

PRENATAL GROWTH AND DEVELOPMENT OF CRANIOFACIAL COMPLEX

A background illustration showing a sequence of human figures from left to right, representing the stages of life: a crawling baby, a toddler, a young child, a woman, a man, and an elderly person using a walker.

GROWTH

“Entire series of sequential anatomic and physiological changes taking place from the beginning of prenatal life to senility”

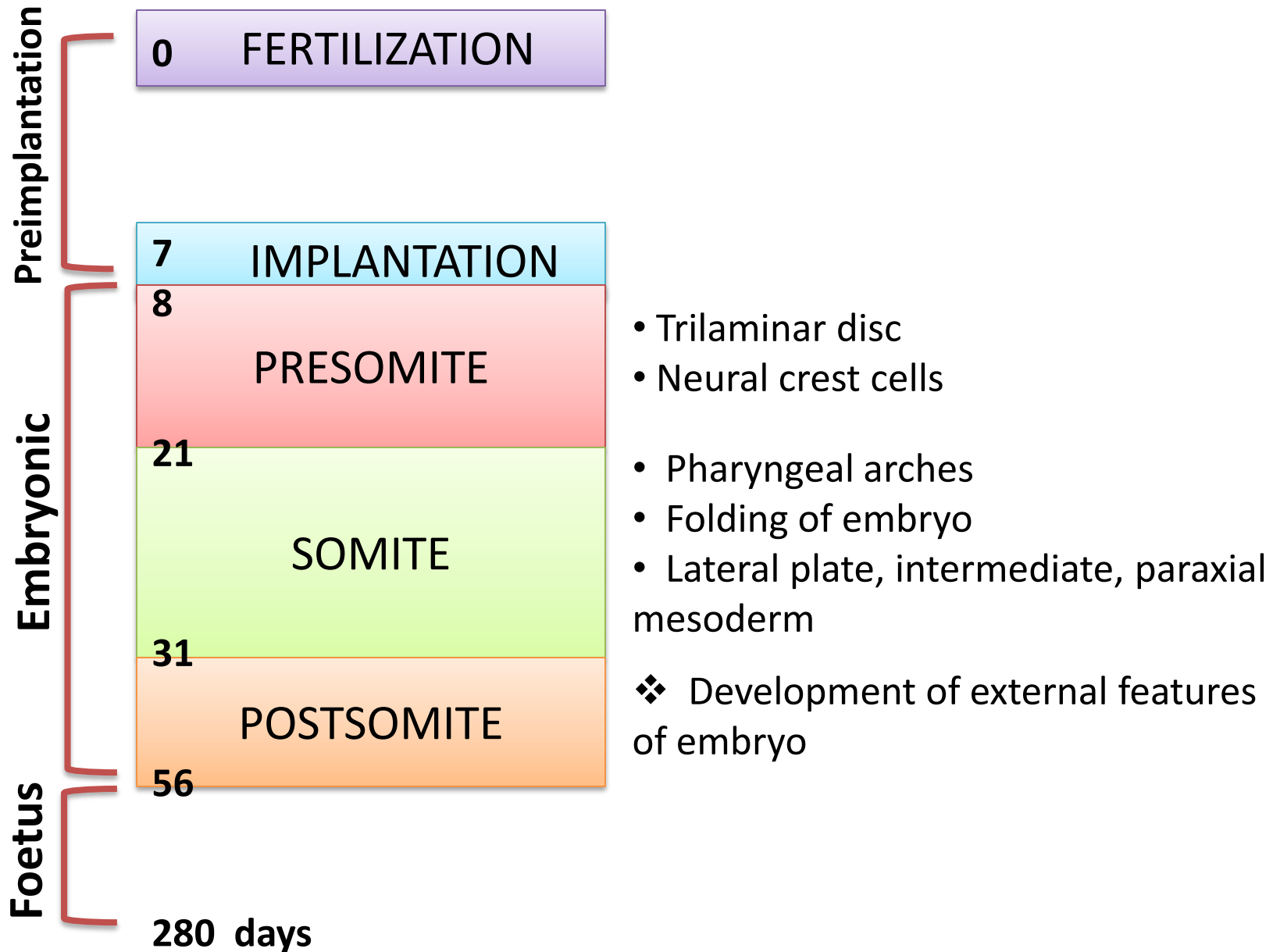
- Meridith

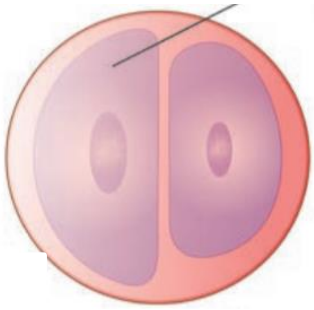
DEVELOPMENT

“All the naturally occurring unidirectional changes in life of an individual from its existence as a single cell to its elaboration as a multifunctional unit terminating in death.”

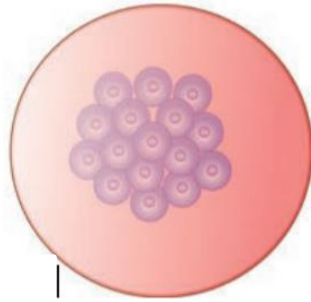
- Moyers

EMBRYOGENESIS

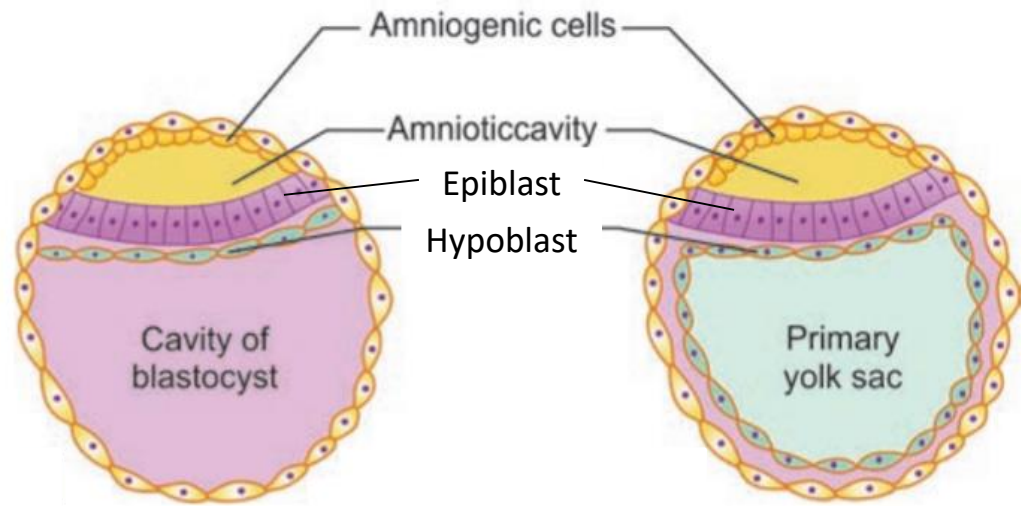




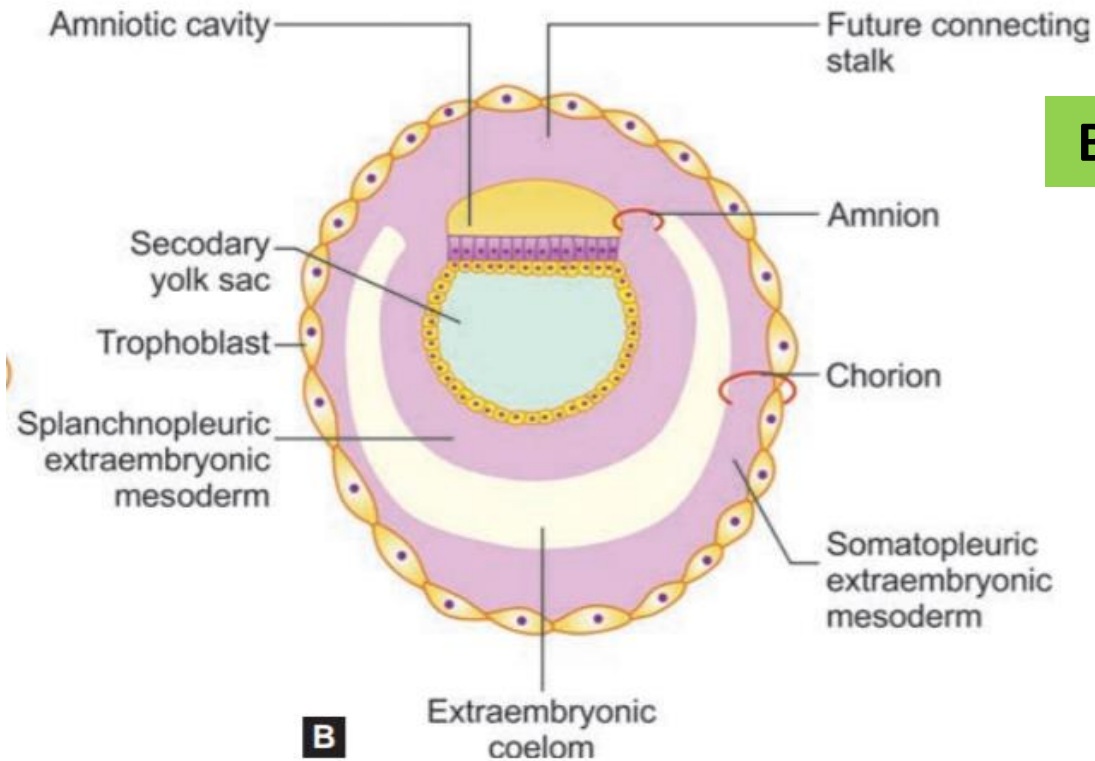
2 cell stage



Morula



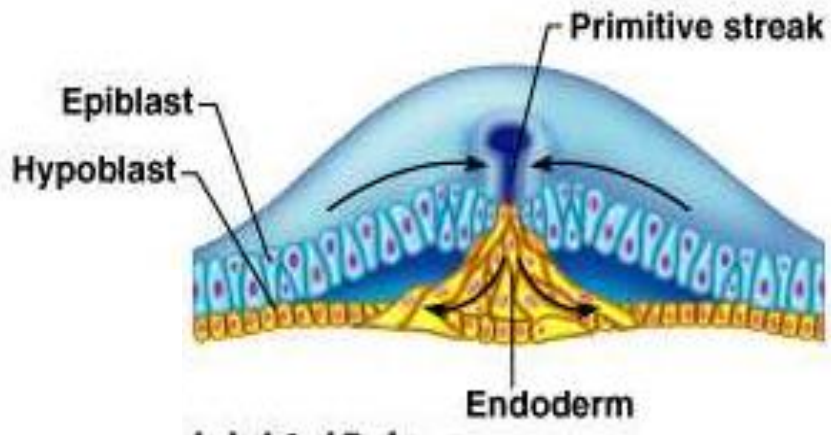
Blastocyst



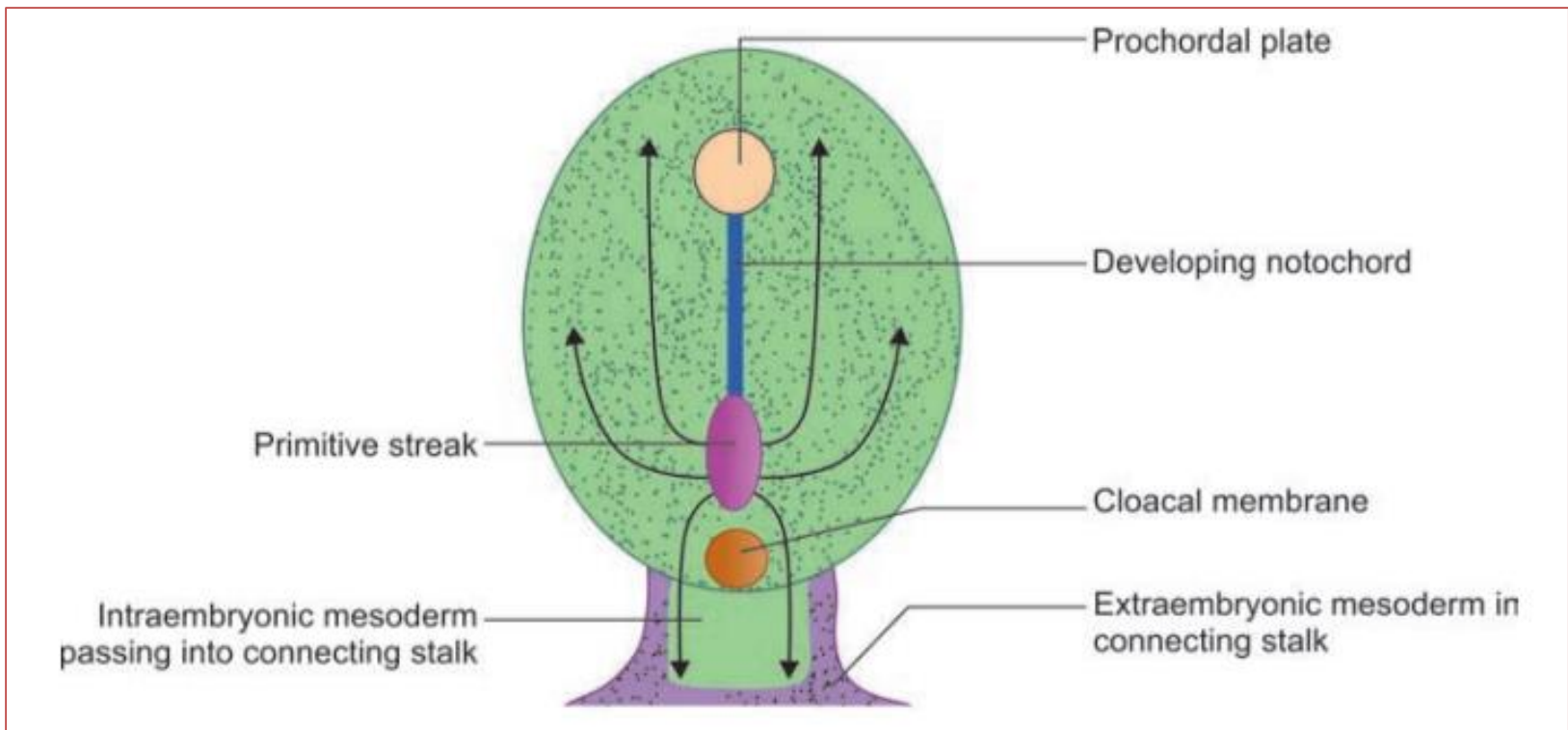
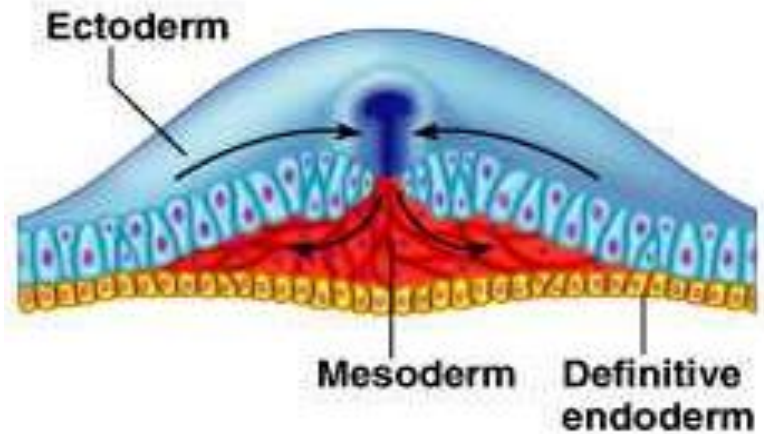
Bilaminar disc

