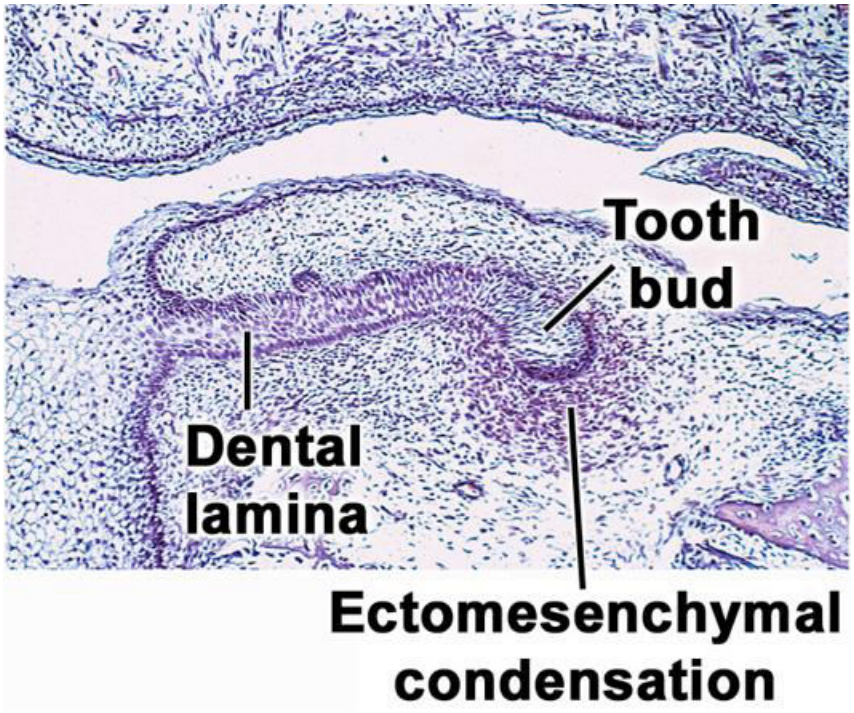
Development of Teeth



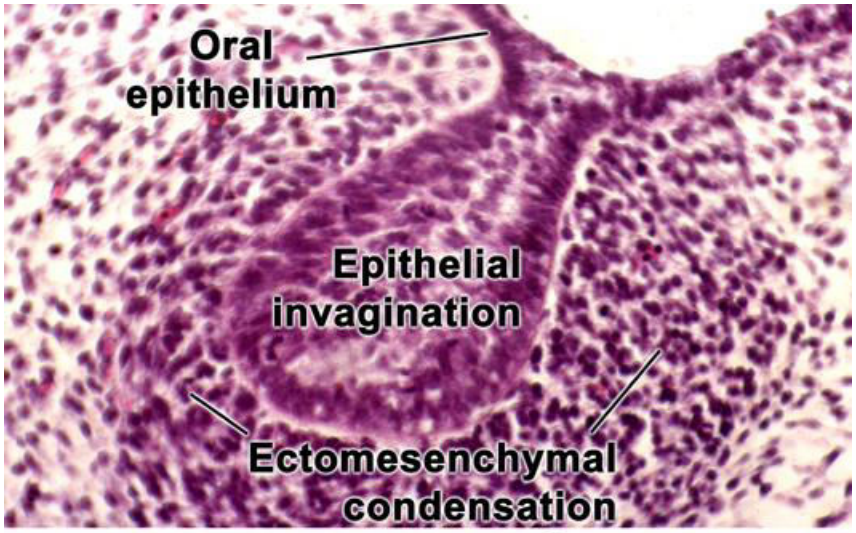
- 6 th week IUL: rupture of buccopharyngeal membrane to form stomatodaeum (primitive mouth)
- 37th day IUL: two thickened primary epithelial bands, which subdivide to form: **dental lamina** and **vestibular lamina**
- Localized proliferative activity within dental lamina leads to formation of series of epithelial ingrowths into ectomesenchyme at sites corresponding to position of future deciduous teeth.

HISTOLOGY OF TOOTH DEVELOPMENT

STAGES OF TOOTH DEVELOPMENT

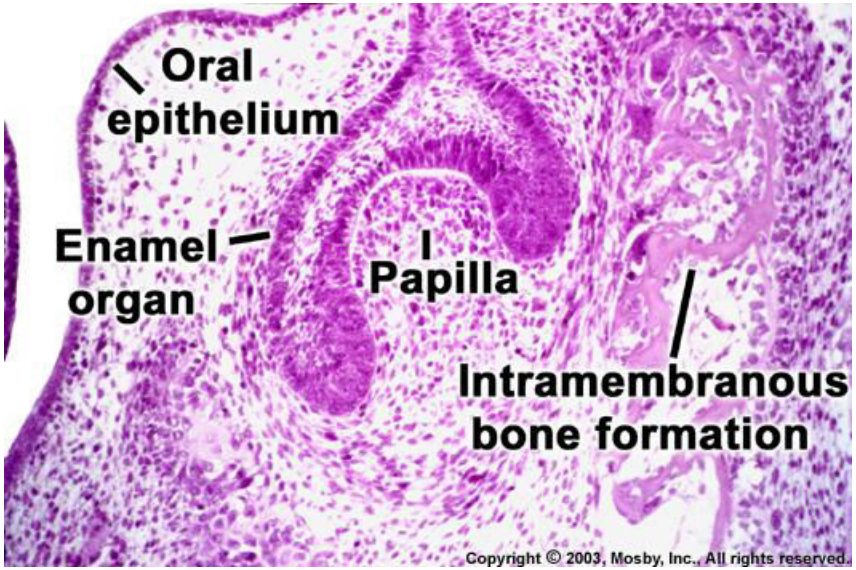
- Bud stage
- Cap stage (proliferation)
- Early bell stage (Histodifferentiation & morphodifferentiation)
- Advanced bell stage

BUD STAGE



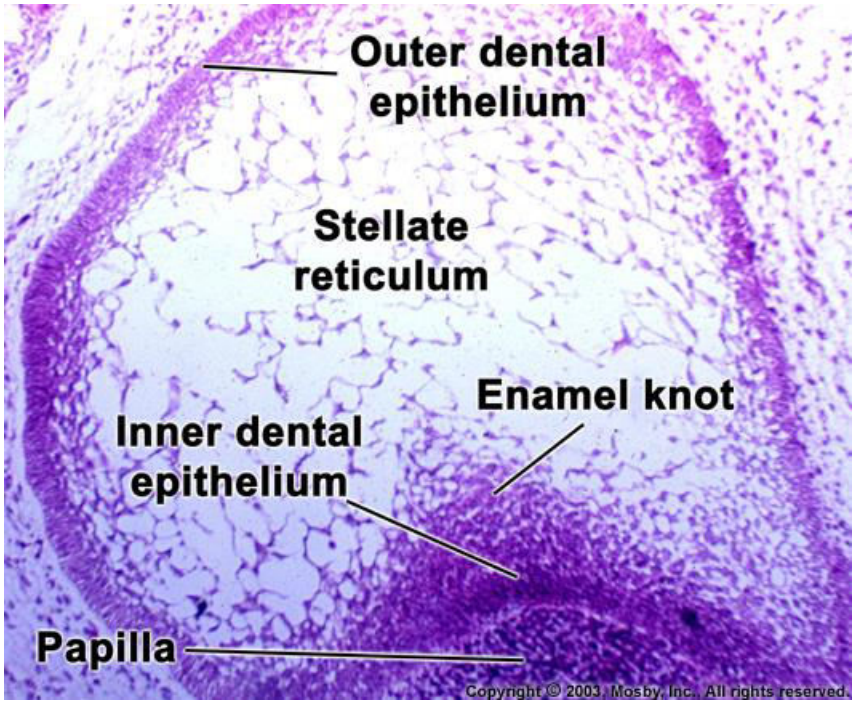
- Epithelial cells show little change in shape or function.
- Supporting ectomesenchymal cells are closely packed beneath and around the epithelial bud.

