

Pharyngeal arches and pouches

L.Moss-Salentijn

Pharyngeal arches: a definition

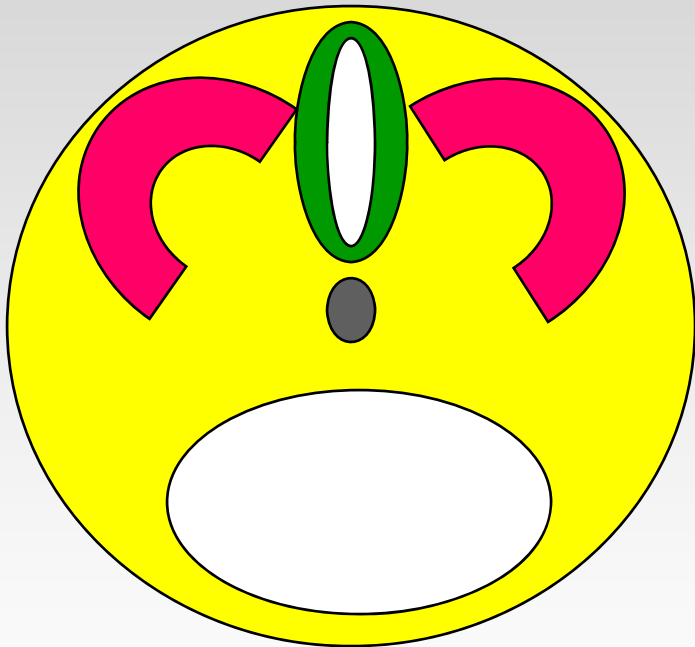
A **segmental series** of five paired swellings that surround the foregut between days 20 to 35 of embryonic development. These segments, which are unique to vertebrates and their immediate precursors, are “wedged” between the developing forebrain and heart.



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

Basic body plan of all chordates (incl. vertebrates)



Dorsal hollow neural tube

Segmented lateral mesoderm

Central notochord

Ventral digestive tube

(Pharyngeal gill slits)



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)

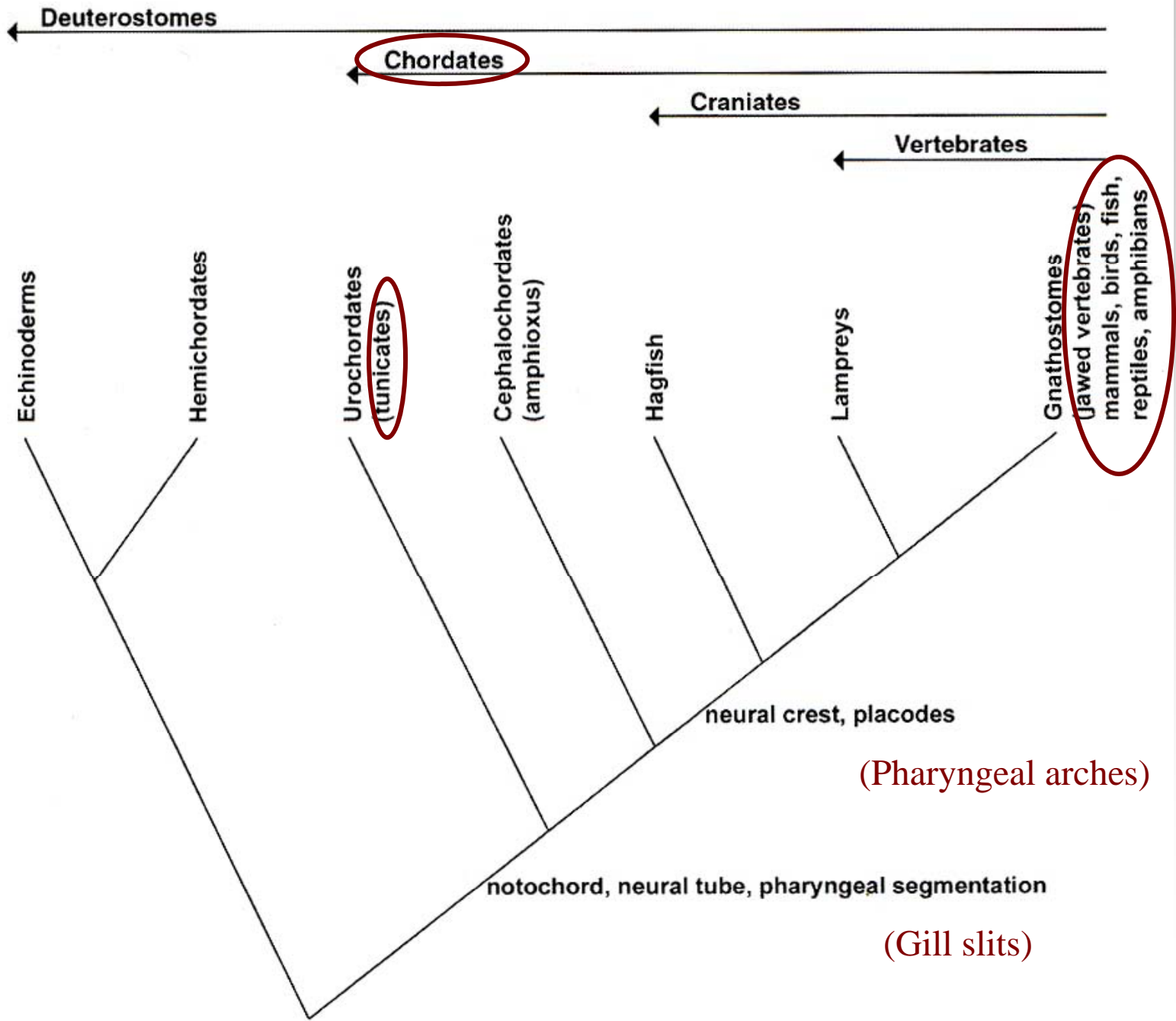
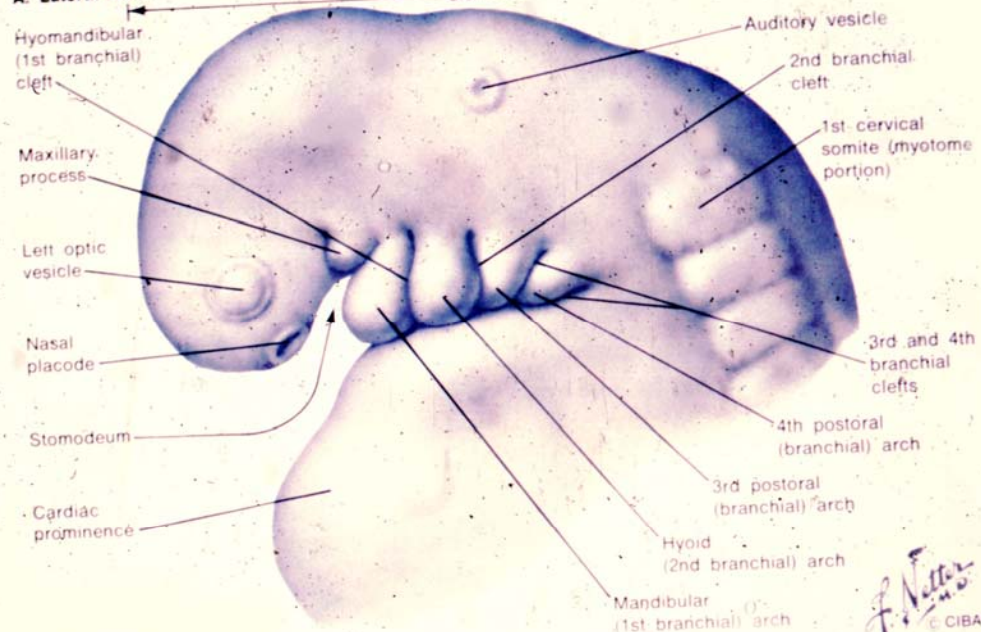


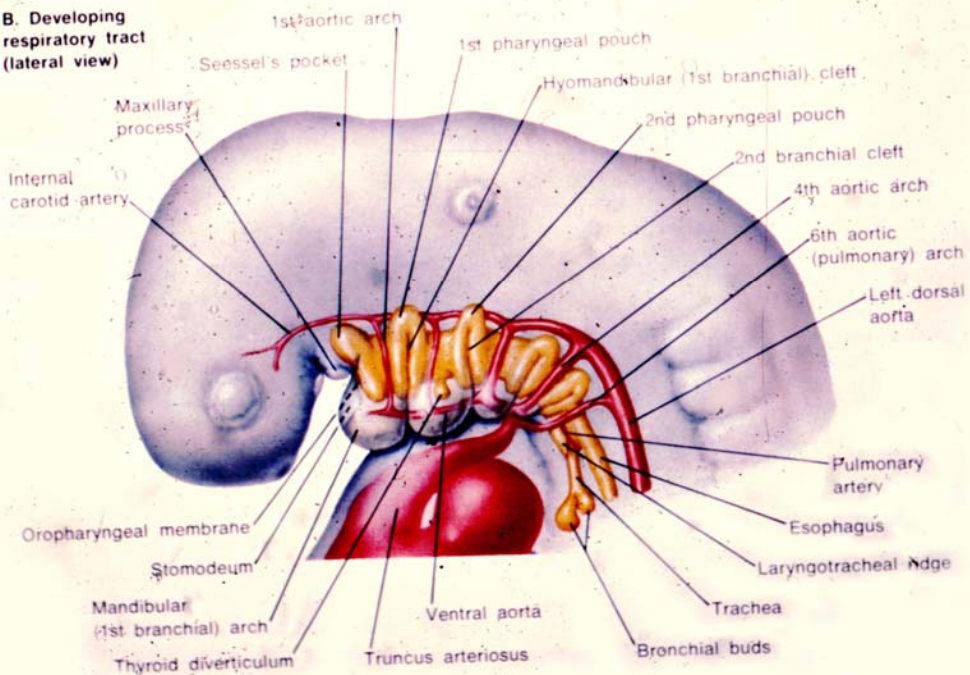
Plate 2

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

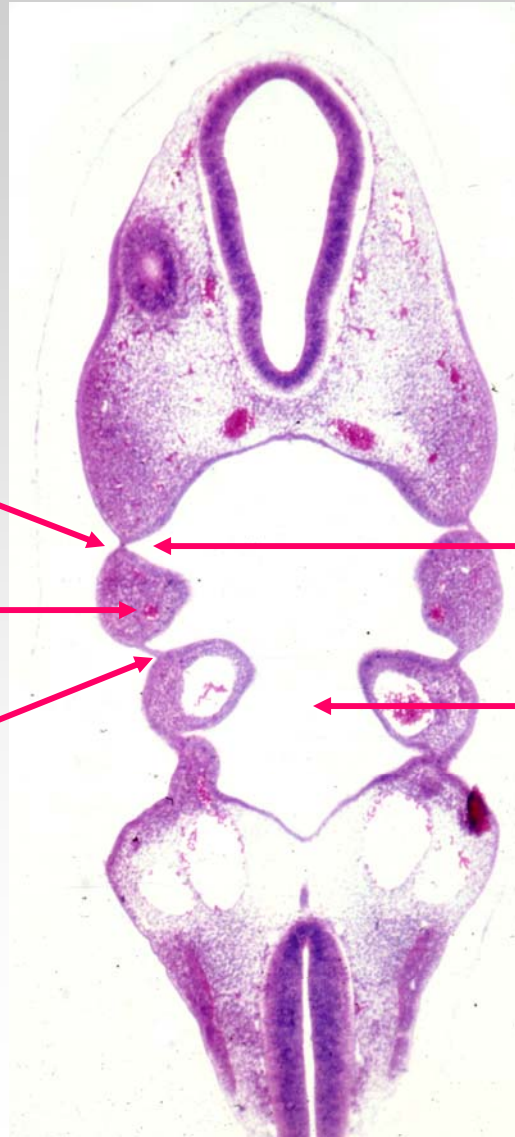
Netter F, Ciba collection

Arches, grooves, pouches, and membranes

Pharyngeal groove

Pharyngeal arch

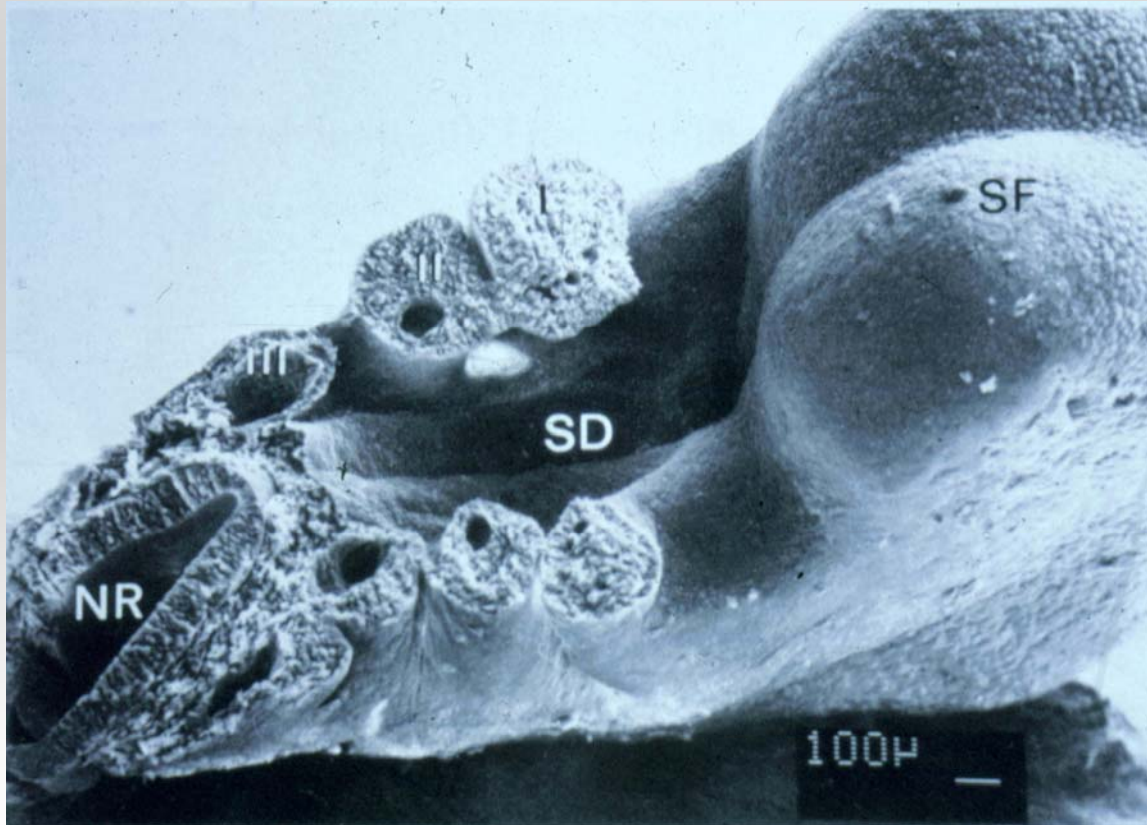
Pharyngeal membrane



Pharyngeal pouch

Foregut

Pharyngeal cleft transient “gill-slit”

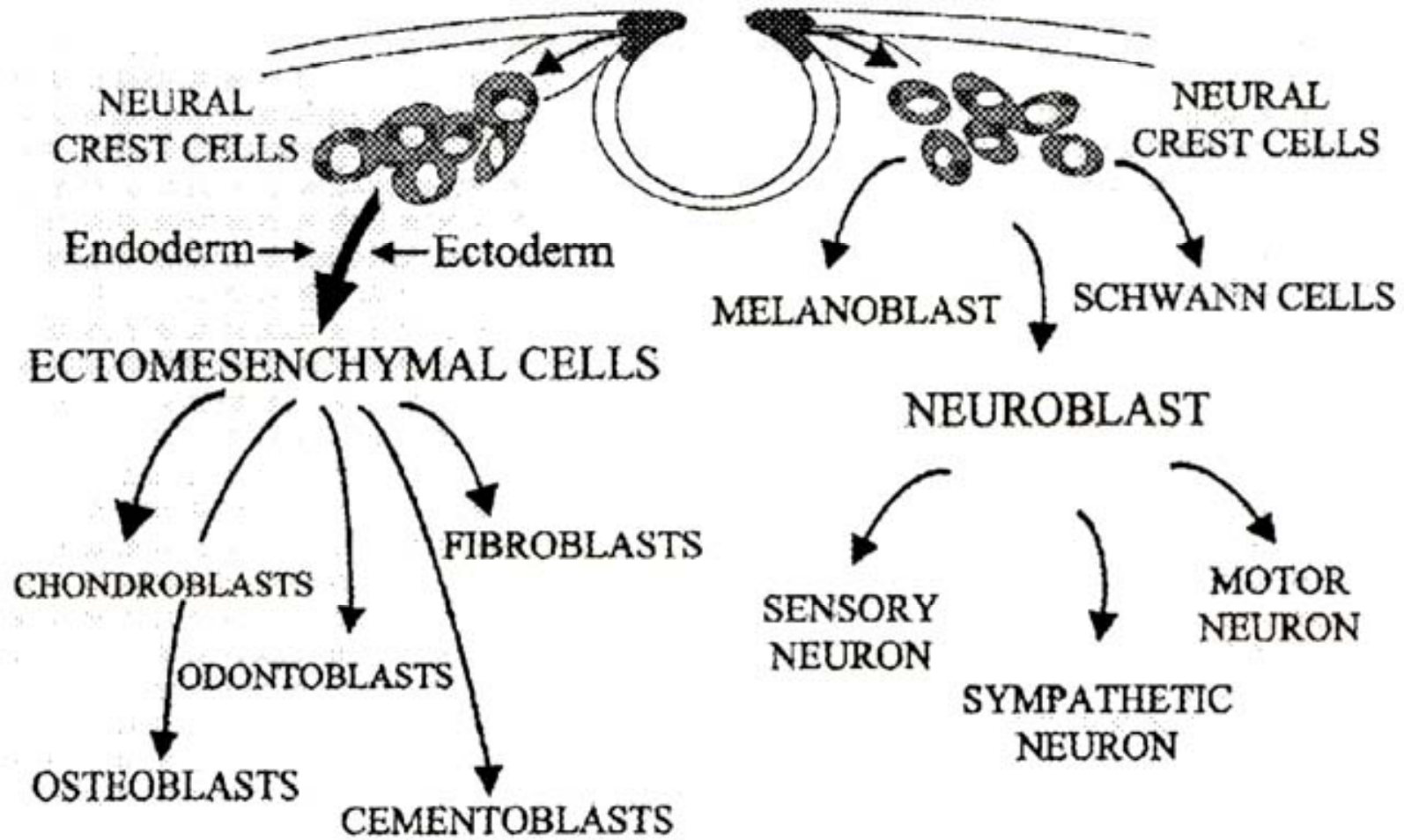


Mangold U et al (1981)



