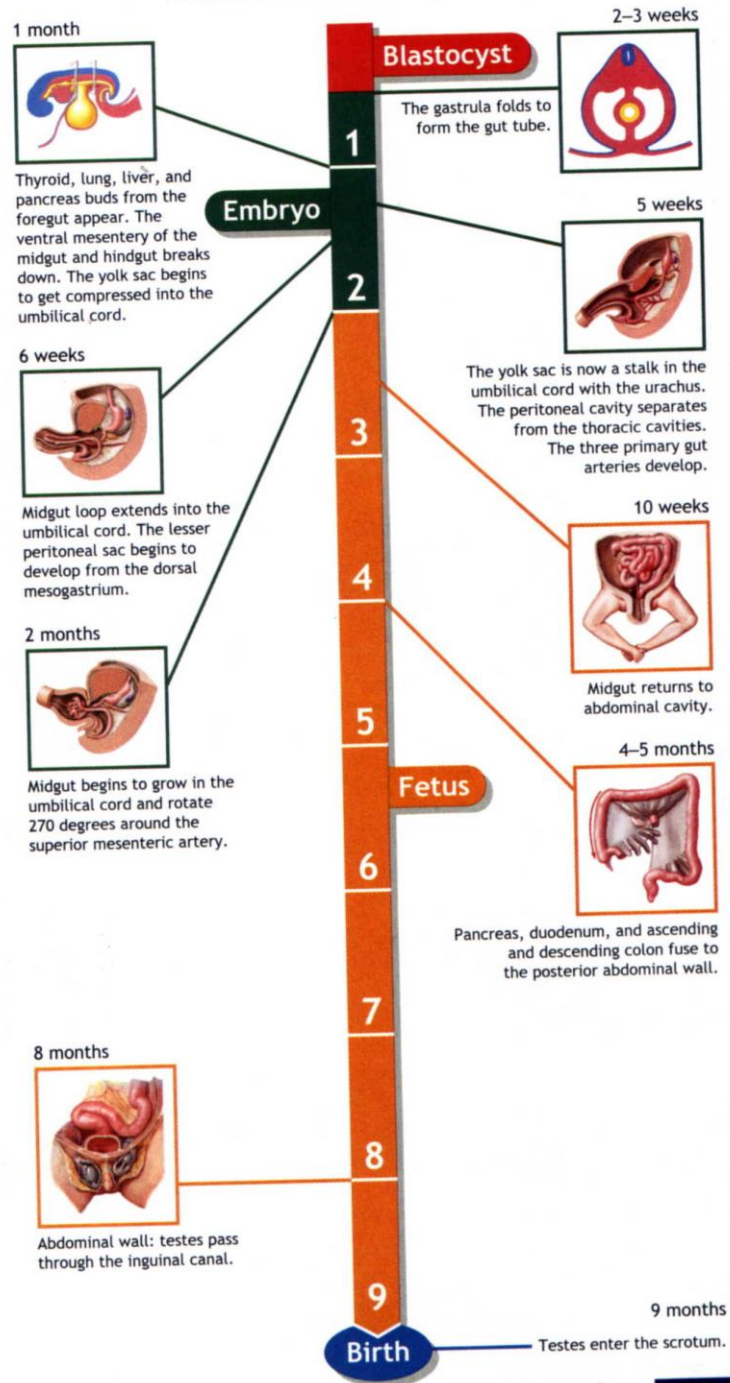


# Development of the Digestive System

*W.S. O*

*The University of Hong Kong*

# Prenatal Time Scale (Months)



1 month



Thyroid, lung, liver, and pancreas buds from the foregut appear. The ventral mesentery of the midgut and hindgut breaks down. The yolk sac begins to get compressed into the umbilical cord.

6 weeks



Midgut loop extends into the umbilical cord. The lesser peritoneal sac begins to develop from the dorsal mesogastrium.

2 months



Midgut begins to grow in the umbilical cord and rotate 270 degrees around the superior mesenteric artery.

8 months



Abdominal wall: testes pass through the inguinal canal.

2-3 weeks



**Blastocyst**

The gastrula folds to form the gut tube.

5 weeks



The yolk sac is now a stalk in the umbilical cord with the urachus. The peritoneal cavity separates from the thoracic cavities. The three primary gut arteries develop.

10 weeks



Midgut returns to abdominal cavity.

4-5 months



Pancreas, duodenum, and ascending and descending colon fuse to the posterior abdominal wall.

9 months

Testes enter the scrotum.

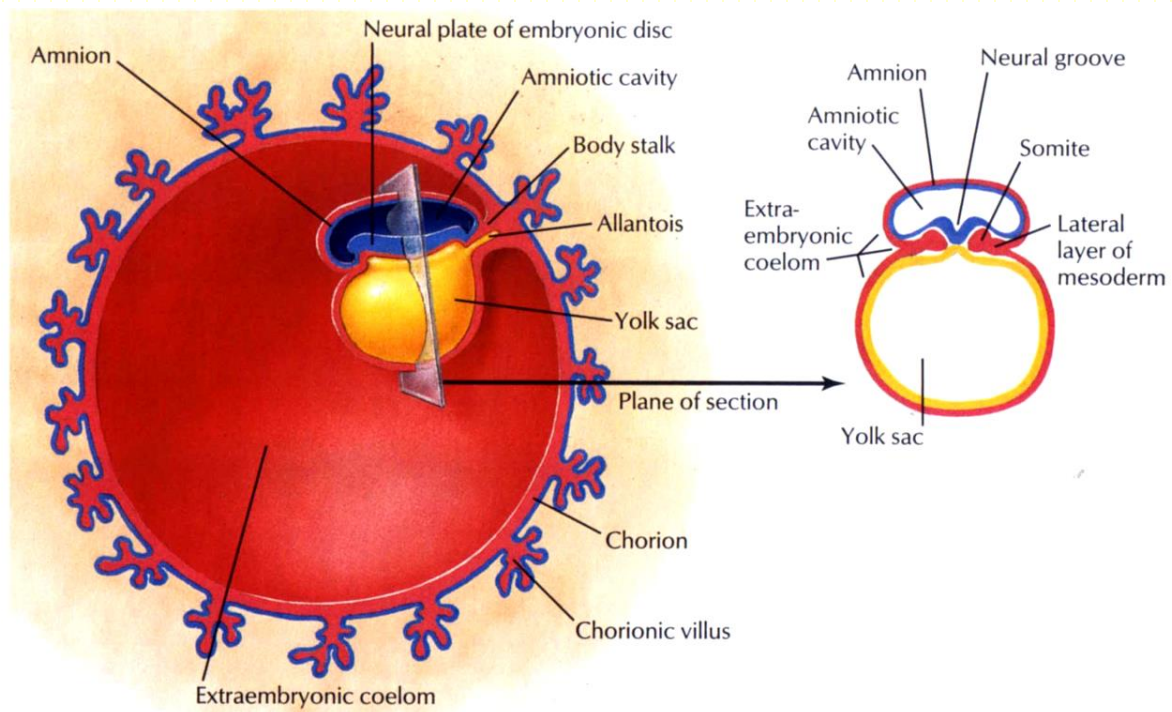
**Birth**

# Plan for the GI system

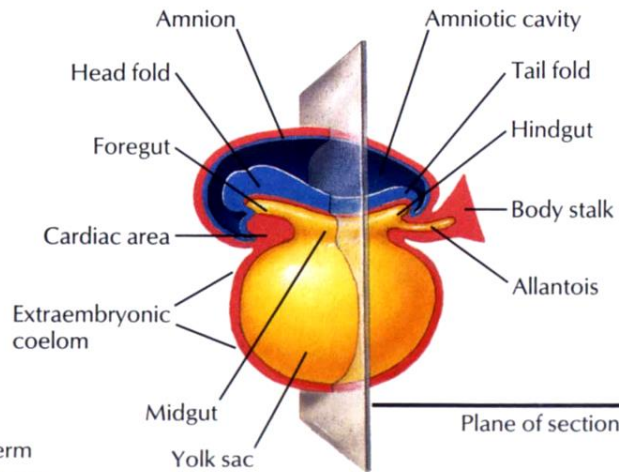
- Then GI system in the abdomen first develops as a tube suspended by dorsal and ventral mesenteries. Blood vessels, autonomic nerves, lymphatic drainage are organized according to abdominal foregut, midgut and hindgut subdivisions.
- The basic relationships persist, but the adult form appears complex because of five developments:
  - (1) rotation of the foregut tube 90° clockwise;
  - (2) dorsal mesentery persists in all subdivisions while ventral mesentery only persists in foregut;
  - (3) rotation of the midgut 270° around the superior mesenteric artery,
  - (4) tremendous growth of the midgut

# Organization of the GI tract:

- **Foregut** (abdominal part) supplied by *coeliac trunk*; derivatives include oral cavity, oesophagus, stomach, duodenum, liver, gall bladder and pancreas
- **Midgut** supplied by *superior mesenteric artery*; derivatives include duodenum, small intestine, caecum, anterior 2/3 transverse colon
- **Hindgut** supplied by *inferior mesenteric artery*; derivatives include distal 1/3 transverse colon, descending colon, sigmoid colon, rectum and upper part of anal canal

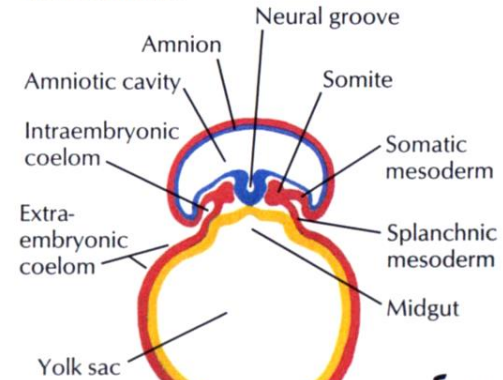


**C. 16 days**



- KEY**
- Endoderm
  - Mesoderm
  - Ectoderm

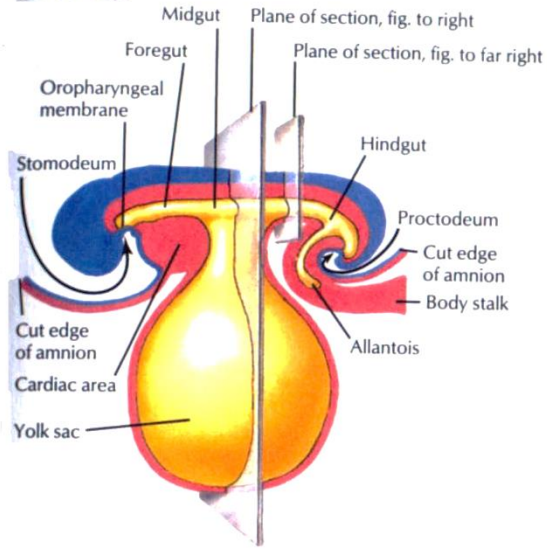
**D. Section of C**



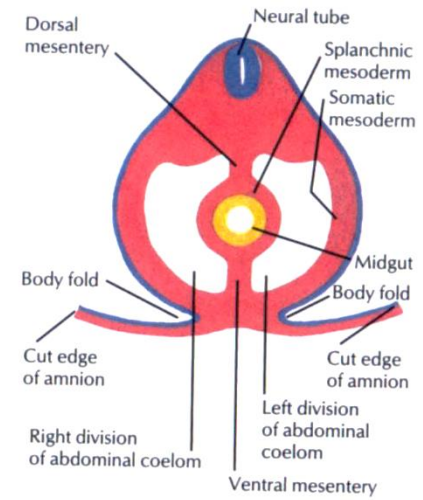
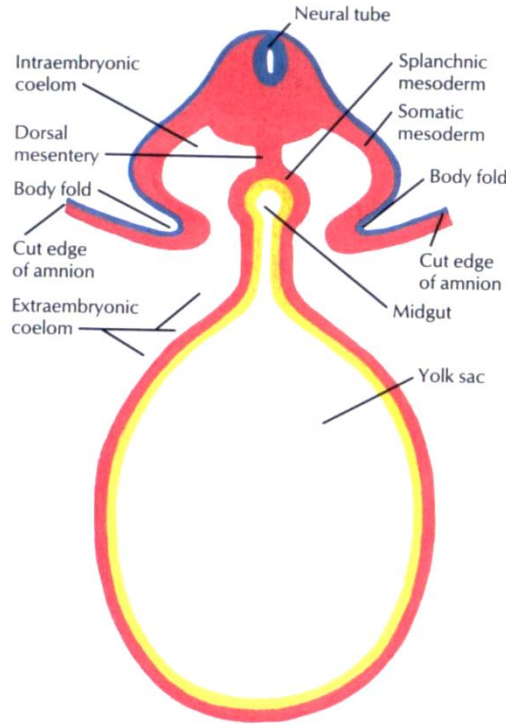
*F. Netter M.D.*  
© IGV



