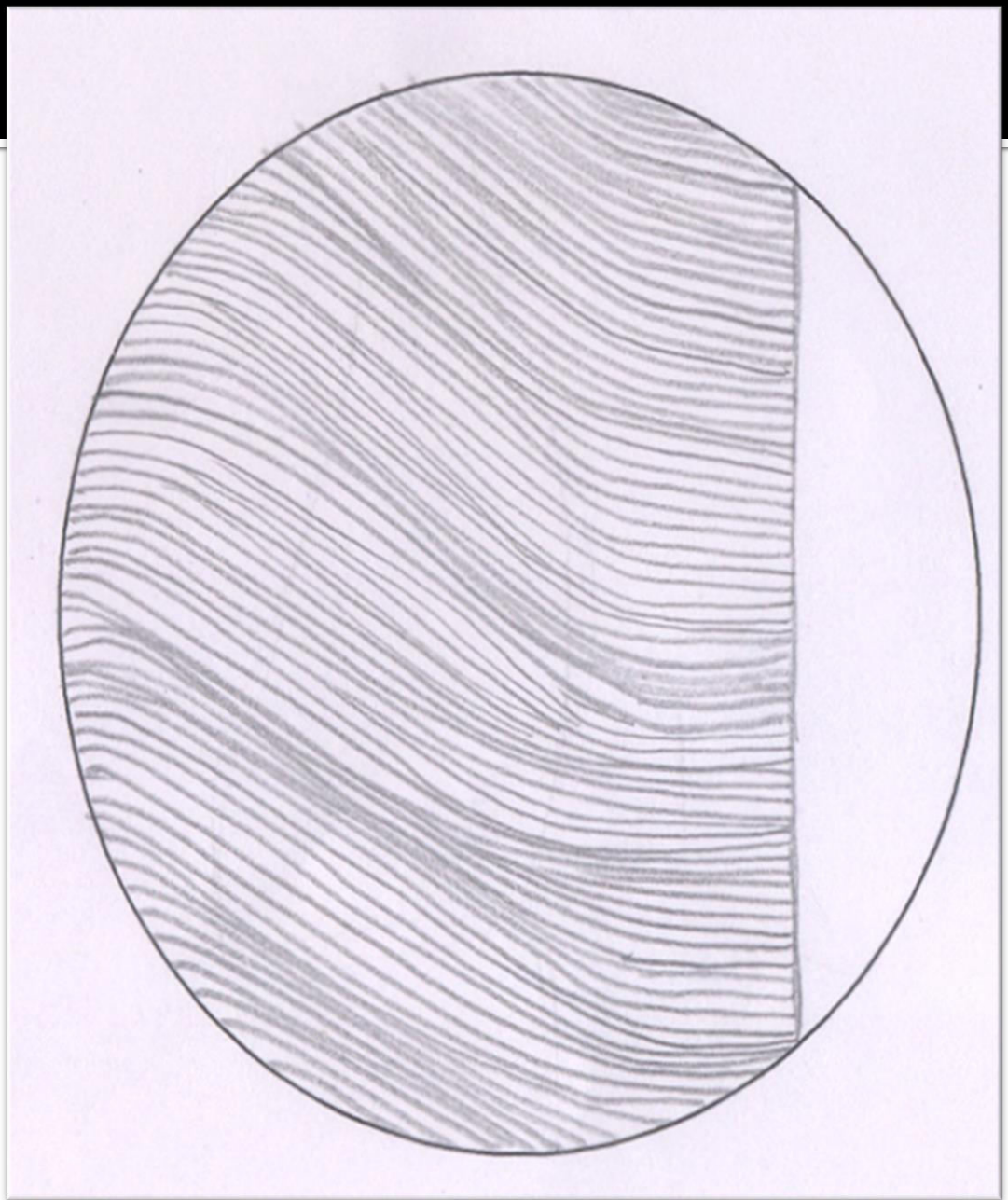
- Odontoblast process –primary structure excited by the