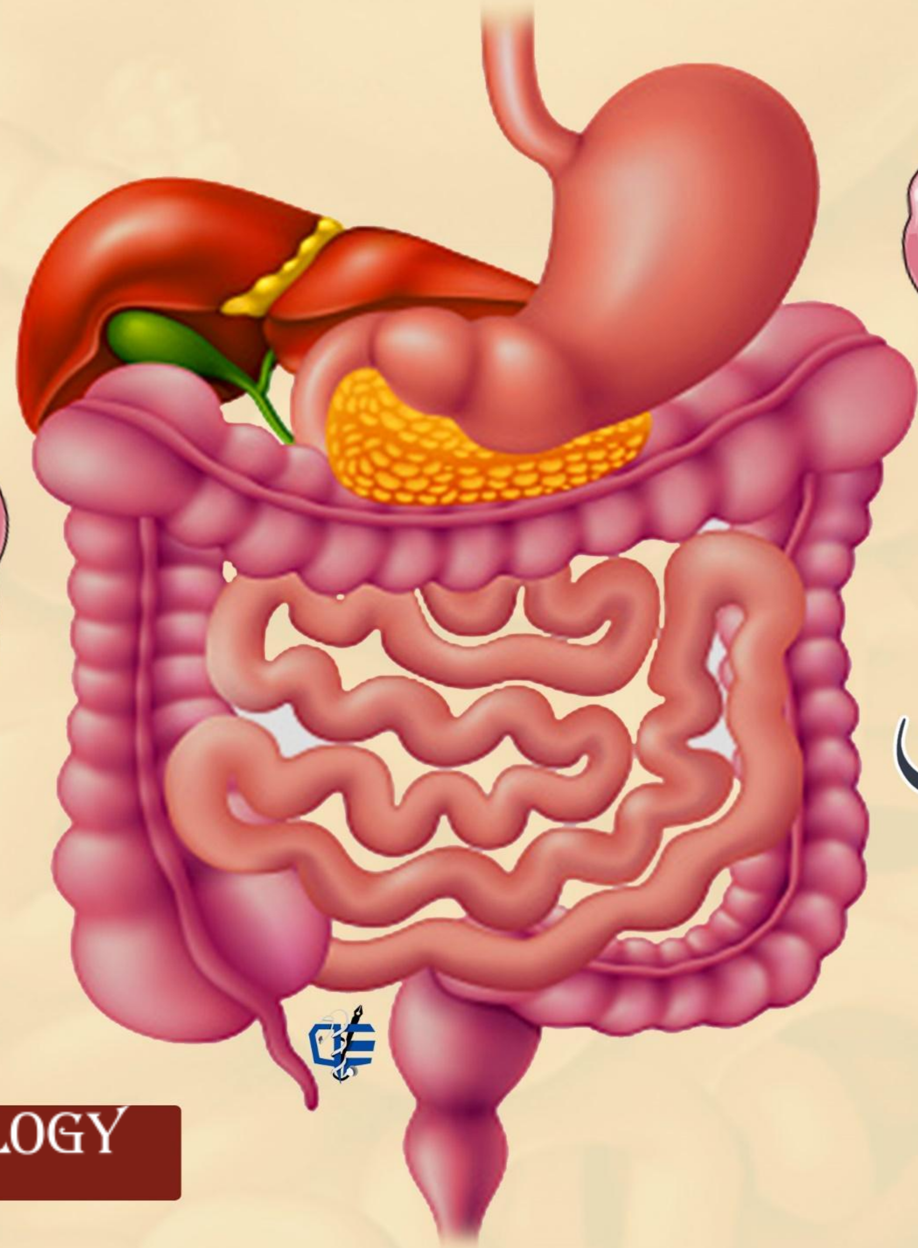
GastroIntestinal System



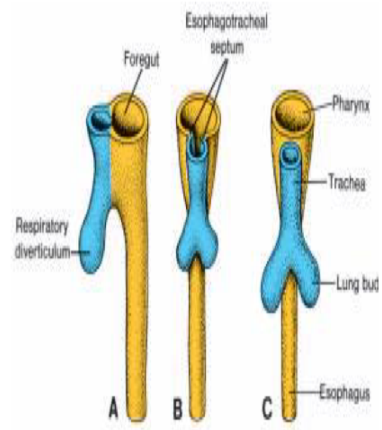
EMBRYOLOGY

Doctor: Mohammad almohtasib

Done by: Rashed alhadidi

Edited by: name

The Foregut



At first the esophagus is short but due to enlargement and descent of the heart and lungs it lengthens rapidly downward.
The muscular coat, which is formed by surrounding splanchnic mesenchyme, is striated in its upper two-thirds so innervated by the vagus nerve while the lower third is smooth muscle so innervated by the splanchnic plexus.

