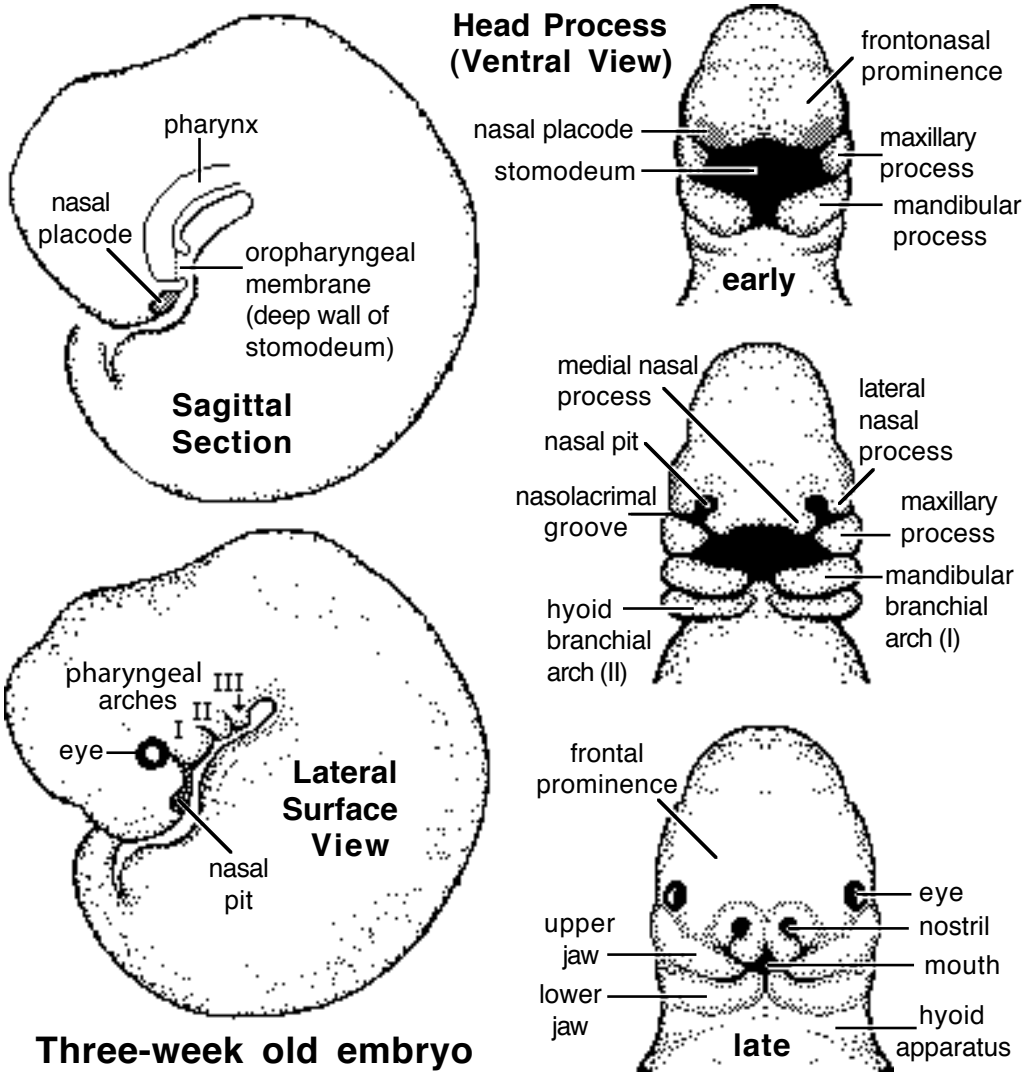
Pharynx, Face, Nasal Cavity & Mouth

Note: The **head** consists of a **face** and **cranium**. The cranium (formed by the head process) houses the brain, eyes, and pharynx. The face (formed later by outgrowth) contains the mouth and nasal cavity. Because the face develops separately, and it can undergo wide variation in shape & size, as seen in dogs.

