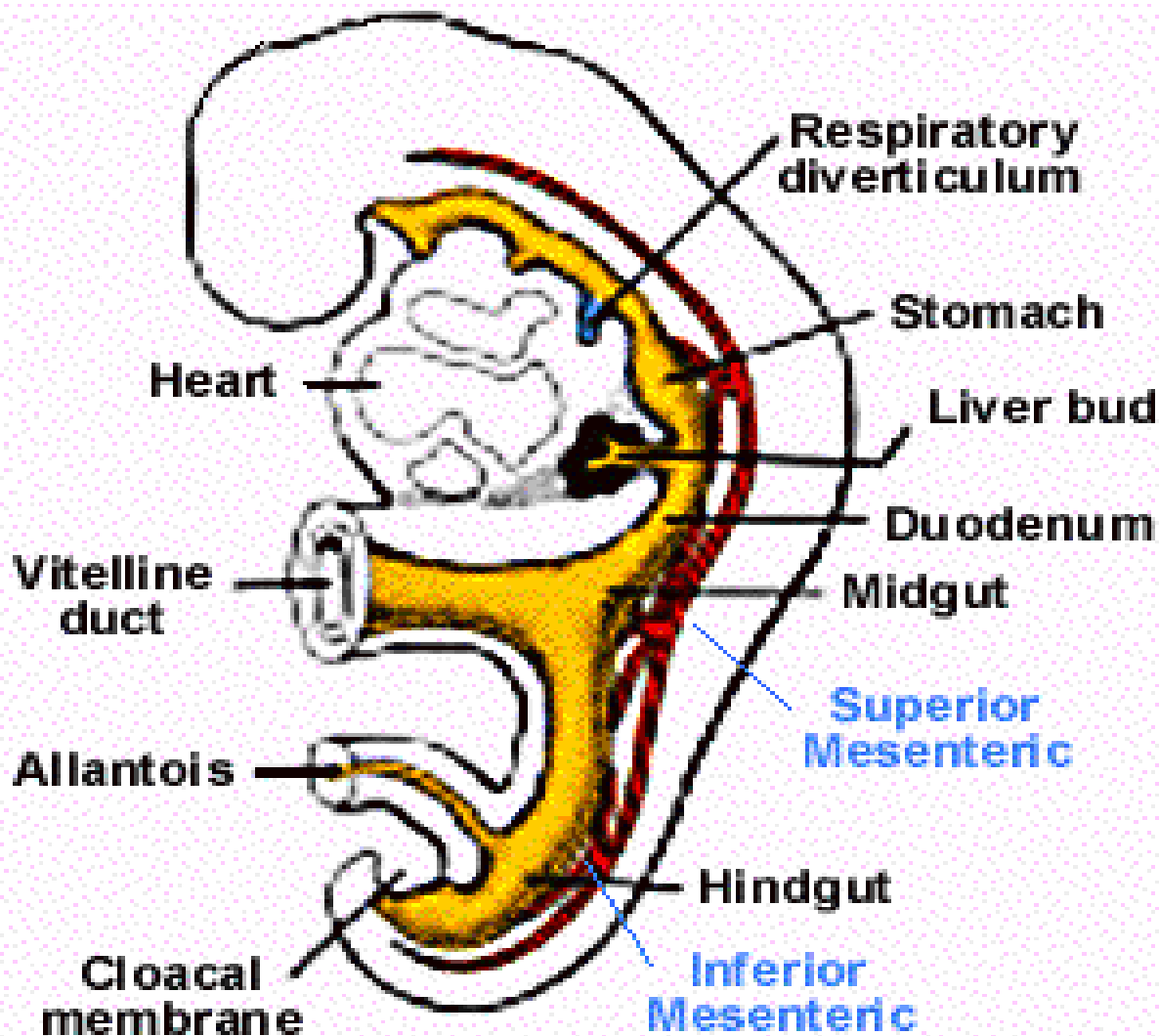
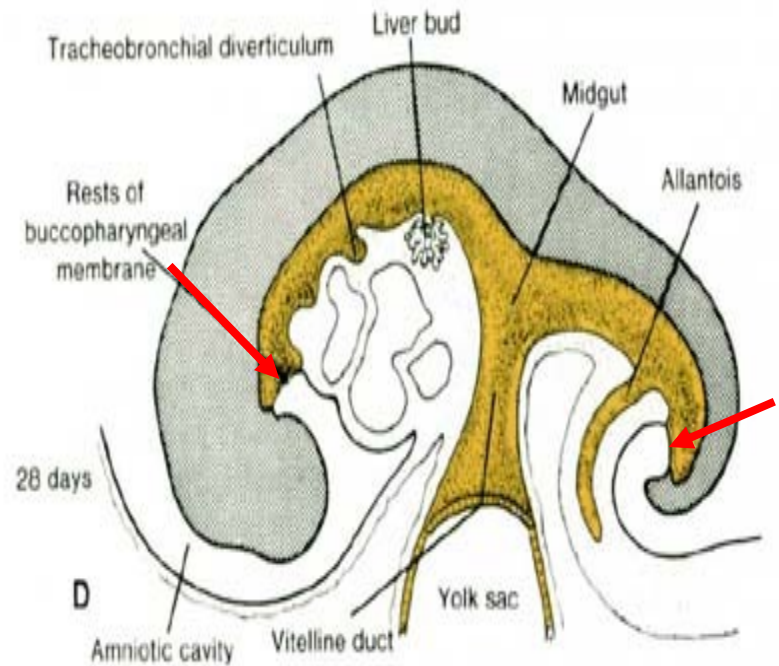
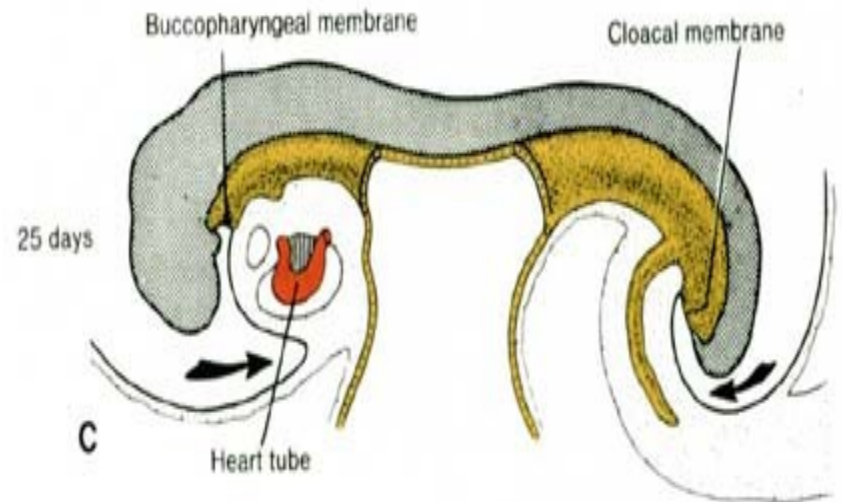
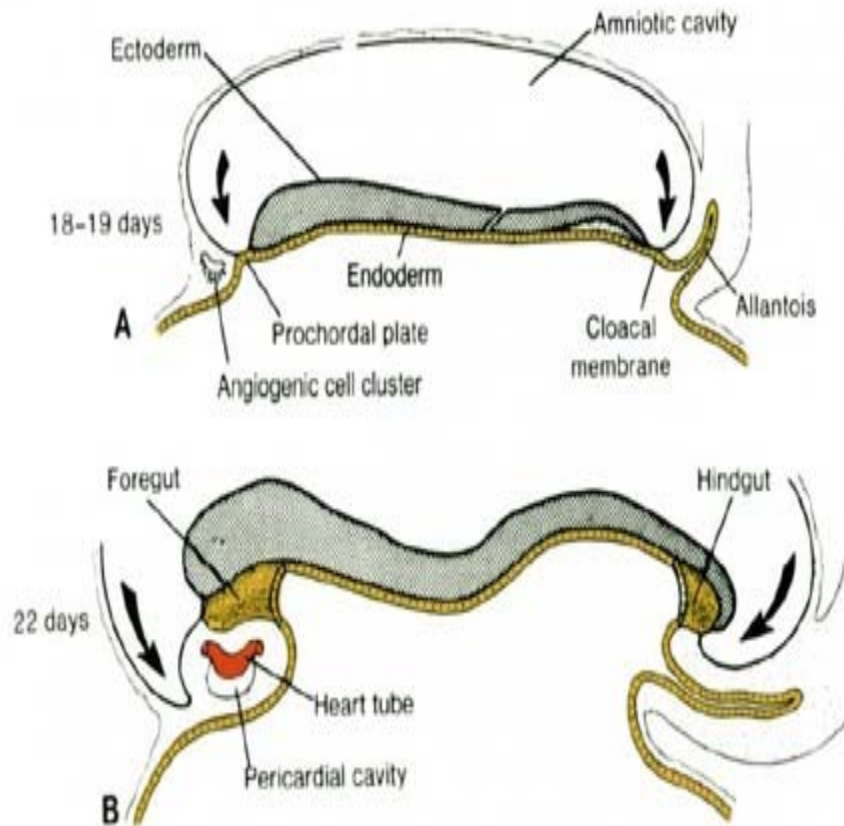


Embryology: Development of digestive system



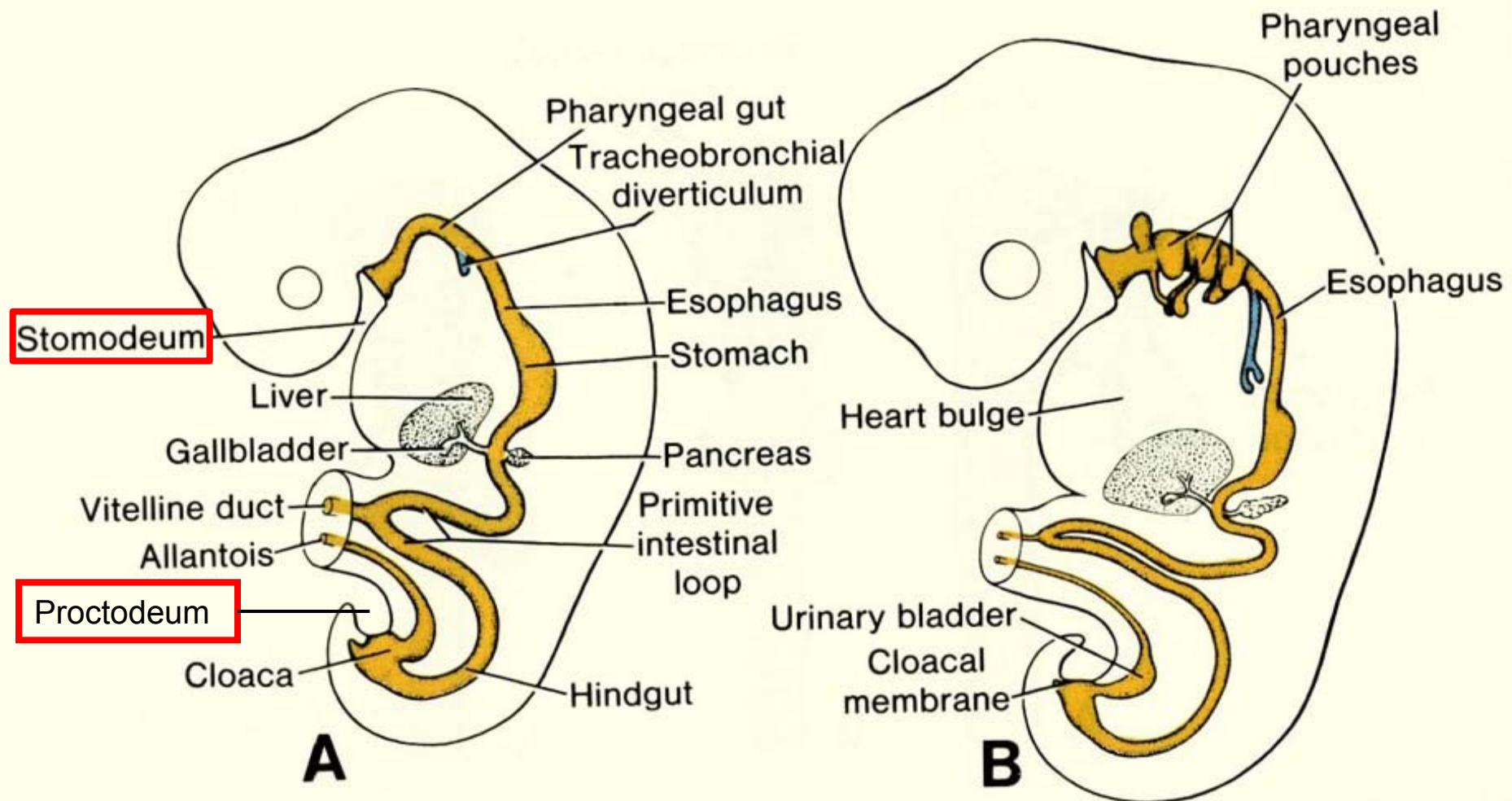


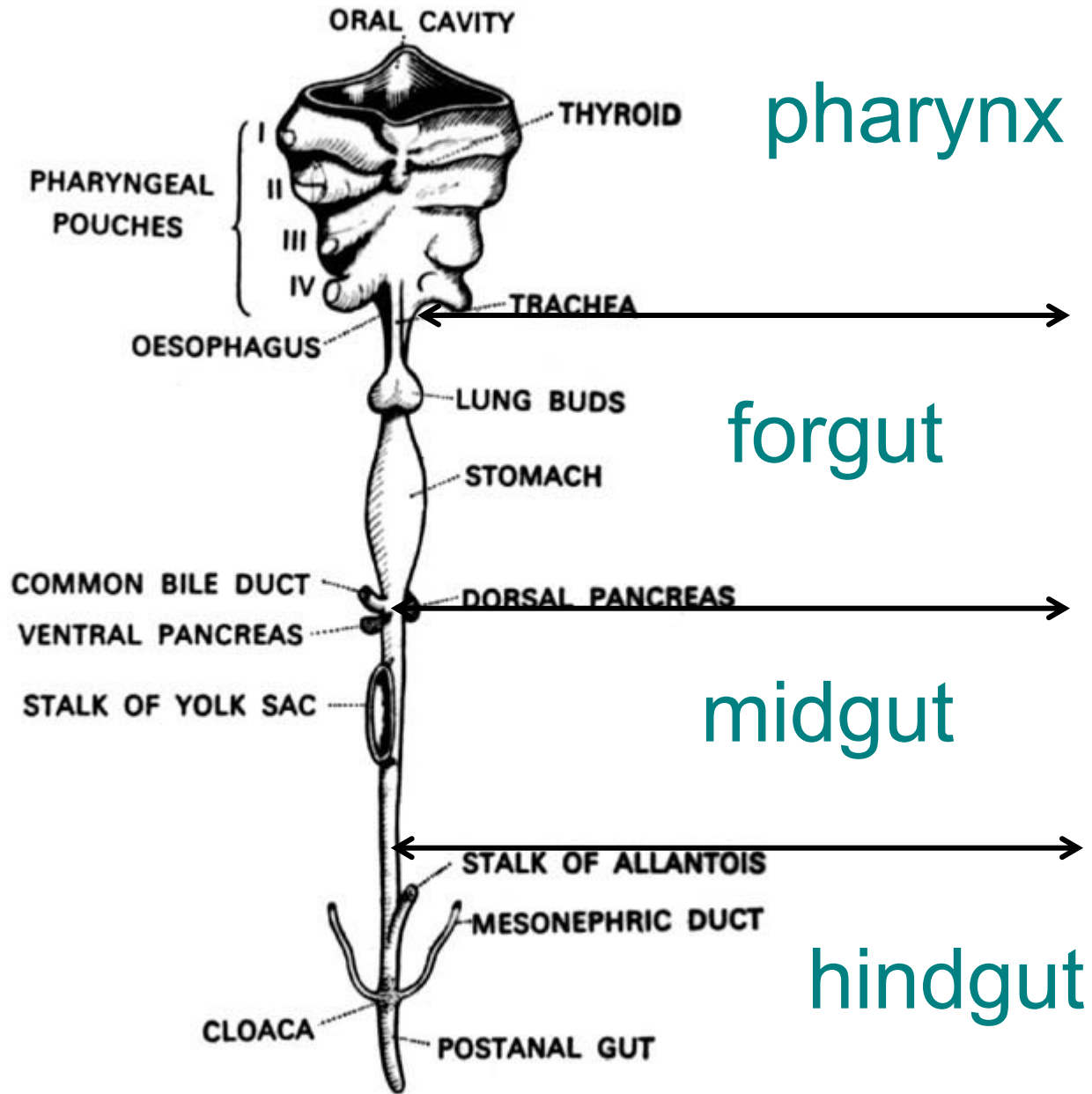
- Embryo folding – incorporation of endoderm to form primitive gut.
- Outside of embryo – yolk sac and allantois.
- Vitelline duct

Stomodeum (primitive mouth) \Rightarrow the oral cavity + the salivary glands

Proctodeum \Rightarrow primitive anal pit

Primitive gut \Rightarrow whole digestive tube + accessory glands





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

primitive gut

foregut

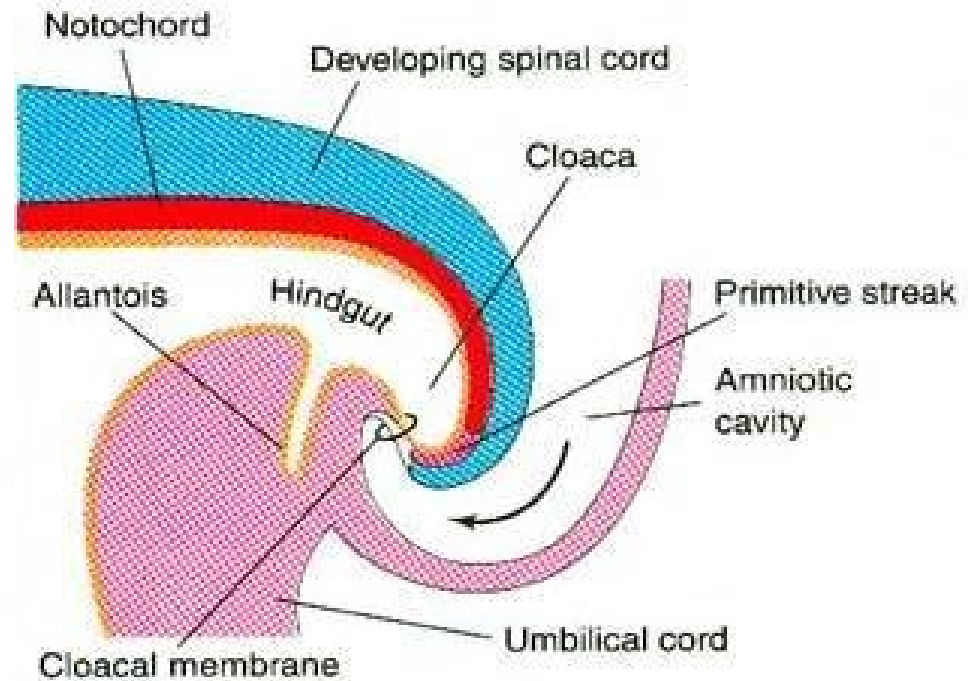
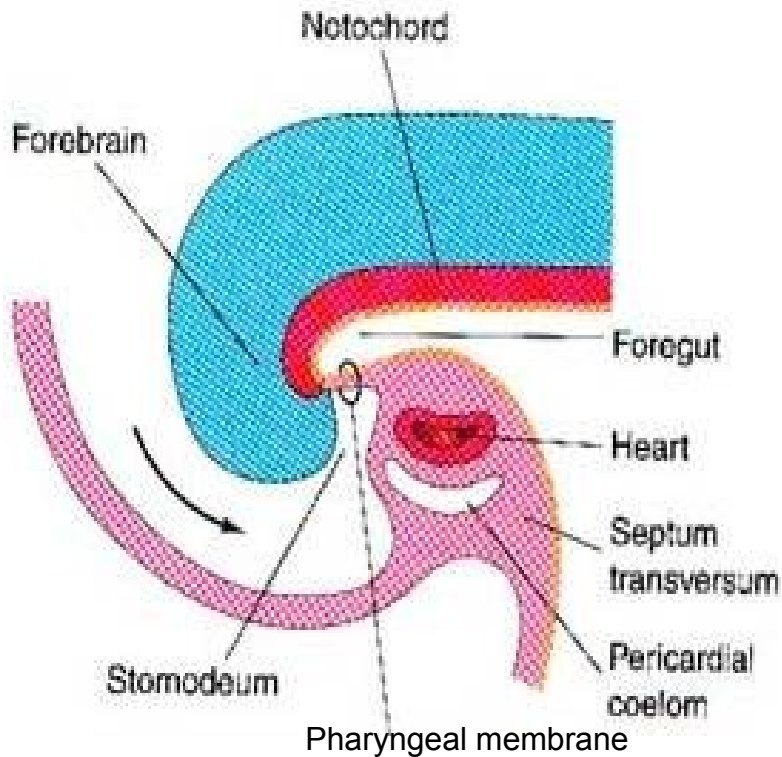
from pharyngeal membrane

midgut

above ductus omphalomesentericus and yolk sack

hindgut

to cloacal membrane

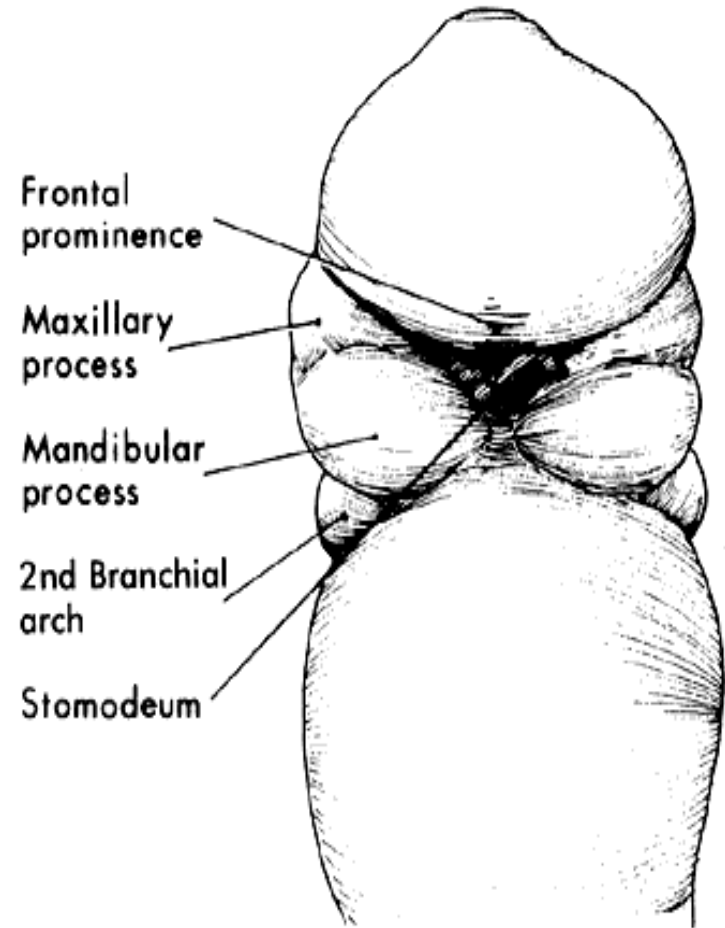


Derivatives of

- foregut** – pharynx, esophagus (+ respiratory diverticle), 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 canalis analis

Oral cavity

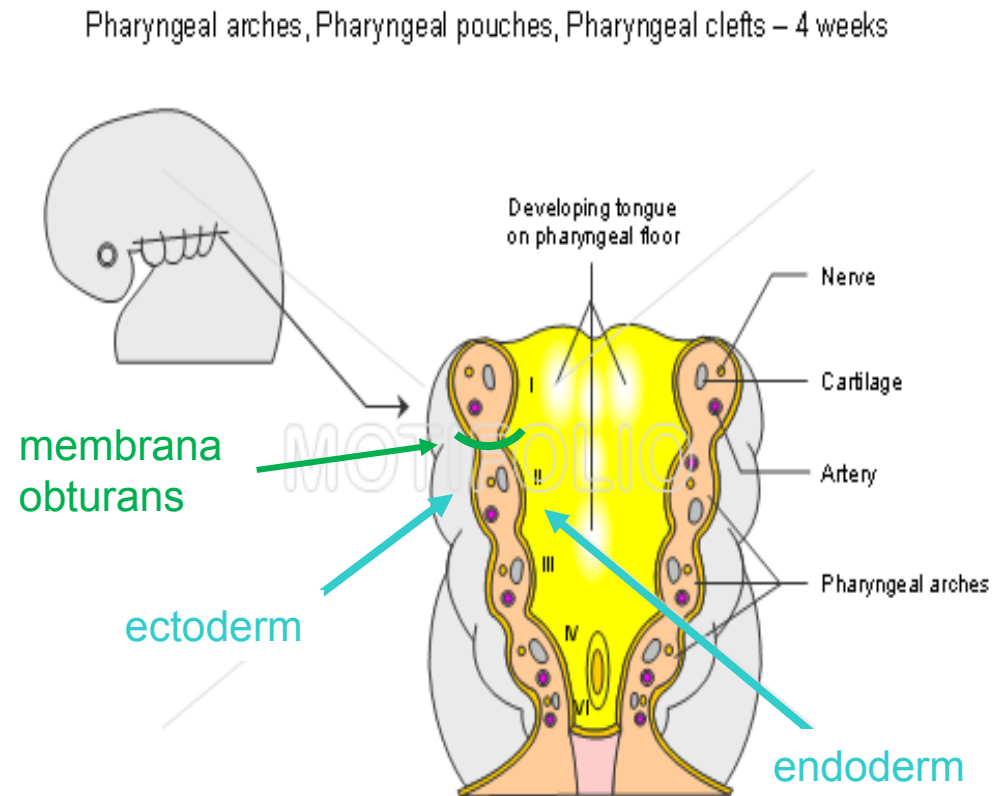
- primitive mouth pit
 - **stomodeum**
- lined with ectoderm
- surrounded by:
 - processus frontalis (single)
 - proc. maxillares (paired)
 - proc. mandibulares (paired)
- **pharyngeal membrane**
(it ruptures during the 4th week, primitive gut communicates with amnionic cavity)



Pharyngeal (branchial) apparatus

Pharyngeal arches

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



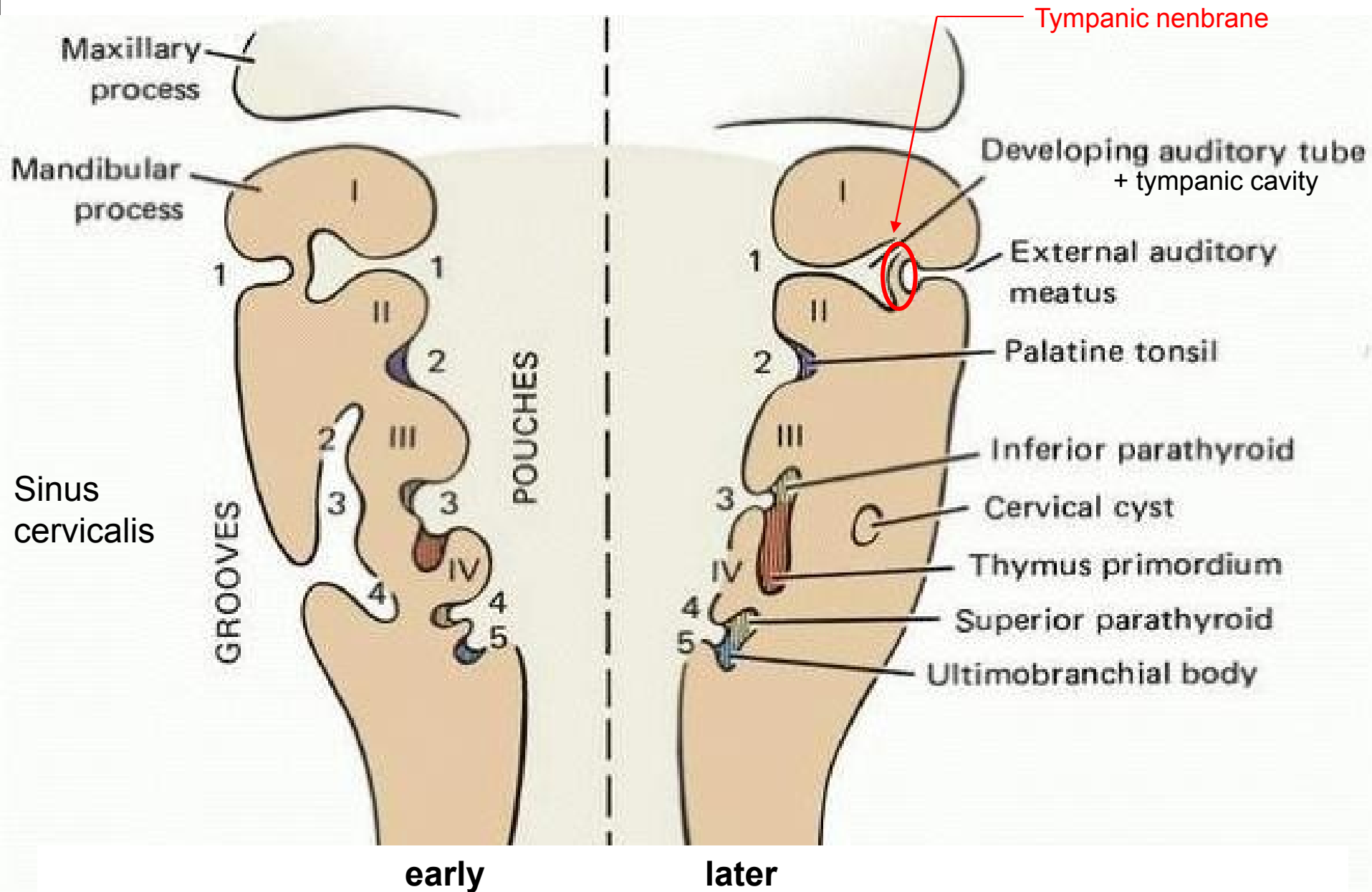
Ectodermal pharyngeal clefts (grooves)

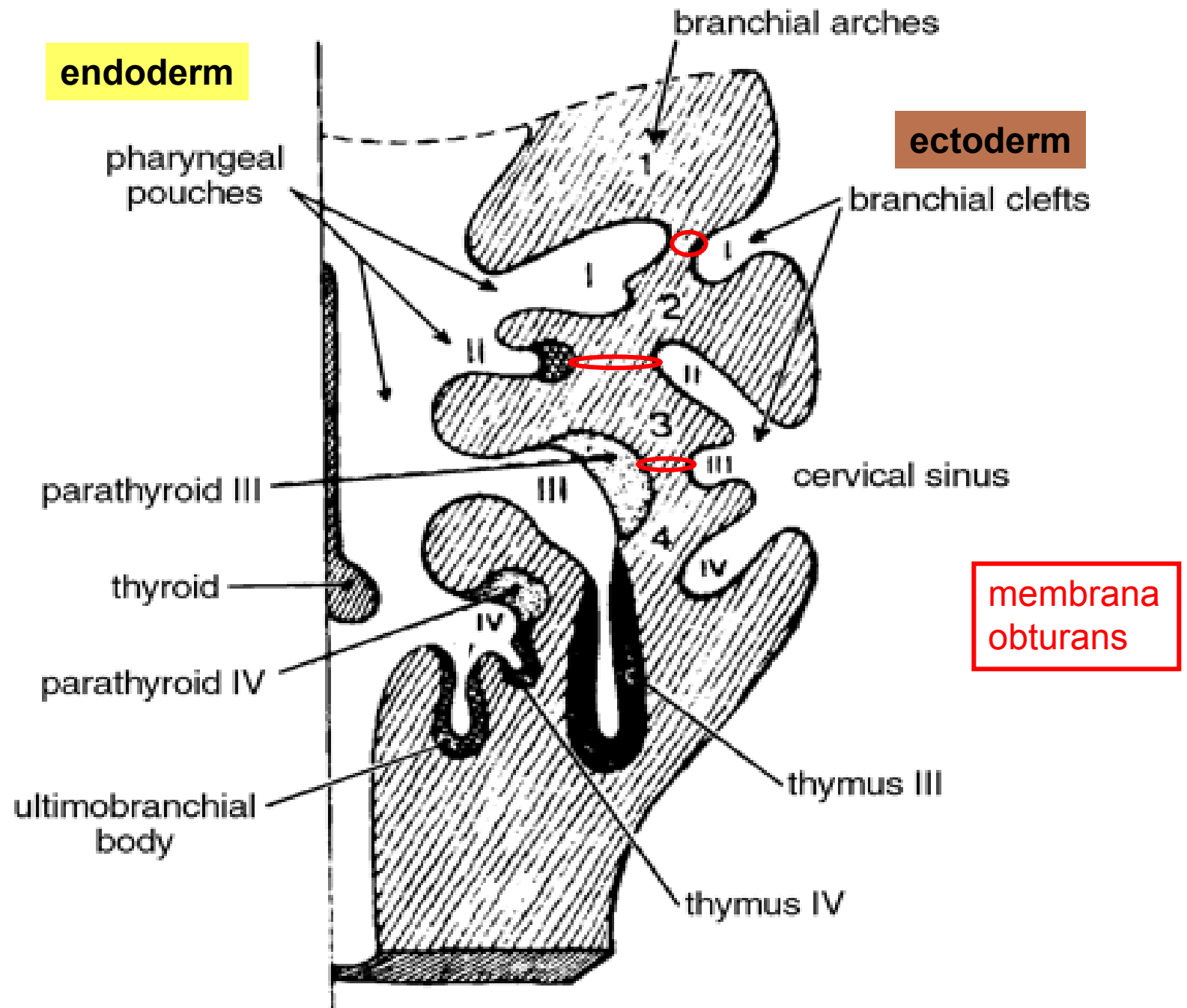


Endodermal pharyngeal pouches



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	

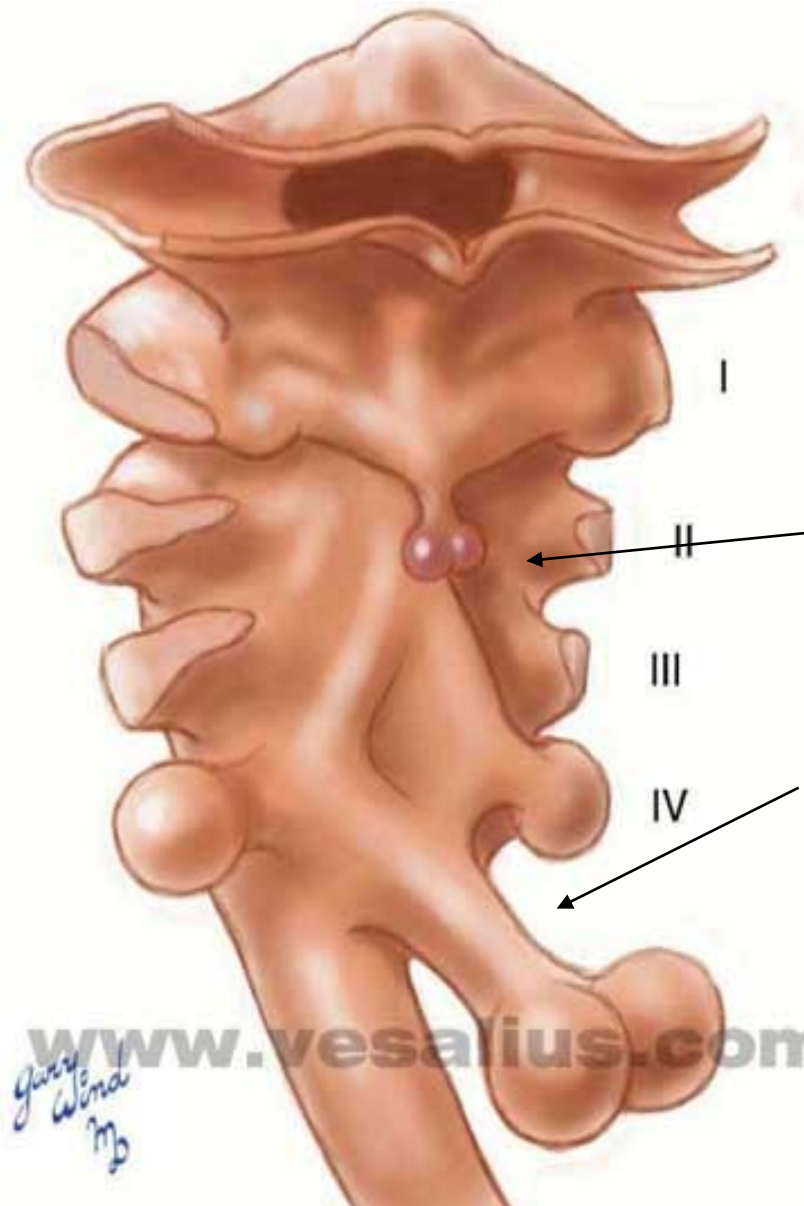
Esophagus development

below respiratory diverticle,
behind larynx and trachea

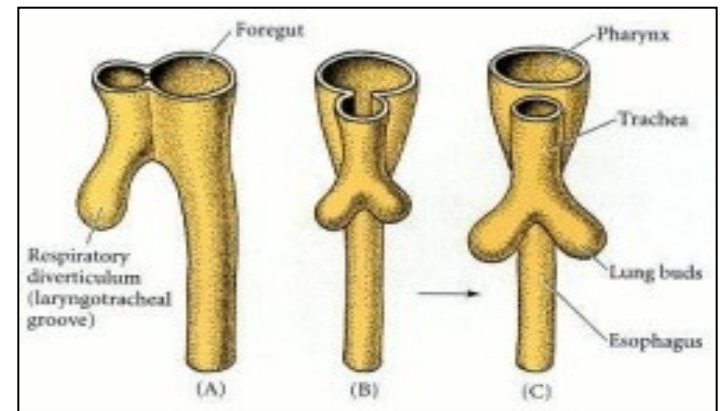
primitive pharynx

thyroid gl.

