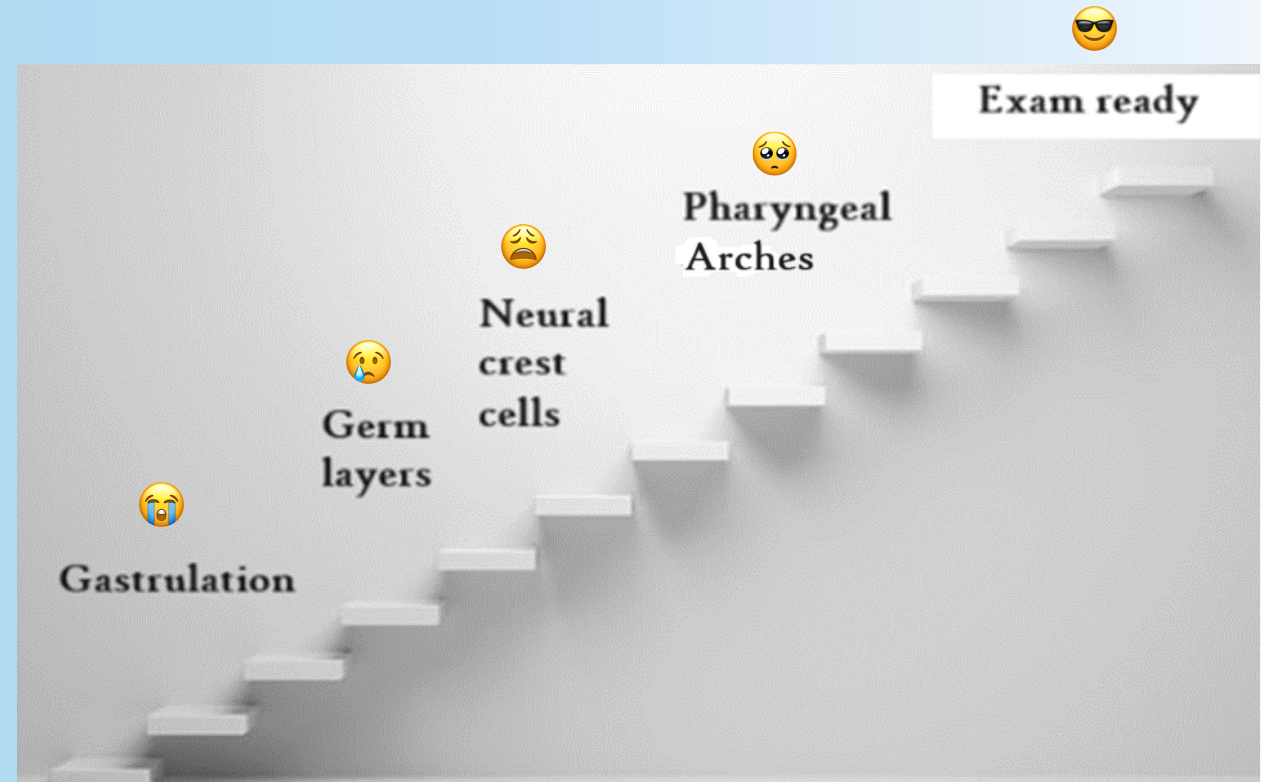


Embryology of head & neck

Overview

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

Use the slides later for repetition to the final exam!



Basic embryology - germ layers

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

Ectoderm

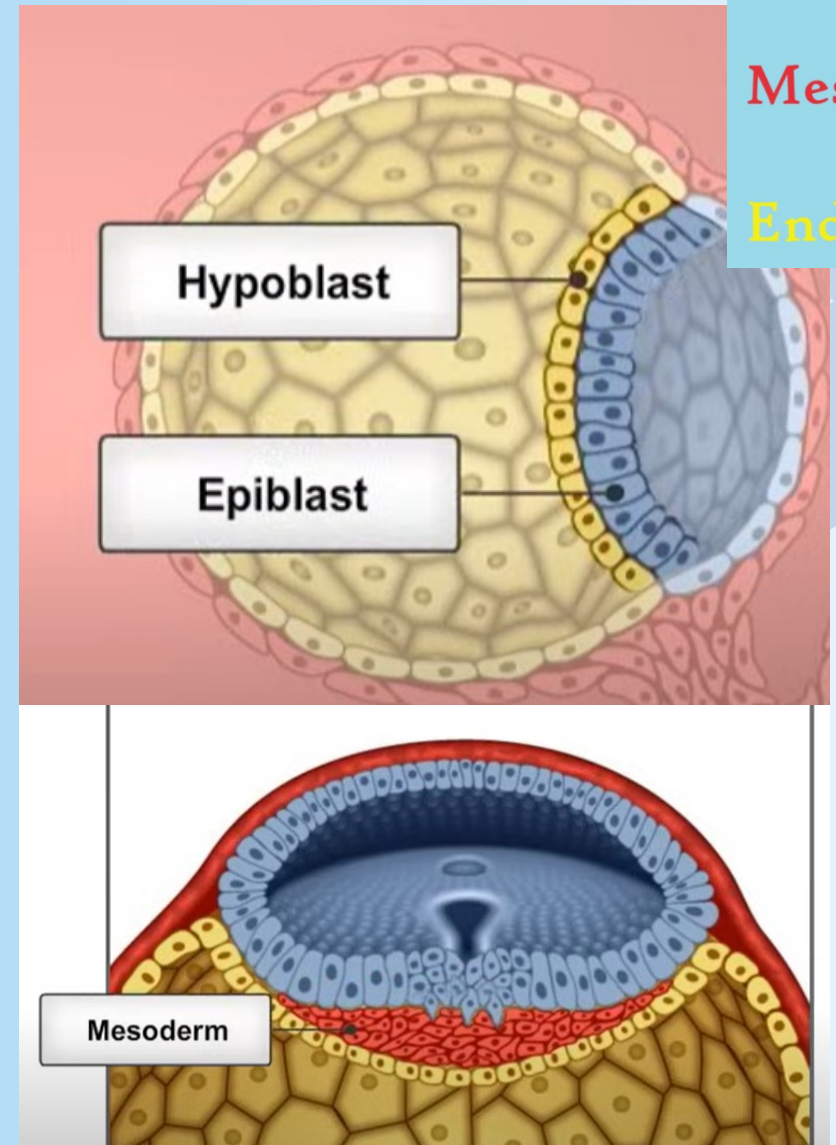
Mesoderm

Endoderm

Gastrulation

- Epiblast = **Ectoderm** (columnar cells)
 - Hypoblast = **Endoderm** (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 memorize?



Ectoderm

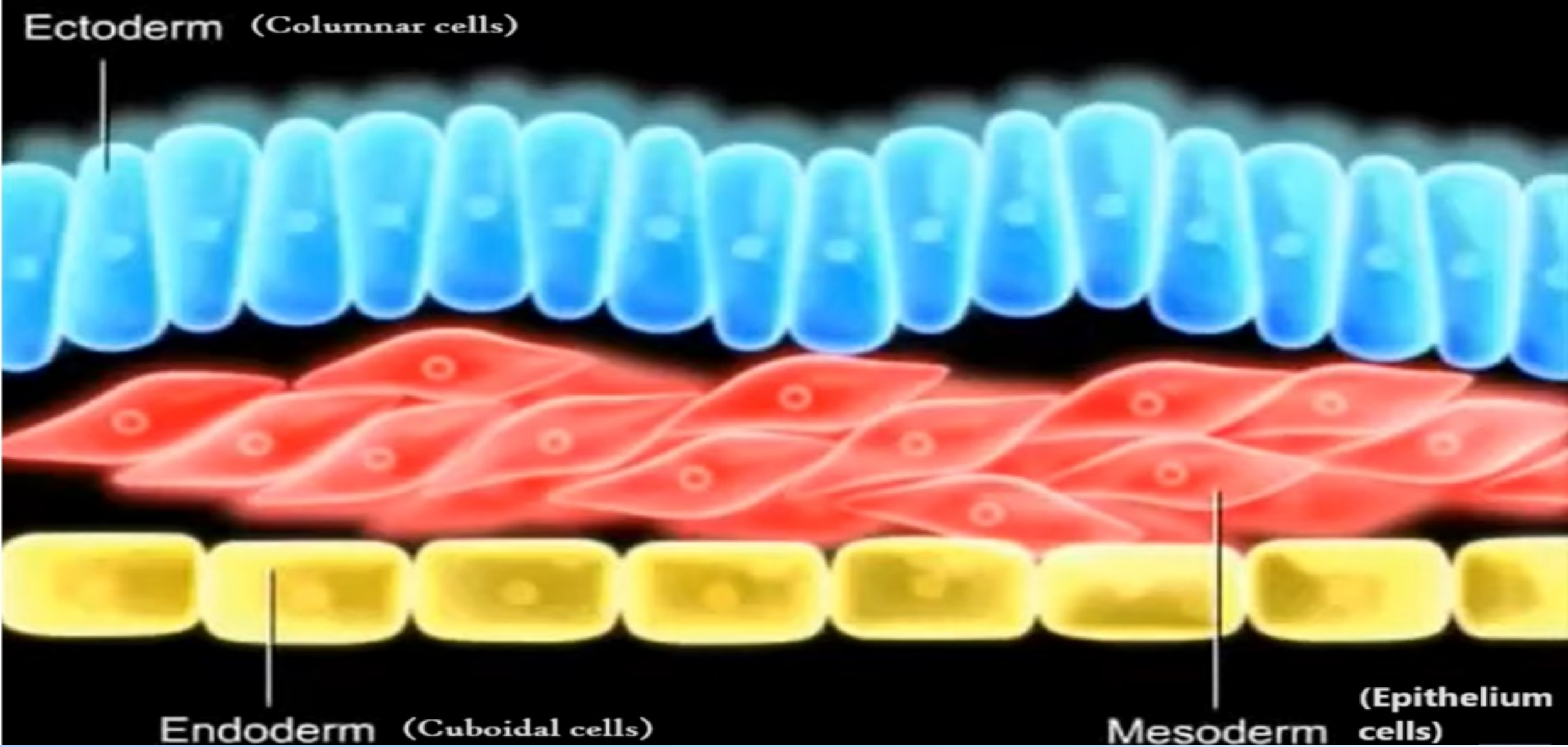
Mesoderm

Endoderm

Hypoblast

Epiblast

Mesoderm



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

table 4.1 Germ Layer Derivatives

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

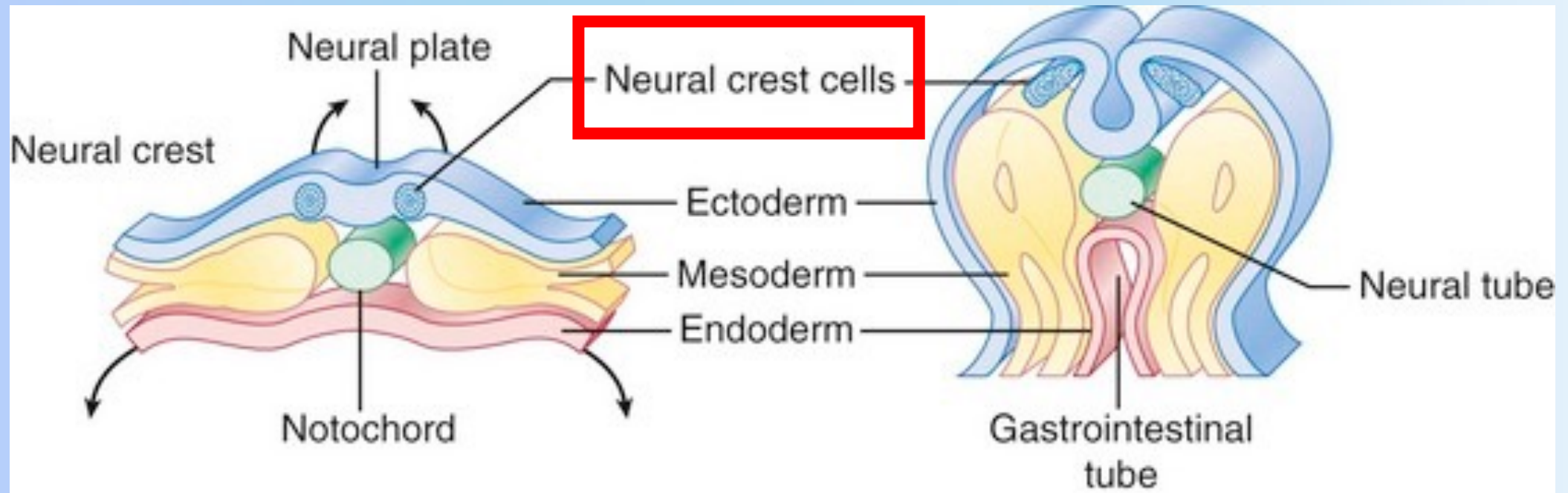


Ectoderm

Ectoderm

Mesoderm

Endoderm



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, tanocytes, 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