Pharynx:

- the embryonic pharynx is the anterior end of the *foregut*, it arises during head process and lateral body fold formation when the embryo becomes cylindrical.
- the pharynx is bounded externally by *pharyngeal arches*; the arches are demarcated externally by pharyngeal clefts and internally by expansions called *pharyngeal pouches*
- initially the pharynx is closed anteriorly by an *oropharyngeal membrane* (composed of pharyngeal endoderm and surface ectoderm); following growth of the *stomadeum* (mouth) the oropharyngeal membrane must degenerate to permit communication
- six pair of pharyngeal arches develop (only three are evident, 5 atrophies and 4 & 6 combine)
- each arch contains an aortic arch vessel, ectomesenchyme from neural crest, myotomes from somites/somitomeres, innervation from one cranial nerve
- pharyngeal arches contribute to the formation of: jaws, larynx, hyoid bones, and head muscles.



More Pharyngeal Arch Products

• Mesenchyme within pharyngeal arches (and the frontonasal prominence) is *ectomesenchyme*, derived from neural crest. Ectomesenchyme forms fascia and ***intramembranous bone*** of the ***face*** and ***calvaria***. (In contrast, bones along the floor of the skull develop endochondrally from occipital somite sclerotomes.)

• Skeletal muscle of the head is derived from *somite* or *somitomere* myotomes that migrate into pharyngeal arches (or the frontonasal prominence). In general, each pharyngeal arch is innervated by one cranial nerve and that nerve supplies all muscles derived from the arch:

Arch I -- mastication muscles (V nerve);
Arch II -- facial muscles (VII nerve);
Arch III -- a pharyngeal muscle (IX nerve); and
Arches IV & VI -- muscles of pharynx, larynx, & esophagus (X nerve).

• In fish, pharyngeal arches are called branchial (gill) arches. Tissue separating external clefts and internal pharyngeal pouches degenerates, creating gill slits.

Note: *Somitomeres* originate from paraxial mesoderm located rostral to the notochord and are less developed somites. There are seven pair of somitomeres. They give rise to extraocular, masticatory, facial, and some pharyngeal muscles.

Pharyngeal Pouch Derivatives

1st pouch —— tympanic (middle ear) cavity and auditory tube

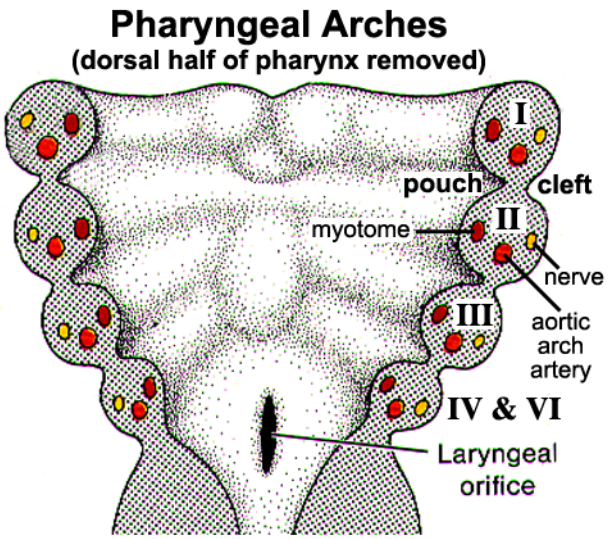
2nd pouch —— fossa for the palatine tonsil and the fold covering it

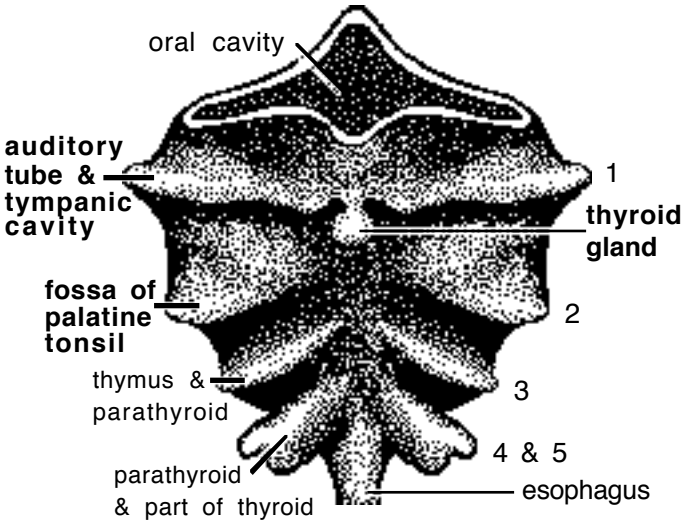
3rd pouch —— external parathyroid gland and thymus

