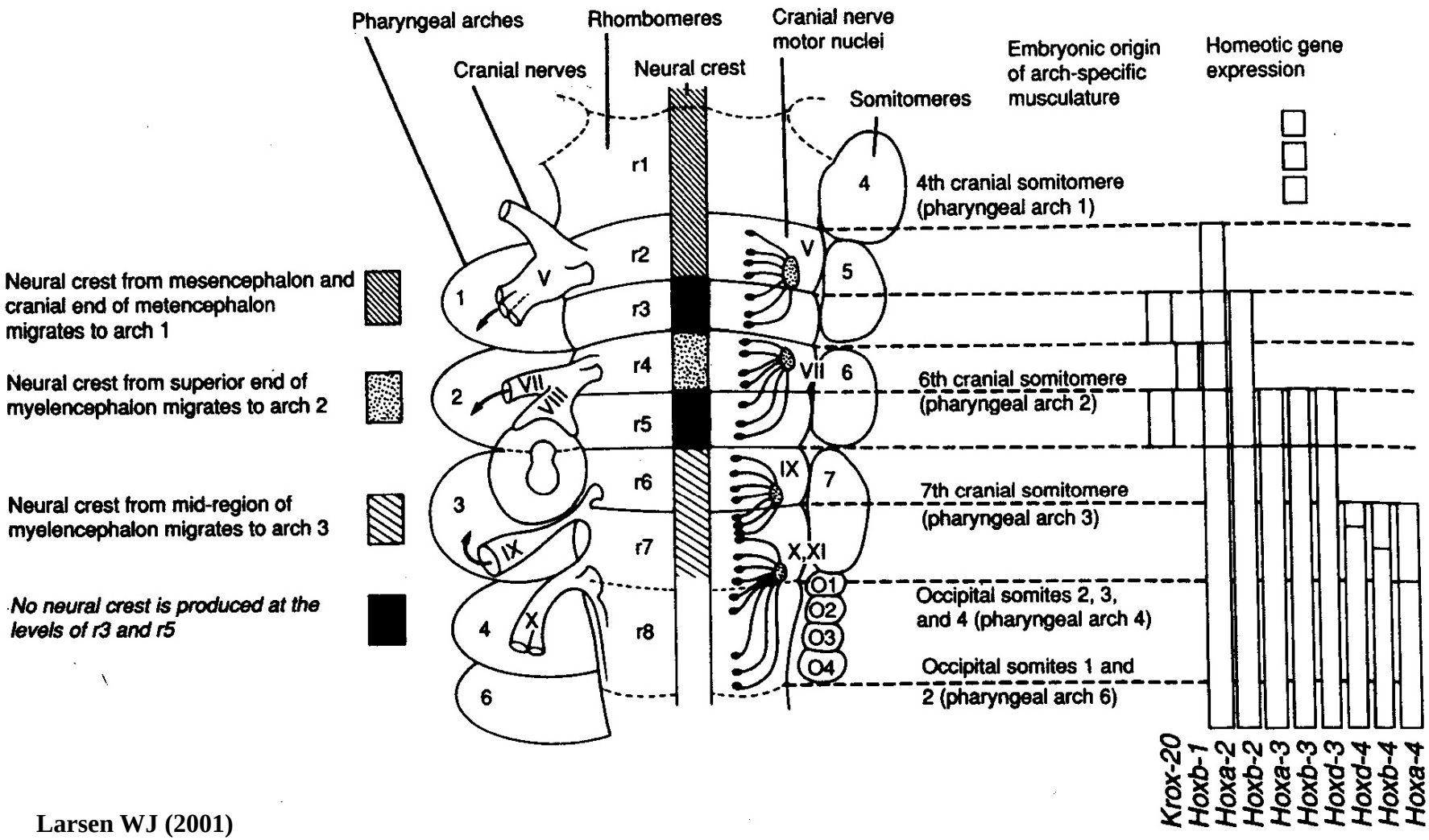
Human development

Head and Neck Review

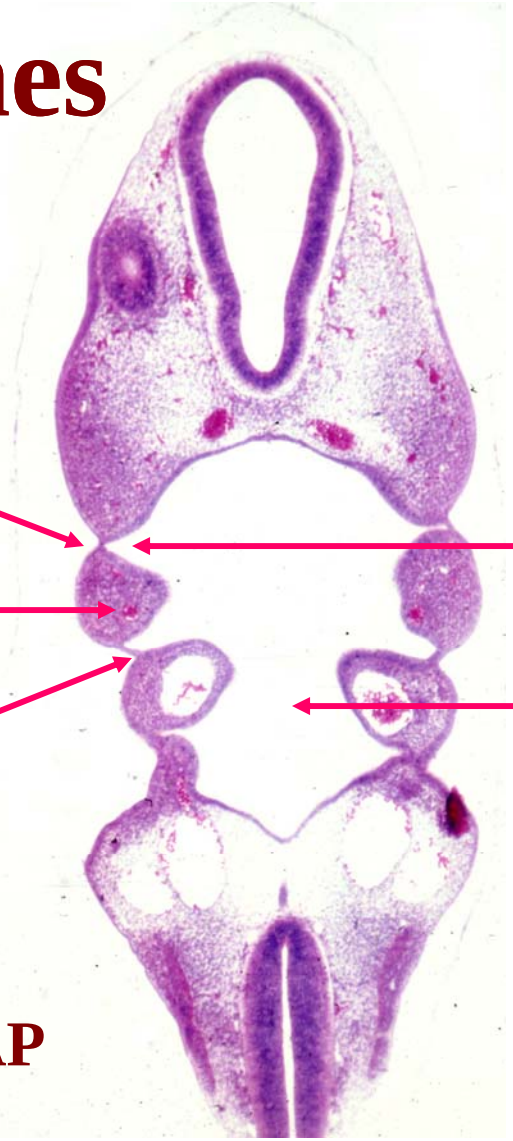
Pharyngeal arches:

The segmentation of pharyngeal arches and rhombomeres of the hindbrain is controlled by Hox gene expression. Almost all neural crest cells that populate the arches originate from the hindbrain region.



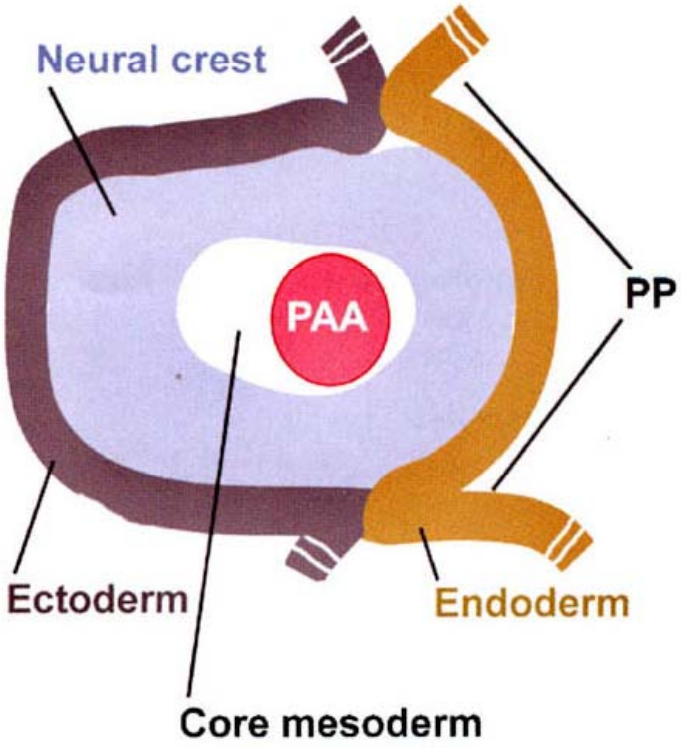
Larsen WJ (2001)

Arches, grooves (clefts), pouches, and membranes



From outside to inside: **GAP**
(grooves, arches, pouches)

Pharyngeal arch tissues are derived from:



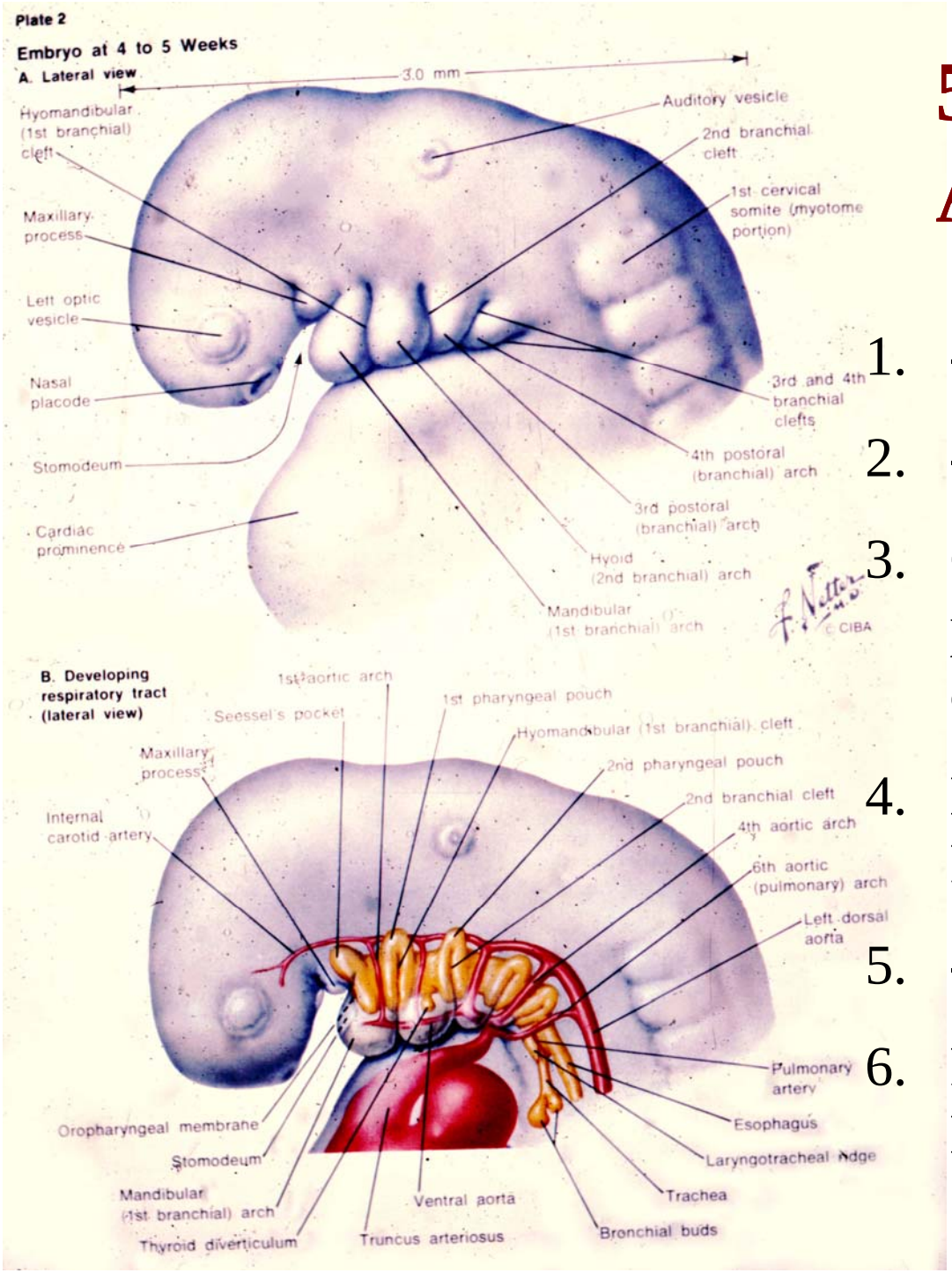
These tissues will form the following structures:

Mesoderm:
Pharyngeal arch artery PAA
Muscle tissue

Neural crest:
Connective tissues
Cartilage skeleton
contribution to PA nerve

Ectoderm:
contribution to PA nerve

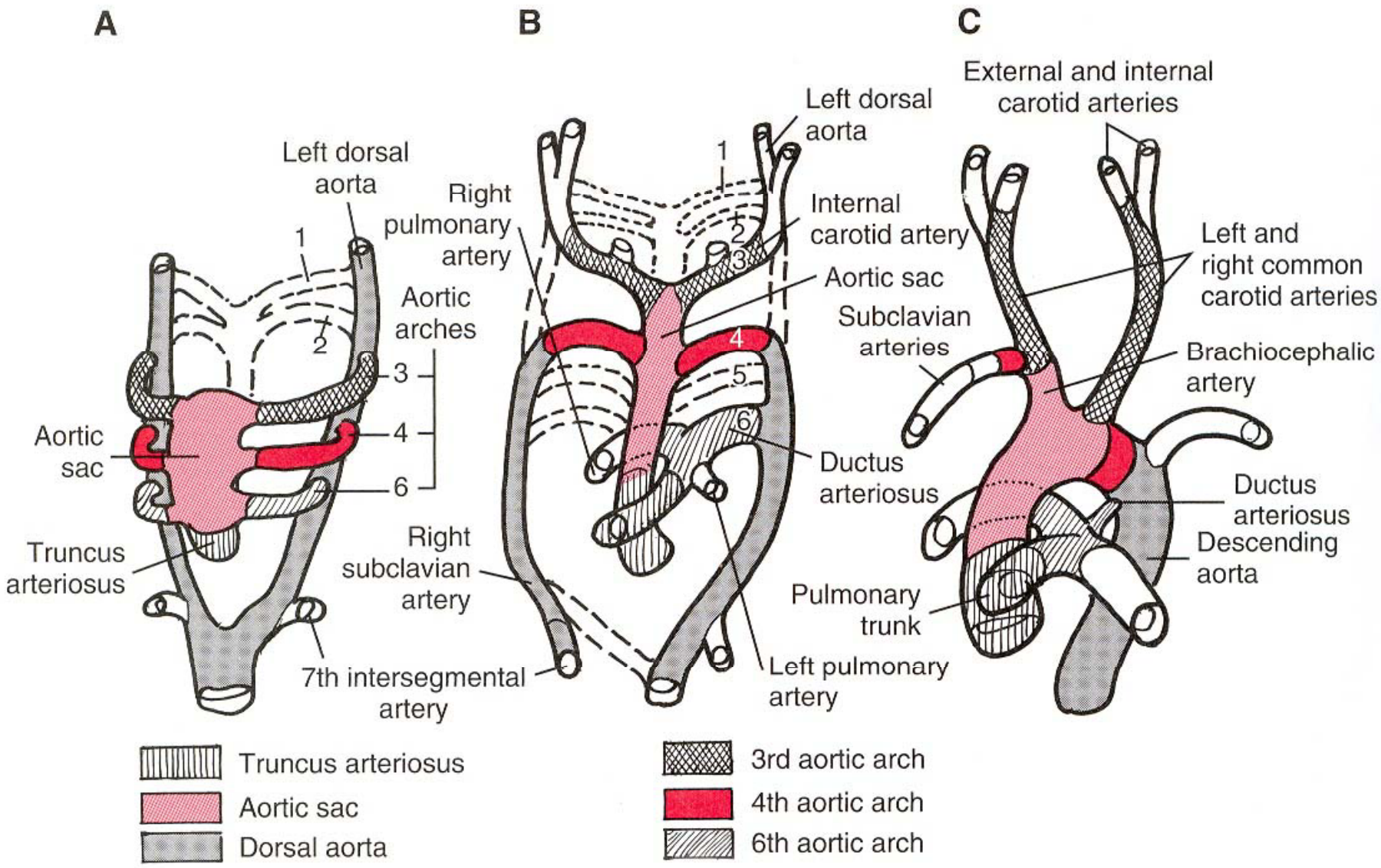
Endoderm:
pharyngeal pouch derivatives



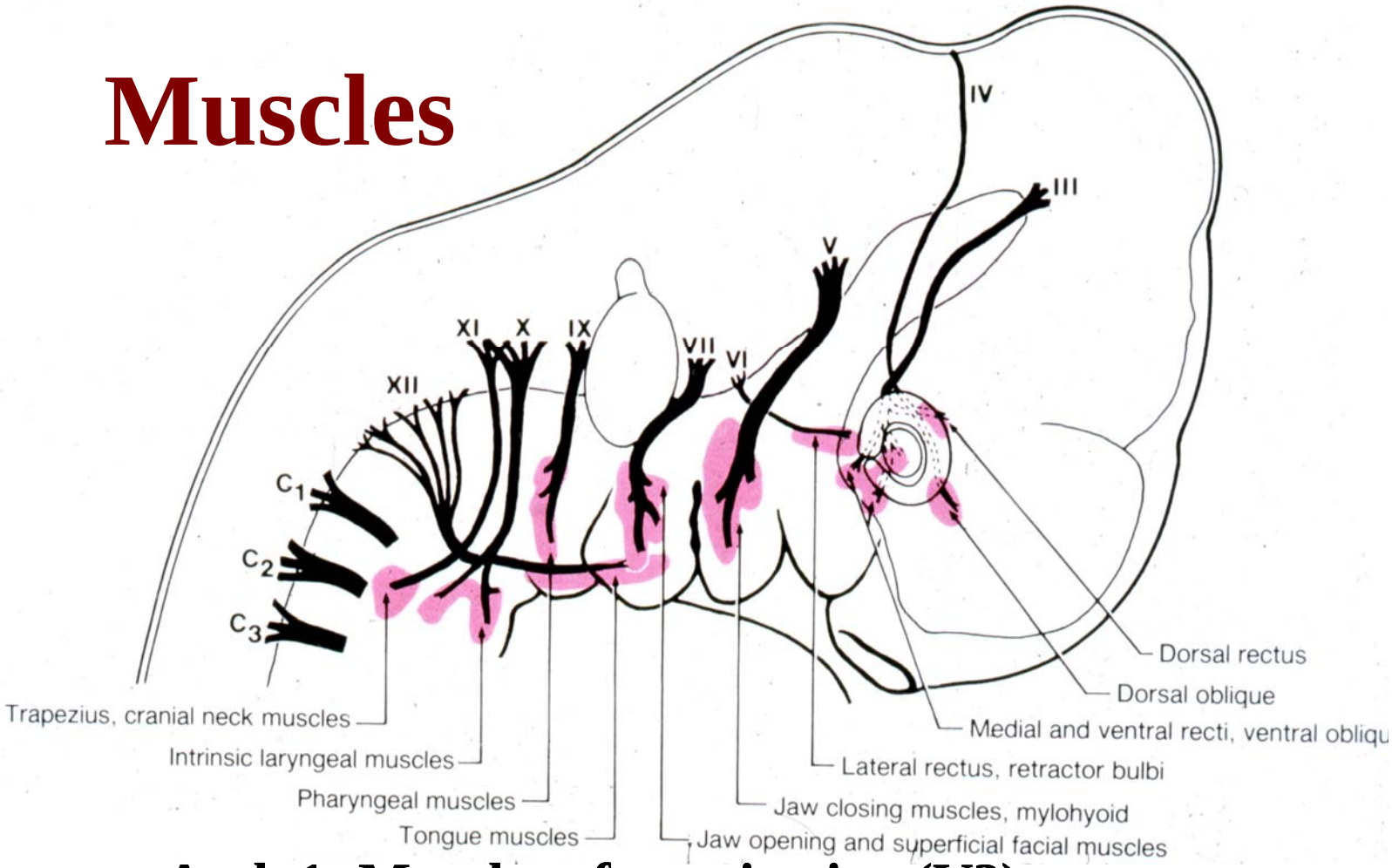
5 Pharyngeal Arch Arteries

1. --- (small part of Max Aa)
2. --- (stapedial Aa, transient)
3. Common carotid Aa
   prox. part of internal carotid Aa
4. L: Aortic arch
   R: prox R subclavian A
5. ----
6. Prox pulmonary Aa
   L: ductus arteriosus

