IBSSD 1525
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L24: Face & Neck Development

Background reading: Langman's Medical Embryology, *15th edition*, Chapter 10: The Axial Skeleton (just read Skull), Chapter 13: Cardiovascular System (just read vascular development: aortic arches) Chapter 17: Head & Neck

OBJECTIVES:

- Describe the relationships between the pharyngeal arches, clefts, and pouches. Identify the specific germ layer structures associated with each. List the derivatives of each pharyngeal arch and pouch.
- Identify the two regions of the skull. List which bones are derived from neural crest and which are derived from paraxial mesoderm. Recall the two different developmental processes that form the bones of the neurocranium
- Match the pharyngeal arches with their associated arteries and cranial nerves.
- Illustrate the main structures of facial development and describe how those structures migrate, fuse, and/or change during development.
- Locate each of the fontanelles and recall what their adult derivatives are.

I. GERM LAYERS

A. **Mesoderm**
   1. **Paraxial mesoderm**
      a. Parts of braincase (neurocranium)
      b. Skeletal musculature
      c. Dermis & connective tissues of dorsal head
      d. Part of the meninges
   2. **Lateral plate mesoderm**
      a. Laryngeal cartilages & adjacent connective tissues

B. **Ectoderm**
   1. **Ectodermal placodes**
      a. Form select (V, VII, IX, X) cranial nerve sensory ganglia
   2. **Neural crest**
      a. Facial skeleton (**viscerocranium**) and parts of **neurocranium** and adjacent connective tissues

C. **Endoderm**
   1. Internal lining as part of **pharyngeal pouches**
   2. Endocrine structures of the neck
      a. Thymus, thyroid, and parathyroid glands
   3. Epithelium of tympanic cavity and auditory tube

D. **Mesenchyme** – embryonic loose connective tissue derived from any germ layer

II. SKULL & NECK BONE DERIVATIVES

A. Derived from **neural crest** and **paraxial mesoderm**
B. **Viscerocranium**
    1. Bones of the face
    2. Derived from **neural crest**
    3. Derived from **pharyngeal arches 1 & 2**
    4. **Pharyngeal arch 1** derivatives
        a. Maxillary process
            - Maxillary, zygomatic, squamous part of temporal bone
        b. Mandibular process
            - Mandible, malleus, incus
        c. **Pharyngeal arch 2** derivatives
            - Stapes, styloid process of temporal bone
C. **Neurocranium**
    1. Bones surrounding the brain
    2. Divided into 2 regions determined by the developmental process that forms the bones
        a. **Flat bones** – develop directly from mesenchyme (**intramembranous ossification**)
            - Surround all but the base of the brain (e.g., parietal)
            - Derived from **neural crest**:
                - Frontal, squamous portion of temporal
            - Derived from **paraxial mesoderm:**
                - Parietal, most of occipital
        b. **Cartilaginous bones** – **mesenchyme** develops into an intermediate cartilaginous stage before ossifying (**endochondral ossification**)
            - Bones of the base of the skull
            - Derived from **neural crest**:
                - Ethmoid, sphenoid
            - Derived from **paraxial mesoderm:**
                - Portions of temporal (mastoid/petrous), base of occipital
    3. **Sutures** & **fontanelles**
        a. During development, thin gaps of connective tissue are maintained between the flat bones of the neurocranium called **sutures**
            - Many of these **sutures** occur along the boundaries between bones derived from **neural crest** vs **paraxial mesoderm**
        b. Where multiple **sutures** meet are larger gaps called **fontanelles**
        c. These gaps serve two purposes:
            - Allow the skull to change shape as it passes through the birth canal
            - Allow for brain growth in early infancy

Fontanelle	Location	Closure Date	Adult Structure
Anterior	Frontals & Parietals	13–24 months	Bregma
Posterior	Parietals & Occipital	1–2 months	Lambda
Mastoid	Parietal, Temporal, & Occipital	6–18 months	Asterion

Sphenoid	Sphenoid, Parietal, Temporal, Frontal	6 months	Pterion

D. Neck structures
   1. **Neural crest** derived
      a. Hyoid
         - **Pharyngeal arch 2**: lesser horn and upper body derived
         - **Pharyngeal arch 3**: greater horn and lower body derived
   2. **Lateral plate mesoderm** derived
      a. Laryngeal cartilages
         - **Pharyngeal arch 4**: epiglottis, thyroid
         - **Pharyngeal arch 6**: arytenoid, cricoid, other laryngeal cartilages

III. PHARYNGEAL ARCHES, CLEFTS, & POUCHES

A. Appear ~ week 4–5 of development
B. **Pharyngeal arches**
   1. Ridges of mesenchymal tissue separated by external **pharyngeal clefts**
   2. 5 **pharyngeal arches**
      a. The 5th pharyngeal arch is transient and disappears, thus the last pharyngeal arch is called the **6th pharyngeal arch**
   3. Composed of:
      a. Outer surface: ectoderm
      b. Core – mesenchymal tissue
         - **Lateral plate mesoderm**
         - **Paraxial mesoderm**
         - **Neural crest**
   4. Each arch has its own:
      a. Associated cartilage
      b. Muscular component
      c. Cranial nerve association
      d. Arterial supply
   5. 4 embryonic facial prominences derived from these structures
      a. 2 **mandibular prominences** (**1st pharyngeal arch**)
      b. 2 **maxillary prominences** (**1st pharyngeal arch**)
C. **Pharyngeal pouches**
   1. Lateral outgrowths of the pharynx
   2. Adjacent to the **pharyngeal clefts** but no open communication with **pharyngeal arches** & **clefts**
D. **Pharyngeal clefts**
   1. Transient external pockets coated in ectoderm that separate each of the **pharyngeal arches**
   2. The 1st cleft deepens, with its ectoderm contacting the endoderm layer of the **1st pharyngeal pouch**
      a. A thin membrane forms between these structures that will become the tympanic membrane
   3. The remaining clefts are eventually overgrown by the expansion of the arches