Esophageal Abnormalities :

1)Esophageal atresia and/or tracheoesophageal fistula(very common and has different types we will talk about them) results either from spontaneous posterior deviation of the tracheoesophageal septum or from some mechanical factor pushing the dorsal wall of the foregut anteriorly toward a trachea .
Notes about this figure :
A)very common (proximal part blind end (proximal end) and fistula in the distal end with trachea we call it tracheoesophageal fistula)
B) rare (atresia distal and proximal without fistula)
C) common fistula between the trachea (proximal and distal part)
D)proximal fistula and distal atresia
E) separated proximal and distal fistula

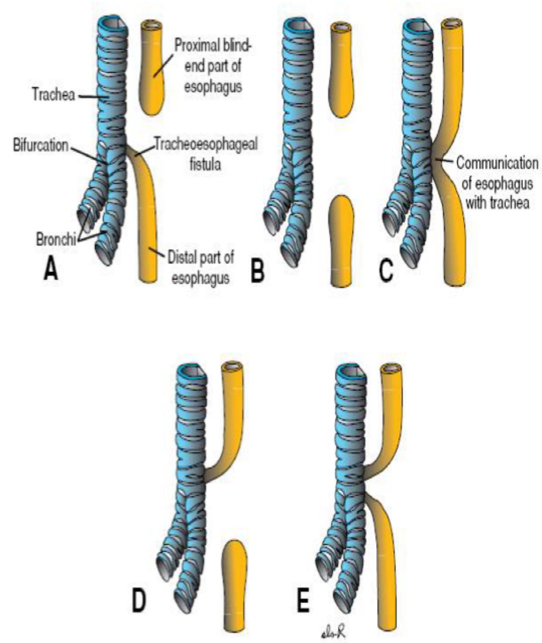


Figure 13.7 Variations of esophageal atresia and/or tracheoesophageal fistula in order of their frequency of appearance: **A**, 90%; **B**, 4%; **C**, 4%; **D**, 1%; and **E**, 1%.

• In 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 .(from slides)
Other types of defects in this region occur much less frequently .(from slides)

Atresia of the esophagus usually associated with polyhydramnios (amount of amniotic fluid around the fetus accumulated and increased) the cause is the fluid enter the esophagus and found blind end so return to amniotic cavity.

Fistula accompanied by other abnormalities like renal agenesis or cardiac abnormalities (common)

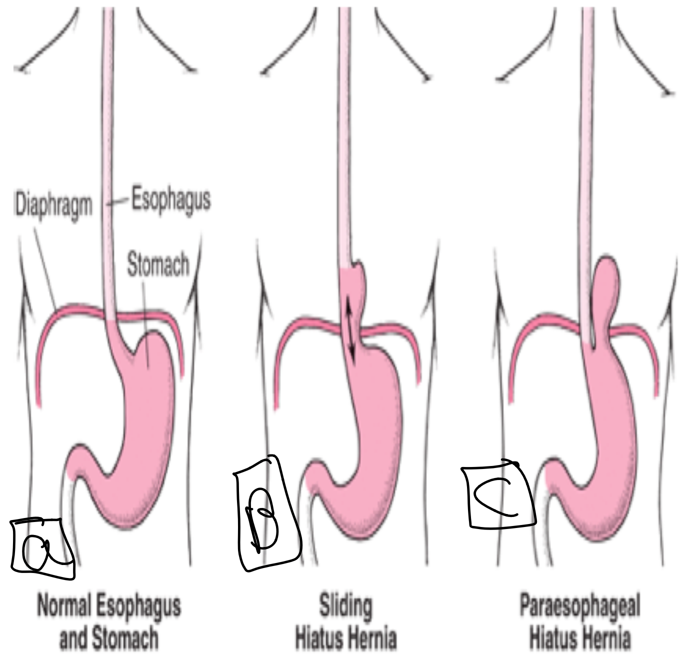
2) esophageal stenosis : usually in lower third of the esophagus

Notes about this figure

A) normal (esophagus enters the diaphragm and end in the cardia of the stomach and the site of the fundus below the diaphragm)

B) sliding hiatus hernia (Occasionally the esophagus fails to lengthen sufficiently and the stomach is pulled up into the esophageal hiatus through the diaphragm)

C)paraesophageal hiatus hernia (fundus of stomach moves upward through the diaphragm cause hernia parallel to the lower end of the esophagus)