B

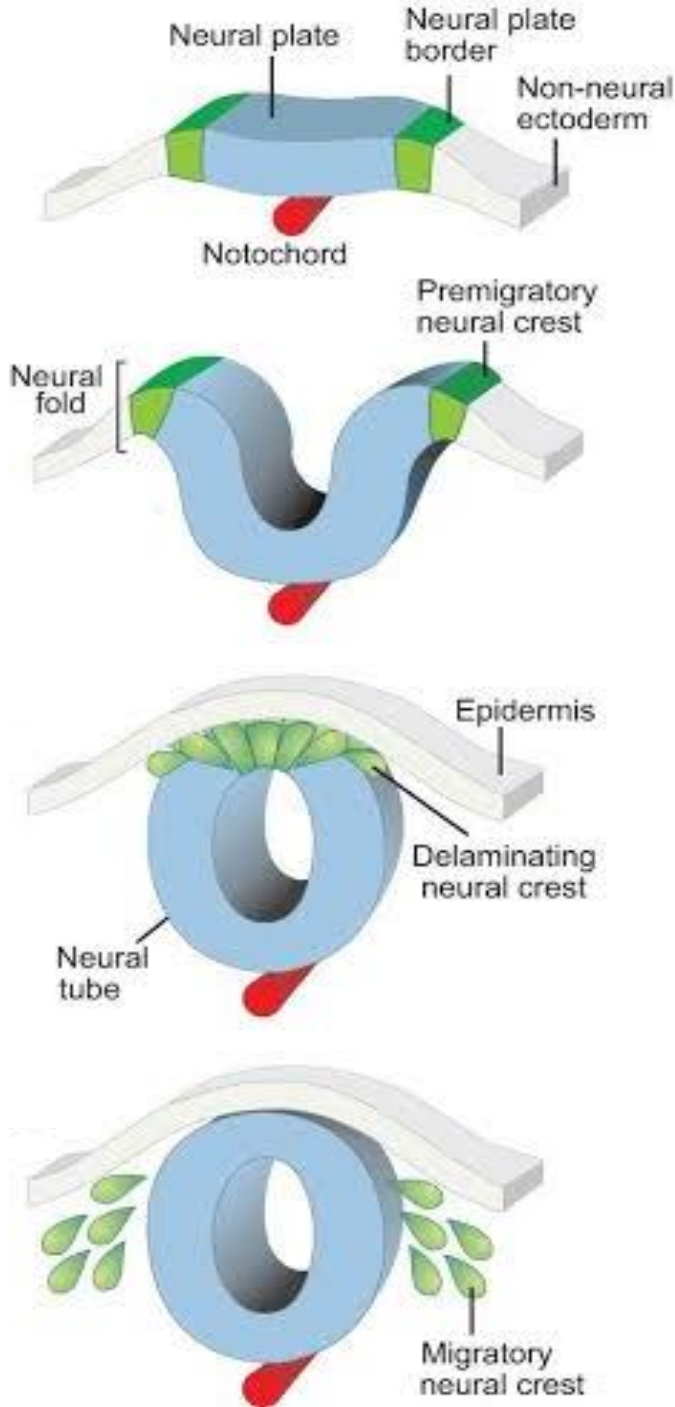
BILAMINAR DISC



TRILAMINAR DISC



NEURAL CREST CELLS



- ectomesenchymal tissue
- pluripotent
- follow natural cleavage planes
- passive translocation / active cell migration
- undergo cytodifferentiation
- neurocristopathy syndromes
- cancer cells – similar cellular & molecular changes

DERIVATIVES

1. NEURAL

- sensory ganglia of 5,7,9,10 nerves
- sympathetic & parasympathetic ganglia
- schwann cells
- supporting cranial nerve cells

2. CONNECTIVE TISSUE

- ectomesenchyme – facial prominences, pharyngeal arches
- dermis, adipose tissue – face, jaws, neck
- melanocytes, melanophores
- blood vessel walls
- dental papilla, cementum, PDL

3. SKELETAL

- branchial arch + basicranial cartilage
- ciliary muscles

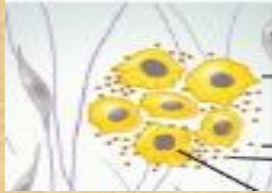
4. SECRETORY CELLS

- odontoblasts, pulpal cells
- carotid body
- calcitonin parafollicular cells

SIGNALLING MOLECULES AND GROWTH FACTORS

FACTORS		DERIVATIVES	ACTION
Bone morphogenetic proteins	BMPs (1-8)	Pharyngeal arches; frontonasal mass	Mesoderm induction Skeletogenesis neurogenesis
Epidermal growth factor	EGF	Various organs Salivary glands	Proliferation and differentiation of cell types
Fibroblast growth factors(1-19)	FGFs	Various organs and organising centres	Proliferation of fibroblasts, endothelium, myoblasts, osteoblasts
Sonic hedgehog	Shh	Various organs	Neural plate, craniocaudal patterning, chondrogenesis
Vascular endothelial growth factor	VEGF	Smooth muscle cells	Stimulates angiogenesis

BONE FORMATION (OSTEOGENESIS)



Condensation of mesenchymal cells
OSSIFICATION CENTRE

ENDOCHONDRAL

- Chondroblasts
- Hyaline cartilage
- Osteogenic cells become osteoblasts

Osteoid matrix

Ca²⁺ deposition

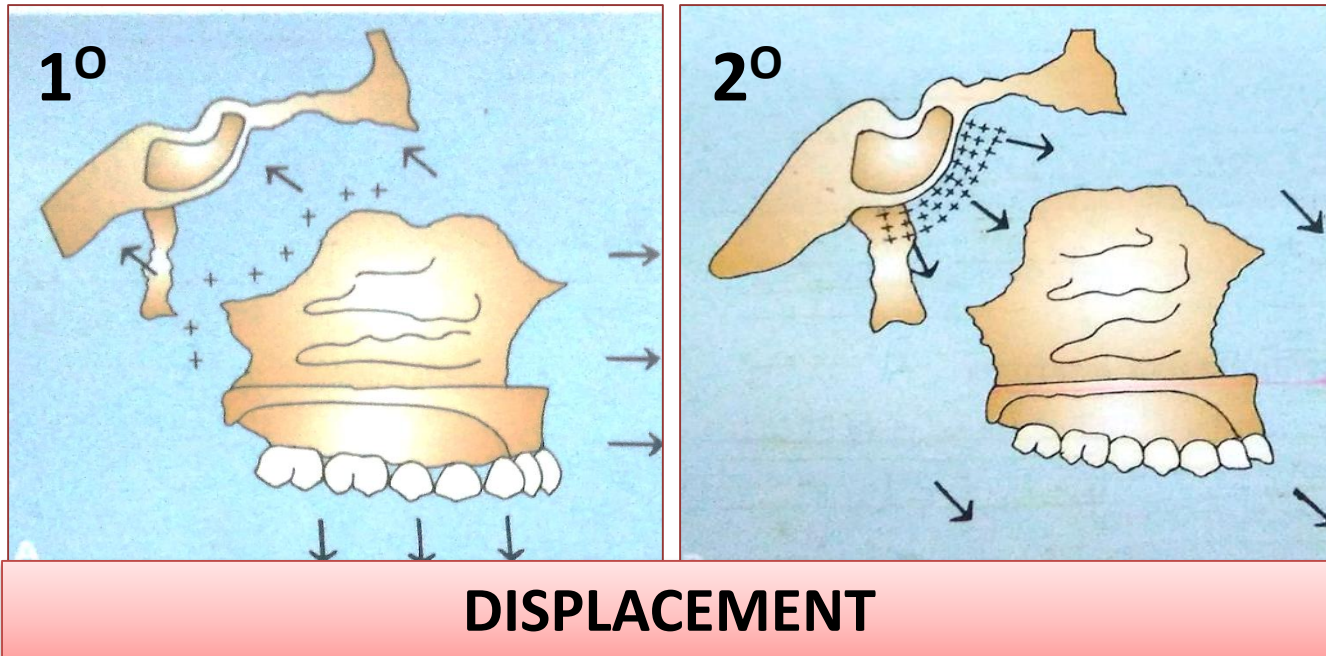
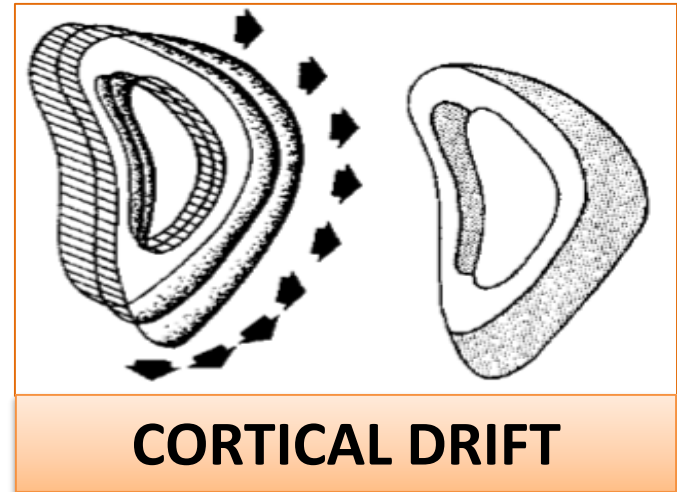
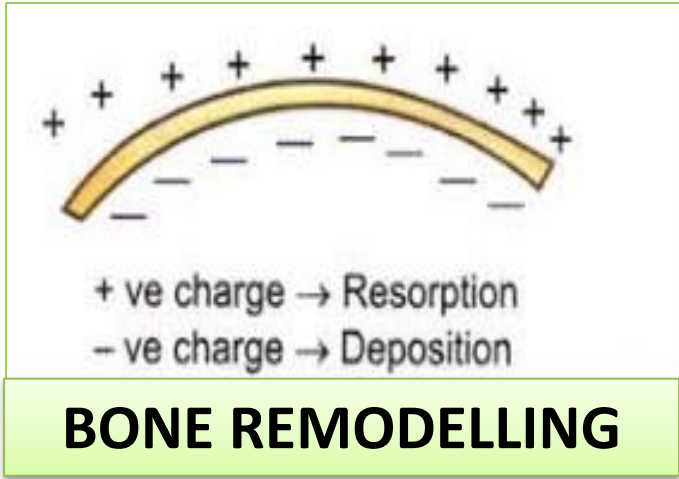
Bone lamellae

