

VIDEO: BRANCHIAL ARCHES

FORM GILLS
IN FISH



~4 weeks → **~11 weeks**

OUTLINE

I. EARLY DEVELOPMENT/
TERMINOLOGY

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

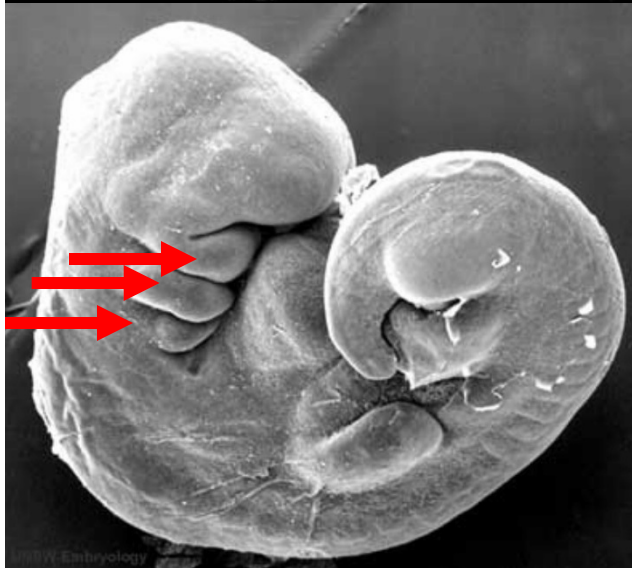
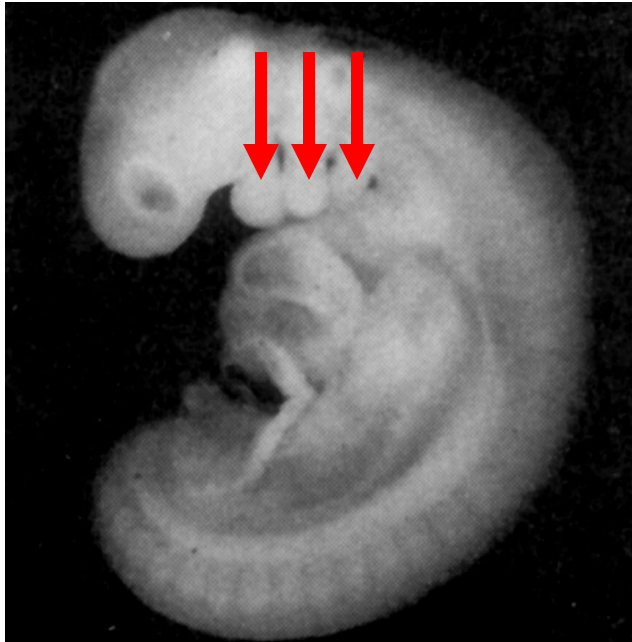
III. BRANCHIAL POUCHES,
GROOVES, MEMBRANES

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**

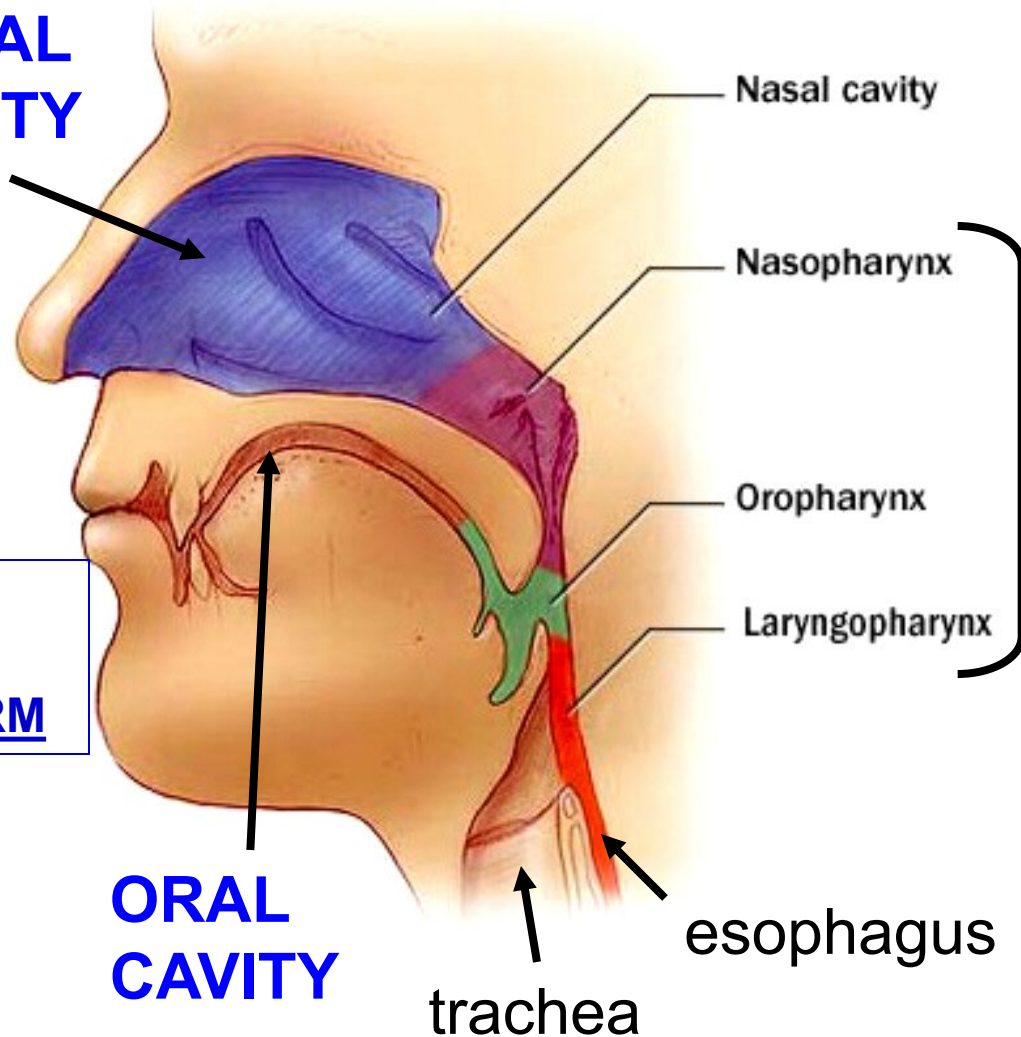
- Ontogeny resembles Phylogeny

- Reorganize to produce Adult structures

Note Terminology :
Branchial Arch =
Pharyngeal Arch

WHERE/WHAT IS THE PHARYNX?

**NASAL
CAVITY**



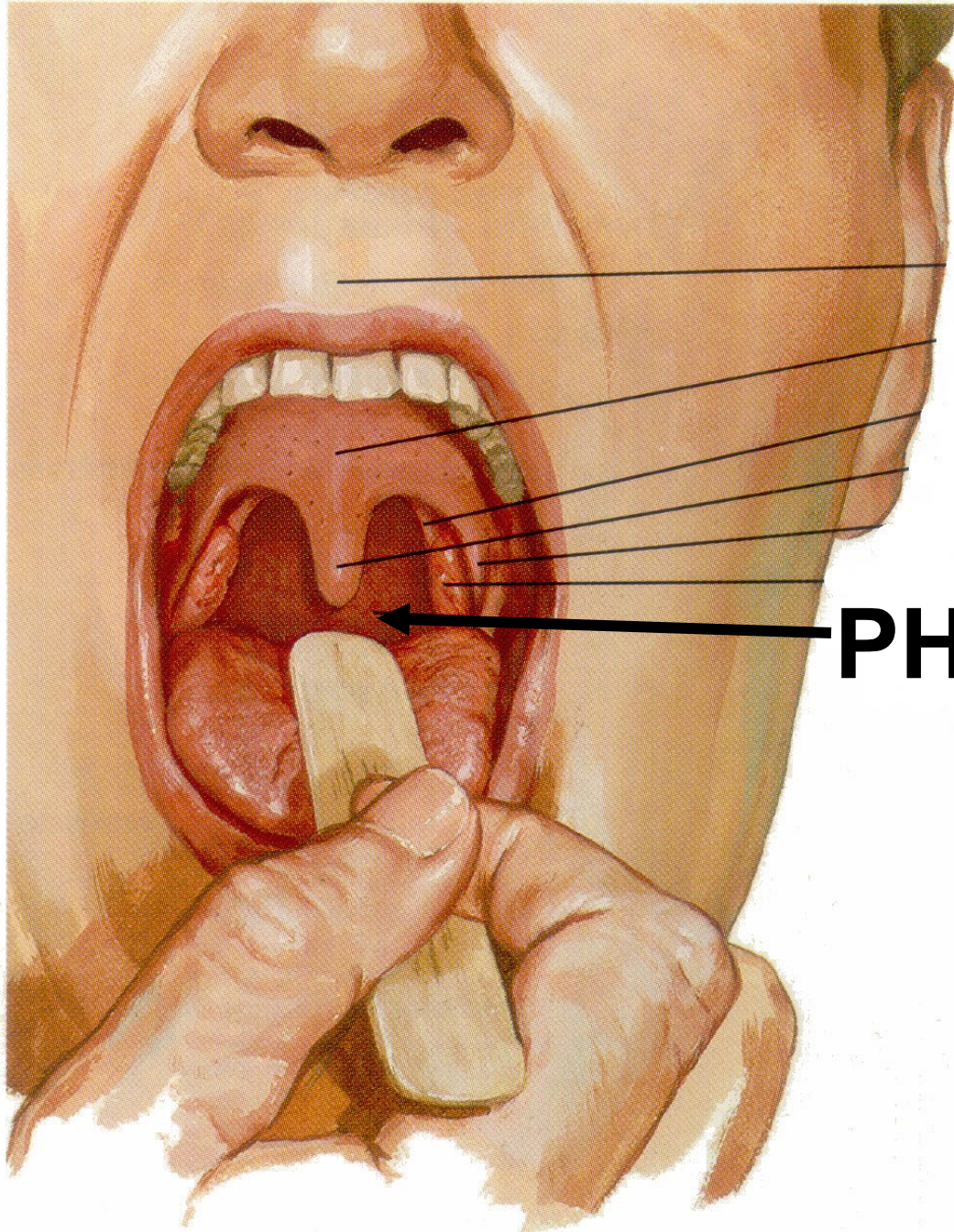
**DERIVED
FROM
ENDODERM**

PHARYNX -
region behind
Oral and Nasal
Cavities

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

**DERIVED
FROM
ECTODERM**

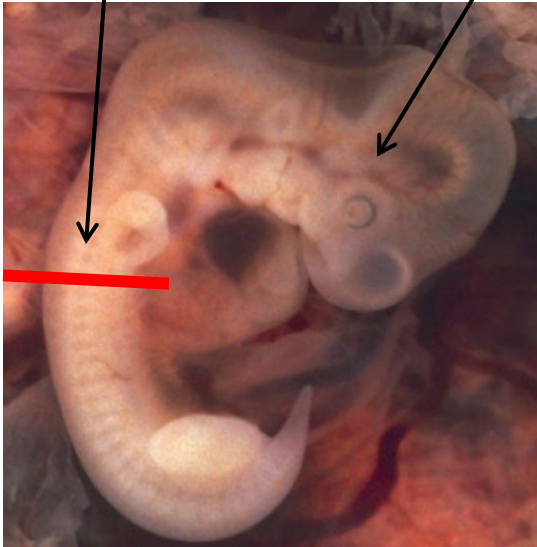
**SAY
AAHH!**



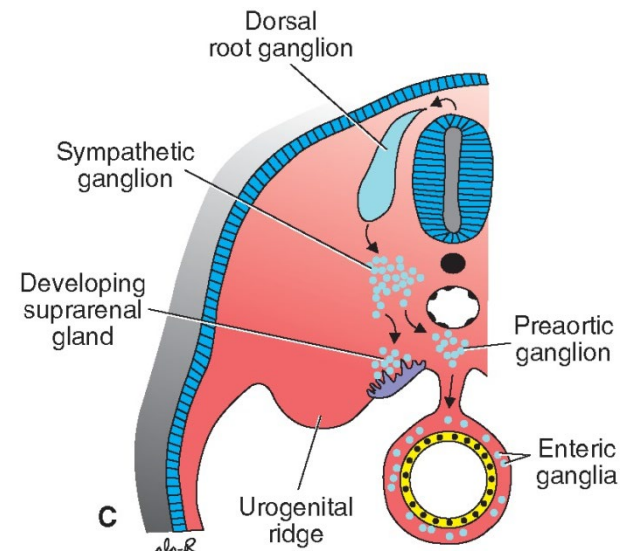
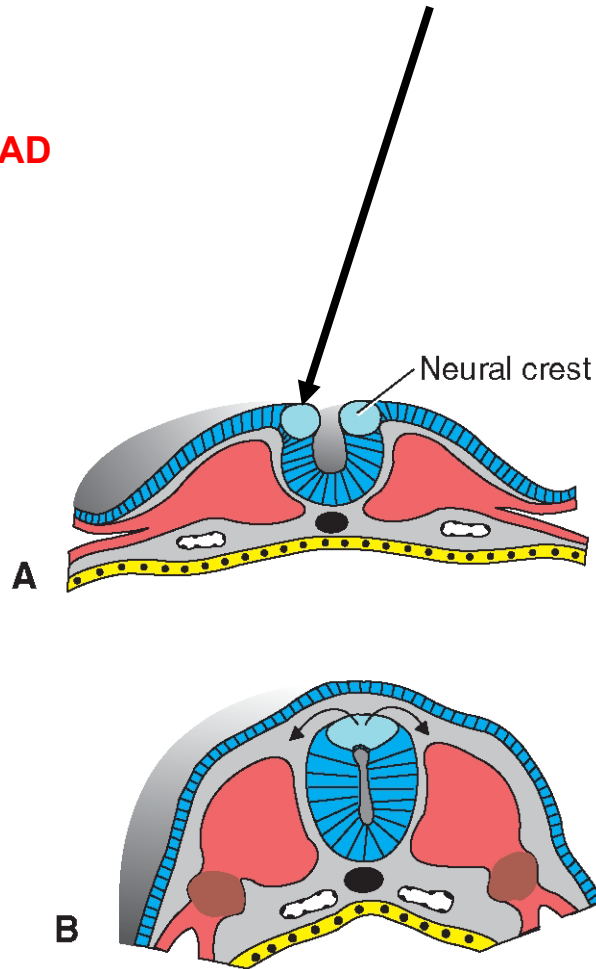
PHARYNX

