
Good
Morning

Development of the Pharyngeal Arches

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- Neural crest cells contribute to the formation of skeletal components.
- The mesoderm from paraxial and lateral plate mesoderm contributes to muscular components.

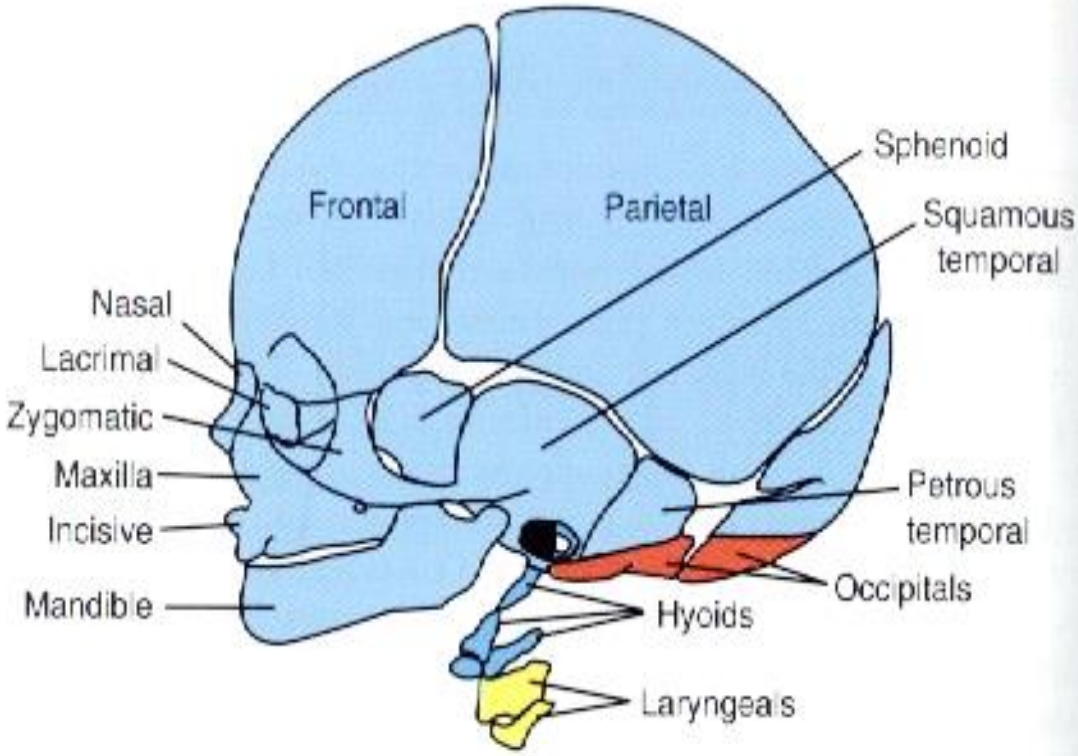


Figure 15.1. Skeletal structures of the head and face. Mesenchyme for these structures is derived from neural crest (*blue*), lateral plate mesoderm (*yellow*), and paraxial mesoderm (somites and somitomeres) (*red*).

Paraxial mesoderm(somites and somitomeres forms

- floor of brain case
- Small portion of occipital region
- Dermis and connective tissue in the dorsal region of head
- All voluntary muscle of the craniofacial region
- Meninges caudal to the prosencephalon

Lateral plate mesoderm forms

- Laryngeal cartilage
- And connective tissue

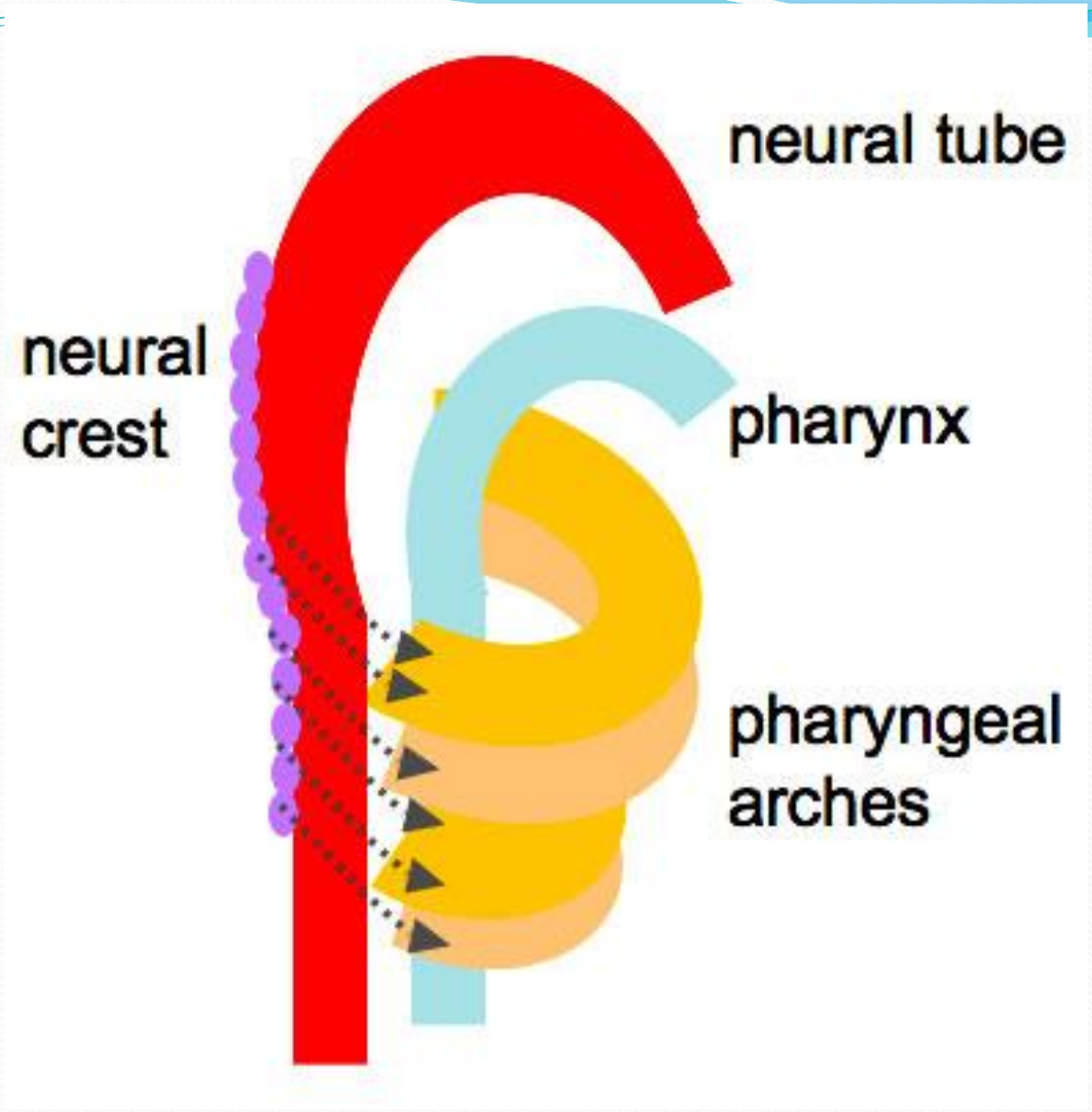
Neural crest cells

- Originate in neuroectoderm of forebrain,midbrain and hindbrain migrate ventrally into the pharyngeal arches and rostrally around forebrain and optic cup into the facial region and forms

Midfacial and pharyngeal arch skeletal structures

- Ectodermal placodes forms

Neurons of the 5^{th},7^{th},9^{th} and 10^{th} cranial sensory ganglia


neural tube
neural crest
pharynx
pharyngeal arches

INTRODUCTION

- Pharyngeal arches appear in the 4th and 5th weeks of development and contribute to the characteristic external appearance of the embryo.
- Play important role in the formation of the face and neck structures.
- Initially they consist of bars of mesenchymal tissue separated by deep clefts known as **pharyngeal** or **branchial clefts.**

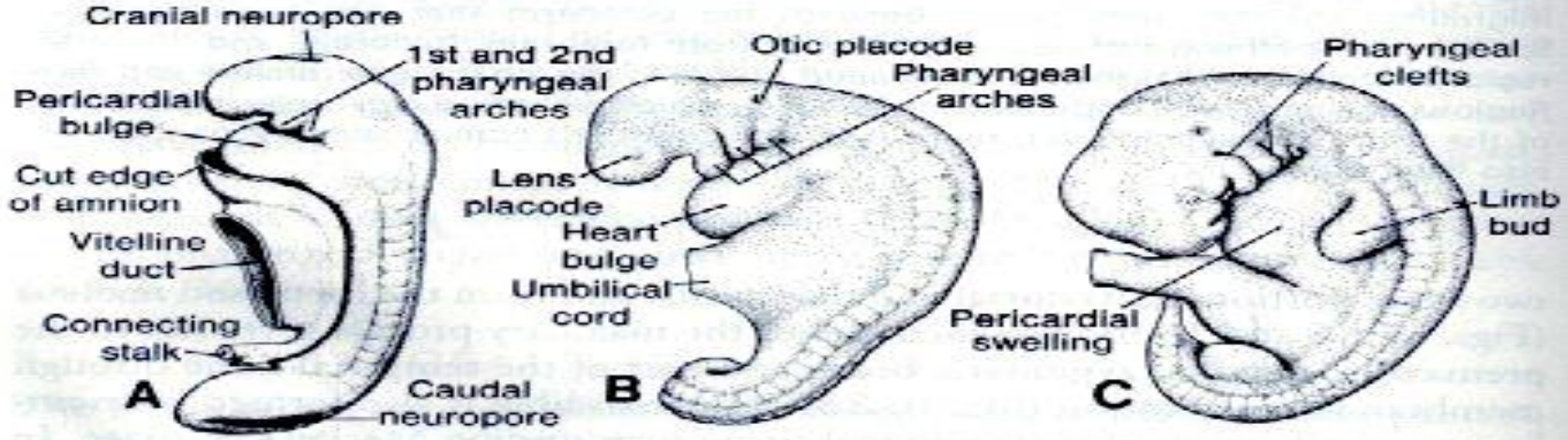


Figure 15.3. Development of the pharyngeal arches. **A.** 25 days. **B.** 28 days. **C.** 5 weeks.

- Simultaneously, a number of outpocketings, the **pharyngeal pouches**, appear along the lateral walls of the pharyngeal gut **but do not establish an open communication** with the external clefts.

