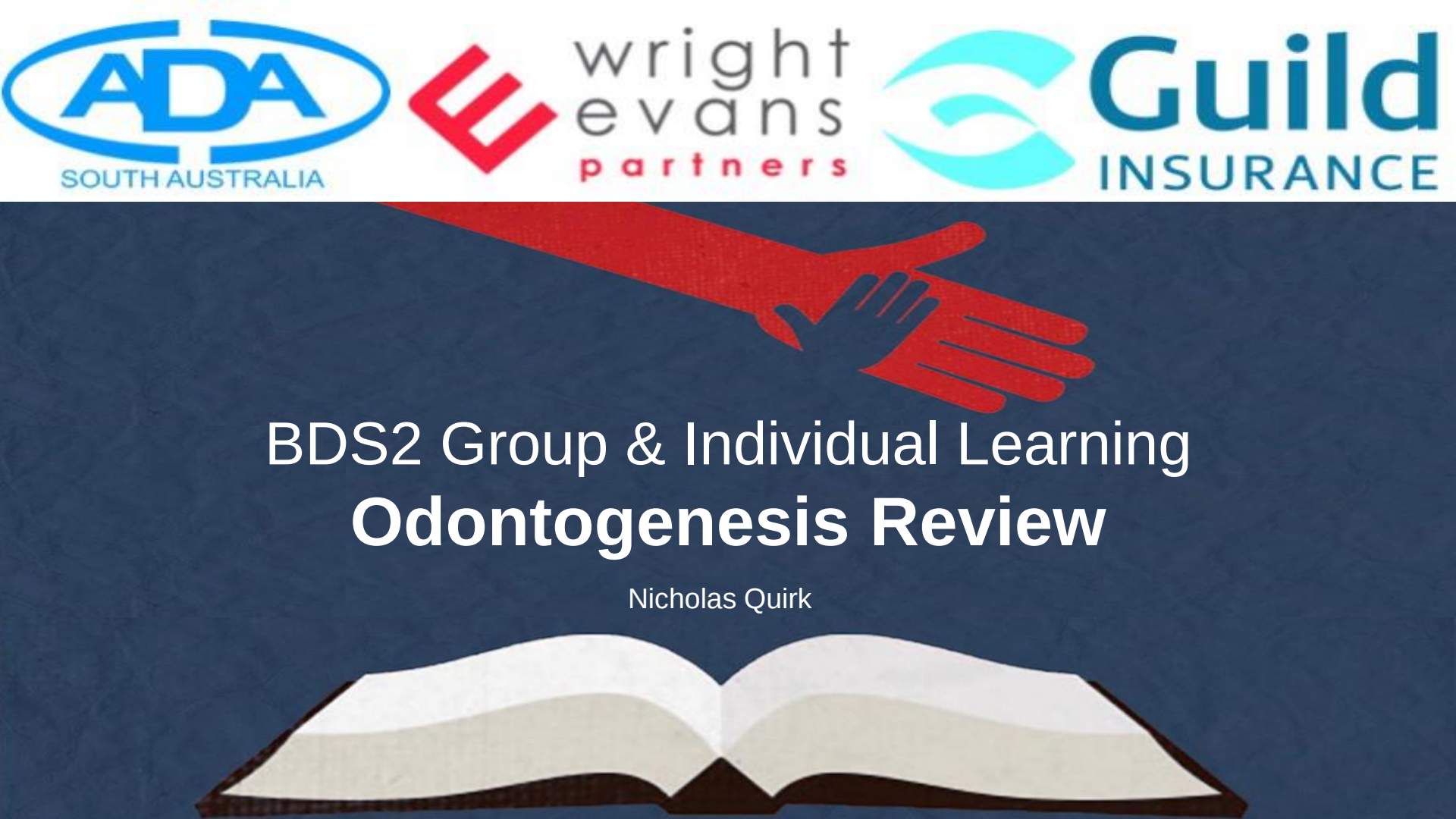
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Odontogenesis Review
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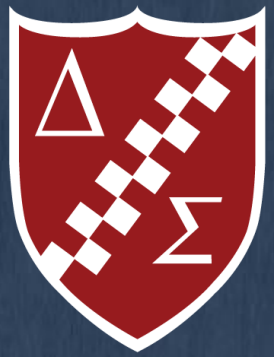

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Outline

Odontogenesis

- Initiation
- Morphogenesis
- Histogenesis
- Amelogenesis
- Dentinogenesis

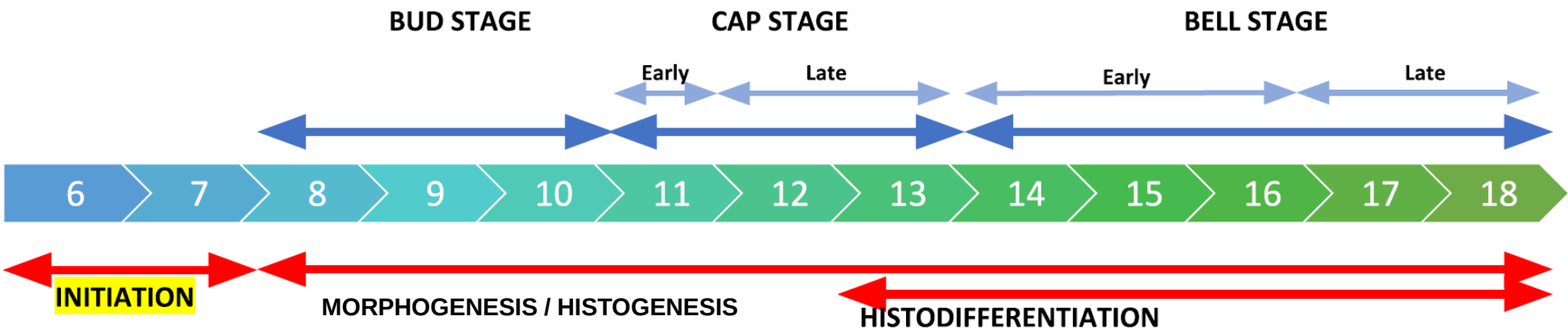
5 overlapping stages

Tooth Eruption / Dental Age

Dental Development Anomalies

Odontogenesis

Initiation

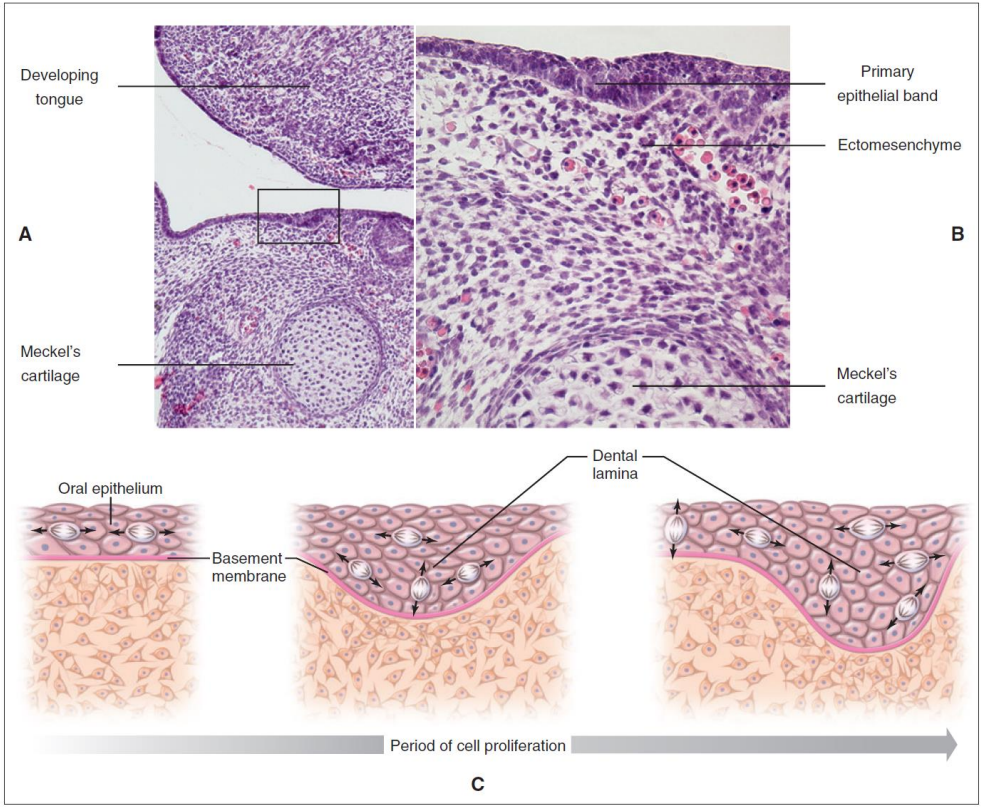

BUD STAGE
CAP STAGE
BELL STAGE
Early
Late
Early
Late
6
7
8
9
10
11
12
13
14
15
16
17
18
INITIATION
MORPHOGENESIS / HISTOGENESIS
HISTODIFFERENTIATION