CAP STAGE



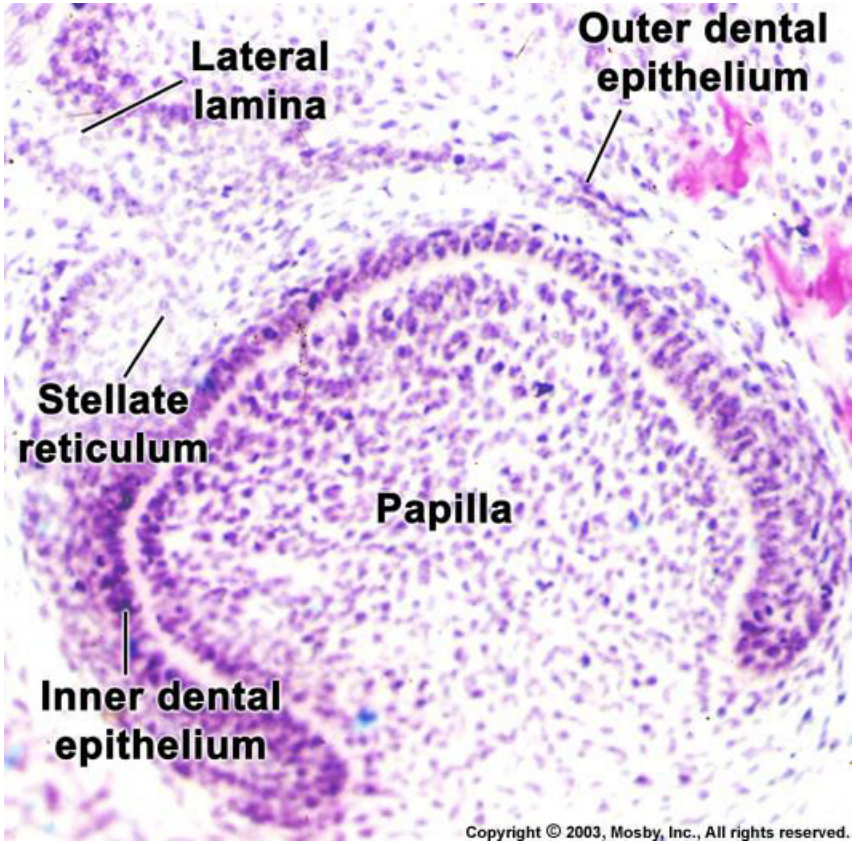
- *Condensation* of ectomesenchyme immediately adjacent to the epithelial ingrowth: due to local grouping of cells that have failed to produce extracellular substance & have not separated from each other.
- It is already possible to identify the formative elements of tooth.
- *Dental/ enamel organ*
- *Dental papilla*
- *Dental follicle*

EARLY BELL STAGE



- By 14th week further morpho and histodifferentiation leads to early bell stage.
- Four types of epithelial cells that are observed on light microscopic examination of enamel organ are:-
  1) Outer enamel epithelium
  2) Stellate reticulum
  3) Stratum intermedium
  4) Inner enamel epithelium

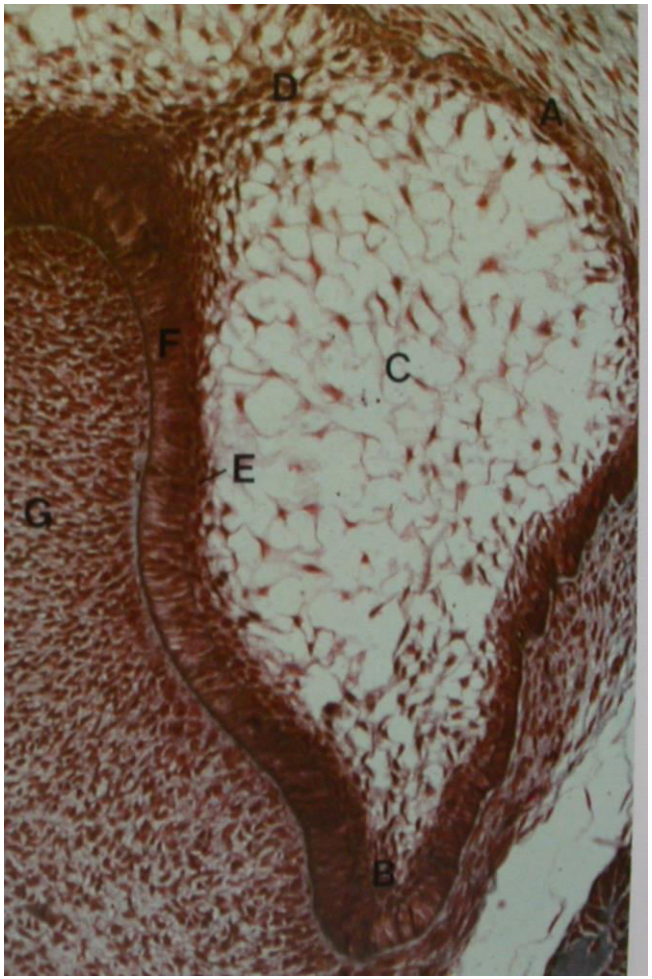
OUTER ENAMEL EPITHELIUM



- Cells are cuboidal with large centrally placed nuclei.cells contain free ribosomes,few profiles of ER , some mitochondria & a few scattered tonofilaments.
- Cells are separated from mesenchymal tissue by basement membrane
- function

STELLATE RETICULUM

- In early development, cells are sqamoid with blunt processes. Their cytoplasm contains usual complement of organelles & tonofilaments.
- Cells continue to synthesize and secrete glycosaminoglycans and pull water and there is increase in volume of extracellular compartment



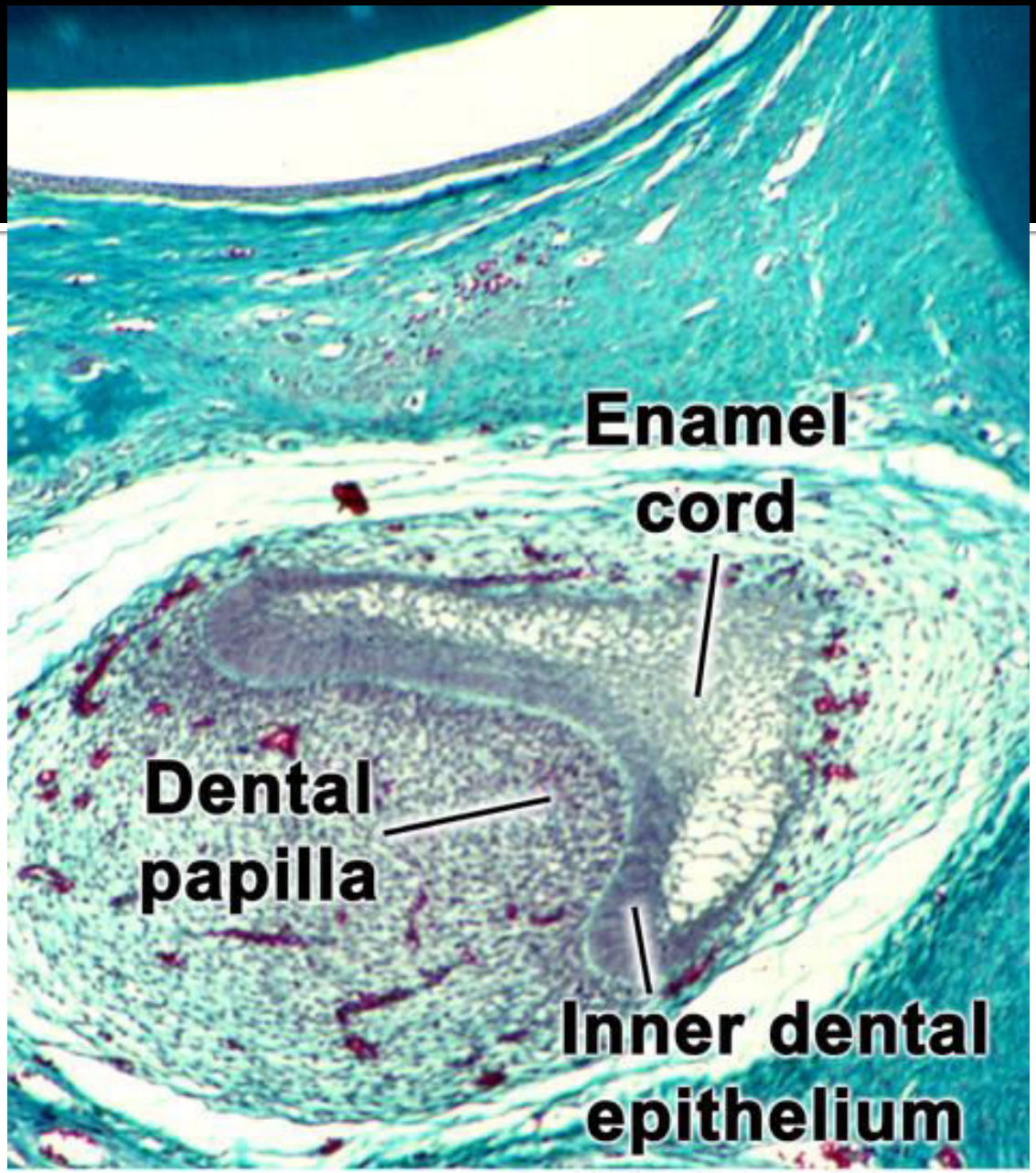
STELLATE RETICULUM…

- As mucoid material accumulates cells in centre become spindle or fusiform and those bordering the OEE and stratum intermedium retain stellate shape.
- Cells contain ER,few mitochondria but well developed golgi complex and they show presence of microvilli.