Netter F, Ciba collection


A
B
C
Left dorsal aorta
Right pulmonary artery
Aortic arches
1
2
3
4
6
Aortic sac
Truncus arteriosus
Right subclavian artery
7th intersegmental artery
Left dorsal aorta
Internal carotid artery
Aortic sac
Subclavian arteries
Ductus arteriosus
Left pulmonary artery
External and internal carotid arteries
Left and right common carotid arteries
Brachiocephalic artery
Ductus arteriosus
Descending aorta
Pulmonary trunk
Truncus arteriosus
Aortic sac
Dorsal aorta
3rd aortic arch
4th aortic arch
6th aortic arch

Muscles



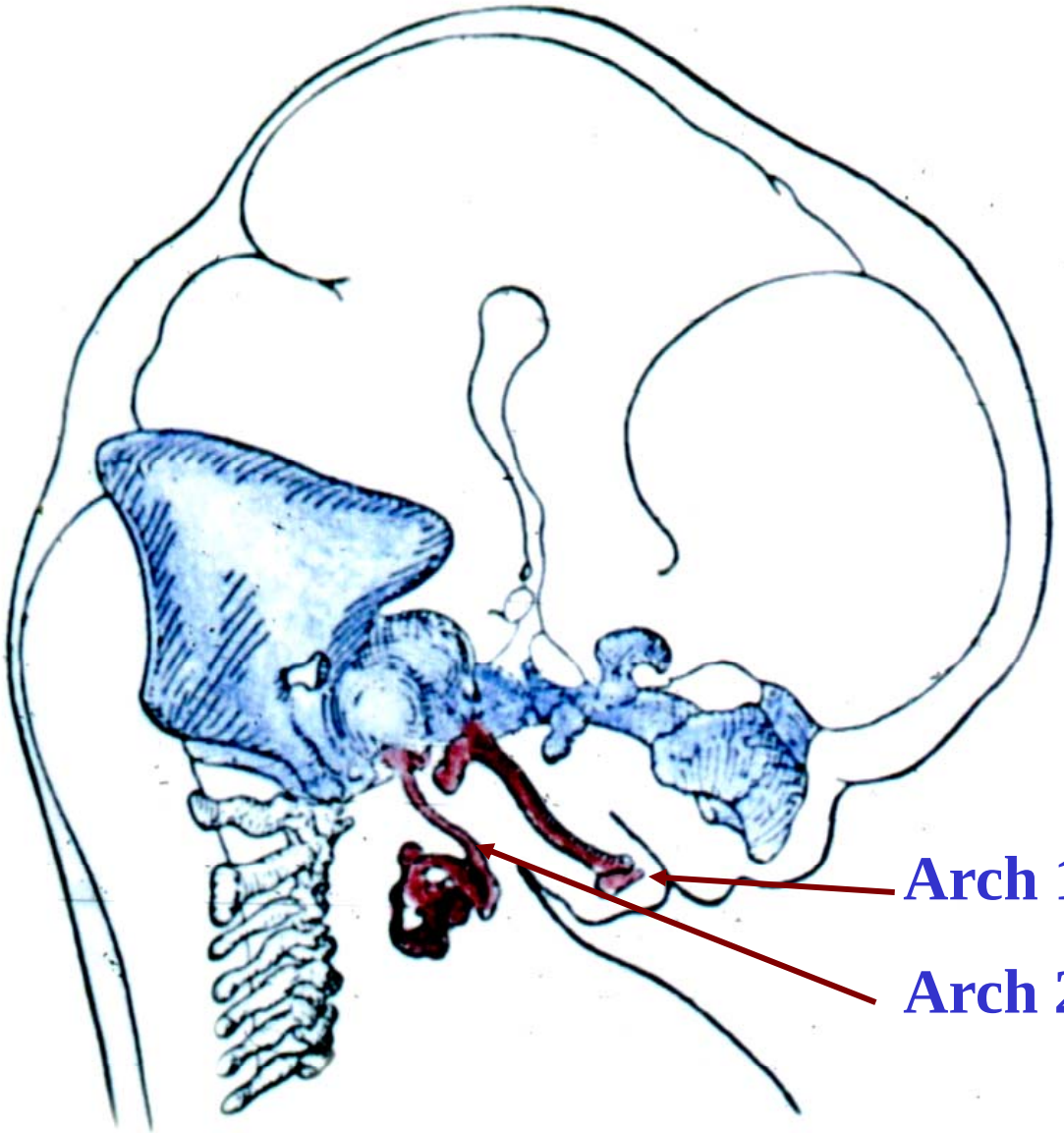
Arch 1: Muscles of mastication (V3)

Arch 2: Muscles of facial expression (VII)

Arch 3: Stylopharyngeus muscle (IX)

Arch 4-6: Laryngeal muscles (X mostly)

Noden D M, Lahunta A de (1985)

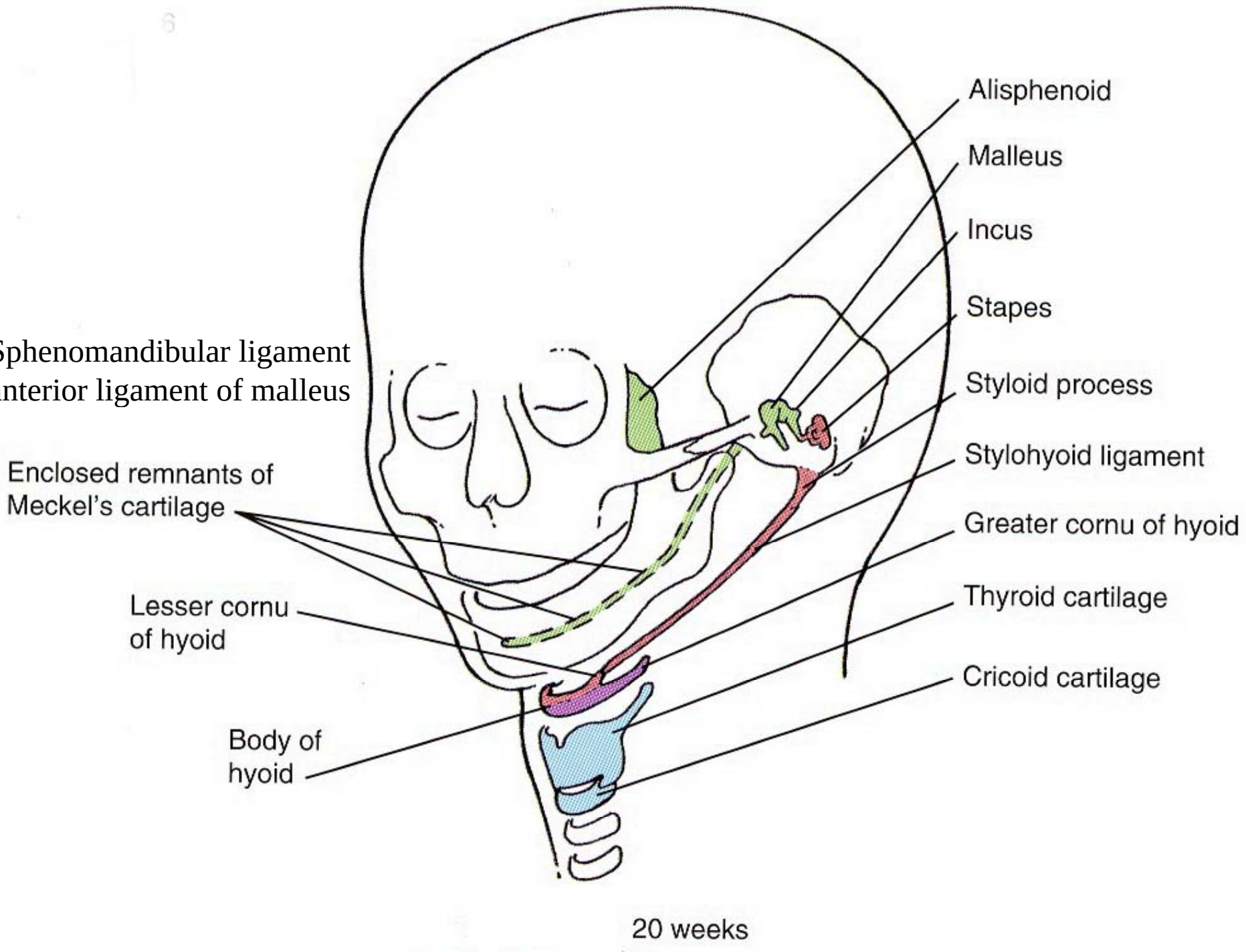


The cartilage elements of the pharyngeal arches (cartilaginous viscerocranium, purple) at 7 weeks.

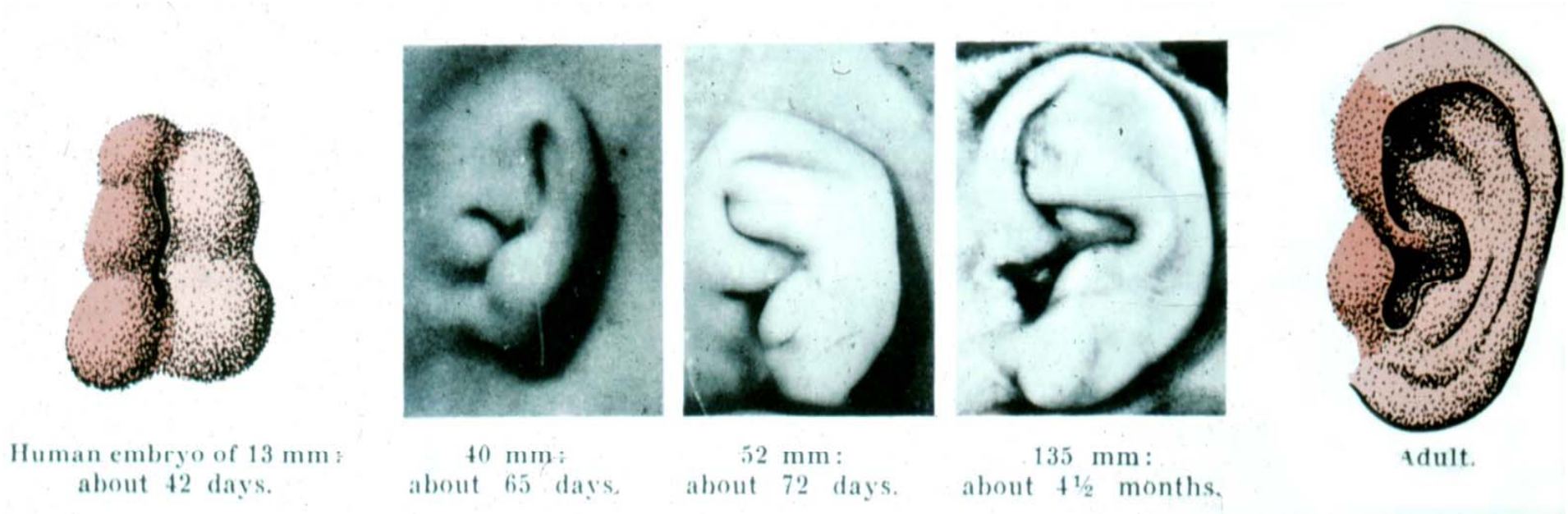
Arch 1: Meckel's cartilage

Arch 2: Reichert's cartilage

Sphenomandibular ligament
anterior ligament of malleus



External ear development by merging of 6 auricular hillocks



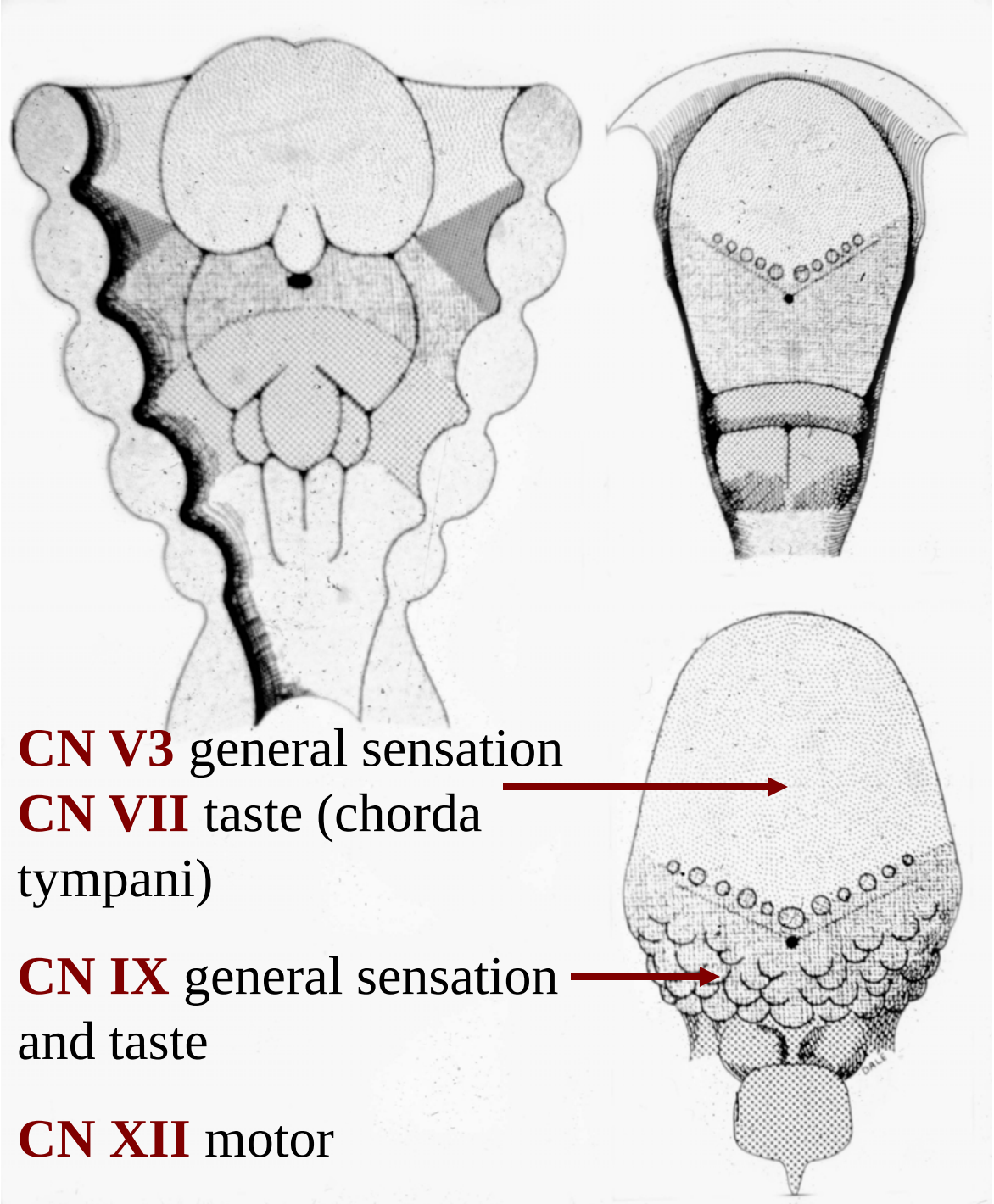
Tuchmann-Duplessis H et al, (1975)

Anterior 2/3 of tongue from arch 1 (bilateral lingual swellings and median tuberculum impar)

Posterior 1/3 of tongue from arch 3 (median hypobranchial eminence)

Merging of lingual swellings

Ten Cate AR (1988)



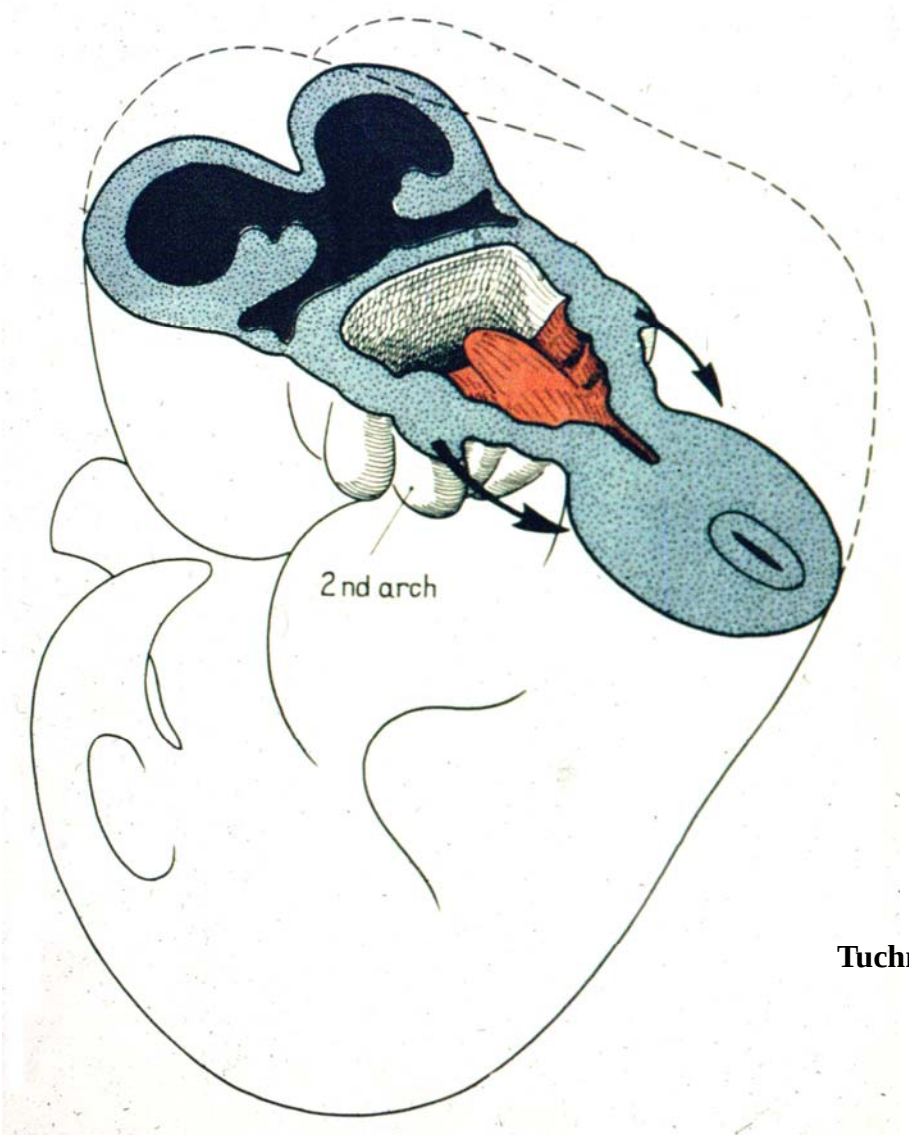
CN V3 general sensation

CN VII taste (chorda tympani)

