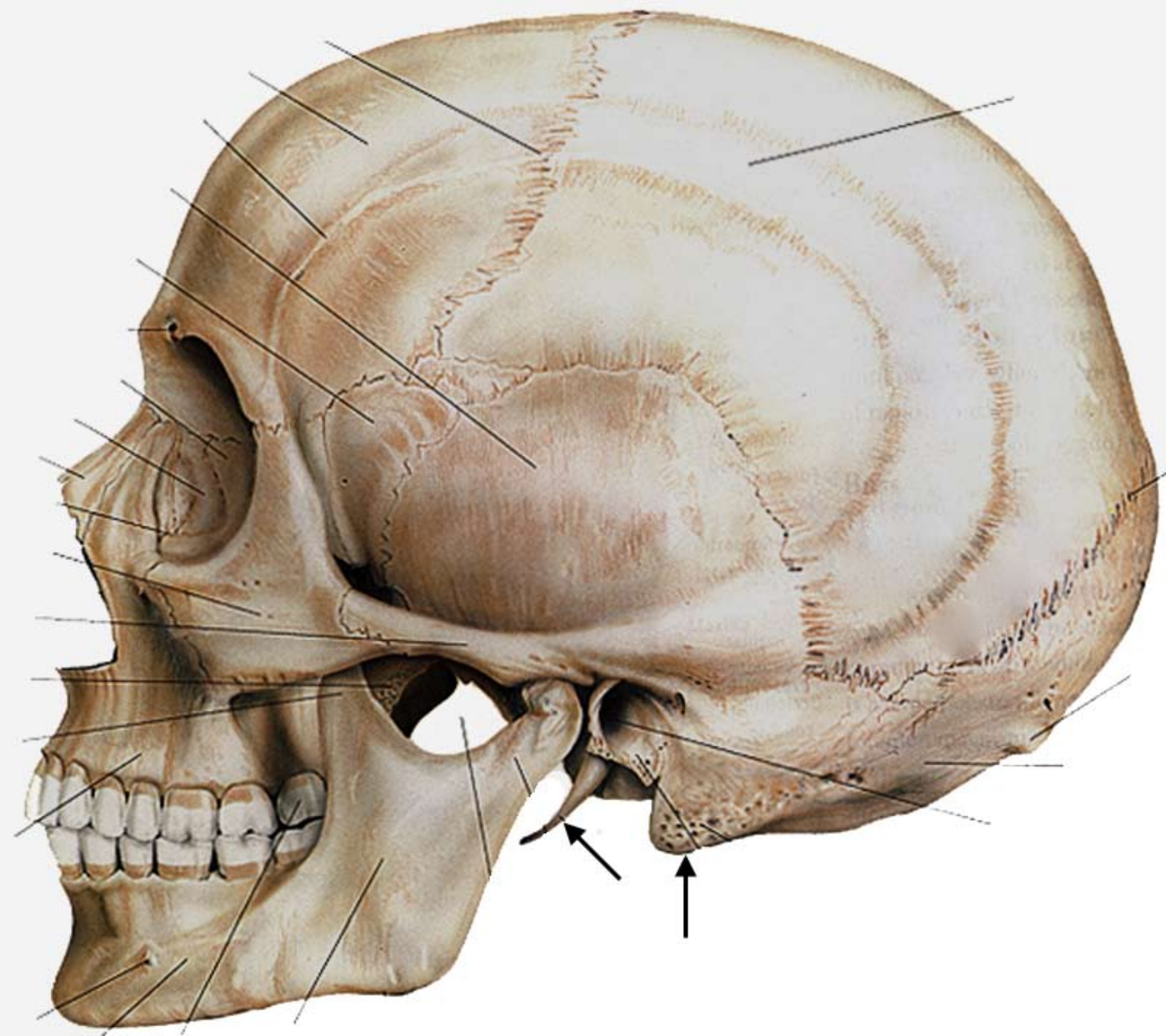
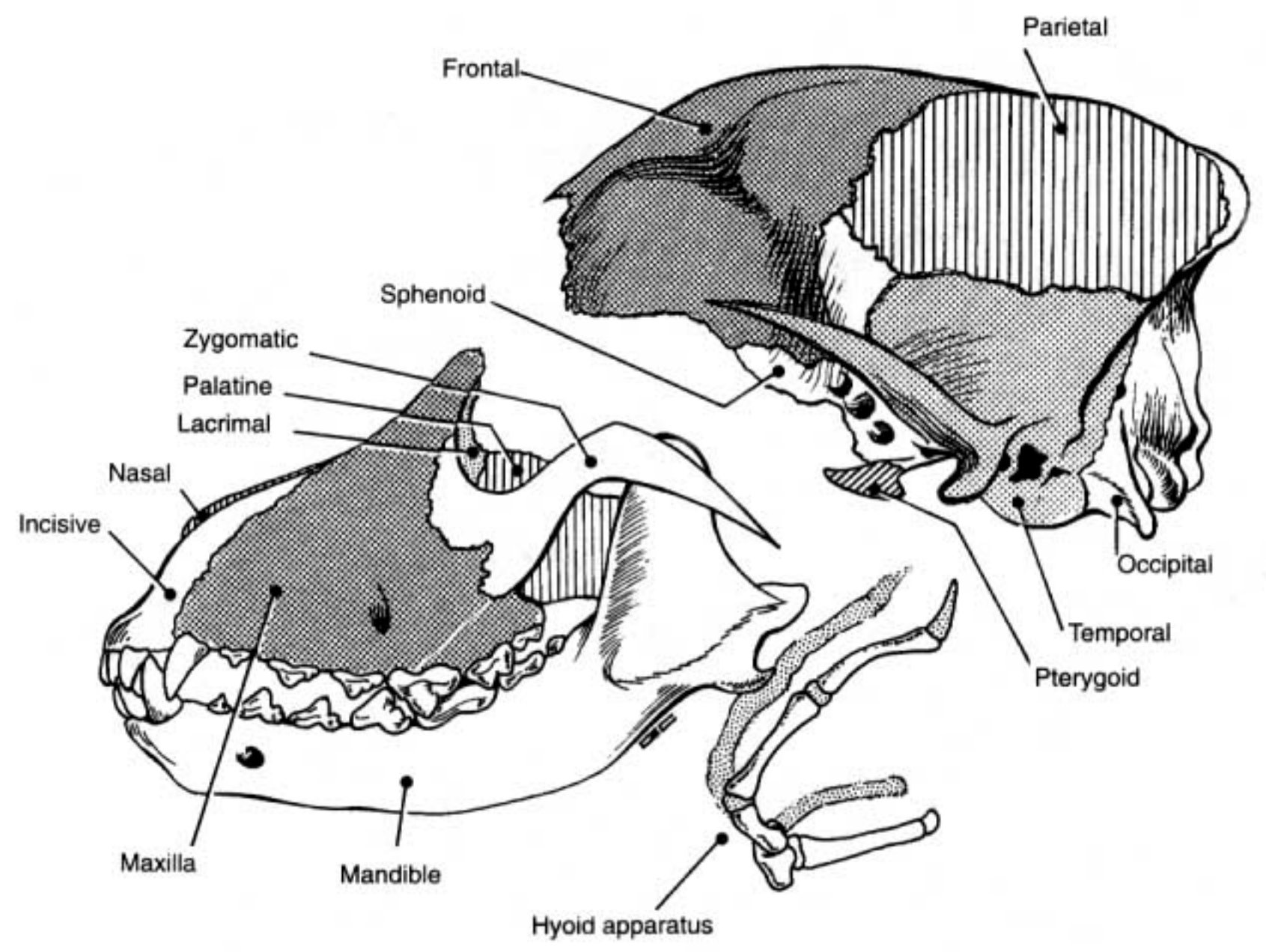
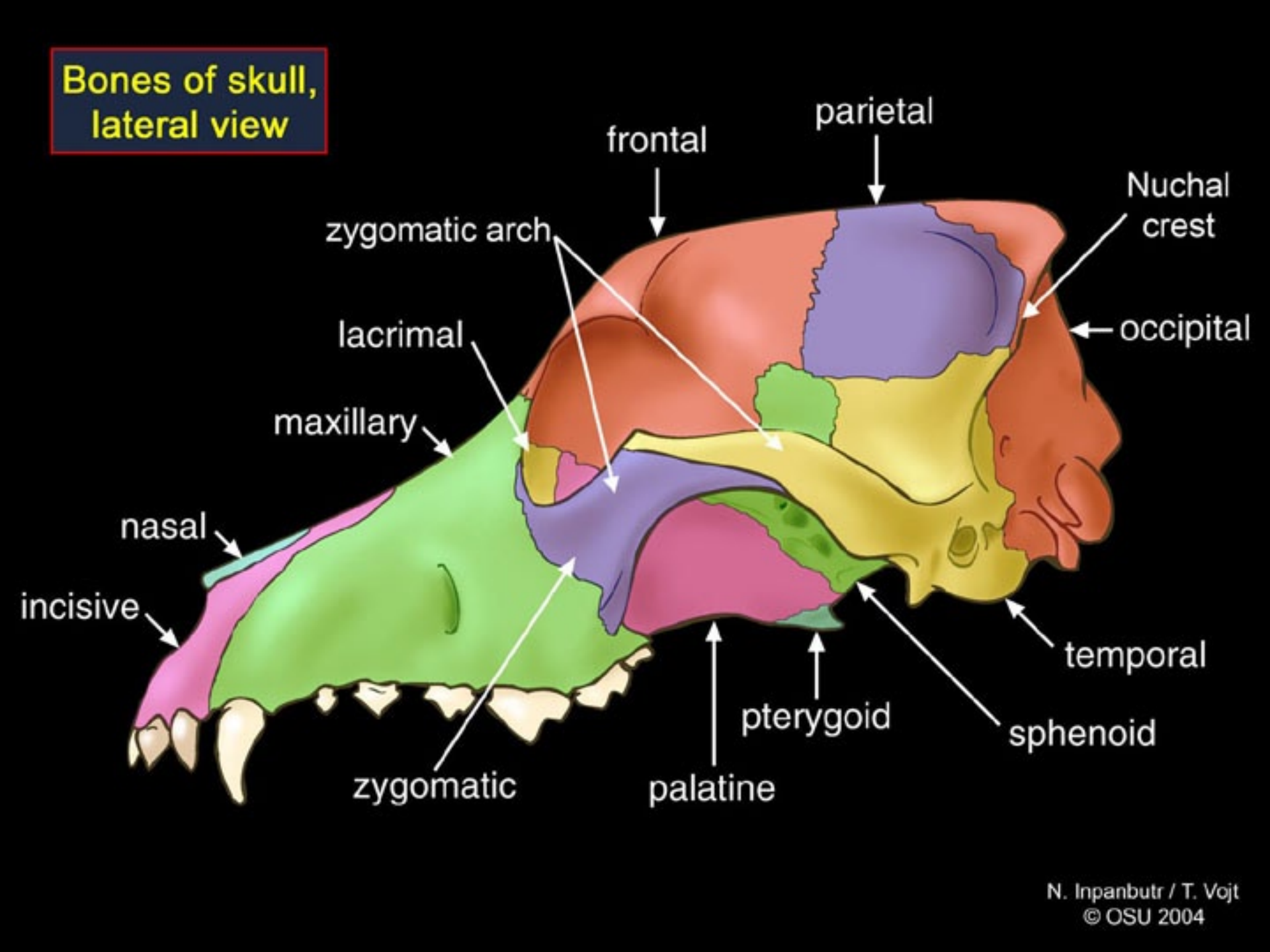



Parietal
Frontal
Sphenoid
Zygomatic
Palatine
Lacrimal
Nasal
Incisive
Occipital
Temporal
Pterygoid
Maxilla
Mandible
Hyoid apparatus


Bones of skull, lateral view
frontal
parietal
Nuchal crest
zygomatic arch
occipital
lacrimal
maxillary
nasal
incisive
temporal
pterygoid
sphenoid
zygomatic
palatine
N. Inpanbutr / T. Vojt
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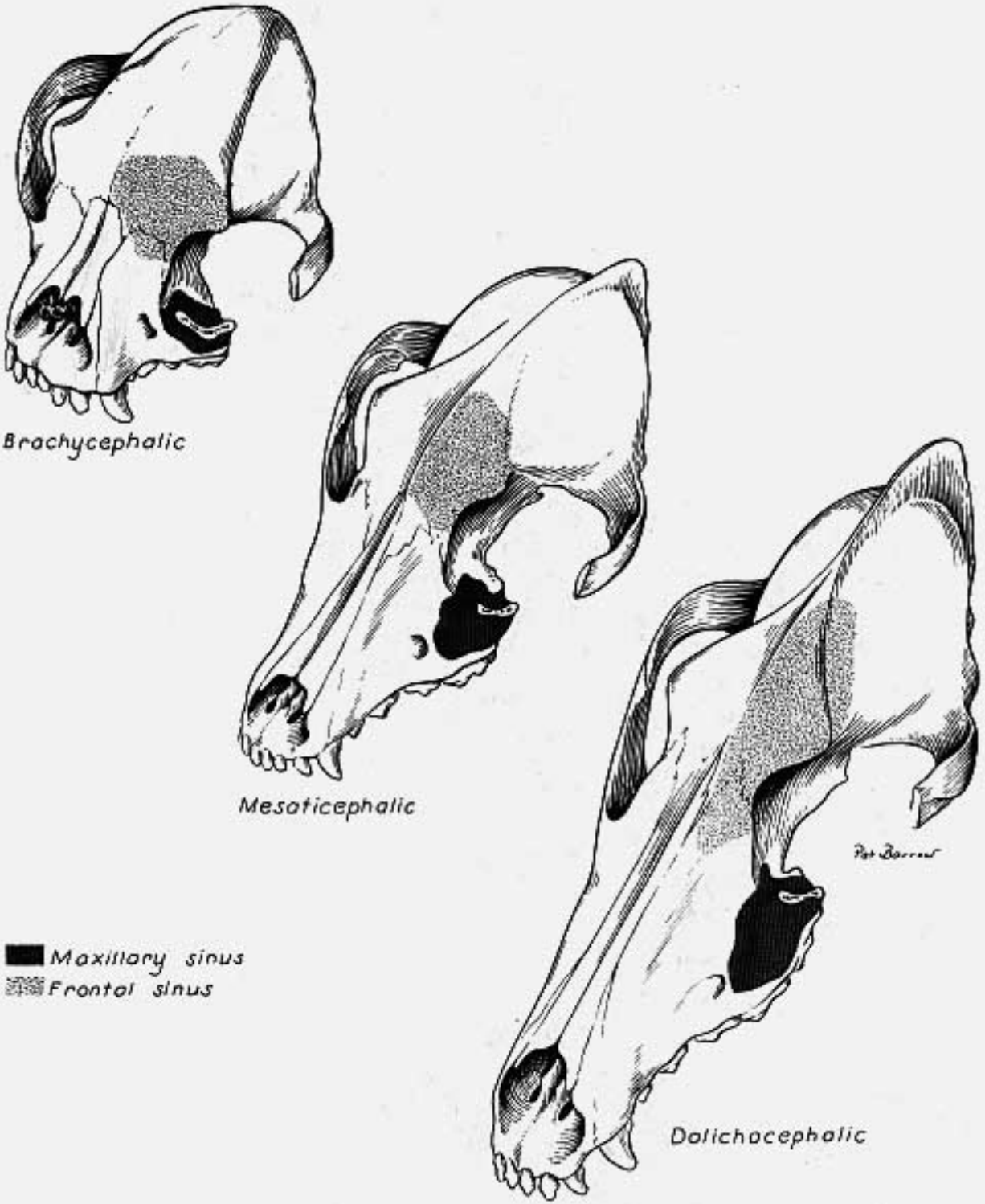

Brachycephalic
Mesaticephalic
Dolichocephalic
Maxillary sinus
Frontal sinus

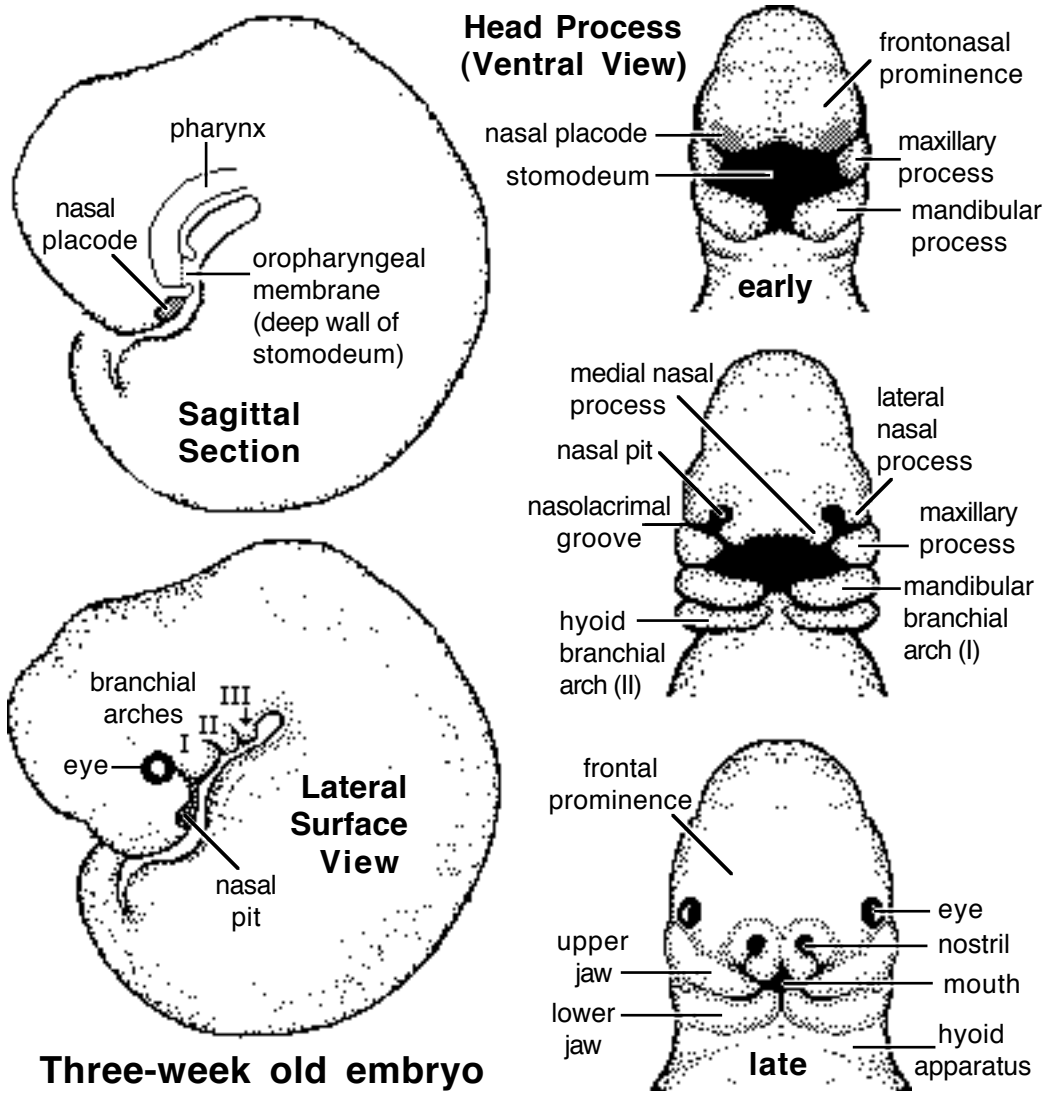
Face, Nasal Cavity, Mouth &Pharynx

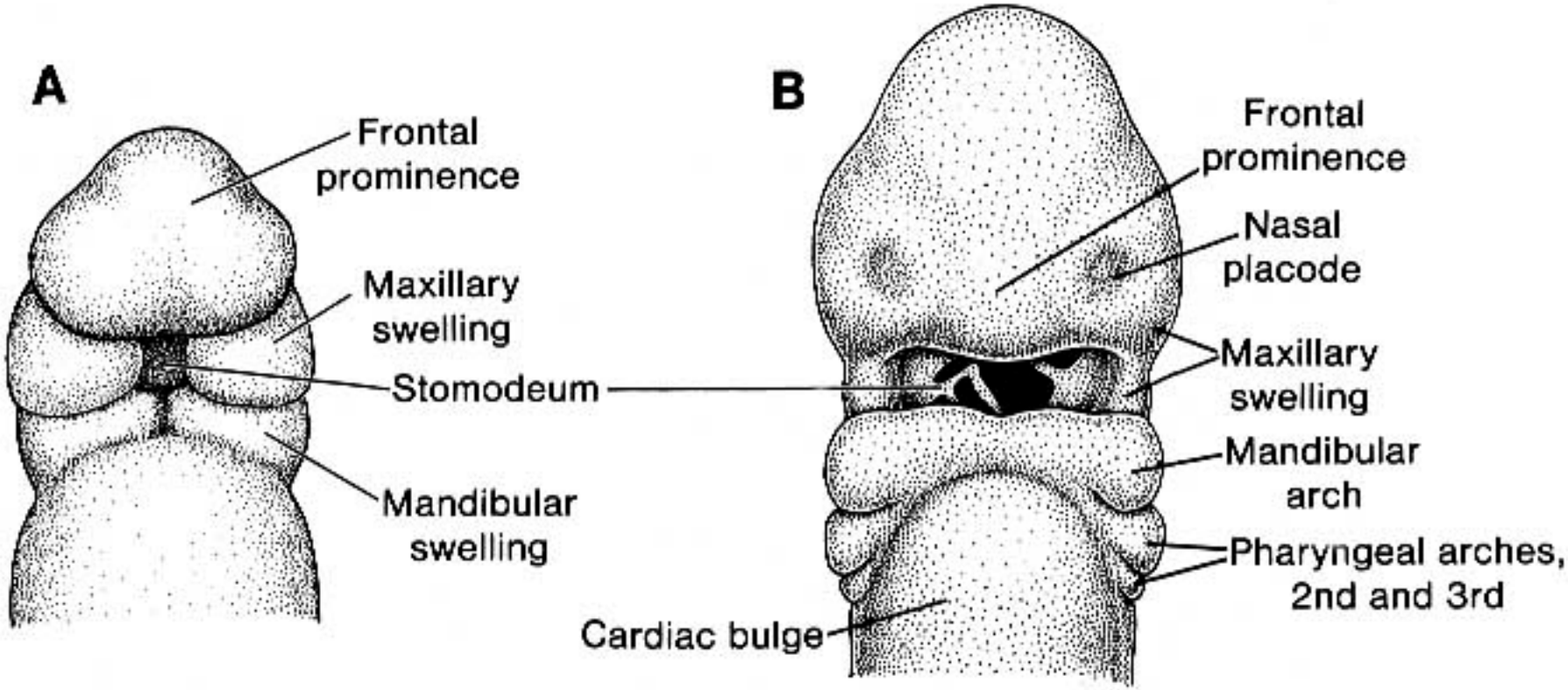
Face:

The face develops from outward growth of tissue located rostral to the cranium & pharynx. The lower jaw and most of the upper jaw are formed by growth of the first pharyngeal (branchial) arch. The upper incisor region and the nose and forehead (frontal region) are formed from tissue located rostral to the neural tube (frontonasal prominence). The development process proceeds as follows:

— the **first pharyngeal (branchial) arch** grows outward as two processes:
- a lower (mandibular) process grows first and forms the *mandible* and soft tissue of the lower jaw (right and left processes fuse to form the mandibular symphysis)
- an upper (maxillary) process grows to form most of the upper jaw (caudal to the incisor teeth)

— dorsal to each maxillary process, a **frontonasal prominence** expands outward; it soon becomes divisible into a *frontal prominence* (which forms frontal bone of the forehead) and *medial & lateral nasal processes*.