- Cells also secrete alkaline phosphatase & contain small amount of RNA & glycogen.
- Functions-mechanical &determination of crown morphogenesis.

STRATUM INTERMEDIUM

- 2-3 layers of squamous cells oriented at right angle to developing ameloblasts.
- Oval or round cells with hyperchromatic nuclei and few intercellular spaces housing microvilli.
- Few intercellular cell organelles.
- Cells are attached by desmosomes.



INNER ENAMEL EPITHELUIM

- Initially cells are 4-5 microns in width and 12 microns in length
- Cells have large centrally placed nuclei with golgi apparatus and centrioles at proximal end and mitochondria evenly dispersed.

- Gap junctions between cells
- Cells continually divide until late bell stage. At the sites of future cusp or incisal edge mitotic division ceases and cell start differentiating.

DENTAL PAPILLA

- Acellular zone separates IEE and dental papilla.
- Cells of papilla are mesenchymal cells and fibroblasts.
- Until late bell stage dental papilla consists of closely packed mesenchymal cells and show developing blood vessels.
- Rich in glycosaminoglycans.
- Cells of the DP start differentiating under the organizing influence of IE.

DENTAL PAPILLA CONT…

- Differentiation begins at the site of deepest invagination and progresses crestward.
- Preodontoblasts do not show well developed organelles and specific orientation and are cuboidal.

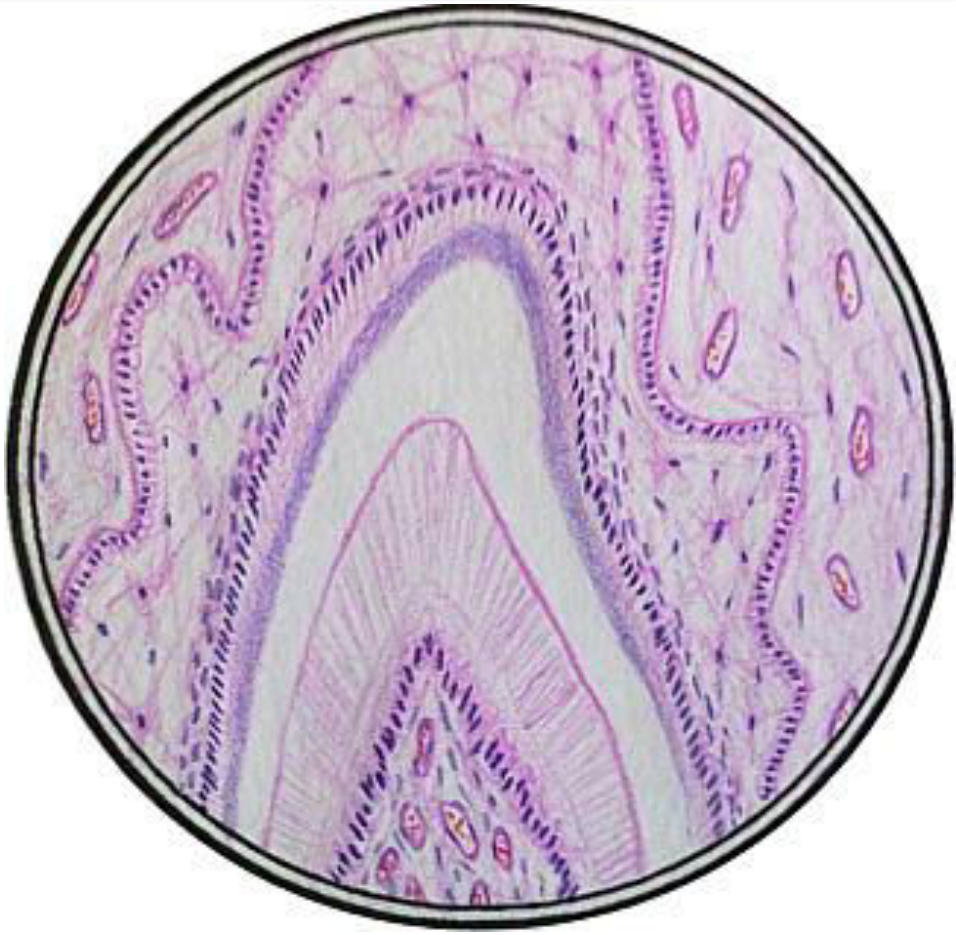
DENTAL SAC

- Loose fibrous connective tissue investing enamel organ.
- Consists of fibroblast and mesenchymal cells.
- Intercellular spaces contain collagen fibrils.
- Dental sac is distinguished from dental papilla.
- Function.

ADVANCED BELL STAGE

- Is associated with terminal differentiation into ameloblasts and odontoblasts and formation of two principle hard tissues.
- This stage commences at about 18th week.

Low power



High power

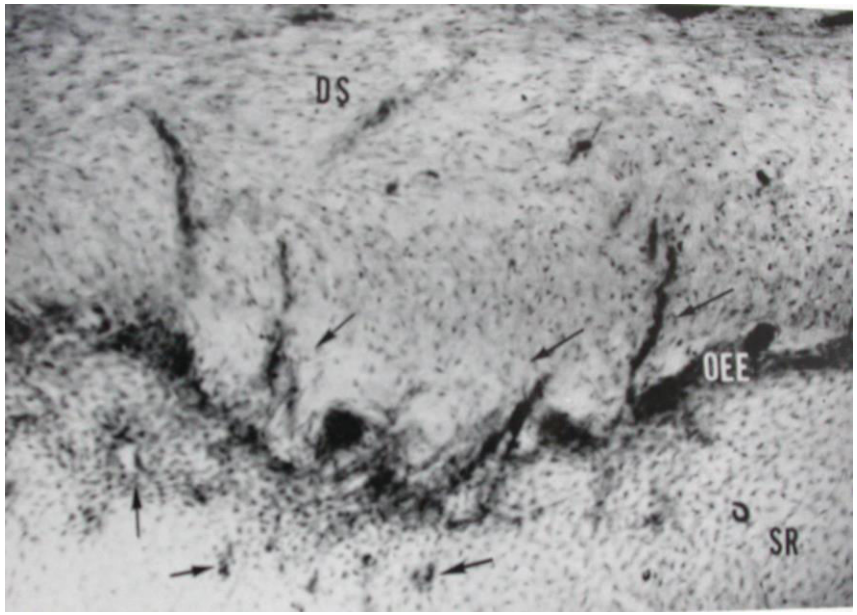
OUTER ENAMEL EPITHELIUM

As maturation of OEE occurs cells become flattened or low cuboidal

- Maturation is also marked by increase in number, size and irregularity of intercellular spaces & reduction in number of organelles which indicates *decrease metabolic need of cells.*

0UTER ENAMEL EPITHELIUM…..

- Maturation progresses crestward.
- OEE is laid down in fold.
- Between the folds mesenchymal cells of DS forms papillae which contain loops and thus provide nutritional supply to avascular enamel organ.



