DEVELOPMENT OF DIGESTIVE SYSTEM

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Embryology Course

DIGESTIVE SYSTEM

the digestive system consists of the:

a. oral cavity

b. pharynx

c. esophagus

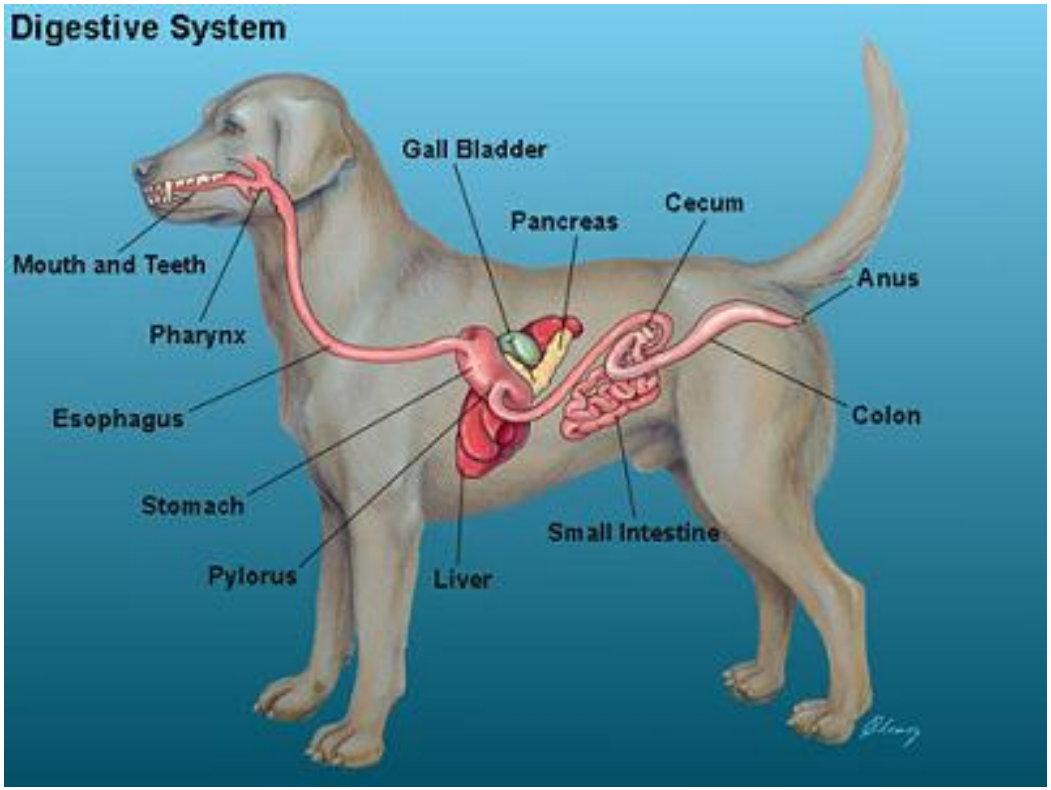
d. gastro – intestinal tract

e. rectum

f. anus

g. liver

h. pancreas



https://www.dog-nutrition-naturally.com/dog-digestive-system.html

DIGESTIVE SYSTEM

1. **the primordial gut closed at its cranial end by the oropharyngeal membrane**
2. **the caudal end of the primordial gut gives rise to most of the epithelium and glands of the alimentary system**
3. **the epithelium at the cranial and caudal ends of the tract derived from the ectoderm of the stomodeum and the proctodeum (anal pit)**
4. **the muscular and connective tissue and other layers of the wall of the digestive tract derived from the splanchnic mesenchyme surrounding the primordial gut**

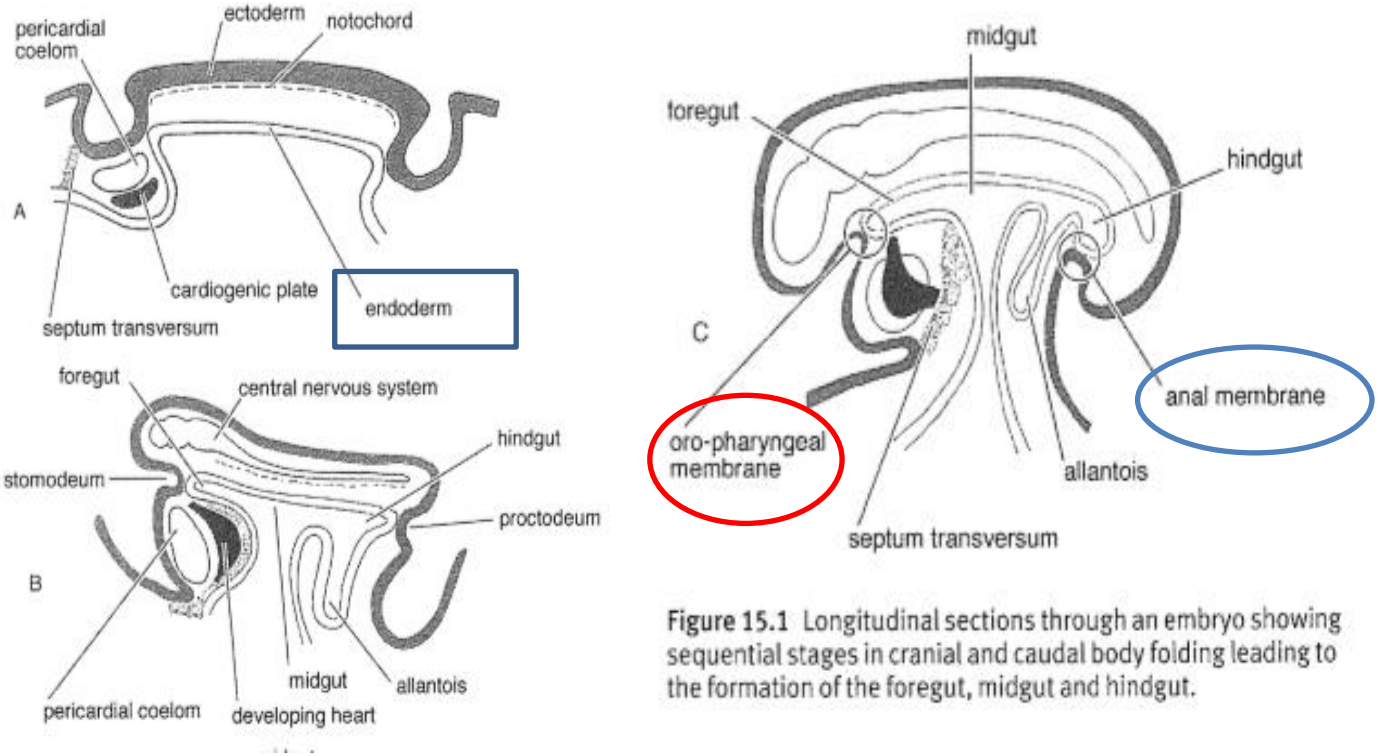


Figure 15.1 Longitudinal sections through an embryo showing sequential stages in cranial and caudal body folding leading to the formation of the foregut, midgut and hindgut.

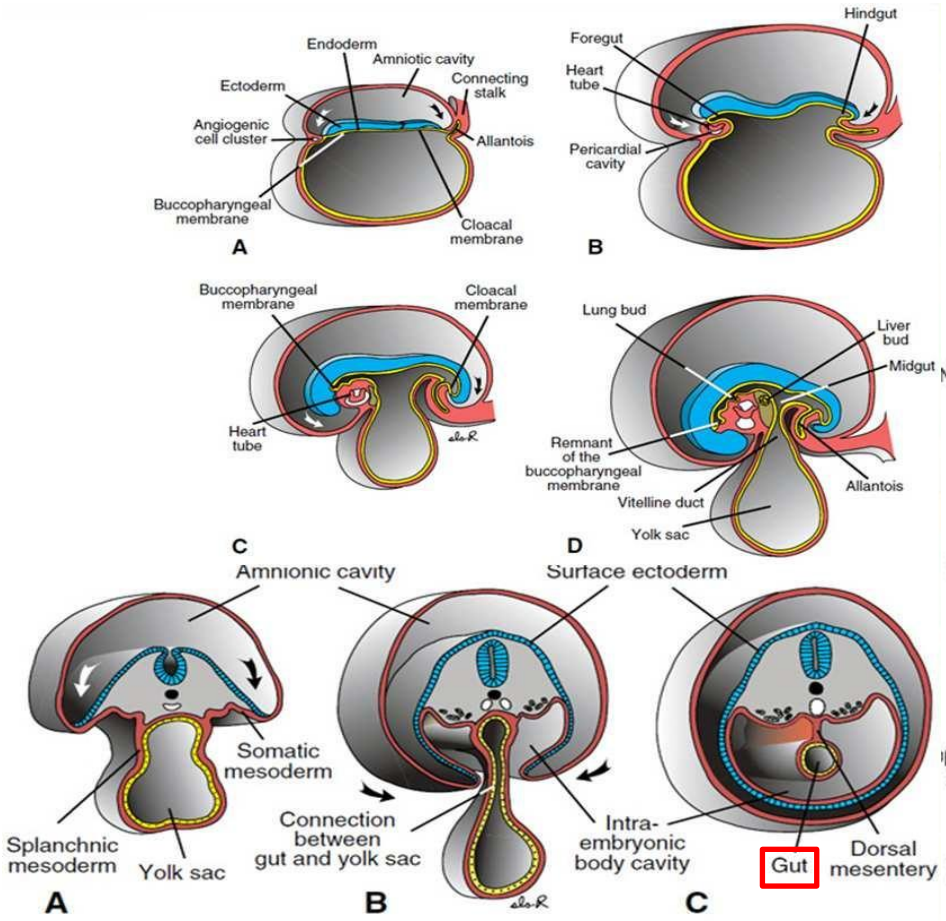
DIGESTIVE SYSTEM

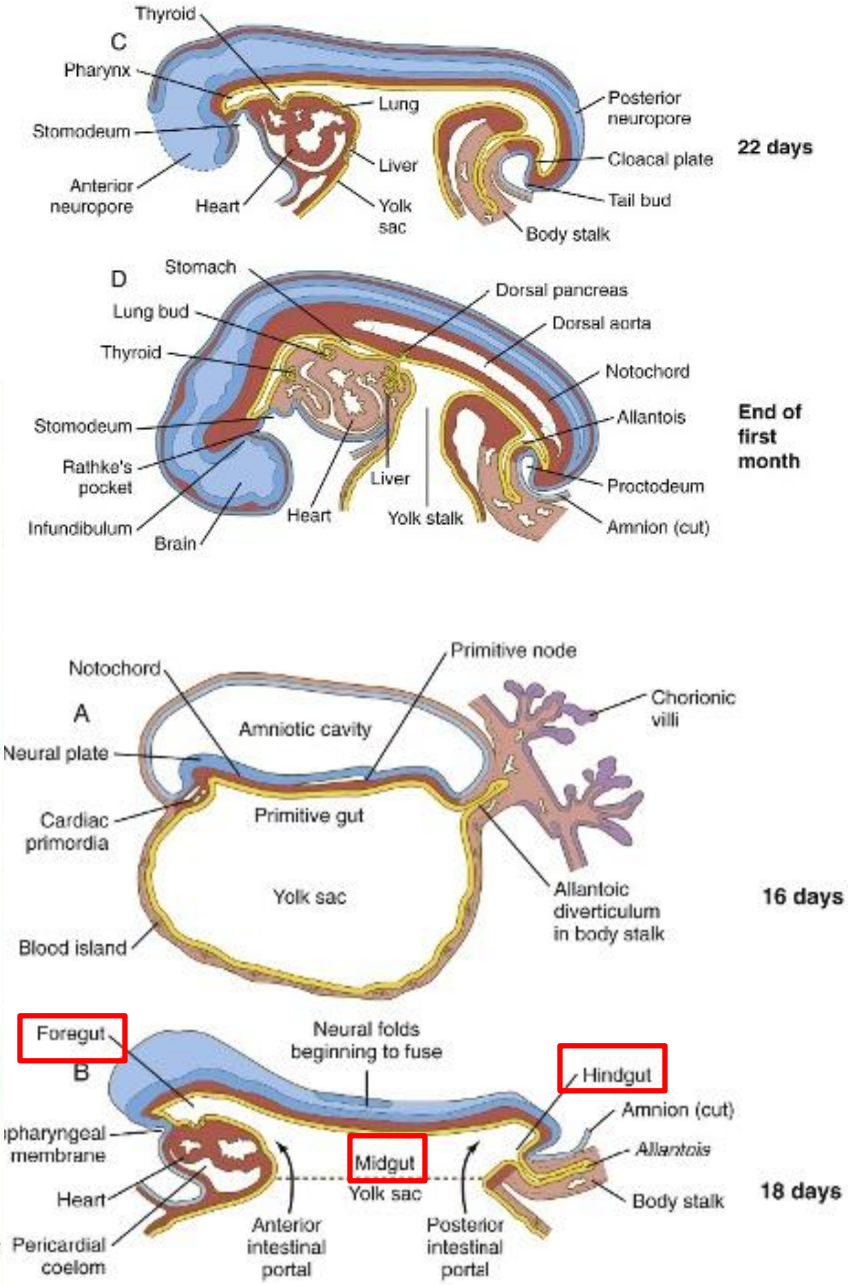
the primordial gut is divided into:

a. **foregut**

b. **midgut**

c. **hindgut**





DIGESTIVE SYSTEM

DERIVATIVES OF THE FOREGUT THE:

a. **primordial pharynx and its derivatives**

b. **lower respiratory system**

c. **esophagus**

d. **stomach**

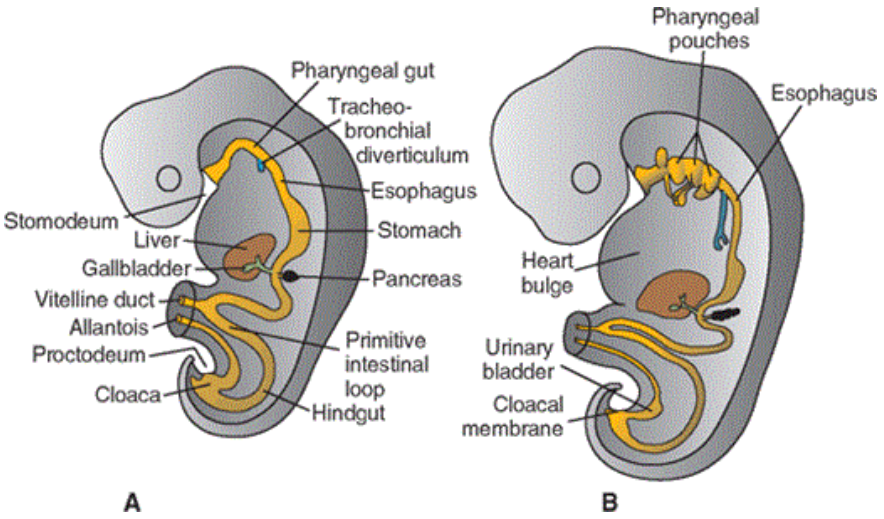
e. ***duodenum, just distal to the opening of the bile duct***

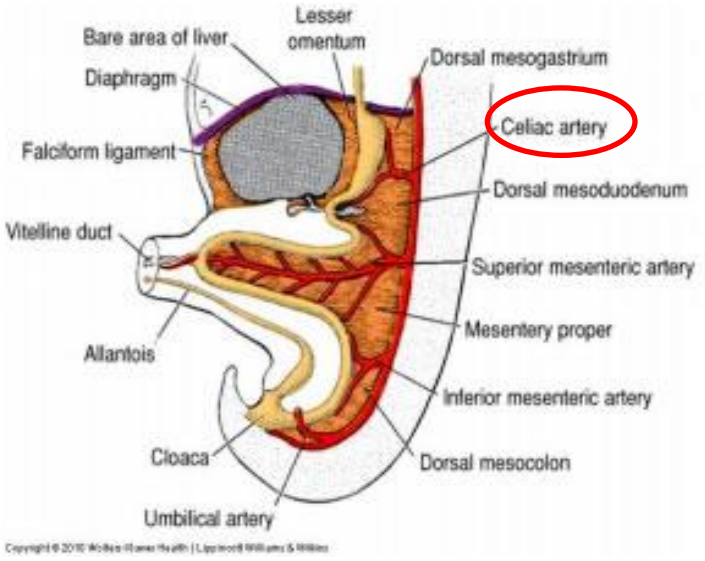
f. **liver**

g. **biliary apparatus (hepatic ducts, gallbladder, bile duct)**

h. **pancreas**

- all of the foregut derivatives, exept the pharynx, respiratory tract, most of the esophagus, are supplied by the celiac artery – the artery of the foregut





DIGESTIVE SYSTEM

DERIVATIVES OF THE MIDGUT THE:

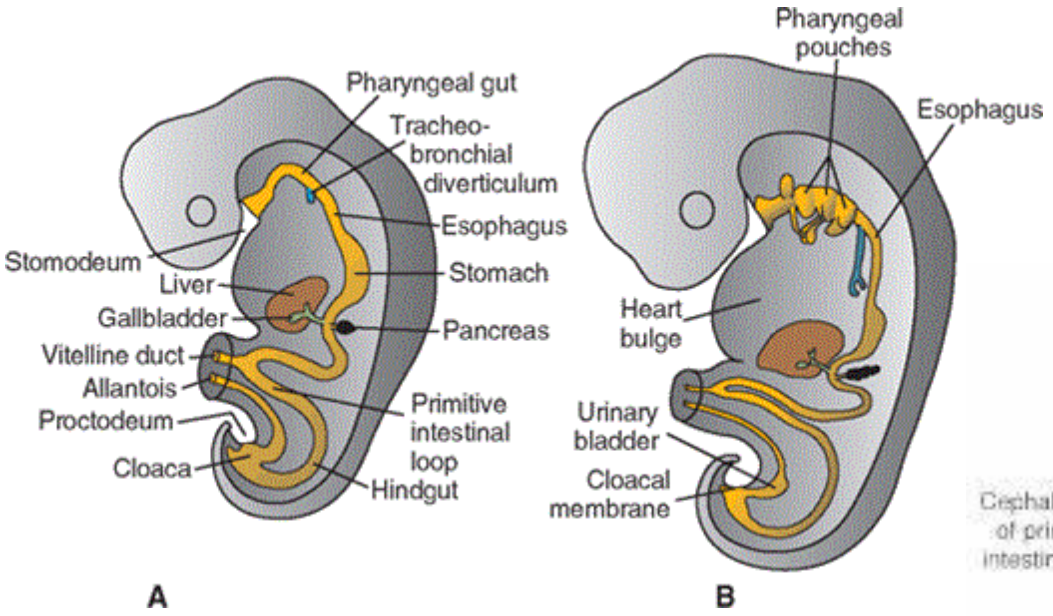
a. small intestine, including the duodenum distal to the opening of the bile duct