Initiation

- **Wk 6: Primary Epithelial Band (PEB)**

Primitive oral epithelium thickens and invagination to underlying mesenchyme

Oral epithelium thickening referred to as Placodes in text



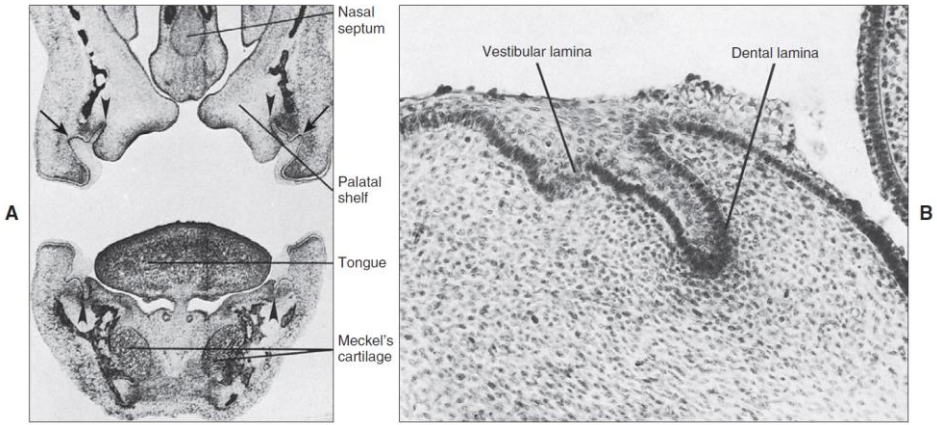
Initiation

- **Wk 6-7: Dental Lamina**

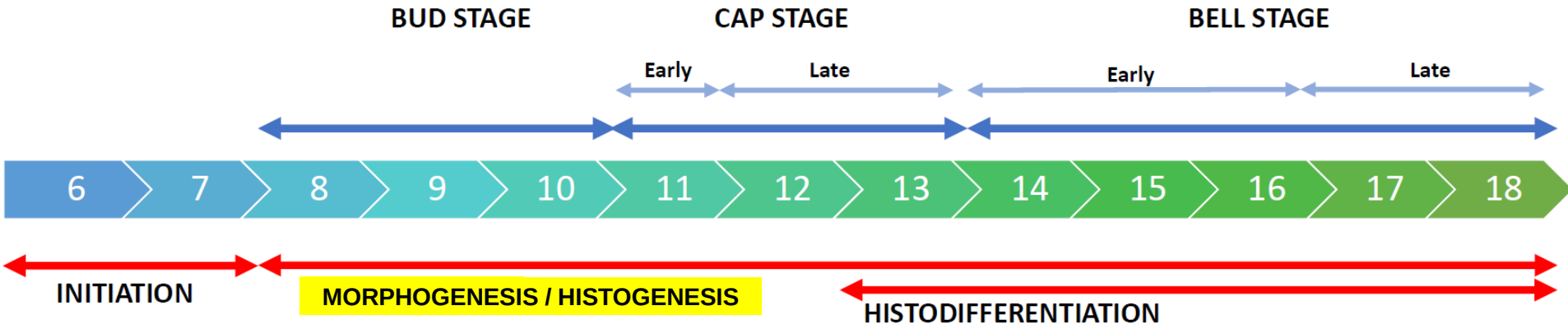
PEB continues invagination and forms vestibular / dental laminar

DL: Tooth Germ (TG)

VL: Vestibular Region



Morphogenesis / Histogenesis



Morphogenesis includes Histogenesis processes; different to Histodifferentiation

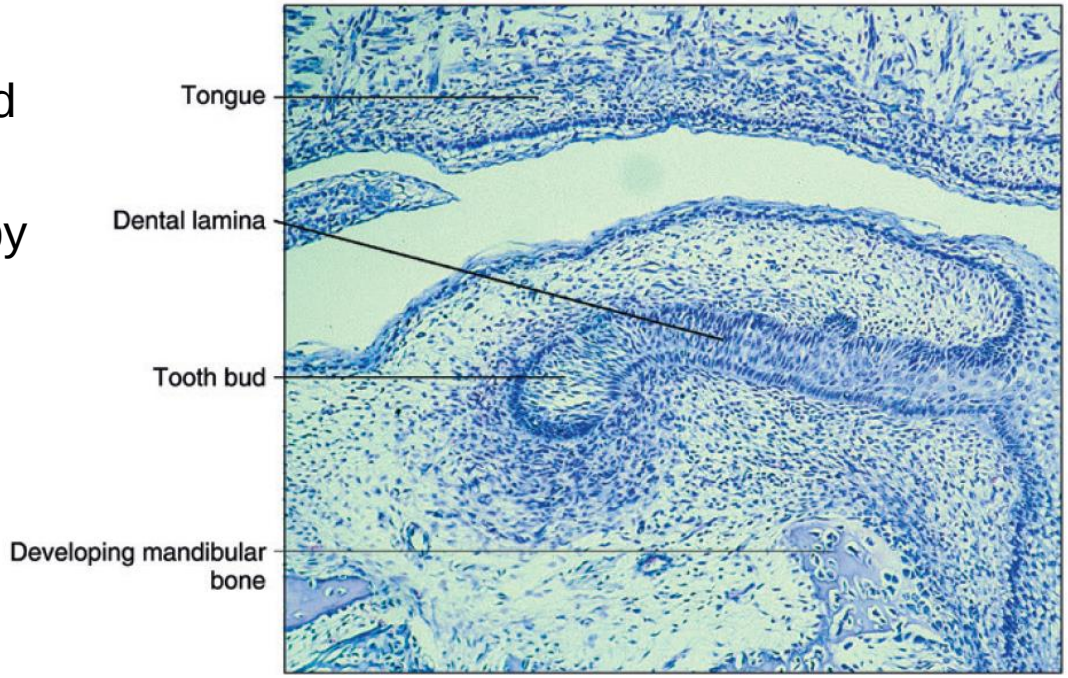
- *Morph – Shape changes*
- *Histo – Cellular changes*

Morphogenesis / Histogenesis – Bud Stage

- **Wk 8-10: Enamel Organ (EO)**

Initial EO forms (poorly differentiated epithelial cells surrounded by ectomesenchyme cells, separated by basement membrane)

As EO grows, surrounding ectomesenchyme cells density increases. (condensation)



Morphogenesis / Histogenesis – Early Cap Stage

- **Wk 11**

Cap form of EO deep surface begins to form

Morphogenesis / Histogenesis– Late Cap Stage

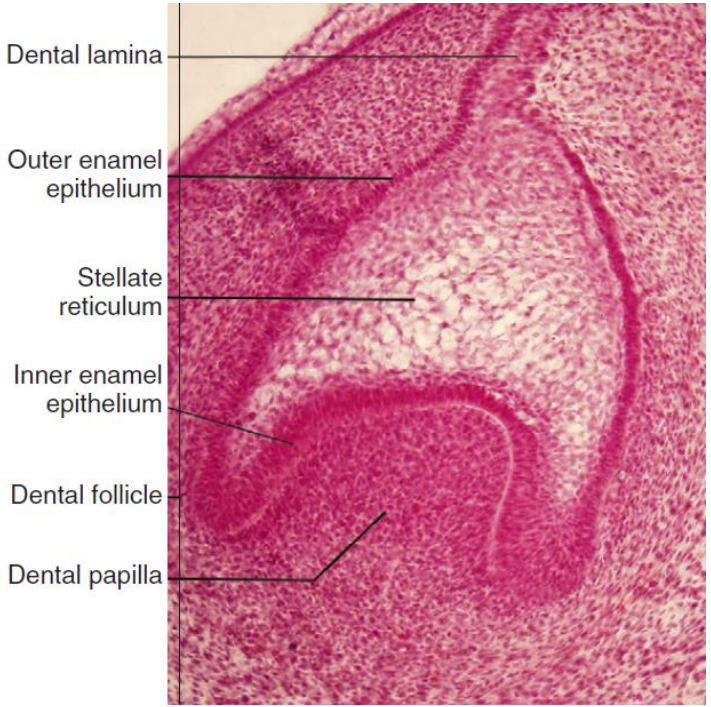
- **Wk 12-13**

EO central cells begin dispersing – desmosomes connection between, known as **Stellate Reticulum**

Internal / External Enamel Epithelium (IEE / EEE) forms

Enamel knots present in molar teeth (precursor nondividing epithelial cells, primary at tooth centre and secondary in molar cusp tips)

