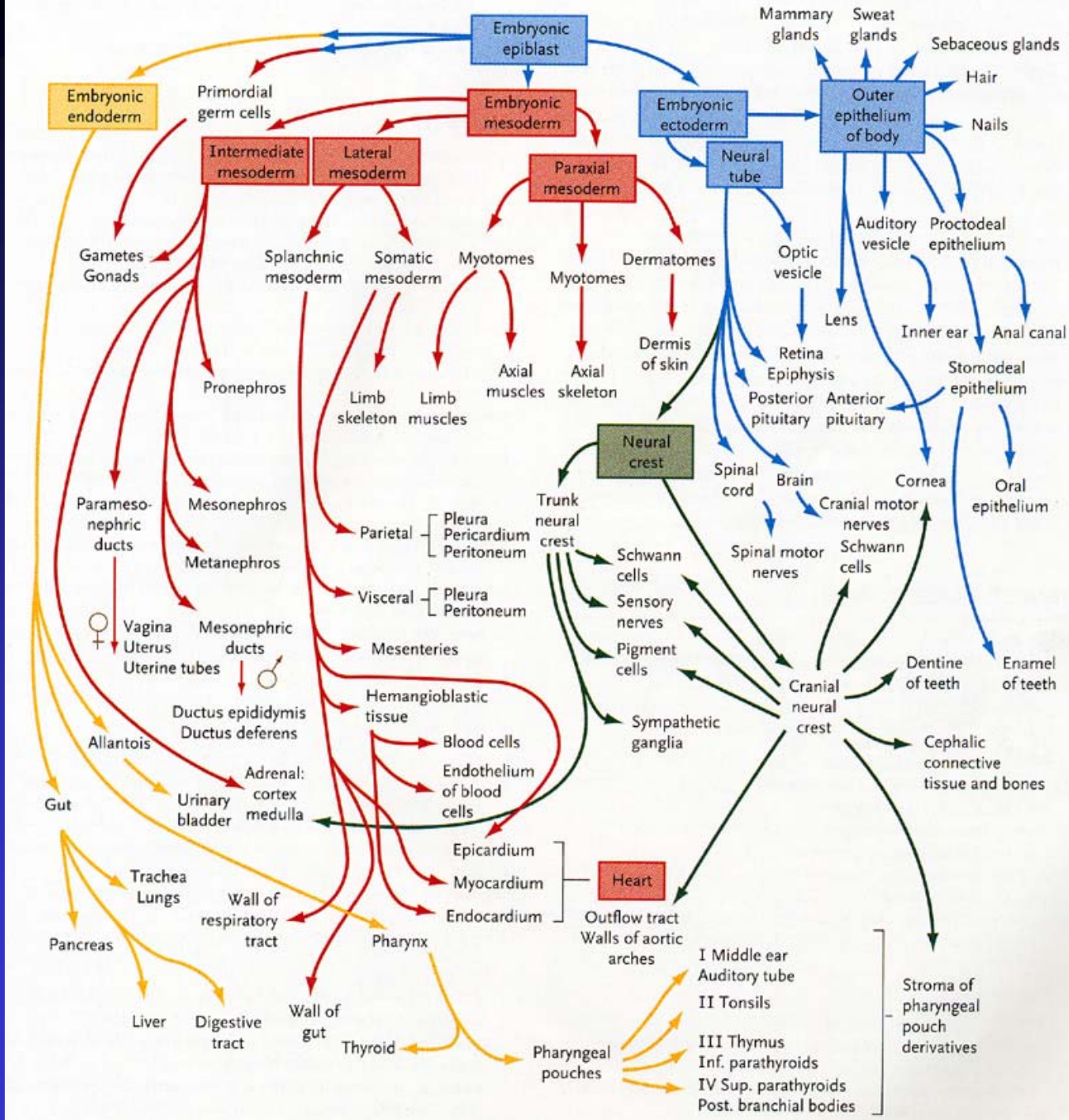

Embryonic epiblast
Embryonic endoderm
Primordial germ cells
Embryonic mesoderm
Embryonic ectoderm
Intermediate mesoderm
Lateral mesoderm
Paraxial mesoderm
Neural tube
Outer epithelium of body
Mammary glands
Sweat glands
Sebaceous glands
Hair
Nails
Gametes
Gonads
Splanchnic mesoderm
Somatic mesoderm
Myotomes
Myotomes
Dermatomes
Optic vesicle
Auditory vesicle
Proctodeal epithelium
Lens
Inner ear
Anal canal
Retina
Epiphysis
Posterior pituitary
Anterior pituitary
Stomodeal epithelium
Oral epithelium
Pronephros
Limb skeleton
Limb muscles
Axial muscles
Axial skeleton
Dermis of skin
Neural crest
Spinal cord
Brain
Cornea
Cranial motor nerves
Schwann cells
Spinal motor nerves
Trunk neural crest
Parameso-nephric ducts
Mesonephros
Metanephros
Parietal
Pleura
Pericardium
Peritoneum
Visceral
Pleura
Peritoneum
Schwann cells
Sensory nerves
Pigment cells
Sympathetic ganglia
Vagina
Uterus
Uterine tubes
Mesonephric ducts
Mesenteries
Ductus epididymis
Ductus deferens
Hemangioblastic tissue
Blood cells
Endothelium of blood cells
Cranial neural crest
Dentine of teeth
Enamel of teeth
Cephalic connective tissue and bones
Allantois
Urinary bladder
Adrenal: cortex medulla
Gut
Epicardium
Myocardium
Endocardium
Heart
Outflow tract
Walls of aortic arches
Trachea
Lungs
Wall of respiratory tract
Pancreas
Pharynx
Liver
Digestive tract
Wall of gut
Thyroid
Pharyngeal pouches
I Middle ear
Auditory tube
II Tonsils
III Thymus
Inf. parathyroids
IV Sup. parathyroids
Post. branchial bodies
Stroma of pharyngeal pouch derivatives

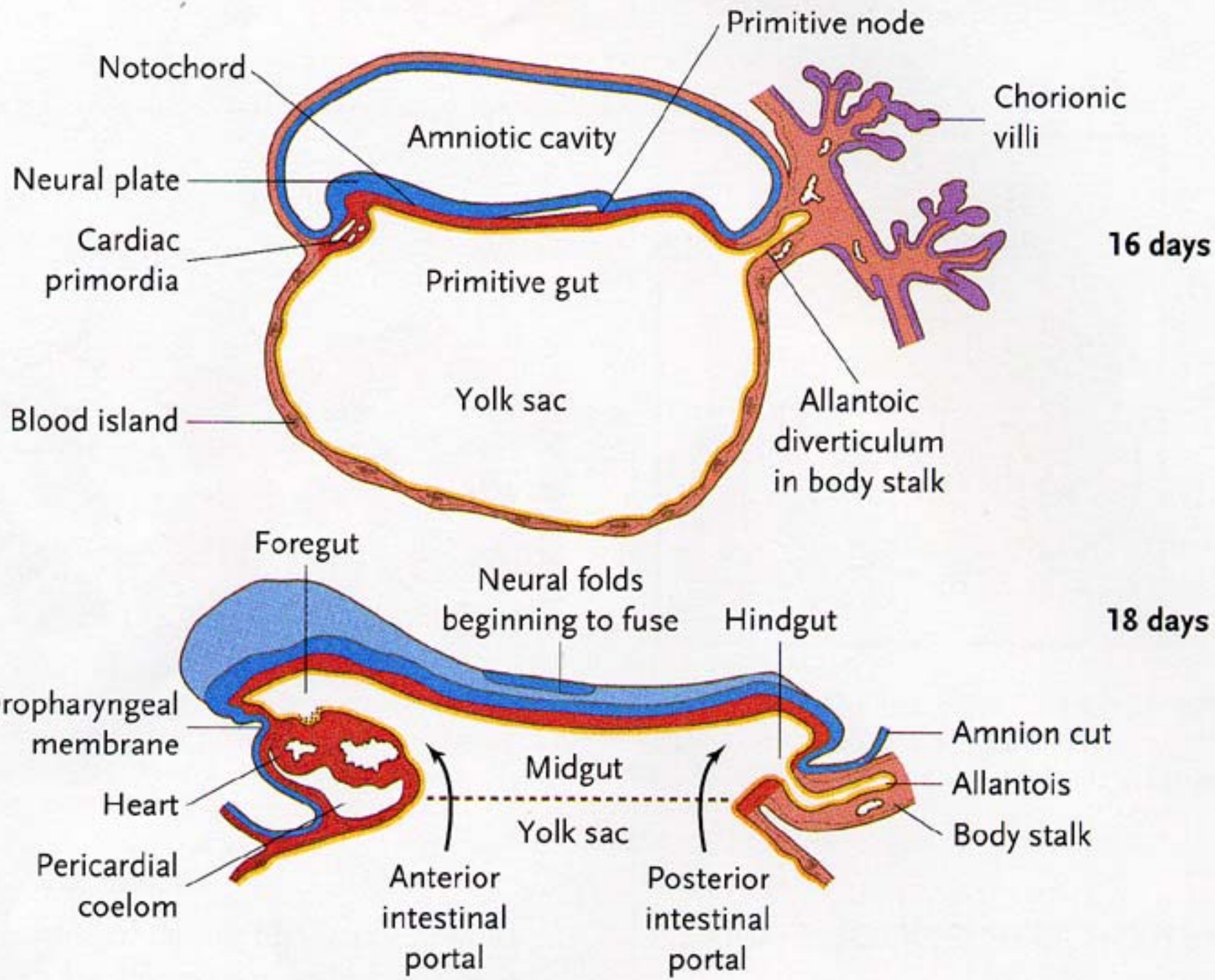
Gastrointestinal Tract Development

Endoderm → cell sheet → tubular gut

- Lateral folding
- Ventral bending cranially → Head fold
- Ventral bending caudally → Tail fold

Yolk sac is connected to the gut in the middle

- Yolk stalk, omphalomesenteric duct, or vitelline duct
- Yolk stalk is progressively delineated.


Primitive node
Notochord
Chorionic villi
Amniotic cavity
Neural plate
Cardiac primordia
Primitive gut
16 days
Yolk sac
Blood island
Allantoic diverticulum in body stalk
Foregut
Neural folds beginning to fuse
Hindgut
18 days
Oropharyngeal membrane
Amnion cut
Midgut
Heart
Allantois
Yolk sac
Body stalk
Pericardial coelom
Anterior intestinal portal
Posterior intestinal portal

Embryonic Gut

Regions:

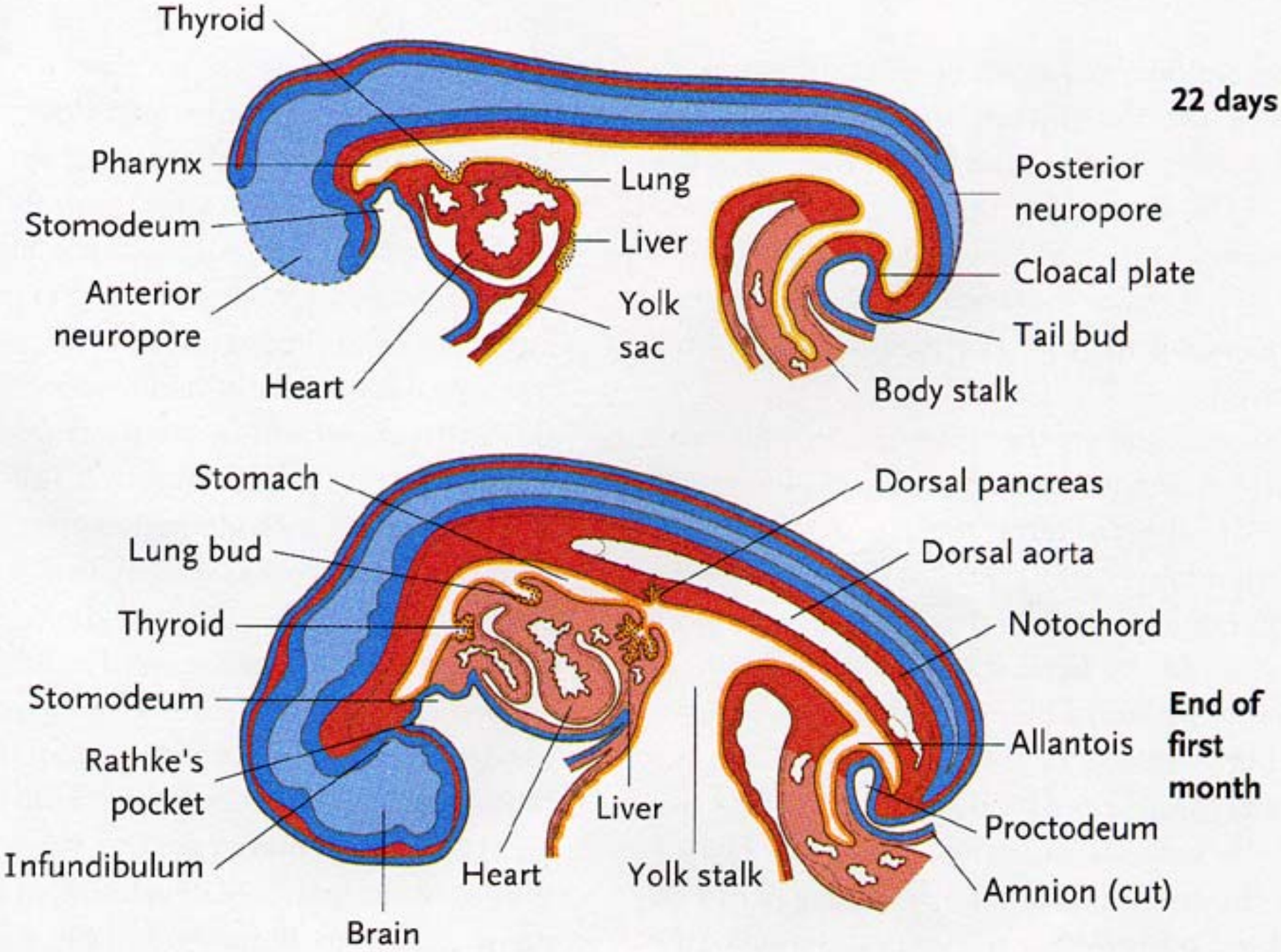
Foregut → Lateral fold and head fold
Hindgut → Lateral fold and tail fold
Midgut → Yolk Stalk Region

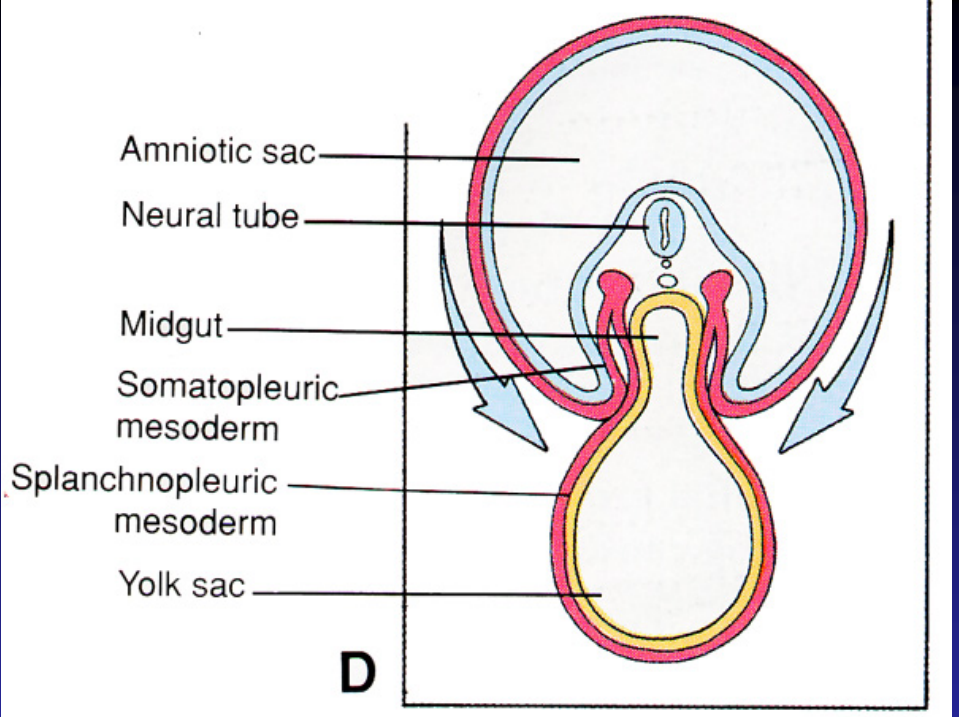
Anterior intestinal portal – foregut / midgut transition

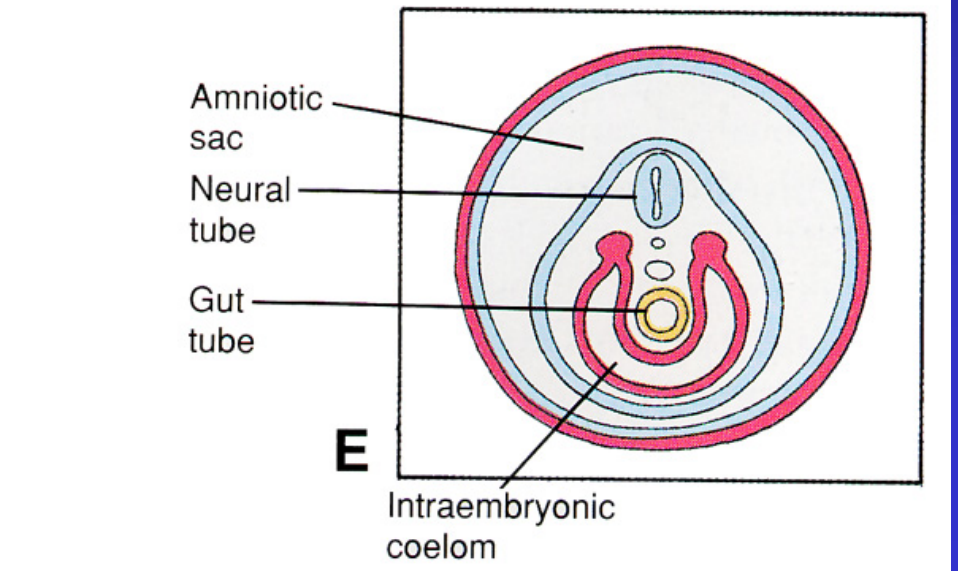
Posterior intestinal portal - midgut / hindgut transition

Oropharyngeal membrane = ectoderm-endoderm bilayer separating stomodeum, future mouth – ectoderm lined, from the future pharynx – endoderm lined.

Cloacal plate or Proctodeal membrane = ectoderm-endoderm bilayer, separates the ectoderm lined proctodeum from the gut endoderm.


Thyroid
22 days
Pharynx
Lung
Posterior neuropore
Stomodeum
Liver
Cloacal plate
Anterior neuropore
Yolk sac
Tail bud
Heart
Body stalk
Stomach
Dorsal pancreas
Lung bud
Dorsal aorta
Thyroid
Notochord
Stomodeum
End of first month
Allantois
Rathke's pocket
Liver
Proctodeum
Infundibulum
Heart
Yolk stalk
Amnion (cut)
Brain


Amniotic sac
Neural tube
Midgut
Somatopleuric mesoderm
Splanchnopleuric mesoderm
Yolk sac
D


Amniotic sac
Neural tube
Gut tube
E
Intraembryonic coelom

Embryonic Gut

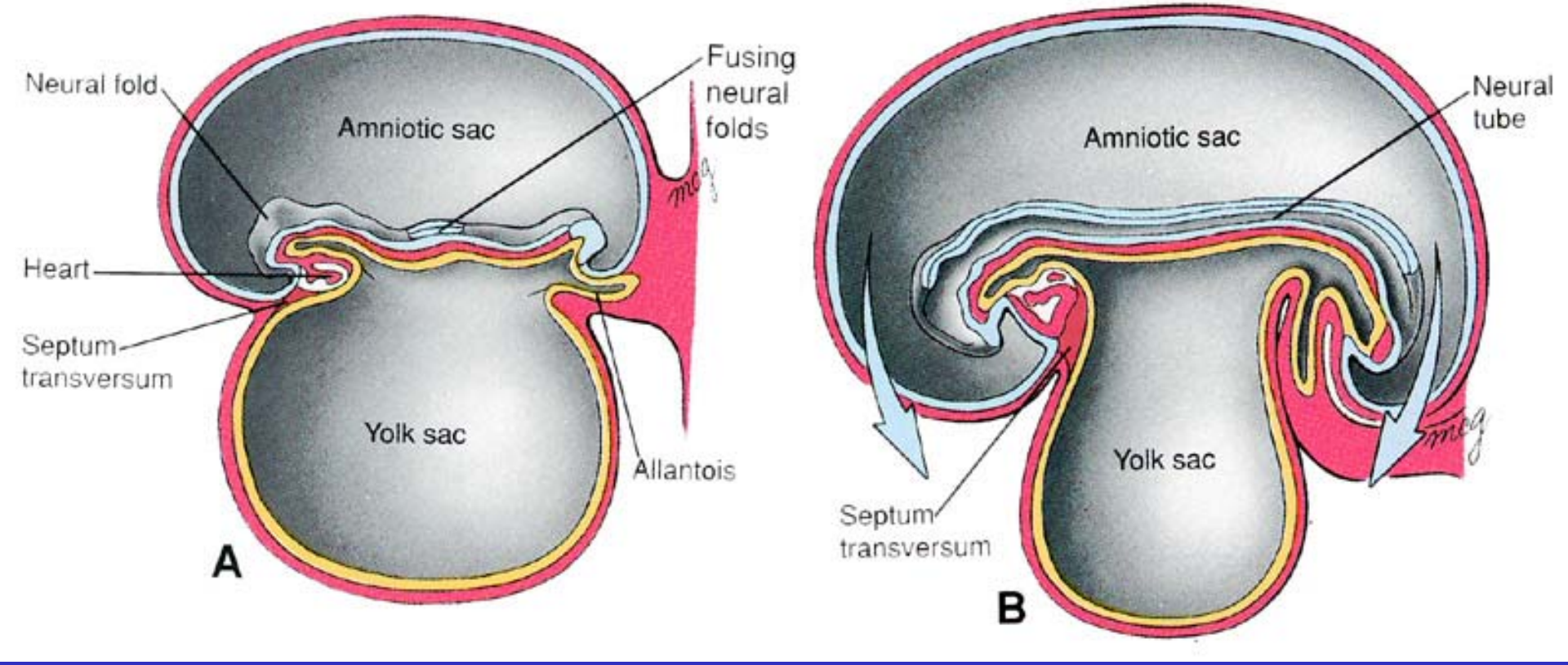
Straight tube suspended by the dorsal mesentery

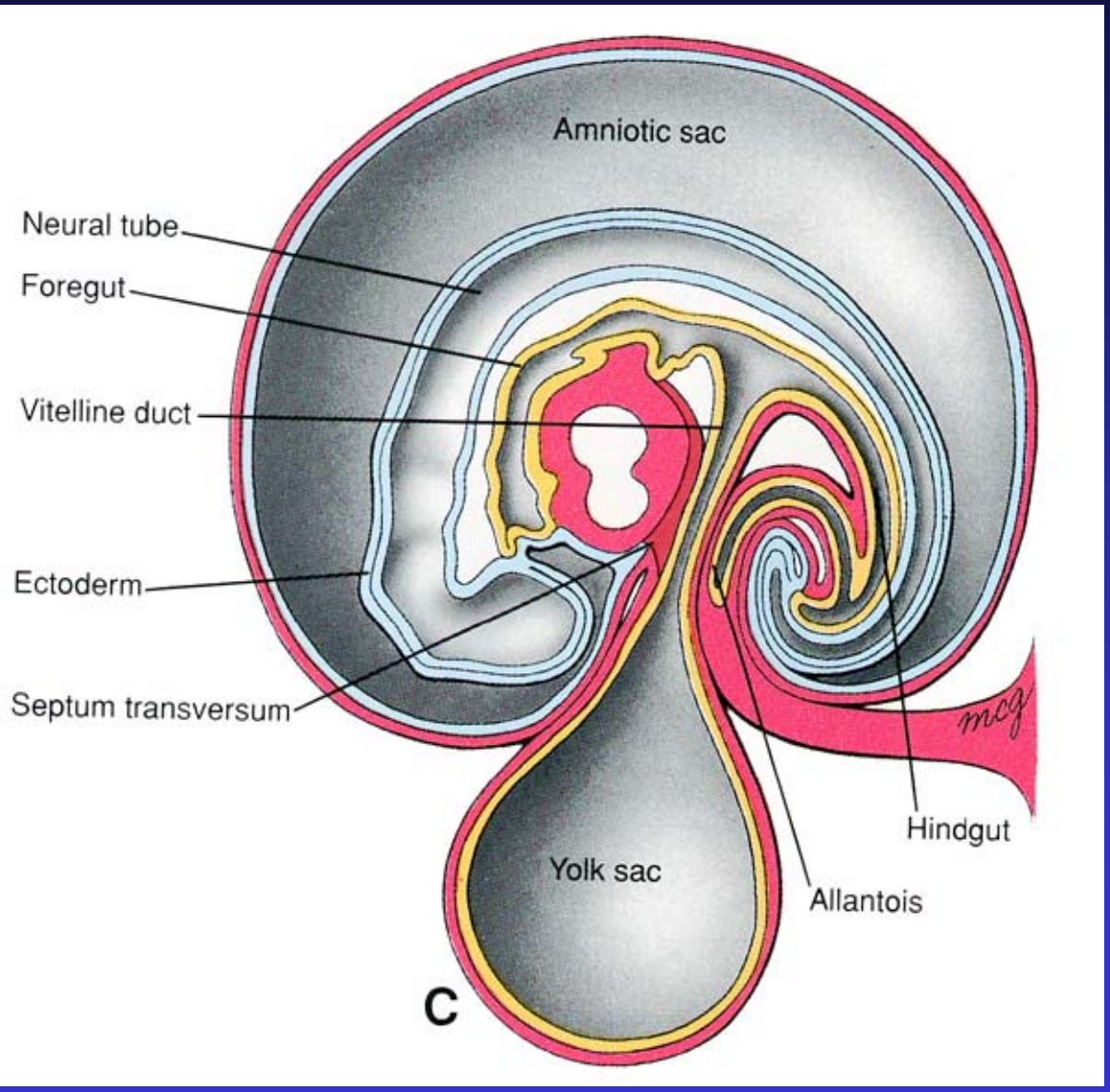
Only ventral connection is the transverse septum
level of stomach and cranial duodenum.

