

ENAMEL

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INTRODUCTION

Good knowledge of 4 main dental tissues & their relationships to each other & of the supporting structures is necessary for excellence in the performance of operative procedures.

- Enamel
- Dentin
- Cementum
- Dental Pulp

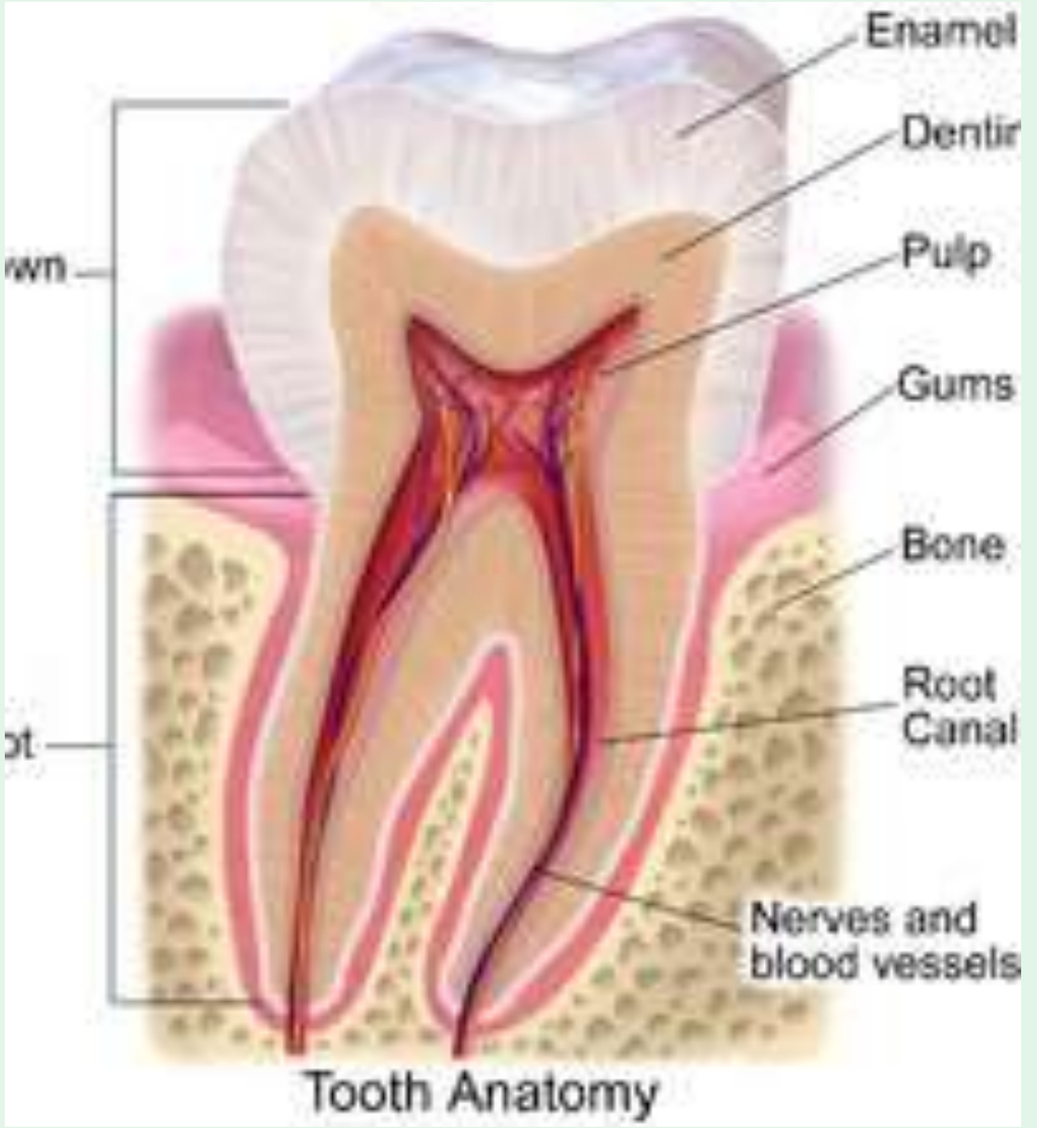
ENAMEL

- Hard protective substance that covers the crown of the tooth
- Hardest biological tissue
- Thins down to almost knife edge at neck of the tooth

PHYSICAL PROPERTIES:

1. Thickness

- **2.5mm** (thickest) Over cusp of molar
- **2.0 mm** over incisal edge
- Knife edge thickness at cervical region
- Thick at maxillary lingual surfaces of molars & Mandibular buccal surfaces



2. Color

- DEPENDS ON THICKNESS & translucency OF enamel

- Grayish white to yellowish white.
- Yellowish - AT THIN areas UNDERLYING DENTIN.
- Grayish - THICK opaque enamel

- Bluish-incisal area

3. Hardness

- Hardest structure in the body
- Peripheral region -more harder

4. Solubility

- Dissolves in acidic media

5. Permeability

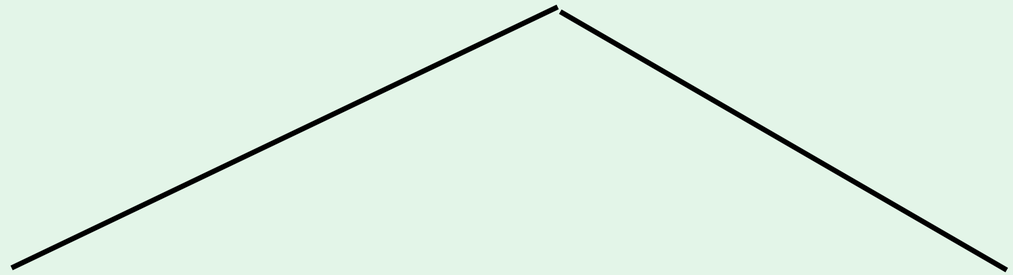
- ***Selectively permeable***

- Route of passage occurs via rod sheath, enamel lamellae & enamel tufts which are rich in organic content

6. Translucency

- *Semi translucent*

C H E M I C A L
P R O P E R T I E S



- Inorganic content - 96%
- Organic content - 4%

INORGANIC CONTENT

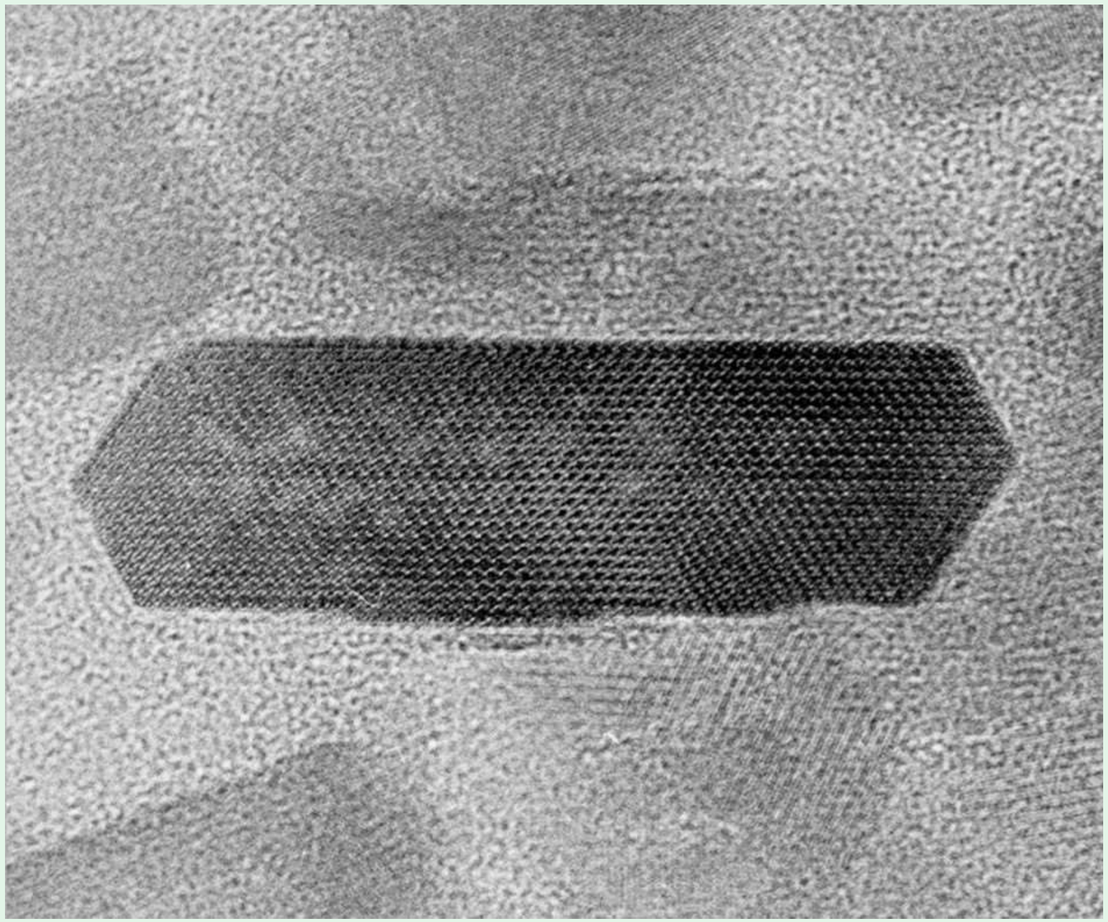
1. **Minerals**

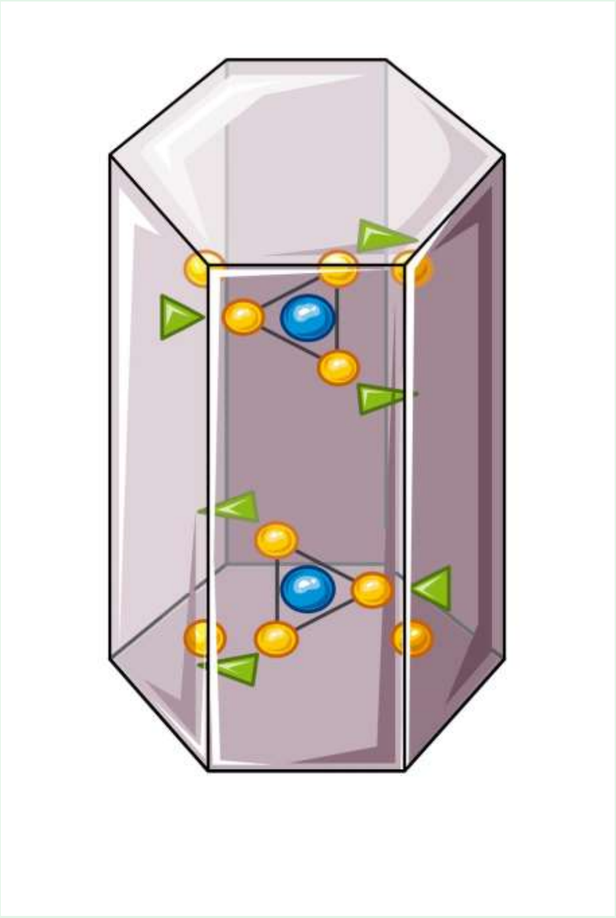
Hydroxyapatite Calcium phosphate

$Ca_{10}(PO_4)_6(OH_4)_2$

Crystals- Hexagonal in cross- section

The shape of single crystal under high resolution scanning electron microscope - rod with equilateral hexagon base





2. IONS

Strontium,
magnesium,
lead,
fluoride .

Organic Content -4%

Amelogenins

90%

- Hydrophobic
- low mol. Wt. Proteins
- Rich in **prolien histidine , glutamine, leucine**

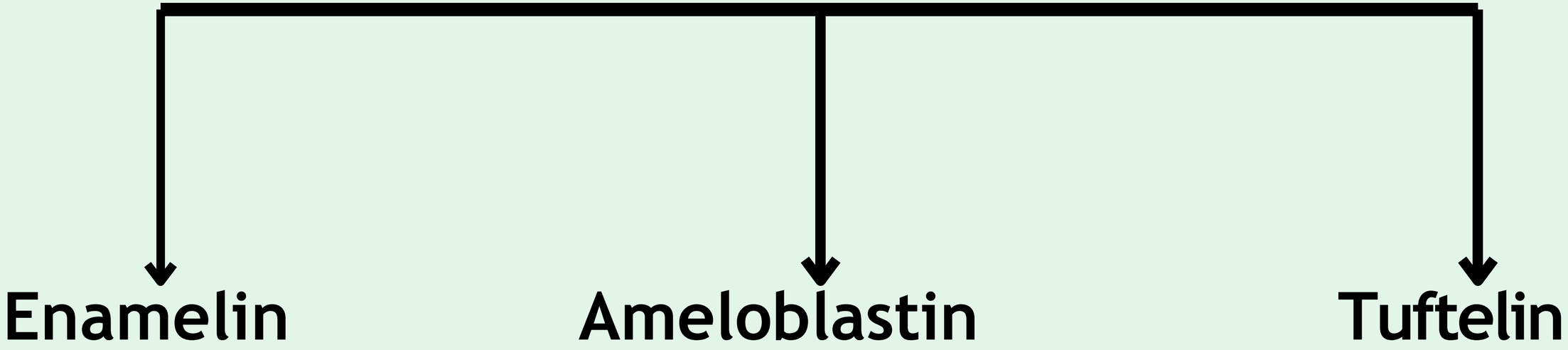
Non- amelogenins

10%

- High mol. Wt. Proteins
- rich in **glycine , aspartic acid, serine**

Non- Amelogenins

10%



HYPOCALCIFIED STRUCTURES OF ENAMEL

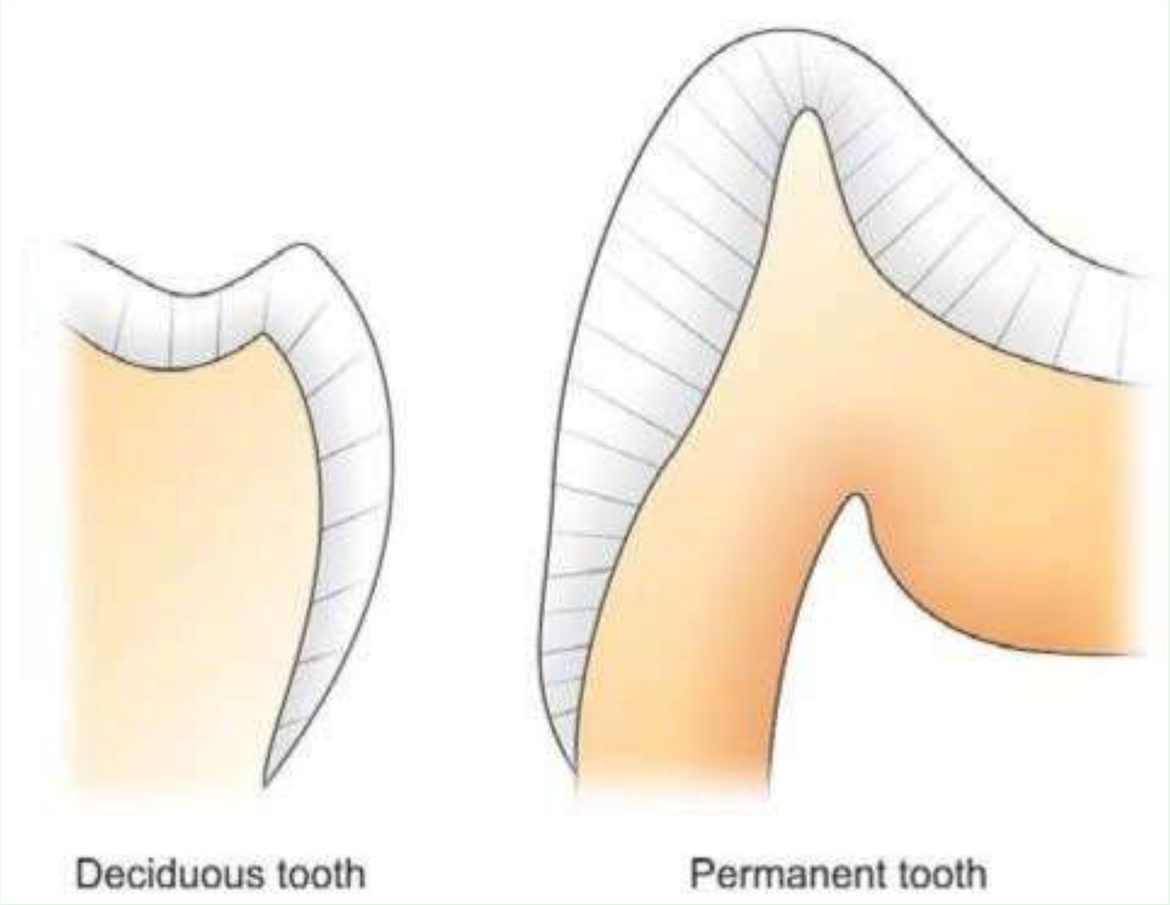
Enamel Rods

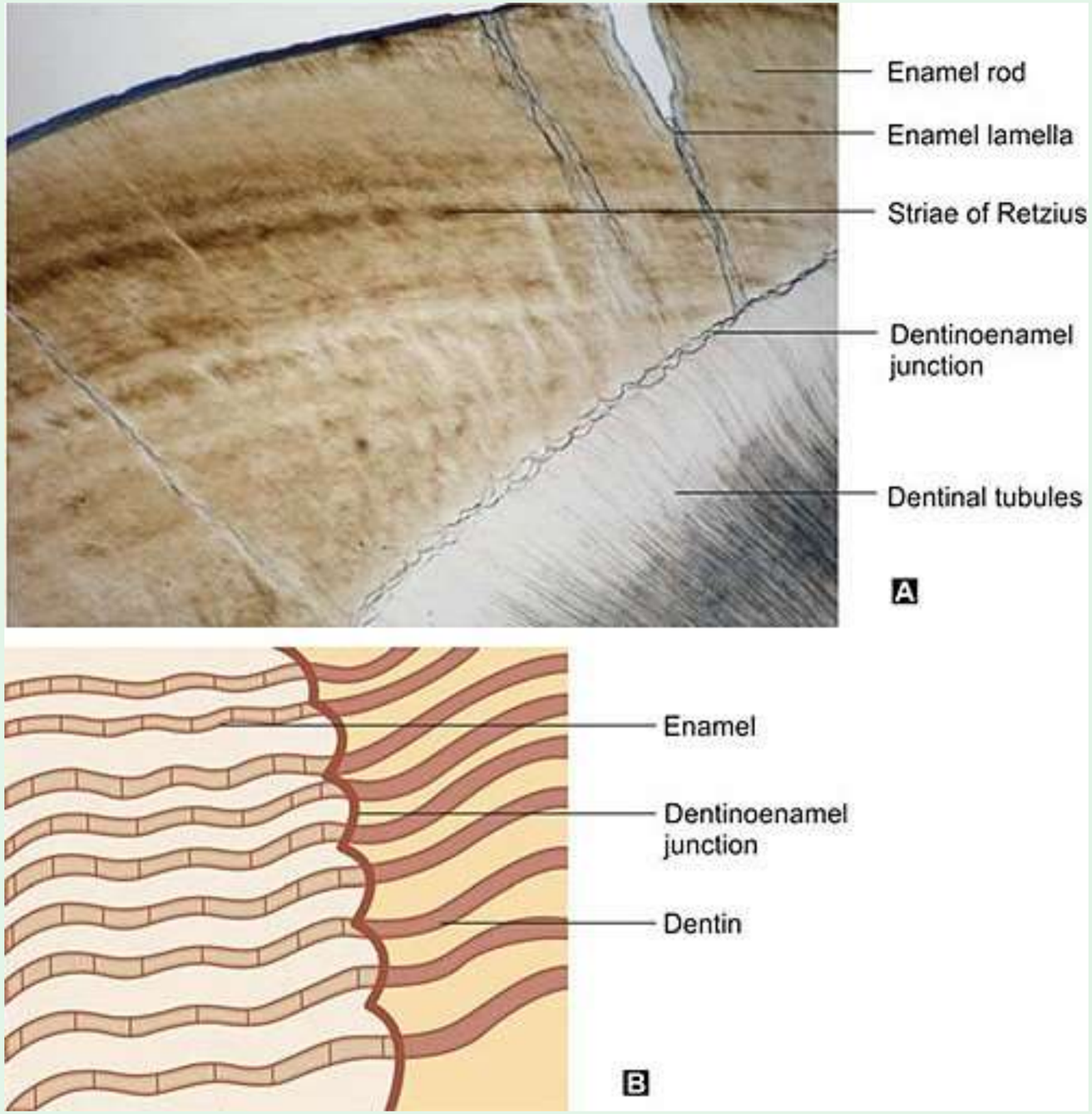
The enamel prism in longitudinal section are cylindrical