DEVELOPMENT - Week 4 - Neural Crest Cells Migrate

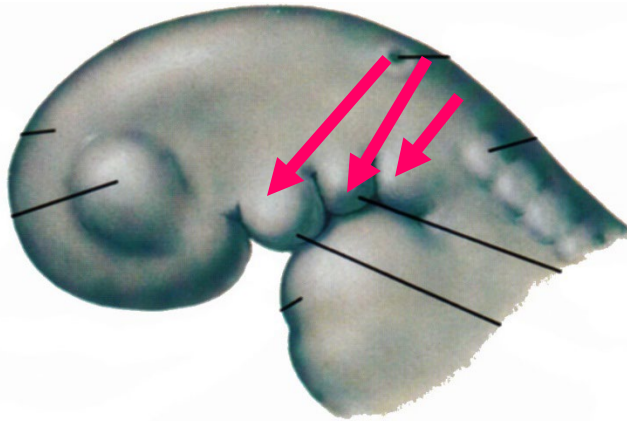
PLANE OF SECTIONS HEAD



Human Embryo
3-4 weeks (length
0.6 inches (15 mm))

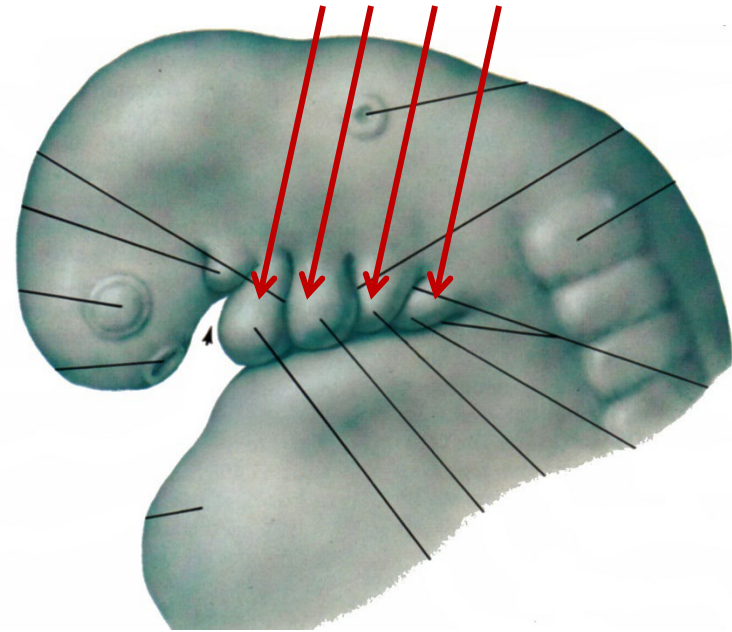


HEAD END ENLARGES



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

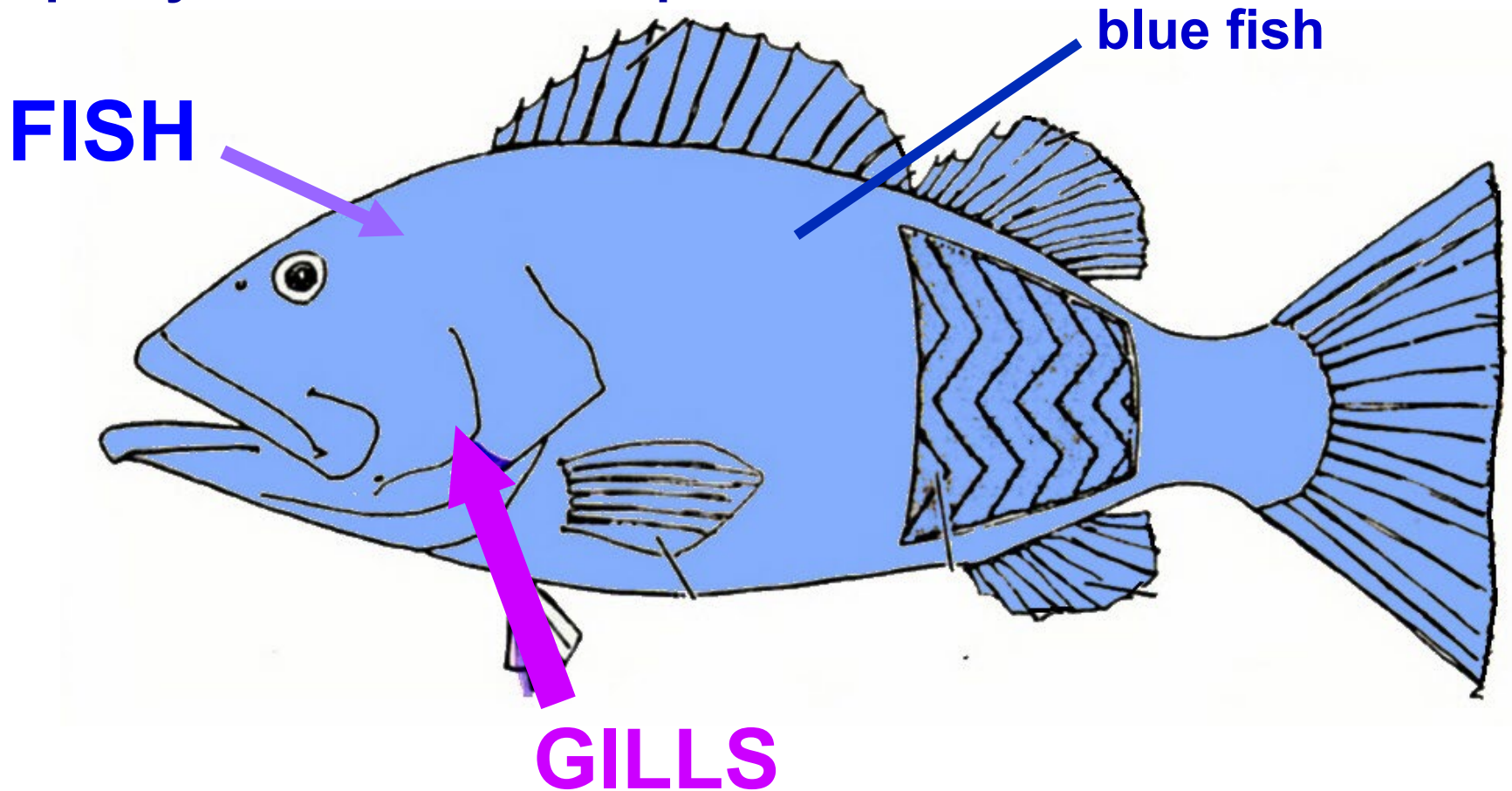
Form Ridges = Branchial Arches



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

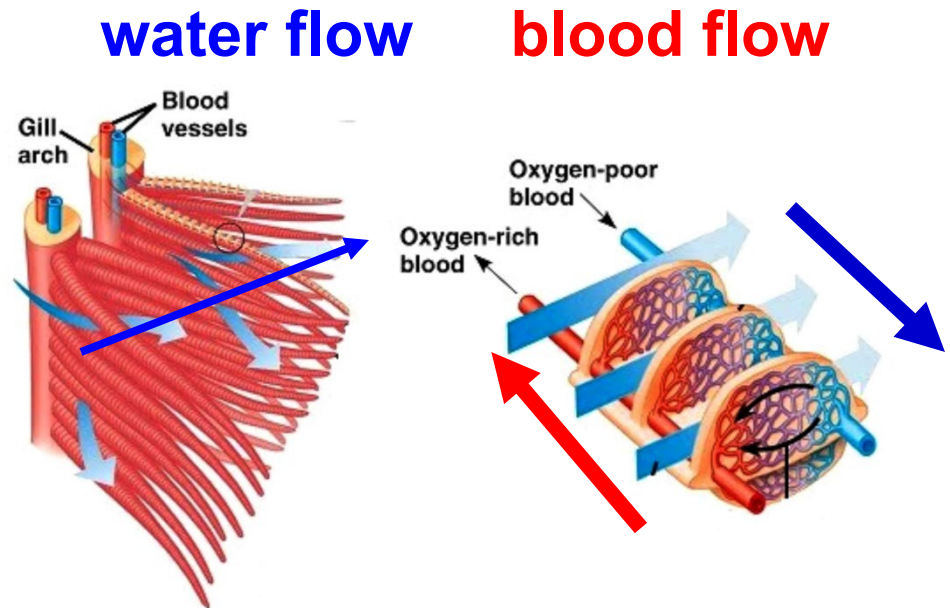


GILLS HAVE ARTERIES, MUSCLES AND NERVES

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)

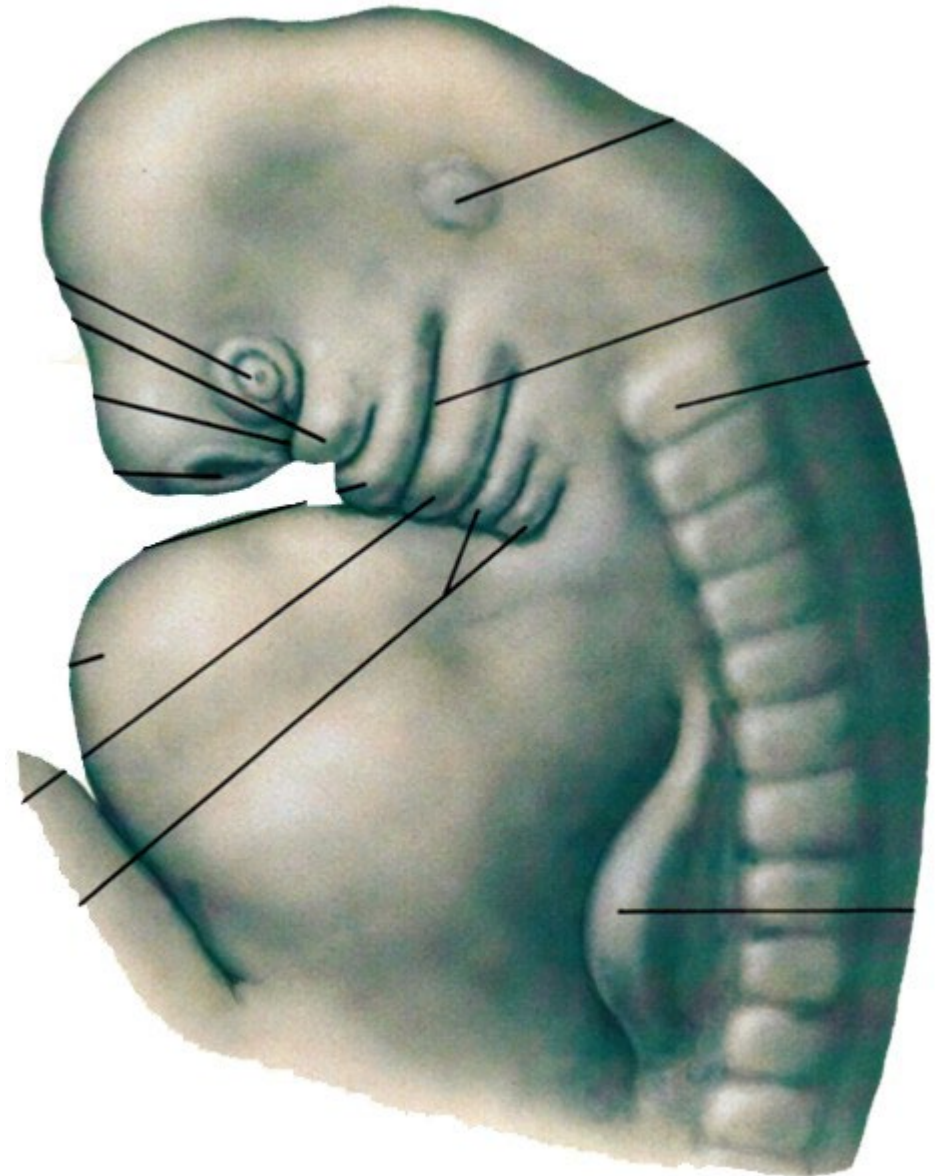


Large surface area - Mackerel (swim a lot) - surface of gills 10 times surface area of body

