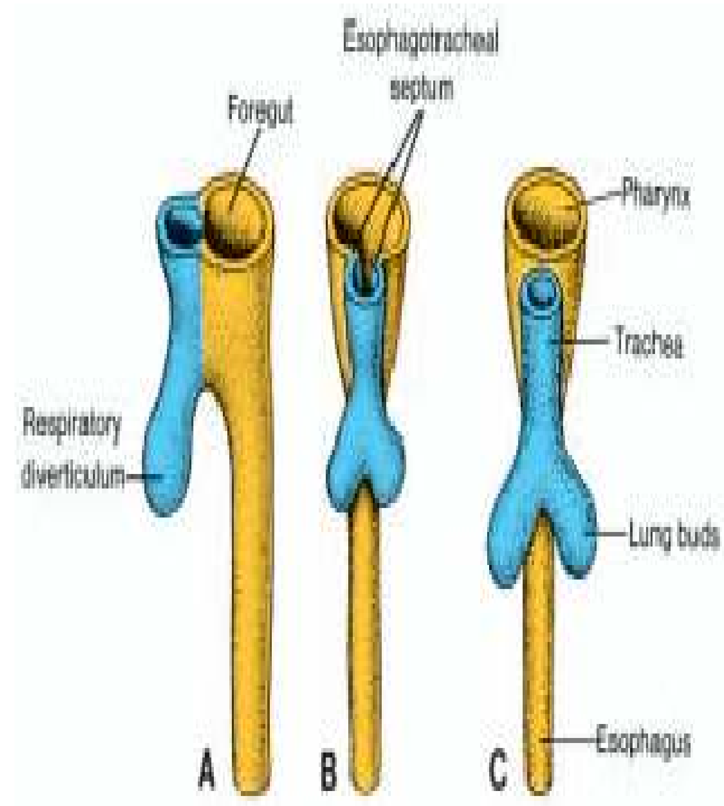
GI embryology 2

The Foregut

- 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.



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

- 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**).

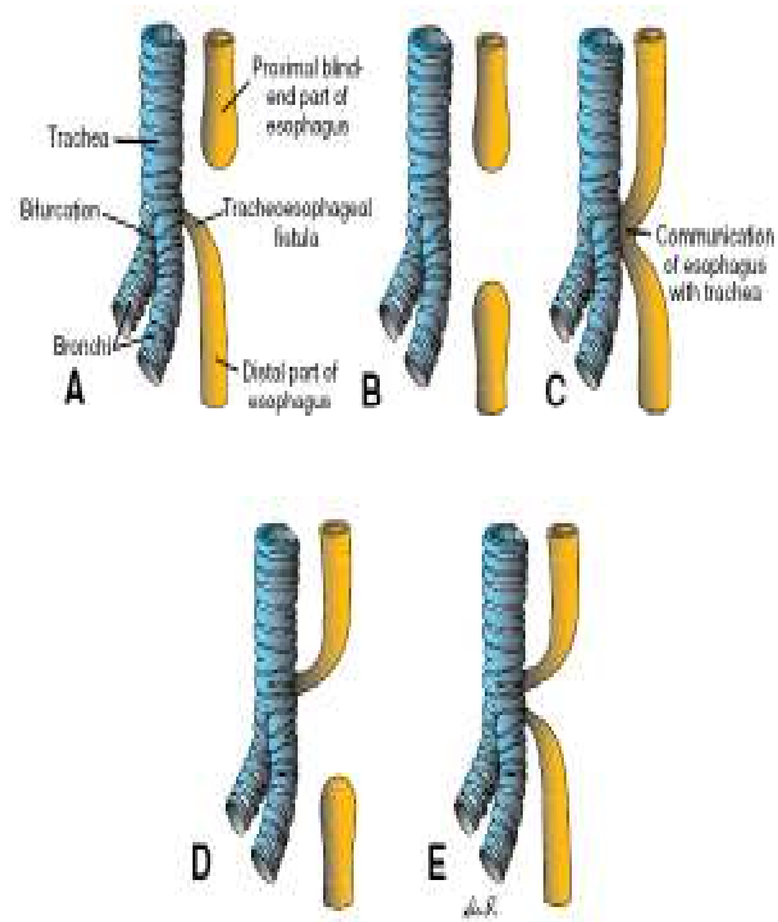
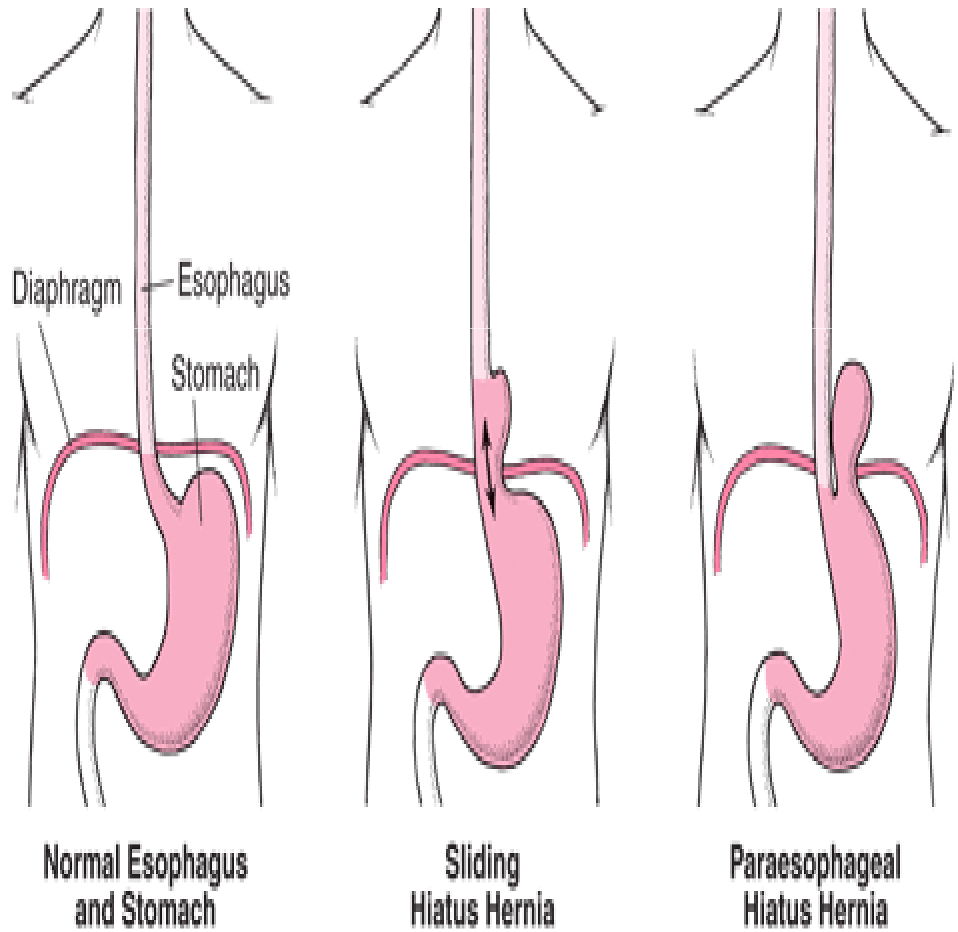