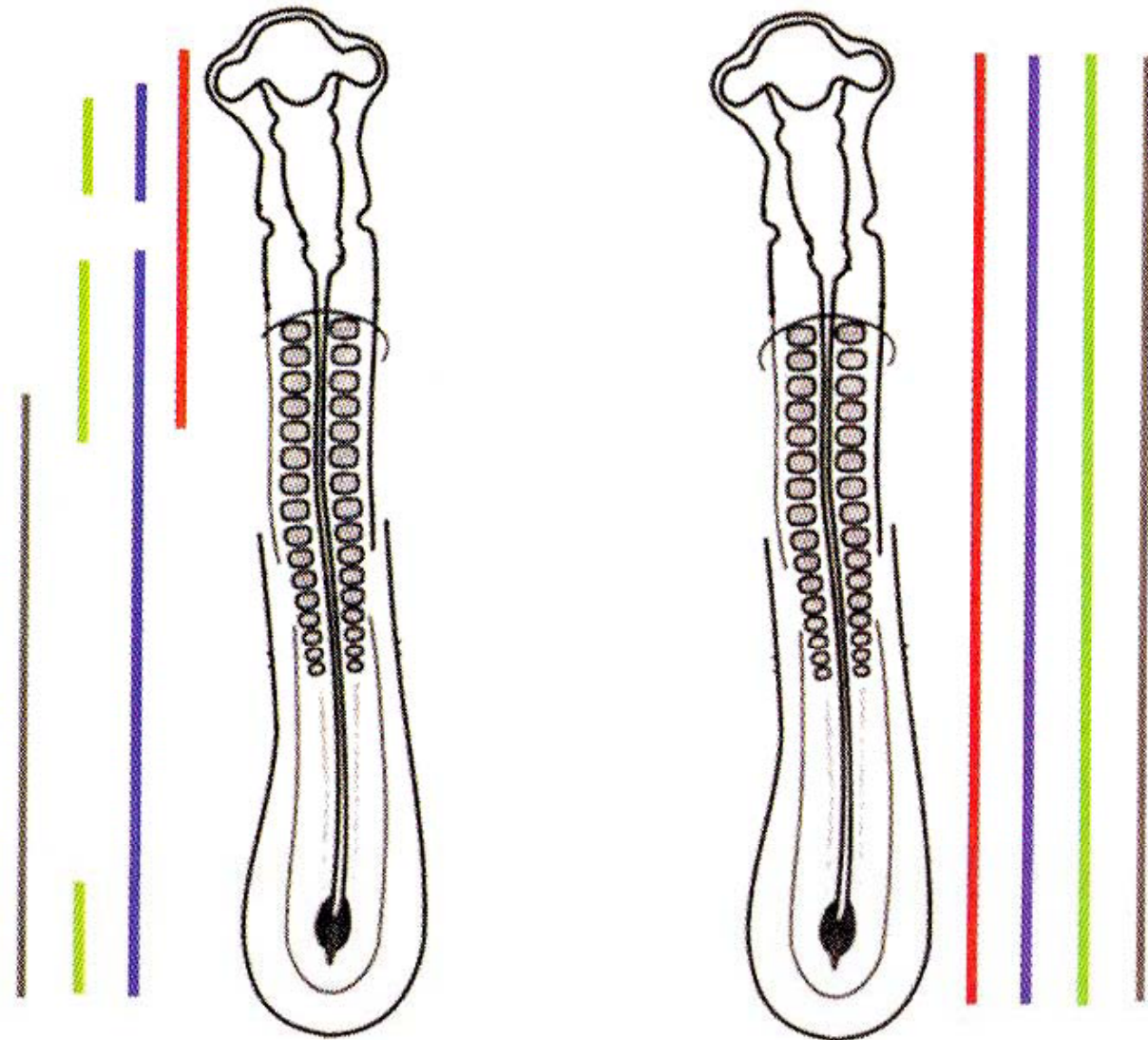
Mesenchyme in cephalic region is derived from:

- **Mesoderm**
- **Neural crest**



Fate

Potential



■ Ectomesenchyme

■ Sensory ganglia

■ Parasymp. ganglia

■ Sympathetic ganglia

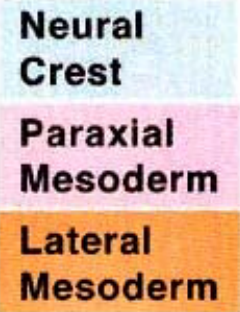
A

Unique to Mesoderm

Skeletal muscle
Cardiac muscle
Visceral smooth muscle
Endothelium
Endocardium
Serosa

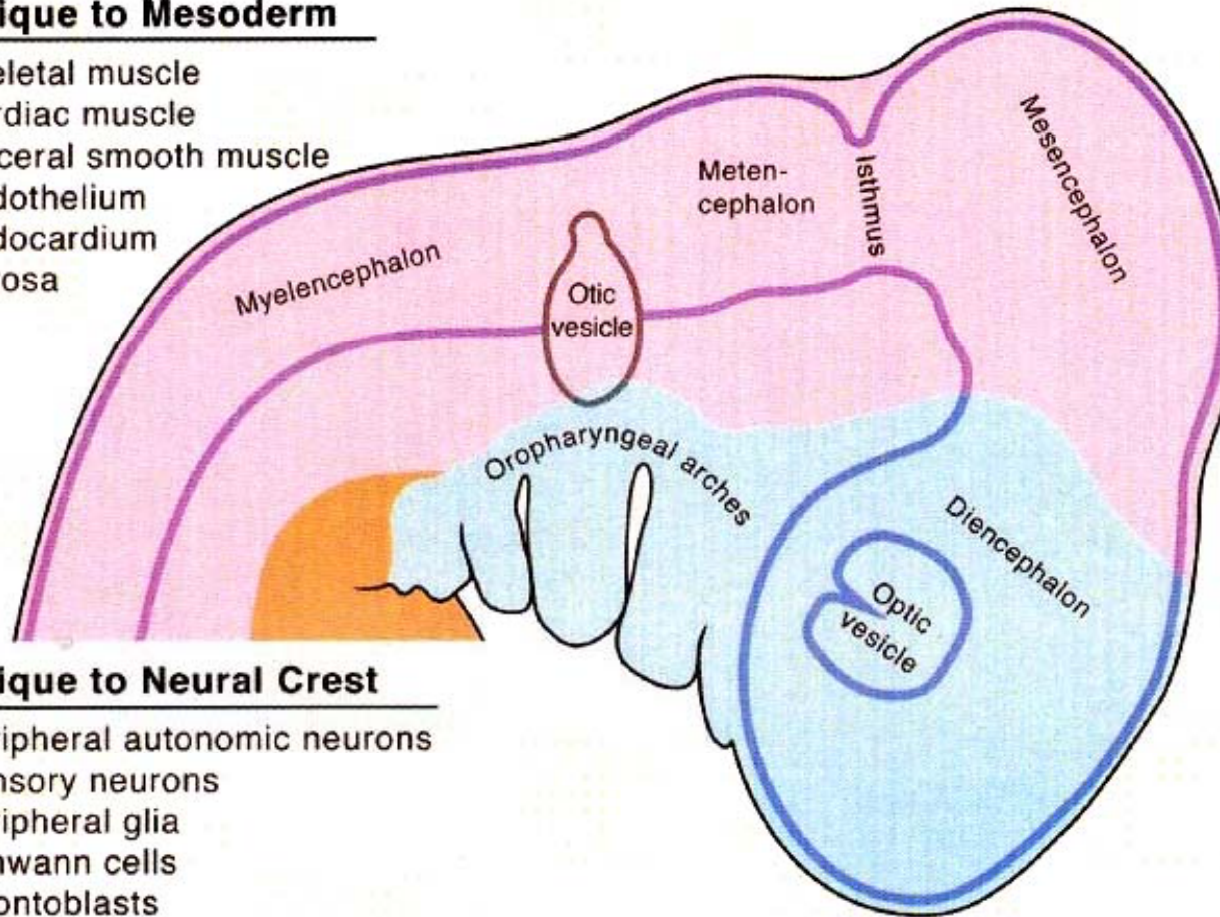
Derived from Mesoderm and Neural Crest

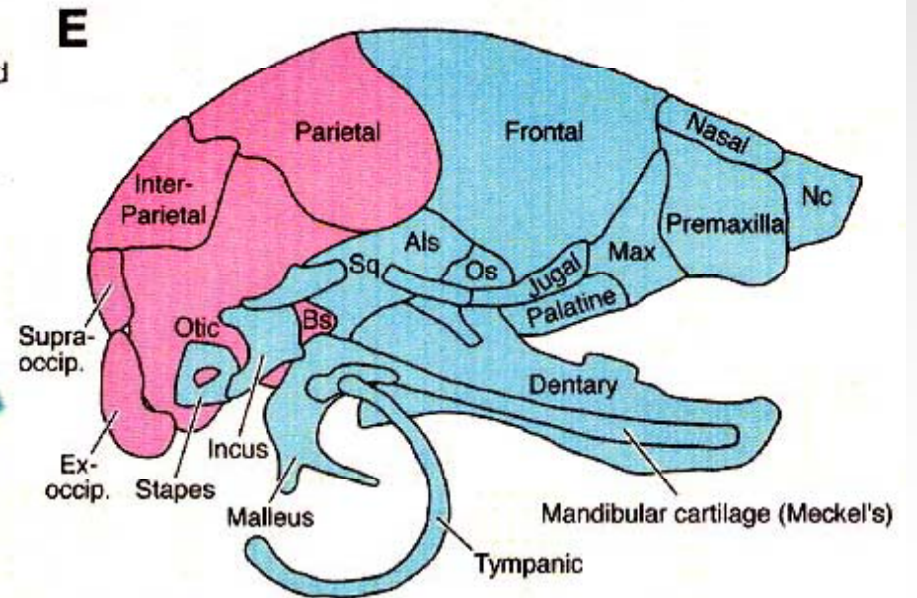
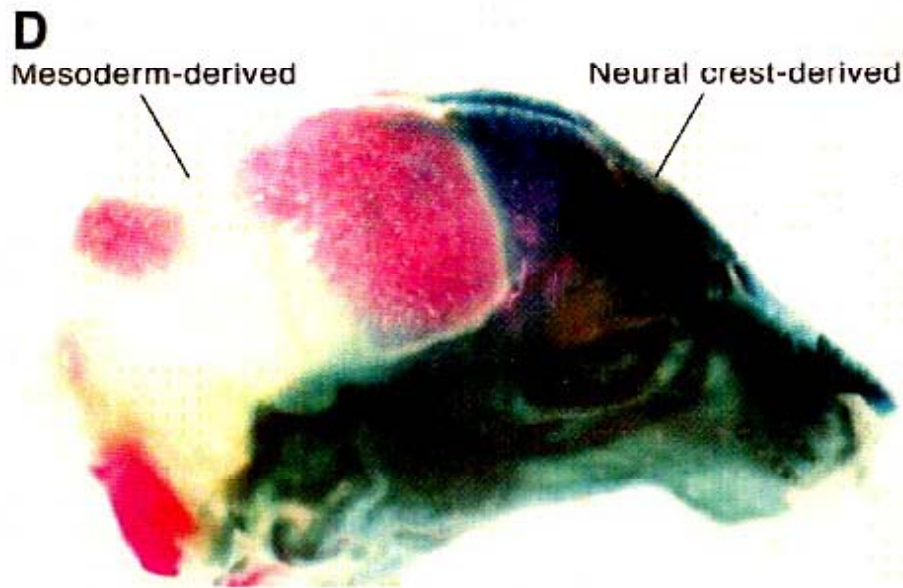
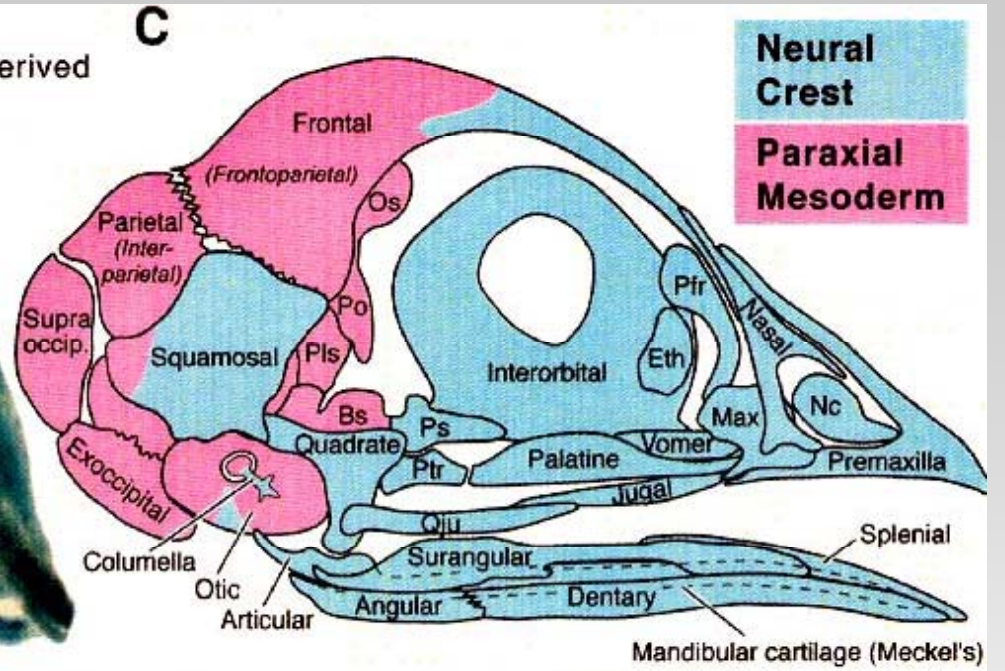
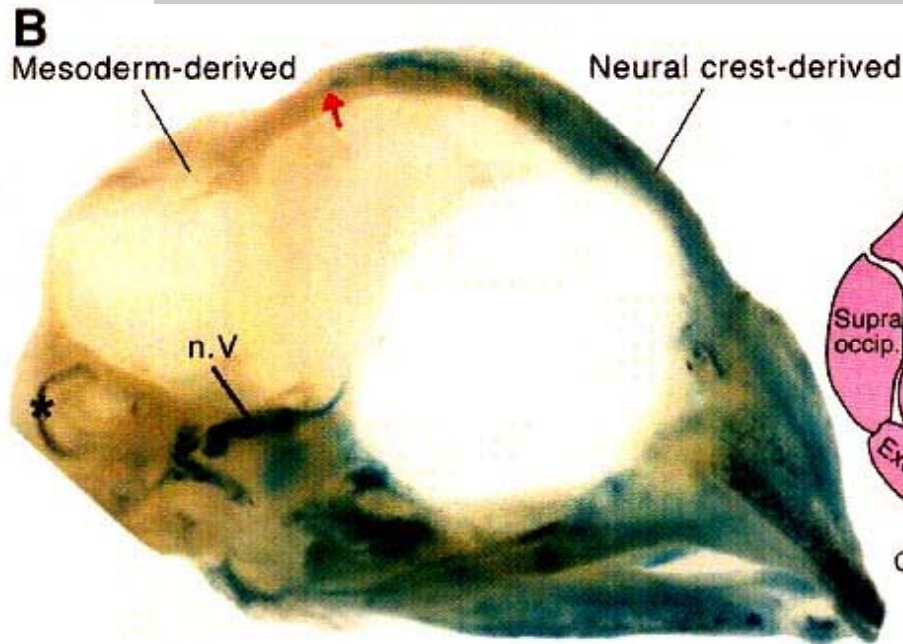
Cartilage
Endochondral bone
Intramembranous bone
Perivascular smooth muscle
Glandular stroma
Meninges
Dermis



Unique to Neural Crest

Peripheral autonomic neurons
Sensory neurons
Peripheral glia
Schwann cells
Odontoblasts

