Entodermal derivatives: formation of the gut, liver, and pancreas

Mike Gershon

Folding forms the gut

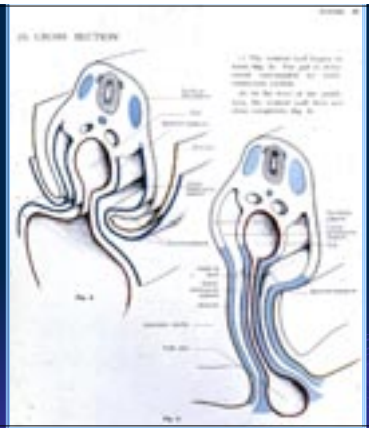
- Primitive gut extends from buccopharyngeal to cloacal membrane.
  - Move toward each other
- Cardiogenic mesenchyme is originally rostral, but folding brings it caudal to buccal membrane.
- Foregut and hindgut become recognizable
- Portion of yolk sac is incoporated into the embro as bowel.
- Midgut remains open.

Cephalocaudal and lateral folding occur simultaneously

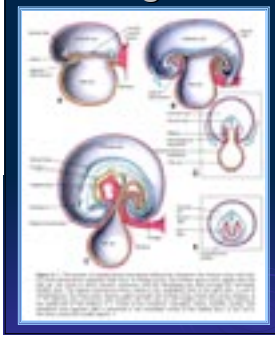
- Meeting and fusion of cranial, lateral, and caudal edges of the embryo create the primordial foregut and hindgut
  - Slow fusion of midgut-due to presence of yolk sac. Midgut remains open until week 6-connects to yolk sac via *vitelline duct*.
  - Buccopharyngeal membrane opens at 4 and cloacal membrane at 7 weeks

Flexion delimits the bowel

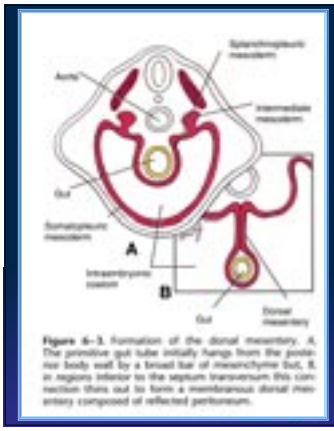
- After the gut forms, it is attached to the body wall by dorsal and ventral mesenteries; ventral is lost except in region of liver. Vetelline duct remains in umbilical cord.



Anterior-posterior and lateral folding form the primitive gut



- Embryonic disc grows faster in length than the yolk sac causing the embryo to bend.
  - Dorsal surface grows more rapidly than the ventral
- Lateral folding
  - Fusion with apposing side except in the region of the yolk sac, and allantois
- Folding brings the heart and septum transversum caudal to bucco-pharyngeal membrane.

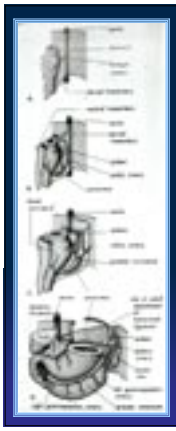


The dorsal mesentery thins to allow the gut to be flexibly suspended

The foregut has many derivatives

- Pharynx and its derivatives
- Lower Respiratory tract
- Esophagus
- Stomach
- Duodenum proximal to ampulla of Vater
- Liver
- Biliary Apparatus
- Pancreas

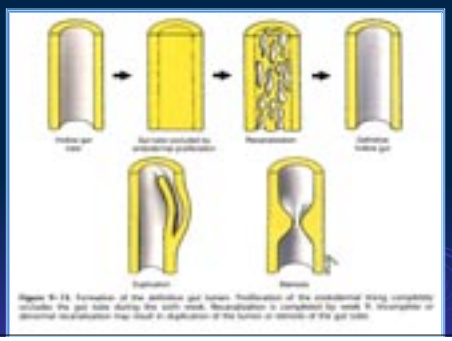
From stomach to biliary apparatus, all are supplied by the celiac artery, "the artery of the foregut."