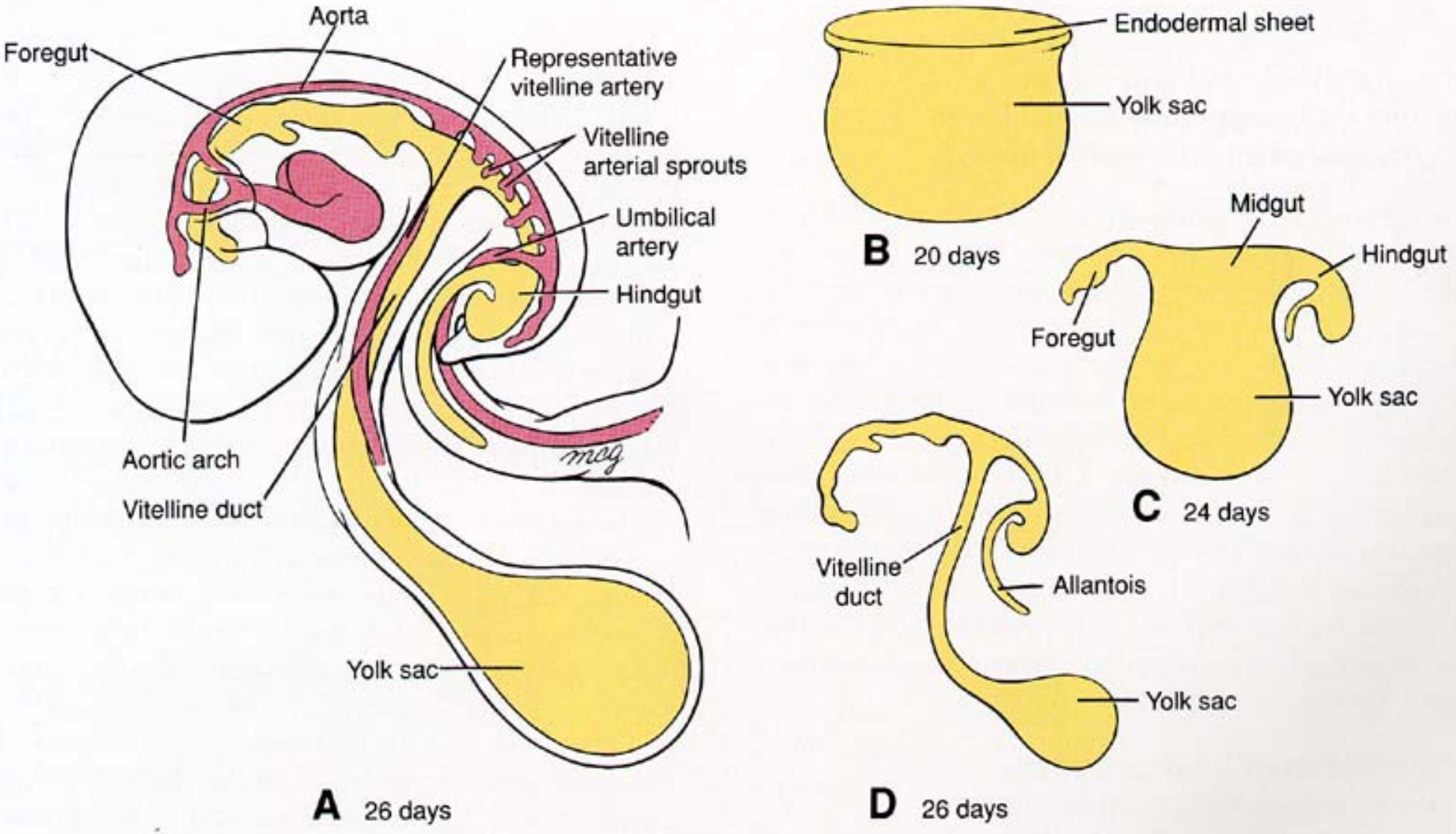
Transverse septum - mesoderm initially between developing heart and the cranial margin of the embryonic disc

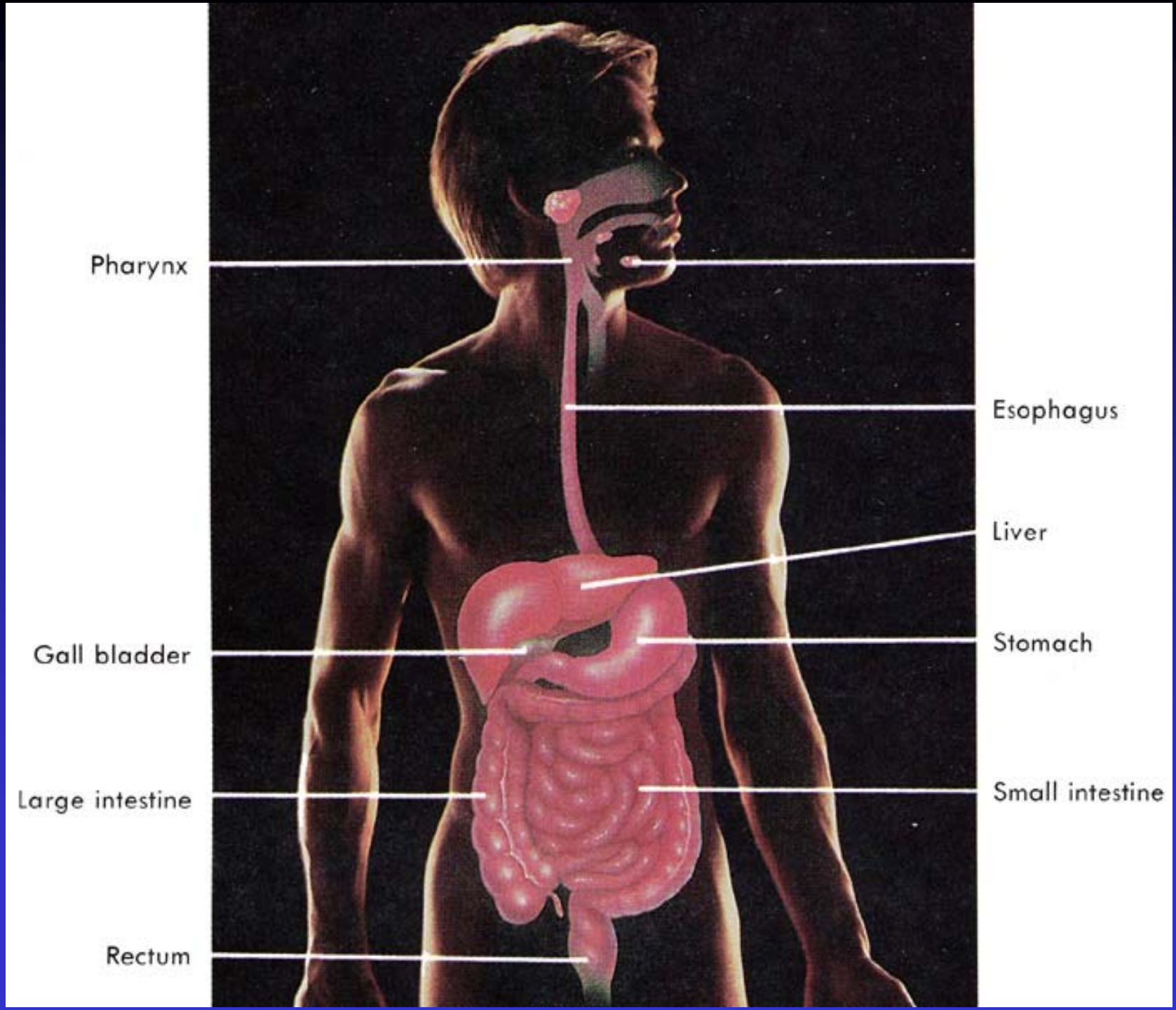
Cranial flexure displaces the transverse septum between the heart and the yolk sac –
Forming the initial partition separating the thoracic and abdominal cavities → part of the diaphragm

Hindgut – evagination is the allantois


Neural fold
Amniotic sac
Fusing neural folds
Heart
Septum transversum
Yolk sac
Allantois
A
Amniotic sac
Neural tube
Yolk sac
Septum transversum
B


Amniotic sac
Neural tube
Foregut
Vitelline duct
Ectoderm
Septum transversum
mcg
Hindgut
Yolk sac
Allantois
C


Aorta
Foregut
Representative vitelline artery
Vitelline arterial sprouts
Umbilical artery
Hindgut
Aortic arch
Vitelline duct
Yolk sac
A 26 days
Endodermal sheet
Yolk sac
B 20 days
Midgut
Hindgut
Foregut
Yolk sac
C 24 days
Vitelline duct
Allantois
Yolk sac
D 26 days


Pharynx
Esophagus
Liver
Gall bladder
Stomach
Large intestine
Small intestine
Rectum

Foregut Deriviatives

Oropharyngeal membrane (cranial end)

Pharynx (deriviatives of the pharyngeal pouches, tongue, thyroid gland)

Thoracic esophagus (lung buds)

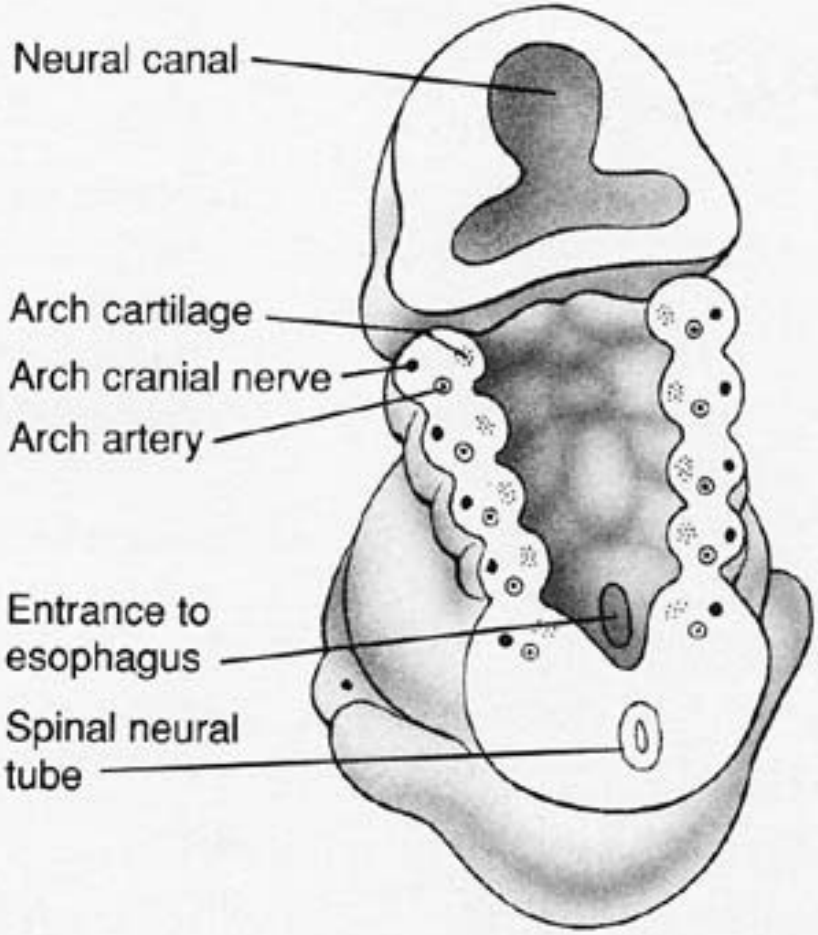
Abdominal esophagus

Stomach

Cranial half of duodenum (liver, gallbladder, pancreas)

Caudal end = Ampulla of Vater (common bile and pancreatic ducts drain into gut)

Pharynx



Pharyngeal:

Pouches (endoderm); Grooves (ectoderm); Arches (mesoderm)

Pharyngeal Pouches

Pharyngeal Pouch #1 – Caudal to Arch #1

Auditory tube (Eustachian tube), **tympanic cavity**

Pharyngeal Pouch #2 – Caudal to Arch #2

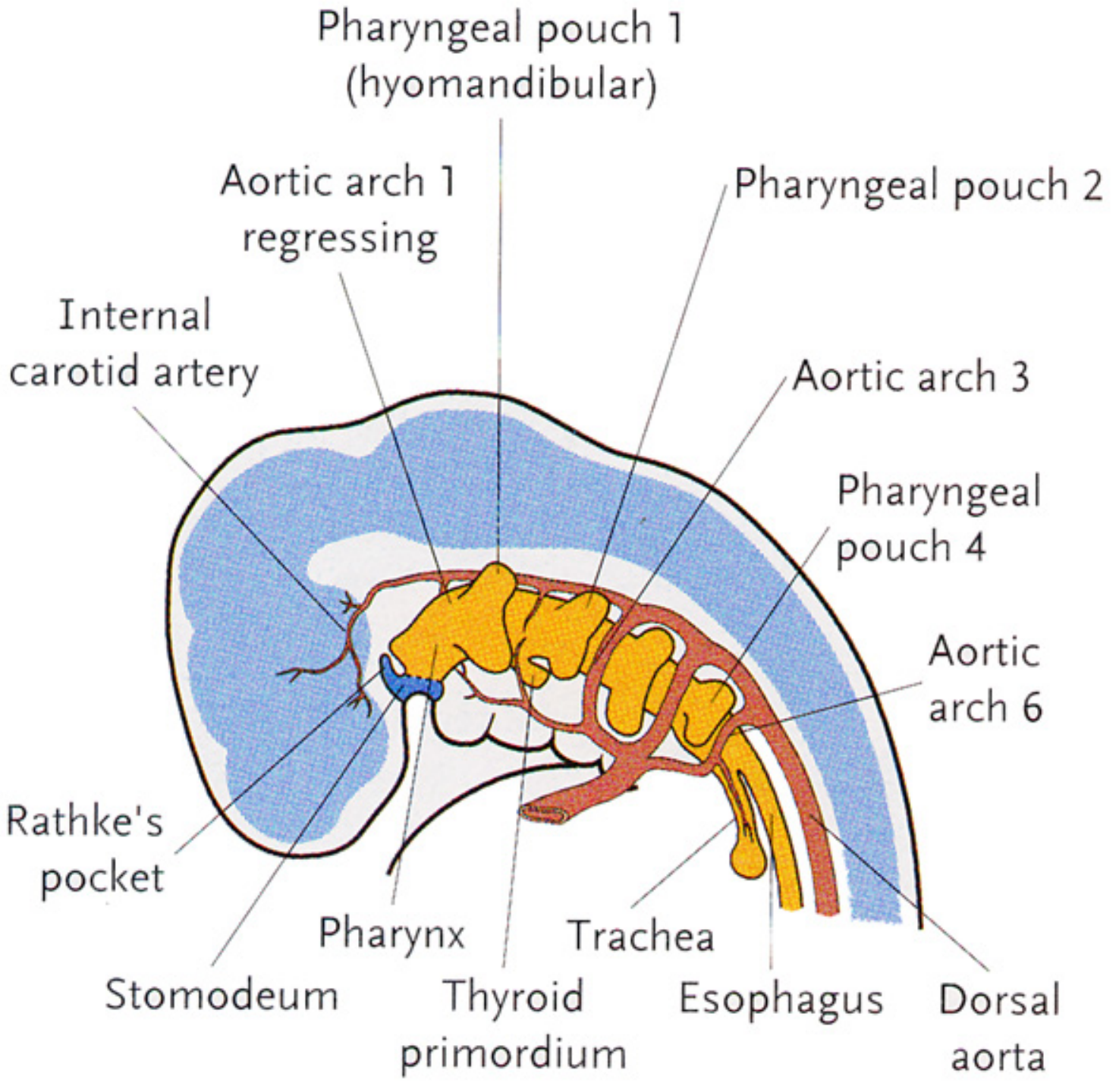
Supratonsillar fossae associated with **Palatine tonsils**

Pharyngeal Pouch #3 – Caudal to Arch #3

Inferior parathyroid, Thymus

Pharyngeal Pouch #4 – Caudal to Arch #4

Superior parathyroids, Postbranchial body


Pharyngeal pouch 1
(hyomandibular)
Aortic arch 1
regressing
Pharyngeal pouch 2
Internal
carotid artery
Aortic arch 3
Pharyngeal
pouch 4
Aortic
arch 6
Rathke's
pocket
Pharynx
Trachea
Stomodeum
Thyroid
primordium
Esophagus
Dorsal
aorta

Tongue

Lateral Lingual Swellings – paired lateral swellings from the 1st pharyngeal arch (ventral)

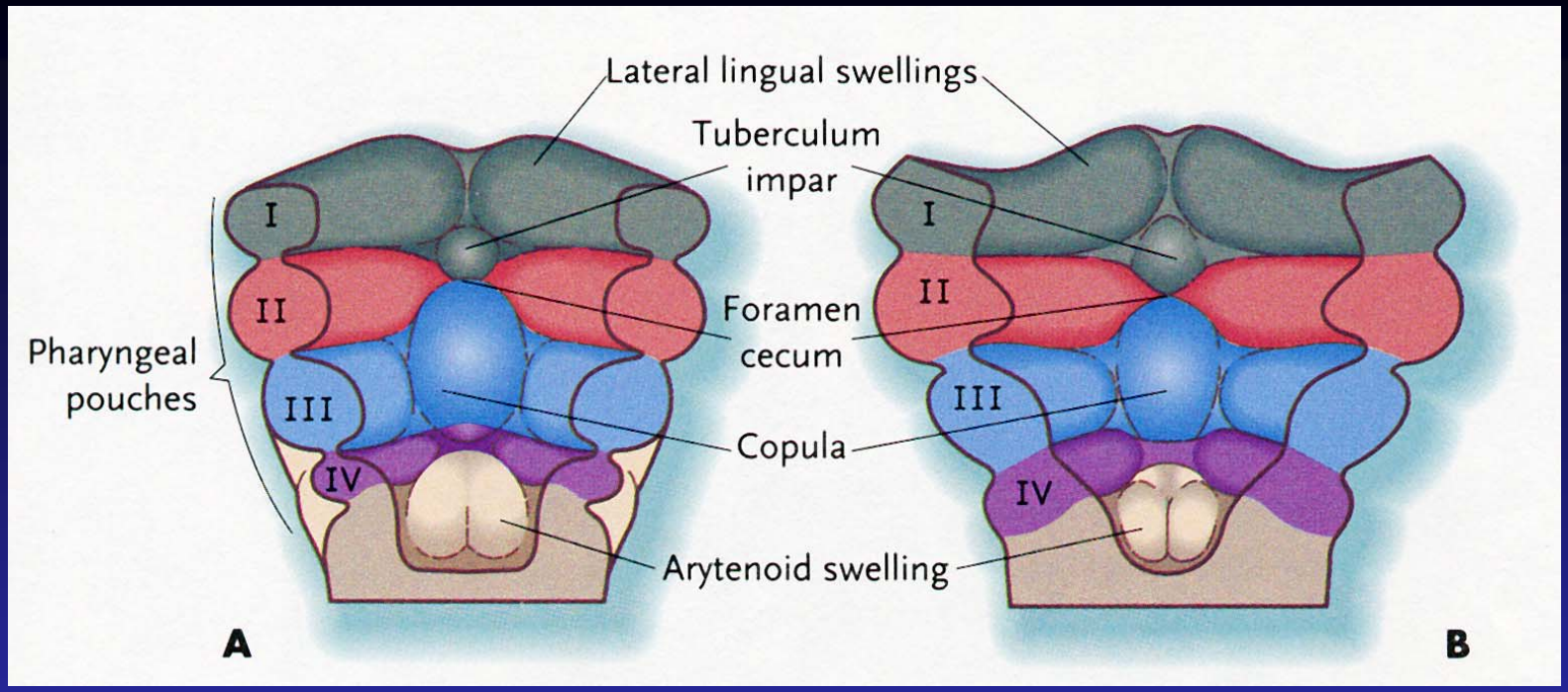
2 unpaired medial swellings from the ventral midline of the pharynx
Tuberculum impar
Copula

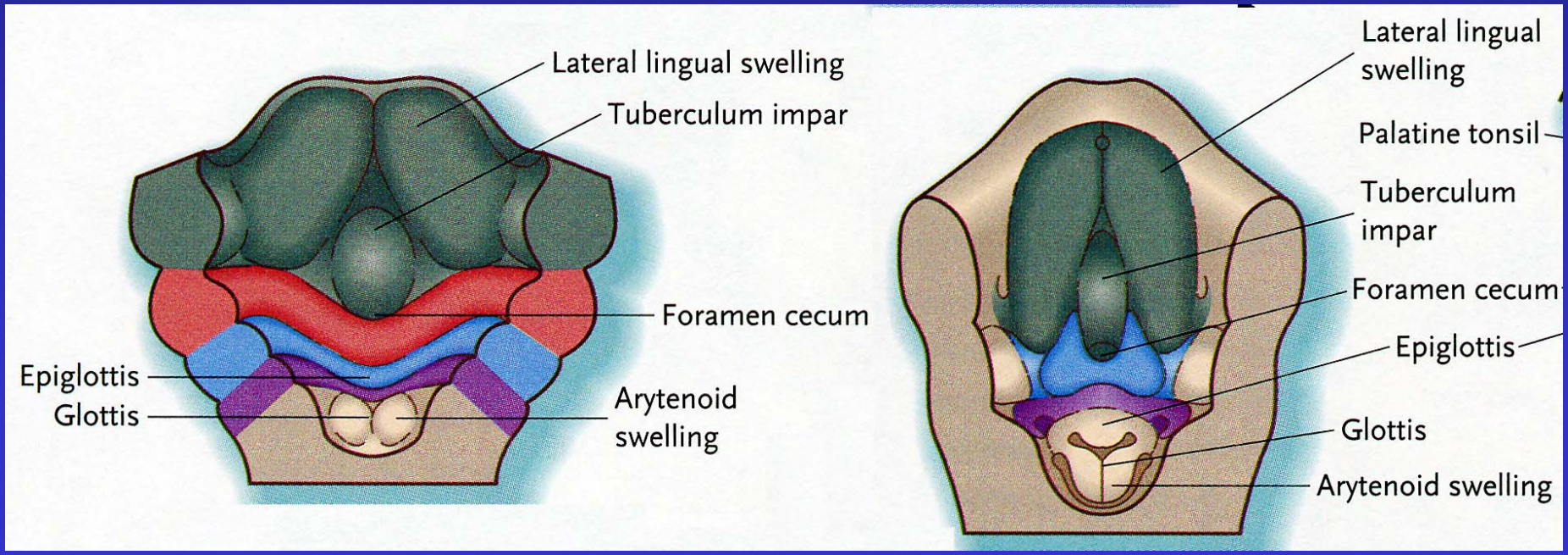
Contribution from the 3rd and 4th pharyngeal arches

Oral Tongue (anterior 2/3) forms from the expansion of lateral swellings and the tuberculum impar - median sulcus of the tongue is the site of midline fusion

Base of the tongue is formed from the copula with contribution from the 3rd and 4th pharyngeal arches

The epiglottis forms from a swelling caudal to the copula


Lateral lingual swellings
Tuberculum impar
Foramen cecum
Copula
Arytenoid swelling
Pharyngeal pouches
I
II
III
IV
A
B


Lateral lingual swelling
Tuberculum impar
Foramen cecum
Epiglottis
Glottis
Arytenoid swelling
Lateral lingual swelling
Palatine tonsil
Tuberculum impar
Foramen cecum
Epiglottis
Glottis
Arytenoid swelling

