Gastro-intestinal Module

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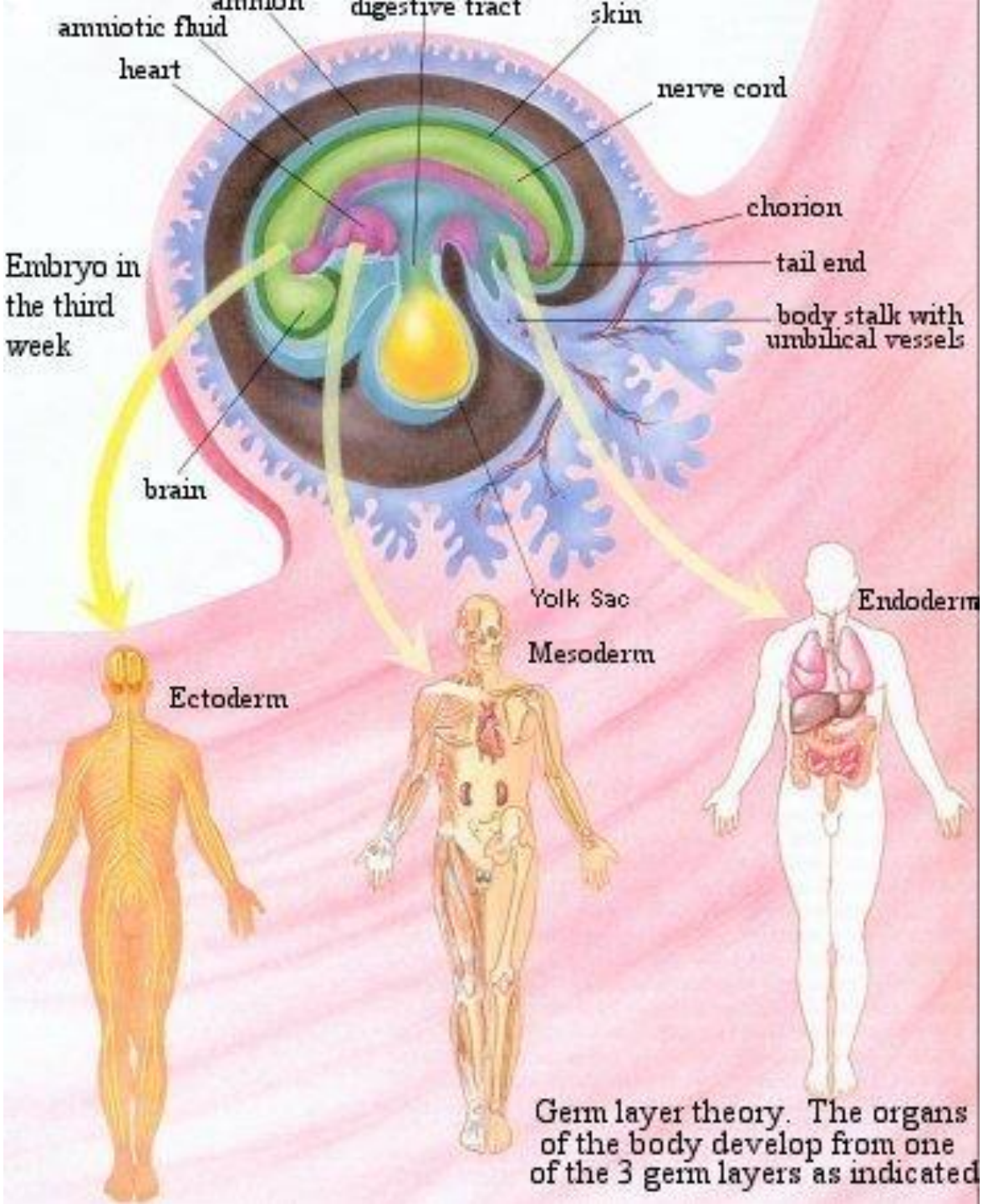
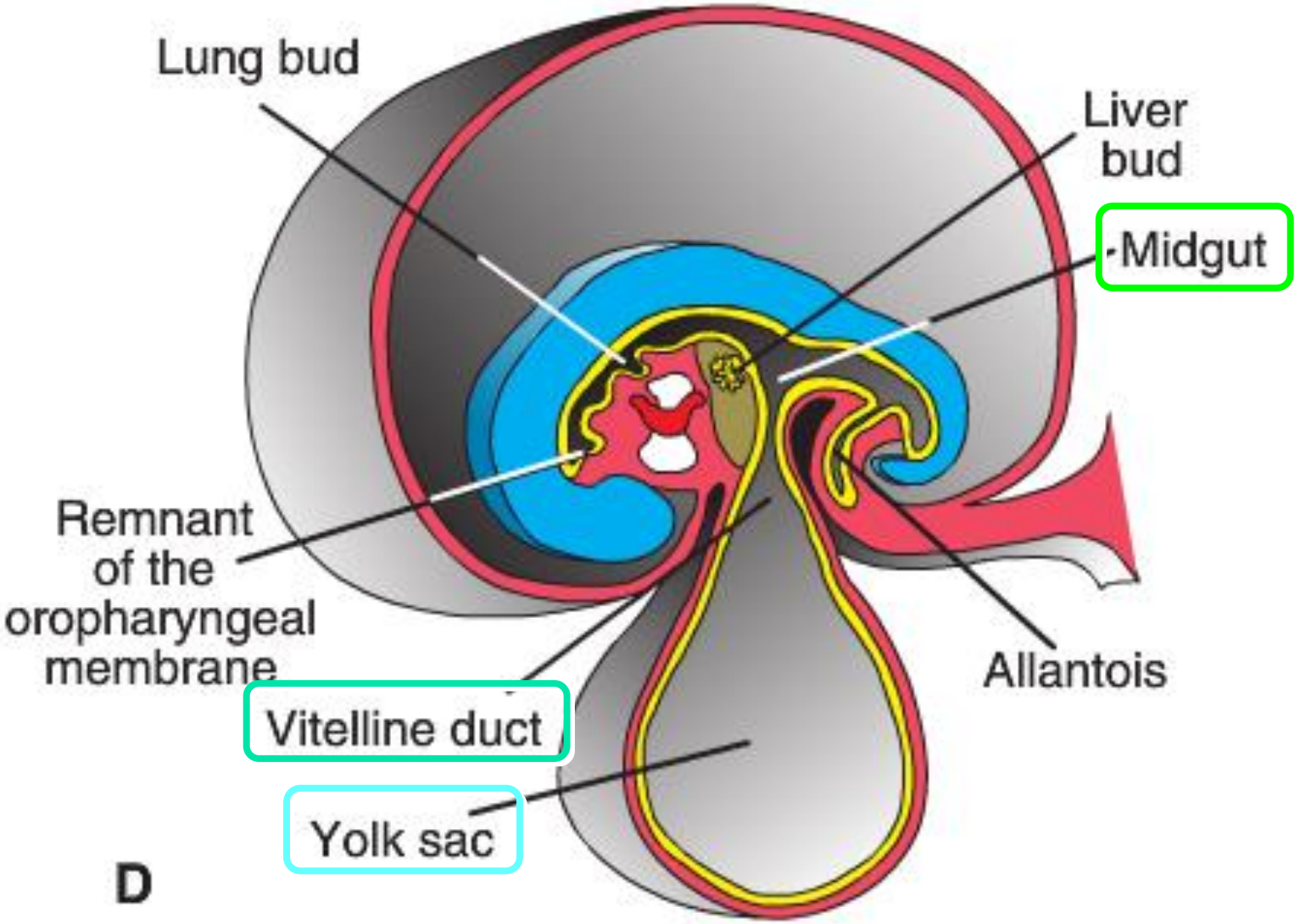
GIT Embryology – Part 1

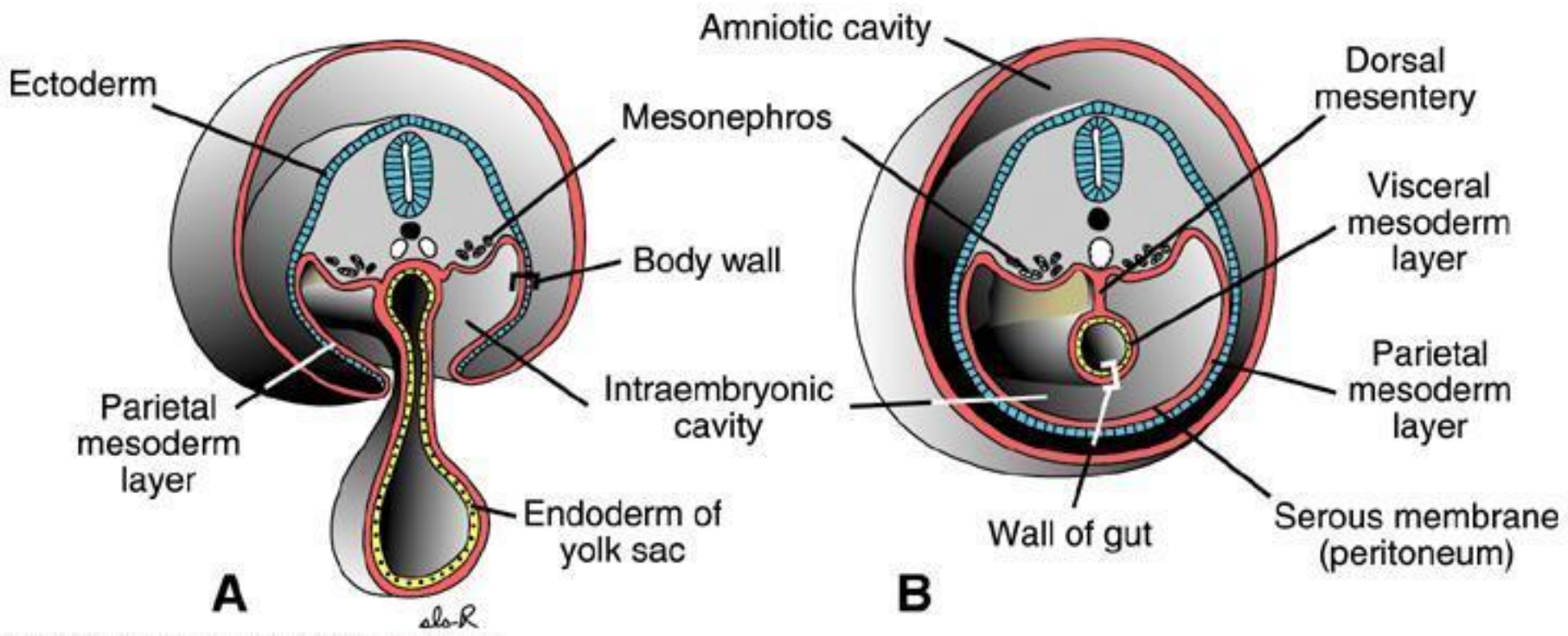


Germ layer theory. The organs of the body develop from one of the 3 germ layers as indicated

The Primitive Gut

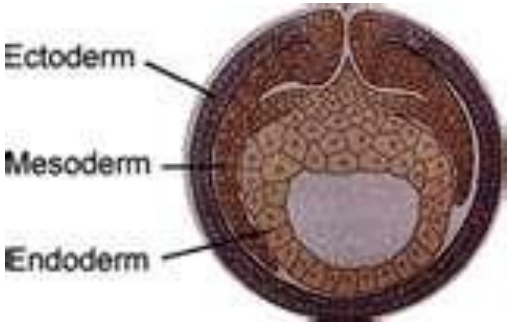
- The primitive gut forms during the 4th week of gestation when the flat embryonic disc folds in median and horizontal planes to form a tubular structure that incorporates part of the yolk sac into the embryo
- Ventral folding of cranial and caudal ends (head and tail folds) form the foregut and the hindgut
- Ventral folding of lateral sides forms the midgut


Lung bud
Liver bud
Midgut
Remnant of the oropharyngeal membrane
Allantois
Vitelline duct
Yolk sac
D



- The stroma (connective tissue) for the glands, muscle, connective tissue, and peritoneal components of the wall of the gut, ***ALL*** are derived from ***visceral mesoderm.***

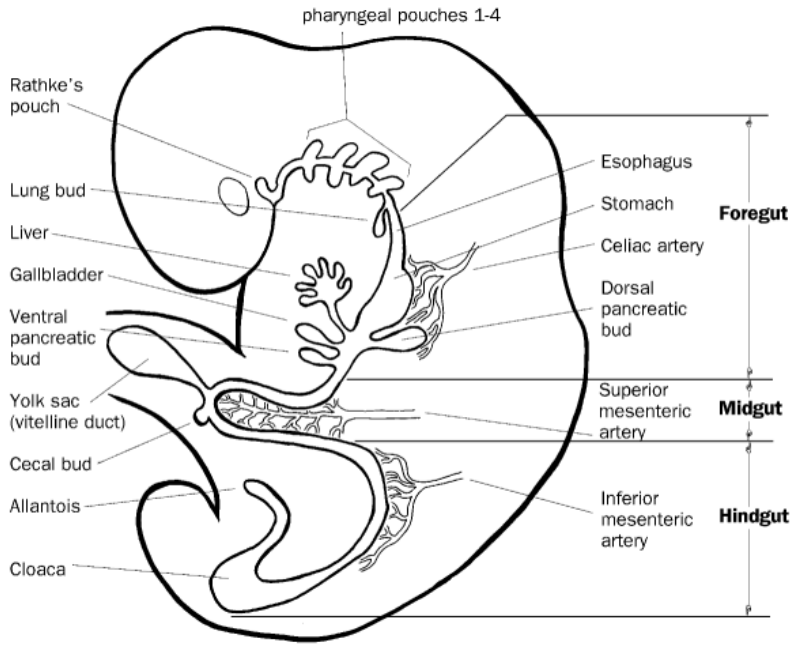
Normal Embryology



- ***Endoderm***
  - Epithelial lining and glands
- ***Mesoderm***
  - Lamina propria, muscularis mucosa, submucosa, muscularis externa and serosa
- ***Ectoderm***
  - Enteric nervous system and posterior luminal digestive structures

Normal Embryology

- ***Primitive Gut Tube***
  - Incorporation of the yolk sac during craniocaudal and lateral folding of the embryo.
    - ***Foregut***
    - ***Midgut***
    - ***Hindgut***



Canalization

- **Canalization**
  - Week 5 - Endoderm portion of GI tract proliferates
  - Week 6 - Occlusion of the lumen
  - Week 8 - Recanalization due to cell degeneration

  - Abnormalities in this process
    - Stenosis/Atresia
    - Duplications

The Derivatives of the Gut Region

- ***FOREGUT***

1. Trachea & respiratory tract
2. Lungs
3. Esophagus
4. Stomach
5. Liver Gallbladder & bile ducts
6. Pancreas (dorsal & ventral)
7. Upper duodenum