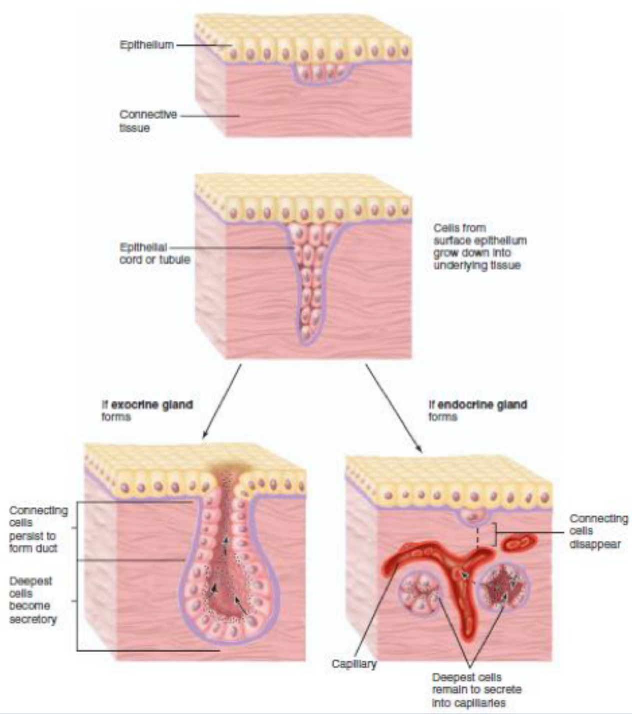


Stenosis may be caused by incomplete recanalization, vascular abnormalities, or accidents that compromise blood flow

The result is 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



Doctor didn't mention this slide during lecture

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

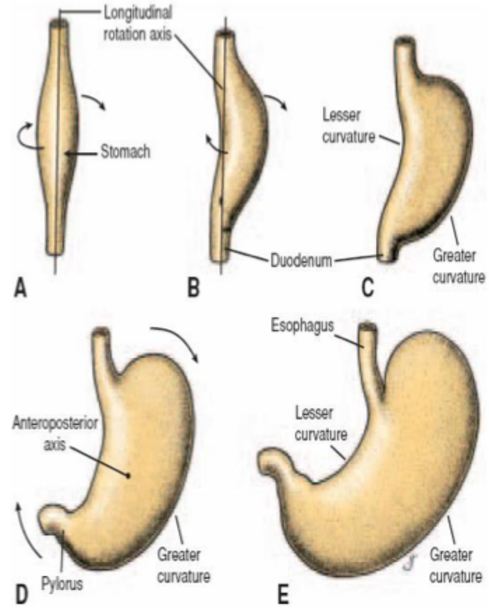
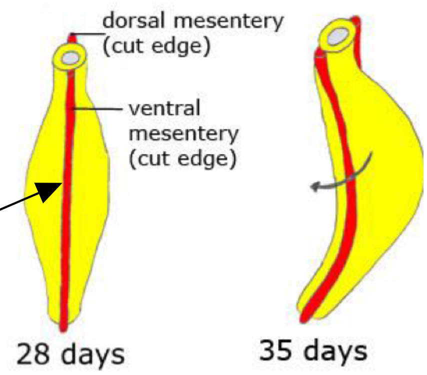


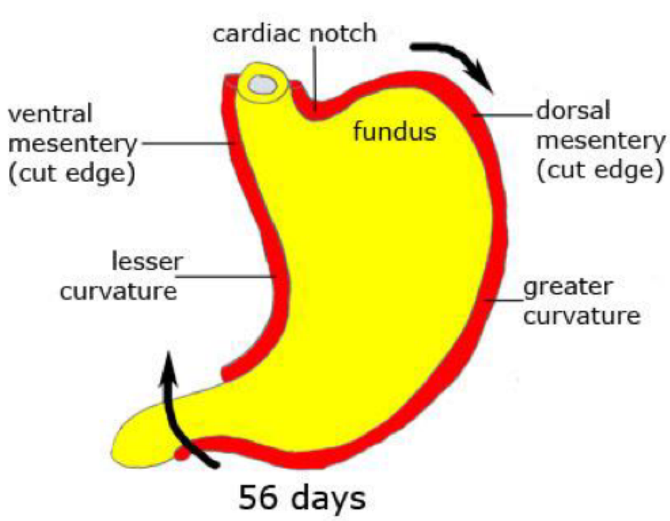
Figure 13.8 A, B, and **C.** Rotation of the stomach along its longitudinal axis as seen anteriorly. **D** and **E.** Rotation of the stomach around the anteroposterior axis. Note the change in position of the pylorus and cardia.