A
Frontal prominence
Maxillary swelling
Stomodeum
Mandibular swelling
B
Frontal prominence
Nasal placode
Maxillary swelling
Mandibular arch
Pharyngeal arches, 2nd and 3rd
Cardiac bulge

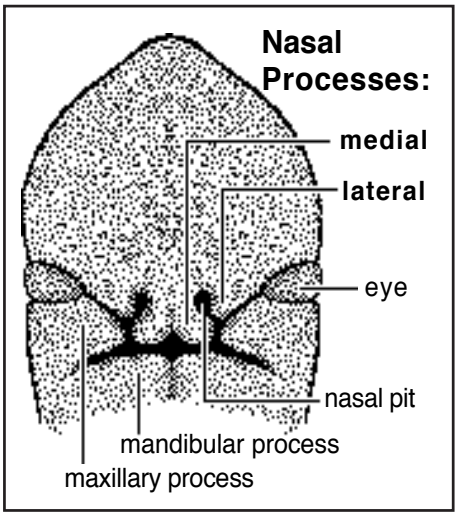
Pharyngeal Arches

- Six pairs of pharyngeal (branchial) arches develop, although only the first three are superficially distinct in mammals (arch V atrophies & arch VI merges with arch IV.) Adjacent pharyngeal arches are separated by pharyngeal clefts (grooves). The external clefts are apposed internally by pharyngeal pouches.
- Mesenchyme within pharyngeal arches (and within the frontonasal prominence) is ectomesenchyme, derived from neural crest. Ectomesenchyme forms intramembranous bone and fascia of the face and cranium. (Bones along the floor of the skull develop endochondrally from mesodermal mesenchyme derived from occipital somites.)
- Skeletal muscle of the head is derived from either 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 structures derived from the arch.

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

Nasal cavity:

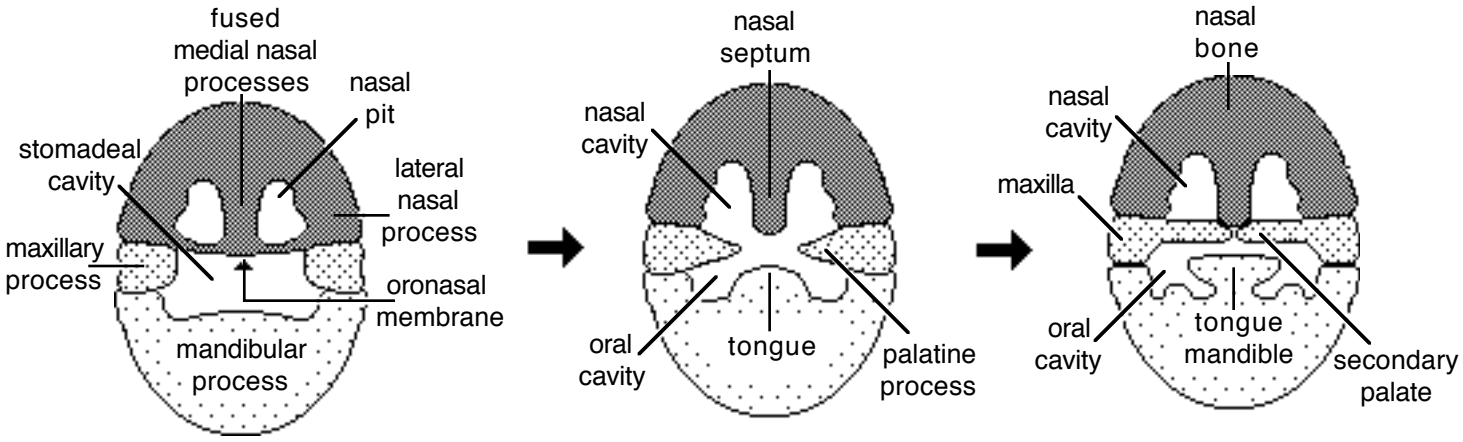
Initially, a *nasal placode* (ectoderm thickening) appears bilaterally at the rostral end of the frontonasal prominence. Subsequent growth of surrounding *medial* and *lateral nasal processes* forms a **nasal pit** (bilaterally). Continued growth of each nasal pit, plus wall erosion, produces a primitive nasal cavity that communicates bilaterally, with the oral cavity.

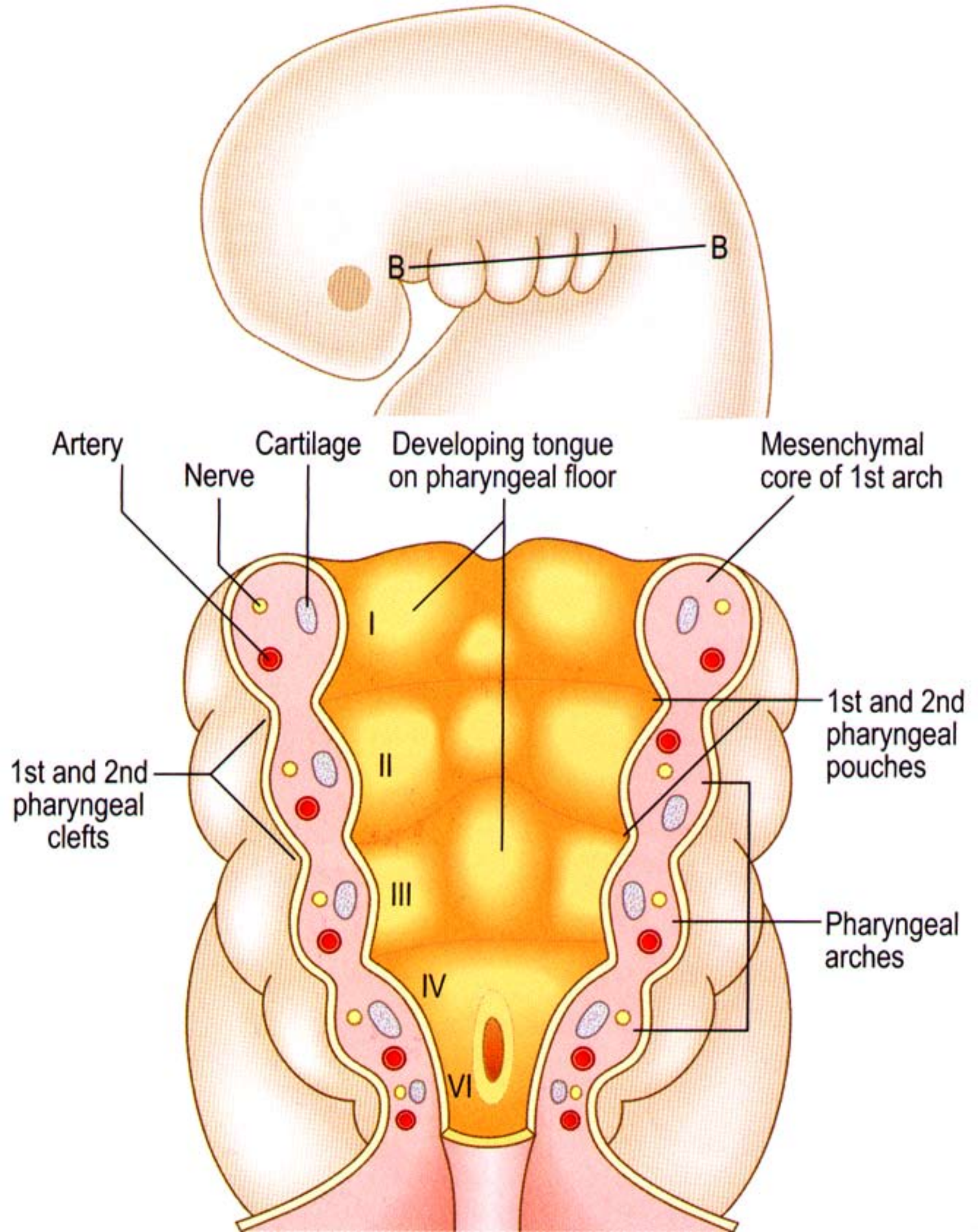


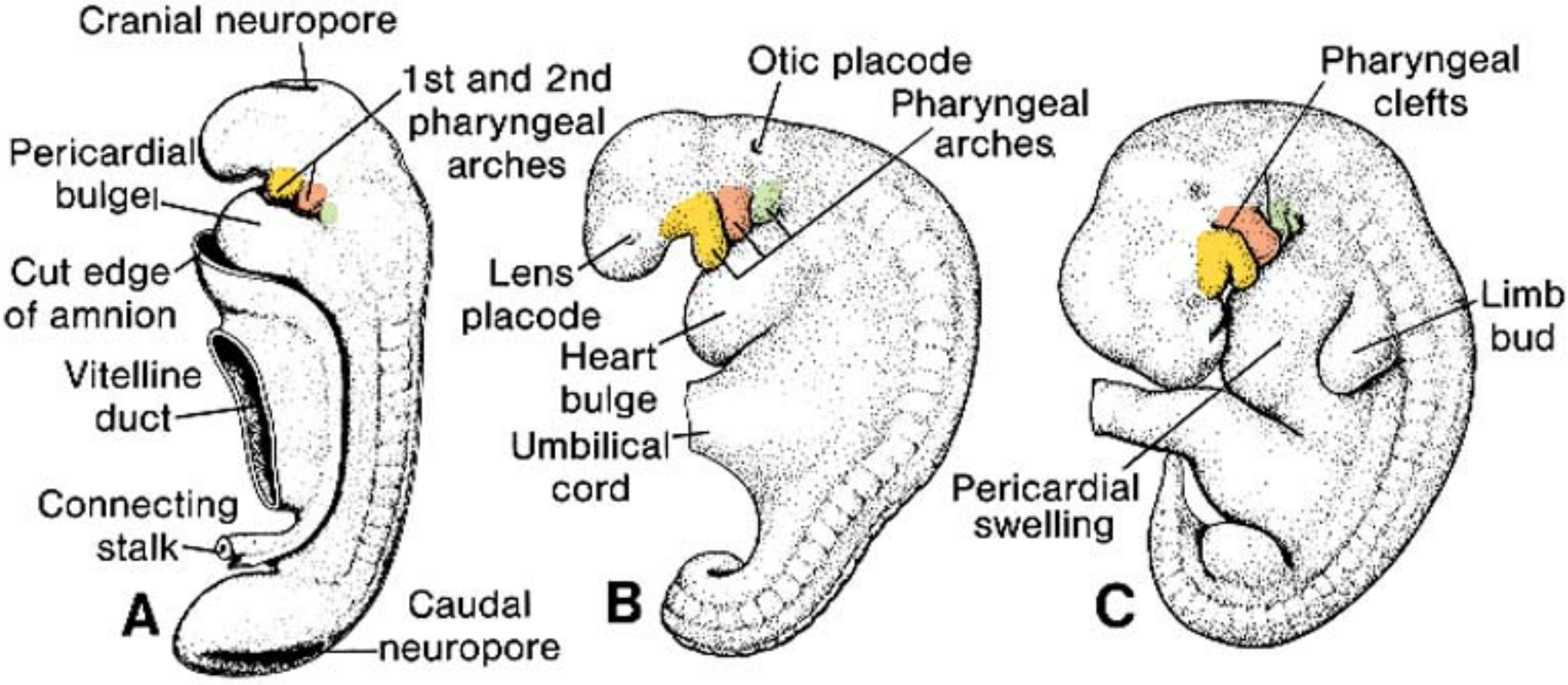
The bilateral rostral openings of the nasal cavity becomes *external nares* (nostrils) and ectomesenchyme surrounding them forms cartilage of the nose. Each **lateral nasal process** give rise to alar cartilage of the nose, nasal bone and lacrimal bone. A nasolacrimal duct is formed by ectoderm along the seam where the lateral nasal process meets the maxillary process.

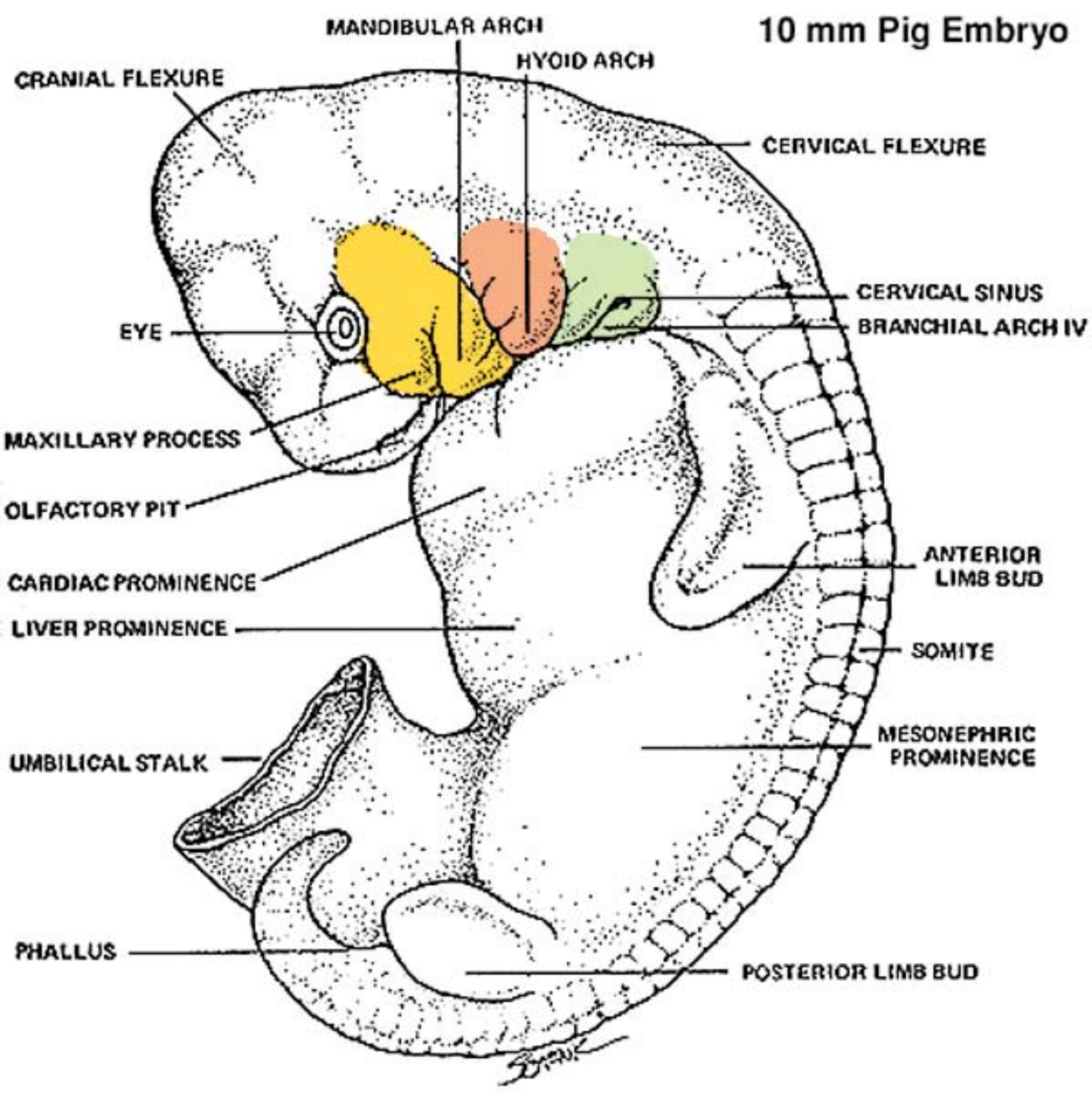
Fusion of right and left **medial nasal processes** forms a *primary palate* rostrally and the *nasal septum* caudally. The incisive bone, including upper incisor teeth and the rostral upper lip, are derived from the primary palate. The nasal septum consists of bone, cartilage, and a patch of soft tissue membrane that separates right & left halves of the nasal cavity.

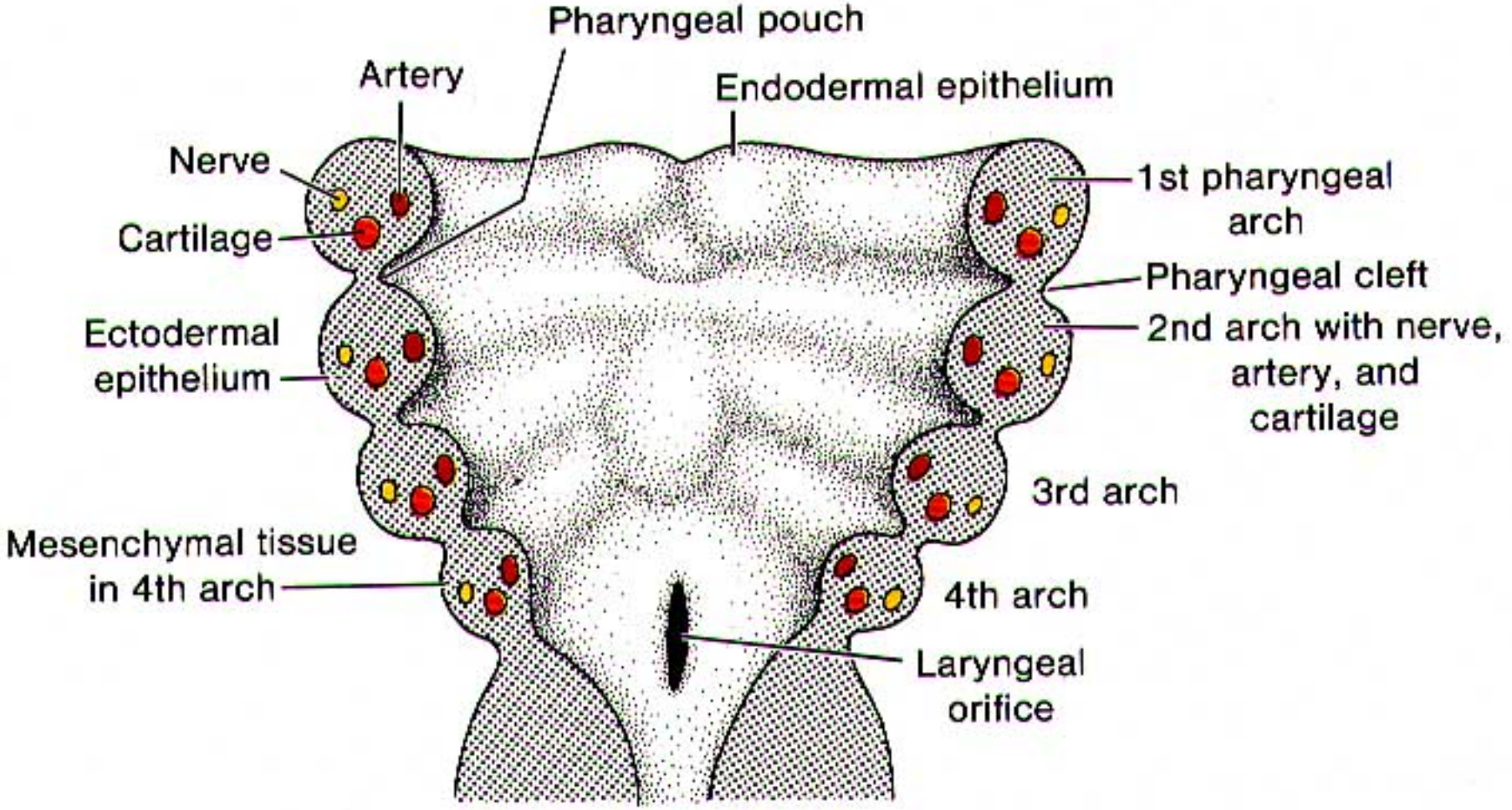
Nasal and oral cavities communicate with one another following erosion of an oronasal membrane that initially separated them. In mammals, nasal and oral cavities are again separated by formation of a *secondary palate* that shifts the nasal-oral communication caudally into the pharynx.

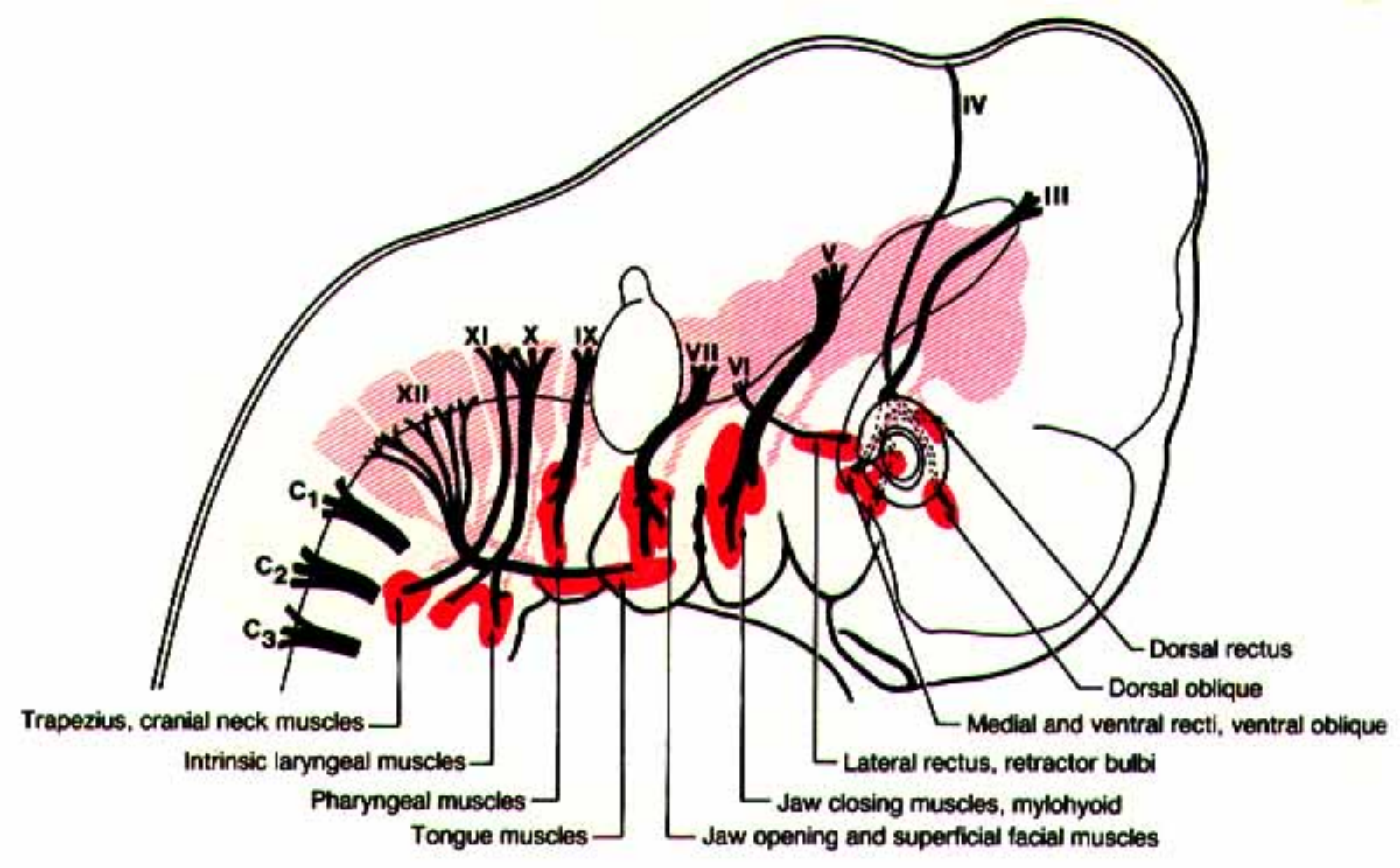



B
B
Artery
Nerve
Cartilage
Developing tongue on pharyngeal floor
Mesenchymal core of 1st arch
I
II
III
IV
VI
1st and 2nd pharyngeal clefts
1st and 2nd pharyngeal pouches
Pharyngeal arches


Cranial neuropore
1st and 2nd pharyngeal arches
Pericardial bulge
Cut edge of amnion
Vitelline duct
Connecting stalk
Caudal neuropore
A
Otic placode
Pharyngeal arches
Lens placode
Heart bulge
Umbilical cord
B
Pharyngeal clefts
Limb bud
Pericardial swelling
C


10 mm Pig Embryo
MANDIBULAR ARCH
HYOID ARCH
CRANIAL FLEXURE
CERVICAL FLEXURE
CERVICAL SINUS
BRANCHIAL ARCH IV
EYE
MAXILLARY PROCESS
OLFACTORY PIT
CARDIAC PROMINENCE
ANTERIOR LIMB BUD
LIVER PROMINENCE
SOMITE
MESONEPHRIC PROMINENCE
UMBILICAL STALK
PHALLUS
POSTERIOR LIMB BUD


