

DEVELOPMENT OF BRANCHIAL ARCHES

FORM GILLS
IN FISH



~4 weeks



~11 weeks



OUTLINE

I. EARLY DEVELOPMENT/
TERMINOLOGY

II. FATE OF ARCHES
(CHART) - CARTILAGES,
LIGAMENTS, NERVES,
MUSCLES

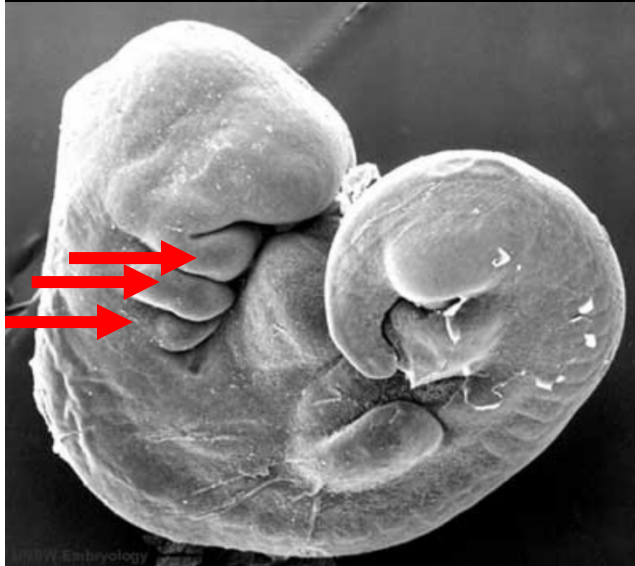
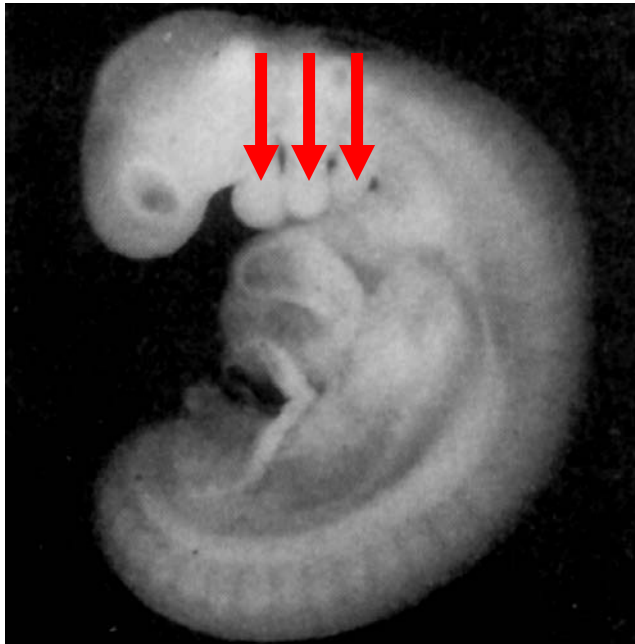
III. BRANCHIAL POUCHES,
GROOVES, MEMBRANES

IV. DEVELOPMENT OF
THYROID

- ADULT STRUCTURE IS RESULT OF TRANSFORMATION;
- SPECIFIC SYNDROMES OCCUR IF DEVELOPMENT IS ABNORMAL

Photo of 4 Week Embryo

BRANCHIAL ARCHES



I. BRANCHIAL ARCHES

- Structures which develop that are similar in origin and structure to gills of fish

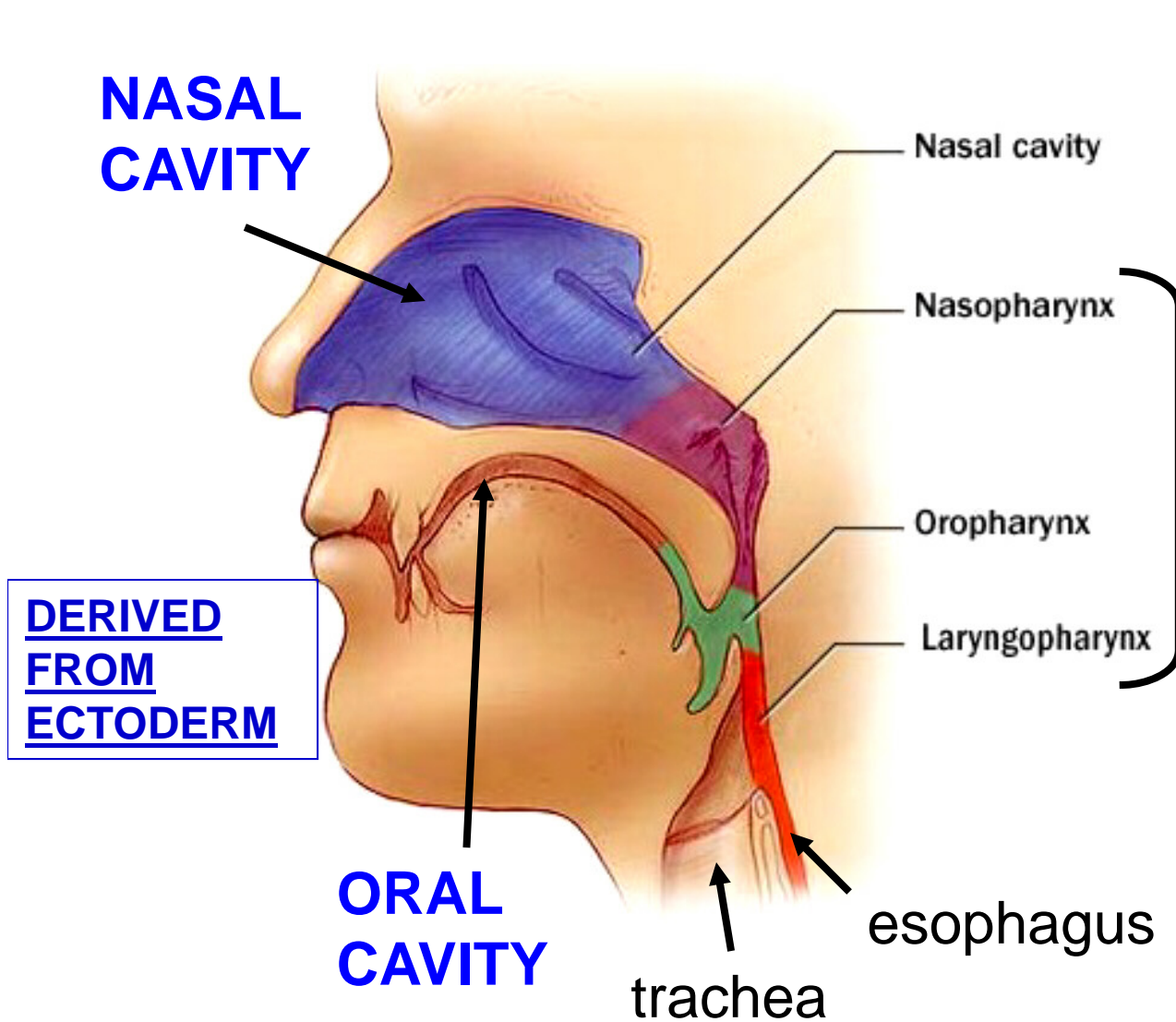
- **Gill = Branchial**

- Ontogeny resembles Phylogeny

- Reorganize to produce Adult structures

Note Terminology :
Branchial Arch = Pharyngeal Arch

WHERE/WHAT IS THE PHARYNX?

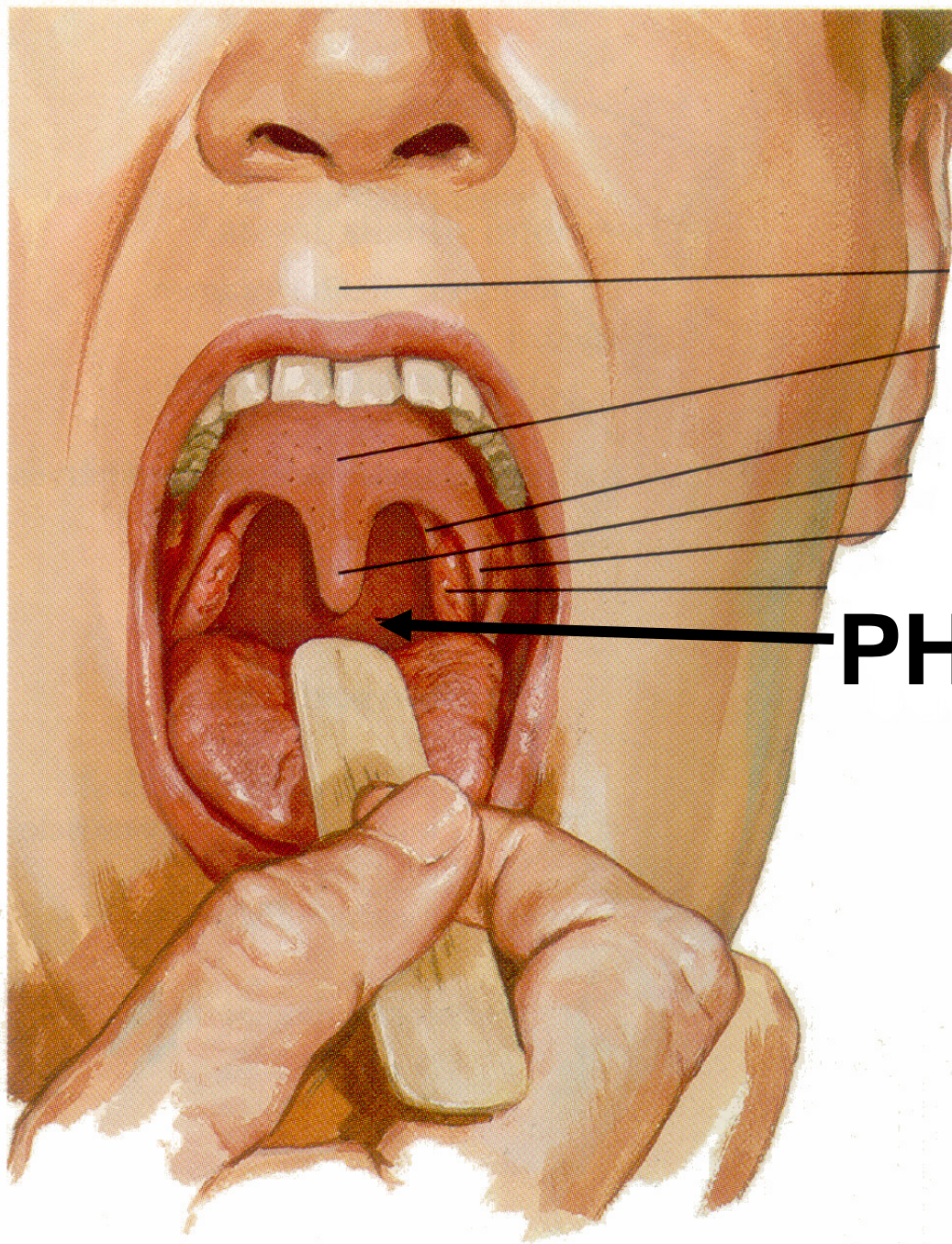


DERIVED
FROM
ENDODERM

PHARYNX -
region behind
Oral and Nasal
Cavities

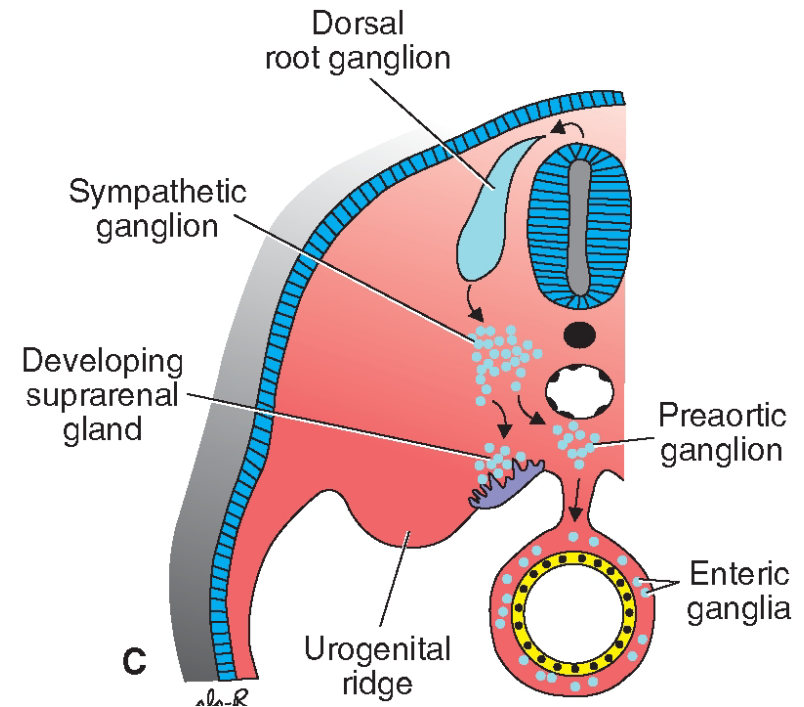
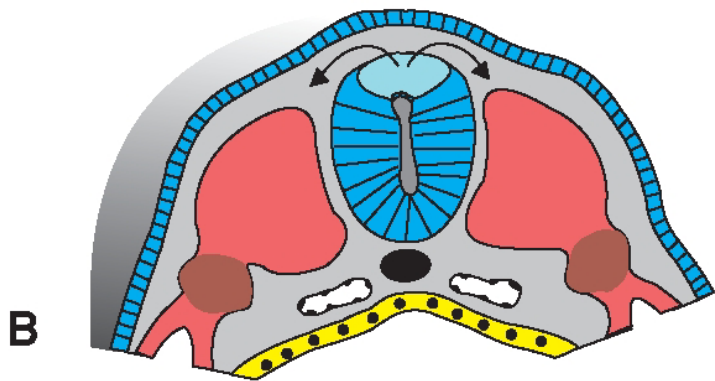
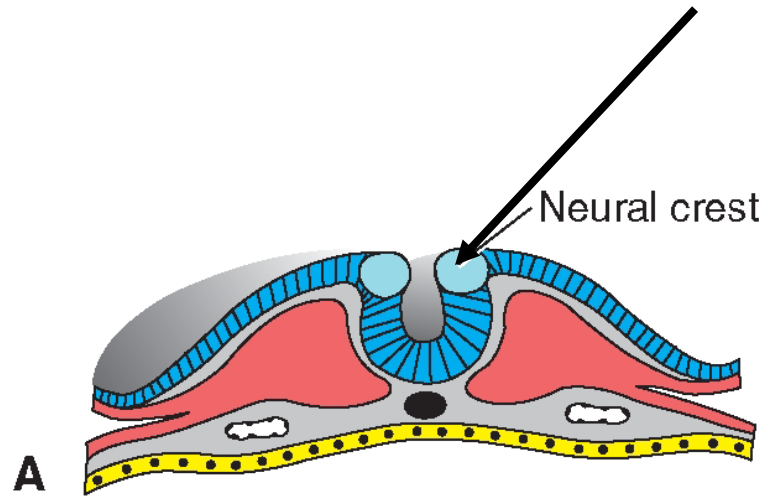
PHARYNX IS
CONNECTED TO
TRACHEA
(RESPIRATORY
SYSTEM) AND
ESOPHAGUS
(GI) SYSTEM

