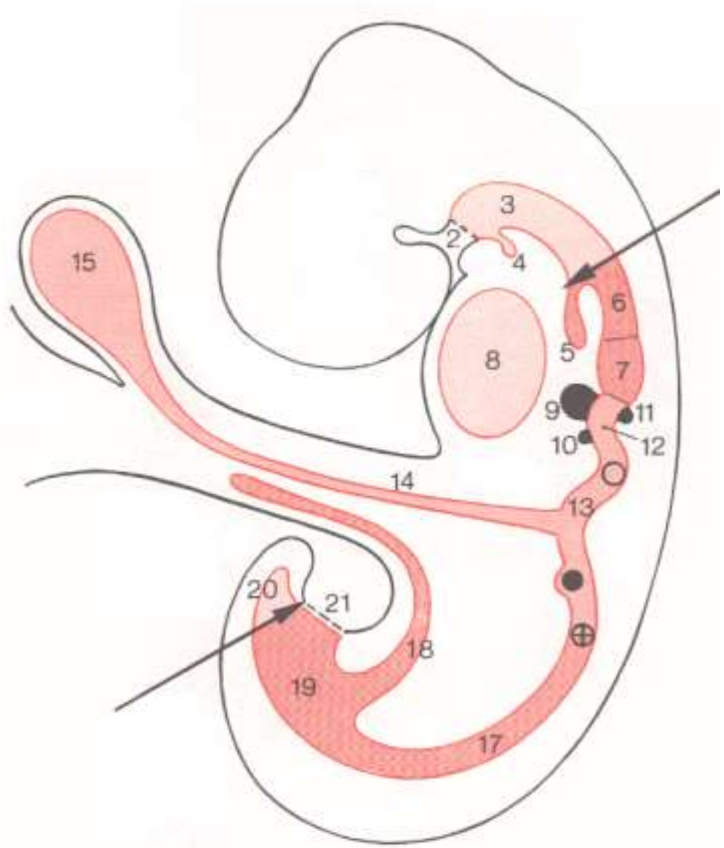
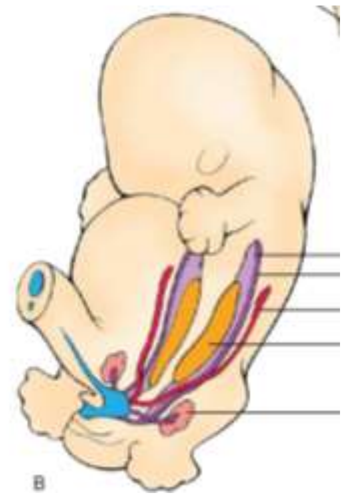
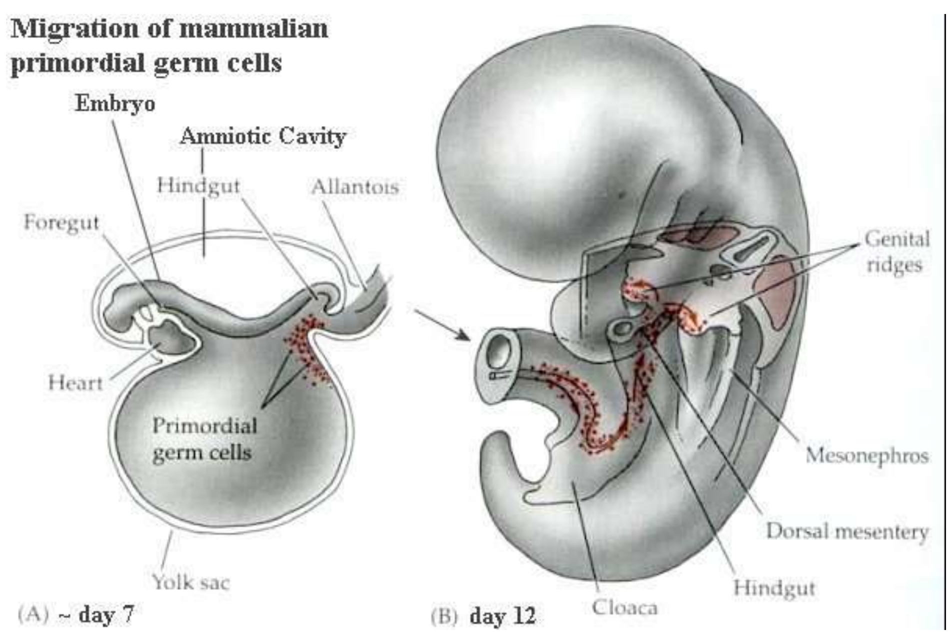


Development of the gastrointestinal tract and the urogenital system and malformations

for pharmacists

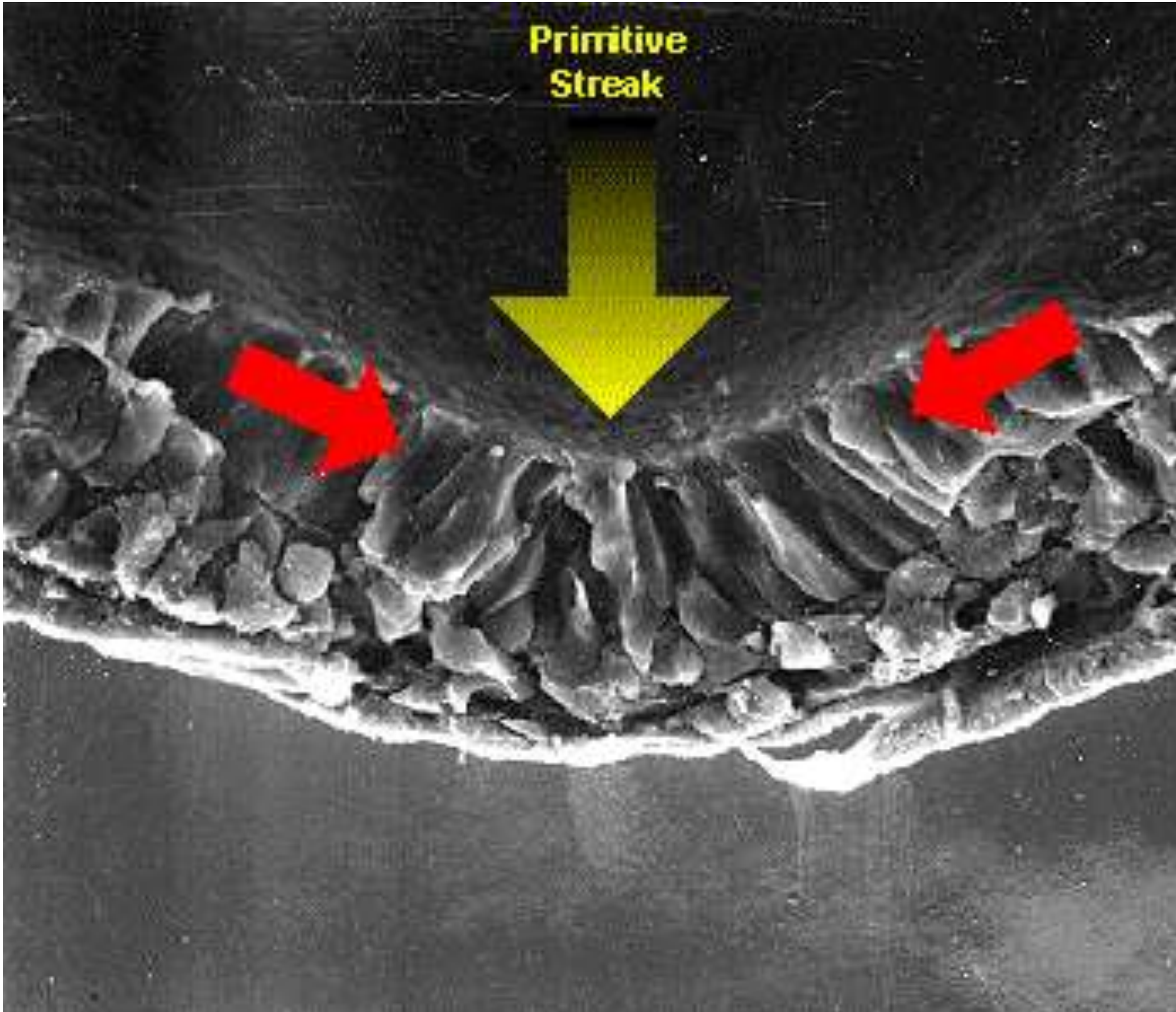


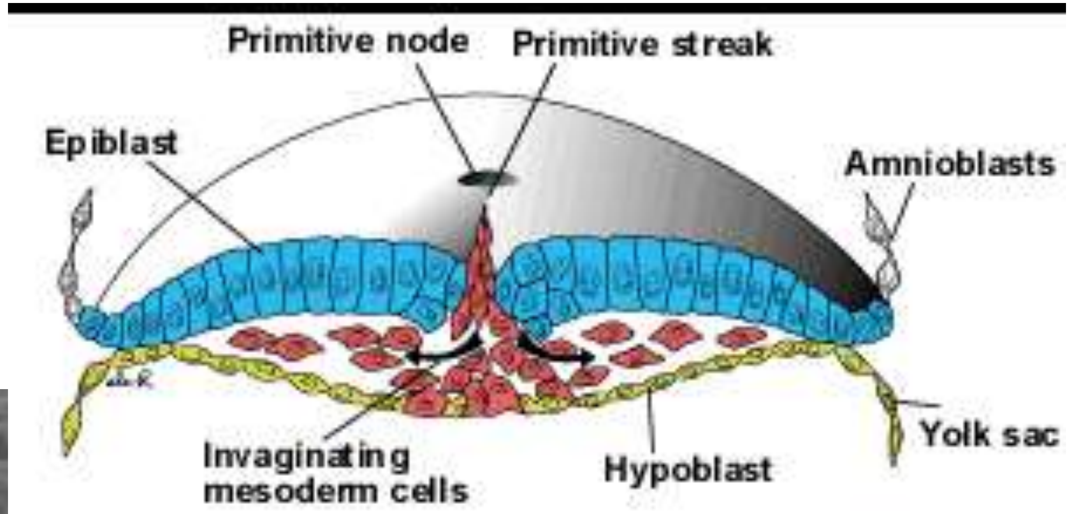


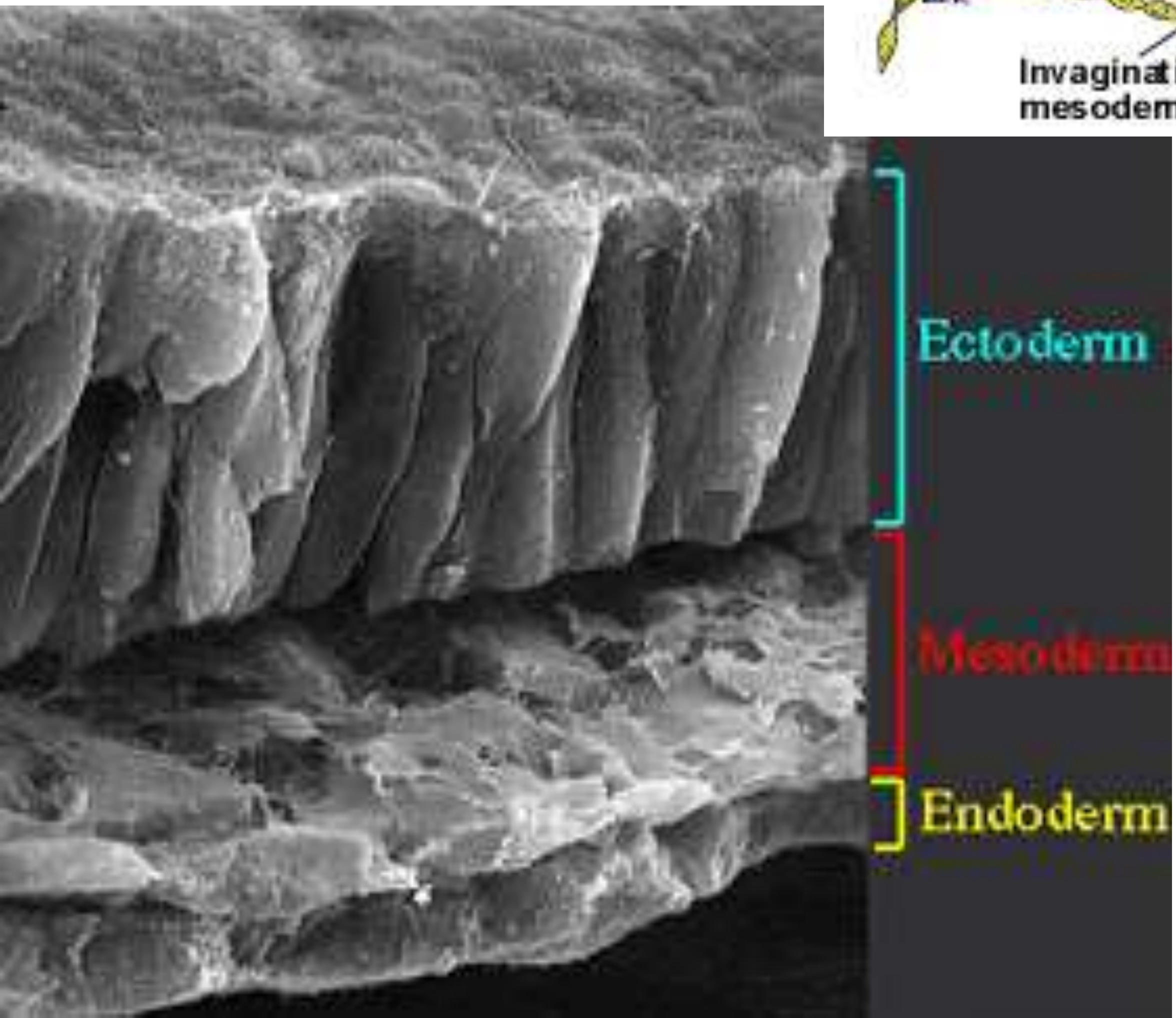
Semmelweis University, Department of Anatomy, Histology and Embryology

2017. 04.03.

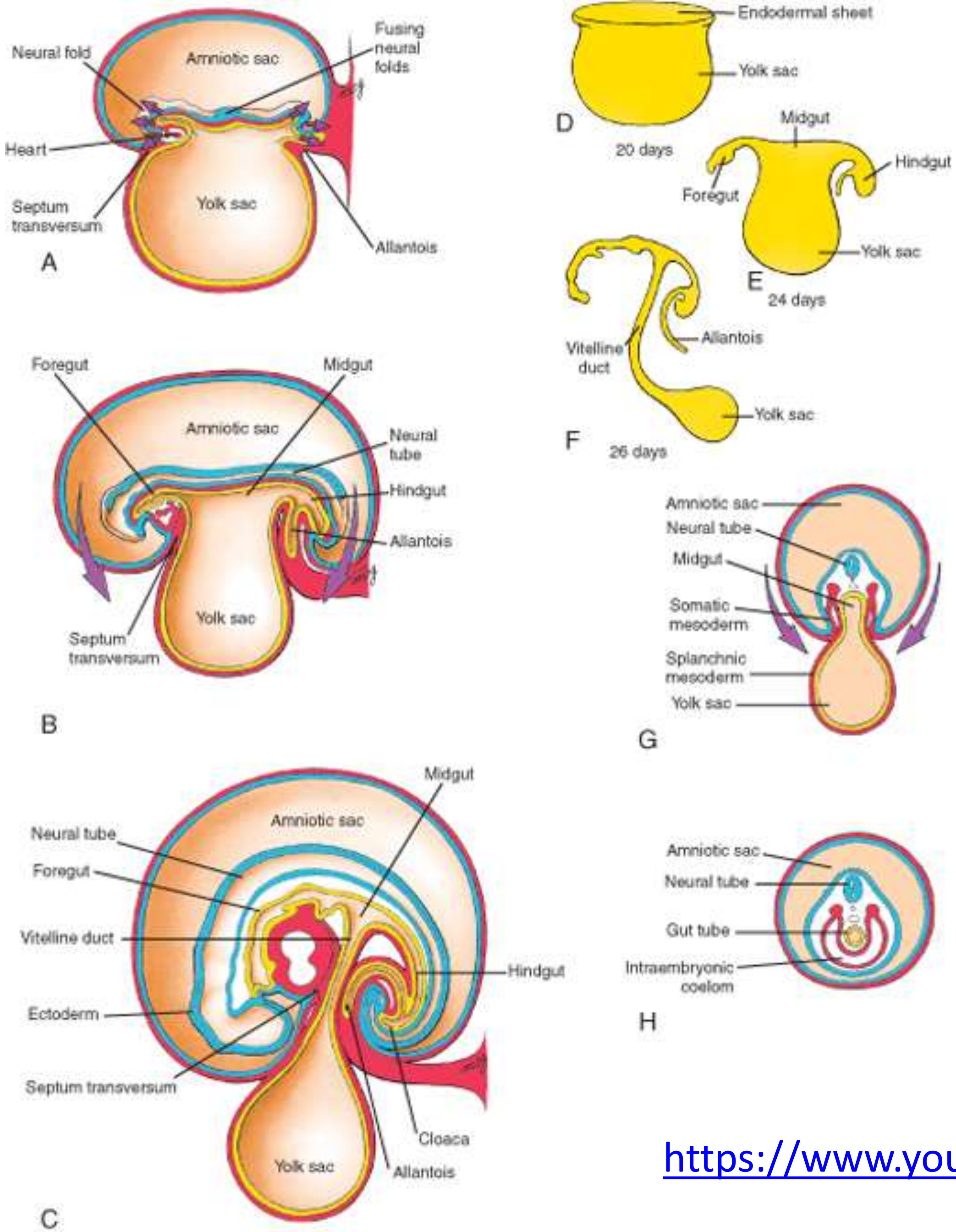
by Krisztina H.-Minkó


Primitive
Streak


Primitive node
Primitive streak
Epiblast
Amnioblasts
Yolk sac
Invaginating mesoderm cells
Hypoblast


Ectoderm
Mesoderm
Endoderm

Folding of the Embryo (cross section)

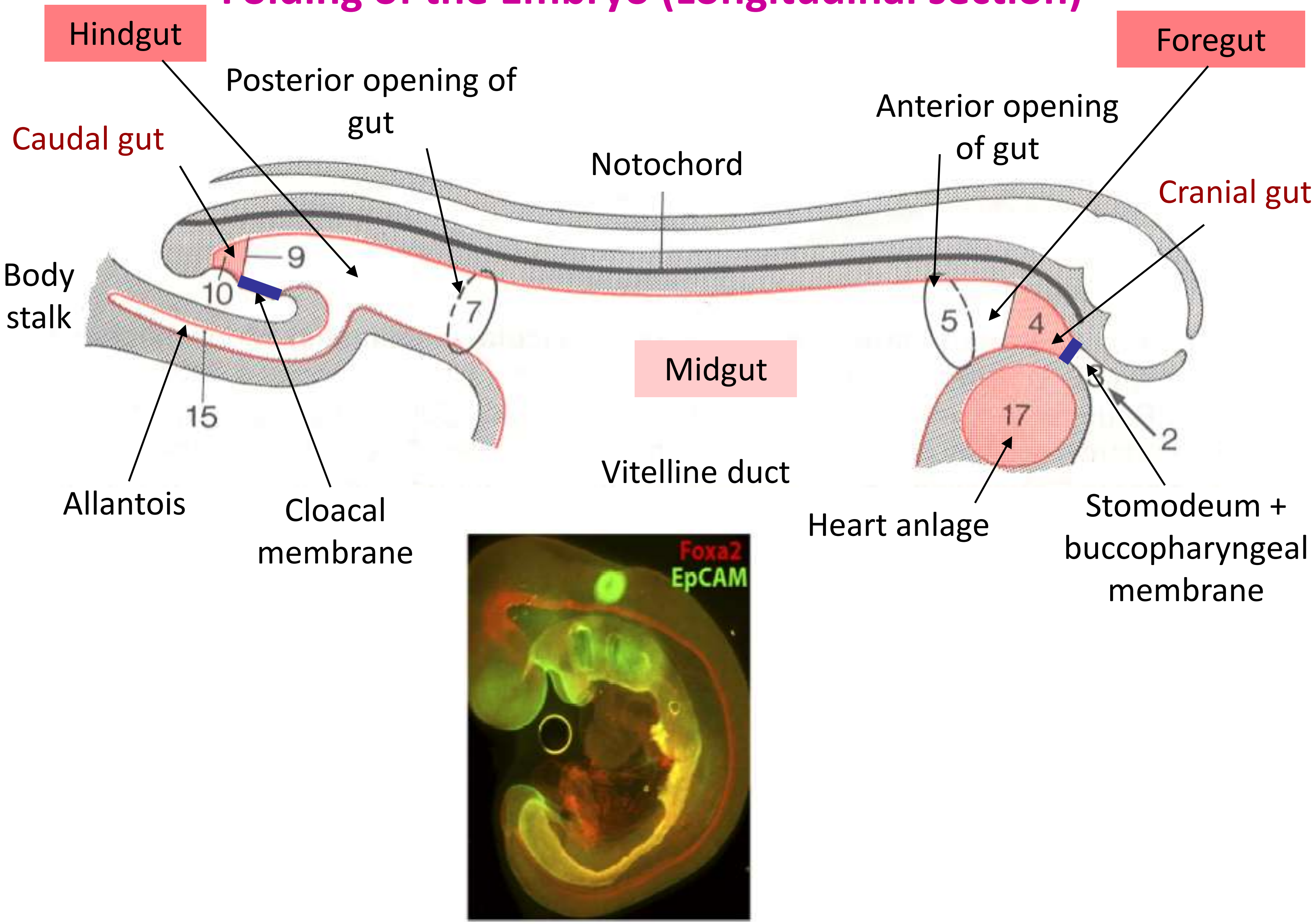


Schoenwolf et al: Larsen's Human Embryology, 4th Edition.

