<table>
<thead>
<tr>
<th>Clinical Condition</th>
<th>Normal development</th>
<th>Abnormal</th>
<th>Signs/ Symptoms</th>
<th>Treatment</th>
</tr>
</thead>
</table>
| **Cleft Lip**  
(chelioschisis) | Fusion of medial nasal and maxillary processes forms upper lip | Failure of fusion of medial nasal and maxillary processes | Cleft at philtrum of upper lip | Surgical repair |
| **Cleft Palate**  
(palatoschisis) | Anterior - Fusion of medial nasal processes (Primary palate) and maxillary processes (Secondary Palate);  
Posterior - Secondary palate formed by fusion of Maxillary processes of two sides | Failure of fusion | Anterior - Cleft anterior to Incisive foramen;  
Posterior - Cleft posterior to Incisive foramen | Surgical repair |
| **Malformation of nasolacrimal duct**  
(dacryostenosis) | Duct forms as cord between maxillary and frontonasal processes extends from lacrimal sac (at medial canthus of eye) to nasal cavity (inferior meatus) | Cord fails to canalize | Continuous flow of tears over lower lid onto face | Surgical repair |
| **First Arch**  
(Treacher Collins) Syndrome | First brachial arch forms skeletal elements:  
1) malleus, incus  
2) contributes to mandible (Meckel's cartilage) | Neural crest cells do not migrate into Arch 1 | 1) Mandibular hypoplasia  
2) Conductive hearing loss  
4) Facial malformation | Some surgical repair |
| **Thyroglossal duct cysts** | Thyroid forms as evagination at foramen cecum of tongue; tissue migrates ant. to Hyoid bone in midline of neck to location below Cricoid cartilage | Glandular tissue or cysts develop anywhere along path of migration | Mass in midline of neck | Surgical removal (remove tract to tongue) |
| **Abnormal location/ Accidental Removal of parathyroid glands** | Normally posterior to thyroid gland or embedded in it; develop from branchial pouches 3 and 4  
Inferior parathyroid - pouch 3  
Superior parathyroid - pouch 4 | Can be located within thyroid gland or ectopic | Normally no symptoms;  
calcium imbalance If accidentally remove (during thyroid surgery) | Treat calcium imbalance pharmaco-logically, etc. |
### Branchial Arches and Derivatives

<table>
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<tr>
<th>ARCH (NERVE)</th>
<th>SKELETAL</th>
<th>LIGAMENTS</th>
<th>MUSCLES</th>
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| 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 (VII) | 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 | ---------- | Stylohyaryngeus |
| Fourth (X)   | Cartilages of Larynx | ---------- | 1) All muscles of Larynx  
2) All muscles of Pharynx (except Stylohyaryngeus)  
3) All muscles of Soft Palate (except Tensor palati) |
| Sixth (XI)   | ---------- | ---------- | 1) Sternocleidomastoid  
2) Trapezius |

### Structures Derived from Branchial Pouches, Cleft and Membrane: Branchial 'Cleft' Cysts (Fistuli = channels from pharynx to skin)

<table>
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<tr>
<th>POUCH</th>
<th>FORMS</th>
<th>CLINICAL</th>
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| First | 1) Auditory tube  
2) Tympanic cavity | First Branchial 'Cleft' cyst - tract to external auditory meatus or auditory tube |
| Second | Lining (crypts) of palatine tonsils | Second Branchial 'Cleft' cyst - tract to tonsillar fossa (palatine tonsils) - **MOST COMMON CYST** |
| Third | 1) Inferior parathyroid gland  
2) Thymus | Third Branchial 'Cleft' cyst - tract to thyrohyoid membrane or piriform recess |
| Fourth | 1) Superior parathyroid gland  
2) C-cells of Thyroid | rare |

Note: Pouch 3 structures migrate below (caudal) to Pouch 4 structures.  
Note: Location of Cysts and Fistuli - *in lateral neck, anterior to Sternocleidomastoid muscle*  
Note: First Branchial Cleft forms Ext. Auditory Meatus; First Branch. Membrane = Tympanic Membrane
1. A neonate is examined and found to have a large defect located at the philtrum of the upper lip (photo above). This condition arises because of failure of fusion of structures in embryonic development. Failure of fusion of which of the following structures would result in this condition?

