Pharyngeal arches and pouches

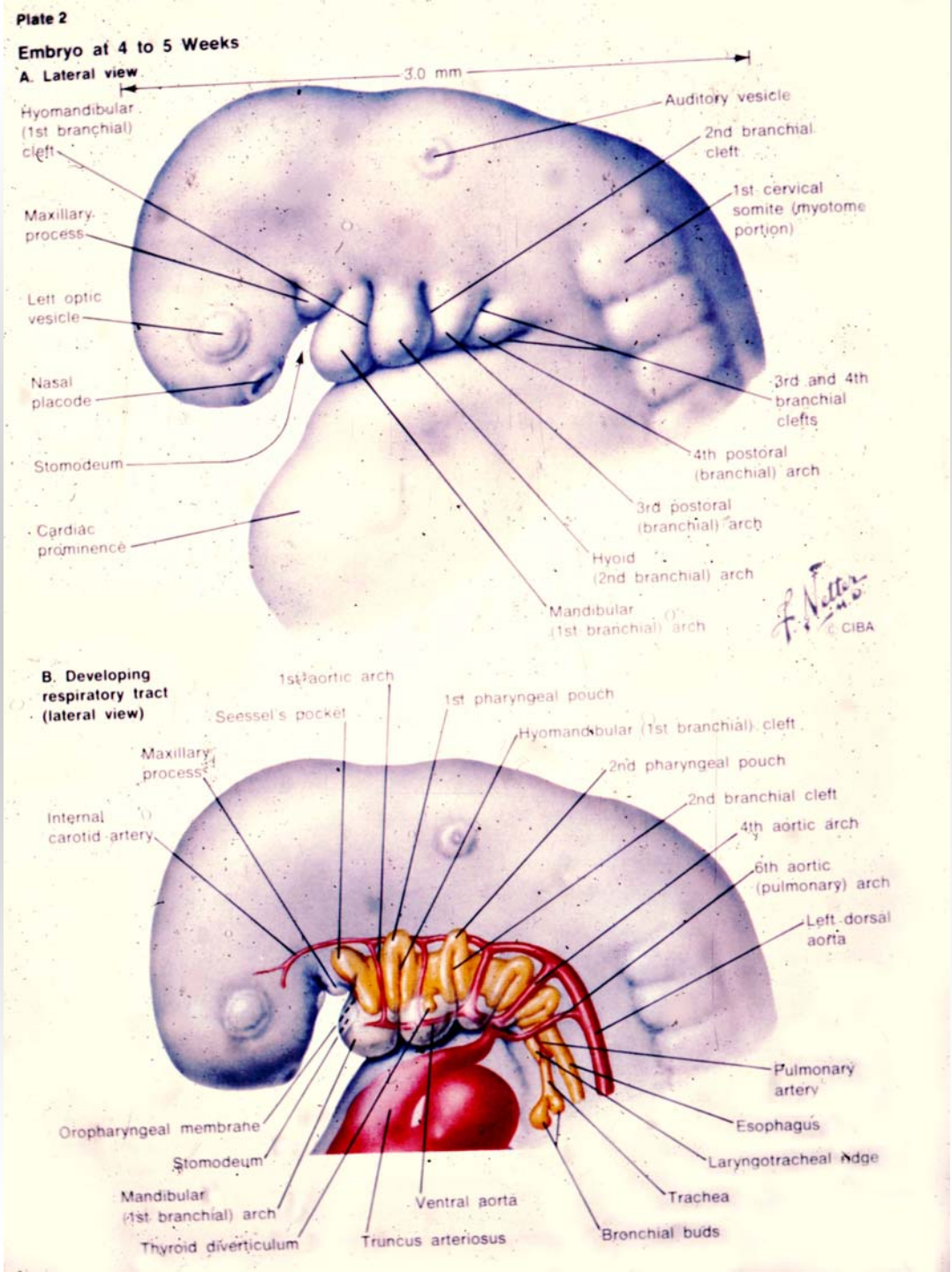
L.Moss-Salentijn

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

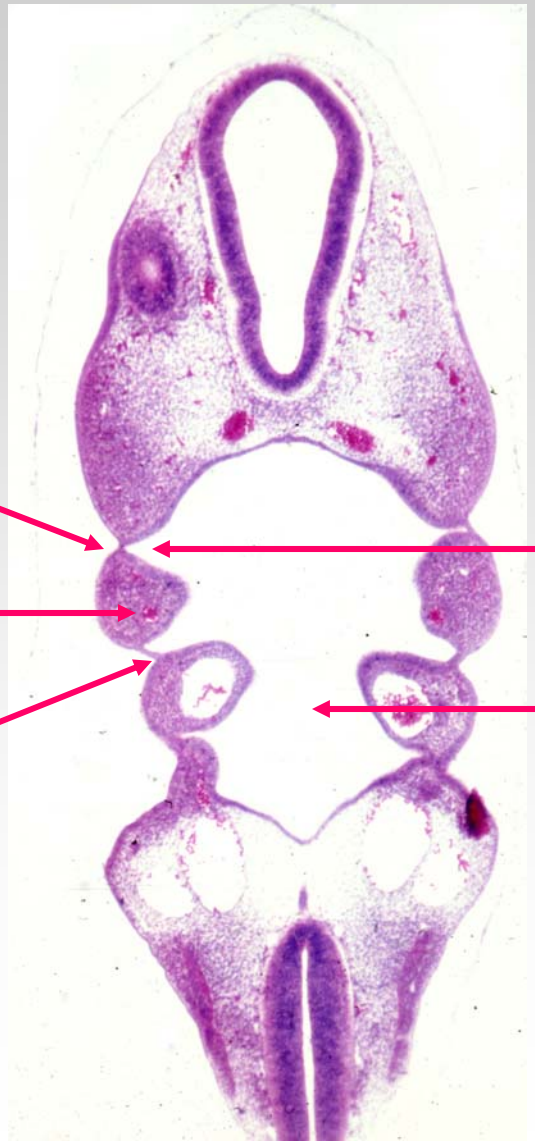


5 Pharyngeal arches

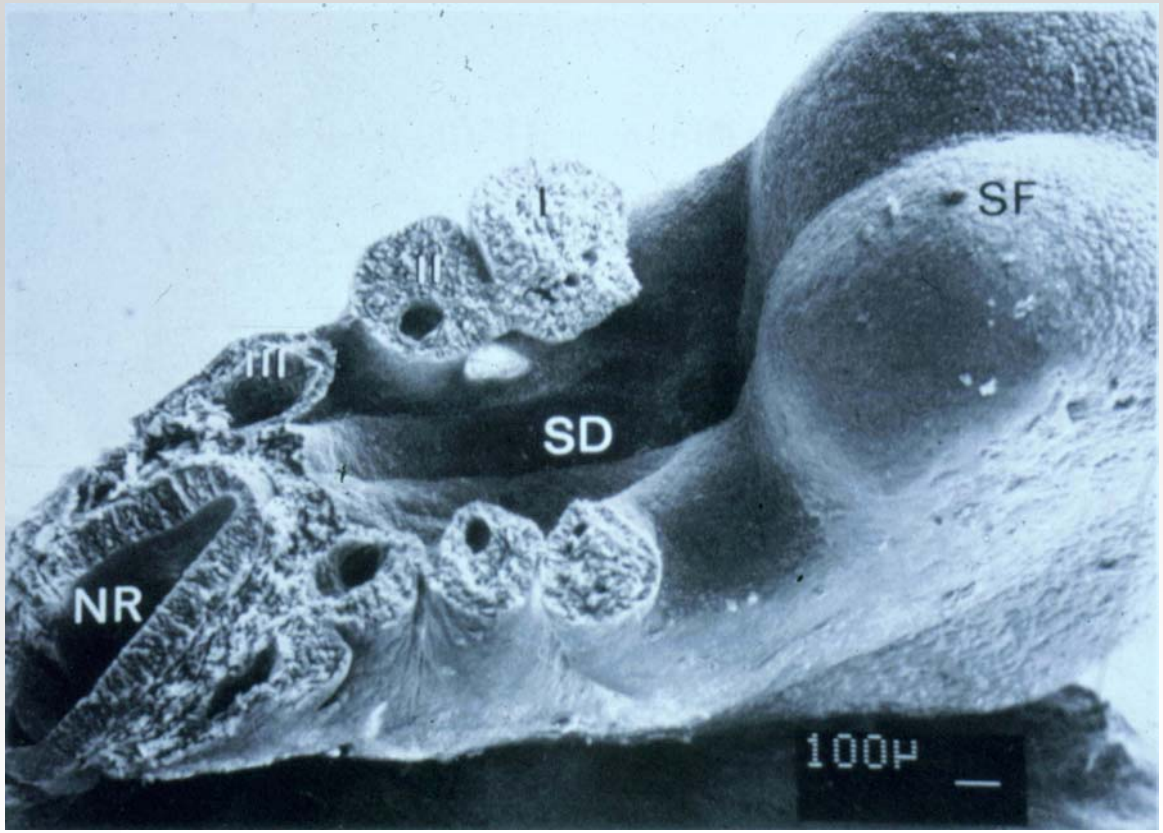
5 Aortic arches

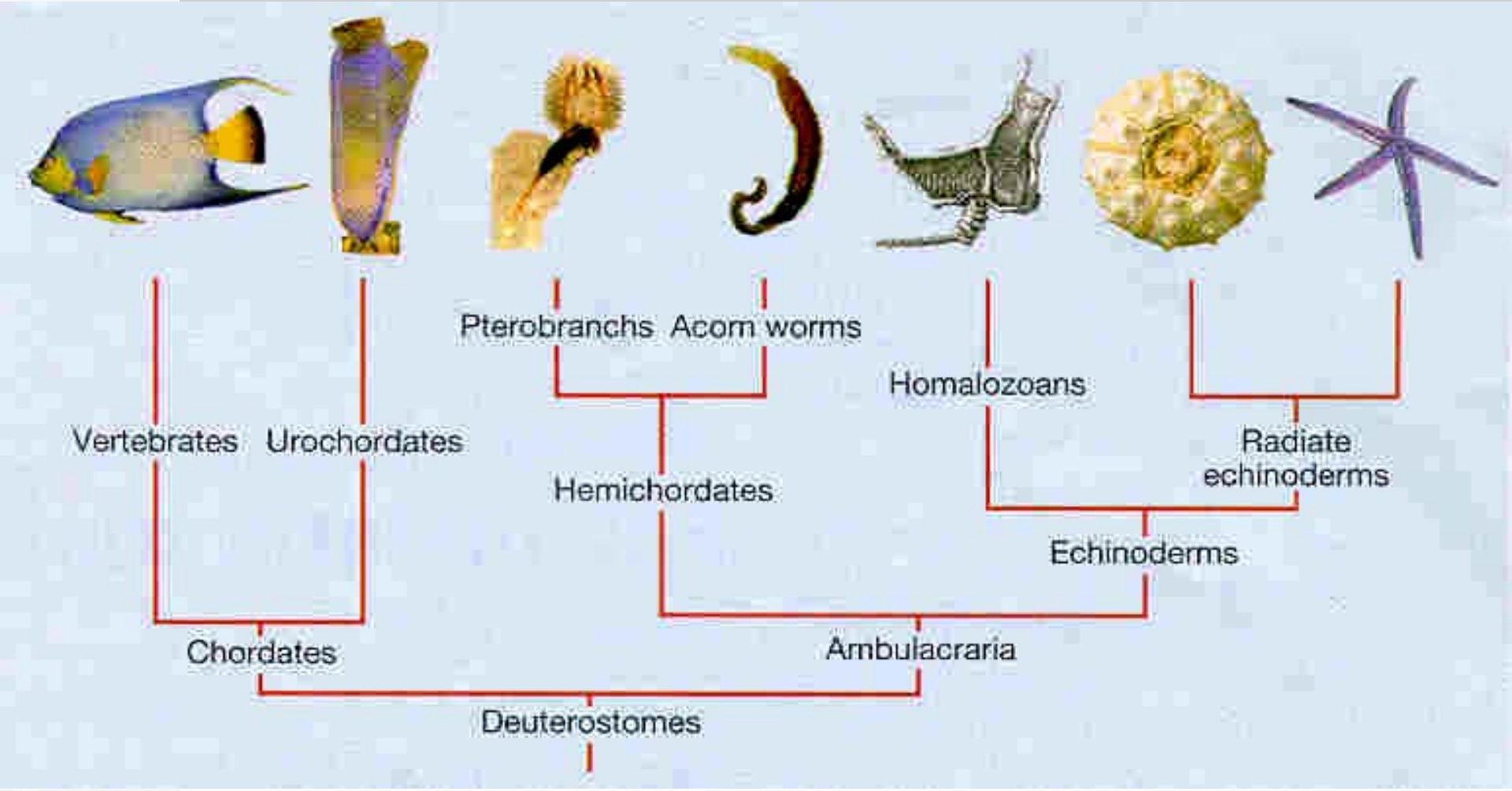
Arches numbered 1-6

Arches, grooves, pouches, and membranes



Pharyngeal cleft transient “gill-slit”




Pterobranchs
Acorn worms
Homalozoans
Vertebrates
Urochordates
Hemichordates
Radiate echinoderms
Echinoderms
Chordates
Ambulacraria
Deuterostomes

CIONA INTESTINALIS, PHOTOGRAPHED AT MARINE BIOLOGICAL LABORATORY, WOODS HOLE

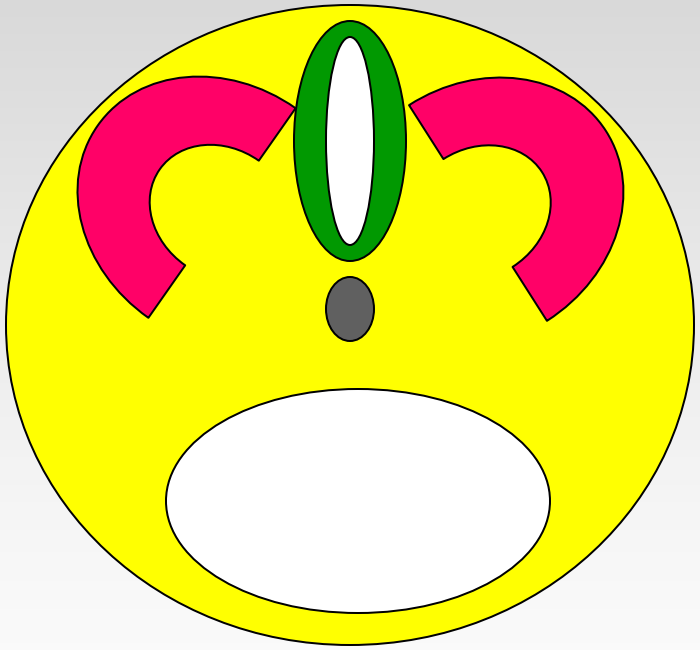
SEA SQUIRT

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)