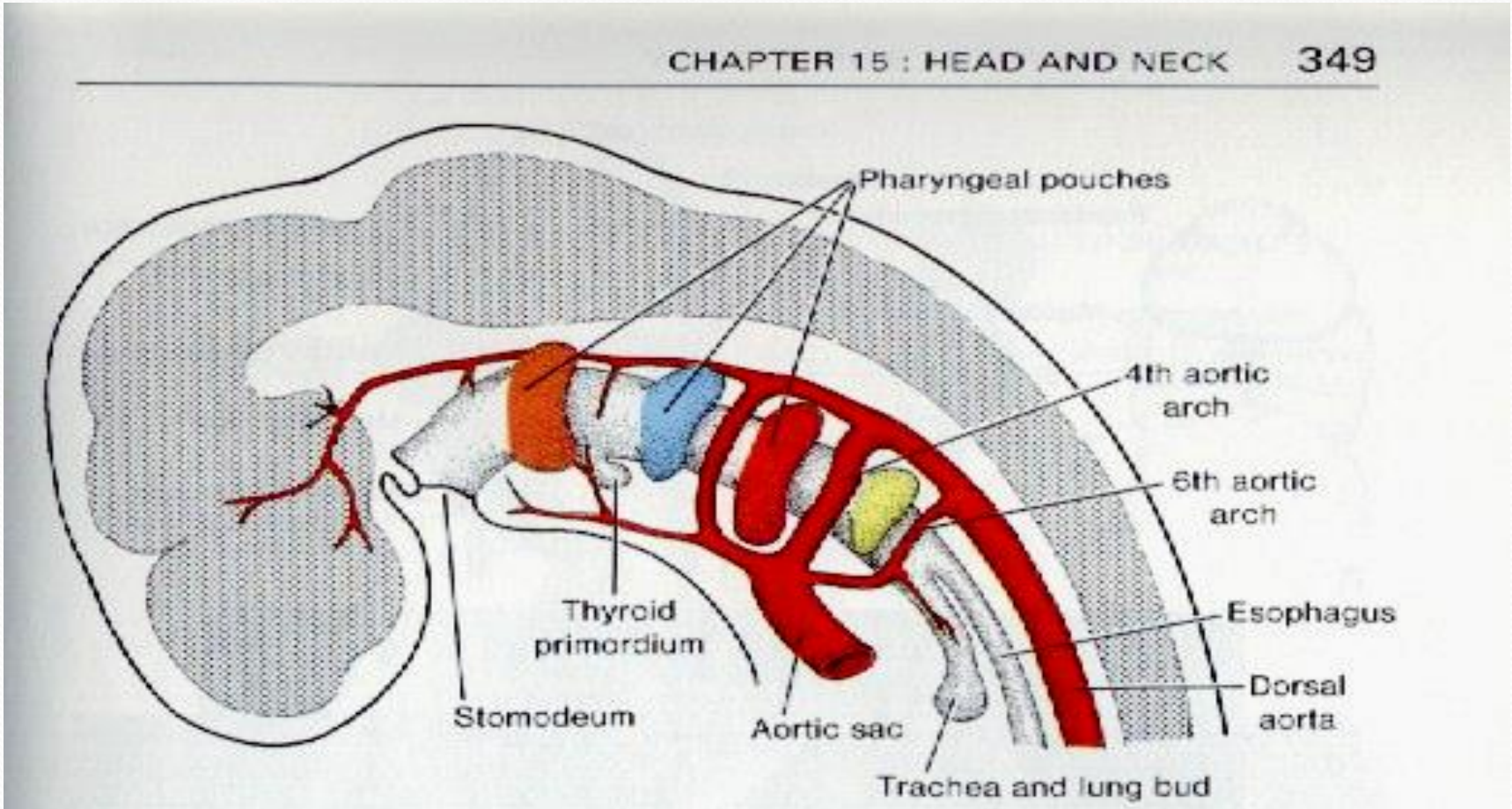
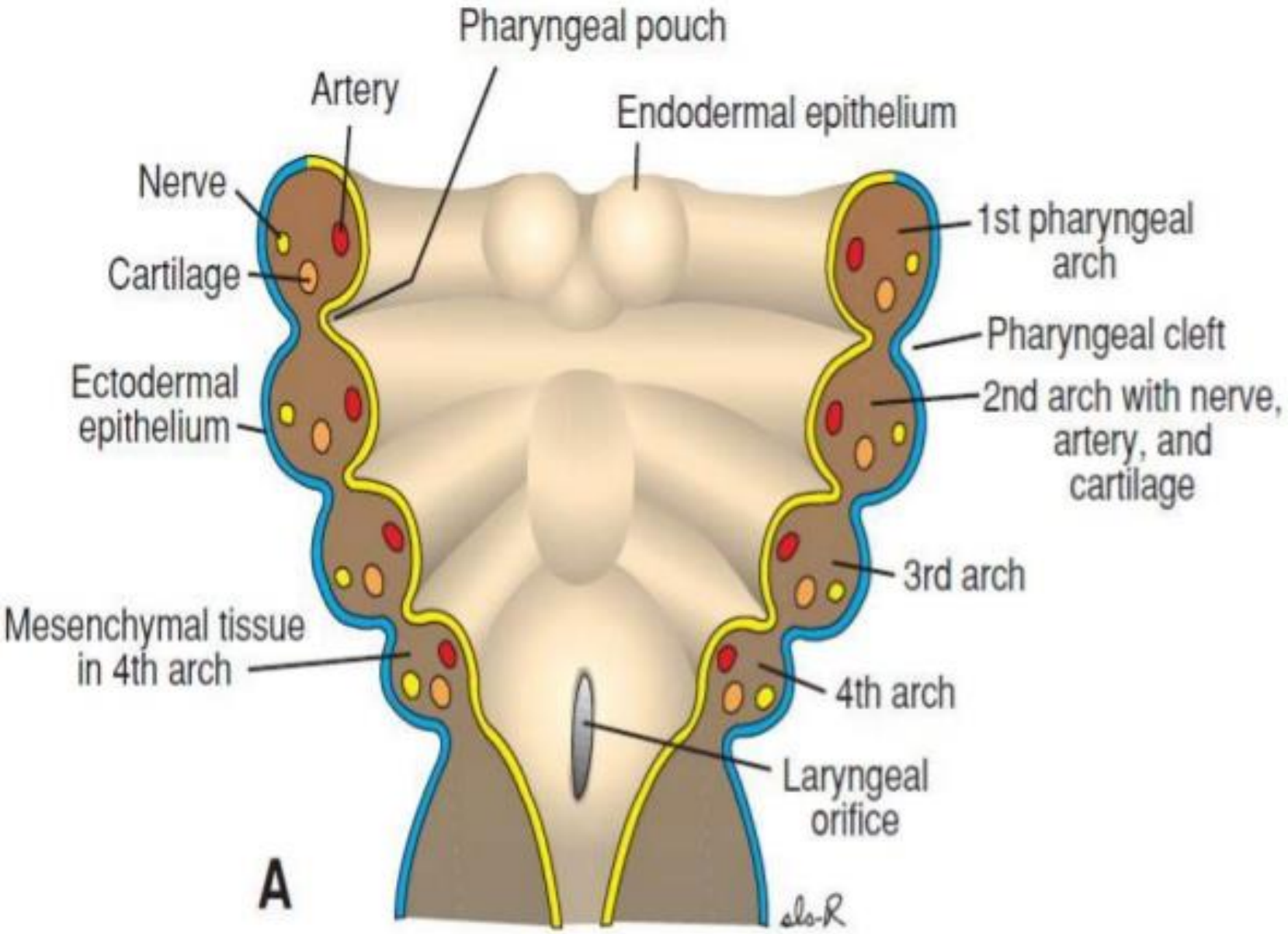
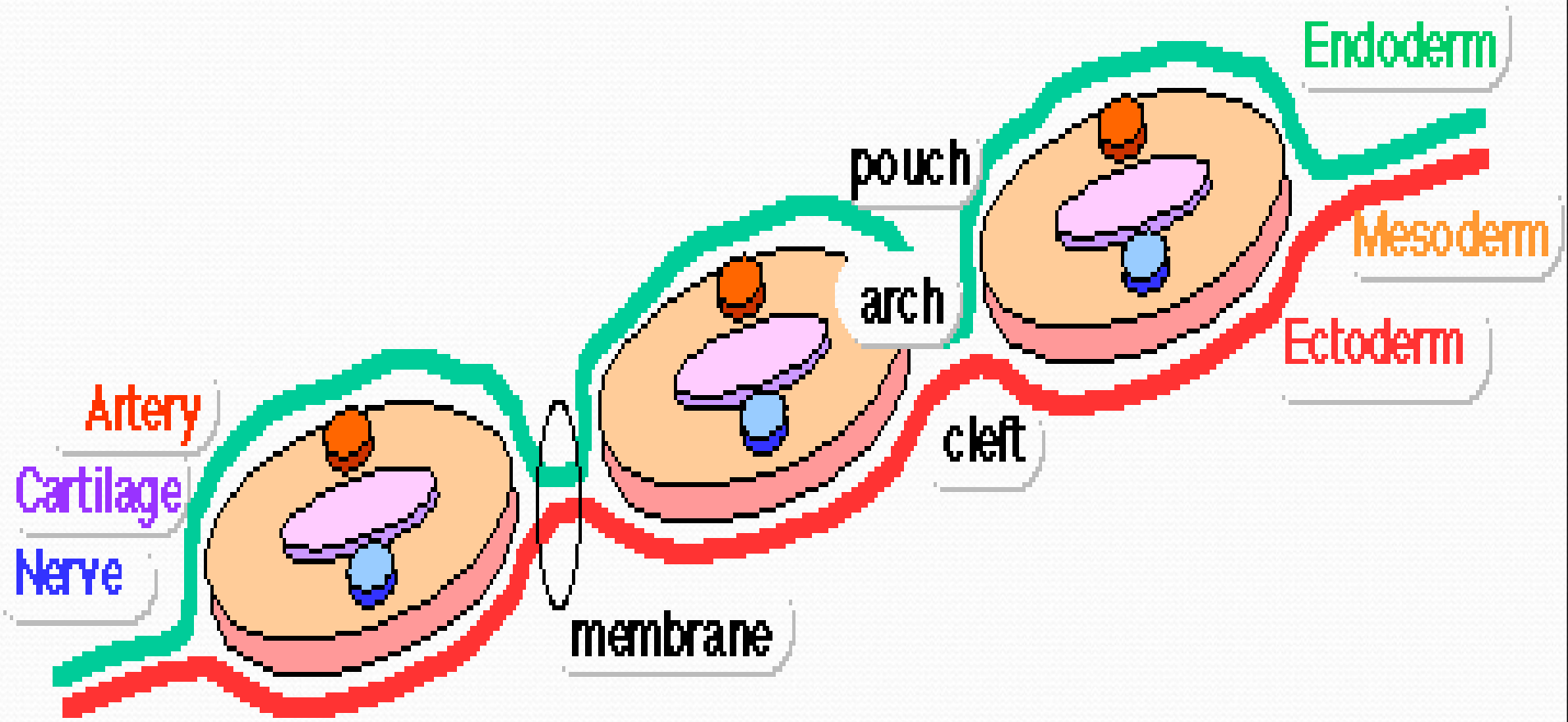
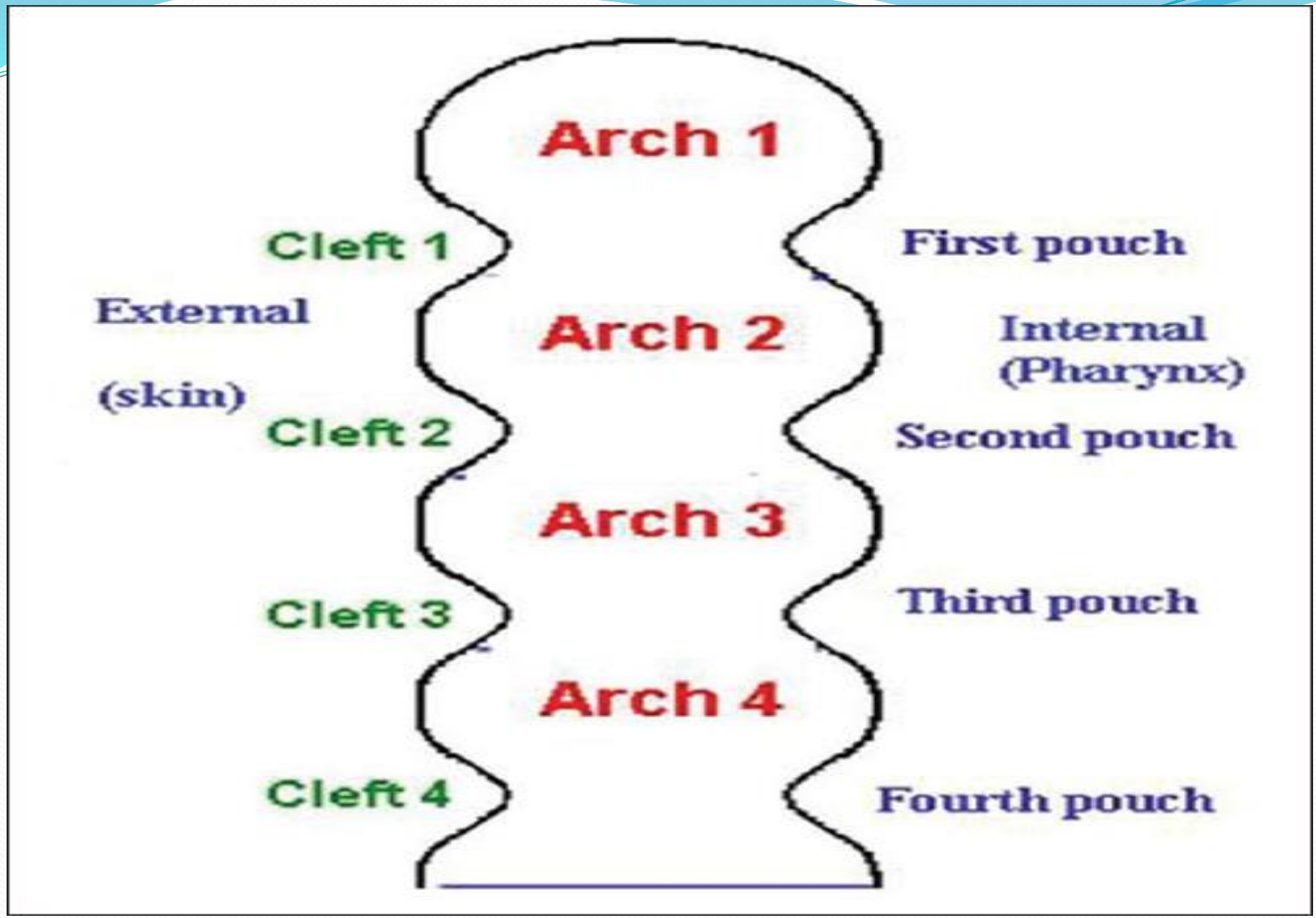


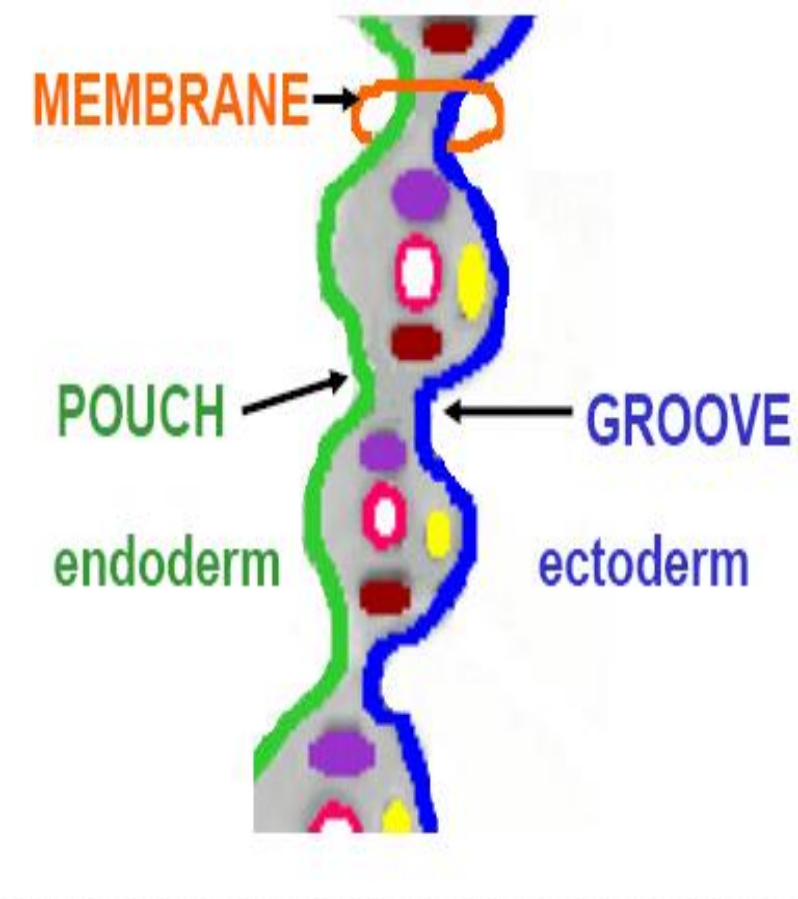
Figure 15.4. Pharyngeal pouches as outpocketings of the foregut and the primordium of the thyroid gland and aortic arches.


Pharyngeal pouch
Artery
Endodermal epithelium
Nerve
Cartilage
1st pharyngeal arch
Pharyngeal cleft
Ectodermal epithelium
2nd arch with nerve, artery, and cartilage
3rd arch
Mesenchymal tissue in 4th arch
4th arch
Laryngeal orifice
A


Endoderm
pouch
Mesoderm
arch
Ectoderm
Artery
cleft
Cartilage
Nerve
membrane

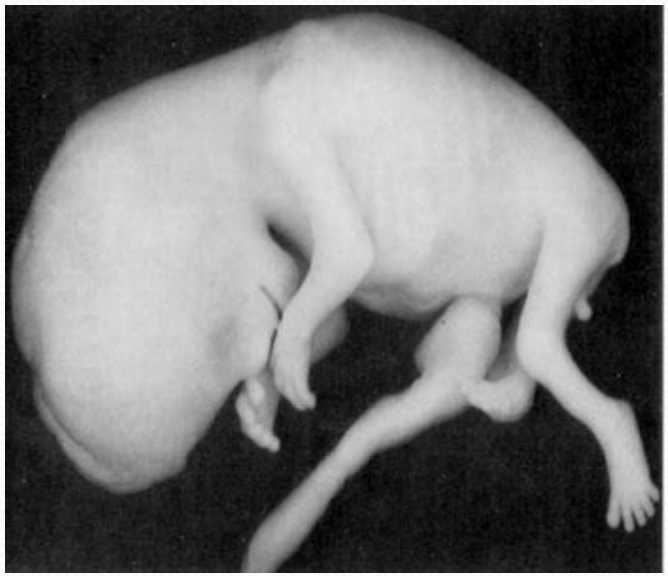

Arch 1
Cleft 1
First pouch
External
Arch 2
Internal
(Pharynx)
(skin)
Cleft 2
Second pouch
Arch 3
Cleft 3
Third pouch
Arch 4
Cleft 4
Fourth pouch

Components of branchial/pharyngeal apparatus

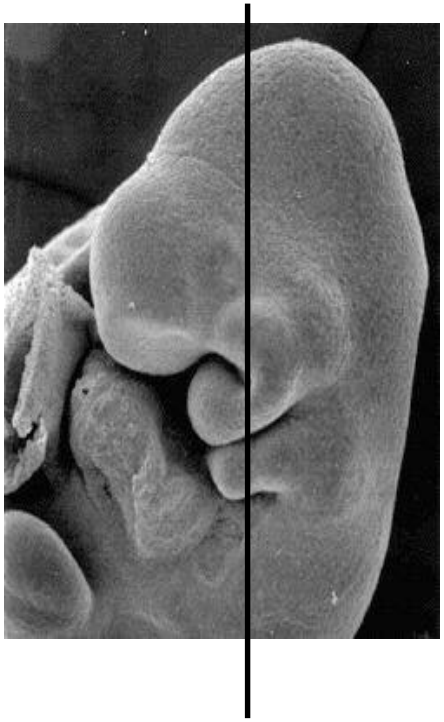


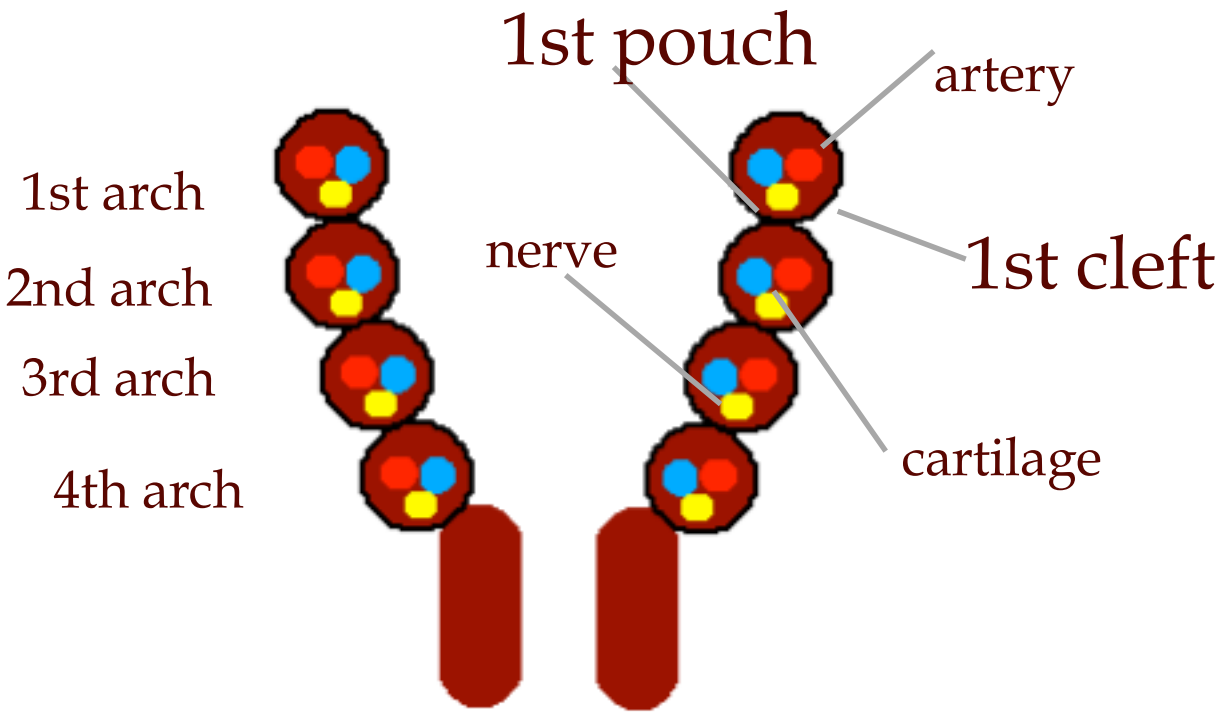
1) Pharyngeal arches
2) Pharyngeal pouches
3) Pharyngeal clefts/grooves
4) Pharyngeal membrane