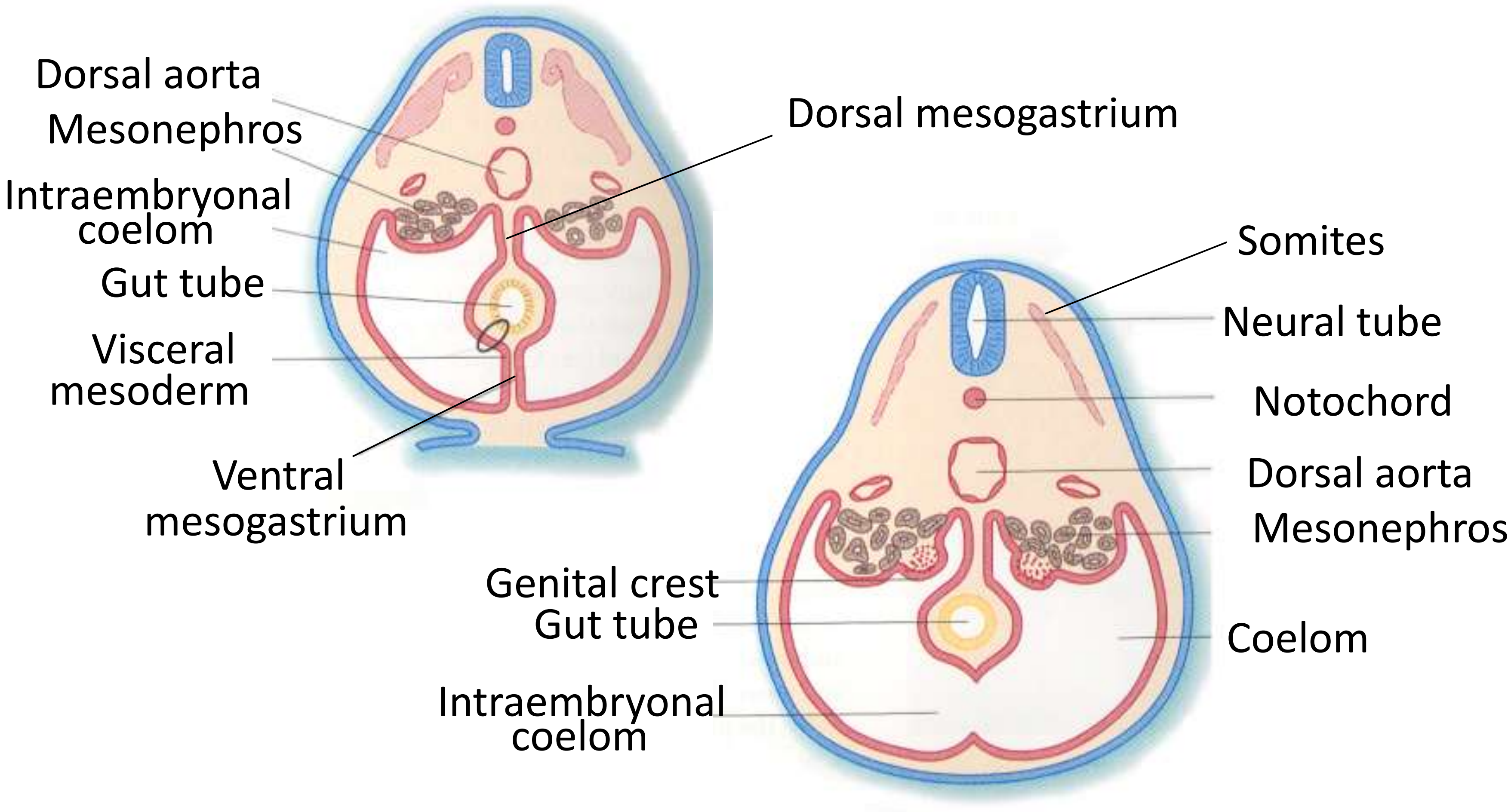
https://www.youtube.com/watch?v=qMnpxP6EeIY

4th week

Folding of the Embryo (Longitudinal section)



Folding of the Embryo
(Intraembryonic Mesoderm)



Ventral mesentery *Dorsal mesentery*

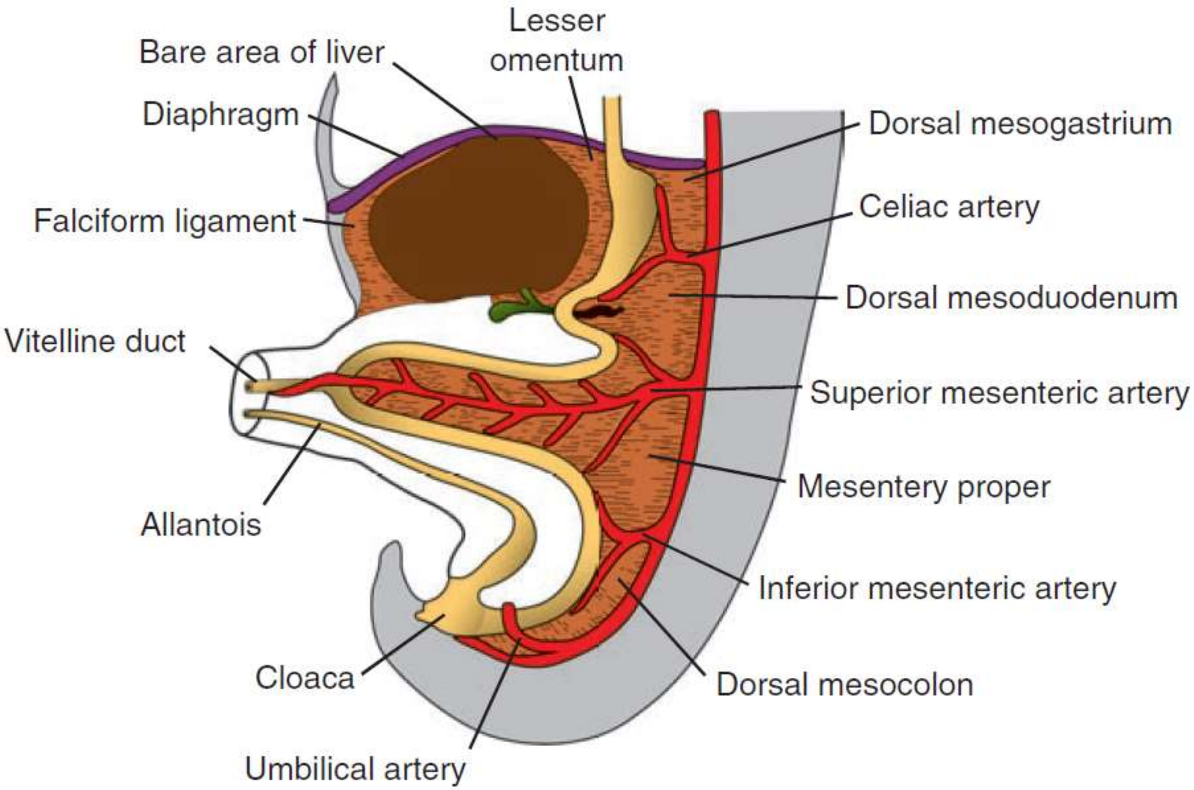
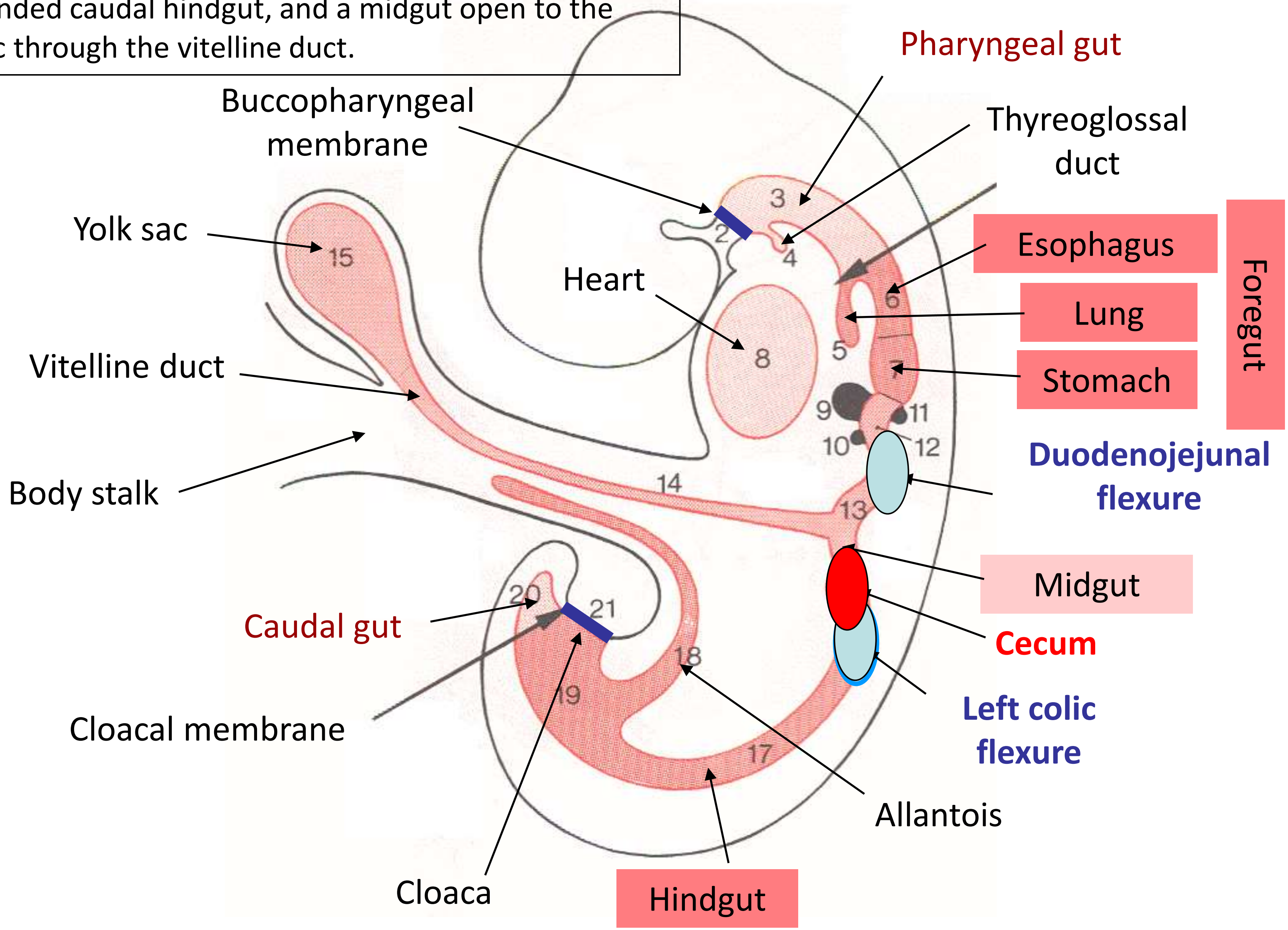


Figure 15.4 Primitive dorsal and ventral mesenteries. The liver is connected to the ventral abdominal wall and to the stomach by the falciform ligament and lesser omentum, respectively. The superior mesenteric artery runs through the mesentery proper and continues toward the yolk sac as the vitelline artery.

The endodermal gut tube created by body folding during the 4th week consists of a blindended cranial foregut, a blind-ended caudal hindgut, and a midgut open to the yolk sac through the vitelline duct.

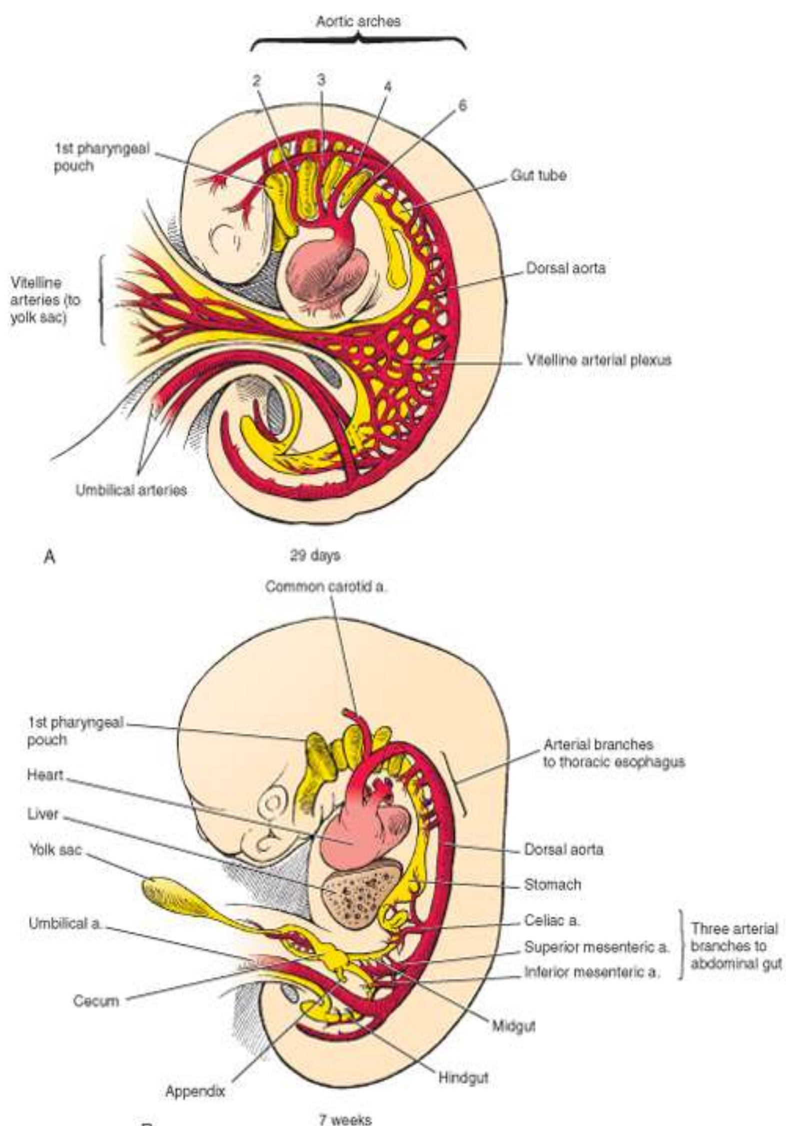
Primitive Gut Tube



Development of GI tract

https://www.youtube.com/watch?v=tx3Cn8g-_e0

Vascularisation of the primitive gut tube



The arterial supply to the gut develops through consolidation and reduction of the ventral branches of the dorsal aortae that anastomose with the vessel plexuses originally supplying blood to the yolk sac.
About five of these vitelline artery derivatives vascularize the thoracic foregut, and three—the celiac, superior mesenteric, and inferior mesenteric arteries—vascularize the abdominal gut.

By convention, the boundaries of the foregut, midgut, and hindgut portions of the abdominal gut tube are determined by the respective territories of these three arteries. However, these segments and the site of some gastrointestinal organs are already demarcated by specific gene expression patterns observable at even earlier stages.

Derivatives of the primitive gut tube endoderm

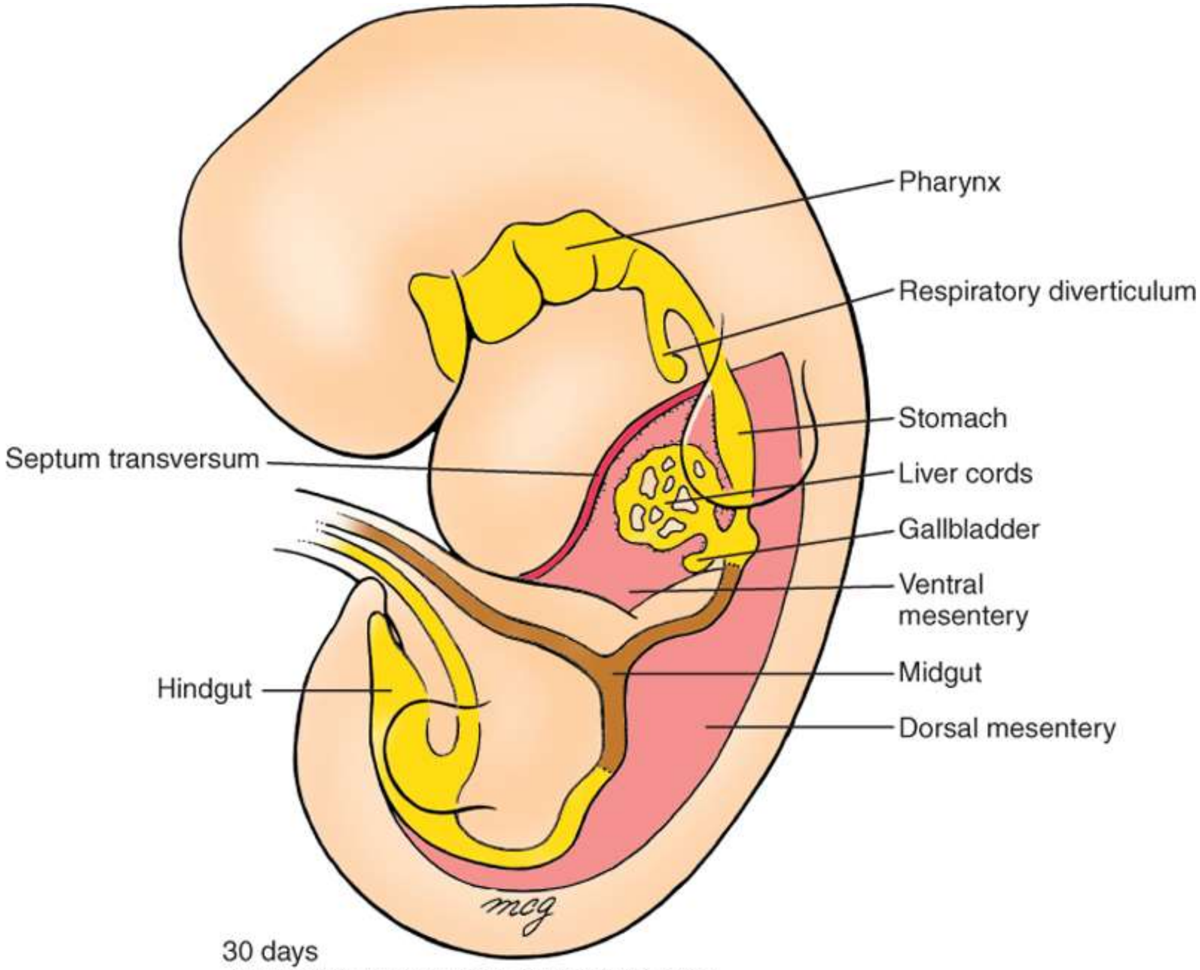
Foregut: pharynx, (the pouch derivatives)
esophagus, stomach,
superior half of duodenum,
liver parenchyma, hepatic duct epithelium, gallbladder,
pancreas

Midgut: inferior half of duodenum, jejunum, ileum,
cecum, appendix, ascending colon,
right two thirds of transverse colon

Hindgut: left one third of transverse colon, descending colon,
sigmoid colon, rectum,
urogenital sinus

*Lamina propria, muscular wall, vascular elements,
and connective tissue of the tract and organs develop
from the splanchnic mesoderm*

By the fifth week, the abdominal portion of the foregut is visibly divided into the esophagus, stomach, and proximal duodenum.



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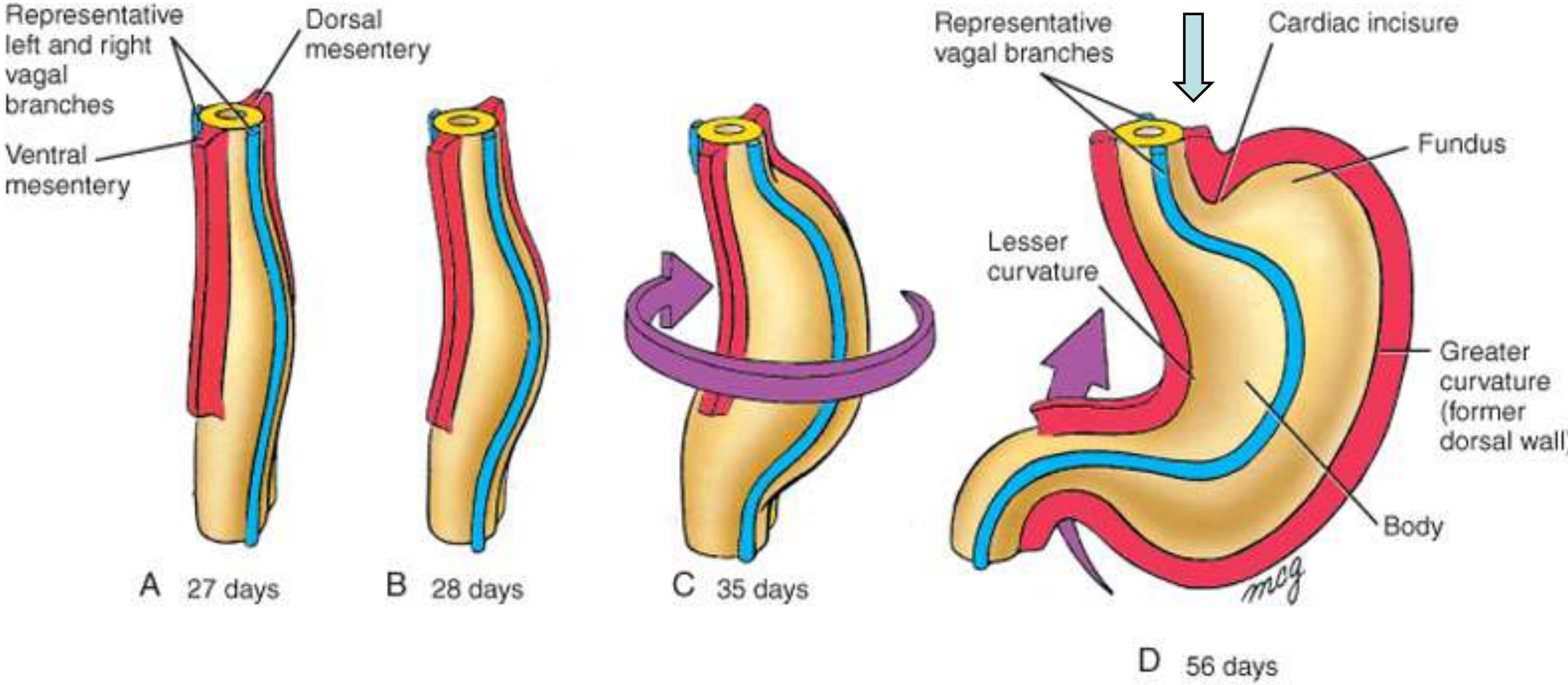
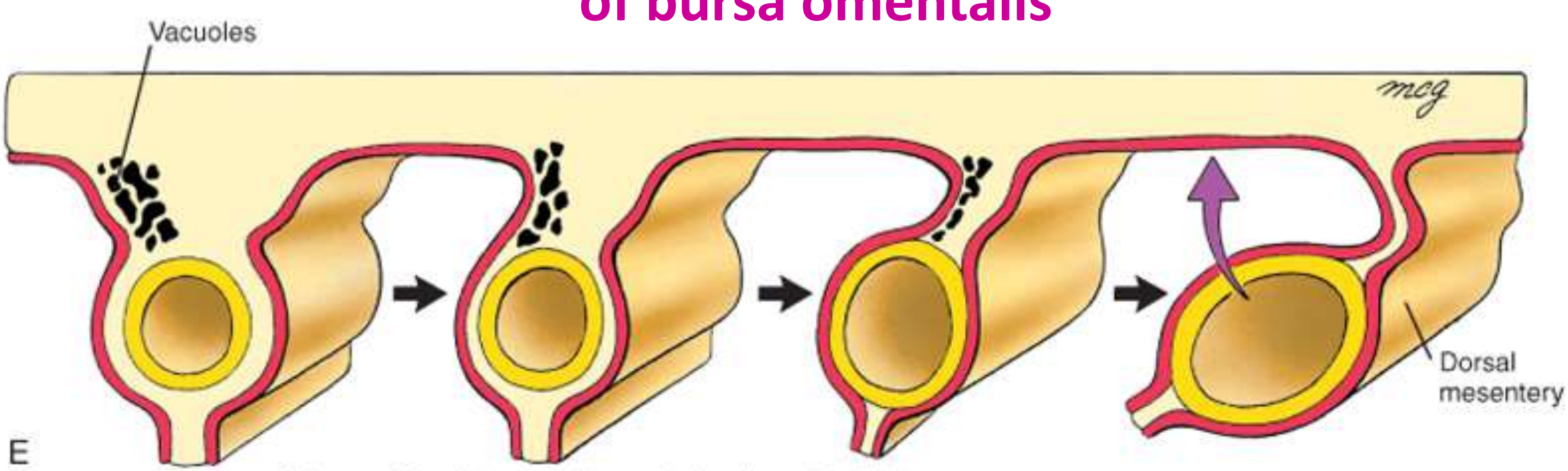