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



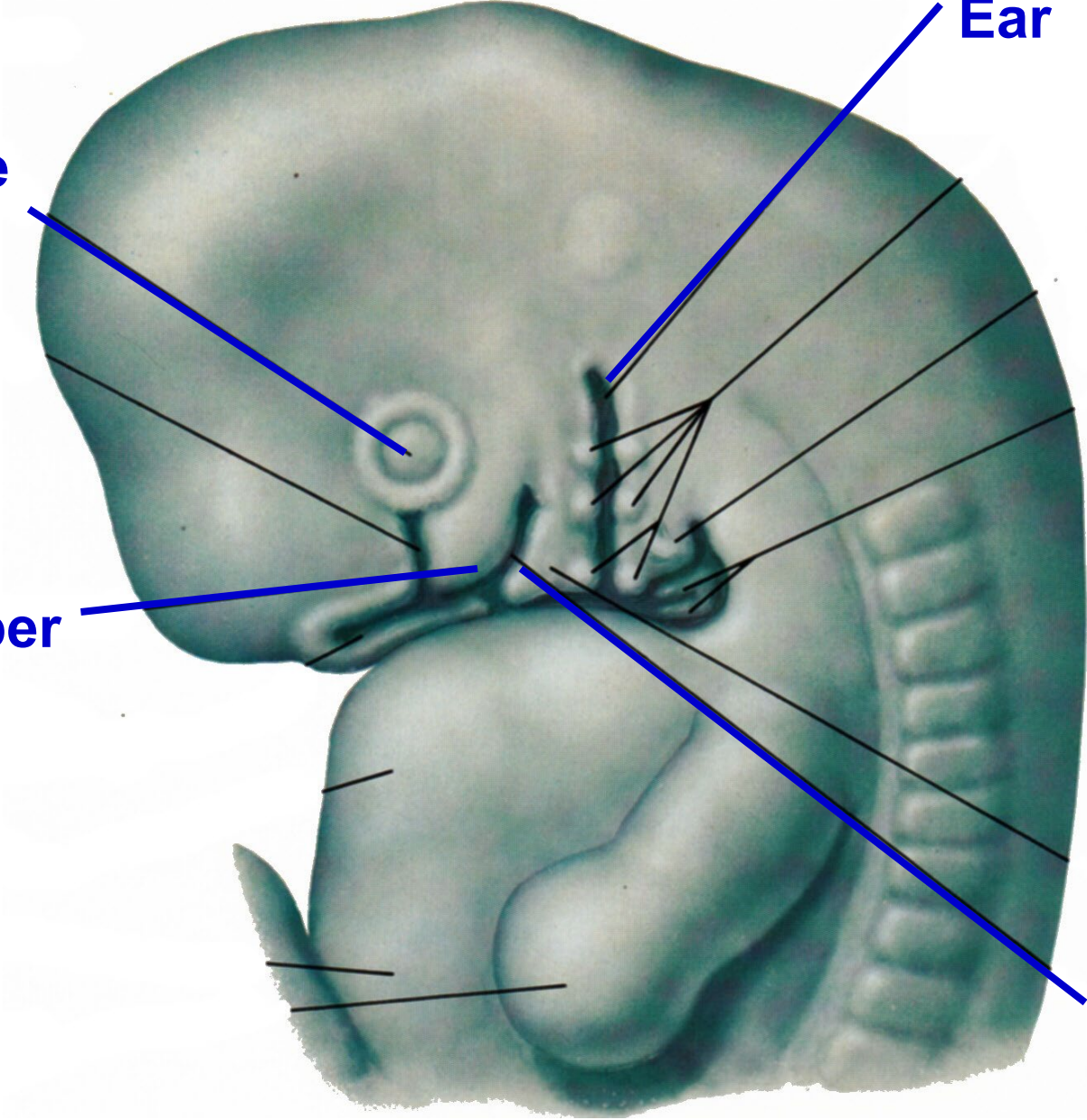
6-7 weeks

Eye

Developing Ear

Upper Lip

Mouth



8-10 weeks



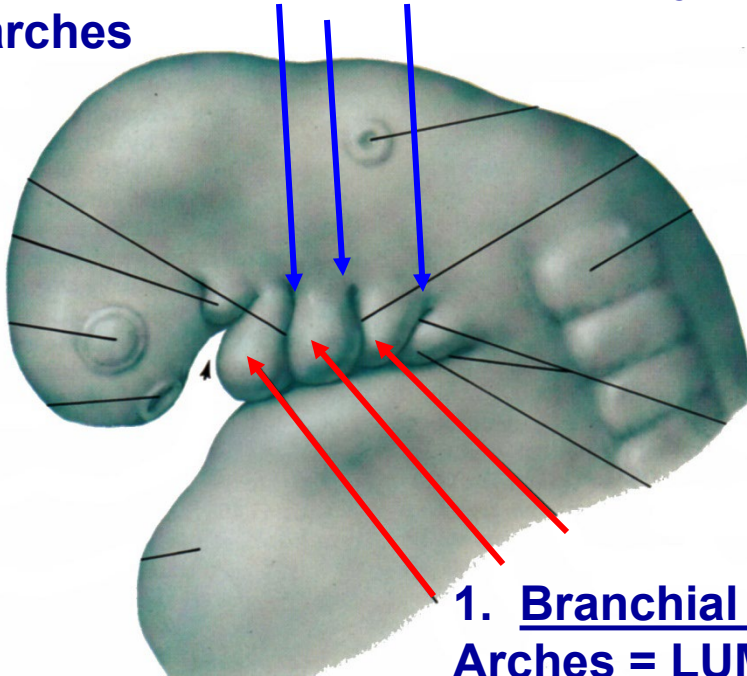
Congenital Malformations of Head and Neck Result from incorrect Transformation of Branchial Apparatus to Adult Structures

TERMINOLOGY: ARCHES, GROOVES, POUCHES, MEMBRANES

VIEW OF EXTERIOR OF EMBRYO

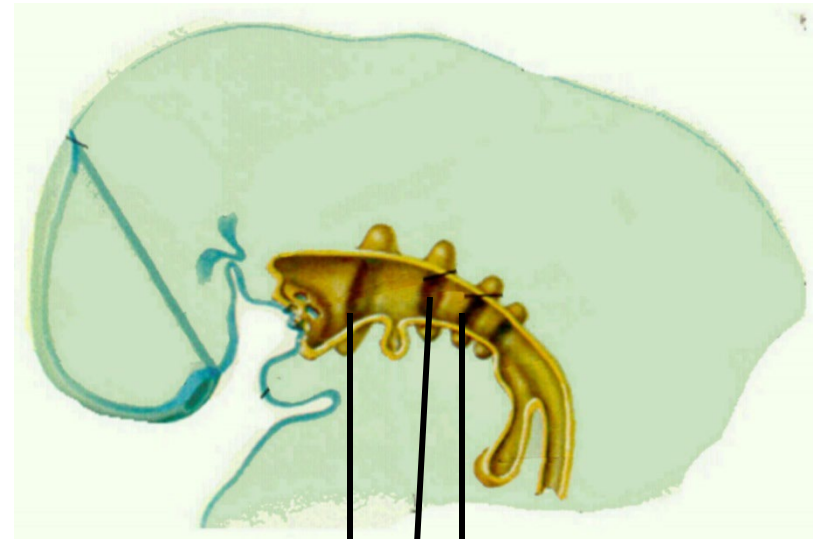
2. Branchial Grooves (Clefts)

- ectodermal clefts between adjacent arches



1. Branchial Arches = LUMPS

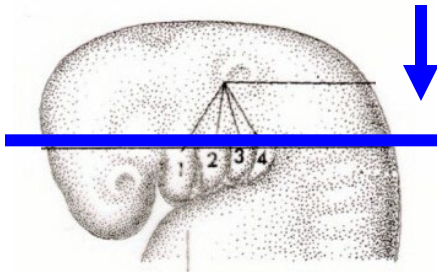
VIEW OF EMBRYO BISECTED IN SAGITTAL PLANE



3. Branchial Pouch

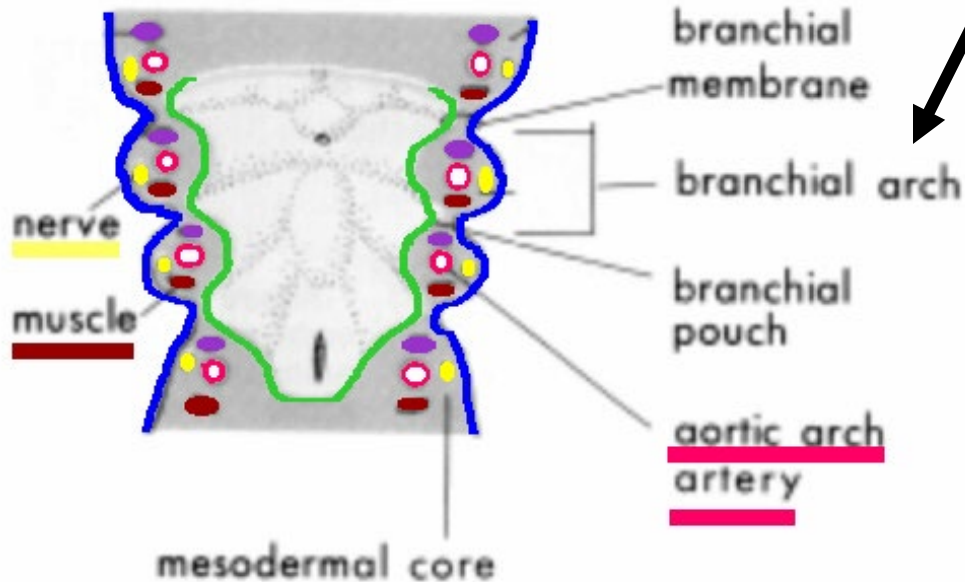
- endodermal out pocketing from rostral foregut
- between adjacent arches

B. BRANCHIAL APPARATUS - 4 elements



ORIENT: LOOKING DOWN

PLANE OF CUT

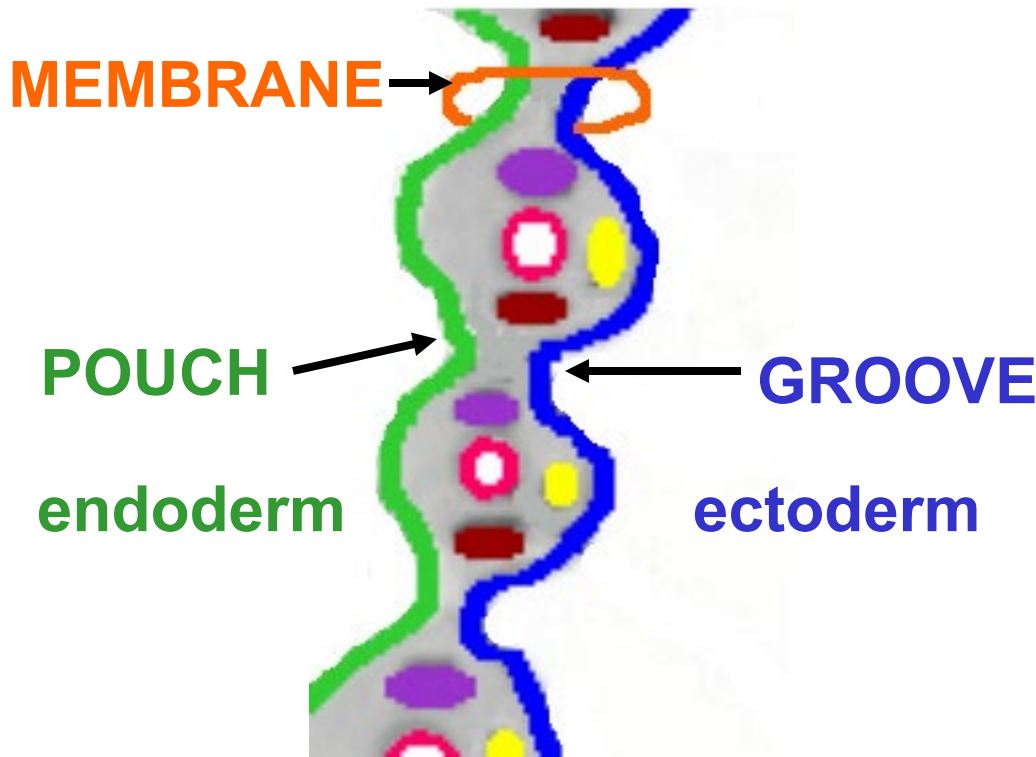
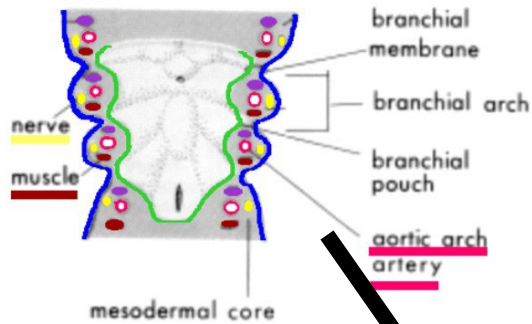