A. maxillary and mandibular processes
B. maxillary and medial nasal processes
C. maxillary and lateral nasal processes
D. medial and lateral nasal processes
E. frontonasal process with medial nasal process.
2. A young boy is brought to a physician working in a field hospital. The mother of the boy says he has difficulty swallowing and that food is expelled through the nasal cavity. Upon examination, the physician finds a large defect in the hard and soft palates (photo above) and suspects that the child developed with a Posterior Cleft palate. Which of the following is the anatomical landmark that would be used to differentiate Posterior and Anterior cleft palate?

A. Greater palatine foramen.
B. Infraorbital foramen
C. Incisive foramen
D. Mental foramen
E. Mandibular foramen
3. An infant has a continuous secretion of tears from the left eye (photo above). MRI of the orbit appears normal and the lacrimal gland is not enlarged. The physician suspects that the condition is resulting from obstruction of the nasolacrimal duct due to failure of canalization of the duct in development. The obstruction prevents normal drainage of tears. The nasolacrimal duct normally drains to which of the following structures?

A. Inferior meatus of the nasal cavity
B. Superior meatus of the nasal cavity
C. Bulla ethmoidalis of the nasal cavity
D. Infraorbital foramen
E. Maxillary sinus

4. During a routine auditory test, a child is found to have a severe conduction deficit in one ear. High resolution CT scan of the tympanic cavity shows a complete agenesis of the stapes. This condition could result from failure of formation of the stapes from which of the following structures?

A. First branchial arch
B. Second branchial arch
C. Third branchial arch
D. Frontonasal process
E. First branchial pouch
5. A 4-year-old boy presents with an asymptomatic, left-sided neck swelling that had been present since birth. CT imaging (above) shows a mass (white arrow) in the anterior neck that had displaced the carotid vessels, the trachea and thyroid gland (black arrows). The mass was determined to be a cyst connected to a tract that extended to the anterior mediastinum. Superiorly the tract terminated in the piriform recess. Which of the following is likely to be the initial embryonic origin of the mass?

A. First branchial pouch  
B. First branchial arch  
C. Second branchial pouch  
D. Second branchial arch  
E. Third branchial pouch
6. _____ A 24 year old woman develops a mass in her neck (see photo above). The mass is located immediately anterior to the sternocleidomastoid muscle. The physician suspects that this condition has result from a branchial cyst. During surgery, the mass is found to be connected to a tract that extends superiorly and medially. The tract is most likely to be connected to which of the following structures?

A. Middle meatus of the nasal cavity
B. Pharyngeal tonsil
C. Tonsillar fossa (palatine tonsils)
D. Lingual tonsil
E. Mandibular fossa
7. ______ A young child develops a mass in the midline of the neck (photo above). The mass is located anterior to the hyoid bone, superior to the thyroid cartilage. Palpation of the salivary glands and thyroid gland show that they are normal in size. The child is scheduled for surgical removal of the mass. During surgery, the mass is found to be connected to a tract that courses superiorly. The tract is most likely to be connected to which of the following structures?

A. foramen cecum of the tongue
B. lingual tonsil
C. sublingual papilla
D. palatine tonsils
E. submandibular duct
8. ____ A young child is brought to a pediatrician by his parents. The child (photo above) shows micrognathia (small mandible) and downward slanting eyes. Tests of auditory function indicate a hearing loss. The physician suspects that the child has Treacher-Collins syndrome, a congenital disorder associated with malformation of structures that develop in association with the first branchial arch. Which of the following structures normally develops with the first branchial arch and could have been malformed to cause the hearing loss?

A. Auditory tube
B. Cochlea
C. Malleus and Incus
D. Vestibulocochlear nerve
E. Stapes

9. _____ Accidental removal of the parathyroid glands during thyroid surgery is the most frequent cause of hypoparathyroidism. The parathyroid glands are typically located on the posterior surface of the thyroid or within the substance of the gland but their location is variable. This variability is due to the multiple origin of the parathyroid glands from the

A. First and second branchial pouches
B. Second and third branchial pouches
C. First and third branchial pouches
D. Third and fourth branchial pouches
E. Second and fourth branchial pouches
Head and Neck Embryology Question Key

1. B
2. C
3. A
4. B
5. E
6. C
7. A
8. C
9. D
REVIEW OF CLINICAL EMBRYOLOGY OF HEAD AND NECK

OUTLINE - EMBRYOLOGY UNDERLYING CLINICAL CONDITIONS

I. EARLY DEVELOPMENT OF FACE: CLEFT LIP, CLEFT PALATE, OBSTRUCTED NASOLACRIMAL DUCT

II. BRANCHIAL ARCHES - STRUCTURES FORMED AND ANOMALIES: BRANCHIAL CYSTS AND FISTULI

III. THYROID DEVELOPMENT - ECTOPIC THYROID, THYROGLOSSAL DUCT CYSTS
I. EARLY DEVELOPMENT - FEW STRUCTURES IN THE HEAD ARE DERIVED FROM SOMITES

Many structures in the body are derived from somites; however, only two groups of muscles in the head are derived from somites.

