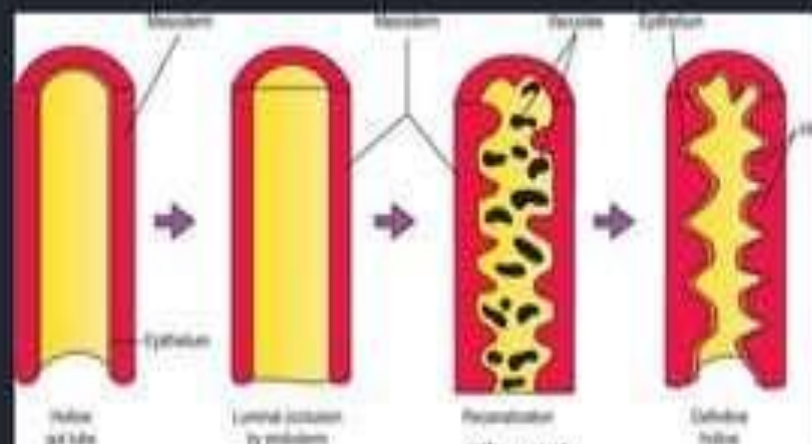
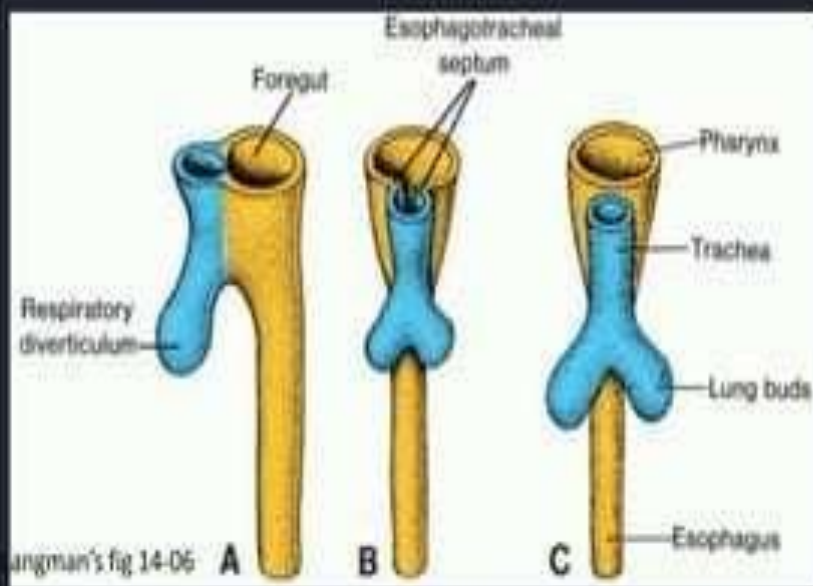


Foregut

- Foregut gives rise to:
 - Esophagus
 - Stomach
 - Liver
 - Gallbladder and bile ducts
 - Pancreas
 - Upper Duodenum

Regional Organogenesis: Esophagus



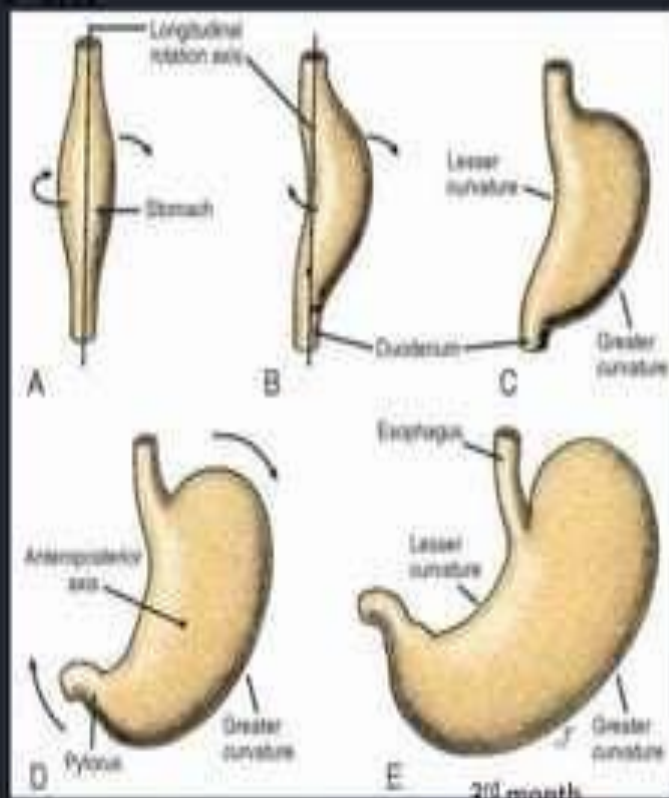
- Region of foregut just caudal to lung bud develops into esophagus - errors in forming the esophagotracheal septa and/or re-canalization lead to tracheoesophageal fistulas and/or esophageal atresia, respectively.

- Endodermal lining is stratified columnar and proliferates such that the lumen is obliterated; patency of the lumen established by re-canalization - errors in this process lead to esophageal stenosis.

- NOTE: this process of recanalization occurs throughout the gut tube, so occlusion can occur anywhere along the GI tract (e.g. duodenal stenosis)

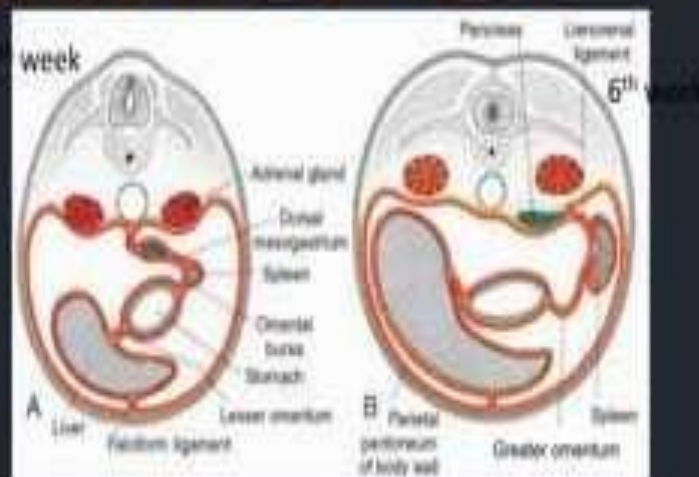
- Tube initially short and must grow in length to "keep up" with descent of heart and lungs - failure of growth in length leads to congenital hiatal hernia in which the cranial portion of the stomach is pulled into the hiatus.