Deuterostomes
Chordates
Craniates
Vertebrates
Echinoderms
Hemichordates
Urochordates (tunicates)
Cephalochordates (amphioxus)
Hagfish
Lampreys
Gnathostomes (jawed vertebrates) mammals, birds, fish, reptiles, amphibians
neural crest, placodes
notochord, neural tube, pharyngeal segmentation

Evolution of vertebrates involved:

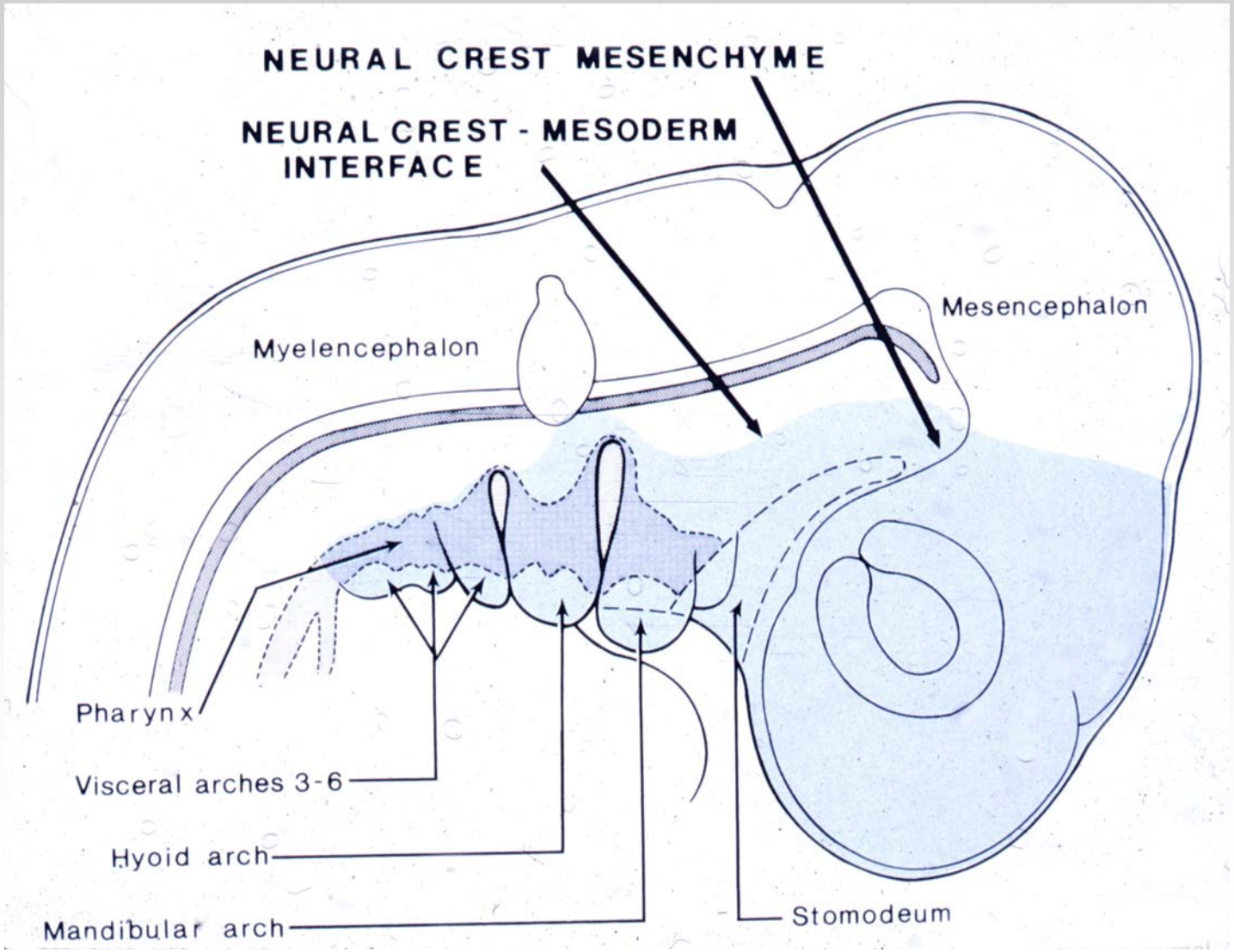
- Development of organs of special sense in head region to detect prey
- Development of a large neural circuitry (the brain) to integrate input and responses
- Development of an effective feeding apparatus (jaws: pharyngeal arch derivatives)
- Development of an improved respiratory apparatus (gills: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

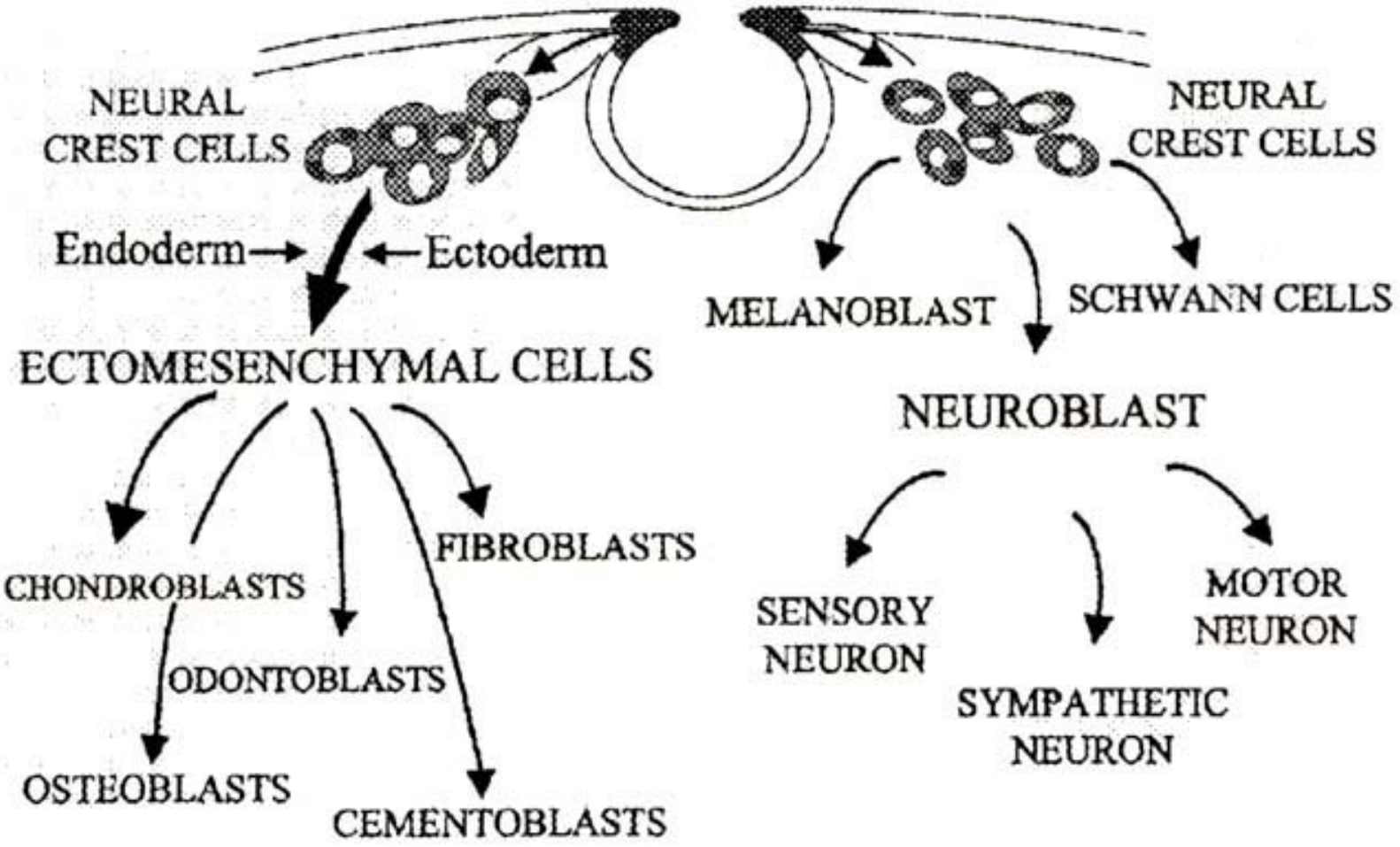
This required the recruitment of an existing group of cells: neural crest cells, for a new role.

Mesenchyme in cephalic region is derived from:

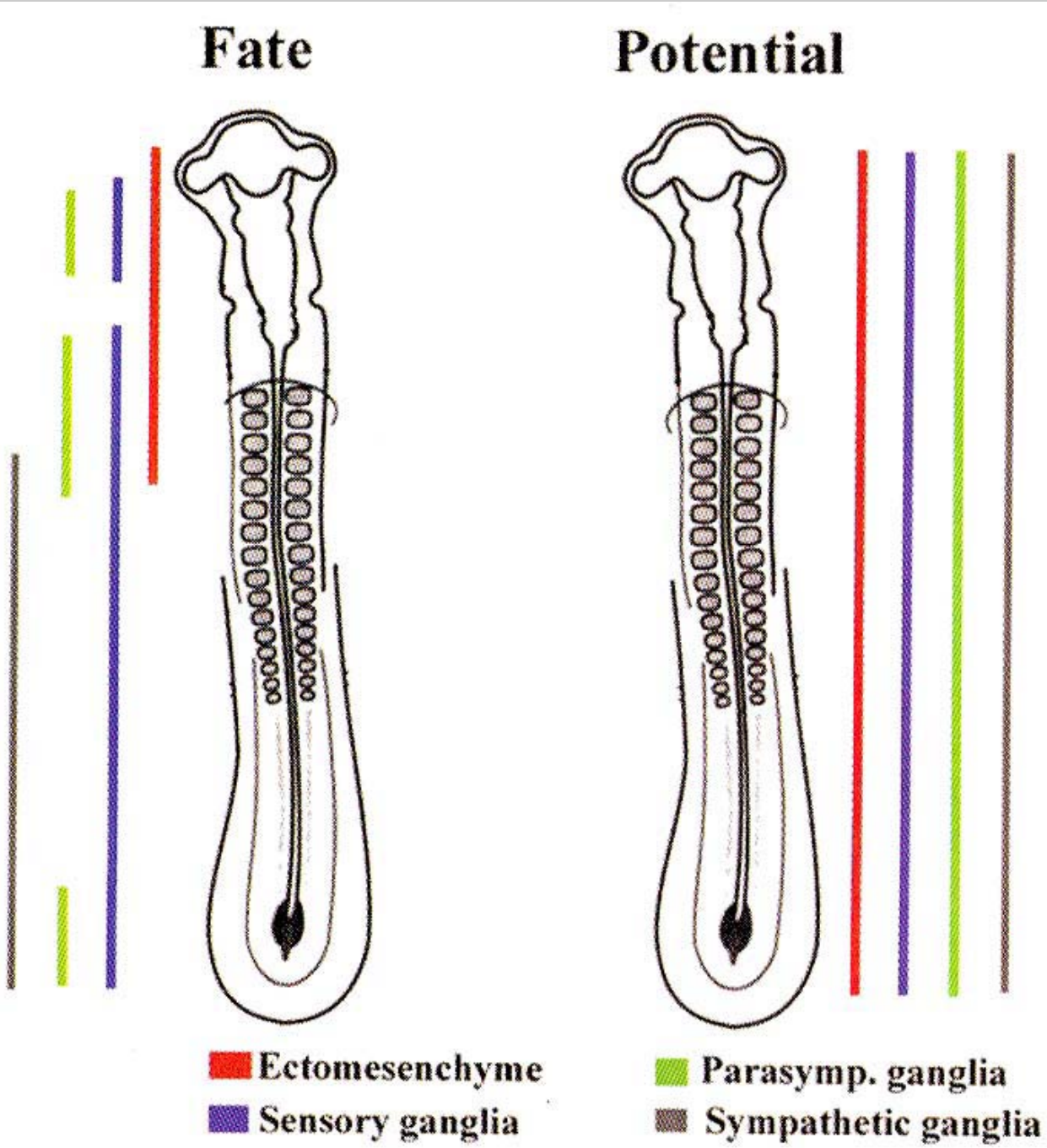
- Mesoderm
- Neural crest

Neural crest and mesoderm in H&N area

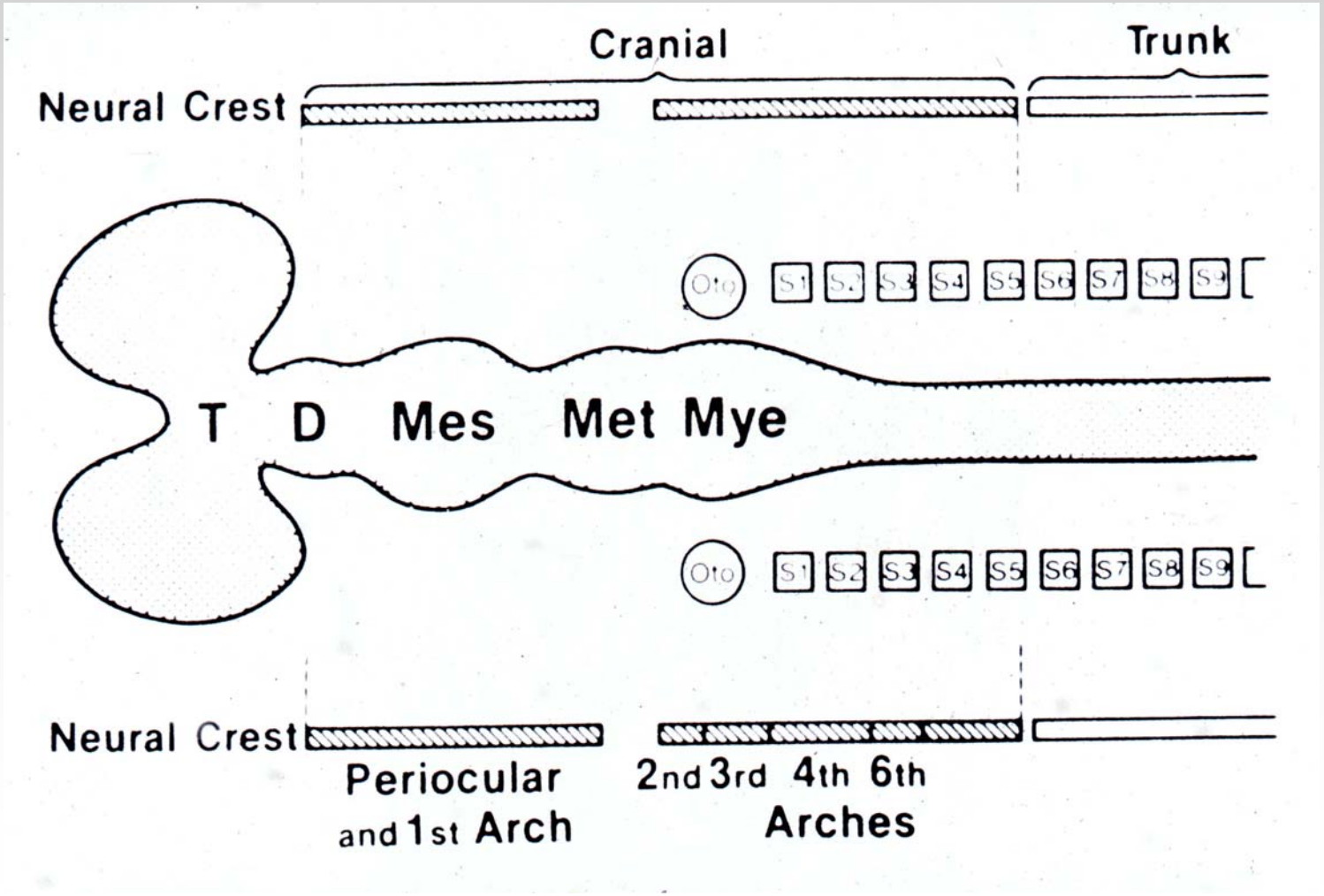




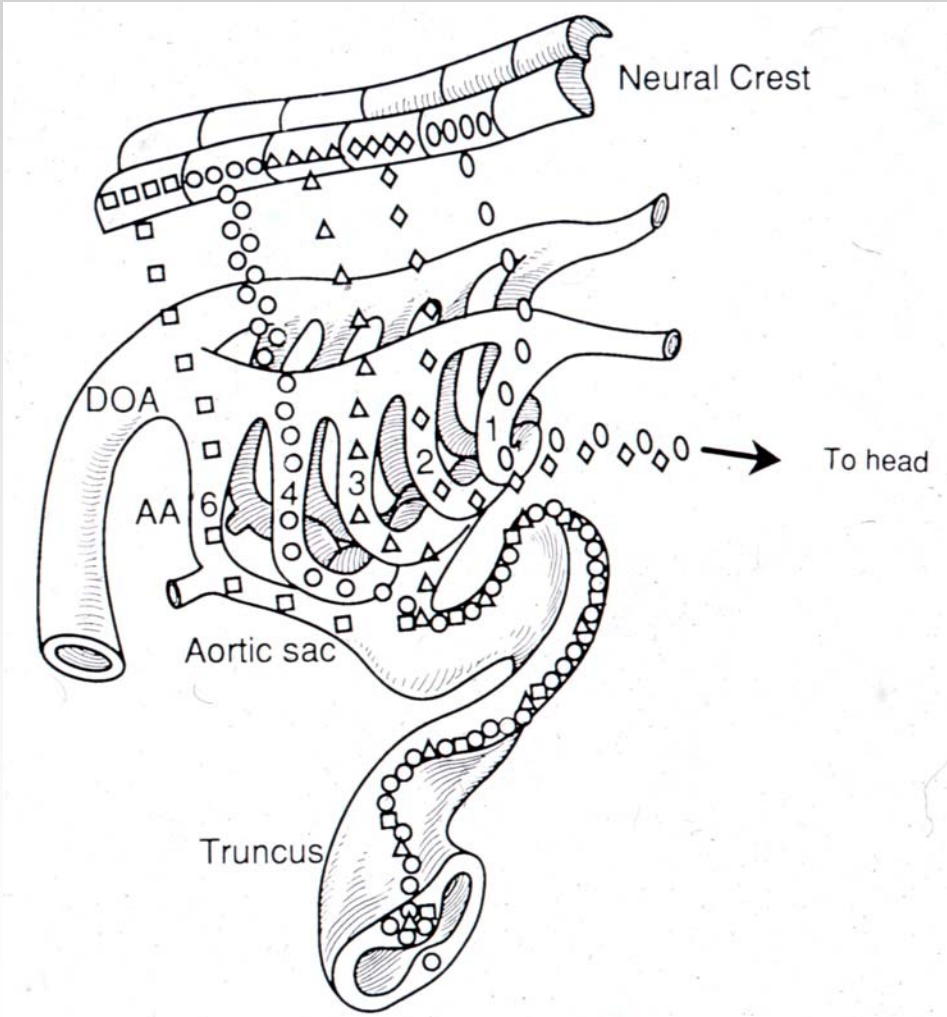
Chai Y, Ito Y, Han J (2003)


Fate
Potential
Ectomesenchyme
Sensory ganglia
Parasymp. ganglia
Sympathetic ganglia

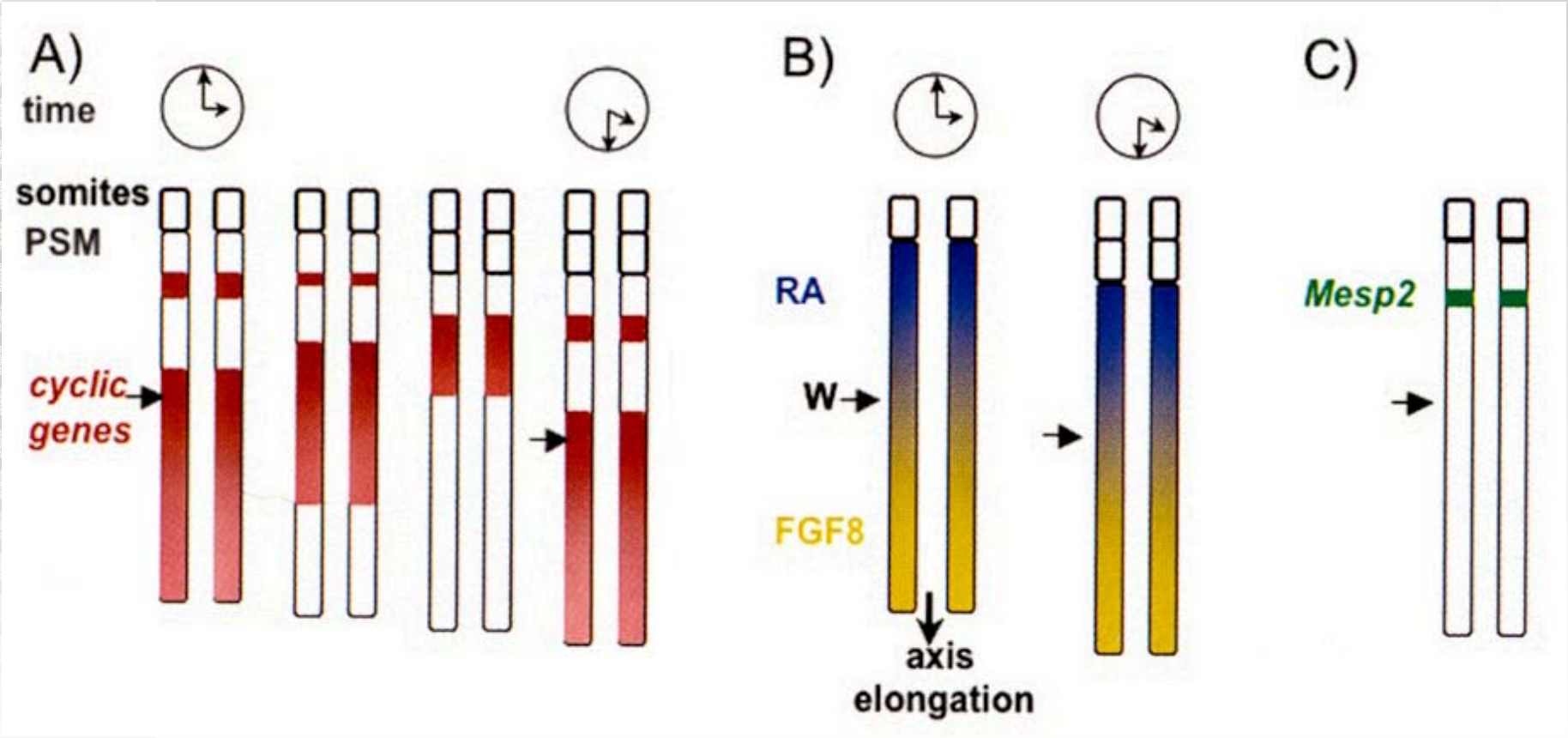
Extent of cephalic (cranial) neural crest



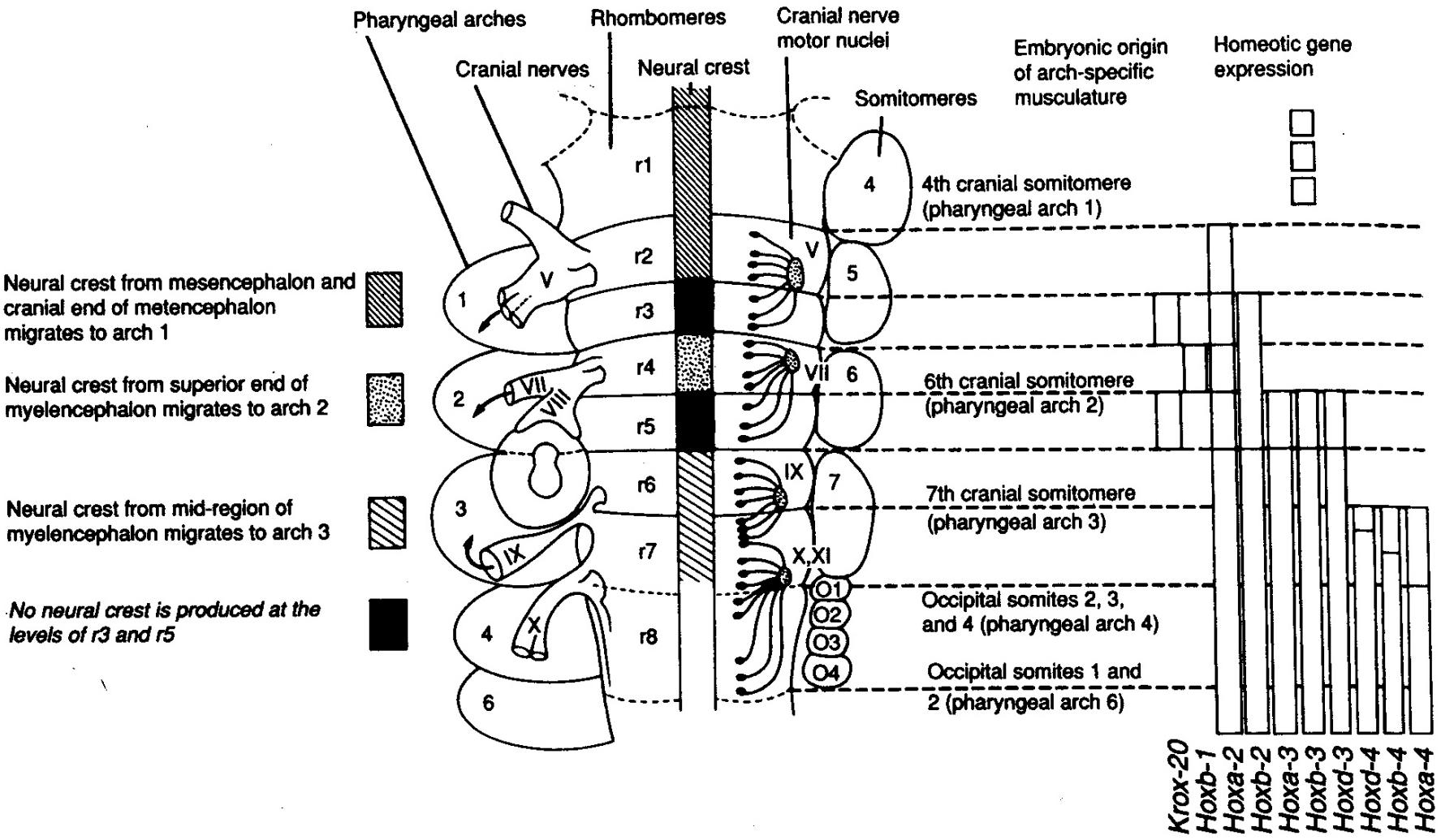
Neural crest involvement in the development of the heart

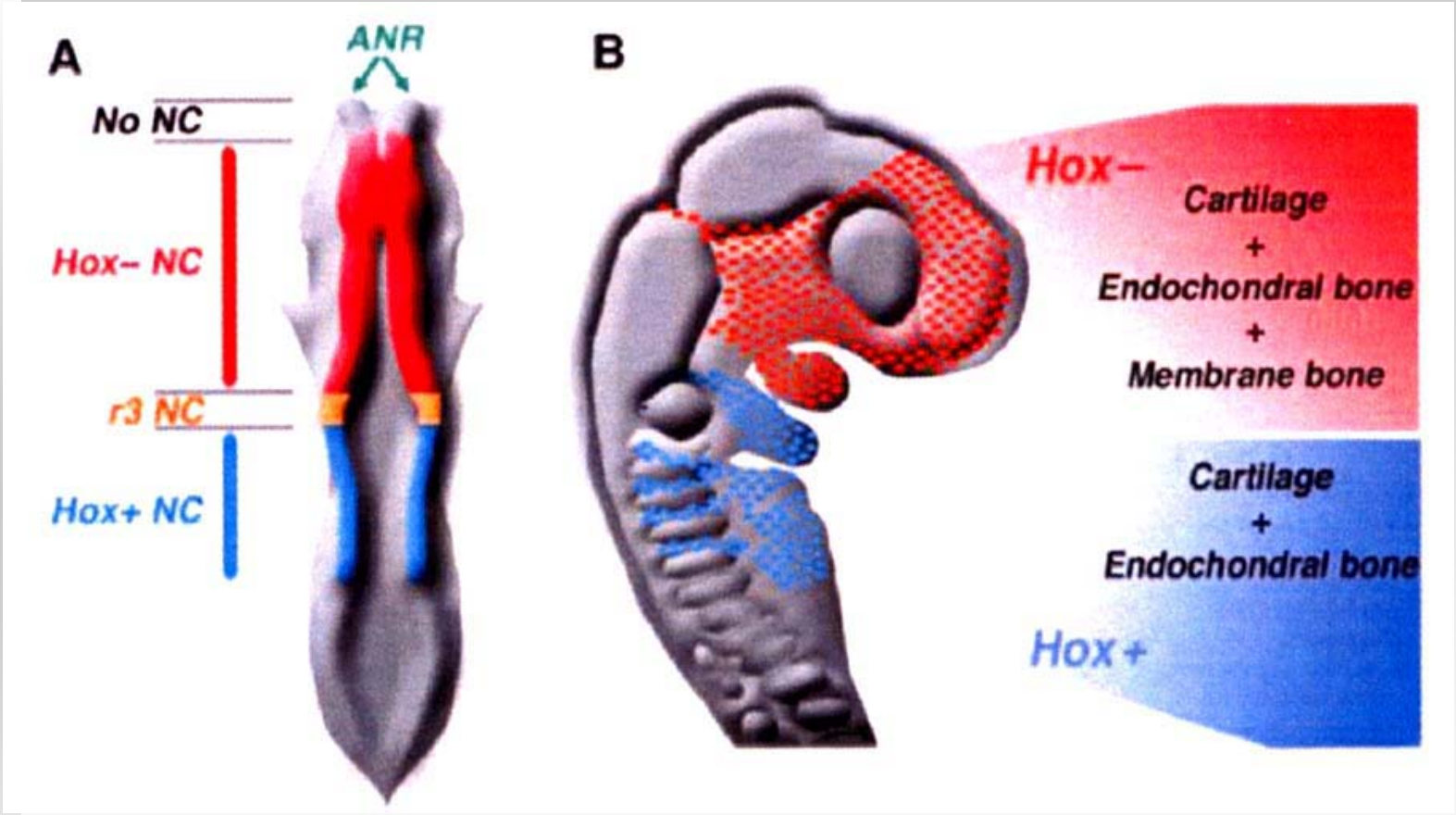


Somite segmentation clock and wavefront (chick embryo)



