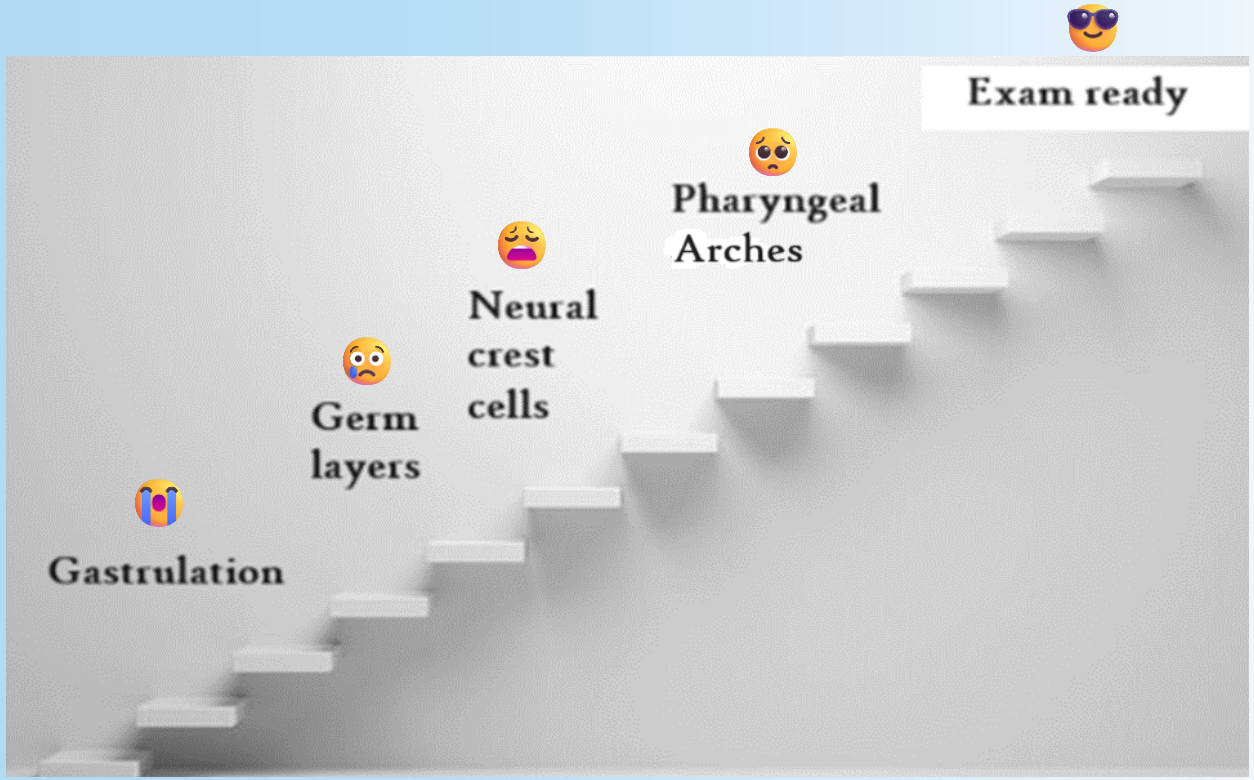
Embryology of head & neck

By Glenn André Breivik

Overview

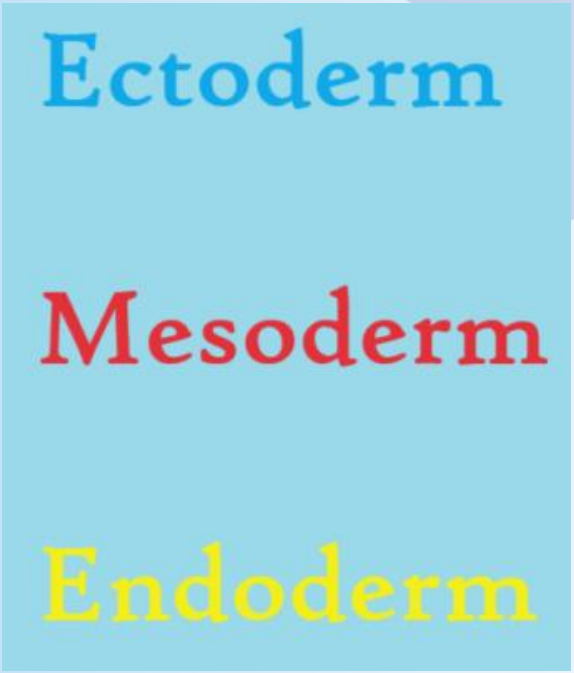
- Basic embryology introduction
  - Gastrulation (important bits)
  - The primordial layers (germ layers)
  - **Neural crest cells**
- Pharyngeal arches, pouches and grooves
  - Structures of the head and neck
- Review (tables)
- Question bank



Use the slides later for repetition for the midterm and the final exam!

Basic embryology - germ layers

- Gastrulation = formation of the three germ layers
- **Different layer - different cell type**
- The germ layers form our organs
- We can differentiate organs derived from different cells/germ layer, but some organs are derived from more than one cell/layer



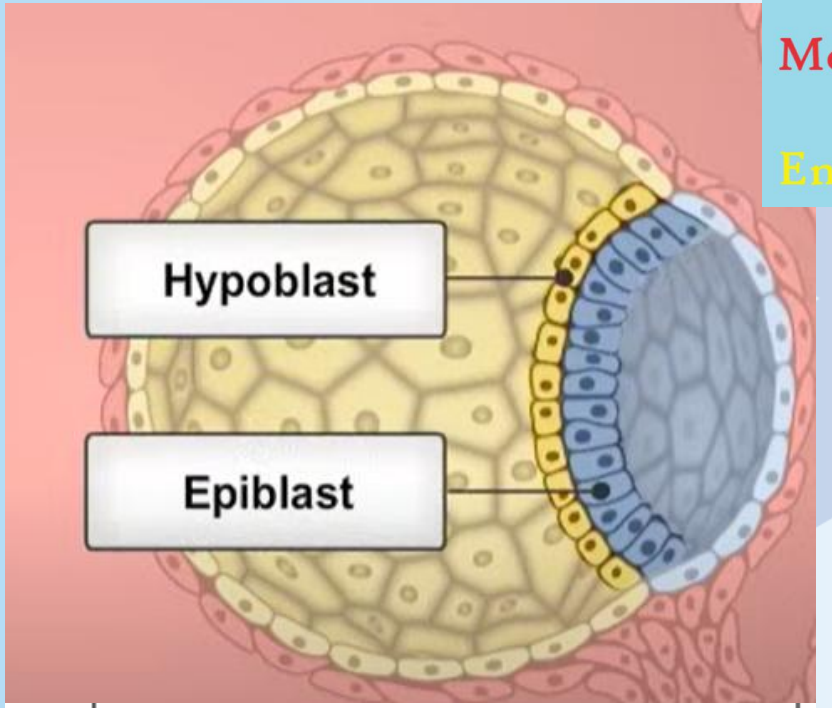
Gastrulation

Ectoderm

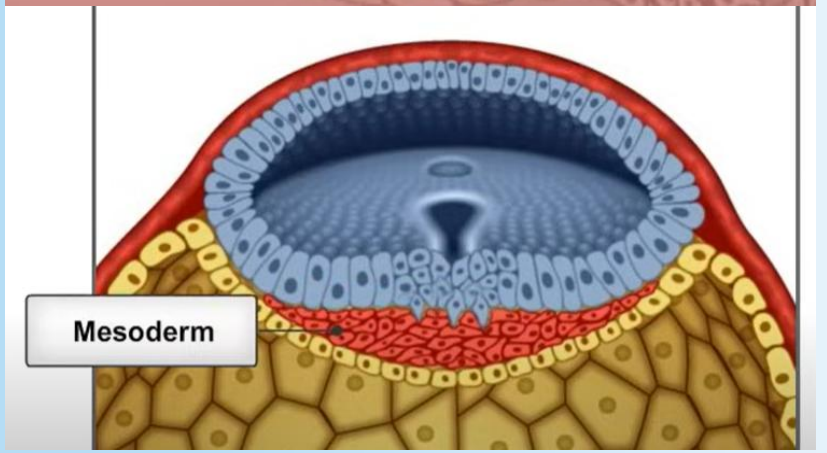
Mesoderm

Endoderm

- Epiblast = Ectoderm (**Looks like** columnar-like cells → **but shifts!**)
- Hypoblast = Endoderm (**Looks like** *cuboidal cells* and stratified squamous cells)



Epiblast cells invaginates (and invades) through the primitive streak and transitions into mesenchymal cells.



- Mesenchymal cells = Mesoderm (epithelium cells +++)
- Mesenchymal cells are **pluripotent stem cells** (can become any type of cell needed - *except for placenta cells*).

How to memorise?

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Gastrulation

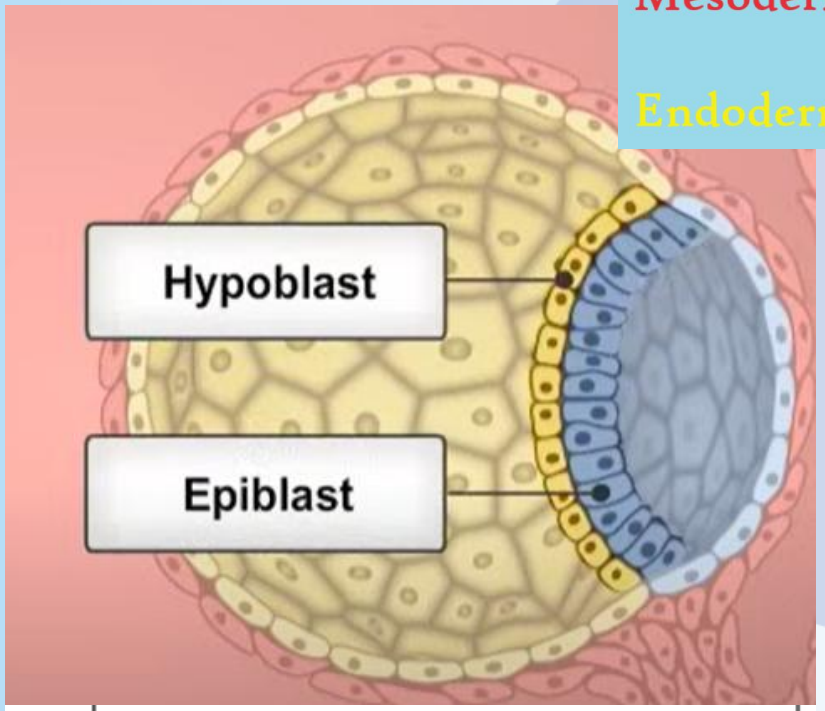
Ectoderm

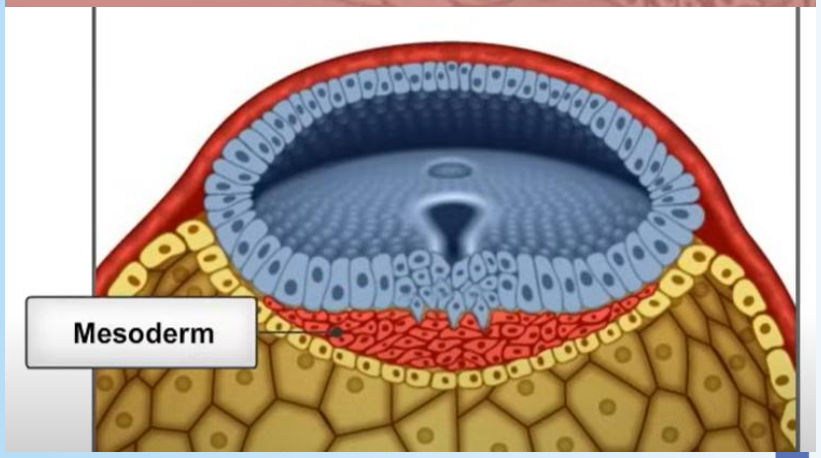
Mesoderm

Endoderm

<u>At the start of gastrulation:</u>

- **Epiblast** => Ectoderm («columnar cells»)→ ***<u>will shift!</u>***
- **Hypoblast** => Endoderm (*<u>cuboidal cells</u>*, stratified squamous cells and **Columnar cells**)
- **Mesenchymal cells** => Mesoderm (epithelium cells+++) → *Kind of «comes from» ectoderm*





