الجهاز الهضمي

علم الأجنّة

رقم المحاضرة : ٢

بسم الله نبدأ وعلى الله توكلنا

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GI embryology 2

المحاضرة دسمة شوي فبدها تركيز، بالتوفيق

This lecture requires you to picture the events of embryonic development clearly and sequentially in order to have a better understanding of the origin of the GI tract, specifically, the foregut.

Good luck.

The color code for these modified slides:

Black text: the professor's slides

<u>Underlined Black text: what the professor has read from the slides</u>

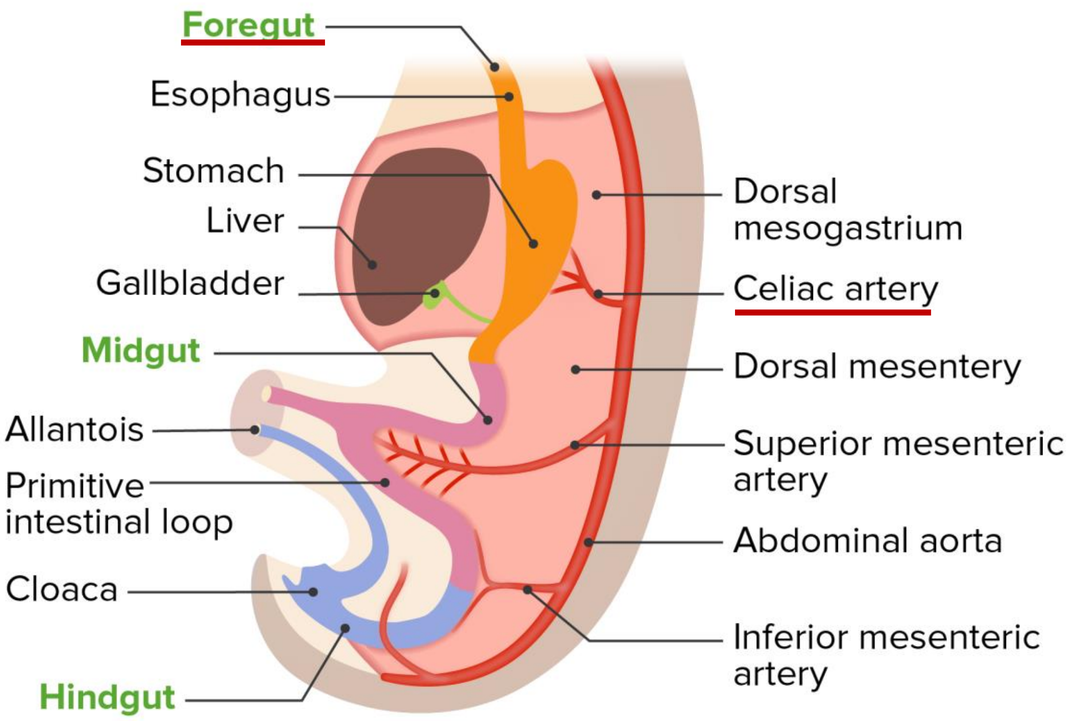
Red text: what the professor has mentioned during the lecture but isn't written in his slides

Blue text: extra information that may be useful

Purple text: information thought to be of greater importance

Introductory overview:
In order to have a better understanding of the development of the GI system, we must first be able to imagine and picture the changes that occur during the embryonic period of the intrauterine life.

- The primitive gut of the embryo is derived from the endoderm of the embryonic yolk sac. At its cephalic end, near the head, it forms the foregut, which is the topic of this lecture.
- The derivatives of the foregut extend from the buccophanyngeal membrane and pharynx, downwards through the esophagus and the stomach, up until the proximal half of the duodenum where the ducts of the liver and pancreas open into.
- The stomach is the most important derivative of the foregut; the development of the duodenum and pancreas directly follow its development.
- Most of the structures derived from the foregut receive their blood supply from the celiac trunk, including the abdominal portion of the esophagus, the stomach, proximal part of the duodenum, liver, and most of the pancreas.



The Foregut: Esophagus

- At first, the esophagus is short.
- But with descent of the heart and lungs it lengthens rapidly.
- The muscular coat, which is formed by surrounding splanchnic mesenchyme, is striated in its upper two-thirds and innervated by the vagus.
- The muscle coat is smooth in the lower third and is innervated by the splanchnic plexus.

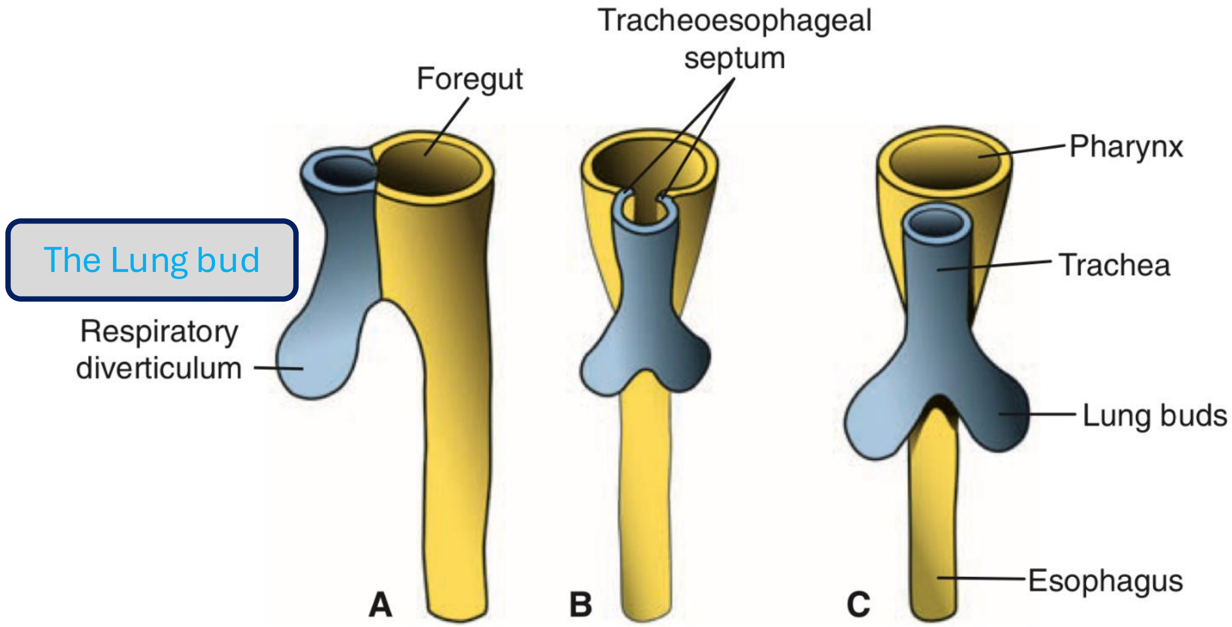


Figure 15.6 Successive stages in development of the respiratory diverticulum and esophagus through partitioning of the foregut. **A.** At the end of the third week (lateral view). **B,C.** During the fourth week (ventral view).

Esophageal Abnormalities

- **Esophageal atresia** and/or **tracheoesophageal fistula** results either from spontaneous posterior deviation of the **tracheoesophageal septum** or from some mechanical factor pushing the dorsal wall of the foregut anteriorly.
- In its most common form, the proximal part of the esophagus ends as a blind sac, and the distal part is connected to the trachea by a narrow canal just above the bifurcation.
- Other types of defects in this region occur much less frequently (they range from 1%-4% out of all esophageal atresias and TEFs).
- Atresia of the esophagus prevents normal passage of amniotic fluid into the intestinal tract, resulting in accumulation of excess fluid in the amniotic sac (polyhydramnios).

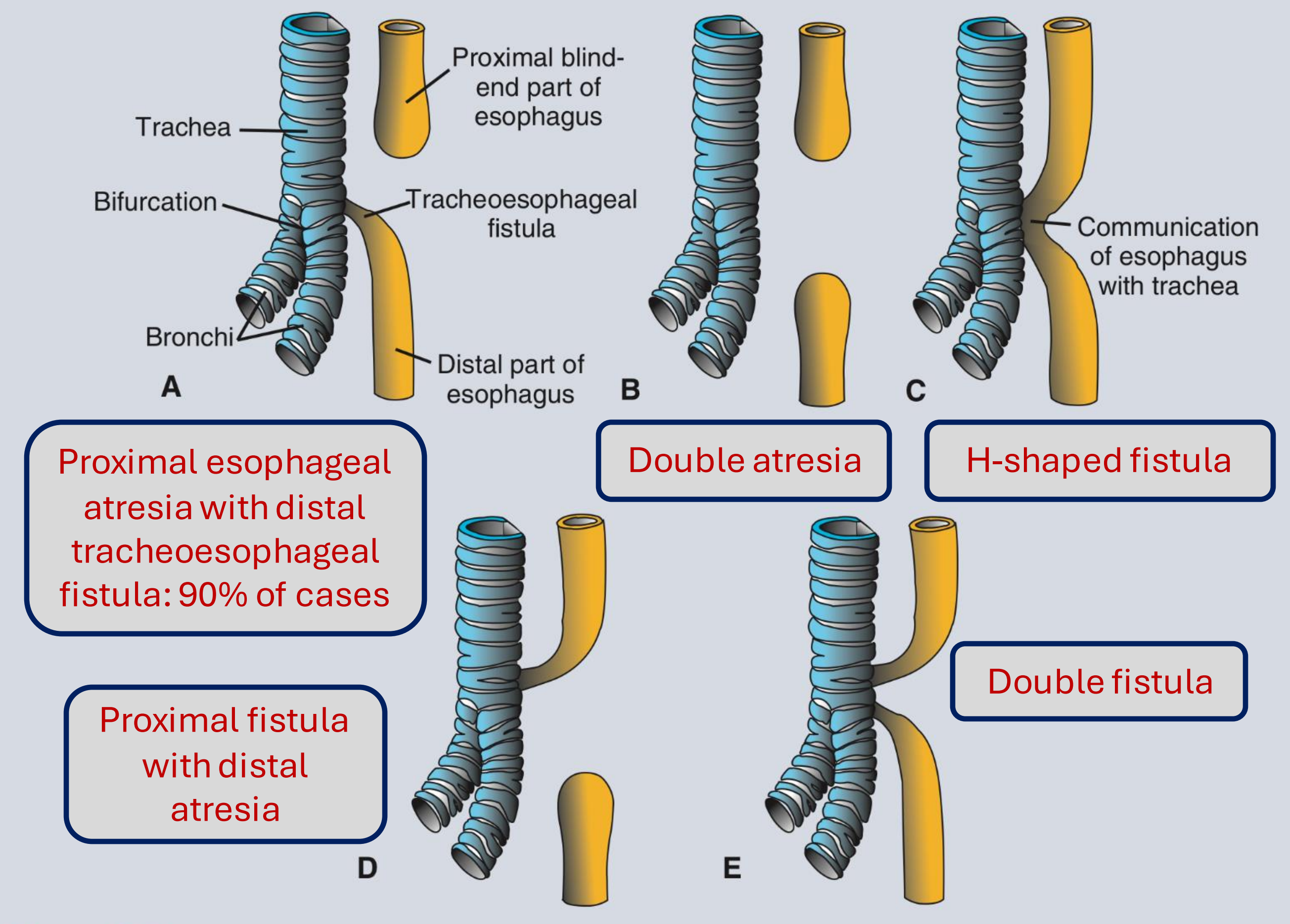
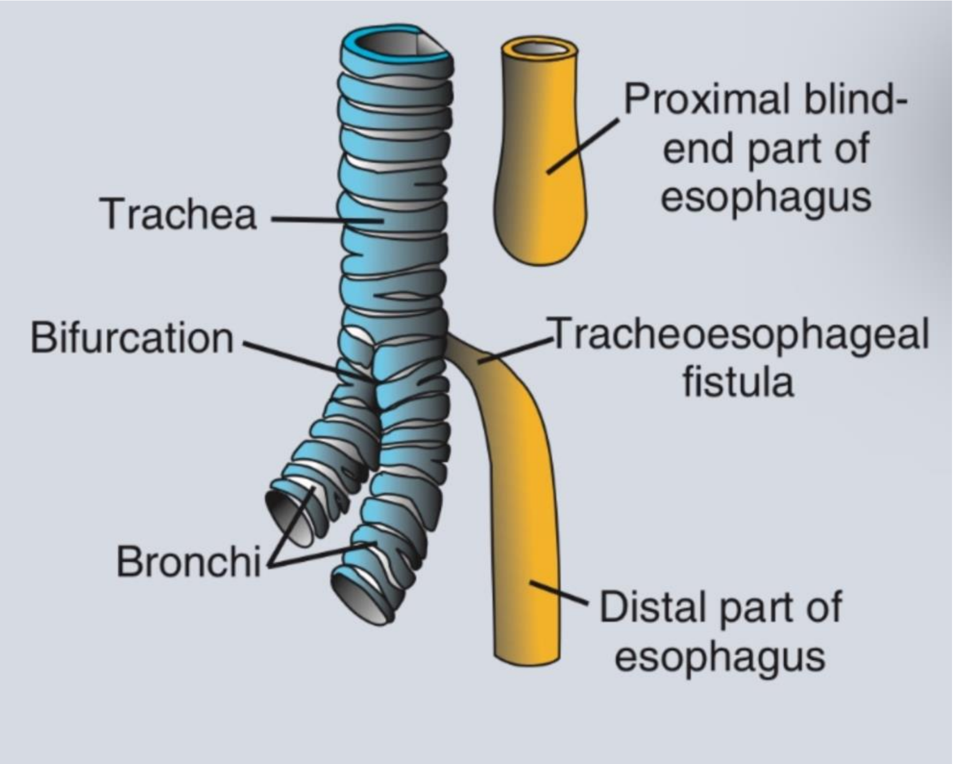


Figure 15.7 Variations of esophageal atresia and/or tracheoesophageal fistula in order of their frequency of appearance: **A.** 90%; **B.** 4%; **C.** 4%; **D.** 1%; and **E.** 1%.

These conditions require rapid and swift surgical interventions to connect the two ends of the esophagus and separate the two tubes from one another.