laryngotracheal diverticle
(respiratory diverticle)



esophagus

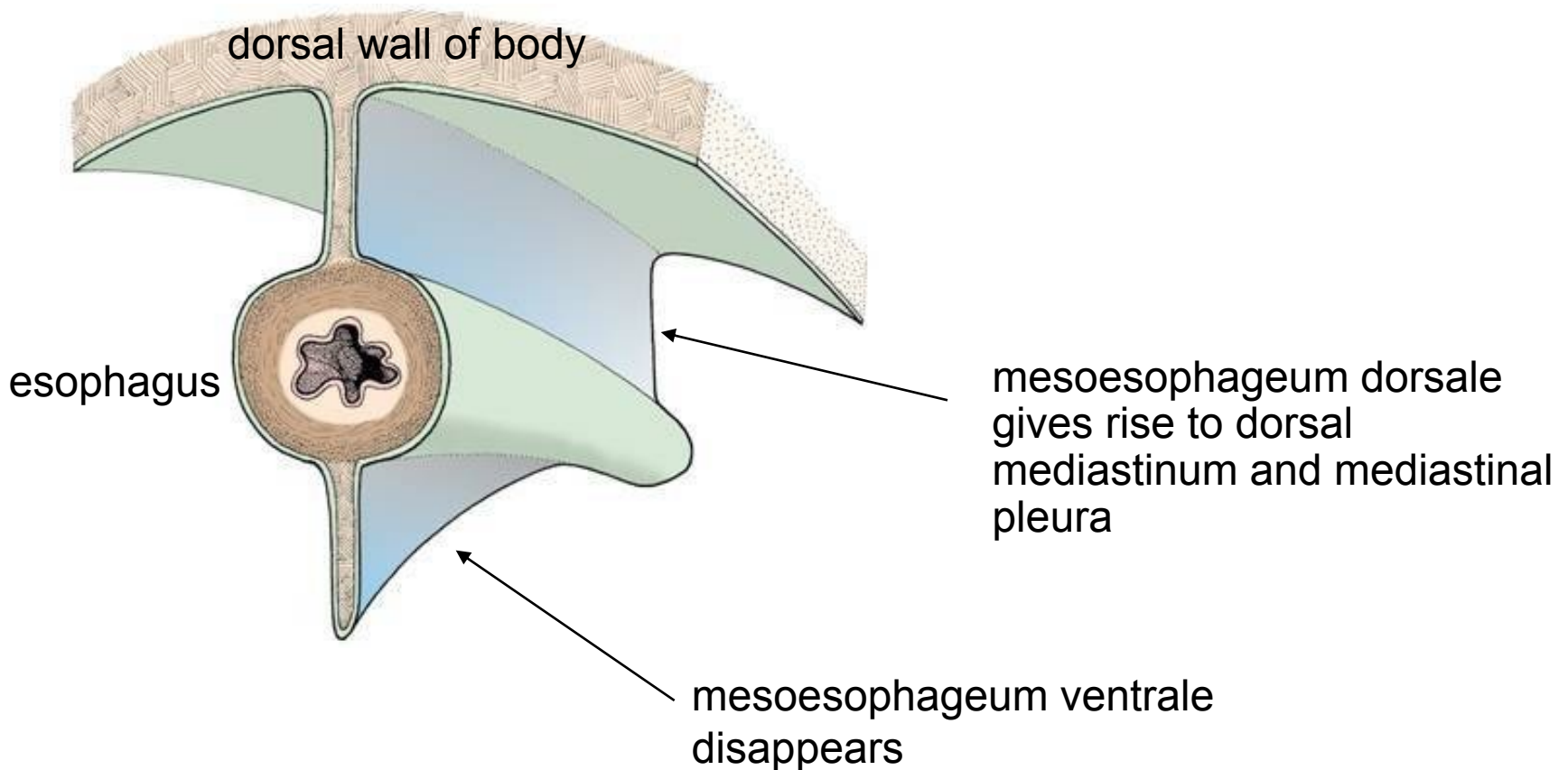


Esophagus development

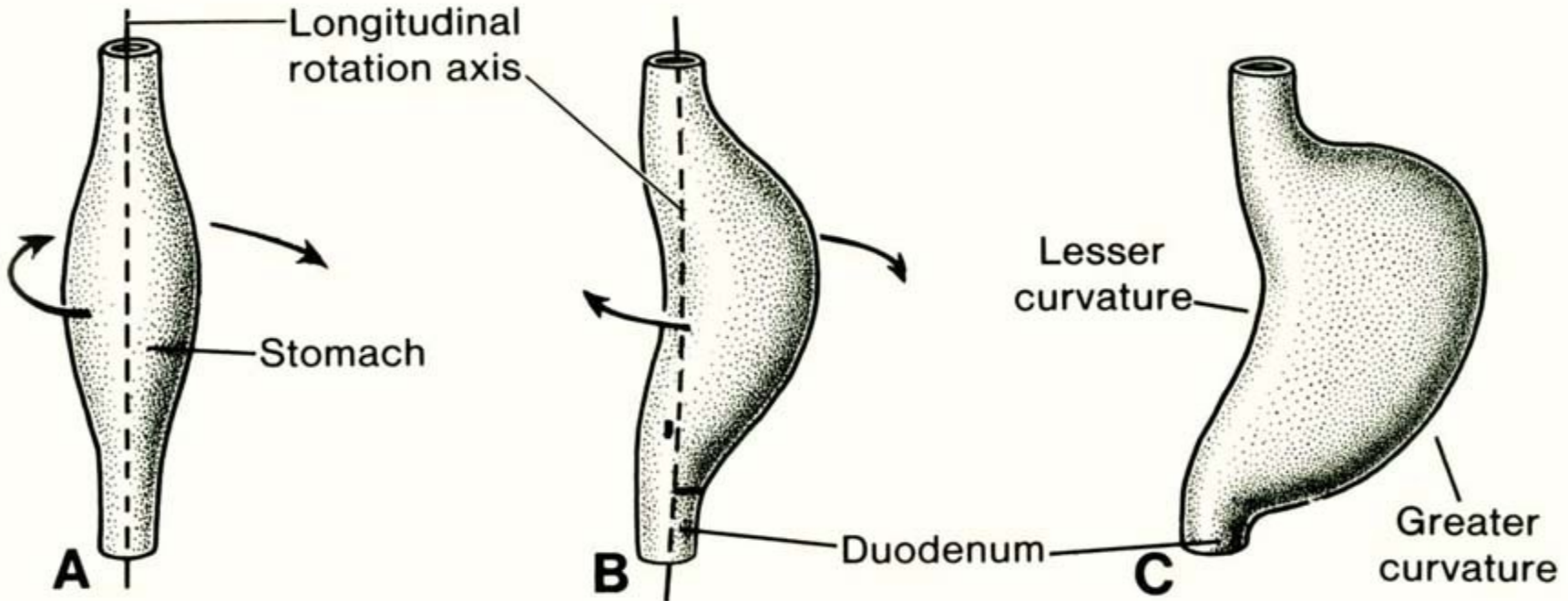
- differentiation of epithelium from endoderm
- during the 2nd month endoderm proliferates and temporarily closes esophageal lumen
- other tissues and structures in the wall arise from splanchnic mesoderm

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

mesoesophageum



Stomach development



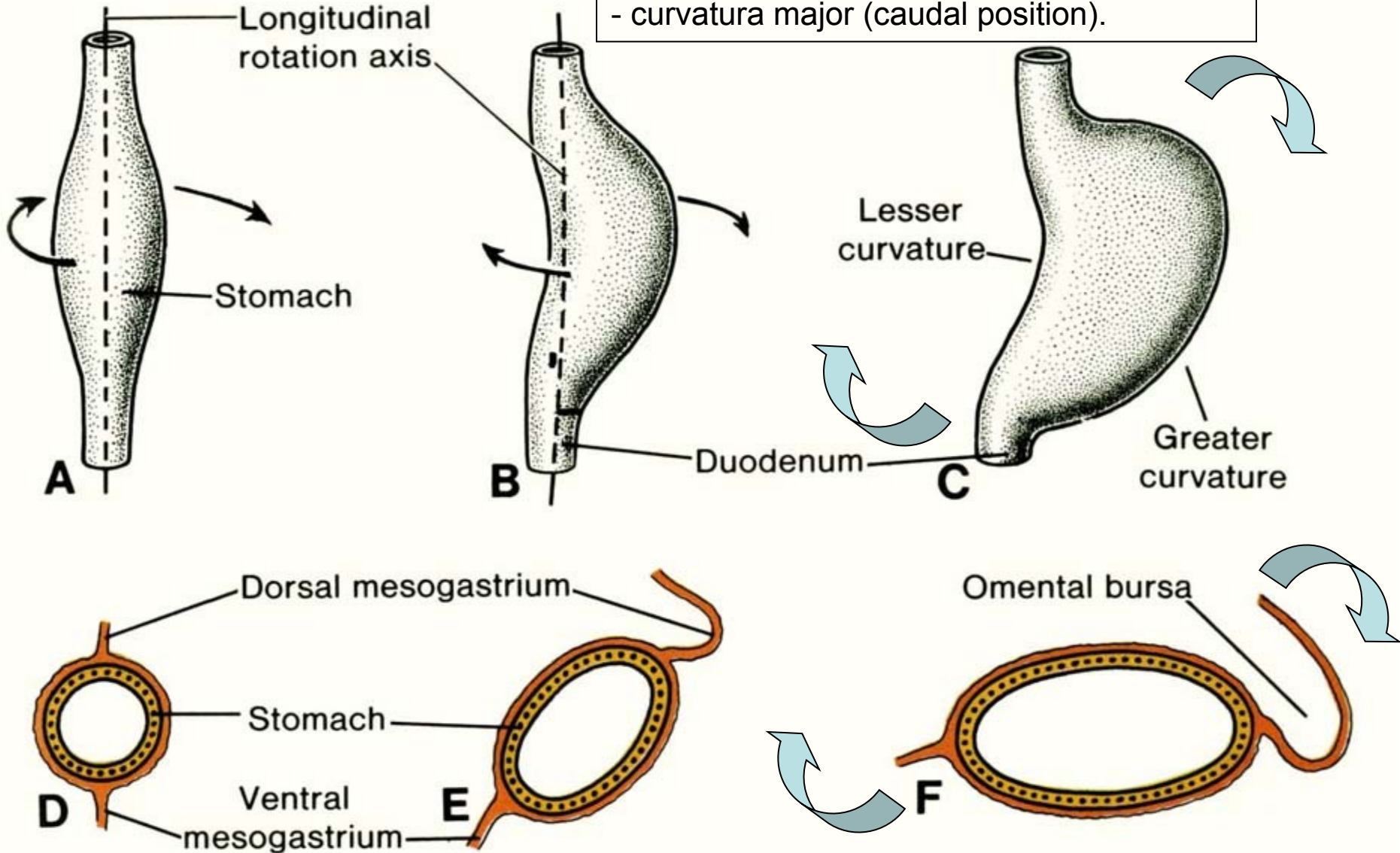
- in the 4th week – spindle dilatation of distal foregut
- endoderm – epithelium and glandular cells
- splanchnic mesoderm – other tissues of stomach wall

Rotation around longitudinal axis:

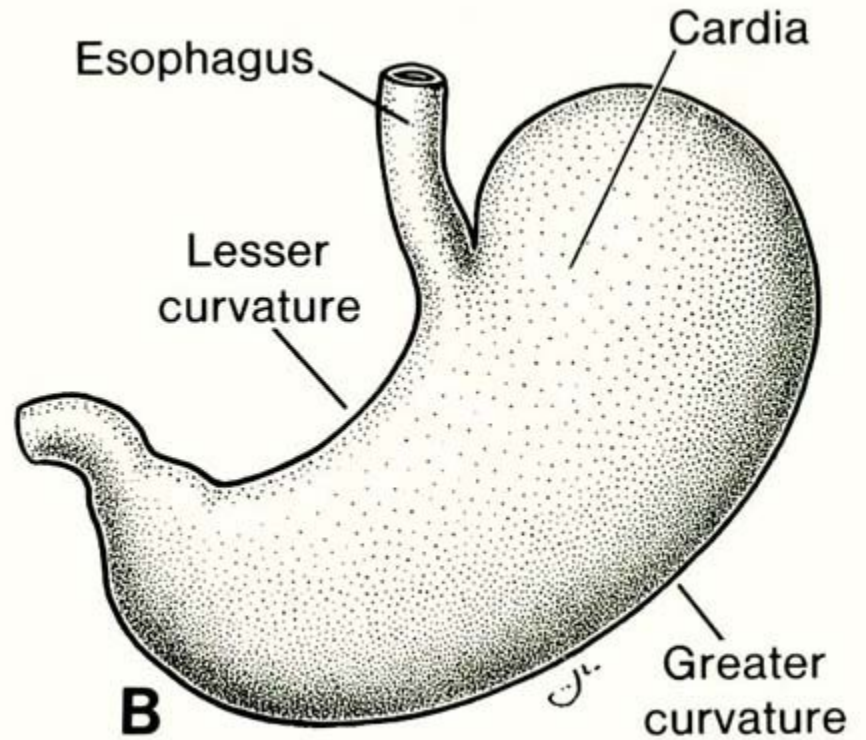
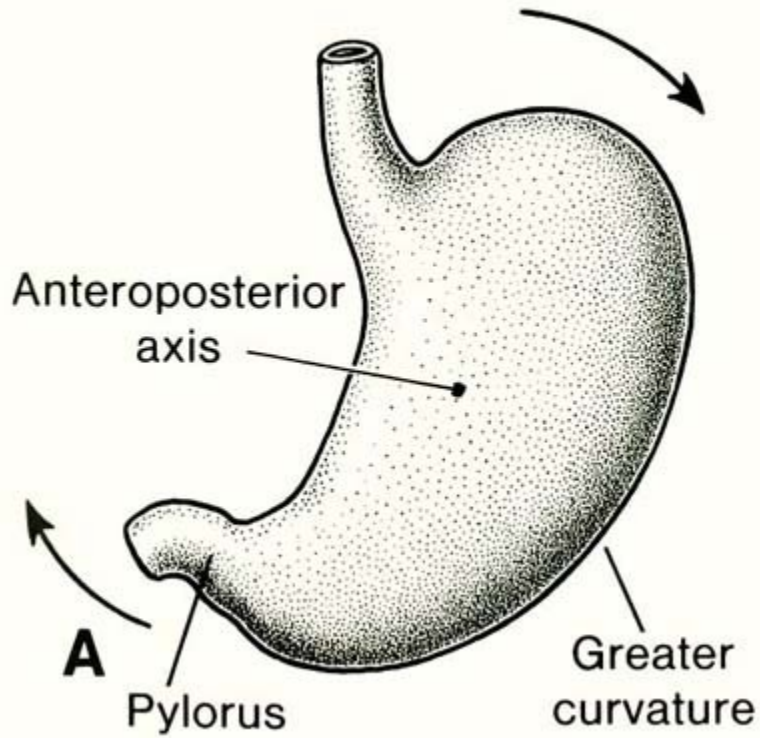
- left side → ventrally,
- right side → dorsally.

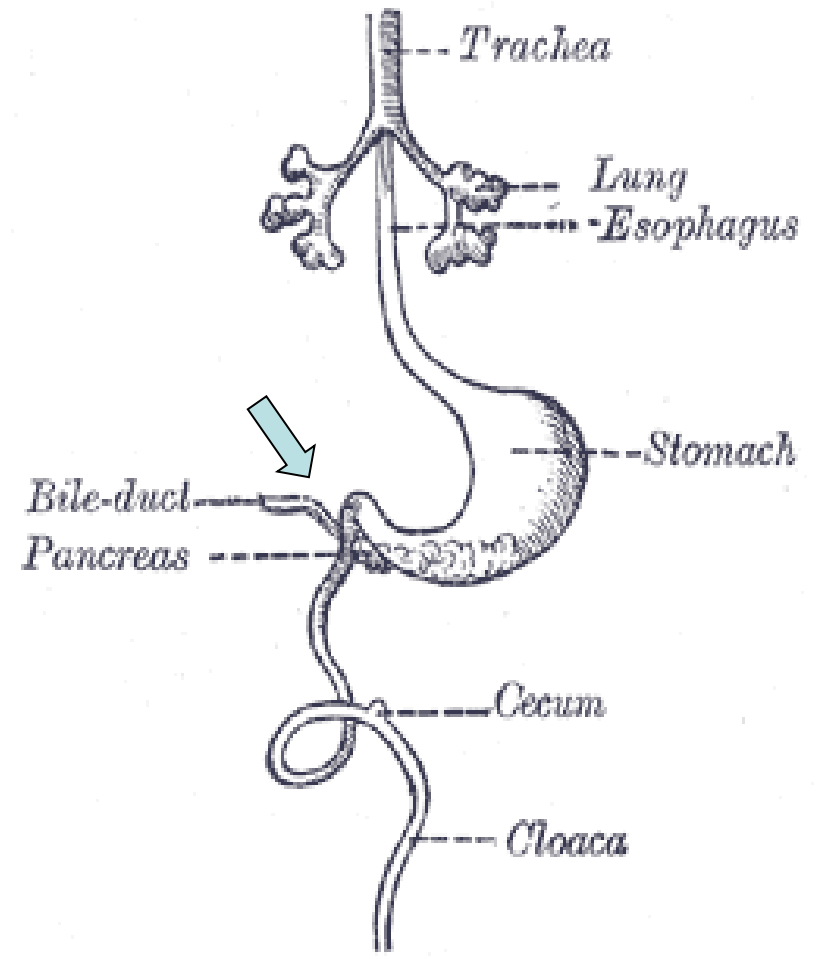
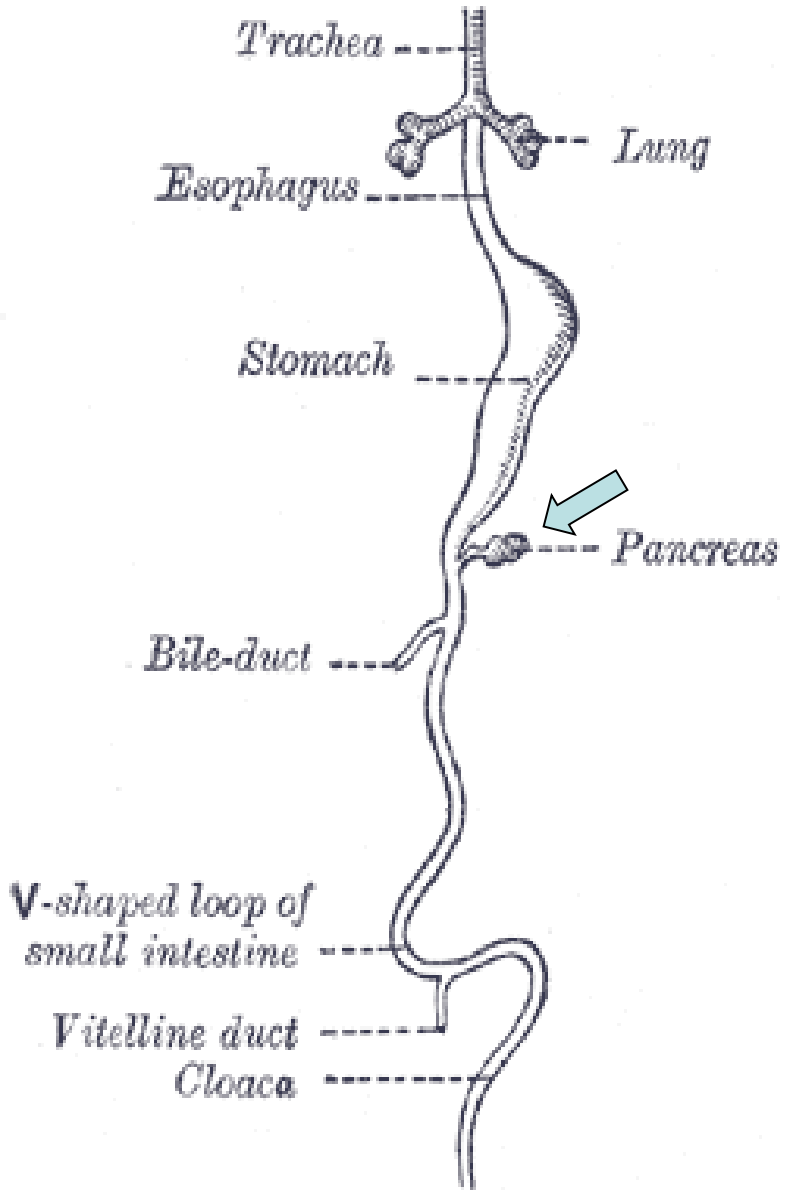
Uneven growth of ventral and dorsal wall:

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

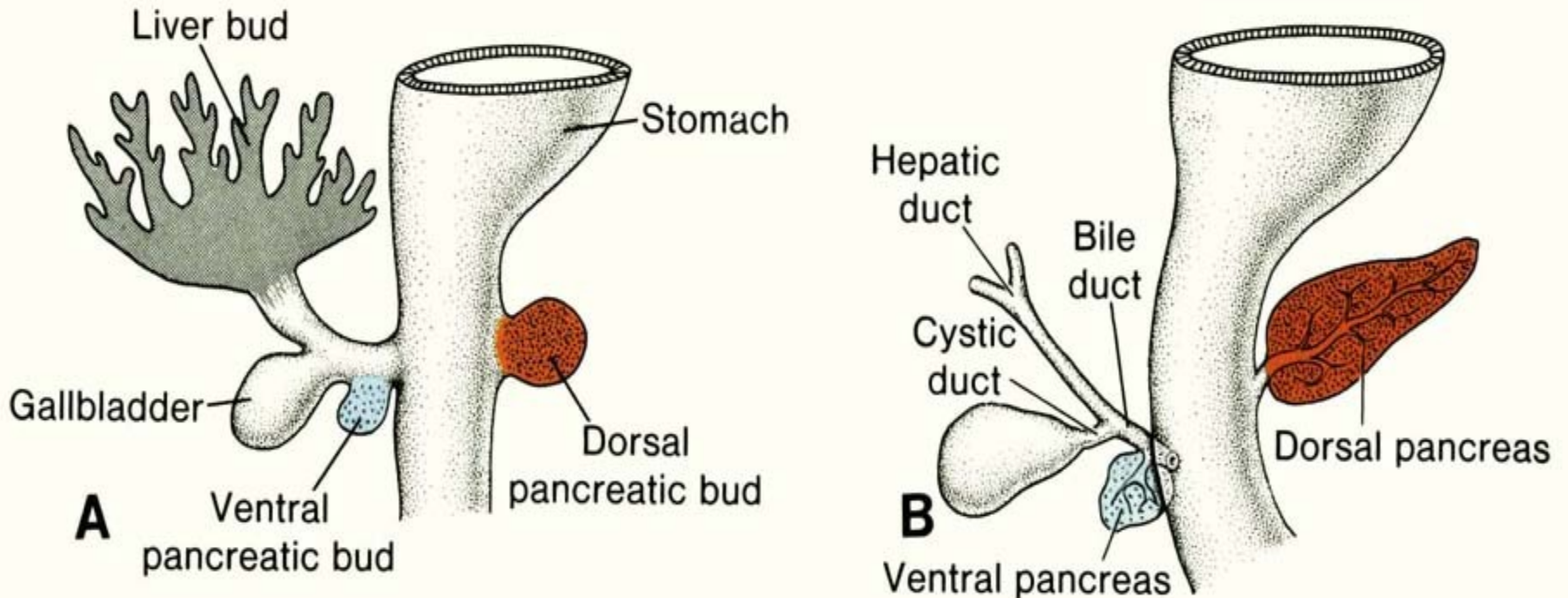


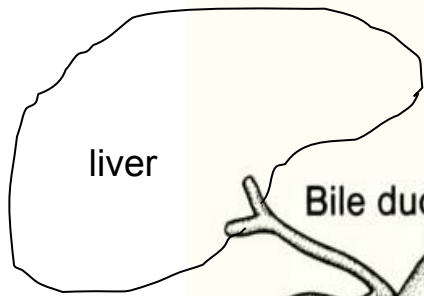
Sagittal rotation axis



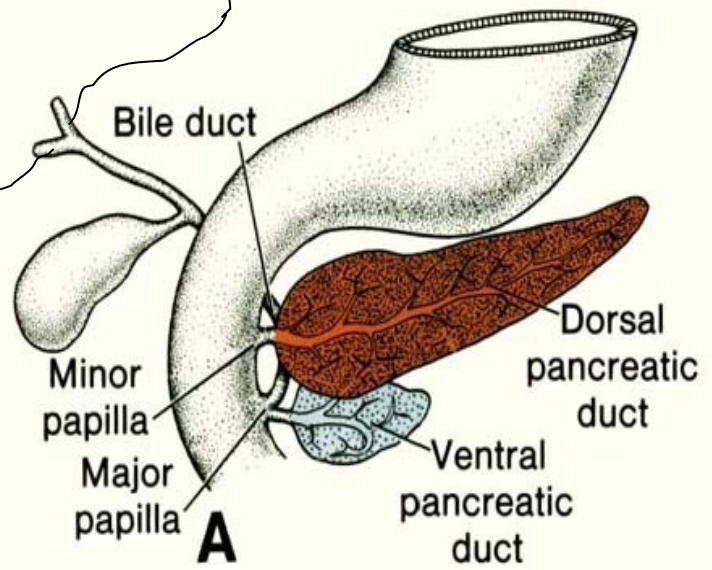


The liver bud (hepatocystic diverticle) appears at the distal end of the foregut (week 4) and divides into hepatic and cystic diverticles, later ventral pancreatic bud and dorsal pancreatic bud (week 5). Both pancreatic buds meet and fuse (week 6).



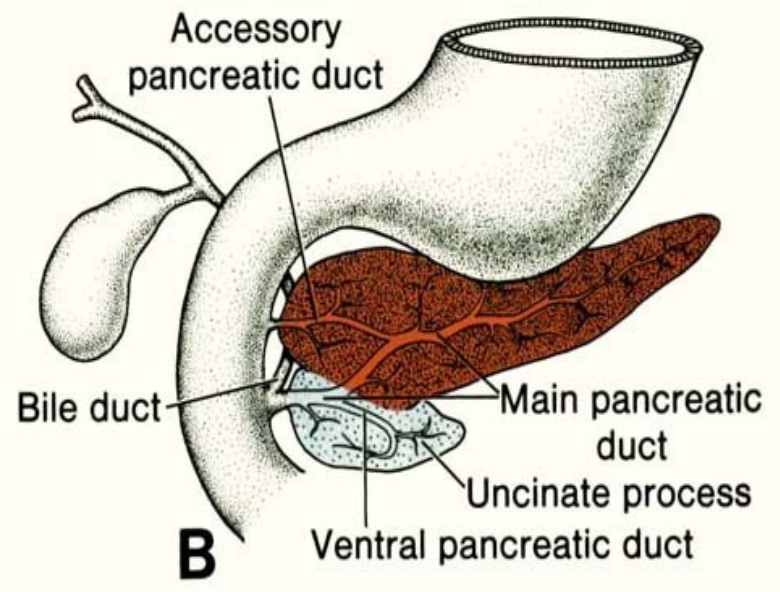


liver

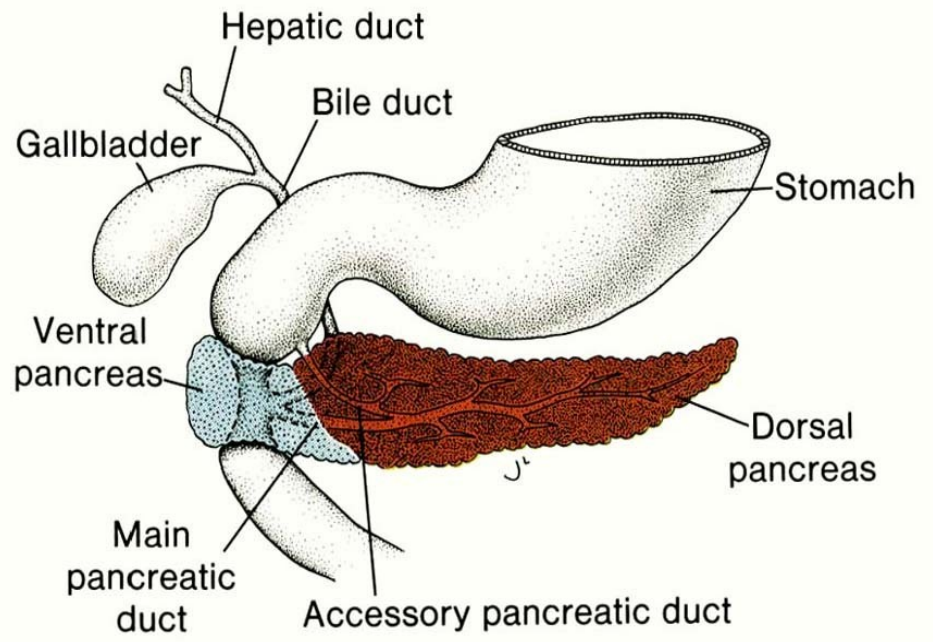


Bile duct
Minor papilla
Major papilla
A

Dorsal pancreatic duct
Ventral pancreatic duct



Accessory pancreatic duct
Bile duct
Main pancreatic duct
Uncinate process
Ventral pancreatic duct
B



Hepatic duct
Gallbladder
Bile duct
Stomach
Ventral pancreas
Dorsal pancreas
Main pancreatic duct
Accessory pancreatic duct

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.

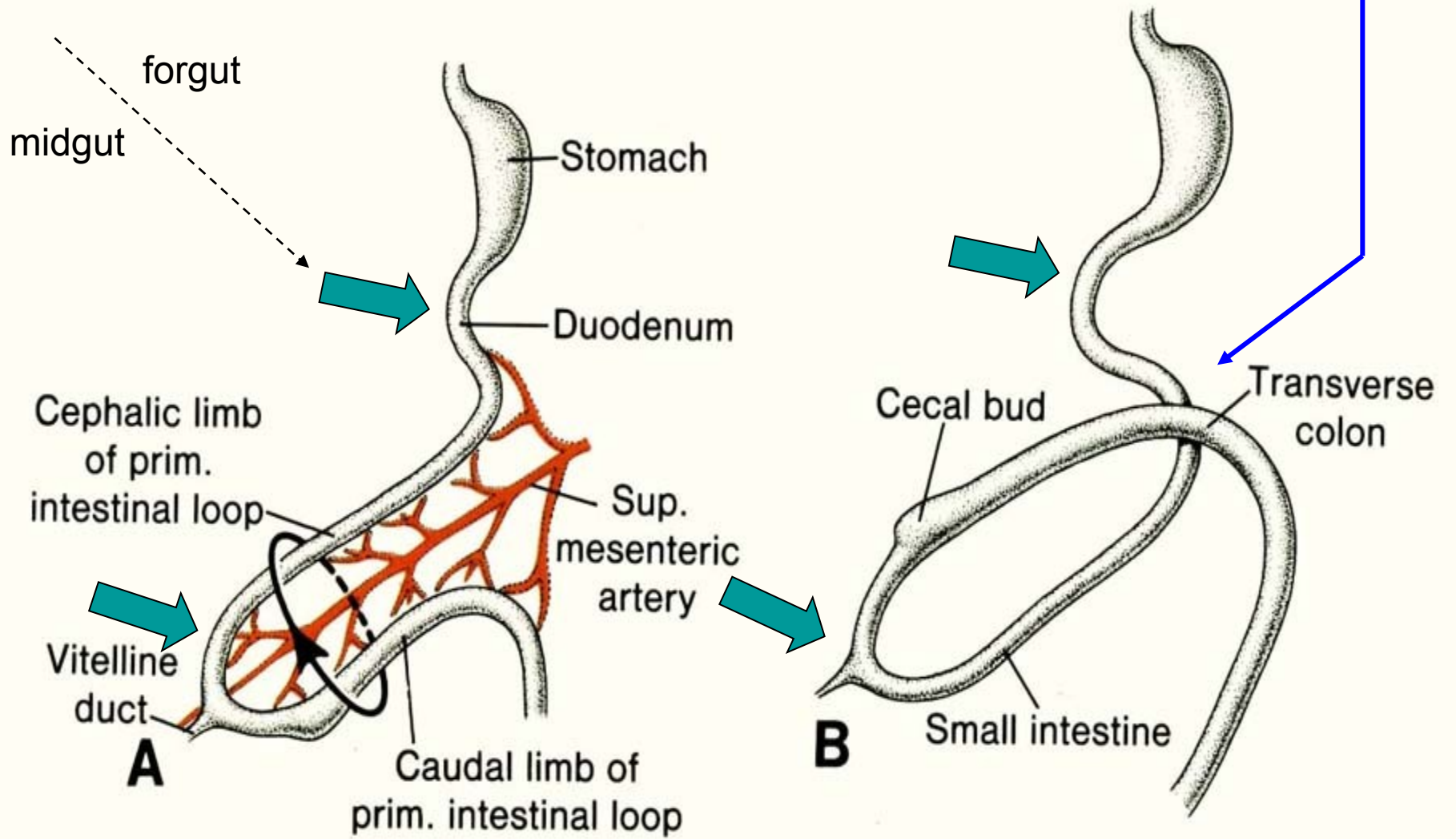
The derivatives of the caudal limb - the distal ileum, cecum, appendix, ascending colon, and proximal 2/3 of transverse colon.