Rotation of stomach and formation of bursa omentalis



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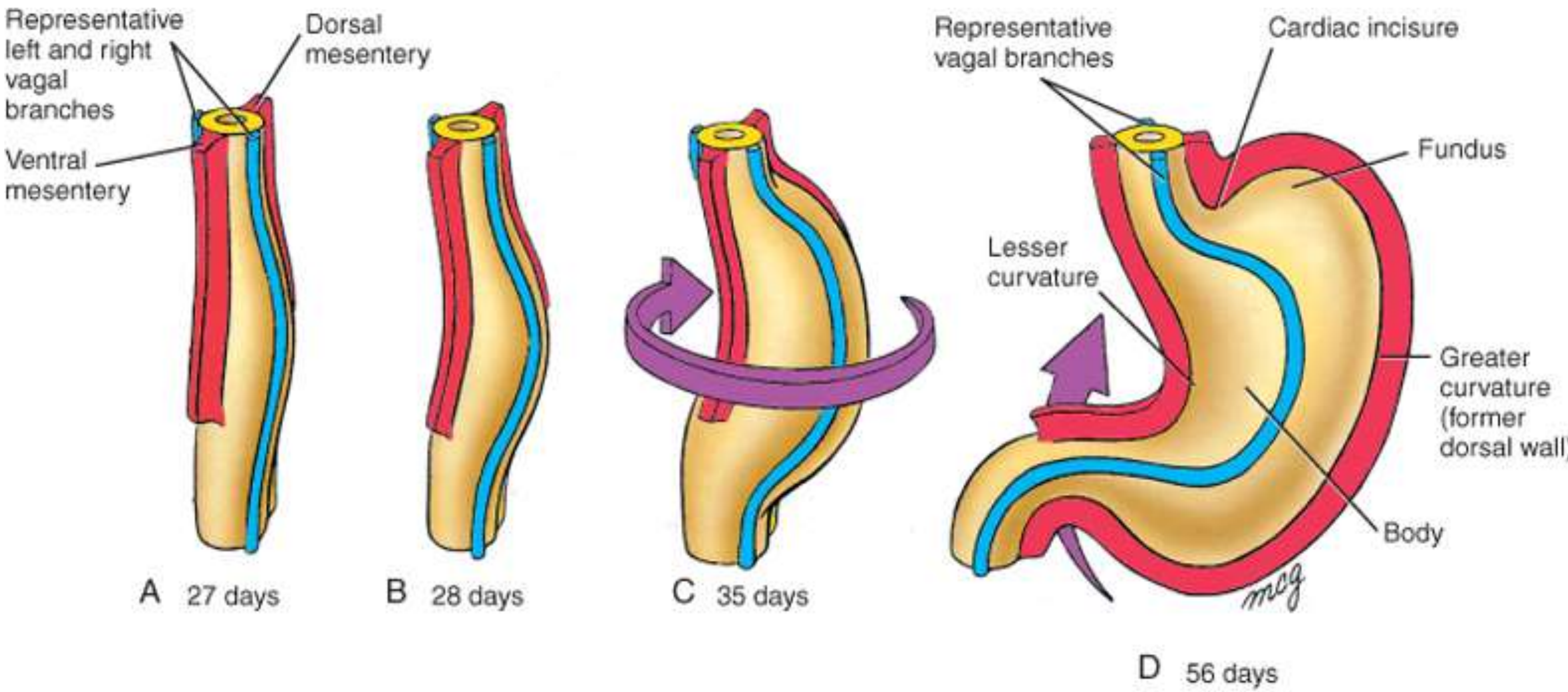
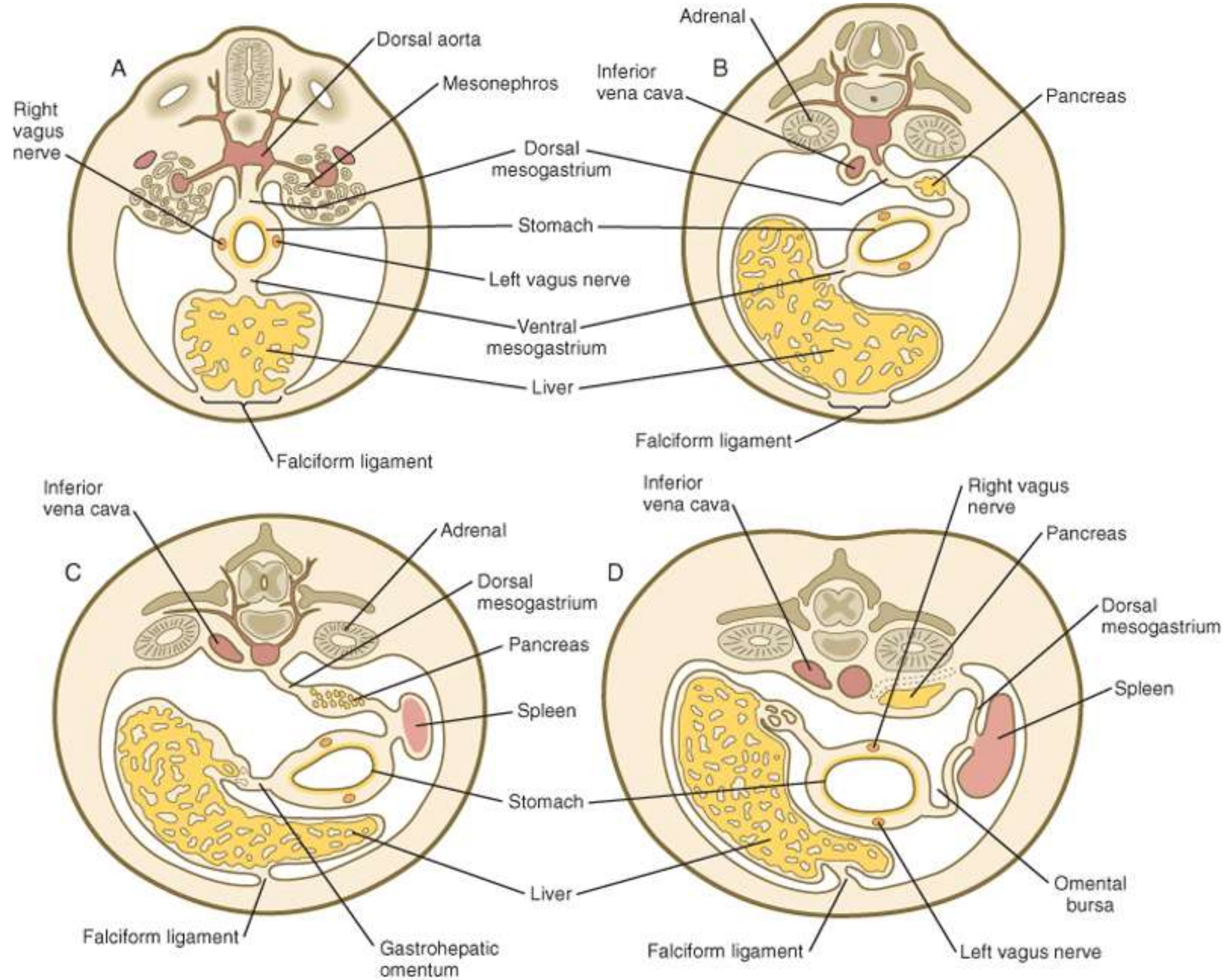
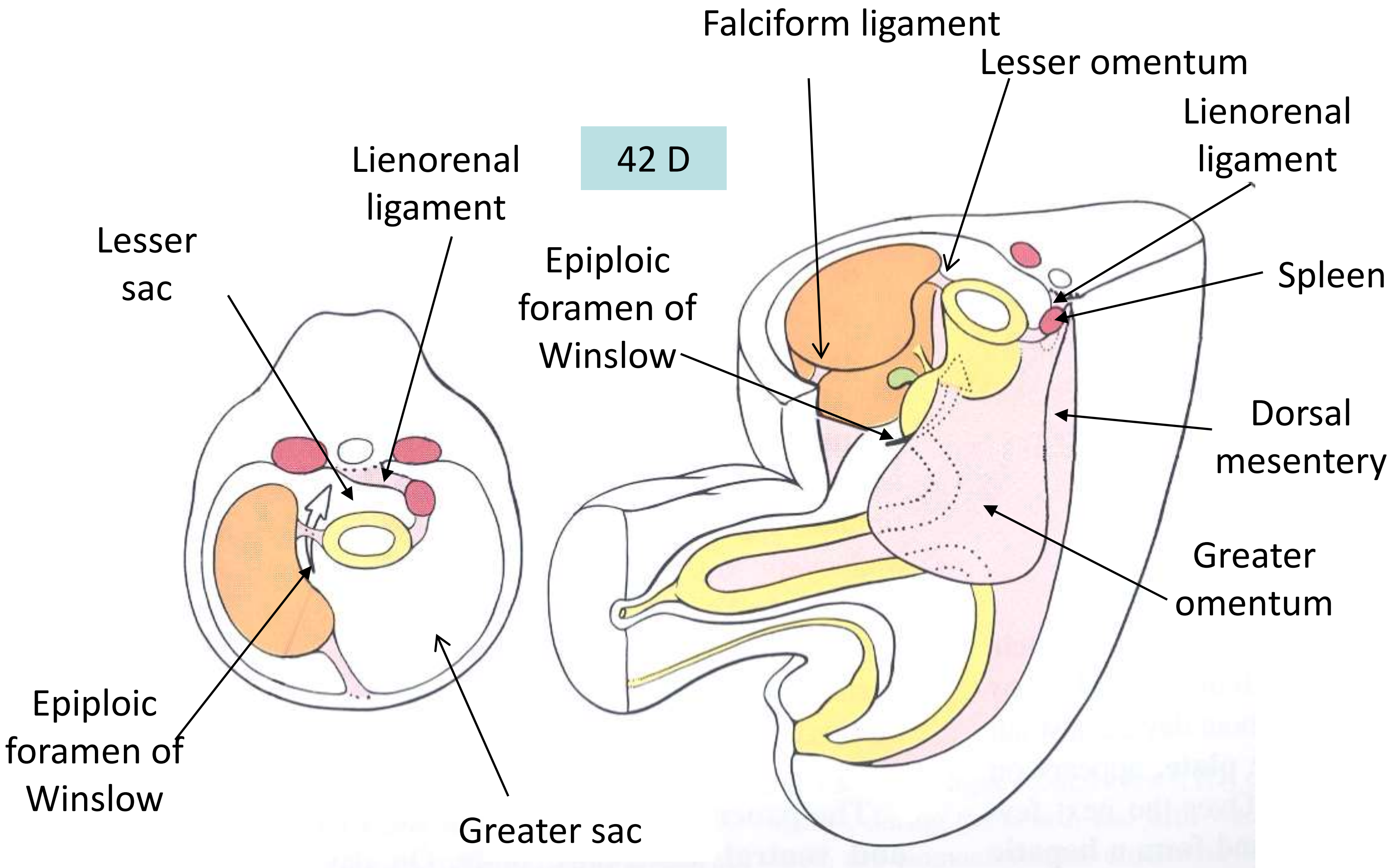


During the 7th and 8th weeks, the developing stomach undergoes a 90-degree rotation around its craniocaudal axis so that the greater curvature lies to the left and the lesser curvature lies to the right.
The stomach also rotates slightly around a ventrodorsal axis so that the greater curvature faces slightly caudally, and the lesser curvature slightly cranially.

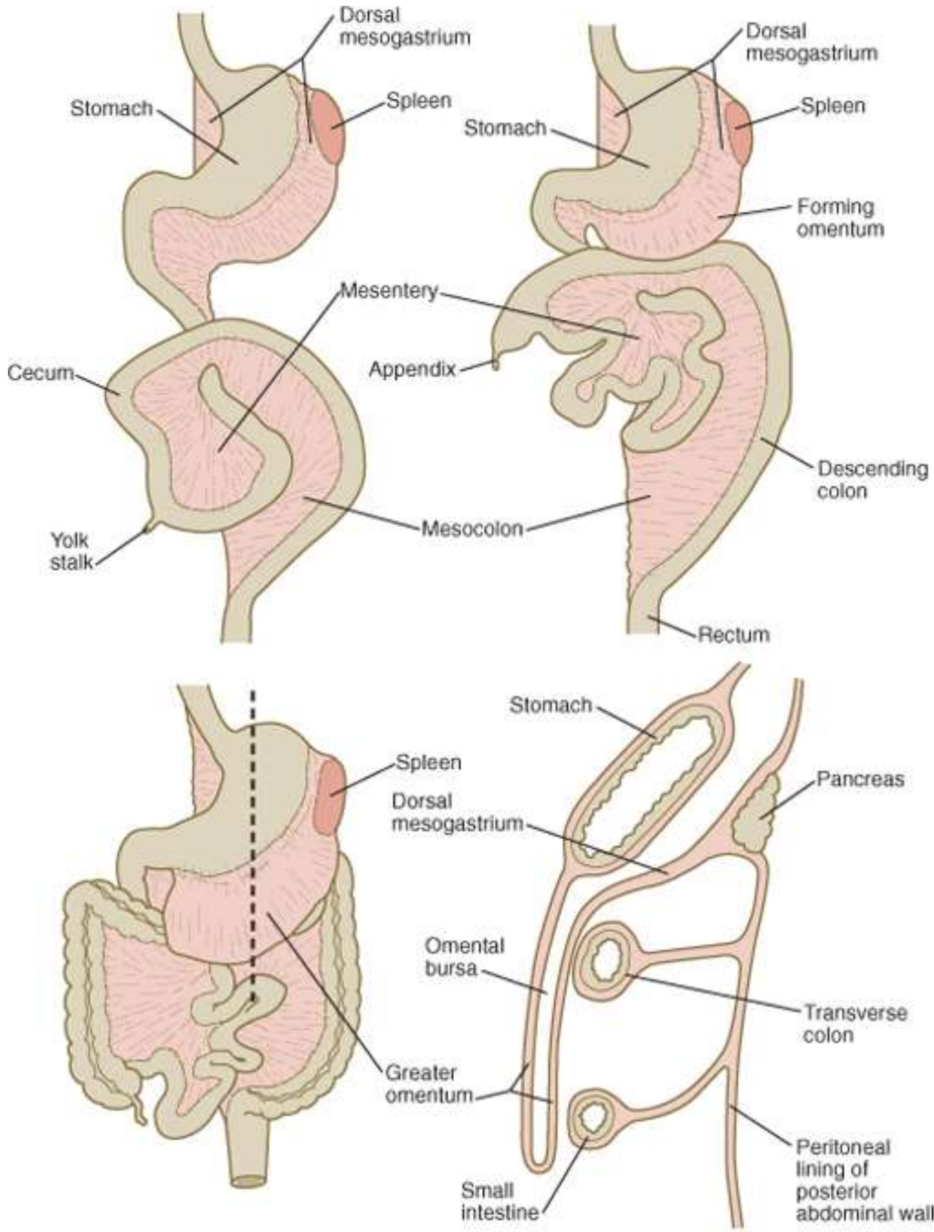


The stomach is initially fusiform, and differential growth of its dorsal and ventral walls produces the greater and lesser curvatures. Meanwhile, hepatic, cystic, and dorsal and ventral pancreatic diverticula bud from the proximal duodenum into the mesogastrium and give rise, respectively, to the liver, gallbladder, cystic duct, and pancreas. In addition, the spleen condenses from mesenchyme in the dorsal mesogastrium.

Anterior and Posterior Mesogastrium



The future ileum elongates more rapidly than can be accommodated by the early peritoneal cavity, so that by the fifth week the midgut is thrown into an anteroposterior hairpin fold, the primary intestinal loop, which herniates into the umbilicus during the sixth week.



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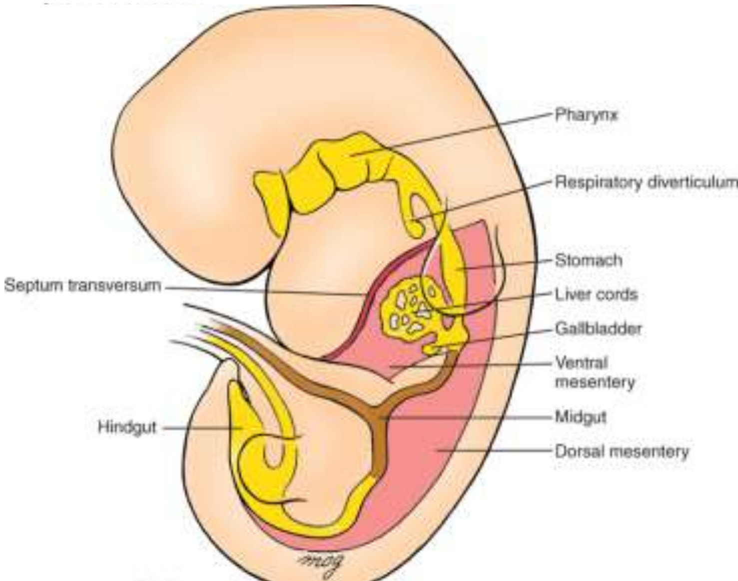
As the primary intestinal loop herniates, it rotates around its long axis by 90 degrees counterclockwise (as viewed from the ventral side) so that the future ileum lies in the right abdomen and the future large intestine lies in the left abdomen. Meanwhile, the cecum and appendix differentiate, and the jejunum and ileum continue to elongate. During the 10th through 12th weeks, the intestinal loop is retracted into the abdominal cavity and rotates through an additional 180 degrees counterclockwise to produce the definitive configuration of the small and large intestines.

Development of Gastrointestinal Glands



30 days

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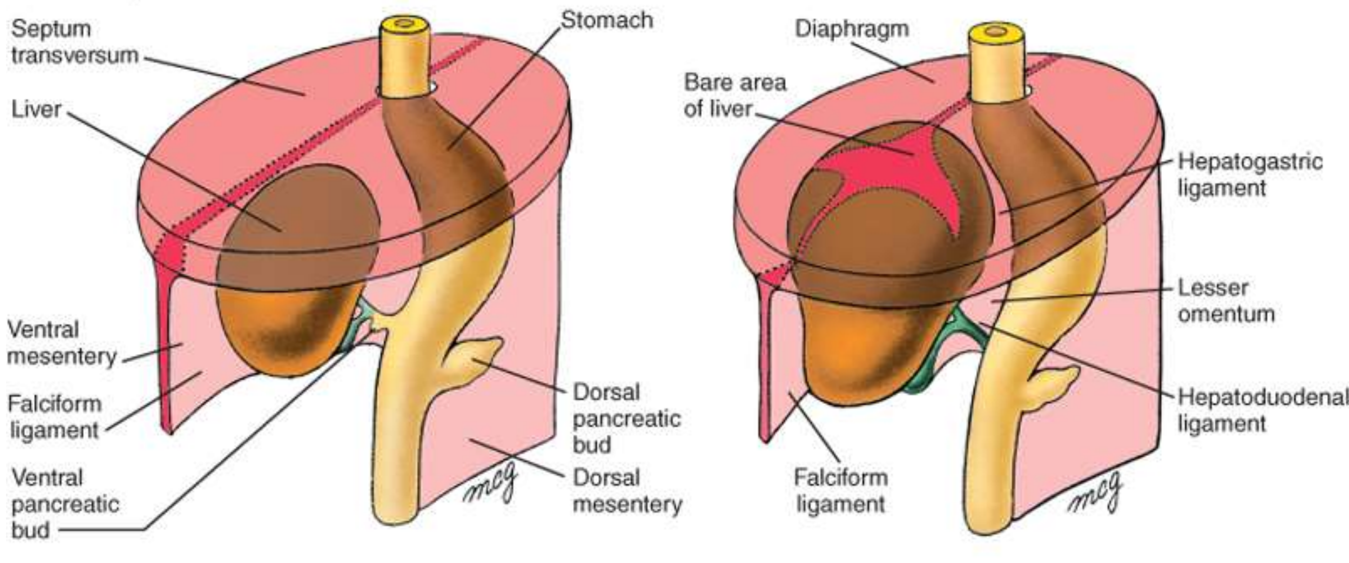