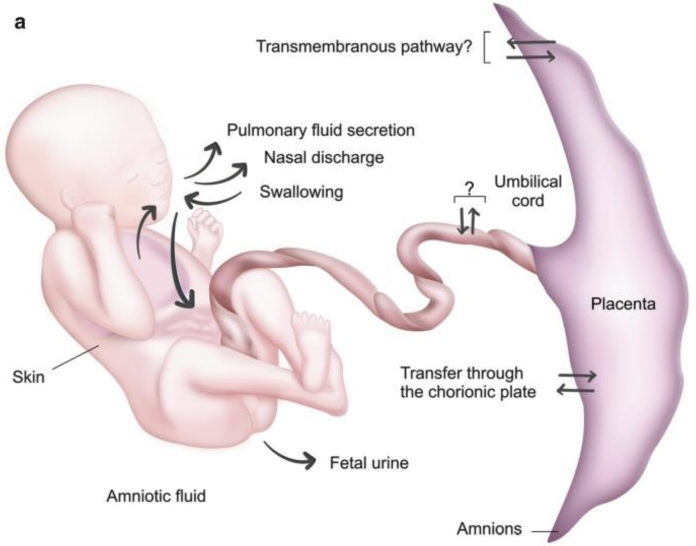
- Congenital esophageal abnormalities appear in 1/3000 newborn babies.
- Esophageal atresia is the closure or the formation of a blind end in the esophagus; preventing a connection between the oral cavity and the stomach.
- Tracheoesophageal fistula is an abnormal connection/opening between the trachea and esophagus.
- 90% of all the congenital esophageal atresia and/or tracheoesophageal fistulas occur as proximal esophageal atresia with distal tracheoesophageal fistulas. Since this condition is the most common form of them all, it is the most clinically significant.
- Fetuses with proximal esophageal atresia and distal tracheoesophageal fistula are commonly present with elevated amniotic fluid volume, termed as polyhydramnios (and is the opposite of oligohydramnios: decreased amniotic fluid).

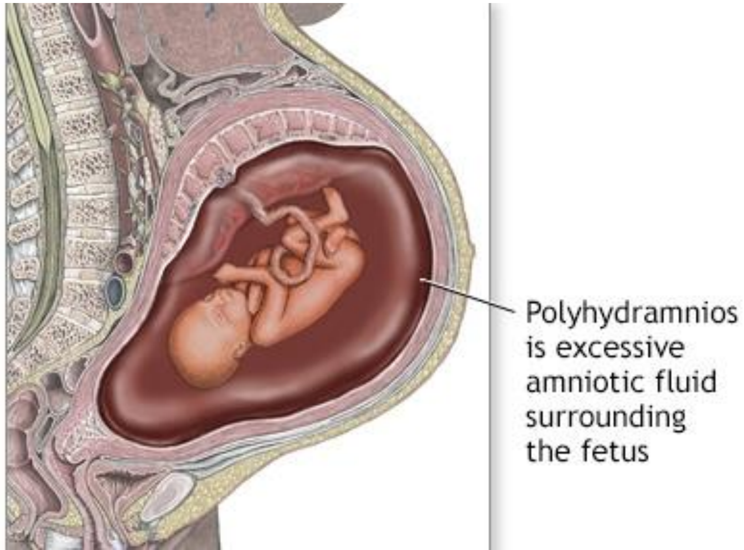


Proximal esophageal Atresia with Distal tracheoesophageal Fistula

- Normally during fetal life, and after the rupture of the buccopharyngeal membrane, there is constant circulation of amniotic fluid between the amniotic cavity/sac and the fetus. Amniotic fluid enters the fetus's body via swallowing, inhalation, and intermembranous absorption.
- A consequence of esophageal atresia in fetuses is the partial obstruction of this amniotic circulation, causing its build up and increase in volume (polyhydramnios). Therefore, esophageal atresia should always be suspected in cases of polyhydramnios.
- Other consequences of this abnormality that affect neonates include the regurgitation of milk during breastfeeding (due to the atresia), the distention of the abdomen (due to the passage of inhaled air from the trachea to the stomach through the fistula), and exposure of the lungs to gastric secretions (through the fistula) which may result in acute pneumonia and lung infections.
- In general, these malformations are associated with other congenital abnormalities, most importantly cardiac abnormalities such as inter-atrial/ventricular septal defect or Fallot's tetralogy.

Amniotic fluid circulation





Esophageal Abnormalities

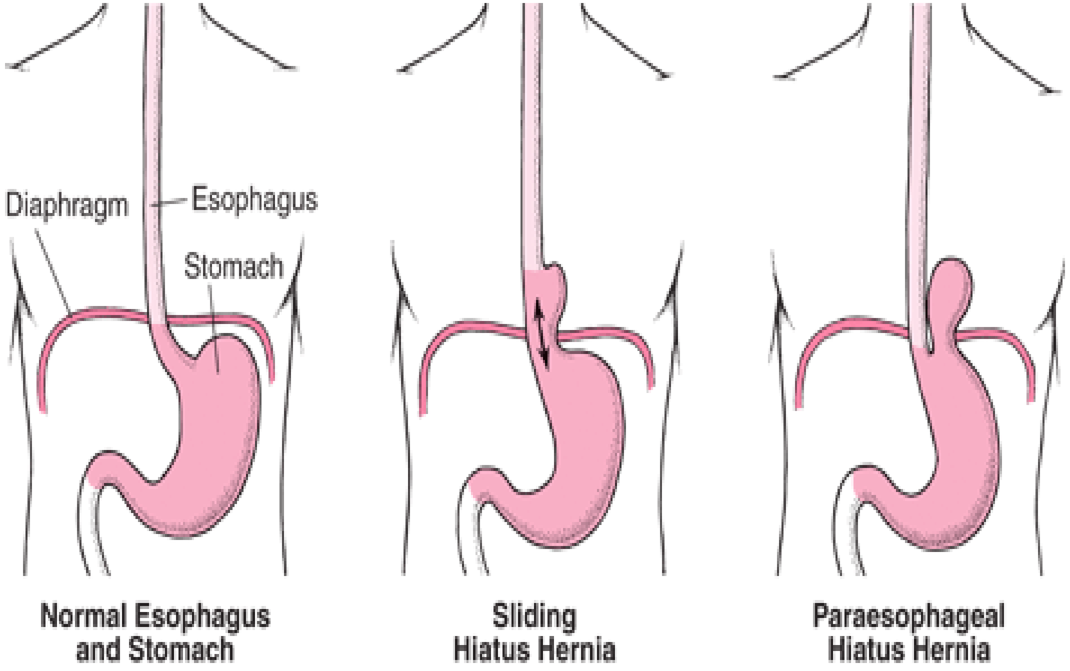
- In addition to atresias, the lumen of the esophagus may narrow, producing **esophageal stenosis**, usually in the lower third.

- Stenosis may be caused by incomplete recanalization, vascular abnormalities, or accidents that compromise blood flow.

- In the early stages of embryonic development, the esophagus is located high up in the chest. With the enlargement and descent of the lungs and heart, the esophagus lengthens downwards slowly.

- Occasionally the esophagus fails to lengthen and descend sufficiently and the stomach is pulled up into the esophageal hiatus through the diaphragm.

- The result is a **congenital hiatal hernia**.

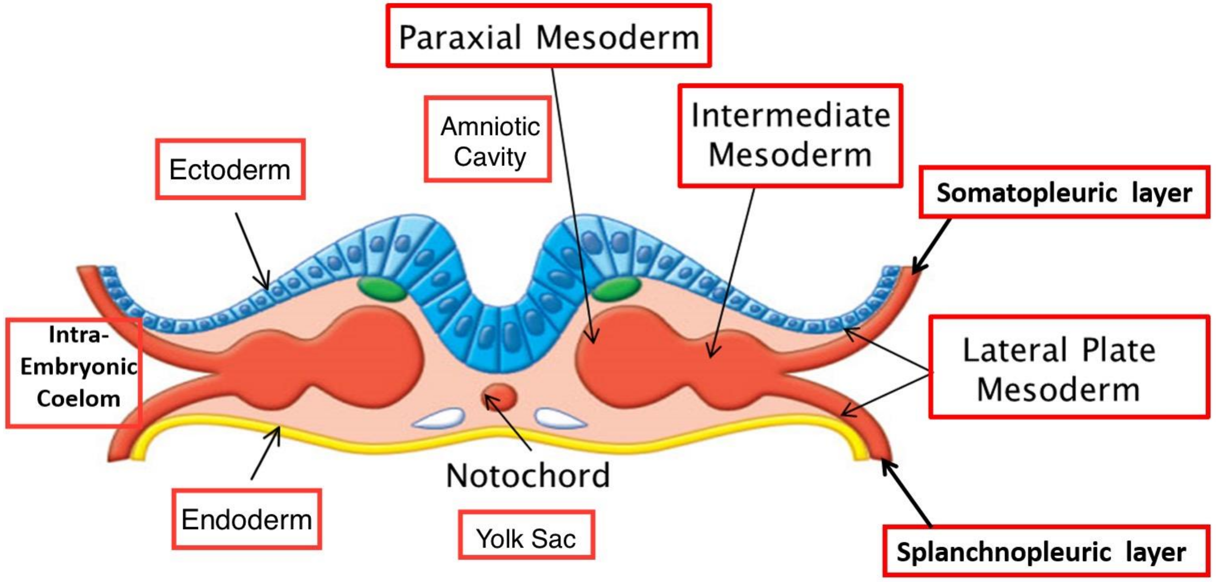


Development of the Dorsal and Ventral Mesentery

- At the end of the third week, intraembryonic mesoderm on each side of the midline differentiates into a paraxial portion, an intermediate portion, and a lateral plate.

- When intercellular clefts appear in the lateral mesoderm, the lateral plates are divided into two layers: the **somatic mesoderm layer** and the **splanchnic mesoderm layer**.

- The latter (the splanchnic mesoderm) is continuous with mesoderm of the wall of the yolk sac and primitive gut.



- The space bordered by these layers (the space between the somatic and splanchnic mesoderm) forms the **intraembryonic cavity (body cavity).**

- **The peritoneal cavity is derived from the intraembryonic coelom caudal to (below) the septum transversum.**

- At first, the right and left sides of the intraembryonic cavity are in open connection with the extraembryonic cavity, but when the body of the embryo folds cephalocaudally and laterally, this connection is lost.

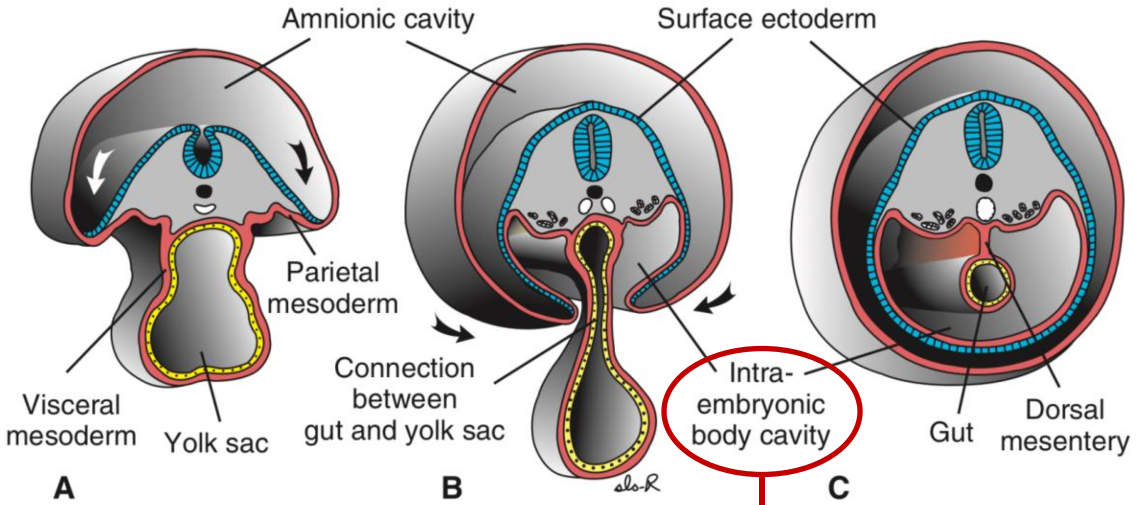
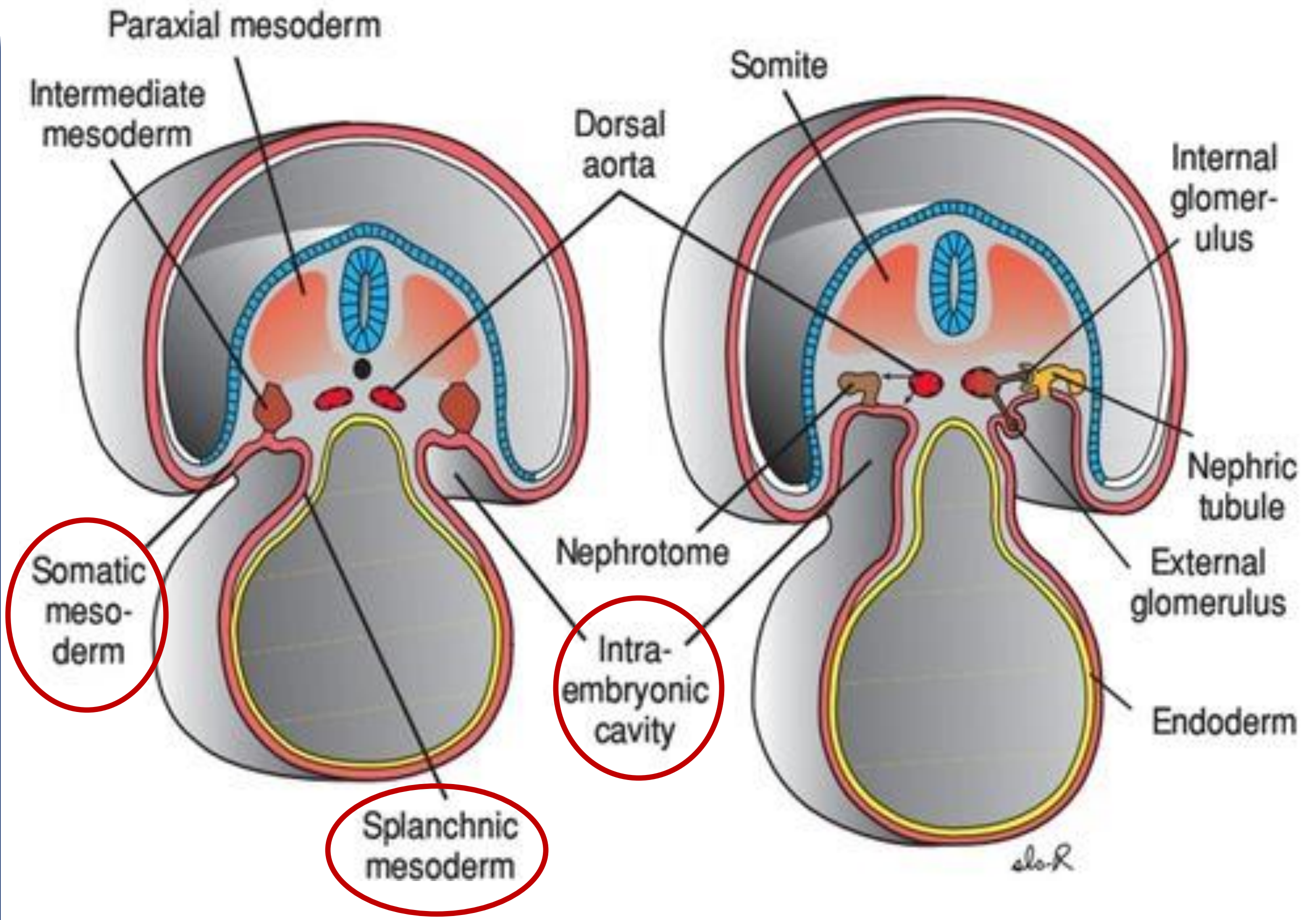


Figure 15.3 Transverse sections through embryos at various stages of development. **A.** The intraembryonic cavity, bordered by visceral and somatic layers of lateral plate mesoderm, is in open communication with the extraembryonic cavity. **B.** The intraembryonic cavity is losing its wide connection with the extraembryonic cavity. **C.** At the end of the fourth week, visceral mesoderm layers are fused in the midline and form a double-layered membrane (dorsal mesentery) between right and left halves of the body cavity. Ventral mesentery exists only in the region of the septum transversum (not shown).