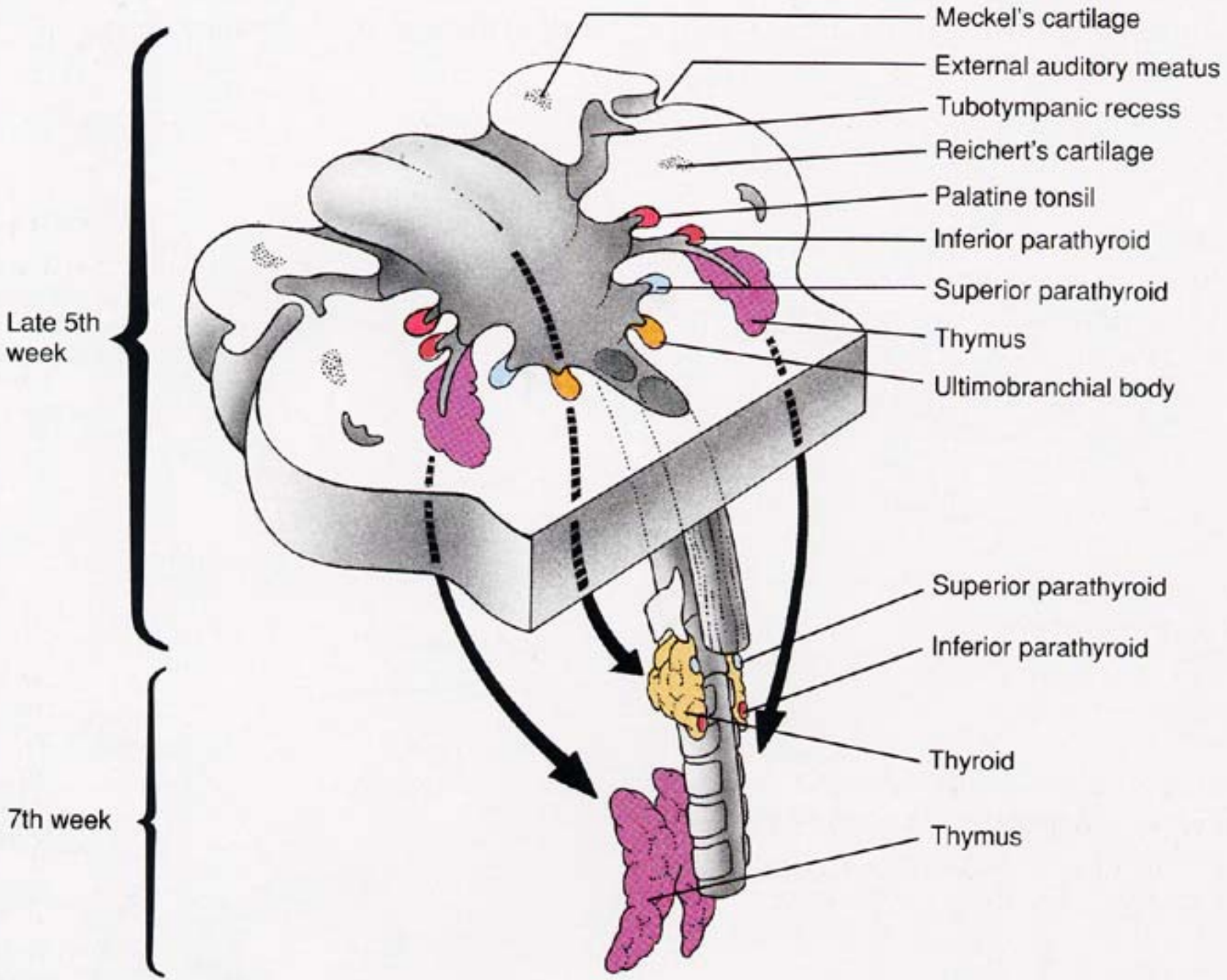
Thyroid Gland

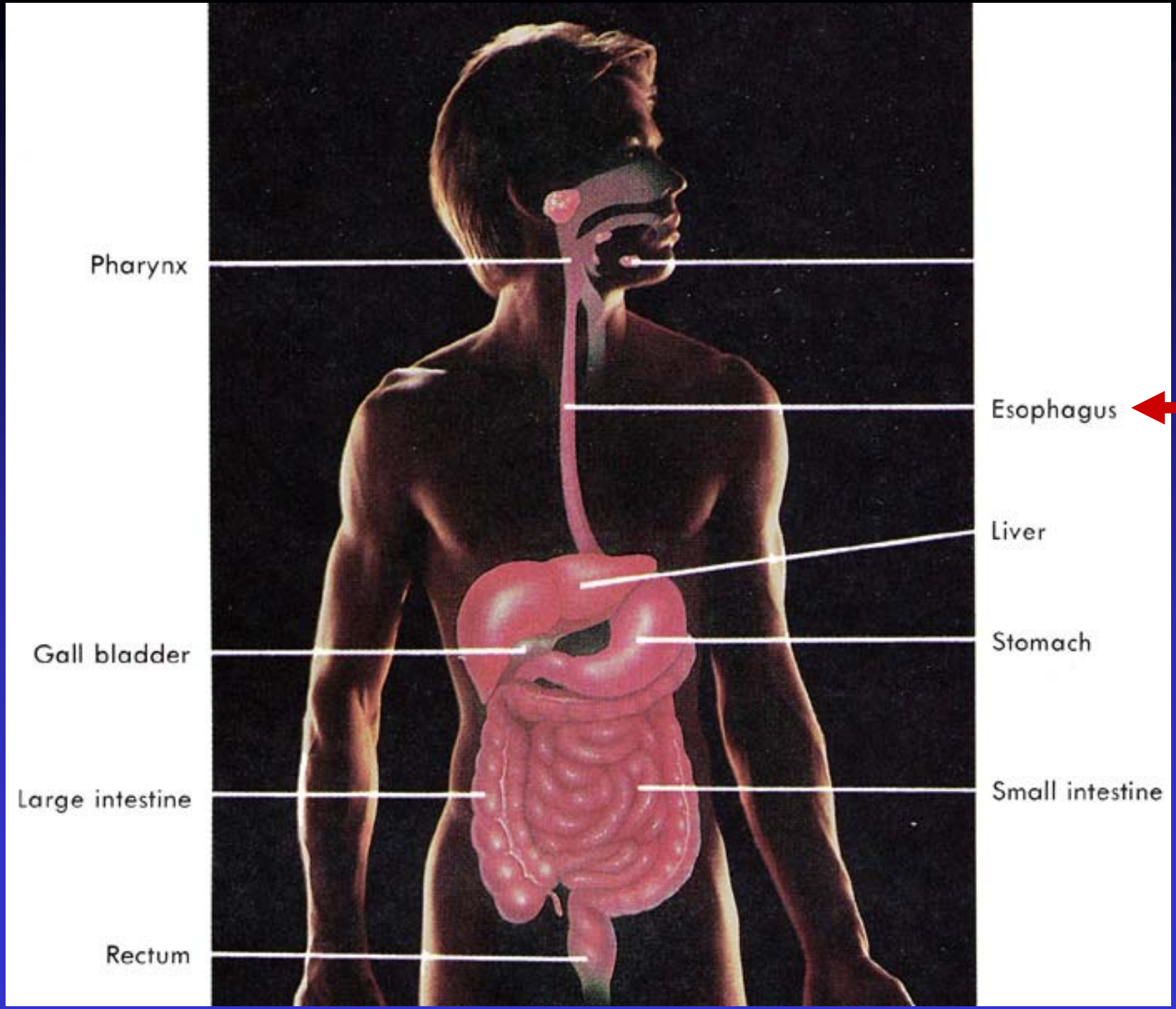
Thyroid Diverticulum

- Midventral thickening, between Pharyngeal Pouch 1 and 2 (base of the tongue)
- Single outgrowth elongates in a caudal direction
- Bifurcates to form the bi-lobed Thyroid gland

The connection – thyroglossal duct regresses about week 7

The site of the thyroid diverticulum persist as the foramen cecum – between the tuberculum impar and the copula


Meckel's cartilage
External auditory meatus
Tubotympanic recess
Reichert's cartilage
Palatine tonsil
Inferior parathyroid
Superior parathyroid
Thymus
Ultimobranchial body
Late 5th week
Superior parathyroid
Inferior parathyroid
Thyroid
Thymus
7th week


Pharynx
Esophagus
Liver
Gall bladder
Stomach
Large intestine
Small intestine
Rectum

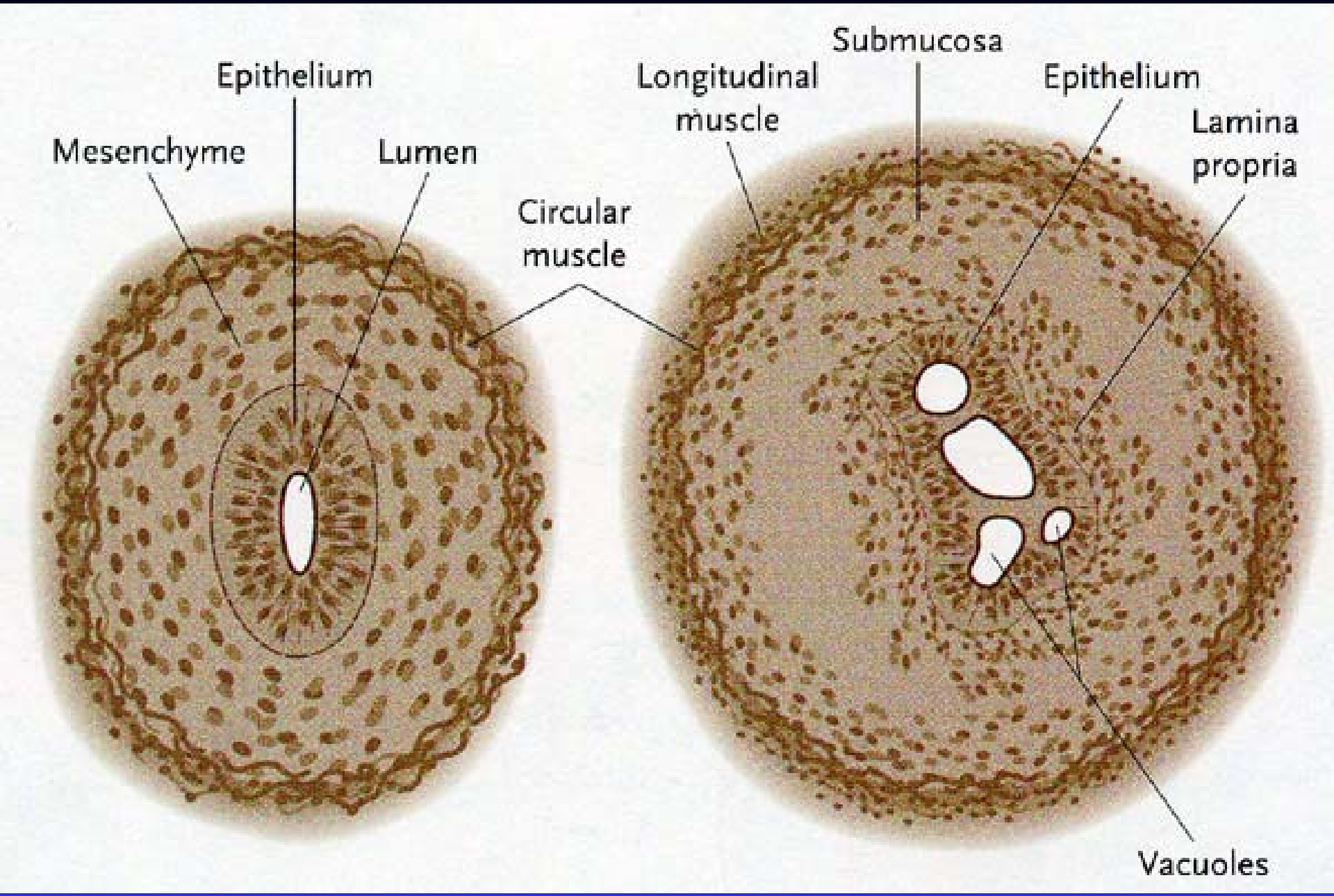
Esophagus

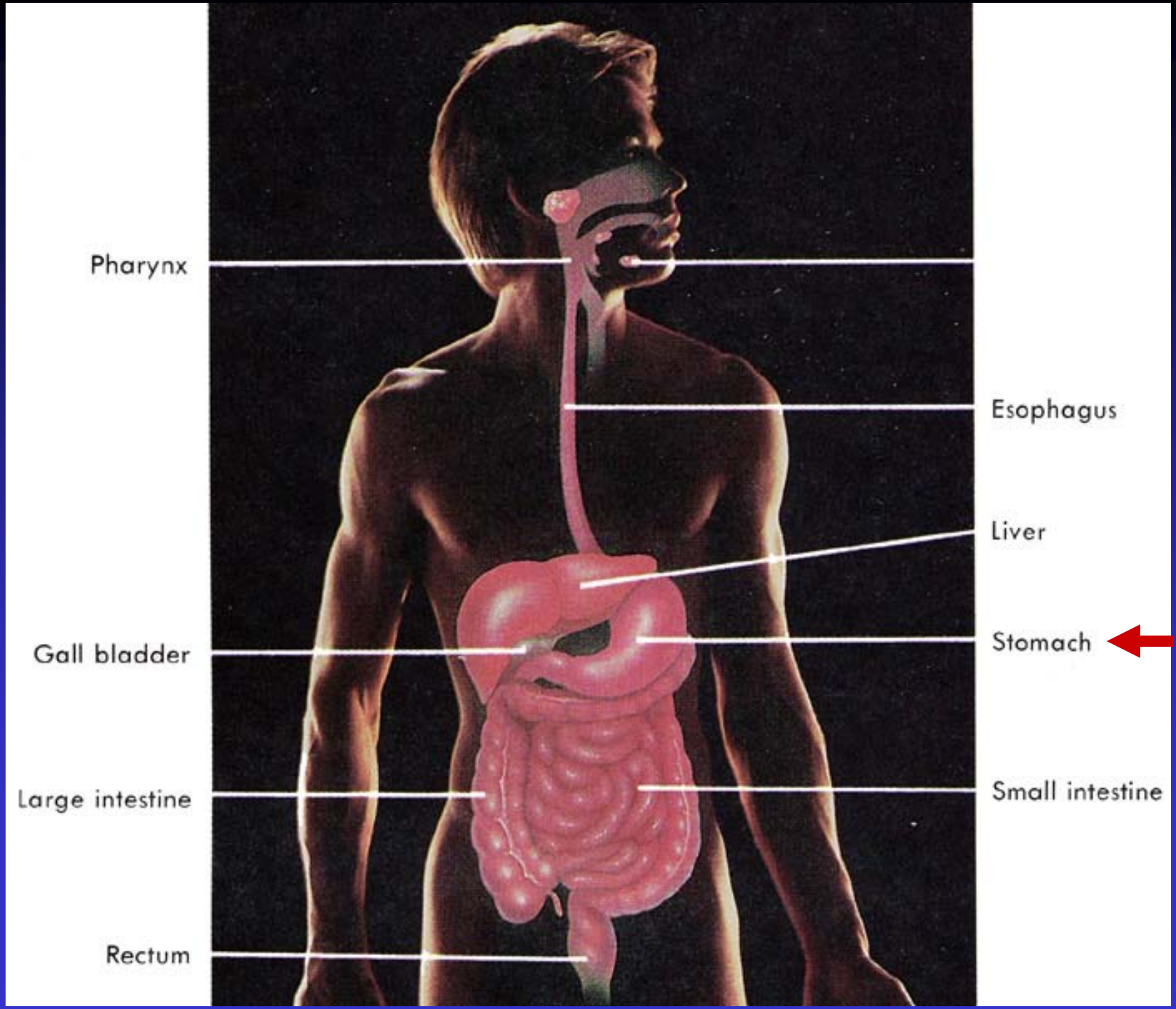
Thoracic Esophagus buds off the lung buds → Respiratory Tract

Abdominal Esophagus – abruptly narrows – extends to the Stomach

Differentiation of Epithelium:

- 7^{th} – 8^{th} Week – epithelium is stratified columnar, Lumen becomes partially occluded
- Appearance of large vacuoles
- Vacuoles coalesce – recanalization
- 12^{th} Week - Epithelium is multilayered and ciliated
- 16^{th} Week – Stratified squamous epithelium


Epithelium
Mesenchyme
Lumen
Circular muscle
Longitudinal muscle
Submucosa
Epithelium
Lamina propria
Vacuoles


Pharynx
Esophagus
Liver
Gall bladder
Stomach
Large intestine
Small intestine
Rectum

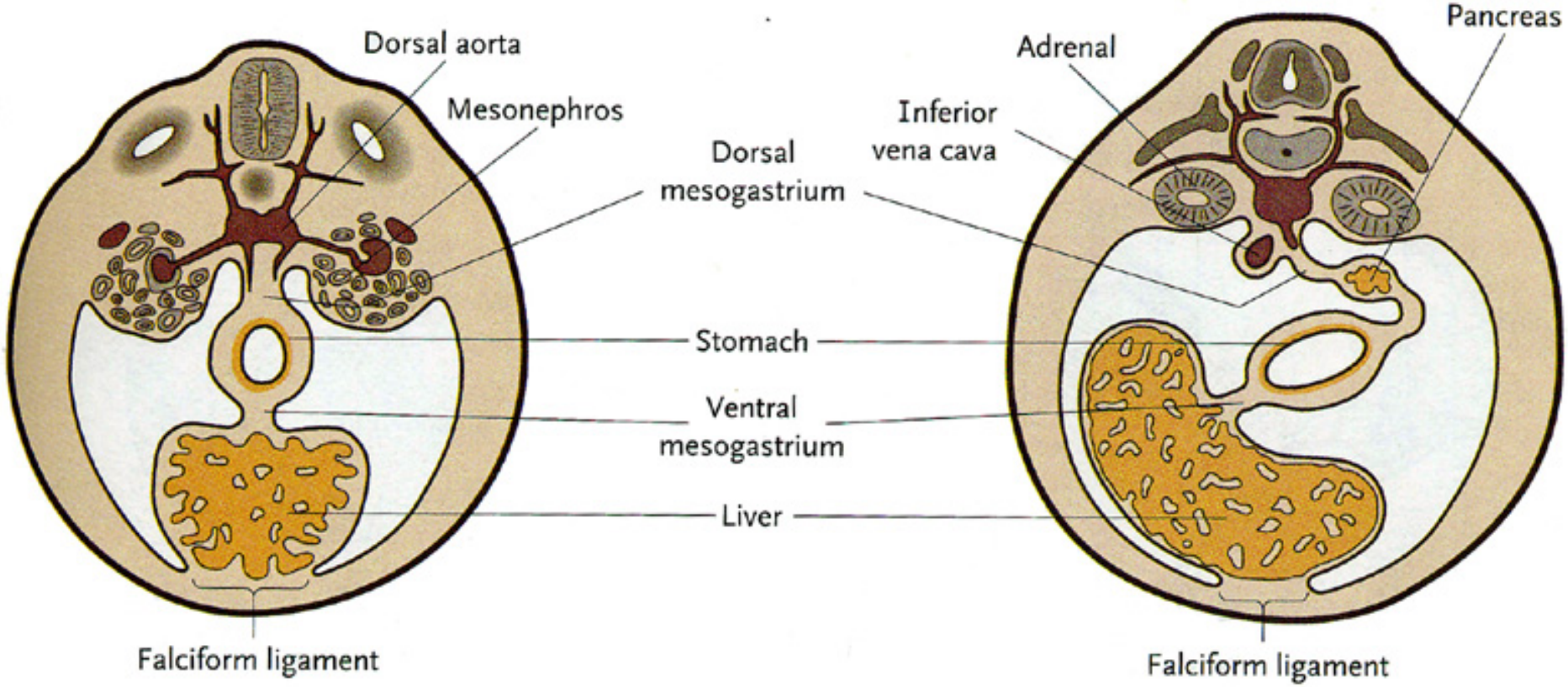
Stomach

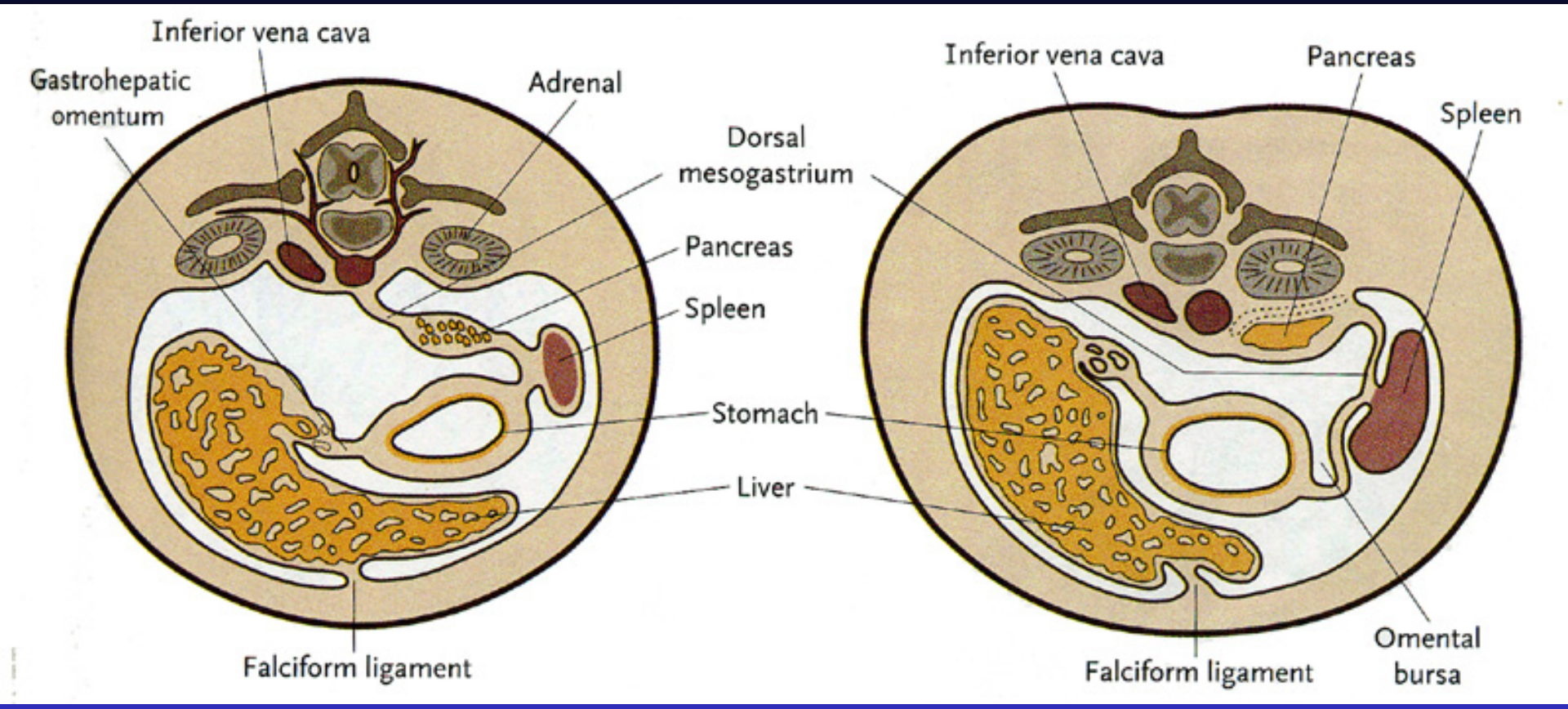
Stomach - initially symmetrical and fusiform (spindle)

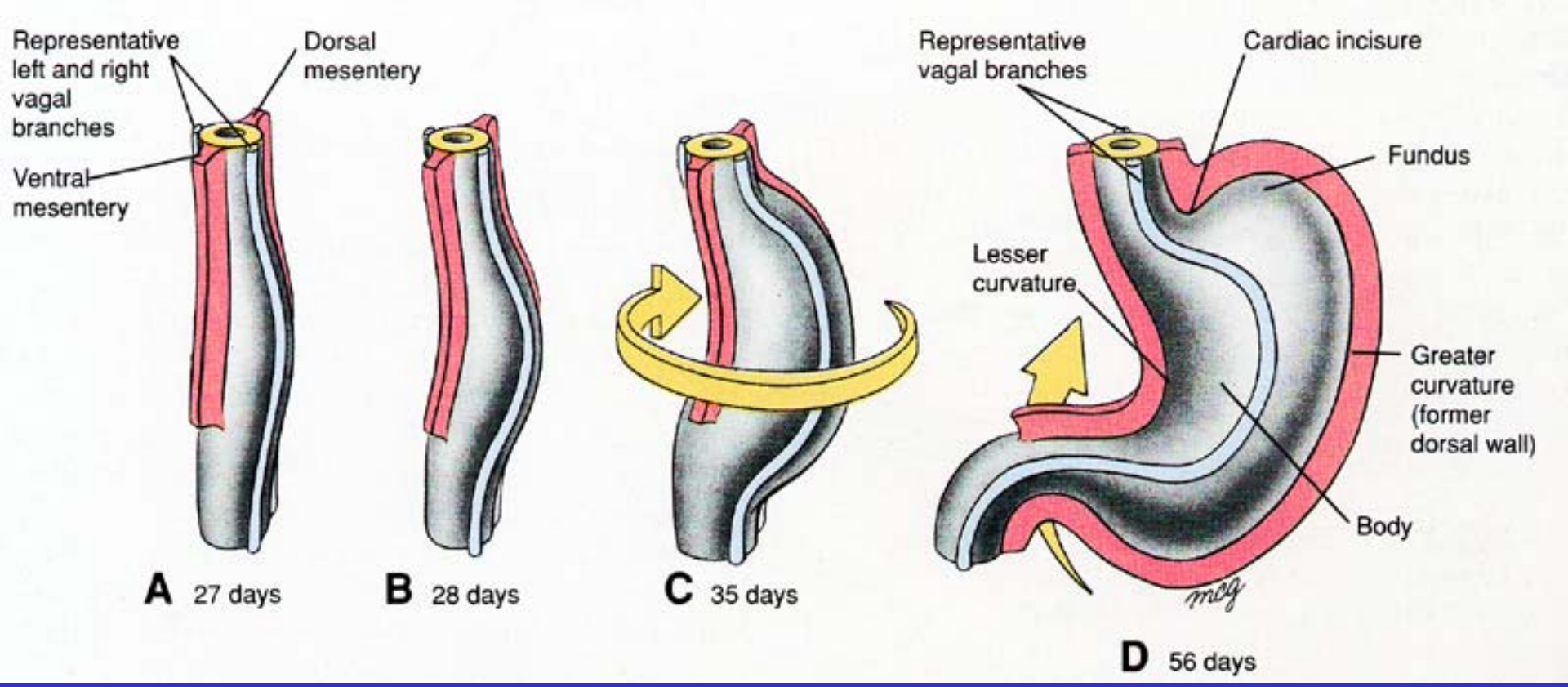
Differential growth - dorsal > ventral - creates the Greater curvature of the stomach (dorsal side) and Lesser curvature (ventral side)

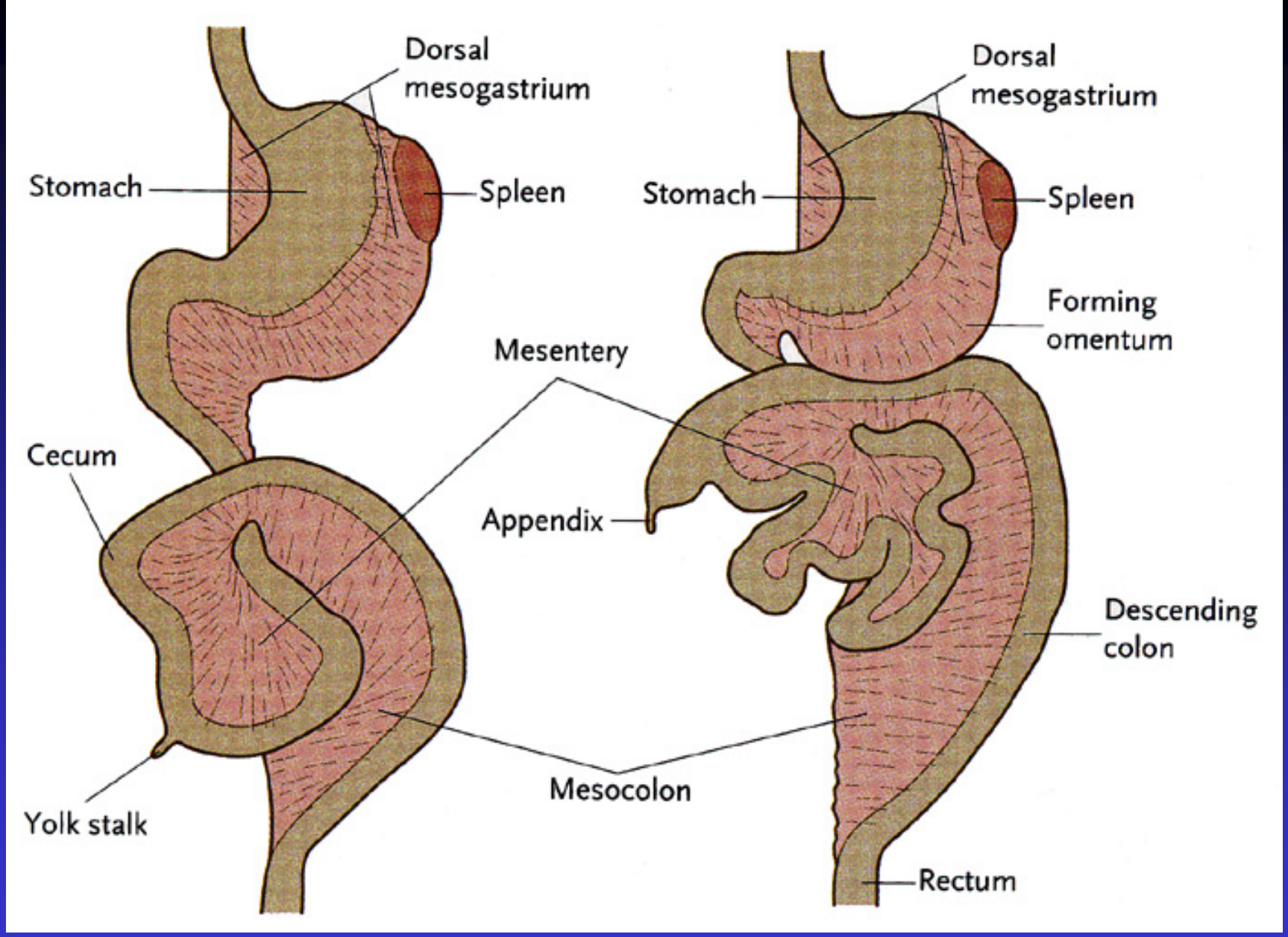
90o rotation of the stomach around craniocaudal axis
greater curvature is to the left and caudal
lesser curvature is to the right and cranial