Pharyngeal pouch
Artery
Endodermal epithelium
Nerve
Cartilage
1st pharyngeal arch
Pharyngeal cleft
Ectodermal epithelium
2nd arch with nerve, artery, and cartilage
3rd arch
Mesenchymal tissue in 4th arch
4th arch
Laryngeal orifice


IV
III
V
XI
X
IX
VII
VI
XII
C1
C2
C3
Dorsal rectus
Dorsal oblique
Medial and ventral recti, ventral oblique
Lateral rectus, retractor bulbi
Jaw closing muscles, mylohyoid
Jaw opening and superficial facial muscles
Tongue muscles
Pharyngeal muscles
Intrinsic laryngeal muscles
Trapezius, cranial neck muscles

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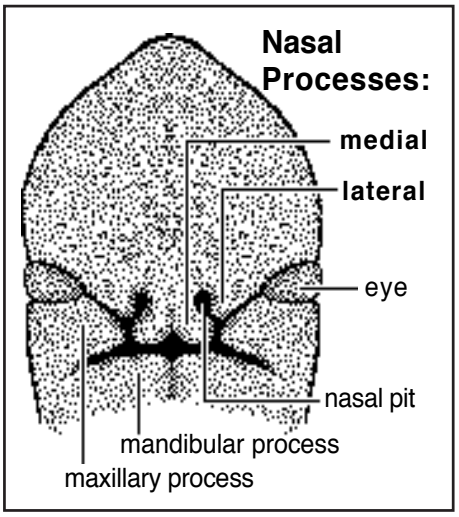

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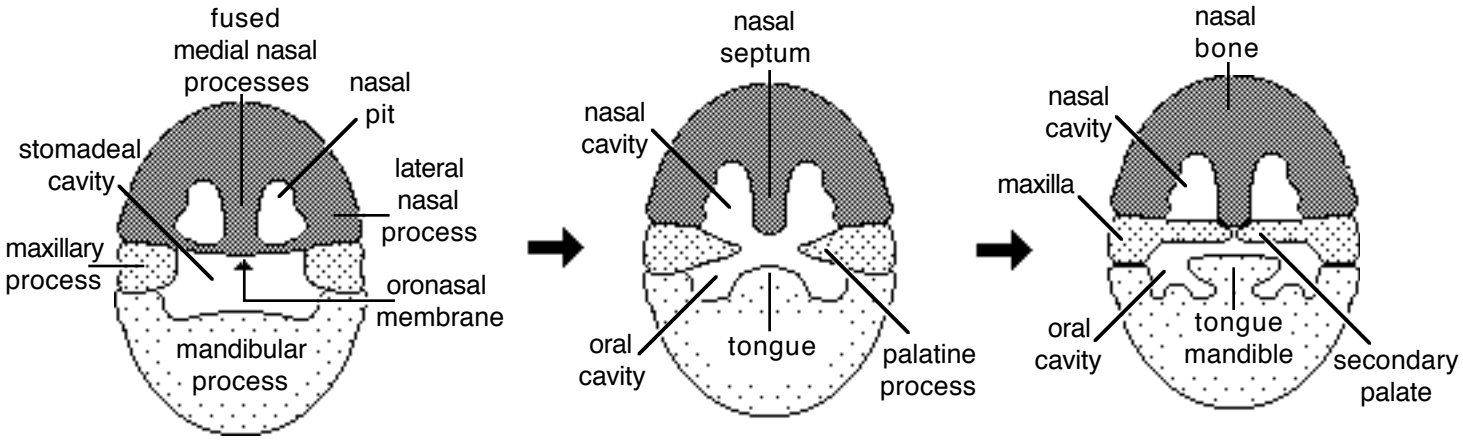
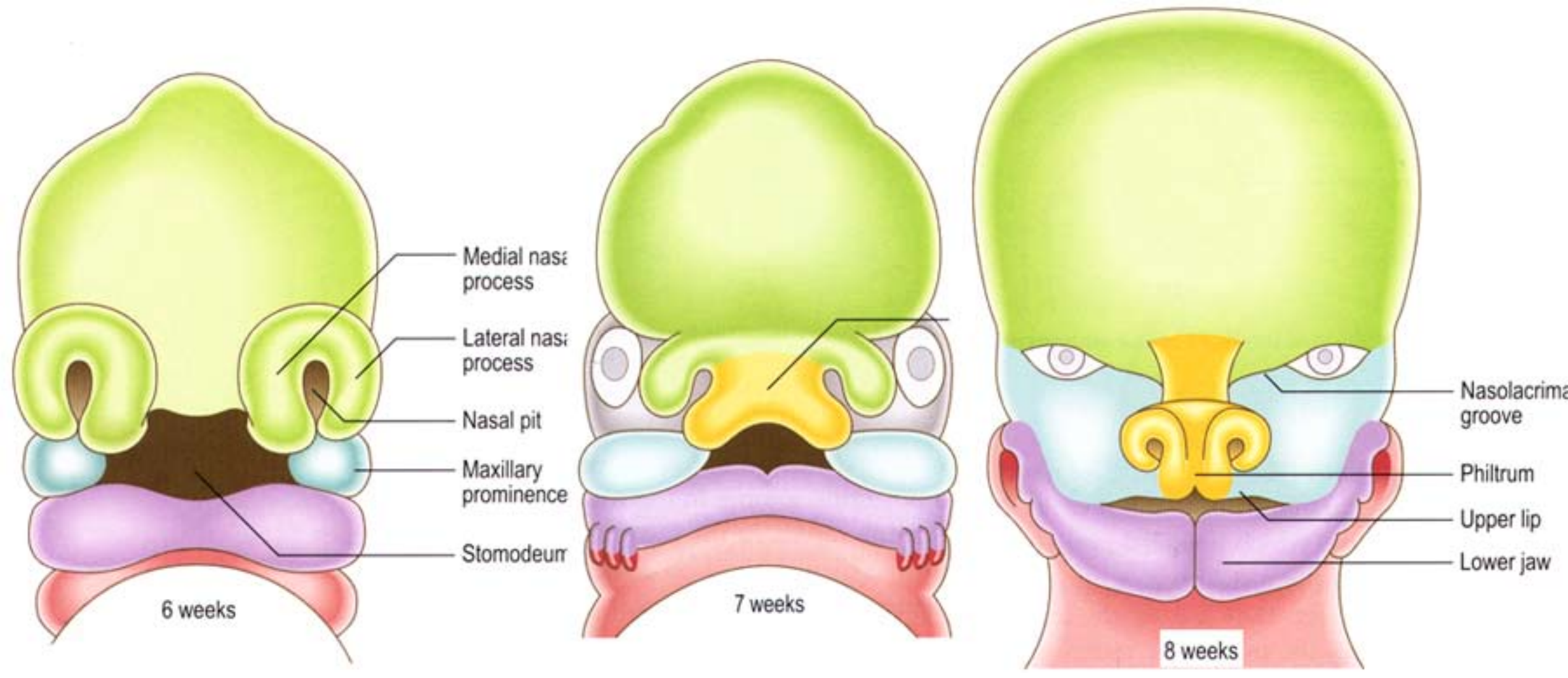
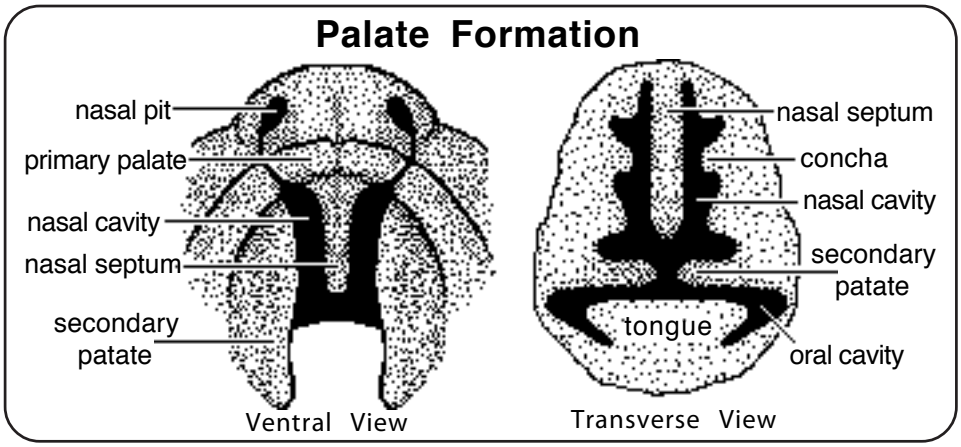



Medial nasal process
Lateral nasal process
Nasal pit
Maxillary prominence
Stomodeum
6 weeks
7 weeks
Nasolacrimal groove
Philtrum
Upper lip
Lower jaw
8 weeks

Palate:

Two palates are formed. The *primary palate,* which becomes incisive bone, is formed by medial nasal processes. The *secondary palate* is formed by bilateral medial extensions of maxillary processes. The extensions (palatine processes) meet at the midline, merging dorsally with nasal septum and rostrally with primary palate. The secondary palate (hard palate) separates nasal and oral cavities. Caudal extension of the secondary palate into the pharynx, forms a *soft palate* which divides the rostral pharynx into dorsal (nasopharynx) and ventral (oropharynx) chambers.



- 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).
- Failure of medial nasal processes to fuse (primary cleft palate), produces hare lip (cheiloschisis) and related defects. (Hare lip alone is normal is hares, sheep, etc.).

Conchae: Conchae (turbinates) are scrolls of thin bone covered by mucosa that grow into each nasal cavity. Conchae originate as cartilaginous ridges of bones of the wall of the nasal cavity.

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 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 the formation of upper and lower jaws. The first evidence of a mouth is the **stomodeum**, a rostral depression surrounded by prominences. Outgrowth of the prominences produces a *stomodeal cavity*.

The deep wall of the stomodeum *(oropharyngeal membrane)* is composed of a layer of surface ectoderm apposed to a layer of endoderm (rostral wall of the pharynx). The oropharyngeal membrane soon becomes fenestrated and disappears (the palatoglossal fold marks its location in the adult).

Initially, stomodeal cavity and nasal pits are separated by an oronasal membrane. Subsequently, the oronasal membrane degenerates and oral and nasal cavities communicate freely. Eventually a secondary palate develops, shifting oral-nasal communication caudally into the pharynx.

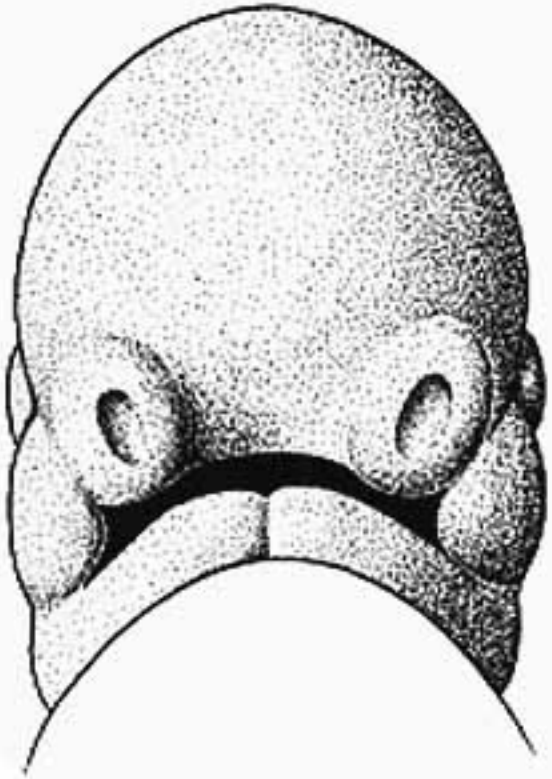


Fig. 3. — *4th-5th week : appearance of nasal placodes.*

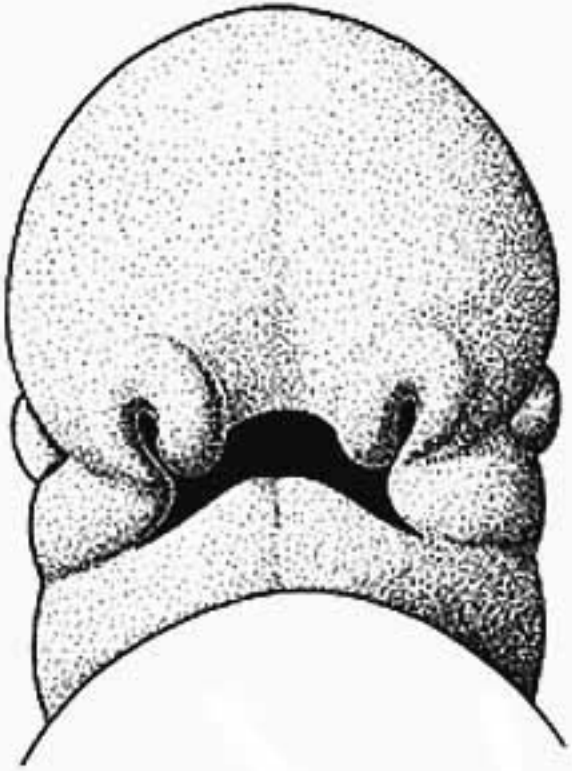


Fig. 4. — *5th-6th week : formation of nasal pits.*

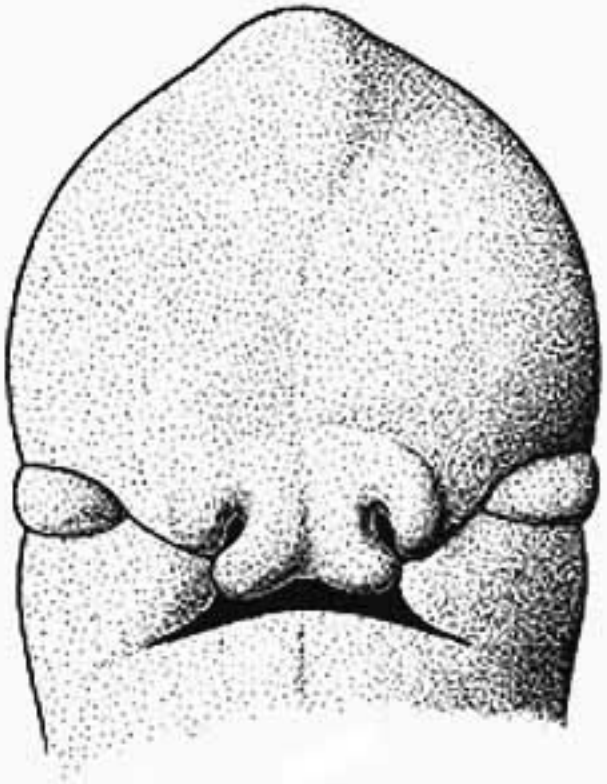
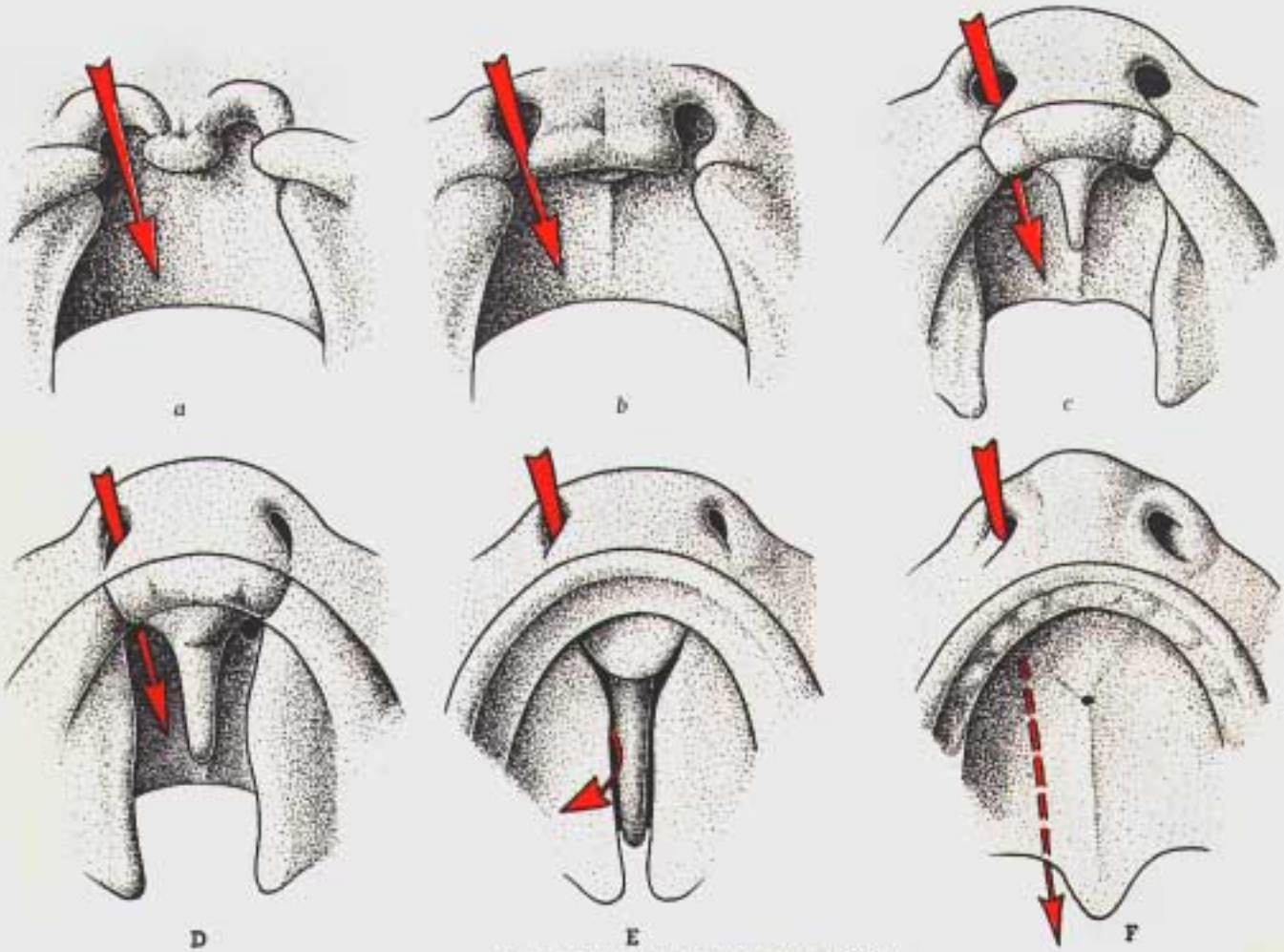
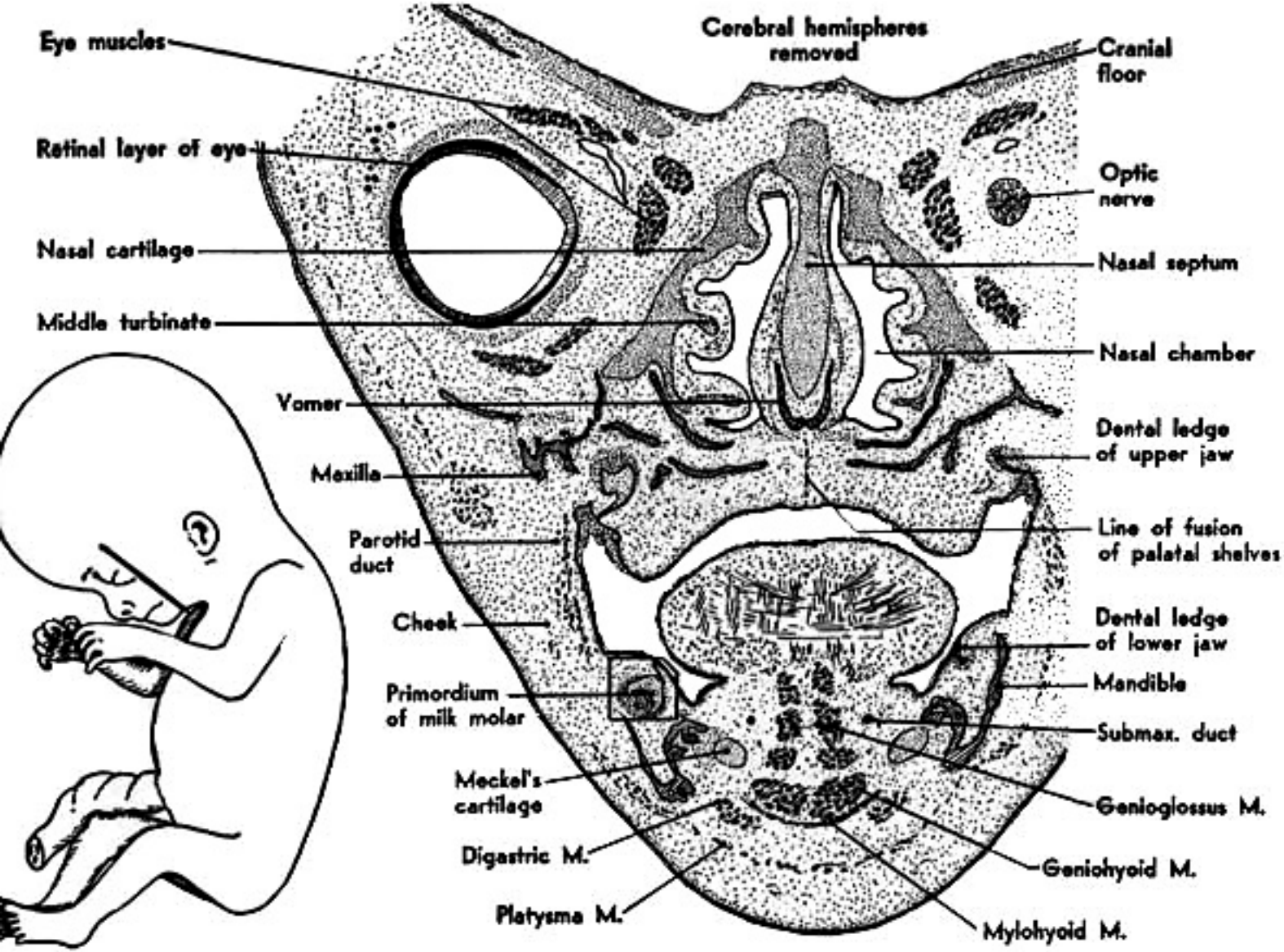


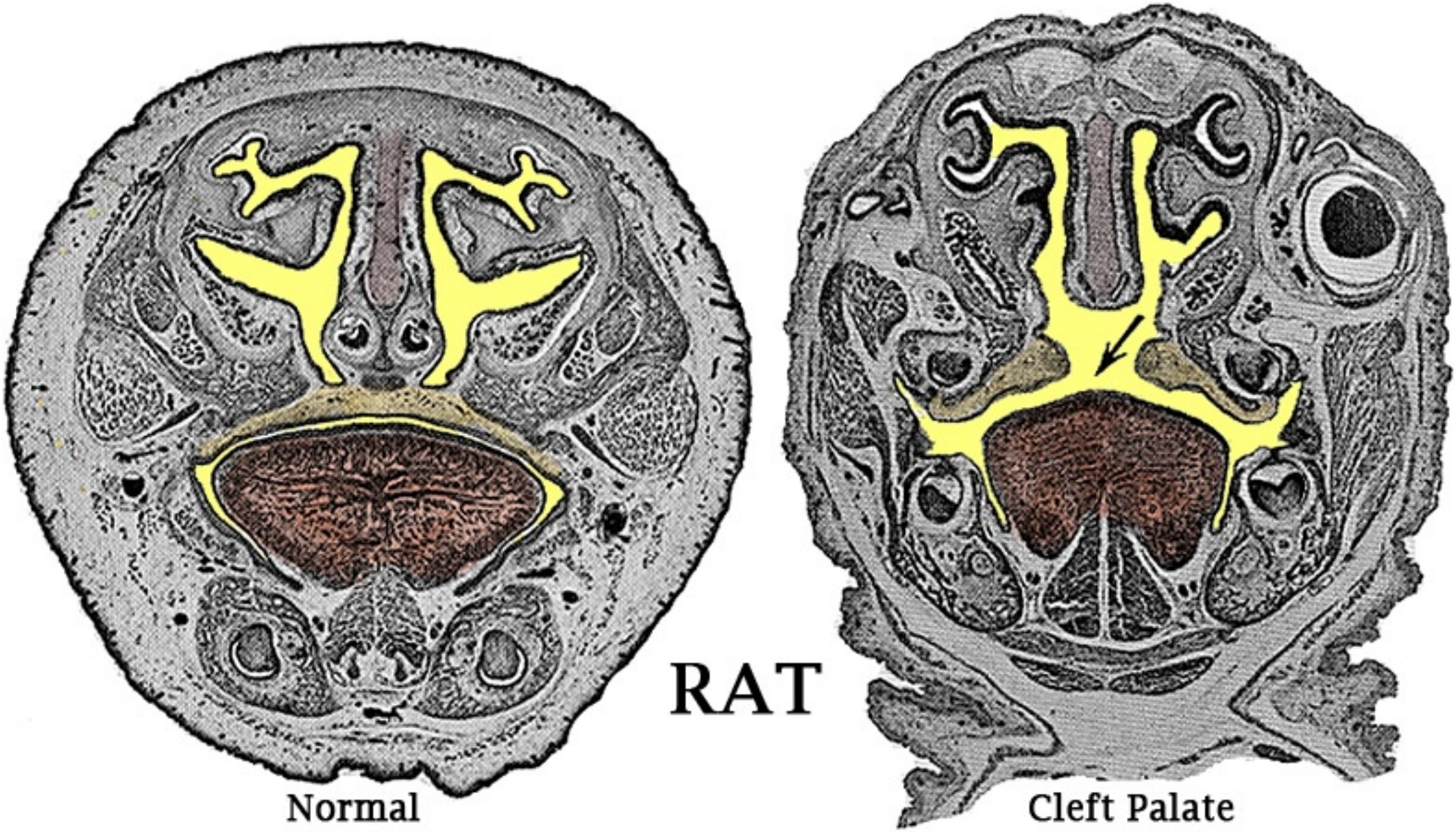
Fig. 5. — *6th-7th week : formation of nasal cavities.*

