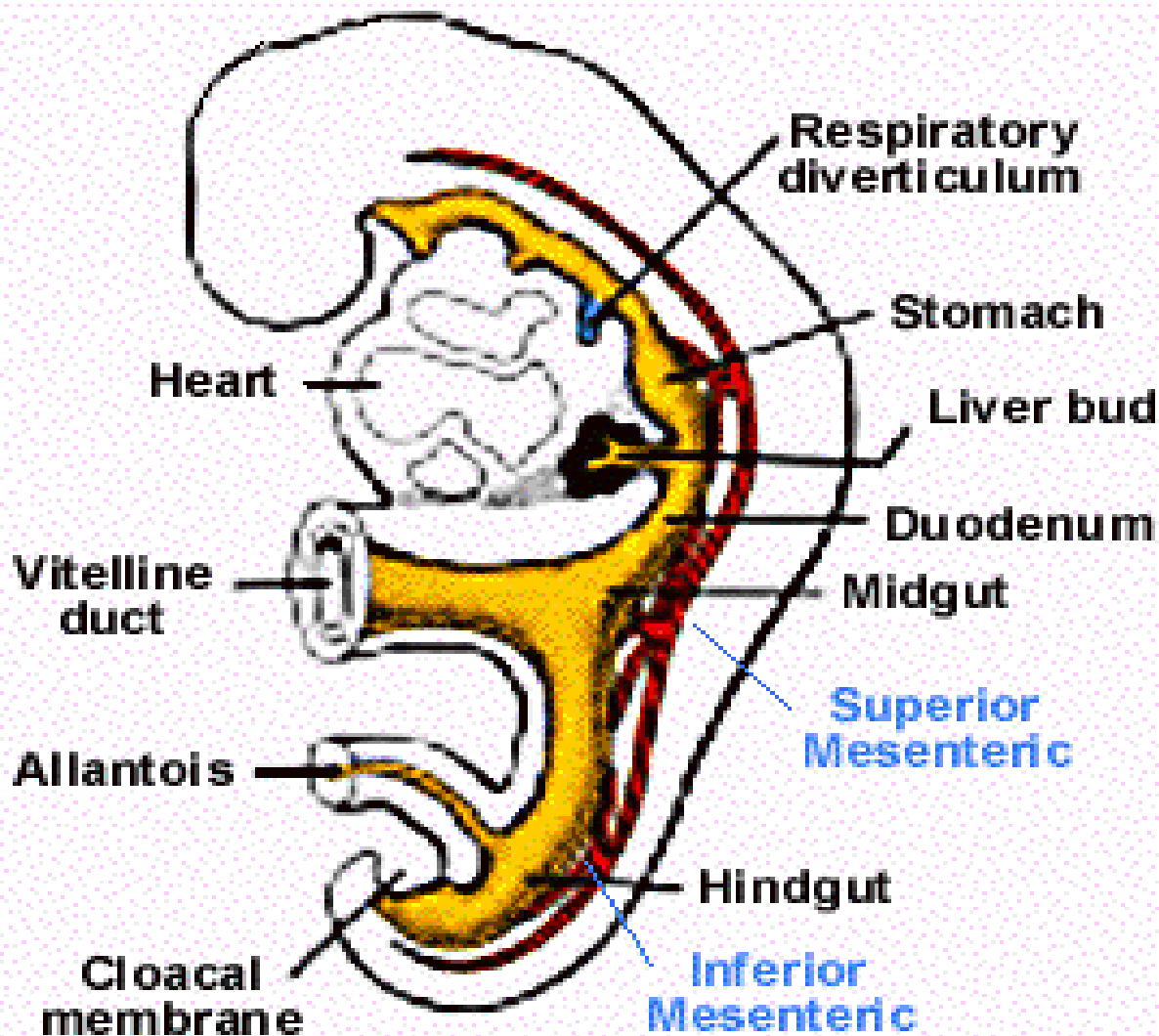
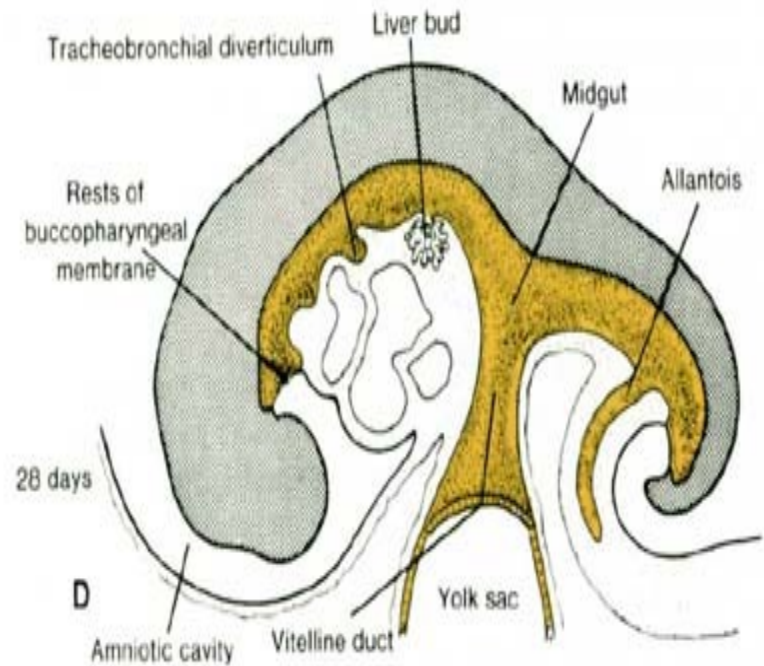
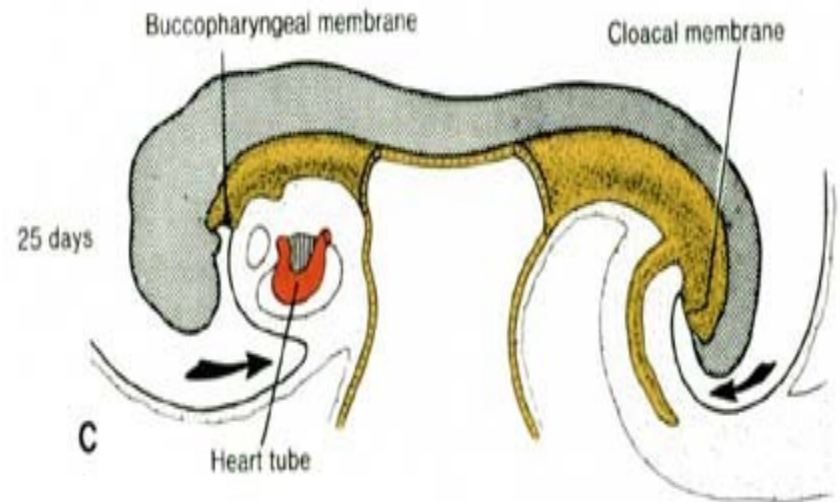
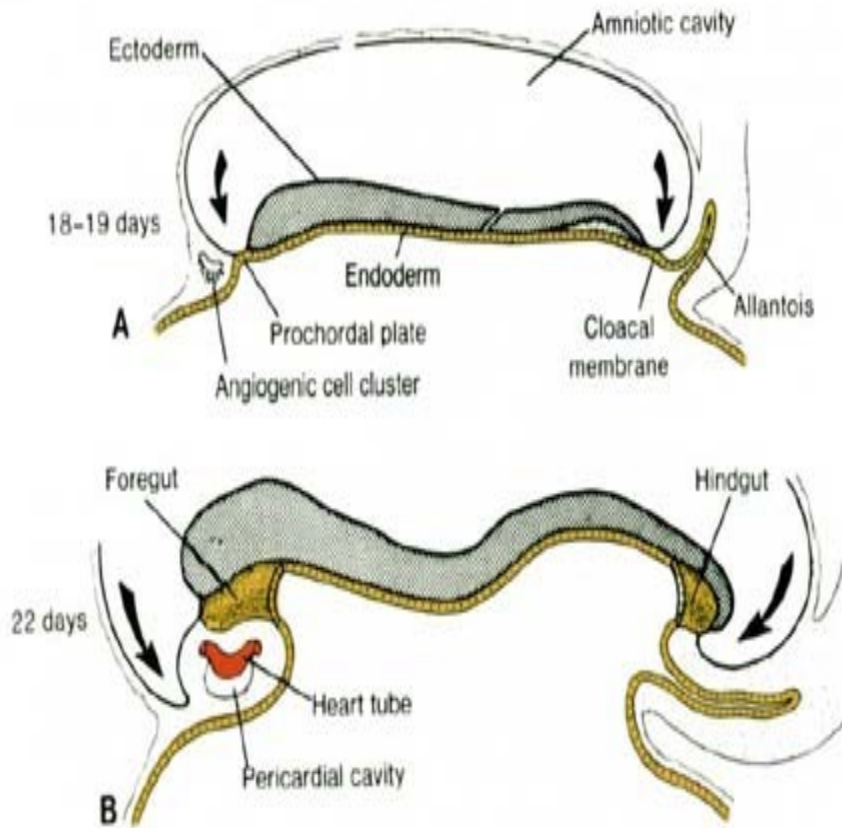


Embryology: Development of digestive system





- Embryo folding – incorporation of endoderm to form primitive gut.
- Outside of embryo – yolk sac and allantois.
- Vitelline duct

Stomodeum

(primitive mouth)

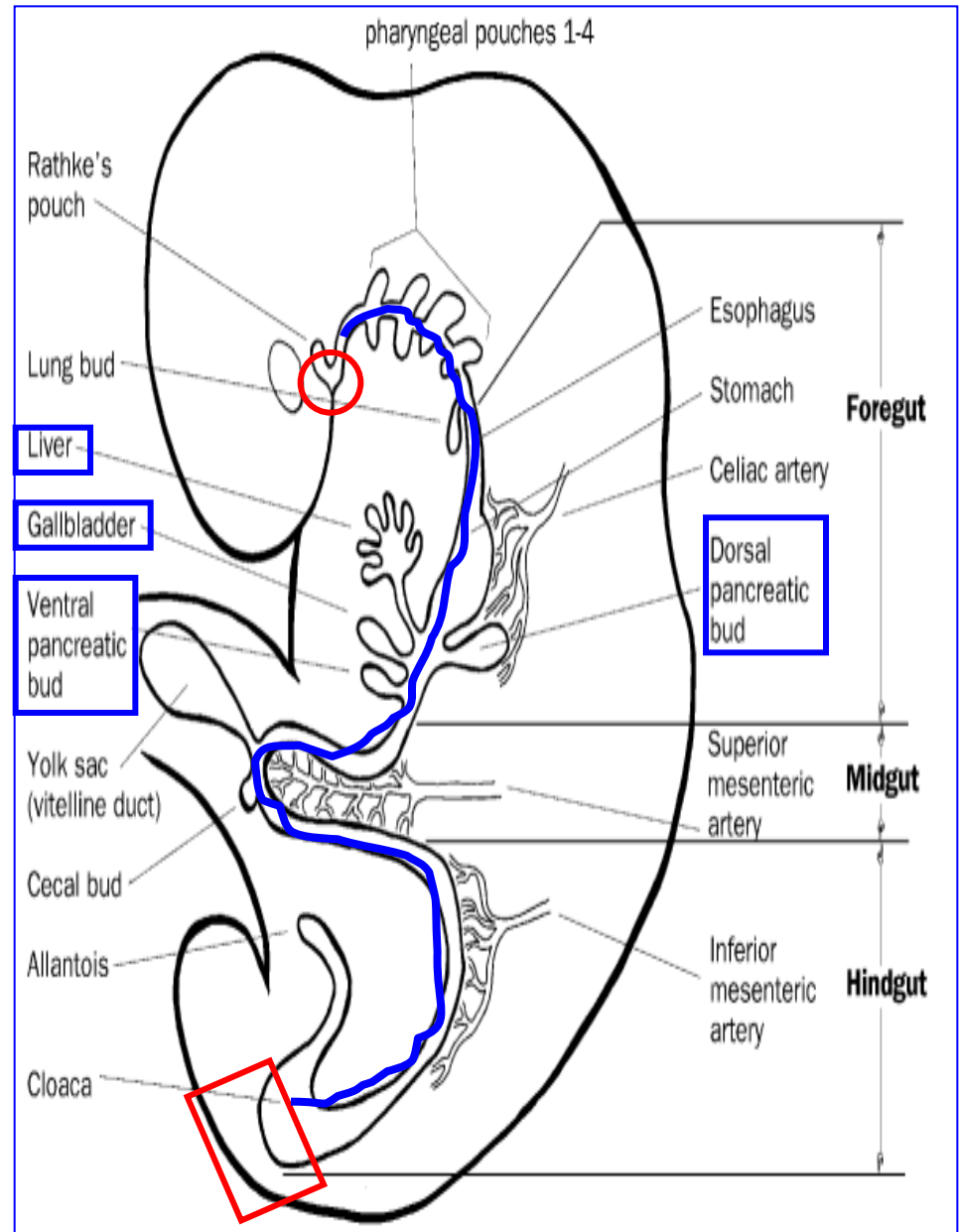
⇒ the oral cavity
+ the salivary glands

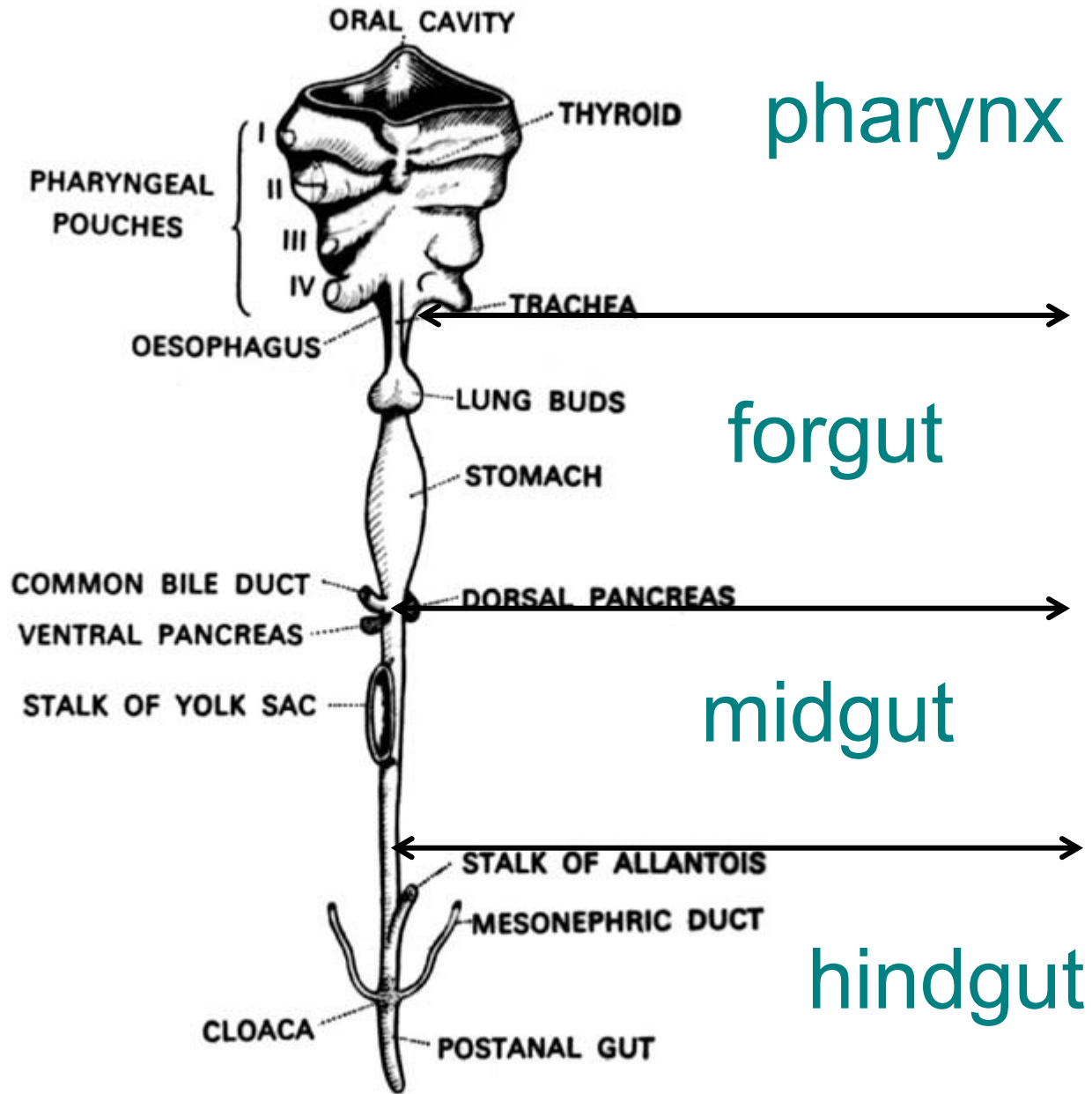
Proctodeum

⇒ primitive anal pit

Primitive gut

⇒ whole digestive tube
+ accessory glands





- The **epithelium** and **glandular cells** of associated glands of the gastrointestinal tract develop **from endoderm**
- The **connective tissue**, **muscle tissue** and **mesothelium** are derived from splanchnic **mesoderm**
- The **enteric nervous system** develops from **neural crest**

primitive gut

foregut

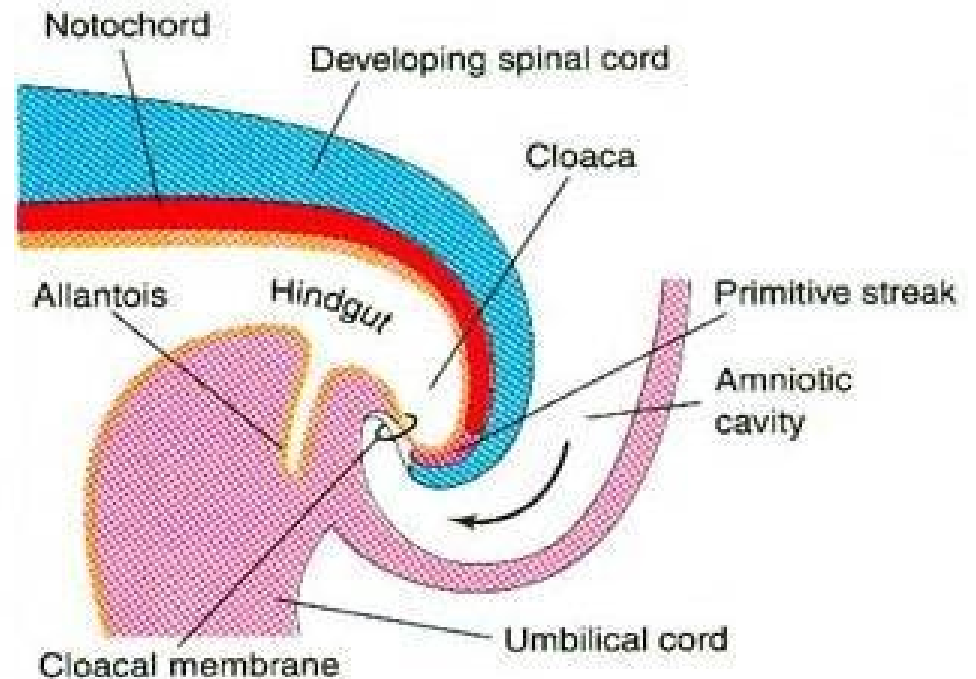
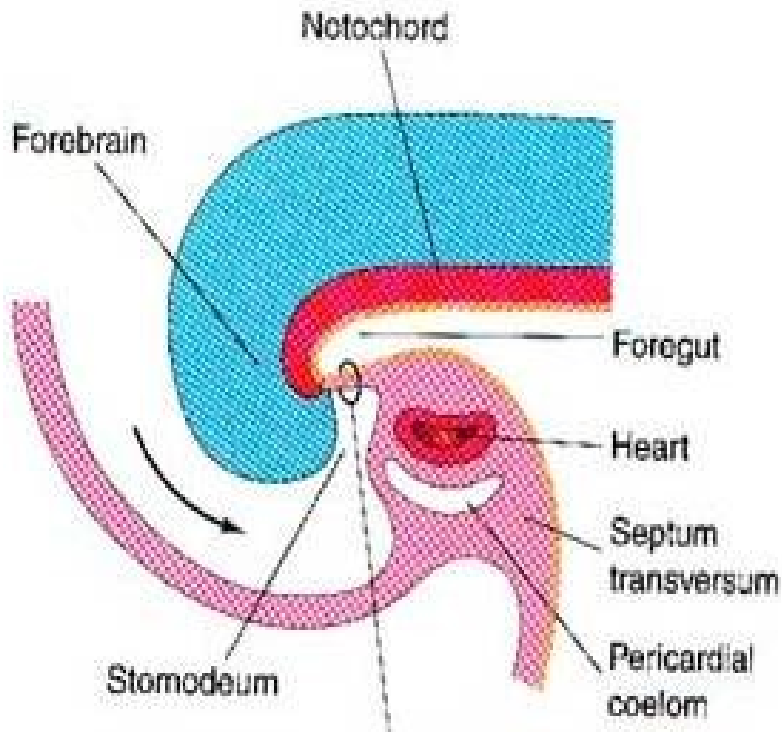
pharyngeal membrane

midgut

above ductus omphalomesentericus and yolk sack

hindgut

cloacal membrane

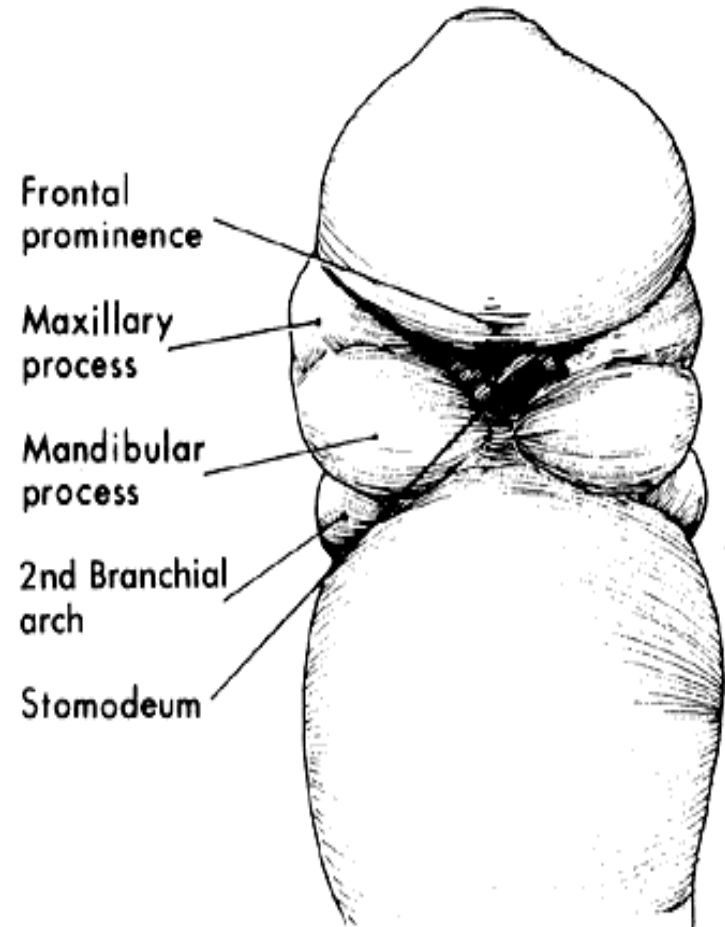


Derivatives of

- foregut** – pharynx, esophagus (+ respiratory diverticulum), stomach, cranial part of duodenum
- midgut** – caudal part of duodenum (+ liver, gall bladder, pancreas), small intestine and part of large intestine (to the flexura coli sin.)
- hindgut** – large intestine (from flexura coli sin.), rectum, upper part of anal canal

Oral cavity

- primitive mouth pit
 - **stomodeum**
- lined with ectoderm
- surrounded by:
 - processus frontalis (single)
 - proc. maxillares (paired)
 - proc. mandibulares (paired)
- **pharyngeal membrane**
(it ruptures during the 4th week, primitive gut communicates with amnionic cavity)

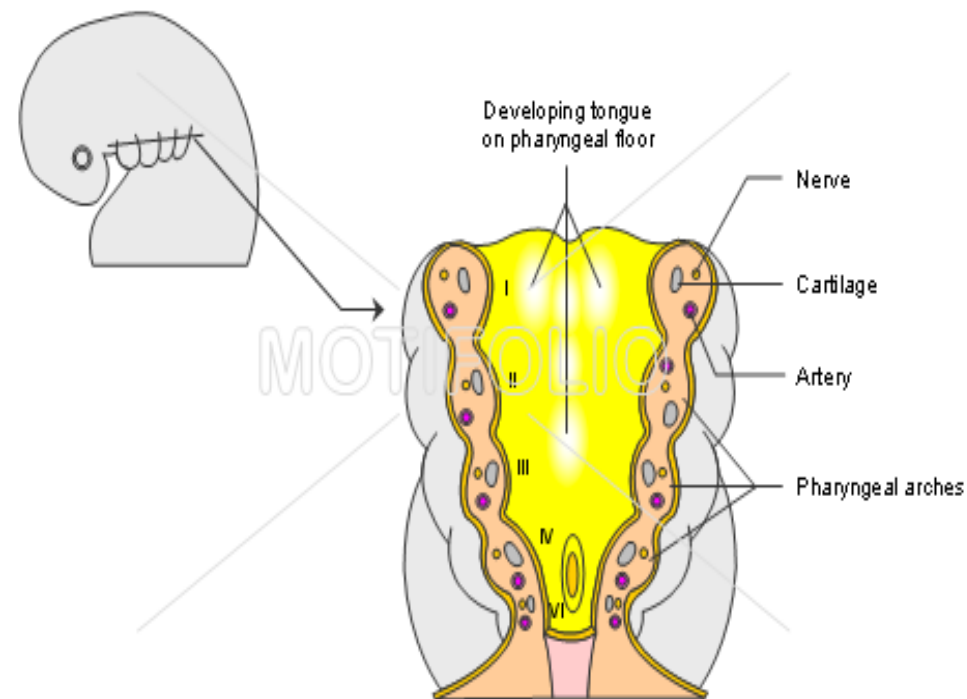


Pharyngeal (branchial) apparatus

Pharyngeal arches

- appear in weeks 4 - 5
- on the ventral side of the pharyngeal gut.
- each arch has cartilage, cranial nerve, aortic arch artery and muscle
- pharyngeal **clefts** and **pouches** are located between the arches
- **membrana obturans**

Pharyngeal arches, Pharyngeal pouches, Pharyngeal clefts – 4 weeks



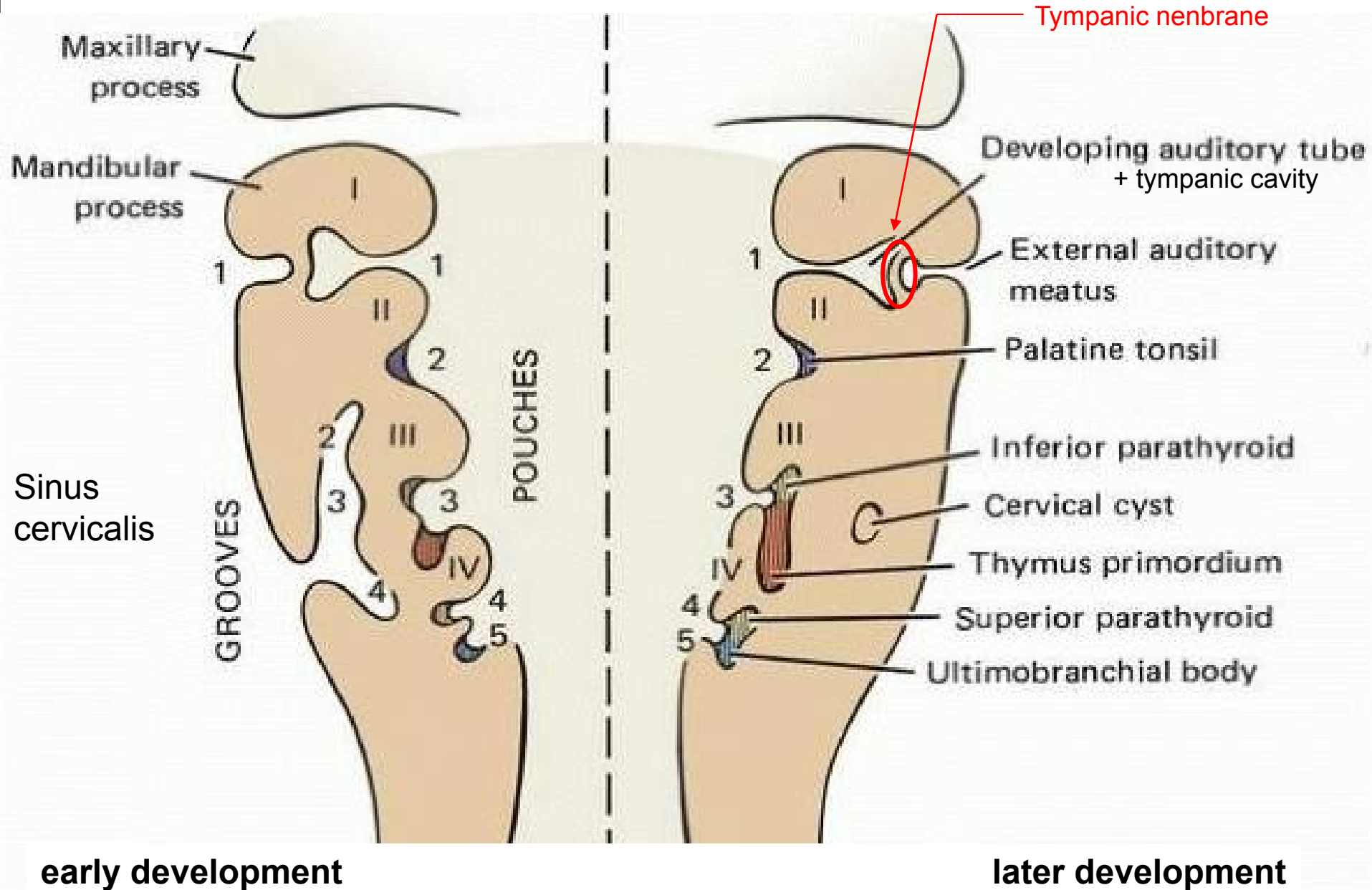
Endodermal pharyngeal pouches

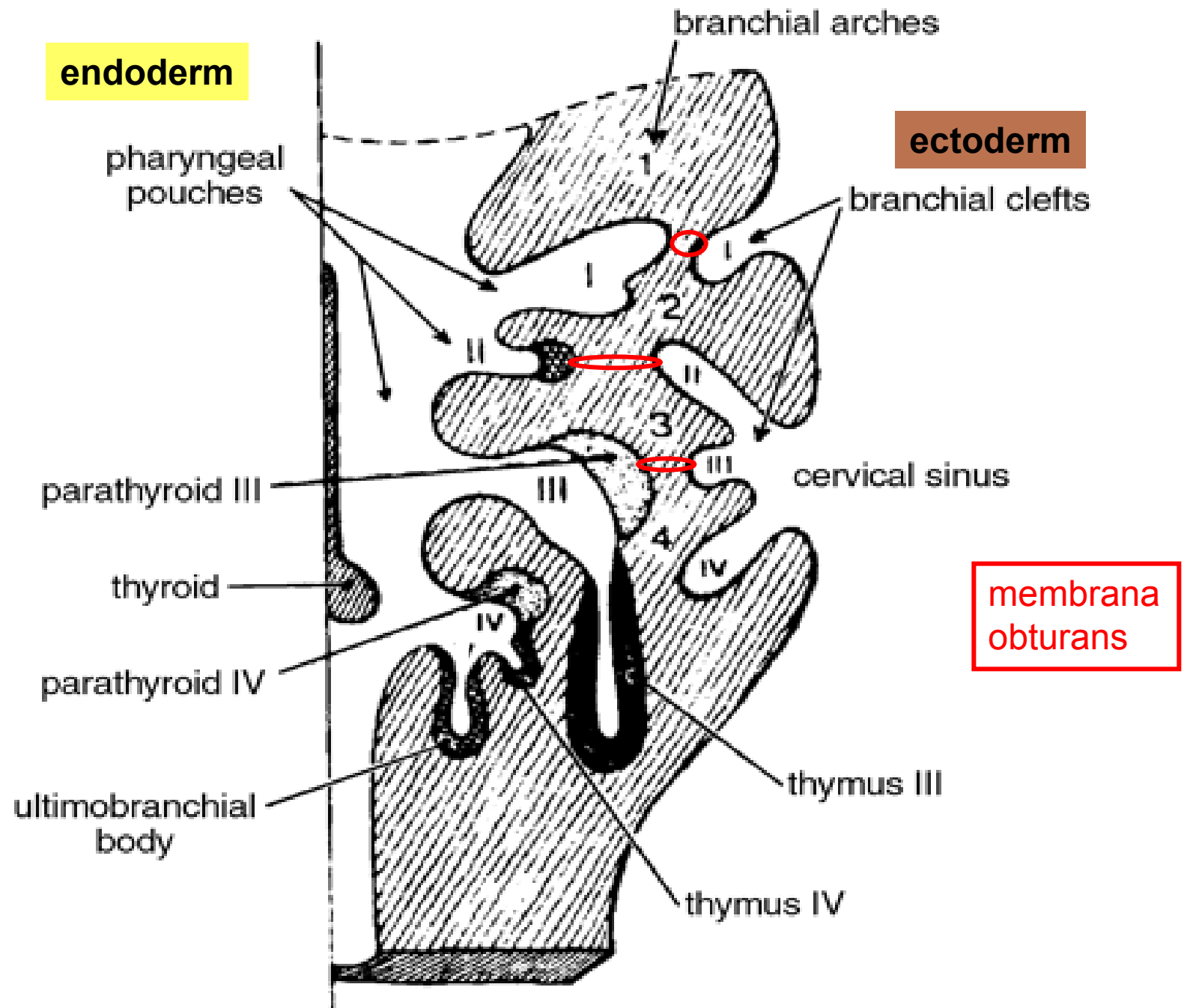


Ectodermal pharyngeal clefts (grooves)



Fate of pharyngeal pouches and clefts





Structures derived from Arches

ARCH	Nerve	Muscles	Skeletal Structures	Ligaments
1 (maxillary/mandibular)	trigeminal (V)		malleus, incus	ant lig of malleus, sphenomandibular ligament
2 (hyoid)	facial (VII)		stapes, styloid process, lesser cornu of hyoid, upper part of body of hyoid bone	stylohyoid ligament
3	glossopharyngeal (IX)		greater cornu of hyoid, lower part of body of hyoid bone	
4 & 6	superior laryngeal and recurrent laryngeal branch of vagus (X)		thyroid, cricoid, arytenoid, corniculate and cuneiform cartilages	

Structures derived from Pouches

Each pouch is lined with endoderm and generates specific structures.