1. Branchial Arch
covered by:
Ectoderm - externally
Endoderm - lined internally
(Mesenchyme - core)

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



2. Branchial Groove (Pharyngeal Cleft)

- ectodermal cleft
between adjacent
arches

3. Branchial Pouch - endodermal

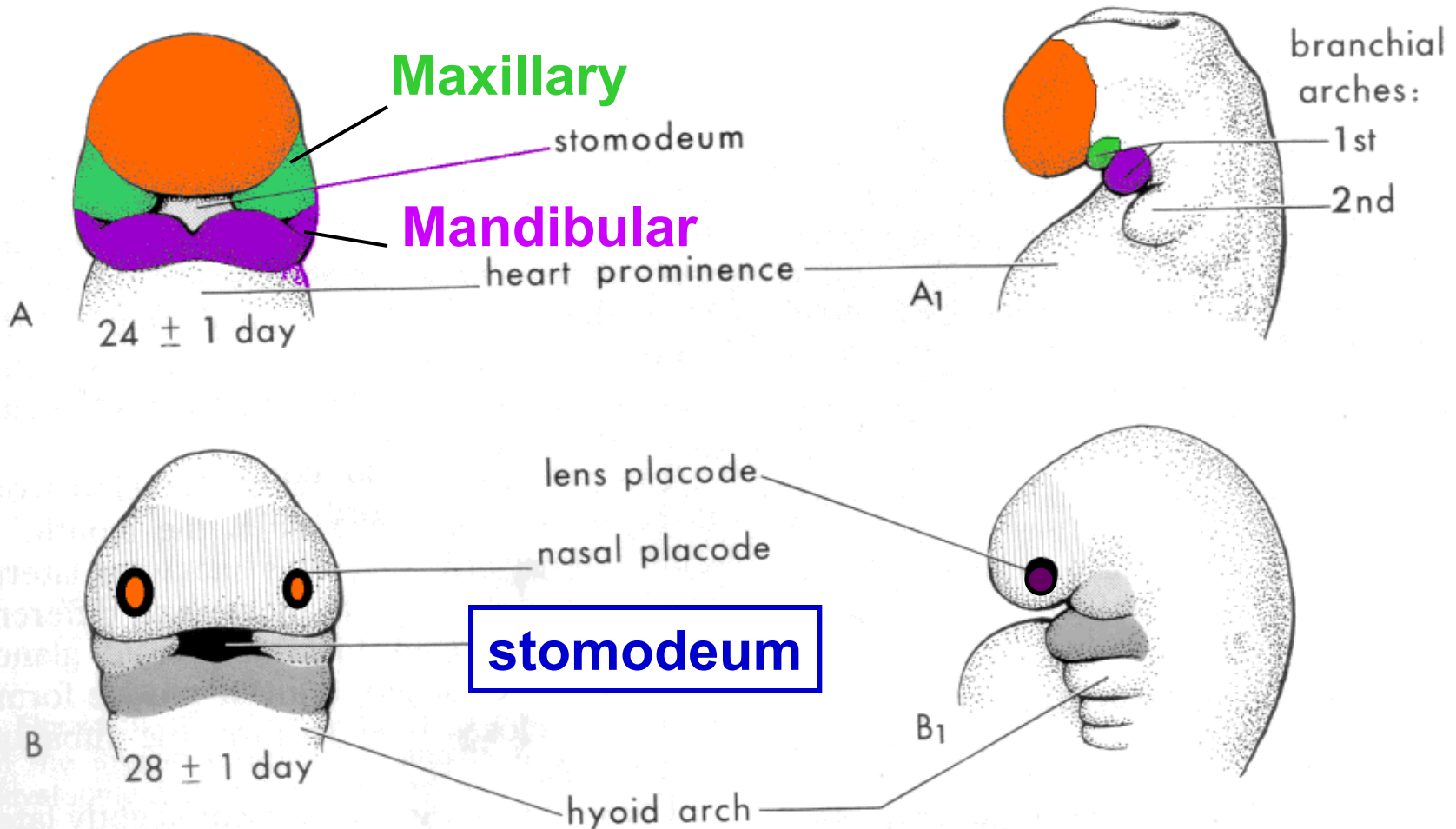
outpocketing from
rostral foregut
-between adjacent
arches

4. Branchial Membrane

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

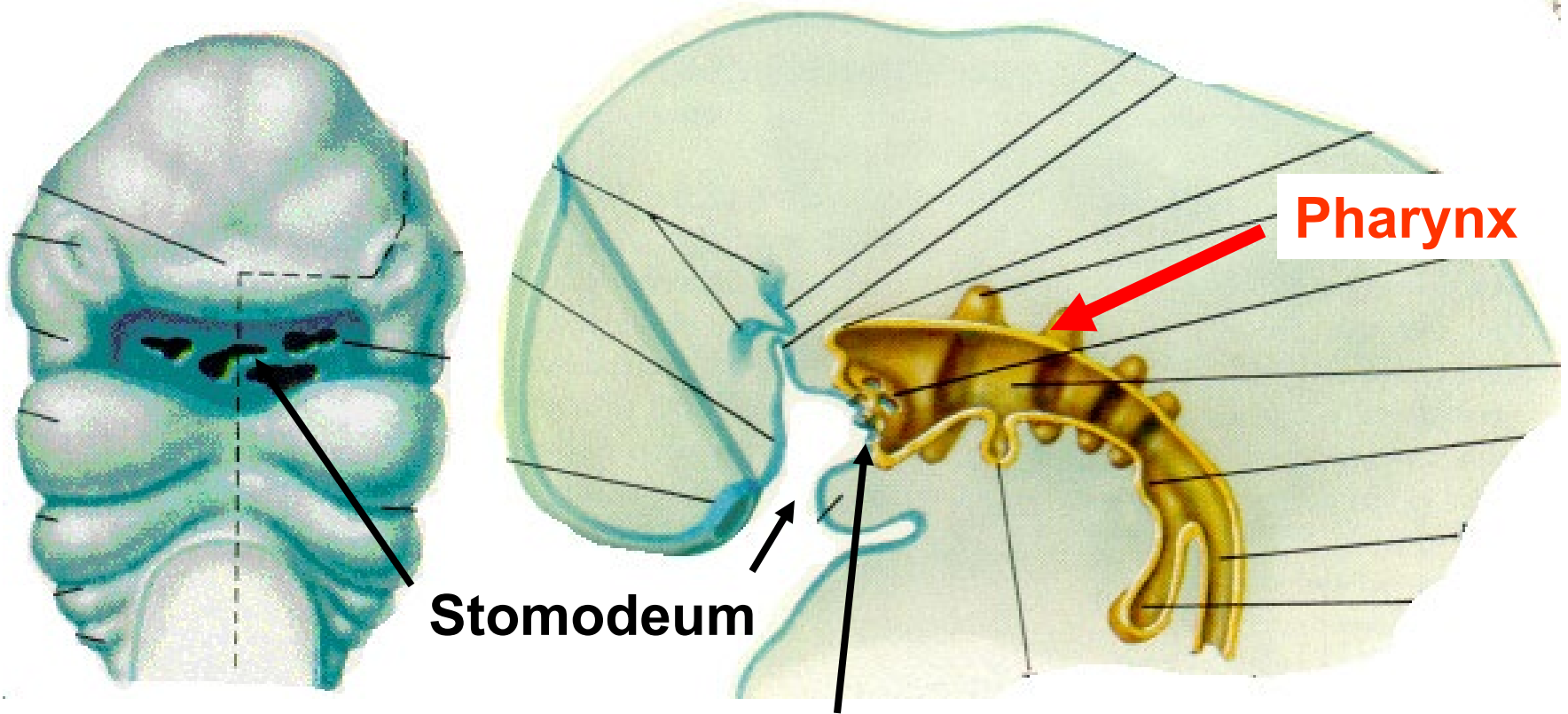
First Arch - forms face, has maxillary and mandibular processes

- surrounds stomodeum (primitive mouth)