CN IX general sensation and taste

CN XII motor

Fate of pharyngeal grooves (clefts) 1-4



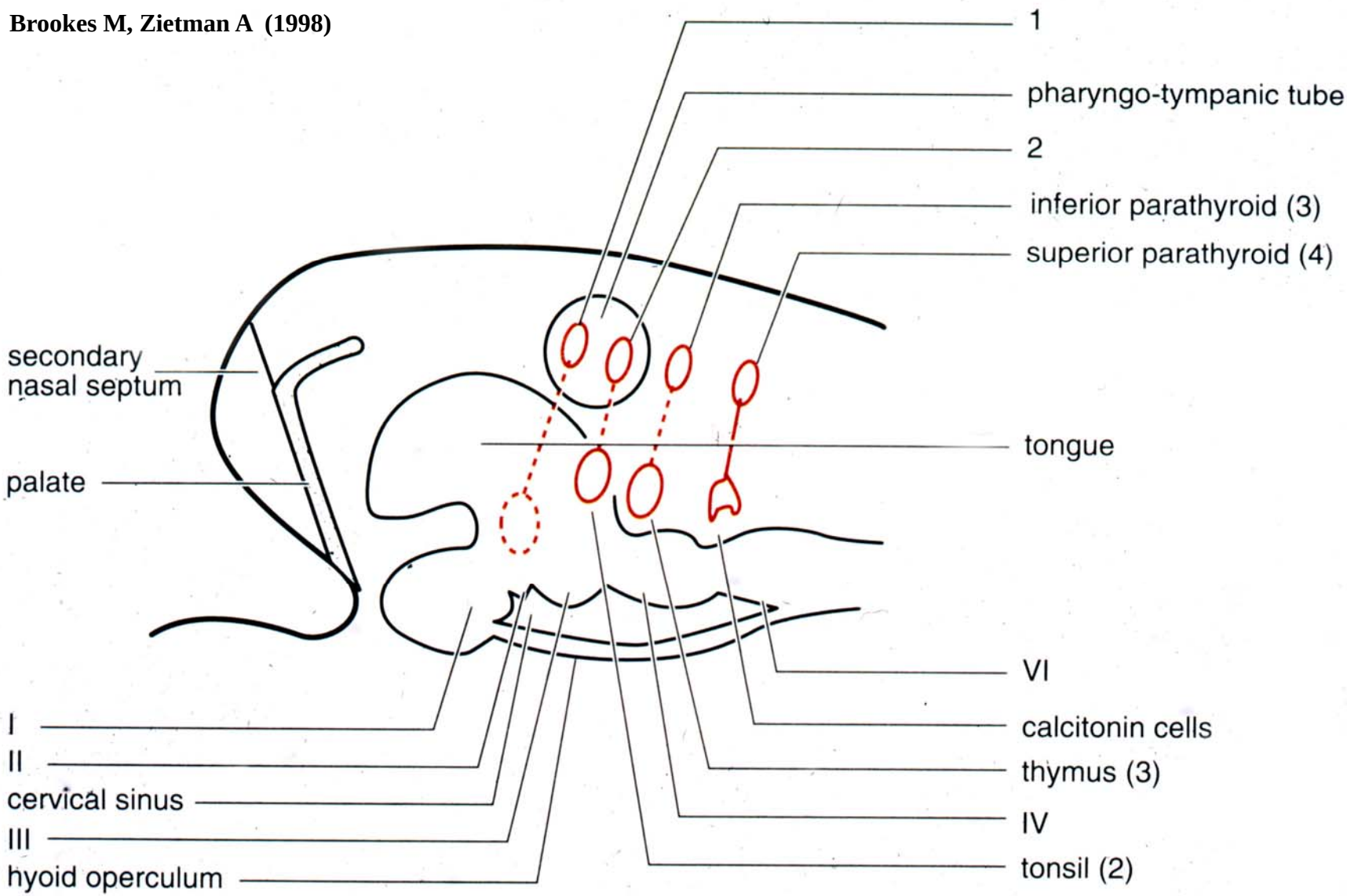
1. External auditory meatus

2-4. ------ (these are overgrown by the second pharyngeal arch. Remnants may form cervical cysts, fistulas)

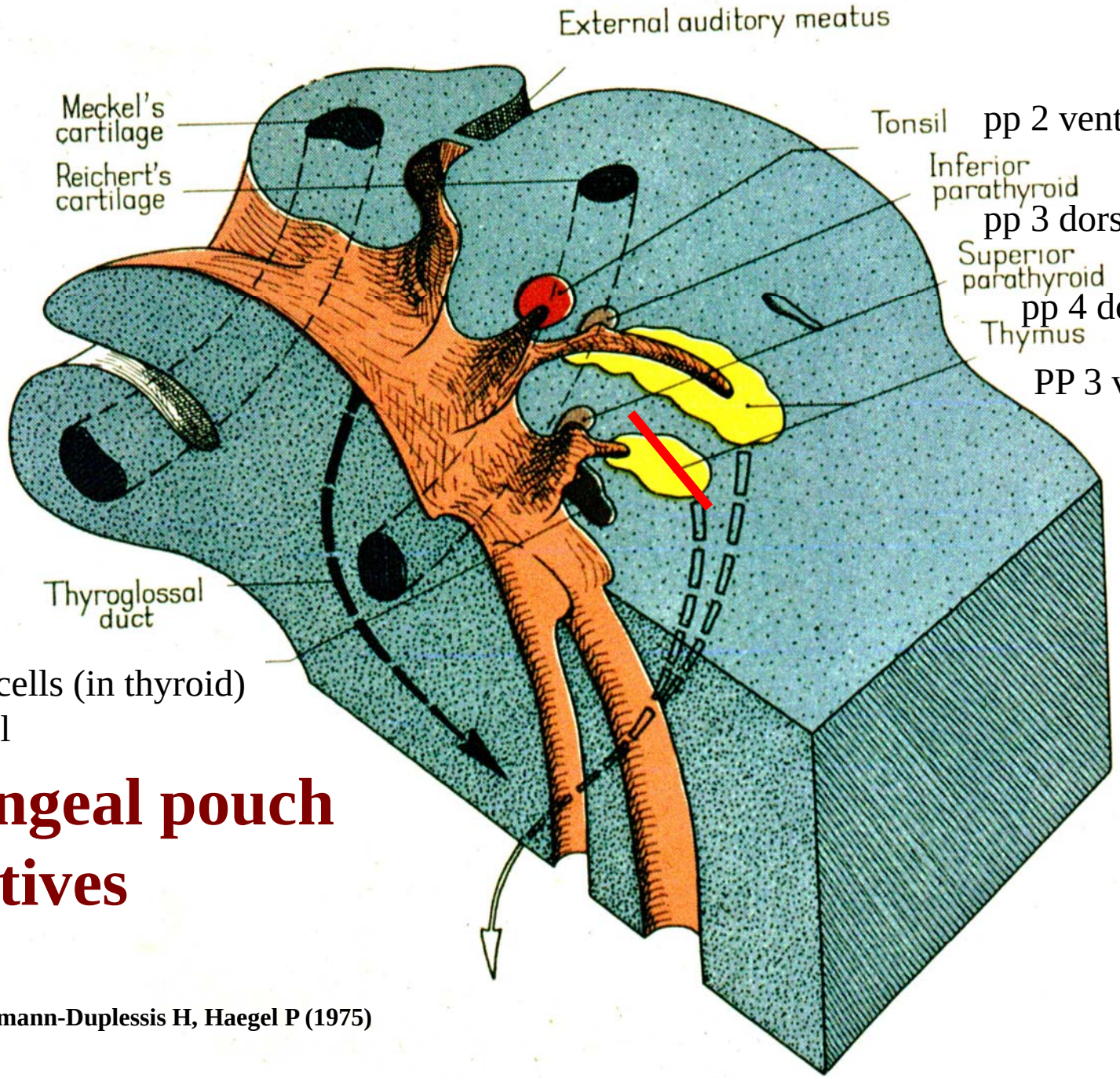
Tuchmann-Duplessis H, Haegel P (1975)

Derivatives of dorsal and ventral parts of pharyngeal pouches

Brookes M, Zietman A (1998)



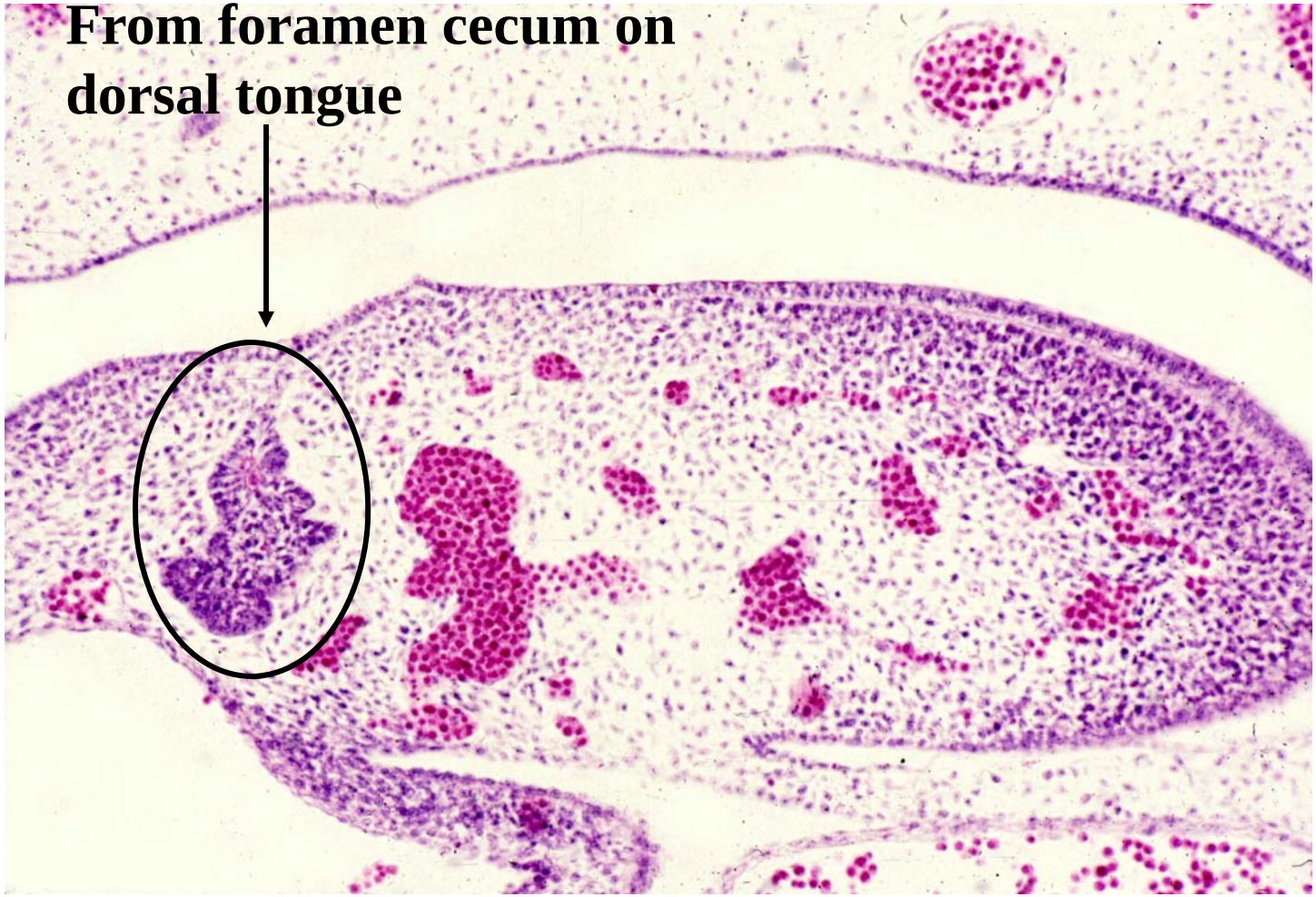
Pharyngeal pouch derivatives



Calcitonin cells (in thyroid)
PP 4 ventral

Tuchmann-Duplessis H, Haegel P (1975)

Thyroid gland development
Thyroglossal duct (occasionally remains as pyramidal lobe)



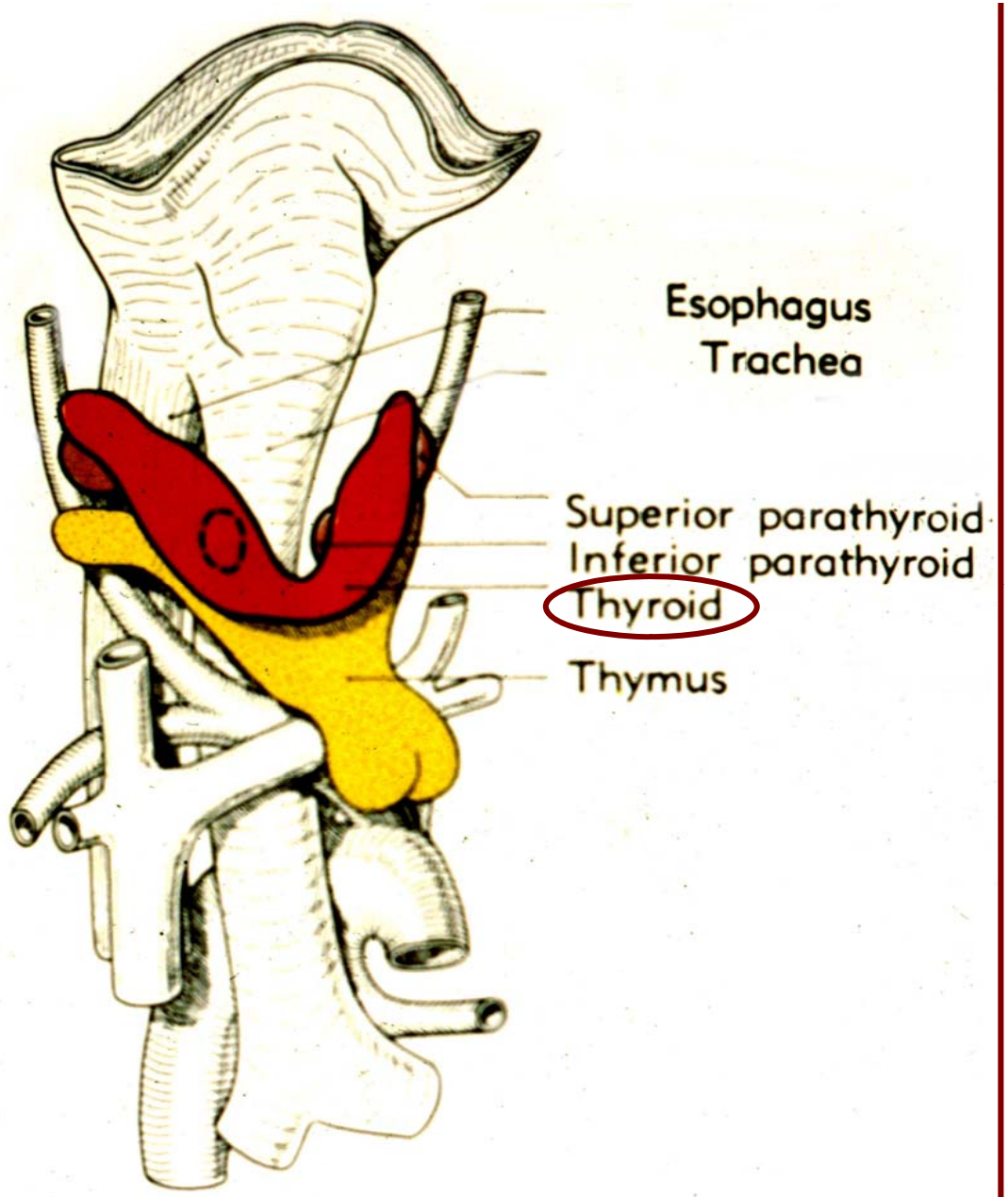
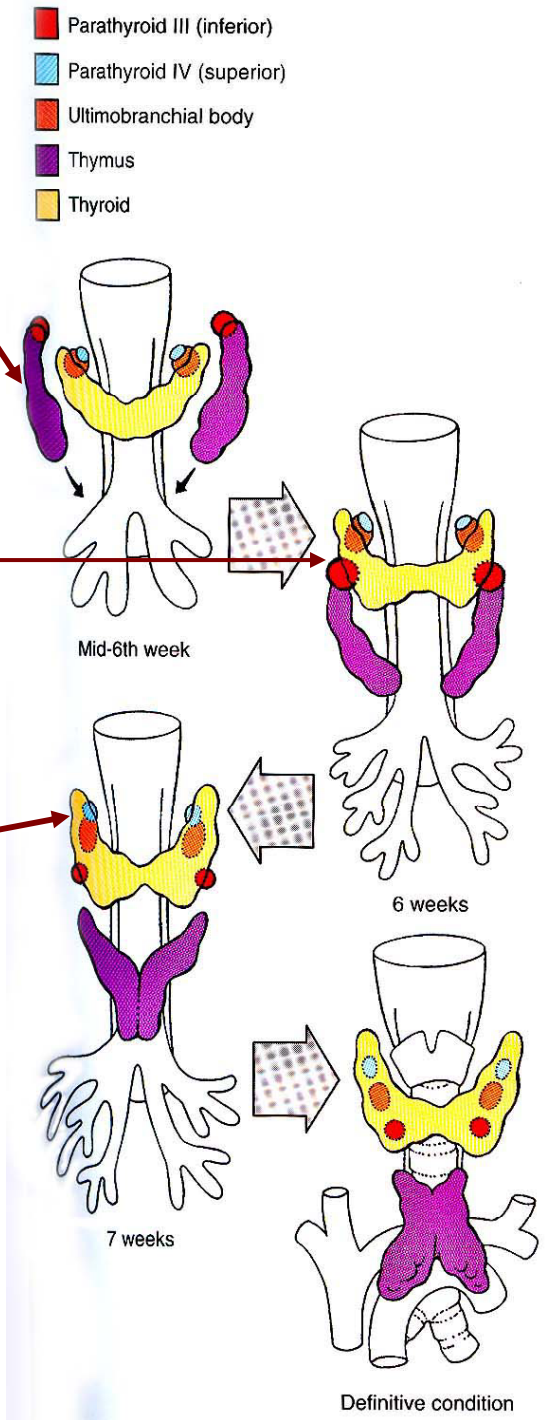


Diagram showing thyroid in place.