The stomach rotates 90 ○ clockwise around its

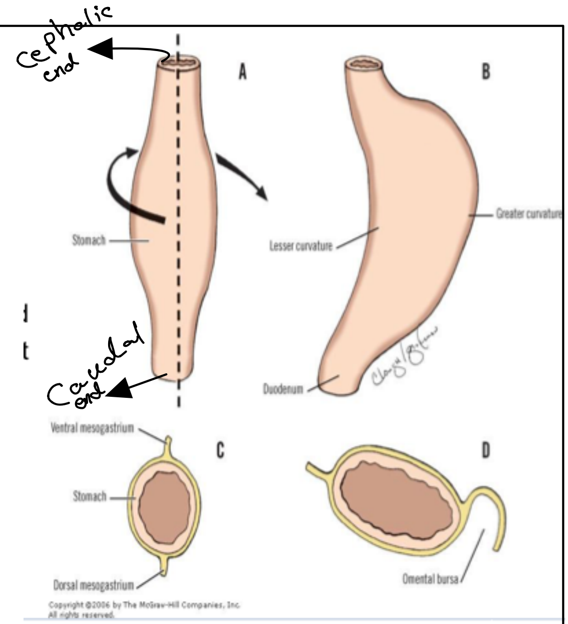
longitudinal
axis (the first rotation) causing its
left side to face anteriorly and its right side to face posteriorly (form lesser and greater curvatures).



The stomach attached with the anterior wall of the abdomen by ventral mesentery (ventral gastromesentery) and dorsal mesentery (posterior gastromesentery)attached with posterior abdominal wall.
Note : gastromesentery =mesogastrium
With rotation : dorsal →left side / ventral →right side
The dorsal mesentery forms the greater omentum , greater curvature and the legaments of the stomach with spleen and with other parts(posteriorly)
The ventral mesentery forms the lesser omentum and ligaments of the liver
The left and right vagus nerve with rotation the left become anterior and the right posterior to the stomach
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.



The mesogastrium is divided to dorsal and ventral mesogastrium
With rotation the dorsal moves backward to the left and ventral anterior to the right

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

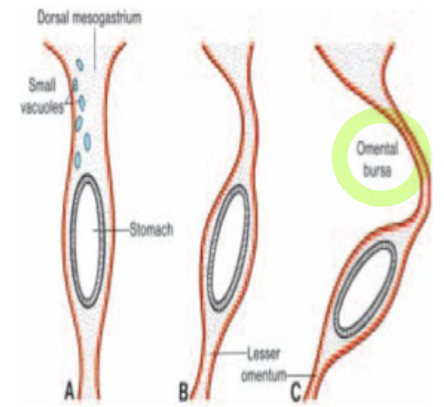
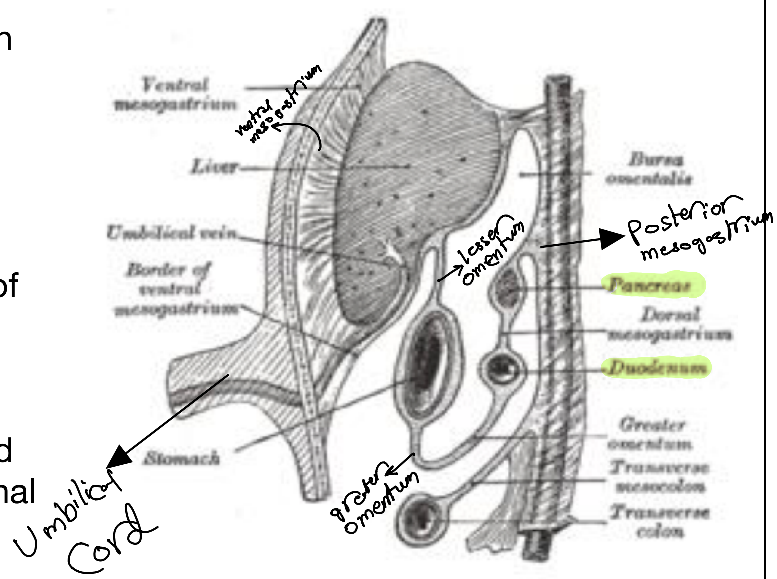


Figure 13.9 A. Transverse section through a 4-week embryo showing intercellular clefts appearing in the dorsal mesogastrium. **B** and **C.** The clefts have fused, and the omental bursa is formed as an extension of the right side of the intraembryonic cavity behind the stomach.

This rotation also pulls the ventral mesogastrium to the right forms the ligament of the liver

The pancreas and duodenum go backward and become retroperitoneal(posterior part of peritoneum or mesogastrium become disappearance)
The small intestine and the transverse colon remain attached to the posterior abdominal wall.



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 to make the pancreas and duodenum retroperitoneal

Note about this figure
Between the stomach and spleen there is ligament called gastrosplenic ligament

With rotation:posterior to the stomach the lesser sac will form .

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 or gastrosplenic ligament
Lengthening and fusion of the dorsal mesogastrium to the posterior body wall also determine the final position of the pancreas and duodenum.