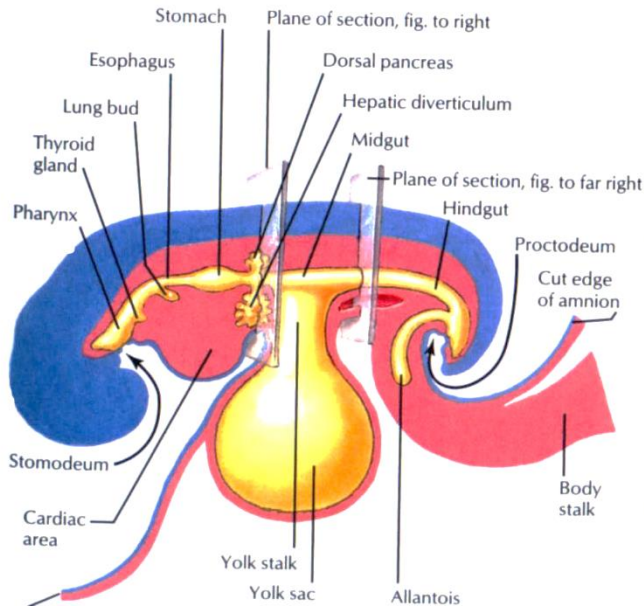
**A. 18 days**



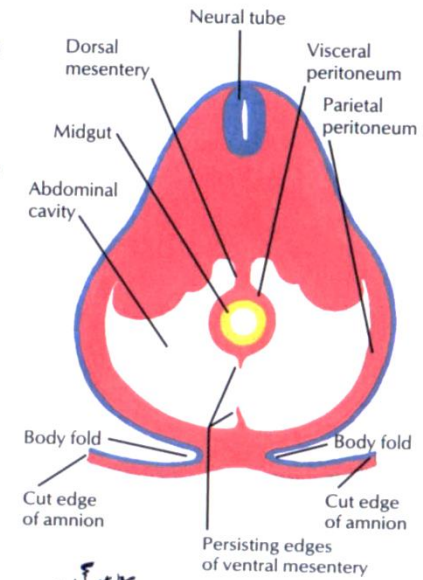
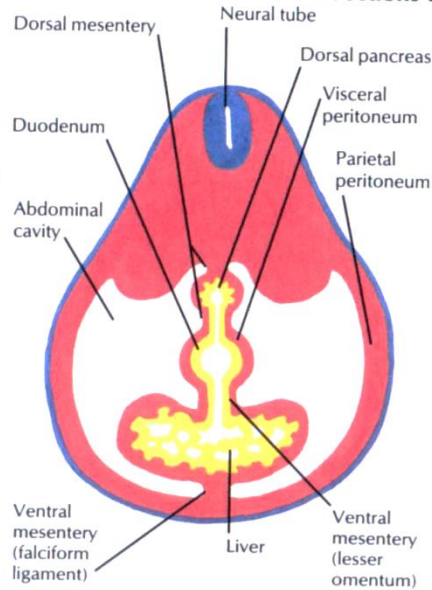
**B. Sections of A**

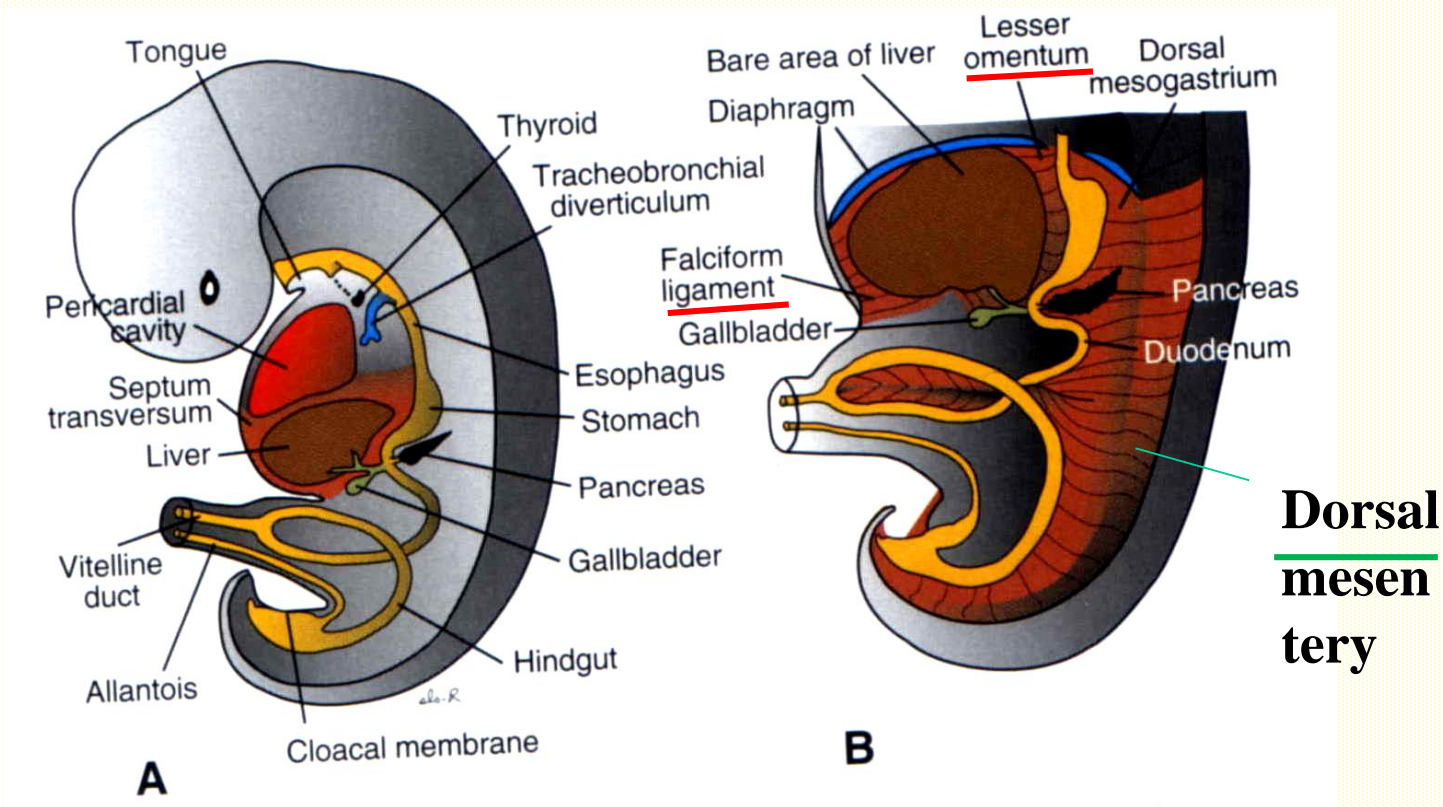


**C. 1 month**



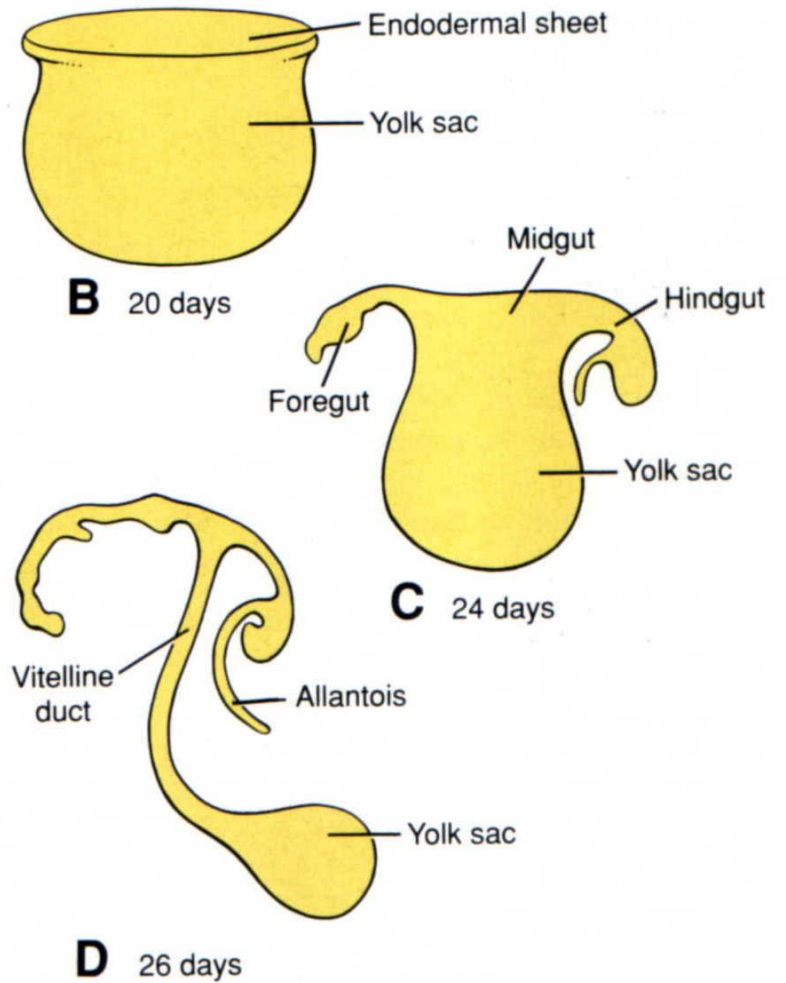
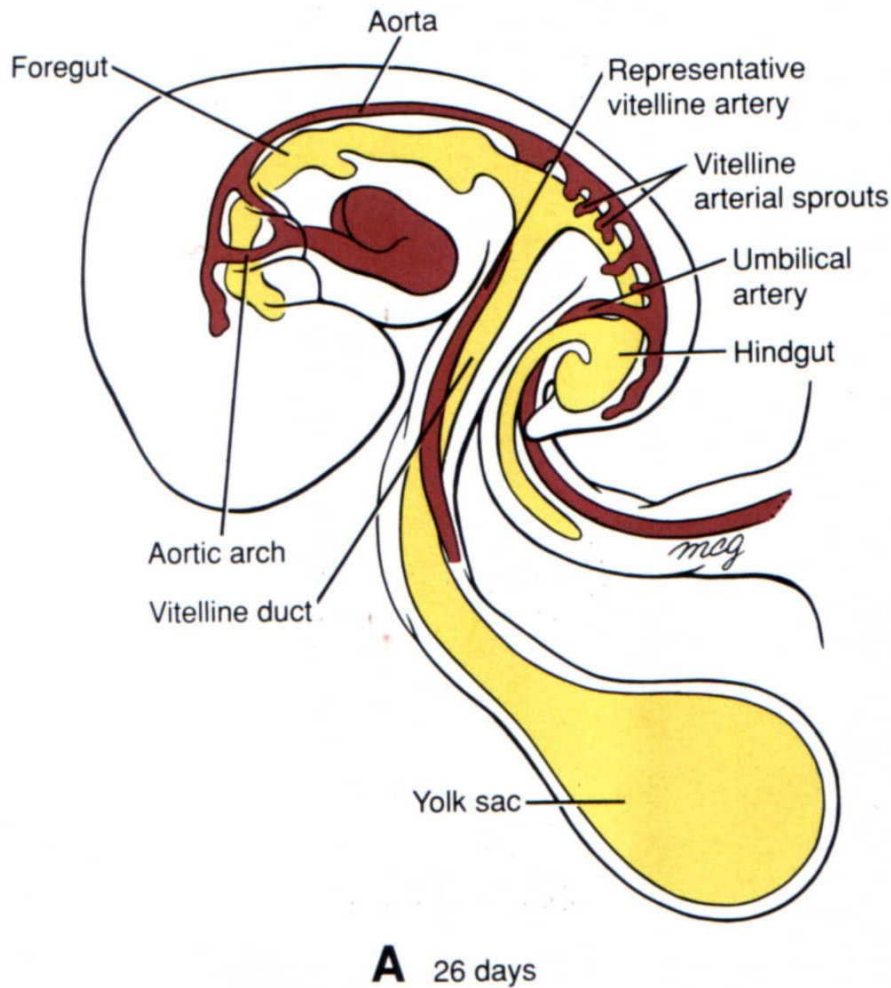
**D. Sections of C**