4th pouch —— internal parathyroid gland

5th pouch —— parafollicular cells of thyroid gland (avian ultimobranchial body)

NOTE: The thyroid gland originates as a single endoderm outgrowth from the floor of the pharynx. Depending on species, the thyroid may remain single (pig) or split into bilateral lobes connected by an isthmus (horse) or become separate paired lobes (dog). The thyroid connection to the pharynx normally degenerates, but rarely a remnant persists as a cyst that can enlarge and interfere with breathing by compressing the pharynx.

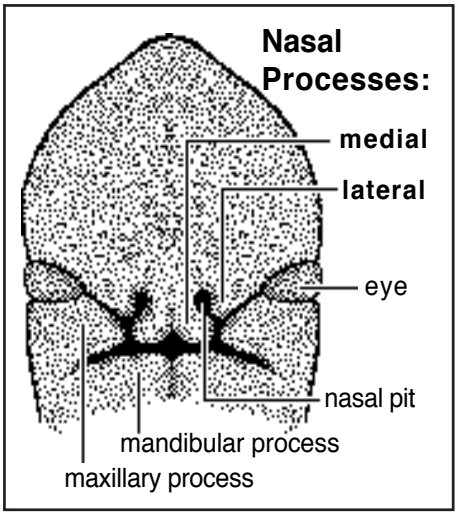




Pharyngeal Pouch Derivatives (ventral view)

Face:

- the face develops from outward growth of the cranium
- the ***lower jaw*** and most of the ***upper jaw*** are formed by growth of the *first pharyngeal arch*
- the ***upper incisor*** region and the ***nose*** and ***forehead*** are formed from the *frontonasal prominence* (ectomesenchyme from neural crest, located rostral to the neural tube)

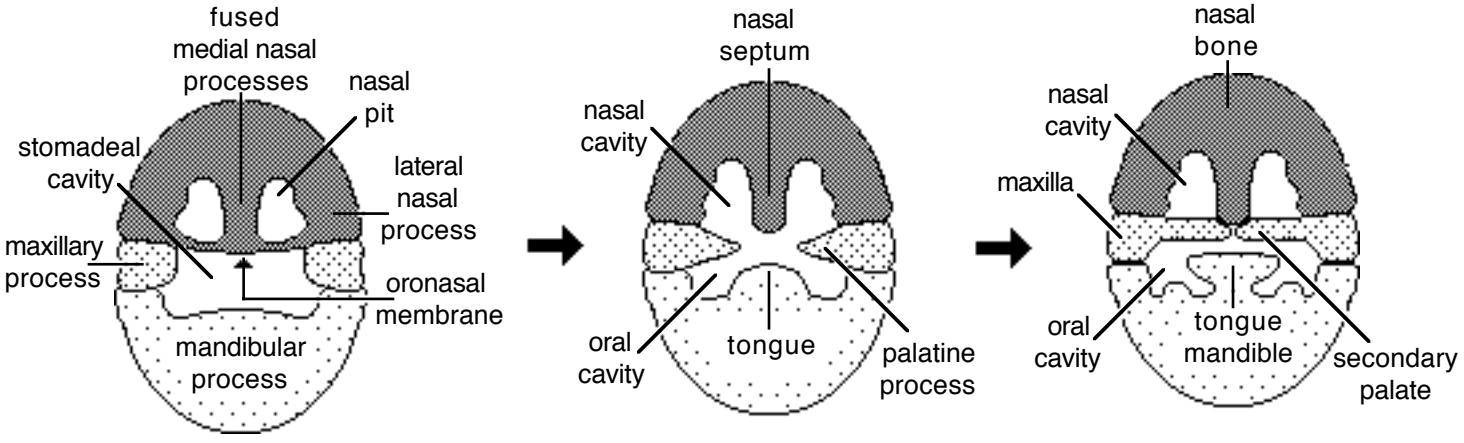


Development proceeds as follows:

- the **first pharyngeal arch** divides into two processes:
  - — a ventral *mandibular process* forms the ***mandible*** and soft tissue of the ***lower jaw***; right & left sides fuse to form the ***mandibular symphysis***
  - — a dorsal *maxillary process* forms most of the ***upper jaw***, caudal to incisor teeth
- dorsal to the first pharyngeal arch, the **frontonasal prominence** expands and divides into:
  - — a *frontal prominence*, which forms frontal bone of the ***forehead***, and
  - — *medial & lateral nasal processes*, which form the ***nose***, ***nasal cavity*** & *primary palate*

Nasal cavity:

- Initially, bilateral *nasal placodes* (ectoderm thickenings) appears at the rostral end of the *frontonasal prominence*
- Subsequently, growth of surrounding *medial* and *lateral nasal processes* establishes bilateral *nasal pits*
- Continued growth of nasal processes produces a primitive ***nasal cavity*** and subsequent oronasal erosion during growth establishes communication between the nasal & oral cavity.
- Fusion of right and left *medial nasal processes* forms a *primary palate* rostrally and the *nasal septum* caudally:
  - — the primary palate becomes ***incisive bone***, ***upper incisor teeth*** and the rostral ***upper lip***
  - — the ***nasal septum*** separates right & left halves of the nasal cavity
  - — the bilateral rostral openings of the nasal cavity becomes ***external nares*** (nostrils) and ectomesenchyme surrounding them forms cartilage of the ***nose***
- Each *lateral nasal process* give rise to alar cartilage of the ***nose***, ***nasal bone***, and ***lacrimal bone***
- A ***nasolacrimal duct*** is formed by ectoderm along the seam where the *lateral nasal process* meets the maxillary process of the *first pharyngeal arch*.



Palates:

• Nasal and oral cavities communicate with one another following erosion of an oronasal membrane that initially separated them.

• In mammals, nasal and oral cavities are again separated by formation of primary and secondary palates that shift the nasal-oral communication caudally into the pharynx.

Two palates are formed:

• the *primary palate,* which becomes ***incisive bone***, is formed by *medial nasal processes*

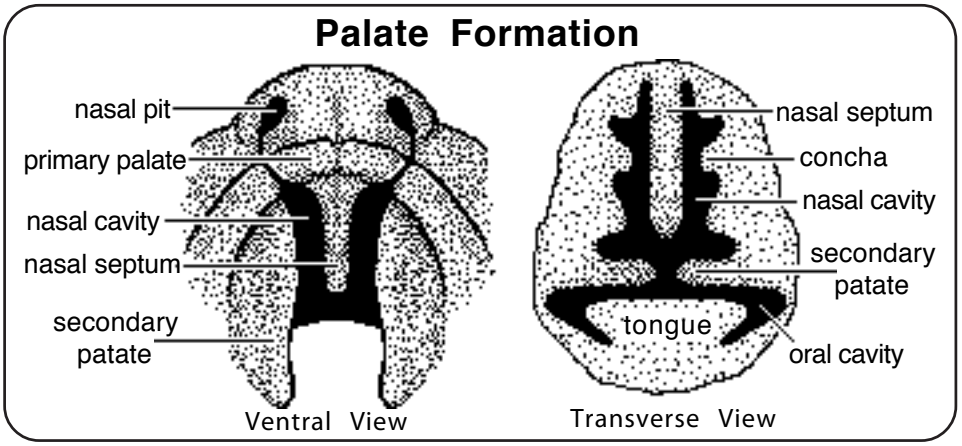
• the *secondary palate* (hard palate) is formed bilaterally by maxillary processes extensions:

— the extensions (*palatine processes*) meet at the midline, merging dorsally with the nasal septum and rostrally with primary palate

— caudal extension of the secondary palate (***hard palate***) into the pharynx, creates the ***soft palate*** which separates the dorsal ***nasopharynx*** from the ventral ***oropharynx***.