Trunk neural crest cells:

Melanocytes

Schwann cells

Chromaffin cells of adrenal medulla

Dorsal root ganglia

Sympathetic chain ganglia

Prevertebral sympathetic ganglia

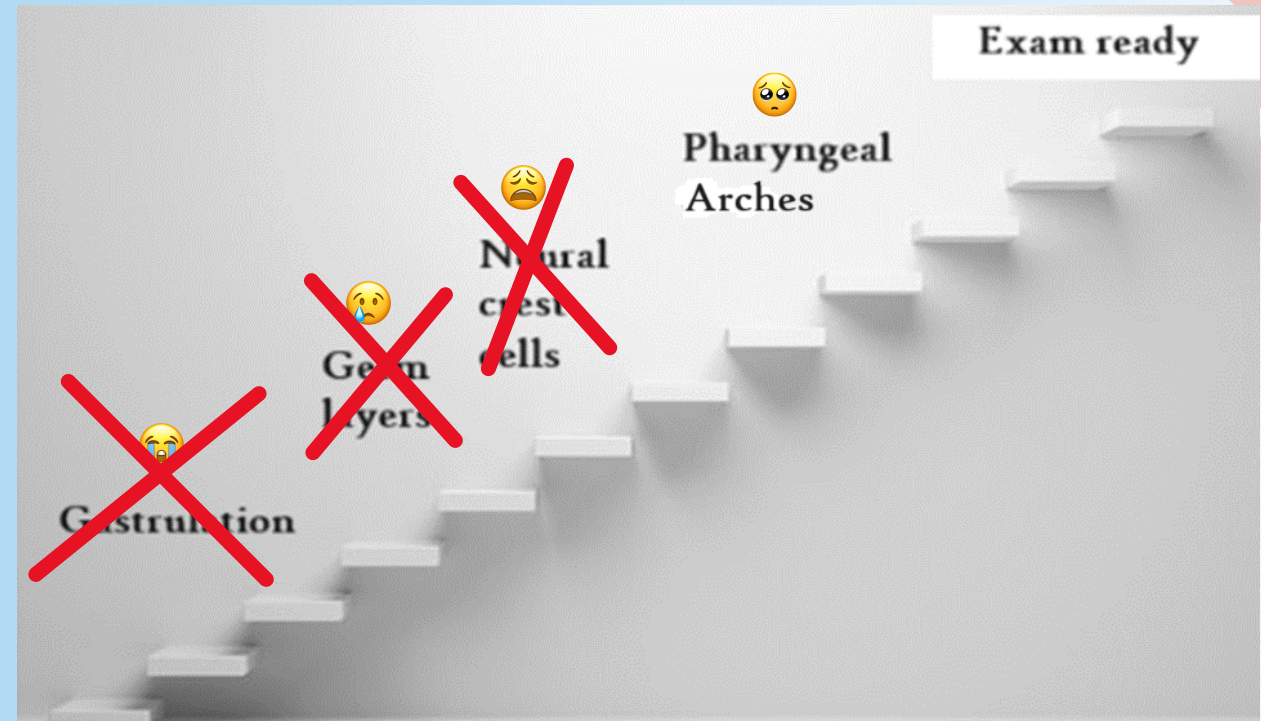
Enteric parasympathetic ganglia of the gut (Meissner and Auerbach; CN X)

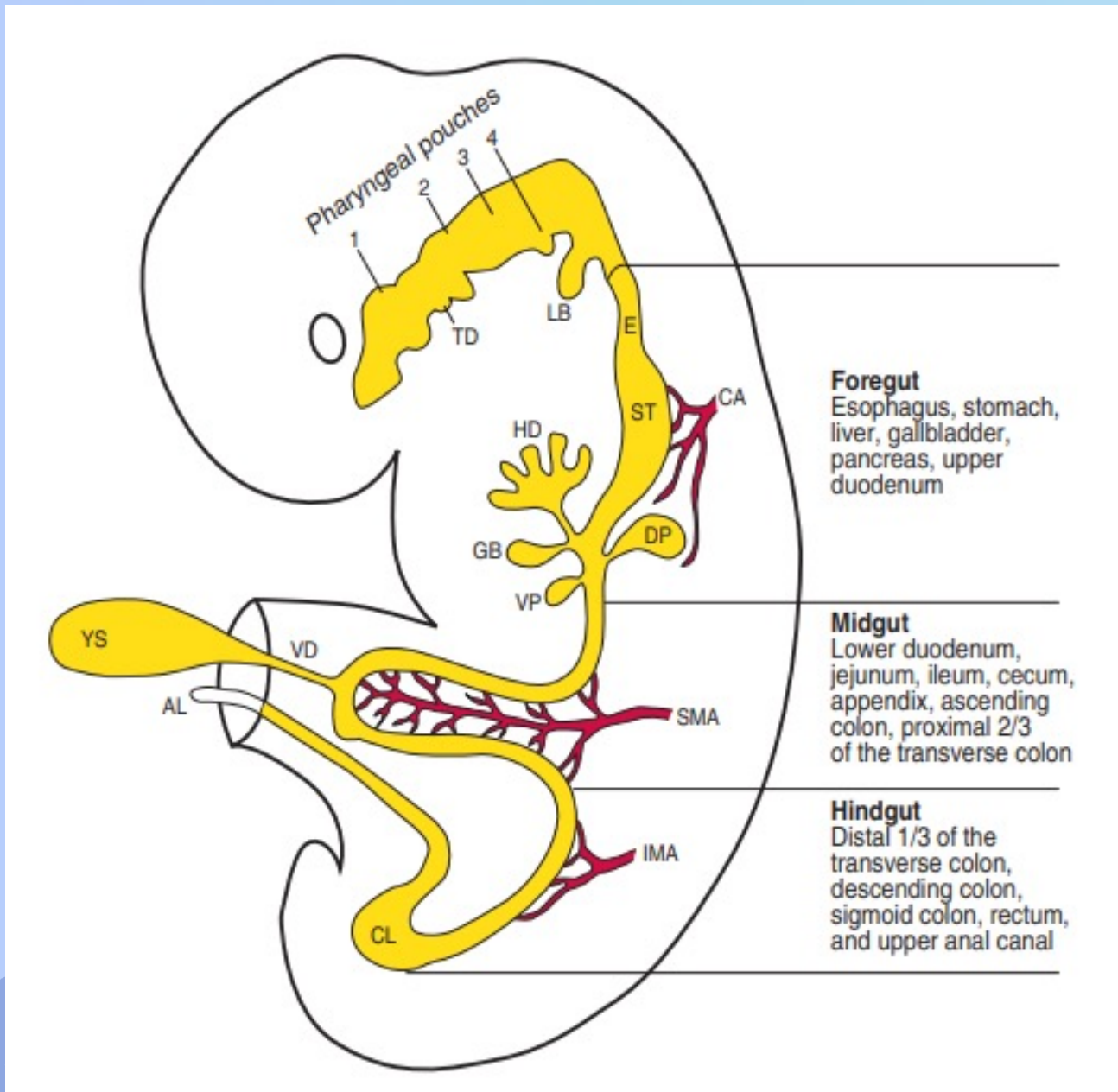
Abdominal/pelvic cavity parasympathetic ganglia

Parasympathetic ganglia!

Overview

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





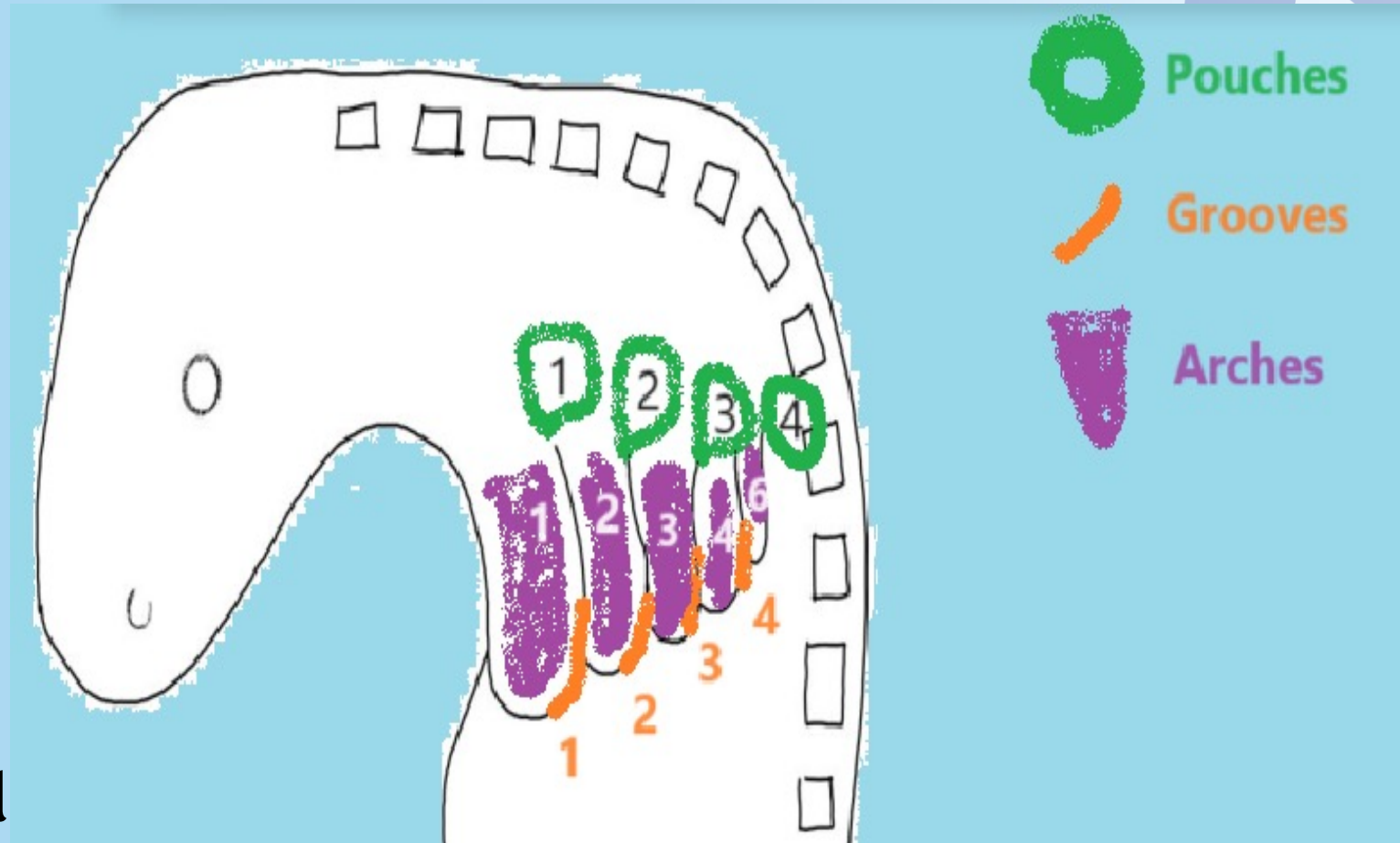
- Pharyngeal arches, pouches and grooves are specific for head & neck embryology, and is not part of foregut - they only surround the foregut.