Layout of Foregut, midgut and hindgut

Dorsal and ventral mesenteries



## Development of the foregut, midgut & hindgut

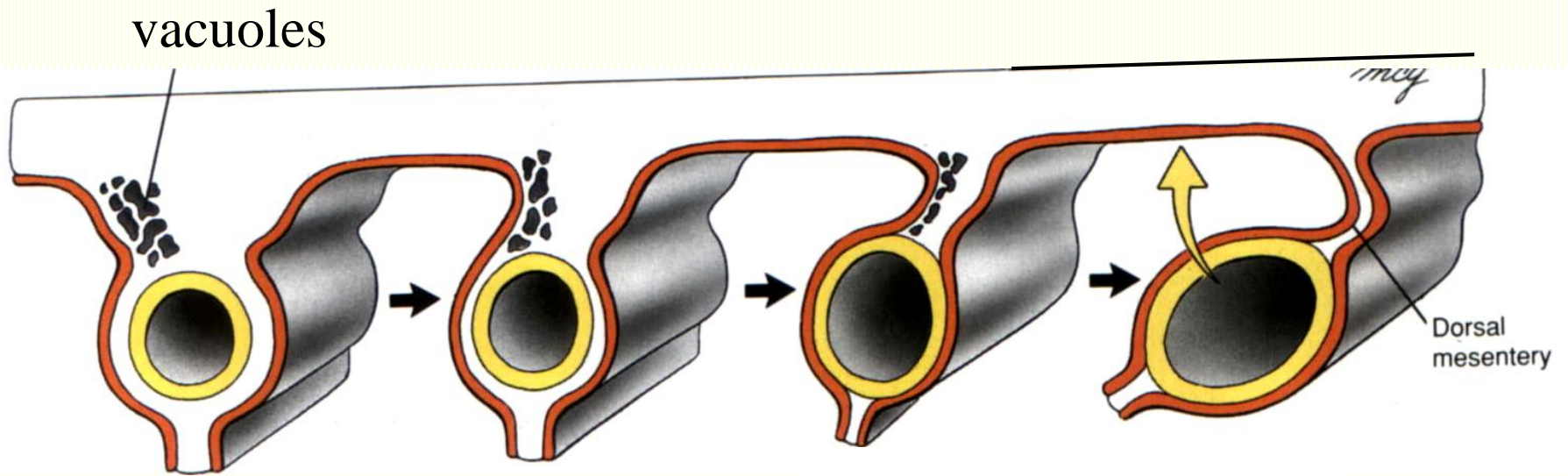


# Early gut development

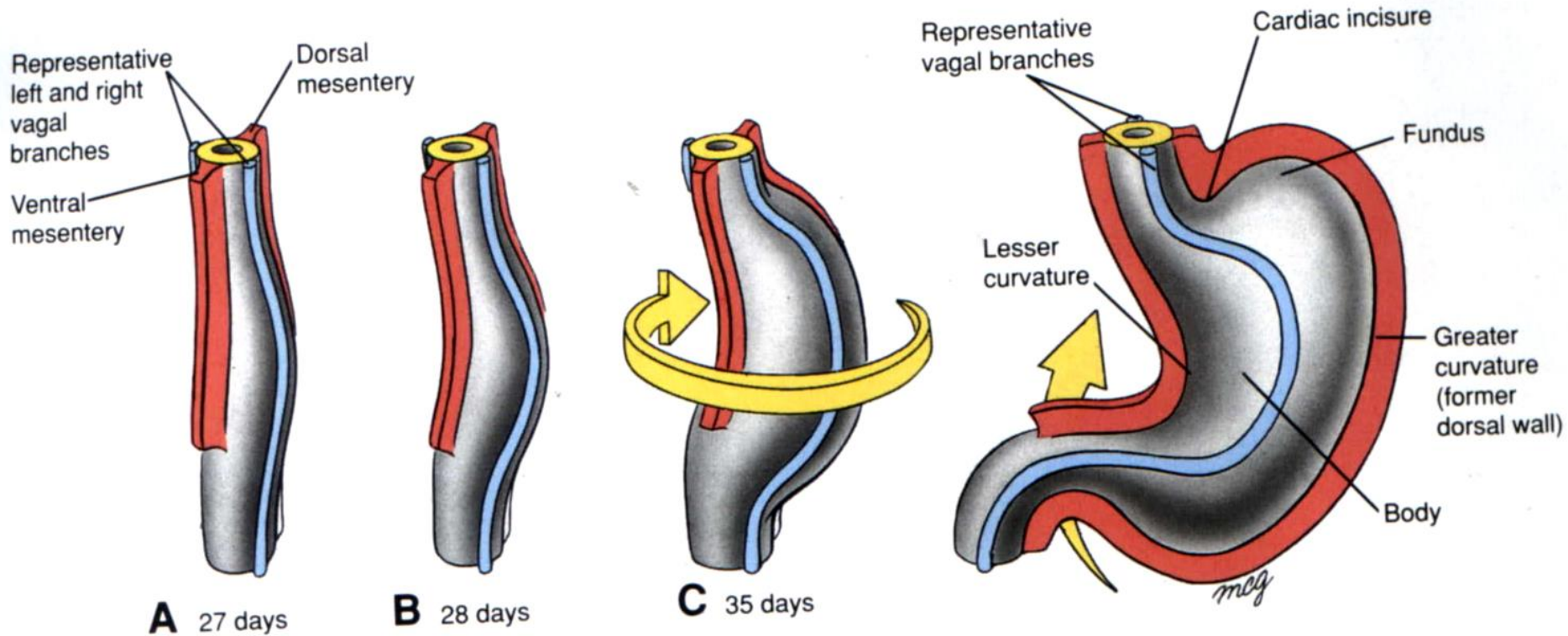
- **Coelom formation**
- **Buccopharyngeal membrane (perforates around 4<sup>th</sup> week) and cloacal membrane (~ 7<sup>th</sup> week)**
- **Primitive gut wall:**
  - epithelial lining & associated glands – endoderm**
  - Connective tissue & smooth muscle – surrounding mesoderm**

# Development of the distal foregut-1

- **Oesophagus –**
  - no coelomic cavity in thorax
  - slow growth
- **Stomach**
  - Rotate 90° (clockwise, longitudinal axis)
  - Rotate 90° (clockwise, AP axis)
  - Differential growth :
    - ventral border slow growth (*lesser curvature*)
    - dorsal border rapid growth (*greater curvature*)