stimulus & impulse is transmitted to the nerve endingss

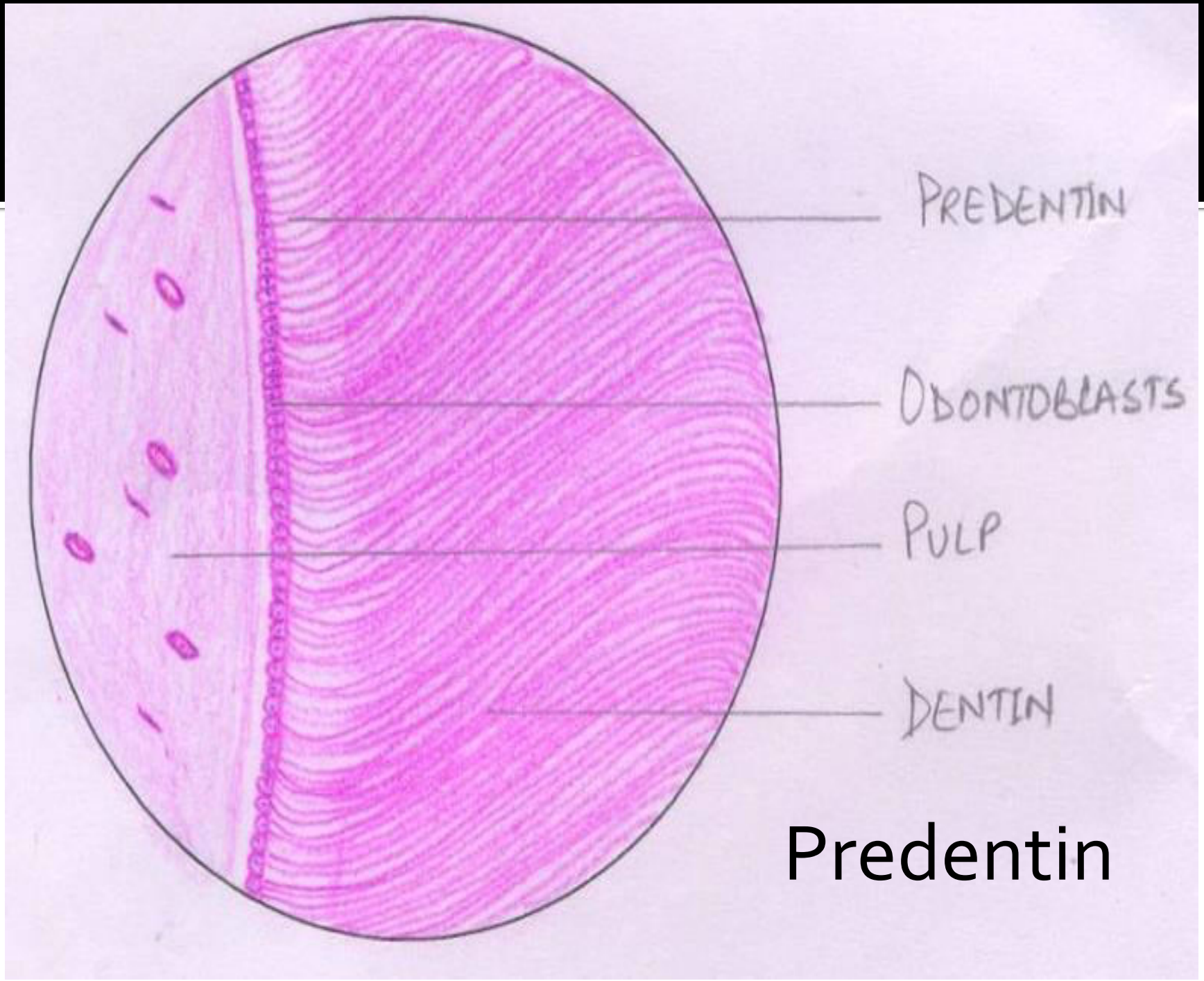