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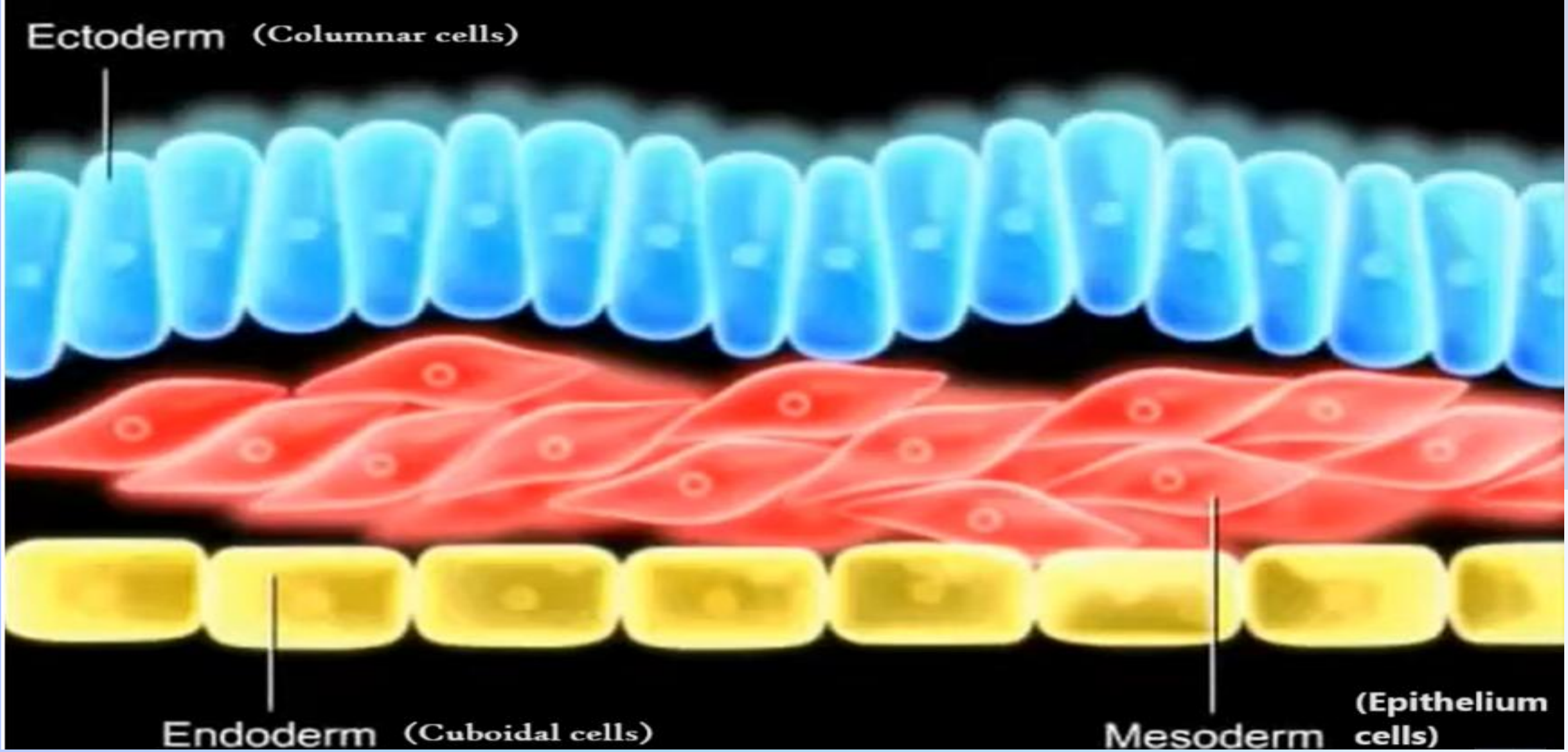

- E and E = c and c → "EctoColumnar" and "EndoCuboidal".
- M + e (me) = Mesoderm is epithelium +++

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table 4.1 Germ Layer Derivatives

Ectoderm	Mesoderm	Endoderm
Epidermis, hair, nails, sweat and sebaceous glands	Muscle (smooth, cardiac, skeletal)	Hepatocytes
Utricle, semicircular ducts, vestibular ganglion of CN VIII	Extraocular muscles, ciliary muscle of eye, iris stroma, ciliary body stroma	Principal and oxyphil cells of parathyroid
Saccule, cochlear duct (organ of Corti), spiral ganglion of CN VIII	Substantia propria of cornea, corneal endothelium, sclera, choroid	Thyroid follicular cells thymus
Olfactory placode, CN I	Muscles of tongue (occipital somites)	Epithelial reticular cells of thymus
Ameloblasts (enamel of teeth)	Pharyngeal arch muscles	Acinar and islet cells of pancreas
Adenohypophysis	Laryngeal cartilages	Acinar cells of submandibular and sublingual glands
Lens of eye	Connective tissue	Epithelial lining of:
Anterior epithelium of cornea	Dermis and subcutaneous layer of skin	Gastrointestinal tract
Acinar cells of parotid gland	Bone and cartilage	Trachea, bronchii, lungs
Acinar cells of mammary gland	Dura mater	Biliary apparatus
Epithelial lining of:	Endothelium of blood and lymph vessels	Urinary bladder, female urethra, most of male urethra
Lower anal canal	Red blood cells, white blood cells, microglia, and Kupffer cells	Inferior 2/3 of vagina
Distal part of male urethra	Spleen	Auditory tube, middle ear cavity
External auditory meatus	Kidney	Crypts of palatine tonsils
"SUPERFICIAL" STRUCTURES	Adrenal cortex	
External auditory mediatus and epidermis CNS and PNS	Testes, epididymis, ductus deferens, seminal vesicle, ejaculatory duct	
	Ovary, uterus, uterine tubes, superior 1/3 of vagina	

Pharyngeal grooves

Muscles, cartilage, connective tissue, bones, eyes, arteries.

Cells of thyroid and parathyroid

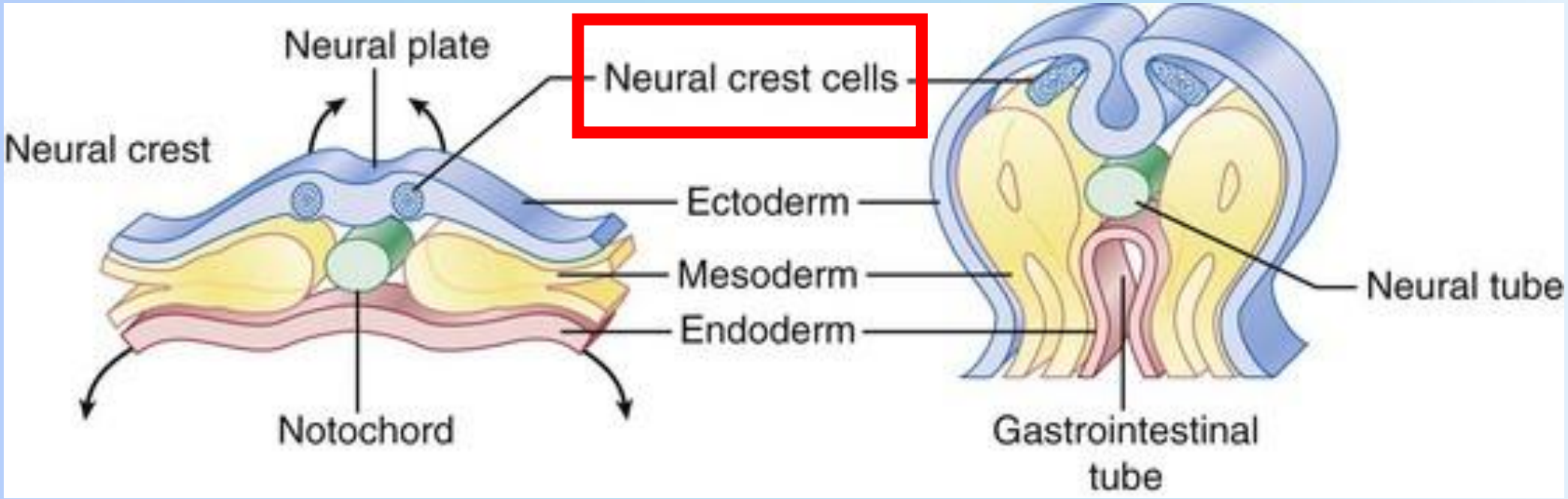
Pharyngeal pouches

Ectoderm

Mesoderm

Endoderm

Ectoderm



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Ectoderm

Mesoderm

Endoderm

Derivatives

Neuroectoderm

All neurons within brain and spinal cord
Retina, iris epithelium, ciliary body epithelium, optic nerve (CN II), optic chiasm, optic tract, dilator and sphincter pupillae muscles
Astrocytes, oligodendrocytes, ependymocytes, tanycytes, choroid plexus cells
Neurohypophysis
Pineal gland

Neural Crest

Cranial neural crest cells:
- Pharyngeal arch skeletal and connective tissue components
- Bones of neurocranium
- Pia and arachnoid
- Parafollicular (C) cells of thyroid
- Aorticopulmonary septum
- Odontoblasts (dentin of teeth)
- Sensory ganglia of CN V, CN VII, CN IX, CN X
- Ciliary (CN III), pterygopalatine (CN VII), submandibular (CN VII), and otic (CN IX) parasympathetic ganglia

Parasympathetic ganglia!

Trunk neural crest cells:
- Melanocytes
- Schwann cells
- Chromaffin cells of adrenal medulla
- Dorsal root ganglia
- Sympathetic chain ganglia
- Prevertebral sympathetic ganglia
- Enteric parasympathetic ganglia of the gut (Meissner and Auerbach; CN X)
- Abdominal/pelvic cavity parasympathetic ganglia

Overview

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  - ~~The primodial layers (germ layers)~~
  - ~~**Neural crest cells**~~