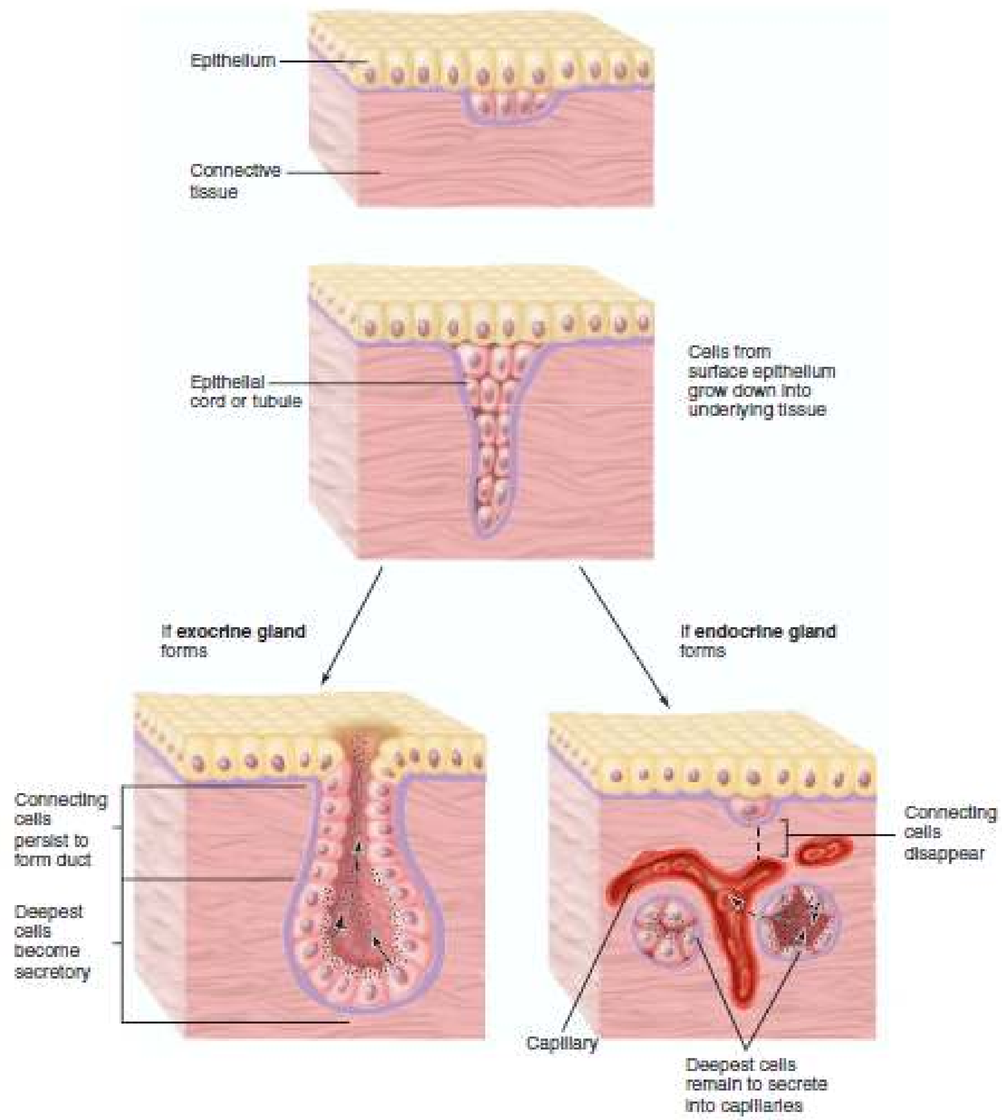
Figure 13.7 Variations of esophageal atresia and/or tracheoesophageal fistula in order of their frequency of appearance: **A**, 90%; **B**, 4%; **C**, 4%; **D**, 1%; and **E**, 1%.

- 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
- Occasionally the esophagus fails to lengthen sufficiently and the stomach is pulled up into the esophageal hiatus through the diaphragm.
- The result is a **congenital hiatal hernia**



Development of the glands

- Most glands are formed during development by proliferation of epithelial cells so that they project into the underlying connective tissue
- Some glands retain their continuity with the surface via a duct and are known as **EXOCRINE GLANDS, as they maintain contact with the surface**
- Other glands lose this direct continuity with the surface when their ducts degenerate during development. These glands are known as **ENDOCRINE** glands, and they lose contact with the surface.
- Endocrine glands are either arranged in cords or follicles



STOMACH

- The stomach appears as a fusiform dilation of the foregut in the fourth week of development
- 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

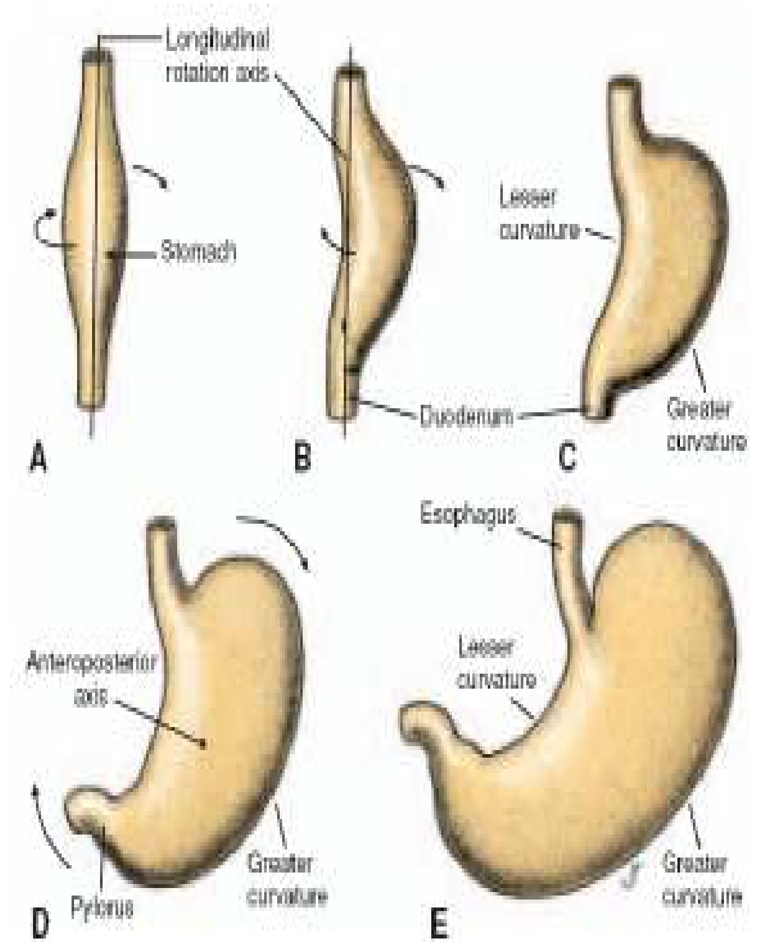


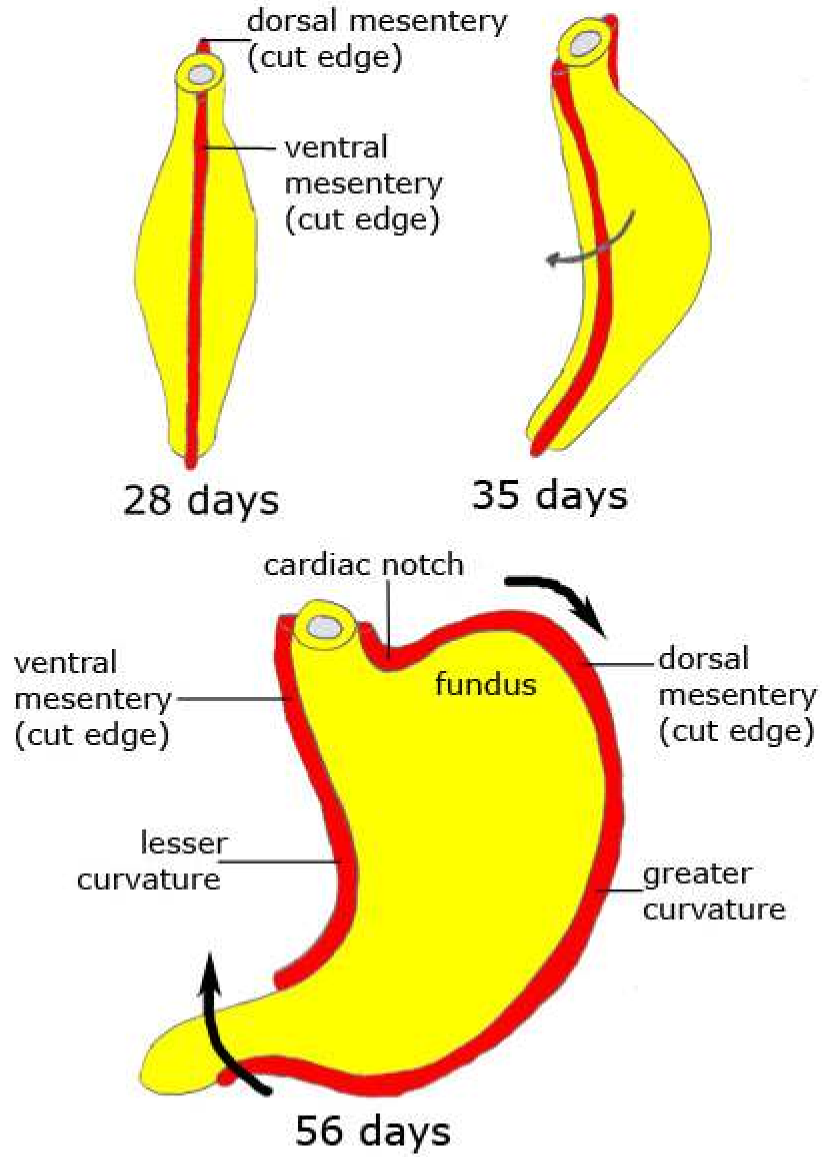
Figure 13.8 A, B, and C. Rotation of the stomach along its longitudinal axis as seen anteriorly. **D and E.** Rotation of the stomach around the anteroposterior axis. Note the change in position of the pylorus and cardia.