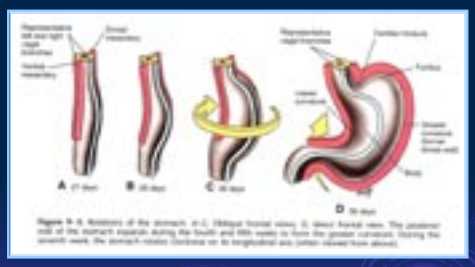
Esophagus elongates rapidly

- Appears to grow faster at its cranial than caudal end.
- Stomach does not descend but arises from a region just caudal to septum transversum that has been fated to be stomach.
- Epithelium obliterates lumen of esophagus and is recanalized by apoptosis (week 8).
  - Failure causes polyhydramnios
  - Esophageal atresia or tracheo-esophageal fistula.
- Stomach enlarges and rotates

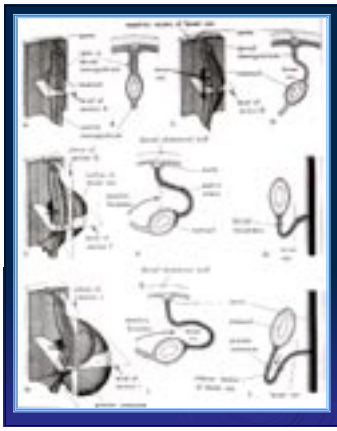
Obliteration of the lumen and recanalization occurs



The stomach rotates 90° in a clockwise direction



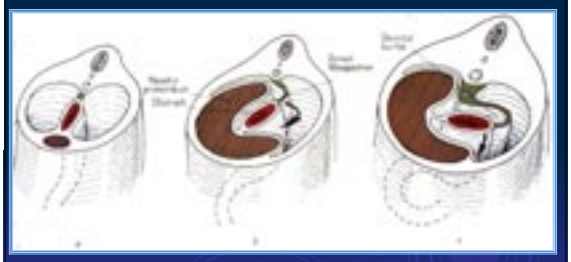
- Dorsal surface grows faster than the ventral to create the greater and lesser curvature. Acquires a transverse position



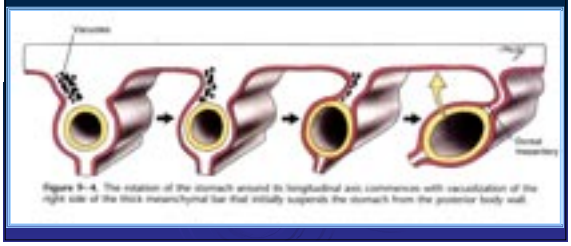
Rotation of the stomach creates the lesser sac

- Dorsal mesogastrium moves to left.
- Ventral mesogastrium attaches to liver and body wall.
- Inferior recess form the greater omentum
  - Layers fuse to obliterate the lesser sac

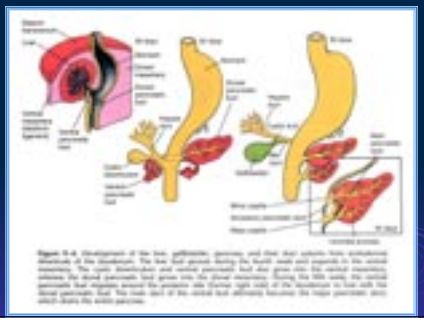
Rotation of the stomach forms the omental bursa



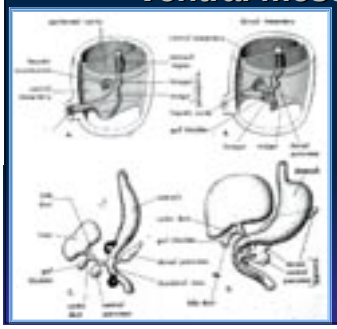
Movements of the mesentery and stomach are made possible by vacuolization due to selective apoptosis