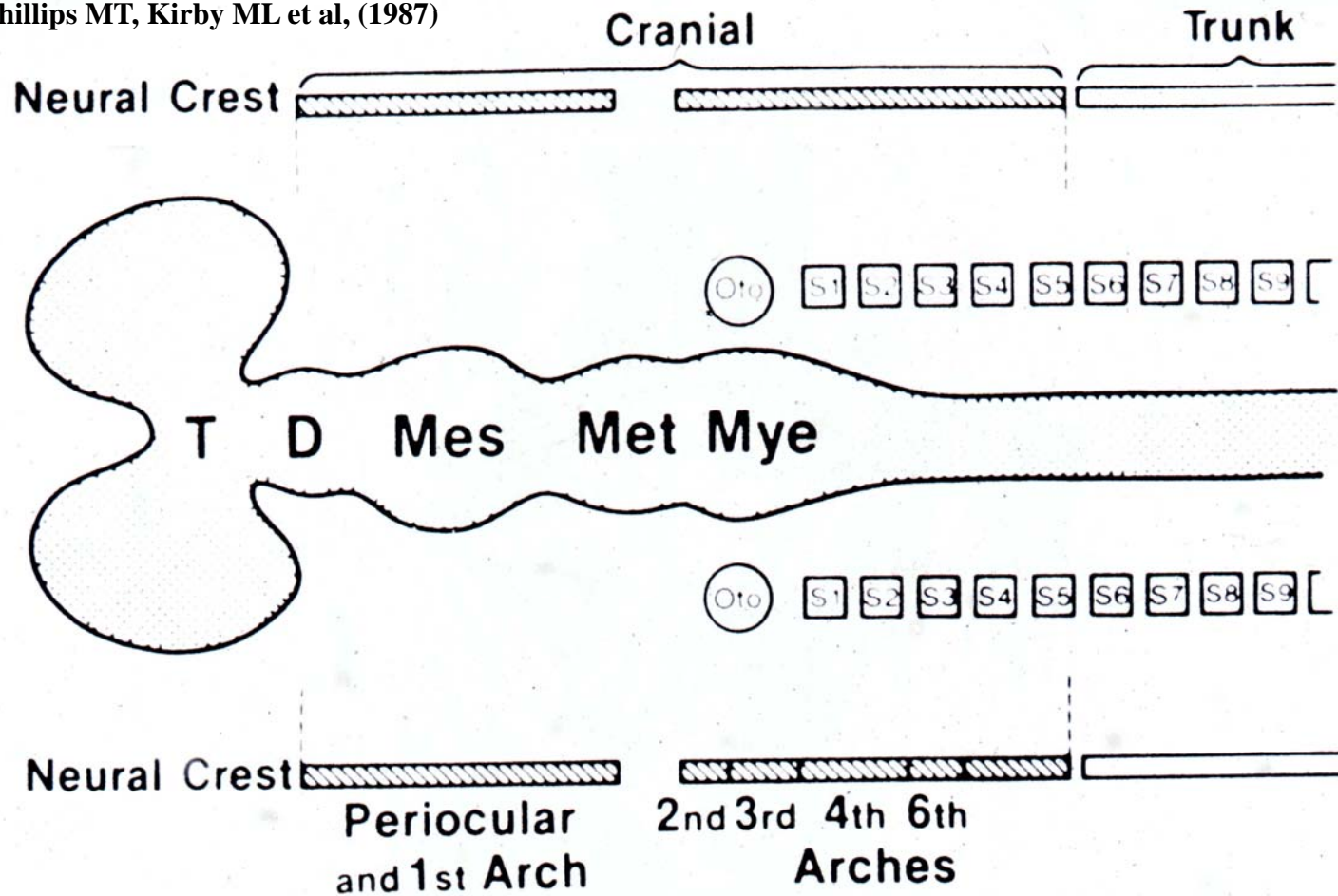




Noden DM, Schneider RA (2006)

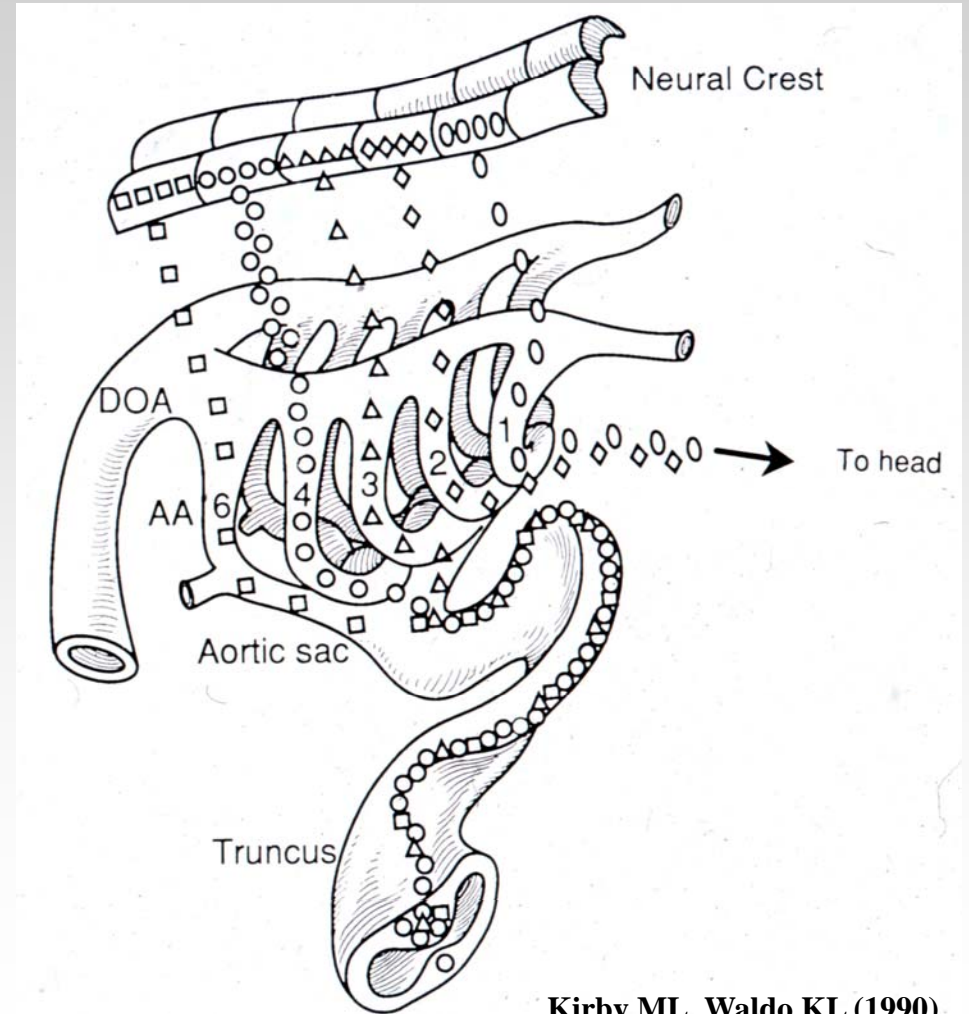
Extent of cephalic (cranial) neural crest

Phillips MT, Kirby ML et al, (1987)

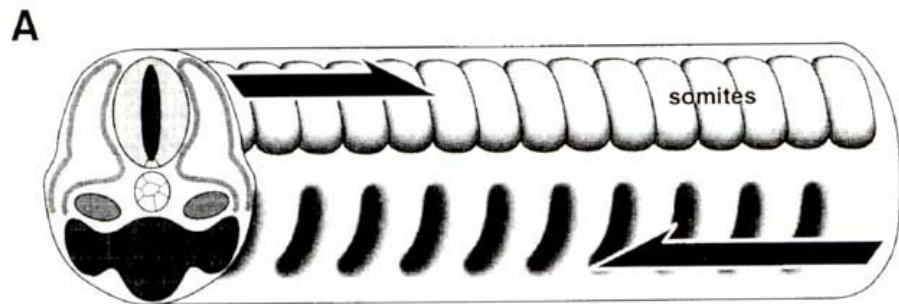


Neural crest involvement in the development of the heart

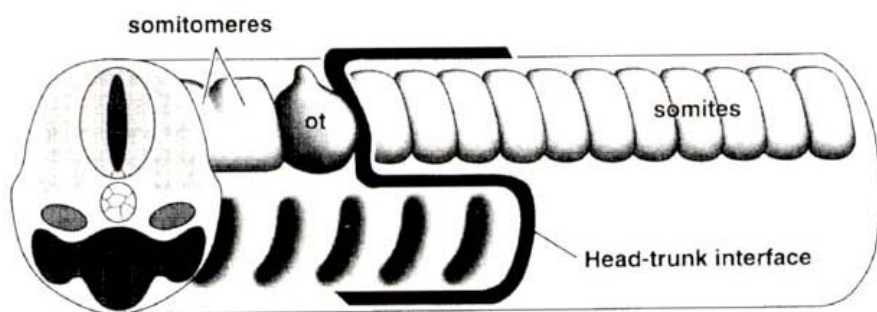
Kuratani S, Horigome N (2000)



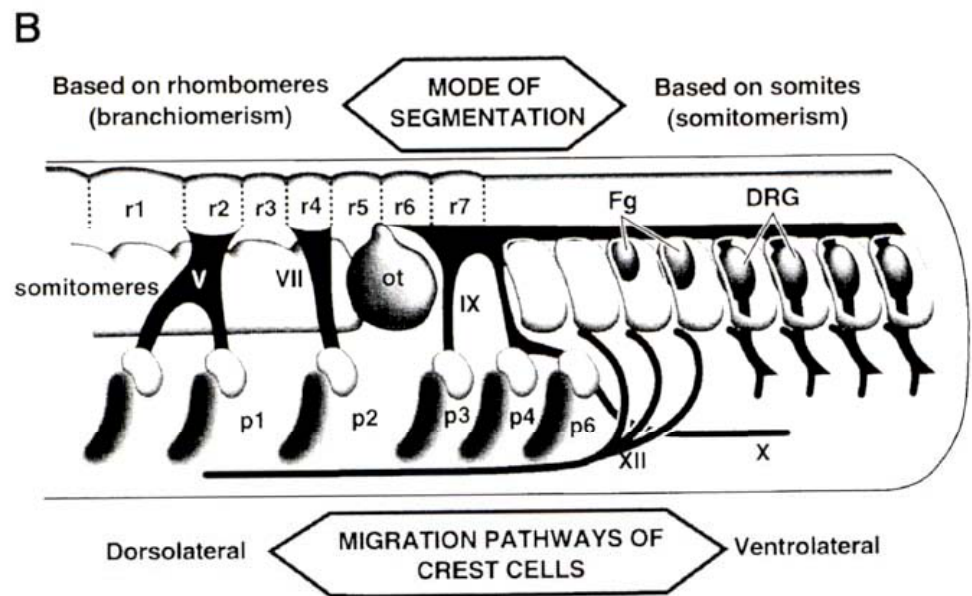
Kirby ML, Waldo KL (1990)



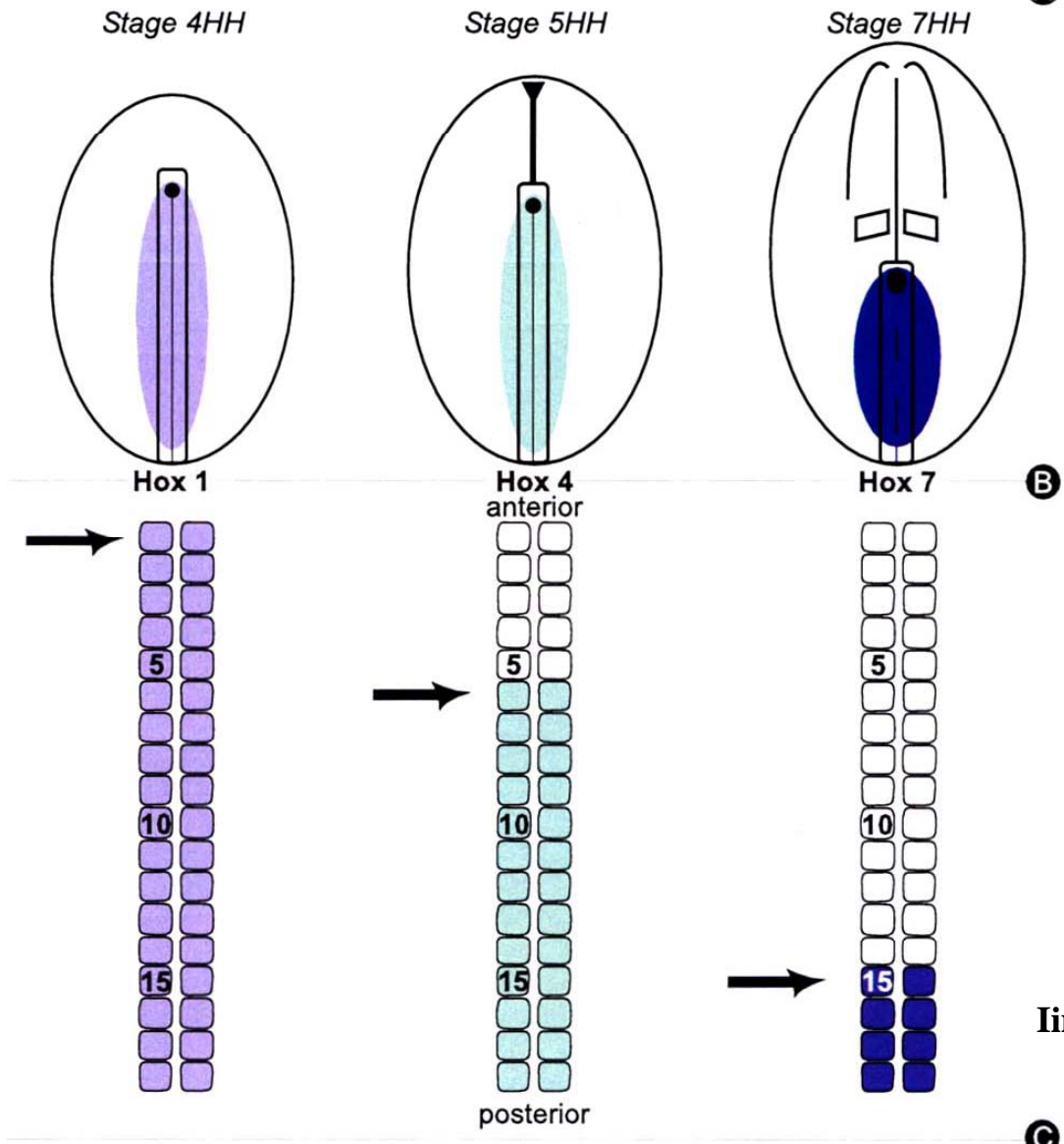
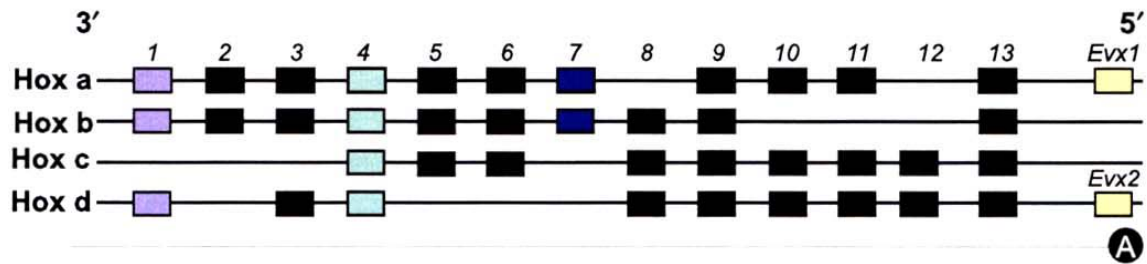
Hypothetical ancestral vertebrates



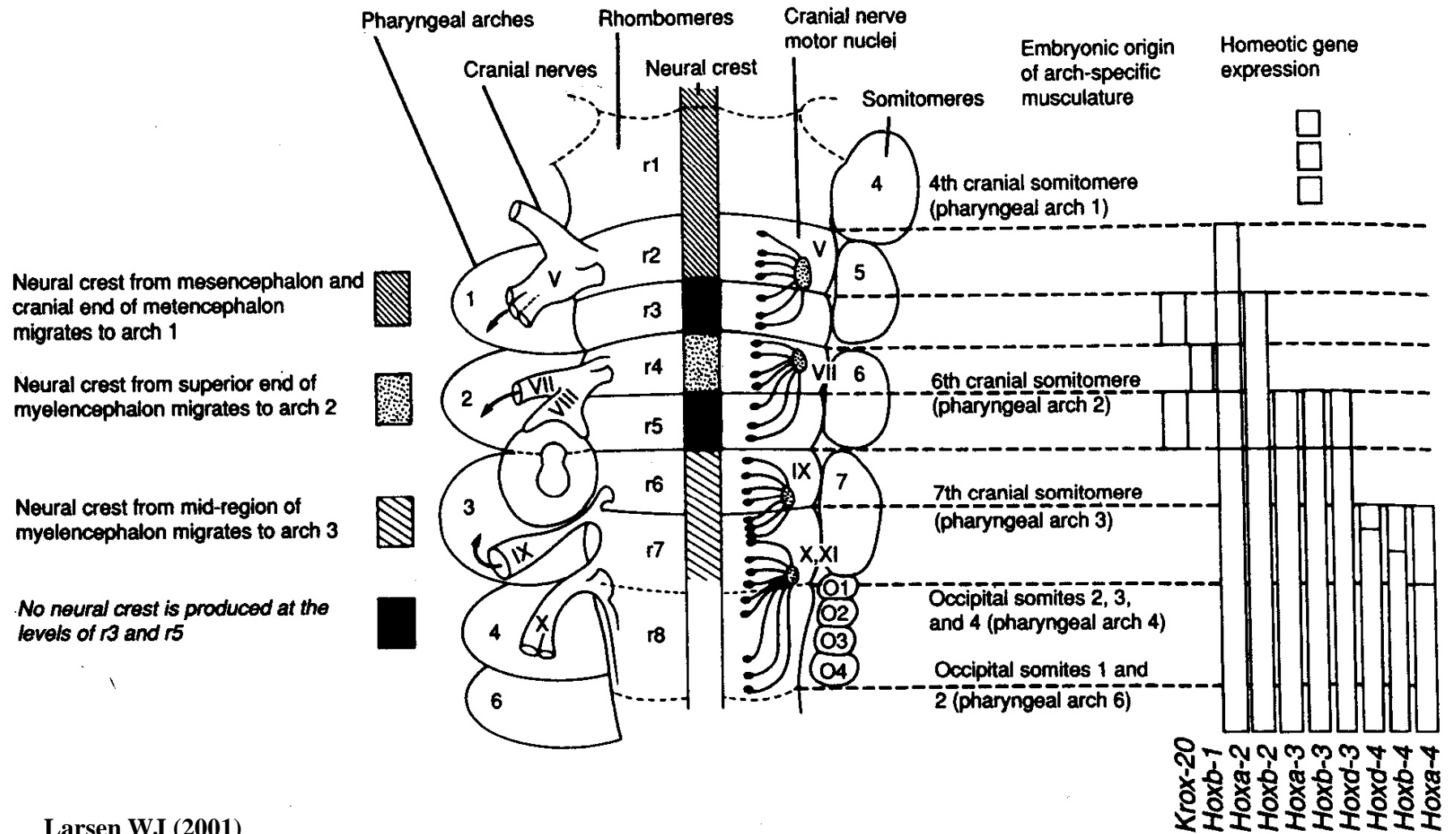
Modern vertebrates



Kuratani, Shigeru (1997)