Direct innervations | Transduction | Hydrodyanamic



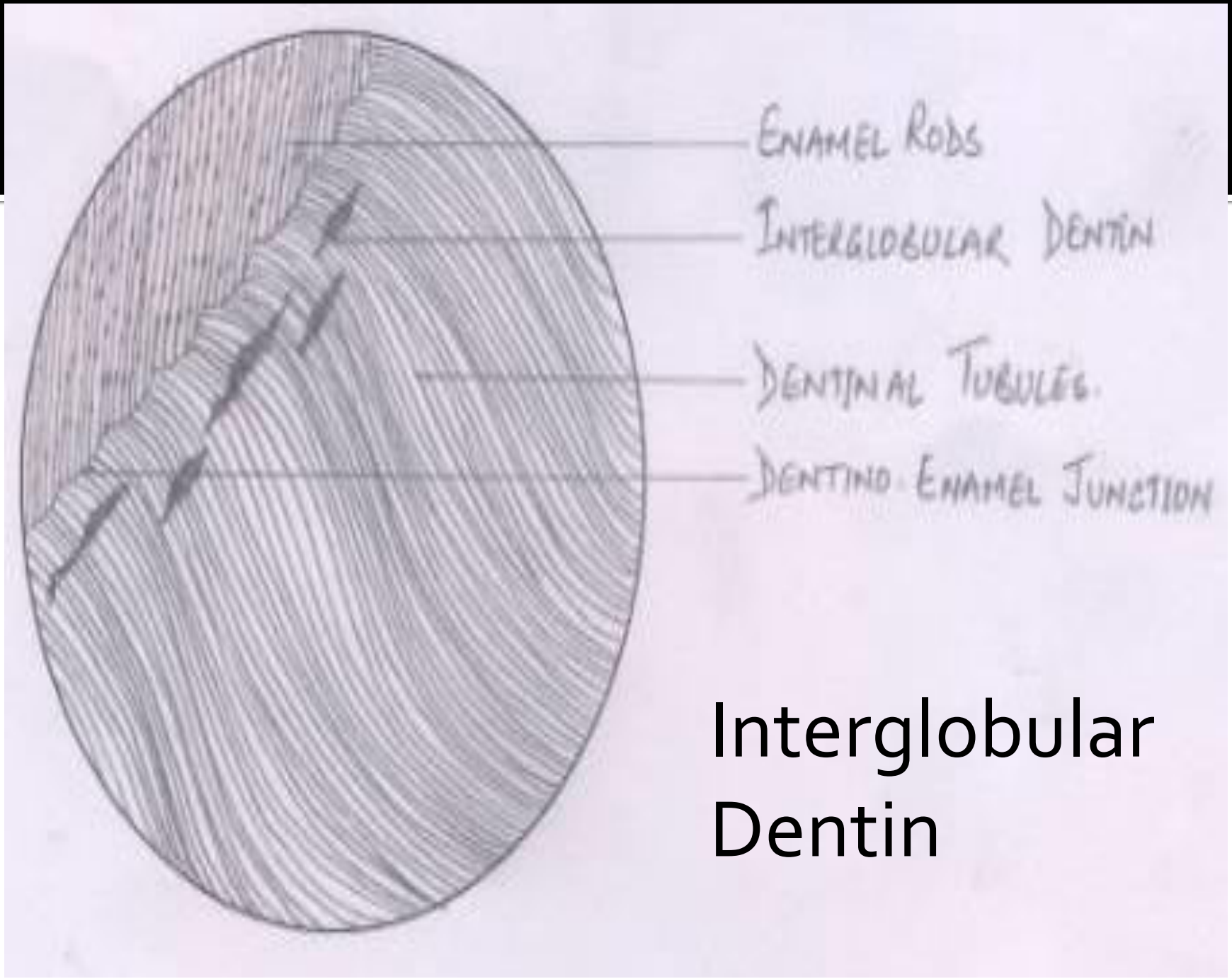

A
A