Arches, pouches and grooves

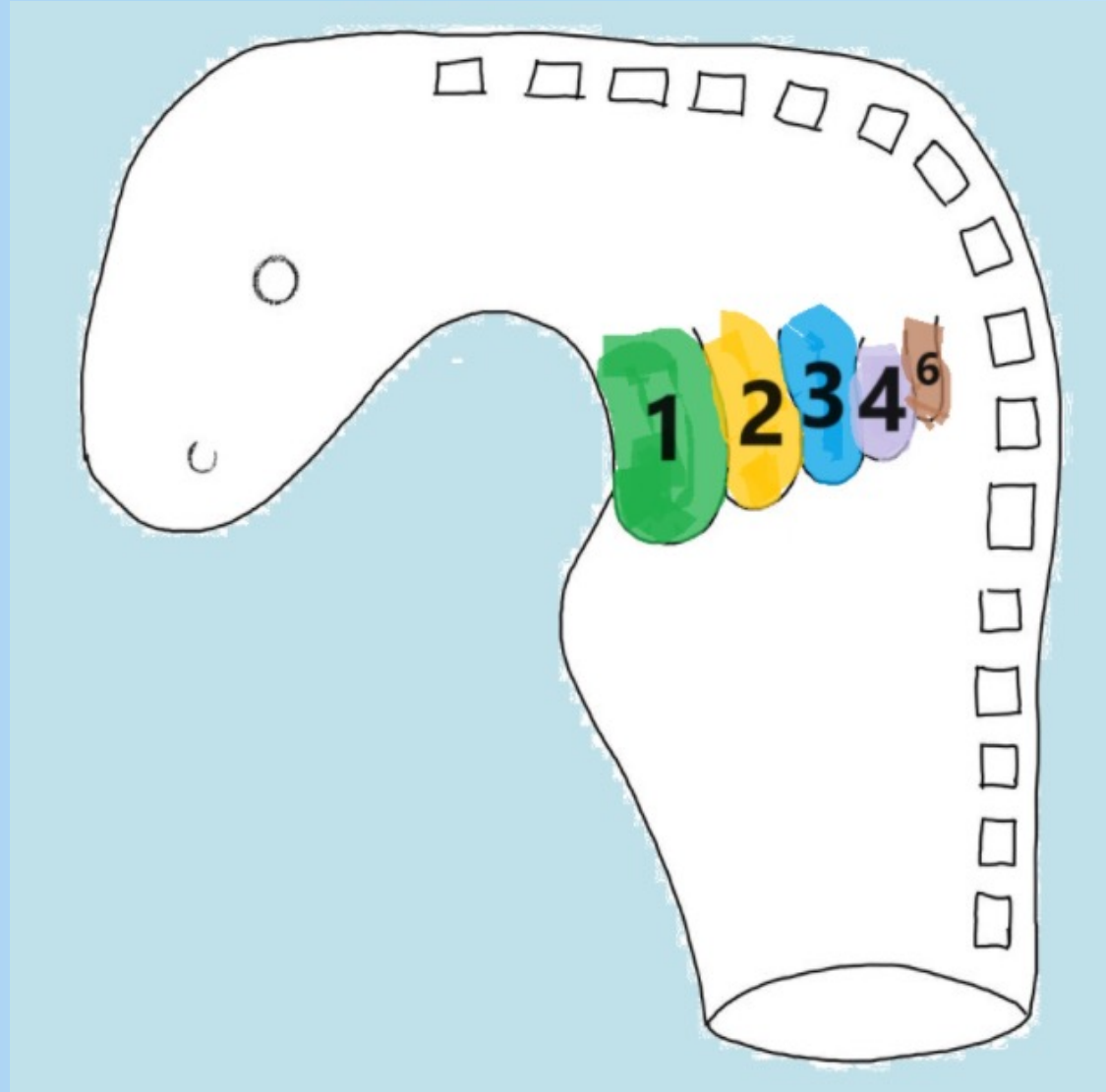
- The 5th arch, pouch or groove does not exist.

Basic rule for separation:

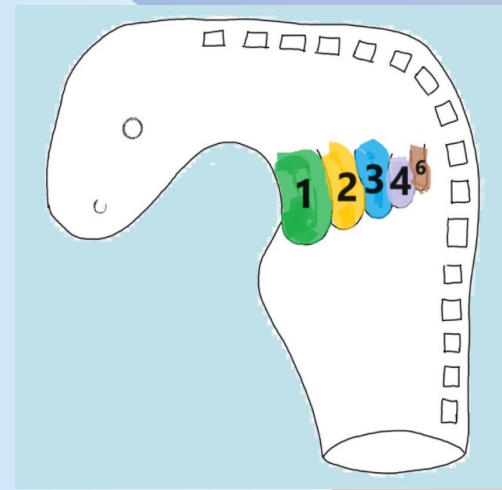
- Arches = Mesoderm (epithelium)
 - Pouches = Endoderm (cuboidal)
 - Grooves = Ectoderm (columnar)
-
- The further «out» we move, the further down the neck we go.
-
- Do not forget about neural crest cells!



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

Ciliary (CN III), pterygopalatine (CN VII), submandibular (CN VII), and otic (CN IX) parasympathetic ganglia

- One arch contains:

1. One or more arteries

2. Cranial nerve/branches related to the cranial nerve - which often innervates the muscles that derives from the arch.

3. Bone(s)/cartilage

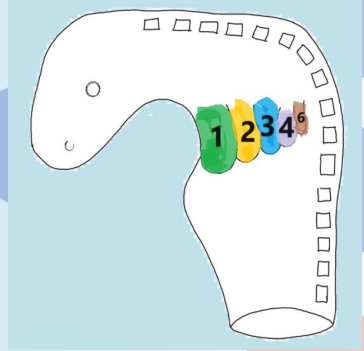
4. Muscles or specific muscle groups

- 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.

Pharyngeal arch 1 and 2



Pharyngeal arch 1 (mandibular arch):

1. Artery:

Portion of maxillary artery and external carotid artery

2. Nerve:

CN V (trigeminal, mandibular branch) → *neural crest cells*

3. Cartilage/bone:

- Maxillary prominence:

(Maxilla, zygomatic bone, squamous part of temporal bone).

❖ Incus (the «anvil») - neural crest cells.

- Mandibular prominence:

(Mandible, malleus).

4. Muscle/muscle group:

Muscles of mastication:

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

Pharyngeal arch 2 (hyoid arch)

(«face arch» / «C-arch» / «stape arch»):

1. Artery:

Portion of stapedial artery (derivates from hyoidal artery, which disappears)

2. Nerve:

CN VII (facial nerve) → *neural crest cells*

3. Cartilage/bone:

Temporal bone. styloid process and lesser horn of hyoid bone.