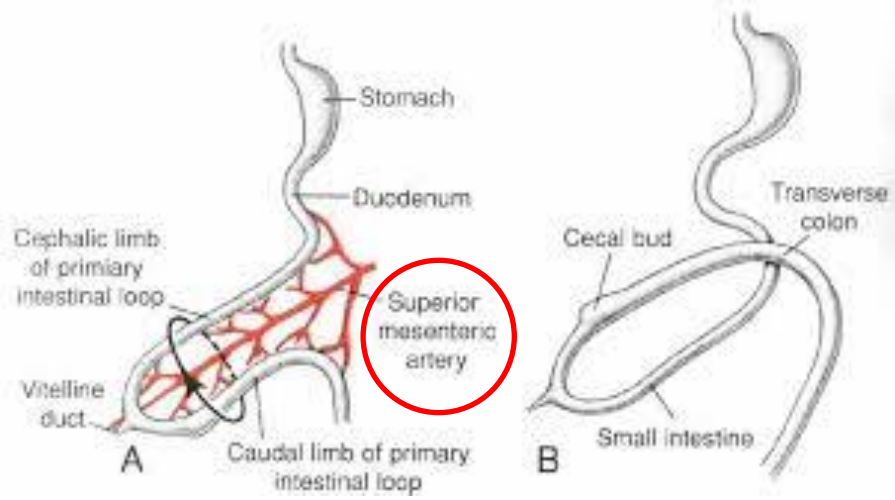
b. caecum

c. ascending colon

d. right half to two thirds of the transverse colon

- all of these derivatives are supplied by the cranial mesenteric artery





DIGESTIVE SYSTEM

DERIVATIVES OF THE HINDGUT THE:

a. left third to half of the transverse colon

b. desceding colon

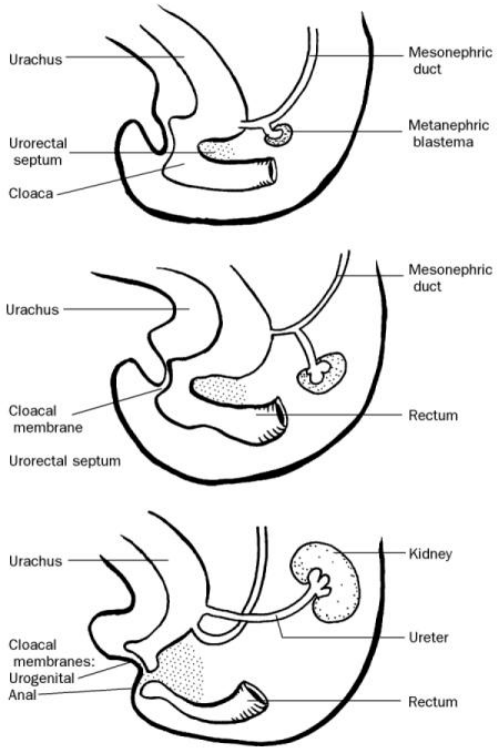
a. sigmoid colon

b. rectum

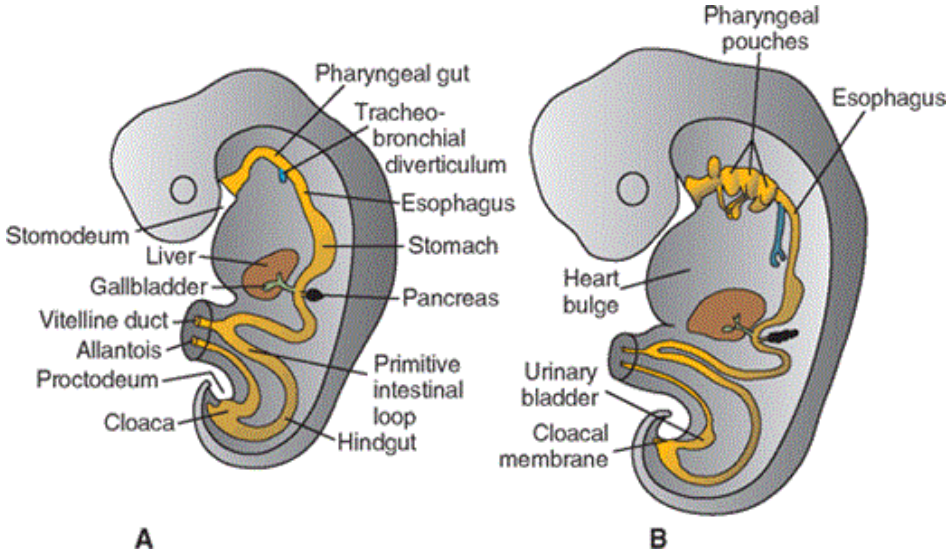
c. cranial part of the anal canal

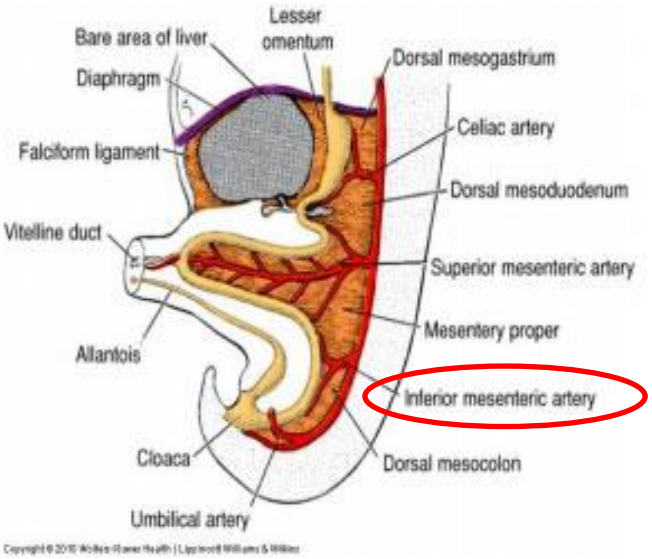
d. epithelium of the urinary bladder and most of the urethra

- all of these derivatives are supplied by the caudal mesenteric artery



https://www.med.umich.edu/lrc/coursepages/m1/embryology/embryo/10digestivesystem.htm

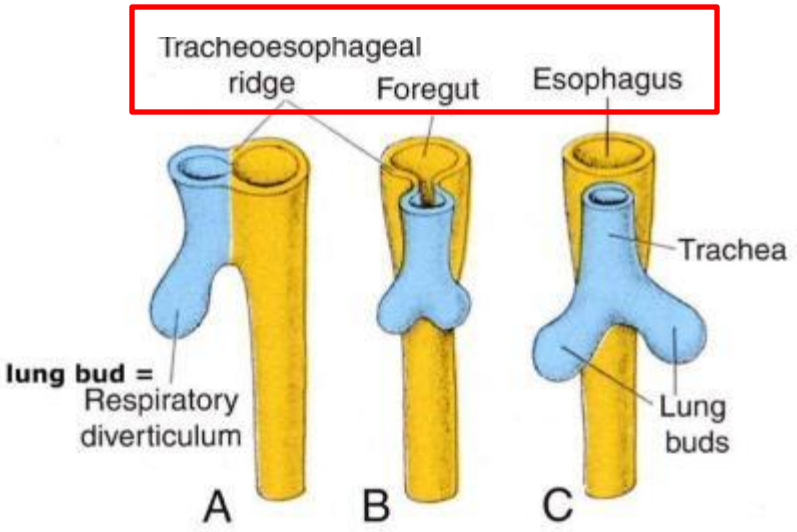


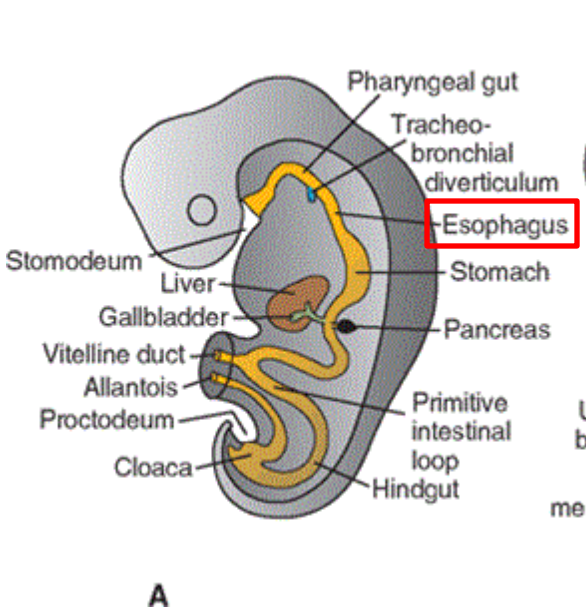


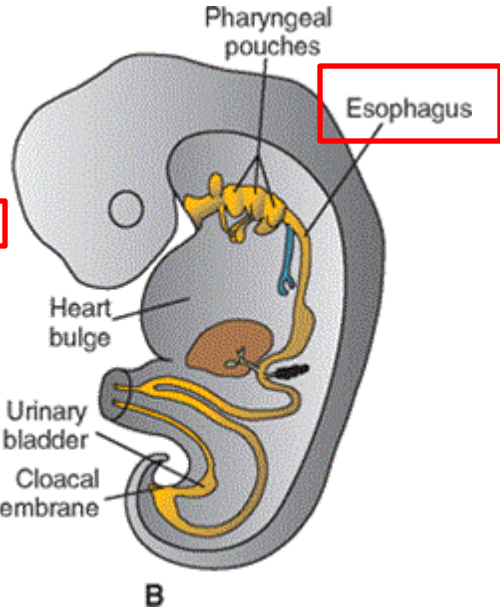
ESOPHAGUS

- formed from that portion of the foregut, that just behind the pharynx
- the tracheopharyngeal ridge and septum separates it from the trachea

1. elongates rapidly and reaches its final relative lentgh
2. its epithelium and glands derived from the endoderm
3. the striated muscle derived from the mesenchyme in the 4th and 6th pharyngeal arches
4. the smooth muscle mainly in the caudal third of the esophagus develops from the surrounding splanchnic mesenchyme

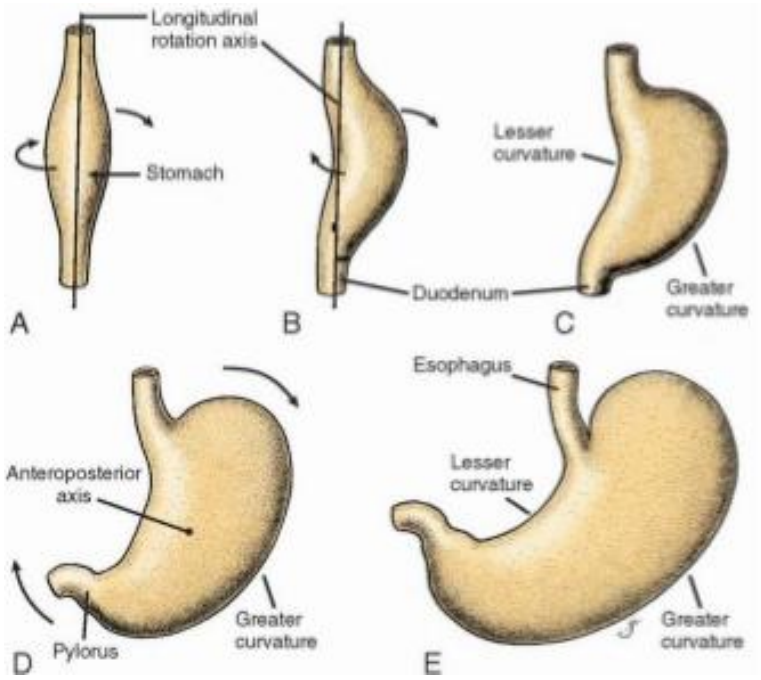


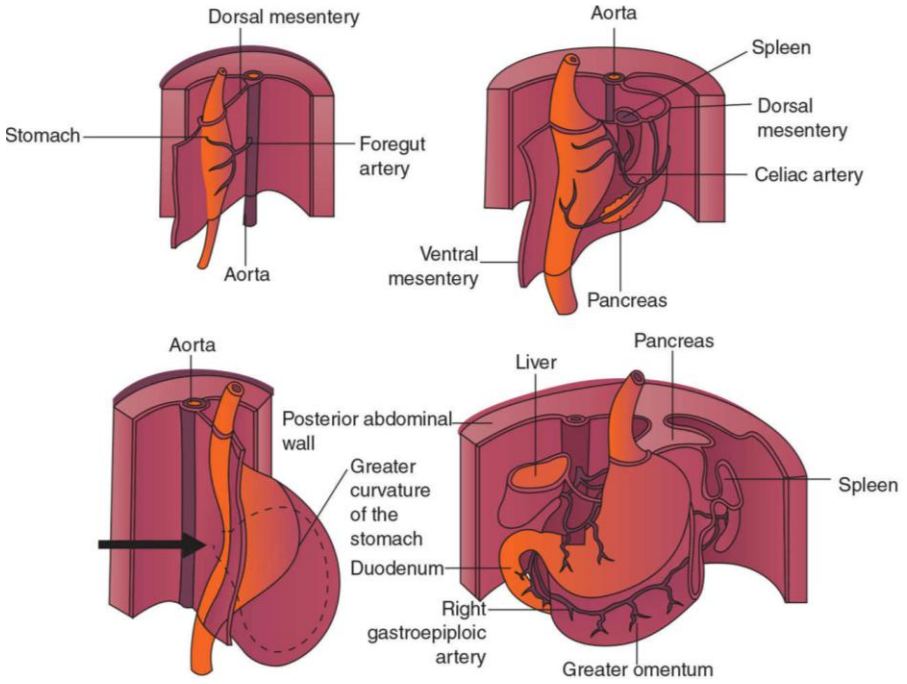




MONOGASTRIC (SIMPLE) STOMACH

1. **a slight dilatation of the tubelike foregut indicates the site of the primordial stomach**
2. **the dilatation enlarges, most of the enlargement occurs dorsally**
3. **once the dorsal enlargement is formed, the stomach area undergoes a 90 degree rotation along its cranial – caudal axis**
4. **the dorsal enlargement rotates toward the left side of the embryo**
5. **so the stomach lies with the former dorsal part directed toward the left and the ventral part toward the right**

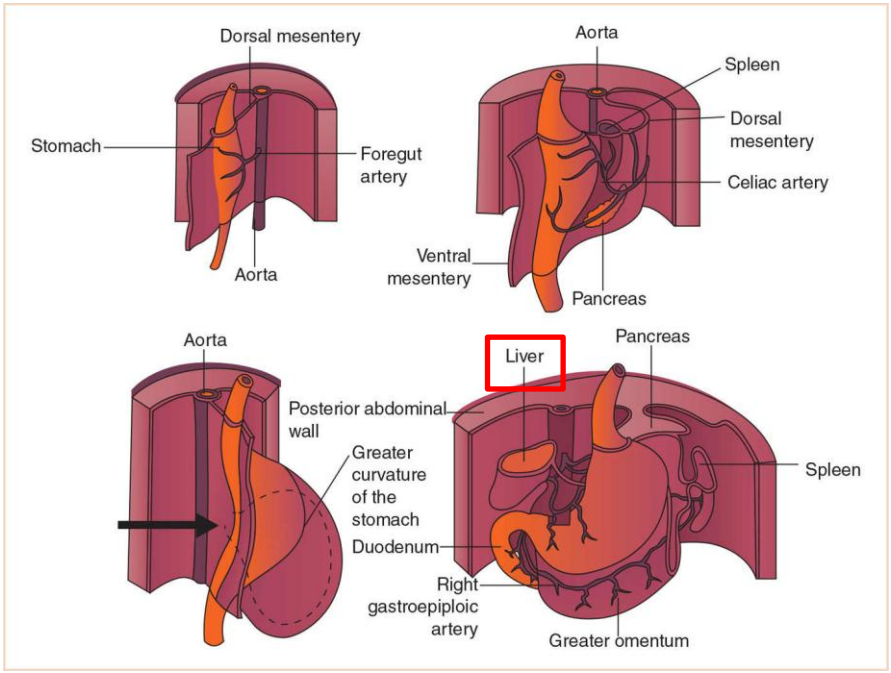




https://aneskey.com/gut-development-surgical-and-anesthetic-implications/

MONOGASTRIC (SIMPLE) STOMACH

6. as this position change occurs, the liver is on the right side of the abdominal cavity, rapidly enlarges
7. this rapid enlargement of the liver pushes the cranial end of the stomach further to the left
8. the cranial part of the dorsal enlargement of the stomach grows more than the caudal part – and forms the fundus
9. the boundary of the dorsal enlargement is the greater curvature of the stomach
10. the original ventral part of the stomach is the lesser curvature



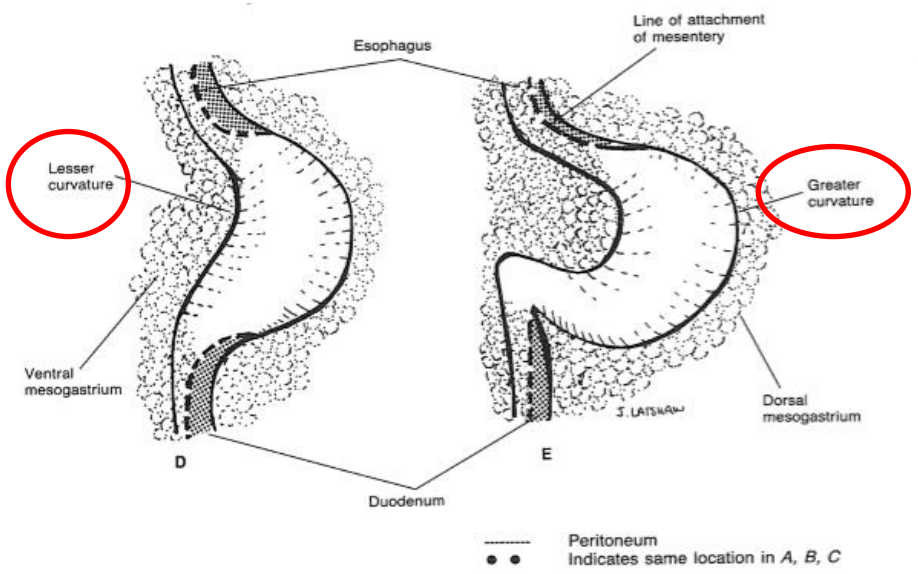


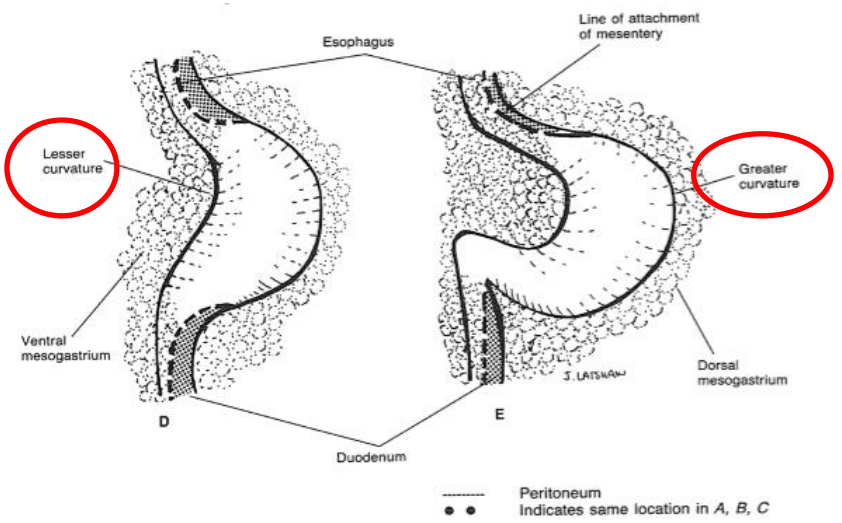
Figure 10–1 Development of the simple stomach. *A*, Before differentiation of stomach; *B*, Formation of dorsal enlargement; *C*, Rotation along long axis toward the left; *D*, *E*, Displacement of cranial end of stomach toward the left. (*A*, *B*, and *C* are cranial views; *D* and *E* are ventral views.) (Modified after Zeitzschmann O, Krolling O. Lehrbuch der Entwicklungsgeschichte des Haustieres. Hamburg: Paul Parey, 1955.)