**Rotation of the stomach around its longitudinal axis**



**Rotates at AP axis**

**Rotates at longitudinal axis**

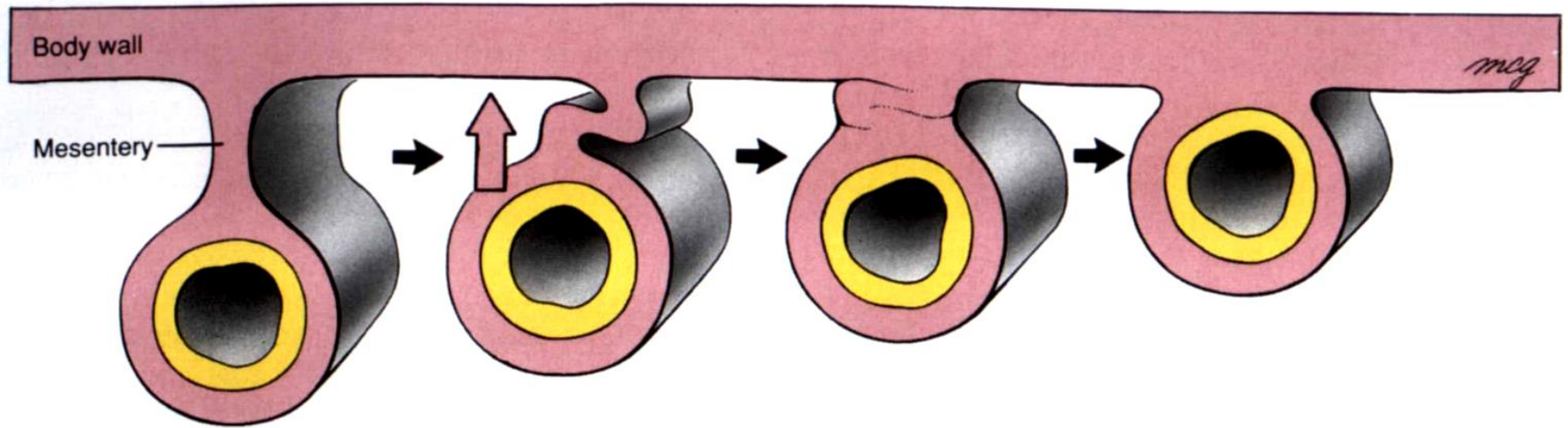
**D 56 days**

## Rotations of the stomach

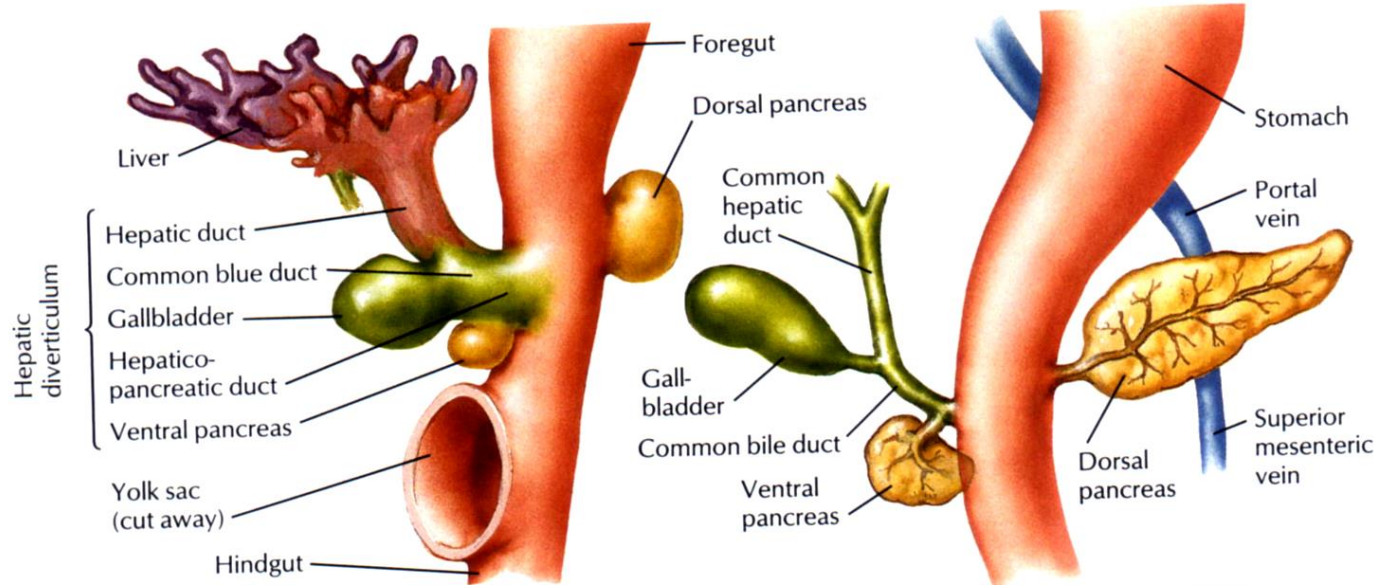
# Development of the distal foregut-2

- **Duodenum** pushed to the right and becomes *secondarily retroperitoneal*.
- **Liver & gall bladder** – ventral outgrowth from duodenum: *hepatic diverticulum* and *cystic diverticulum*
- **Pancreas** – **dorsal pancreatic bud** (*main gland* with head, body and tail) and **ventral pancreatic bud** (*uncinate process*); the two buds fuse after the stomach rotates.



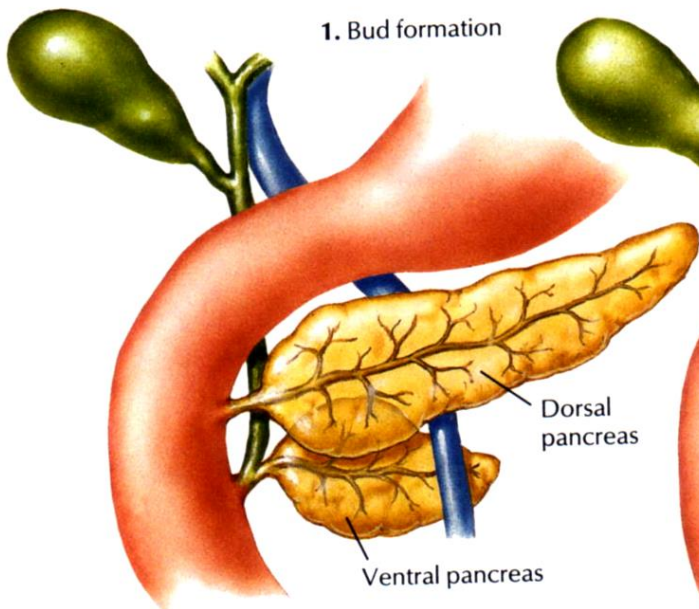


**Mechanism by which portions of the gut  
become secondarily retroperitoneal**

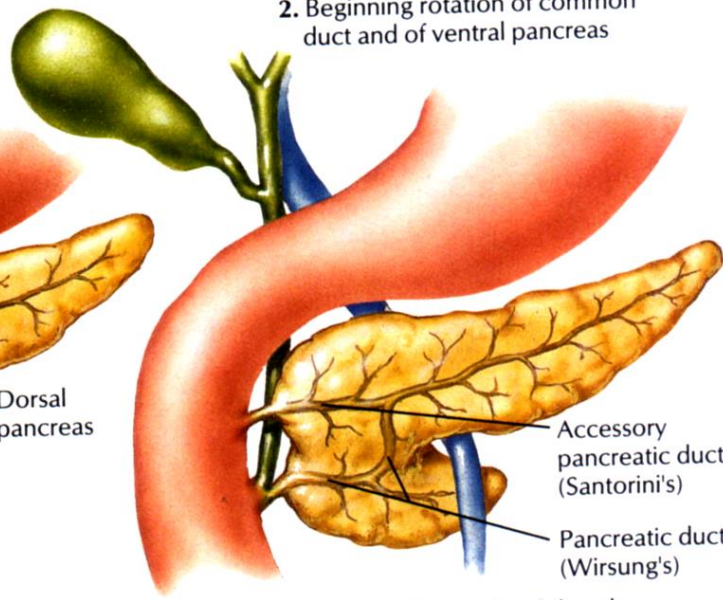


1. Bud formation

2. Beginning rotation of common duct and of ventral pancreas



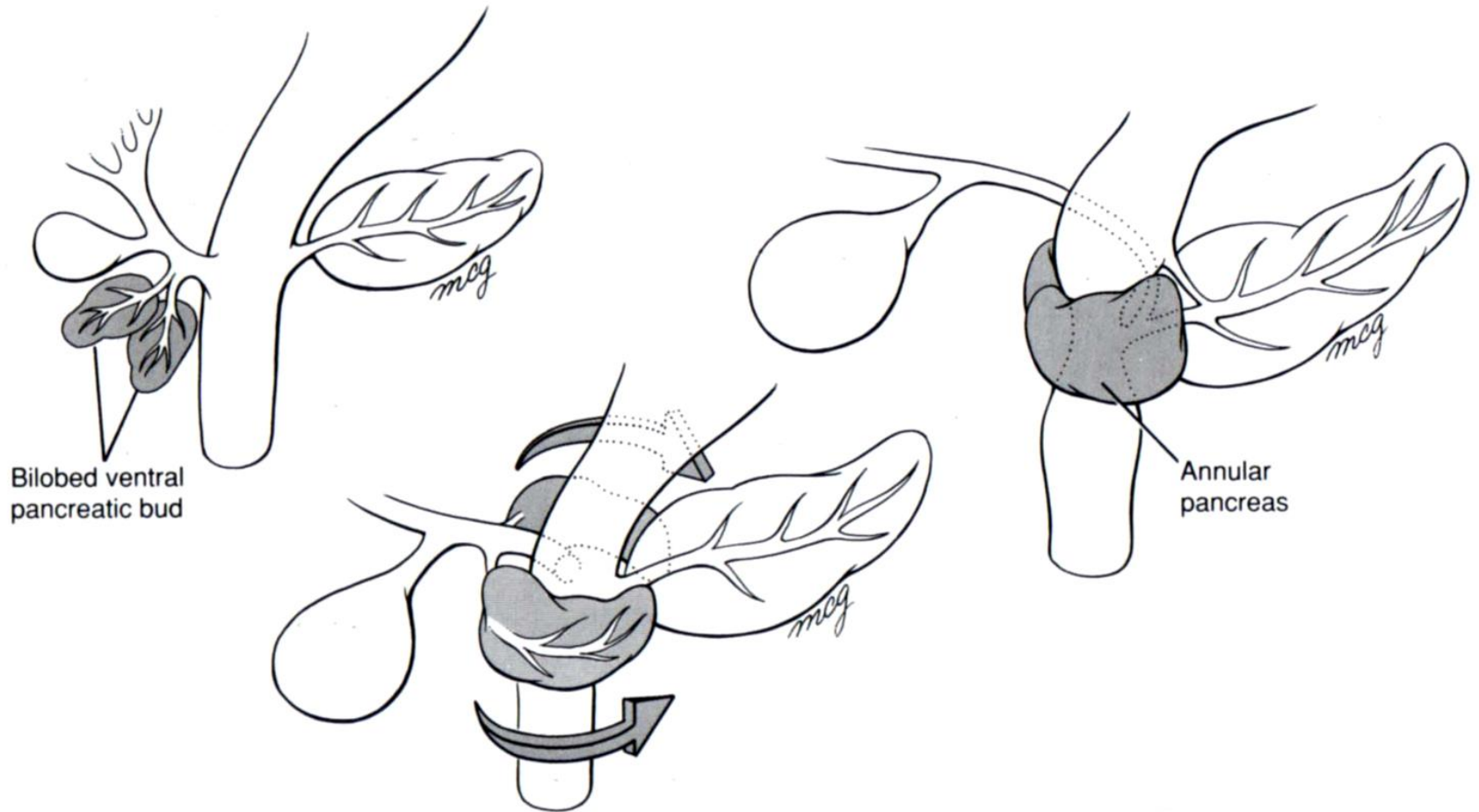
3. Rotation completed but fusion has not yet taken place



4. Fusion of ventral and dorsal pancreas and union of ducts

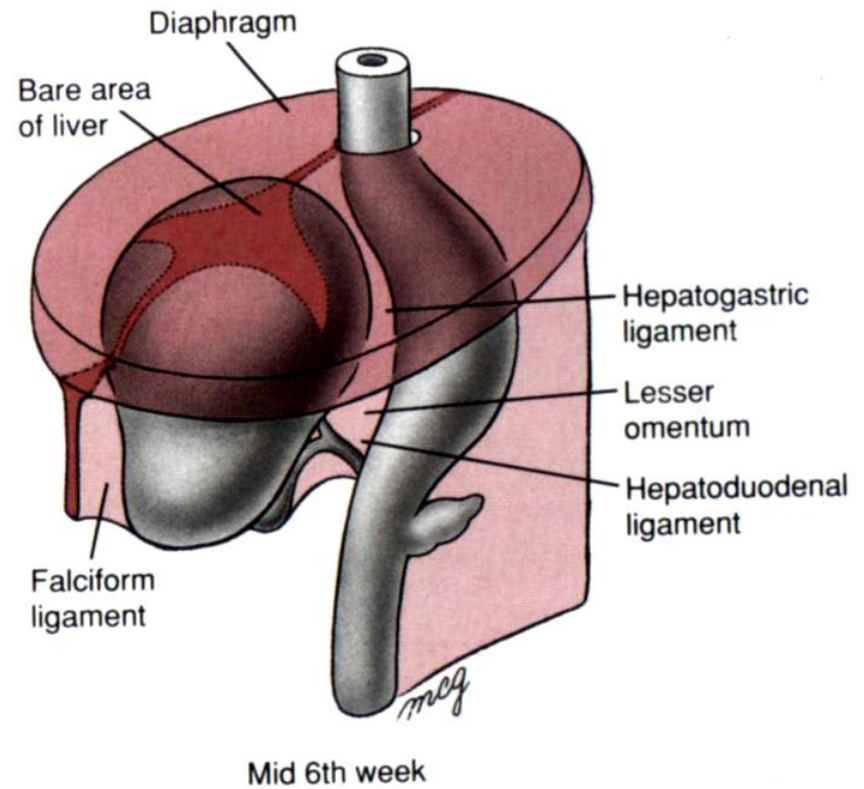
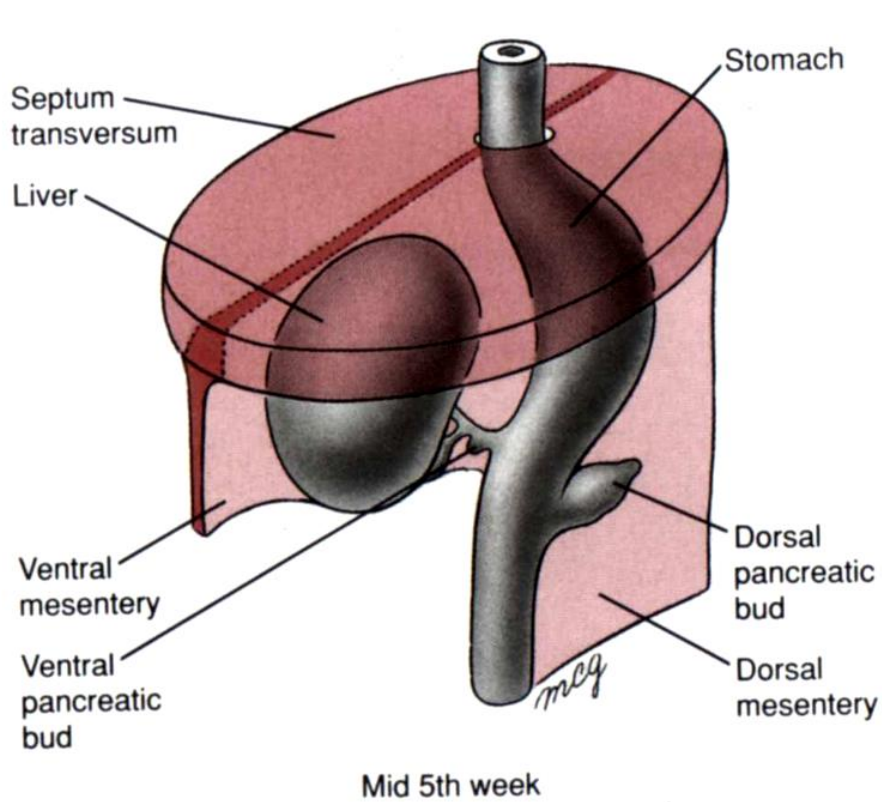
*F. Netter M.D.*  
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# Development of the liver and pancreas