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

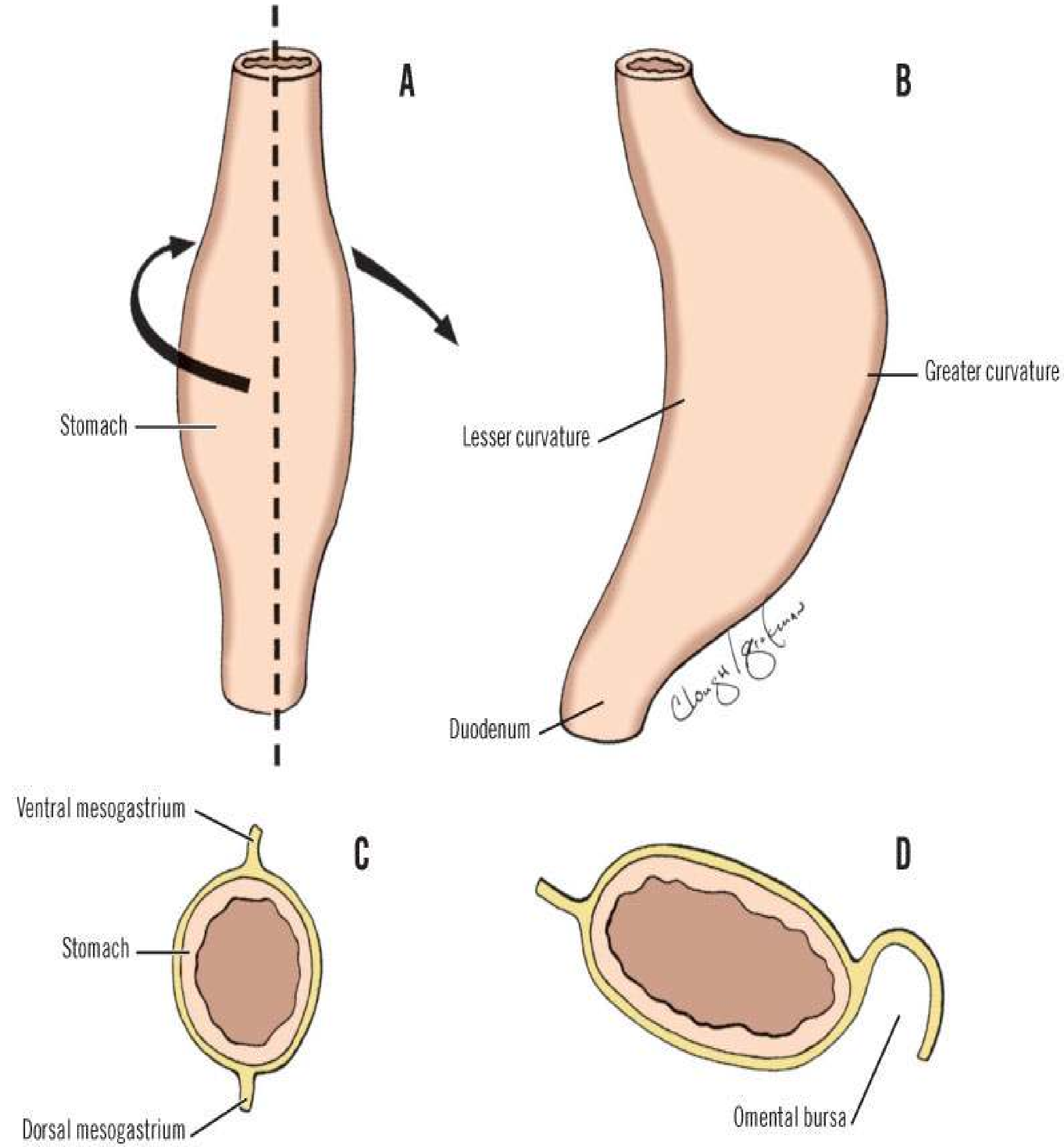
- Hence the left vagus nerve, initially innervating the left side of the stomach, now innervates the anterior wall

- 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**



- The cephalic and caudal ends 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.

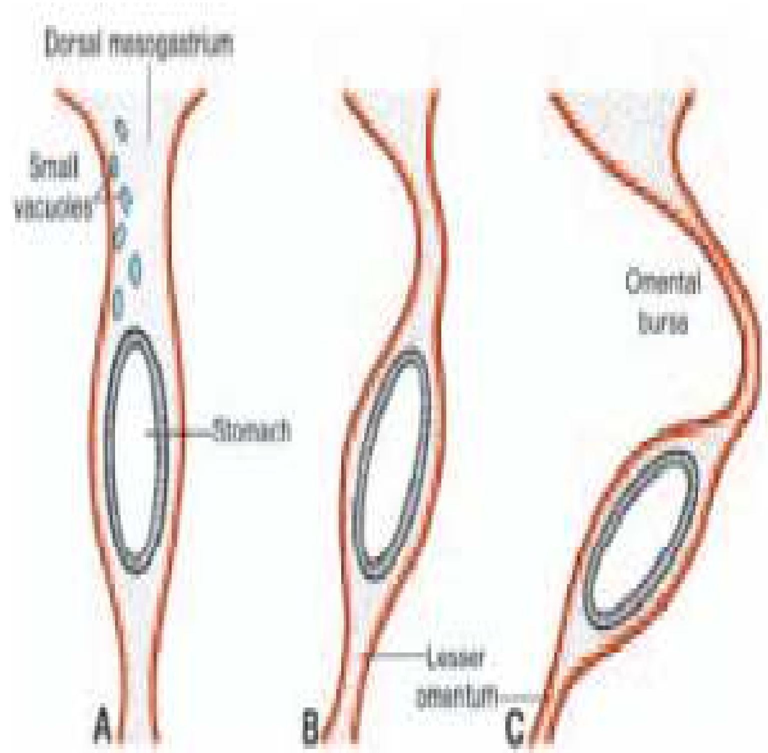
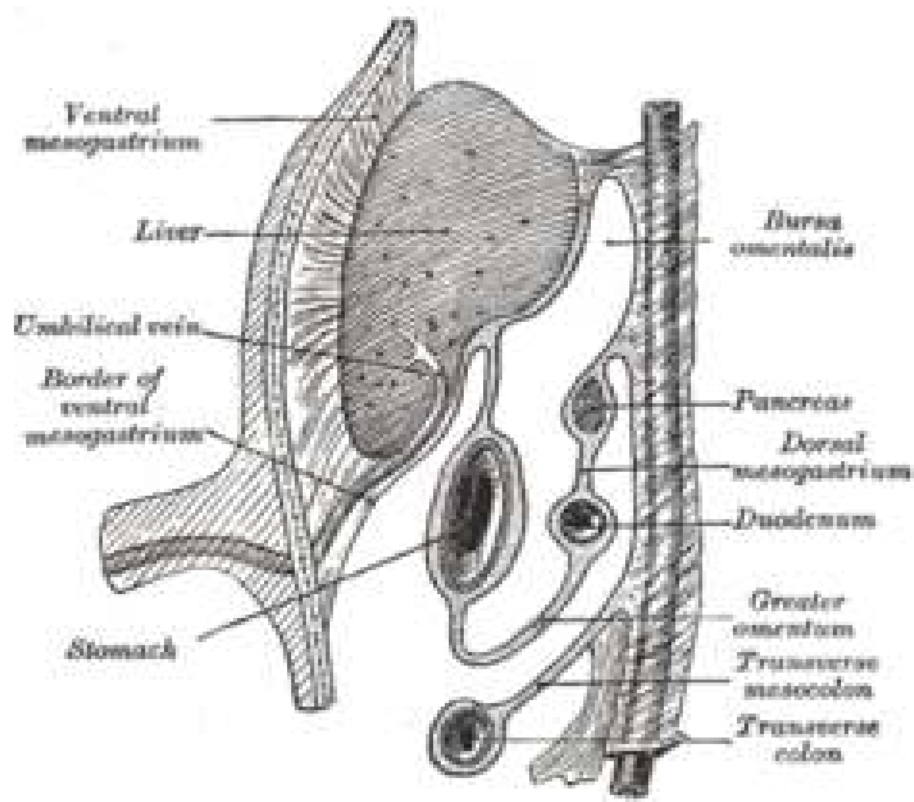


Figure 13.9 A. Transverse section through a 4-week embryo showing intercellular clefts appearing in the dorsal mesogastrium. **B** and **C.** The clefts have fused, and the omental bursa is formed as an extension of the right side of the intraembryonic cavity behind the stomach.