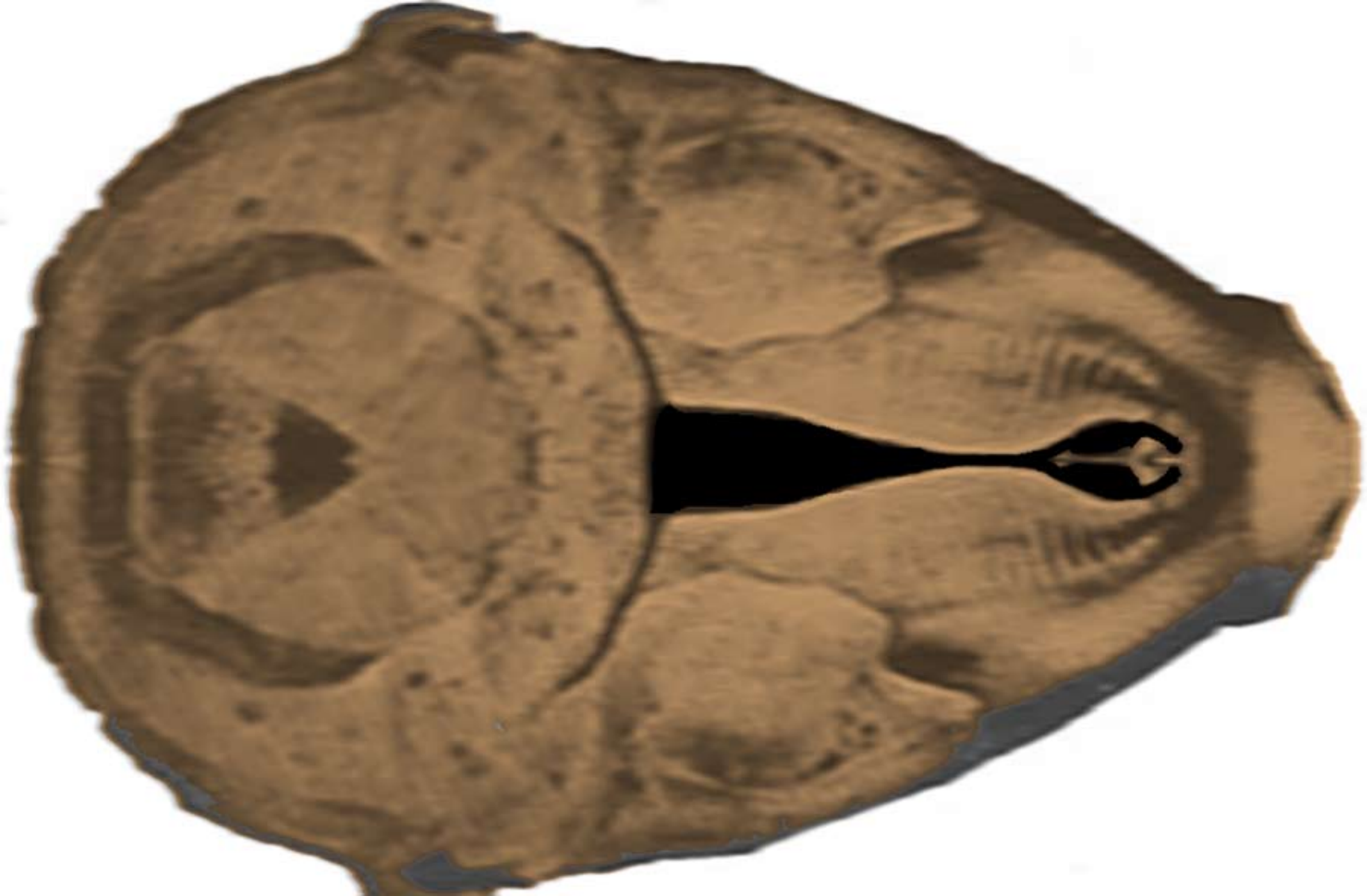
Anterior view : **development of the nostril.**



Ventral view : **the secondary palate.**


Eye muscles
Retinal layer of eye
Nasal cartilage
Middle turbinate
Vomer
Maxilla
Parotid duct
Cheek
Primordium of milk molar
Meckel's cartilage
Digastric M.
Platysma M.
Cerebral hemispheres removed
Cranial floor
Optic nerve
Nasal septum
Nasal chamber
Dental ledge of upper jaw
Line of fusion of palatal shelves
Dental ledge of lower jaw
Mandible
Submax. duct
Genioglossus M.
Geniohyoid M.
Mylohyoid M.


RAT
Normal
Cleft Palate



Give A Child With A Cleft A Second Chance At Life.

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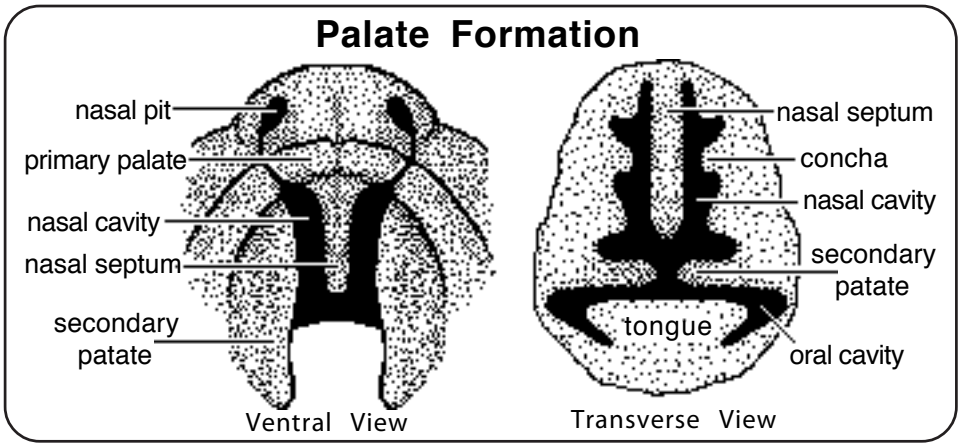

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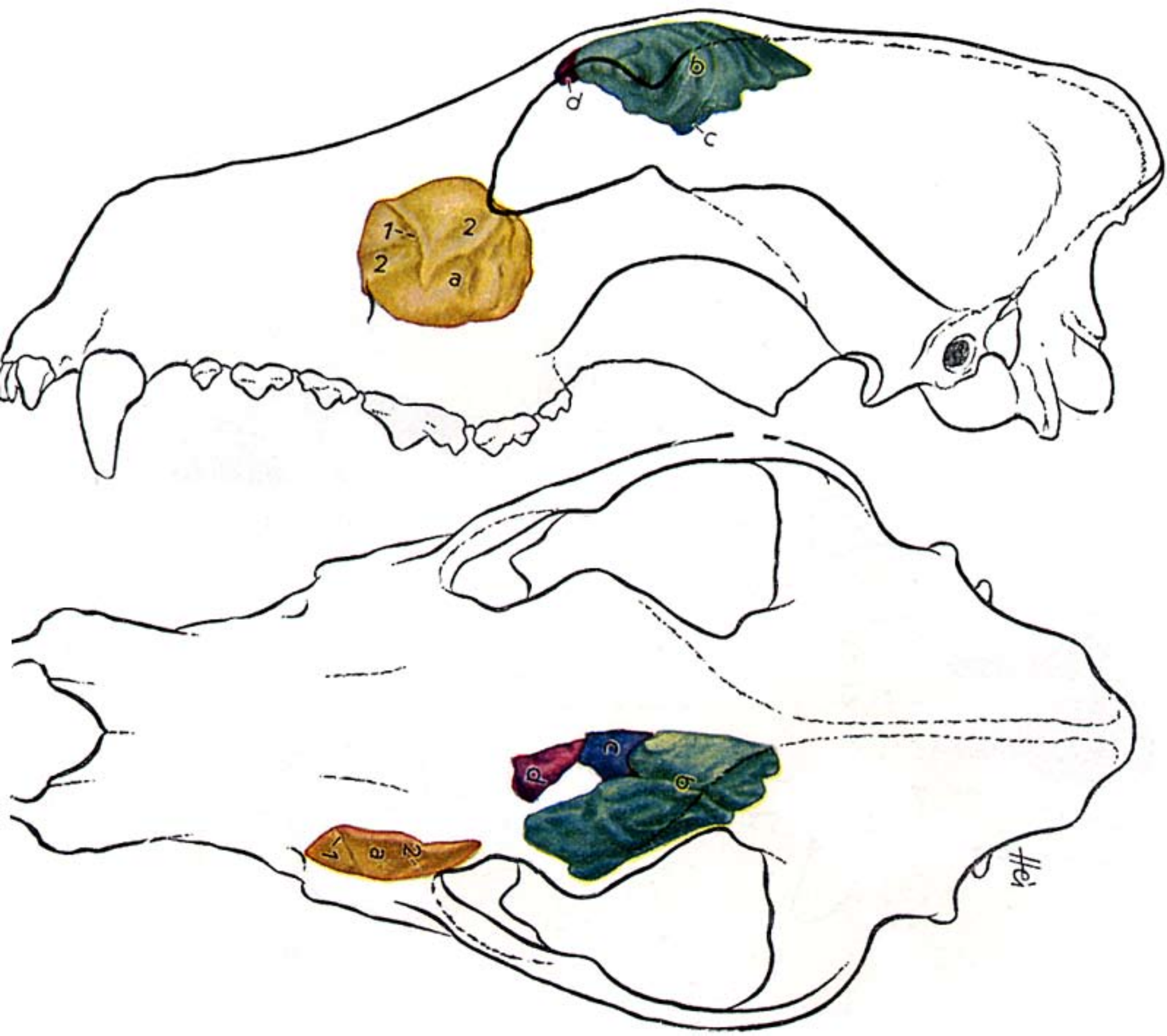
b
d
c
1
2
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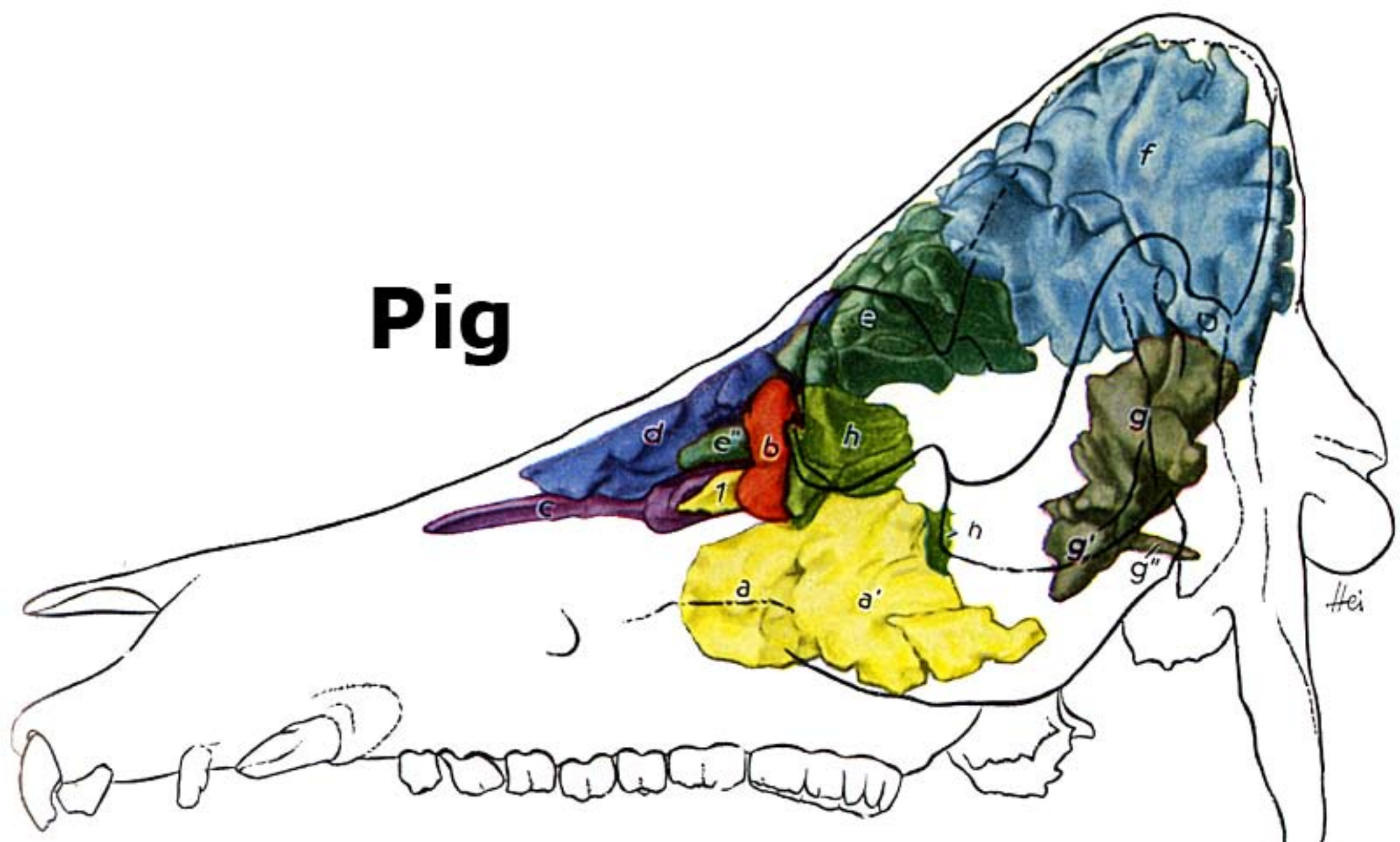
e
2


Pig
f
e
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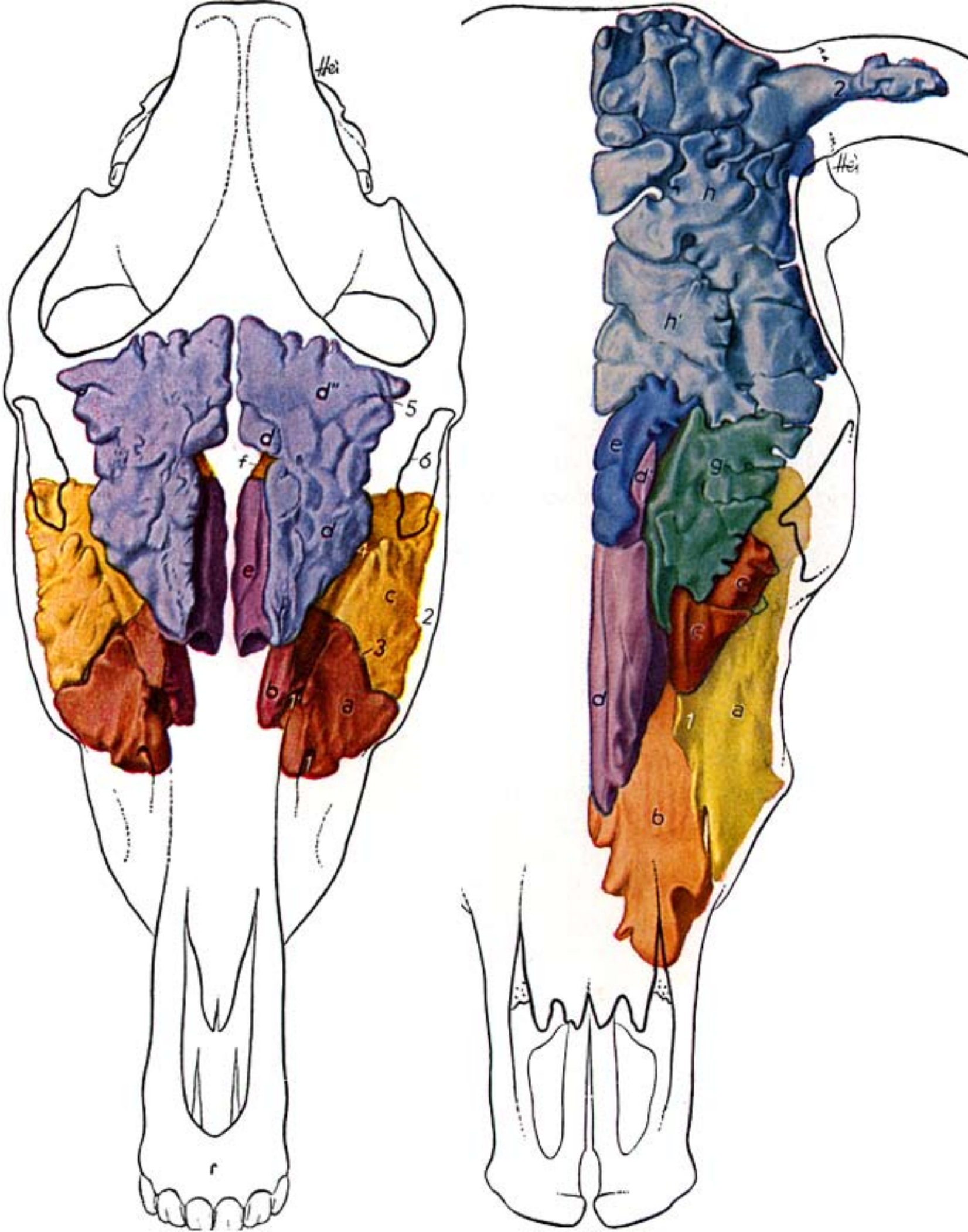
e''
b
h
1
c
g
g'
g''
h
a
a'


Hei
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Hei
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d
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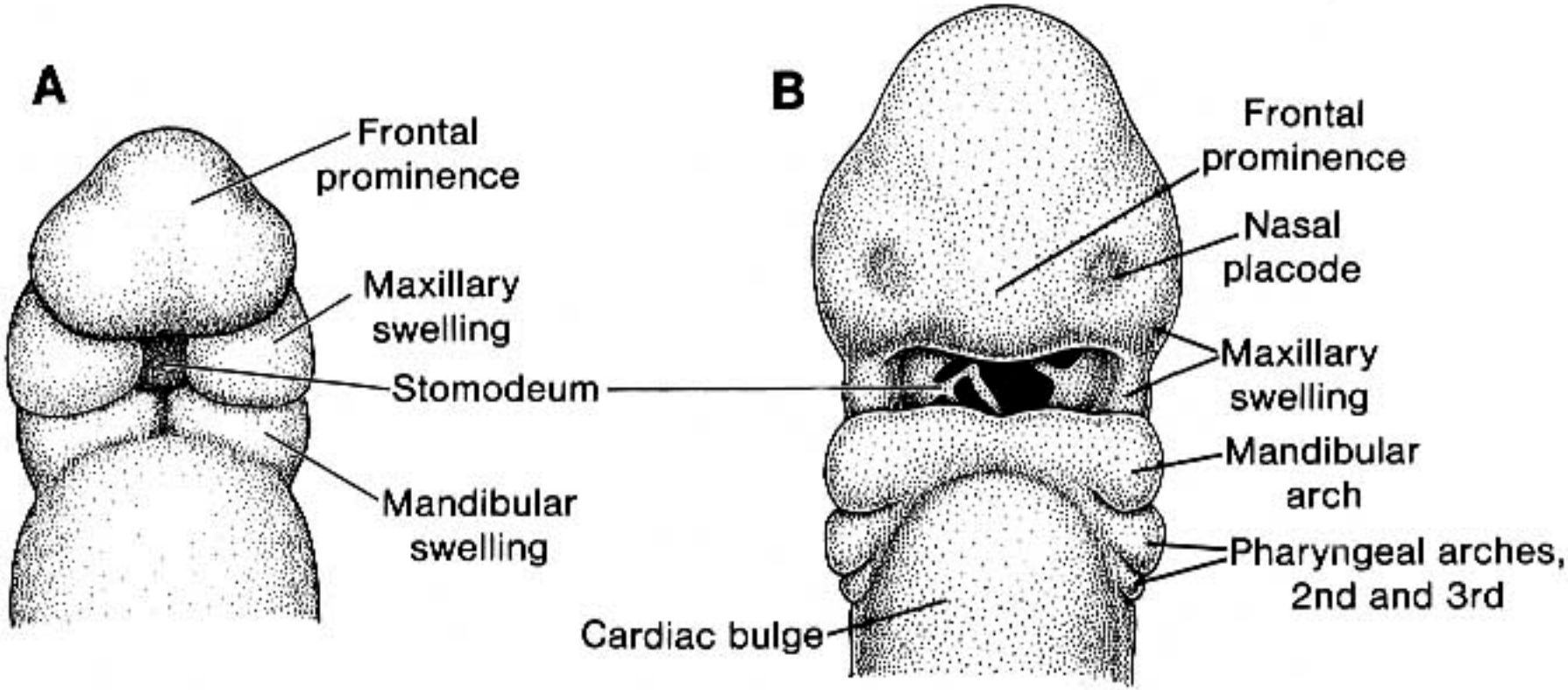
a
b


A
Frontal prominence
Maxillary swelling
Stomodeum
Mandibular swelling
B
Frontal prominence
Nasal placode
Maxillary swelling
Mandibular arch
Pharyngeal arches, 2nd and 3rd
Cardiac bulge

Lips and gingivae:

In the ectoderm lining the stomodeal cavity, an arc of thickened ectoderm, the *labiogingival lamina*, forms along upper and lower jaws. The lamina invaginates into underlying ectomesenchyme, forming a *labiogingival groove*. The groove forms the future vestibule. Tissue external to the groove forms the future lips, and tissue medial to the groove forms gingivae. Fusion of upper and lower lips caudally forms cheeks.