Superior and inferior parathyroid glands

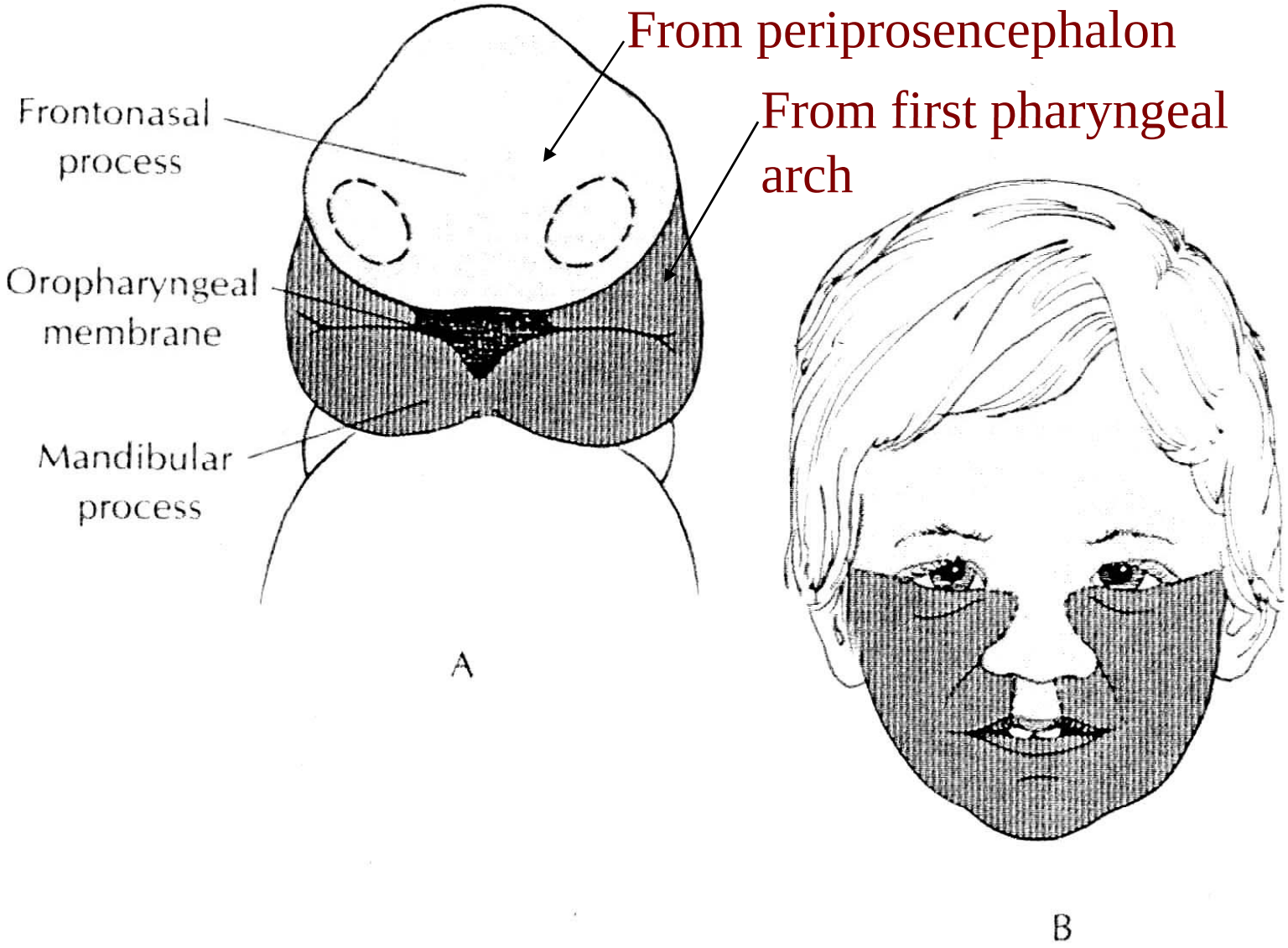
Tuchmann-Duplessis H, Haegel P (1975)

- **Thymus from pp 3 ventral. Bilateral structures grow downward to fuse in midline below thyroid gland.**
- **Parathyroid III from pp 3 dorsal travels with thymus primordium, then attaches to dorsal thyroid as inferior parathyroid gland**
- **Parathyroid IV from pp 4 dorsal and ultimobranchial body from pp4 ventral are in proximity of dorsal thyroid. They attach to it as superior parathyroid gland and become incorporated as calcitonin cells respectively**

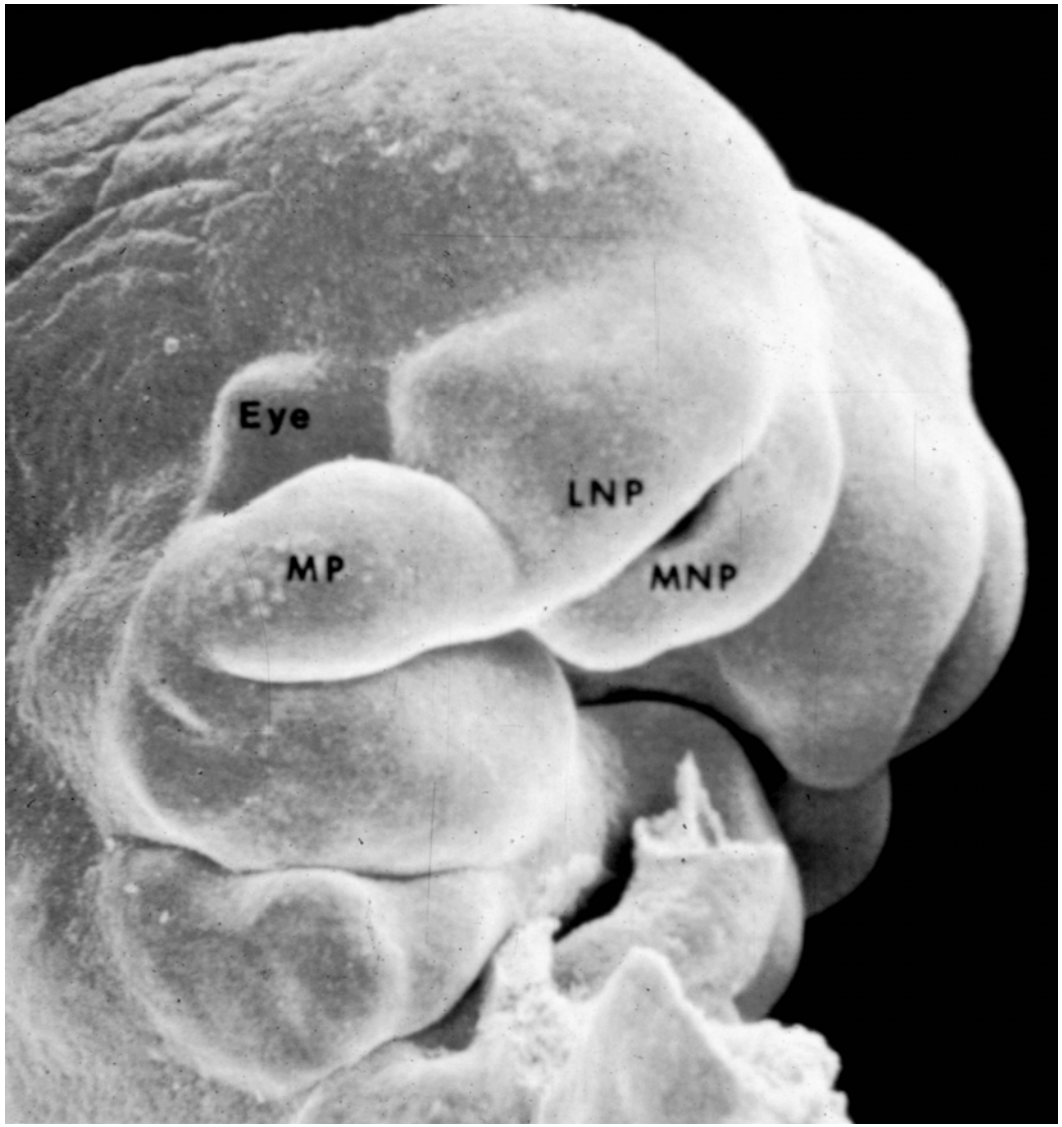


Larsen WJ (2001)

Contributions to external face



Facial processes (prominences)



Sulik K, Johnston M et al (1980)

Bilaterally:

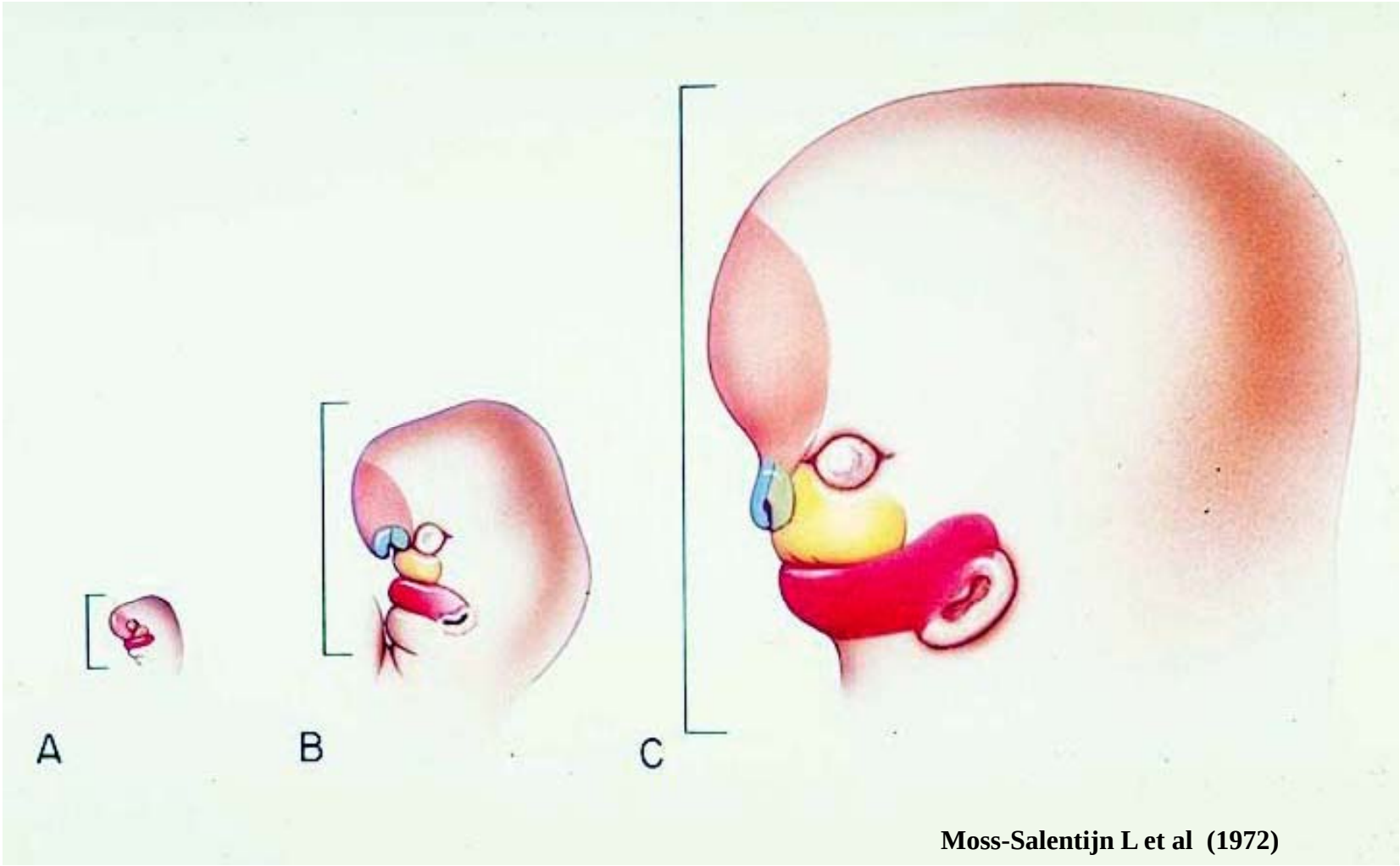
Lateral nasal

Medial nasal

Maxillary

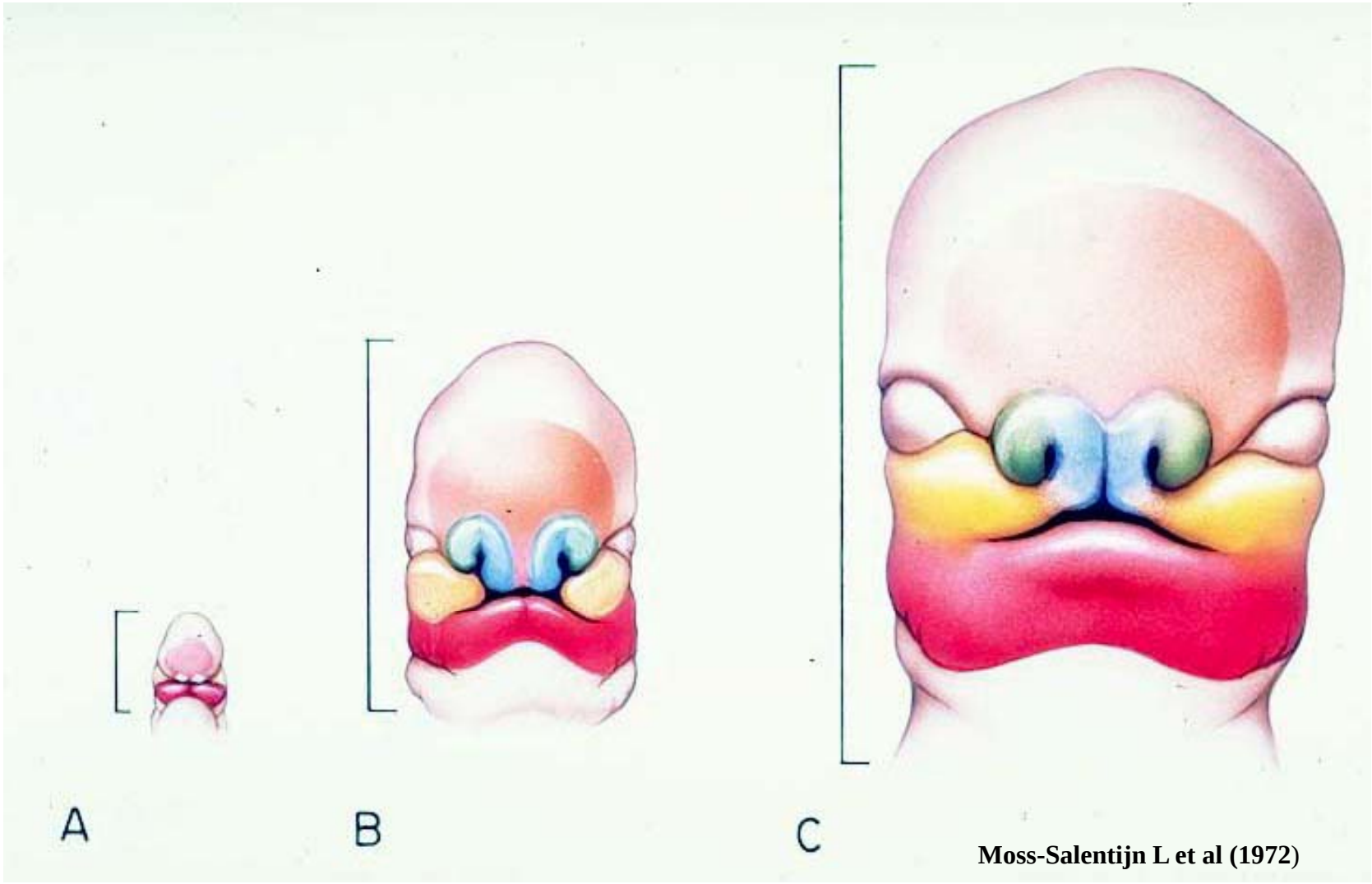
Mandibular

Dimensional changes (4-6 wks)



Moss-Salentijn L et al (1972)

10-fold linear increase in size !



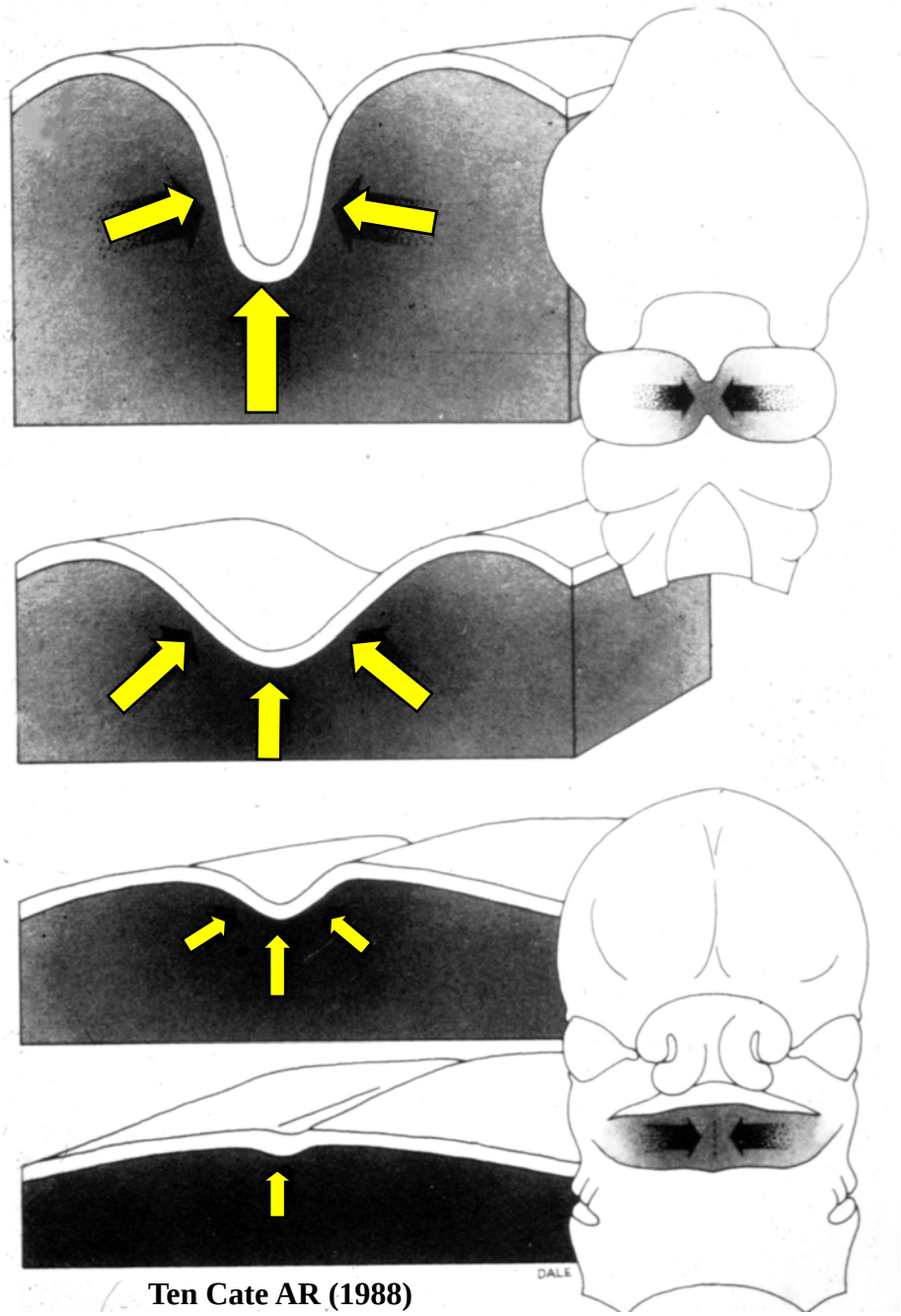
Moss-Salentijn L et al (1972)