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

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

Duodenal loop and umbilical loop

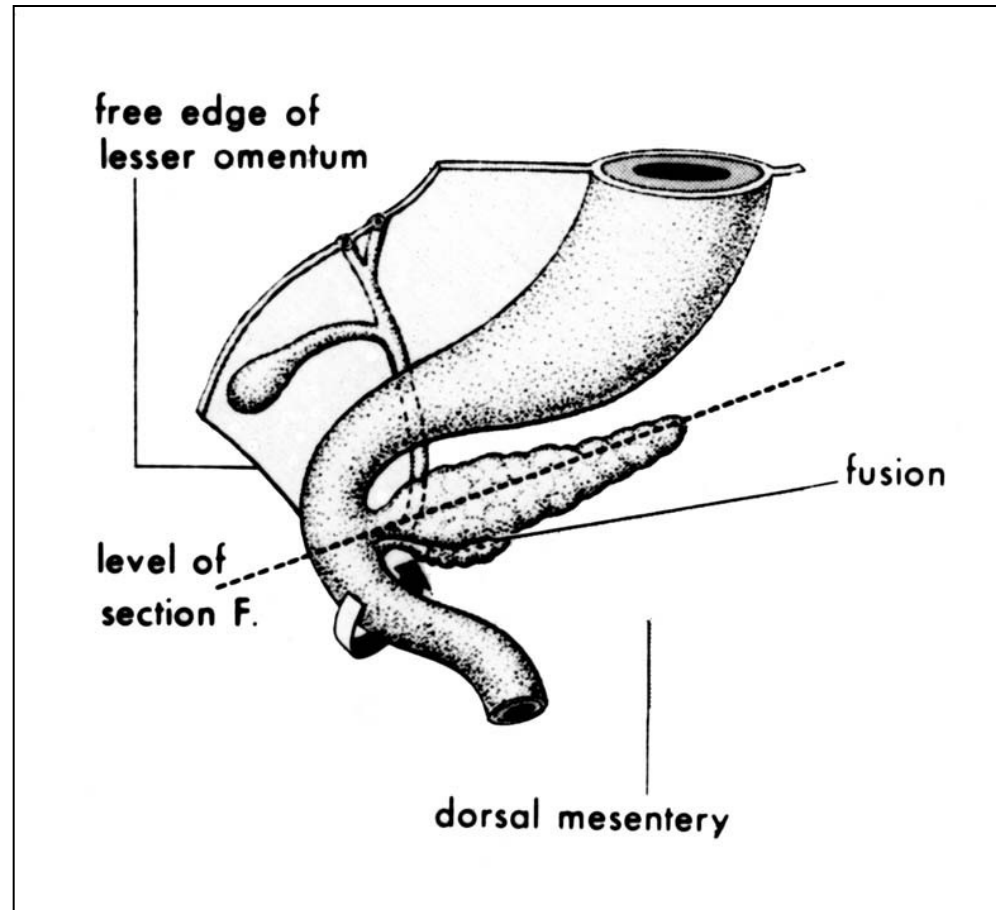
Flexura duodenojejunalis



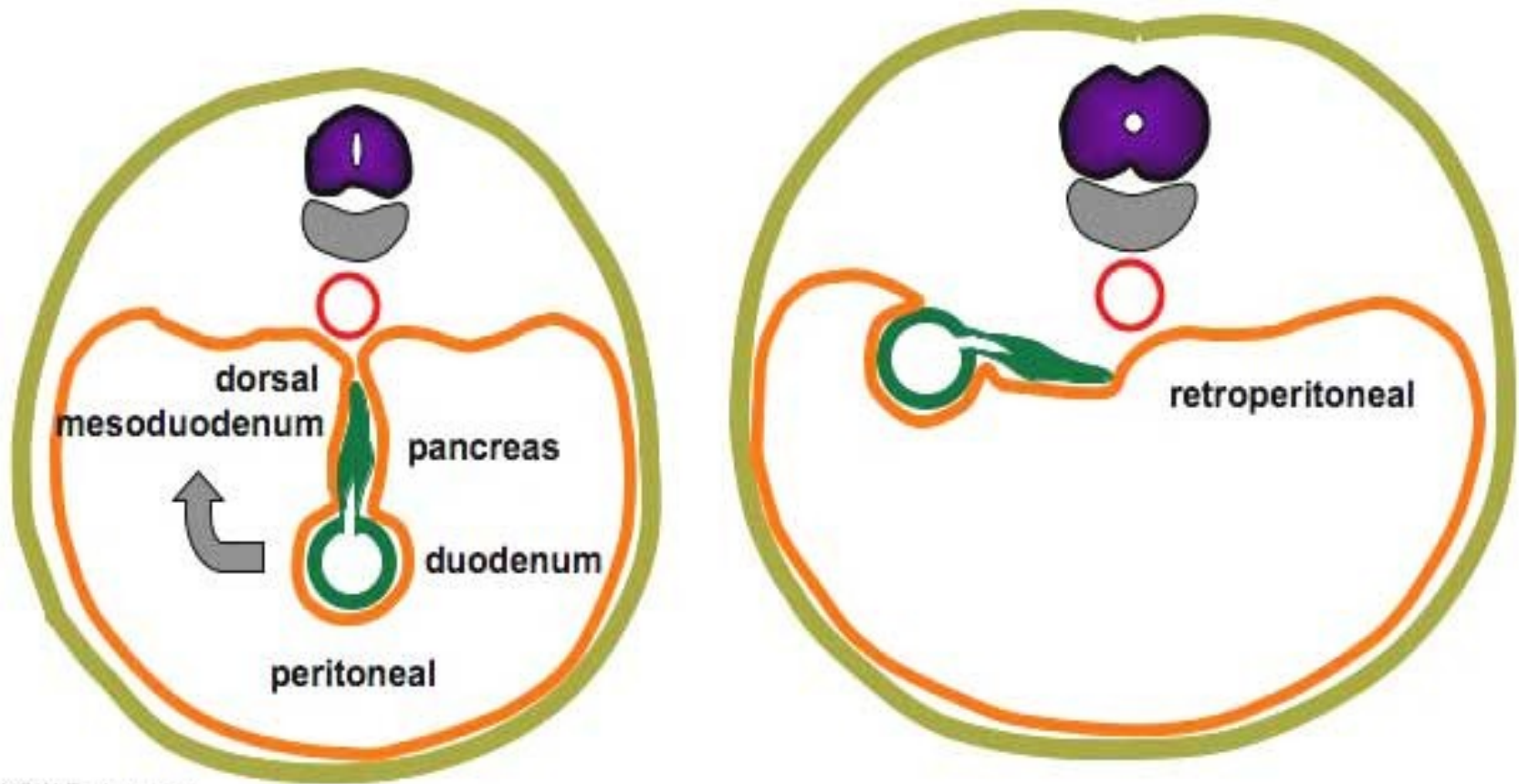
Umbilical loop herniates into the umbilical cord (**physiologic herniation**, in week 6-10)

Duodenum development

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

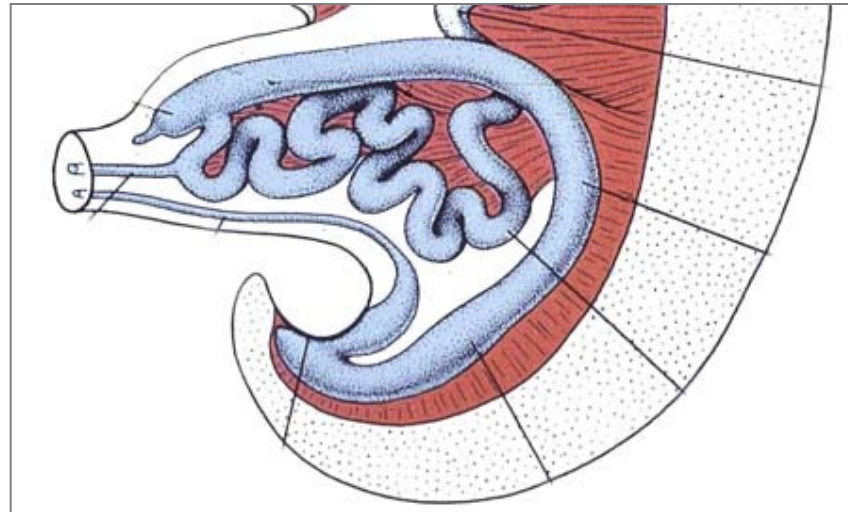


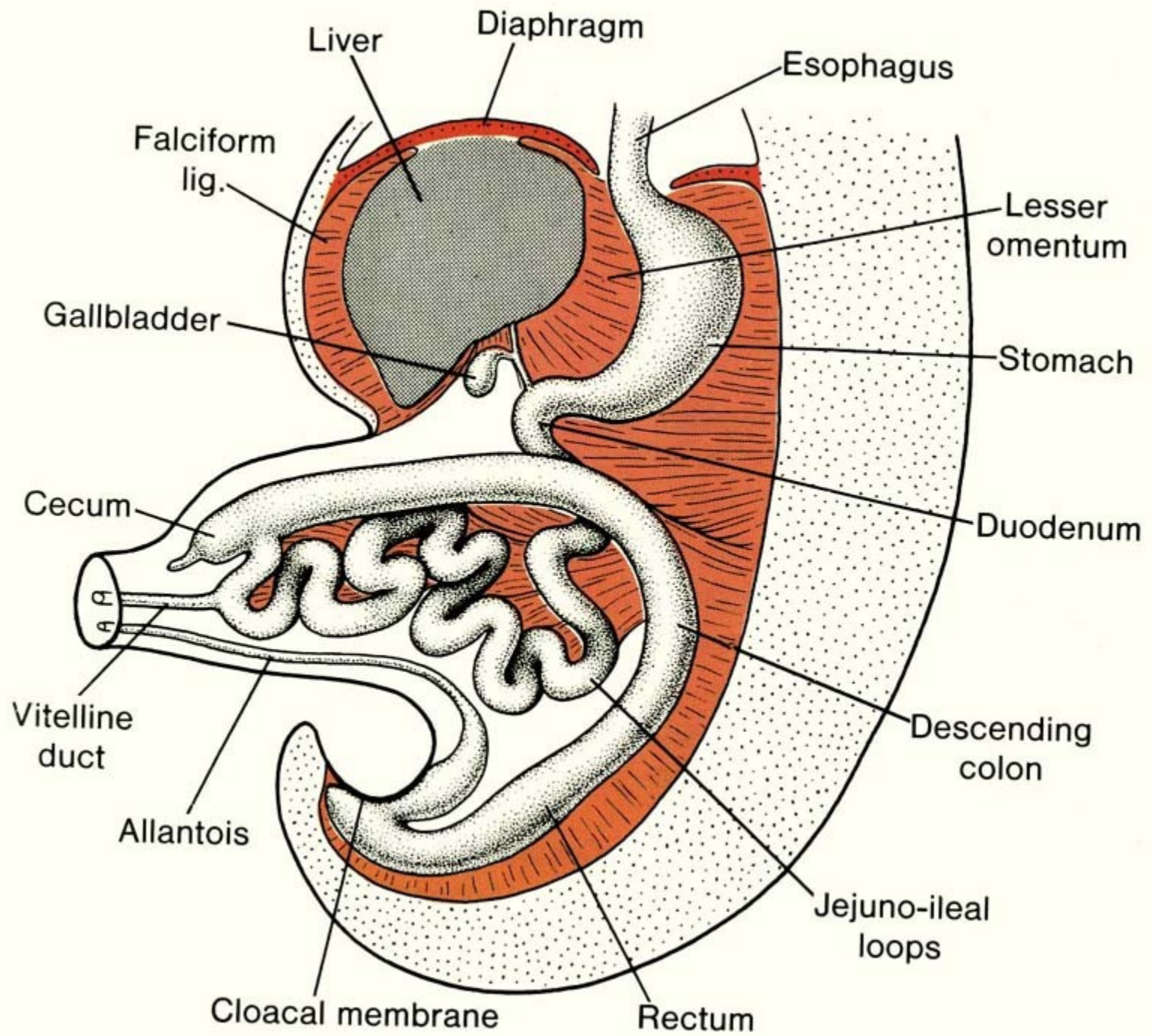
Due to rotation of umbilical loop, duodenal loop changes its position (from front to the right) and becomes retroperitoneal organ (together with pancreas)

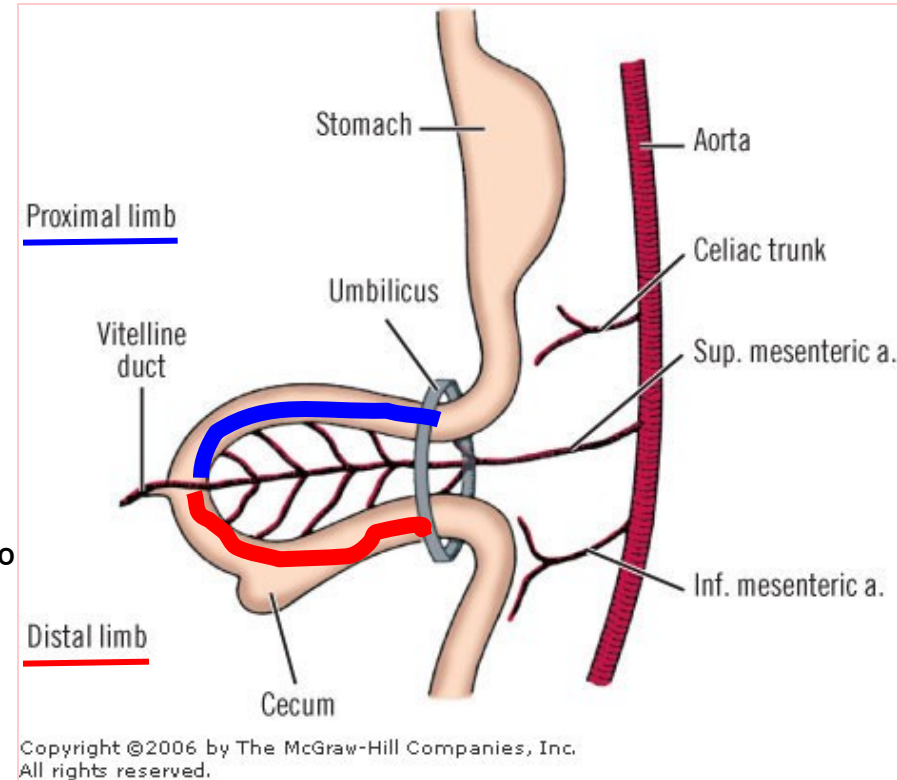
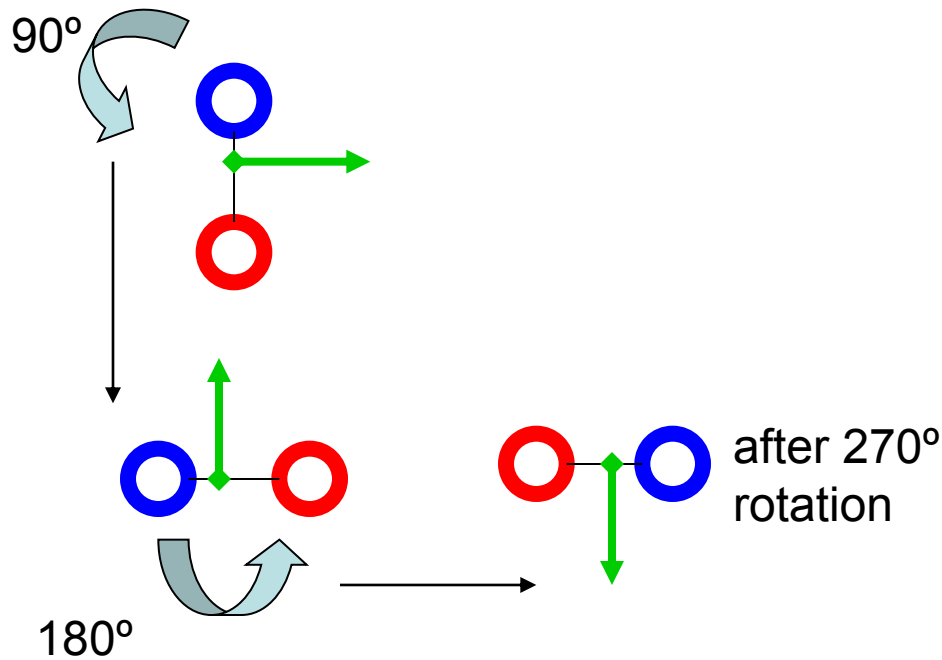


Intestines development

- 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





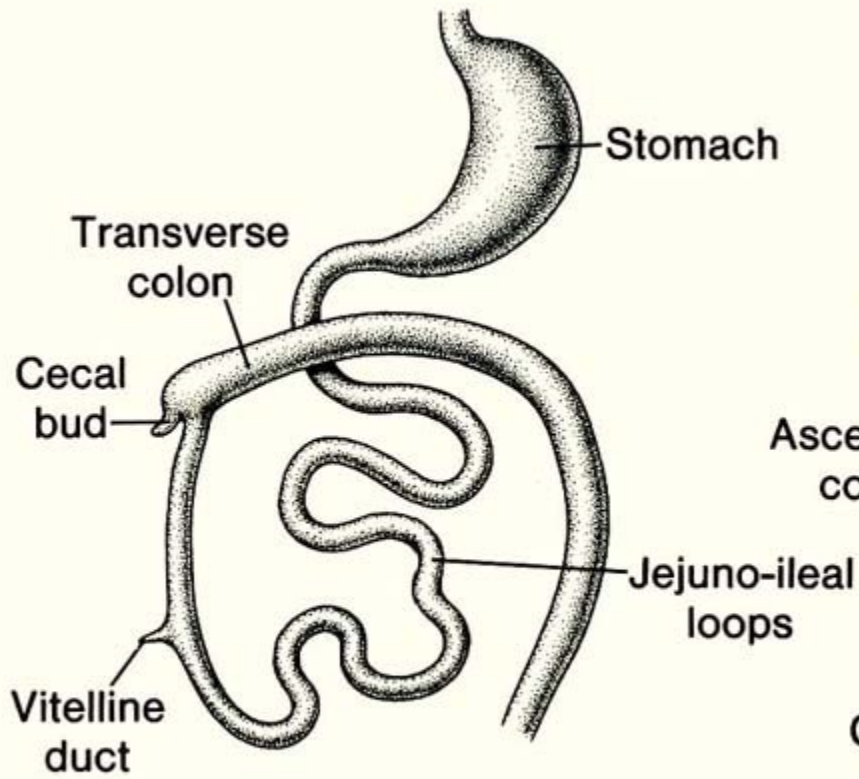


- In the umbilical cord, the midgut loop rotates **90°** counter-clockwise around the axis of the superior mesenteric artery.
- Upon returning, the gut undergoes another **180°** counter-clockwise rotation, placing the cecum and appendix near the right lobe of the liver.
- The total rotation of the gut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

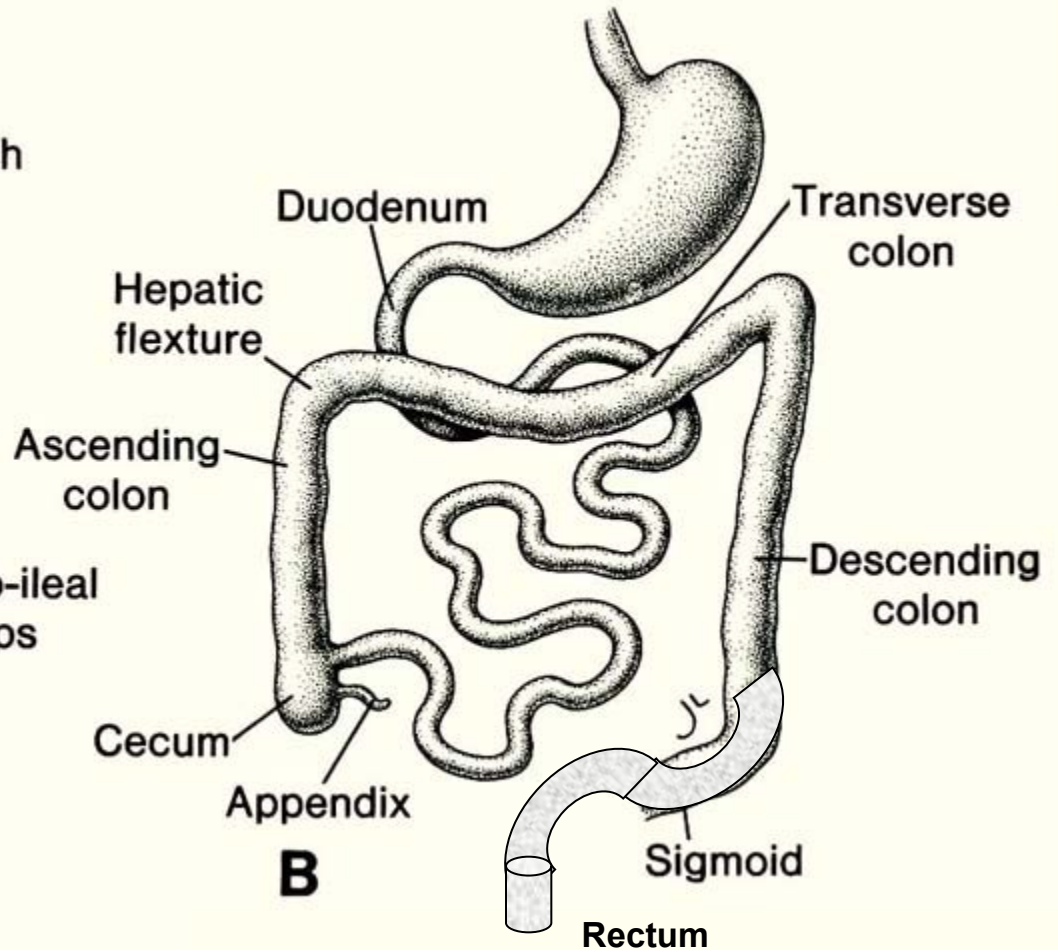
Hindgut

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

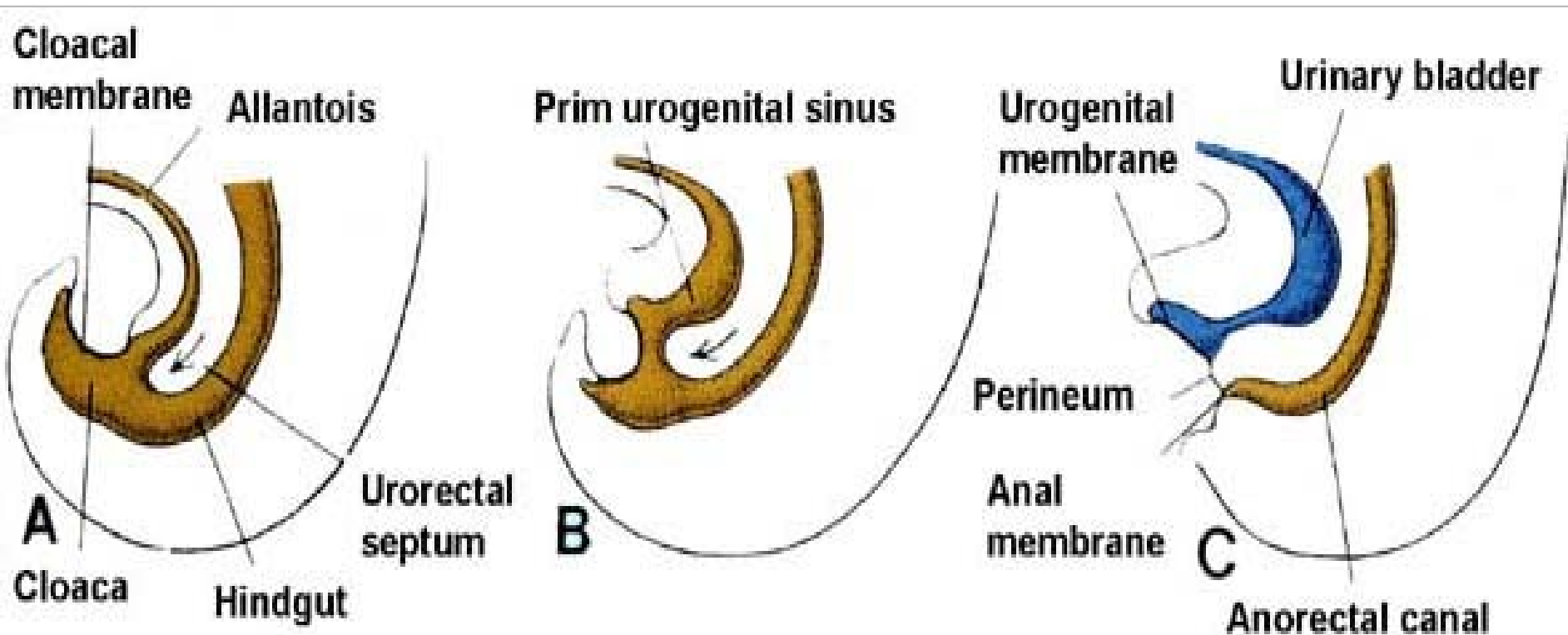


B

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

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

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

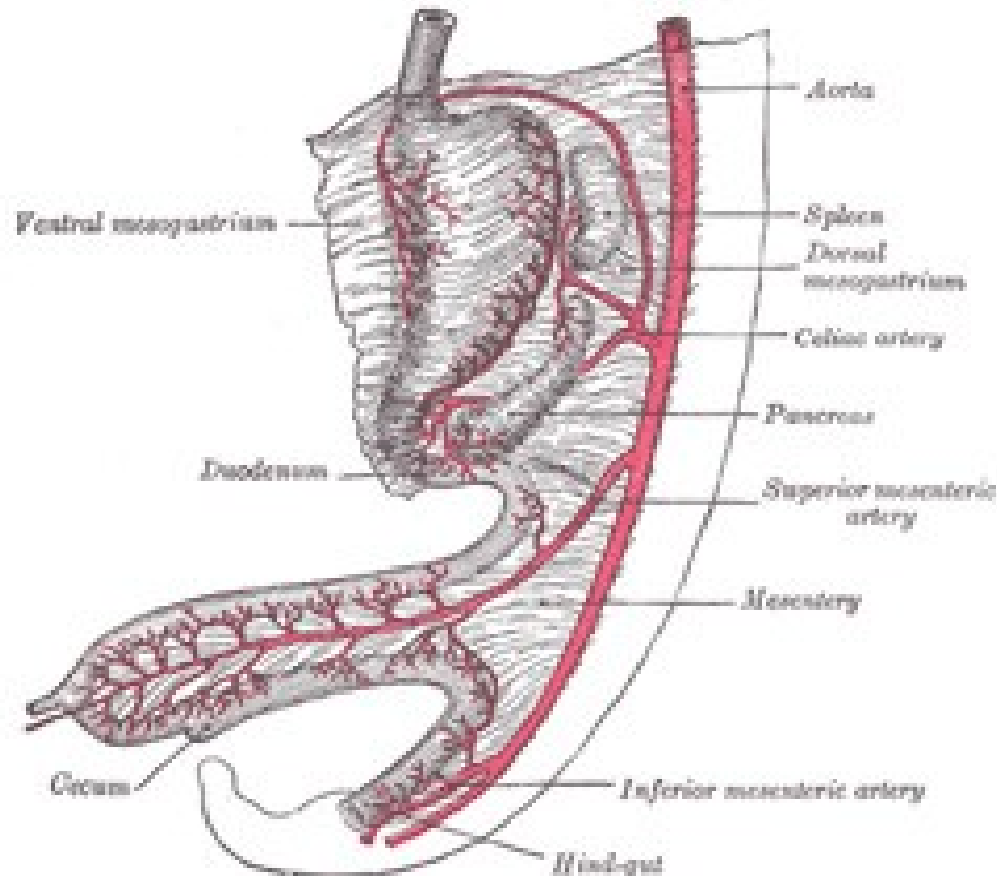


Mesenteries

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

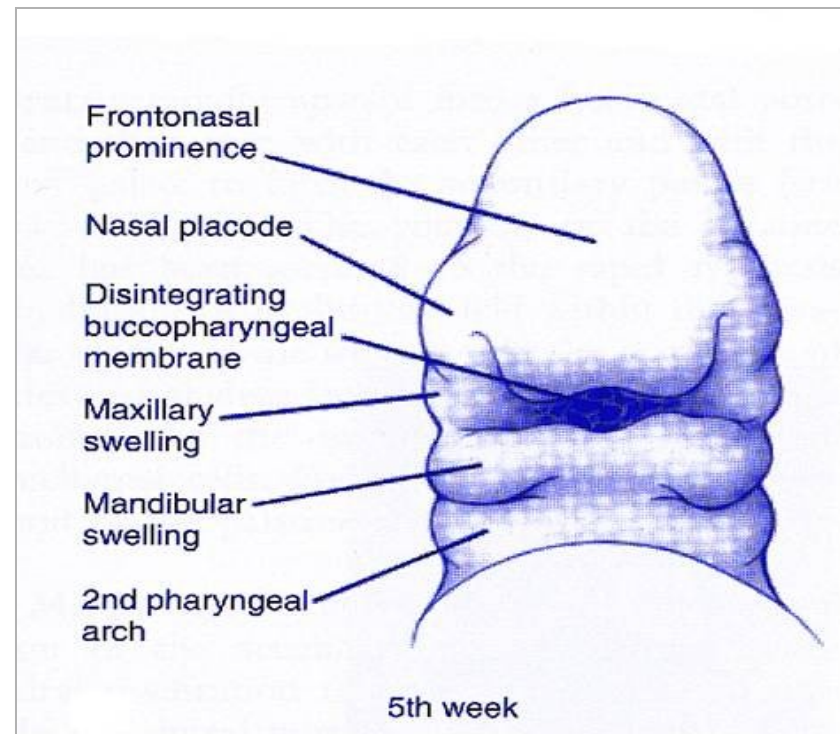
Ventral mesentery exists only in region of distal part of esophagus, stomach (lesser omentum) and upper part of duodenum

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



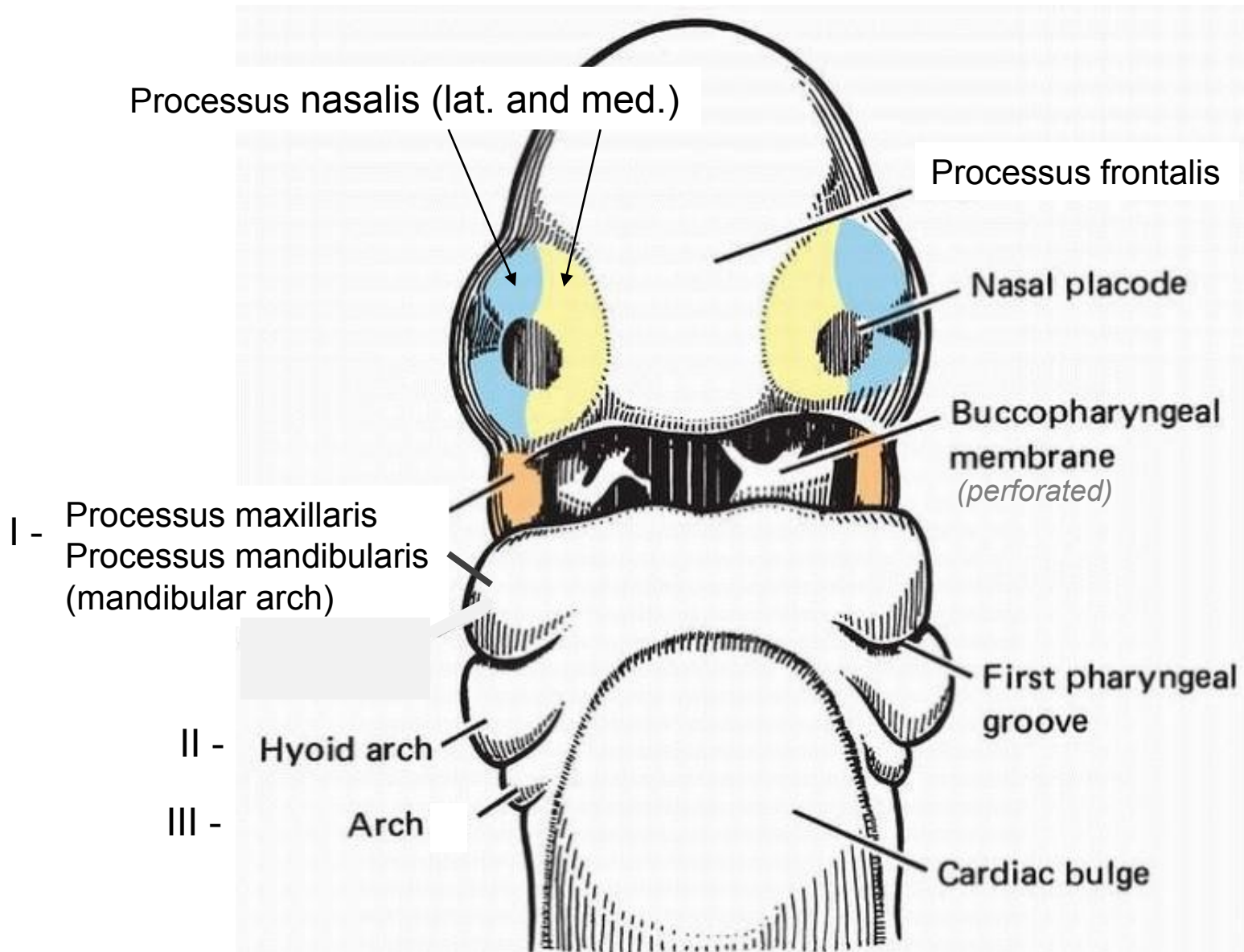
Stomodeum and face development

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

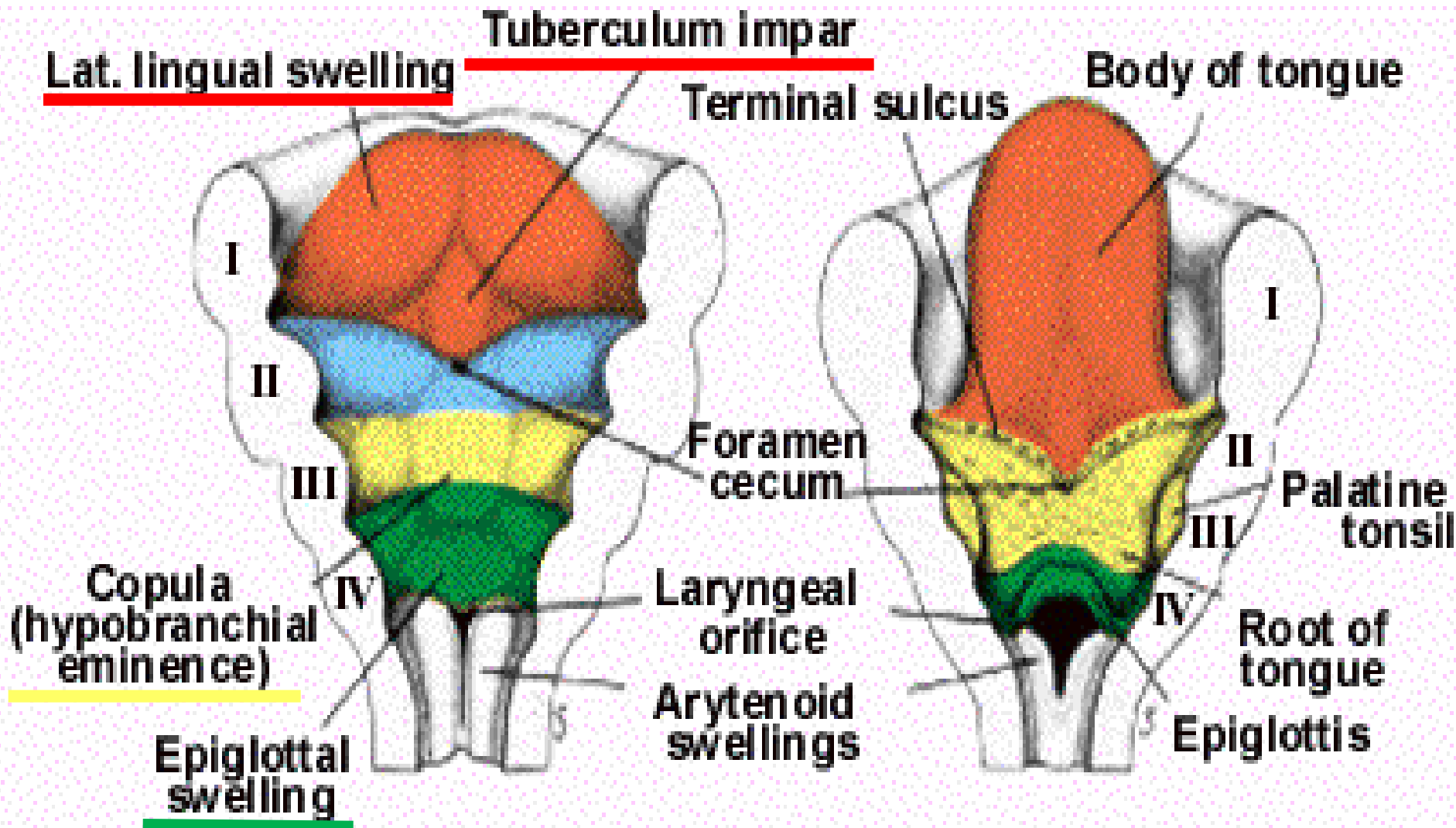


Frontal view of an embryo at 4 to 5 weeks of age.

Observe the branchial arch formation and the ruptured buccopharyngeal membrane.