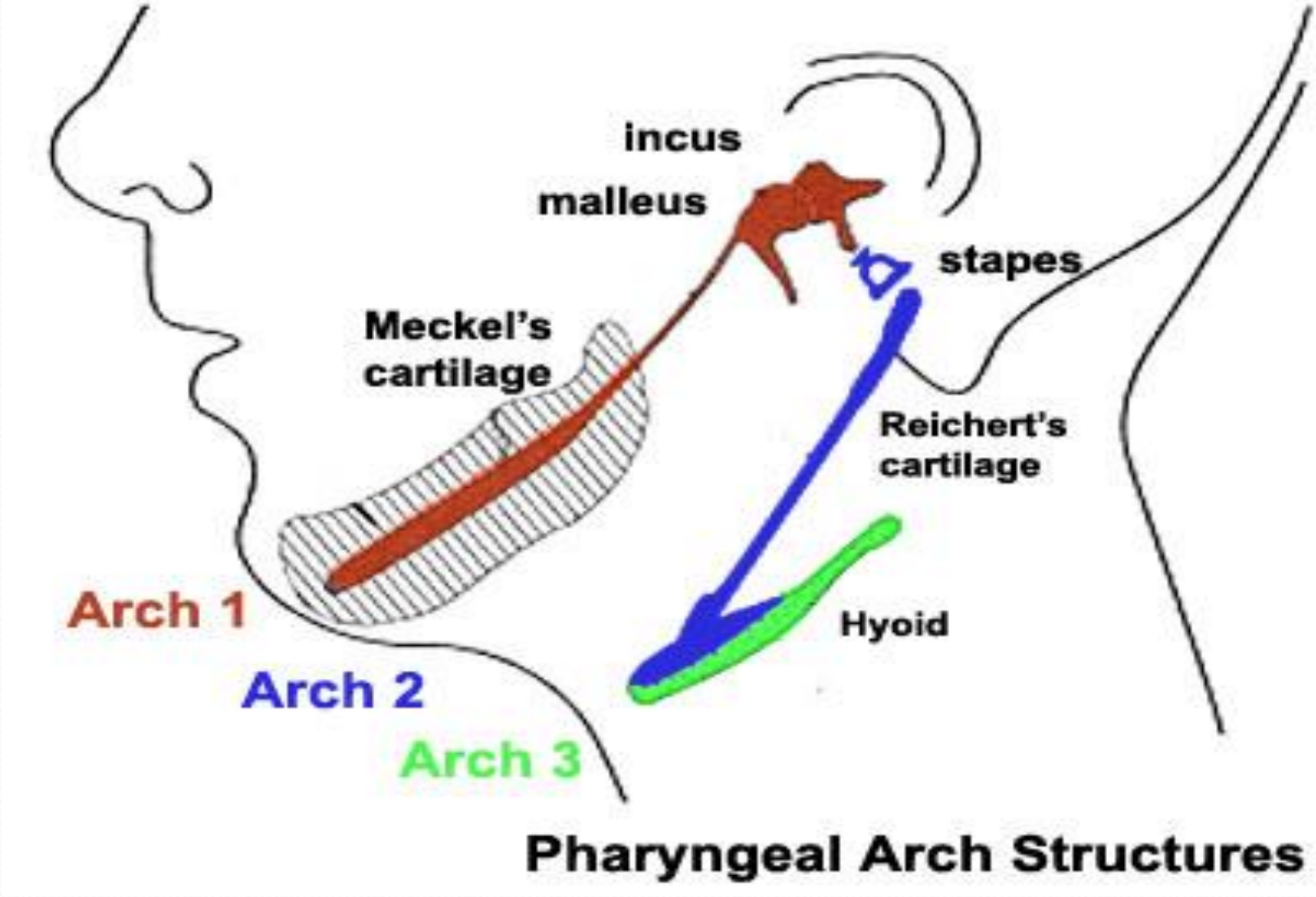
Pharyngeal Apparatus



- 6 pairs of pharyngeal arches separated by endodermally lined pouches and ectodermally lined clefts.
- Each arch consists of a nerve, artery, and cartilaginous structures.
- The remaining neck musculature gains contributions from cervical somites.




1st pouch
artery
1st arch
nerve
2nd arch
1st cleft
3rd arch
cartilage
4th arch



Pharyngeal Arch Structures

Pharyngeal (branchial) arches

- Derived from neural crest cells
- Resemble fish gills (branchia)
- Begin to develop early in the 4^{th} week
- By end of 4^{th} week, four pairs of arches are visible on the surface (not 5^{th} and 6^{th}) and a buccopharyngeal membrane ruptures forming communication between primitive oral cavity and foregut

A typical pharyngeal arch contains:

- An **aortic arch**, an artery that arises from the truncus arteriosus of the primordial heart and passes around the primordial pharynx to enter the dorsal aorta.
- A **cartilaginous rod** that forms the skeleton of the arch.
- A **muscular component** that differentiates into muscles in head and neck
- A **nerve** that supplies the mucosa and muscles derived from the arch. These are derived from the neuroectoderm of the primordial brain.

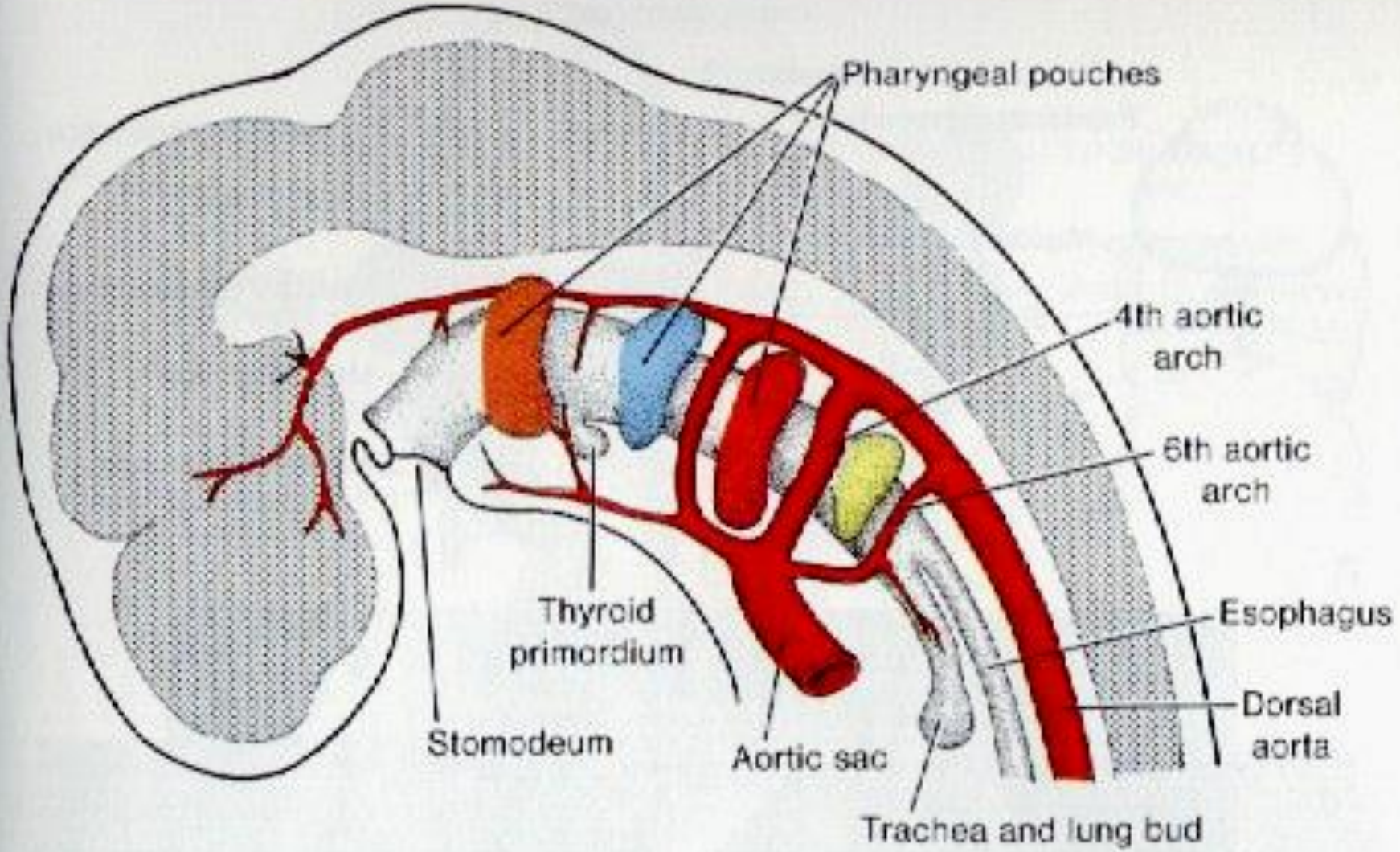
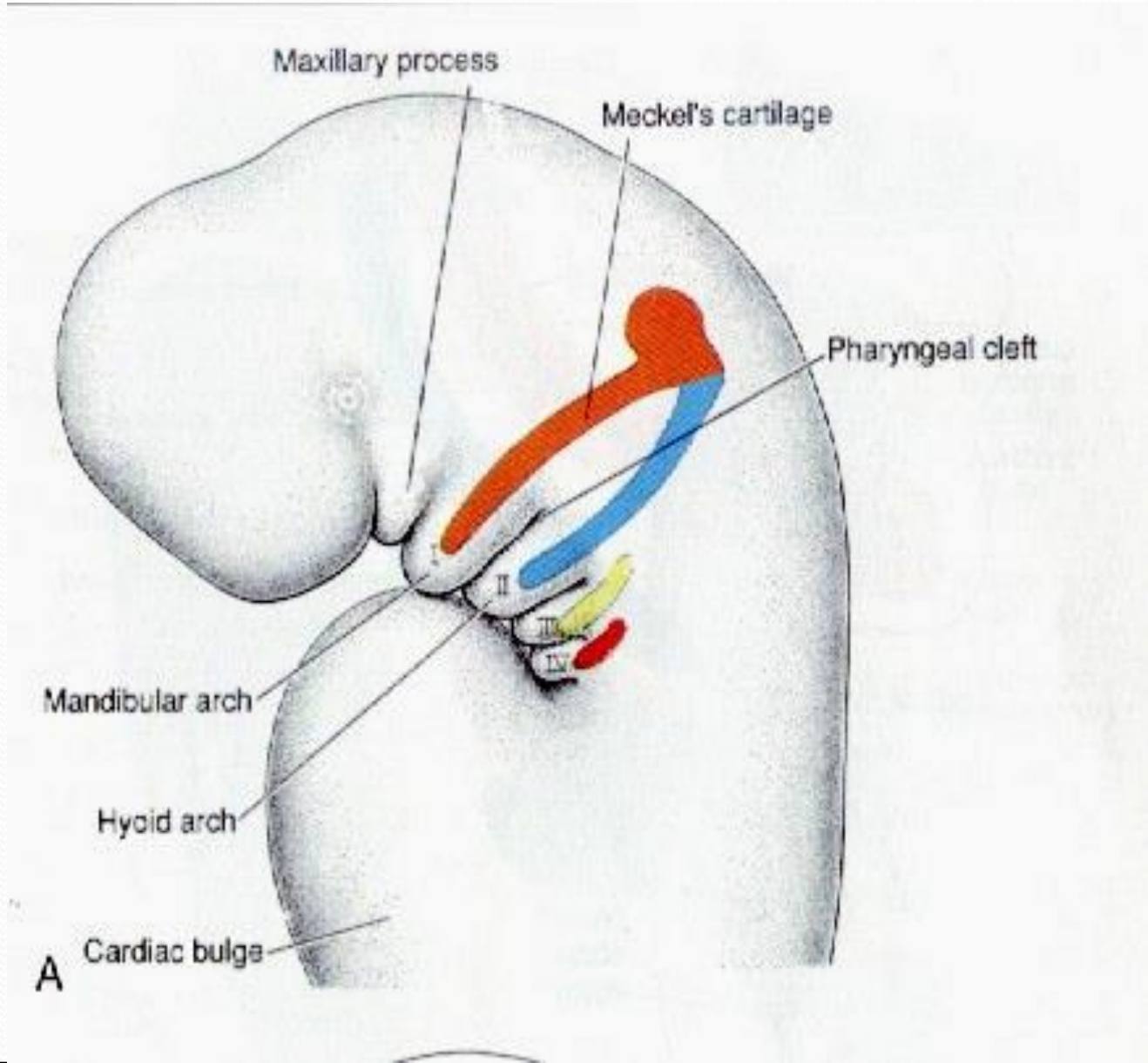


Figure 15.4. Pharyngeal pouches as outpocketings of the foregut and the primordium of the thyroid gland and aortic arches.

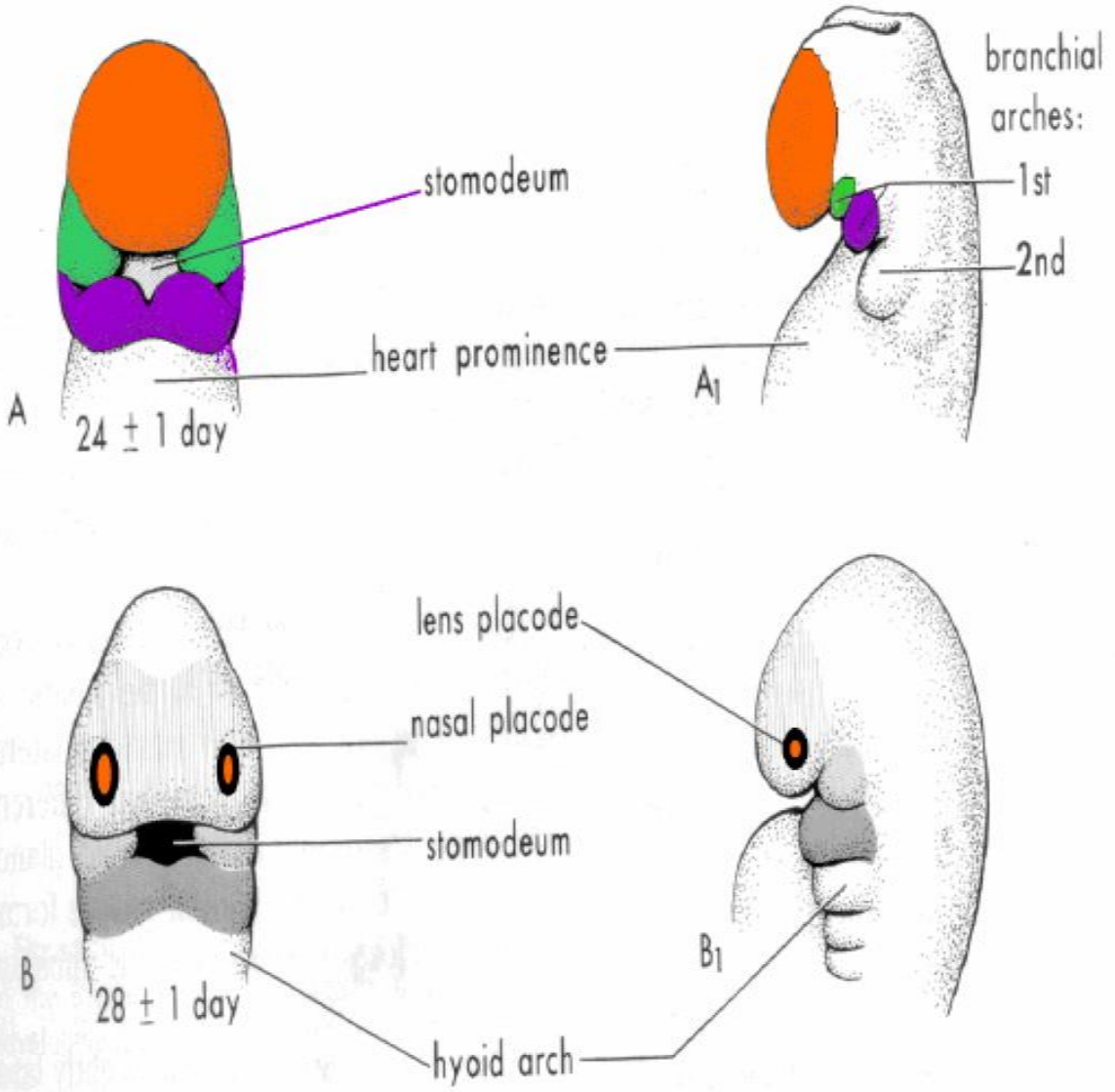
FIRST PHARYNGEAL ARCH (MANDIBULAR)