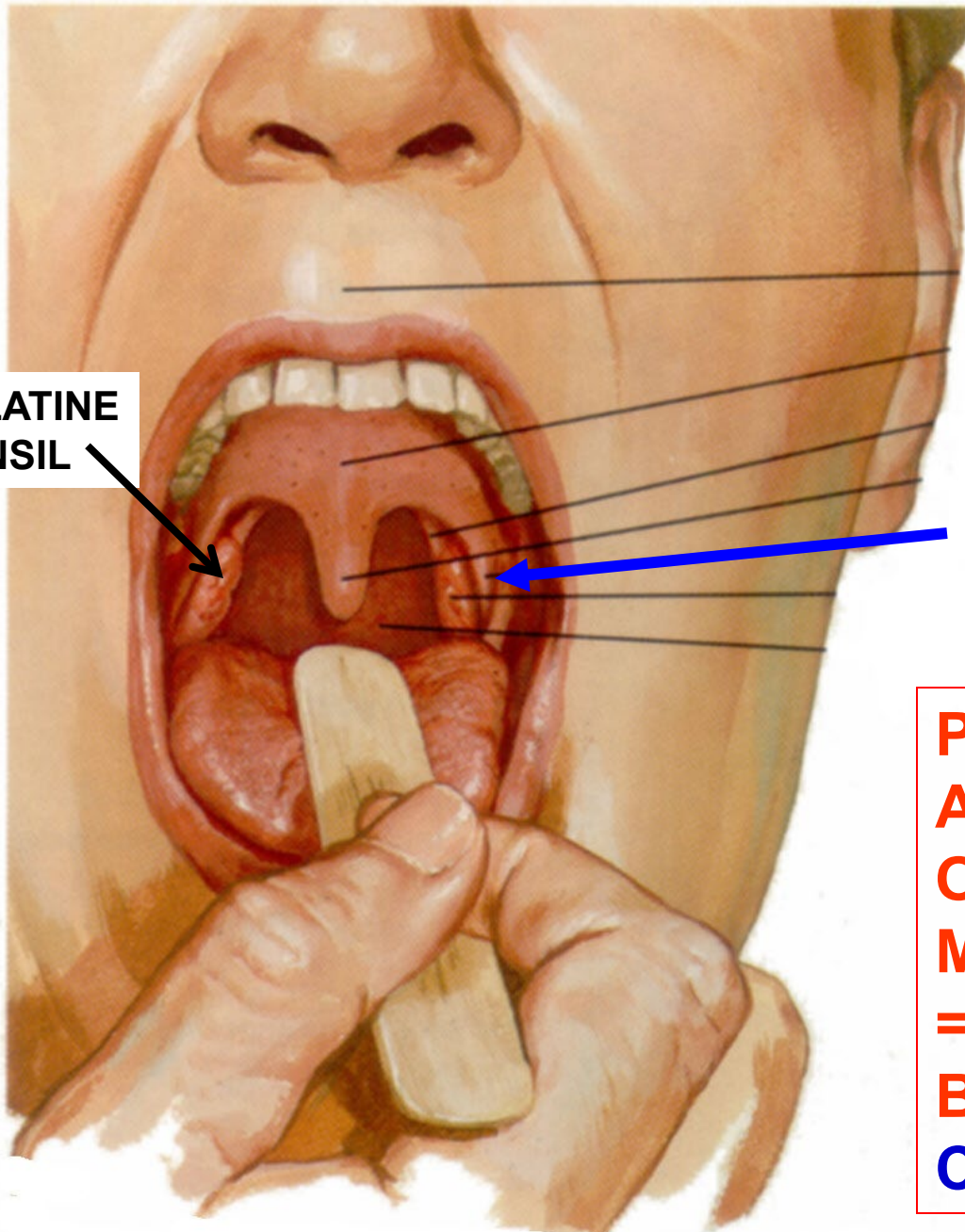


NOTE: LENS PLACODE IS CORRECT

- 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!**

**PALATINE
TONSIL**

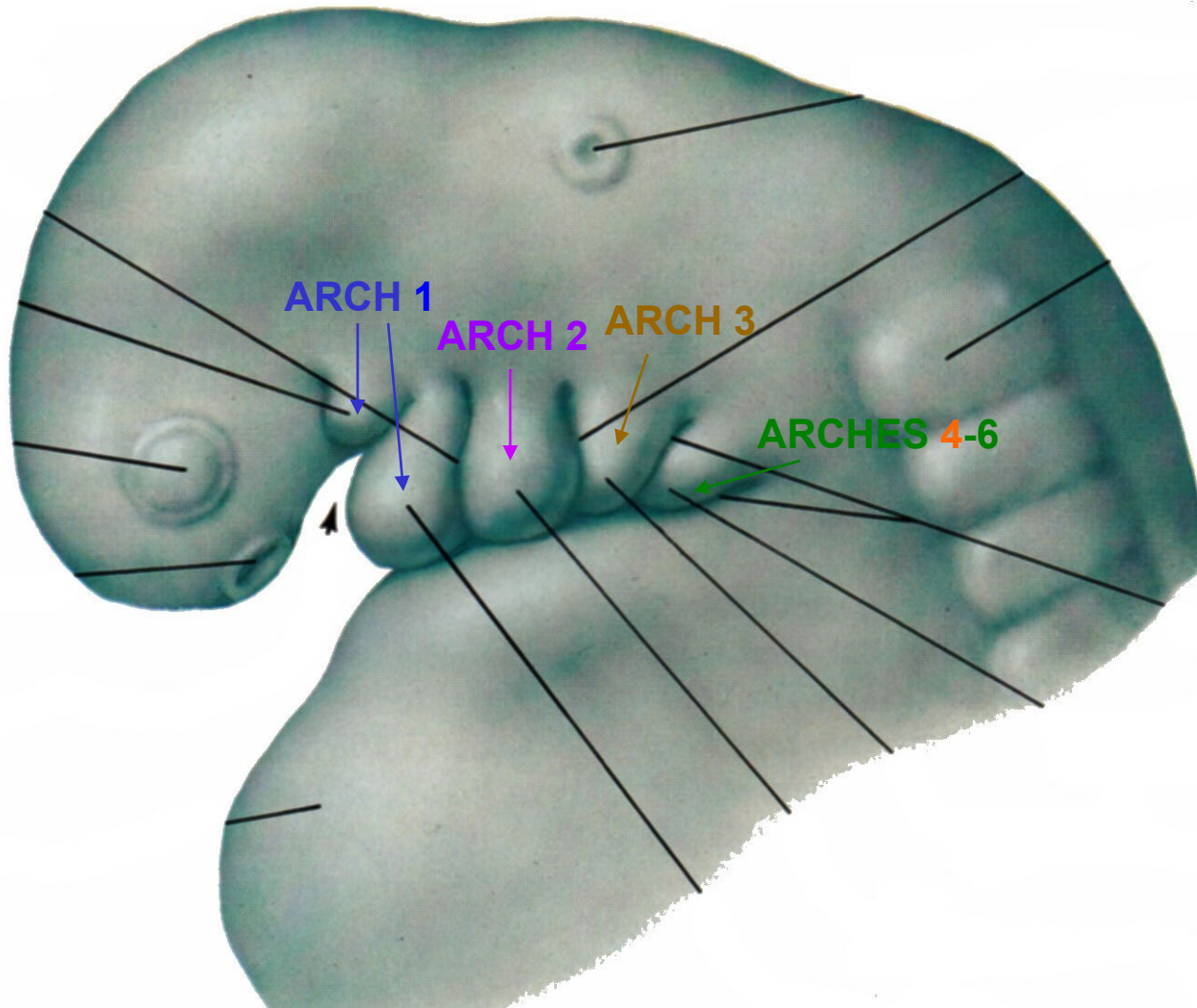
**PALATOGLOSSAL
ARCH - FOLD ANTERIOR
TO (IN FRONT OF) PALATINE
TONSIL****

**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:

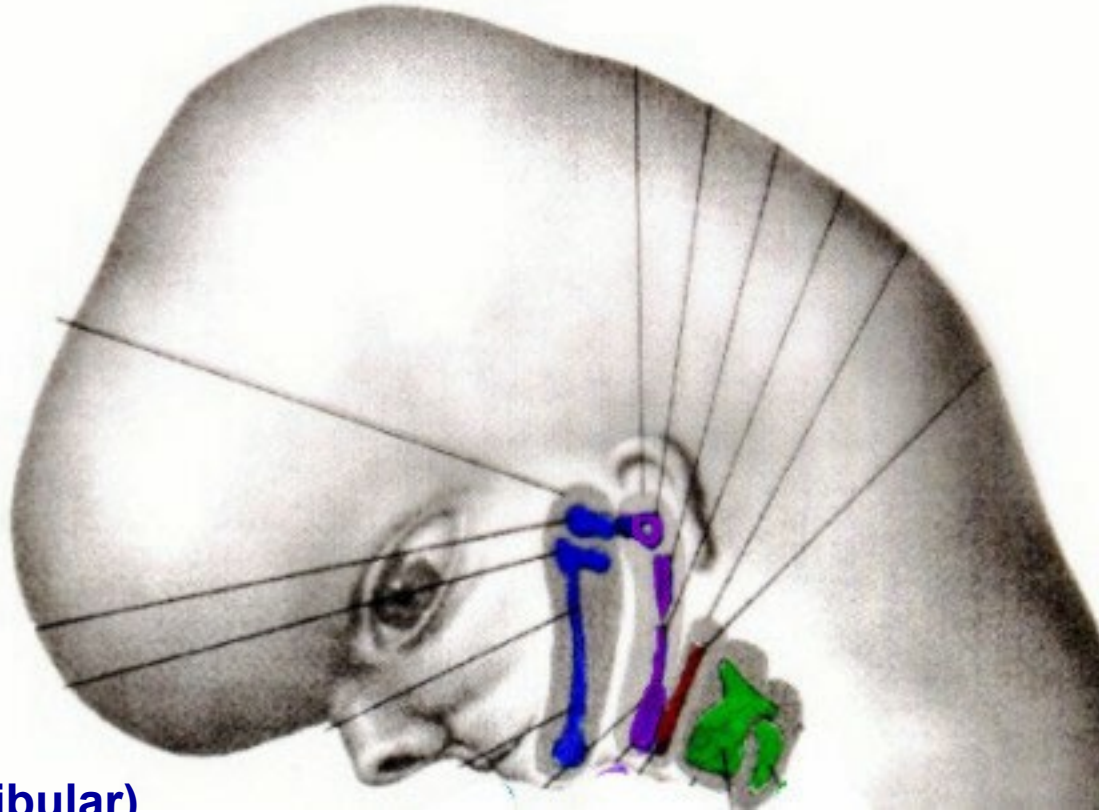
All authors agree on:

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 -

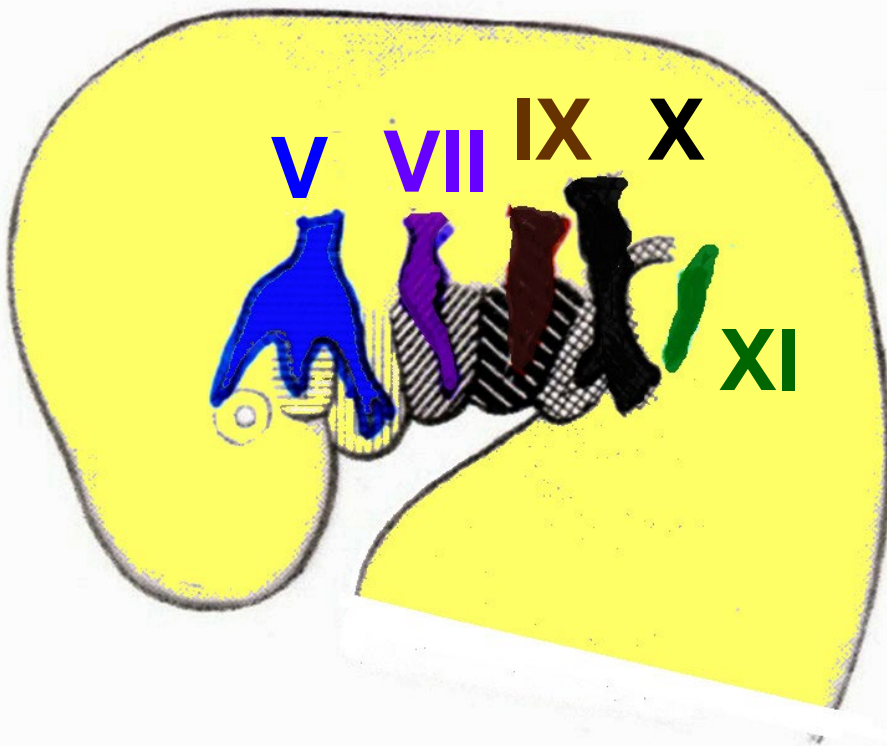
- Lower $\frac{1}{2}$
Body, Greater
Horn Of hyoid

IV Fourth (Sixth) Arch -

- Cartilages
Of larynx

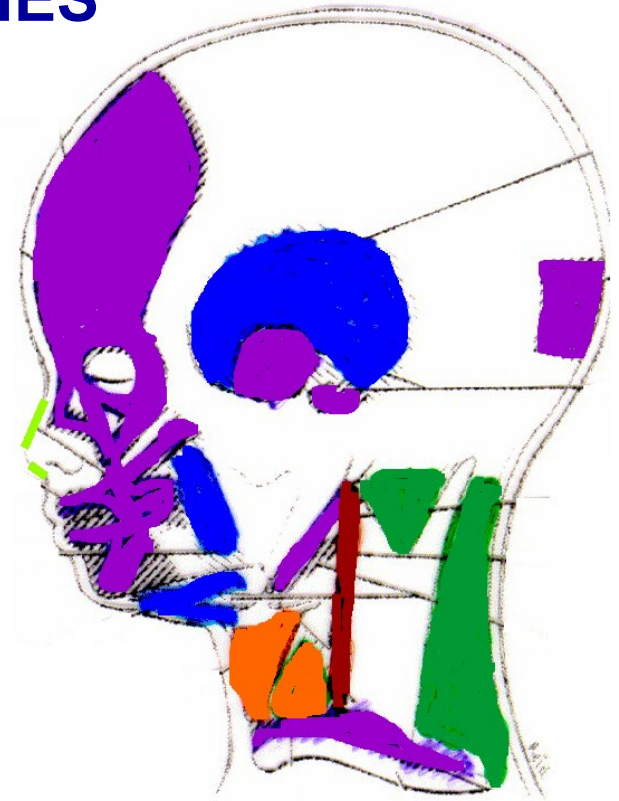
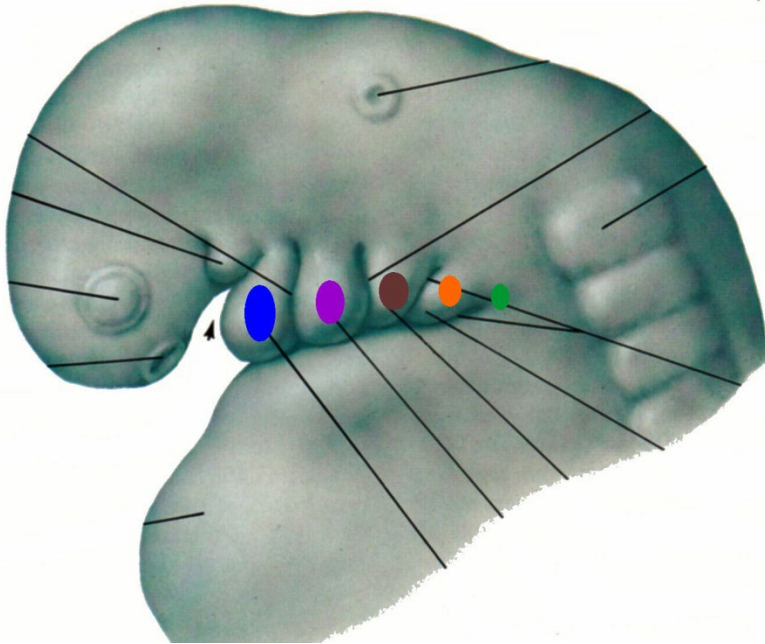
BRANCHIAL ARCH NERVES

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.

**FIRST
ARCH**

Nerve

V (Trigeminal)
(all in V3)

Innervates

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

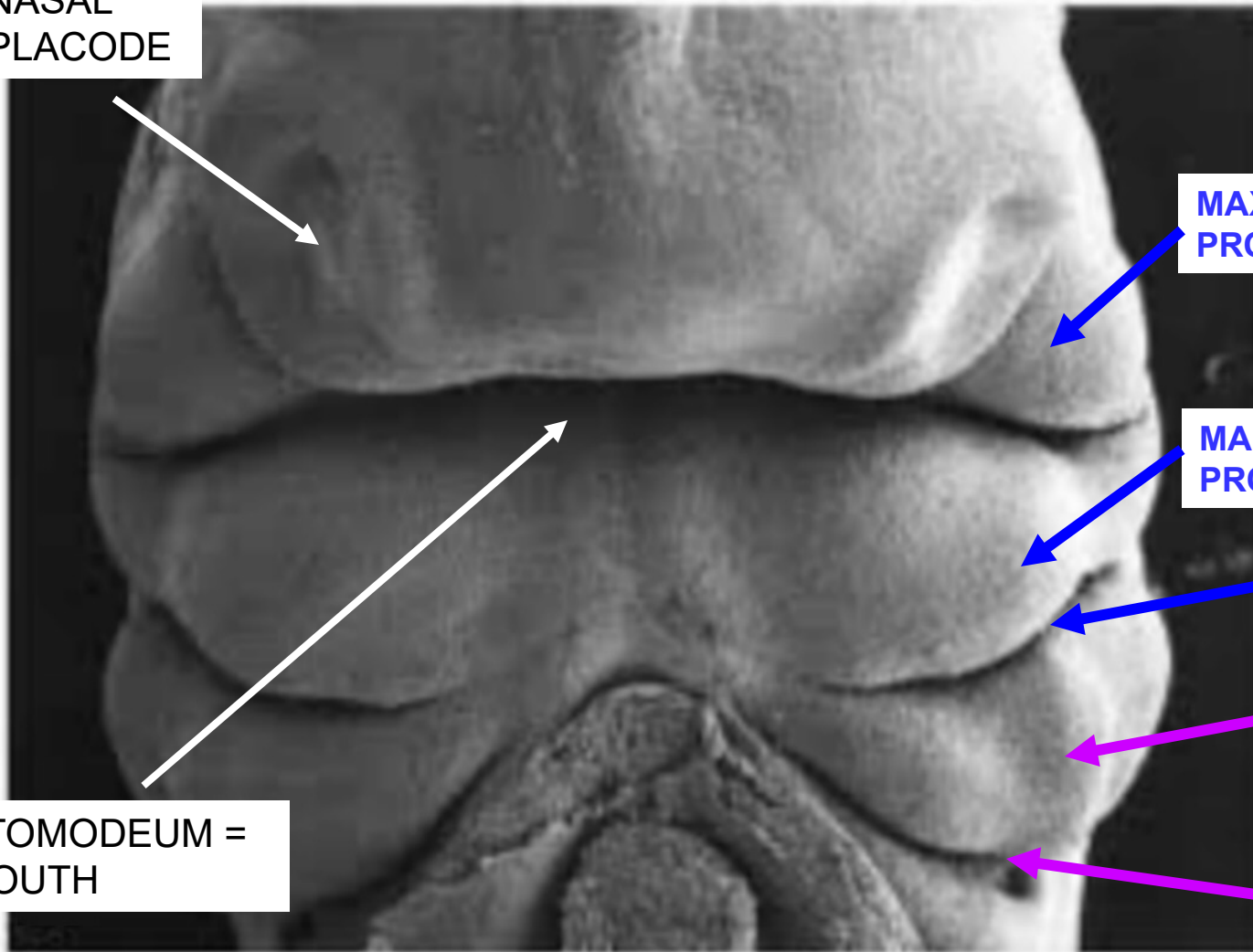
BRANCHIOMOTOR (SVE) = SKELETAL MUSCLES DERIVED FROM BRANCHIAL ARCHES

ARCH/NERVE	SKELETAL	LIGAMENTS	MUSCLES
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Sixth (XI)	-----	-----	1) Sternocleidomastoid 2) Trapezius