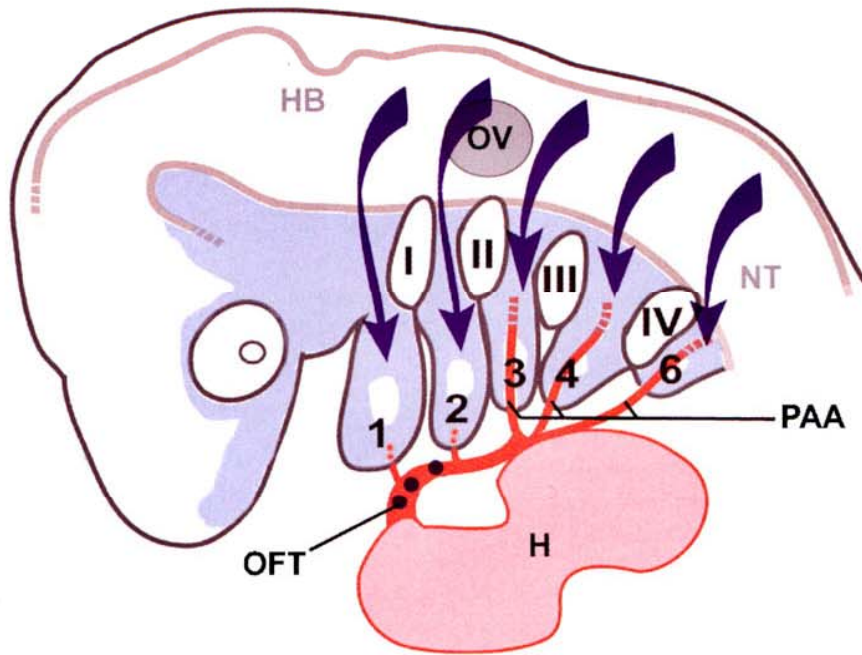


Imura T, Pourquié O (2007)



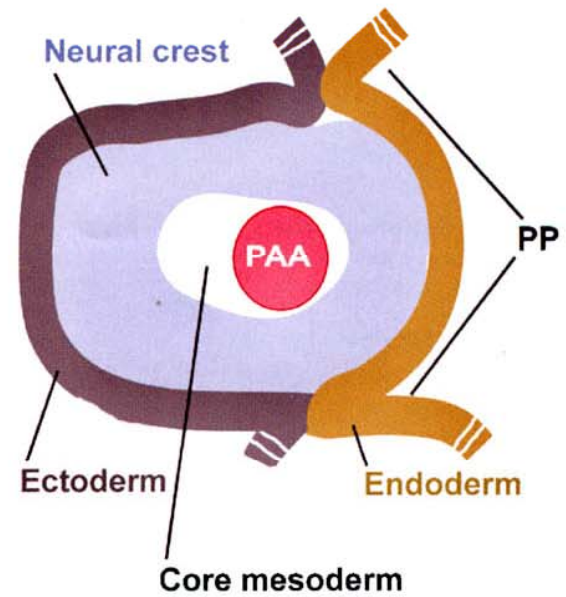
Larsen WJ (2001)

A

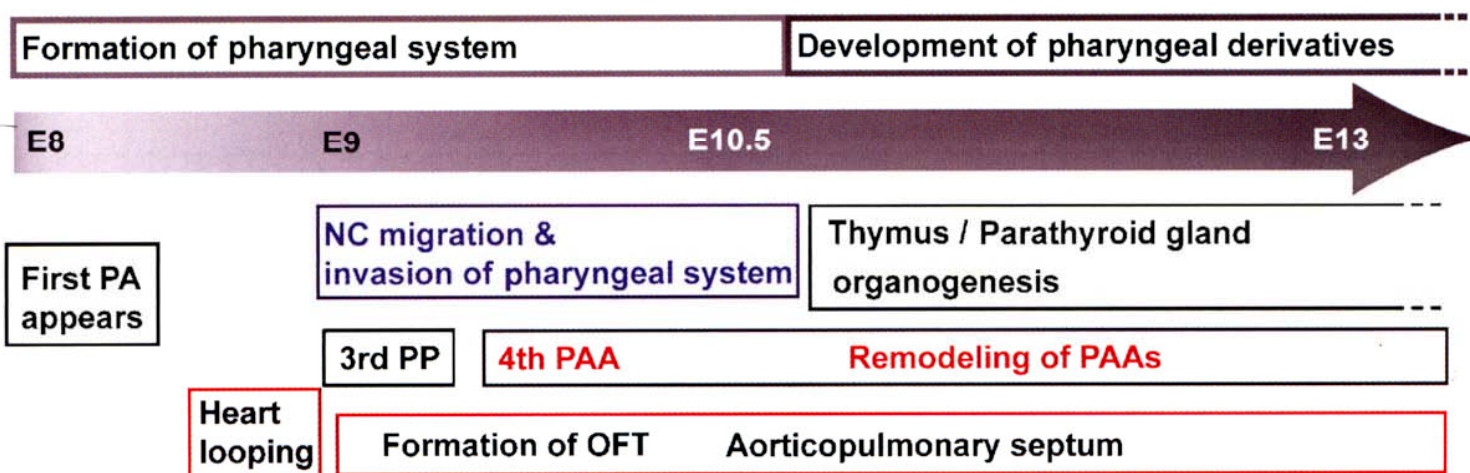


B

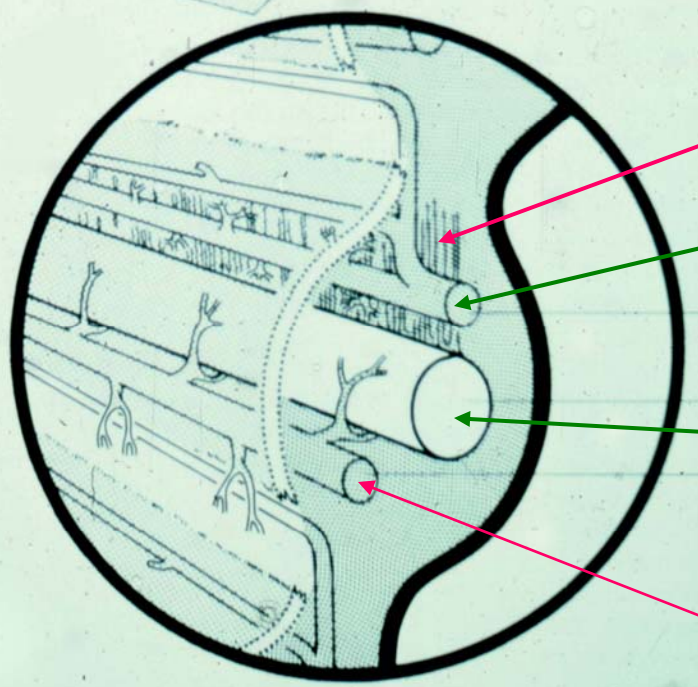
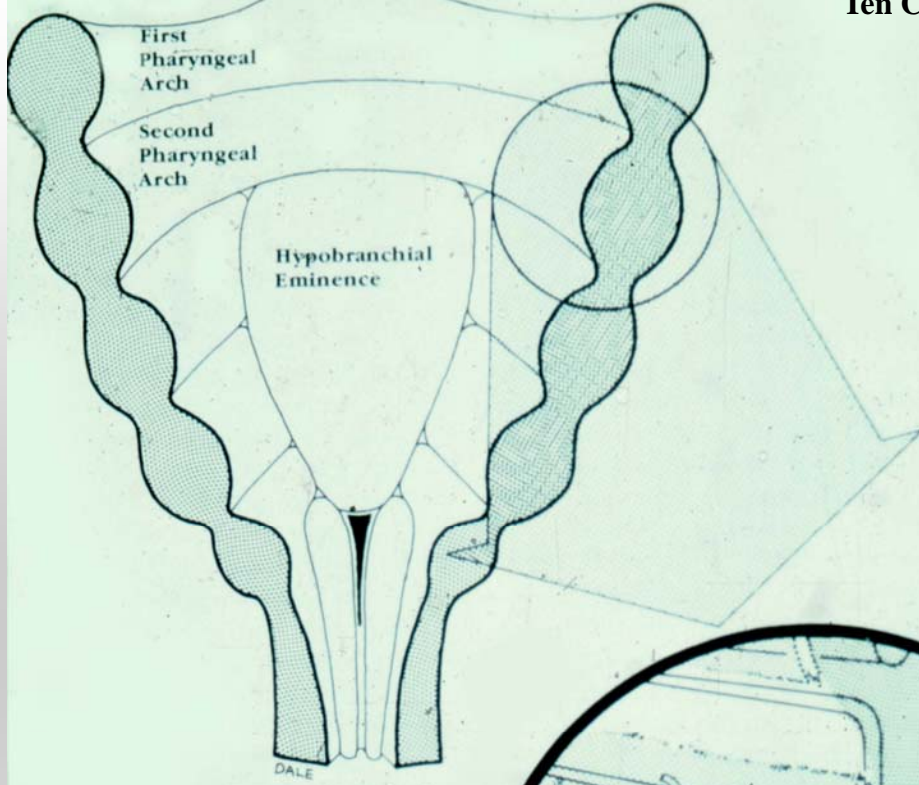
Wurdak H et al (2006)



C



Ten Cate AR (1988)



Segmental components of arches

Connective tissues - nc

Muscle – mesoderm

Branchiomeric nerve –
nc,ectoderm,neurectoderm

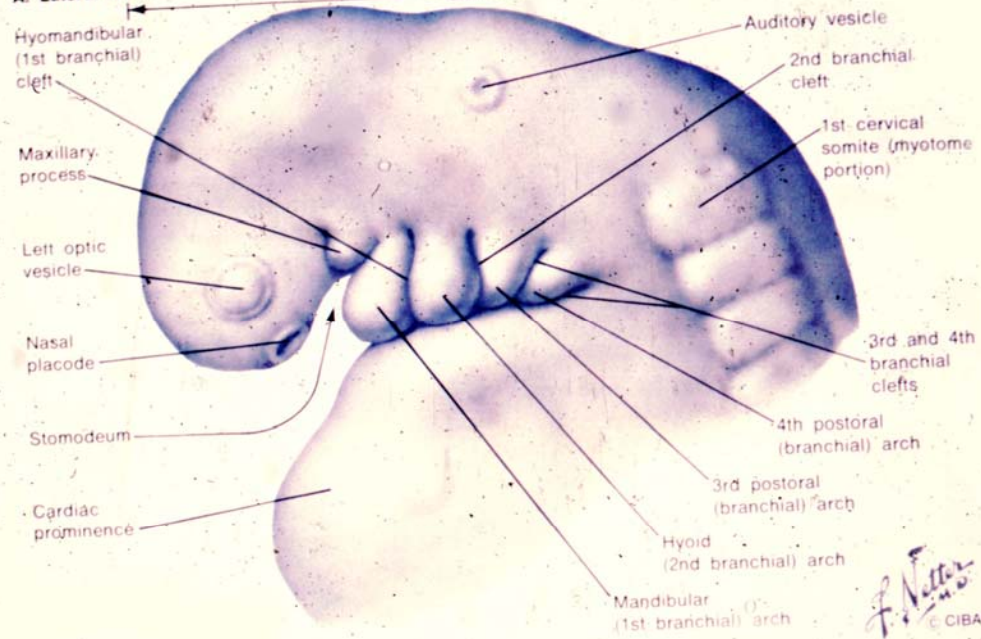
Skeletal bar- nc -
(cartilage) last to form

Artery – mesoderm-
first to appear

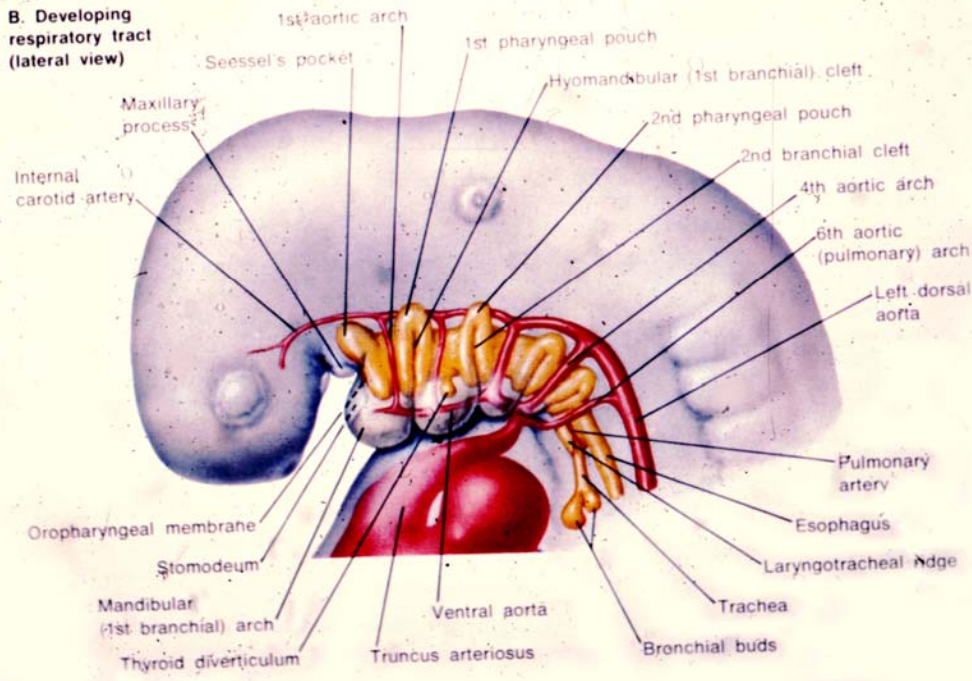
Plate 2

Embryo at 4 to 5 Weeks

A. Lateral view



B. Developing respiratory tract (lateral view)



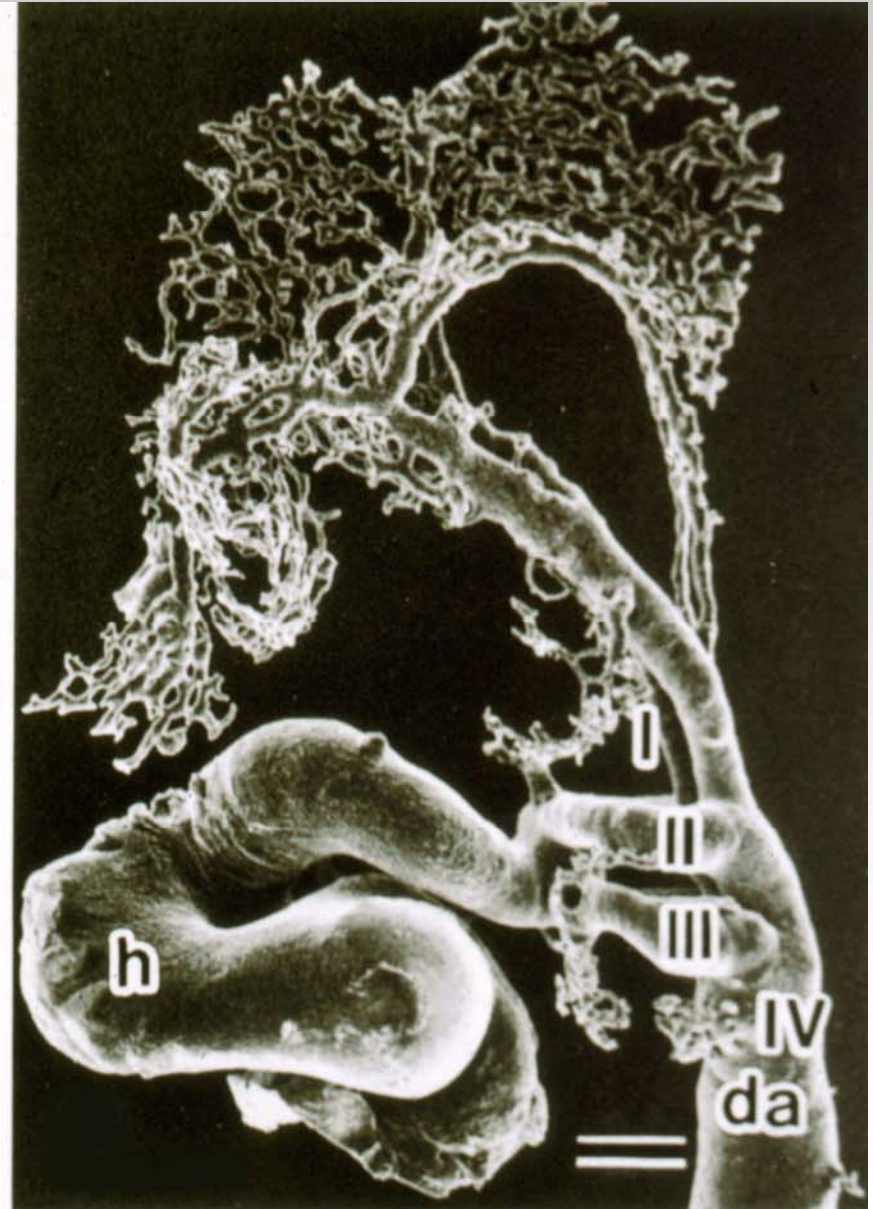
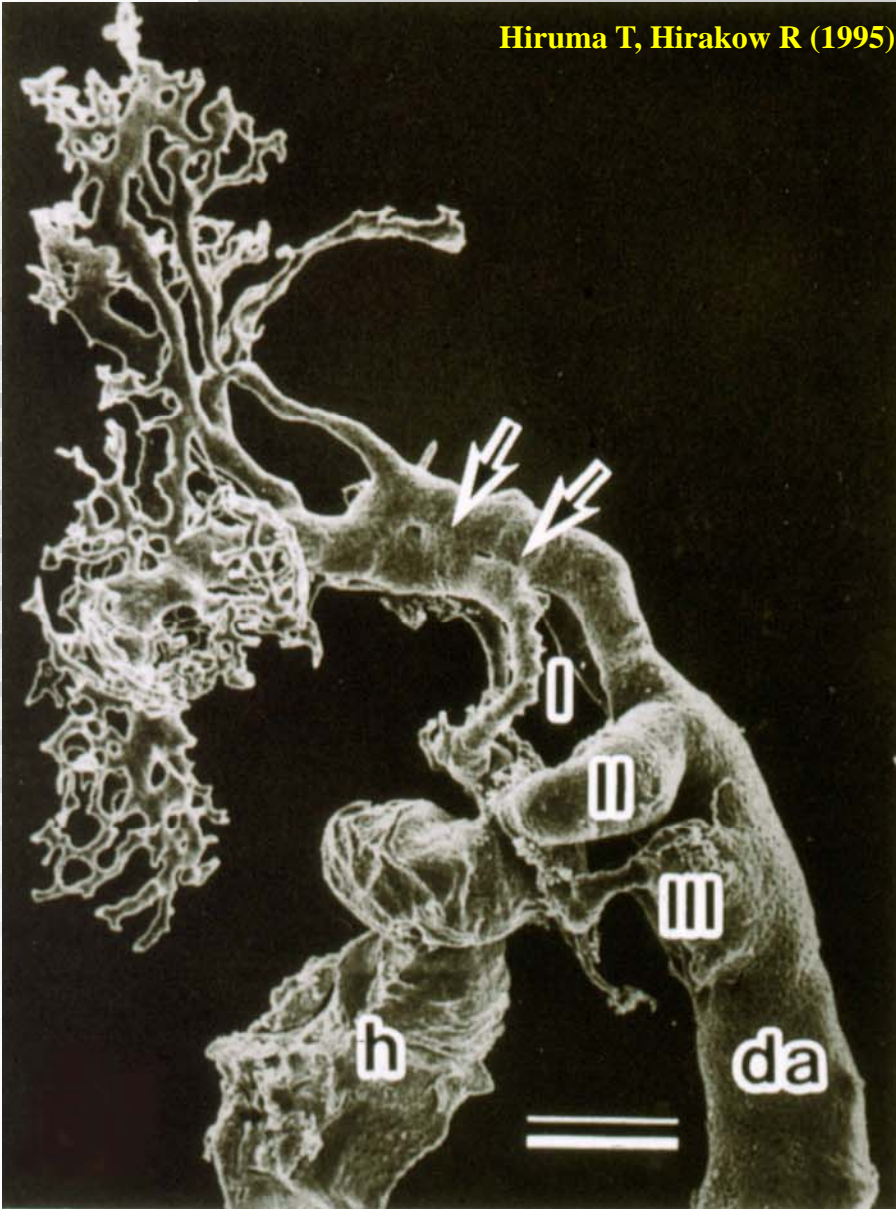
5 Aortic arches