The Derivatives of the Gut Region

- ***MIDGUT***

1. Lower duodenum
2. Jejunum
3. Ileum
4. Caecum
5. Appendix
6. Ascending colon
7. Proximal transverse 2/3 colon

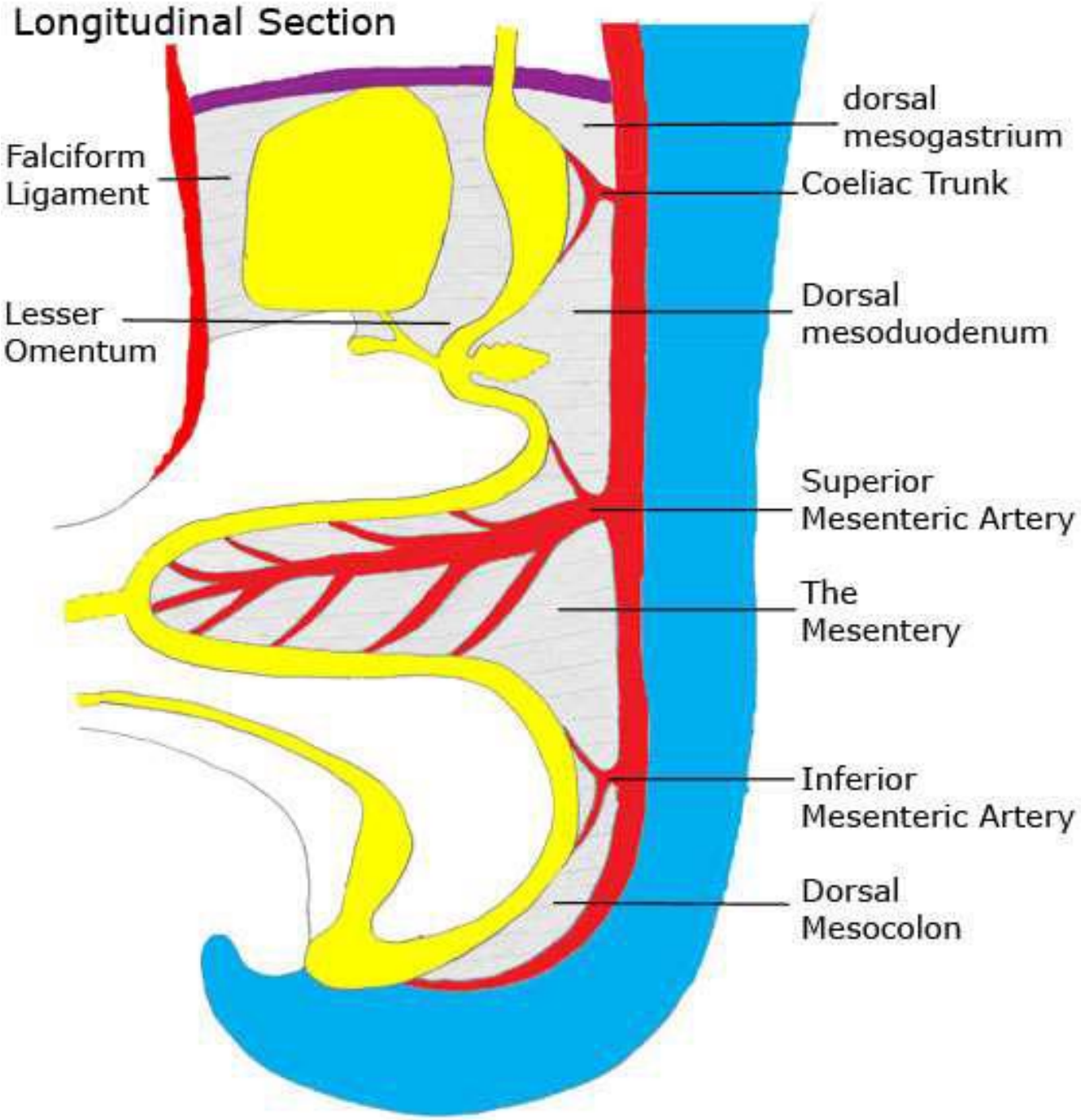
The Derivatives of the Gut Region

- ***HINDGUT***

1. Distal 1/3 transverse colon
2. Descending colon
3. Sigmoid colon
4. Rectum
5. Upper anal canal
6. Urogenital sinus

The Derivatives of the Gut Region

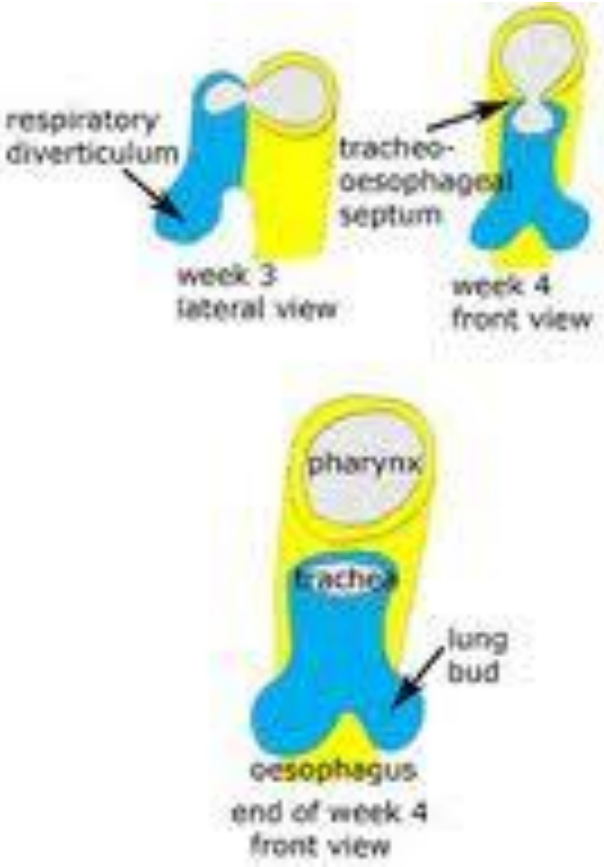
- ***BASED ON THE ARTERIAL SUPPLY:***
- ***Foregut*** derivatives in the abdomen are supplied by branches of the ***celiac artery***
- ***Midgut*** derivatives are supplied by branches of the ***superior mesenteric artery***
- ***Hindgut*** derivatives are supplied by branches of the ***inferior mesenteric artery***


Longitudinal Section
dorsal mesogastrium
Falciform Ligament
Coeliac Trunk
Lesser Omentum
Dorsal mesoduodenum
Superior Mesenteric Artery
The Mesentery
Inferior Mesenteric Artery
Dorsal Mesocolon

Foregut

- Esophagus

The tracheoesophageal bud, at the ventral side of the primitive esophagus, approximately at 4 weeks old, develops a septum that divides foregut into the esophagus and trachea



- ***Clinical Correlation***
  - Esophageal atresia
  - Tracheoesophageal fistula

Stages in the Development of the Esophagus

- Elongation occurs during the 2nd month; by the 8th week the proliferating epithelium has partly occluded the lumen.
- Recanalization occurs during the 3rd month by vacuolation in the multilayered columnar epithelium.
- Differentiation of stratified squamous epithelium occurs during the 4th month.

Stages in the Development of the Esophagus

- Induction of muscle formation in the splanchnic mesoderm occurs during the 2nd month in response to signals from the endoderm. Initially only smooth muscle forms.

- Trans-differentiation of smooth to skeletal muscle occurs in the upper two-thirds of the esophagus

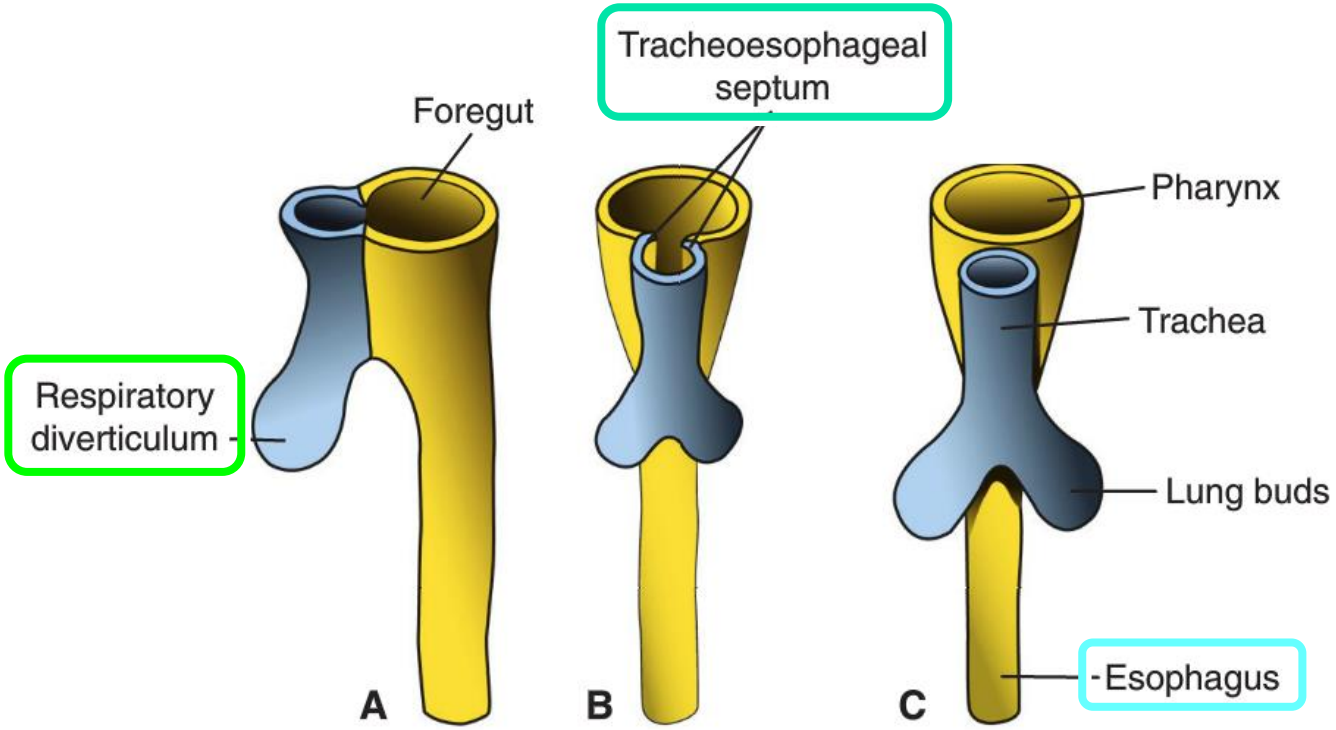


Figure 15.6 Successive stages in development of the respiratory diverticulum and esophagus through partitioning of the foregut. **A.** At the end of the third week (lateral view). **B,C.** During the fourth week (ventral view).

- The **tracheoesophageal septum** gradually partitions this diverticulum from the dorsal part of the foregut.
- In this manner, the foregut divides into:
  - A ***ventral*** *portion,* the **respiratory primordium**, and
  - A ***dorsal*** *portion,* the **esophagus**

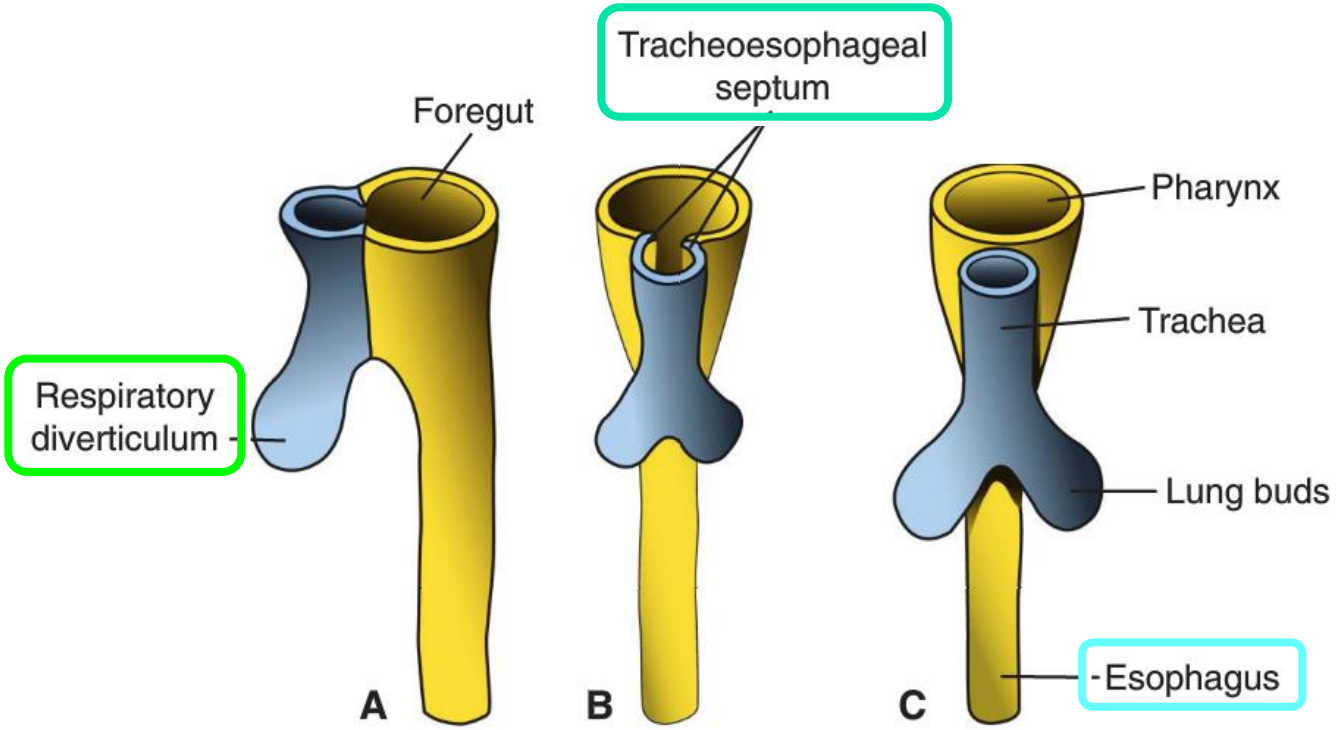


Figure 15.6 Successive stages in development of the respiratory diverticulum and esophagus through partitioning of the foregut. **A.** At the end of the third week (lateral view). **B,C.** During the fourth week (ventral view).

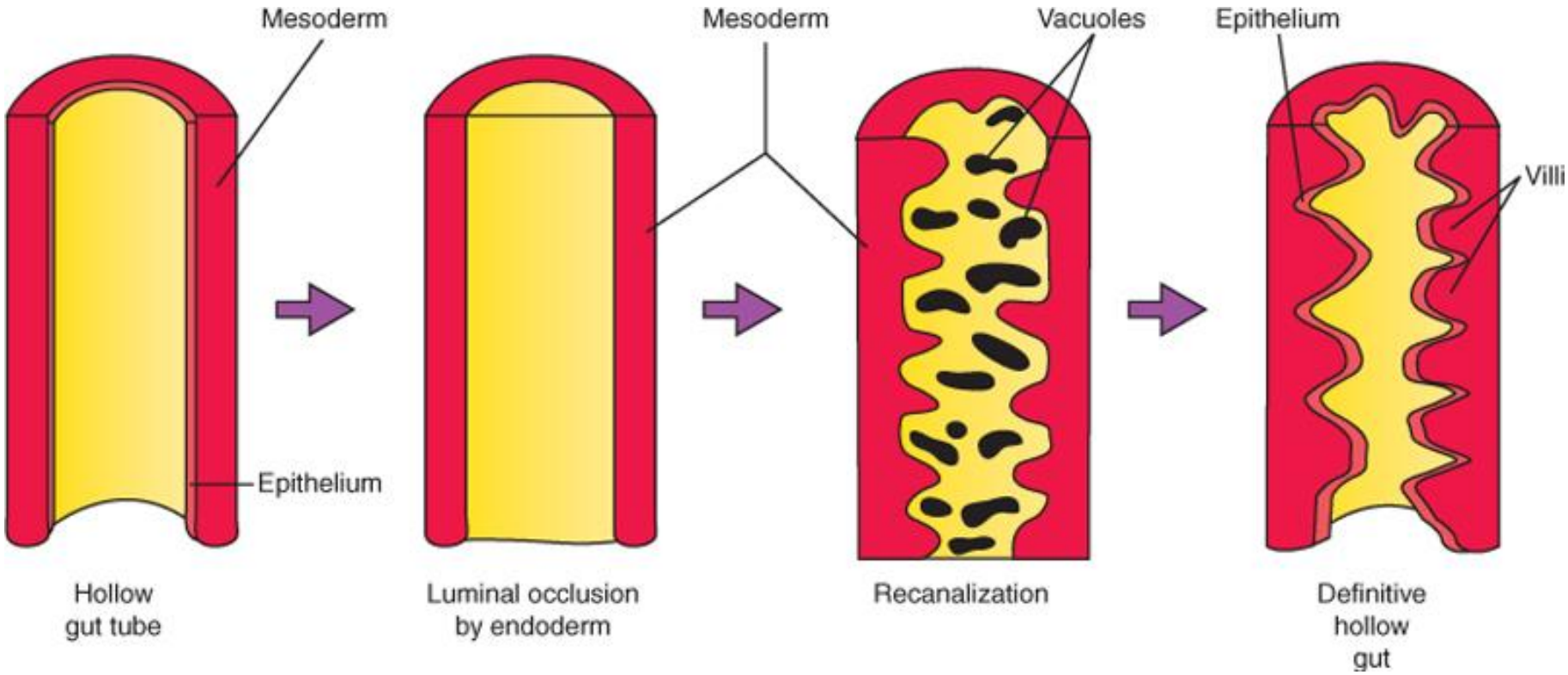
- At first, the ***Esophagus*** is short, but with descent of the heart and lungs, and further development of the respiratory tract, it lengthens rapidly.

Clinical Correlation

- ***Esophageal atresia***

- Usually is accompanied by a tracheoesophageal fistula, in which case gut contents can be Aspirated into the lungs after birth causing inflammation (pneumonitis) or even infection (Pneumonia).