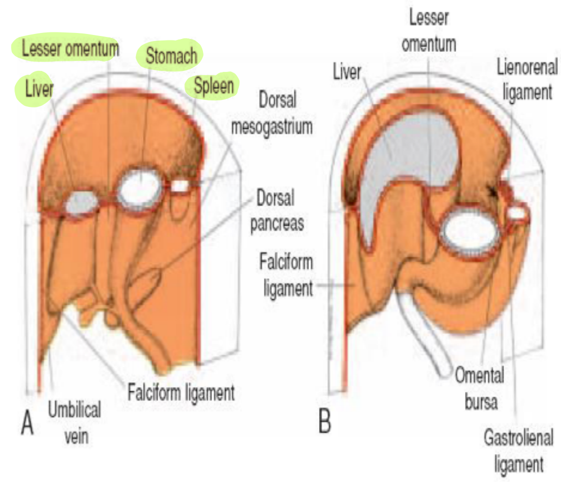
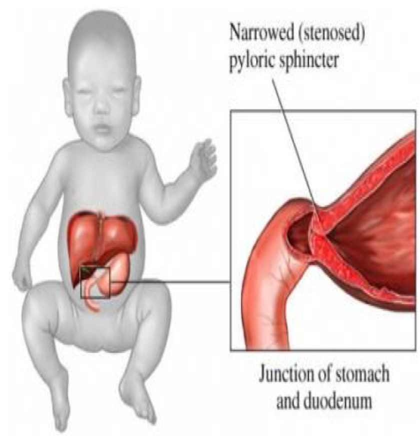


Figure 13.10 A. The positions of the spleen, stomach, and pancreas at the end of the fifth week. Note the position of the spleen and pancreas in the dorsal mesogastrium. **B.** Position of spleen and stomach at the 11th week. Note formation of the omental bursa or lesser peritoneal sac.

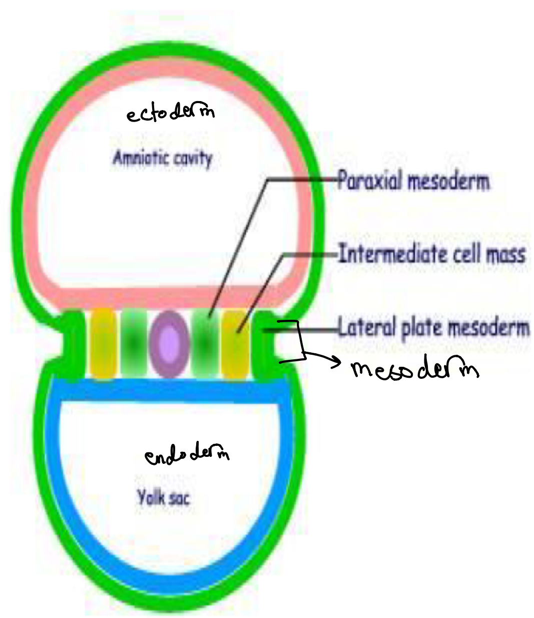
Stomach abnormalities :
1)pyloric stenosis:thickening in the inner circular(mainly) and outer longitudinal muscles cause pylorus hypertrophy
Baby after delivery has projectile vomiting (strong vomiting)

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

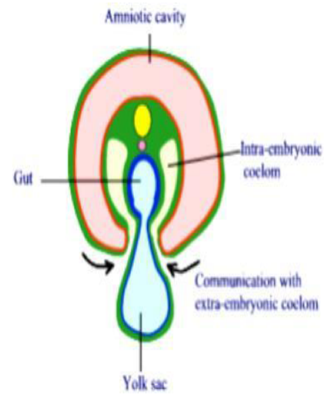
When intercellular clefts appear in the lateral mesoderm, the plates are divided into two layers: the somatic mesoderm layer(outer /gives parietal peritoneum) and the splanchnic mesoderm layer(gives visceral peritoneum around the yalk sac).



The space bordered by these layers forms the intraembryonic cavity(body cavity).
When the embryo folds the intraembryonic cavity has a connection with the extra embryonic cavity and with folding

The peritoneal cavity is derived from the intraembryonic coleam caudal to the septum transversum (that is located between the pericardium and the stalk of the umbilicus)

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 (make the duodenum backward and become retroperitoneal)and in the region of the colon it forms the dorsal mesocolon(connected with posterior abdominal wall and go to the anterior border of the pancreas)
- Dorsal mesentery of the jejunal and ileal loops forms the mesentery proper attached to the posterior abdominal wall.