• Cleft palate results from failure of the palate to close along the midline, leaving a gap or cleft. The secondary palate is affected more commonly than the primary palate. The condition may be inherited or be the result of exposure to a teratogen (an agent that causes birth defects). Cleft palate is often fatal in animals due to inability to suckle or because of aspiration of milk into the lungs (aspiration pneumonia).

• Failures of medial nasal process fusion (primary cleft palate), produces hare lip (cheiloschisis) and related defects. (Hare lip alone is normal is hares, sheep, etc.).



Conchae:

• Conchae (turbinates) are thin bone scrolls covered by mucosa within the nasal cavity.

• Conchae originate bilaterally as cartilaginous ridges of bones that form the nasal cavity wall.

Paranasal sinuses:

• Sinuses arise as epithelial lined diverticula of the lining of the nasal cavity; the extent of sinus development varies with species

• Most of the sinus development occurs postnatally, newborn animals have cute, rounded heads that become angular with age as sinuses develop.

Vomeronasal organ:

• This is a specialized olfactory sense organ located rostrally in the floor of each nasal cavity.

• The organ is produced by an outgrowth of nasal epithelium that forms a caudally-closed tube.

Mouth:

- The mouth (oral cavity) develops as a consequence of upper and lower jaw formation
- The first evidence of an oral cavity is called a *stomadeum*; containing a *stomadeal cavity*.
- The deep boundary of the stomadeum *(oropharyngeal membrane)* is composed of a layer of stomadeal ectoderm apposed to a layer of pharyngeal endoderm; the oropharyngeal membrane becomes fenestrated and disintegrates (the palatoglossal fold marks its location in adults)
- The stomadeal cavity and nasal pits are separated initially by an oronasal membrane that subsequently degenerates so the cavities communicate freely; eventually, palates develops, shifting oral-nasal communication caudally into the pharynx.

Lips and gingivae:

- An arc of thickened ectoderm, the *labiogingival lamina*, forms in ectoderm lining the stomadeal cavity on upper and lower jaws.
- The lamina invaginates into underlying ectomesenchyme, forming a *labiogingival groove*
- The groove forms the future oral ***vestibule***; tissue external to the groove forms ***lips*** and medial tissue forms ***gingivae***.
- Caudal fusion of upper & lower lips forms cheeks.

Teeth:

• The *dental lamina* is an arc of thickened ectoderm, situated inside of the labiogingival lamina

• Periodic thickenings of the lamina produce *dental buds*, which give rise to individual teeth

• If a bud is destined to form a deciduous tooth, then an additional bud for its permanent replacement develops superficial and medial to the deciduous bud

• Each *dental bud* develops into a tooth in the following way:

— the bud assumes a cup-shaped configuration, becoming an *enamel organ*

— condensation of ectomesenchyme within the concavity of the cup forms a *dental papilla*

— the concave epithelial layer of the enamel organ induces ectomesenchyme of the dental papilla to form an epithelial layer of *odontoblasts* that deposit the dentin of the tooth