It run from DEJ to the enamel surface

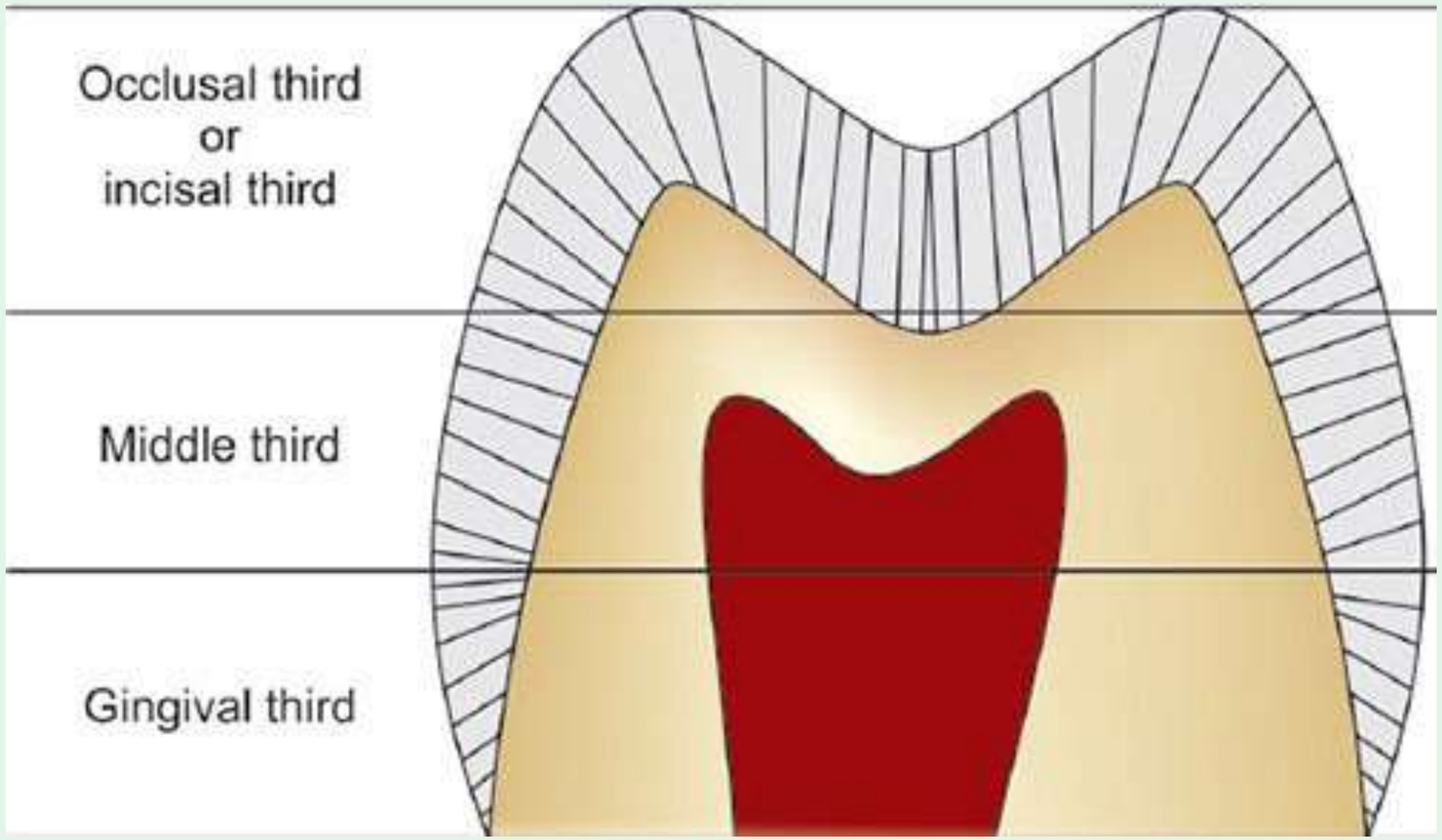
The average diameter of enamel rod is 4 um

The length of rods is greater than the thickness of enamel.

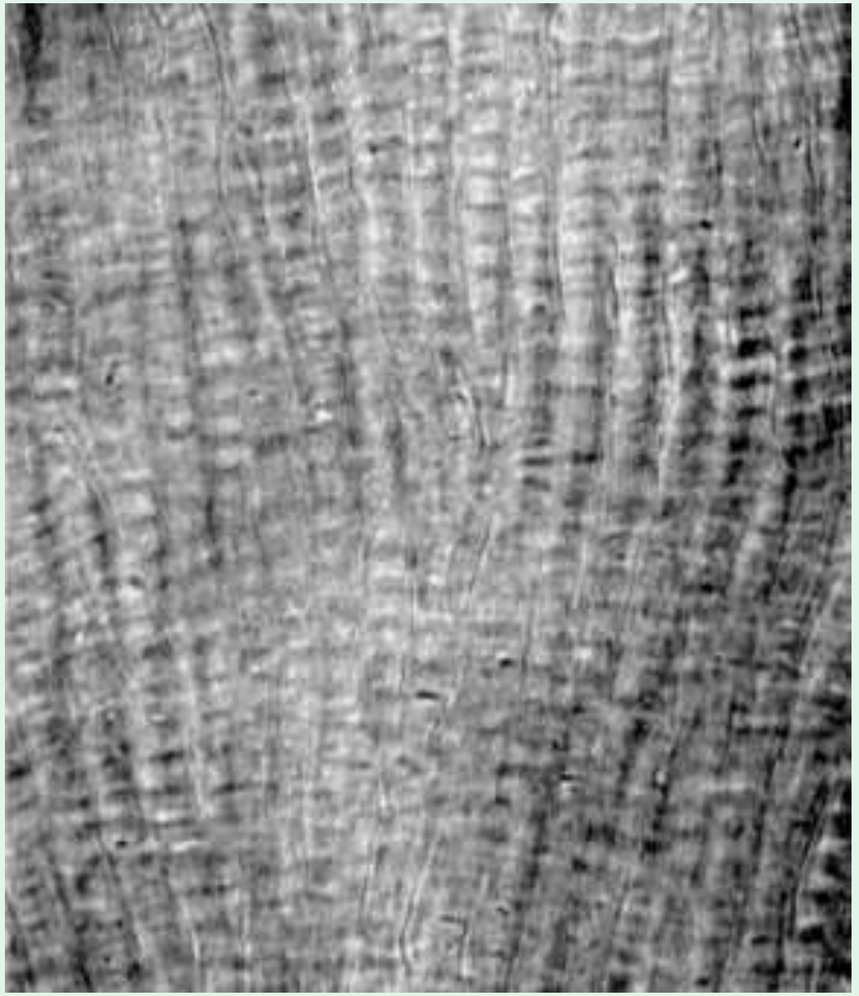



Enamel rod
Enamel lamella
Striae of Retzius
Dentinoenamel junction
Dentinal tubules
A
Enamel
Dentinoenamel junction
Dentin
B

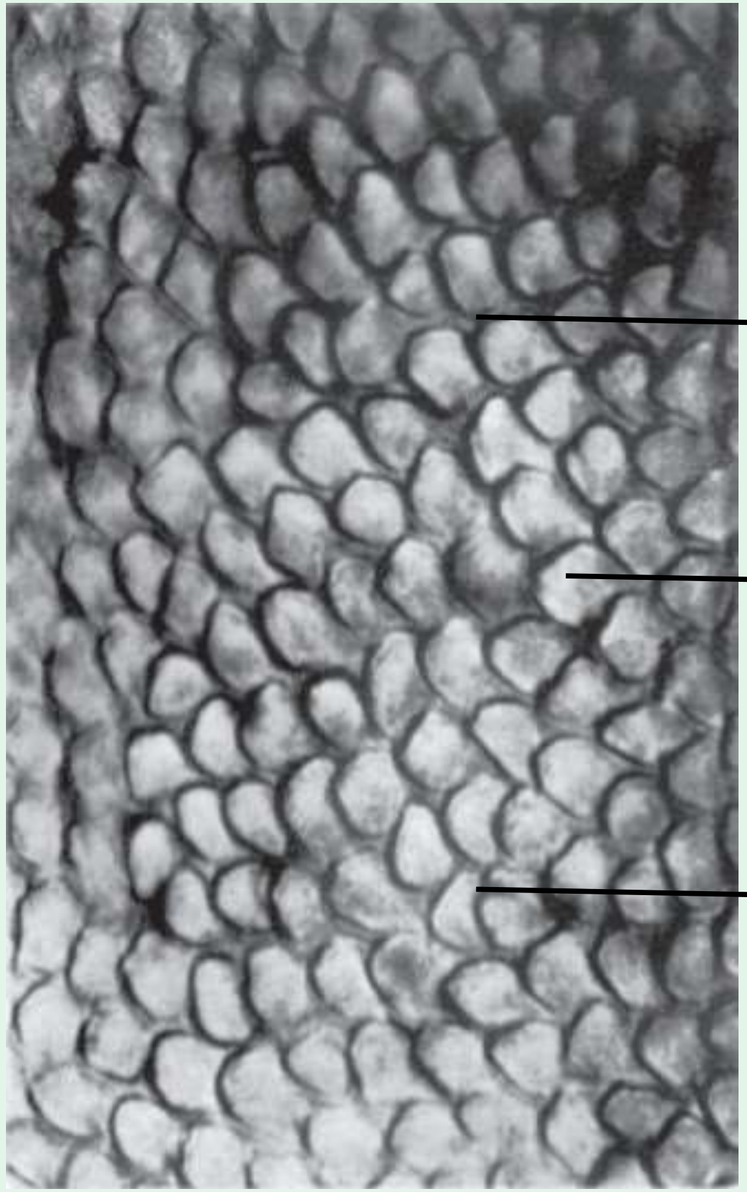
- Direction of rods- rods are oriented at the right angles to the dentin surface



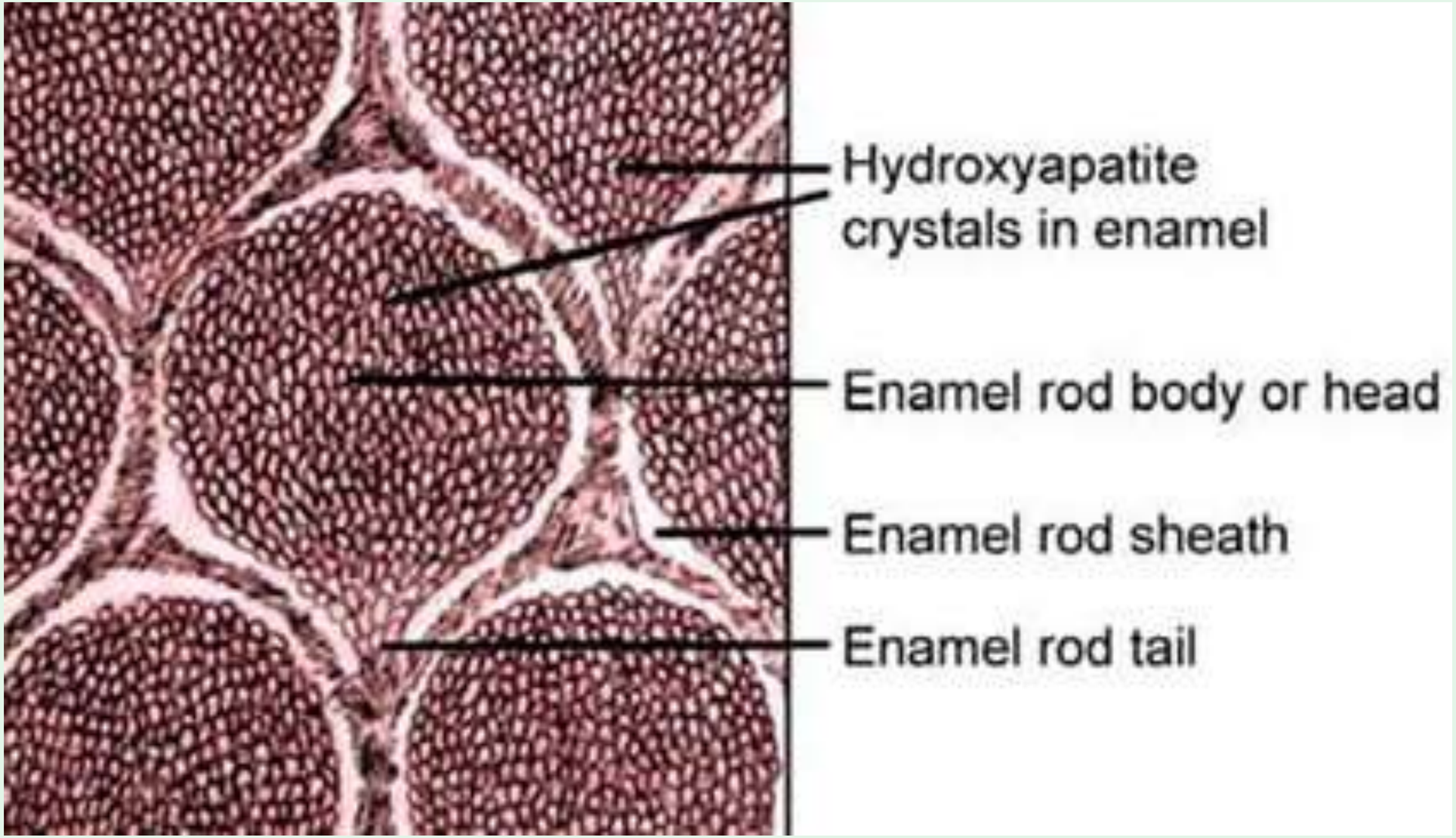
In longitudinal Section, the enamel rods show cross striation.

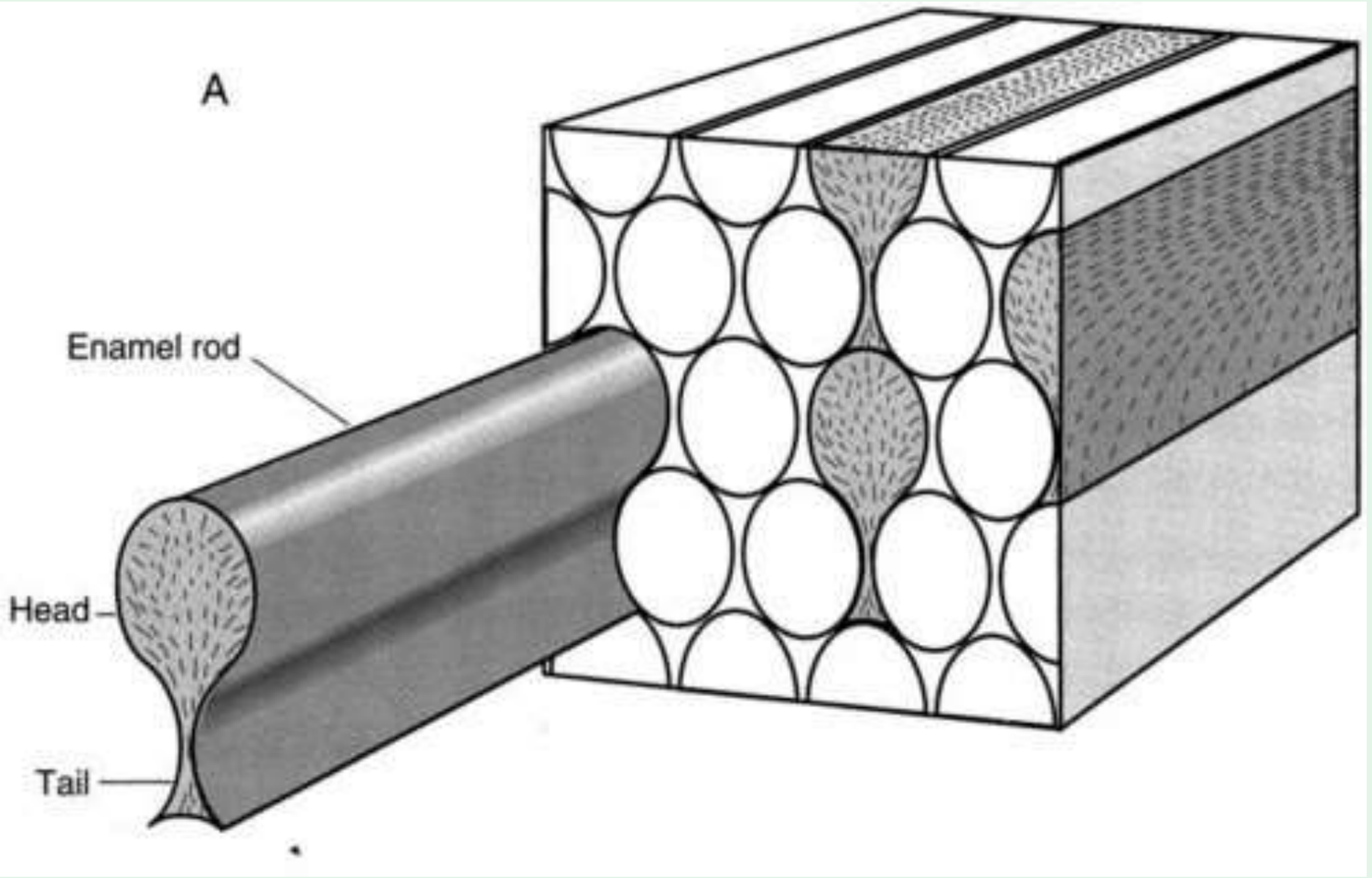


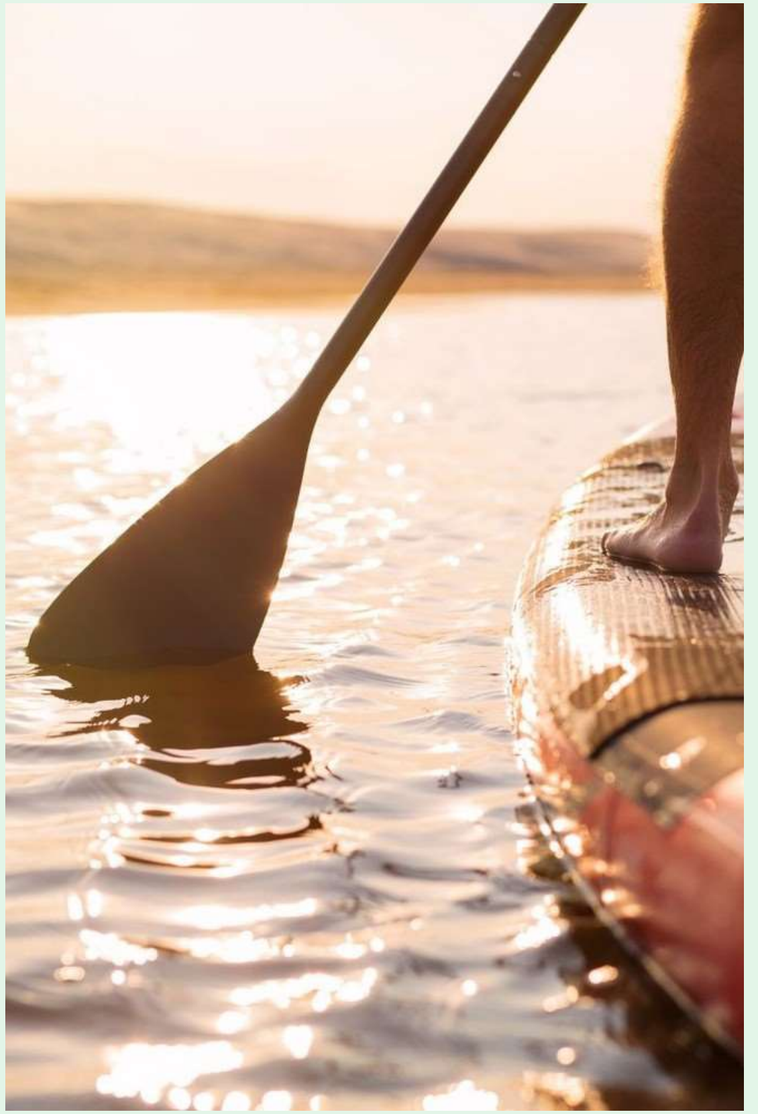
- In transverse sections of human enamel rods resemble FISH SCALES under light eletron microscope.