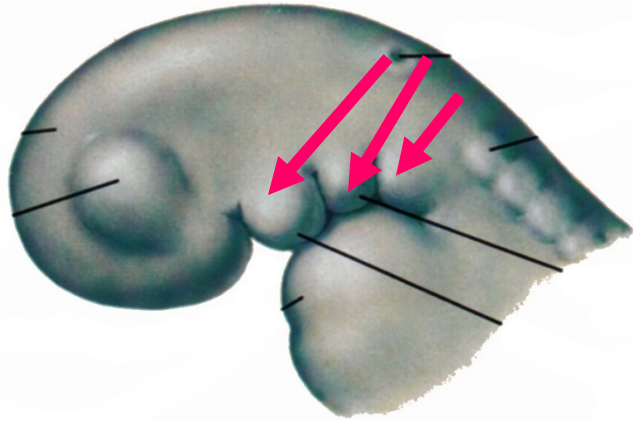
**SAY
AAHH!**



PHARYNX

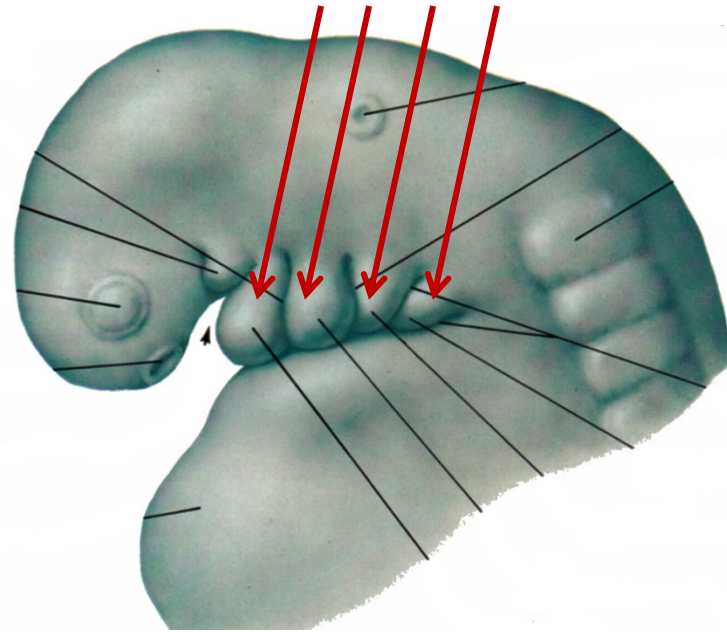
A. Week 4 - Neural Crest Cells Migrate





**Neural Crest
Cells
Invade Head
and Neck
Lateral
To Rostral Part
of Foregut
= PHARYNX**

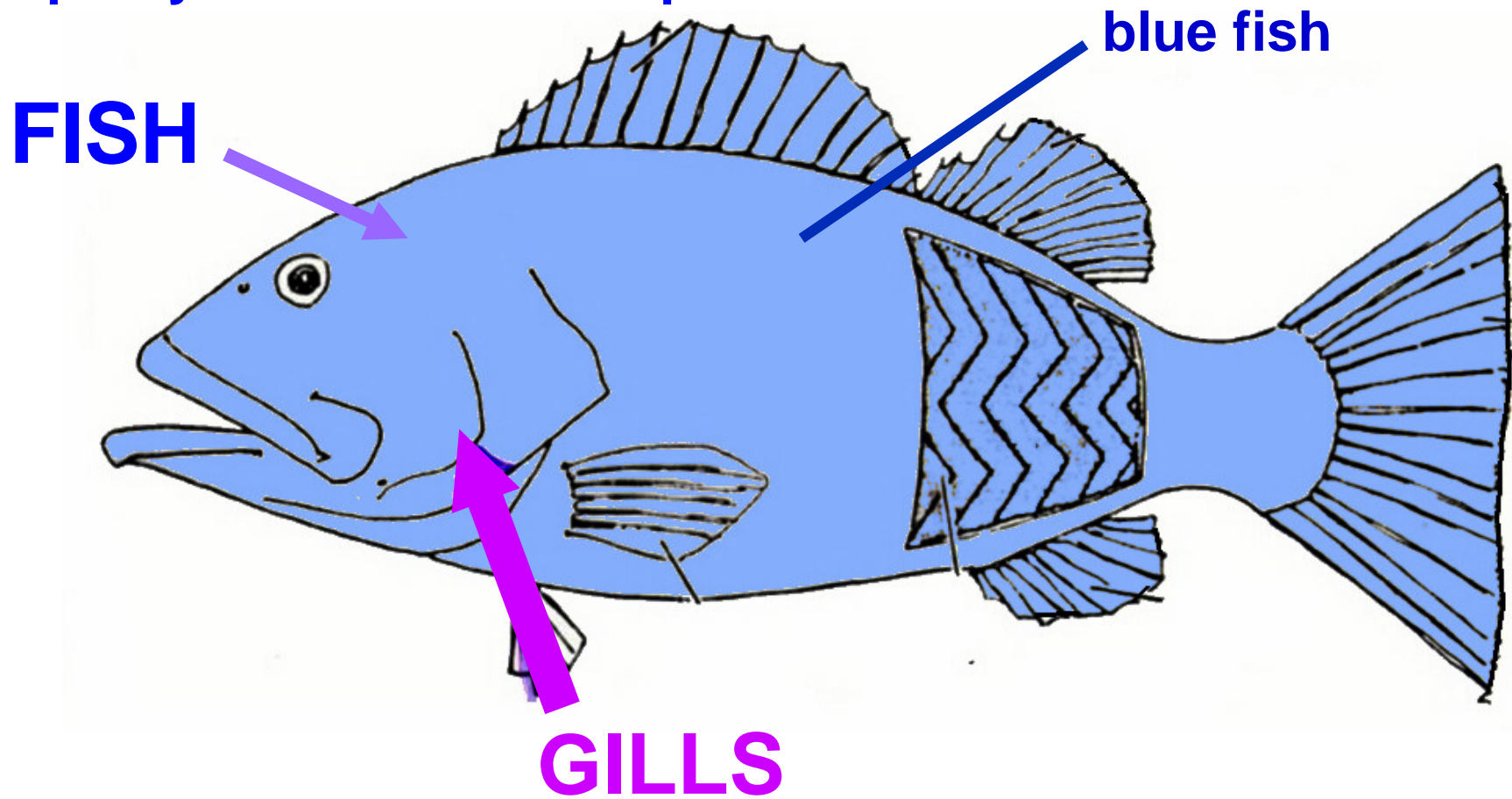
Form Ridges = Branchial Arches



**Branchia
Means Gill
In Greek;
In fish, similar
structures
form Gills**

GILLS OF FISH

Gills - located lateral to Rostral (proximal) end of pharynx - covered and protected



GILLS HAVE ARTERIES, MUSCLES AND NERVES

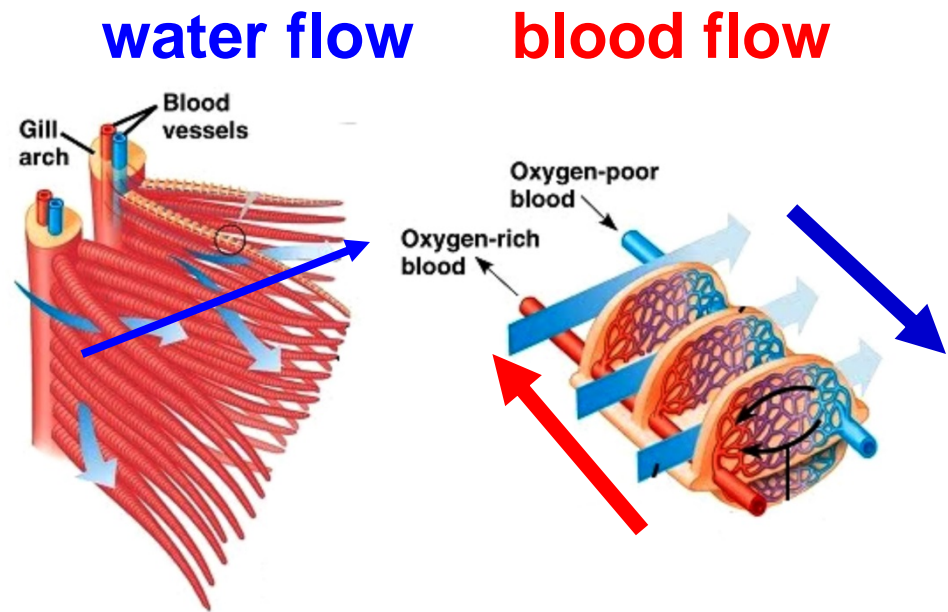
Gills have filaments attached to cartilages

- arteries pass through filaments for gas exchange

- Gills moveable (filter feeding) - each has skeletal muscle and nerve
(CRANIAL NERVE)



Gills

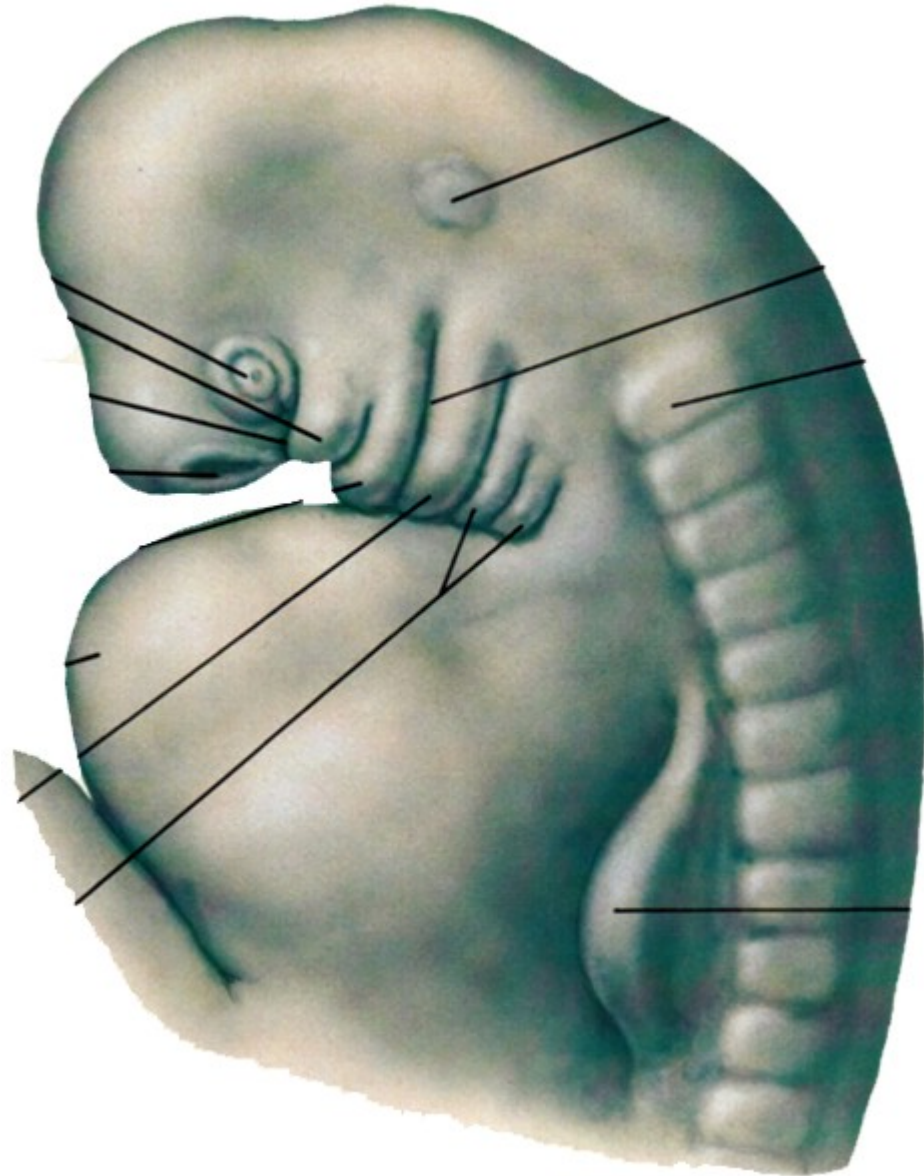


Large surface area - Mackerel (swim a lot) - surface of gills 10 times surface area of body