Regional Organogenesis: Stomach



Langman's figs-14-08, 11, 12

- Stomach appears first as a fusiform dilation of the foregut endoderm which undergoes a 90° rotation such that the left side moves ventrally and the right side moves dorsally (the vagus nerves follow this rotation which is how the left vagus becomes anterior and the right vagus becomes posterior).
- Differential growth establishes the greater and lesser curvatures; cranio-caudal rotation tips the pylorus superiorly



Stomach

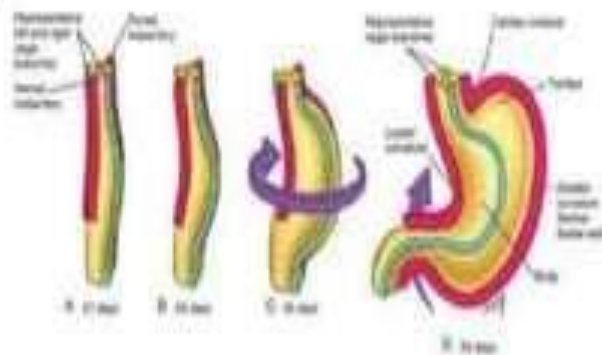
During week 4 where the stomach will form, the GIT tube begins to dilate (forming an enlarged lumen in the tube).

In the stomach region the gut tube stays attached to the ventral body wall via the septum transversum which thins in the caudal region to form the **ventral mesentery** connecting the stomach and liver to the ventral body wall.

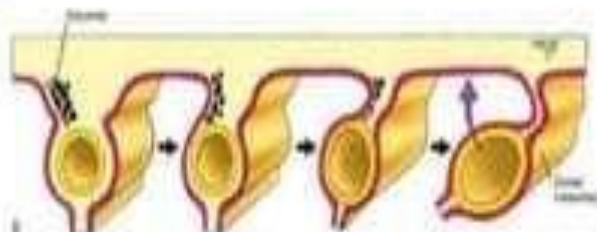
During the **5th week** the dorsal wall grows more rapidly than ventral, establishing the greater curvature of the stomach.

7-8 weeks a second rotation (of 90 degrees) occurs on the longitudinal axis establishing the adult orientation of the stomach.

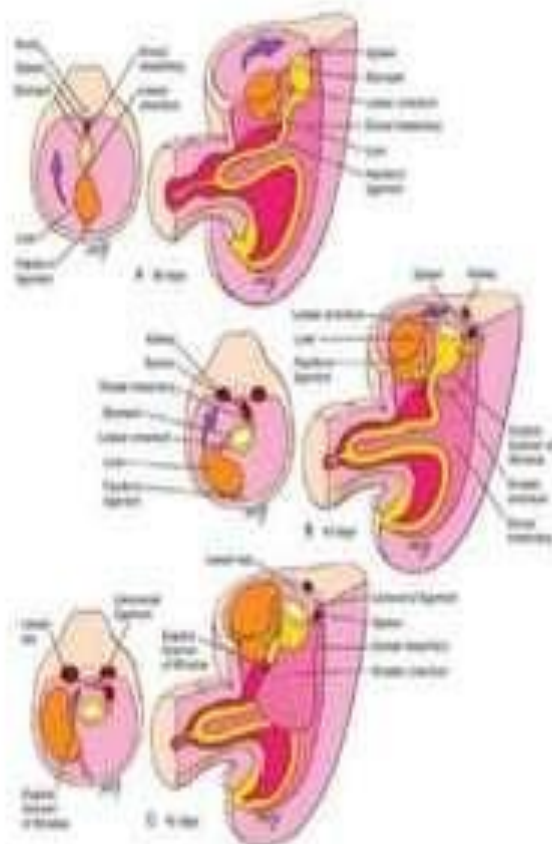
The stomach then attaches to the dorsal body wall becoming **secondarily retroperitoneal**.



Schoenwolf: Larsen's Human Embryology, 4th ed.
Copyright © 2008



The greater omentum begins as an extended fold of the dorsal mesogastrium that continues to grow and extend down into the peritoneal cavity and eventually lies anterior to the small intestines. This fold of mesentery will also fuse to form a single sheet.



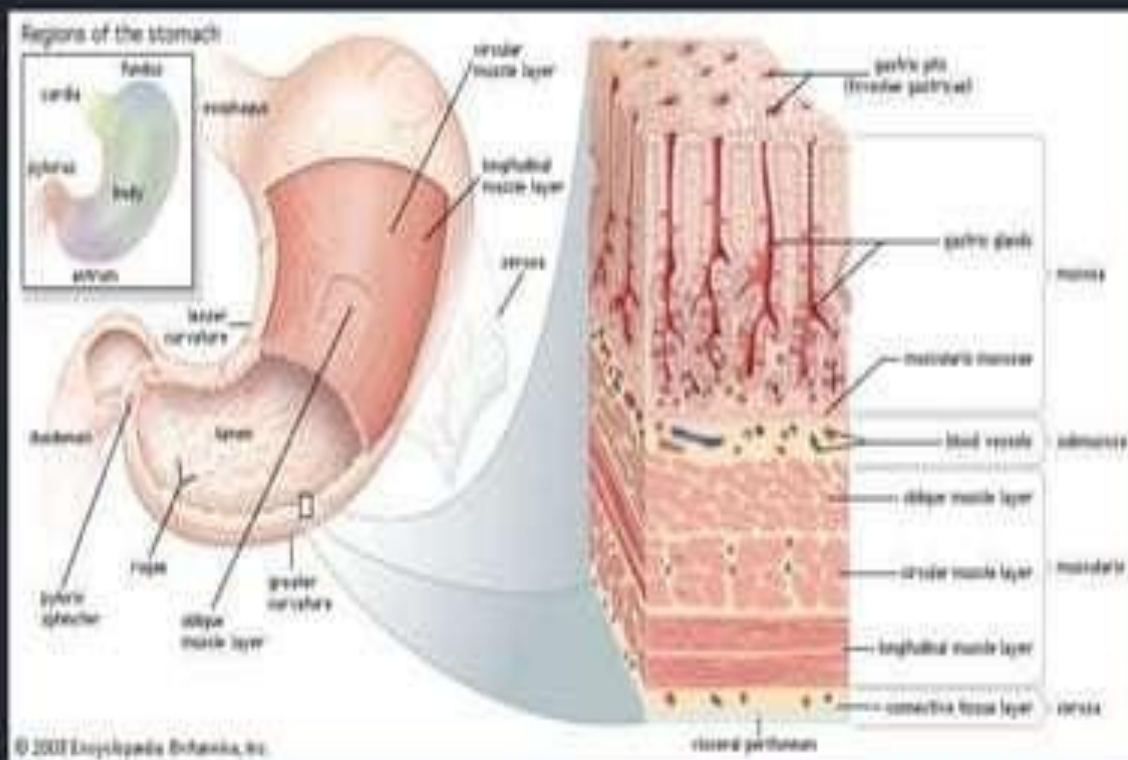
Gastric Features

- Mixes and Emulsifies
- Reservoir
- Secretes
 - Acid → Host Defense and Digestion
 - Digestive Enzymes → Pepsin, Lipase
 - Intrinsic Factor → Vitamin B₁₂ absorption
- Regulates release of gastric chyme
- Prevents acid reflux - (LES)