- 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
- 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 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.

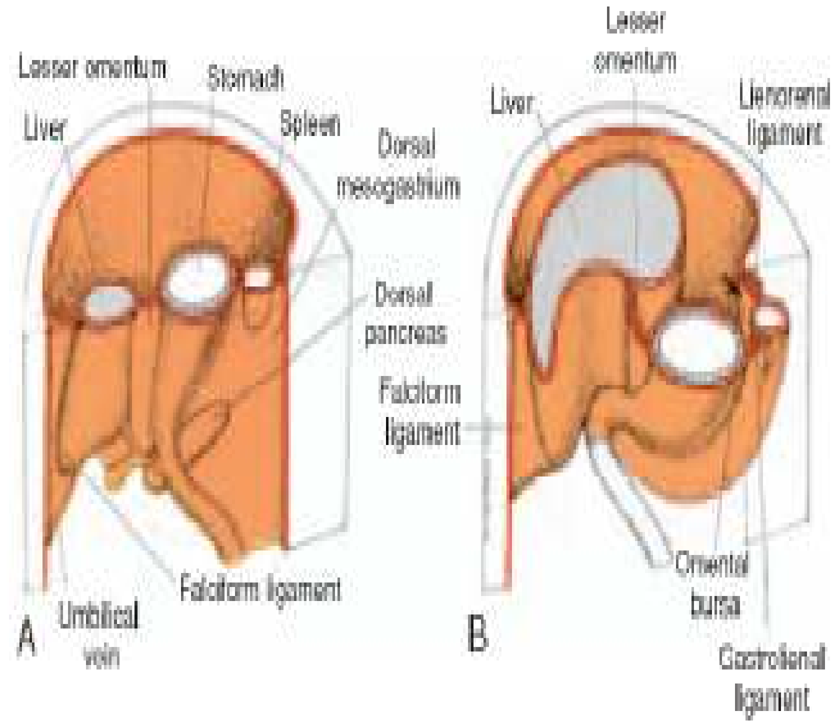
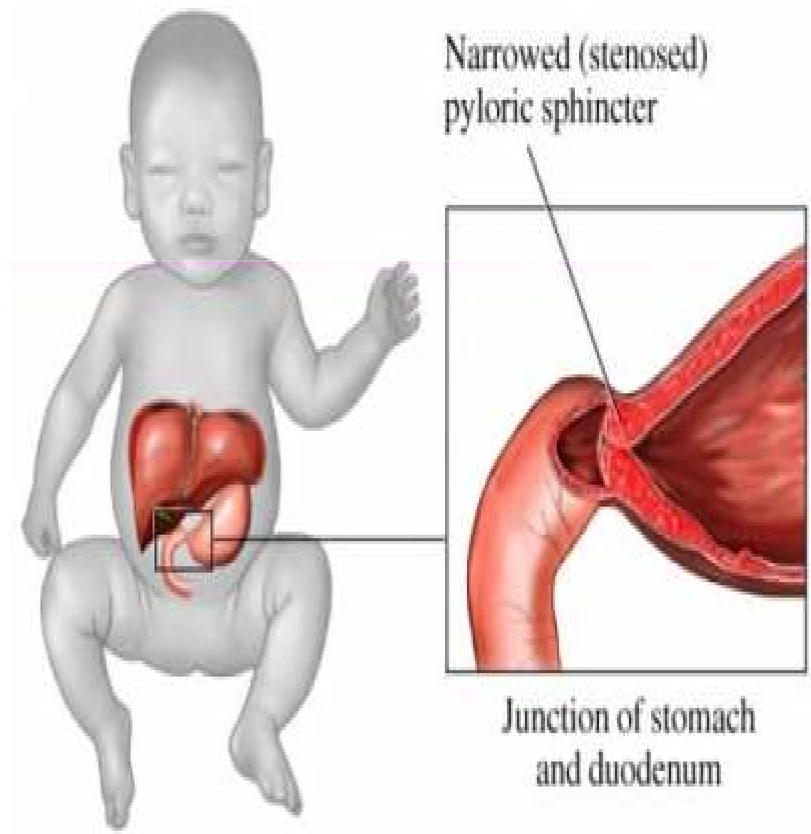


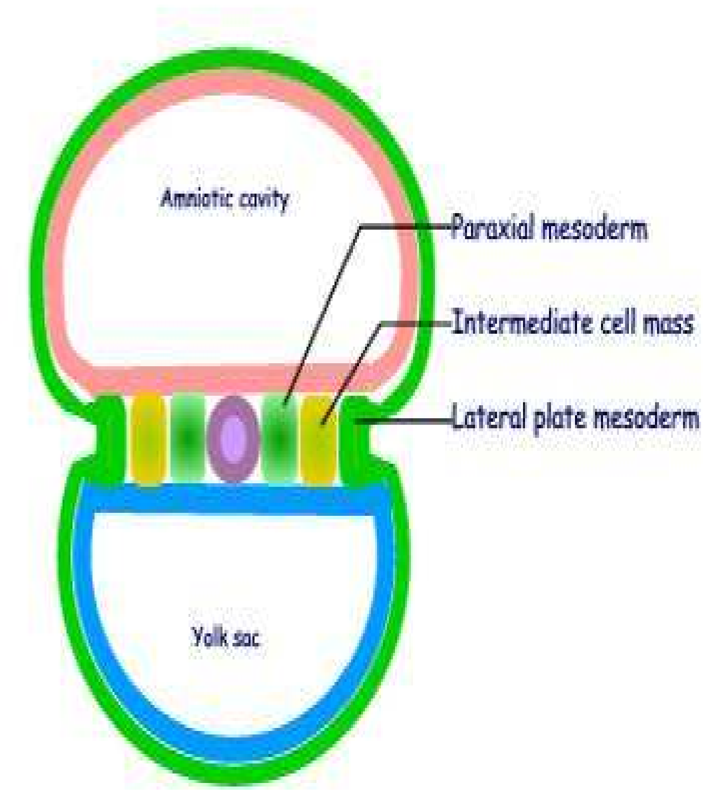
Figure 13.10 A. The positions of the spleen, stomach, and pancreas at the end of the fifth week. Note the position of the spleen and pancreas in the dorsal mesogastrium. **B.** Position of spleen and stomach at the 11th week. Note formation of the omental bursa or lesser peritoneal sac.

- **Pyloric stenosis** occurs when the circular and, to a lesser degree, the longitudinal musculature of the stomach in the region of the pylorus hypertrophies

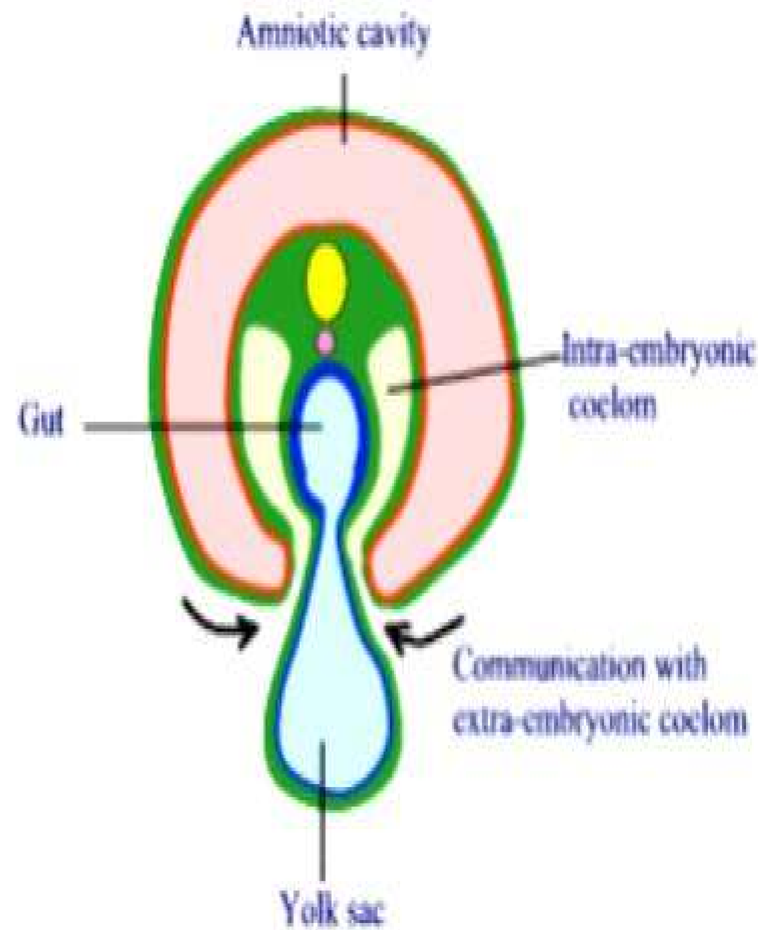
- One of the most common abnormalities of the stomach in infants, pyloric stenosis is believed to develop during fetal life.(3-6) weeks