INTRAMEMBRANOUS

- Osteoblasts

New layer of osteoid secreted + calcified

BONE GROWTH MECHANISMS



PRENATAL EMBRYOLOGY OF CRANIUM

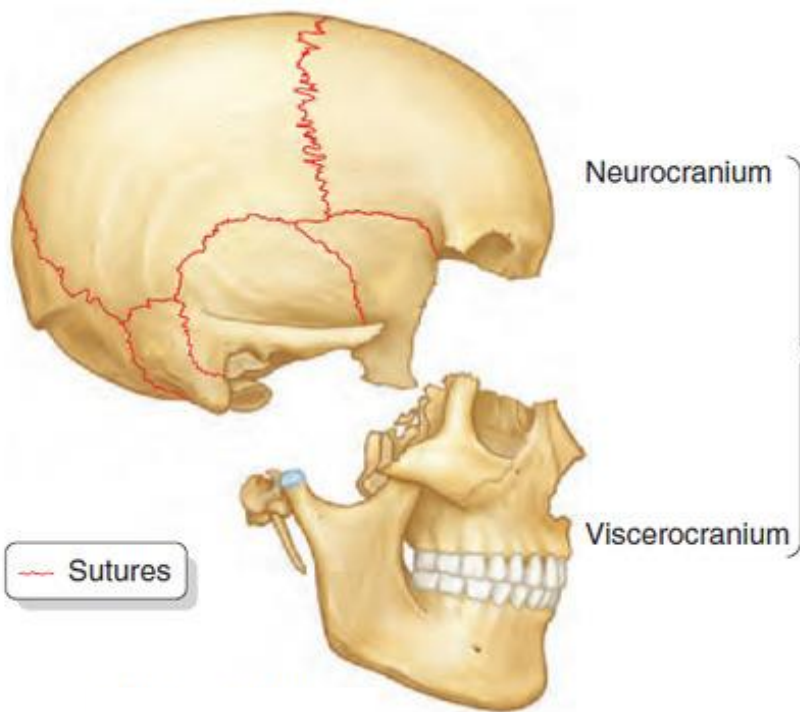


- Mesenchyme condense around developing brain

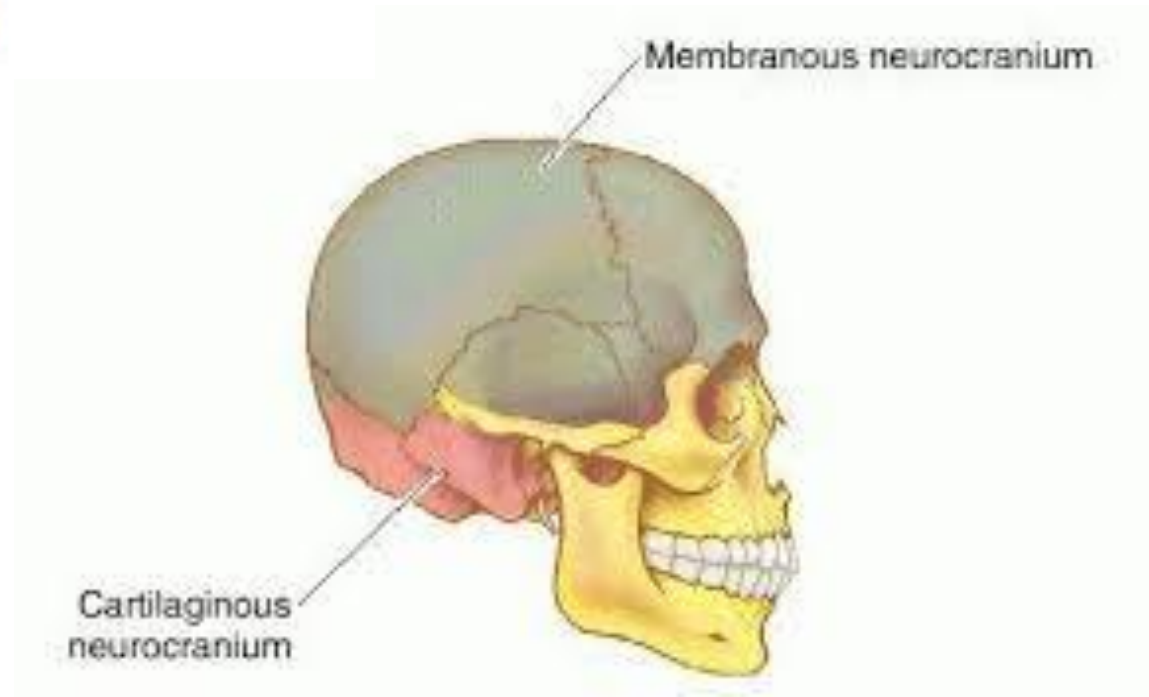
CAPSULE = Endomeninx + Ectomeninx

LAYERS	ORIGIN	DERIVATIVES
Endomeninx	Neural crest cells	<ul style="list-style-type: none"> • Piamater • arachnoid
Ectomeninx	Neural crest cells Paraxial mesoderm Occipital sclerotomes	<ul style="list-style-type: none"> • duramater • outer superficial membrane with chondrogenic and osteogenic properties

- Desmocranium \longrightarrow skull vault
- Chondrocranium \longrightarrow cranial base



CRANIUM



DESMOCRANIUM

- end of 1st month
- first evident in basilar part of occipital bone
- forms OCCIPITAL PLATE

1. Foramen around hypoglossal nerve
2. Clivus of cranial base
Dorsum sellae of future sphenoid bone
3. Greater + lesser wings of sphenoid
Ethmoid bone
Nasal septum

13th day IU

1st sign of vault

Curved plates of mesenchyme

- Join with each other
- Become part of chondrocranium

5th week IU

B/L auditory vesicles (otocysts)

Vestibular + cochlear parts

Fuse with occipital plate

Hiatus – IJV, 9, 10, 11 nerves pass

ANOMALIES



Brachycephalic skull



Craniosynostosis



Frontal encephalocele

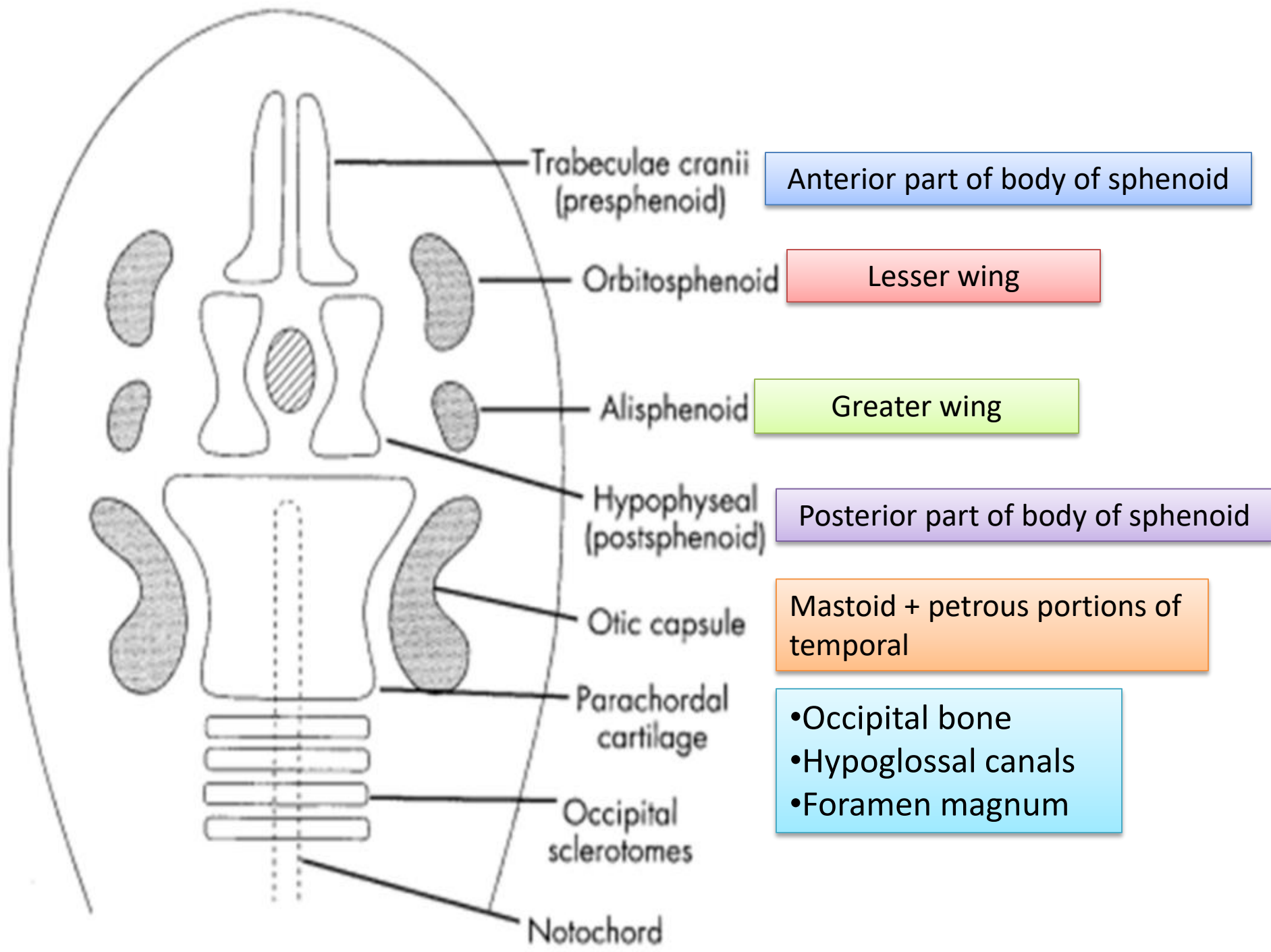


Occipital encephalocele

CHONDROCRANIUM

- 14th day – ectomeninx converted into cartilage
- 4 regions

1. Parachordal
2. Hypophyseal
 - presphenoid
 - orbitosphenoid
 - alisphenoid
 - postspenoid
3. Nasal
4. Otic



Trabeculae cranii
(presphenoid)

Anterior part of body of sphenoid

Orbitosphenoid

Lesser wing

Alisphenoid

Greater wing

Hypophyseal
(postsphenoid)

Posterior part of body of sphenoid

Otic capsule

Mastoid + petrous portions of
temporal

Parachordal
cartilage

- Occipital bone
- Hypoglossal canals
- Foramen magnum

Occipital
sclerotomes

Notochord

Both endochondral & intramembranous ossification

BONE	OSSIFICATION CENTRES	INTRAMEMBRANOUS	ENDOCHONDRAL
Occipital	7	Supranuchal squamous part (2)	<ul style="list-style-type: none"> • Infranuchal squamous part (2) • Basilar part(1) • Lateral boundary of foramen magnum (1) • Posterior portion of occipital condyles (1)
Temporal	11	<ul style="list-style-type: none"> ▪ Squamous part (1) ▪ Tympanic ring (4) 	<ul style="list-style-type: none"> ➤ Petrous part (4) ➤ Styloid process (2)
Ethmoid	3		<ul style="list-style-type: none"> • Median floor of anterior cranial fossa • Nasal capsule
Sphenoid	15	<ul style="list-style-type: none"> • Lesser wing (1) • Greater wing (1) • Lateral pterygoid plate (1) • Medial pterygoid plate (1) 	<ul style="list-style-type: none"> ▪ Anterior part of body (5) ▪ Posterior part of body (4)

- Centres of chondrification fuse – single irregular & perforated cranial base
- Numerous foramina
- Ossifying chondrocranium + desmocranium



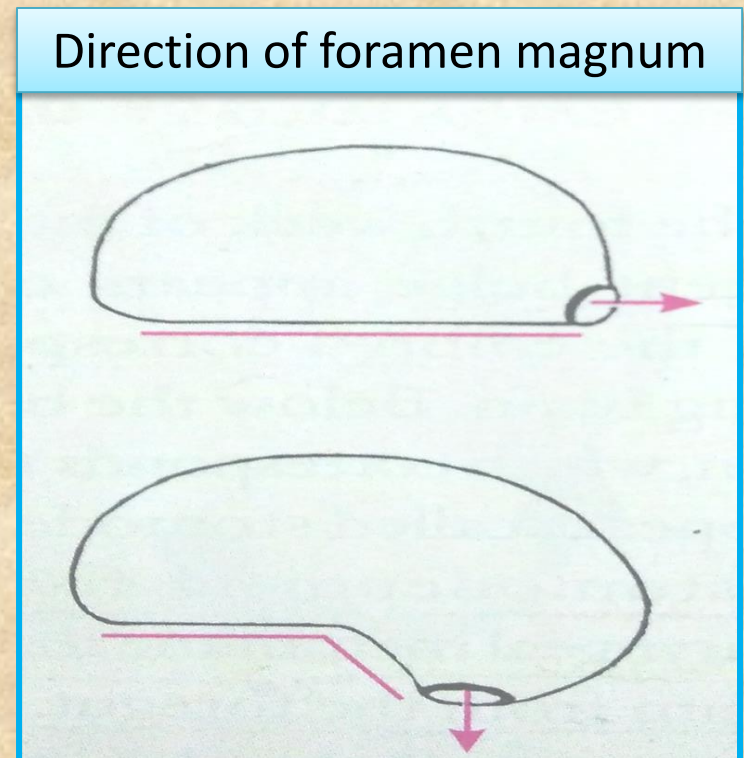
neurocranium

- Cranial base relatively stable
- Growth – highly uneven

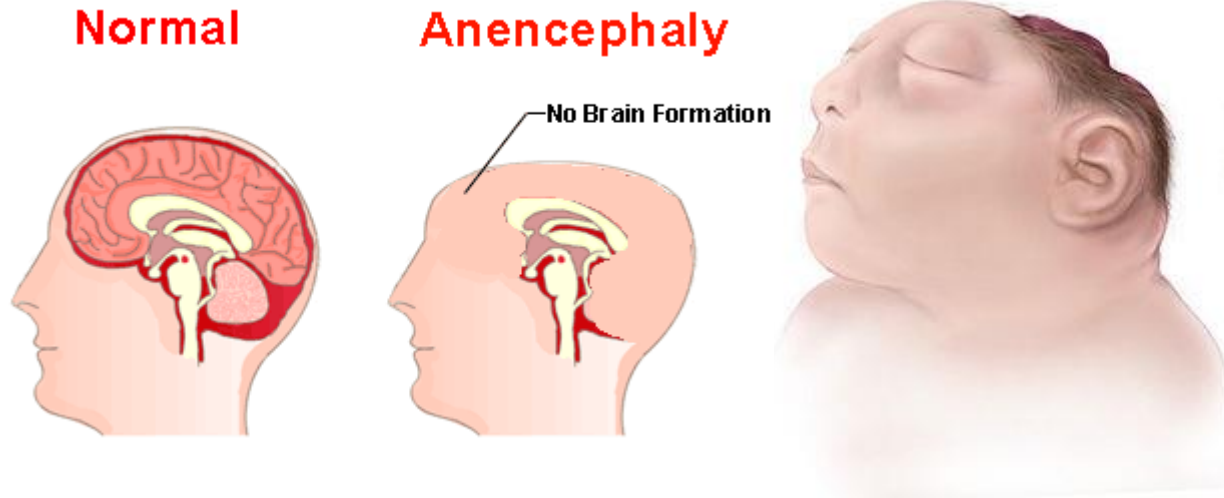
Flexed in region between pituitary fossa & spheno-occipital junction

Face tucked under cranium
Flexure of developing brain stem

10 th week IU	Flexion of base 65°
At birth	Flattens out a bit



ANOMALIES



Dish deformity

reduced cranial base with increased angulation

- achondroplasia
- cretinism
- down syndrome

VISCEROCRANIUM

Intramembranous ossification

- **Maxilla**
- **Squamous temporal bones**
- **Vomer**
- **Palatine bones**

Mandible

Endochondral ossification

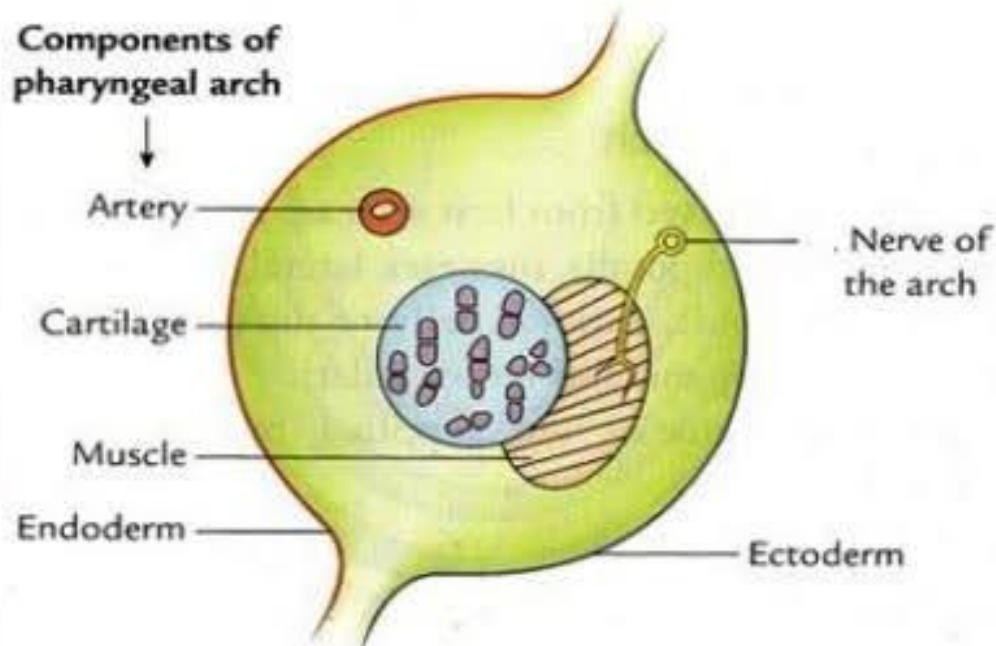
- **Malleus**
- **Incus**
- **Stapes**
- **Styloid process**