This is the intraembryonic coelom/cavity from which the peritoneal cavity is formed.
This space is initially open and connected with extraembryonic cavity but eventually closes along with the formation of the septum transversum.

- During embryonic growth, the three germinal layers (ectoderm, mesoderm, and endoderm) undergo two types of folding: cephalocaudal and lateral folding.
- Lateral folding occurs due to the rapid growth of the amniotic cavity, and this results in the amniotic cavity enclosing a part of the yolk sac. The part of the of the yolk sac that is enclosed by the rapidly growing amniotic cavity is what's known as the primitive gut, while the remaining part of the yolk sac forms the umbilical vesicle and the yolk stalk (which forms the vitelline duct).
- A space is created by this lateral folding, and it lies between the amnion and the the primitive gut. This cavity is known as the intraembryonic cavity/coelom which will develop into the the three serous cavities of the body, including the peritoneal cavity of the abdomen.
- The layer of mesoderm that surrounds the amniotic cavity is known as the somatic mesoderm, and develops into parietal peritoneum in the abdomen. The layer of mesoderm that surrounds the yolk sac - including the primitive gut- however, is known as the splanchnic mesoderm and develops into the visceral peritoneum in the abdomen.



The abdominal cavity and its parietal and visceral peritoneum are derived from the somatopleuric and splanchnopleuric mesoderm along with the intraembryonic coelom.

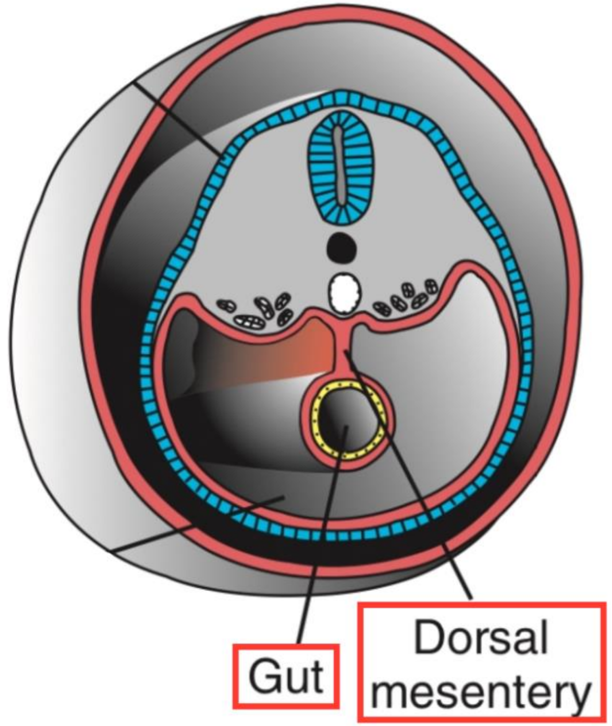
- Initially the foregut, midgut, and hindgut are in broad contact with the mesenchyme of the posterior abdominal wall.

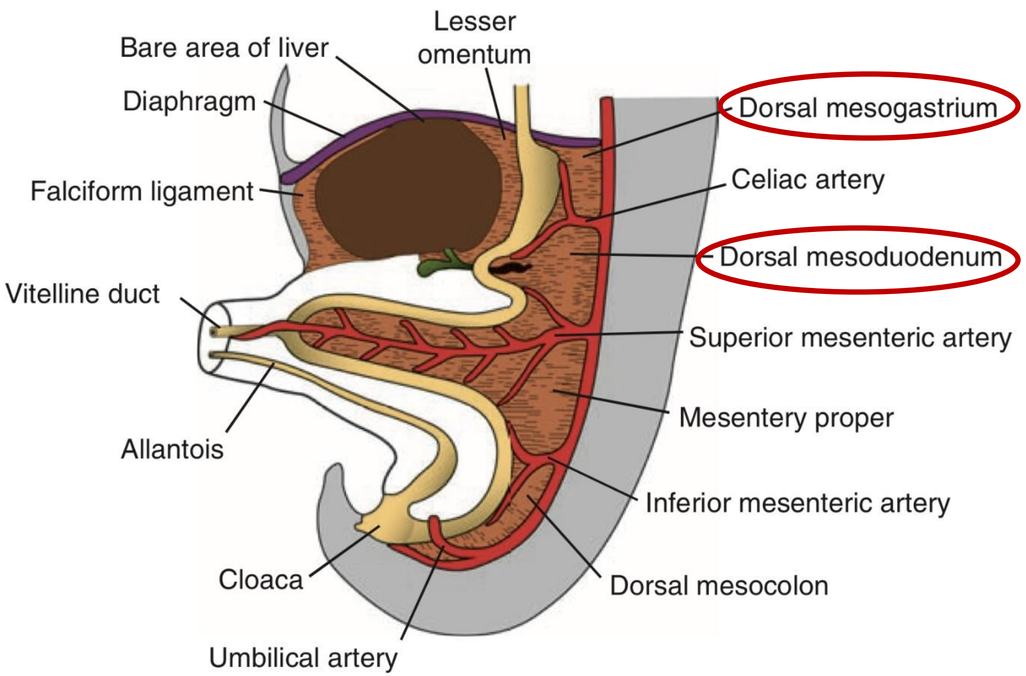
- By the fifth week however, the connecting tissue bridge has narrowed, and the caudal part of the foregut, the midgut, and a major part of the hindgut are suspended from the abdominal wall by the **dorsal mesentery.**

- The **dorsal mesentery** extends from the lower end of the esophagus to the cloacal region of the hindgut.

- In the region of the stomach, the dorsal mesentery forms the **dorsal mesogastrium** or **greater omentum** (forming the lienorenal and gastrosplenic ligaments as well)**;** in the region of the duodenum it forms the dorsal **mesoduodenum;** and in the region of the colon it forms the **dorsal mesocolon** (covering the transverse and sigmoid colon).

- Dorsal mesentery of the jejunal and ileal loops forms the **mesentery proper.**





<u>Ventral mesentery</u> extends from the anterior wall of the stomach to the anterior abdominal wall and diaphragm.

It exists only in the region of the terminal part of the esophagus, the stomach, and the upper part of the duodenum. It is <u>derived from the septum transversum</u>. Growth of the liver into the mesenchyme of the septum transversum divides the ventral mesentery into (structures derived from the ventral mesentery):

(A) the <u>lesser omentum</u>, extending from the lower portion of the esophagus, the stomach, and the upper portion of the duodenum to the liver,

(B) the <u>falciform ligament, extending from the liver to the ventral body wall (anterior abdominal wall)</u>, <u>and the coronary and the triangular ligaments</u> **but not the ligamentum teres which is the obliterated umbilical vein.**

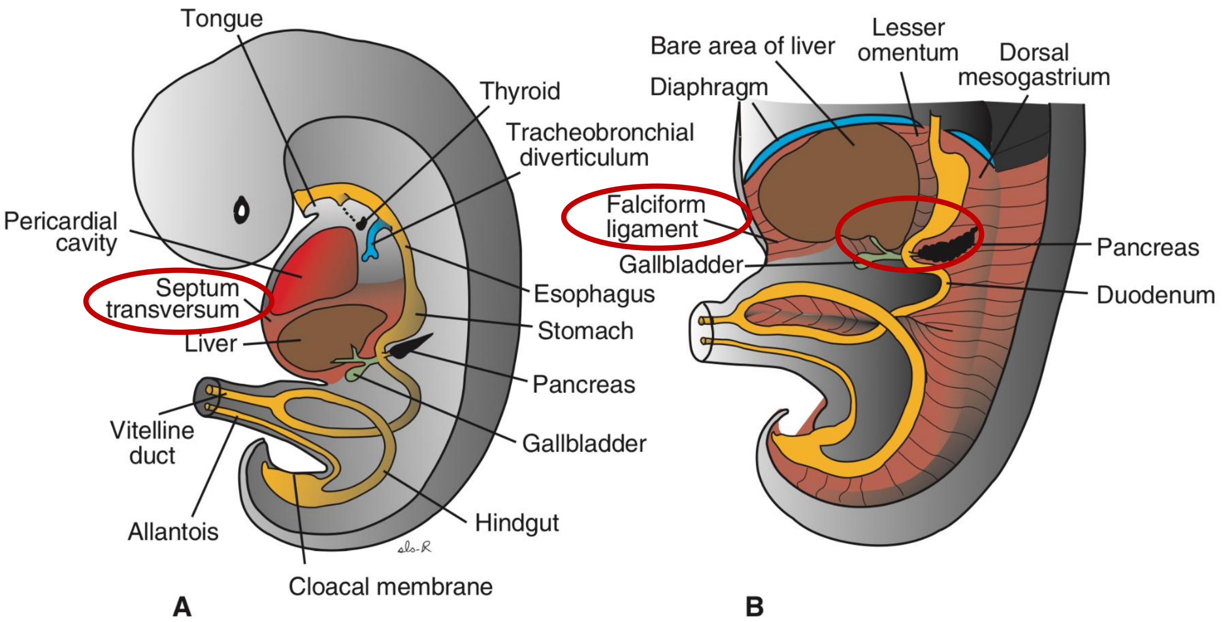


Figure 15.15 A. A 9-mm embryo (approximately 36 days). The liver expands caudally into the abdominal cavity. Note condensation of mesenchyme in the area between the liver and the pericardial cavity, foreshadowing formation of the diaphragm from part of the septum transversum. **B.** A slightly older embryo. Note the falciform ligament extending between the liver and the anterior abdominal wall and the lesser omentum extending between the liver and the foregut (stomach and duodenum). The liver is entirely surrounded by peritoneum except in its contact area with the diaphragm. This is the bare area of the liver.

Please note that the ventral mesentery forms the lesser omentum as well as all of the ligaments attached to the liver except for the ligamentum teres.

- The free margin of the falciform ligament contains the umbilical vein.

- This umbilical vein is obliterated after birth to form the **round ligament of the liver (ligamentum teres hepatis)** and it is not formed by the ventral mesentery.

- The lesser omentum is divided into two ligaments: the hepatoduodenal ligament and the hepatogastric ligament.

- The free margin of the lesser omentum connecting the duodenum and liver (**hepatoduodenal ligament**) contains the bile duct, portal vein, and hepatic artery (**portal triad**).

- This free margin also forms the roof of the **epiploic foramen of Winslow** (meaning that the foramen of Winslow is posterior to the free margin of the lesser omentum / posterior to the hepatoduodenal ligament), which is the opening connecting the omental bursa (lesser sac) with the rest of the peritoneal cavity (greater sac).