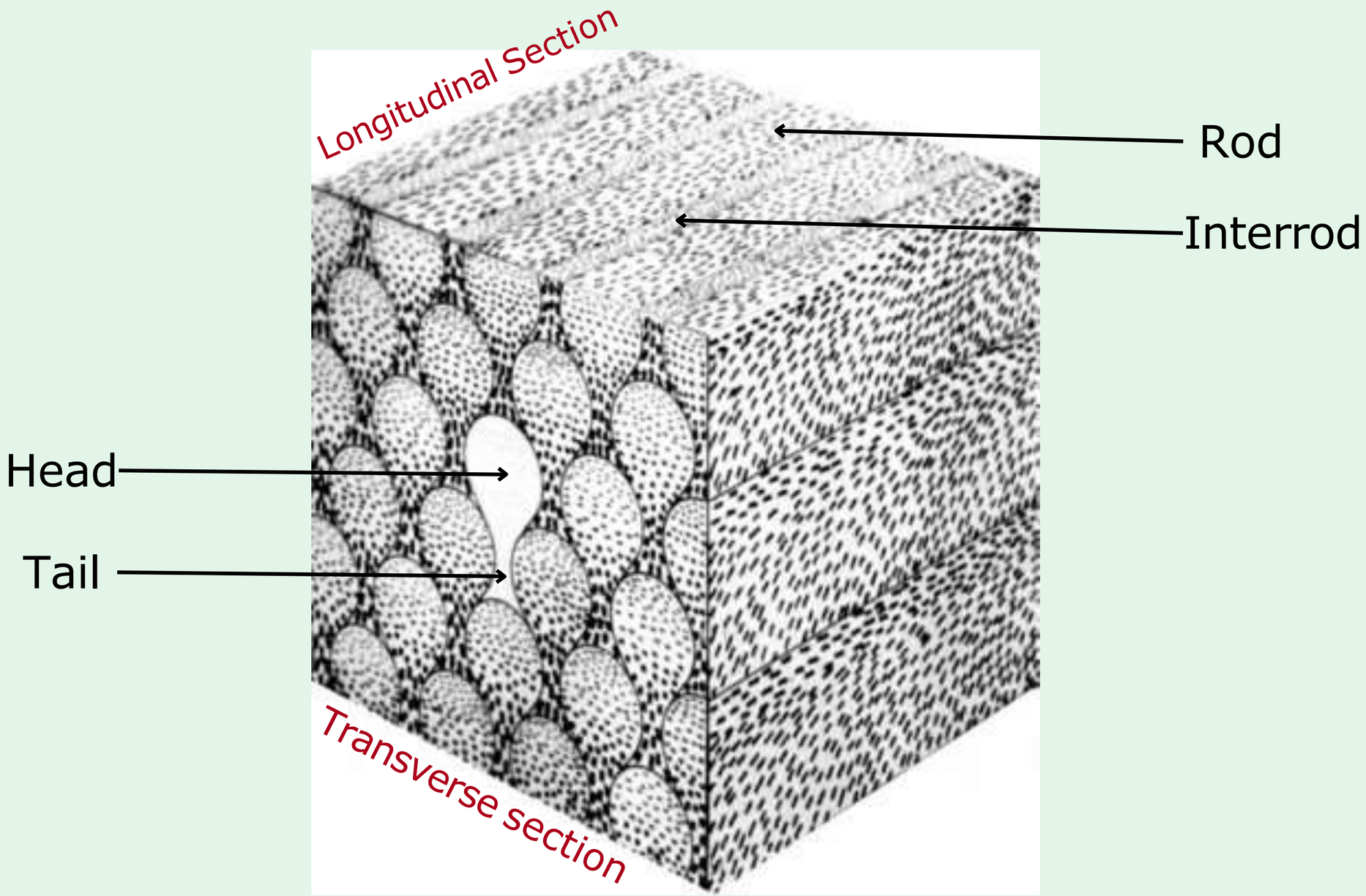

Interrod substance
Rod
Rod sheath

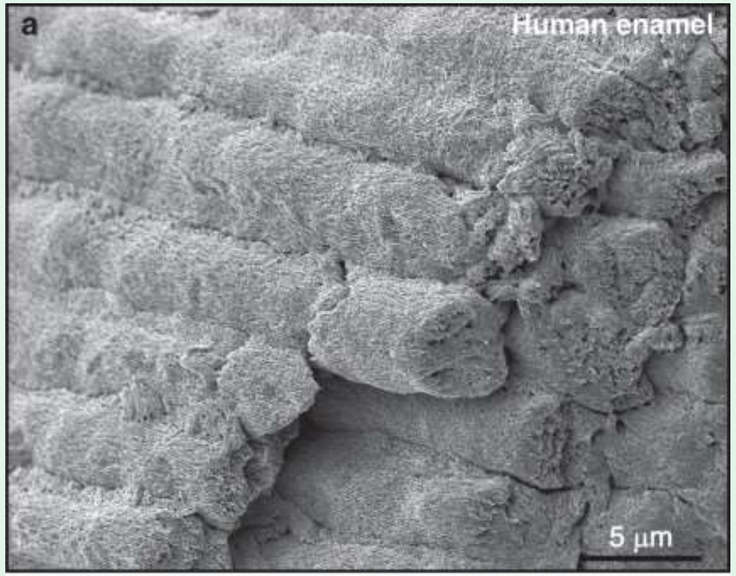
- Under high magnification it appears as KEY HOLE shape or PADDLE Shape.

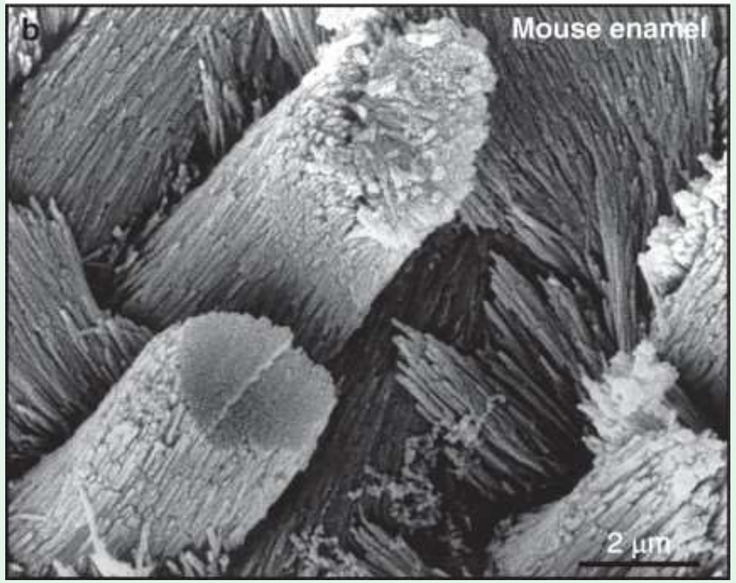

Hydroxyapatite
crystals in enamel
Enamel rod body or head
Enamel rod sheath
Enamel rod tail


A
Enamel rod
Head
Tail




Longitudinal Section
Rod
Interrod
Head
Tail
Transverse section





SCANNING ELECTRON MICROSCOPE

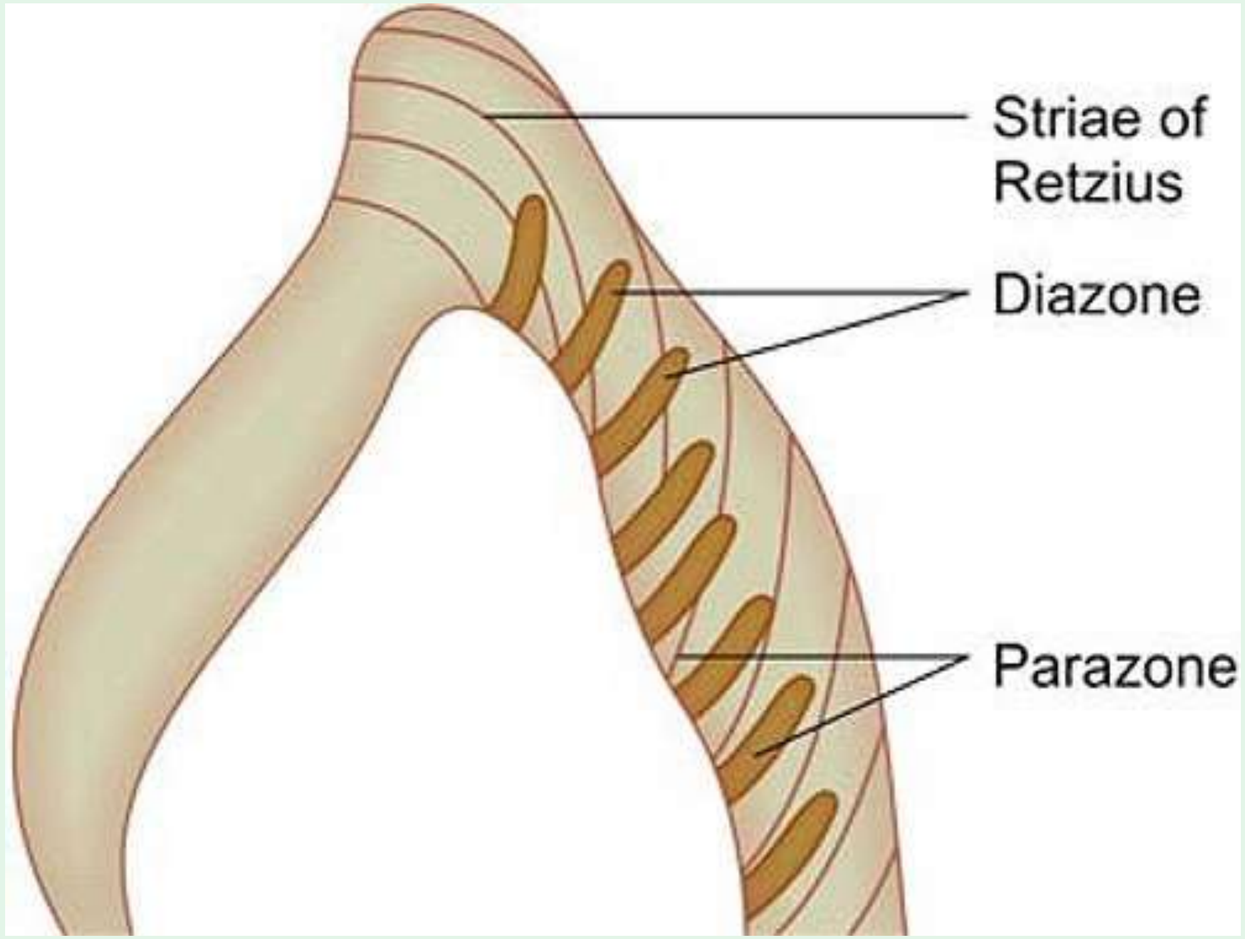


Hunter- schreger bands

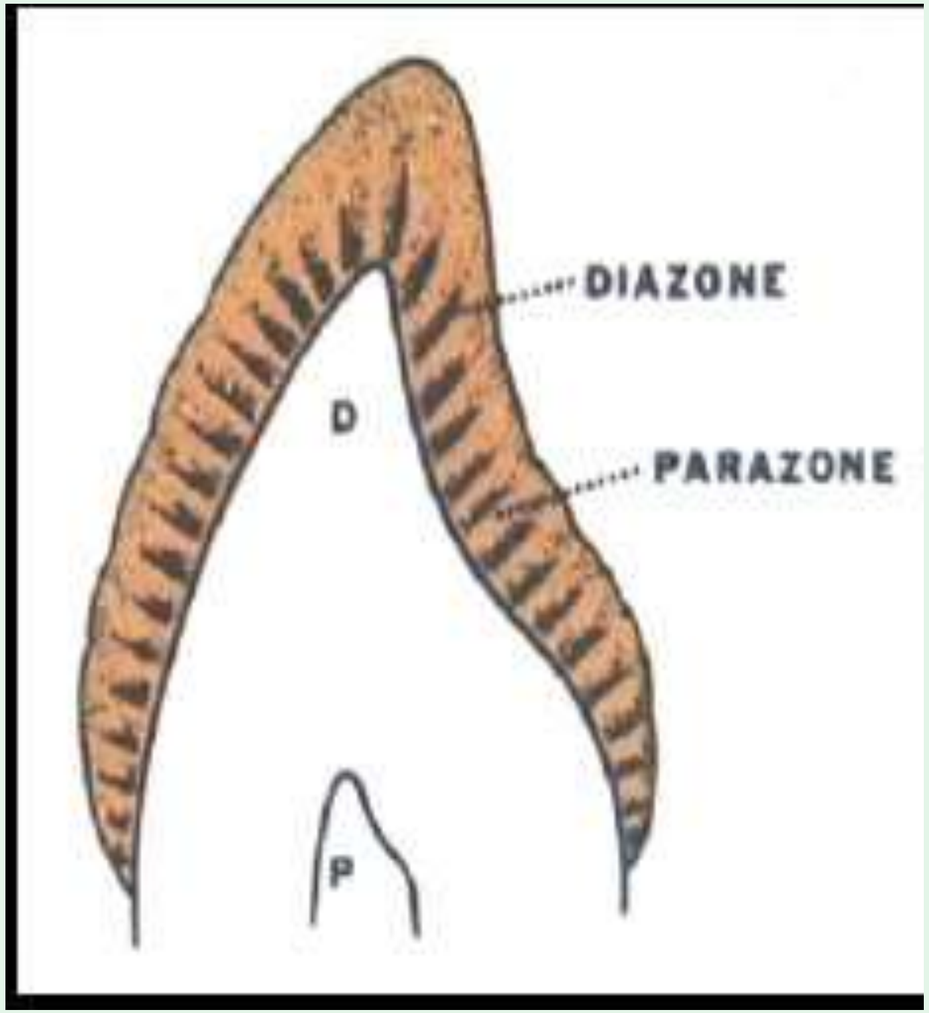
- The *change in the direction of the rods* is responsible for Hunter Schreger bands

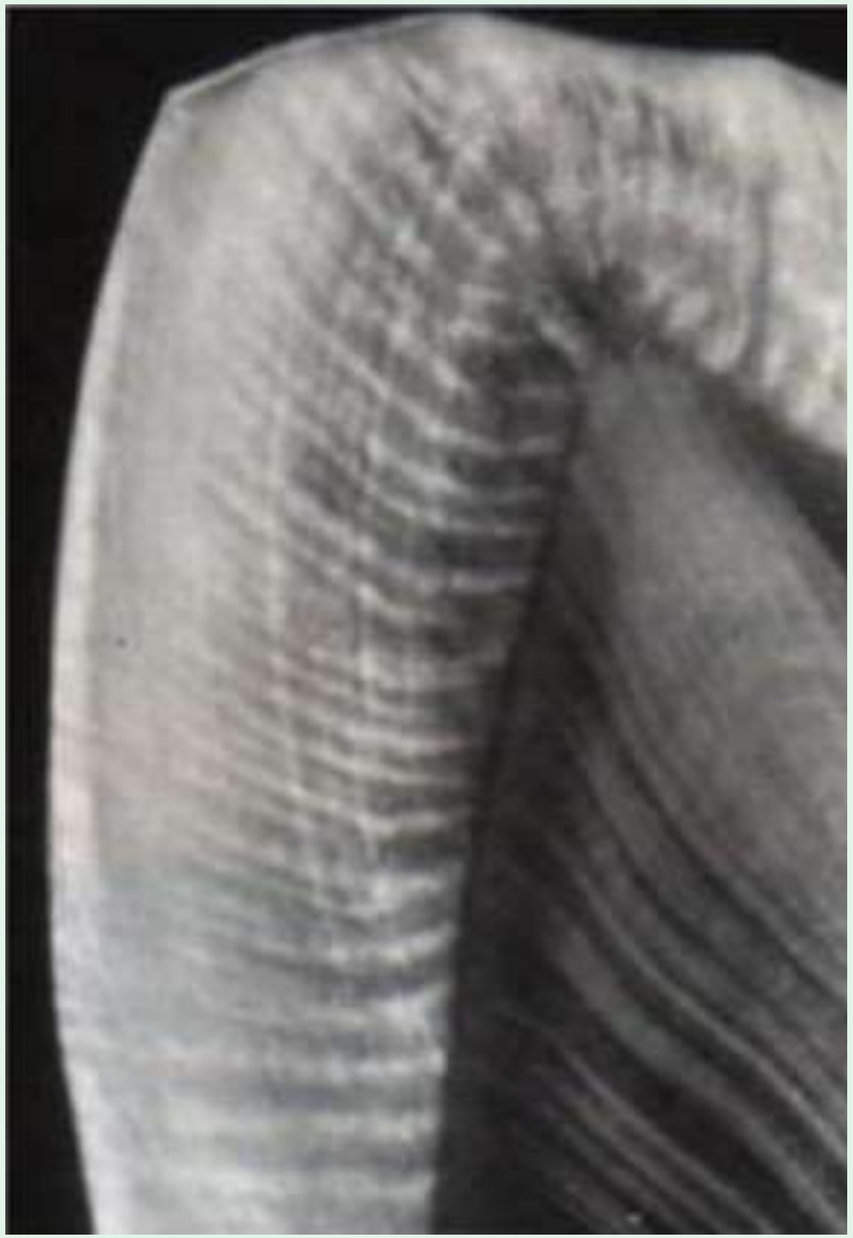
  - They are alternating dark & light strips of varying widths
  - They originate at the DEJ border & pass outward,ending at some distance from outer enamel surface.

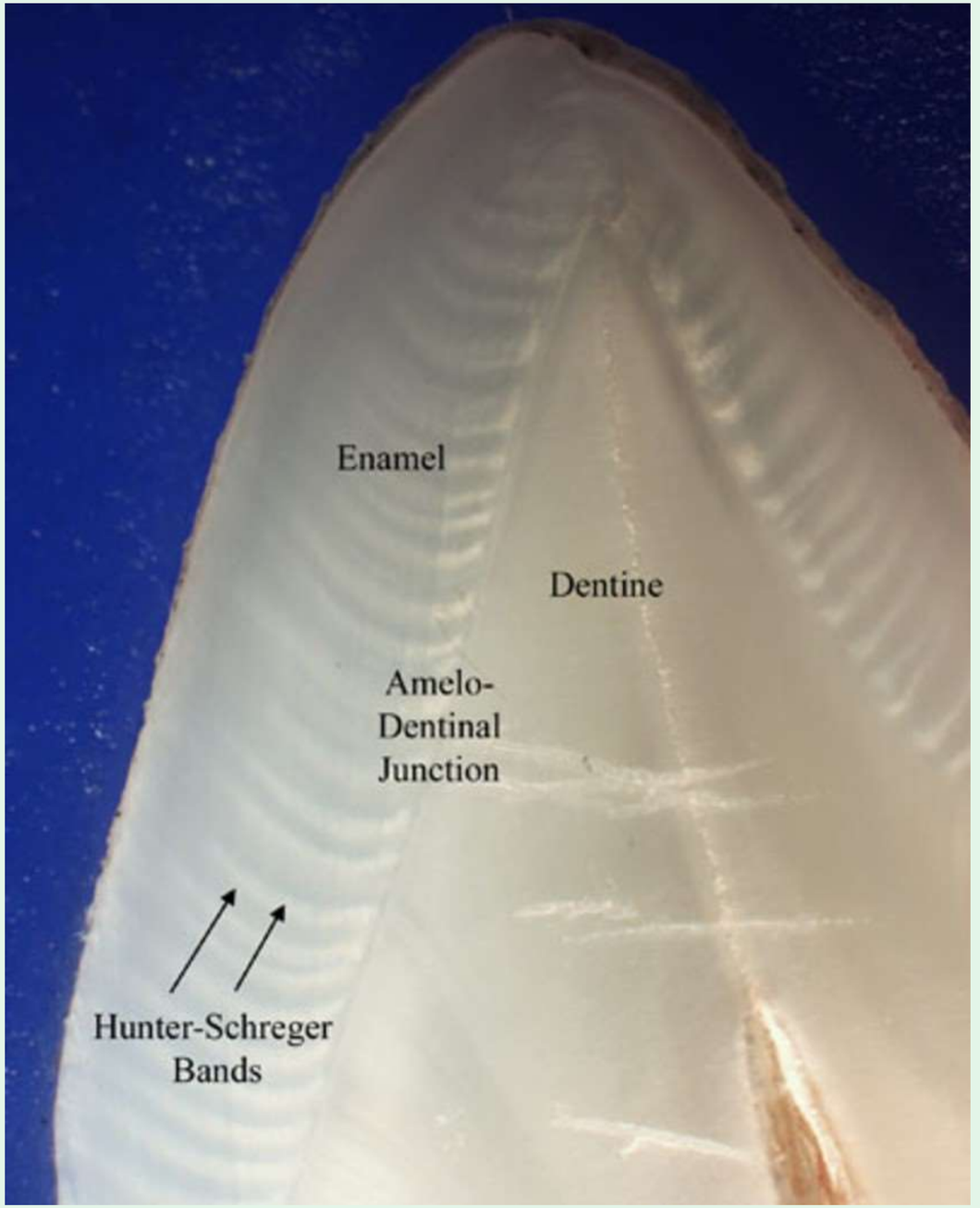
In longitudinal section- dark bands - Diazones