Gastric Anatomy

- Neuromuscular

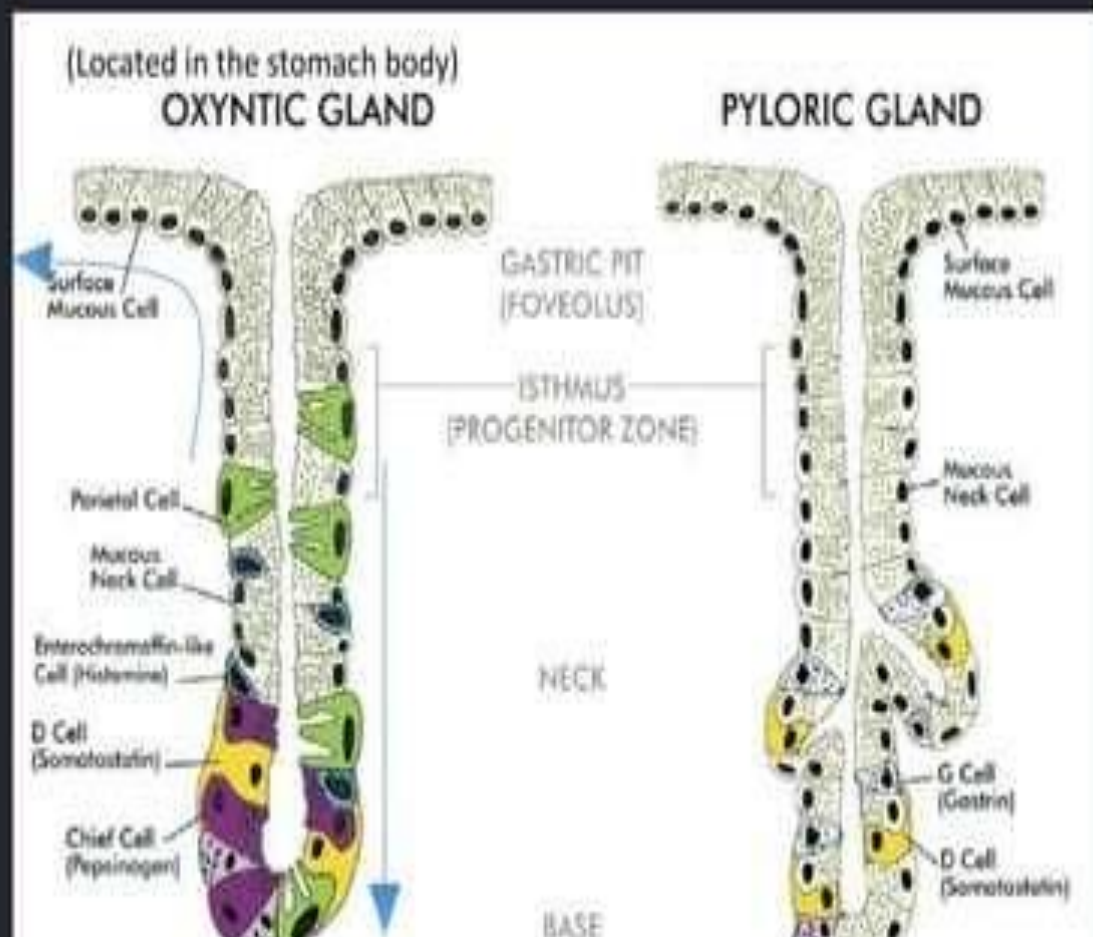


Gastric Glands

- Cells line the gastric pits with differing products
 - Acid secretion
 - Mucus secretion
 - Bicarbonate secretion
 - Hormone secretion