- Postnatally, the child will regurgitate ***IMMEDIATELY*** upon starting breast feeding



5th week **7th week** **9th week**

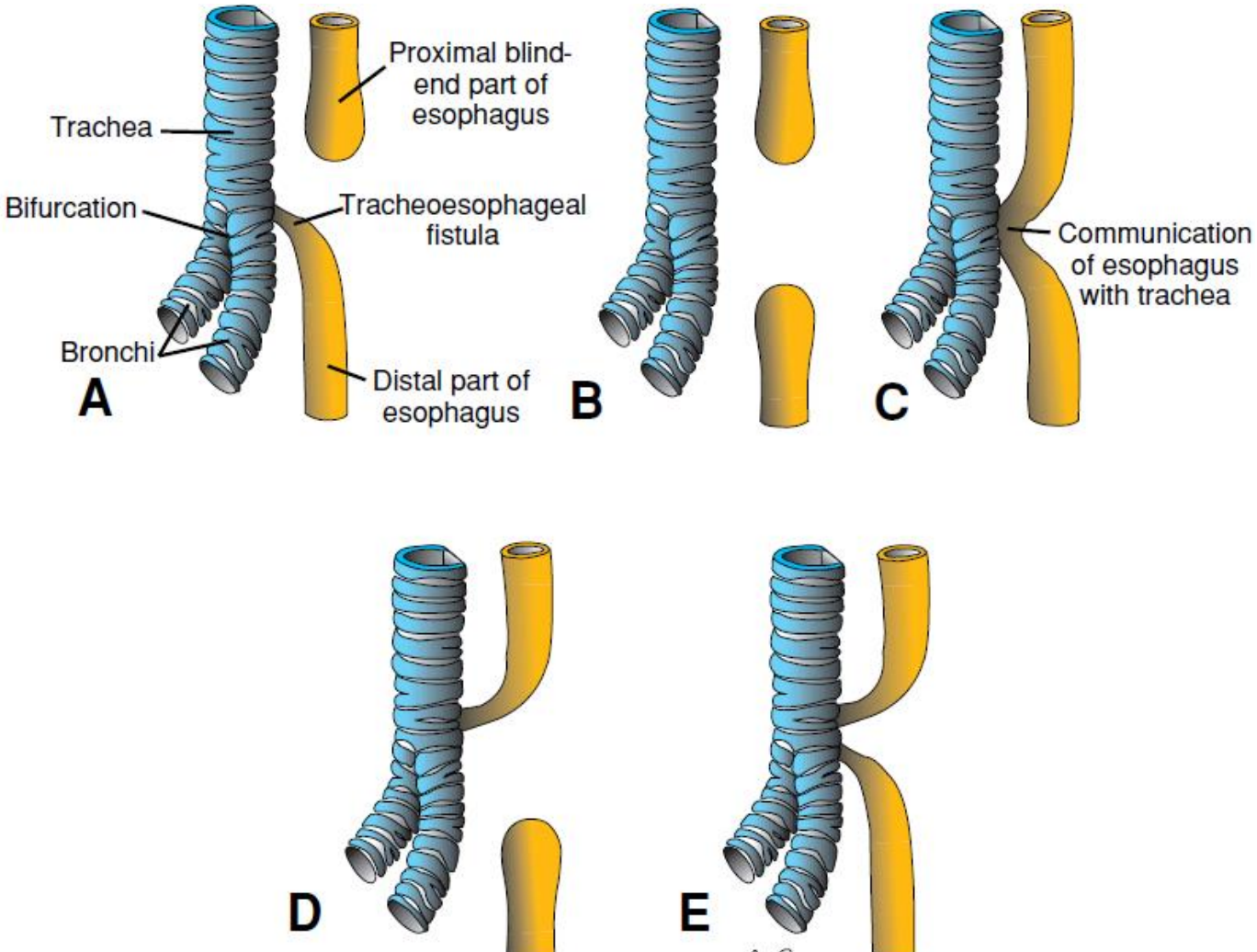
Clinical Correlation

- Occurs in 1 in ~ 3000 births
- Highest incidence in Caucasians
- 50% have associated congenital anomalies

- Diagnosis
  - Prenatal Ultrasound – polyhydramnios
  - CXR – absence of gastric bubble, tracheal deviation
  - CT
  - Feeding difficulties with respiratory symptoms

- Etiology
  - Canalization defect
  - Defect with tracheoesophageal septum development

Clinical Correlation



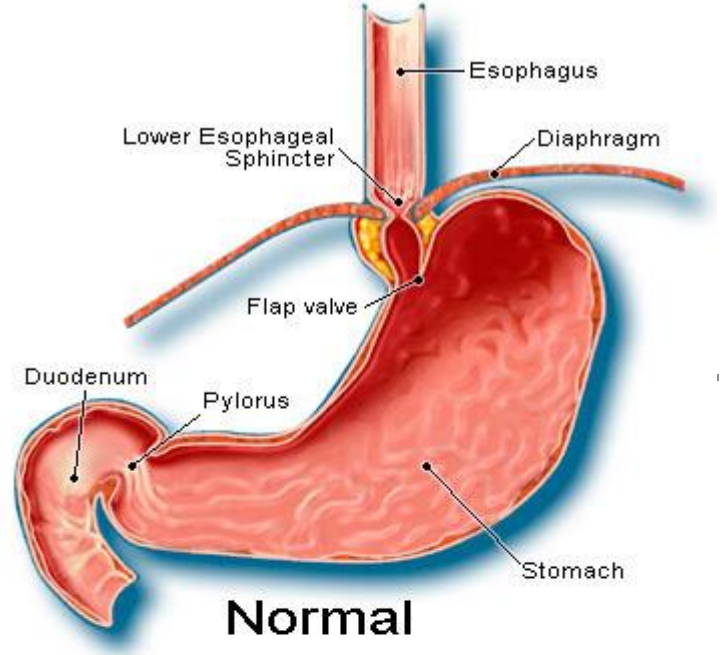
Clinical Correlation

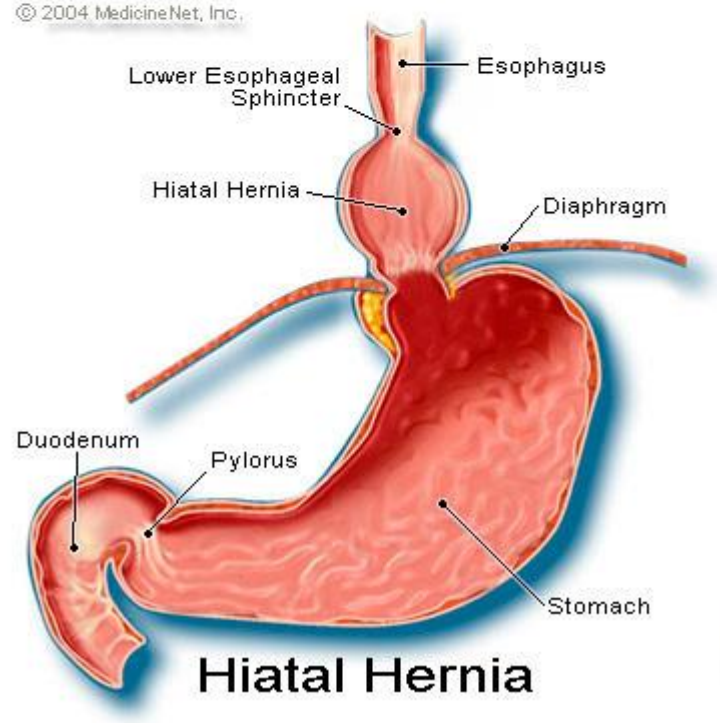
Esophageal stenosis

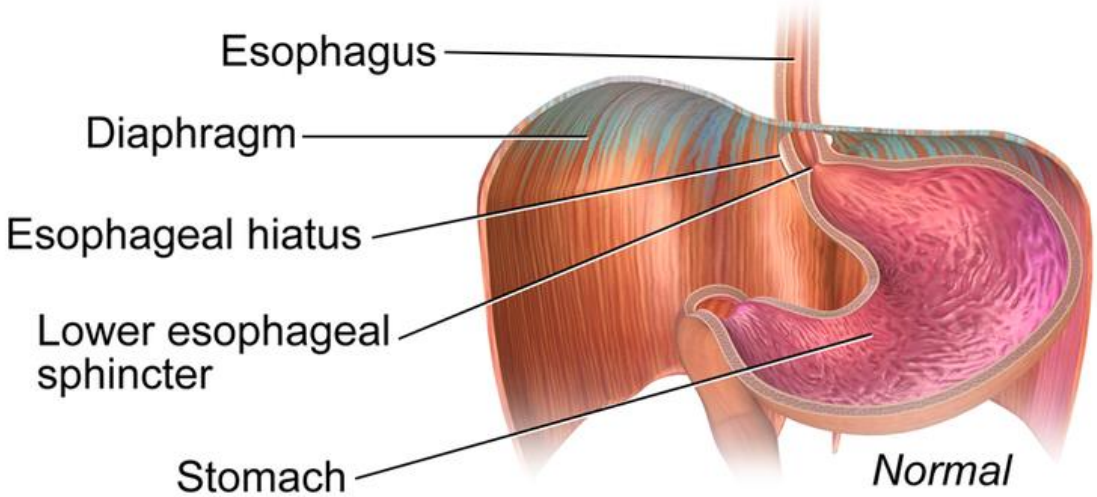
- It occurs when the esophagus fails to recanalize also typically associated with polyhydramnios prenatally. Postnatally, the child will regurgitate ***frequently*** upon feeding. However, there is usually NOT a tracheoesophageal fistula, so the lungs will usually NOT be congested.

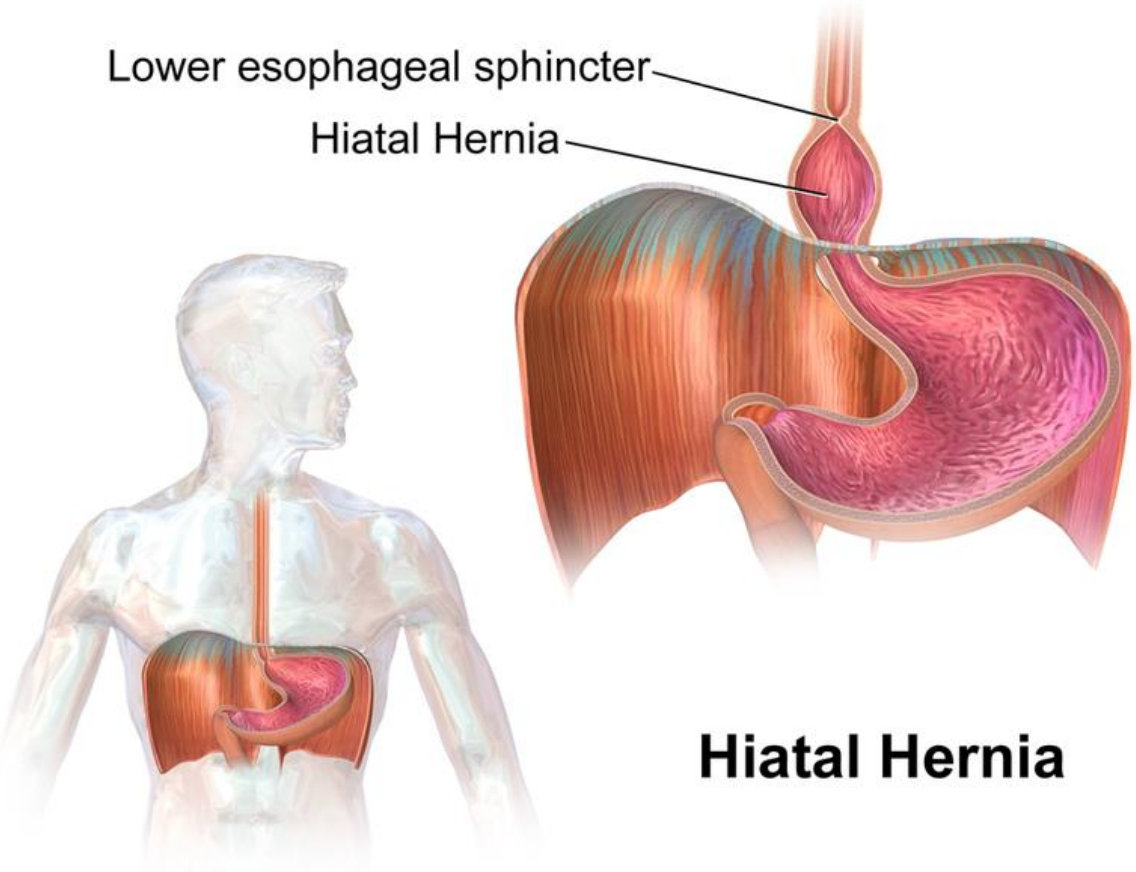
Congenital hiatal hernia

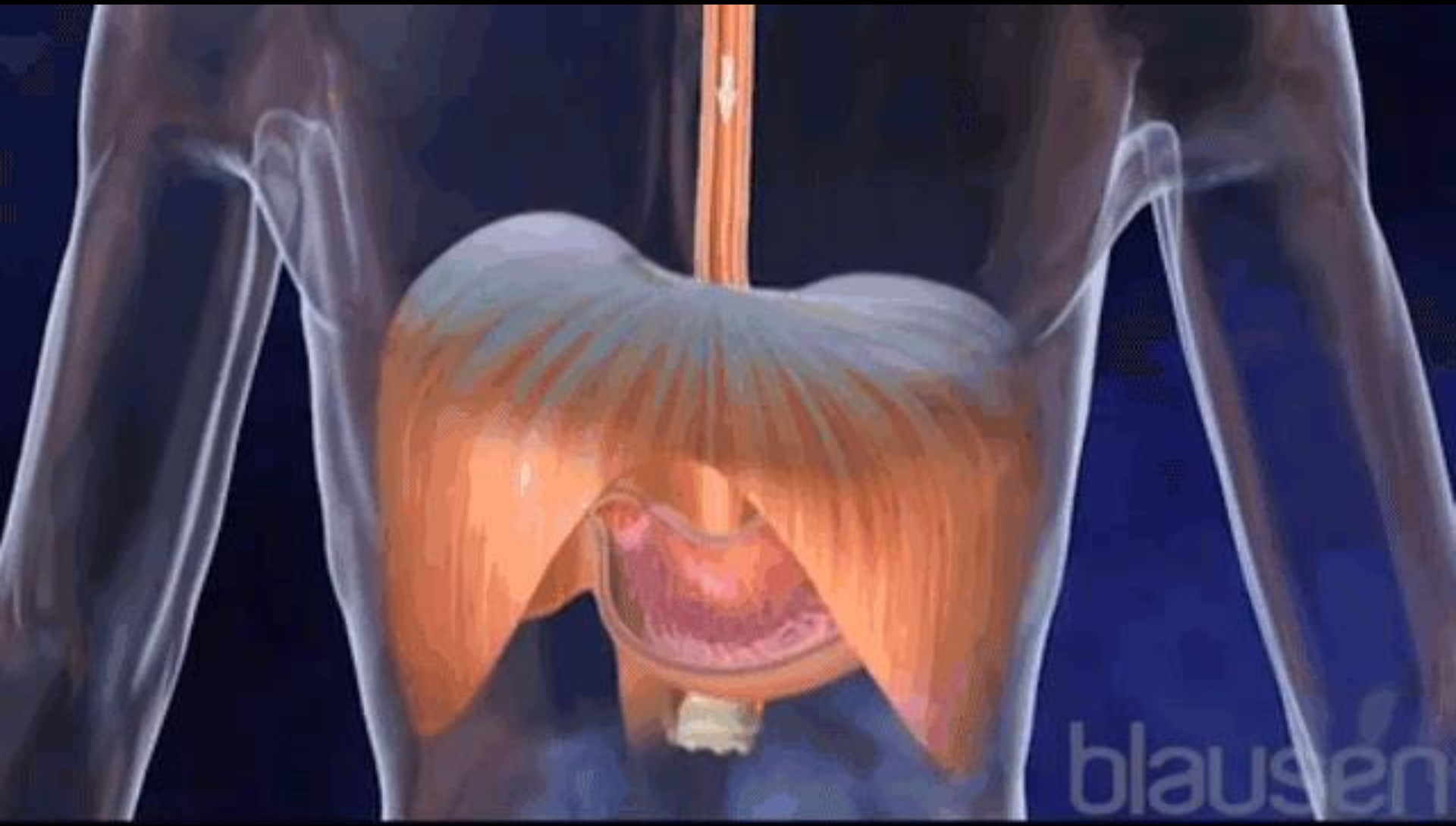
- It occurs when the esophagus fails to grow adequately in length. As a result, the esophagus is too short and therefore pulls the cardiac stomach into the esophageal hiatus in the diaphragm. The resulting compromised structure of the hiatus can allow other gut to herniate