Dorsal mesogastrium (dorsal mesentery) – differential growth is responsible for the rotation. Dorsal mesogastrium becomes the greater omentum

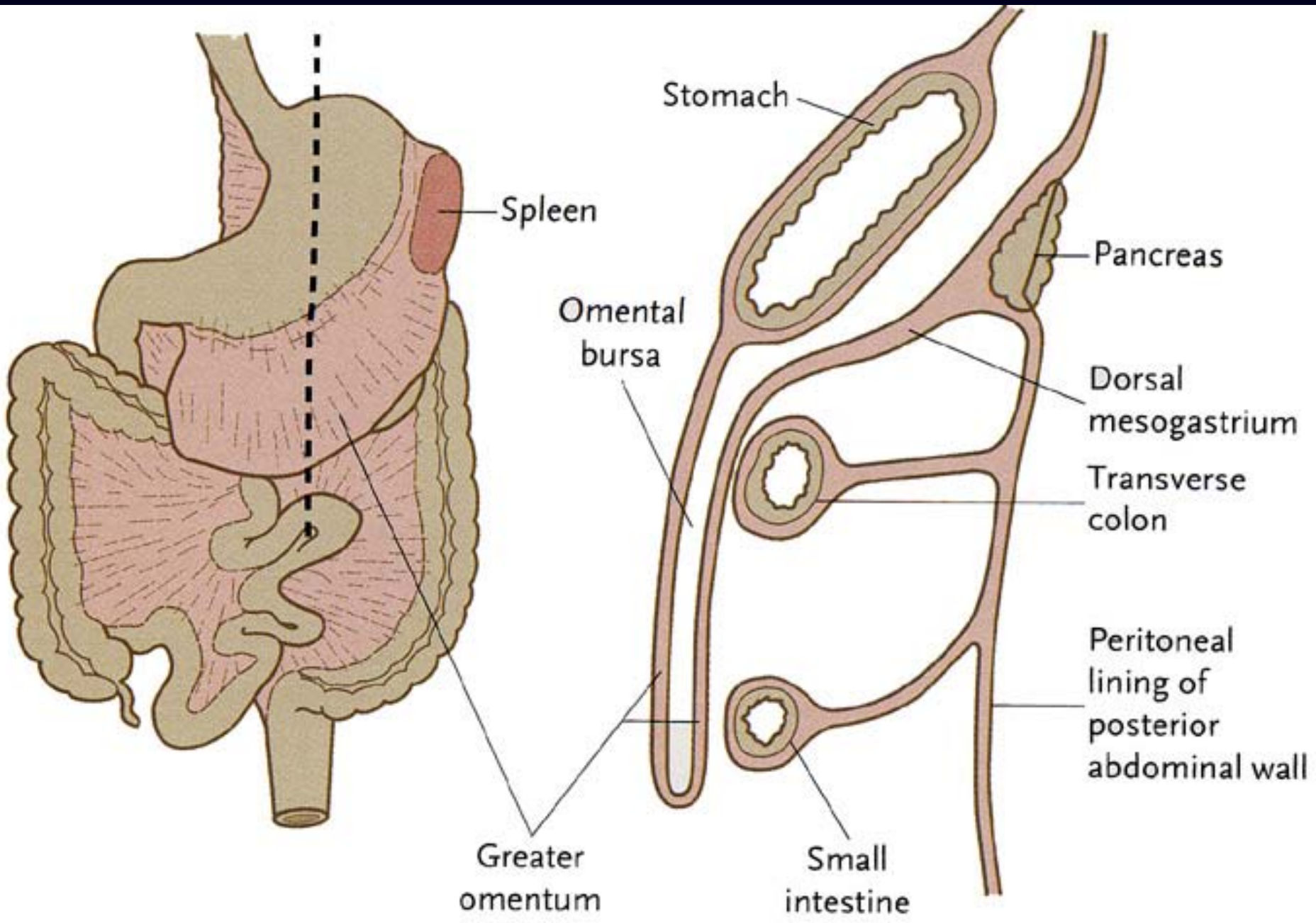

Dorsal aorta
Mesonephros
Dorsal mesogastrium
Stomach
Ventral mesogastrium
Liver
Falciform ligament
Adrenal
Pancreas
Inferior vena cava
Falciform ligament

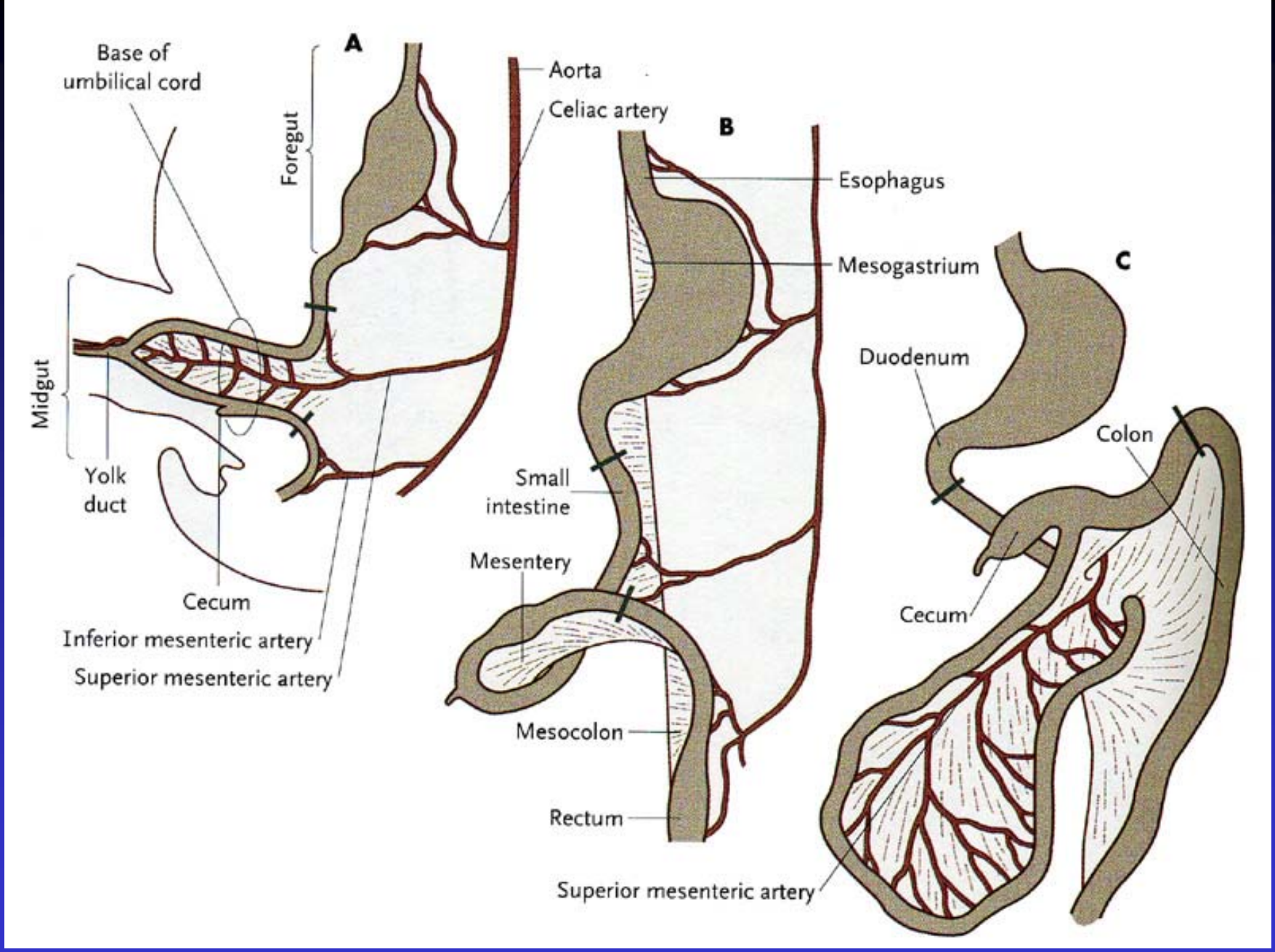

Inferior vena cava
Gastrohepatic omentum
Adrenal
Dorsal mesogastrium
Pancreas
Spleen
Stomach
Liver
Falciform ligament
Inferior vena cava
Pancreas
Spleen
Omental bursa
Falciform ligament


Representative left and right vagal branches
Dorsal mesentery
Ventral mesentery
A 27 days
B 28 days
C 35 days
Representative vagal branches
Cardiac incisure
Fundus
Lesser curvature
Greater curvature (former dorsal wall)
Body
D 56 days

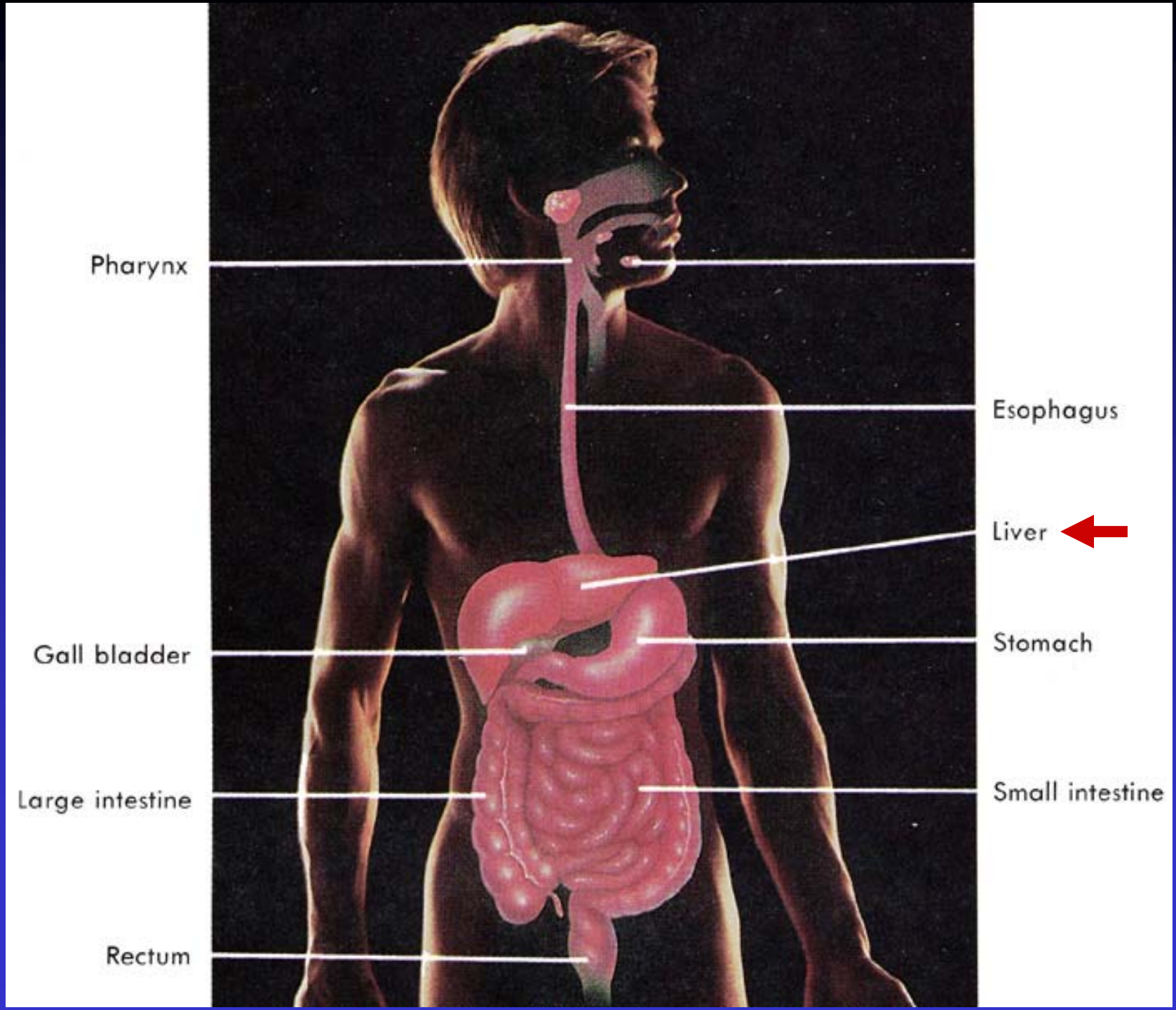


Dorsal mesogastrium becomes the greater omentum


Spleen
Stomach
Pancreas
Omental bursa
Dorsal mesogastrium
Transverse colon
Peritoneal lining of posterior abdominal wall
Greater omentum
Small intestine



Stomach rotation moves the duodenum to the left and cranially


Pharynx
Esophagus
Liver
Gall bladder
Stomach
Large intestine
Small intestine
Rectum

Liver is Derived from the Duodenum

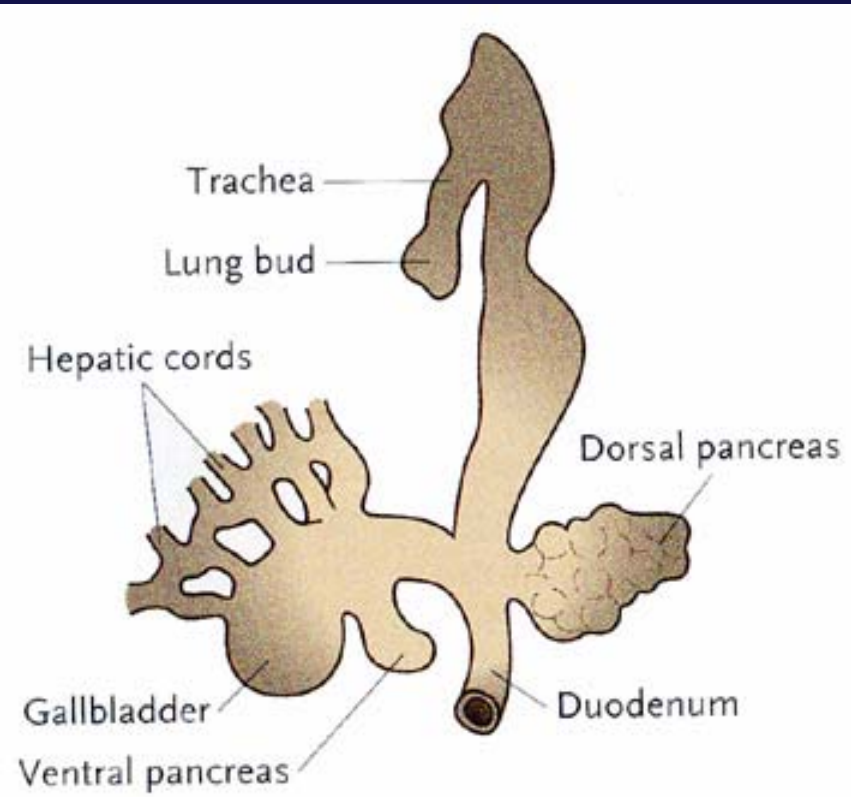
Endodermal thickening – ventral side of Duodenum

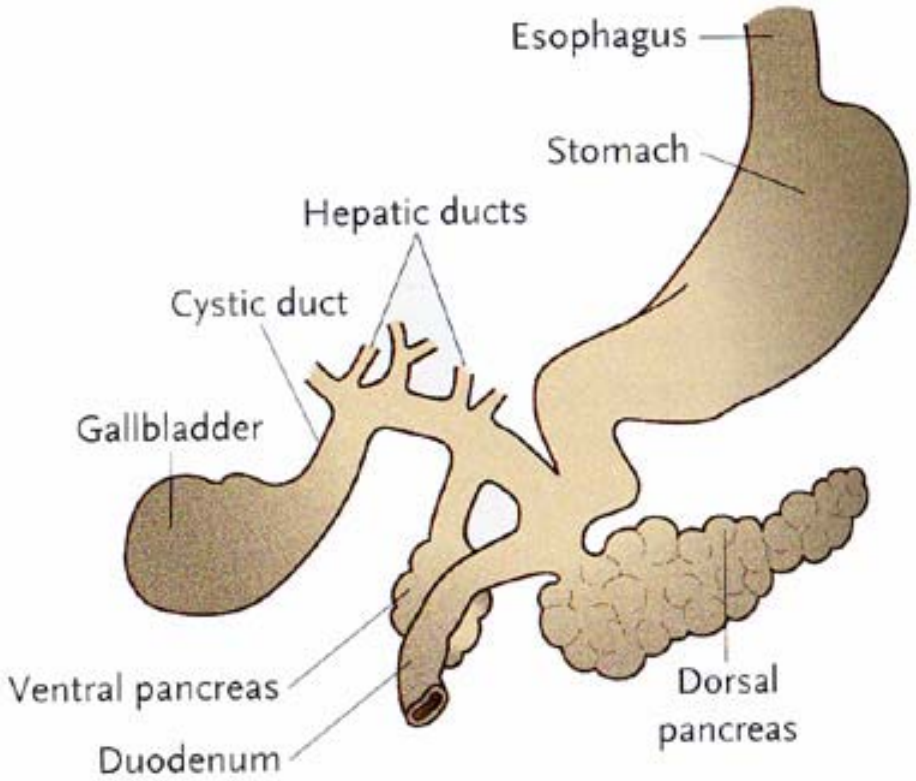
Hepatic diverticulum - grows ventrally into the transverse septum

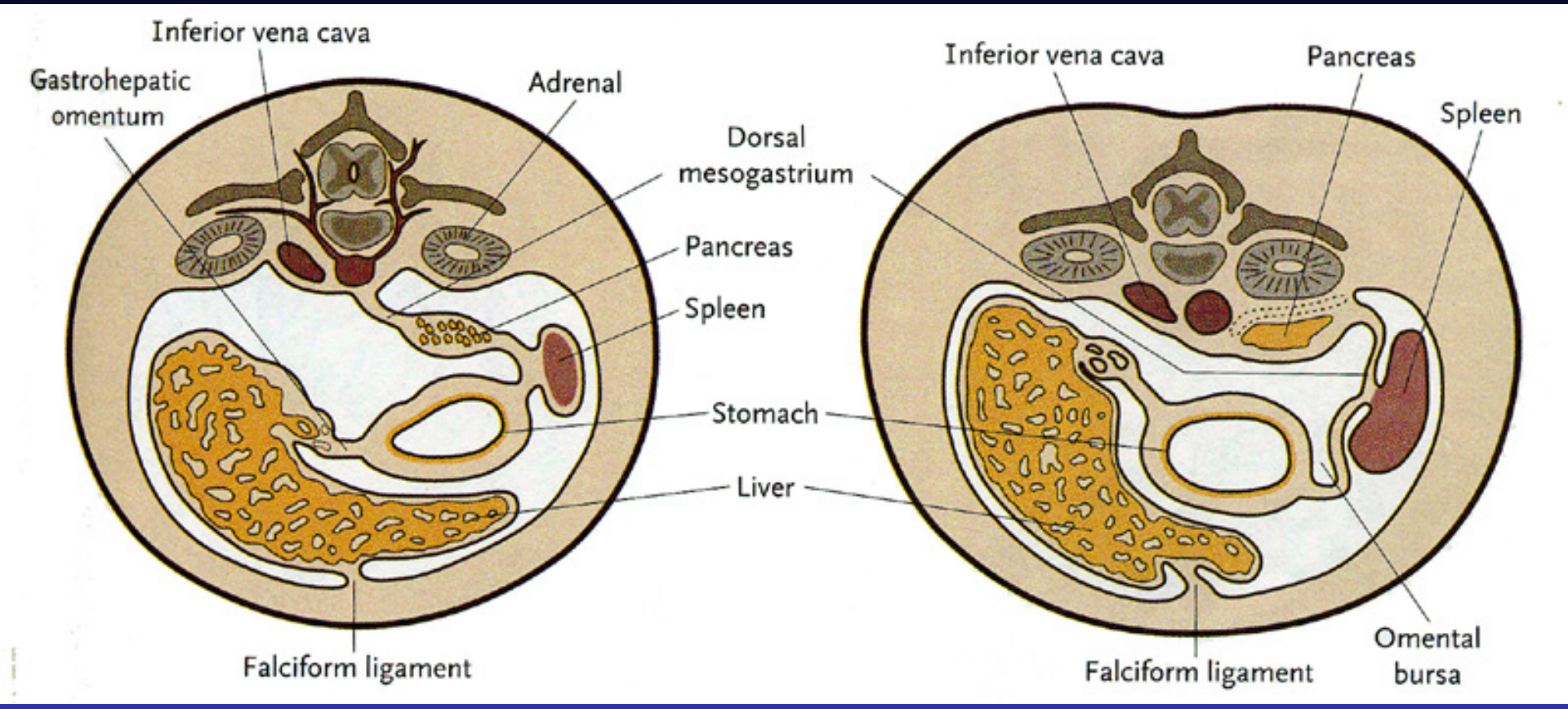
Hepatic diverticulum branches into many Hepatic cords that form hepatocytes and the drainage ducts (bile canaliculi, hepatic ducts).

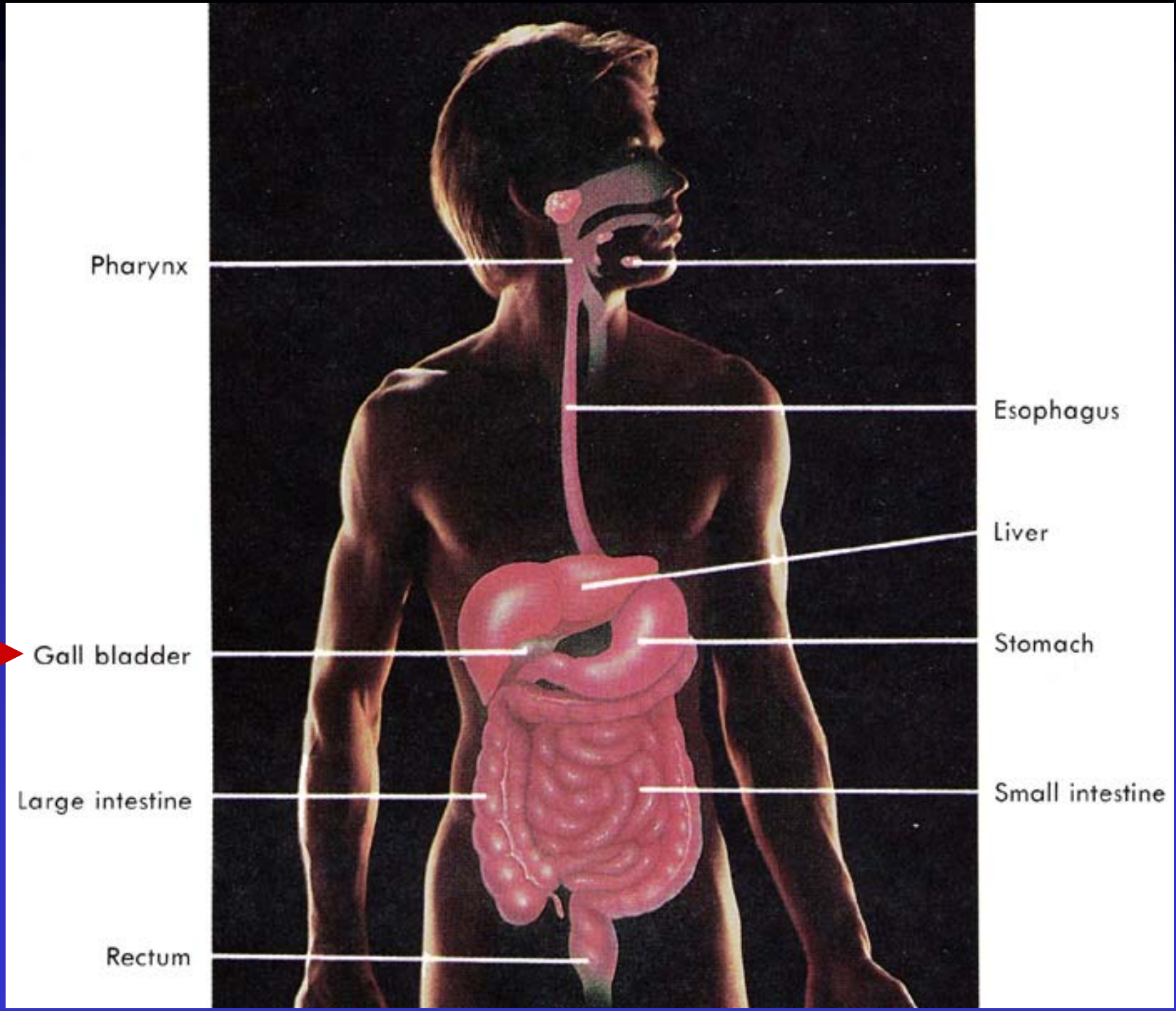
Gastrohepatic omentum – connection to the stomach – becomes the lesser omentum

Falciform ligament – ventral mesentery connection to the body wall


Trachea
Lung bud
Hepatic cords
Dorsal pancreas
Gallbladder
Duodenum
Ventral pancreas


Esophagus
Stomach
Hepatic ducts
Cystic duct
Gallbladder
Ventral pancreas
Duodenum
Dorsal pancreas


Inferior vena cava
Gastrohepatic omentum
Adrenal
Dorsal mesogastrium
Pancreas
Spleen
Stomach
Liver
Falciform ligament
Inferior vena cava
Pancreas
Spleen
Omental bursa
Falciform ligament

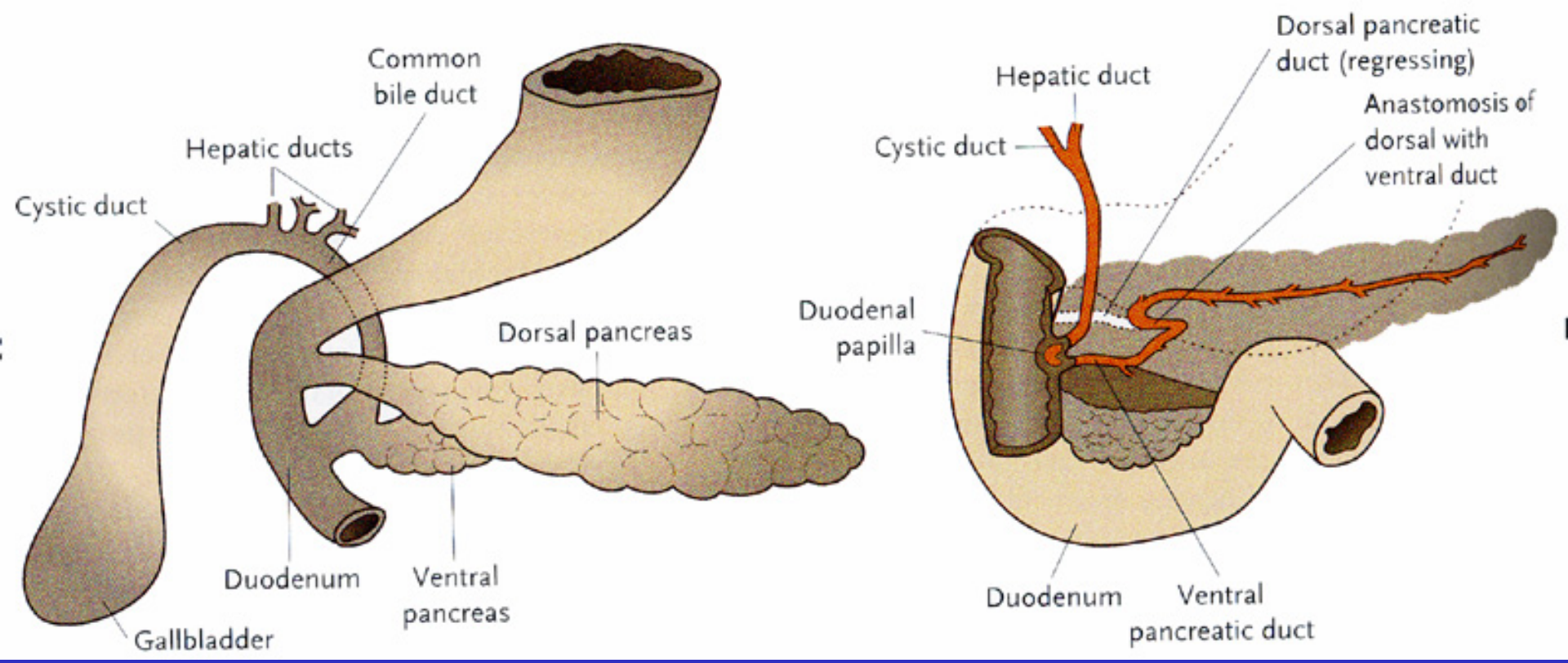

Pharynx
Esophagus
Liver
Gall bladder
Stomach
Large intestine
Small intestine
Rectum

Gallbladder / Cystic Duct

Cystic diverticulum arises from a ventral endodermal thickening just posterior to the hepatic diverticulum

The cystic diverticulum gives rise to the gallbladder and cystic duct.