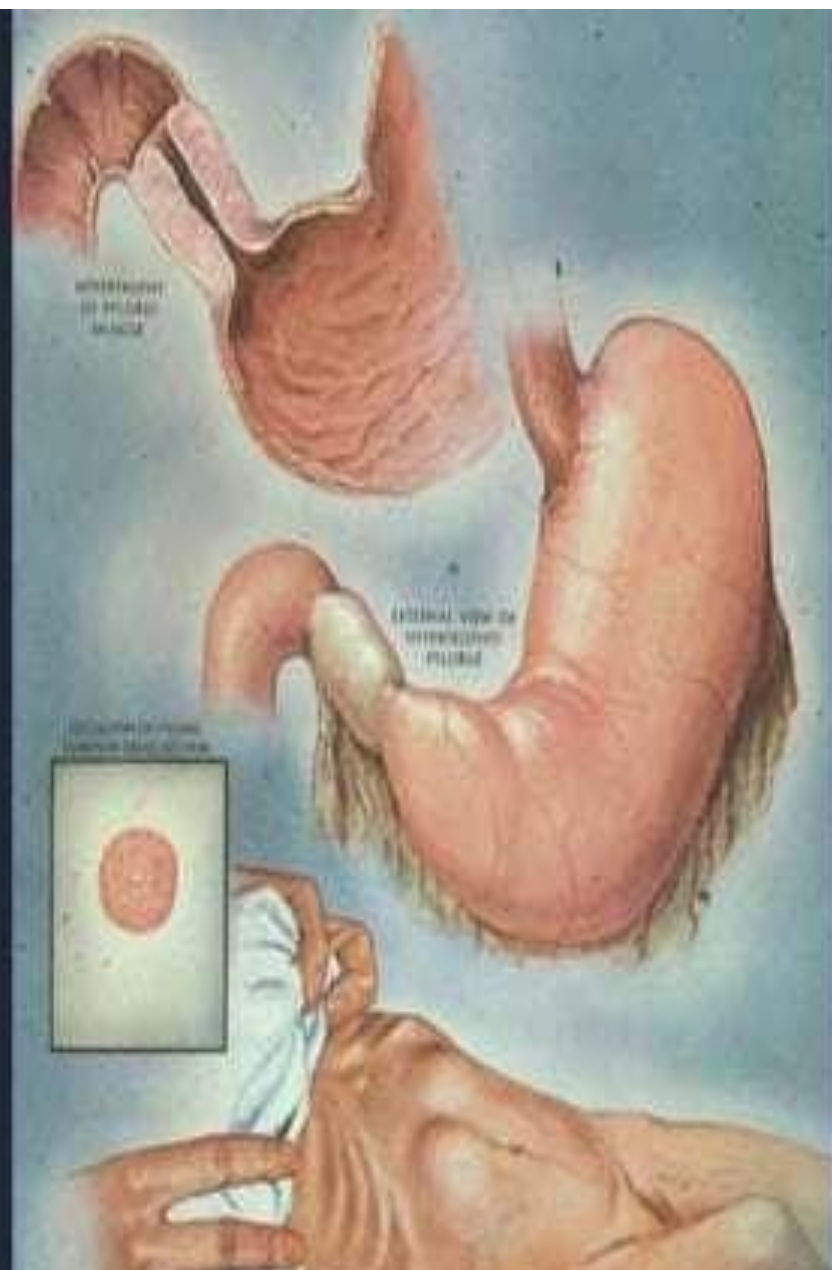
Endocrine Cells of Stomach



Pyloric Stenosis

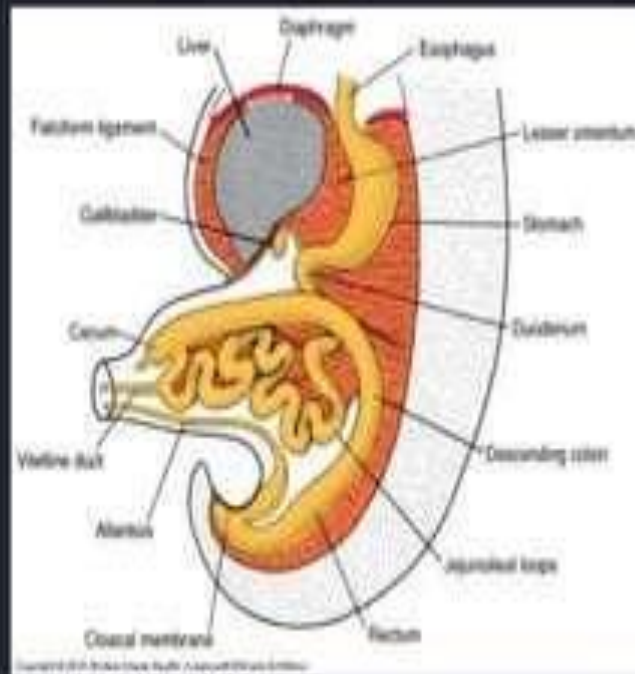
- Rather common malformation: present in 0.5% - 0.1% of infants
- Characterized by very forceful (aka "projectile"), non-bilious vomiting ~1hr. after feeding (when pyloric emptying would occur).
NOTE: the presence of bile would indicate POST-duodenal obstruction of some sort.
- Hypertrophied sphincter can often be palpated as a spherical nodule; peristalsis of the sphincter seen/felt under the skin.
- Stenosis is due to overproliferation / hypertrophy of pyloric sphincter... NOT an error in re-canalization.

- More common in males than females, so most likely has a genetic basis which is as yet undetermined.



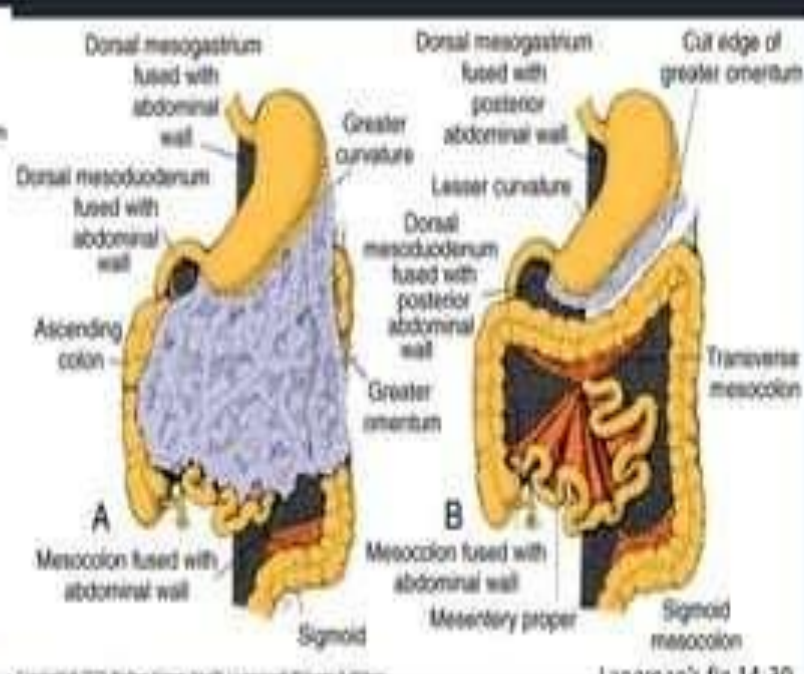
A closer look at the mesenteries

5 weeks



Langman's fig 14-26

Last trimester



Langman's fig 14-30

- The stomach and liver are suspended in a mesentery that is attached to the dorsal AND ventral body walls
 - Dorsal mesentery of stomach becomes the greater omentum
 - Ventral mesentery of stomach/dorsal mesentery of the liver becomes the lesser omentum
 - Ventral mesentery of the liver becomes the falciform ligament