1) Preotic myotomes (somitomeres) form extrinsic muscles of eye:
   III - Oculomotor,
   IV - Trochlear,
   VI - Abducens.

2) Occipital myotomes form muscles of tongue:
   - XII - Hypoglossal N.

Note: this is GSE innervation
MANY STRUCTURES ARE FROM BRANCHIAL ARCHES

1. BRANCHIAL ARCHES - Structures which develop in foregut (pharynx) and are similar to gills of fish

- Gill = Branchial

- Gills of fish are composed of cartilage and have muscles, nerves, arteries

~4 weeks → ~11 weeks
EARLY DEVELOPMENT: HEAD END ENLARGES

HEAD END OF TRILAMINAR EMBRYO

FRONTONASAL PROCESS = Central swelling

NEURAL CREST CELLS

Trilaminar embryo folds and head end enlarges

Neural crest cells invade head and neck lateral to rostral part of foregut to develop branchial arches
DEVELOPMENT OF FACE

First arch develops Maxillary and Mandibular process; Maxillary processes (bilateral) form part of upper lip and palate

Frontonasal Process - formed by mesenchyme below brain

Maxillary and Mandibular processes surround developing mouth (Stomodeum)

Nasal Placode

Maxillary Process

Mandibular Process

Nasal Placode

Nasal Placodes (thickenings) form in Frontonasal process at site of external nares (nostrils)

Stomodeum = primitive mouth
DEVELOPMENT OF UPPER LIP

Medial & Lateral Nasal Processes—form at margins of nasal placodes

Medial nasal processes and Maxillary Processes—fuse at philtrum to form upper lip

Medial nasal processes fuse
Terminology: process = prominence
PHILTRUM OF LIP = central region of upper lip

Philtron - Greek to love, to kiss
CLEFT LIP (cheiloschisis) = Failure of fusion of Medial Nasal Process and Maxillary process - 1/1000 Births, can be unilateral or bilateral - At philtrum of lip

CLEFT LIP CAN OCCUR IN COMBINATION WITH CLEFT PALATE
INCISIVE FORAMEN
- connects oral cavity and nasal cavity;
contains Nasopalatine nerve (branch of V2), Sphenopalatine artery

view of bones of hard palate from inside mouth looking superiorly
a. Primary Palate – Anterior to Incisive Foramen formed by union Medial Nasal Processes

b. Secondary Palate – Posterior to Incisive Foramen formed by fusion of Maxillary process of each side
MALFORMATIONS: CLEFT PALATE

1) Anterior Cleft Palate
   - Not fuse Medial Nasal Process and Maxillary Process (Primary and Secondary Palate)
   - 1:1000 Births
   - Note: Ant. Cleft Palate is same as Cleft Lip

2) Posterior Cleft Palate
   - Maxillary Processes from each side (Secondary Palate)
   - 1:2500 births

Note: Ant. Cleft Palate is same as Cleft Lip
1) CLEFT LIP AND ANTERIOR CLEFT PALATE (PRIMARY PALATE)– failure of fusion of Medial Nasal Process and Maxillary process 1:1000 births

2) POSTERIOR CLEFT PALATE (SECONDARY PALATE)– failure of fusion of Maxillary process of each side 1:2500 births

INCISIVE FORAMEN is landmark
ANATOMY OF LACRIMAL APPARATUS

**LACRIMAL GLAND** - LOCATED IN SUPEROLATERAL ORBIT - OPENS BY DUCTS (~12) THROUGH CONJUNCTIVA TO SUPERIOR FORNIX - TEARS CONSTANTLY PRODUCED

**LACRIMAL GLAND**

LACRIMAL GLAND IS **INNervated by VII-Facial nerve (Parasympathetics)**
DRAINAGE OF TEARS

- TEARS FLOW ACROSS EYE TO LACRIMAL PUNCTA ON MEDIAL END OF EYELIDS (eyelids meet at MEDIAL CANTHUS);
- TEARS THEN PASS THROUGH LACRIMAL CANALICULI TO LACRIMAL SAC;
- SAC CONNECTS TO NASOLACRIMAL DUCT WHICH DRAINS TO INFERIOR MEATUS OF NASAL CAVITY

LACRIMAL GLAND IS INNERVATED BY VII - FACIAL NERVE
OBSTRUCTED NASOLACRIMAL DUCT

- extends from Medial Canthus of eye to Inferior Meatus of nasal cavity
- Develops as a fold between maxillary process and frontonasal process
- then forms a solid cord that becomes canalized.

