Gastro-intestinal Module

Dr. Gamal Taha Abdelhady
Assistant Professor of Anatomy & Embryology

GIT Embryology – Part 2

The Duodenum

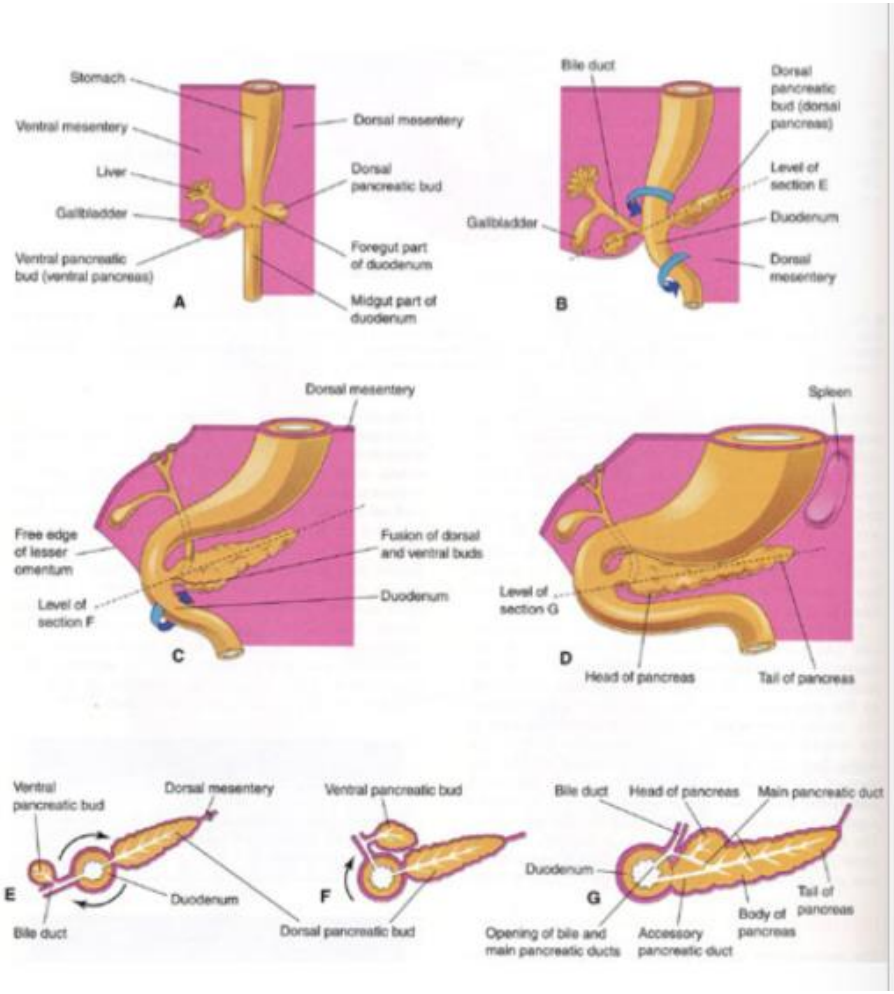
- Starts developing by the 4th week.
- Begins to develop from the endoderm of the distal part of the foregut and the proximal part of the midgut.
- The developing duodenum grows rapidly, forming a C- shaped loop that projects ventrally due to differential growth of its parts.

The Duodenum

- Receives a dual blood supply from foregut and midgut arteries (***coeliac and superior mesenteric arteries***)
- Originally in the midline, it rotates 90° to the right (the same rotation as occurs in the stomach)
- It loses its mesentery and becomes ***secondarily retroperitoneal***
- Gives rise to the liver and pancreatic buds from the distal foregut.

The Duodenum

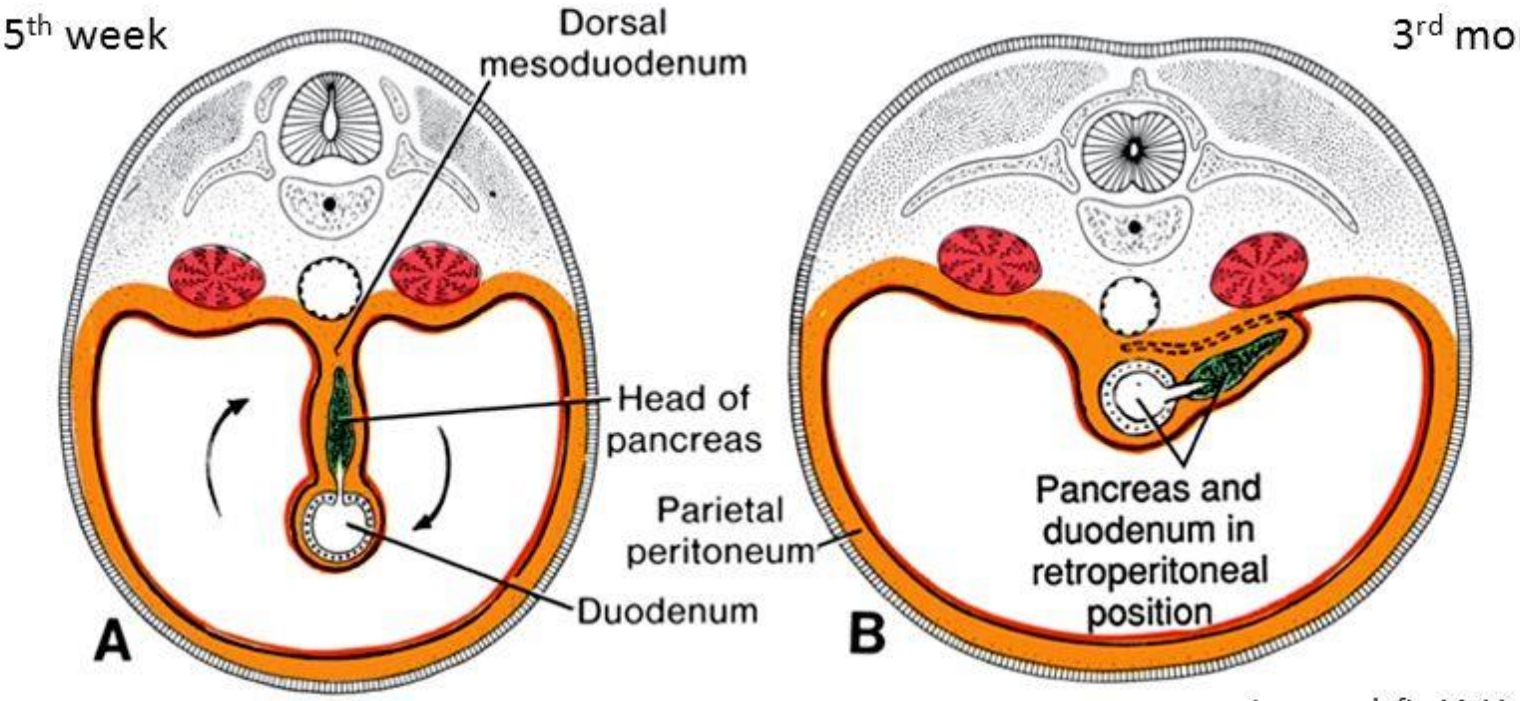
- The duodenum is attached to the posterior abdominal wall by ***dorsal mesoduodenum*** and with the liver and anterior abdominal wall by ***ventral mesoduodenum***.



The Duodenum

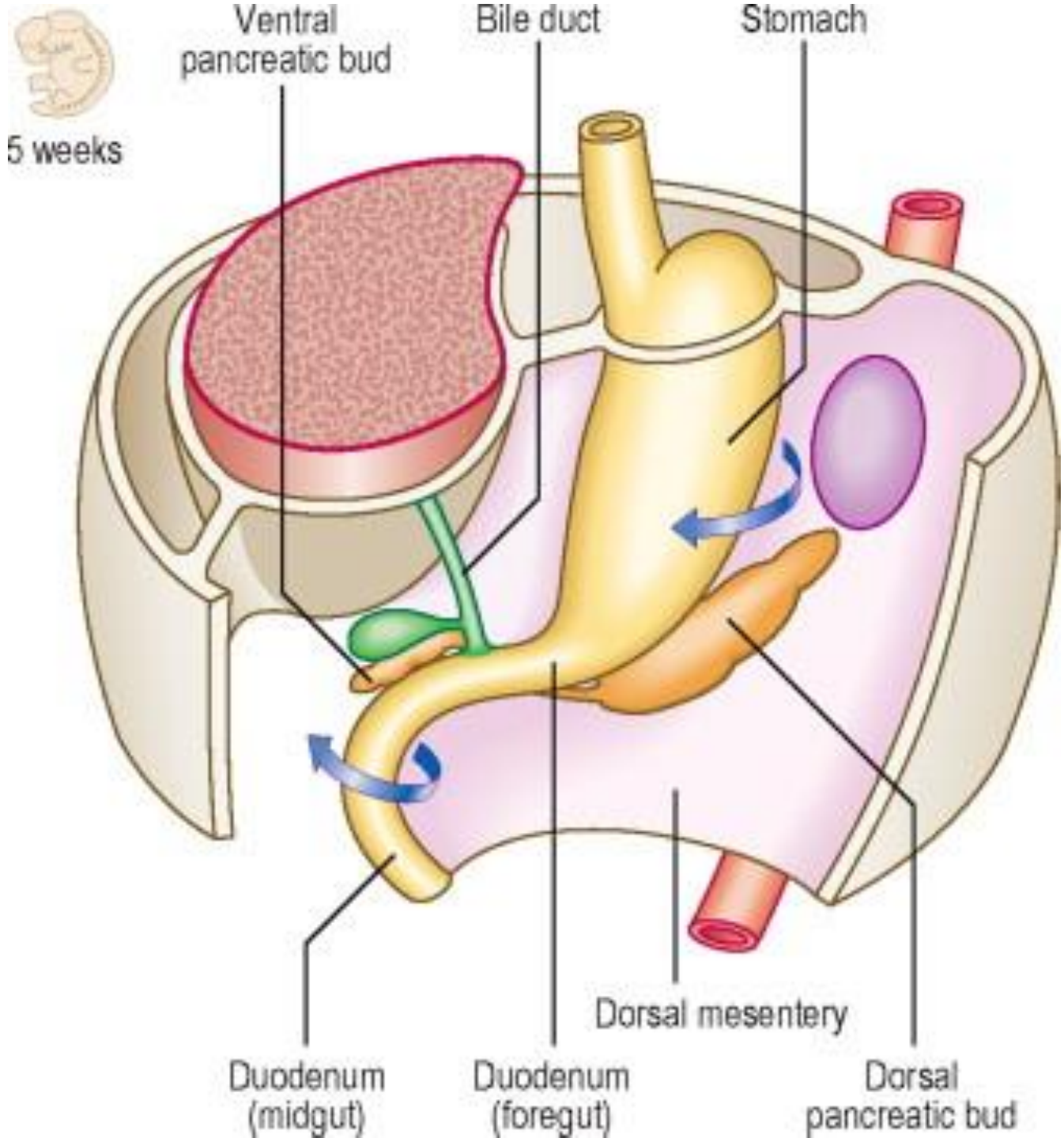
- As the stomach rotates, the duodenal loop rotates to the right and the ***dorsal mesoduodenum fuses*** with the peritoneum of the posterior abdominal wall and both ***disappear***.
- By the ***end*** of the ***embryonic period***, most of the ***ventral mesoduodenum*** has ***disappeared***.
- The lumen of the duodenum becomes obliterated because of the proliferation of its epithelial cells.
- Latter recanalization occurs.