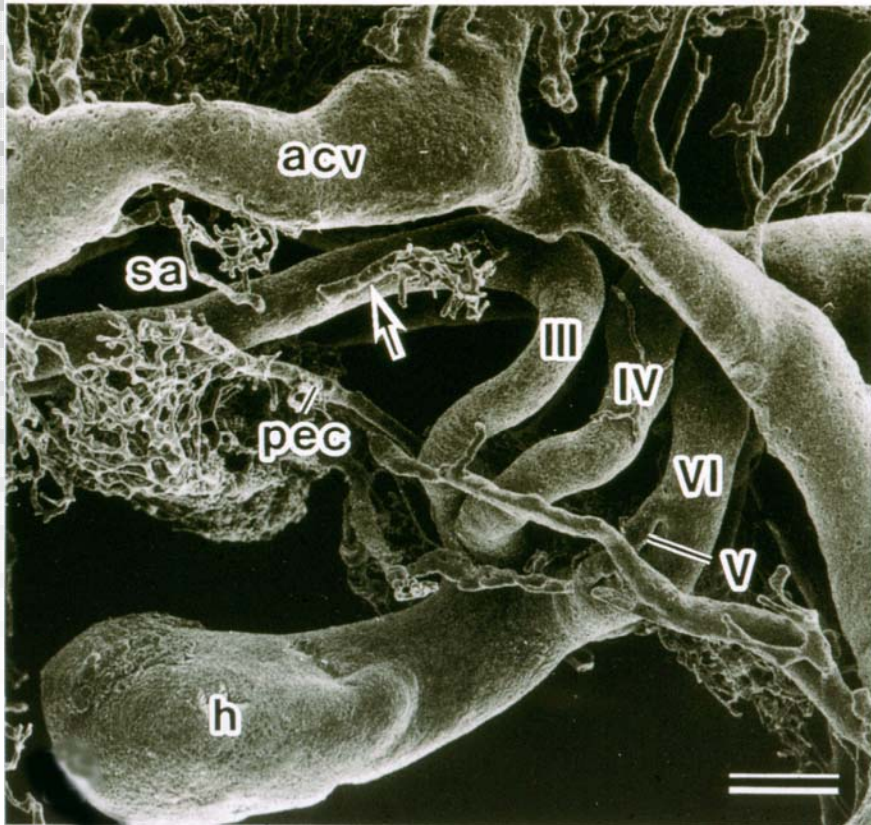
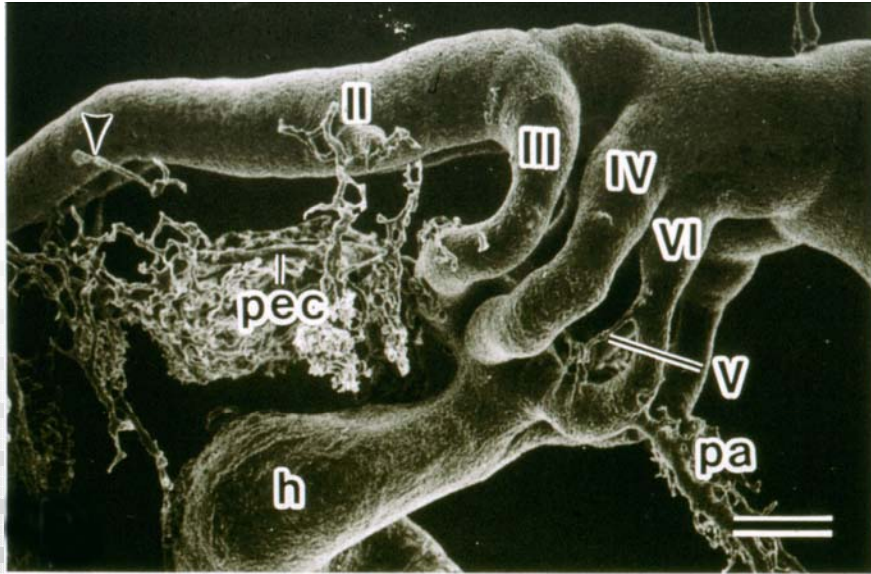
Arches numbered 1-6

Netter F, Ciba collection

Aortic arch development

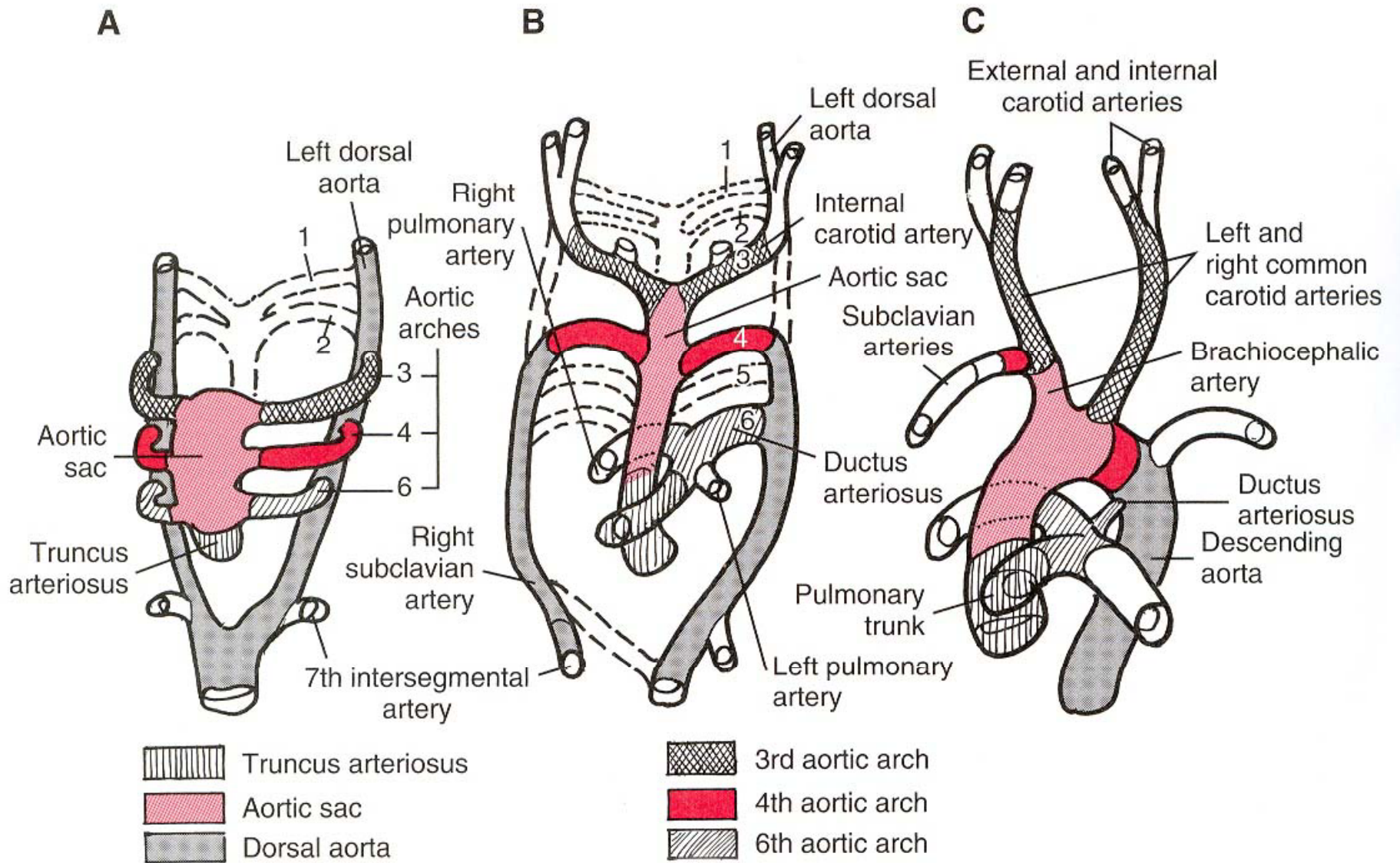
Hiruma T, Hirakow R (1995)



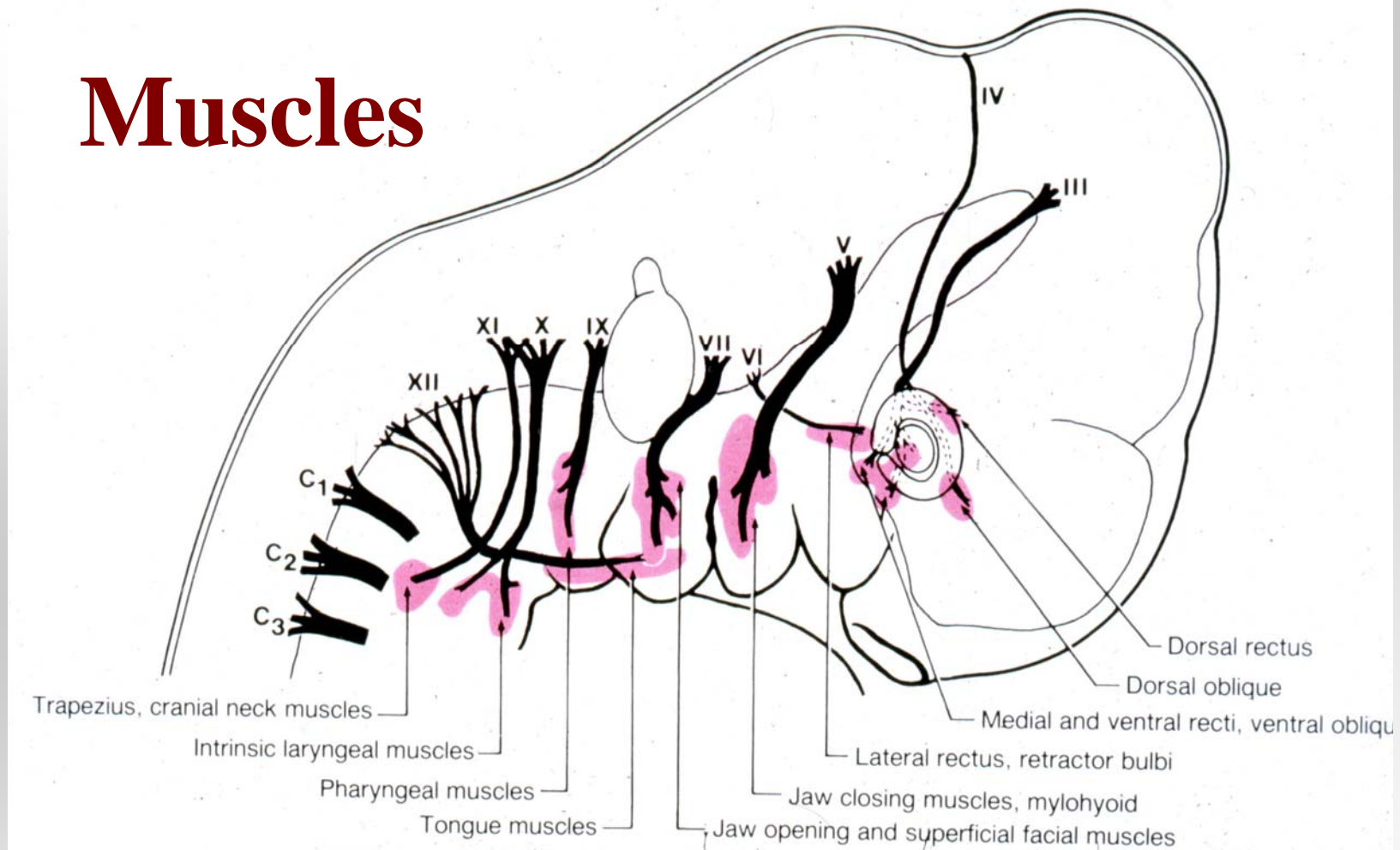


Aortic arch development cont'd

Hiruma T, Hirakow R (1995)



Muscles



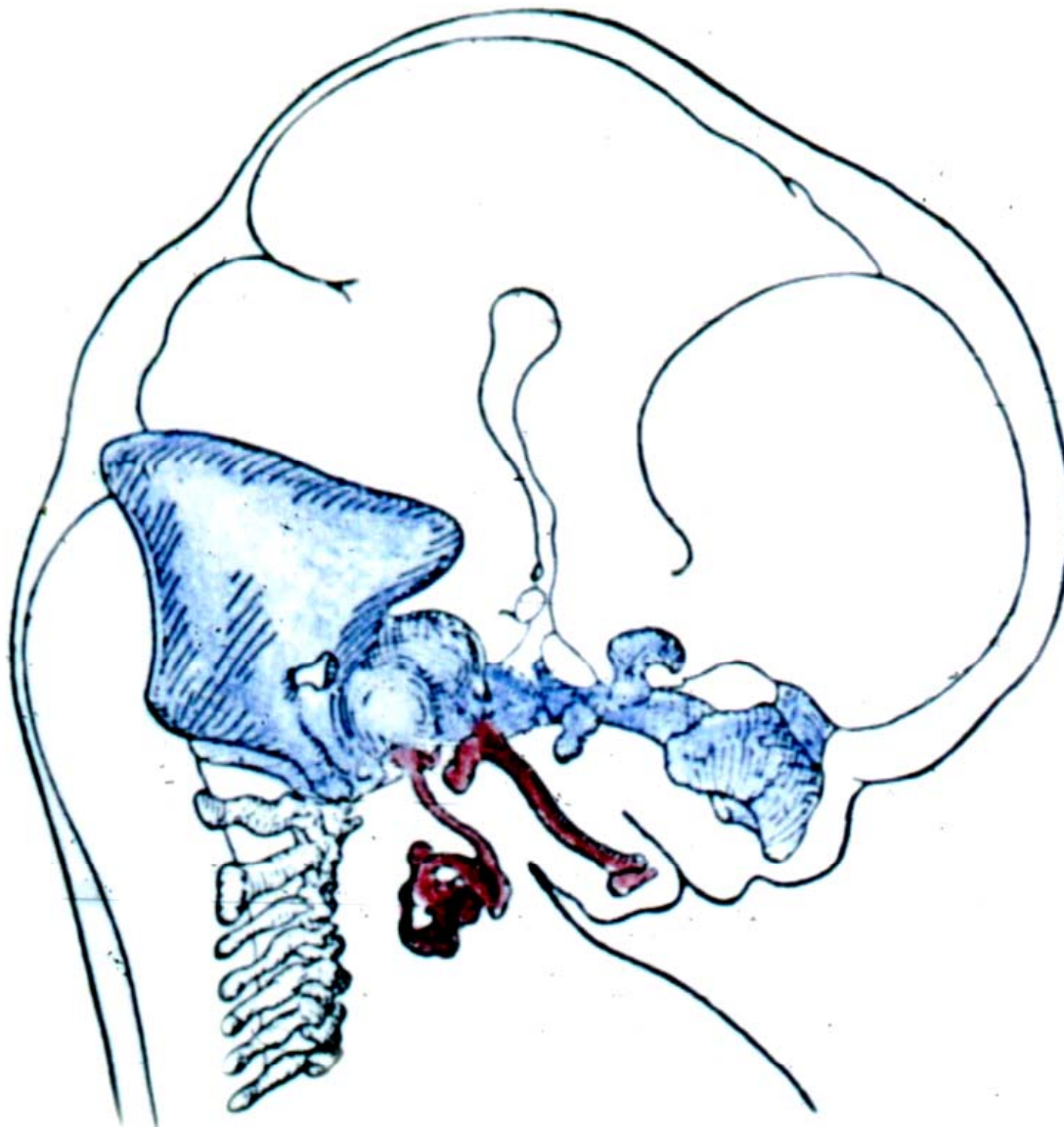
Arch 1: Muscles of mastication (V)