POUCH	Overall Structure	Specific Structures
1	tubotympanic recess	tympanic membrane, tympanic cavity, mastoid antrum, auditory tube
2	intratonsillar cleft	crypts of palatine tonsil, lymphatic nodules of palatine tonsil
3	inferior parathyroid gland, thymus	
4	superior parathyroid gland, ultimobranchial body	

Esophagus development

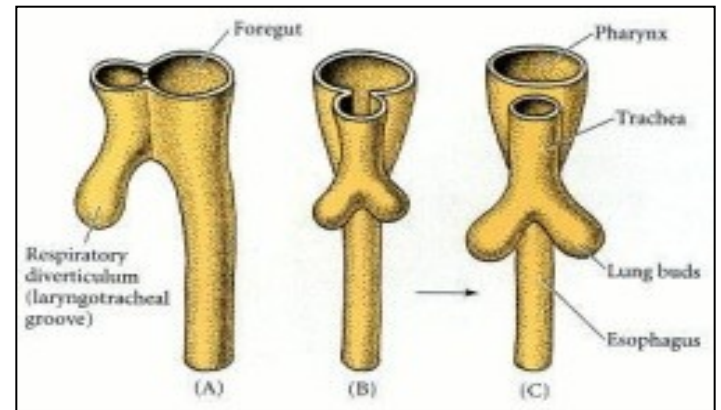
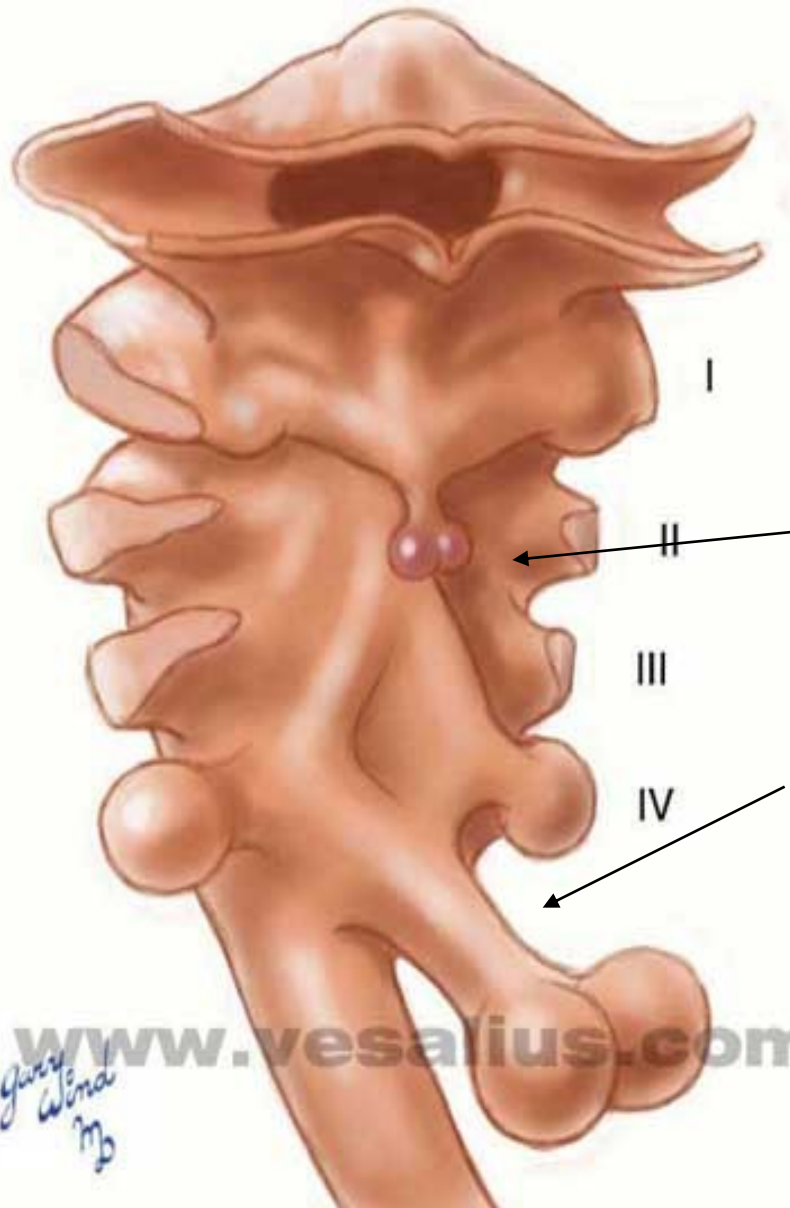
below respiratory diverticle,
behind larynx and trachea

primitive pharynx

thyroid gl.

laryngotracheal diverticle
(respiratory diverticle)

esophagus

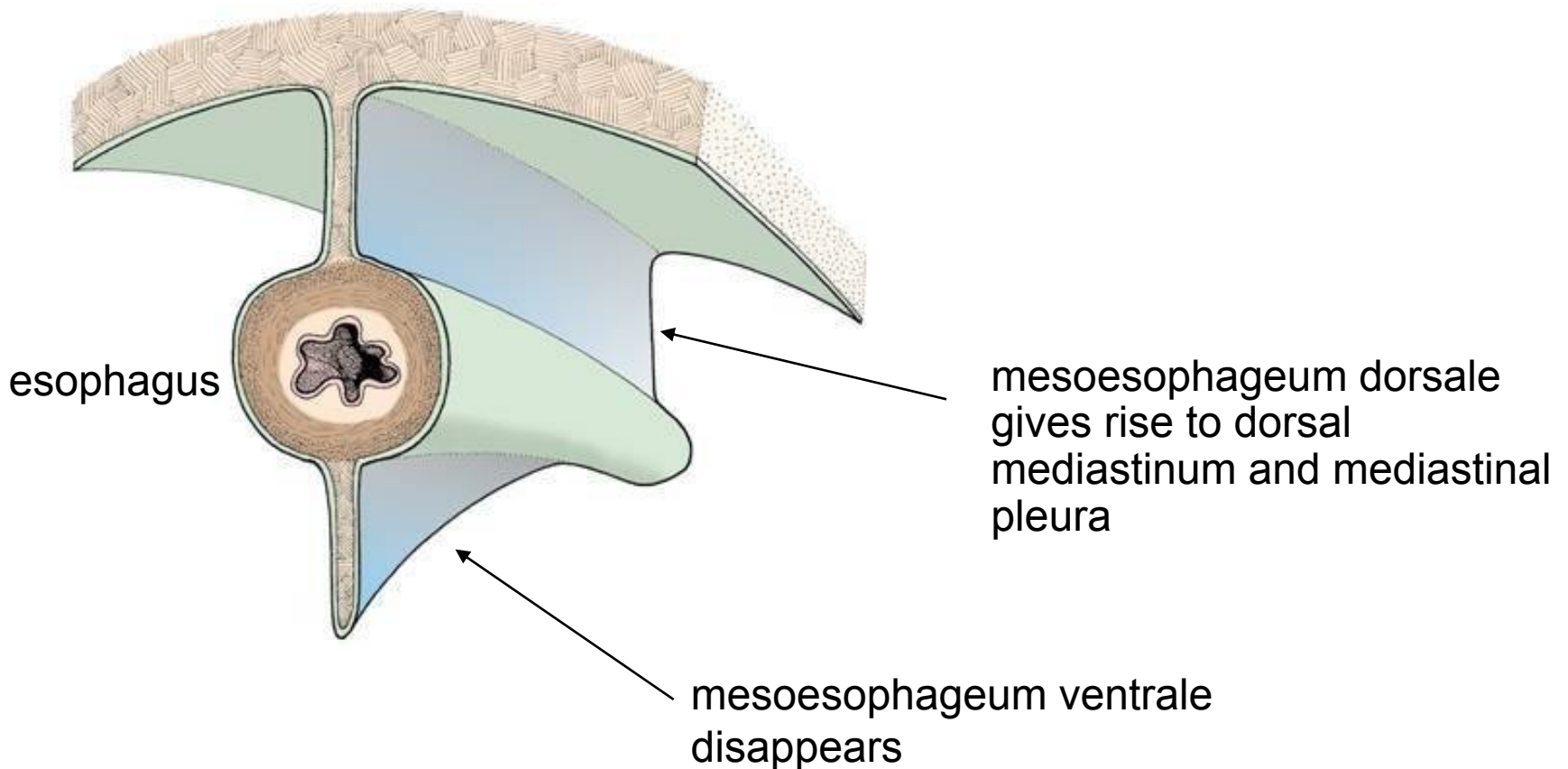


Esophagus development

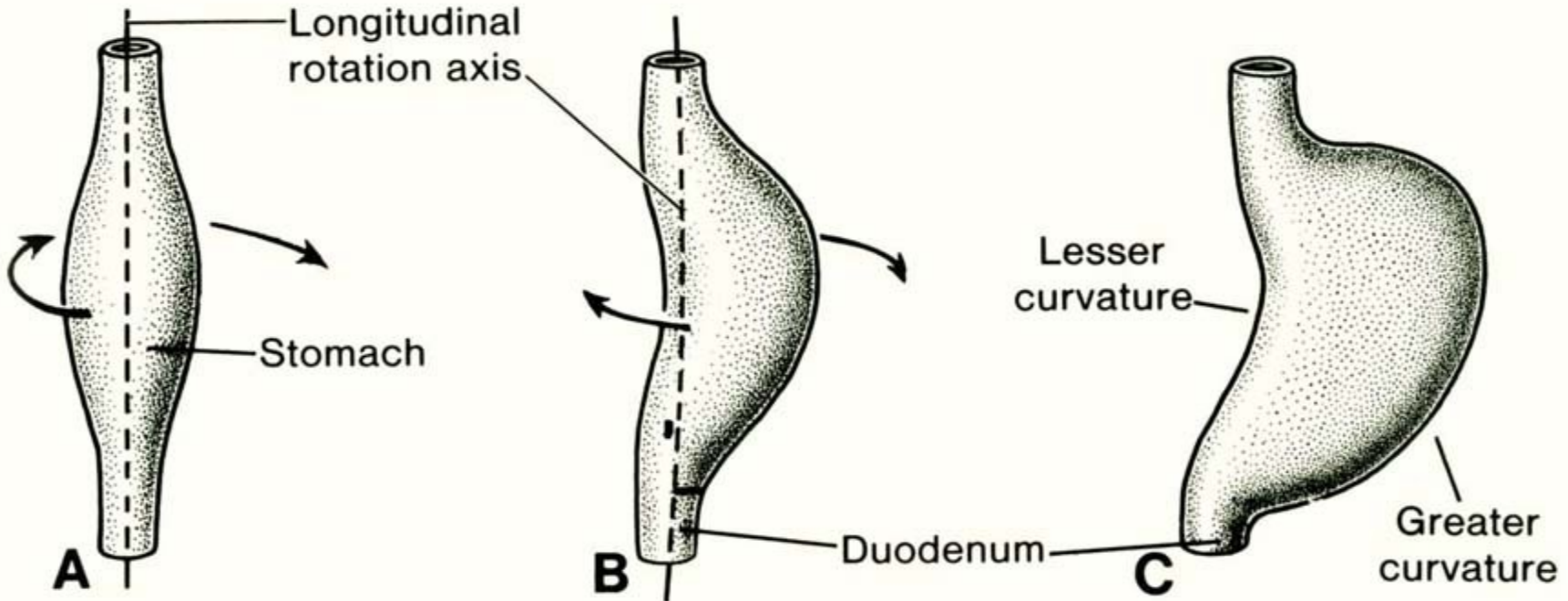
- differentiation of epithelium from endoderm
- during the 2nd month endoderm proliferates and temporarily closes esophageal lumen
- other tissues and structures in the wall arise from splanchnic mesoderm

Mesenteries – suspensory duplicature derived from mesoderm and mesenchyme (a fold of tissue that attaches organs to the body wall)

mesoesophageum



Stomach development



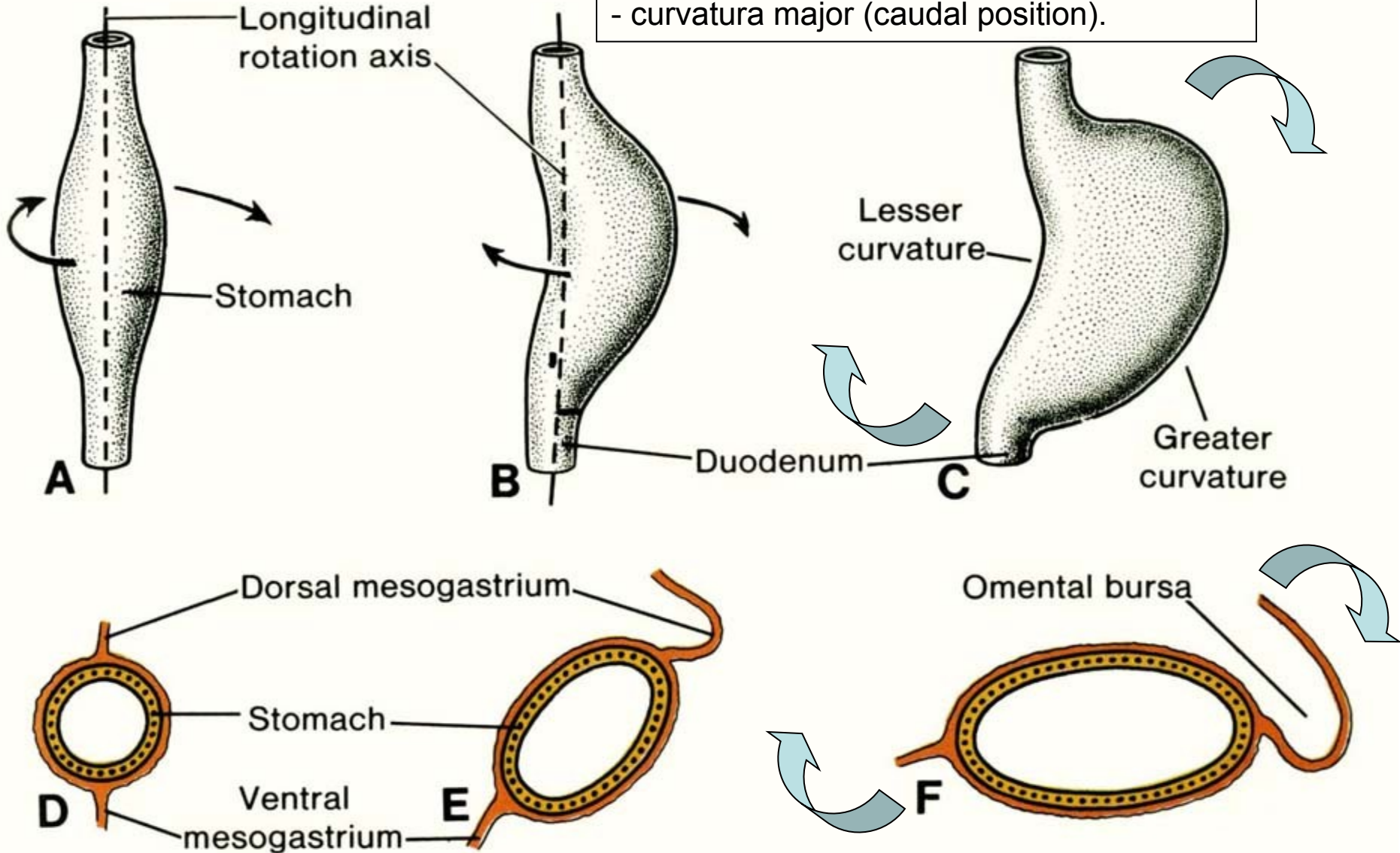
- in the 4th week – spindle dilatation of distal foregut
- endoderm – epithelium and glandular cells
- splanchnic mesoderm – other tissues of stomach wall

Rotation around longitudinal axis:

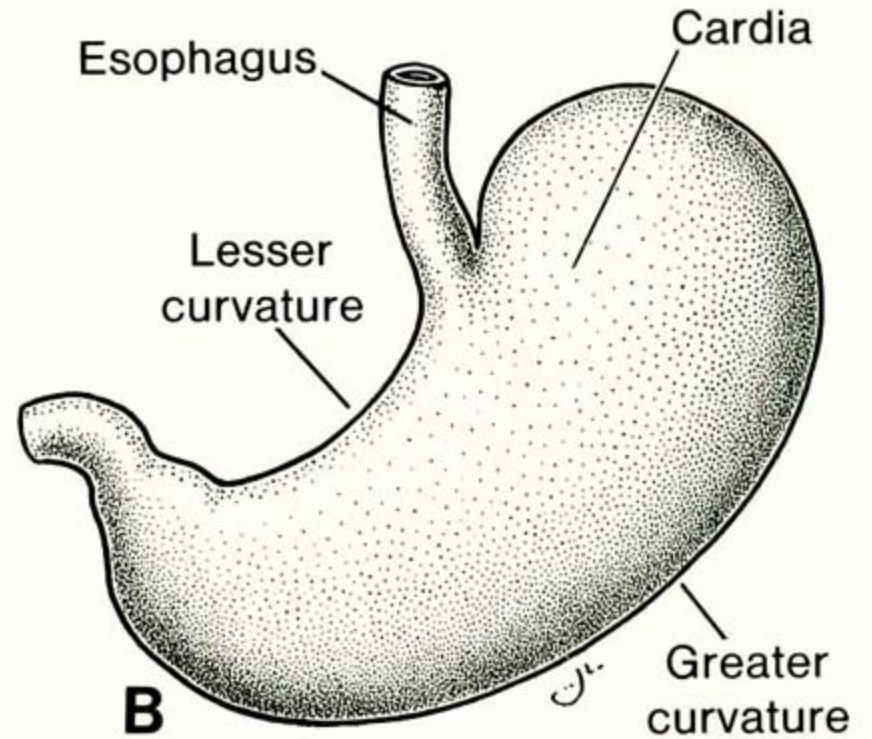
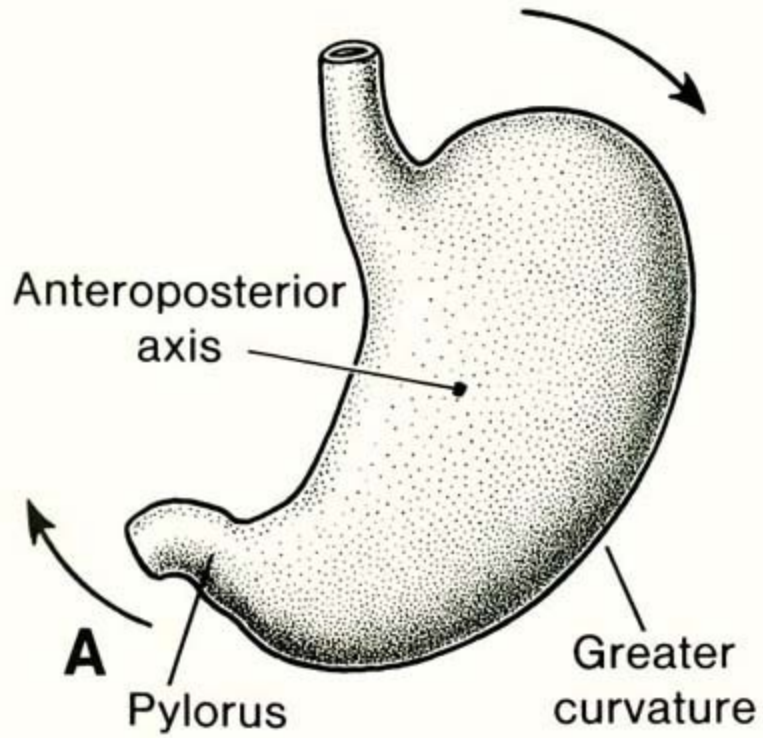
- left side → ventrally,
- right side → dorsally.

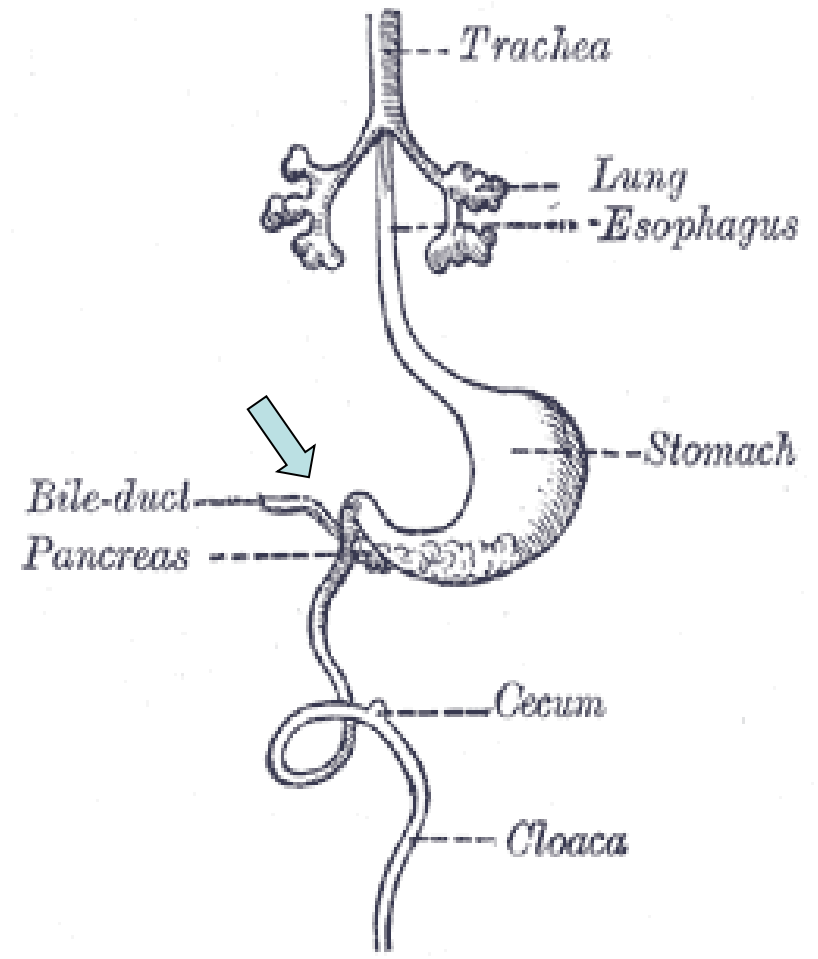
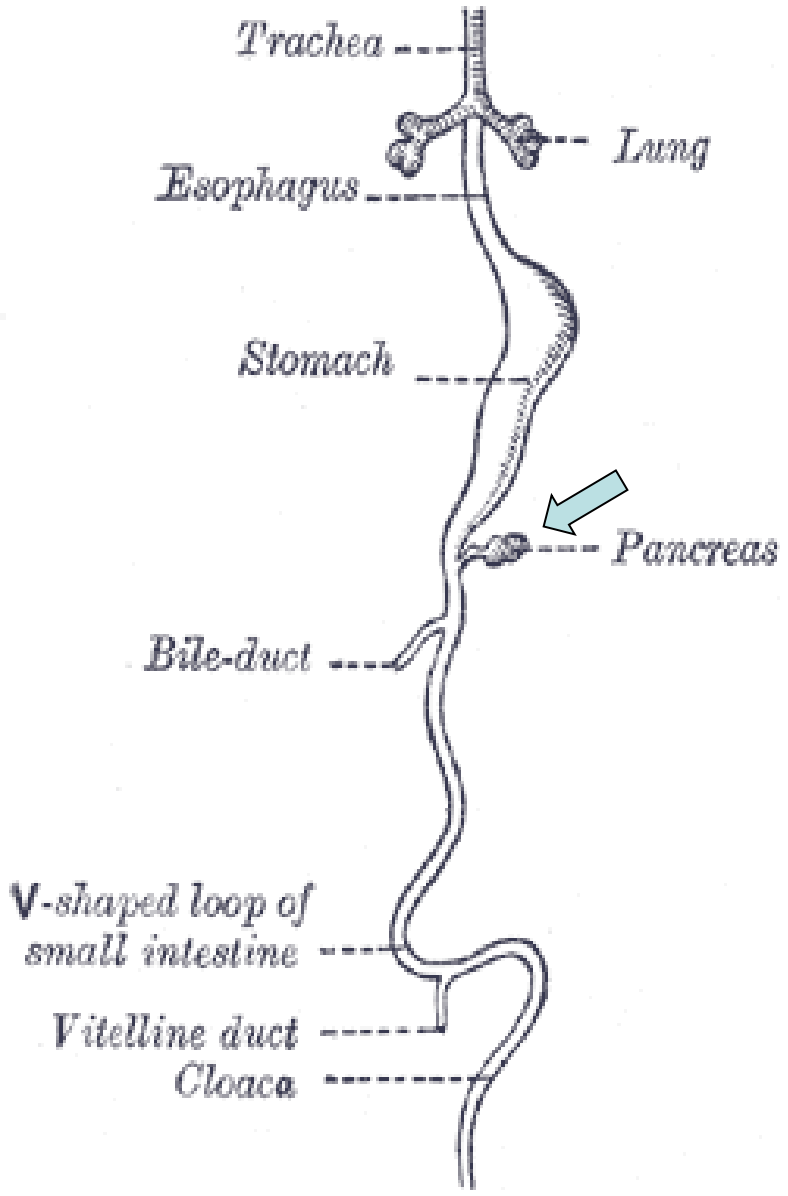
Uneven growth of ventral and dorsal wall:

- curvatura minor (to the right),
 - curvatura major (to the left).
- Rotation around sagittal axis :
- curvatura minor (cranial position),
 - curvatura major (caudal position).

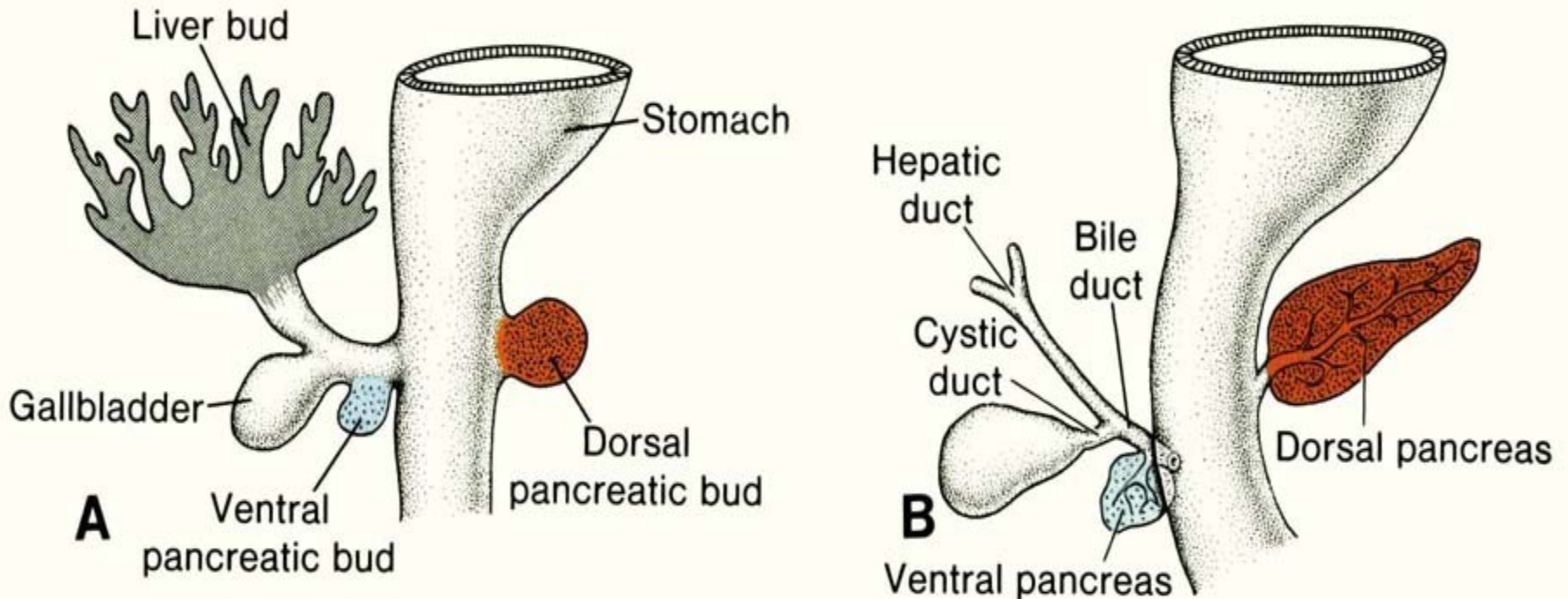


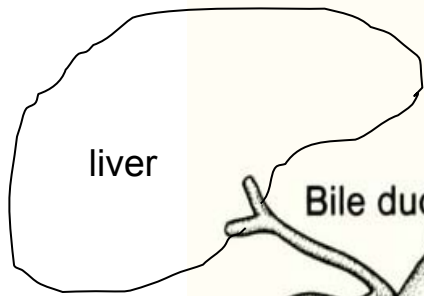
Sagittal rotation axis



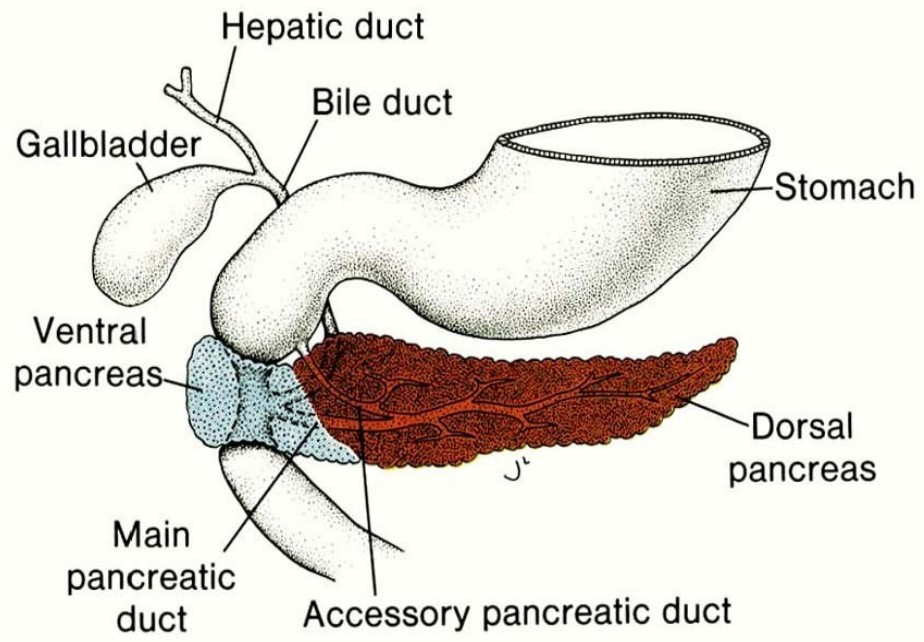
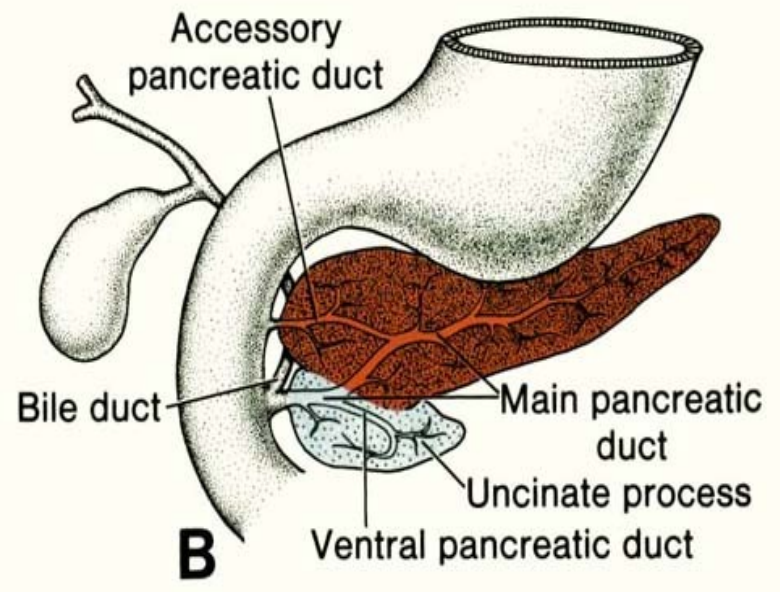
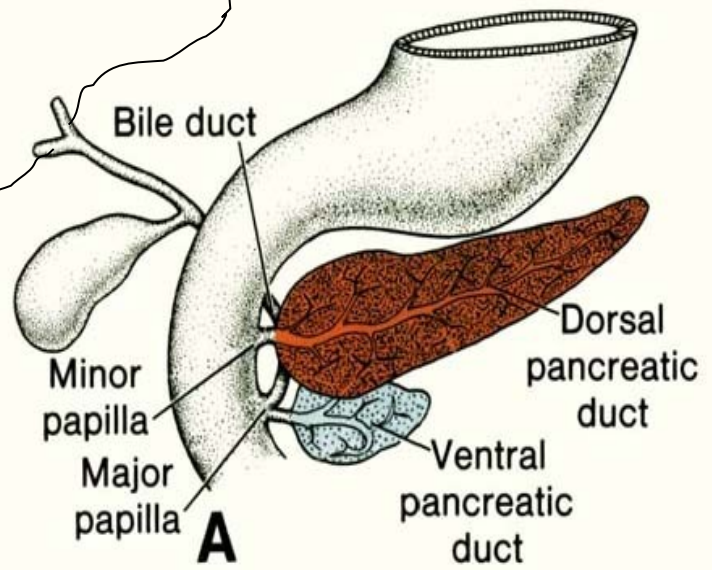


The liver bud (hepatocystic diverticlle) appears at the distal end of the foregut (week 4) and divides into hepatic and cystic diverticles, later ventral pancreatic bud and dorsal pancreatic bud (week 5). Both pancreatic buds meet and fuse (week 6).





liver



Midgut

The midgut is divided into two regions at the viteline duct: the cranial and caudal limbs.

The derivatives of the cranial limb - the distal duodenum, jejunum, and proximal ileum.

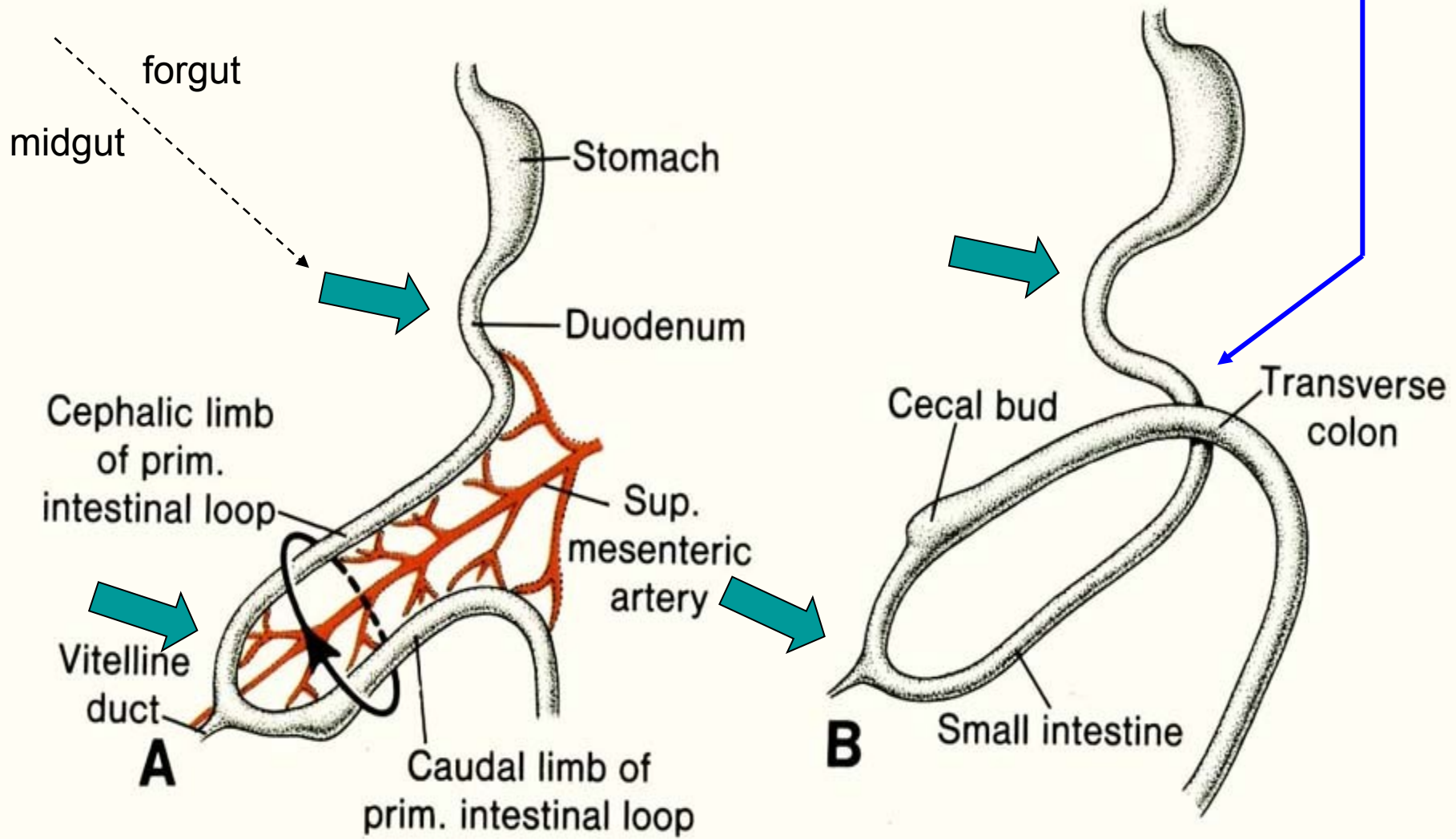
The derivatives of the caudal limb - the distal ileum, cecum, appendix, ascending colon, and proximal 2/3 of transverse colon.

the midgut grows faster than that of the embryo, creating:

- **duodenal loop**
- **umbilical loop**

Duodenal loop and umbilical loop

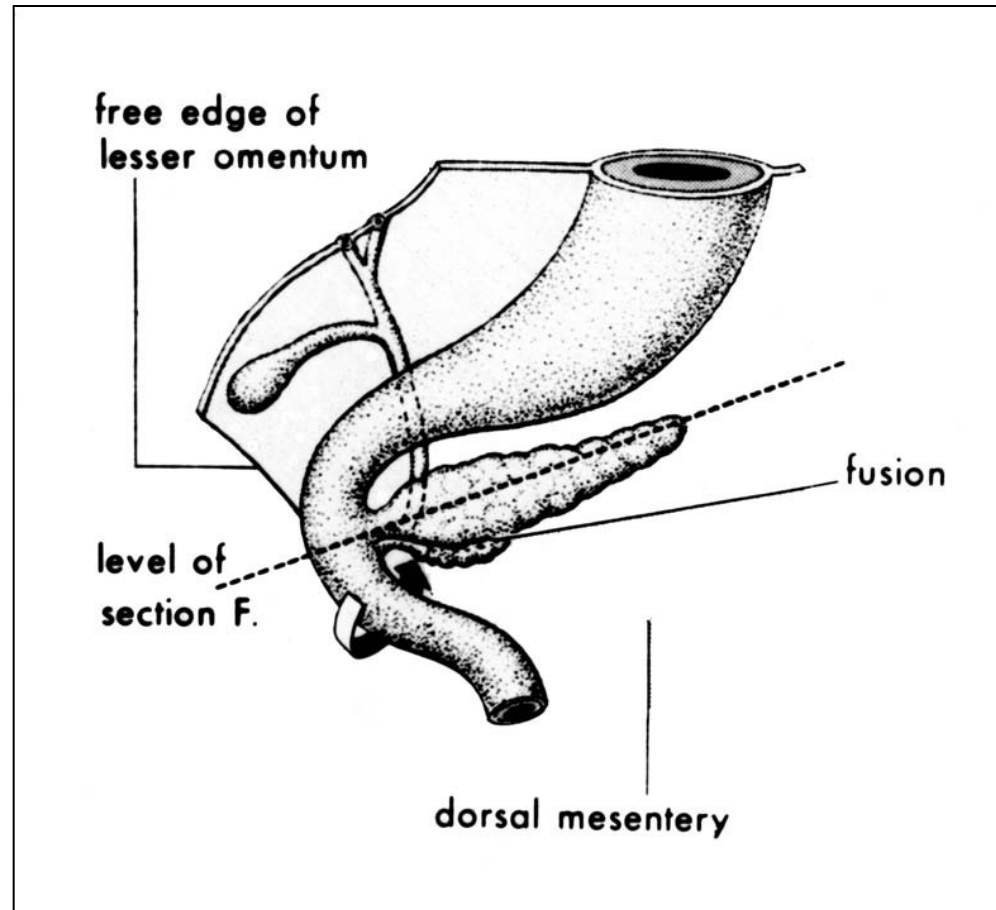
Flexura duodenojejunalis



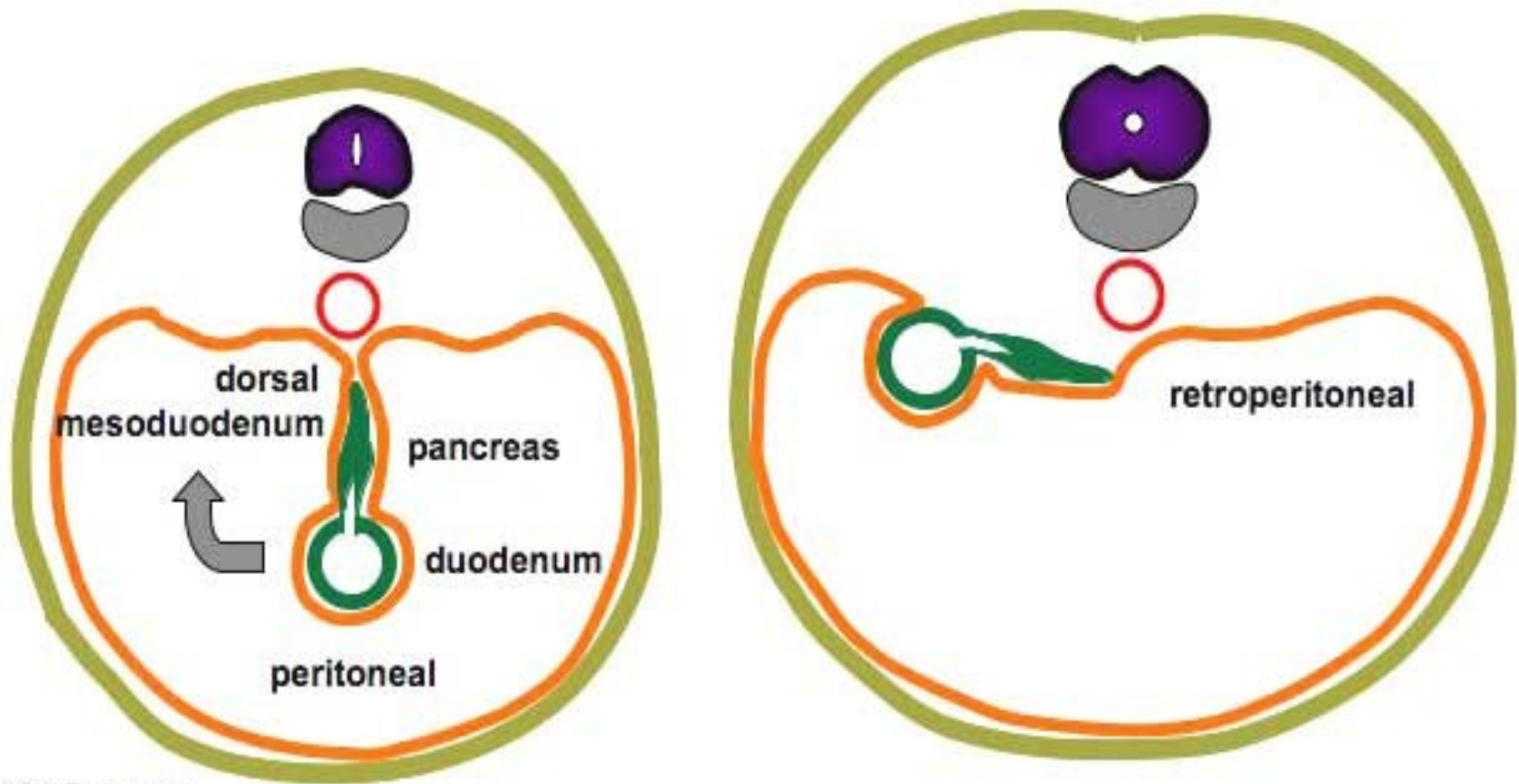
Umbilical loop herniates into the umbilical cord (**physiologic herniation**, in week 6-10)