Mid 5th week

Mid 6th week

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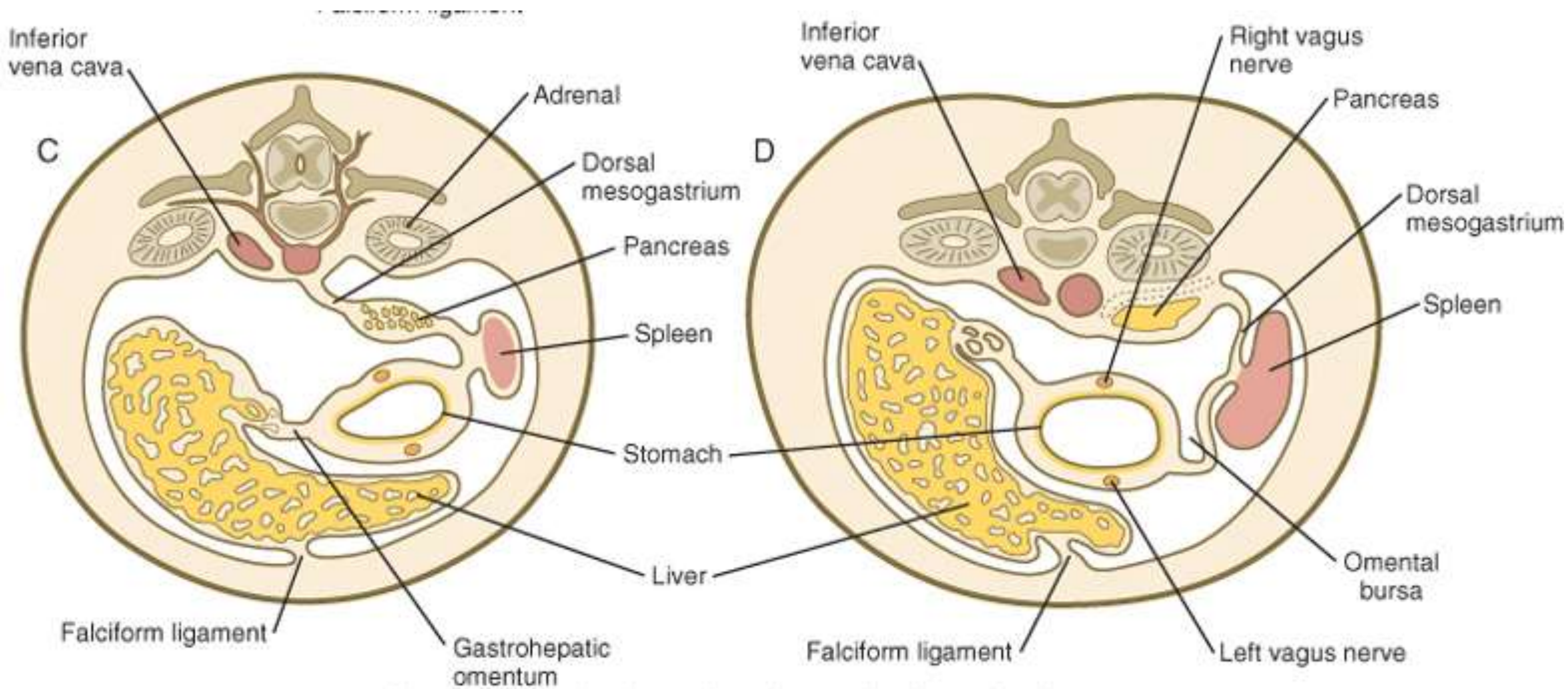
The spleen, a vascular lymphatic organ is a mesodermal derivative, not a product of the gut tube endoderm like most of the intraabdominal viscera



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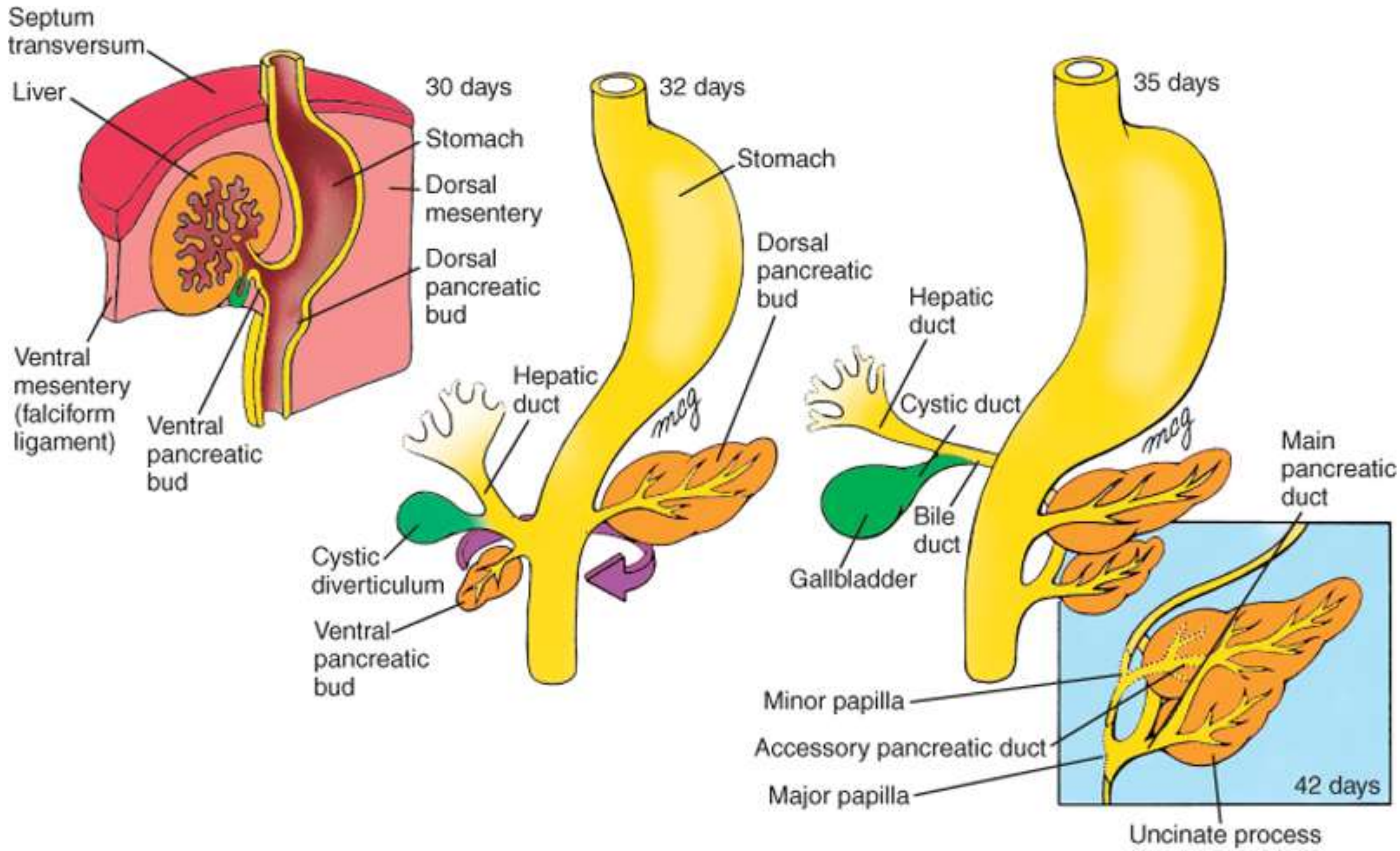
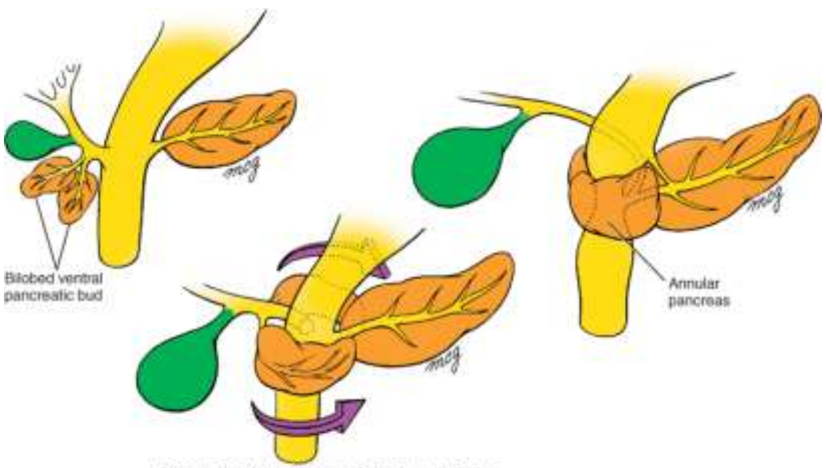


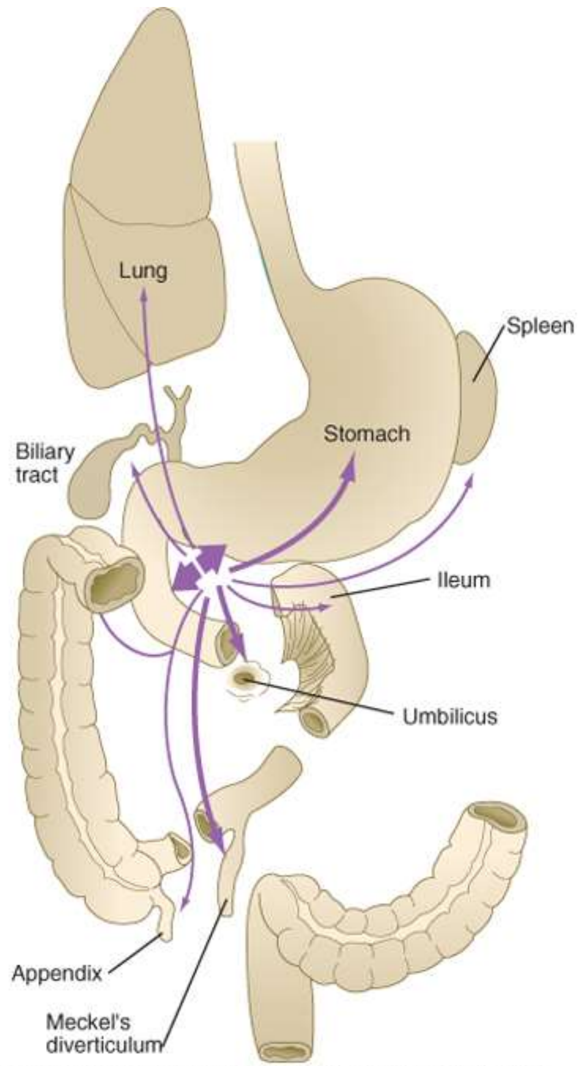
Septum transversum
Liver
30 days
Stomach
Dorsal mesentery
Dorsal pancreatic bud
Ventral mesentery (falciform ligament)
Ventral pancreatic bud
32 days
Stomach
Dorsal pancreatic bud
Hepatic duct
Cystic diverticulum
Ventral pancreatic bud
mcg
35 days
Hepatic duct
Cystic duct
Bile duct
Gallbladder
mcg
Main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

Pancreatic malformations

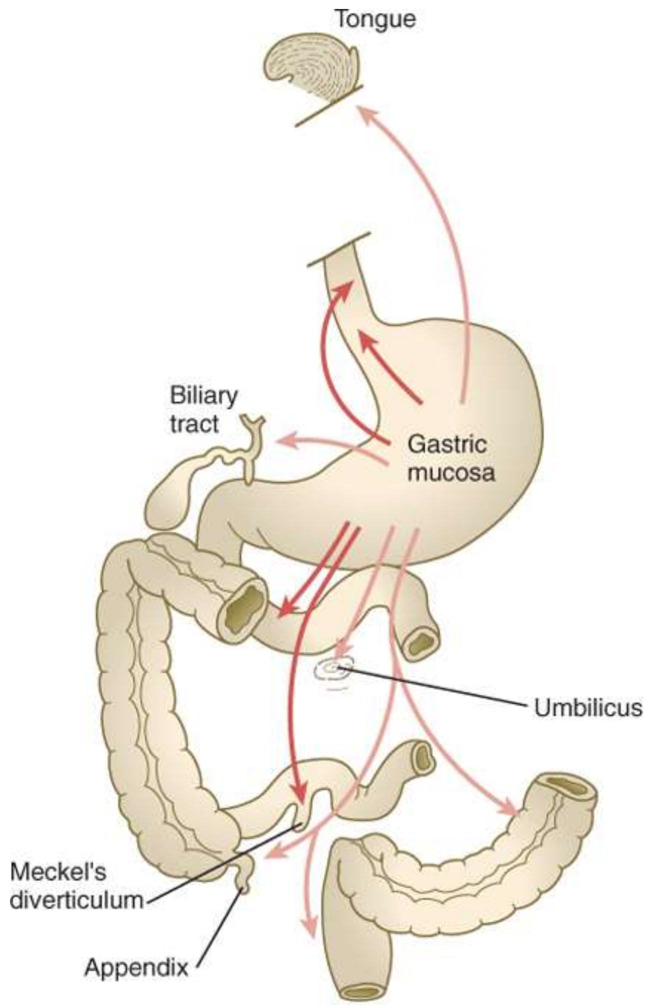
Annular pancreas



Heterotopic pancreas tissue



Heterotopic gastric glands



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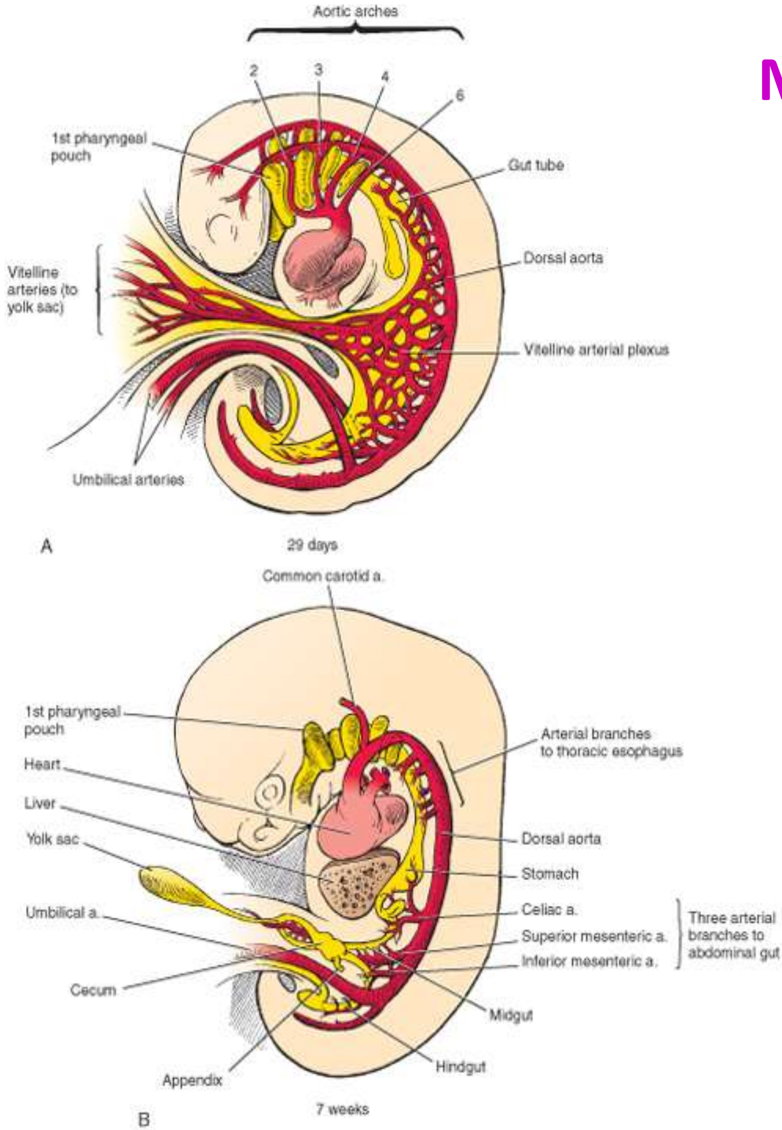
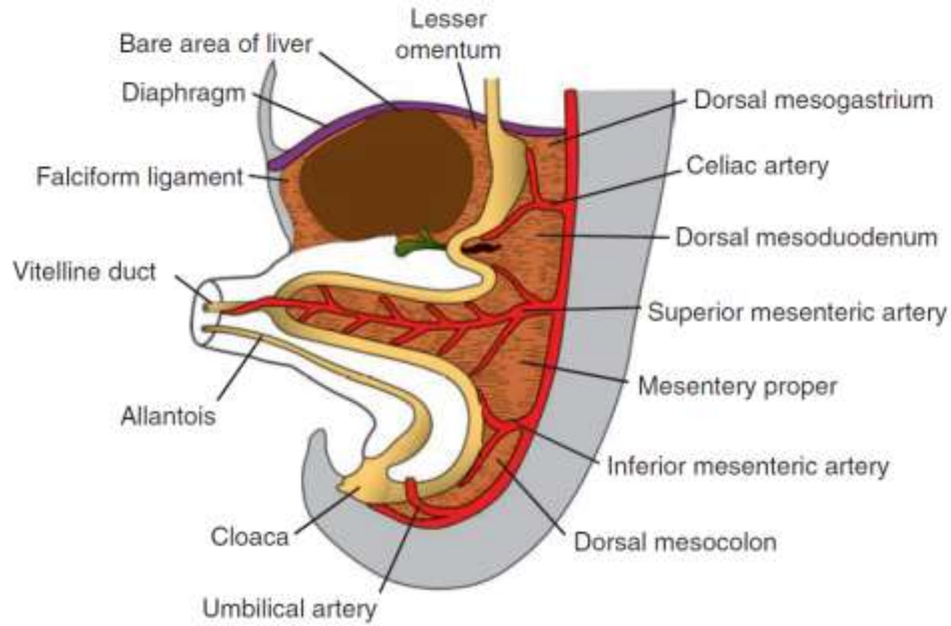
MIDGUT

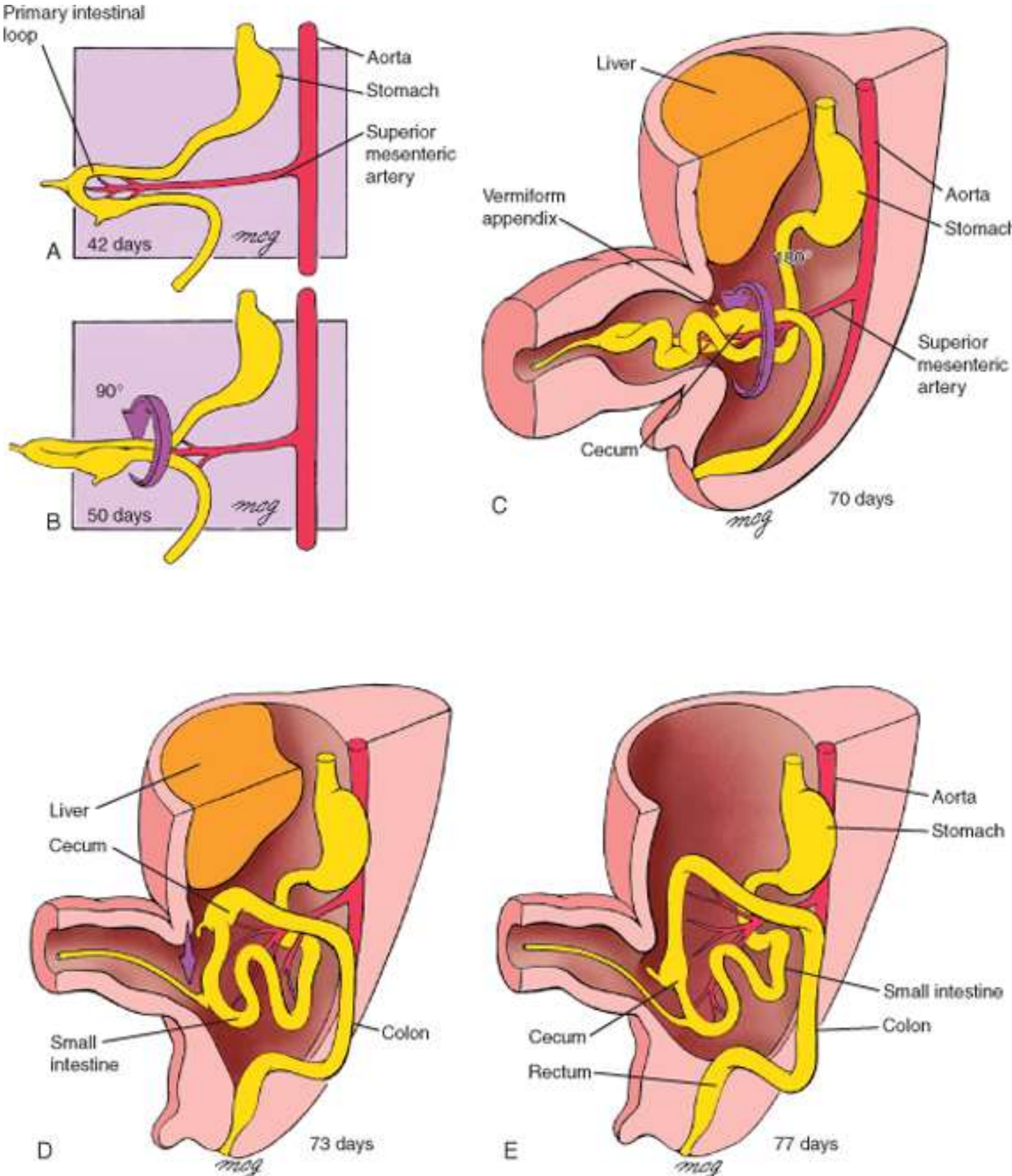
Primary intestinal loop





The midgut differentiates into the distal duodenum, jejunum, ileum, cecum, ascending colon, and proximal two thirds of the transverse colon.

The future ileum elongates more rapidly than can be accommodated by the early peritoneal cavity, so that by the fifth week the midgut is thrown into an anteroposterior hairpin fold, the primary intestinal loop, which herniates into the umbilicus during the sixth week.



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Rotation and physiological herniation of the midgut

By the early 6th week, the continuing elongation of the midgut, combined with the pressure resulting from the dramatic growth of other abdominal organs (particularly the liver),forces the primary intestinal loop to herniate into the umbilicus.

Rotation of the midgut
https://www.youtube.com/watch?v=AscKR_cQExY

An animation for students and teachers of human embryology by Dr. Robert Acland, Department of Anatomical Sciences, Univ..