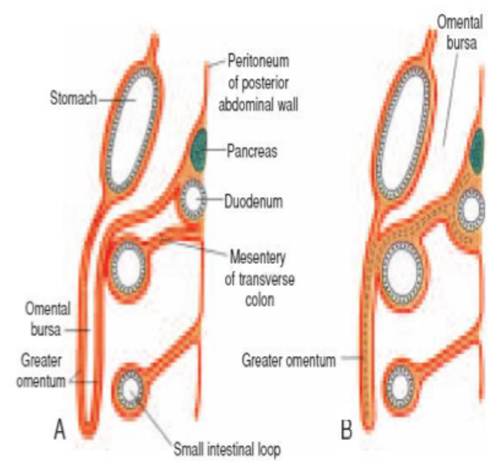
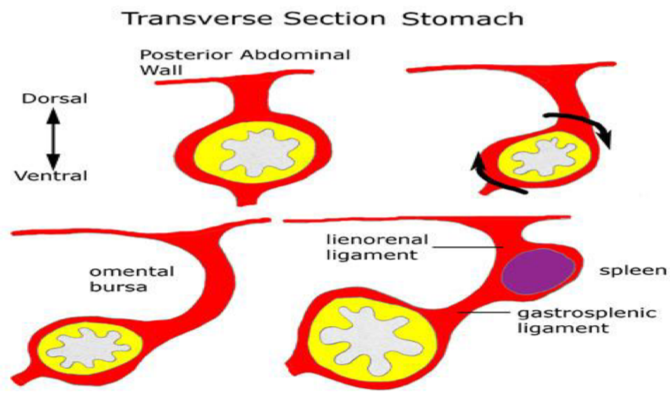
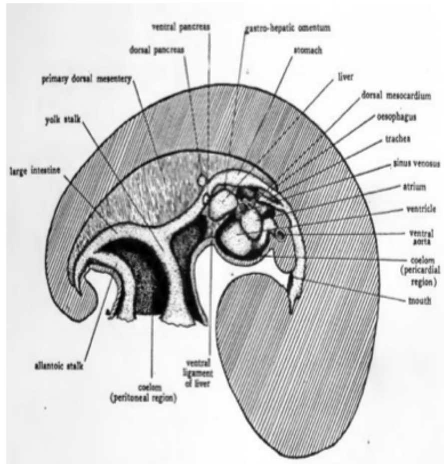


Figure 13.13 A. Sagittal section showing the relation of the greater omentum, stomach, transverse colon, and small intestinal loops at 4 months. The pancreas and duodenum have already acquired a retroperitoneal position. **B.** Similar section as in **A,** in the newborn. The leaves of the greater omentum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

With rotation of the stomach the dorsal go to the left and form all the gastrosplenic and lienorenal ligaments and the greater omentum and the ventral go to the right side to the liver and form the ligaments of the liver .
And with rotation the omental bursa formed and will grow up to form the lesser sac behind the stomach .
The spleen forms inside the dorsal mesogastrium and completely surrounded by peritoneum (intraperitoneal).



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



So all ligaments of the liver from ventral mesogastrium(mesentery)
(Lesser omentum/ falciform ligament /coronary ligament and triangular ligament)

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)

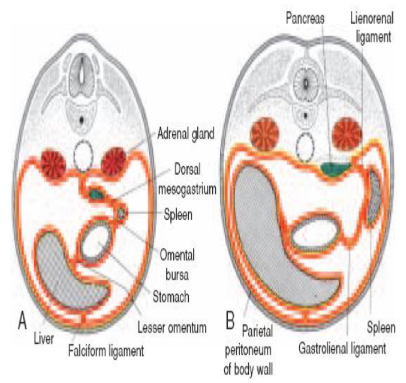


Figure 13.11 Transverse sections through the region of the stomach, liver, and spleen, showing formation of the lesser peritoneal sac, rotation of the stomach, and position of the spleen and tail of the pancreas between the two leaves of the dorsal mesogastrium. With further development, the pancreas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

• 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

-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
Note : metaphorically we say the ascending 2 layers of greater omentum surround the transverse colon and form mesocolon but in the embryo it ends in the transverse colon and meet the mesentery of transverse colon .

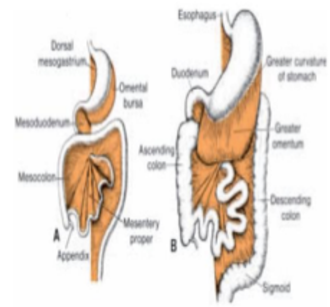


Figure 13.12 A. Derivatives of the dorsal mesentery at the end of the third month. The dorsal mesogastrium bulges out on the left side of the stomach, where it forms part of the border of the omental bursa. **B.** The greater omentum hangs down from the greater

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 transversum it thins to form
(a) the peritoneum of the liver • b) the falciform ligament, extending from the liver to the ventral body wall
C)the lesser omentum, extending from the stomach and upper duodenum to the liver

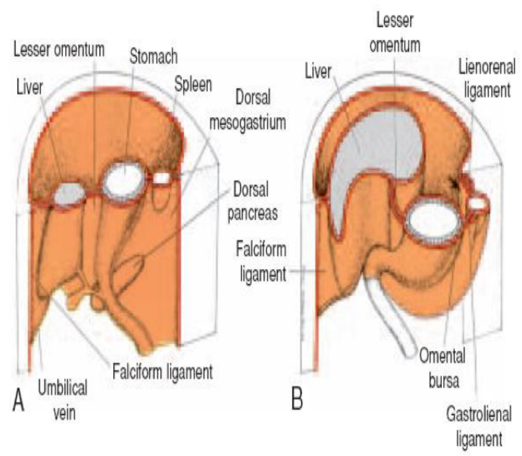


Figure 13.10 A. The positions of the spleen, stomach, and pancreas at the end of the fifth week. Note the position of the spleen and pancreas in the dorsal mesogastrium. **B.** Position of spleen and stomach at the 11th week. Note formation of the omental bursa or lesser peritoneal sac.