Merging

Differential mesenchymal proliferation. Elimination of groove

In all locations except between

- maxillary and medial nasal processes, and
- palatal processes

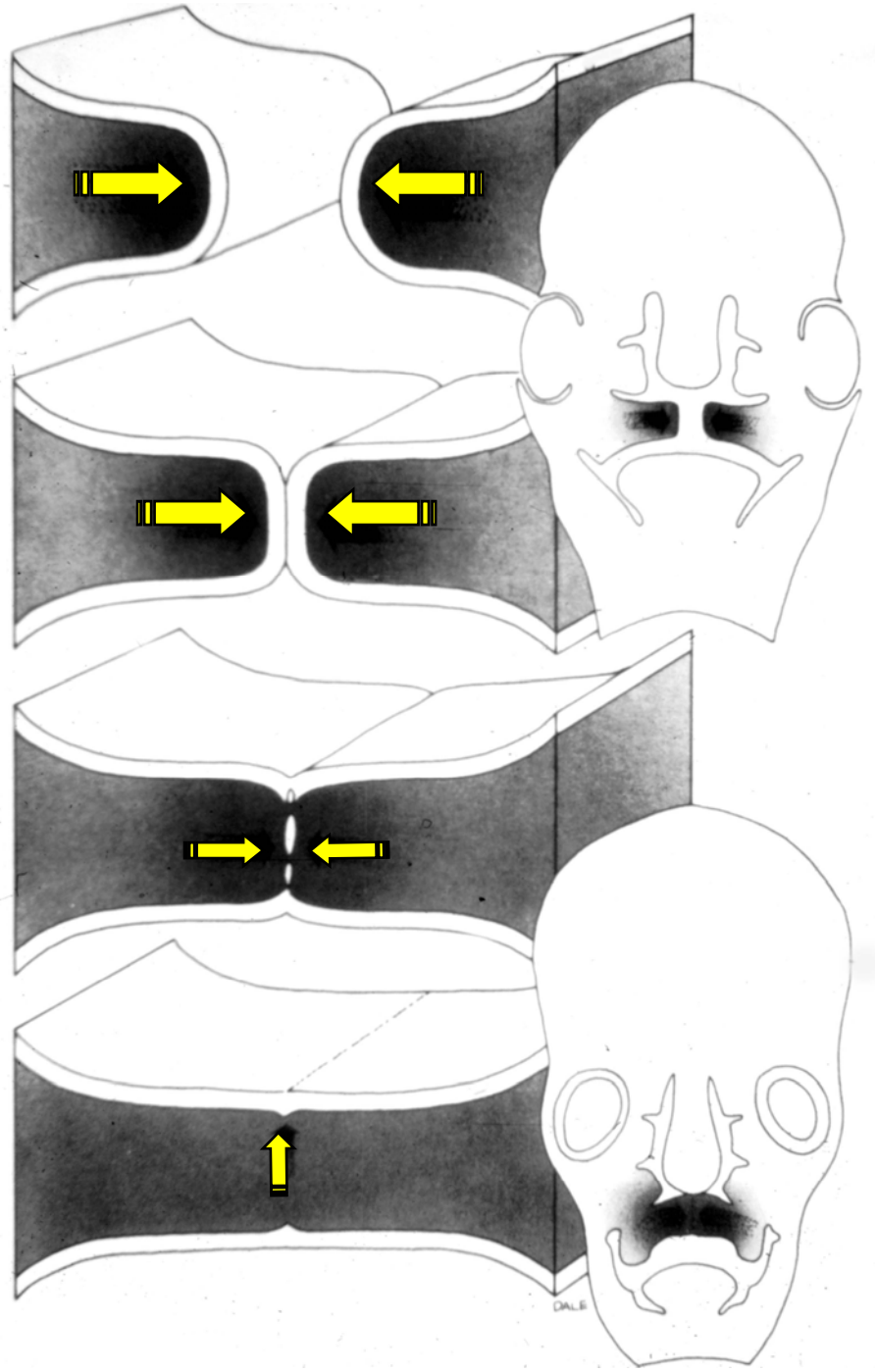


Ten Cate AR (1988)

Fusion

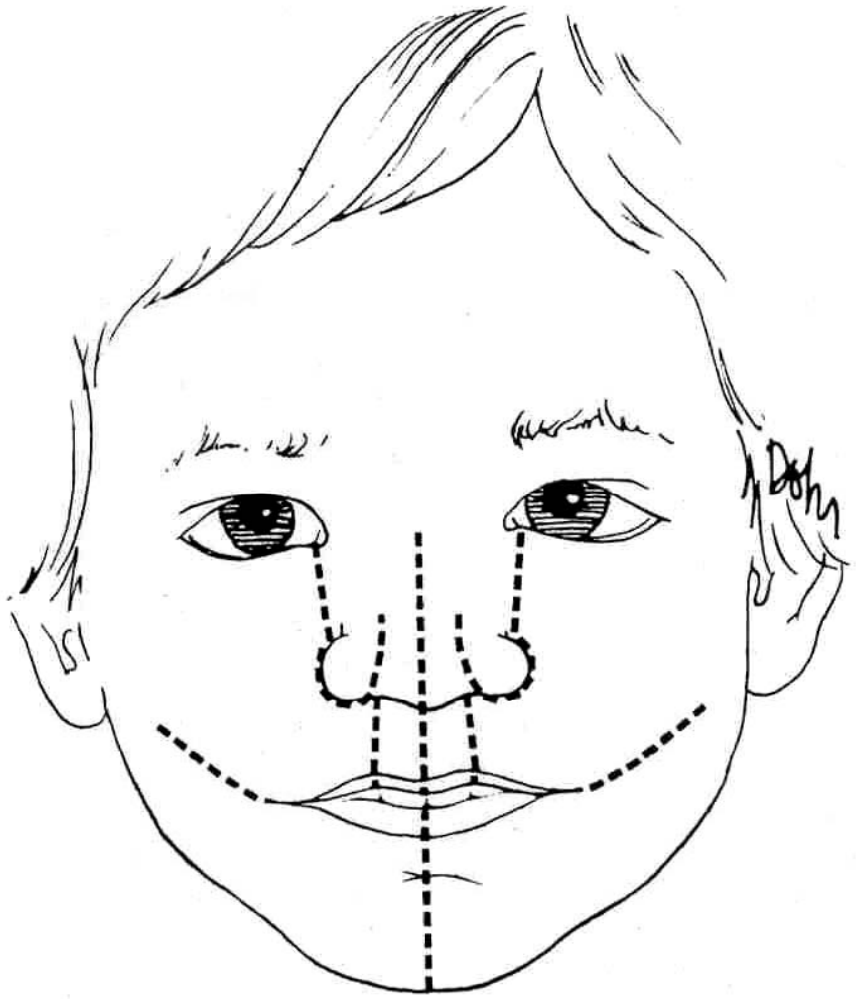
Contact and fusion of epithelium-covered surfaces. Removal of epithelium

Primary and secondary palate



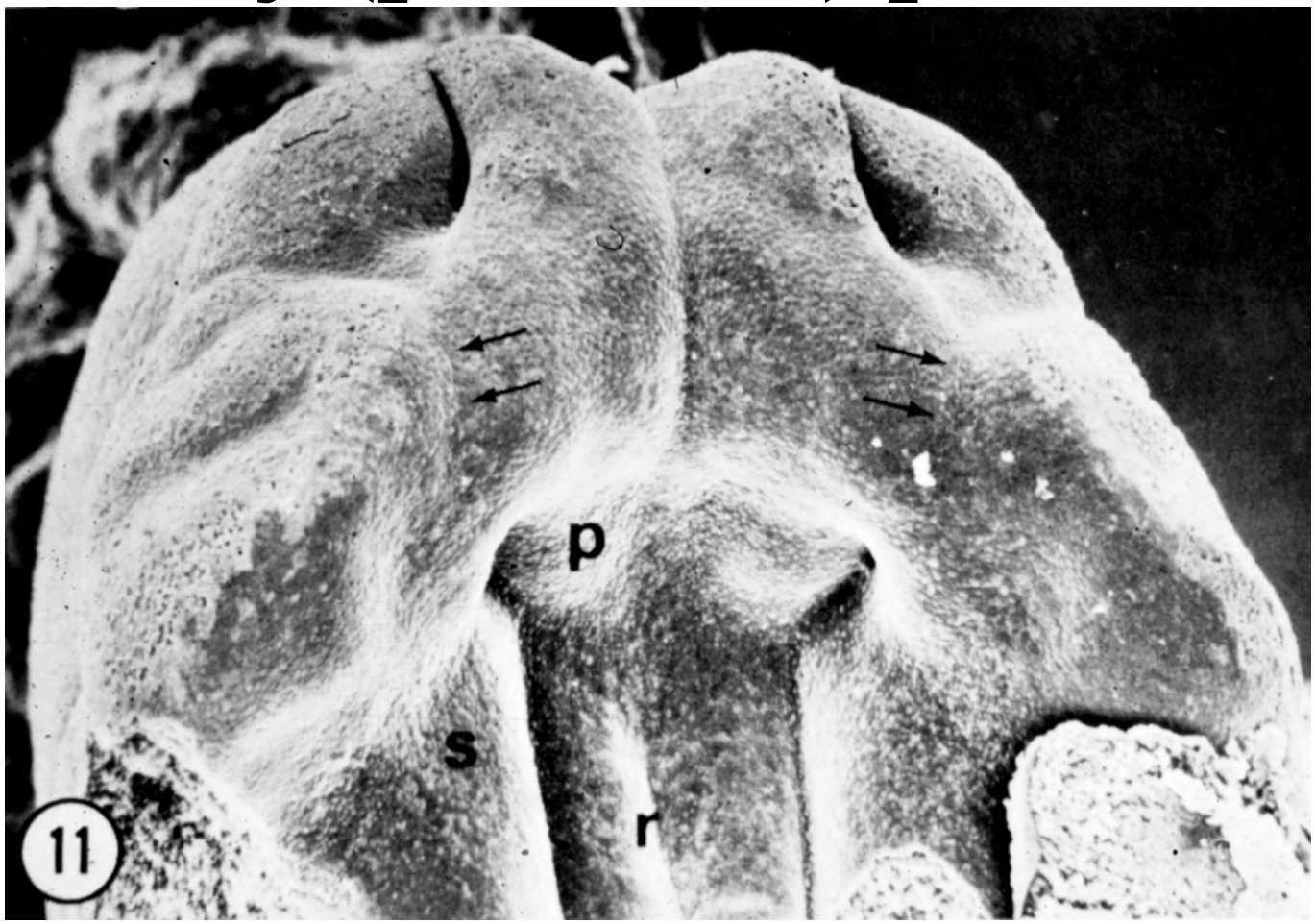
Ten Cate AR (1988)

Sites of potential facial clefts



Moss-Salentijn L, Klyvert M (1990)

Primary (primitive) palate

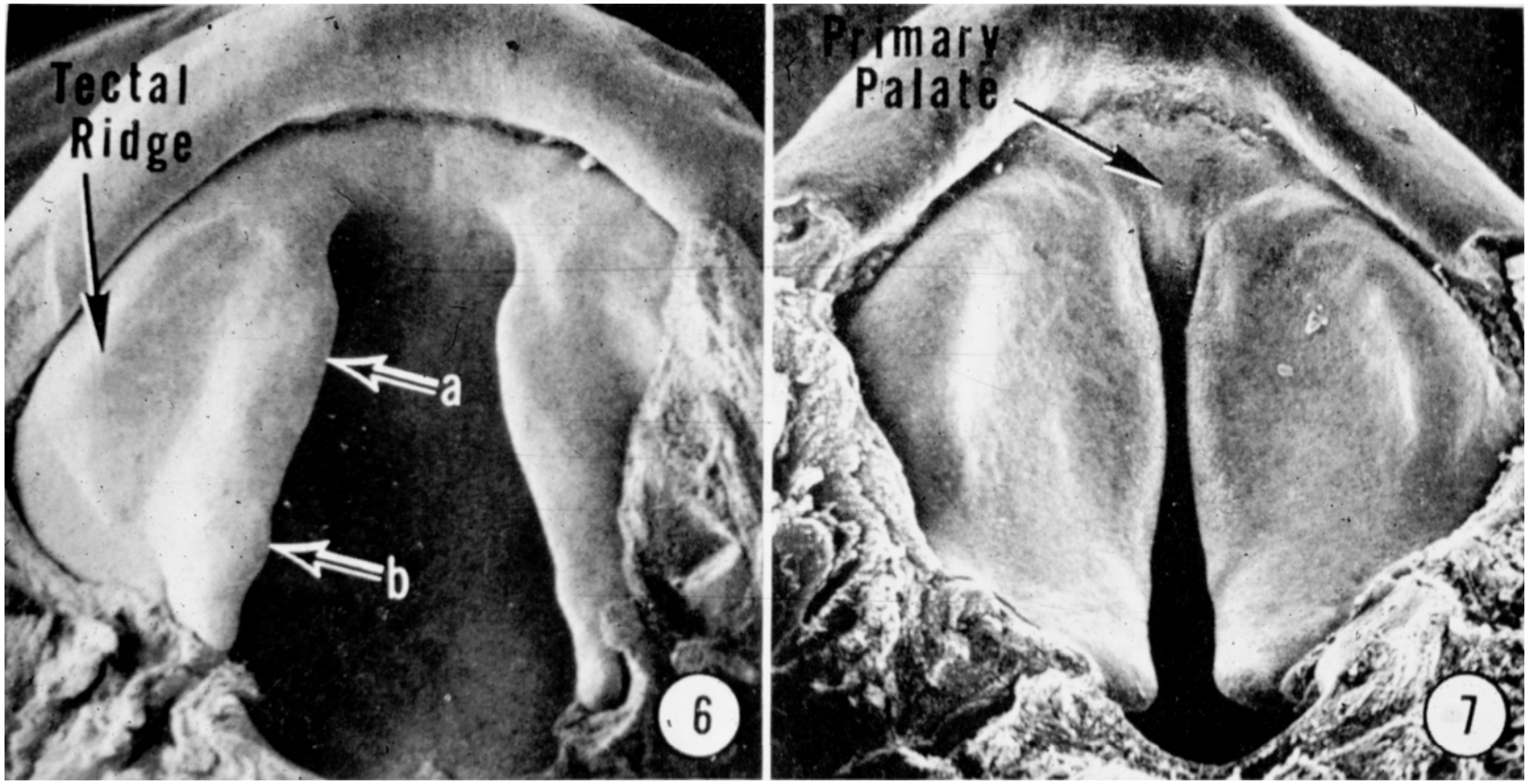


Tamarin A (1982)

Primary palate composed of: intermaxillary segment of merged MNP's and the rostral tips of the maxillary processes.

P: primary (primitive) choana permitting oro-nasal communication

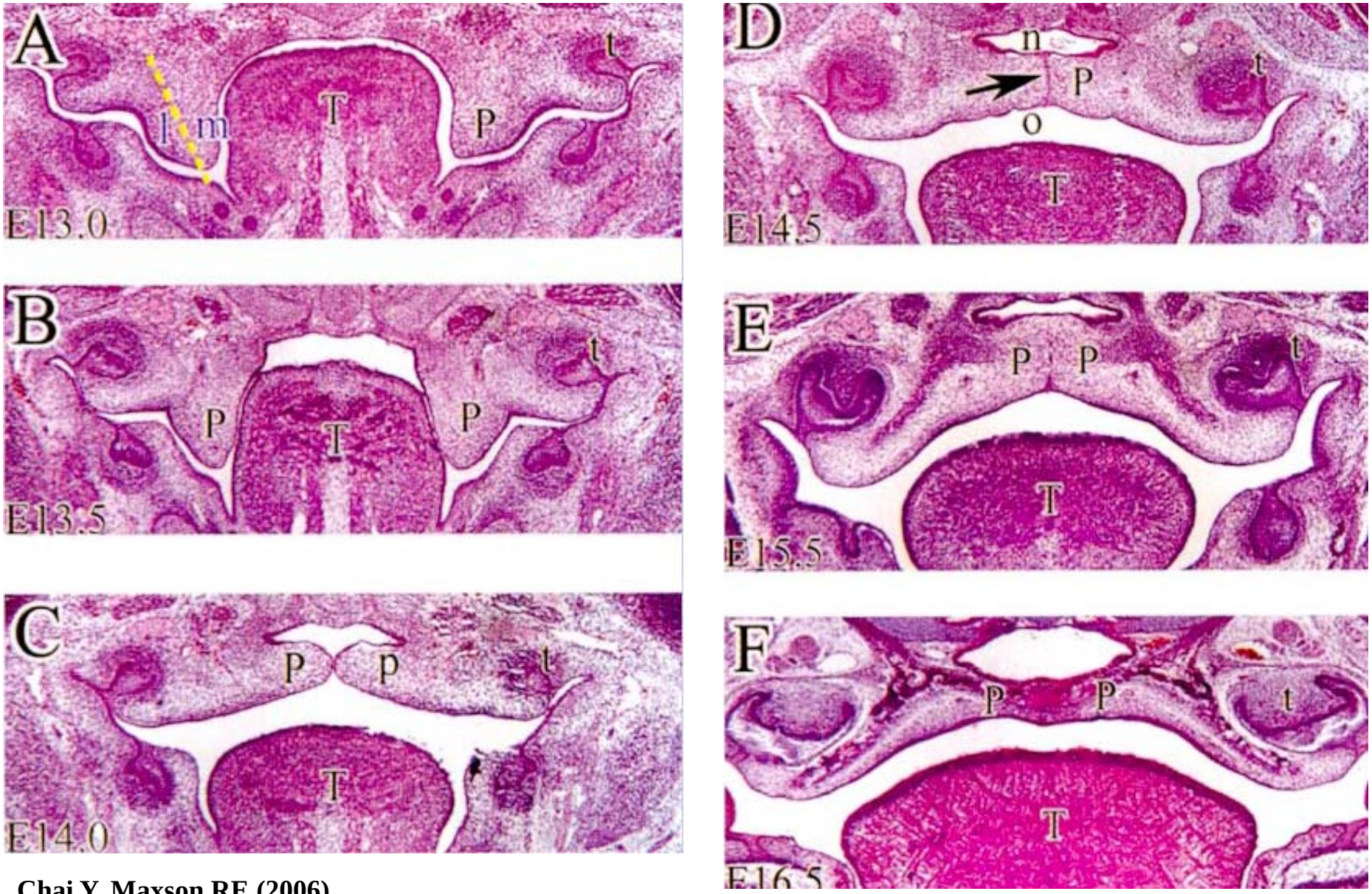
Secondary palate development



Waterman RE, Meller SM (1974)

Palatal processes develop on the oral surfaces of the maxillary processes: initially vertically oriented, they assume horizontal orientation during eighth week of development.