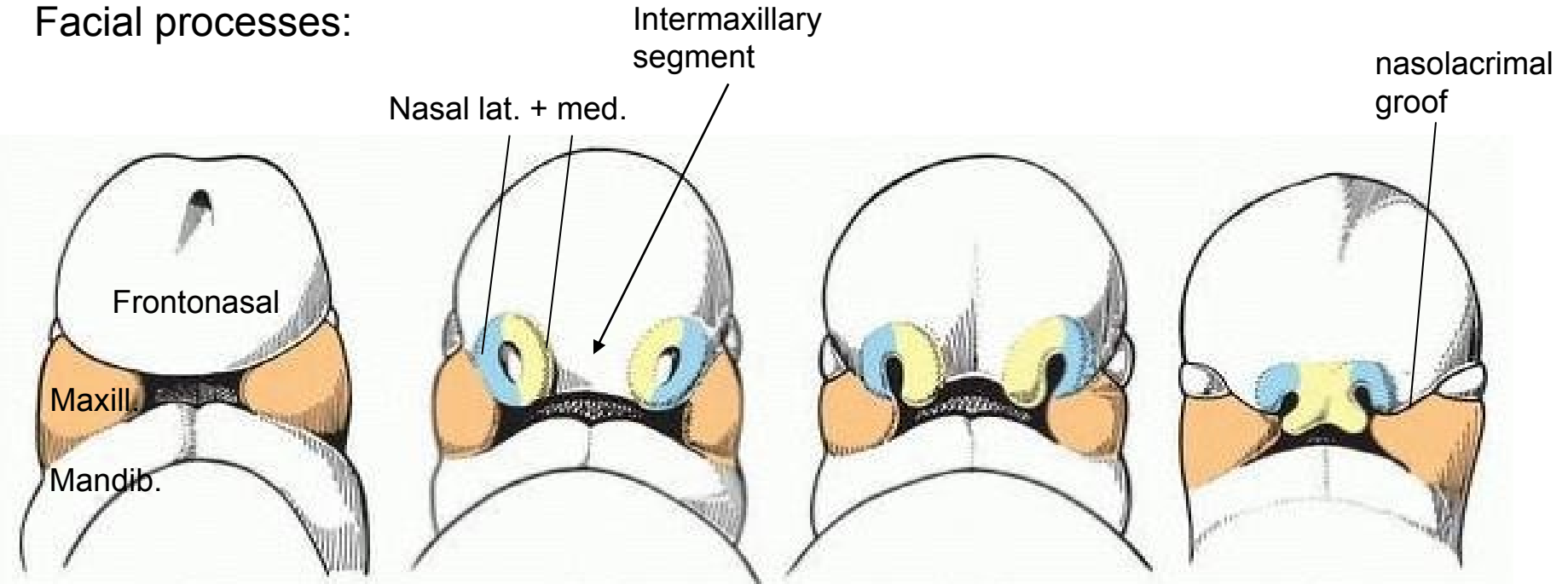


Development of the tongue (from pharyngeal arches)



Developing face

Facial processes:

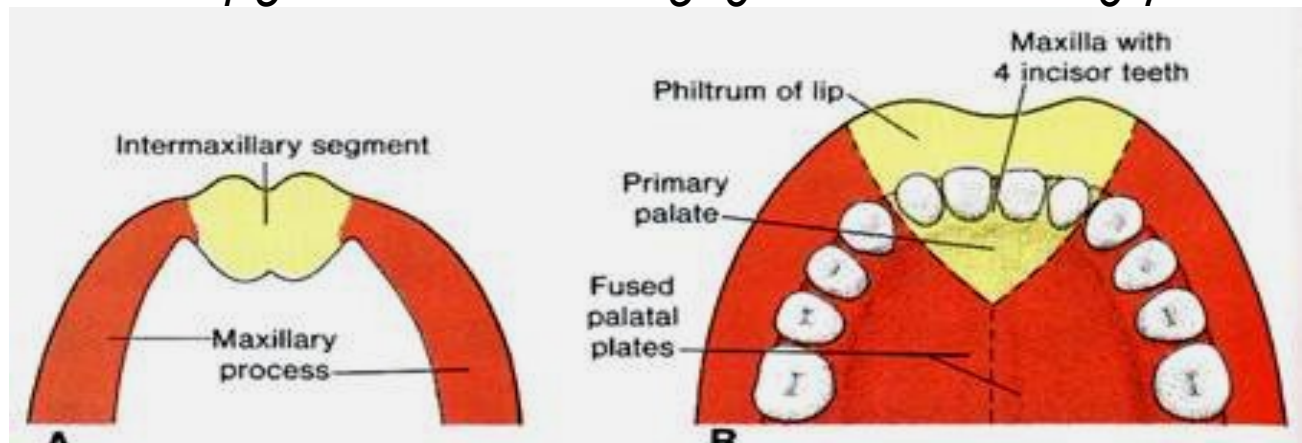


week 4

4-5

5-6

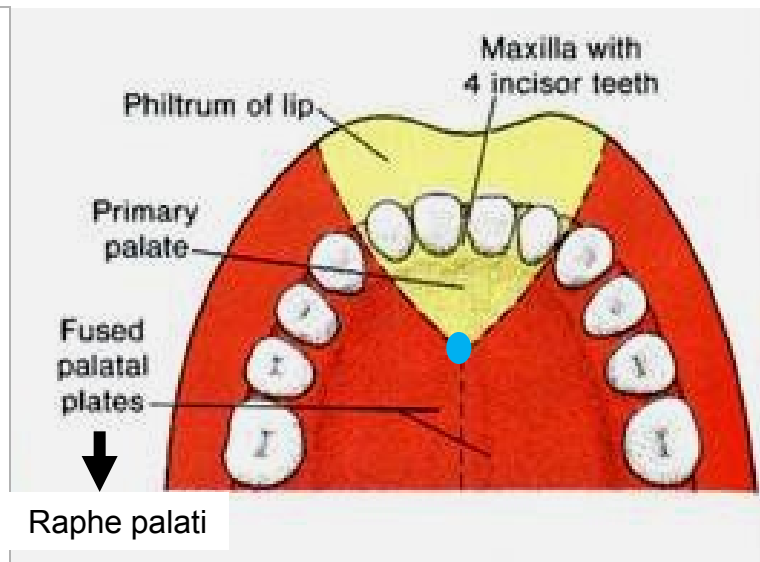
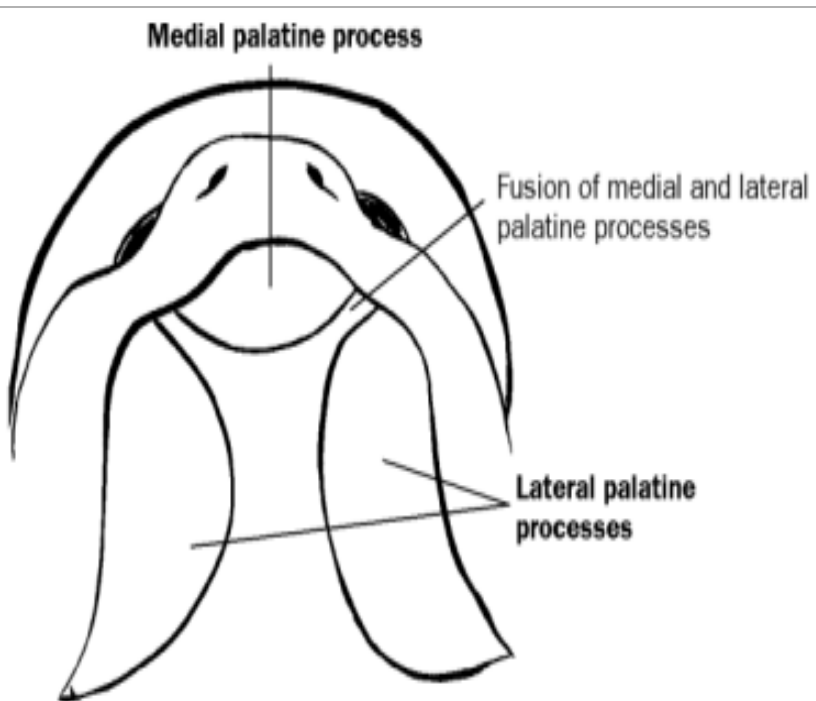
6-7

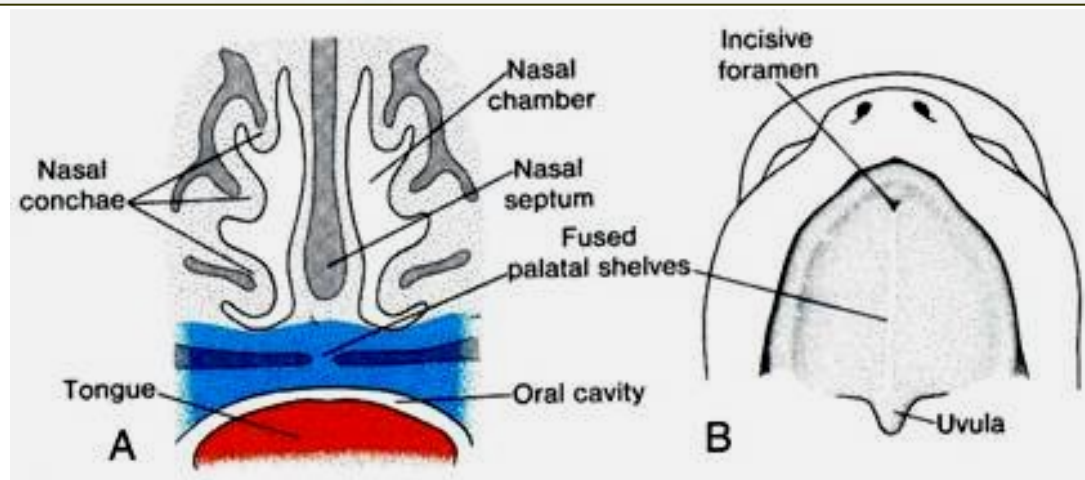
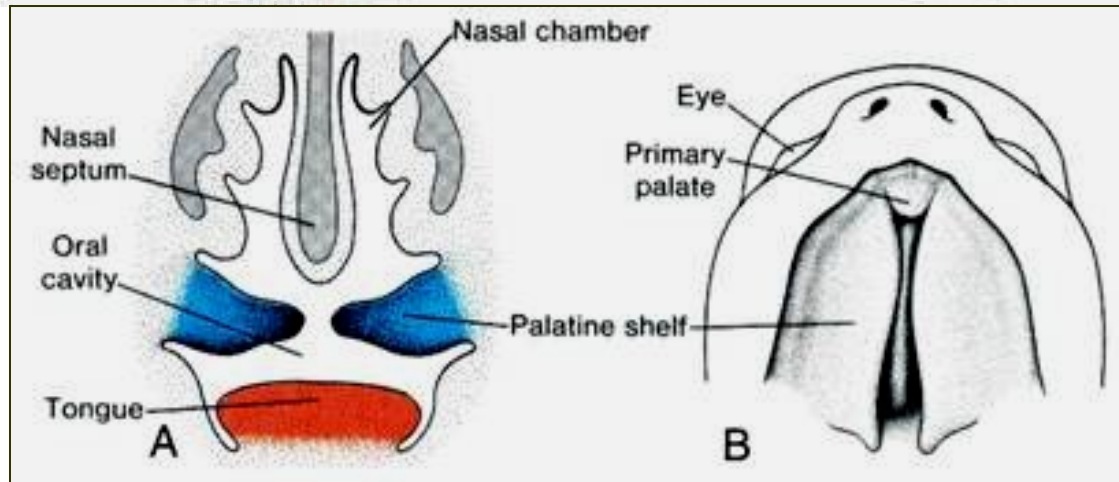
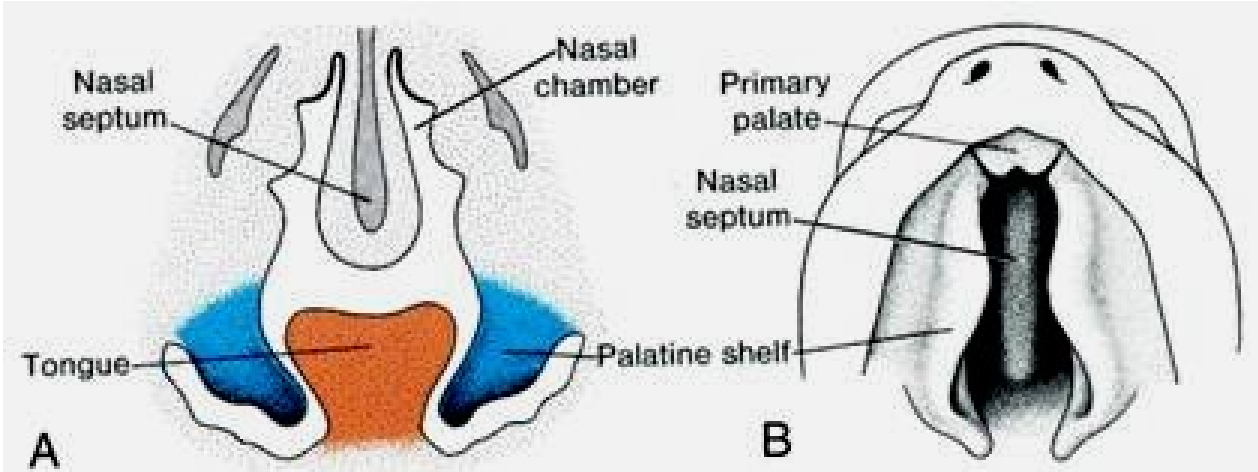


Palate development

3 ectoderm-mesenchymal 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

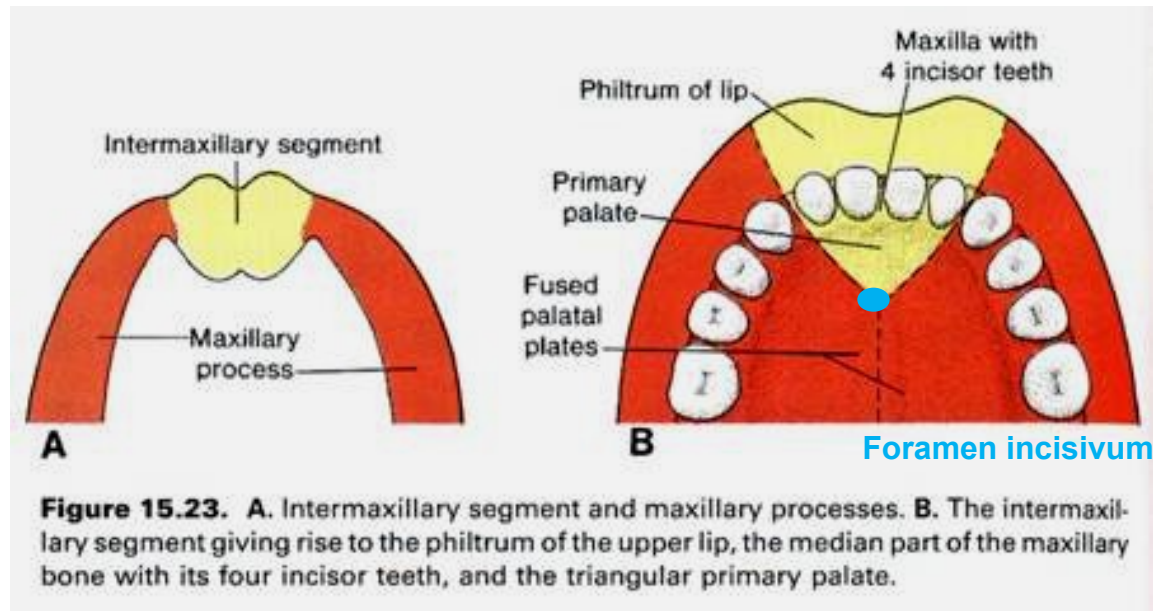
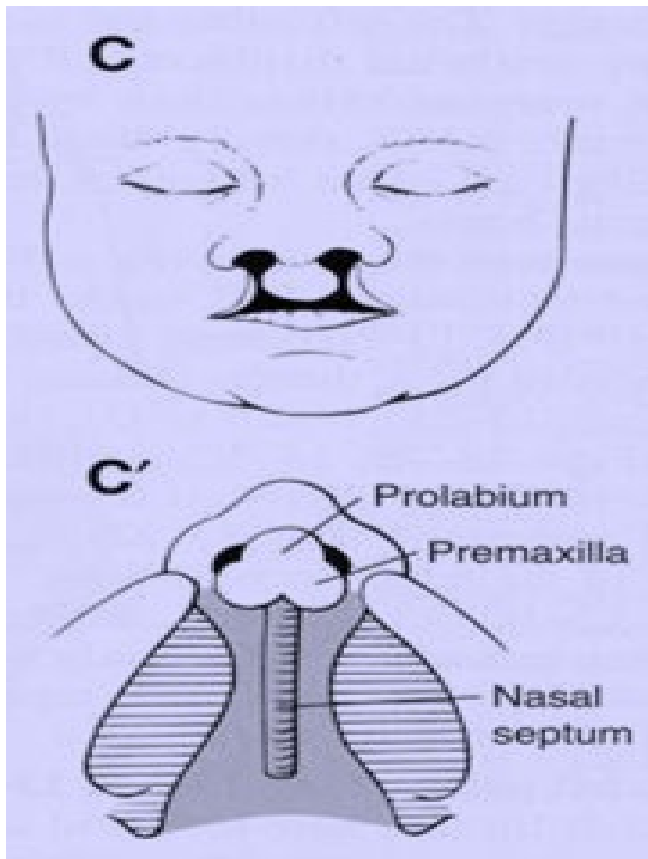




Clefts of maxilla and palate

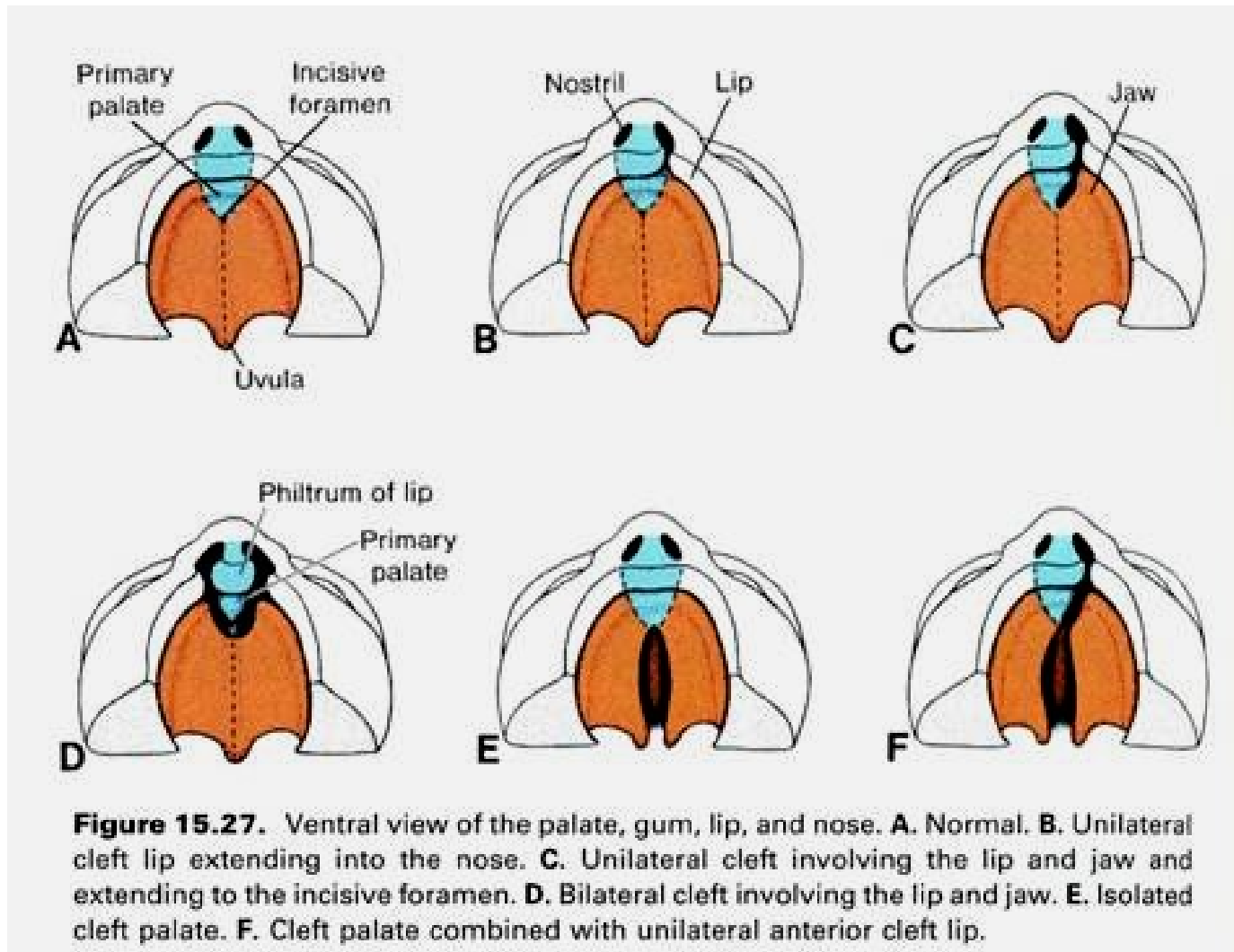
Cleft between lateral incisivus and caninus

Cheilo-gnatho-palato-schisis unilateralis or bilateralis



cheilo – gnatho – palatoschisis

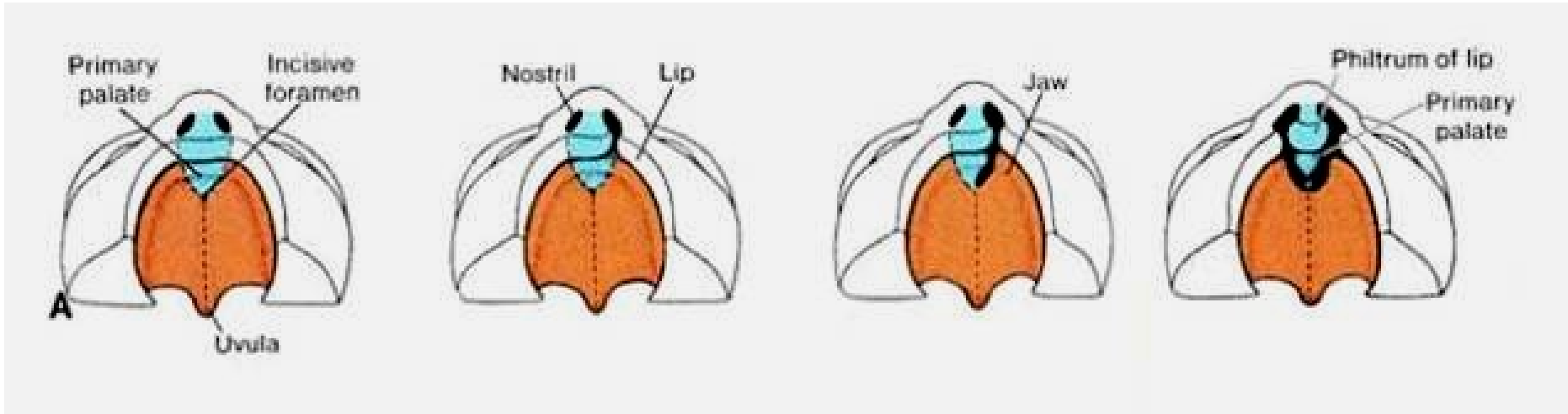
1: 2500, heredity- autosomal dominant



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

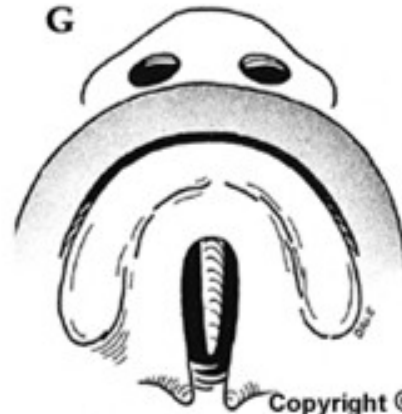
Nasal septum is free if lateral plates are not fused (raphe palati is absent)

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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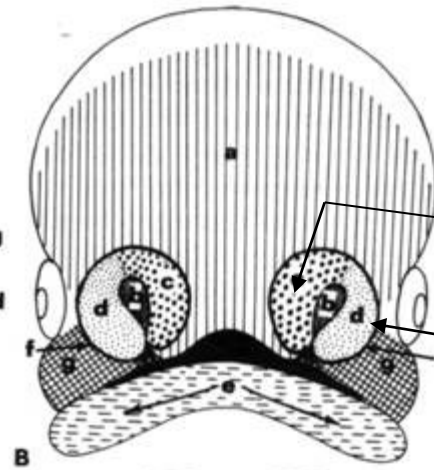
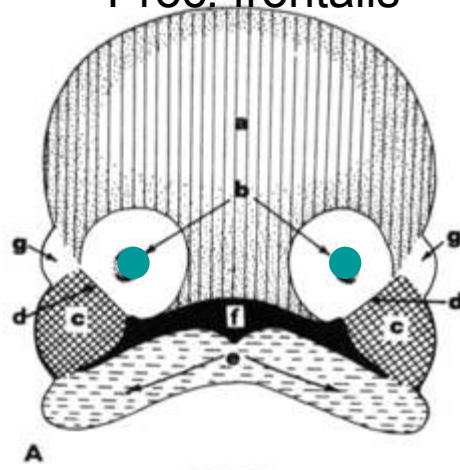


Proc. frontalis

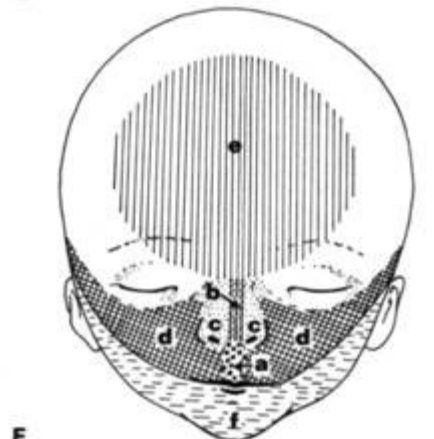
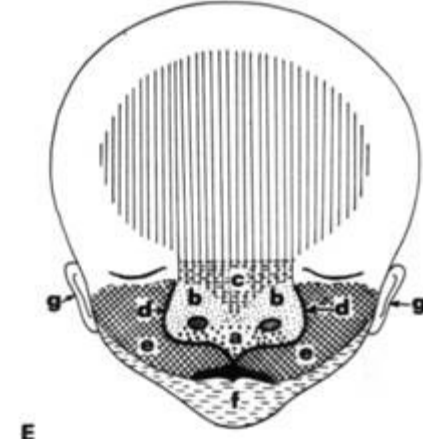
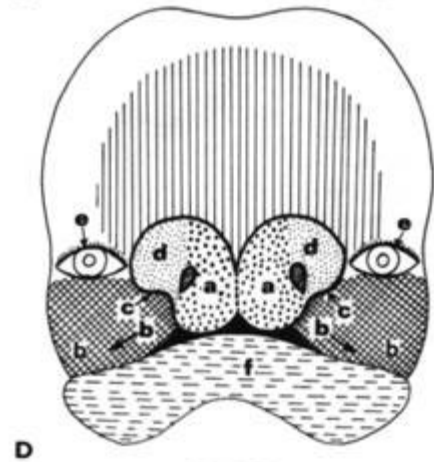
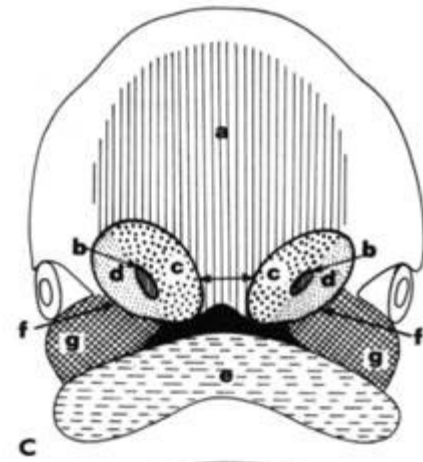
Nasal placodes

Nasal pits

Nasal canals



Proc. nasalis
medialis
et
lateralis



Scanning electron micrograph (SEM): human embryo



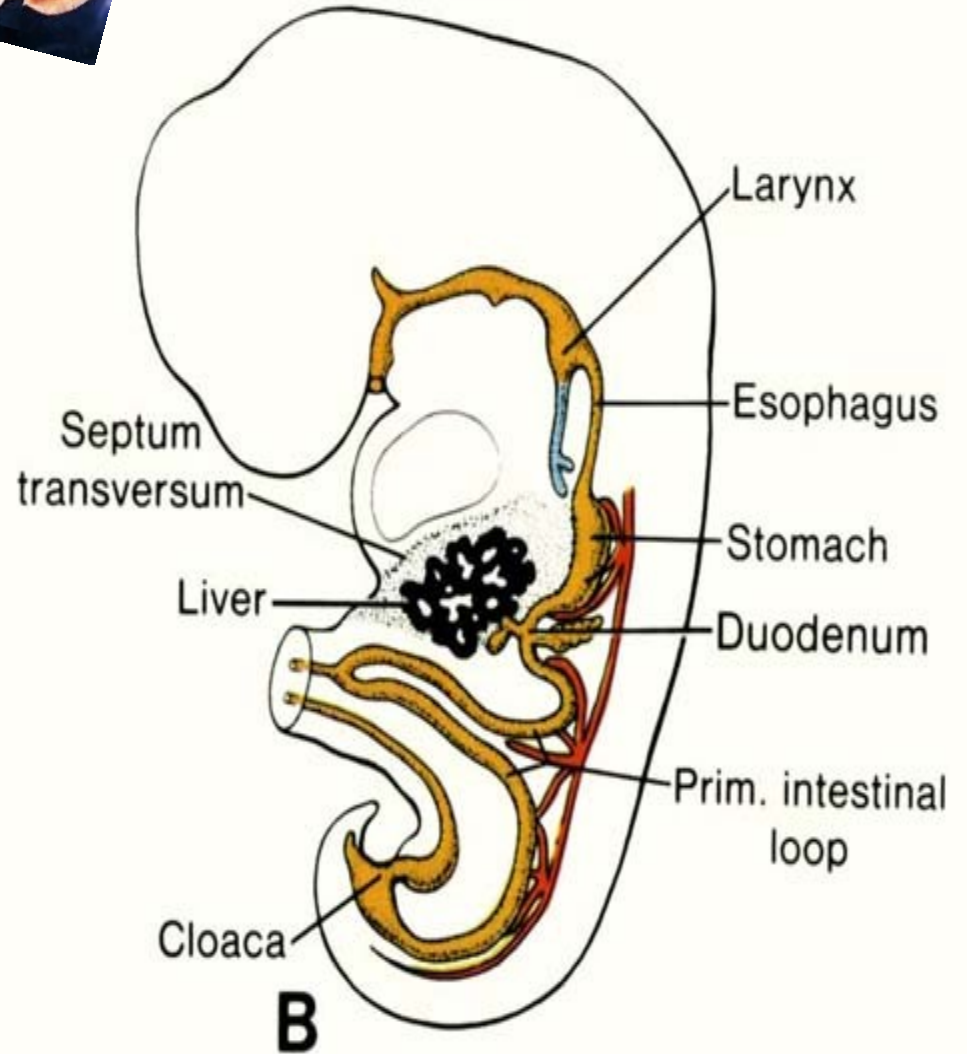
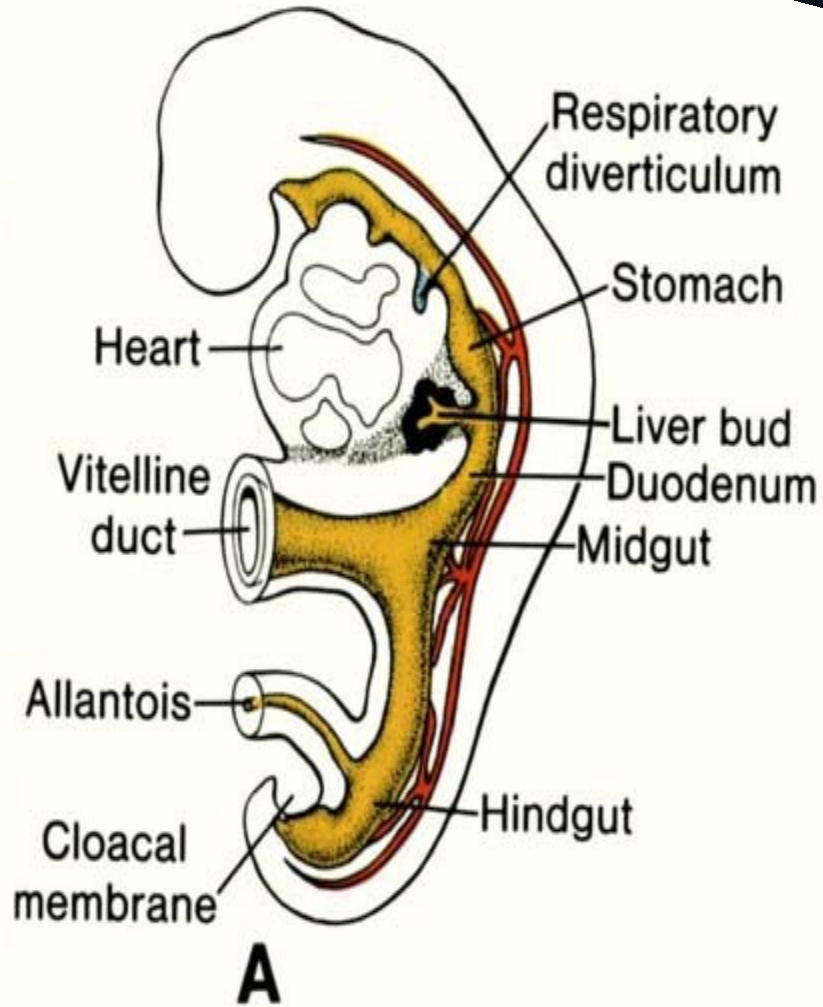
stage 15 (8.0-mm), ×52.