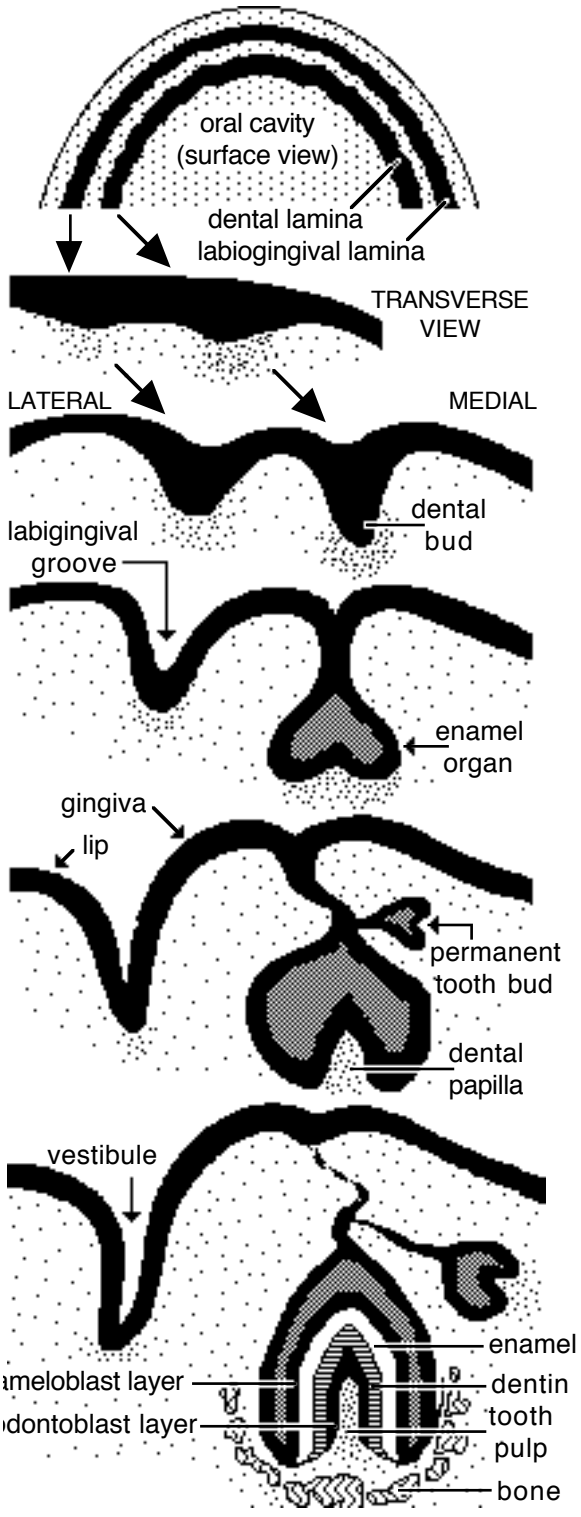
— the odontoblasts induce the concave epithelium of the enamel organ to differentiate into *ameloblasts* that form enamel of the crown of the tooth

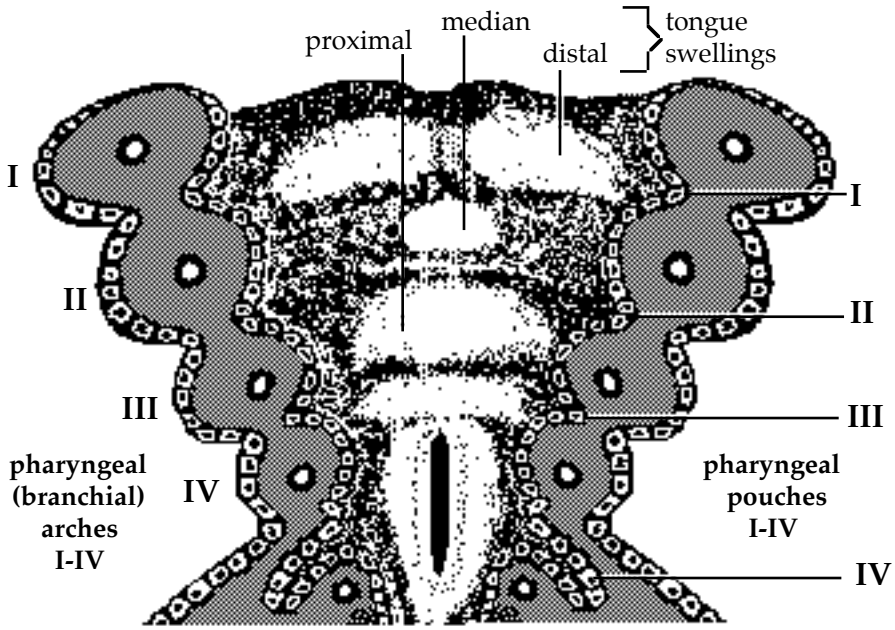
— ectomesenchyme surrounding the enamel organ condenses into a *dental sac* that gives rise to three layers:

1] Outer cells of the dental sac differentiate into osteoblasts that deposit alveolar (tooth socket) bone (osteoclasts re-absorb bone in prior to eruption).