MONOGASTRIC (SIMPLE) STOMACH

the result of the positional changes is that:

– the greater curvature lying towards the left

- the lesser curvature lying toward the right



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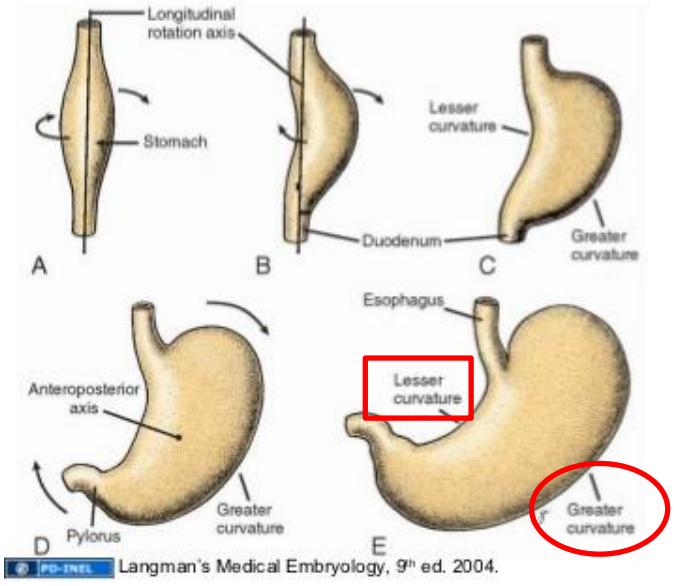
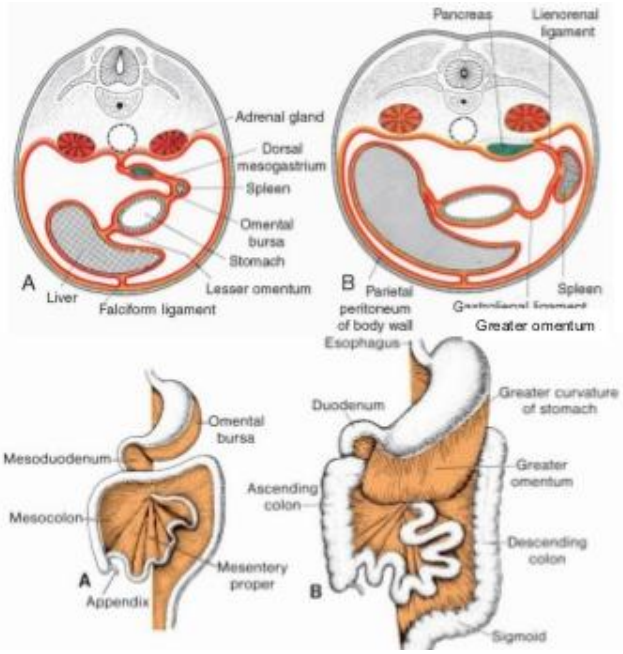




RUMINANT STOMACH

PRENATAL DEVELOPMENT

1. **in the cow the monogastric stage is reached by 33 days**

2. **the 90 degree rotation to the left is completed by 33 days**

3. **the area corresponding to the fundus in a monogastric stomach expanded toward the left – this expansion is the rumen**

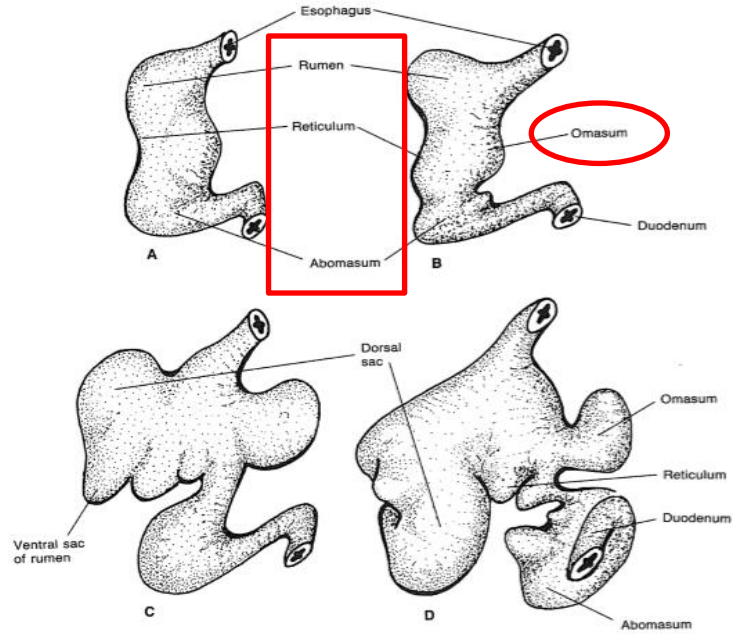


Figure 10–2 Development of the ruminant stomach (cow). *A* to *E* are dorsal views; *A*, 3 weeks; *B*, 4 weeks; *C*, 6 weeks; *D*, 8 weeks; *E*, 14 weeks. *(Continued on next page)*

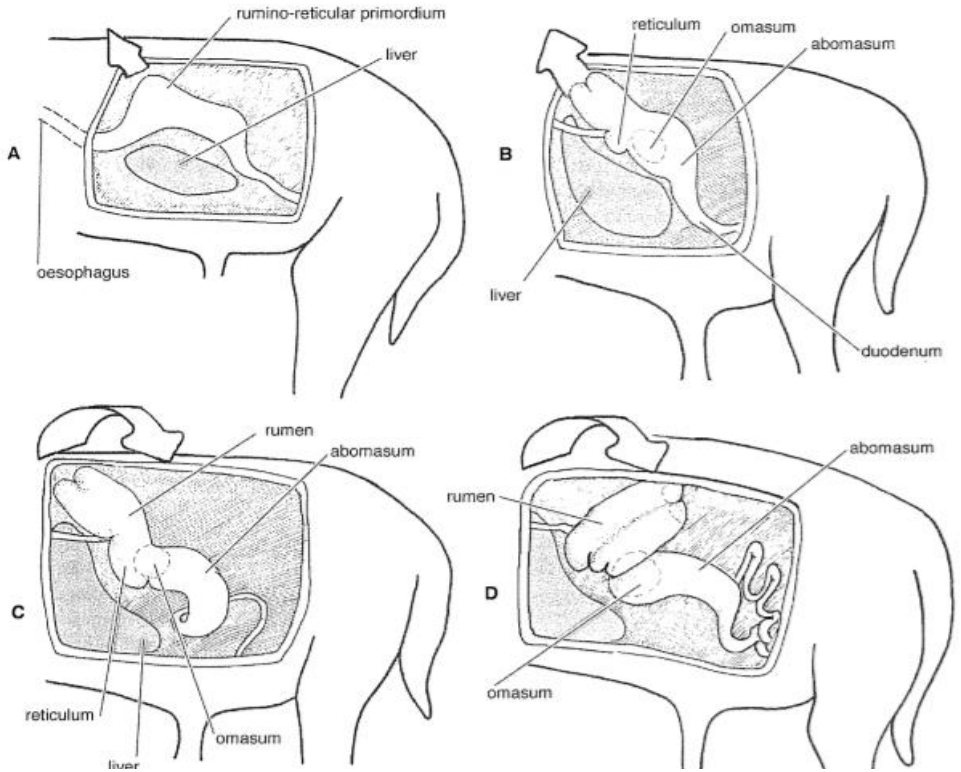


Figure 15.5 Sequential stages in the formation of the four compartments of the ruminant stomach. A, Simple gastric primordium. B, Primordia of the rumen, reticulum, omasum and abomasum and formation of ruminal groove. C and D, Stages in caudal rotation of rumen. E, Final arrangement of the four compartments of the ruminant stomach.

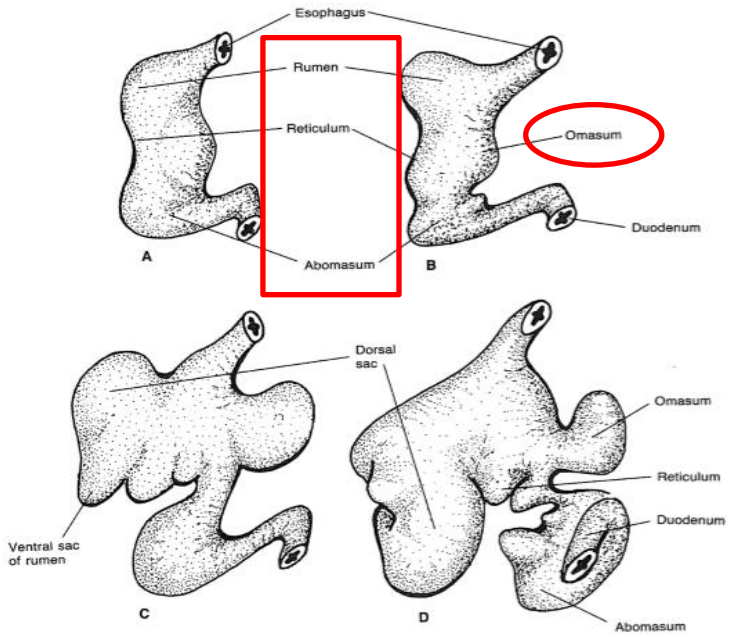
RUMINANT STOMACH

PRENATAL DEVELOPMENT

4. immediately thereafter **the reticulum is formed along the greater curvature of the embryonic stomach caudal and ventral to the forming rumen**

5. along the lesser curvature the omasum appears

6. abomasum forms from the pyloric region



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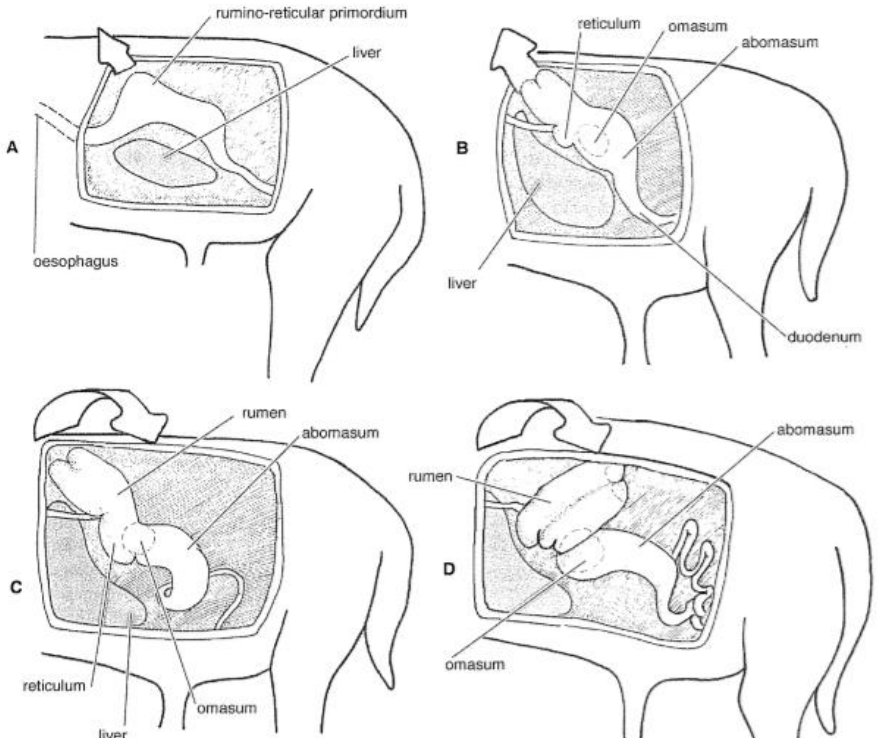

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RUMINANT STOMACH

PRENATAL DEVELOPMENT

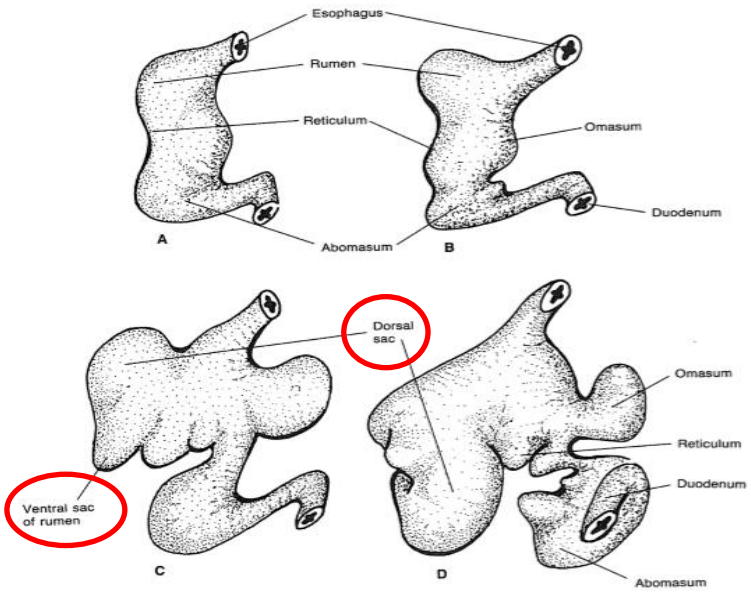
7. by 40 days the rumen becomes differentiated by two cranially directed outgrowth from the fundic region

- **these are the dorsal and ventral sacs**

8. by the day 43 the rumen is growing caudodorsally and toward the right

9. the dorsal and ventral sac become directed caudally

10. the dorsal sac is dorsal to the ventral sac



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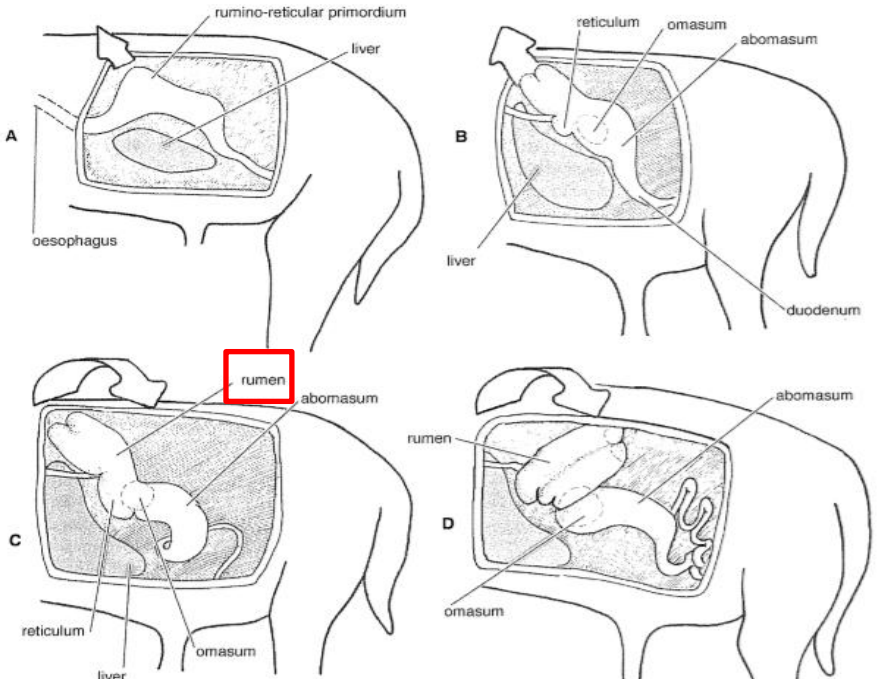

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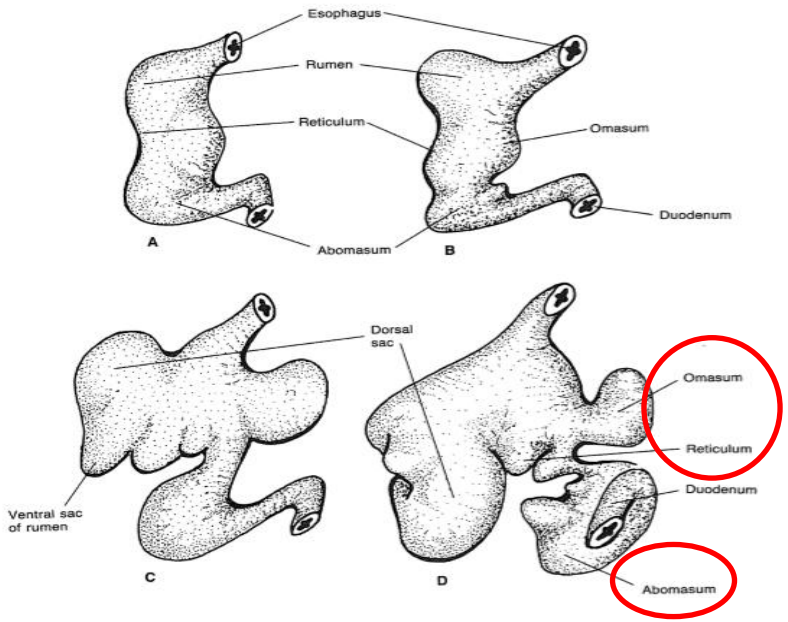
RUMINANT STOMACH

PRENATAL DEVELOPMENT

11. **the rumen is in its definitive position in the left side of the abdominal cavity**

12. the change in position of the rumen forces **the reticulum to shift to a more cranioventral position and pushes the omasum and abomasum toward the right**



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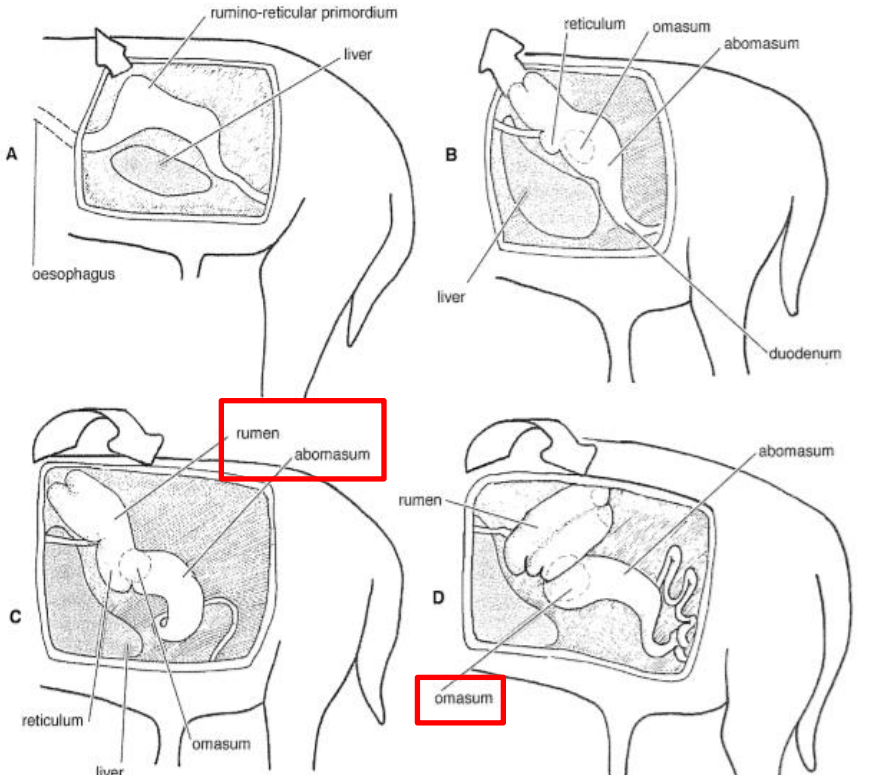

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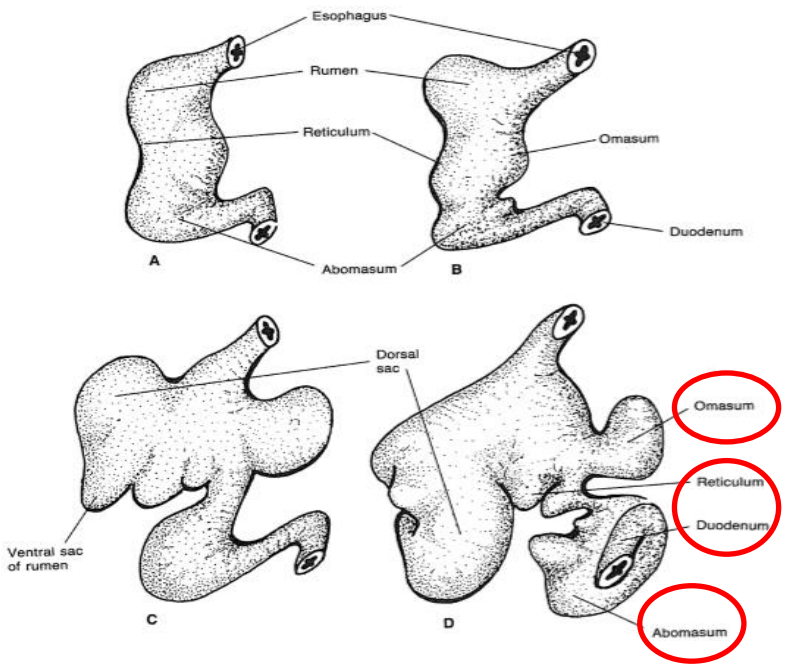
RUMINANT STOMACH