Duodenum development

- **Duodenal loop** – 2 limbs:
upper limb (from foregut)
lower limb (from midgut)
- On top of loop – diverticles
(for liver, gallbladder,
pancreas)

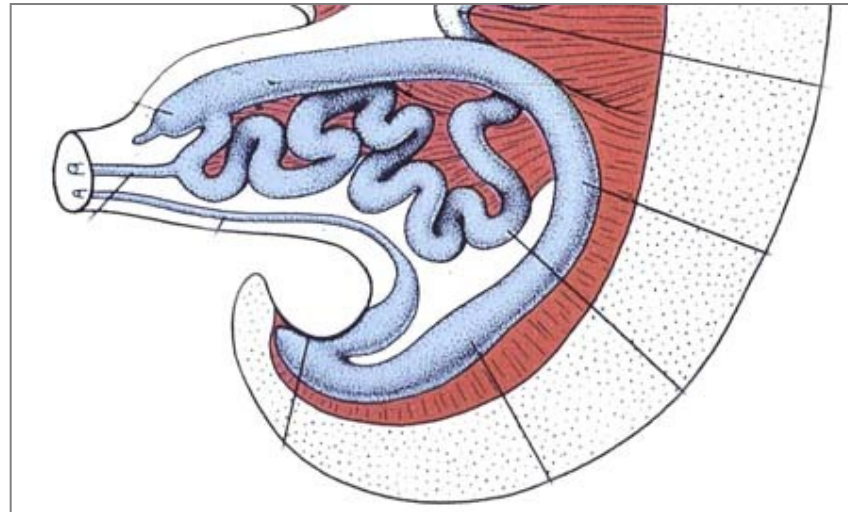


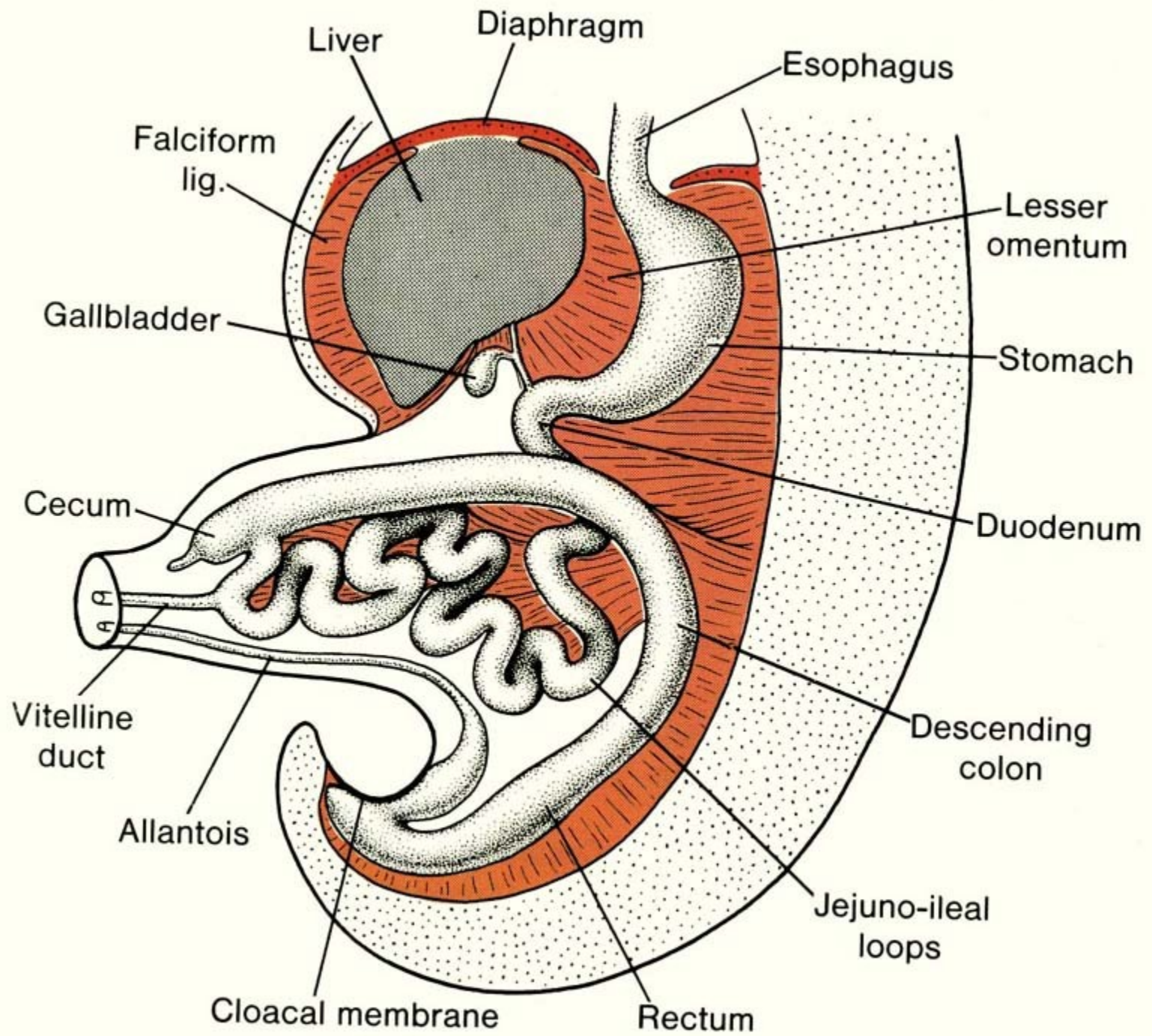
Due to rotation of umbilical loop, duodenal loop changes its position (from front to the right) and becomes retroperitoneal organ (together with pancreas)



Intestines development

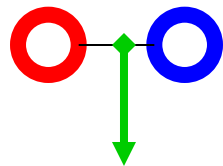
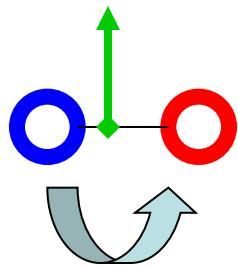
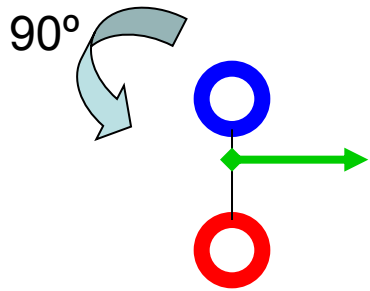
- Umbilical loop – 2 limbs:
 - cranial – jejunoileal limb (jejunum, major part of ileum)
 - caudal – ileocecal limb (rest of ileum, caecum + appendix, colon ascendens and 2/3 of colon transversum)
- A. mesenterica sup. – axis of rotation
- week 6 – **physiologic herniation** into the umbilical cord, week 10 – reposition into abdominal cavity



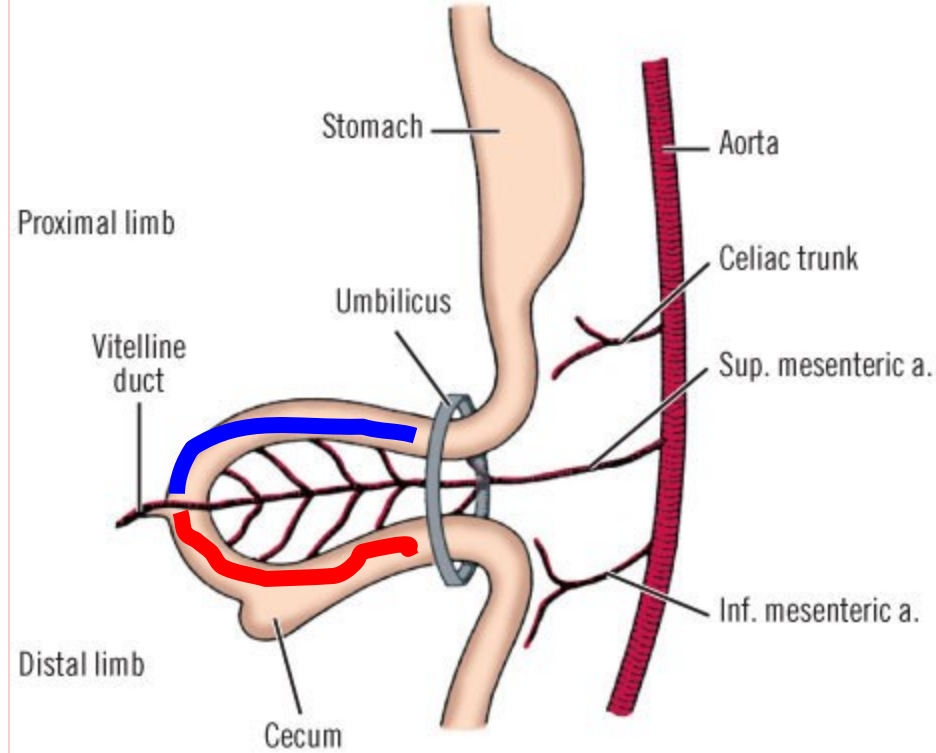


Umbilical loop rotation

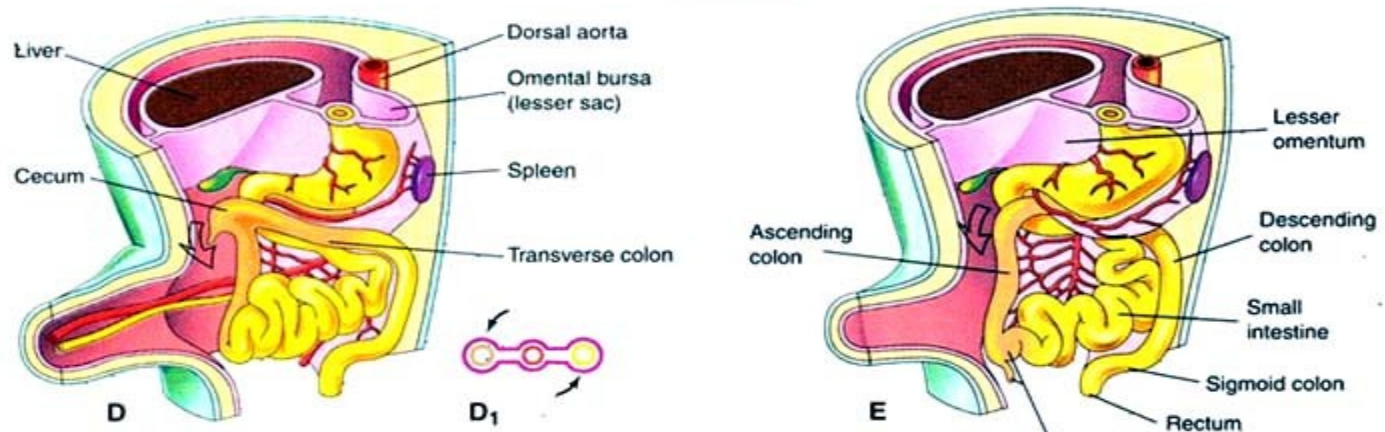
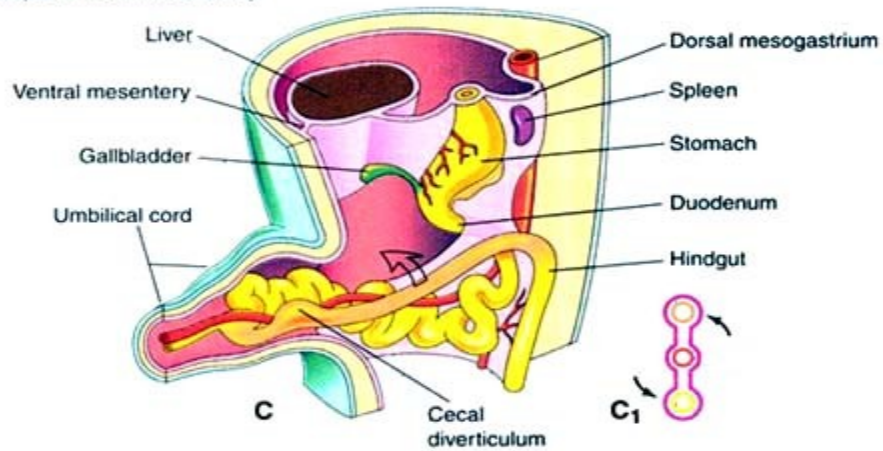
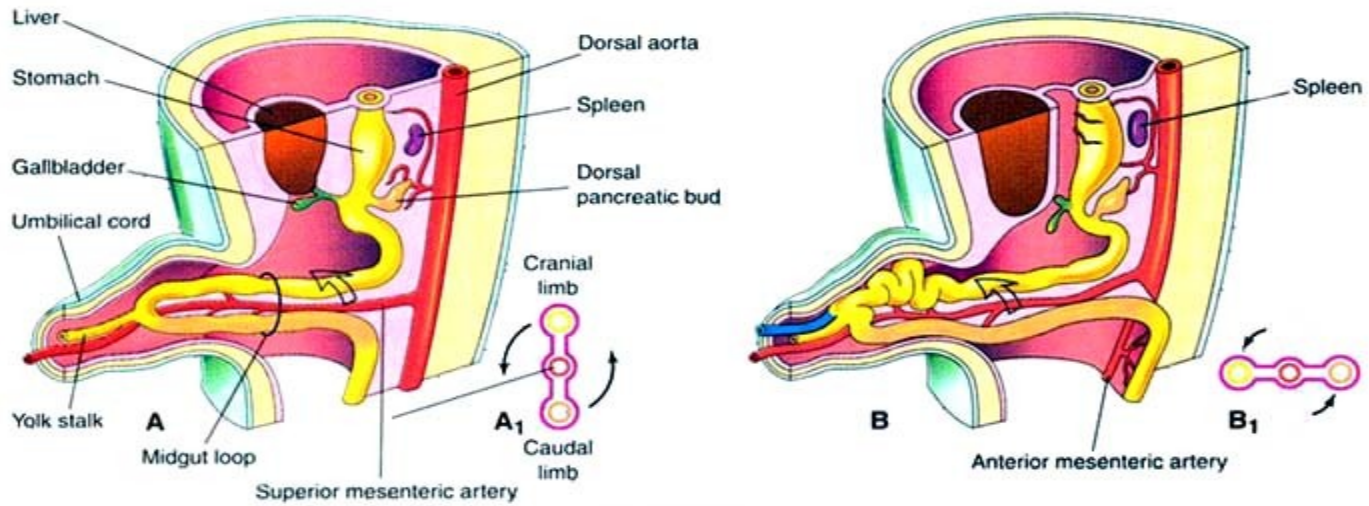
- The midgut loop rotates 90° counter-clockwise in the umbilical cord around the axis of the superior mesenteric artery
- Upon returning, the gut undergoes another 180° counterclockwise rotation, placing the cecum and appendix near the right lobe of the liver.
- The total rotation of the gut is 270° .



after 270°
rotation



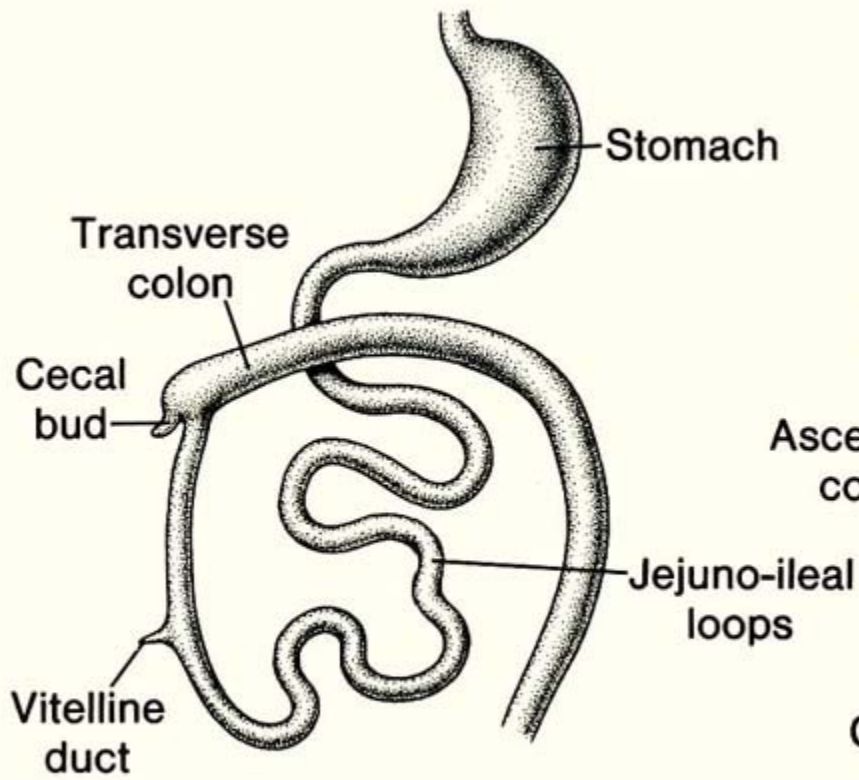
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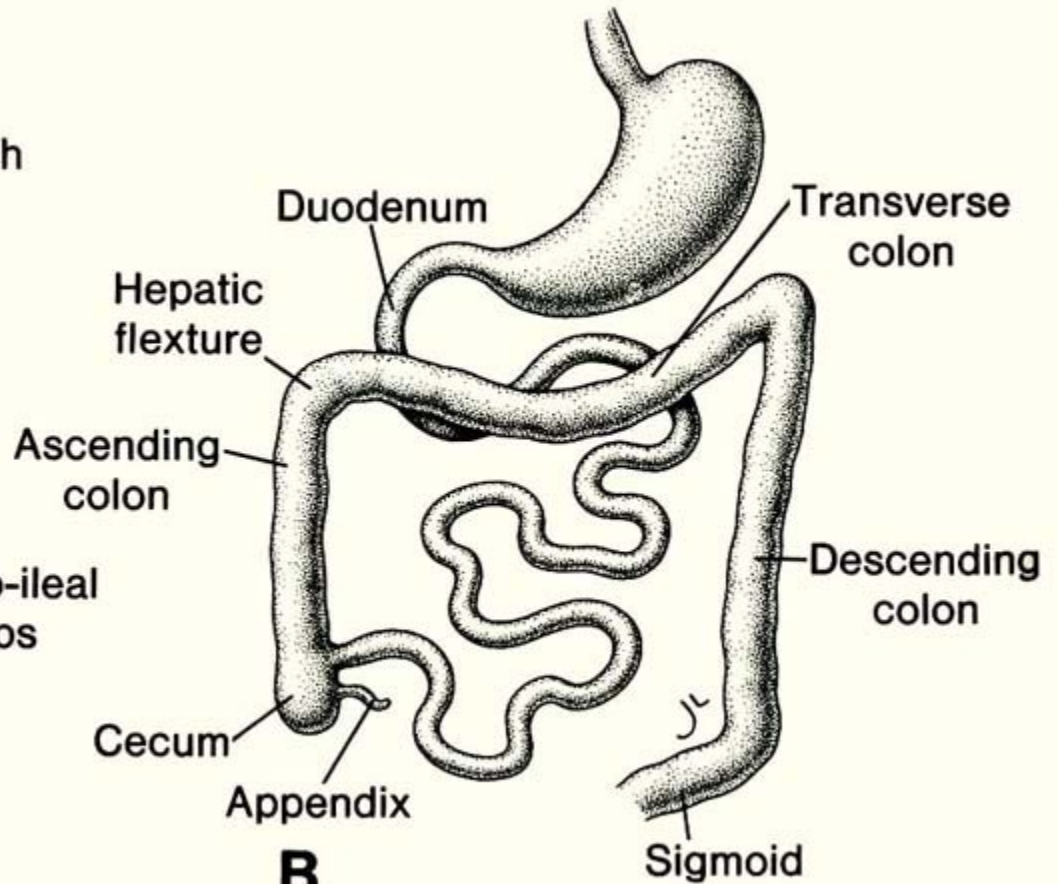
Hindgut

The distal end of the hindgut – the cloaca.

Derivatives of the hindgut: the distal 1/3 of the transverse colon, descending colon, sigmoid colon, rectum and upper part of anal canal (above the pectinate line).



A

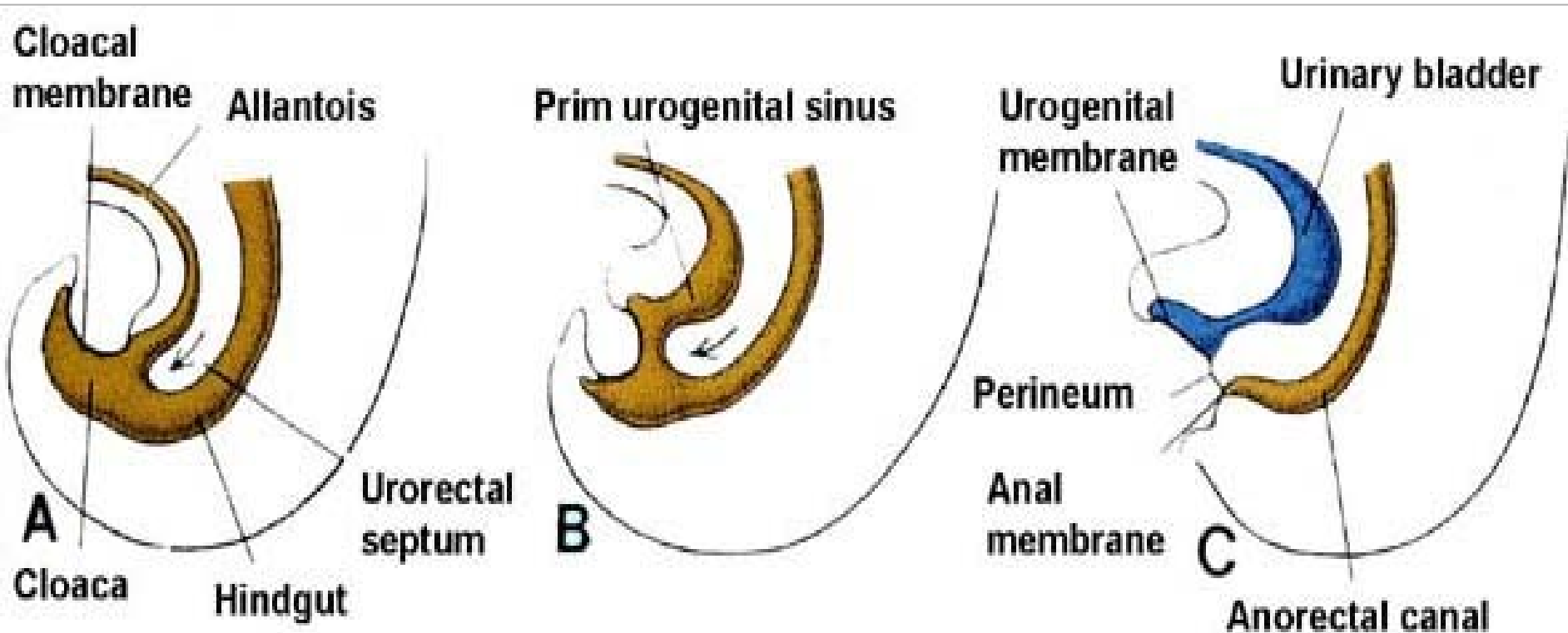


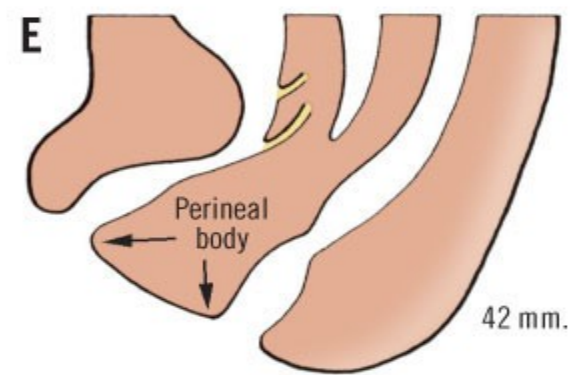
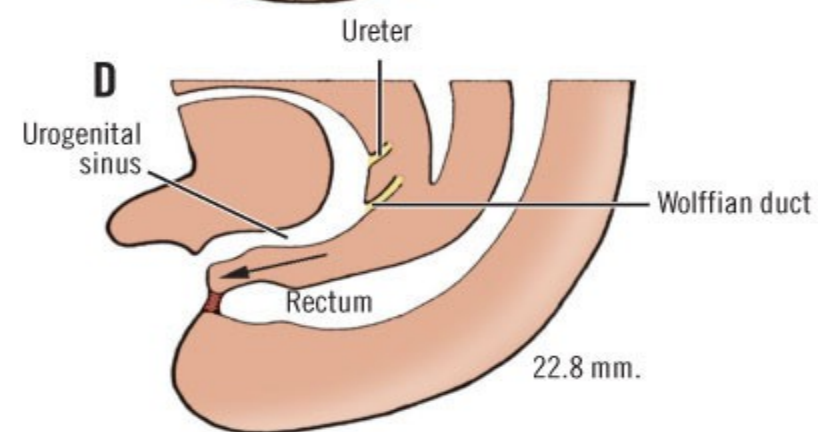
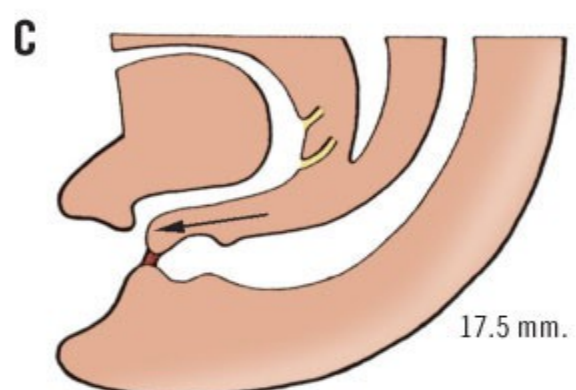
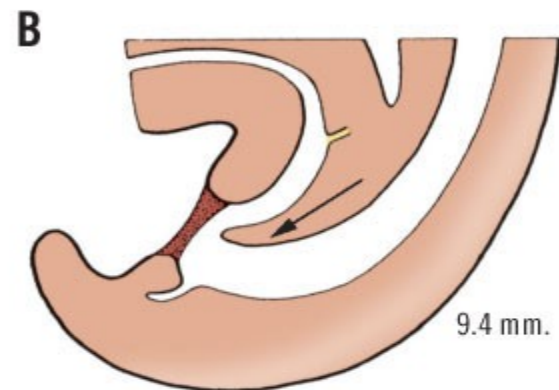
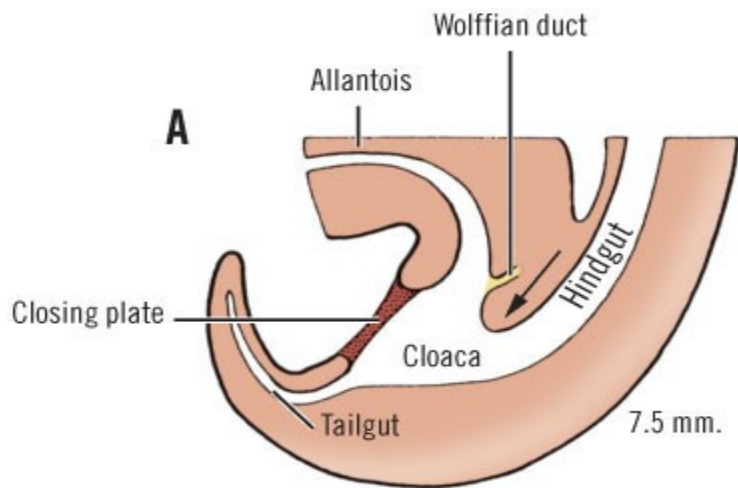
B

Division of the cloaca - urorectal septum divides the cloaca into a ventral primitive urogenital sinus and a dorsal primitive **anorectal canal**.

The **cloacal membrane** breaks down in the 7th week.

Distal to the pectinate line (site of the former cloacal membrane), the epithelium of the anal canal is derived from ectoderm of **proctodeum** (primitive anal pit)



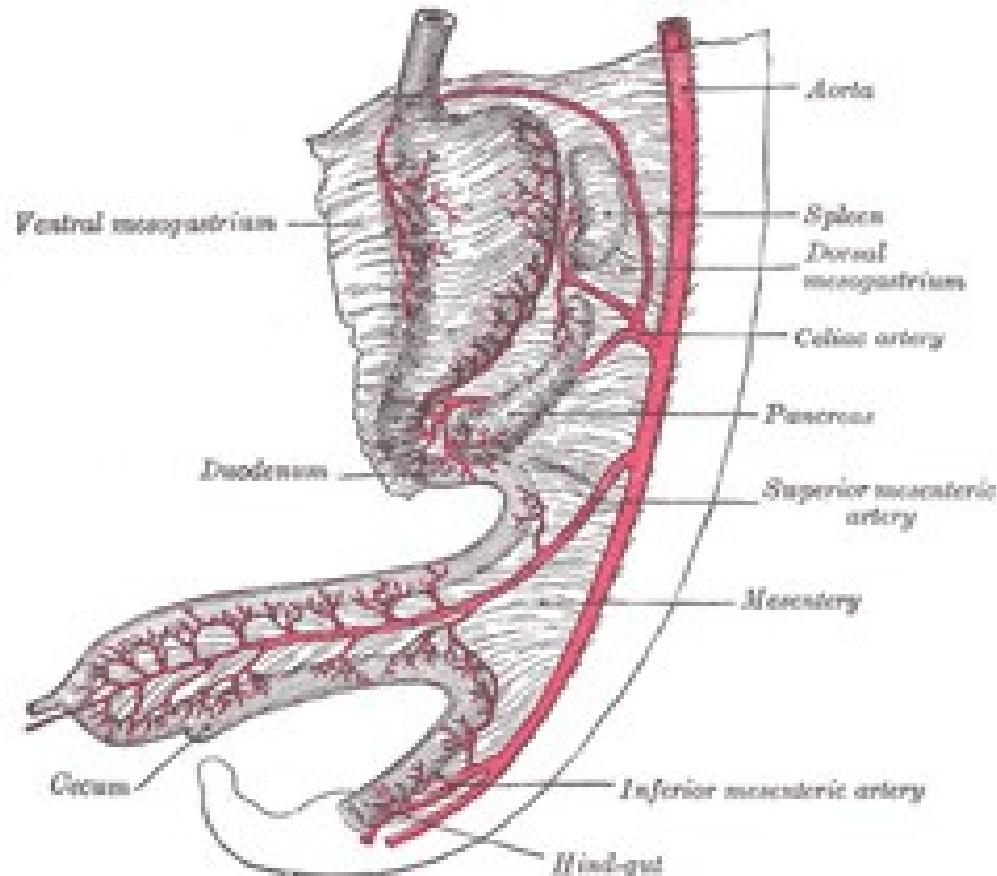


Mesenteries

- double layer of peritoneum enclosing organs and connecting them to the body wall

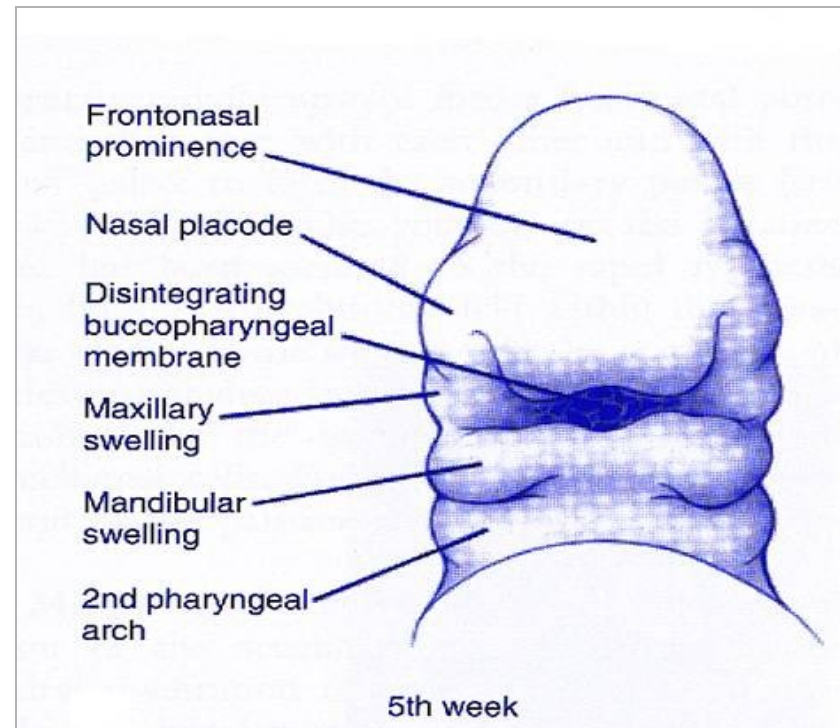
Ventral mesentery exists only in region of distal part of esophagus, stomach (lesser omentum) and upper part of duodenum

Dorsal mesentery forms dorsal mesogastrium (greater omentum), dorsal mesoduodenum, mesentery proper (jejunum, ileum)

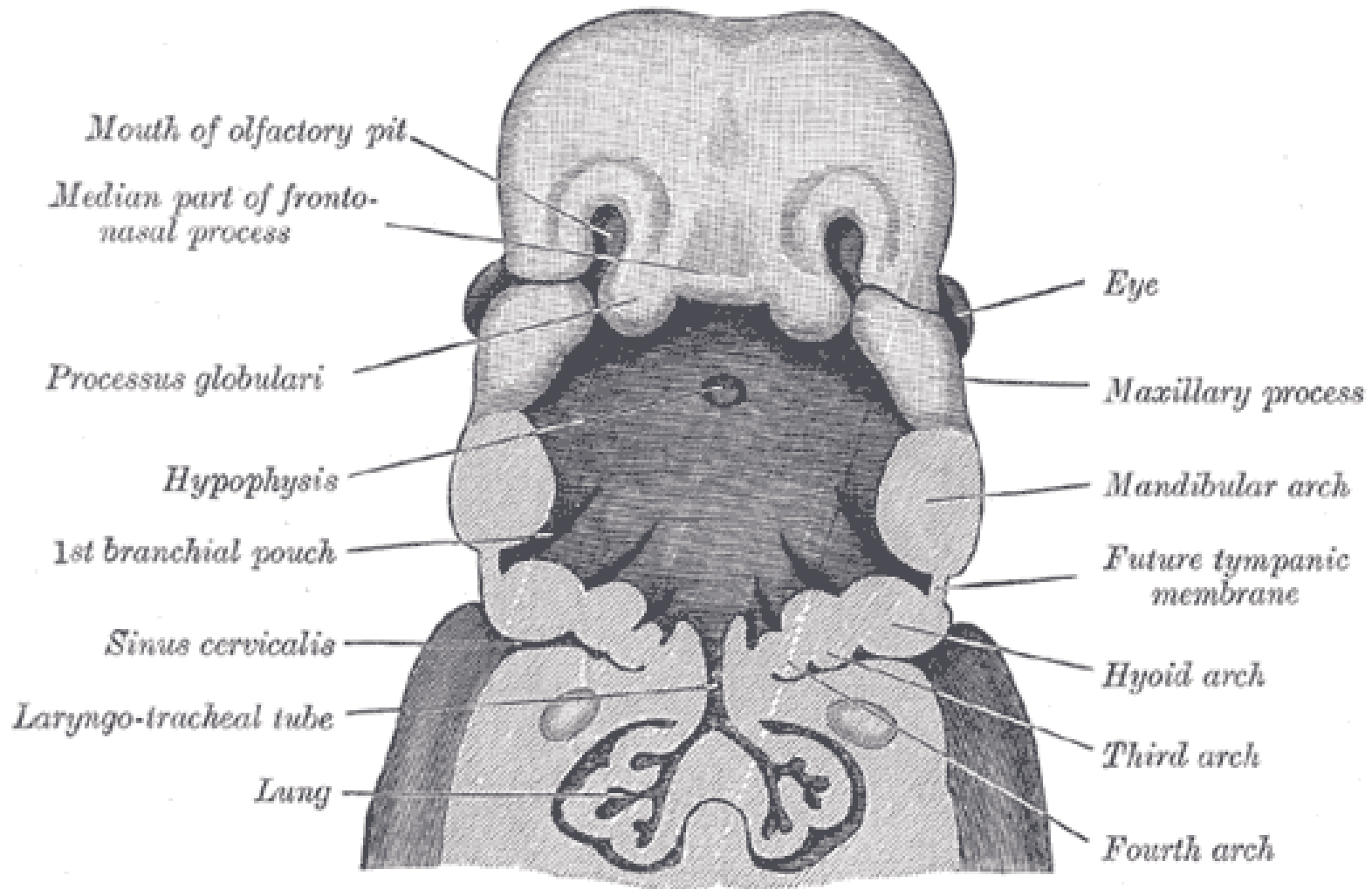


Face development

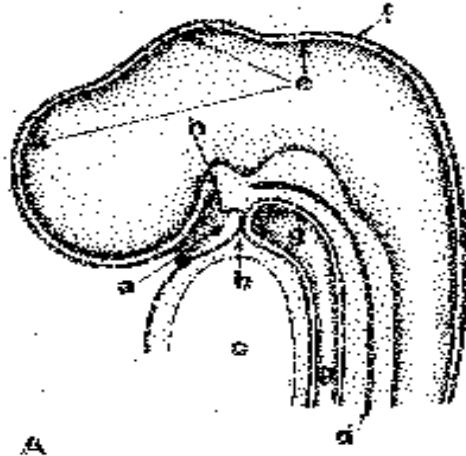
- During 2nd month i.u.
- Stomodeum
- Mesenchymal processes covered with ectoderm
 - processus frontonasalis
 - processus mandibulares
 - processus maxillares



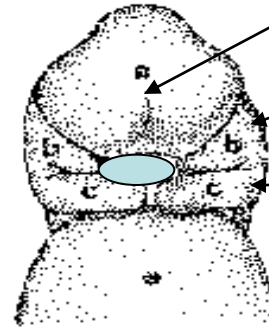
Stomodeum



The head and neck of a human embryo 32 days old, seen from the ventral surface. The floor of the mouth and pharynx have been removed.