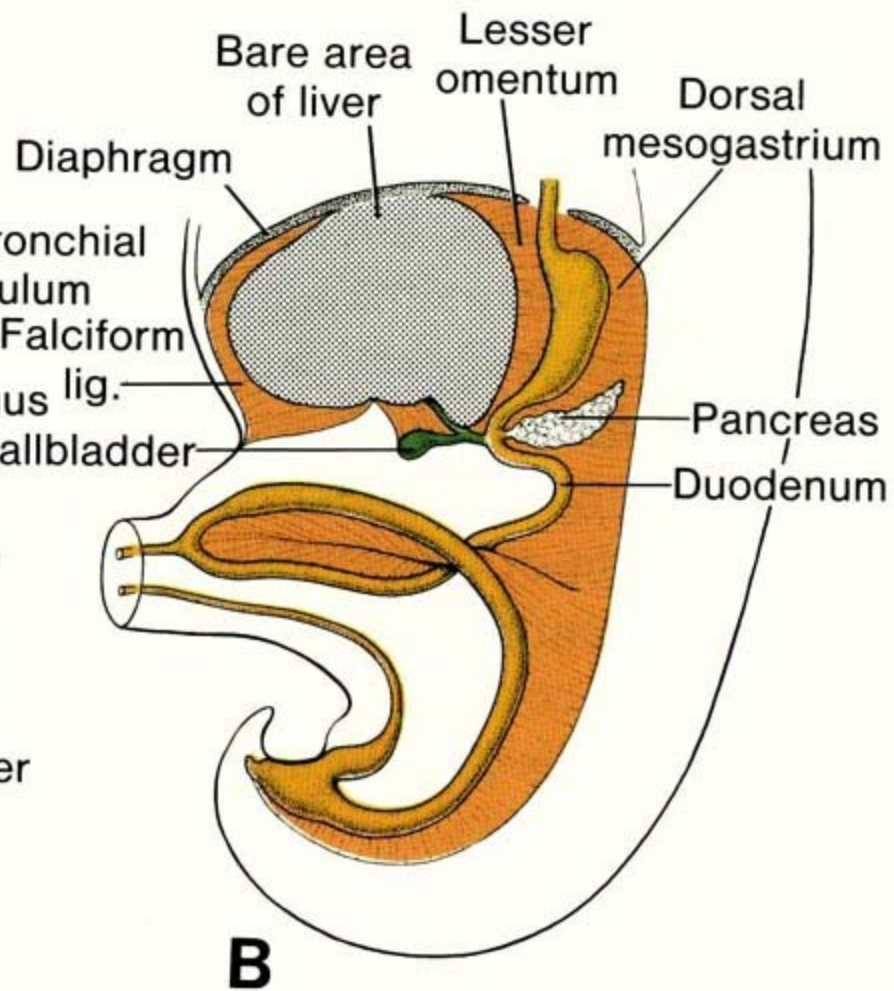
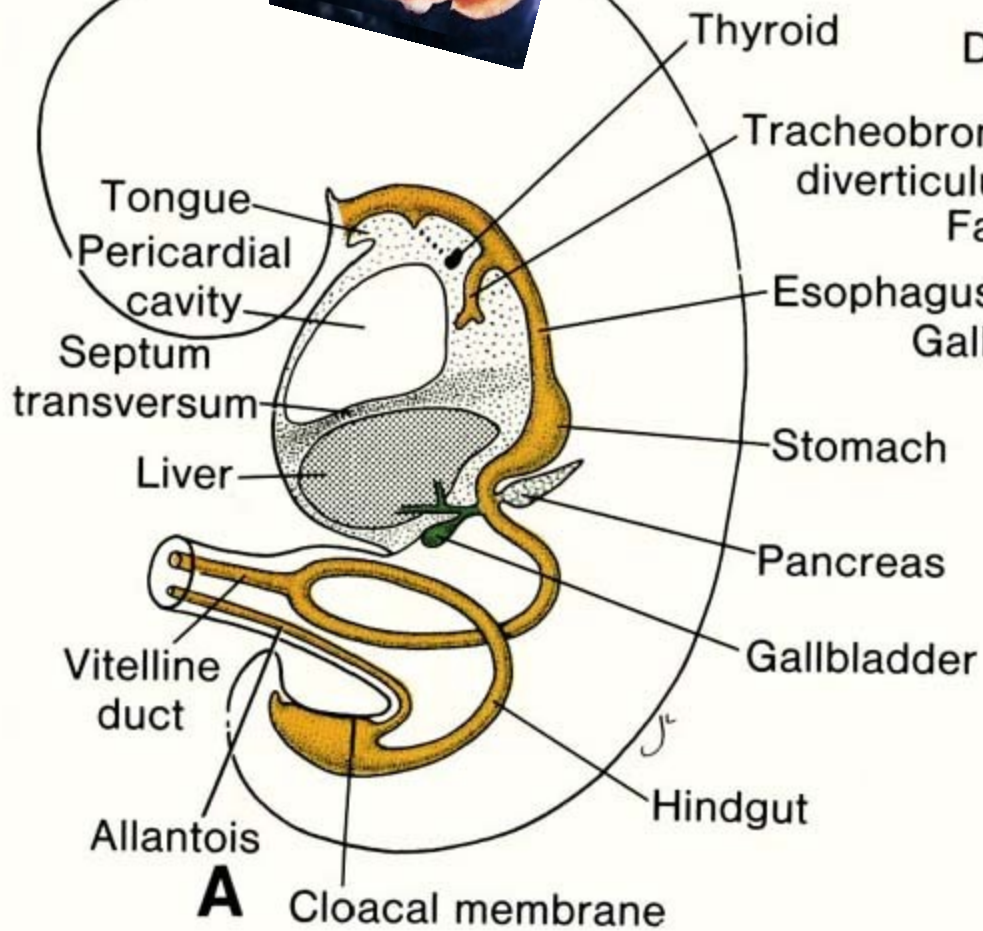


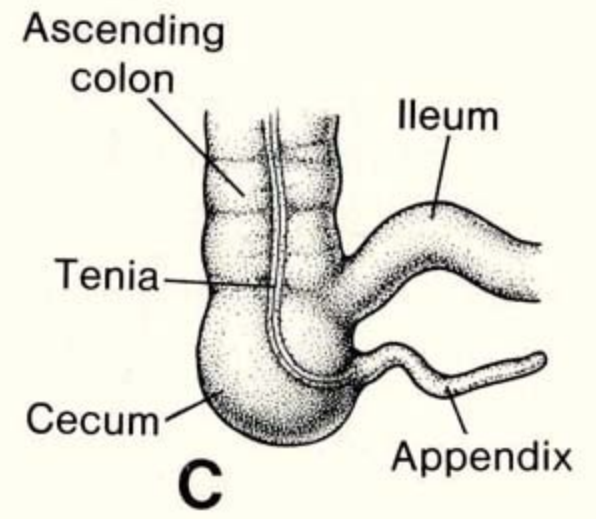
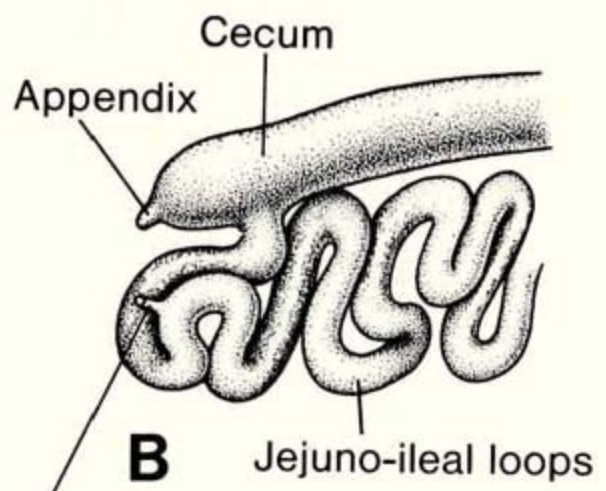
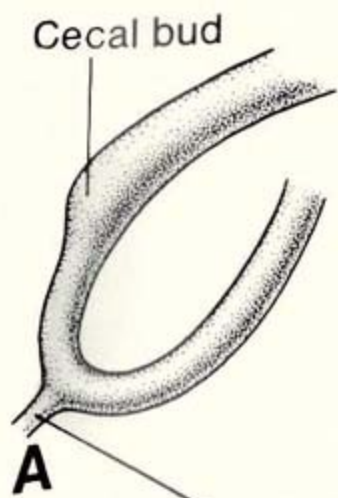
stage 17 (11.7-mm), 57x

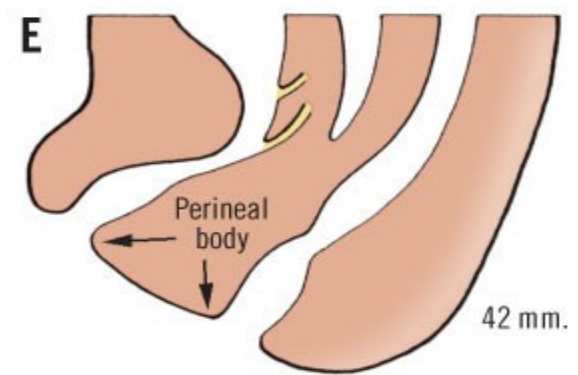
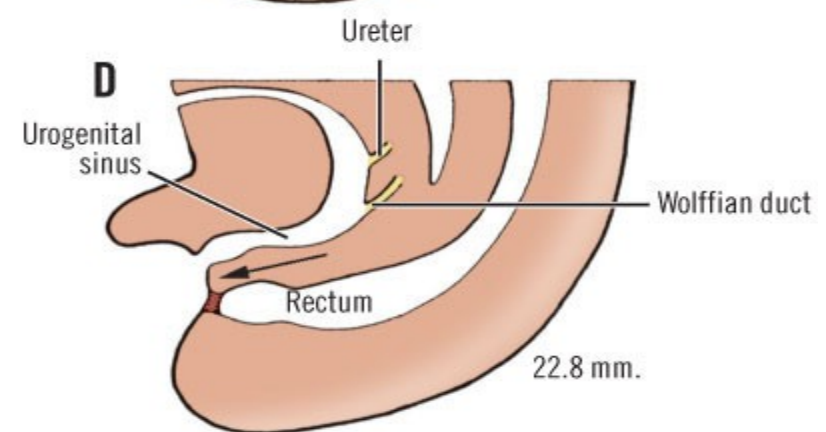
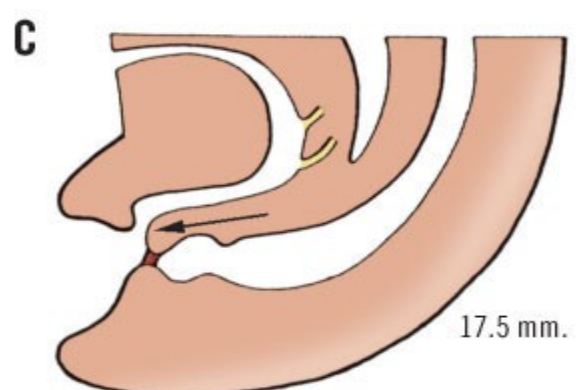
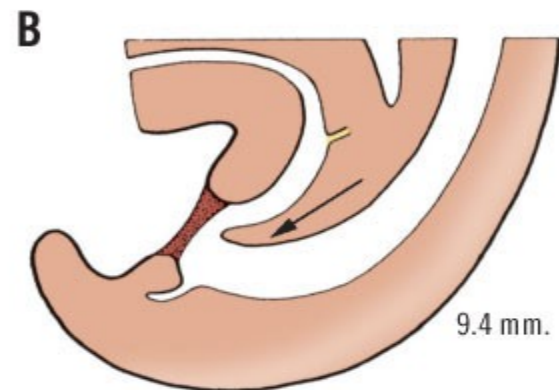
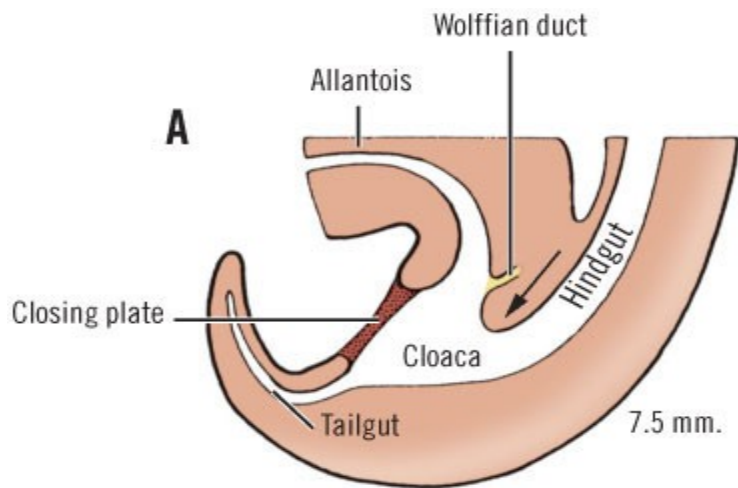


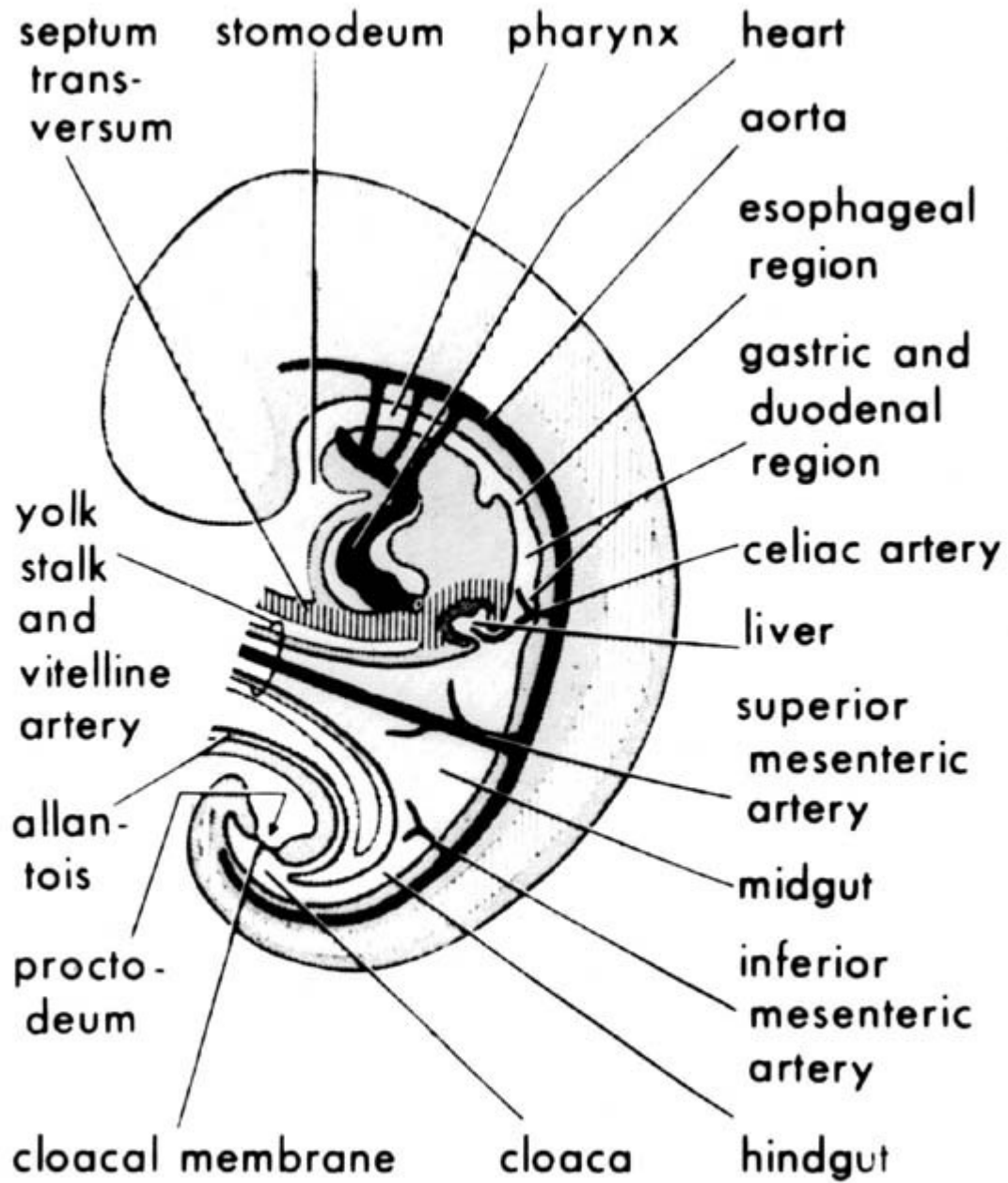
stage 17 (11.7-mm), 14x

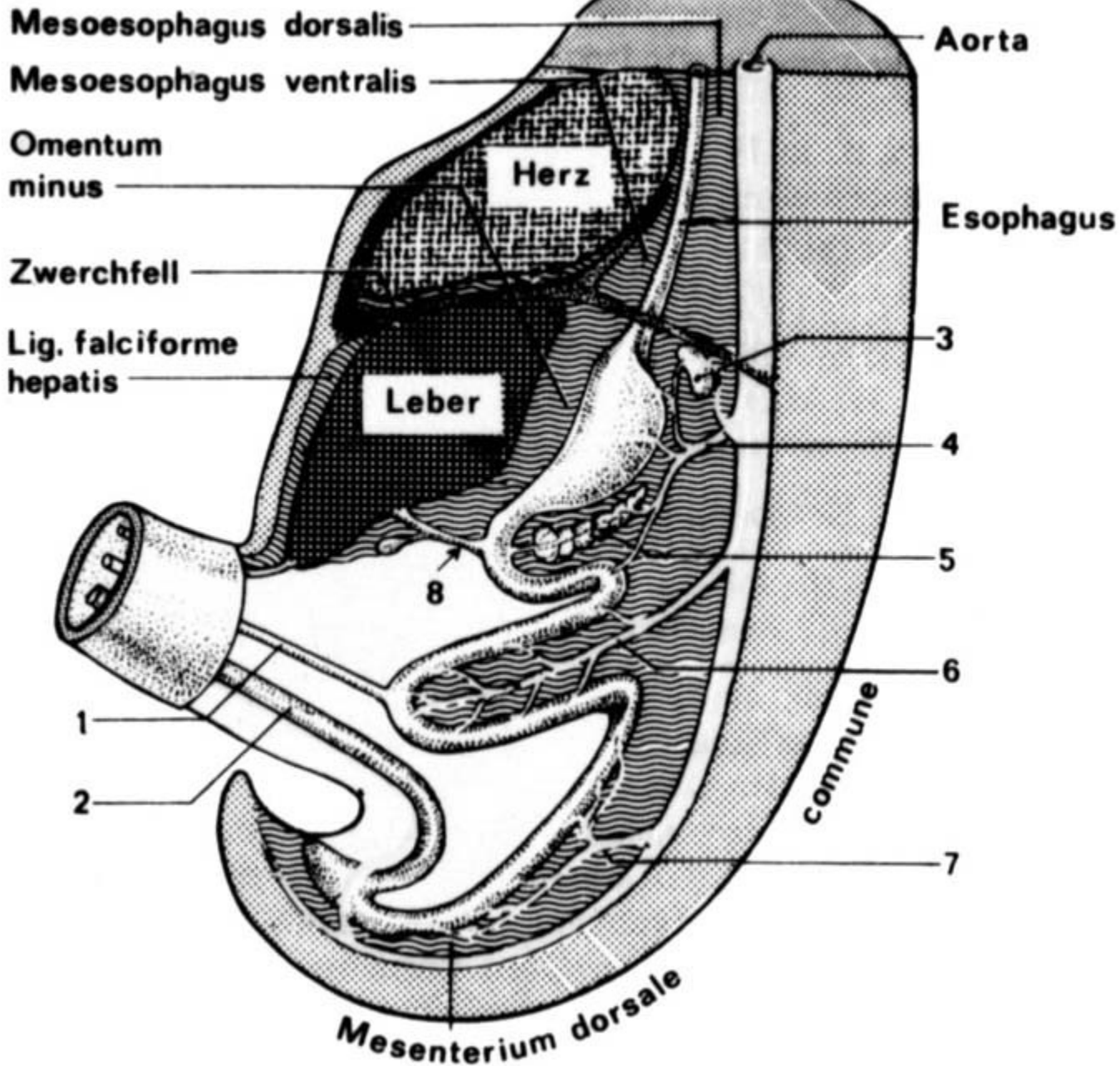


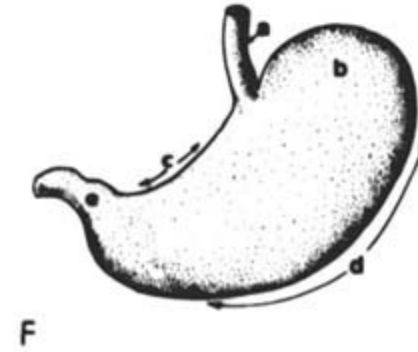
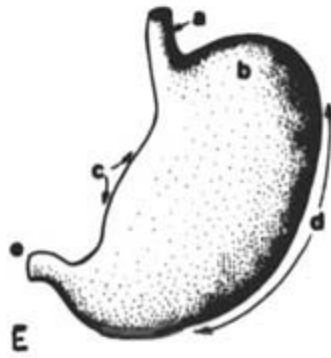
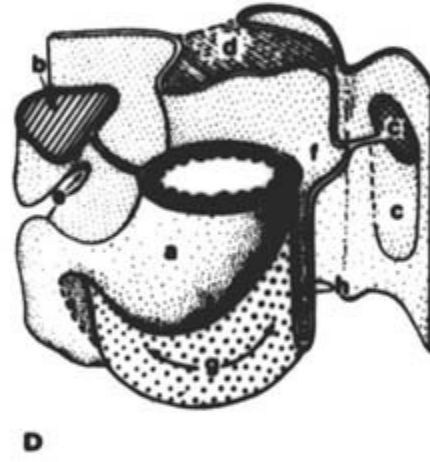
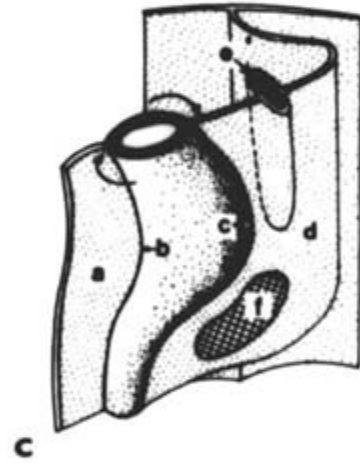
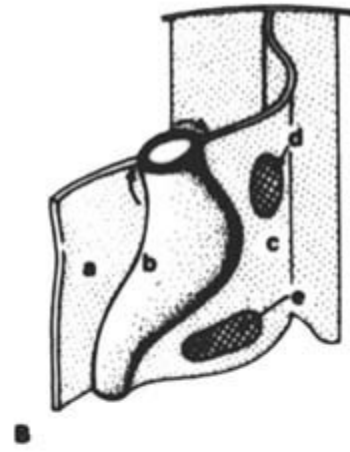
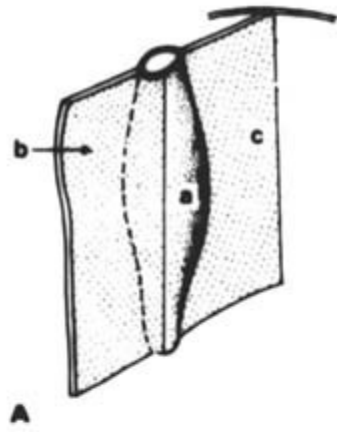


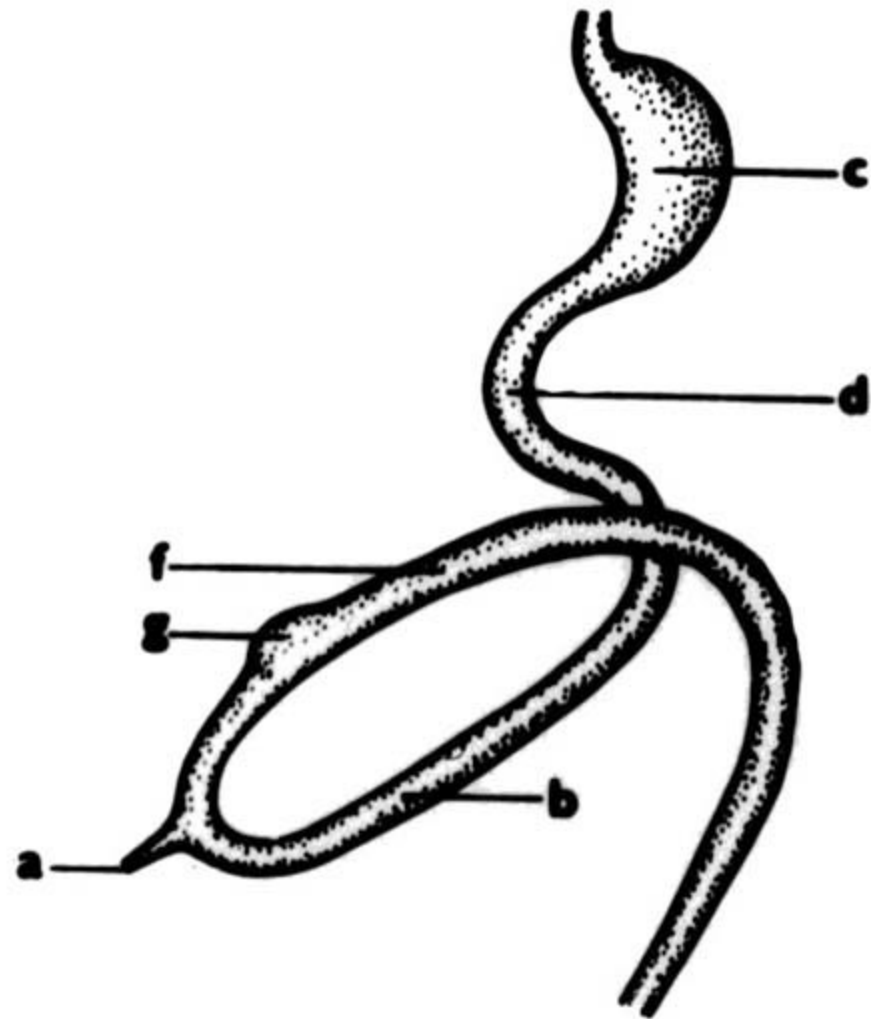
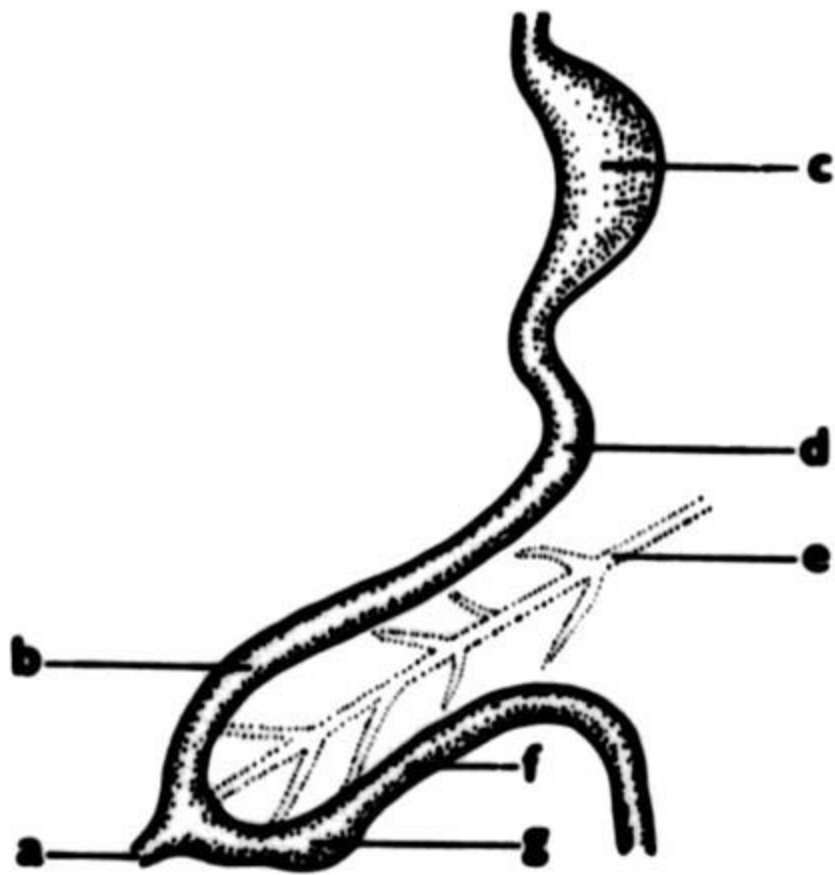




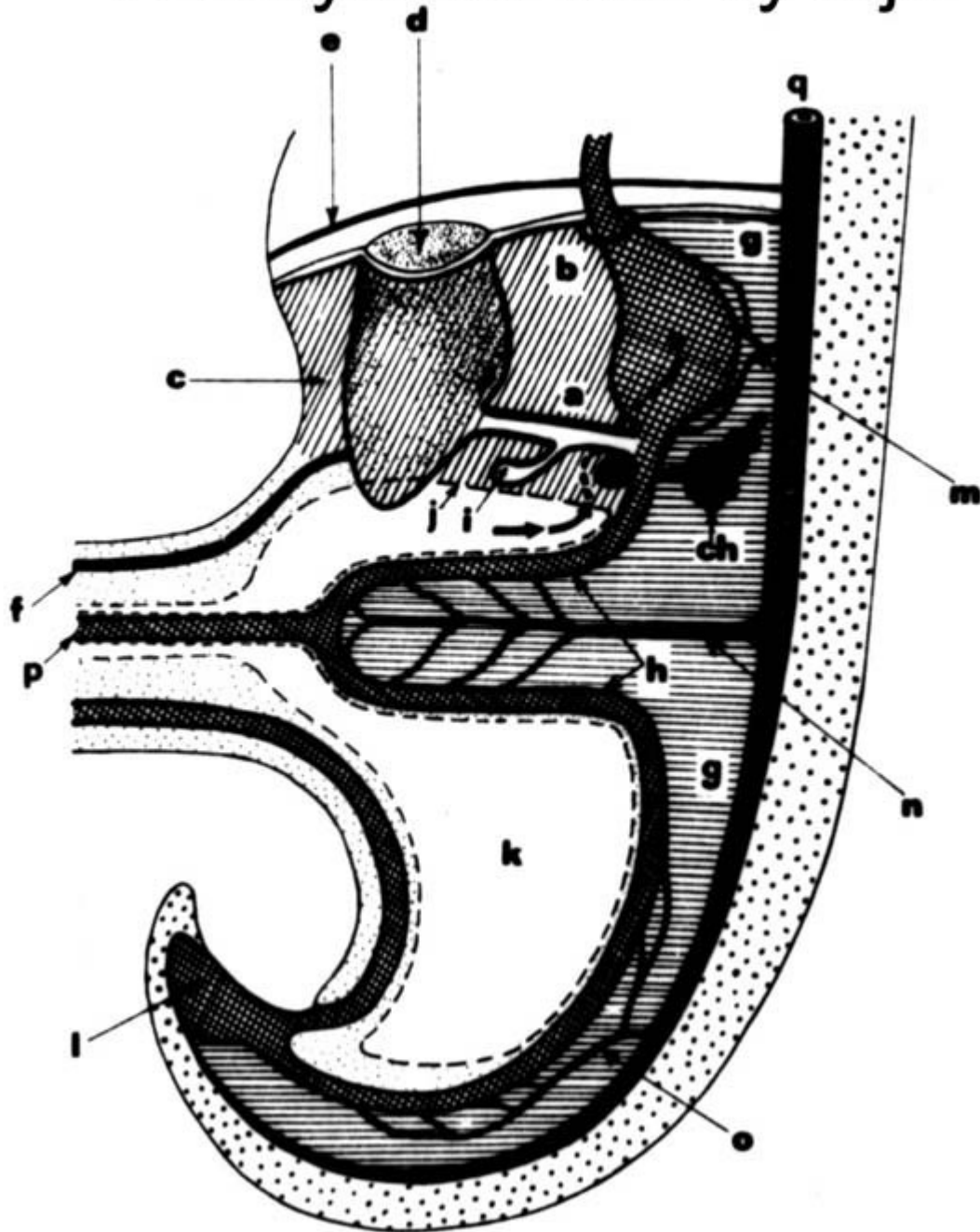








Embryo 33. den vývoje



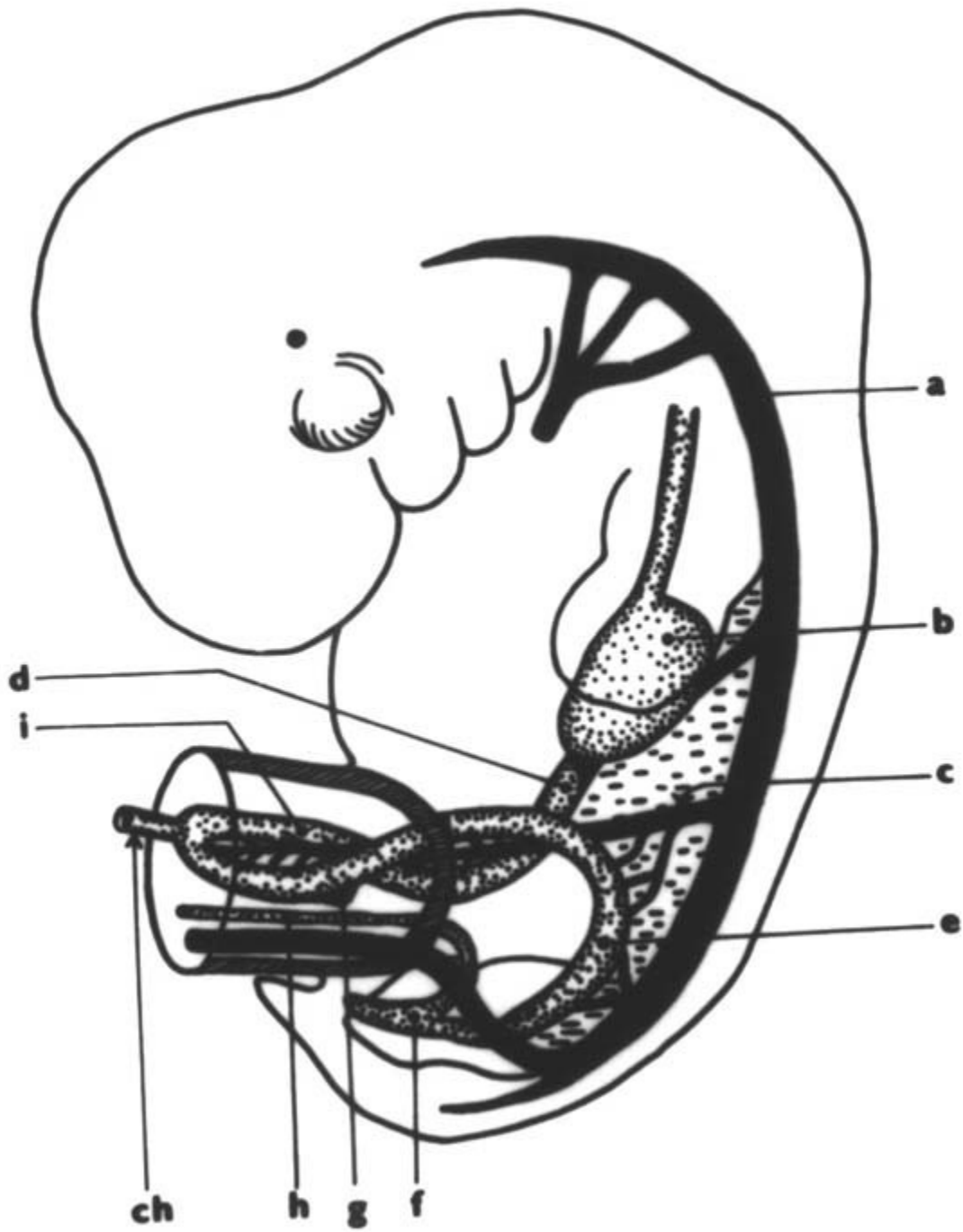
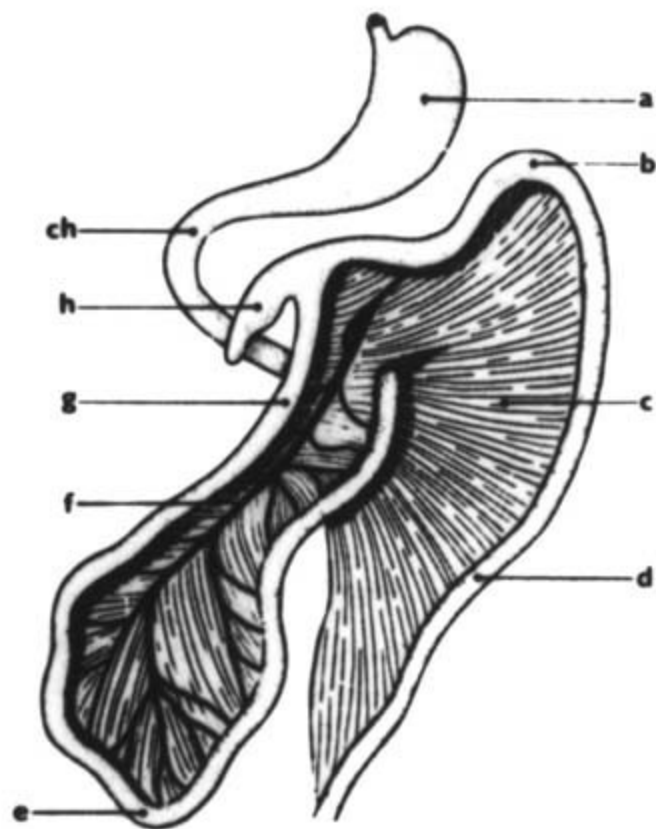
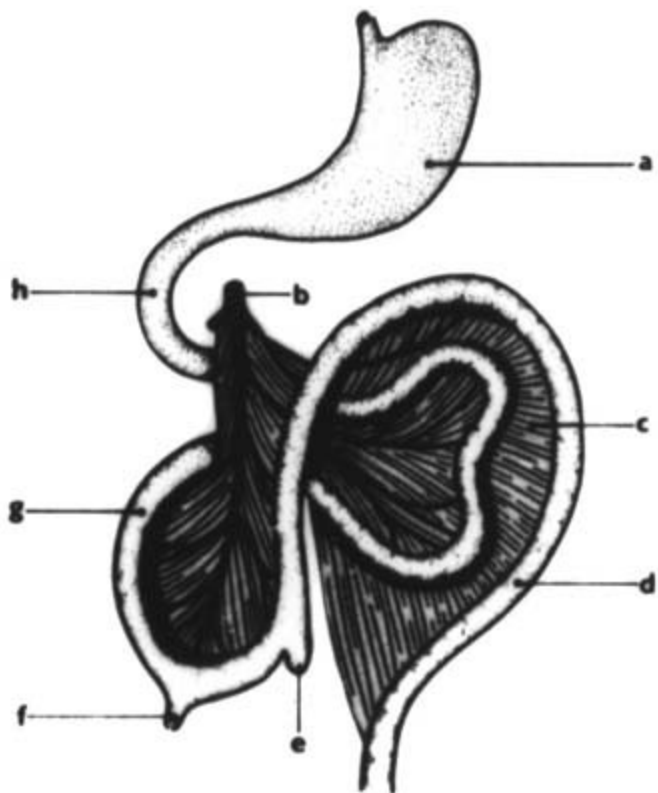
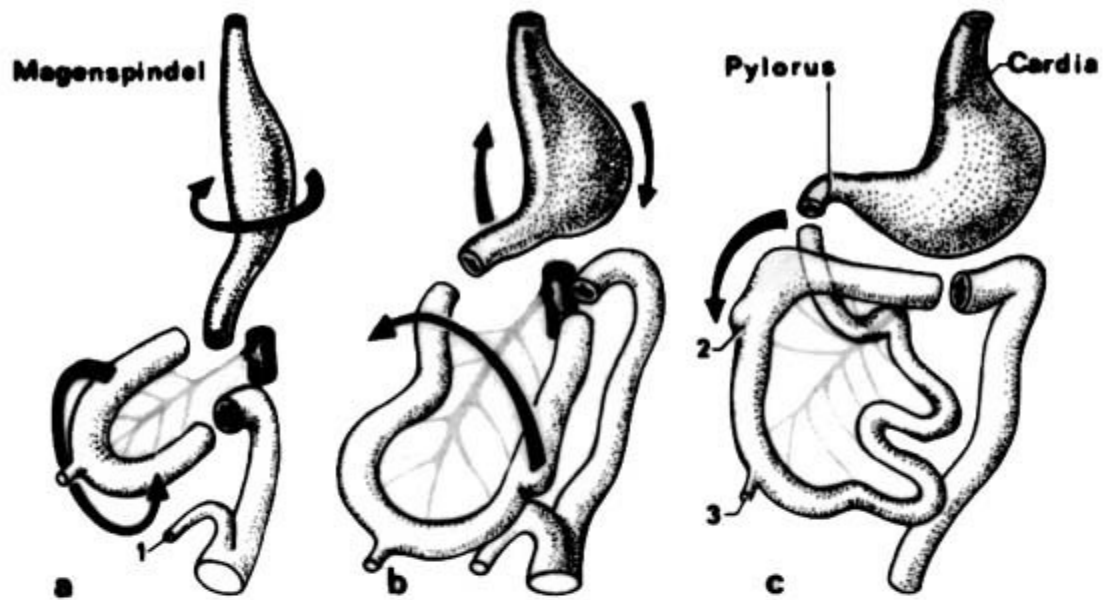
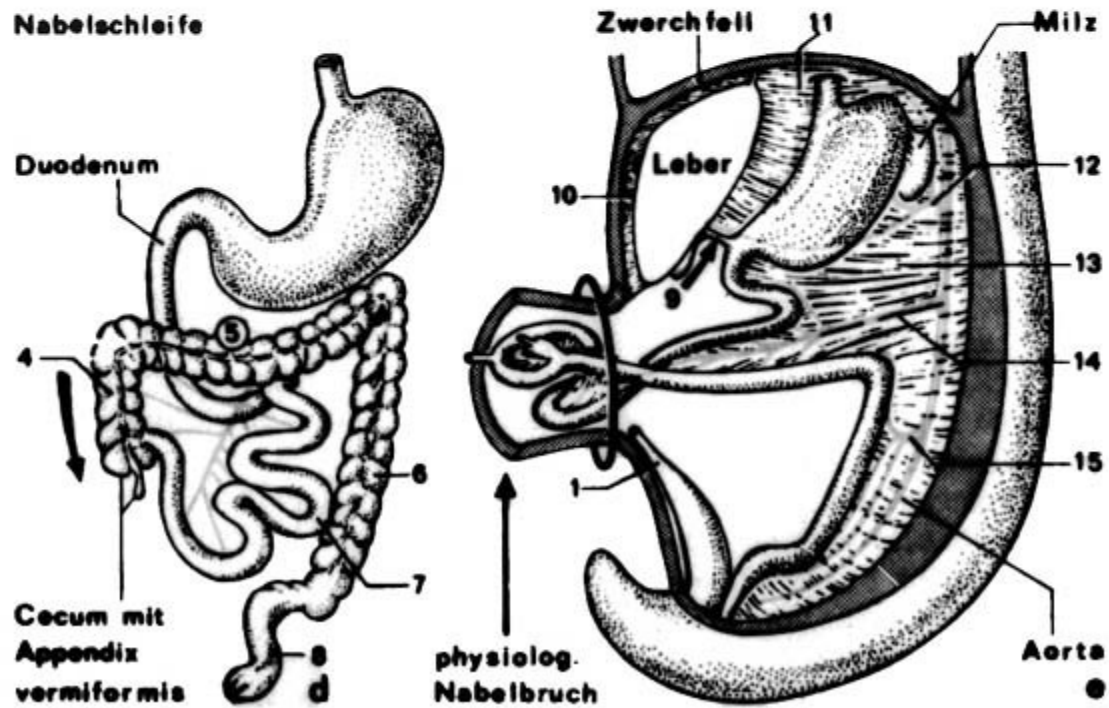


