

Pharyngeal arches and pouches

L.Moss-Salentijn

Pharyngeal arches: a definition

A **segmental series** of five paired swellings that surround the foregut between days 20 to 35 of embryonic development. These segments, which are unique to vertebrates, are “wedged” between the developing forebrain and heart.

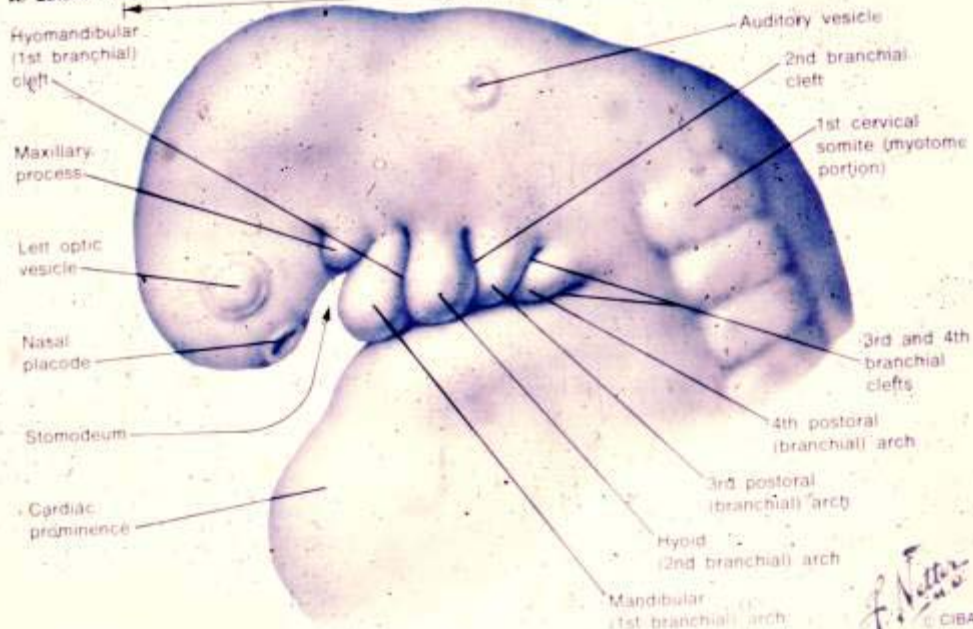


Pharyngeal arches

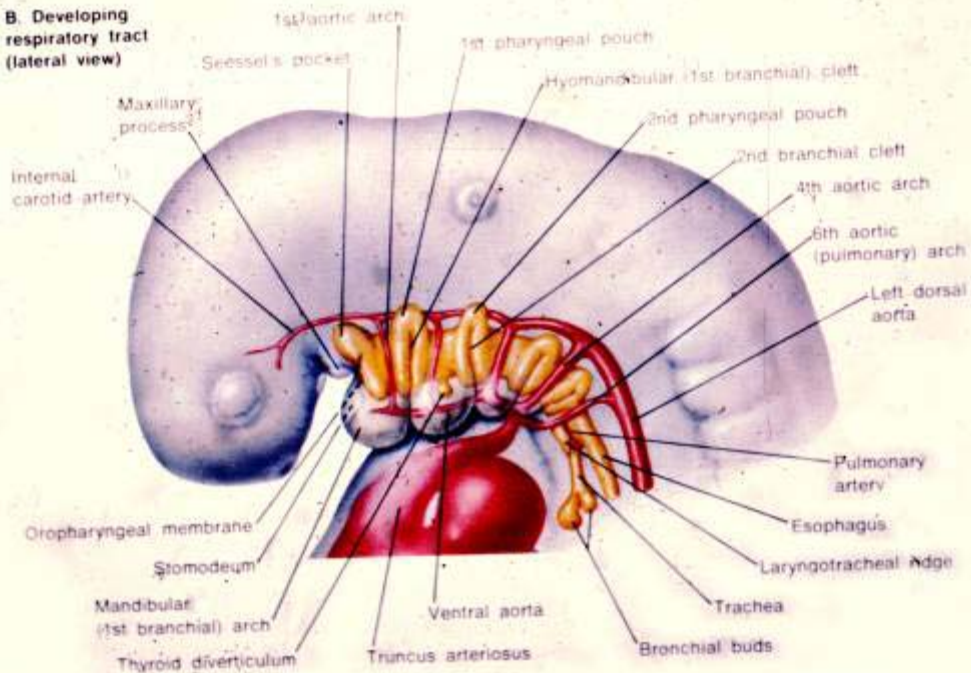
- a.k.a. visceral or branchial arches
- Develop (and disappear as distinctively visible structures) in a rostro-caudal sequence
- Require neural crest cells for their development
- Even after they are no longer visible externally, they have a lasting impact on the anatomy of the head and neck and of the great vessels

Embryo at 4 to 5 Weeks

A. Lateral view



B. Developing respiratory tract (lateral view)



5 Pharyngeal arches

5 Aortic arches

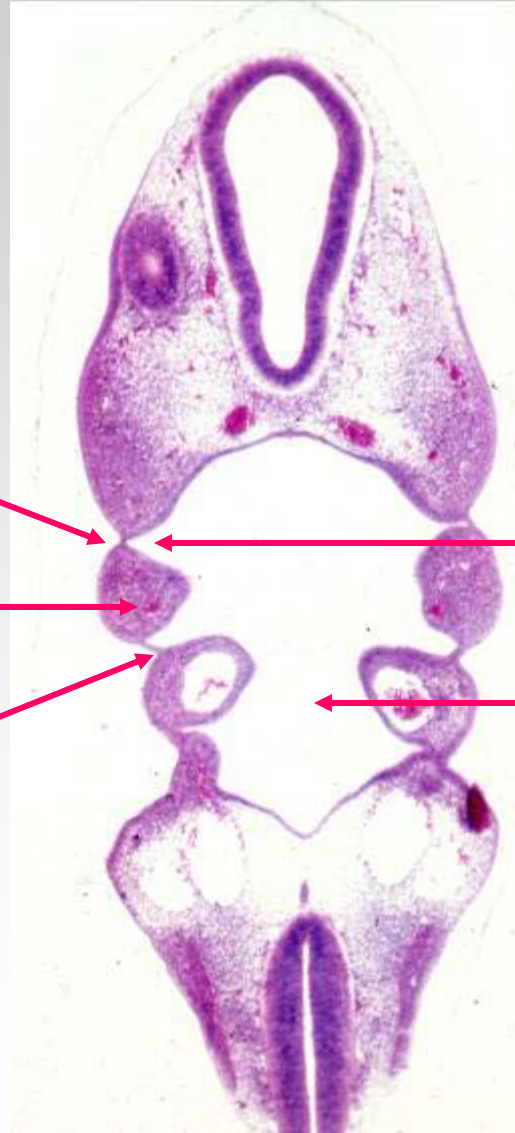
Arches numbered 1-6

Arches, grooves, pouches, and membranes

Pharyngeal groove

Pharyngeal arch

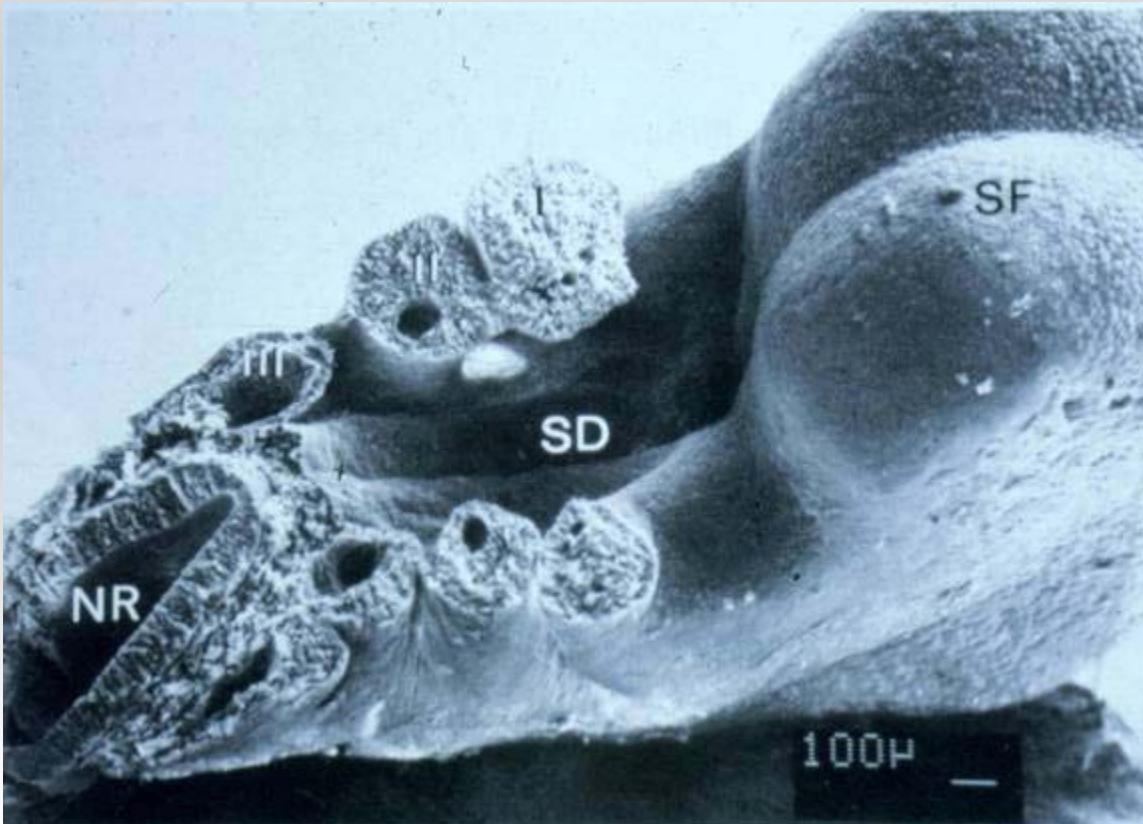
Pharyngeal membrane



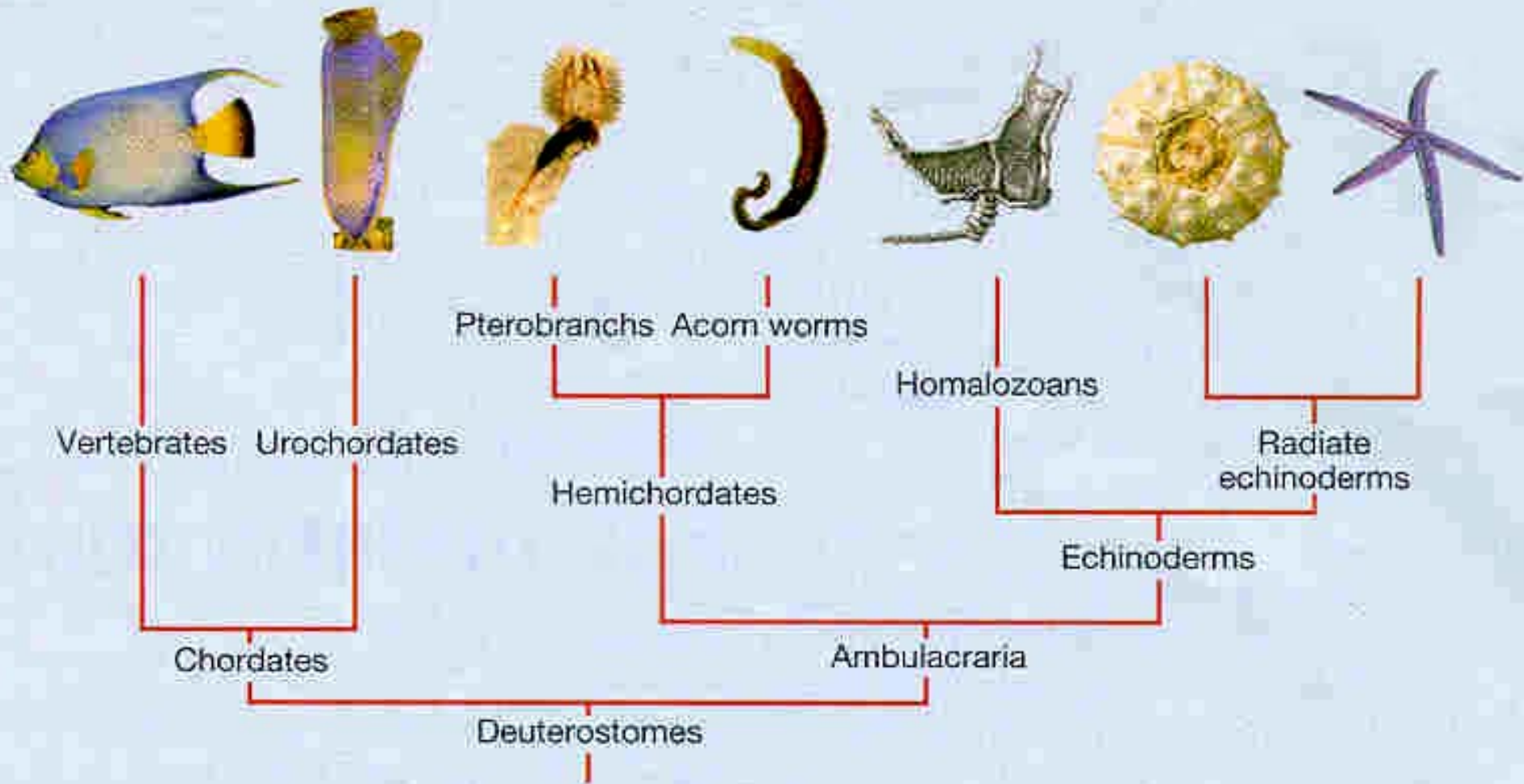
Pharyngeal pouch

Foregut

Pharyngeal cleft transient “gill-slit”



Mangold U et al (1981)



Smith AB (2004)



CIONA INTESTINALIS, PHOTOGRAPHED AT MARINE BIOLOGICAL LABORATORY, WOODS HOLE

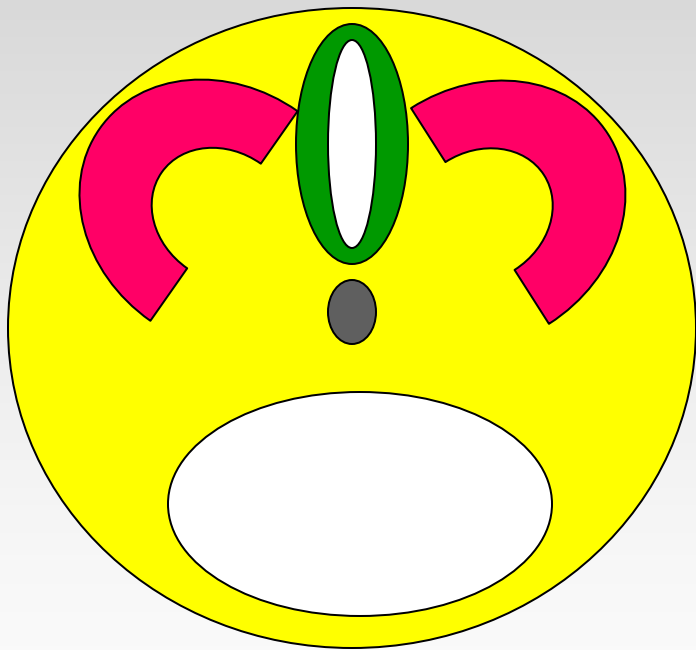
SEA SQUIRT

photograph by Purcell R, National Geographic November 2006



K. TELNES/IMAGE QUEST MARINE
Dell H (2006)

Basic body plan of all chordates (incl. vertebrates)