Dental Papilla present (condensation of ectomesenchyme cells underneath TG

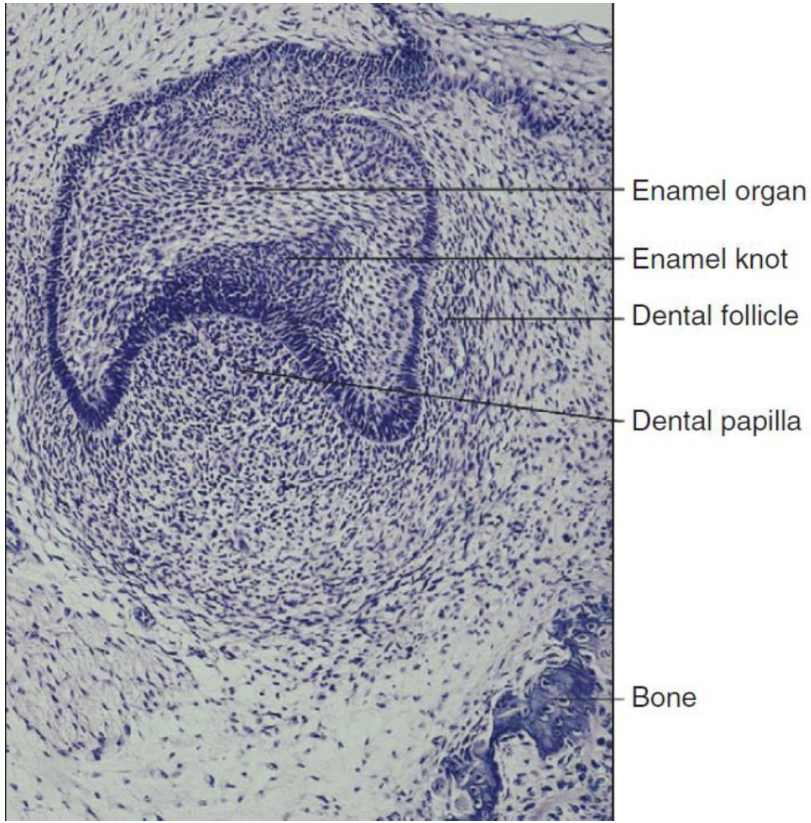


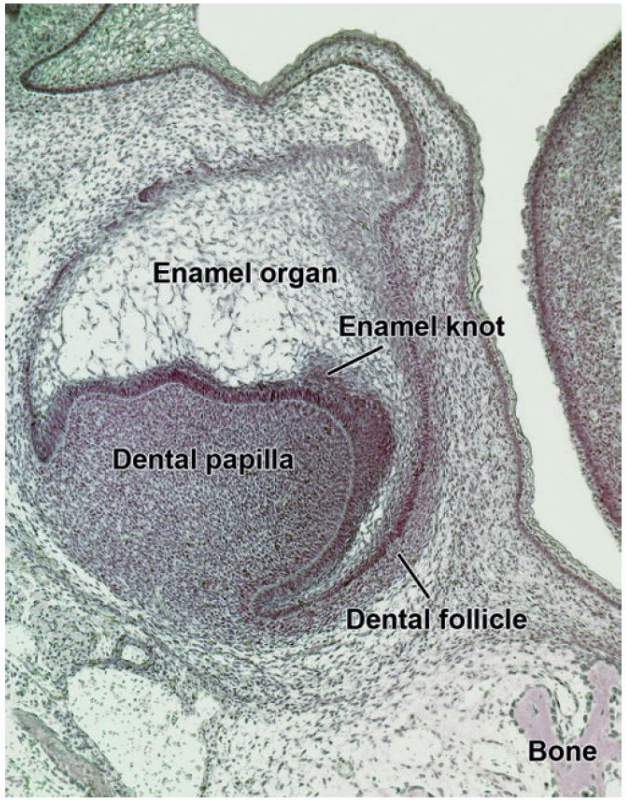
Enamel knots
present in molar teeth (precursor nondividing epithelial cells, primary at tooth centre and secondary in molar cusp tips)

Key signalling centre producing dozens of different signalling molecules (BMP, FGF, Shh, Wnt)

Non dividing epithelial cells

Primary knot regulates secondary knot formation in molar tips





Morphogenesis / Histogenesis – Early Bell Stage

- **Wk 14-16**

Crown surface develops from IEE – resembles bell shape

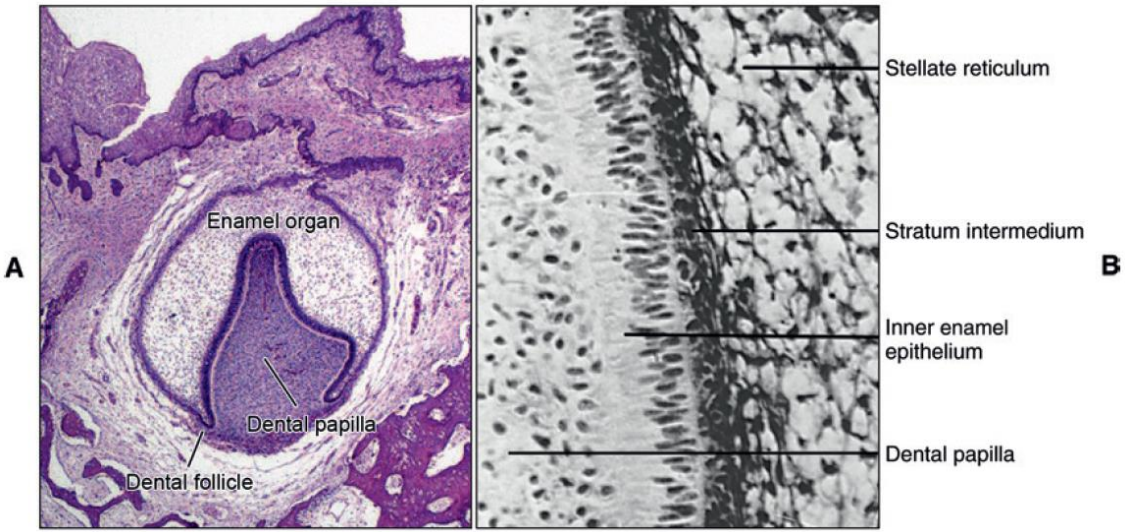
Dental Lamina degenerates and separates from TG

High degree histodifferentiation (EEE / IEE / SR)

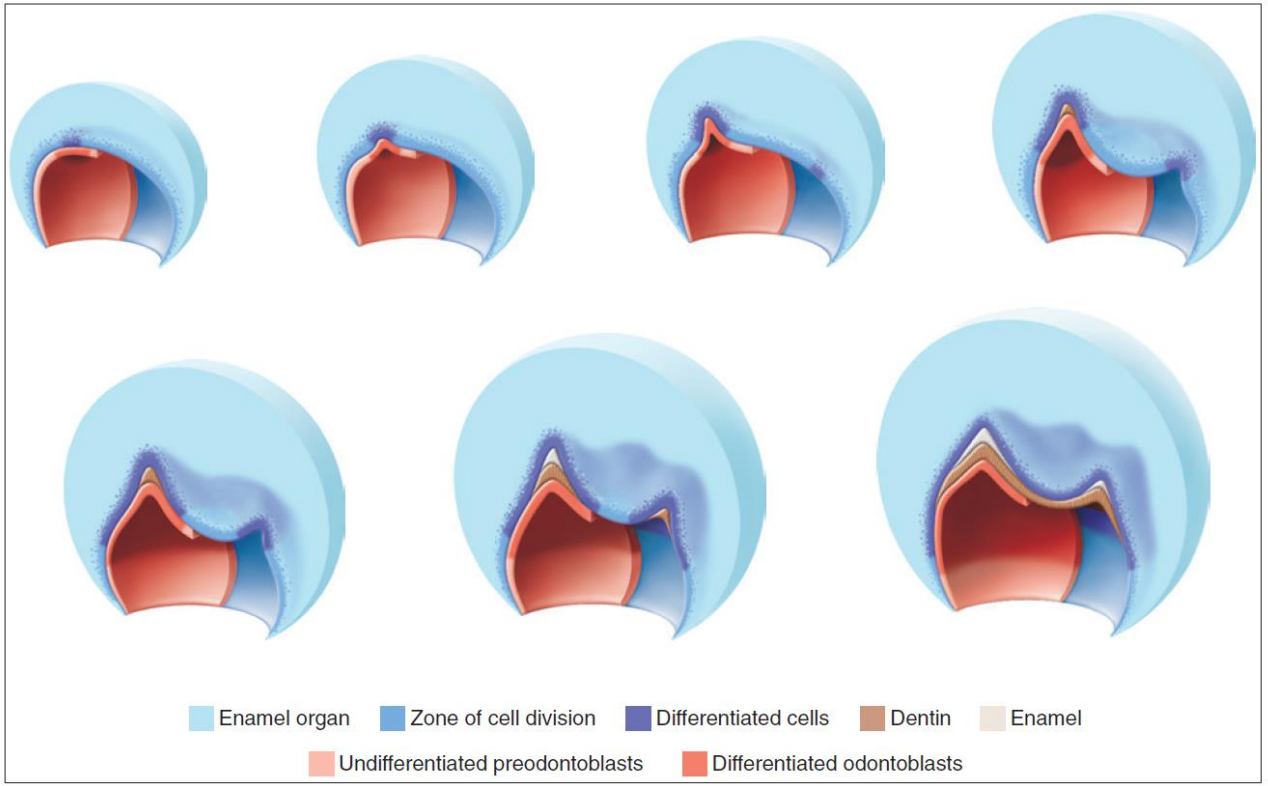
Stellate Intermedium (SI) forms between SR and IEE