Liver, biliary system and pancreas arise from the duodenum

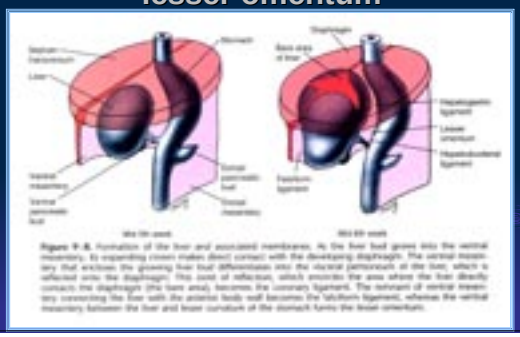


Hepatic diverticulum grows from the duodenum into the ventral mesentery

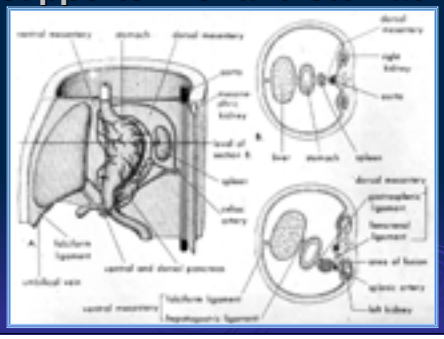


- Begins ~ week 4
- Divides into cranial and caudal buds.
- Cranial bud grows faster and becomes the hepatic parenchyma;
  - Hematopoietic colonists arrive ~ week 6
- Caudal bud gives rise to the biliary system.

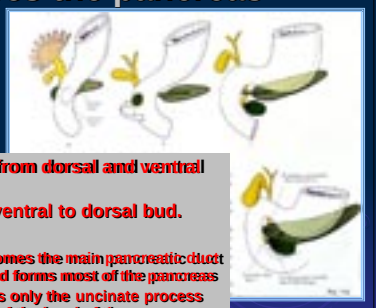
Ventral mesentery forms falciform ligament, hepatic peritoneum, and lesser omentum



Ventral mesogastrium supports liver and stomach

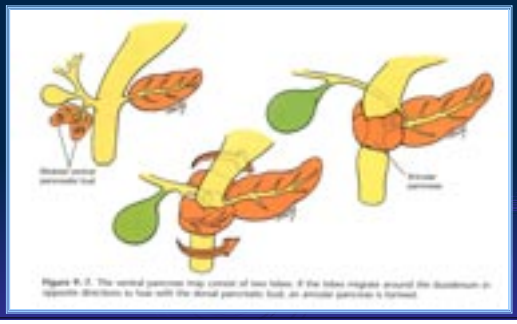


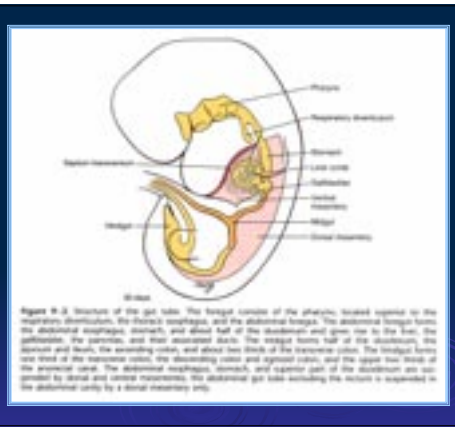
Rotation of the stomach shapes the pancreas



- Pancreas arises from dorsal and ventral buds.
- Rotation brings ventral to dorsal bud.
- Buds fuse.
  - Ventral duct becomes the main pancreatic duct but the dorsal bud forms most of the pancreas
  - Ventral bud forms only the uncinate process and inferior part of the head of the pancreas.

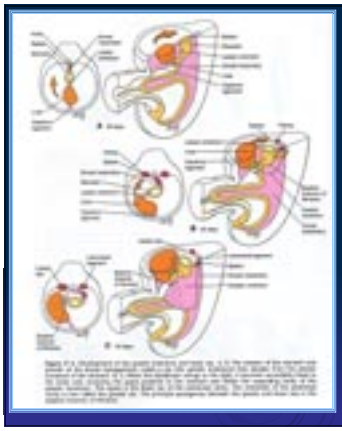
Aberrant rotation causes an annular pancreas