It consists of:

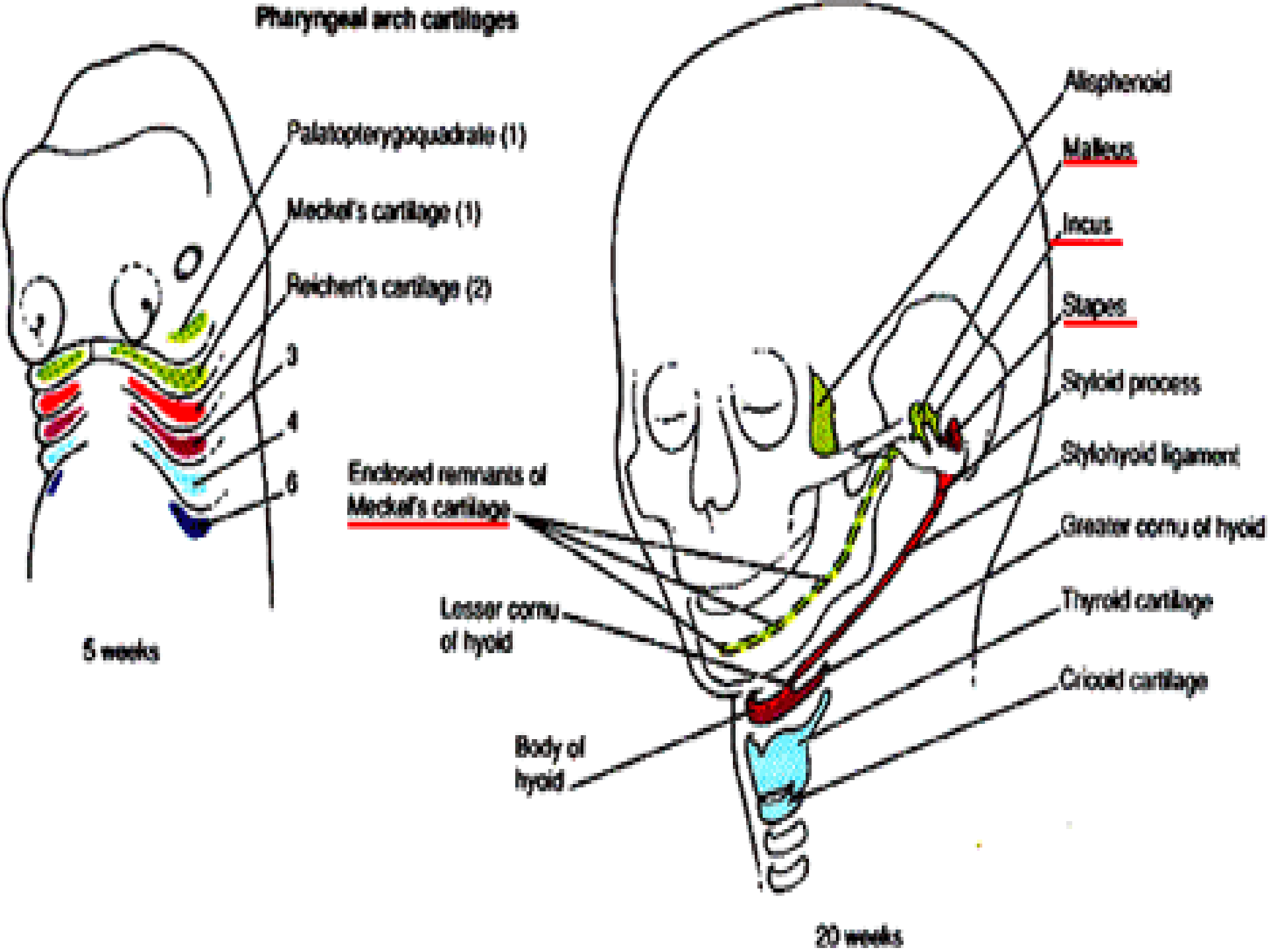
- Dorsal portion, known as **maxillary process**, that extends forward beneath the region of eye
- Ventral portion, the **mandibular process,** which contains Meckel's cartilage.



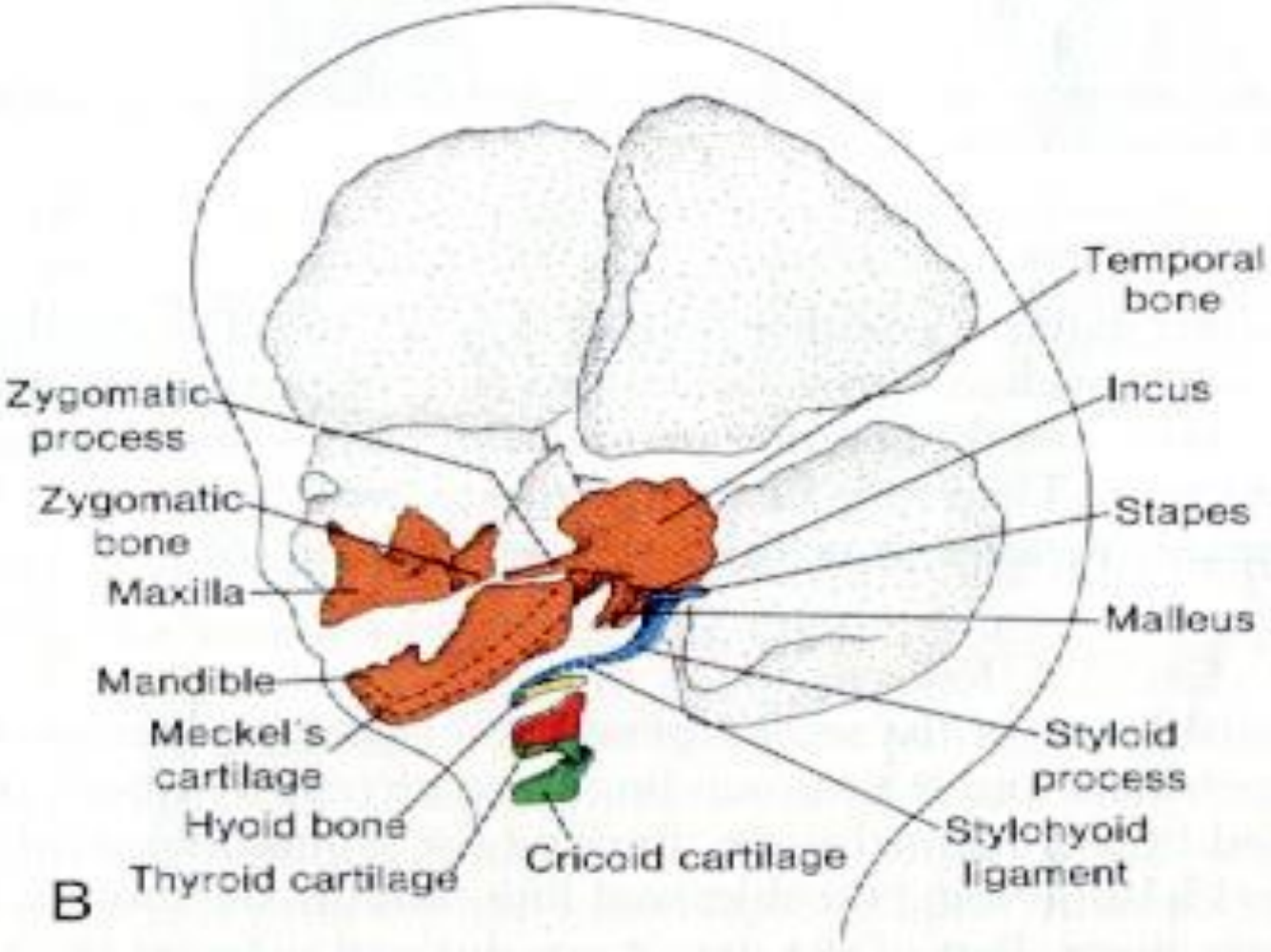
First pharyngeal arch



- Maxillary process (dorsal)
- Mandibular process (ventral)


Pharyngeal arch cartilages
Palatopterygoquadrate (1)
Meckel's cartilage (1)
Reichert's cartilage (2)
3
4
6
5 weeks
Alisphenoid
Malleus
Incus
Stapes
Styloid process
Stylohyoid ligament
Greater cornu of hyoid
Thyroid cartilage
Cricoid cartilage
Enclosed remnants of Meckel's cartilage
Lesser cornu of hyoid
Body of hyoid
20 weeks

- During further development, Meckel's cartilage disappears except for two small portions at its dorsal end that persist and form the **incus** and **malleus**.
- Mesenchyme of the maxillary process gives rise to the **premaxilla, maxilla, zygomatic bone** and part of the **temporal bone.**



- The **mandible** is also formed by membranous ossification of mesenchymal tissue surrounding Meckel's cartilage.
- In addition, 1st arch contributes to the formation of the bones of middle ear.
- Musculature of the 1st pharyngeal arch includes the **muscles of mastication** (temporalis, digastric, and pterygoids), **anterior belly of the digastric, mylohyoid, tensor tympani**, and **tensor palatine**.

Arch 1

Arch 2

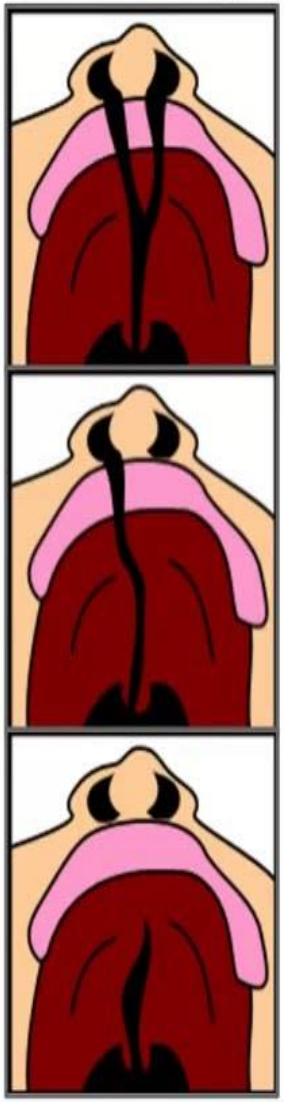
Arch 3

Arch 4

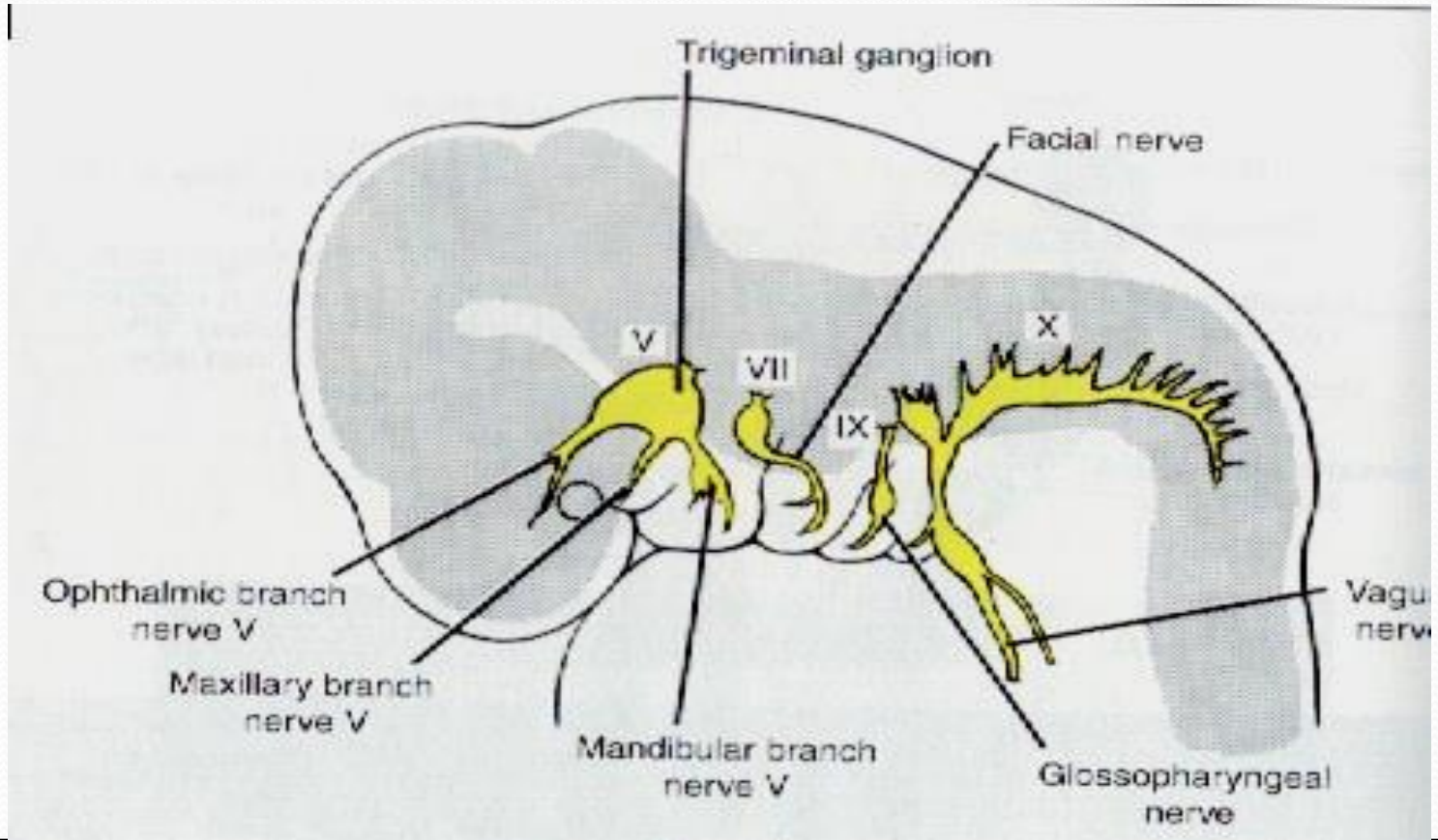
Arch 6

Arch 1 - "mandibular arch"

- Innervated by **V3 of the trigeminal nerve (CN5)**
- Skeletal derivatives are in two subdivisions:
  - Maxillary process (upper jaw)
    - Maxilla, zygomatic bone, squamous part of temporal bone
    - Maxillary processes fuse with medial nasal process to form upper lip and jaw. Abnormalities here causes
      - Cleft lip - anterior to incisive foramen
      - Cleft palate - posterior to incisive foramen
  - Mandibular process (lower jaw) derived from **Meckel cartilage**
    - Mandible, sphenomandibular ligament, incus, malleus
    - Mandibular process fuses in midline to form **lower jaw**
- Muscle derivatives
  - Muscles of mastication (temporalis, masseter, medial/lateral pterygoid), mylohyoid, anterior belly of digastric, tensor veli palatini, tensor tympani
- Aortic arch 1 becomes part of the maxillary artery