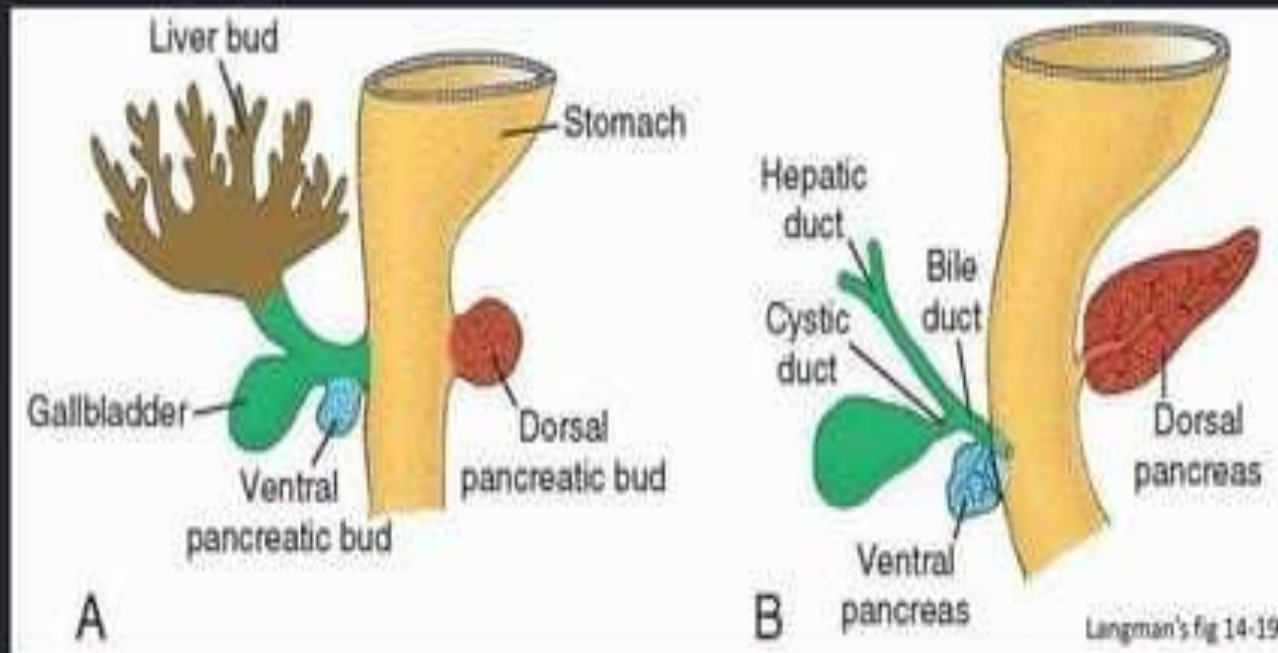
Liver

- **Day 22** an endodermal thickening begins in the wall of the duodenum called the **hepatic plate**.
- The cells of the hepatic plate proliferate to form the **hepatic diverticulum** which grows into the septum transversum.
- Hepatic diverticulum gives rise to **liver cords** which become the **hepatocytes**.
- The supporting stromal cells of the liver come from splanchnic mesoderm near the stomach
- The liver is also a fetal haematopoietic organ. The blood stem cells are derived from mesenchyme of the septum transversum.
- **Day 26** endodermal thickening appears on the ventral side of the duodenum just caudal to the hepatic diverticulum called the **cystic diverticulum** which will form the gall bladder and the cystic duct.

Pancreas

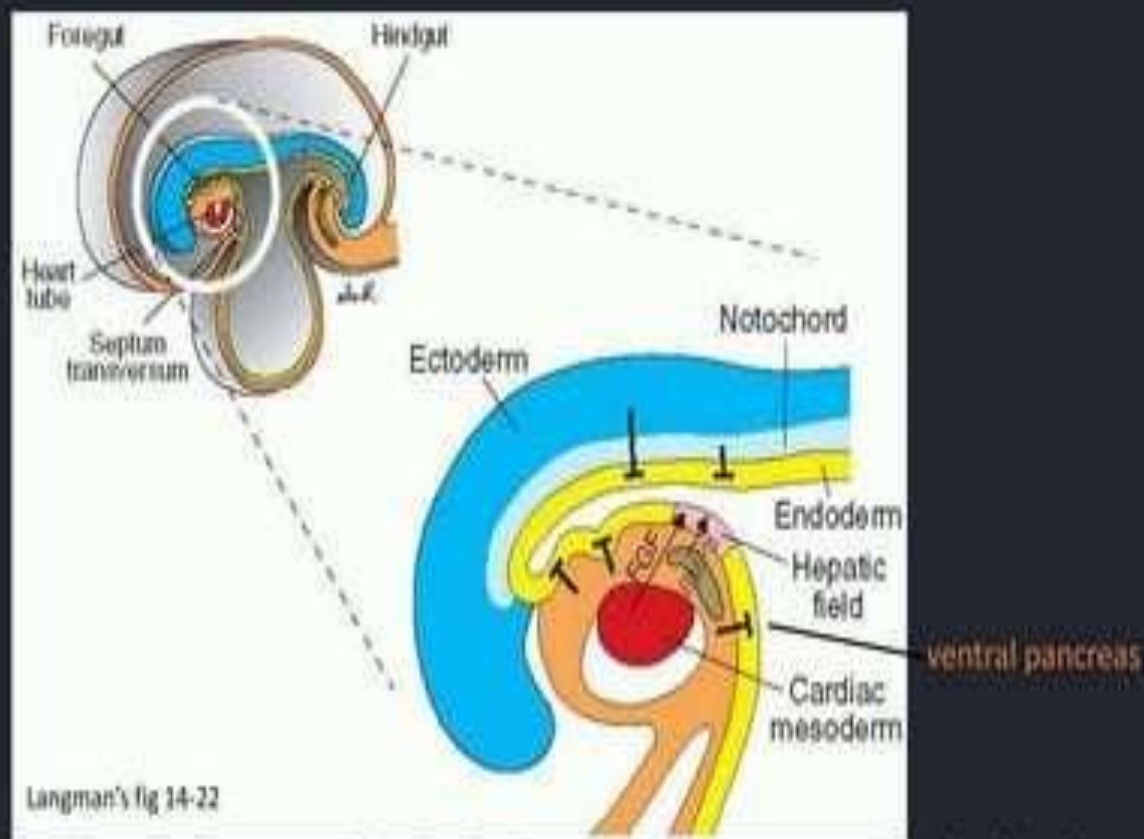
- **1. Development.**
- The **dorsal pancreatic bud** is a direct outgrowth of foregut endoderm, whose formation is induced by the notochord. The **ventral pancreatic bud** is a direct outgrowth of foregut endoderm, whose formation is induced by hepatic mesoderm. Within both pancreatic buds, endodermal tubules surrounded by mesoderm branch repeatedly to form acinar cells and ducts (i.e., exocrine pancreas). Isolated clumps of endodermal cells bud from the tubules and accumulate within the mesoderm to form **islet cells** (i.e., endocrine pancreas) in the following sequence (first S last): **alpha cells** (glucagon) S **beta cells** (insulin) S **delta cells** (somatostatin) and **PP cells** (pancreatic polypeptide). Because of the 90° clockwise rotation of the duodenum, the ventral bud rotates dorsally and fuses with the dorsal bud to form the definitive adult pancreas. The ventral bud forms the **uncinate process** and a **portion of the head of the pancreas**. The dorsal bud forms the **remaining portion of the head, body, and tail of the pancreas**.

Regional Organogenesis: Liver & Pancreas



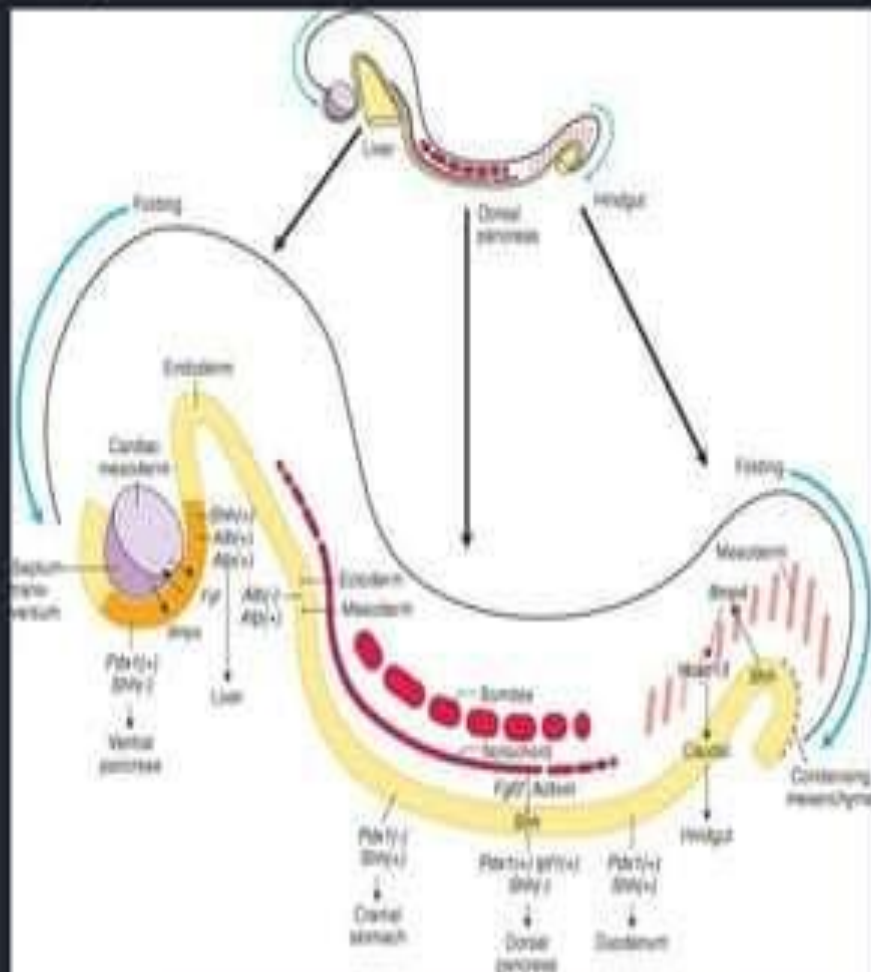
- Liver and pancreas arise in the 4th week from foregut endoderm in response to signals from nearby mesoderm
- Pancreas actually has ventral and dorsal components, each specified in a different manner