Ameloblasts
Enamel rods
Dentin
Odontoblasts
Basal lamina
B

Primary & Secondary Dentin

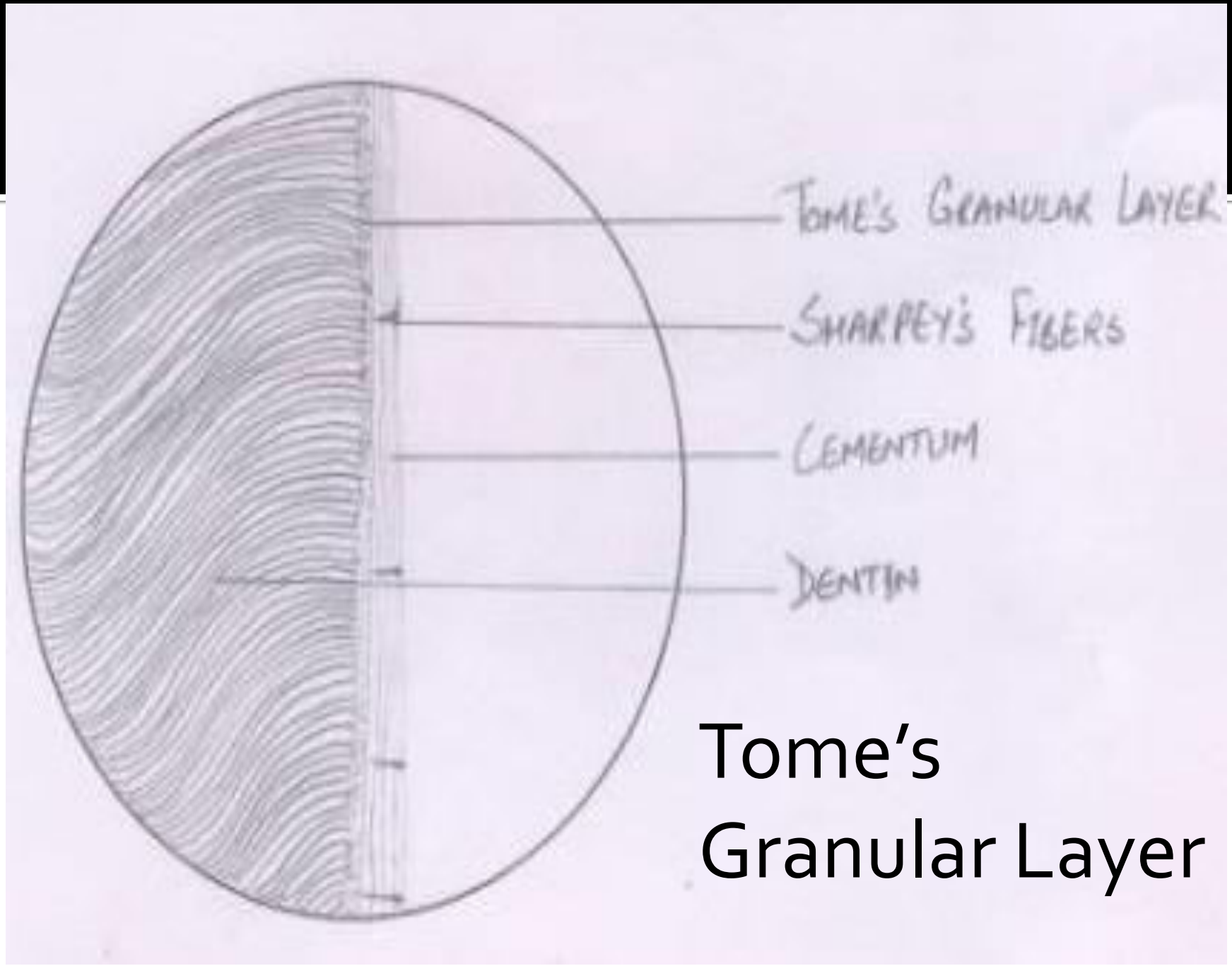




Predentin

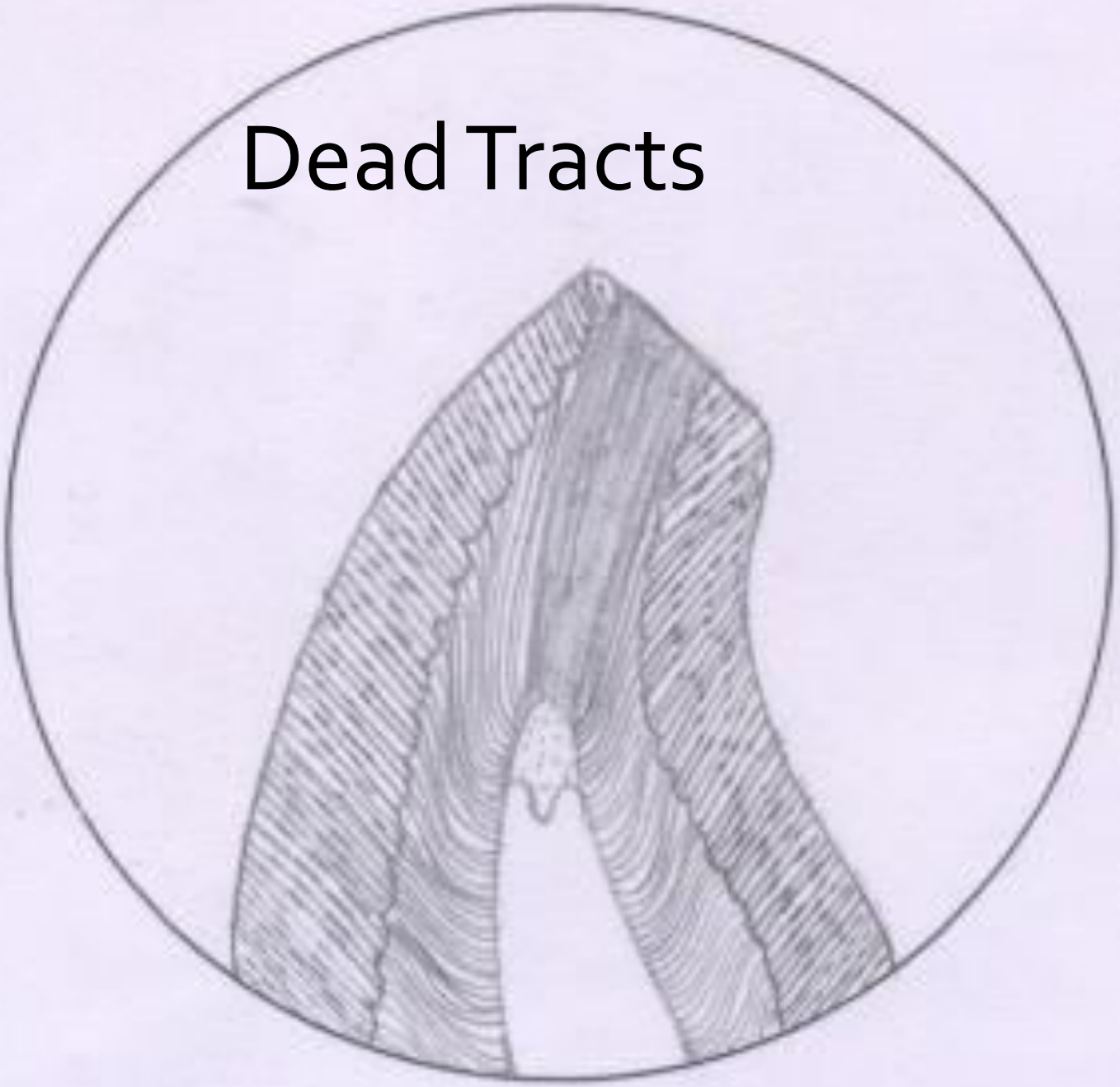