STELLATE RETICULUM

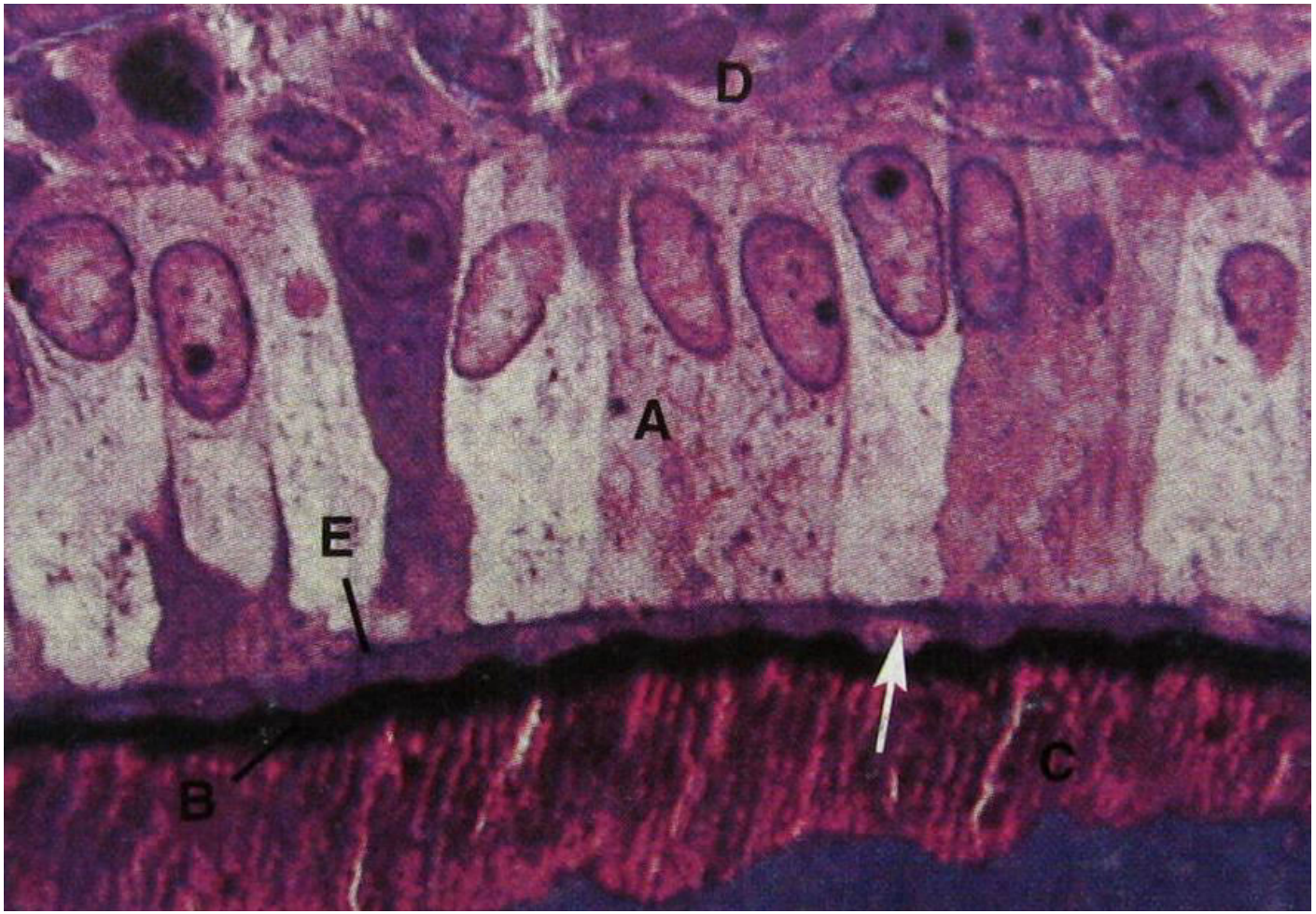
- Maturation of this layer begins at the height of the cusp or incisal edge and progresses cervically.
- The intercellular spaces are greatly increased.
- Just before enamel formation begins, SR collapses at places.

INNER ENAMEL EPITHELIUM

- Cells become tall columnar.
- As they elongate , the nucleus free zone at the distal end becomes as long as proximal parts.
- Reversal of polarity.
- Lengthening of preameloblasts and migration of nuclei basalward are products of prospective functional maturity.

INNER ENAMEL EPITHELIUM CONT....

- As cells of IEE elongate, cell free zone between IEE & DP disappears.
- Mature secreting ameloblast is 35-50 microns long & 5-10 microns wide.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INNER ENAMEL EPITHELIUM CONT…

- Enamel matrix proteins are assembled in ER and are carried by transitional vesicles to golgi apparatus where glycosylation and sulphation takes place before packaging into electron dense secretory granules.

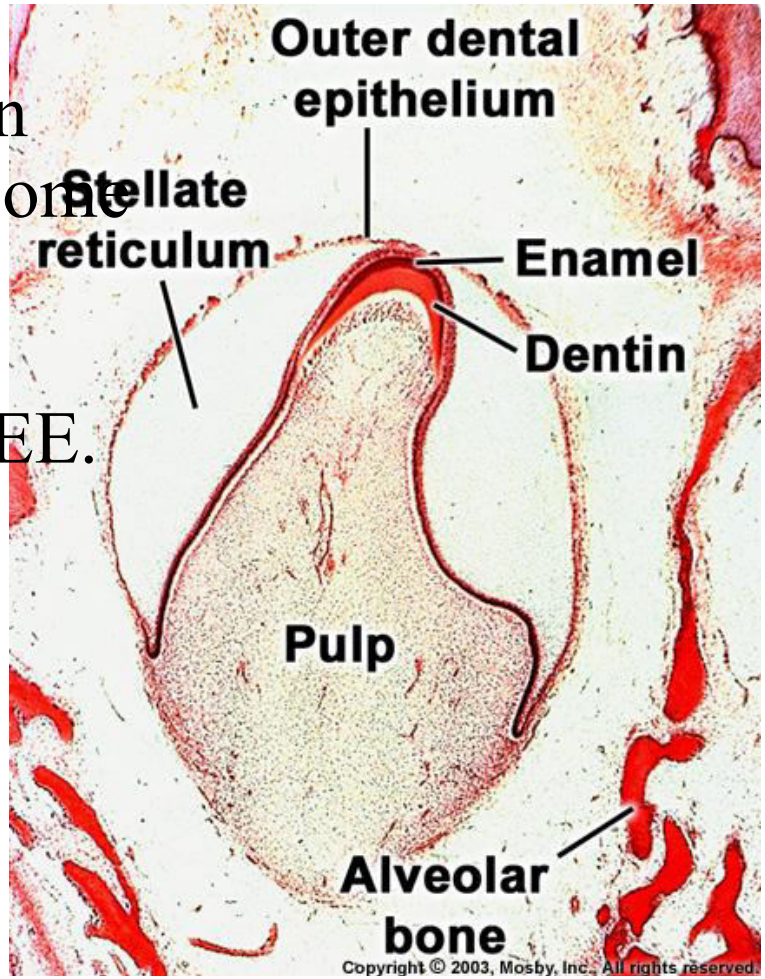
INNER ENAMEL EPITHELIUM CONT…

- After secreting a thin layer of enamel matrix, cells retreat from DEJ.
- Formation of Tome's process.
- Zone of mineralized matrix analogous to predentin or osteoid is never seen.
- Once the entire thickness of enamel is formed, it is structurally complete but only 30% mineralized.

- changes into final form.

- After maturation ameloblasts become flattened.