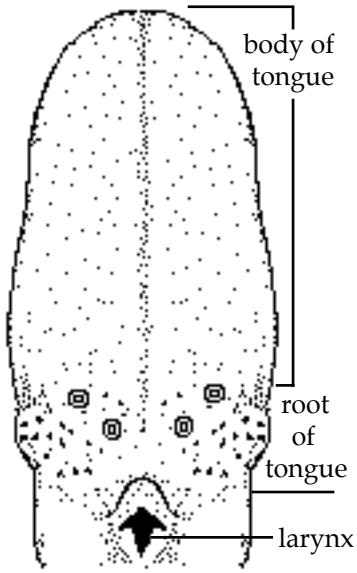
2] Middle layer of the dental sac forms a periodontal ligament (which anchors the tooth within the alveolus).

3] Inner cells of the dental sac become cementoblasts, producing cementum (modified bone) which adheres to the surface of the tooth, particularly the dentin surface of the root of the tooth.





Dorsal View of Floor of Pharynx (roof removed)



Canine Tongue (dorsal view)

Tongue:

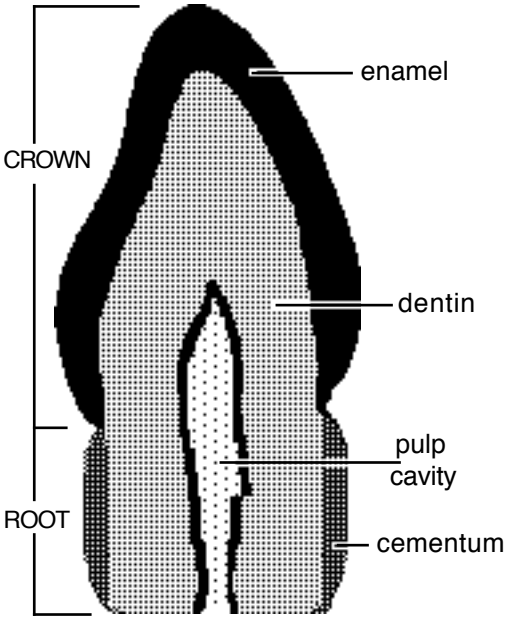
• The tongue develops from four swellings situated on the floor of the pharynx:

— the ***body*** & ***apex*** of the ***tongue*** arise from paired *distal (lateral) swellings* in the floor of the pharynx, the swellings fuse along the midline and grow forward into the oral cavity (thereby acquiring an ectodermal covering)

— the ***body*** & ***apex*** of the ***tongue*** arises predominantly from the *first pharyngeal arch* (general sensation is from the trigeminal nerve, V). The *second pharyngeal arch* also contributes (taste sensation is from the facial nerve, VII).

— the ***root*** of the ***tongue*** is formed by the *proximal swelling* and covered by endoderm. It arises from the third pharyngeal arch (sensation is supplied by the glossopharyngeal nerve, IX) .

— the *median swelling* contributes significantly to the tongue only in ungulates (especially cattle where it forms a prominent bulge);



• The muscles of the tongue originate from occipital somites (innervated by the hypoglossal nerve, XII).

Salivary glands:

• Salivary glands are derived from *ectoderm* (parotid, zygomatic, and labial and buccal accessory salivary glands) or from *endoderm* (mandibular and mono- and poly-stomatic sublingual salivary glands).