In transverse section - light bands- Parazones



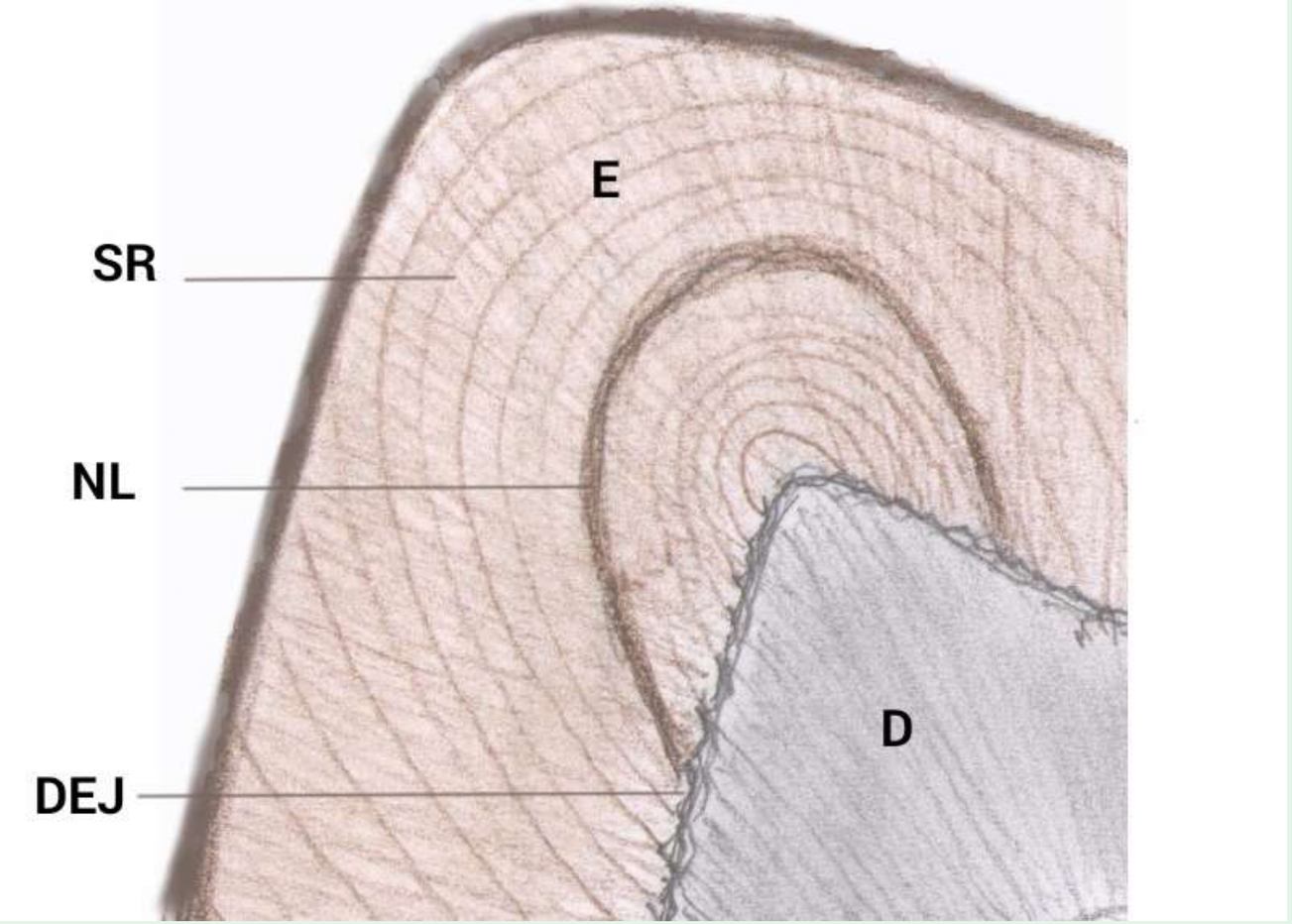



Enamel
Dentine
Amelo-
Dentinal
Junction
Hunter-Schreger
Bands

Incremental lines of Retzius

- They appear as brownish bands in ground section of enamel
  - They surround the tip of the dentin
  - Appear as concentric circles
- Incremental lines reflect variations in the structure & mineralization either hypo & hyper mineralization



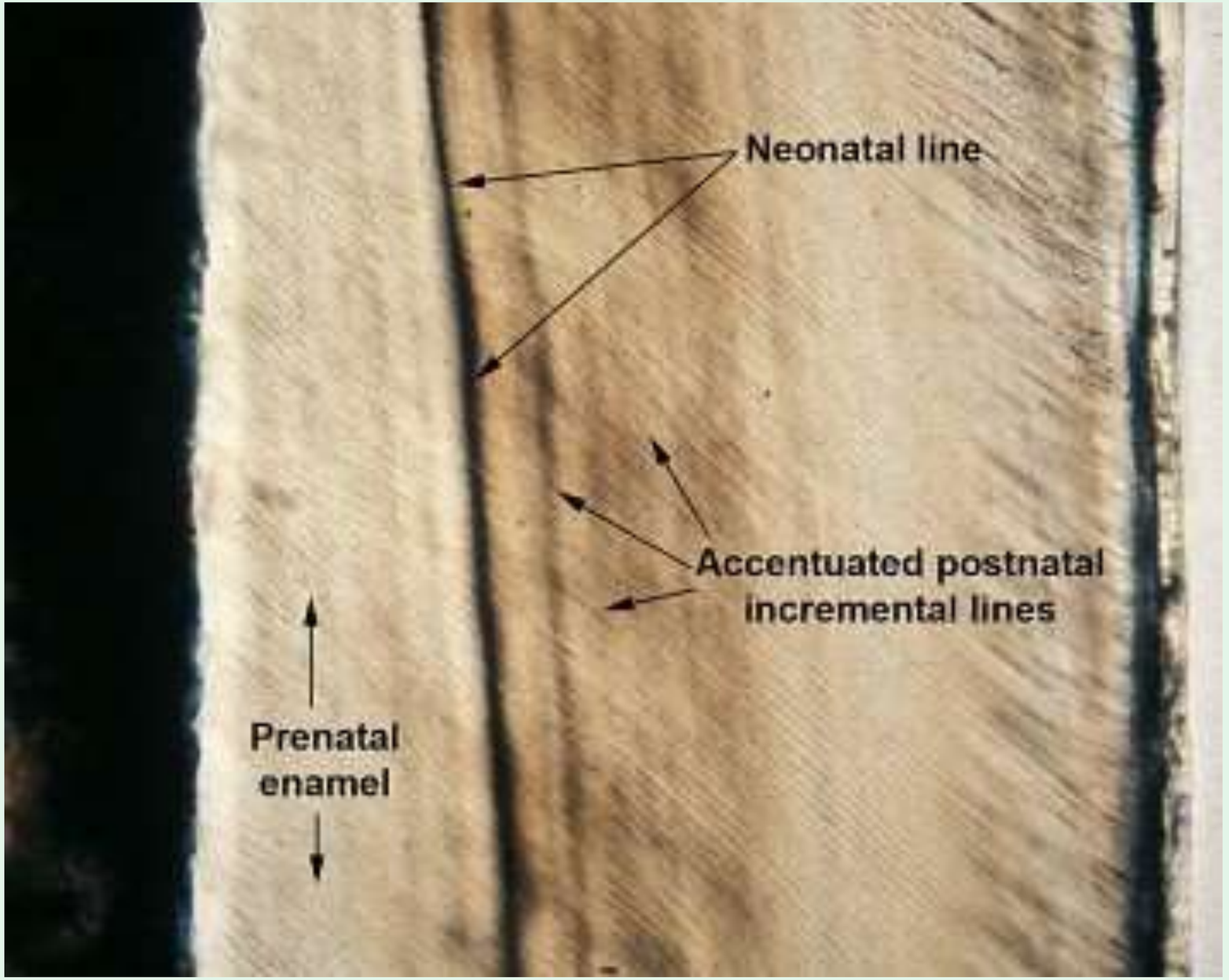

E
SR
NL
D
DEJ



NEONATAL LINE

- The enamel of deciduous teeth develop partly before or partly after birth.

- The boundary between two portions of enamel in deciduous teeth is marked by an accentuated incremental line of Retzius,NEONATAL LINE.


Neonatal line
Accentuated postnatal incremental lines
Prenatal enamel

- **Prenatal enamel is well developed than postnatal enamel

DO YOU KNOW WHY ???

Because the fetus is developed in well protected environment with an adequate supply of essential minerals

ENAMEL LAMELLAE

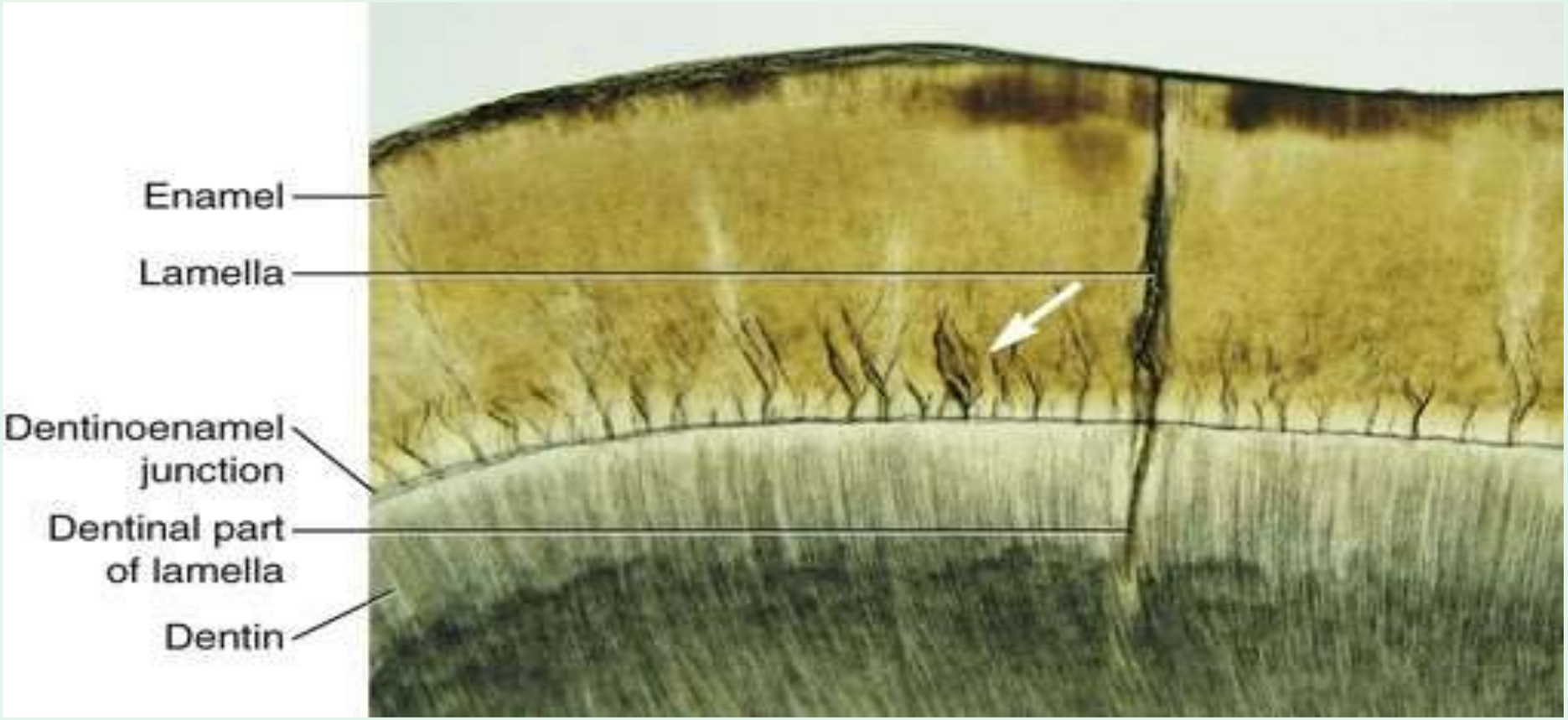
- Are linear hypocalcified structures seen in enamel, resemble thin leaf-like structure

- Extend from the enamel surface toward the DE junction

- They may extend to, & sometimes penetrate into the dentin

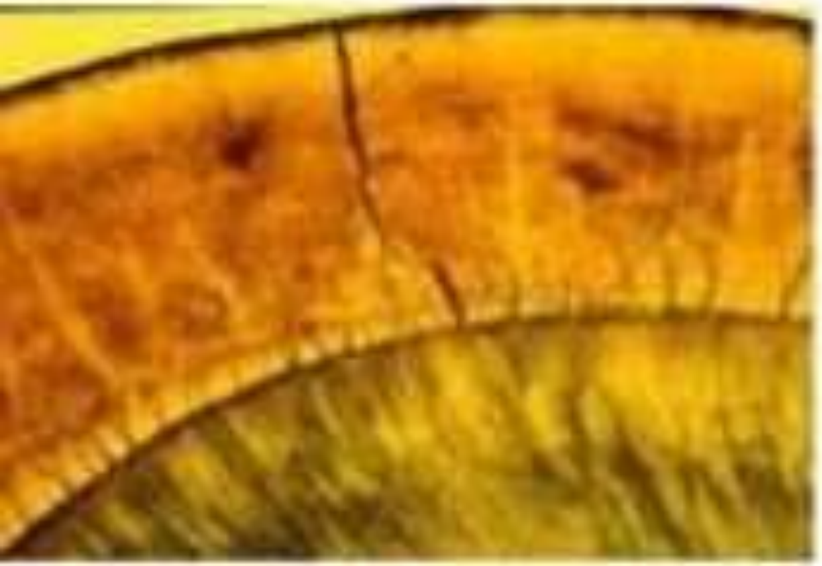
ENAMEL LAMELLAE

- Lamellae extend in the longitudinal & radial direction of the tooth from the tip of the crown toward the cervical region



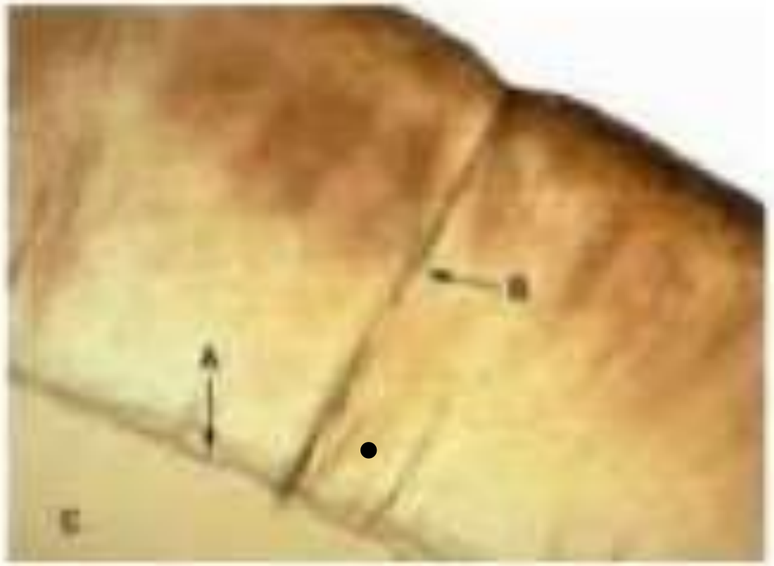
Types of lamellae:

Type A



Lamellae composed of poorly calcified rod segments.

Type B



Lamellae consisting of degenerated cells

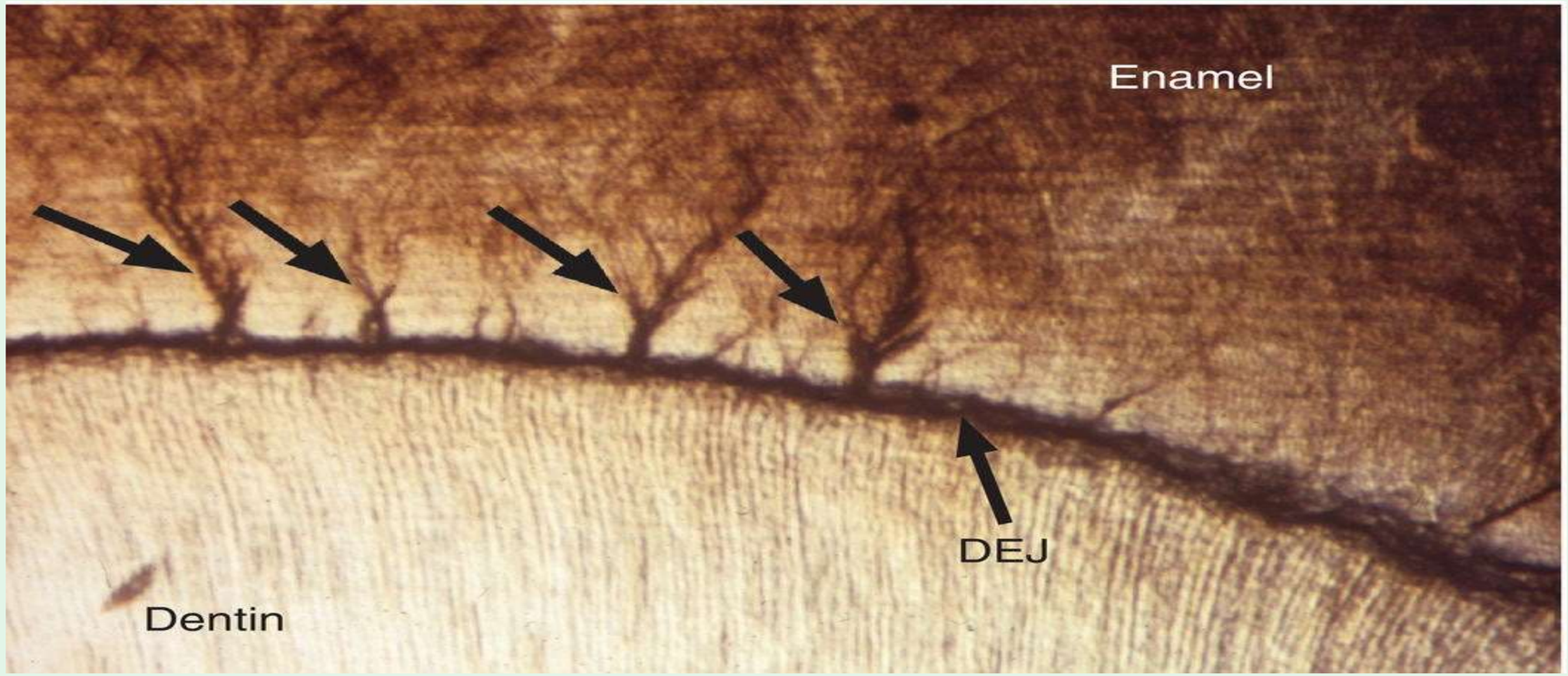
Type C



Lamellae arising in erupted teeth where the cracks are filled with oraganic material.

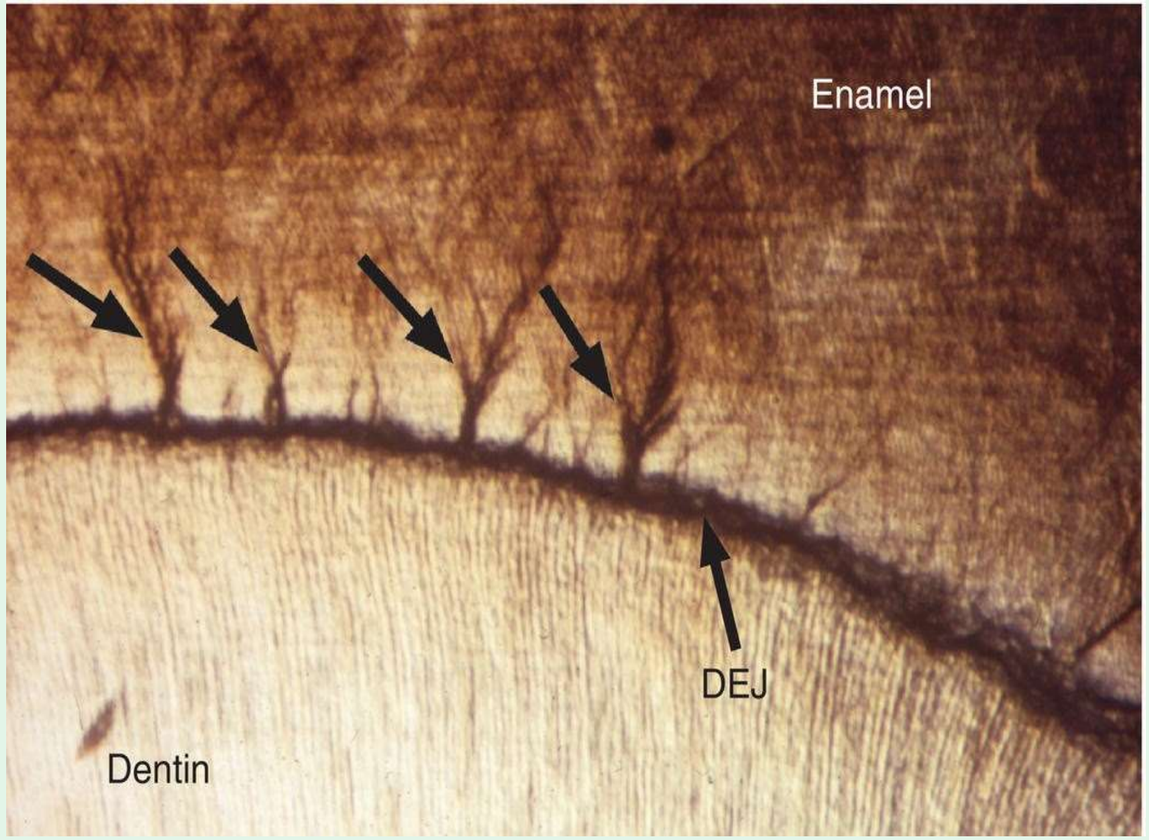
ENAMEL TUFTS

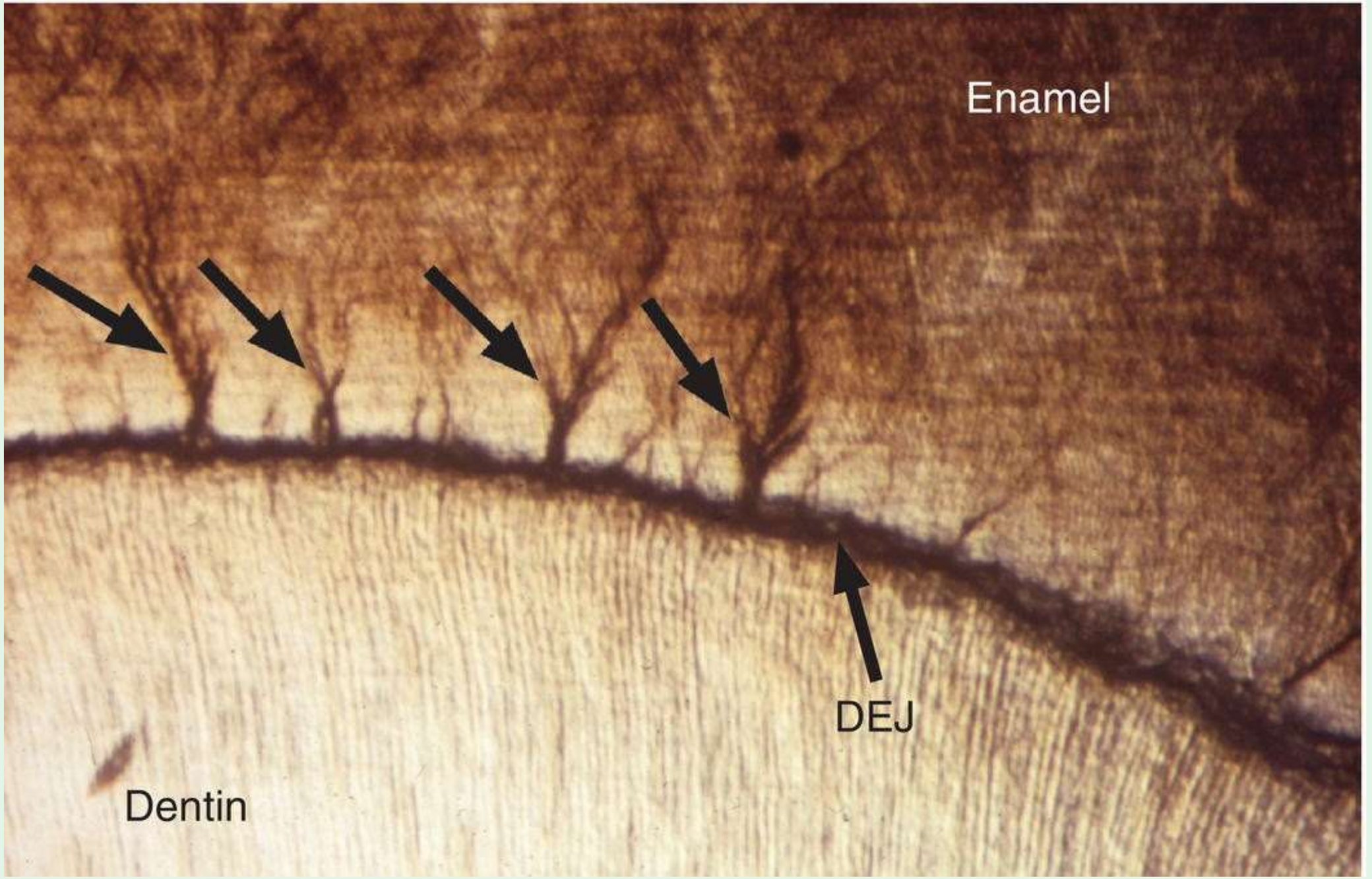
- Arises at the DEJ & reach into the enamel to approximately one- fifth to one - third of its thickness



ENAMEL TUFTS

- Resemble **tufts of grass** in ground sections, but they are actually **ribbon - like structure made up of hypocalcified enamel rods**.
- Major organic component of tuft - **13.17 kD protein**, rather than amelogenin.