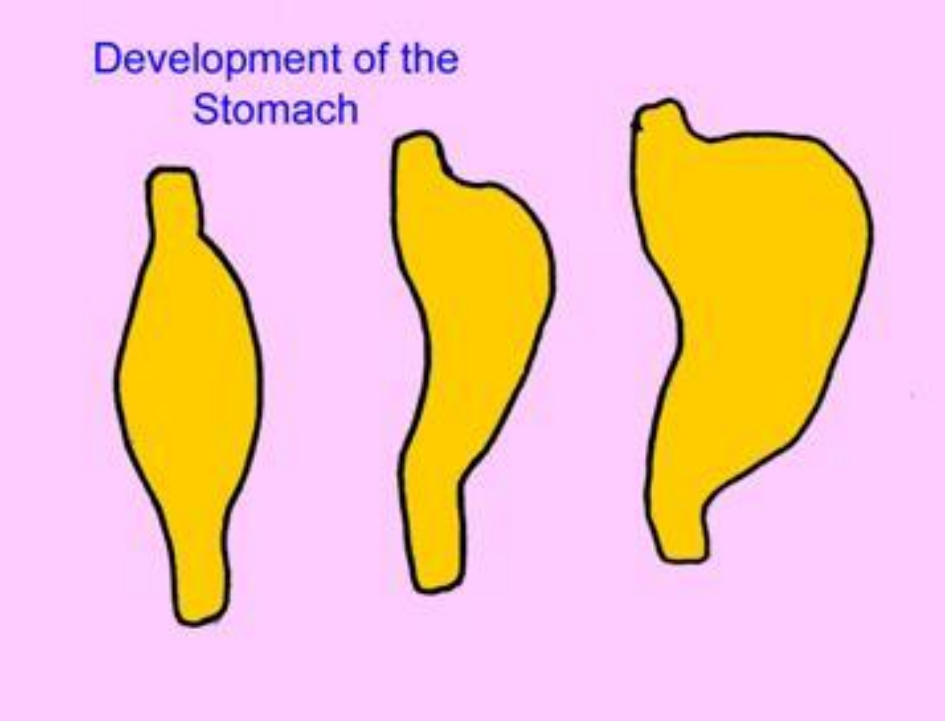


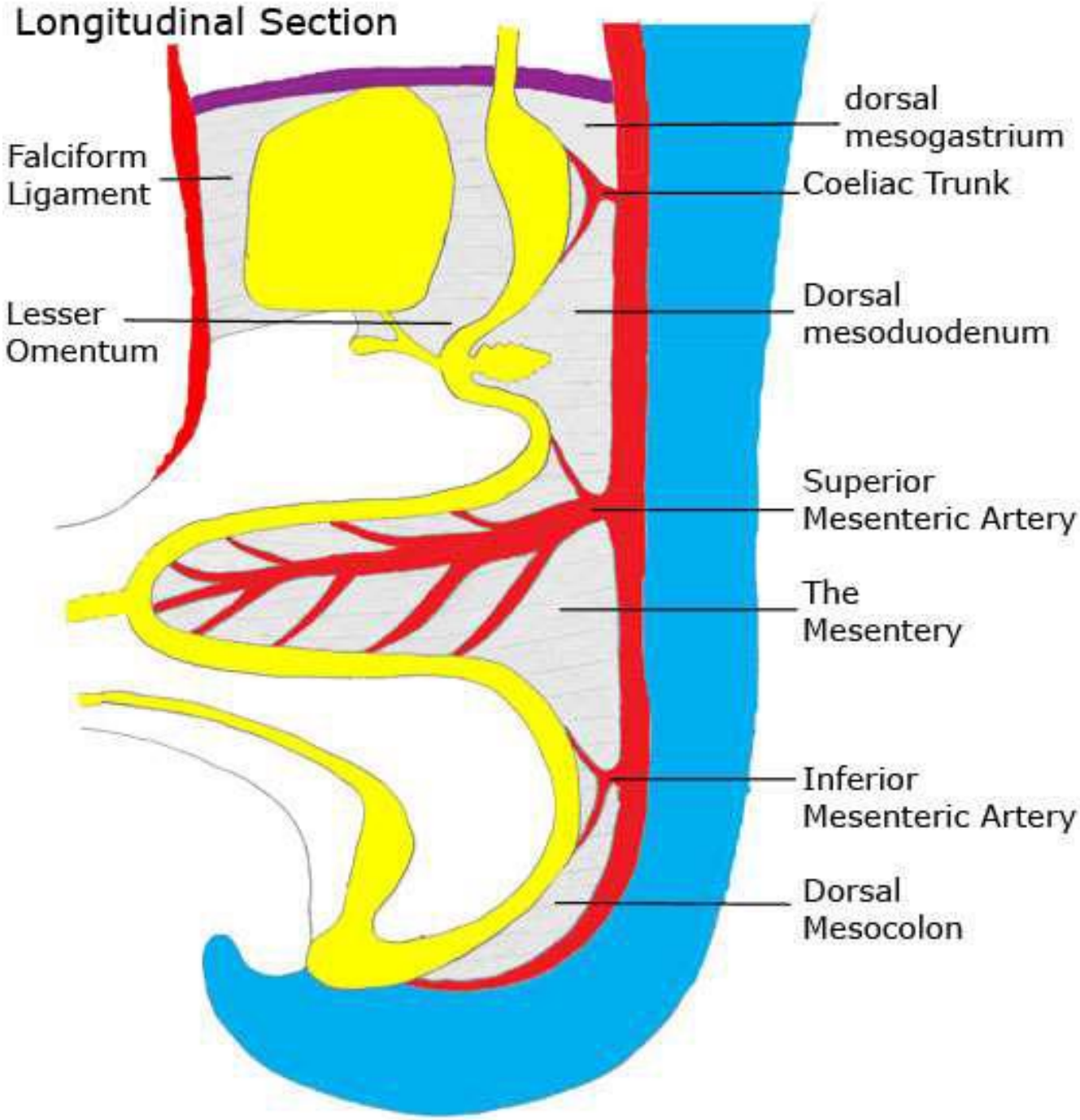

blausen

Foregut

- Stomach

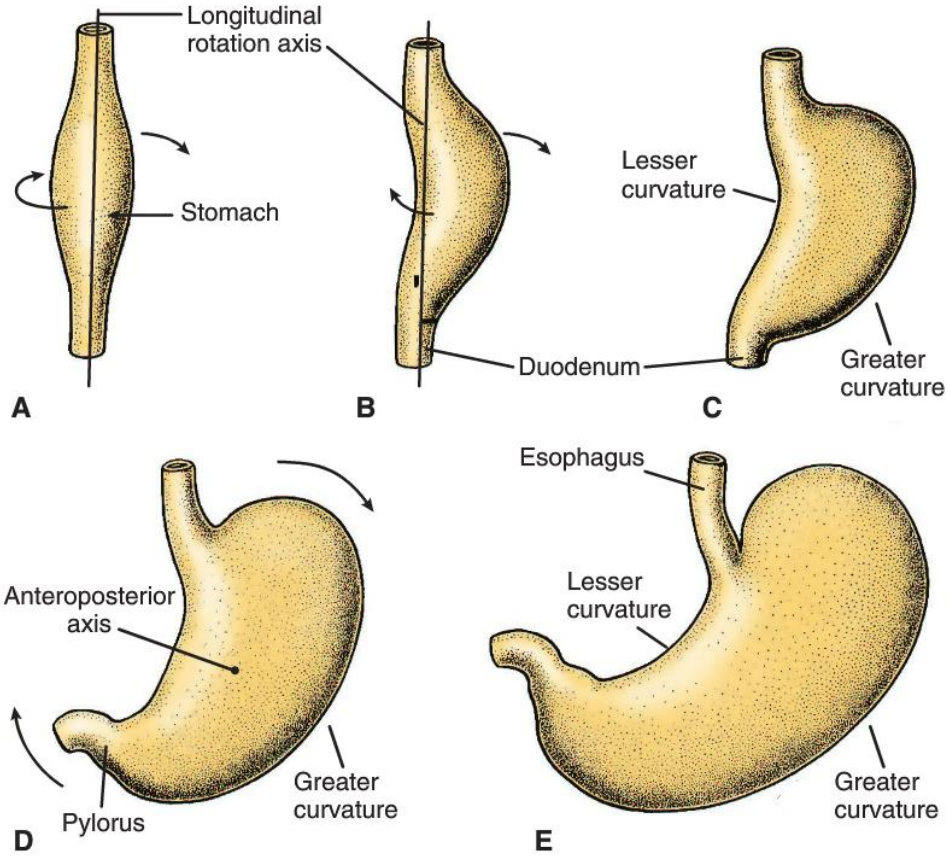
A fusiform dilation in the foregut occurring during the 4th week. 90 degree clockwise rotation, creates the lesser peritoneal sac just behind the stomach.




Longitudinal Section
dorsal mesogastrium
Falciform Ligament
Coeliac Trunk
Lesser Omentum
Dorsal mesoduodenum
Superior Mesenteric Artery
The Mesentery
Inferior Mesenteric Artery
Dorsal Mesocolon

Stomach

- The Vagus nerves follow this rotation which is how the left Vagus becomes anterior and the right becomes posterior.
- Differential growth occurs to establish the greater and lesser curvatures
- Unlike other parts of the gut tube, the dorsal AND ventral mesenteries are ***retained*** to become the greater and lesser omenta, respectively



Rotation of the Stomach

Around its longitudinal axis:

1. The ***anterior border*** (lesser curvature): becomes ***right***
2. The ***posterior border*** (greater curvature) becomes ***left***
3. The ***left side*** becomes ***anterior surface***.
4. The ***right side*** becomes ***posterior surface***.

Rotation of the Stomach

Around its transverse axis:

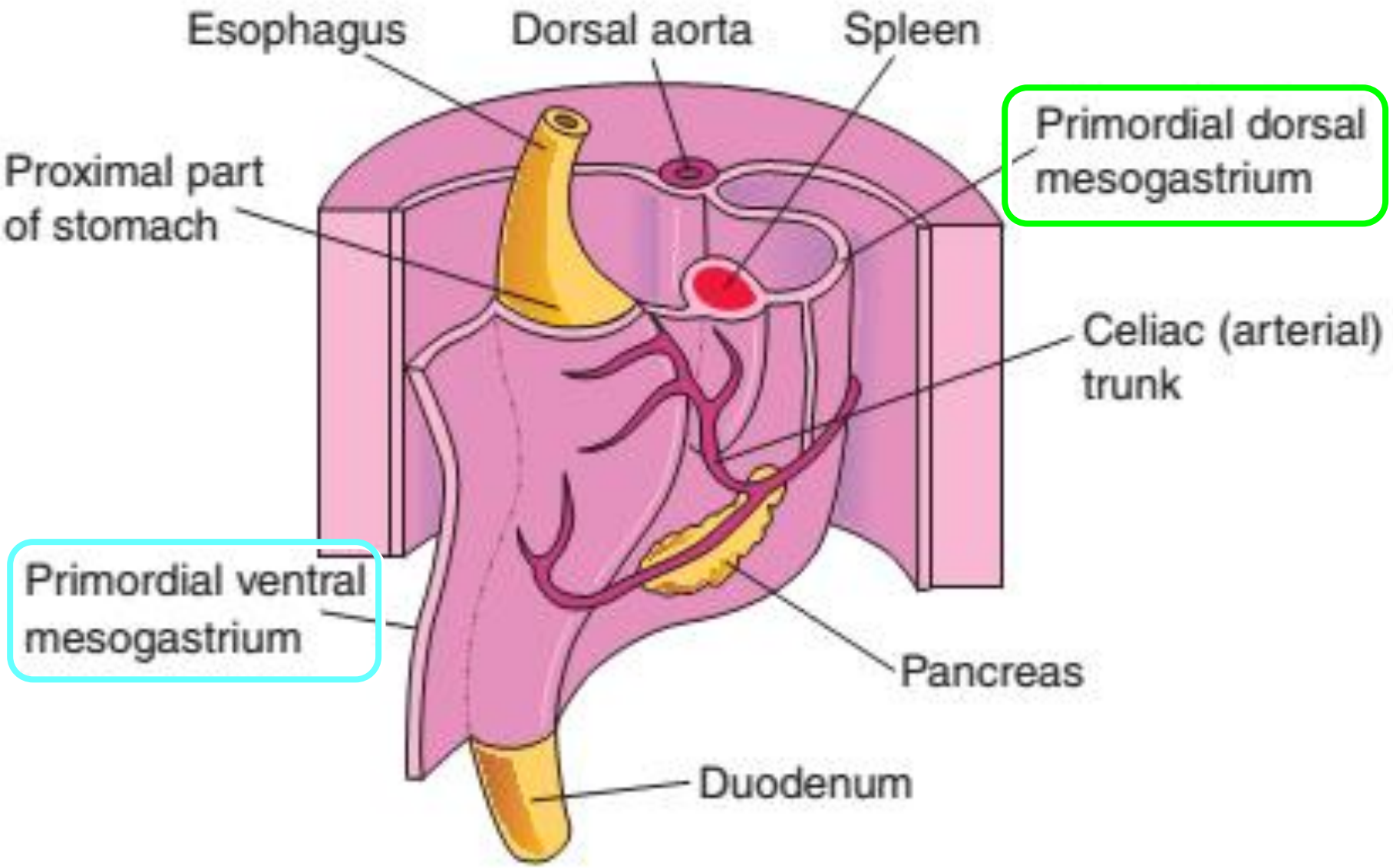
Before rotation:

The cranial & caudal ends of the stomach are in the median plane,

After rotation:

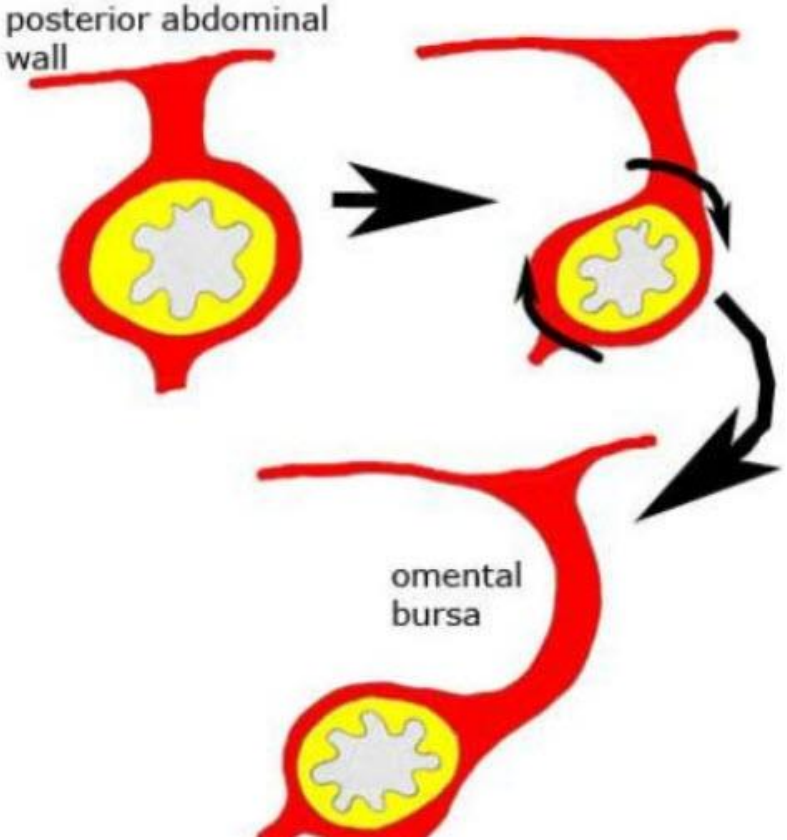
The cranial end moves to the left and slightly inferiorly and its caudal end moves to the right and superiorly

The long axis of the stomach becomes transverse to the long axis of the body.


Esophagus
Dorsal aorta
Spleen
Primordial dorsal mesogastrium
Proximal part of stomach
Celiac (arterial) trunk
Primordial ventral mesogastrium
Pancreas
Duodenum

- **The lesser sac of peritoneum:**

Rotation of the stomach is thought to pull the dorsal mesogastrium to the left and the lesser sac becomes expanded transversely between the stomach and the posterior abdominal wall.



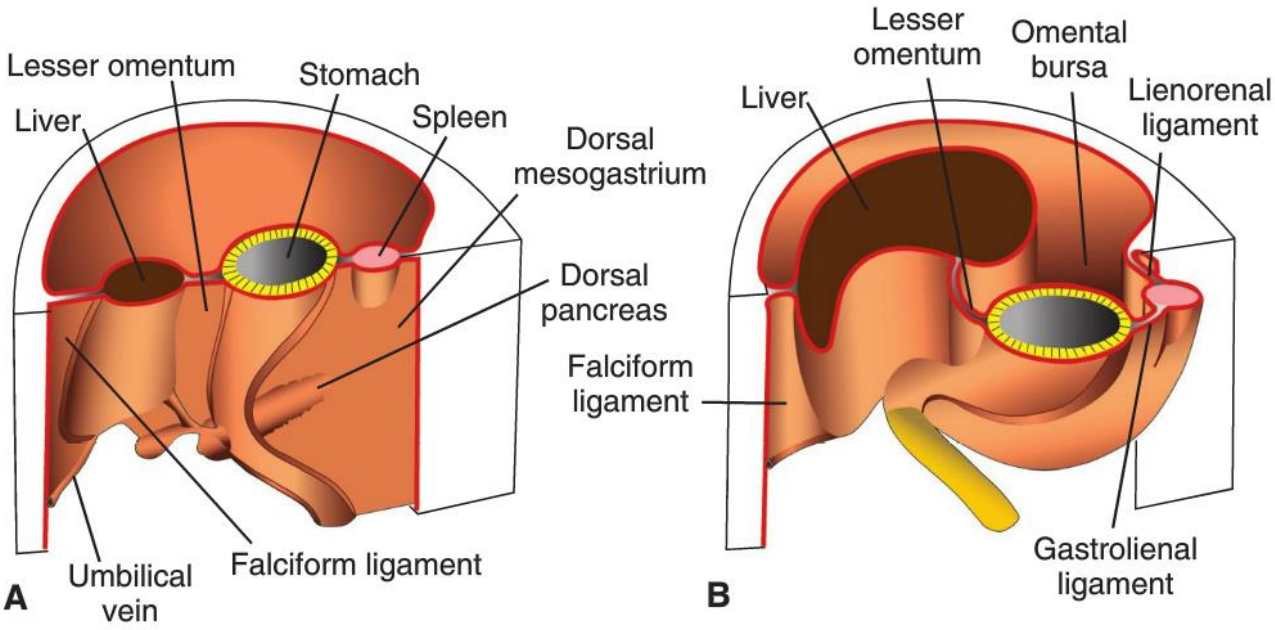


Figure 15.10 **A.** The positions of the spleen, stomach, and pancreas at the end of the fifth week. Note the position of the spleen and pancreas in the dorsal mesogastrium. **B.** Position of spleen and stomach at the 11th week. Note formation of the omental bursa (lesser peritoneal sac).