PRENATAL DEVELOPMENT

13. the junction between the abomasum and duodenum directed toward the rigth

14. the abomasal - duodenal junction forced to fold back on itself and becomes directed in dorsal direction



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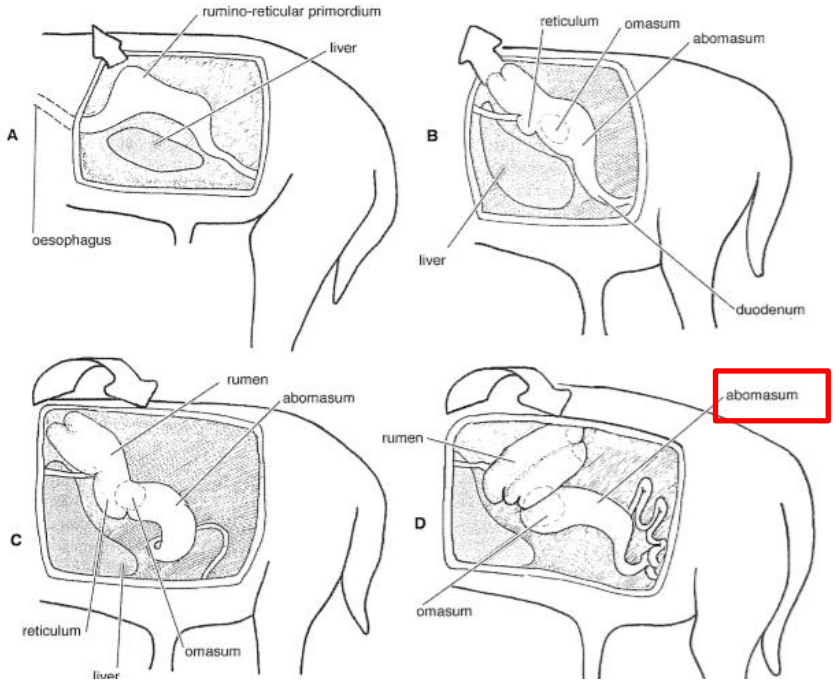

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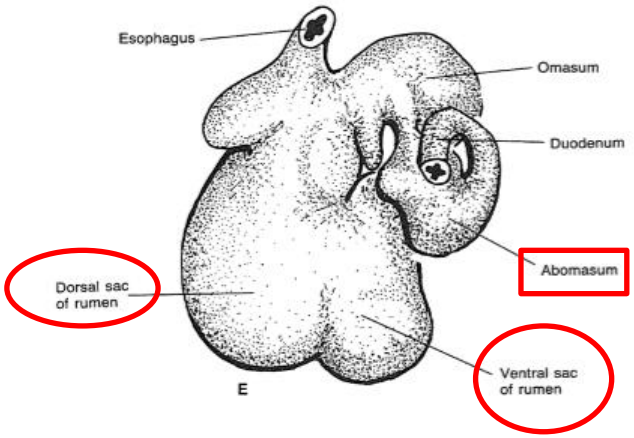
RUMINANT STOMACH

POSTNATAL DEVELOPMENT

1. **the adult positions are reached at 14 weeks of gestation in the cow, the growth of the rumen slows, and by birth the rumen is about one – half the size of the abomasum**
2. **after birth, the rumen again enlarges until at 8 weeks of age**
3. **the rumen and abomasum are about the same size**



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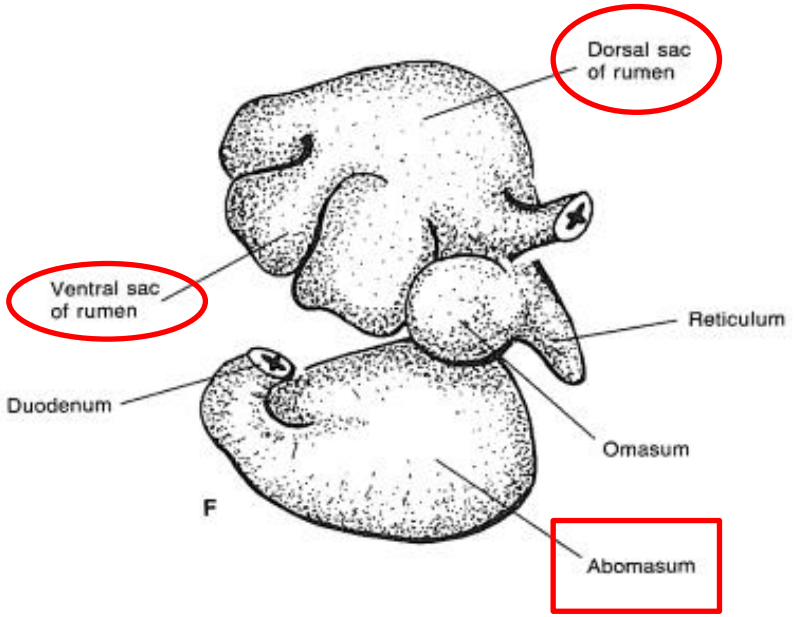


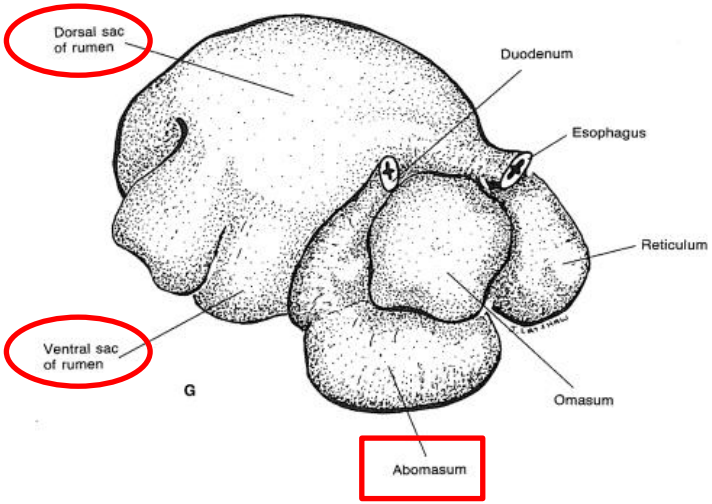
RUMINANT STOMACH

POSTNATAL DEVELOPMENT

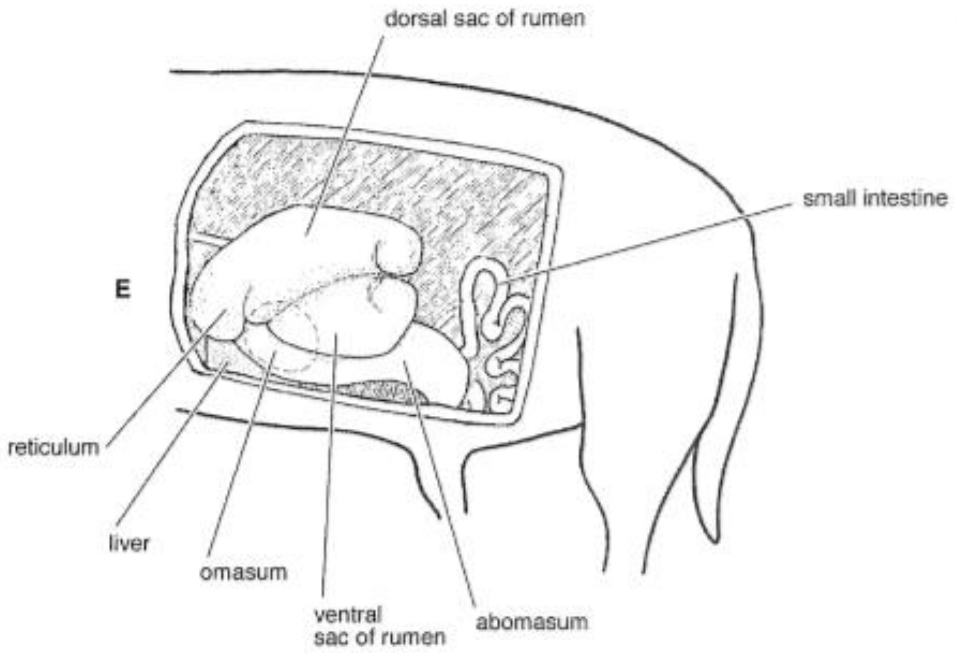
4. **by 12 weeks the rumen is twice the size of the abomasum**

5. **by 1 – 1,5 years of age the relative sizes of the ruminant stomach parts approach that of adult**

6. the rate of the rumen growth depends upon how much roughage is included in the diet



Continued. F, birth; *G,* adult (1½ years).



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RUMINANT STOMACH

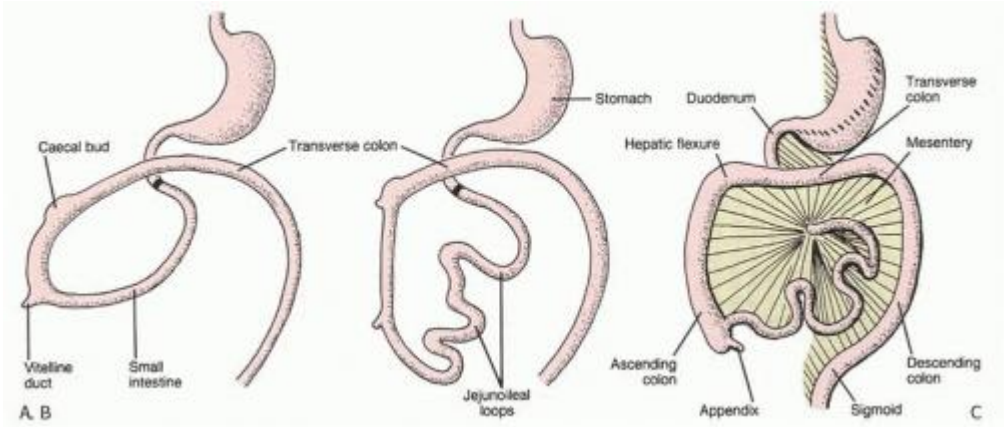
INTERNAL STRUCTURES

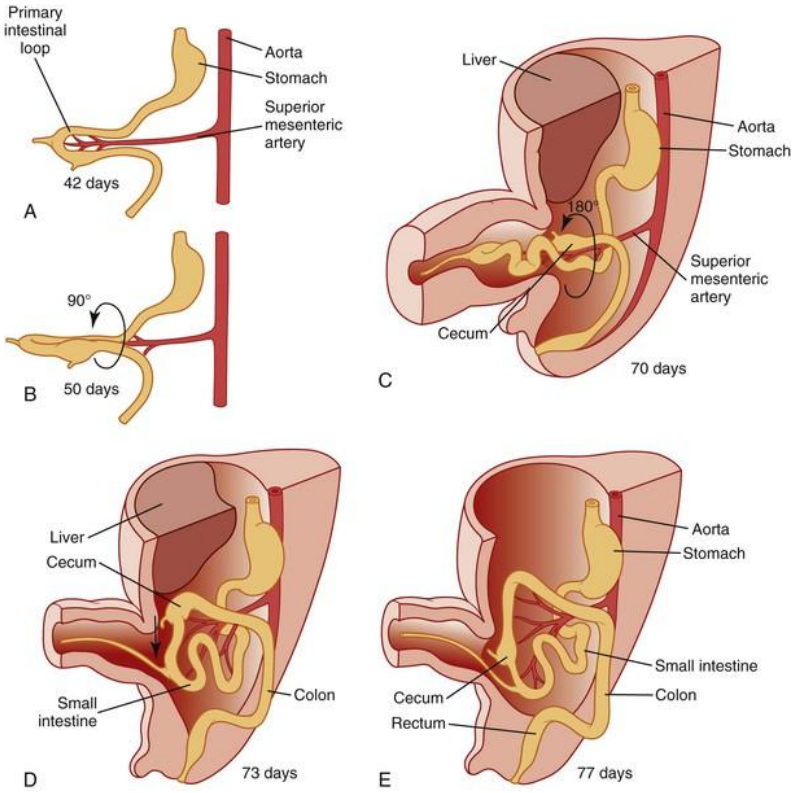
1. the internal structures of ruminant forestomach follows closely the development of their external features
2. the lamina formation in the omasum indicated by 40 days
3. by 50 – 60 days of gestation there are reticular crest and cells in the reticulum
4. definitive omasal lamina are also presented by 50 – 60 days
5. by 3 month definitive reticular crests and cells are presents
6. distinctive ruminal papillae do not appear until nearly 5 months of gestation

INTESTINAL TRACT

PHYSIOLOGICAL ATRESIA:

1. **the esophagus, intestine, rectum normally become occluded by a proliferation of epithelium that lines the intestinal tube - this occlusion referred as physiological atresia**
2. **the occlusion is temporary – by the end of the embryonic phase – recanalization has begun**
3. **recanalization – formation of vacuoles, in the epithelium that coalesce to form a definitive lumen**





INTESTINAL DEVELOPMENT

the midgut form:

a. ascending duodenum

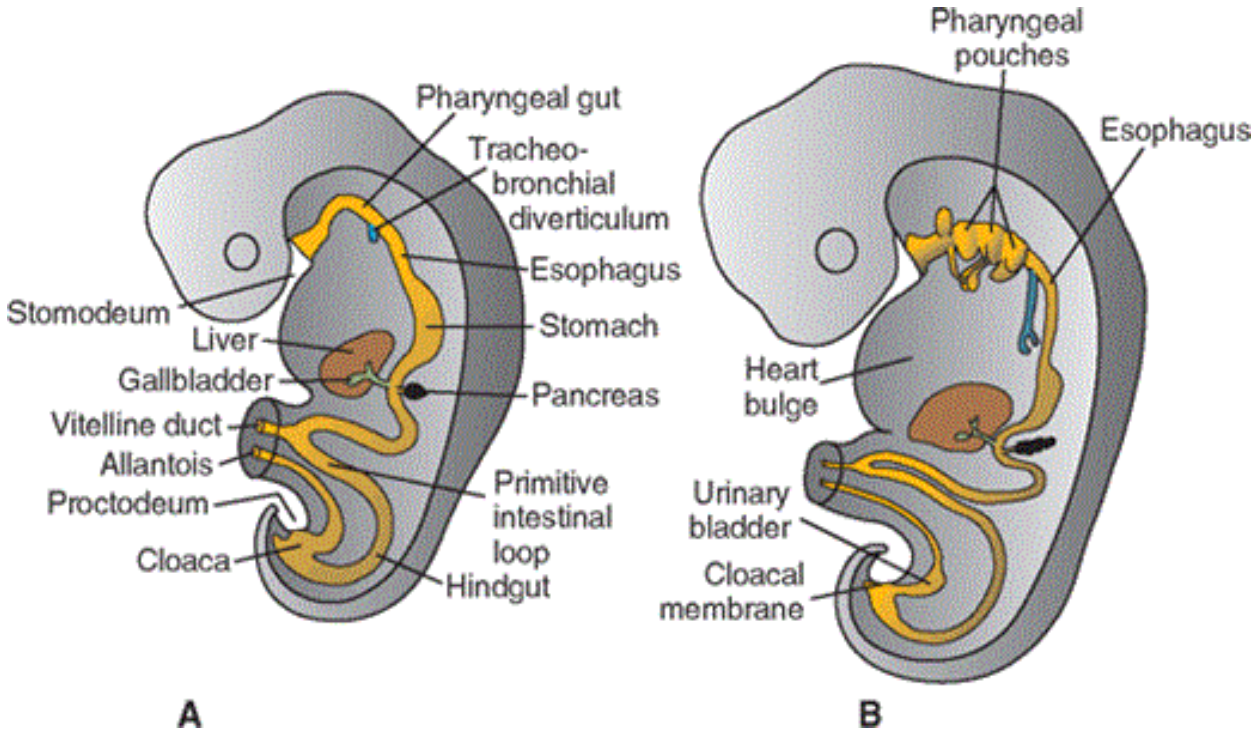
b. jejunum

c. ileum

d. caecum

e. ascending colon

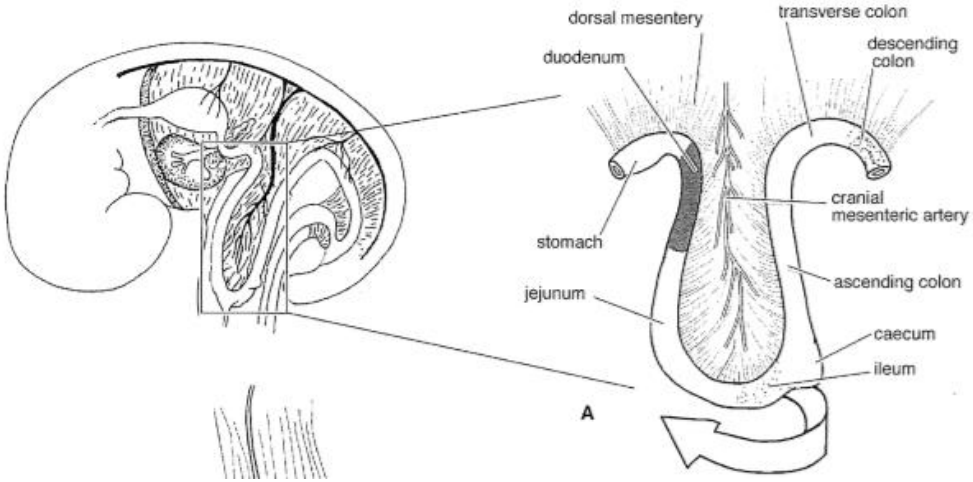
f. transverse colon

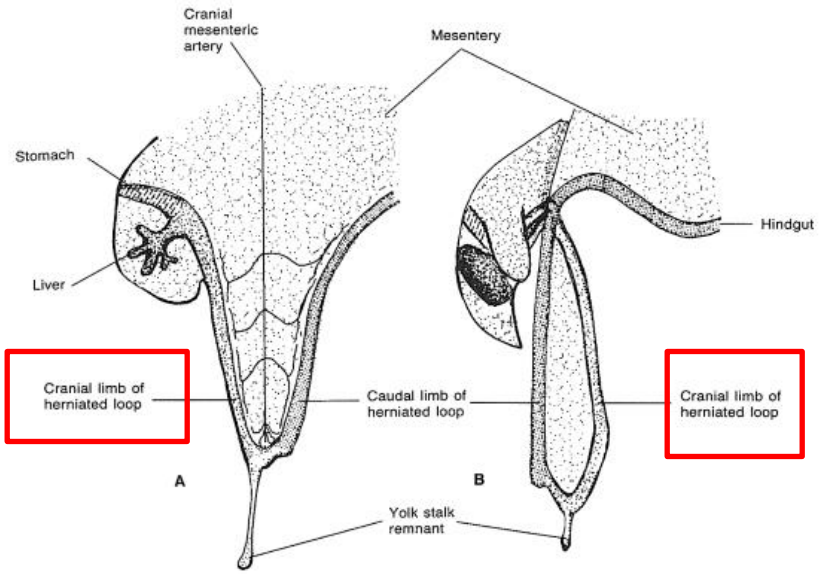


DERIVATIVES OF THE MIDGUT

CARNIVORES

1. at a very early stage in development **the midgut grows in length faster it can be accomodated in the abdominal cavity**
2. the **midgut herniates into the coelomic cavity of the umbilical cord**
3. the **herniated midgut in the form of a loop , termed the umbilical intestinal ansa**
4. **the cranial limb of the loop is attached to the foregut**





DERIVATIVES OF THE MIDGUT

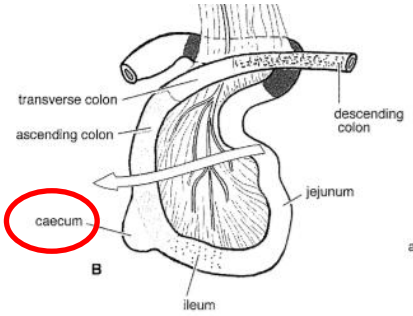
CARNIVORES

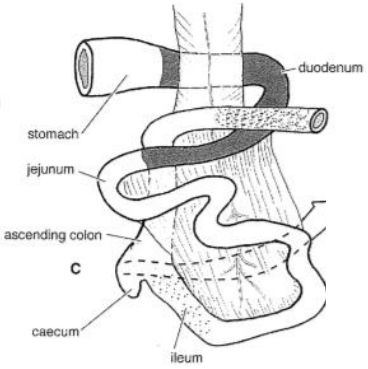
5. the caudal limb of the loop is attached to the hindgut

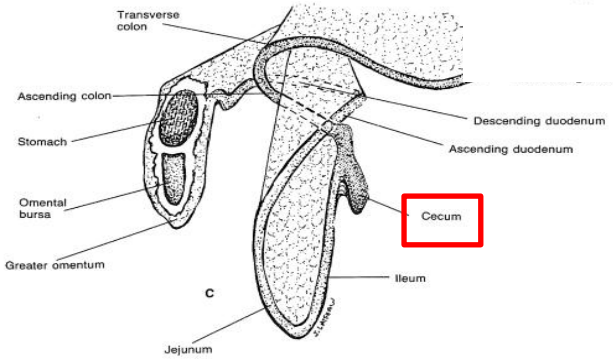
6. the loop undergoes a twisting in which the caudal limb moves cranially and to the left – the result is a double – twist in the loop with both cranial and caudal limbs undergoing 90 degree rotations

7. the axis of these rotation is a branch of the aorta located in the mesentery of the loop – this branch becomes the cranial mesenteric artery in adult

8. the caudal limb of the loop develops a diverticulum – becomes the caecum







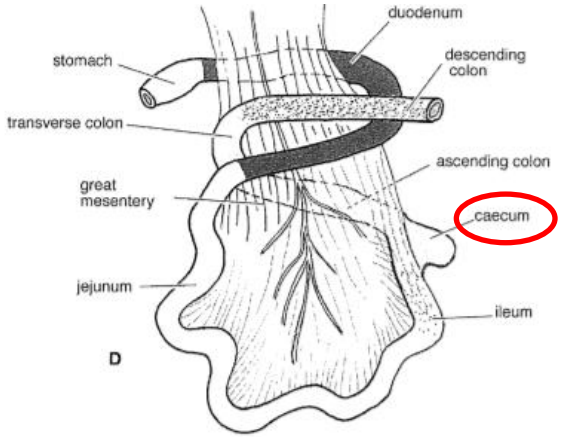


Figure 10–3 Development of intestine (left lateral views). *A*, Herniated loop; *B*, First rotation of caudal limb; *C*, Arrangement after second rotation (the adult configuration in the carnivore). (Modified after Horowitz).