Sequence of secondary palate development: P=palatal process



Chai Y, Maxson RE (2006)

Intrinsic factors in the successful development of the secondary palate: increase in size of palatal processes

- Mesenchymal cell proliferation – ceases hours before palatal processes become horizontal
- ECM production increasing volume of palatal processes
- Hydration of ECM – major increase in volume and turgor just prior to horizontalization

Factors contributing to the horizontalization of the palatal processes

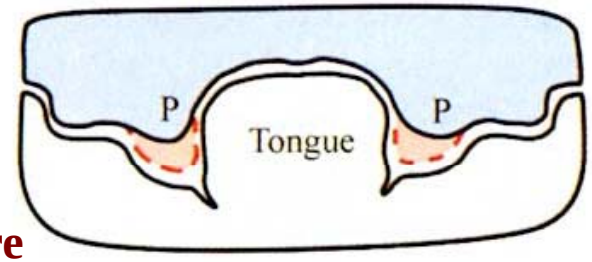
- Turgor in the palatal processes
- Movements of the tongue – primitive swallowing- allowing tongue to move out of the way
- Downward and forward growth of lower jaw complex – providing space for the secondary palate
- Straightening of the cranial base – providing mechanical conditions for horizontalization

Factors contributing to the successful fusion of the secondary palate: the medial edge epithelium (MEE)

- Apoptosis of MEE surface cells immediately prior to fusion
- Development of temporary glycoprotein membrane coating, enabling adhesion between MEE cells of opposing palatal processes
- Successful removal of MEE from fusion line

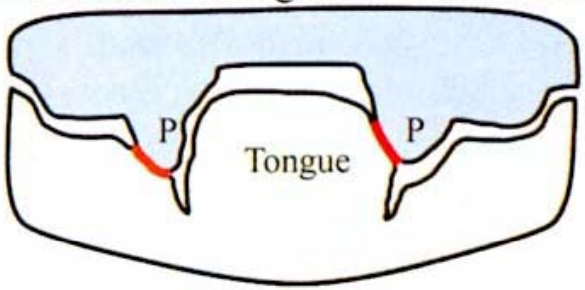
Potential palatal shelf (process) defects that may result in cleft palate

Failure of palatal shelf formation

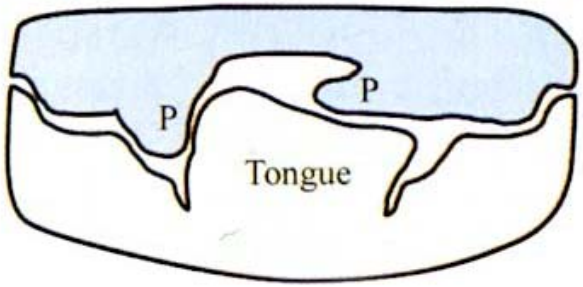


Rare

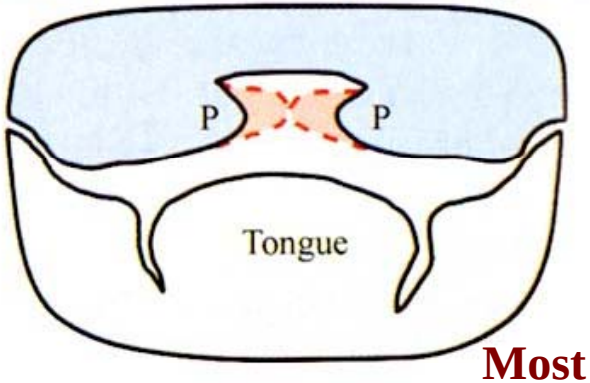
Fusion with the tongue or the mandible



Failure of palatal shelf elevation

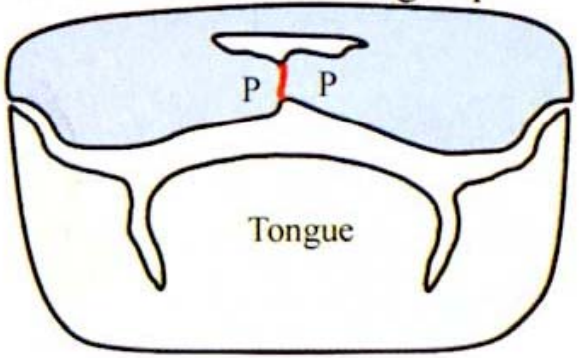


Failure of shelves to meet following elevation



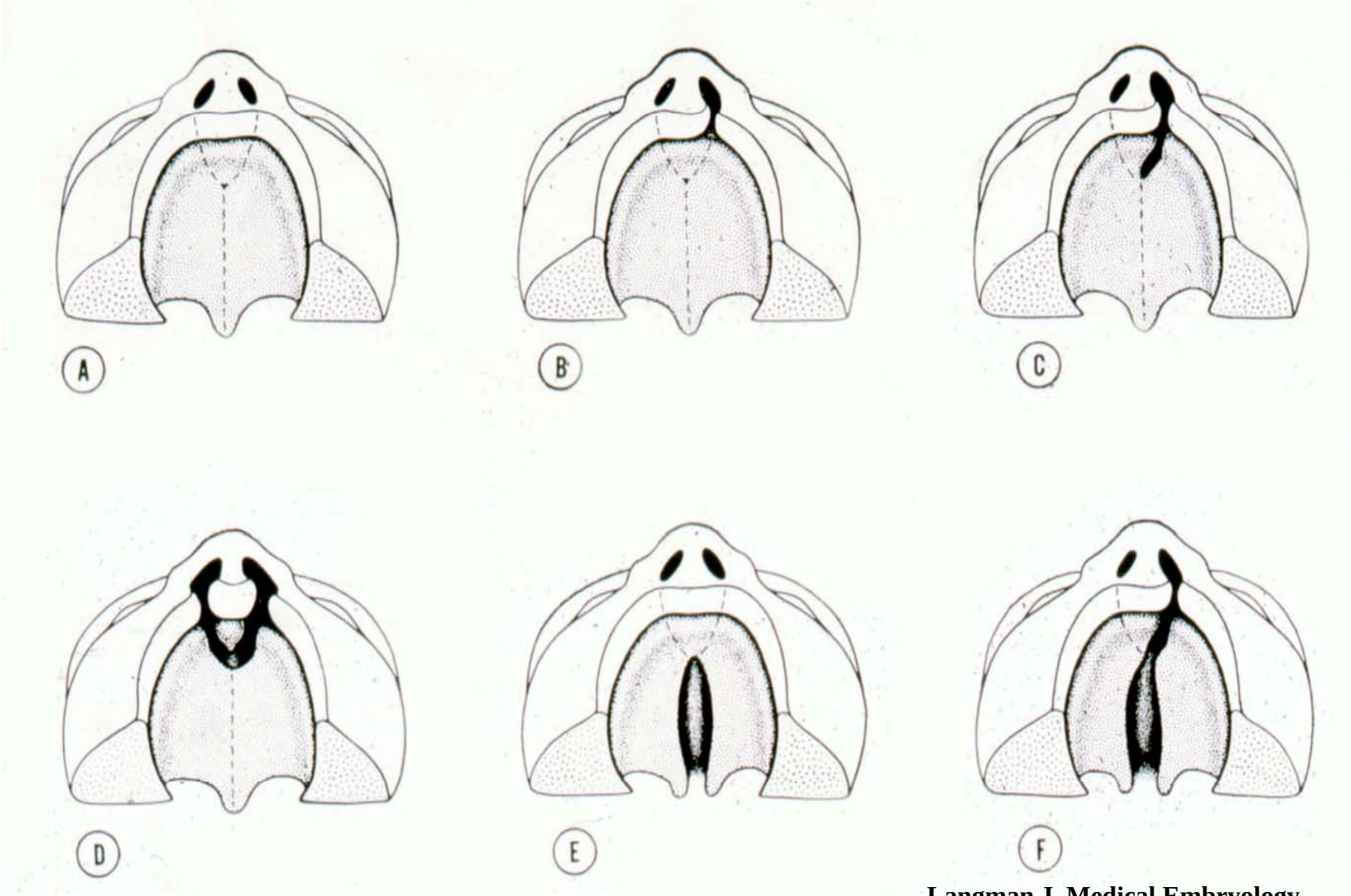
Most common

Persistence of medial edge epithelium



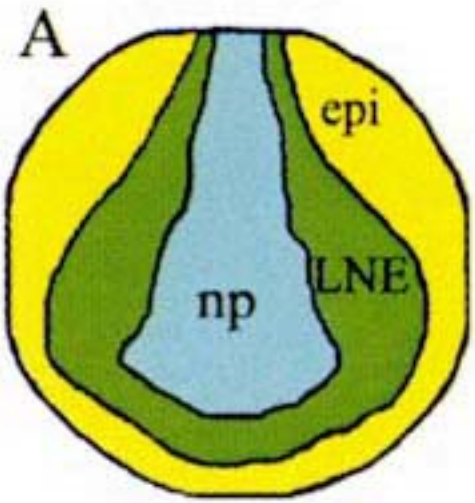
Chai Y, Maxson RE (2006)

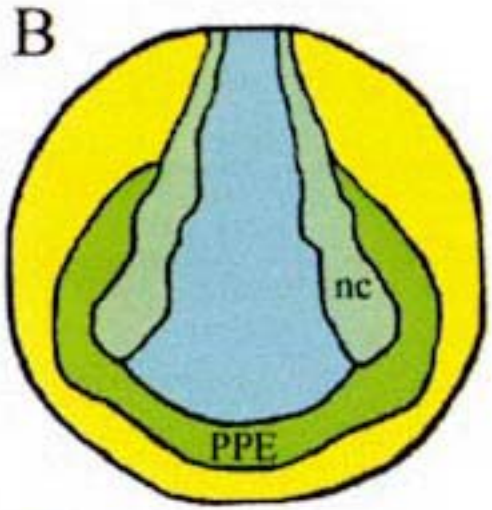
Sites of potential palatal clefts

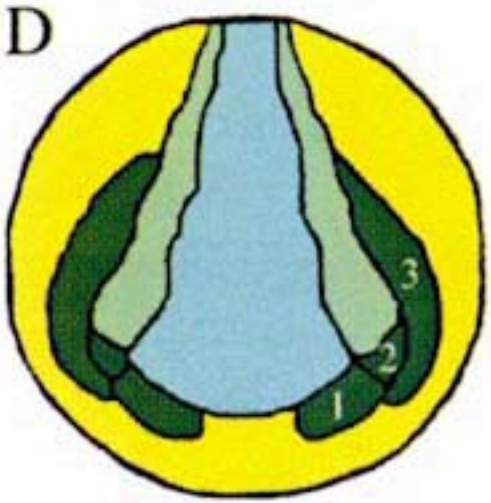


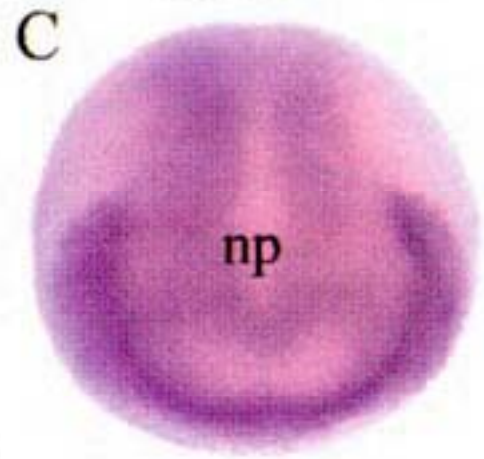
Langman J, Medical Embryology

Panplacodal ectoderm









Expression of genes for generic placodal development :

Six1/2, *Six4/5*, *Eya*

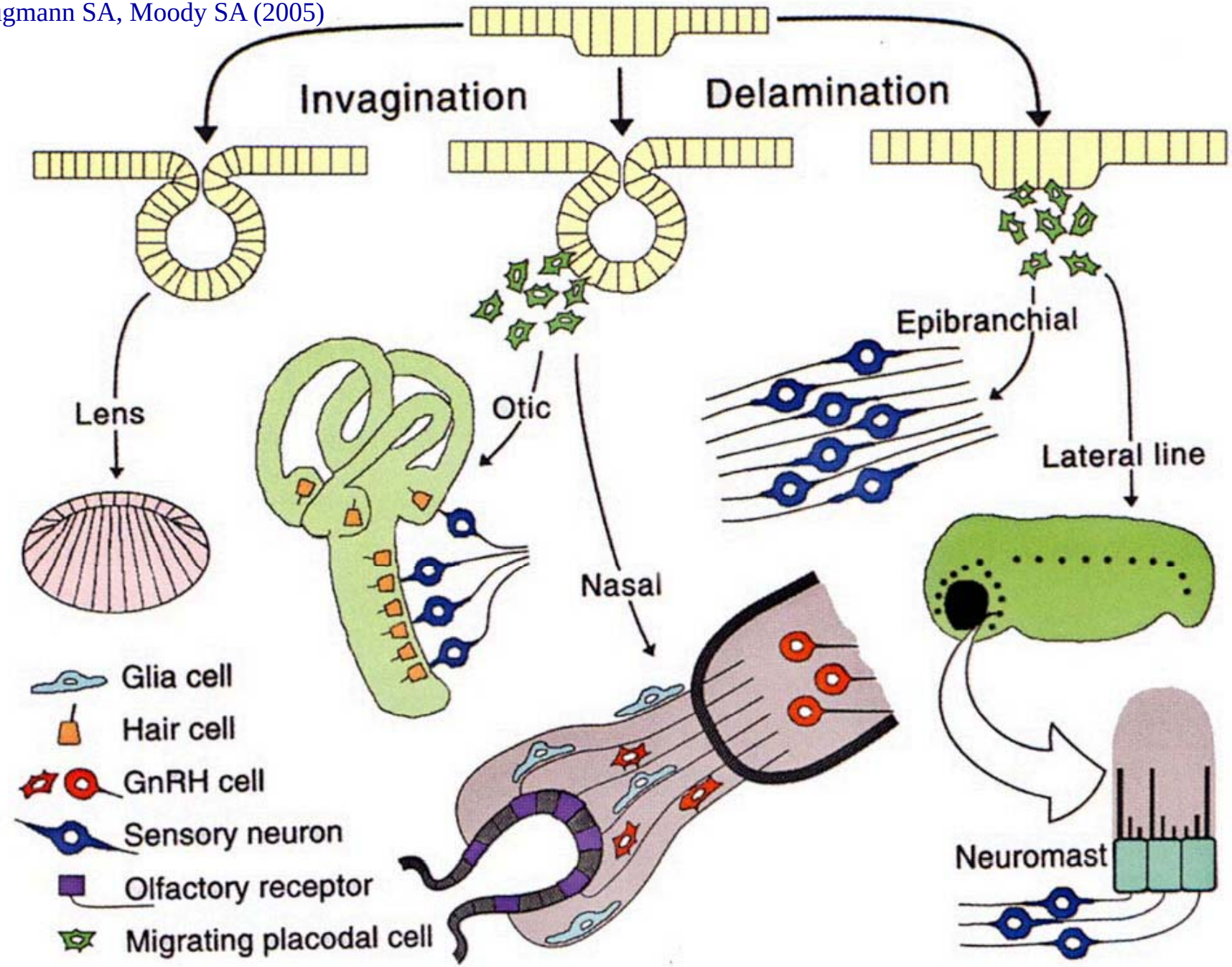
Brugmann SA, Moody SA (2005)

1: combined hypophyseal, olfactory, lens and trigeminal

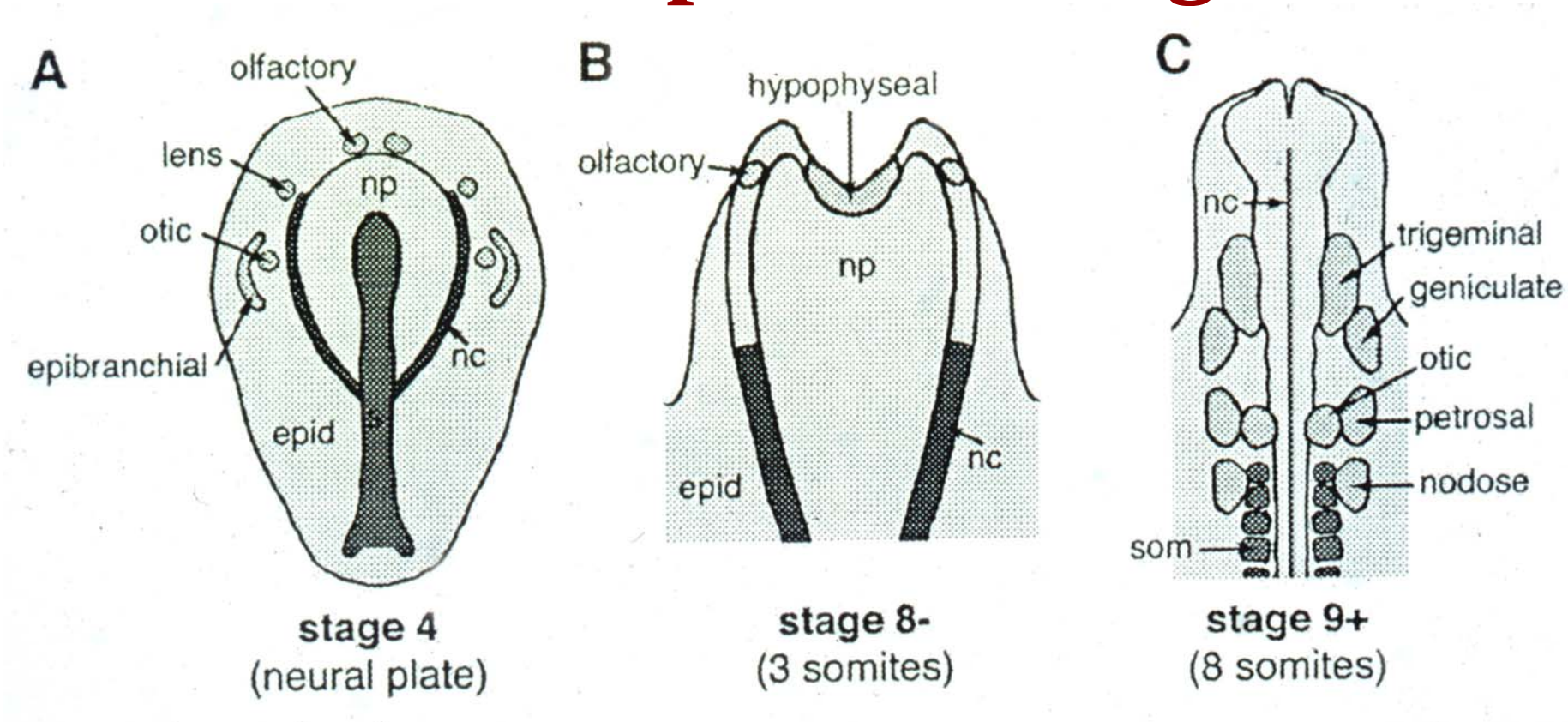
2: profundal

3: combined otic, lateral line and epibranchial

Brugmann SA, Moody SA (2005)



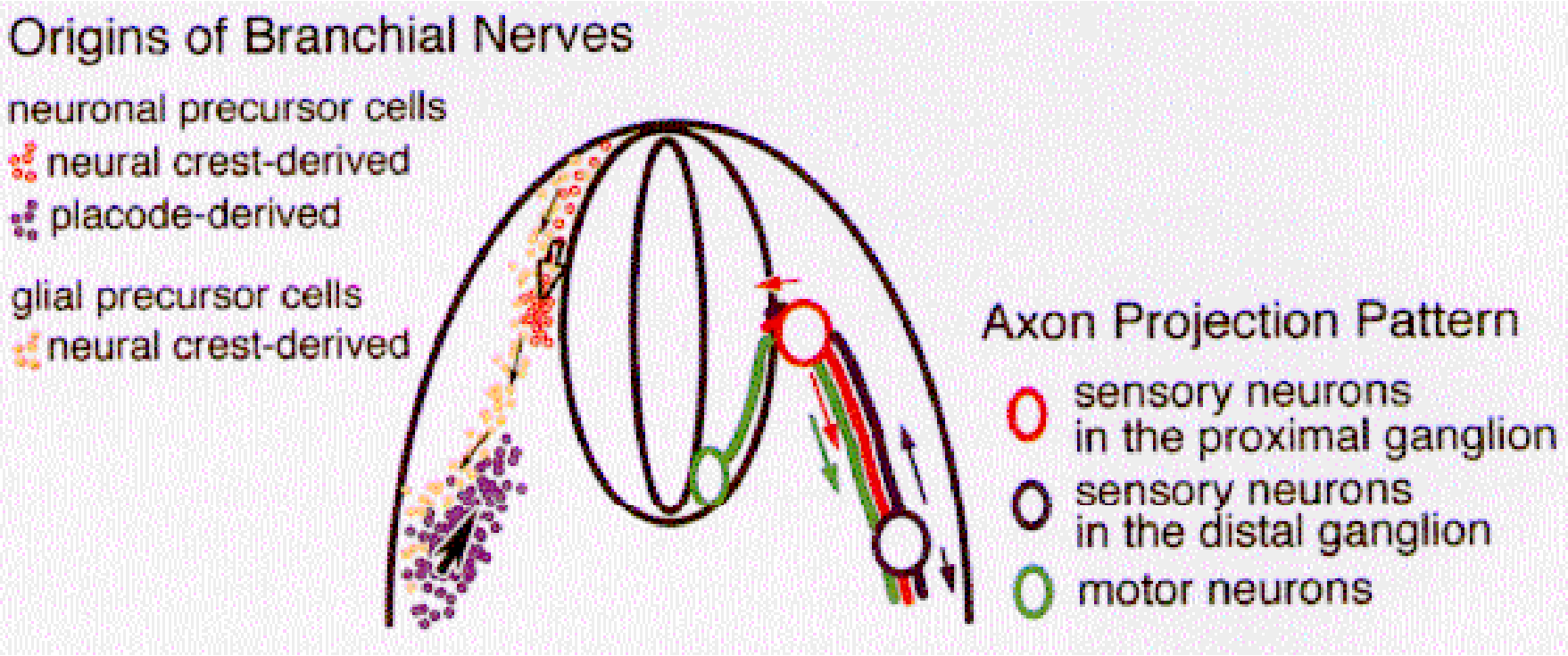
Distribution of placodes at 3 developmental stages