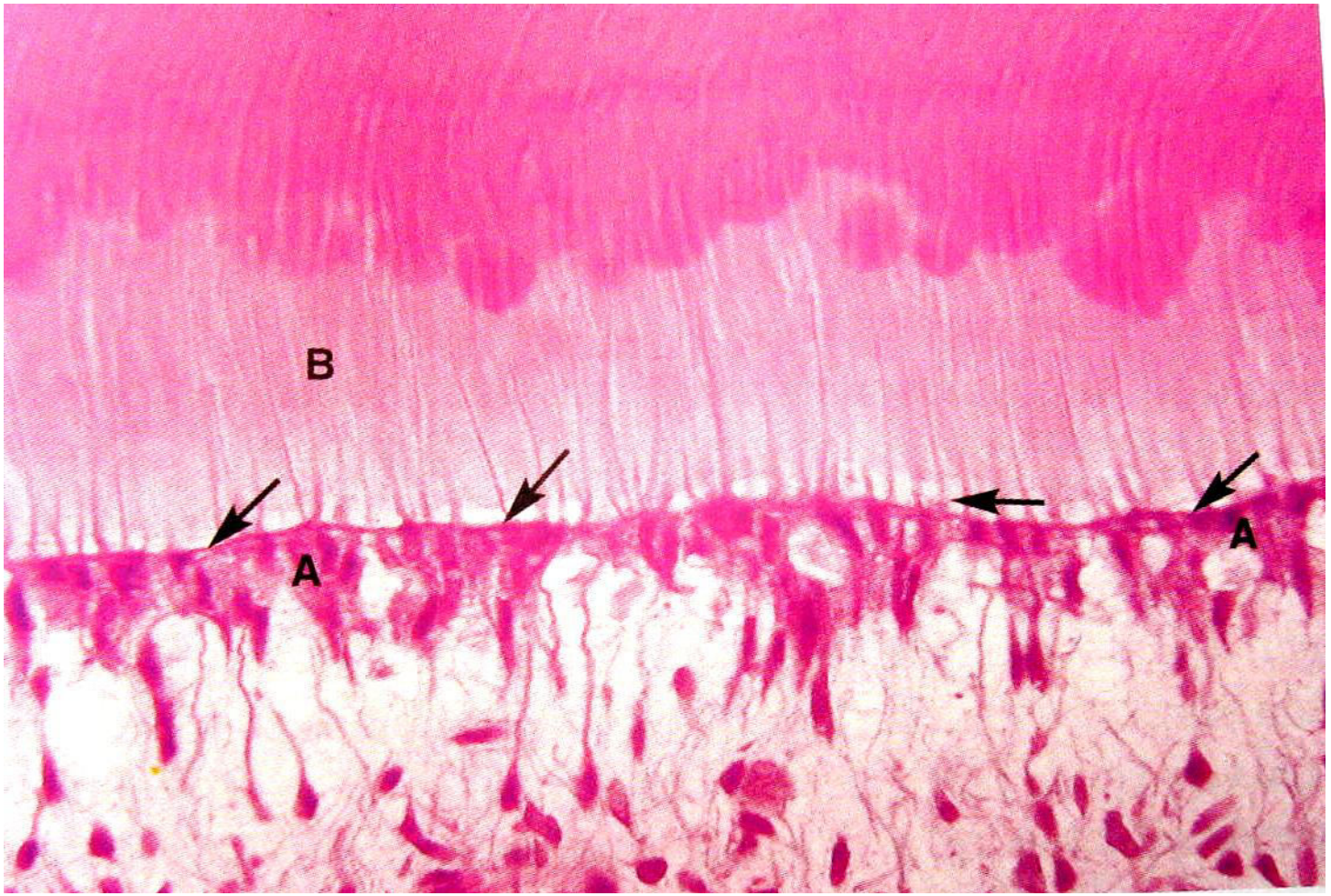
- Formation of REE.



DENTAL PAPILLA

- Peripheral mesenchymal cells start differentiating under organizing influence of IEE.
- The mesenchymal changes precede those in enamel.

PREDENTINE & DENTINE



DENTAL SAC

- Tissues of dental follicle comprises 3 layers-inner investing layer is said to be derived from ectomesenchyme,while intermediate &outer layers are said to be mesodermal in origin.

- Cells of dental sac initiate the formation of cementum, PDL & alveolar bone.

Two major events in bell stage-

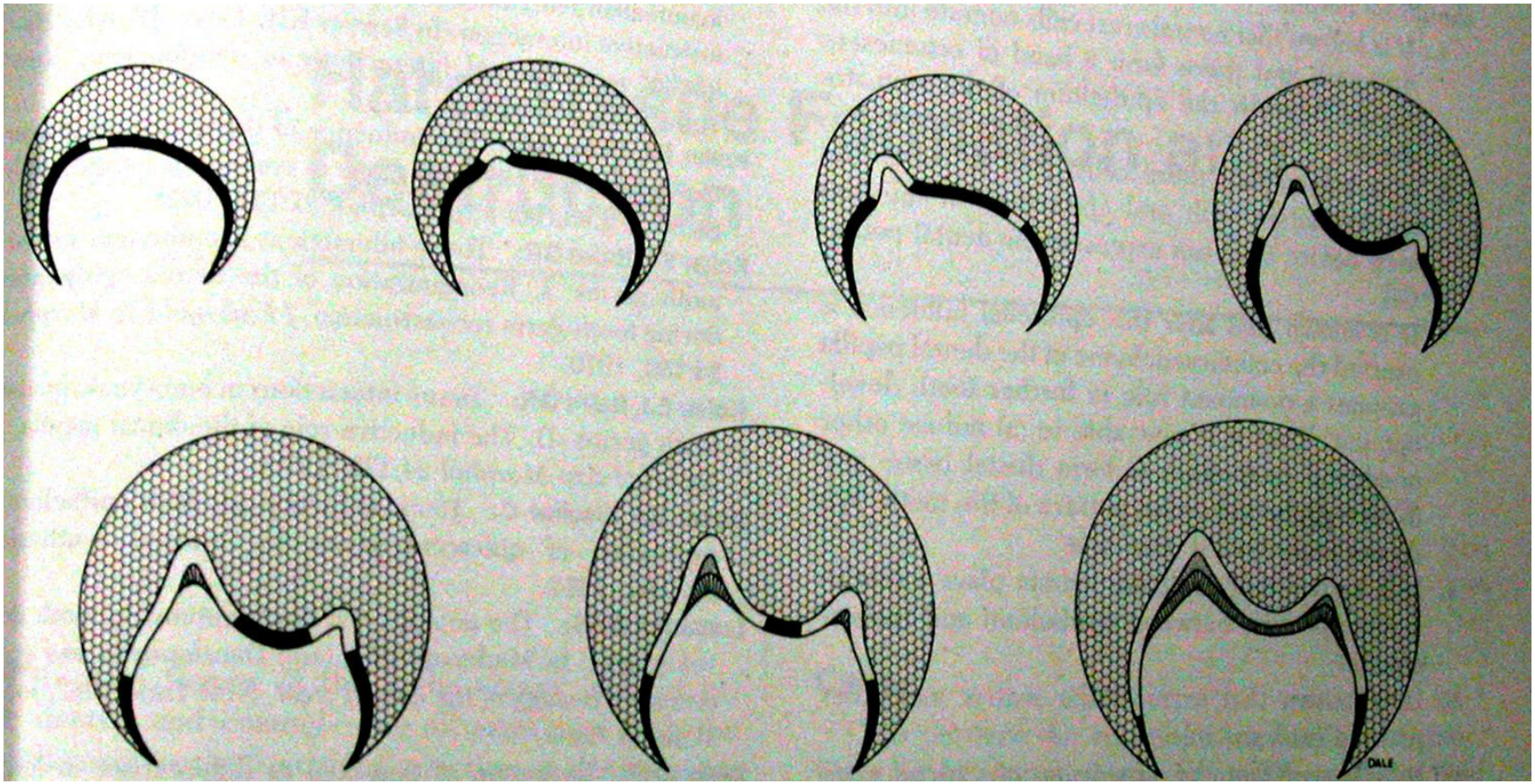
- Crown pattern determination
- Break up of dental lamina

DETERMINATION OF CROWN SHAPE

- Increased folding of IEE which is related to differential mitosis.
- At the site of future cusp IEE buckles & forms a cuspal outline.

DETERMINATION OF TOOTH SHAPE cont…

- Zone of maturation sweeps down the cusp slope.
- Occurrence of second zone of maturation.
- Final pattern of crown is determined.


DALE

BREAKUP OF DENTAL LAMINA

- Dental lamina joining the tooth germ to the oral epithelium breaks up into discrete island of epithelial cells, thus separating developing tooth from the oral epithelium.
- Epithelial clusters normally degenerate, but some may persist as epithelial pearls.

DENTAL PAPILLA

- Peripheral cells differentiate into odontoblasts under organizing influence of IEE.
- Elongation &polarization is accompanied by redistribution of intracellular skeletal proteins.
- Increased expression of fibronectin.
- Formation of odontoblast process.

- Cell to cell junctions.
- Formation of predentin, mantle dentin & circumpulpal dentin.
- Mineralization.