- At the end of the third week, intraembryonic mesoderm on each side of themidline differentiates into a paraxial portion, an intermediate portion, and a lateral plate
- When intercellular clefts appear in the lateral mesoderm, the plates are divided into two layers: the **somatic mesoderm layer** and the **splanchnic mesoderm layer.**
- The latter is continuous with mesoderm of the wall of the yolk sac



- The space bordered by these layers forms the **intraembryonic cavity (body cavity).**
- **The peritoneal cavity is derived from the intraembryonic coleam caudal to 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



- 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 it forms the **dorsal mesogastrium** or **greater omentum;** in the region of the duodenum it forms the dorsal **mesoduodenum;** and in the region of the colon it forms the **dorsal mesocolon.**

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

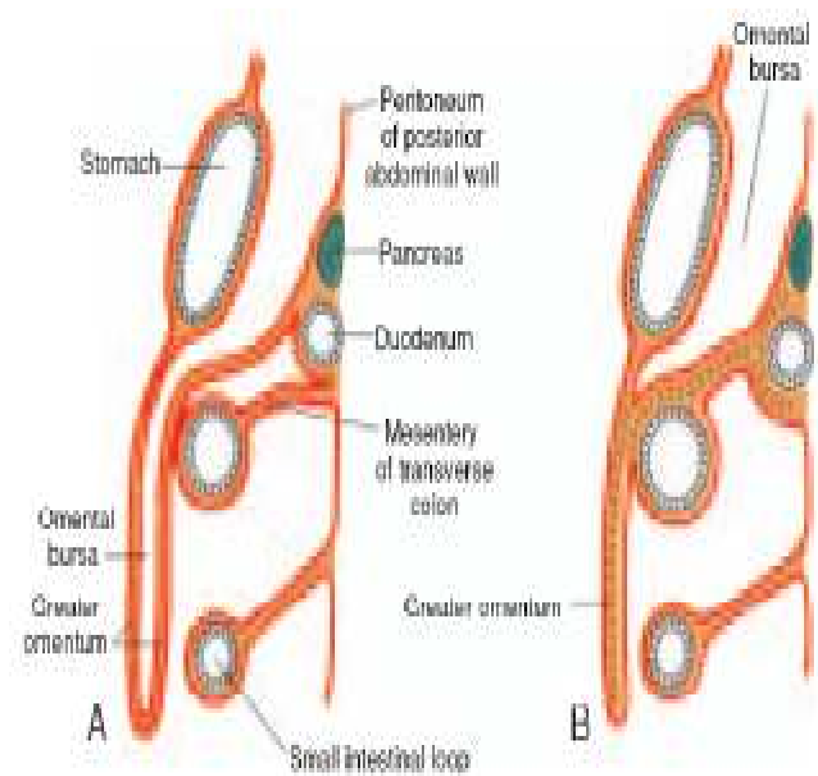
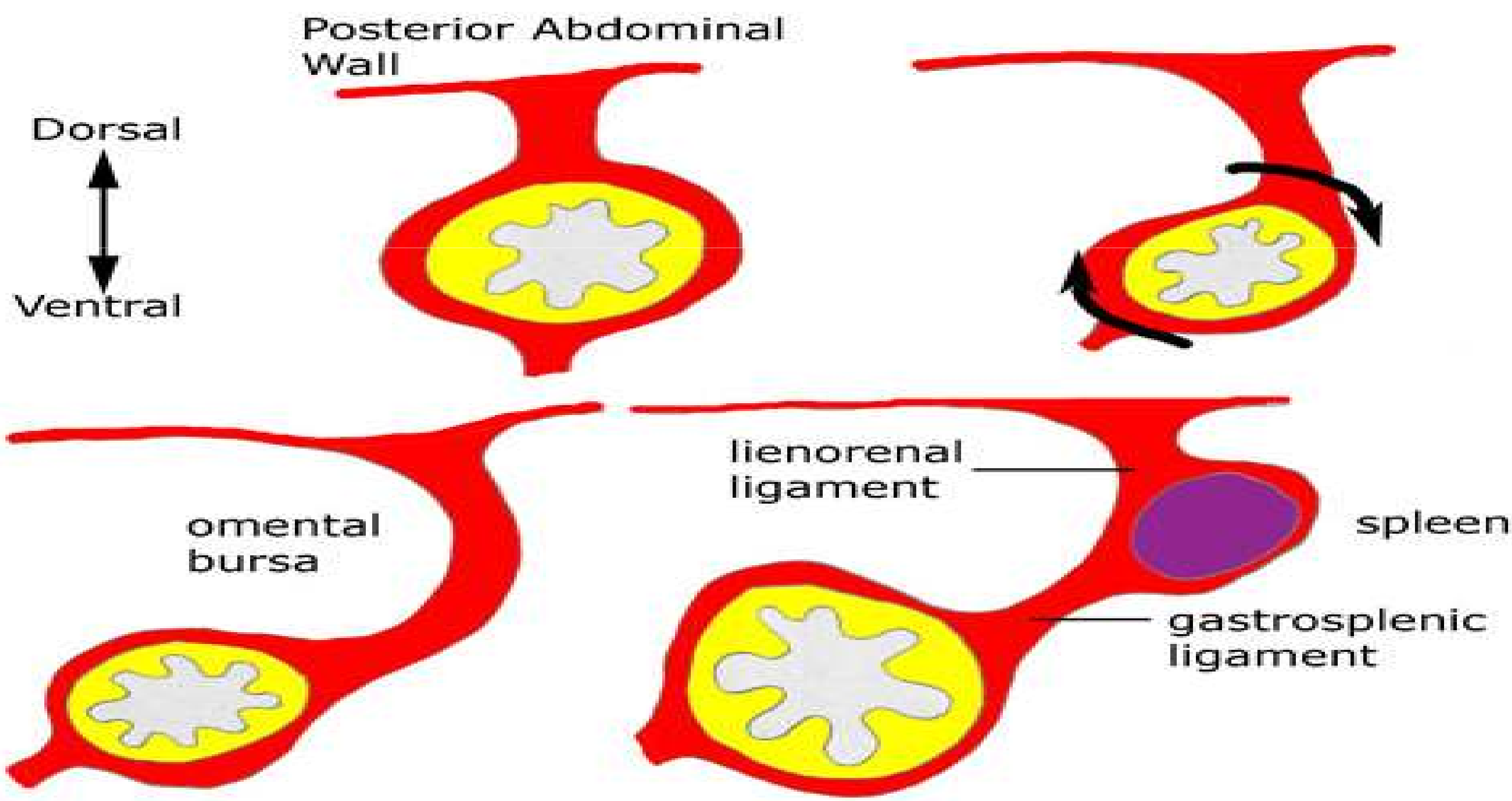
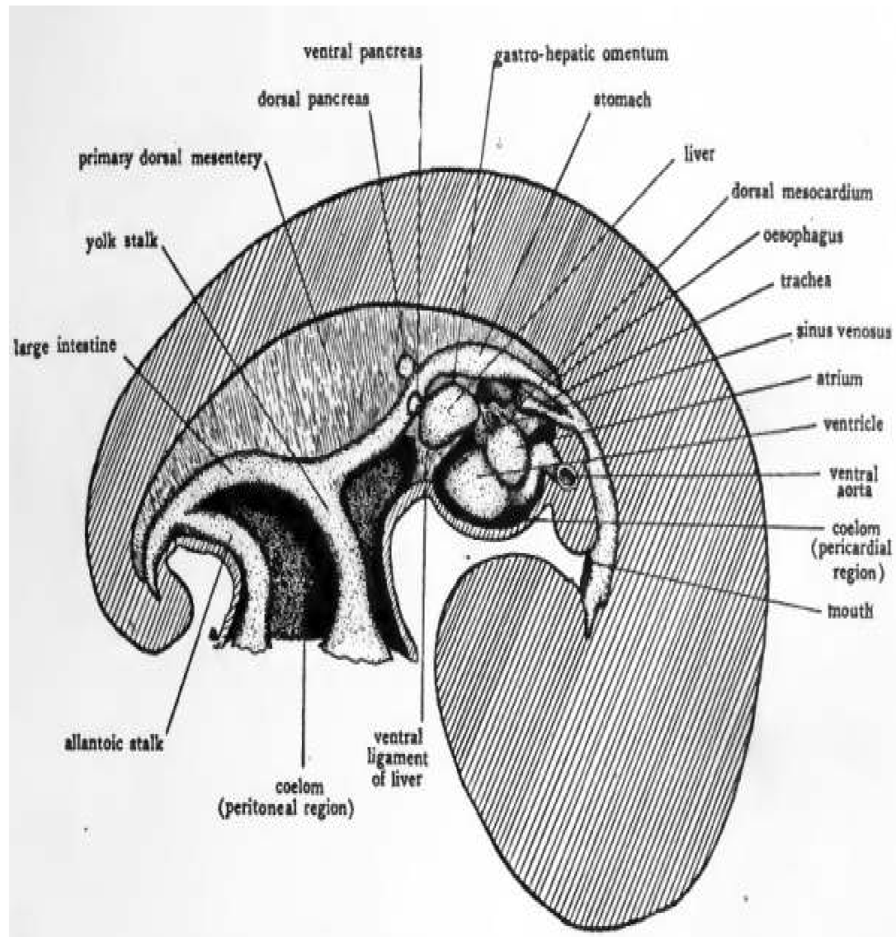