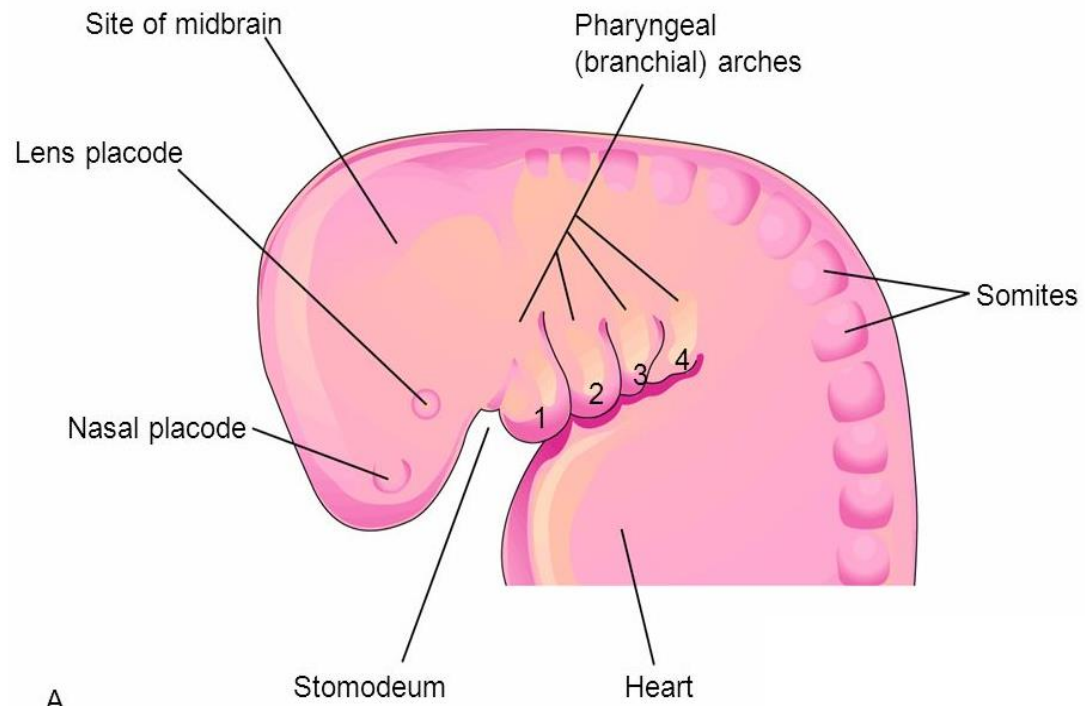
Hyoid bone

PHARYNGEAL ARCH

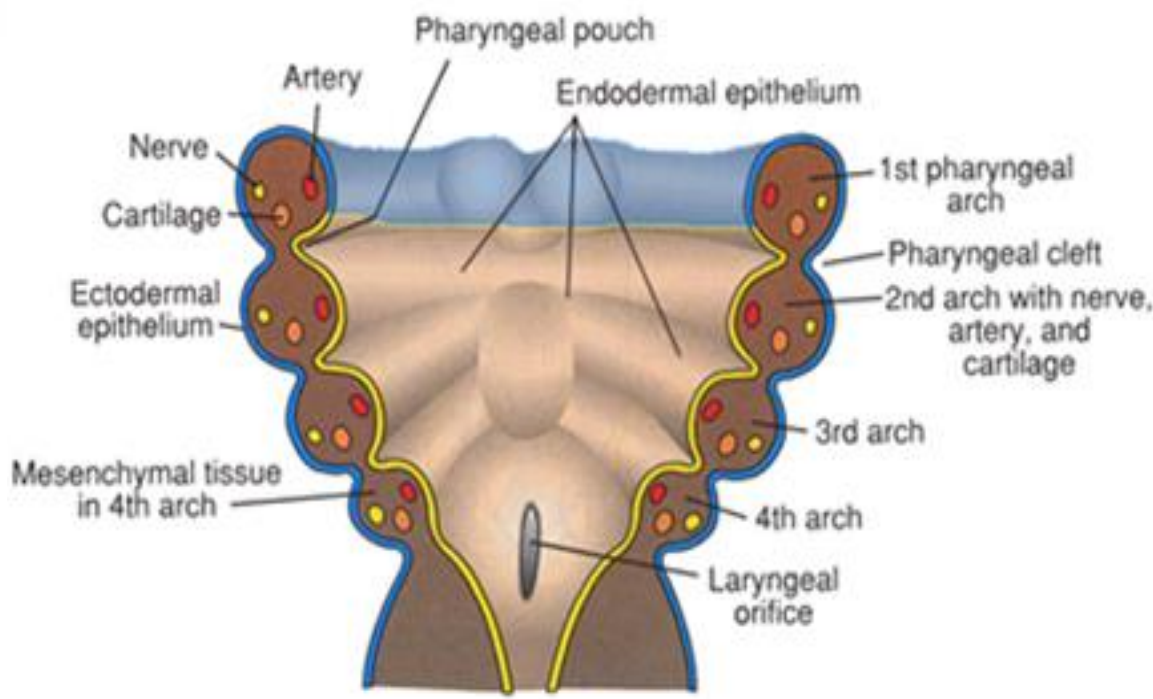
- 4th week IU – lateral plate mesoderm of ventral foregut segments

5 bilateral mesenchyme swellings





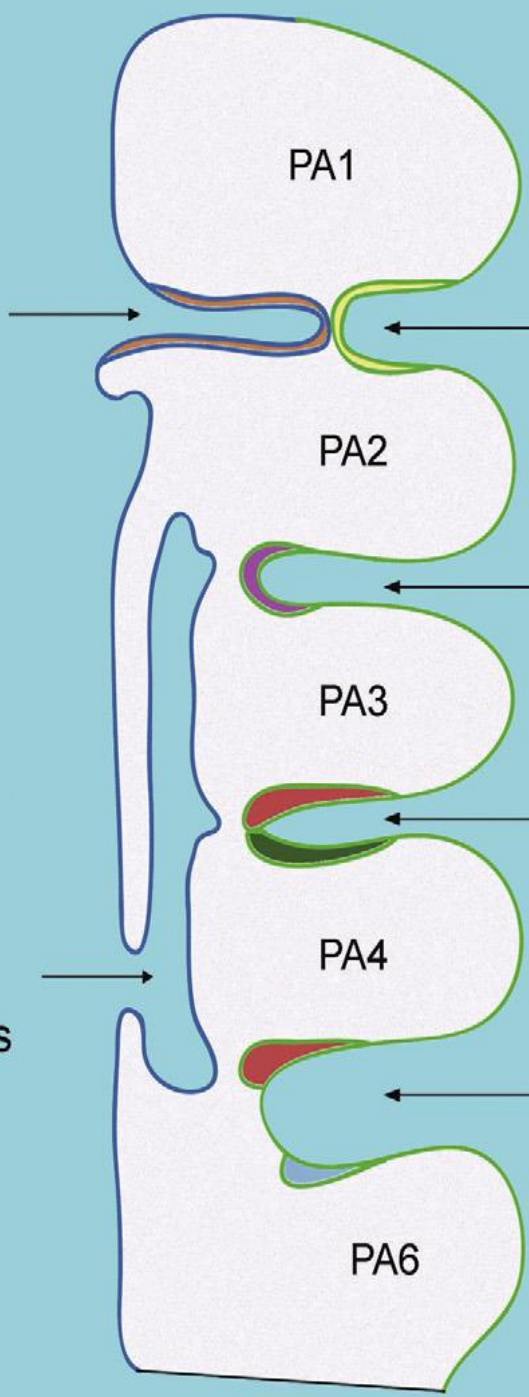
A



ARCH	CARTILAGE DERIVATIVES	MUSCLE	NERVE	ARTERY
1 st (mandibular)	<ul style="list-style-type: none"> • malleus, incus • ant. Ligament of malleus • spine of sphenoid • sphenomandibular ligament • genial tubercles of mandible 	<ul style="list-style-type: none"> • muscles of mastication • mylohyoid • ant. belly of digastric • tensor tympani • tensor veli palatini 	V ₃	First aortic arch
2 nd (hyoid)	<ul style="list-style-type: none"> ▪ stapes ▪ styloid process of temporal ▪ stylohyoid ligament ▪ lesser cornua & superior part of body of hyoid 	<ul style="list-style-type: none"> ▪ muscles of facial expression ▪ platysma ▪ stylohyoid ▪ stapedius ▪ post. belly of digastric 	VII	Stapedial
3 rd	Greater cornua & lower part of body of hyoid	Stylopharyngeus	IX	CCA + ICA (1 st part)
4 th	Thyroid, arytenoid, corniculate, cuneiform cartilages	<ul style="list-style-type: none"> • cricothyroid • pharyngeal muscles • soft palate muscles 	X	Subclavian
5 th		DISAPPEARS		
6 th	Cricoid cartilage	<ul style="list-style-type: none"> • laryngeal muscles • constrictors of pharynx 	X	Ductus arteriosus

External Auditory Meatus

First cleft



First Pouch

Eustachian Tube
Tympanic cavity

PA2

Second Pouch

Palatine Tonsil

PA3

Third Pouch

Inferior Parathyroid
Thymus

PA4

Fourth-Sixth Pouch

Superior Parathyroid
Ultimobranchial Body

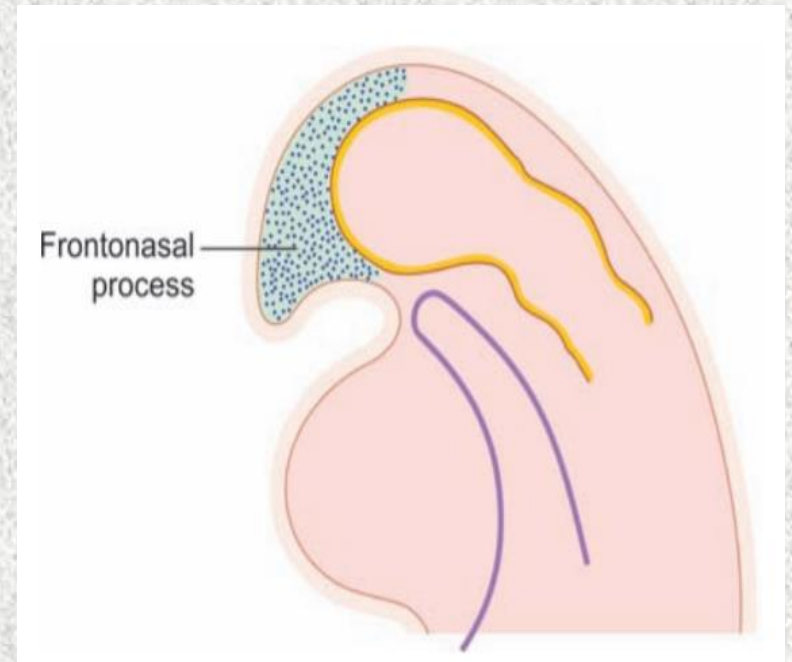
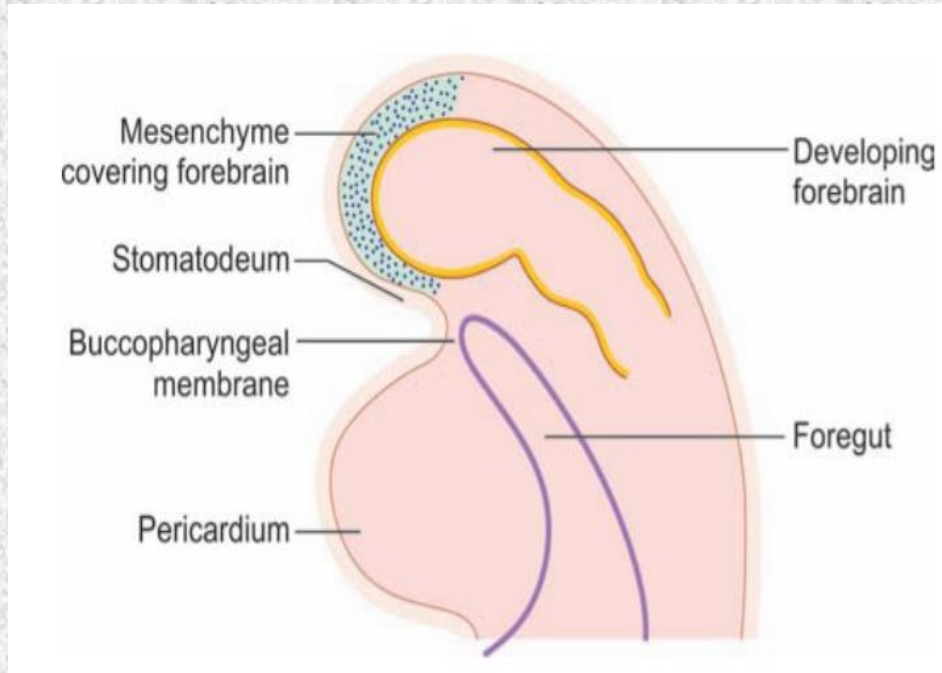
PA6