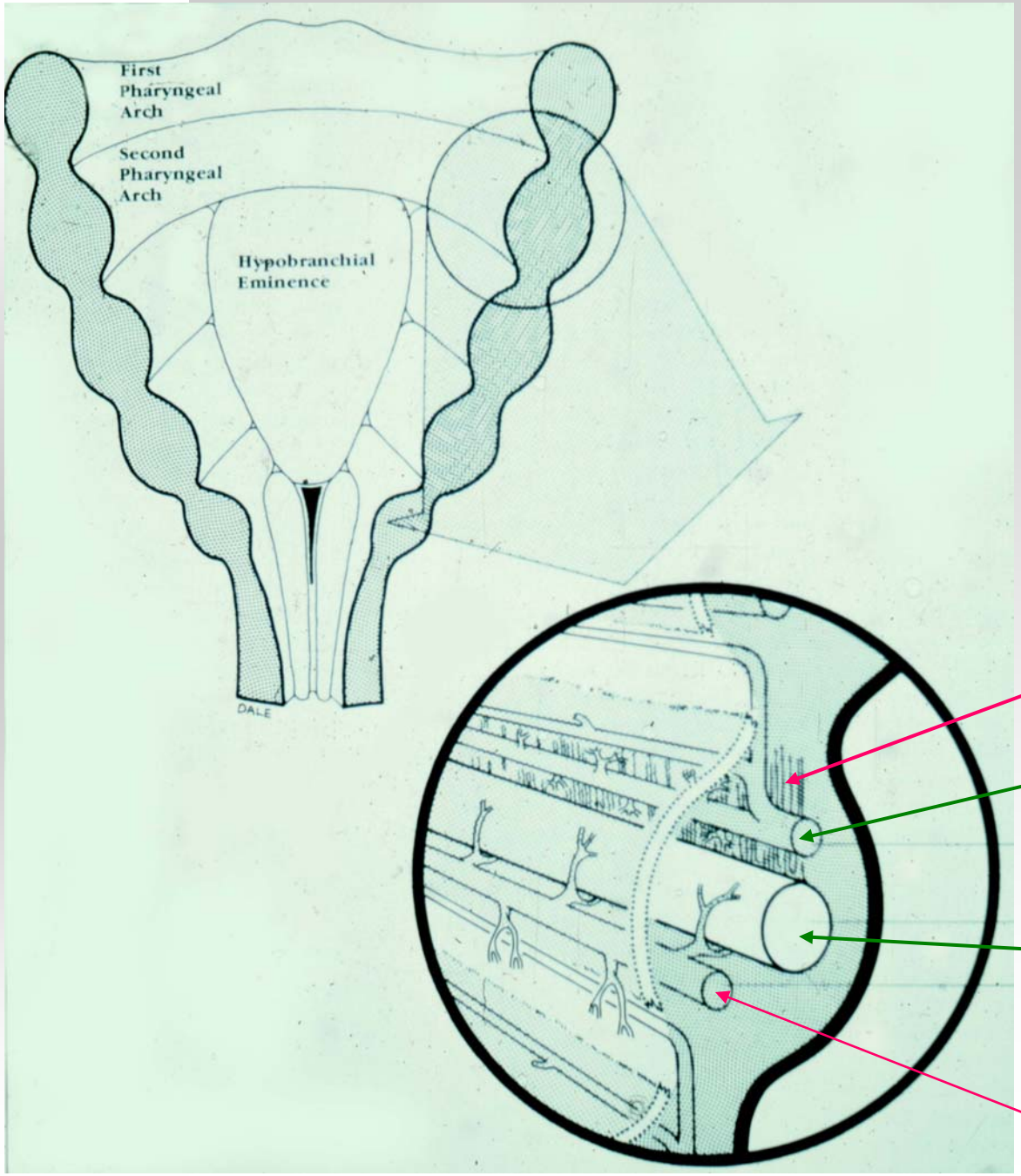
Kiefer, JC (2005)


Pharyngeal arches
Rhombomeres
Cranial nerve motor nuclei
Cranial nerves
Neural crest
Somitomeres
Embryonic origin of arch-specific musculature
Homeotic gene expression
r1
r2
r3
r4
r5
r6
r7
r8
1
2
3
4
5
6
V
VII
VIII
IX
X
X,XI
O1
O2
O3
O4
4th cranial somitomere (pharyngeal arch 1)
6th cranial somitomere (pharyngeal arch 2)
7th cranial somitomere (pharyngeal arch 3)
Occipital somites 2, 3, and 4 (pharyngeal arch 4)
Occipital somites 1 and 2 (pharyngeal arch 6)
Neural crest from mesencephalon and cranial end of metencephalon migrates to arch 1
Neural crest from superior end of myelencephalon migrates to arch 2
Neural crest from mid-region of myelencephalon migrates to arch 3
No neural crest is produced at the levels of r3 and r5
Krox-20
Hoxb-1
Hoxa-2
Hoxb-2
Hoxa-3
Hoxb-3
Hoxd-3
Hoxd-4
Hoxb-4
Hoxa-4



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

Segmental components of arches



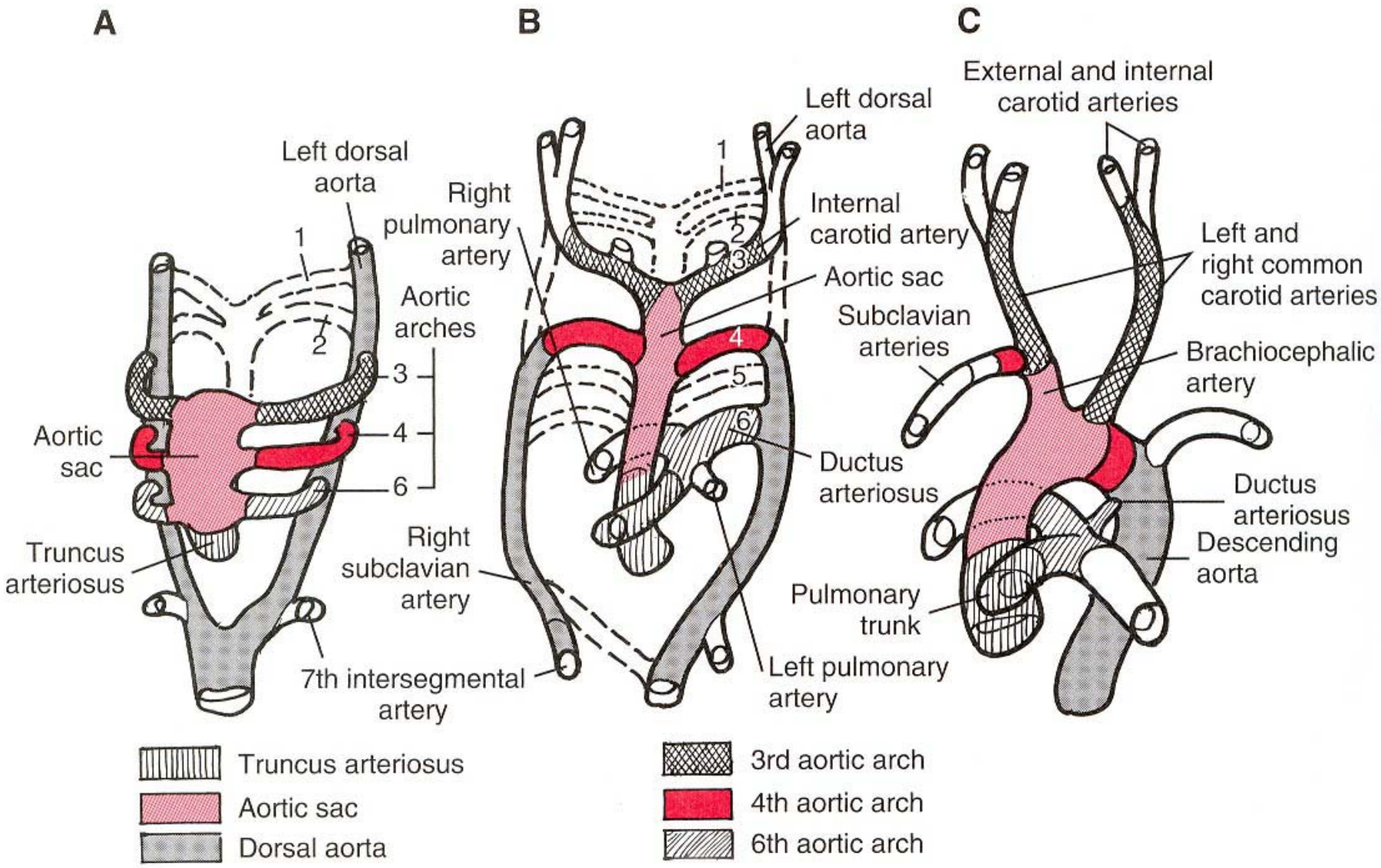
Connective tissues - nc

Muscle – mesoderm

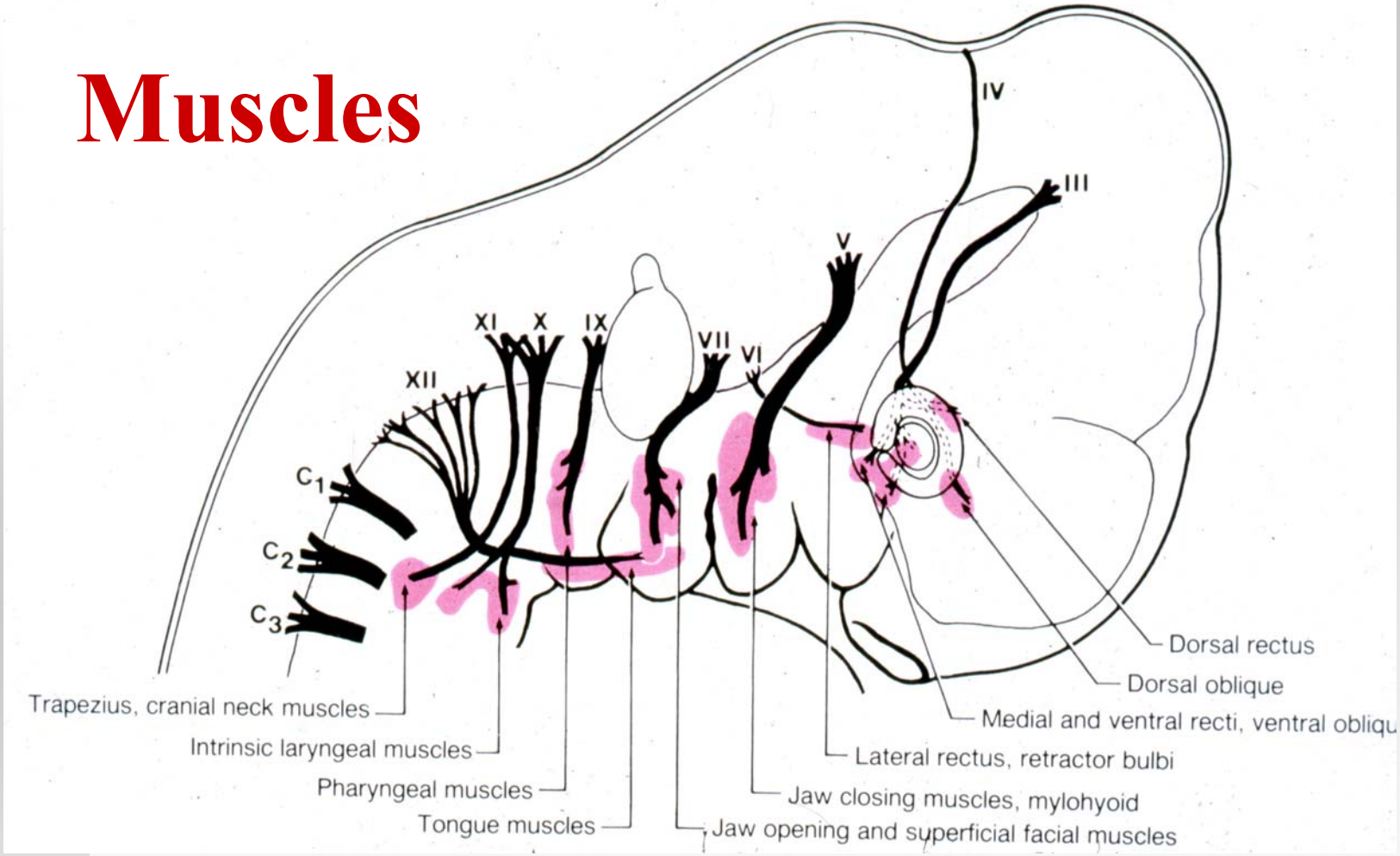
Branchiomeric nerve – nc,ectoderm,neurectoderm