Figure 13.13 A. Sagittal section showing the relation of the greater omentum, stomach, transverse colon, and small intestinal loops at 4 months. The pancreas and duodenum have already acquired a retroperitoneal position. **B.** Similar section as in **A,** in the newborn. The leaves of the greater omentum 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.

Transverse Section Stomach



- **Ventral mesentery,** which exists only in the region of the terminal part of the esophagus, the stomach, and the upper part of the duodenum
- is derived from the **septum transversum.** Growth of the liver into the mesenchyme of the septum transversum divides the ventral mesentery into
- (*a*) the **lesser omentum,** extending from the lower portion of the esophagus, the stomach, and the upper portion of the duodenum to the liver,
- and (*b*) the **falciformligament,** extending from the liver to the ventral body wall,and the coronary and the triangular ligaments



- 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**

- 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 apron is the **greater omentum**

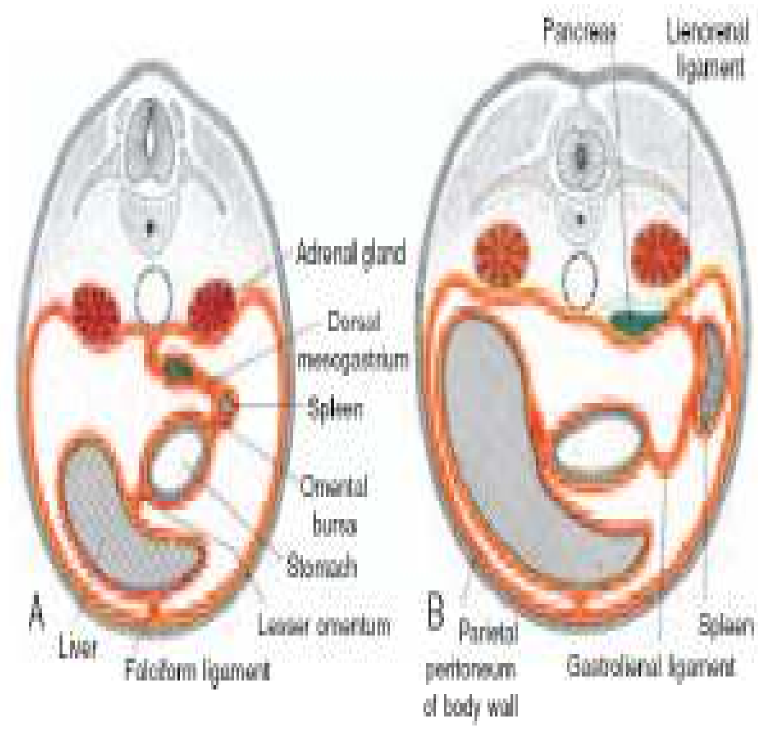


Figure 13.11 Transverse sections through the region of the stomach, liver, and spleen, showing formation of the lesser peritoneal sac, rotation of the stomach, and position of the spleen and tail of the pancreas between the two leaves of the dorsal mesogastrium. With further development, the pancreas assumes a retroperitoneal position.

- 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

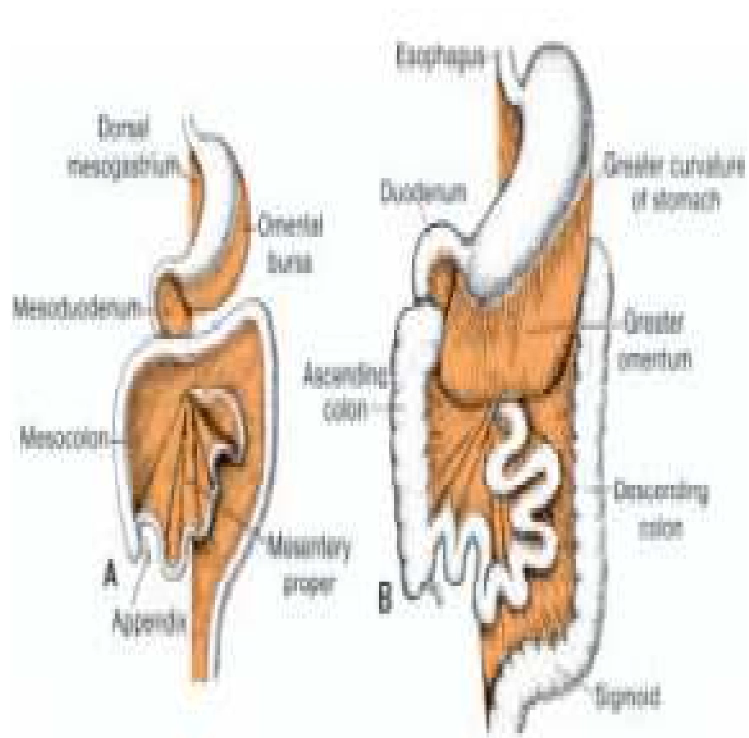


Figure 13.12 A. Derivatives of the dorsal mesentery at the end of the third month. The dorsal mesogastrium bulges out on the left side of the stomach, where it forms part of the border of the omental bursa. **B.** The greater omentum hangs down from the greater curvature of the stomach in front of the transverse colon.

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

- When liver cords grow into the septum, it thins to form (*a*) the peritoneum of the liver, (
- *b*) the **falciform ligament,** extending from the liver to the ventral
- body wall,
- and (*c*) the **lesser omentum,** extending from the stomach and upper duodenum to the liver

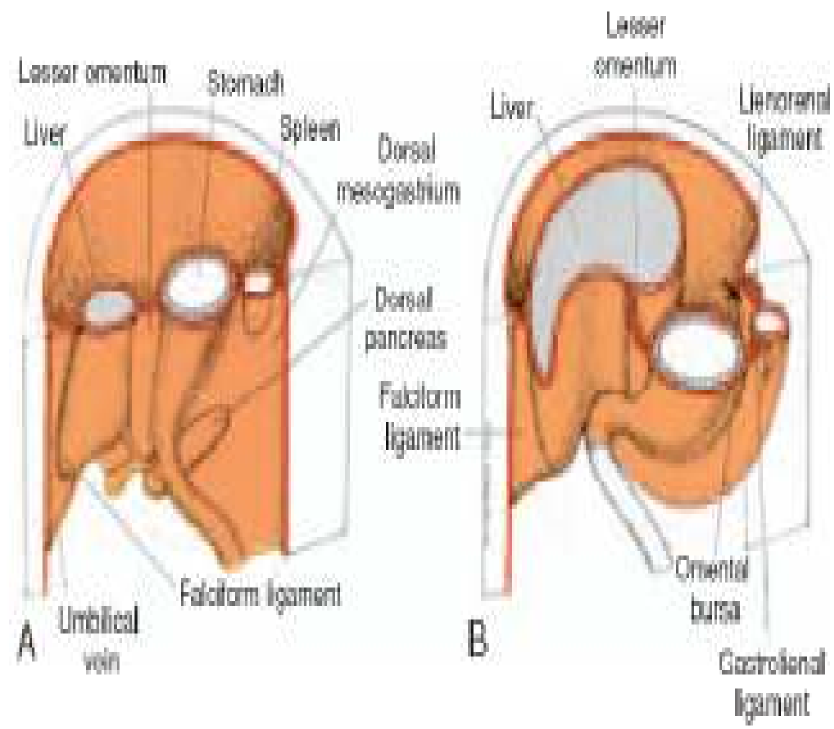


Figure 13.10 A. The positions of the spleen, stomach, and pancreas at the end of the fifth week. Note the position of the spleen and pancreas in the dorsal mesogastrium. **B.** Position of spleen and stomach at the 11th week. Note formation of the omental bursa or lesser peritoneal sac.