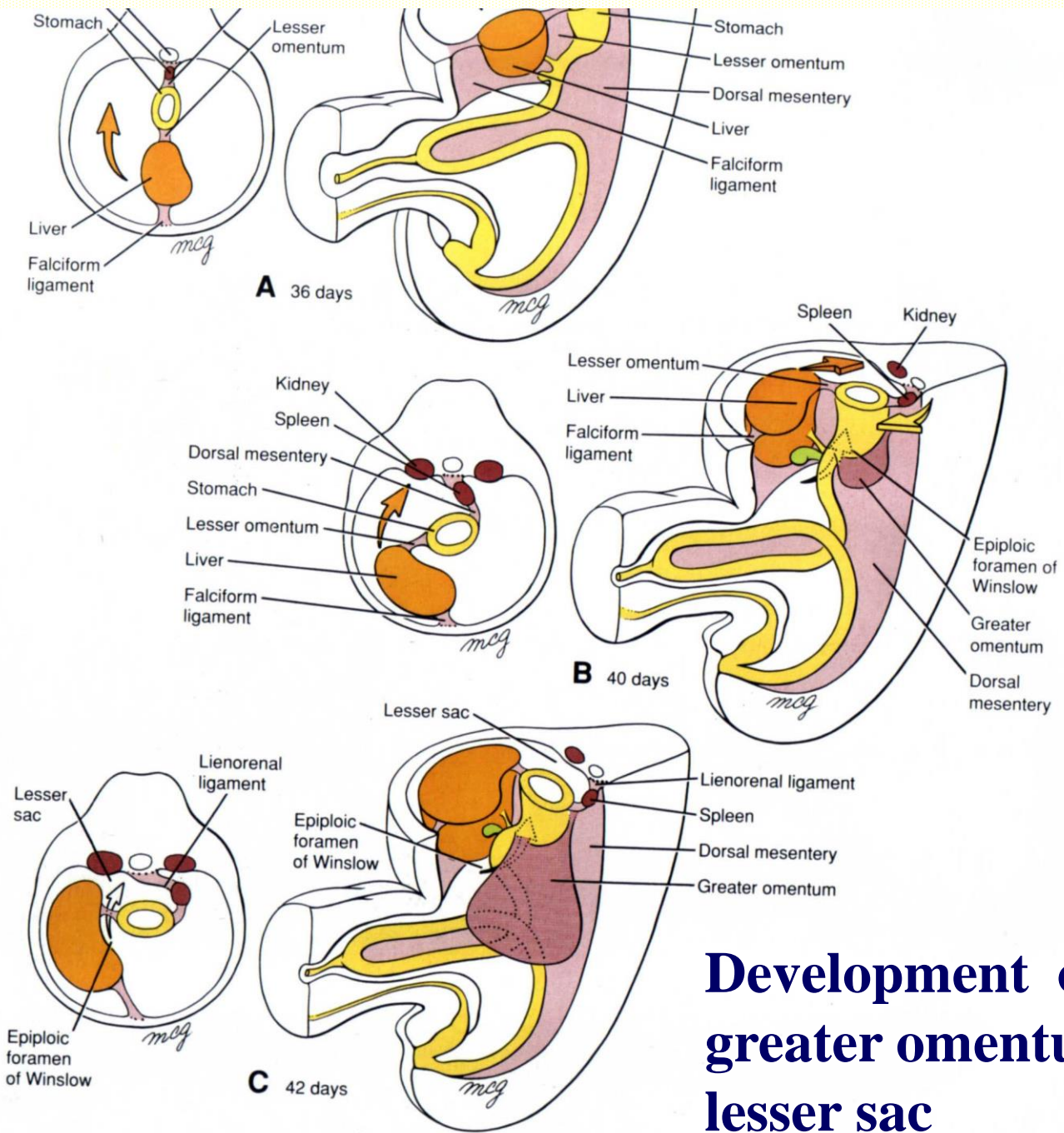


## Anomalous pancreas





## Formation of the liver and associated membranes



# Development of the greater omentum and lesser sac



# Development of the midgut - 1

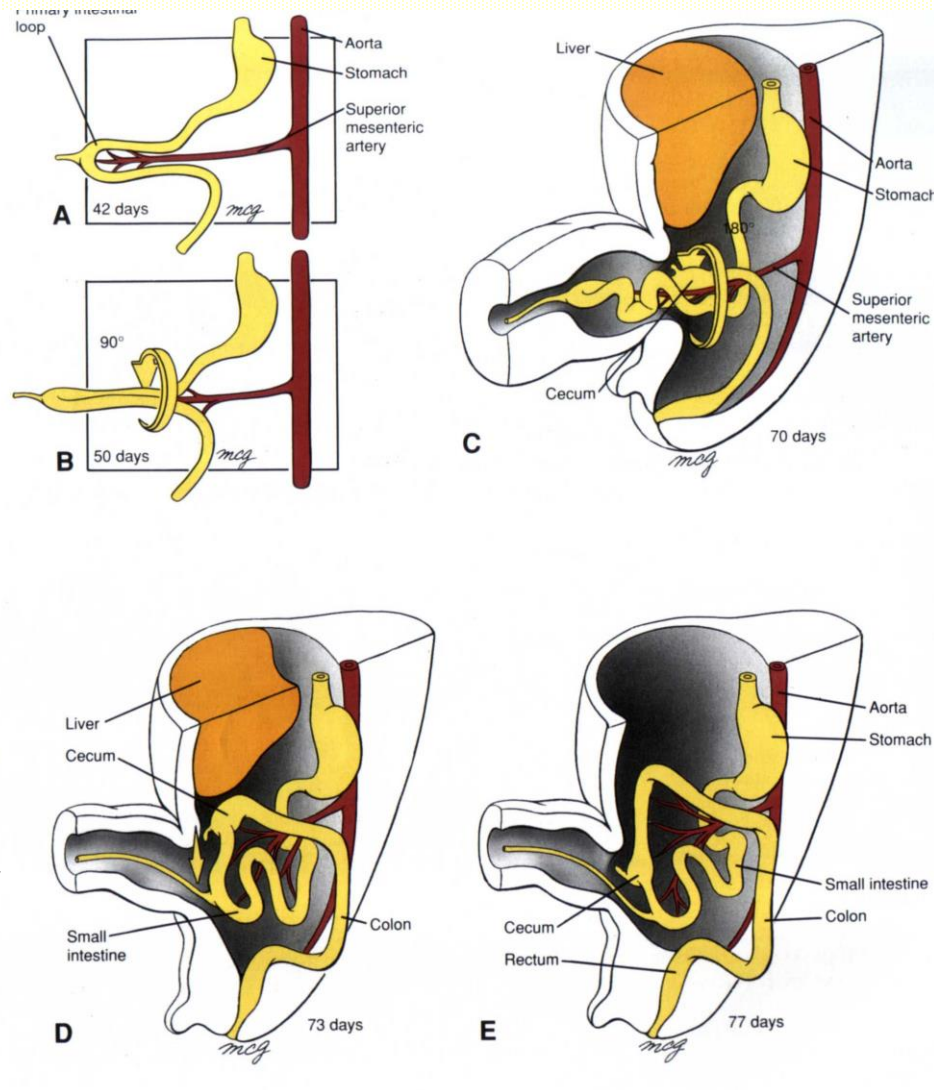
## Cranial limb of the midgut

- Characterized by rapid elongation and rotation
- Axis of rotation is around the superior mesenteric artery (dorsoventral axis)  $90^\circ$  *anticlockwise* and herniates into the umbilical cord (~ 6-8 wk)
- Rapid elongation and retraction of herniated gut into abdominal cavity ~10 wk (further rotates  $180^\circ$ ; i.e. a total of  $270^\circ$  rotation)

Axis of *rotation* is around superior mesenteric artery

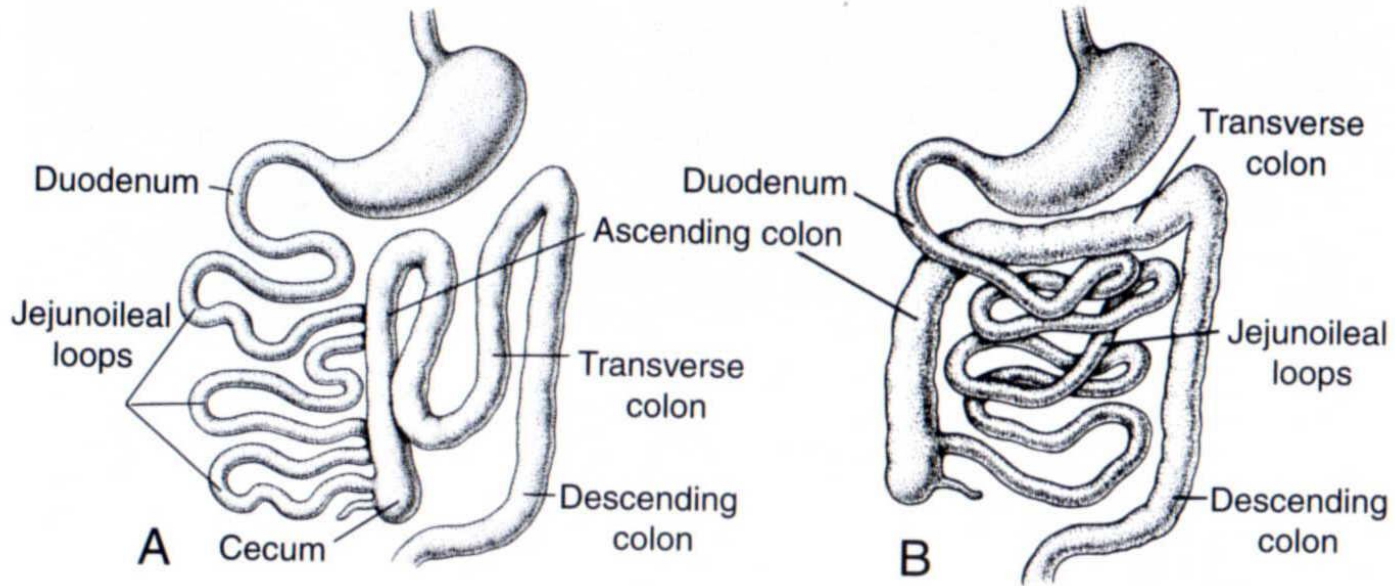
*Rotation* is 90° anticlockwise

Reduction of herniated gut into the abdominal cavity with a further 180° rotation - 10 wk



Growth in length of the cranial limb; herniation into the umbilical cord – 6-8 wk

A total of 270° rotation; cecum descend to lower abdomen.