Dorsal hollow neural tube

Segmented lateral mesoderm

Central notochord

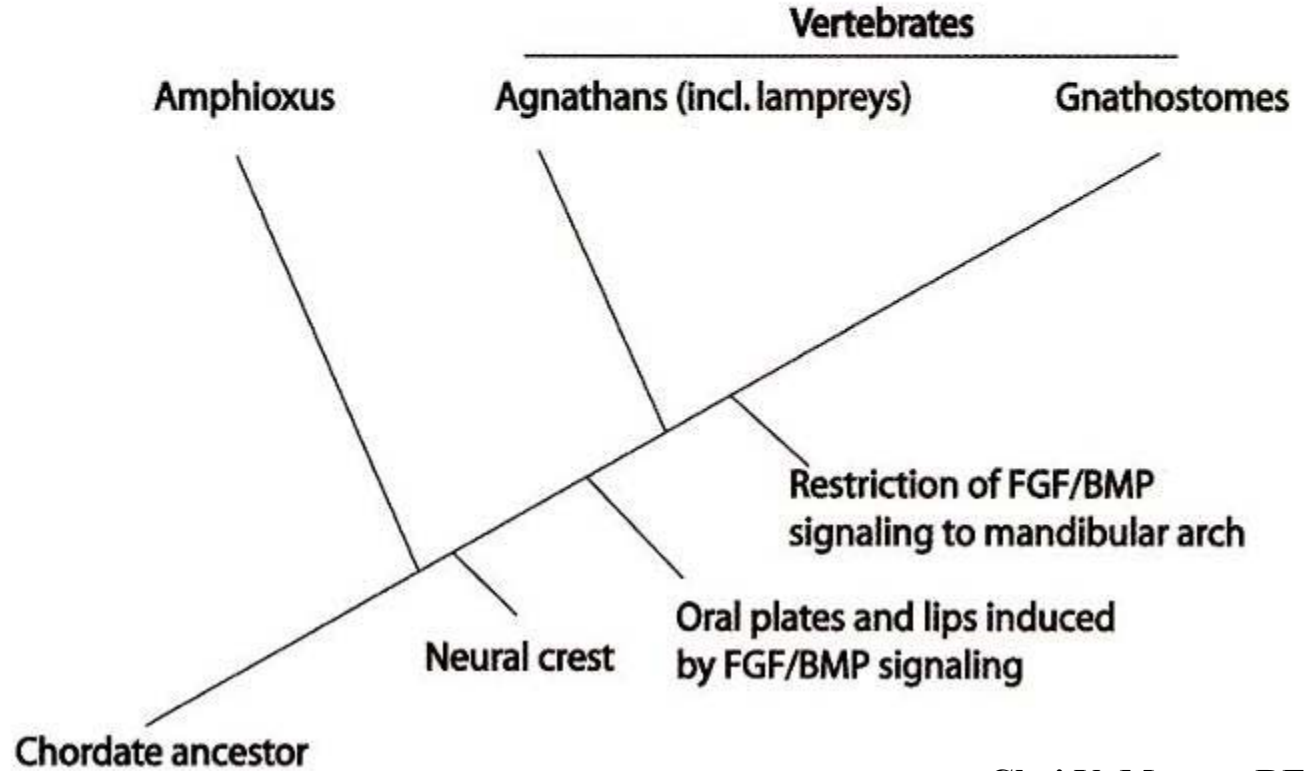
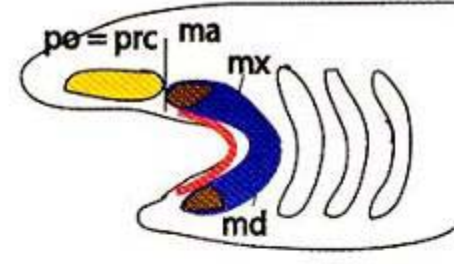
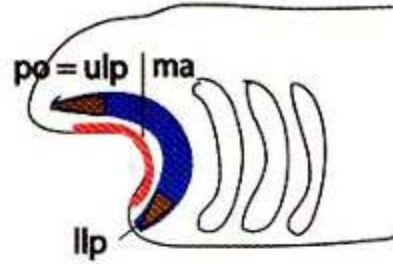
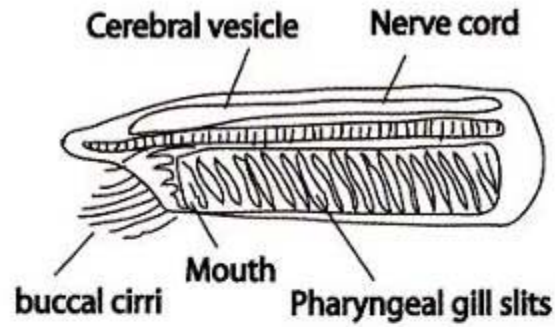
Ventral digestive tube

(Pharyngeal gill slits)

Evolution of vertebrates involved:

- Development of organs of special sense in head region to detect prey
- Development of a large neural circuitry (the brain) to integrate input and responses
- Development of an effective feeding apparatus (jaws: pharyngeal arch derivatives)
- Development of an improved respiratory apparatus (gills: pharyngeal arch derivatives).

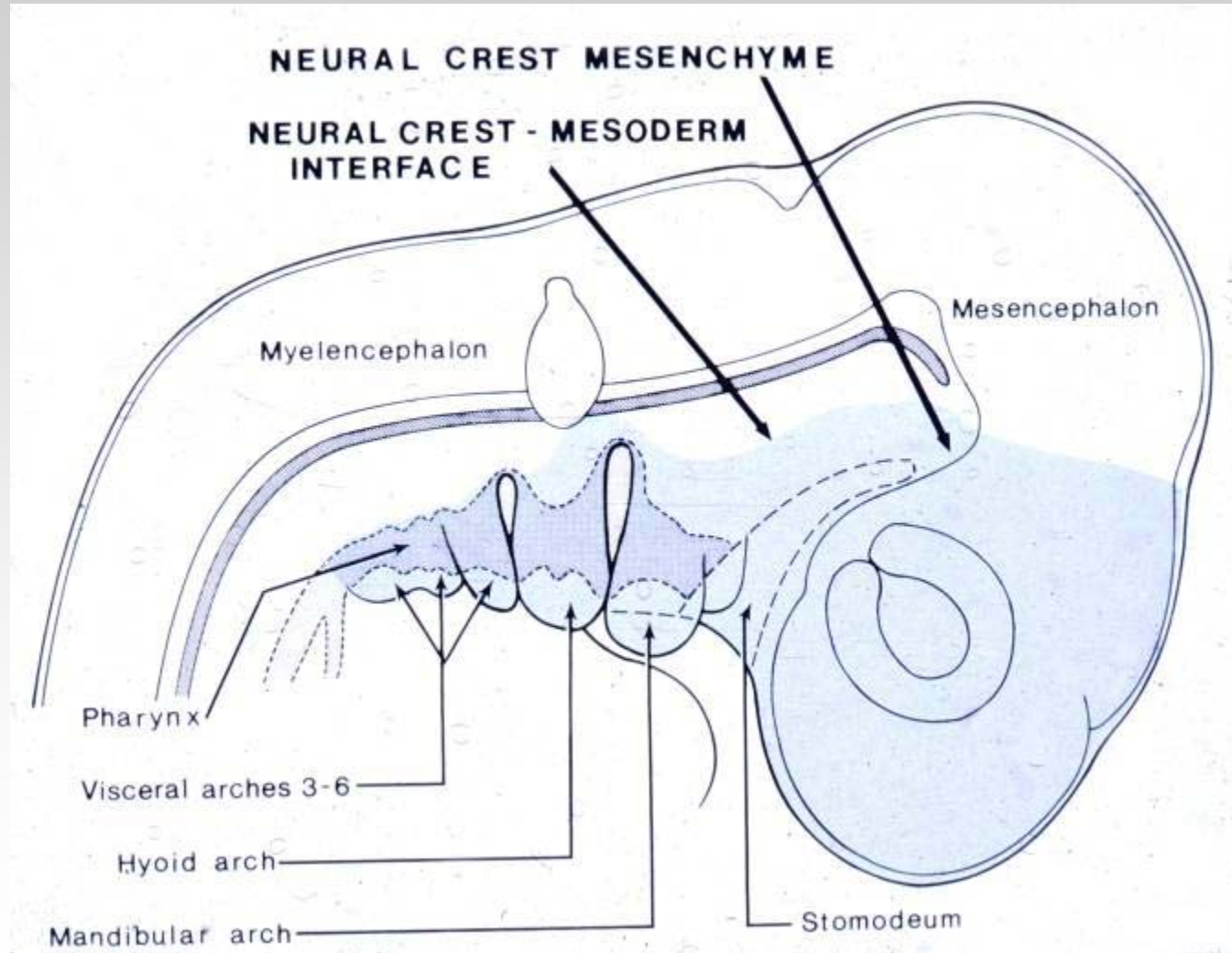
This required the recruitment of an existing group of cells: neural crest cells, for a new role.



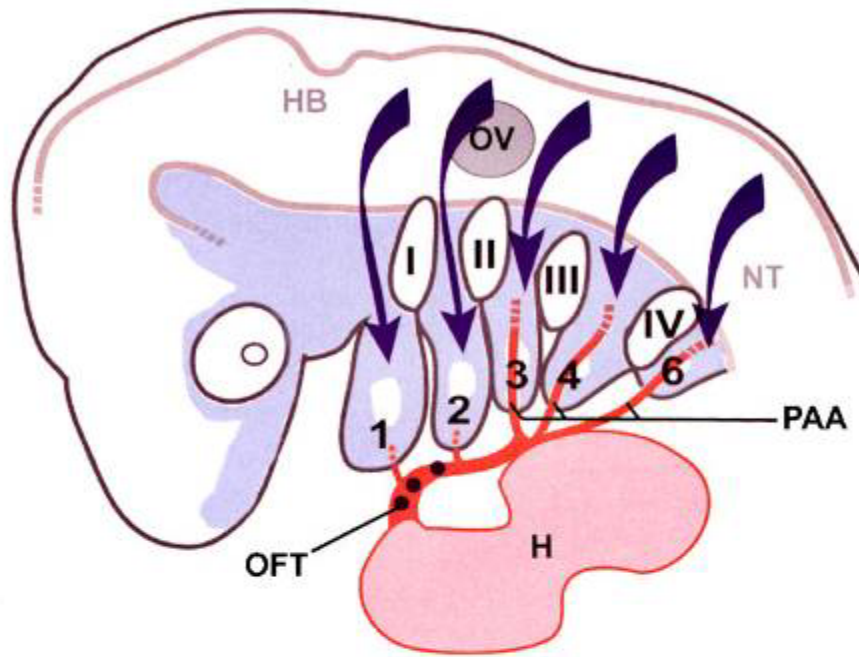
Mesenchyme in cephalic region is derived from:

- Mesoderm
- Neural crest

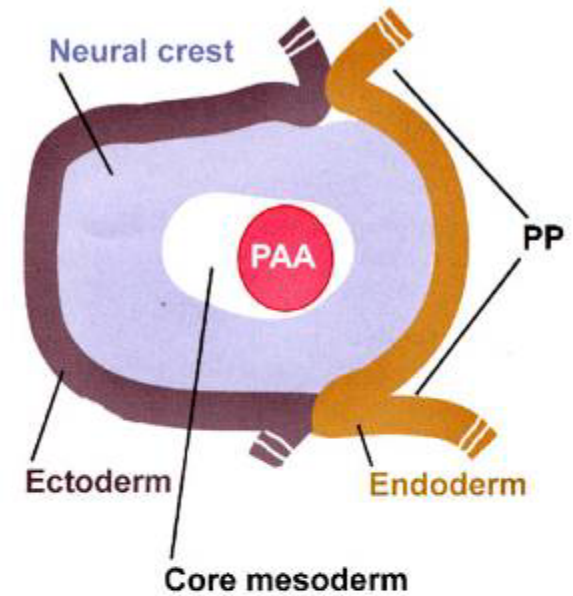
Neural crest and mesoderm in H&N area



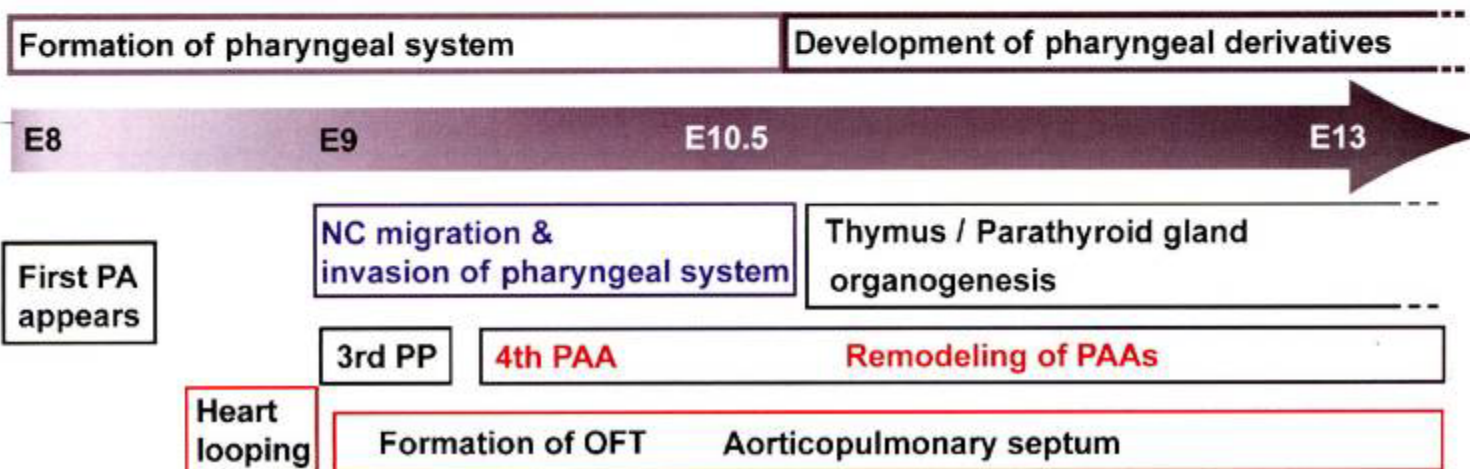
A

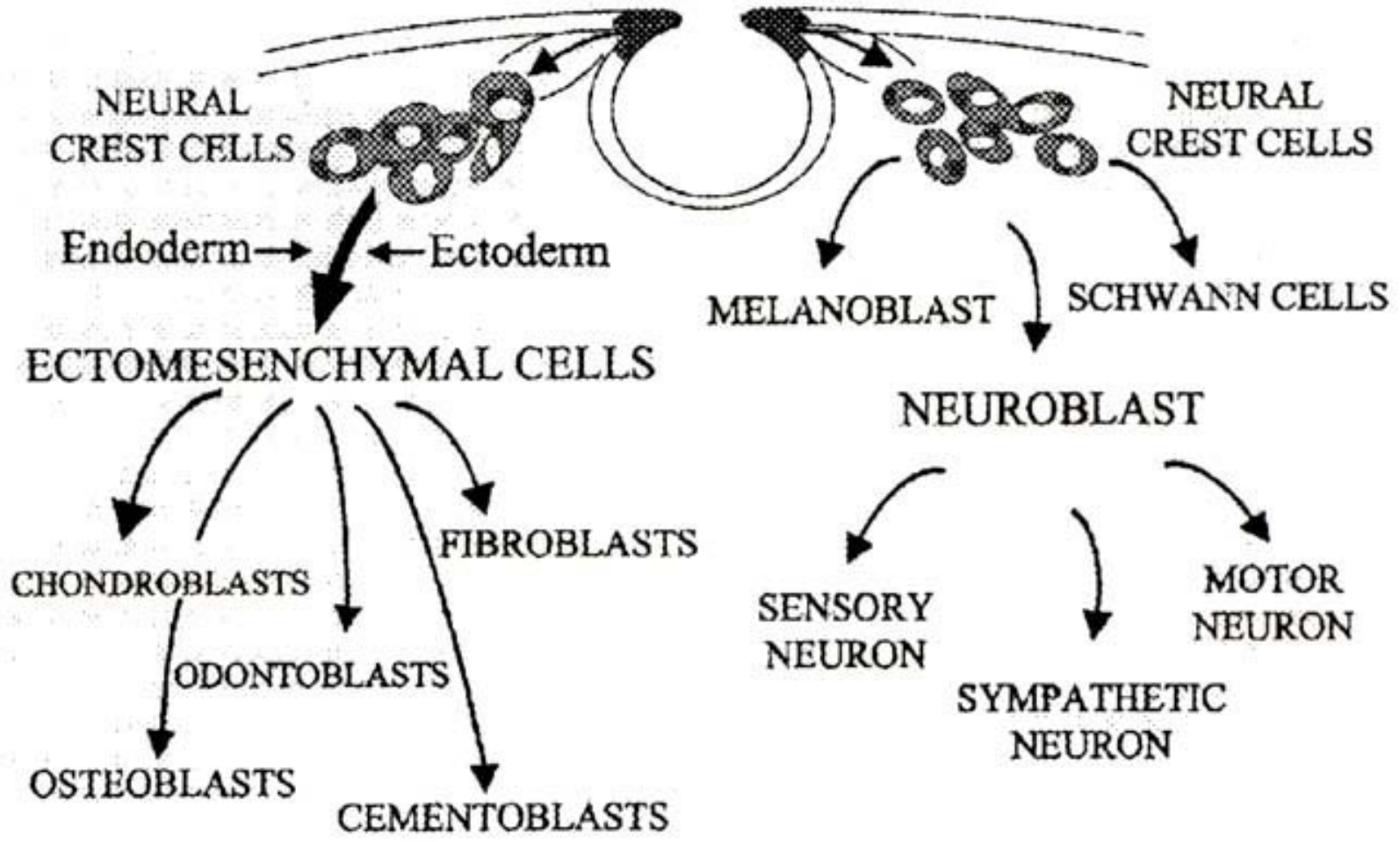


B



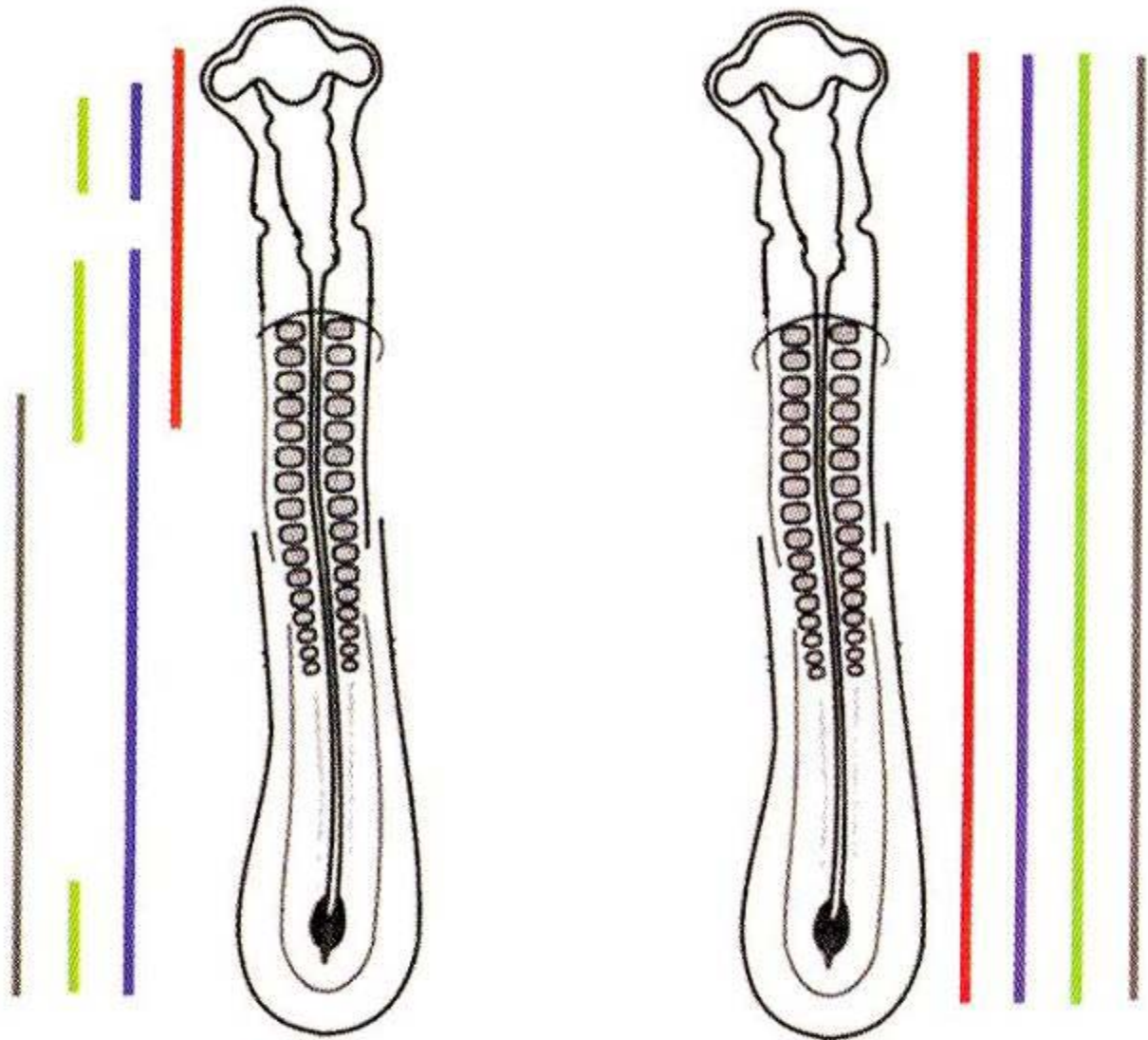
C





Fate

Potential

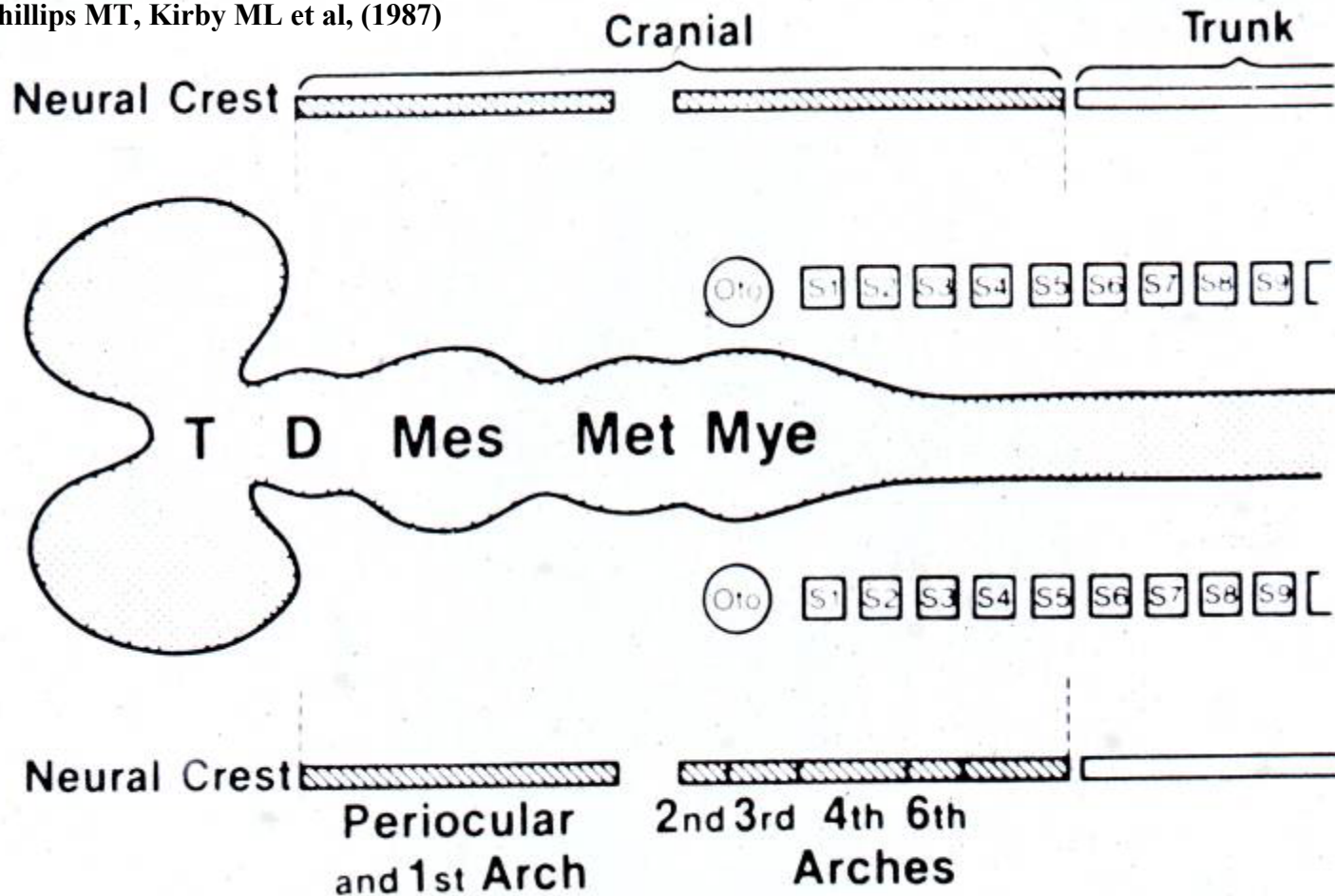


■ Ectomesenchyme
■ Sensory ganglia

■ Parasymp. ganglia
■ Sympathetic ganglia

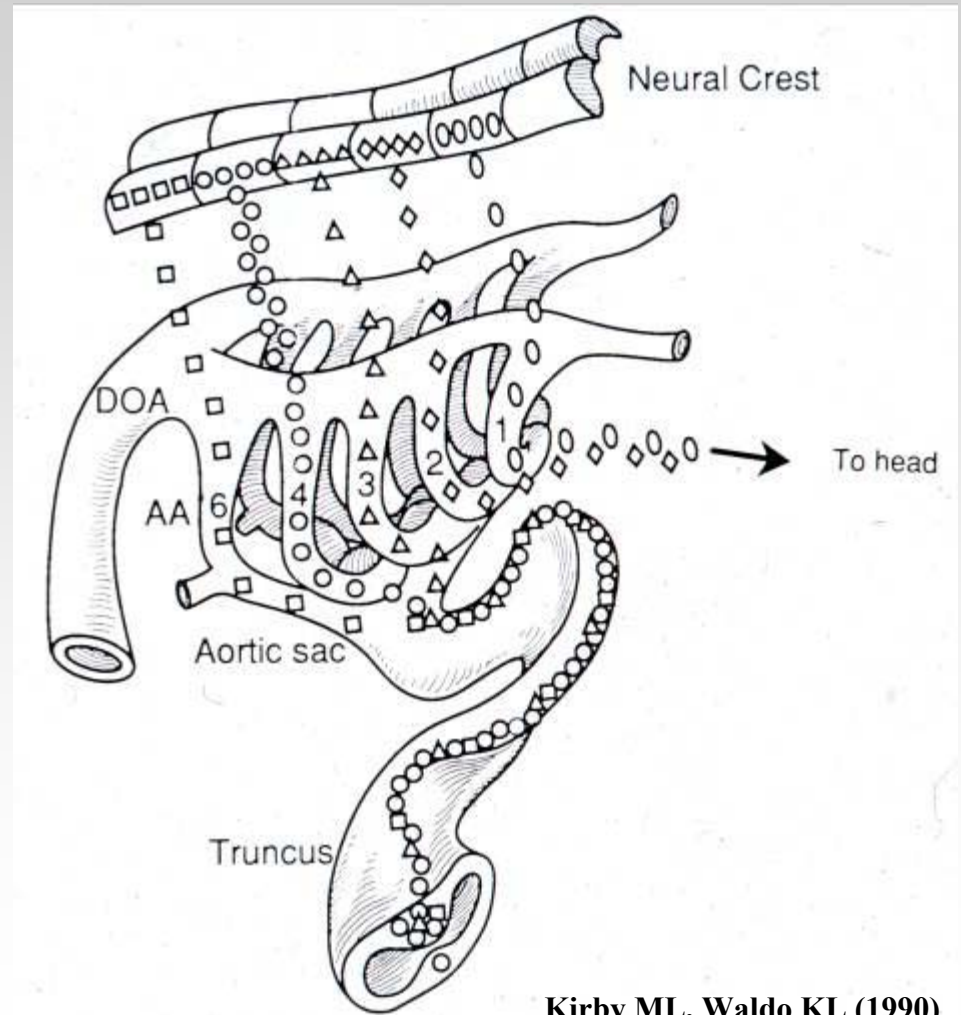
Extent of cephalic (cranial) neural crest

Phillips MT, Kirby ML et al, (1987)

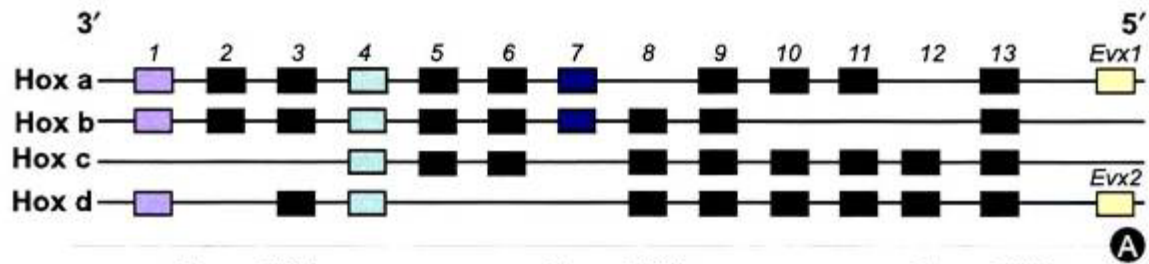


Neural crest involvement in the development of the heart

Kuratani S, Horigome N (2000)



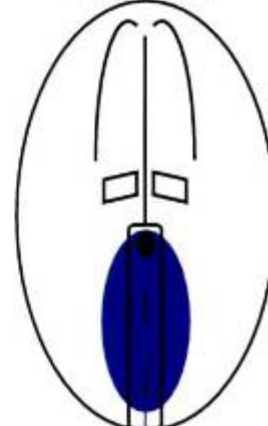
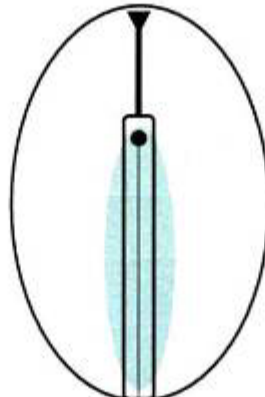
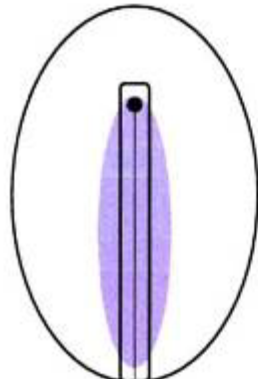
Kirby ML, Waldo KL (1990)