Cardiac mesoderm and septum transversum specifies liver and ventral pancreas (sort of...)

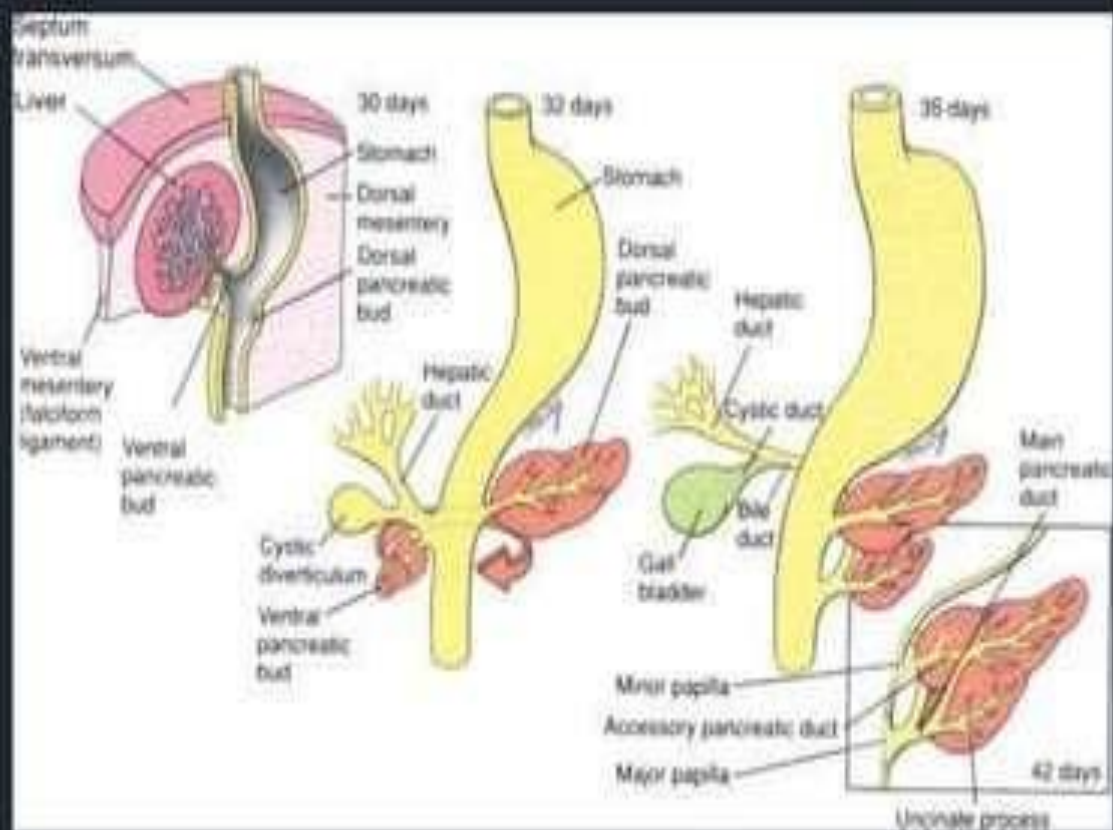


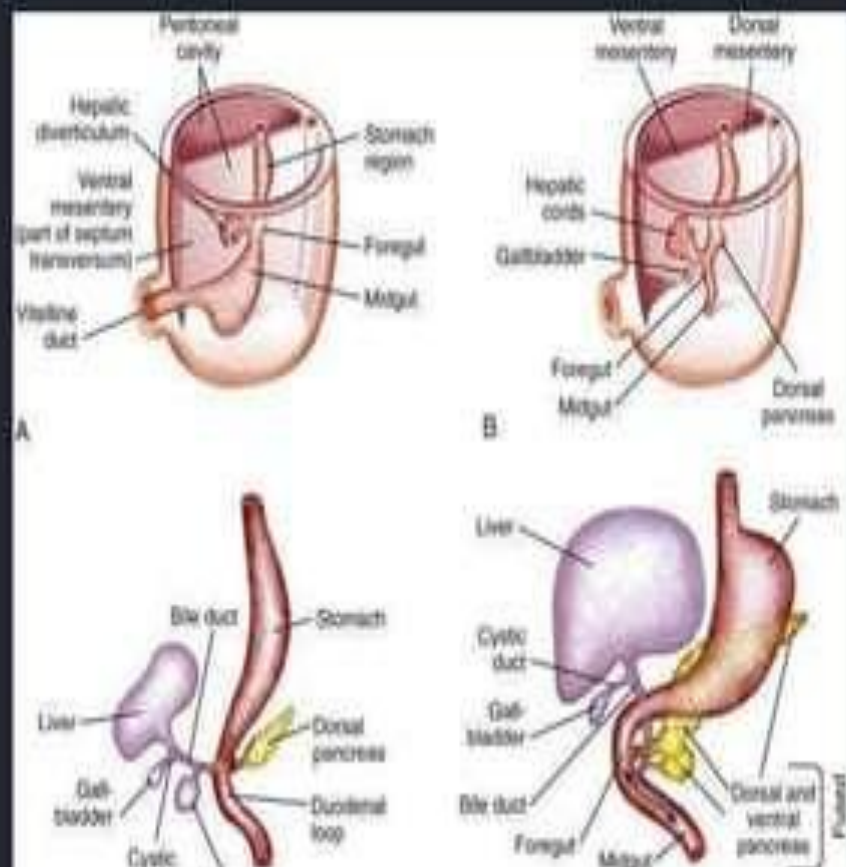
- ALL foregut endoderm has the potential to develop into either liver or pancreas but local signals repress these fates (mesodermal Wnts \downarrow Liver; mesodermal Wnts + endodermal Shh \downarrow Pancreas)
- FGFs and BMPs from cardiac mesoderm and septum transversum inhibit Wnt signaling, but the endoderm still expresses Shh and thus develops into liver.