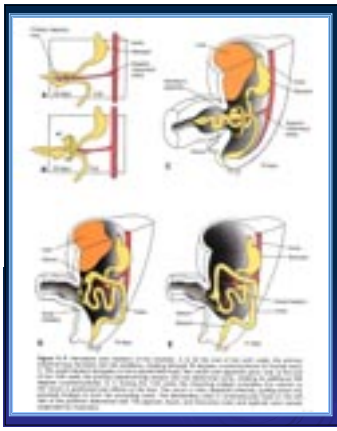
Derivatives of the midgut

- Small intestine (except for the proximal duodenum.
- Cecum
- Appendix
- Ascending colon
- Right 1/2 to 2/3 of the proximal transverse colon
- All are supplied by the superior mesenteric artery ("the artery of the midgut")



The midgut grows rapidly and herniates into the umbilical cord

Week 6



The midgut rotates around an axis of the superior mesenteric artery:

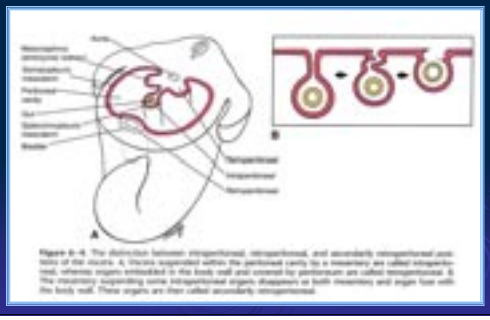
1. 90°
2. 180°

Midgut hernia reduced at week 10.

Rotation of the midgut

- 1. Cranial and caudal loop form.
- 2. Cranial growth >>> caudal growth.
- 3. Apex of loop is vitelline duct.
- 4. Cranial loop moves to right and caudal loop to left (90° counterclockwise).
- 4. Reduction of midgut hernia with rotation a further 180°.
  - Brings cecum to right
  - Moves down
  - Becomes secondarily retroperitoneal.

Loops of bowel fuse with the body wall and become secondarily retroperitoneal



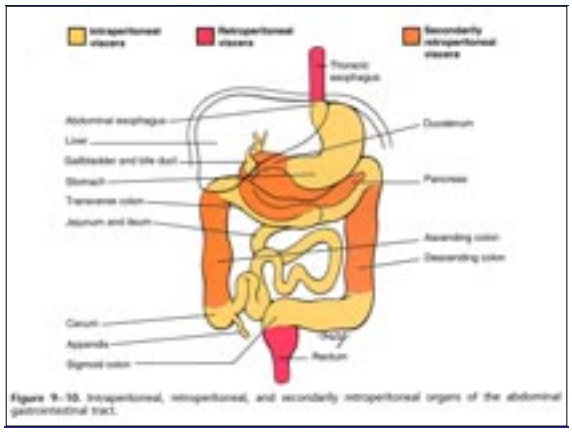
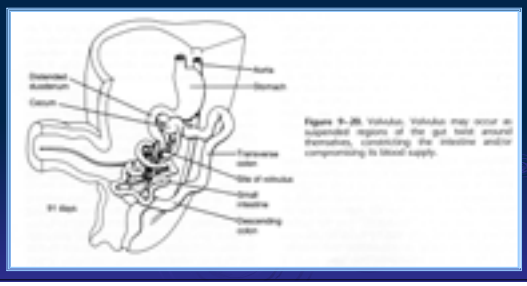


Figure 9–10. Intraperitoneal, retroperitoneal, and secondarily retroperitoneal organs of the abdominal gastrointestinal tract.