Hepatoduodenal ligament / free edge of the lesser omentum

Hepatogastric ligament

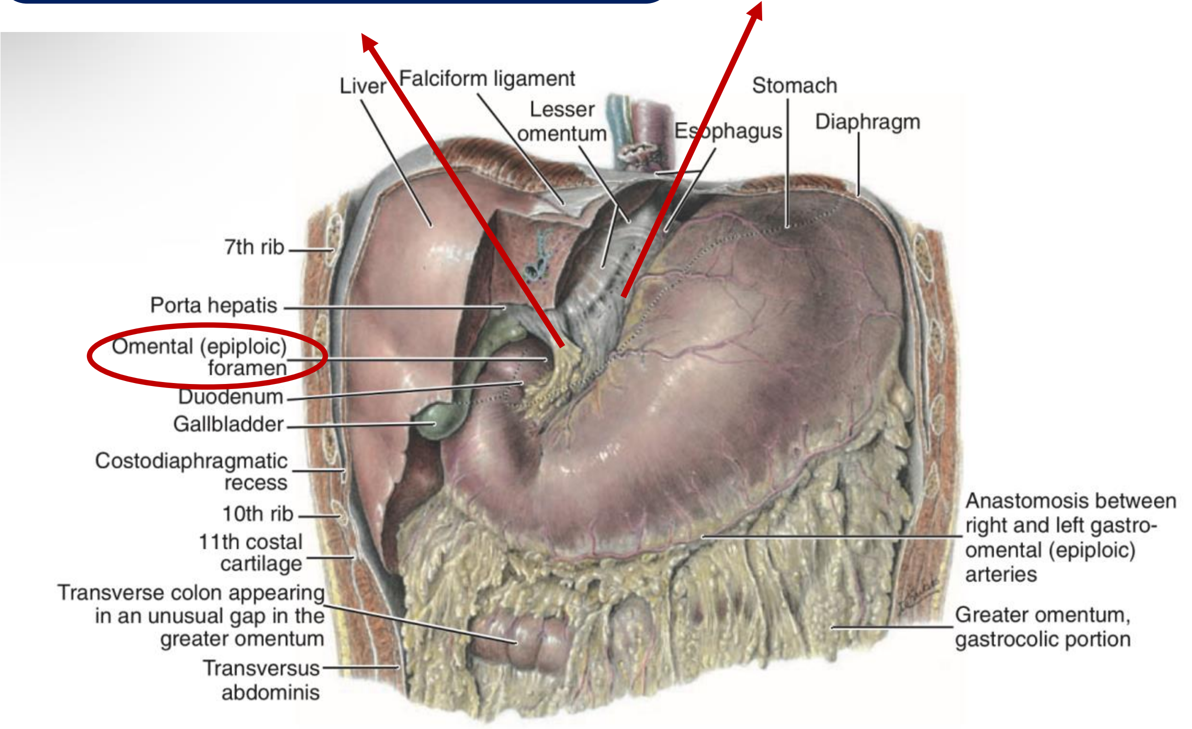


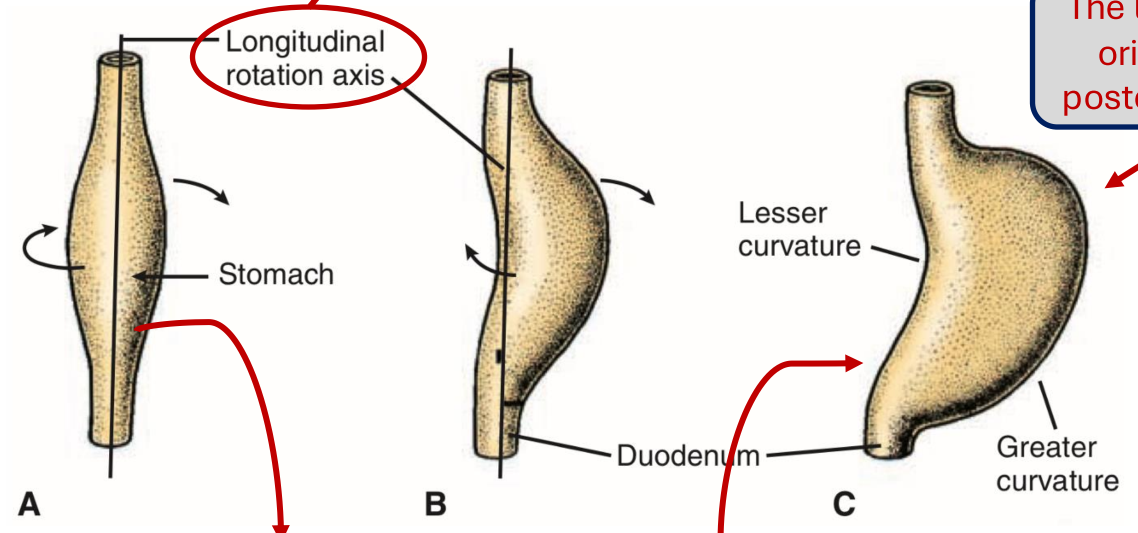
Figure 15.16 Lesser omentum extending from the liver to the lesser curvature of the stomach (hepatogastric ligament) and to the duodenum (hepatoduodenal ligament). In its free margin anterior to the omental foramen (epiploic foramen of Winslow) are the hepatic artery, portal vein, and bile duct (portal triad).

STOMACH

- <u>The stomach appears as a fusiform dilation of the foregut in the fourth week of development.</u>
- During the following weeks, its appearance and position change greatly as a result of the different rates of growth in various regions of its wall and the changes in position of surrounding organs.
- Positional changes of the stomach are most easily explained by assuming that it rotates around a longitudinal and an anteroposterior axis.

The <u>longitudinal axis</u> of the stomach is the line that passes from both its openings early in its development. After the dilation of the stomach forms, it begins to rotate about its longitudinal axis 90° clockwise, causing its <u>posterior surface to face the left side of the body</u>, and its <u>anterior surface to be on the right</u>.

The left side was originally the posterior surface



The anterior view of the fusiform (spindle-like) dilation of the stomach. It has a superior and inferior opening that lie along its longitudinal axis.

The right side was originally the anterior surface

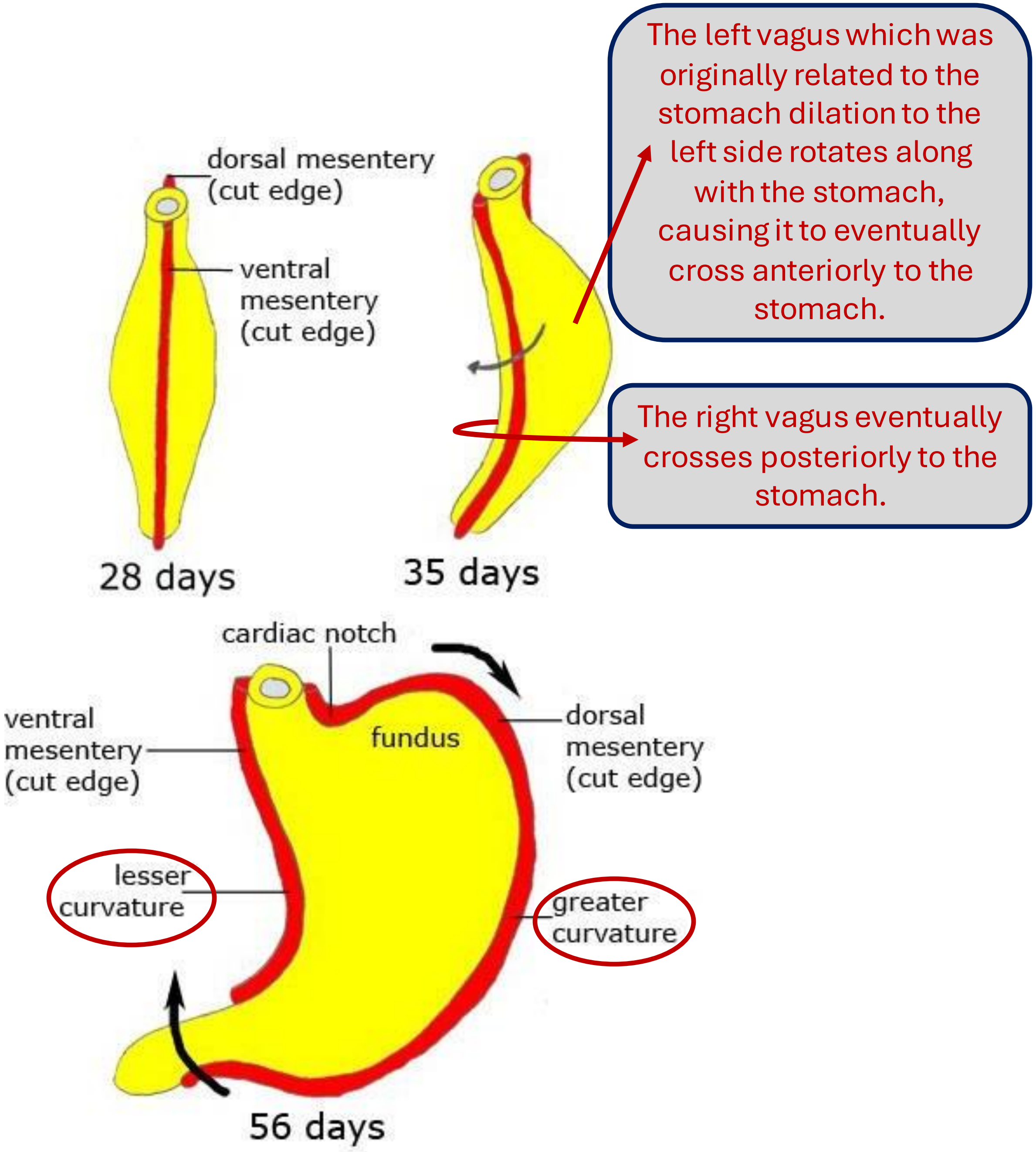
- The stomach rotates 90° clockwise around its longitudinal axis, causing its left side to face anteriorly and its right side to face posteriorly.

- Hence the left vagus nerve, initially innervating the left side of the stomach, now innervates the anterior wall.

- Similarly, the right vagus nerve innervates the posterior wall.

- During this rotation the original posterior wall of the stomach grows faster than the anterior portion, forming the **greater and lesser curvatures**.

- Due to the fact that the original posterior wall of the stomach grows relatively faster that the original anterior wall, after the rotation, the left side of the stomach will eventually be larger in comparison to the right side and will form the greater curvature.
- On the other hand, the original anterior wall will form the lesser curvature on the right side of the stomach.



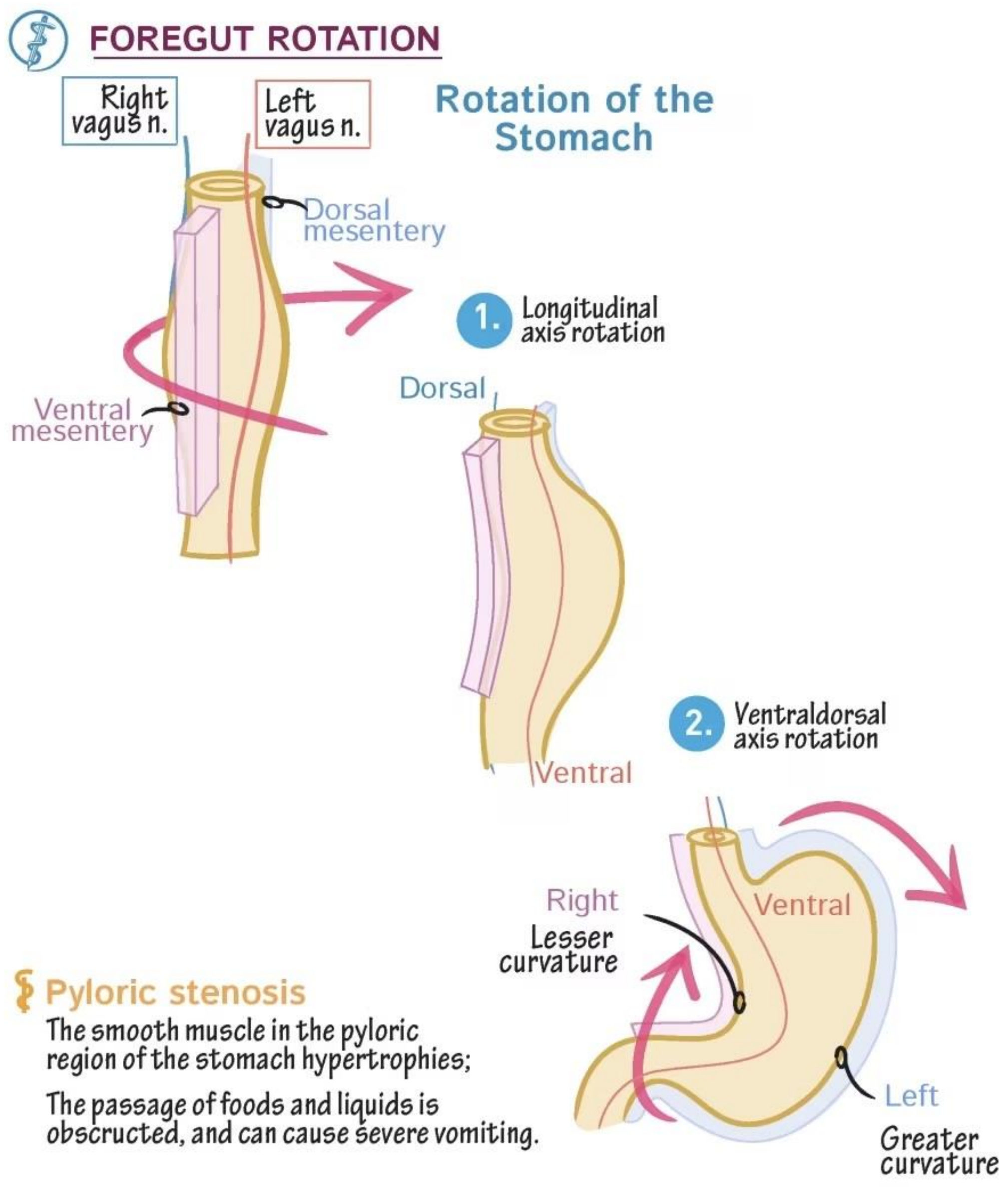
To summarize the changes that result from the 90° clockwise rotation of the stomach along its longitudinal axis:

- The original anterior surface ➔
becomes on the right side of the stomach and formed the lesser curvature.

- The original left surface ➔
becomes on the anterior side, and this is why the left vagus now supplies the anterior wall of the stomach.

- The original posterior surface ➔
becomes on the left side and creates the greater curvature on the left side of the stomach (because the original posterior wall grows faster the the original anterior wall).

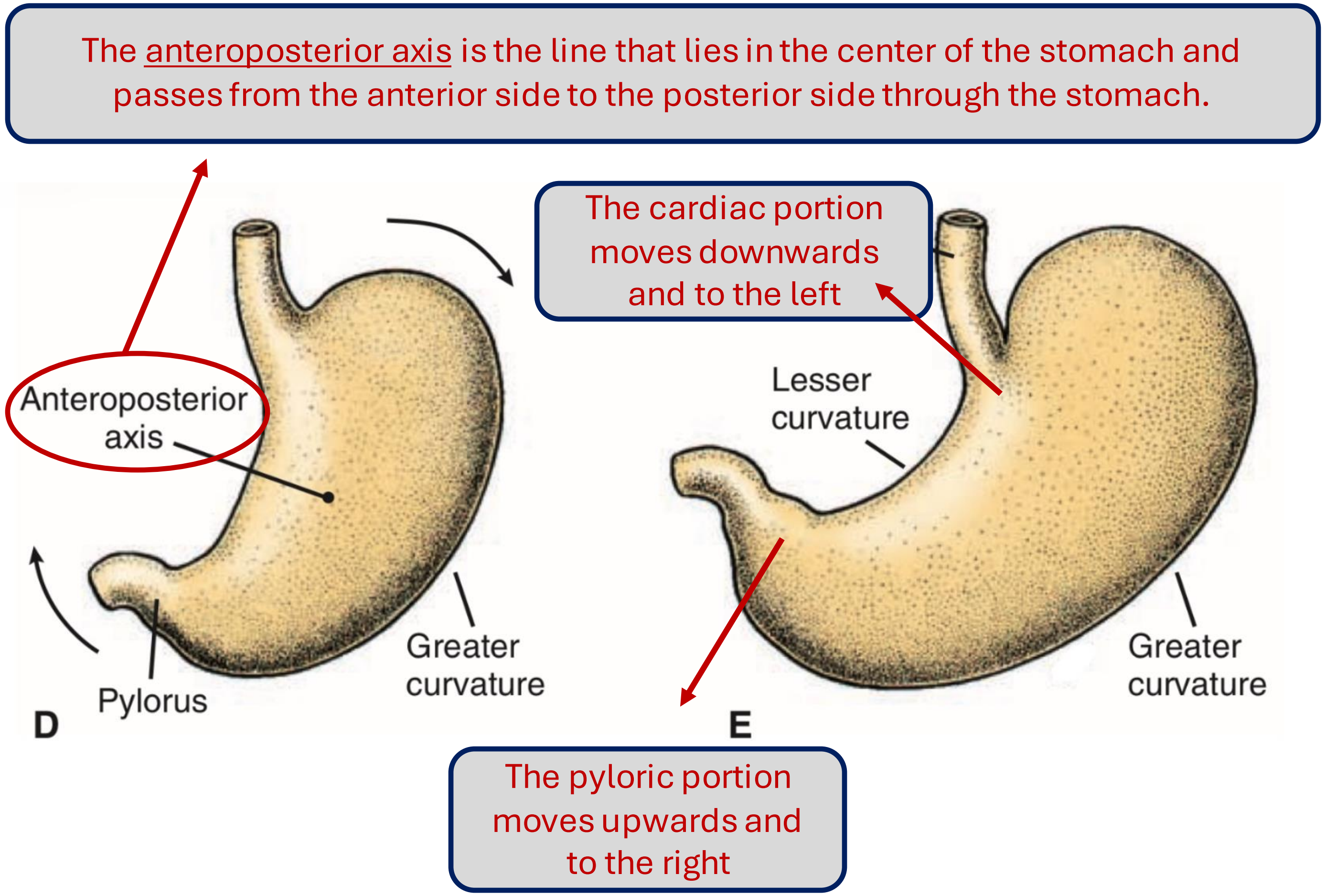
- The original right surface ➔
is now on the posterior side, dragging the right vagus with it. That's the reason the right vagus innervates the posterior wall of the stomach.