Stage 4HH

Stage 5HH

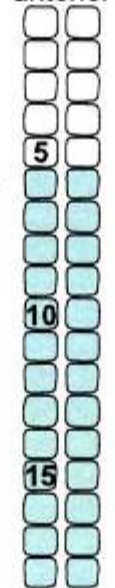
Stage 7HH



Hox 1

Hox 4
anterior

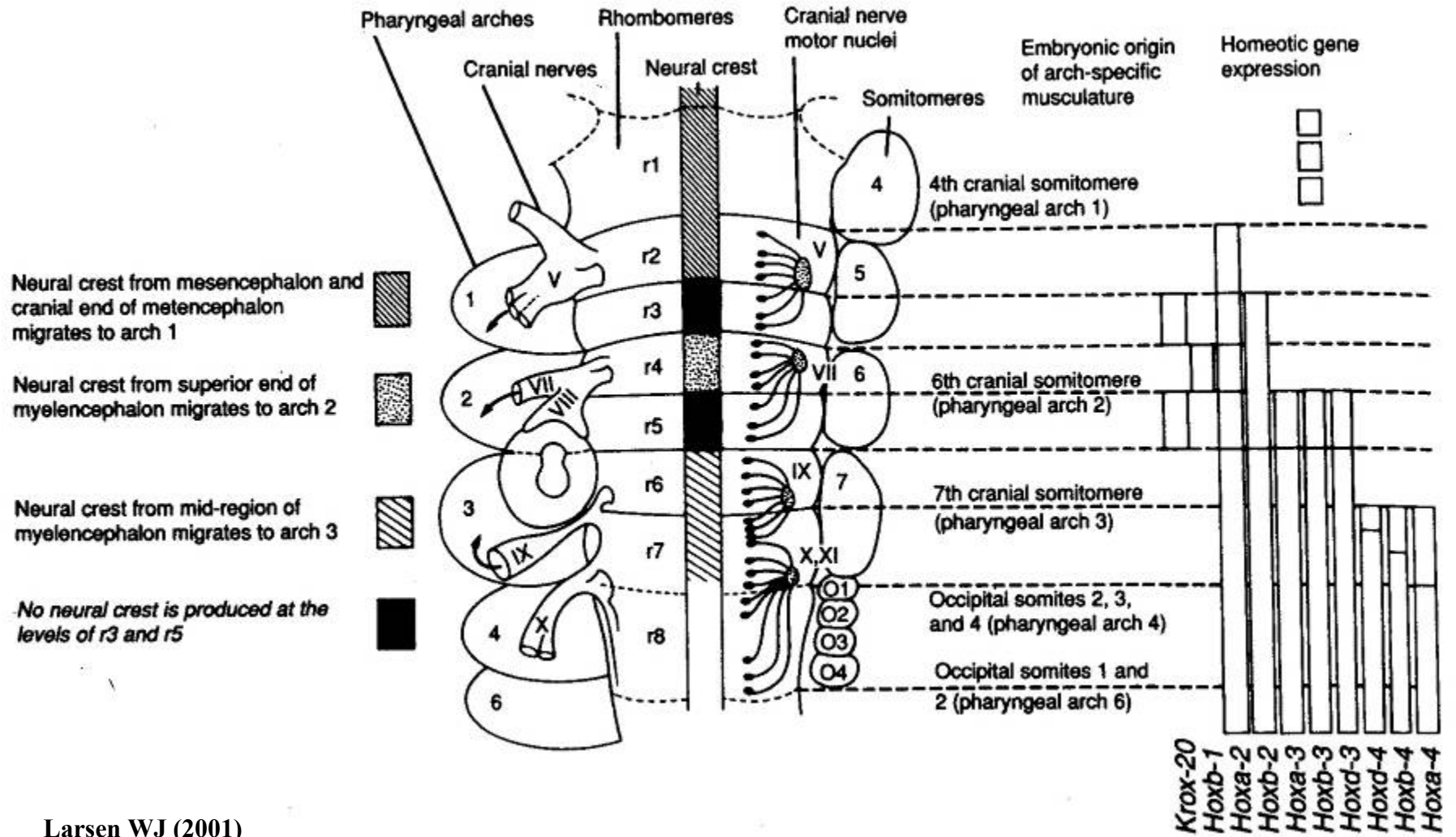
Hox 7



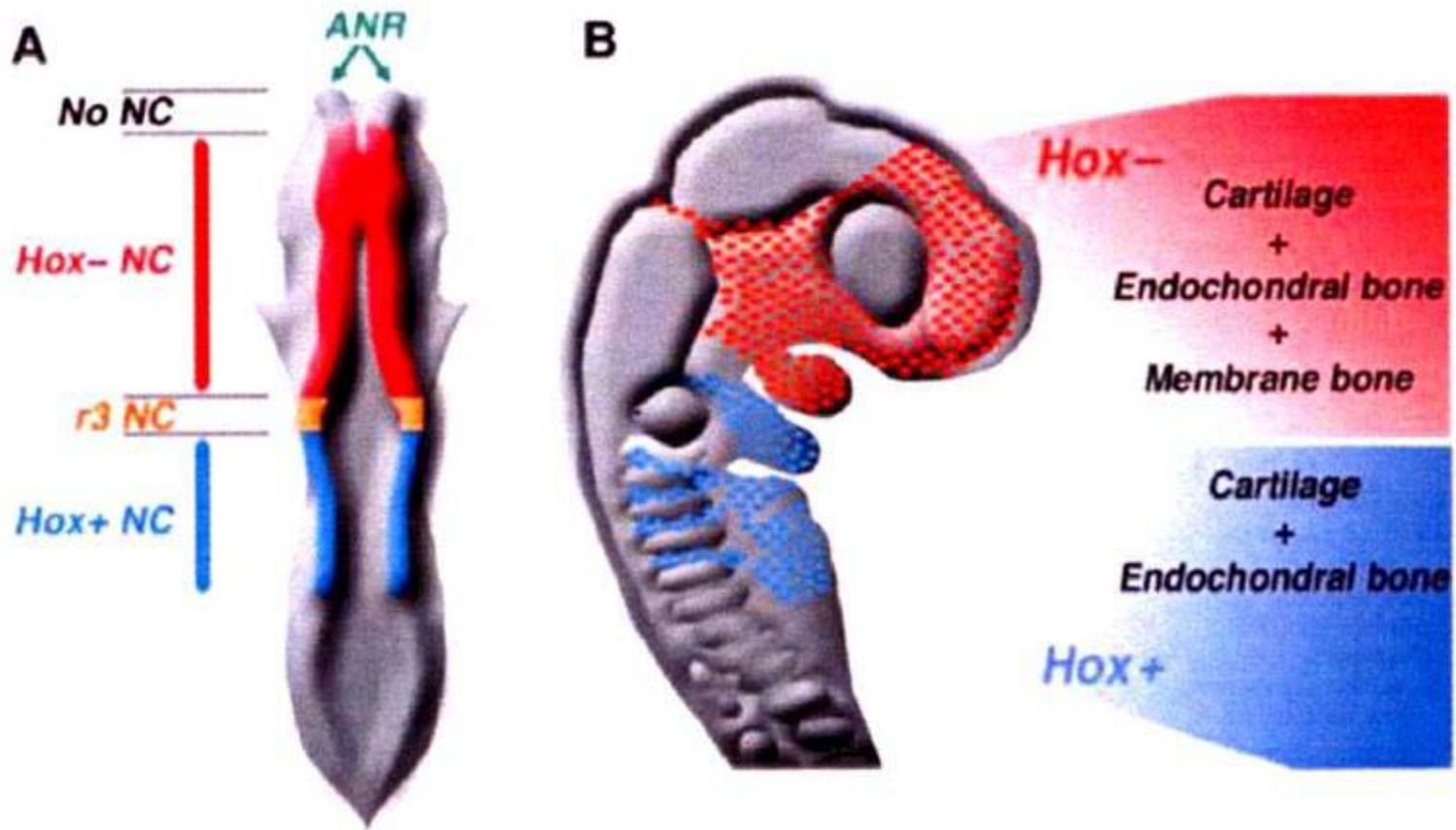
posterior

Imura T, Pourquié O (2007)

B



Larsen WJ (2001)



Creuzet S, Couly G, Le Douarin NM (2005)

Ten Cate AR (1988)

Segmental components of arches

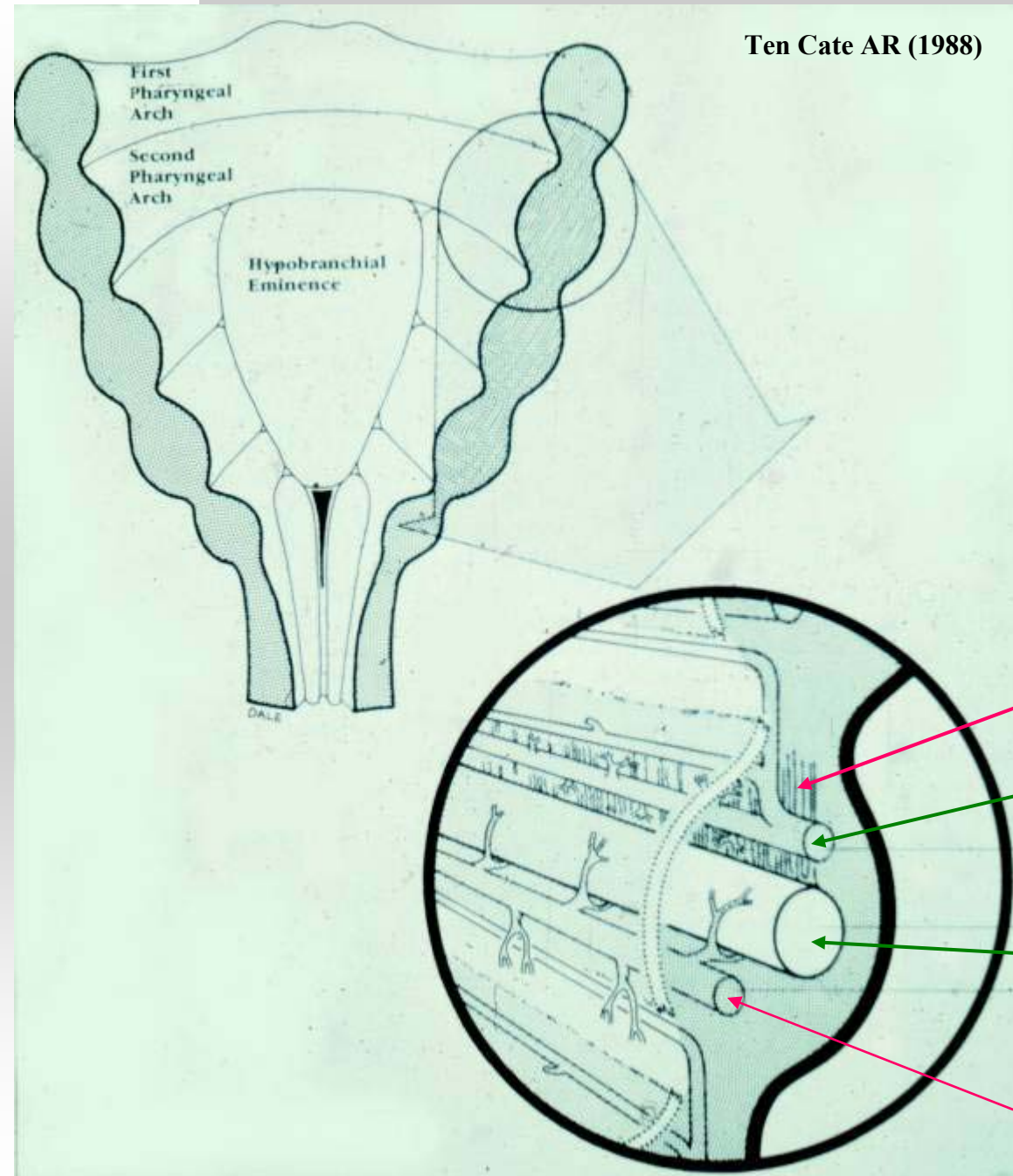
Connective tissues - nc

Muscle – mesoderm

Branchiomeric nerve –
nc,ectoderm,neurectoderm

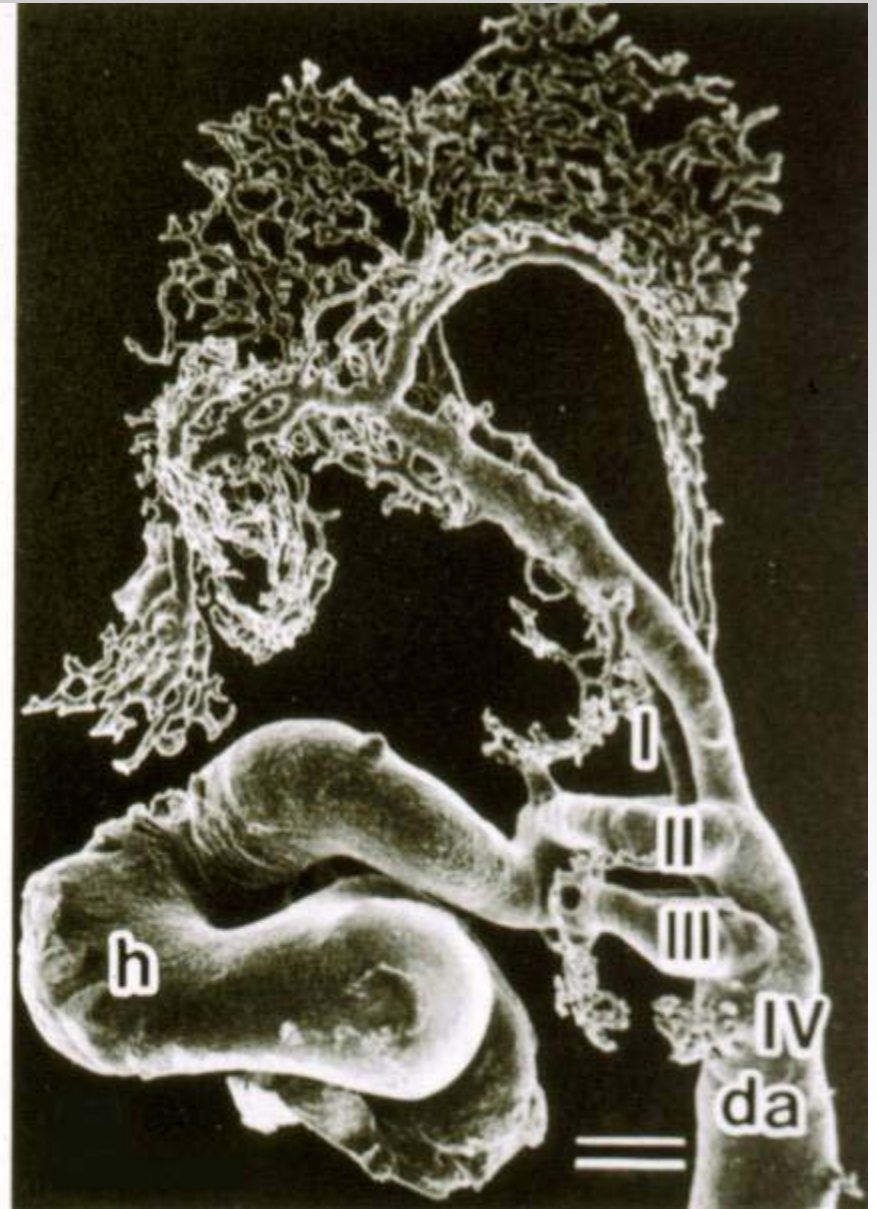
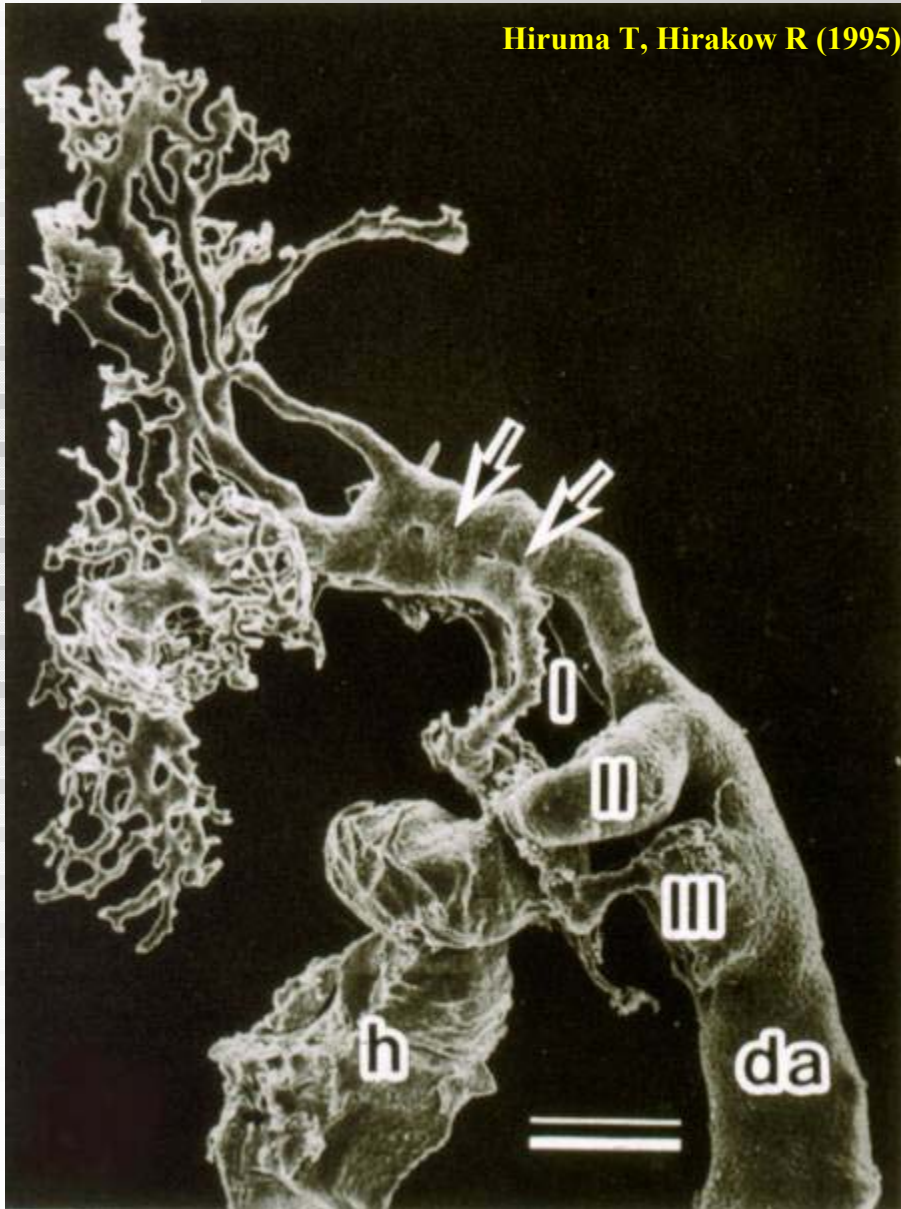
Skeletal bar- nc -
(cartilage) last to form