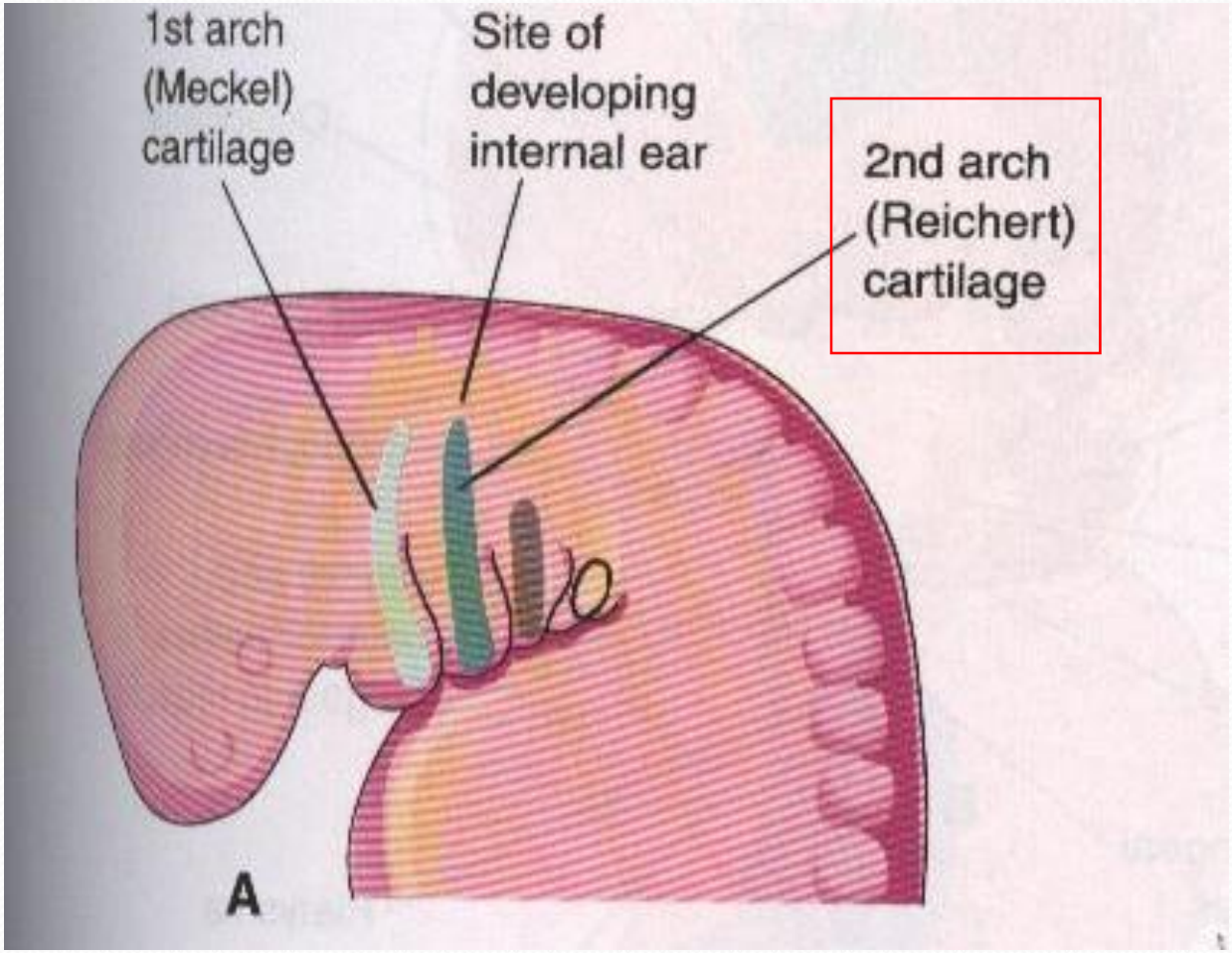
- The nerve supply to the muscles of the 1st arch is provided by the **mandibular branch of the trigeminal nerve**.
- Since mesenchyme from the 1st arch also contributes to the dermis of the face, sensory supply to the skin of the face is provided by **ophthalmic, maxillary,** and **mandibular branches of the trigeminal nerve**.



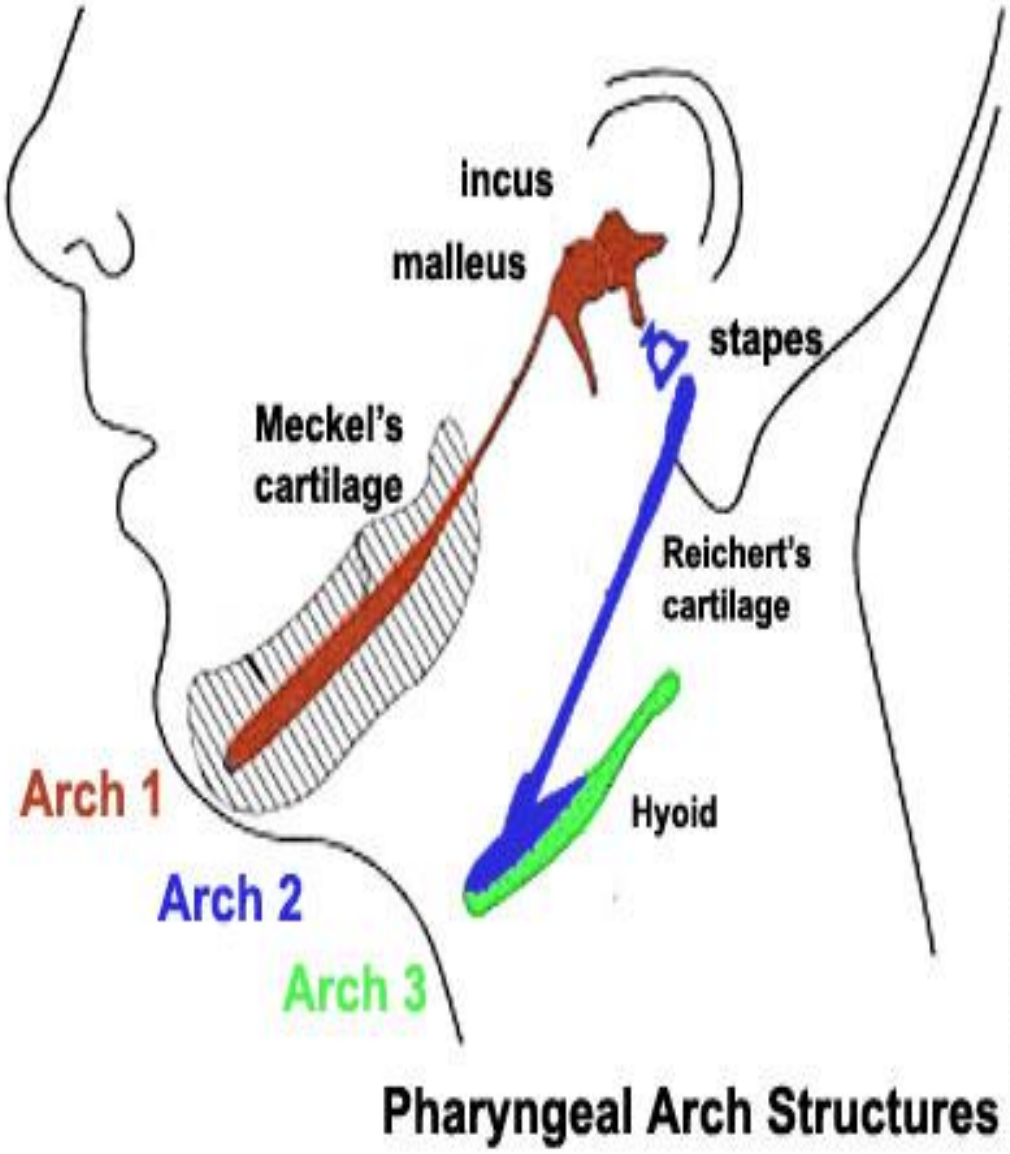
First pharyngeal arch

- Therefore, the accompanying motor nerve is the mandibular branch of trigeminal (V2) and sensory are V1, V2, and V3
- 1st aortic arch practically disappears but forms the maxillary artery

Second pharyngeal arch

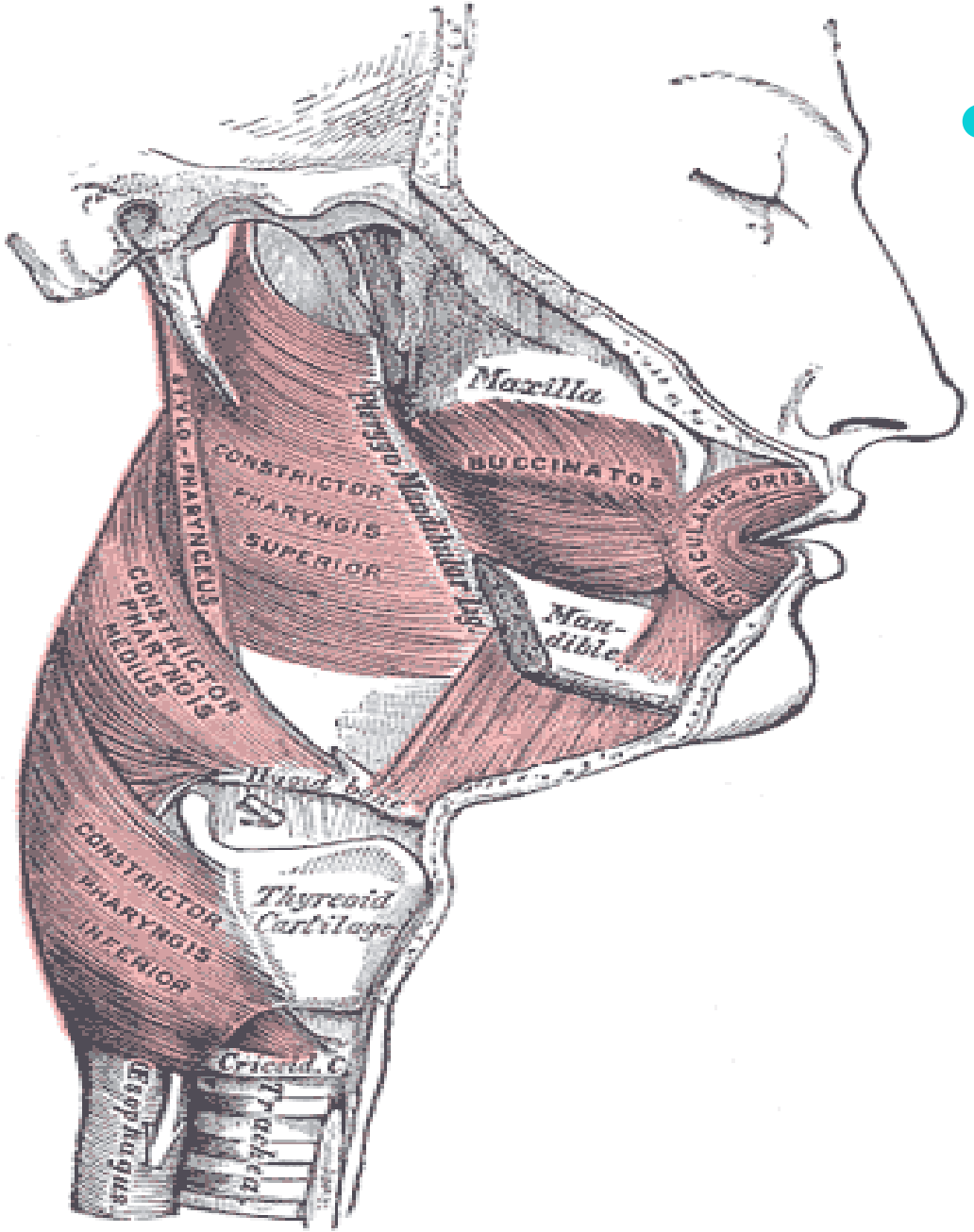


SECOND PHARYNGEAL ARCH (HYOID)



Pharyngeal Arch Structures

- The cartilage of the 2nd arch (Reichert's cartilage) gives rise to the **stapes, styloid process of temporal bone, stylohyoid ligament,** and ventrally, the **lesser horn** and **upper part of the body of the hyoid bone.**



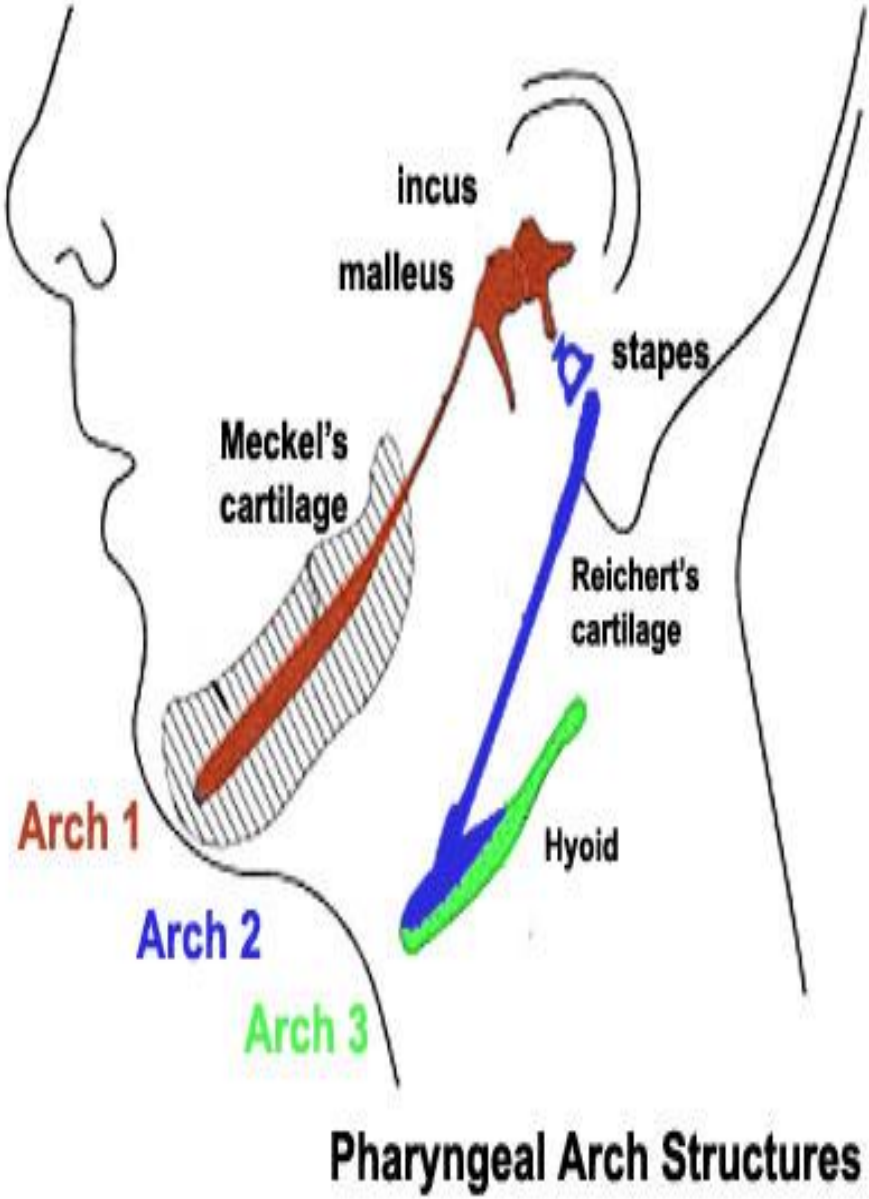
- The muscles of the 2nd arch are the **stapedius, stylohyoid, posterior belly of the digastric, auricular and muscles of facial expression**.