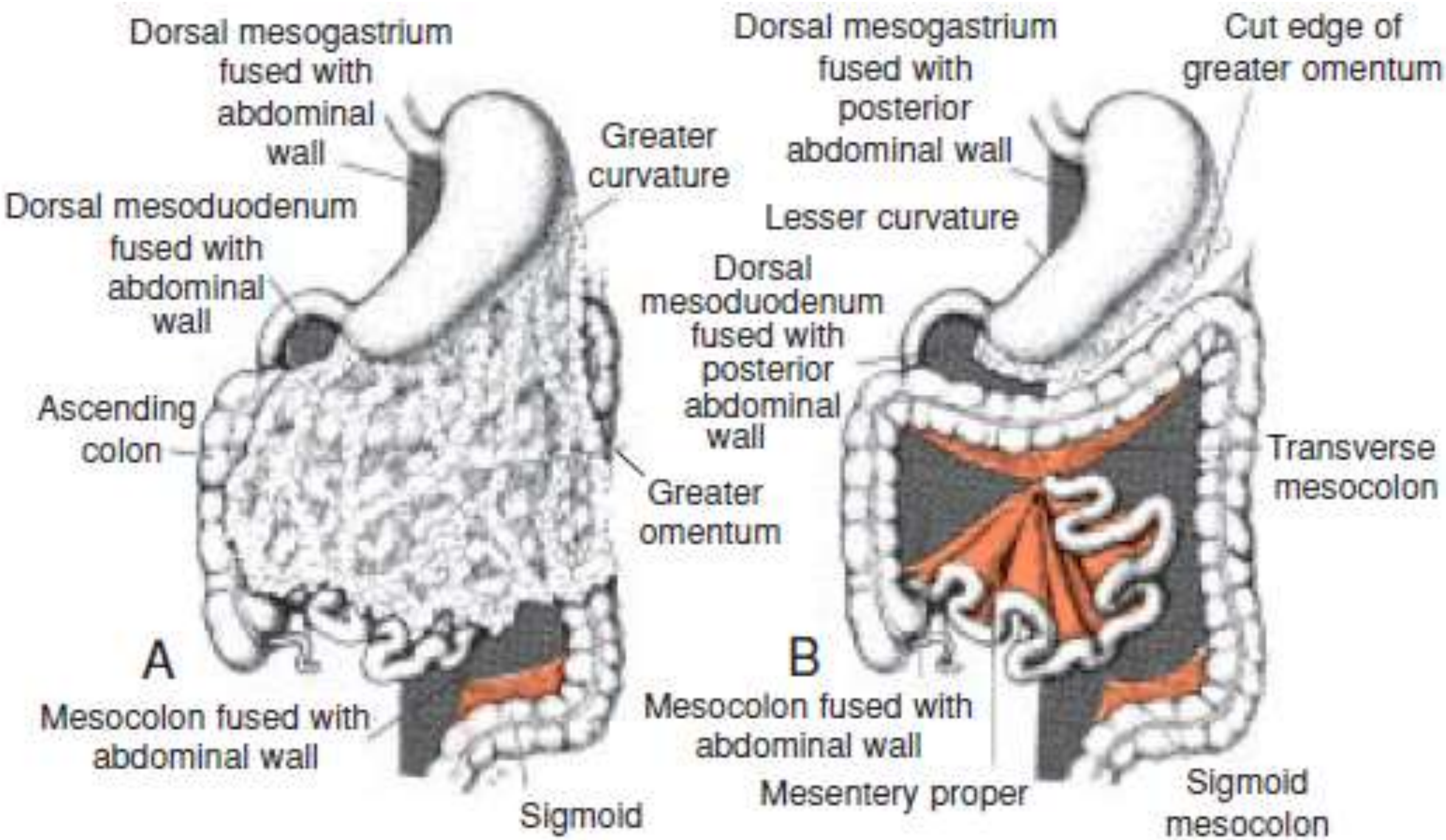
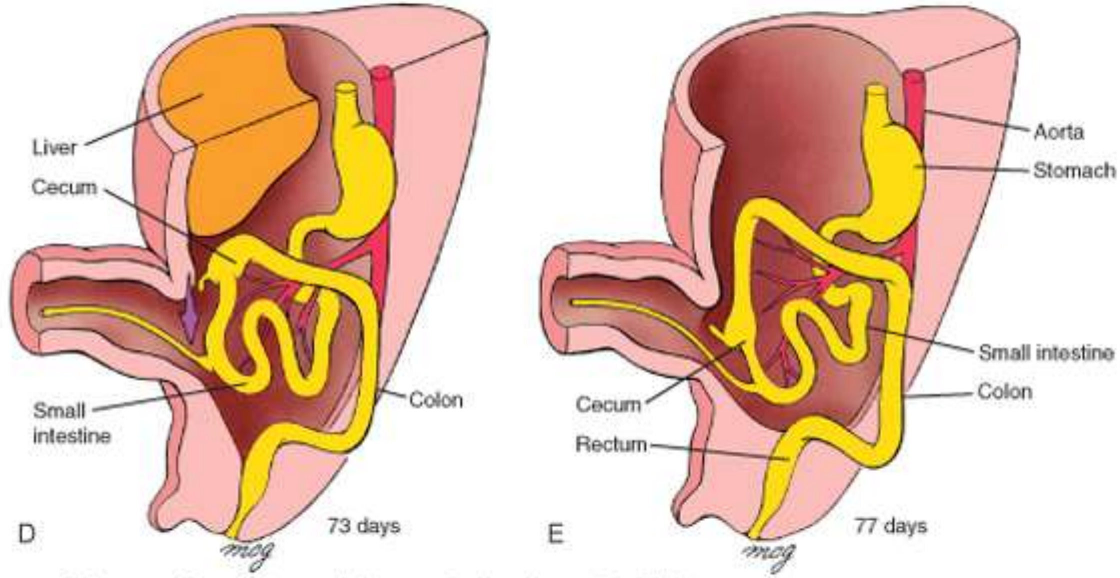


Figure 13.30 Frontal view of the intestinal loops with (**A**) and after removal of (**B**) the greater omentum. *Gray areas*, parts of the dorsal mesentery that fuse with the posterior abdominal wall. Note the line of attachment of the mesentery proper.



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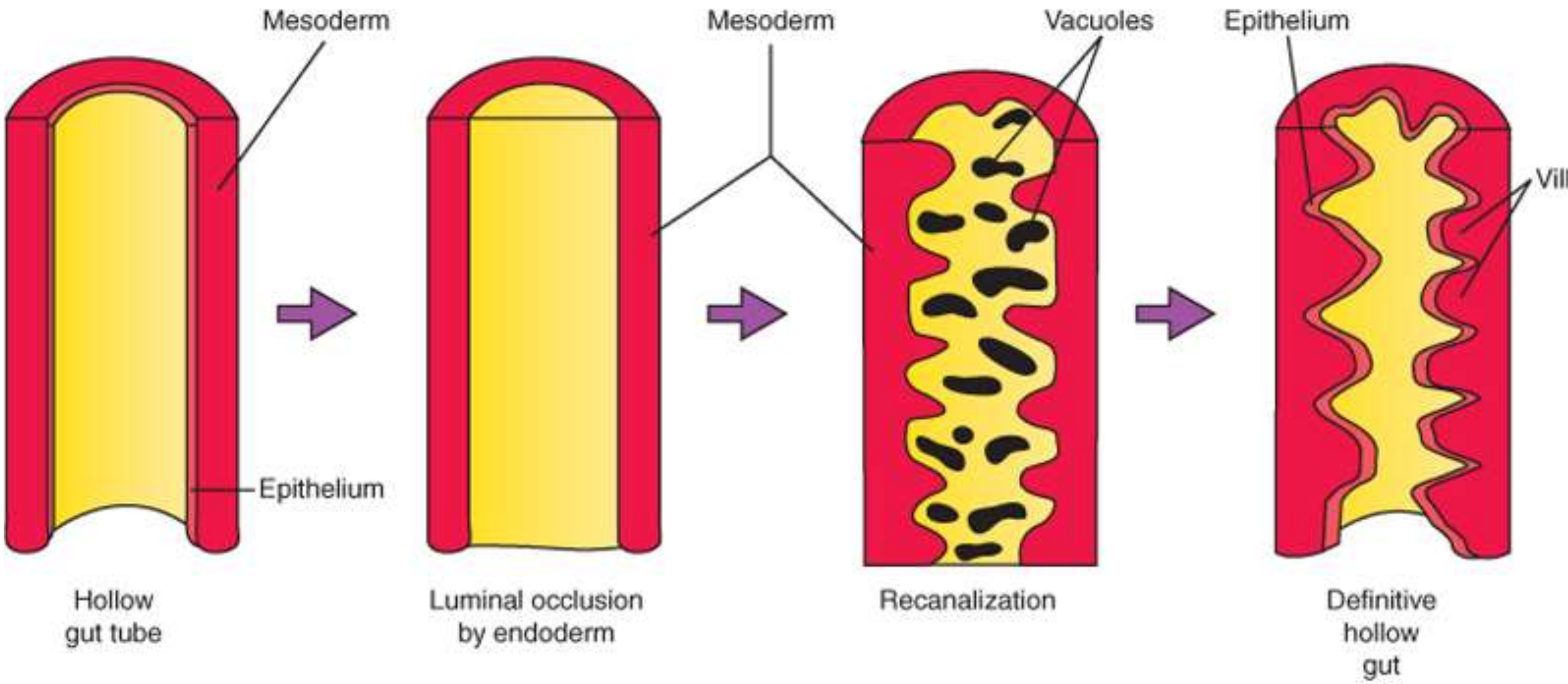
During the 10th week, the midgut retracts into the abdomen and rotates an additional 180 degrees. The mechanism responsible for the rapid retraction of the midgut into the abdominal cavity during the 10th week is not understood but may involve an increase in the size of the abdominal cavity relative to the other abdominal organs. As the intestinal loop reenters the abdomen, it rotates counterclockwise through an additional 180 degrees, so that now the retracting colon has traveled a 270-degree circuit relative to the posterior wall of the abdominal cavity (Fig. 14-15D, E; see Fig. 14-15 C). The cecum consequently rotates to a position just inferior to the liver in the region of the right iliac crest. The intestines have completely returned to the abdominal cavity by the 11th week.

Formation of gut lumen and villi

6-8 w.



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Between the 6th and 8th weeks, the lumen of the gut tube becomes solidly filled by epithelium, and then is gradually recanalized. During recanalization, mesodermal extensions project into the lumen and together with the overlying epithelium form the villi of the intestines.

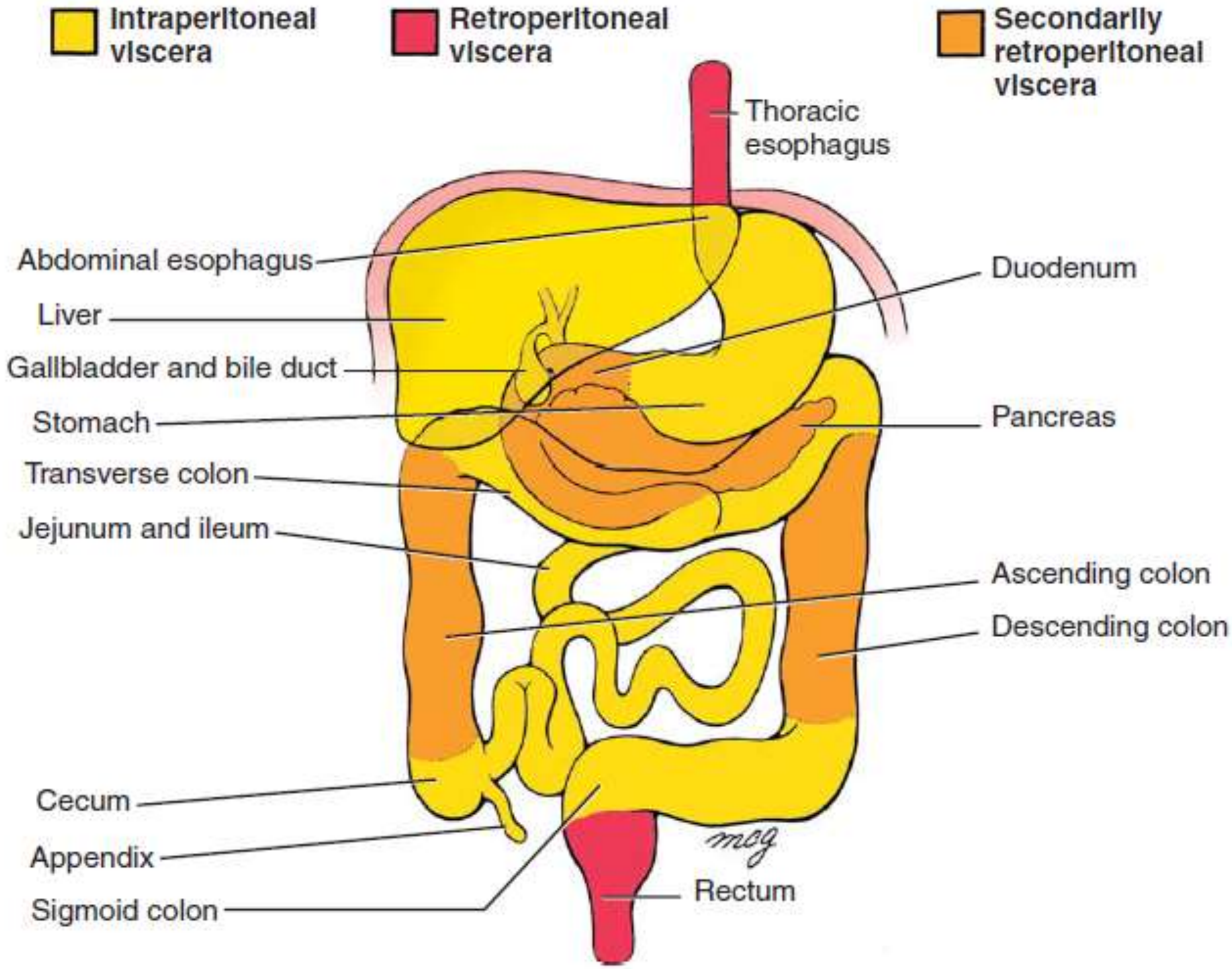
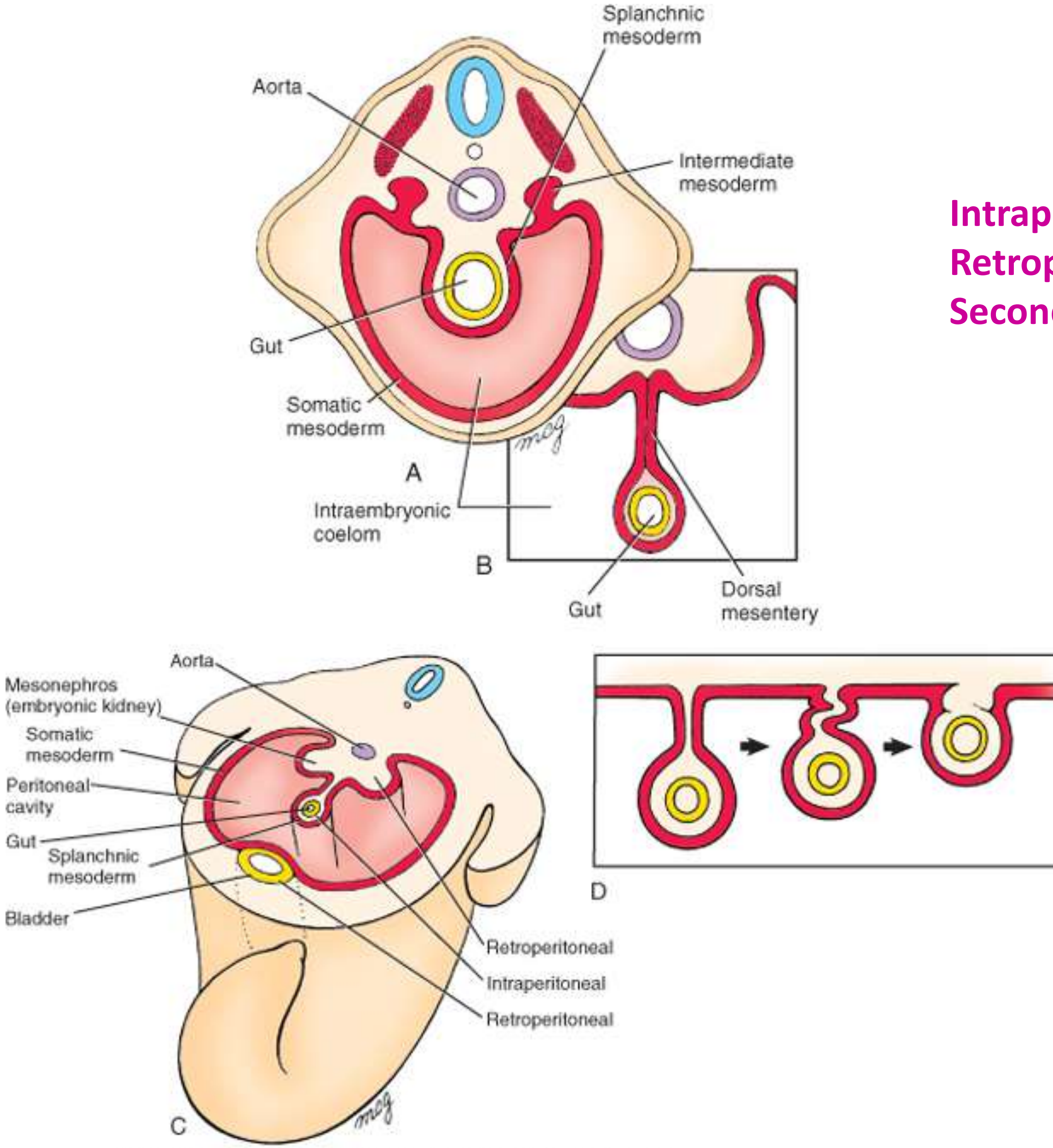


Figure 14-16. Intraperitoneal, retroperitoneal, and secondarily retroperitoneal organs of the abdominal gastrointestinal tract.



Intraperitoneal
Retroperitoneal
Secondarily retroperitoneal

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Omphalocele: failure of the loops to return

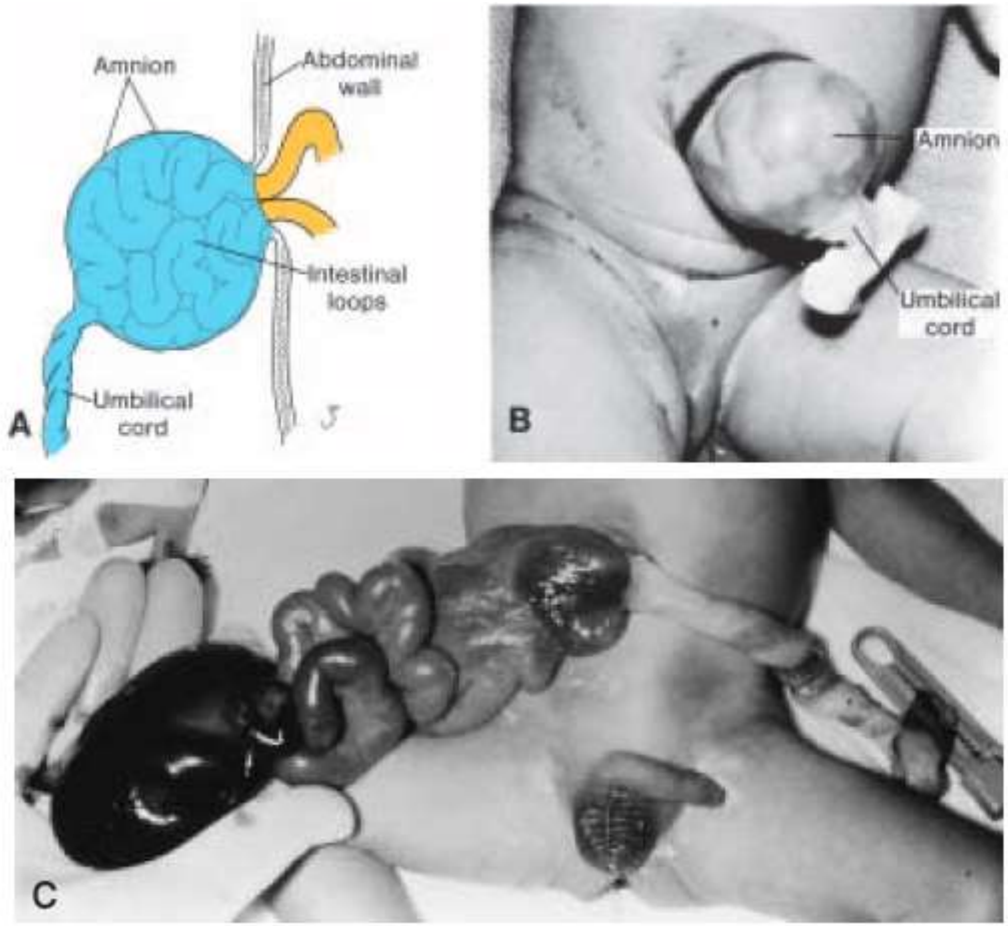
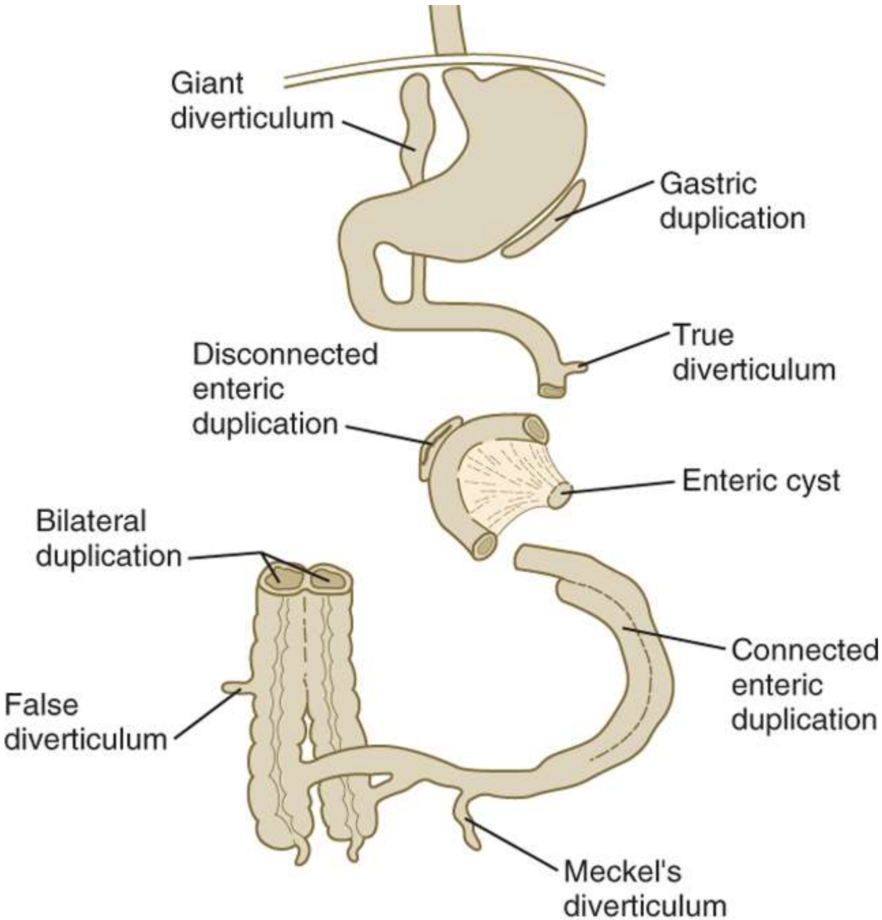


Figure 13.31 A. Omphalocele showing failure of the intestinal loops to return to the body cavity after physiological herniation. The herniated loops are covered by amnion. **B.** Omphalocele in a newborn. **C.** Newborn with gastroschisis. Loops of bowel return to the body cavity but herniate again through the body wall, usually to the right of the umbilicus in the region of the regressing right umbilical vein. Unlike omphalocele, the defect is not covered by amnion.