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

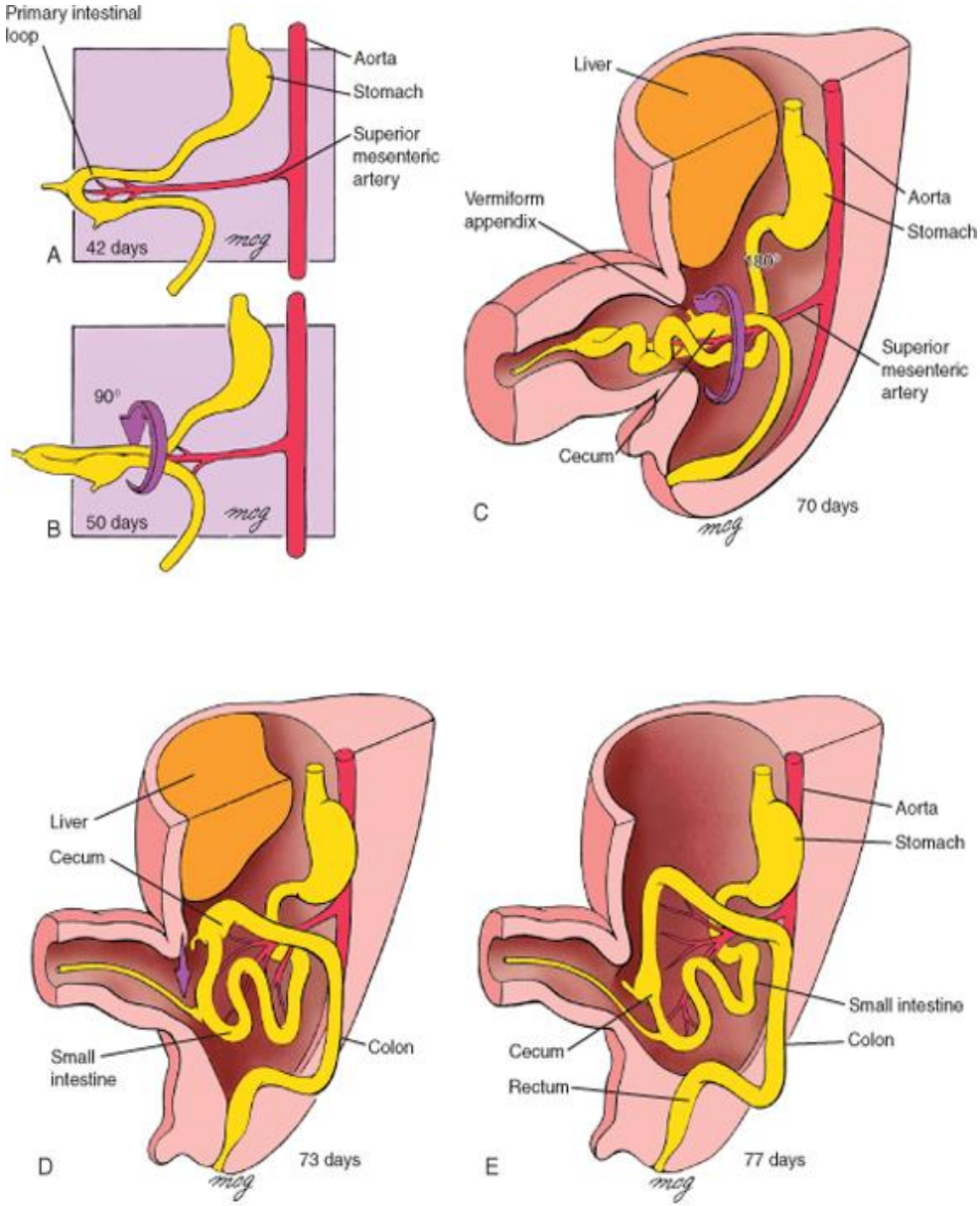


Langman's fig 14-11

Secondarily retroperitoneal = a structure that was originally in the body coelom but then got pushed into the body wall during development


5 weeks
Ventral pancreatic bud
Bile duct
Stomach
Dorsal mesentery
Duodenum (midgut)
Duodenum (foregut)
Dorsal pancreatic bud

Development of the midgut and colon



Midgut

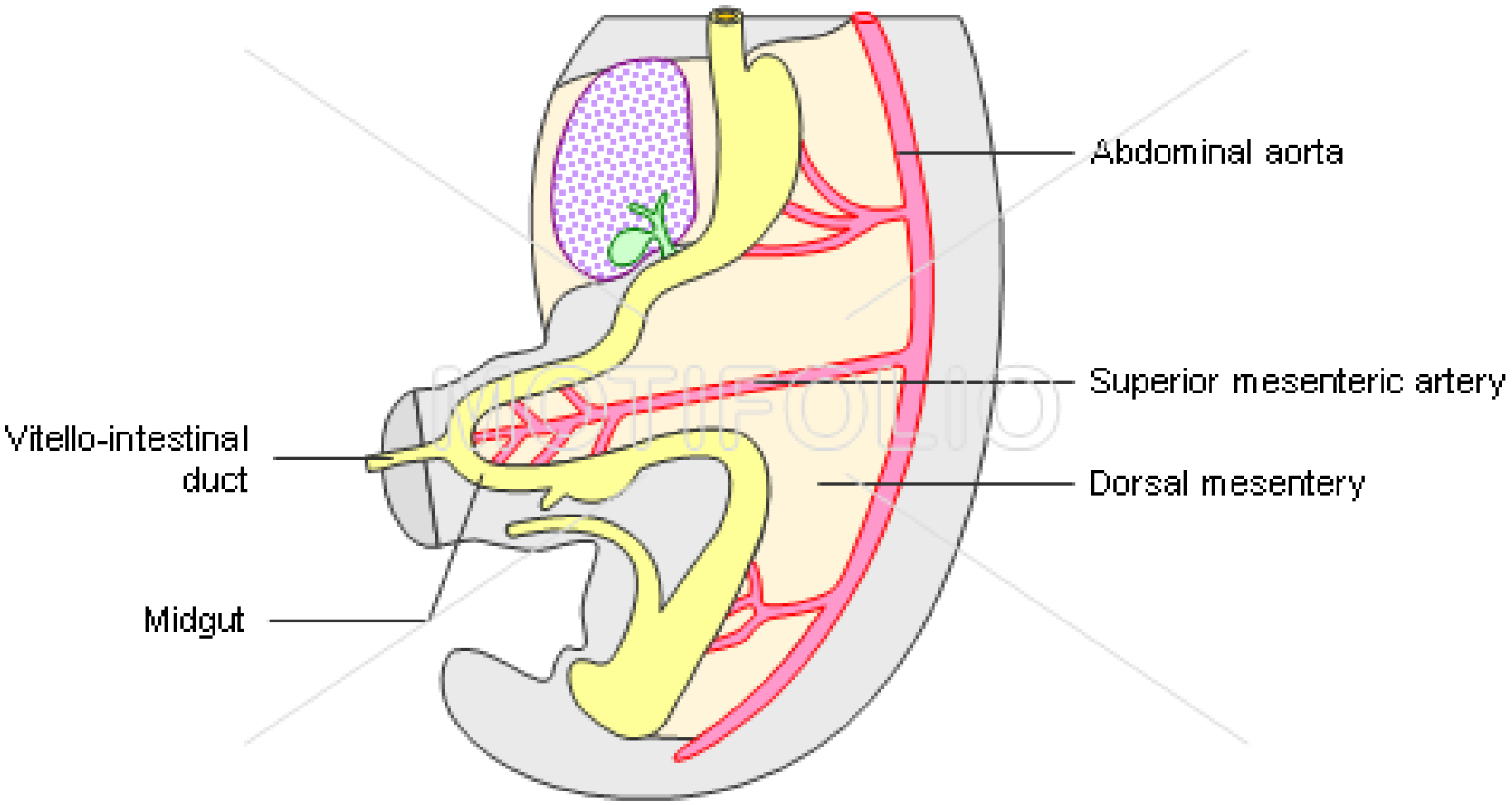
- In the adult, the ***midgut*** begins immediately distal to the entrance of the bile duct into the duodenum and terminates at the junction of the proximal two-thirds of the transverse colon with the distal third.

Midgut

- Over its entire length, the midgut is supplied by the ***superior mesenteric artery.***

- The ***midgut*** is suspended from the dorsal abdominal wall by a short mesentery and communicates with the ***yolk sac*** by way of the ***vitelline duct*** or yolk stalk

Herniation of the midgut loop – 6 weeks embryo



Derivatives of Midgut

- The cranial limb of the midgut elongates rapidly during development and forms the jejunum and cranial portion of the ileum.

- The caudal limb forms the cecum, appendix, caudal portion of the ileum, ascending colon, and proximal two-thirds of the transverse colon.

Derivatives of Midgut

- The ***caudal limb*** is easily ***recognized*** during development because of the presence of the ***cecal diverticulum***.

- The midgut ***herniates*** outside the abdominal cavity ***then*** the loop ***retracts*** and ***rotates 270° counterclockwise*** around the superior mesenteric artery as it retracts into the abdominal cavity during the ***10th week*** of development.

Herniation and Rotation

- Growth of the GI tract exceeds volume of abdominal cavity so the tube herniates through umbilicus by the ***6th week***

- Even during rotation, elongation of the small intestinal loop continues, and the jejunum and ileum ***form a number of coiled loops.***

- **The large intestine likewise lengthens considerably but does not participate in the coiling phenomenon.**

Midgut Retraction

- ***Although the factors responsible for this return are not precisely known, it is thought that:***

1. Regression of the developing kidney
2. Reduced growth of the liver
3. Expansion of the abdominal cavity, all play important roles

Midgut Retraction

- While herniated, gut undergoes a ***primary rotation*** of ***90° "counterclockwise"*** (when looking at the embryo); this corresponds with the rotation of the stomach and positions the appendix to the left.