❖ Stapes - neural crest cells

4. Muscle/muscle group:

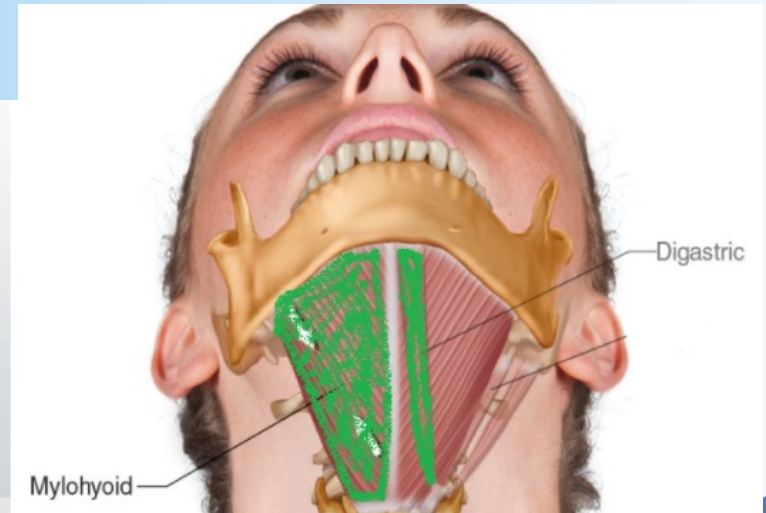
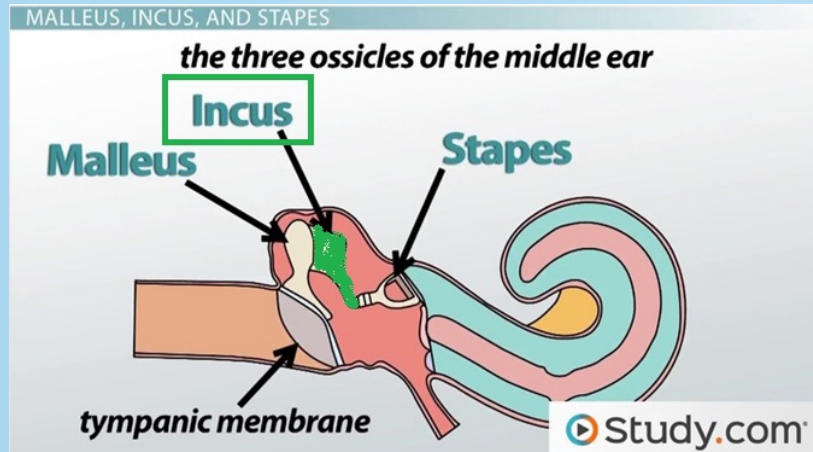
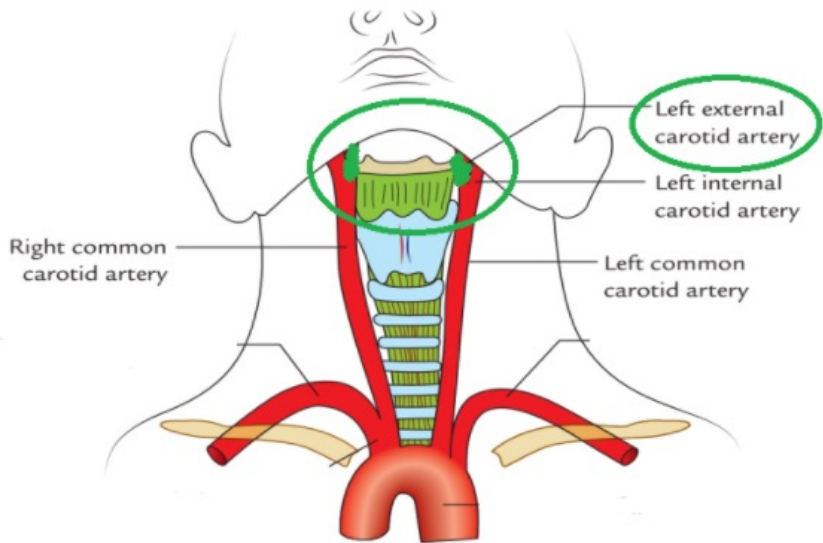
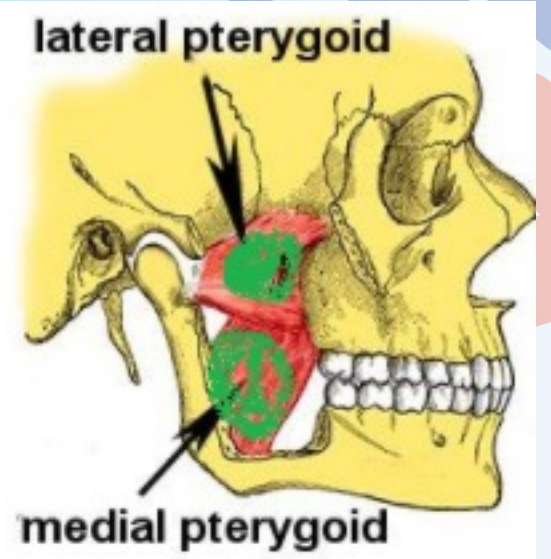
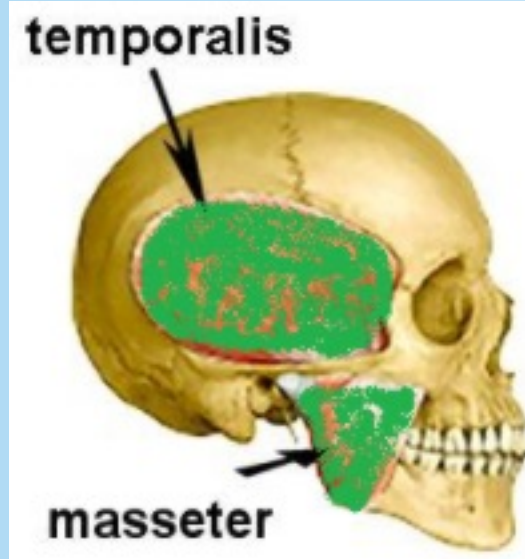
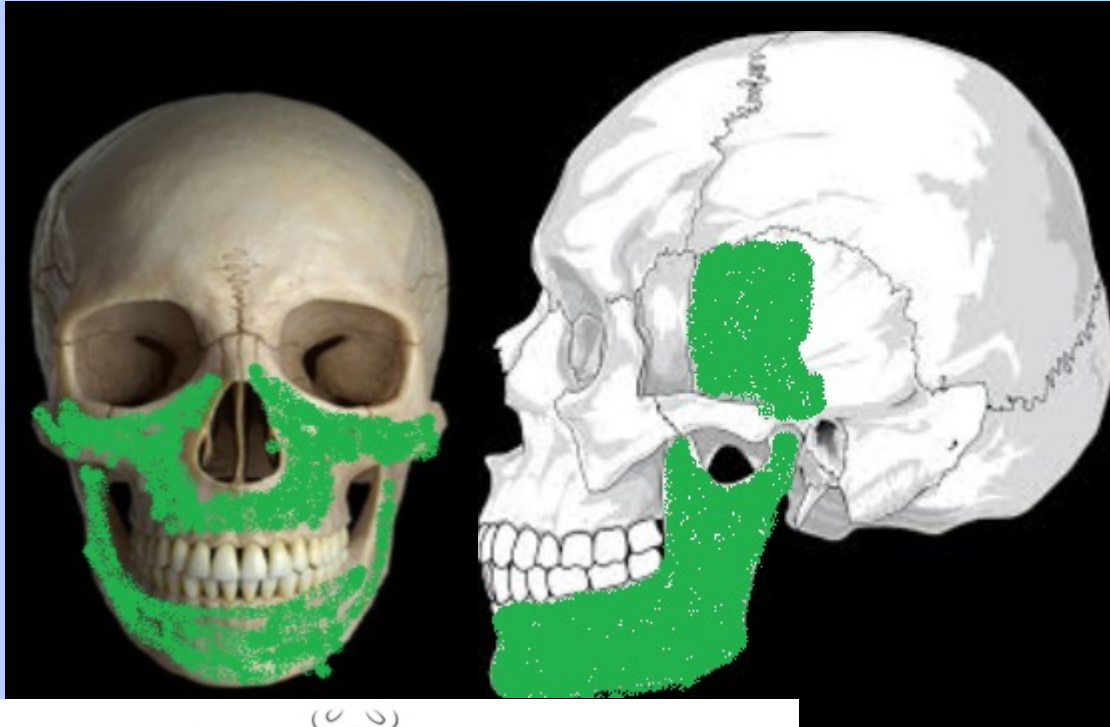
Muscles of facial expression (20 muscles)

Stapedius muscle

One exception on each arch!



Pharyngeal arch 1 (mandibular arch):



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

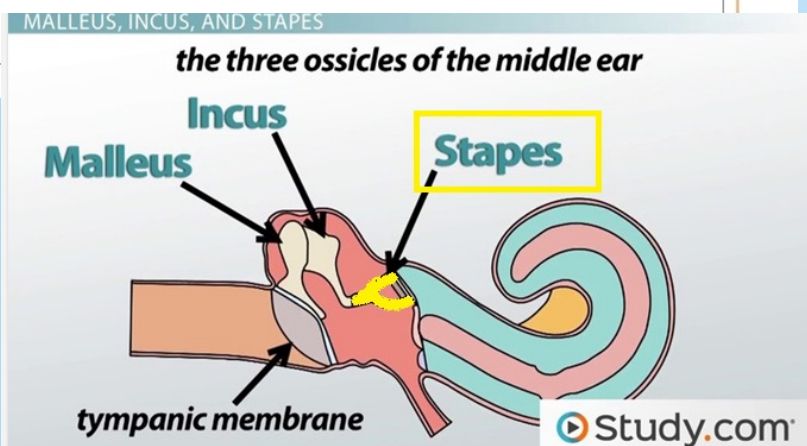
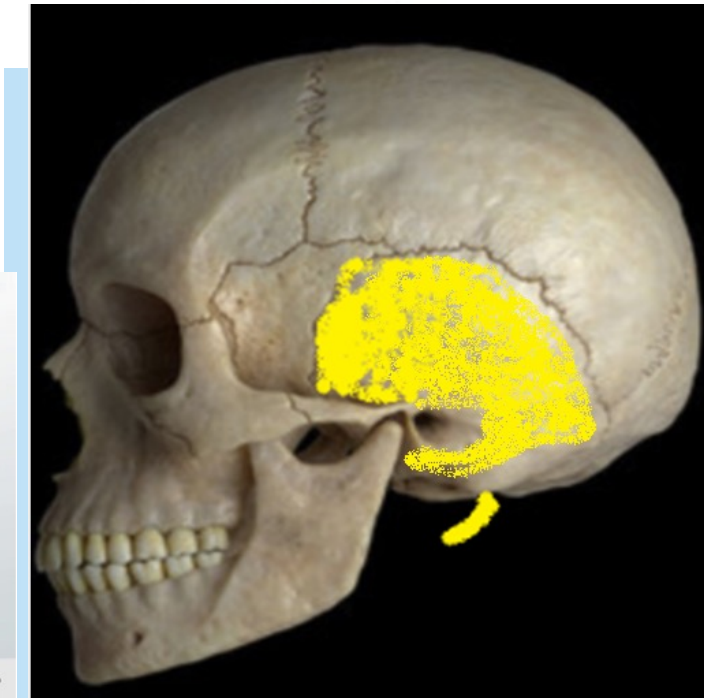
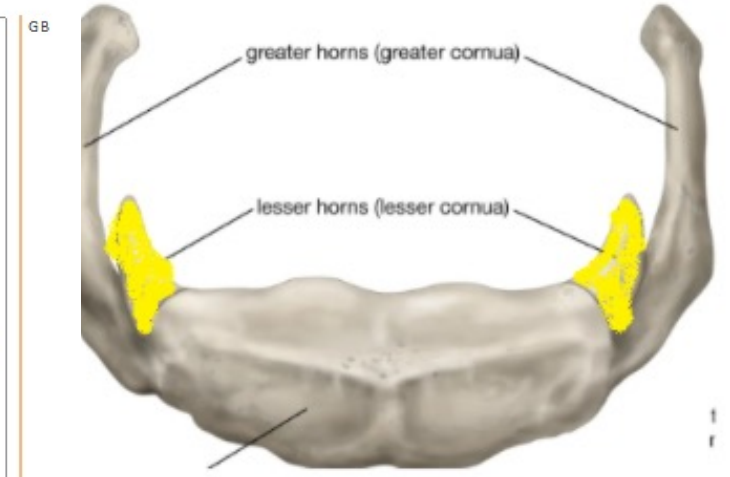
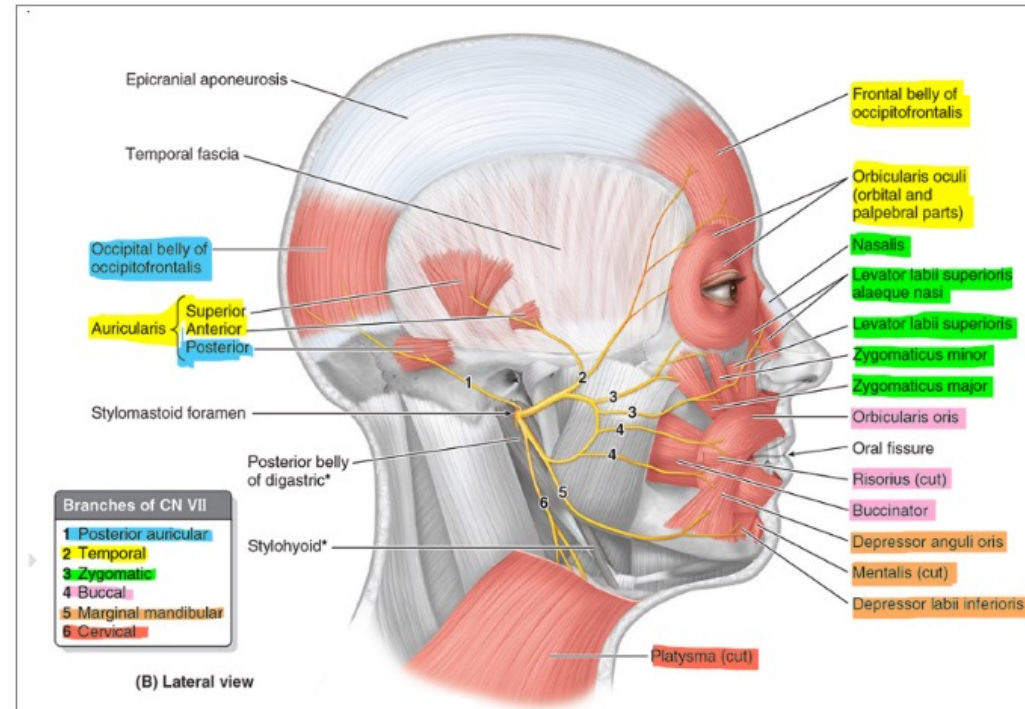
- Facial nerve supplies the muscles of facial expression and the muscles of the head and neck (which is mainly derived from the the **mesoderm, second pharyngeal arch**, during the embryological stage) as a motor root. It branches out from the facial nerve plexus, which we find just posterior to the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