Skeletal bar- nc - (cartilage) last to form

Artery – mesoderm- first to appear


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
5
Ductus arteriosus
Left pulmonary artery
External and internal carotid arteries
Left and right common carotid arteries
Subclavian 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



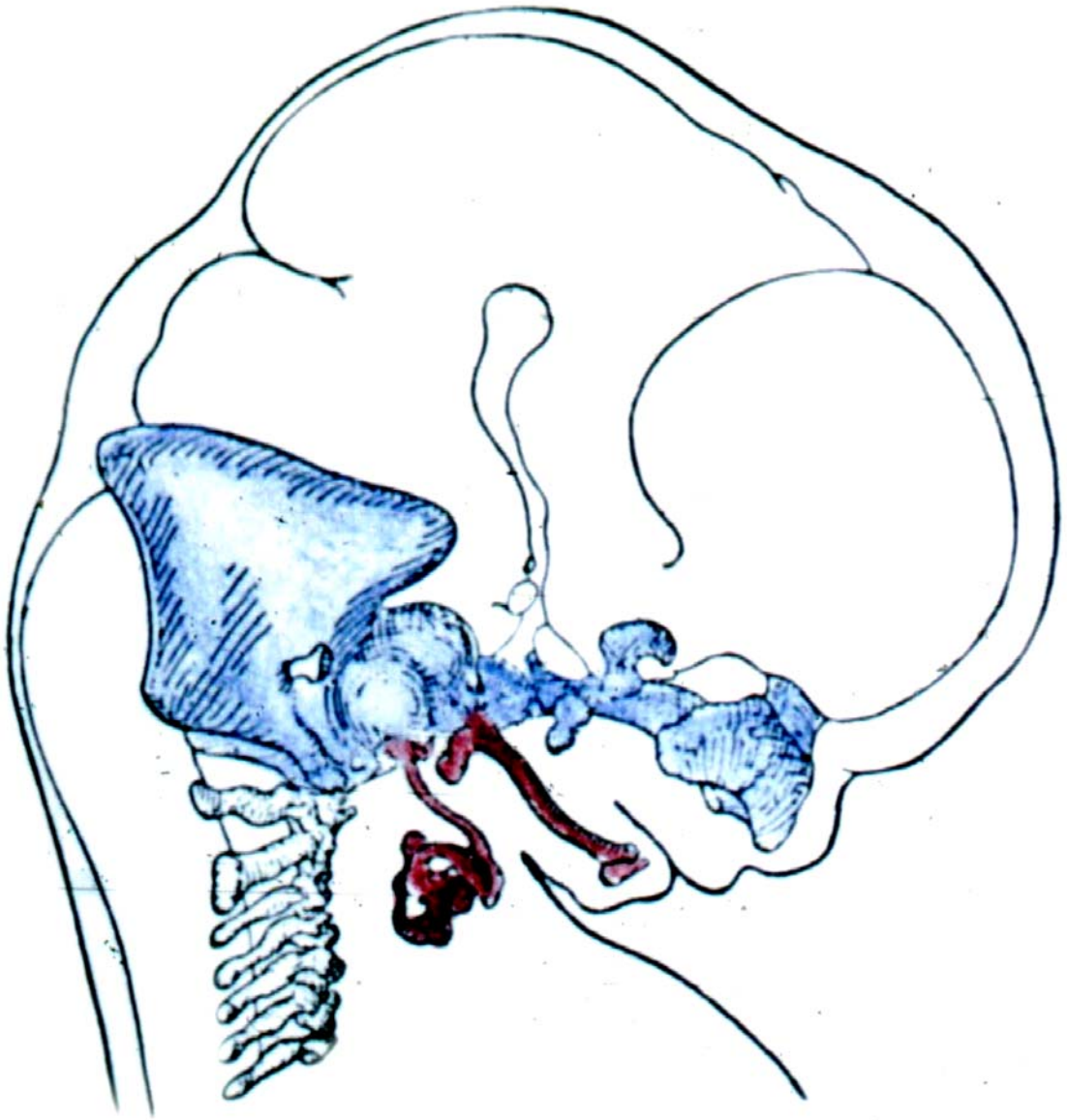
Arch 1: Muscles of mastication (V)

Arch 2: Muscles of facial expression (VII)

Arch 3: Stylopharyngeus muscle (IX)

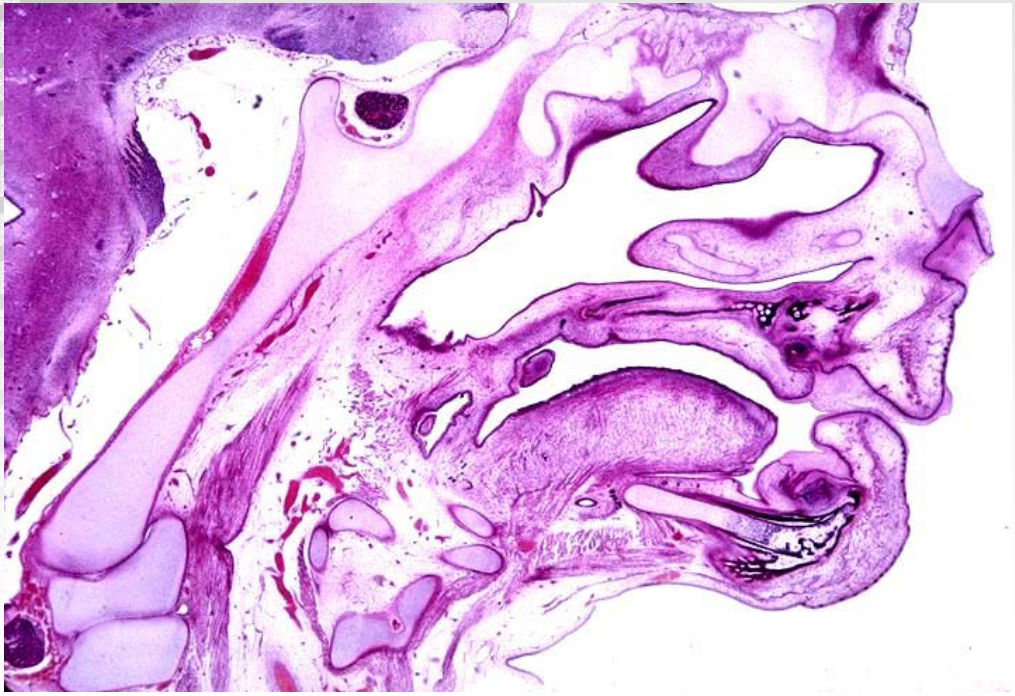
Arch 4-6: Laryngeal muscles (X-XI)

Arey's Embryology

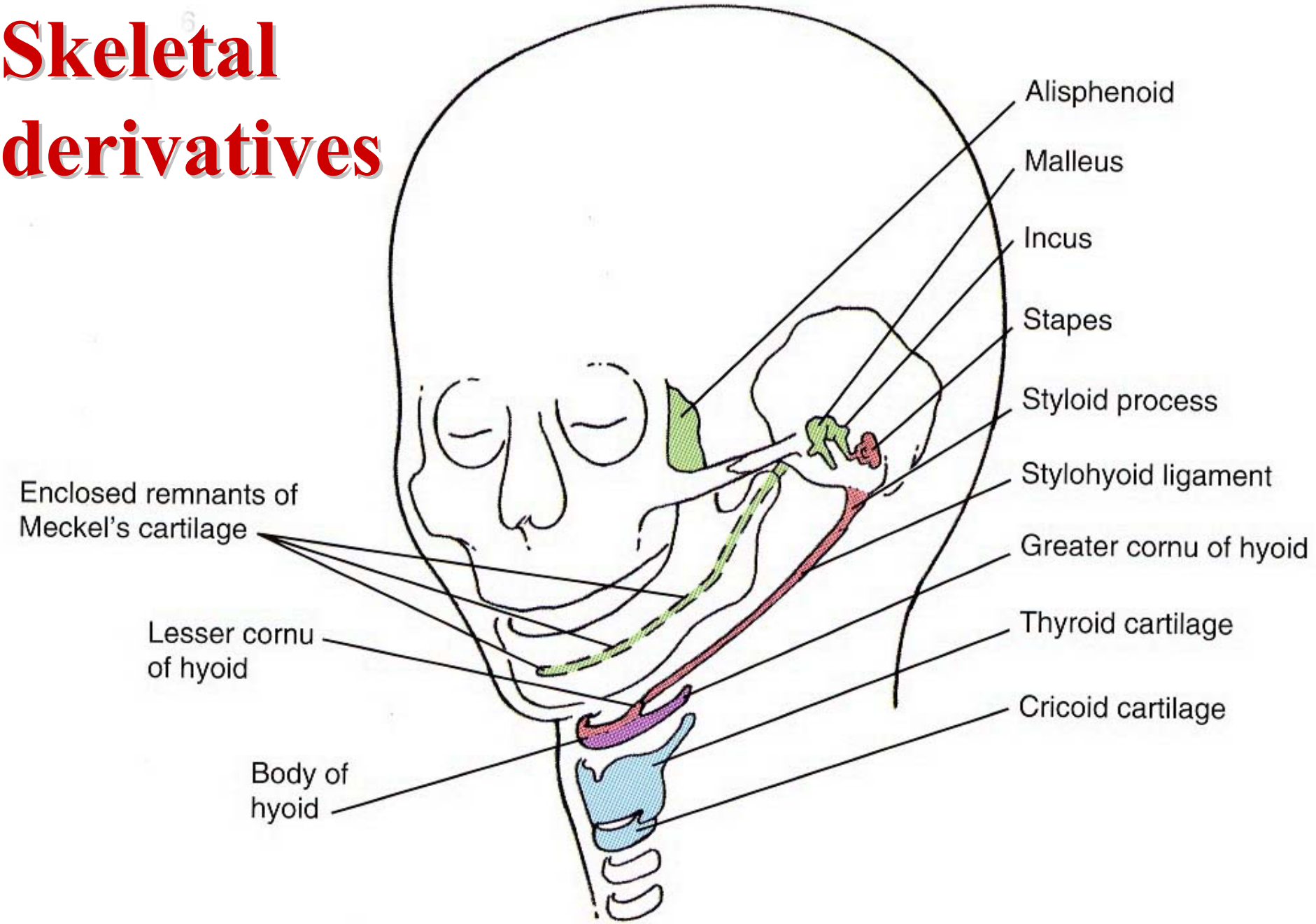


The cartilage elements of the pharyngeal arches (cartilaginous viscerocranium, purple) at 7 weeks.