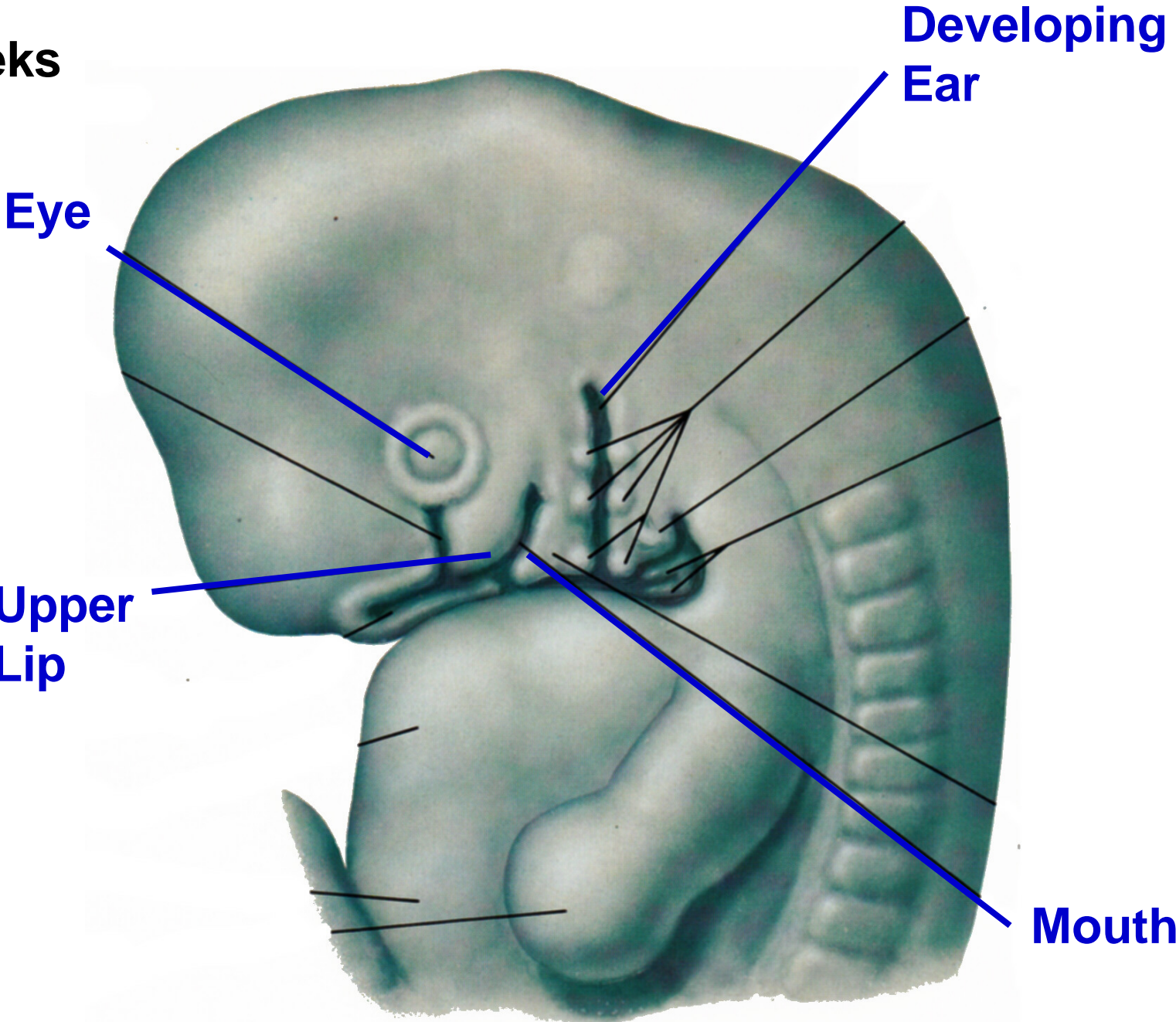
Structures in Embryonic Branchial Arches Reorganize to form cartilages, nerve, muscles & arteries in fetus.

5- 6 weeks

Forms much of musculature of head some of neck



6-7 weeks



Developing Ear

Eye

Upper Lip

Mouth

8-10 weeks



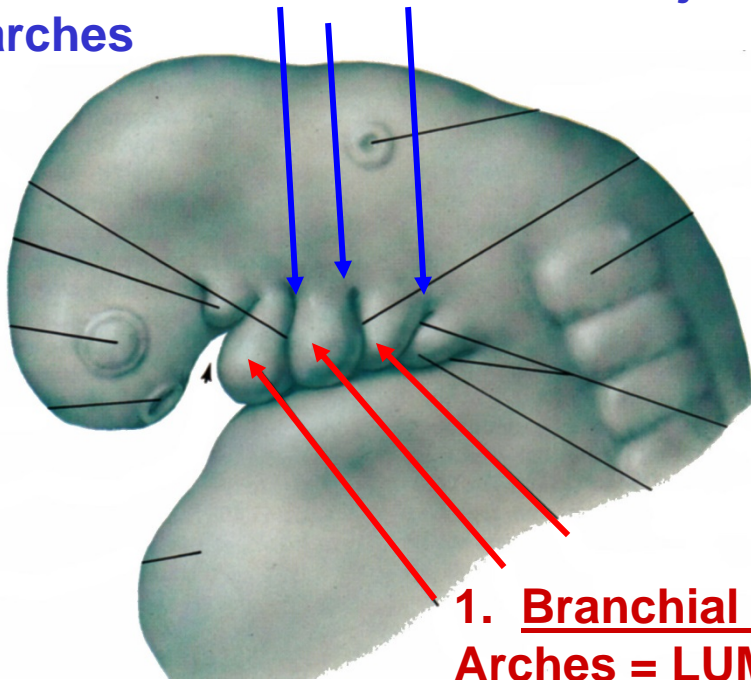
Congenital Malformations of Head and Neck Result from incorrect Transformation of Branchial Apparatus to Adult Structures

TERMINOLOGY: ARCHES, GROOVES, POUCHES, MEMBRANES

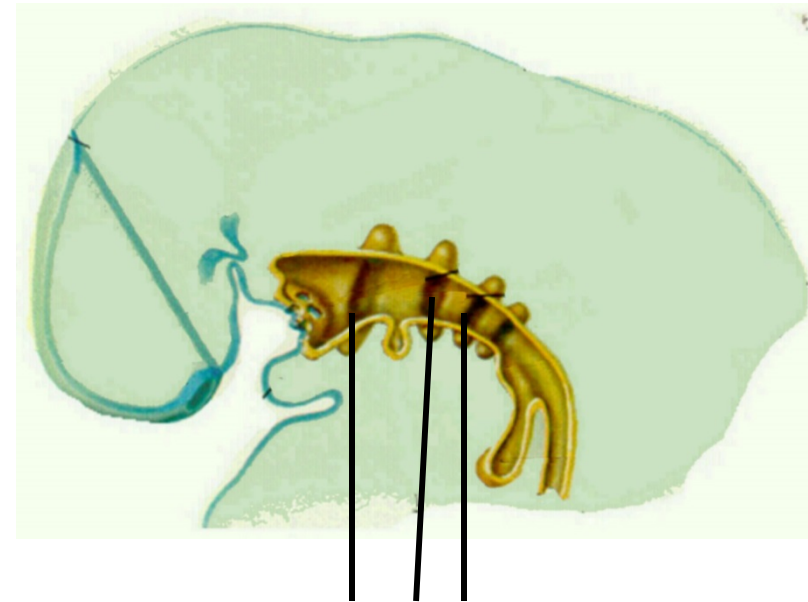
VIEW OF EXTERIOR OF EMBRYO

2. Branchial Grooves (Clefts)

- ectodermal clefts between adjacent arches



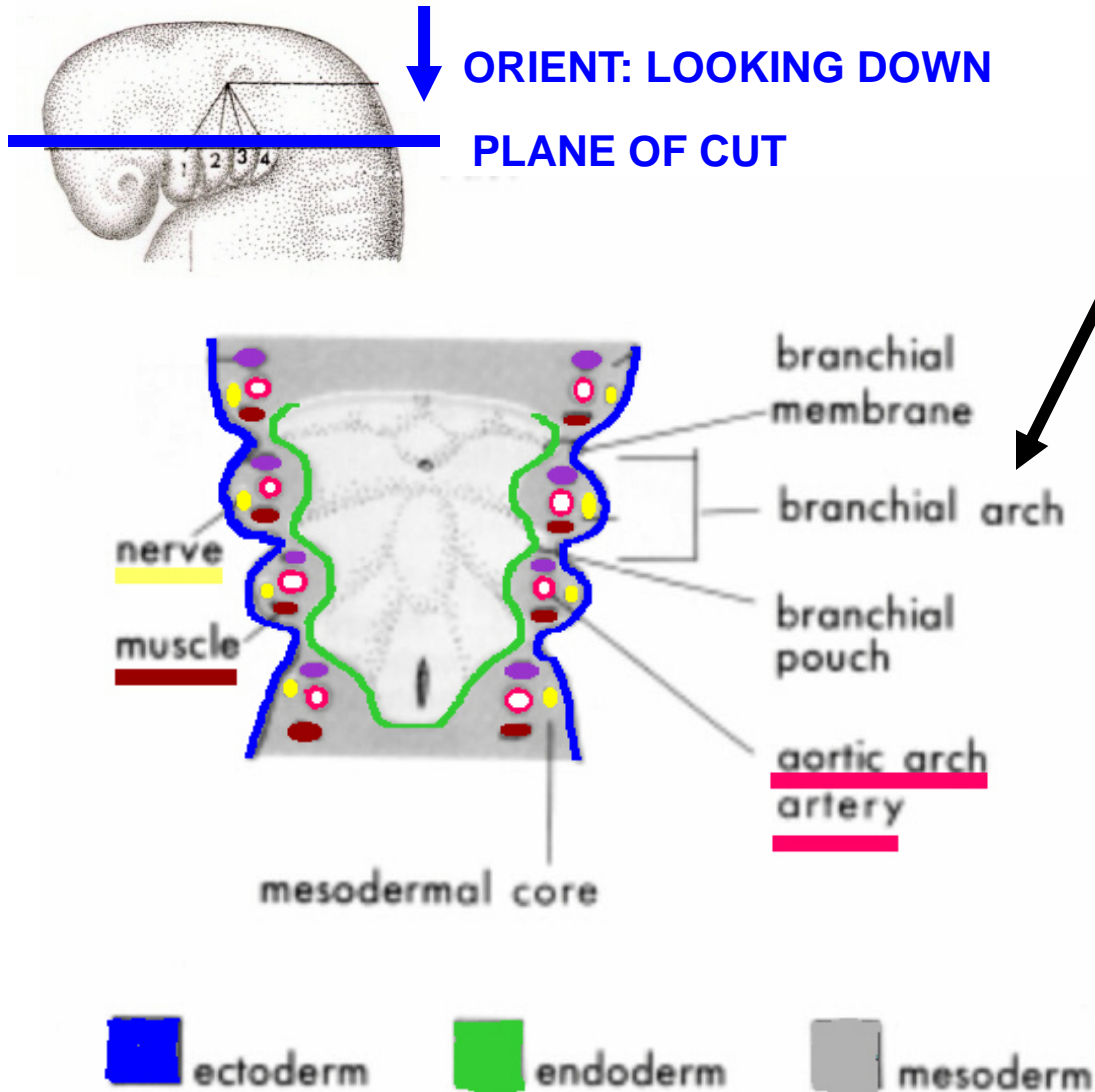
VIEW OF EMBRYO BISECTED IN SAGITTAL PLANE



3. Branchial Pouch

- endodermal out pocketing from rostral foregut
- between adjacent arches

B. BRANCHIAL APPARATUS - 4 elements

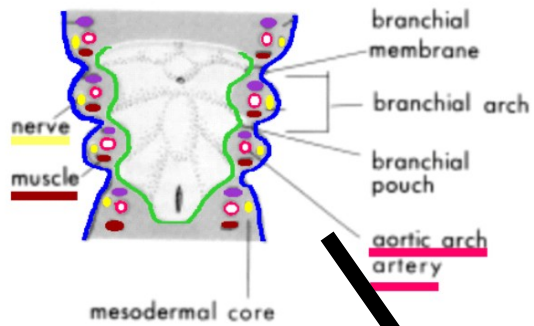


1. Branchial Arch
covered by:
Ectoderm - externally
Endoderm - lined internally
(Mesenchyme - core)

Each arch has own cartilage, nerve, muscle and artery (= aortic arch artery)