Hepatic duct and cystic duct merge to form the common bile duct


Common bile duct
Hepatic ducts
Cystic duct
Dorsal pancreas
Duodenum
Ventral pancreas
Gallbladder
Dorsal pancreatic duct (regressing)
Hepatic duct
Anastomosis of dorsal with ventral duct
Cystic duct
Duodenal papilla
Duodenum
Ventral pancreatic duct

Pancreas

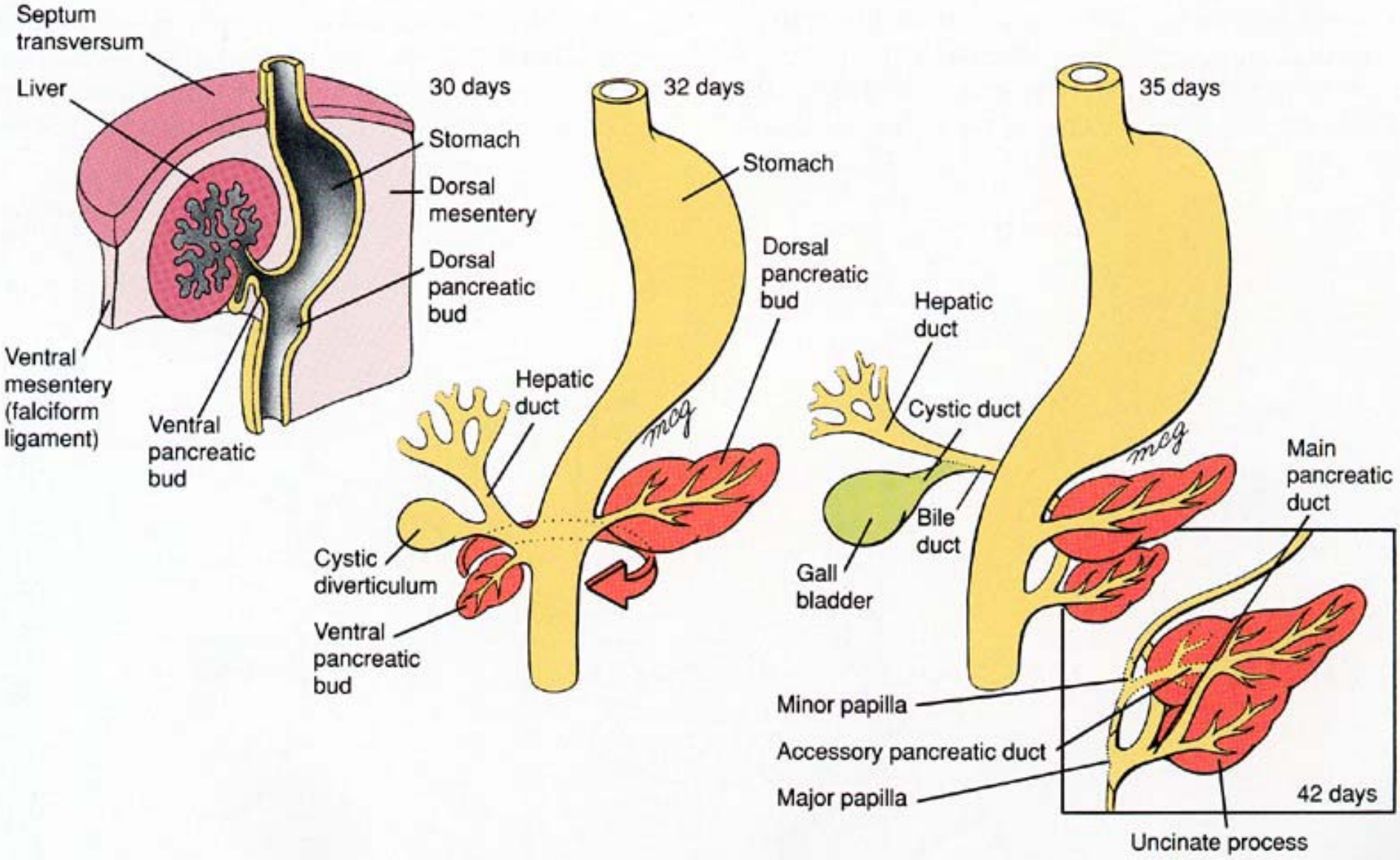
Pancreas forms from two distinct outgrowths from the duodenum

Dorsal pancreatic bud grows into the dorsal mesentery

Ventral pancreatic bud sprouts from the hepatic diverticulum into the ventral mesentery caudal to the forming gallblader

The main duct of the ventral pancreas bud merges at the proximal end of the common bile duct

The mouth of the common bile duct is displaced to the dorsal mesentery


Septum transversum
Liver
30 days
Stomach
Dorsal mesentery
Dorsal pancreatic bud
Ventral mesentery (falciform ligament)
Ventral pancreatic bud
32 days
Stomach
Dorsal pancreatic bud
Hepatic duct
Cystic diverticulum
Ventral pancreatic bud
35 days
Hepatic duct
Cystic duct
Bile duct
Gall bladder
Main pancreatic duct
Minor papilla
Accessory pancreatic duct
Major papilla
42 days
Uncinate process

Pancreas

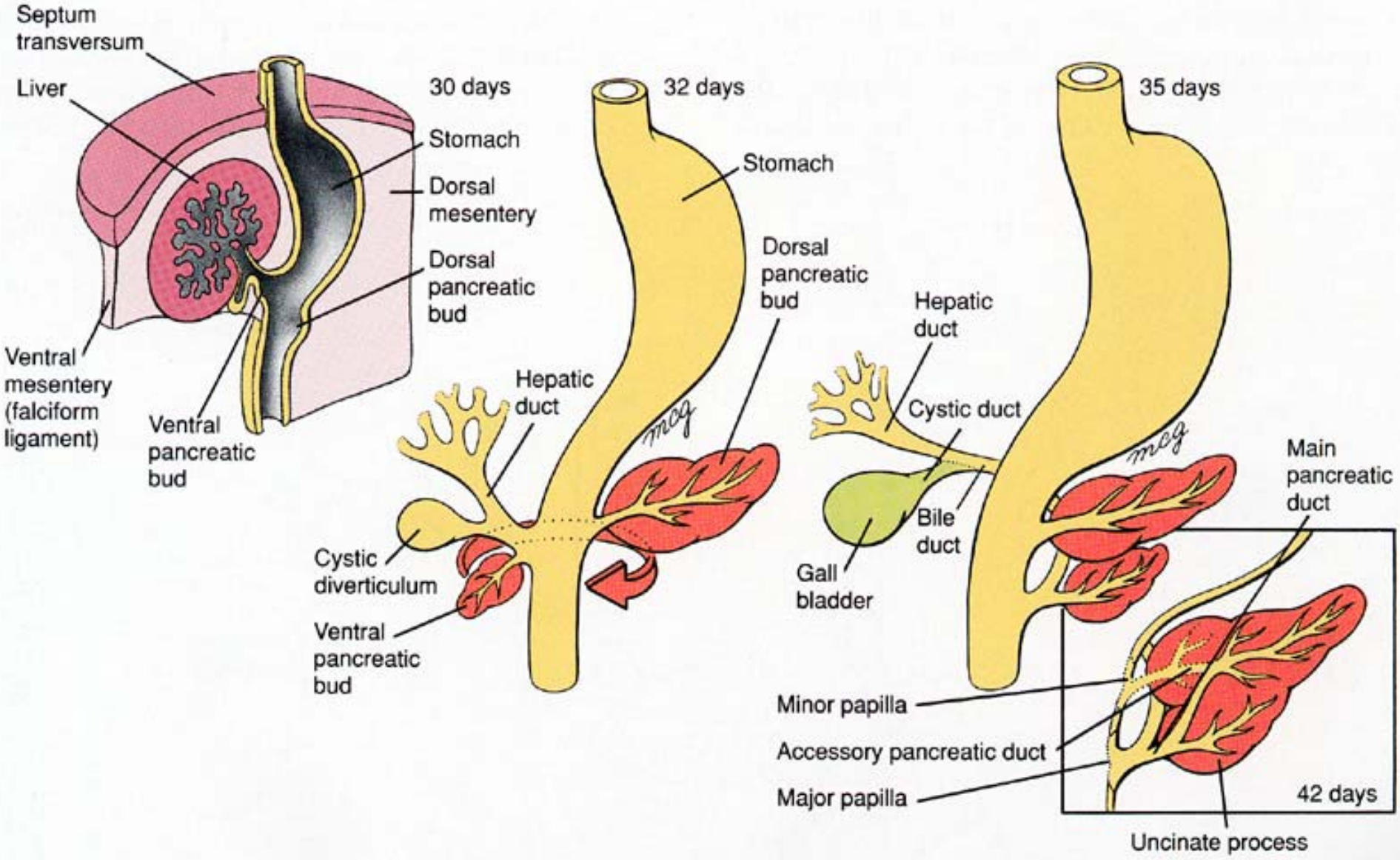
The dorsal and ventral pancreatic rudiments fuse

The dorsal duct degenerates and the dorsal and ventral parts merge their duct systems. The ventral duct becomes the main pancreatic duct (Duct of Wirsung)

Where the common bile duct and pancreatic ducts empty into the duodenum is called the Ampulla of Vater

Exocrine function - acinar cells - production of digestive enzymes

Endocrine function - islets of langerhans - production of insulin and glucogon (β cells and α cells)


Septum transversum
Liver
30 days
Stomach
Dorsal mesentery
Dorsal pancreatic bud
Ventral mesentery (falciform ligament)
Ventral pancreatic bud
32 days
Stomach
Dorsal pancreatic bud
Hepatic duct
Cystic diverticulum
Ventral pancreatic bud
35 days
Hepatic duct
Cystic duct
Bile duct
Gall bladder
Main pancreatic duct
Minor papilla
Accessory pancreatic duct
Major papilla
42 days
Uncinate process

Spleen

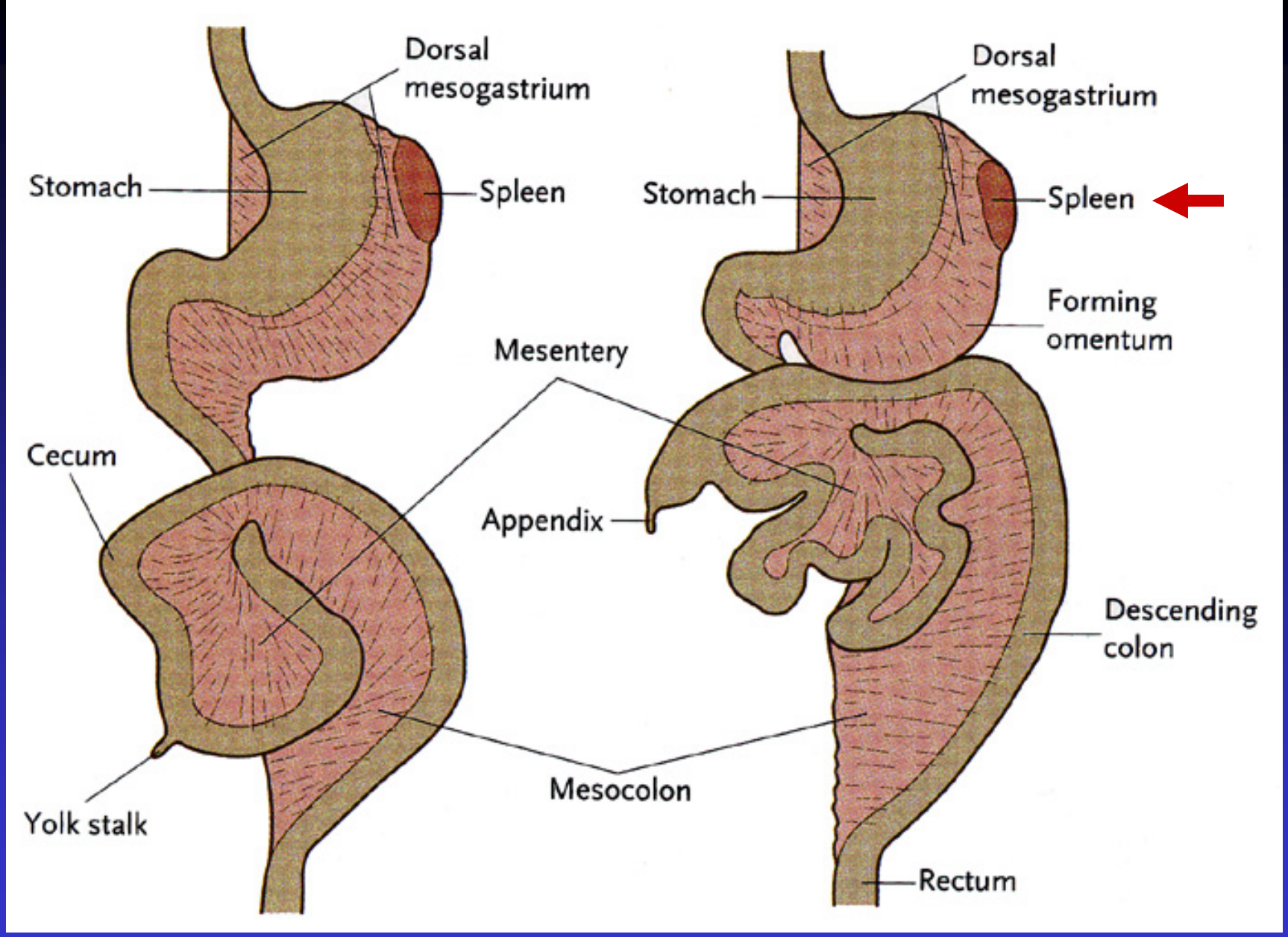
The Spleen is an intra-abdominal organ that is not an endodermal derivitive

The Spleen is mesodermal and develops in the dorsal mesogastrium

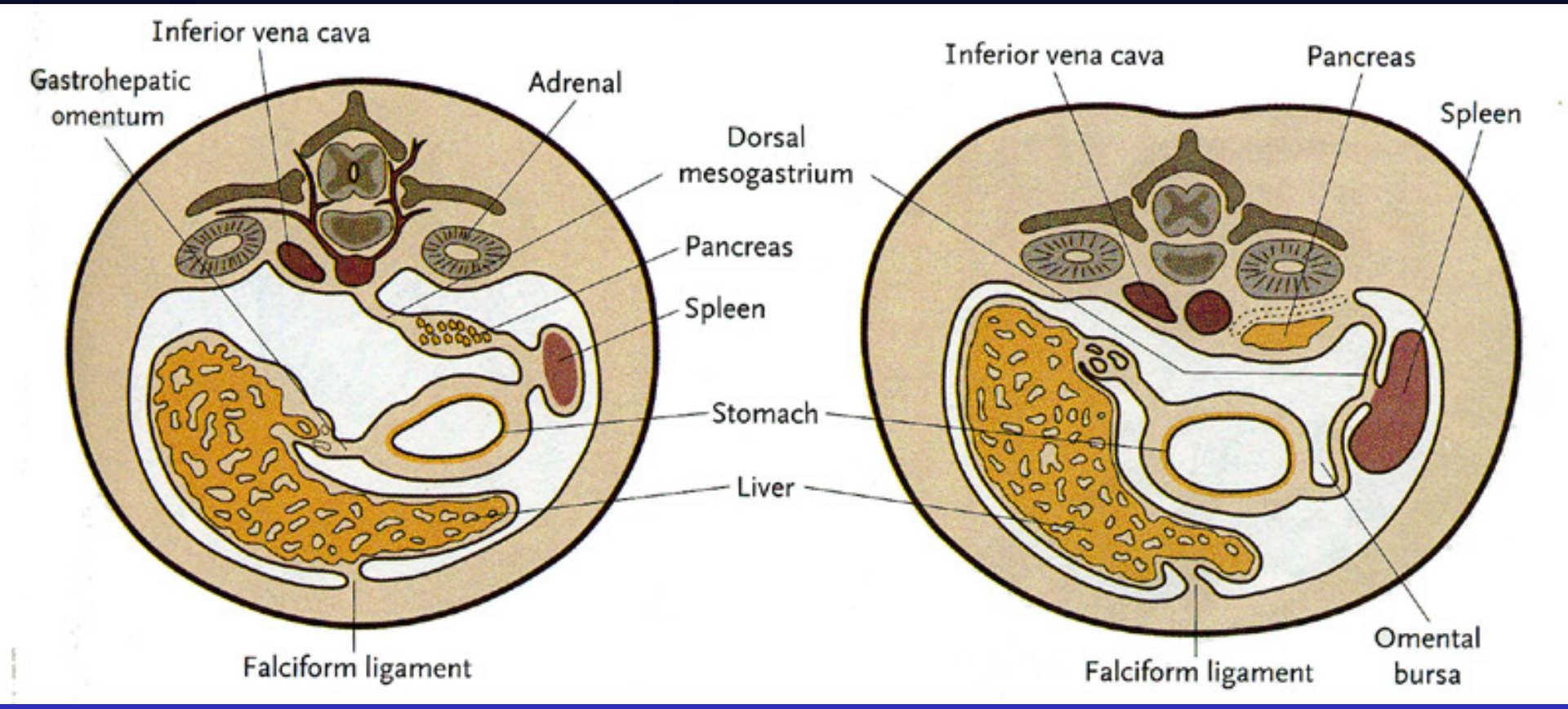
The Spleen is a vascular lymphatic organ

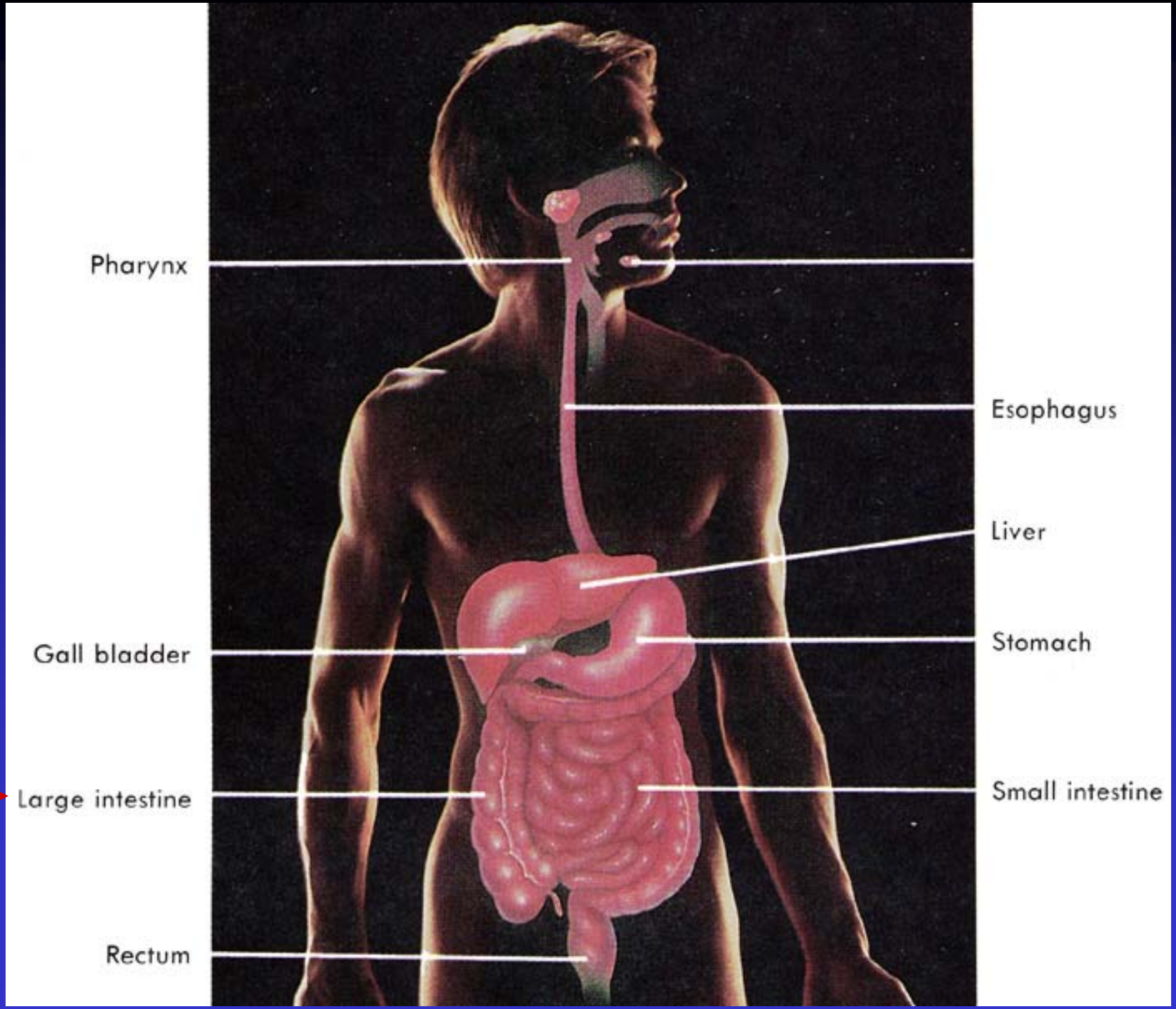
The Speen moves to the left side of the abdominal cavity with the rotation of the stomach.

Initially a hematopoietic organ, later gets colonized by T-lymphocyte precursor cells



Dorsal mesogastrium becomes the greater omentum


Inferior vena cava
Gastrohepatic omentum
Adrenal
Dorsal mesogastrium
Pancreas
Spleen
Stomach
Liver
Falciform ligament
Inferior vena cava
Pancreas
Spleen
Omental bursa
Falciform ligament


Pharynx
Esophagus
Liver
Gall bladder
Stomach
Large intestine
Small intestine
Rectum

Formation of the Intestine

Midgut derivatives:

- Caudal half of duodenum
- Jejunum
- Ileum
- Cecum
- Appendix
- Ascending colon
- Right 2/3 of transverse colon

Hindgut derivatives:

- Left 1/3 of transverse colon
- Descending colon
- Sigmoid colon
- Rectum
- Cloacal membrane at caudal end

Primary Intestinal Loop

The intestine is essentially a long straight tube, but it's development is complicated by its length.

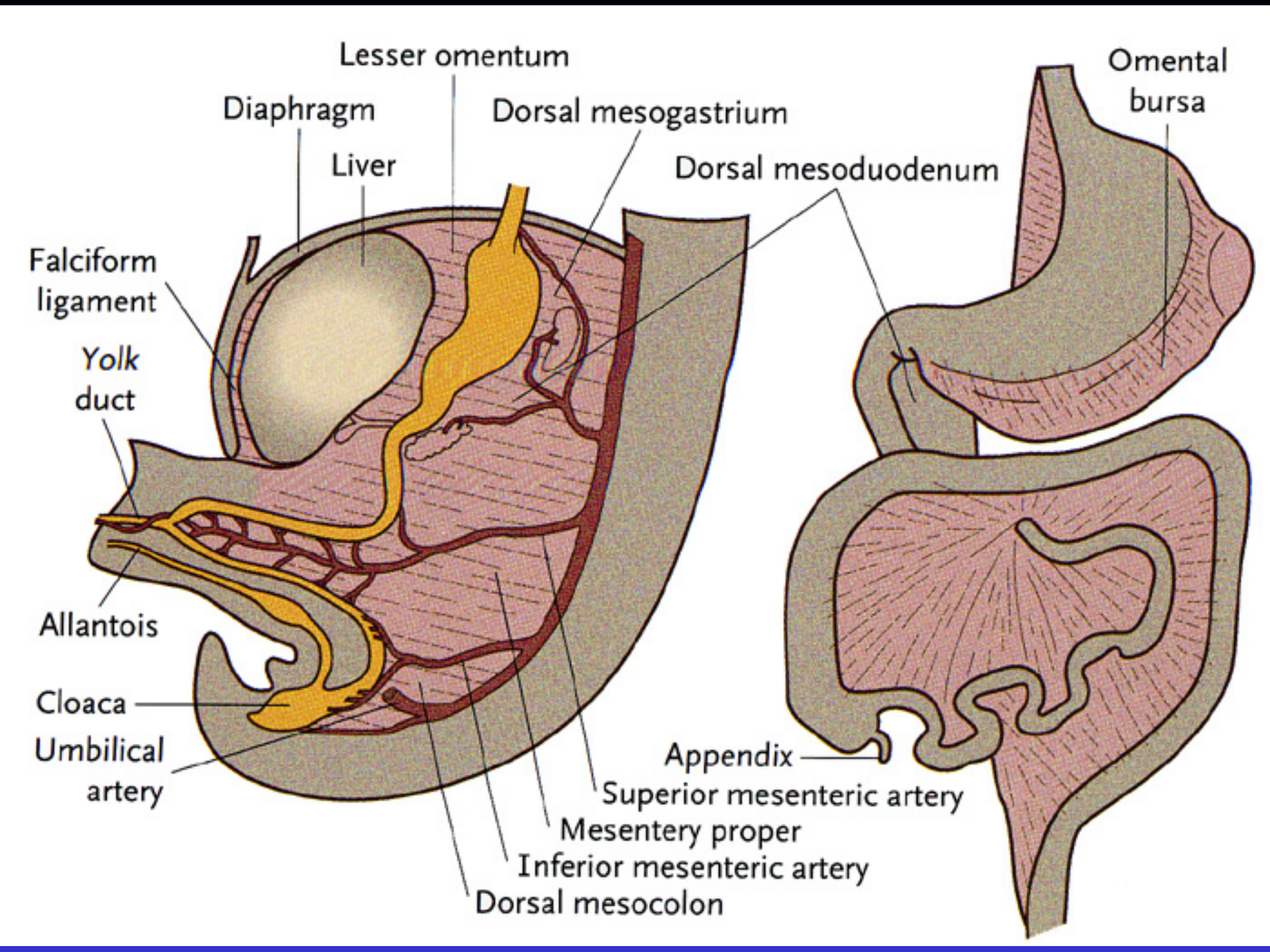
Two important points of reference:

Yolk Stalk – near border of small and large intestine

Superior Mesenteric Artery – branch of Dorsal Aorta

Ileum – elongates too rapidly for the size of the abdominal cavity causing a herniation into the umbilicus

Dorsal-ventral hairpin - called the primary intestinal loop.