Second, Third and Fourth Clefts

Incorporated into the Cervical Sinus

PRENATAL EMBRYOLOGY OF MAXILLA

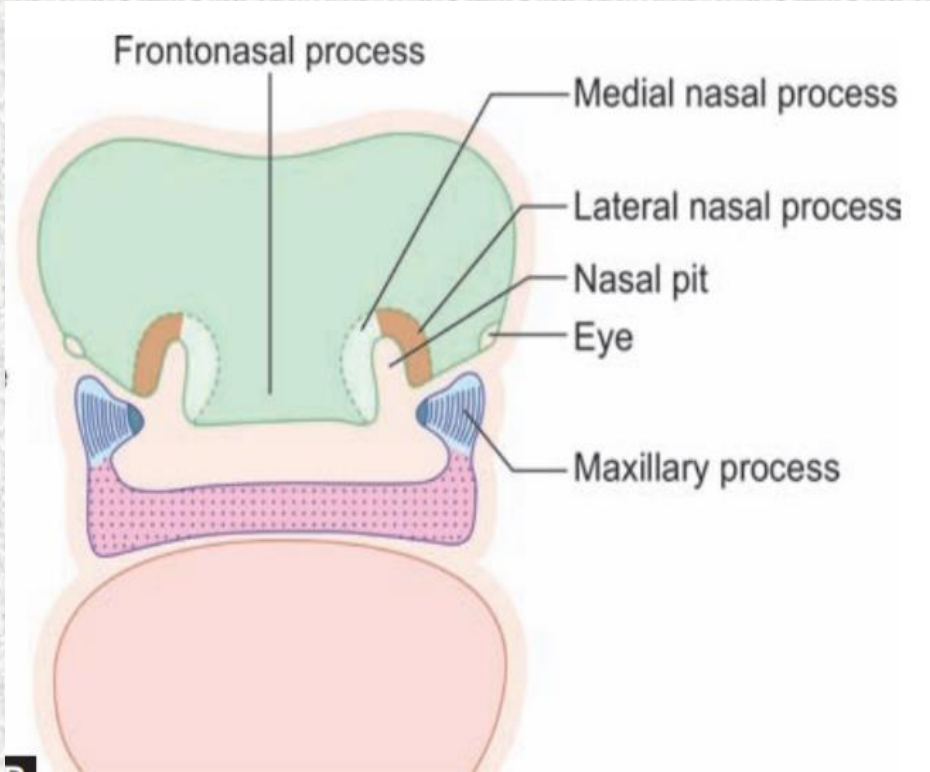
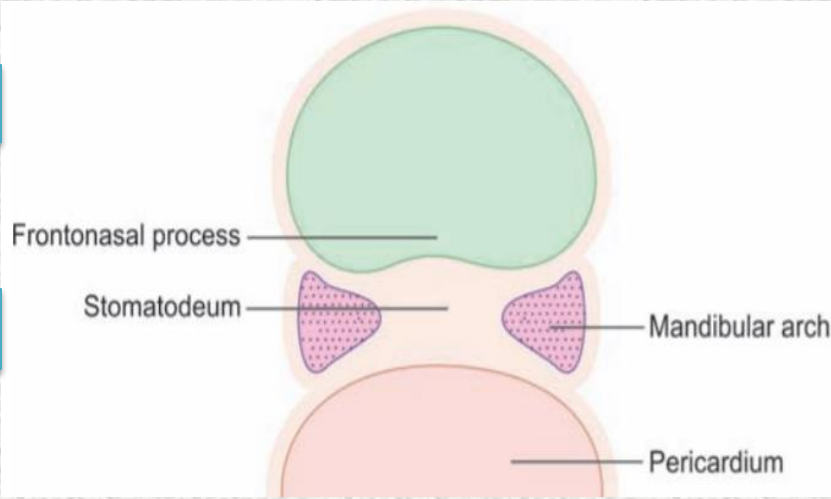
- 4th week IU



- Buccopharyngeal membrane
 - floor of stomatodeum
 - separates stomatodeum from foregut

Maxillary process

Mandibular process

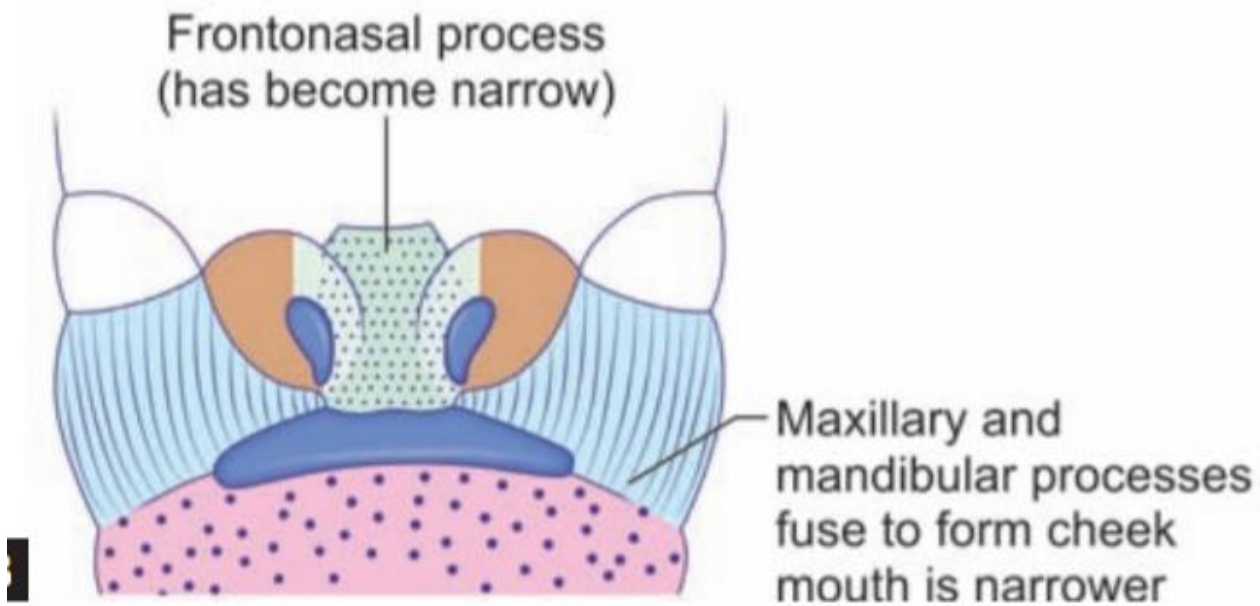
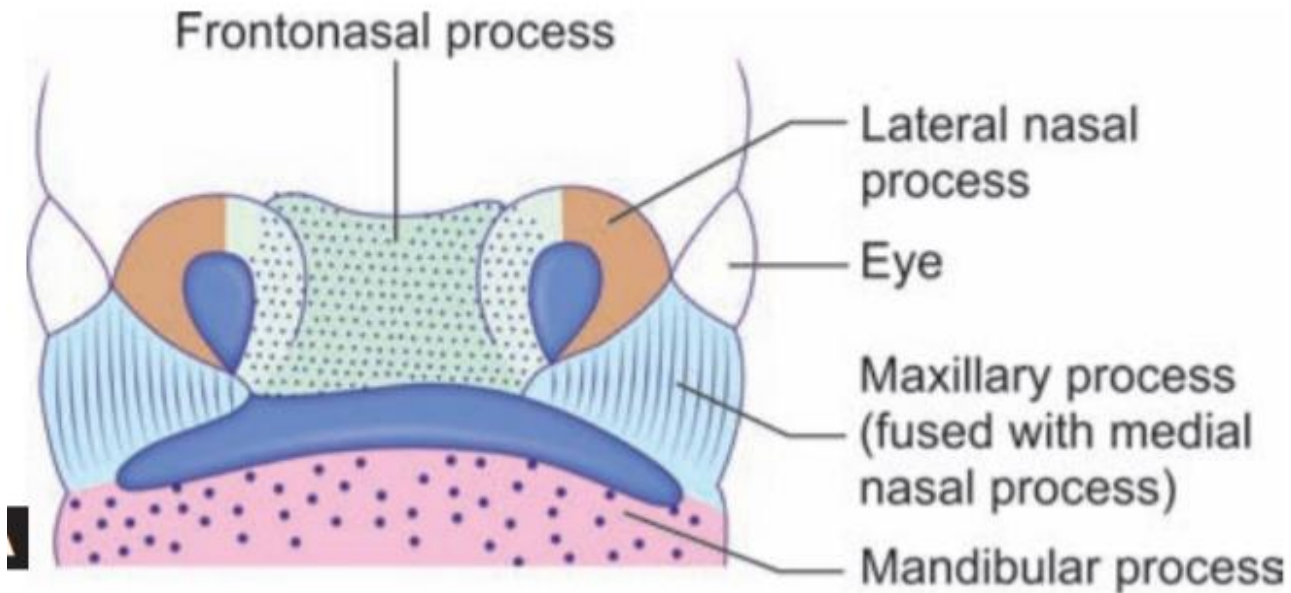


Ectoderm of frontonasal process

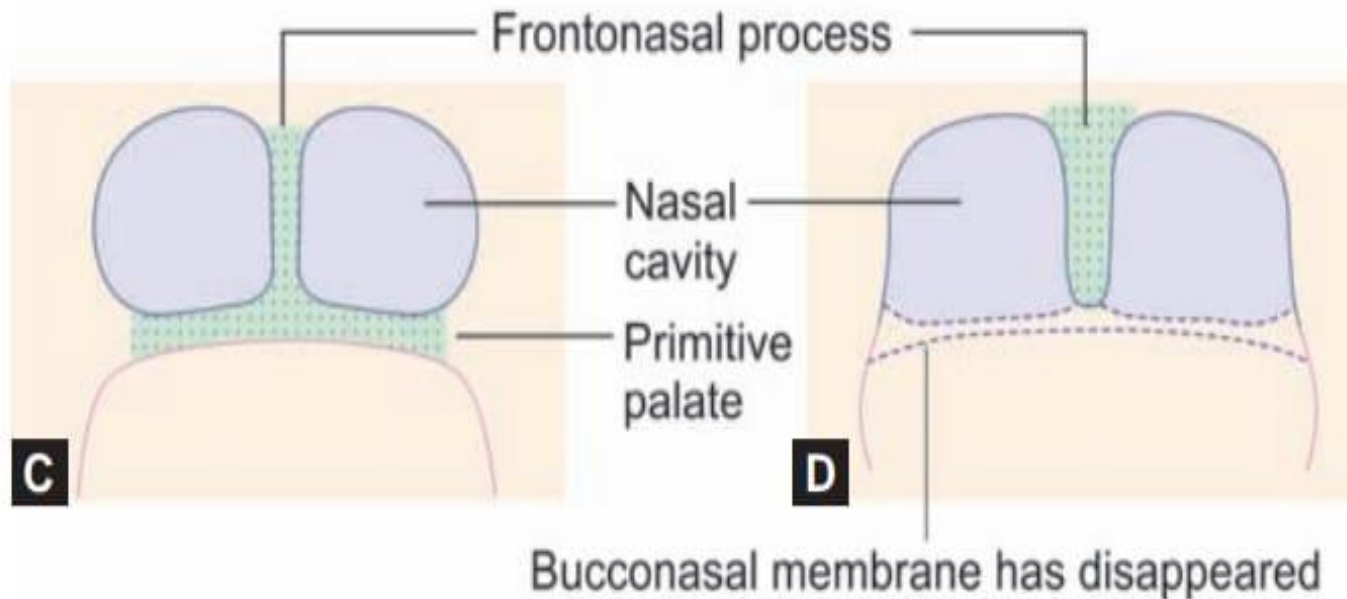
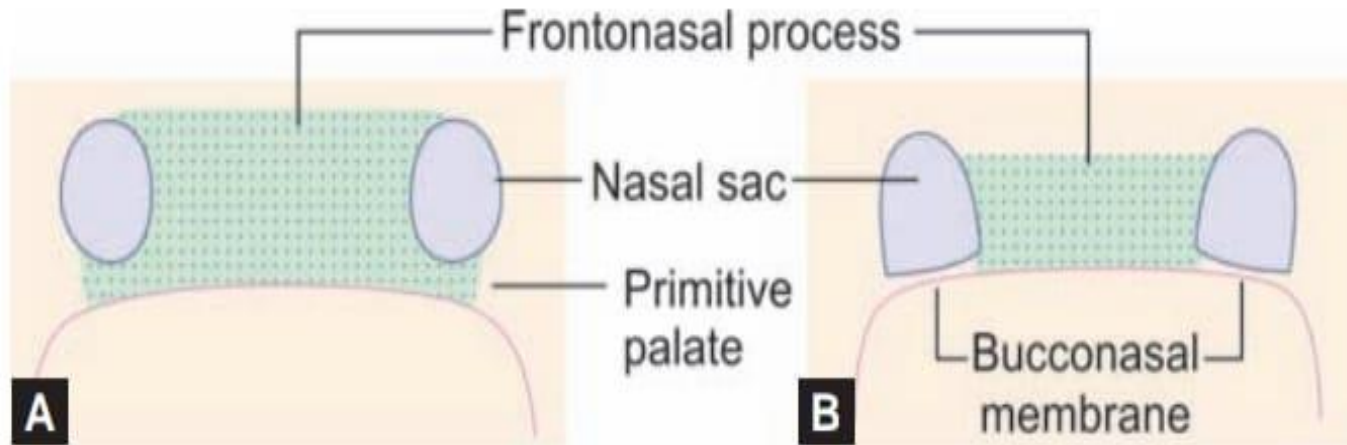
Nasal placodes

