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

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 incorporated into the embryo 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. Vitelline 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 buccopharyngeal membrane.
The septum transversum partially separates the thoracic and abdominal cavities

- The superior portion is the primitive pericardial cavity.
- The inferior portion is the future peritoneal cavity.
- The pericardial and peritoneal cavities communicate through the pericardioperitoneal canals.

The pericardioperitoneal canals are closed by the formation of the pleuropertoneal membranes

- The pleuropertoneal membranes contribute muscle to the definitive diaphragm.

The definitive diaphragm is a composite structure

- 1. Septum transversum
- 2. Pleuropericardial membranes
- 3. Paraxial mesoderm
- 4. Esophageal mesenchyme

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

- figure 4.3 formation of the dorsal mesentery. A. The primitive gut tube is initially hanging from the posterior body wall by a broad sheet of mesenchyme but it is rapidly inferior to the epidermic tissues. The gut develops a narrow mesentery composed of reflected peritoneum.

The gut is regionally specified early in development

- Endoderm is specified before gut tube is complete.
- Specification is manifest as a series of regionally specific transcription factors.
- The boundaries between regions, however, are plastic and depend on interactions with mesoderm.

Signals and transcription factors specify regionalization of the gut
The language is paracrine secretion.
- Secreted growth factors
- Detected by appropriate receptors.
- Coupled to transduction channels that affect transcription.

Begins with Shh expression in posterior endoderm—spreads to whole gut
- Induces series of Hox genes in mesoderm
- Mesoderm then influences epithelial differentiation

### 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.”

### Obliteration of the lumen and recanalization occurs

- Dorsal surface grows faster than the ventral to create the greater and lesser curvature. Acquires a transverse position.
Dorsal mesogastrium moves to left.
Ventral mesogastrium attaches to liver and body wall.
Inferior recess forms the greater omentum.
Layers fuse to obliterate the lesser sac.

Liver, biliary system and pancreas arise from the duodenum.

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.

Rotation of the stomach creates 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

Hepatic diverticulum grows from the duodenum into the ventral mesentery

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

Figure 9-4. The rotation of the stomach around its longitudinal axis commences with vacuolization of the right side of the trunk mesenchyme (par diaphragm). This event proceeds to the left side of the stomach, and finally, the stomach is suspended from the posterior body wall.

Figure 10-4. Formation of the liver and associated structures. In the four-week old embryo, the hepatic diverticulum grows into the ventral mesentery. This expansion causes the liver to move away from the developing stomach. The cranial region of the diverticulum starts to differentiate into the dorsal pancreas of the duodenum. As the diverticulum grows further, it contacts the diaphragm and begins to form the falciform ligament. The development of the hepatic peritoneum occurs as the liver expands, and the lesser omentum forms the connection between the liver and the posterior body wall.
**Ventral mesogastrium supports liver and stomach**

**Rotation of the stomach shapes the pancreas**

**Aberrant rotation causes an annular pancreas**

**Review of the Gut Tube**

- 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.

Figure 9-7: The ventral pancreas may consist of two lobes. If the liver buds are in opposite directions, the ventral pancreas forms an annular pattern.
**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")

**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.

**The midgut**
- The midgut grows rapidly and herniates into the umbilical cord.

**Week 6**
- 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.**
Meckel's diverticulum is bad news

- Persistent attachment to umbilicus
- Meckel's diverticulum

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 urinary bladder and most of urethra
- All are supplied by the inferior mesenteric artery, "the artery of the" hindgut

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

Volvulus is a serious complication of excessive flexibility

Figure 9-10: Meckel's diverticulum may occur as an outpouching of the distal ileum near the ileocelecal valve. It may be associated with gastrointestinal symptoms or complications. 

Figure 9-20: Volvulus may occur in the sigmoid colon or the cecum. It can lead to intestinal ischemia and subsequent necrosis if not treated promptly.

Figure 9-21: The surgical treatment of volvulus involves reducing the bowel twist, restoring bowel viability, and performing an anastomosis when possible.
Urorectal septum divides the cloaca

Figure 8-13. Subdivision of the cloaca into an anterior primitive urogenital sinus and a posterior rectum between 4 and 5 weeks. The urorectal septum that divides the cloaca is comprised of three distinct parts. Initially, a superior Urethral fold grows anteroinferior to the base of the future pelvic urethra. Separation is then completed to left and right halves that give rise to a central plane.

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

Figure 9-12. The lower third of the anorectal canal is lined by an epithelial folding called the anal pit. The edge between the superior end of the anal pit and the inferior end of the rectum is demarcated by anorectal folds called the pectinate line in the adult.

Never forget the pectinate line

If anything can go wrong it will; anorectal malformations

The END

Have a nice day!