A



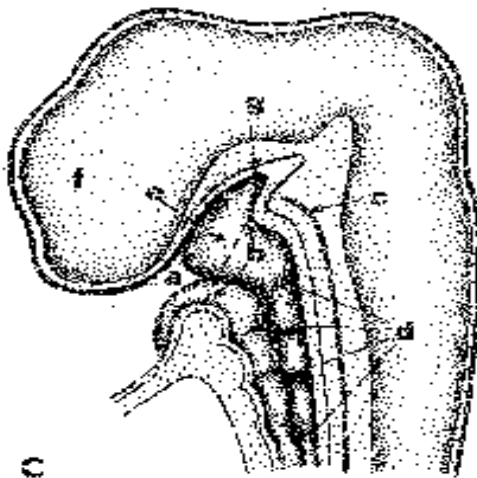
B

Frontonasal process

Maxillar process

Mandibular process

Stomodeum 



C



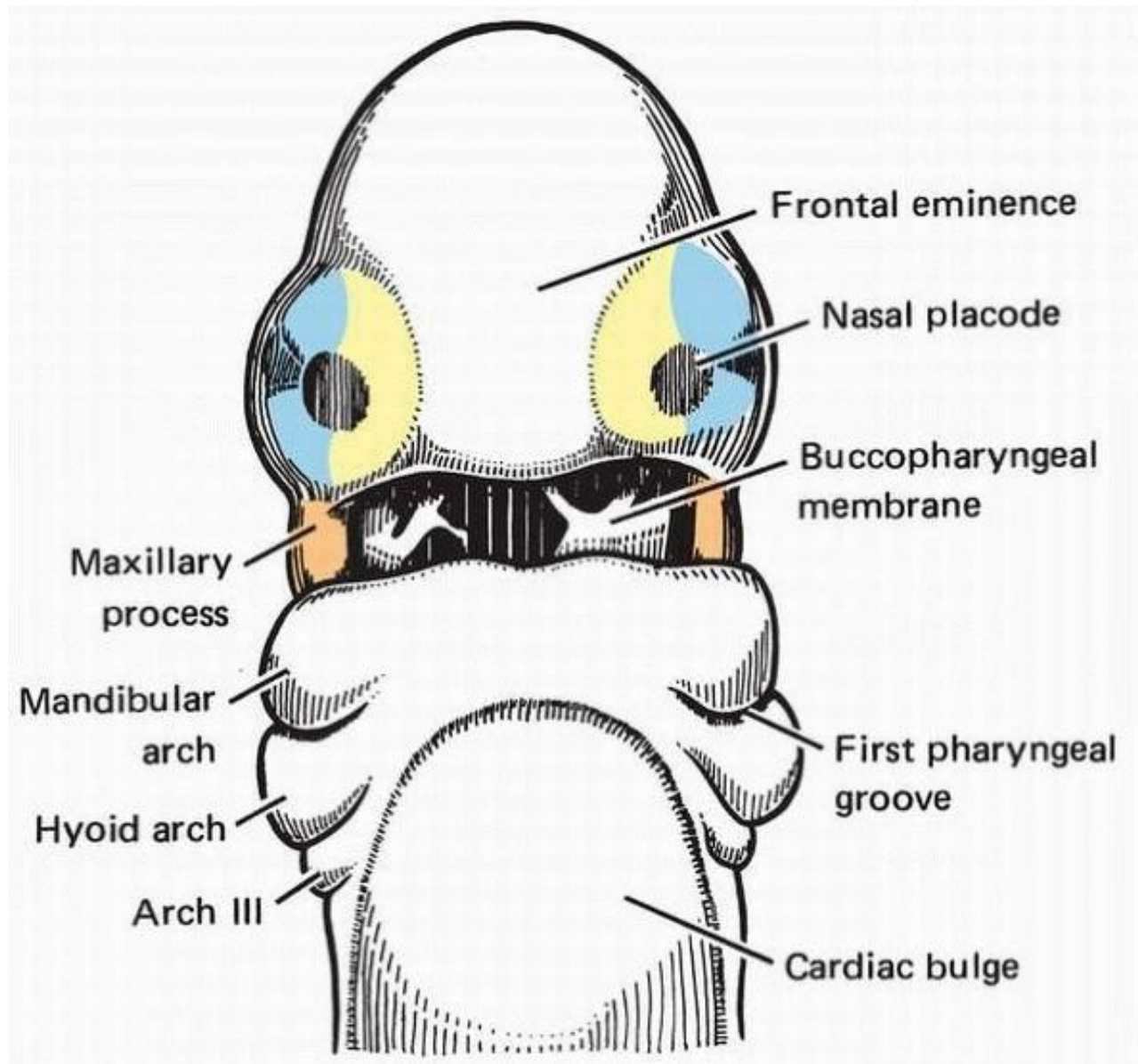
D

Intermaxillary segment
(intermaxillare)

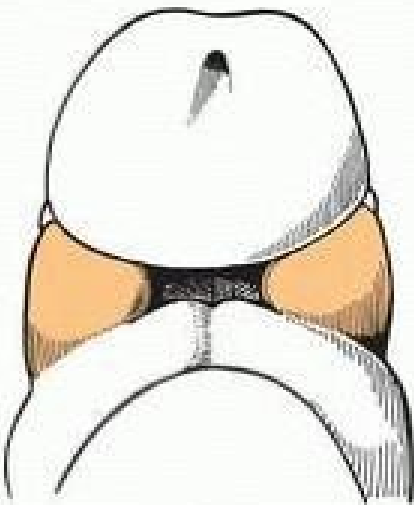
Nasal placode (plate) 

Frontal view of an embryo at 4 to 5 weeks of age.

Observe the branchial arch formation and the ruptured buccopharyngeal membrane.



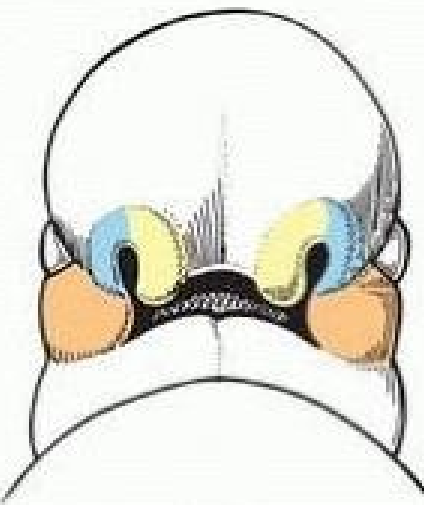
Developing face



week 4



4-5



5-6



6-7

Scanning electron micrograph (SEM): human embryo



stage 15 (8.0-mm), ×52.



stage 17 (11.7-mm), 57x



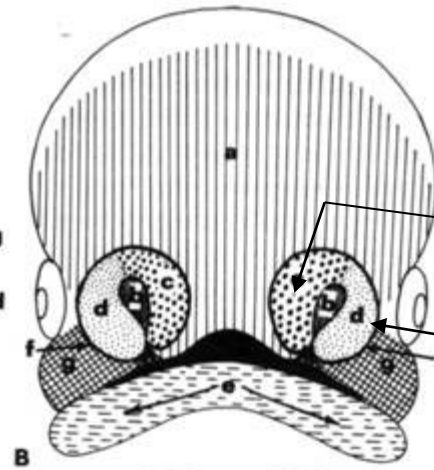
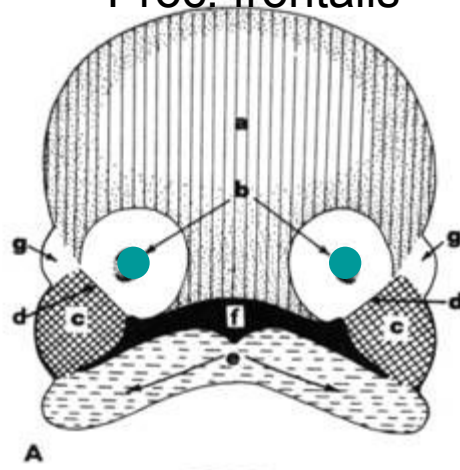
stage 17 (11.7-mm), 14x

Proc. frontalis

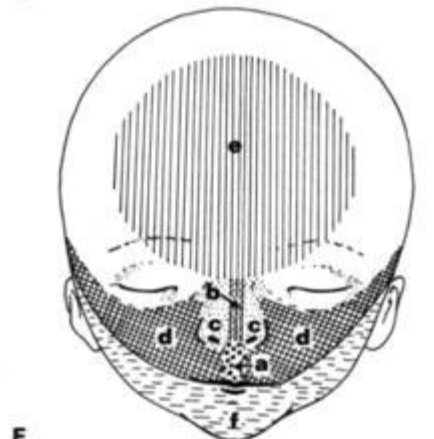
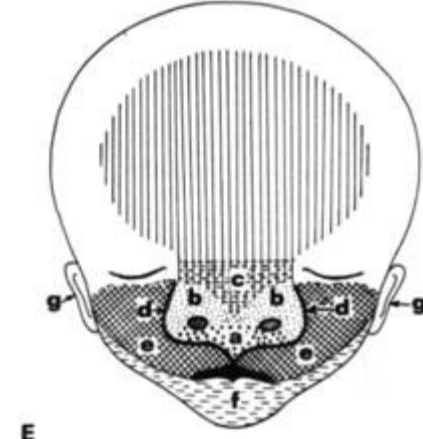
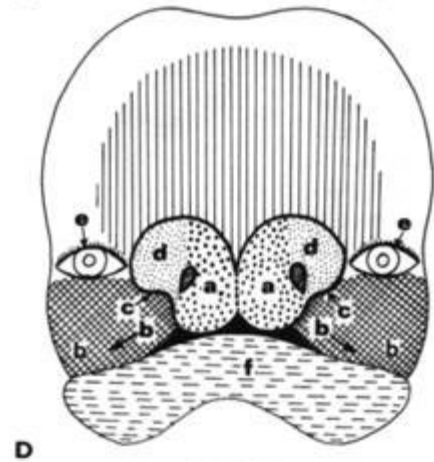
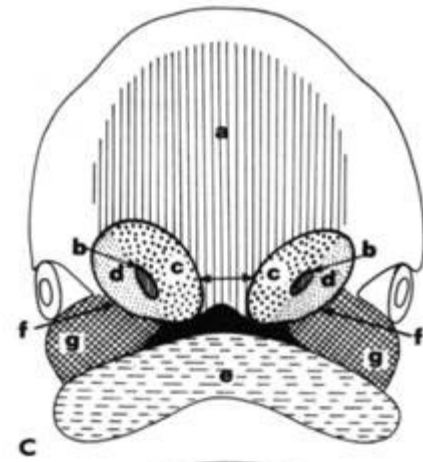
Nasal placodes

Nasal pits

Nasal canals



Proc. nasalis
medialis
et
lateralis

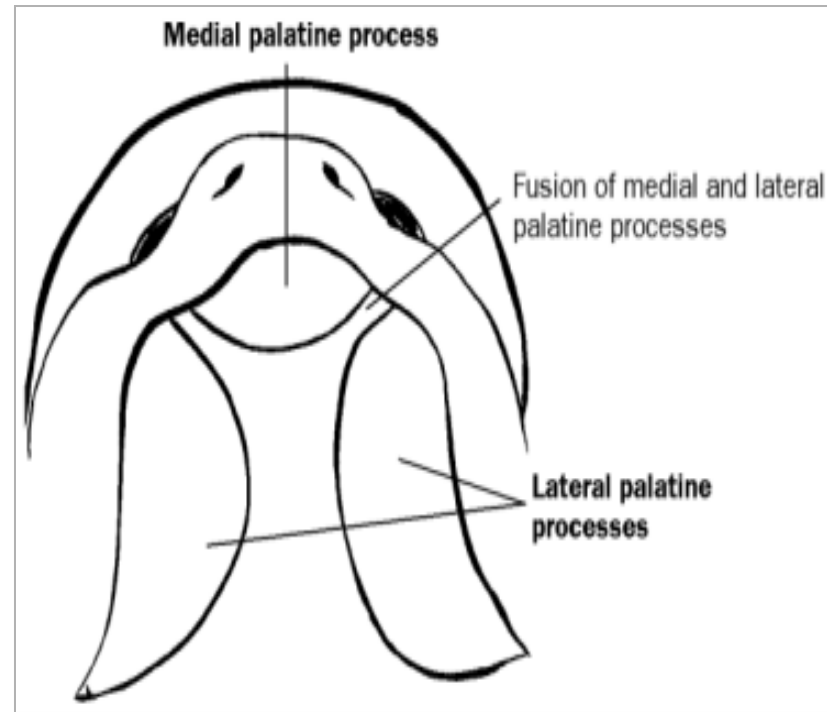


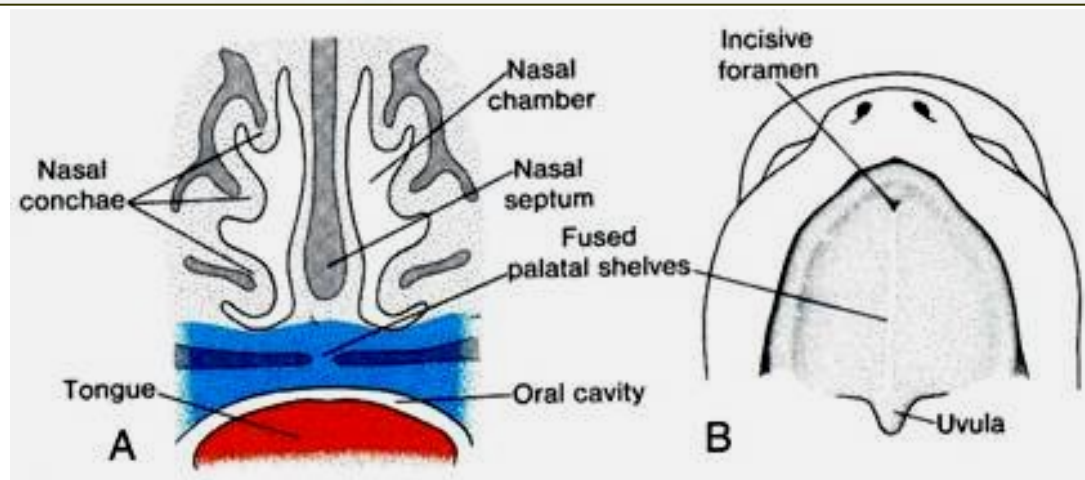
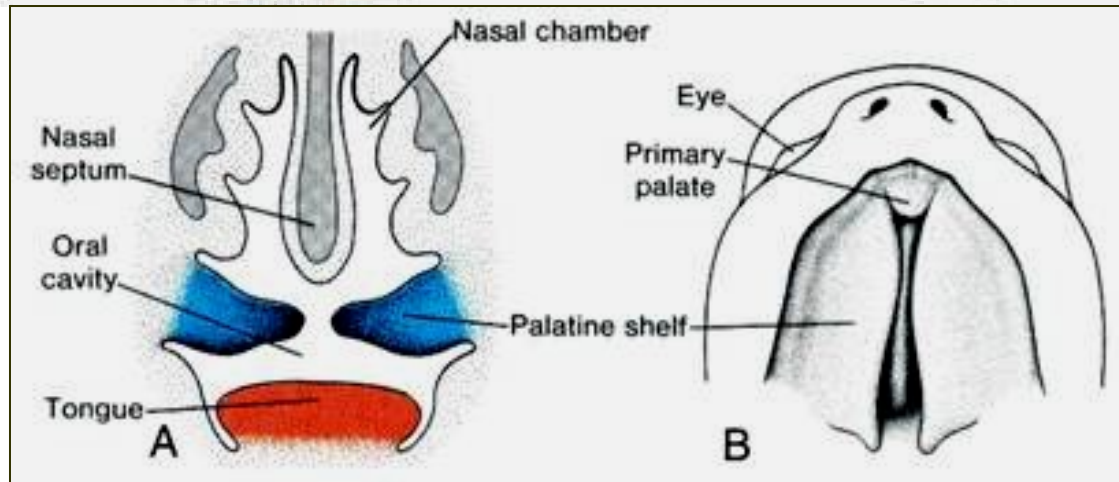
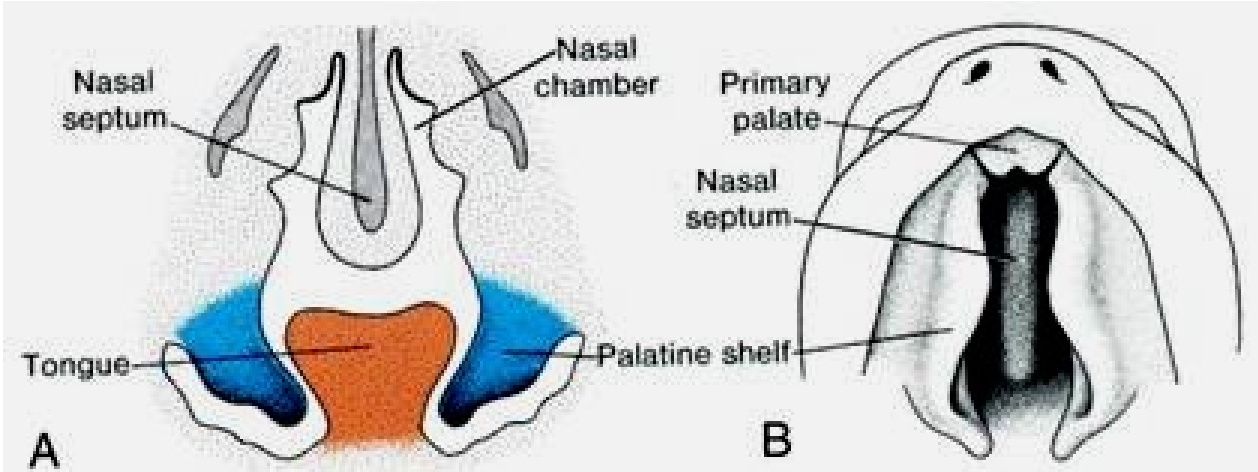
Palate development

3 ectoderm-mezenchymal plates:

- a) **medial palatine plate (1)** – from processus nasalis medialis (intermaxillare) ⇒ primary palate
- b) **lateral palatine plates (2)** – from medial side of maxillary processes ⇒ secondary palate

Fusion of plates = raphe palati





Clefts of maxilla and palate

Maxilla

Cleft between lateral incisivus and caninus

Uni- or bilateral

(cheilognathoschisis unilateralis, cheilognathoschisis bilateralis)

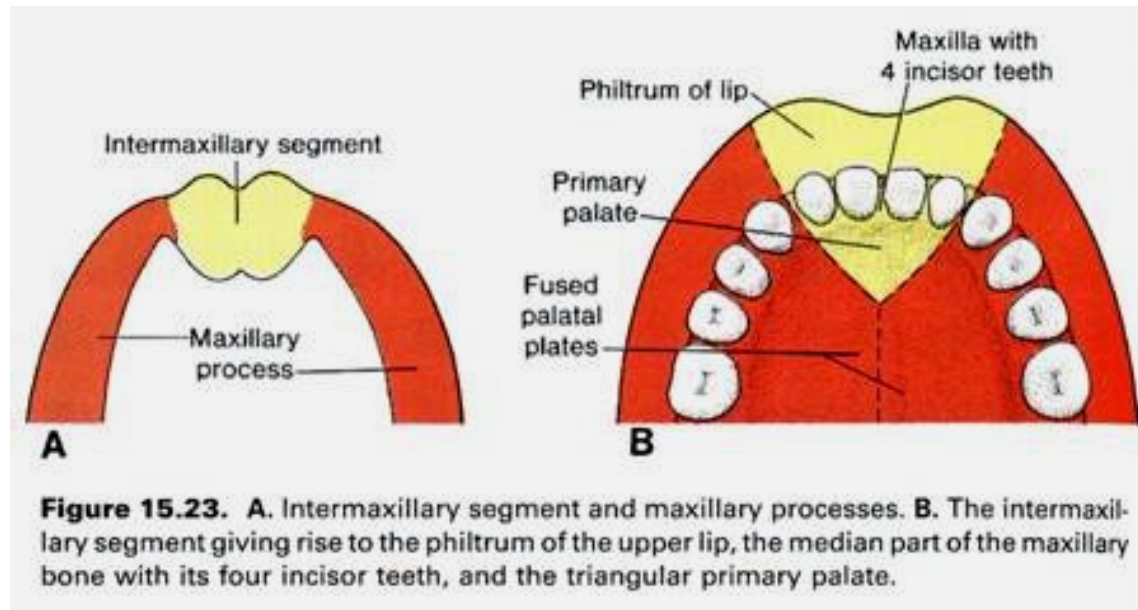
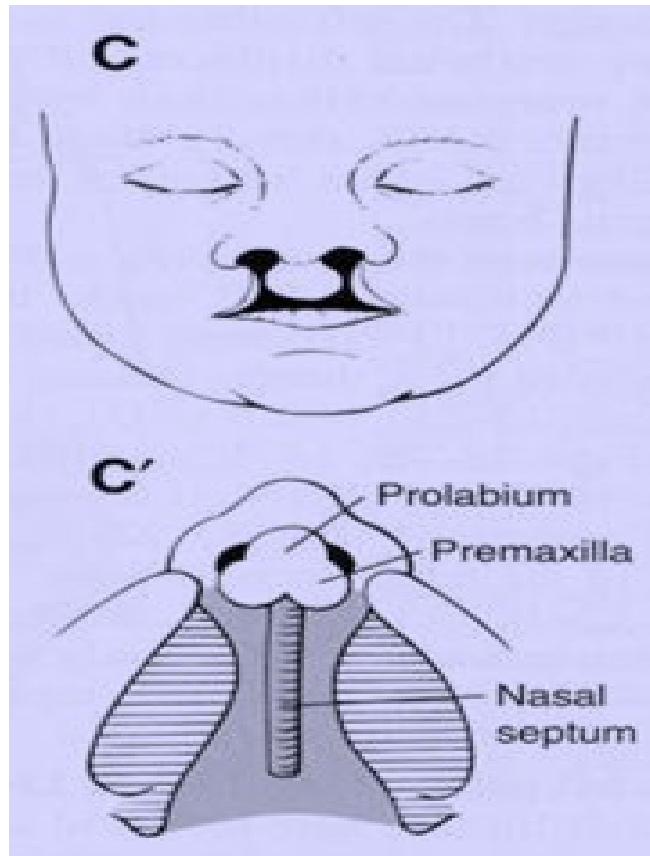


Figure 15.23. A. Intermaxillary segment and maxillary processes. B. The intermaxillary segment giving rise to the philtrum of the upper lip, the median part of the maxillary bone with its four incisor teeth, and the triangular primary palate.

Palate

Uni- or bilateral

Single or combined (cheilo – gnatho – palatoschisis)

1: 2500

heredity- autosomal dominant

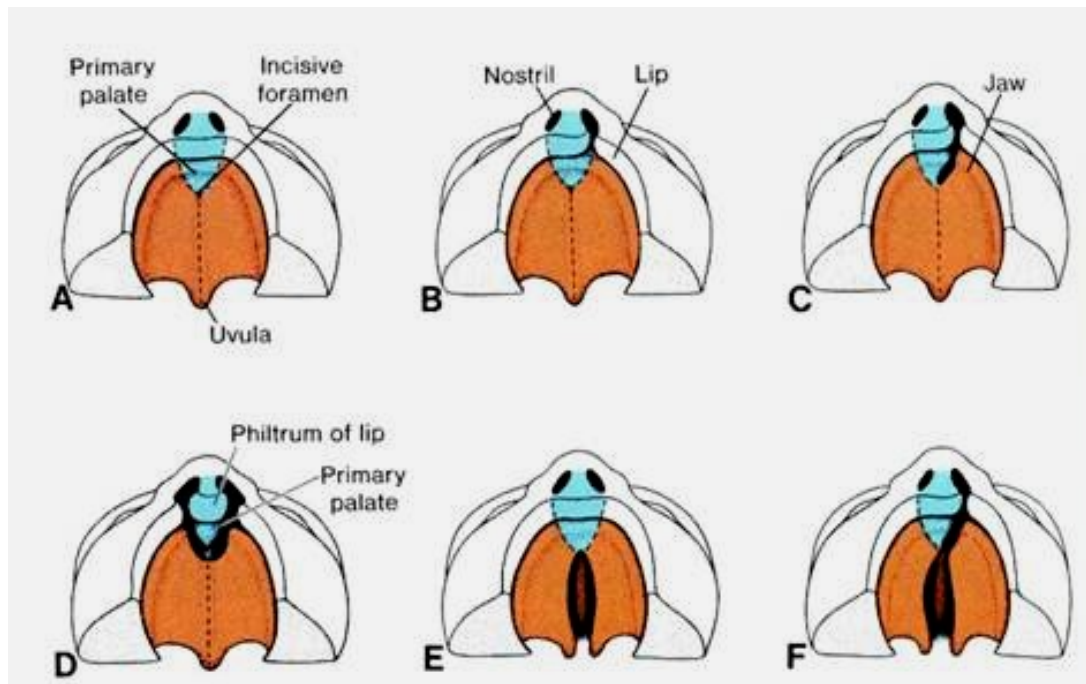
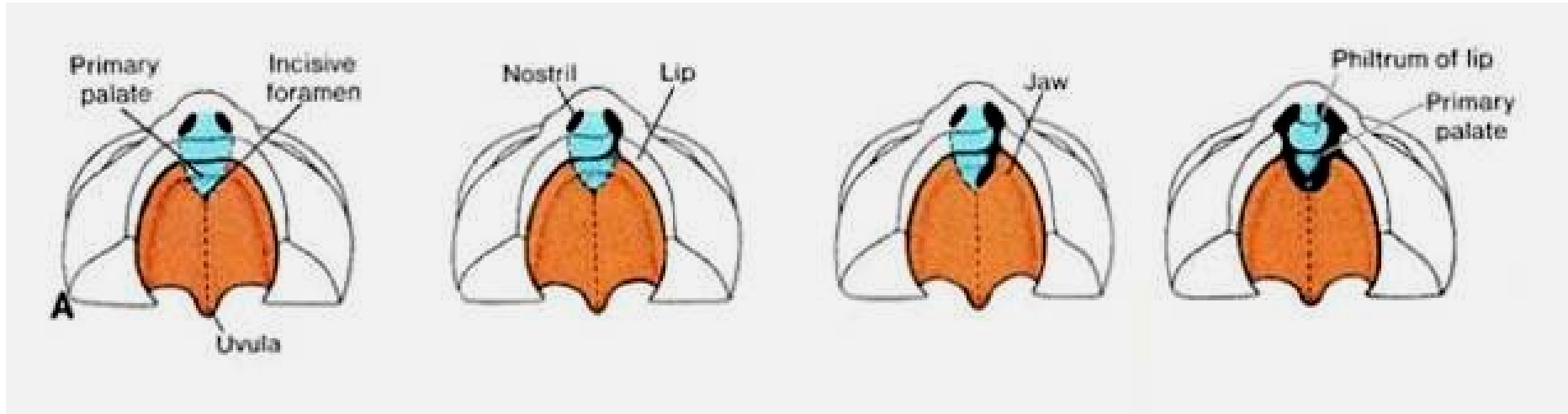


Figure 15.27. Ventral view of the palate, gum, lip, and nose. **A.** Normal. **B.** Unilateral cleft lip extending into the nose. **C.** Unilateral cleft involving the lip and jaw and extending to the incisive foramen. **D.** Bilateral cleft involving the lip and jaw. **E.** Isolated cleft palate. **F.** Cleft palate combined with unilateral anterior cleft lip.

Clefts of primary palate

Ventrally from foramen incisivum

One or both lateral plates don't fuse with primary palate

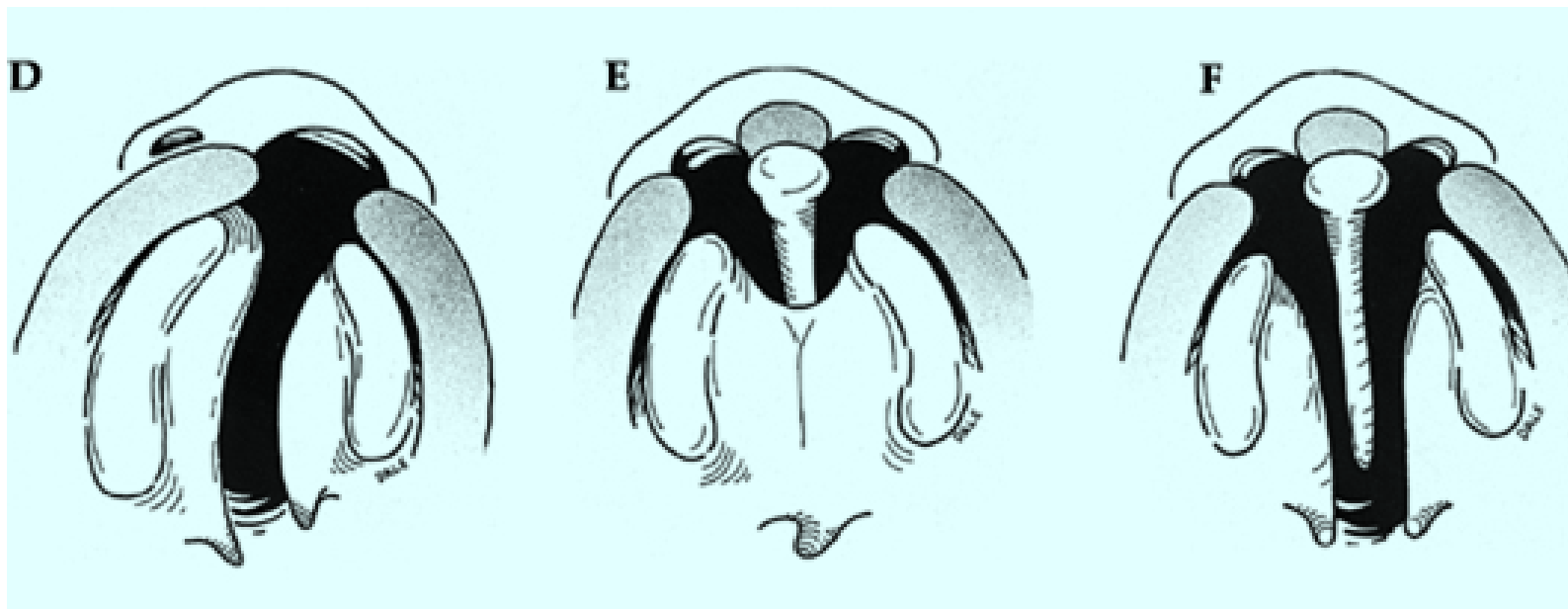
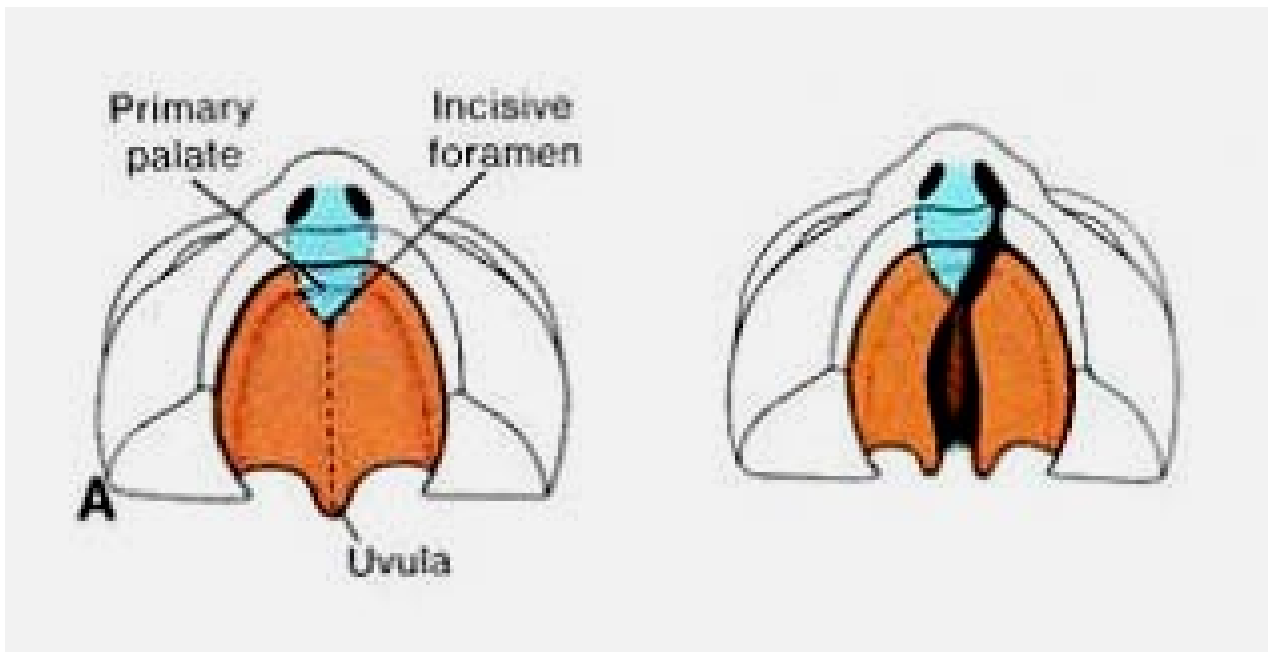


Clefts of secondary and primary palates

Ventrally and dorsally from foramen incisivum

Lateral palatine plates are not fused with primary palate

Nasal septum is free

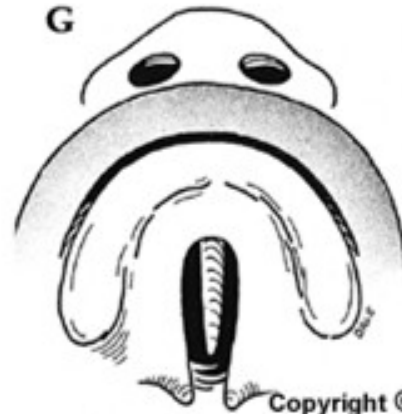


Clefts of secondary palate (palatoschisis)

behind foramen incisivum

Nonfused palatine plate in middle plane (completely – soft and hard palate and uvula)

staphyloschisis (uvula bifida)



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H – fissura orbitofacialis bilat.