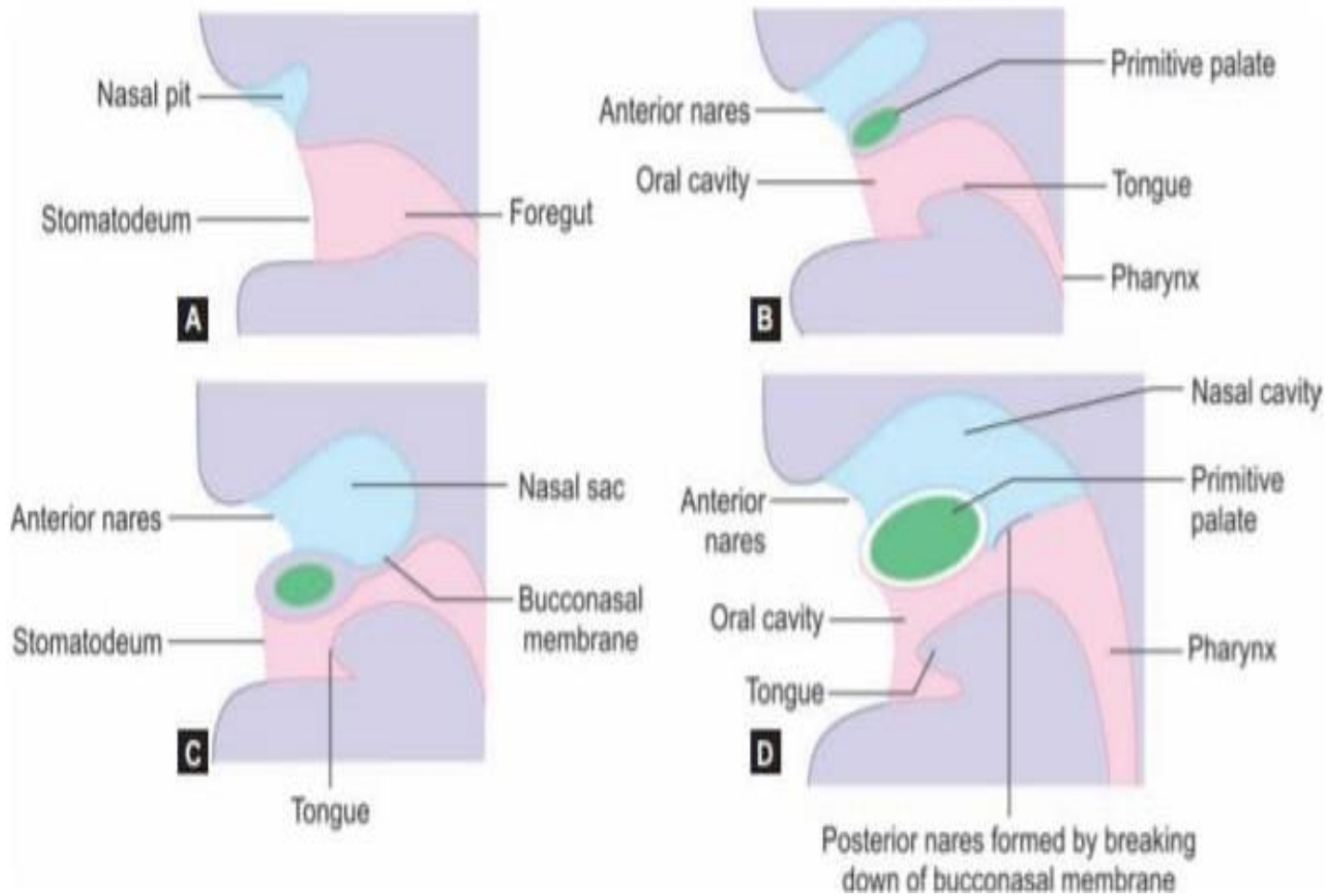
Nasal pits

Medial nasal process
Lateral nasal process



NASAL CAVITY

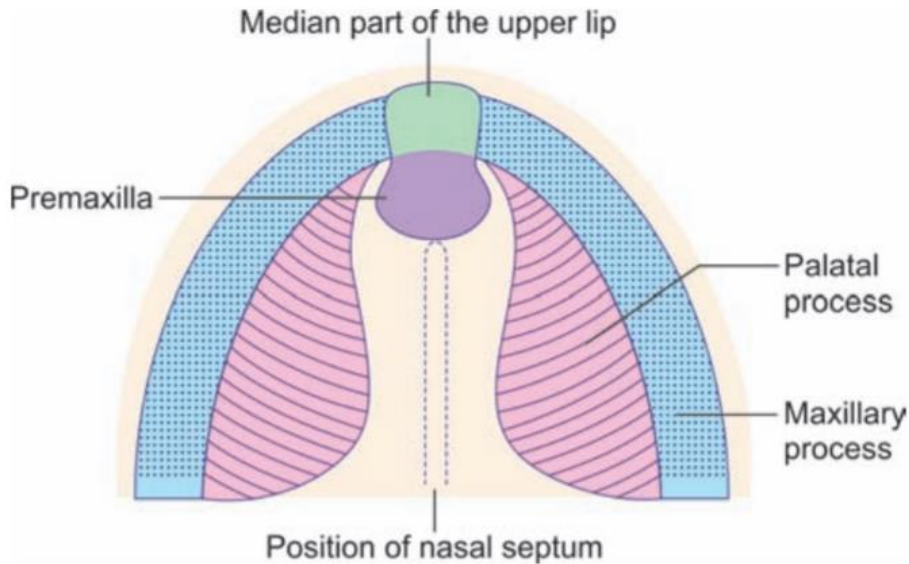




- Frontonasal process – dorsum & tip of nose
- Nasal pit – anterior nares
- Nasal sacs – nasal cavity
- Bucconasal membrane – posterior nares

STRUCTURE	FUSION
Lower lip	2 mandibular processes
Upper lip	2 maxillary processes + medial nasal process + lateral nasal process
Philtrum	Frontonasal process Skin – ectoderm of maxillary process
Cheek	Maxillary + mandibular processes
Nose	Frontonasal + medial nasal + lateral nasal processes

PALATE



PREMAXILLA

PALATAL PROCESSES

MAXILLARY PROCESS

- Frontonasal process ➡ premaxilla / primary palate
- Maxillary process ➡ palatal processes / secondary palate

Tongue prevents union of palatal processes
grow vertically downwards towards floor of mouth
8th week IU : vertical ➡ horizontal position

RAPID ELEVATION OF PALATAL SHELVES

Biochemical and physical consistency of
connective tissue matrix of shelves

Alteration in
vasculature

Muscular movements

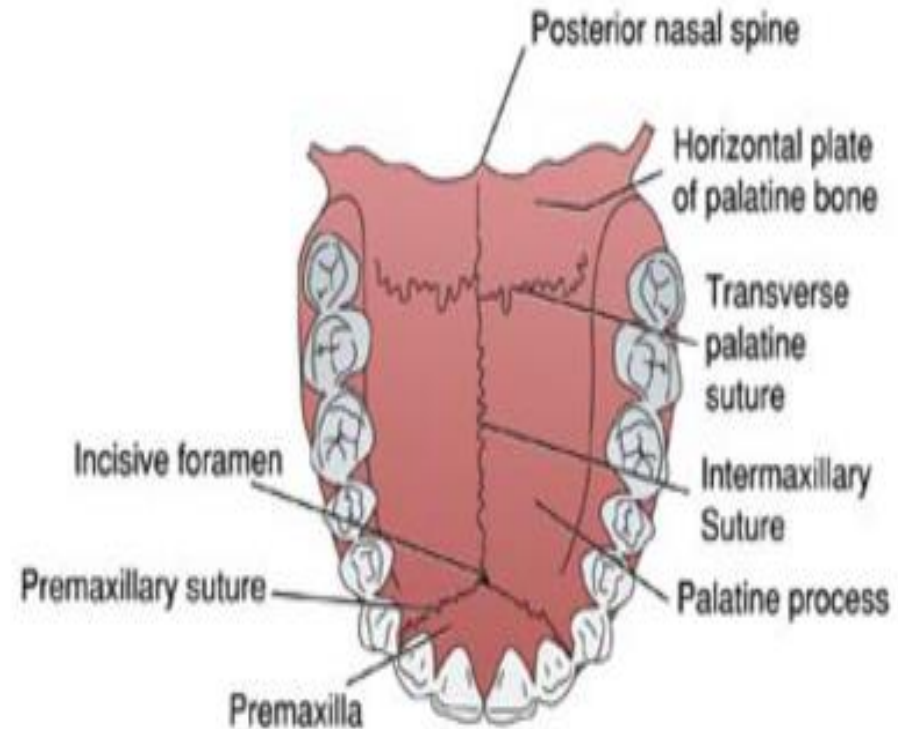
Intrinsic shelf
elevating force

Withdrawal of face
from above heart
prominence

- 8½ week IU – palatal processes come close to each other
- Initial contact – central region of secondary palate
- Closure occurs anteriorly & posteriorly
 - Mandible – more prognathic
 - Stomodeal chamber – height increases
 - Maxilla – width constant
- Ossification – premaxillary centres
- Fusion of palatal processes with lower edge of nasal septum – separates nasal cavities from each other and oral cavity

MID PALATAL SUTURE

- 10^{1/2} weeks
- Infancy – Y shape
binds vomer with palatal shelves
- Childhood – T shape
- Adolescence – interdigitated
- Adulthood – transverse palatomaxillary sutures
- Growth cessation
1-2 yrs but no synostosis
7 yrs – anterior portion
upto 30 yrs – posterior portion



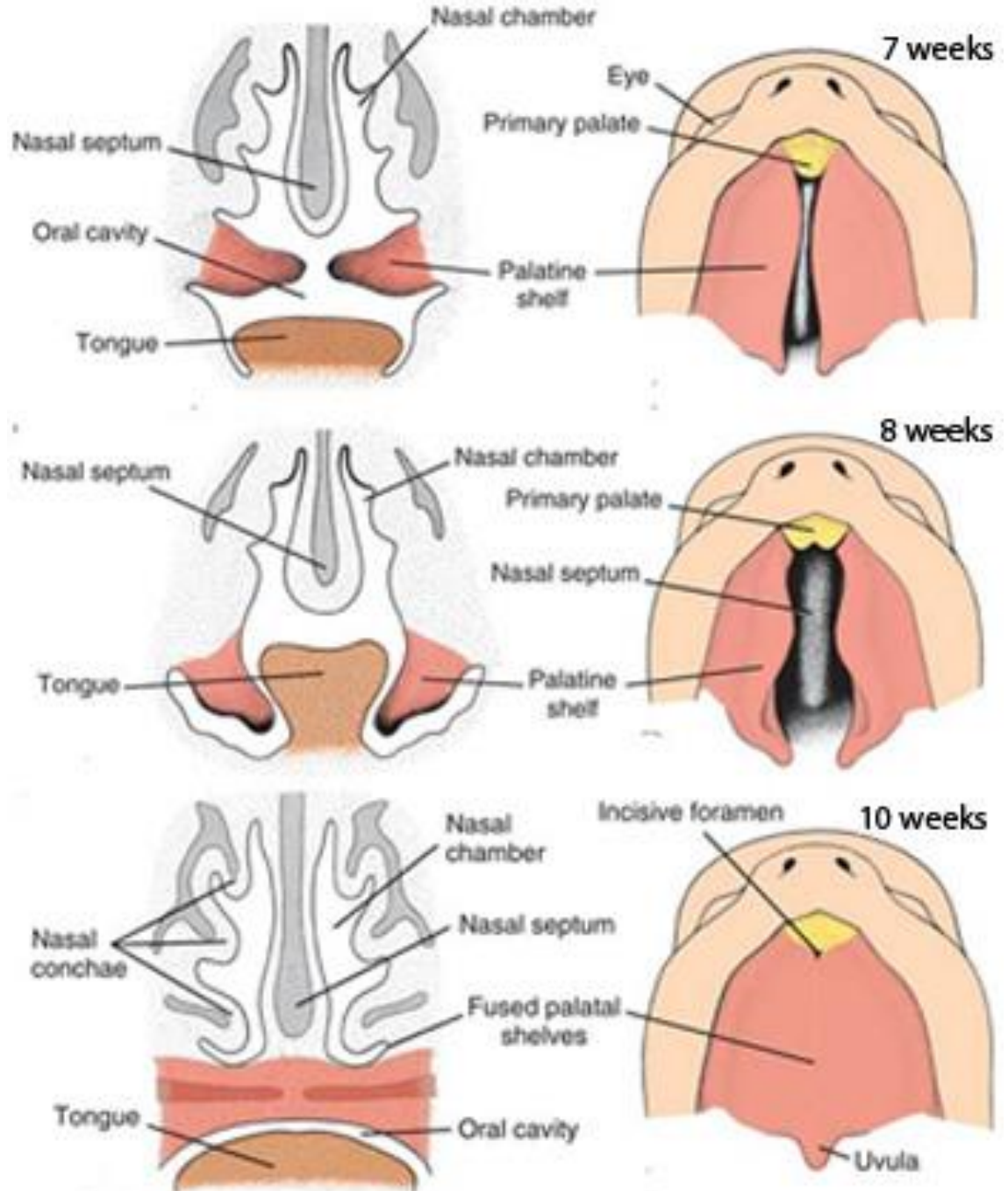
Mesoderm of palate

Intramembranous
ossification

HARD PALATE

No ossification

SOFT PALATE



ANOMALIES

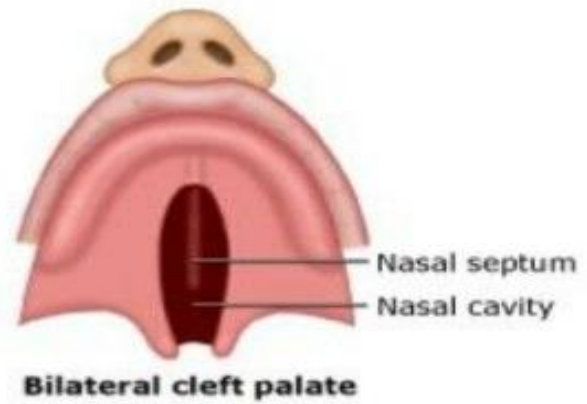
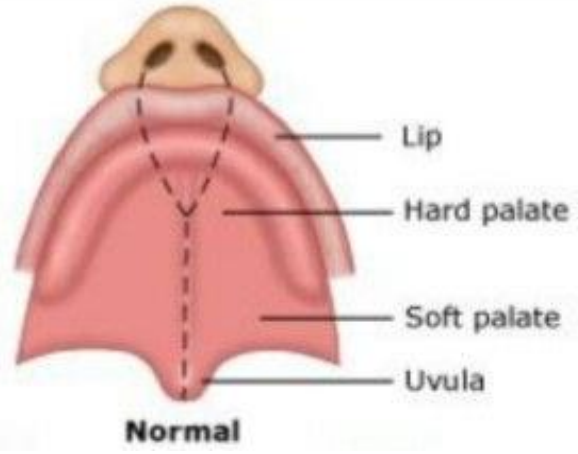
CLEFT PALATE

- delayed elevation of shelves
- defective shelf fusion
- post -fusion rupture
- mesenchymal consolidation + differentiation

Difficulty in :

- Swallowing
- Speech
- feeding

- Treacher collins syndrome
- Pierre robin syndrome
- Down syndrome
- Marfan syndrome
- Cleidocranial dysostosis