- The cephalic (the cardiac sphincter) and caudal ends (the pyloric sphincter) of the stomach originally lie in the midline.

- But during further growth, the stomach rotates around an anteroposterior axis, such that the caudal or pyloric part moves to the right and upward and the cephalic or cardiac portion moves to the left and slightly downward.

- The stomach thus assumes its final position, its axis running from above left to below right.



- Since the stomach is attached to the dorsal body wall by the **dorsal mesogastrium** and to the ventral body wall by the **ventral mesogastrium,** its rotation and disproportionate growth alter the position of these mesenteries.

- Rotation about the **longitudinal axis** pulls the dorsal mesogastrium to the left, creating a space behind the stomach called the **omental bursa** (**lesser peritoneal sac**)

- This rotation also pulls the ventral mesogastrium to the right.

The omental bursa is the space present behind the stomach in the embryo.
Later in development, it becomes a permanent and fixed space known as the lesser (peritoneal) sac.

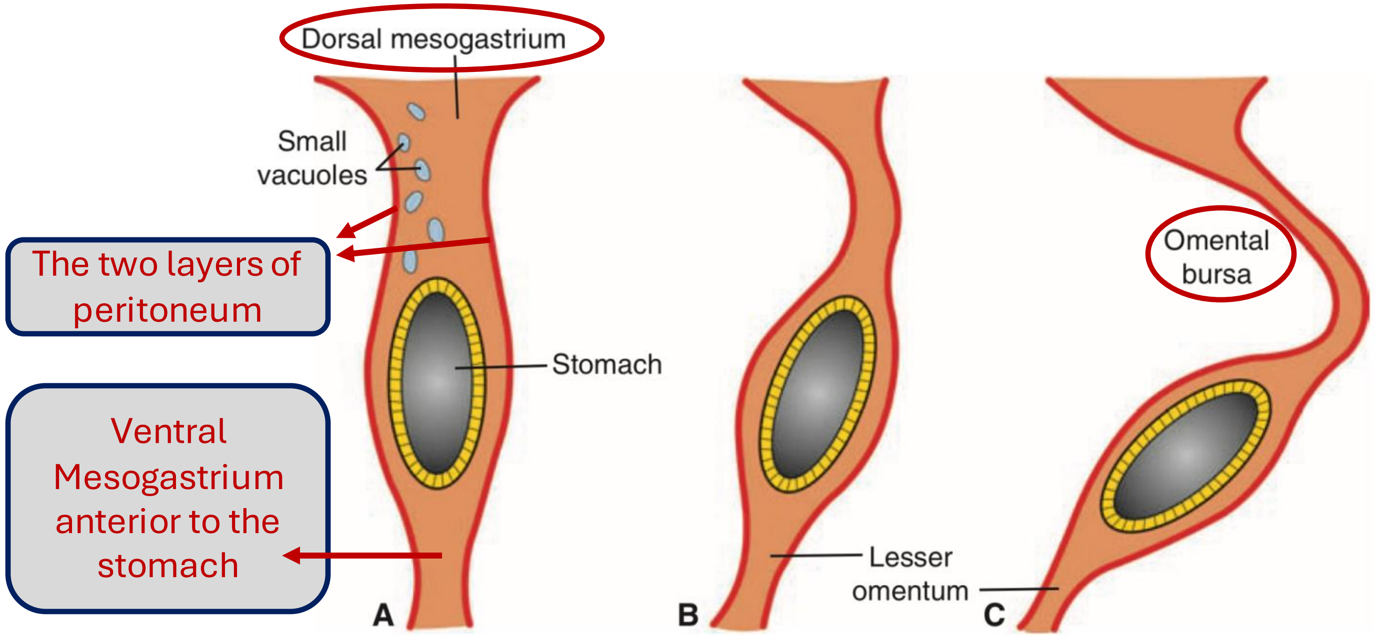


Figure 15.9 A. Transverse section through a 4-week embryo showing intercellular clefts appearing in the dorsal mesogastrium. **B,C.** The clefts have fused, and the omental bursa is formed as an extension of the right side of the intraembryonic cavity behind the stomach.

Remember that the ventral and dorsal mesogastria are two layers of continuous peritoneum.
Since they are double layered peritoneum, they will eventually form either omentum, mesentery, or ligaments (reflections).
Initially, the ventral mesogastrium connects between the stomach and the anterior abdominal wall while the dorsal mesogastrium connects it with the posterior abdominal wall.

- As a result of rotation of the stomach about its anteroposterior axis, 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.
- This double leafed/layered apron is the **greater omentum.**
- Later its layers fuse 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.
- The transverse mesocolon is composed of a total of four layers and connects the transverse colon with the anterior border of the pancreas: two layers of the greater omentum fuse with two layers of the original mesentery of the transverse colon.

The transverse mesocolon is composed of four layers of peritoneum fusing together to connect the transverse colon to the anterior surface of the pancreas

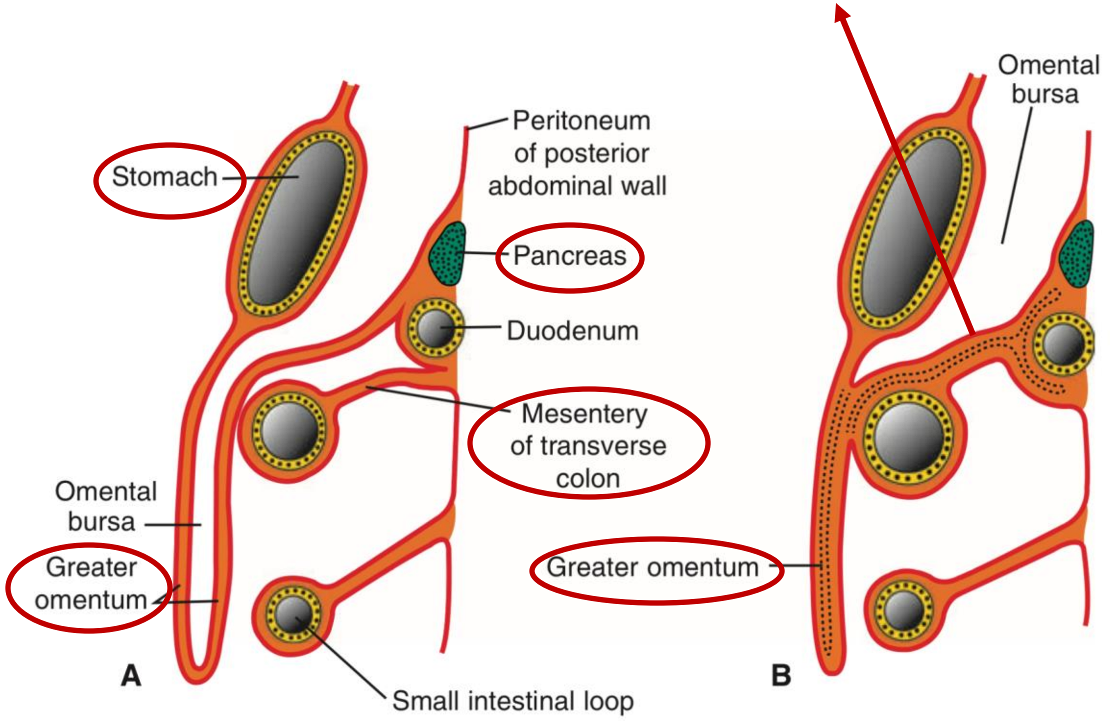
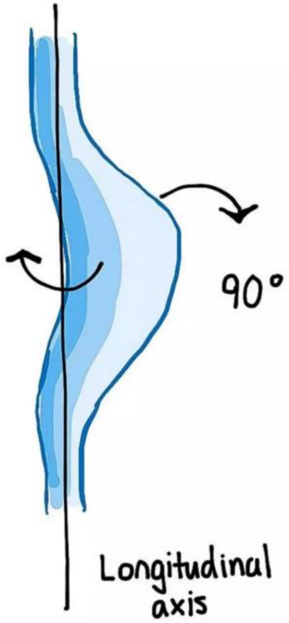


Figure 15.13 **A.** Sagittal section showing the relation of the greater omentum, stomach, transverse colon, and small intestinal loops at 4 months. The pancreas and duodenum have already acquired a retroperitoneal position. **B.** Similar section as in **A** in the newborn. The leaves of the greater omentum have fused with each other and with the transverse mesocolon. The transverse mesocolon covers the duodenum, which fuses with the posterior body wall to assume a retroperitoneal position.

Extra note:
Notice how rotation of the stomach about its longitudinal axis resulted in a space behind the stomach (the omental bursa).
Its rotation about its anteroposterior axis (which occurs afterwards) however, results in forming the descending greater omentum which reflects into the ascending greater omentum. This reflection of peritoneum extends beneath the stomach to reach the transverse colon and the small intestine, eventually fusing with the transverse colon mesentery to take part in the transverse mesocolon.

The creation of the omental bursa posterior to the stomach is due to rotation of the stomach about its longitudinal axis



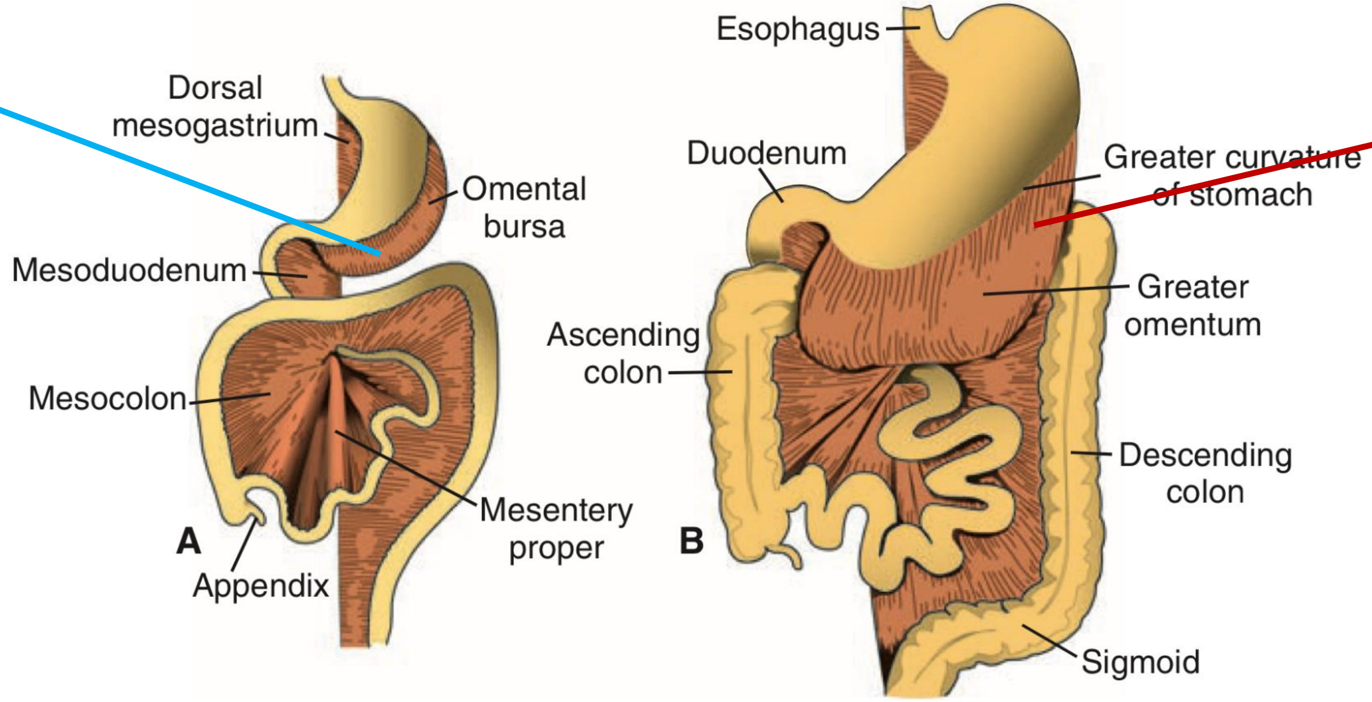
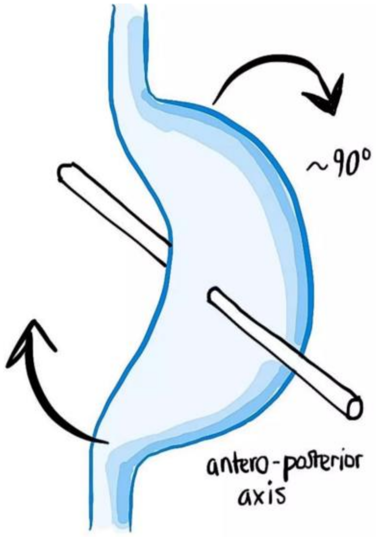