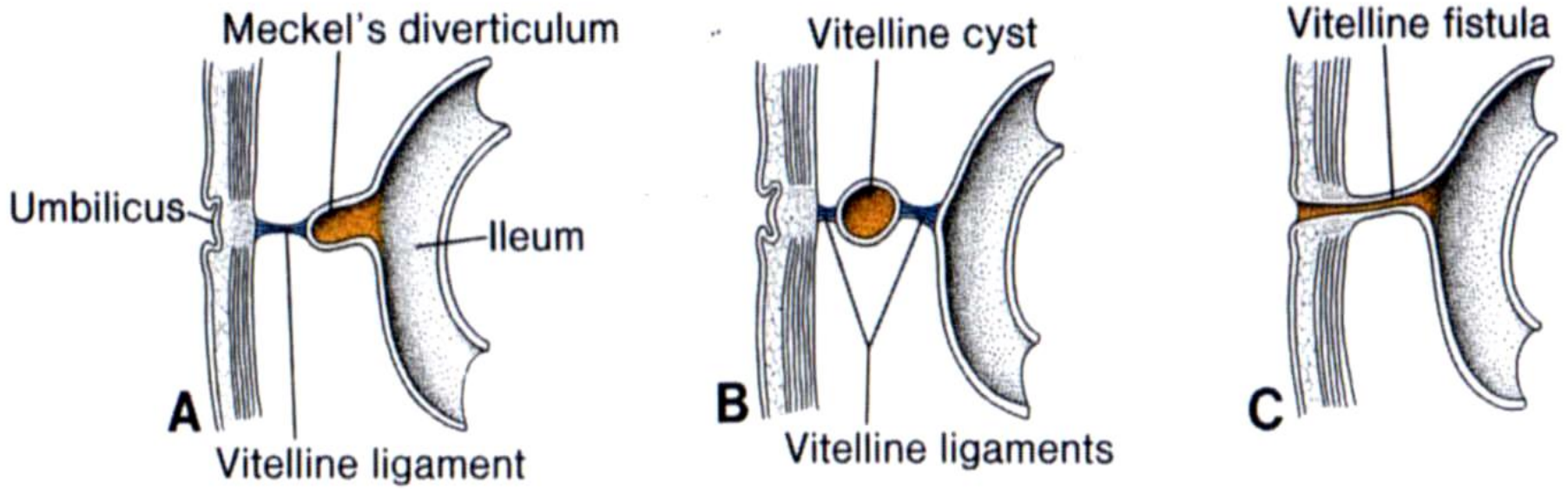
**Rotates 90° anticlockwise  
without further 180° rotation**

**Rotates 90° clockwise**

**Malformation during rotation of the gut**

## Development of the midgut - 2

- **Mid point of midgut loop** – remains connected with yolk sac with a narrow vitelline duct embedded in the umbilicus
- Vitelline duct normally regresses between the 5-8<sup>th</sup> week and later obliterates into a fibrous cord and degenerates complete.
- In 2% of the infants, abnormal remains of the vitelline duct forms *Meckel's diverticulum*; *vitelline cyst* or *vitelline fistula*.



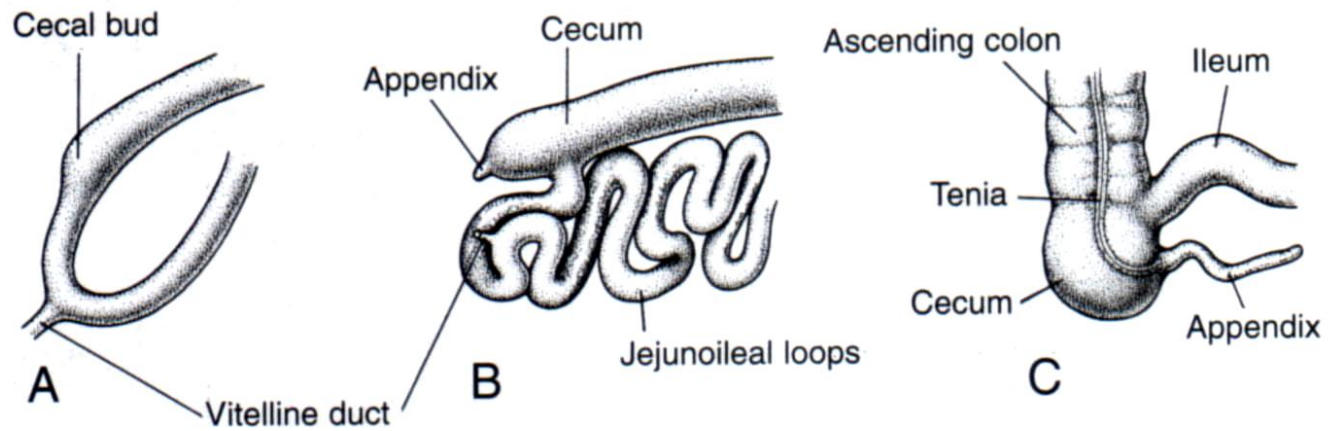
## Remnants of the vitelline duct



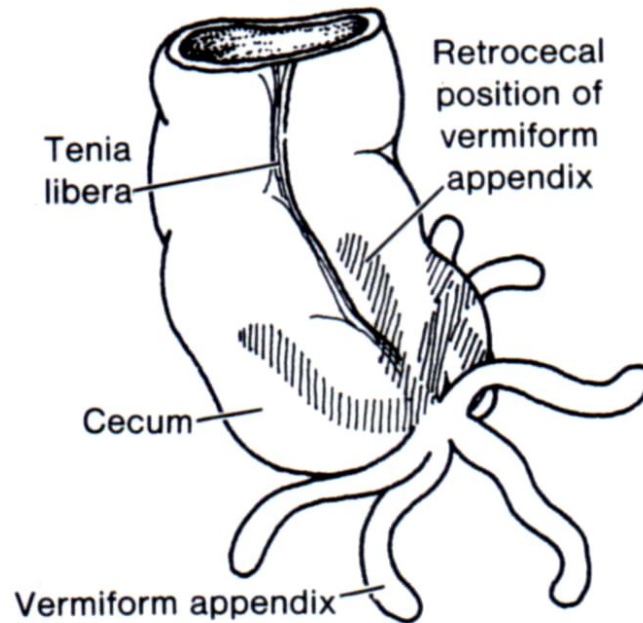
# Development of the midgut - 3

**Caudal limb of midgut** is characterized by slow growth.

- Rotation of the cranial limb throws the caudal limb into an arch at the perimeter of the abdominal cavity.
- The caecum rests below the liver and later ‘**descends**’ in the abdomen.
- The ascending and descending colon become ***secondarily retroperitoneal***.



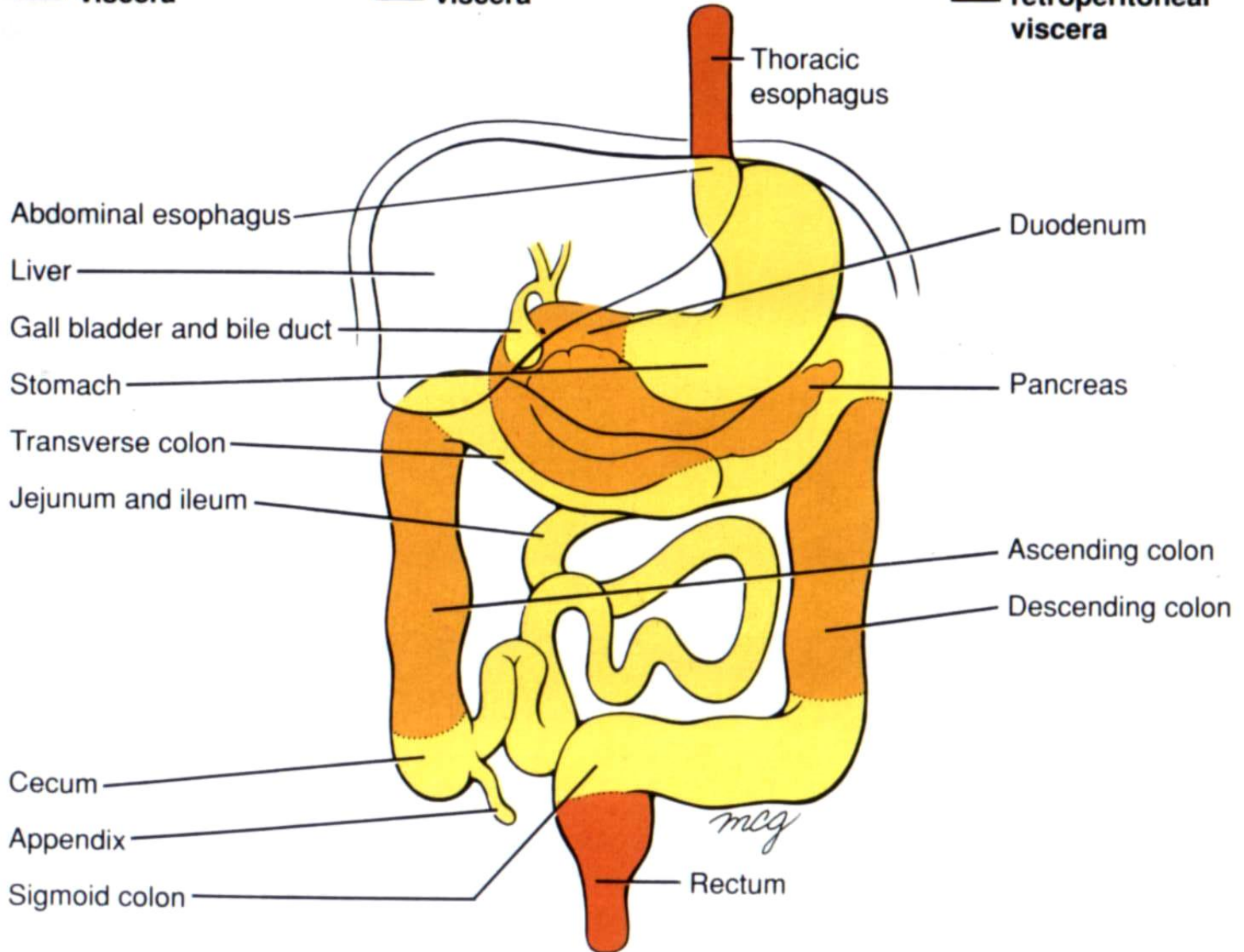
**Figure 13.26.** Successive stages in development of the cecum and appendix. **A.** 7 weeks. **B.** 8 weeks. **C.** Newborn.