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  - **Structures of head and neck**
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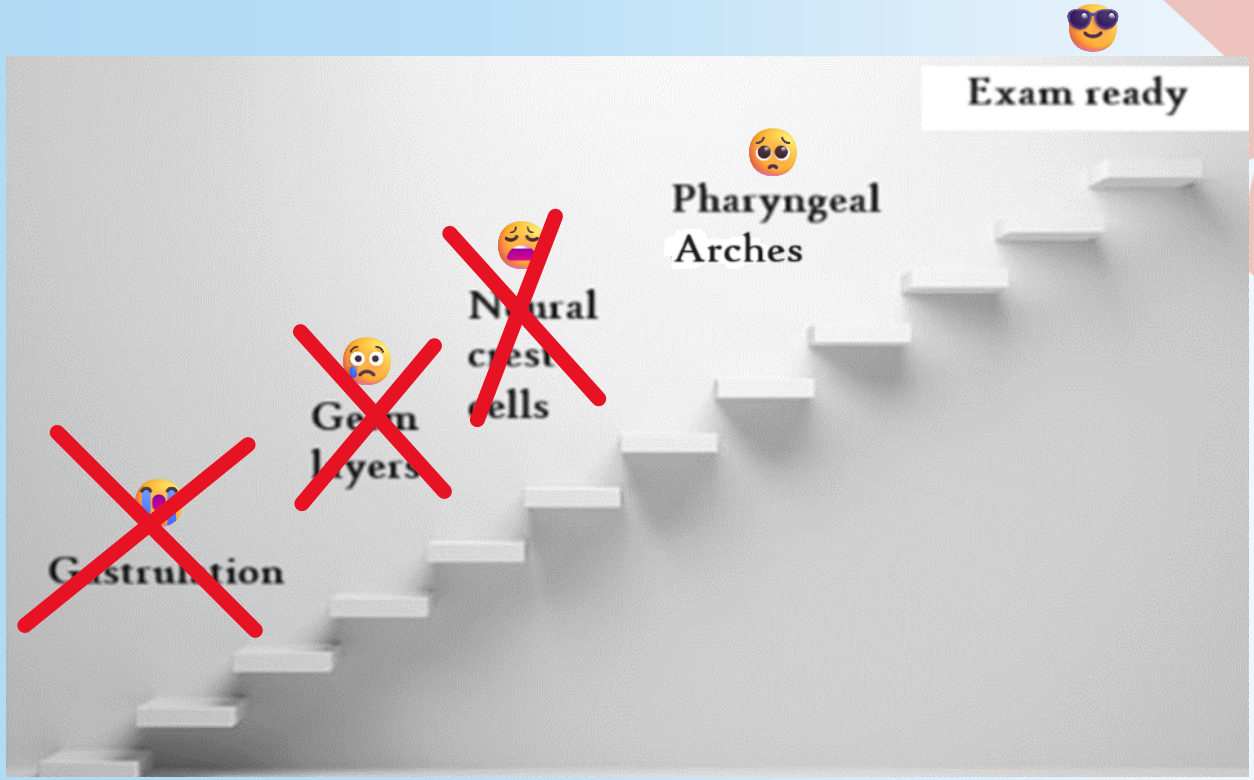
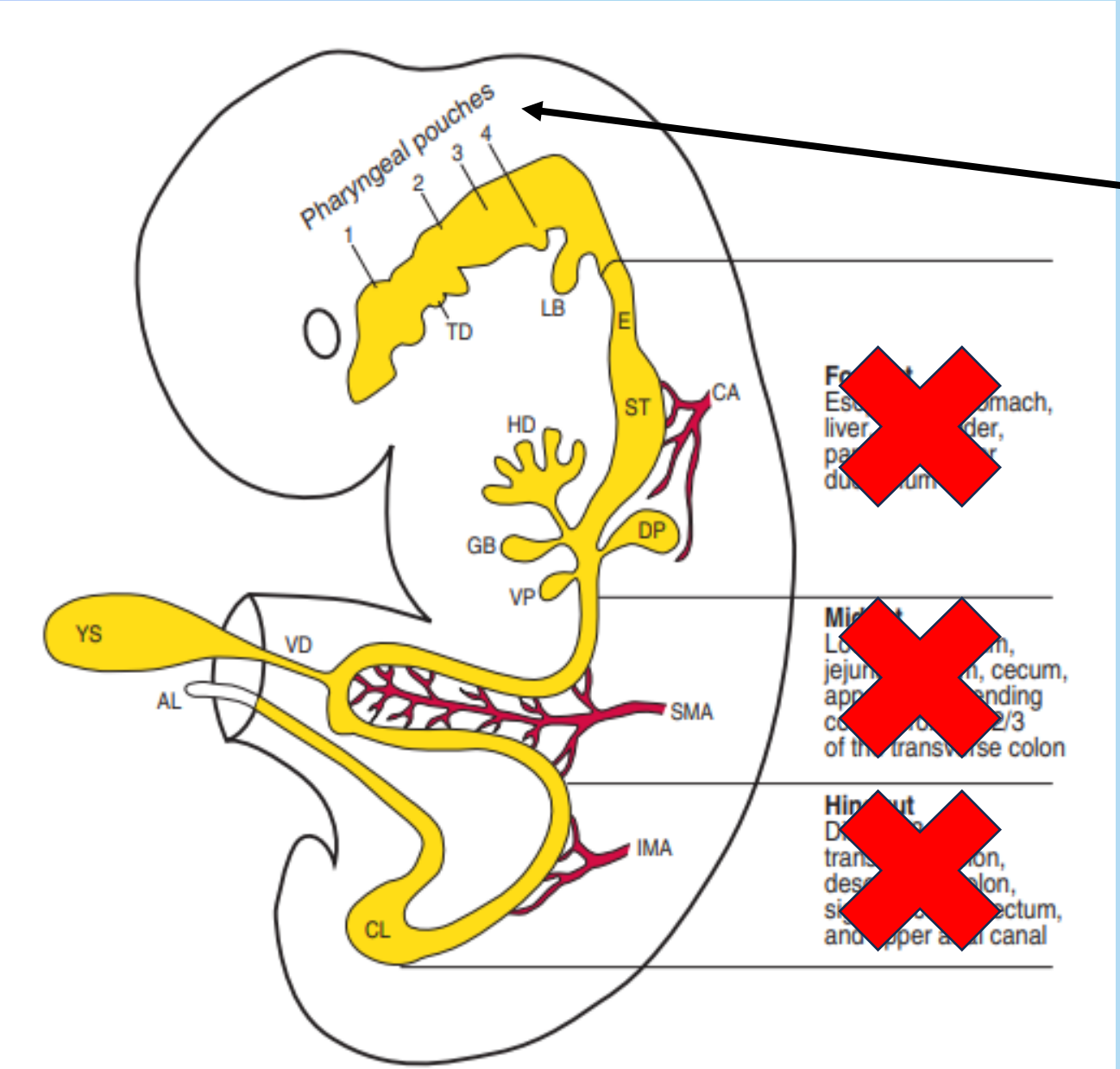




- Pharyngeal arches, pouches and grooves are specific for head & neck embryology, and is ***not*** part of foregut – **they only surround the foregut.**

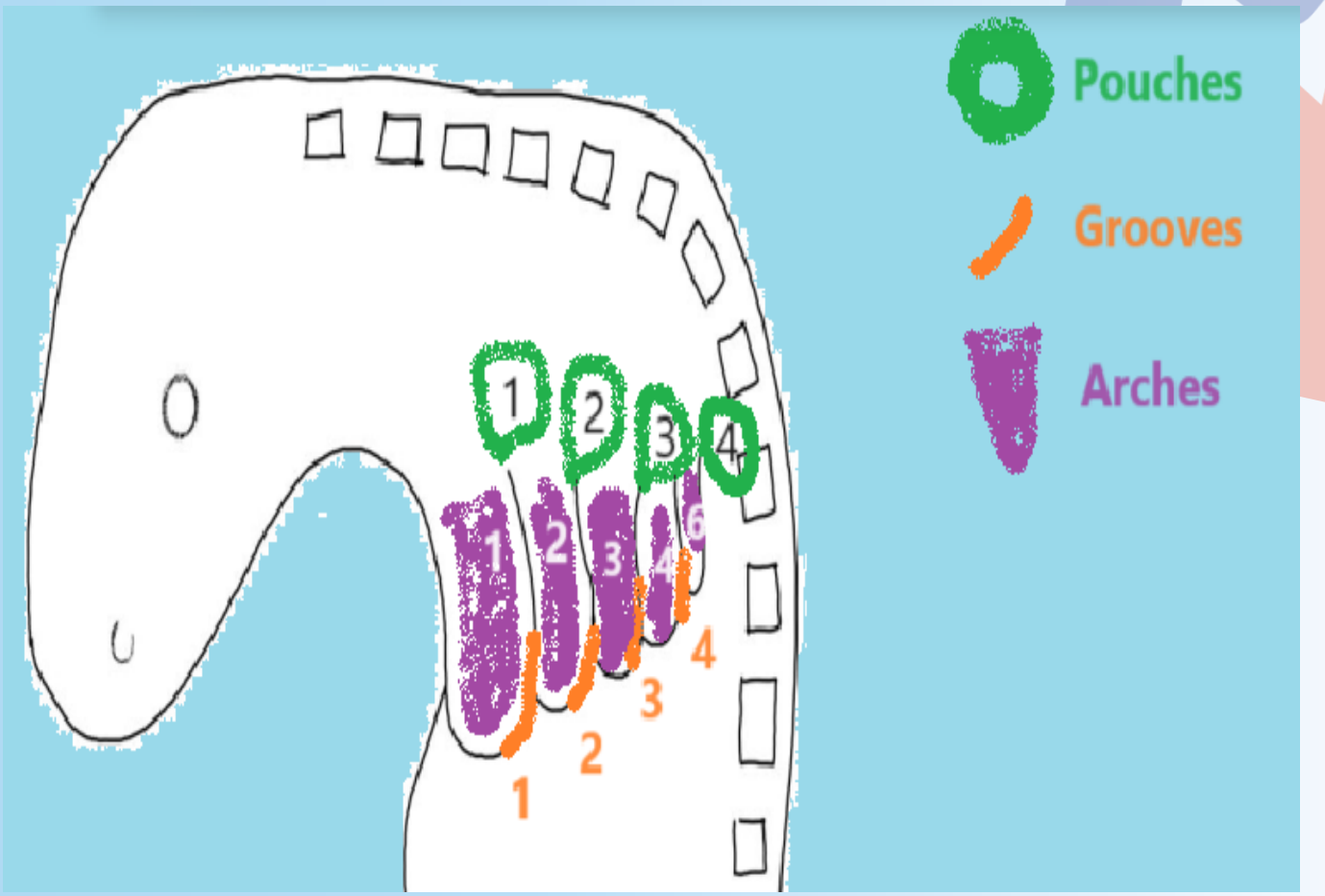
Arches, pouches and grooves

- **The 5th arch, pouch or groove does not exist.**

Basic rules for separation:

- Arches = **Mesoderm** (Mesenchymal)
- Pouches = **Endoderm** (cuboidal + stratified squamous cells)
- Grooves = **Ectoderm** (Stratified squamous cells + specialised neuro cells)

With some exceptions of course



- The further «out in arches» we move, the further down the neck we go.

Do not forget about neural crest cells!

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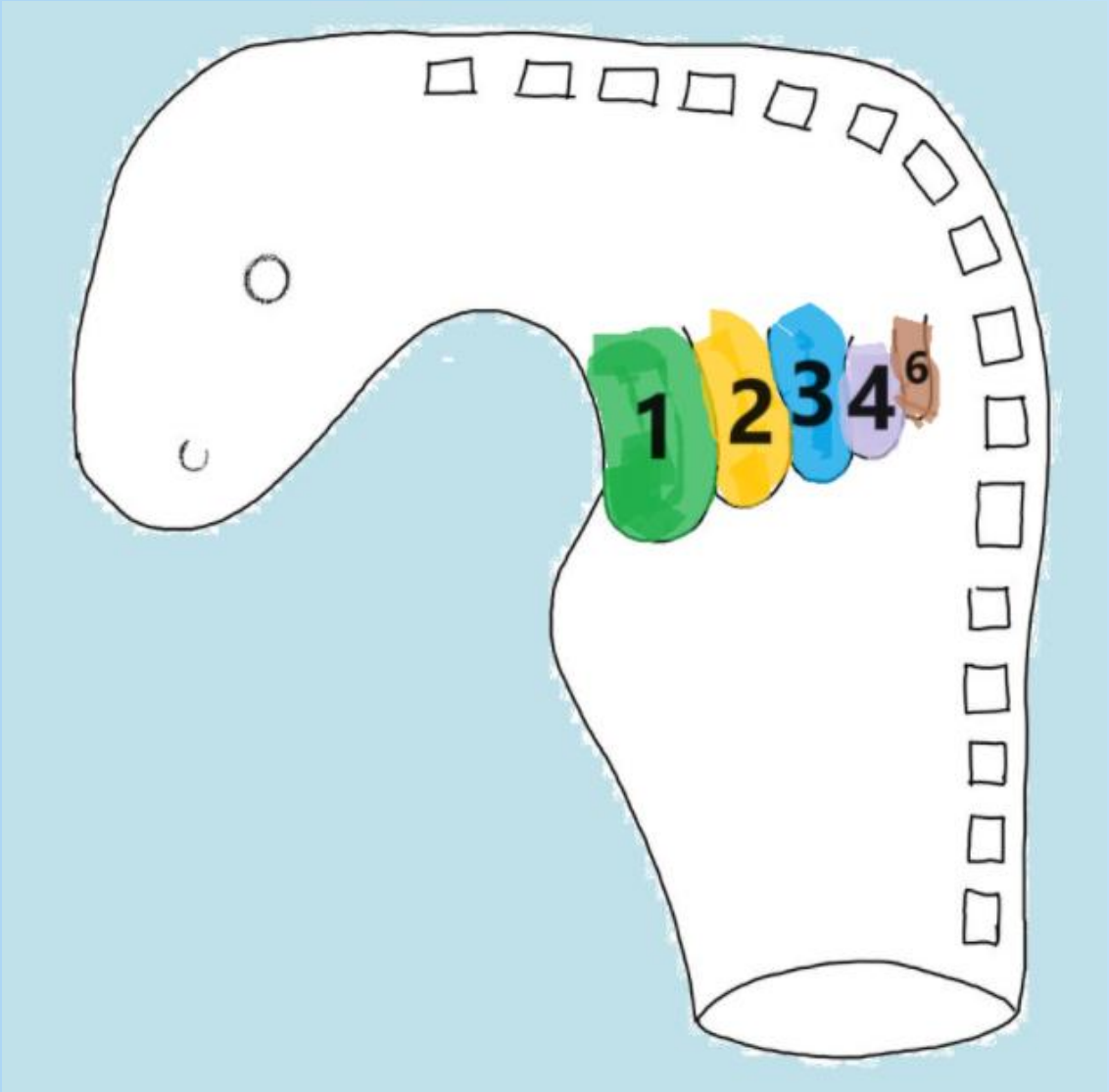
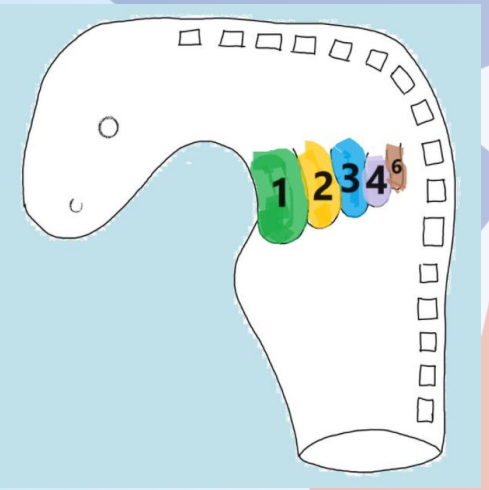
Pharyngeal arches (brachial arches)



Pharyngeal arches basic overview



- **Neural crest cells:**

  Part of all the pharyngeal arches through the cranial nerves and bones.