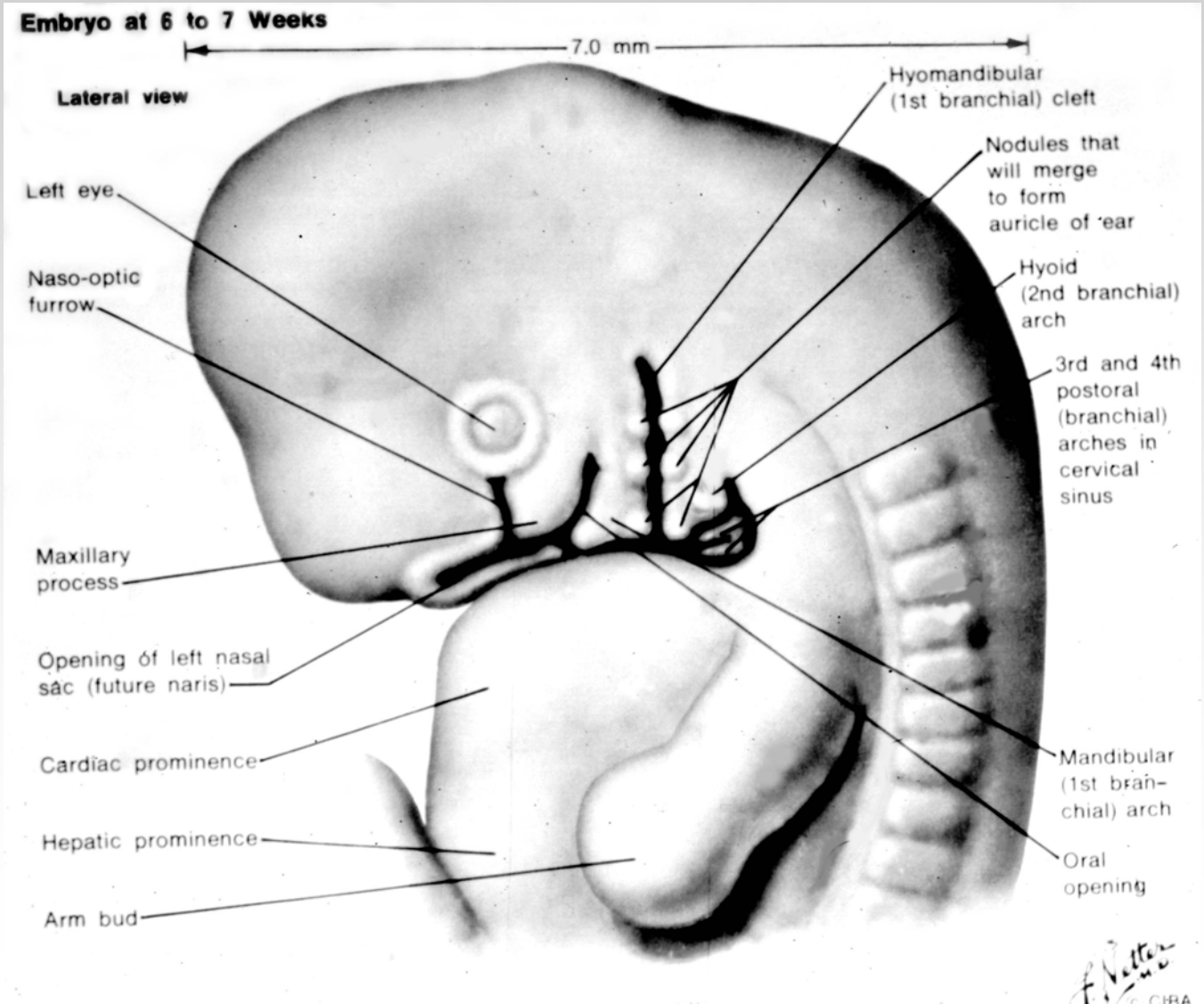
Skeletal elements



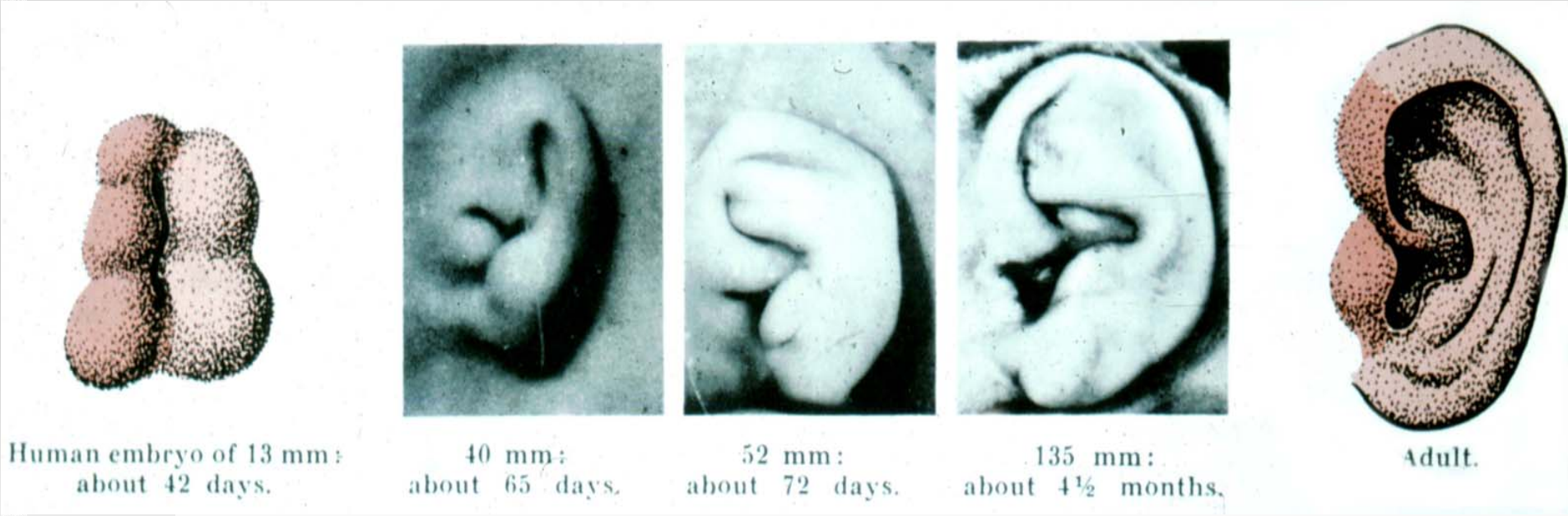
Skeletal derivatives



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.

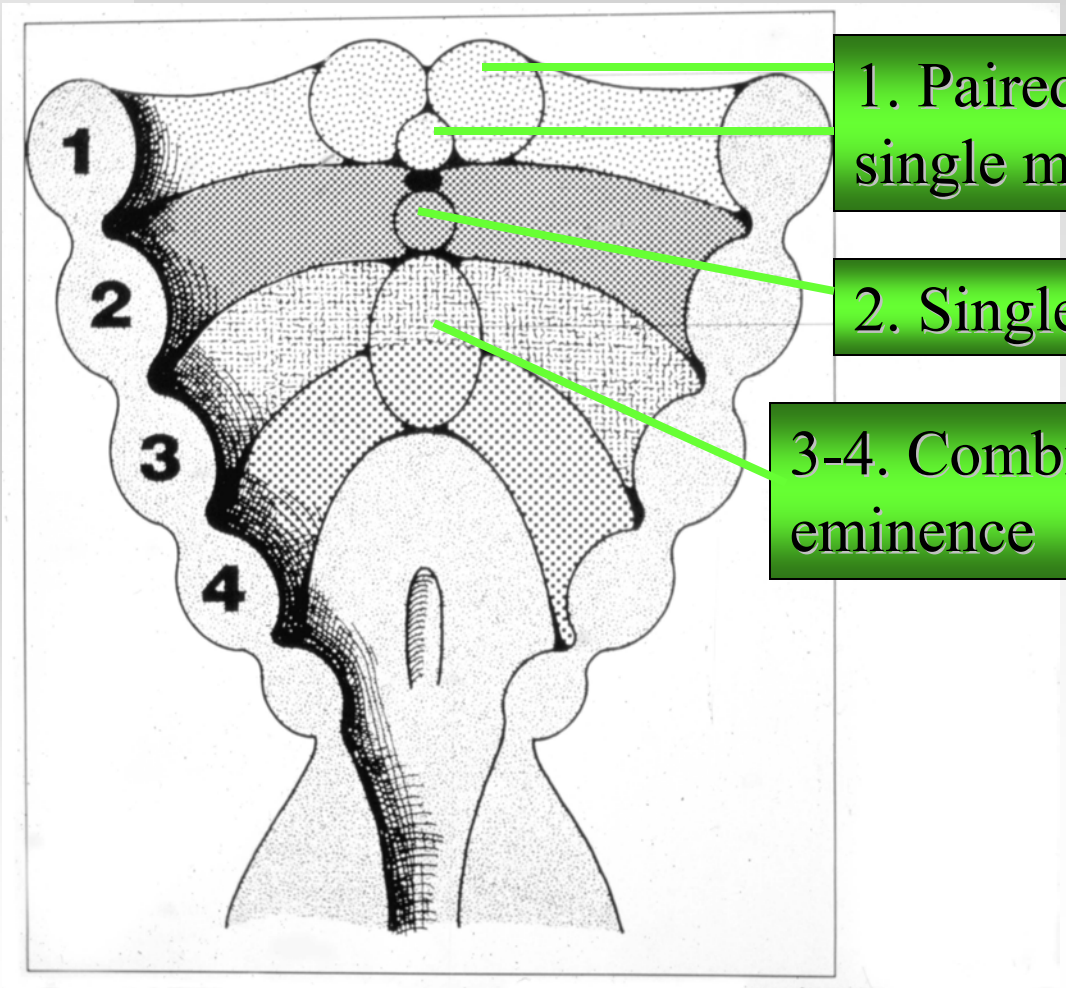
40 mm: about 65 days.

52 mm: about 72 days.

135 mm: about 4½ months.

Adult.