Cusp shape develops into EO, SR develops down cuspal inclines and forms cervical loop where IEE and EEE meet **(Hertwig's epithelial root sheath (HERS))**

Note: Cervical loop where IEE and EEE meet (important for root formation)



Inner Enamel Epithelium

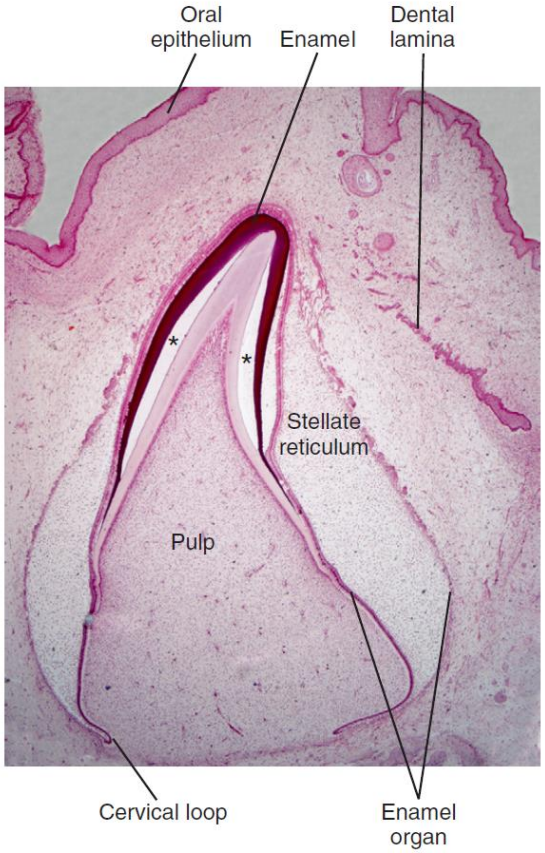


Morphogenesis / Histogenesis – Late Bell Stage

- **Wk 17-18**

Rapid change in size and shape

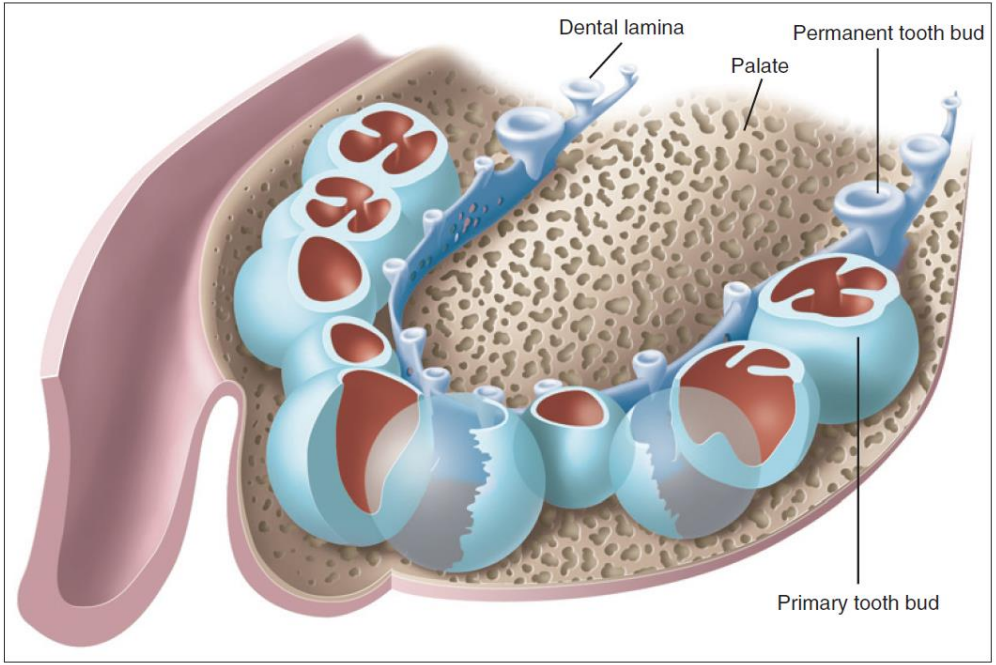
Formation of permanent TG



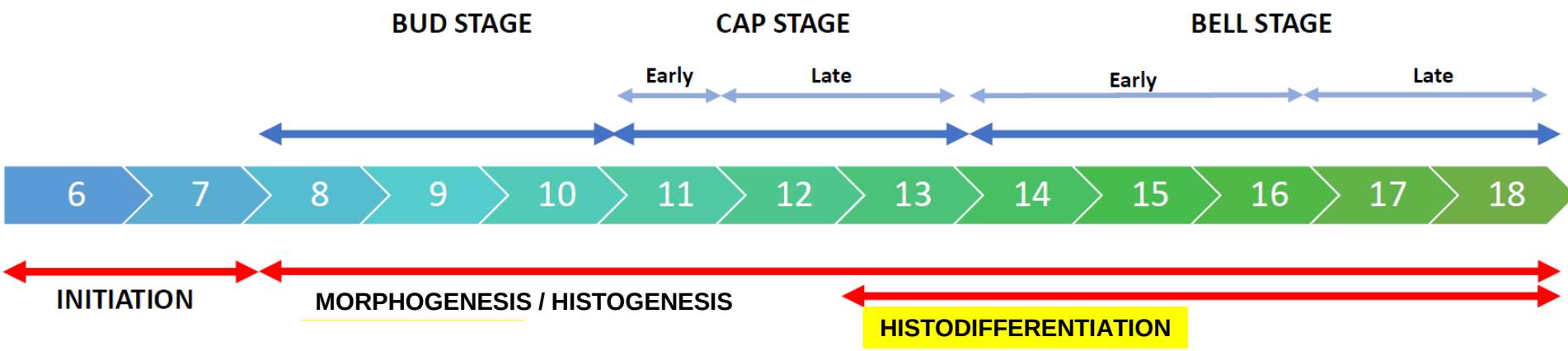
Morphogenesis / Histogenesis – Late Bell Stage

Formation of permanent TG

- #1-5 – EEE lingual down growth
  - Successional Lamina (preceding tooth)
- #6-8 = EEE posterior extension
  - Accessional Lamina (no preceding tooth)



Histodifferentiation



- Amelogenesis
- Dentinogenesis

Amelogenesis

1). Pre-Secretory Stage

2). Secretory

3). Transition

4). Maturation

5). Post-Maturation

1). Pre-Secretory Stage

Reciprocal Induction (Important Concept)

I. IEE Pre differentiate to Ameloblasts that then release growth factors…….

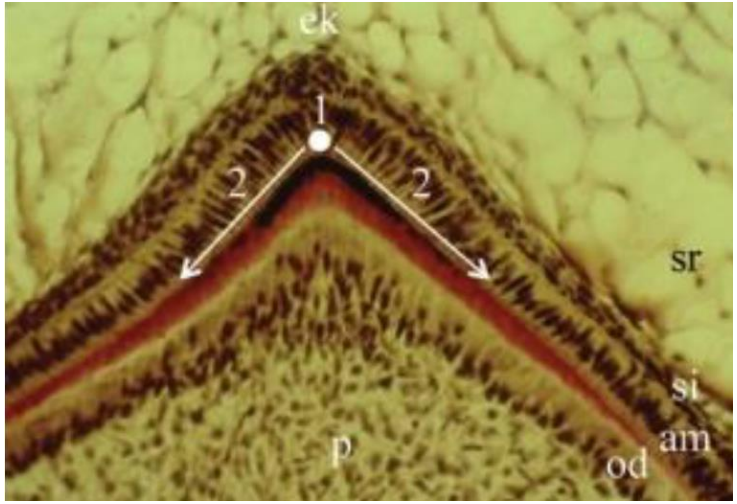
II. Growth factors that traverse basement membrane into contact with adjacent Dental Papilla cells……

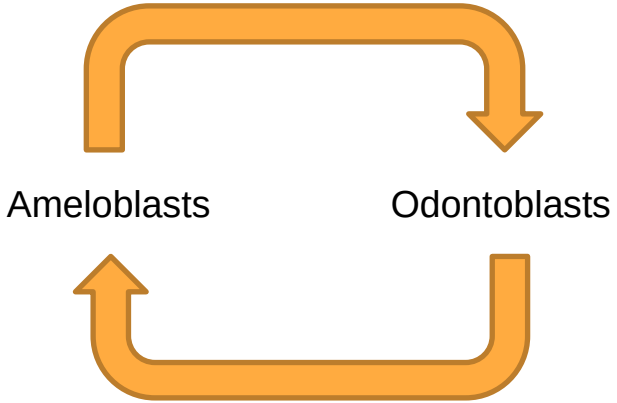
III. Dental Papilla cells differentiate into Odontoblasts which then secrete dentine matrix while…..