- The primary rotation also brings the ***left vagus n.*** to the ***front*** (hence the change in its name to ***Anterior vagus n.***

Midgut Retraction

- With the growth of the embryo, the abdominal cavity expands thus drawing the gut tube back within the abdominal cavity and causing an additional, ***secondary rotation*** (fig C) of ***180° CCW (positioning the appendix on the RIGHT)*** by the ***10th week***

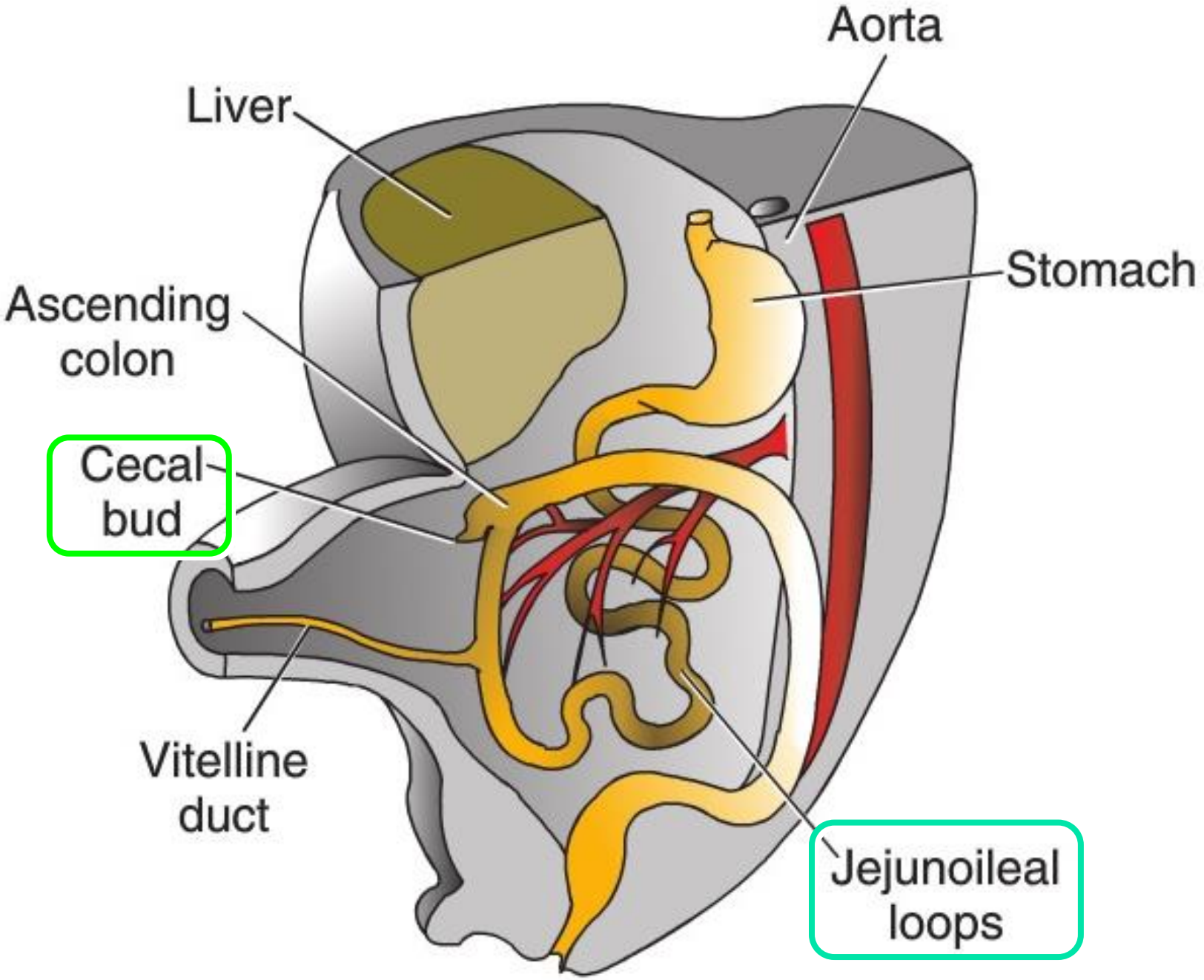
- Note the attachment of the ***vitelline duct*** to the gut at the region of the ileum. The duct ***normally regresses*** during development, but not always….

Midgut Retraction

The ***proximal portion of the jejunum***, the ***first*** part ***to reenter*** the abdominal cavity, comes to lie *on the left side.*

- The later returning loops gradually settle more and more to the right.

- The ***cecal bud***, which appears at about the sixth week as a small conical dilation of the caudal limb of the primary intestinal loop, is *the* ***last part*** *of the gut* ***to reenter*** *the abdominal cavity.*


Aorta
Liver
Stomach
Ascending colon
Cecal bud
Vitelline duct
Jejunoileal loops

Midgut Retraction

- Temporarily, ***the cecal bud*** lies in the right upper quadrant directly below the right lobe of the liver

- From here, ***the cecum*** descends into the right iliac fossa, placing the ascending colon and hepatic flexure on the right side of the abdominal cavity

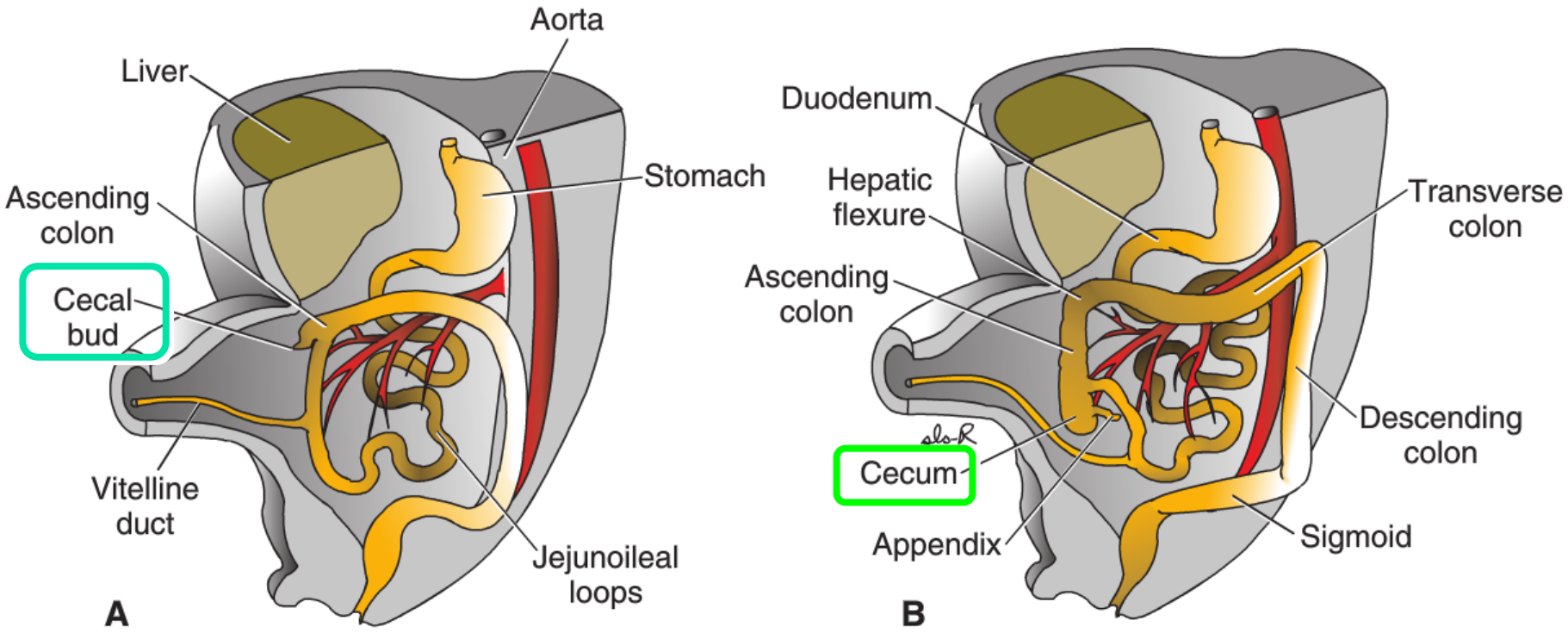


Figure 15.27 **A.** Anterior view of the intestinal loops after 270° counterclockwise rotation. Note the coiling of the small intestinal loops and the position of the cecal bud in the right upper quadrant of the abdomen. **B.** Similar view as in **A** with the intestinal loops in their final position. Displacement of the cecum and appendix caudally places them in the right lower quadrant of the abdomen.