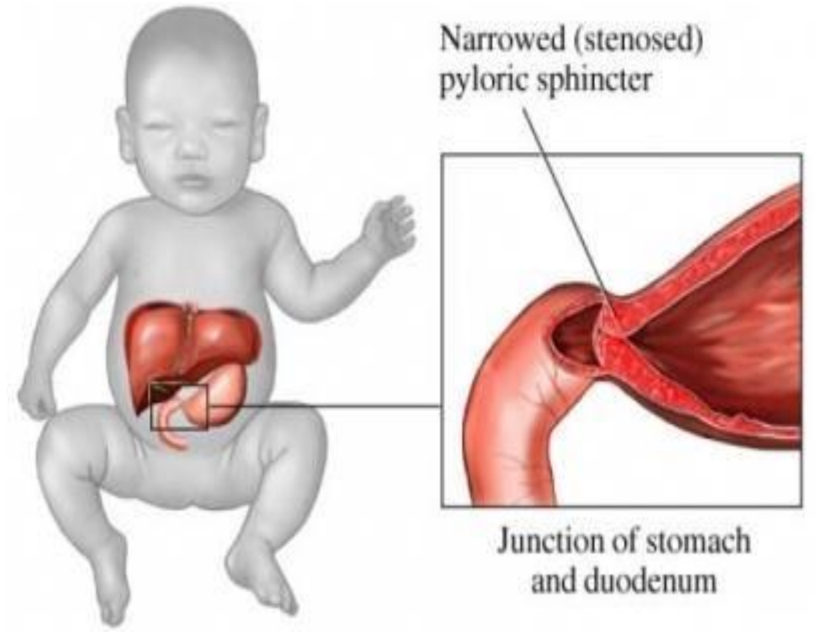
Figure 15.12 A. Derivatives of the dorsal mesentery at the end of the third month. The dorsal mesogastrium bulges out on the left side of the stomach, where it forms part of the border of the omental bursa. **B.** The greater omentum hangs down from the greater curvature of the stomach in front of the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

Afterwards, rotation about the anteroposterior axis results in the two layers of the greater omentum extending below the stomach and returning upwards behind the stomach, covering the transverse colon anteriorly



Stomach Abnormalities

- **Pyloric stenosis** occurs when the circular and, to a lesser degree, the longitudinal musculature of the stomach in the region of the pylorus hypertrophies.
- One of the most common abnormalities of the stomach in infants, pyloric stenosis is believed to develop during fetal life (3-6) weeks.
- A common symptom of pyloric stenosis is forceful vomiting after the newborn has been breastfed, also referred to as projectile vomiting.
- Treatment is usually straightforward and involves a surgical procedure to make a longitudinal incision along the external wall of the sphincter to relieve the pressure of the sphincter. Sutures are then placed using a specific technique.



The pyloric sphincter is mostly composed of inner circular smooth muscle bands. In pyloric stenosis, the pyloric sphincter is abnormally thick due to the hypertrophy of the smooth muscles. This stenosis prevents the drainage of the stomach's contents to the small intestine.

Spleen

- In the fifth week of development, the spleen primordium appears as a mesodermal proliferation between the two leaves of the dorsal mesogastrium.
- With continued rotation of the stomach, the dorsal mesogastrium lengthens, and the portion between the spleen and dorsal midline swings to the left and fuses with the peritoneum of the posterior abdominal wall.
- The posterior leaf of the dorsal mesogastrium and the peritoneum along this line of fusion degenerate.

The two leaves/layers of dorsal mesogastrium in which mesodermal cells begin to proliferate in order to form the spleen

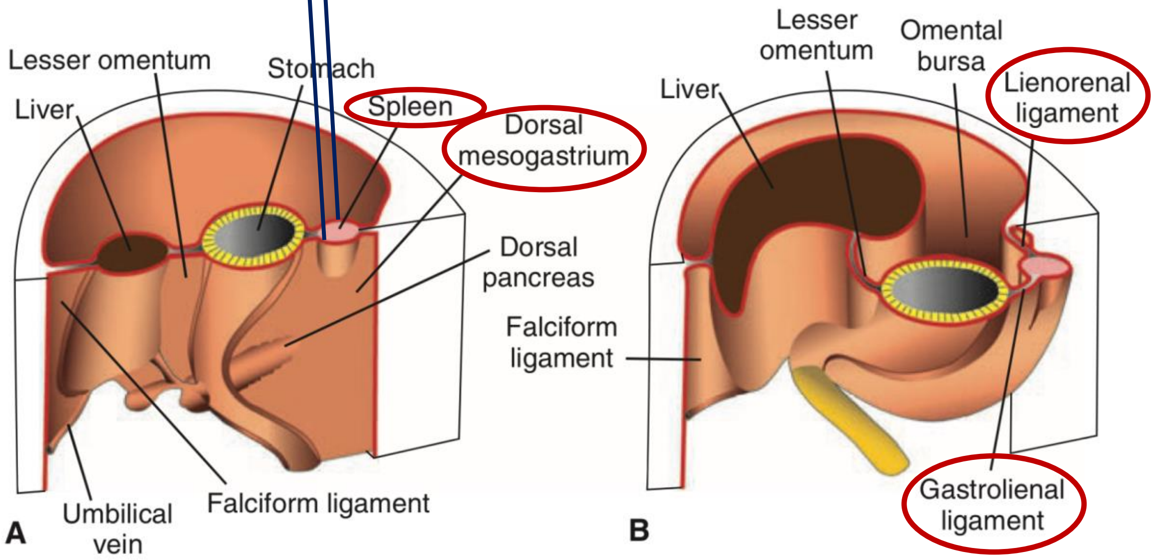


Figure 15.10 A. The positions of the spleen, stomach, and pancreas at the end of the fifth week. Note the position of the spleen and pancreas in the dorsal mesogastrium. **B.** Position of spleen and stomach at the 11th week. Note formation of the omental bursa (lesser peritoneal sac).

The portion of the dorsal mesogastrium that connects the spleen with the posterior abdominal wall and the left kidney is known as the lienorenal (splenicorenal) ligament/reflection.

The portion of the dorsal mesogastrium that connects the stomach with the spleen is known as the gastrosplenic (gastrolienic) ligament/reflection.

- The spleen, which remains intraperitoneal, is then connected to the body wall in the region of the left kidney by the **lienorenal ligament** and to the stomach by the **gastrolienal ligament.**

- Lengthening and fusion of the dorsal mesogastrium to the posterior body wall also determine the final position of the pancreas.

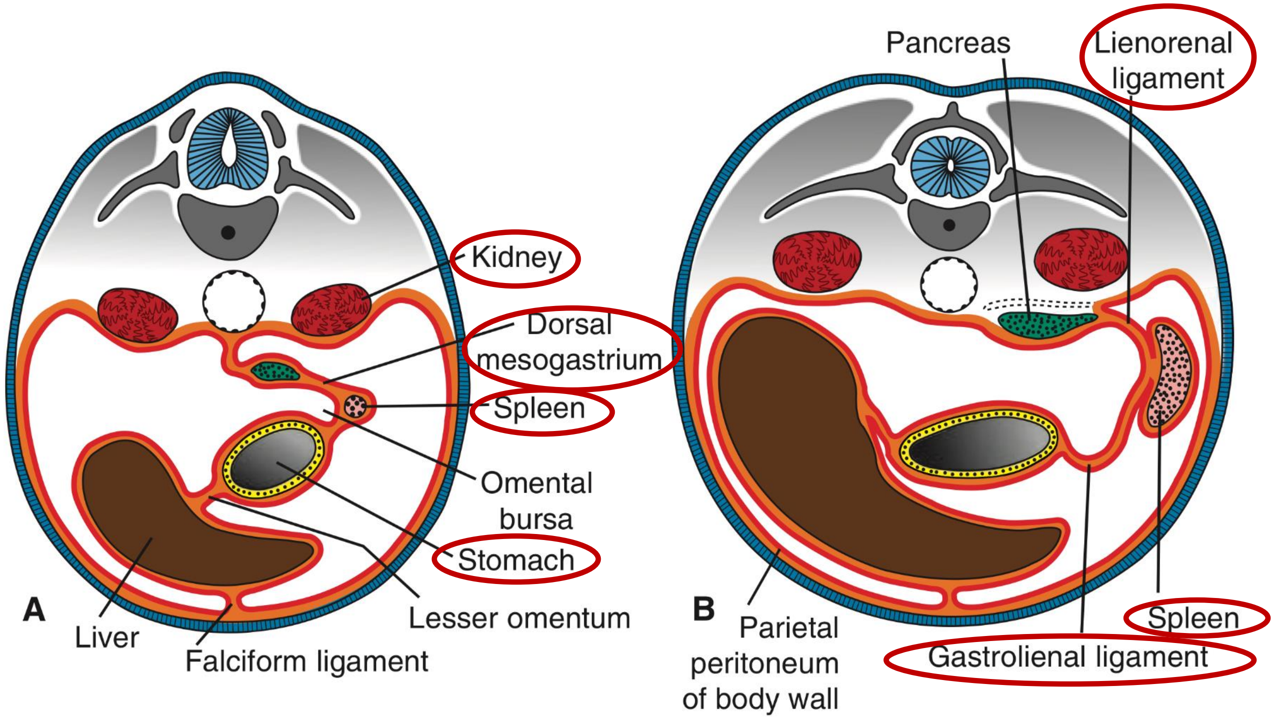
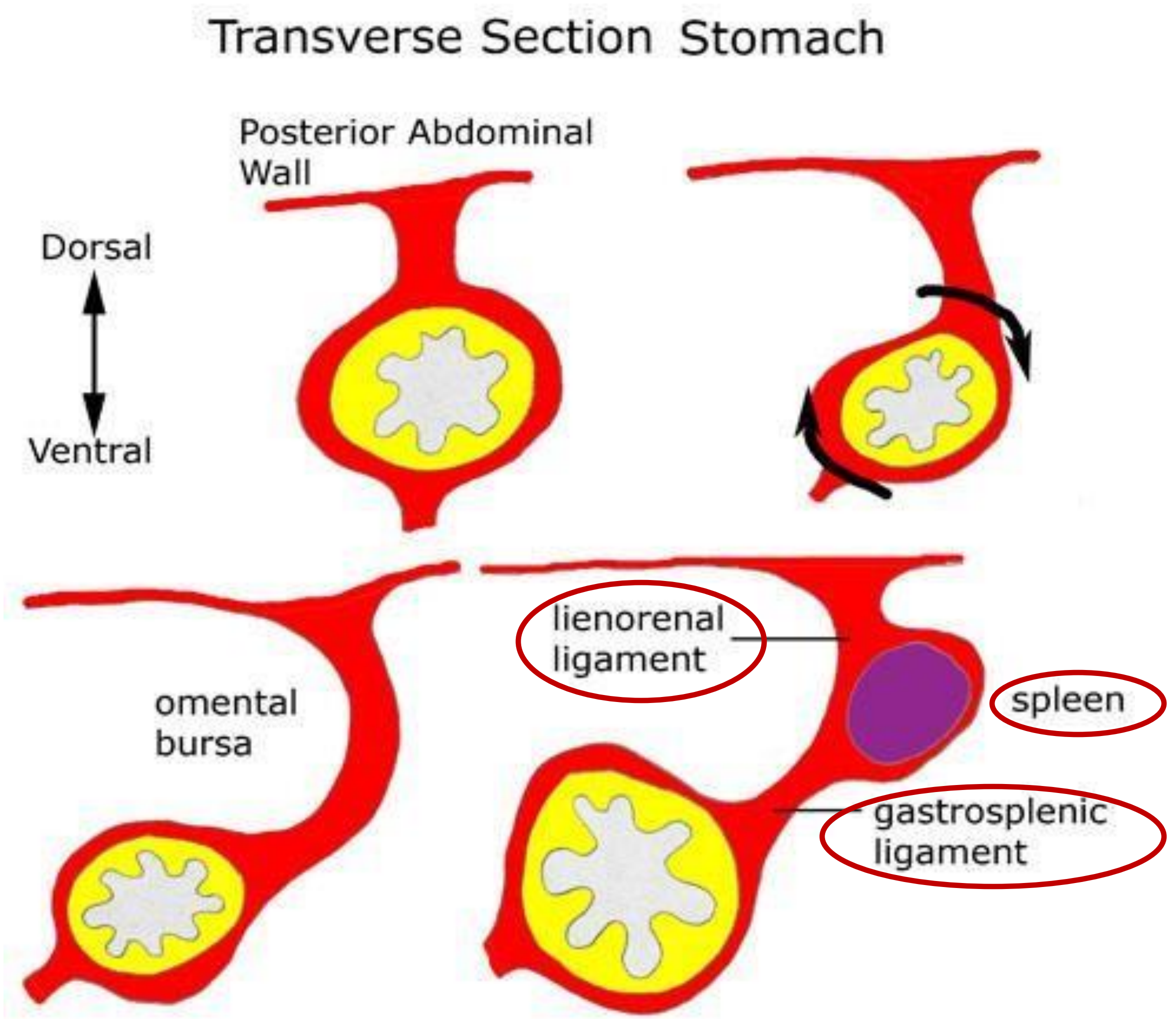


Figure 15.11 Transverse sections through the region of the stomach, liver, and spleen, showing formation of the omental bursa (lesser peritoneal sac), rotation of the stomach, and position of the spleen and tail of the pancreas between the two leaves of the dorsal mesogastrium. With further development,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


Transverse Section Stomach
Posterior Abdominal
Wall
Dorsal
Ventral
omental
bursa
lienorenal
ligament
spleen
gastrosplenic
ligament

LIVER AND GALLBLADDER

- The liver primordium appears in the middle of the third week as an outgrowth of the endodermal epithelium at the distal end of the foregut (in the proximal half of the duodenum).

- This outgrowth, the **hepatic diverticulum,** or **liver bud,** consists of rapidly proliferating cells that penetrate the **septum transversum,** that is, the mesodermal plate between the pericardial cavity and the stalk of the yolk sac.
- The proliferation of the liver bud cells give rise to the parenchyma of the liver.

- While hepatic cells continue to penetrate the septum, the connection between the hepatic diverticulum and the foregut (duodenum) narrows, forming the **bile duct.**
- The bile duct forms after the formation the liver bud and from it. At first it's composed of a solid column of cells and gets canalized afterwards.