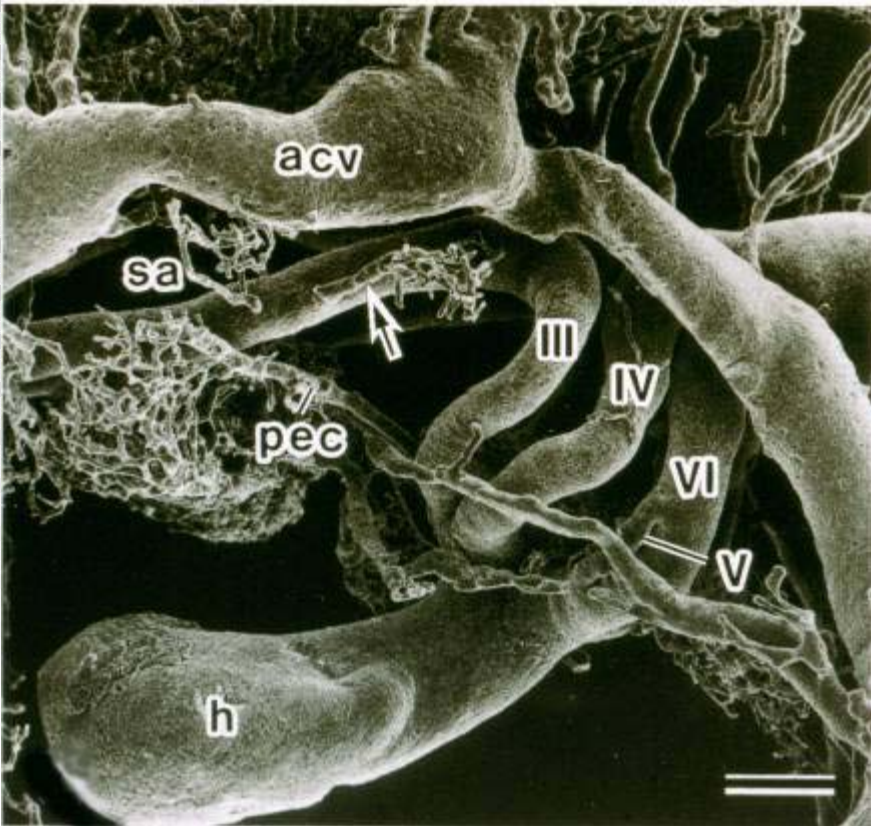
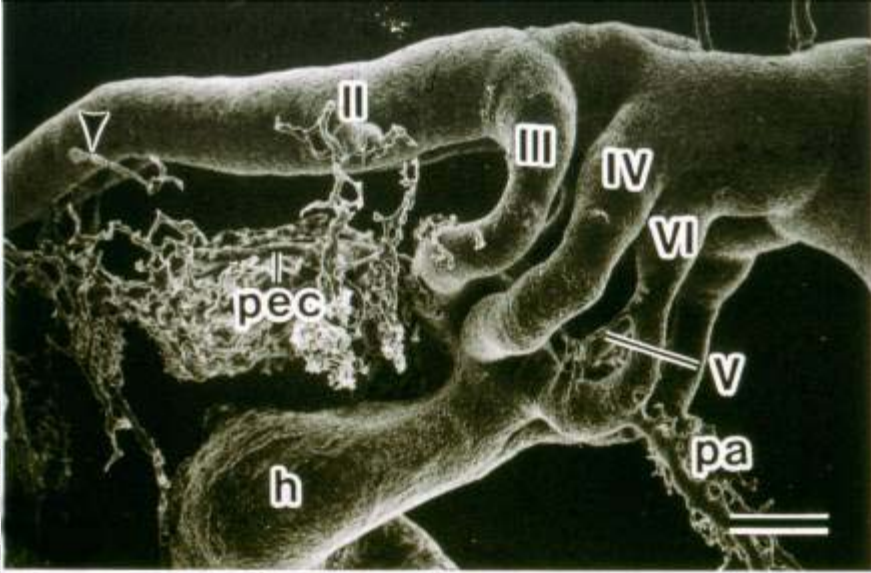
Artery – mesoderm-
first to appear



Aortic arch development

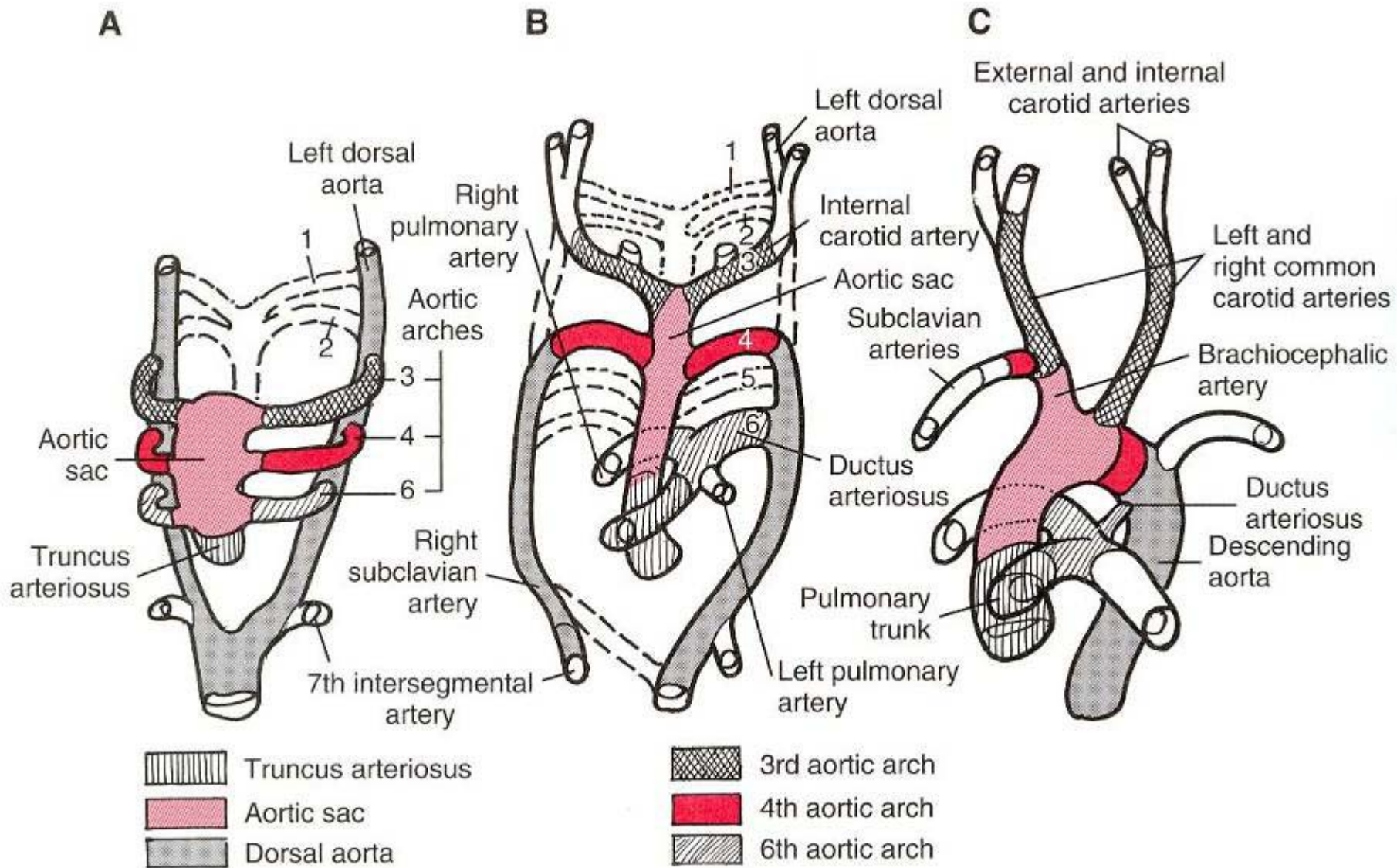
Hiruma T, Hirakow R (1995)



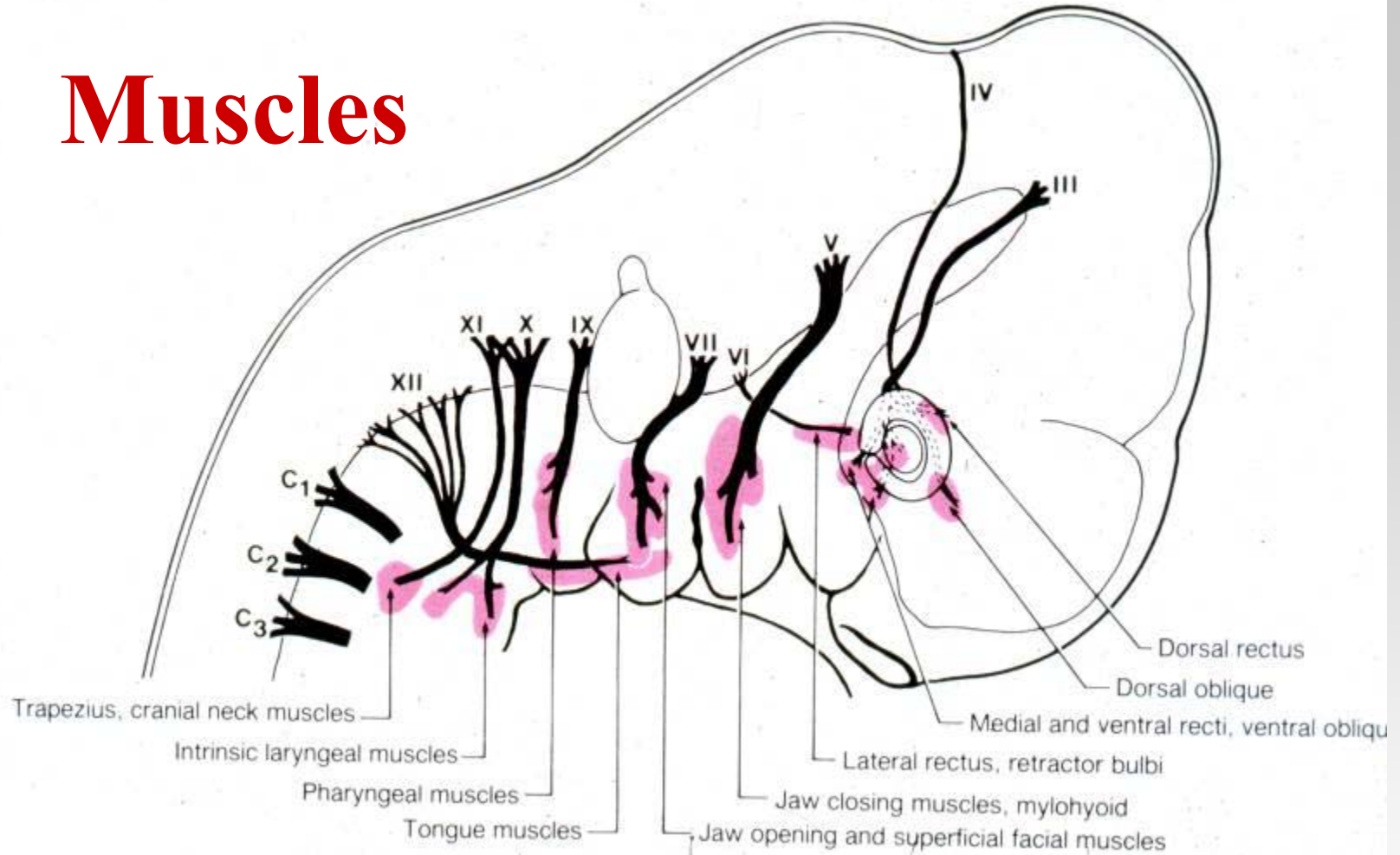


Aortic arch development cont'd

Hiruma T, Hirakow R (1995)



Muscles



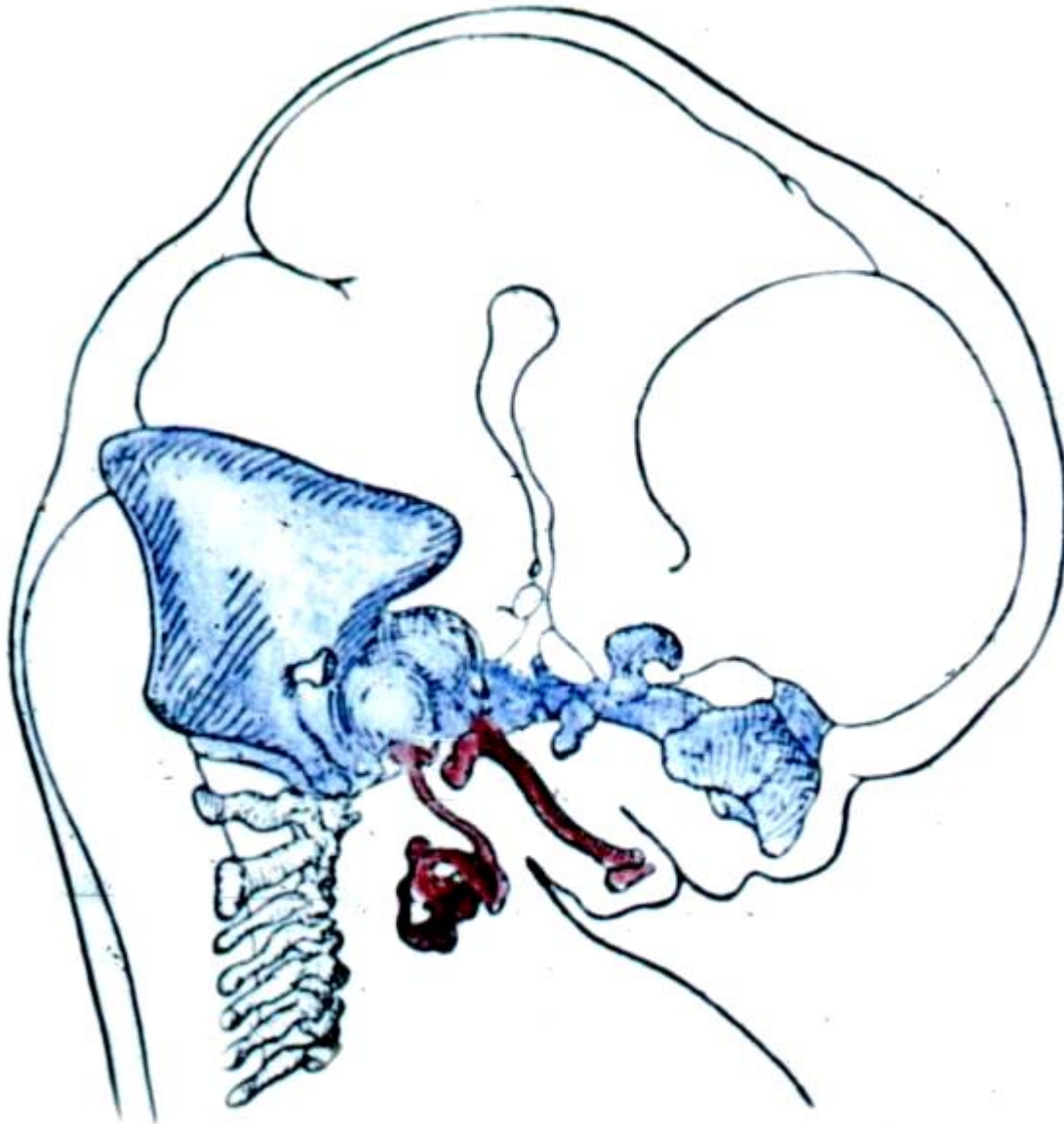
Arch 1: Muscles of mastication (V)