IV. Ameloblast degrade basement membrane until they come into contact with dentine matrix which…….

V. Induce Ameloblasts to produce enamel matrix!

Progresses from future cusp tip / incisal edge to root





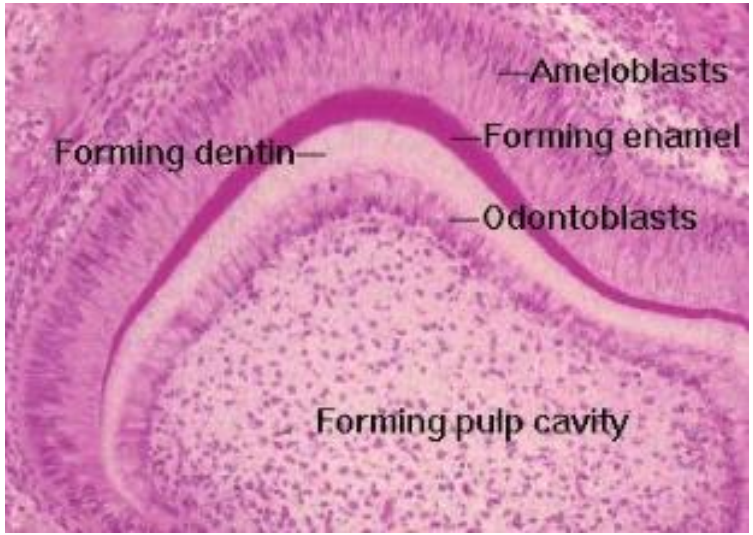
2). Secretory

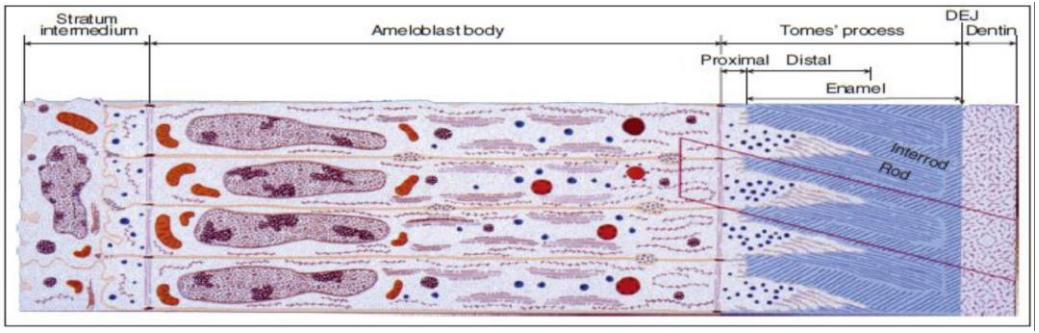
Ameloblasts form secretory tomes processes, move away from produced enamel during formation towards EEE (deposit internal layers first, move away towards outer surface)

Virtually immediate enamel hydroxyapatite crystallisation with low mineralised content

Tomes process retract after full enamel thickness forms

Note: Perikymata (enamel striations) formed through daily incremental enamel deposition





3). Transition

Following enamel matrix secretion and tomes process retraction; approx. 50% Ameloblast population apoptosis

Current high protein content (approx. 25-30% weight)

4). Maturation

Matrix matures: (transition to maturation stage)

- H_2O 65% ⟶ 1-2%
- HA 15% ⟶ 96-98%
- Proteins 20% ⟶ 1-2%

Maturation by Enamel Organ proteases and remaining Ameloblasts moving Ca, PO_4 and CO_3 ions into matrix

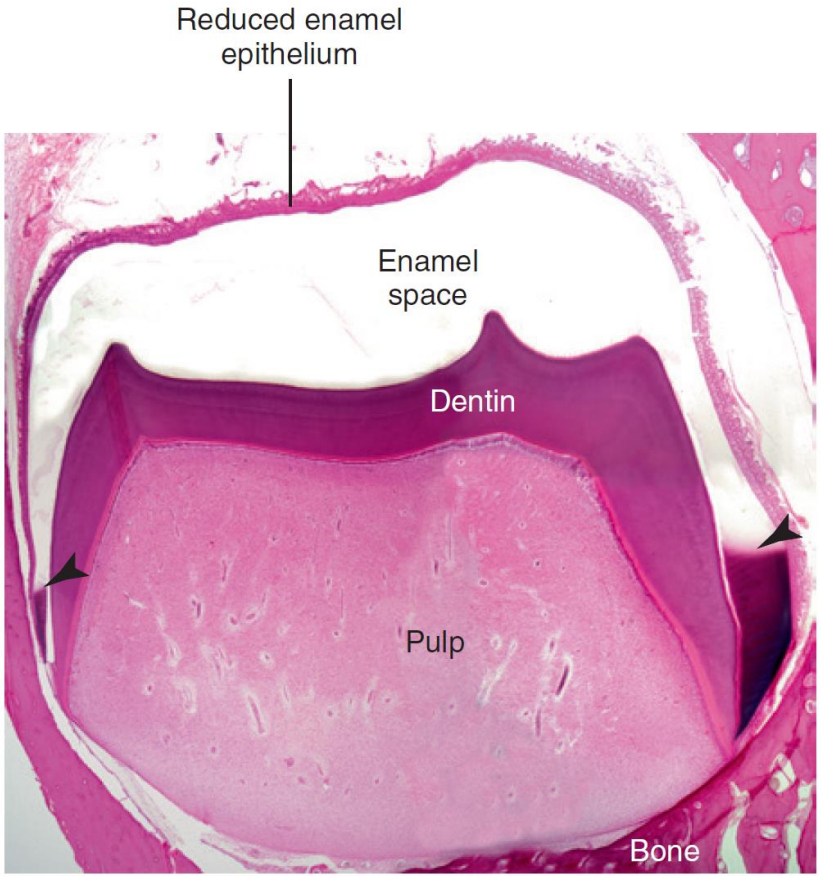
Ions moved in whilst water and degraded proteins removed

Process thickens enamel prisms from 1.5nm to 25nm diameter

5). Post-Maturation

Remaining Ameloblasts flatten and merge with residual Enamel Organ forming reduced enamel epithelium cover (remains until tooth eruption)

Mineralization post eruption via saliva / oral cavity environment interaction – Fluorapatite!