Transverse clefts

J – macrostomia

K - microstomia

D



E



F



G



H



I

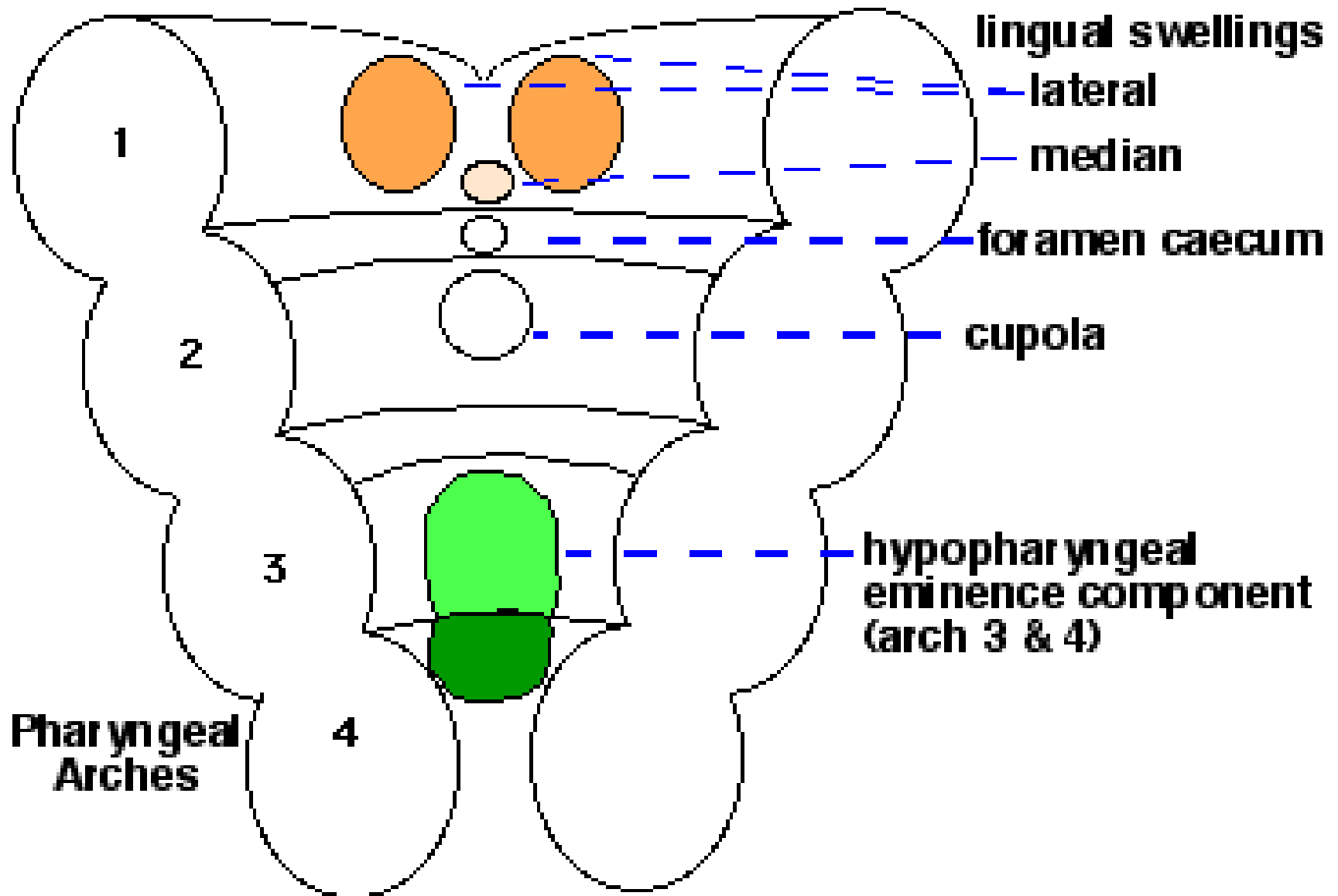


J

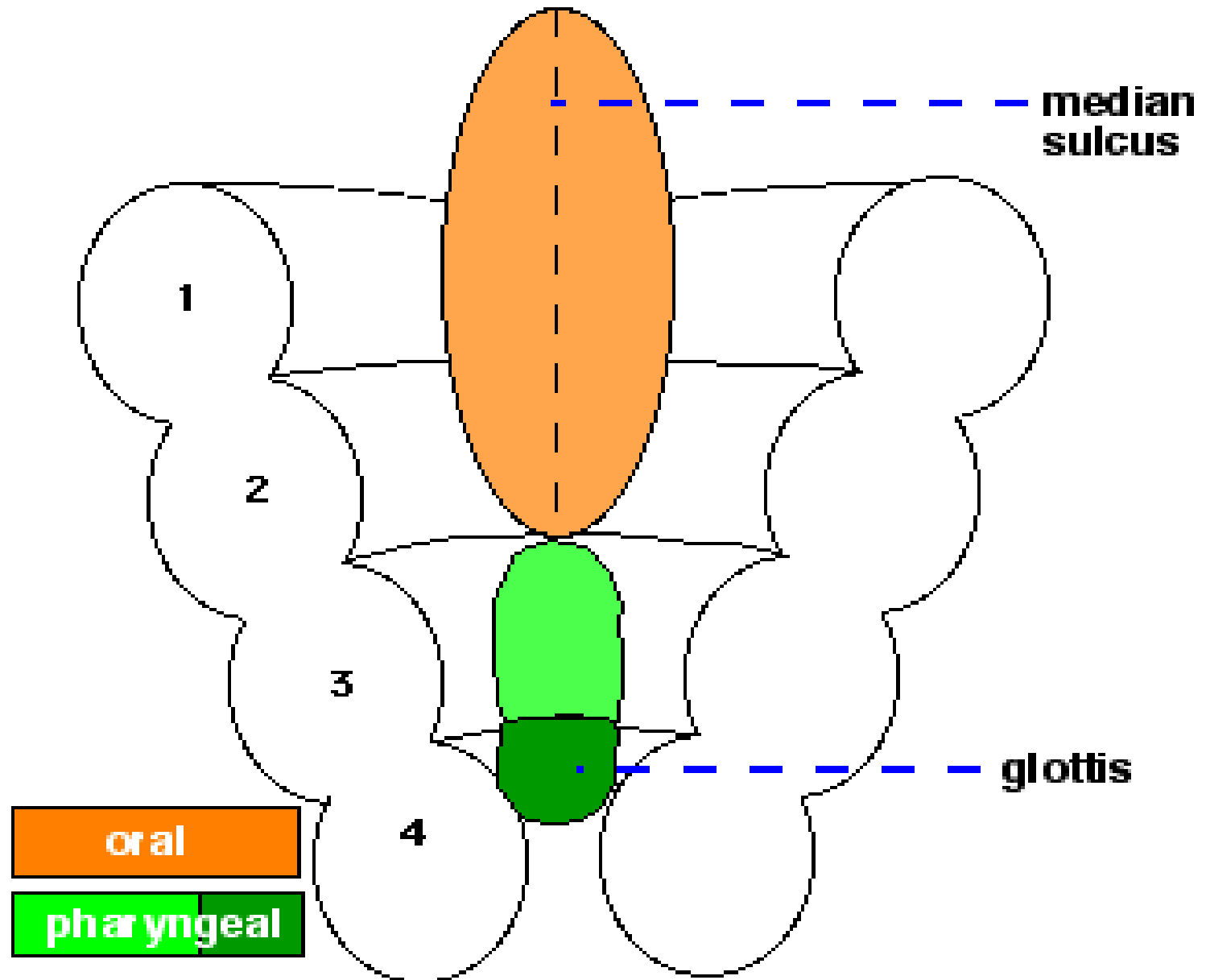
K

L

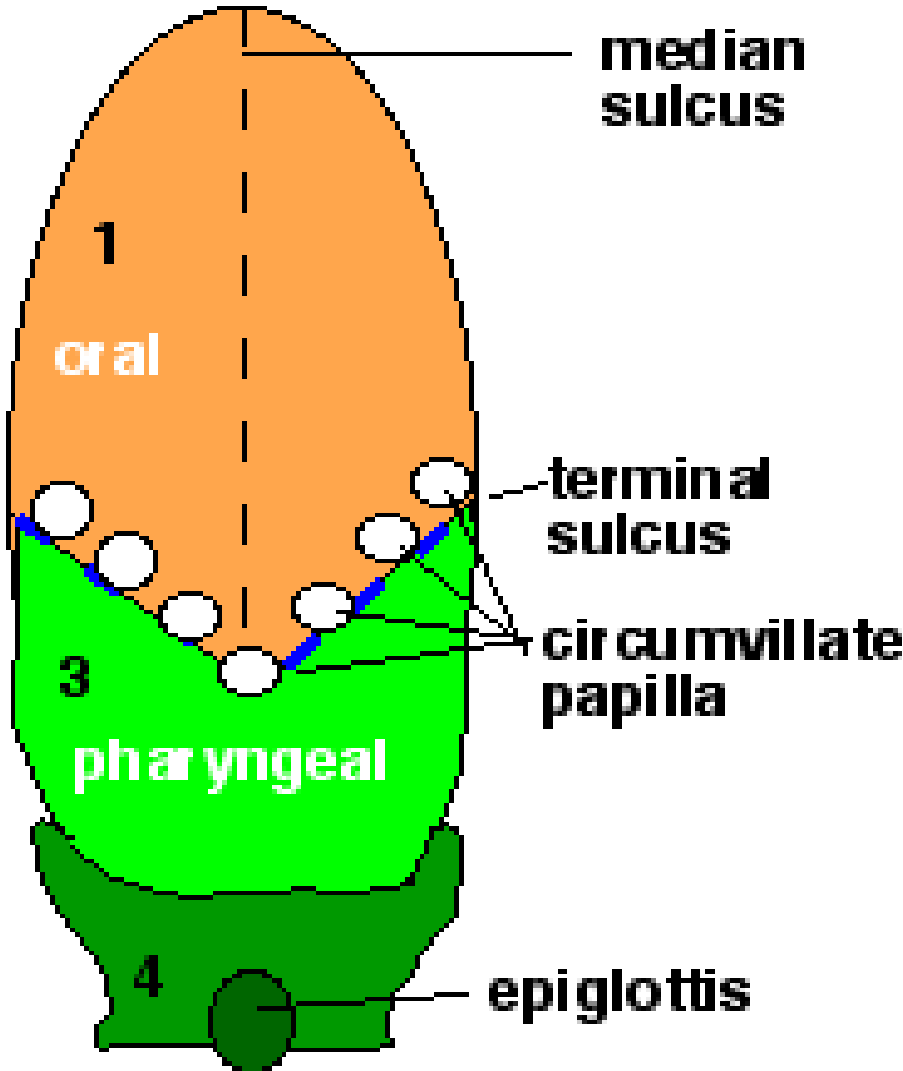
Development of the Tongue (part 1)



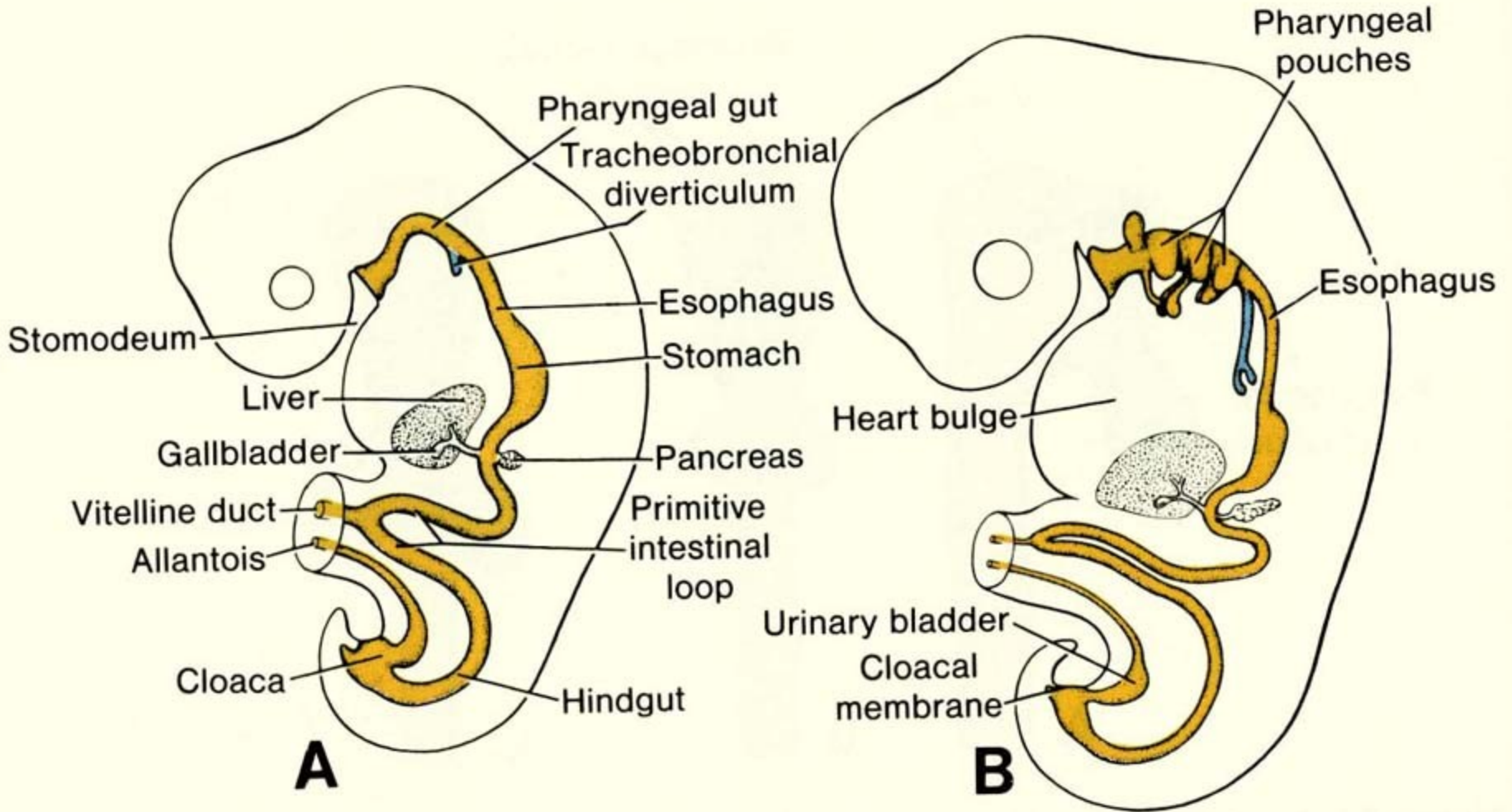
Development of the Tongue (part 2)

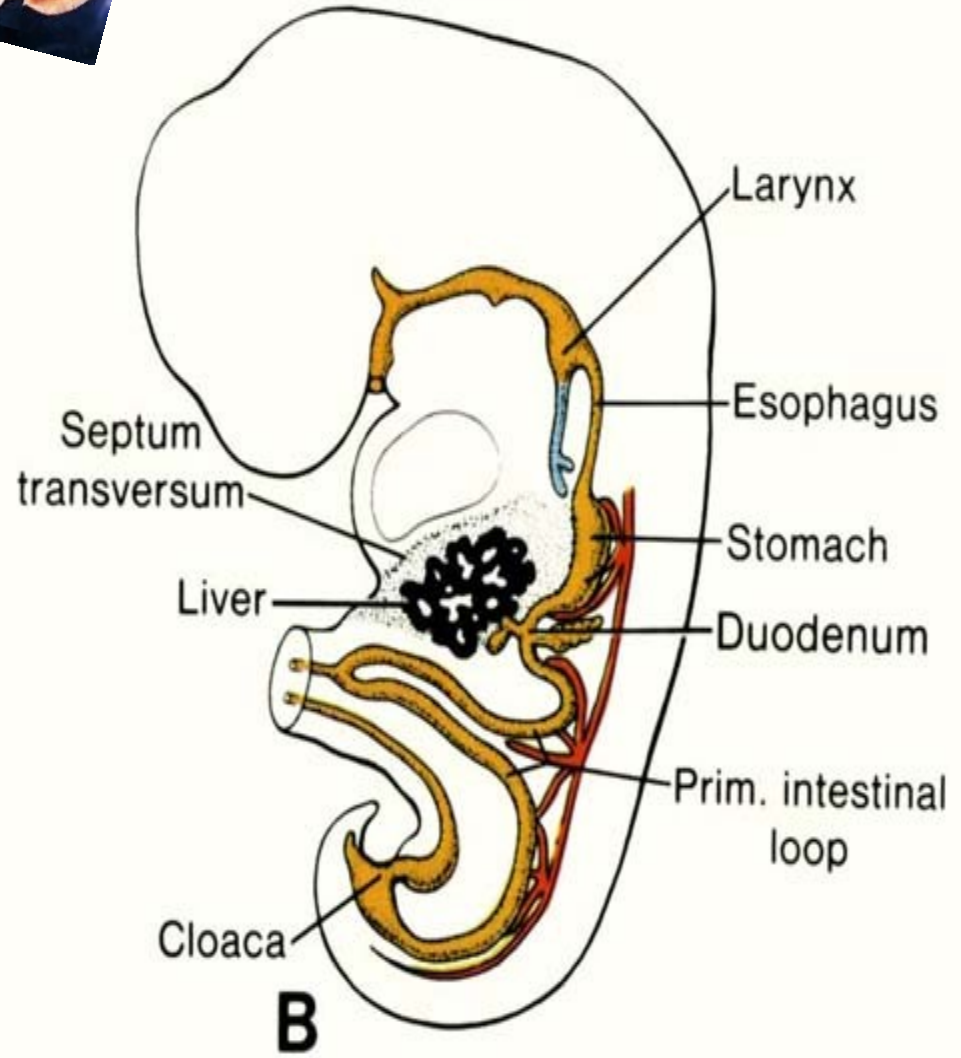
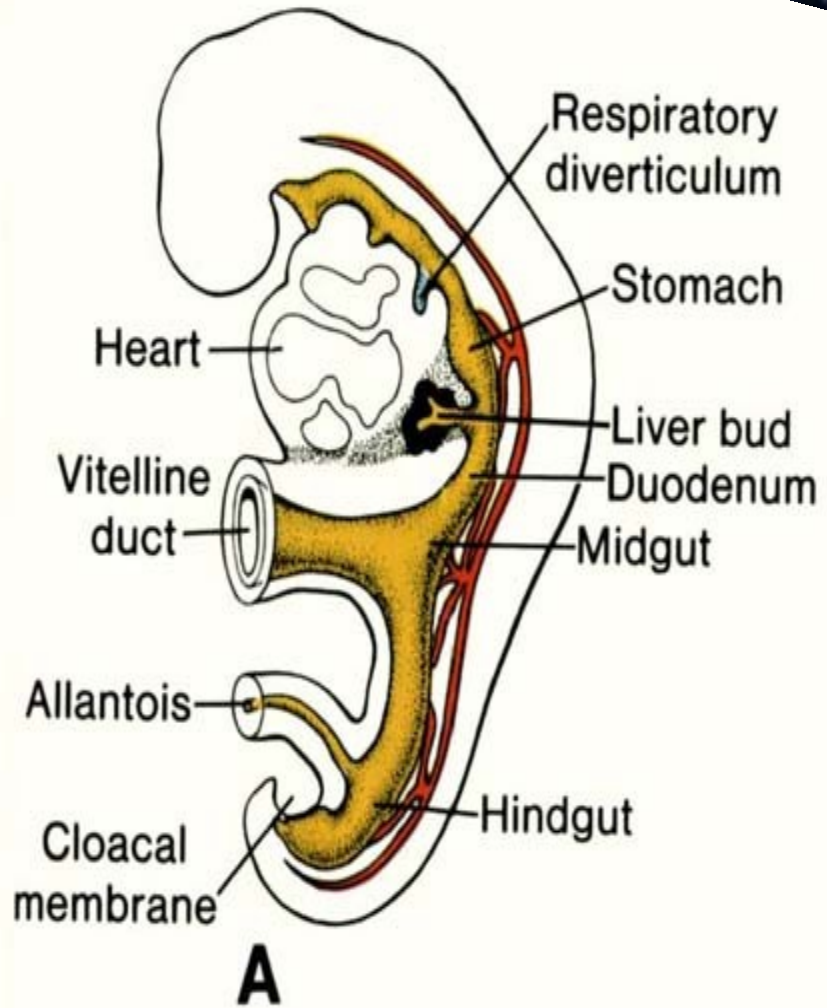


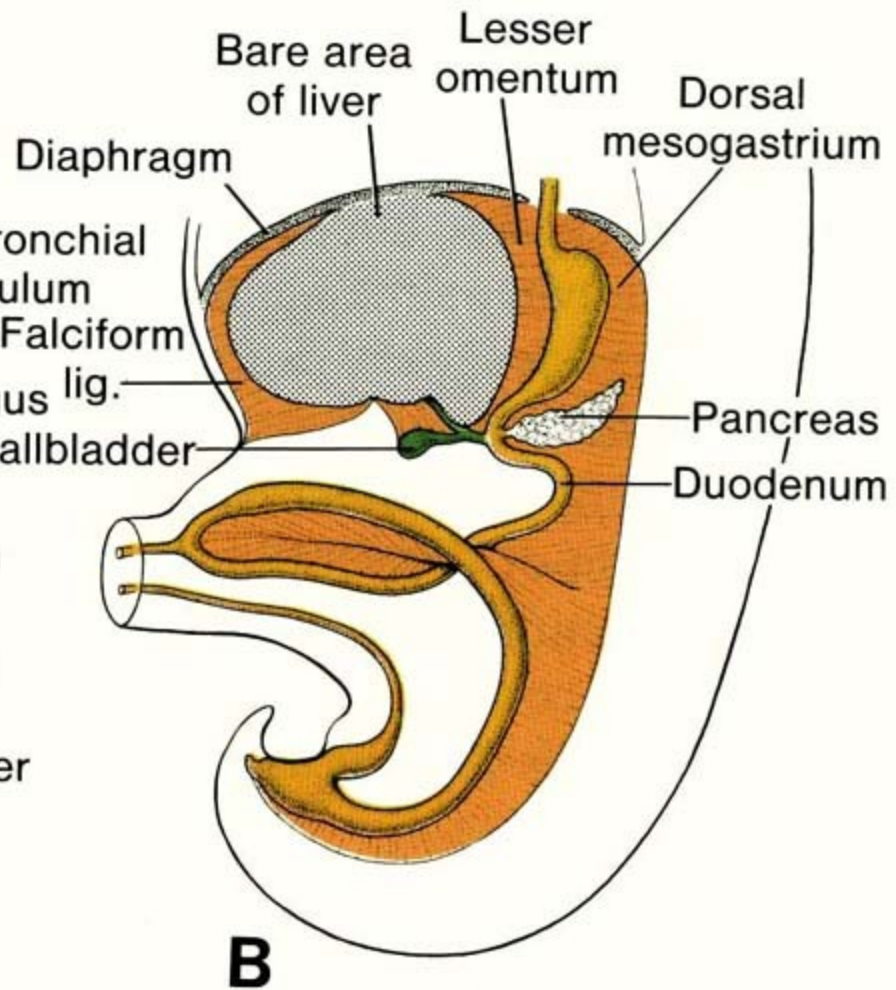
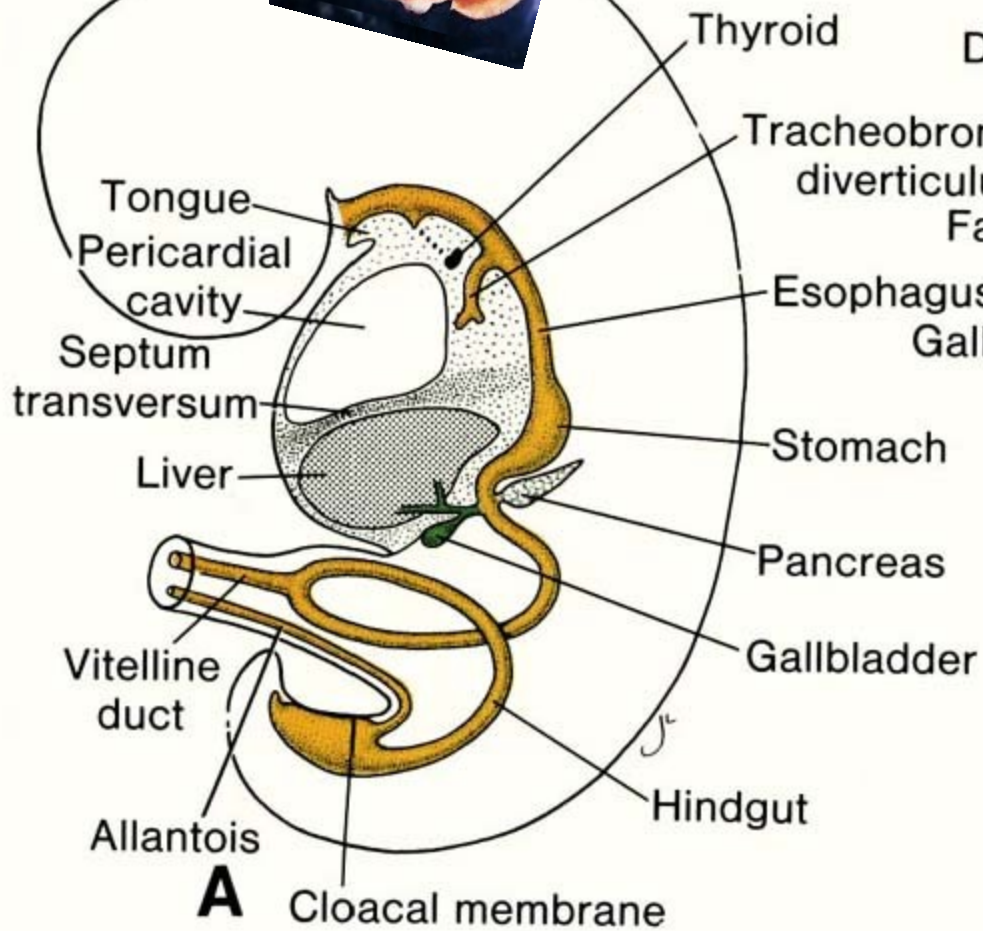
Development of the Tongue (part 3)

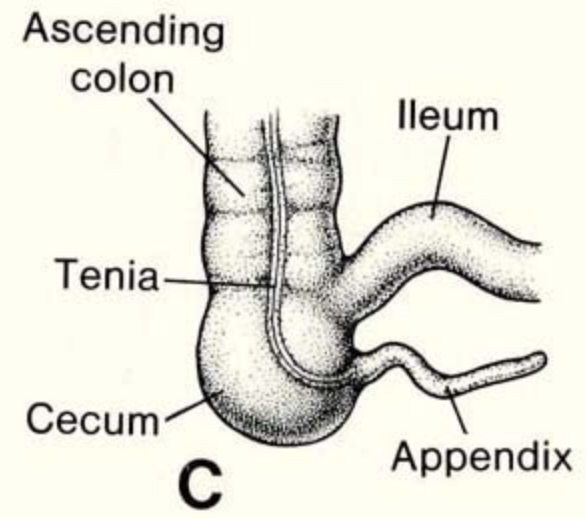
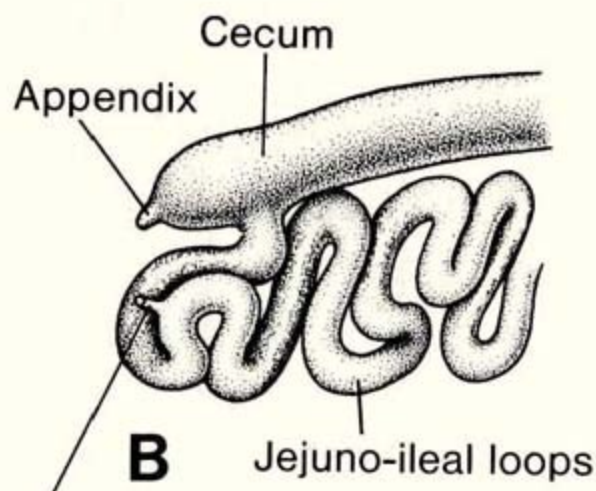
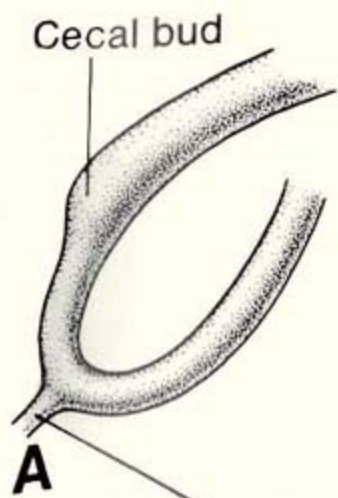




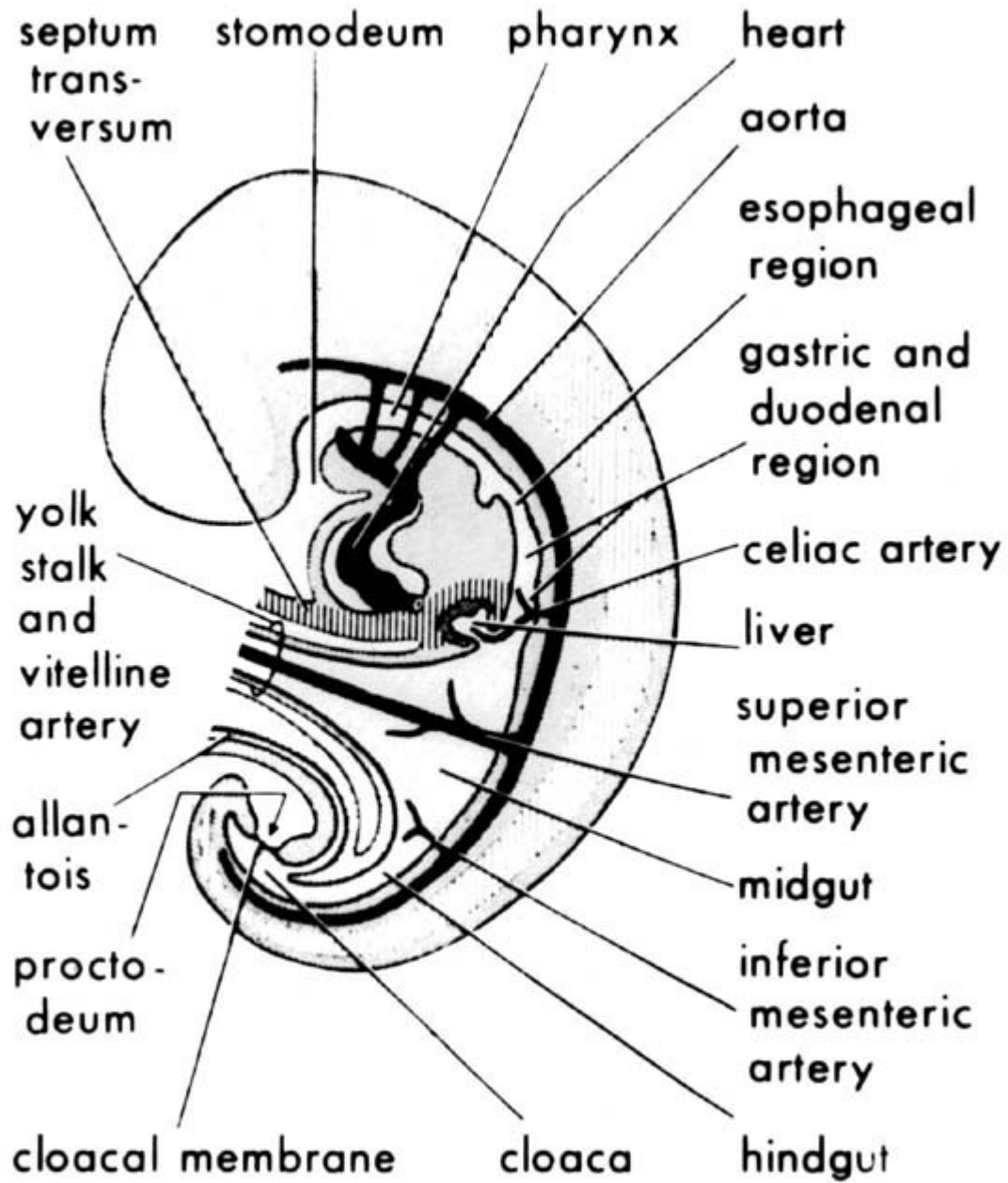


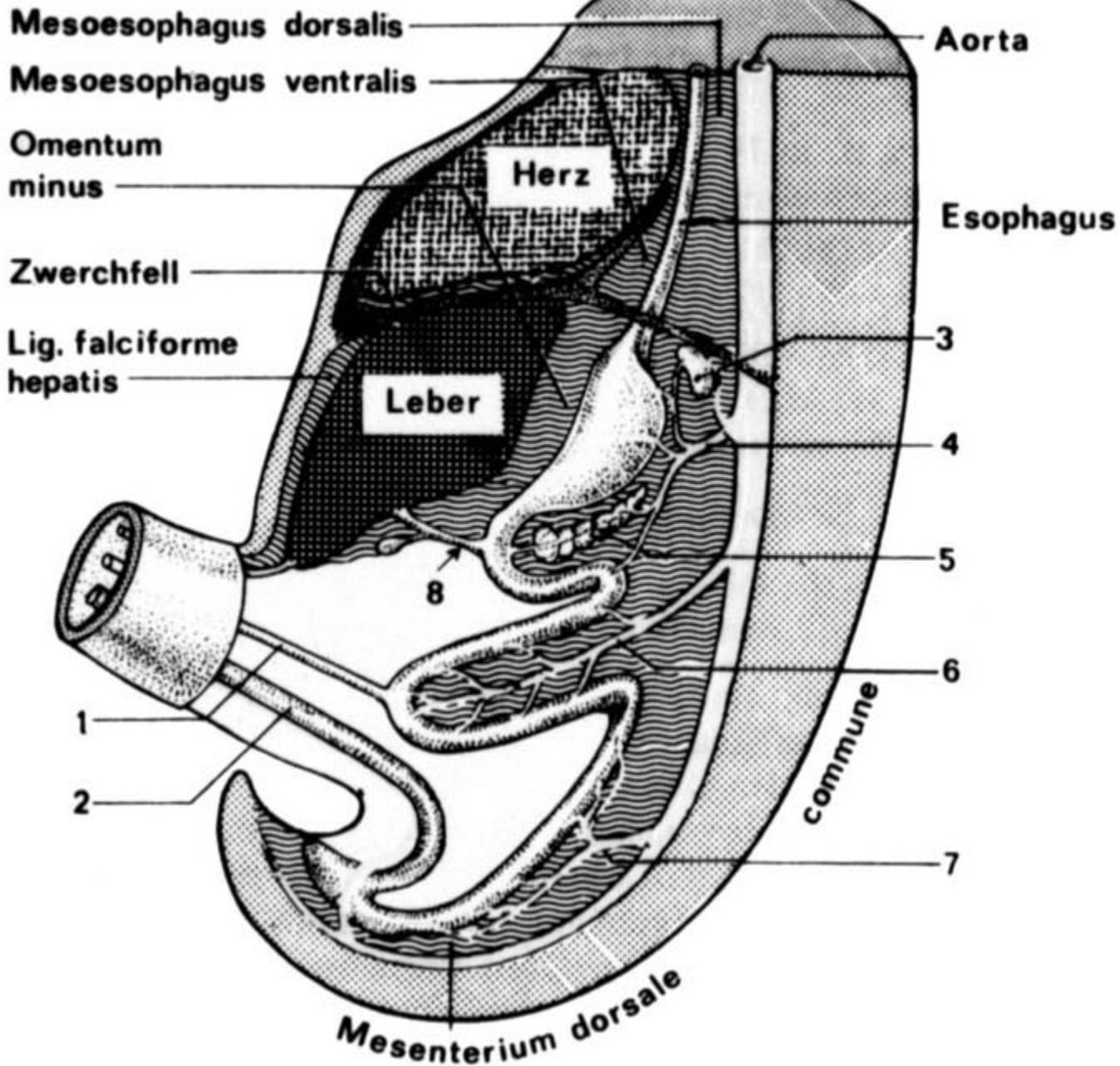


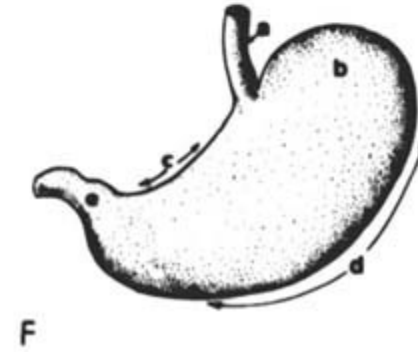
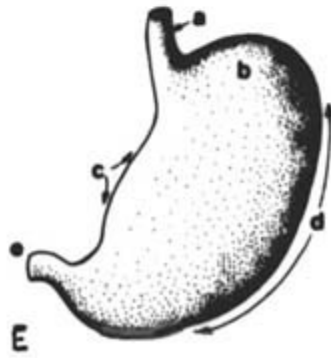
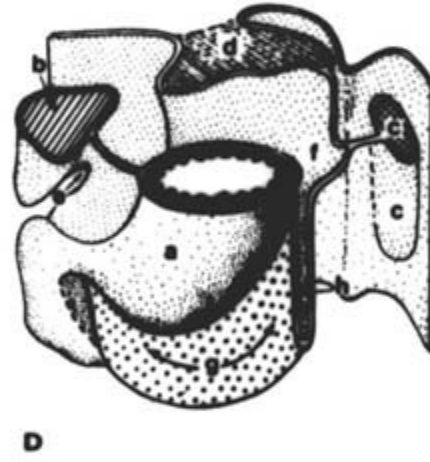
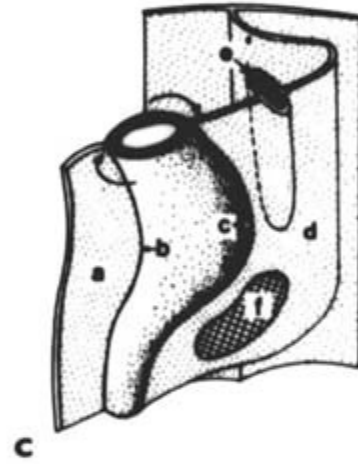
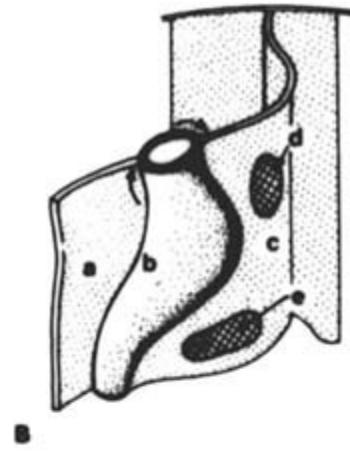
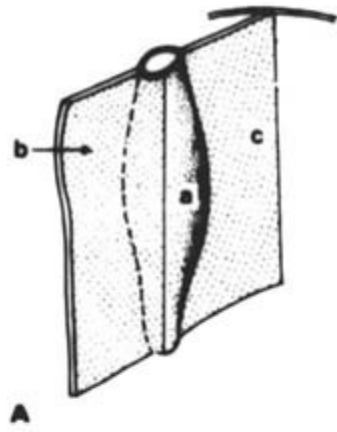


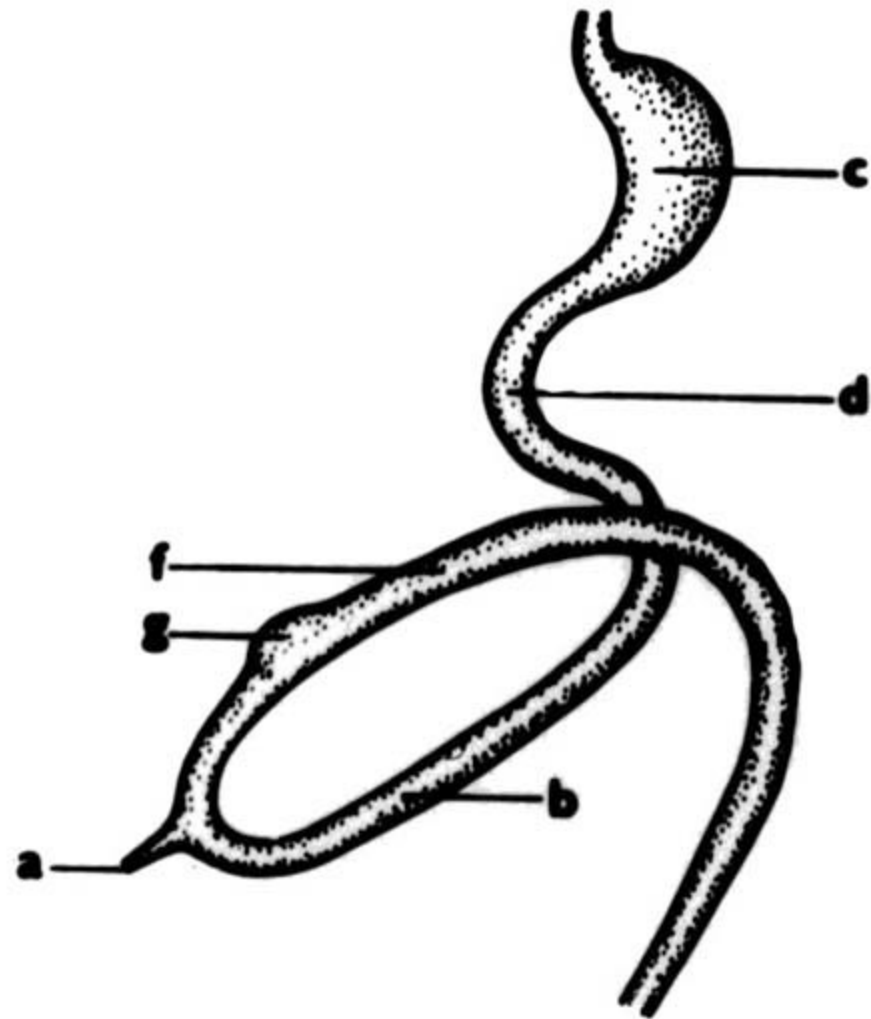
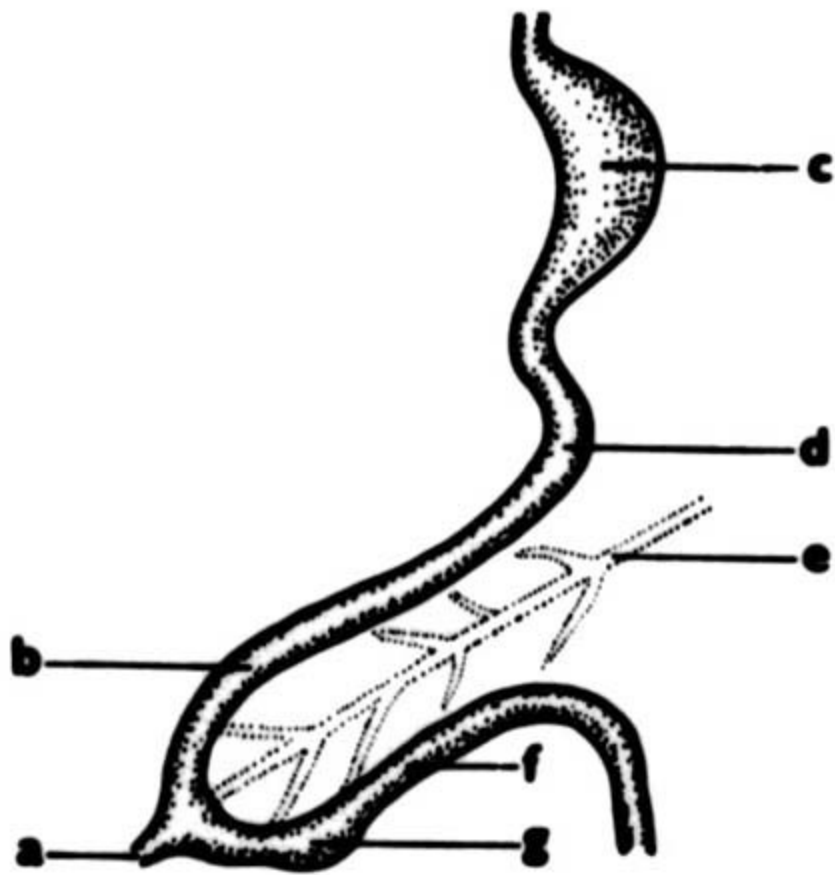