Arch 2: Muscles of facial expression (VII)

Arch 3: Stylopharyngeus muscle (IX)

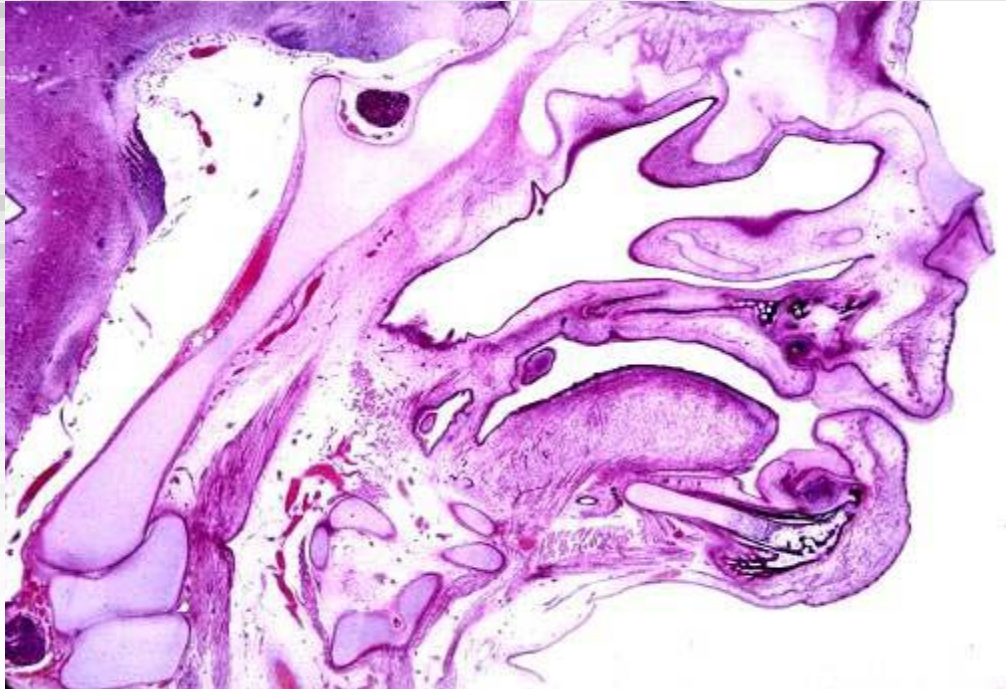
Arch 4-6: Laryngeal muscles (X-XI)

Noden D M, Lahunta A de (1985)



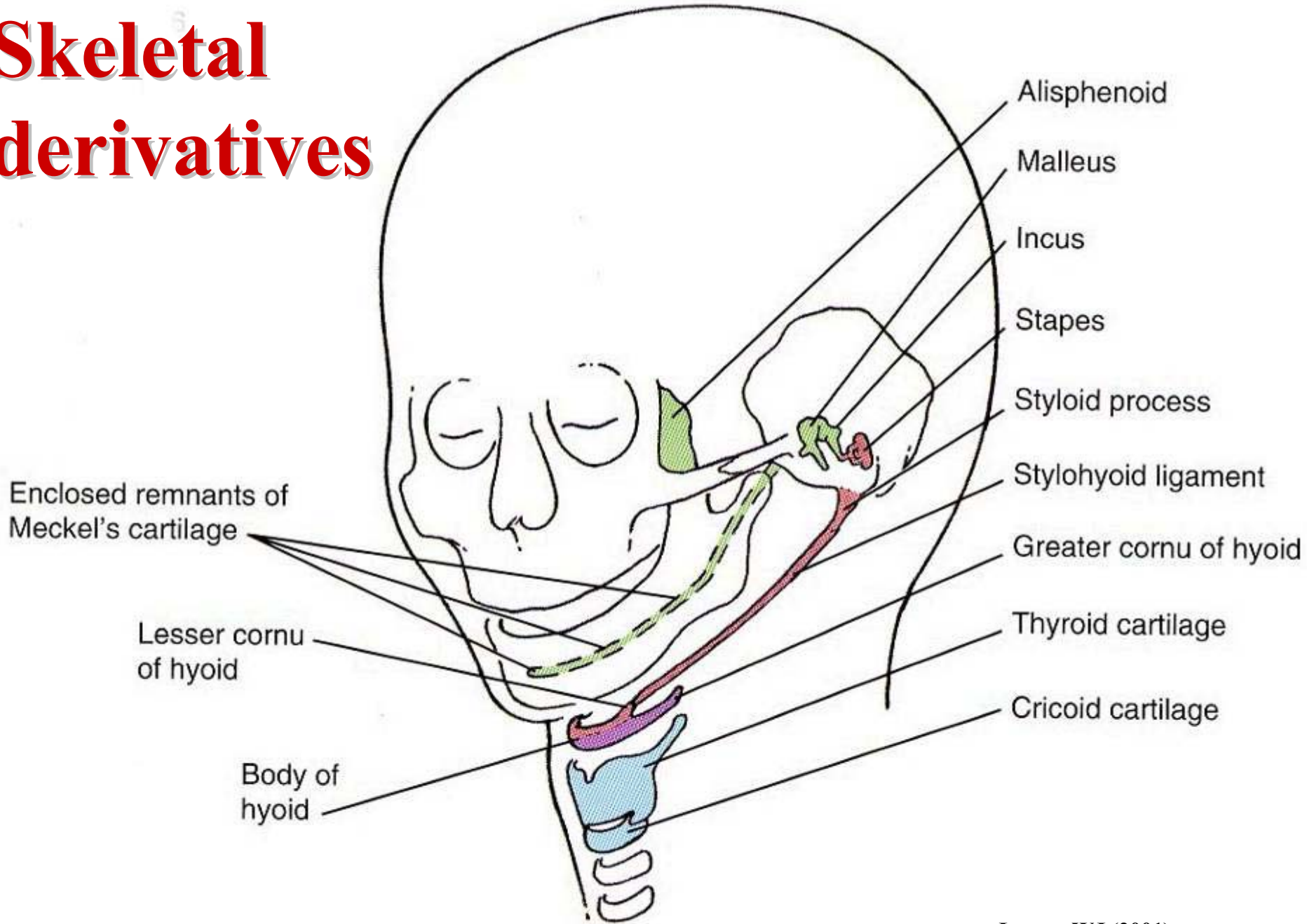
The cartilage elements of the pharyngeal arches (cartilaginous viscerocranium, purple) at 7 weeks.

Skeletal elements



Moss-Salentijn L et al (1972)

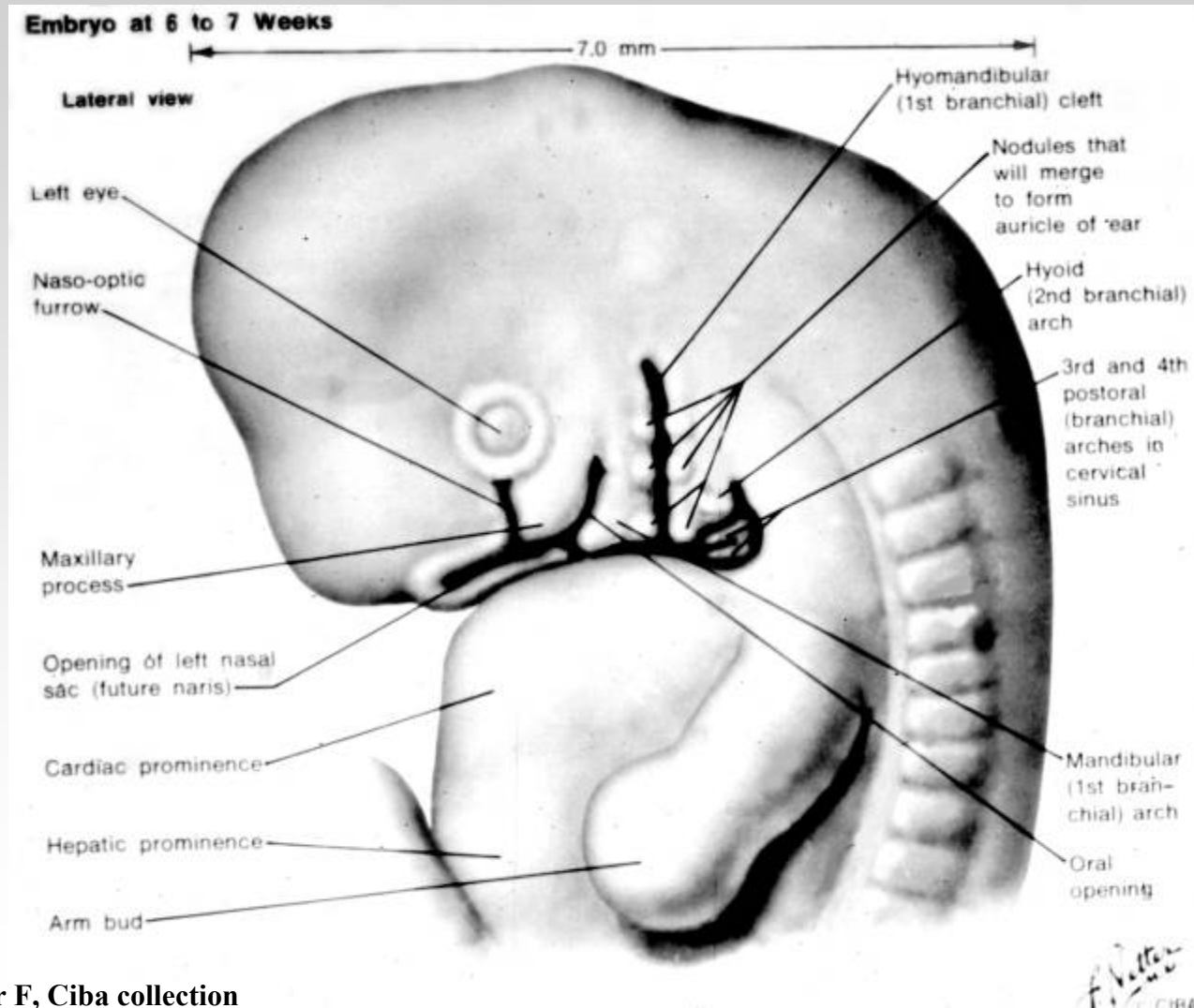
Skeletal derivatives



Larsen WJ (2001)

20 weeks

External ear receives contributions from arches 1 and 2



External ear development by merging of 6 auricular hillocks



Human embryo of 13 mm :
about 42 days.



40 mm :
about 65 days.



52 mm :
about 72 days.



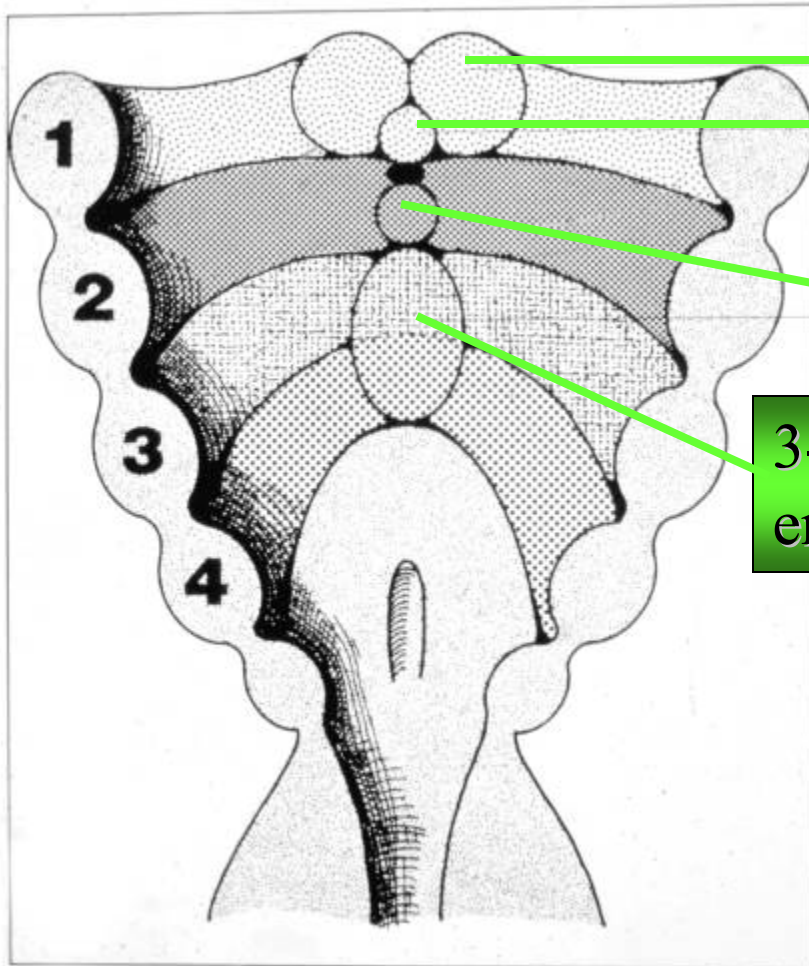
135 mm :
about 4½ months.



Adult.