- A small ventral outgrowth is formed by the bile duct, and this outgrowth gives rise to the **gallbladder** and the **cystic duct.**

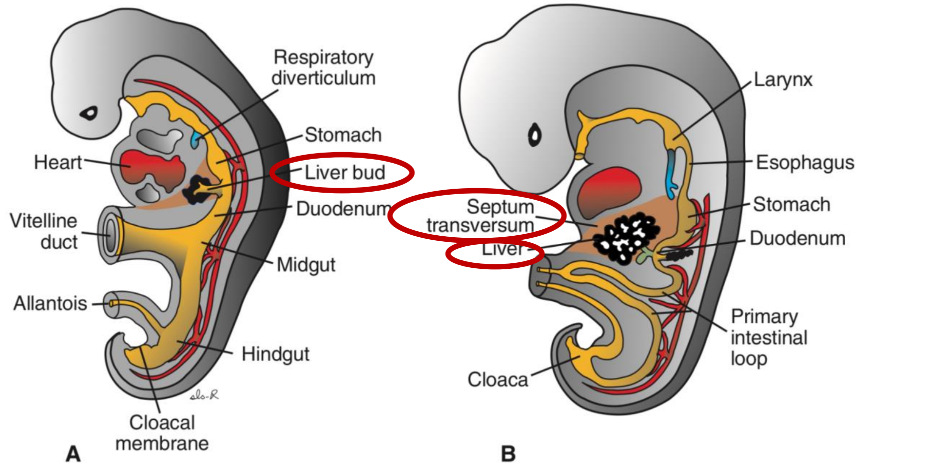


Figure 15.14 **A.** A 3-mm embryo (approximately 25 days) showing the primitive gastrointestinal tract and formation of the liver bud. The bud is formed by endoderm lining the foregut. **B.** A 5-mm embryo (approximately 32 days). Epithelial liver cords penetrate the mesenchyme of the septum transversum.

- During further development, epithelial liver cords intermingle with <u>the vitelline duct and umbilical veins, which form hepatic sinusoids</u>.

- Liver cords differentiate into the **parenchyma (liver cells)** and form the lining of the biliary ducts.

- <u>**Hematopoietic cells, Kupffer cells,** and **connective tissue cells** are derived from mesoderm of the septum transversum</u> (mesenchymal tissue).

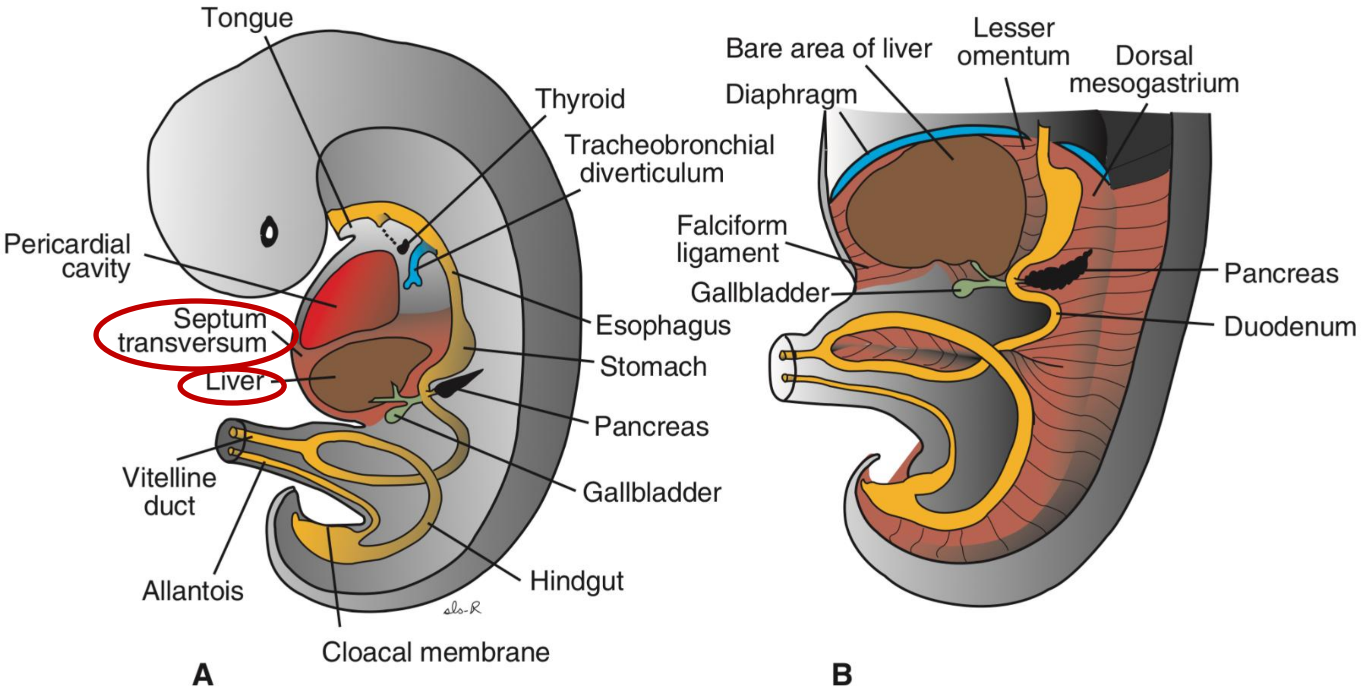


Figure 15.15 A. A 9-mm embryo (approximately 36 days). The liver expands caudally into the abdominal cavity. Note condensation of mesenchyme in the area between the liver and the pericardial cavity, foreshadowing formation of the diaphragm from part of the septum transversum. **B.** A slightly older embryo. Note the falciform ligament extending between the liver and the anterior abdominal wall and the lesser omentum extending between the liver and the foregut (stomach and duodenum). The liver is entirely surrounded by peritoneum except in its contact area with the diaphragm. This is the bare area of the liver.

- <u>The **lesser omentum** and **falciform ligament** form from the ventral mesogastrium</u>, <u>which itself is derived from mesoderm of the septum transversum.</u>

- When liver cords grow into the septum, it thins to form:

(a) the peritoneum of the liver,

(b) the **<u>falciform ligament,</u>** <u>extending from the liver to the ventral body wall</u>, and

(c) the **<u>lesser omentum,</u>** <u>extending from the stomach and upper duodenum to the liver.</u>

The septum transversum is a mass of mesenchyme present in the chest region of the embryo. It plays a role in the development of the diaphragm and heart. <u>It also forms the ventral mesentery</u> which <u>forms all the ligaments that connect the liver to its surrounding structures except for the round round ligament of the liver (ligamentum teres forms due to the obliteration of the right umbilical vein)</u>.

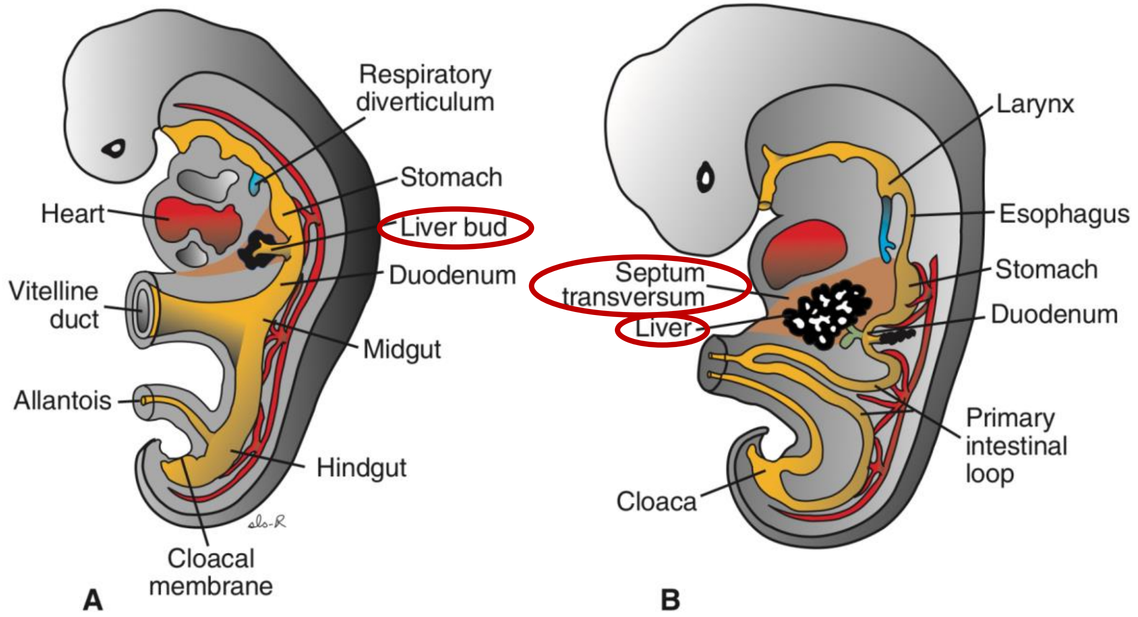


Figure 15.14 **A.** A 3-mm embryo (approximately 25 days) showing the primitive gastrointestinal tract and formation of the liver bud. The bud is formed by endoderm lining the foregut. **B.** A 5-mm embryo (approximately 32 days). Epithelial liver cords penetrate the mesenchyme of the septum transversum.

Liver and Gallbladder Abnormalities

- Variations in liver lobulation are common but not clinically significant, **Accessory hepatic ducts** and **duplication of the gallbladder** are also common and usually asymptomatic

- However, they become clinically important under pathological conditions. In some cases the ducts, which pass through a solid phase in their development, fail to recanalize

- This defect, **extrahepatic biliary atresia,** occurs in 1/15,000 live births.

- Patients with extrahepatic biliary atresia, 15 to 20% have patent proximal ducts and a correctable defect, but the remainder usually die unless they receive a liver transplant

Distended hepatic duct due to obliteration of the common bile duct

Double gallbladder with one cystic duct

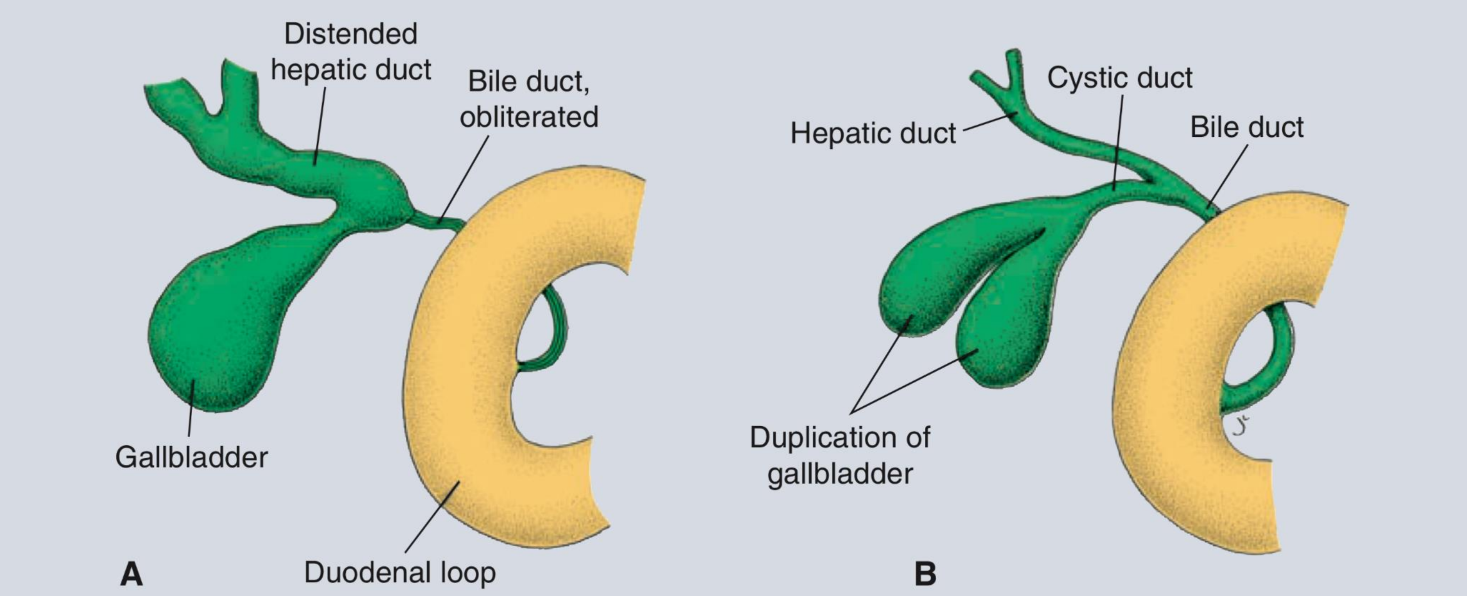


Figure 15.22 A. Obliteration of the bile duct resulting in distention of the gallbladder and the hepatic ducts distal to the obliteration. **B.** Duplication of the gallbladder.

Surgical interventions are only required if there are complications associated with the abnormality, such as obstruction or decrease of the flow of bile.
If everything is functioning normally, nothing should be done regarding these cases.

- Another problem with duct formation lies within the liver itself; it is **intrahepatic biliary duct atresia** and **hypoplasia**
- This rare abnormality (1/100,000 live births) may be caused by fetal infections.
- It may be lethal but usually runs an extended benign course.

DUODENUM

- The terminal part of the foregut and the cephalic part of the midgut form the Duodenum.
- The junction of the two parts is directly distal to the origin of the liver bud.
- The cephalic/upper portion of the duodenum is part of the foregut and gets its blood supply from the celiac trunk.
- The lower portion is part of the midgut and receives branches from the superior mesenteric artery.

- The duodenum is originally vertical, but as the stomach rotates 90° clockwise, it causes the duodenum to take on the form of a C-shaped loop (its concavity is directed backwards and to the left) and to rotate to the right.

- This rotation, together with rapid growth of the head of the pancreas, swings the duodenum from its initial midline position to the right side of the abdominal cavity.

- As as result of their rotation, the duodenum and head of the pancreas press against the dorsal body wall, and the right surface of the dorsal mesoduodenum fuses with the adjacent peritoneum.

- Both layers subsequently disappear, and the duodenum and head of the pancreas become fixed in a **retroperitoneal position.**

- The entire pancreas thus obtains a retroperitoneal position.

- The dorsal (posterior) mesoduodenum disappears entirely except in the region of the pylorus of the stomach, where a small portion of the duodenum (**duodenal cap** / the first inch of the duodenum) retains its mesentery and remains intraperitoneal.

As the duodenum and pancreas rotate towards the right side, the layer of dorsal mesentery covering their right side will face the posterior abdominal wall and will keep getting closer to it until they come in contact.