The dorsal pancreas is specified by signaling from the notochord



- The main pancreatic duct is formed by the anastomosis of the **distal two thirds of the dorsal pancreatic duct** (the proximal one third regresses) and the **entire ventral pancreatic duct** (48% incidence). The main pancreatic duct and common bile duct form a single opening (**hepatopancreatic ampulla of Vater**) into the duodenum at the tip of a major papillae (**hepatopancreatic papillae**).





- **2. Sources.** Acinar cells, islet cells, and simple columnar or cuboidal epithelium lining the pancreatic ducts of the definitive pancreas are derived from endoderm. Surrounding connective tissue and vascular components of the definitive pancreas are derived from visceral mesoderm.
- **3. Clinical considerations**
 - **a. Accessory pancreatic duct:** develops when the proximal one third of the dorsal pancreatic duct persists and opens into the duodenum through minor papillae at a site proximal to the ampulla of Vater (33% incidence).

60%

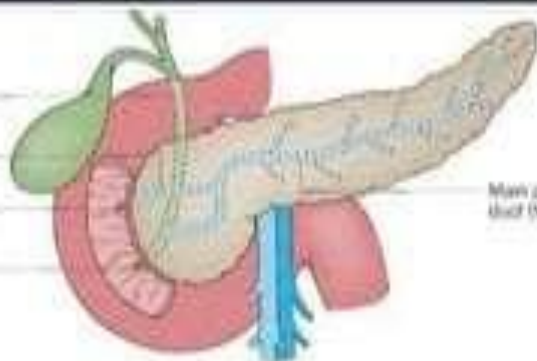
Common duct

Accessory pancreatic duct

Accessory ampulla

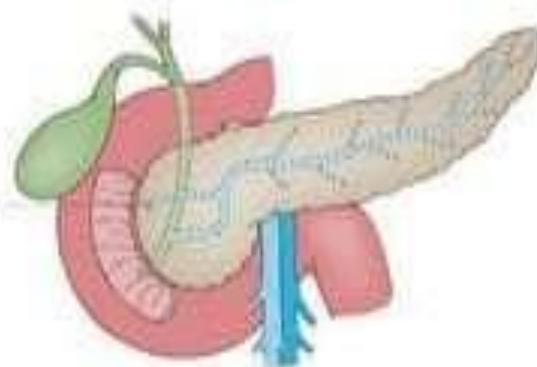
Ampulla of Vater

Main pancreatic duct (Wirsung)



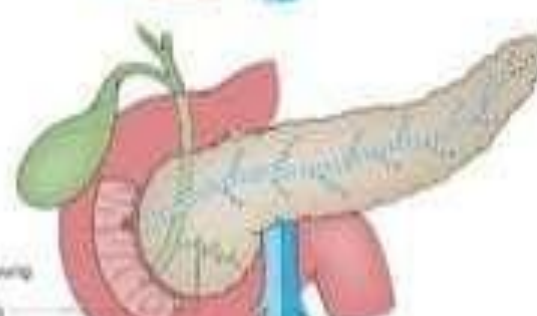
30%

Third accessory duct

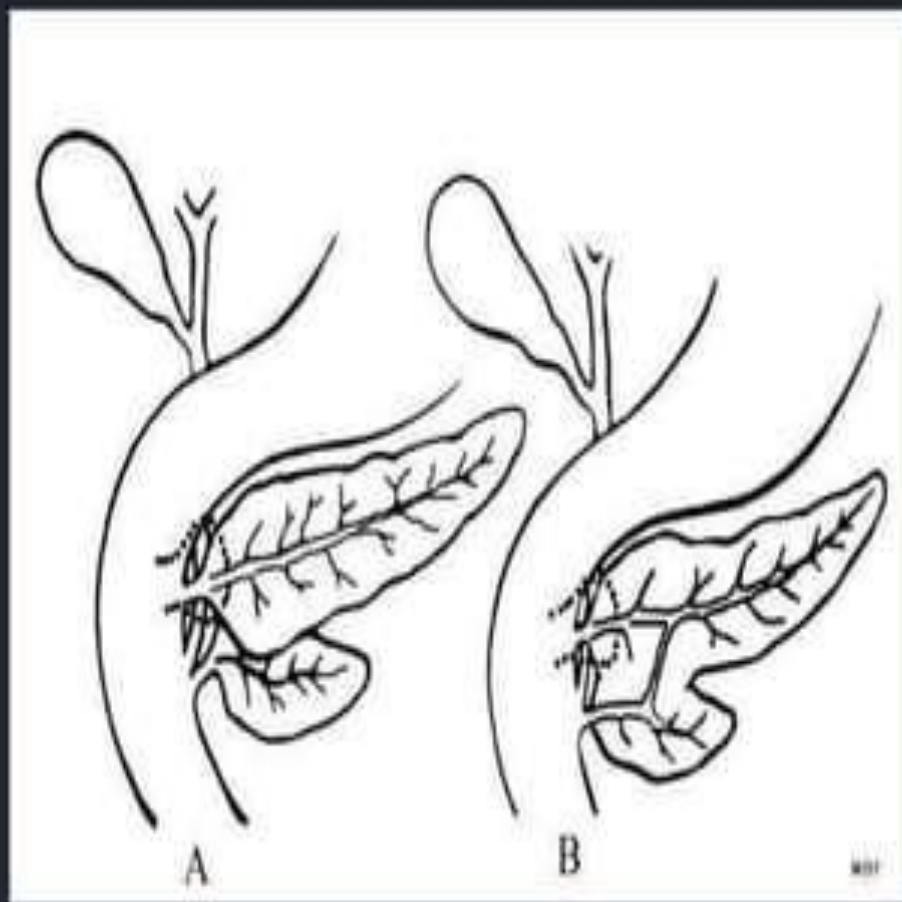


10%

Atrophic duct of Wirsung (processus duodeni) (progressively atrophied)