Tuchmann-Duplessis H et al, (1975)

Endodermal swellings on arches 1-4 contribute to the tongue

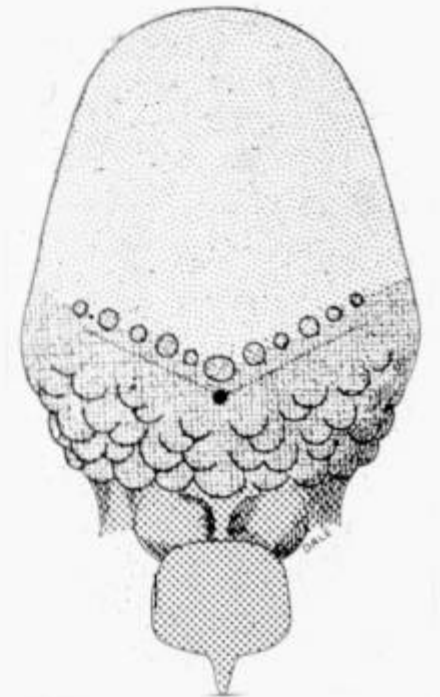
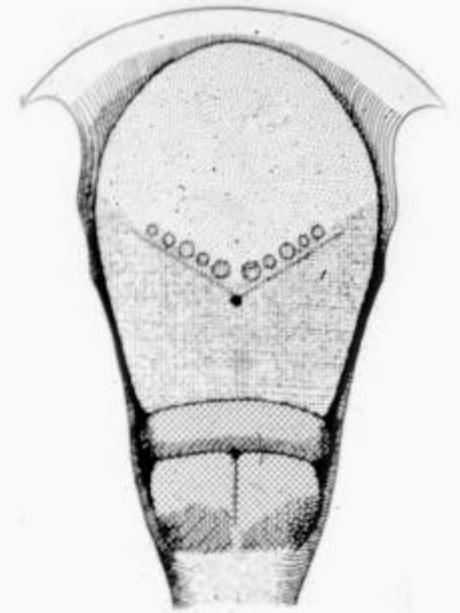
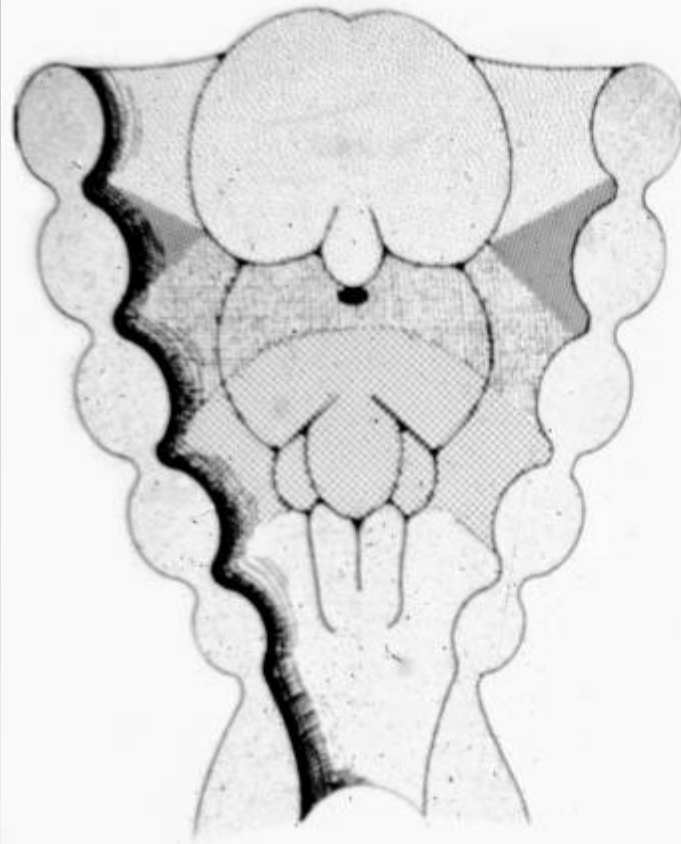


1. Paired lingual swellings and single median tuberculum impar

2. Single median copula

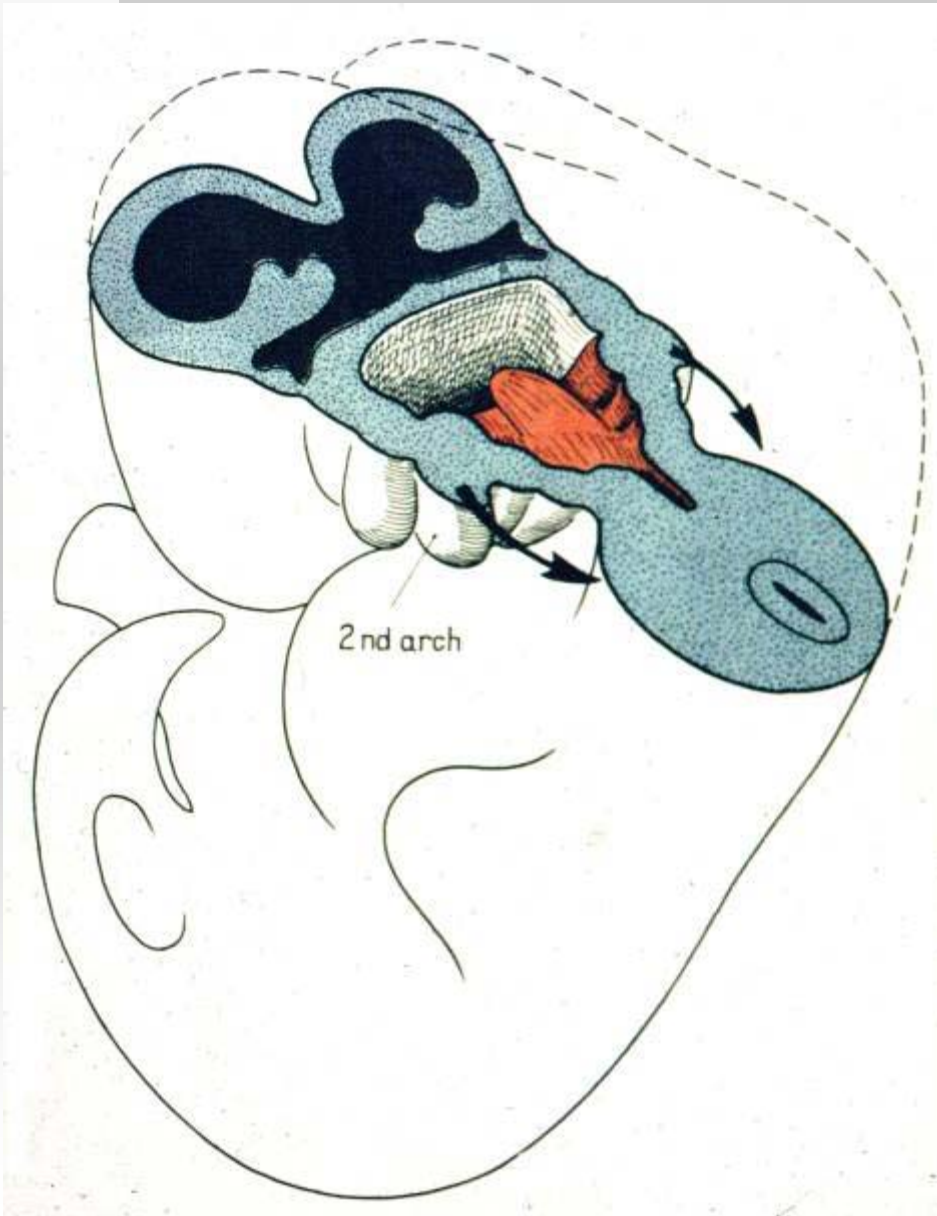
3-4. Combined median hypobranchial eminence

Merging of lingual swellings



Ten Cate AR (1988)

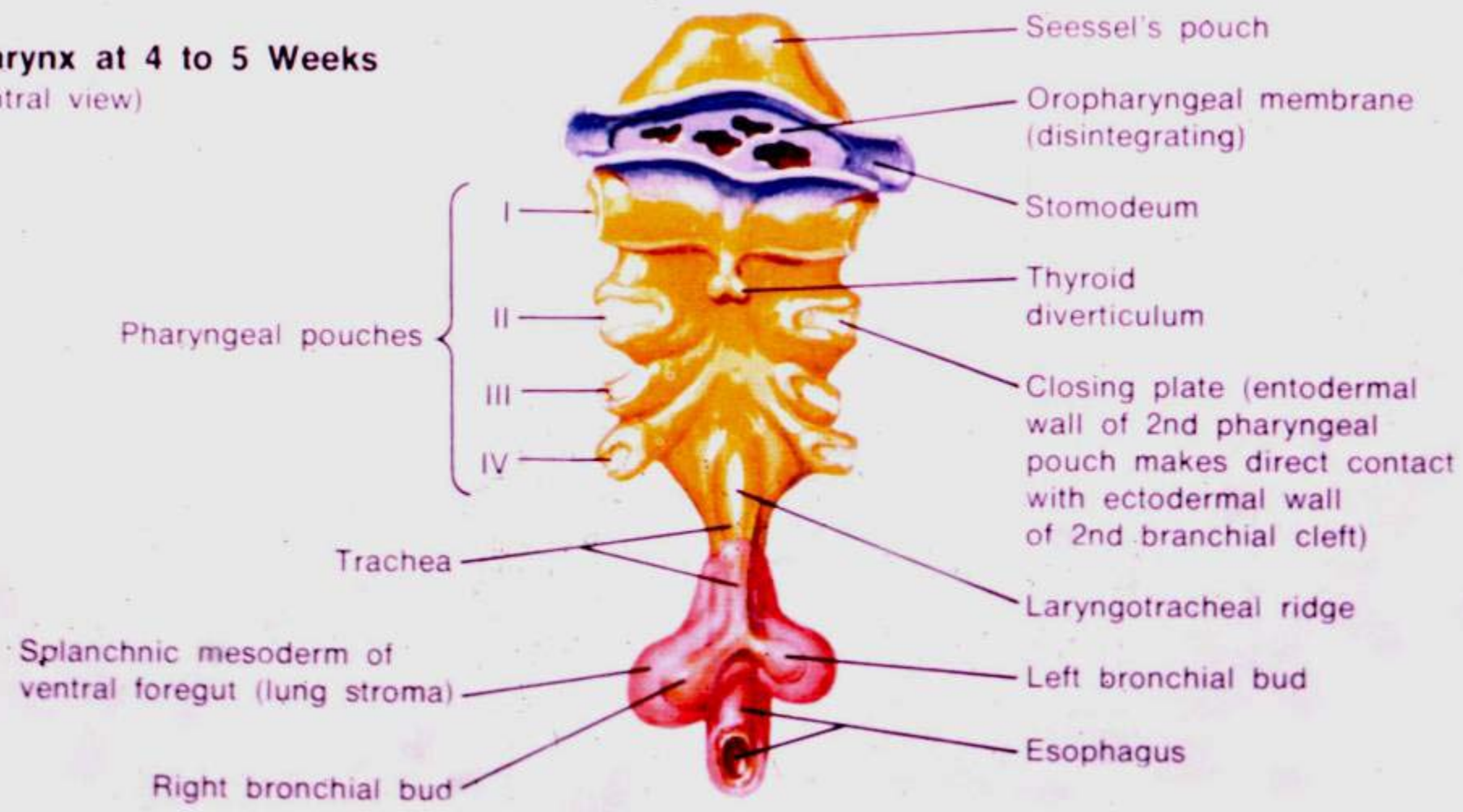
Fate of pharyngeal grooves 2-4



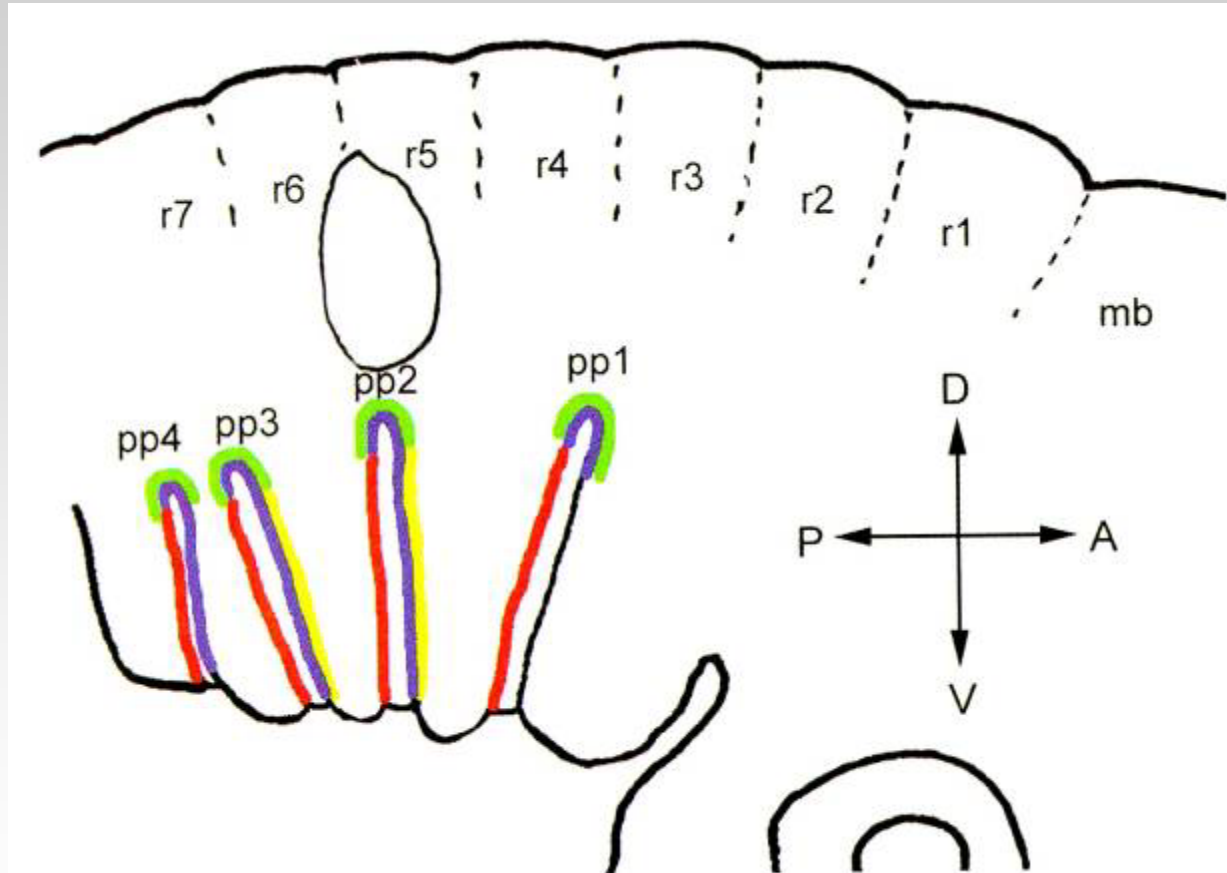
Covered by rapid outgrowth of 2nd arch “operculum.”