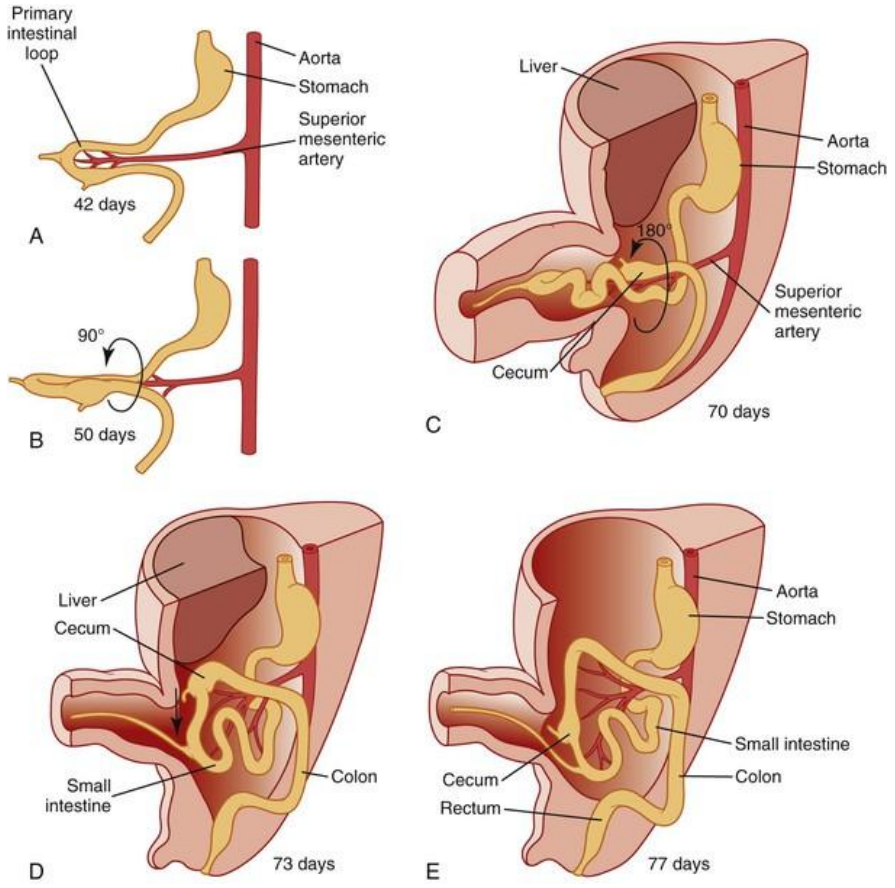
DERIVATIVES OF THE MIDGUT

CARNIVORES

- by this time the abdominal cavity become sufficiently enlarged to accomodate the intestine
- the midgut returns to the body cavity

second 180 degree rotation:

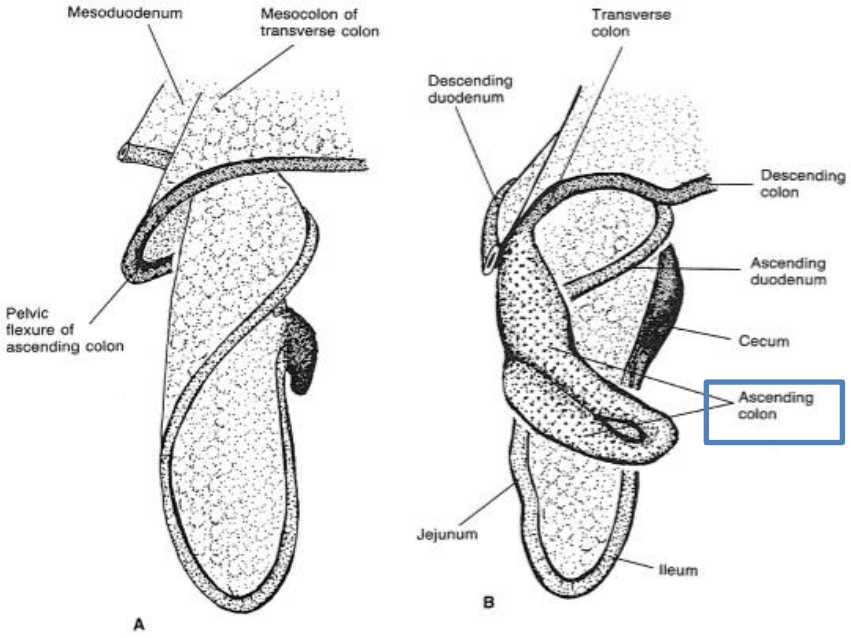
1. **the caudal limb rotates to the right side**
2. **the cranial limb rotates to the left side**



DERIVATIVES OF THE MIDGUT

UNGULATES

- **the initial steps in intestinal development in ungulates are the same as those in the carnivore**
- **further changes occur in the part of the caudal limb of the loop , that forms the ascending colon**



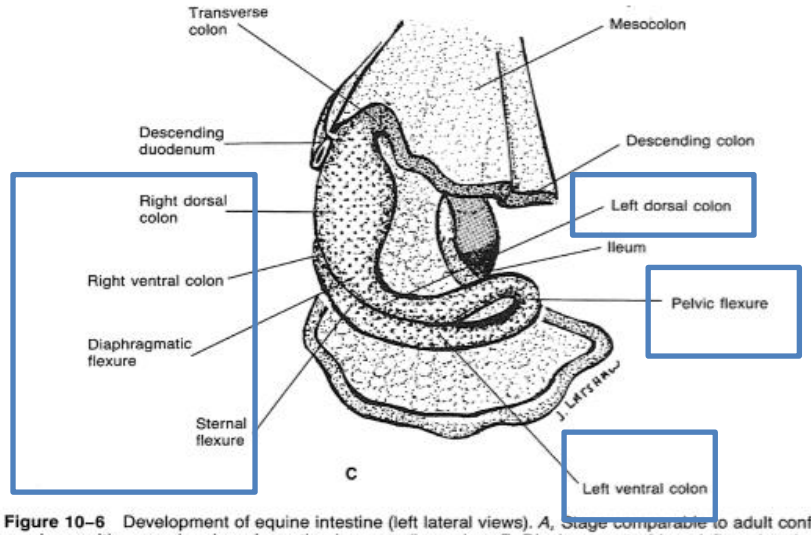


Figure 10–6 Development of equine intestine (left lateral views). *A,* Stage comparable to adult configuration in carnivore with secondary loop formation in ascending colon; *B,* Displacement of loop leftward and caudally (tip of loop will be pelvic flexure of great colon in adult); *C,* Folding of loop to form diaphragmatic and sternal flexures and create ''double horseshoe'' configuration characteristic of adult. *(Continued on next page)*

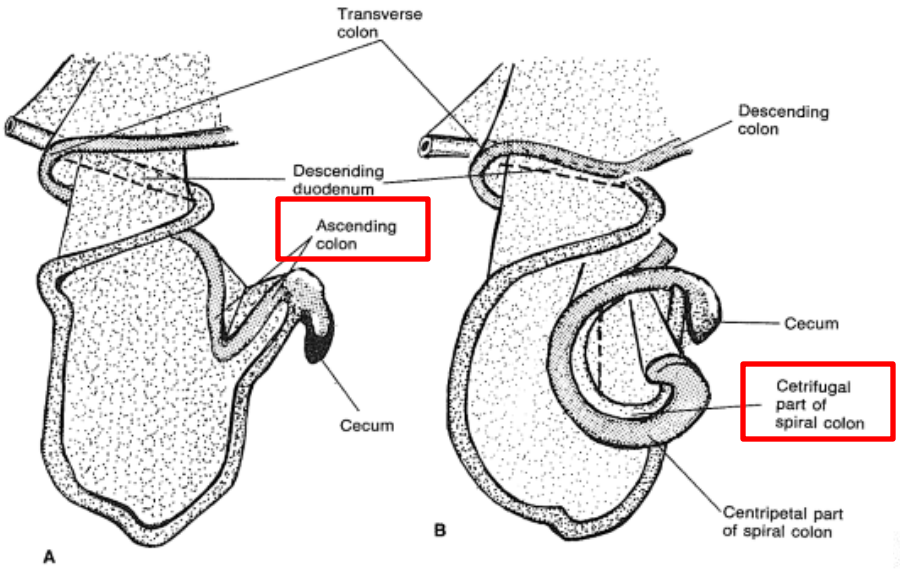
DERIVATIVES OF THE MIDGUT

UNGULATES

IN PIG:

1. **the ascending colon forms a secondary loop, which then coils to form the spiral colons**

2. **the center of the spiral colon is the tip of the secondary loop – which forms the ascending colon**



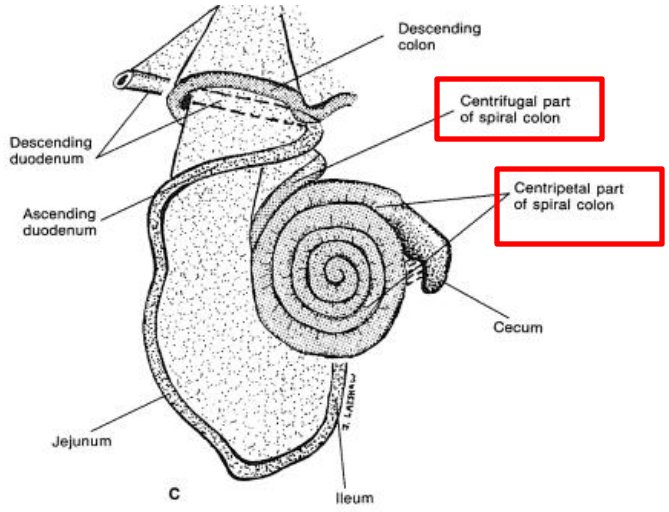


Figure 10–5 Development of porcine intestine (left lateral views). *A*, Initial formation of secondary loop in ascending colon; *B*, Parallel folding of loop; *C*, Coiling of loop to form spiral colon. (Modified after Horwitz)

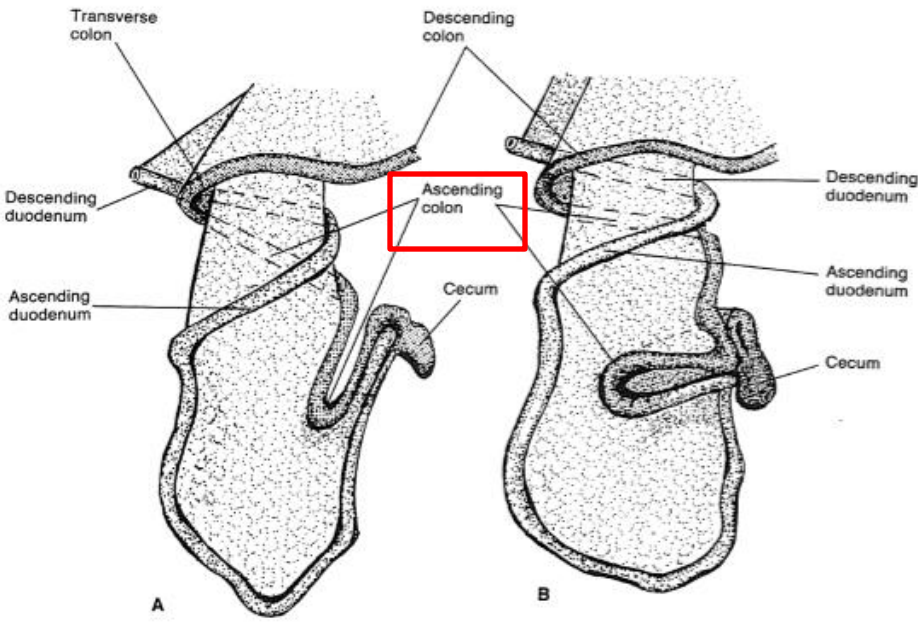
DERIVATIVES OF THE MIDGUT

UNGULATES

IN OX:

1. **the ascending colon forms a secondary loop, which then coils to form the spiral colons**

2. **the center of the spiral colon is the tip of the secondary loop – which forms the ascending colon**



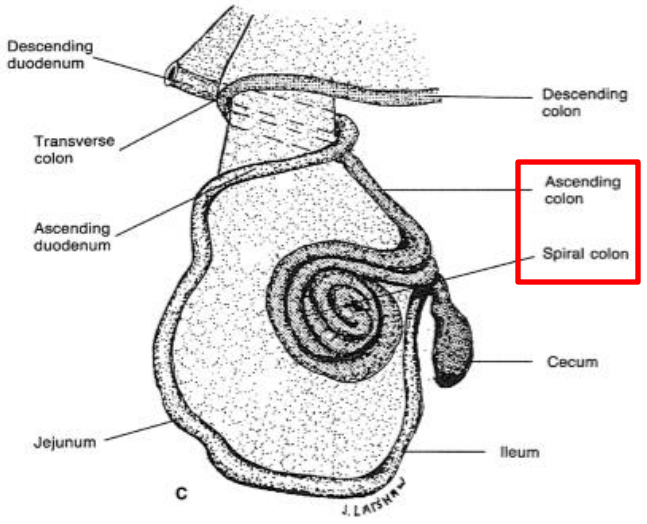


Figure 10–4 Development of ruminant intestine (left lateral views). *A*, Initial formation of secondary loop in ascending colon; *B*, Folding of secondary loop; *C*, Coiling of loop to form spiral colon. (Modified after Horowitz)

DERIVATIVES OF THE MIDGUT

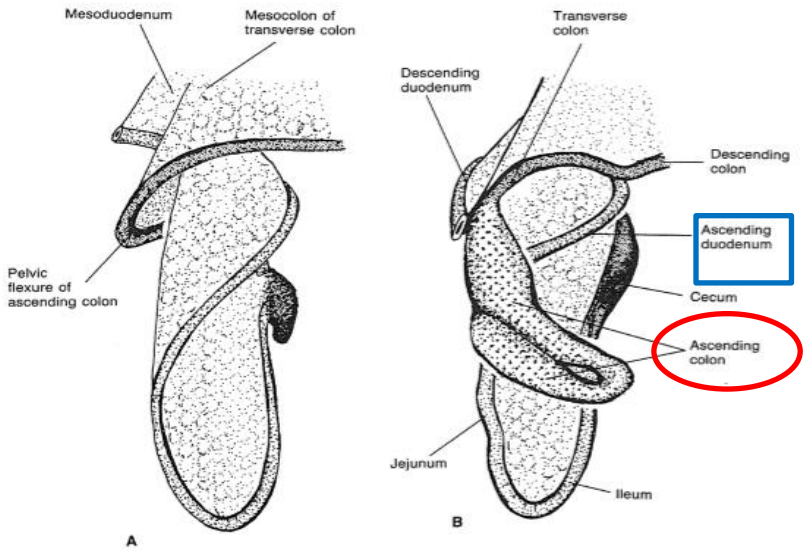
UNGULATES

IN HORSE:

- **a secondary loop also forms in the future ascending colon**
- **the tip of the loop displaced leftward and caudally due to the extensive growth of the caecum**
- **the tip of the secondary loop corresponds to the pelvic flexure of the great colon in adult**
- **the loop then folds upon itself to form two cranial flexures:**

a. the more ventral one is the sternal flexure

b. the dorsal one is the diaphragmatic flexure



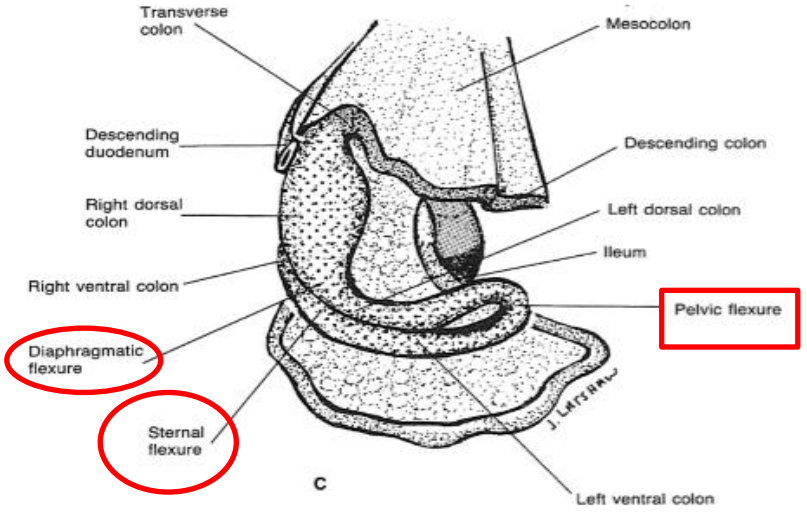
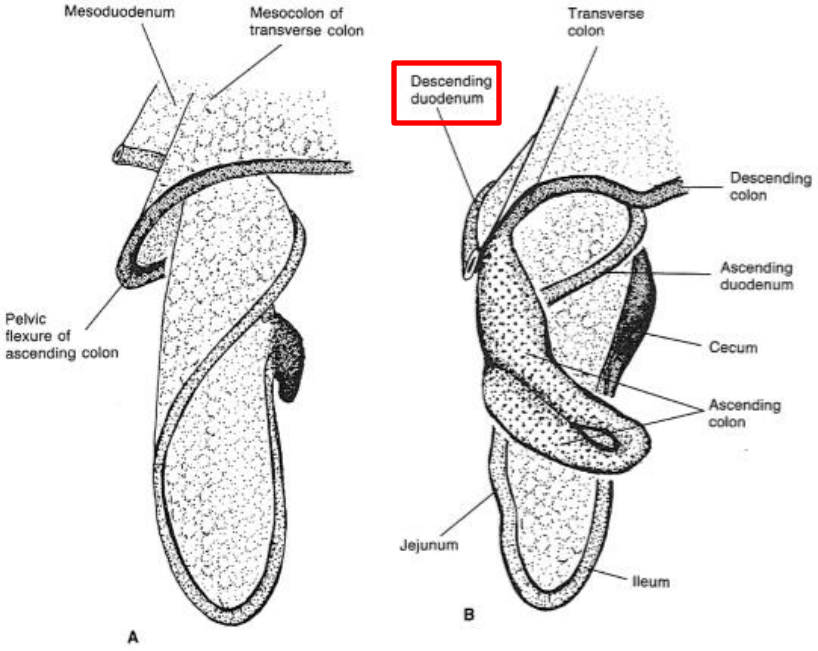