Gastroschisis: herniation through the body wall

Duplications and diverticula



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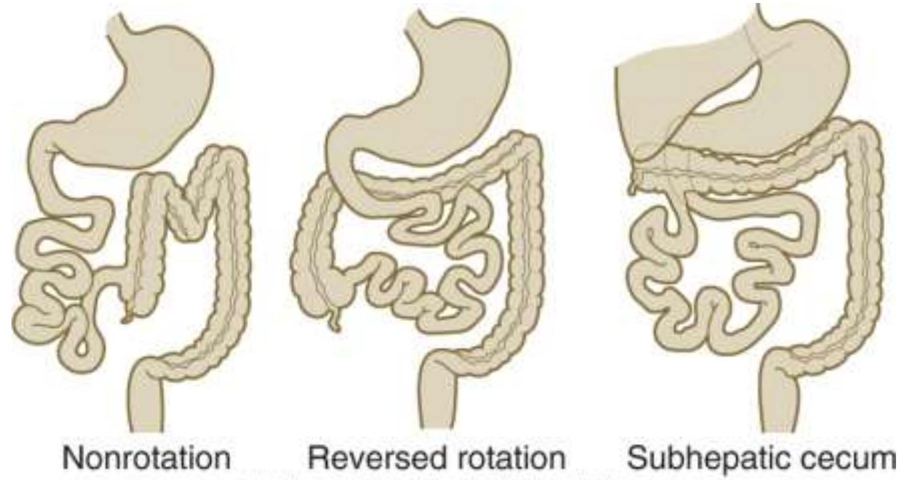
Abnormal rotation



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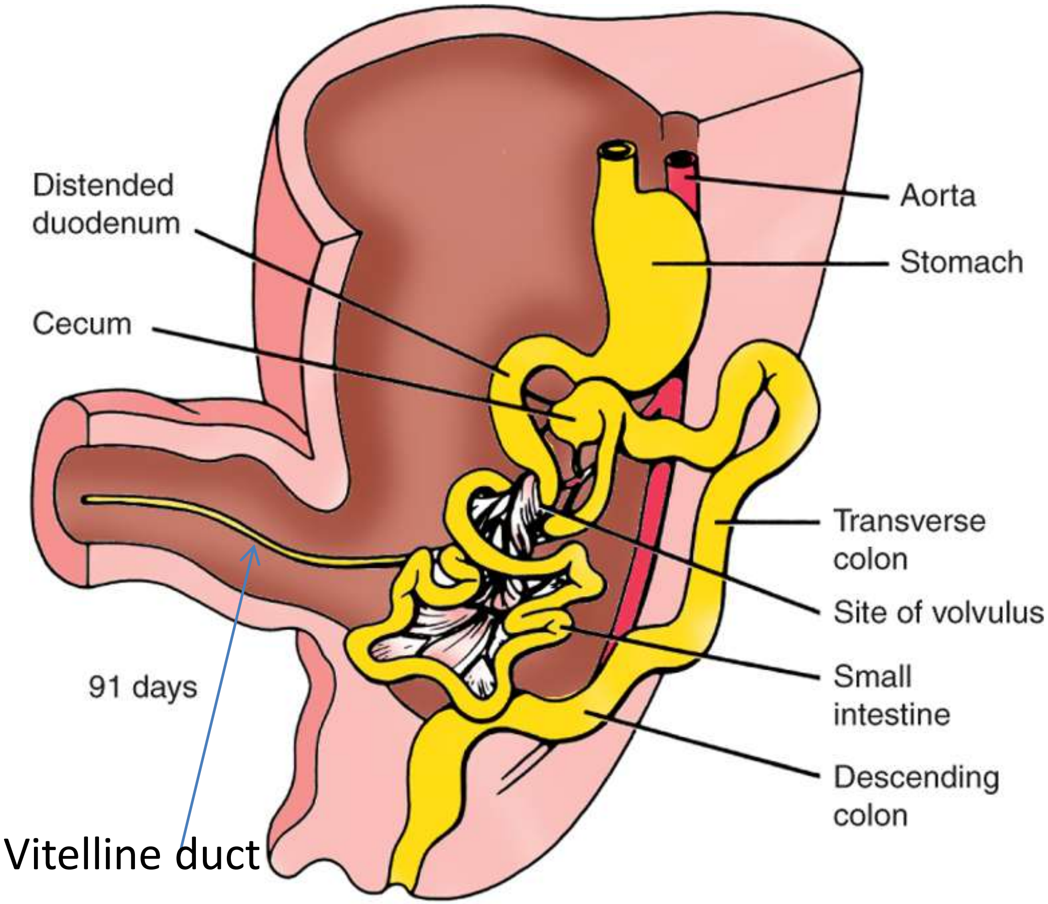
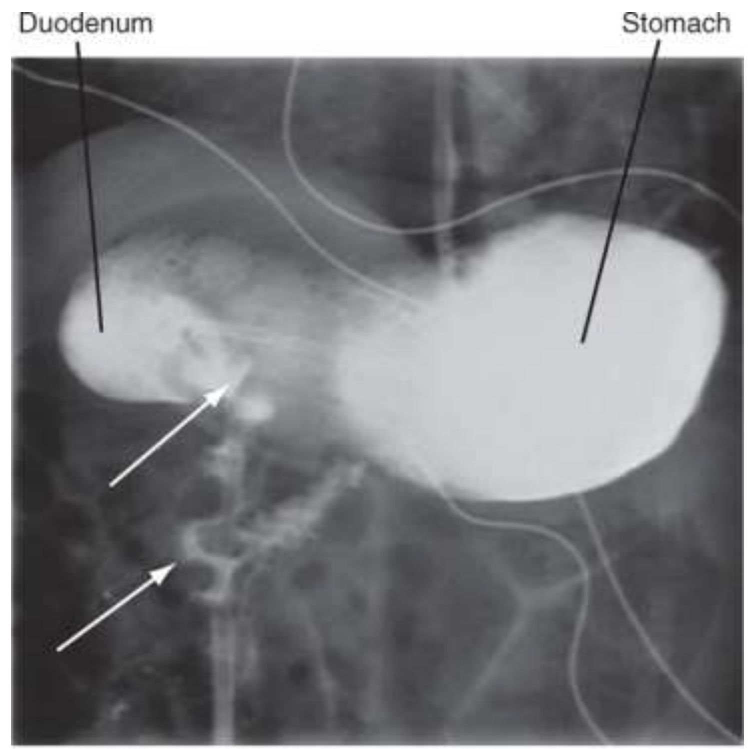
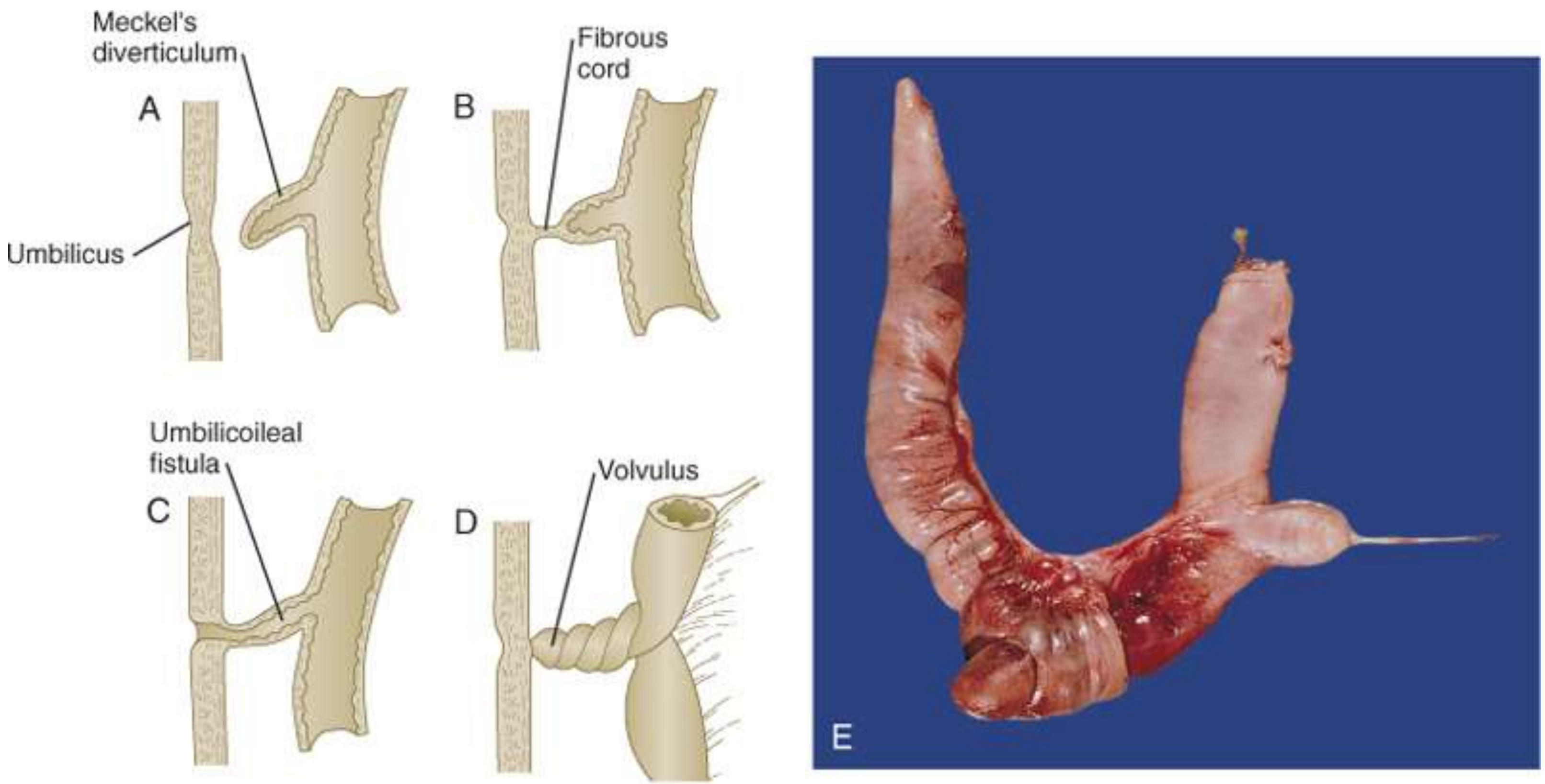
Volvulus: the gut twist around themselves





Remnant of vitelline duct/Meckel diverticulum



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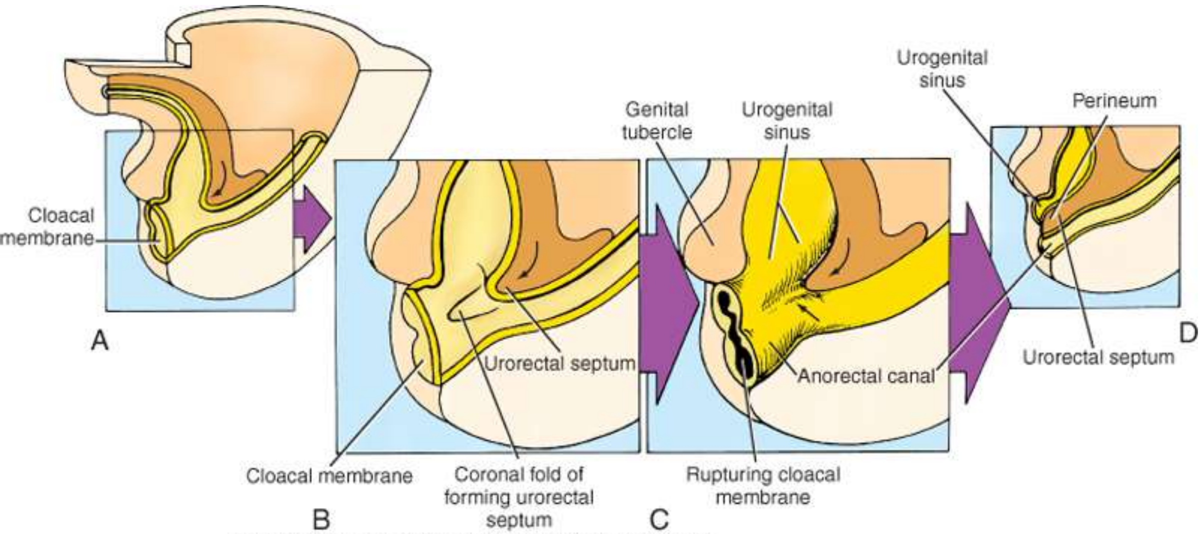
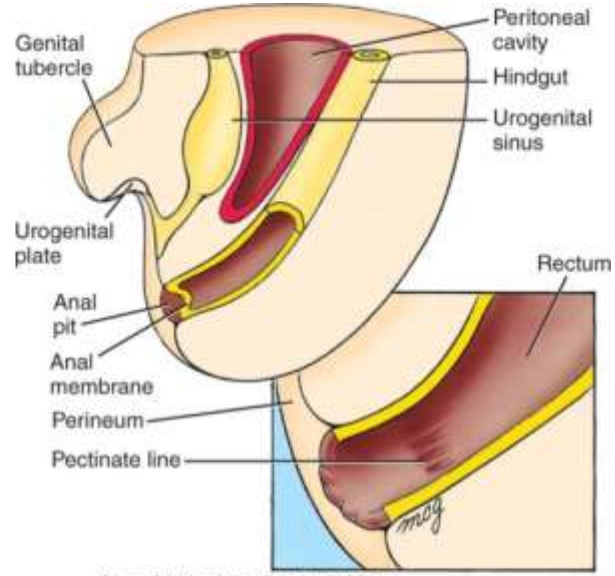
Development of hindgut



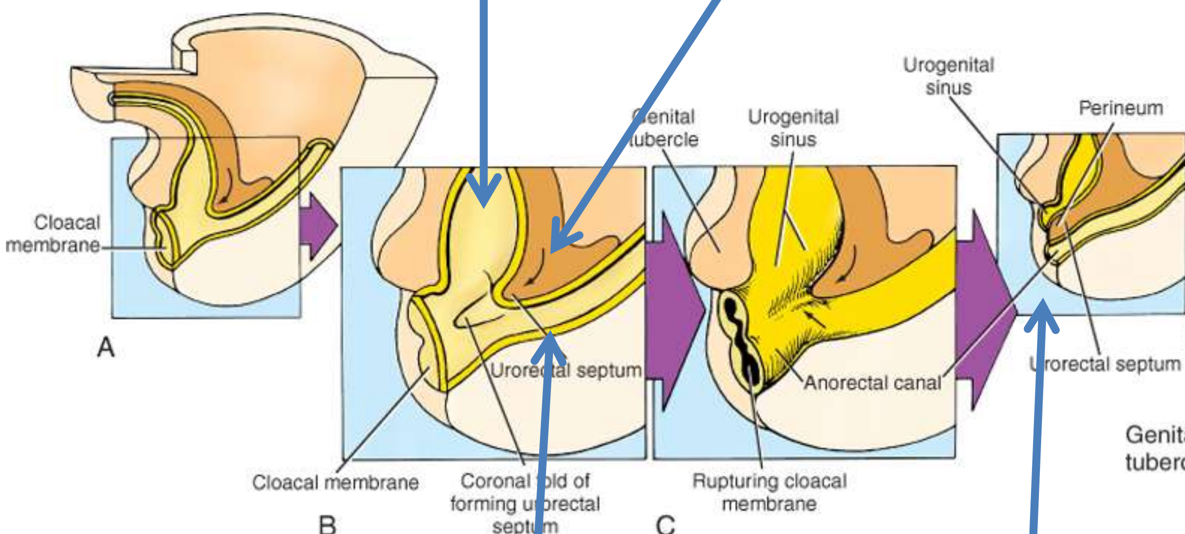


The hindgut gives rise to the distal one third of the transverse colon, the descending and sigmoid colon, and rectum.
Just superior to the cloacal membrane, the primitive gut tube forms an expansion called the cloaca.

Hindgut/urorectal septum

Septum urorectale

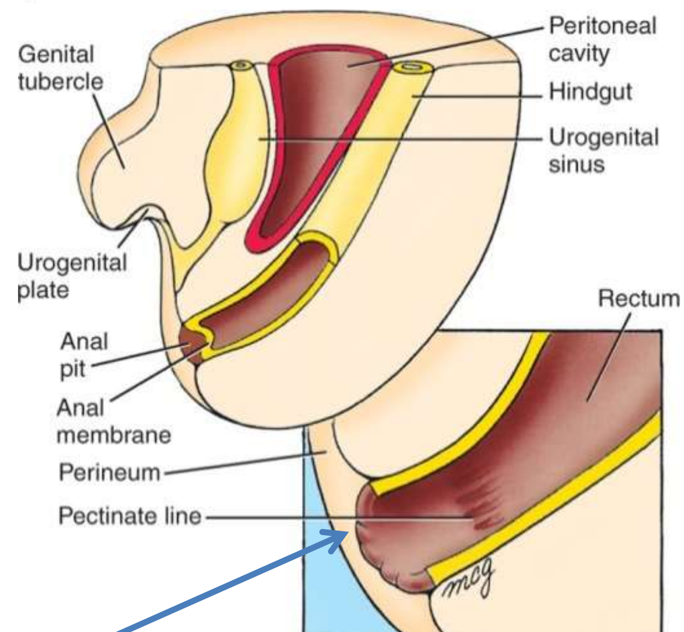
Sinus urogenitalis



Canalis anorectalis

Primer anus

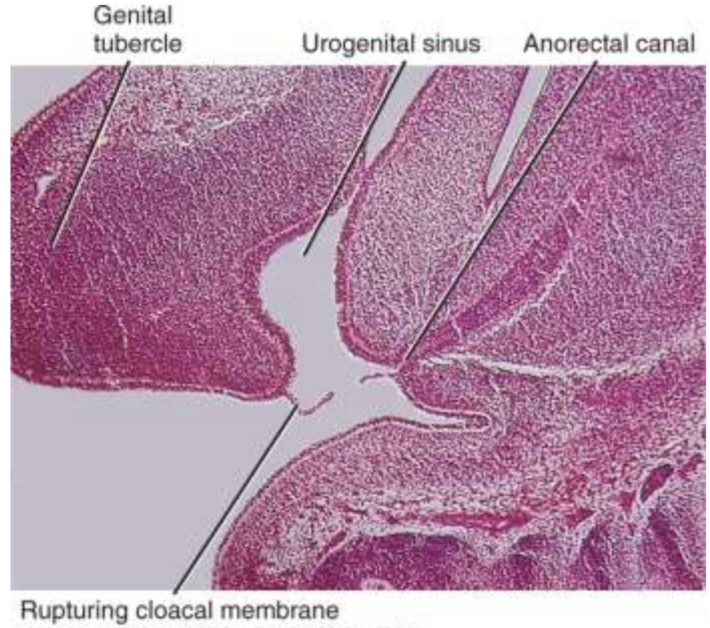
Proctodeum: mesenchymal ring around primer anus

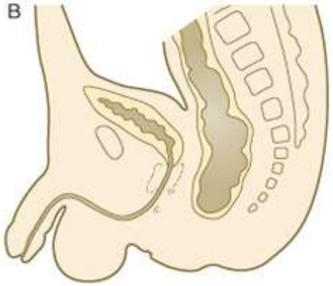


During the 4th to 6th weeks, a coronal urorectal septum partitions the cloaca into the urogenital sinus, which will give rise to urogenital structures and a dorsal anorectal canal. The distal one third of the anorectal canal forms from an ectodermal invagination called the anal pit.

Definitive anus

No proctodeum

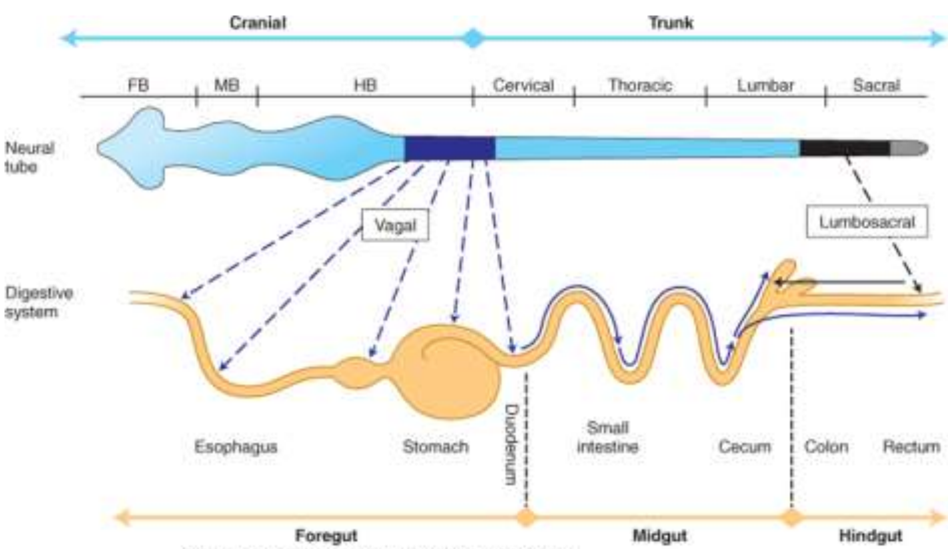


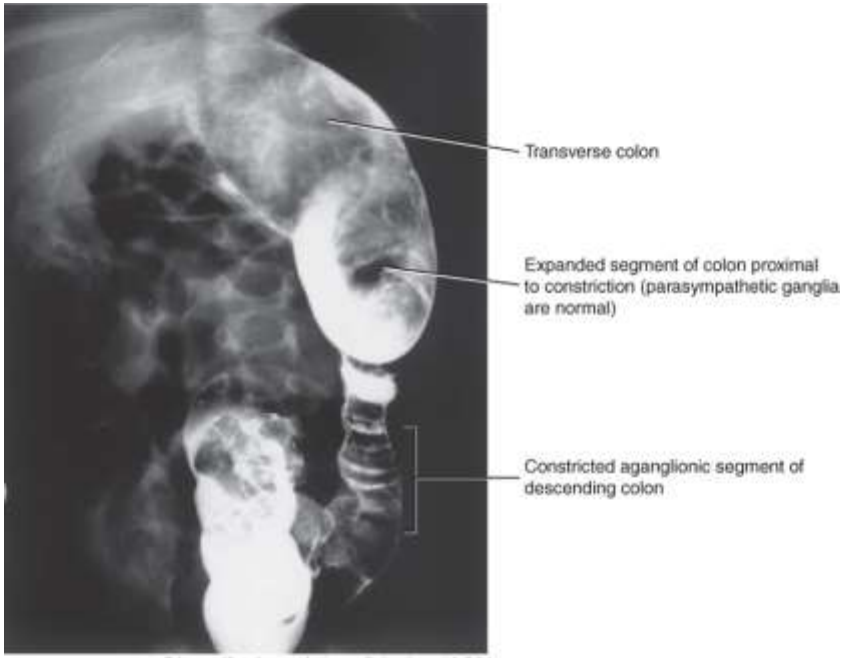


Enteric nervous system develops from the neural crest cells

(Auerbach and Meissner plexus)

it is sometimes referred to as "the brain" of the gastrointestinal tract, or "the second brain" of the body.