Summary : dorsal mesogastrium moves backward to the left while the ventral anterior to the right
Ventral form the lesser omentum and the ligaments of the liver
Dorsal moves backward make the pancreas and duodenum retroperitoneal and extend to the left and surround the spleen and make it intraperitoneal and form the ligaments of the stomach (greater omentum / gastrosplenic /lienorenal ligaments)
And the result of the rotation the lesser sac will form behind the stomach .

• 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(dilatation of the end of this bud form the gallbladder)and the cystic duct(narrow proximal part)

Notes about this figure :
We see liver bud (come from anterior wall of duodenum) after grow up and meet with septum transversum (lies between the pericardium of the heart and the umbilical cord (stalk of the umbilicus).

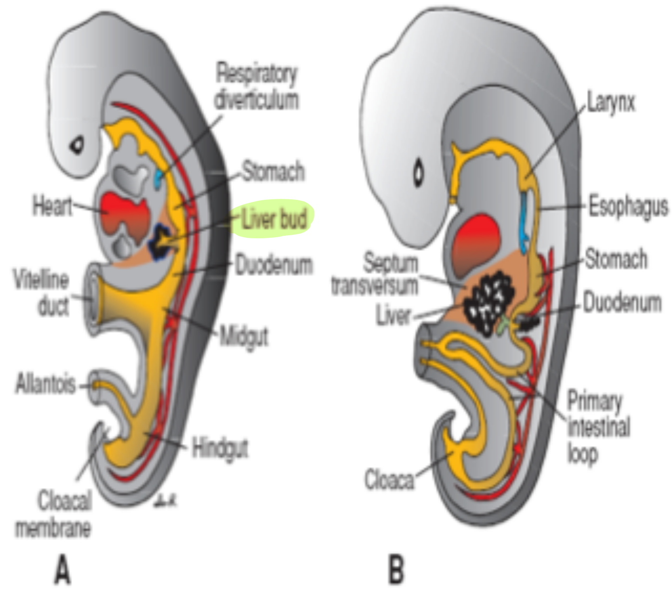


Figure 13.14 A. A 3-mm embryo (approximately 25 days) showing the primitive gastrointestinal tract and formation of the liver bud. The bud is formed by endoderm lining the foregut. **B.** A 5-mm embryo (approximately 32 days). Epithelial liver cords penetrate the mesenchyme of the septum transversum.

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(macrophage cells) , and connective tissue cells are derived from mesoderm of the septum transversum.

Liver and gallbladder abnormalities:

Variations in liver lobulation are common but not clinically significant, 1)Accessory hepatic ducts and 2)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. (Very rare)
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

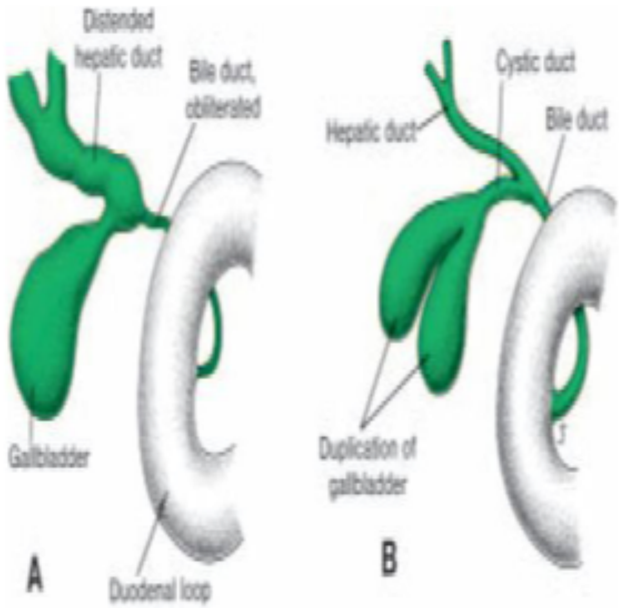


Figure 13.20 A. Obliteration of the bile duct resulting in distention of the gallbladder and hepatic ducts distal to the obliteration. **B.** Duplication of the gallbladder.

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.