Dentinogenesis

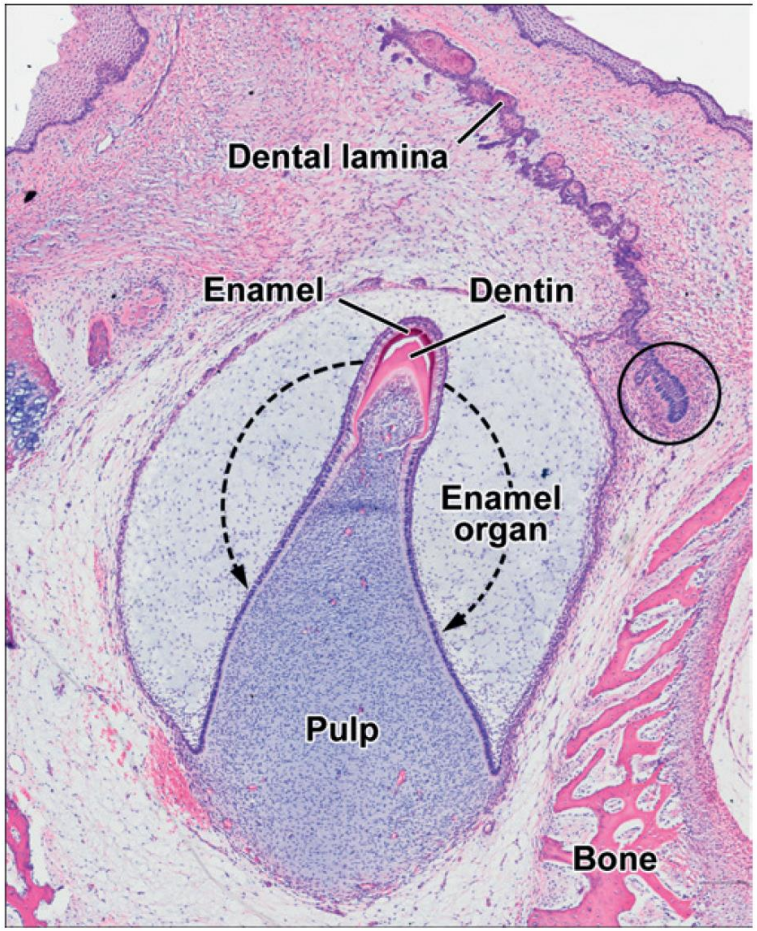
1). Odontoblast Differentiation

2). Matrix Deposition

3). Matrix Mineralisation

4). Peritubular & Secondary Dentine Formation

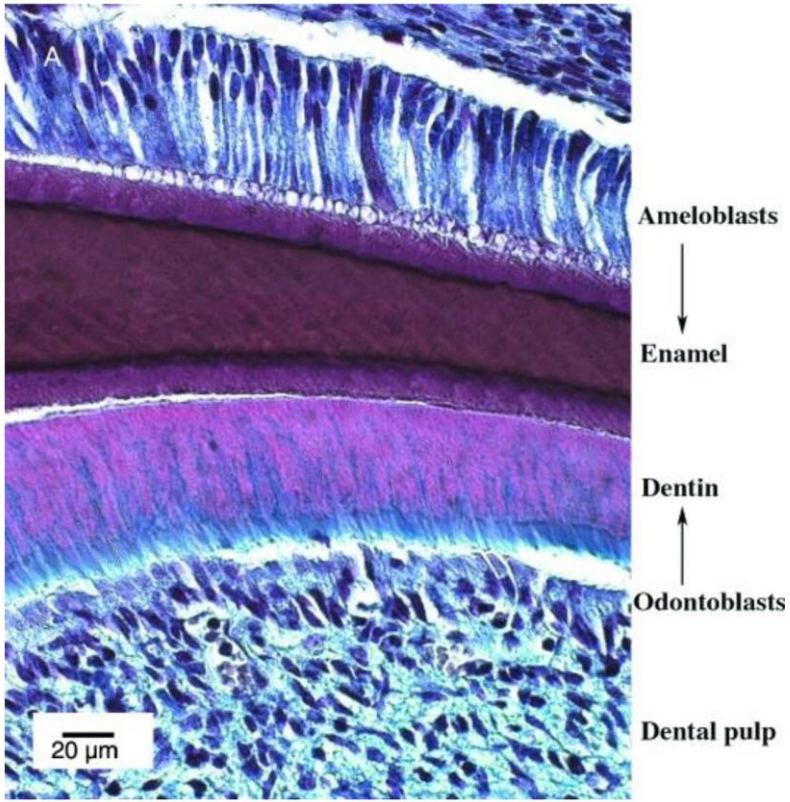
5). Tertiary Dentine Formation



1). Odontoblast Differentiation

Odontoblasts (OD) from Dental Papilla ectomesenchyme cells following Ameloblast growth factor

Pre-OD develop cellular processes aimed towards IEE (pointing towards Ameloblasts and exterior surface)

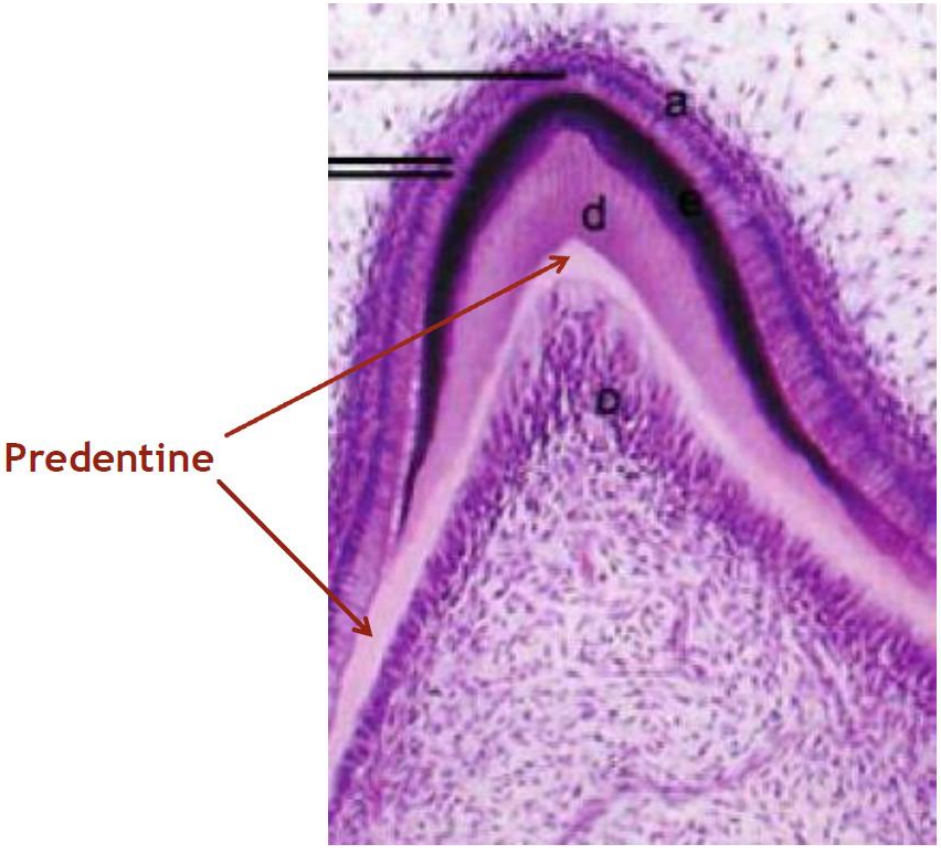


2). Matrix Deposition

Odontoblasts secrete organic matrix (Collagen Type I, III, V and VI & Dentine Phosphoproteins (not exhaustive))

Odontoblasts migrate pulpally away from Ameloblasts

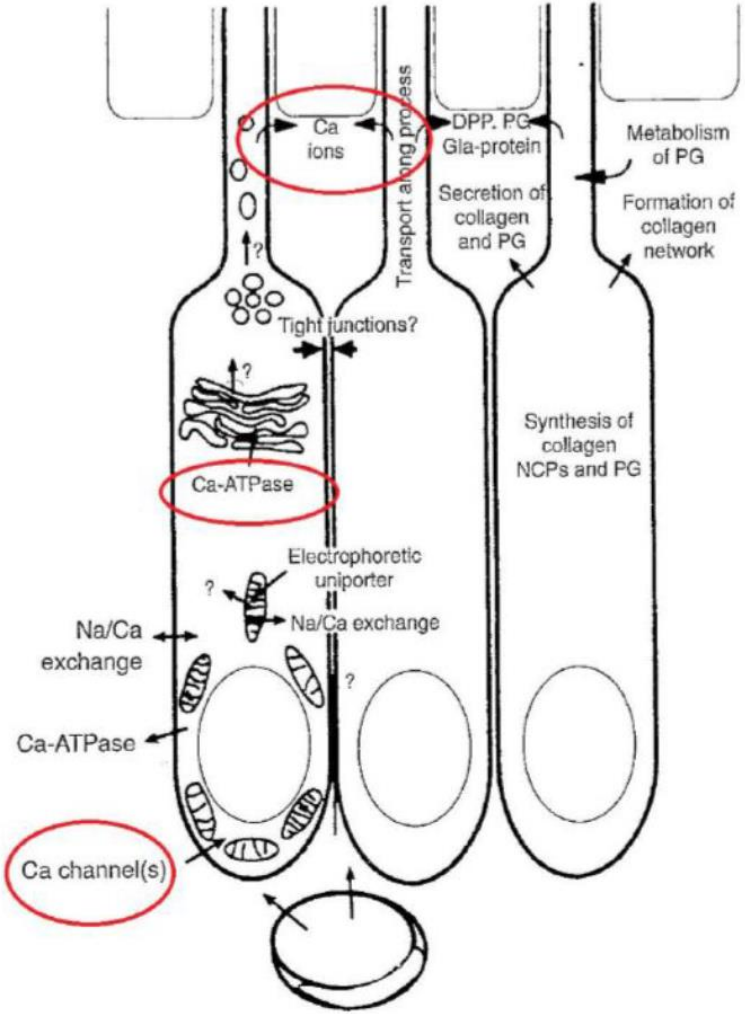
Initial dentine layer does not mineralize immediately, pre-dentine layer!