Teeth:

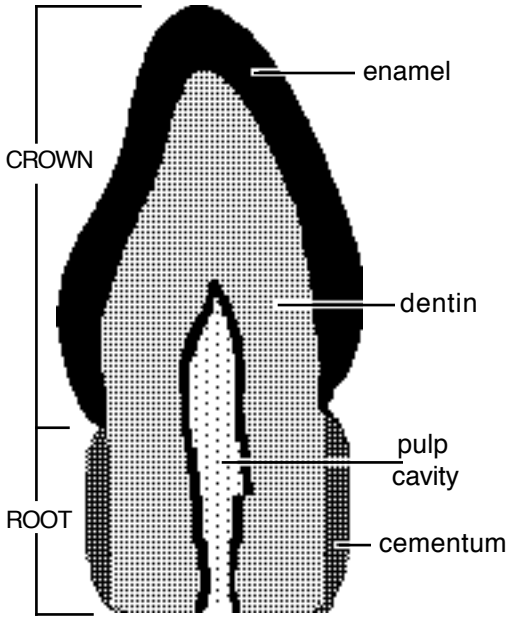
An arc of periodically thickened ectoderm, situated inside of the labiogingival lamina, constitutes the *dental lamina*. Invaginations of laminar cells form *dental buds*. If a bud is to form a deciduous tooth, an additional bud for its permanent replacement develops superficial and medial to the deciduous dental bud. Each 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;

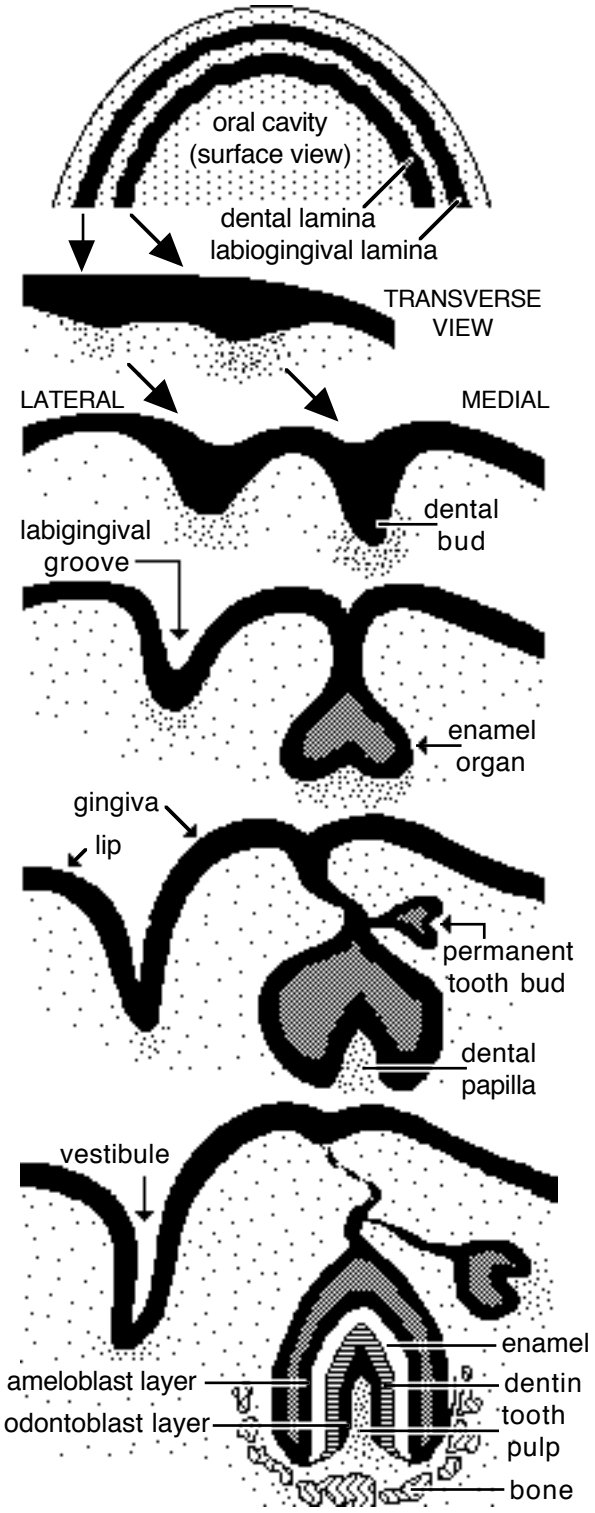
— ectomesenchyme surrounding the enamel organ condenses into a *dental sac* that gives rise to three layers:



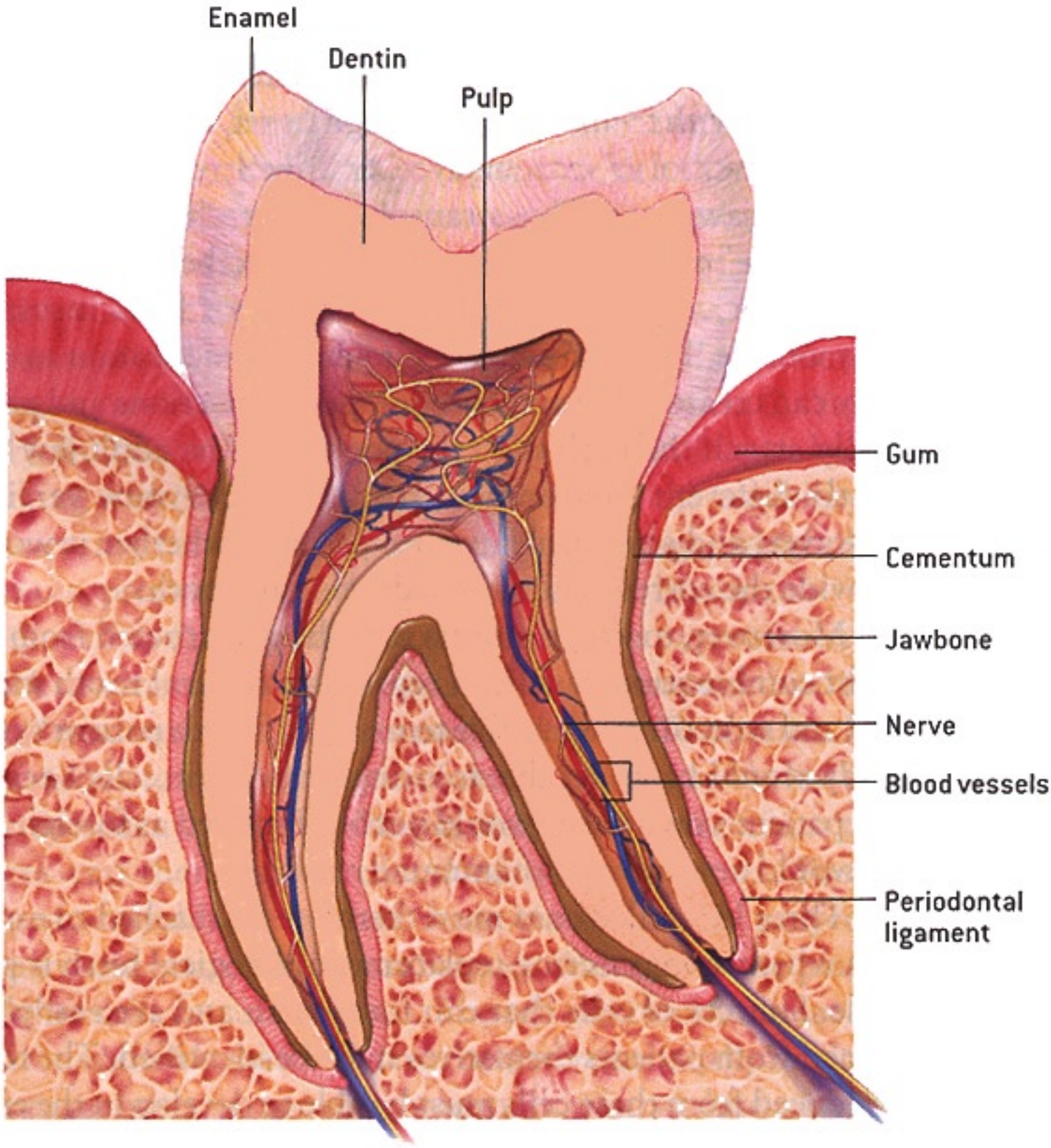
1] Outer cells of the dental sac differentiate into osteoblasts that deposit bone of the alveolus (socket receiving the tooth).

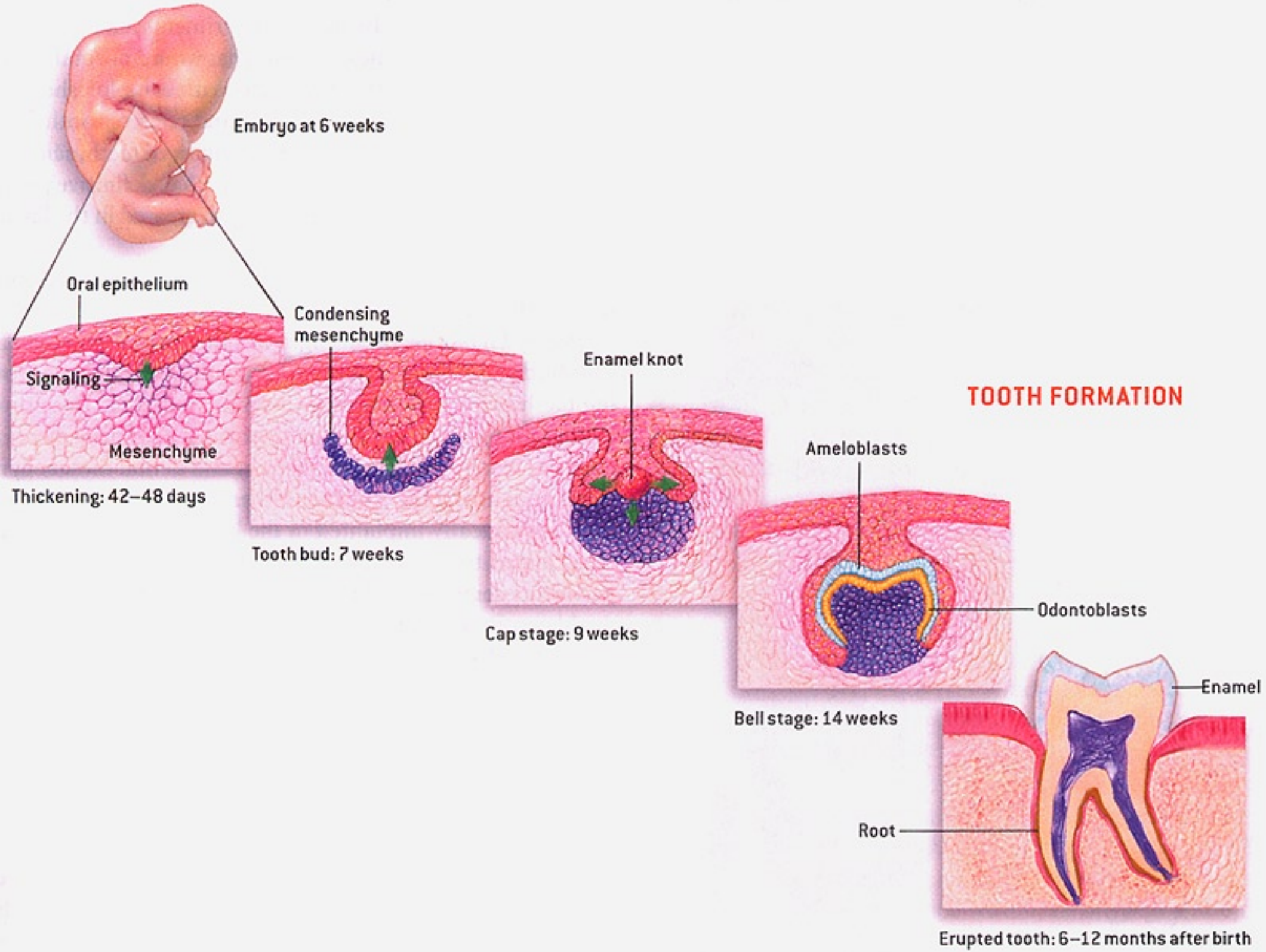
2] Middle layer of the dental sac forms periodontal ligament (which anchors the tooth within the alveolus).

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



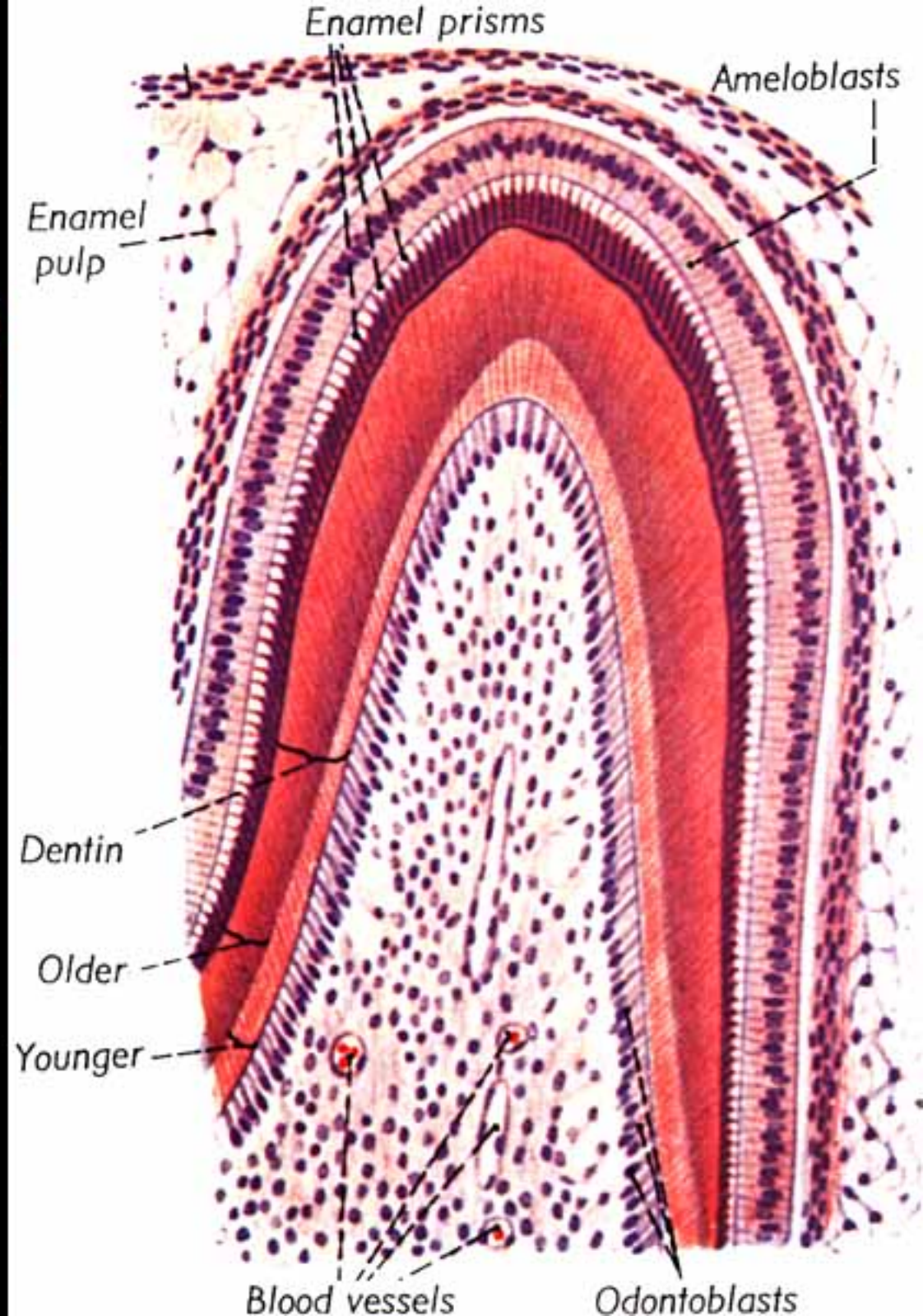
Note: Eventually, osteoclasts re-absorb encasing superficial bone in preparation for tooth eruption.