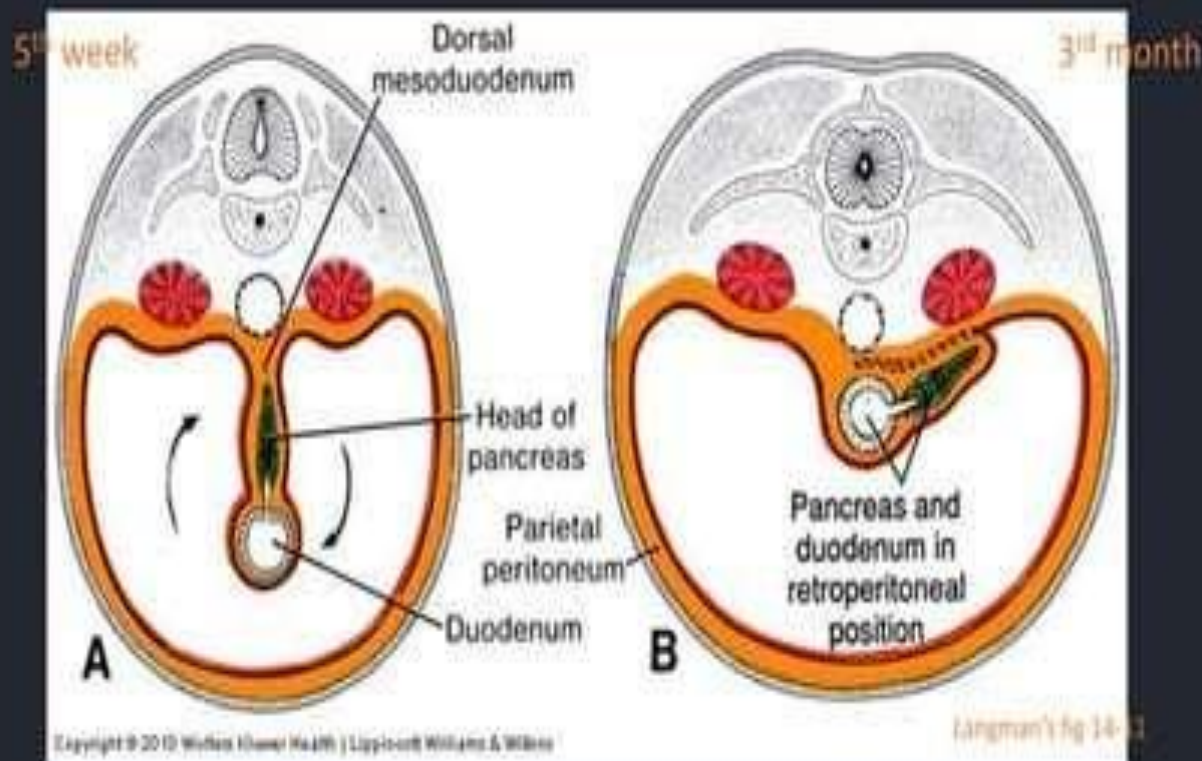


- **b. Pancreas divisum:** occurs when the **distal two thirds of the dorsal pancreatic duct** and the **entire ventral pancreatic duct** fail to anastomose and the proximal one third of the dorsal pancreatic duct persists, thereby forming two separate duct systems (4% incidence). The dorsal pancreatic duct drains a **portion of the head, body, and tail of the pancreas** by opening into the duodenum through minor papillae. The ventral pancreatic duct drains the **uncinate process** and a **portion of the head of the pancreas** by opening into the duodenum through the major papillae. Patients with pancreas divisum are prone to pancreatitis, especially if the opening of the dorsal pancreatic duct at the minor papillae is small. Note that the distal two thirds of the dorsal pancreatic duct and the ventral pancreatic bud fail to anastomose, thereby forming two separate duct systems.

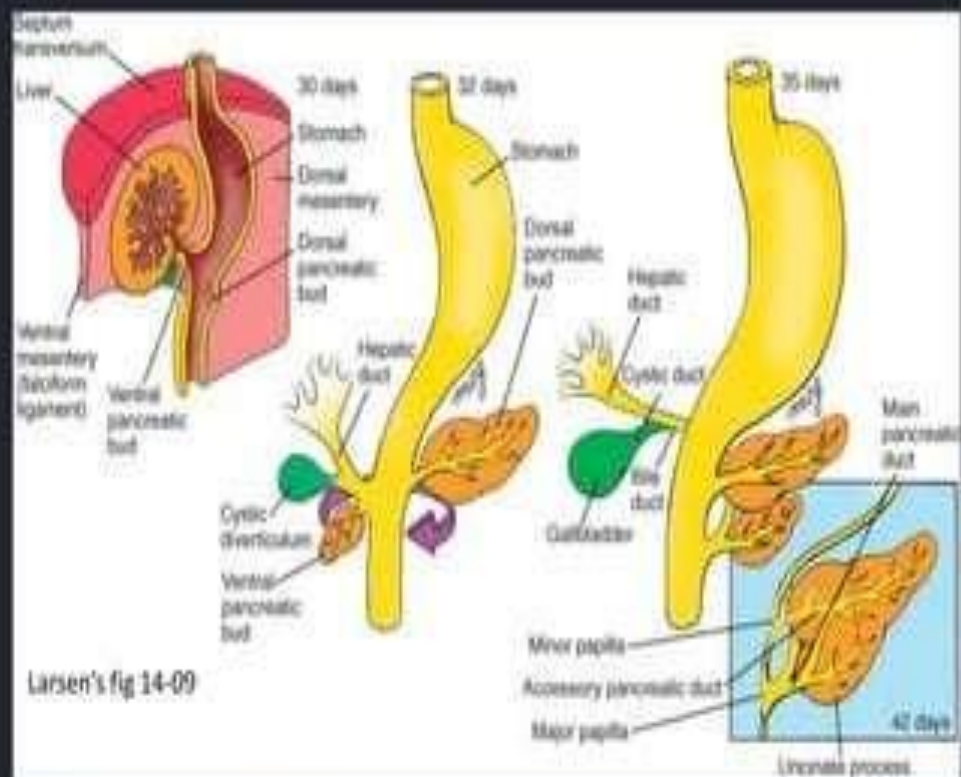


- **c. Annular pancreas:** occurs when the ventral pancreatic bud fuses with the dorsal bud both dorsally and ventrally, thereby forming a **ring of pancreatic tissue** around the duodenum and causing severe **duodenal obstruction**. Newborns and infants are intolerant of oral feeding and often have bilious vomiting. Radiographic evidence of an annular pancreas is indicated by a duodenal obstruction, where a **“double bubble” sign** is often seen due to dilation of the stomach and distal duodenum (also associated with Down syndrome).

Rotation of the duodenum also causes it and the pancreas to become SECONDARILY retroperitoneal



Secondarily retroperitoneal - a structure that was originally in the body cavity but



Rotation of the duodenum brings the ventral and dorsal pancreas together



Aberrations in this process may result in an annular pancreas, which can constrict the duodenum.

Also, since the dorsal and ventral pancreas arise by different mechanisms, it's possible that one or the other may be absent in the adult.

Spleen

The spleen is formed from mesodermal derivatives

It develops within the dorsal mesogastrium not from gut tube endoderm

It initially forms as a mesenchymal condensation in the 5th week
The spleen translocates to the left side during the rotation of the stomach

The spleen is initially a haematopoietic organ and only becomes a lymphoid organ later on at 15-18 weeks when lymphoid colonization occurs

Intraperitoneal vs. retroperitoneal vs. secondarily retroperitoneal