Median palatal cyst



Epstein's pearls

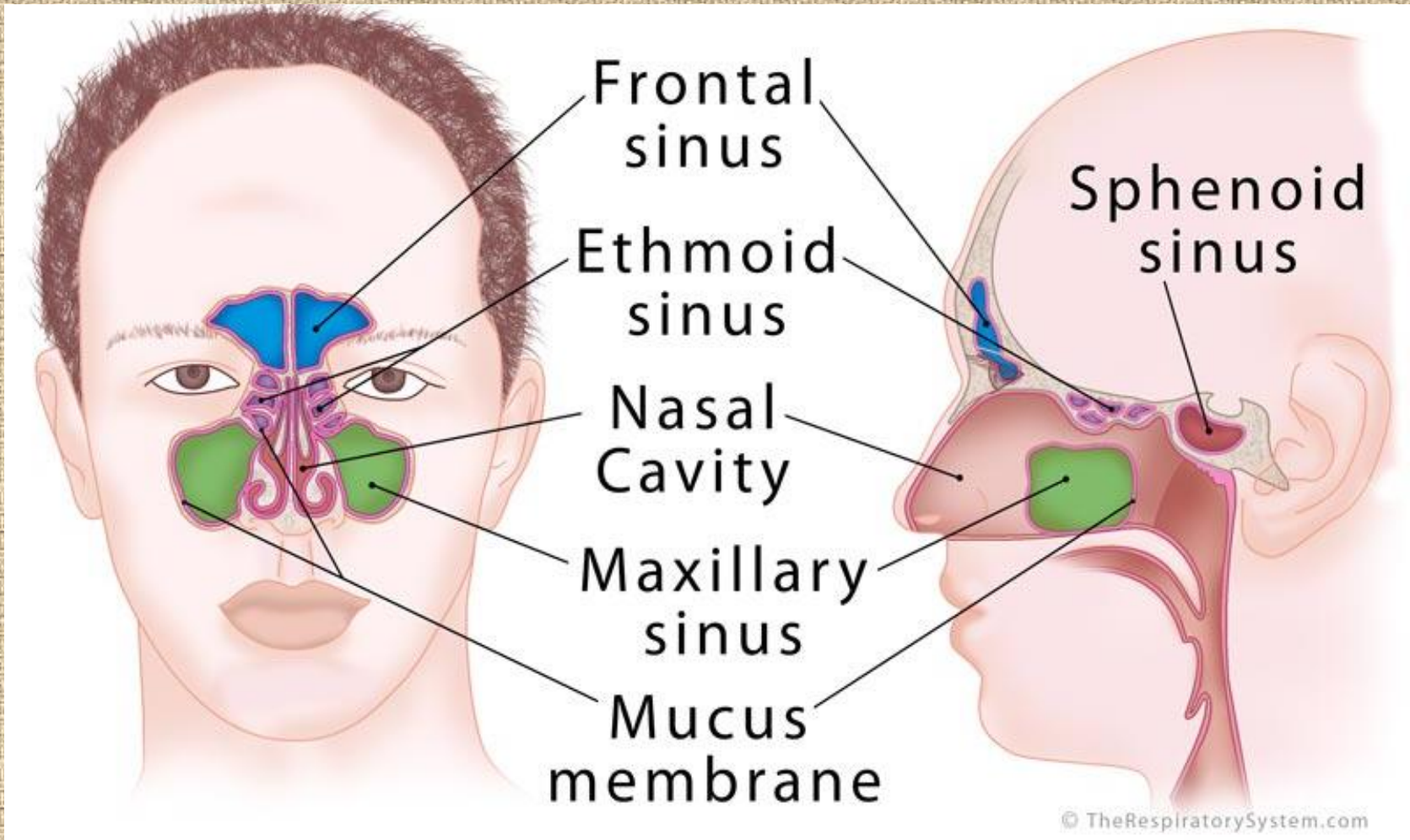


Bohn's nodules



Torus palatinus

PARANASAL SINUSES

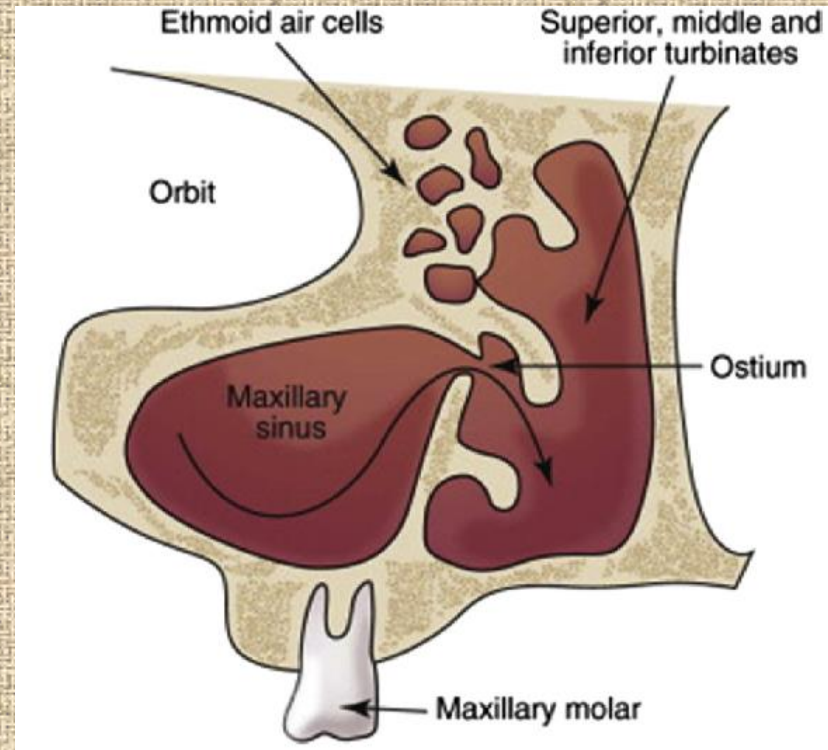


- Appear as diverticula from nasal cavity
- Gradually invade bones & expand
- Origin – ectodermal

SINUSES	STATUS AT BIRTH	RADIOGRAPHIC EVIDENCE	REACHES ADULT SIZE BY
Maxillary	Present	4-5 months after birth	15 years
Ethmoid	Present	1 year	12 years
Sphenoid	Absent	4 years	15 years
Frontal	Absent	6 years	Size increases until teens

MAXILLARY SINUS

- 1st – 10 weeks IU
- From middle meatus
- Pneumatization :
 - 1° – into ectethmoid cartilage
 - 2° – into ossifying maxilla
- Rapid & continuous downward growth
- Roots of molar project into sinus lumen



PRENATAL EMBRYOLOGY OF MANDIBLE

- First structure to develop in lower jaw

Mandibular division of Trigeminal nerve

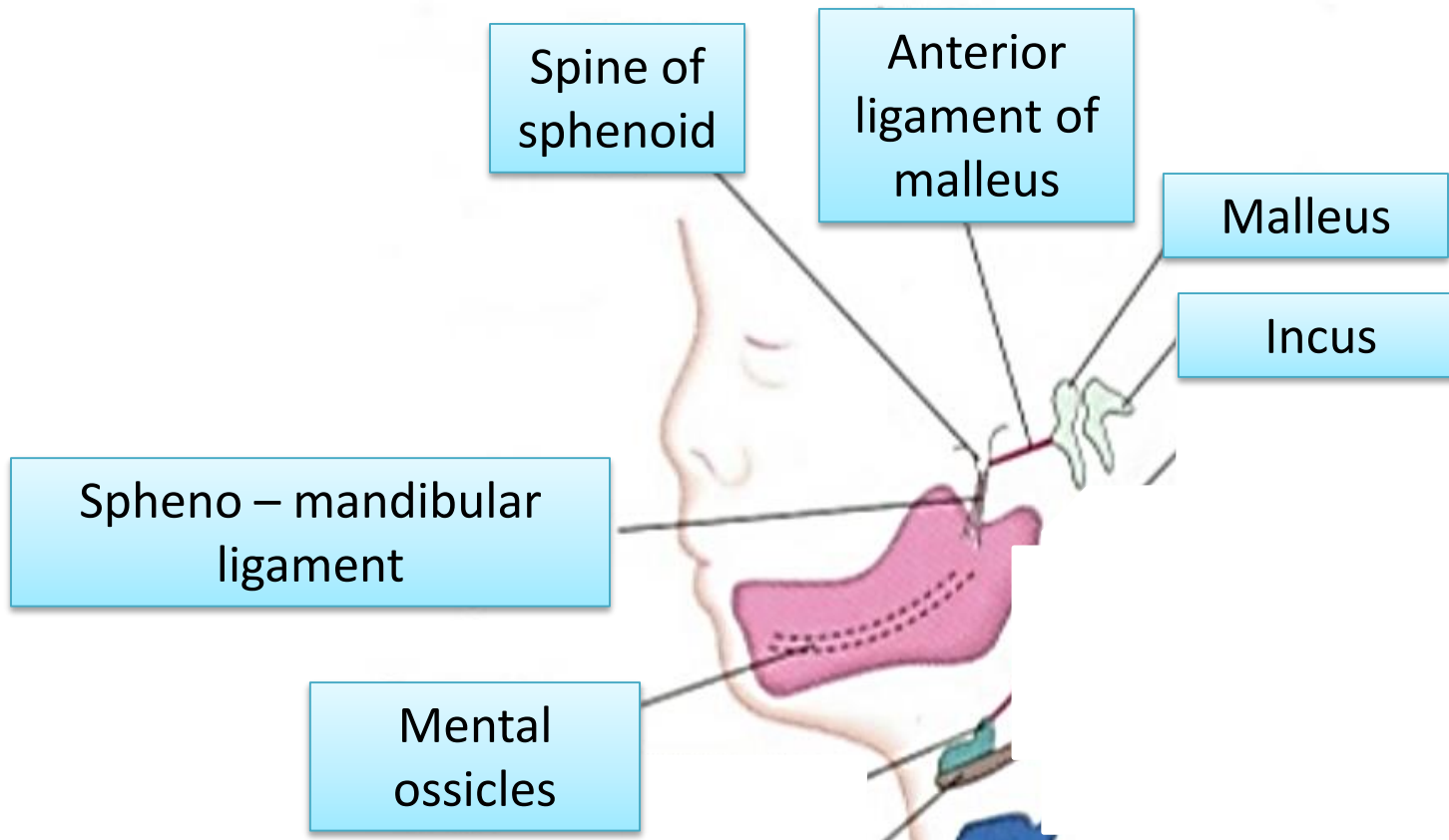
Produce neurotropic factors

Induce osteogenesis

MECKEL'S CARTILAGE

- Around 41st - 45th day IU
- Origin – mandibular arch
- From otic capsule to symphysis
- Solid hyaline cartilaginous rod surrounded by fibrocellular capsule
- Provides only template for guiding growth of mandible

- No phosphatase – no ossification
- Major portion disappears by 24th week IU



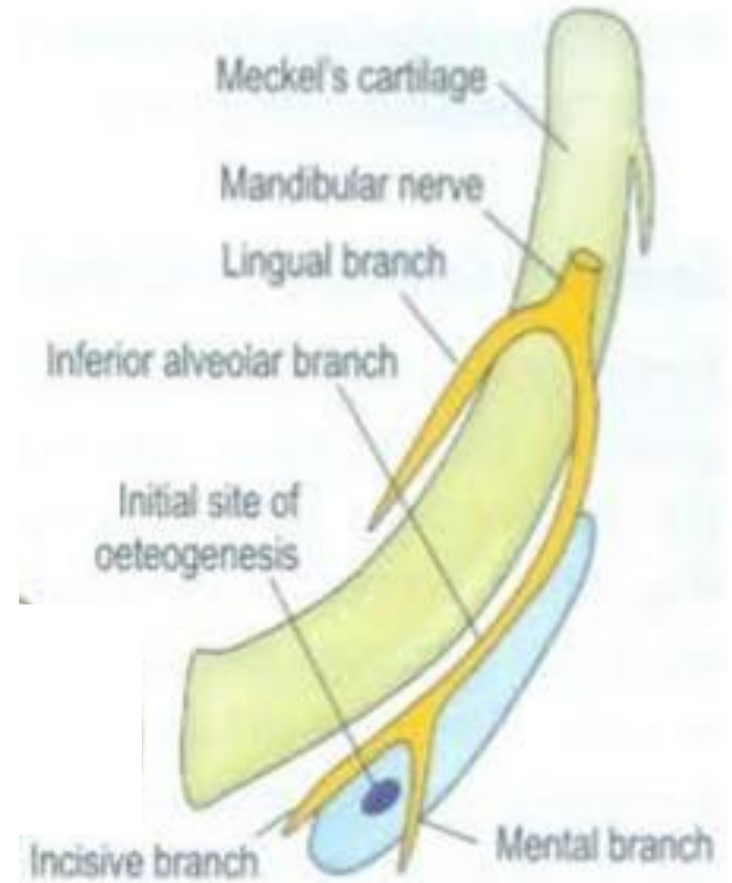
Osteogenic membrane

Intramembranous
ossification

- Trough of developing teeth
- Body & ramus of mandible

Meckel's cartilage
surrounded + invaded by
bone

Ossification stops at site of
lingula



SECONDARY ACCESSORY CARTILAGES

- Endochondral ossification
- Differences from primary cartilage
 - histological organization
 - appositional proliferation
 - react to growth stimuli after additional modulation by local growth factors

Condylar cartilage

- 5th week IU – mesenchymal condensation
- 14th week IU – ossification starts
- 4th month IU – fusion with mandibular ramus
- Much of cartilage replaced by bone
- Upper part persists into adulthood
- Both growth & articular cartilage