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

BRANCHIAL ARCHES AND CLEFTS

NASAL
PLACODE



MAXILLARY
PROCESS

MANDIBULAR
PROCESS

ARCH
I

GROOVE =
CLEFT I

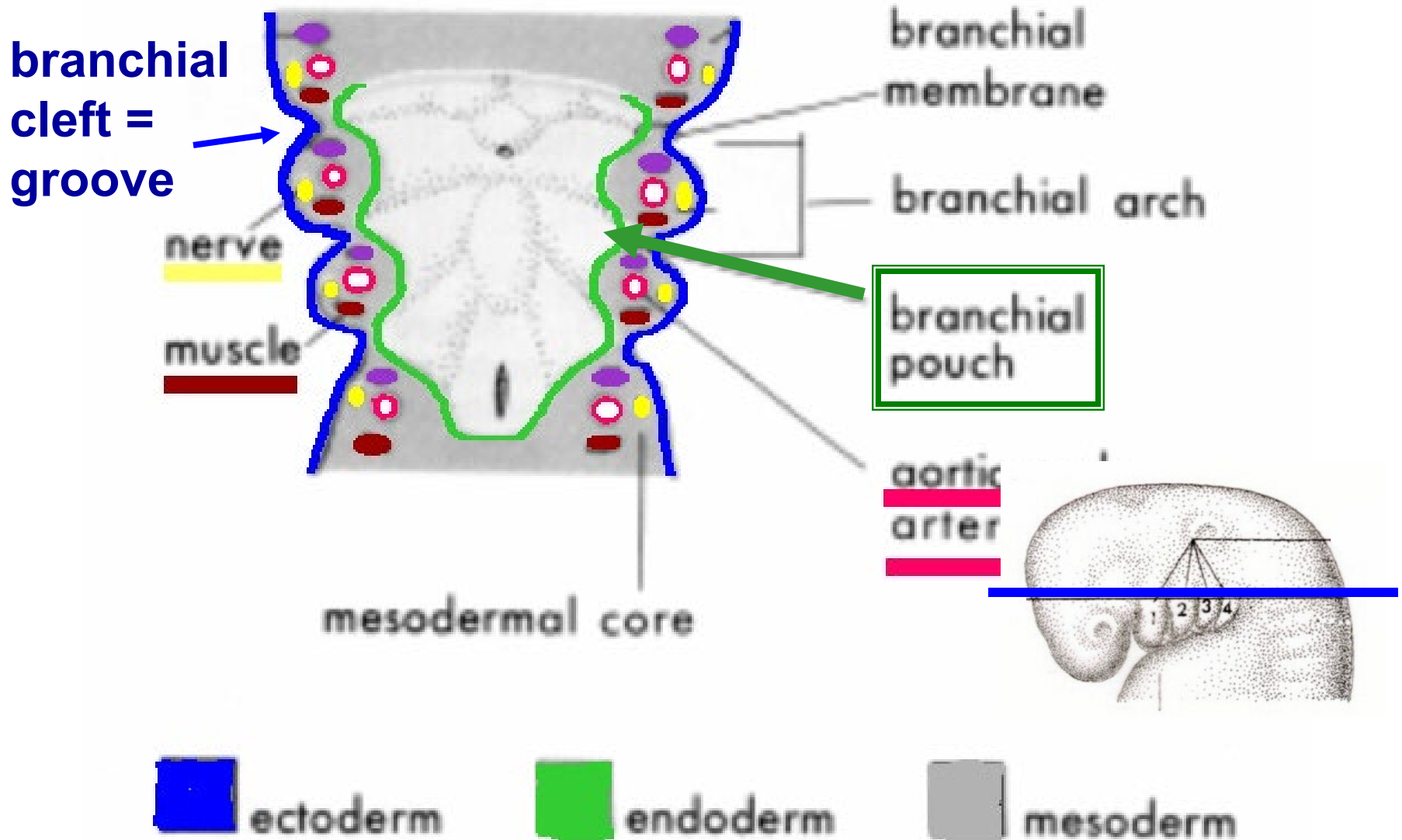
ARCH
II

GROOVE =
CLEFT II

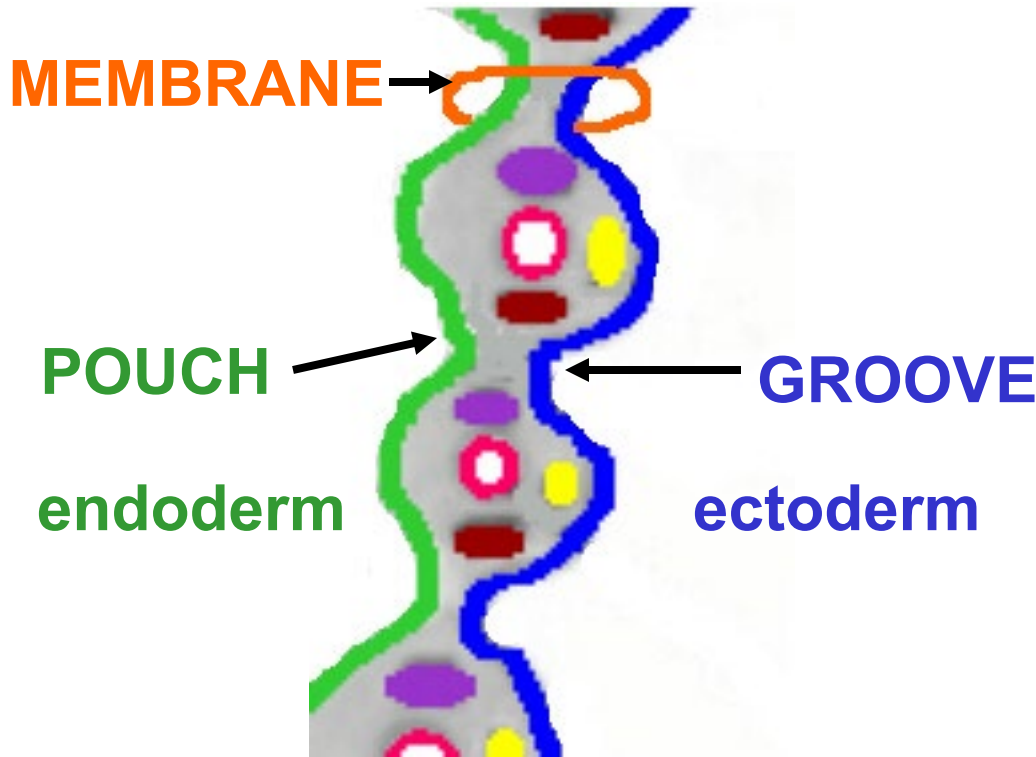
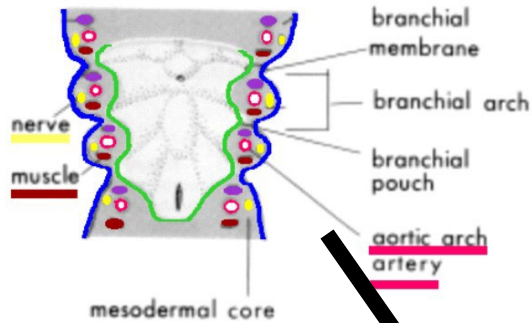
STOMODEUM =
MOUTH

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)	-----	-----

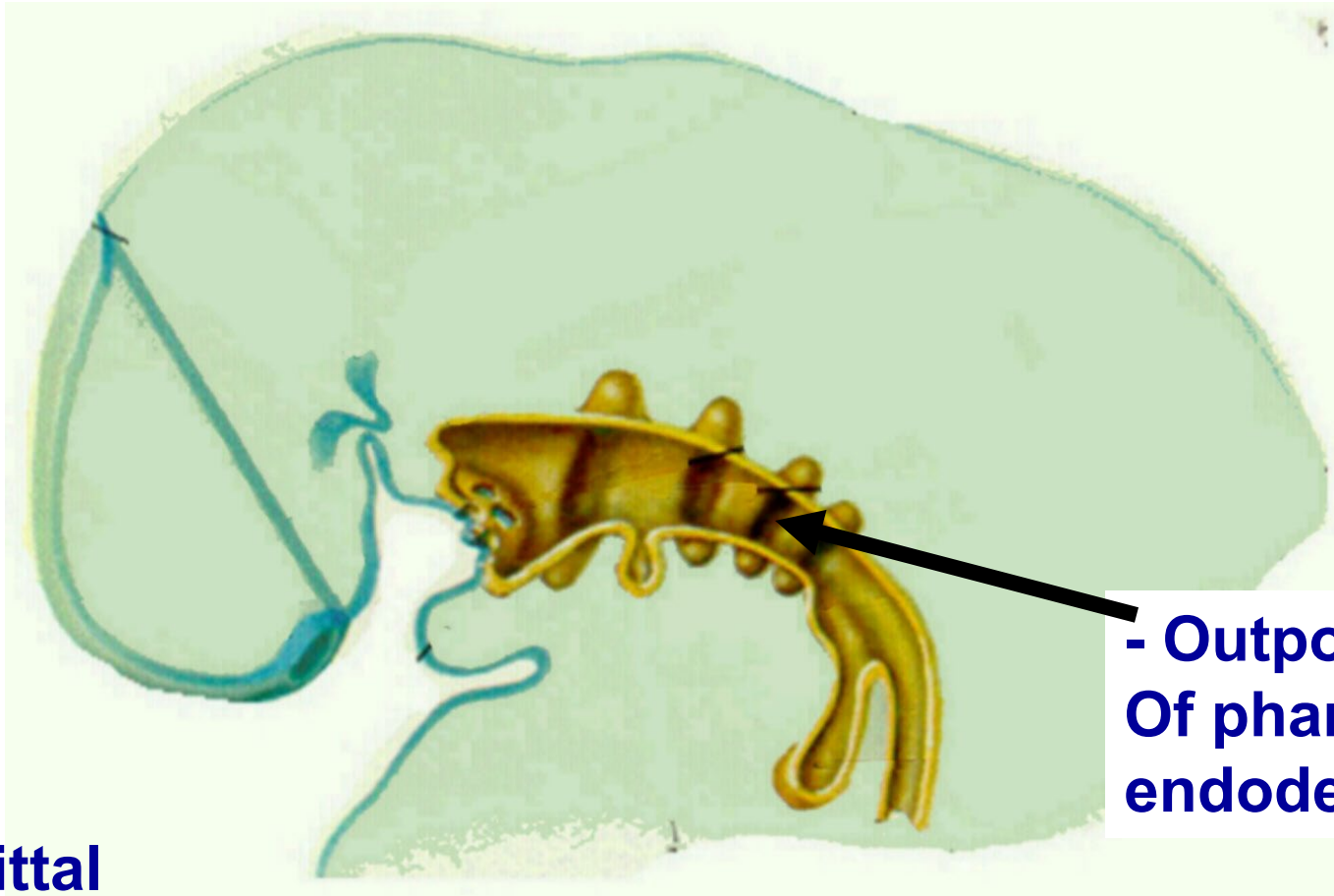
Note: Cysts and fistuli - in lateral neck are **anterior to Sternocleidomastoid muscle**