• The process of salivary ***gland formation*** is typical of exocrine gland development in general:

— surface epithelial cells undergo localized proliferation, forming a cellular cord that invades underlying ectomesenchyme

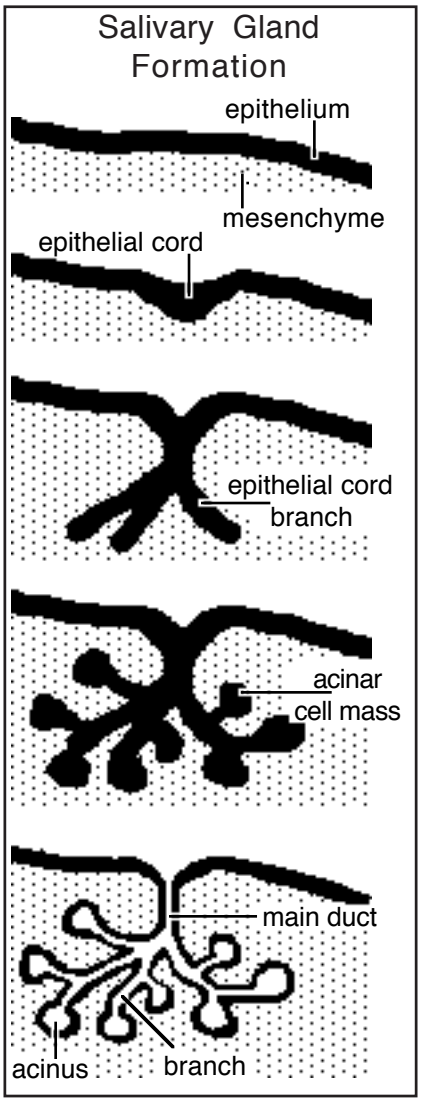
— the initial site of penetration ultimately becomes the ***duct opening*** at the surface

— the invading cord of cells begins to branch, ultimately becoming the ***main duct*** and ***branched ducts*** of the gland;

— masses of epithelial cells accumulate at the ends of each branch, forming ***secretory acini*** of the gland;

— the epithelial cords and masses canalize (become hollow) and the gland becomes functional; growth of the jaw causes elongation of the main duct.

> **NOTE**: A polystomatic gland is one that has many duct openings to the surface. Such glands arise as a series of independent epithelial cords. Although they are independent glands embryologically, they appear to form a single mass and in gross anatomy they are collectively identified as a single gland.



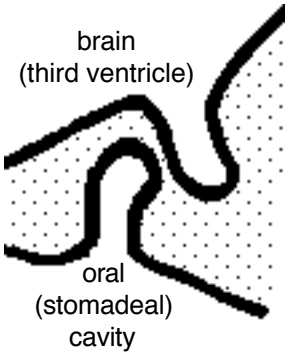
Adenohypophysis:

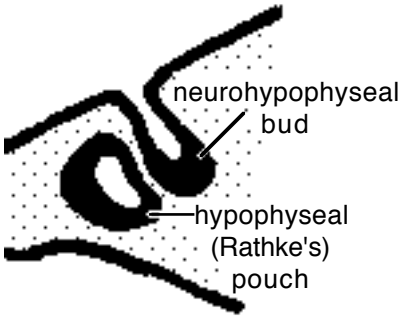
• The adenohypophysis develops from an ectodermal thickening (*placode*) in the roof of the *stomadeal cavity*.

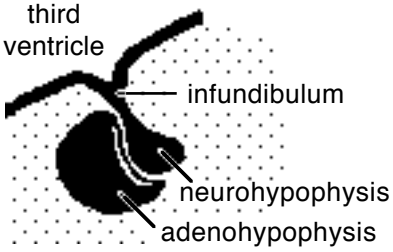
• The placode evaginates to form an hypophyseal pouch (Rathke's pouch).

• The pouch separates from the stomadeal ectoderm and wraps around the neurohypophysis, an outgrowth of the hypothalamus.

• Depending on species, the cavity of the pouch may persist as a cleft (separating a pars tuberalis from a more voluminous pars distalis of the adenohypophysis).







NOTE:
The ***hypophysis*** (pituitary gland) consists of a ***neurohypophysis*** and an ***adenohypophysis***. Both components are controlled by the hypothalamus of the brain.

Hypothalamic neurons must release hormones into the blood stream to control the adenohypophysis.

The neurohypophysis is connected to the hypothalamus by means of an infundibulum. Axons of hypothalamic neurons run through the infundibulum and terminate in the neurohypophysis.