Lesser omentum
Diaphragm
Dorsal mesogastrium
Liver
Dorsal mesoduodenum
Omental bursa
Falciform ligament
Yolk duct
Allantois
Cloaca
Umbilical artery
Appendix
Superior mesenteric artery
Mesentery proper
Inferior mesenteric artery
Dorsal mesocolon

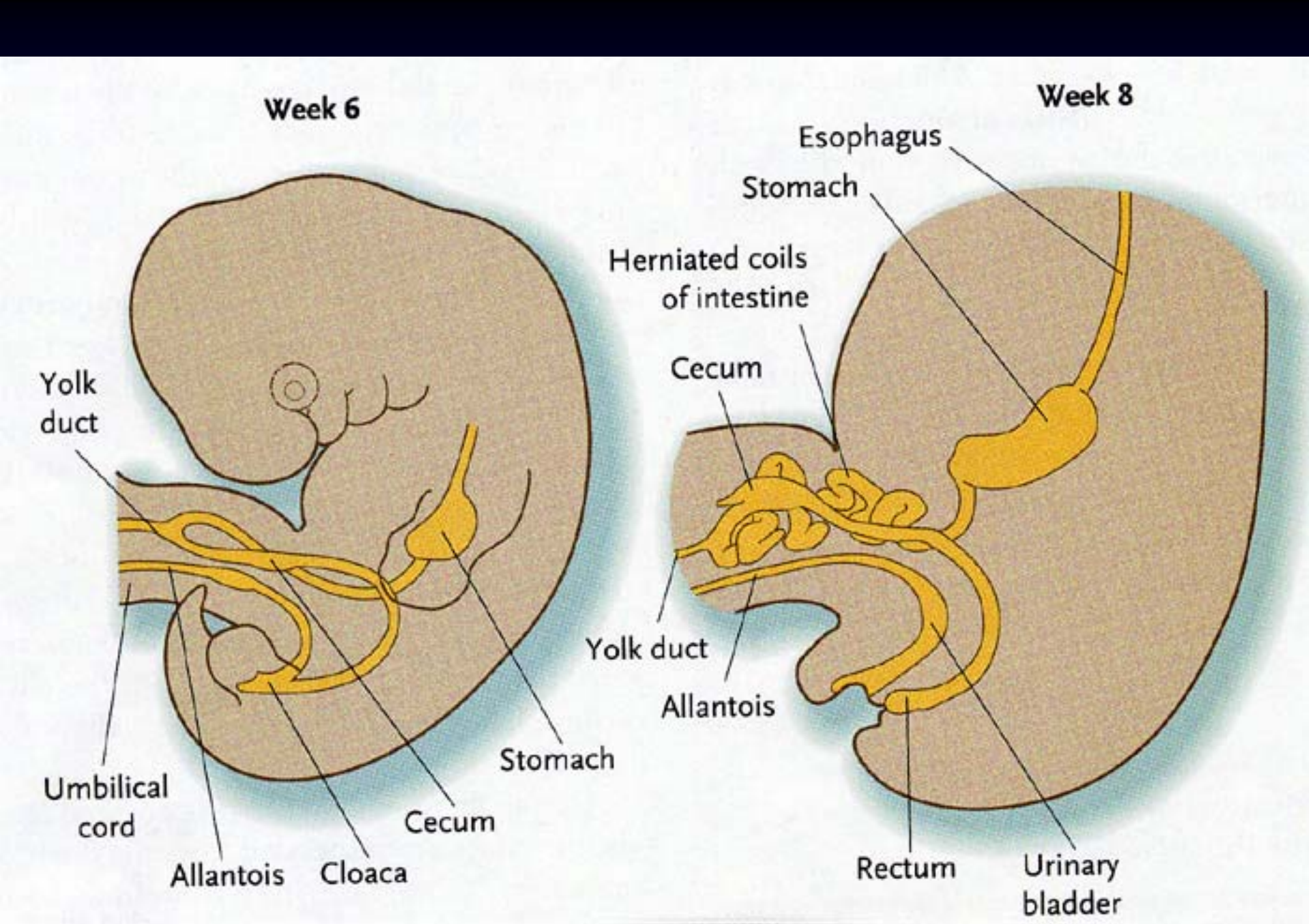
Intestine Development

Cranial part of loop gives rise to most of the ileum

Caudal loop becomes part of ileum, the ascending colon and 2/3 of the transverse colon

Initially - the loop does a 90^{o} counterclockwise rotation (viewed from the front) - cranial loop → right, caudal loop → left

Jejunum and Ileum lengthens resulting in a series of folds called the jejunal-ileal loops


Week 6
Week 8
Esophagus
Stomach
Herniated coils of intestine
Cecum
Yolk duct
Yolk duct
Allantois
Umbilical cord
Allantois
Cloaca
Cecum
Stomach
Rectum
Urinary bladder

Retraction

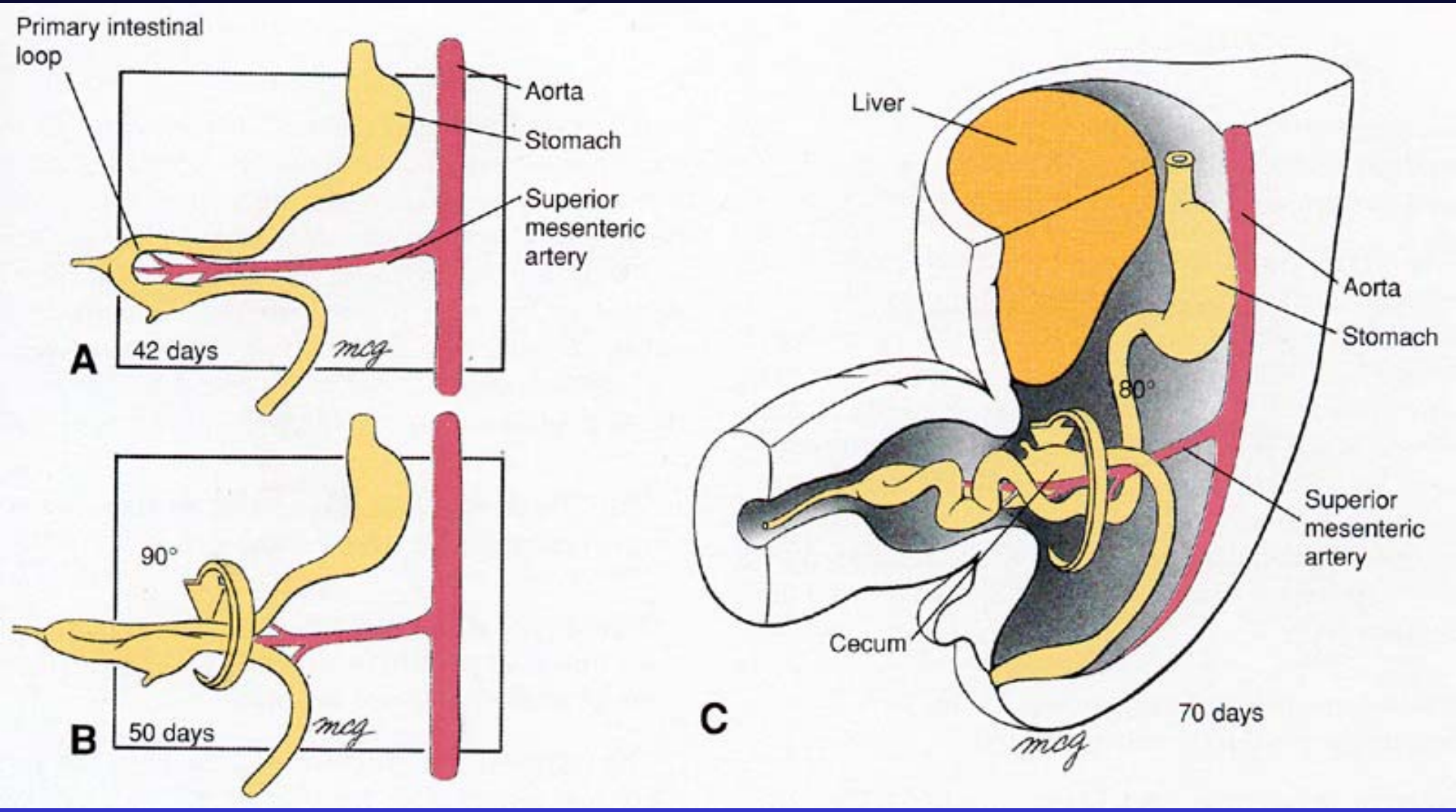
Cecum defines junction between small and large intestines – producing the appendix

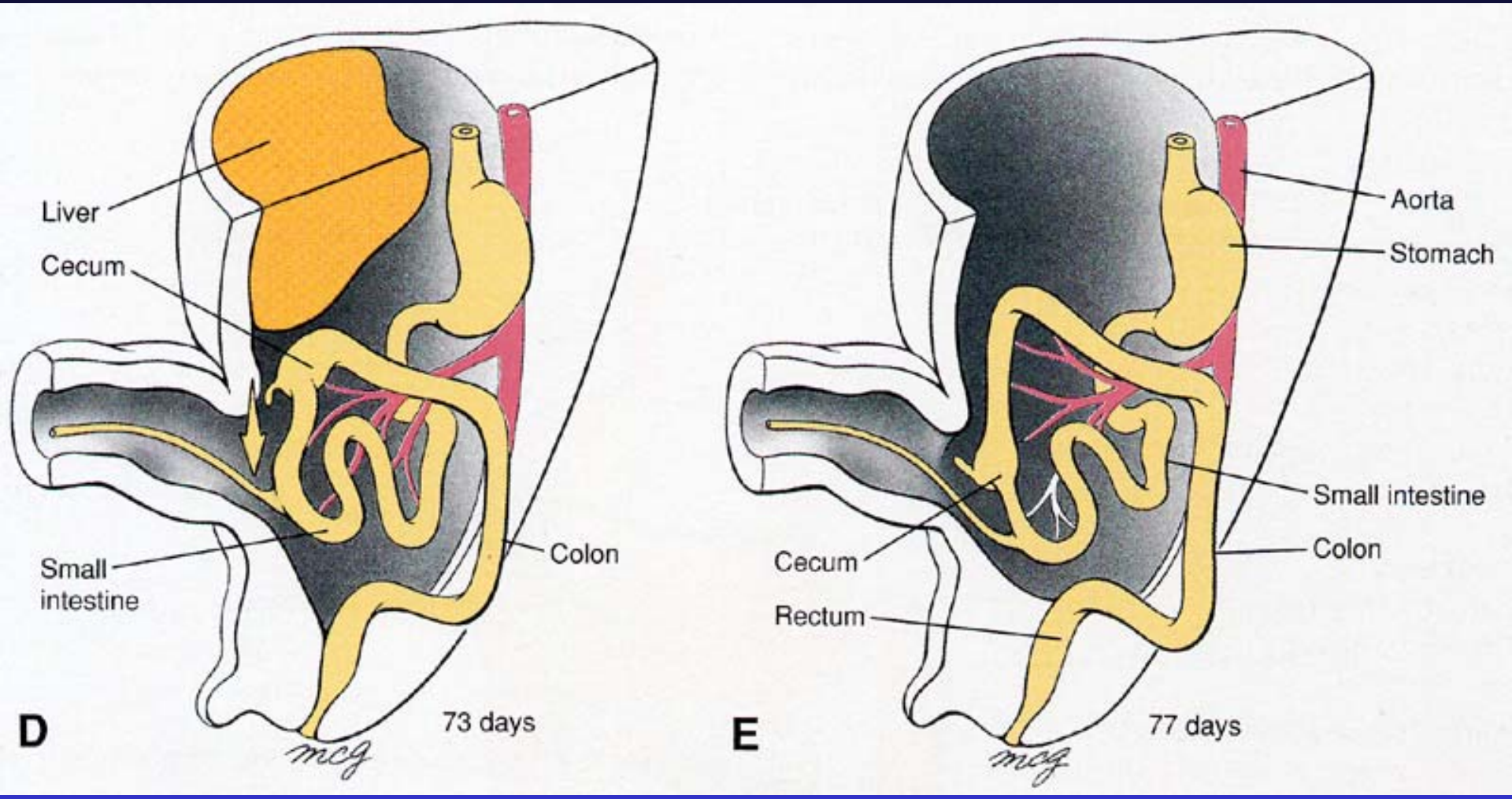
Retraction of the loop into the abdomen

Associated with a 180^{o} rotation - total rotation is

270^{o}Cecum lies just inferior to the liver

The cecum moves in a cranial to caudal direction to lie in the lower left abdomen


Primary intestinal loop
Aorta
Stomach
Superior mesenteric artery
A
42 days
mcg
90°
B
50 days
mcg
Liver
Aorta
Stomach
80°
Superior mesenteric artery
Cecum
C
70 days
mcg

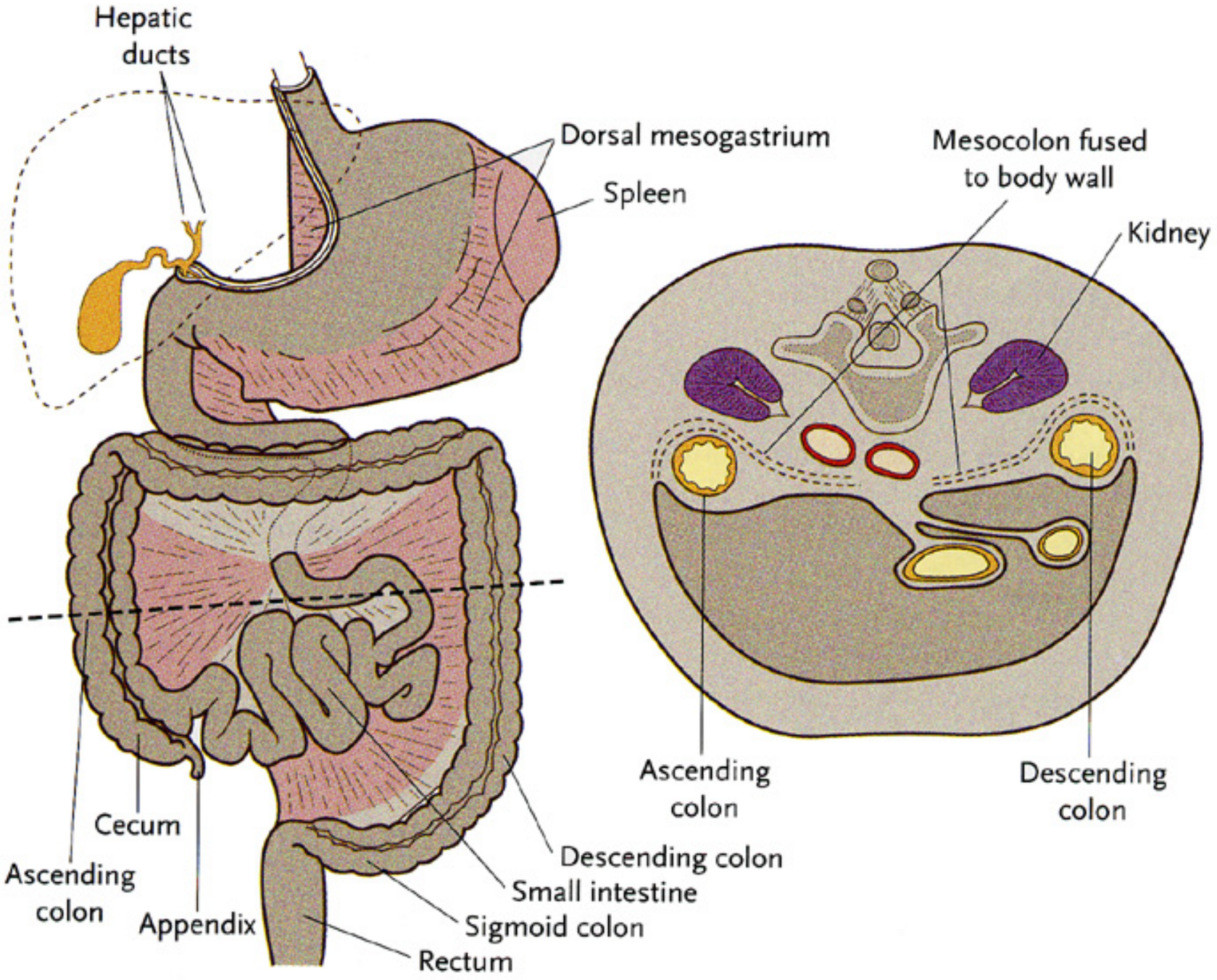

Liver
Cecum
Small intestine
Colon
D
73 days
mcg
Aorta
Stomach
Small intestine
Colon
Cecum
Rectum
E
77 days
mcg

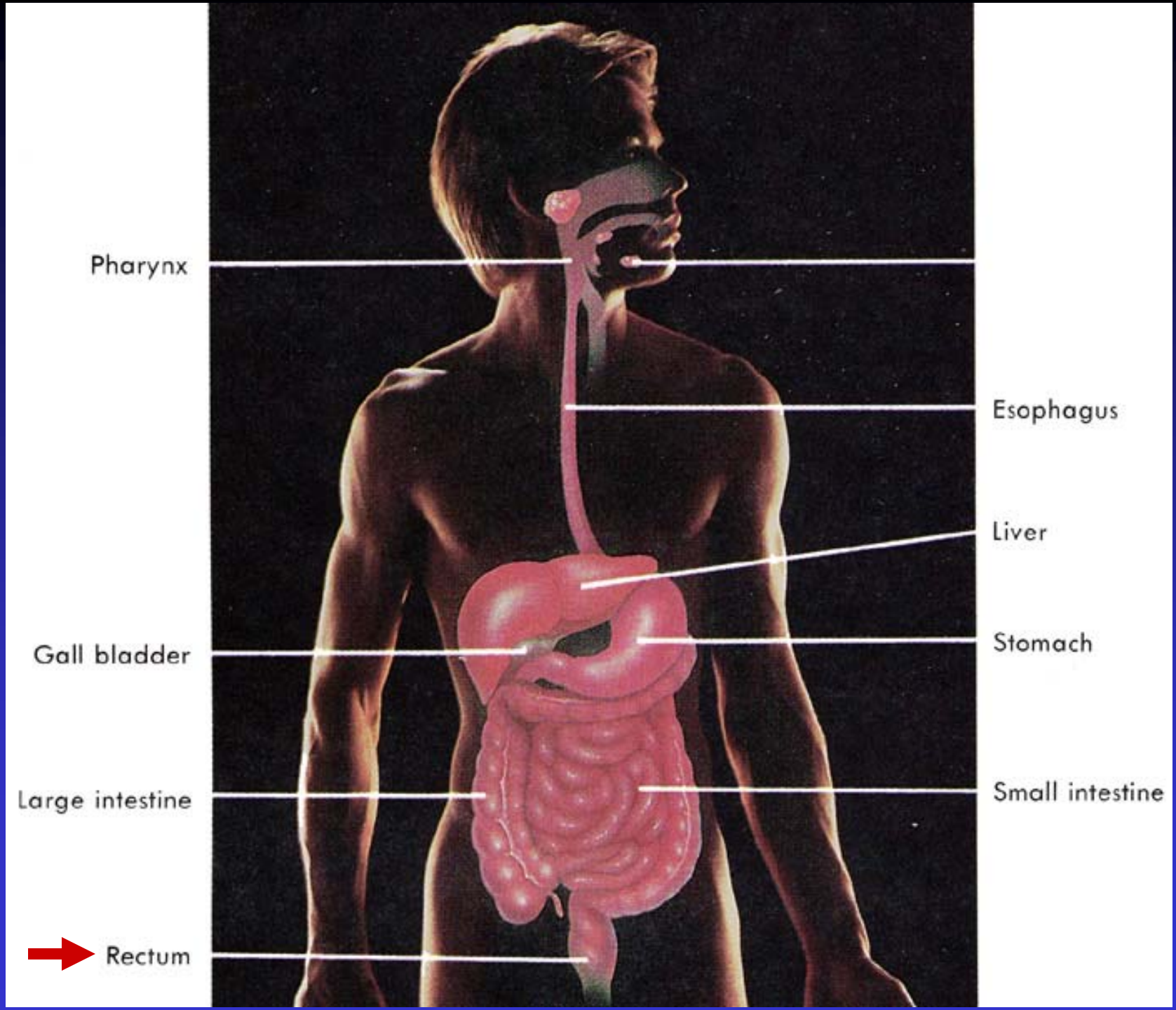
Ascending and Descending Colon

Dorsal mesentery associated with the ascending and descending colon shortens and disappears

These regions adhere directly to the dorsal body wall

Transverse colon does not become fixed


Hepatic ducts
Dorsal mesogastrium
Spleen
Mesocolon fused to body wall
Kidney
Ascending colon
Descending colon
Cecum
Ascending colon
Appendix
Descending colon
Small intestine
Sigmoid colon
Rectum


Pharynx
Esophagus
Liver
Gall bladder
Stomach
Large intestine
Small intestine
Rectum

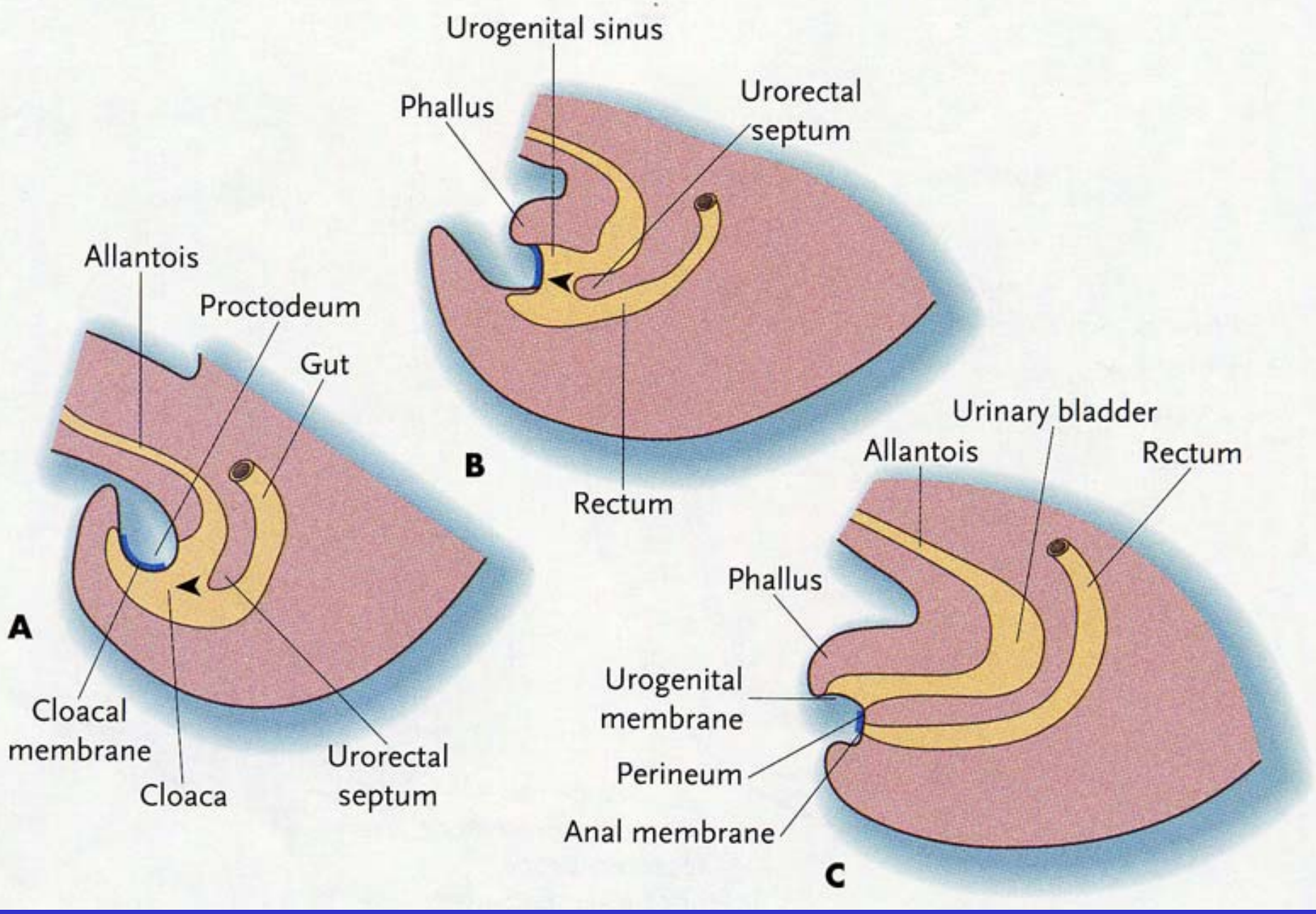
Cloaca

Cloaca (latin = sewer) - where allantois and gastrointestinal tract merge

Cloaca is partitioned into the rectum (posterior) and the primitive urogenital sinus (anterior) - by the growth of the urorectal septum

Urorectal septum is the composite of two septal system - Tourneux fold (central) and Rathke folds (lateral)

Urorectal septum fuses with cloacal membrane - forming the urogenital membrane and the anal membrane