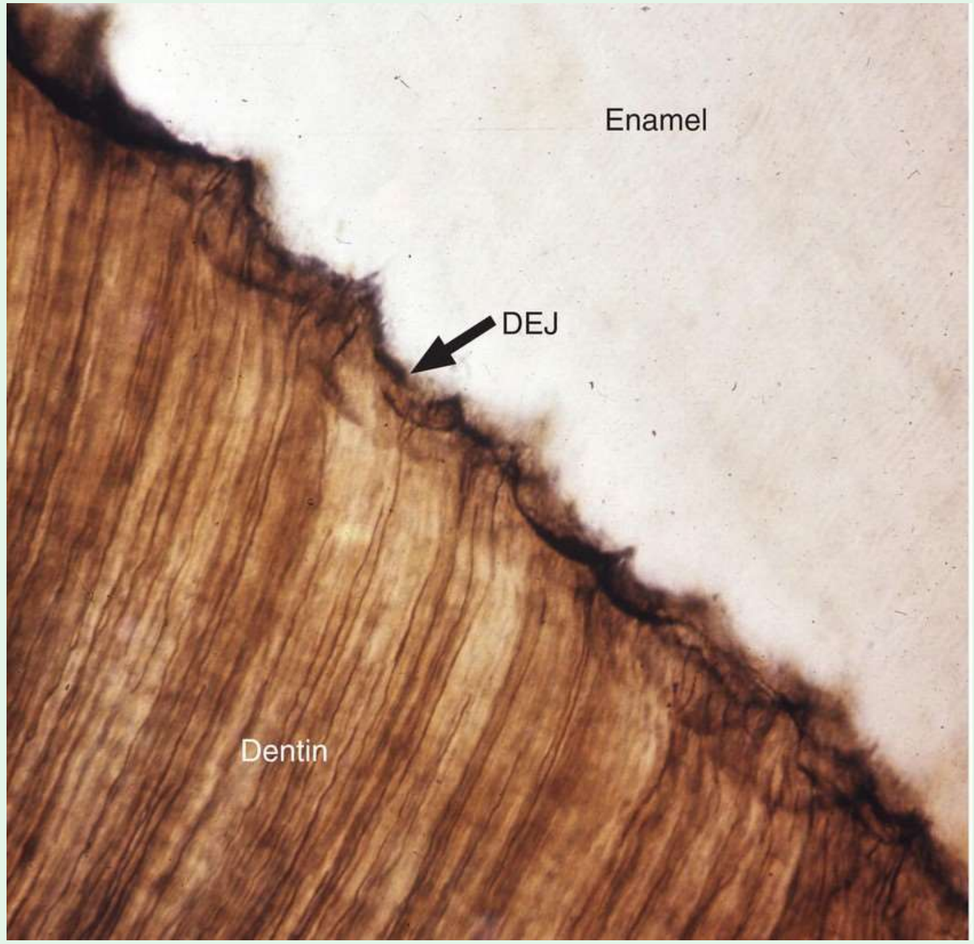

Enamel
DEJ
Dentin

DENTINO- ENAMEL JUNCTION(DEJ)

- A **scalloped line structure**

- Convexity of scallops are directed toward the dentin &

- Concavity towards the enamel



DENTINO- ENAMEL JUNCTION(DEJ)

- In DEJ, the crystals of dentin & enamel mix with each other

- Hypermineralized zone approximately 30 um.

- It is prominent before Mineralization is complete

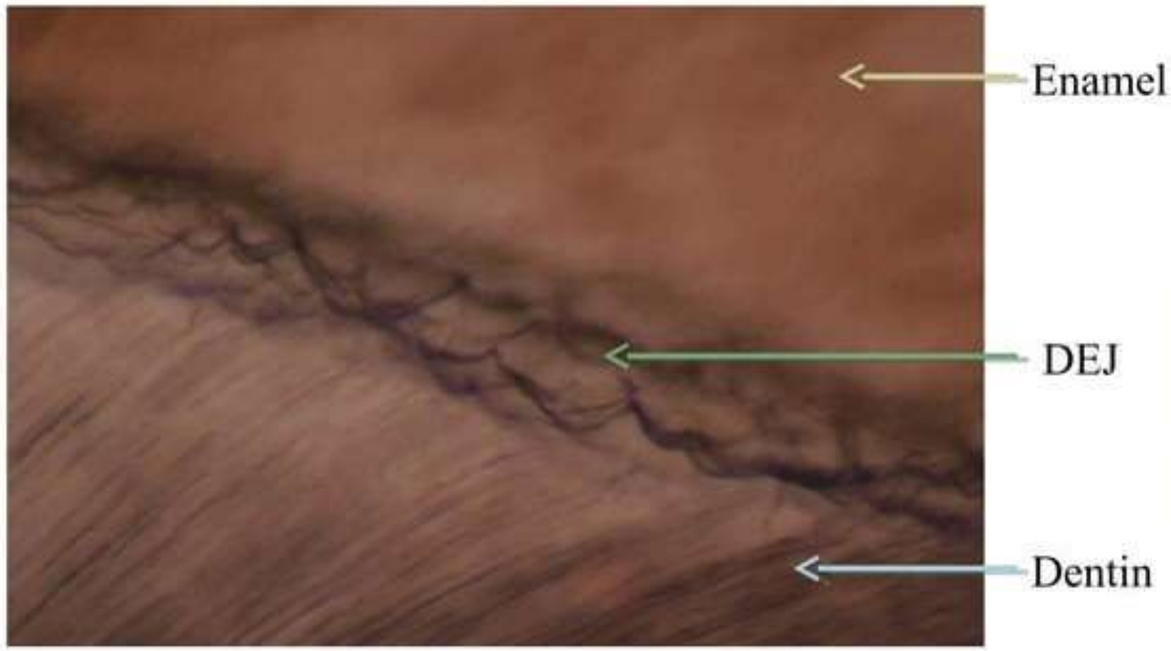
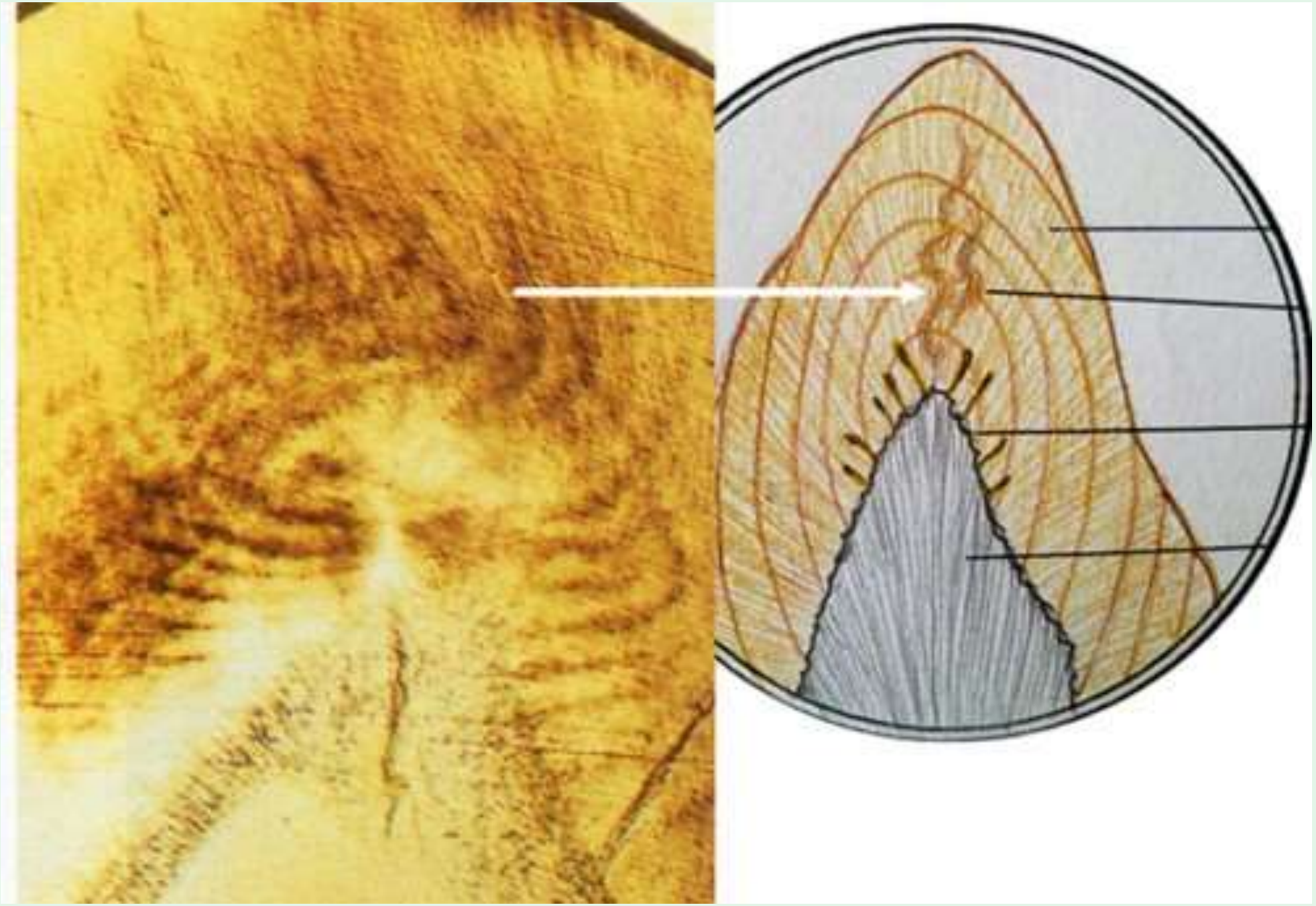


Fig:- Dentinoenamel Junction

Gnarled enamel

- Enamel in the region of the **cusp tips** appears to have more complex arrangement of the rods
- The **rods show intertwining & wavy course**, probably an optical phenomenon, due to their increased numbers in a very small area.
- It is thought that this arrangement **helps in withstanding the masticatory forces.**

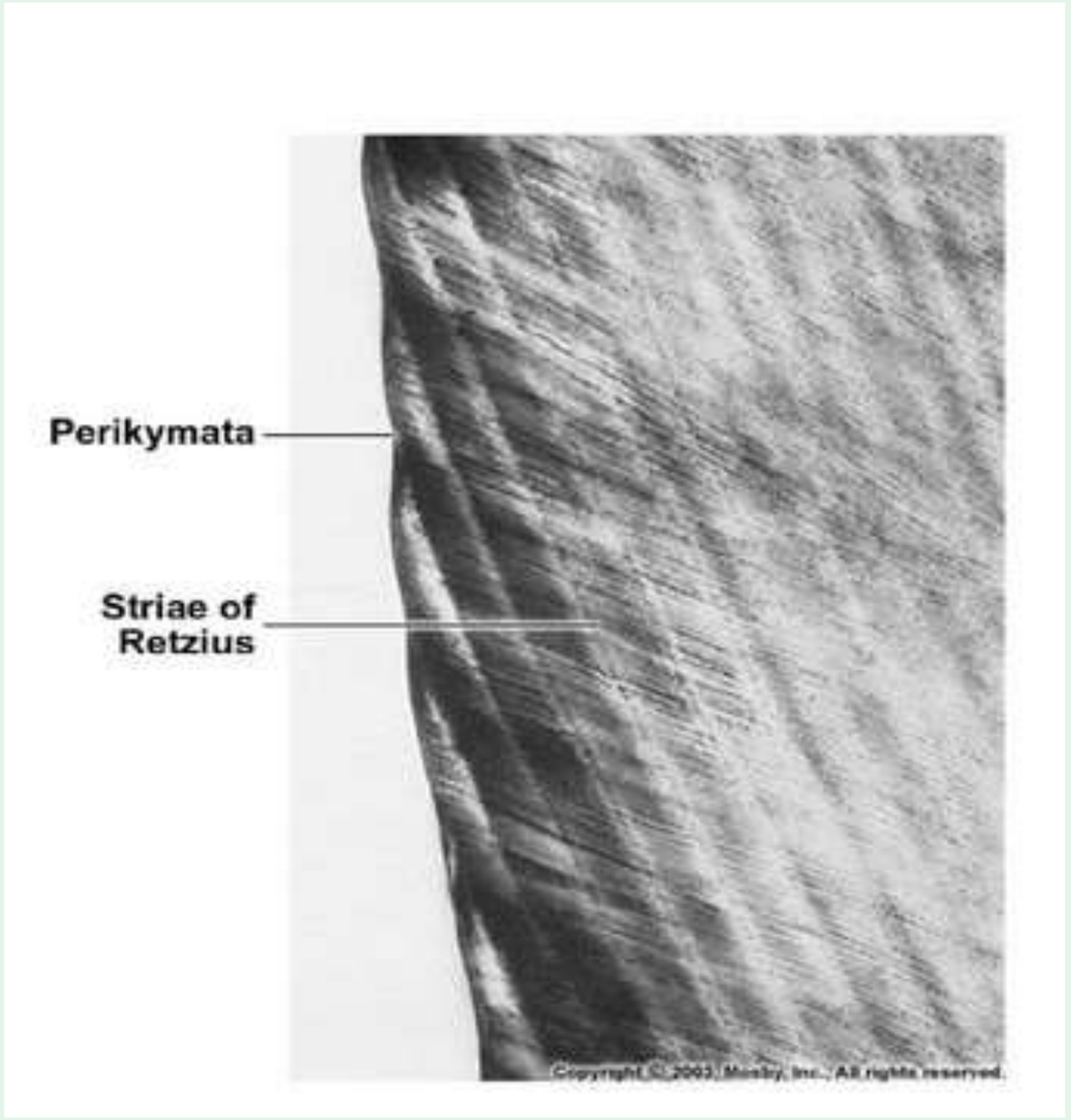


PERIKYMATA

- Are transverse, wale like grooves, believed to be the external manifestations of the striae of Retzius.

- They are continuous around a tooth & usually lie parallel to each other & to CEJ

In CEJ, approximately **30 perikymata/mm.**

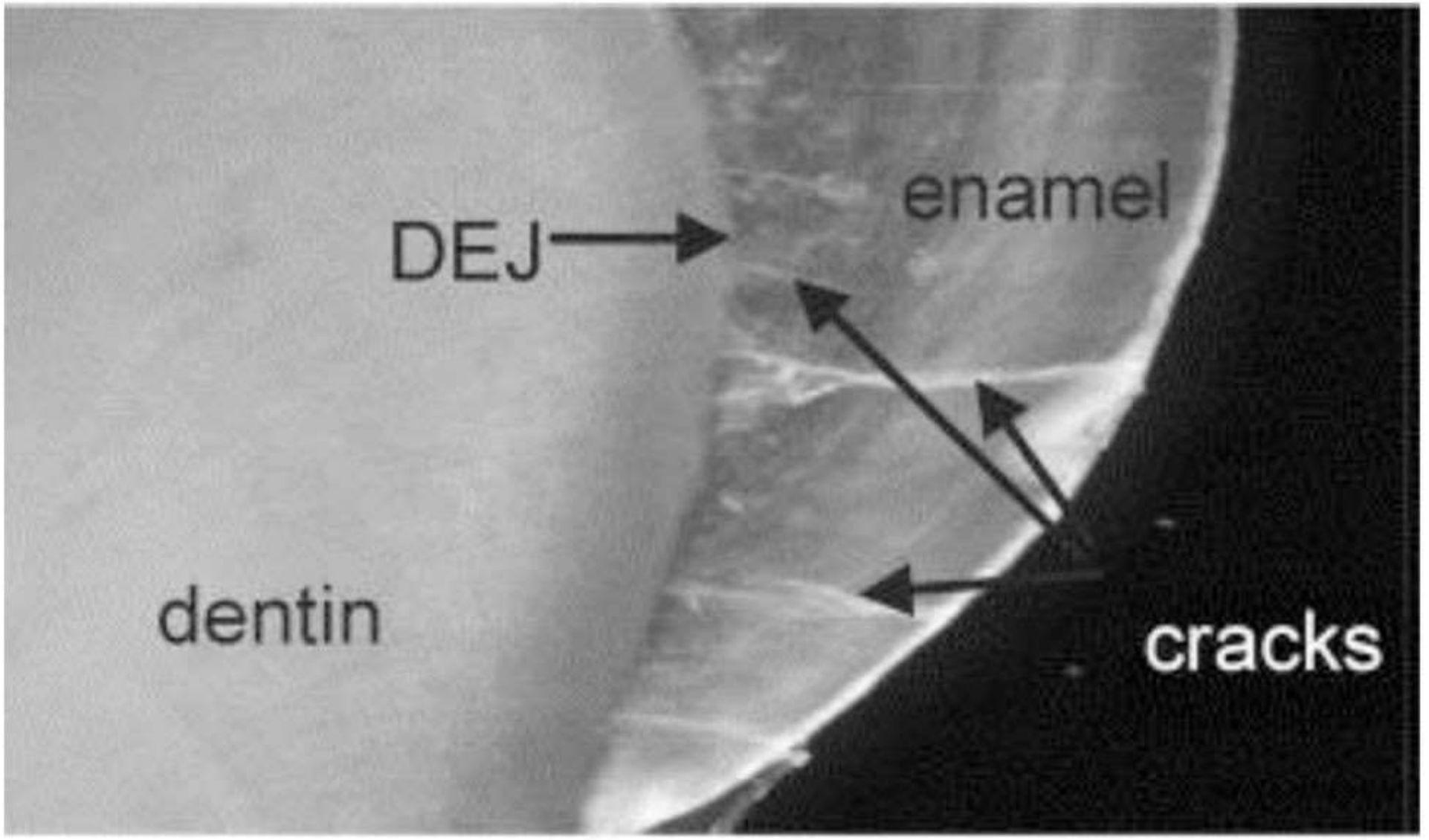

Perikymata
Striae of Retzius
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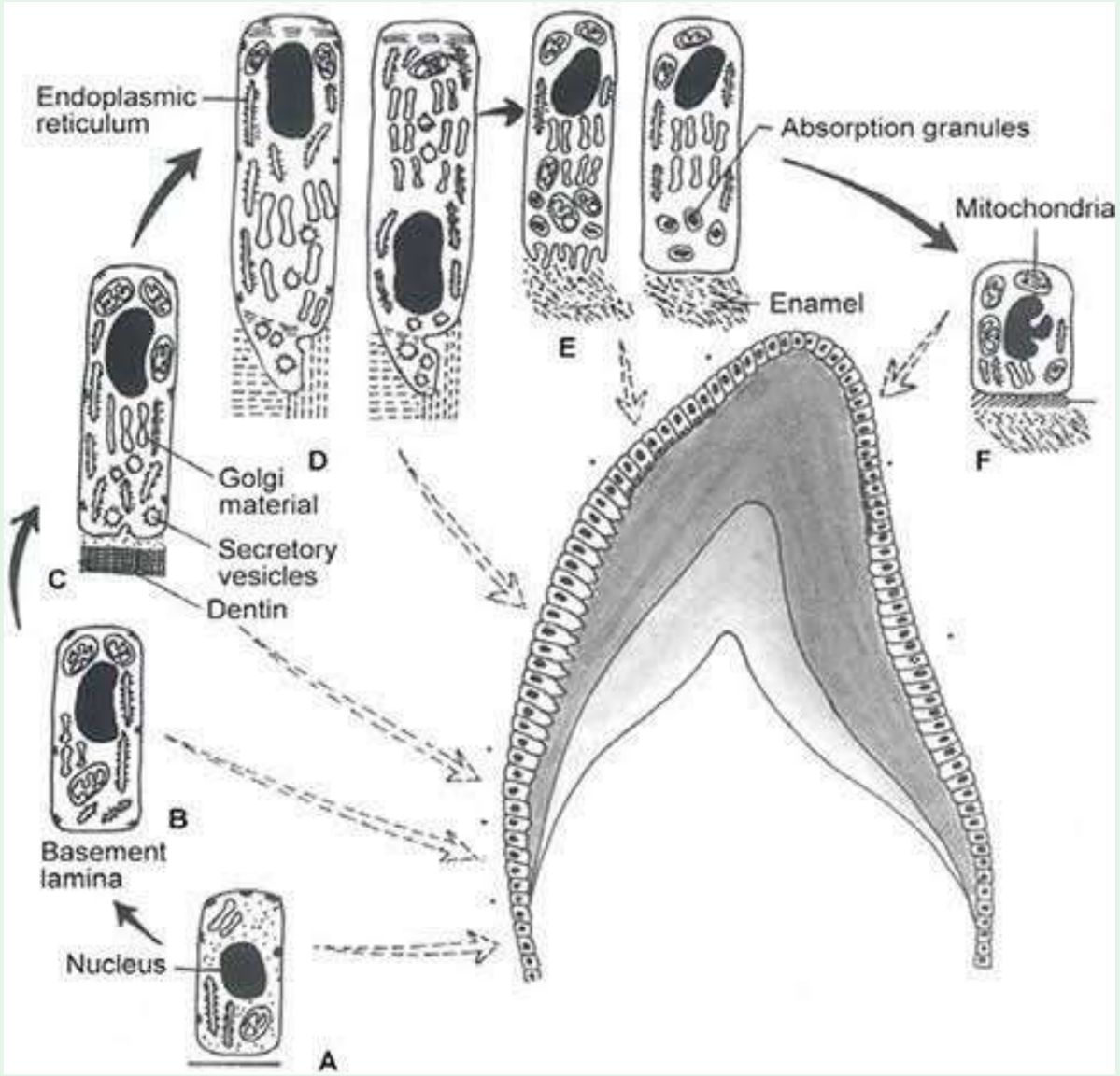

Perikymata

ENAMEL CRACKS

- The term "cracks" Originally was used to describe the **narrow, fissure-like structurs** that are seen on almost all surfaces.