ROOT FORMATION

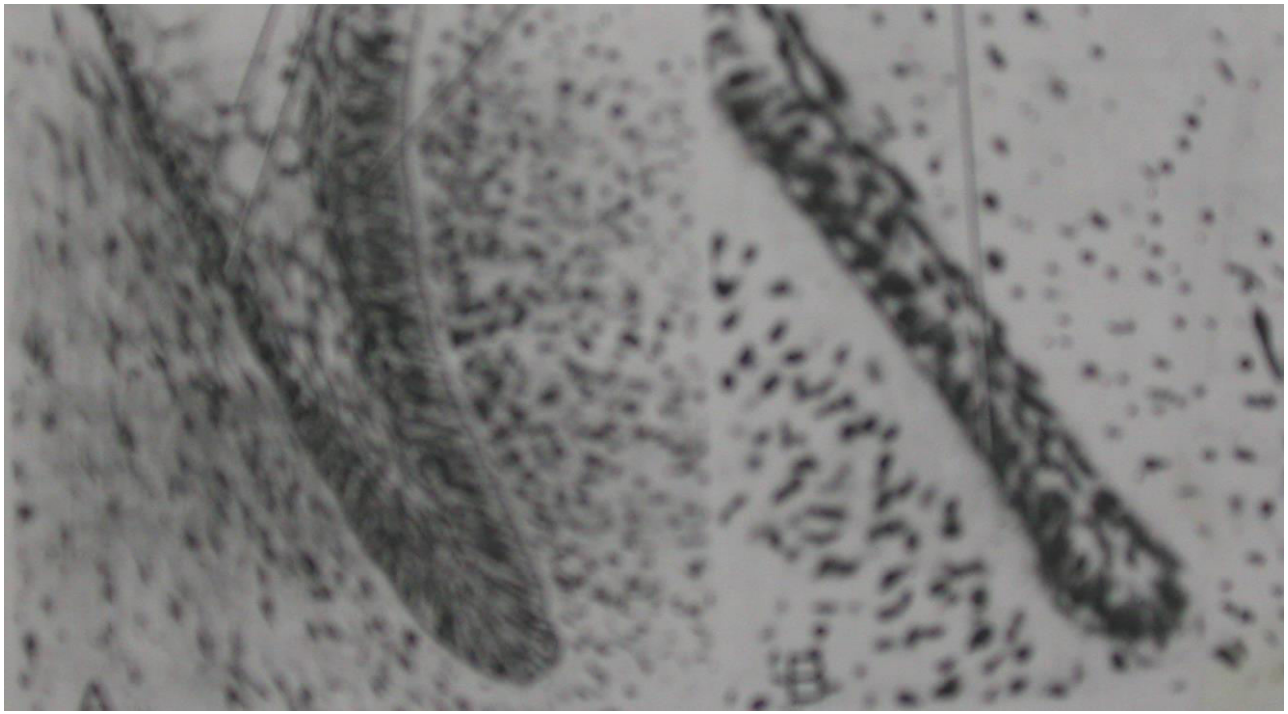
- Development of root occurs after crown has formed and involves interactions between dental follicle, HERS & dental papilla.
- Cervical loop
- Formation of HERS

- Significance of HERS-

  1) Determines root length, curvature, thickness & number of roots.

  2) Differentiation of odontoblasts.

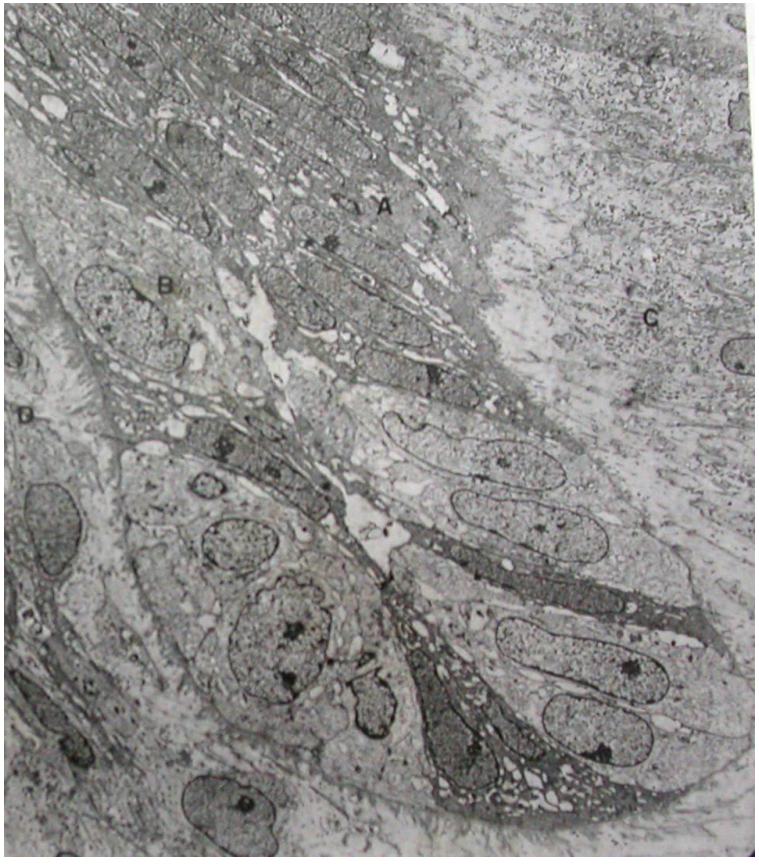
CERVICAL LOOP & HERTWIG'S EPITHELIAL ROOT SHEATH



ROOT FORMATION CONT…

- Formation of epithelial diaphragm and its significance.

- Structure of HERS



ROOT FORMATION CONT…

- FORMATION OF SINGLE ROOT
  - Occurs by growth of root sheath like a cuff or tube followed by development of root dentin.

  FORMATION OF MULTIPLE ROOTS

  -Occurs by differential growth of HERS

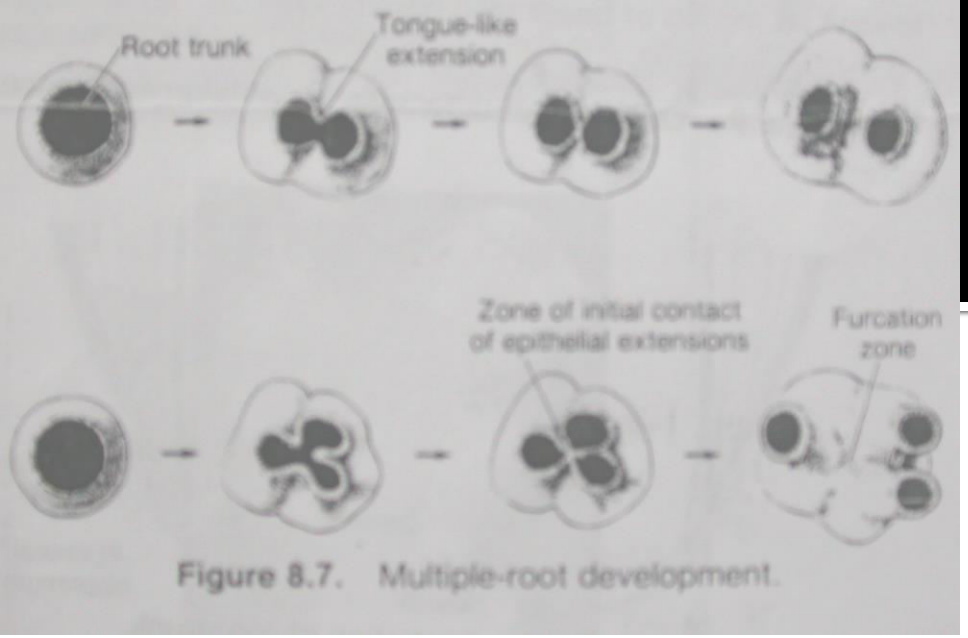
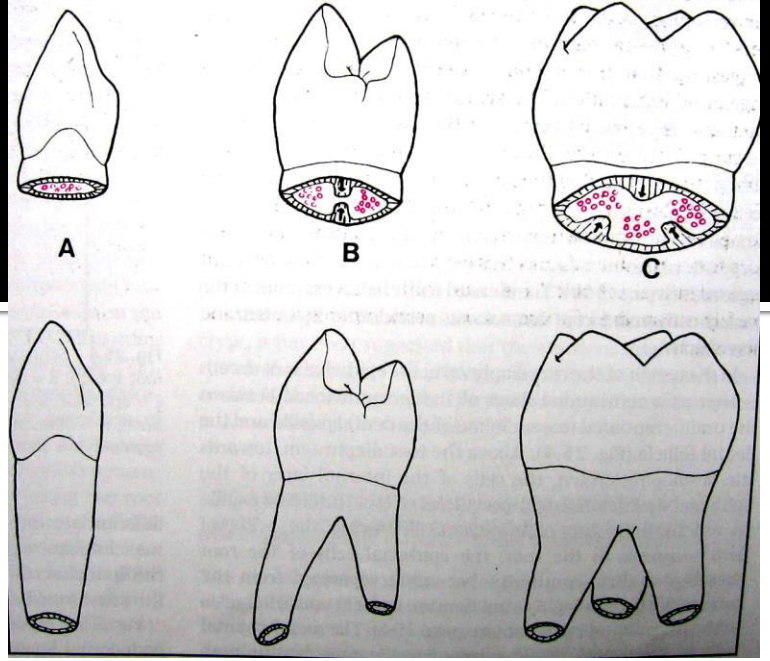
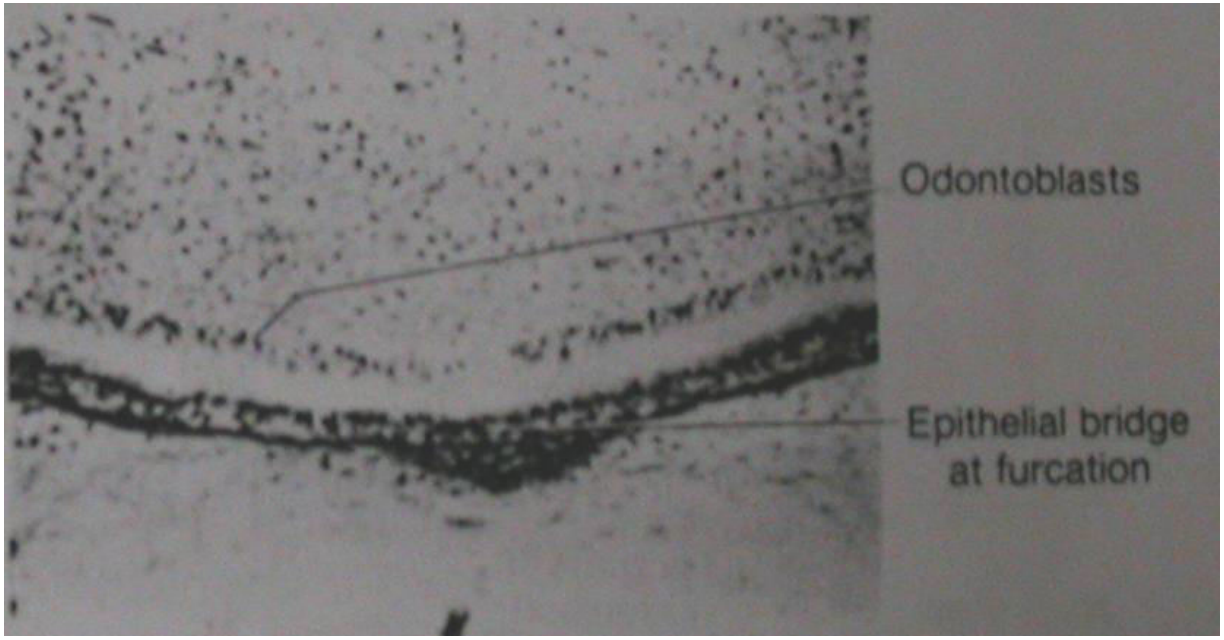