Obstructed Duct - failure of duct to canalize; tears drain over lower eyelid to face; opened surgically for tears to drain to nasal cavity
II. BRANCHIAL ARCH DERIVATIVES - EACH ARCH HAS A NERVE, MUSCLES AND CARTILAGES

I. MANDIBULAR ARCH - TRIGEMINAL NERVE (V) has Maxillary and Mandibular Processes

II. HYOID ARCH - FACIAL NERVE (VII)

III. THIRD ARCH - GLOSSOPHARYNGEAL NERVE (IX)

IV. FOURTH ARCH - VAGUS NERVE (X)

VI. SIXTH ARCH - ACCESSORY NERVE (XI)
TERMINOLOGY: ARCHES, GROOVES, POUCHES, MEMBRANES

1. Branchial Arches = LUMPS

2. Branchial Grooves (Clefts)
   - ectodermal clefts between adjacent arches

3. Branchial Pouch
   - endodermal outpocketing from rostral foregut
   - between adjacent arches
1. **Branchial Arch** = LUMP covered by:
   - **Ectoderm** - externally
   - **Endoderm** - lined internally
   (Mesenchyme-core); arch form skeletal elements, muscles, arteries;
   Each nerve innervates structures derived from its associated arch

2. **Branchial Groove (Cleft)** - ectodermal cleft between adjacent arches

3. **Branchial Pouch** - endodermal outpocketing between adjacent arches (from rostral foregut)

4. **Branchial Membrane** - site of contact of Groove (ectoderm)
## STRUCTURES DERIVED FROM BRANCHIAL ARCHES

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<td>------------------</td>
<td>------------------</td>
<td>1) Sternocleidomastoid 2) Trapezius</td>
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I. MANDIBULAR ARCH - forms
   a) BONES OF MIDDLE EAR (malleus, incus, also ant. lig. of malleus);
   b) STRUCTURES ASSOCIATED WITH MANDIBLE sphenomandibular lig., (Meckel's cartilage, framework of mandible)

II. HYOID ARCH -
   a) ONE BONE OF MIDDLE EAR (stapes);
   b) STYLOID PROCESS and stylohyoid lig.
   c) part of HYOID BONE (upper half of body of hyoid bone)

III. THIRD ARCH - REST OF HYOID BONE - lower half of body of hyoid

IV. FOURTH ARCH - cartilages of larynx

note: FIRST ARCH SYNDROME (TREACHER COLLINS) - genetic disorder; Neural crest cells do not migrate into Arch 1:
- mandibular hypoplasia
- conductive hearing loss
- facial malformation
1. **Branchial Groove** (Pharyngeal Cleft) - ectodermal cleft between adjacent arches
2. **Branchial Pouch** - endodermal outpocketing from rostral foregut - between adjacent arches
3. **Branchial Membrane** - site of contact of Groove (ectoderm) Pouch (endoderm)
BRANCHIAL POUCH DERIVATIVES

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

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

C. Pouch 3 - Inferior Parathyroid Glands & Thymus

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

Note: Pouch 3 derivatives migrate caudal to pouch 4
Middle Ear and Auditory Tube - extends from Nasopharynx to middle ear; derived from first branchial pouch - endoderm

External Auditory Meatus - derived from first branchial cleft - ectoderm

TYMPANIC MEMBRANE = first branchial membrane

First Cleft - Ext. Aud. Meatus

First Pouch - Auditory Tube

First Membrane — Tympanic Membrane

OUTER AND MIDDLE EAR DEVELOP FROM FIRST BRANCHIAL, CLEFT, MEMBRANE AND POUCH : SIMILAR TO ADULT ANATOMY
BRANCHIAL 'CLEFT' CYSTS - PERSISTENT CERVICAL SINUS