Second pharyngeal arch

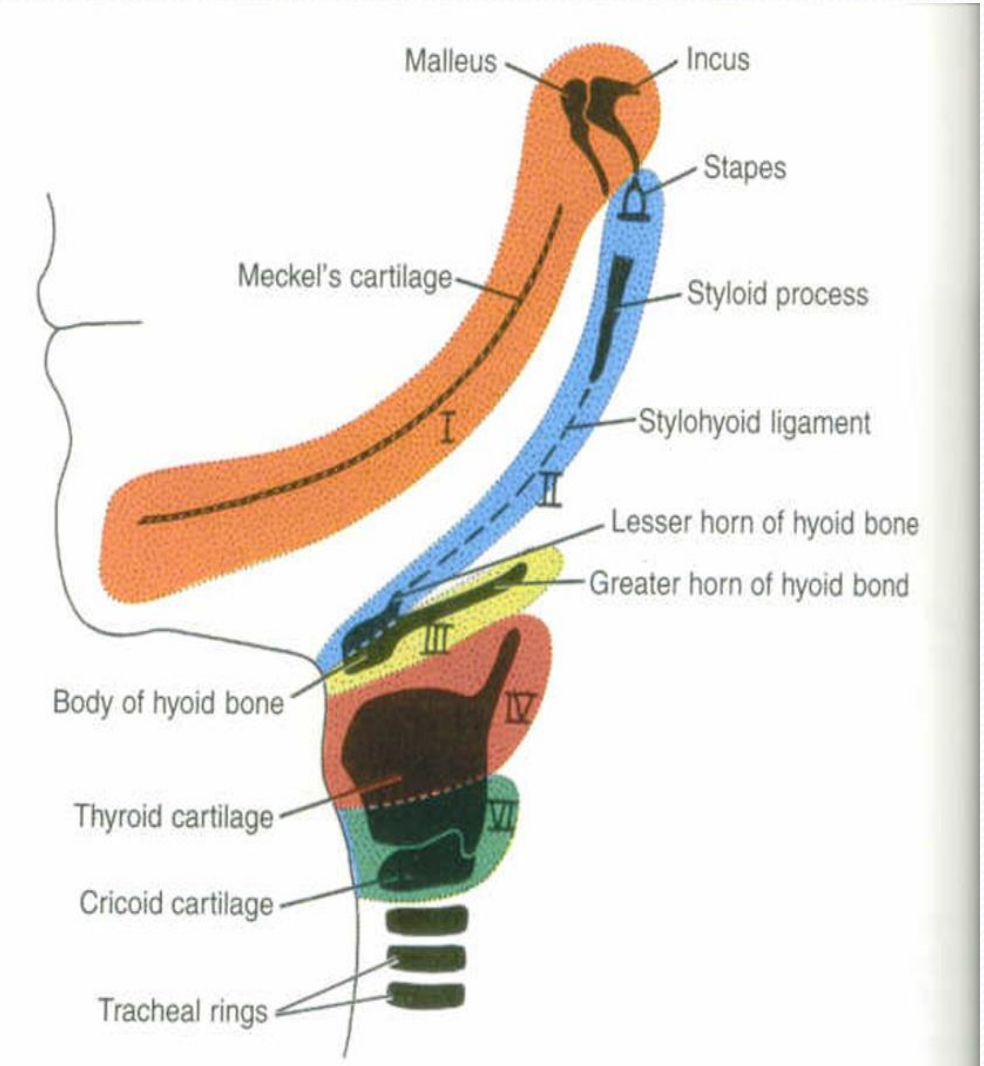
- Facial nerve (CN VII)
- 2nd aortic arch – stapedial & hyoid arteries

THIRD PHARYNGEAL ARCH

- The cartilage of the 3rd pharyngeal arch produces the **lower part of the body** and **greater horn of the hyoid bone.**
- The musculature from this arch produces only **stylopharyngeus muscle.**
- The nerve of the 3rd arch is **glossopharyngeal nerve** which supplies these muscles



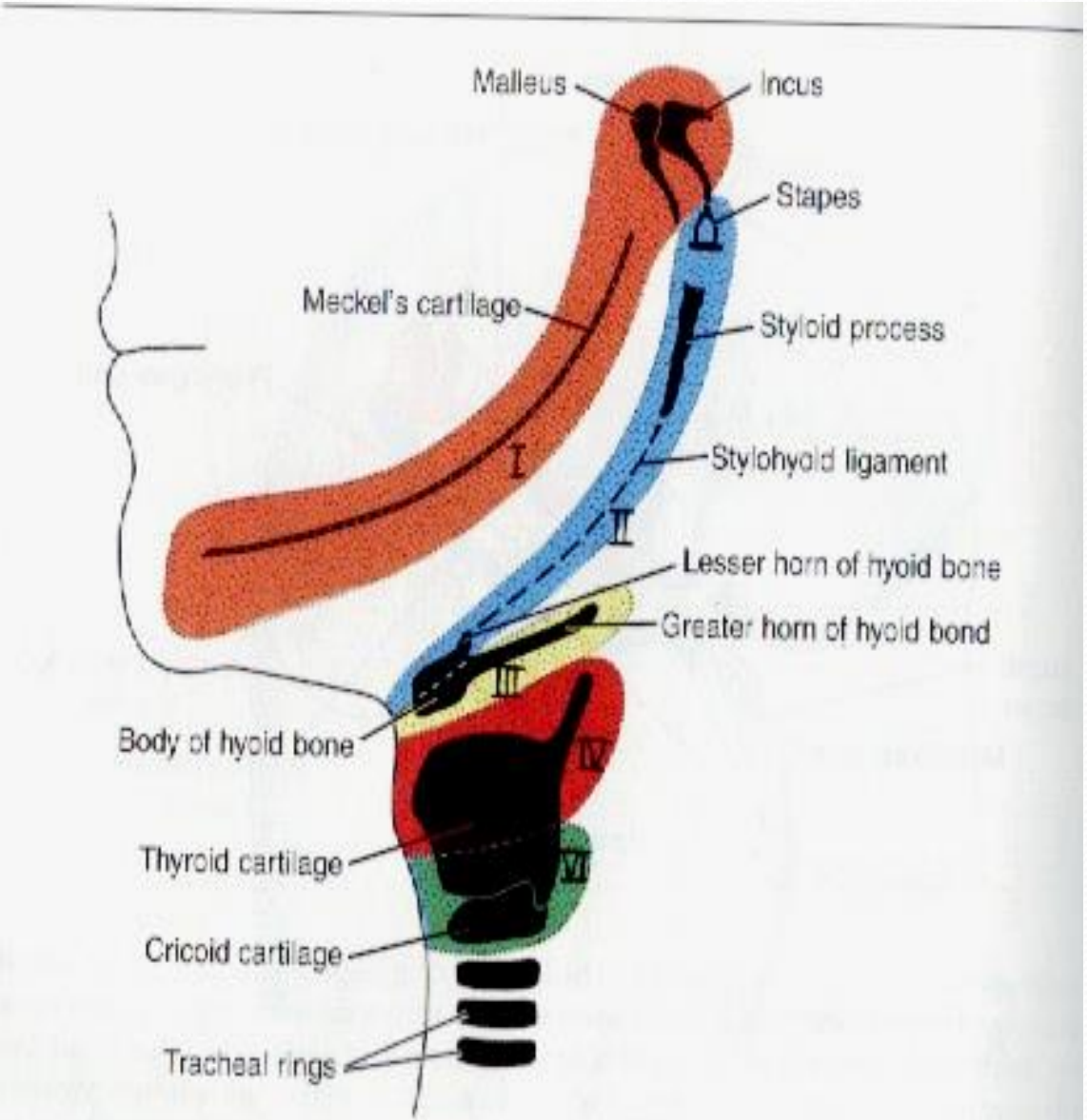
Third pharyngeal arch



- 3rd aortic arch (quite large): common carotid, 1st portion of internal carotid (remainder dorsal aorta), and external carotid

FOURTH AND SIXTH PHARYNGEAL ARCHES

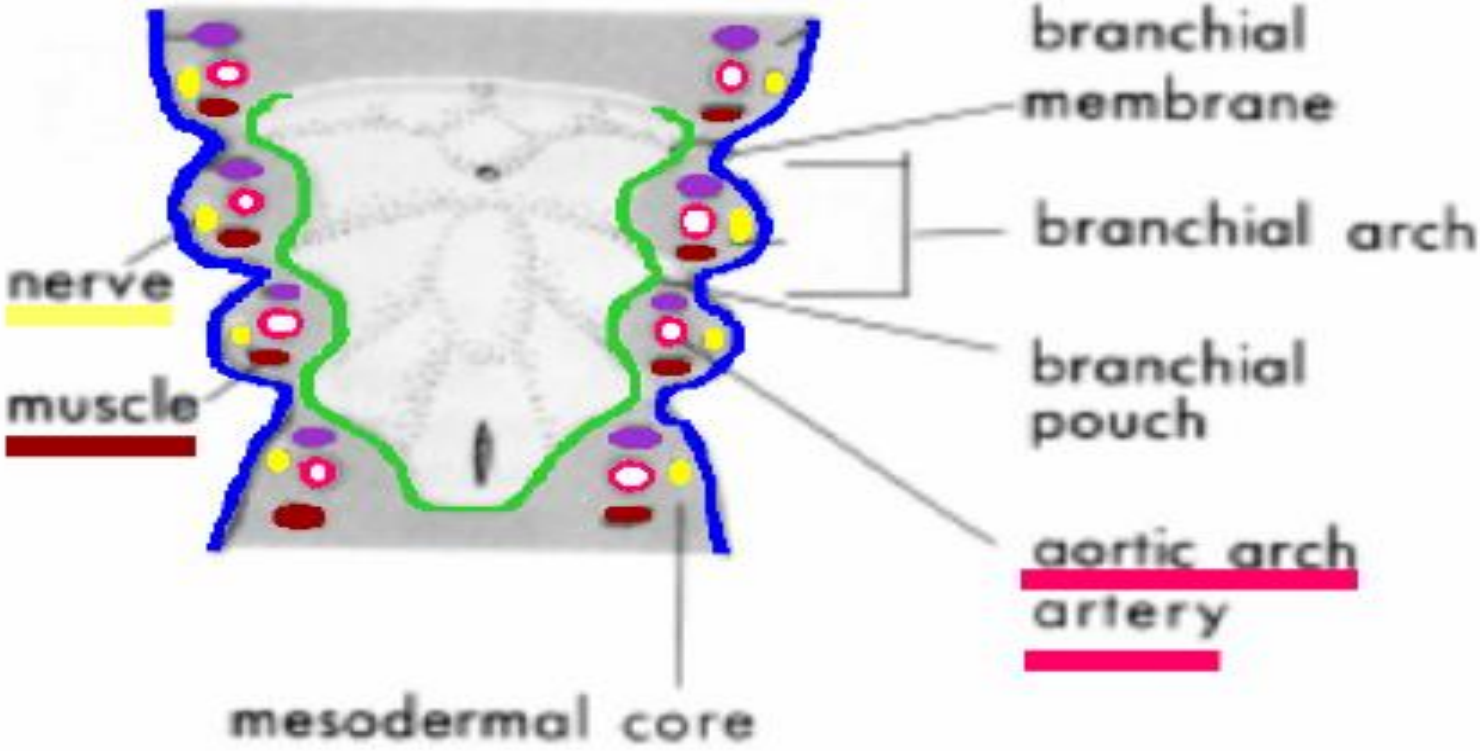
- Cartilaginous components of the 4th and 6th pharyngeal arches fuse to form the **thyroid, cricoid, arytenoid, corniculate, and cuneiform cartilages of the larynx.**
- The muscles of the 4th arch are **cricothyroid, levator palatini and constrictors of the pharynx.**



- The nerve of the 4th arch is **superior laryngeal branch of the vagus nerve** which supplies all these muscles.
- The muscles of the 6th arch are **intrinsic muscles of the larynx** which are supplied by the **recurrent laryngeal branch of the vagus**, the nerve of the 6th arch.

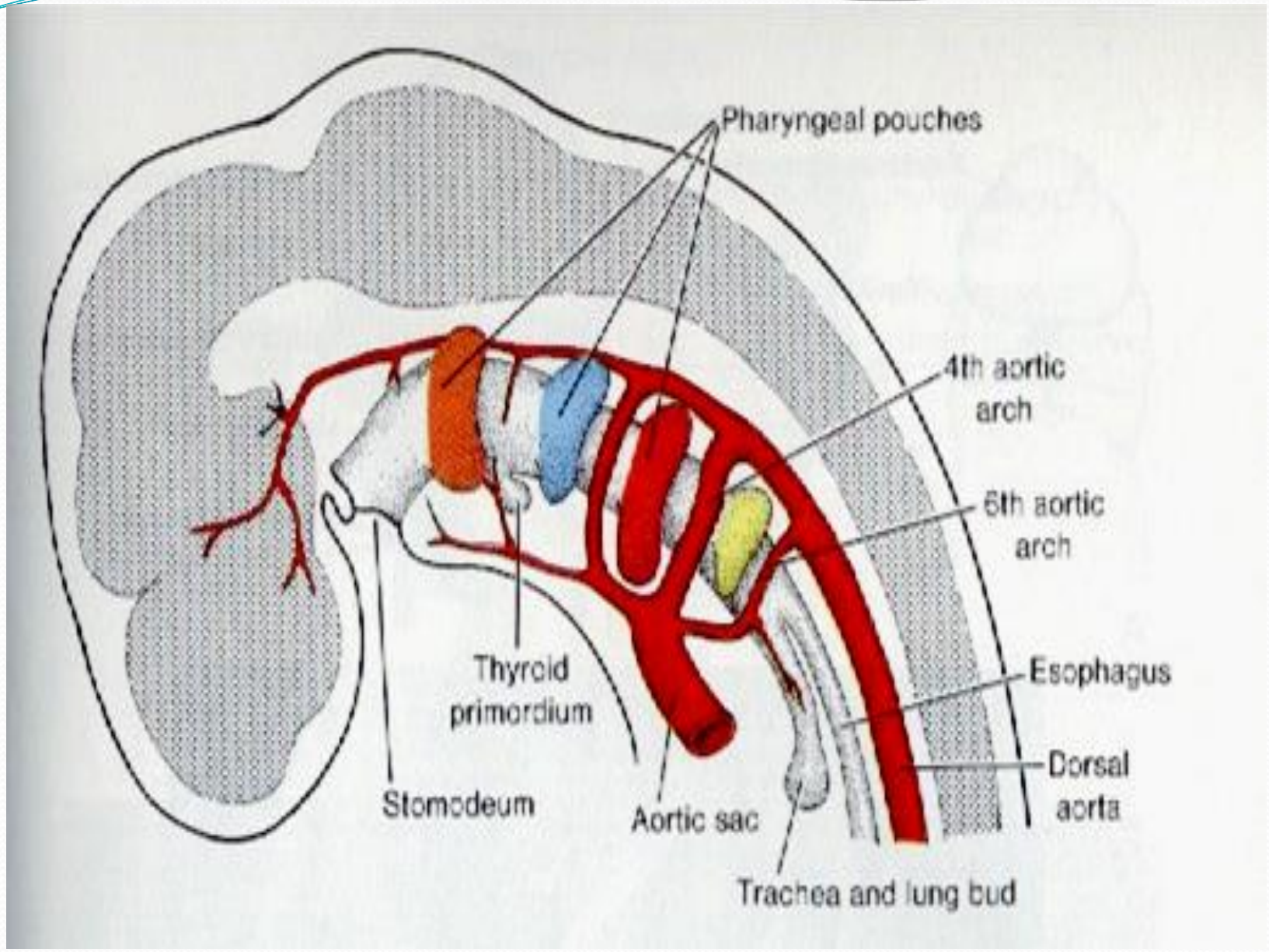
Pharyngeal pouches

Pharyngeal pouches are outpocketings of the developing Pharyngeal endothelium



PHARYNGEAL POUCHES

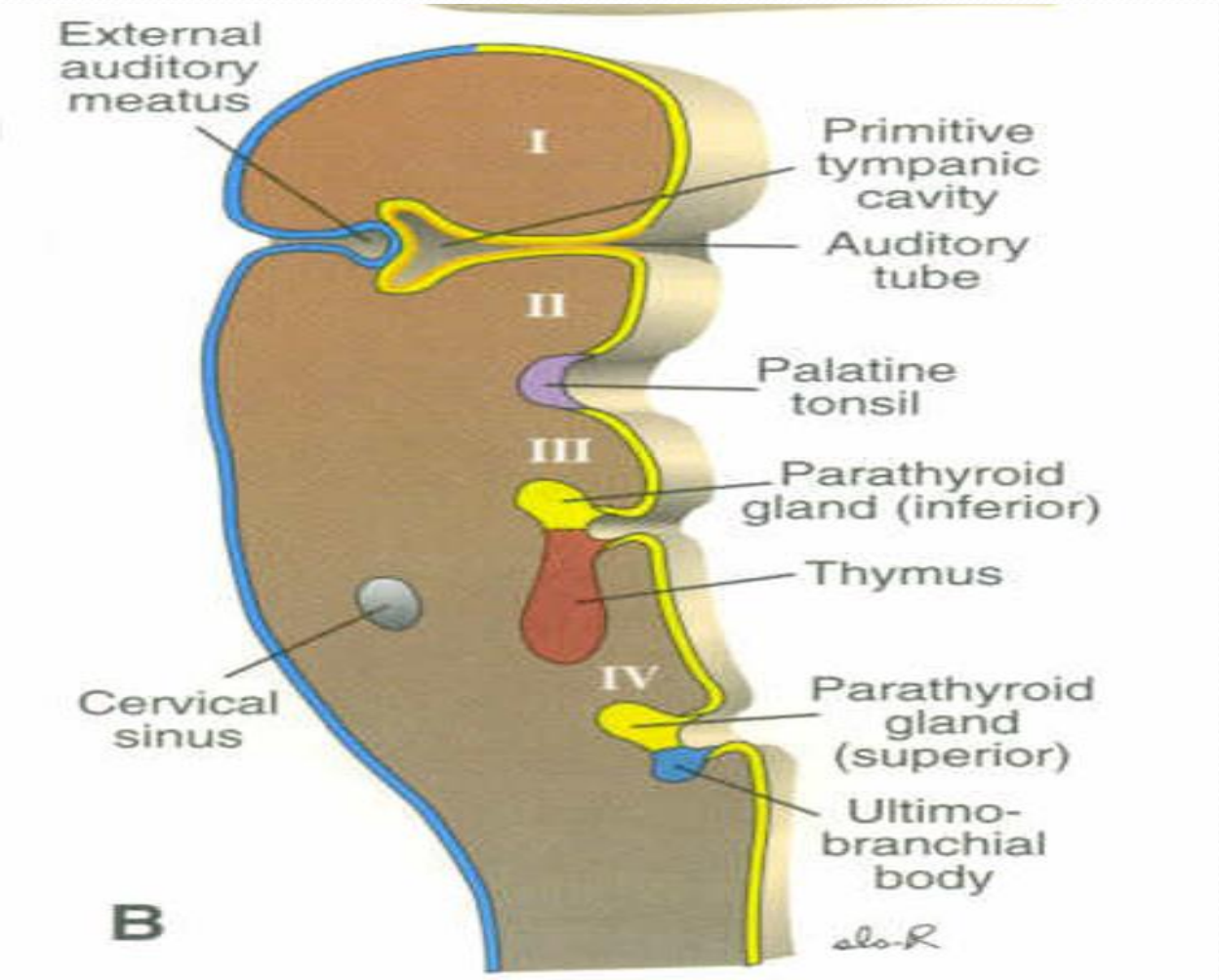
- The endoderm of the pharynx lines the internal aspects of the pharyngeal arches and passes into balloon like diverticula – the **pharyngeal pouches**.
- The pair of pouches develops in a craniocaudal sequence between the arches.
- There are four well-defined pairs of pharyngeal pouches; the fifth pair is absent or rudimentary.