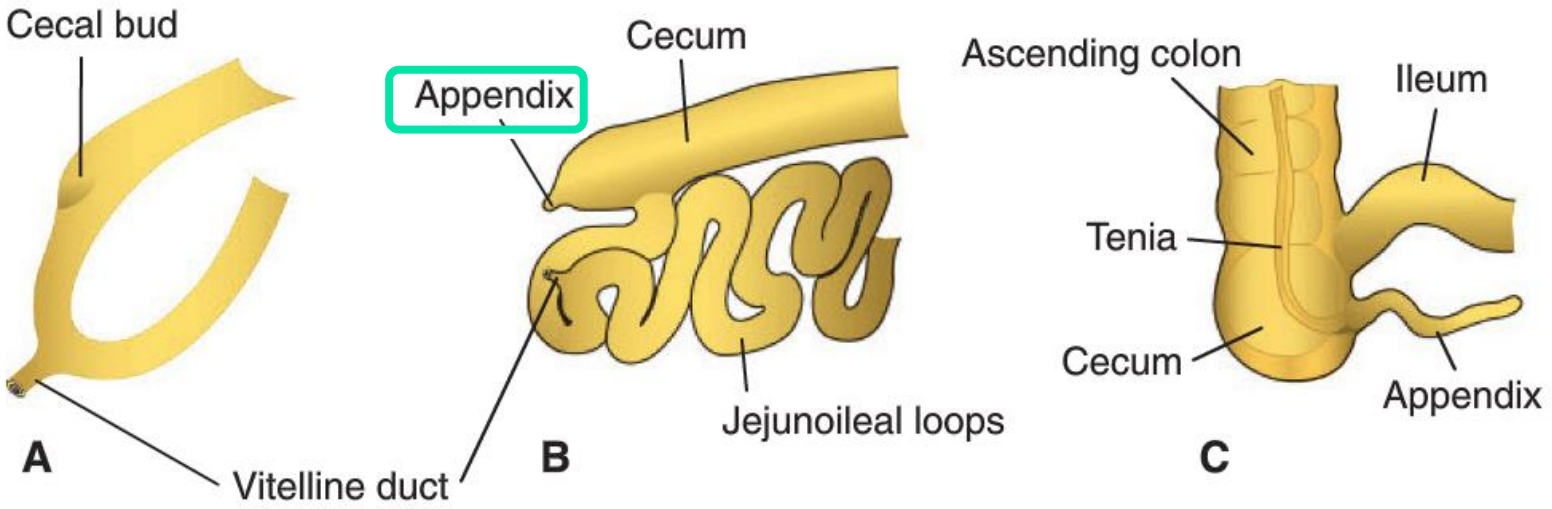
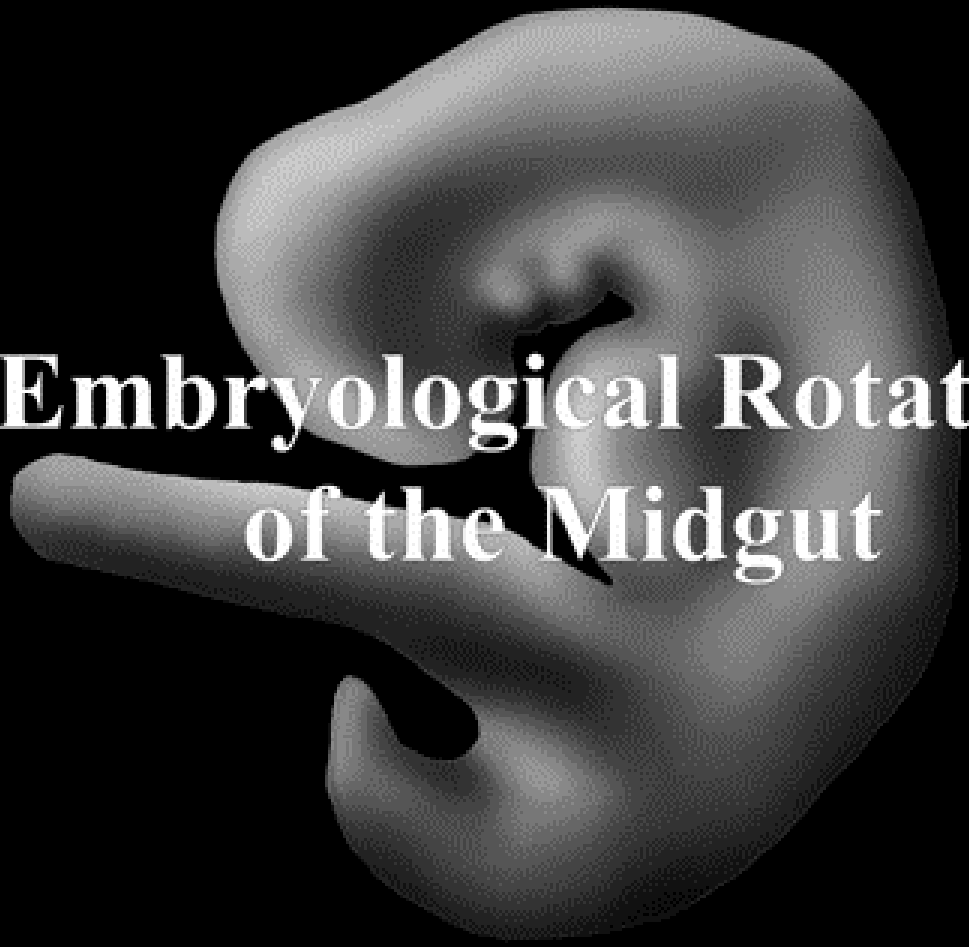


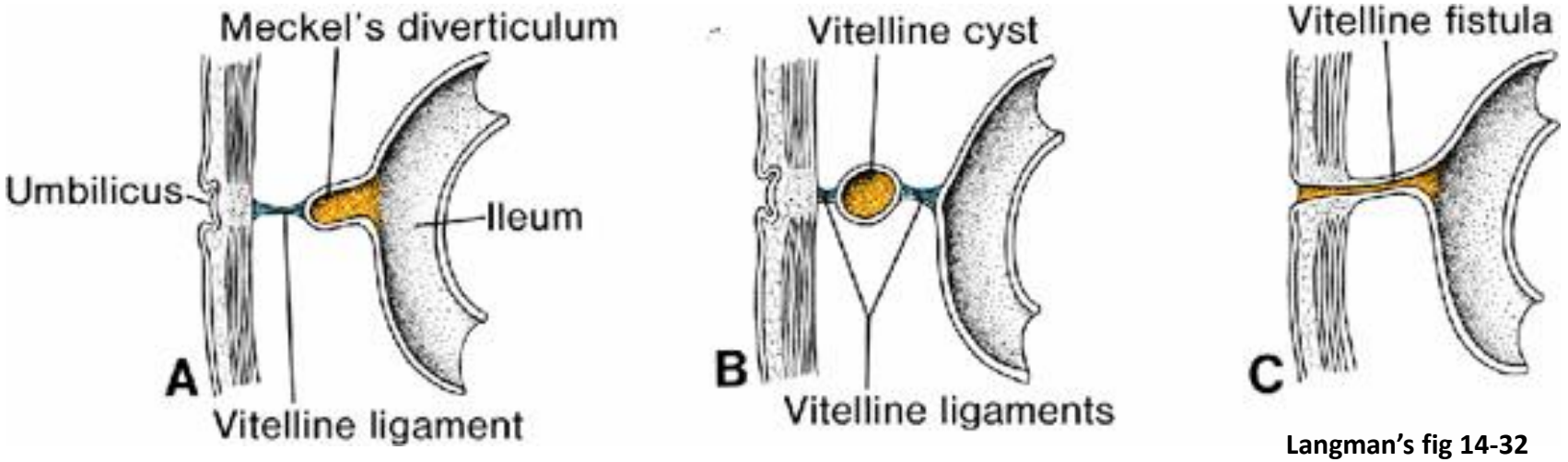
Figure 15.28 Successive stages in development of the cecum and appendix. **A.** 7 weeks. **B.** 8 weeks. **C.** Newborn.

- During this process, the distal end of the cecal bud forms a narrow diverticulum, the ***appendix.***



Embryological Rotation of the Midgut

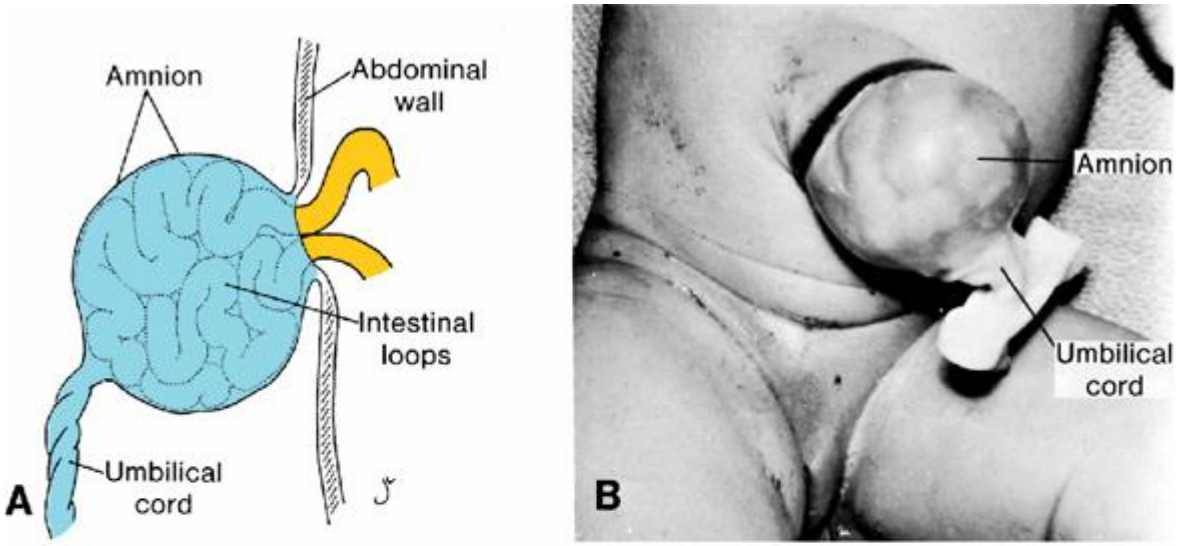
Defects associated with gut herniation and rotation: vitelline duct abnormalities



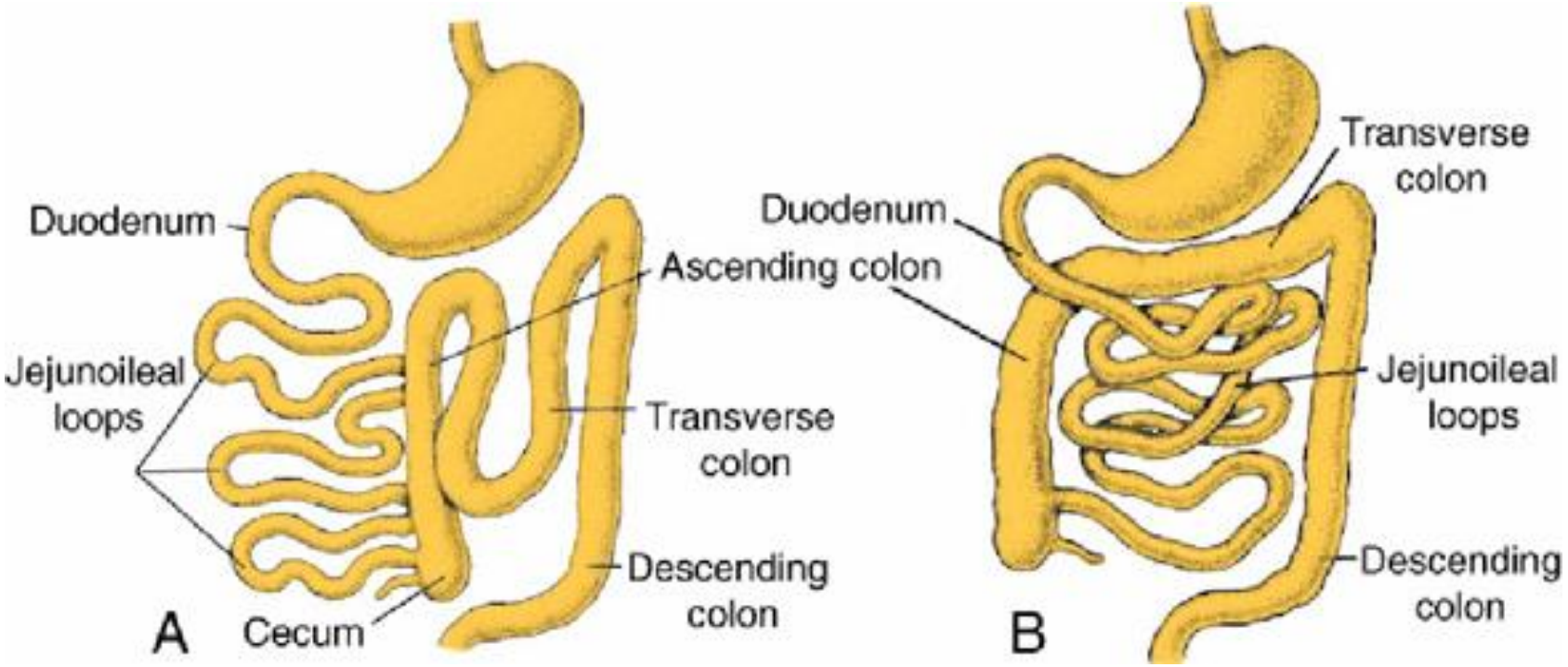
Langman's fig 14-32

- Vitelline duct abnormalities of some sort occur in ~2% of all live births. Note that these aberrant structures are almost always found along the ileal portion of the GI tract.