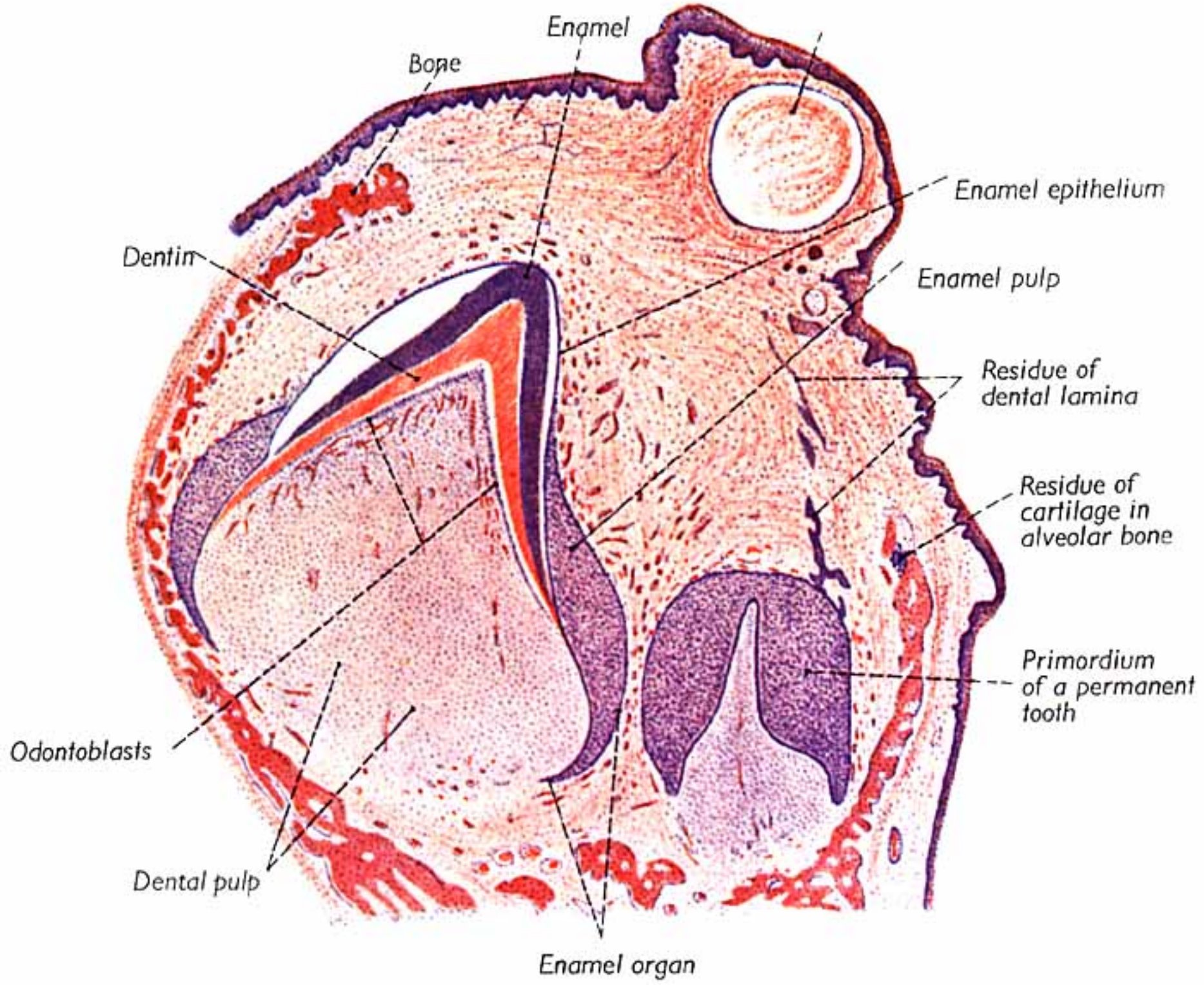

Enamel
Dentin
Pulp
Gum
Cementum
Jawbone
Nerve
Blood vessels
Periodontal ligament

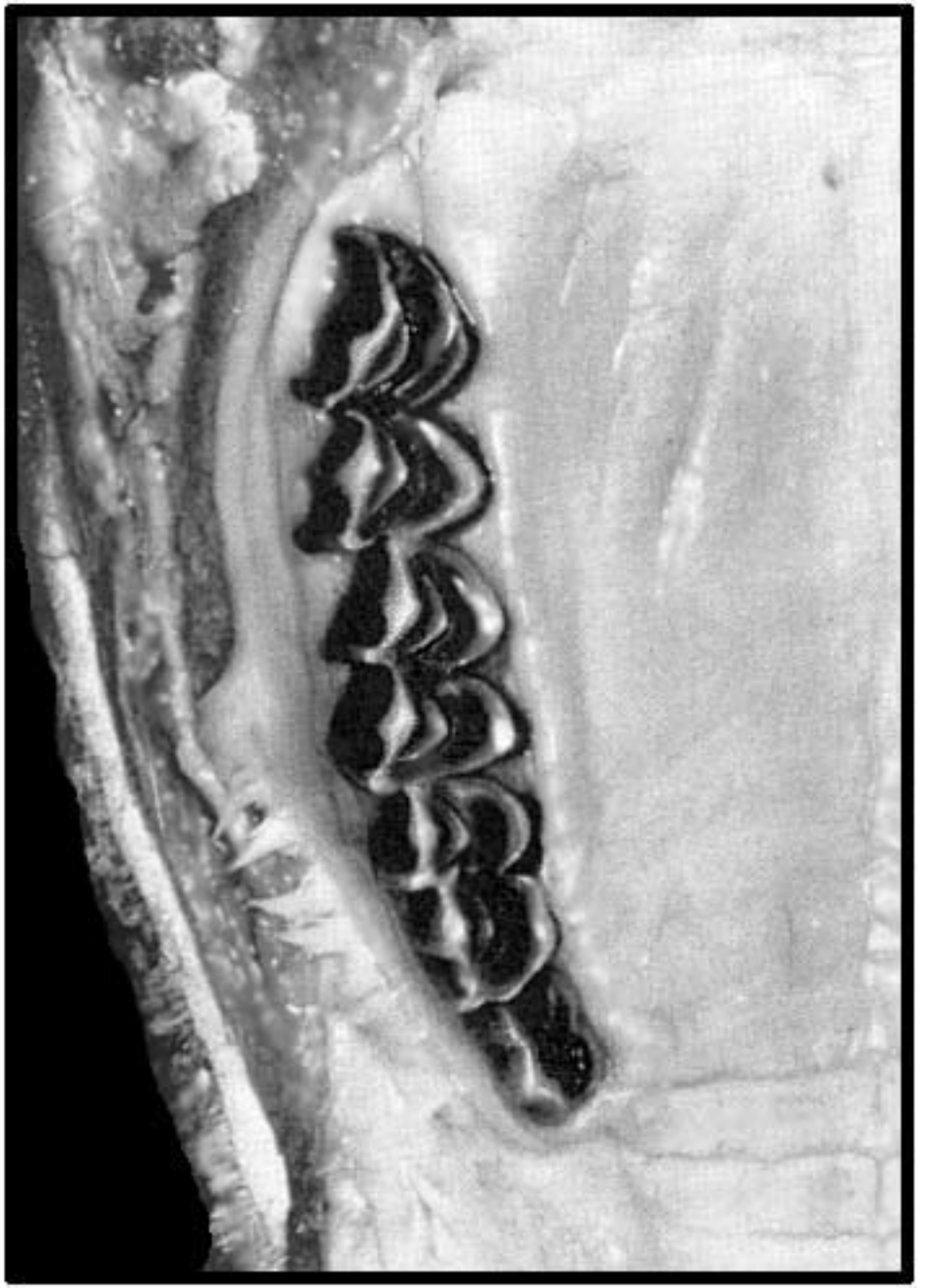


TOOTH FORMATION

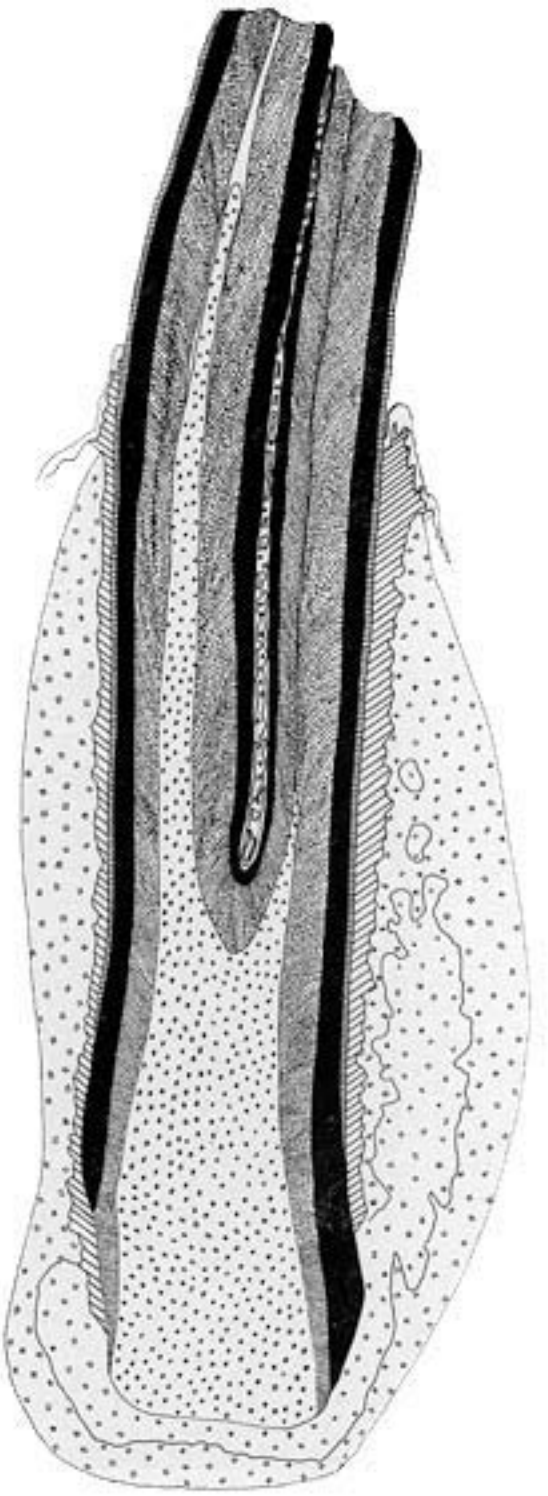

Oral epithelium
Enamel pulp
Stellate reticulum
Dental papilla
Connective tissue

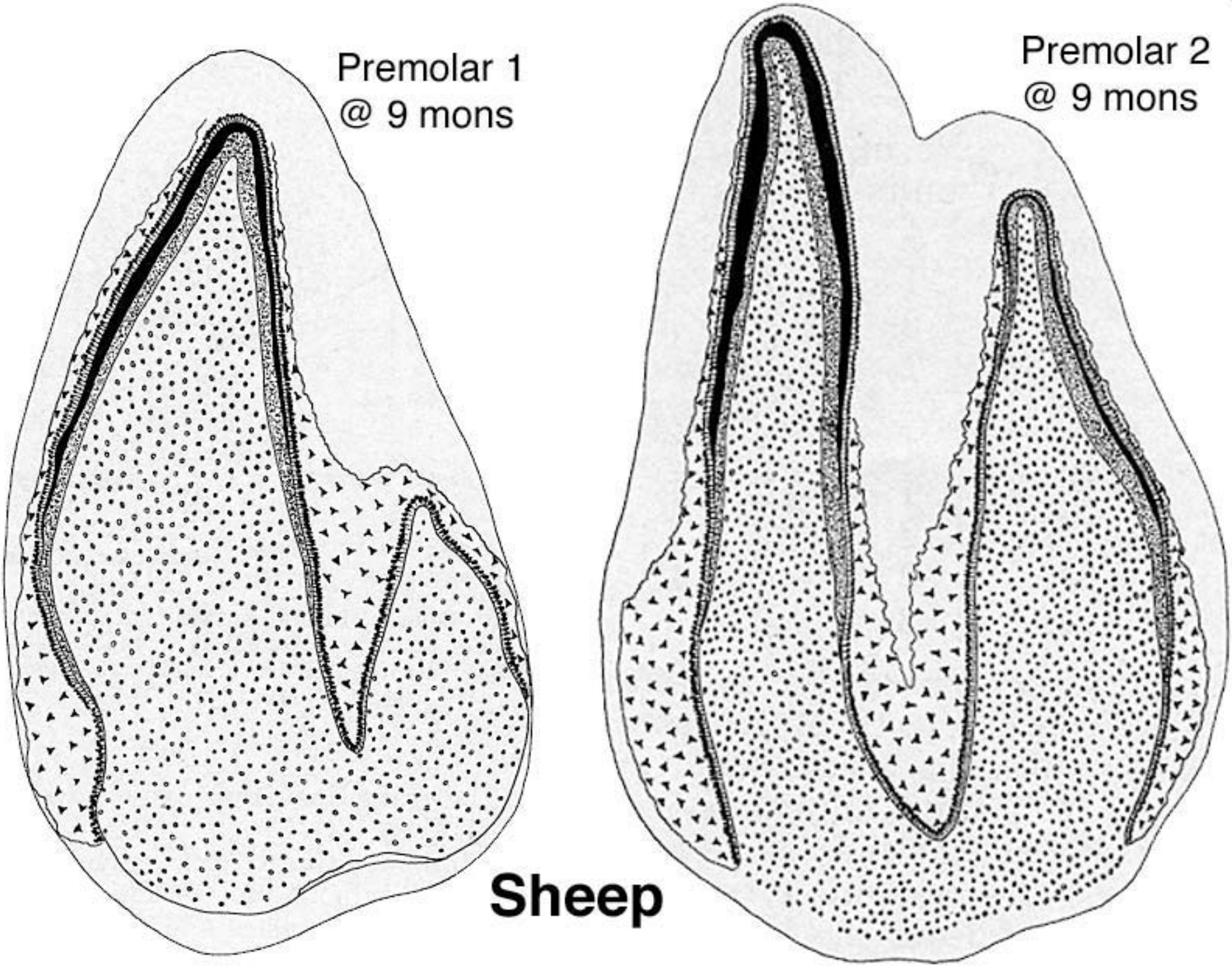

Enamel prisms
Ameloblasts
Enamel pulp
Dentin
Older
Younger
Blood vessels
Odontoblasts


Enamel
Bone
Enamel epithelium
Dentin
Enamel pulp
Residue of dental lamina
Residue of cartilage in alveolar bone
Primordium of a permanent tooth
Odontoblasts
Dental pulp
Enamel organ



Sheep




Premolar 1
@ 9 mons
Premolar 2
@ 9 mons
Sheep

Tongue:

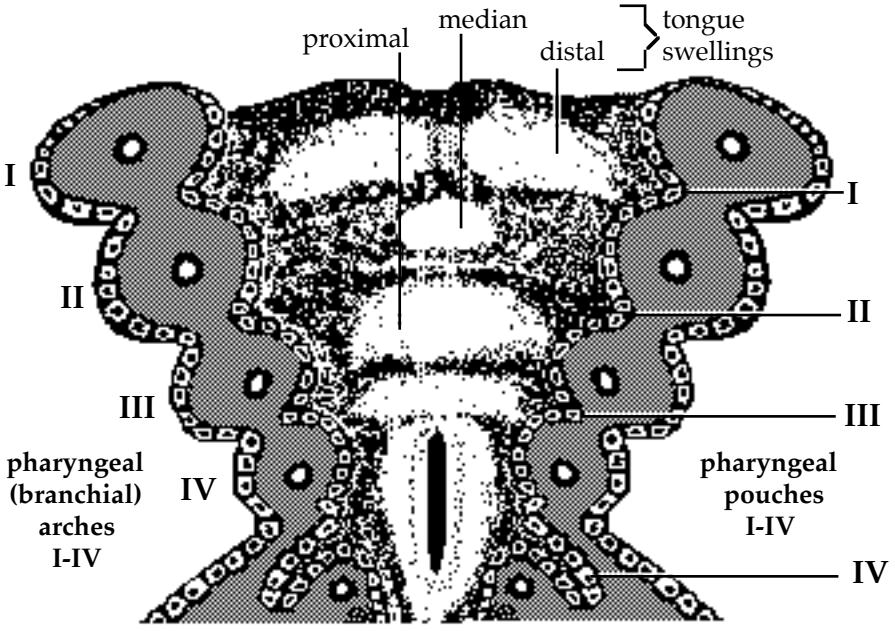
The tongue develops from four swellings situated on the floor of the pharynx:

— the *body/apex* of the tongue is formed by paired distal (lateral) swellings that fuse along the midline and grow forward into the oral cavity, thereby acquiring an ectodermal coat. The body 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).

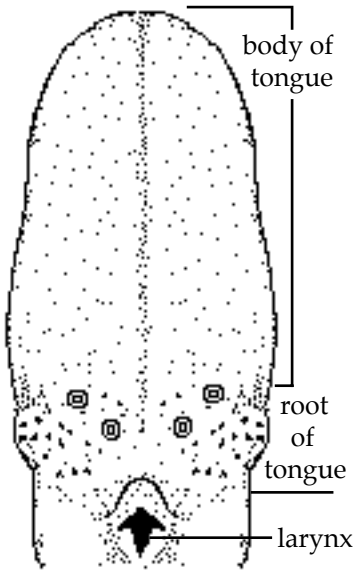
— the *root* of the tongue is formed by the proximal swelling and covered by endoderm. It arises from the third pharyngeal arch. Sensation is supplied by the glossopharyngeal nerve (IX) .

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

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



Dorsal View of Floor of Pharynx (roof removed)



Canine Tongue (dorsal view)

Salivary glands:

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

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

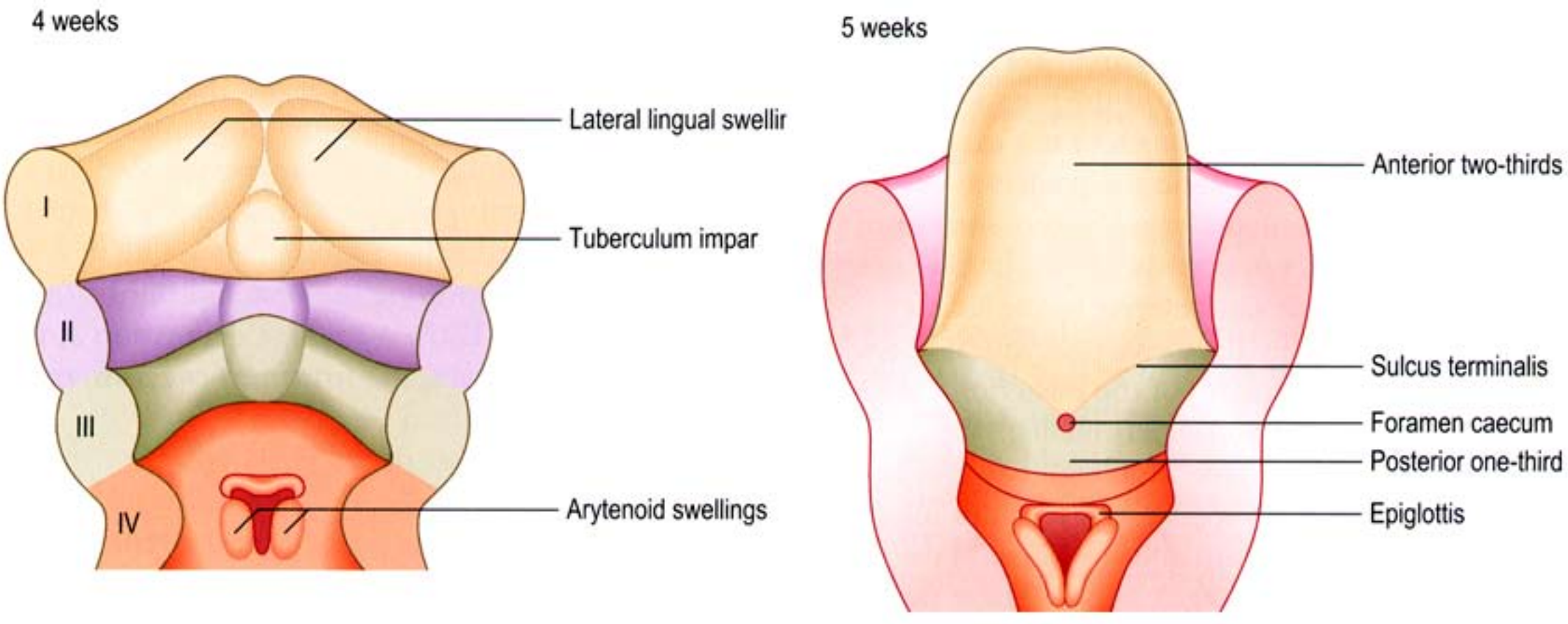
— localized proliferation of surface epithelial cells forms a cellular cord that invades the underlying ectomesenchyme; the initial site of proliferation ultimately becomes the *duct opening* to the surface;

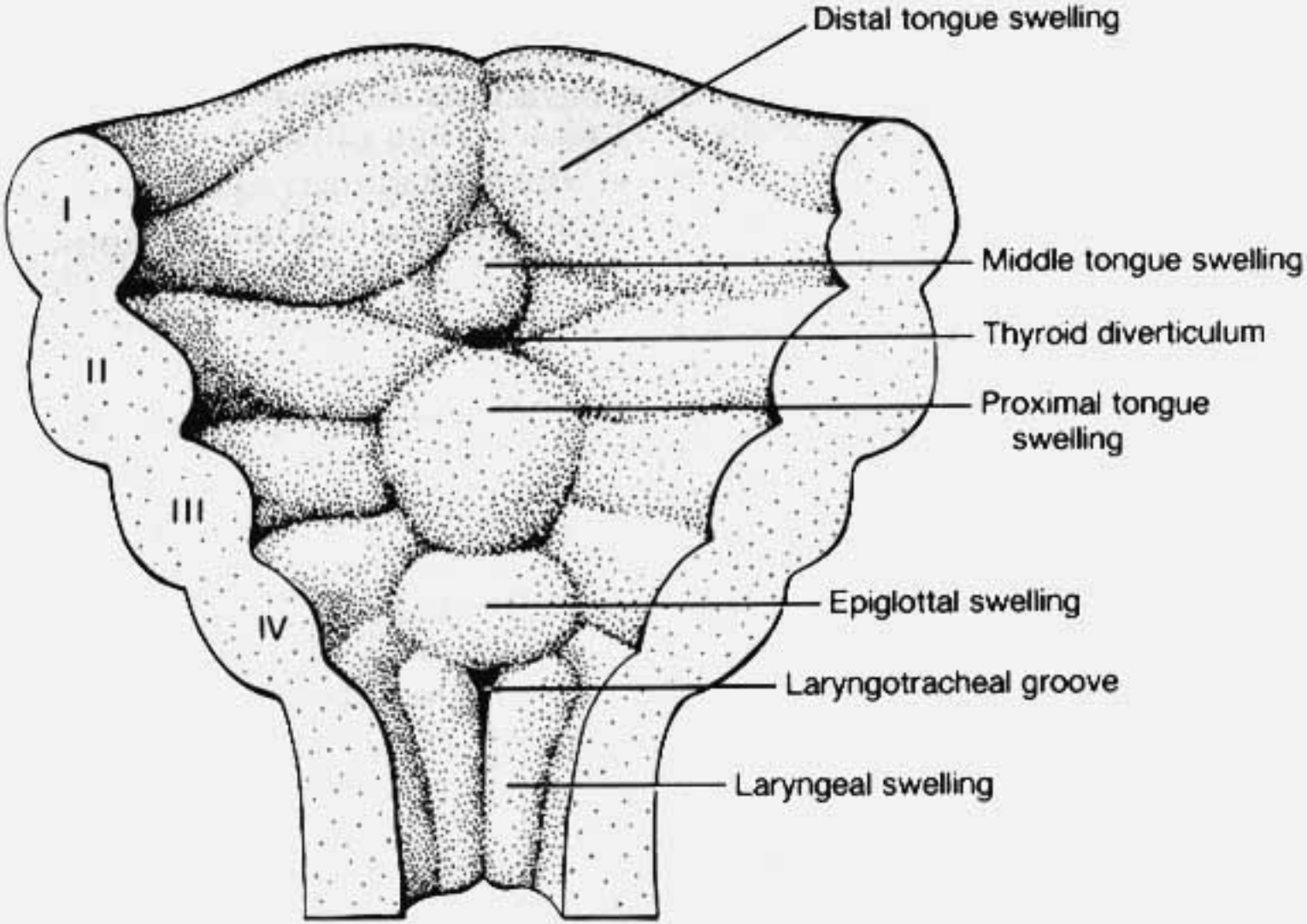
— the invading cord of cells begins to branch, ultimately becoming the main duct and branched *ducts* of the gland;

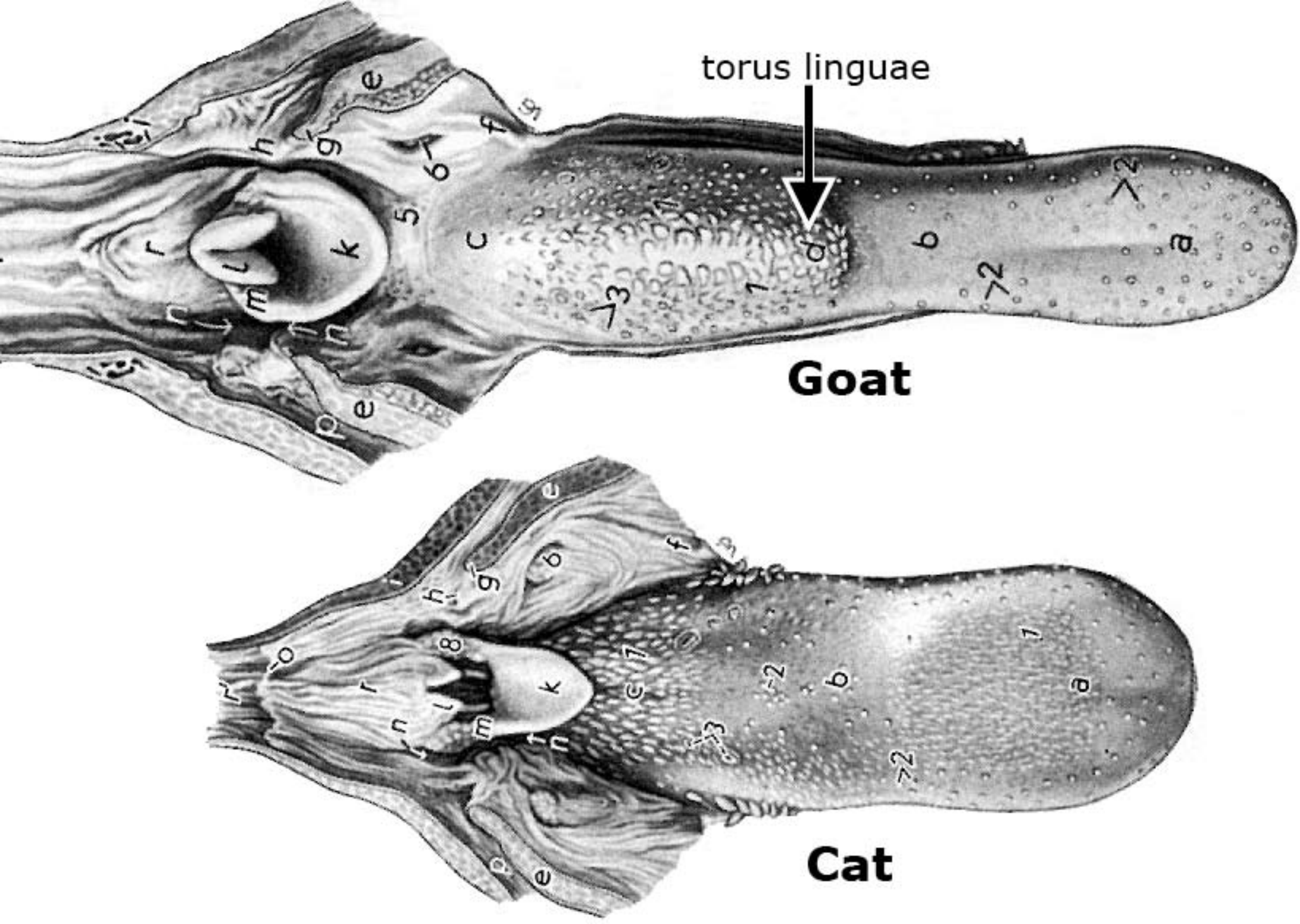
— masses of epithelial cells accumulate at the ends of each branch, ultimately forming *secretory acini* of the gland;

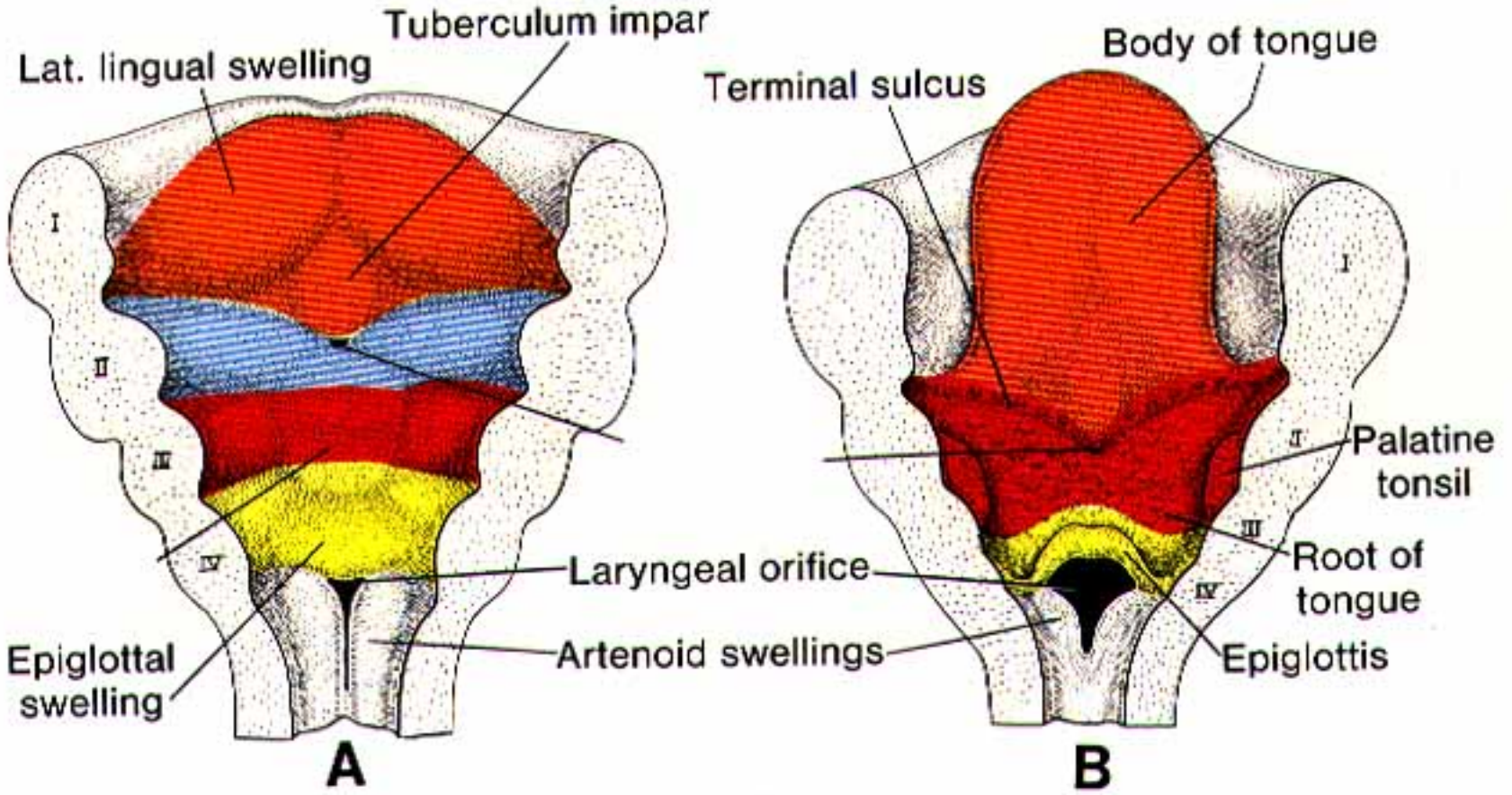
— the epithelial cords and masses canalize (become hollow) and the gland becomes functional; growth of the jaw causes elongation of the main duct.