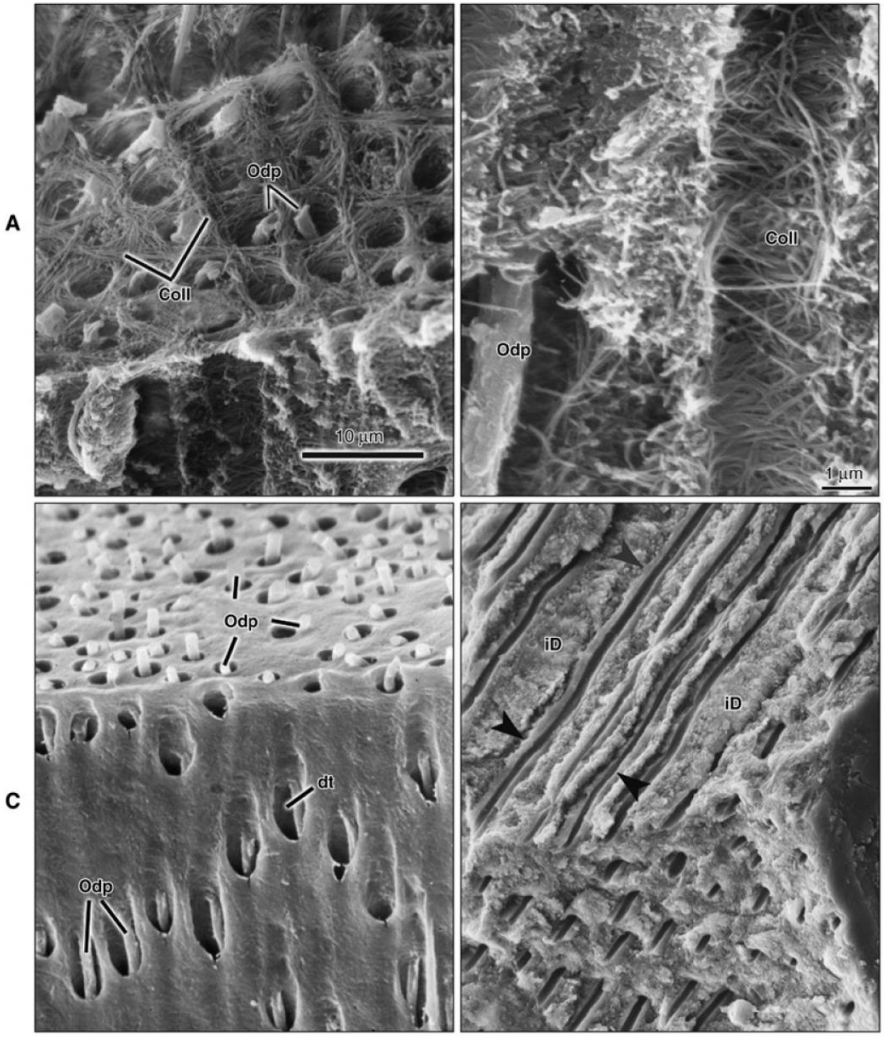


3). Matrix Mineralisation

Currently accepted in literature:

- Odontoblasts deliver Ca ions
- Dentine matrix template (scaffold) of collagen type I which is secreted following initial collagen type III material
- Noncollagenous matrix proteins (such as Dentine Phosphoprotein [DPP]) from Odontoblasts regulate subsequent matrix mineralization
- Lags behind initial matrix deposition (compared to enamel which as immediate initial mineralization activity)




A
Odp
Coll
10 µm
B
Coll
Odp
1 µm
C
Odp
dt
Odp
D
iD
iD

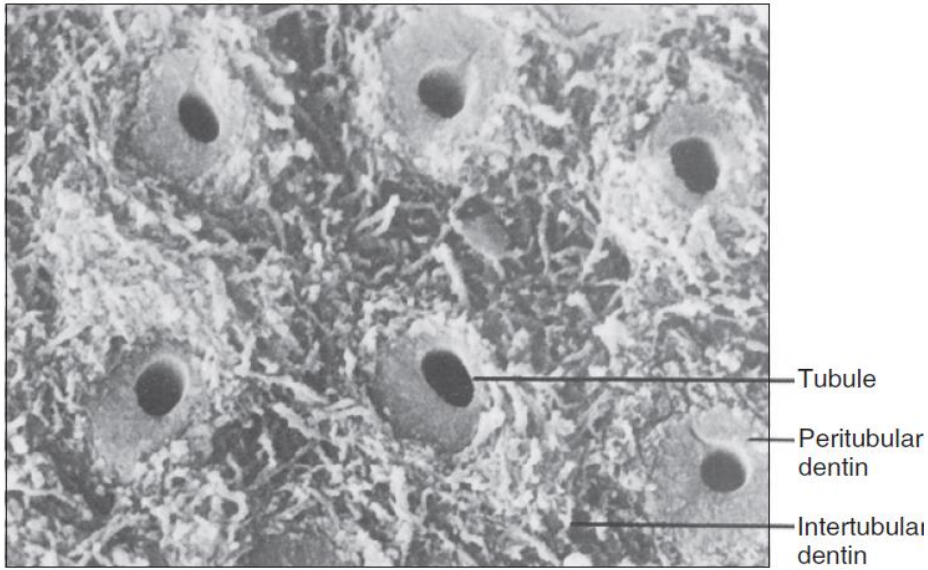
4). Peritubular & Secondary Dentine Formation

Peritubular (Intratubular) Dentine (Bonding implications)

- 5-12% higher mineralisation then intertubular type
- Continually laid down with age (progressive dentinal tubule narrowing – sclerotic dentine)

Secondary (Intertubular) Dentine (Vitality testing implications)

- Continuous dentine deposited pulpally with age (pulp shrinkage)
- As pulp shrinks, Odontoblast population gradually apoptosis



5). Tertiary Dentine Formation

Process occurs post eruption and over lifespan in response to trauma / stimuli (caries, injury, etc)

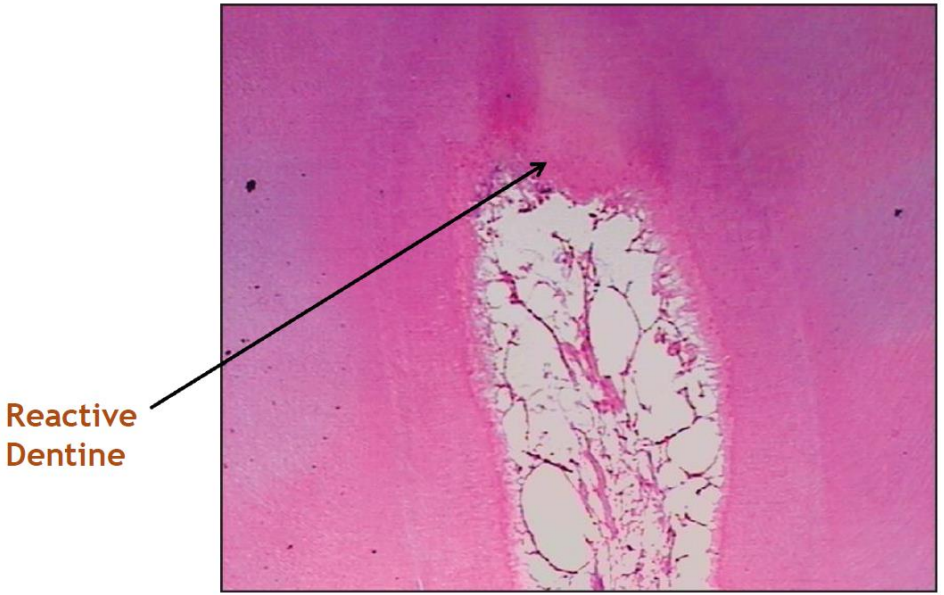
Reactive / Reactionary Dentine:

- Mild stimuli, Odontoblasts survive, tubular structure remains

Reparative Dentine:

- Severe stimuli kill existing Odontoblasts, newly differentiated odontoblasts form new atubular dentine

- *Newly differentiated odontoblasts do not produce DPP*



Note: Root Dentine

Similar process to coronal dentine with some differences

Lack of adjacent Ameloblasts mean Odontoblast differentiation is stimulated by Hertwig’s root sheath (cervical root)

Tooth Eruption / Dental Age

Primary Teeth

Calcification pattern: A, D, B, C, E

Eruption pattern: A, B, D, C, E
(Also shedding sequence)

Note:
- Teeth erupt when roots approx. ½ formed
- Generally female teeth eruption at younger age than males
- Primary teeth apex remains open during lifecycle

Teeth	A	B	C	D	E
Mx / Md Calcification	Mx before Md	Mx before Md	Md before Mx	Mx before Md	M before Md
Approx. calcification at birth	3/4	1/2	1/3	Cusps unified	Cusps isolated
Approx. age of crown completion	2.5 months	3 months	10 months	6 months	11 months
Approx. age of root completion	18 months	24 months	40 months	30 months	42 months
Approx. eruption age (months)	**Mx:** 10 **Md:** 7	**Mx:** 12 **Md:** 14	**Mx:** 20 **Md:** 20	**Mx:** 16 **Md:** 16	**Mx:** 29 **Md:** 28

Permanent Teeth

Eruption pattern:
Mx: 6, 1, 2, 4, 3, 5, 7, 8
Md: 6, 1, 2, 3, 4, 5, 7, 8

Calcification pattern:
6,1, Mx 2, 3, Md 2, 4, 5, 7, 8

Notes:

- Crown development takes 4 years
- Root development: 4 years (incisors), 7-8 years remainder
- 1st molar: 3 years crown development, 6 years root development
- Teeth begin eruption when roots ½ - ¾ formed
- Root apex closure indicates complete development