- As this process continues in the fifth week of development, the ***Spleen*** primordium appears as a mesodermal proliferation between the two leaves of the dorsal mesogastrium.

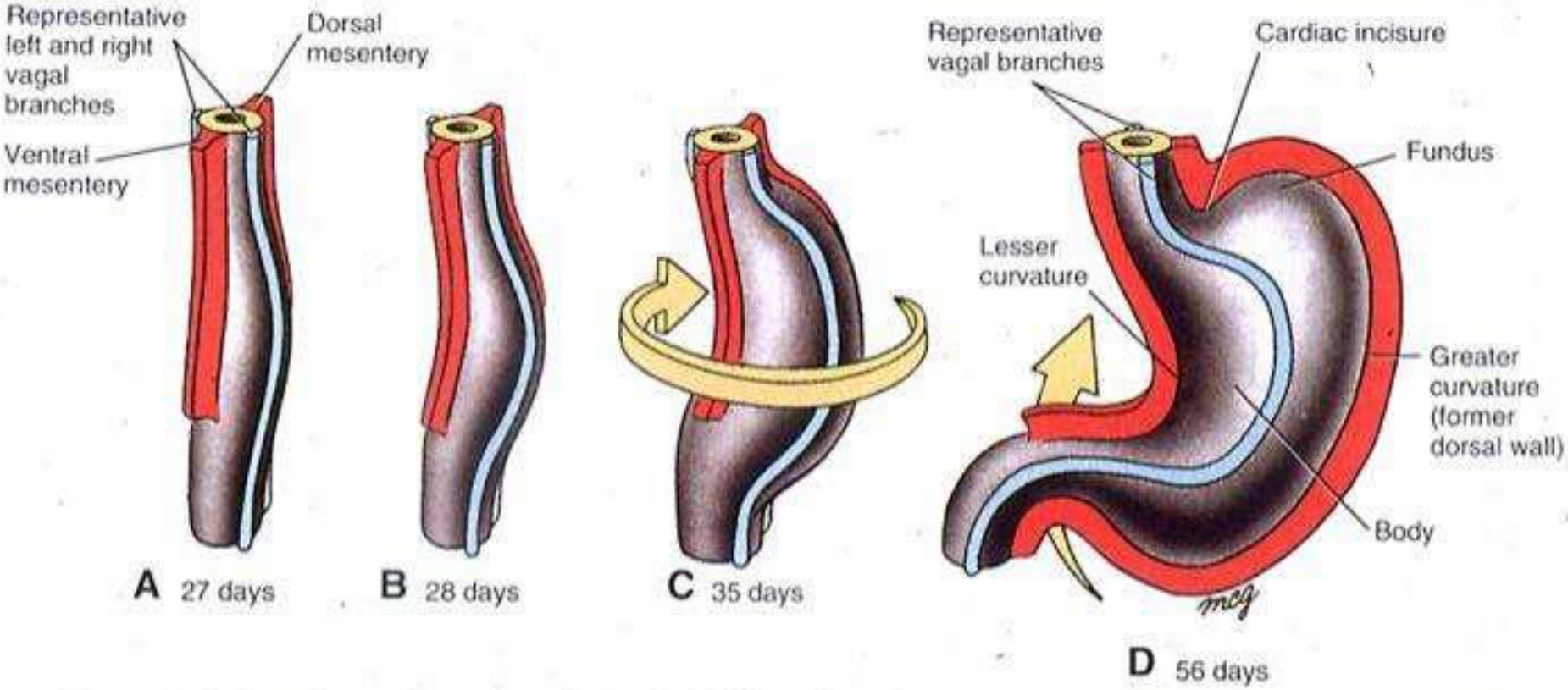


Figure 9–3. Rotations of the stomach. *A–C,* Oblique frontal views; *D,* direct frontal view. The posterior wall of the stomach expands during the fourth and fifth weeks to form the greater curvature. During the seventh week, the stomach rotates clockwise on its longitudinal axis (when viewed from above).

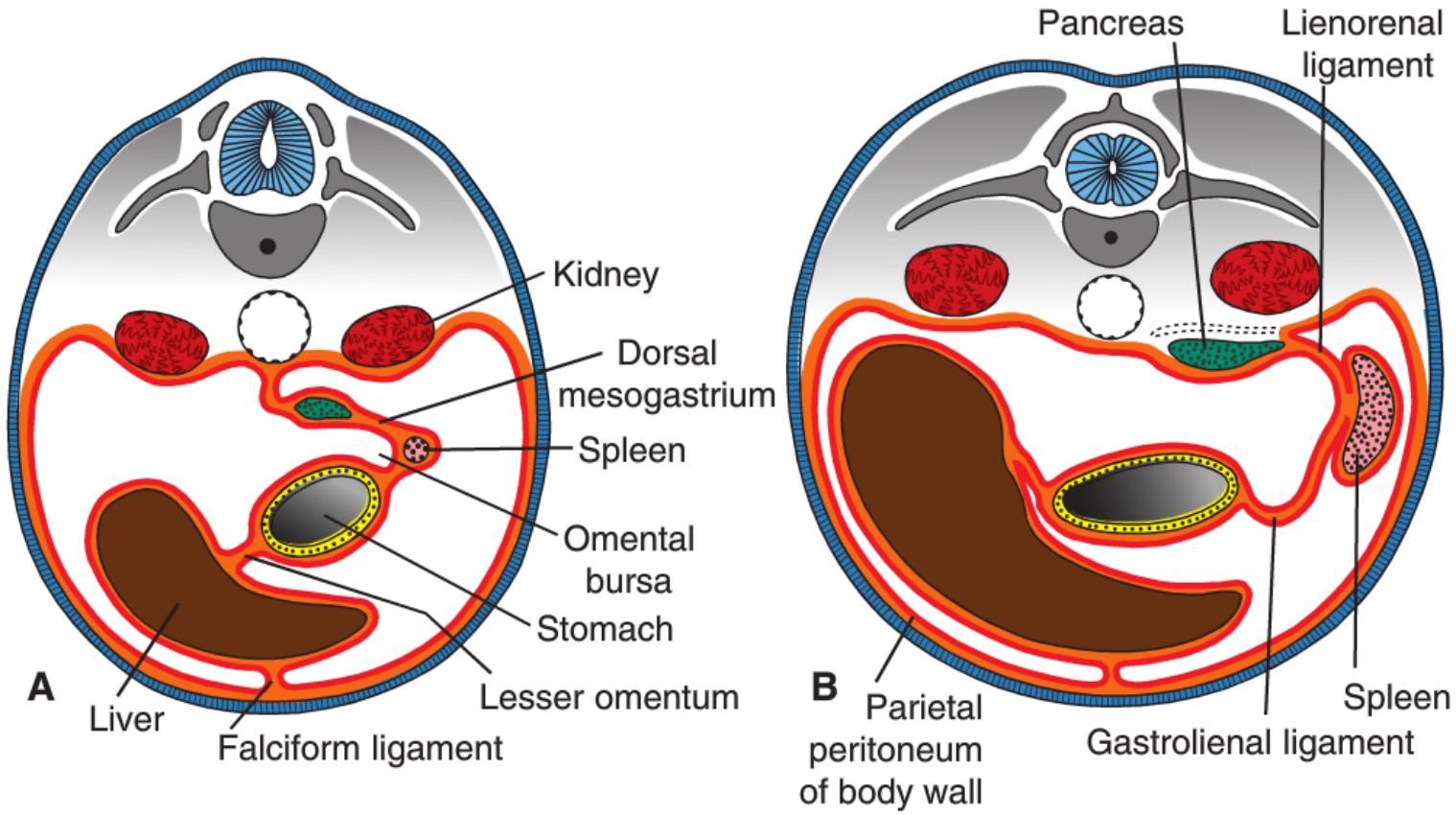


Figure 15.11 Transverse sections through the region of the stomach, liver, and spleen, showing formation of the omental bursa (lesser peritoneal sac), rotation of the stomach, and position of the spleen and tail of the pancreas between the two leaves of the dorsal mesogastrium. With further development, the pancreas assumes a retroperitoneal position.

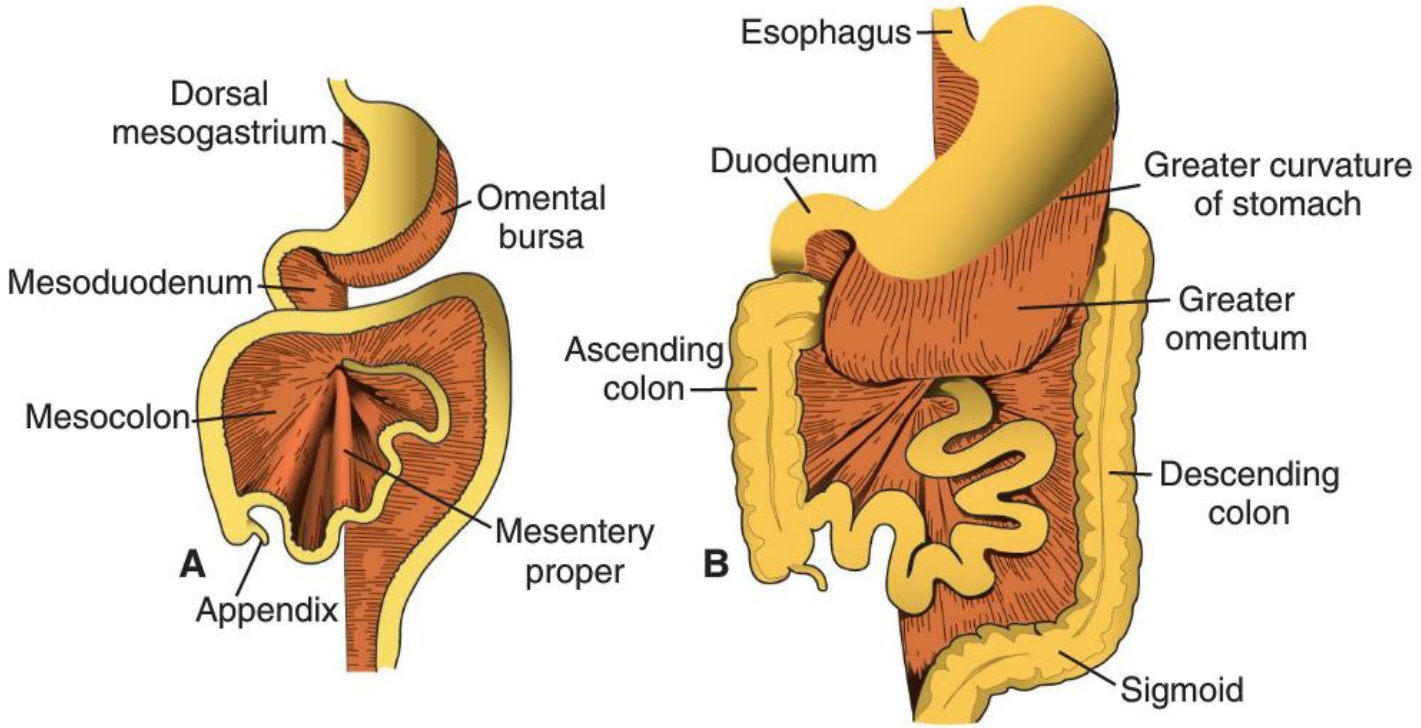
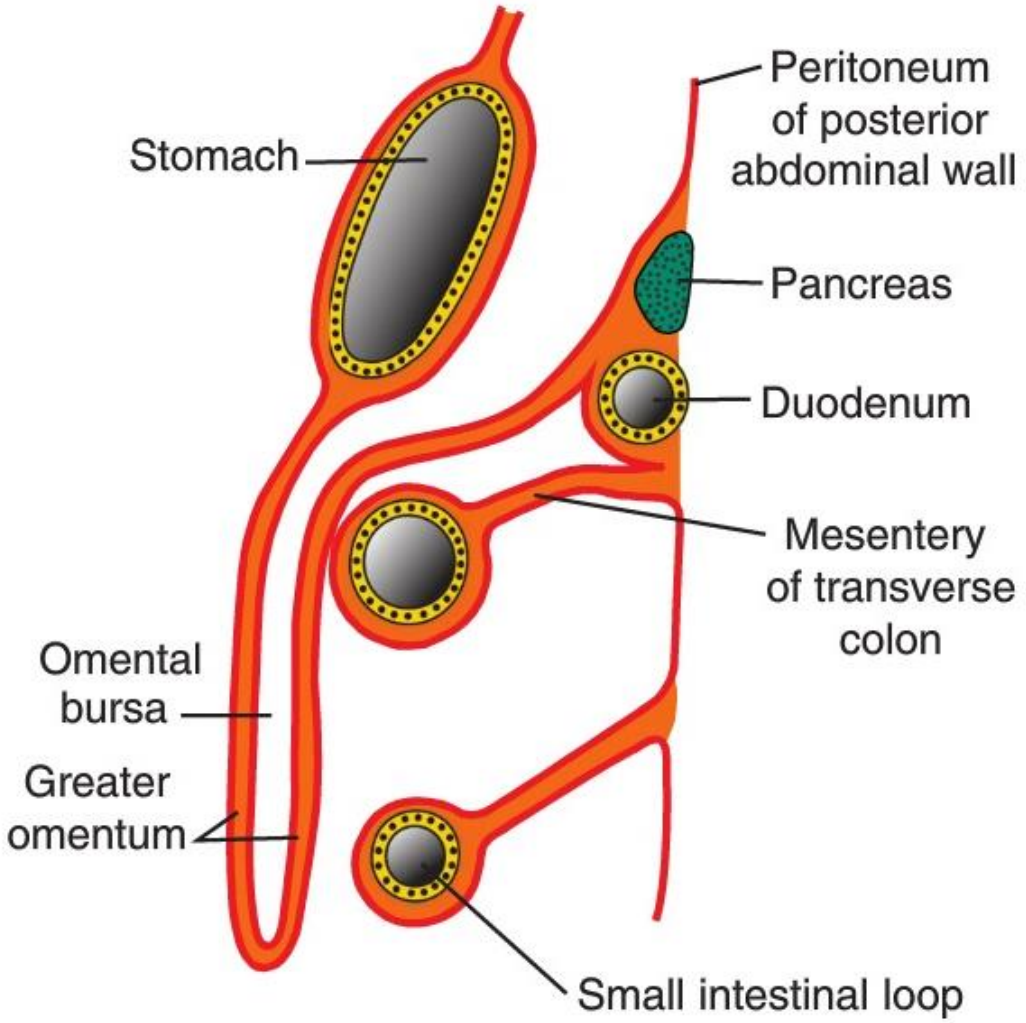


Figure 15.12 A. Derivatives of the dorsal mesentery at the end of the third month. The dorsal mesogastrium bulges out on the left side of the stomach, where it forms part of the border of the omental bursa. **B.** The greater omentum hangs down from the greater curvature of the stomach in front of the transverse colon.