Pharyngeal arch 3

Pharyngeal arch 3

1. Artery:

Common carotid arteries + internal carotid arteries

2. Nerve:

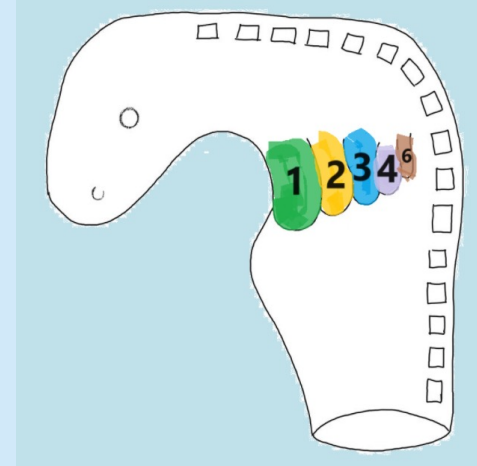
CN IX (glossopharyngeal nerve) → *neural crest cells*

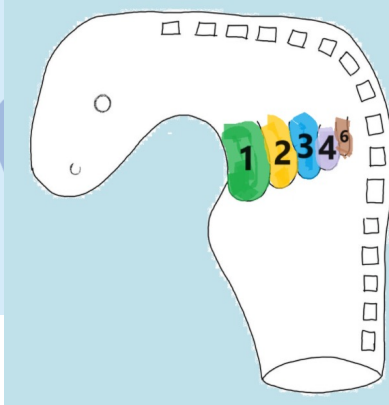
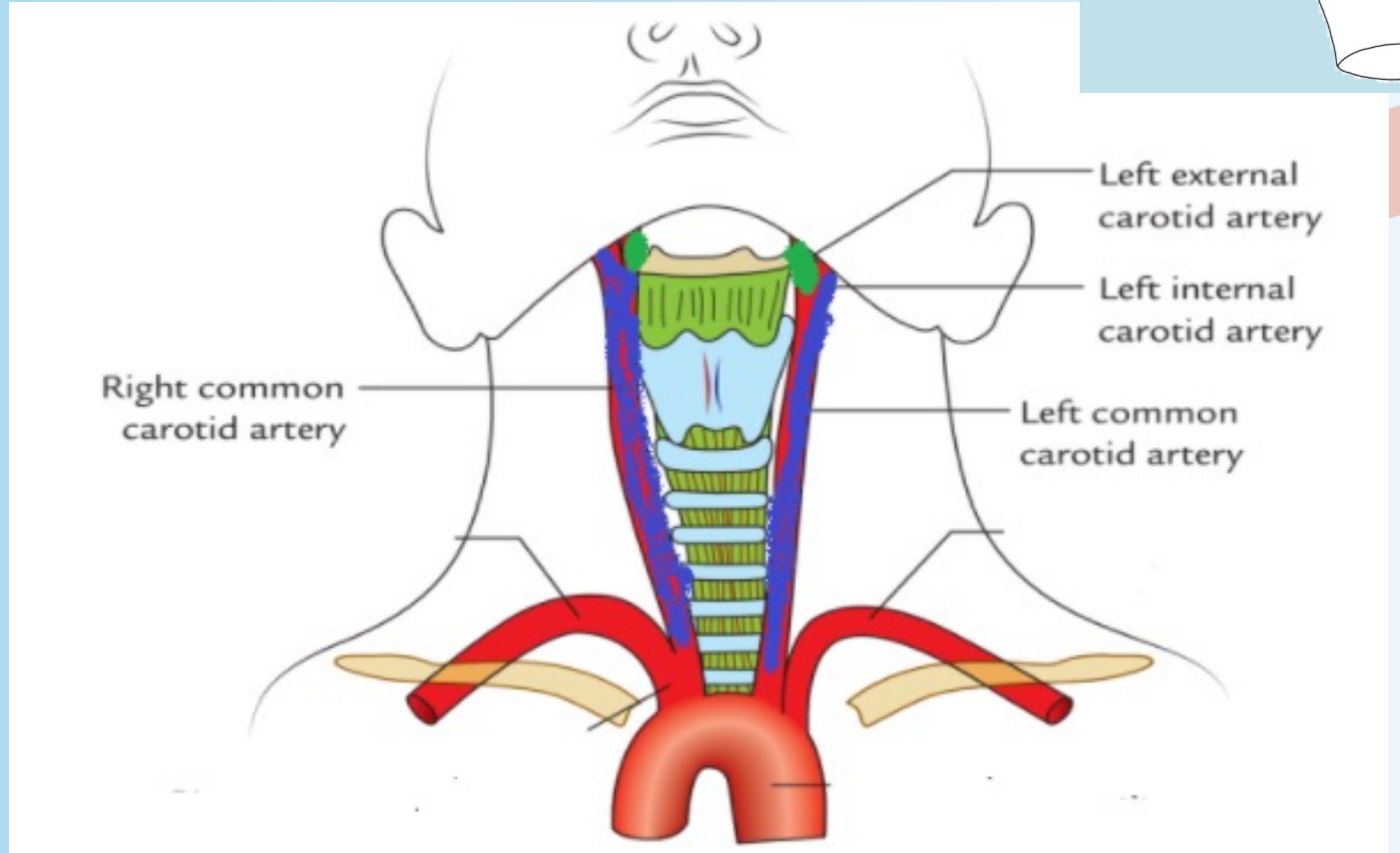
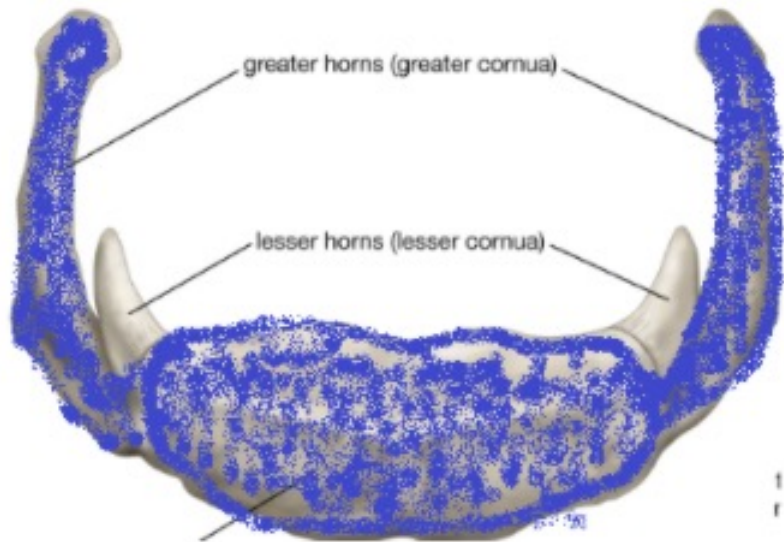
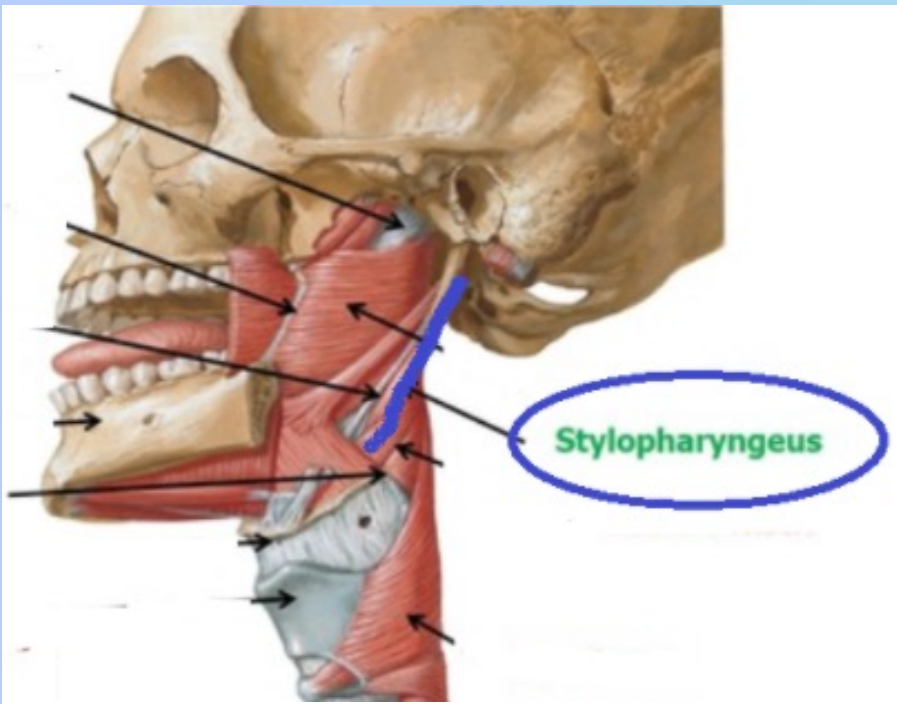
3. Cartilage/bone:

Body and great horn of hyoid bone

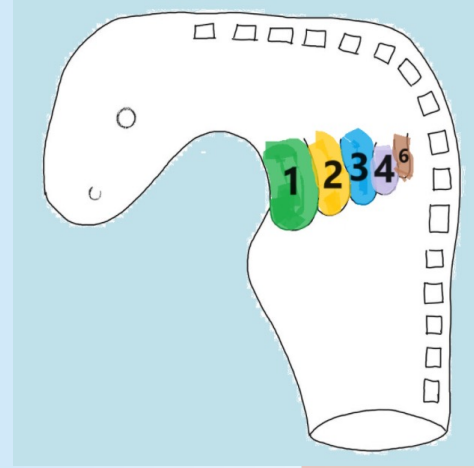
4. Muscle/muscle group:

Stylopharyngeus muscle





Pharyngeal arch 4 and 6



Pharyngeal arch 4 («pharyngeal arch»):