Urogenital sinus
Phallus
Urorectal septum
Allantois
Proctodeum
Gut
B
Rectum
Urinary bladder
Allantois
Rectum
Phallus
A
Urogenital membrane
Perineum
Anal membrane
Cloacal membrane
Cloaca
Urorectal septum
C

Anorectal Canal

Anorectal canal - between rectum and anus

Superior 2/3 is endodermal from hindgut

Inferior 1/3 is derived from the proctodeum - ectodermal

The Ectodermal-Endodermal boundary in adult is marked by an irregular folding of mucosa in the anorectal canal called the Pectinate line

Canalization and Histogenesis

The developing digestive tract lumen becomes occluded and secondary lumina form and coalesce during recanalization

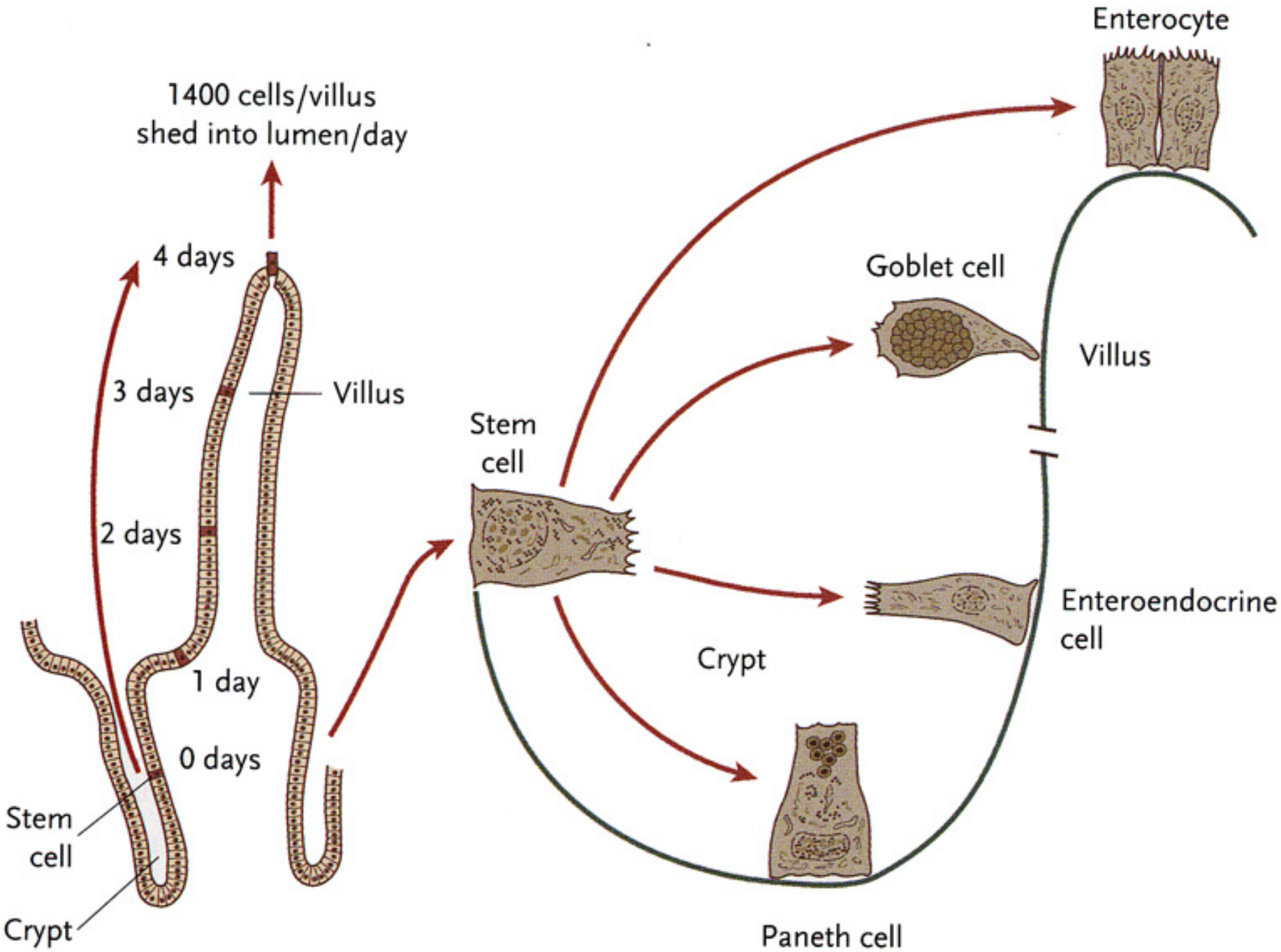
Stomach – Gastric mucosa – folds called rugae, pits called gastric pits, HCl secretion begins postnatal

Intestine - Intestinal Villi form by mesodermal growth during recanalization

Intestinal Crypts form at the base of the intestinal villi

Each crypts contains a clone of Epithelial Stem Cells that produce intestinal cells throughout adult life

Intestinal epithelial cells have a 4 day life span


1400 cells/villus
shed into lumen/day
4 days
3 days
Villus
2 days
1 day
0 days
Stem
cell
Crypt
Stem
cell
Enterocyte
Goblet cell
Villus
Enteroendocrine
cell
Crypt
Paneth cell

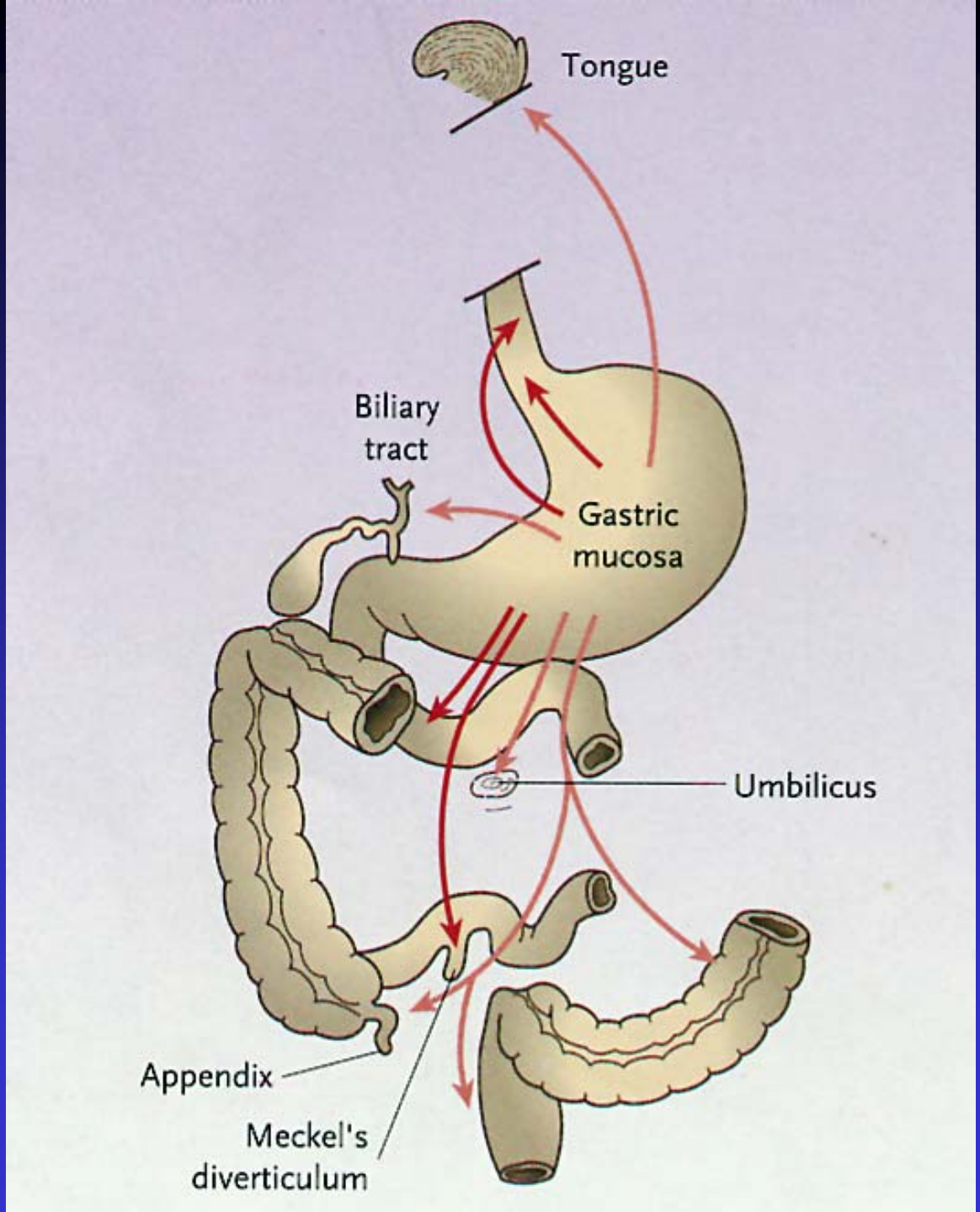
Anomalies - Foregut

Esophagus:

- Esophageal stenosis (narrowing) – abnormal recanalization – impaired swallowing
- Esophageal atresia (abnormal opening) – abnormal branching of the respiratory tract – impaired swallowing

Stomach:

- Pyloric stenosis – hypertrophy of smooth muscle, projectile vomiting
- Heterotopic gastric mucosa – Misplaced gastric mucosa cells


Tongue
Biliary tract
Gastric mucosa
Umbilicus
Appendix
Meckel's diverticulum

Anomalies - Foregut

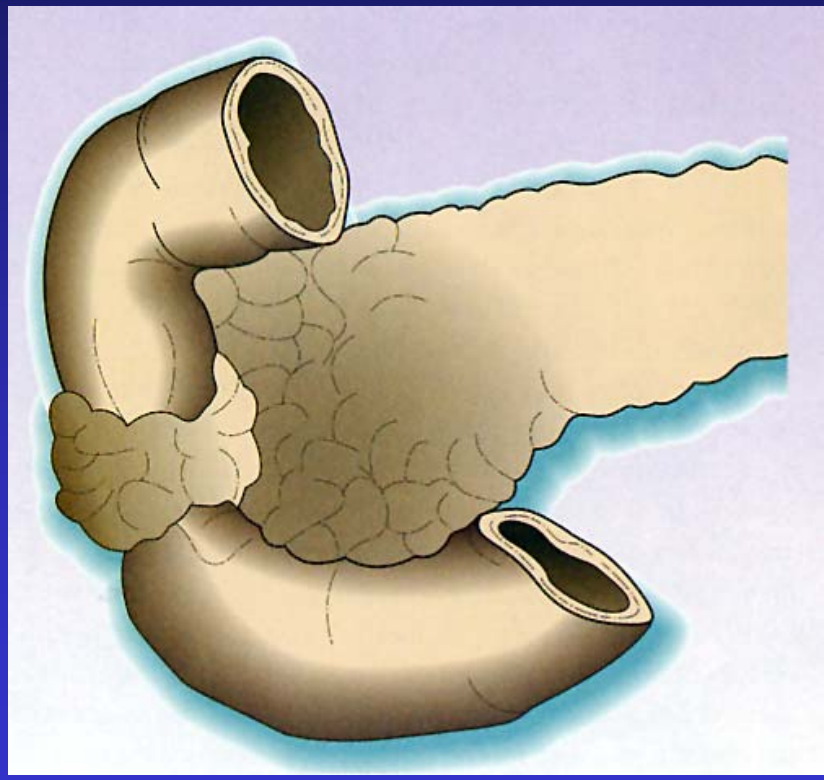
Liver:

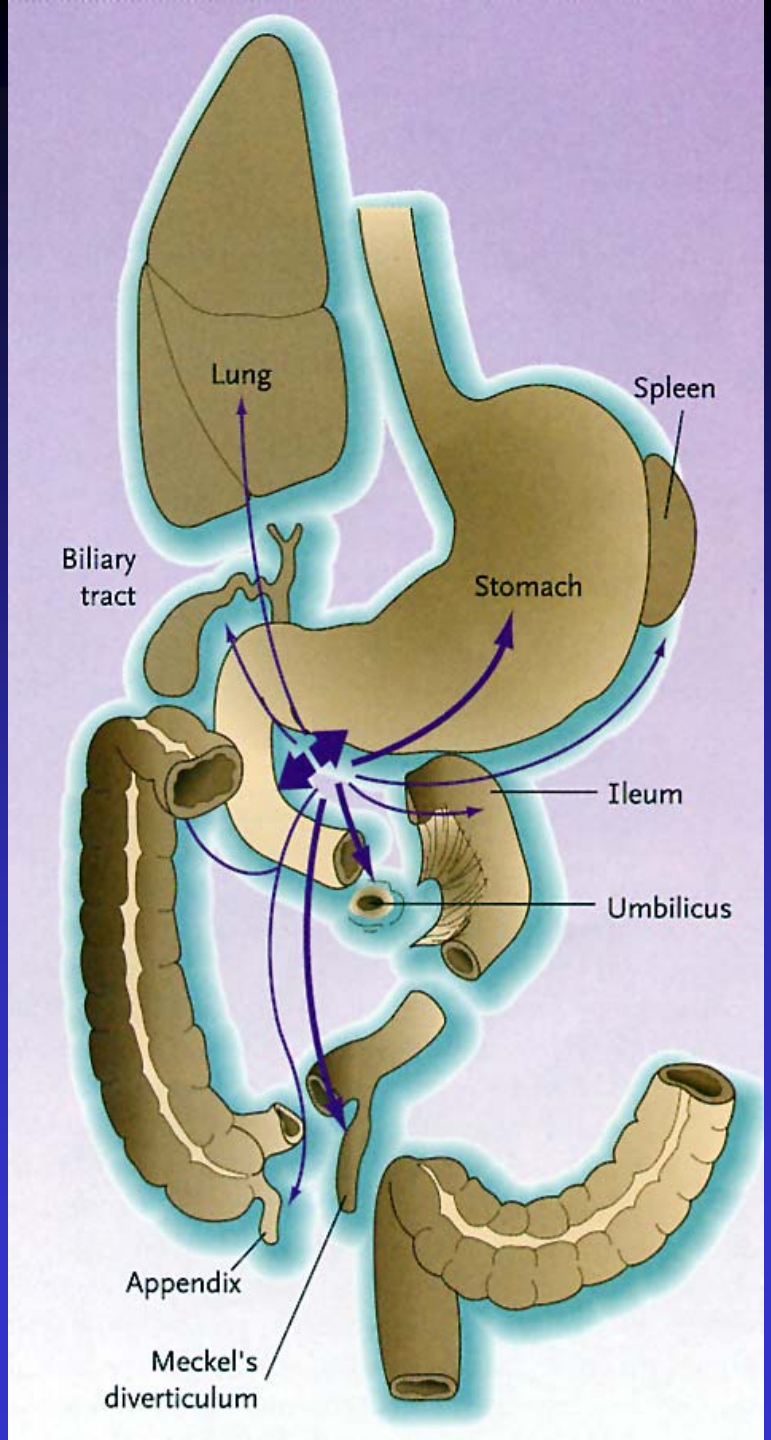
- Biliary atresia – abnormal hepatic duct formation – varying severity postnatal jaundice

Pancreas:

- Annular pancreas – Pancreatic tissue encircling the duodenum sometimes causing obstruction

- Heterotopic pancreatic tissue
  Misplaced pancreatic cells



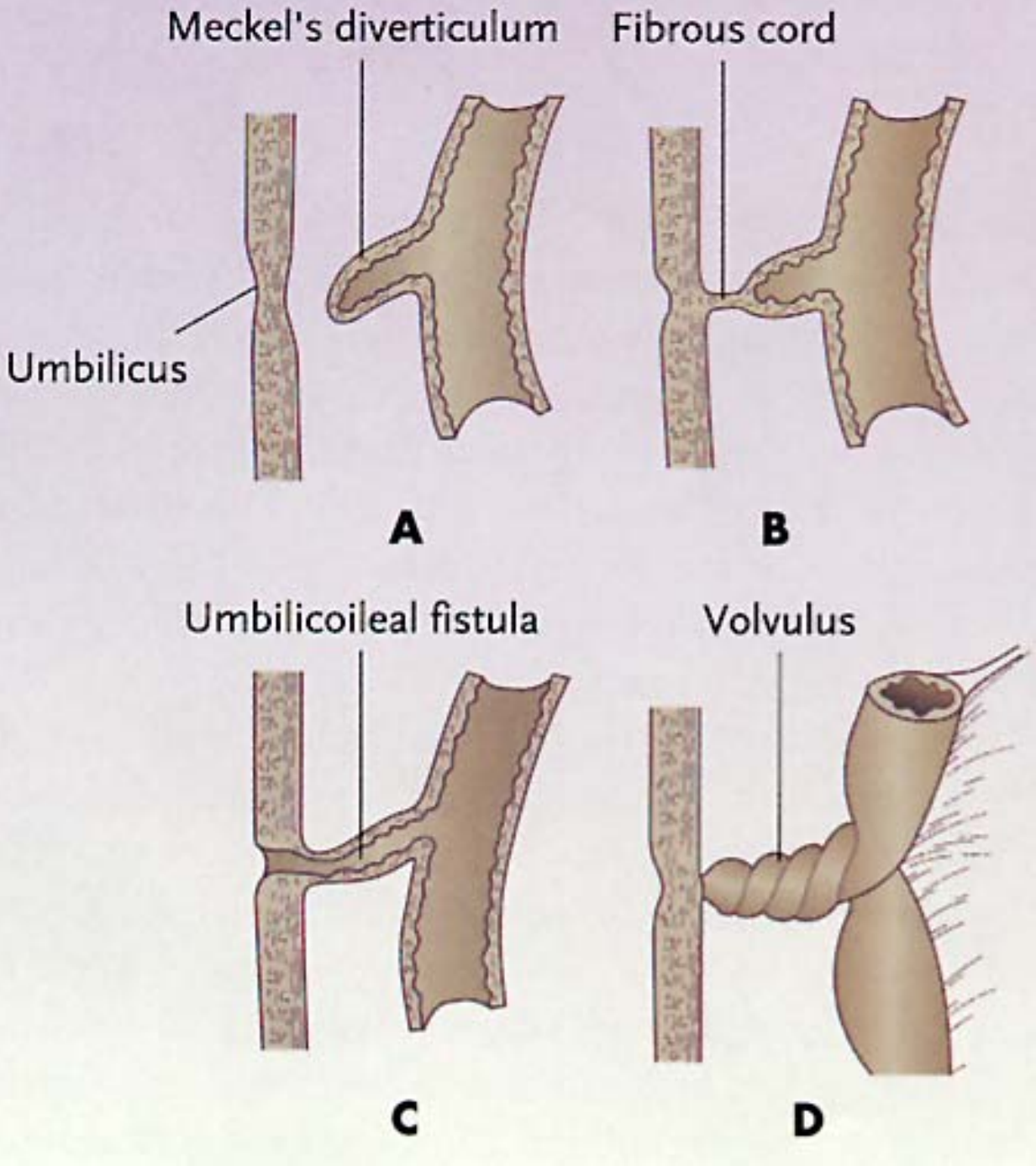

Lung
Spleen
Biliary tract
Stomach
Ileum
Umbilicus
Appendix
Meckel's diverticulum

Anomalies - Midgut

Duodenal stenosis and atresia – abnormal recanalization

Persistent vitelline duct –

- Meckel's diverticulum - (2-4% of population) – blind pouch
- Fibrous cord – connection to umbilicus
- Volvulus – intestinal rotation → bowel strangulation
- Umbilicoil fistula – direct opening

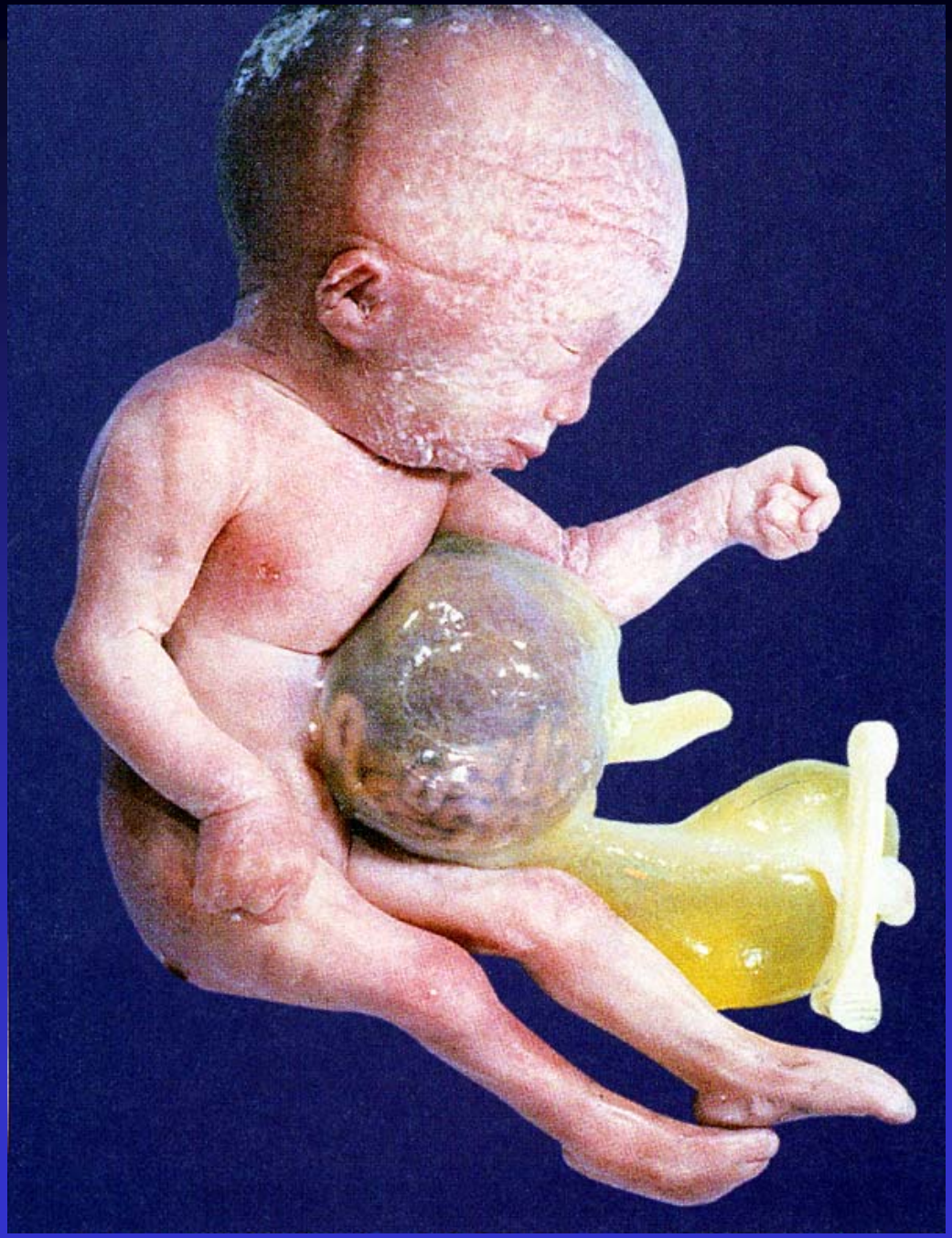

Meckel's diverticulum
Fibrous cord
Umbilicus
A
B
Umbilicoileal fistula
Volvulus
C
D

Anomalies – Midgut
Omphalocele

Failure of the umbilicus to close - newborn with organs protruding from the abdominal walll

Organs protruding into a thin sac of amniotic tissue from normal herniation - incomplete retraction

Organs in a sac of peritoneum and amniotic tissue - indicates normal herniation and retraction, but a secondary herniation resulting from the failure of the ventral abdominal wall to close