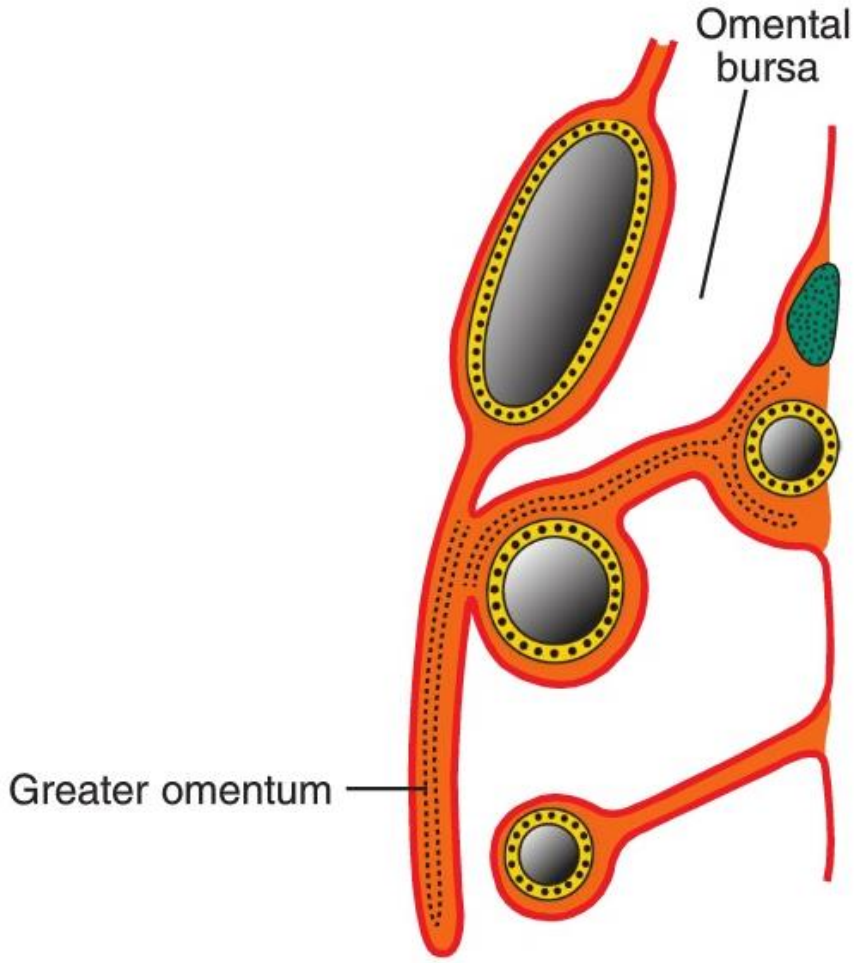
As a result of *rotation of the stomach* **the dorsal mesogastrium bulges down.**

It continues to grow down and **forms a double-layered sac** extending over the transverse colon and small intestinal loops like an apron.



- The greater omentum; later, **Fuses its layers,** to form a single sheet hanging from the greater curvature of the stomach.

- The posterior layer of the greater omentum **also fuses with the mesentery of the transverse colon.**

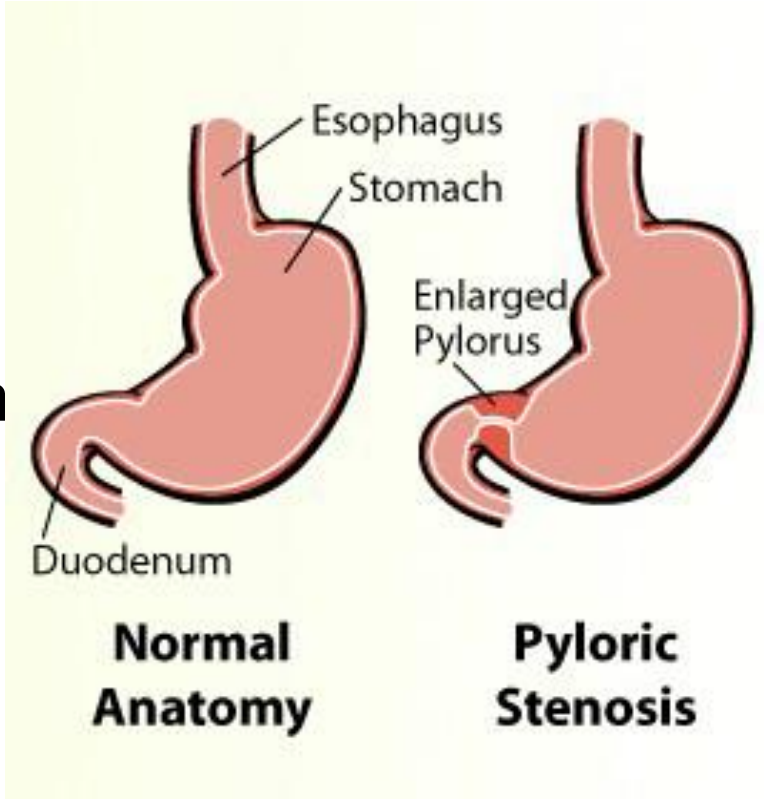


Clinical Correlation

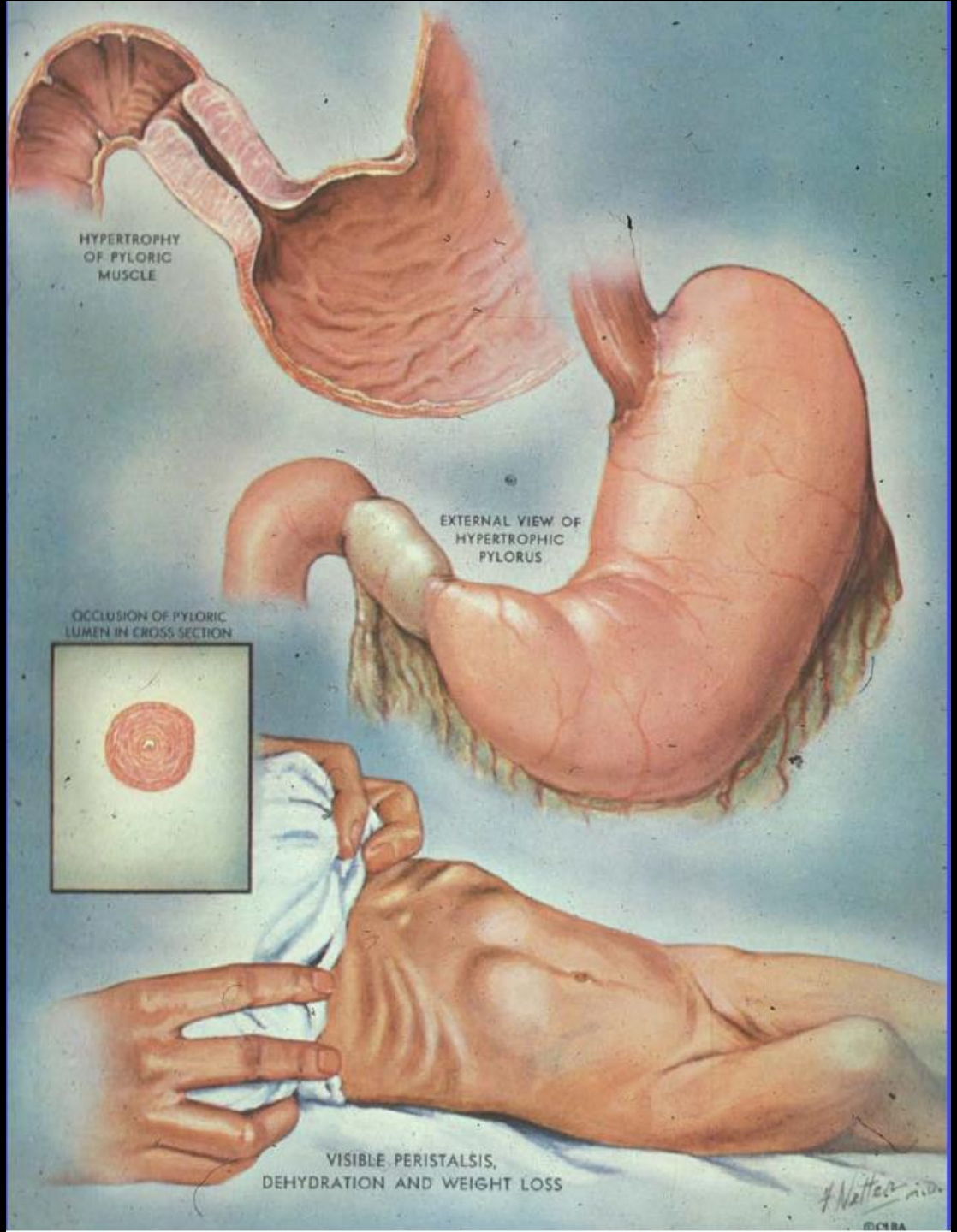
- ***Pyloric Stenosis***

- Rather common malformation: present in 0.5% - 0.1% of infants, more in males

- Characterized by very forceful (aka "projectile"), non-bilious vomiting ~1hr. After feeding (when pyloric emptying would occur).



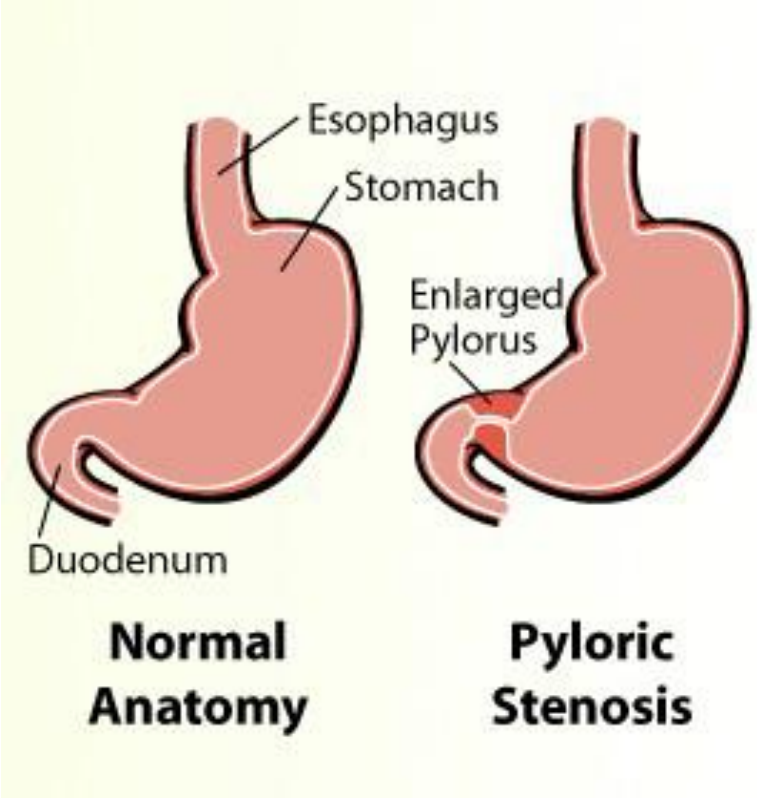
*NOTE: the presence of **bile** would indicate POST-duodenal blockage of some sort.*


HYPERTROPHY OF PYLORIC MUSCLE
EXTERNAL VIEW OF HYPERTROPHIC PYLORUS
OCCLUSION OF PYLORIC LUMEN IN CROSS SECTION
VISIBLE PERISTALSIS, DEHYDRATION AND WEIGHT LOSS

Clinical Correlation

Pyloric Stenosis

- Hypertrophied sphincter can often be palpated as a spherical nodule; peristalsis of the sphincter seen/felt under the skin.
- Stenosis is due to over proliferation / hypertrophy of pyloric sphincter… NOT an error in re-canalization.
- Treated by ***sphincterotomy***



Spleen

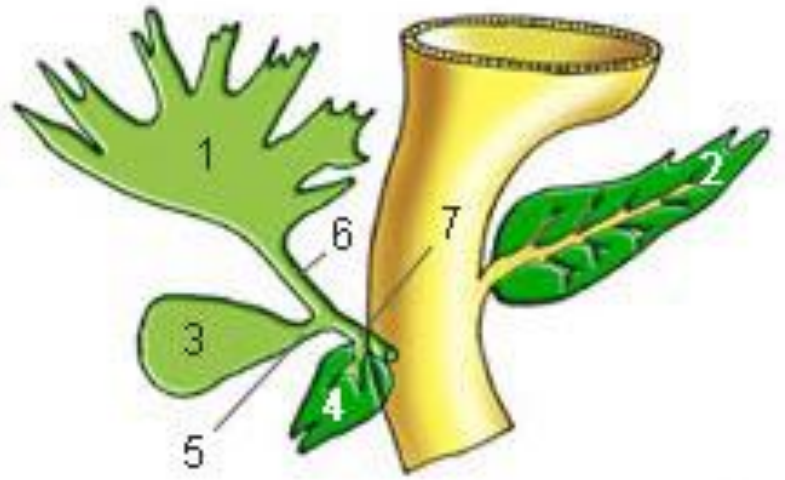
- The **Spleen,** which remains intraperitoneal (between 2 layers of peritoneum), formed by scattered splenules that fuse and form a single spleen, is then connected to:

The body wall in the region of the left kidney by the **lienorenal ligament** and to the stomach by the **gastrosplenic ligament**

The Liver

- Develops from an endodermal outgrowth at cranioventral portion of the foregut (hepatobiliary diverticulum) by the middle of the 4^{td} week

- The diverticulum divides into 2 buds and the hepatocytes invade the mesoderm of the septum transversum.



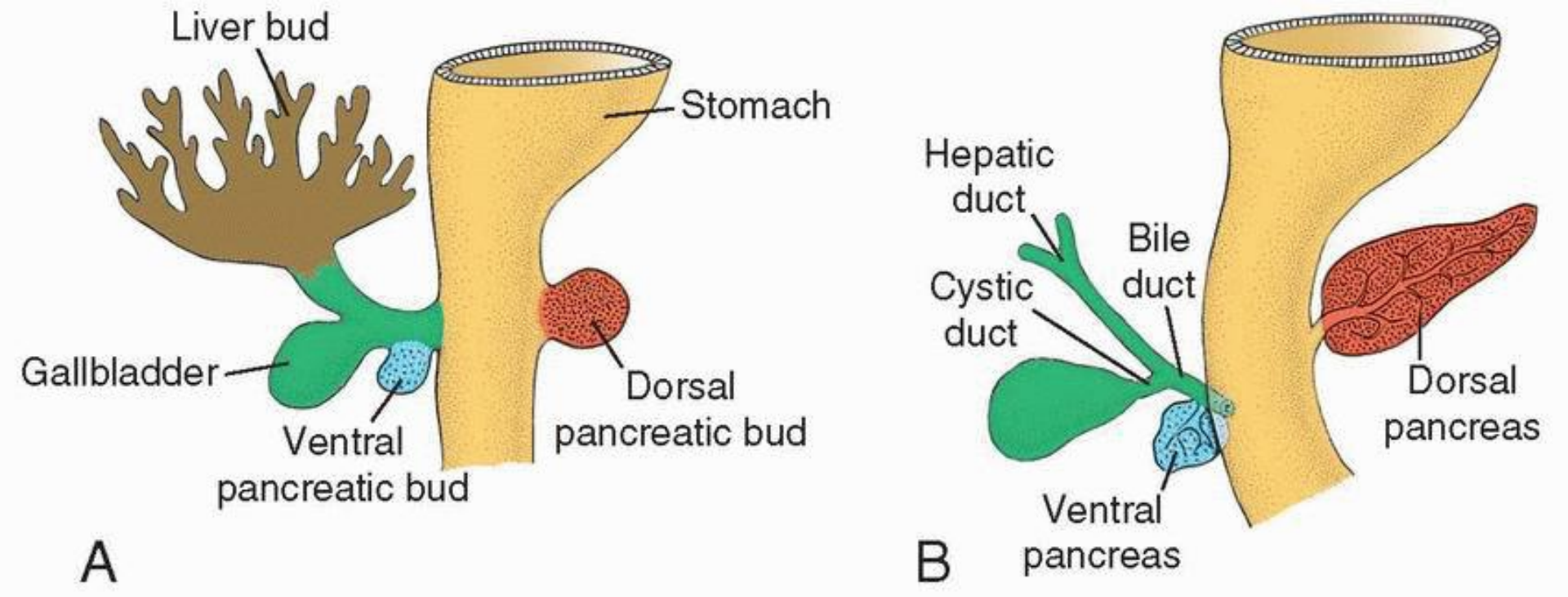
The Liver

- Hepatic cells (hepatoblasts) migrate into the ***Lightly packed*** part of the septum transversum.
- The migrating cells are both hematopoietic and endothelial precursors.
- The hepatic cells surround the endothelial precursor cells, vitelline veins, to form the ***hepatic sinusoids***.

The Liver

- ***The hepatic diverticulum divides into 2 parts: Pars Hepatica and Pars Cystrica***
- ***Pars Hepatica*** forms the larger cranial part of the hepatic diverticulum.
- Gives rise to: Hepatic cells, Hepatic sinusoids, Kupffer cells & hematopoietic tissue.
- The liver grow rapidly to fill a large part of the abdominal cavity.
- At first, the 2 lobes are of the same size but soon the right become larger.
- Bile formation start during the 12^{th} week.