Arch 2: Muscles of facial expression (VII)

Arch 3: Stylopharyngeus muscle (IX)

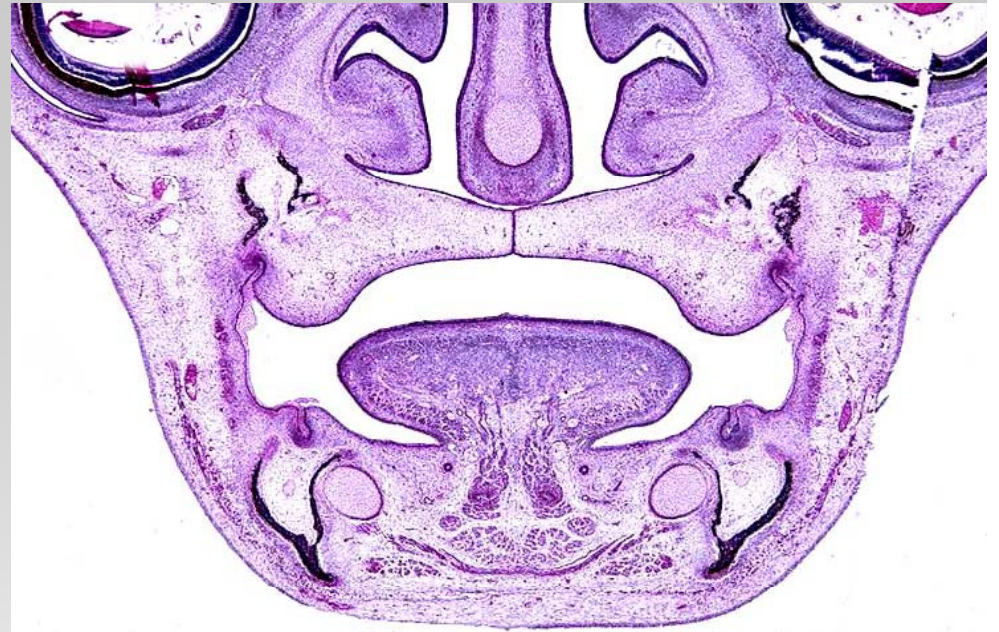
Arch 4-6: Laryngeal muscles (X-XI)

Noden D M, Lahunta A de (1985)

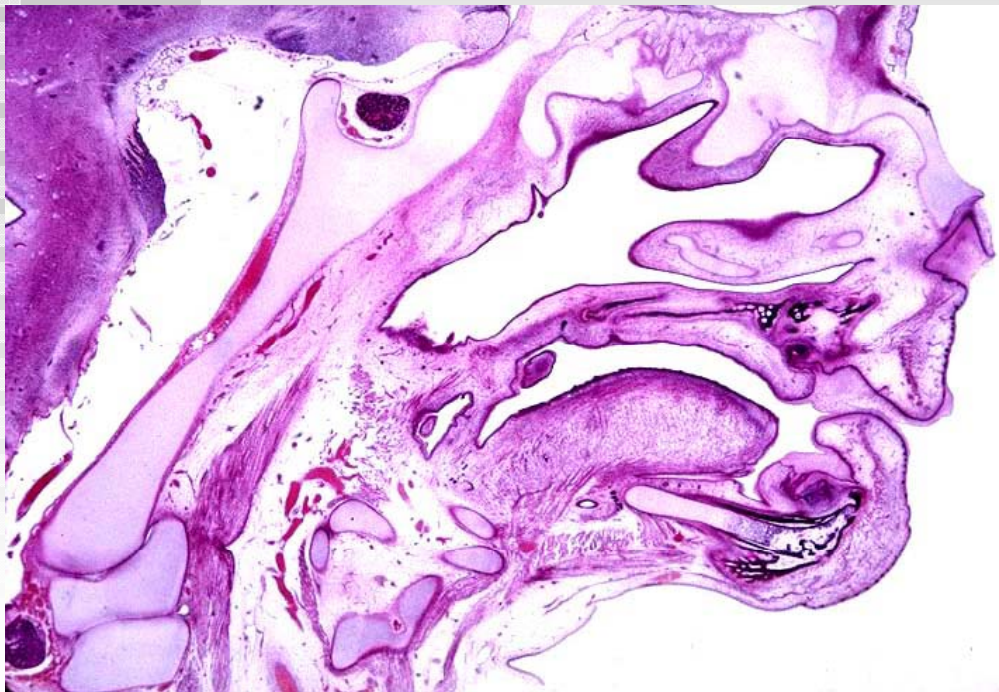


The cartilage elements of the pharyngeal arches (cartilaginous viscerocranium, purple) at 7 weeks.

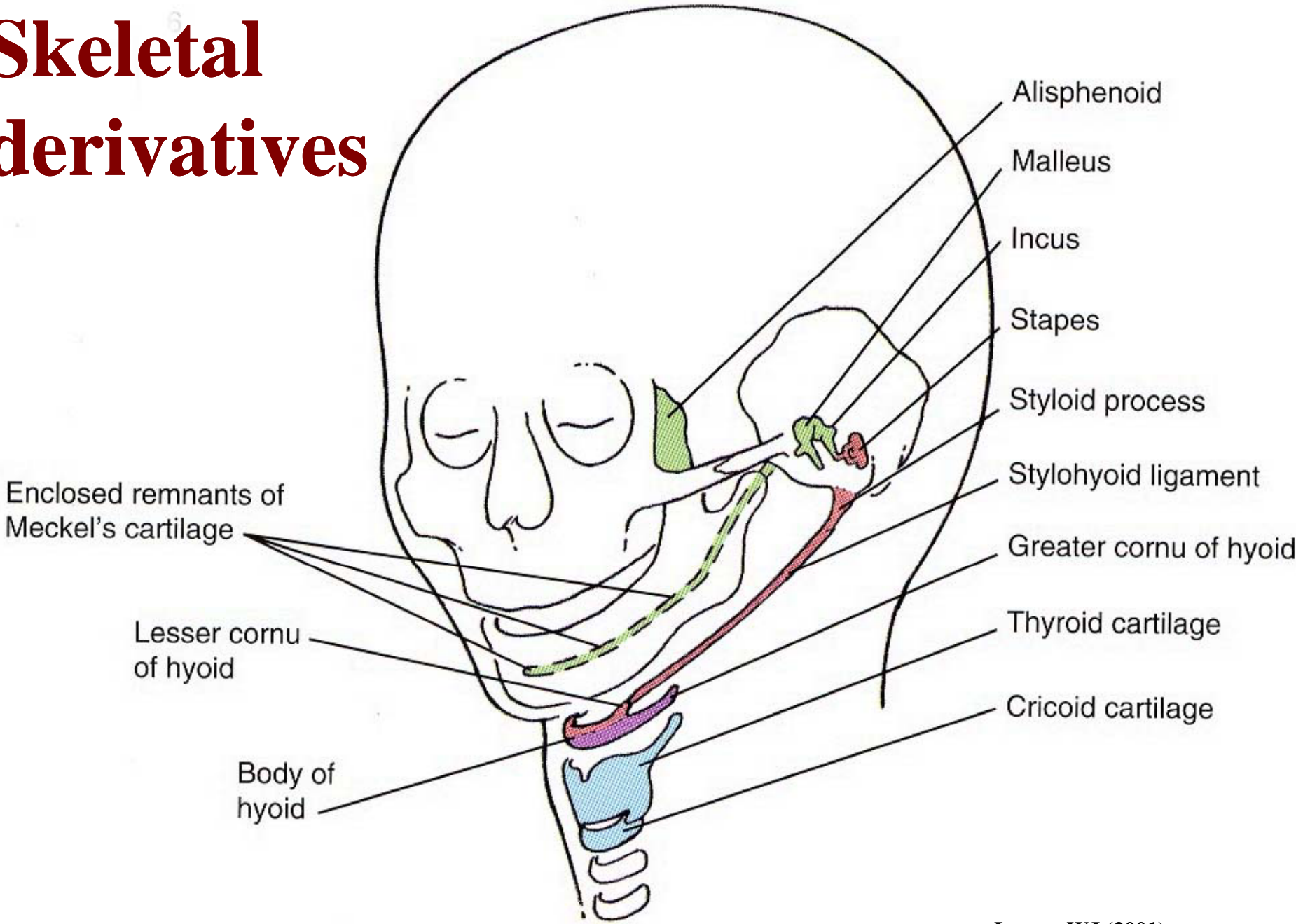
Skeletal elements



Moss-Salentijn L et al (1972)



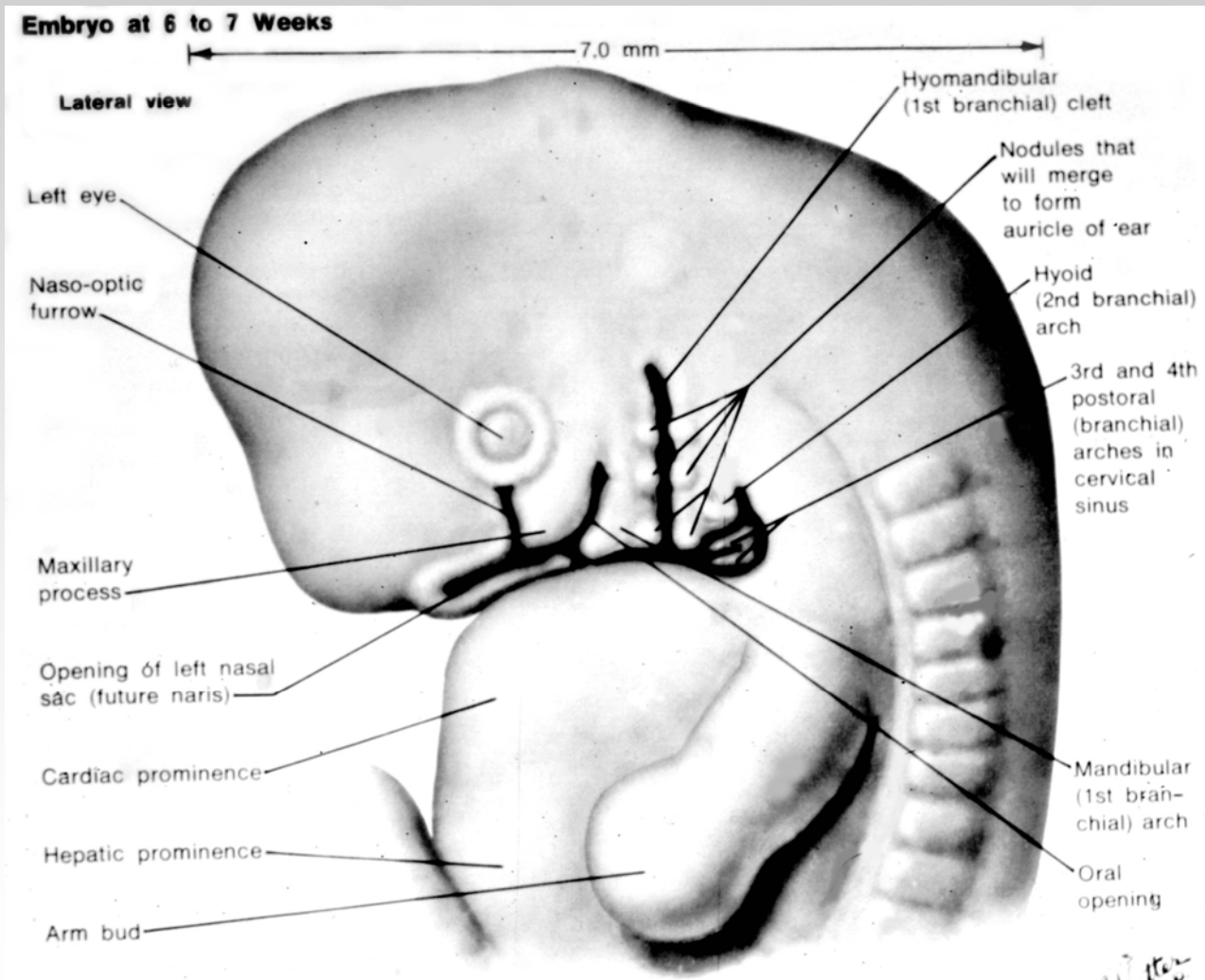
Skeletal derivatives



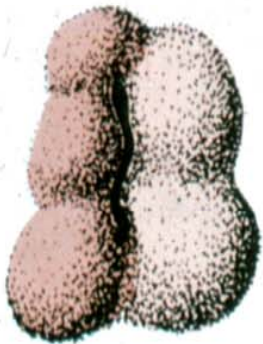
Larsen WJ (2001)

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.



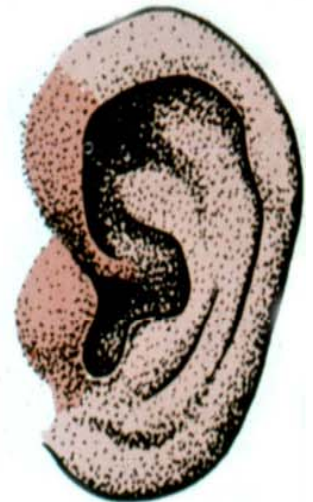
40 mm:
about 65 days.



52 mm:
about 72 days.



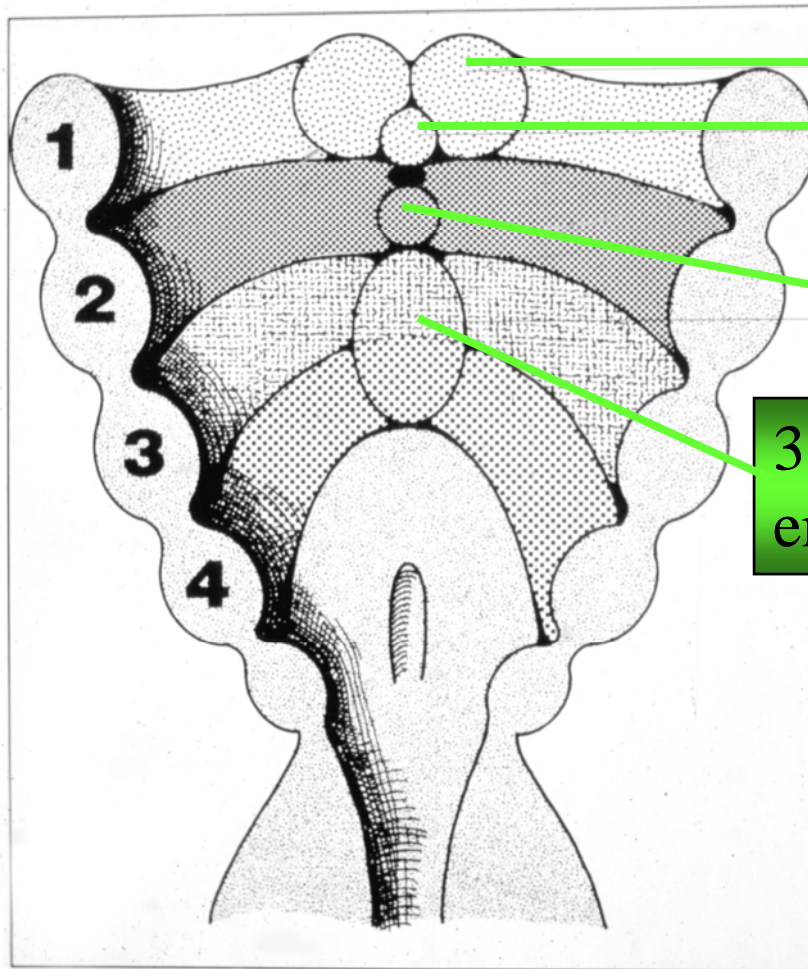
135 mm:
about 4½ months.



Adult.