- The free margin of the falciform ligament contains the umbilical vein
- which is obliterated after birth to form the **round ligament of the liver** (**ligamentum teres hepatis**).
- 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,** which is the opening connecting the omental bursa (lesser sac) with the rest of the peritoneal cavity (greater sac)

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
- 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
- While hepatic cells continue to penetrate the septum, the connection between the hepatic diverticulum and the foregut (duodenum) narrows, forming the **bile duct**
- A small ventral outgrowth is formed by the bile duct, and this outgrowth gives rise to the **gallbladder** and the **cystic duct**

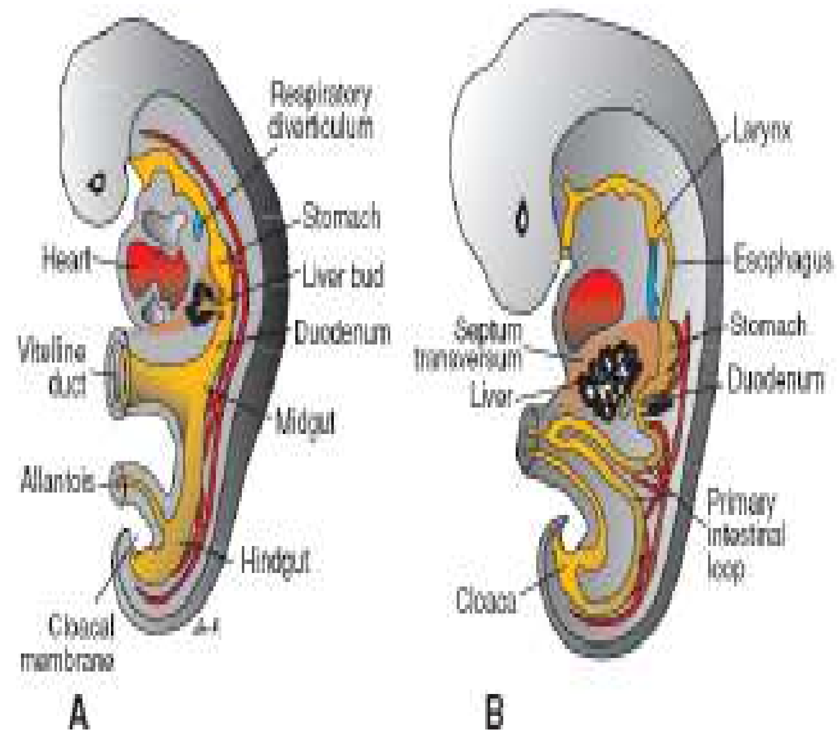


Figure 13.14 A. A 3-mm embryo (approximately 25 days) showing the primitive gastrointestinal tract and formation of the liver bud. The bud is formed by endoderm lining the foregut. **B.** A 5-mm embryo (approximately 32 days). Epithelial liver cords penetrate the mesenchyme of the septum transversum.

- During further development, epithelial liver cords intermingle with the vitelline and umbilical veins, which form hepatic sinusoids

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

- **Hematopoietic cells, Kupffer cells,** and **connective tissue cells** are derived from mesoderm of the septum transversum.

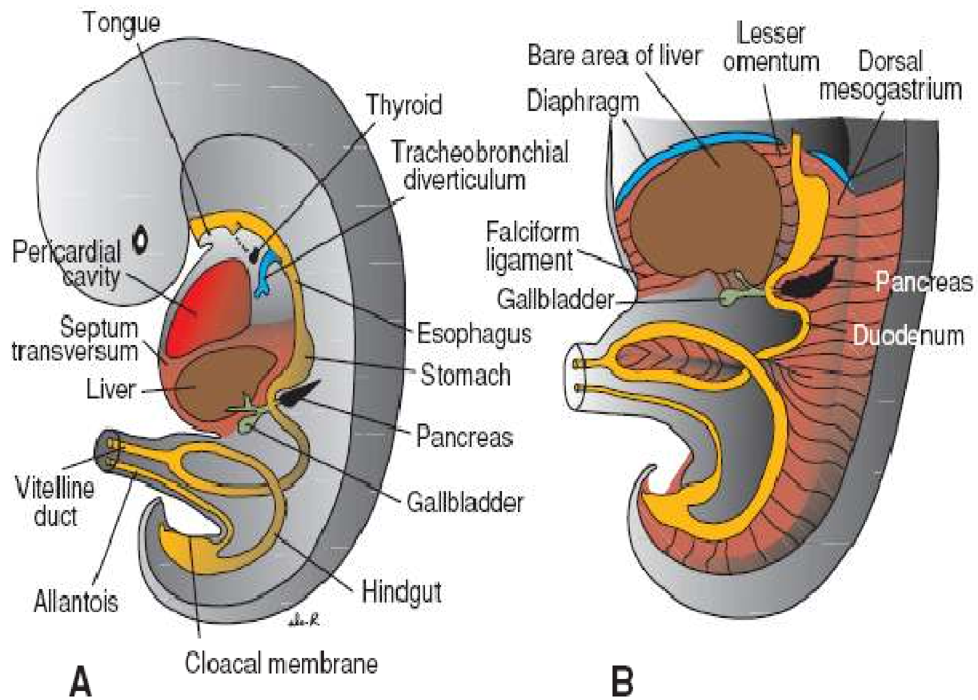


Figure 13.15 A. A 9-mm embryo (approximately 36 days). The liver expands caudally into the abdominal cavity. Note condensation of mesenchyme in the area between the liver and the pericardial cavity, foreshadowing formation of the diaphragm from part of the septum transversum. **B.** A slightly older 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.

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

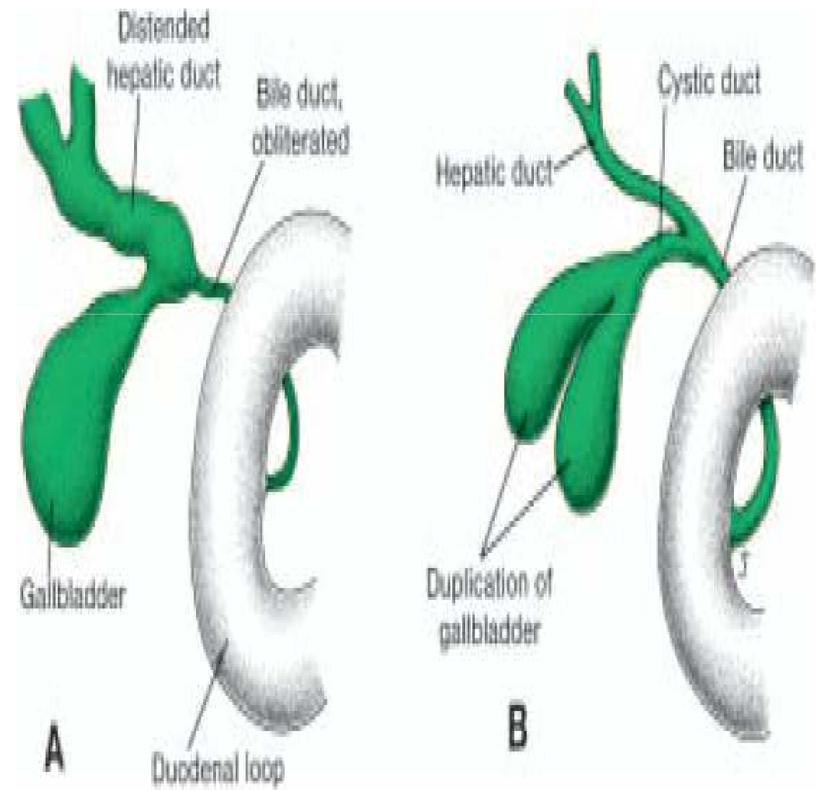


Figure 13.20 A. Obliteration of the bile duct resulting in distention of the gallbladder and hepatic ducts distal to the obliteration. **B.** Duplication of the gallbladder.