The Liver


Liver bud
Stomach
Gallbladder
Ventral pancreatic bud
Dorsal pancreatic bud
A
Hepatic duct
Bile duct
Cystic duct
Dorsal pancreas
Ventral pancreas
B

The Liver

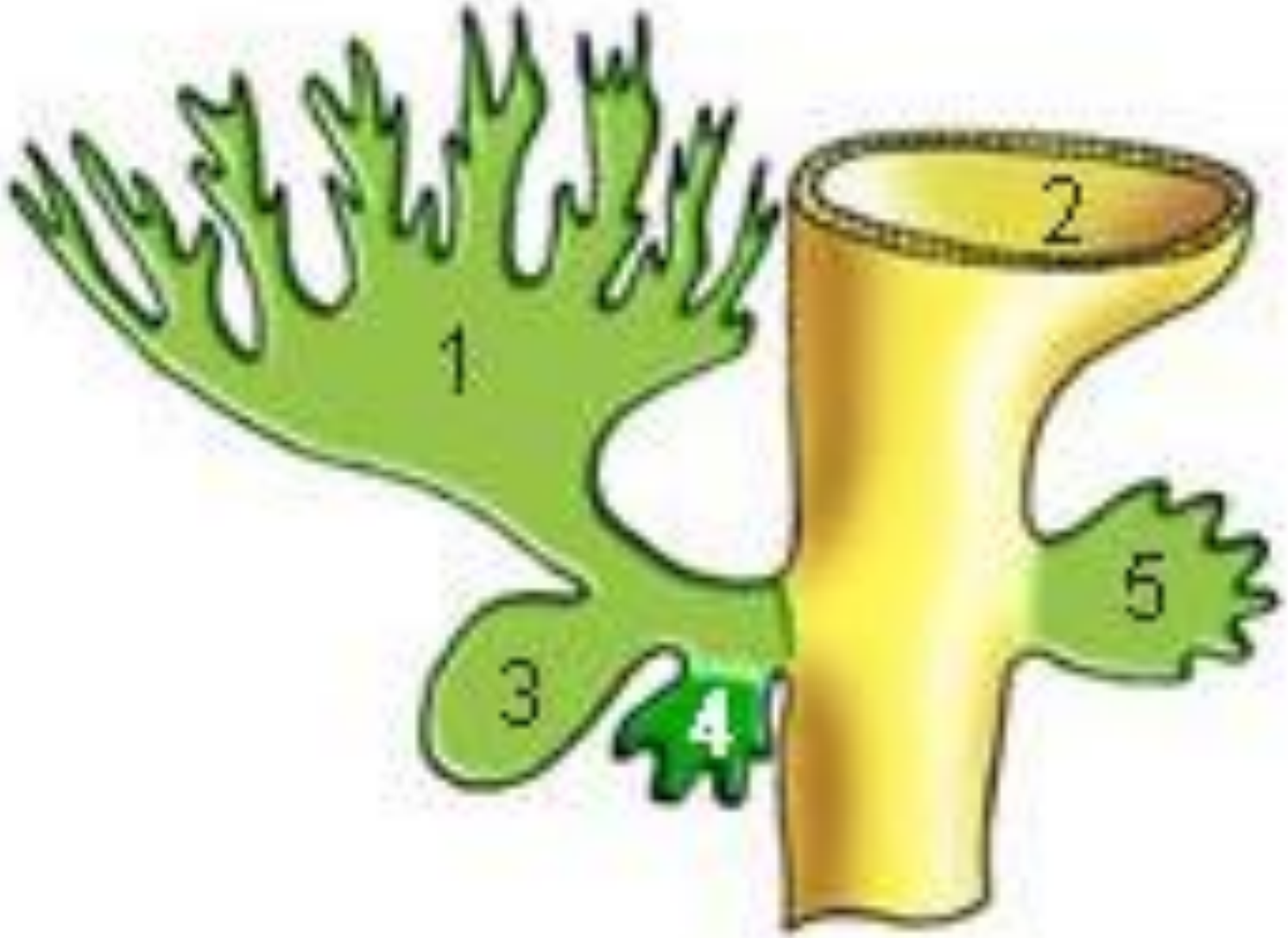
- Connective tissue cells of the liver are derived from mesoderm of the ***Septum Transversum***

- The portion of the septum, which consists of ***densely packed mesoderm***, will form the ***central tendon of the diaphragm.***

- The surface of the liver that is in contact with the future diaphragm is never covered by peritoneum; it is the ***bare area of the liver.***

Gallbladder and Bile Ducts

- ***Pars Cystrica*** becomes the gall bladder and the stem of the diverticulum forms the cystic duct.
- The stalk connecting the hepatic and cystic ducts to the duodenum becomes the common bile duct.
- The right and left branches of the pars hepatica become canalized to form the right and left hepatic ducts.


1
2
3
4
5

Ligaments of the Liver

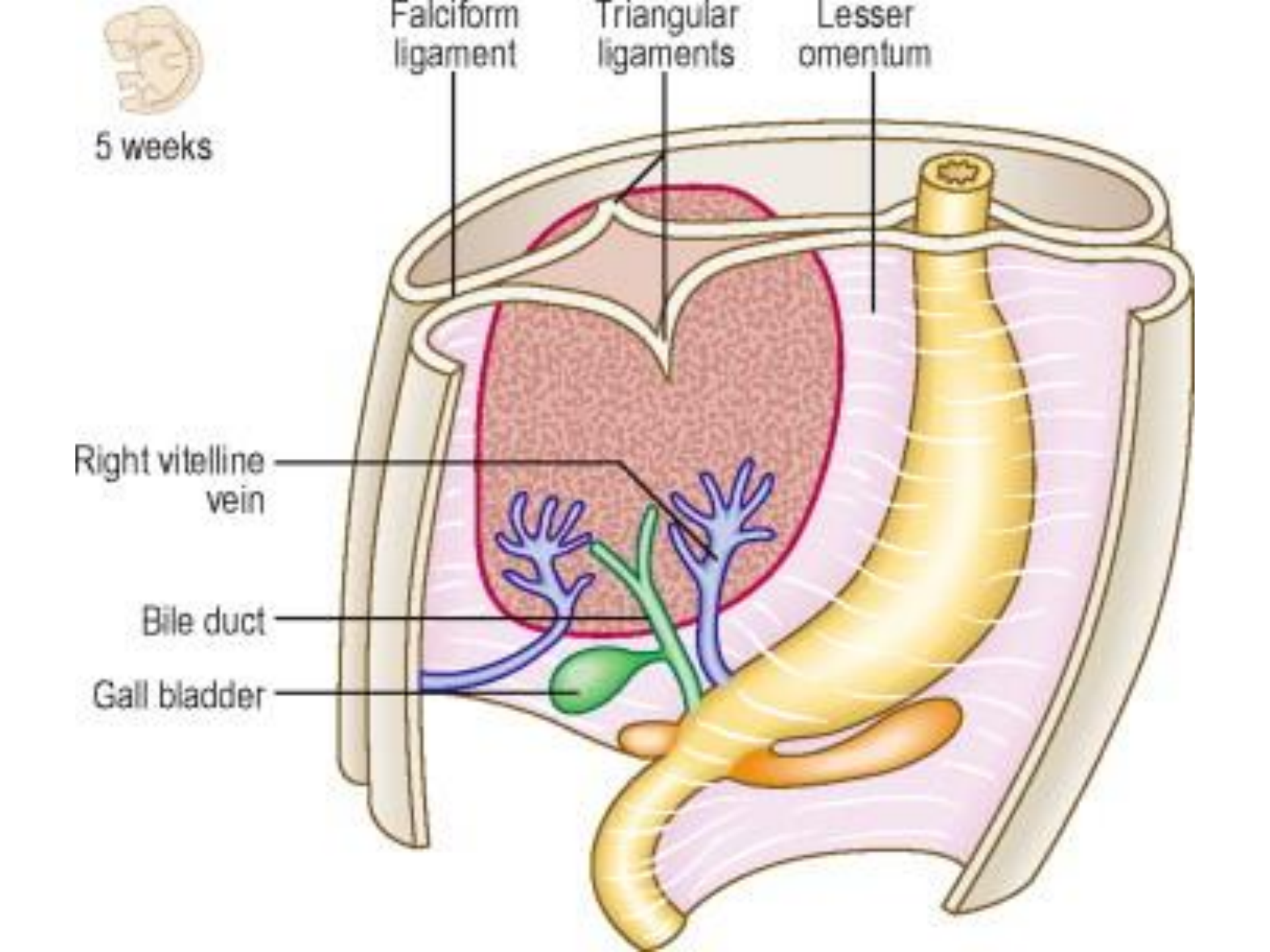
- As the septum transversum is penetrated by the growing pars hepatica.

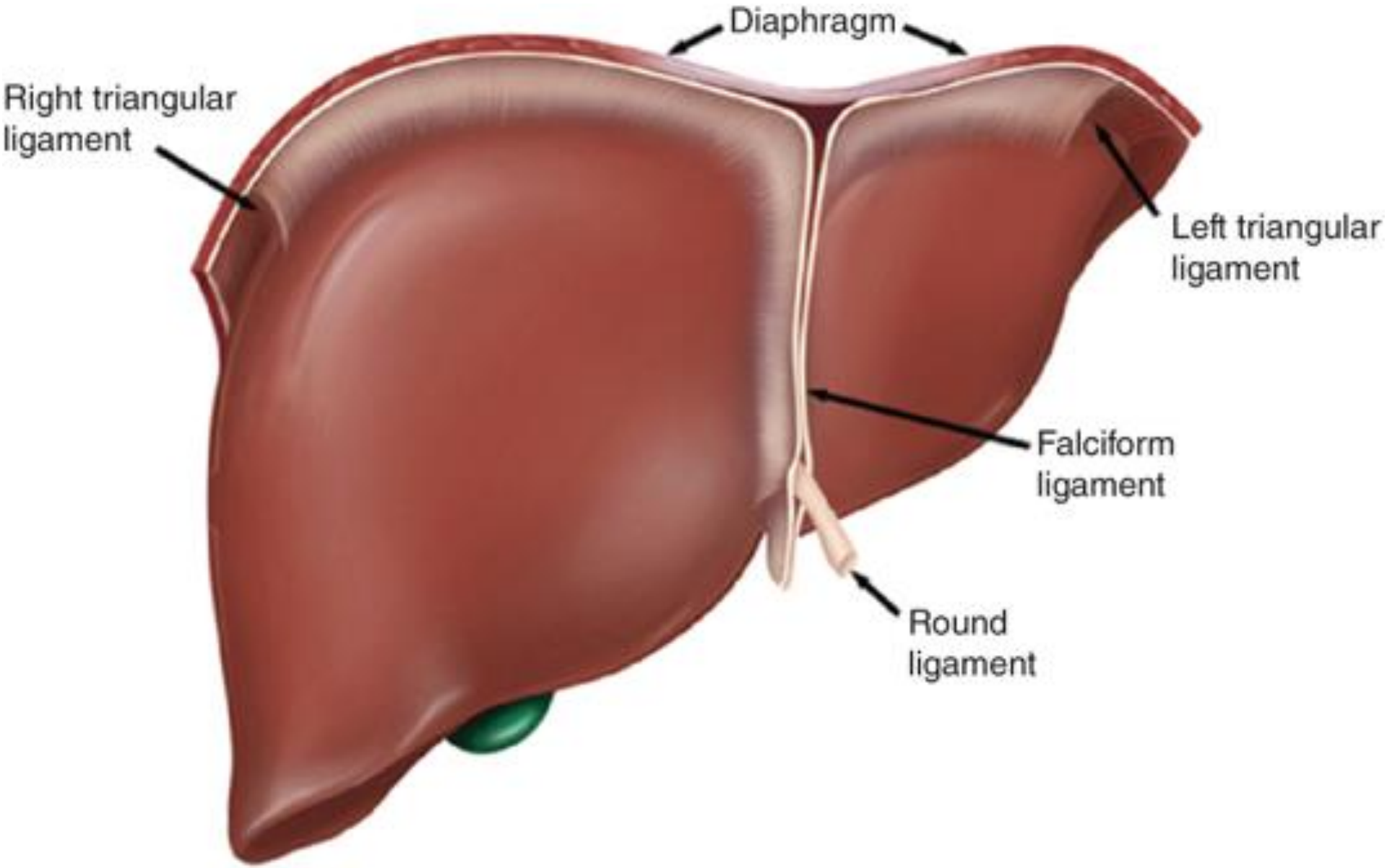
- The mesoderm of the septum transversum between the liver and the anterior abdominal wall becomes the FALCIFORM LIGAMENT.

Ligaments of the Liver

- The mesoderm of the septum transversum between the liver and the foregut (stomach and duodenum); form the LESSER OMENTUM.

- The mesoderm on the surface of the liver differentiates into CAPSULE AND PERITONEAL COVERING


5 weeks
Falciform ligament
Triangular ligaments
Lesser omentum
Right vitelline vein
Bile duct
Gall bladder


Diaphragm
Right triangular ligament
Left triangular ligament
Falciform ligament
Round ligament

Pancreas

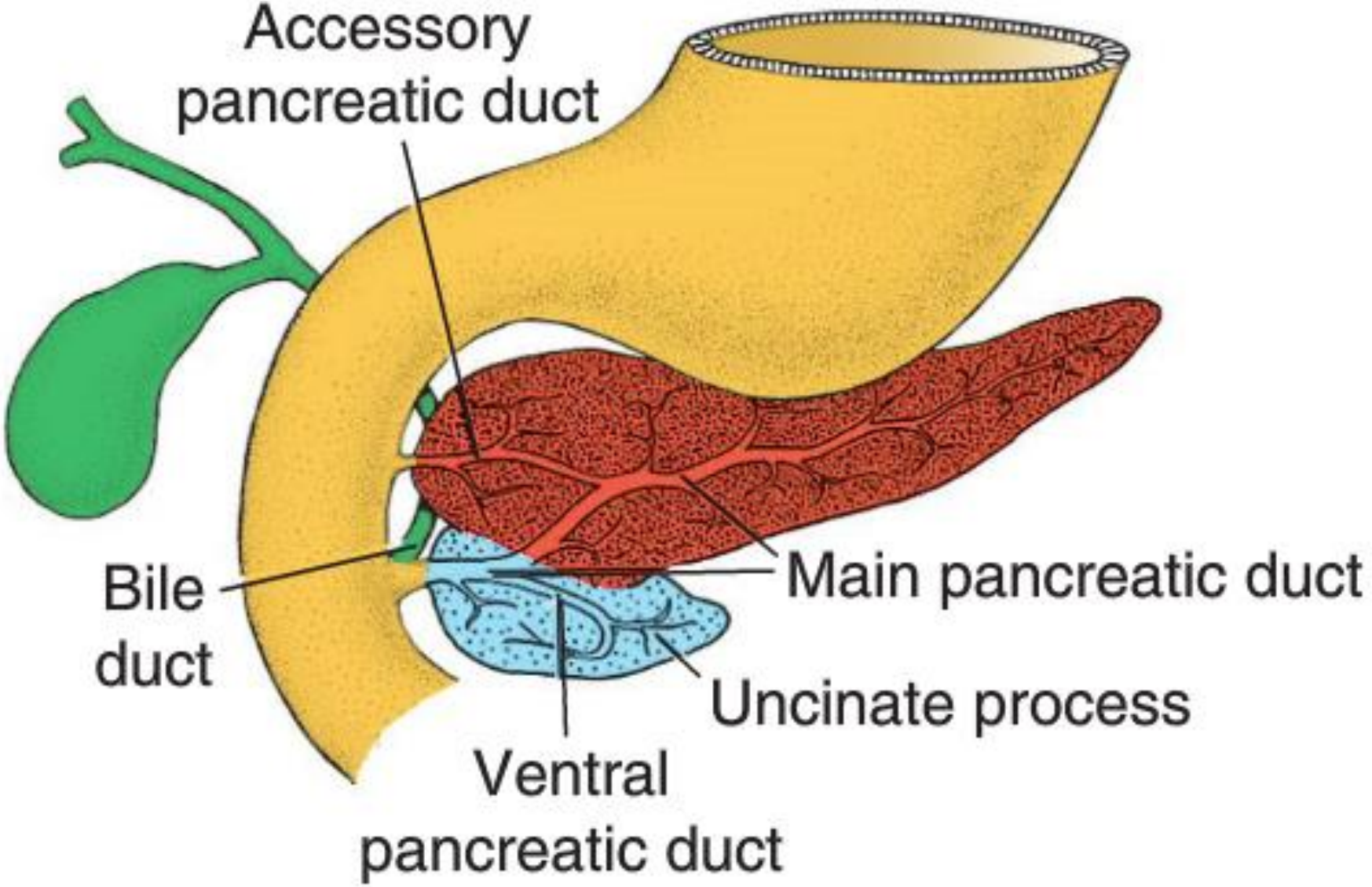
- Develops from 2 pancreatic buds between (weeks 4-5).
  - Ventral pancreatic bud forms the uncinate process and the head of the pancreas.
  - The larger dorsal pancreatic bud forms the remaining head, body and tail.