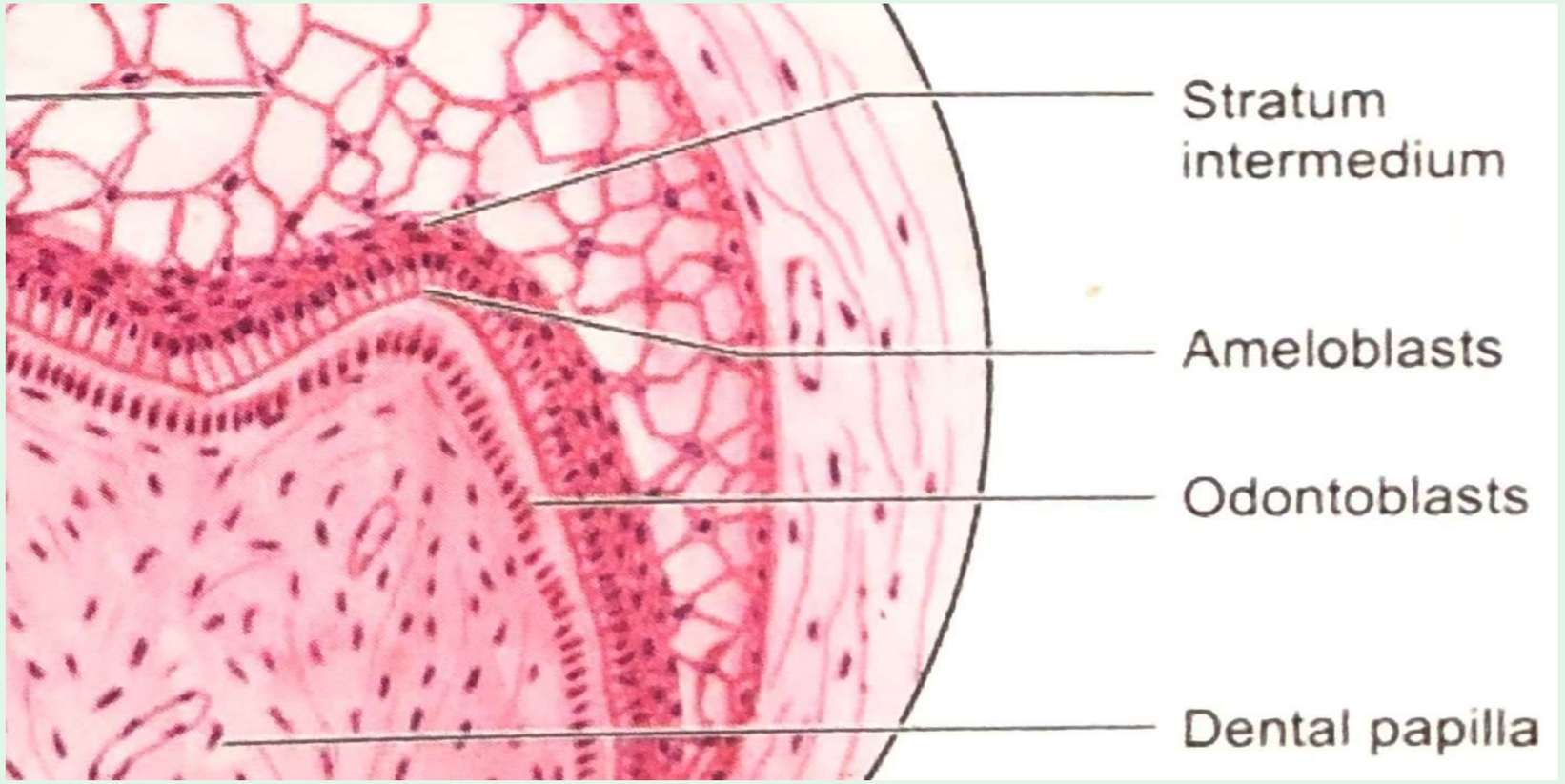
- Most of them are less than a millimeter in length, but some are longer, & few reach the occlusal or incisal edge of a surface


DEJ
enamel
dentin
cracks



Life cycle of Ameloblasts

Life cycle of ameloblast are the **functional stages of the cells of the inner enamel epithelium** which they pass through during tooth development & eruption



It can be divided into six stages:

1. **Morphogenic stage**
2. **Organizing stage**
3. **Formative stage**
4. **Maturative stage**
5. **Protective stage**
6. **Desmolytic stage**

} presecretory stage

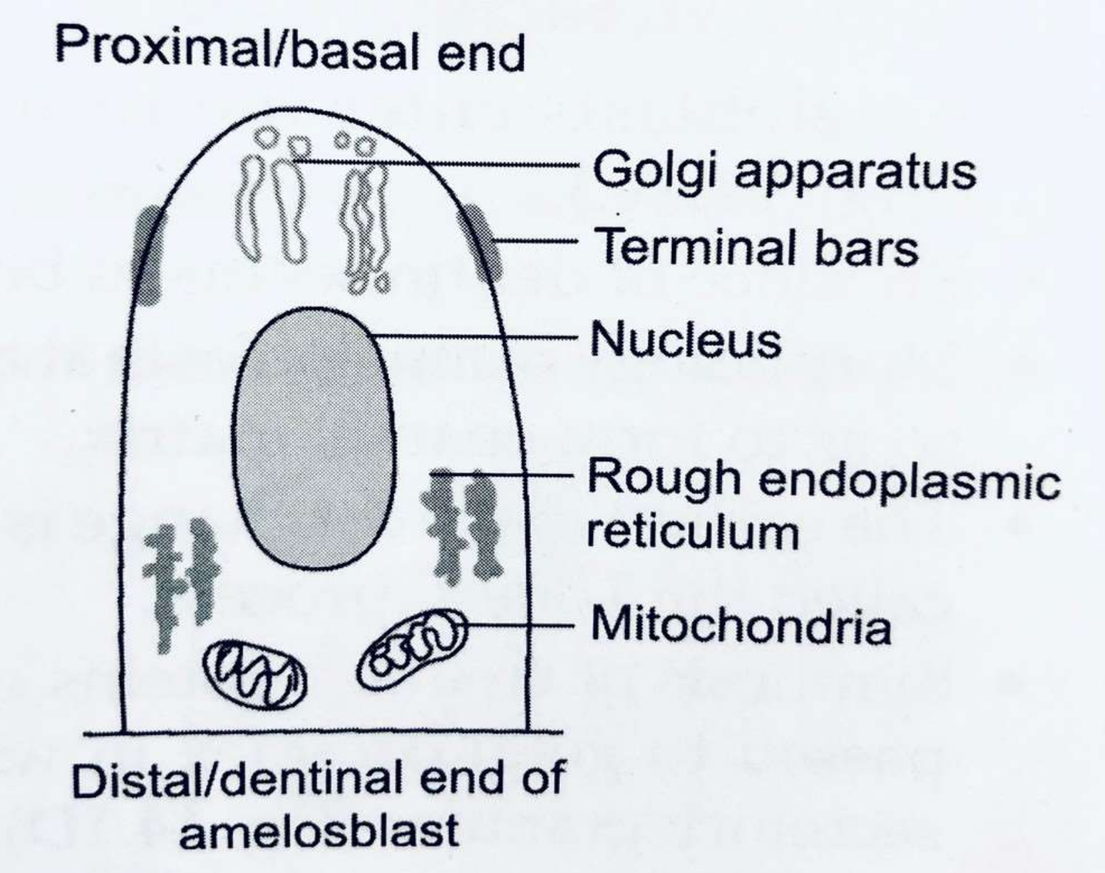
Secretory stage

} post secretory stage

M
O
F
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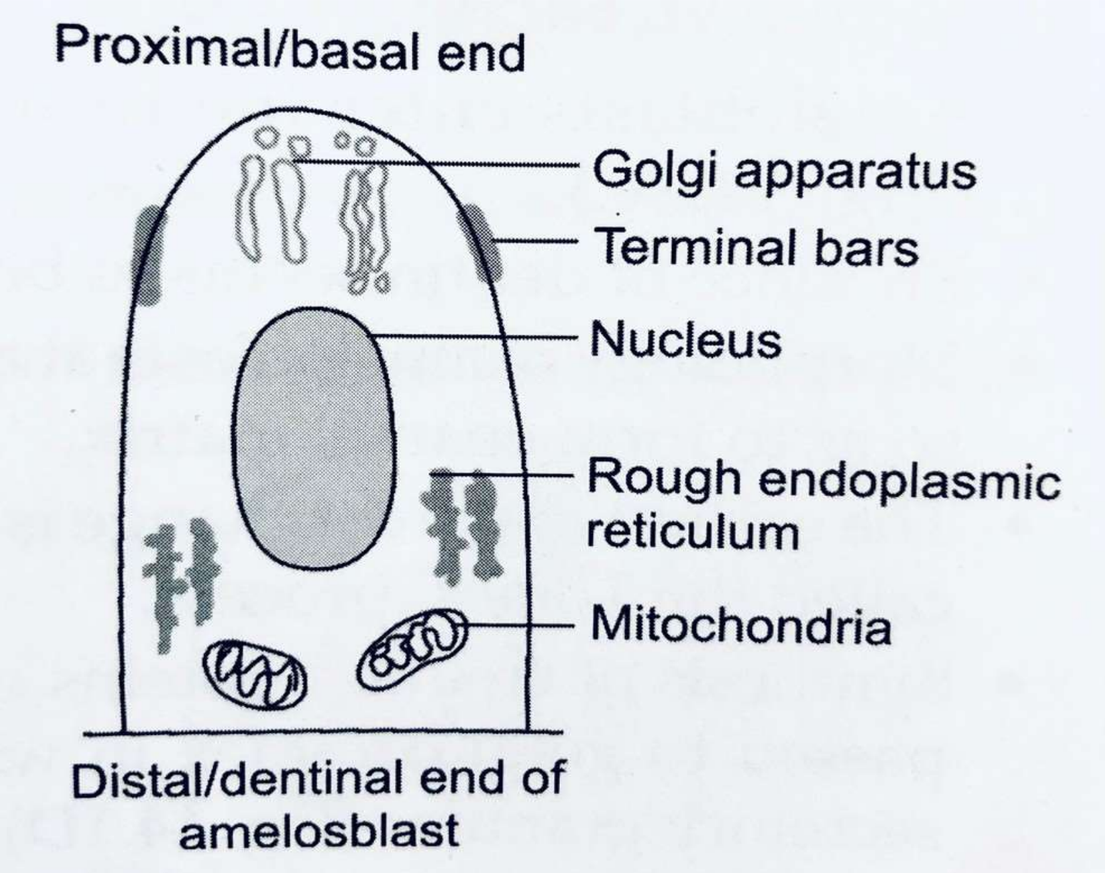
MORPHOGENIC STAGE

- **Cells**- short columnar
- **Nucleus-** large & oval that almost fills the cell body
- **Golgi apparatus** & centrioles - located in proximal end
- **Mitochondria** - evenly dispersed throughout the cytoplasm



MORPHOGENIC STAGE

- During Ameloblast differentiation , terminal bars appear between the adjacent cells which represent the area of **close contact between the cells.**



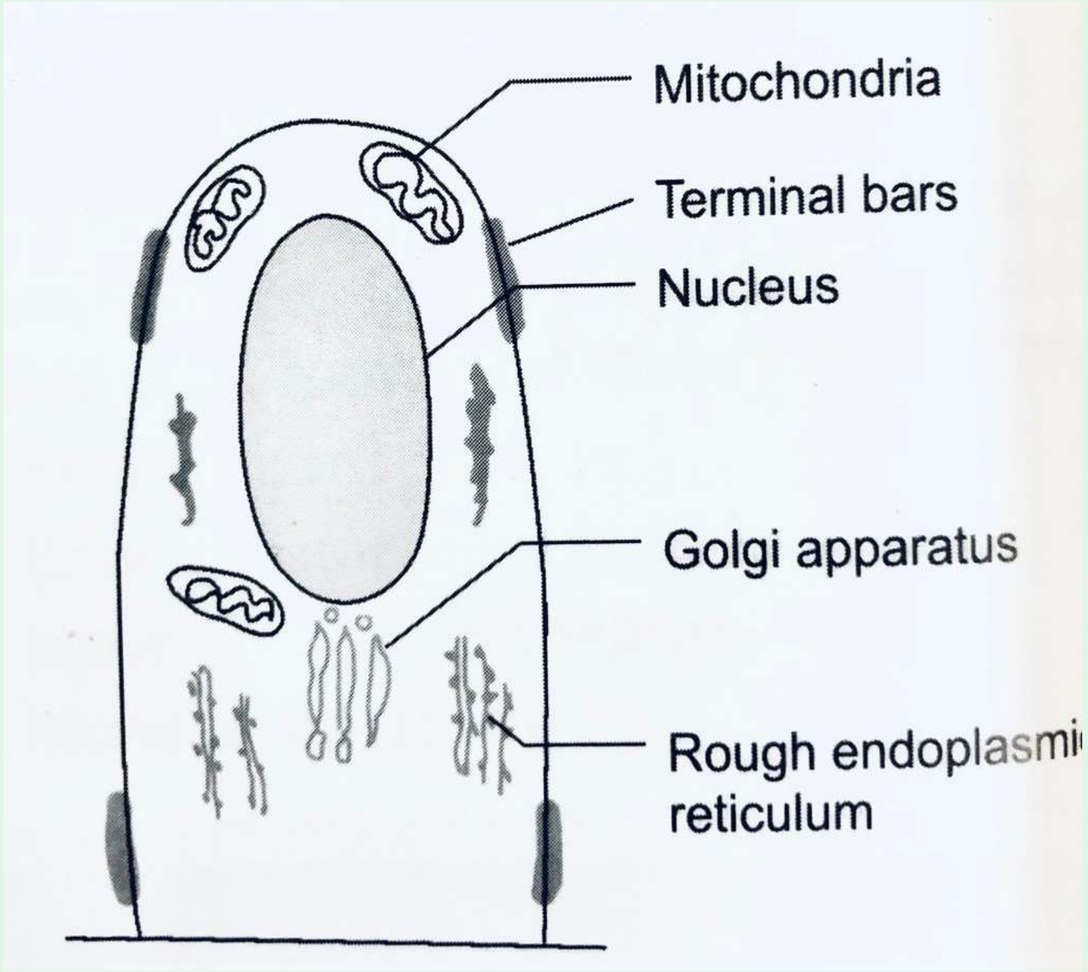
ORGANIZING STAGE

- **Cells-** tall columnar

- The nucleus free zones at the distal end become almost as long as the proximal part containing the nuclei

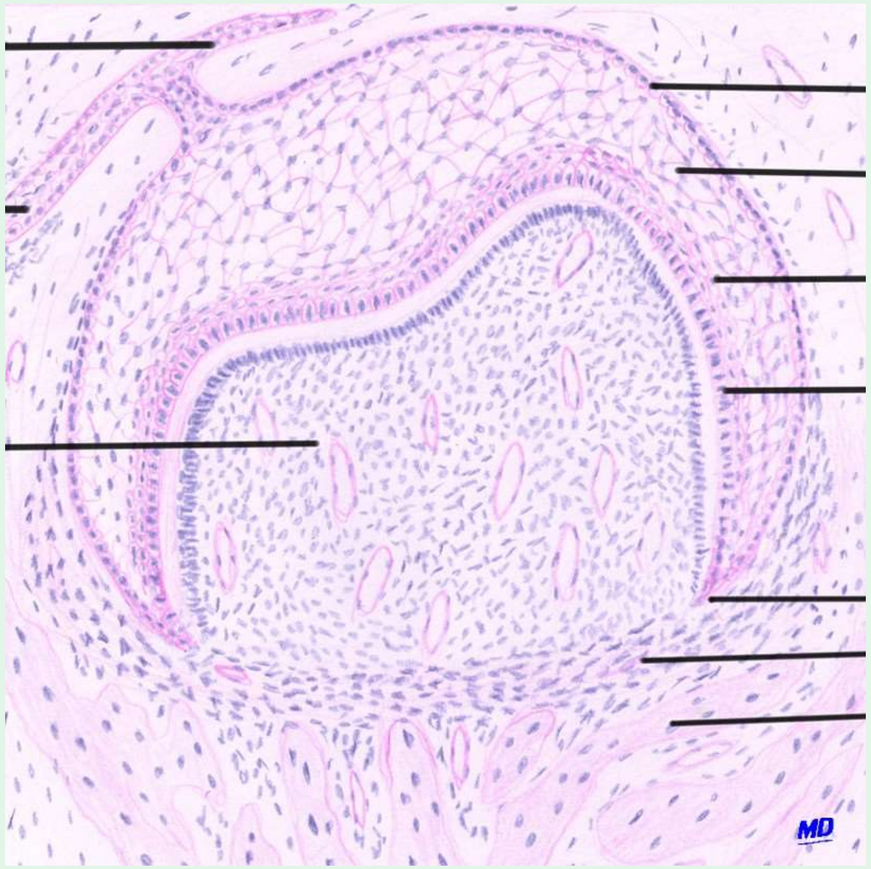
- **REVERSAL OF POLARITY** - Nucleus shifts towards the proximal end

- **Golgi bodies & centrioles**-migrates from proximal to distal end of the cell.



ORGANIZING STAGE

•During the terminal phase, the **formation of dentin by odontoblasts begins**.



•First appearance of dentin seems to a critical phase in the life cycle of the IEE as ameloblasts cuts off their original source of nourishment i.e dental papilla.