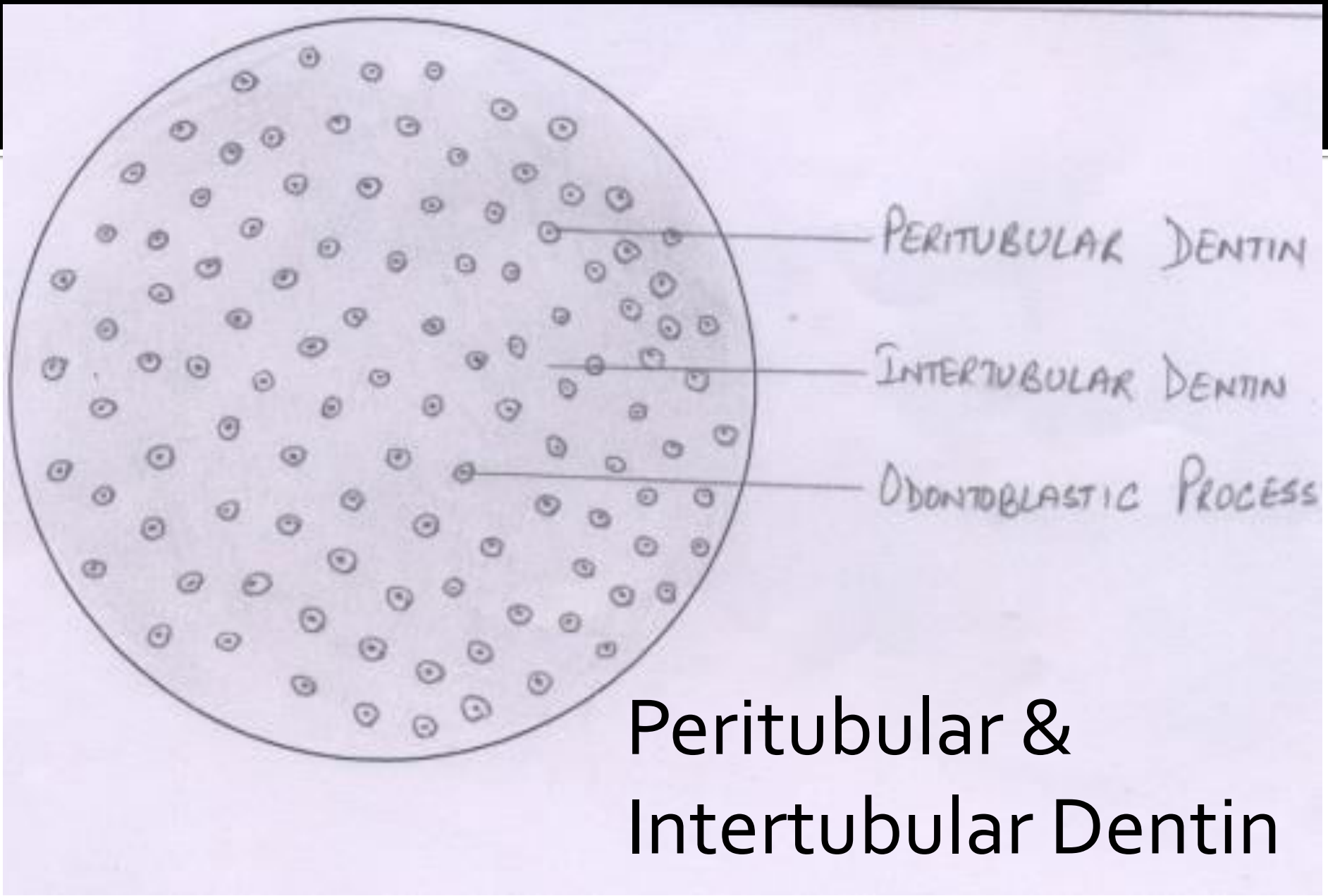
Interglobular Dentin



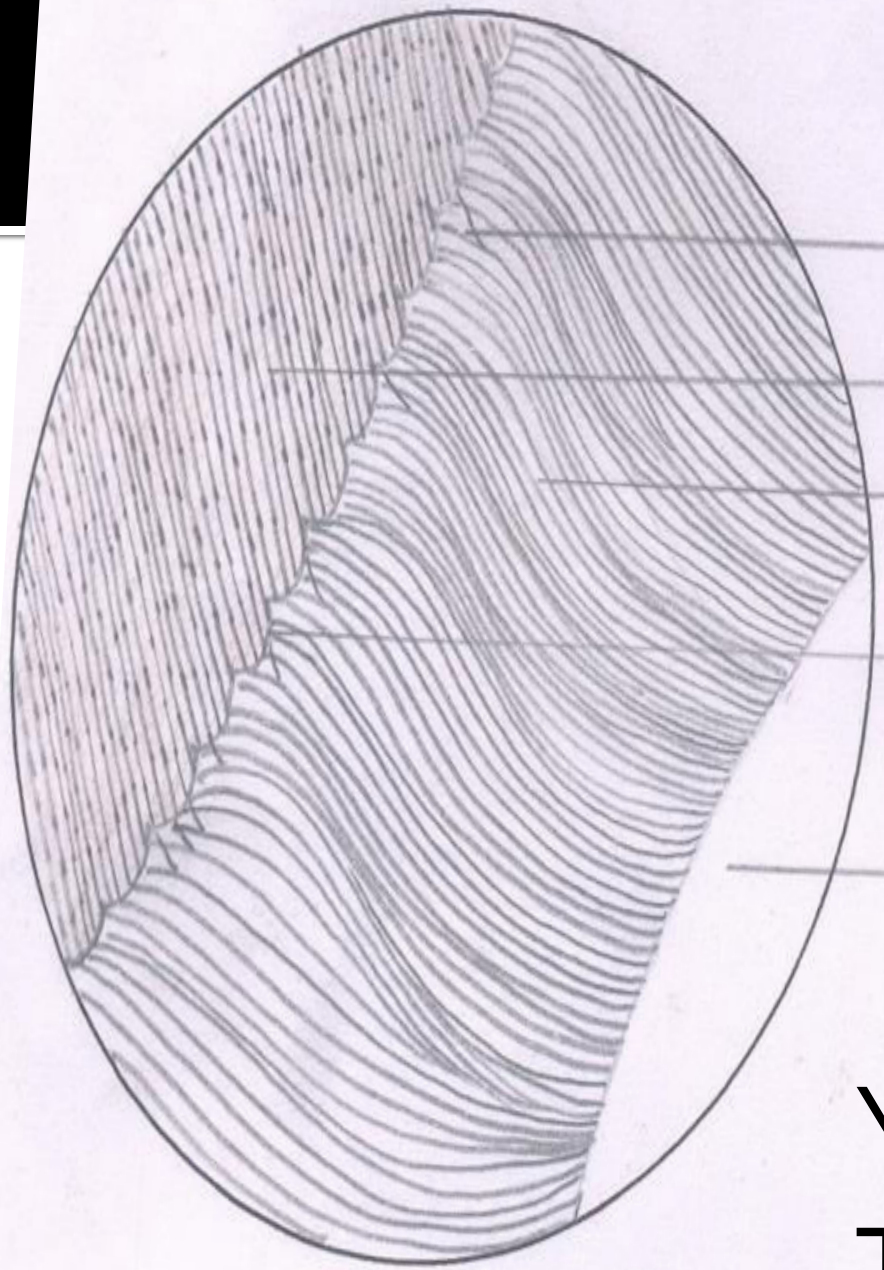
Tome's Granular Layer

Dead Tracts





Peritubular & Intertubular Dentin



Y-Shaped Dentinal Tubules