1. Artery:

Proximal/first part of 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

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*

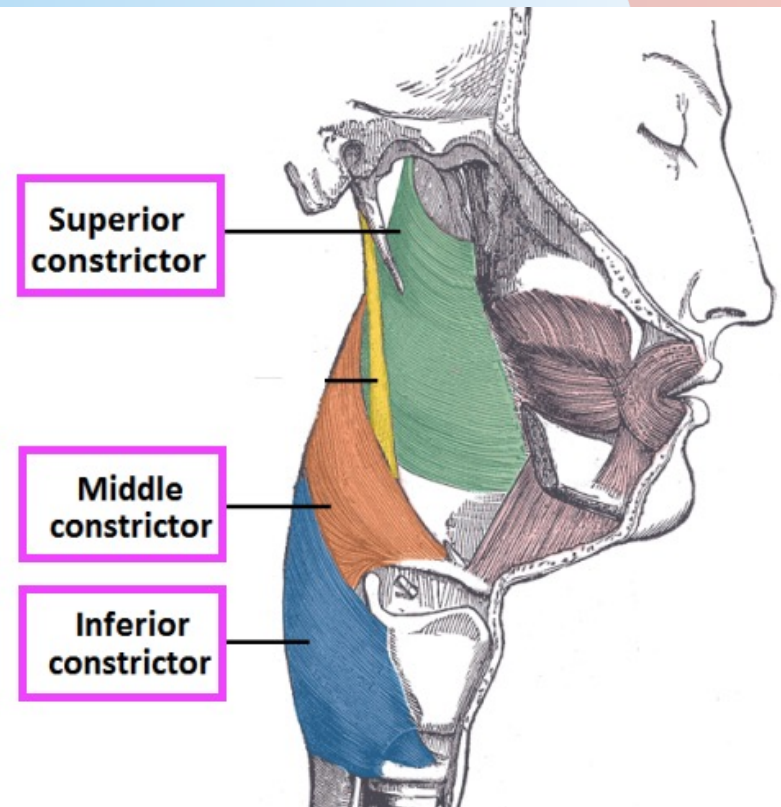
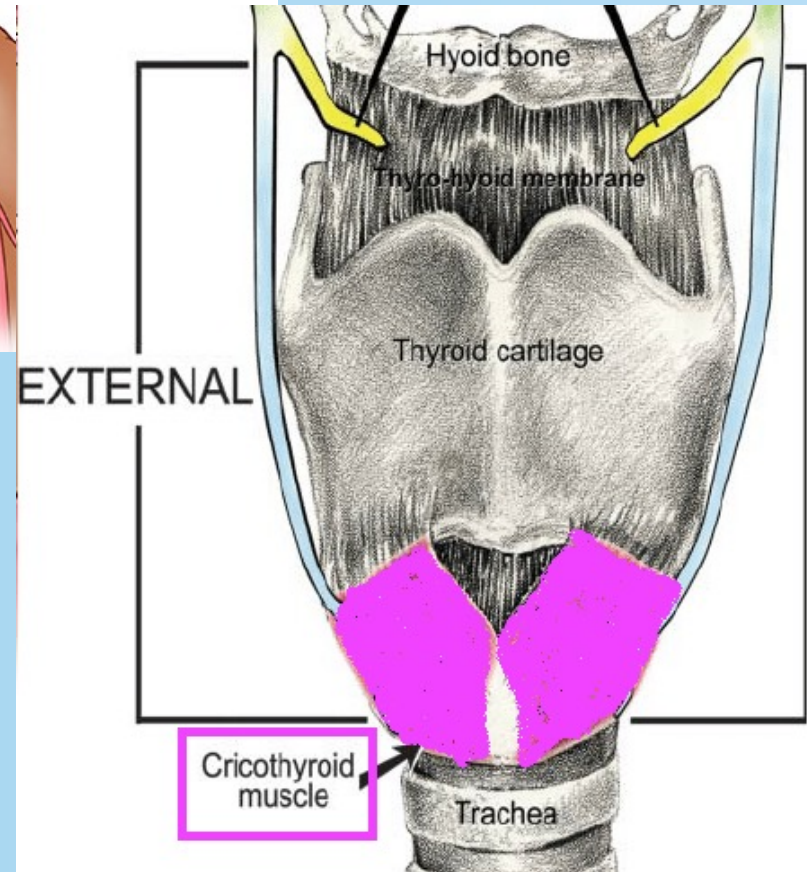
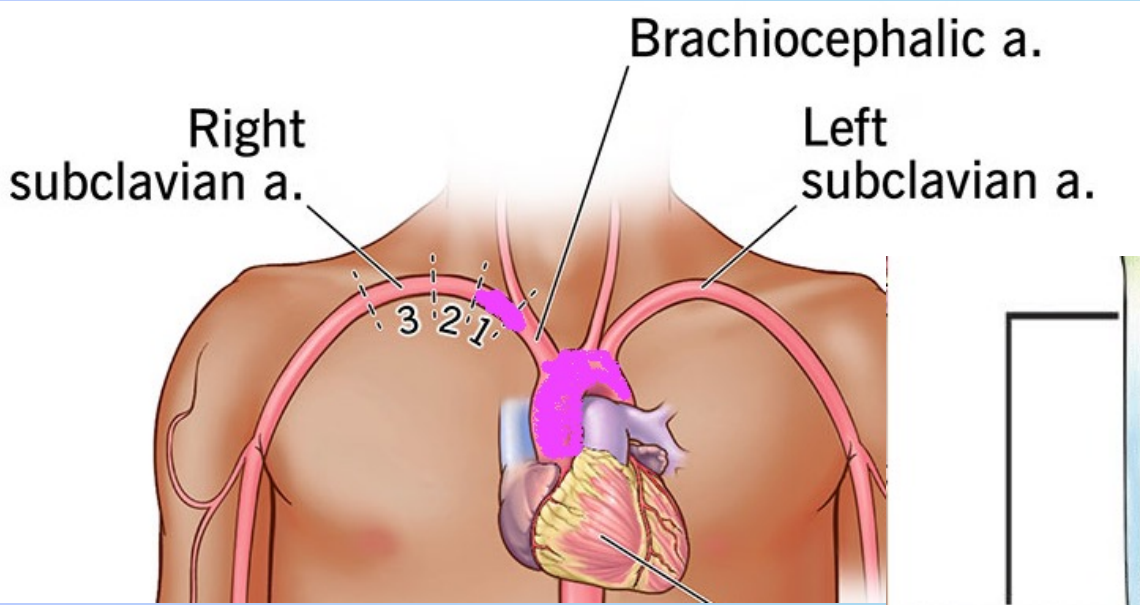
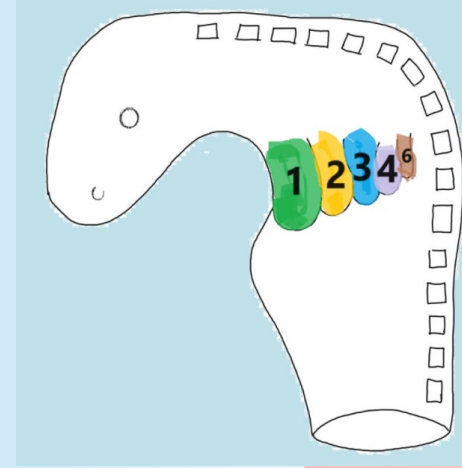
3. Cartilage:

Laryngeal cartilages (*no bones*)

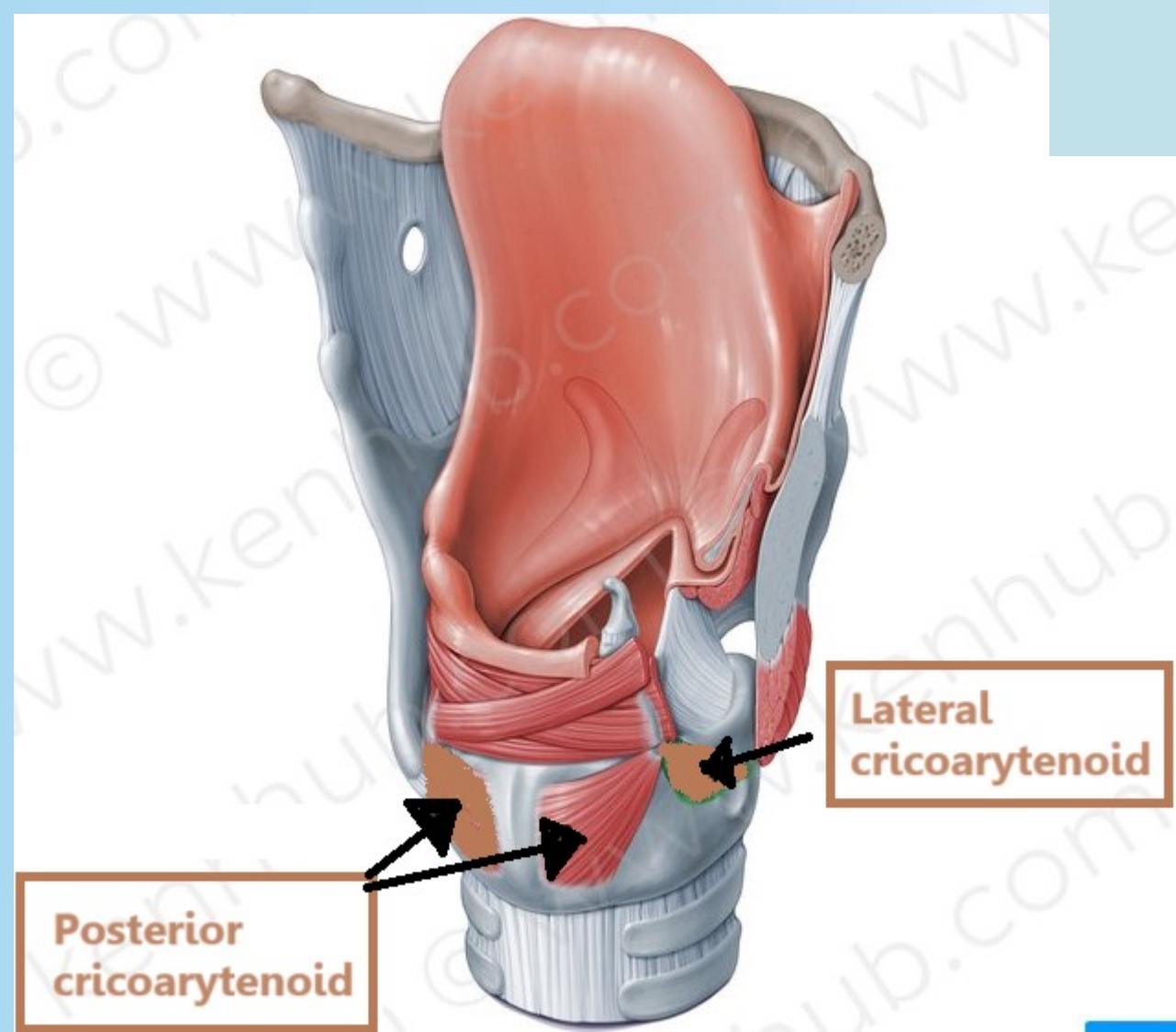
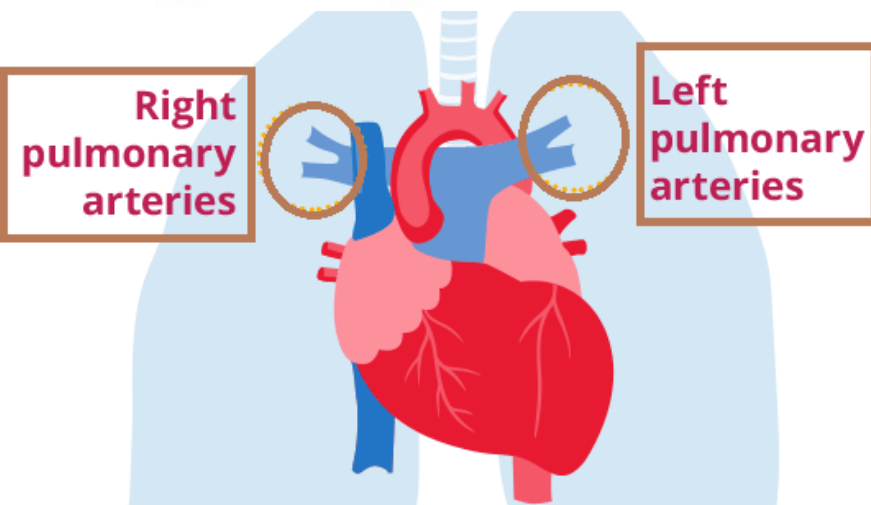
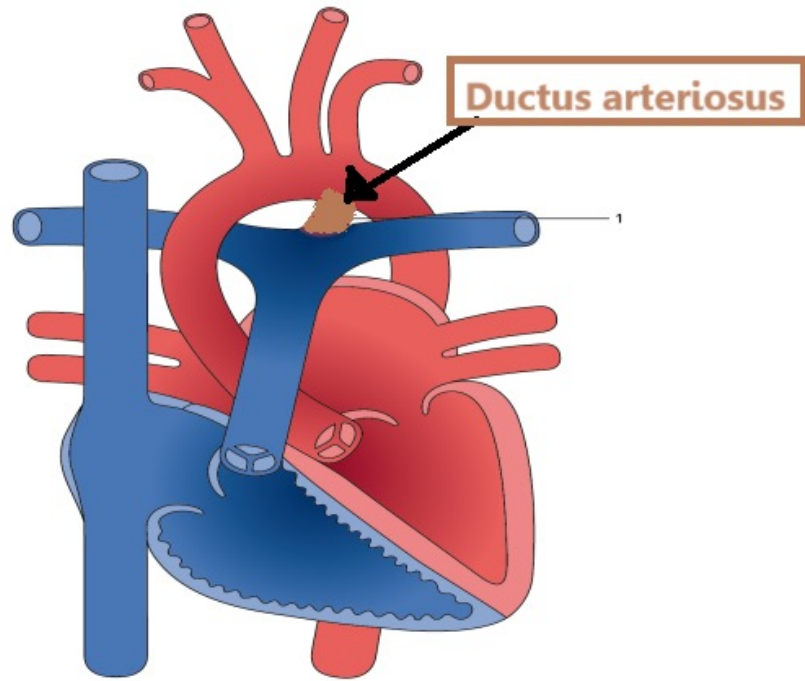
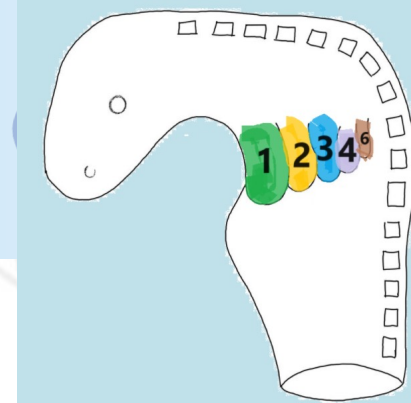
4. Muscle/muscle group (laryngeal area):