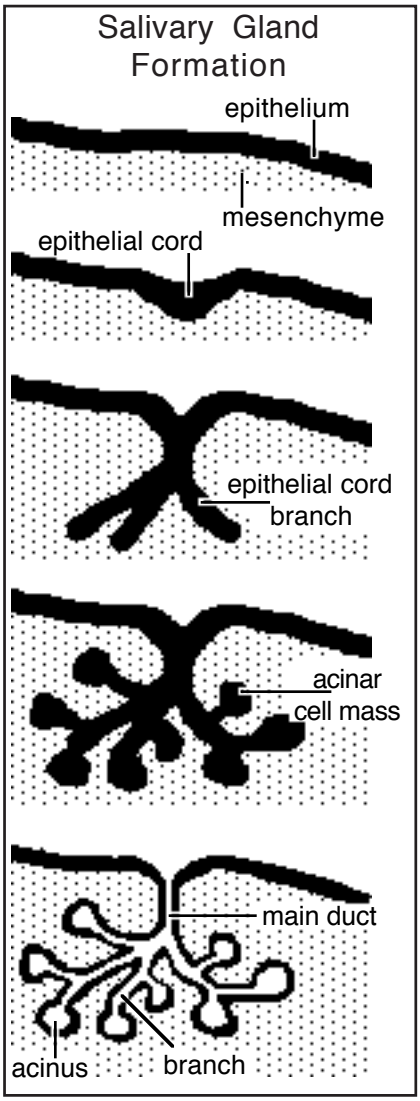
> **NOTE**: A polystomatic gland is one that has many duct openings to the surface. Such glands arise as a series of independent epithelial cords. Although they are independent glands, they appear to form a single mass and in gross anatomy they are collectively identified as a single gland.


4 weeks
Lateral lingual swellir
Tuberculum impar
I
II
III
IV
Arytenoid swellings
5 weeks
Anterior two-thirds
Sulcus terminalis
Foramen caecum
Posterior one-third
Epiglottis


Distal tongue swelling
I
II
III
IV
Middle tongue swelling
Thyroid diverticulum
Proximal tongue swelling
Epiglottal swelling
Laryngotracheal groove
Laryngeal swelling

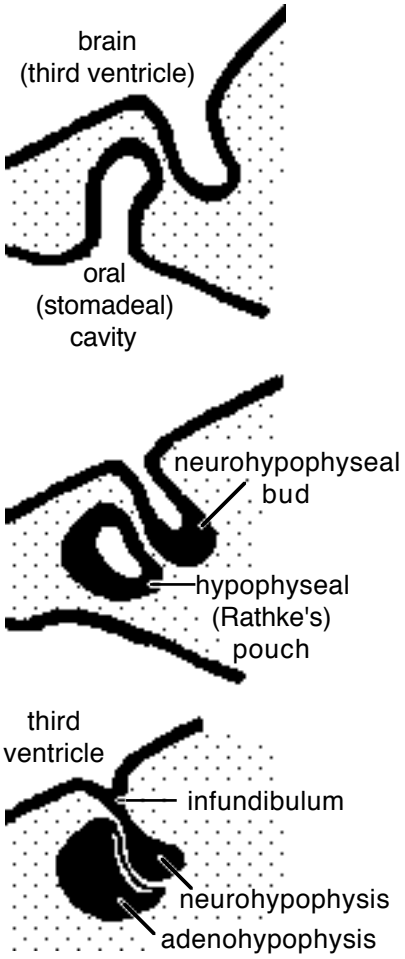

torus linguae
Goat
Cat


Tuberculum impar
Lat. lingual swelling
I
II
III
IV
Laryngeal orifice
Epiglottal swelling
Artenoid swellings
A
Body of tongue
Terminal sulcus
I
II
Palatine tonsil
III
Root of tongue
IV
Epiglottis
B



Adenohypophysis:

The adenohypophysis develops from an ectodermal thickening (placode) in the roof of the stomodeal cavity. The placode evaginates to form an hypophyseal pouch (Rathke's pouch). The pouch separates from the stomodeal ectoderm and wraps around the neurohypophysis, an outgrowth of the hypothalamus (brain). 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. 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. Hypothalamic neurons must release hormones into the blood stream to control the adenohypophysis.

Pharyngeal pouch derivatives:

A series of lateral evaginations of pharyngeal endoderm constitute pharyngeal pouches. There are five pairs of pouches but in mammals the fifth pair is rudimentary, appearing as buds of the fourth.

The endoderm of each pharyngeal pouch is apposed to the ectoderm of a corresponding pharyngeal cleft. Pharyngeal clefts separate adjacent pharyngeal arches. In fish, the apposed endoderm-ectoderm degenerates forming a branchial cleft that becomes a gill slit (in mammals only one branchial cleft develops and it is transitory). [branchia (Gr.) = gills]

Pharyngeal pouches develop into various structures:

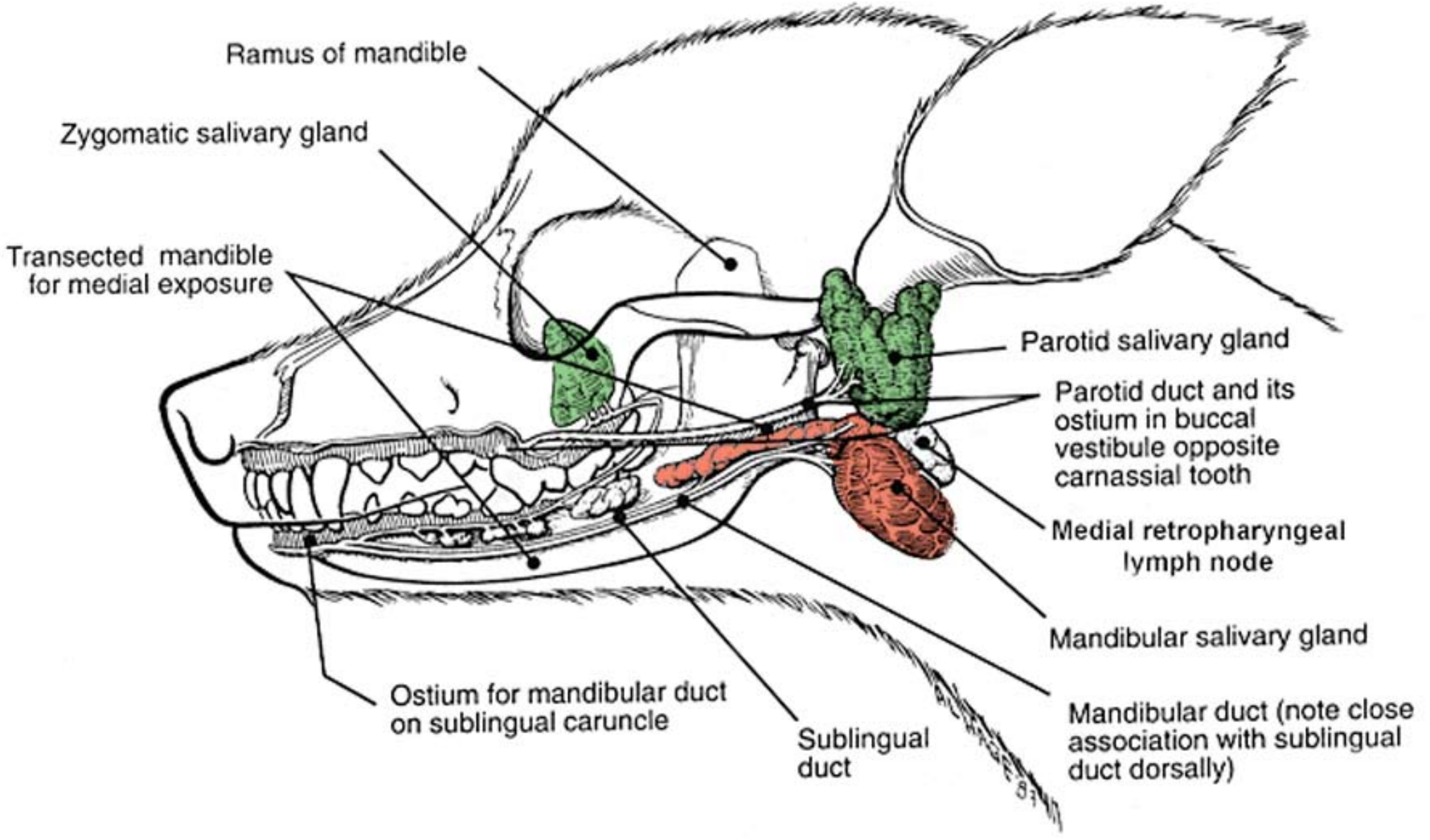
1st pouch —— tympanic (middle ear) cavity and auditory tube

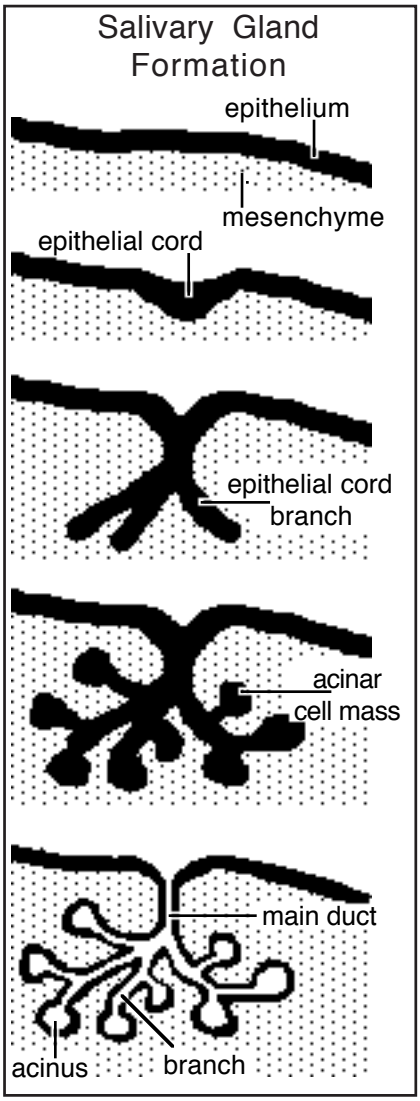
2nd pouch —— fossa for the palatine tonsil and the fold covering it

3rd pouch —— external parathyroid gland and thymus

4th pouch —— internal parathyroid gland

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


Ramus of mandible
Zygomatic salivary gland
Transected mandible for medial exposure
Parotid salivary gland
Parotid duct and its ostium in buccal vestibule opposite carnassial tooth
Medial retropharyngeal lymph node
Mandibular salivary gland
Mandibular duct (note close association with sublingual duct dorsally)
Ostium for mandibular duct on sublingual caruncle
Sublingual duct



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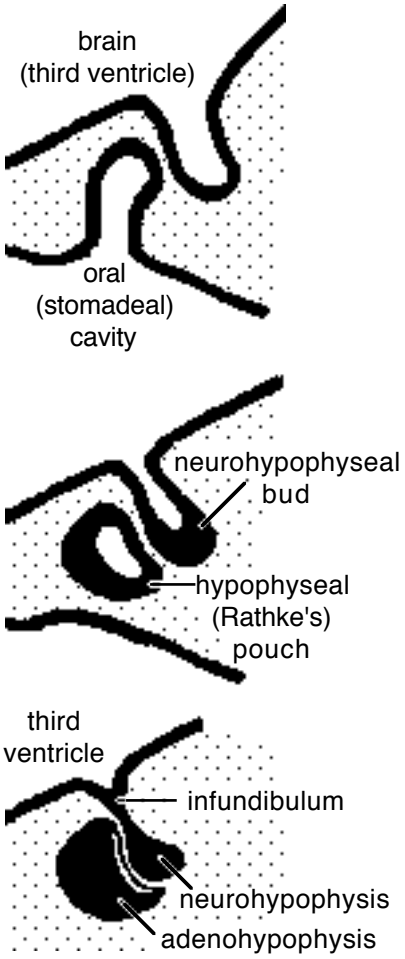

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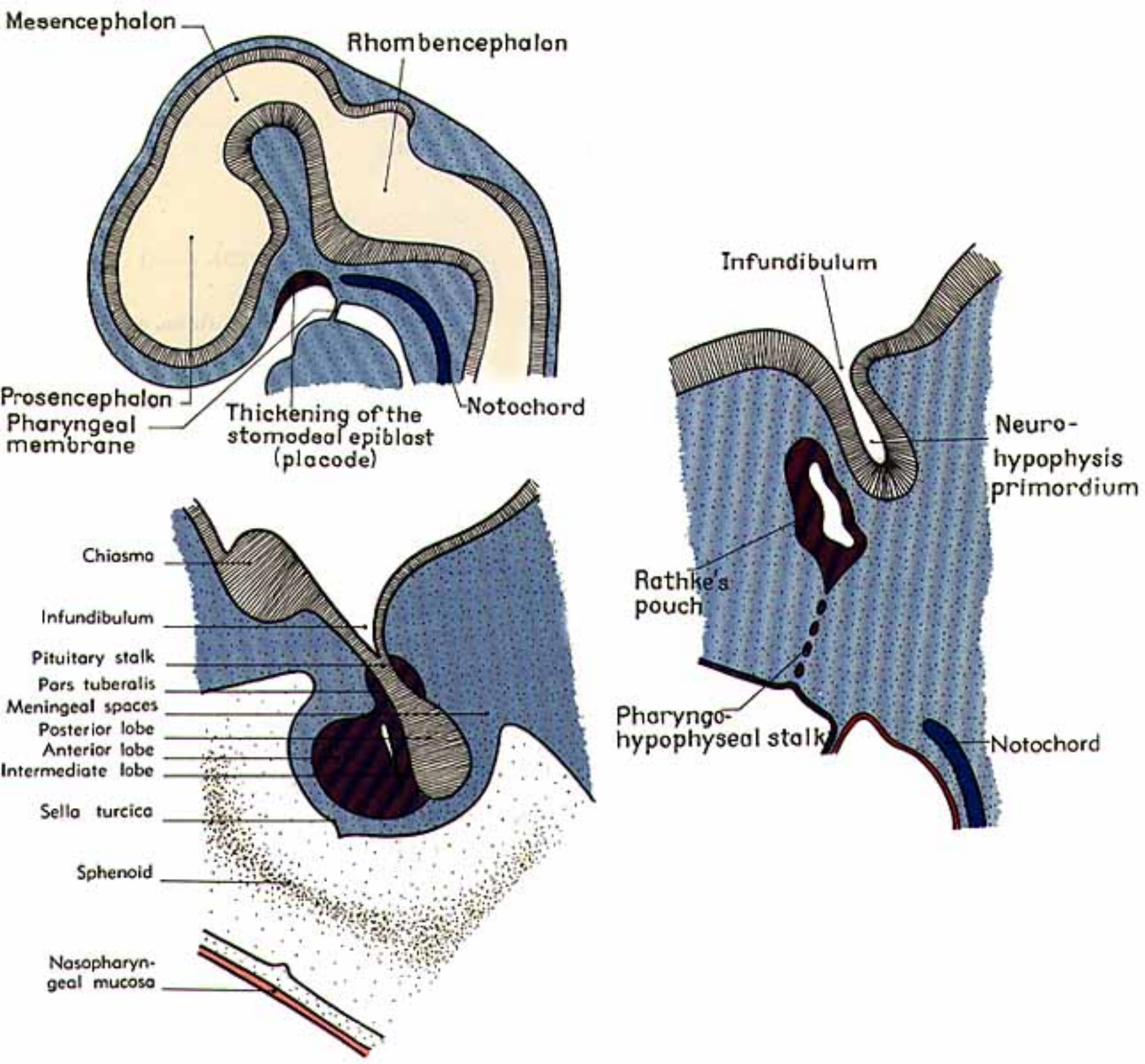
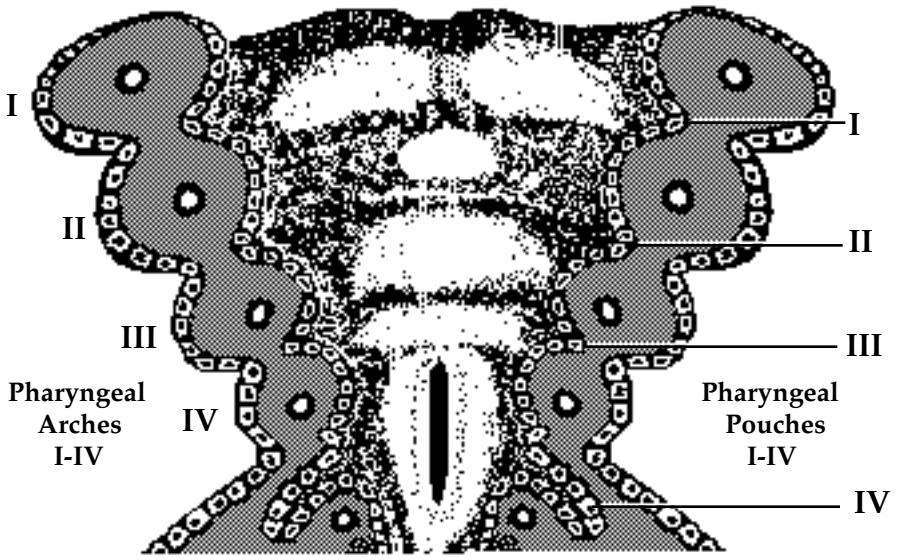

Mesencephalon
Rhombencephalon
Prosencephalon
Pharyngeal membrane
Thickening of the stomodeal epiblast (placode)
Notochord
Infundibulum
Neuro-hypophysis primordium
Rathke's pouch
Pharyngo-hypophyseal stalk
Notochord
Chiasma
Infundibulum
Pituitary stalk
Pars tuberalis
Meningeal spaces
Posterior lobe
Anterior lobe
Intermediate lobe
Sella turcica
Sphenoid
Nasopharyn-geal mucosa

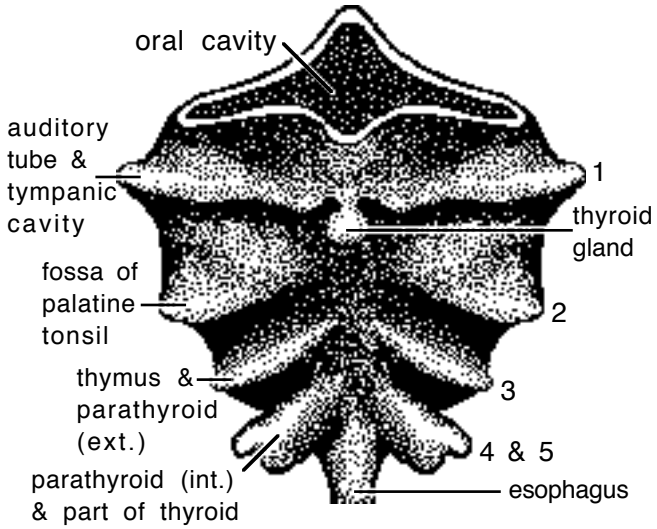


Floor of Pharynx (roof removed)

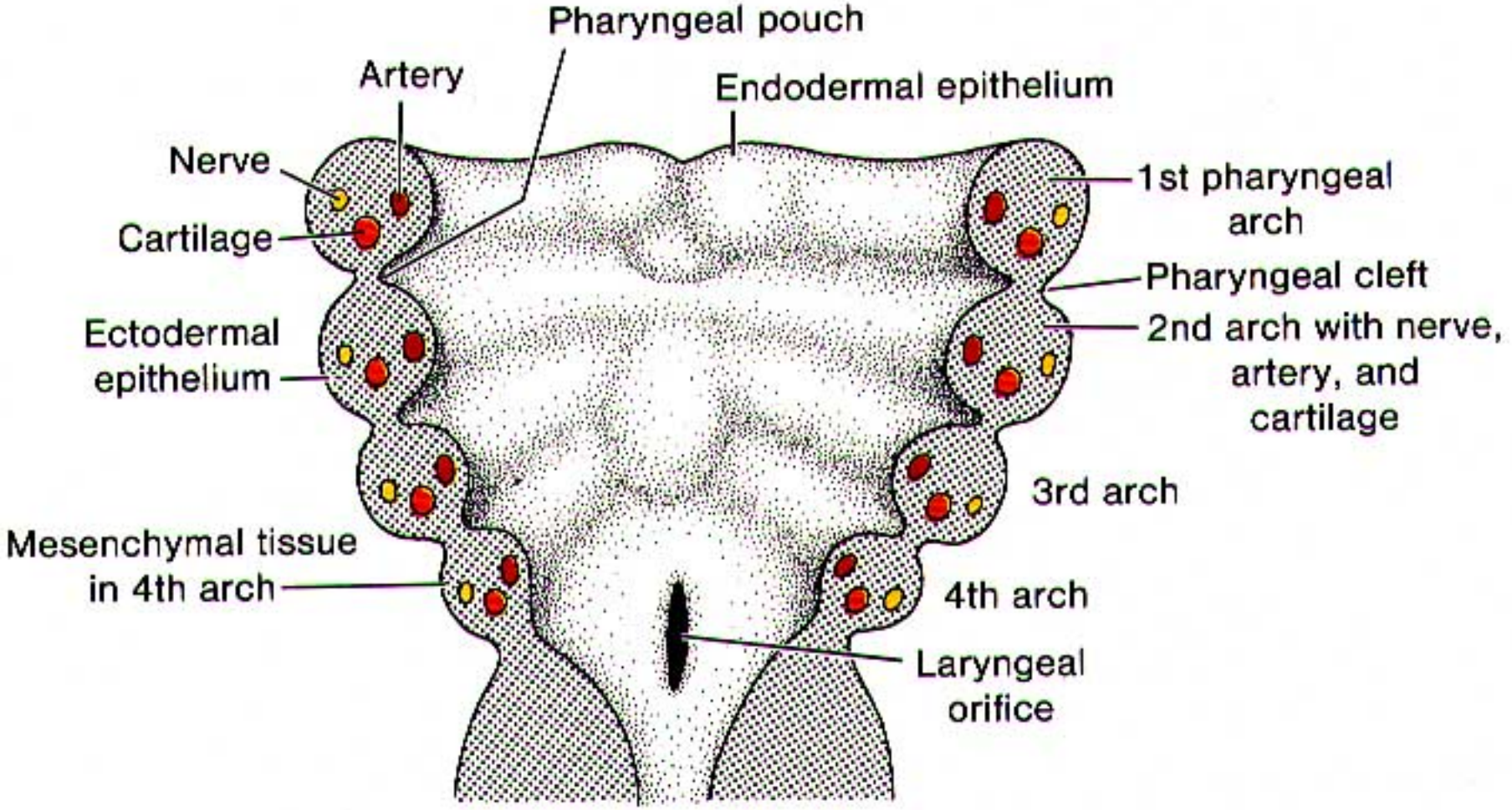
The thyroid gland develops from endoderm of the floor of the pharynx. Initially there is formed a *thyroid diverticulum* connected to the pharynx by a thyroglossal duct. (The duct degenerates since the thyroid is an endocrine gland, but rarely a remnant of the duct persists as a cyst that can enlarge and interfere with breathing by compressing the pharynx). Depending on the species, the thyroid may remain single (pig) or split into bilateral lobes connected by an isthmus (horse) or become separate paired lobes (dog).