Each nerve innervates structures derived from its associated arch

BRANCHIAL APPARATUS - 4 elements



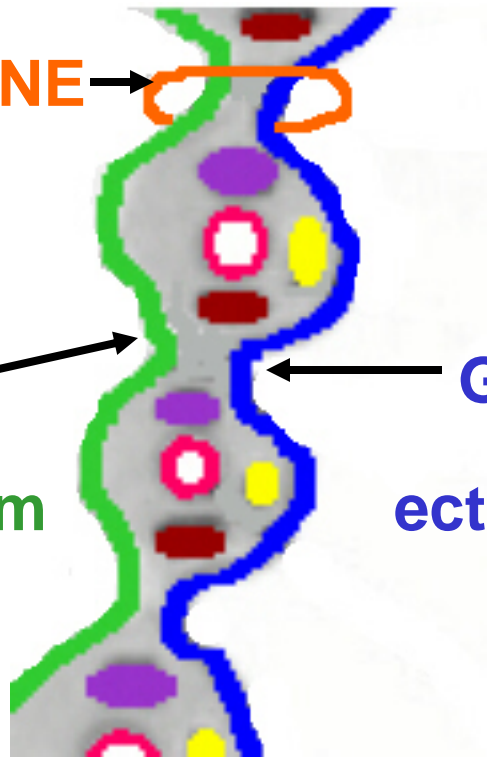
MEMBRANE

POUCH

endoderm

GROOVE

ectoderm



2. Branchial Groove
(Pharyngeal Cleft)

- ectodermal cleft
between adjacent
arches

3. Branchial Pouch -

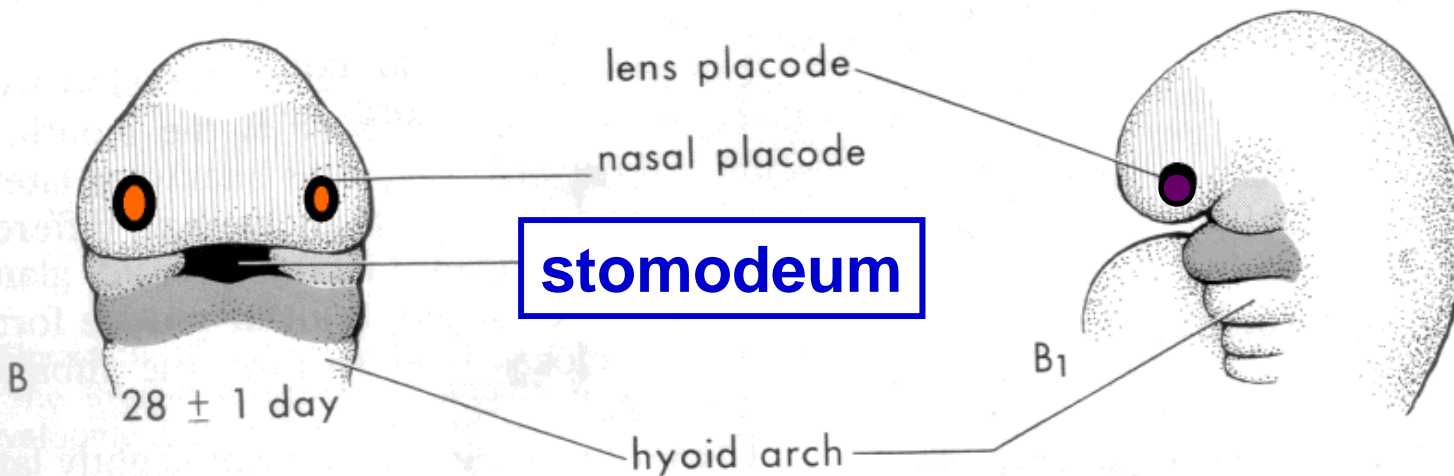
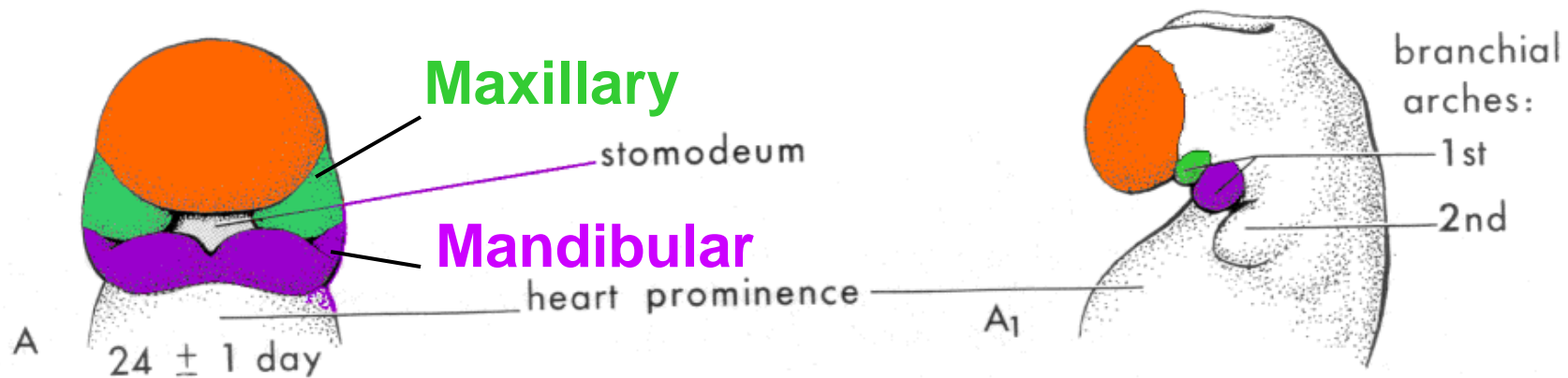
endodermal
outpocketing from
rostral foregut
-between adjacent
arches

4. Branchial Membrane

- site of contact of
Groove (ectoderm)
Pouch (endoderm)

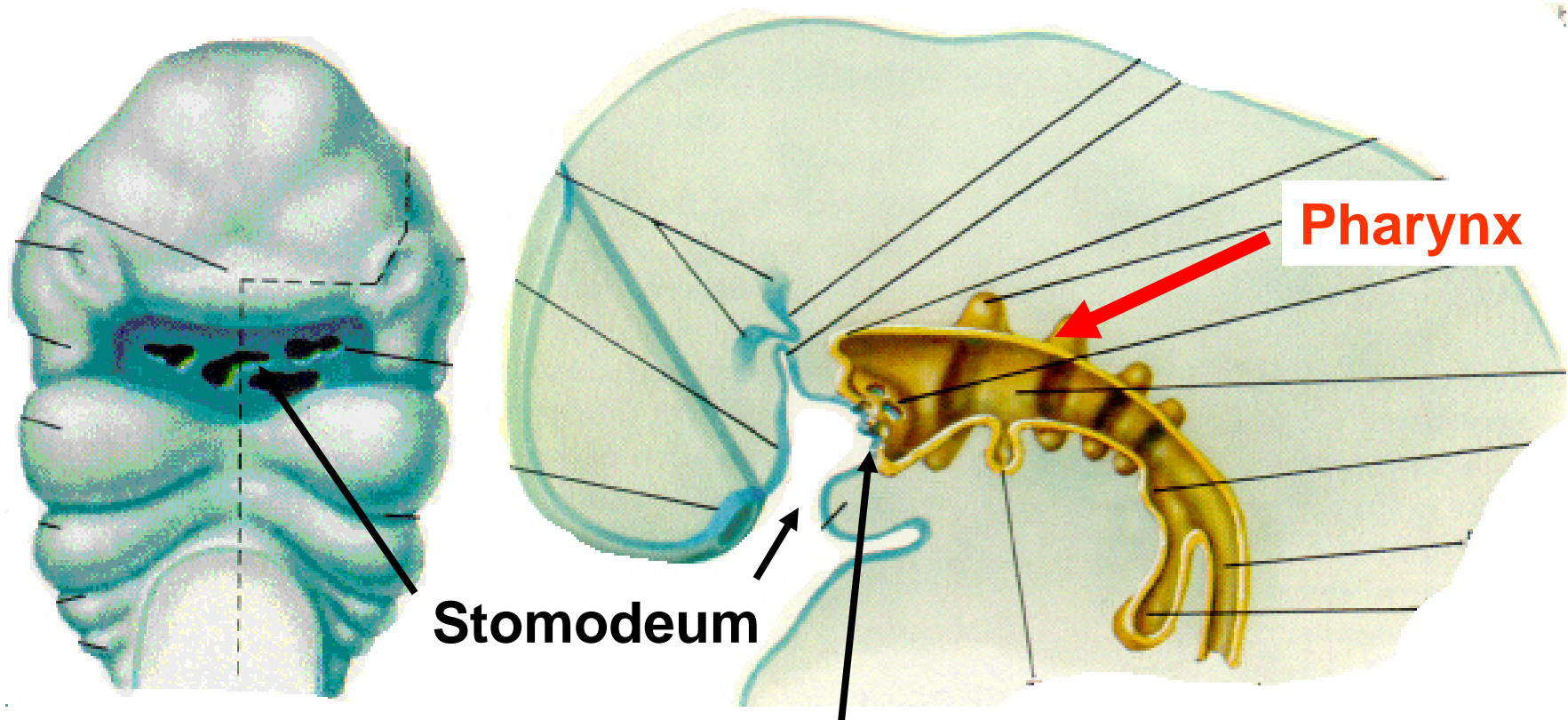
First Arch - forms face, has maxillary and mandibular processes

- surrounds stomodeum (primitive mouth)

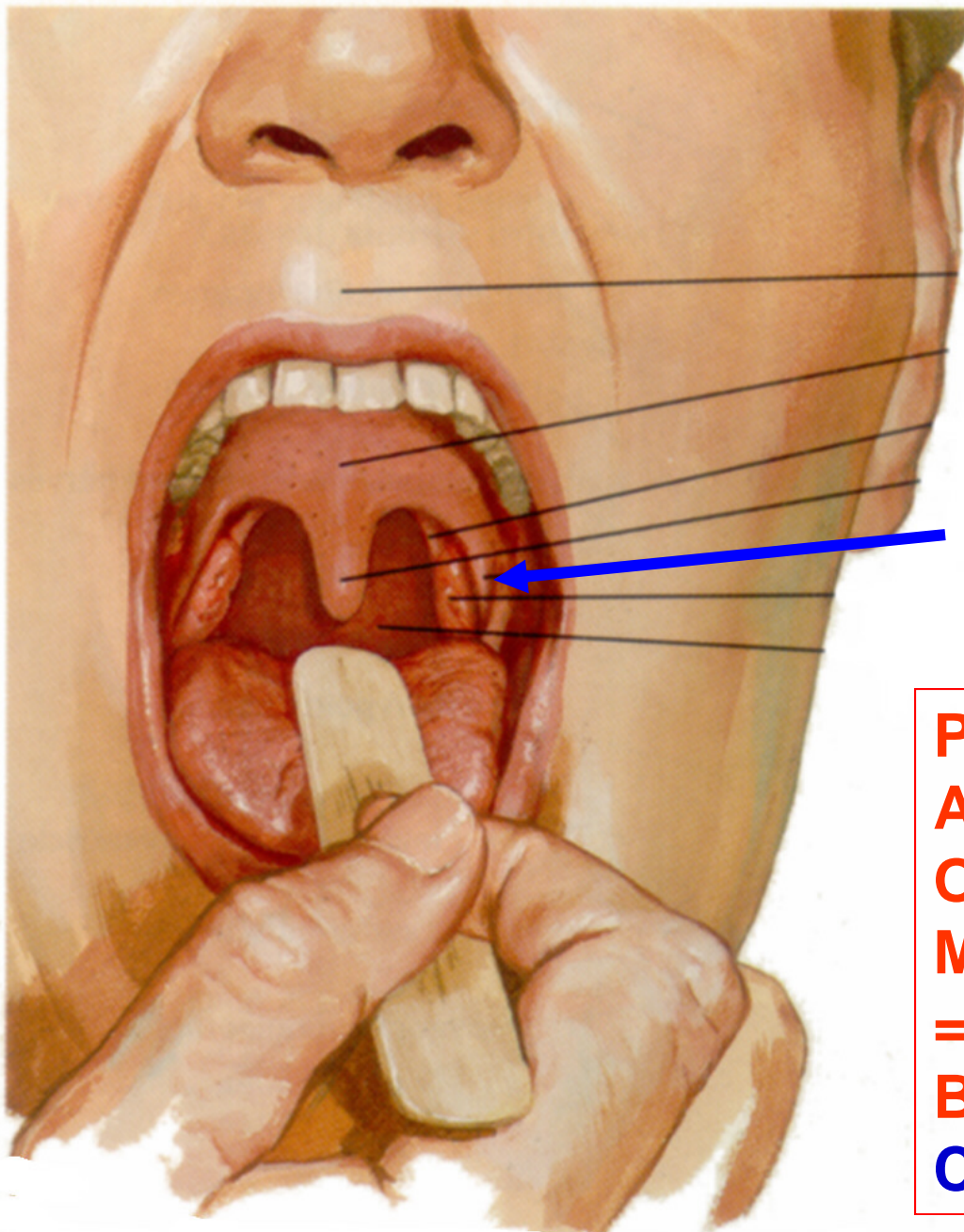


NOTE: LENS PLACODE IS CORRECT

- Stomodeum formed by Ectoderm; forms Oral Cavity and Nasal Cavity
- Contacts Endoderm at Oropharyngeal Membrane
- Pharynx – rostral foregut - formed by Endoderm



Oropharyngeal Membrane = BOUNDARY



**SAY
AAHH!**

**PALATOGLOSSAL
ARCH****

**PALATOGLOSSAL
ARCH = SITE OF
OROPHARYNGEAL
MEMBRANE
= BOUNDARY,
BETWEEN ORAL
CAVITY AND PHARYNX**



ARCH/NERVE	SKELETAL	LIGAMENTS	MUSCLES
First (V)	1) Malleus 2) Incus	1) Ant. ligament of malleus 2) Sphenomandibular ligament	1) Muscles of Mastication 2) Tensor tympani 3) Tensor palati 4) Mylohyoid 5) Ant. belly of Digastric
Second (VI)	1) Stapes 2) Styloid process 3) Hyoid bone - lesser horn, upper half of body	Stylohyoid ligament	1) Muscles of Facial Expression 2) Stapedius 3) Stylohyoid 4) Post. belly of Digastric
Third (IX)	Hyoid bone - greater horn, lower half of body	-----	Stylopharyngeus
Fourth (X)	Cartilages of Larynx	-----	1) All muscles of Larynx 2) All muscles of Pharynx (except Stylopharyngeus) 3) All muscles of Soft Palate (except Tensor palati)
Sixth (XI)	-----	-----	1) Sternocleidomastoid 2) Trapezius

Note: First Branchial Groove (Cleft) becomes External Auditory Meatus
First Branchial Membrane becomes Tympanic Membrane

Note:

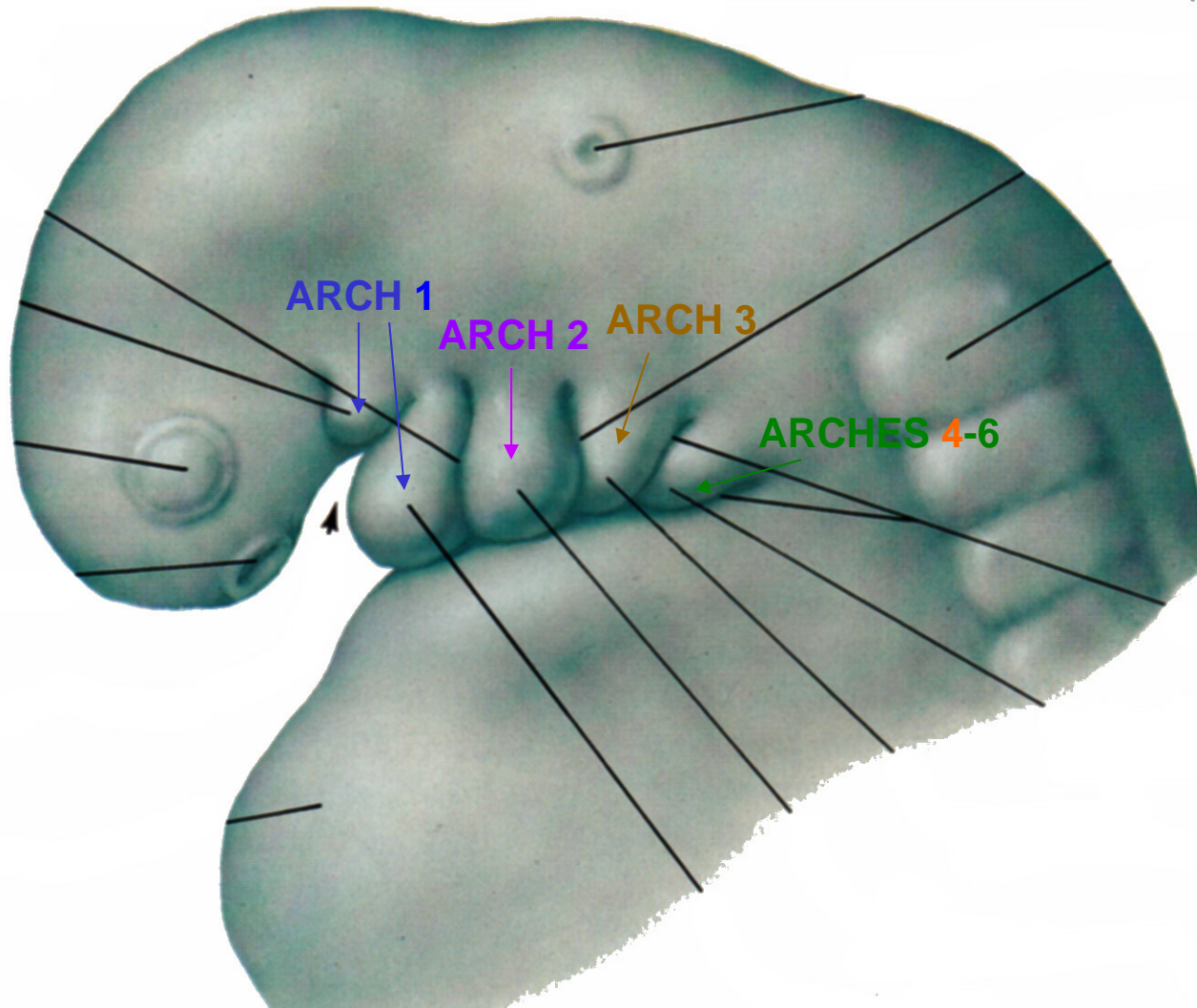
All authors agree on:

1) Fate of Arches

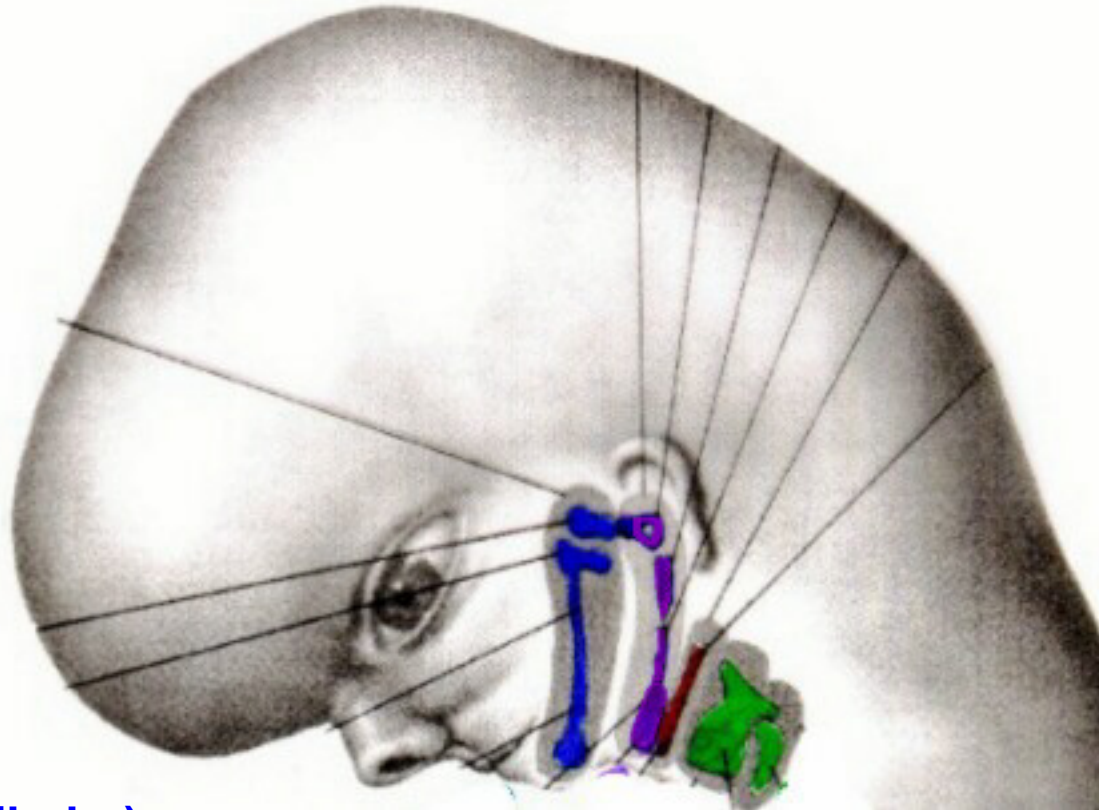
1- 3;

2) Arch 5 does not form structures in humans

Accounts vary on Arches 4 and 6 (6 is small)



BRANCHIAL ARCH CARTILAGES



I First (Mandibular)

Arch -

1. Malleus
2. Incus
3. Ant. Ligament
Of malleus
4. Sphenomandibular
ligament

II Second (Hyoid) Arch

1. Stapes
2. Styloid Process
3. Stylohyoid Ligament
4. Lesser horn, Upper
 $\frac{1}{2}$ body Hyoid

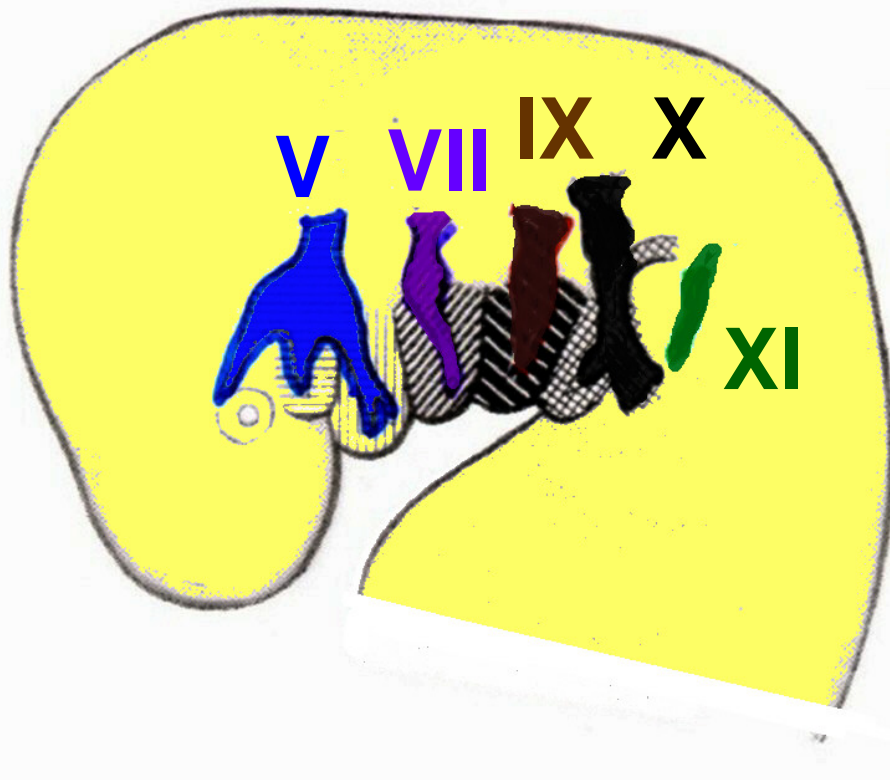
III Third Arch -

- Lower $\frac{1}{2}$
Body, Greater
Horn Of hyoid

IV Fourth (Sixth) Arch - Cartilages Of larynx

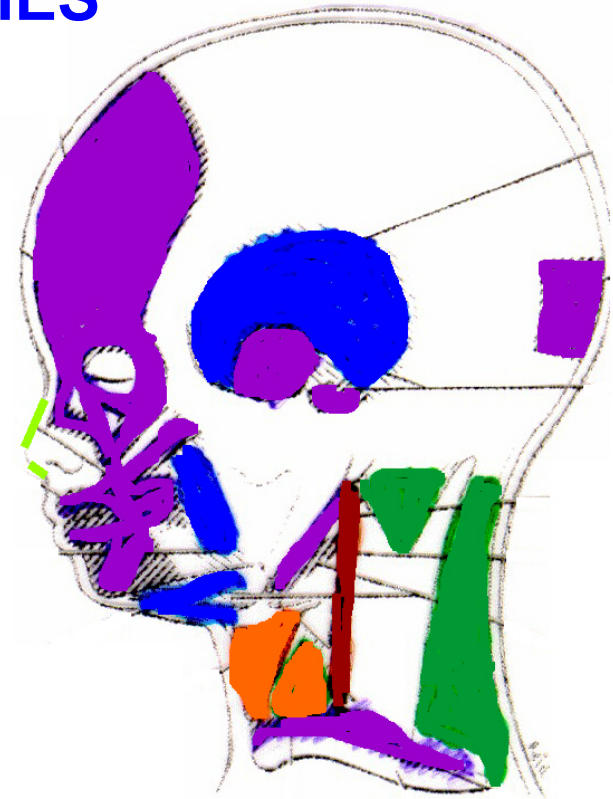
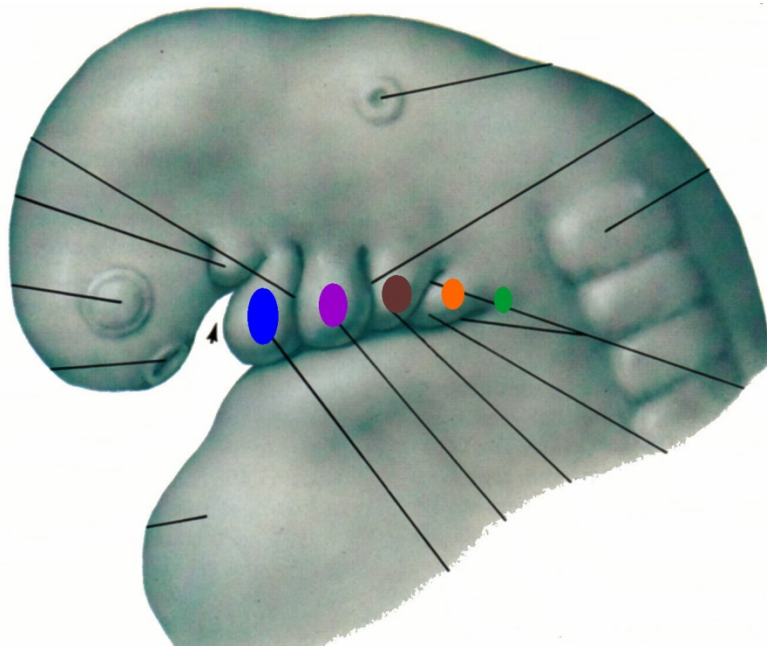
BRANCHIAL ARCH NERVES

Muscles of Arches are innervated by Cranial Nerves



- 1) First Arch – Trigeminal (V)
- 2) Second Arch – Facial (VII)
- 3) Third Arch – Glossopharyngeal (IX)
- 4) Fourth Arch – Vagus (X)
- 5) Caudal Sixth – Accessory (XI)

MUSCLES OF BRANCHIAL ARCHES



Innervated by

First -
Trigeminal
V

Second -
Facial
VII

Third
Glosso-
pharyngeal
IX

Fourth
Vagus
X

Sixth
Accessory
XI

When muscles migrate, they carry the nerve branch with them.

10) BRANCHIOMOTOR - voluntary motor to skeletal muscles of face, ear, pharynx and neck that are derived from branchial arches.