Vitelline duct

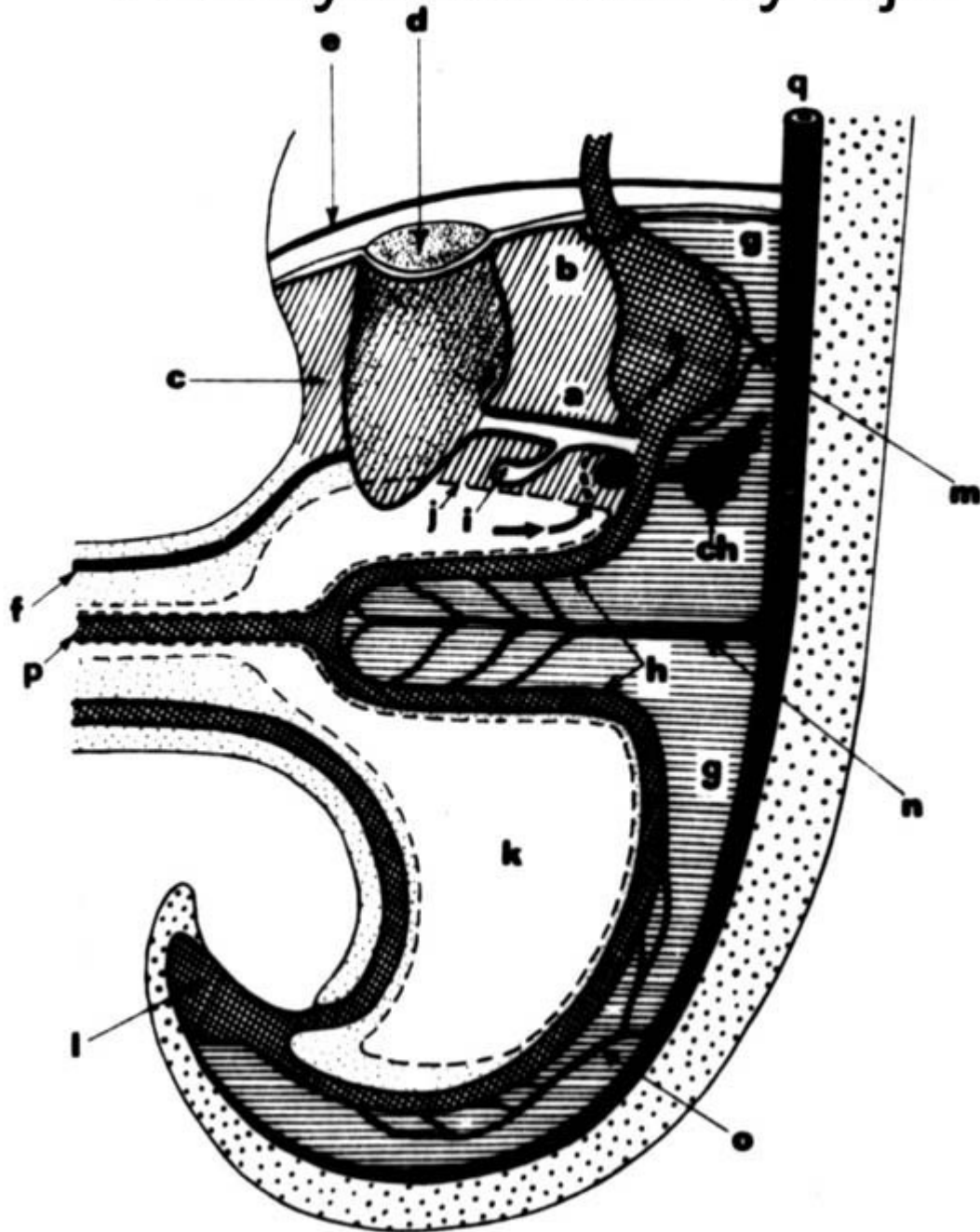








Embryo 33. den vývoje



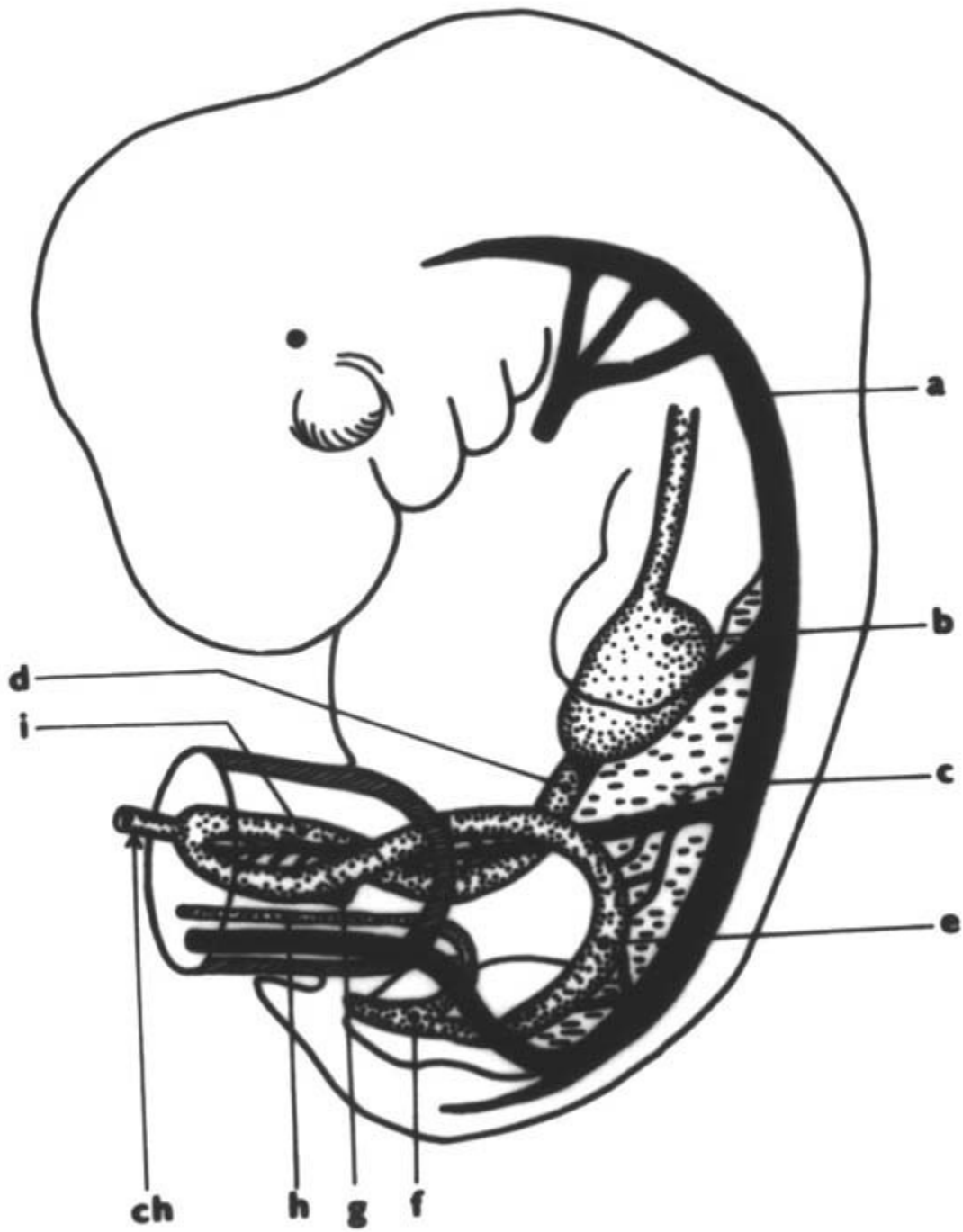
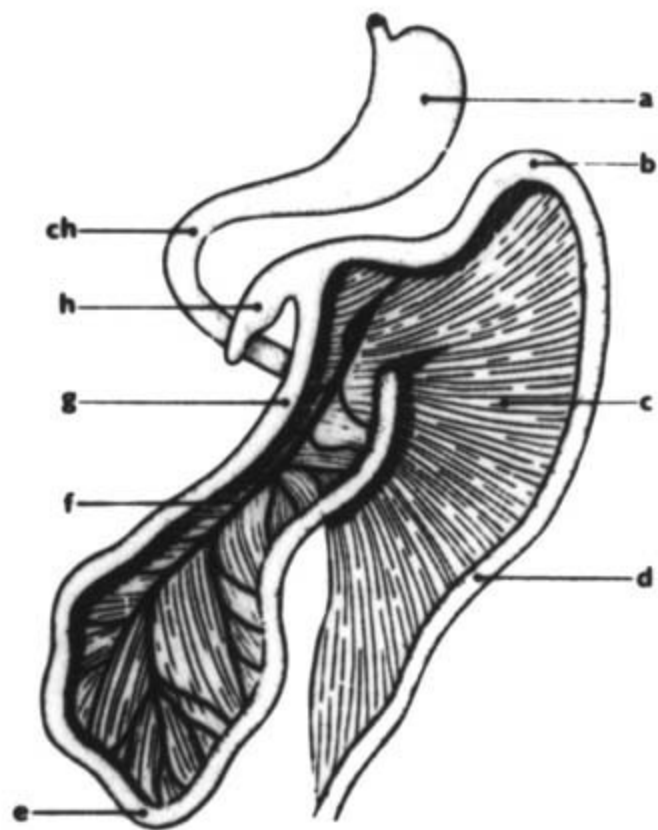
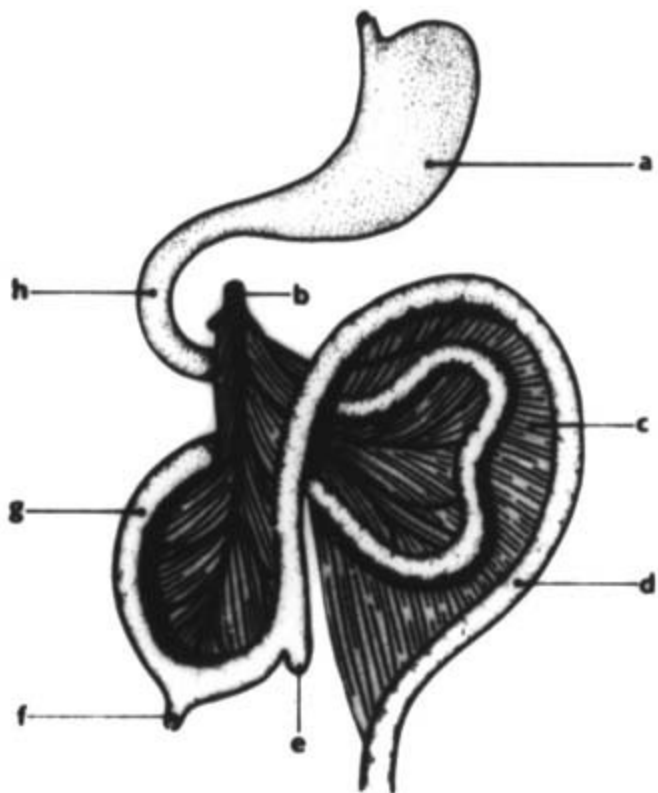
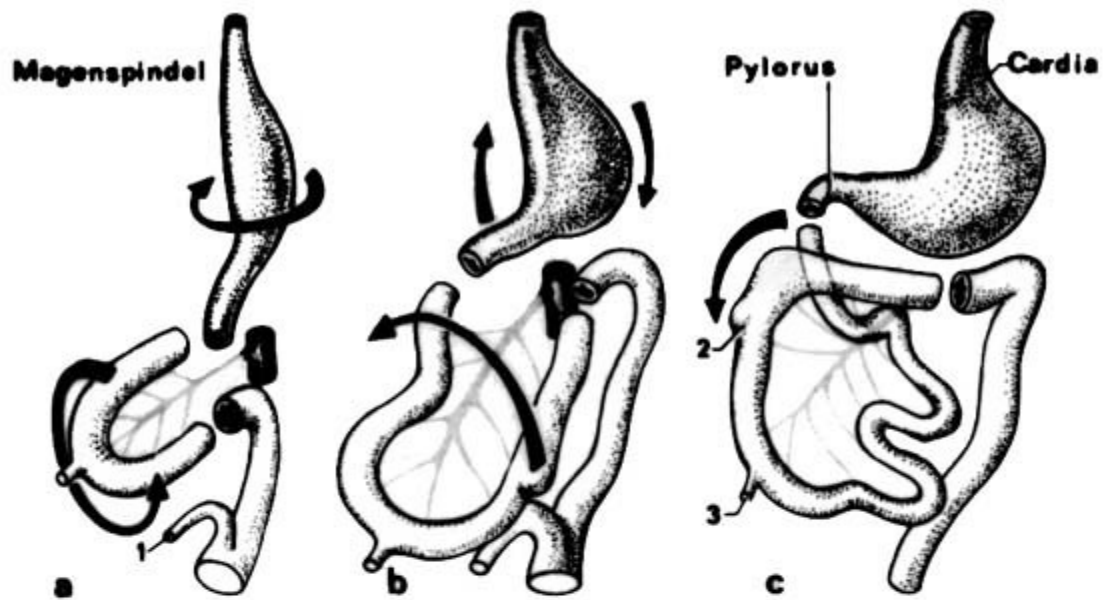
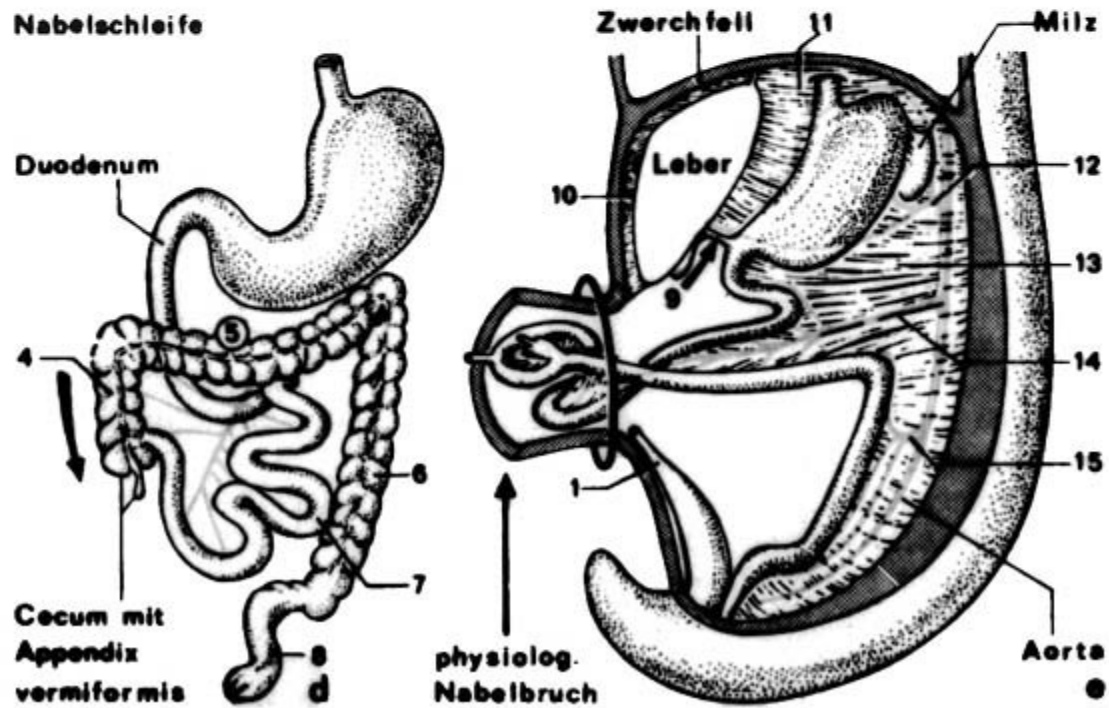


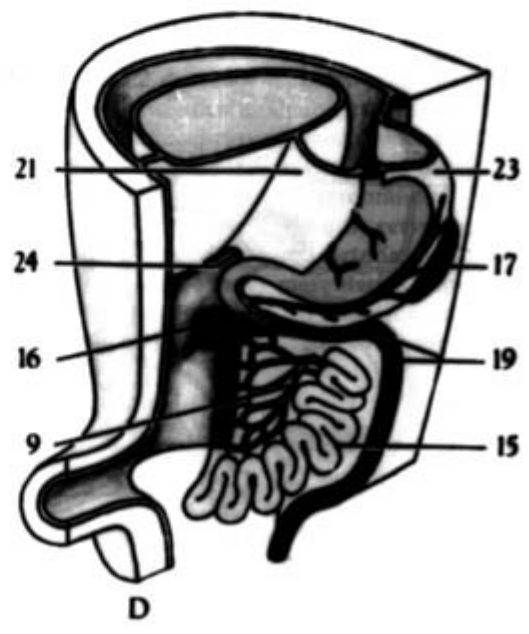
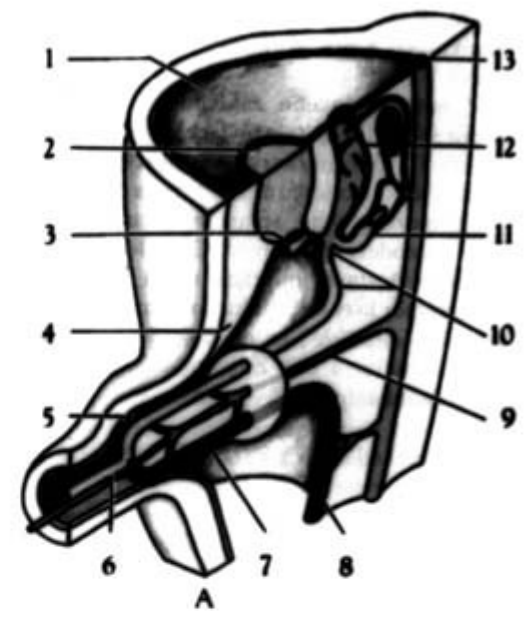
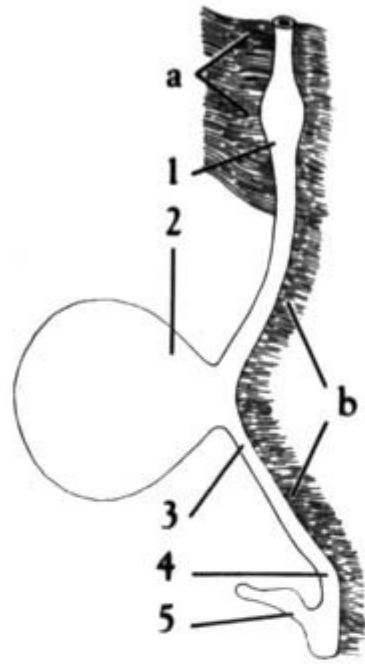
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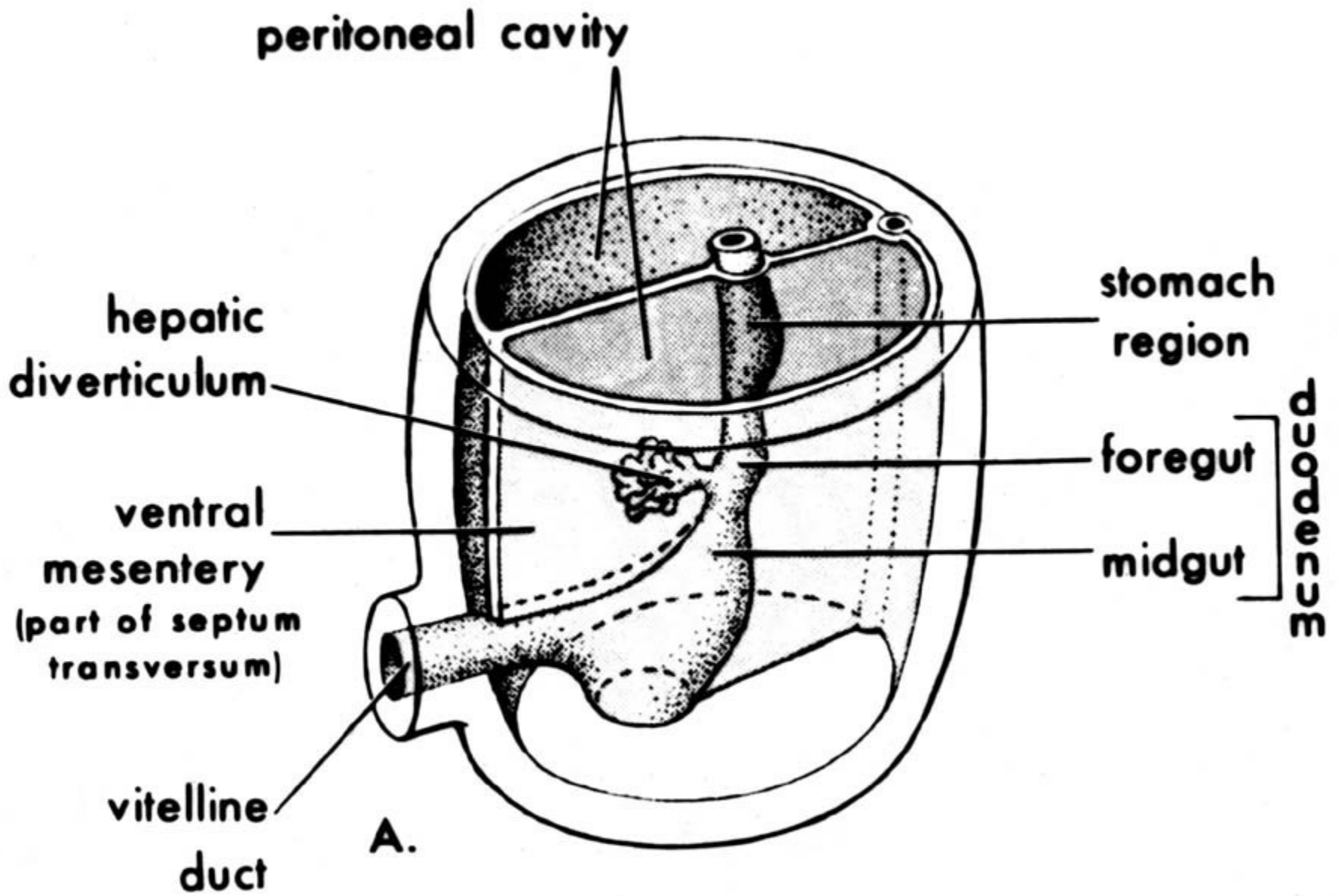


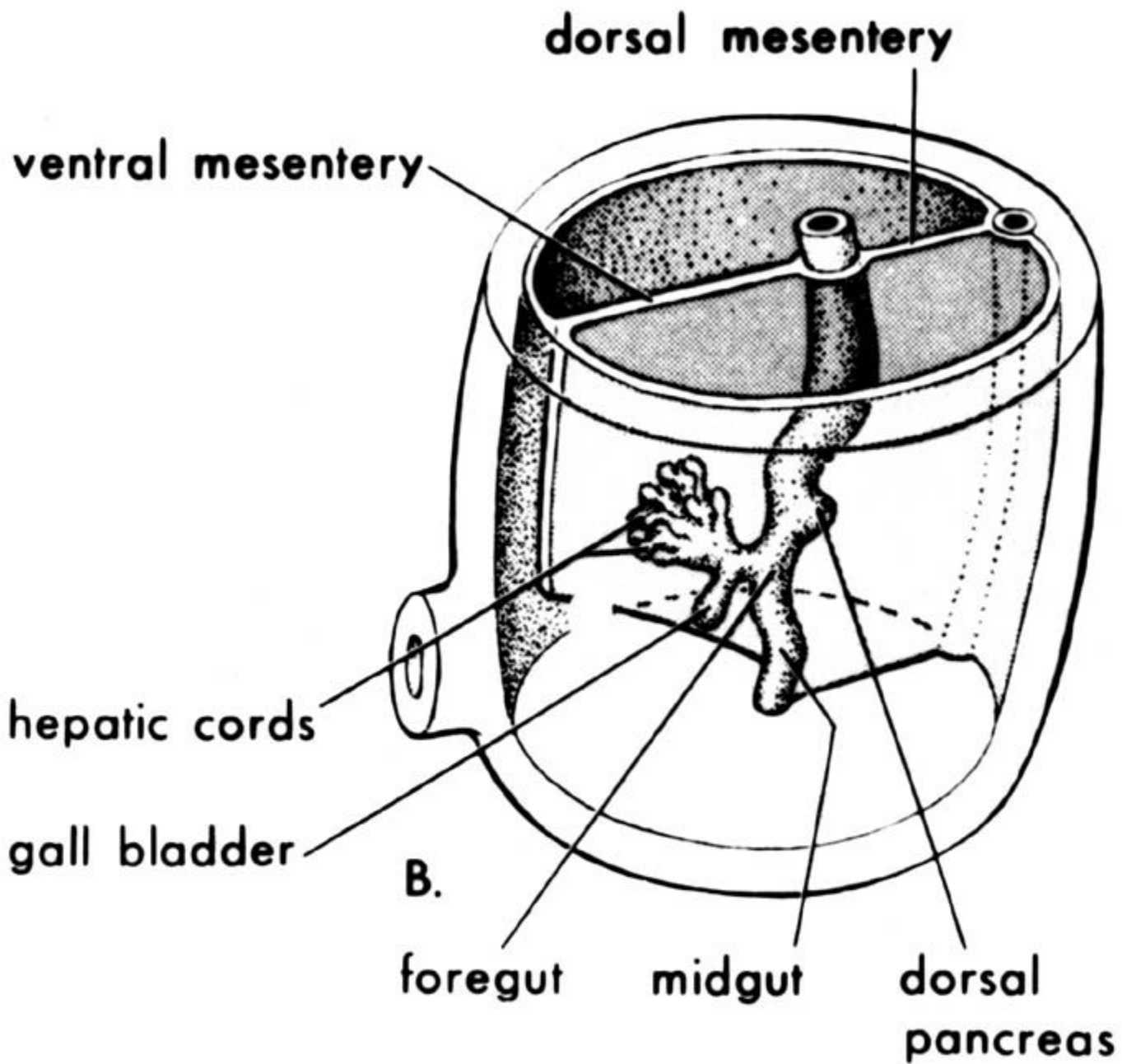


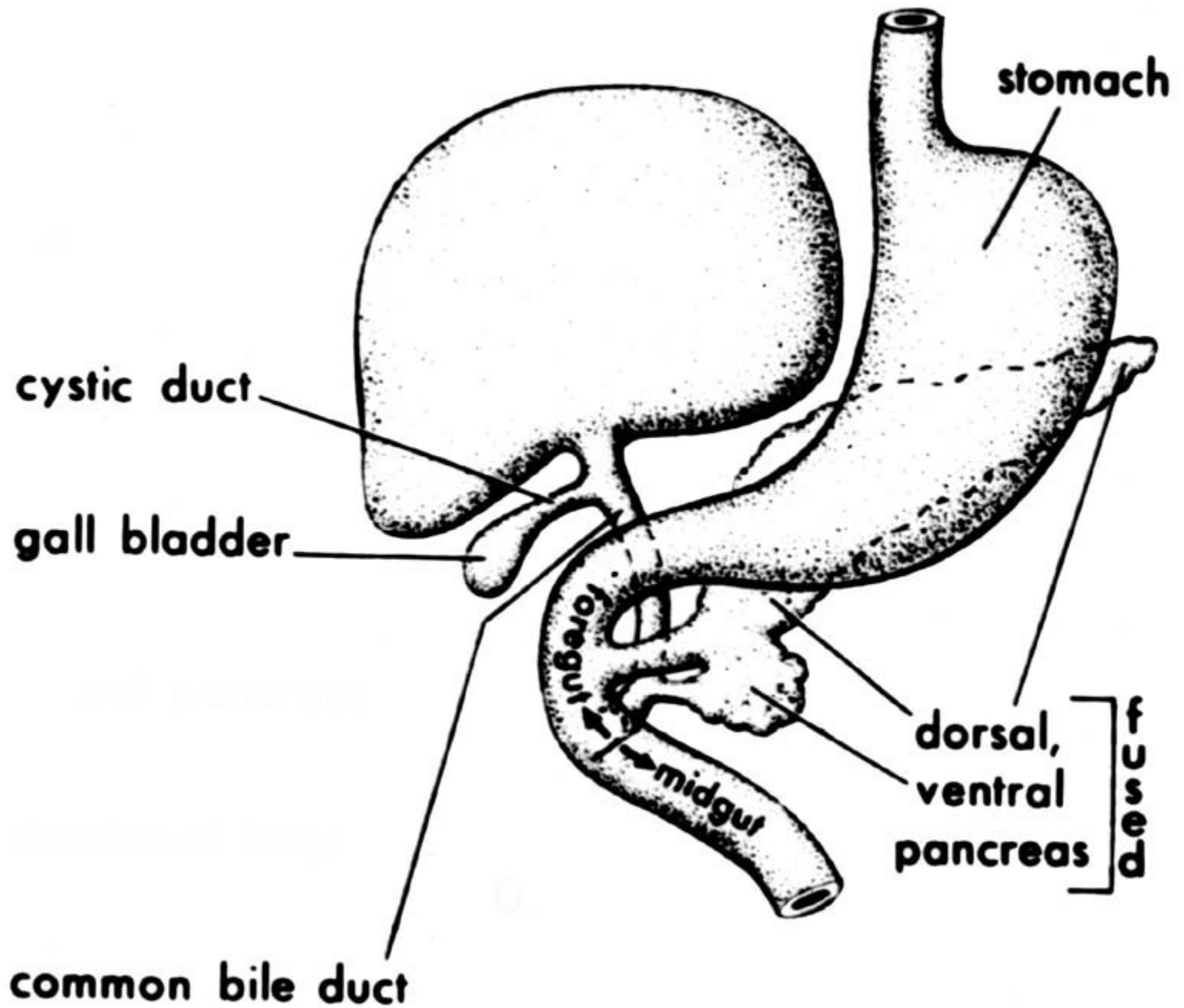
Nabelschleife









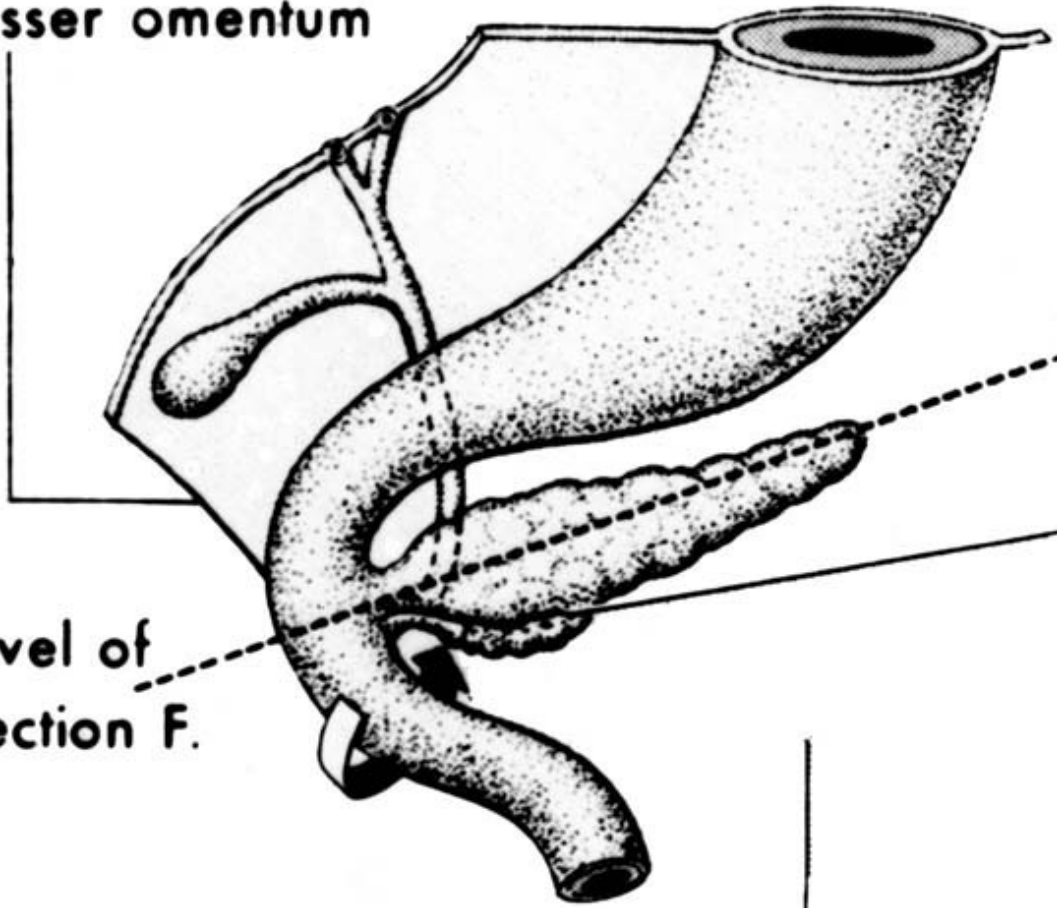


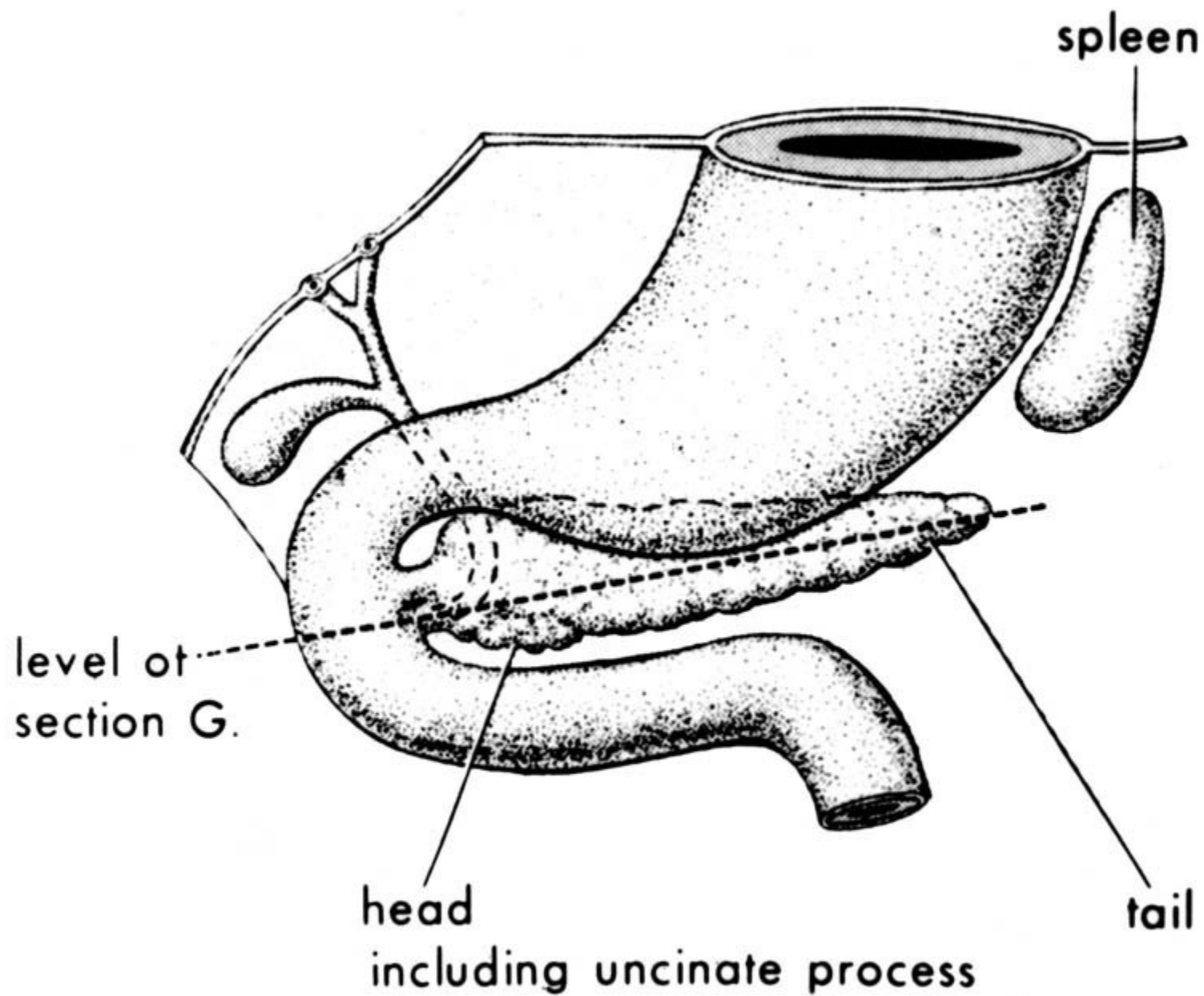
free edge of
lesser omentum

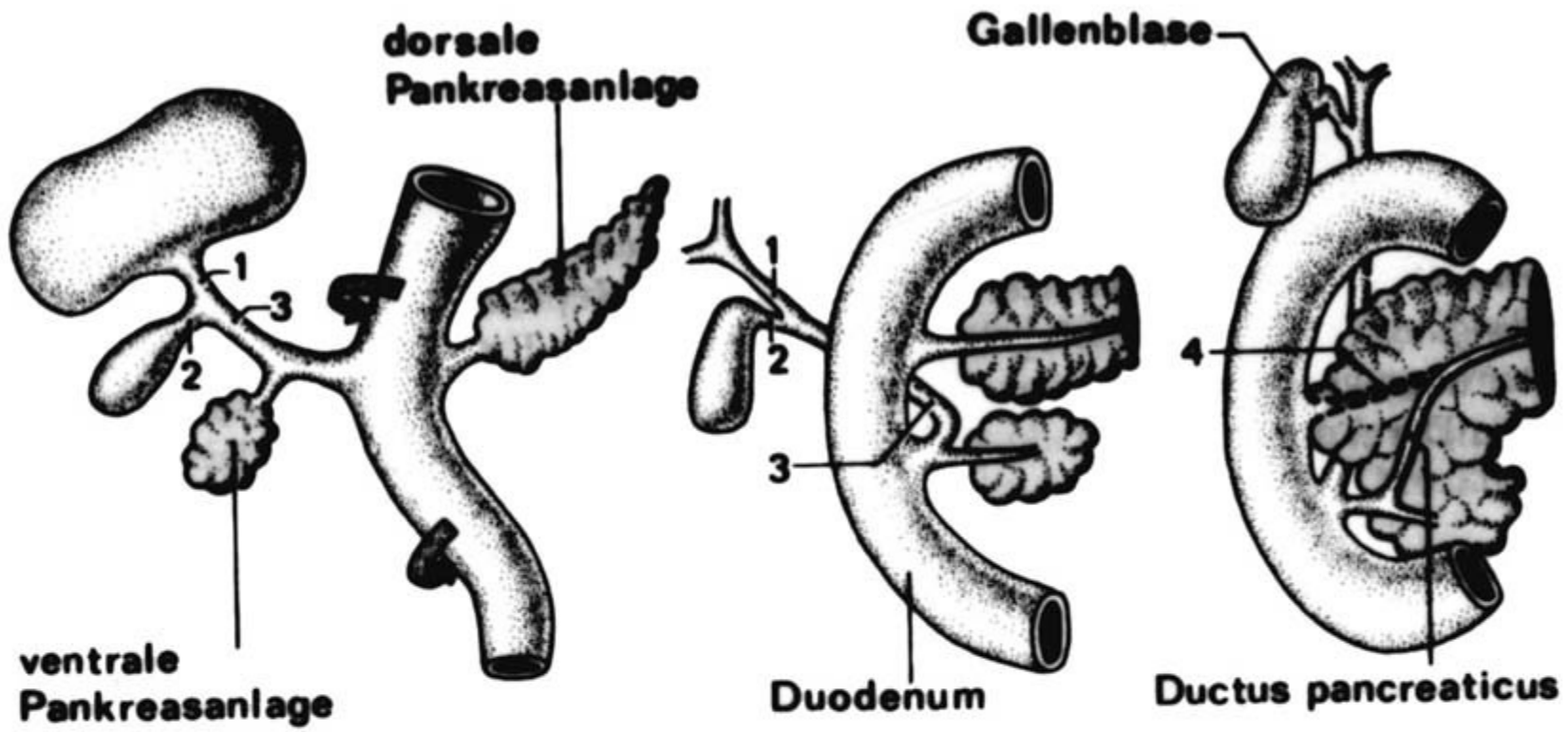
level of
section F.