Tuchmann-Duplessis H et al, (1975)

Endodermal swellings on arches 1-4 contribute to the tongue

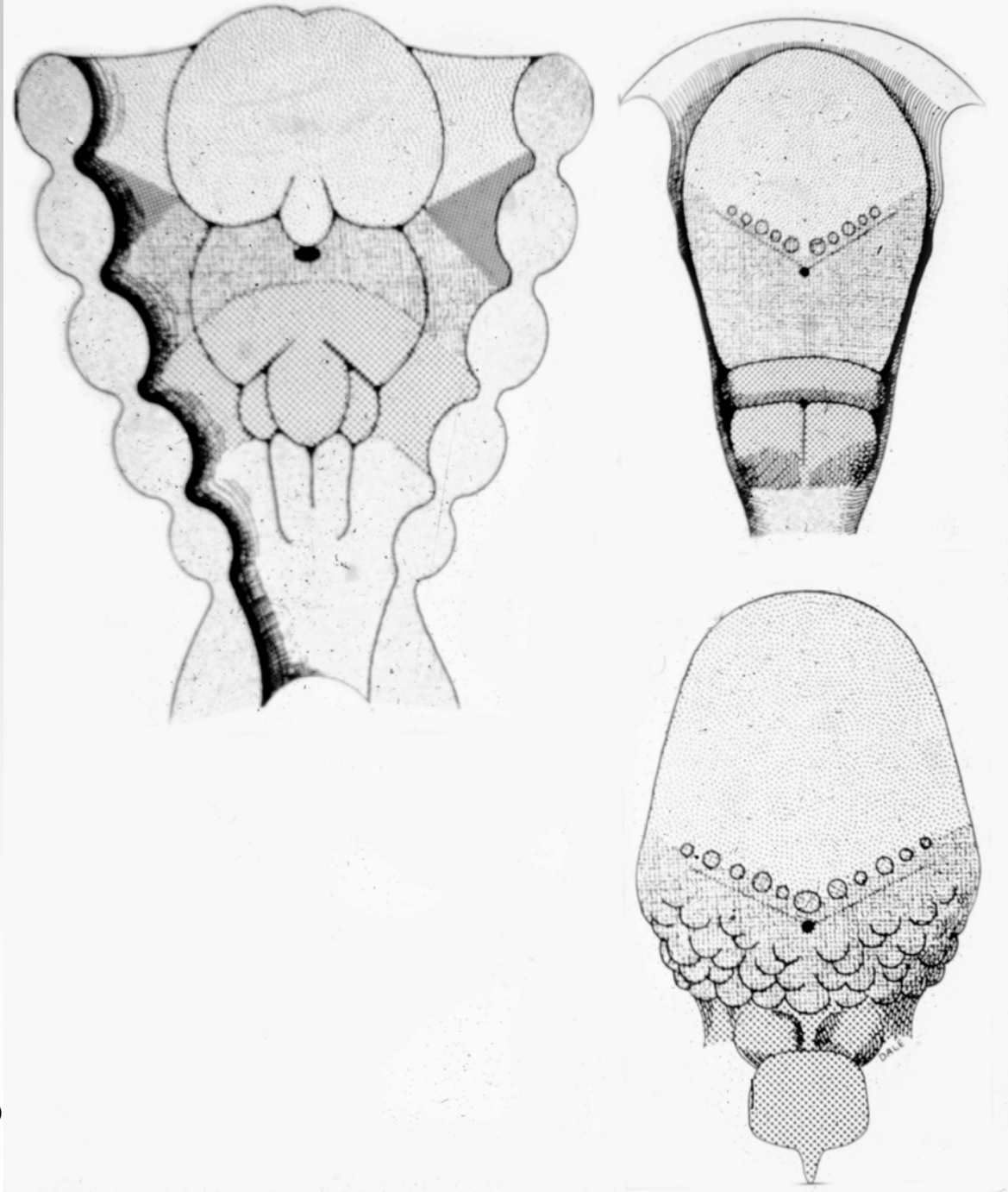


1. Paired lingual swellings and single median tuberculum impar

2. Single median copula

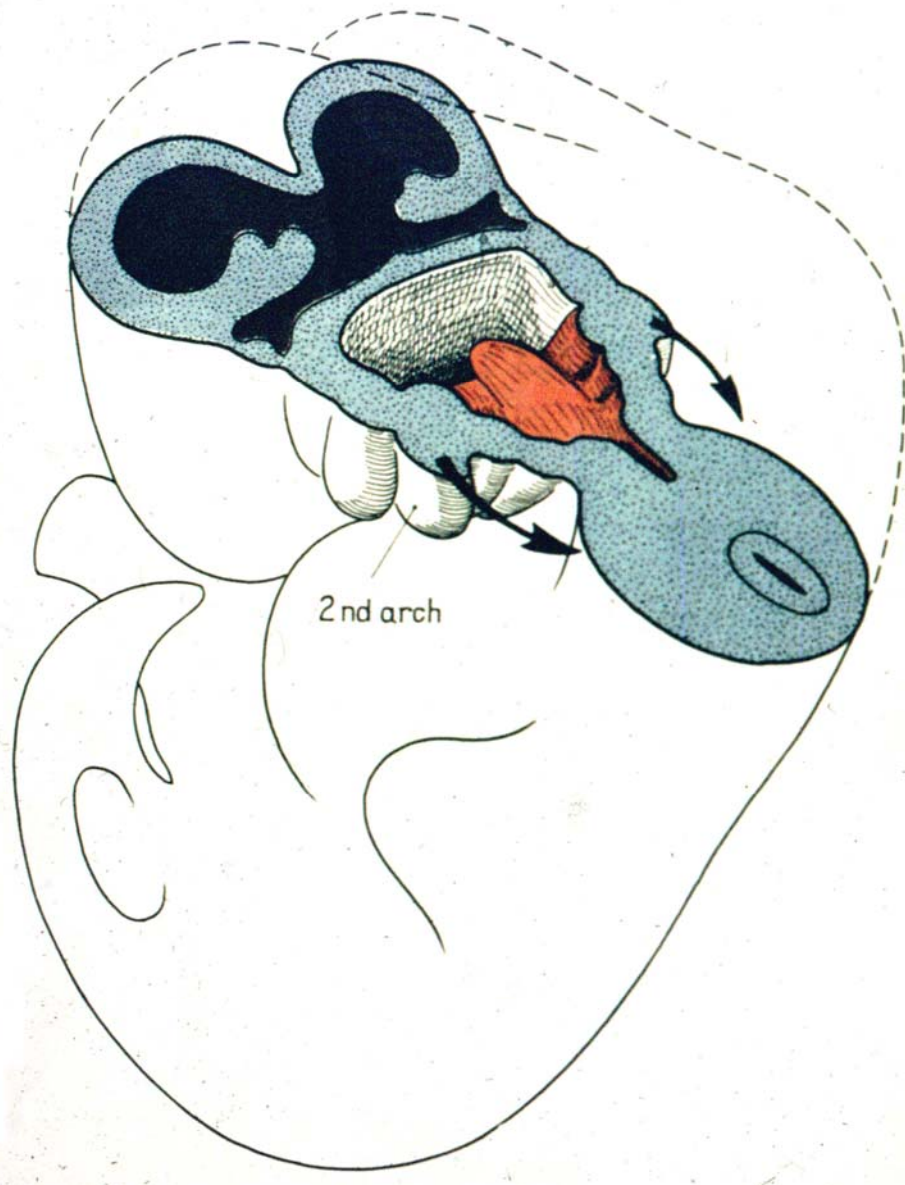
3-4. Combined median hypobranchial eminence

Merging of lingual swellings



Ten Cate AR (1988)

Fate of pharyngeal grooves 2-4

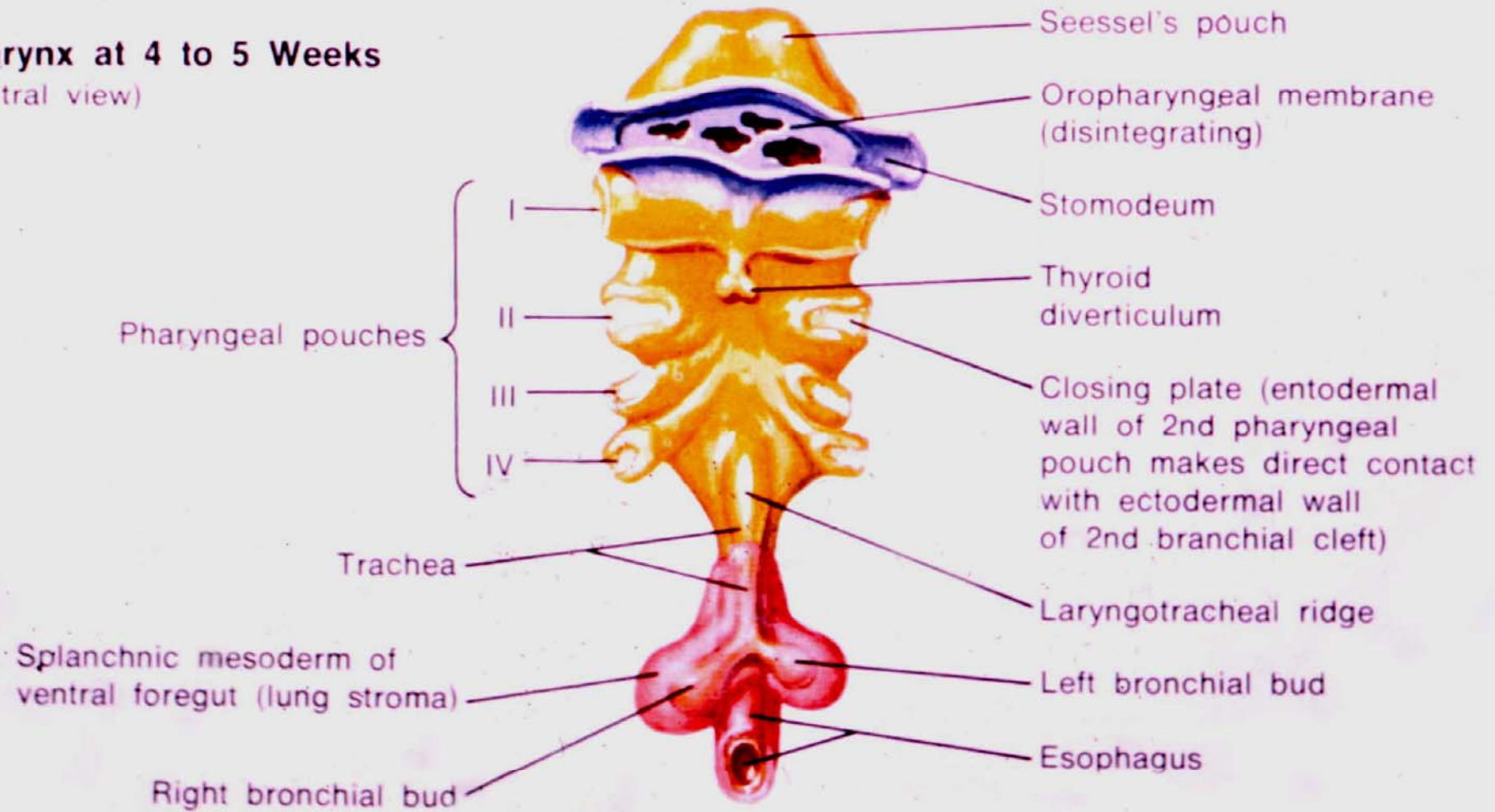


Covered by rapid outgrowth of 2nd arch “operculum.”

Tuchmann-Duplessis H, Haegel P (1975)

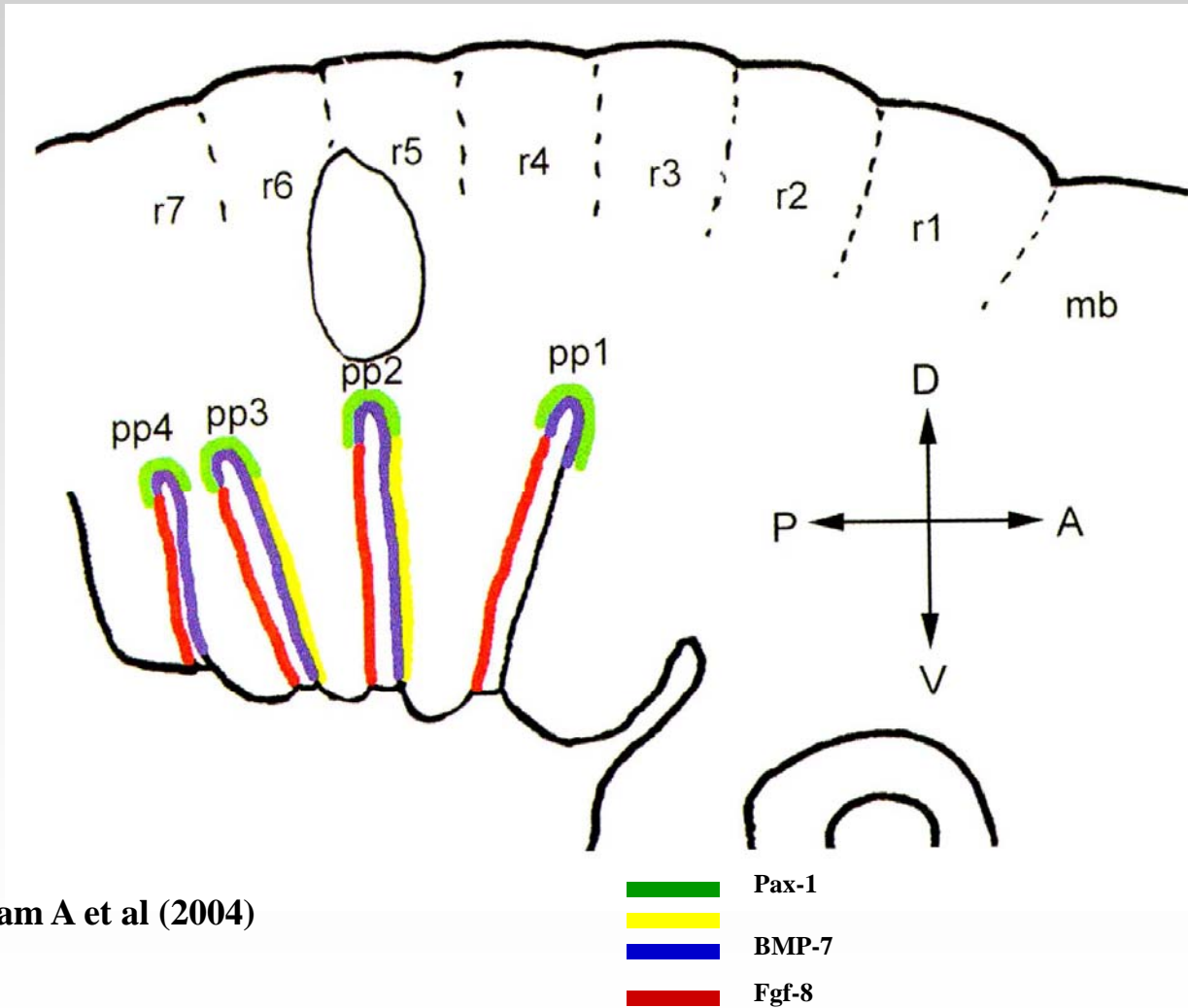
Pharynx at 4 to 5 Weeks

(ventral view)