	<u>Nerve</u>	<u>Innervates</u>	
FIRST ARCH	V (Trigeminal) (all in V3)	muscles of mastication mylohyoid tensor tympani tensor palati anterior belly of digastric	KNOW THIS: QUESTIONS ON EXAM, BOARDS
SECOND ARCH	VII (Facial)	muscles of facial expression stylohyoid posterior belly of digastric stapedius	
THIRD ARCH	IX (Glossopharyngeal)	stylopharyngeus	
FOURTH ARCH	X (Vagus)	all muscles of pharynx (except stylopharyngeus) muscles of larynx all muscles of palate (except tensor palati)	
CAUDAL SIXTH ARCH	XI (Accessory)	sternocleidomastoid trapezius	

*** * ***

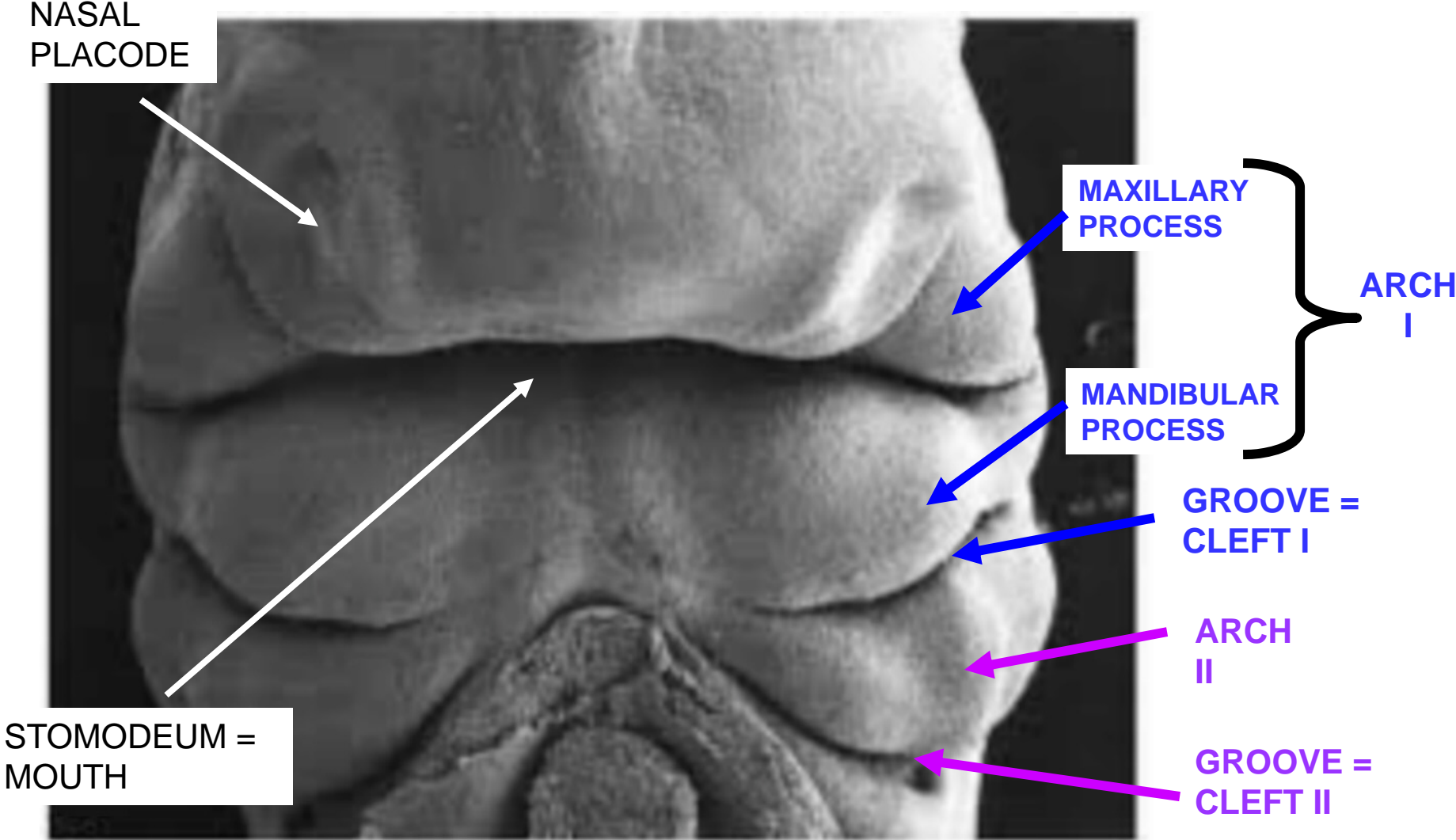
note: Innervation pattern of Cranial Nerves applies to muscles of BRANCHIAL ARCHES: DOES NOT APPLY TO POUCHES OR CLEFTS

BRANCHIOMOTOR (SVE) = SKELETAL MUSCLES DERIVED FROM BRANCHIAL ARCHES

ARCH/NERVE	SKELETAL	LIGAMENTS	MUSCLES
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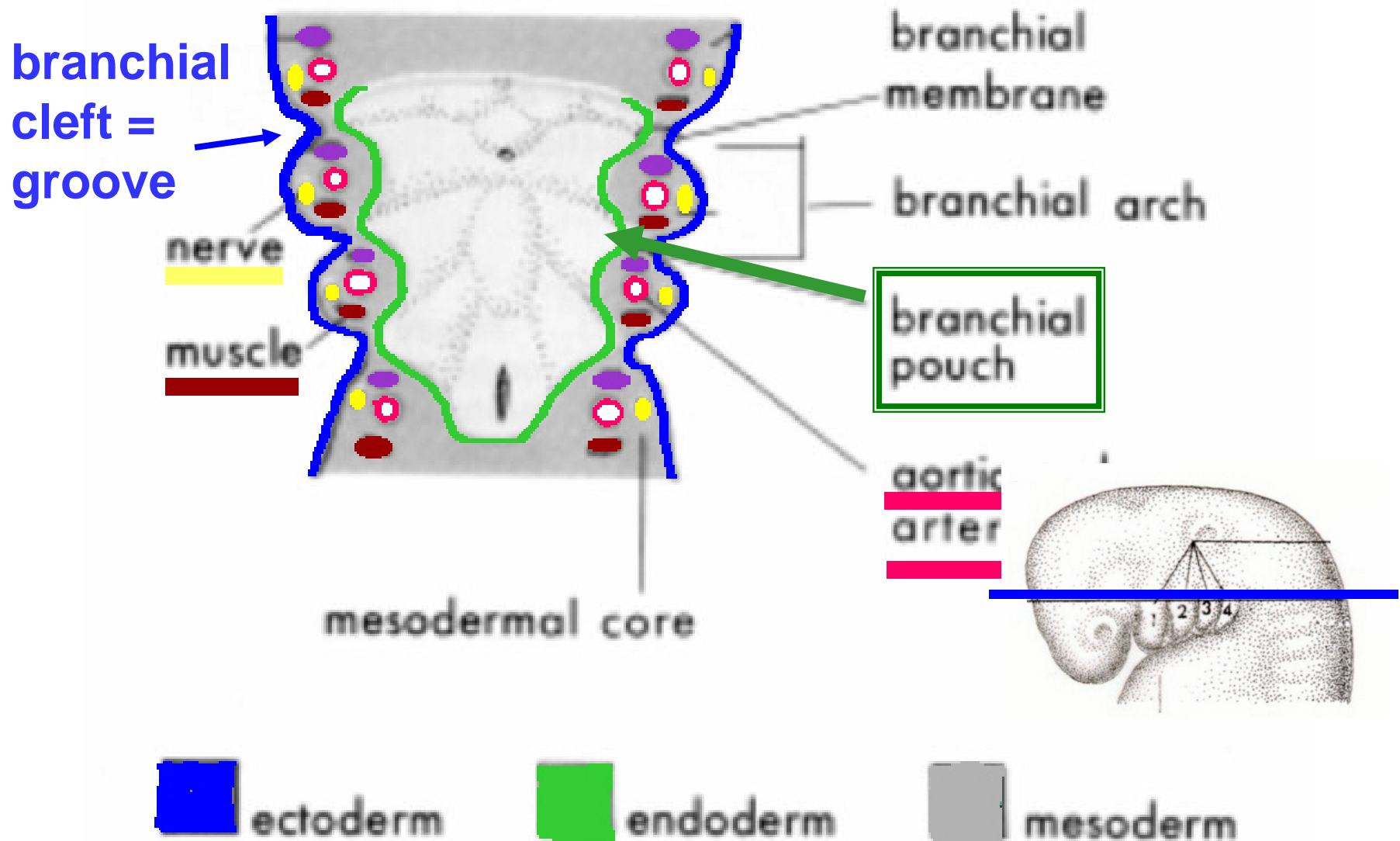
Note: First Branchial Groove (Cleft) becomes External Auditory Meatus
First Branchial Membrane becomes Tympanic Membrane

BRANCHIAL ARCHES AND CLEFTS

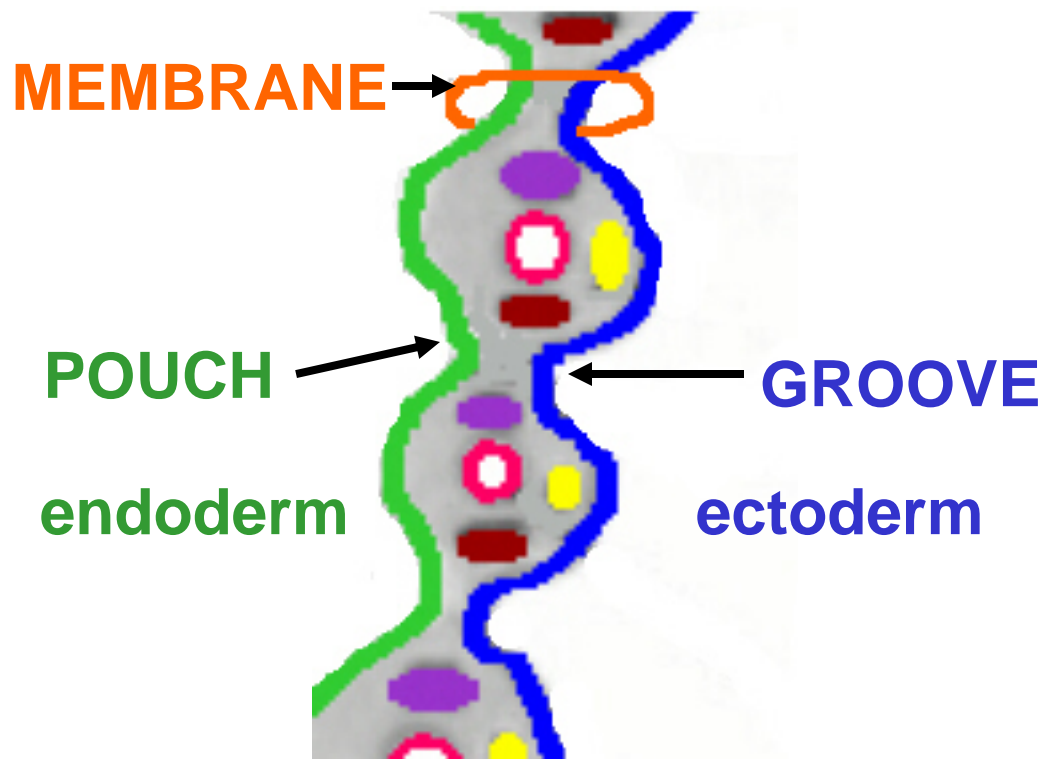
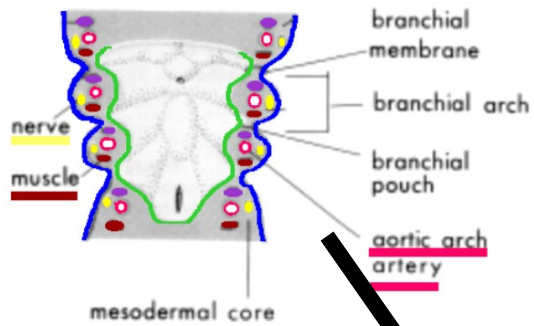


24 DAY HUMAN EMBRYO

BRANCHIAL POUCHES, GROOVES, MEMBRANES



BRANCHIAL APPARATUS - 4 elements



2. Branchial Groove (Pharyngeal Cleft)

- ectodermal cleft
between adjacent
arches

3. Branchial Pouch -

endodermal
outpocketing from
rostral foregut
-between adjacent
arches

4. Branchial Membrane

- site of contact of
Groove (ectoderm)
Pouch (endoderm)

BRANCHIAL POUCHES, GROOVES, MEMBRANES

**KNOW THIS:
QUESTIONS ON
EXAM, BOARDS**

POUCH	FORMS	CLINICAL
First	1) Auditory tube 2) Tympanic cavity	First Branchial 'Cleft' cyst - tract linked to external auditory meatus
Second	Lining (crypts) of palatine tonsils	Second Branchial 'Cleft' cyst - tract linked to tonsillar fossa (palatine tonsils)
Third	1) Inferior parathyroid gland 2) Thymus	Third Branchial 'Cleft' cyst - tract at thyrohyoid membrane or piriform recess
Fourth	1) Superior parathyroid gland 2) C-cells of Thyroid	does not form
Sixth (XI)	-----	-----

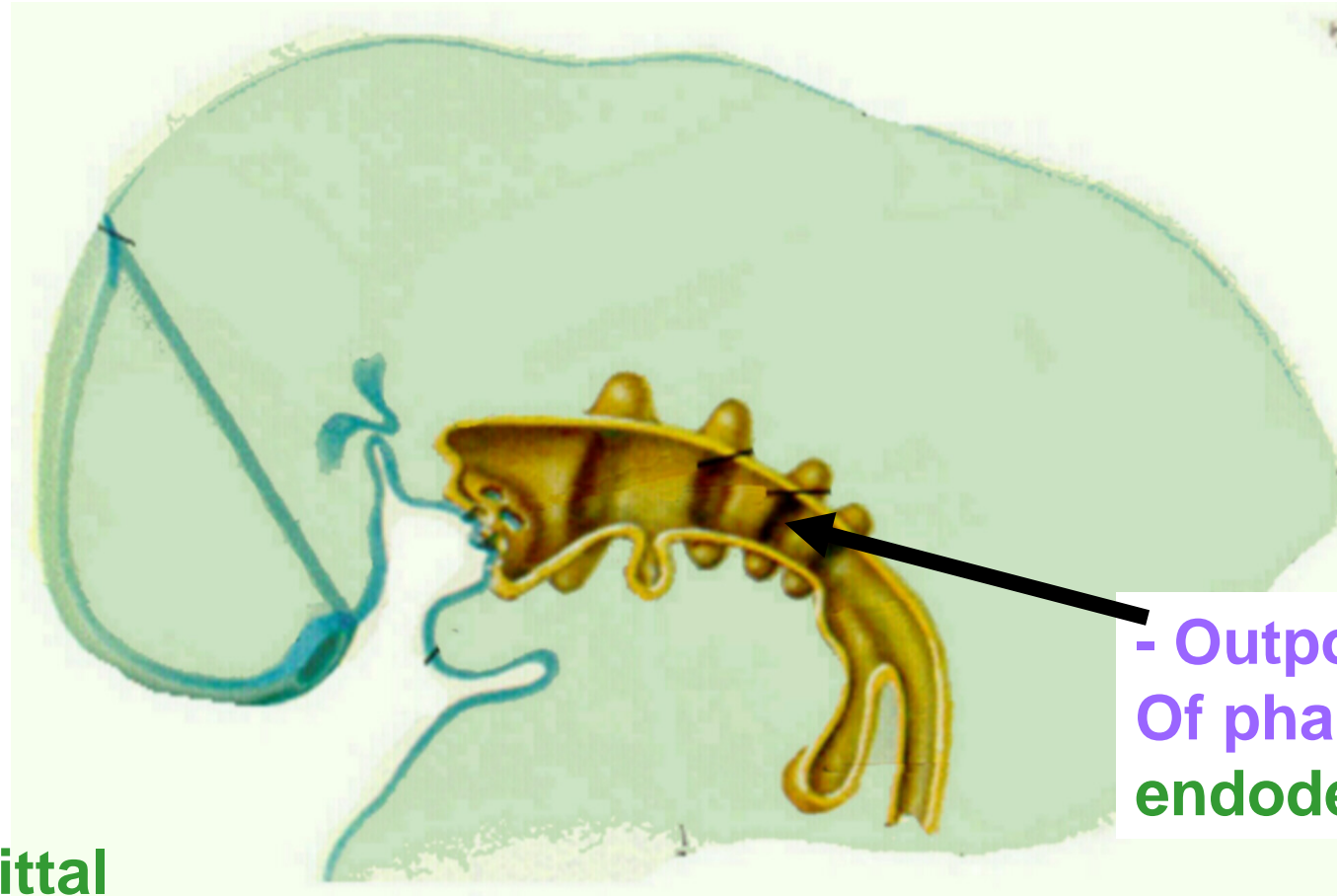
Note: Cysts and fistuli - in lateral neck are **anterior to Sternocleidomastoid muscle**