Volvulus is a serious complication of excessive flexibility



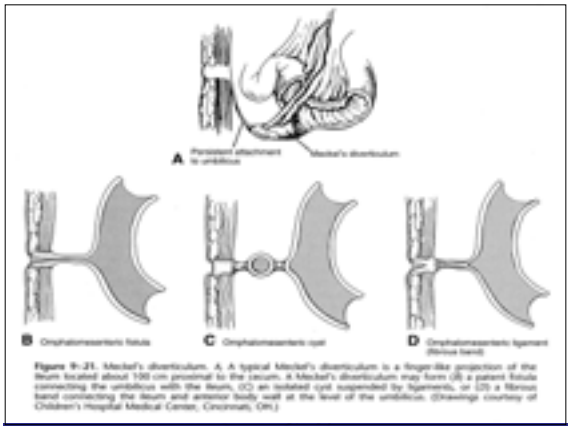
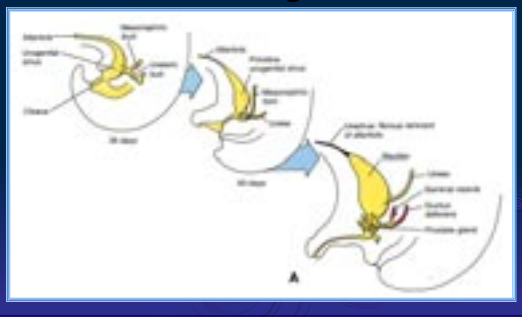


Figure 9–21. Meckel's diverticulum. A, A typical Meckel's diverticulum is a finger-like projection of the ileum located about 100 cm proximal to the cecum. B Meckel's diverticulum may form (B) a patent fistula connecting the umbilicus with the ileum, (C) an isolated cyst suspended by ligaments, or (D) a fibrous band connecting the ileum and anterior body wall at the level of the umbilicus. (Drawings courtesy of Children's Hospital Medical Center, Cincinnati, OH.)

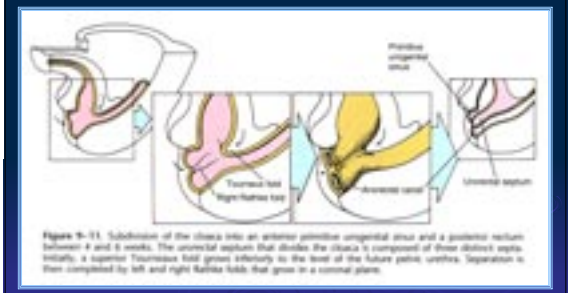
Derivatives of the hindgut

- Left 1/3 to 1/2 of the distal transverse colon
- Descending colon
- Sigmoid colon
- Rectum
- Superior part of anal canal
- Epithelium of unrinary bladder and most of the urethra
- **All are supplied by the inferior mesenteric artery, "the artery of the". hindgut**

The hindgut is originally a cloaca-partioned to form rectum and urogenital sinus



Urorectal septum divides the cloaca



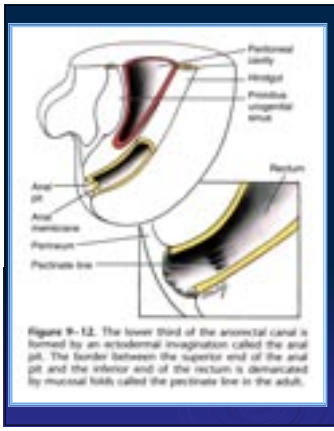
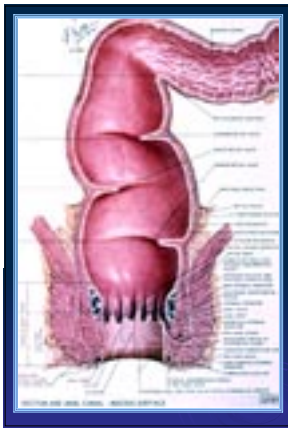


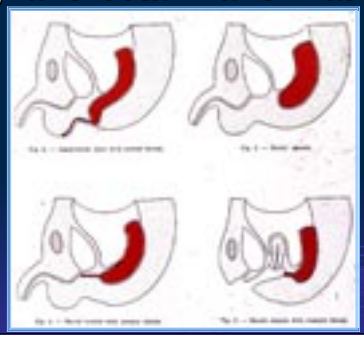
Figure 9–12. The lower third of the anorectal canal is formed by an ectodermal invagination called the anal pit. The border between the superior end of the anal pit and the inferior end of the rectum is demarcated by mucosal folds called the pectinate line in the adult.