Congenital umbilical hernia: Omphalocele



Defects associated with gut herniation and rotation: Malrotation

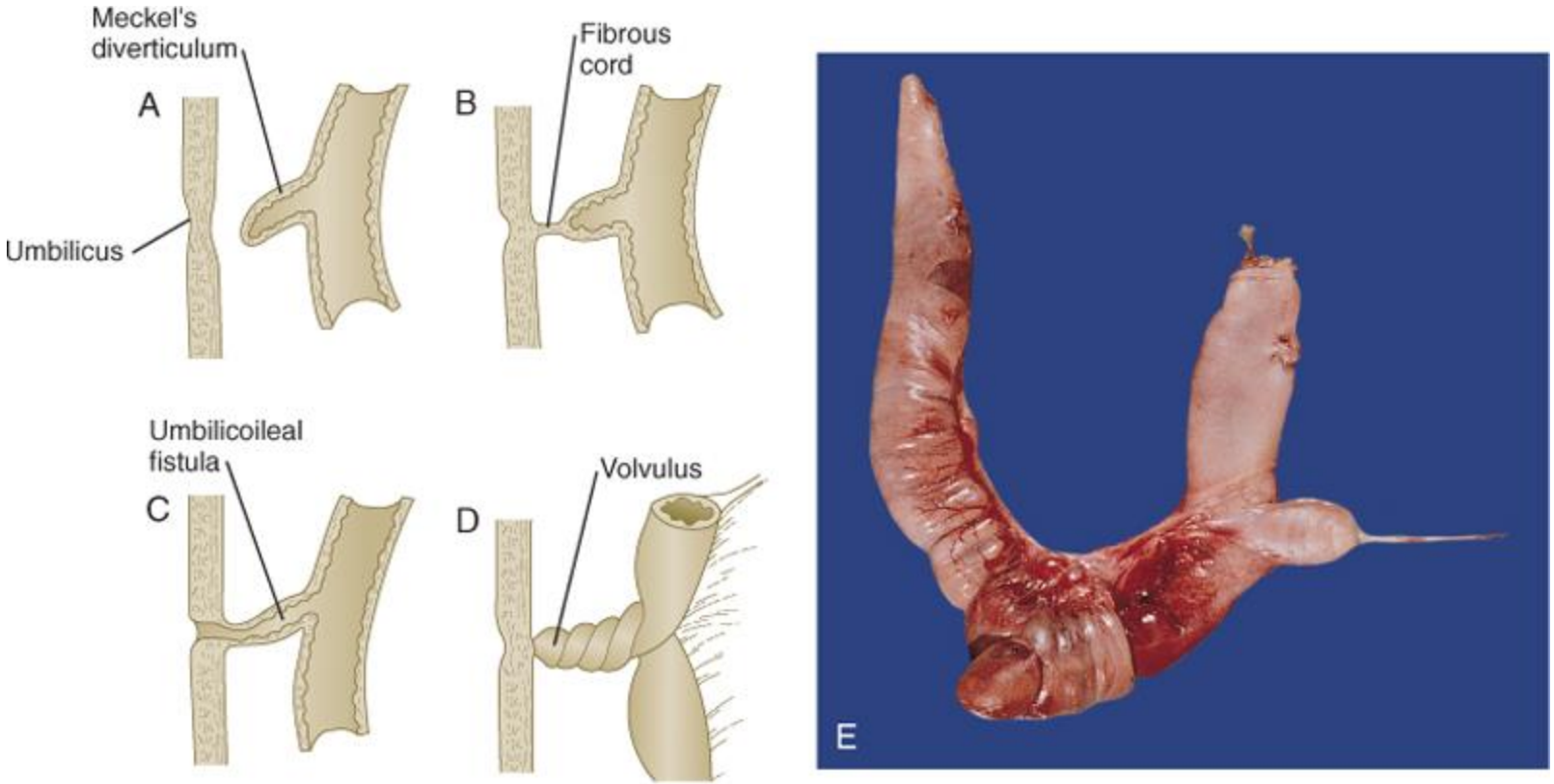


- Absent or incomplete secondary rotation

- **Reversed secondary rotation**

- **(90 CCW primary rotation occurs as usual but followed by abnormal 180 CW rotation. <u>Net</u> rotation is 90° CW; viscera are in their normal location, but note that the duodenum is anterior to the transverse colon)**

Defects associated with gut herniation and rotation: Volvulus



Carlson fig 15-13

Fixation of a portion of the gut tube to the body wall; subsequent rotation causes twisting of the tube, possibly resulting in stenosis and/or ischemia.

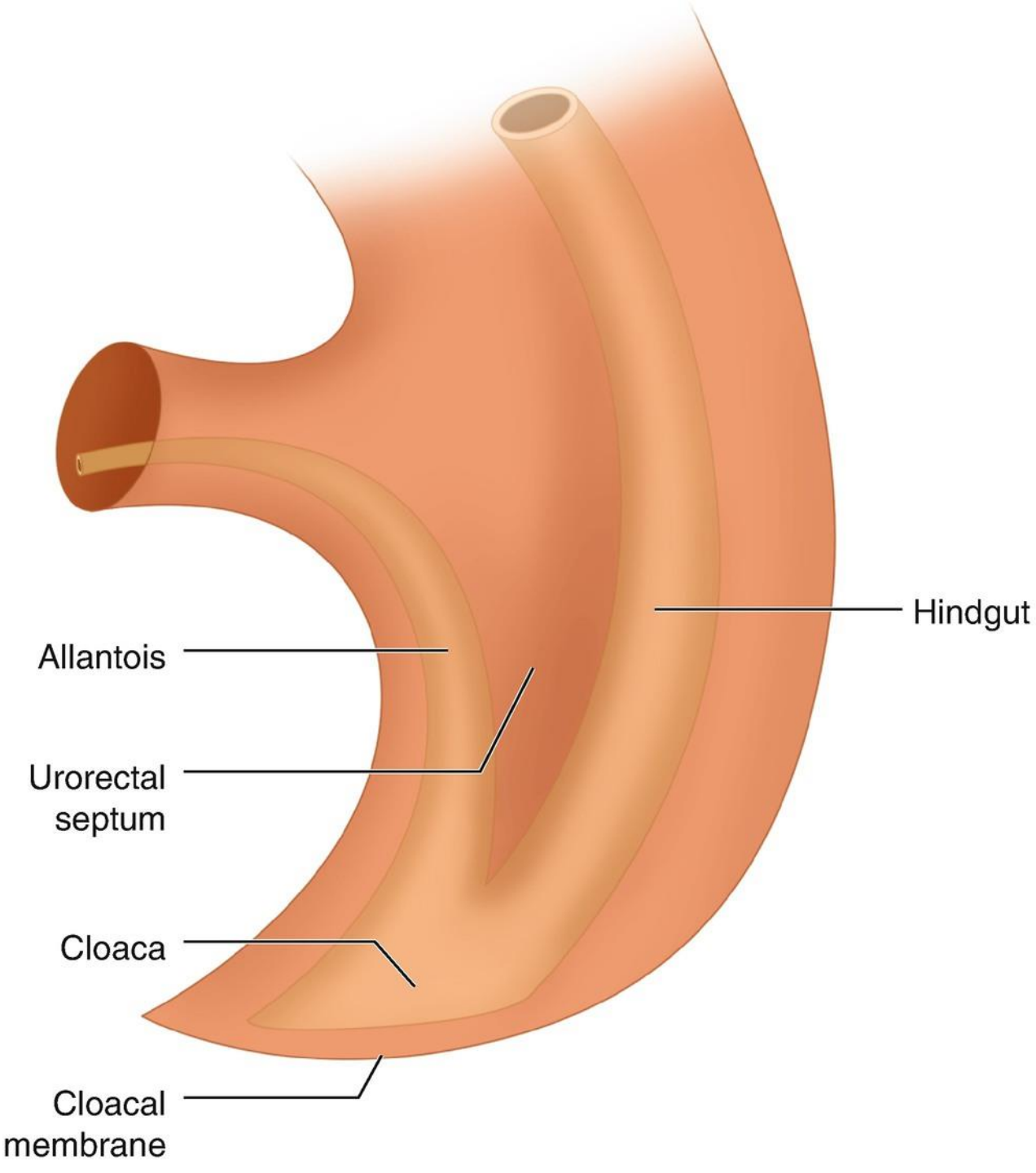
Hind Gut

Derivatives of Hindgut

1. Left one-third to half or distal part of the transverse colon
2. Descending colon
3. Sigmoid colon
4. Rectum
5. Superior portion of the anal canal
6. Epithelium of the urinary bladder and most of urethra

Partitioning of the Cloaca

- The cloaca is the endodermally lined cavity at the end of the gut tube.
- It has a diverticulum into the body stalk called the allantois.
- The cloacal membrane separates the cloaca from the proctodeum (anal pit).