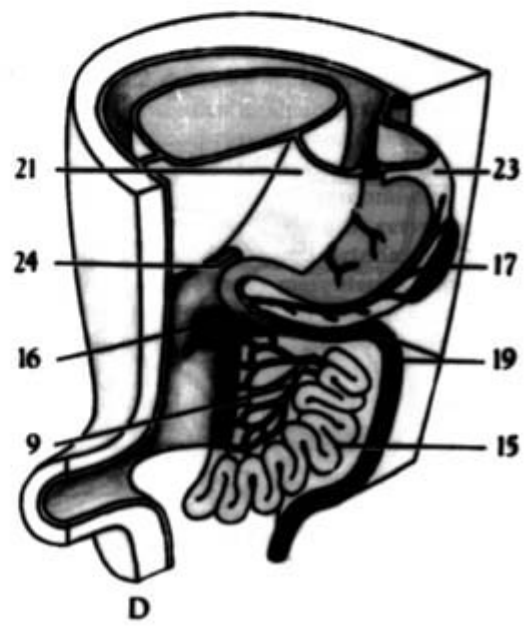
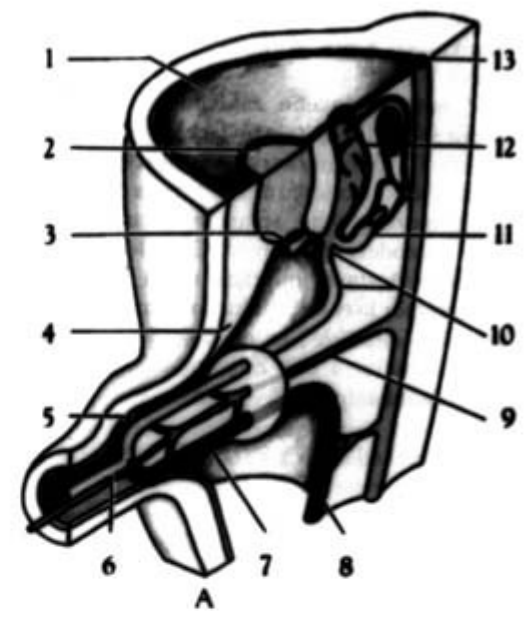
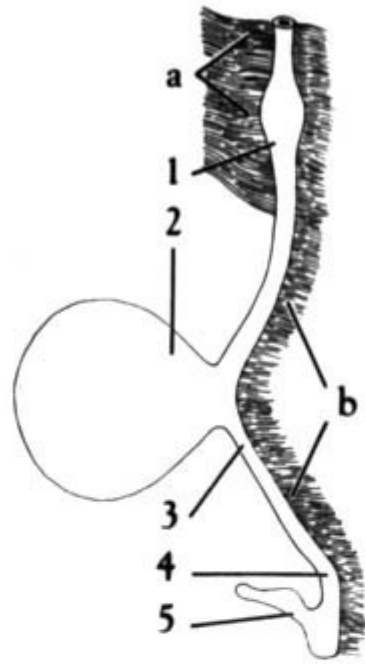
Schéma vývoje pupeční kličky

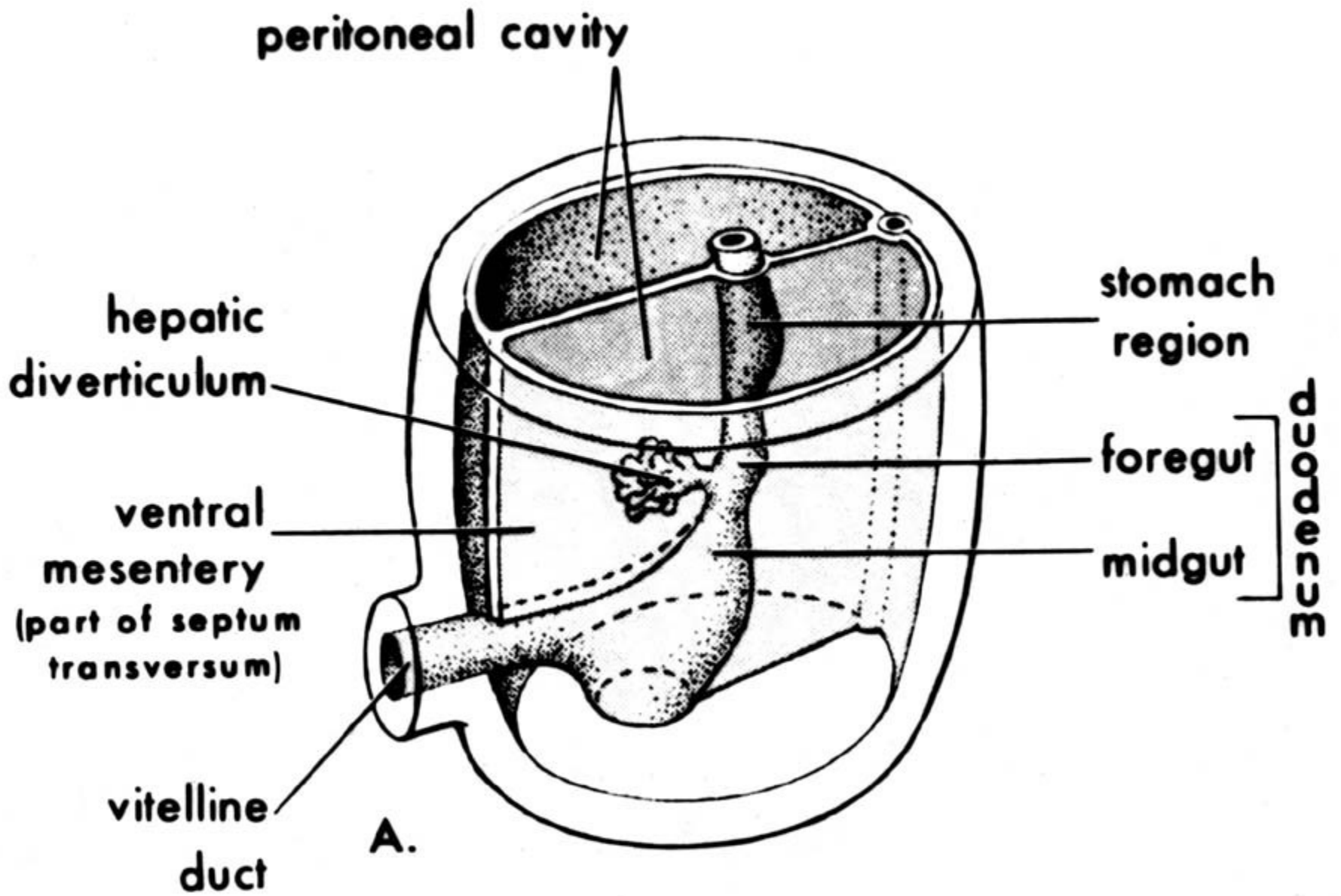


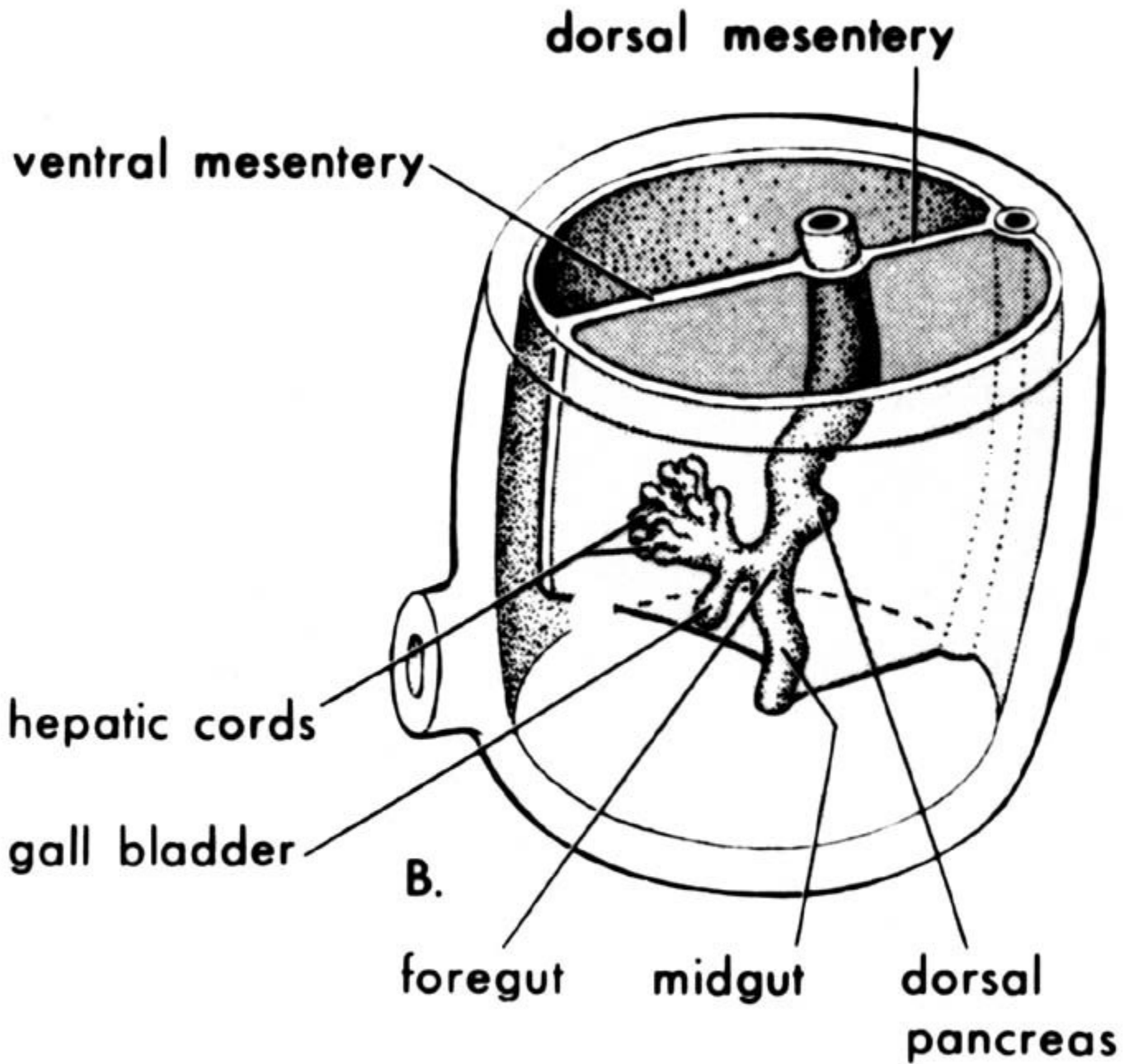


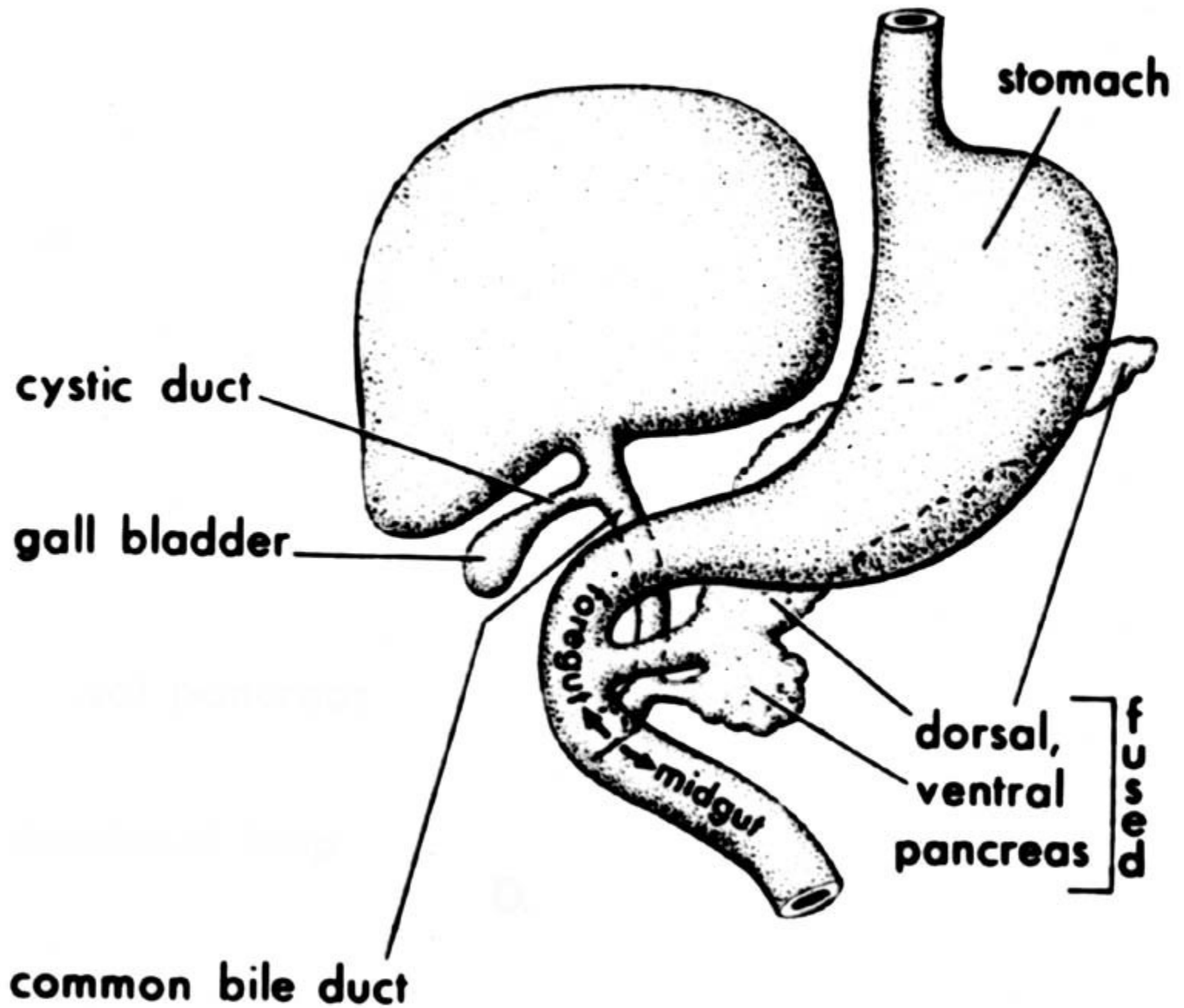
Nabelschleife



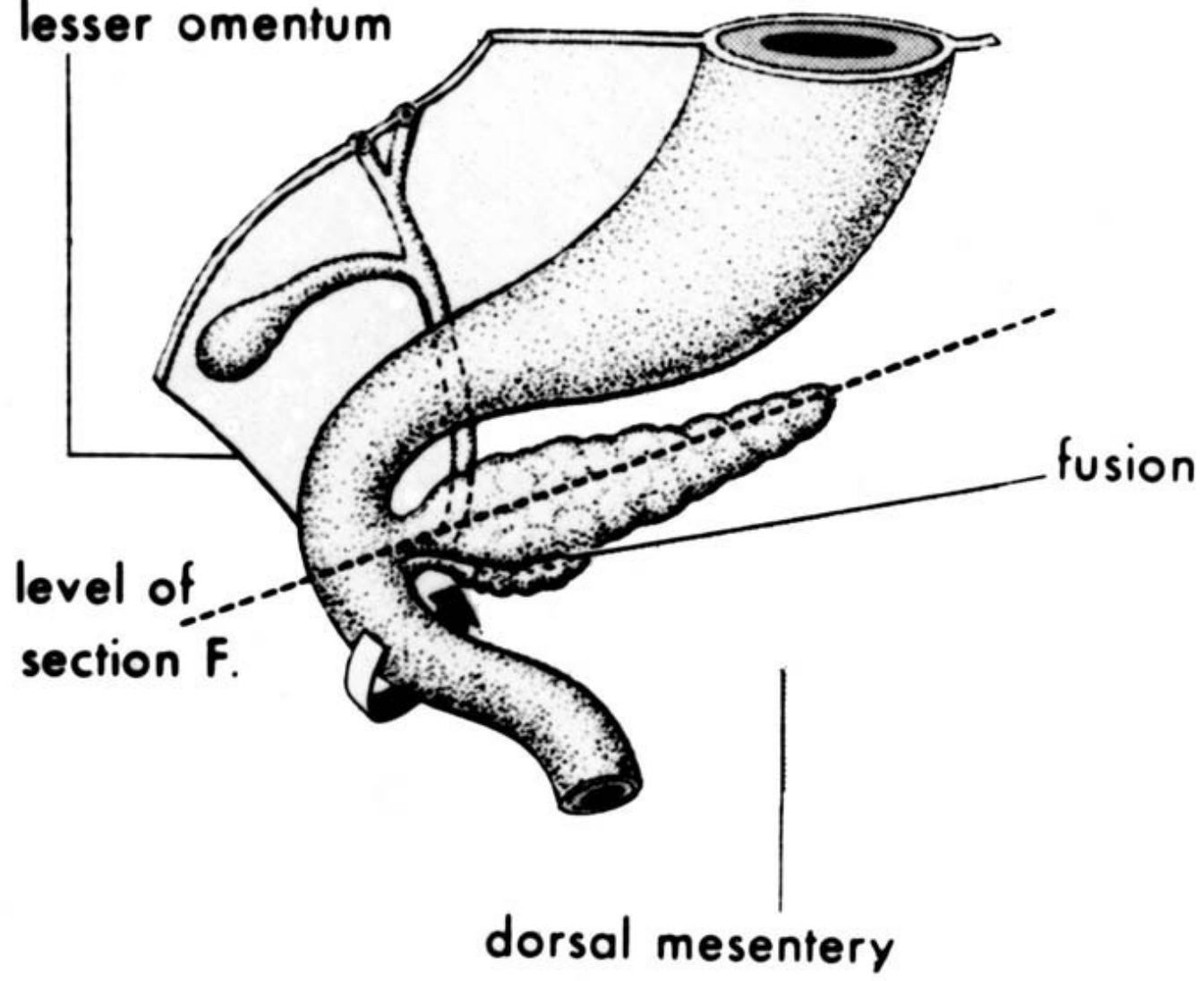








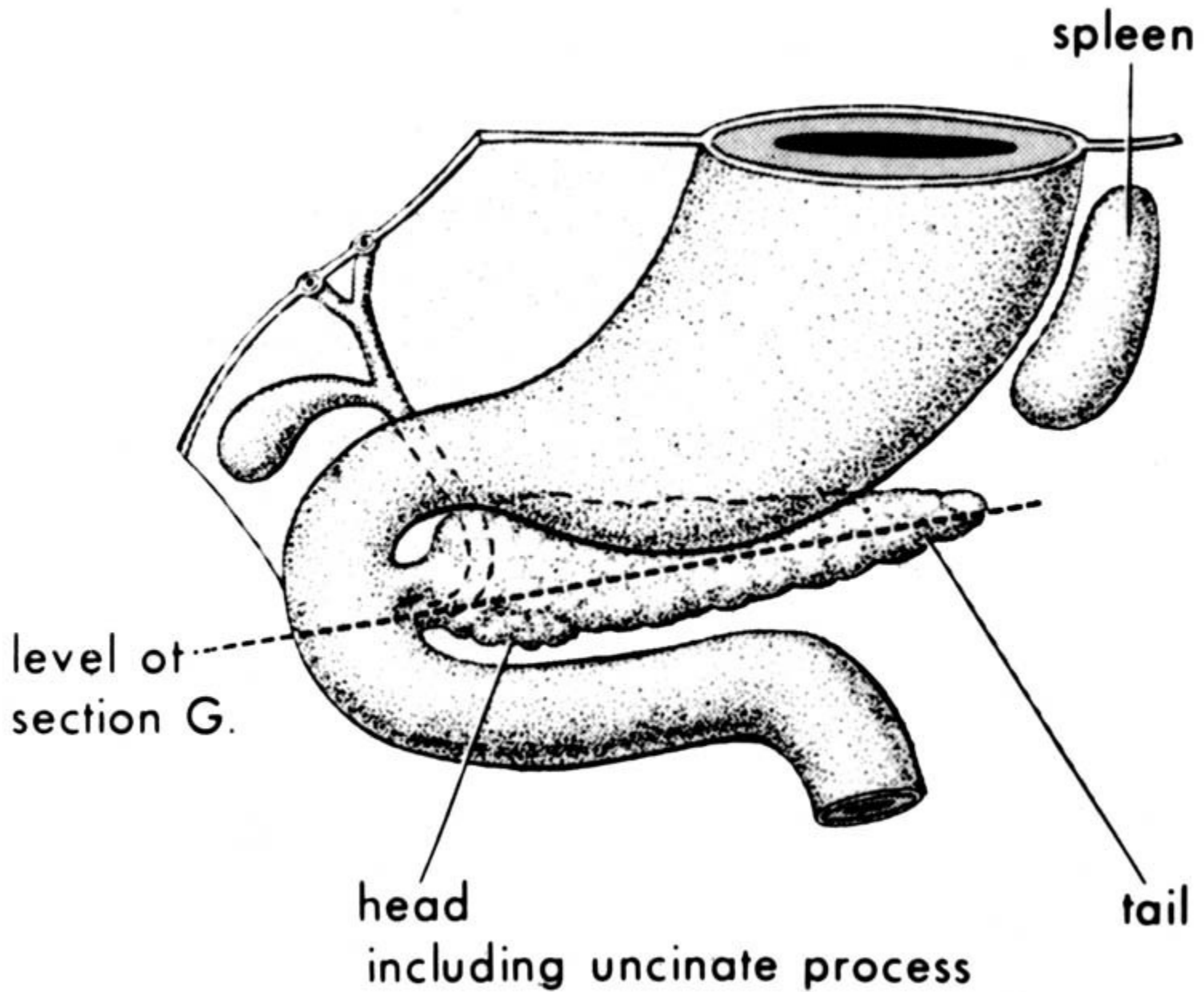
free edge of
lesser omentum

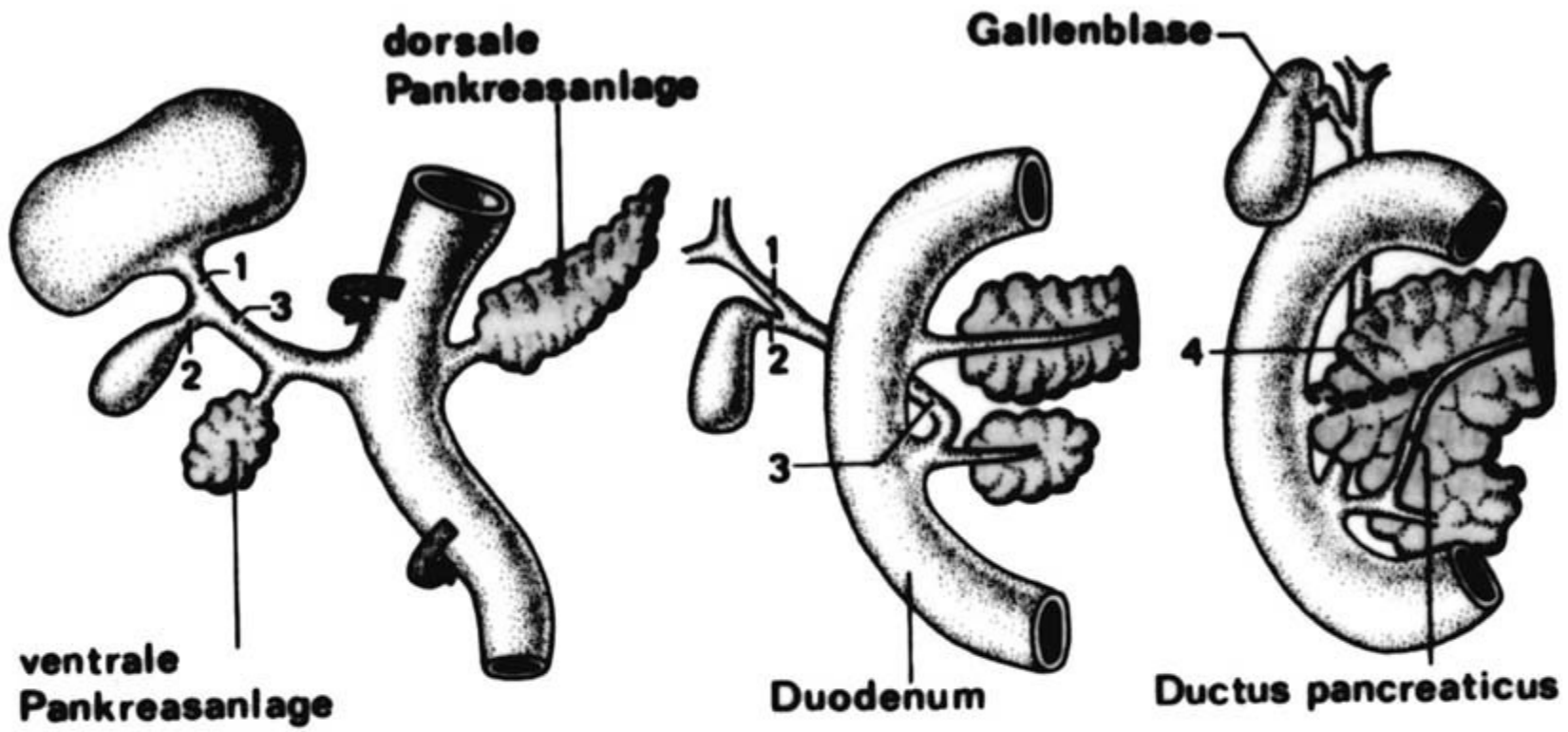


level of
section F.

fusion

dorsal mesentery





a

b

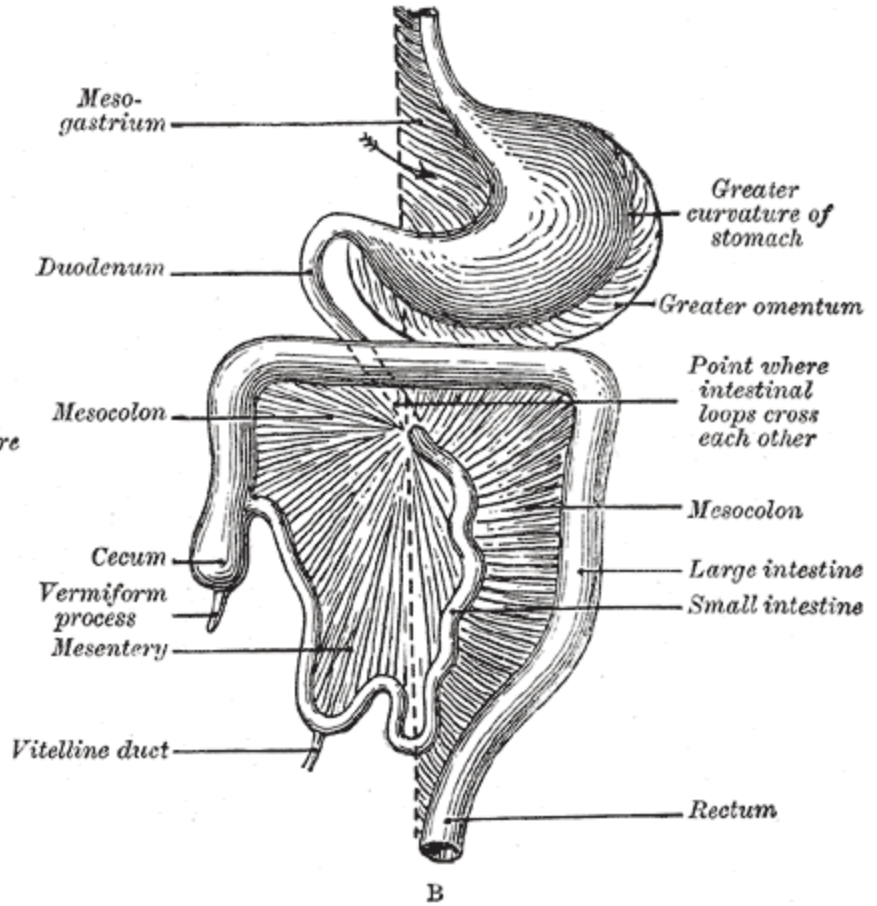
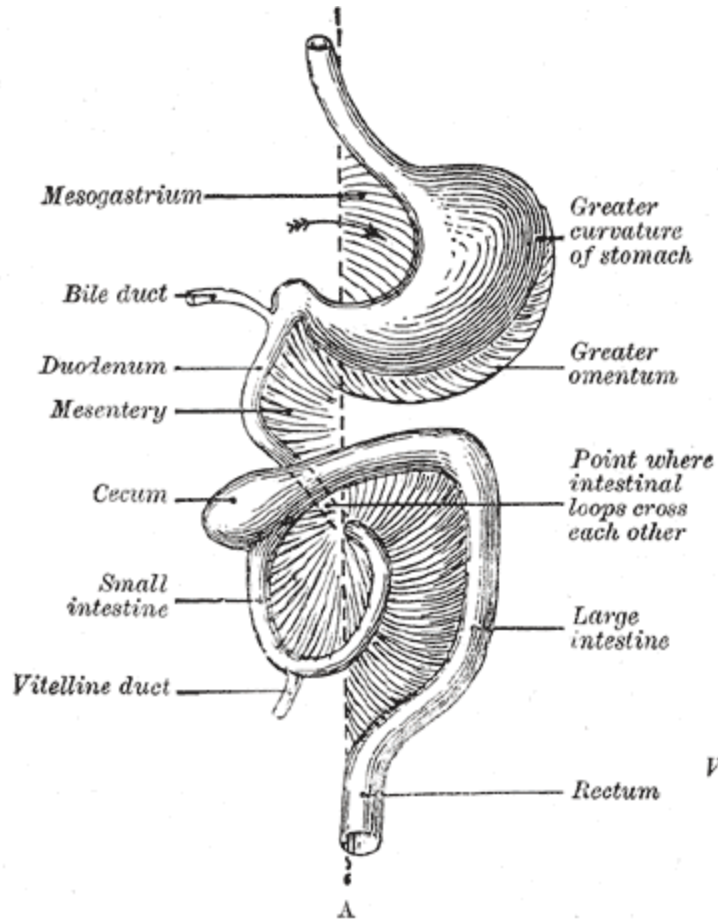
c