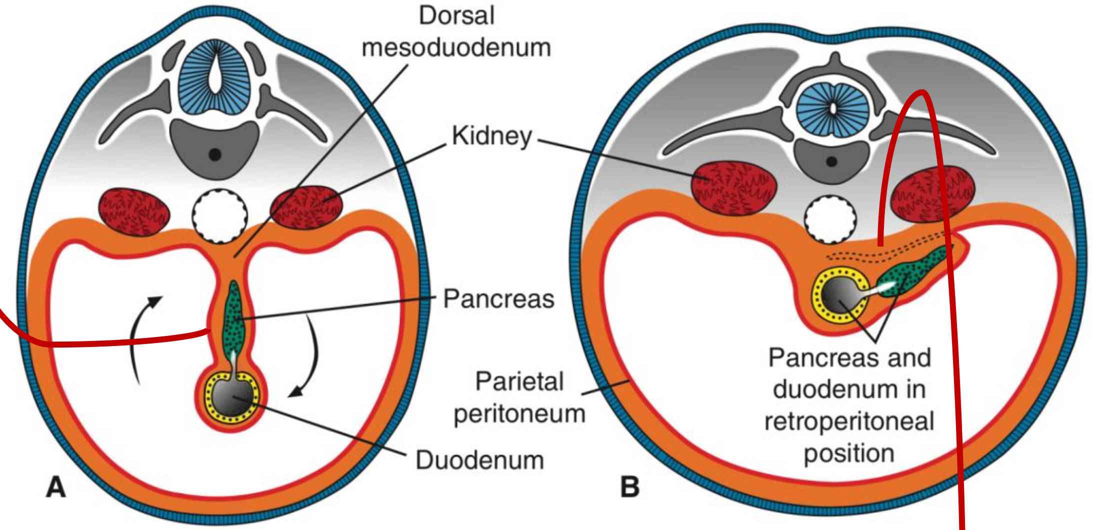


Figure 15.17 Transverse sections through the region of the duodenum at various stages of development. At first, the duodenum and head of the pancreas are located in the median plane. **A**, but later, they swing to the right and acquire a retroperitoneal position. **B**.

Due to this contact, the layer of mesentery covering the right side of the duodenum and pancreas (afterwards it becomes posterior to them) will fuse with the parietal peritoneum of the posterior abdominal wall, and both layers will disappear. This leaves them to be covered by peritoneum only anteriorly deeming them as retroperitoneal.

- During the second month, the lumen of the duodenum is obliterated by proliferation of cells in its walls producing a solid structure.

- However, the lumen of the duodenum is recanalized by invagination shortly thereafter in order to create one connected cavity/lumen.

- Since the **foregut** is supplied by the **celiac artery** and the midgut is supplied by the **superior mesenteric artery,** the duodenum is supplied by branches of both arteries.

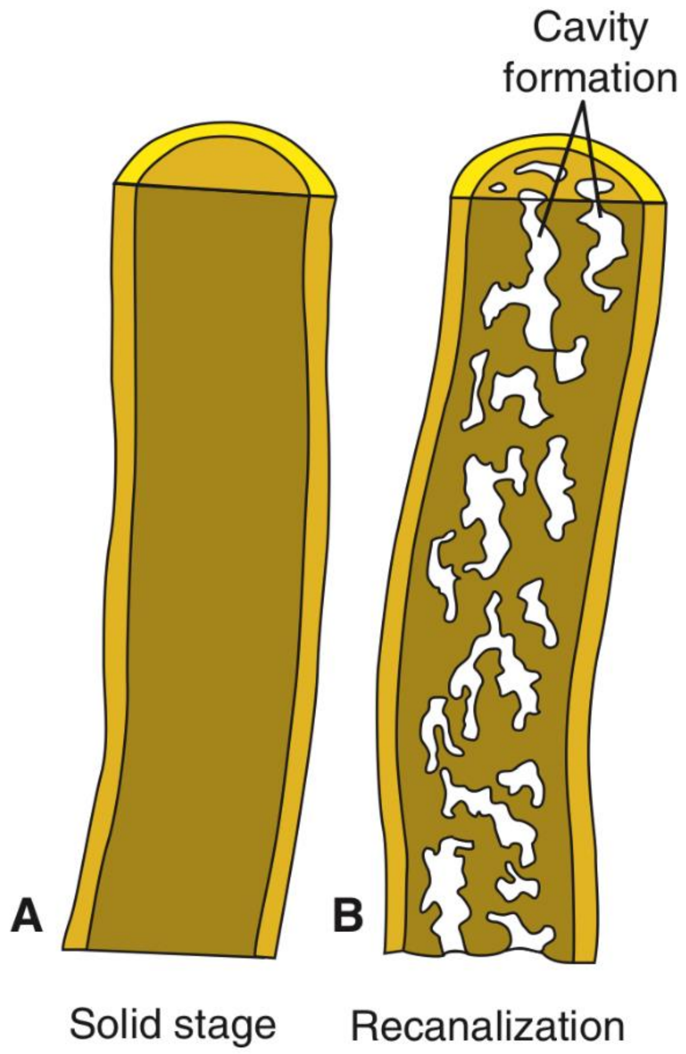


Figure 15.18 Upper portion of the duodenum showing the solid stage. **A** and cavity formation. **B** produced by recanalization.

PANCREAS

- The pancreas is formed by two buds originating from the endodermal lining of the second part of the duodenum.

- Whereas the **dorsal pancreatic bud** is in the dorsal mesentery close to the left side of the duodenum, the **ventral pancreatic bud** is close to the bile duct near the duodenum's right side.

- When the duodenum rotates to the right and becomes C-shaped, the ventral pancreatic bud moves dorsally in a manner similar to the shifting of the entrance of the bile duct while the dorsal bud doesn't move.

- 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.

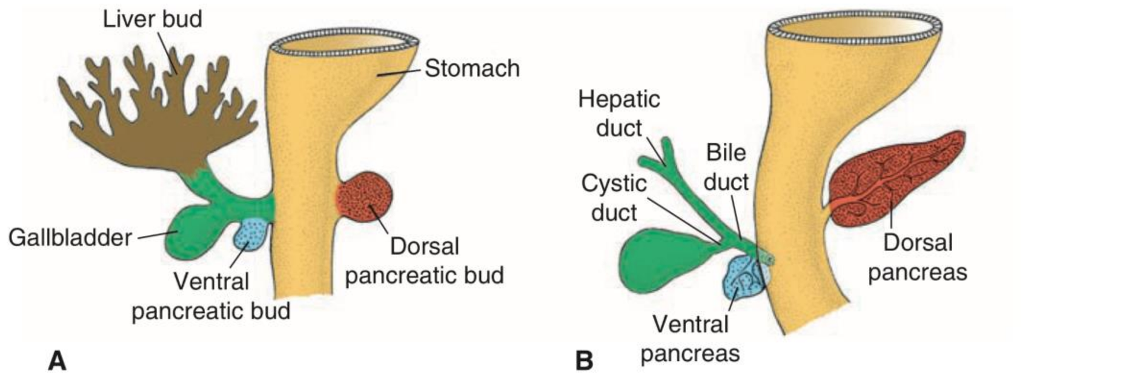


Figure 15.19 Stages in development of the pancreas. **A.** 30 days (approximately 5 mm). **B.** 35 days (approximately 7 mm). Initially, the ventral pancreatic bud lies close to the liver bud, but later, it moves posteriorly around the duodenum toward the dorsal pancreatic bud.

- The ventral bud forms the **uncinate process** and inferior part of the head of the pancreas.

- The remaining part of the gland is derived from the dorsal bud.

- The **main pancreatic duct** (of **Wirsung**) is formed by the distal part of the dorsal pancreatic duct and the entire ventral pancreatic duct.

- The proximal part of the dorsal pancreatic duct either is obliterated or persists as a small channel, the **accessory pancreatic duct** (of **Santorini**).

- In the third month of fetal life, **pancreatic islets** (of **Langerhans**) which are the endocrine portions of the pancreas, develop from the parenchymatous pancreatic tissue and scatter throughout the pancreas.

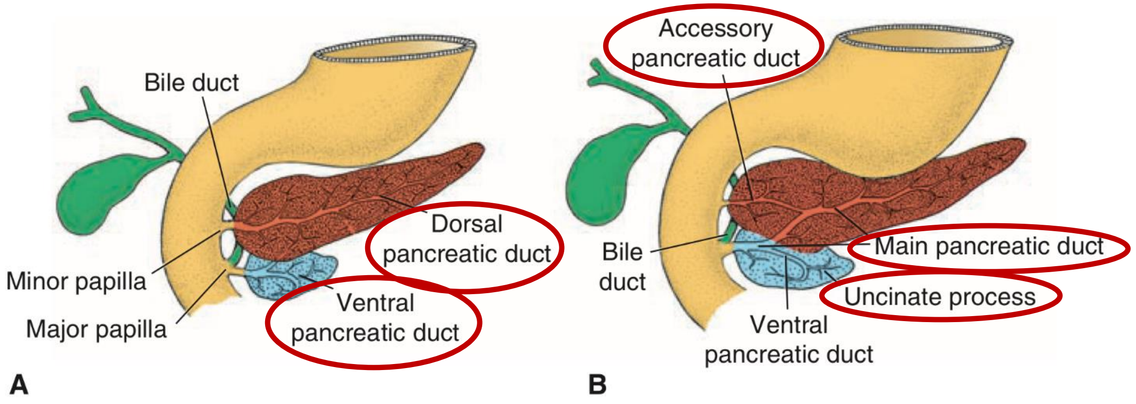


Figure 15.20 A. Pancreas during the sixth week of development. The ventral pancreatic bud is in close contact with the dorsal pancreatic bud. **B.** Fusion of the pancreatic ducts. The main pancreatic duct enters the duodenum in combination with the bile duct at the major papilla. The accessory pancreatic duct (when present) enters the duodenum at the minor papilla.

- **Insulin secretion** begins at approximately the fifth month.
- Glucagon -and somatostatin- secreting cells also develop from parenchymal cells.
- Splanchnic mesoderm surrounding the pancreatic buds forms the pancreatic connective tissue

Pancreatic Abnormalities

- The ventral pancreatic bud consists of two components that normally fuse and rotate around the duodenum so that they come to lie below the dorsal pancreatic bud.

- Occasionally, however, the right portion of the ventral bud migrates along its normal route, but the left migrates in the opposite direction.

- In this manner, <u>the duodenum is surrounded by pancreatic tissue, and an **annular pancreas** is formed.</u>

- <u>The malformation sometimes constricts the duodenum and causes complete obstruction.</u>

The most common type of pancreatic abnormality is the formation of an <u>annular pancreas</u>. In this condition, a <u>part of the ventral pancreas</u> doesn't go underneath the dorsal pancreas as it normally should.
Instead, it <u>surrounds the duodenum and results in its obstruction</u>.

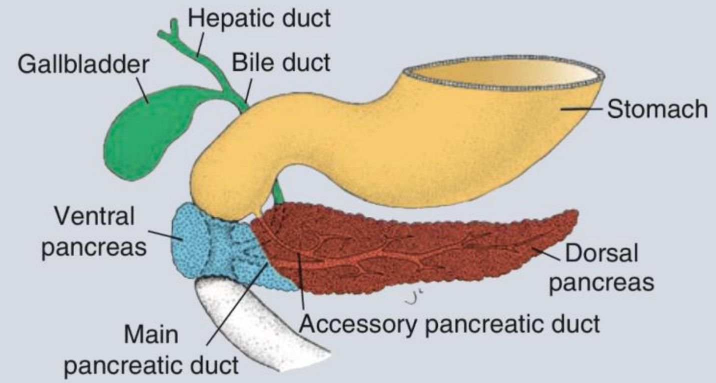


Figure 15.23 Annular pancreas. The ventral pancreas splits and forms a ring around the duodenum, occasionally resulting in duodenal stenosis.

- **Accessory or ectopic pancreatic tissue** may be anywhere from the distal end of the esophagus to the tip of the primary intestinal loop.
- If the pancreatic tissue is present in any location other than the pancreas itself, it is termed ectopic tissue.

- Most frequently it lies in the mucosa of the stomach and in Meckel's diverticulum, where it may show all of the histological characteristics of the pancreas itself.

Past paper questions about this lecture:

1. A neonate baby was born with diabetes mellitus due to an inadequate production of insulin. Which one of the following is the origin of the cells of pancreas, which produce the insulin?

A) Endoderm. B) Mesoderm. C) Septum transversum. D) Ectoderm. E) Proctodeum.

2. Ventral mesogastrium gives off the origin of all of the following except:

A) Hepatogastric ligament. B) Coronary ligaments. C) Falciform ligament. D) Round ligament of the liver. E) Triangular ligament.

3. Not True about the embryogenesis of the stomach:

A) 90 ante-clockwise rotation of the stomach around the anteroposterior axis.
B) 90 clockwise rotation of the stomach around the longitudinal axis.
C) Left vagus nerve will innervate the anterior wall while the right vagus nerve innervates the posterior wall.
D) The cardiac and the pyloric ends will take their final position by the rotation around the anteroposterior axis.

4. All of the following happen during the rotation of the stomach except:

A) the right part becomes posterior.
B) the ventral mesogastrium gives omental bursa.
C) the posterior surface grows to be the greater curvature.
D) The left vagus supplies the anterior part.
E) the proximal and distal ends come approximate to each other

Past paper questions about this lecture:

5. The dorsal pancreatic bud forms all the following parts of the pancreas EXCEPT:

A) Uncinate process of the pancreas. B) Superior part of the head. C) Neck. D) Body. E) Tail.

6. Six-week-old infant projectile vomiting, constipation, and weight loss. Which of the following can produce these symptoms?

A) pyloric stenosis.
B) duodenal stenosis
C) anal stenosis
D) esophageal stenosis
E) any of the above can cause those symptoms

7. The liver develops from all of the following EXCEPT:

A) endoderm of the gut.
B) umbilical vein sinuses.
C) cardinal sinuses.
D) vitelline venous sinuses.
E) septum transversum.

Past paper questions about this lecture:

8. All of the followings are results of development and rotation of the stomach EXCEPT:
A) Formation of lesser Sac.
B) The stomach appears as a fusiform dilatation with an upper and lower opening at the third week of development.
C) Change in the position of pylorus and cardia.
D) The left vagus becomes anterior to the stomach.
E) Active and rapid growth along the left border of the stomach forming the convex greater curvature of the stomach.

9. Concerning the development of the abdominal wall and peritoneum, choose the unsuitable combination:
A) Abdominal wall → Ectoderm + somatic mesoderm.
B) Linea alba → Fusion of right and left mesenchyme in midline.
C) Peritoneal cavity → Intraembryonic coelom.
D) Visceral peritoneum → Splanchnic mesenchyme.
E) Ventral mesentery → All ligaments of the liver.

10. Main pancreatic duct is formed by: Answer: All ventral and distal dorsal pancreatic buds

1	2	3	4	5	6	7	8	9
A	D	A	B	A	A	C	B	E


اللهم كن لأهل
فلسطين نصـيـرًا وظهـيرًا
اللهم ارحم شهداءهم، وداوِ
جرحاهم، واحقن دماءهم