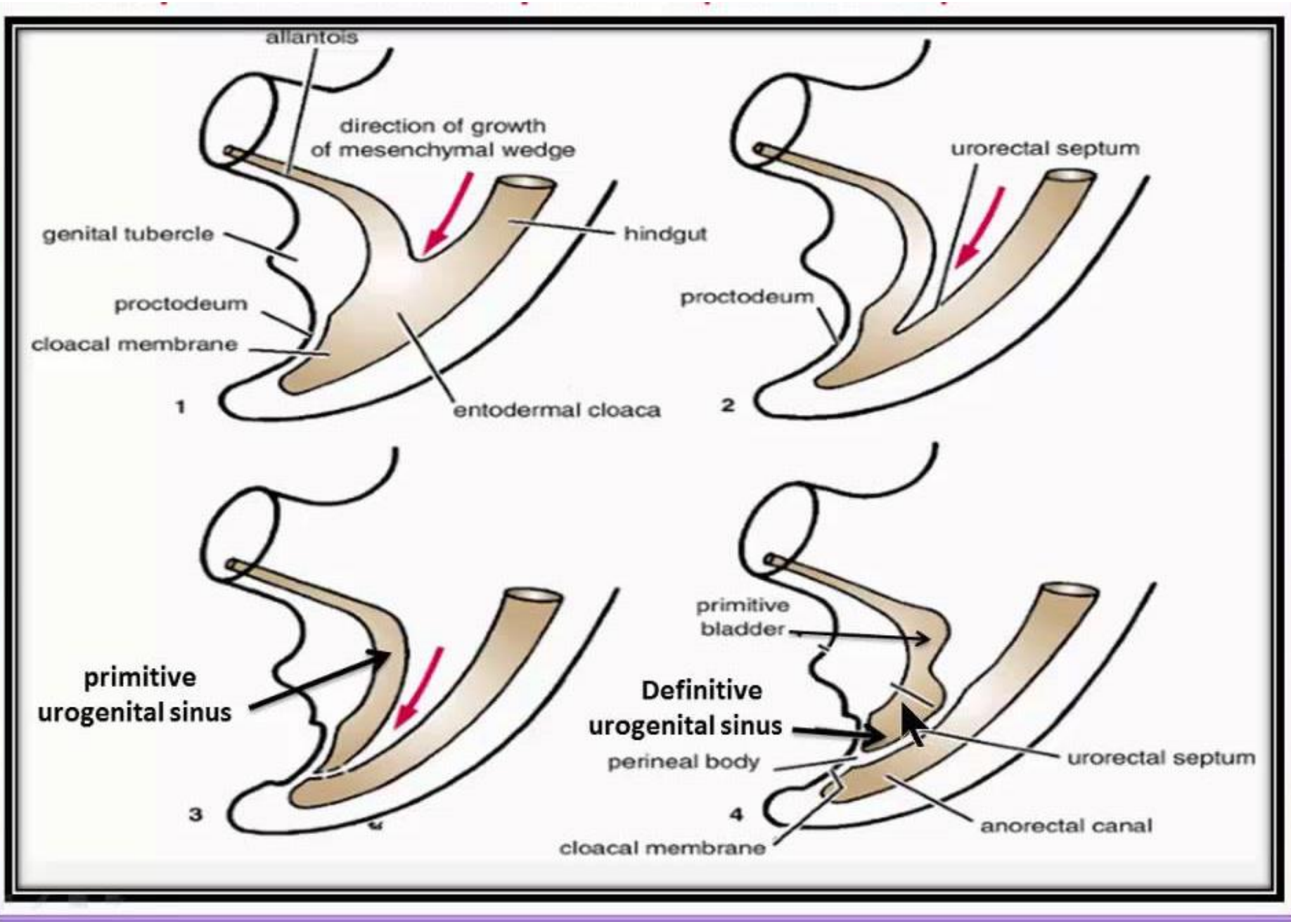

Hindgut
Allantois
Urorectal septum
Cloaca
Cloacal membrane

Cloaca

- During **the fourth to seventh weeks** of development the **cloaca divides into** the **urogenital sinus anteriorly and the anal canal posteriorly**.

- The **uro-rectal septum is a layer of mesoderm between the** primitive anal canal and the urogenital sinus.

- **The tip of the septum will form the perineal body.**


allantois
direction of growth
of mesenchymal wedge
genital tubercle
hindgut
proctodeum
cloacal membrane
entodermal cloaca
1
urorectal septum
proctodeum
2
primitive
urogenital sinus
3
primitive
bladder
Definitive
urogenital sinus
perineal body
urorectal septum
4
anorectal canal
cloacal membrane

Partitioning of the Cloaca

- By ***7th week***, the uro-rectal septum reaches the cloacal membrane, dividing it into : ***ventral (urogenital membrane)*** and ***dorsal (anal membrane) portions.***

- While the septum itself divides the ***cloaca*** into two divisions.

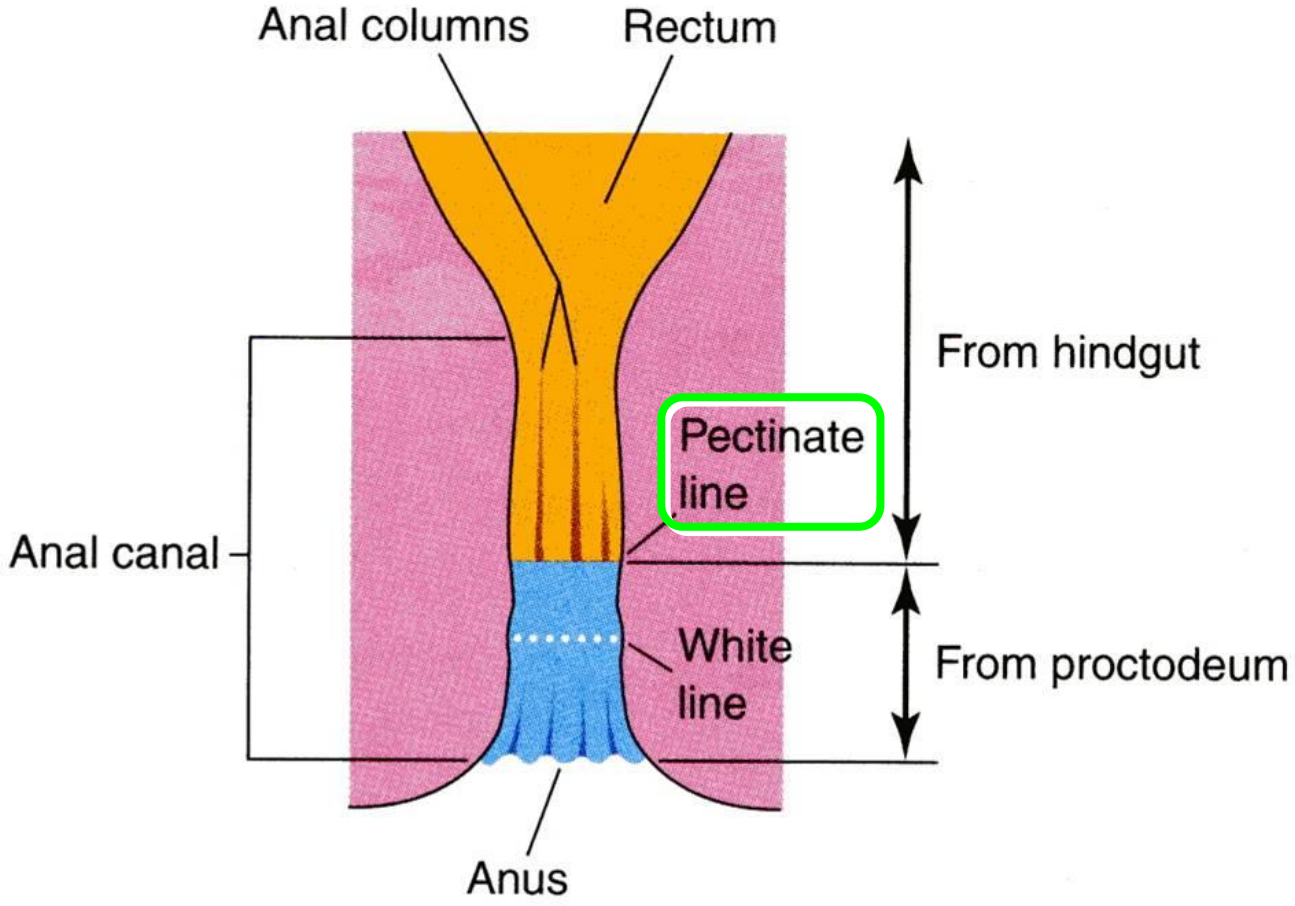
1. ***Urogenital sinus anteriorly***
2. ***Rectal, anal canal posteriorly***

- ***Perineal Body*** - Fusion of uro-rectal septum and cloaca membrane

Anal Canal

- The epithelium of the ***superior two-thirds*** of the ***anal canal*** is derived from the ***endodermal*** hindgut; the ***inferior one-third*** develops from the ***ectodermal*** proctodeum.

- The junction of these two epithelia is indicated by the ***pectinate line***, which also indicates the ***approximate former*** site of the ***anal membrane*** that normally ruptures during the 8th week of development.



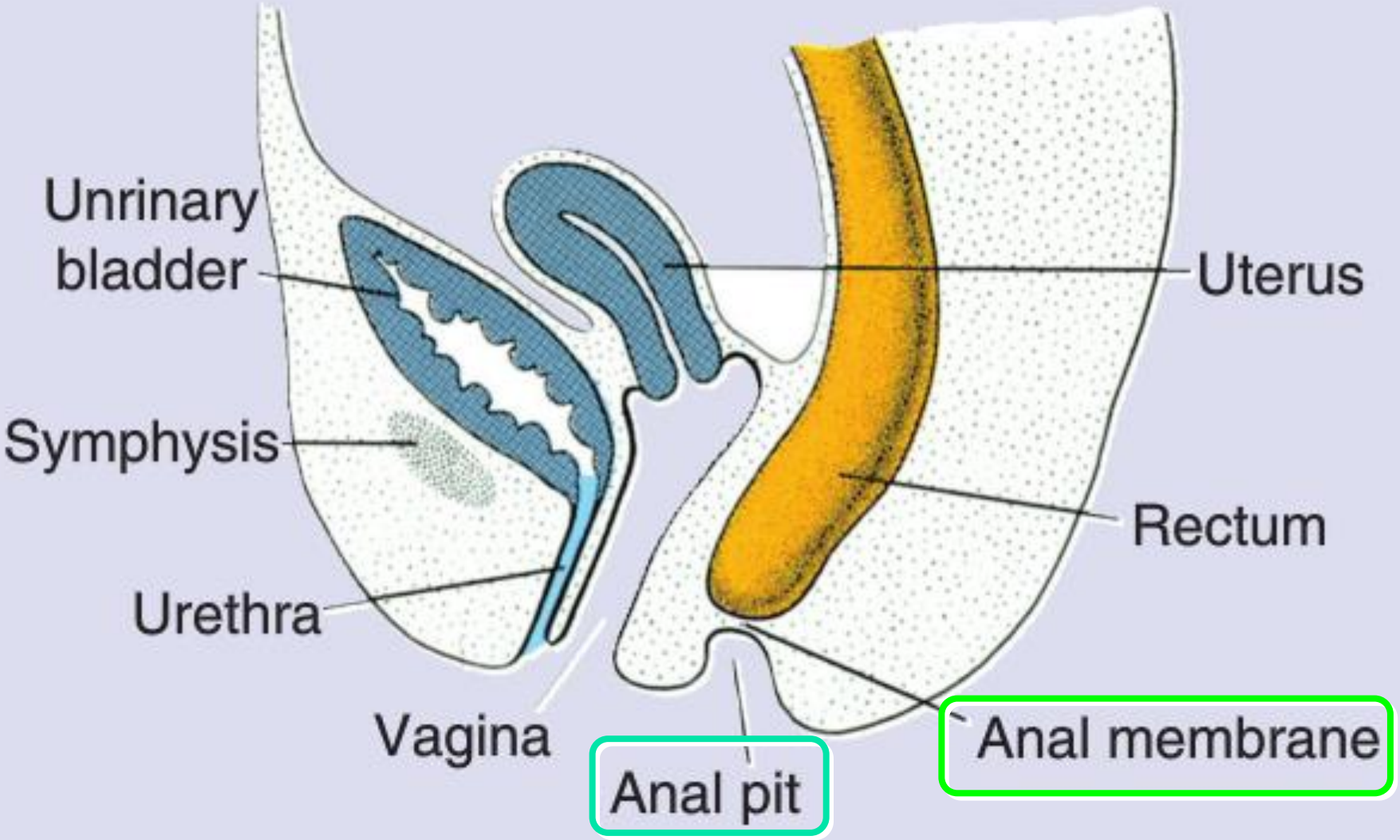
- ***The junction between the endodermal and ectodermal regions of the anal canal*** **is delineated by the pectinate line, just below the anal columns.**