CLEFT	FORMS
First	External Auditory Meatus

MEMBRANE	FORMS
First	Tympanic membrane

NOTE: CLEFT = GROOVE

IV. BRANCHIAL POUCHES

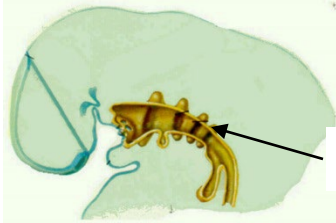


- Outpocketings
Of pharynx
endoderm

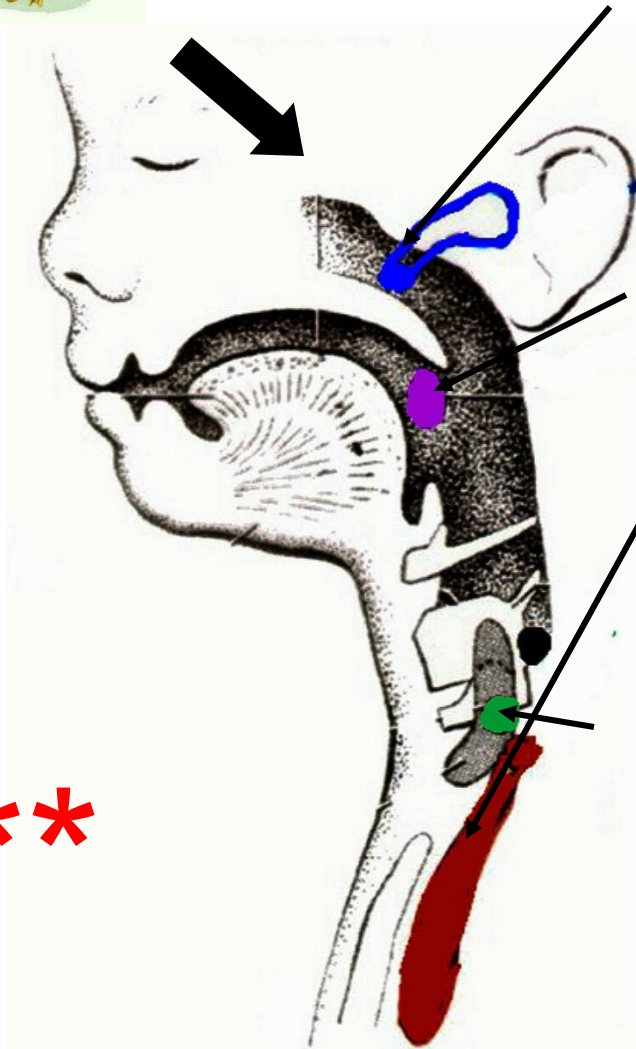
**Sagittal
View – embryo
6-7 weeks**

**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

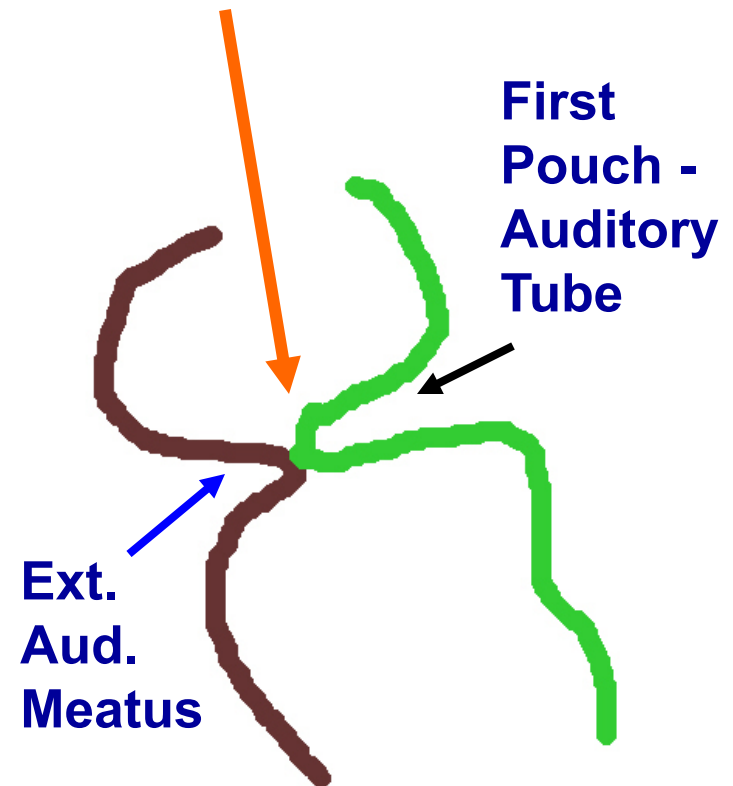
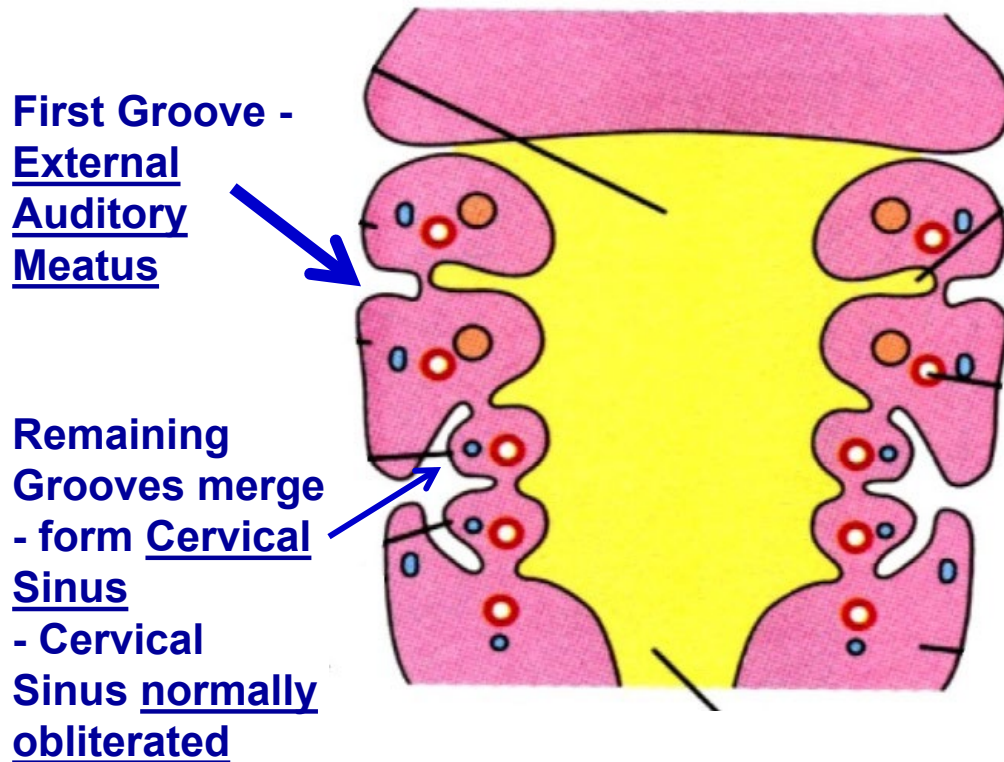
Note: Pouch 3 derivatives migrate caudal to pouch 4

III. BRANCHIAL GROOVES (CLEFTS) AND MEMBRANES

Only First Branchial Groove and Membrane Normally form Structures in Adult

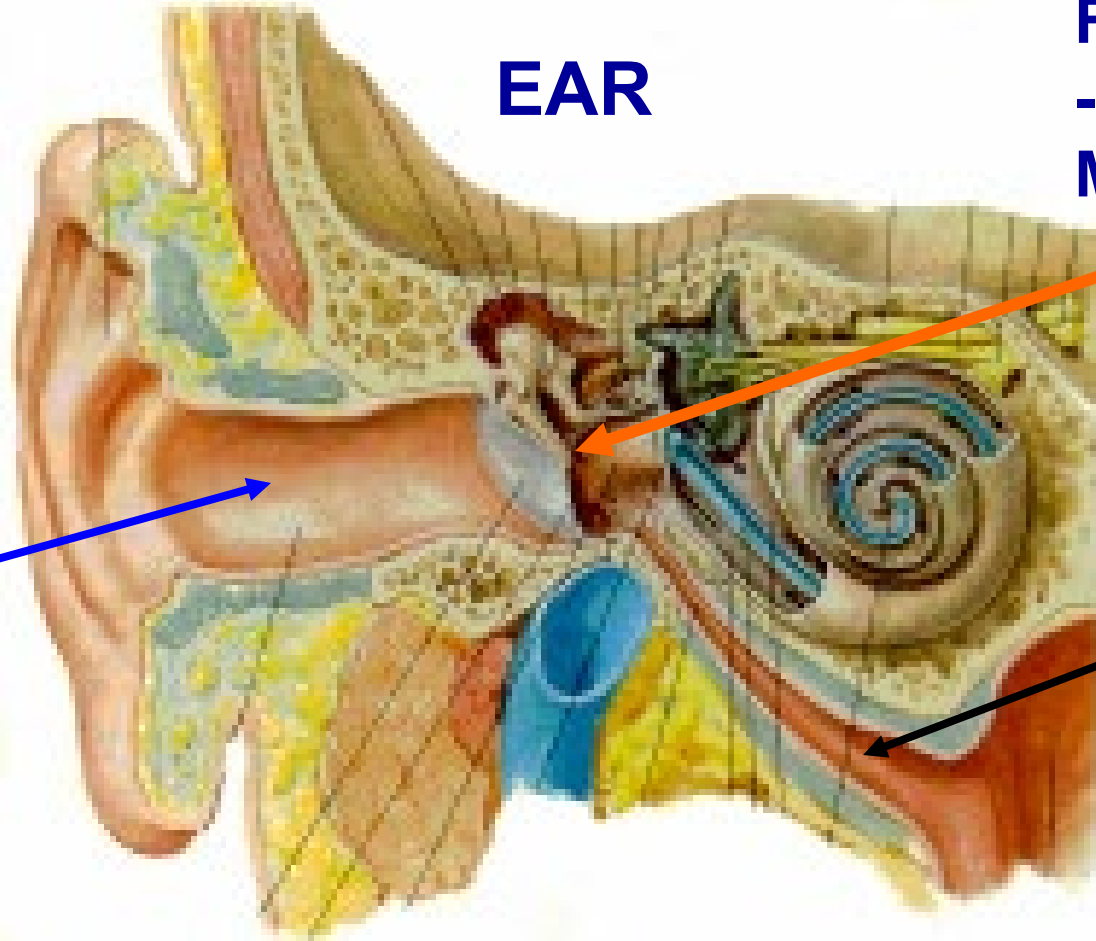
First Groove - External Auditory Meatus

First Membrane = Tympanic Membrane



EAR

**First Membrane
- Tympanic
Membrane**



**FIRST
GROOVE -**
Ext. Aud.
Meatus

**FIRST
POUCH -**
Auditory
Tube,
Tympanic
Cavity

Outer Ear

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

Middle Ear

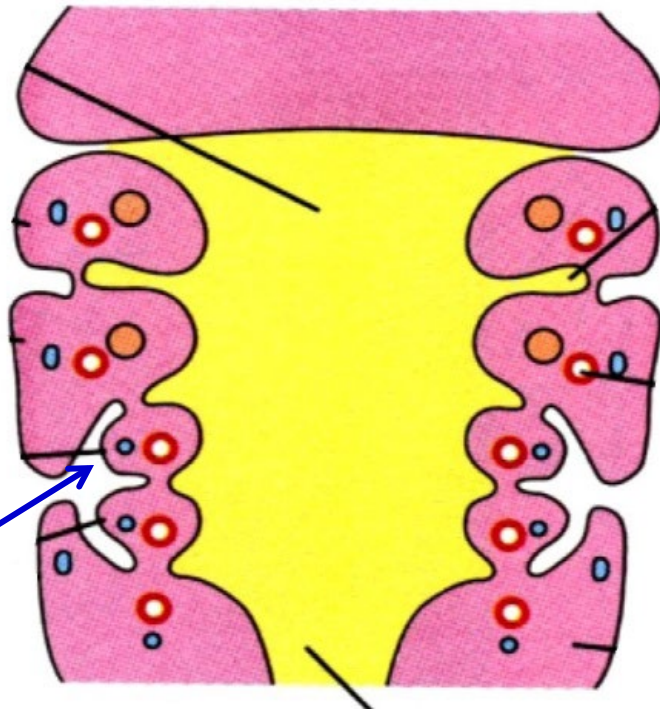
- 1) bones link tympanic membrane to cochlea
amplify pressure
- 2) muscles can dampen loud sounds