Lateral and posterior cricoarytenoid muscles

Pharyngeal arch 4:



Pharyngeal arch 6:



How to memorize which cranial nerve relates to which arch

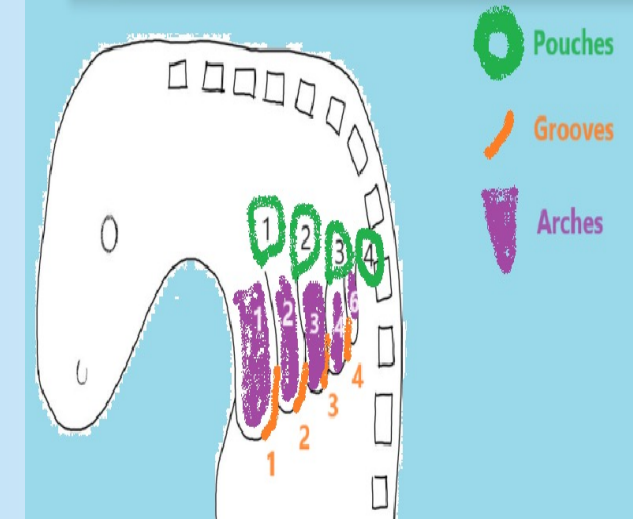
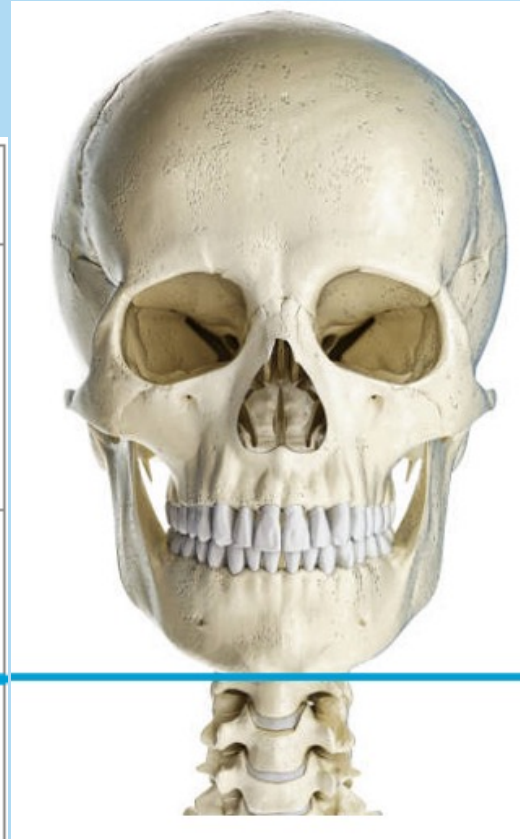
| Arch | Nerve |
|--------------------------------|---|
| First (mandibular) | Trigeminal* (CN V) |
| | Start on cranial nerve five (trigeminal) |
| | +2 Add two (5+2 = 7) |
| Second (hyoid) | Facial (CN VII) |
| | +2 Add two (7 + 2 = 9) |
| Third | Glossopharyngeal (CN IX) |
| | +1 Add one (9 + 1 = 10) |
| Fourth and sixth ^{II} | Superior laryngeal branch of vagus (CN X) Recurrent laryngeal branch of vagus (CN X) |

These four cranial nerves are the ones relevant to pharyngeal arches

Pharyngeal pouches overview

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

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



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

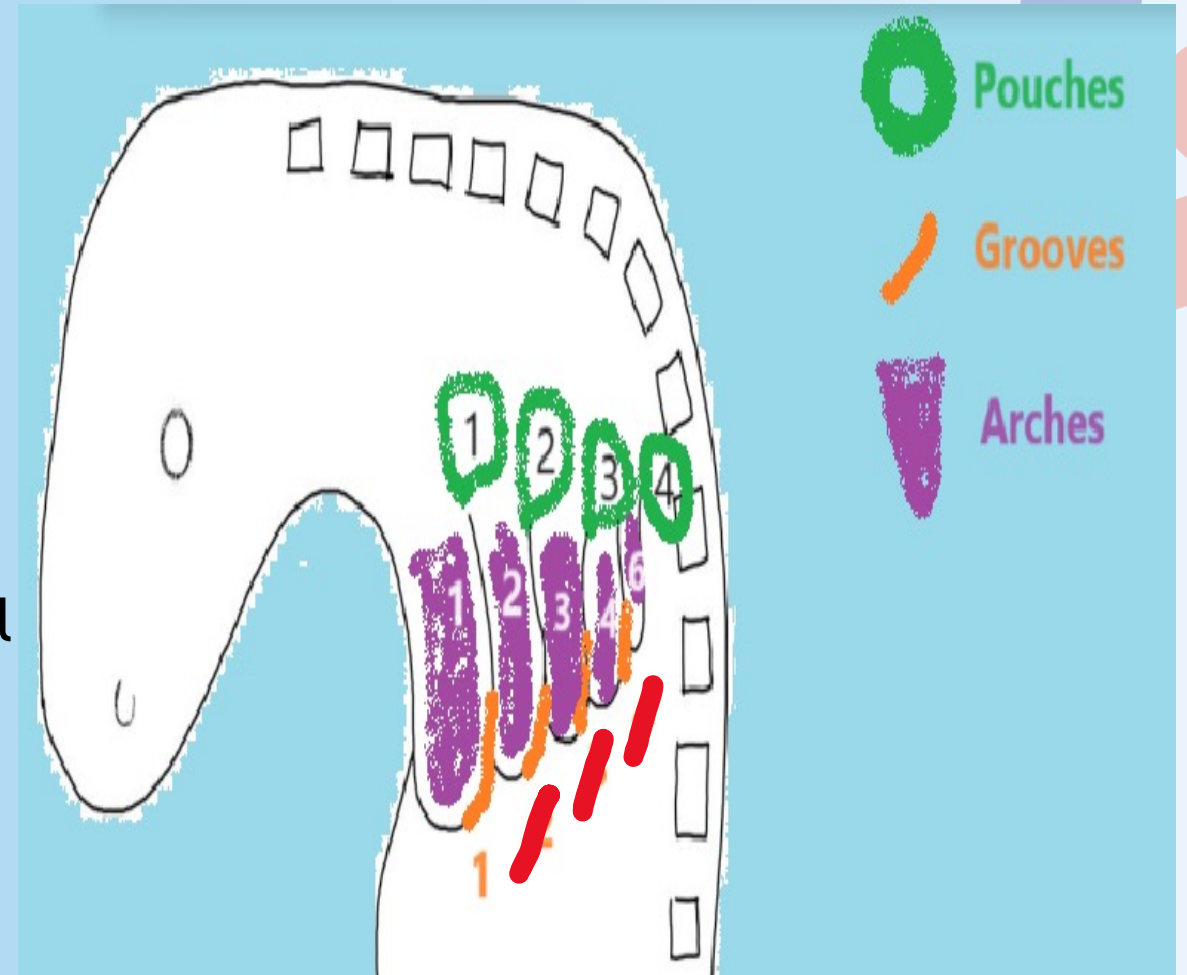
Cuboidal cells in all except for crypts of palatine tonsil (stratified squamous cells)

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

Cuboidal cells in all except for thymus (Specialized squamous cells)

Pharyngeal grooves

- Grooves = Ectoderm (columnar)
- Groove 2-4 obliterates in utero (during pregnancy)
- Groove 1:
 - Epithelial lining of the external auditory canal (columnar cells will transition to stratified squamous epithelium in a metaplasia process).