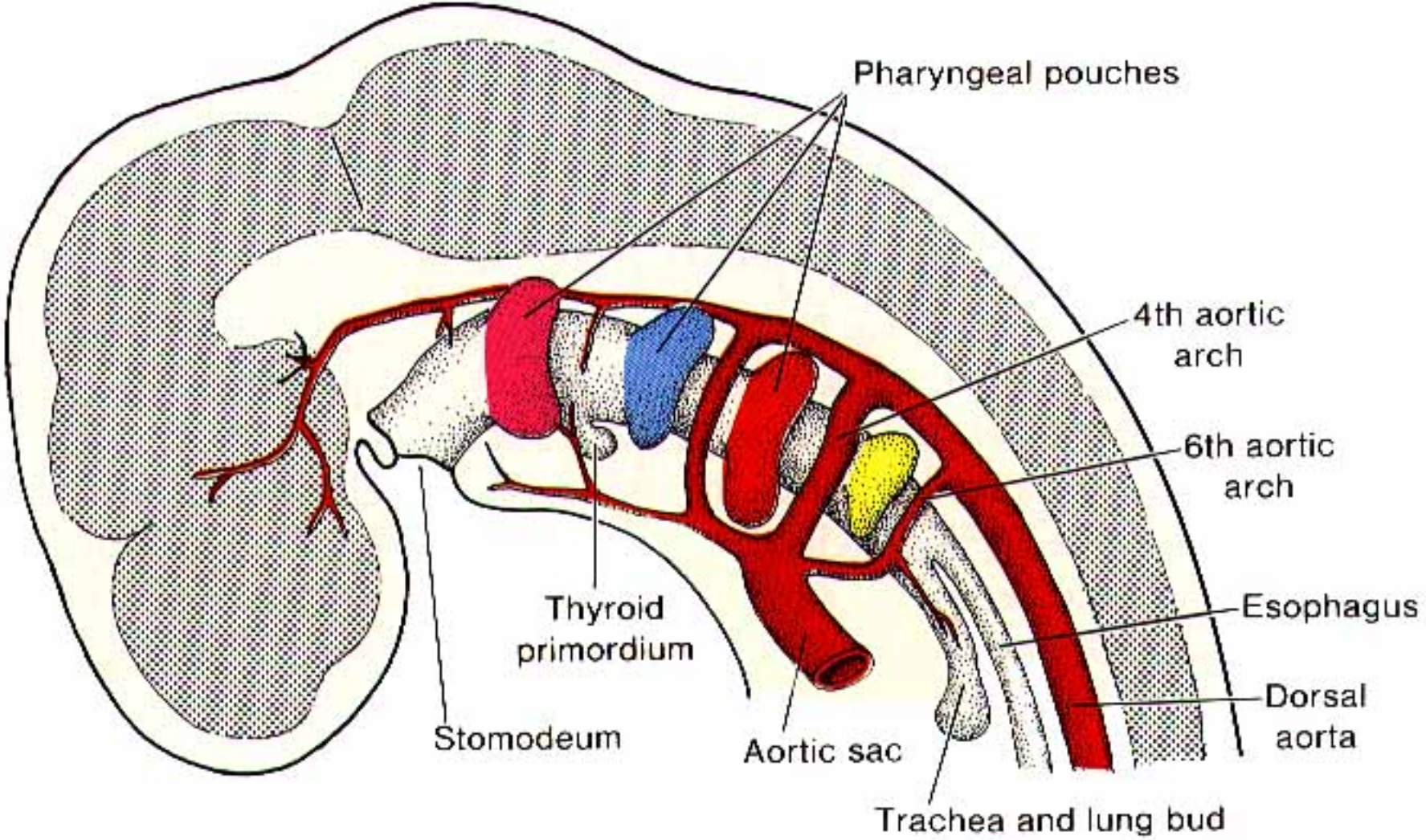
Thyroid hormones have multiple metabolic effects. Parafollicular cells of the thyroid gland decrease blood Ca^{++} while parathyroid gland hormones increases blood Ca^{++}.

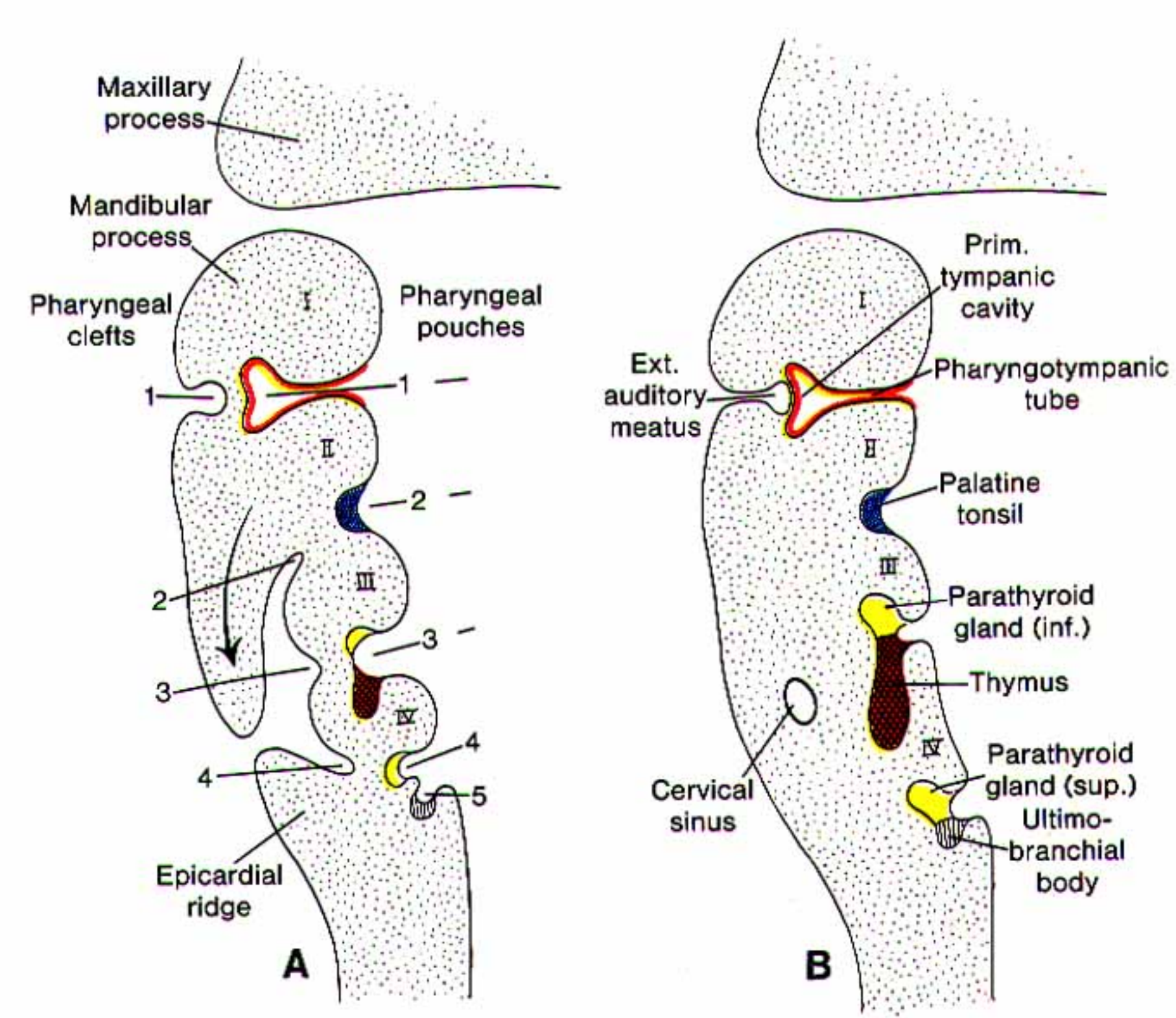
The thyroid and parathyroids are endocrine glands and thus they lack ducts to an epithelial surface.

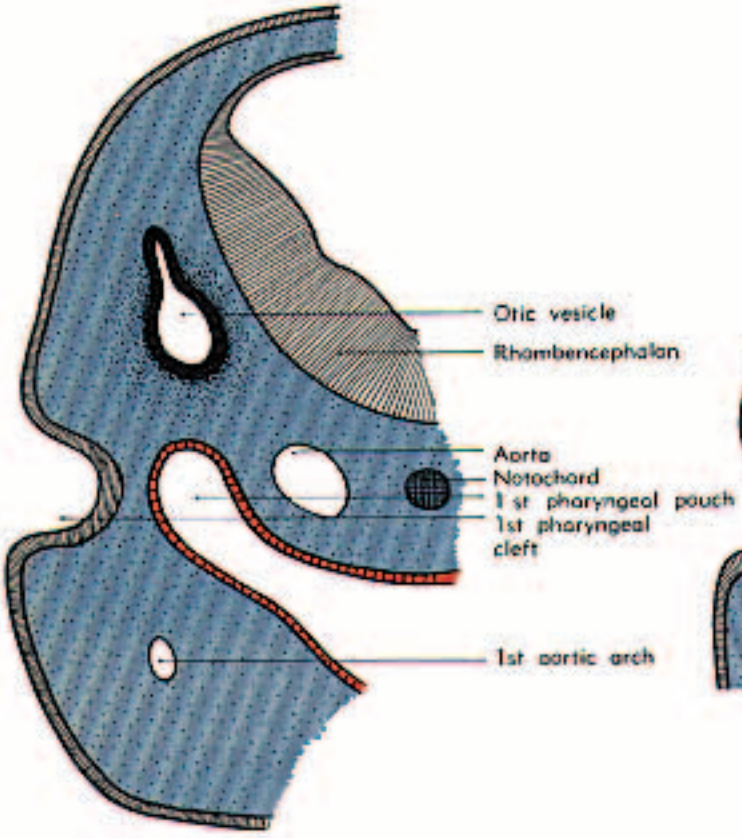


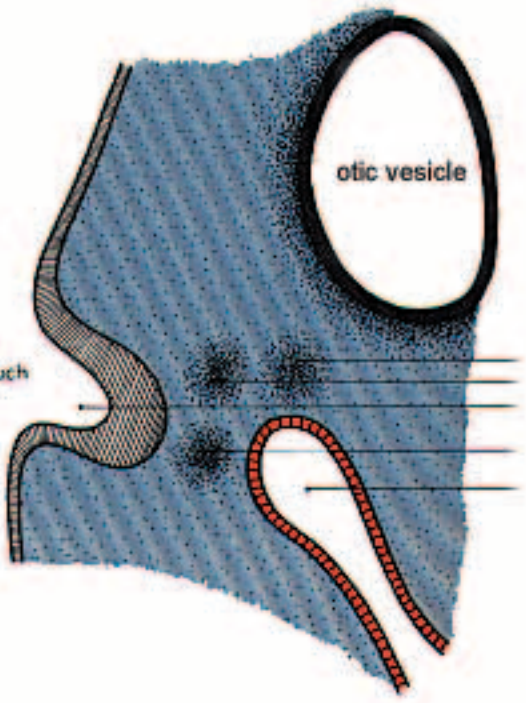
Pharyngeal Pouch Derivatives (ventral view)

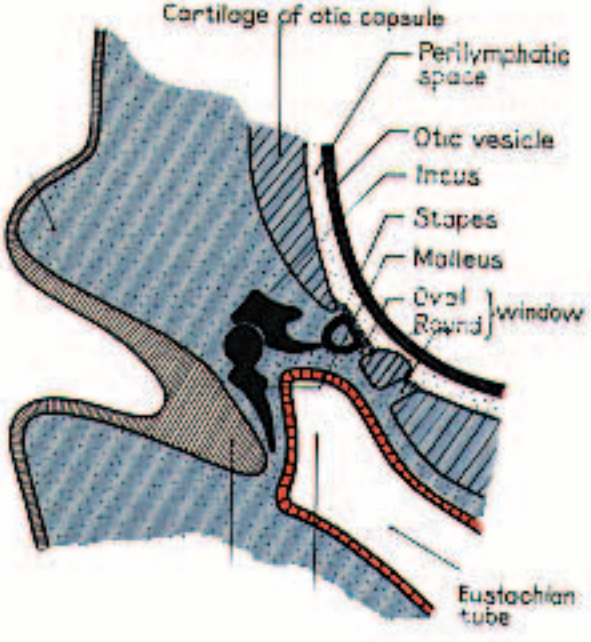

Pharyngeal pouch
Artery
Endodermal epithelium
Nerve
Cartilage
1st pharyngeal arch
Pharyngeal cleft
Ectodermal epithelium
2nd arch with nerve, artery, and cartilage
3rd arch
Mesenchymal tissue in 4th arch
4th arch
Laryngeal orifice

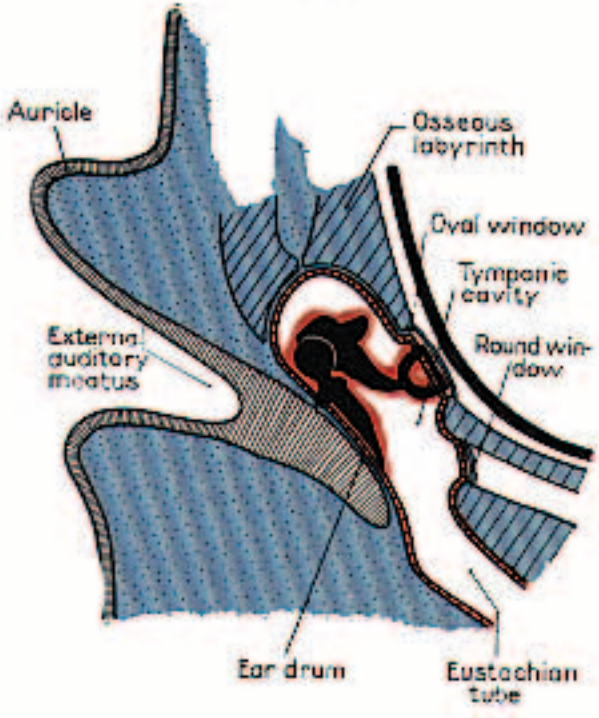

Pharyngeal pouches
4th aortic arch
6th aortic arch
Esophagus
Dorsal aorta
Thyroid primordium
Stomodeum
Aortic sac
Trachea and lung bud

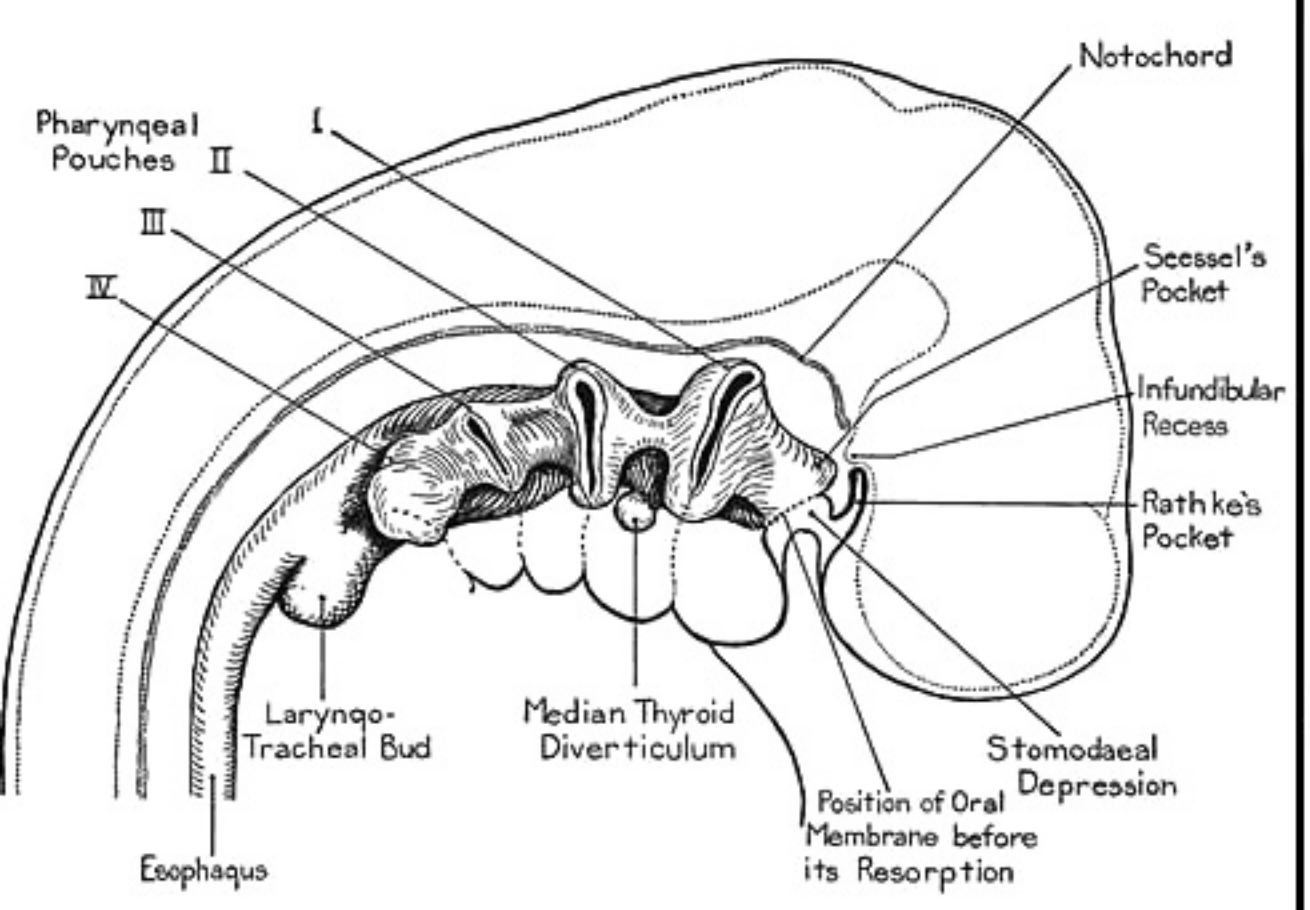

Maxillary process
Mandibular process
Pharyngeal clefts
Pharyngeal pouches
I
II
III
IV
1
2
3
4
5
Epicardial ridge
A
Prim. tympanic cavity
Ext. auditory meatus
Pharyngotympanic tube
Palatine tonsil
Parathyroid gland (inf.)
Thymus
Parathyroid gland (sup.)
Ultimo-branchial body
Cervical sinus
B

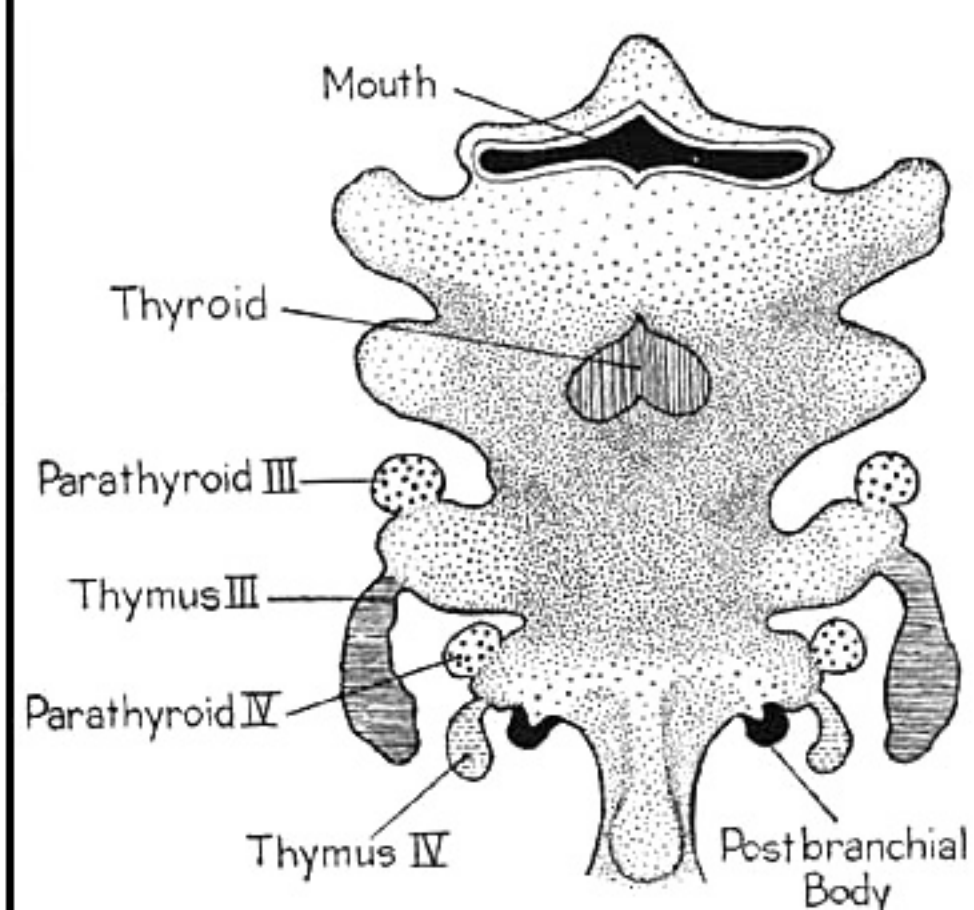

Otic vesicle
Rhombencephalon
Aorta
Notochord
1 st pharyngeal pouch
1st pharyngeal cleft
1st aortic arch

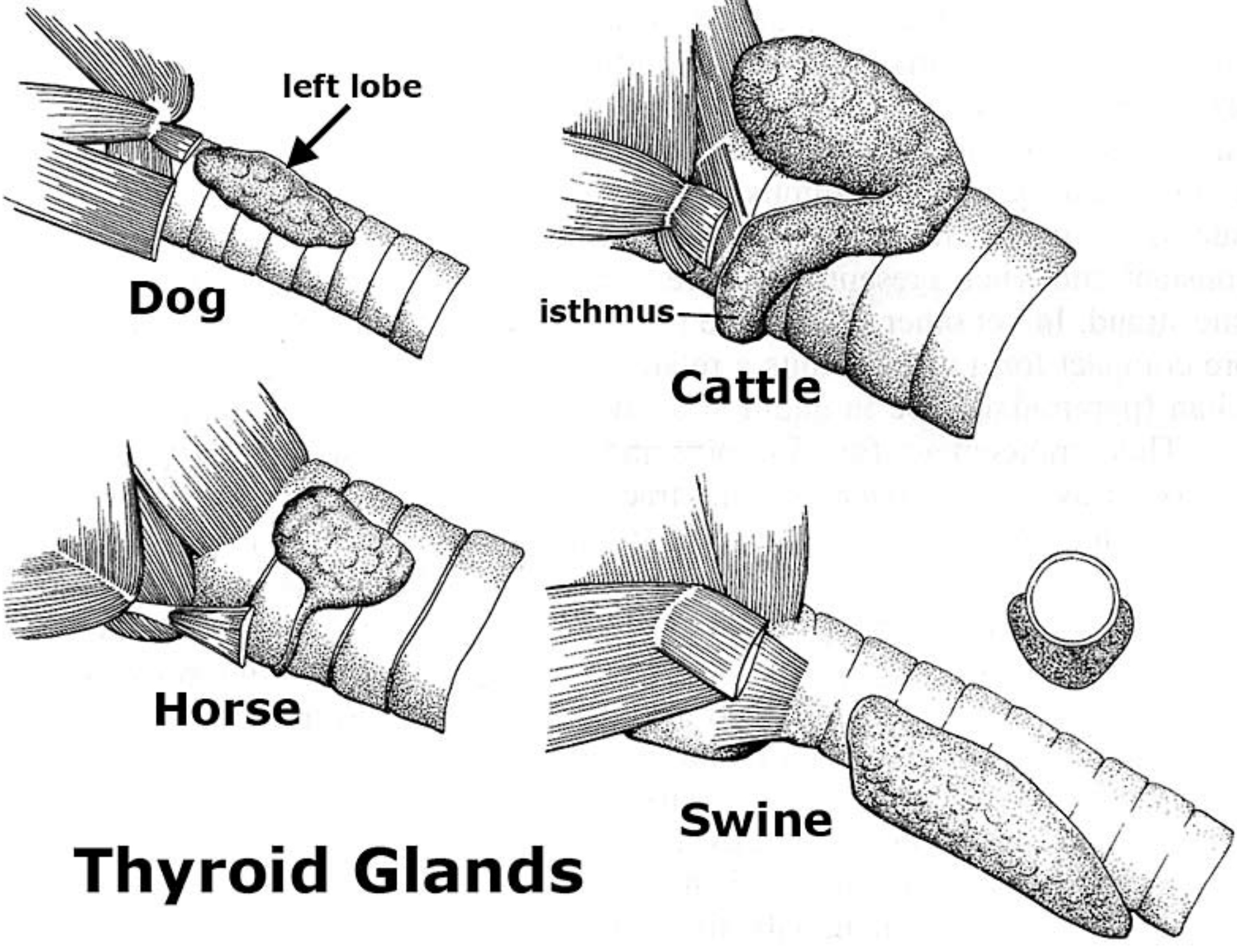

otic vesicle


Cartilage of otic capsule
Perilymphatic space
Otic vesicle
Incus
Stapes
Malleus
Oval
Round
window
Eustachian tube


Auricle
Osseous labyrinth
Oval window
Tympanic cavity
External auditory meatus
Round window
Ear drum
Eustachian tube


Notochord
Pharyngeal Pouches I II III IV
Seessel's Pocket
Infundibular Recess
Rathke's Pocket
Laryngo-Tracheal Bud
Median Thyroid Diverticulum
Stomodaeal Depression
Position of Oral Membrane before its Resorption
Esophagus


Mouth
Thyroid
Parathyroid III
Thymus III
Parathyroid IV
Thymus IV
Postbranchial Body



Thyroid Glands