fusion

dorsal mesentery







a

b

c

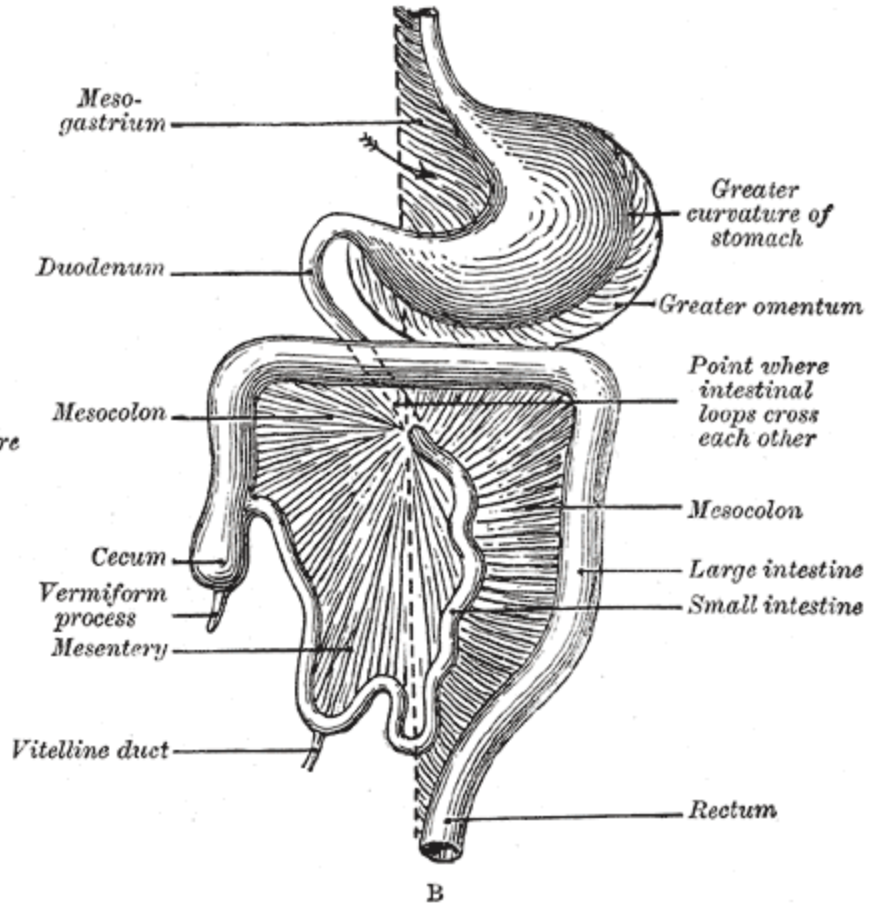
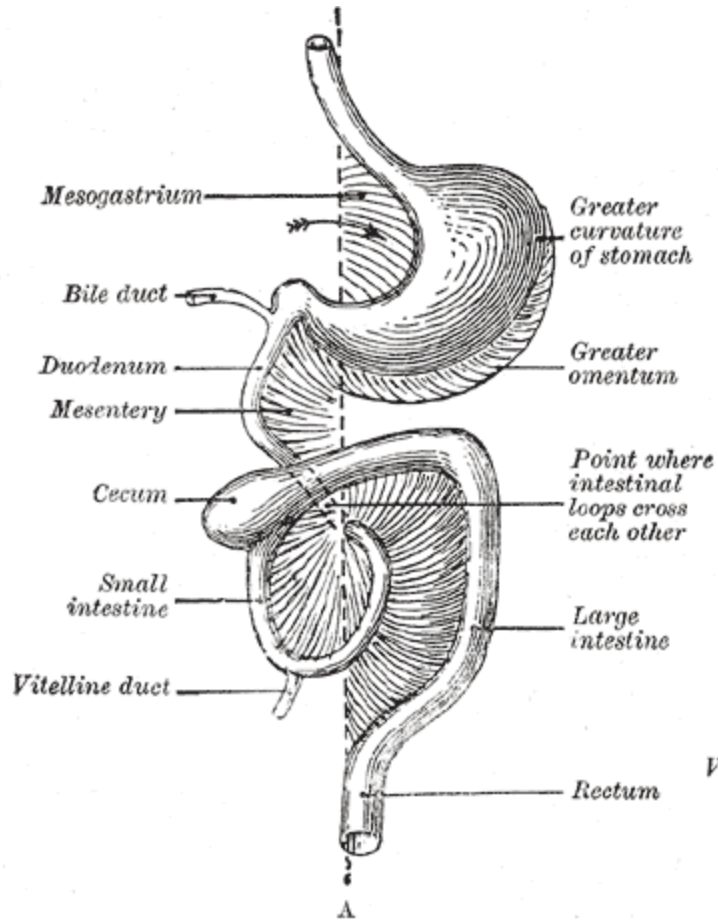


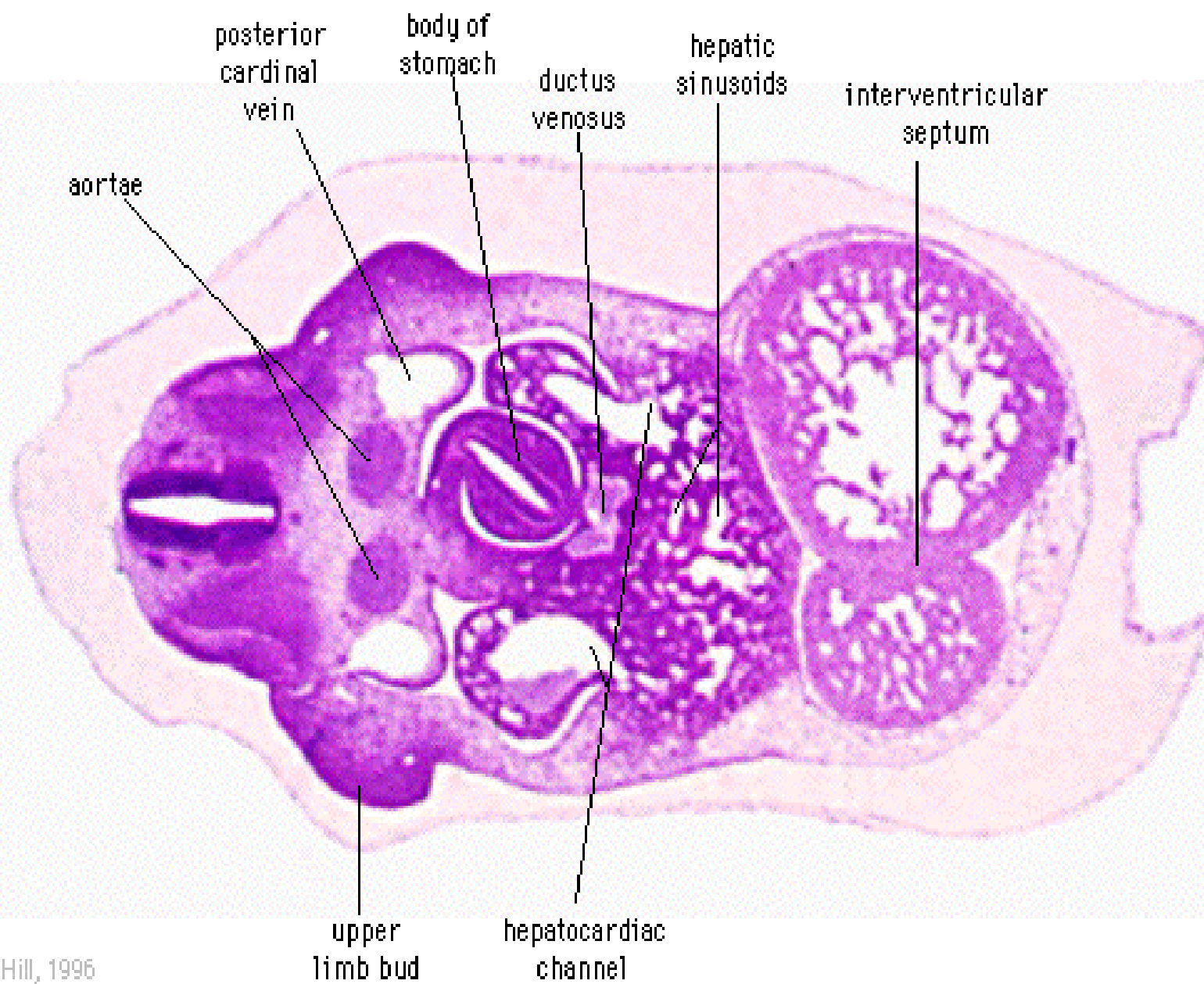
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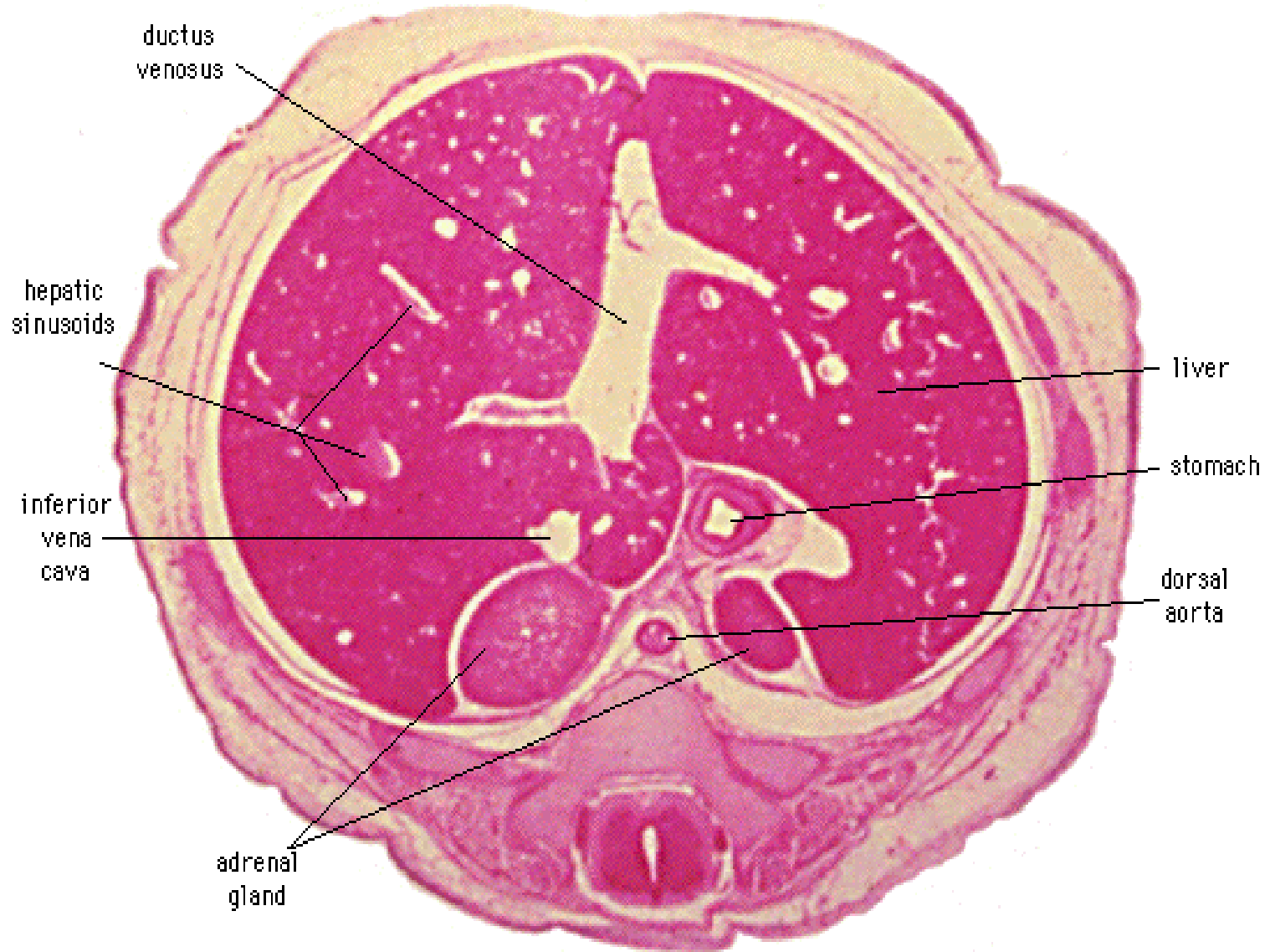
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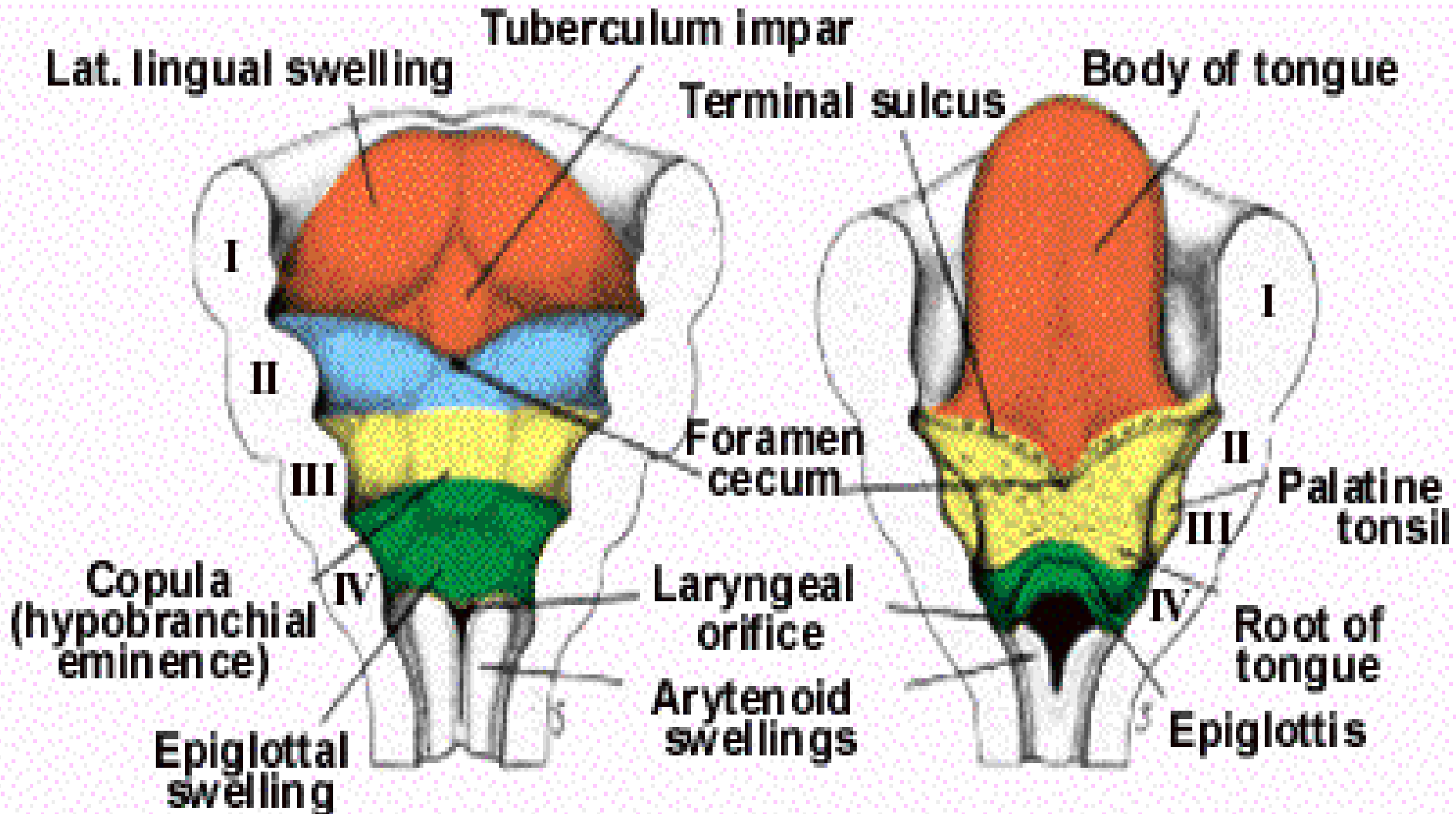
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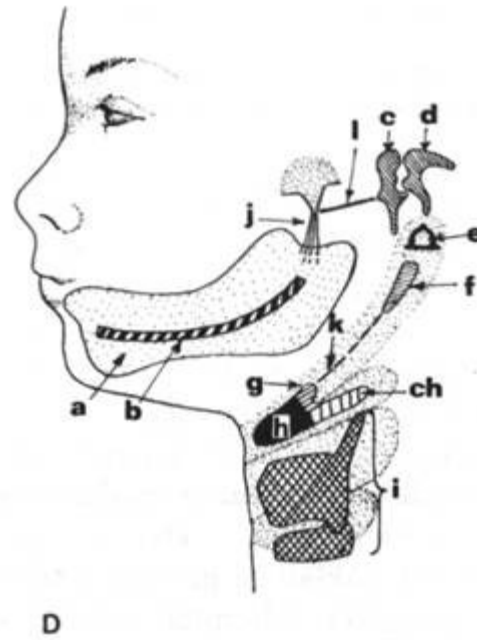
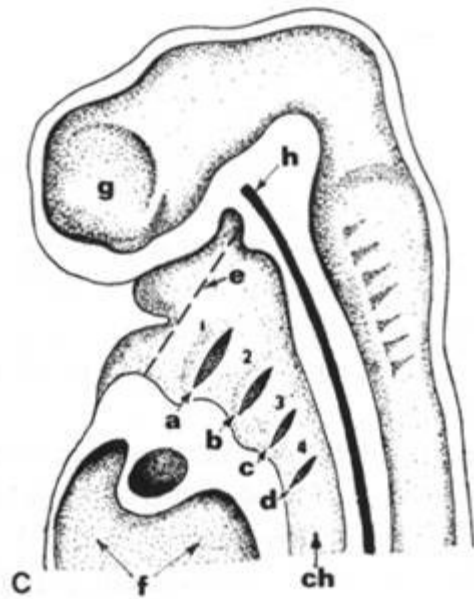
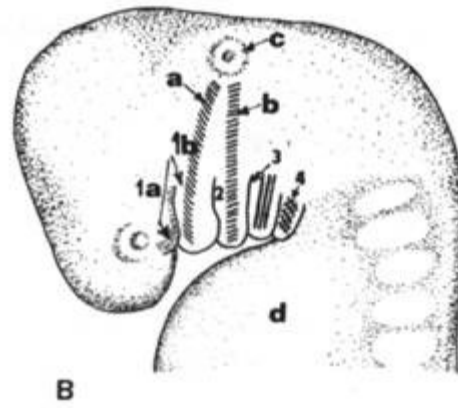
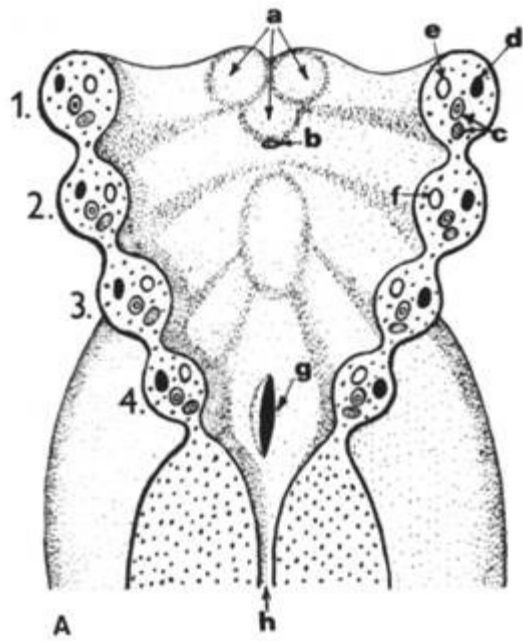