CLEFT	FORMS
First	External Auditory Meatus

MEMBRANE	FORMS
First	Tympanic membrane

NOTE: CLEFT = GROOVE

IV. BRANCHIAL POUCHES

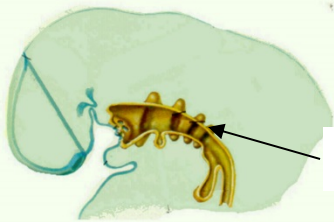


- Outpocketings
Of pharynx
endoderm

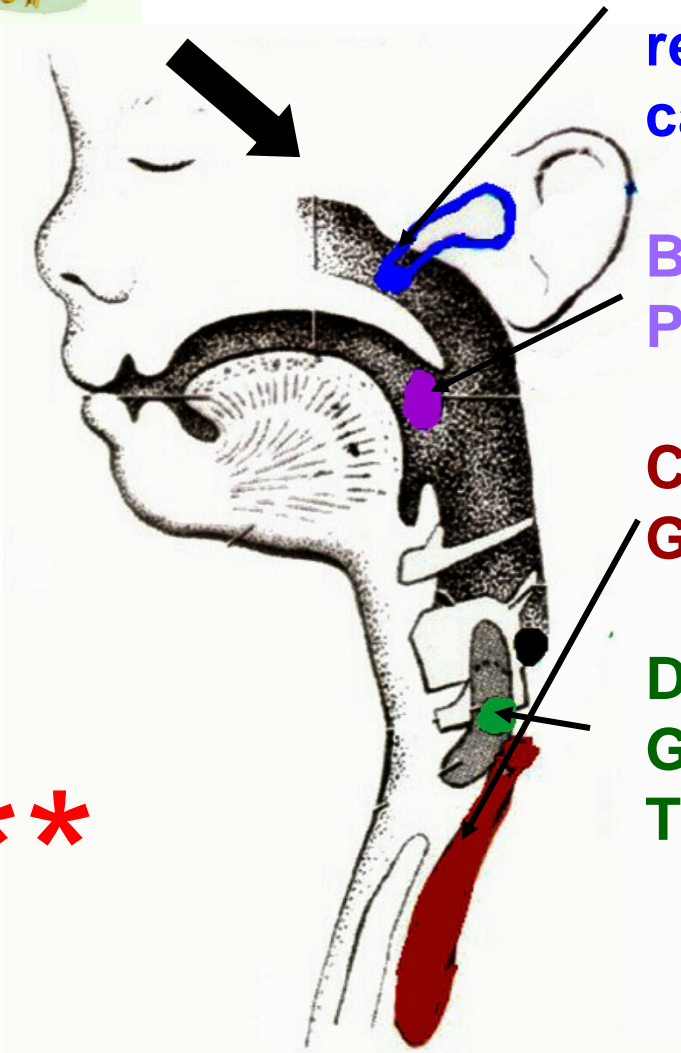
Sagittal
View – embryo
6-7 weeks

View
Inside Pharynx
Endoderm

BRANCHIAL POUCH DERIVATIVES



Branchial Pouch



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

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

C. Pouch 3- Inferior Parathyroid Glands and Thymus Gland

D. Pouch 4 - Superior Parathyroid Glands and C-Cells (Calcitonin) of Thyroid

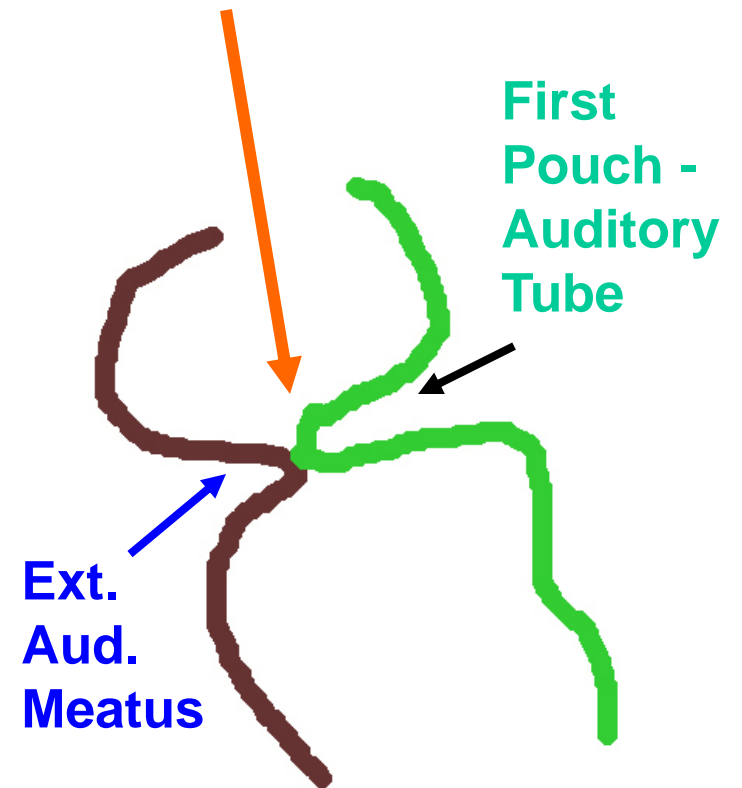
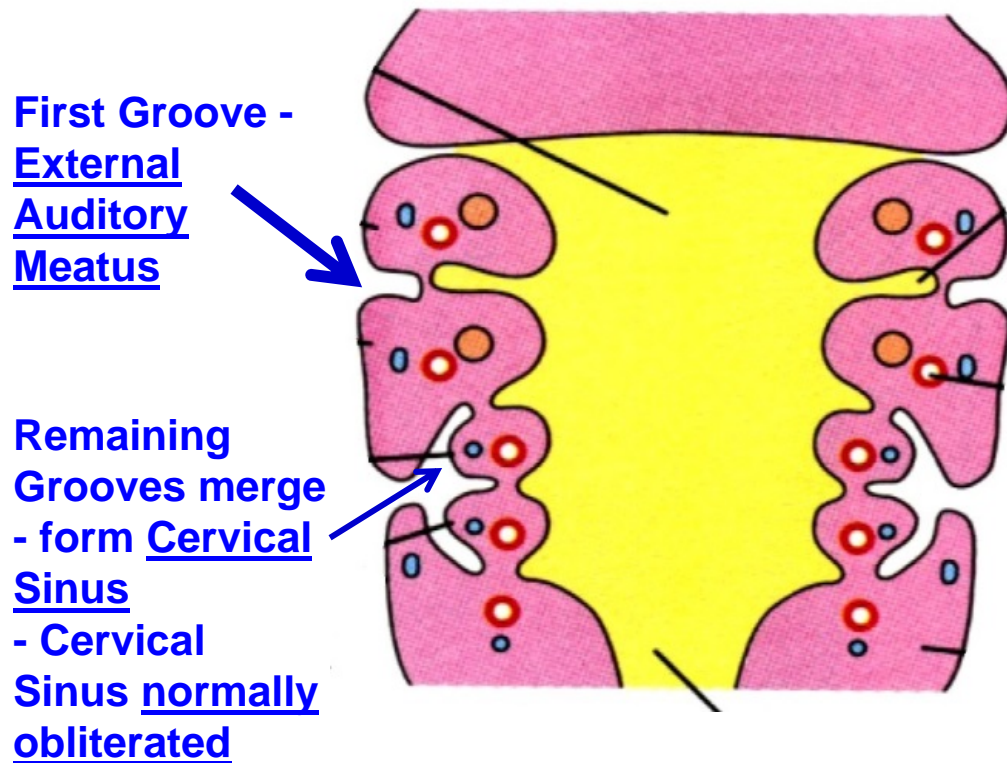
Note: Pouch 3 derivatives migrate caudal to pouch 4

III. BRANCHIAL GROOVES (CLEFTS) AND MEMBRANES

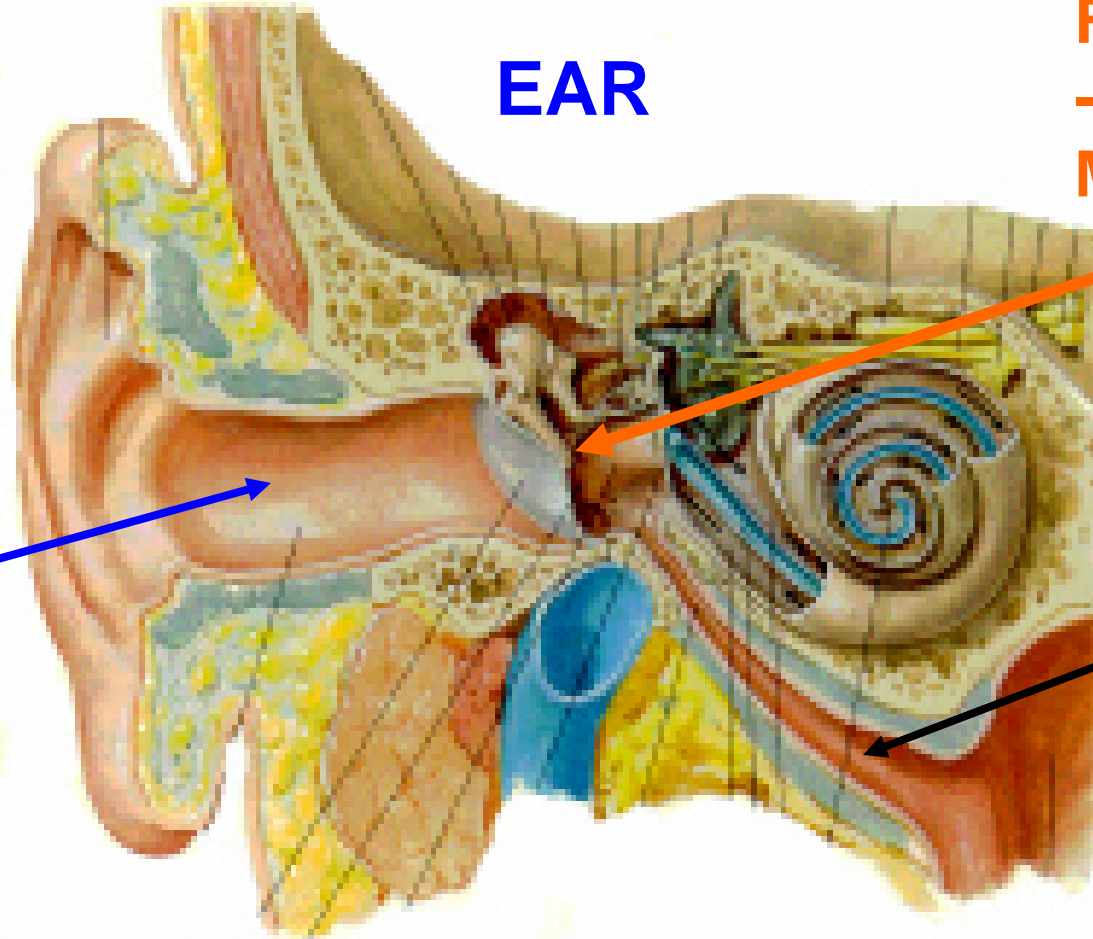
Only First Branchial Groove and Membrane Normally form Structures in Adult

First Groove - External Auditory Meatus

First Membrane = Tympanic Membrane



EAR



FIRST GROOVE -
Ext. Aud.
Meatus

First Membrane
- Tympanic
Membrane

FIRST POUCH -
Auditory
Tube,
Tympanic
Cavity

Outer Ear

- 1) funnel shaped
- 2) directs sounds to tympanic membrane
- 3) binaural hearing

Middle Ear

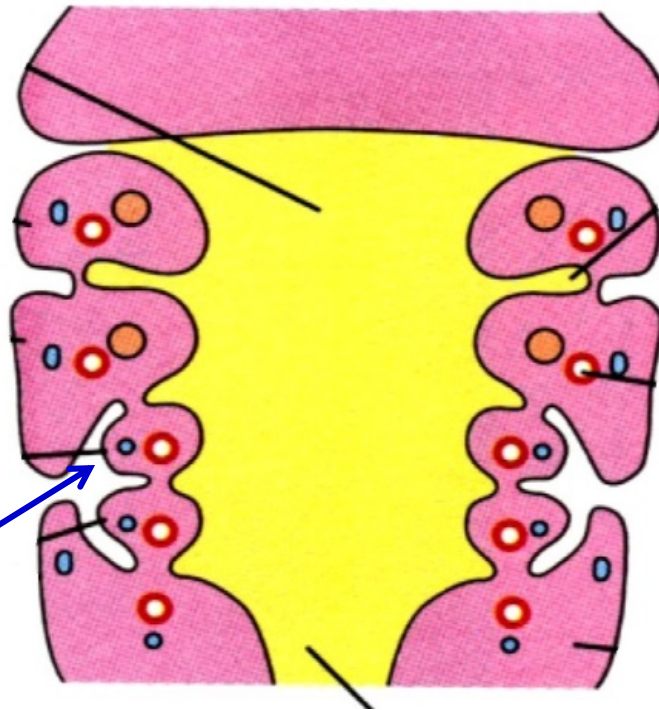
- 1) bones link tympanic membrane to cochlea
amplify pressure
- 2) muscles can dampen loud sounds