Figure 10–6 Development of equine intestine (left lateral views). *A,* Stage comparable to adult configuration in carnivore with secondary loop formation in ascending colon; *B,* Displacement of loop leftward and caudally (tip of loop will be pelvic flexure of great colon in adult); *C,* Folding of loop to form diaphragmatic and sternal flexures and create "double horseshoe" configuration characteristic of adult. *(Continued on next page)*

DERIVATIVES OF THE HINDGUT

DESCENDING COLON:

- **derived from the hindgut**
- **changes very little from its original tubular configuration**
- **it is placed to the left side of the abdominal cavity by the midgut, when it returns to the abdomen - this is the adult position in all species**



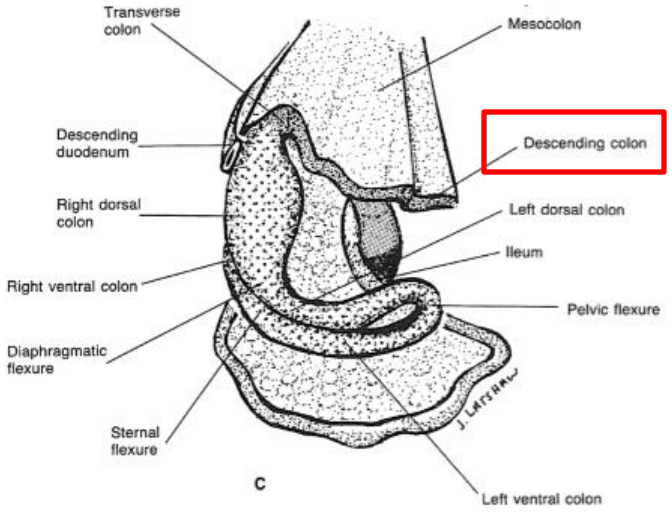
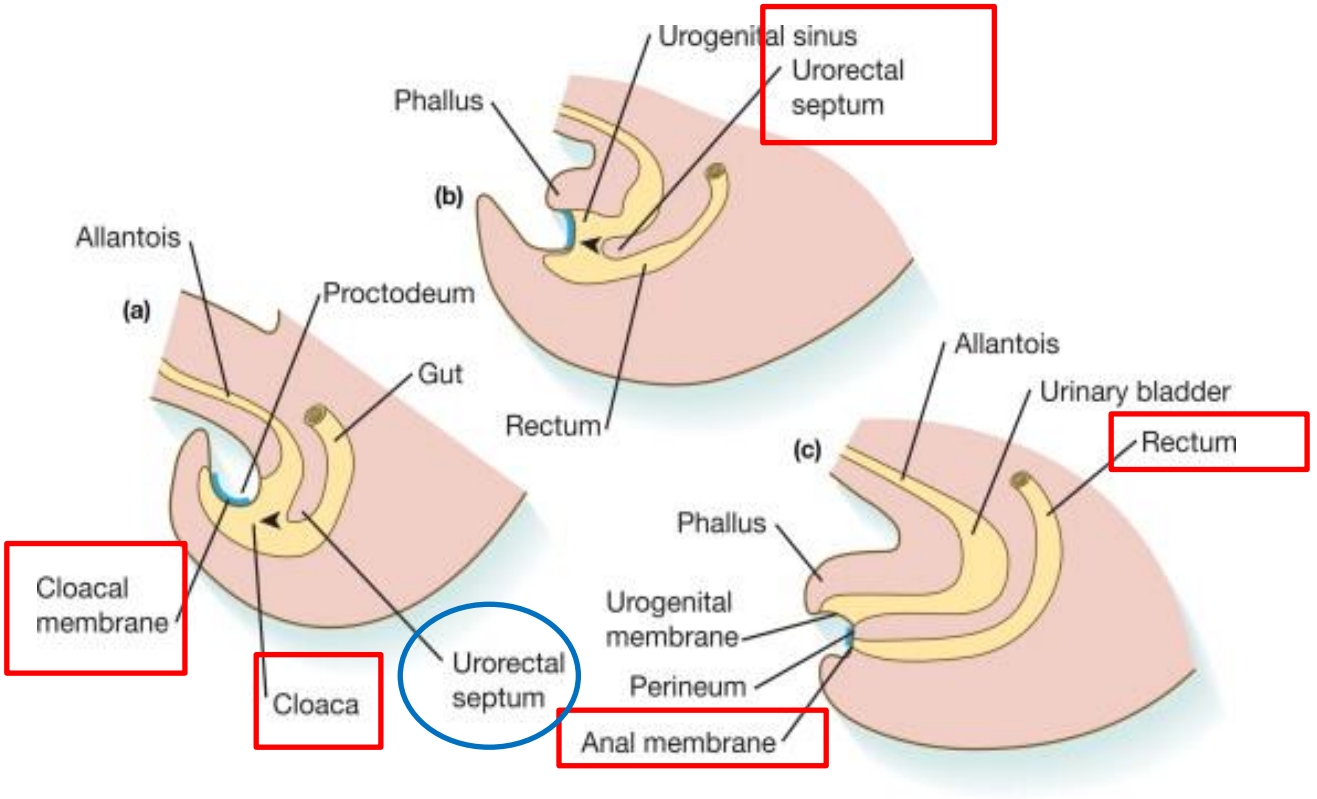


Figure 10–6 Development of equine intestine (left lateral views). *A,* Stage comparable to adult configuration in carnivore with secondary loop formation in ascending colon; *B,* Displacement of loop leftward and caudally (tip of loop will be pelvic flexure of great colon in adult); *C,* Folding of loop to form diaphragmatic and sternal flexures and create ''double horseshoe'' configuration characteristic of adult. *(Continued on next page)*

DERIVATIVES OF THE HINDGUT

RECTUM:

- **in all sepcies formed by a partitioning of the dorsal part of the cloaca by two masses of tissue that grow medially from the cloacal wall and fuse to form the urorectal septum**



DERIVATIVES OF THE HINDGUT

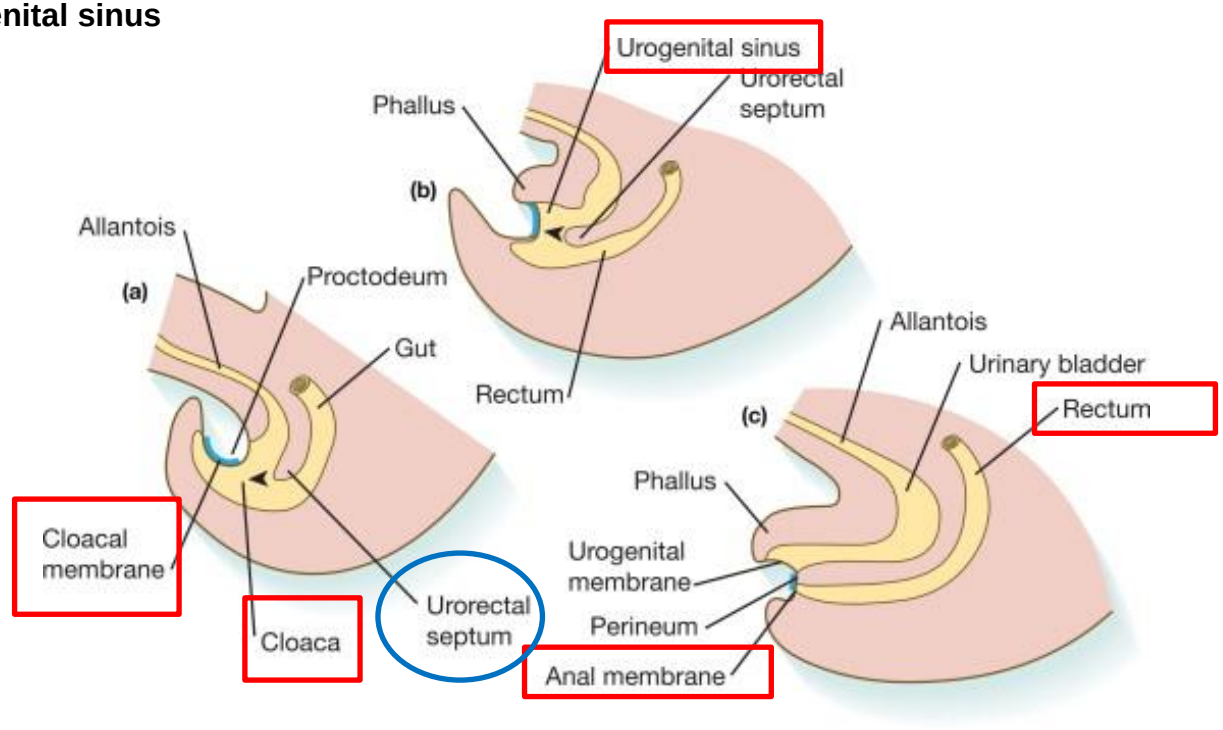
THE CLOACA:

- **the terminal part of the primitive gut**
- **receives the digestive, urinary and genital tract**

in mammalian it becomes subdivided into:

a. dorsal part forms the rectum and the cranial part of anal canal

b. ventral part becomes the urogenital sinus



DERIVATIVES OF THE HINDGUT

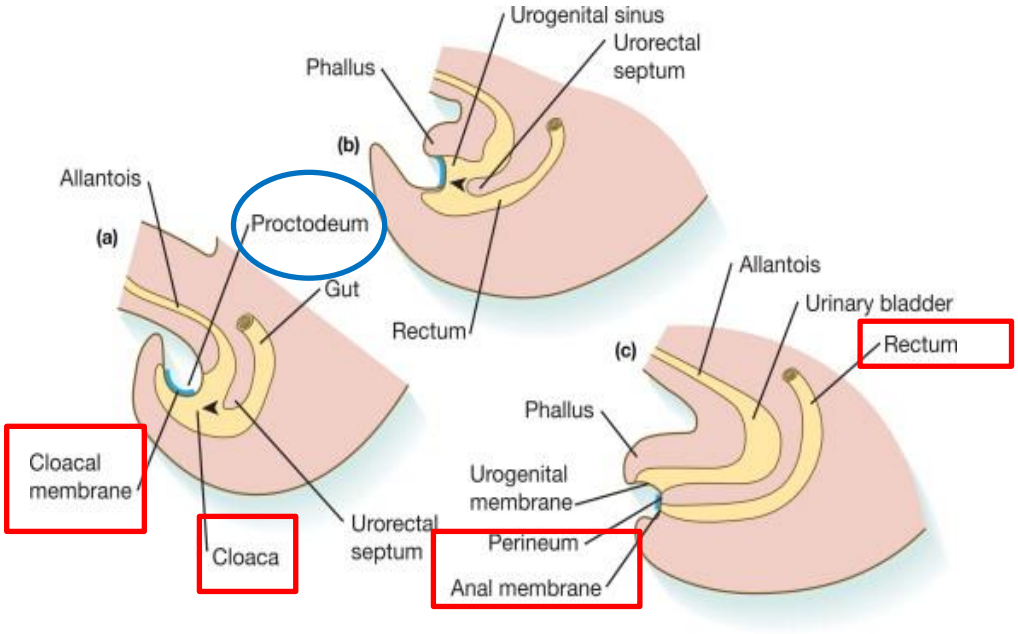
ANAL CANAL:

- **formed from two sources**

a. **its cranial part formed by the partitioning of the cloaca**

b. **its caudal part formed by in ingrowth of ectoderm (proctodeum), that comes into close apposition to the endoderm of the cloaca**

c. **the endodermal – ectodermal membrane between the cloaca and proctodeum is the cloacal membrane**



DERIVATIVES OF THE HINDGUT

ANAL CANAL:

d. the cloaca is separated by the urorectal membrane

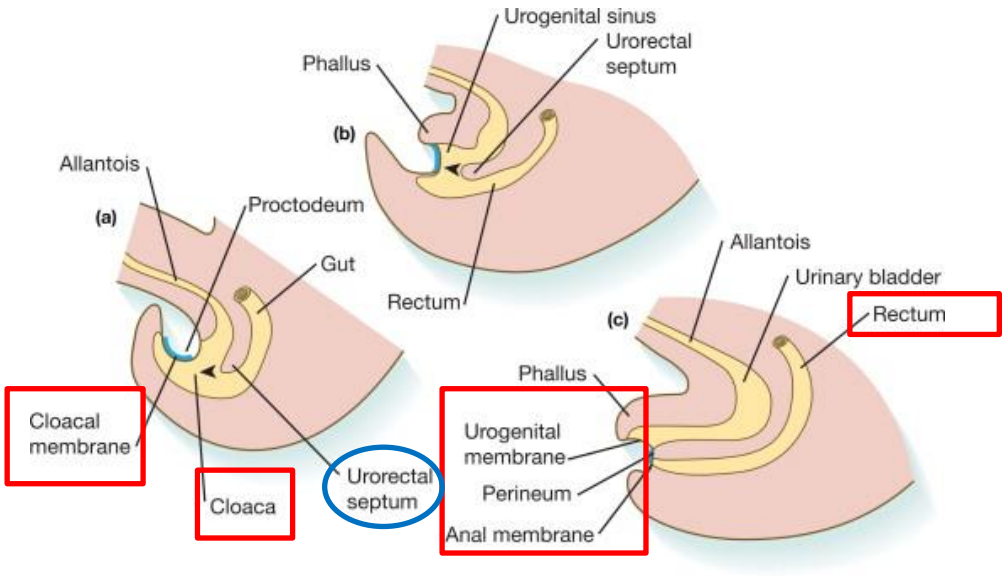
e. the caudal part of the urorectal membrane - forms the perineum

f. the part of the cloacal membrane covering the anal canal is the anal membrane

g. when the anal membrane ruptures – the cranial and caudal parts of the anal canal are continous

h. in adult the position of the anal membrane is indicated by the anocutaneous line

i. the part of the anal canal deriveted from the proctodeum lined by cutaneous stratified squamous epithelium

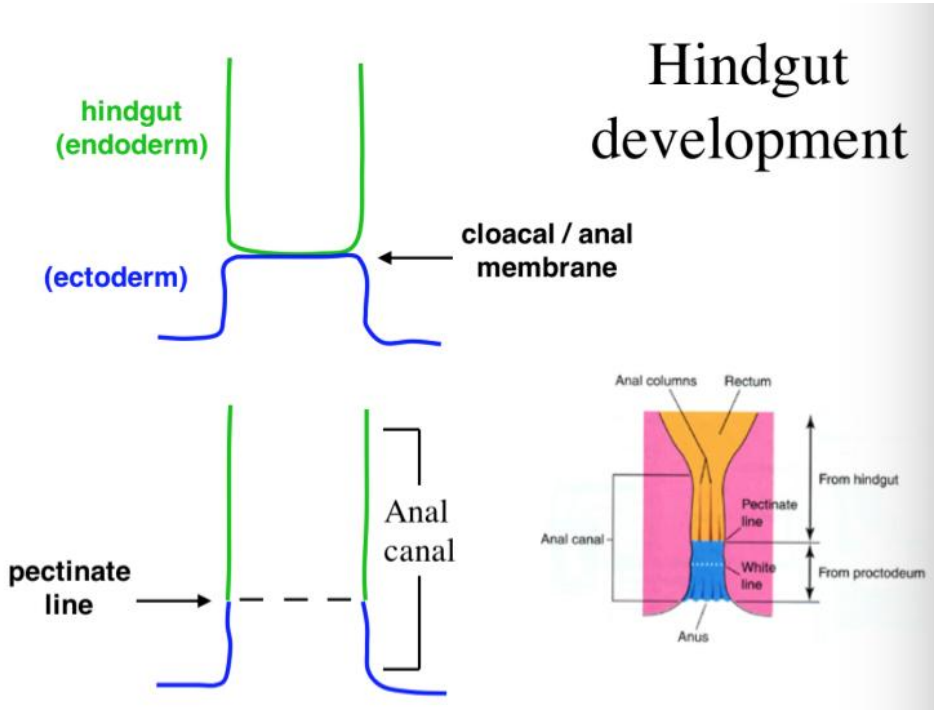


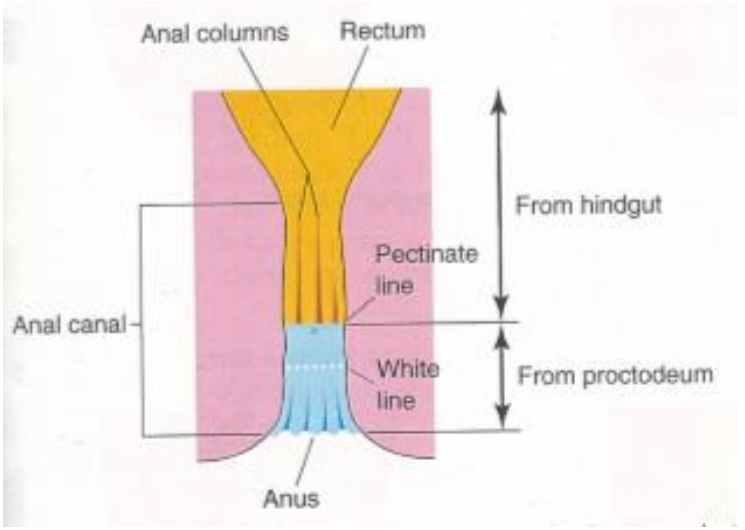
DERIVATIVES OF THE HINDGUT

ANAL CANAL:

IN CARNIVORE:

- **two ventro-lateral outpouchings of the proctodeal ectoderm occur at its junction with the anal canal - these form the anal sacs (paranal sinuses) and their associated glands**





LIVER

The parenchymal cells:

1. **are endodermal derivatives**
2. **arise from the hepatic diverticulum (folding of the endodermal layer of the floor of the foregut in the area of the future descending duodenum)**
3. **the hepatic diverticulum extends into the septum transversum (mass of splanchnic mesoderm between the developing heart and midgut)**
4. **the hepatic diverticulum enlarges**