Pancreas

- When the duodenum rotates to the right and becomes C-shaped, *the* **ventral pancreatic bud** *moves* ***dorsally*** in a manner leading to the shifting of the entrance of the bile duct.

- **Finally, the ventral bud comes to lie immediately below and behind the dorsal bud.**

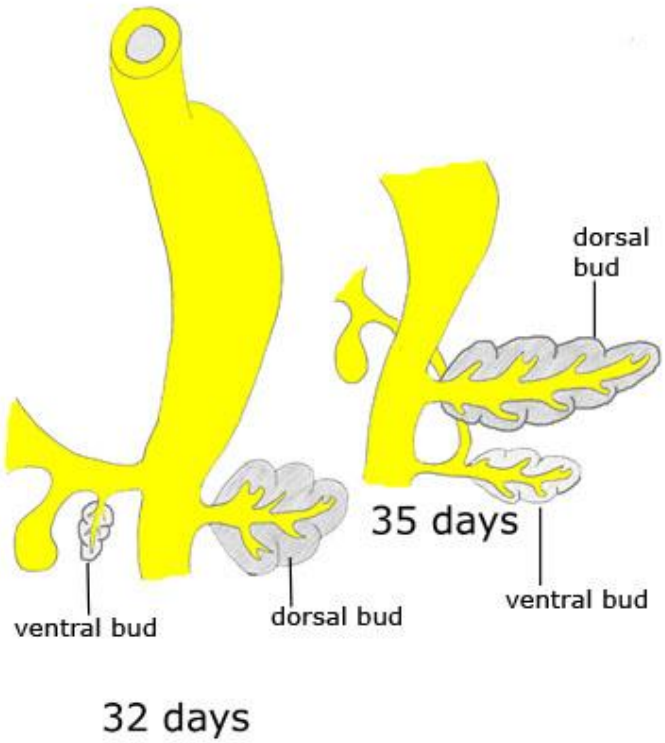
- *Later, the parenchyma and the duct systems of the dorsal and ventral pancreatic buds fuse.*


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

Pancreas

- The ventral pancreatic bud rotates clockwise with the rotation of the duodenum. During 7th week the 2 buds fuse.

- Within each bud, the endoderm develops into branched tubules attached to secretory acini (the exocrine pancreas).



Pancreas

- Side branches extend from the ducts to the surrounding mesoderm.
- Some of them become canalized -► Pancreatic Acini.
- Others separate & not canalized Islets of Langerhans.

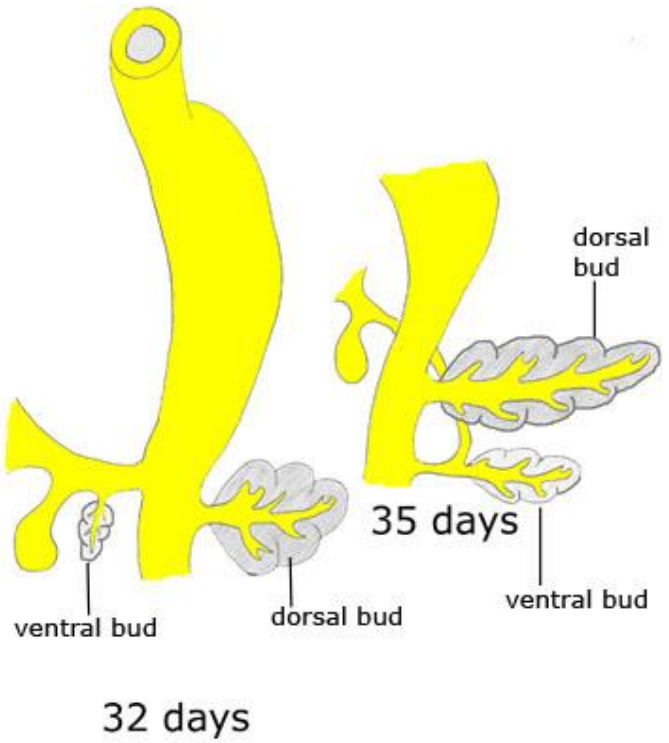
Pancreas

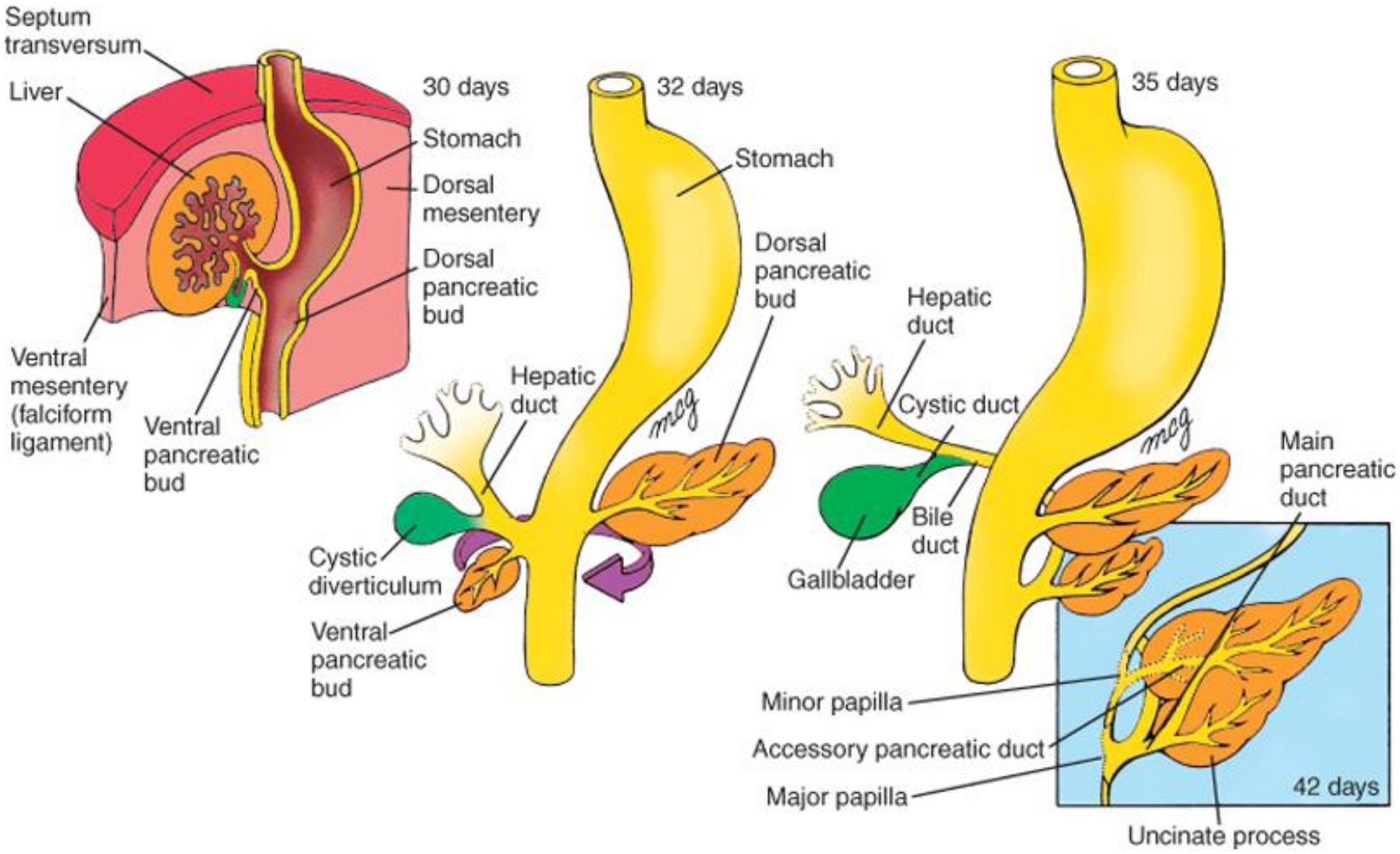
- Insulin secretion begins during the fetal period (10 weeks) and the total pancreatic insulin contents also increase with the fetal age.

- The pancreatic connective tissue stroma and interlobar septa: from the splanchnic mesoderm.

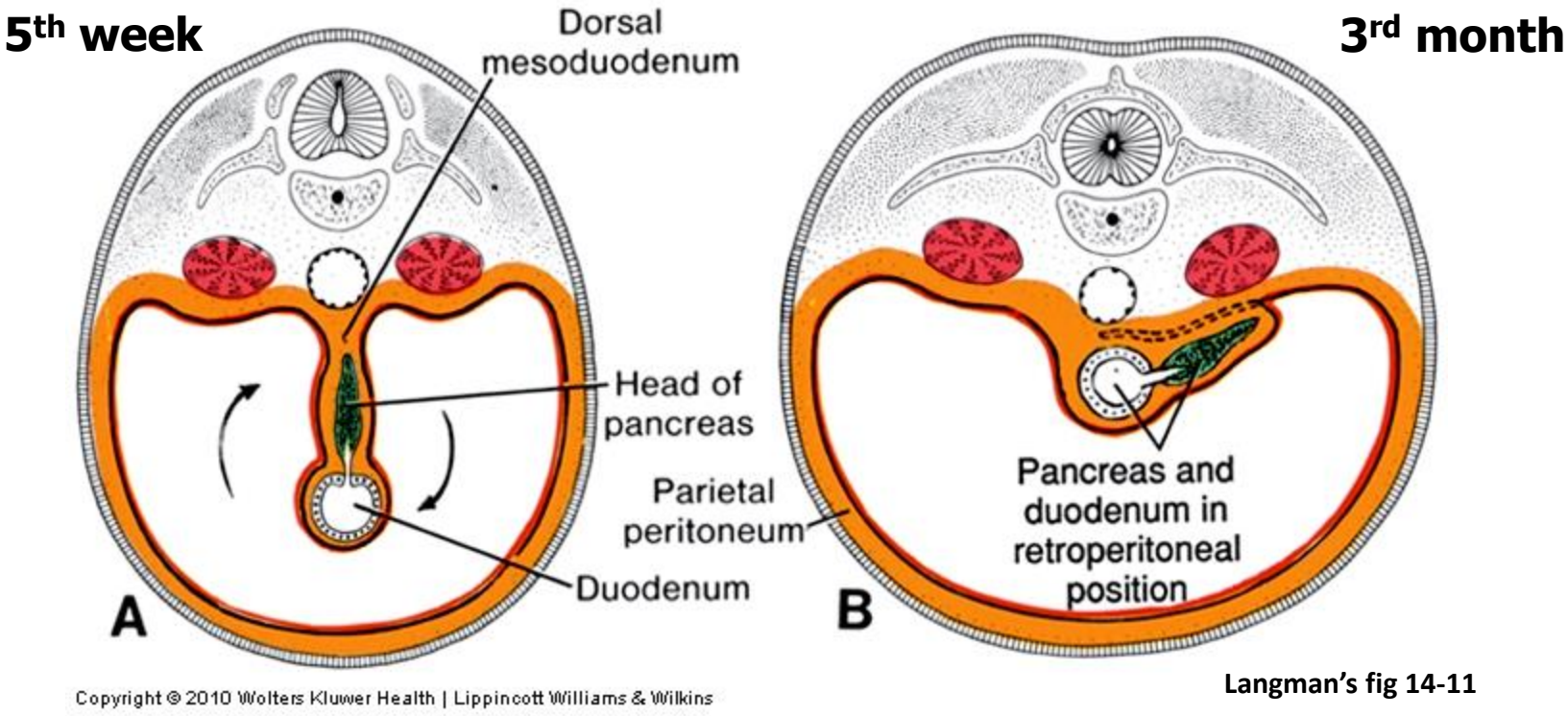
Pancreas

- The endocrine pancreas (islets of Langerhans) arise from stem cells at the duct branch points that then develop into discrete islands of vascularized endocrine tissue within the pancreas




Septum transversum
Liver
30 days
Stomach
Dorsal mesentery
Dorsal pancreatic bud
Ventral mesentery (falciform ligament)
Ventral pancreatic bud
32 days
Stomach
Dorsal pancreatic bud
Hepatic duct
mcg
Cystic diverticulum
Ventral pancreatic bud
35 days
Hepatic duct
Cystic duct
mcg
Main pancreatic duct
Bile duct
Gallbladder
Minor papilla
Accessory pancreatic duct
Major papilla
42 days
Uncinate process

Rotation of the duodenum also causes it and the pancreas to become retroperitoneal

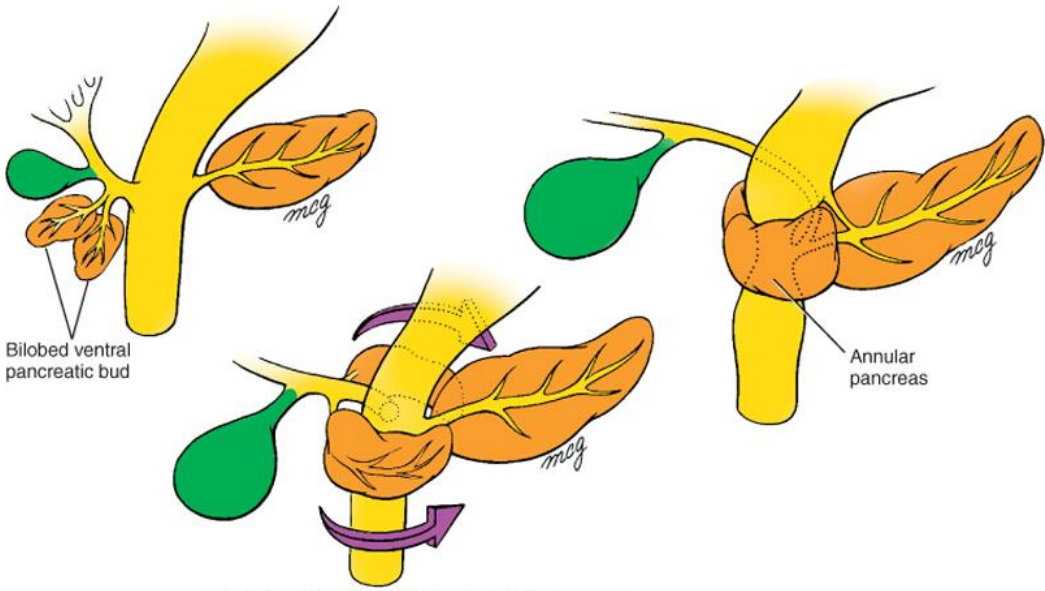


Langman's fig 14-11

Secondarily retroperitoneal **= a structure that was originally in the body coelom but then got pushed into the body wall during development**

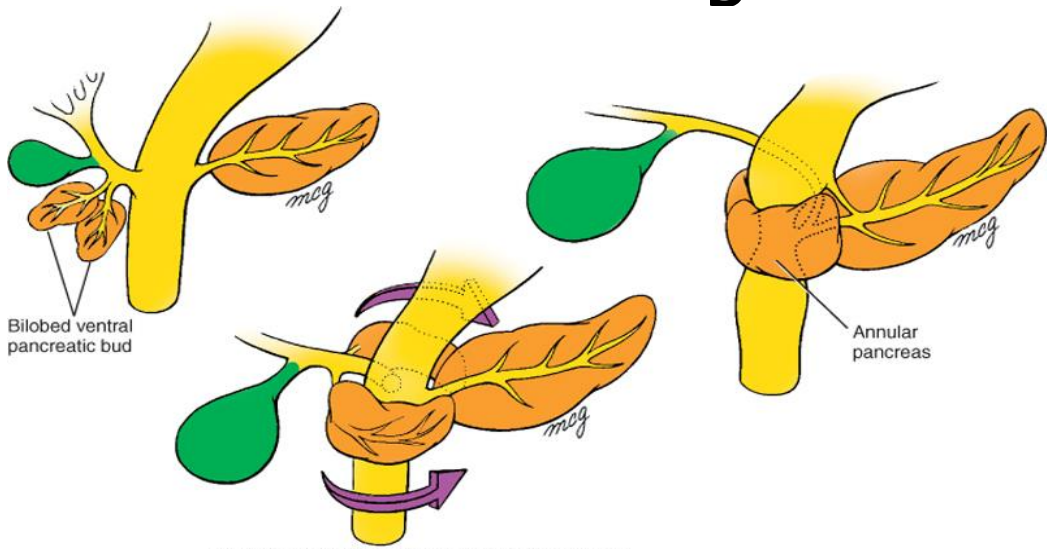
Clinical Correlation

- Errors in the fusion process can result in an annular pancreas that wraps around the duodenum, which can cause obstruction (***Bilious Vomiting***)



Clinical Correlation

- Also, since the dorsal and ventral pancreas arise by different mechanisms, it's possible that one or the other may be absent in the adult or extra pancreatic tissue might be present else where.



- For further inquiries ***PLZ*** feel free to contact at any time through email

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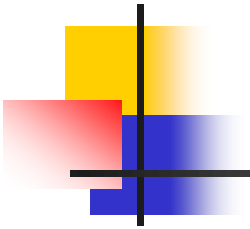

Thank You