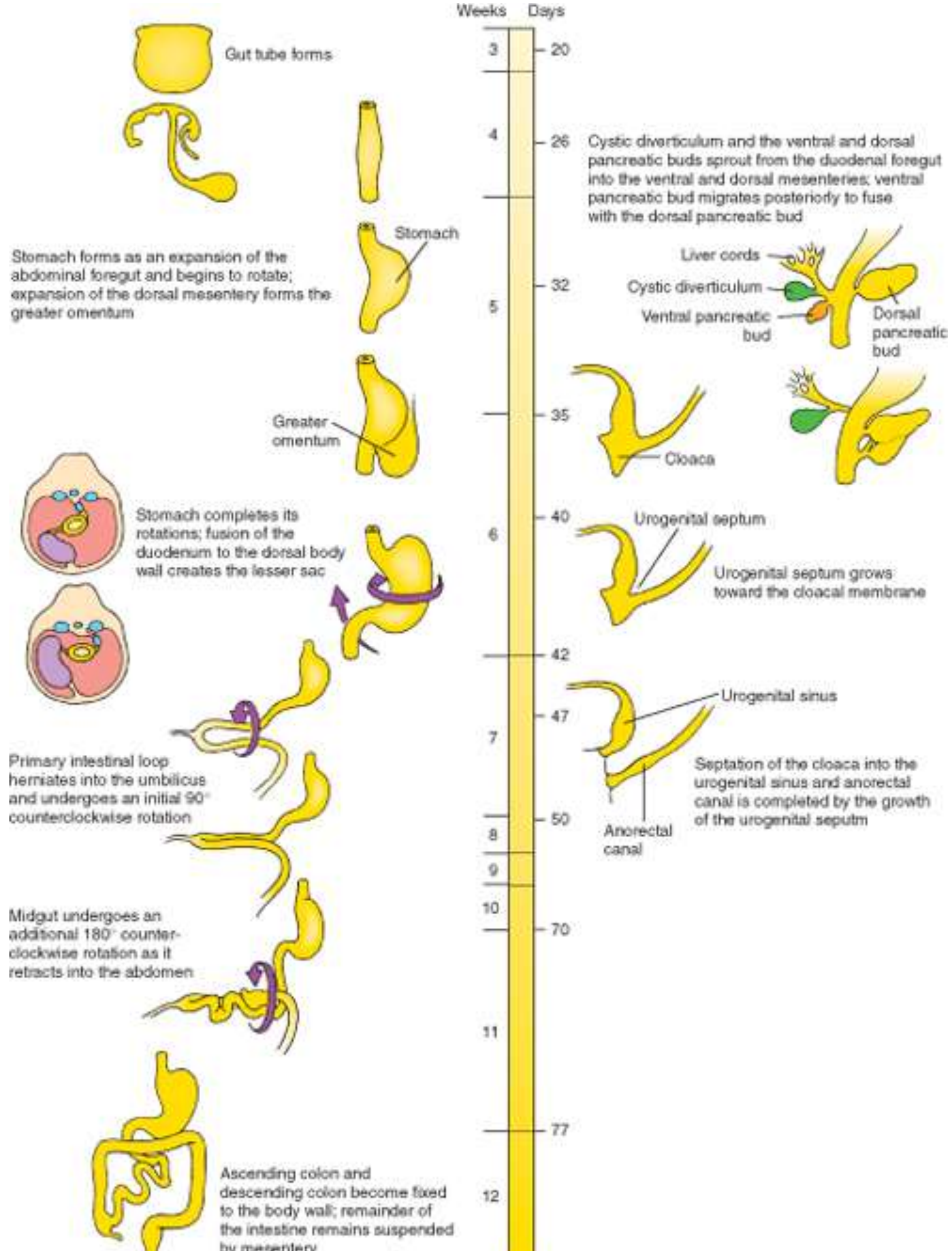


Hirschprung disease
or congenital aganglionic megacolon

Normal

Hirschsprung-disease

Review of gastrointestinal development



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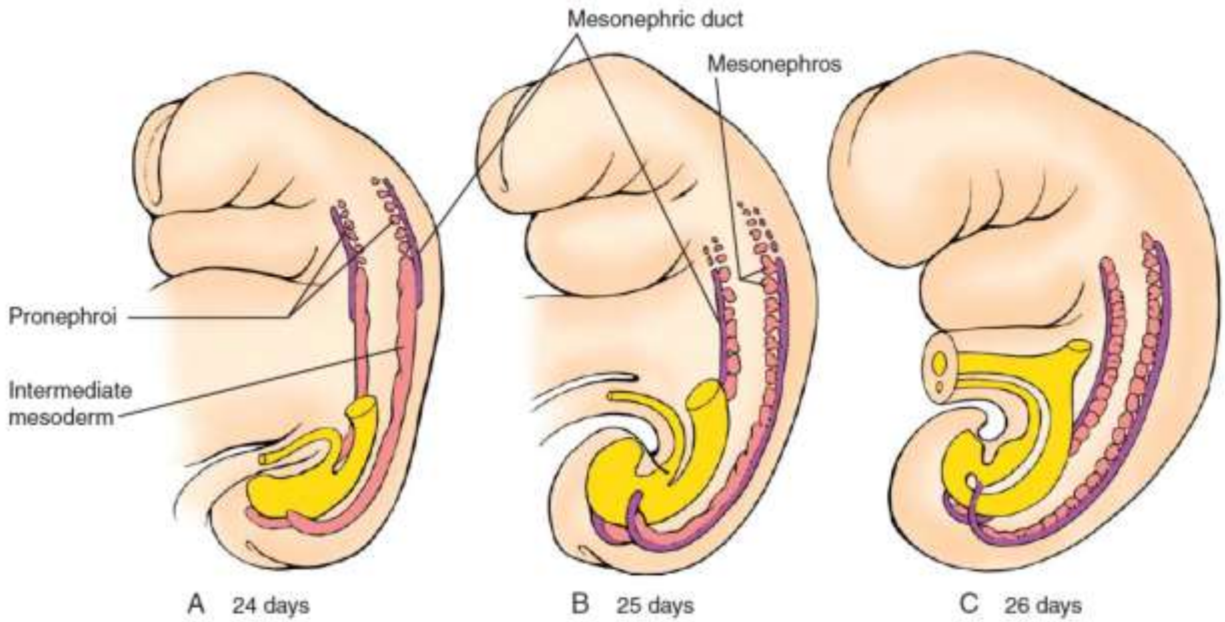
Development of the urogenital system

urinary system

https://www.youtube.com/watch?v=v3Tv86bITZ4

The urinary system maintains the electrolyte and water balance of the body fluids that bathe the tissues in a salty, aqueous environment. The development of this system involves the transient formation and subsequent regression or remodeling of vestigial primitive systems, thereby providing a glimpse of evolutionary history



The intermediate mesoderm on either side of the dorsal body wall gives rise to three successive nephric structures of increasingly advanced design. The intermediate mesoderm, also known as the nephrotome, forms a segmental series of epithelial buds. In the cervical region, these structures presumably represent a vestige of the pronephroi, or primitive kidneys, which develop in some lower vertebrates.

Early in the 4th week, intermediate mesoderm along the fifth to seventh cervical axial levels gives rise to a small duct generated by epithelialization of some of the intermediate mesoderm. This duct is called the **mesonephric duct** (or **wolffian duct**). The mesonephric ducts first appear as a pair of solid longitudinal rods that condense within the intermediate mesoderm beginning in the pronephric region (Figs. 15-2*A*, 15-3). These rods grow in a caudal direction owing to the proliferation and migration of the cells at their caudal tips. Meanwhile, intermediate mesoderm ventromedial and adjacent to the mesonephric duct, condenses and reorganizes into a series of epithelial buds (see Fig. 15-2). These buds, which quickly become hollow, constitute the **pronephros** (plural, pronephroi; derived from the Greek for "first kidney") because they resemble the functional embryonic pronephroi of some lower vertebrates. In humans, these units do not differentiate into functional excretory structures but instead cease developing and disappear by day 24 or 25.

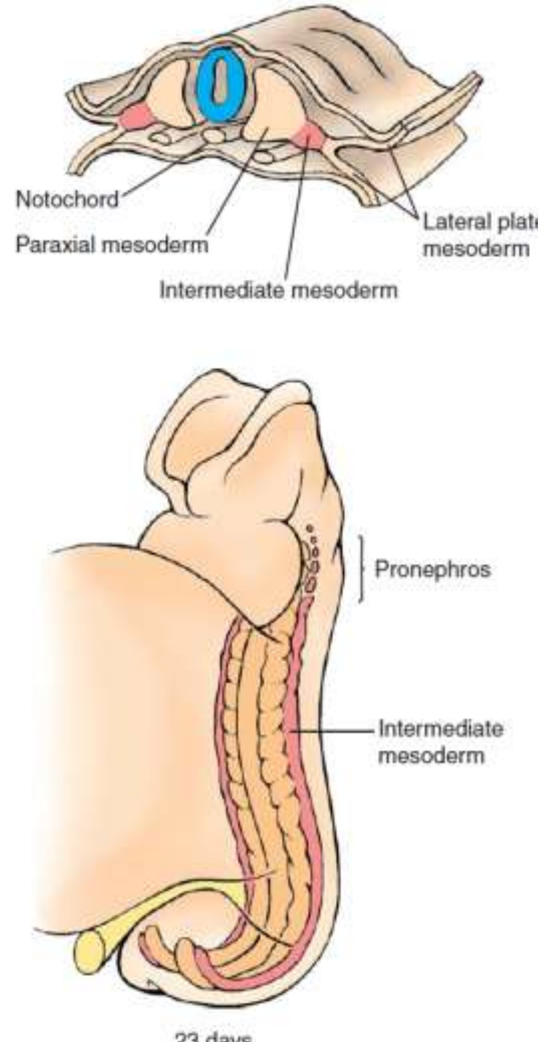


Figure 15-1. The intermediate mesoderm gives rise to paired, segmentally organized buds from the cervical to the sacral region. The pronephros is initially formed early in the 4th week in the cervical region.

As the mesonephric ducts develop and extend caudally, they induce the formation of **mesonephric tubules** from mesenchyme in the more caudal intermediate mesoderm, thereby initiating mesonephros formation (Fig. 15-2*B*, *C*). As the ducts grow into the lower lumbar region, they diverge from the intermediate mesoderm and grow toward and fuse with the ventrolateral walls of the cloaca on day 26 (Figs. 15-4*A*, see Fig. 15-2). This region of fusion will become a part of the posterior wall of the future bladder. As the rods fuse with the cloaca, they begin to cavitate at their distal ends to form a lumen, and this canalization progresses cranially. At its caudal end, the mesonephric duct induces the evagination of the ureteric bud (see Fig. 15-4).

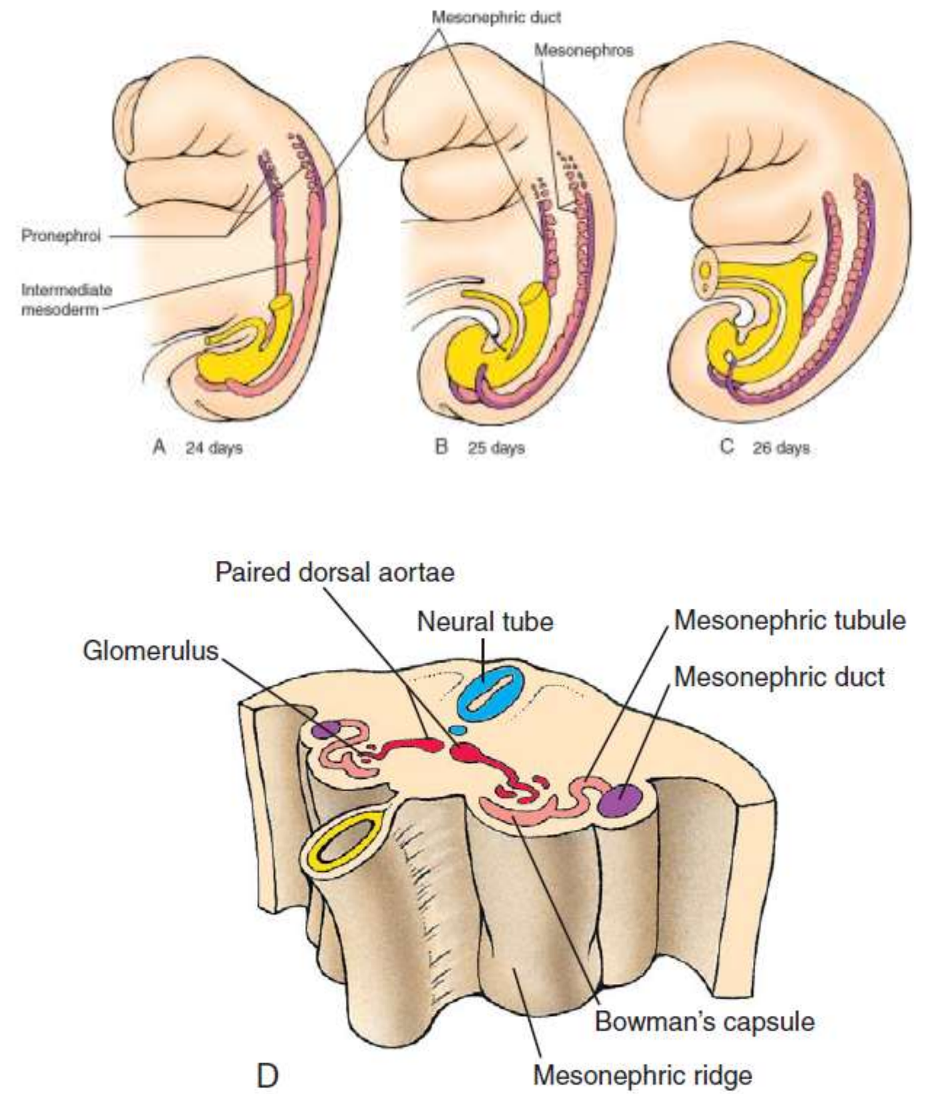


Figure 15-2. Development of the pronephros and mesonephros. *A*, A pair of pronephroi form along the fifth to seventh cervical segments, but these quickly degenerate during the 4th week. The mesonephric ducts first appear on day 24. *B*, *C*, Mesonephric tubules form in craniocaudal sequence throughout the thoracic and lumbar regions. The more cranial pairs regress as caudal pairs form, and the definitive mesonephroi contain about 20 pairs, confined to the first three lumbar segments. *D*, The mesonephroi contain functional nephric units consisting of glomeruli, Bowman's capsules, mesonephric tubules, and mesonephric ducts.

Development of Mesonephros

Early in the 4th week, mesonephric tubules begin to develop within intermediate mesoderm adjacent the mesonephric duct on either side of the vertebral column, from the upper thoracic region to the third lumbar level (see Fig. 15-2*B*, *C*). About 40 **mesonephric tubules** are produced in craniocaudal succession; thus, several form in each segment. Because the gonads begin developing just medial to the mesonephric ridge, this region is sometimes collectively referred to as the **urogenital ridge**. As the more caudal tubules differentiate, the more cranial ones regress, so there are never more than about 30 pairs in the mesonephroi. By the end of the 5th week, the cranial regions of the mesonephroi undergo massive regression, leaving only about 20 pairs of tubules occupying the first three lumbar levels. The mesonephric tubules differentiate into excretory units resembling an abbreviated version of the adult metanephric nephron (see Fig. 15-2*D*; discussed later) with the medial end of the tubule forming a cup-shaped sac, called a **Bowman's capsule**, which wraps around a knot of capillaries called a **glomerulus** to form a **renal corpuscle**.

The lateral tip of each developing mesonephric tubule fuses with the mesonephric duct, thus opening a passage from the excretory units to the cloaca. The mesonephric excretory units are functional between about 6 and 10 weeks and produce small amounts of urine. After 10 weeks, they cease to function and then regress. As discussed later, the mesonephric ducts also regress in the female. However, in the male the mesonephric ducts, plus a few modified mesonephric tubules, persist and form important elements of the male genital duct system.

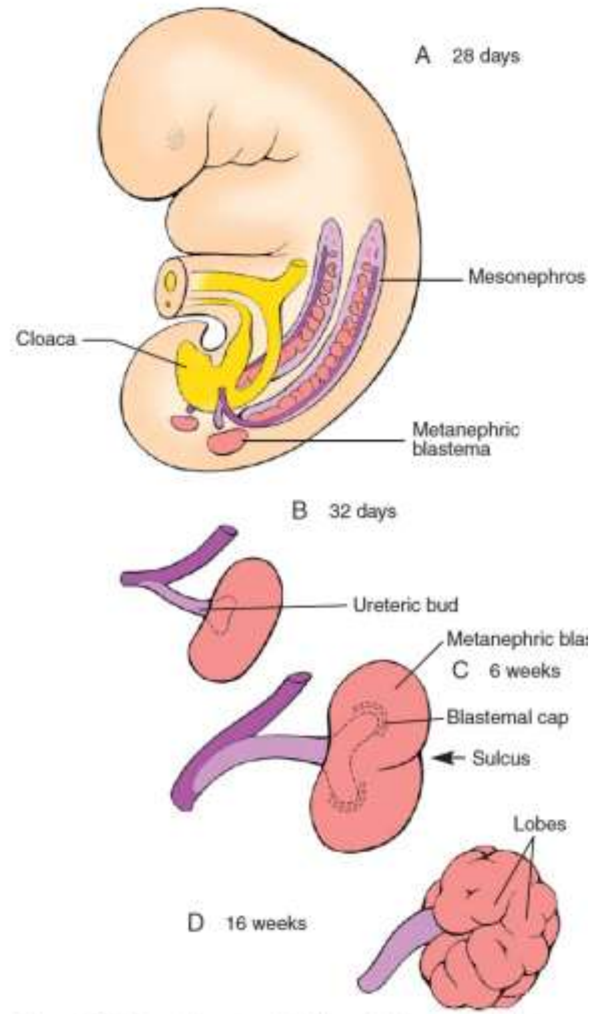


Figure 15-4. Origin of the metanephric kidneys. *A*, A metanephric blastema develops from intermediate mesoderm on each side of the body axis early in the 5th week. *B*, Simultaneously, each mesonephric duct sprouts a ureteric bud that grows into each metanephric blastema. *C*, By the 6th week, the ureteric bud bifurcates and the two growing tips (ampullae) induce cranial and caudal lobes in the metanephros. *D*, Additional lobules form during the next 10 weeks in response to further bifurcation of the ureteric buds.

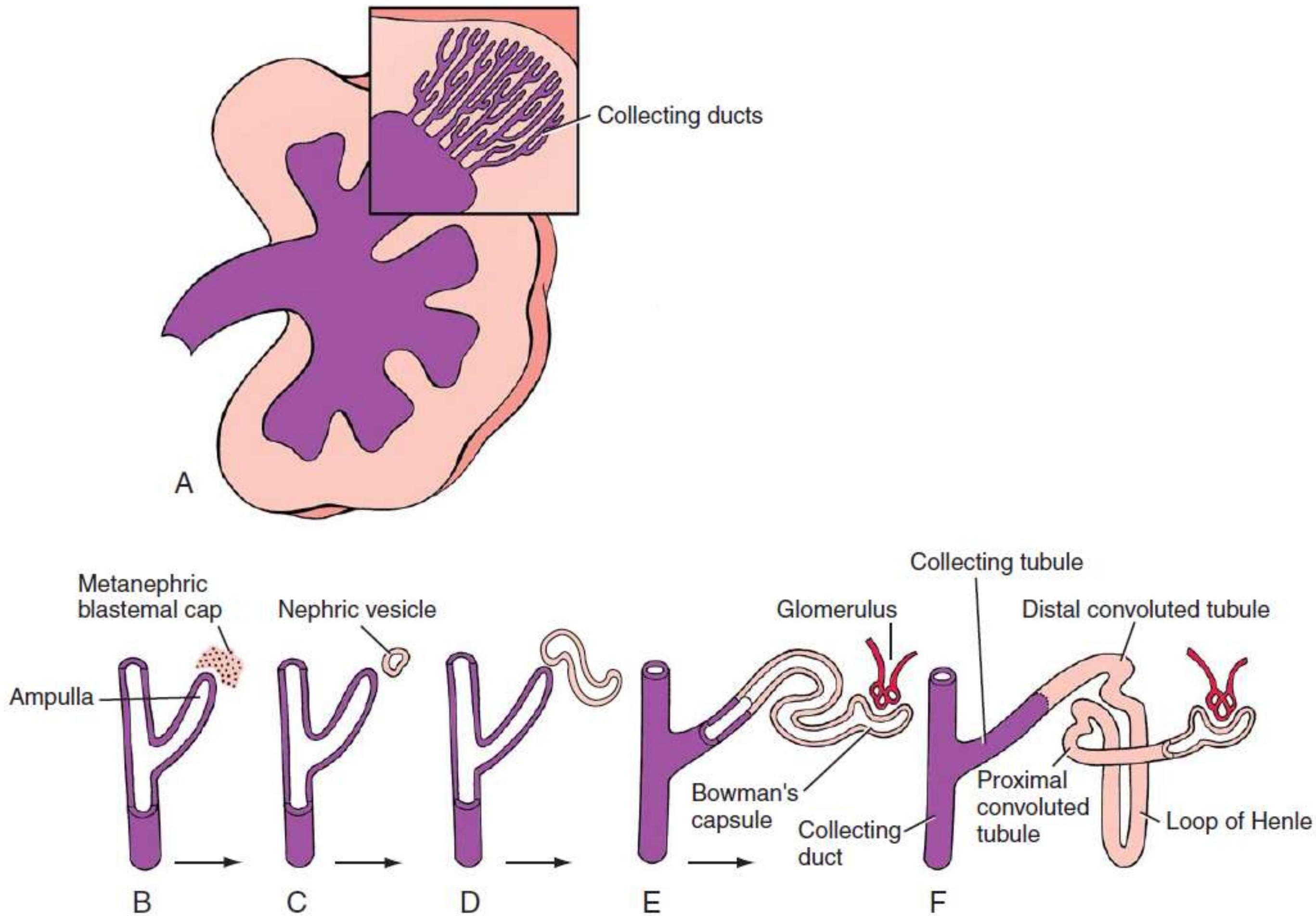
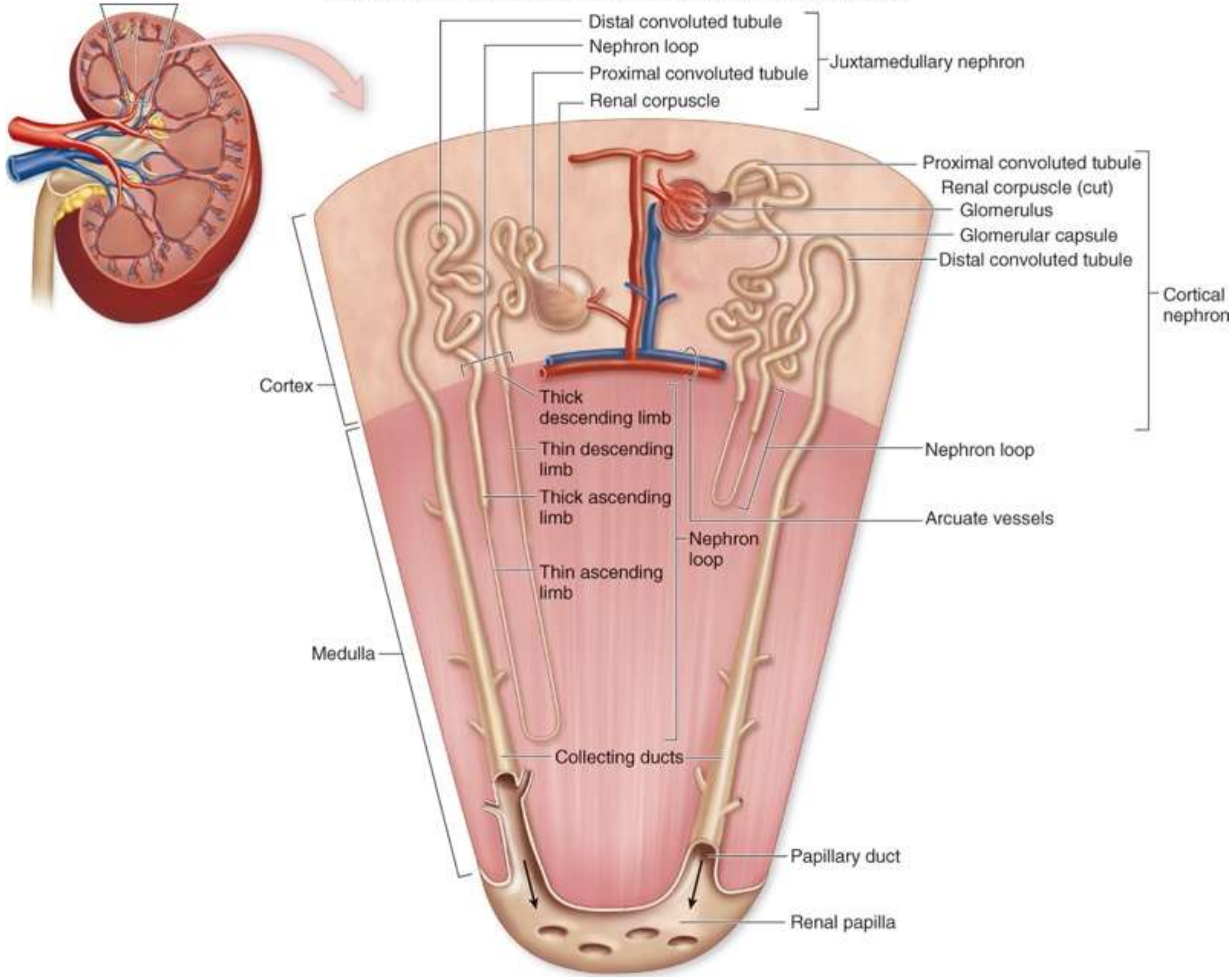