**Intraperitoneal  
viscera**

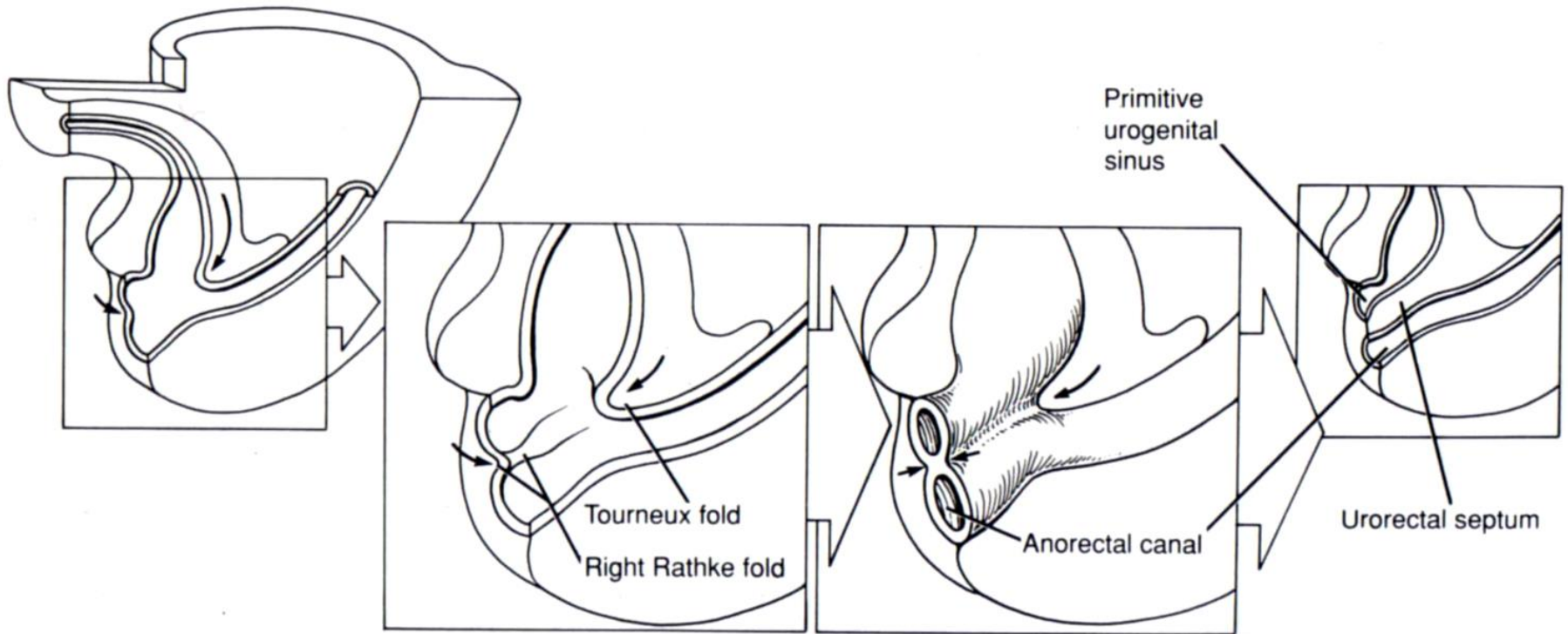
**Retroperitoneal  
viscera**

**Secondarily  
retroperitoneal  
viscera**



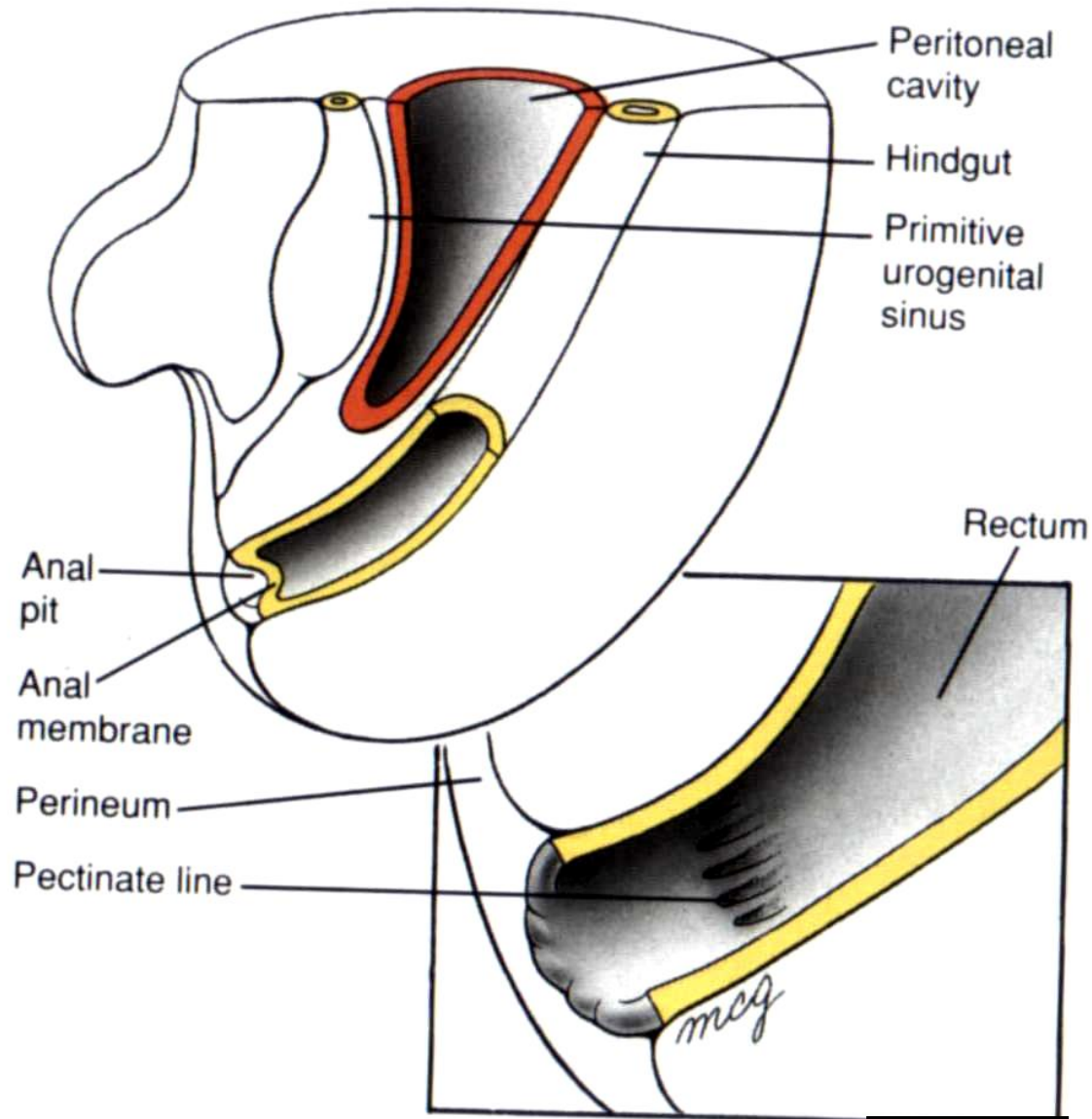
# Development of the hindgut

- The distal end of the primitive gut expand to form the **cloaca**.
- Between the 4<sup>th</sup> – 6<sup>th</sup> week, the cloaca is partitioned into a **dorsal anorectal canal** and a ventral primitive **urogenital sinus** by the growth of a coronal partition called the **urorectal septum**.
- The urorectal septum consists of a superior Tourneux fold and a pair of lateral folds called the Rathke folds.



**Subdivision of the cloaca into an anterior primitive *urogenital sinus* and a posterior *rectum* (week 4-6).**



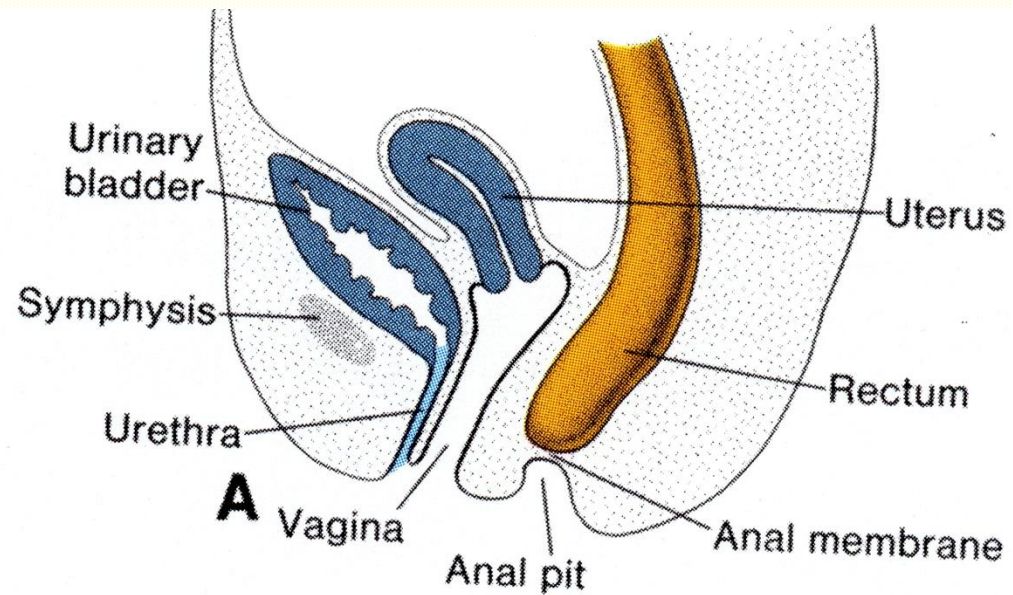


**Lower third of anorectal canal formed by ectodermal invagination**

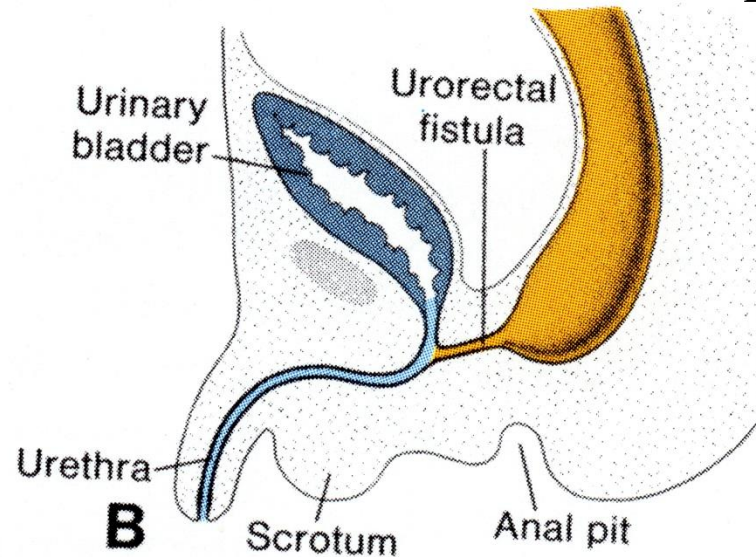
# Inferior third of anorectal canal

- The superior two-third of the anorectal canal forms from the distal part of the hindgut.
- Inferior third formed from an **ectodermal pit** called the anal pit or **proctodeum**.
- The membrane separating the endoderm and ectoderm breaks in the 8<sup>th</sup> week.(Pectinate line)
  - **Superior** to pectinate line supplied by branches of *inferior mesenteric artery*
  - **Inferior** to pectinate line supplied by branches of the *internal iliac arteries*.