Figure 8.7. Multiple-root development.





FORMATION OF ROOT DENTIN

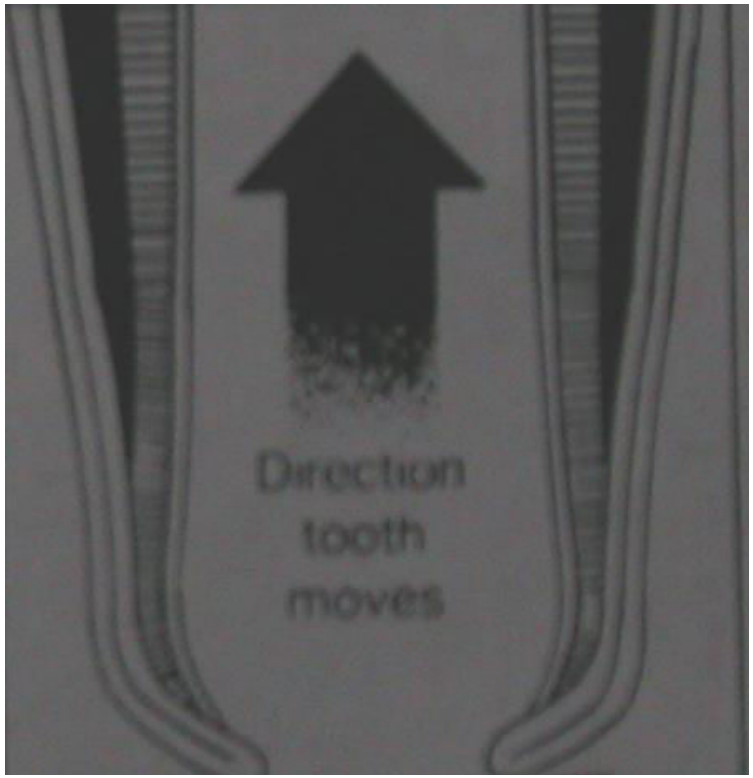
- HERS sends an inductive message to ectomesenchymal cells, possibly by secreting some enamel proteins, to the facing ectomesenchymal cells which differentiate into odontoblast and produce a layer of predentin.
- Differentiation of odontoblasts & formation of dentin follows lengthening of root sheath.

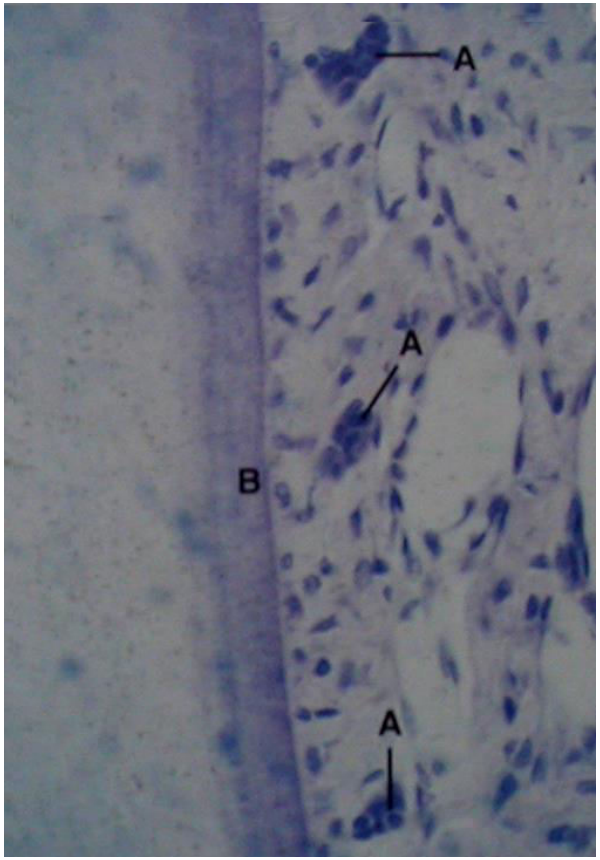
ROOT DENTIN FORMATION

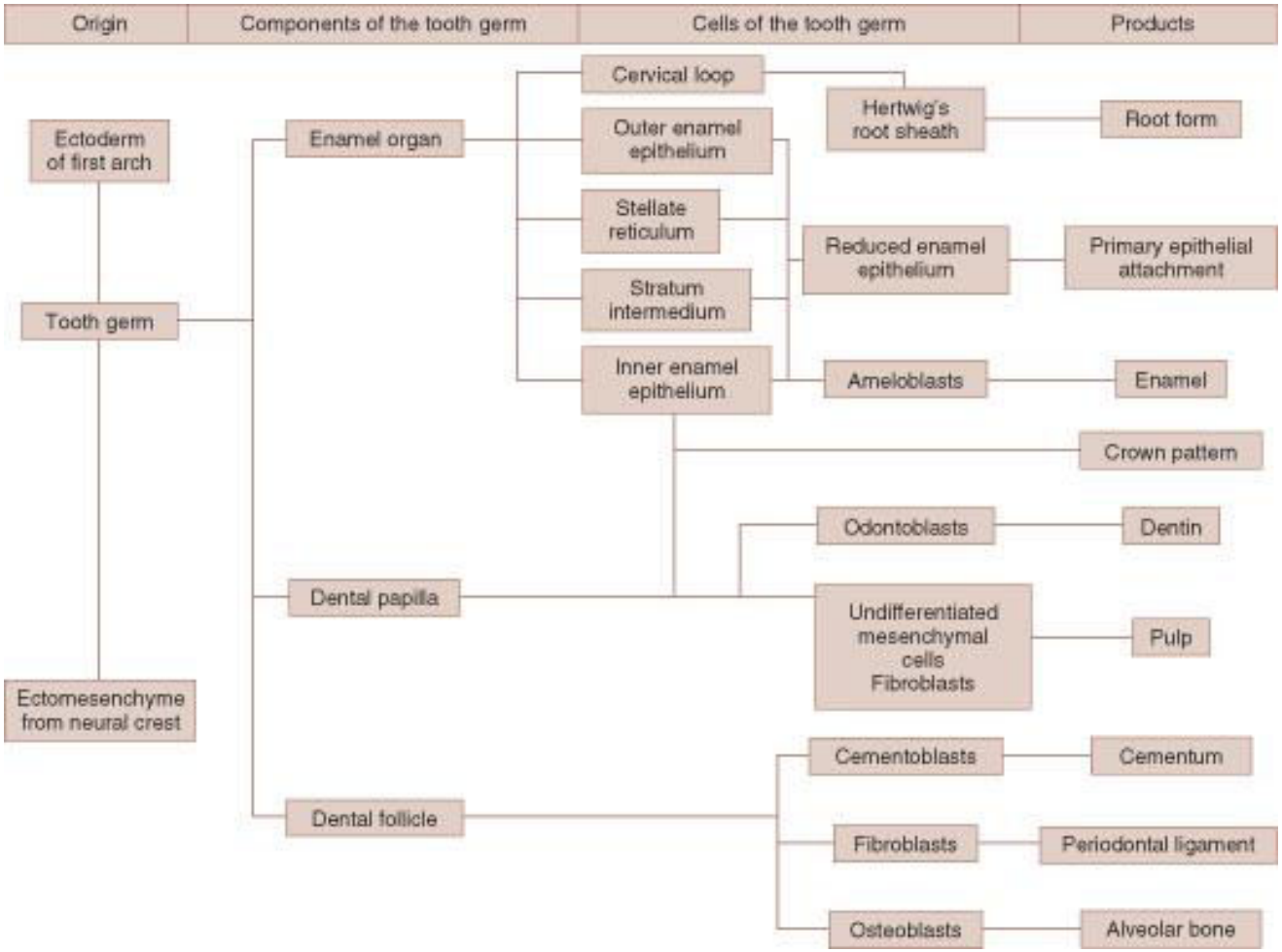
- Process of root dentin formation is similar to crown dentin formation except for few differences.