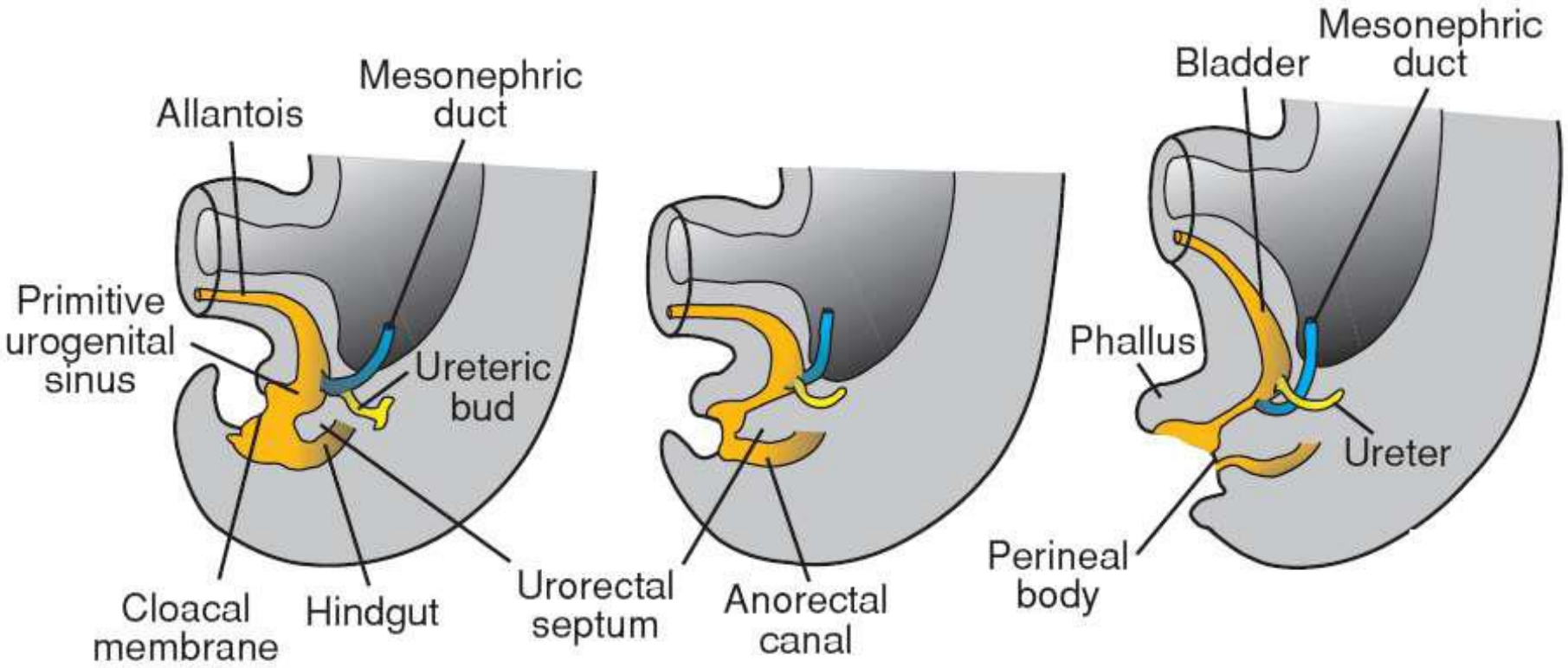
- **At this line, the epithelium changes from columnar to stratified squamous epithelium.**

Anal Opening

- ***Ectoderm*** in the region of the cloaca ***proliferates*** and ***invaginates*** to create the ***anal pit***.

- Subsequently, ***degeneration*** *of the cloacal membrane* (now called the ***anal membrane***) <u>establishes continuity between the upper and lower parts of the anal canal</u>.

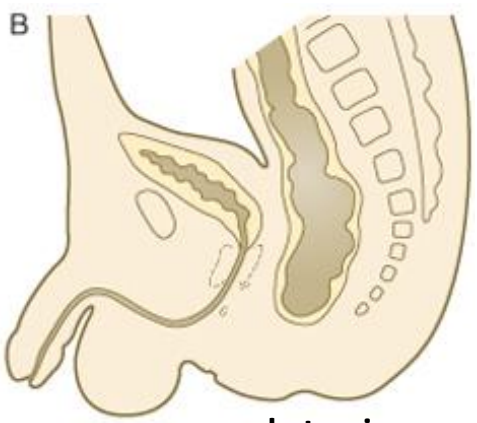

Unrinary bladder
Symphysis
Urethra
Vagina
Anal pit
Anal membrane
Rectum
Uterus


Allantois
Mesonephric duct
Primitive urogenital sinus
Ureteric bud
Cloacal membrane
Hindgut
Urorectal septum
Anorectal canal
Bladder
Mesonephric duct
Phallus
Ureter
Perineal body

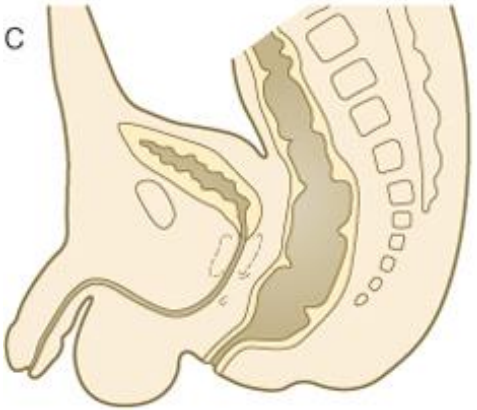
Development of the Hindgut

- The posterior ectodermal portion of the alimentary canal is formed in the embryo by invagination of the outer body wall.
  - Becomes the lower 1/3 of the anal canal
- *Errors in this process can lead to imperforate anus, atresia and/or fistulas*

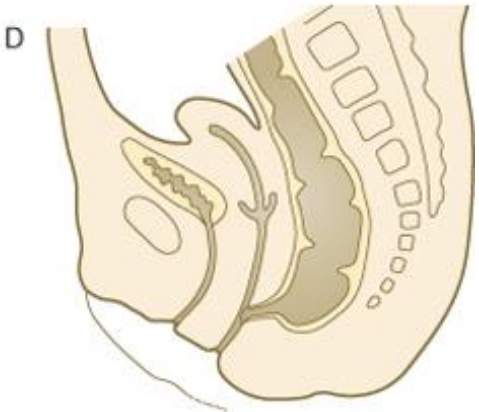
imperforate anus



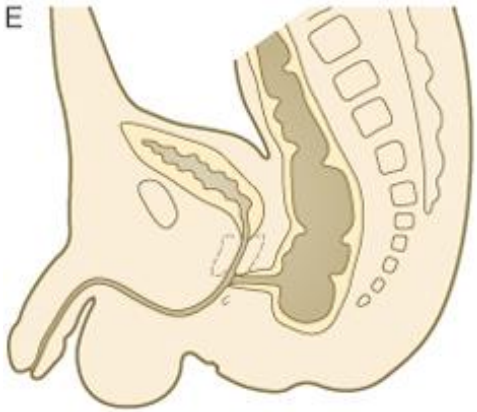
anal atresia



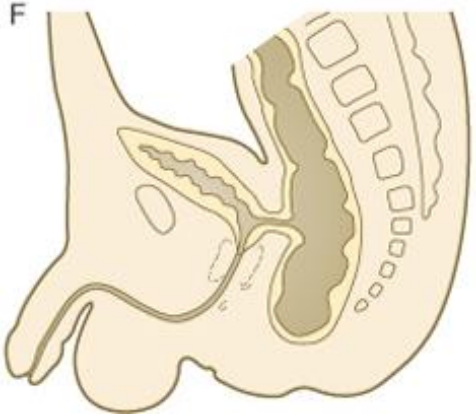
anoperineal fistula



rectovaginal fistula



rectourethral fistula



rectovesical fistula

Development of the Hindgut

- As with the rest of the GI tract, enteric neurons in the hindgut arise from vagal neural crest (plus some sacral crest).

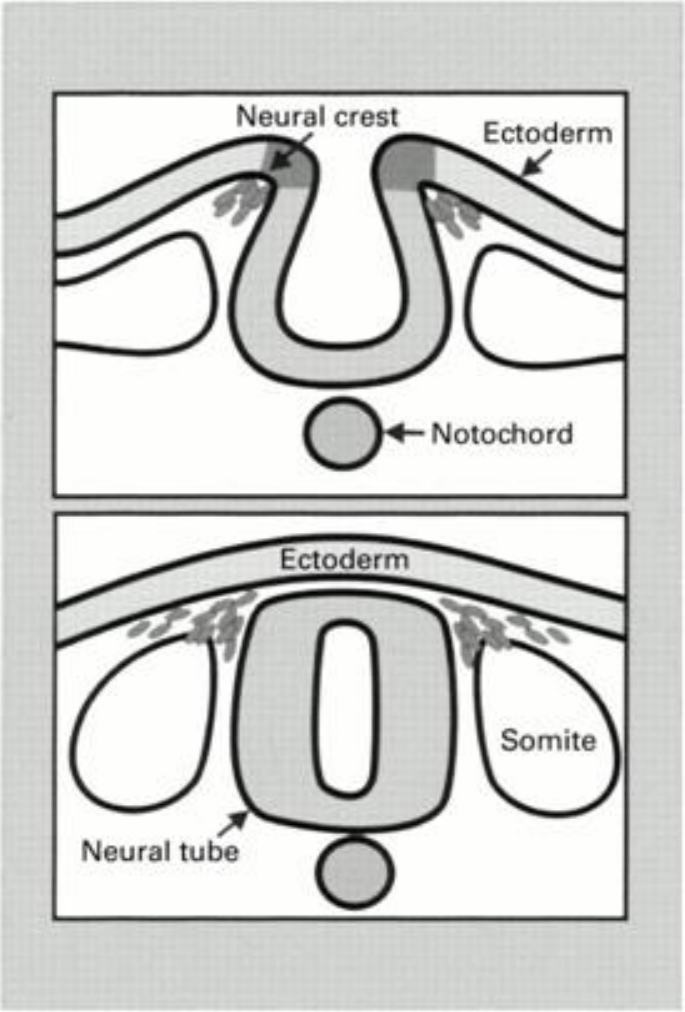
- Distal most portions of the hindgut are farthest away and therefore more sensitive to mutations, resulting in ***congenital megacolon (Hirschsprung's Disease).***

Hindgut Anomalies

- **Clinical Correlation**
  - Anorectal agenesis occurs if the urorectal septum does not develop appropriately.
  - Hirschsprung disease – failure of the neural crest cells to form the myenteric plexus (see Enteric Nervous System).