NORMALLY - OTHER GROOVES (CLEFTS) OBLITERATED

Branchial Sinus = Blind pouch from Pharynx

Branchial cleft cysts - persist anywhere along path between pouch and cleft

Confusion: Clinically can be called Branchial cleft cysts and refer to embryological pouches or clefts

FORM CERVICAL SINUS THAT NORMALLY DISAPPEARS
BRANCHIAL CLEFT CYSTS, FISTULI

Branchial Fistula = Channel, often connecting Pharynx to skin of neck; usually passes Anterior to Sternocleidomastoid Muscle.
BRANCHIAL CLEFT 'CYSTS' (FISTULAE) - often have tracts that extend from site of embryological origin

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       | 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) - **MOST COMMON CYST** |
| 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 | rare |
BRANCHIAL 'CLEFT' CYSTS (FISTULAE)

First Branchial 'Cleft' Cyst - external auditory meatus/auditory tube

Second Branchial 'Cleft' Cyst - tract to palatine tonsils

NOTE: OPENING ANTERIOR TO STERNO-CLEIDOMASTOID MUSCLE

Third Branchial 'Cleft' Cyst - tract to piriform recess, Thyrohyoid membrane
1st Branchial Cleft
Cyst
- opens on face or near ear
Type 1 - tract to external auditory meatus
Type 2 - tract to auditory tube
1st Branchial Cleft Cyst
- opens on face or near ear
Type 1 - tract to external auditory meatus
Type 2 - tract to auditory tube
**BRANCHIAL 'CLEFT' CYSTS**

2nd Branchial Cleft Cyst - MOST COMMON - opens on neck ANTERIOR TO STERNOCLEIDOMASTOID MUSCLE - tract to PALATINE TONSIL

OPENING - clinical sign - mucous secretion; can increase when have respiratory infection.
BRANCHIAL 'CLEFT' CYSTS

2nd Branchial Cleft Cyst - MOST COMMON - opens on neck ANTERIOR TO STERNOCLEIDOMASTOID MUSCLE - TRACT TO PALATINE TONSIL

3rd Branchial Cleft Cyst - more inferior on neck; also ANTERIOR TO STERNOCLEIDOMASTOID MUSCLE - tract opens to piriform recess or thyrohyoid membrane
BRANCHIAL 'CLEF'T CYSTS

- can also become apparent in adult
- lateral neck mass
- slow growing
- anterior to Sterno-cleidomastoid muscle
DEVELOPMENT OF ORAL CAVITY

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

Oropharyngeal Membrane

Stomodeum

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

SAY AAHH!

PALATOGLOSSAL ARCH
ANATOMY OF TONGUE - HAS ORAL AND PHARYNGEAL PARTS

**ORAL PART OF TONGUE**
= ant. 2/3
SENSORY INNERVATION
1) TASTE - VII Facial N.
2) TOUCH - V Trigeminal N.

**PHARYNGEAL PART OF TONGUE**
= post. 1/3
SENSORY INNERVATION
TASTE AND TOUCH - most CN IX
CN X (small part anterior to epiglottis)

**ALL MUSCLES OF TONGUE**
- XII HYPOGLOSSAL N.

**FORAMEN CECUM** - pit in midline of sulcus terminalis

**SULCUS TERMINALIS** - marks boundary

**PHARYNGEAL PART**
1) Thyroid start as Median endodermal thickening on floor of pharynx at future junction of ant 2/3 & post 1/3 of tongue (marked by foramen cecum)

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

- Two Lateral Lobes - below & on sides cricoid cartilage
- Isthmus - links lateral lobes below cricoid cartilage
- Pyramidal Lobe - 50% of people; attached to hyoid by fibrous strand; no clinical problems
Thyroglossal Duct Remnants - can have thyroid tissue or form Thyroglossal Duct cysts anywhere along path Symptom - **Midline neck mass**, anterior to hyoid bone, larynx
Thyroglossal Duct Cyst - Midline of Neck
Thyroglossal Duct Cyst - Anterior to Hyoid Bone
PARATHYROID GLANDS

- 4 small bodies (2 on each side) located posterior to or within Thyroid gland

Location variable due to migration after embryological origin from Branchial Pouches 3 and 4;
Inferior parathyroid glands from 3, Superior parathyroid gland from 4

Abnormal location - Normally no symptoms
Clinical consequence Surgical removal of thyroid - calcium imbalance
GOOD LUCK!