Teeth	Initial Calcification Time	Eruption Time (years)	
		Mx	Md
1	3 months	**F:** 7 **M:** 7	**F:** 6 **M:** 7
2	Mx: 5 months Md: 1 year	**F:** 8 **M:** 9	**F:** 8 **M:** 8
3	5 months	**F:** 11 **M:** 12	**F:** 10 **M:** 11
4	1 ½ - 2 ½ years	**F:** 11 **M:** 11	**F:** 11 **M:** 11
5	2 ½ - 3 ½ years	**F:** 12 **M:** 12	**F:** 12 **M:** 12
6	Birth	**F:** 7 **M:** 7	**F:** 6 **M:** 7
7	2 ½ - 3 ½ years	**F:** 12 **M:** 13	**F:** 12 **M:** 12
8	7 – 12 years	NA	NA

Calculating Dental Age

Pick 3 teeth, for each tooth calculate:

- Age = calcification age + (crown development x total time) + (root development x total time)

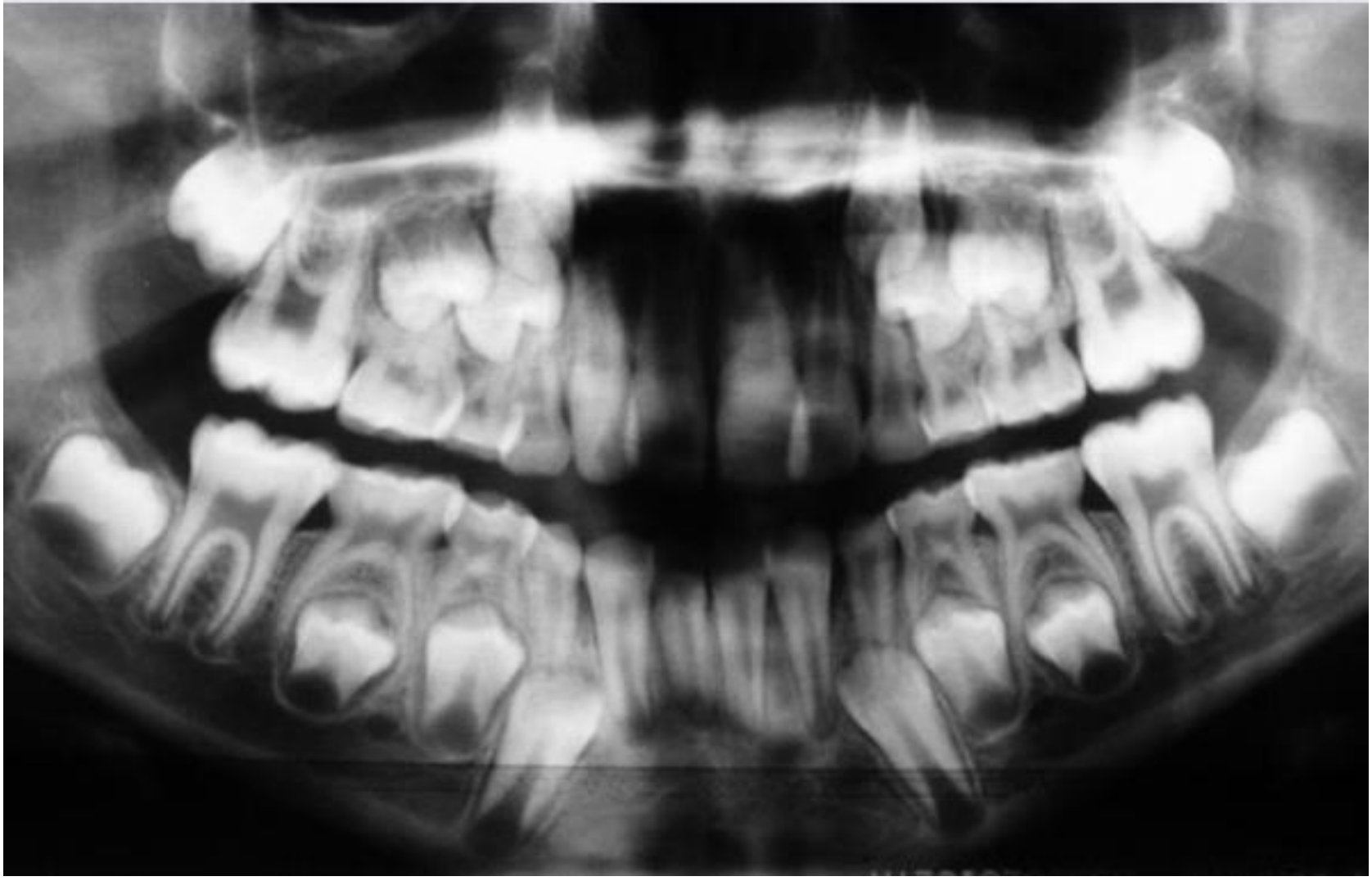
Average the 3 teeth using calcification age range for min – max

Example:

17 crown fully developed, roots ½ developed:

- Dental Age = calcification (2 ½ - 3 ½ years) + crown (1 x 4 years) + root (½ developed x 7 - 8 years) = 10 – 11 ½ years

This wide range can be narrowed down through use of other teeth calculations, however you will always have at least 6 month age range

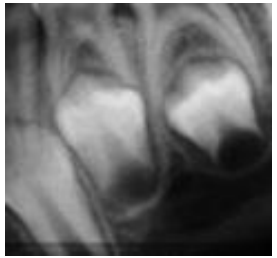


Example

A). Tooth 43: Calcification (5 mnths) + Crown (4 yrs) + Roots (60%ish x 7 – 8 yrs) = 8 – 9yrs

B). Tooth 46: Calcification (0) + Crown (3 yrs) + Roots (95% x 6 yrs) = Max 9 yrs old

C). Tooth 34: Calcification (1.5 – 2.5 yrs) + Crown (4 yrs) + Roots (20% x 7 – 8 yrs) = 7.5 - 8.5 yrs



Therefor we could estimate pnt dental age to be 8 – 8.5 yrs

Dental Developmental Anomalies

Tooth Structure Anomalies

Amelogenesis Imperfecta

- Complex group of hereditary conditions presenting with enamel structure abnormalities, classification difficult, broadly speaking:

Hypoplastic: Abnormal enamel matrix deposition, mineralisation / maturation normal

Hypomature: Normal enamel matrix deposition, abnormal maturation

Hypocalcified: Normal enamel matrix deposition, abnormal minerilisation

Tooth Structure Anomalies

Dentinogenesis Imperfecta

- Effecting mineralization pathways / controls
  - Type 1(Due to Osteogenesis Imperfecta) vs Type 2 (DSPP associated)

Molar-Incisor Hypomineralisation

- Key to look for relationships between affected teeth

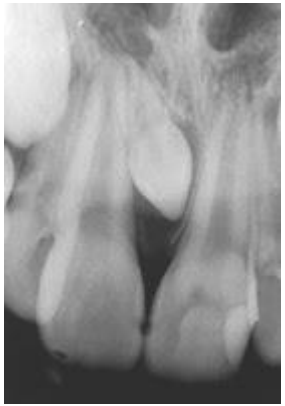
Tooth Number Anomalies

Hypodontia

- Agenesis of 1 – 6 teeth (oligodontia > 6 teeth, anodontia for entire dentition)
- 8s, Md 5s, Mx 2s common

Hyperdontia

- Supernumeries, mostly in permanent Mx dentition involving single tooth
- Mesiodens common



Tooth Size Anomalies

Microdontia

- Small teeth (peg laterals)
- Associated with hypodontia

Macrodontia

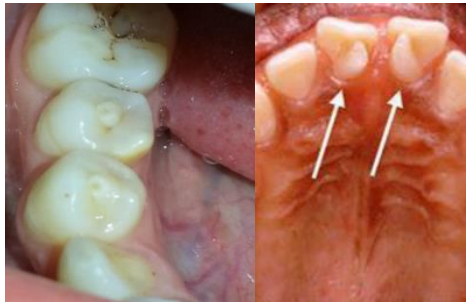
- Large teeth, isolated usually to 1s and 3s

Tooth Shape Anomalies

Number of anomalies; review lecture notes for full coverage

Gemination / Fusion:

- Gemination = normal tooth #s or extra (TG differentiated)
- Fusion = tooth #s – 1 (coronal fusion)



Dens Evaginatus (vs Dens Ivaginatus)

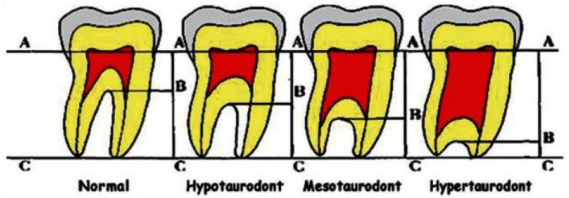
- Tubercle on tooth surface, contains pulpal tissue, do not remove!

Hypercementosis

- Excess cementum formation

Taurodontism

- Enlarged pup chamber, assioated with systemic conditions



Thankyou!

Questions?