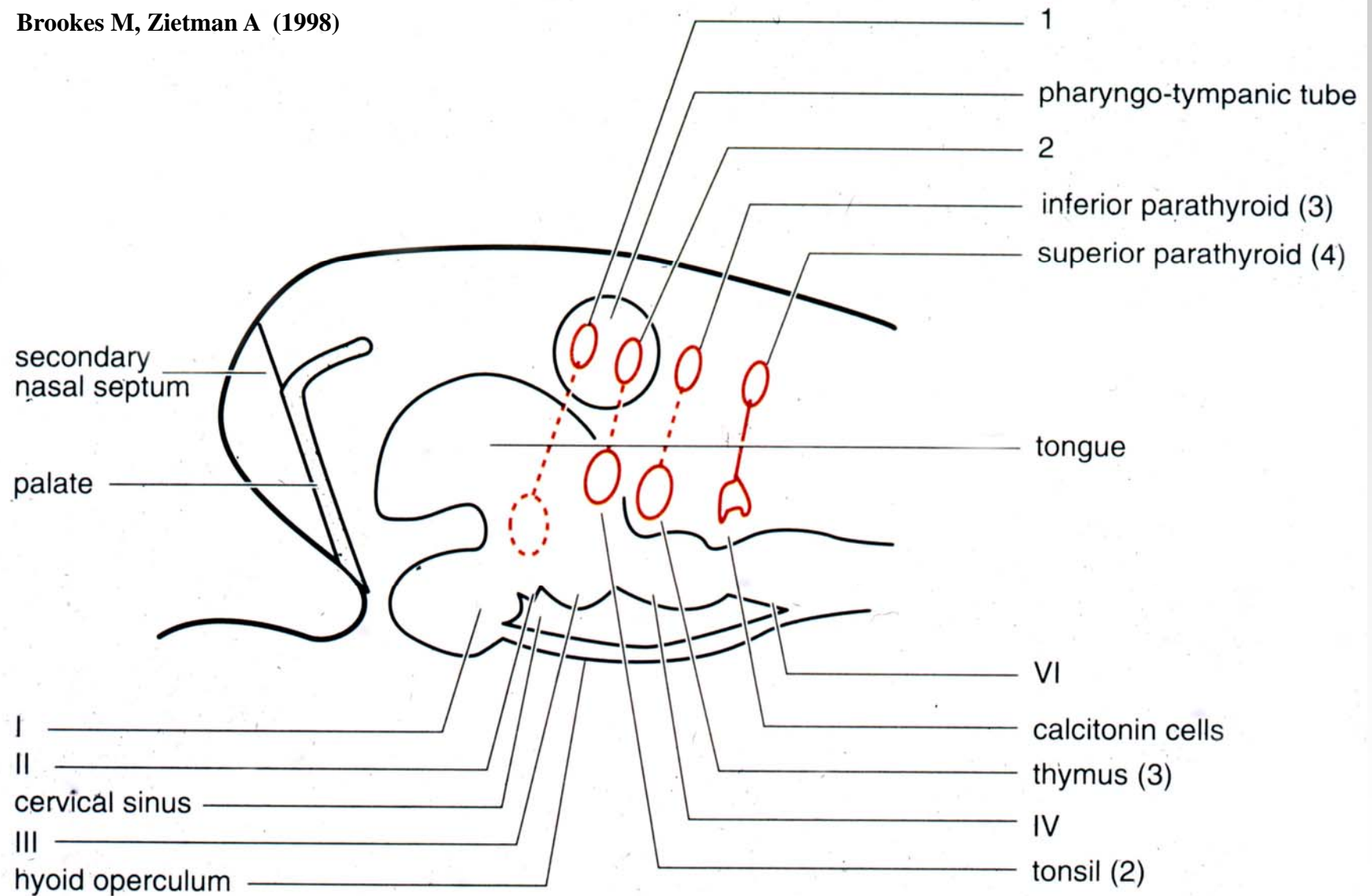
Netter F, Ciba collection

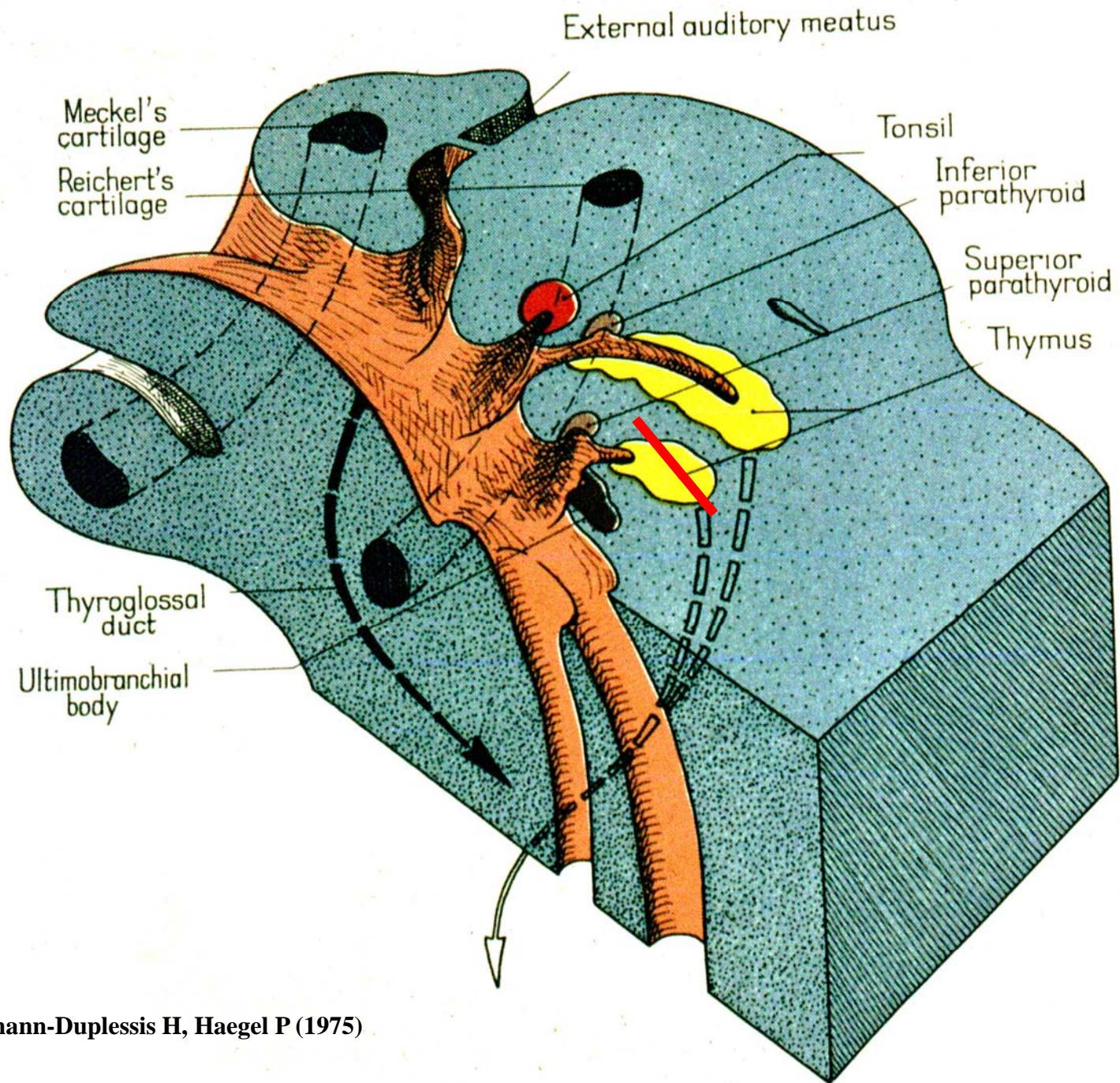
Endoderm plays key role in morphogenesis of pharyngeal region



Derivatives of dorsal and ventral parts of pharyngeal pouches

Brookes M, Zietman A (1998)

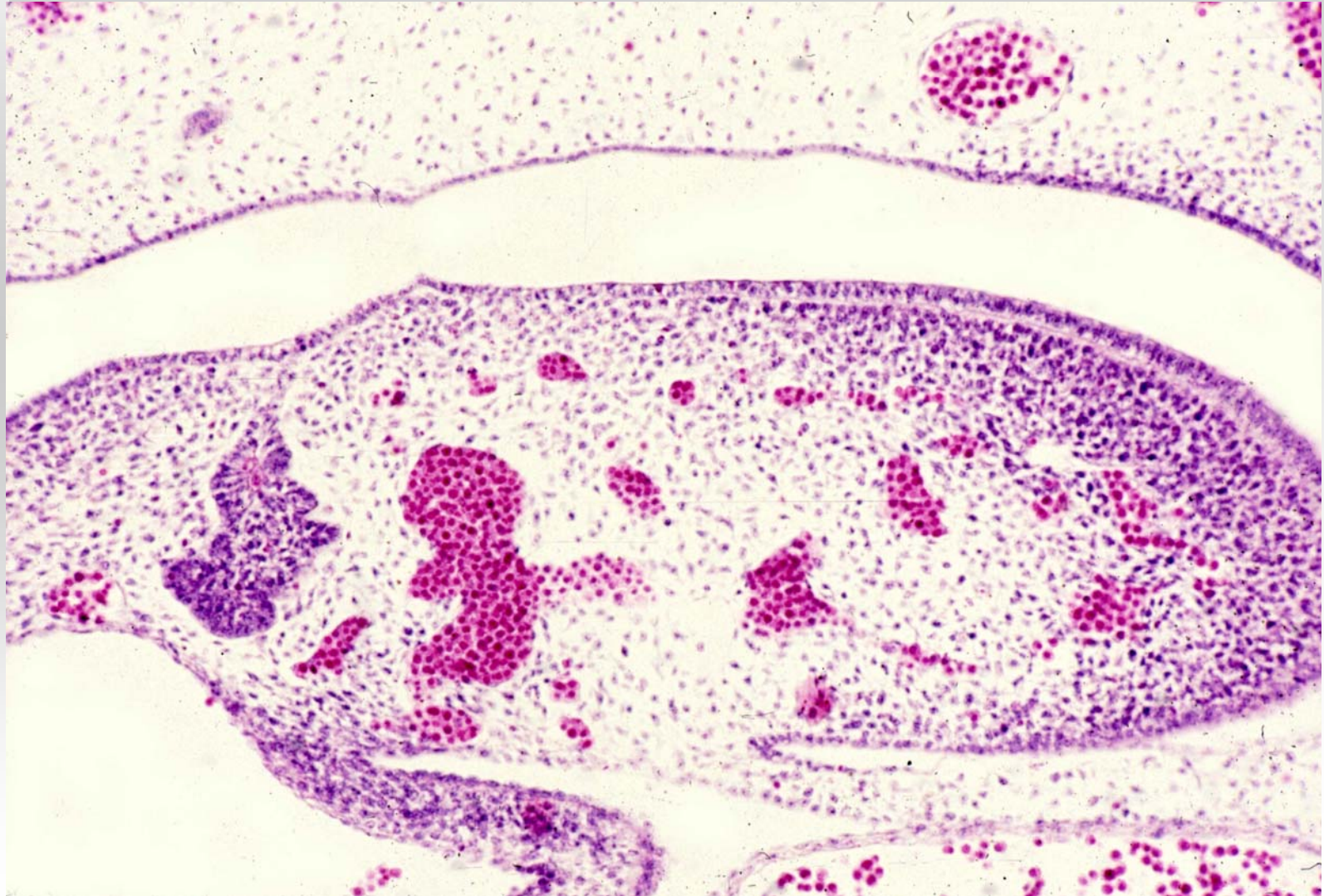


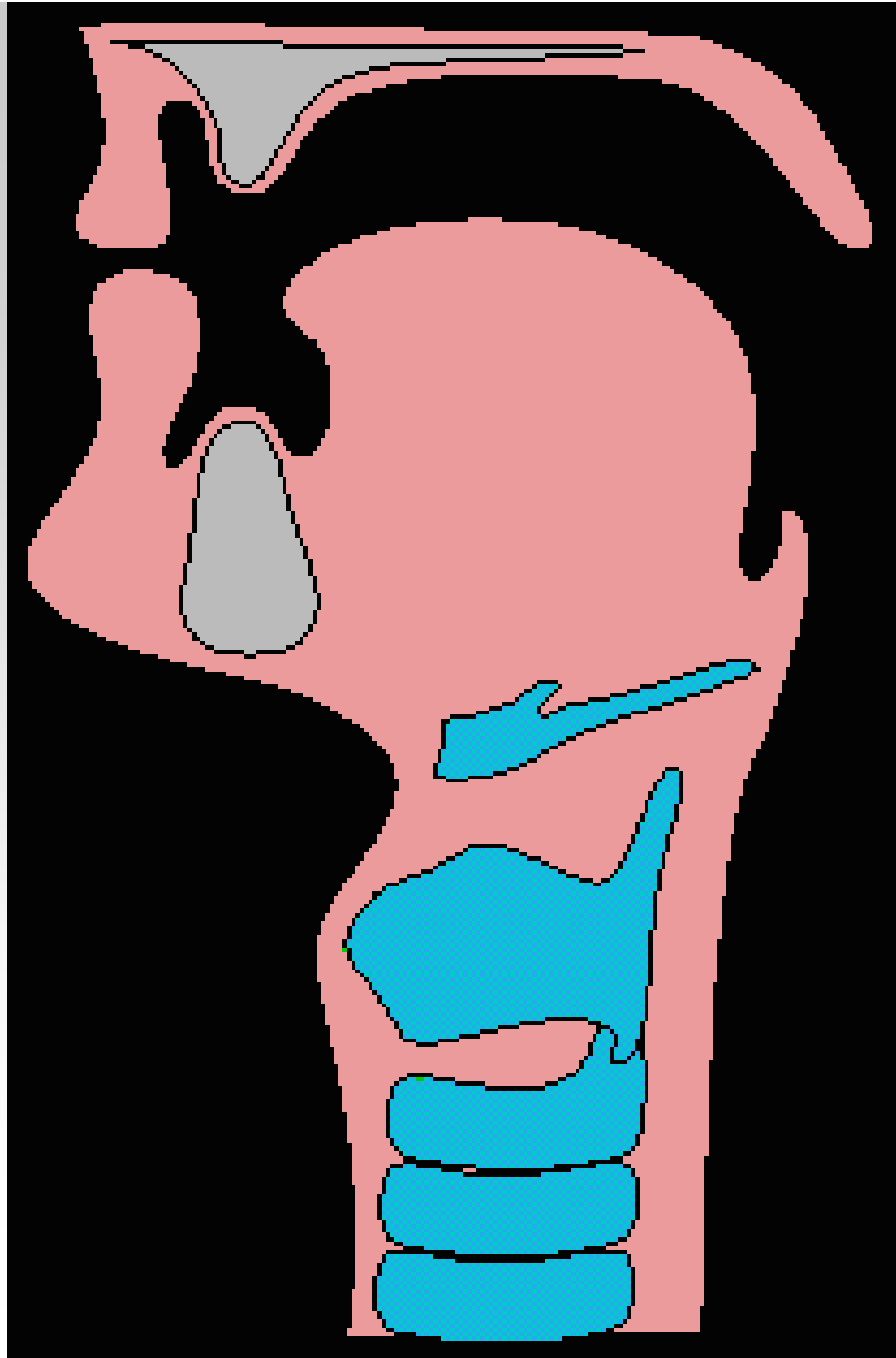


Tuchmann-Duplessis H, Haegel P (1975)

Thyroid gland development

Thyroglossal duct





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

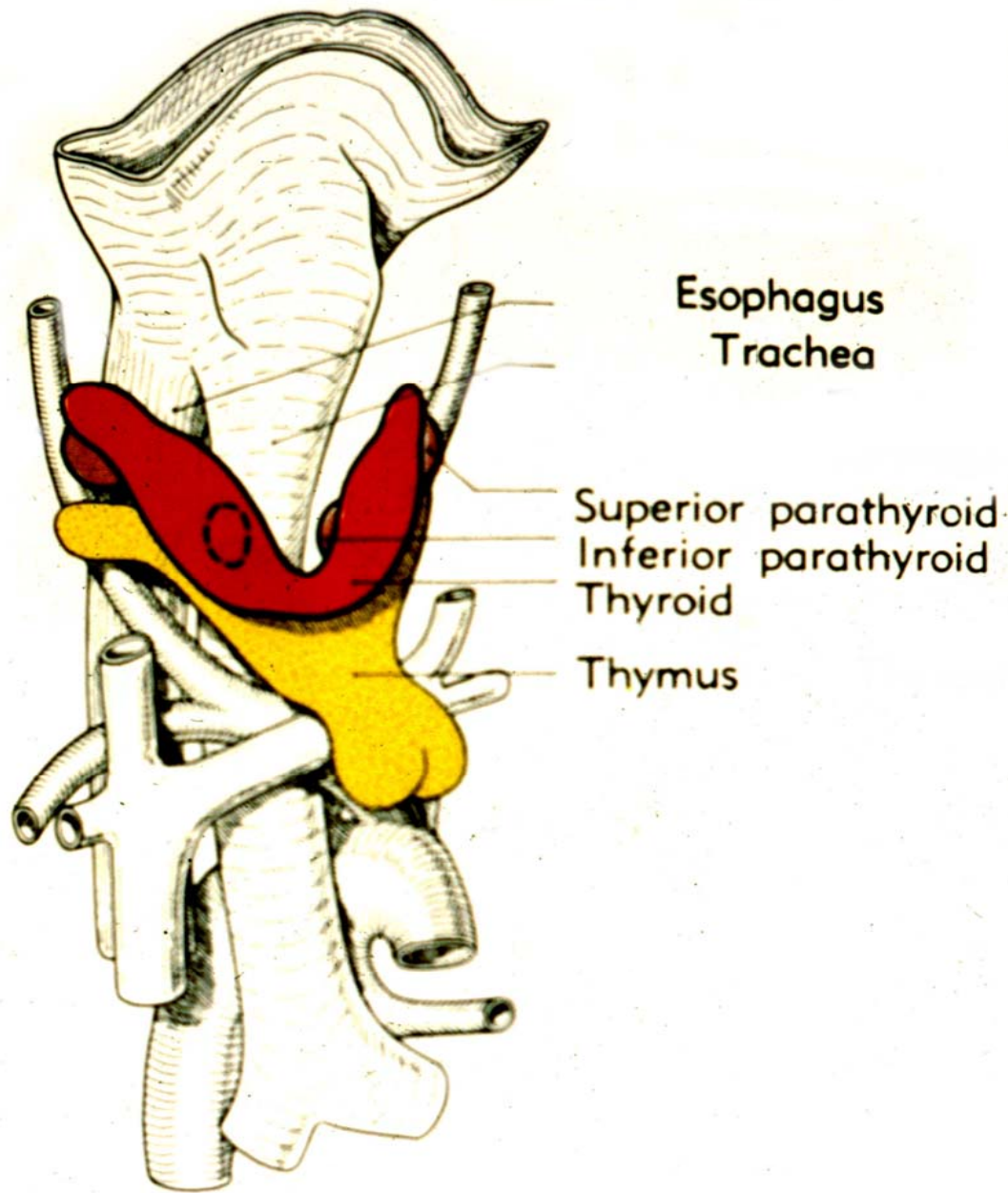
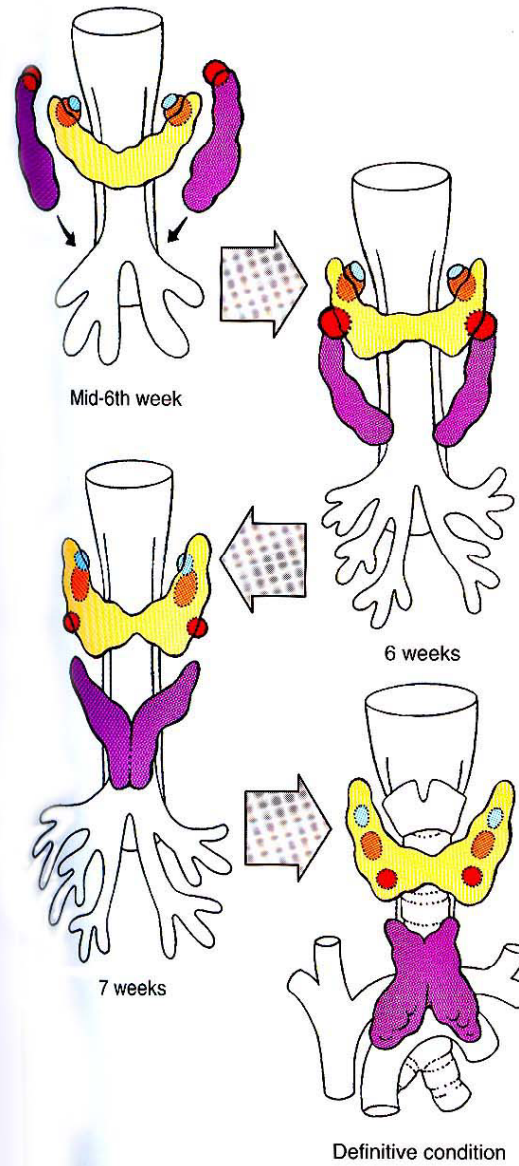


Diagram
showing thyroid in place.

Superior and inferior parathyroid glands

Tuchmann-Duplessis H, Haegel P (1975)

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



Larsen WJ (2001)