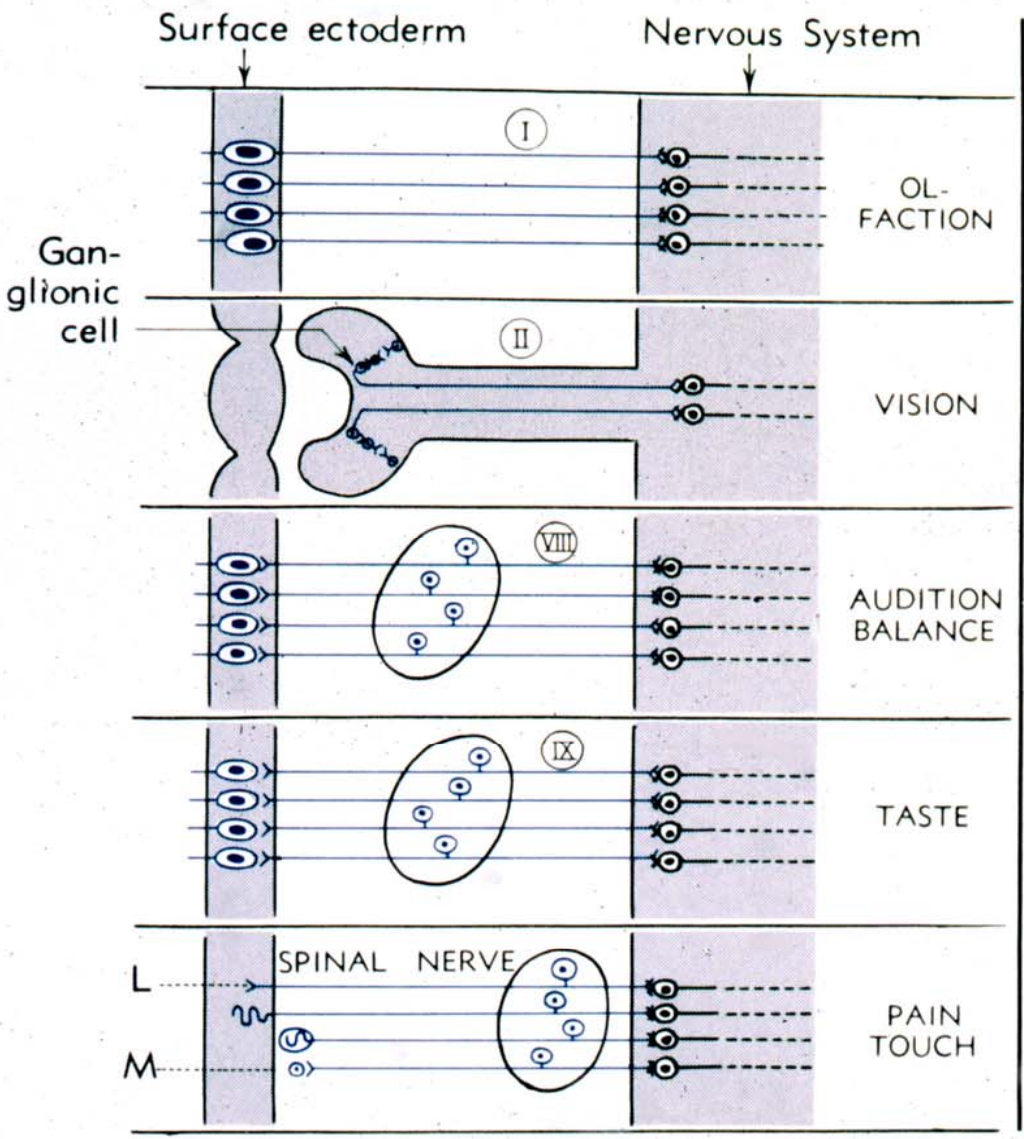
A. Initial induction of placodes in pre-placodal ectoderm field

B. Olfactory placodal cells are incorporated in outer folds of anterior neural ridge

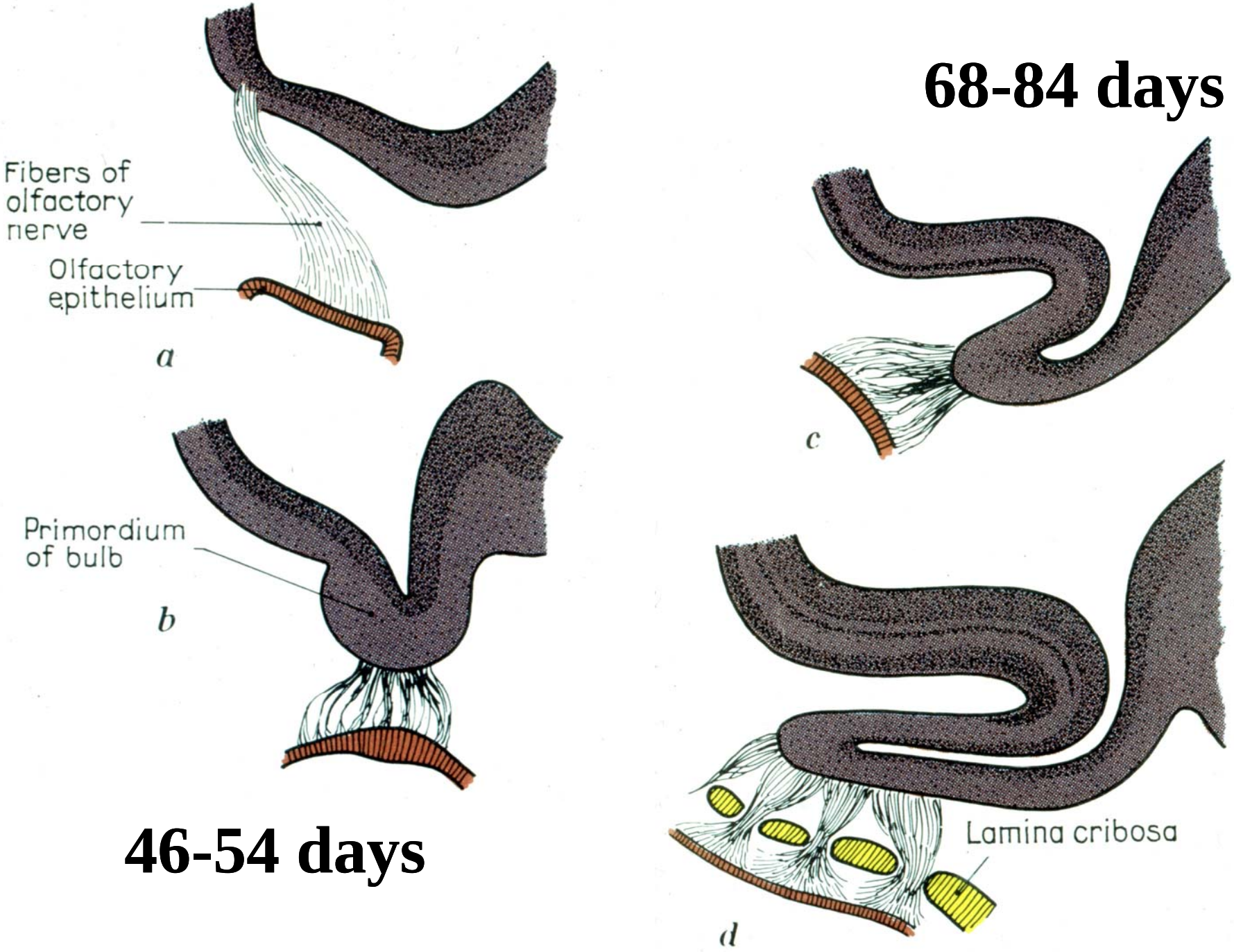
Branchiomeric nerves: origins and axon projection patterns



Development of organs of special sense



	ORIGIN OF SENSORY ELEMENTS	ORIGIN OF NERVOUS CONDUCTORS
OL-FACTION	Placode	Placode
VISION	Neural tube	Neural tube
AUDITION BALANCE	Placode	Placode
TASTE	Sensory differentiation of certains cells of surface ectodermal covering of tongue	Neural crest (spinal ganglia)
PAIN TOUCH	Free nerve endings (L) : neural crest. Mesenchymal cells (M)	Neural crest (spinal ganglia)

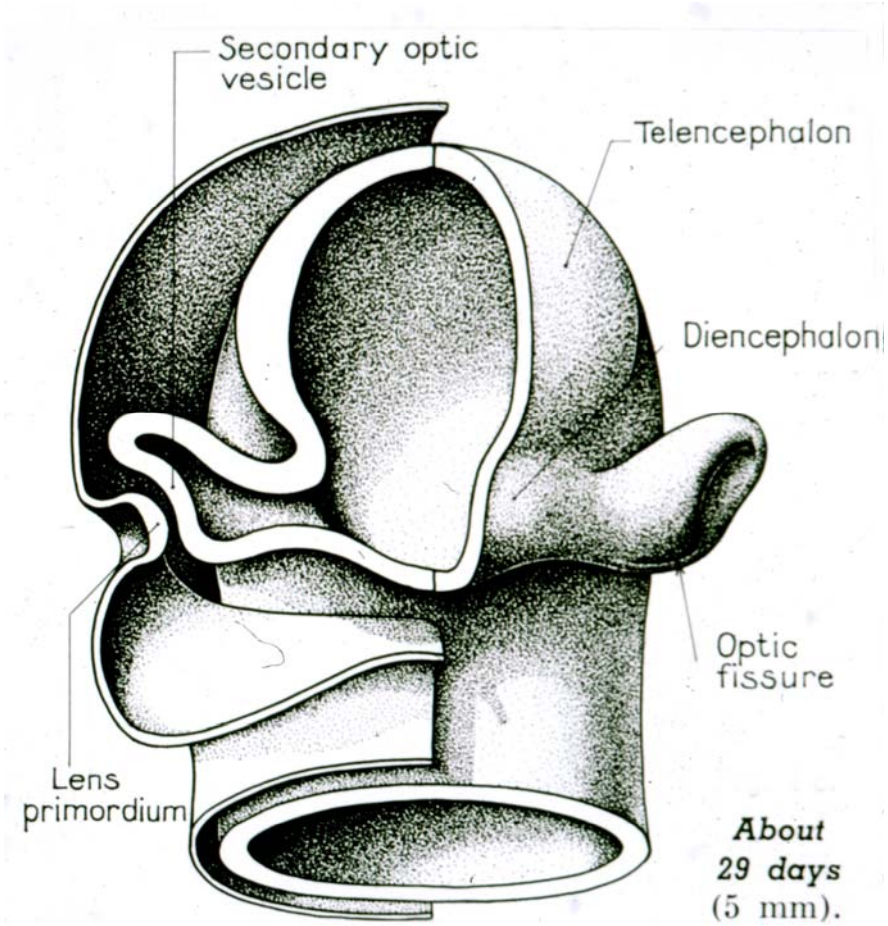


68-84 days

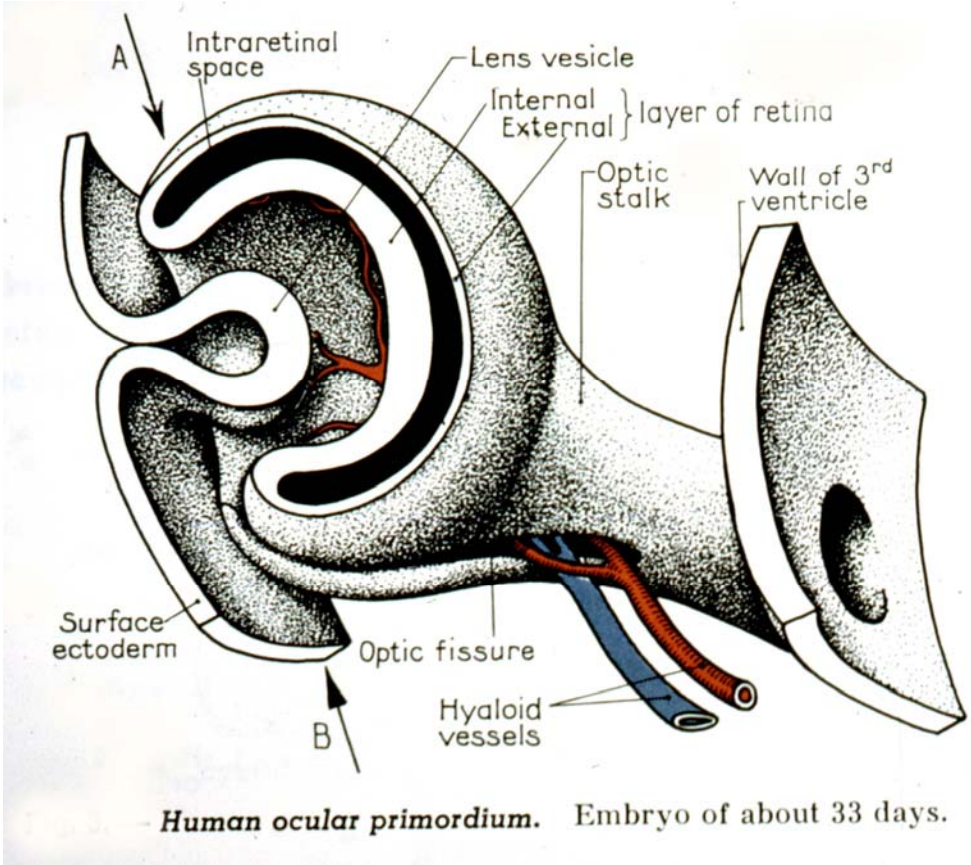
46-54 days

Olfactory placode gives rise to:

- Sensory receptor cells of olfactory epithelium of the nose (odorant sensing)
- Sensory receptor cells of vomeronasal epithelium (pheromone sensing)
- Basal cells and support cells (olfactory ensheathing cells - glia)



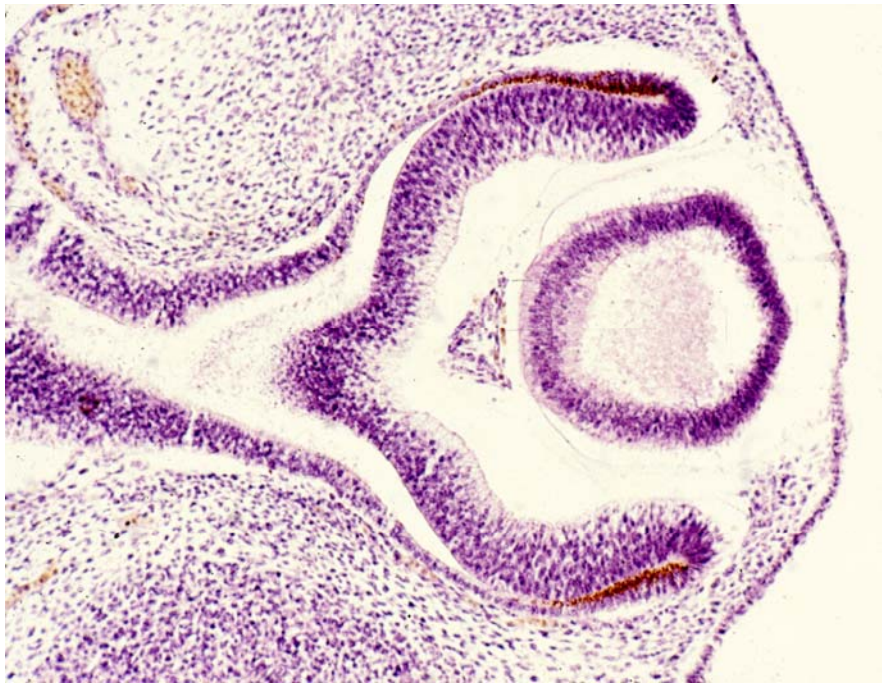
Optic vesicle forms optic cup under influence of lens primordium. Between developing lens vesicle and optic cup : primary vitreous body.

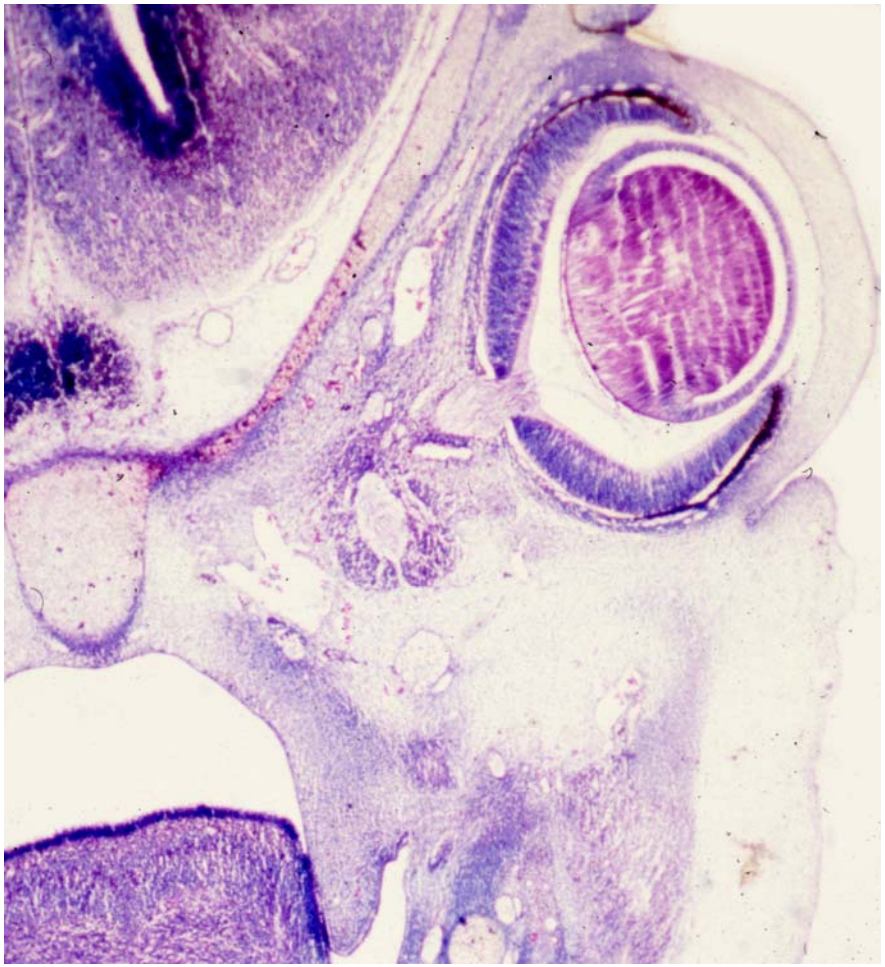


Human ocular primordium. Embryo of about 33 days.