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(upper cephalic and lower caudal parts)
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 (so the rotation of duodenum with the rotation of the stomach) the rotation in the right side and backwards and form the C-shaped of duodenum.
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.
With rotation the common bile duct that was in the right side become in the left side of the duodenum
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
Remember: the duodenum is retroperitoneal except the 1st and last inches

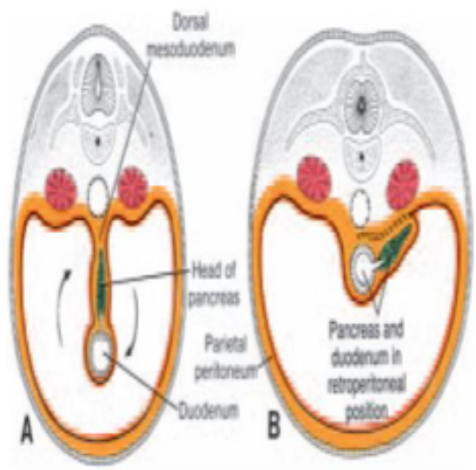


Figure 13.17 Transverse sections through the region of the duodenum at various stages of development. At first the duodenum and head of the pancreas are located in the median plane (**A**), but later they swing to the right and acquire a retroperitoneal position (**B**).

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 (upper half from celiac through superior pancreaticoduodenal artery and the lowe part from superior mesenteric through inferior pancreaticoduodenal artery)

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 (epithelial growth)
Whereas the dorsal pancreatic bud is in the dorsal mesentery(in the left side) the ventral pancreatic bud is close to the bile duct
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
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 fused together .

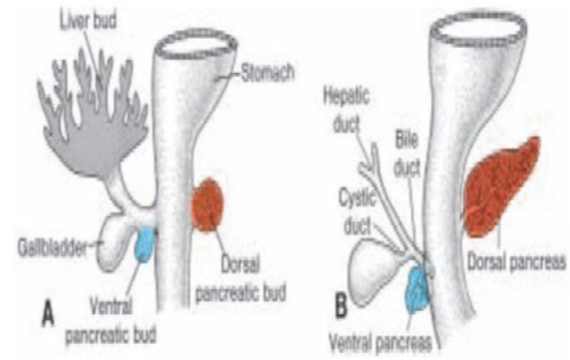


Figure 13.21 Stages in development of the pancreas. **A.** 30 days (approximately 5 mm). **B.** 35 days (approximately 7 mm). Initially the ventral pancreatic bud lies close to the liver bud, but later it moves posteriorly around the duodenum toward the dorsal pancreatic bud.

The ventral bud forms the uncinate process and inferior part of the head of the pancreas
• The remaining part of the gland (pancreas) 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 (Santorini duct).
• In the third month of fetal life, pancreatic islets (of Langerhans) (endocrine part) develop from the parenchymatous pancreatic tissue and scatter throughout the pancreas

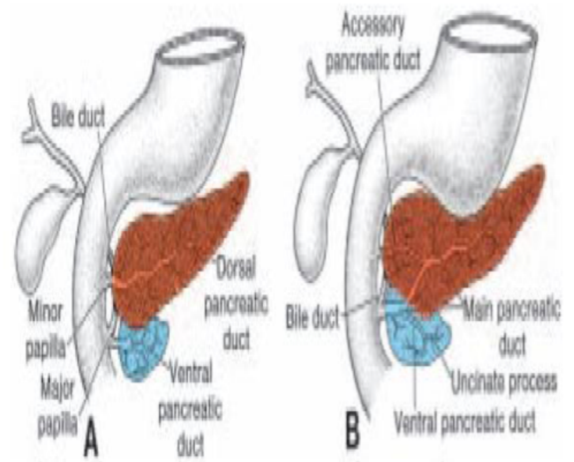


Figure 13.22 A. Pancreas during the sixth week of development. The ventral pancreatic bud is in close contact with the dorsal pancreatic bud. **B.** Fusion of the pancreatic ducts. The main pancreatic duct enters the duodenum in combination with the bile duct at the major papilla. The accessory pancreatic 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 of the pancreas.
• Splanchnic mesoderm surrounding the pancreatic buds forms the pancreatic connective tissue(and convert it to lobes and lobules like any gland)

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 condition the 2 parts is opposite to each other cause an obliteration to the duodenum)

• 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

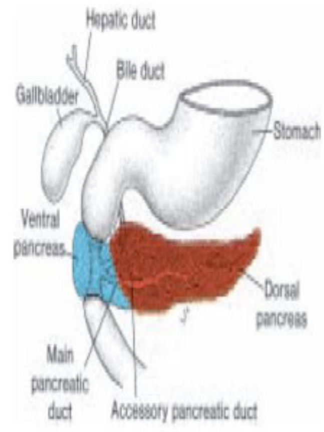


Figure 13.23 Annular pancreas. The ventral pancreas splits and forms a ring around the duodenum, occasionally resulting in duodenal stenosis.

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.

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