Endodermal swellings on arches 1-4 contribute to the tongue

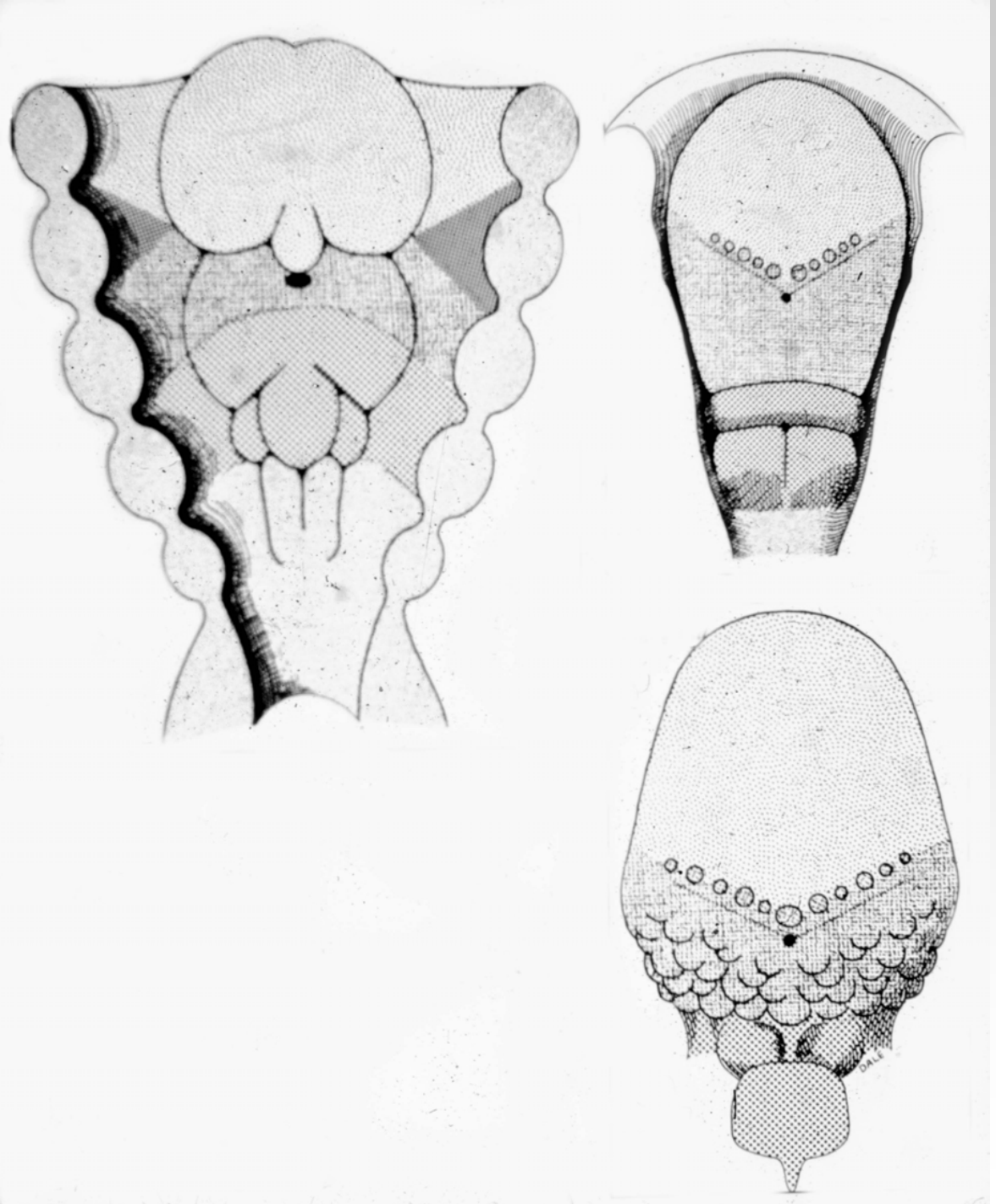


1. Paired lingual swellings and single median tuberculum impar

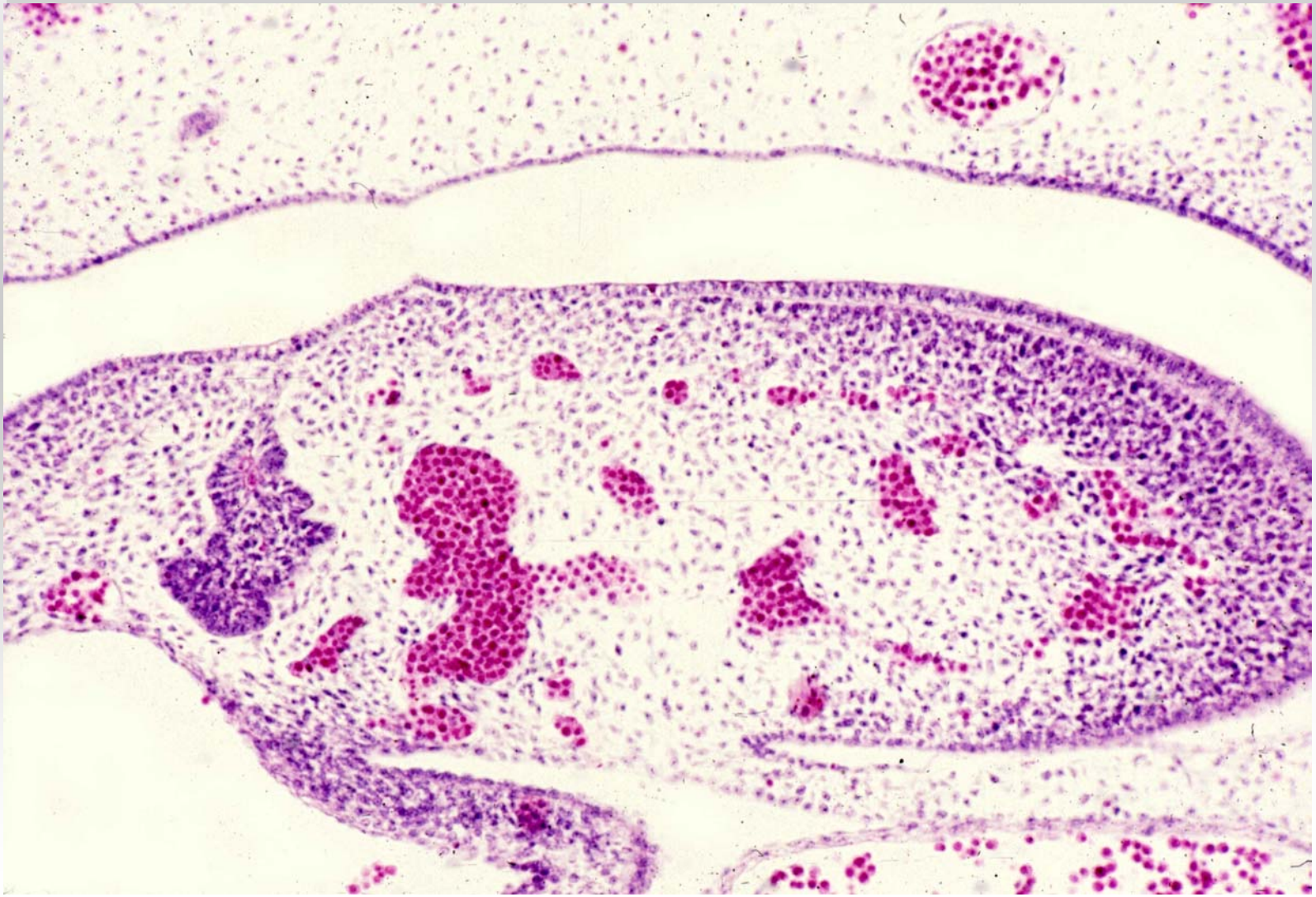
2. Single median copula

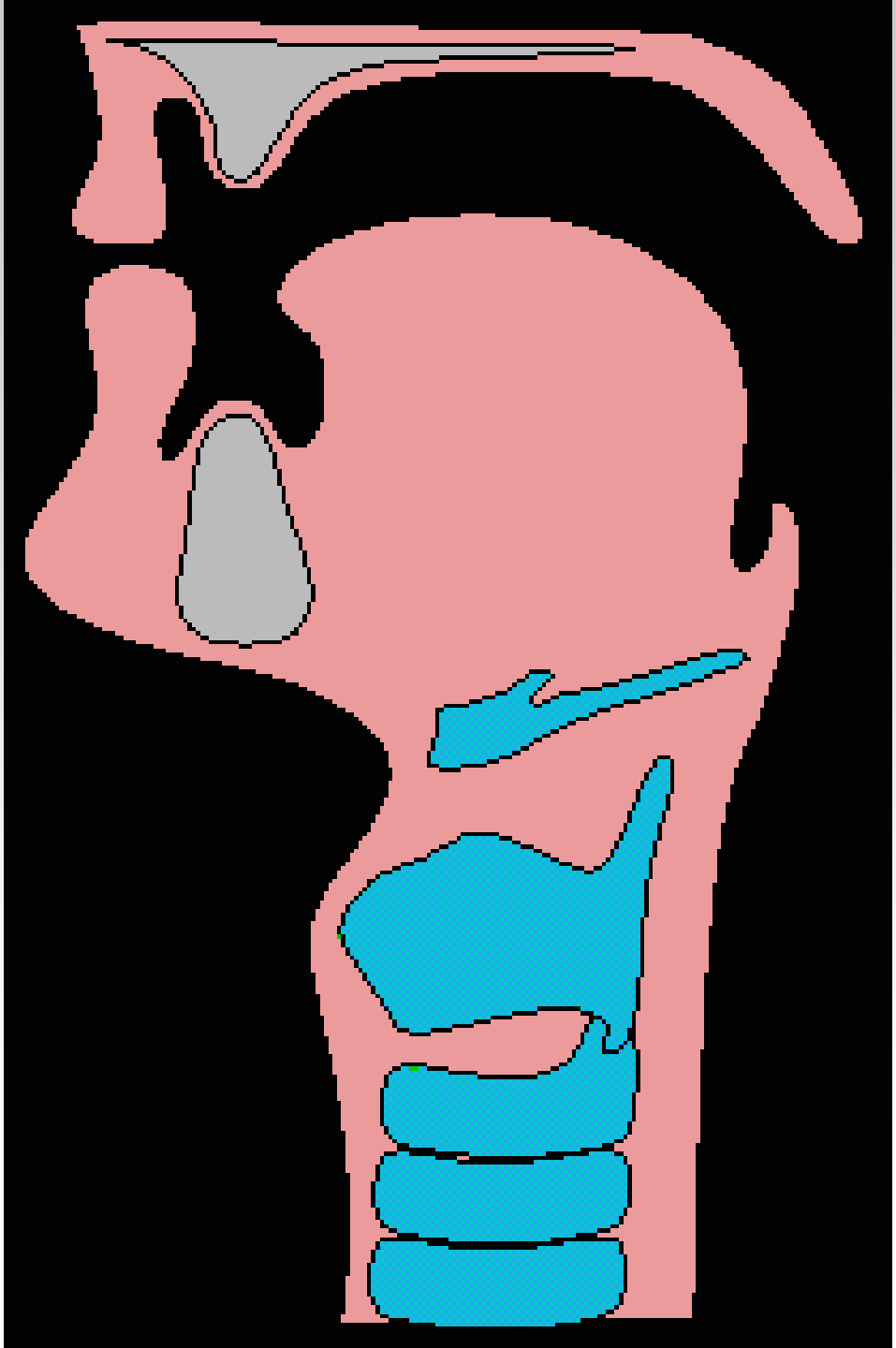
3-4. Combined median hypobranchial eminence

Merging of lingual swellings

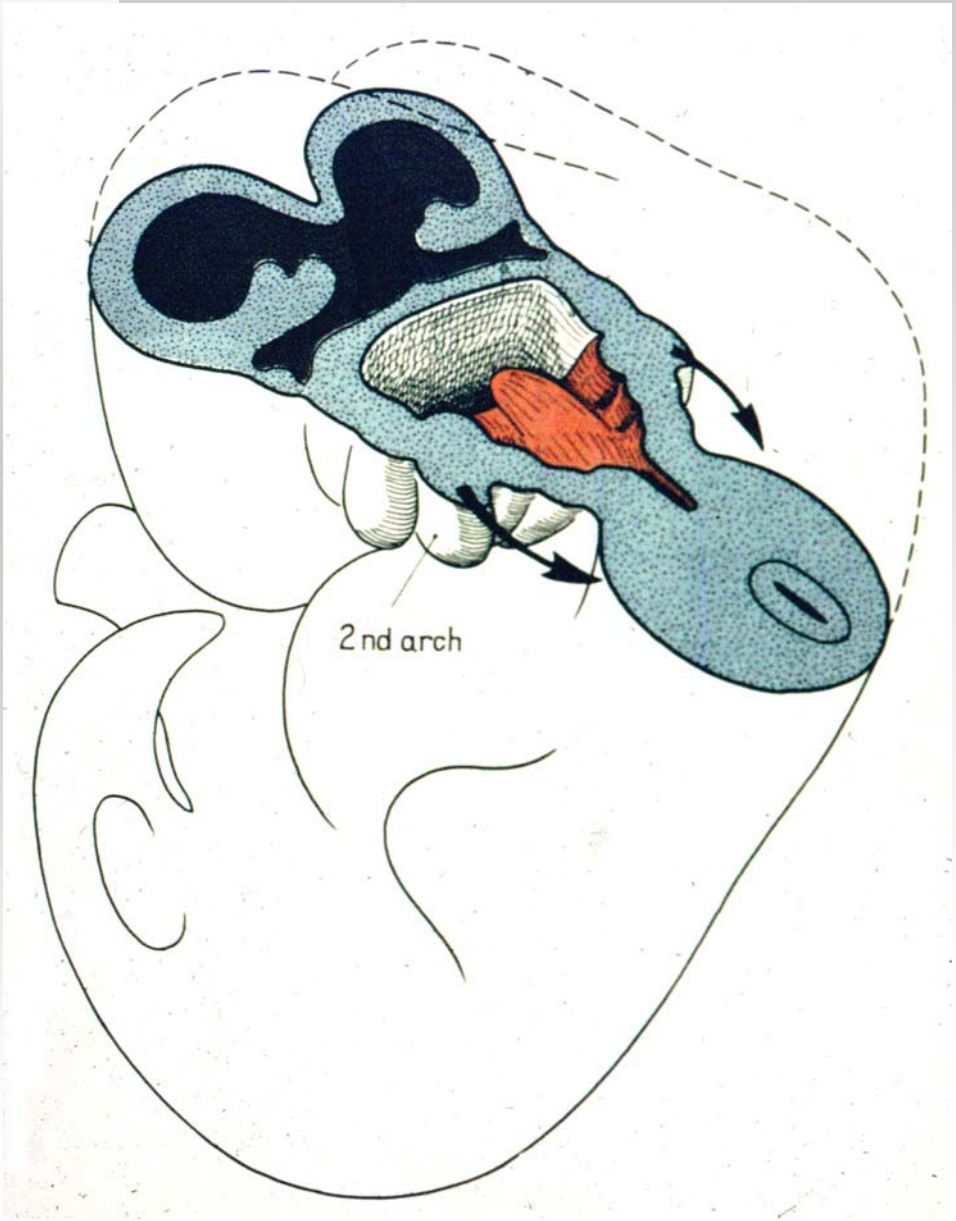


Thyroid gland development
Thyroglossal duct



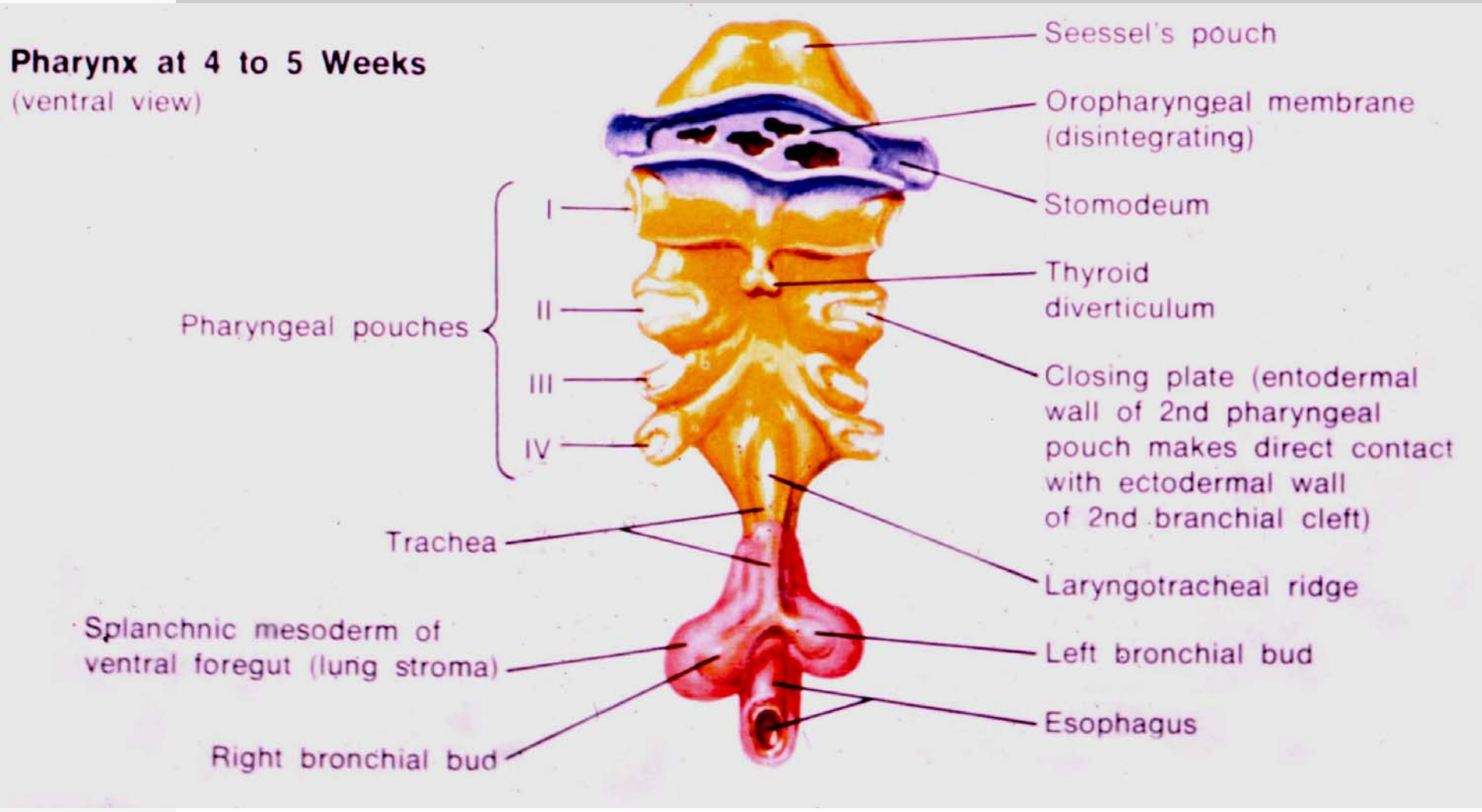


Fate of pharyngeal grooves 2-4

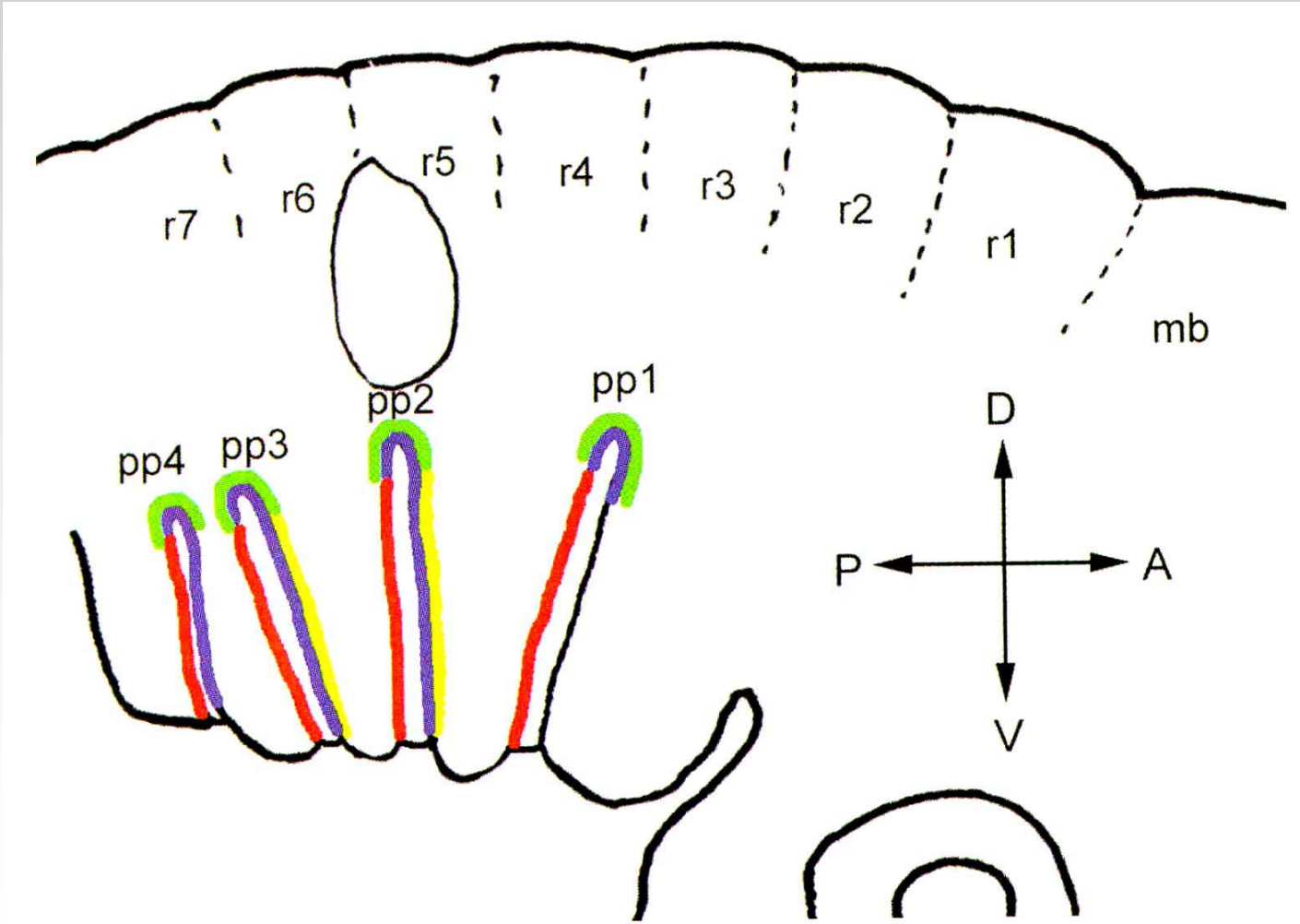


Covered by rapid outgrowth of 2nd arch "operculum."