Inner Ear

- 1) cochlea-
hearing
vestibular
apparatus-
gravity

BRANCHIAL GROOVES

Other Grooves develop in longer depression
Cervical Sinus



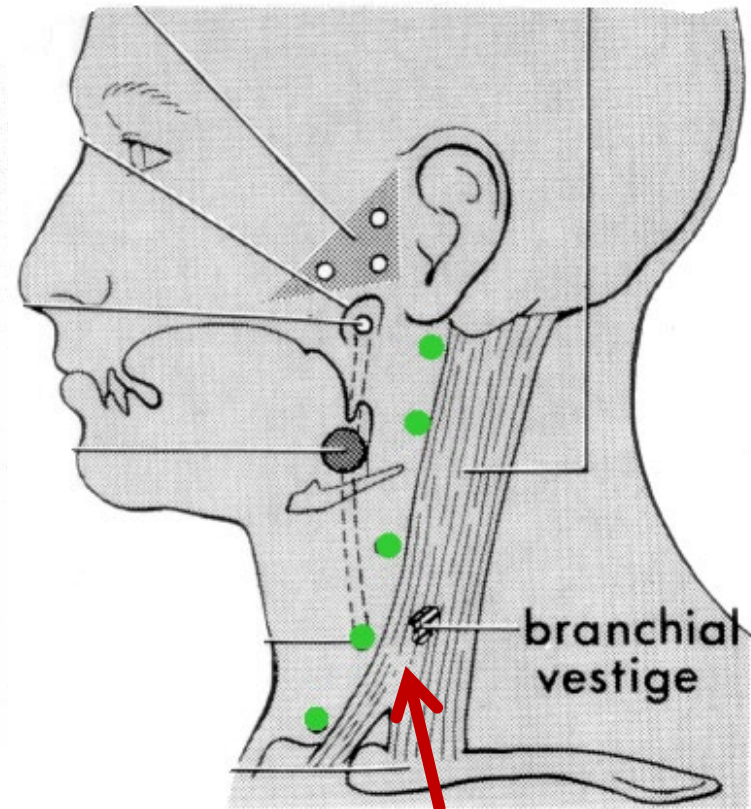
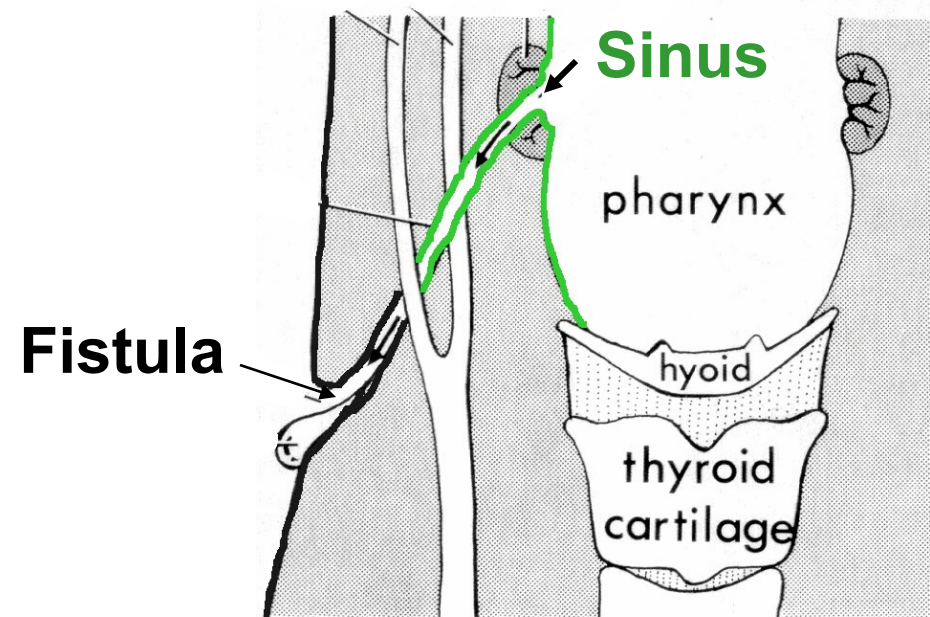
Remaining
Grooves merge
- form Cervical
Sinus
- Cervical
Sinus normally
obliterated

Note:
Cervical
sinus
normally
obliterated
but
can persist

BRANCHIAL ANOMALIES

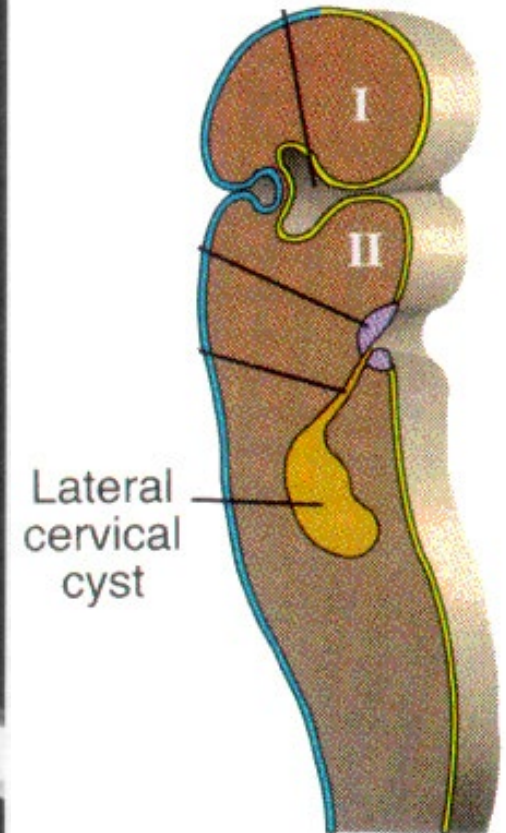
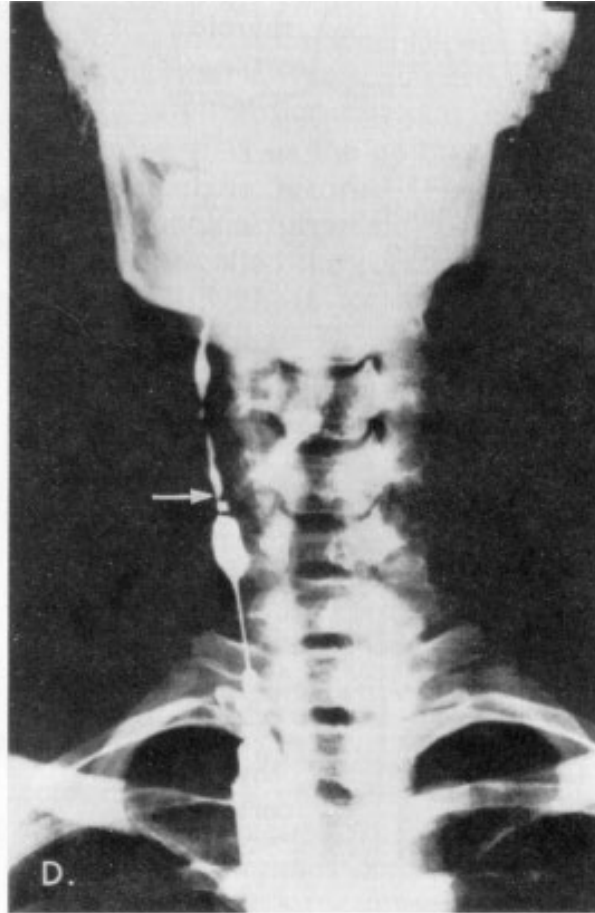
Branchial Sinus = Blind pouch from Pharynx

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



Sternocleidomastoid muscle

BRANCHIAL ANOMALIES



Branchial Fistula - drains to neck

**Branchial Cyst
often remnant
of Cervical Sinus**

BRANCHIAL POUCHES, GROOVES, MEMBRANES

POUCH	FORMS	CLINICAL
First	1) Auditory tube 2) Tympanic cavity	First Branchial 'Cleft' cyst - tract linked to external auditory meatus
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Sixth (XI)	-----	-----

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

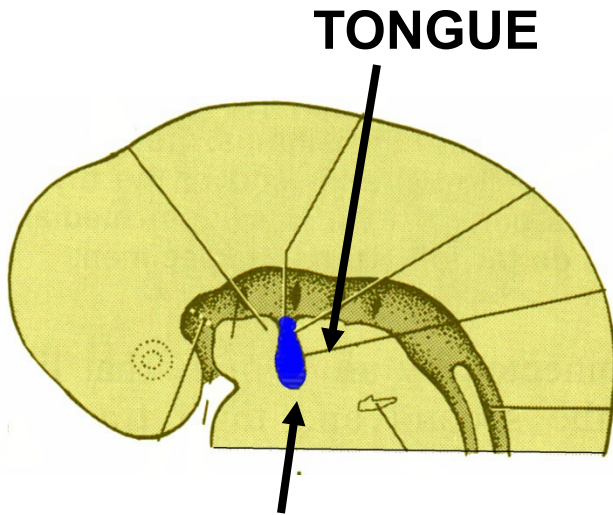
CLEFT	FORMS
First	External Auditory Meatus

MEMBRANE	FORMS
First	Tympanic membrane

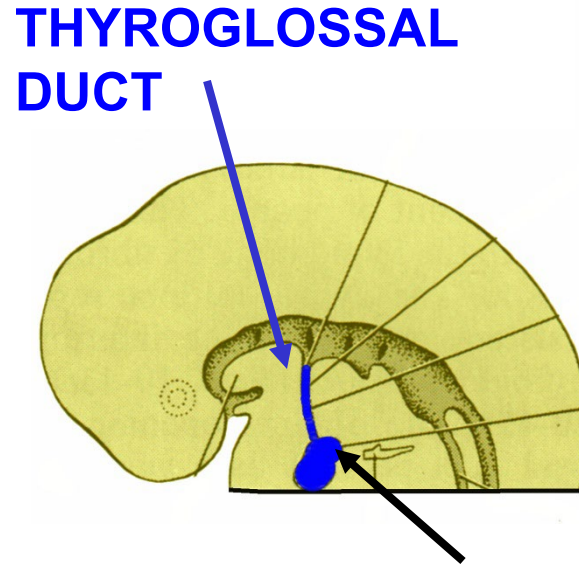
KNOW THESE CHARTS QUESTIONS ON EXAM, BOARDS

NOTE: CLEFT = GROOVE

V. DEVELOPMENT OF THYROID

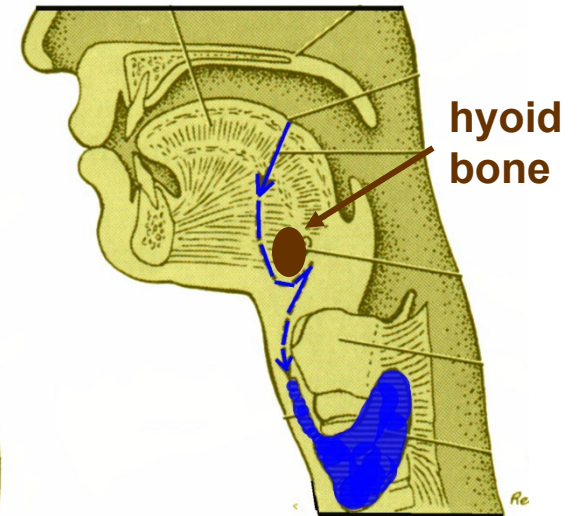


1) Thyroid start as Median endodermal Thickening on floor of pharynx at future junction of anterior 2/3 and posterior 1/3 of tongue (marked by Foramen Cecum)

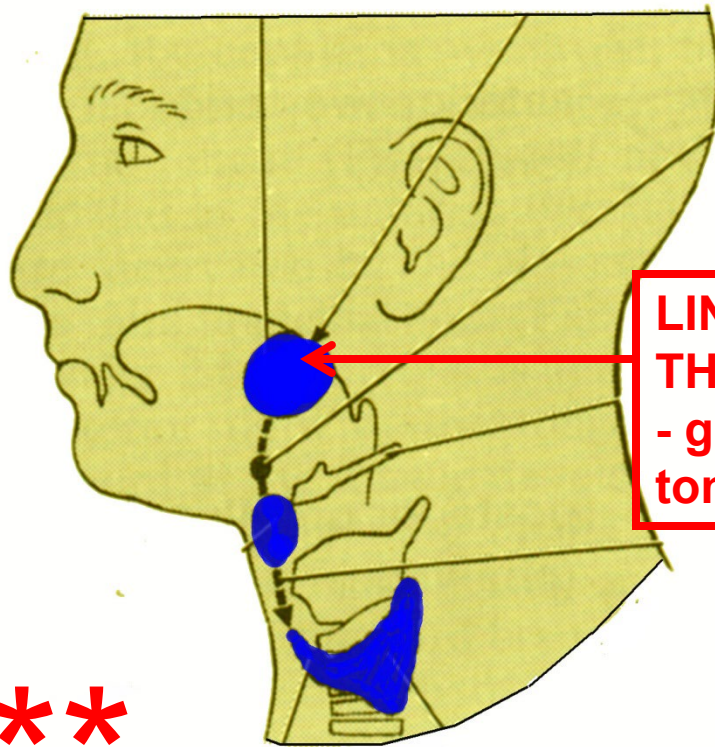


2) Elongates to form Thyroid Diverticulum; descends ant. to hyoid bone and larynx

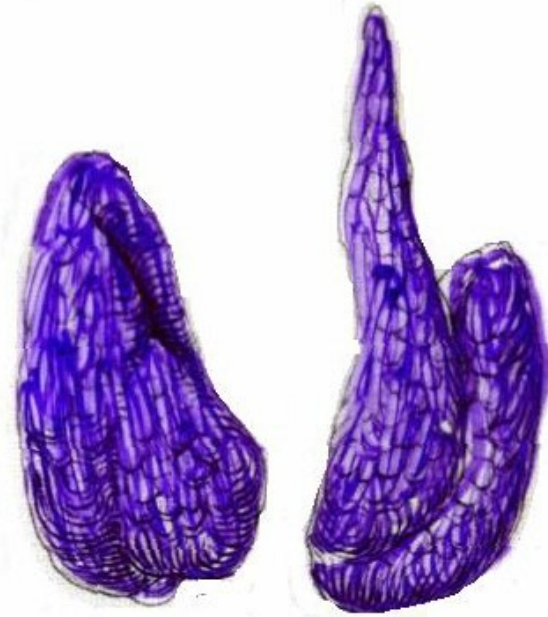
3) Thyroglossal duct connects Diverticulum to Foramen cecum



CONGENITAL MALFORMATIONS



**LINGUAL
THYROID
- gland in
tongue**



C. PYRAMIDAL LOBE. ABSENCE OF ISTHMUS

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

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

LINGUAL THYROID* - Thyroid gland in tongue



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