Enteric Nervous System

- Collection of neurons in the GI tract.
- Controls motility, exocrine and endocrine secretion and microcirculation.
- Regulates immune and inflammatory process.
- Functions independent of CNS.

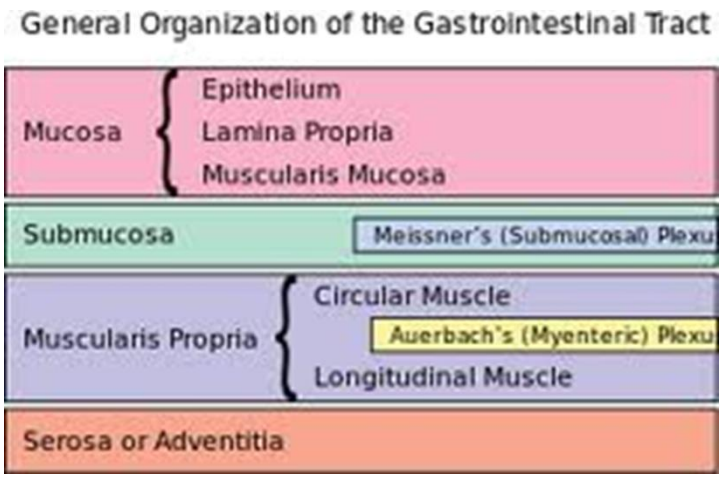


Development of Enteric Nervous System

- Primarily derived from the vagal segment of neural crest cells.
- Cells initially migrate to the cranial section and then caudally
- Hindgut ganglia receive contributions of cells from the cranial and sacral segments of the neural crest cells
- Interstitial cells of Cajal arise from the local gut mesenchyme

Development of the Enteric Nervous System

- Nerve cell bodies are grouped into ganglia
- Ganglia are connected to bundles of nerves forming two plexus
  - Myenteric (Auerbach's)
  - Submucosal (Meissner's)



Enteric Nervous System

- Myenteric plexus
  - Lies between the circular and longitudinal muscles
    - Regulates
      - Motility
      - Secretomotor function to mucosa
    - Connections to
      - gallbladder and pancreas
      - sympathetic ganglia
      - esophageal striated muscle

Enteric Nervous System

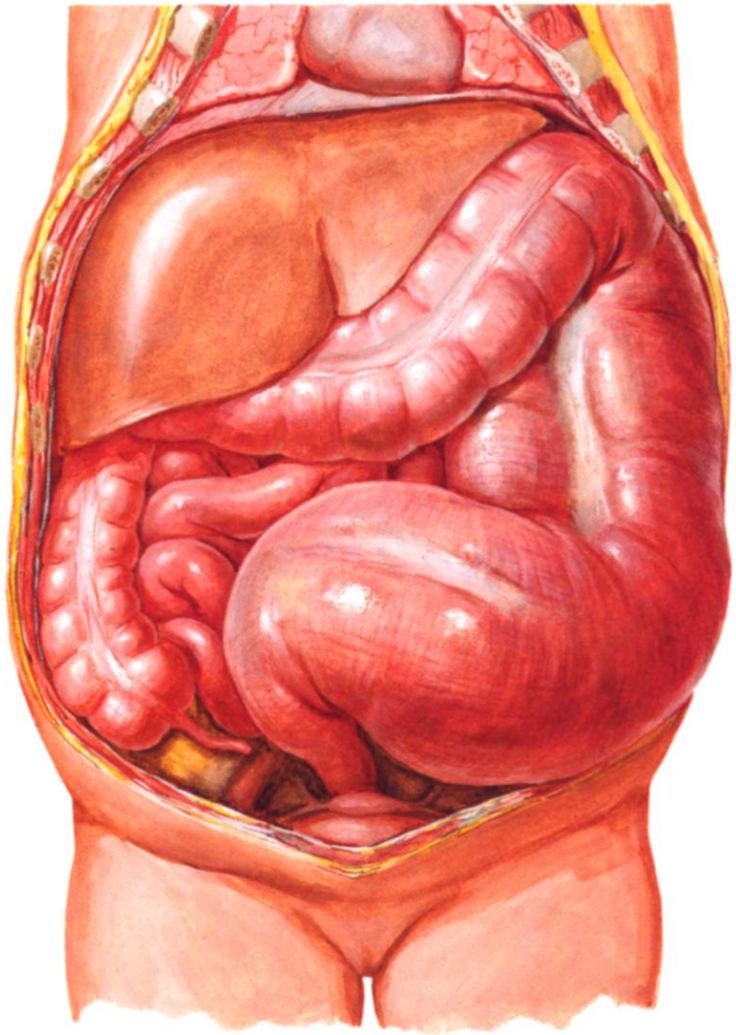
- Submucosal plexus
  - Lies between circular muscle layer and the muscularis mucosa
    - Regulates:
      - Glandular secretions
      - Electrolyte and water transport
      - Blood flow
  - Similar structure found in gallbladder, cystic duct, common bile duct and the pancreas

Hirschsprung's Disease

- Congenital disorder
- 1:5000 live births
- Failure of neural crest cells to colonize the entire gut resulting in an aganglionic zone
  - Tonic constriction of aganglionic section

Hirschsprung's Disease

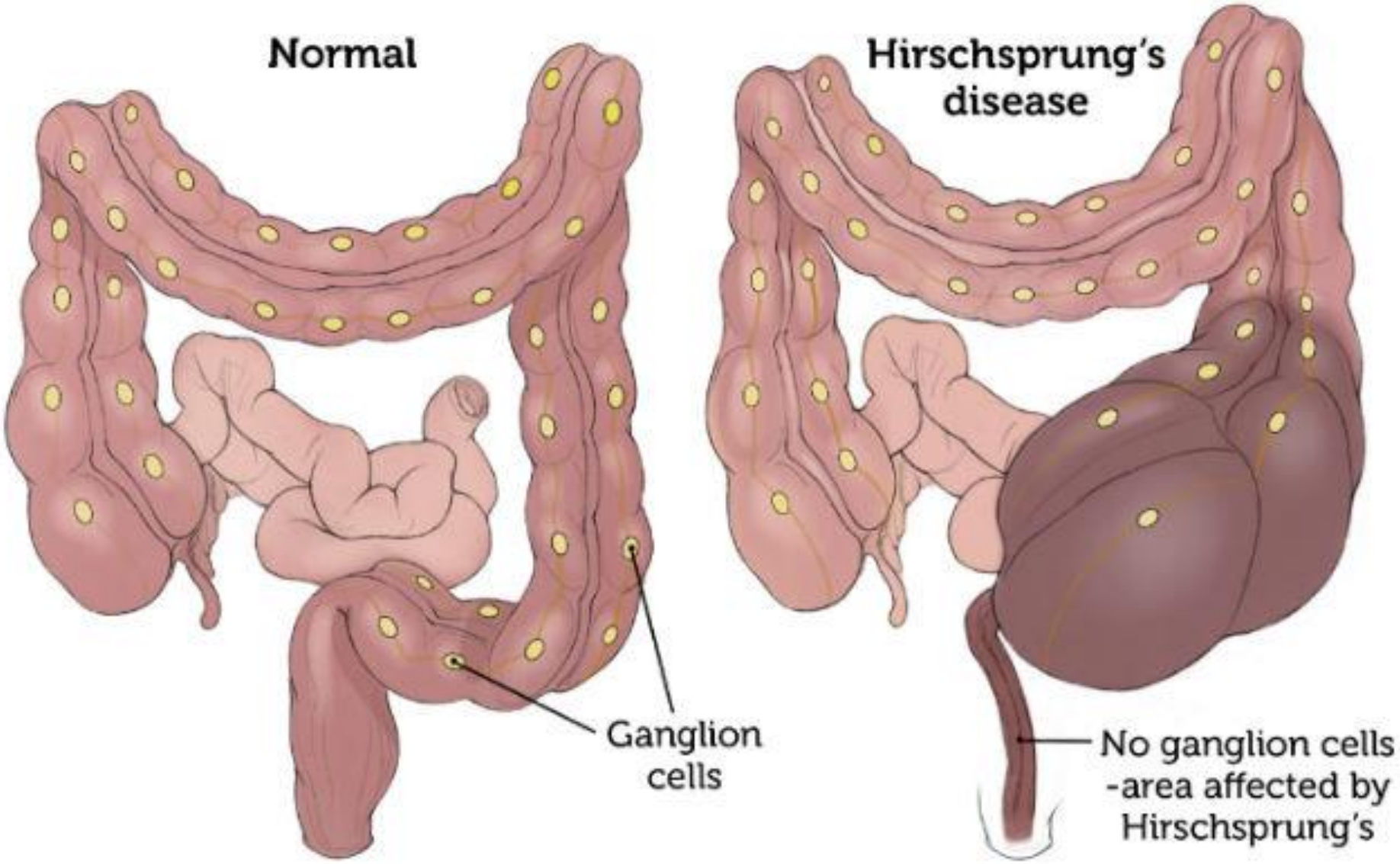
- Isolated anomaly in 70% of cases
- Multiple genes and modifier genes identified
- Upstream regions become distended (hence "megacolon")
- Surgically repaired by removing affected region



Tremendous distention and hypertrophy of sigmoid and descending colon; moderate involvement of transverse colon; distal constricted segment

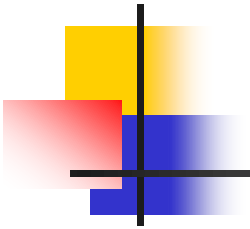
Typical abdominal distention

F. Netter M.D.


Normal
Hirschsprung's disease
Ganglion cells
No ganglion cells -area affected by Hirschsprung's

- For further inquiries ***PLZ*** feel free to contact at any time through email

gamal.abdelhady@yu.edu.jo
gamaltaha@med.asu.edu.eg



Thank You