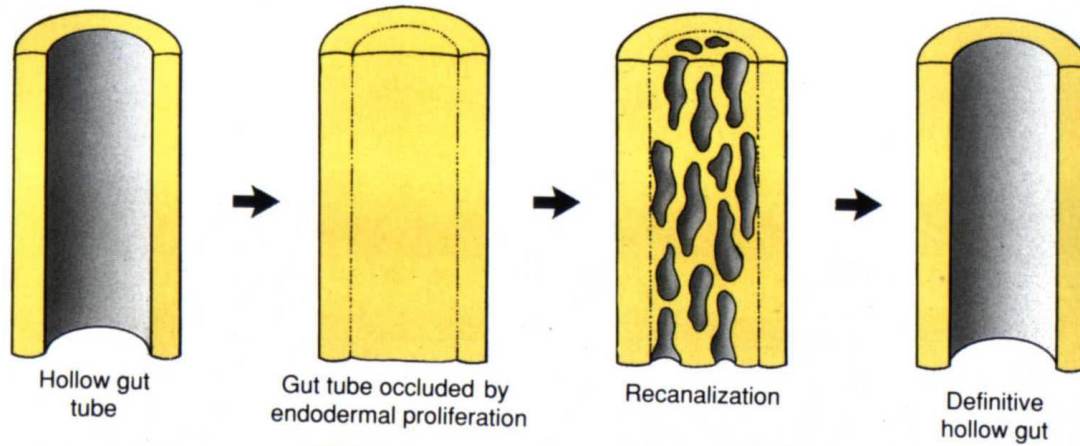
# Congenital malformations



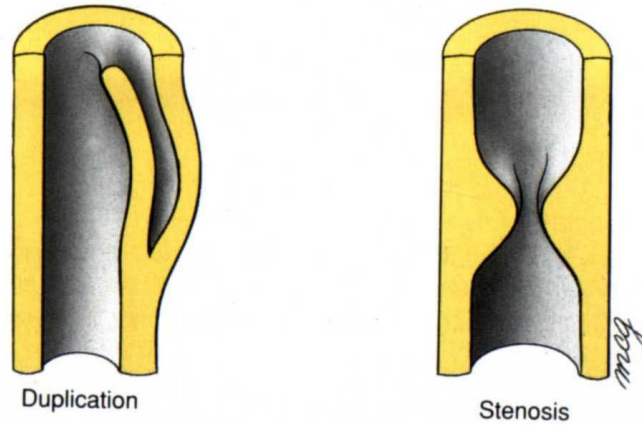
Imperforate anus – anal membrane persists



Imperforate anus with rectal atresia

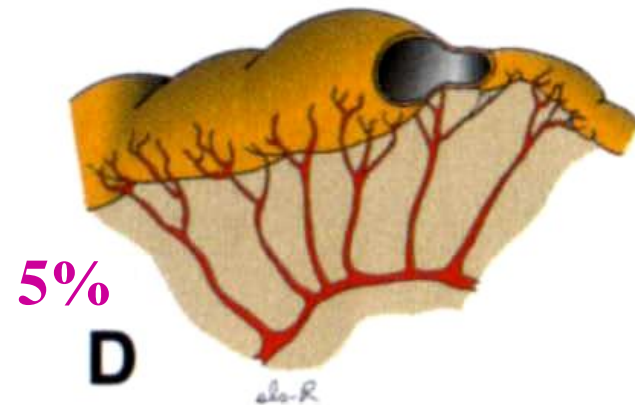
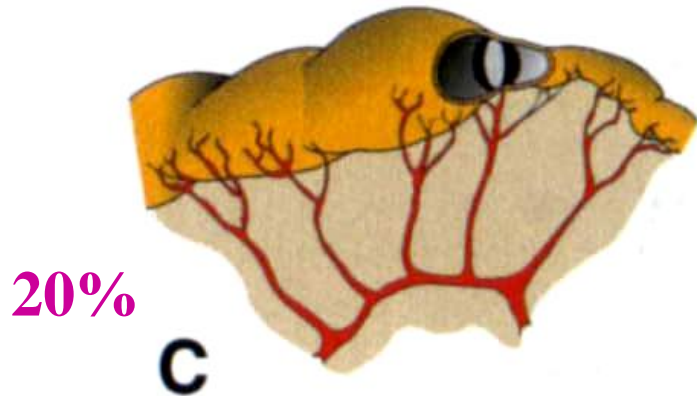
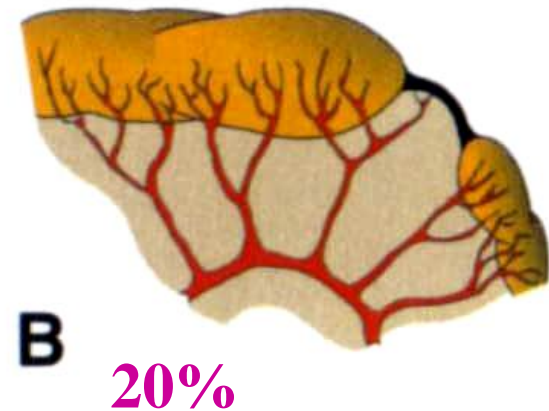
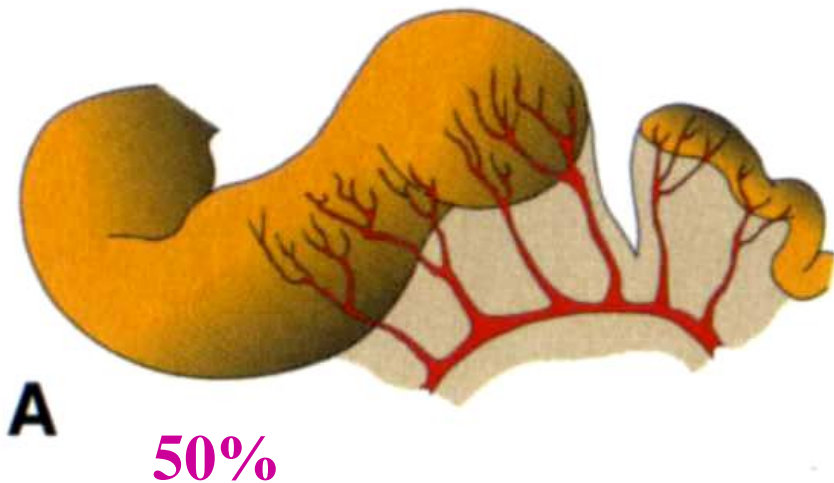


Normal  
Development



Anomalous  
Development

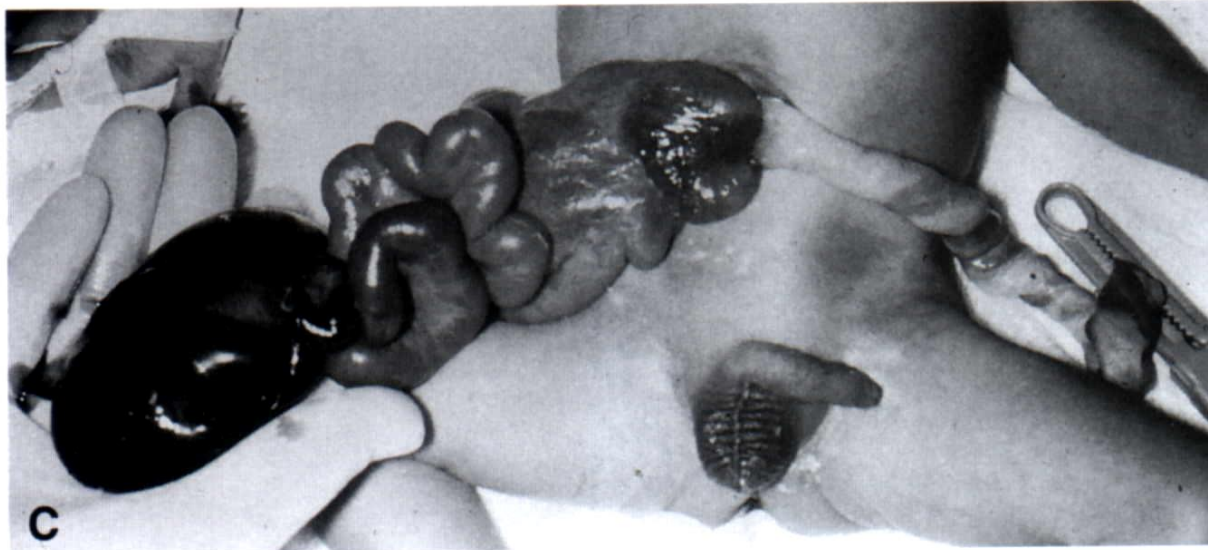
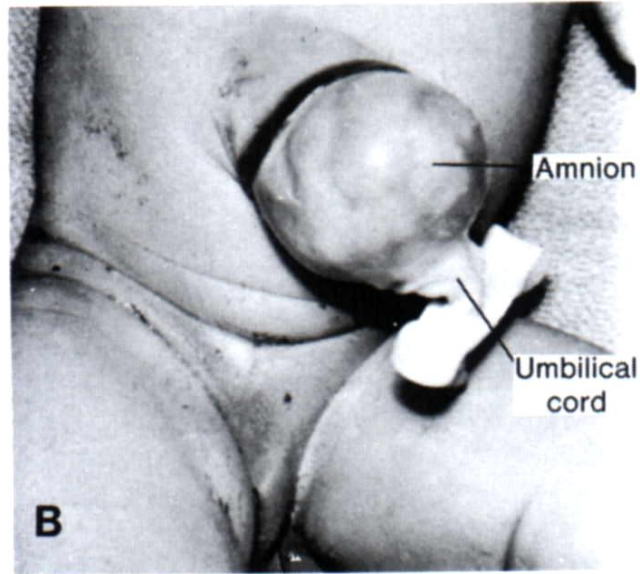
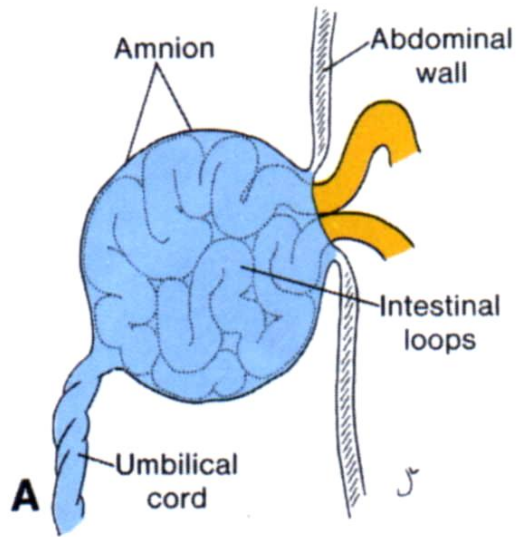
**Formation of definitive gut lumen**



## The most common bowel atresias and stenoses

Most are caused by vascular accidents; stenosis in the upper duodenum may be caused by a lack of recanalization.





**Congenital defect – A & B omphalocele; C gastroschisis**

**Combined incidents -1/2000 births**

# Reference:

Sadler TW Langman's Medical Embryology  
9<sup>th</sup> edition, 2004, pp. 285-319.