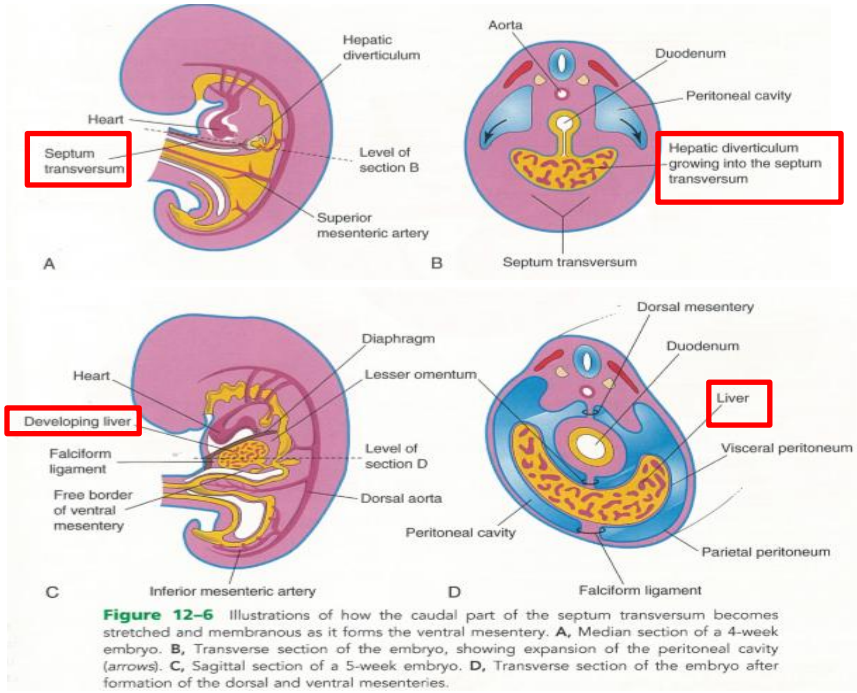
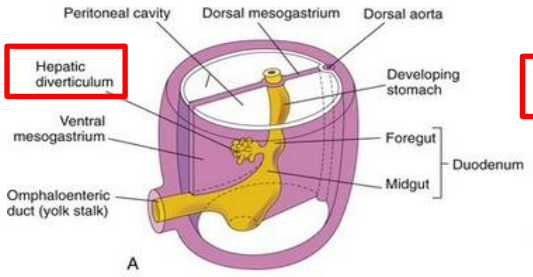
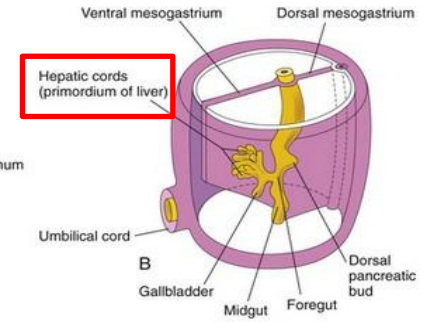
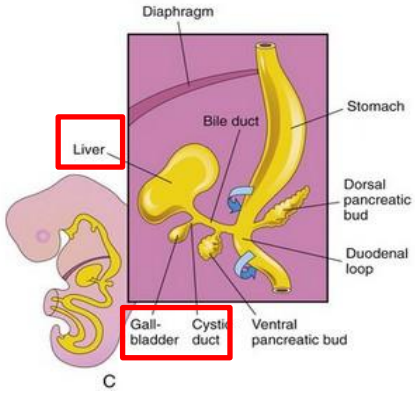
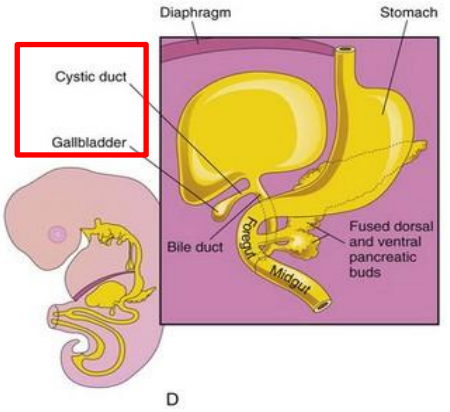


Figure 12–6 Illustrations of how the caudal part of the septum transversum becomes stretched and membranous as it forms the ventral mesentery. **A,** Median section of a 4-week embryo. **B,** Transverse section of the embryo, showing expansion of the peritoneal cavity (*arrows*). **C,** Sagittal section of a 5-week embryo. **D,** Transverse section of the embryo after formation of the dorsal and ventral mesenteries.







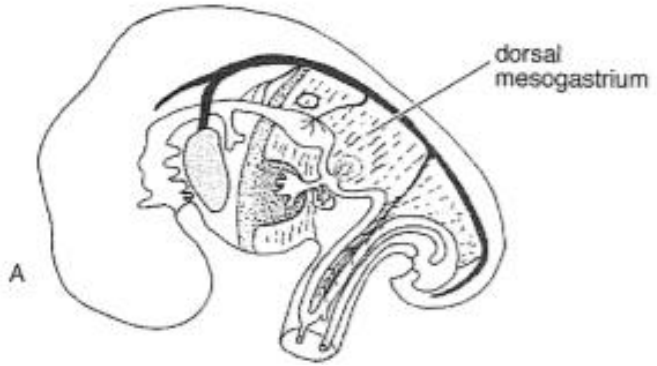


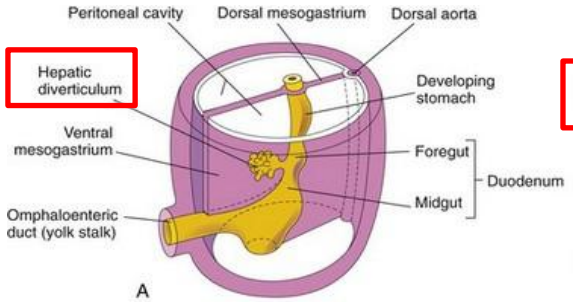
LIVER

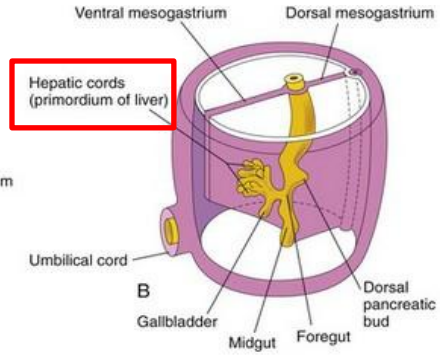
5. the **hepatic diverticulum divides into two parts as it grows between the layers of the ventral mesogastrium:**

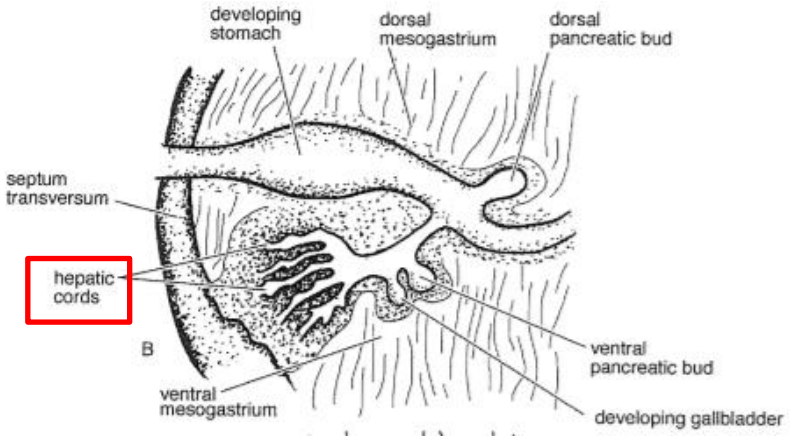
a. the **larger, cranial part of the diverticulum is the primordium of the liver**

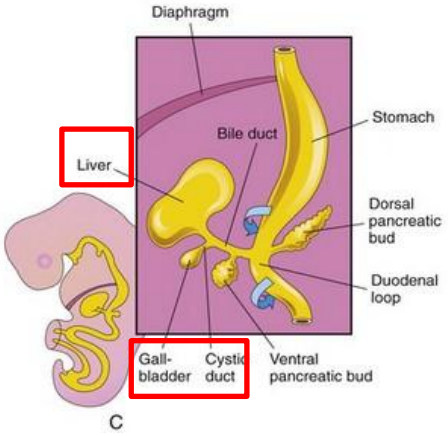
b. the **smaller caudal portion becomes the biliary apparatus**

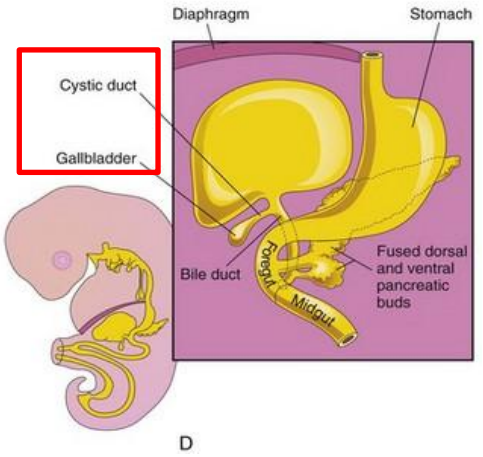










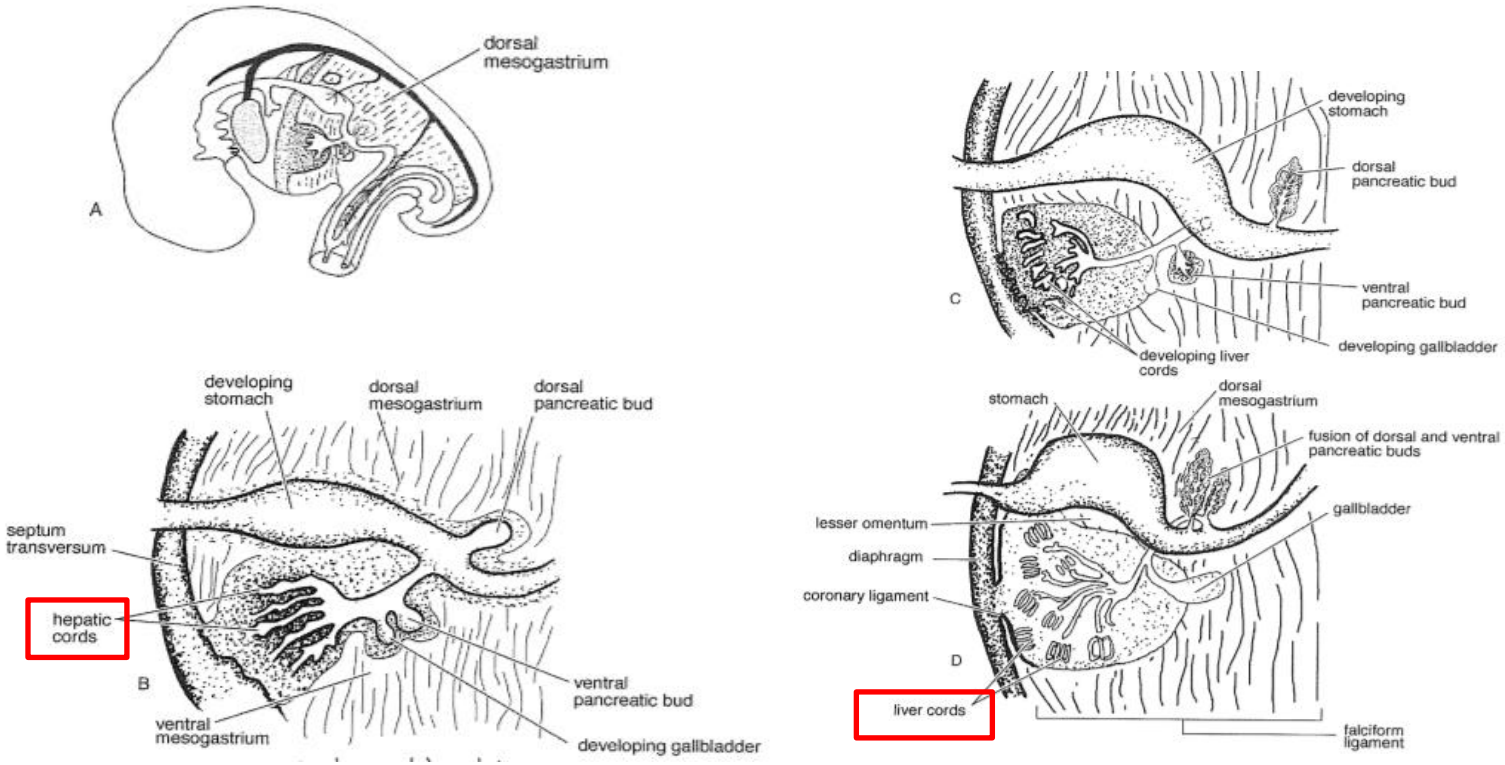


LIVER

6. the proliferating endodermal cells give rise to interlacing cords of hepatocytes (hepatic cords) and to the epithelial lining of the intrahepatic part of the biliary apparatus

7. the hepatic cords anastomose around endothelium - lined spaces the primordia of the hepatic sinusoids

8. the fibrous and hematopoietic tissue and Kupffer – cells derived from the mesenchy in the septum transversum



LIVER

9. the liver grows rapidly and fils a large part of the abdominal cavity

10. hematopoiesis begins in the liver during 6th week

11. bile formation by the hepatic cells begins during 12 weeks

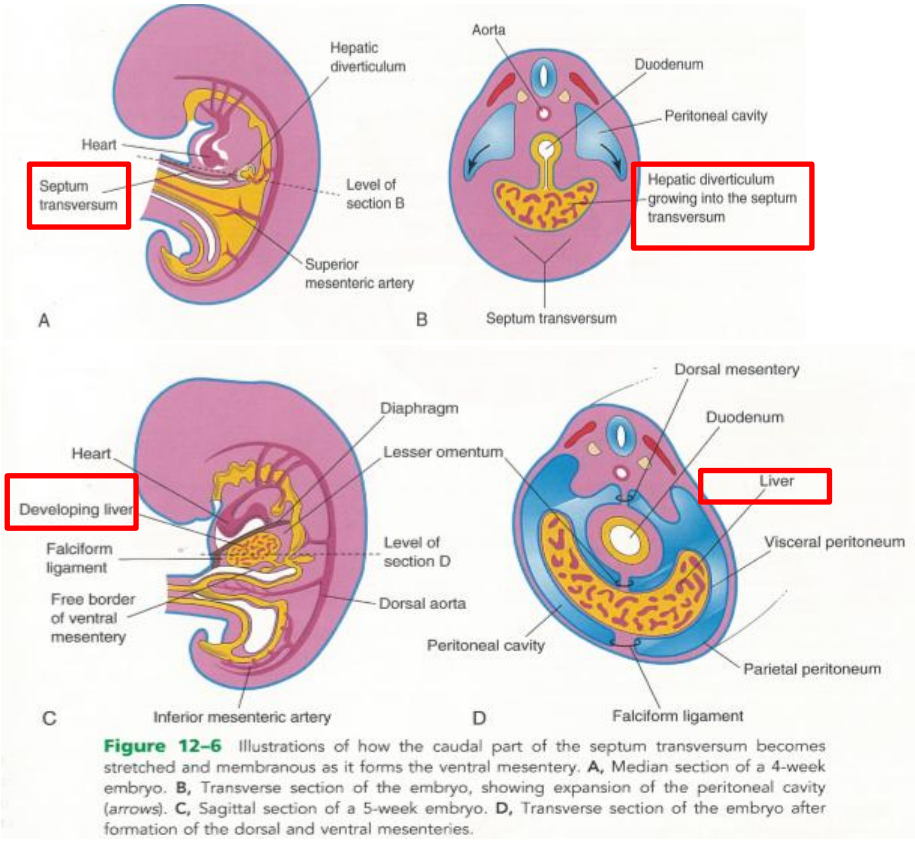
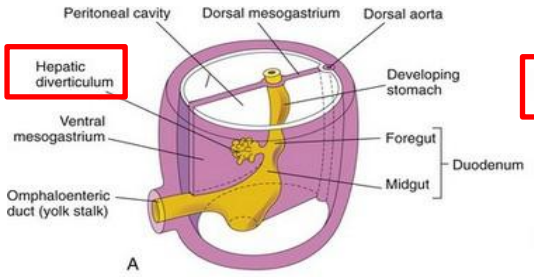
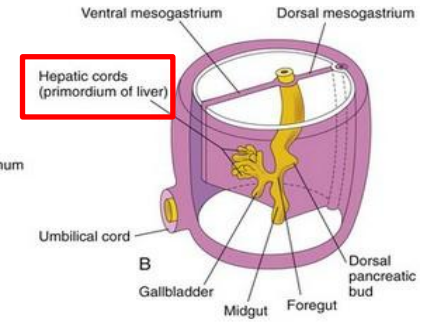
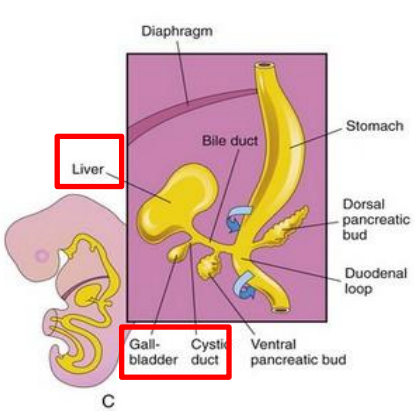
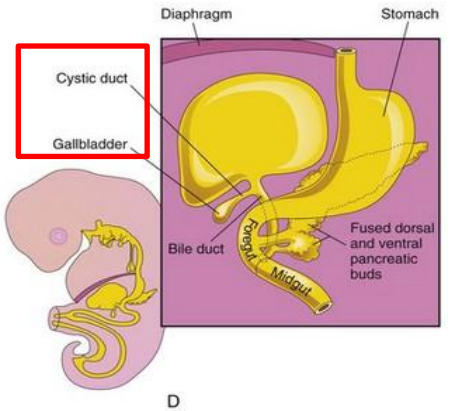


Figure 12–6 Illustrations of how the caudal part of the septum transversum becomes stretched and membranous as it forms the ventral mesentery. **A,** Median section of a 4-week embryo. **B,** Transverse section of the embryo, showing expansion of the peritoneal cavity (*arrows*). **C,** Sagittal section of a 5-week embryo. **D,** Transverse section of the embryo after formation of the dorsal and ventral mesenteries.