Pharyngeal pouches
4th aortic arch
6th aortic arch
Esophagus
Dorsal aorta
Thyroid primordium
Stomodeum
Aortic sac
Trachea and lung bud

FIRST PHARYNGEAL POUCH

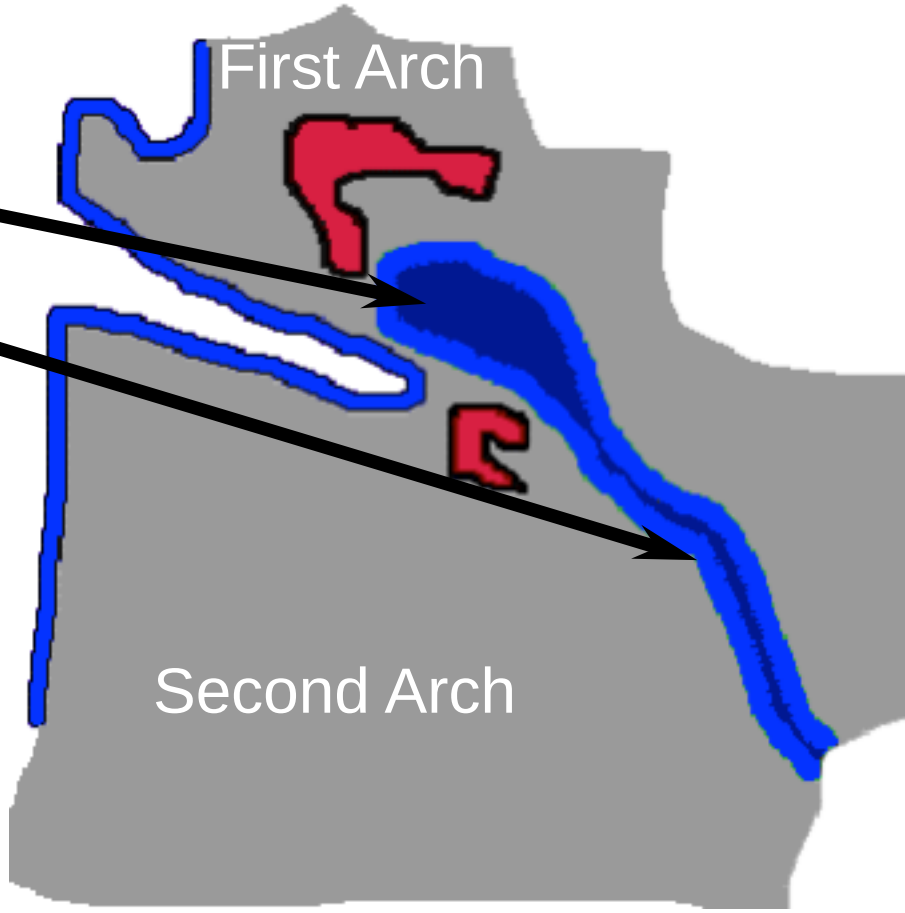
- The 1st pharyngeal pouch forms a stalk – like diverticulum, **the tubotympanic recess**, that comes in contact with the epithelial lining of the 1st pharyngeal cleft, the future **external auditory meatus.**
- The distal portion of the diverticulum widens into a sac-like structure, the **primitive tympanic or middle ear cavity,** whereas the proximal part remains narrow, forming the **auditory (eustachian) tube.**
- The lining of the tympanic cavity later forms the **tympanic membrane or ear drum.**

Pharyngeal pouches (5)



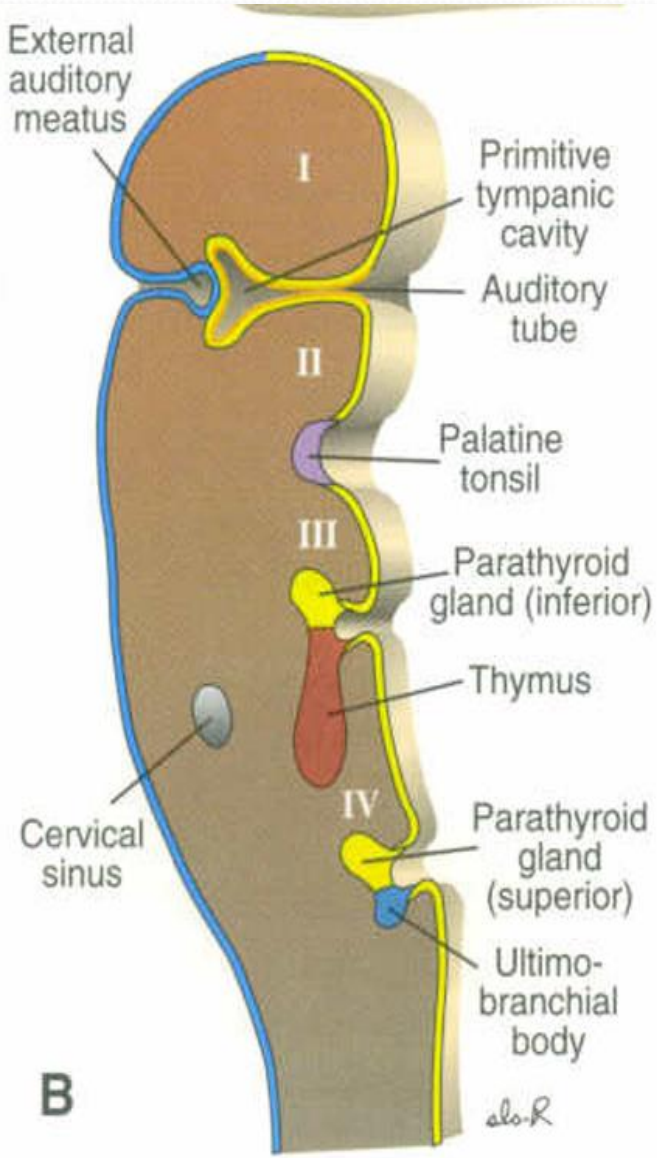
Development of the Pharyngeal Pouches

- First pouch gives rise to:
  - middle ear cavity
  - auditory tube

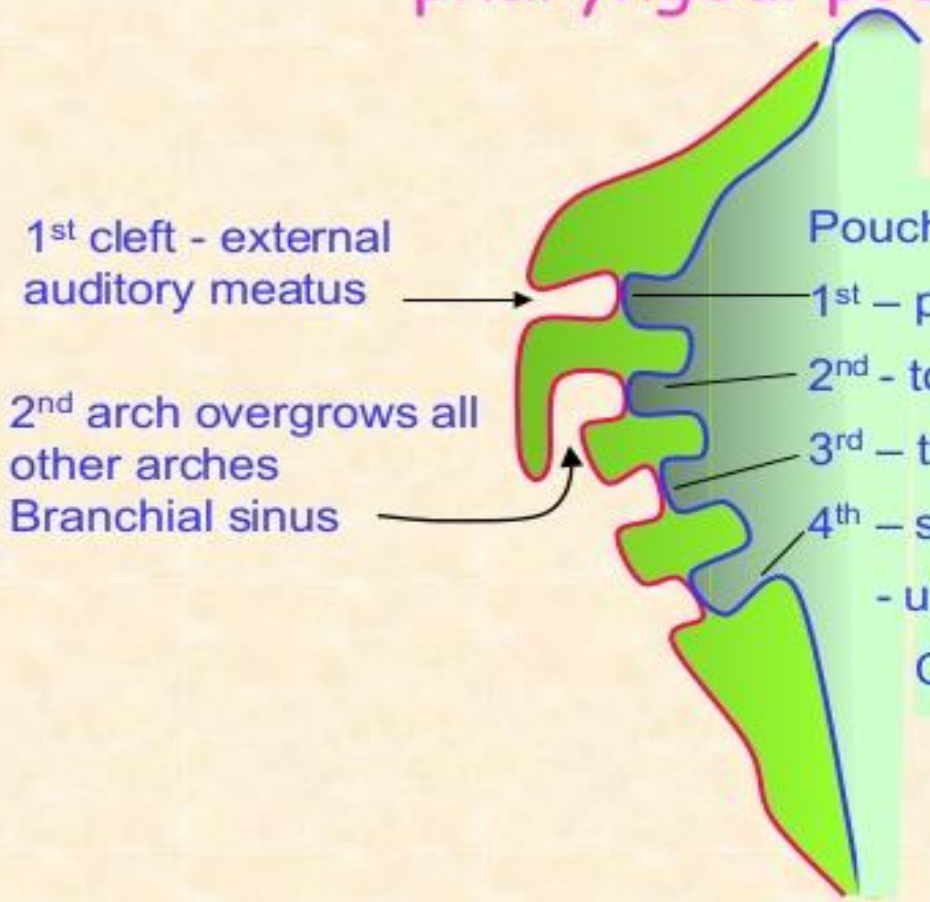


SECOND PHARYNGEAL POUCH

- The epithelial lining of the 2nd pharyngeal pouch proliferates and forms buds that penetrate into the surrounding mesenchyme.
- The buds are secondarily invaded by the mesodermal tissue, thus forming the primordium of **the palatine tonsil.**
- During the 3rd and 5th months, the tonsil is infiltrated by the lymphatic tissue.
- Part of the pouch remains and is found in adult as tonsillar fossa.



Derivatives of branchial clefts and pharyngeal pouches



1st cleft - external auditory meatus

2nd arch overgrows all other arches
Branchial sinus

Pouches

1st – pharyngotympanic tube

2nd - tonsil

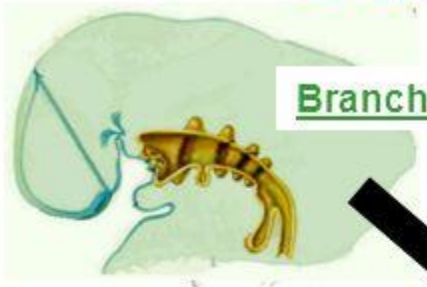
3rd – thymus and inferior parathyroid

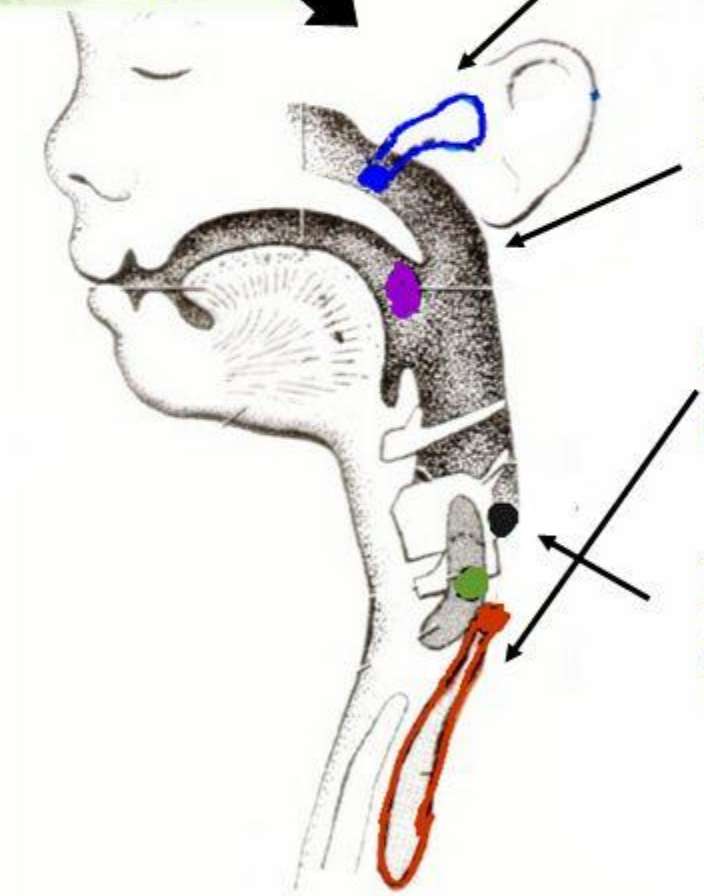
4th – superior parathyroid

- ultimobranchial body

C-cells of thyroid

BRANCHIAL POUCH DERIVATIVES





A. Pouch 1 - forms Tubotympanic recess - Auditory Tube, Tympanic cavity

B. Pouch 2 - lining (crypts) of Palatine Tonsils

C. Pouch 3- Inferior Parathyroid Glands & Thymus

D. Pouch 4 - Superior Parathyroid Glands & C-Cells (Calcitonin)

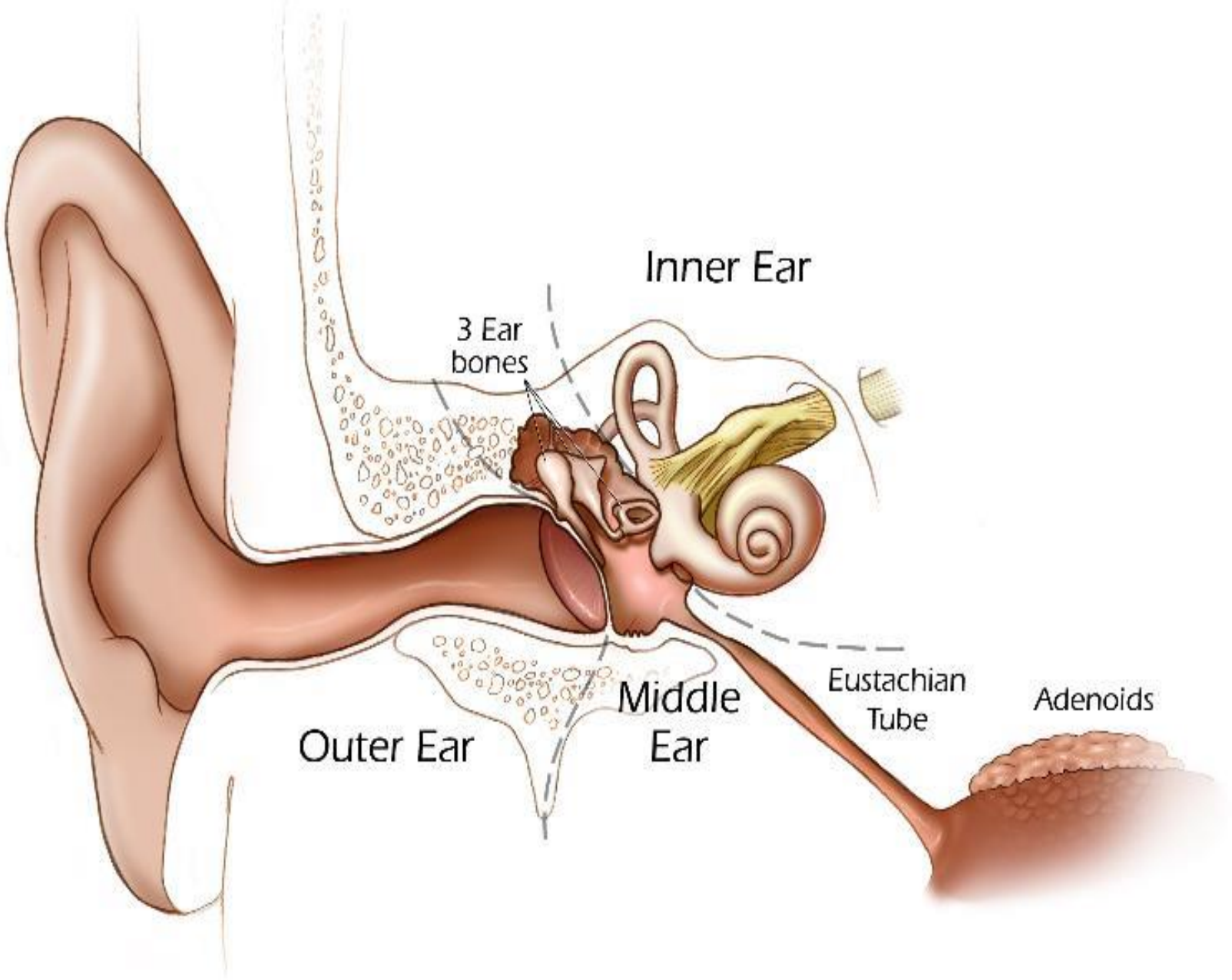
Note: Pouch 3 derivatives migrate caudal to pouch 4