- Disruption of HERS.

EPITHELIAL CELL REST OF MALASSEZ






Origin
Components of the tooth germ
Cells of the tooth germ
Products
Ectoderm of first arch
Tooth germ
Ectomesenchyme from neural crest
Enamel organ
Dental papilla
Dental follicle
Cervical loop
Outer enamel epithelium
Stellate reticulum
Stratum intermedium
Inner enamel epithelium
Hertwig's root sheath
Root form
Reduced enamel epithelium
Primary epithelial attachment
Ameloblasts
Enamel
Crown pattern
Odontoblasts
Dentin
Undifferentiated mesenchymal cells Fibroblasts
Pulp
Cementoblasts
Cementum
Fibroblasts
Periodontal ligament
Osteoblasts
Alveolar bone

HISTOPHYSIOLOGY & CLINICAL CONSIDERATION

- A number of physiological growth processes participate in the progressive development of the teeth, which includes-
- Initiation
- Proliferation
- Histodifferentiation
- Morphodifferentiation
- Apposition

INITIATION=DENTAL LAMINA

- Dental lamina & associated tooth bud parts has potential for tooth formation
- Different teeth initiated at different times
- Initiation requires ecto-mesenchymal-epithelial interaction.

PROLIFERATION=BUD/CAP STAGE

- Proliferative activity at the point of initiation ensuses & results in bud cap & bell stage.
- Causes changes in size & proportion.

HISTODIFFERENTIATION=EARLY BELL STAGE

- Cells undergo definitive morphologic as well as functional changes & acquire functional assignment.
- They differentiate & give up the capacity to multiply –form ameloblast /odontoblast.
- In vit A deficiency ameloblast fail to differentiate ameloblast.

MORPHODIFFERENTIATION=ADVANCED BELL STAGE

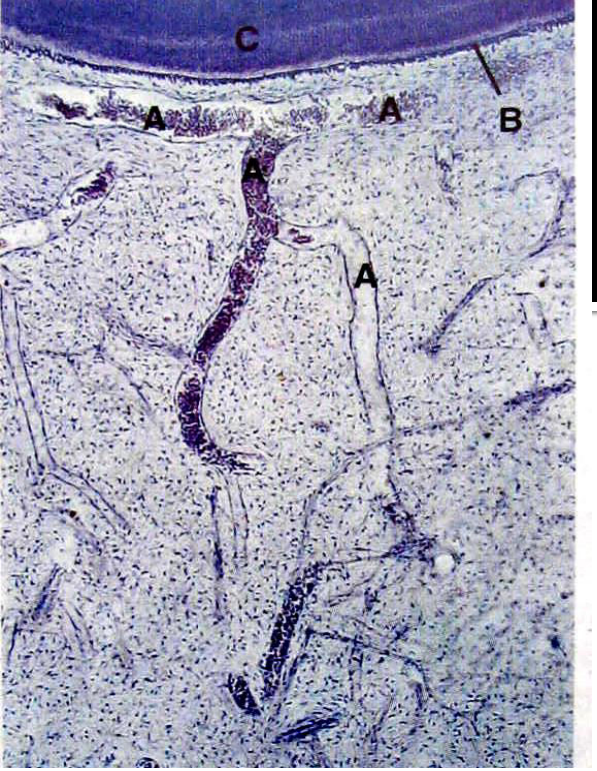
- The morphologic pattern, or basic form & relative size of the future tooth is established during this, by differential growth.
- Disturbances during it affects form & size of tooth without imparing the function of amelo/odonto blast eg. supernumerary cusp

APPOSITION=FORMATION OF ENAMEL & DENTIN MATRIX

- Is deposition of matrix of hard dental structures
- Usually layer like deposition, with periods of activity and rest alternating at definite interval
- Disturbances lead into enamel hypoplasia /hypocalcification.

VASCULAR SUPPLY DURING DEVELOPMENT

- During cap stage clusters of blood vessels are found ramifying around the tooth germ in the dental follicle.
- Their number increases, reaching a maximum during bell stage.
- Vessels entering the papilla are clustered into groups that coincide with the position where the roots will form.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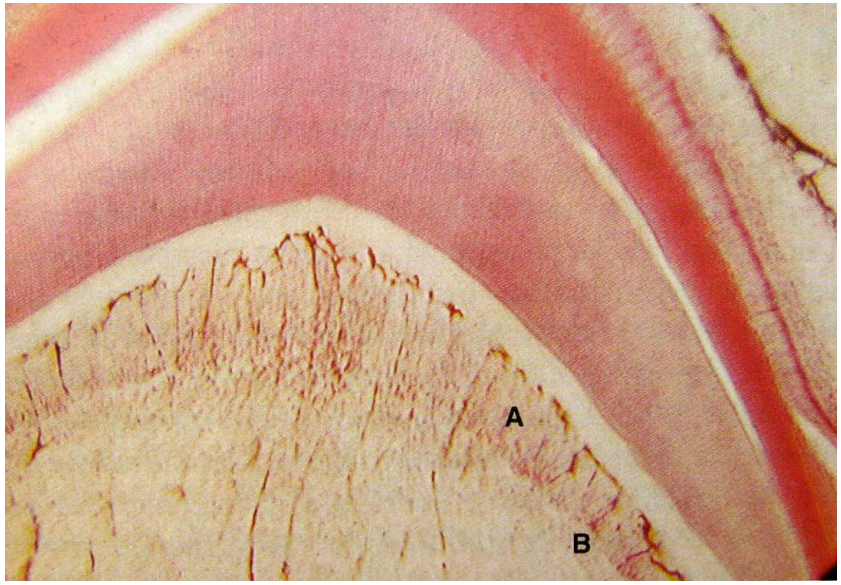
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VASCULAR SUPPLY CONT…

- Few becomes the principal pulpal vessels, they enlarge and run through the pulp towards the cuspal regions .here they give small branches which form a bed of venules, arterioles and capillaries..

NERVE SUPPLY

- Pioneer nerve fibres approach the developing tooth during bud to cap stage.
- Nerves do not enter the dental papilla until much later.
- These fibres penetrate dental pulp after dentinogenesis begins.

NERVE SUPPLY CONT…

- These nerves although anatomically part of the sensory nervous system, play an important role in controlling blood flow and perhaps via this and possibly also by trophic effects ,may influence development.

NERVE SUPPLY CONT…

- Sympathetic innervation follows later and is restricted largely to the radicular pulp.
- Final pattern including the formation of the subodontoblastic plexus of Raschkow is established after root formation.
- Some sensory fibres insinuate between the odontoblasts and enter the dentinal tubules.