Pharynx at 4 to 5 Weeks

(ventral view)



Endoderm plays key role in morphogenesis of pharyngeal region

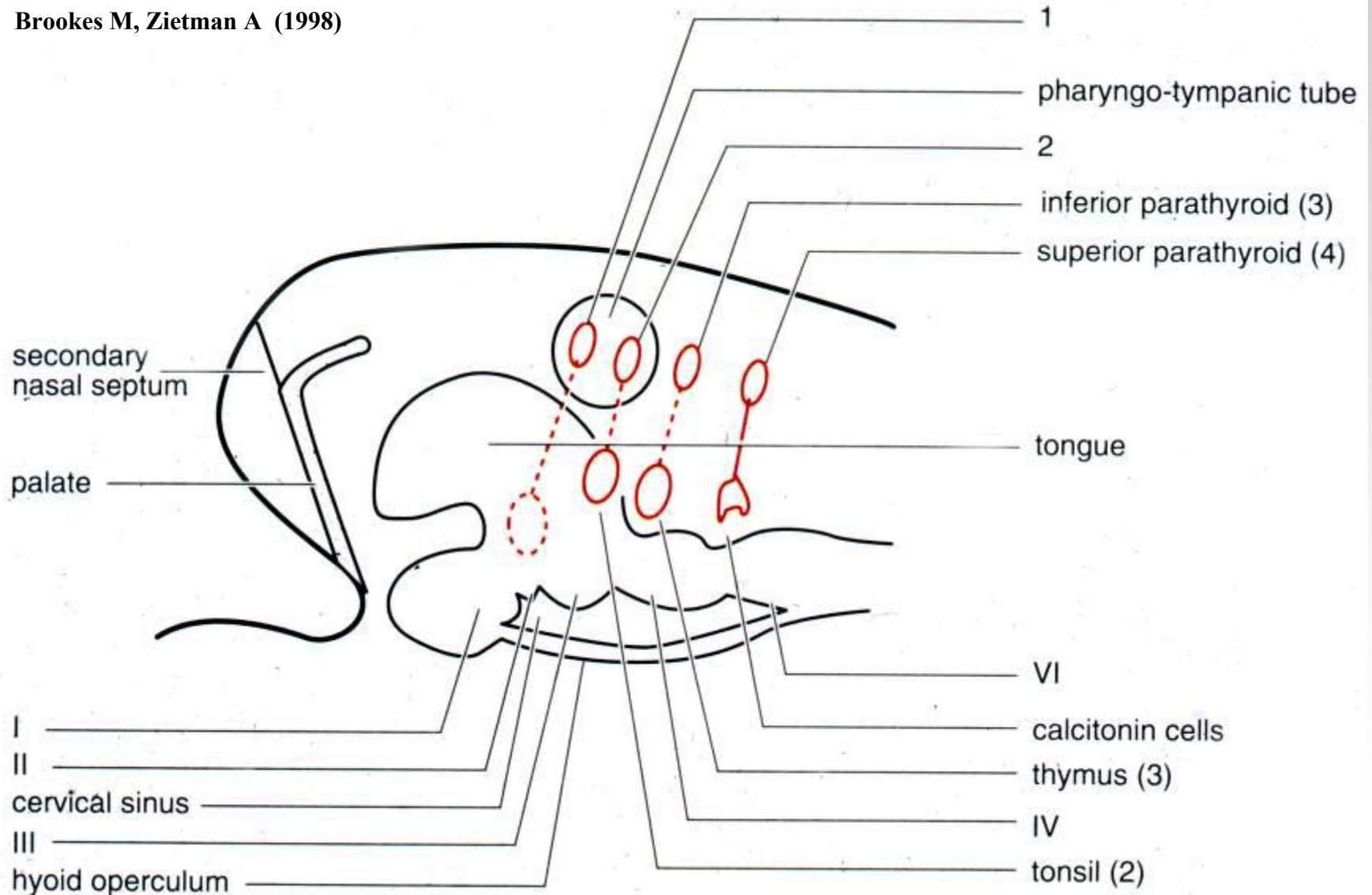


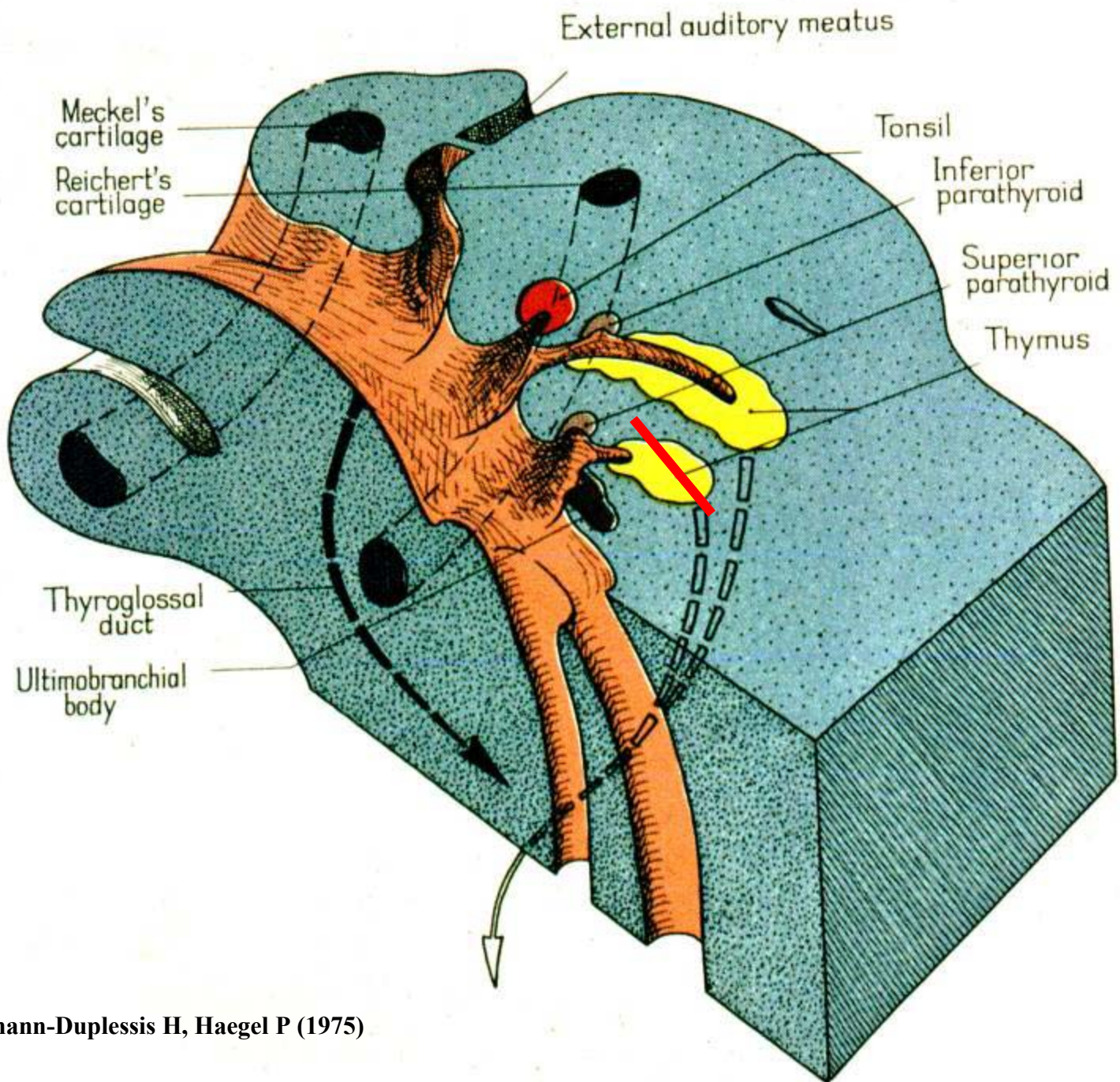
Graham A et al (2004)

-  Pax-1
-  BMP-7
-  Fgf-8
-  Fgf-8

Derivatives of dorsal and ventral parts of pharyngeal pouches

Brookes M, Zietman A (1998)



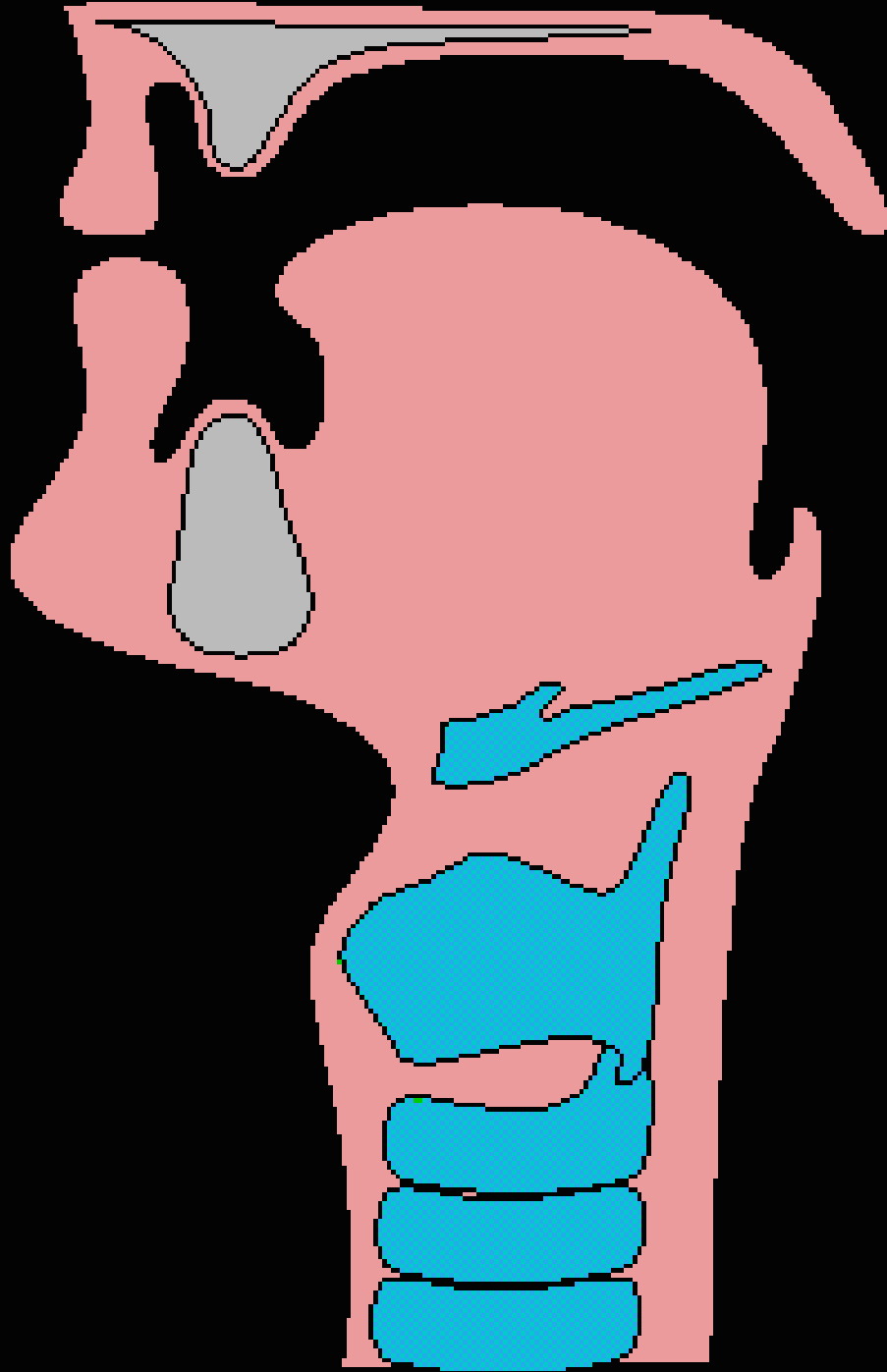


Tuchmann-Duplessis H, Haegel P (1975)

Thyroid gland development

Thyroglossal duct





Watt, Marie A, and Sanders, Colin
University of Glasgow

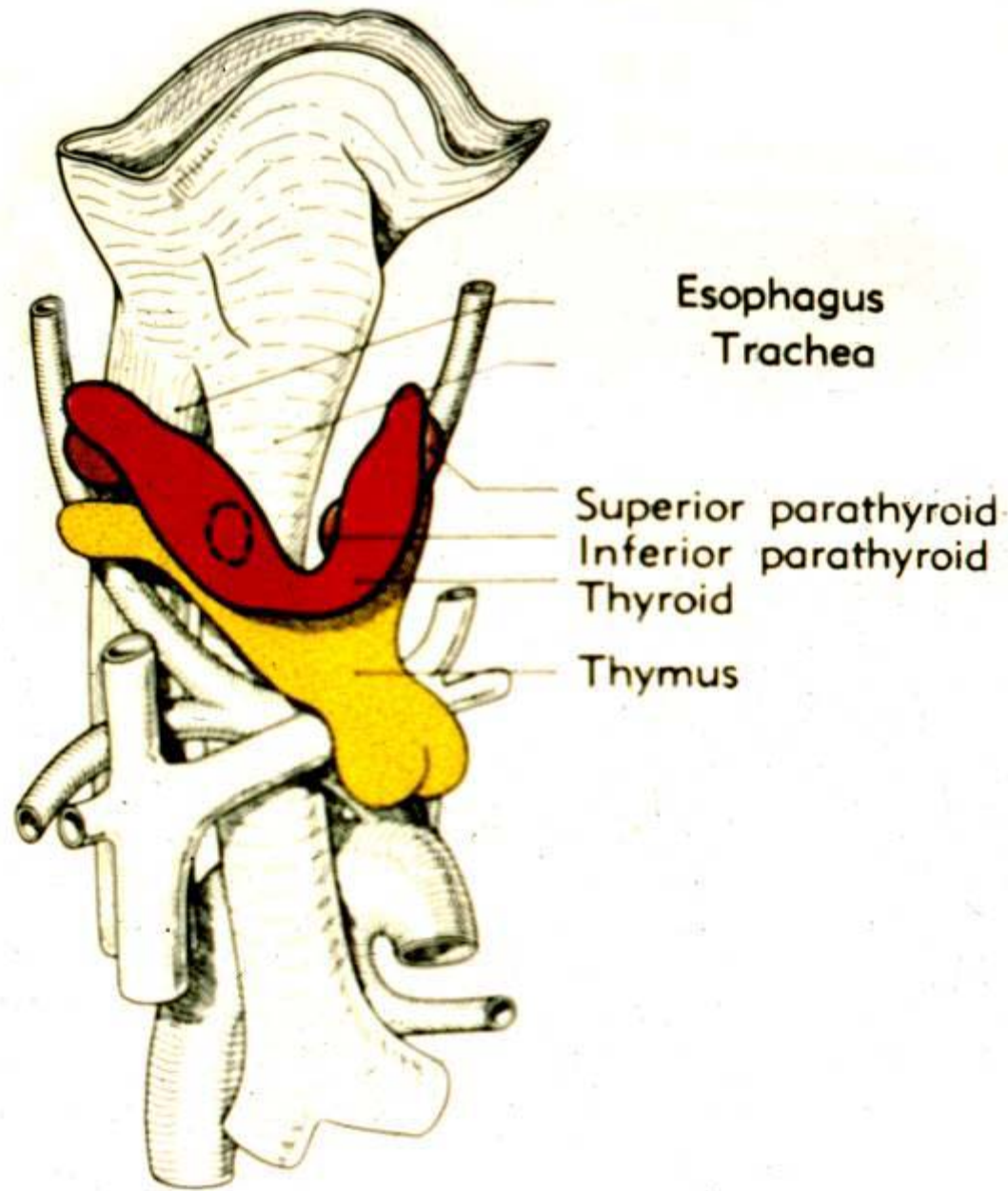
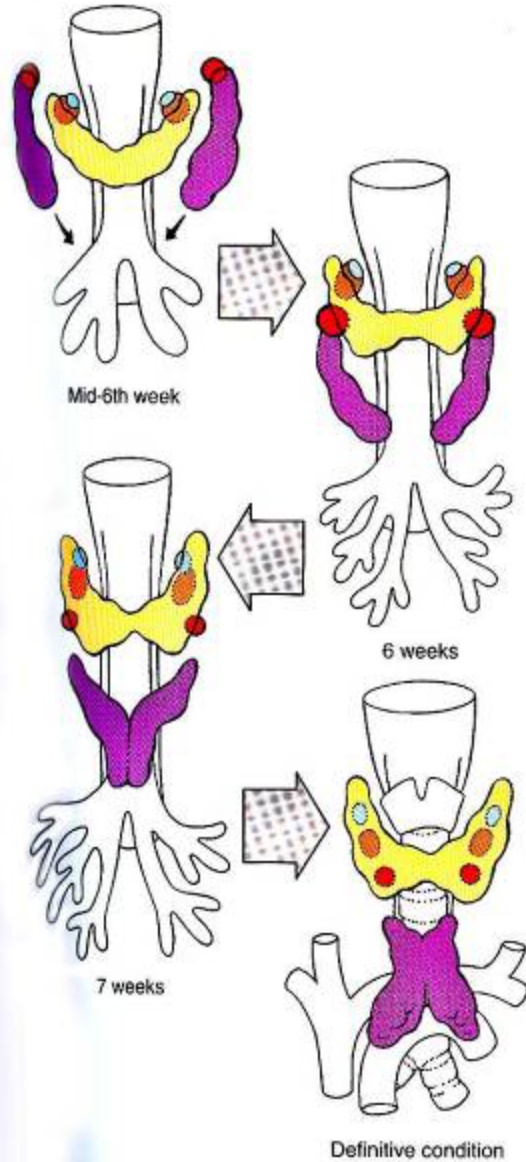


Diagram
showing thyroid in place.

Superior and inferior parathyroid glands

- Parathyroid III (inferior)
- Parathyroid IV (superior)
- Ultimobranchial body
- Thymus
- Thyroid



Larsen WJ (2001)