Neural Crest
Cranial neural crest cells:
- Pharyngeal arch skeletal and connective tissue components
- Bones of neurocranium
- Pia and arachnoid
- Parafollicular (C) cells of thyroid
- Aorticopulmonary septum
- Odontoblasts (dentin of teeth)
- Sensory ganglia of CN V, CN VII, CN IX, CN X
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- The pharyngeal arches contain cells of mesoderm and neural crest cells mainly

➢ Mesoderm = epithelium → muscle, arteries, bones.

➢ Neural crest cells = bone, connective tissue and **cranial nerves.**

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One arch contains:

1. One or more arteries
2. Cranial nerve/branches related to the cranial nerve
3. Bone(s)& cartilage/ligament
4. Muscles or specific muscle groups related to the *nerve* the arch is connected with

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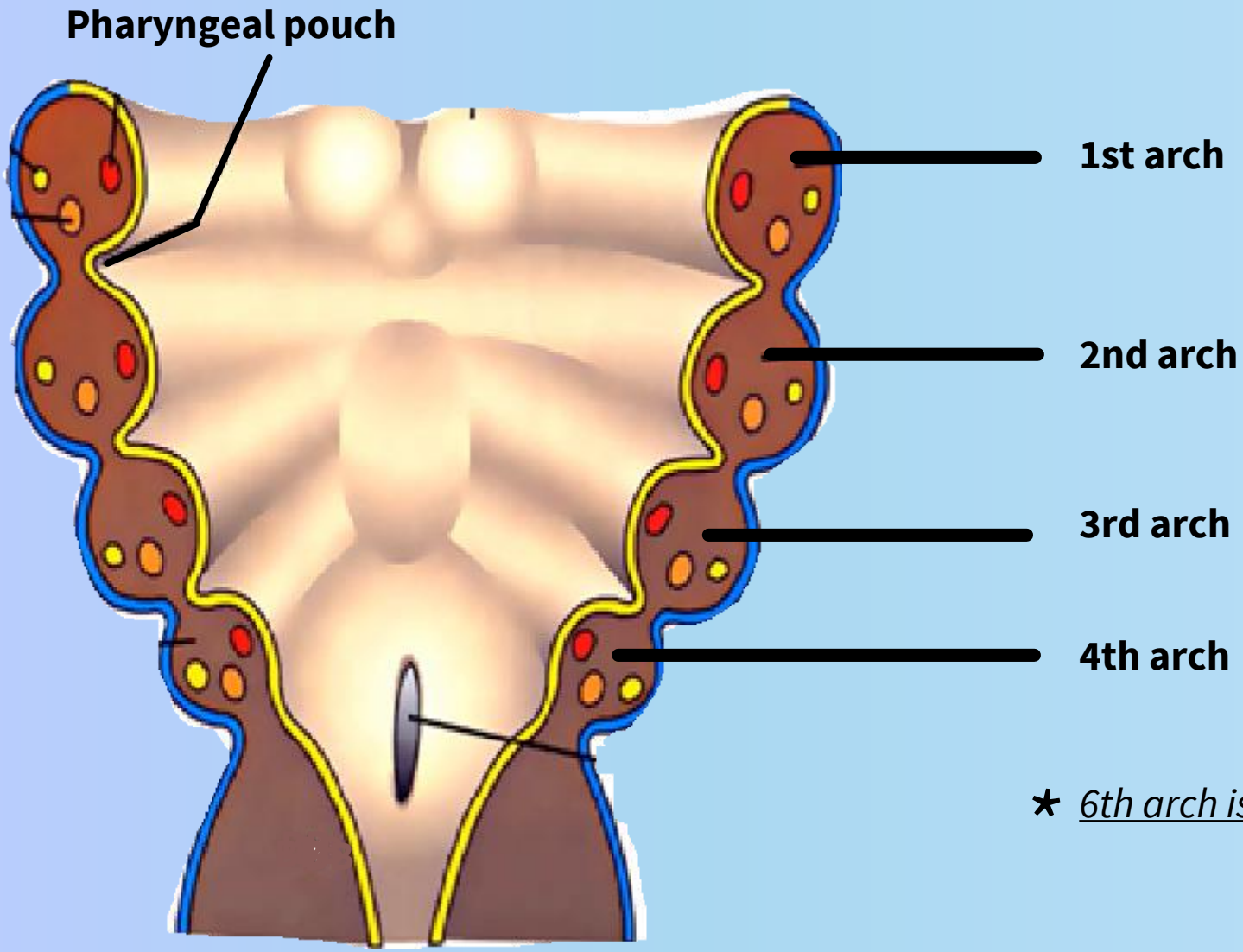


★ *6th arch is hidden*

1. **Artery**
2. **Nerve**
3. **Cartilage/Ligament & Bone**
4. ***Mesenchymal tissue (muscles)***

Pharyngeal arch 1 (mandibular arch):

1. Artery:
Maxillary artery and external carotid artery

2. Nerve:
CN V (trigeminal, mandibular branch) → *neural crest cells*

3. Cartilage/Ligaments/bone:

- Maxillary prominence:
(Maxilla, zygomatic bone, squamous part of temporal bone).

❖ *Incus* (the «anvil») – *neural crest cells*

- Mandibular prominence:
(Mandible, ❖*malleus*) – *neural crest cells*

2-to-1 with ossicles!

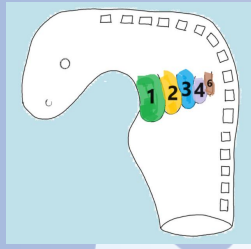
Ligaments:

- *Sphenomandibular ligament and anterior ligament of malleus*

4. Muscle/muscle group:

Muscles of mastication+:
(masseter, temporalis, medial and lateral pterygoid)
+ mylohyoid and anterior digastric muscle, tympanic tensor muscle.

Pharyngeal arch 2 (hyoid arch) («face arch» / «C-arch» / «stape arch»):



1. Artery («stape arch»):
Proximal part of stapedial artery
(derivates from hyoidal artery, which disappears)

2. Nerve:
CN VII (facial nerve) → *neural crest cells*

3. Cartilage/bone (C-arch):

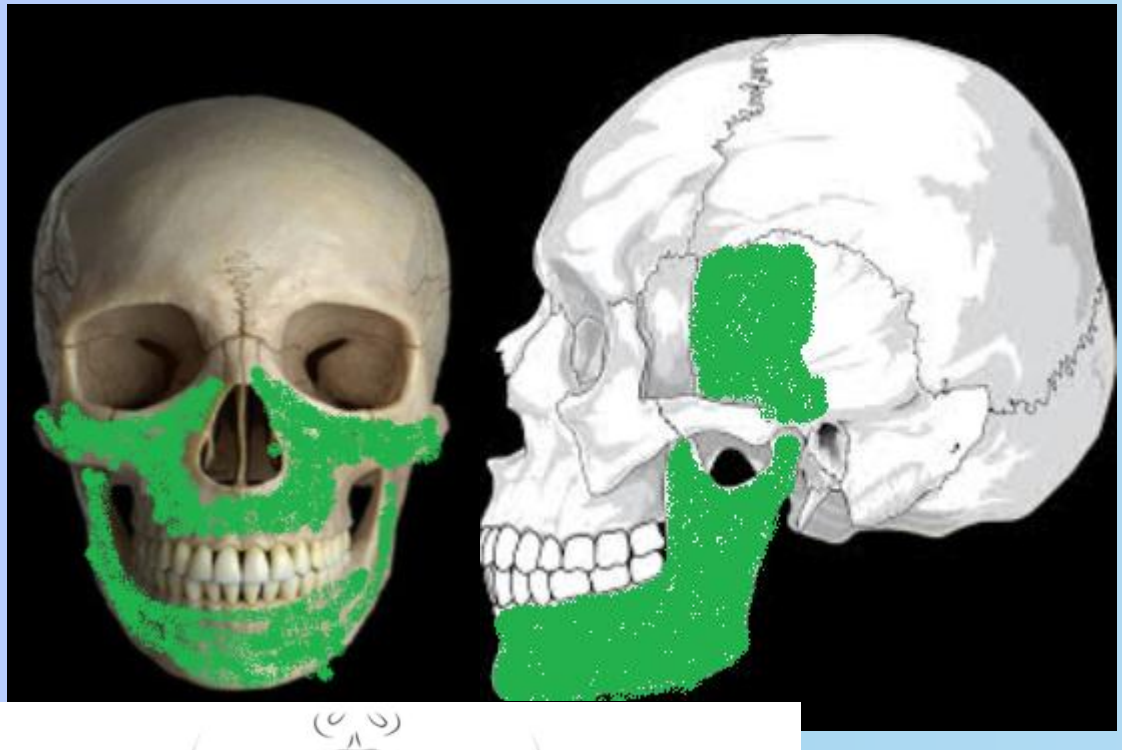
Petromastoid part of temporal bone, styloid process, and lesser horn with *upper body of hyoid bone*.

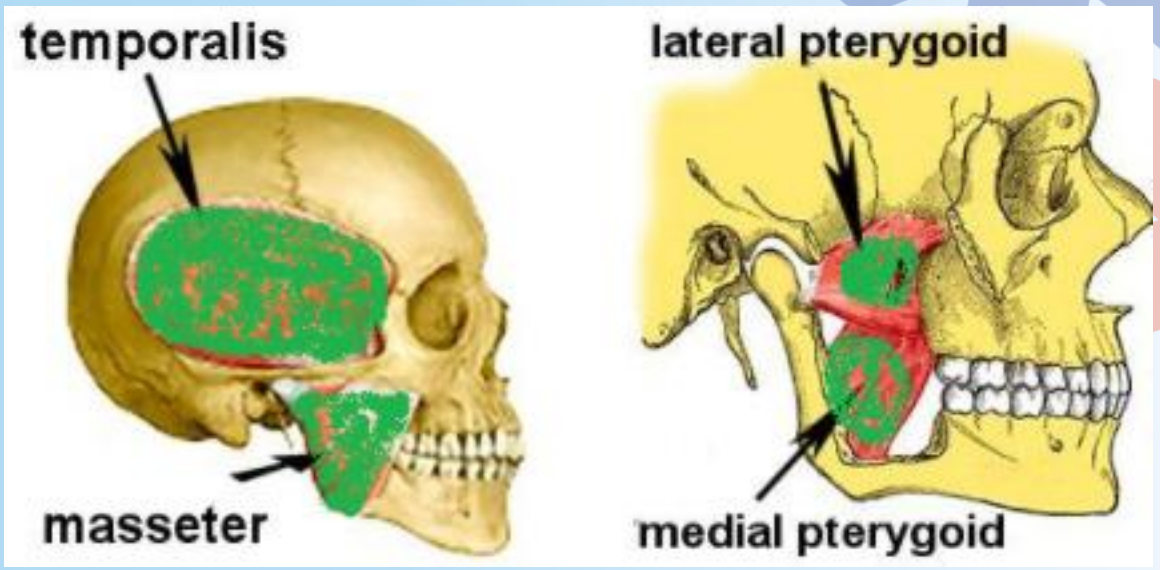
❖ *Stapes* – *neural crest cells*

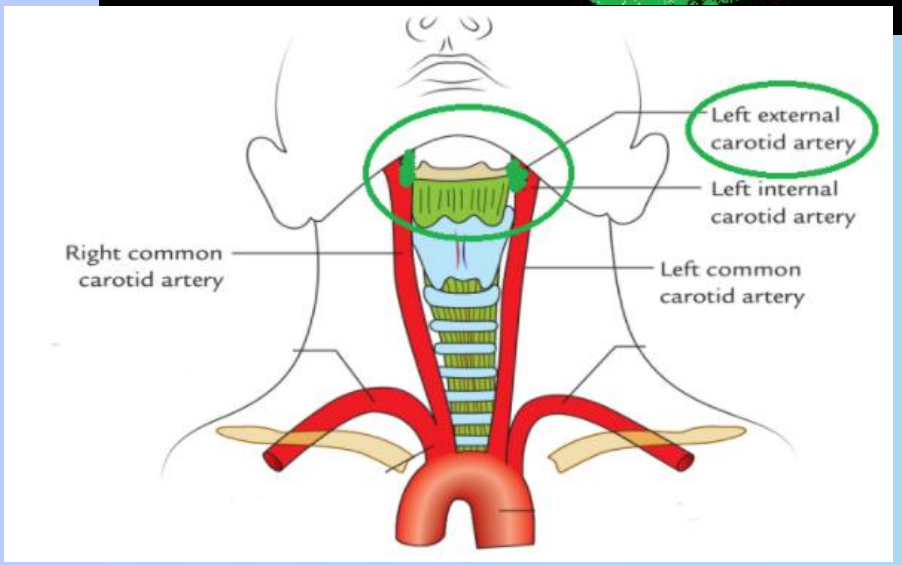
4. Muscle/muscle group («face arch»):