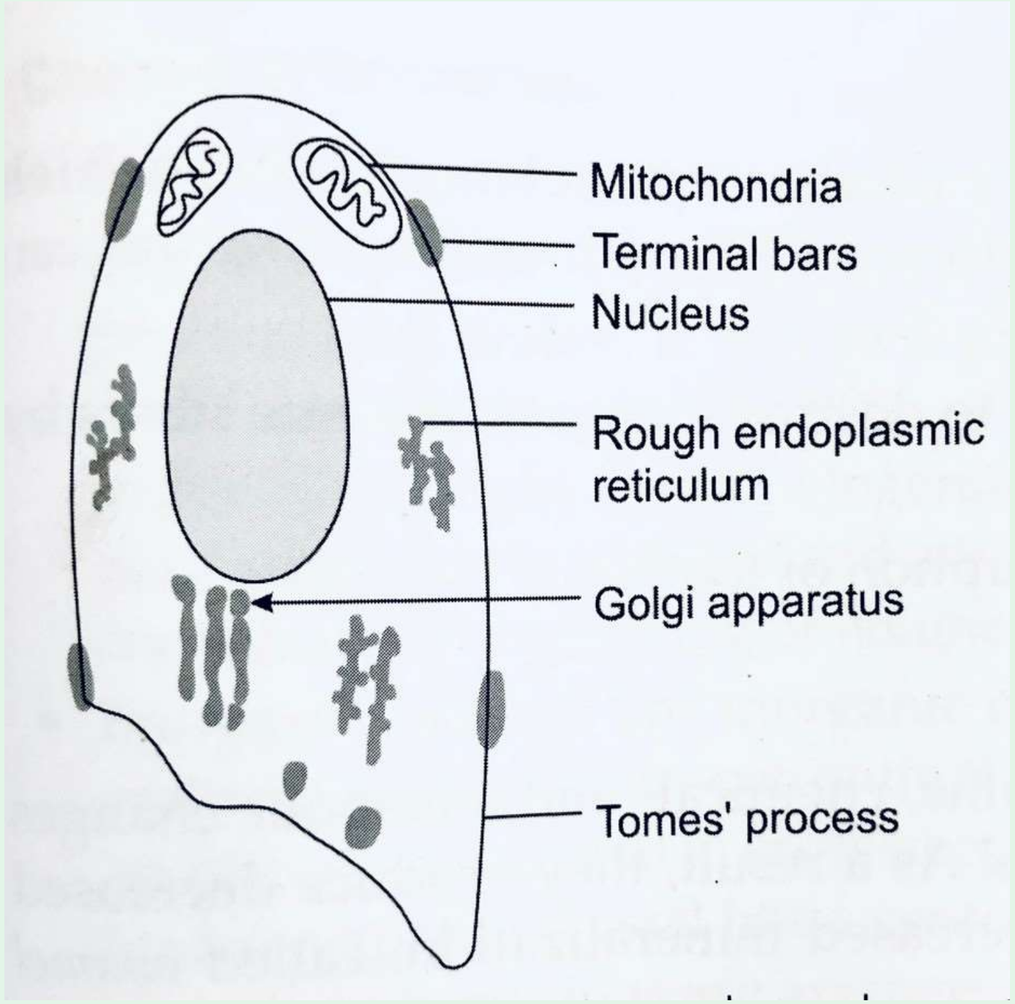
•They are supplied by capillaries that surround the outer enamel epithelium

FORMATIVE STAGE

- Enters this stage after the first layer of dentin has been formed

- During formation of the enamel matrix, the ameloblasts retain approximately the same length & arrangement

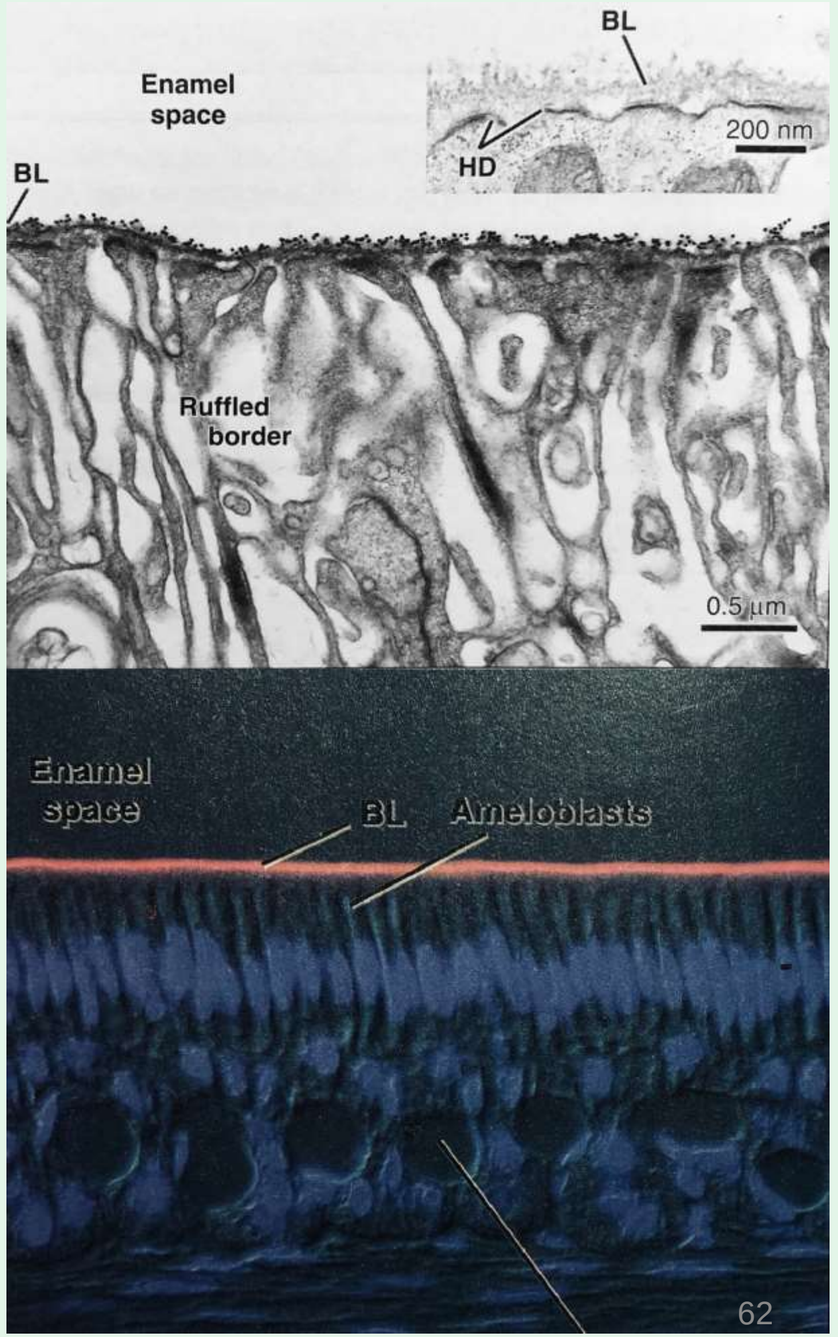
- Ameloblasts develop pyramidal processes at the distal end called **TOME'S PROCESS.**



MATURATIVE STAGE

- Enamel **maturation** occurs after most of the thickness of the **enamel matrix** has been formed in the occlusal or incisal area.

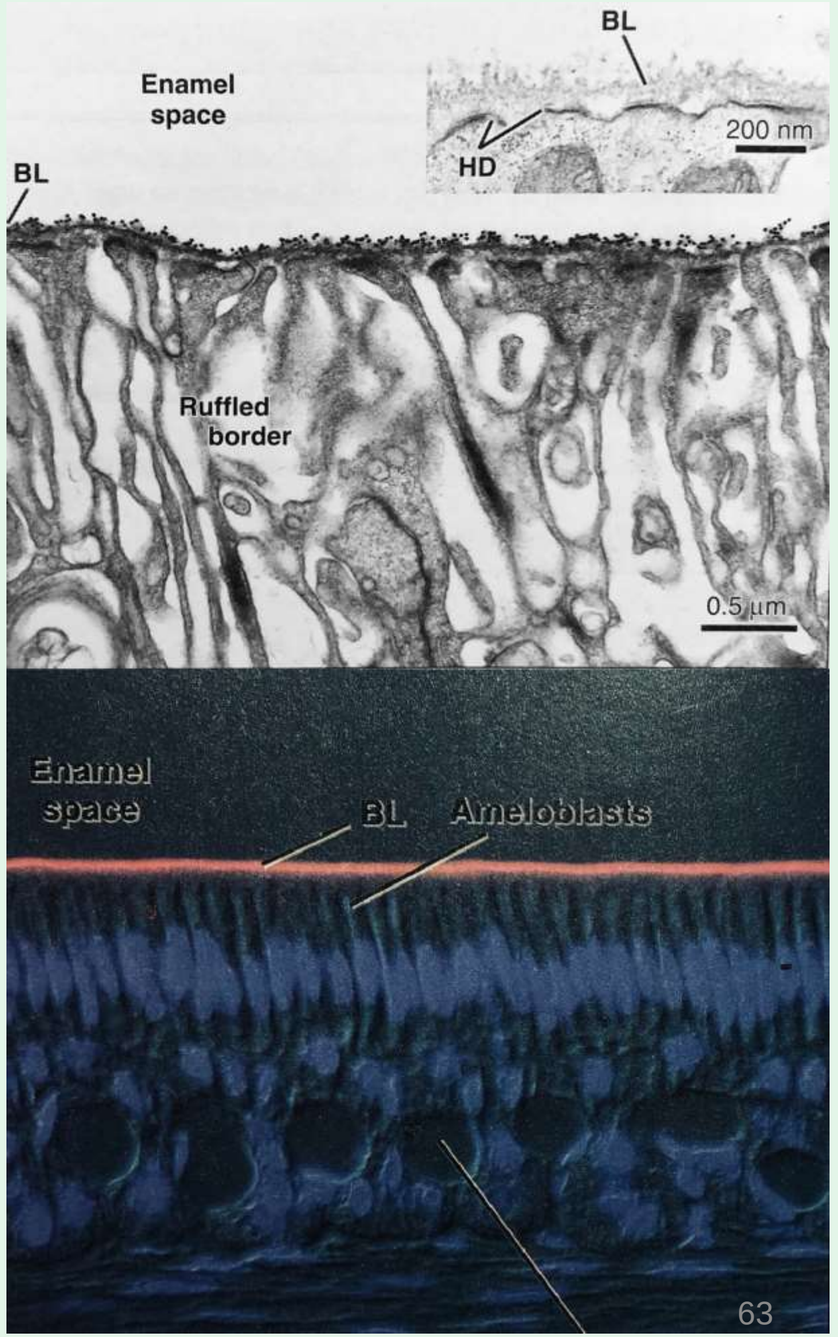
- AMELOBLASTS are <u>slightly reduced in length</u> & are closely attached to enamel matrix.



MATURATIVE STAGE

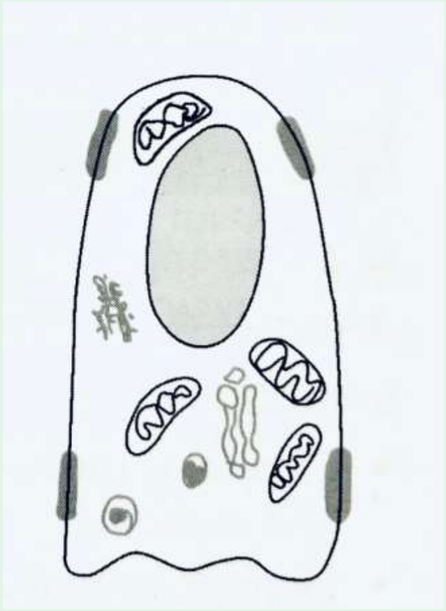
- During maturation, **ameloblasts display microvilli at their distal extremities.**

- These structure indicate an **absorptive function** of these cells

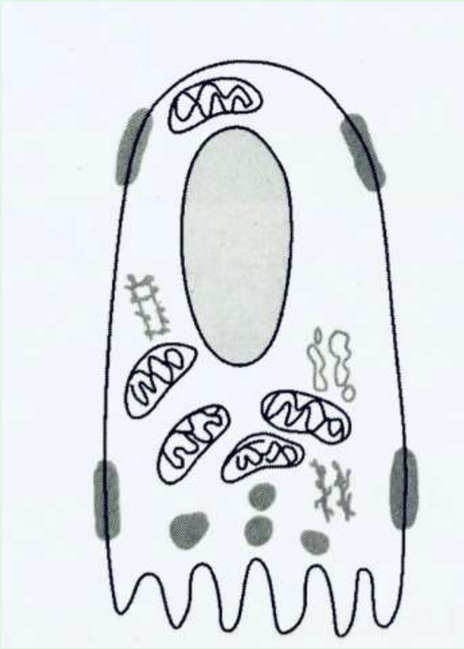


MATURATIVE STAGE

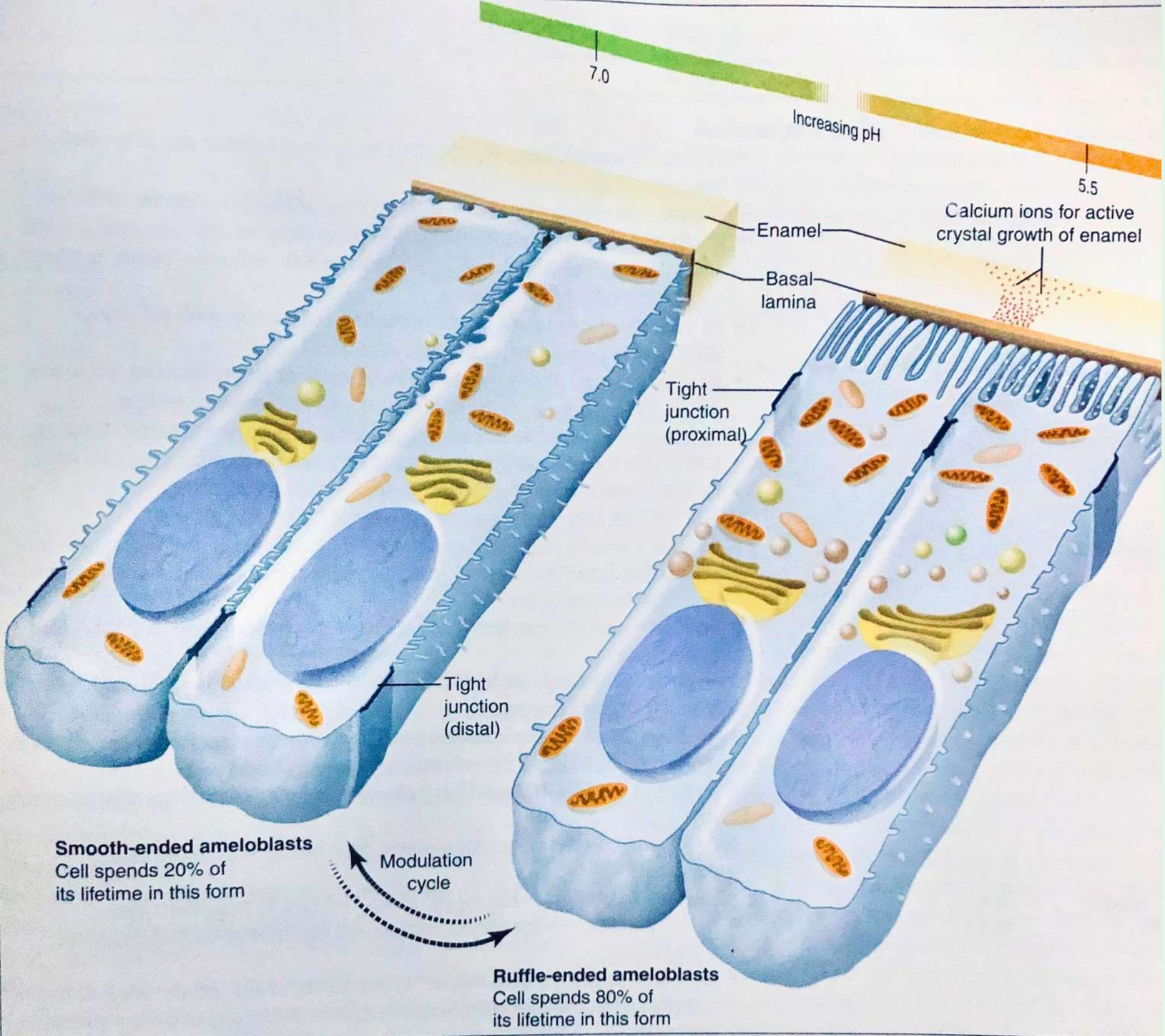
- The distal surface of the ameloblasts now alter between being **smooth & ruffled**



- Promotes the removal of proteins & water



- Promote Calcium influx into the maturing enamel.



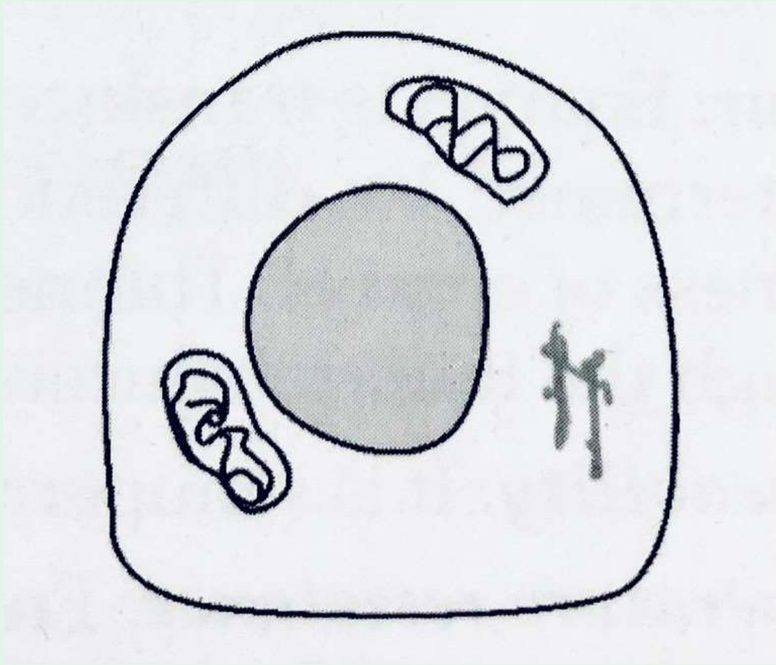
Smooth and Ruffle ended ameloblasts

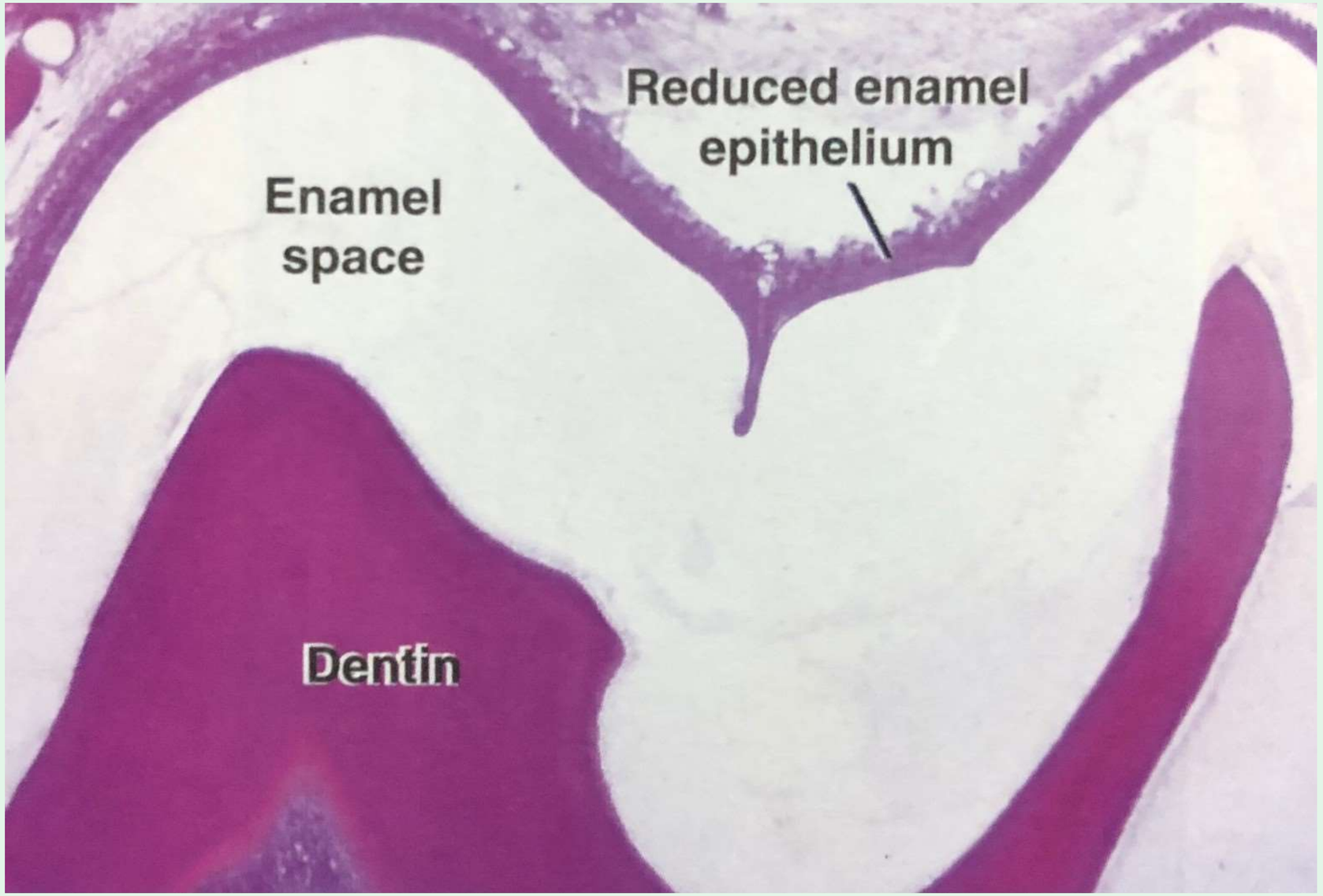
PROTECTIVE STAGE

- When the enamel has completely developed & has fully calcified, they can **no longer be differentiated from the cells of the stratum intermedium & OEE.**

- These cells form a stratified epithelial covering of the enamel i.e the **REDUCED ENAMEL EPITHELIUM**.