Hyaloid A.: terminal branch of ophthalmic A. (future central artery of retina)

In lens vesicle posterior cells elongate to form primary lens fibers. In third month the equatorial cells of the anterior epithelium form secondary lens fibers (most of mature lens).





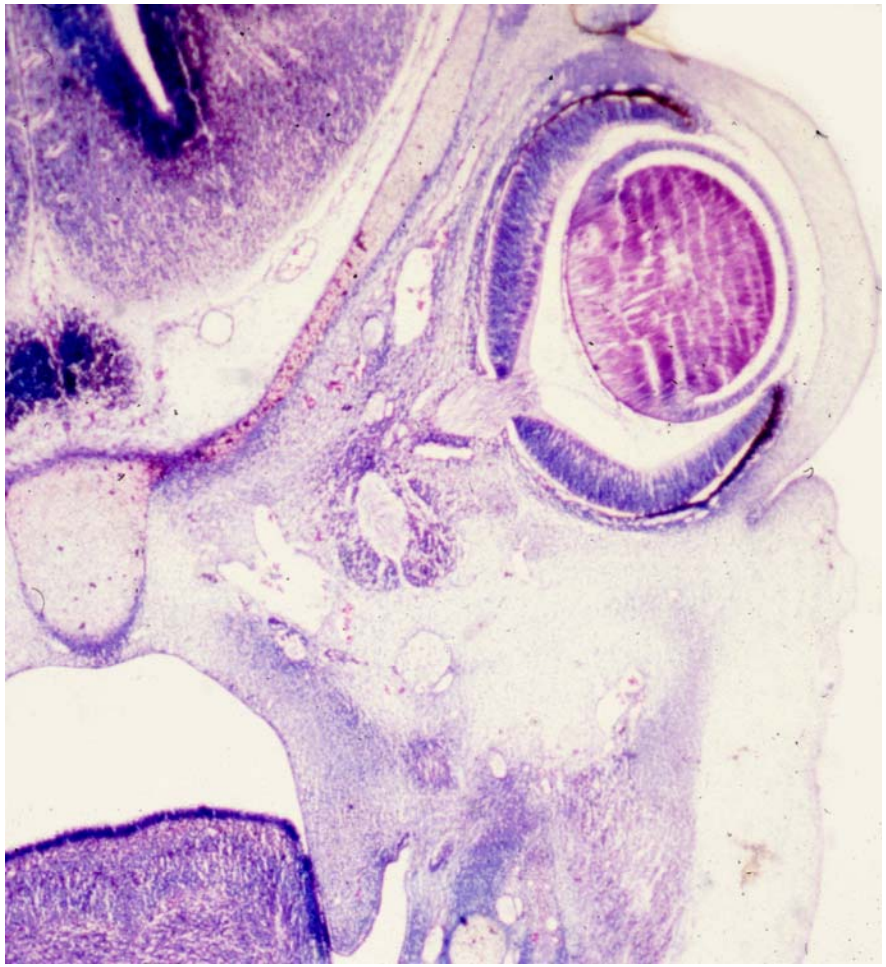
Optic cup:

Inner layer ⟶ neural retina

Outer layer ⟶ pigment retina

Optic stalk:

Axons from neural retina grow through the choroidal fissure to brain ⟶ optic nerve



NC derived mesenchyme around the optic cup:

Thin inner choroid

Outer fibrous sclera

NC derived mesenchyme anterior to lens:

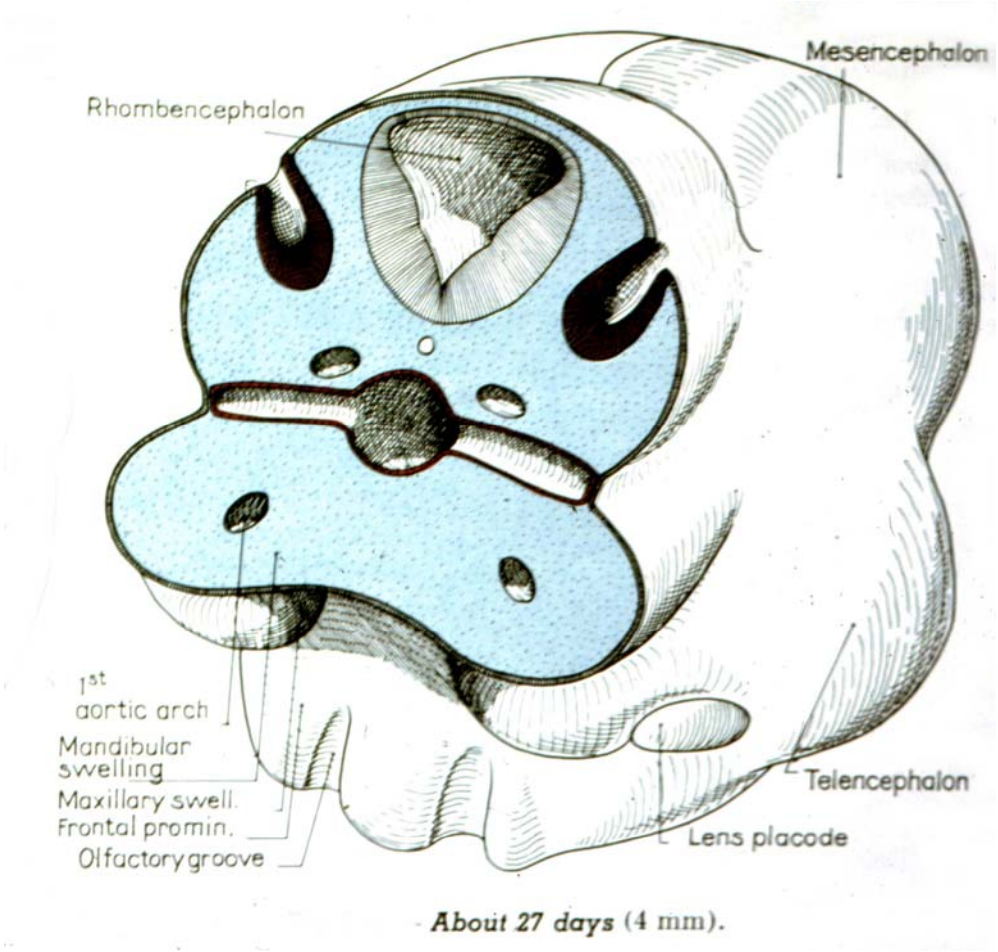
Anterior layer ⟶
contributes to cornea

Posterior layer ⟶
pupillary membrane

Between anterior and posterior layers: anterior chamber of eye

Behind posterior layer: posterior chamber.

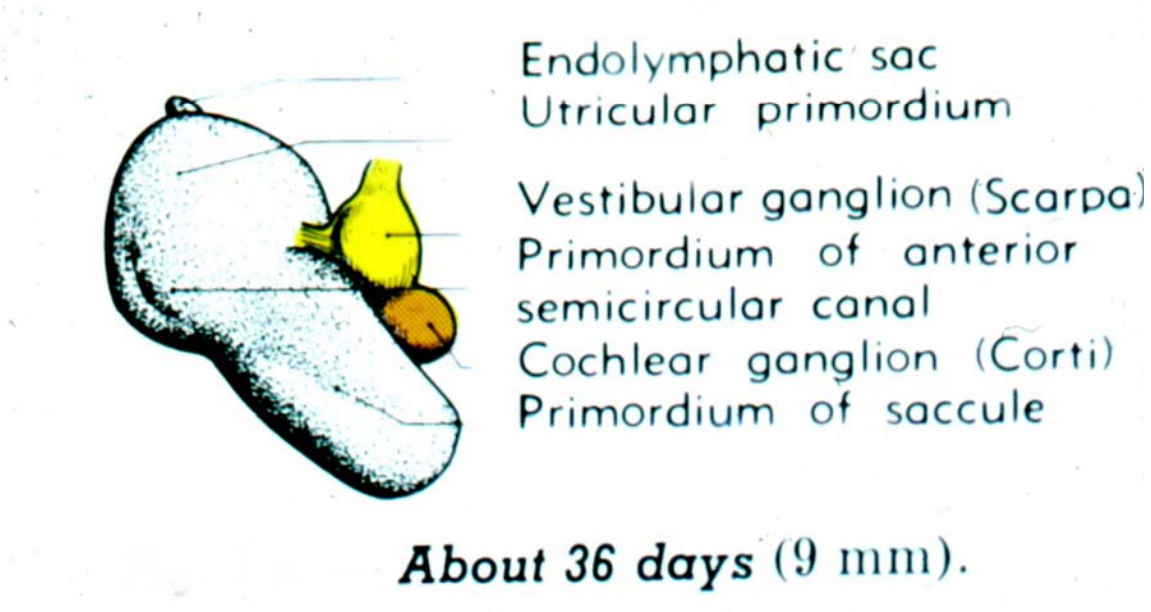
Otic pit to otic vesicle



About 27 days (4 mm).

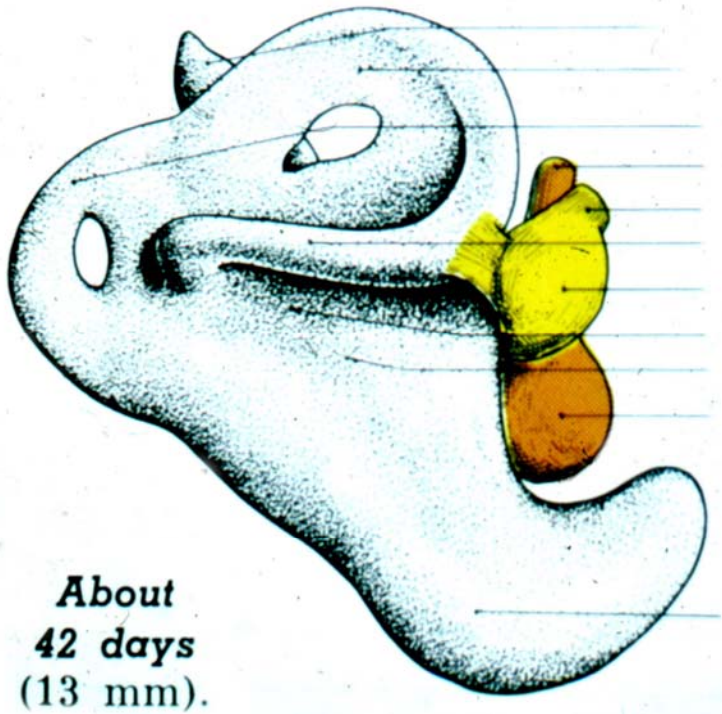
Some placodal cells migrate out of vesicular wall: ⟶ statoacoustic ganglion of CN VIII

Differential growth of otic vesicle

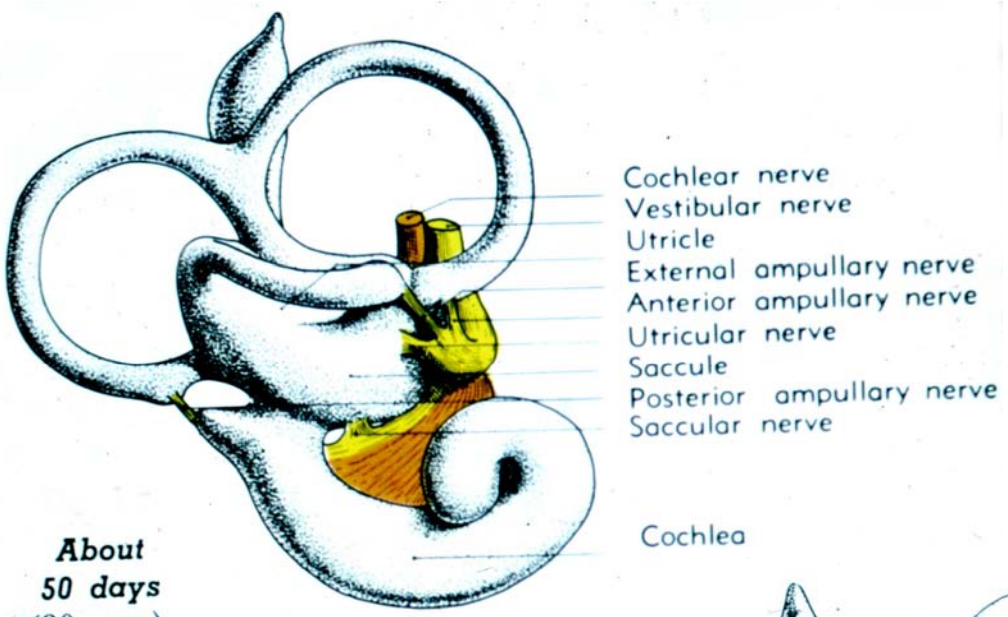


Saccule: ventral, will give rise to mature saccule and cochlea.

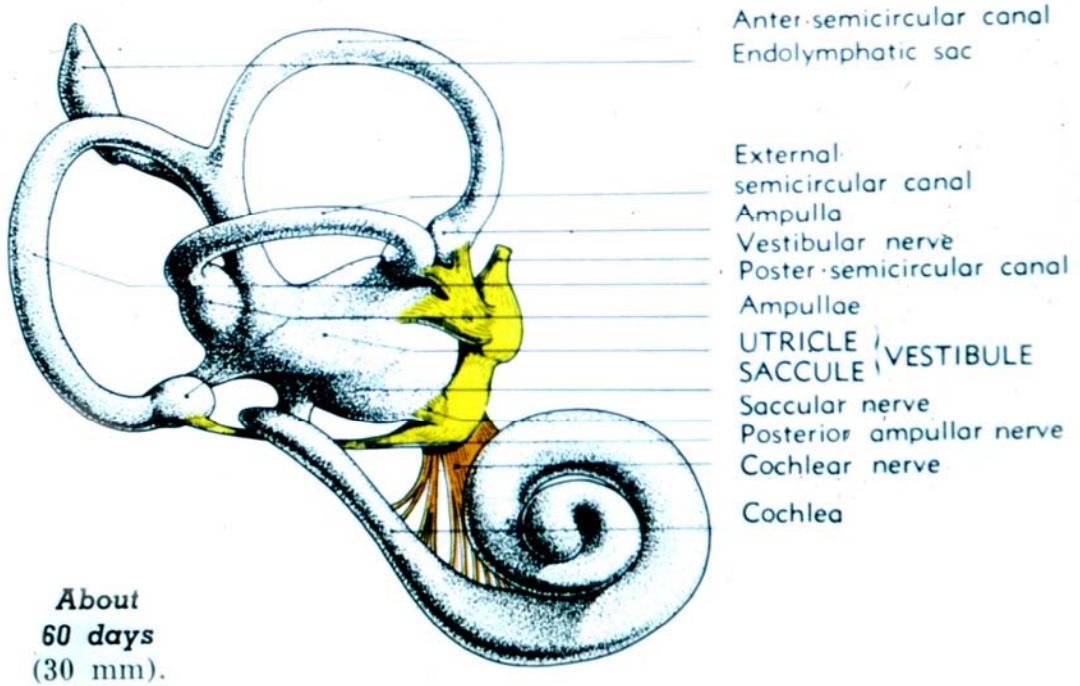
Utricle: dorsal, will give rise to mature utricle, semicircular canals and endolymphatic duct.



About 42 days (13 mm).

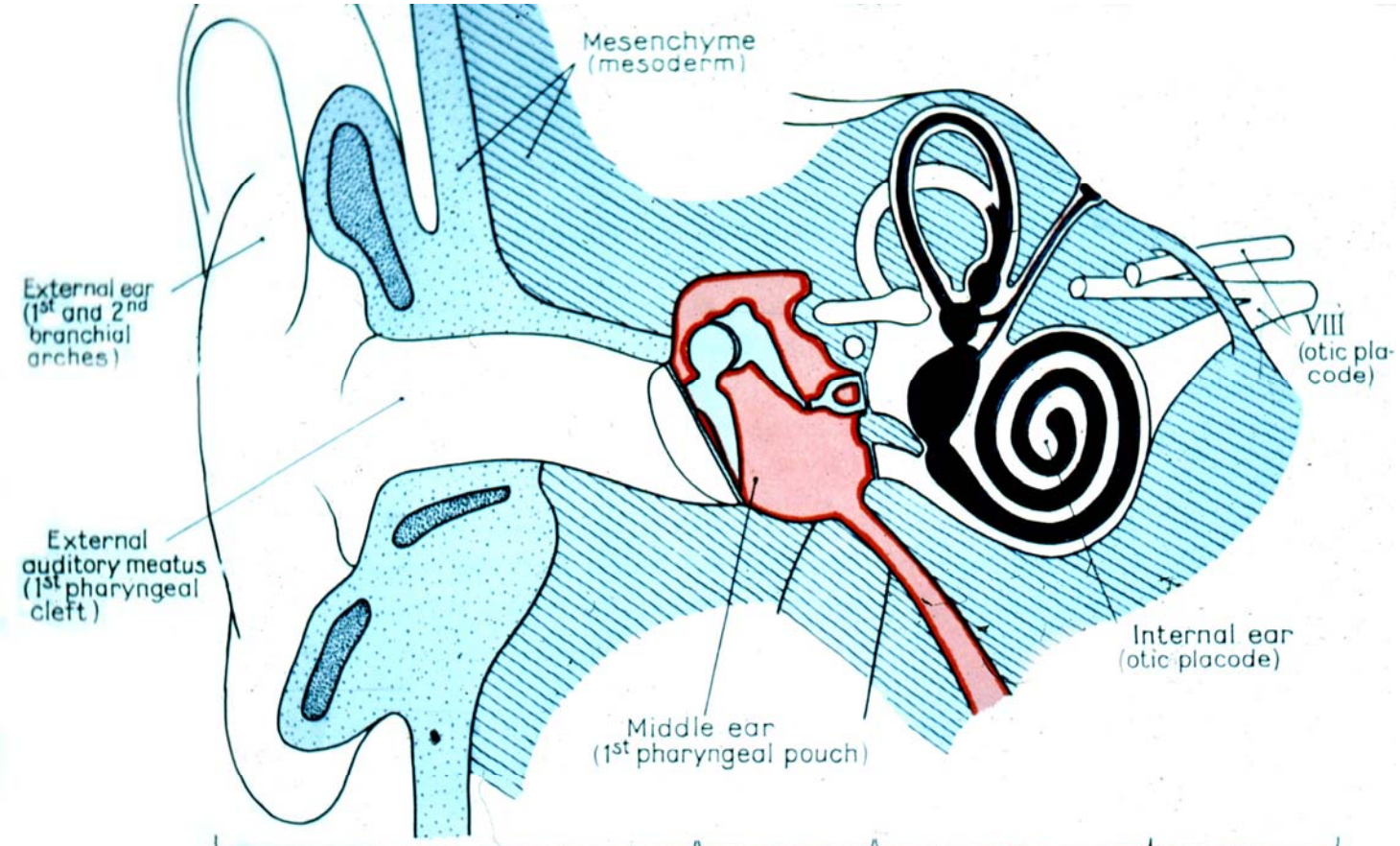


About 50 days (20 mm).



About 60 days (30 mm).

Development of inner ear



Human adult ear.