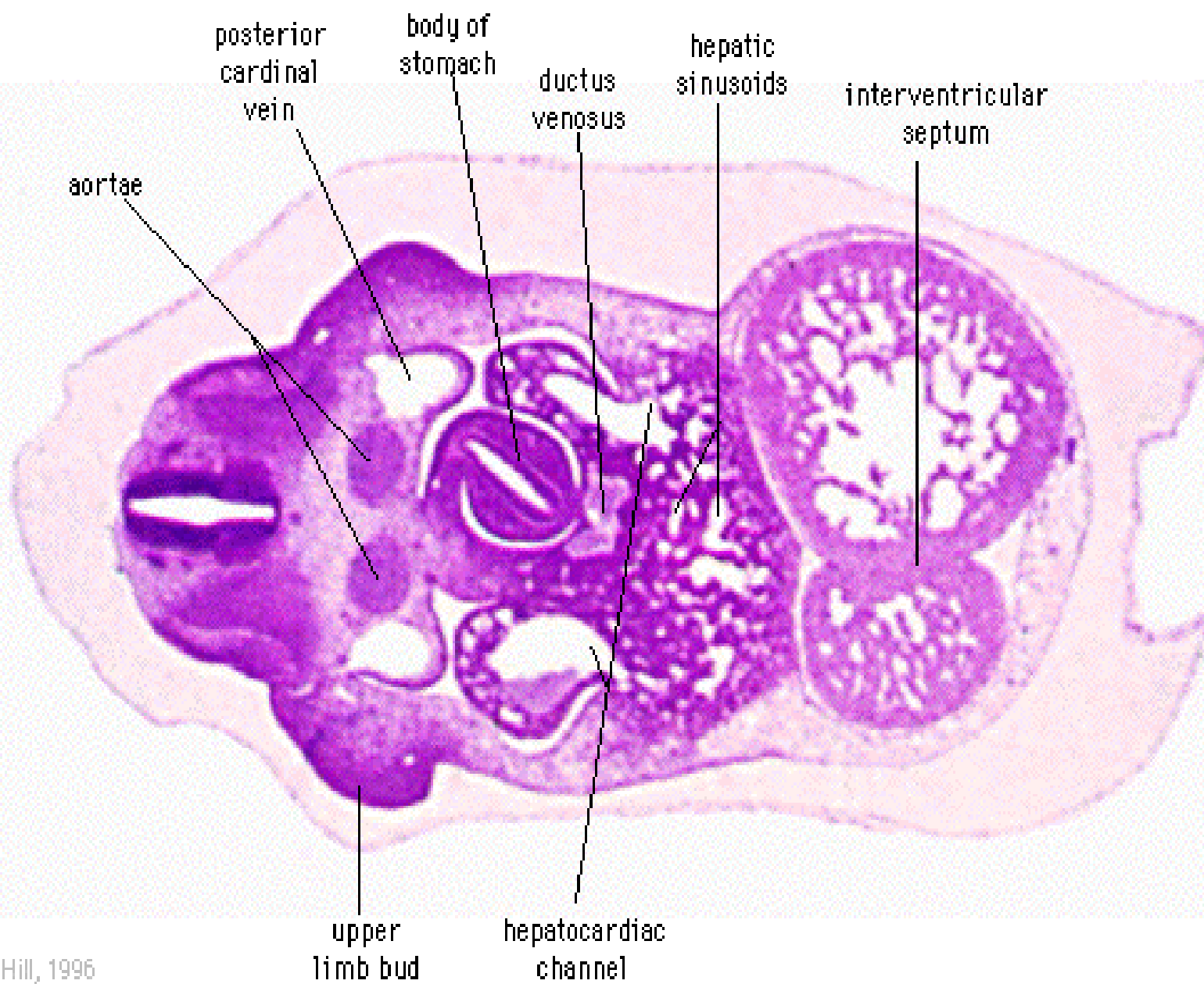


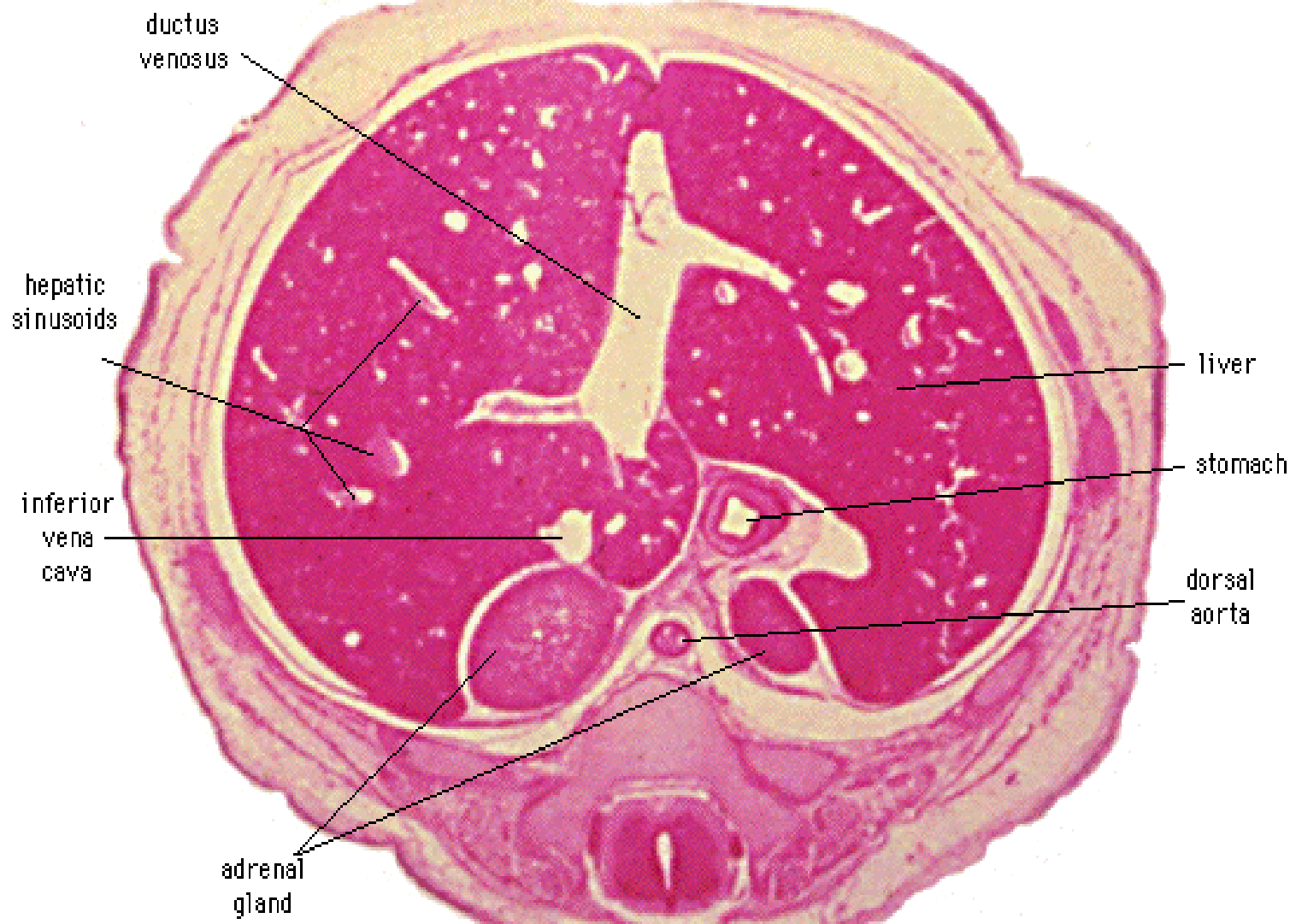
d

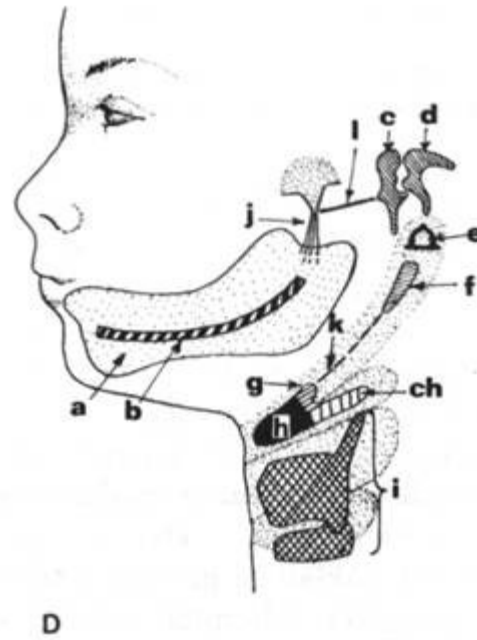
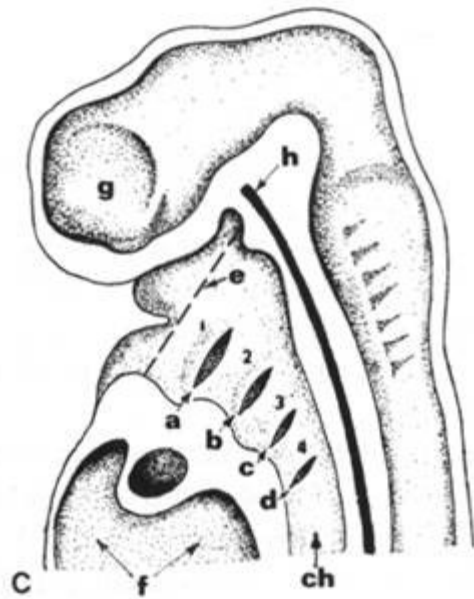
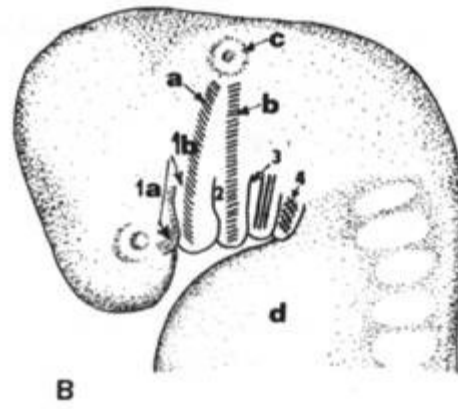
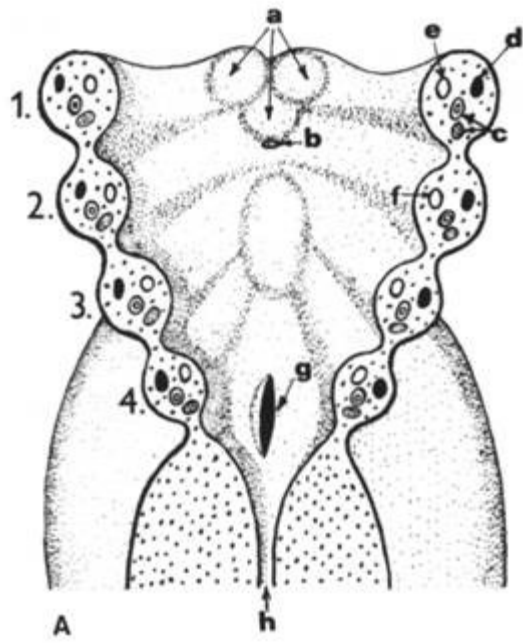
e

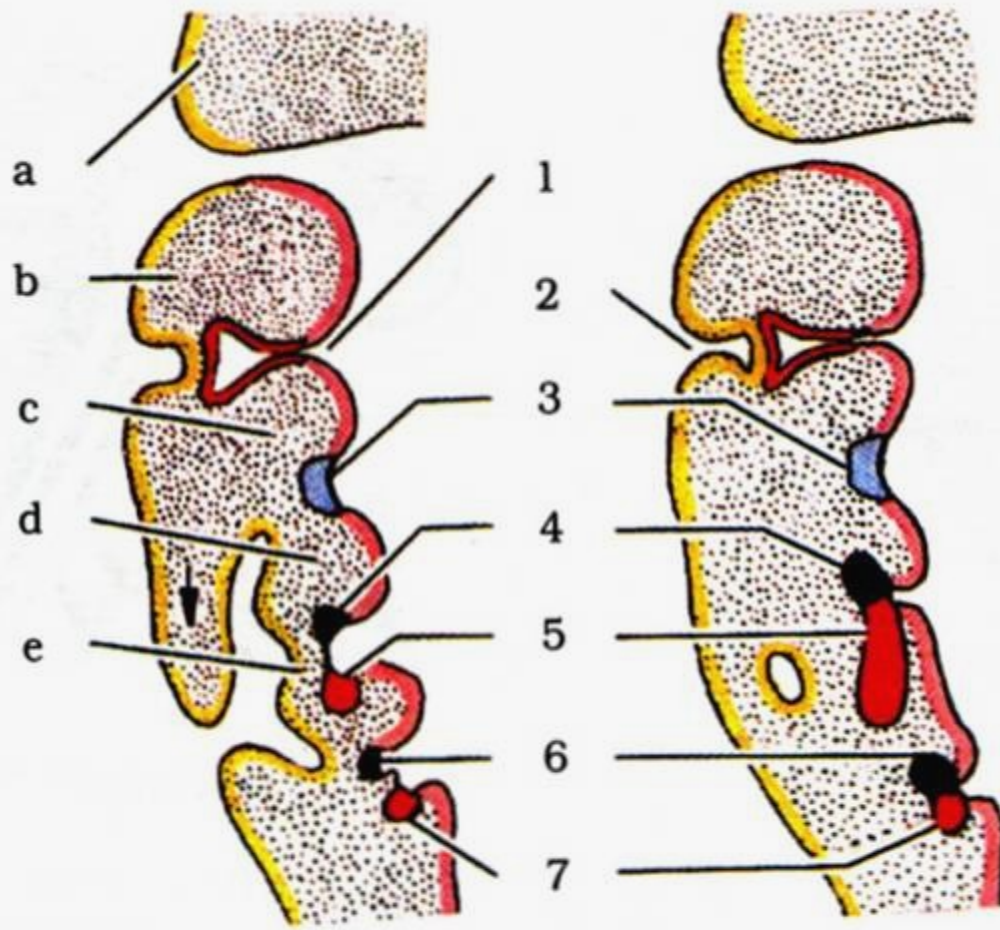
f





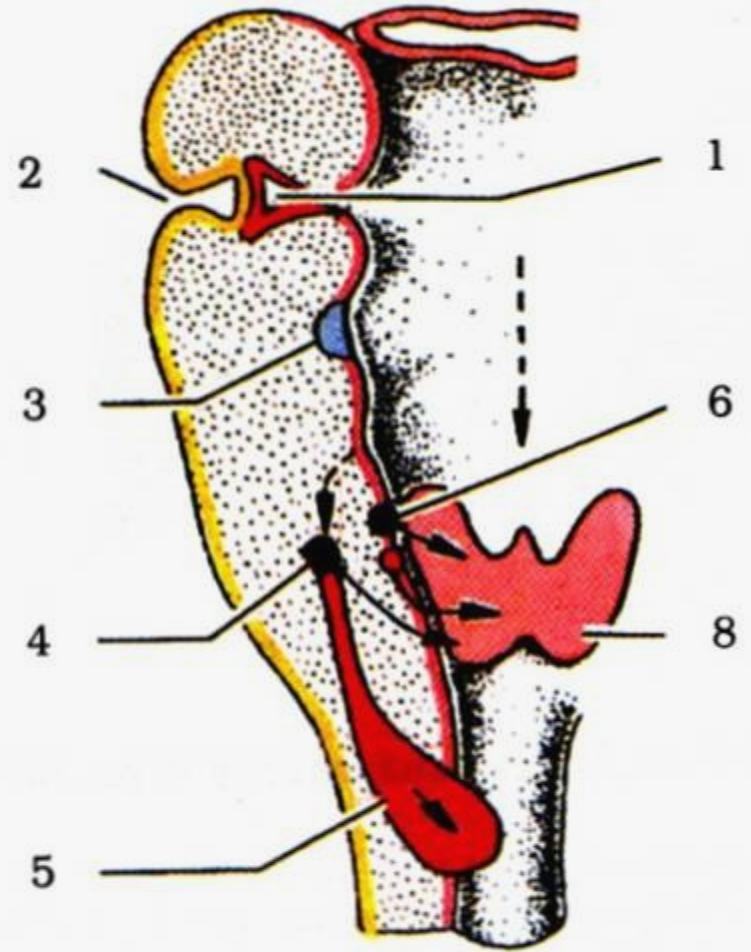




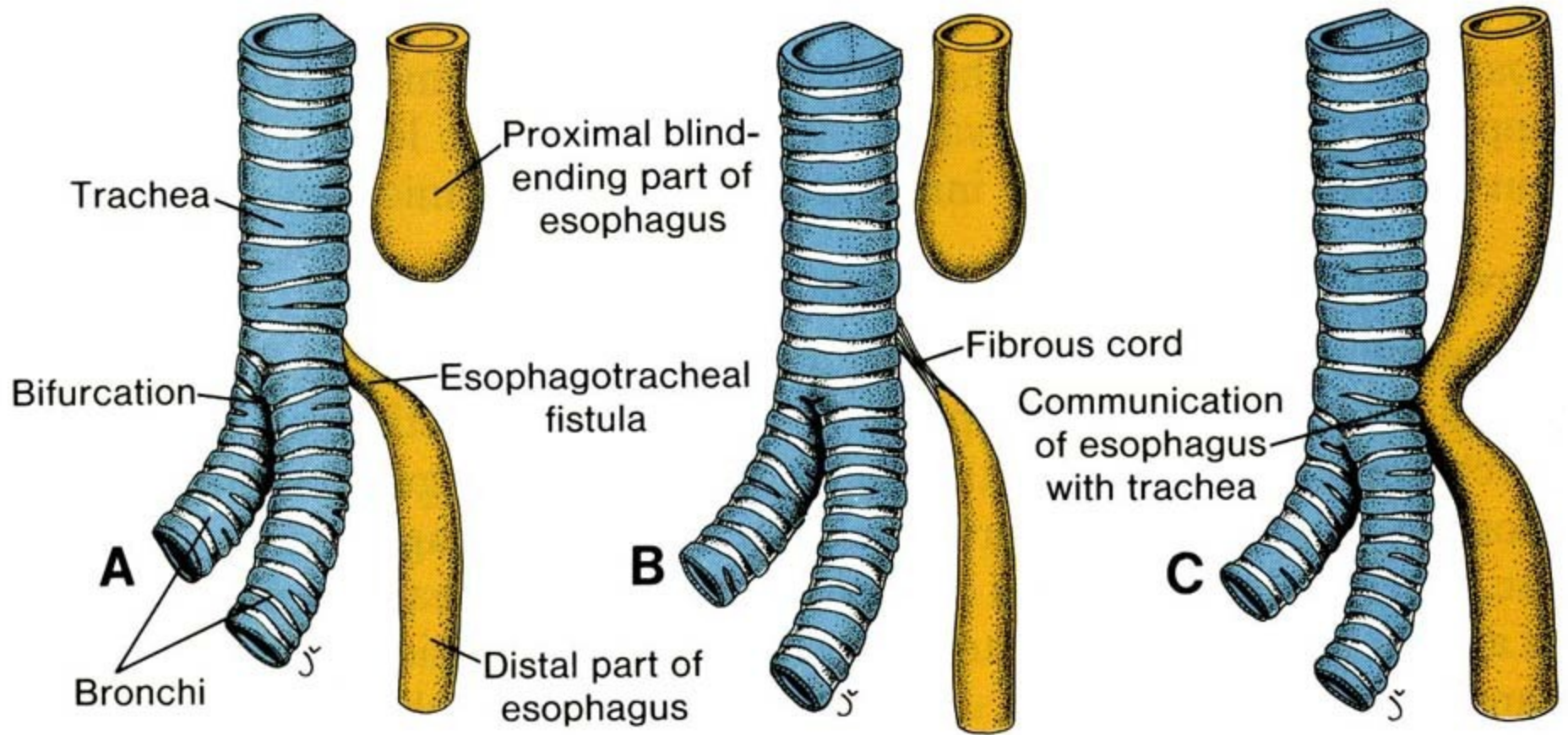


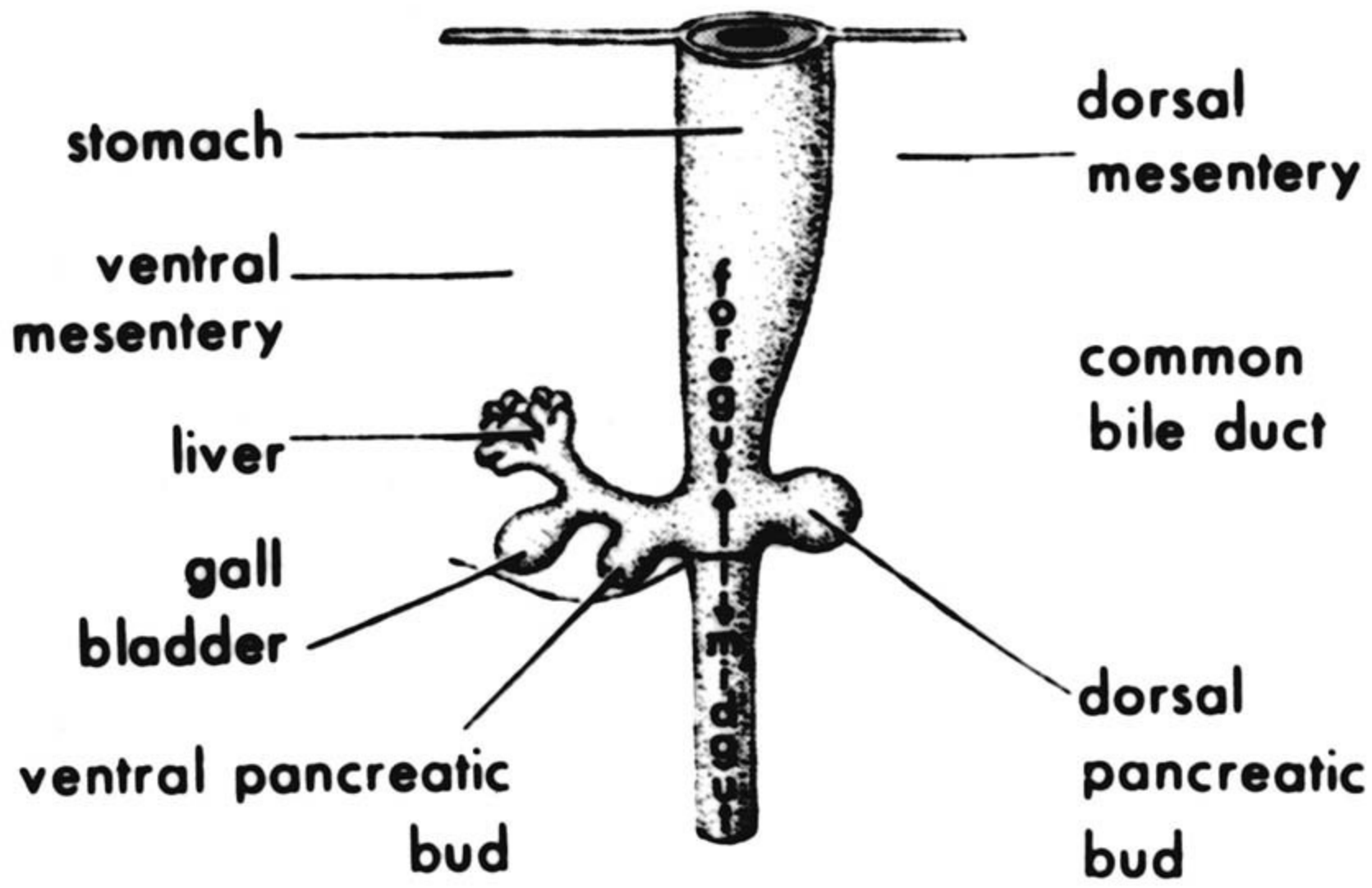
A

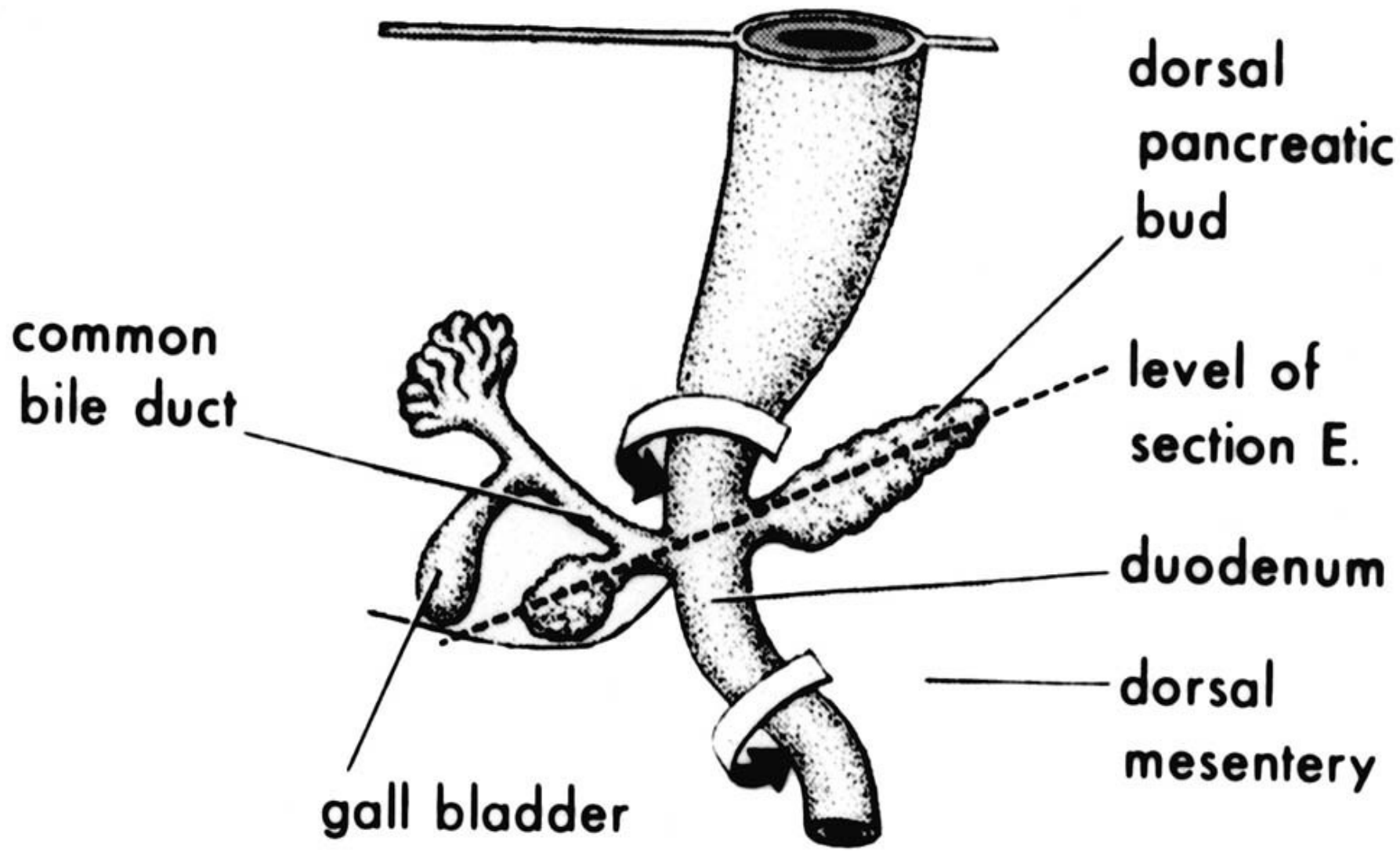
B

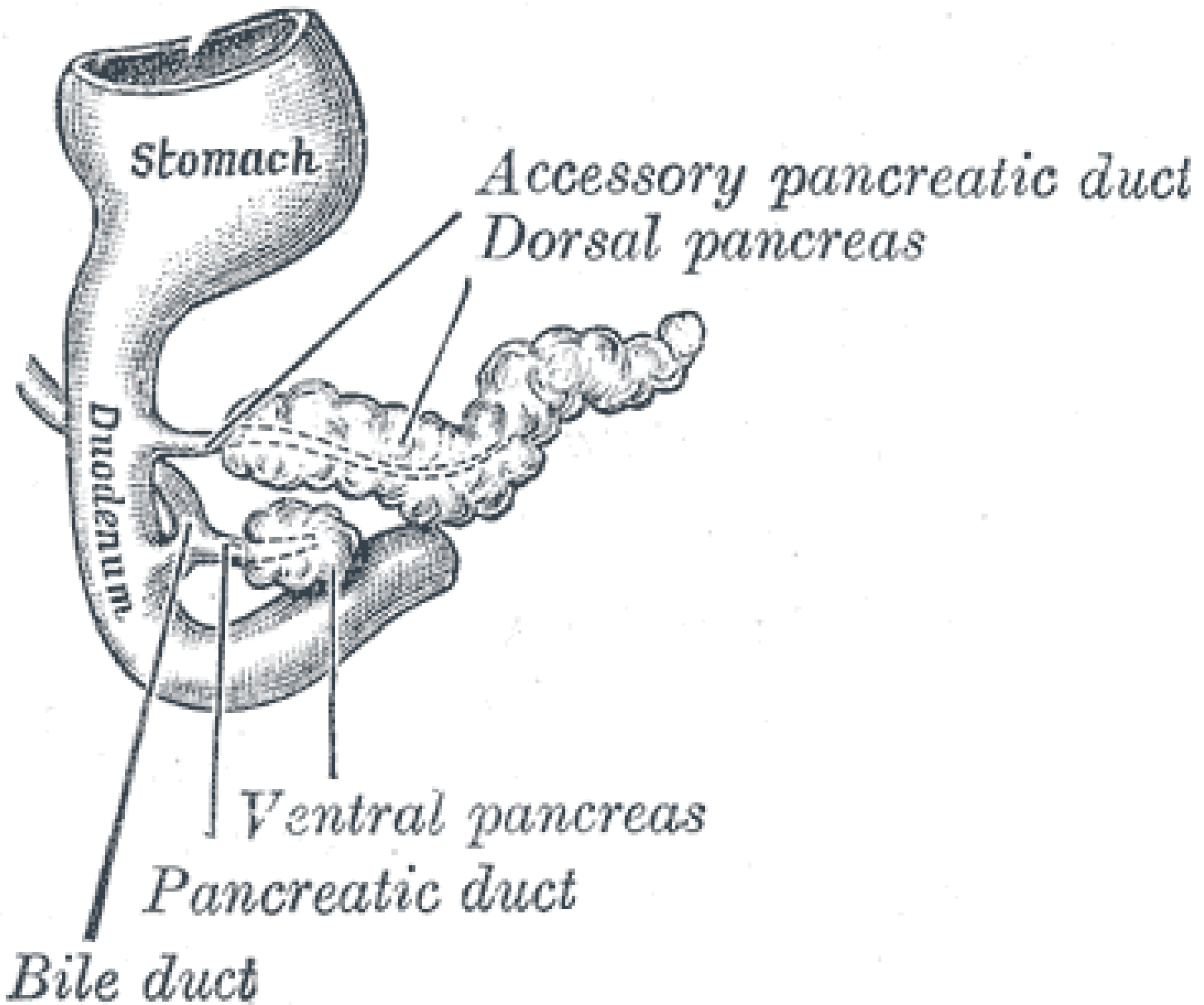


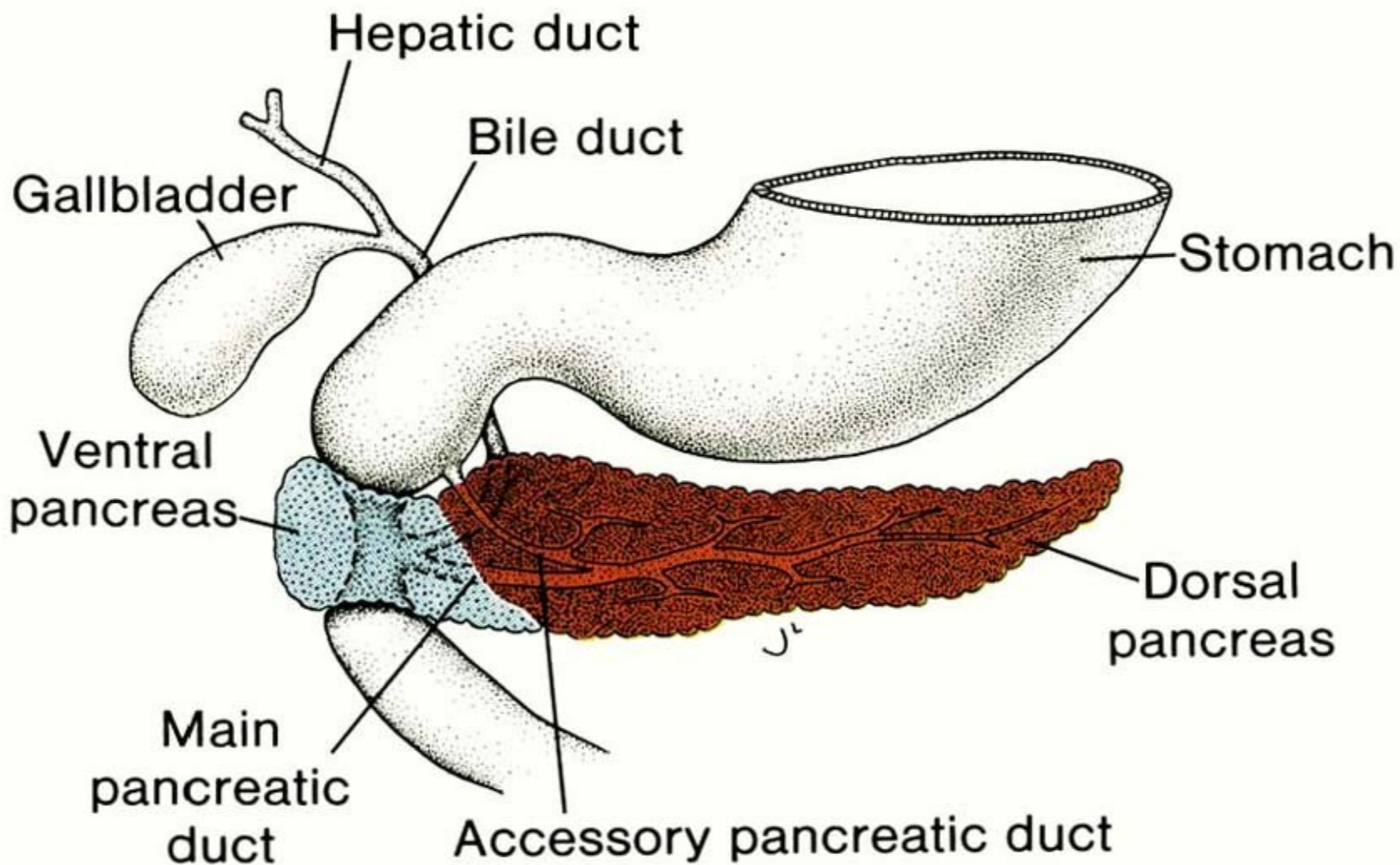
C

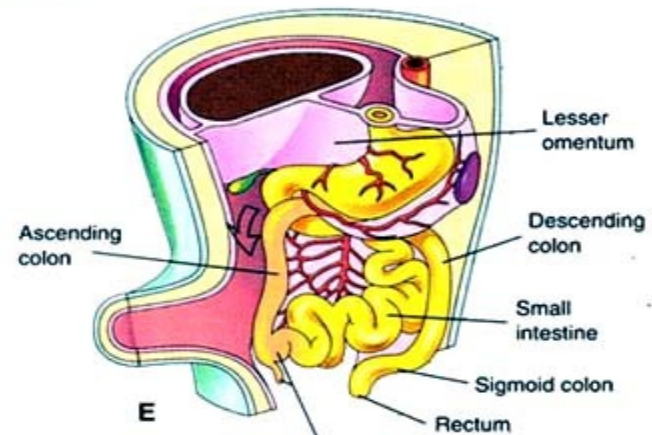
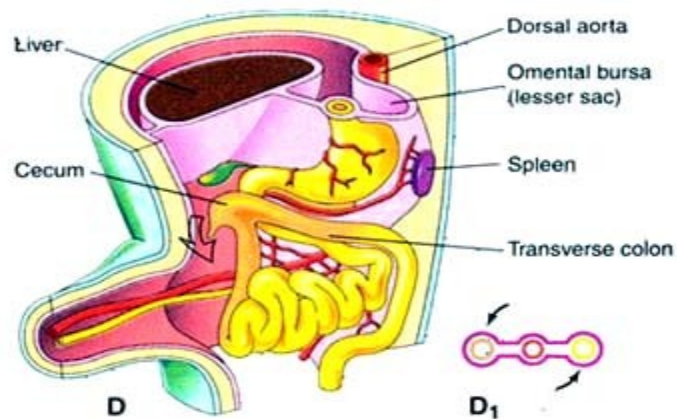
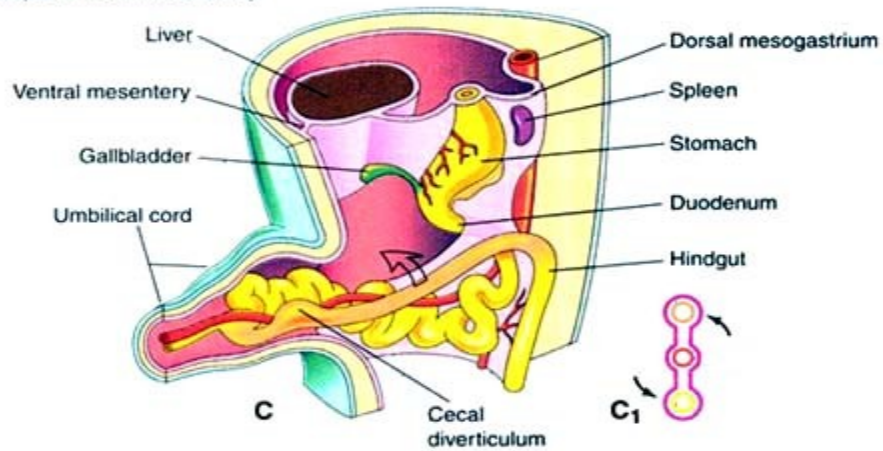
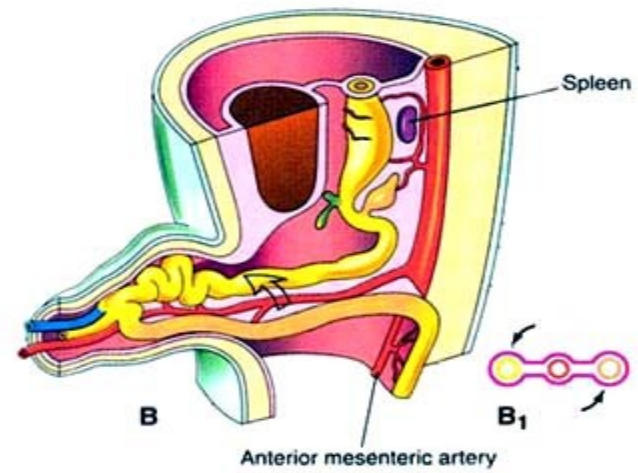
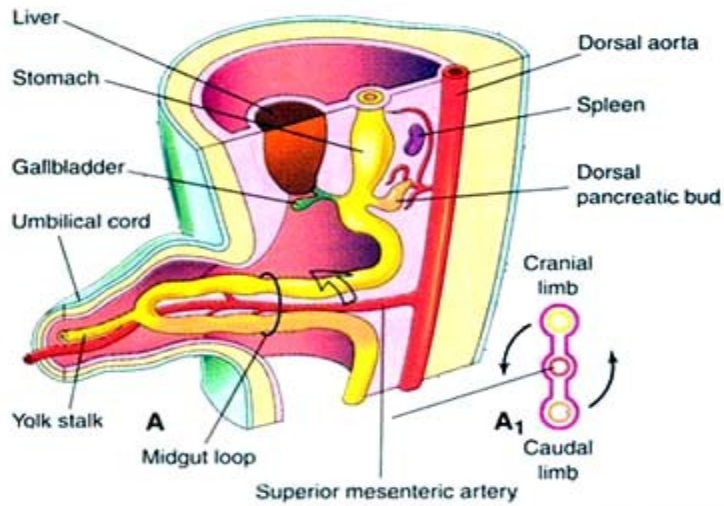