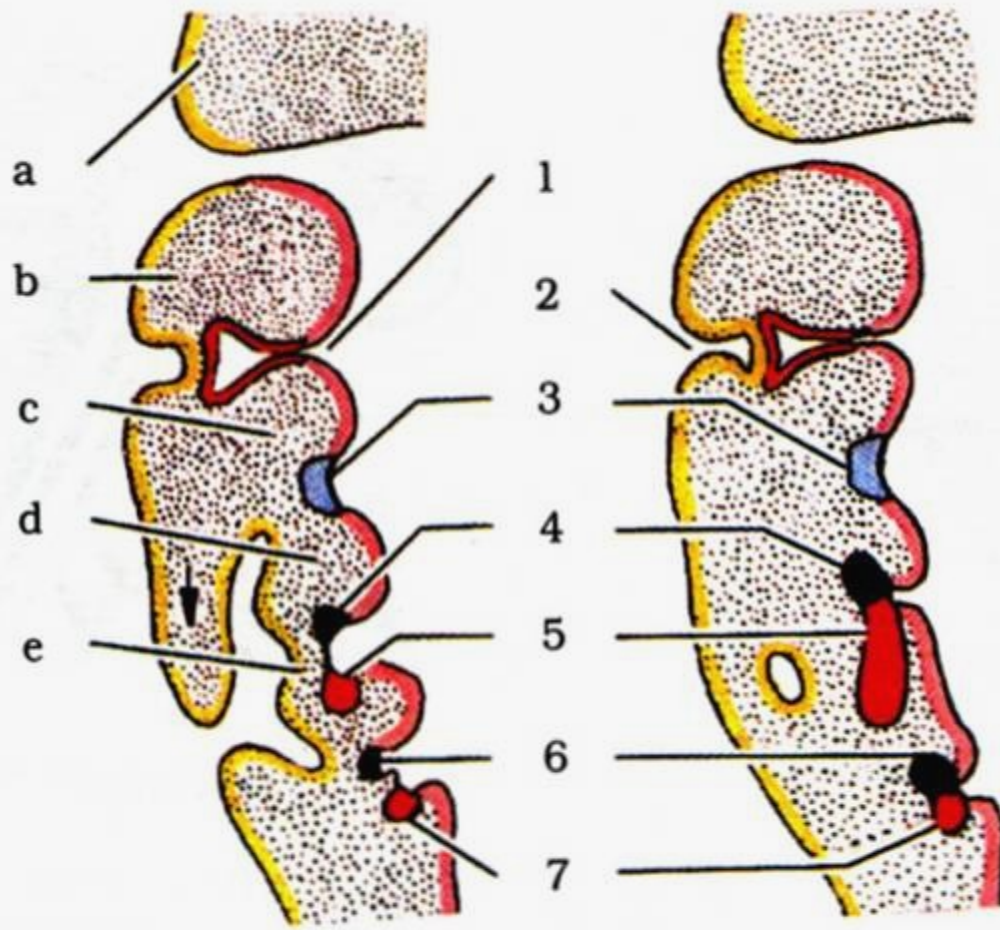




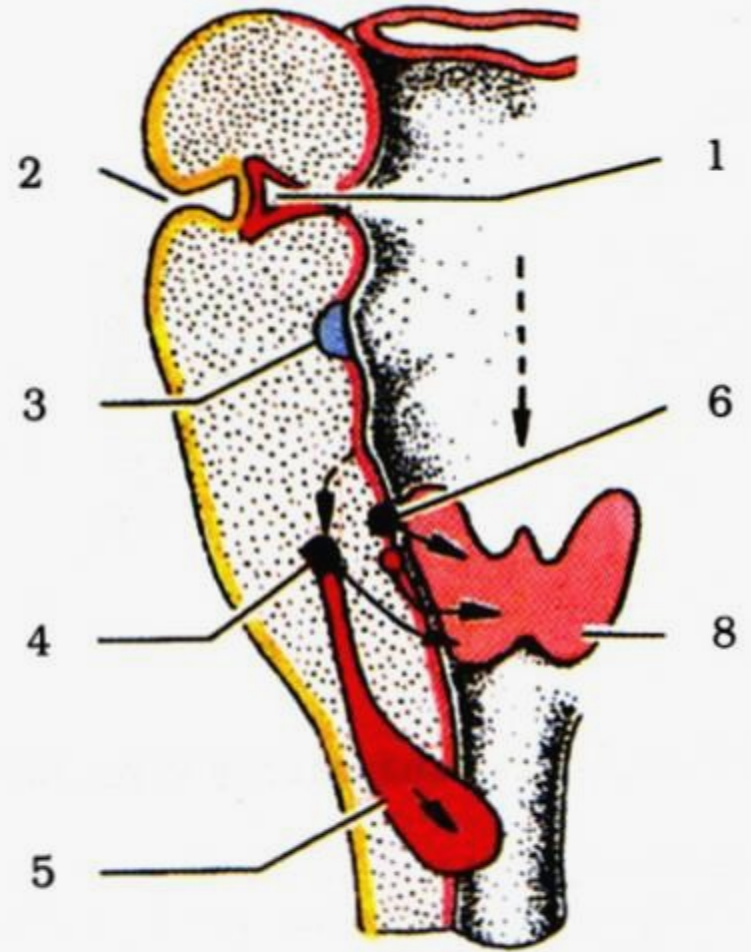
Pharyngeal arches, pouches and clefts



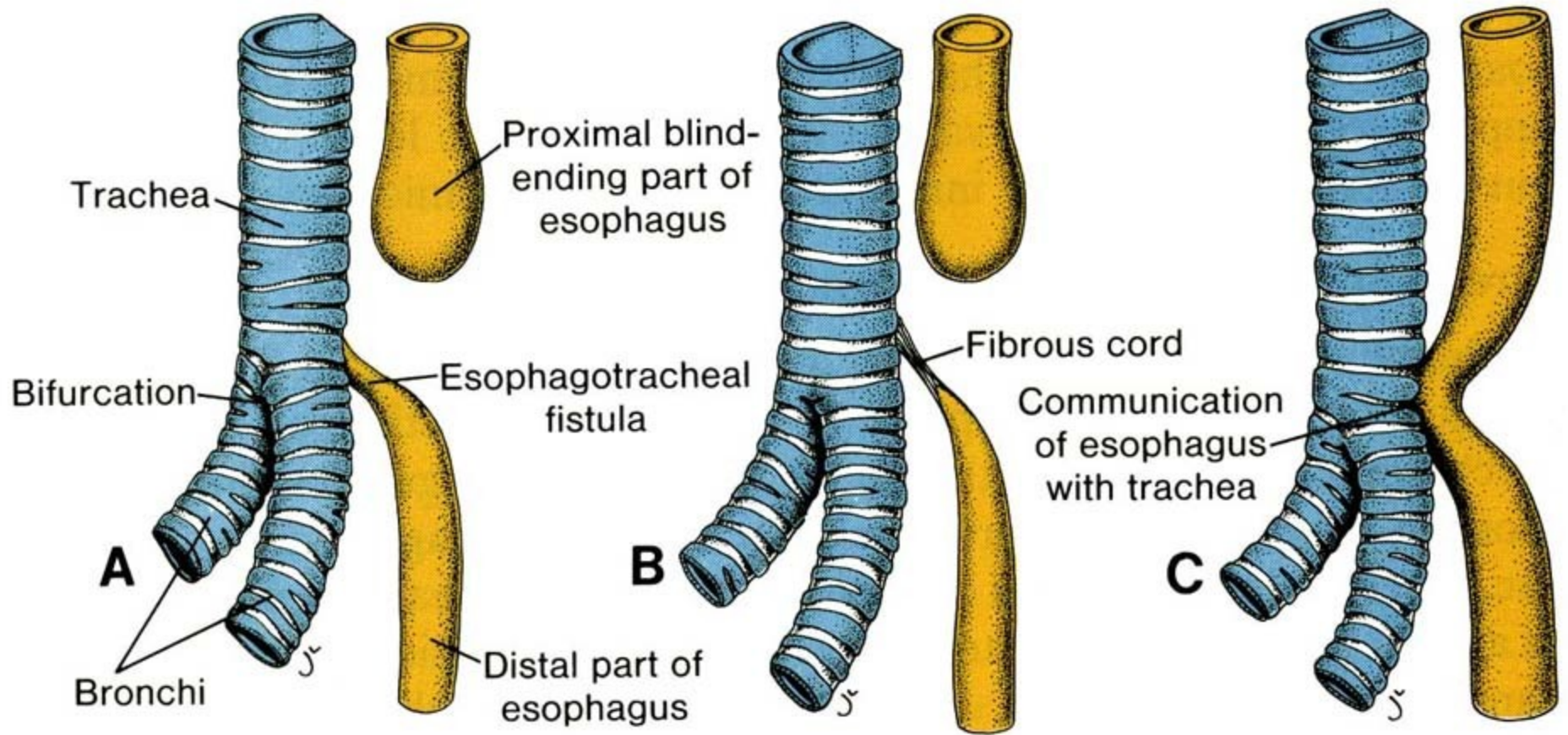


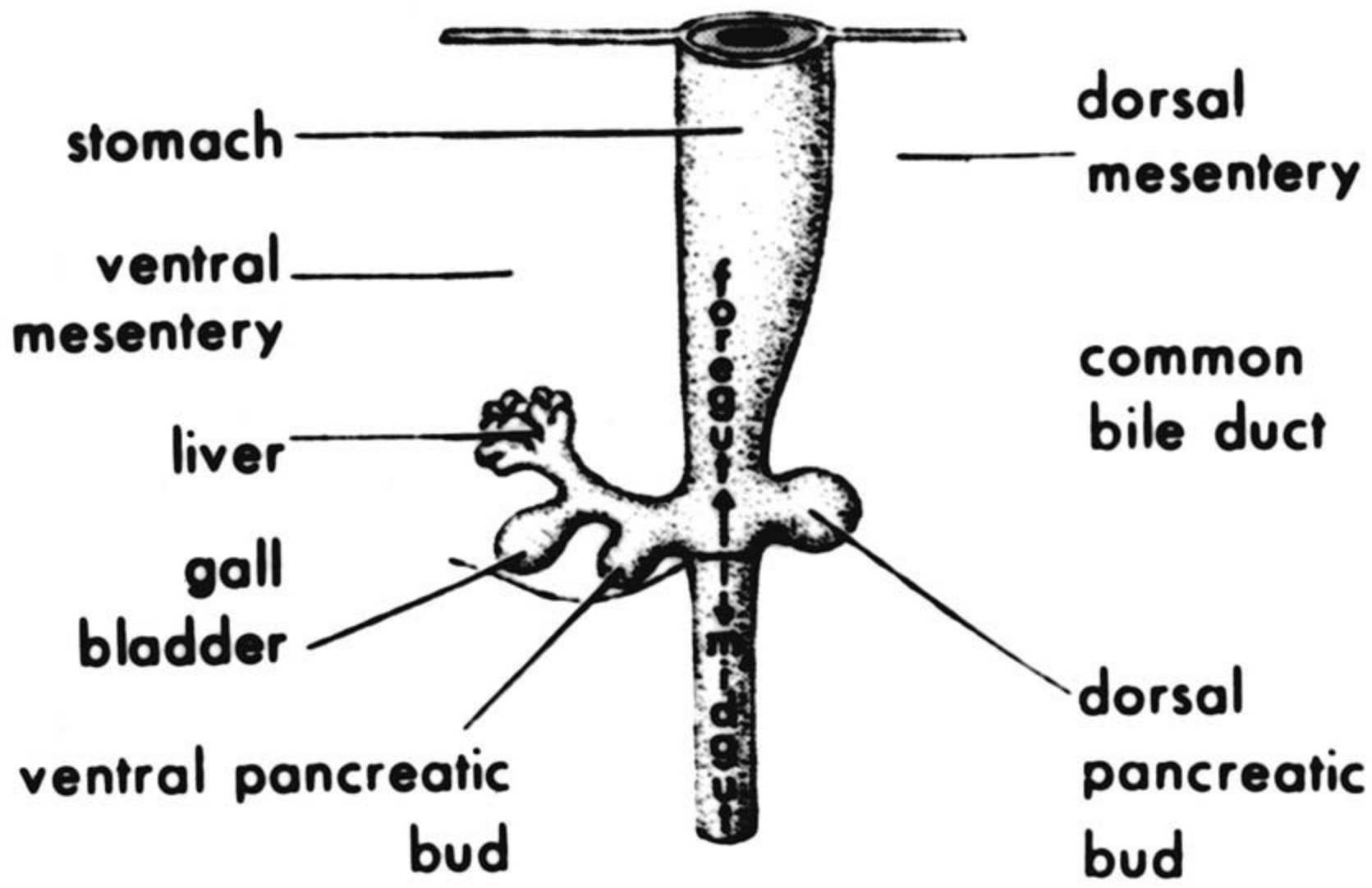


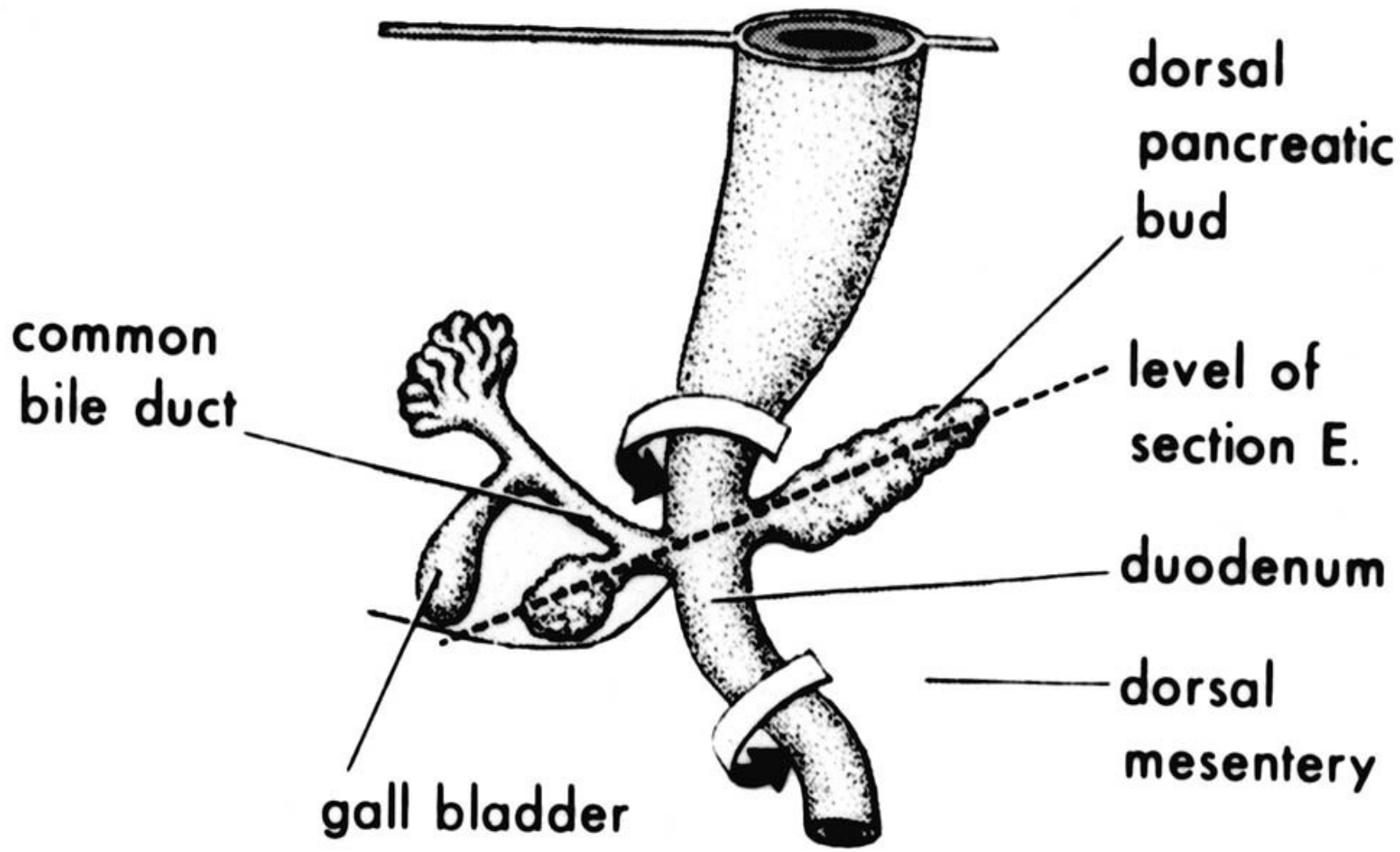
A

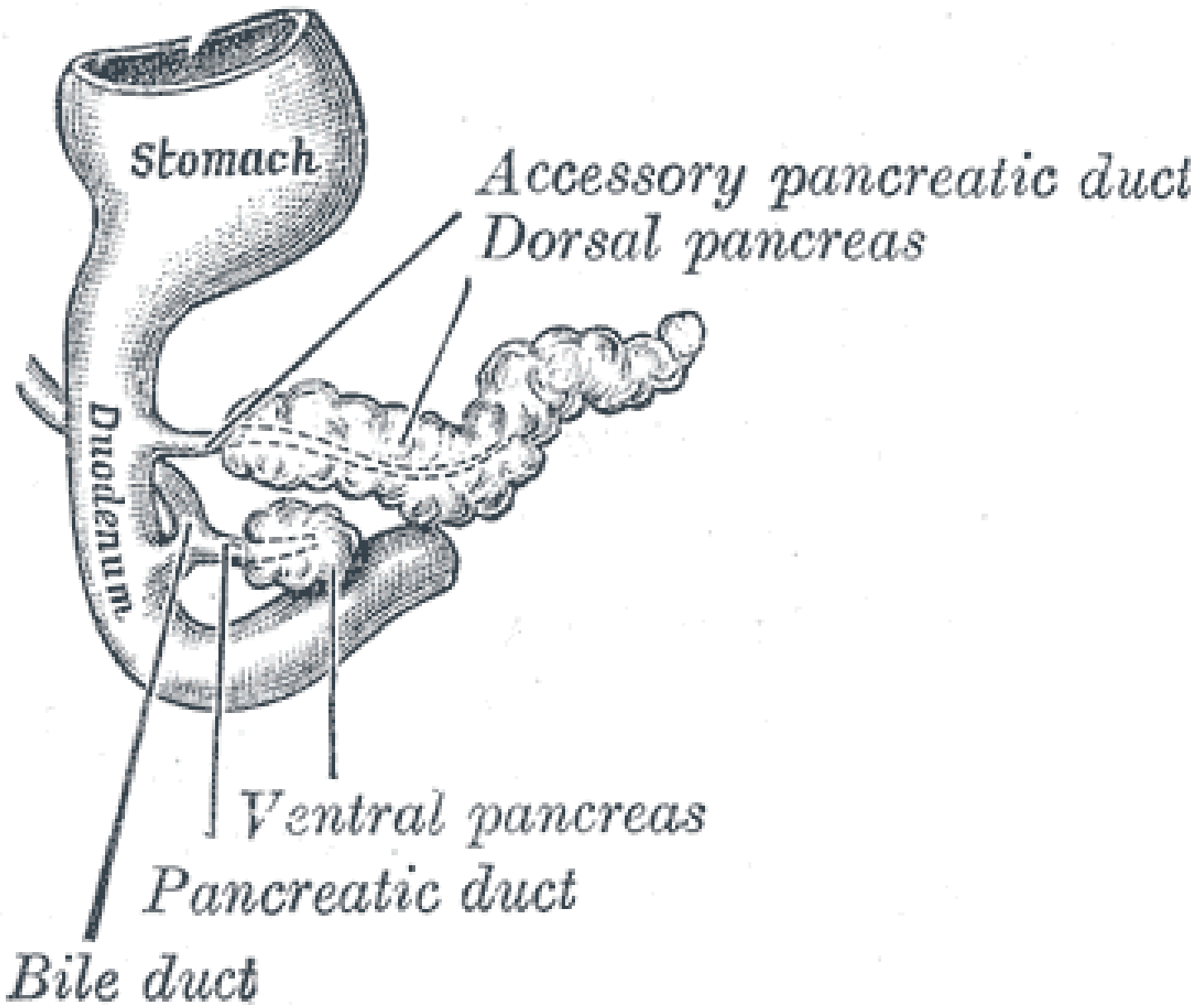


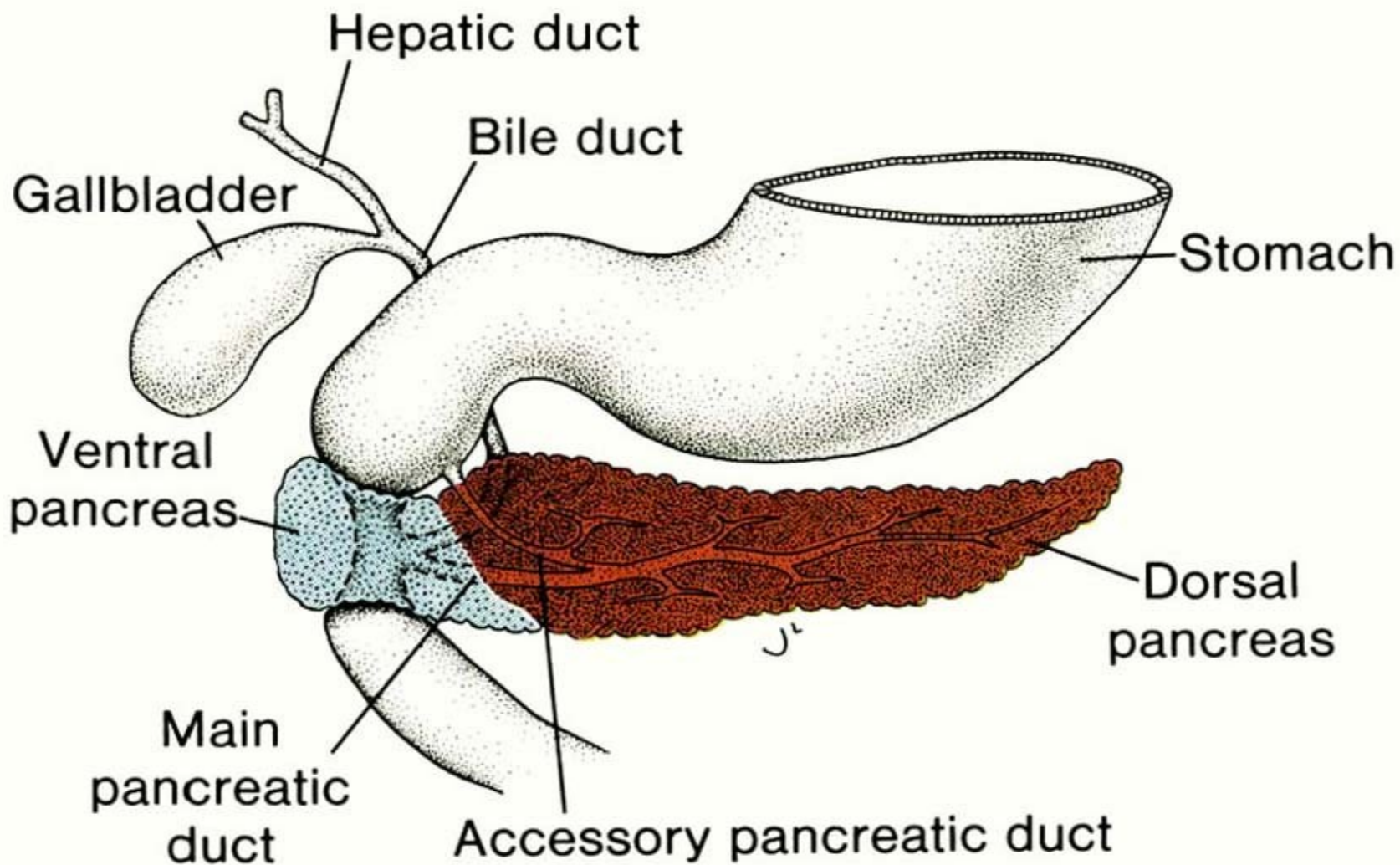
C

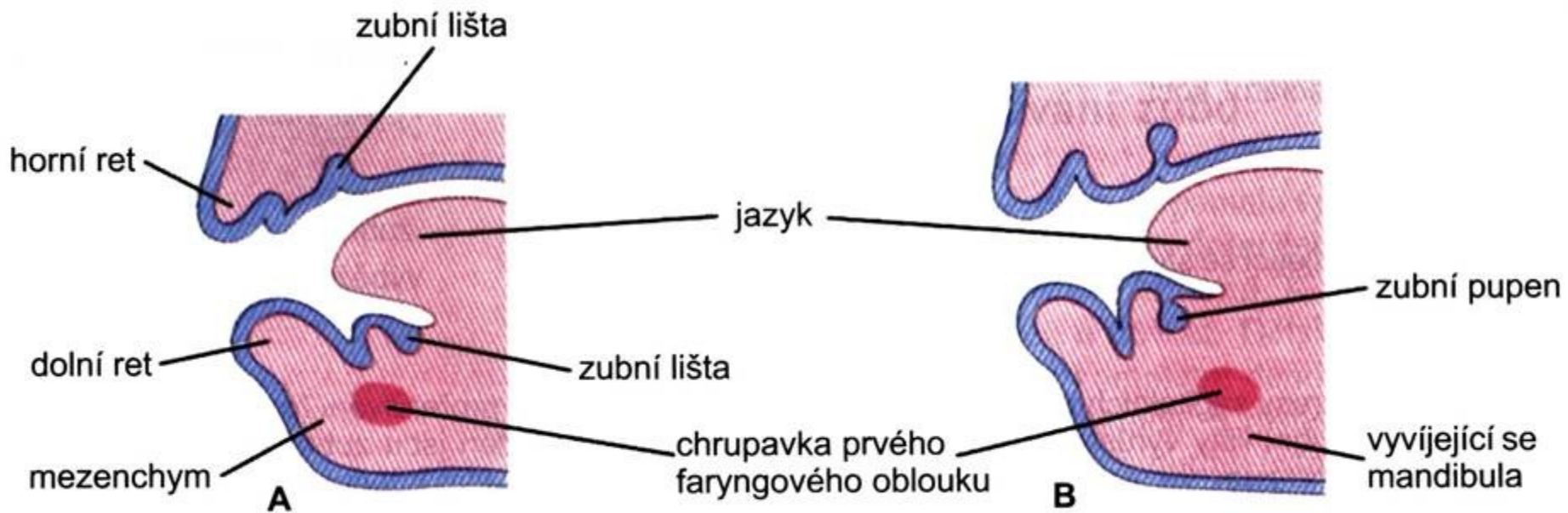








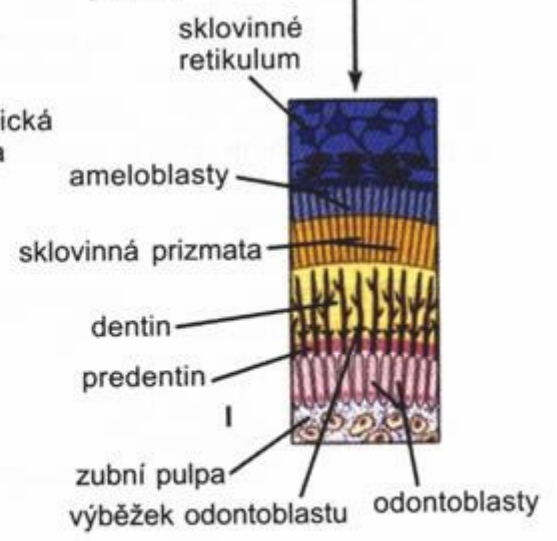
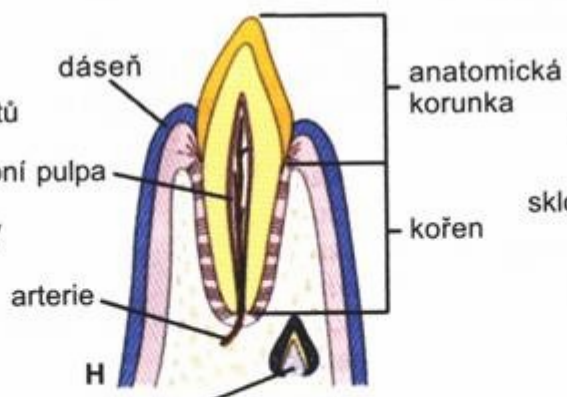
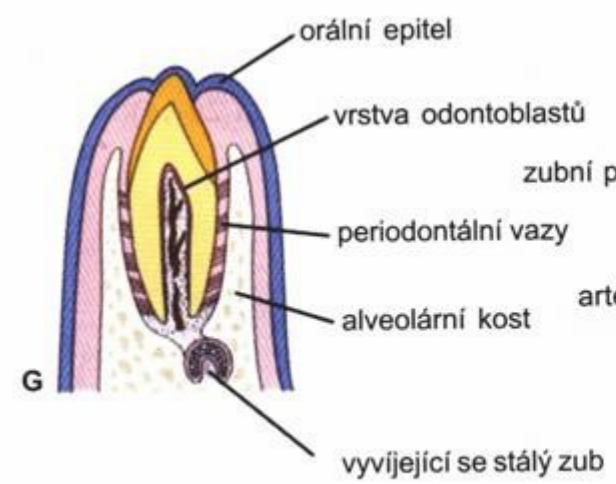
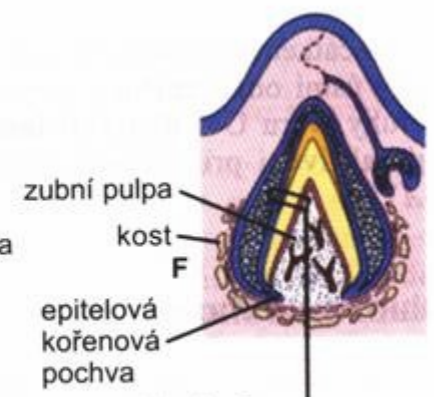
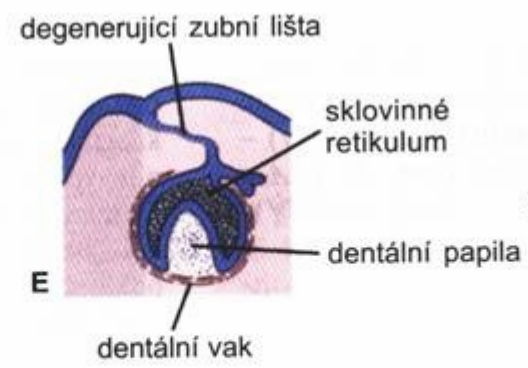
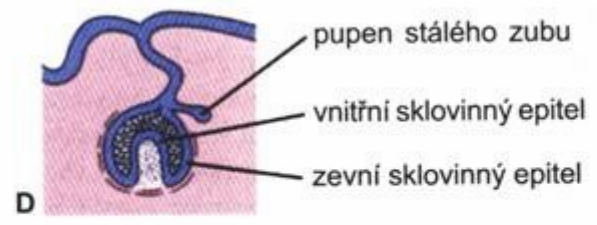
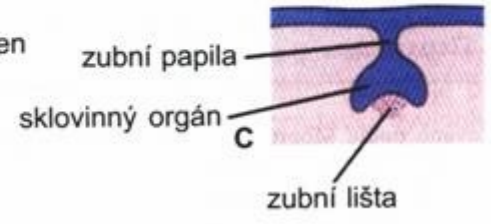
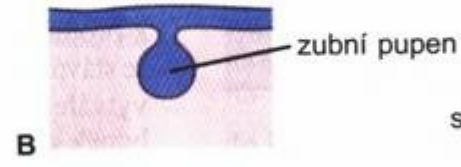
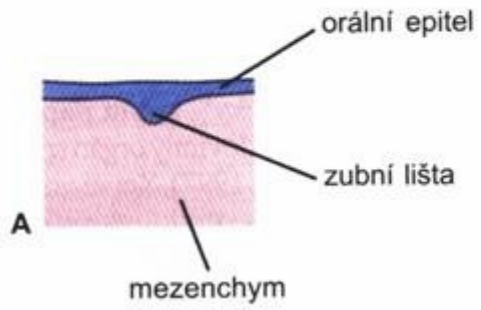


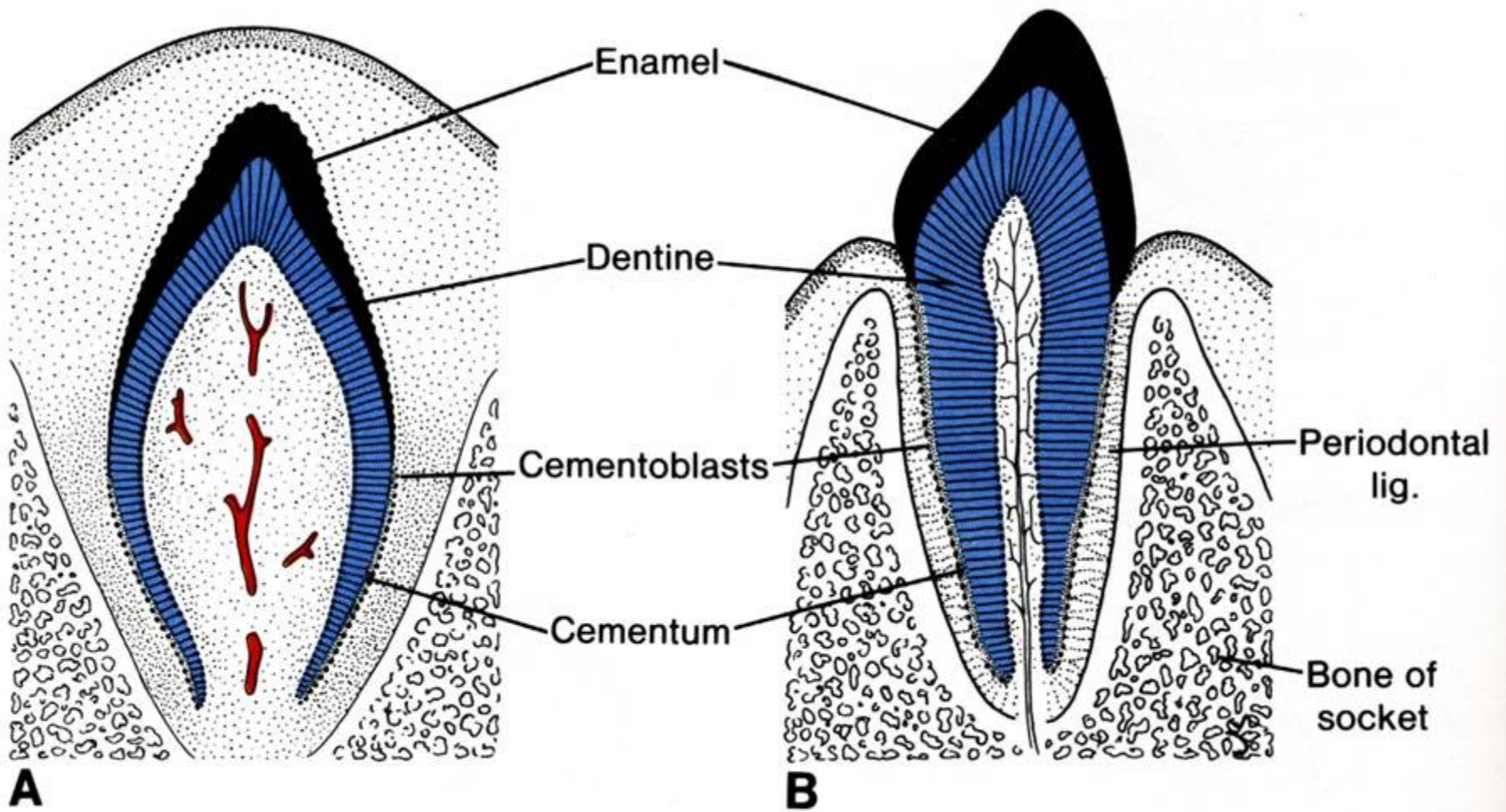


sklovina

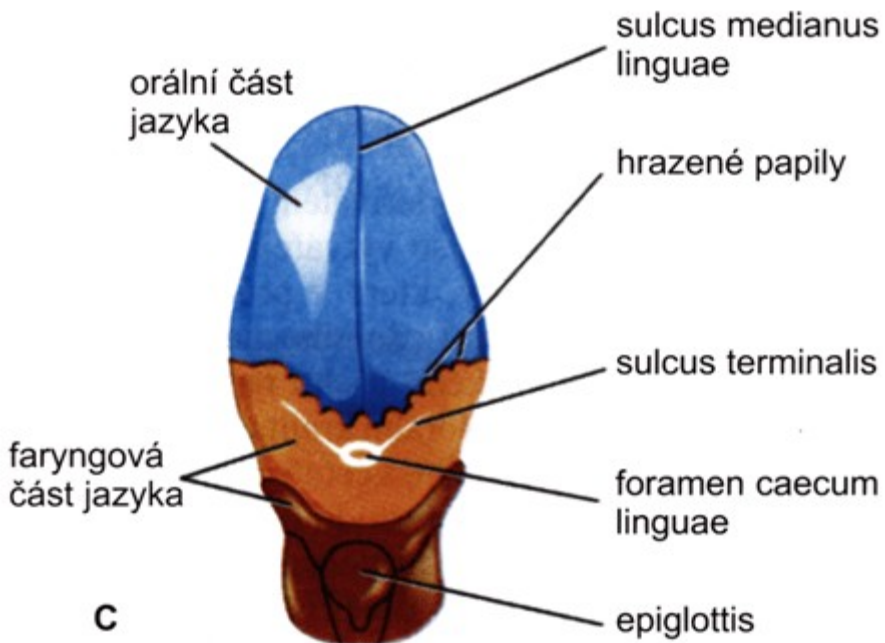
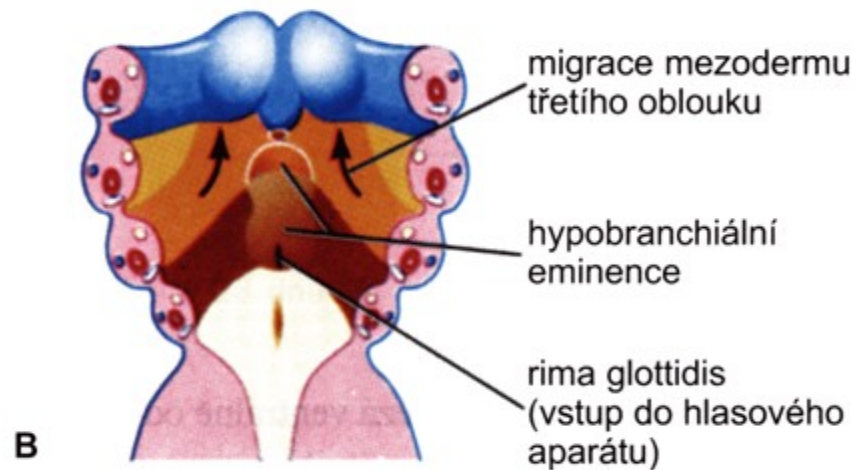
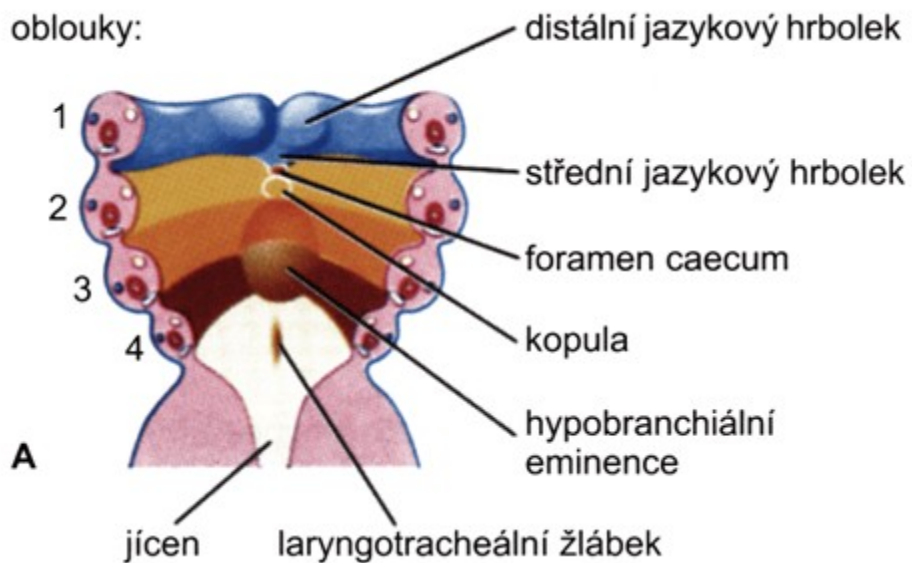
dentin

dentální papila a zubní pulpa









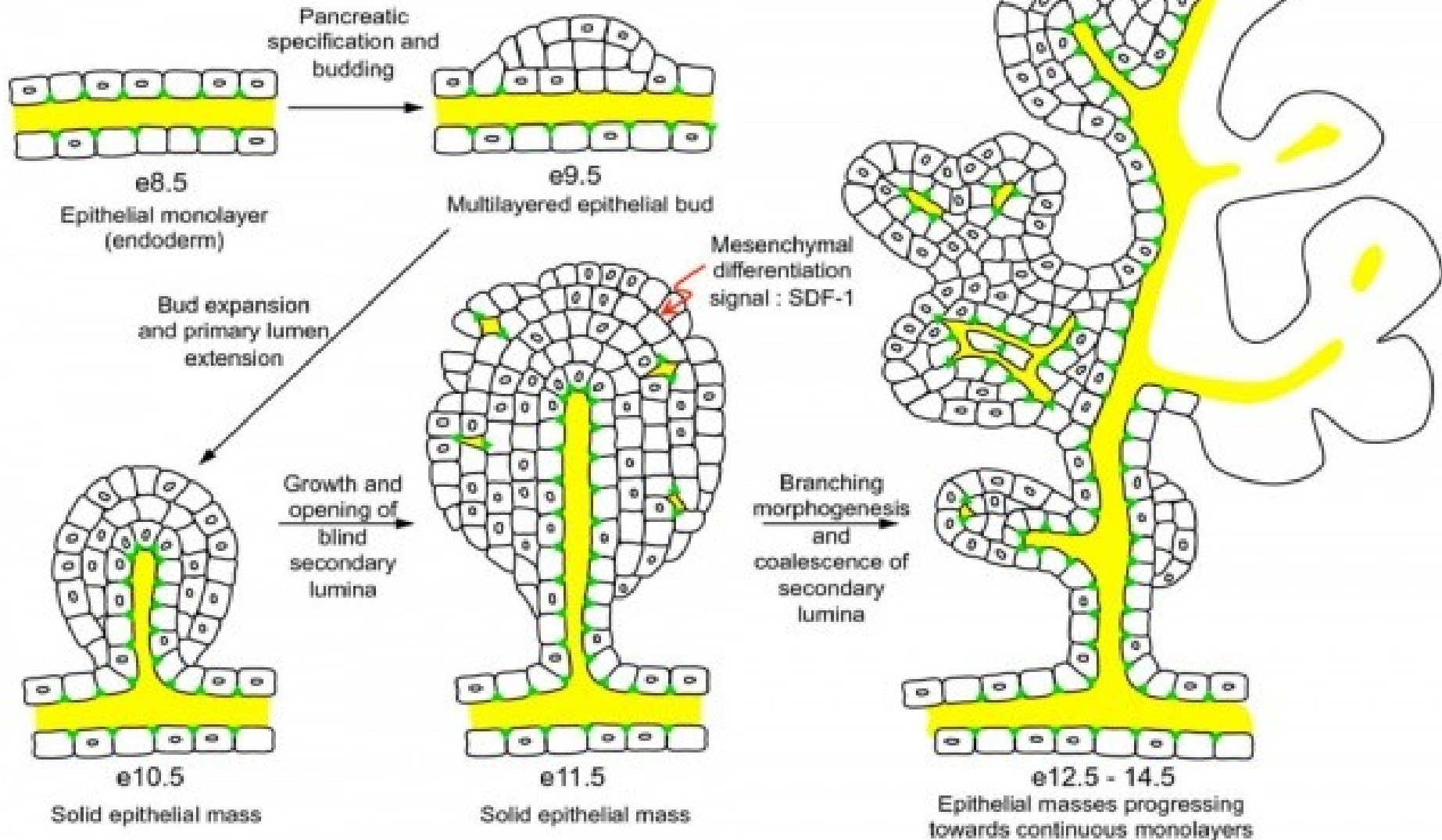
oblouky:



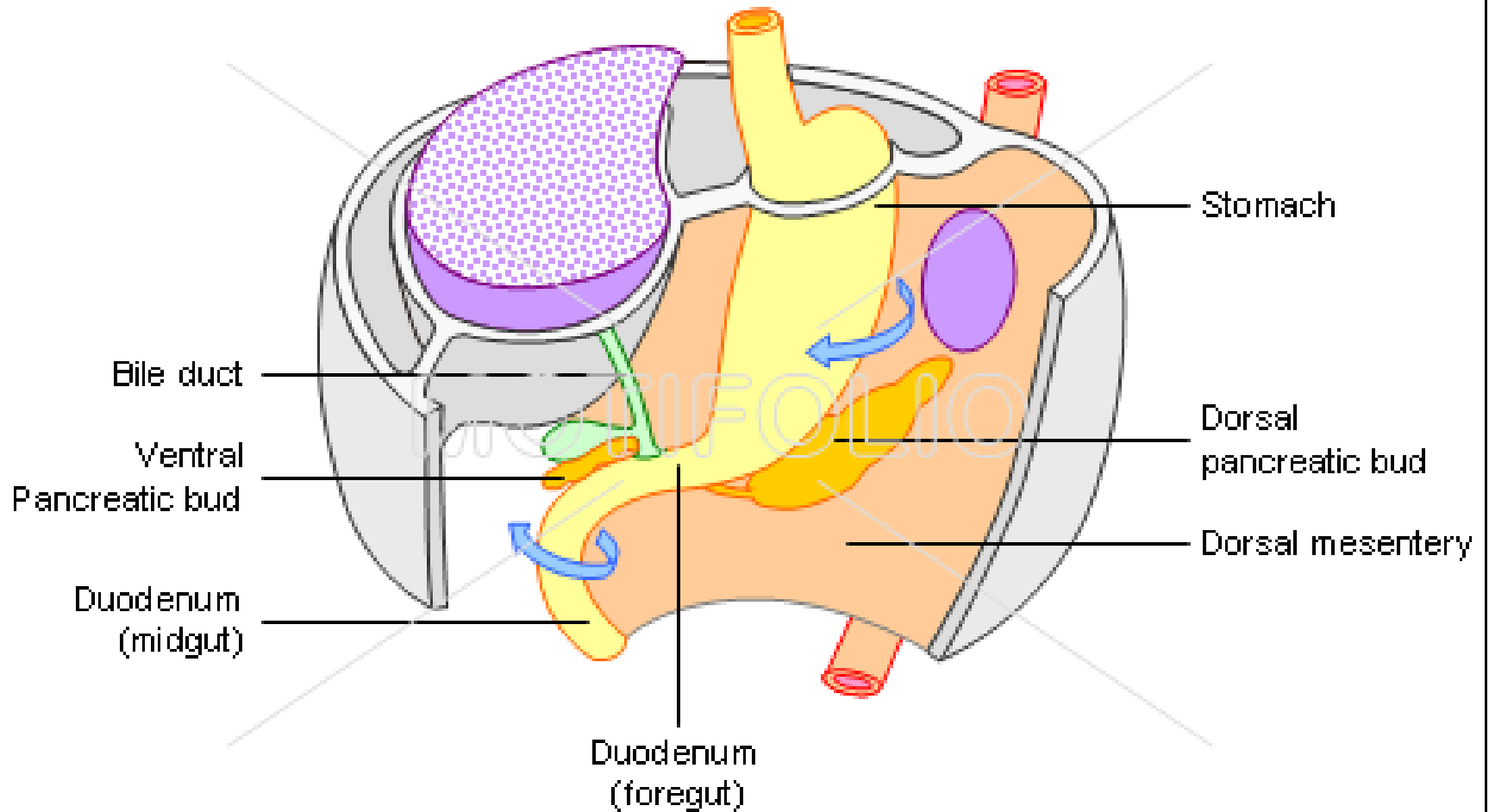
Deriváty faryngových oblouků obsažené v jazyku

- | | |
|--|---|
|  1. faryngový oblouk (CN V – ramus mandibularis) |  2. faryngový oblouk (CN VII – chorda tympani) |
|  3. faryngový oblouk (CN IX – glossopharyngeus) |  4. faryngový oblouk (CN X – vagus) |

Pancreas – ducts and parenchyma development (from endoderm)

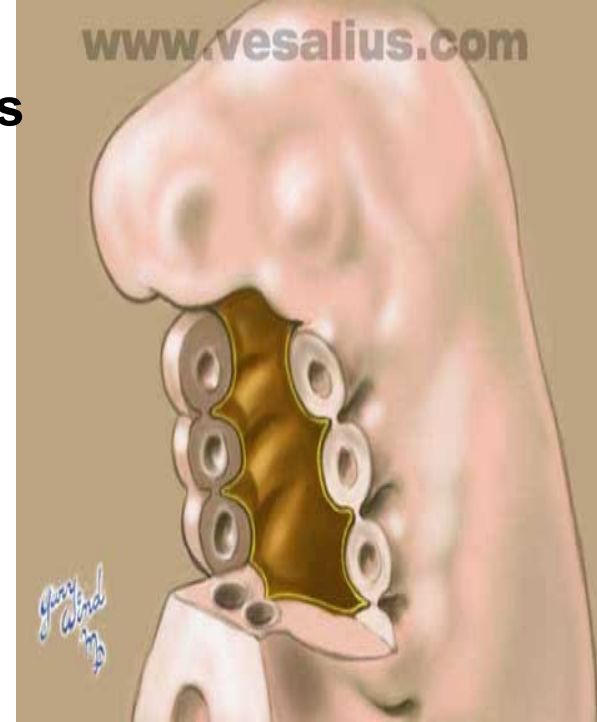


Development of the duodenum and mesenteries – 5 weeks embryo

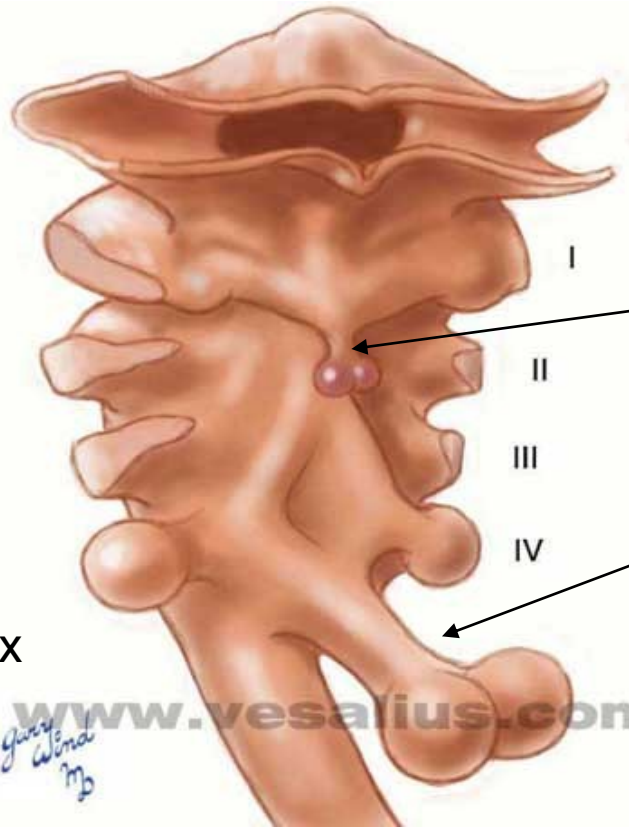




**Ectodermal
pharyngeal clefts
(grooves)**



**Endodermal
pharyngeal pouches**

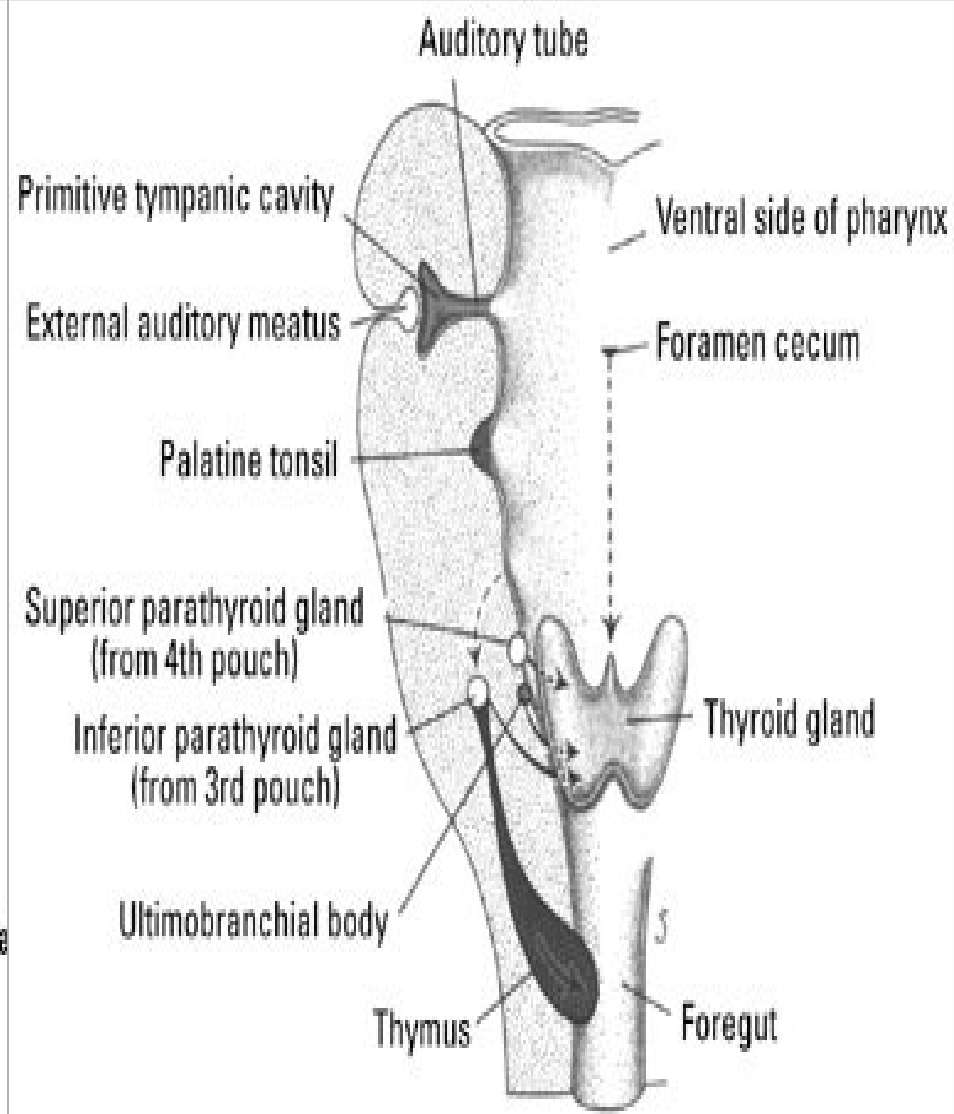
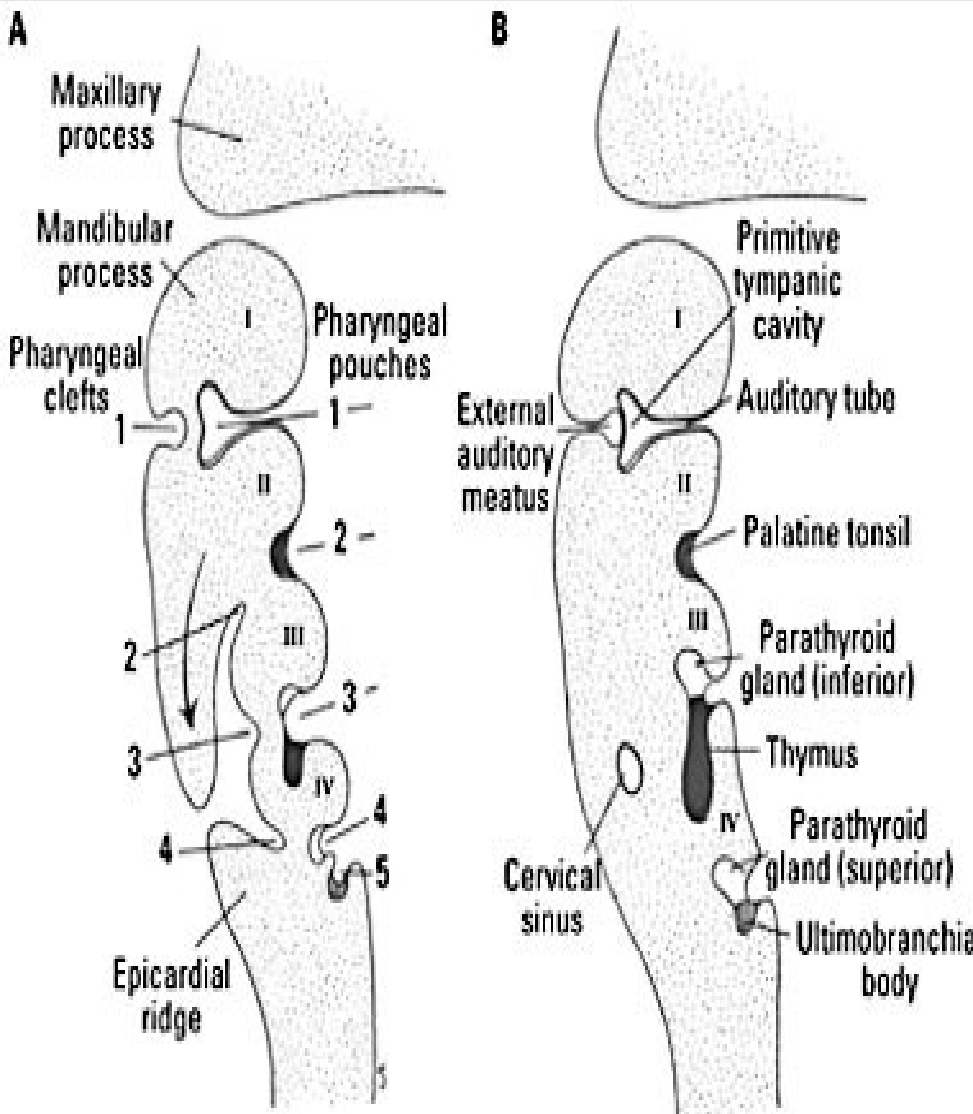


Thyroid gl.

Laryngotracheal diverticle

primitive pharynx

Pharyngeal arches, pouches and clefts



At 6 weeks, the pancreatic buds meet and fuse.