Hindgut forms superior 2/3 of rectal canal; proctodeum forms lower 1/3; divided at pectinate line



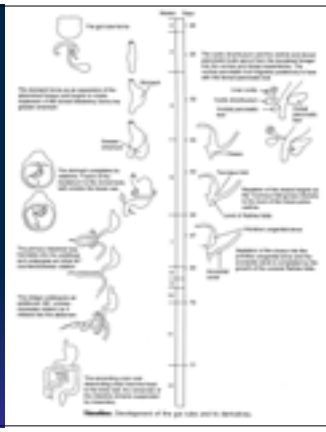
Never forget the pectinate line

If anything can go wrong it will; anorectal malformations



The END

Have a nice day!



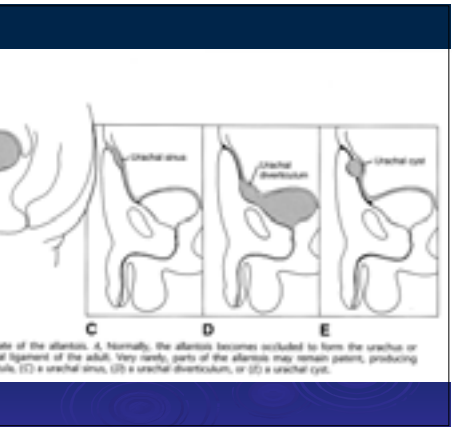


Table 9–2
Derivatives of the Septum Transversum

REGIONS OF SEPTUM TRANSVERSUM	DERIVATIVES
Cranial region	Central tendon of the diaphragm Myocytes of the pleuroperitoneal membranes
Central mesenchyme	Hematopoietic cells of liver
Caudal region (ventral mesentery)	Falciform ligament Visceral peritoneum of the liver, including the coronary ligament Visceral peritoneum of the gallbladder Lesser omentum, including the hepatoduodenal and hepatogastric ligaments

Table 9–1
The Derivatives of the Primitive Gut Tube

REGIONS OF THE DIFFERENTIATED GUT TUBE	ACCESSORY ORGANS DERIVED FROM THE GUT TUBE ENDODERM
Foregut	
Pharynx	Pharyngeal pouch derivatives (see Ch. 12)
Thoracic esophagus	Lungs
Abdominal esophagus	
Stomach	
Superior half of duodenum (superior to the ampulla of Vater)	Liver parenchyma and hepatic duct epithelium Gallbladder, cystic duct, and common bile duct Dorsal and ventral pancreatic buds (exocrine cells and pancreatic duct epithelium; probably also pancreatic endocrine cells)
Midgut	
Inferior half of duodenum	
Jejunum	
Ileum	
Cecum	
Appendix	
Ascending colon	
Right two thirds of transverse colon	
Hindgut	
Left one third of transverse colon	
Descending colon	
Sigmoid colon	
Rectum	Urogenital sinus and derivatives (see Ch. 10)

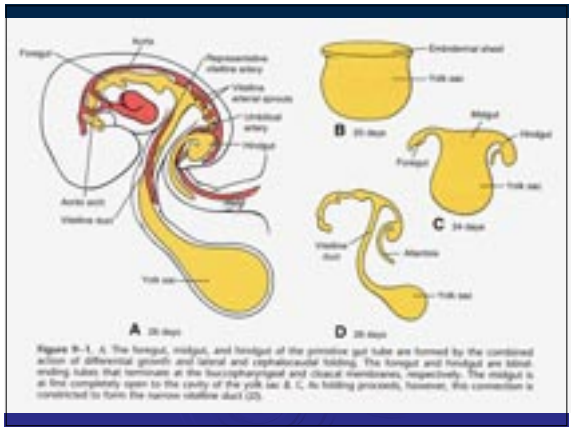


Figure 9–1. *A*, The foregut, midgut, and hindgut of the primitive gut tube are formed by the combined action of differential growth and lateral and cephalocaudal folding. The foregut and hindgut are blind-ending tubes that terminate at the buccopharyngeal and cloacal membranes, respectively. The midgut is at first completely open to the cavity of the yolk sac. *B*, *C*, As folding proceeds, however, this connection is constricted to form the narrow vitelline duct (*D*).