- **Function of REE-** Protect the mature enamel by separating it from the connective tissue until the tooth erupts.




Reduced enamel epithelium
Enamel space
Dentin

DESMOLYTIC STAGE

- The reduced enamel epithelium cells elaborate enzymes that are able to **destroy connective tissues fibers by desmolysis**.

- Premature degeneration of the reduced enamel epithelium may prevent the eruption of a tooth

Clinical significance of AMELOBLAST

1. Ameloblasts are very sensitive cells

1. Infections, trauma, chemical changes involving calcium & phosphorus affect ameloblasts

2. As a result, they produce decreased thickness of enamel called **ENAMEL HYPOPLASIA** or decreased mineralization called **ENAMEL HYPOMINERALIZATION**.

Clinical significance of AMELOBLAST

4. Fluorosis affects enamel

- It is chemical intoxication of ameloblasts when drinking water has fluoride in excess

Amelogenesis

On the basis of composition two processes are involved in development of enamel.

1. Organic Matrix formation

2. Mineralization

Formation of Enamel Matrix

Ameloblasts begin their secretory activity when a small amount of dentin has been laid down

↓

Reciprocal epithelial mesenchymal interaction lead to **differentiation of Odontoblasts & Ameloblasts**.

Amelogenin is the major component of enamel matrix protein

↓

Undergoes extra cellular degradation into smaller low molecular weight fragments & suggested to have specific functions as in **regulating crystal growth**.

↓

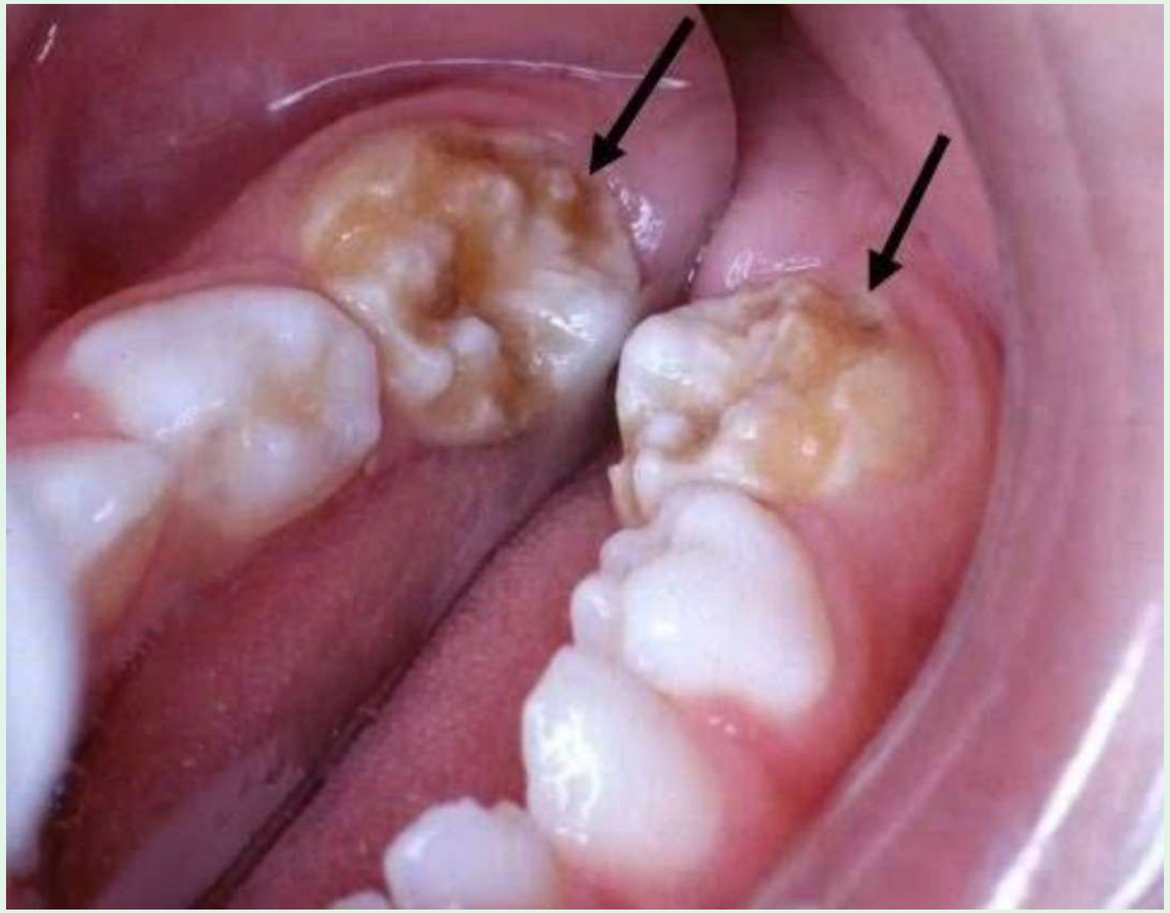
Most of the **secreted amelogenin is removed during maturation**

It form minute nanospheres between **which enamel crystals form.**

In fully formed enamel, amelogenin remains in between the crystals & also surrounding them.

Ameloblastin ,enamelin , tuftelin & amelotin are the other important proteins of enamel matrix.

Experimentally, **absense of amelogenin resulted in the formation of hypoplastic teeth**

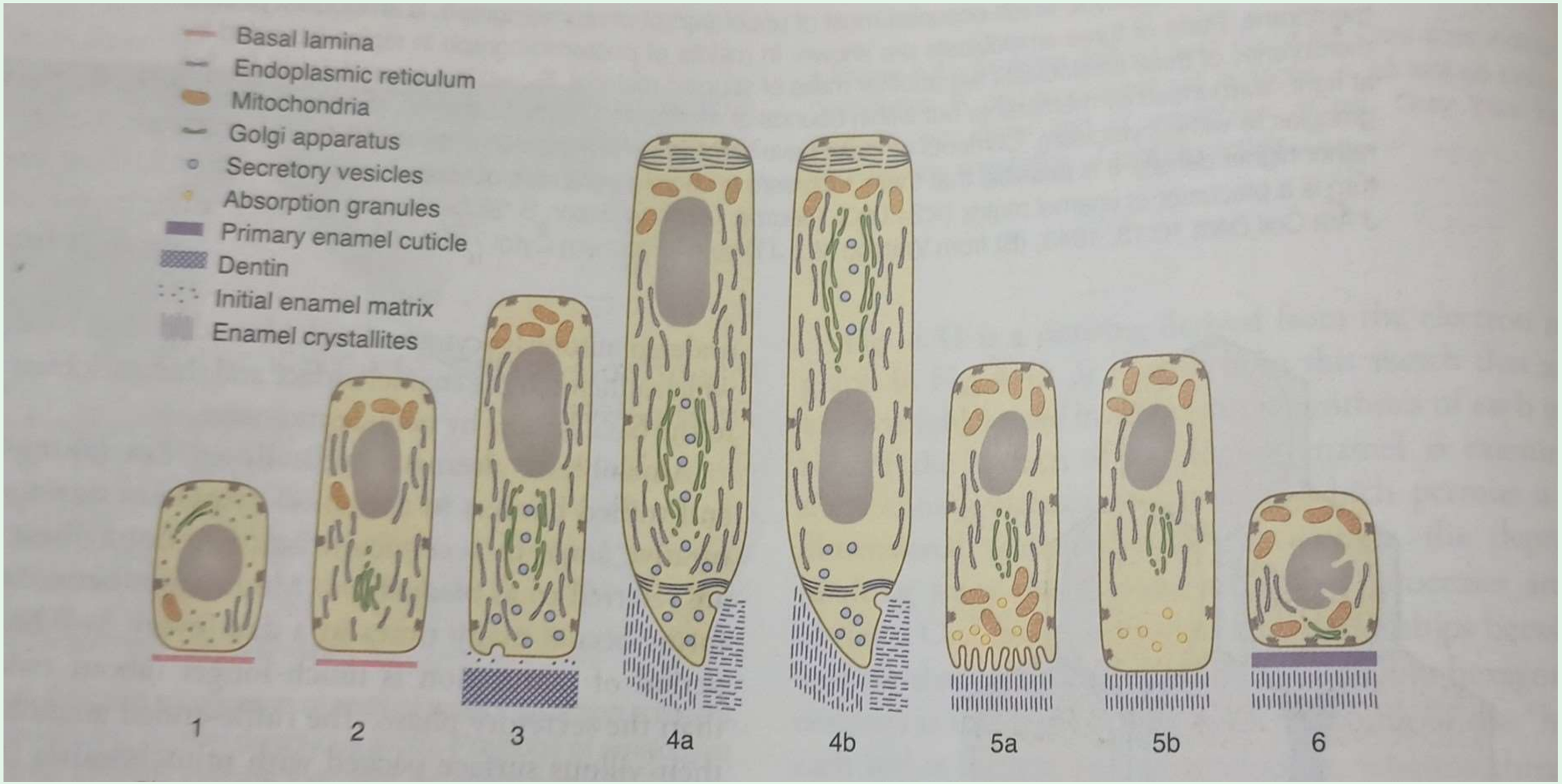


Development of Tome's Process

After the initial enamel matrix is laid down, Ameloblasts develop **cone like projection called as Tome's Process**

All **enamel matrix secretions** occur through the Tome's Process.

The enamel matrix is partially mineralized matrix


Basal lamina
Endoplasmic reticulum
Mitochondria
Golgi apparatus
Secretory vesicles
Absorption granules
Primary enamel cuticle
Dentin
Initial enamel matrix
Enamel crystallites
1
2
3
4a
4b
5a
5b
6

Mineralization and Maturation of the Enamel Matrix

Mineralization of the enamel matrix takes place in **two stages**

First stage is **partial mineralization** in matrix segments & inter prismatic substance as they are laid down.

Second stage is **maturation** characterized by the gradual completion of mineralization

After the full thickness of enamel matrix is laid down it undergoes mineralization

↓

Ameloblast develop villous projection on their process

↓

During maturation, the Ameloblasts alter from ruffled ended to smooth ended Ameloblasts. This is **modulation.**

↓

Enamel proteins like ***tuftelin*** help in mineralization & others regulate the growth of crystals

Unique Features of Amelogenesis

In enamel mineralization, **only non-collagenous protein are involved** ;in all other hard tissue, collagen plays an important part.

After formation of enamel, the Ameloblasts undergo apoptosis therefore there is **no formation later in life** unlike in other hard tissue.

Amelogenesis imperfecta (AI) is a congenital disorder which presents with a rare abnormal formation of the enamel.



CLINICAL IMPLICATIONS

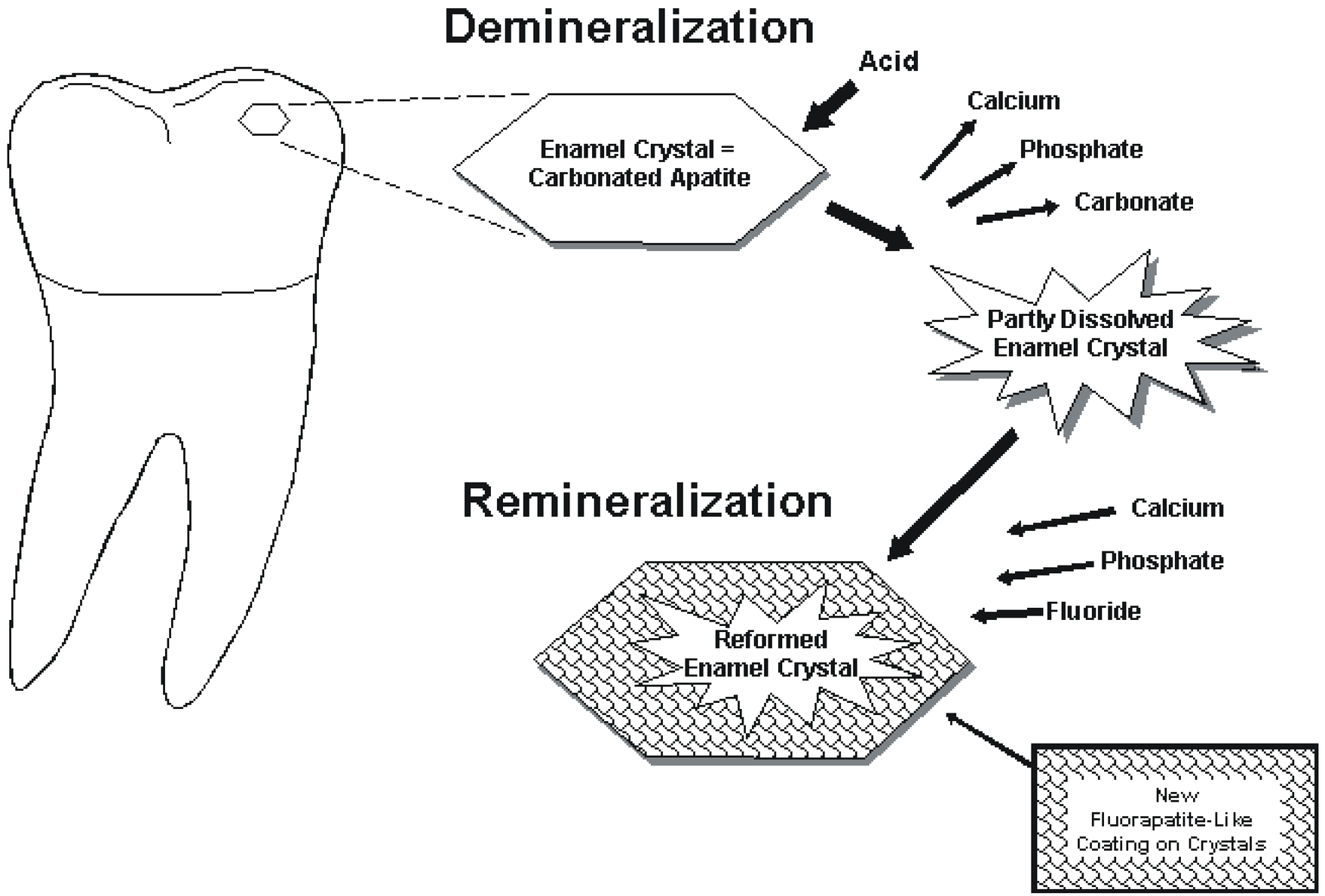
An appreciation of the histology of enamel is important for understanding the principles of **fluoridation, acid-etching techniques, & dental caries.**

FLUORIDATION

If the fluoride ion is incorporated into or adsorbed on the hydroxyapatite crystal, the **crystal becomes more resistant to acid dissolution**.

This reaction partly explains **the role of fluoride in caries prevention**, for the caries process is initiated by demineralization of enamel.

Obviously, if **fluoride** is present as enamel is being formed,
all the **enamel crystals will be more resistant to acid dissolution.**


Demineralization
Acid
Enamel Crystal =
Carbonated Apatite
Calcium
Phosphate
Carbonate
Partly Dissolved
Enamel Crystal
Remineralization
Calcium
Phosphate
Fluoride
Reformed
Enamel Crystal
New
Fluorapatite-Like
Coating on Crystals

The presence of fluoride enhances chemical reactions that lead to the **precipitation of calcium phosphate**.

An equilibrium exists in the oral cavity between calcium & phosphate ions in the solution phase i.e in SALIVA & in the solid phase i.e. ENAMEL , & fluoride shifts this equilibrium to favor the solid

phase.

The amount of fluoride must be controlled carefully, however, because of the sensitivity of ameloblasts to the fluoride ion & the possibility of producing unsightly **mottling.**

small, opaque, "paper white" areas
scattered irregularly over the tooth





ACID ETCHING

Acid etching of the enamel surface, or **enamel conditioning** has become an important technique in clinical practice

- Use of fissure sealants,
- bonding of restorative materials to enamel,
- Cementing of orthodontic brackets to tooth surfaces

ACID ETCHING

The process achieves the desired effect in two stages:

First	Second
• Removes plaque & other debris, along with a thin layer of enamel	• Increases the porosity of exposed surfaces through selective dissolution of crystals which provides a better bonding surface for restorative & adhesive materials.

ACID ETCHING

Three etching patterns predominate:

Type I

- Preferential removal of rods

Type II

- Interrod enamel is removed preferentially & rod remains intact

Type III

- Occurring less frequently is type III, which is irregular & indiscriminate

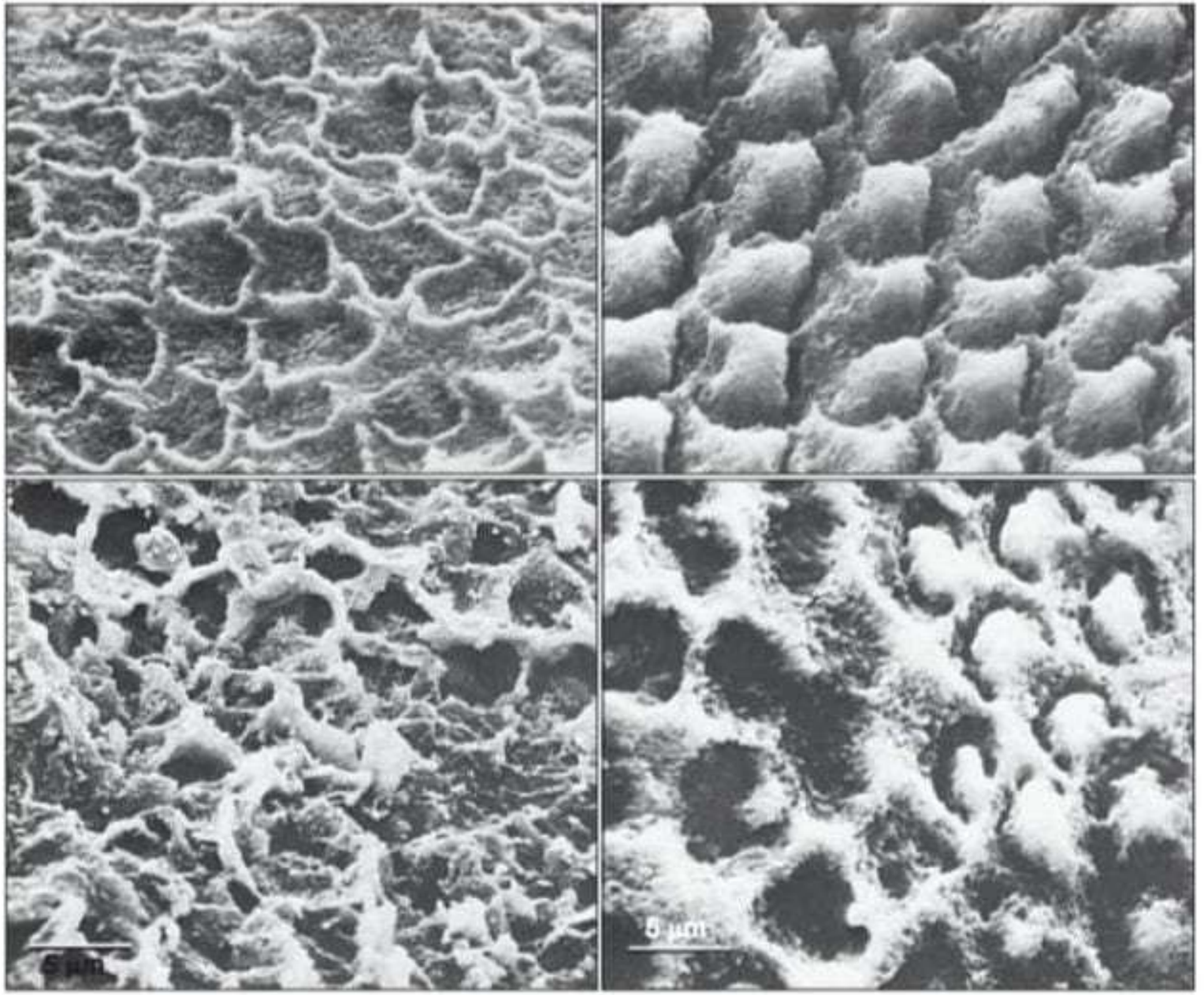


FIGURE 7-67 Scanning electron micrographs of etching patterns in enamel. **A,** Type I pattern: rod preferentially eroded. **B,** Type II pattern: rod boundary (interrod) preferentially eroded. **C,** Type III pattern: indiscriminate erosion. **D,** Junction between type I and type II etching zones. (Courtesy of L. Silverstone.)

- In summary, acid conditioning of enamel surfaces is an accepted procedure for obtaining improved bonding of resins to enamel.

- Retention depends mainly on a **mechanical interlocking**.

- The **conditioning agent** removes the organic film from the tooth surface & preferentially etches the enamel surface so that firmer contact is established.

Age changes in Enamel

- Earliest clinical change - **loss of mamelons**

- Most apparent age change in enamel -**attrition** or wear of the occlusal surfaces & proximal contact points as a result of mastication

- Evidenced by **a loss of vertical dimension** of the crown & by a flattening of the proximal contour

.

LAQ

1. Describe in detail process of Amelogenesis .
2. Describe briefly the Hypocalcified areas of enamel.
3. Discuss the physical and chemical properties of enamel. Describe the stages in life cycle of ameloblast.

SAQ

1. Hunter schregerband
2. Neonatalline
3. Surface structure of enamel

4. Incremental lines of retzius
5. Gnarled Enamel

Thank You !