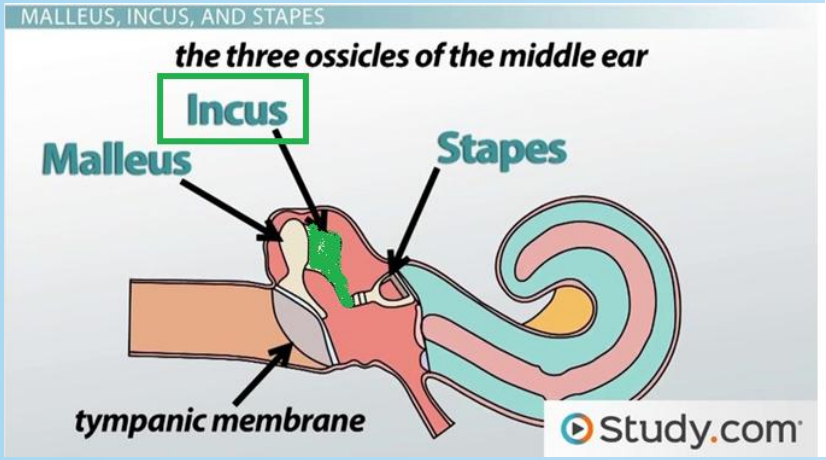
Muscles of facial expression (20 muscles)
+ Stapedius muscle

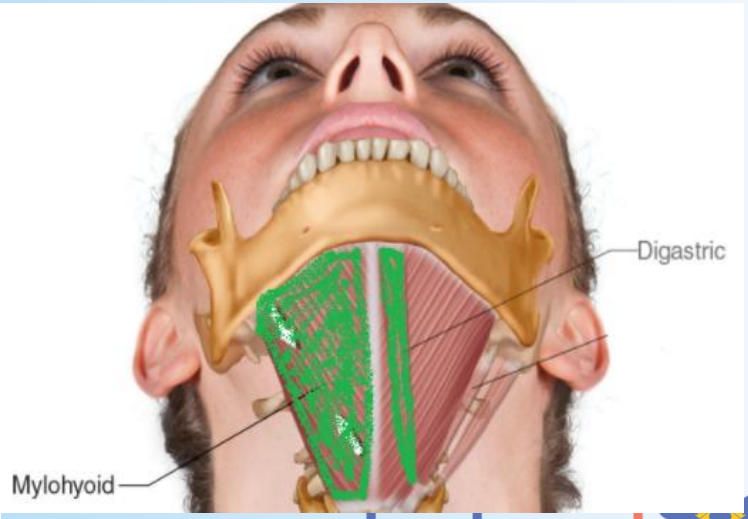
Pharyngeal arch 1 (mandibular arch):











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Pharyngeal arch 2 (hyoid arch/«face arch»/«C-arch»):

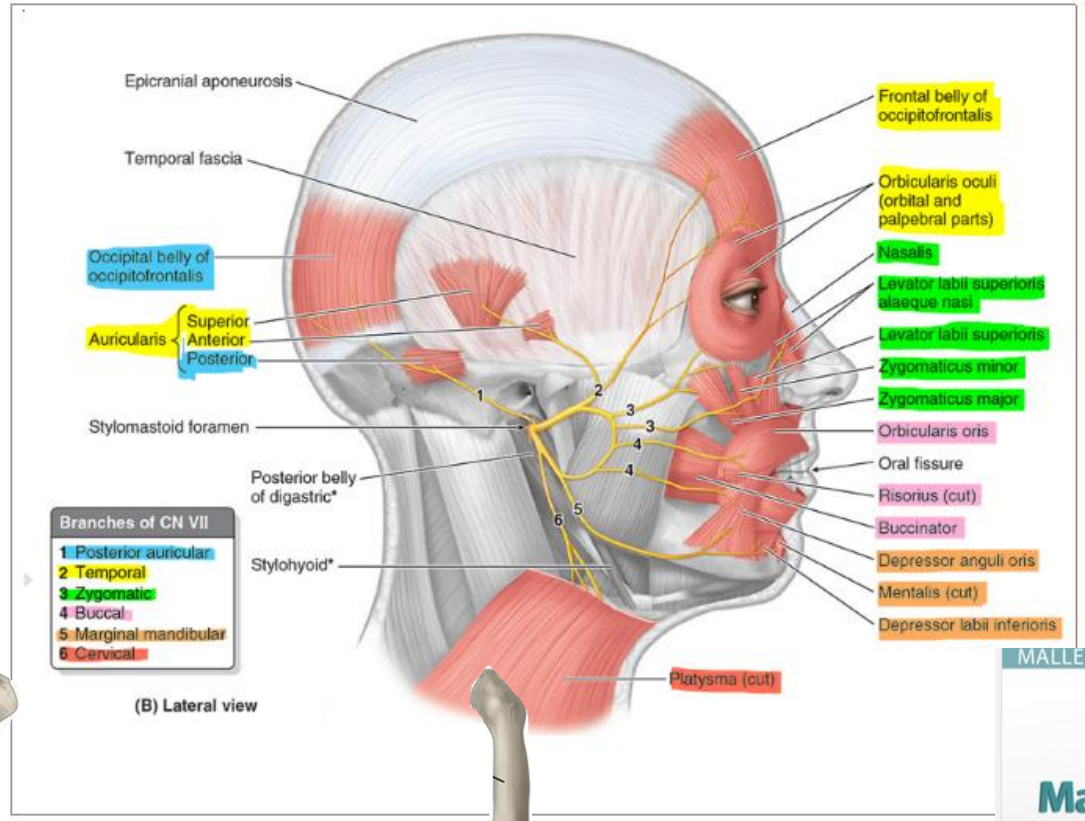
- Facial nerve supplies the muscles of facial expression and the muscles of the head and neck (which is mainly derived from the the **mesoderm, second pharyngeal arch**, during embryological stage) as a motor root. It branches out from the facial nerve plexus, which we find just posterior to the parotid gland.

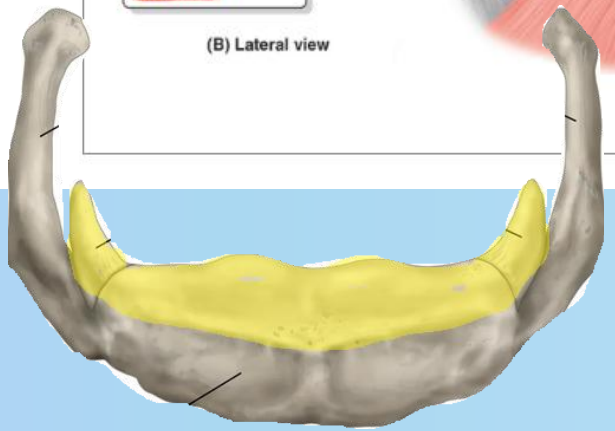
Facial expression:

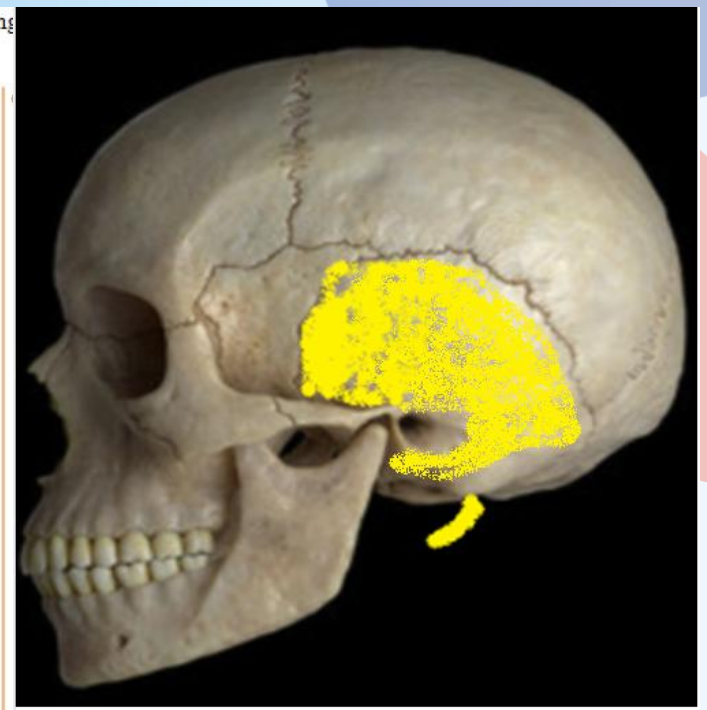
- Occipital belly of occipitofrontalis muscle
- Frontal belly of occipitofrontalis muscle.
- Corrugator supercilii muscle.
- Nasalis muscle
- Inferior part of orbicularis oculi
- Levator labii superioris
- Levator labii superioris alaeque nasi
- Zygomaticus major and minor muscles
- Buccinator muscle.
- Orbicularis oris
- Procerus.
- Superior part of orbicularis oris.
- Levator anguli oris
- Depressor labii inferioris
- Risorius muscle
- Depressor anguli oris.
- Inferior part of orbicularis oris
- Mentalis muscle

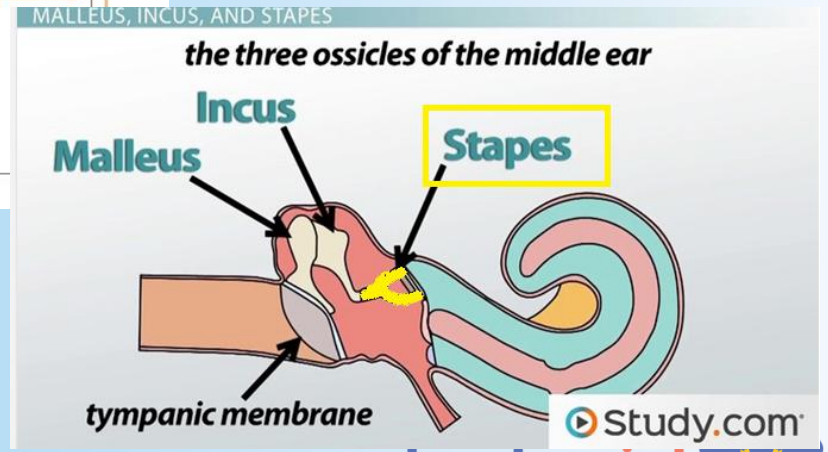
Muscles of the neck and head:

- Platysma
- Auricular muscles (anterior, superior and posterior).