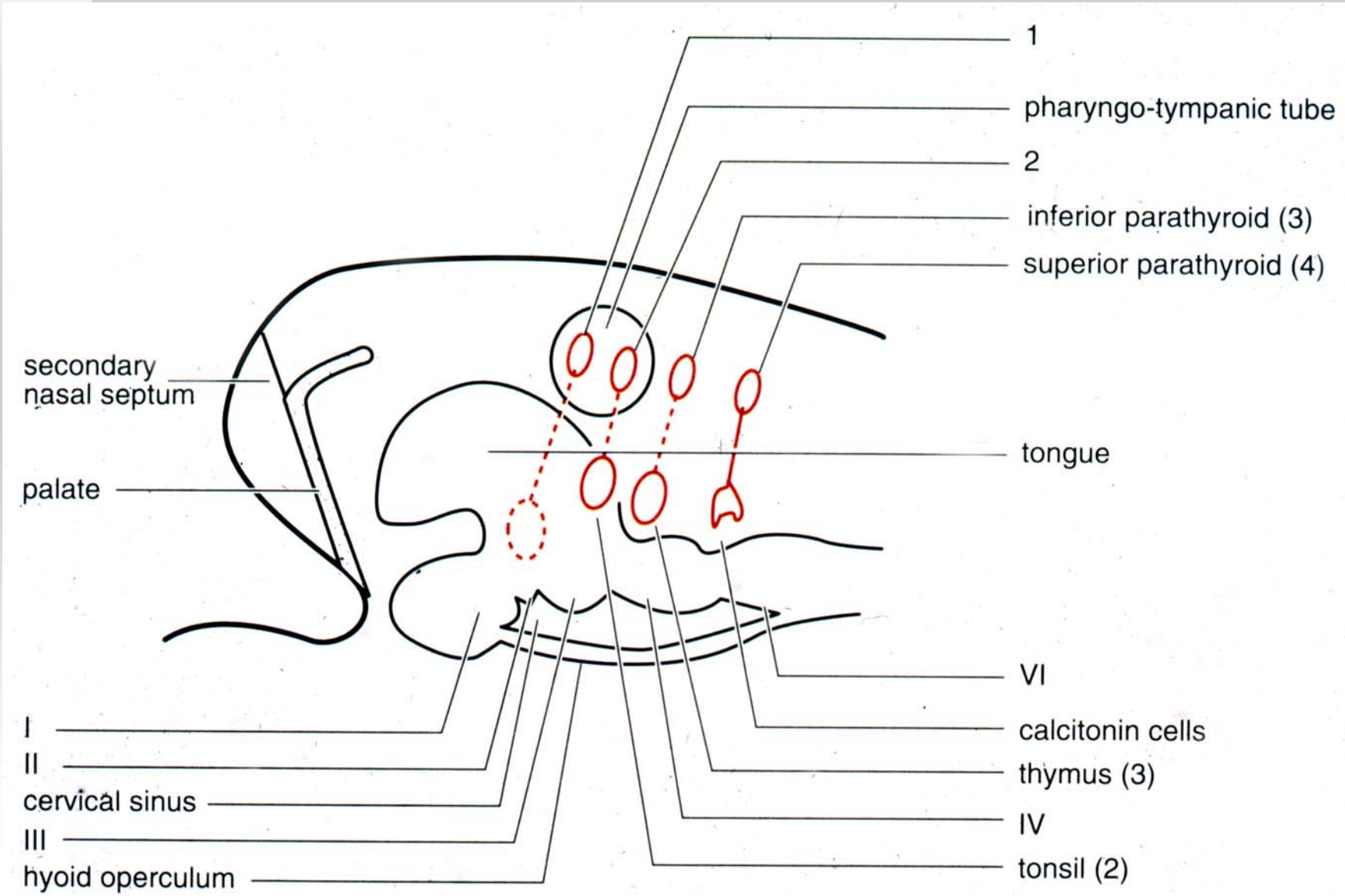
Pharynx at 4 to 5 Weeks
(ventral view)

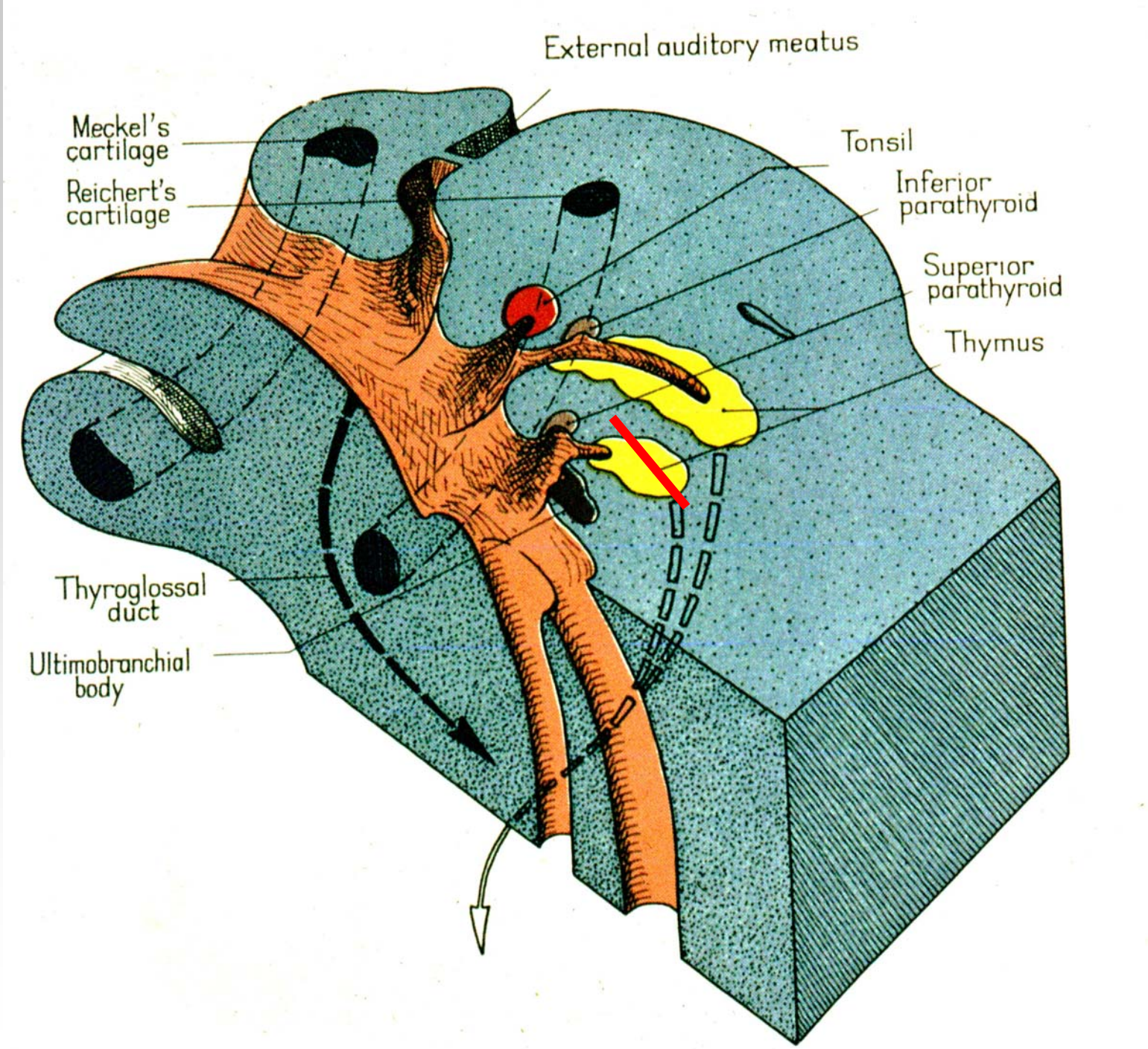


Endoderm plays key role in morpho-genesis of pharyngeal region



Derivatives of dorsal and ventral parts of pharyngeal pouches




External auditory meatus
Meckel's cartilage
Reichert's cartilage
Tonsil
Inferior parathyroid
Superior parathyroid
Thymus
Thyroglossal duct
Ultimobranchial body

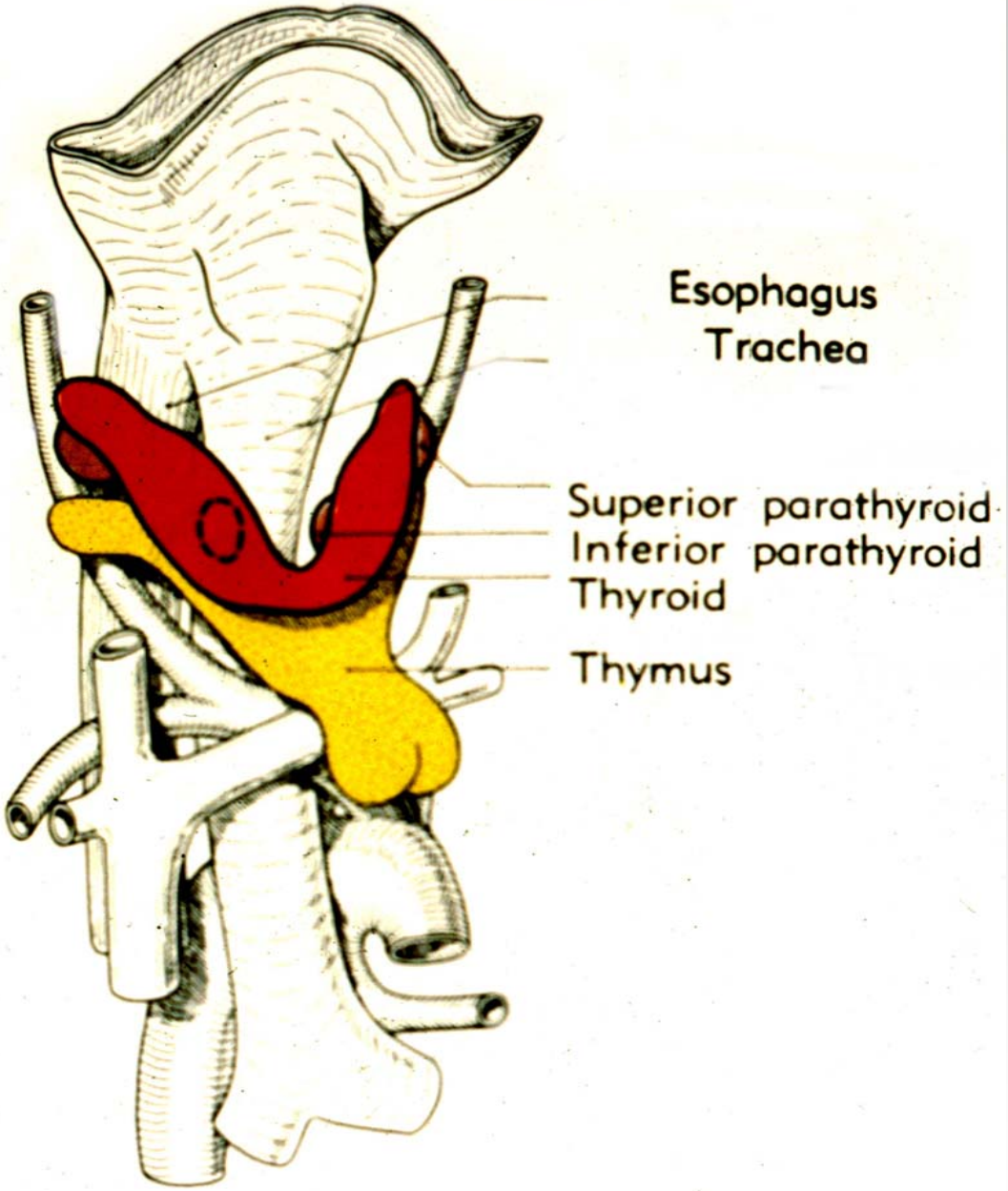
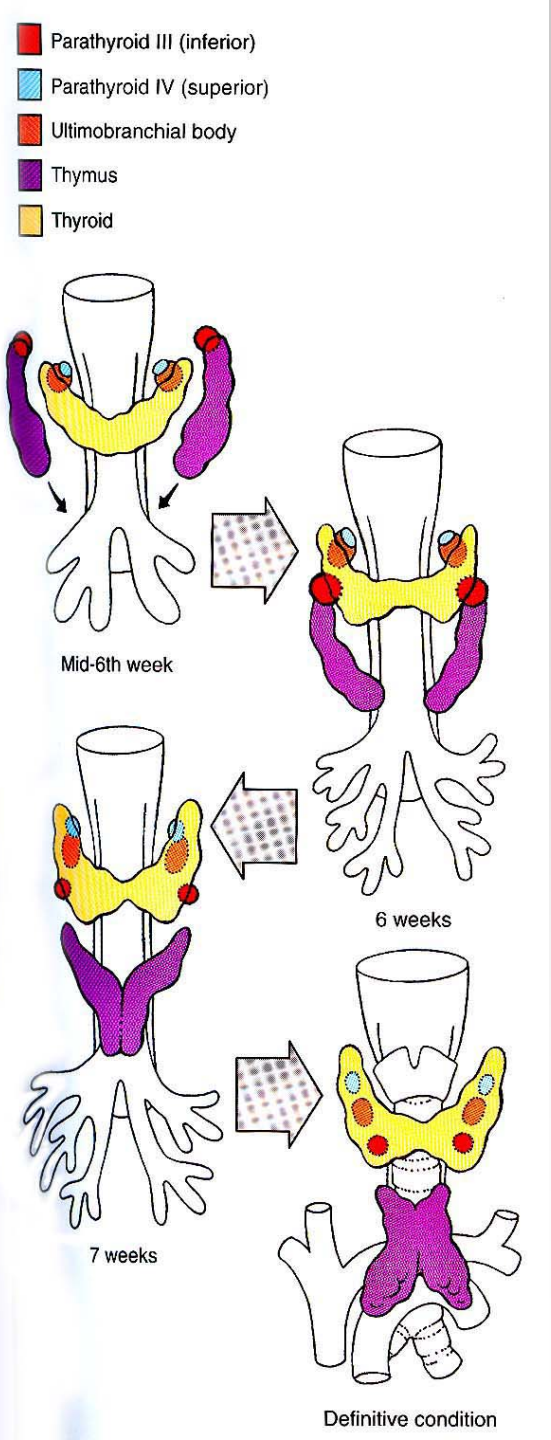


Diagram showing thyroid in place.

Superior and inferior parathyroid glands


Parathyroid III (inferior)
Parathyroid IV (superior)
Ultimobranchial body
Thymus
Thyroid
Mid-6th week
6 weeks
7 weeks
Definitive condition