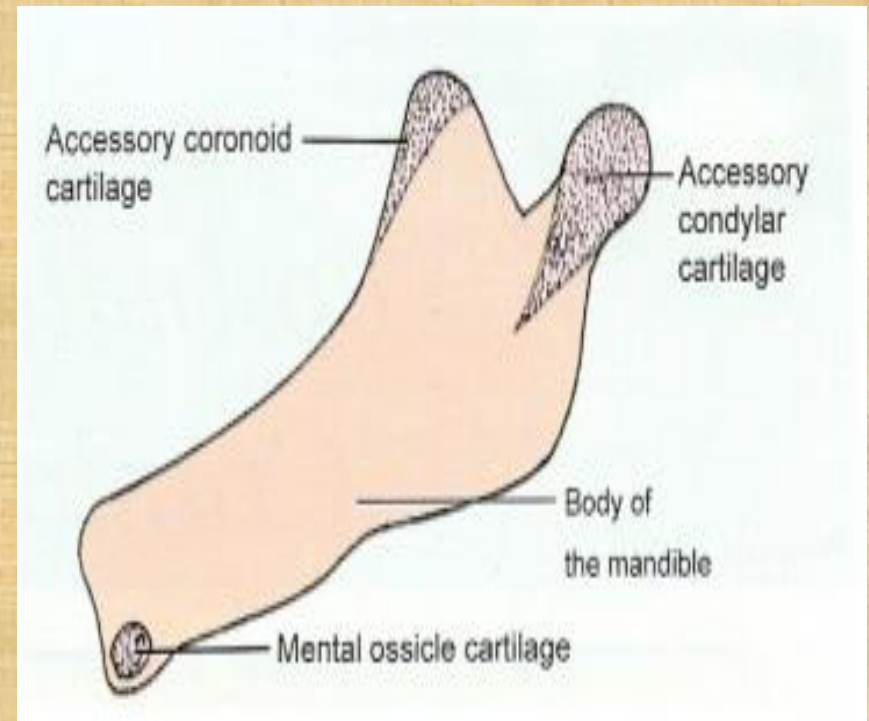


Coronoid cartilage

- 10 – 14th week IU
- Transient – disappears before birth
- Develops within temporalis muscle
- Incorporate into expanding intramembranous bone of ramus

Symphyseal cartilage

- Either side of symphysis
- 7th month IU – ossify into mental ossicles
- 1st yr postnatal – incorporate into symphysis



ANOMALIES



AGNATHIA



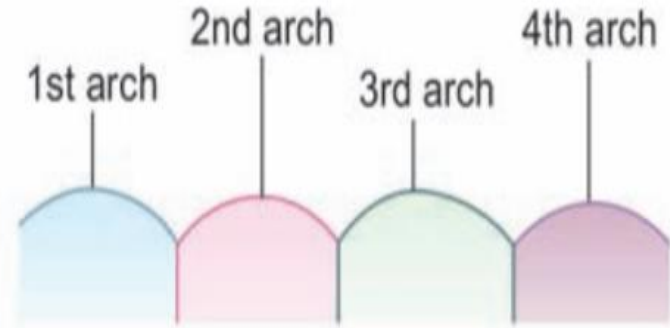
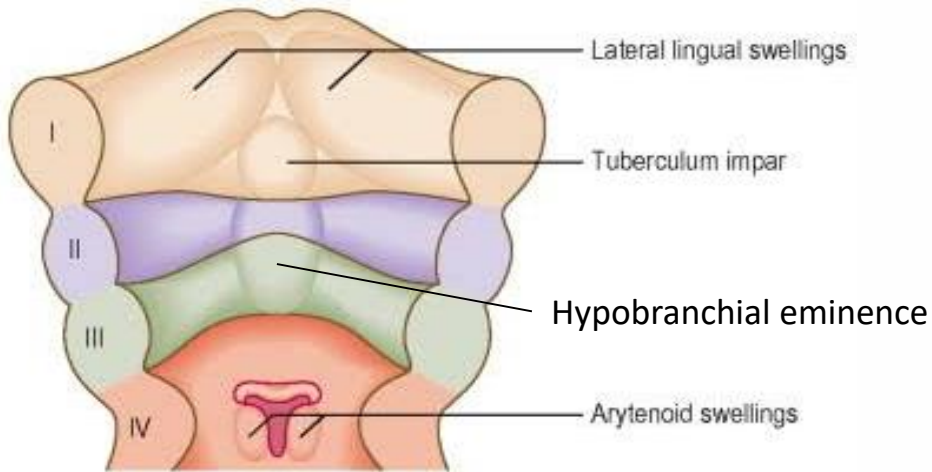
MICROGNATHIA



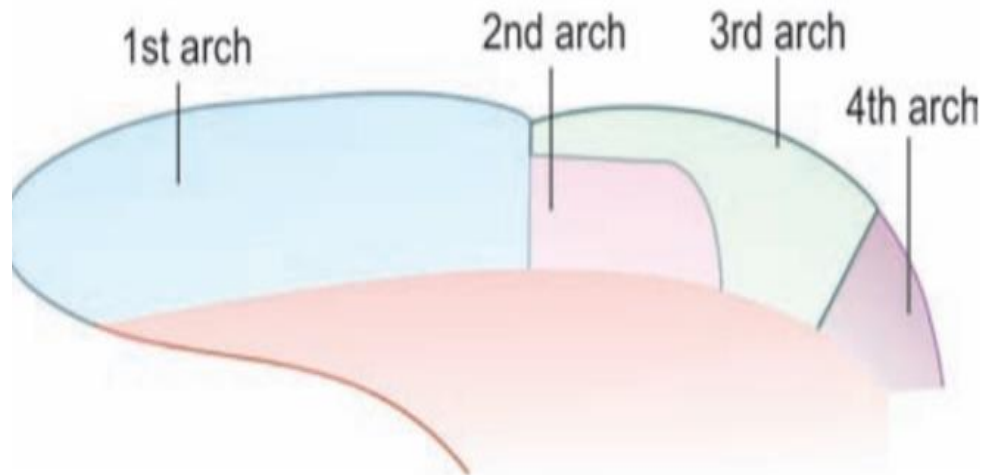
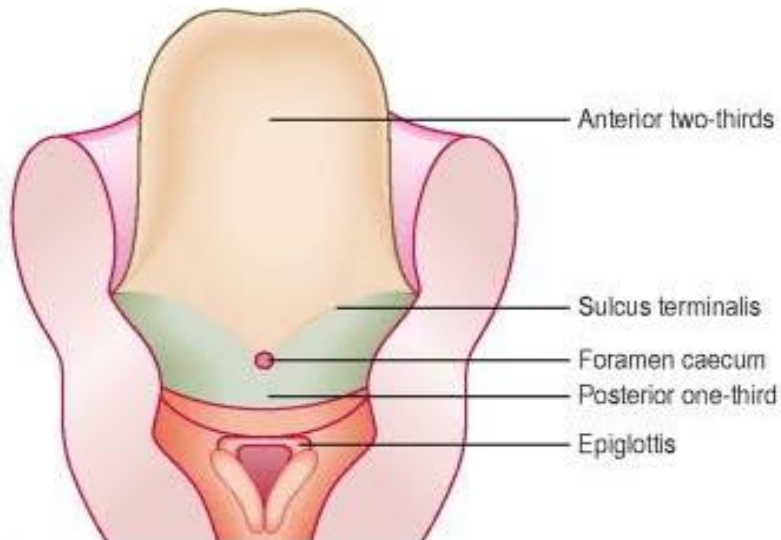
MACROGNATHIA

TONGUE

- 4-8th week
- mesenchymal thickening



B 5 weeks



- Lingual swellings + tuberculum impar ----- ant. 2/3rd
- Hypobranchial eminence ----- post. 1/3rd
- Caudal part ----- epiglottis
- Foramen caecum ----- site of origin of thyroid diverticulum

Circumvallate papillae	2-5 months IU
Fungiform papillae	11 weeks IU
Filiform papillae	Not complete until birth
Lingual tonsil	At birth

- Gustatory cells start to form – 7th week
- Taste perception initiated – 13-15 weeks
- Entire tongue within mouth at birth
- Posterior part descends into pharynx - 4 yrs
- Maximal size – 8 yrs

ANOMALIES



ANKYLOGLOSSIA



LINGUAL THYROID



AGLOSSIA



MICROGLOSSIA



MACROGLOSSIA

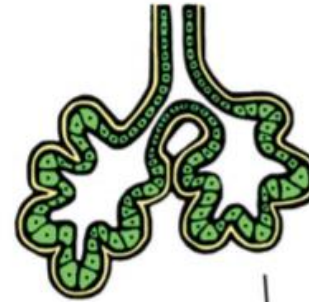


BIFID TONGUE

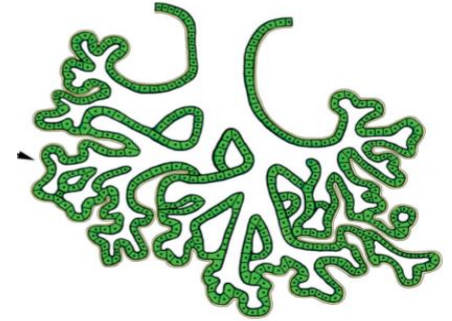
SALIVARY GLANDS



Outgrowth of epithelium



Canalization

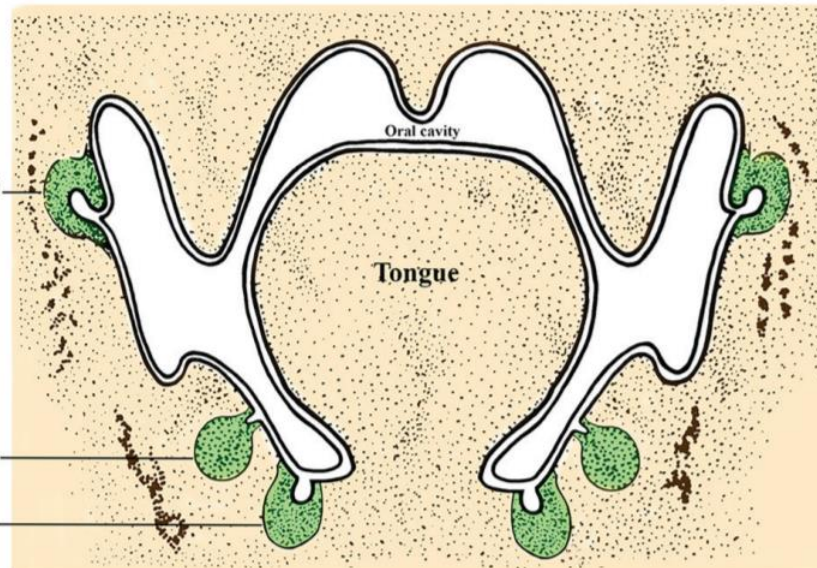


Duct system + secretory acini

Parotid gland primordia

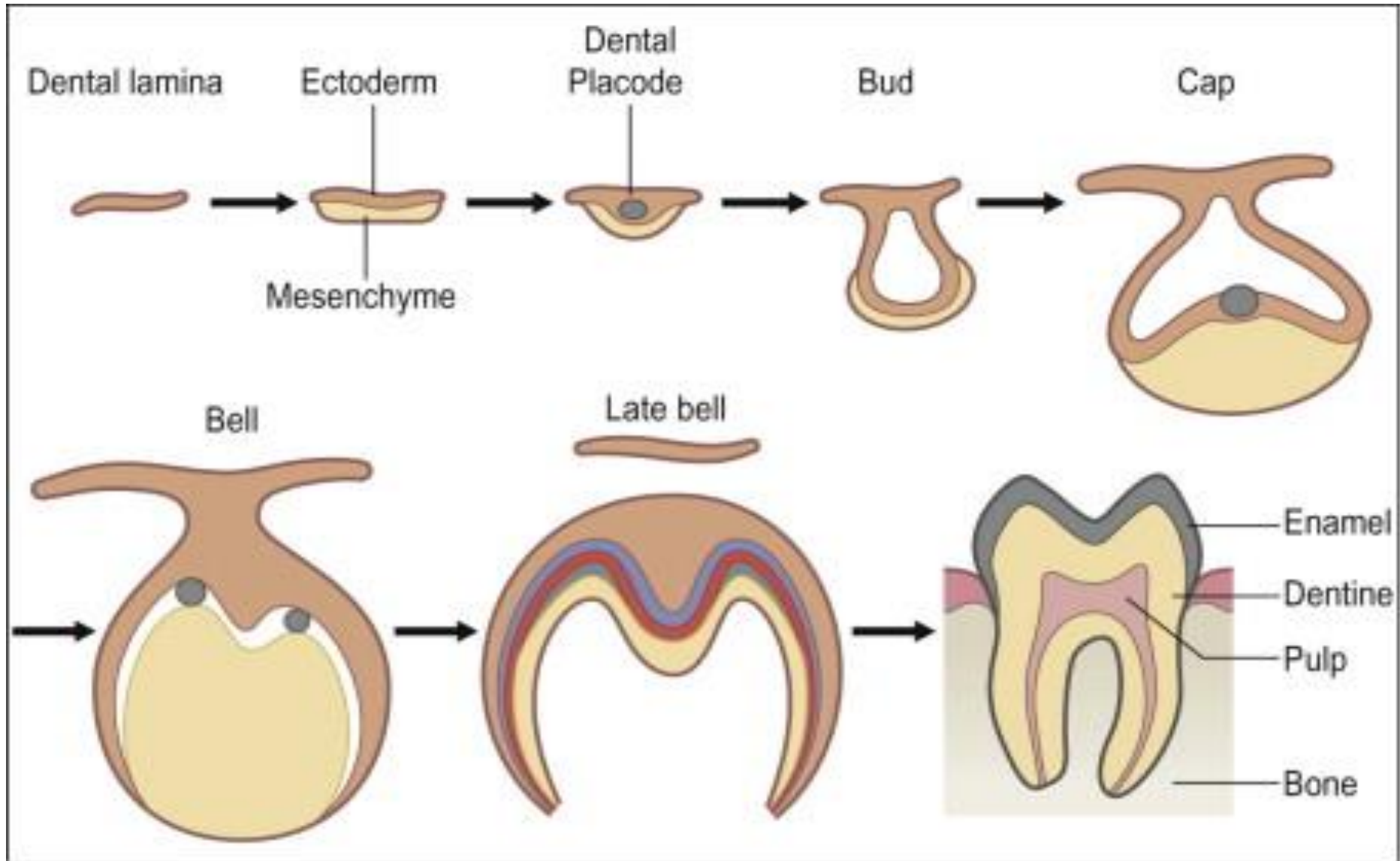
Sublingual gland primordia

Submandibular gland primordia



Parotid gland	6 th week Duct – vestibule opp. 2M
Submandibular gland	6 th week Duct – sublingual papilla
Sublingual gland	8 th week
Minor salivary gland	9 th week

TEETH



REFERENCES

- Human embryology - Inderbir Singh
- Oral histology – Ten Cate's
- Craniofacial development – Sperber
- Gray's Anatomy – Henry Gray
- Orthodontics the art and science - Bhalajhi
- Internet sources



Thank You
Thank You
Thank You!!!