- 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
- As the stomach rotates, the duodenum takes on the form of a C-shaped loop and rotates 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 left side of the abdominal cavity

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

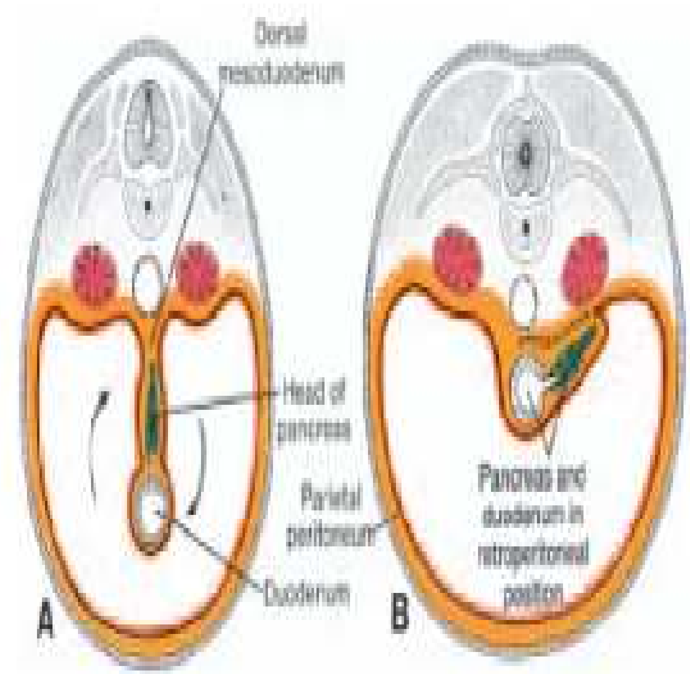


Figure 13.17 Transverse sections through the region of the duodenum at various stages of development. At first the duodenum and head of the pancreas are located in the median plane (**A**), but later they swing to the right and acquire a retroperitoneal position (**B**).

- During the second month, the lumen of the duodenum is obliterated by proliferation of cells in its walls.
- However, the lumen is recanalized shortly thereafter
- 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

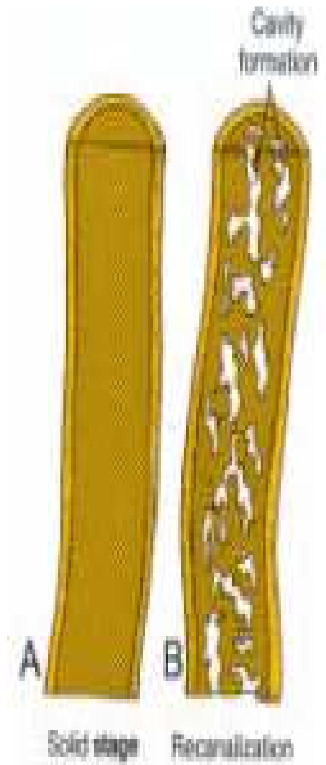


Figure 13.18 Upper portion of the duodenum showing the solid stage (**A**) and cavity formation (**B**) produced by recanalization.

PANCREAS

- The pancreas is formed by two buds originating from the endodermal lining of the duodenum
- Whereas the **dorsal pancreatic bud** is in the dorsal mesentery, the **ventral pancreatic bud** is close to the bile duct
- When the duodenum rotates to the right and becomes C-shaped, the ventral pancreatic budmoves dorsally in a manner similar 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

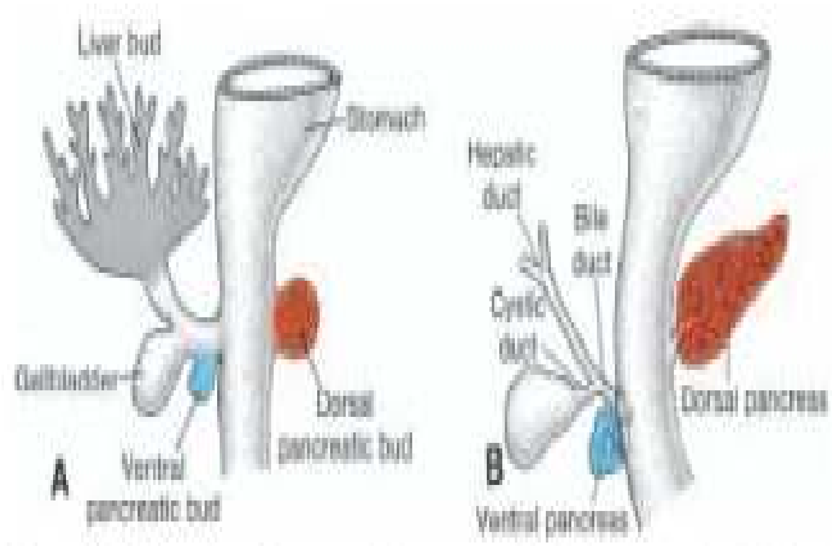


Figure 13.21 Stages in development of the pancreas. **A.** 30 days (approximately 5 mm). **B.** 35 days (approximately 7 mm). Initially the ventral pancreatic bud lies close to the liver bud, but later it moves posteriorly around the duodenum toward the dorsal pancreatic bud.

- 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**) develop from the parenchymatous pancreatic tissue and scatter throughout the pancreas

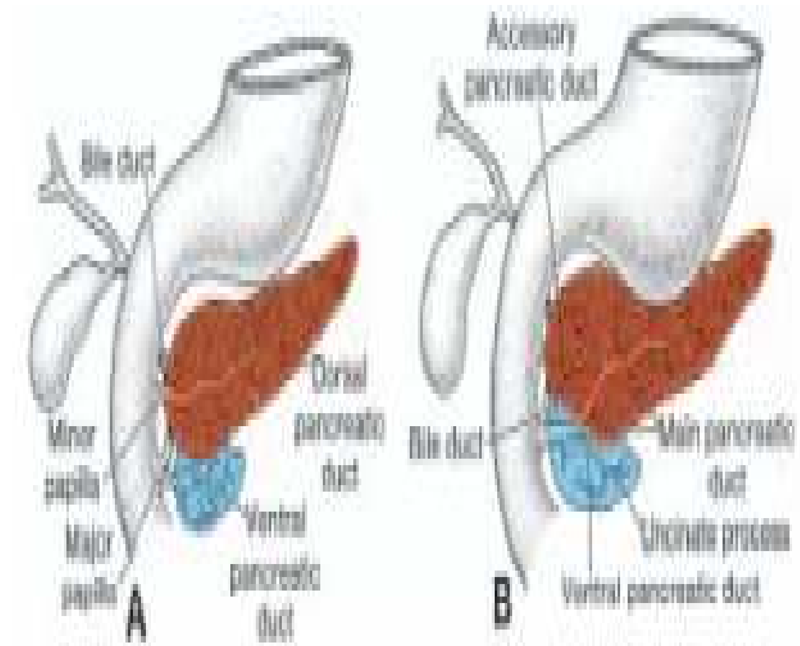


Figure 13.22 A. Pancreas during the sixth week of development. The ventral pancreatic bud is in close contact with the dorsal pancreatic bud. **B.** Fusion of the pancreatic ducts. The main pancreatic duct enters the duodenum in combination with the bile duct at the major papilla. The accessory pancreatic 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, the duodenum is surrounded by pancreatic tissue, and an **annular pancreas** is formed
- The malformation sometimes constricts the duodenum and causes complete obstruction

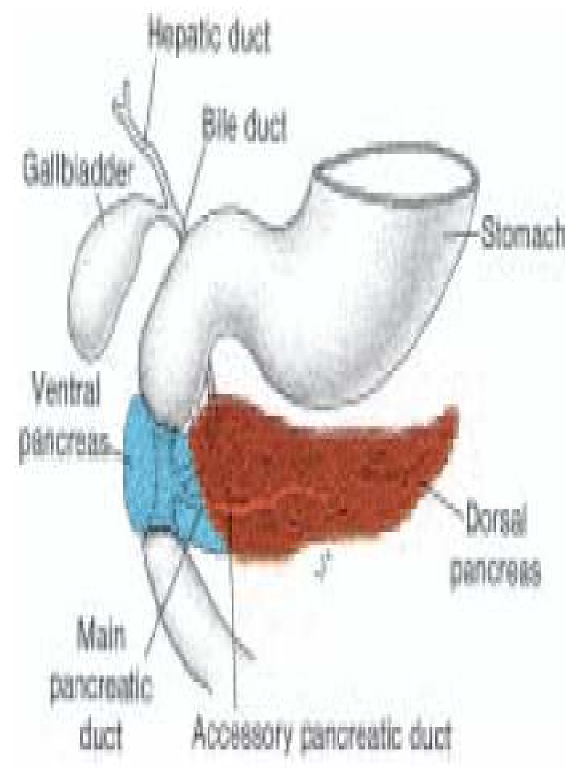


Figure 13.23 Annular pancreas. The ventral pancreas splits and forms a ring around the duodenum, occasionally resulting in duodenal stenosis.

- **Accessory pancreatic tissue** may be anywhere from the distal end of the esophagus to the tip of the primary intestinal loop

- 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.