Inner Ear

- 1) cochlea-
hearing
vestibular
apparatus-
gravity

BRANCHIAL GROOVES

Other Grooves develop in longer depression
Cervical Sinus



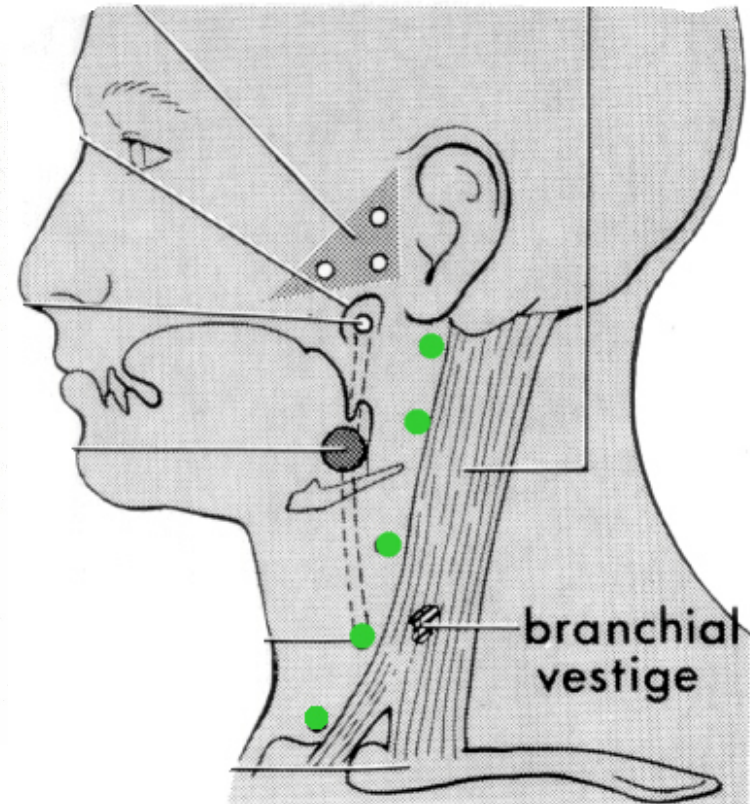
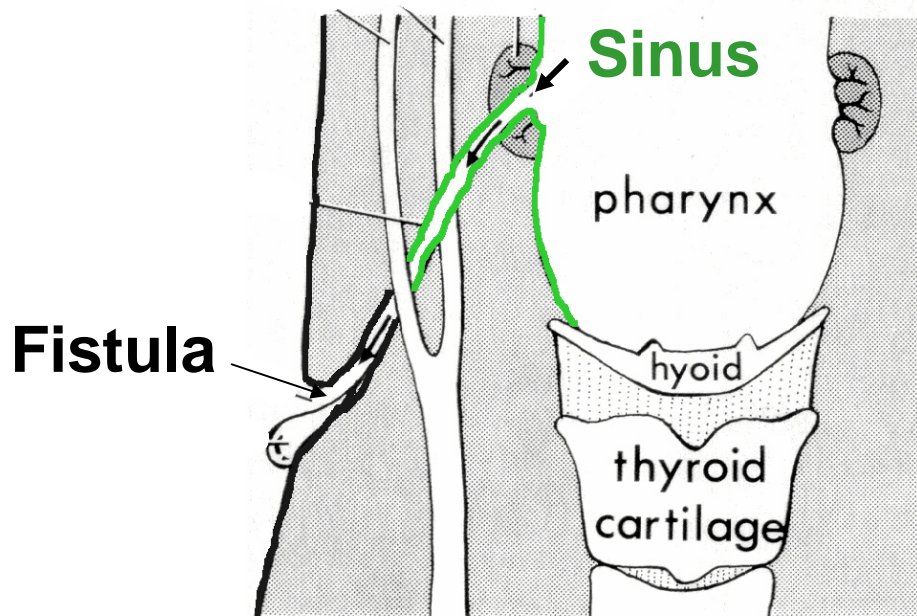
Remaining
Grooves merge
- form Cervical
Sinus
- Cervical
Sinus normally
obliterated

Note:
Cervical
sinus
normally
obliterated
but
can persist

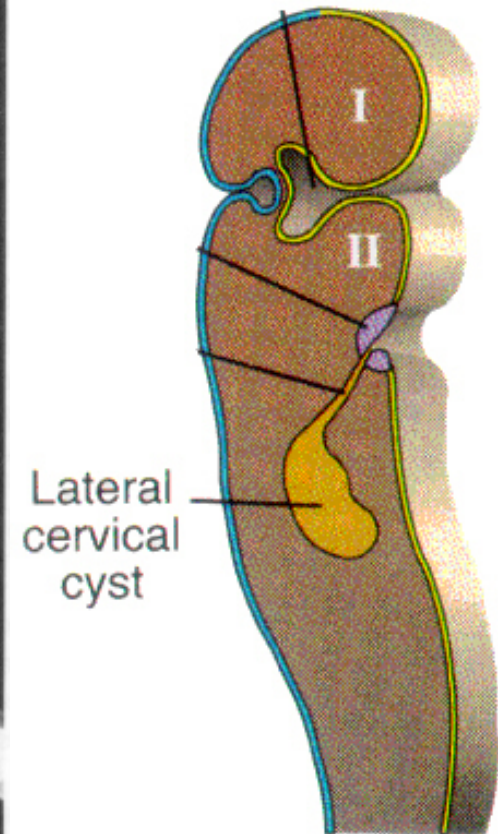
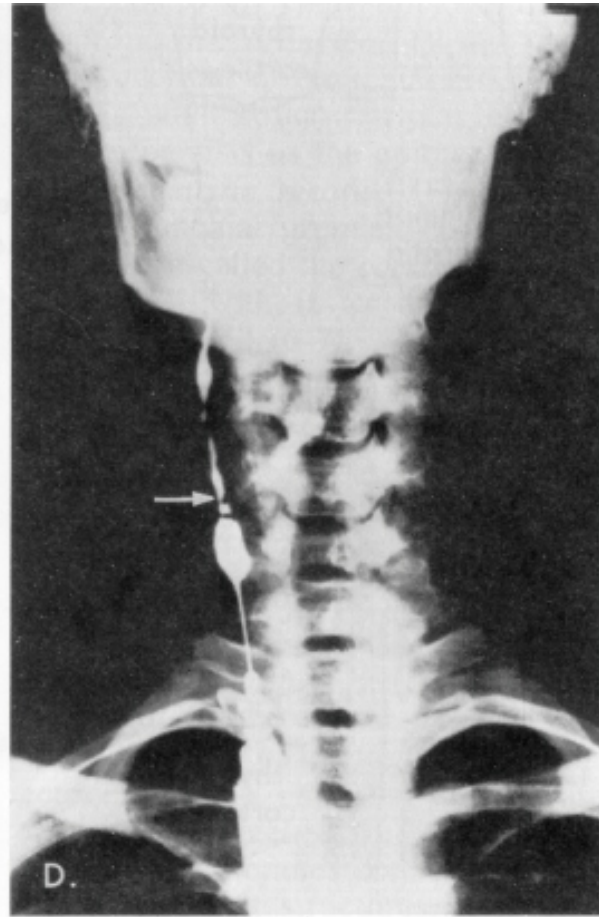
BRANCHIAL ANOMALIES

Branchial Sinus = Blind pouch from Pharynx

Branchial Fistula = Channel, often connecting Pharynx to skin of neck; usually passes Anterior to Sternocleidomastoid, between Int. and Ext. Carotid A.



BRANCHIAL ANOMALIES



Branchial Fistula - drains to neck

**Branchial Cyst
often remnant
of Cervical Sinus**

BRANCHIAL POUCHES, GROOVES, MEMBRANES

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Note: Cysts and fistuli - in lateral neck are **anterior to Sternocleidomastoid muscle**

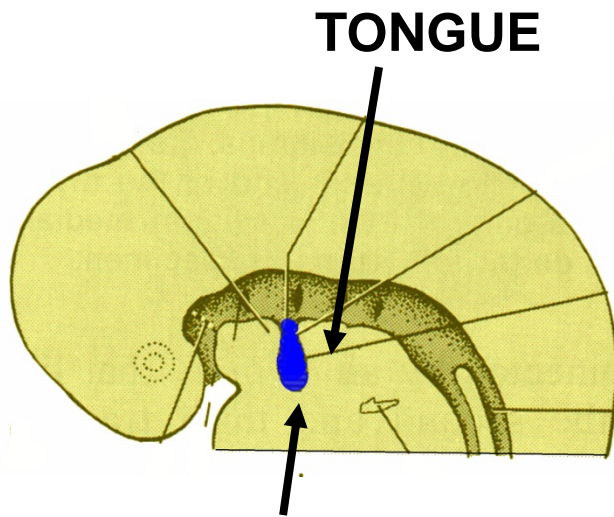
CLEFT	FORMS
First	External Auditory Meatus

MEMBRANE	FORMS
First	Tympanic membrane

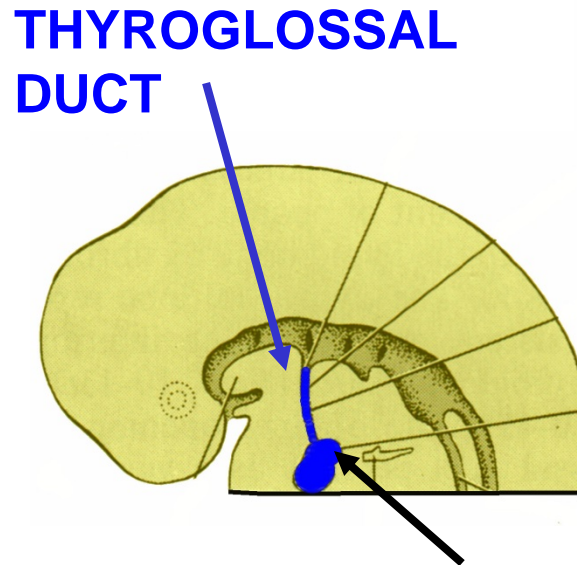
KNOW THESE CHARTS QUESTIONS ON EXAM, BOARDS

NOTE: CLEFT = GROOVE

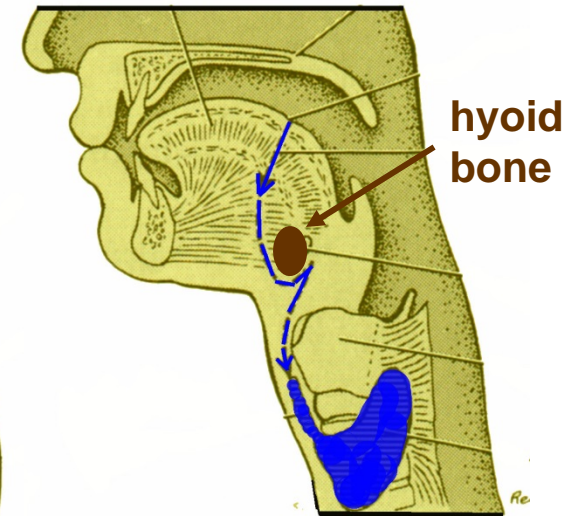
V. DEVELOPMENT OF THYROID



1) Thyroid start as Median endodermal Thickening on floor of pharynx at future junction of anterior 2/3 and posterior 1/3 of tongue (marked by Foramen Cecum)

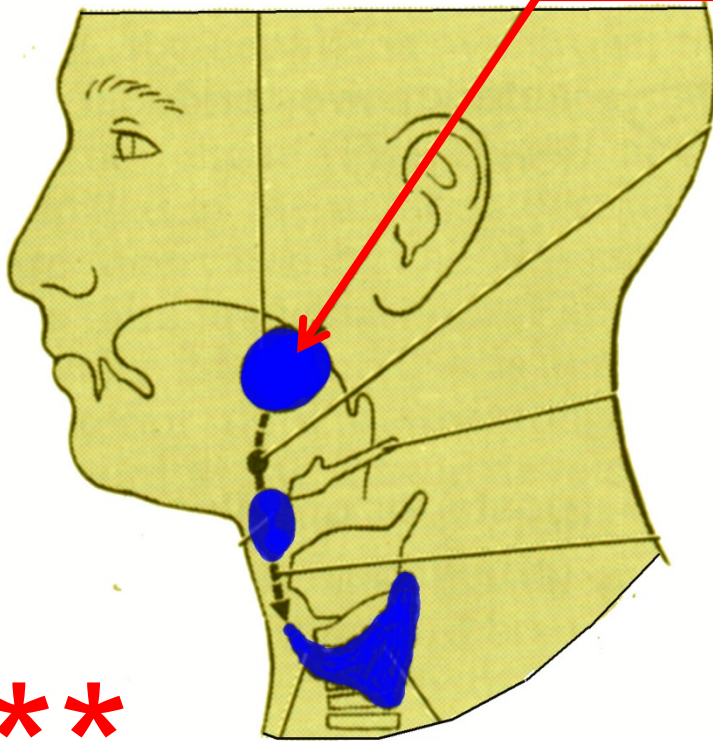


2) Elongates to form Thyroid Diverticulum; descends ant. to hyoid bone and larynx
3) Thyroglossal duct connects Diverticulum to Foramen cecum



CONGENITAL MALFORMATIONS

LINGUAL THYROID* - gland in tongue



Thyroglossal Duct Remnants - can form thyroid tissue (cysts) along path (midline, ant. to hyoid, larynx)



C. PYRAMIDAL LOBE. ABSENCE OF ISTHMUS

Pyramidal Lobe - 50% of people; attached to hyoid by fibrous strand; no clinical problems

LINGUAL THYROID* - Thyroid gland in tongue



AT: Junction of anterior 2/3 and posterior 1/3 of tongue