IV. PHARYNGEAL ARCHES

A. **First (mandibular arch)**
   1. Maxillary and mandibular processes
   2. **Meckel's cartilage** – scaffolding for the 1st pharyngeal arch; forms incus, malleus, and part of the mandible,
   3. Bony derivatives: maxilla, temporal (part), zygomatic, malleus, incus
   4. Muscular derivatives: muscles of mastication (temporalis, masseter, pterygoids), mylohyoid, anterior belly of digastric, tensor tympani, tensor veli palatini
   5. Associated cranial nerve: trigeminal (CN V)
   6. Associated artery: maxillary artery
   7. Other structures derived from arch: part of external ear and external acoustic meatus, part of dermis of face, sphenomandibular ligament

B. **Second (hyoid arch)**
   1. Bony derivatives: stapes, styloid process of temporal bone, part of hyoid bone
   2. Muscular derivatives: stapedius, posterior belly of digastric, stylohyoid; muscles of facial expression
   3. Associated cranial nerve: facial (CN VII)
   4. Associated arteries: stapedial and hyoid arteries
      a. Stapedial artery atrophies, derivatives include:
         - Middle meningeal, infraorbital, inferior alveolar, other external carotid branches
      b. Hyoid → tympanic branch of internal carotid artery
   5. Other structures derived from this arch: most of external ear, stylohyoid ligament

C. **Third arch**
   1. Bony derivatives: Parts of hyoid
   2. Muscular derivatives; stylopharyngeus
   3. Associated cranial nerve: glossopharyngeal (CN IX)
   4. Associated arteries: common carotid & proximal internal carotid arteries

D. **Fourth & Sixth Arches**
   1. Cartilaginous derivatives: thyroid, epiglottis, cricoid, arytenoid, and other laryngeal cartilages
   2. Muscular derivatives: cricothyroid, levator veli palatini, pharyngeal constrictors, palatoglossus, muscular uvula, salpingopharyngeus
   3. Associated cranial nerve: vagus (X)
      a. 4th arch: superior laryngeal branch of vagus
      b. 6th arch: recurrent laryngeal branch of vagus
   4. Associated arteries:
      a. Fourth – arch of the aorta, proximal right subclavian
      b. Sixth – pulmonary arteries and ductus arteriosus

V. PHARYNGEAL POUCHES

A. Four pairs of pouches
    1. A fifth that is rudimentary in humans
B. Have epithelial endodermal lining
C. 1st Pouch
    1. Forms a long process called the **tubotympanic recess**
    2. Comes into contact with epithelial lining of **1st pharyngeal cleft**
        a. Contact between ectoderm of cleft and endoderm of pouch will eventually form the tympanic membrane
    3. Derivatives:
        a. Tympanic cavity (middle ear) from distal end of tubotympanic process
        b. Stem forms the eustachian tube
        c. Lining will help form tympanic cavity
D. 2nd Pouch
    1. Forms buds that penetrate adjacent **mesenchyme**
    2. Develop into palatine tonsil
        a. The remains of the pouch become the tonsillar fossa
E. 3rd Pouch
    1. Forms a dorsal and ventral wing
    2. Ventral wing derivative
        a. Thymus
            - Loses connection with pharyngeal wall, migrates medially and inferiorly to anterior thorax
    3. Dorsal derivative
        a. Inferior parathyroid gland
F. 4th Pouch
    1. Forms a dorsal and ventral wing
    2. Ventral wing derivative
        a. Forms the ultimobranchial body, which joints the thyroid gland and eventually develops into the C cells of the thyroid gland
            - C cells release calcitonin, a hormone that regulates calcium in the body
    3. Dorsal derivative
        a. Superior parathyroid gland

VI. FACIAL DEVELOPMENT

A. **Neural crest** derived
B. Begins (~ week 4) centered on the **stomodeum**, the primordial oral cavity
C. **Placode** – thickening of ectoderm that forms special structures
D. Main structures
    1. **Stomodeum**
    2. **Frontonasal prominence**
        a. Located above the **stomodeum**
        b. Becomes forehead and bridge of nose
    3. **Lens placodes**
        a. Lateral to **frontonasal prominence**, migrate medially during development

   b. Develop into eyes and associated tissues
4. **Otic placodes**
   a. Form internal ear structures
5. **Nasal placodes**
   a. Anterolateral to **frontonasal prominence**
   b. Invaginate to make **nasal pits**
      - Creates two nasal prominences (**lateral** and **medial nasal prominences**)
6. **Maxillary prominences** (**1st pharyngeal arch**) lateral to the **stomodeum**
   a. Becomes lateral upper lip and cheeks
7. **Mandibular prominences** (**1st pharyngeal arch**) below the **stomodeum**
   a. Lower lip

Self-study questions and exercises:

- Identify specific structures from each germ layer that are associated with pharyngeal arches and pouches.
- Name the bones that derive from the neural crest and from the paraxial mesoderm. Which bones belong to the viscerocranium and neurocranium? Differentiate the neurocranial bones by their developmental processes.
- List the derivatives of each of the pharyngeal arches. What are the nerves associated with each arch? Which arteries are associated with each arch?
- What adult structures are associated with the pharyngeal pouches?
- What are some of the main developmental structures of the face? What do they develop into in adults?
- Name the fontanelles, which bones they unite, and what the adult derivative is called.

Practice exam question

1. Which of the following structures is associated with the 2nd pharyngeal arch?
   A. Trigeminal nerve
   B. Malleus and incus
   C. Muscles of facial expression
   D. Laryngeal cartilages