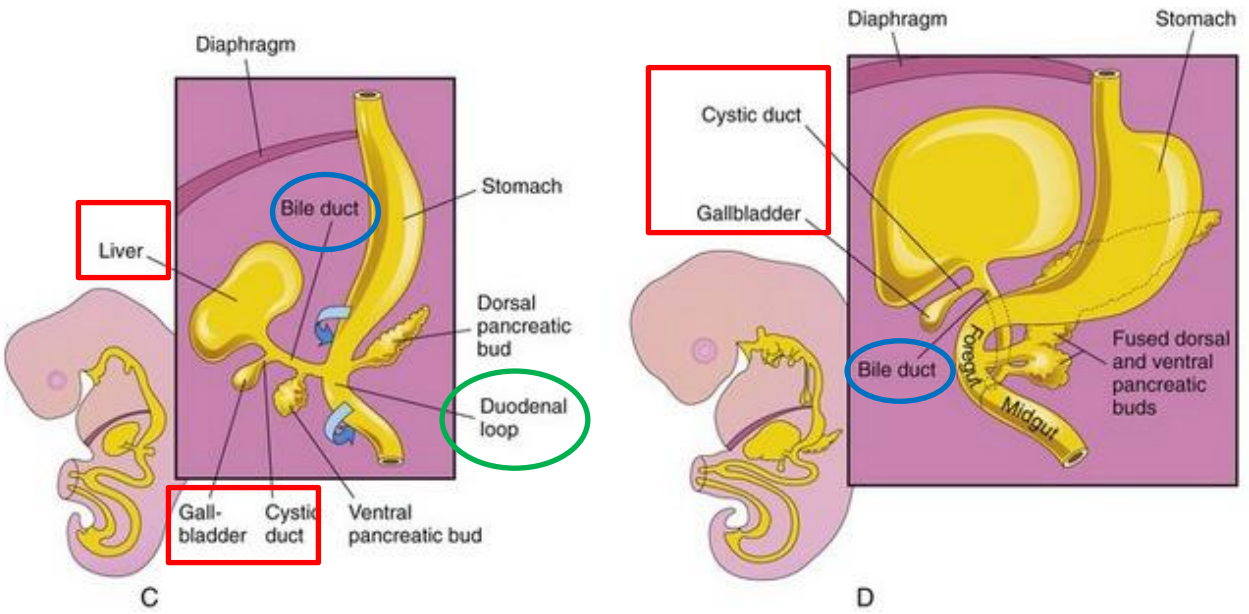
LIVER

12. the caudal portion of the hepatic diverticulum becomes:

a. the gallbladder

b. the stalk forms the cystic duct

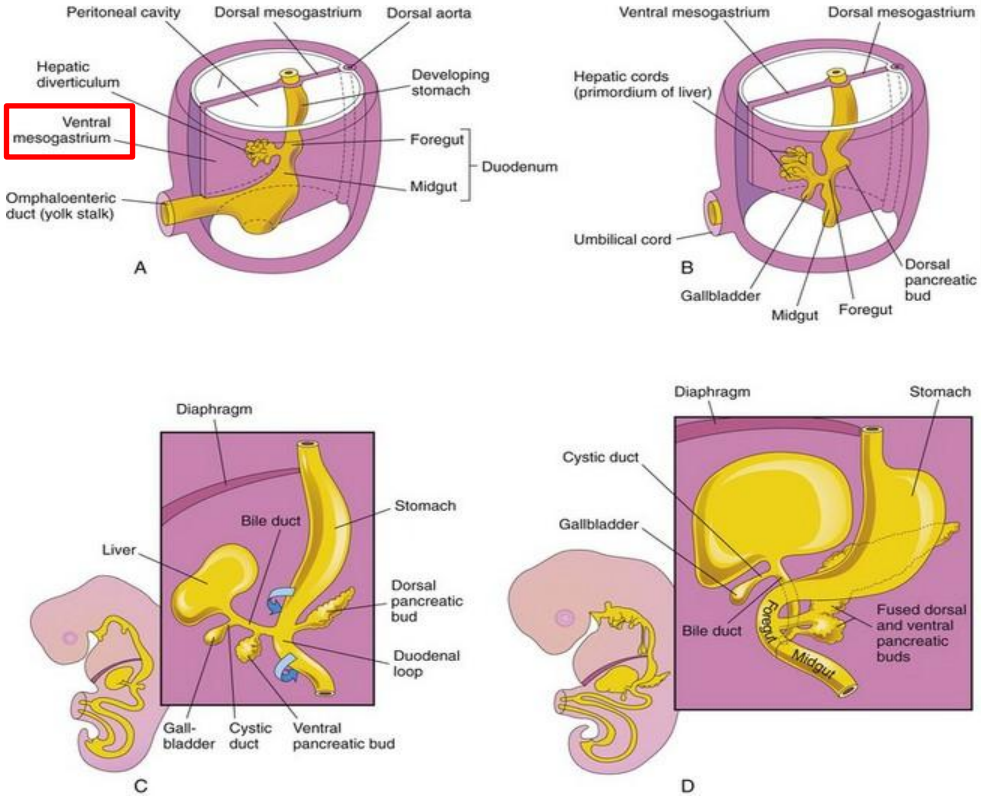
- **the extrahepatic biliary apparatus occluded with epithelial cells**
- **the stalk connecting the hepatic duct and cystic duct to the duodenum becomes the bile duct – which attaches to the ventral aspect of the duodenal loop – as the duodenum grows and rotates, the entrance of the bile duct carried to the dorsal aspect of the duodenum**



VENTRAL MESENTERY

- **derived from the mesogastrium**
- **forms the visceral peritoneum of the liver**

from the umbilical cord to the liver



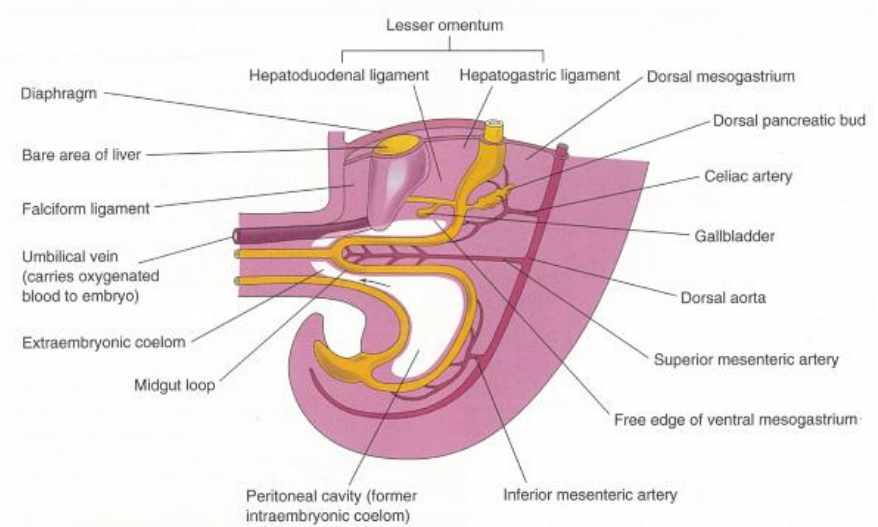


Figure 12–7 Median section of the caudal half of an embryo at the end of the fifth week, showing the liver and its associated ligaments. The *arrow* indicates the communication of the peritoneal cavity with the extraembryonic coelom. Because of the rapid growth of the liver and the midgut loop, the abdominal cavity temporarily becomes too small to contain the developing intestines; consequently, they enter the extraembryonic coelom in the proximal part of the umbilical cord (see Fig. 12-11*B*).

VENTRAL MESENTERY

the double – layered ventral mesentery gives rise to:

a. lesser omentum

– passes from the liver to the lesser curvature of the stomach (hepatogastric ligament)

- **passes from the liver to the duodenum (hepatoduodenal ligament)**

b. falciform ligament

- **extends from the liver to the ventral abdominal wall**

- **the *umbilical vein passes in the free border of the falciform ligament from the umbilical cord to the liver***

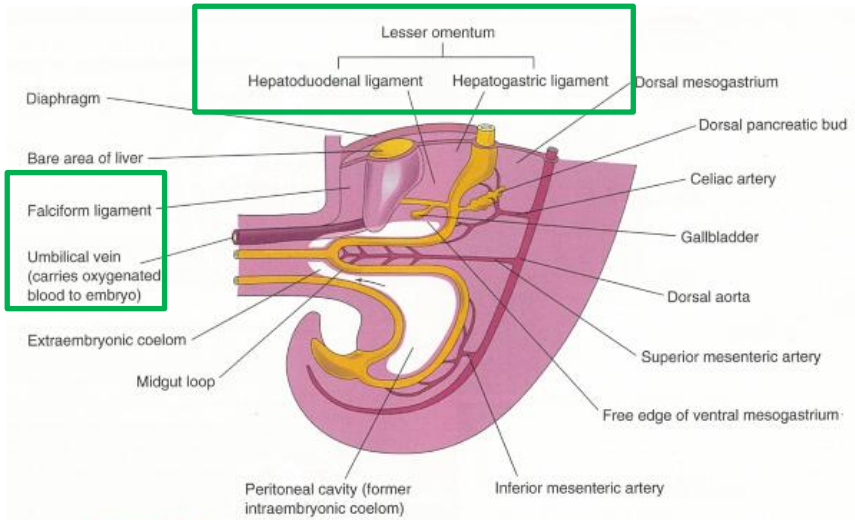
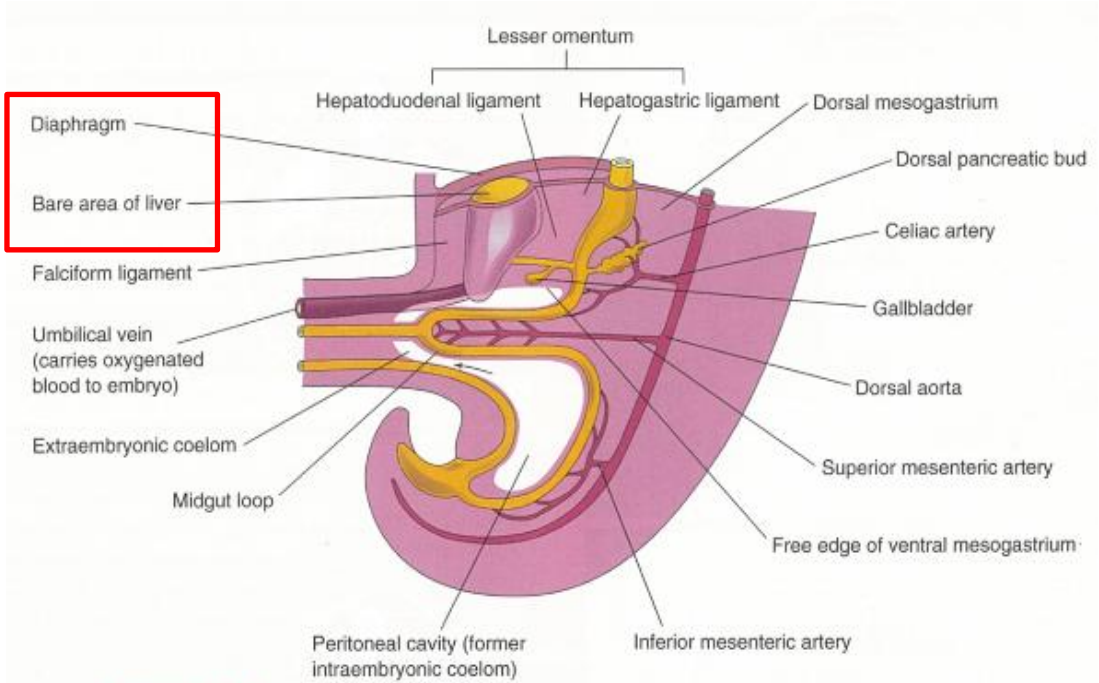


Figure 12–7 Median section of the caudal half of an embryo at the end of the fifth week, showing the liver and its associated ligaments. The arrow indicates the communication of the peritoneal cavity with the extraembryonic coelom. Because of the rapid growth of the liver and the midgut loop, the abdominal cavity temporarily becomes too small to contain the developing intestines; consequently, they enter the extraembryonic coelom in the proximal part of the umbilical cord (see Fig. 12-11*B*).

LIVER

AREA NUDA (BARE AREA OF LIVER):

- **the liver lies within the abdominal cavity with cranialmost part resting against the septum transversum**
- **in adult, the cranial part of the liver rests against the diaphragm – and its not covered by peritoneum at the point of contact**



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PANCREAS

develops from:

a. the dorsal pancreatic bud – dorsal evagination from the duodenum

b. the ventral pancreatic bud - branch of the hepatic diverticulum

- **the torsion of the initial part of the duodenum bring the two pancreatic diverticuli together to fuse into a single mass**
- **the duct system of the two parts become interconnected**

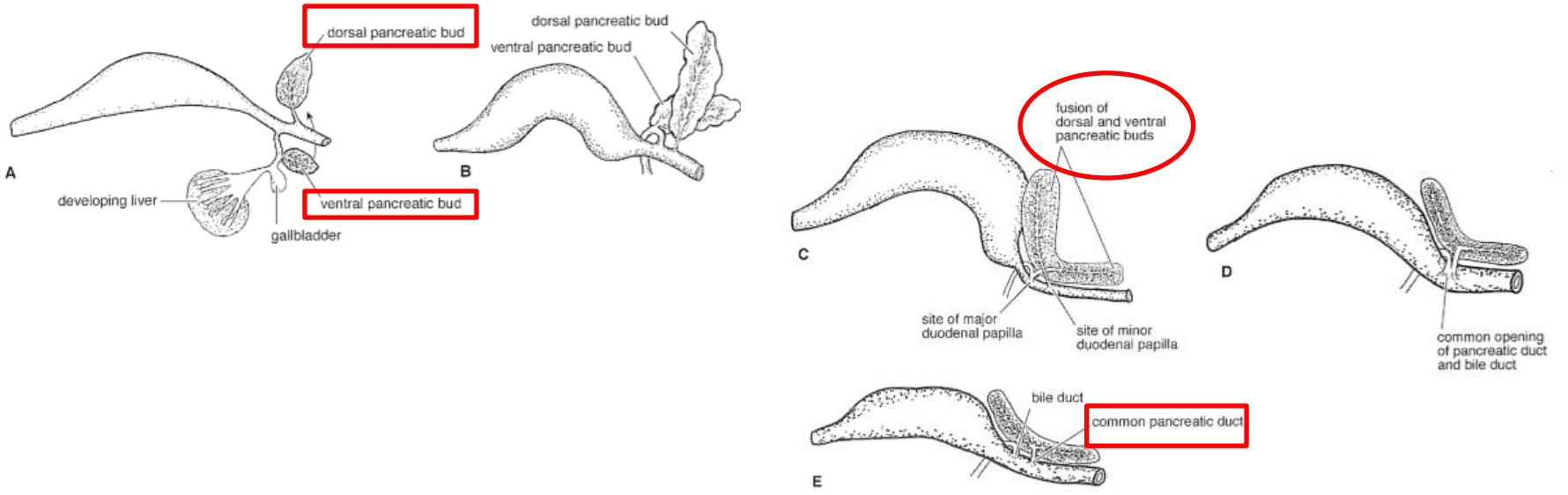
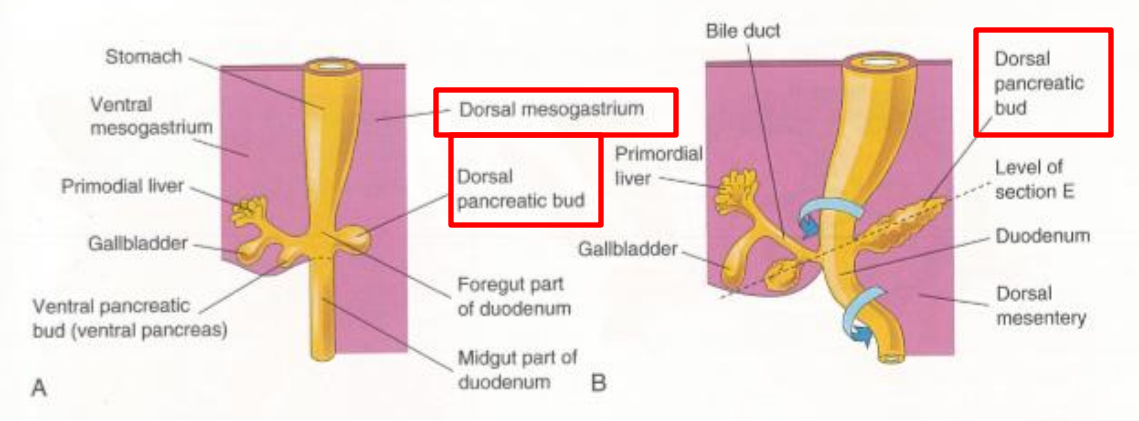


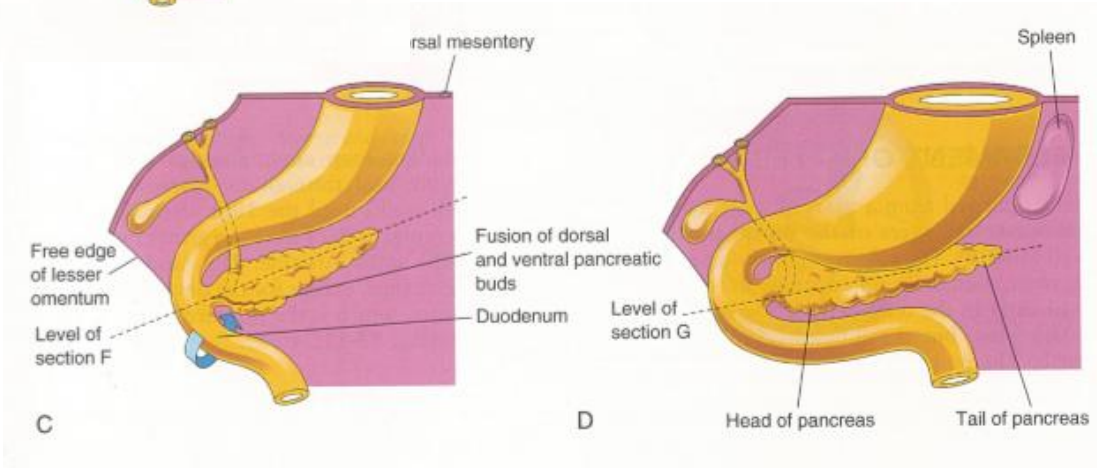
Figure 15.8 Sequential stages in the development of the pancreas, A and B. Final arrangement of the pancreatic duct system in humans, horses and dogs, C, in sheep, goats and cats, D, and in cattle and pigs, E.

PANCREAS

DORSAL PANCREATIC BUD:

- **grows into a part of the dorsal mesentery, that contributes to the greater omentum**
- **the bulk of the left lobe of the adult pancreas derived from this diverticulum**
- **the accessory duct drains the left lobe, formed from the duct of the dorsal bud**

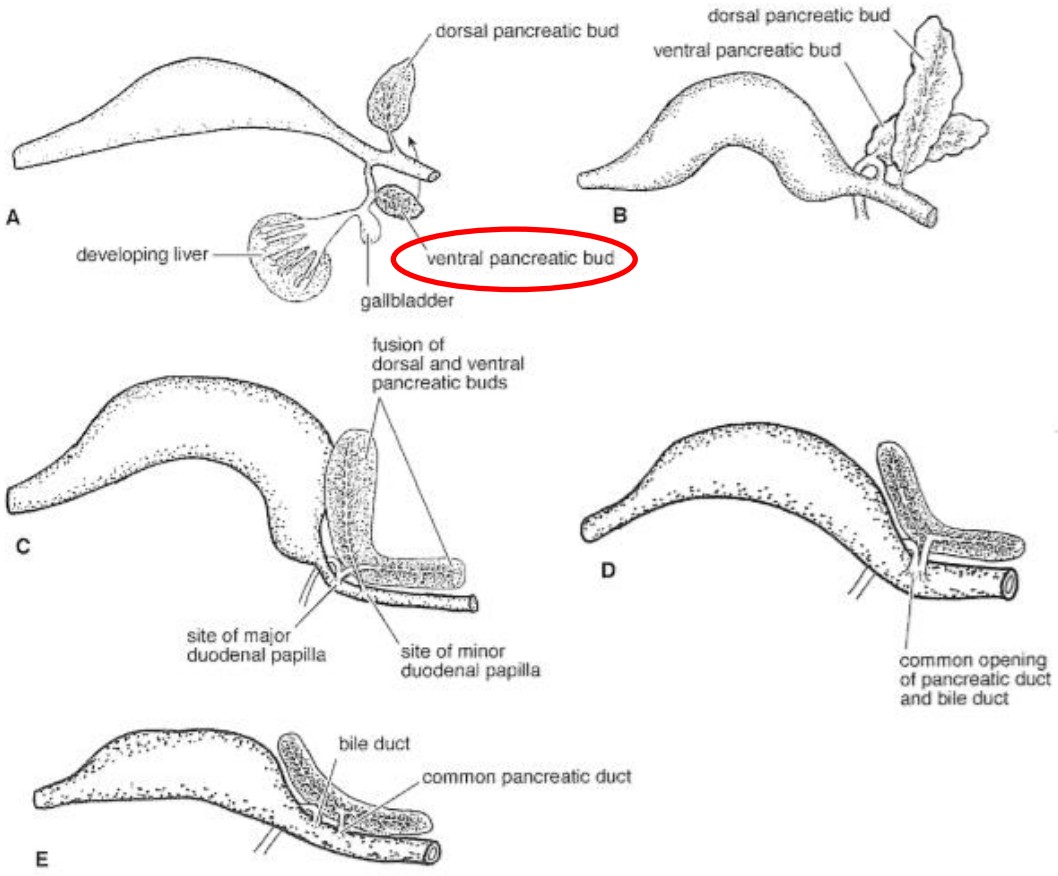




PANCREAS

VENTRAL PANCREATIC BUD:

- **most of the right lobe arises from the ventral diverticulum**
- **the main pancreatic duct drains the right lobe, formed from the duct of the ventral bud**



PANCREAS

- the connective tissue sheath and the interlobular septa of the pancreas developed from surrounding splanchnic mesenchyme
- Islet cells appear by the early fetal stage (35 – 43 days)
- hormones are present in the islet cells
- digestive enzyme precursors and gastrointestinal hormones are detected in acinar cells
- early appearance of hormones may have a role in the development of the rest of the gastrointetstinal tarct

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