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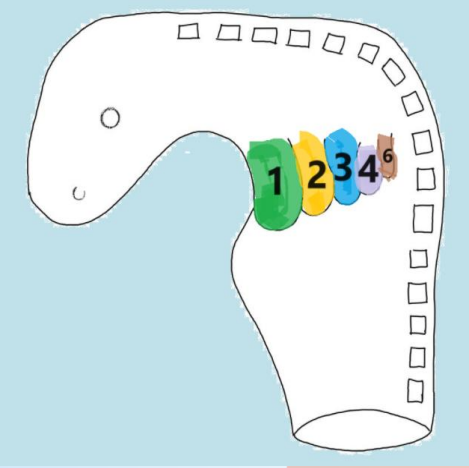


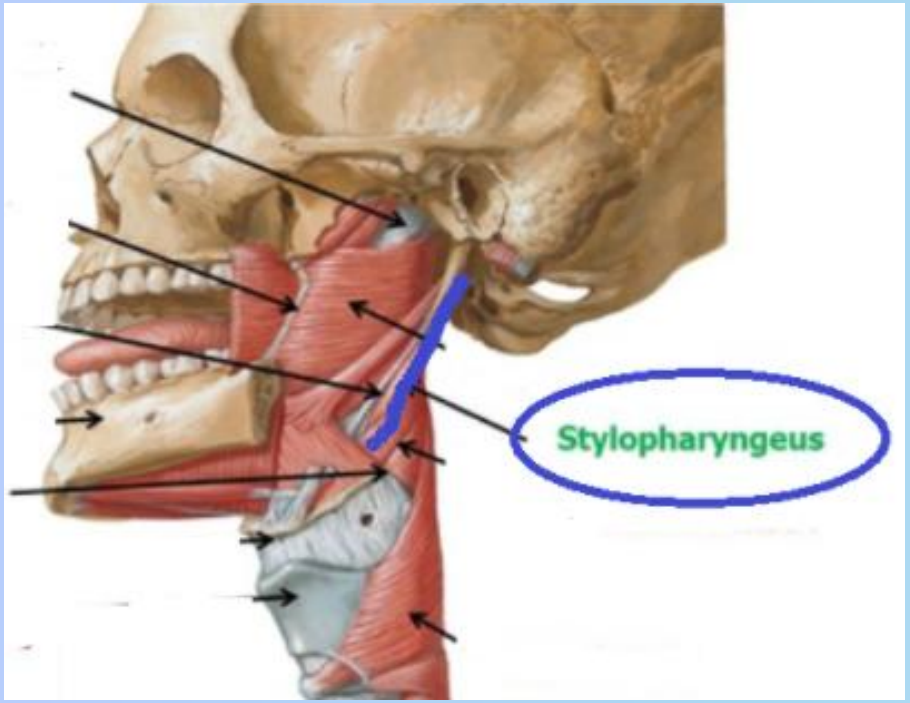
Pharyngeal arch 3

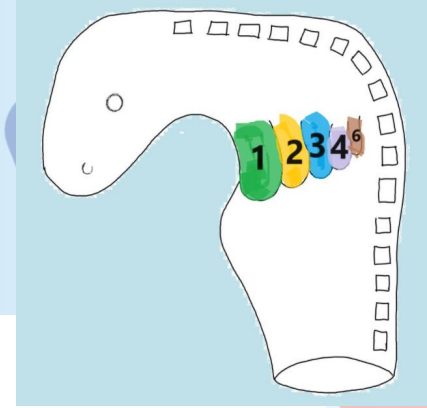
1. Artery:
Common carotid arteries + internal carotid arteries

2. Nerve:
CN IX (glossopharyngeal nerve) → *neural crest cells*

3. Cartilage/bone:
Greater horns with the lower body of hyoid bone

4. Muscle/muscle group:
Stylopharyngeus muscle


Stylopharyngeus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2
3
4
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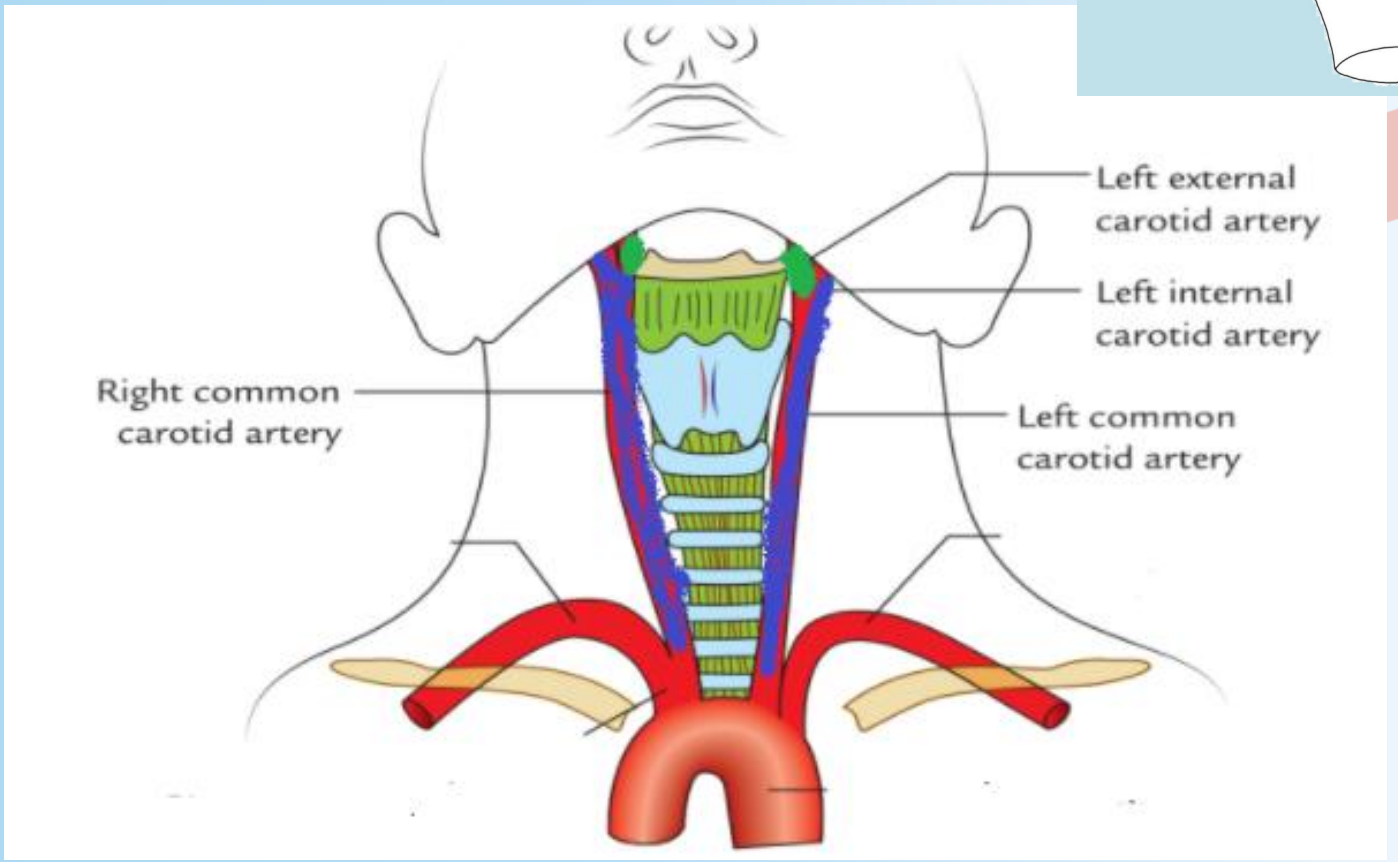
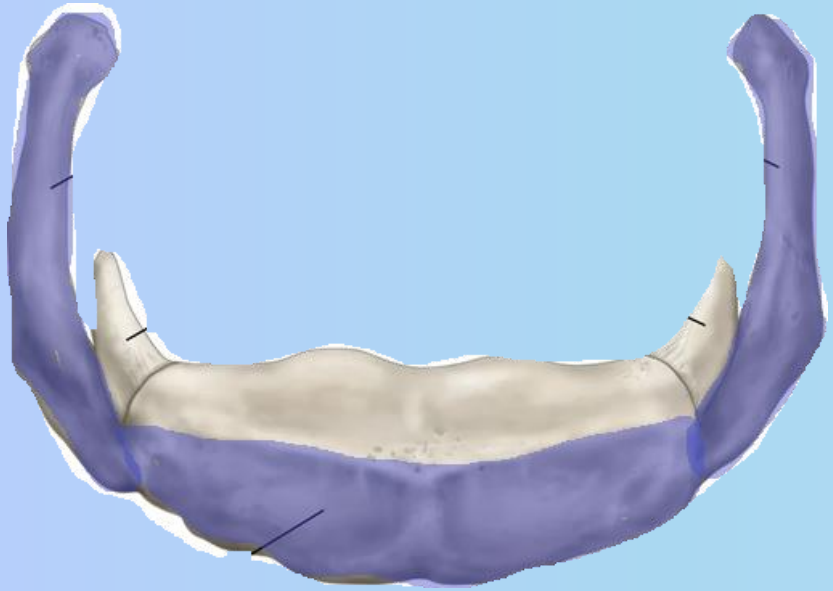
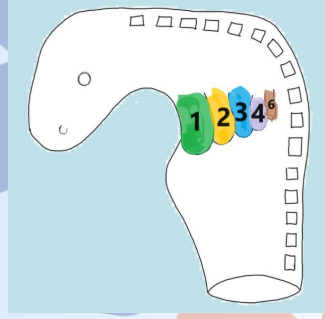

Left external carotid artery
Left internal carotid artery
Right common carotid artery
Left common carotid artery





Pharyngeal arch 4:

(«pharyngeal arch»)

1. Artery:

Proximal part of the right subclavian artery and arch of aorta.

2. Nerve

CN X (**superior laryngeal** branch of vagus nerve) → *neural crest cells*

3. Cartilage:

Laryngeal cartilages *(no bones)*

4. Muscle/muscle group

(pharyngeal area):
Superior, middle and inferior pharyngeal constrictor muscles +
cricothyroid muscle and ***palatoglossus muscle***

Pharyngeal arch 6:

(«laryngeal arch»)

1. Artery:

Pulmonary arteries and ductus arteriosus.

2. Nerve:

CN X (**recurrent laryngeal** branch of vagus nerve) → *neural crest cells*

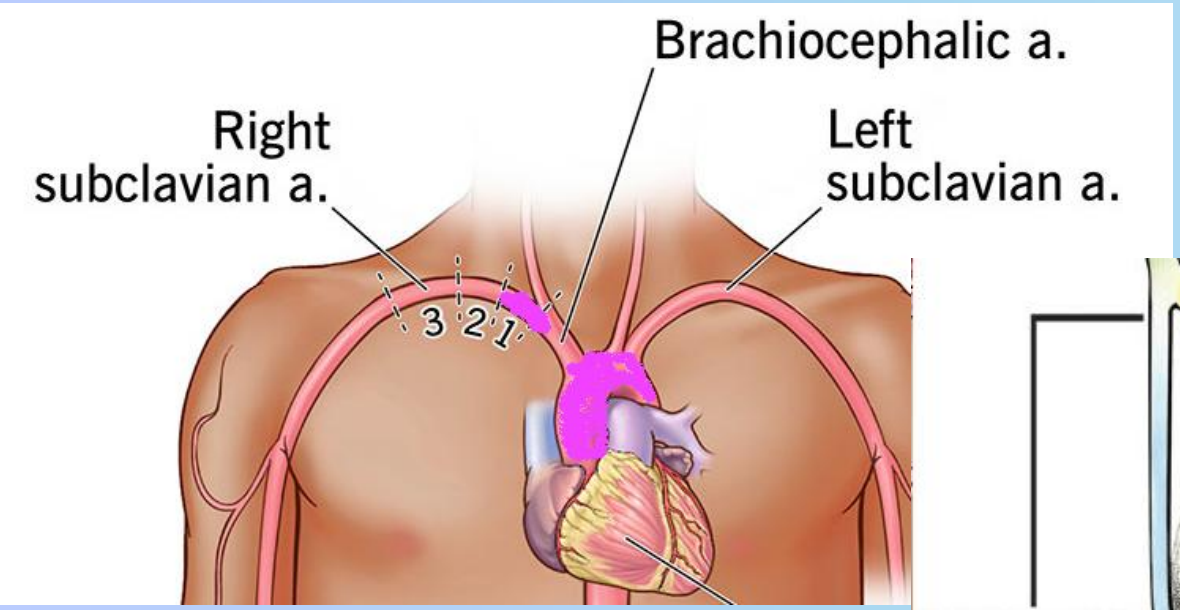
3. Cartilage:

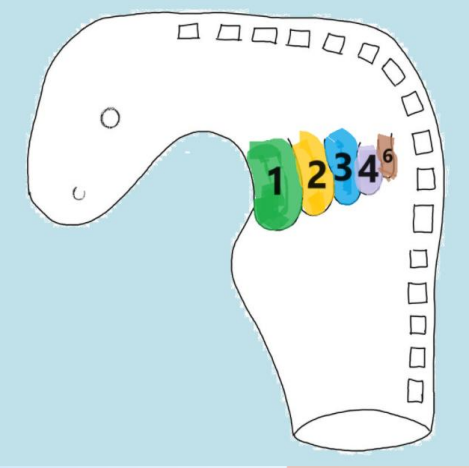
Laryngeal cartilages *(no bones)*

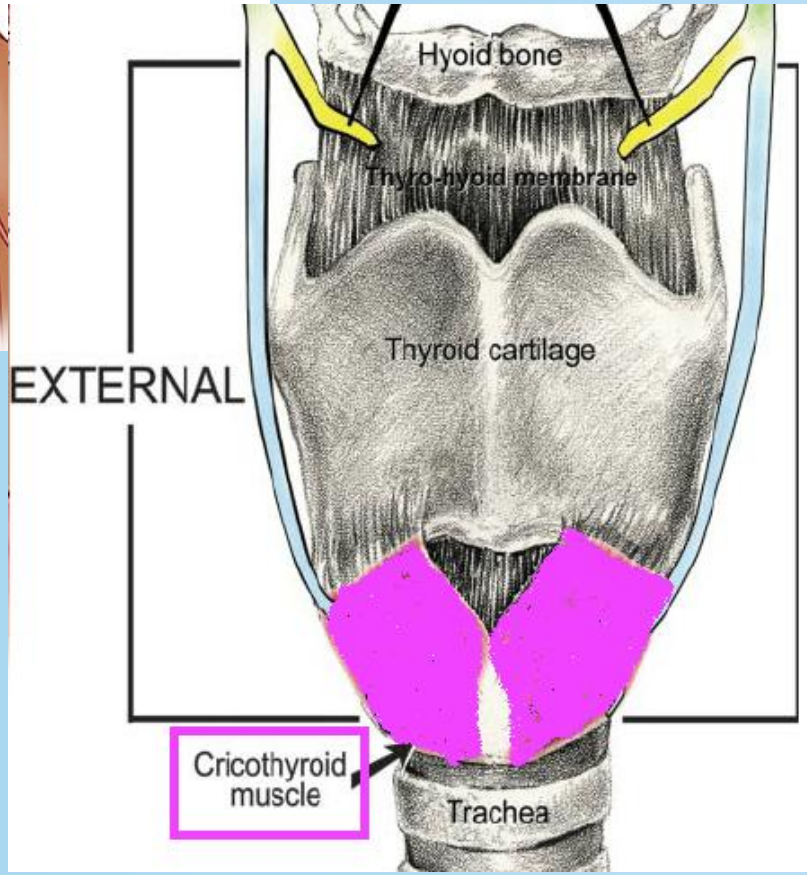
4. Muscle/muscle group

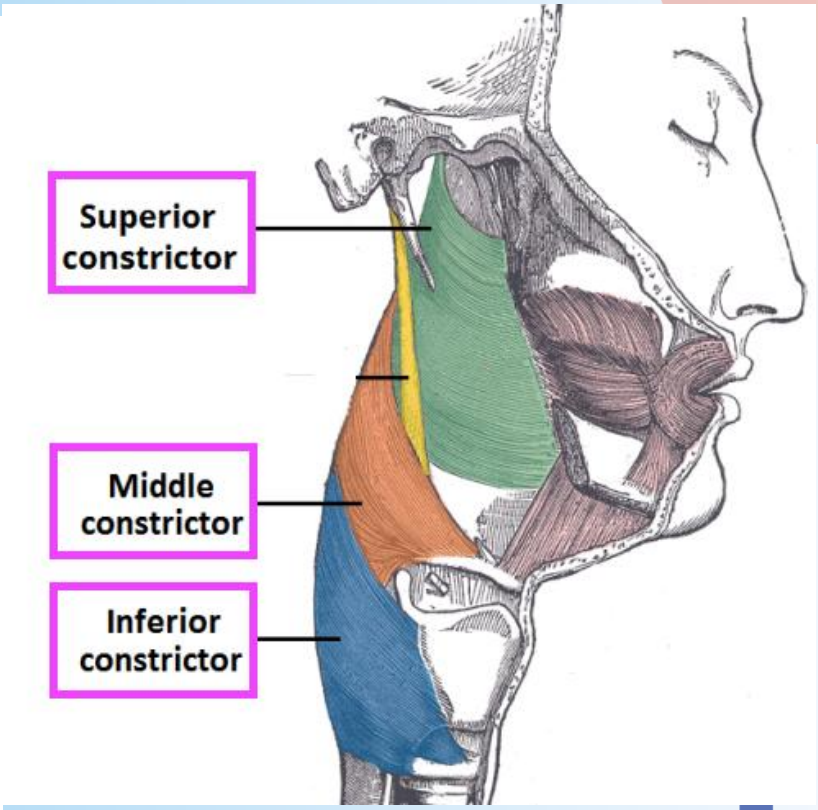
(laryngeal area):
Lateral and posterior cricoarytenoid muscles

Pharyngeal arch 4:









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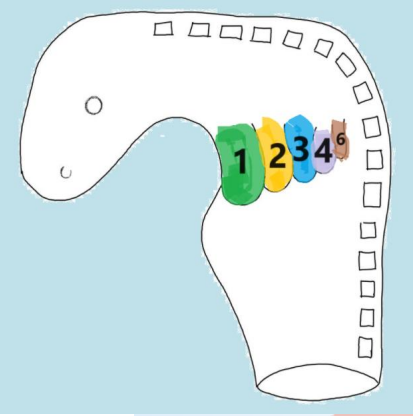
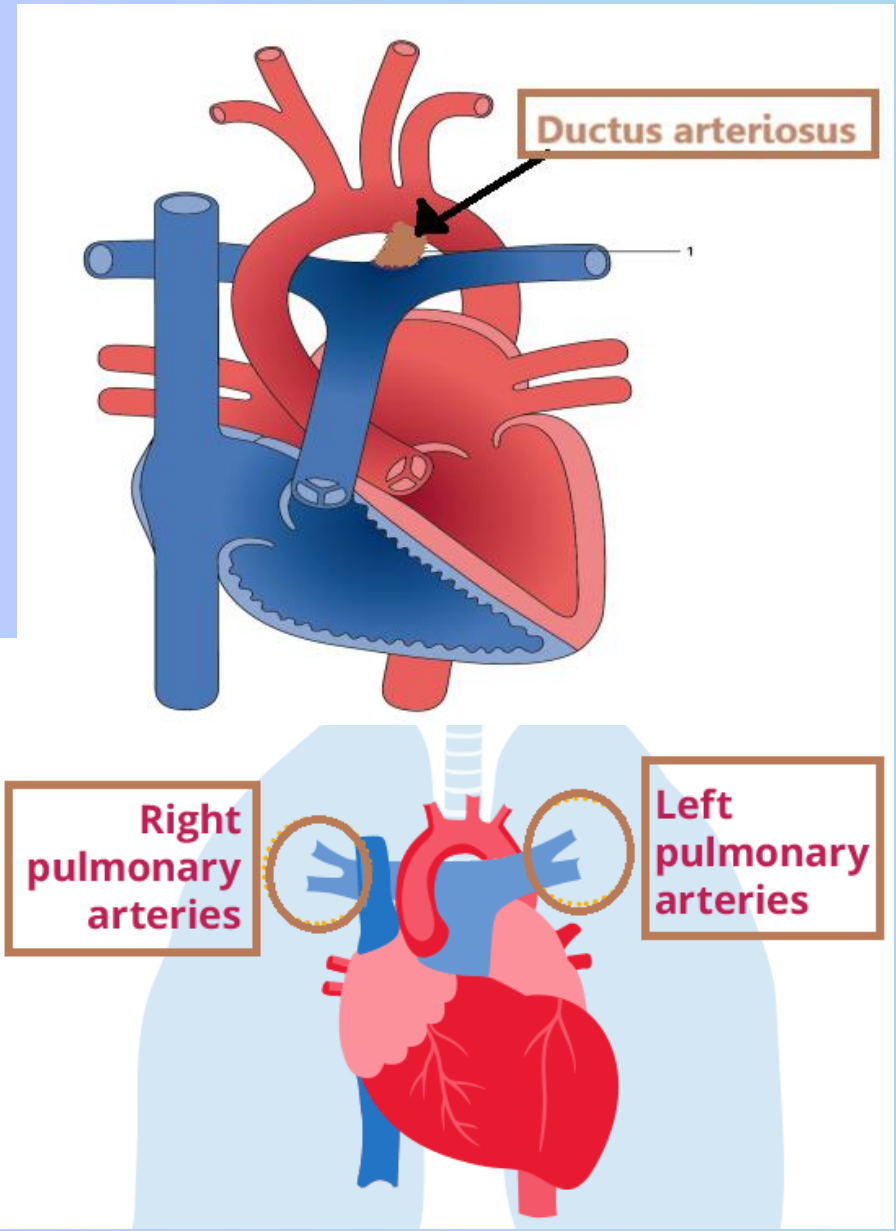
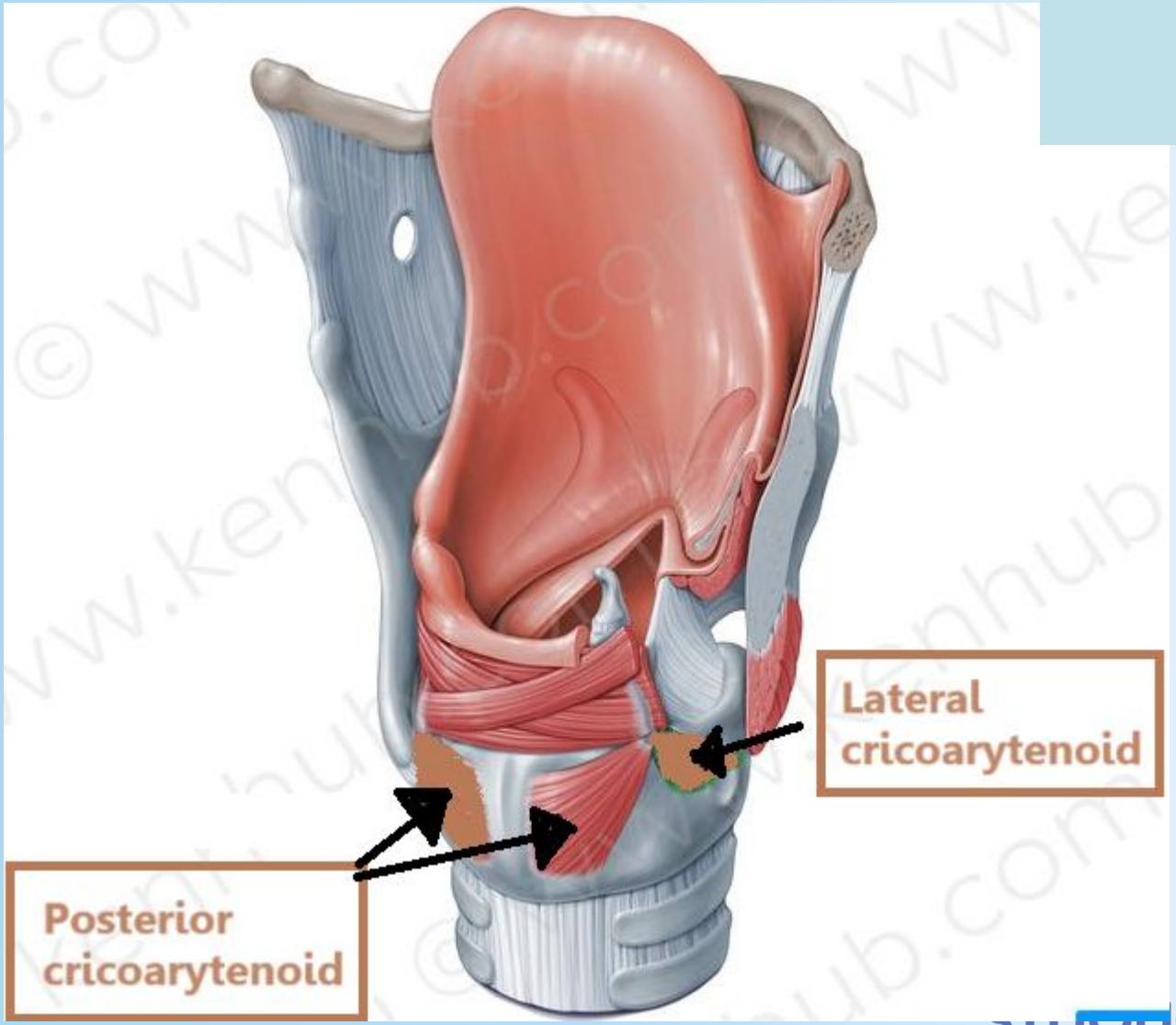
Pharyngeal arch 6:







How to memorize which cranial nerve relates to which arch

Arch	Nerve
First (mandibular)	Trigeminal[†] (CN V)
Second (hyoid)	Facial (CN VII)
Third	Glossopharyngeal (CN IX)
Fourth and sixth[‖]	Superior laryngeal branch of vagus (CN X) Recurrent laryngeal branch of vagus (CN X)

Start on cranial nerve five (trigeminal)

+2 Add two (5+2 = 7)

+2 Add two (7 + 2 = 9)

+1 Add one (9 + 1 = 10)