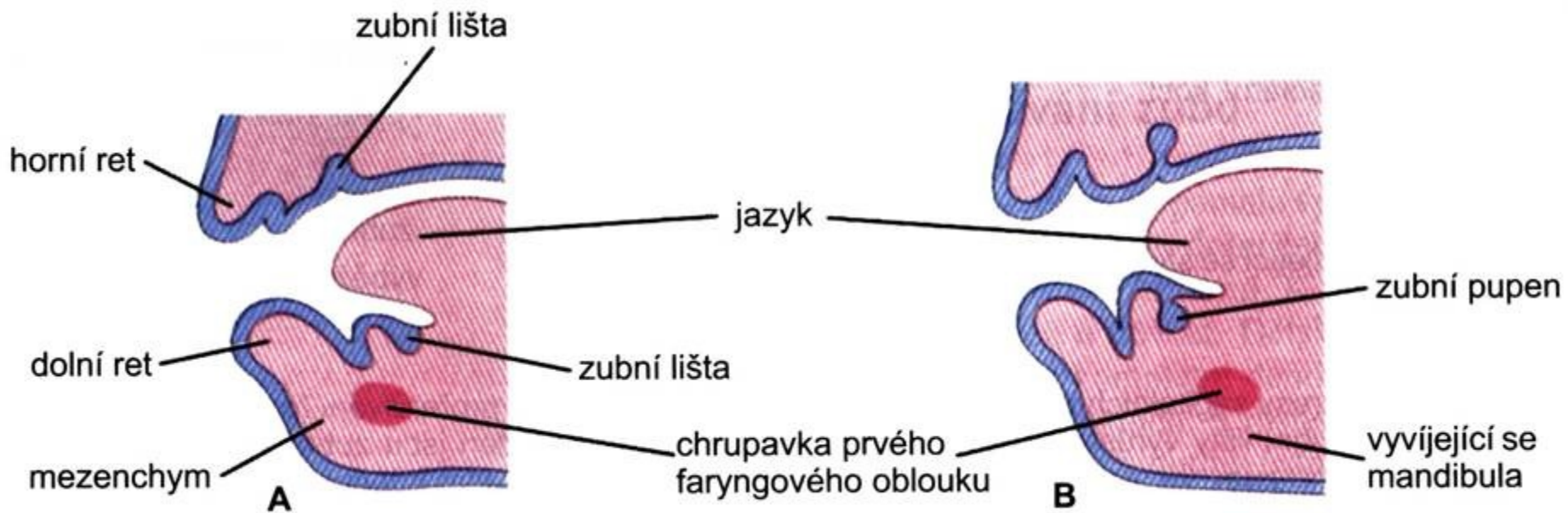








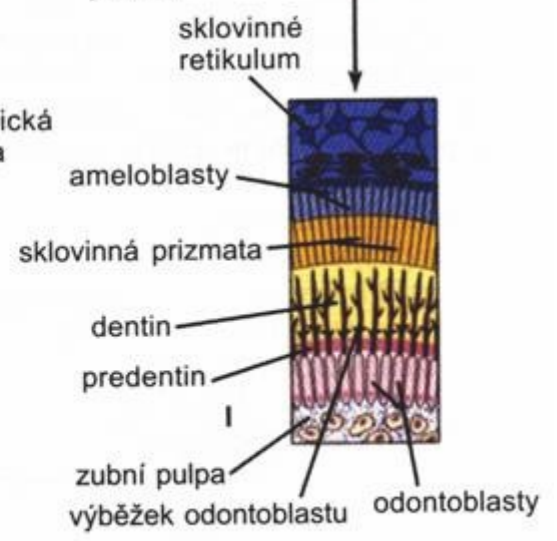
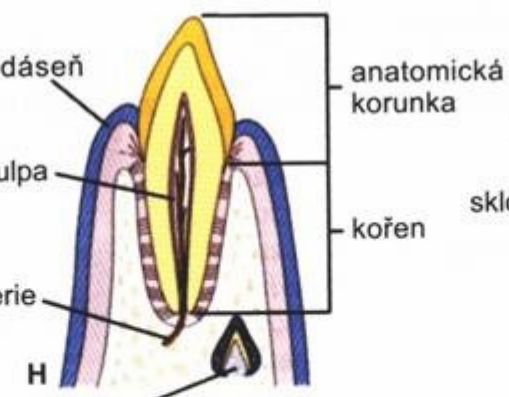
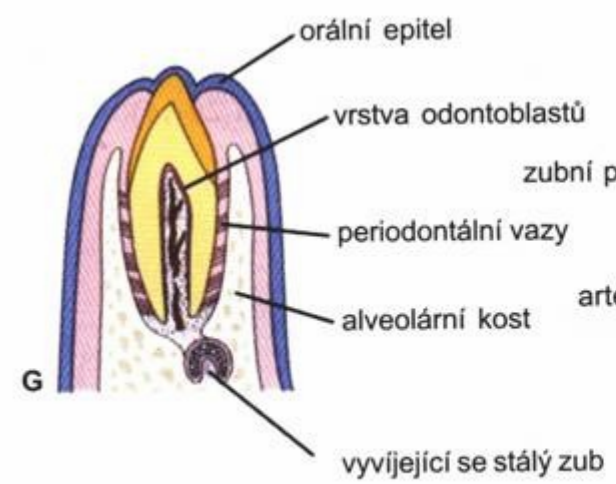
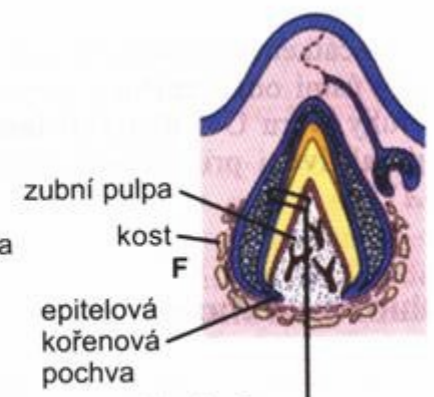
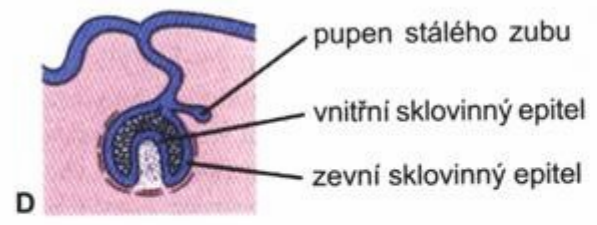
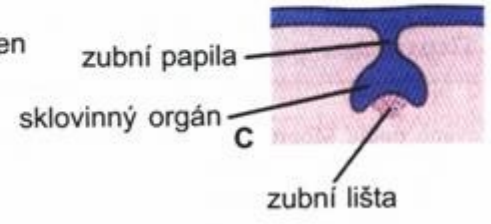
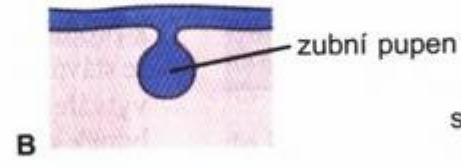
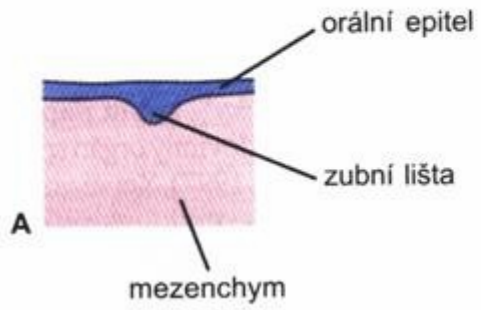


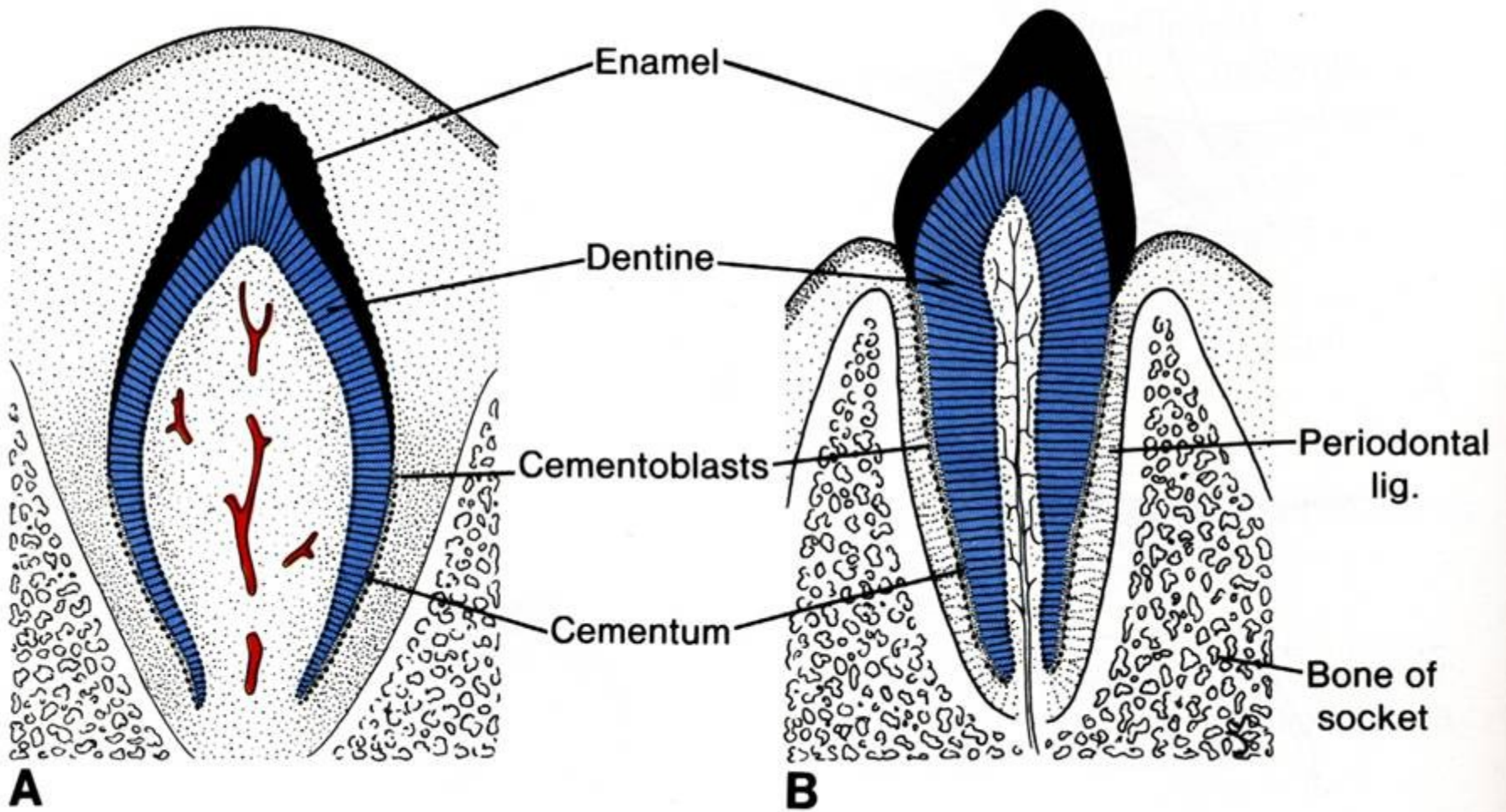


sklovina

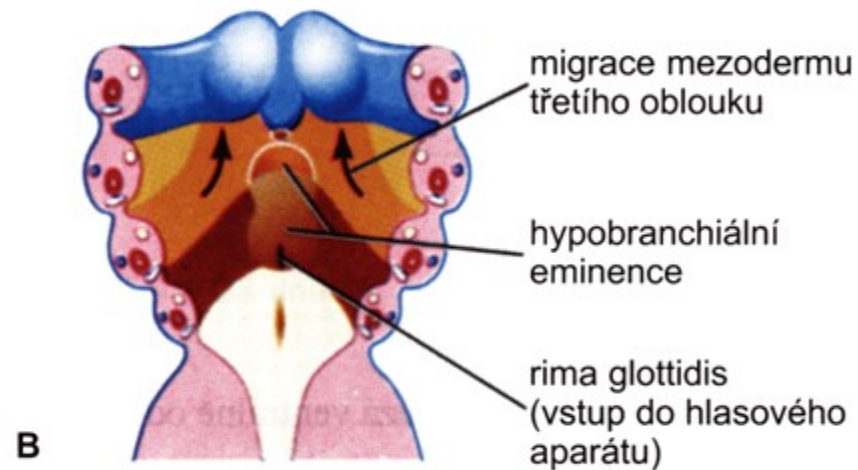
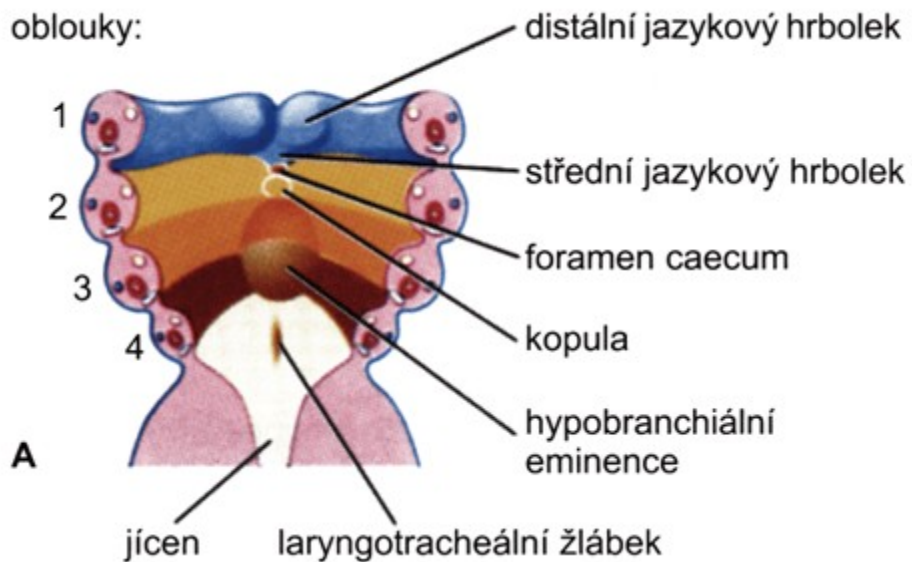
dentin

dentální papila a zubní pulpa









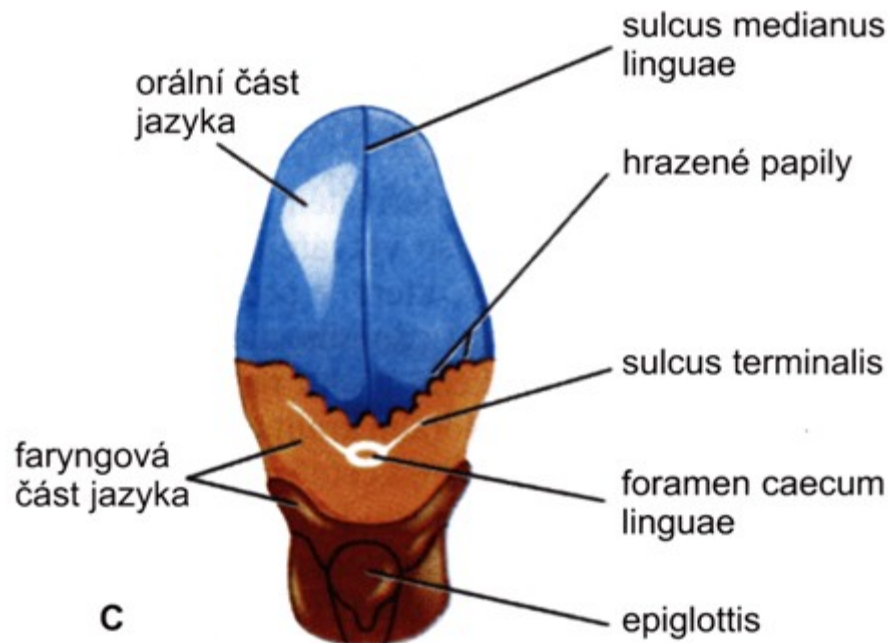
oblouky:



B

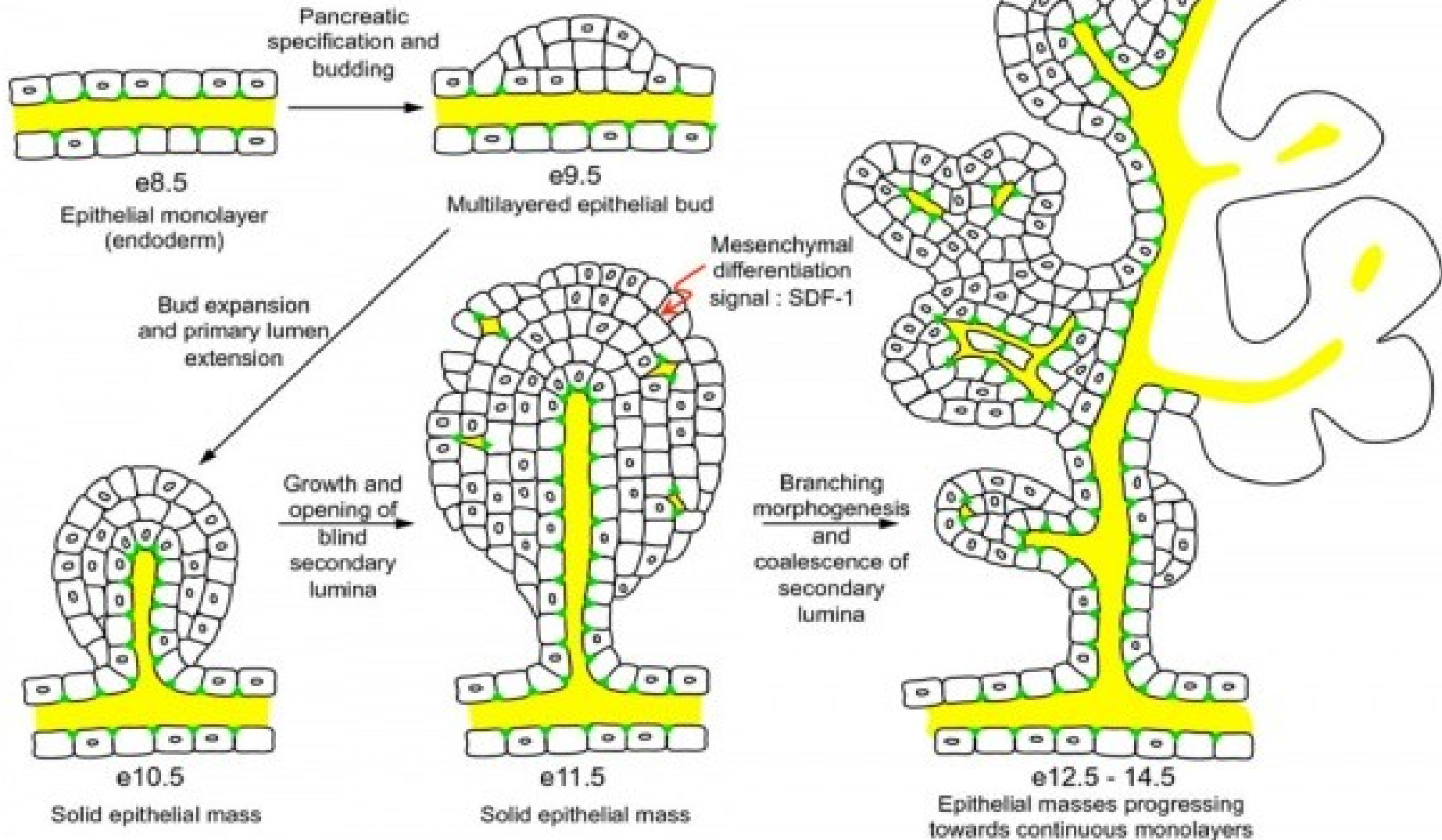
Deriváty faryngových oblouků obsažené v jazyku

- | | |
|--|---|
|  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) |

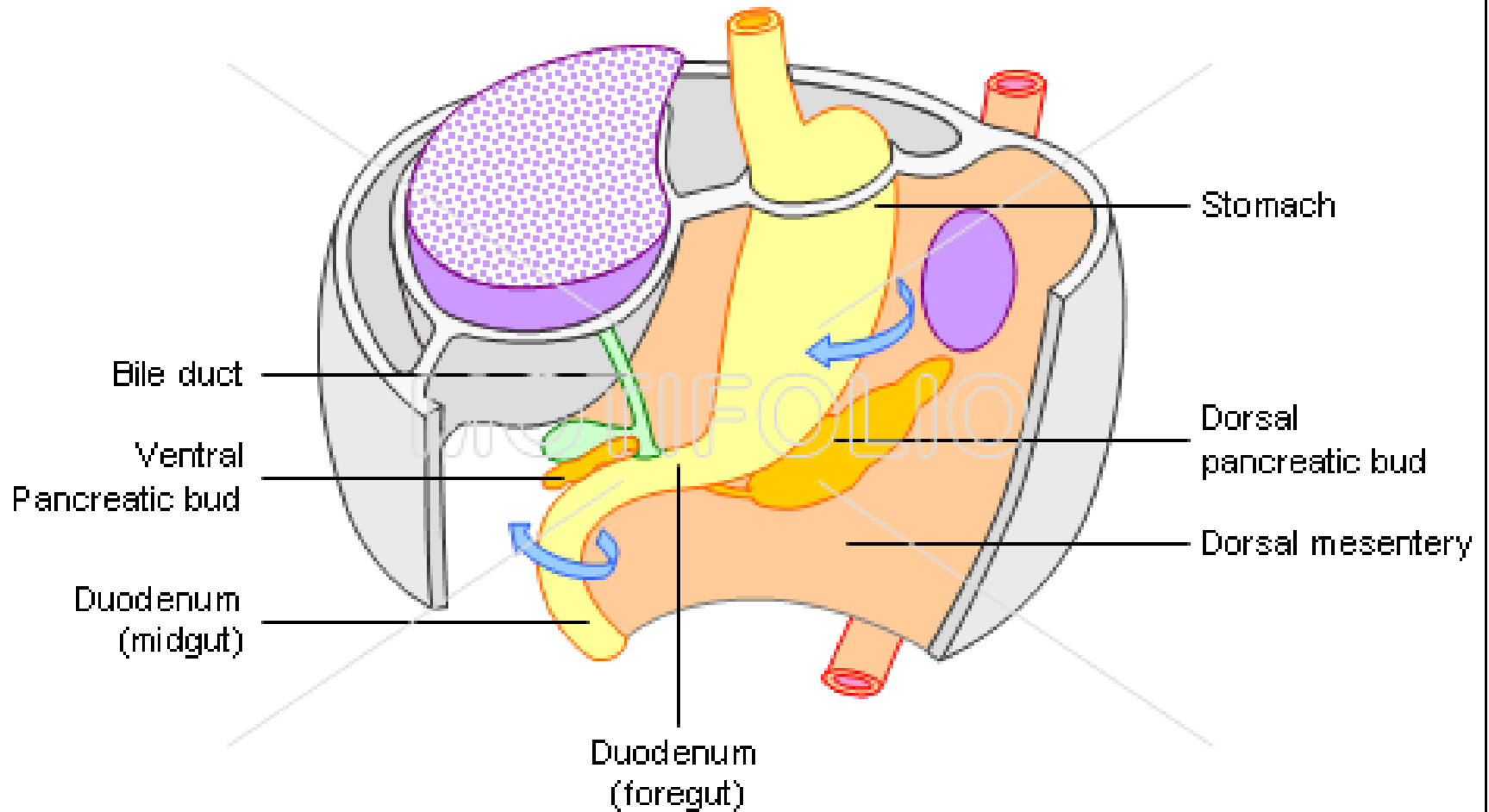


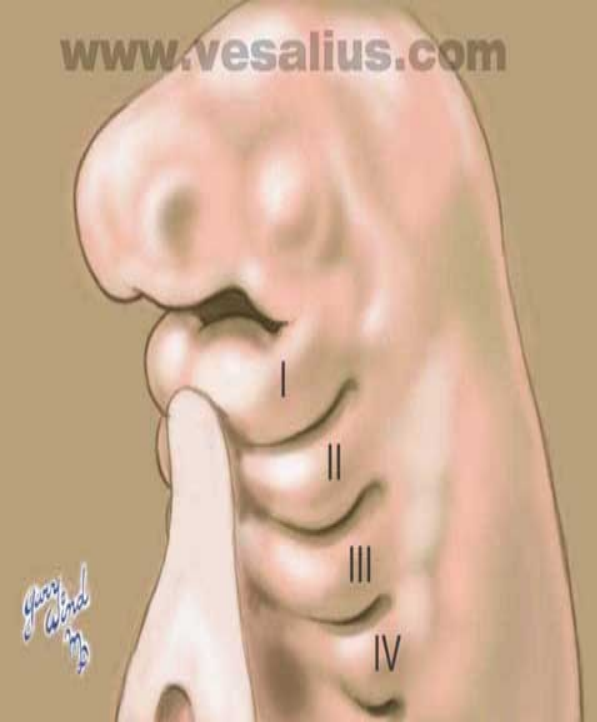
C

Pancreas – ducts and parenchyma development (from endoderm)

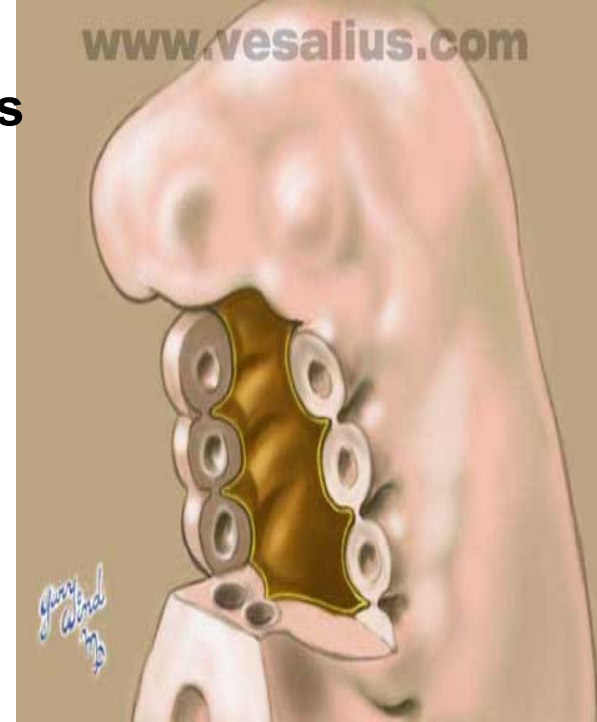


Development of the duodenum and mesenteries – 5 weeks embryo



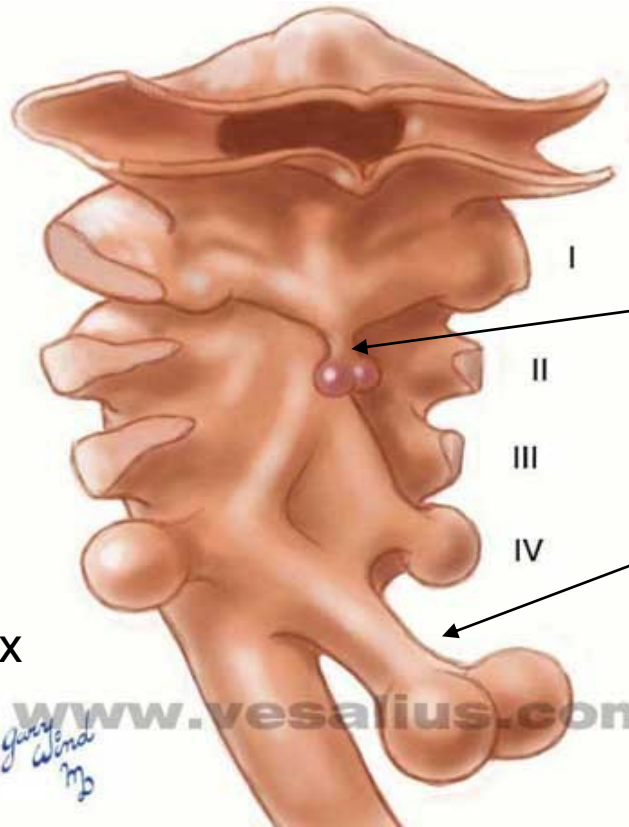


Ectodermal pharyngeal clefts (grooves)



Endodermal pharyngeal pouches

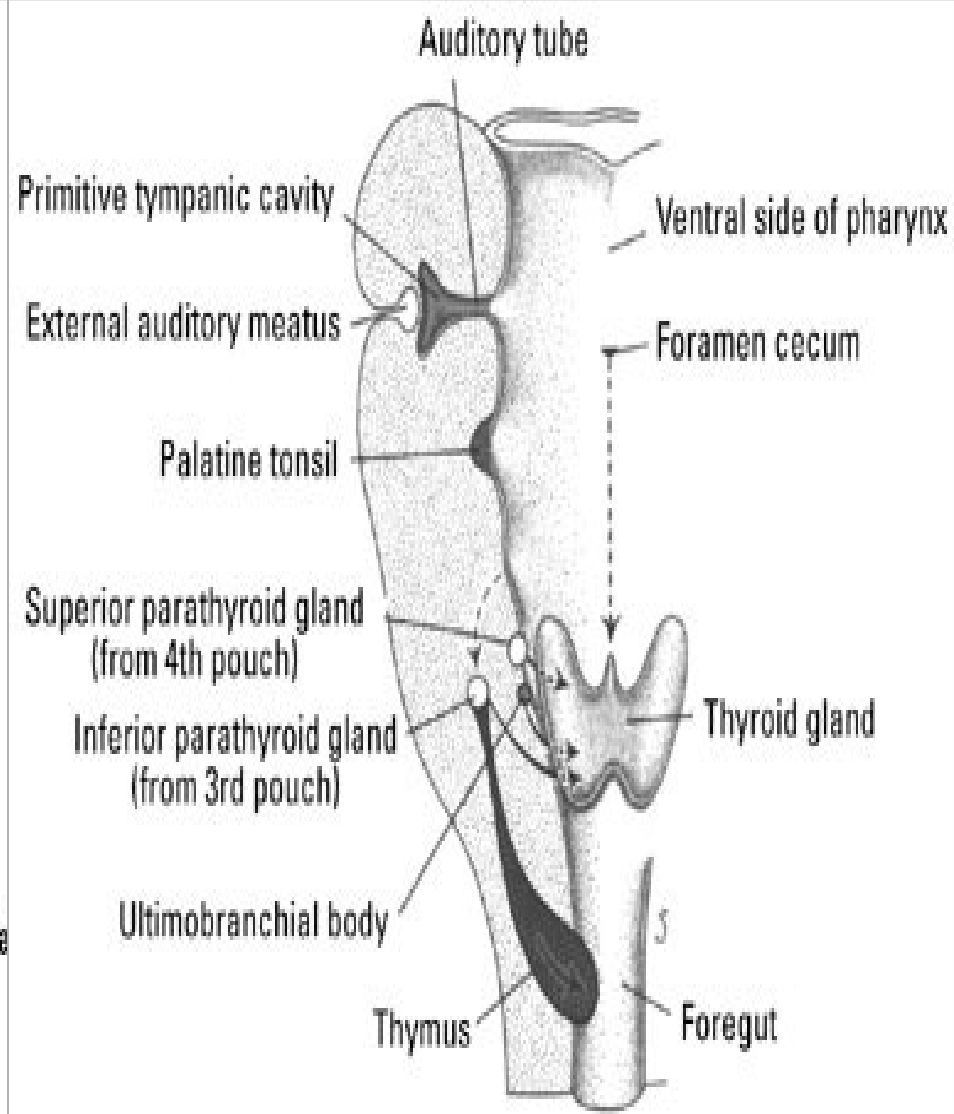
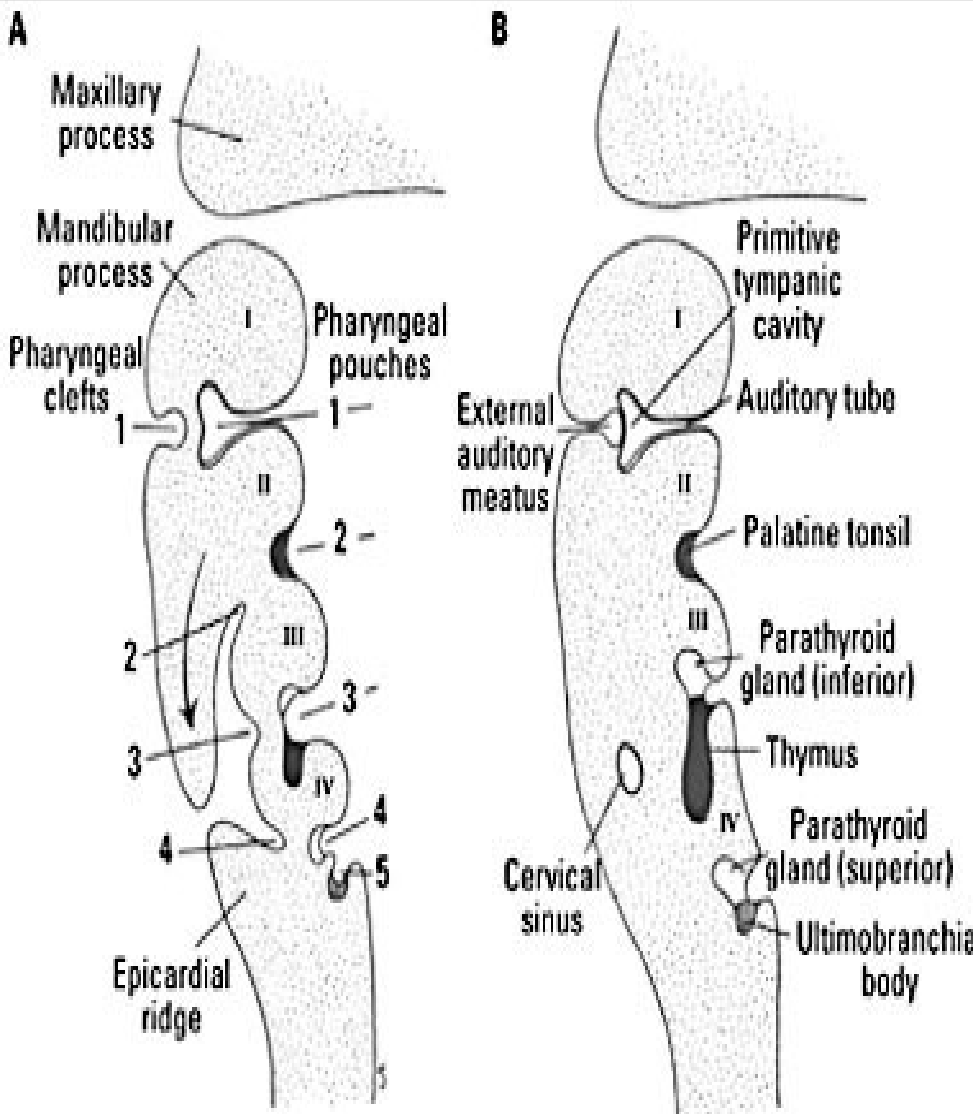
primitive pharynx



Thyroid gl.

Laryngotracheal diverticle

Pharyngeal arches, pouches and clefts



At 6 weeks, the pancreatic buds meet and fuse.