Review slides (tables)

Pharyngeal arch 1 (mandibular arch):

| | |
|---------------------|---|
| Artery | Portion of maxillary artery and external carotid artery |
| Nerve | CN V (trigeminal, mandibular branch) |
| Cartilage/bone | <p><u>Maxillary prominence:</u> Maxilla, zygomatic bone, squamous part of temporal bone</p> <p>Incus = maxillary prominence area, but derives from <i>neural crest cells</i>.</p> <p><u>Mandibular prominence:</u> Mandible, malleus.</p> |
| Muscle/muscle group | <p><u>Muscles of mastication:</u> (masseter, temporalis, medial and lateral pterygoid muscles)</p> <p>+ mylohyoid and anterior digastric muscle and tympanic tensor muscle.</p> |

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

| | |
|---------------------|--|
| Artery | Portion of stapedial artery (derivates from hyoidal artery, which disappears) |
| Nerve | CN VII (facial nerve) |
| Cartilage/bone | Temporal bone. styloid process, lesser horn of hyoid bone. Stapes – <i>neural crest cells</i> |
| Muscle/muscle group | Muscles of facial expression (20 muscles) Stapedius muscle |

Pharyngeal arch 3

| | |
|---------------------|---|
| Artery | Common carotid arteries + internal carotid arteries |
| Nerve | CN IX (glossopharyngeal nerve) |
| Cartilage/bone | Body and great horn of hyoid bone |
| Muscle/muscle group | Stylopharyngeus muscle |

Pharyngeal arch 4:

| | |
|---------------------|--|
| Artery | Proximal/first part of subclavian artery and arch of aorta. |
| Nerve | CN X (superior laryngeal branch of vagus nerve) |
| Cartilage/bone | Laryngeal cartilages (<i>no bones</i>) |
| Muscle/muscle group | Superior, middle and inferior pharyngeal constrictor muscles, cricothyroid muscle. |

Pharyngeal arch 6:

| | |
|---------------------|--|
| Artery | Pulmonary arteries and ductus arteriosus. |
| Nerve | CN X (recurrent laryngeal branch of vagus nerve) |
| Cartilage/bone | Laryngeal cartilages (<i>no bones</i>) |
| Muscle/muscle group | Lateral and posterior cricoarytenoid |

Check yourself

(question bank)

Question 1

Where does the carotid sinus (baroreceptors) and carotid body (chemoreceptors) derive from?

- A. Neural crest cells
- B. Pharyngeal arch 6
- C. Pharyngeal arch 1
- D. Pharyngeal arch 3
- E. Neuroectoderm

Answer question 1

Where does the carotid sinus (baroreceptors) and carotid body (chemoreceptors) derive from?

- A. Neural crest cells
- B. Pharyngeal arch 6
- C. Pharyngeal arch 1
- D. Pharyngeal arch 3**
- E. Neuroectoderm

- We have two ways of knowing:

1. The third pharyngeal arch gives rise to common carotid and internal carotid arteries (which is where we find the carotid sinus and body). We are asked about the structures directly, and not their function.

2. Glossopharyngeal nerve (CN IX) is related to the carotid sinus through a branch called Hering's nerve (or carotid branch of glossopharyngeal nerve, which conveys afferent nerve fibres). **CN IX derives from the third pharyngeal arch.** Vagus nerve conveys efferent fibres to carotid sinus and body, but is not related to carotid sinus and body with pharyngeal arch 6 because it raises structures further down in the neck, *and the branches related to pharyngeal arch 4 and 6 does not relate to carotid sinus and body.*

Question 2

Relate the correct germ layer to the correct cell type:

- A. Ectoderm - Columnar cells
- B. Endoderm - All epithelial cells
- C. Endoderm - Columnar cells
- D. Mesoderm - Cuboidal cells
- E. None of the options are correct

Answer question 2

- Relate the correct germ layer to the correct cell type:
 - A. Ectoderm - Columnar cells
 - B. Endoderm - All epithelial cells
 - C. Endoderm - Columnar cells
 - D. Mesoderm - Cuboidal cells
 - E. None of the options are correct

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

Question 3

The neural crest cells derives from where?

- A. Neuroectoderm
- B. Mesoderm
- C. Endoderm
- D. Ectoderm
- E. Somites

Question 4

Which germ layer is the neural crest cells working together with in the pharyngeal arches, and what is an example of structures they develop?

- A. Ectoderm. Bones of the neurocranium and cranial nerves.
- B. Endoderm. Cells of parathyroid
- C. Mesoderm. Development of muscles related to facial expression.
- D. Ectoderm. Development of the inner ear
- E. Mesoderm. Cranial nerves and for example development of stapes in the second pharyngeal arch

Answer question 4

Which germ layer is the neural crest cells working together with in the pharyngeal arches, and what is an example of structures they develop?

- A. Ectoderm. Bones of the neurocranium and cranial nerves.
- B. Endoderm. Cells of parathyroid
- C. Mesoderm. Development of muscles related to facial expression.
- D. Ectoderm. Development of the inner ear
- E. Mesoderm. Cranial nerves and for example development of stapes in the second pharyngeal arch.

Basic rule for separation:

- Arches = Mesoderm (epithelium)
- Pouches = Endoderm (cuboidal)
- Grooves = Ectoderm (columnar)

C is wrong because neural crest cells do not have anything to do with muscle development. They do develop stapes in the second pharyngeal arch however.

Question 5.

One pharyngeal arch typically contains:

- A. Arteries, nerves, bones/cartilage and muscles/muscle groups.
- B. Arteries, nerves, muscle/muscle groups and connective tissue.
- C. Arteries, veins, nerves and bones/cartilage
- D. Arteries, nerves, bones/cartilage and components of inner ear
- E. None of the answers are correct.

Answer question 5.

One pharyngeal arch typically contains:

- A. Arteries, nerves, bones/cartilage and muscles/muscle groups.
- B. Arteries, nerves, muscle/muscle groups and connective tissue.
- C. Arteries, veins, nerves and bones/cartilage
- D. Arteries, nerves, bones/cartilage and components of inner ear
- E. None of the answers are correct.

- One arch contains:

1. One or more arteries

2. Cranial nerve/branches related to the cranial nerve - which often innervates the muscles that derives from the arch.

3. Bone(s)/cartilage

4. Muscles or specific muscle groups

Question 6

The bones derives from the second pharyngeal arch, mesoderm layer is:

- A. Styloid process, temporal bone and greater horn of hyoid bone
- B. Temporal bone, lesser horn of hyoid bone and laryngeal cartilage
- C. Temporal bone, styloid process, lesser horn of hyoid bone
- D. Temporal bone, mastoid process and lesser horn of hyoid bone
- E. Temporal bone, mastoid process and greater horn of hyoid bone

Answer question 6

The bones that derives from the second pharyngeal arch, mesoderm layer is:

- A. Temporal bone, styloid process, and greater horn of hyoid bone
- B. Temporal bone, lesser horn of hyoid bone and laryngeal cartilage
- C. Temporal bone, styloid process, lesser horn of hyoid bone**
- D. Temporal bone, mastoid process and lesser horn of hyoid bone
- E. Temporal bone, mastoid process and greater horn of hyoid bone

3. Cartilage/bone:

Temporal bone. styloid process, lesser horn of hyoid bone.

Question 7

Which muscle derives from the third pharyngeal arch?

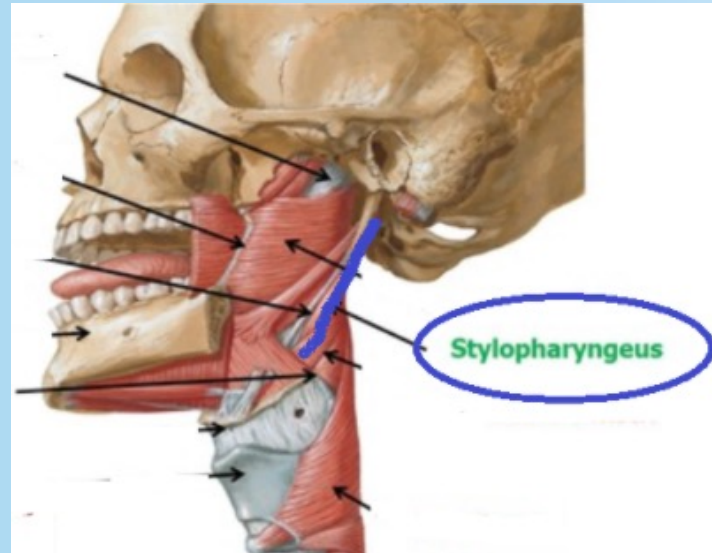
- A. Masseter muscle
- B. Stylopharyngeus muscle
- C. Anterior digastric muscle
- D. Mylohyoid muscle
- E. Genioglossus muscle

Answer question 7

Which muscle derives from the third pharyngeal arch?

- A. Masseter muscle
- B. Stylopharyngeus muscle
- C. Anterior digastric muscle
- D. Mylohyoid muscle
- E. Genioglossus muscle

4. Muscle/muscle group:
Stylopharyngeus muscle



Question 8

What is not a common feature between the fourth and sixth pharyngeal arches?

- A. They do not give rise to bony structures
- B. They are both related to cranial nerve X (vagus nerve)
- C. They both give rise to laryngeal cartilage
- D. They both give rise to cricoarytenoid muscles
- E. All of the options are correct

Answer question 8

What is not a common feature between the fourth and sixth pharyngeal arches?

- A. They do not give rise to bony structures
- B. They are both related to cranial nerve X (vagus nerve)
- C. They both give rise to laryngeal cartilage
- D. They both give rise to cricoarytenoid muscles**
- E. All of the options are correct

Only the sixth pharyngeal arch is giving rise to the cricoarytenoid muscles. They share the other features.

Question 9

The second pharyngeal pouch gives rise to:

- A. Epithelial lining of palatine tonsils (crypts)
- B. Mastoid air cells
- C. Epithelial lining of Eustachian tube
- D. C-cells of thyroid gland
- E. Mental foramen of the mandible

Answer question 9

The second pharyngeal pouch gives rise to:

- A. Epithelial lining of palatine tonsils (crypts)
- B. Mastoid air cells
- C. Epithelial lining of Eustachian tube
- D. C-cells of thyroid gland
- E. Mental foramen of the mandible

| <u>Pouch</u> | <u>Structure</u> |
|--------------|--|
| 1 | Epithelial lining of Eustachian tube and tympanic cavity (middle ear) + Mastoid air cells. |
| 2 | Epithelial lining of palatine tonsils (crypts) |



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

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

Question 10

The second pharyngeal groove gives rise to epithelial lining of the external auditory canal. What cell layer is related to this structure?

- A. Cuboidal cells
- B. Mesenchymal cells
- C. Columnar cells
- D. Stratified squamous cells
- E. None of the answers are correct

Answer question 10

The second pharyngeal groove gives rise to epithelial lining of the external auditory canal. What cell layer is related to this structure?

- A. Cuboidal cells
- B. Mesenchymal cells
- C. Columnar cells
- D. Stratified squamous cells
- E. None of the answers are correct**

The second pharyngeal groove does not exist, and can therefore not give rise to anything or have any cells.

Question 11

Relate the correct pharyngeal arch, pouch and groove with the correct germ layer:

- A. Arches with mesoderm, pouches with ectoderm and grooves with endoderm.
- B. Arches with endoderm, pouches with endoderm, grooves with ectoderm
- C. Arches with mesoderm, pouches with endoderm and grooves with ectoderm.
- D. Arches with ectoderm, pouches with mesoderm and grooves with endoderm
- E. Arches with mesoderm, pouches with neural crest cells and grooves with mesoderm

Answer question 11

Relate the correct pharyngeal arch, pouch and groove with the correct germ layer:

- A. Arches with mesoderm, pouches with ectoderm and grooves with endoderm.
- B. Arches with endoderm, pouches with endoderm, grooves with ectoderm
- C. Arches with mesoderm, pouches with endoderm and grooves with ectoderm.**
- D. Arches with ectoderm, pouches with mesoderm and grooves with endoderm
- E. Arches with mesoderm, pouches with neural crest cells and grooves with mesoderm

Basic rule for separation:

- Arches = Mesoderm (epithelium)
- Pouches = Endoderm (cuboidal)
- Grooves = Ectoderm (columnar)