These four cranial nerves are the ones relevant to pharyngeal arches

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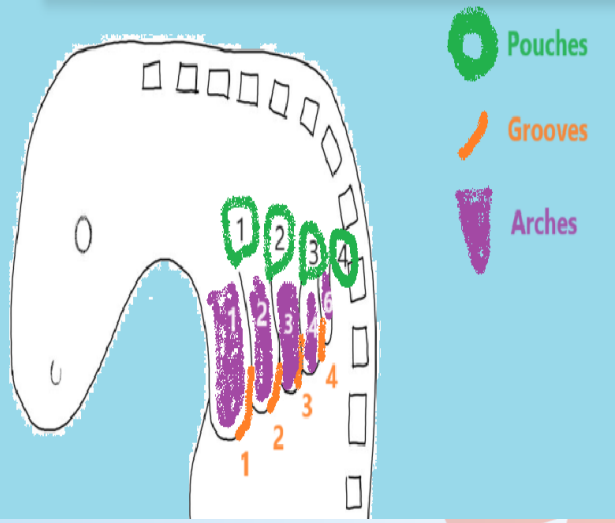
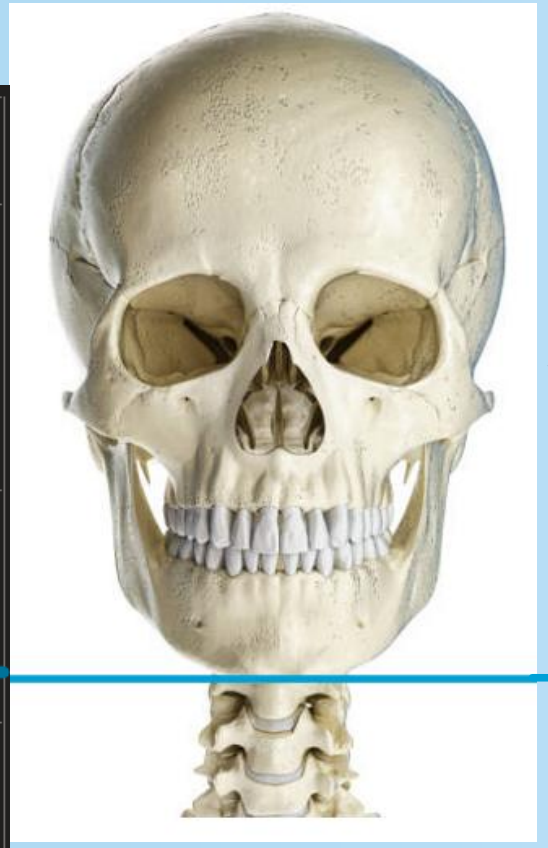
Pharyngeal pouches overview

- Pouches = Endoderm, cuboidal cells (+ stratified squamous cells and columnar cells)

Pouch	Structure
1	Epithelial lining of Eustachian tube and tympanic cavity (middle ear) + Mastoid air cells.
2	Epithelial lining of palatine tonsils (crypts and tonsillar fossa)
3	Inferior parathyroid gland + Thymus
4	Superior parathyroid gland + Ultimobranchial body (C-cells of thyroid)





Above the mandible (pouch 1 & 2)
(ear + palatine tonsils):

Cuboidal cells in all except for crypts of palatine tonsil
(stratified squamous cells)

Below the mandible (pouch 3 & 4)
(parathyroid gland + thymus + thyroid C-cells)

Columnar cells
in pouch 1

Cuboidal cells in all except for thymus (Specialised squamous cells) and crypts of P.tonsils

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Pouch	Structure
1	Epithelial lining of Eustachian tube and tympanic cavity (middle ear) + Mastoid air cells.
2	Epithelial lining of palatine tonsils (crypts and tonsillar fossa)
3	Inferior parathyroid gland + Thymus
4	Superior parathyroid gland + Ultimobranchial body (C-cells of thyroid)

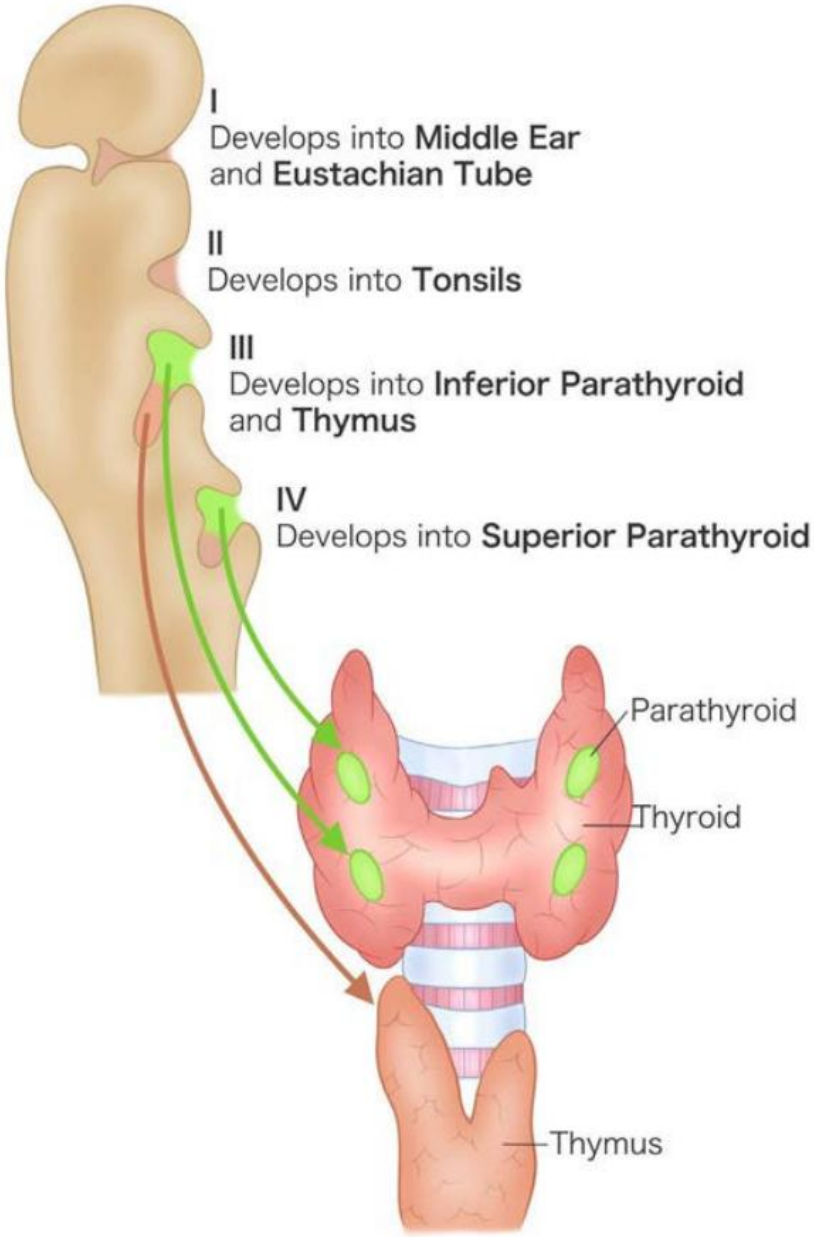


Fig. 25. Schematic drawing depicting the embryology of the parathyroid glands.

Pharyngeal grooves (also called clefts)

- Grooves = Ectoderm ~~(columnar)~~
  → Stratified squamous epithelium

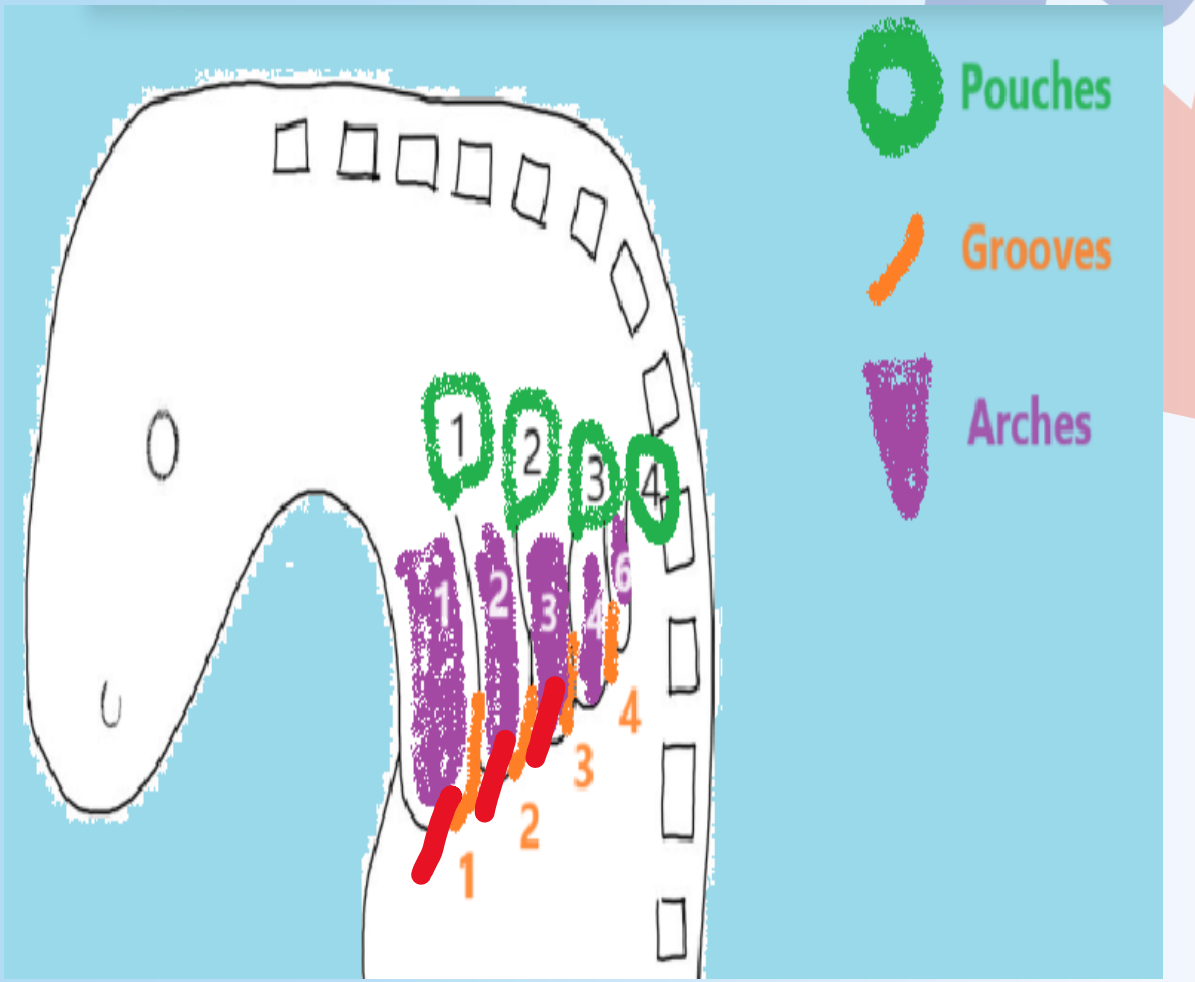
- **Groove 2-4 obliterates in utero (between 5th - 7th week of pregnancy)**

- **Groove 1:**
  - Epithelial lining of the external auditory canal
  + external part of the tympanic membrane

Do we need secretory cells in the external ear canal?

Columnar cells will *transition*:
Columnar → Stratified squamous epithelium in a metaplasia process.

- Stratified cells are for protection – we want those!



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Review slides (tables)

Pharyngeal arch 1 (mandibular arch):

Arteries	Maxillary artery and external carotid artery
Nerve	CN V (Trigeminal nerve)
Cartilage/bone/ligament	**Bones:** Maxilla, zygomatic, squamous part of temporal bone and mandible **Ossicles:** Incus and Malleus **Ligaments:** Sphenomandibular ligament and anterior ligament of malleus
Muscles	**Muscles of mastication** (Masseter, Temporalis, Medial pterygoid and Lateral pterygoid) + Mylohyoid, tympanic tensor muscle and anterior digastric muscle

Pharyngeal arch 2 (hyoid arch) «face arch»/«C-arch» / «stape-arch»):

Arteries	Proximal part of stapedial artery
Nerve	CN VII (Facial nerve)
Cartilage/bone/ligament	- Petromastoid part of temporal bone - Styloid process - Lesser horn with upper body of hyoid bone
Muscles	Muscles of facial expression + stapedius muscle

Pharyngeal arch 3

Arteries	Common carotid arteries + internal carotid arteries
Nerve	CN IX (Glossopharyngeal nerve)
Cartilage/bone/ligament	Greater horns with the lower body of hyoid bone
Muscles	Stylopharyngeus muscle

Pharyngeal arch 4:

Arteries	Proximal part of the subclavian artery and arch of aorta
Nerve	CN X (Superior laryngeal branch of Vagus nerve)
Cartilage/bone/ligament	Laryngeal cartilage (no bones)
Muscles	Superior, middle and inferior pharyngeal constrictor muscles, cricothyroid muscle and palatoglossus muscle

Pharyngeal arch 6:

Arteries	Pulmonary arteries and ductus arteriosus
Nerve	CN X (Recurrent laryngeal branch of Vagus nerve)
Cartilage/bone/ligament	Laryngeal cartilage (no bones)
Muscles	Lateral and posterior cricoarytenoid