Anomalies - Midgut
Abnormal Rotation and Fixation

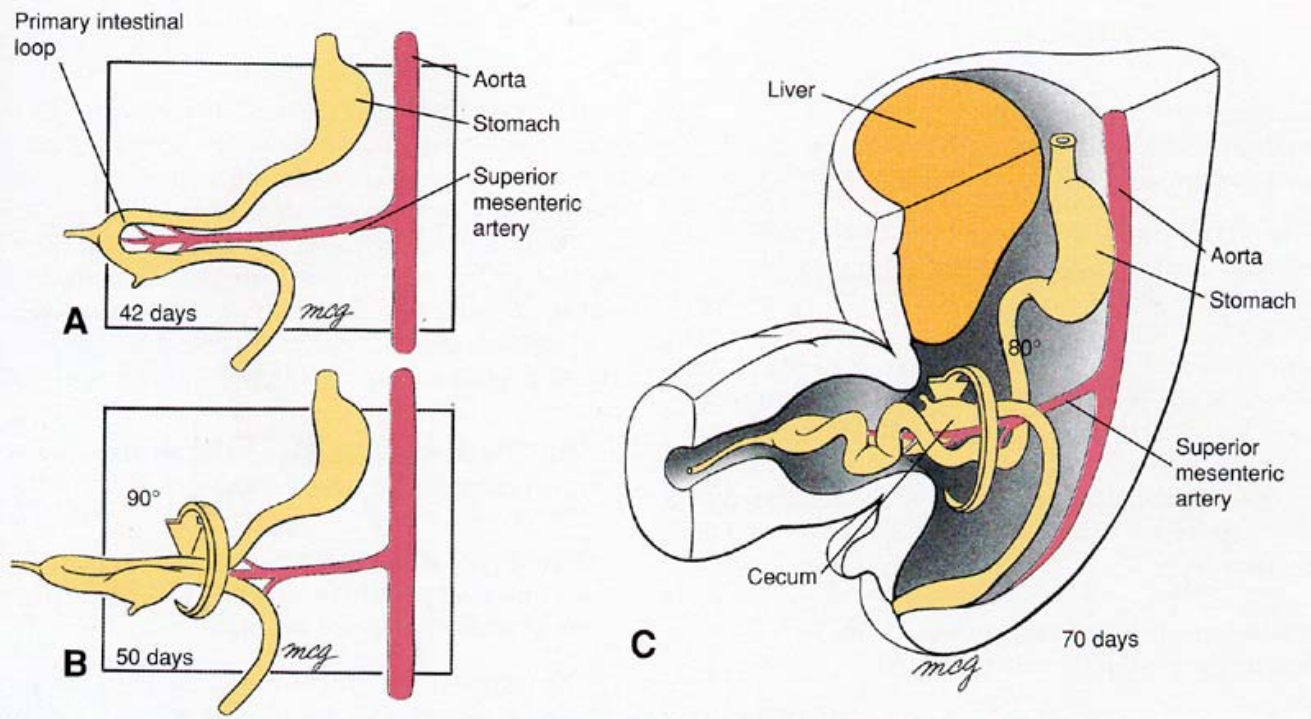
Spectrum of abnormalities

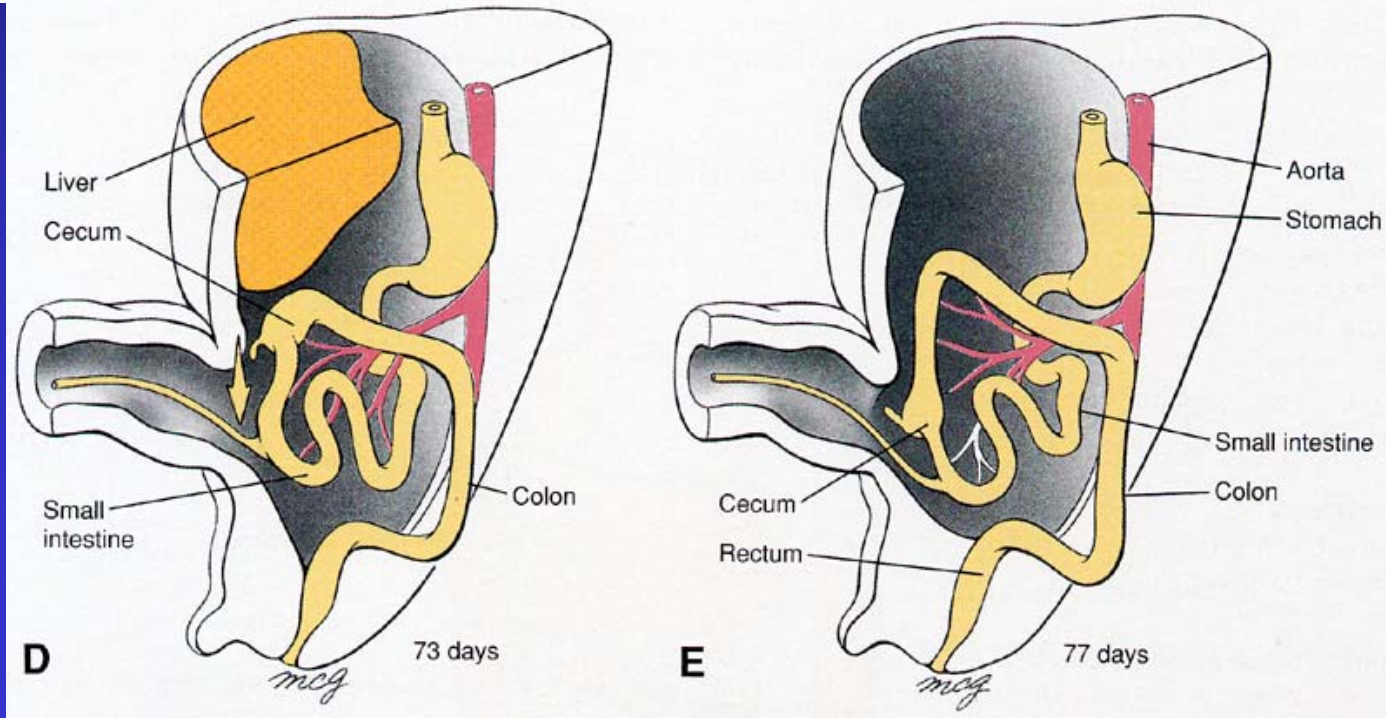
Non-rotation

Reverse rotation

Mixed rotation

Subhepatic cecum


Primary intestinal loop
Aorta
Stomach
Superior mesenteric artery
A
42 days
mcg
90°
B
50 days
mcg
Liver
Aorta
Stomach
80°
Superior mesenteric artery
Cecum
C
70 days
mcg


Liver
Cecum
Small intestine
Colon
D
73 days
mcg
Aorta
Stomach
Small intestine
Cecum
Colon
Rectum
E
77 days
mcg

Non-Rotation

Called left-sided colon

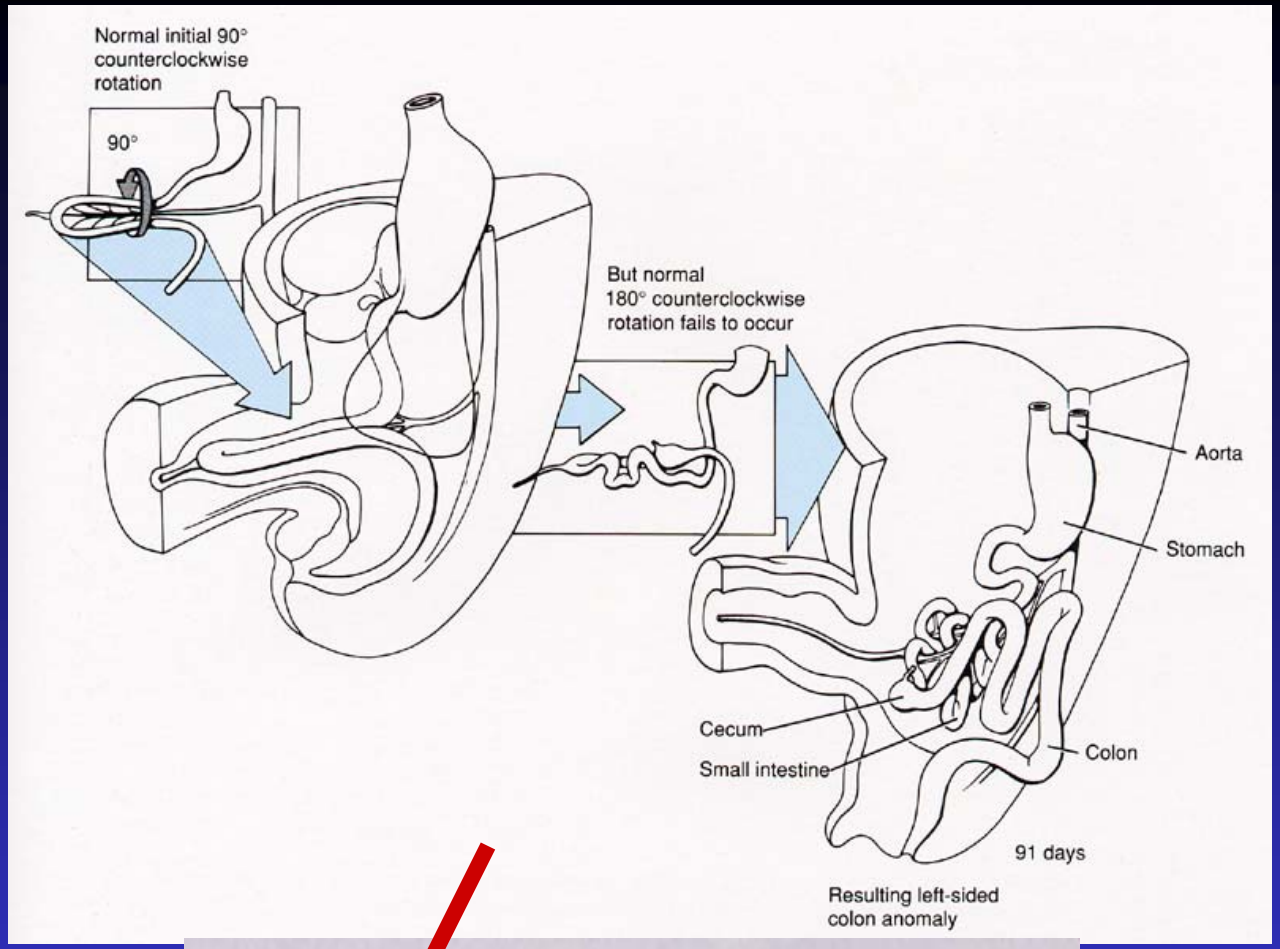
1st rotation is Normal

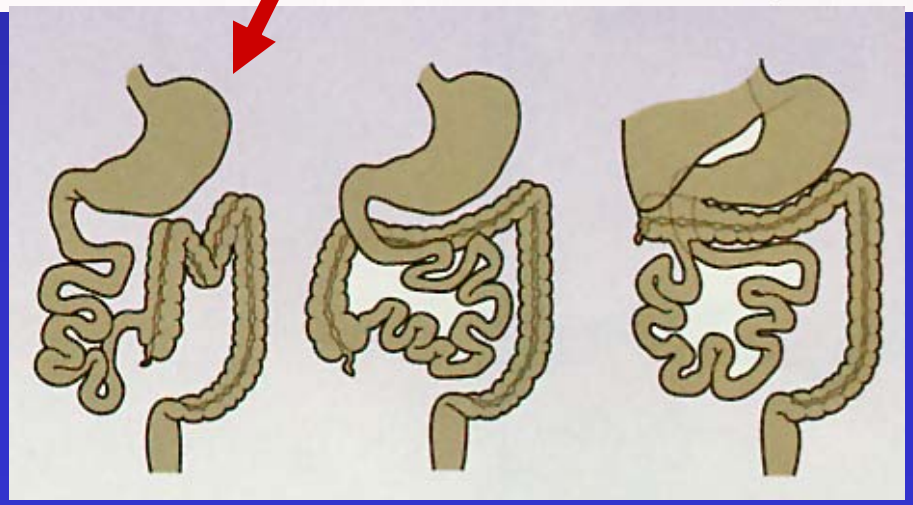
2nd rotation is Absent

Cranial loop ends up on the right side

Caudal loop on the left side

Some organs may or may not get fixed to the body wall


Normal initial 90° counterclockwise rotation
90°
But normal 180° counterclockwise rotation fails to occur
Aorta
Stomach
Cecum
Small intestine
Colon
91 days
Resulting left-sided colon anomaly



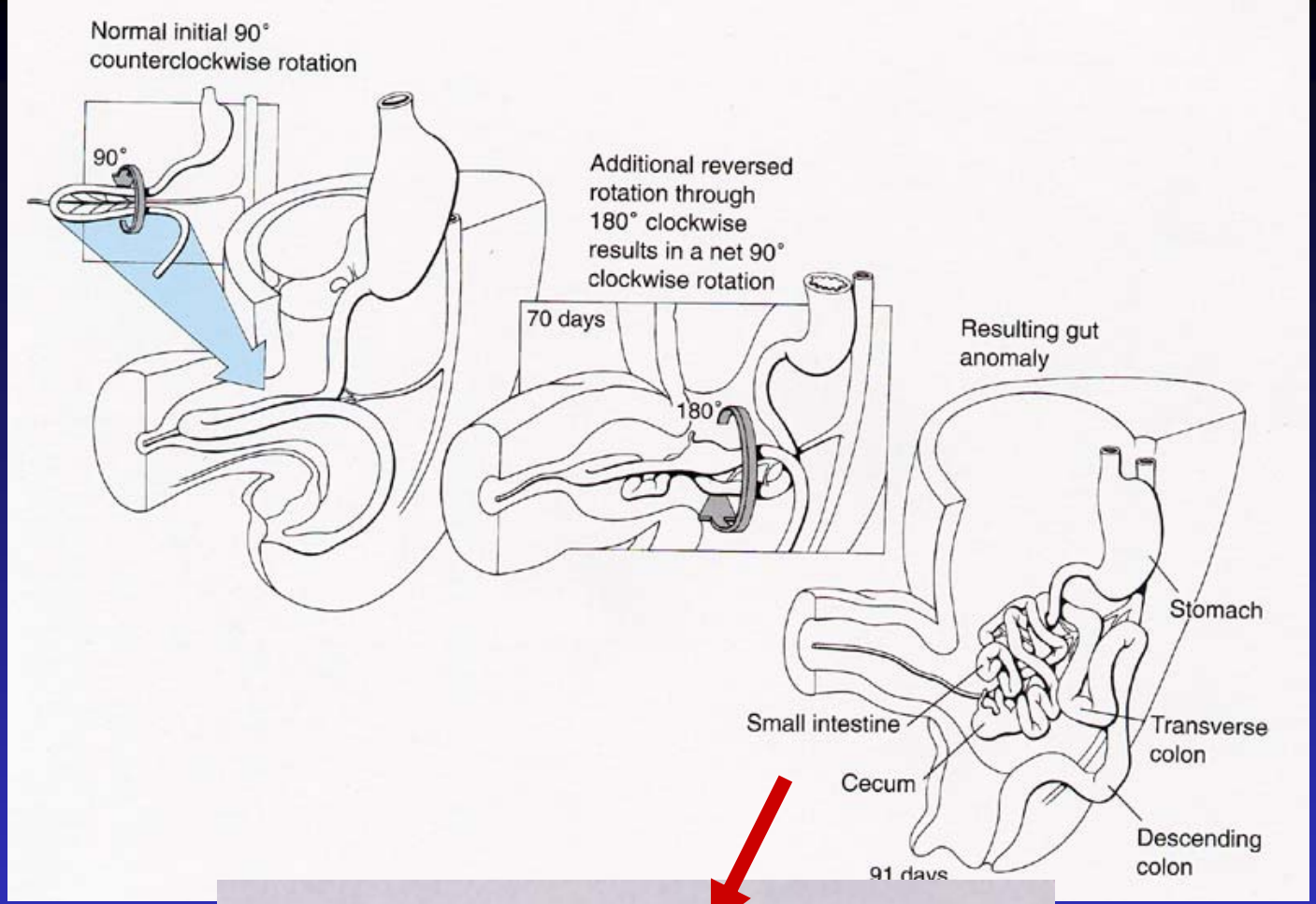
Reverse Rotation

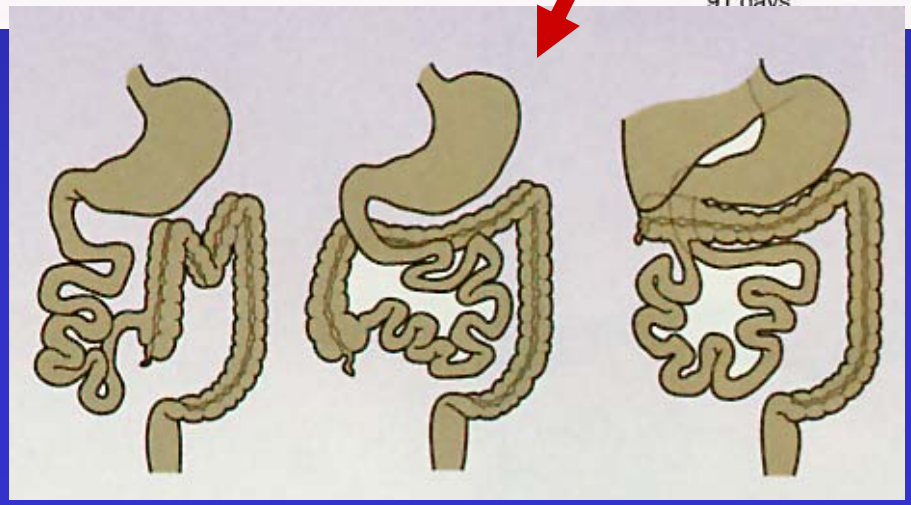
Normal 1st rotation

2nd rotation is clockwise instead of counter clockwise

Net rotation is 90° clockwise

This is equivalent to a 270° counter clockwise rotation except the duodenum is ventral to the transverse colon and does not get fixed to dorsal wall, transverse colon does get fixed


Normal initial 90° counterclockwise rotation
90°
Additional reversed rotation through 180° clockwise results in a net 90° clockwise rotation
70 days
180°
Resulting gut anomaly
Stomach
Small intestine
Transverse colon
Cecum
Descending colon
91 days



Mixed Rotation

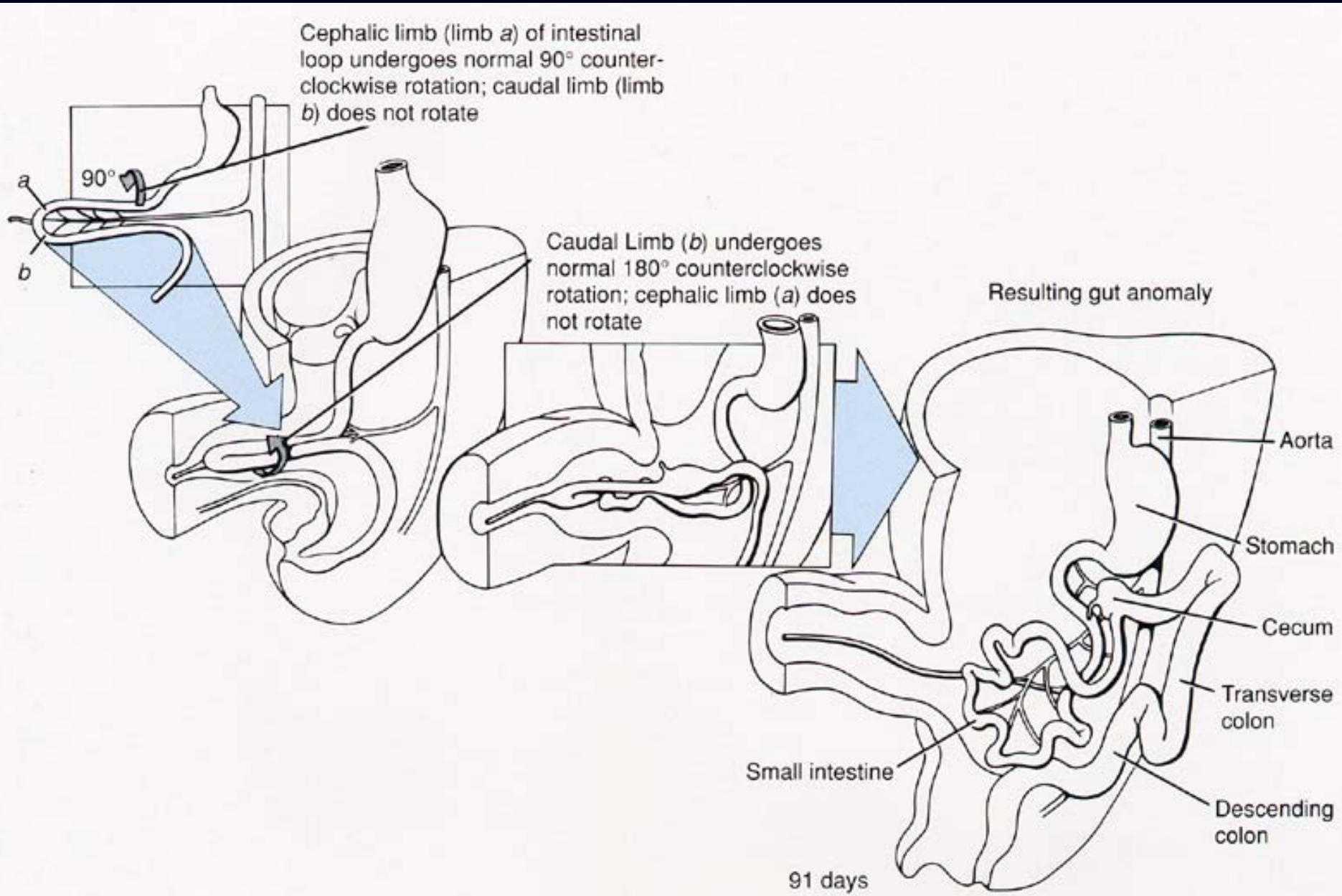
Cranial and caudal loops behave independently

Cranial loop rotates only the 1st 90o

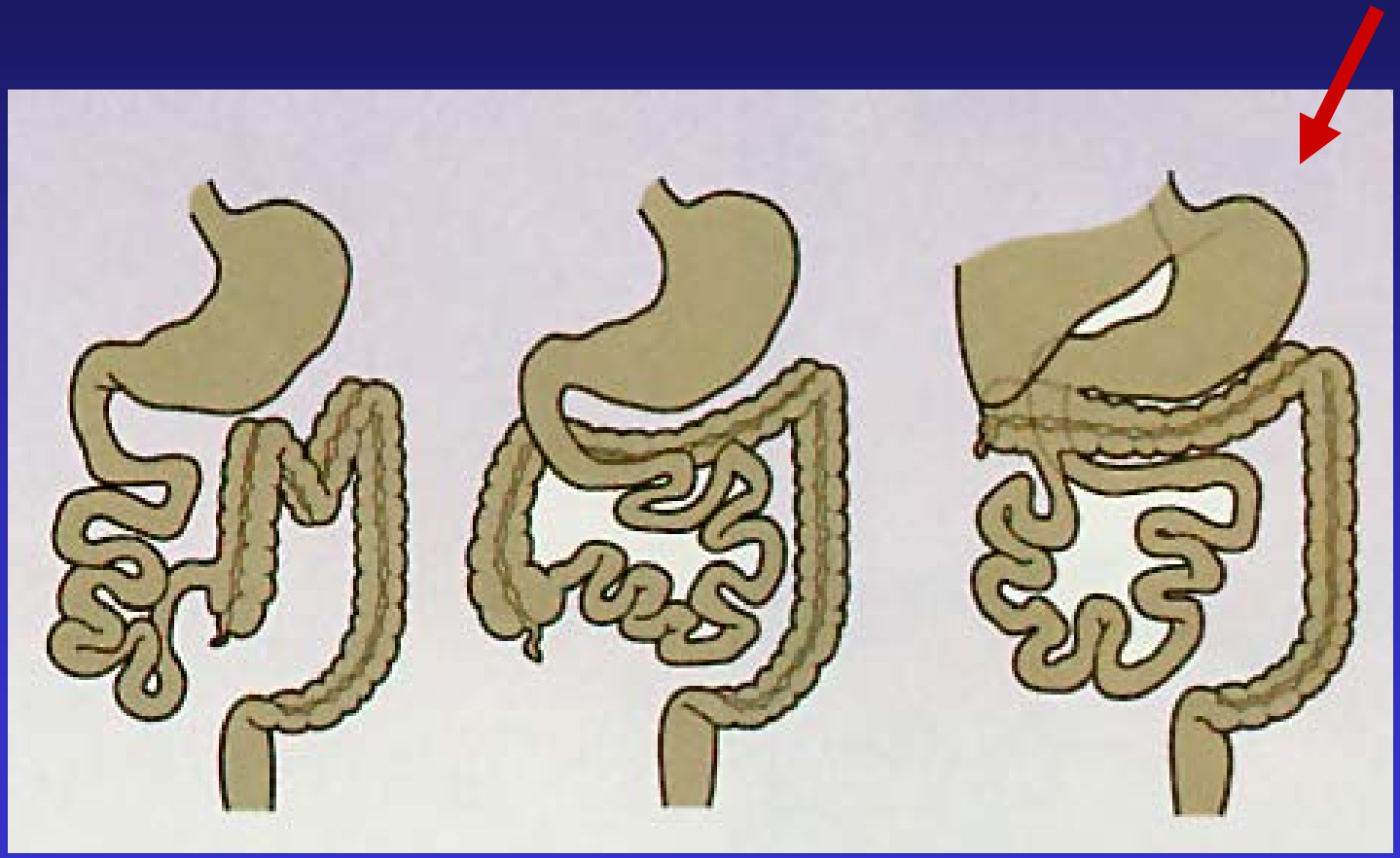
Caudal loop only rotates the 2nd 180o

Results in misplaced organs - abnormal fixation

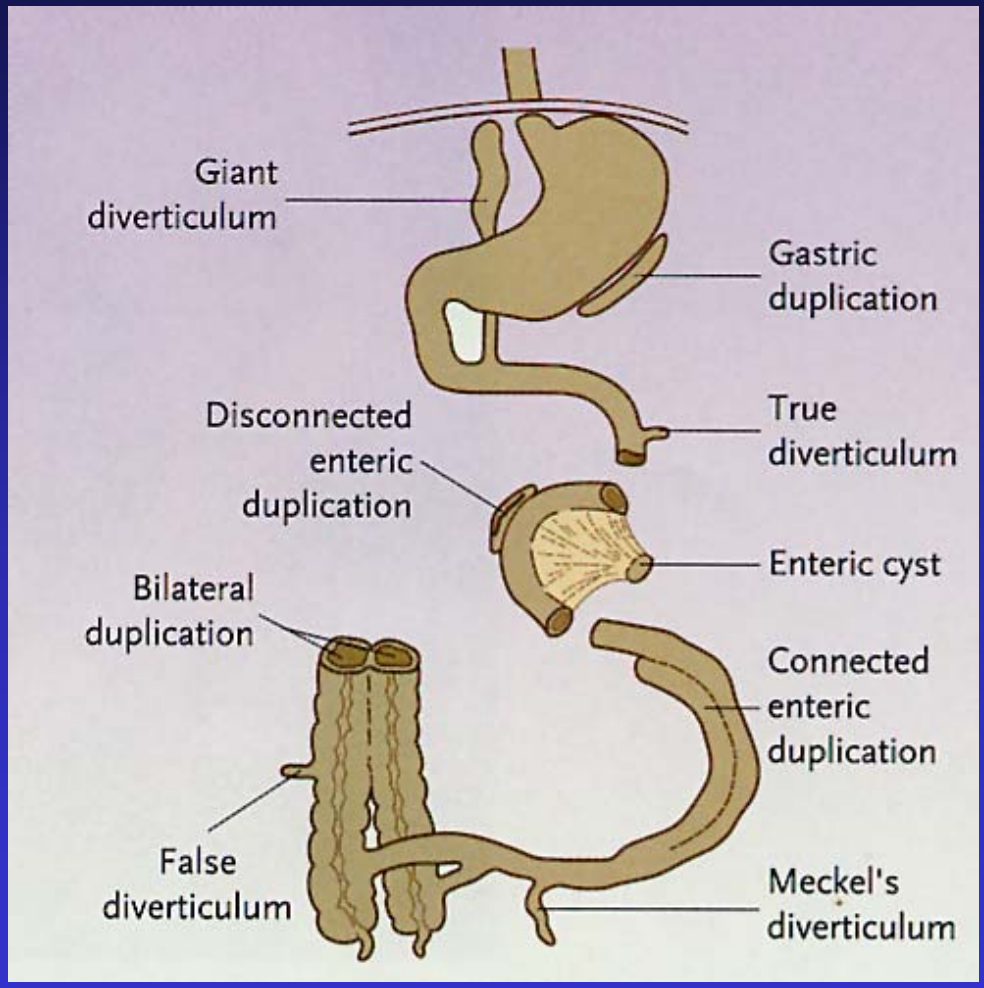
Typical outcome from abnormal rotations - obstructions of the gastrointestinal tract, compression of intestinal vasculature - resulting in intestinal ischemia; compression of lymphatic vessels - resulting in gastrointestinal bleeding


Cephalic limb (limb a) of intestinal loop undergoes normal 90° counter-clockwise rotation; caudal limb (limb b) does not rotate
90°
a
b
Caudal Limb (b) undergoes normal 180° counterclockwise rotation; cephalic limb (a) does not rotate
Resulting gut anomaly
Aorta
Stomach
Cecum
Transverse colon
Small intestine
Descending colon
91 days

Anomalies – Midgut
Subhepatic Cecum



Intestinal Duplication, Diverticula, and Atresia



Unknown Causes

Anomalies - Hindgut

Hirschsprung's Disease – Dilation of the colon – defective neural crest migration → absence of parasympathetic ganglia in the colon wall

Imperforate anus – absence of anal opening

Hindgut Fistula

Often connecting the hindgut to the urogenital system