FIFTH PHARYNGEAL POUCH

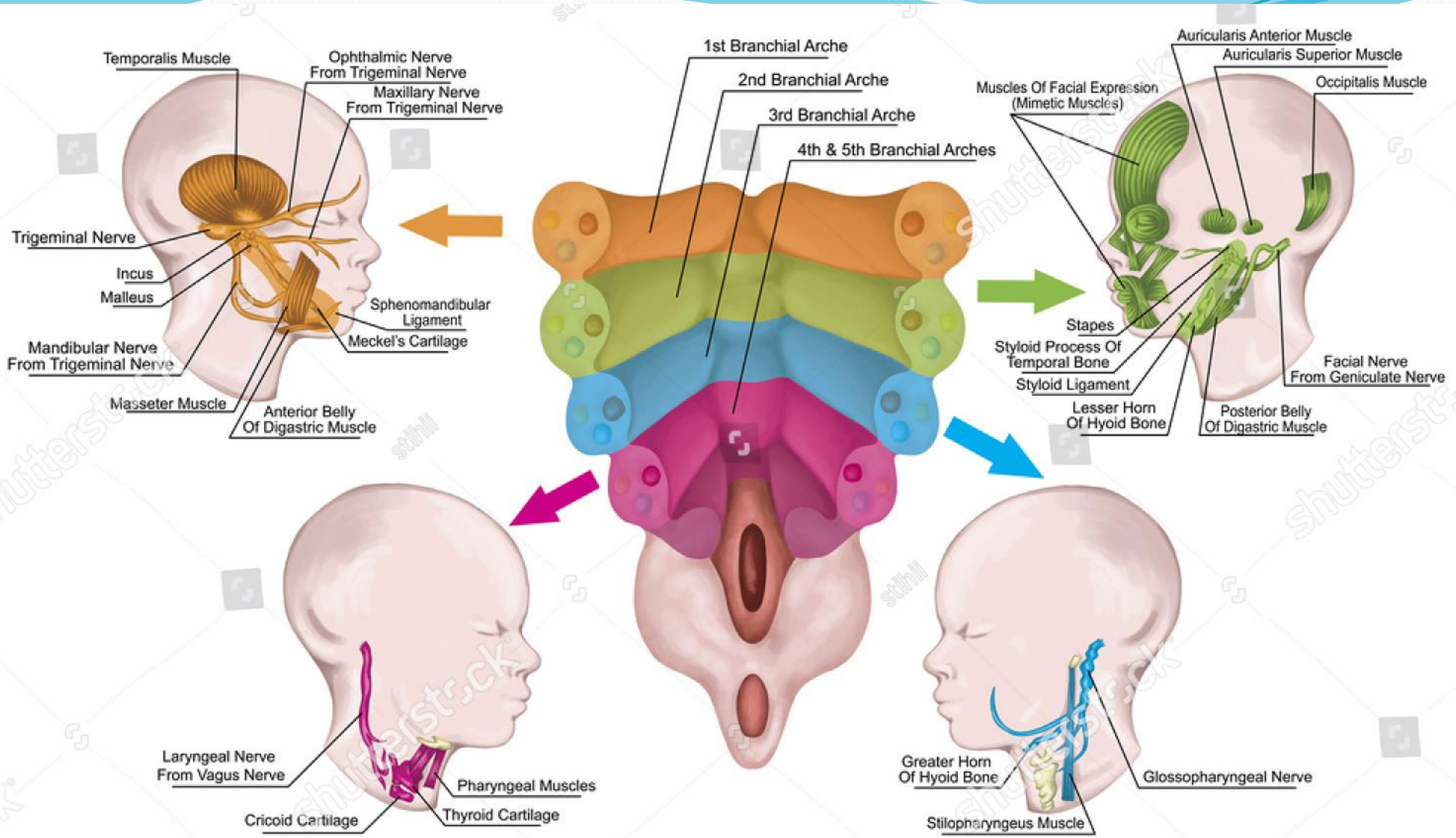
- It gives rise to the **ultimobranchial body,** which is later incorporated into the thyroid gland **as parafollicular** or **C cells** of the thyroid gland.
- These cells **secrete calcitonin**, a hormone involved in regulation of the calcium level in the blood.

PHARYNGEAL CLEFTS OR GROOVES

- The 5-week embryo is characterized by the presence of four pharyngeal clefts, of which only one contributes to the definitive structure of the embryo.
- The dorsal part of the 1st cleft penetrates the underlying mesenchyme and gives rise to the **external auditory meatus**.
- The epithelial lining at the bottom of the meatus participates in formation of the **eardrum.**

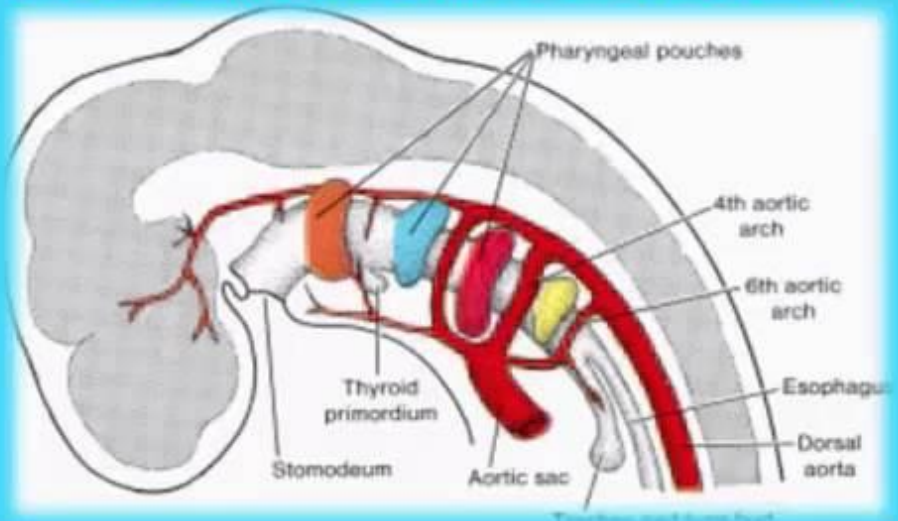

Inner Ear
3 Ear bones
Eustachian Tube
Adenoids
Middle Ear
Outer Ear

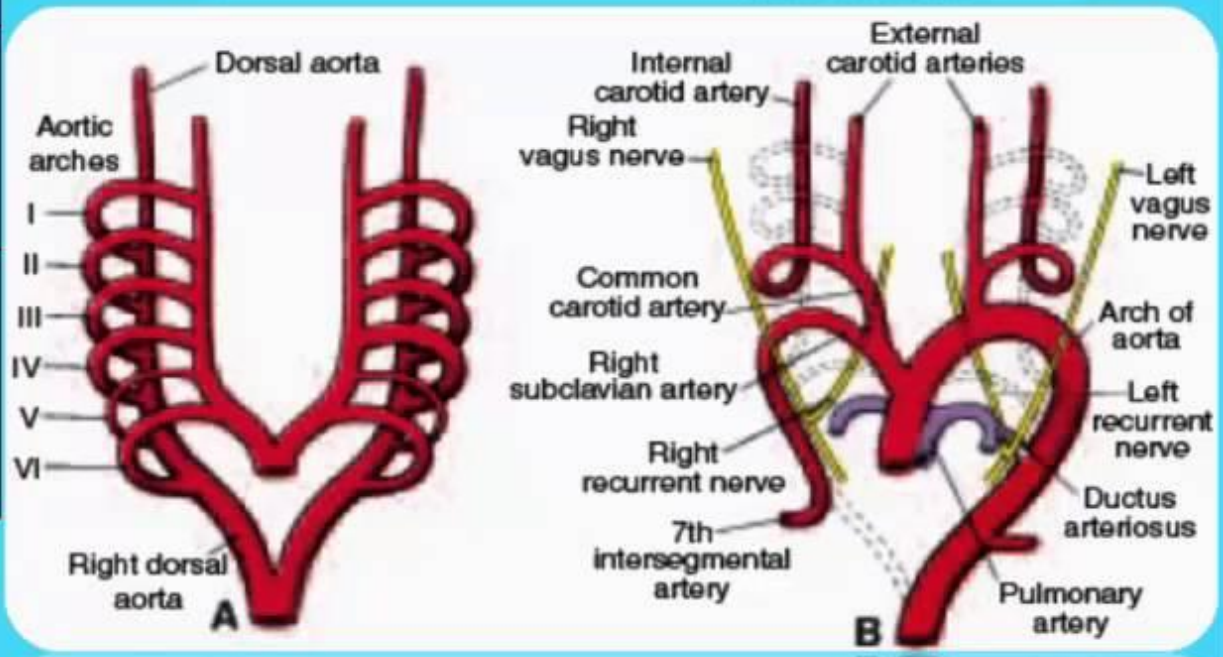
Pouch	Location	Embryonic Structure	Adult Structure
1	Opposite the 1st pharyngeal cleft, separated by the 1st pharyngeal membrane	Tubotympanic recess	Epithelium of the auditory tube and tympanic cavity
2	Opposite the 2nd pharyngeal cleft, separated by the 2nd pharyngeal membrane	Primitive palatine tonsils	Tonsilar fossa Epithelium of the palatine tonsil
3	Opposite the 3rd pharyngeal cleft, separated by the 3rd pharyngeal membrane	Divides into a dorsal and a ventral part Dorsal part migrates inferiorly toward the thorax	Inferior parathyroid gland (from the dorsal part) Thymus (from the ventral part)
4	Opposite the 4th pharyngeal cleft, separated by the 4th pharyngeal membrane	Divides into a dorsal and a ventral part Ventral part is invaded by neural crest to form the parafollicular cells	Superior parathyroid gland (from the dorsal part) Ultimobranchial body (from the ventral part)



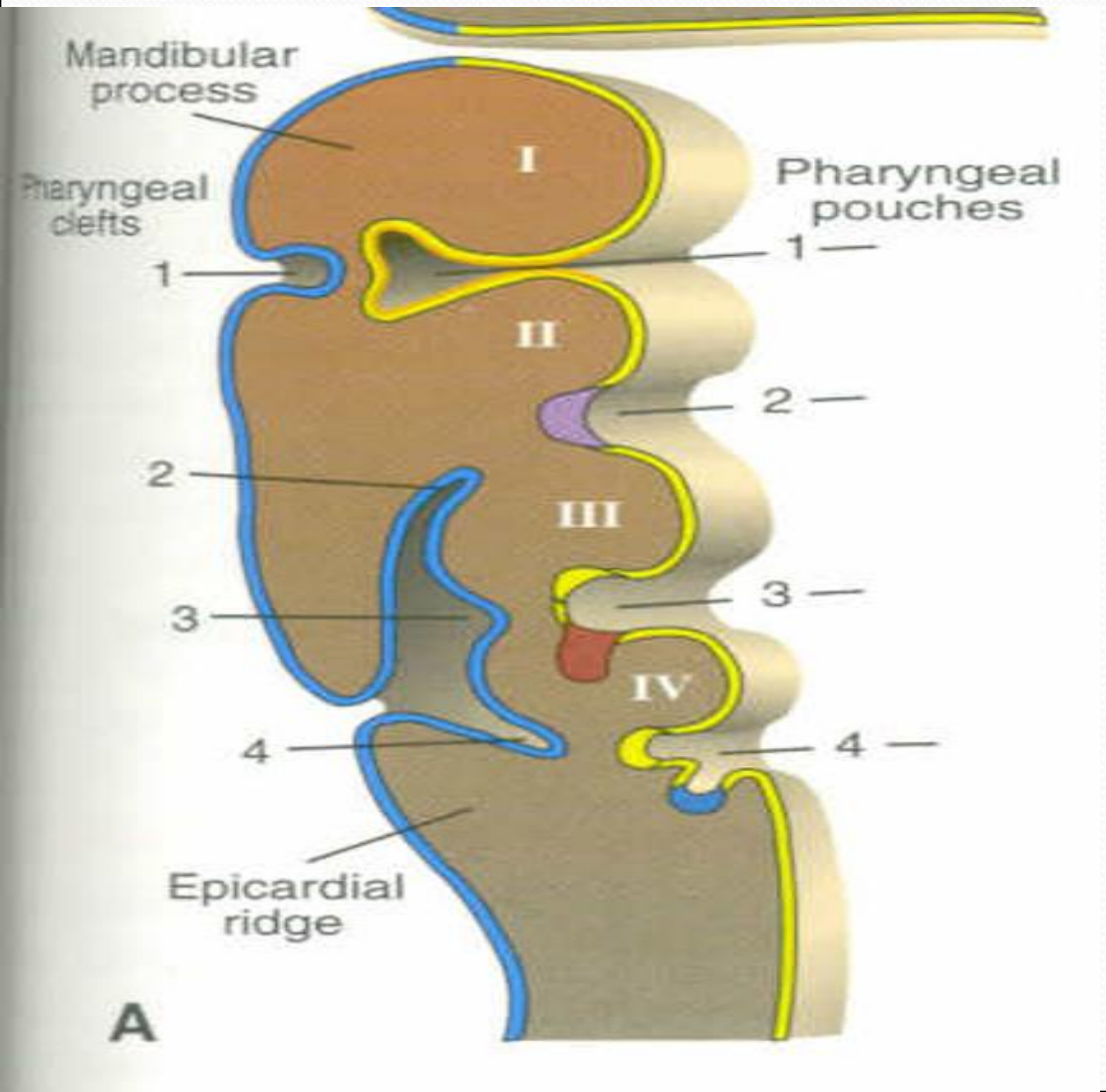
Derivatives of the pharyngeal arches (Vascular Element)

Arch	Vascular element (aortic arches)
First (mandibular) arch	Maxillary a.
Second (hyoid arch)	Artery to stapedius
Third	Internal and common carotid as.
Fourth	Aortic arch on left side. Subclavian a. on right side.
Sixth	Pulmonary arteries (one on each side). Ductus arteriosus on left side.





Pharyngeal clefts/grooves (4)



- Active proliferation of mesenchymal tissue in the 2nd arch causes it to overlap the 3rd and 4th arches.
- Finally it merges with the **epicardial ridge** in the lower part of the neck, and the 2nd, 3rd, and 4th clefts lose contact with the outside.
- Temporarily, the clefts form a cavity lined with ectodermal epithelium, the **cervical sinus**, but with further development this sinus disappears.

DiGeorge syndrome

- **DiGeorge syndrome is also known as congenital thymic aplasia and absence of the parathyroid glands. It is characterized by congenital hypoparathyroidism, low set ears, a malformed mouth, nasal clefts, thyroid hypoplasia, cardiac abnormalities and increased susceptibility to infections.**
  It is the result of a failure of differentiation of the third and foruth pharyngeal pouches.