Figure 15-5. Development of the renal collecting system and nephrons. *A*, The ureteric buds continue to bifurcate until the 32nd week, producing 1 to 3 million collecting tubules and ducts. *B-F*, The tip of each collecting tubule induces the development of a metanephric blastemal cap, which differentiates into a nephric vesicle. This vesicle ultimately forms a Bowman's capsule and the proximal and distal convoluted tubules and loops of Henle. Functional nephric units (of the type shown in *E*) first appear in distal regions of the metanephros at 10 weeks.



Distal convoluted tubule
Nephron loop
Proximal convoluted tubule
Renal corpuscle
Juxtamedullary nephron
Proximal convoluted tubule
Renal corpuscle (cut)
Glomerulus
Glomerular capsule
Distal convoluted tubule
Cortical nephron
Cortex
Thick descending limb
Thin descending limb
Thick ascending limb
Thin ascending limb
Nephron loop
Nephron loop
Arcuate vessels
Medulla
Collecting ducts
Papillary duct
Renal papilla

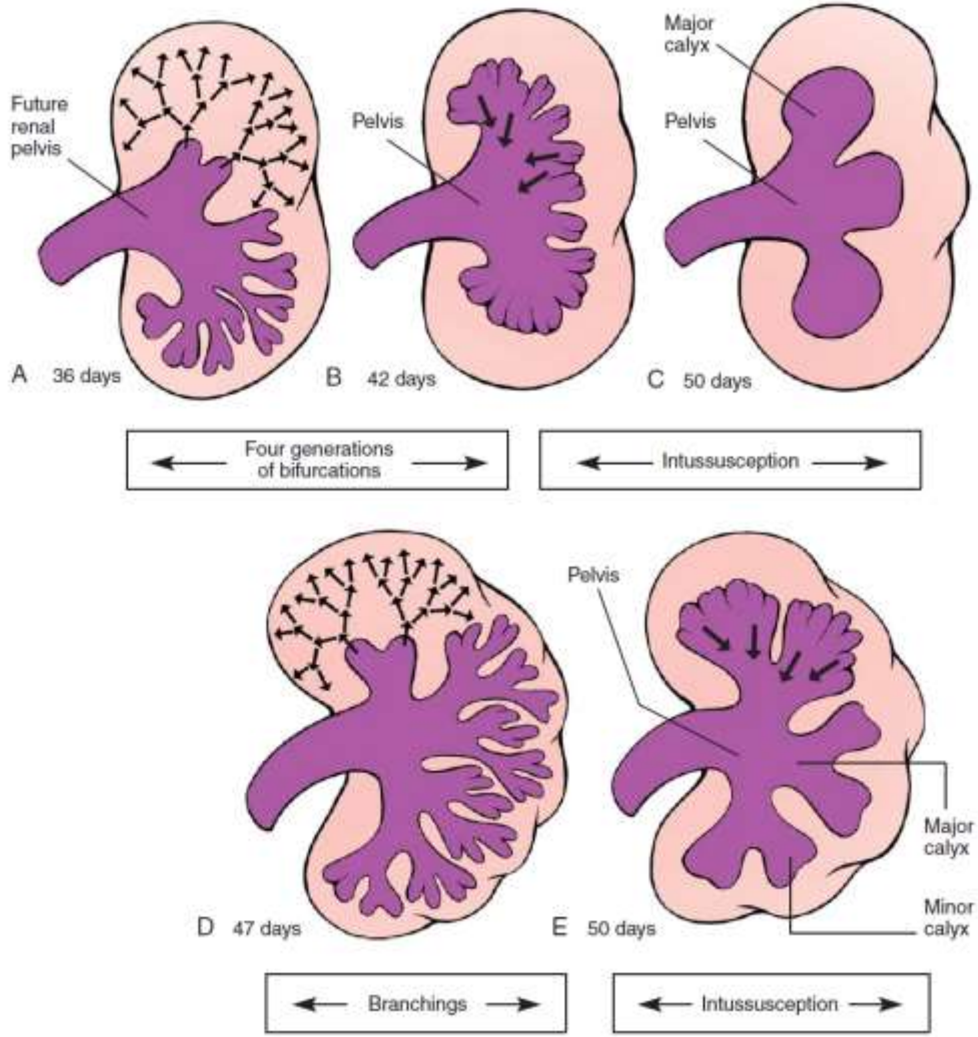


Figure 15-6. Development of the renal pelvis and calyces. *A–C*, The first bifurcation of the ureteric bud forms the renal pelvis, and the coalescence of the next 4 generations of bifurcations produces the major calyces. *D*, *E*, The next 4 generations of bifurcation coalescese to form the minor calyces of the renal collecting system.

By the 7th week, the next four generations of branches also coalesce, forming the **minor calyces**. By 32 weeks, approximately 11 additional generations of bifurcation have formed 1 to 3 million branches, which will become the future collecting tubules and ducts of the kidney (see Fig. 15-5*A*). The definitive morphology of the collecting ducts is created by variations in the pattern of branching and by a tendency for distal branches to elongate.

Each nephron originates as an epithelial (nephric) vesicle within the blastemic cap surrounding the ampulla of a collecting tubule (see Fig. 15-5*B*). Formation of nephron involves several stages (see Fig. 15-5*B-F*). First, the nephric vesicle develops into a comma-shaped structure and then forms an S-shaped tubule. The S-shaped tubule fuses with the ureteric duct, and eventually the two lumina become continuous forming the so-called **uriniferous tubule**. Meanwhile, the renal corpuscle segment of the nephric tubule forms the outer (parietal) layer of Bowman's capsule and glomerular epithelial cells (**podocytes**) that surround the glomerular tuft of capillaries forming within the adjacent stroma. While the renal corpuscle is forming, the lengthening nephric tubule forms the remaining elements of the nephron: the proximal convoluted tubule, descending and ascending limbs of the loop of Henle, and distal convoluted tubule. The definitive nephron with its renal corpuscle is also called a **metanephric excretory unit**. The medulla of the kidney also begins to take shape as the growing nephron tubules and interstitial tissue develops. **Nephrogenesis** is complete by birth in humans.

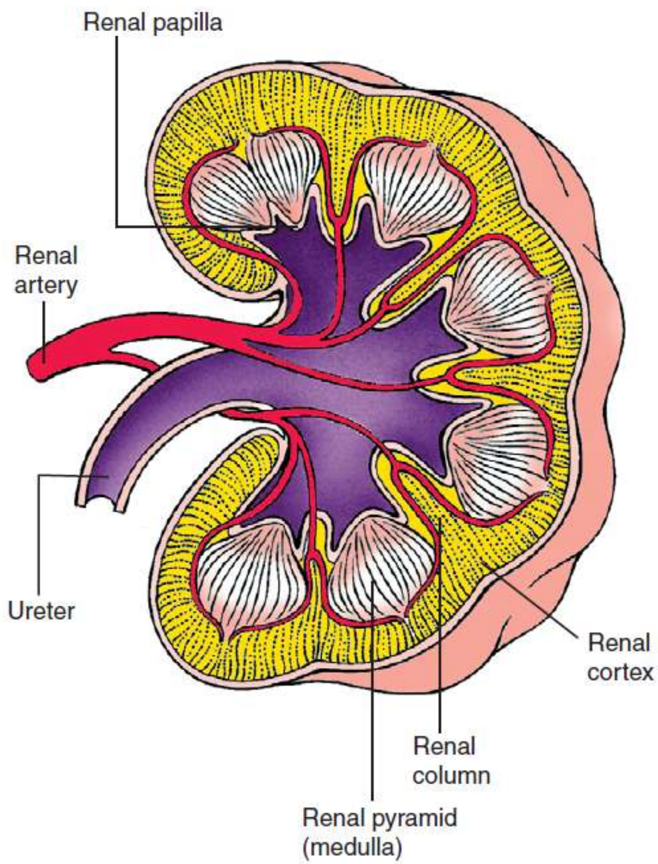
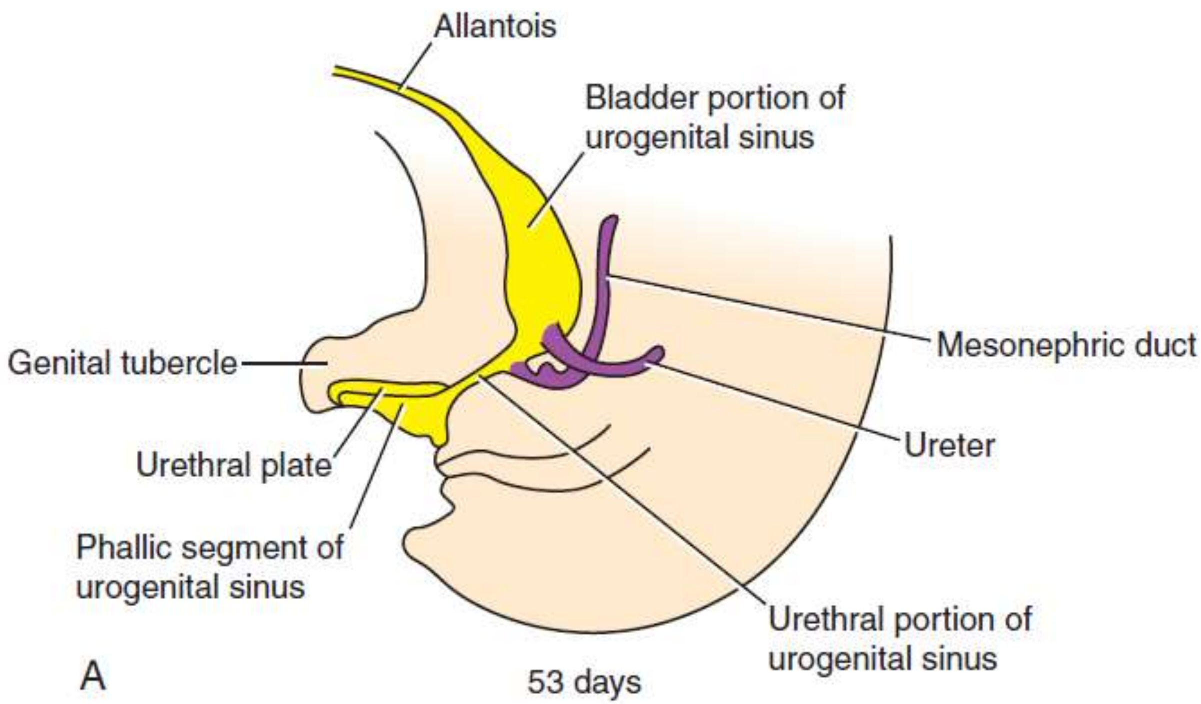


Figure 15-7. The definitive renal architecture of the metanephros is apparent by the 10th week.

Morphogenesis of the renal vascular supply during the development of the nephron and collecting systems is poorly understood. Organ cultures and interspecies grafting experiments show that angiogenesis is likely the major mechanism responsible for the development of the renal vasculature, including the glomerular capillaries. However, the prevascular metanephric

The cloaca (the distal expansion of the hindgut) is partitioned into a dorsal anorectal canal and a ventral urogenital sinus. The latter is continuous with the allantois, which projects toward the umbilical cord.



The expanded superior portion of the urogenital sinus becomes the bladder, whereas its inferior portion gives rise (in males) to the pelvic urethra (membranous and prostatic) and penile urethra and (in females) to the pelvic urethra (membranous) and vestibule of the vagina. During this period, the openings of the mesonephric ducts are translocated down onto the pelvic urethra by a process that also emplaces the openings of ureters on the bladder wall.

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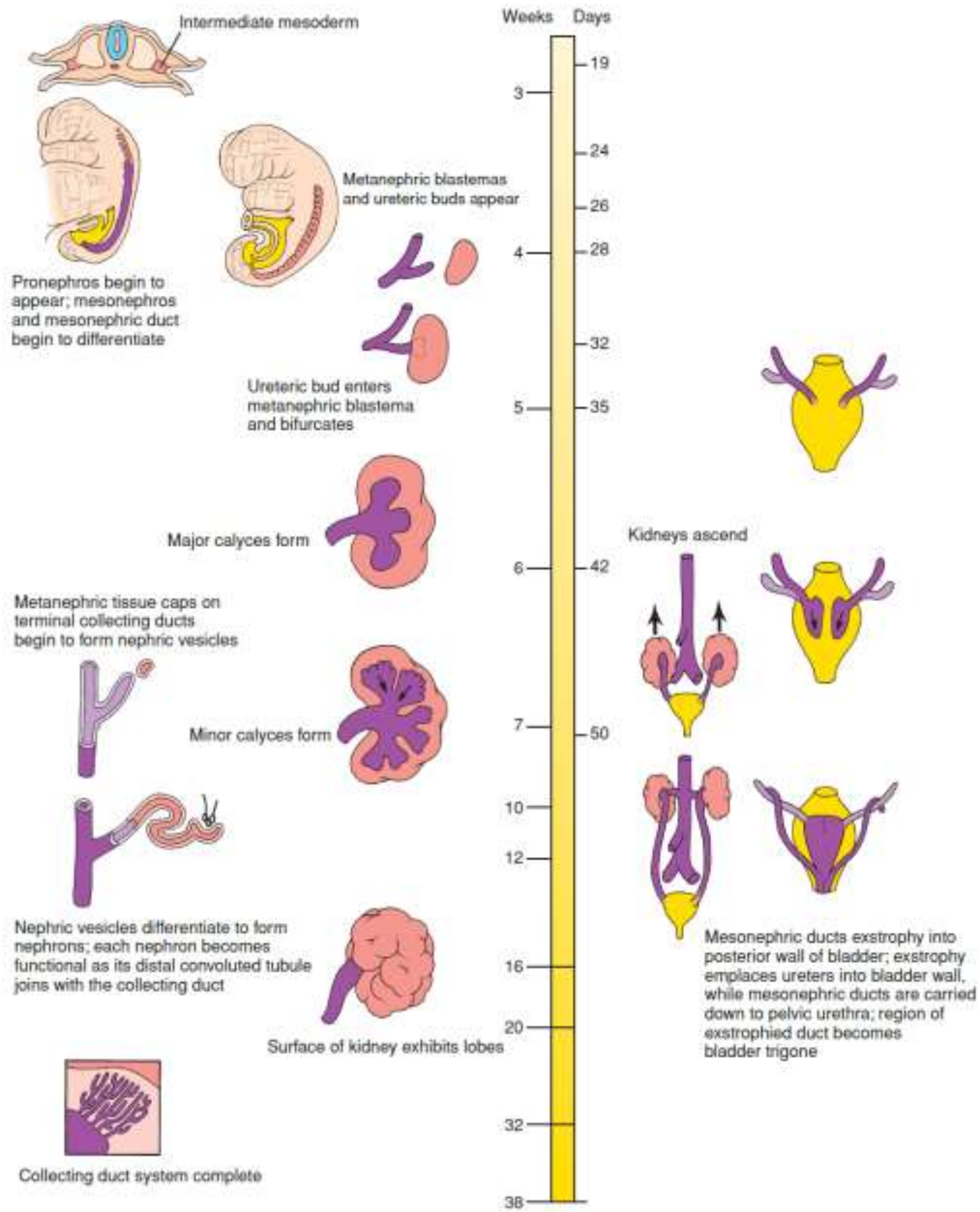


Time line. Development of the urinary system.

Genital System Arises with Urinary System

The development of the genital system is closely integrated with the primitive urinary organs in both males and females, as they share similar common tubular structures enabling both uresis and gamete transport.

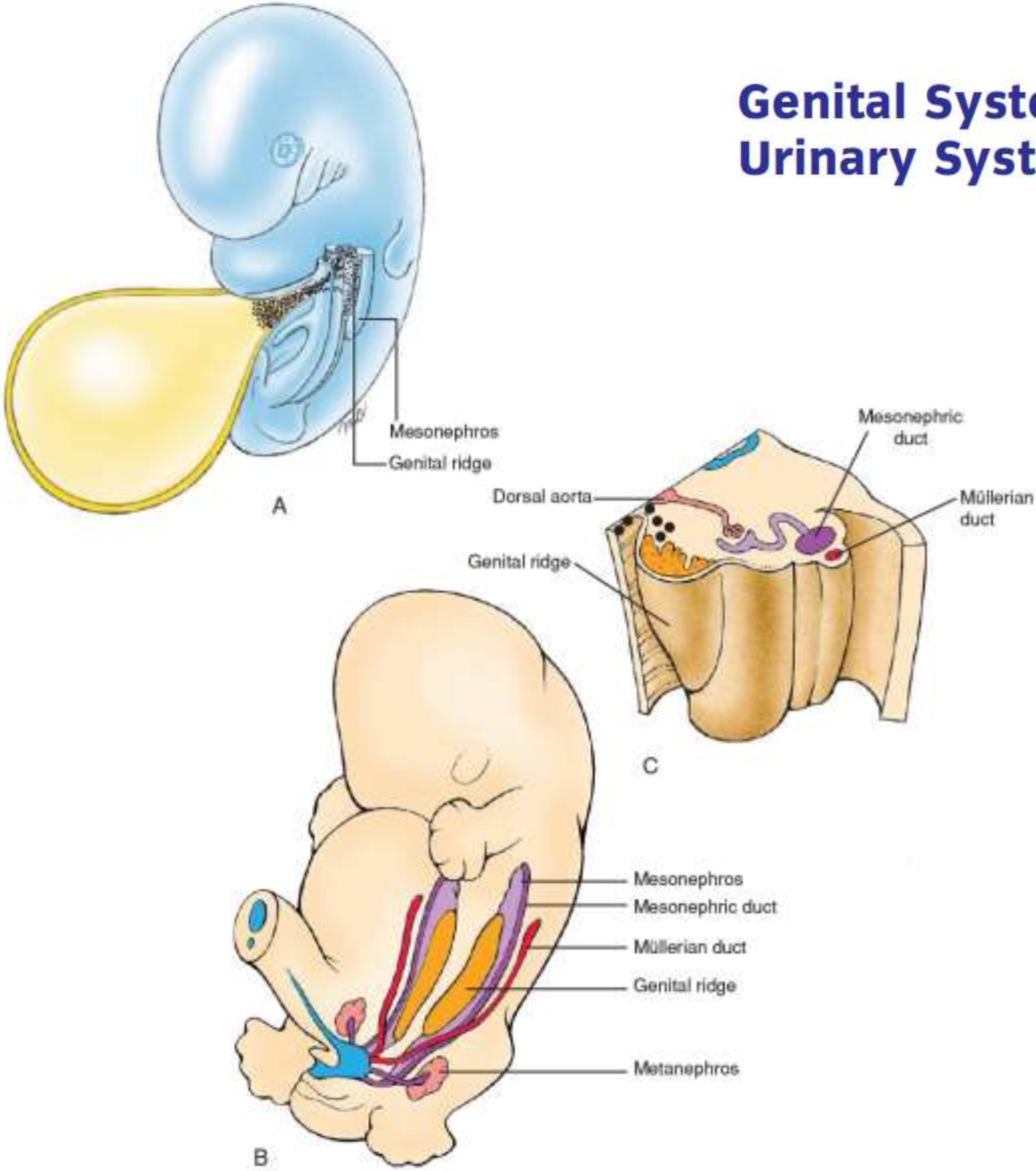
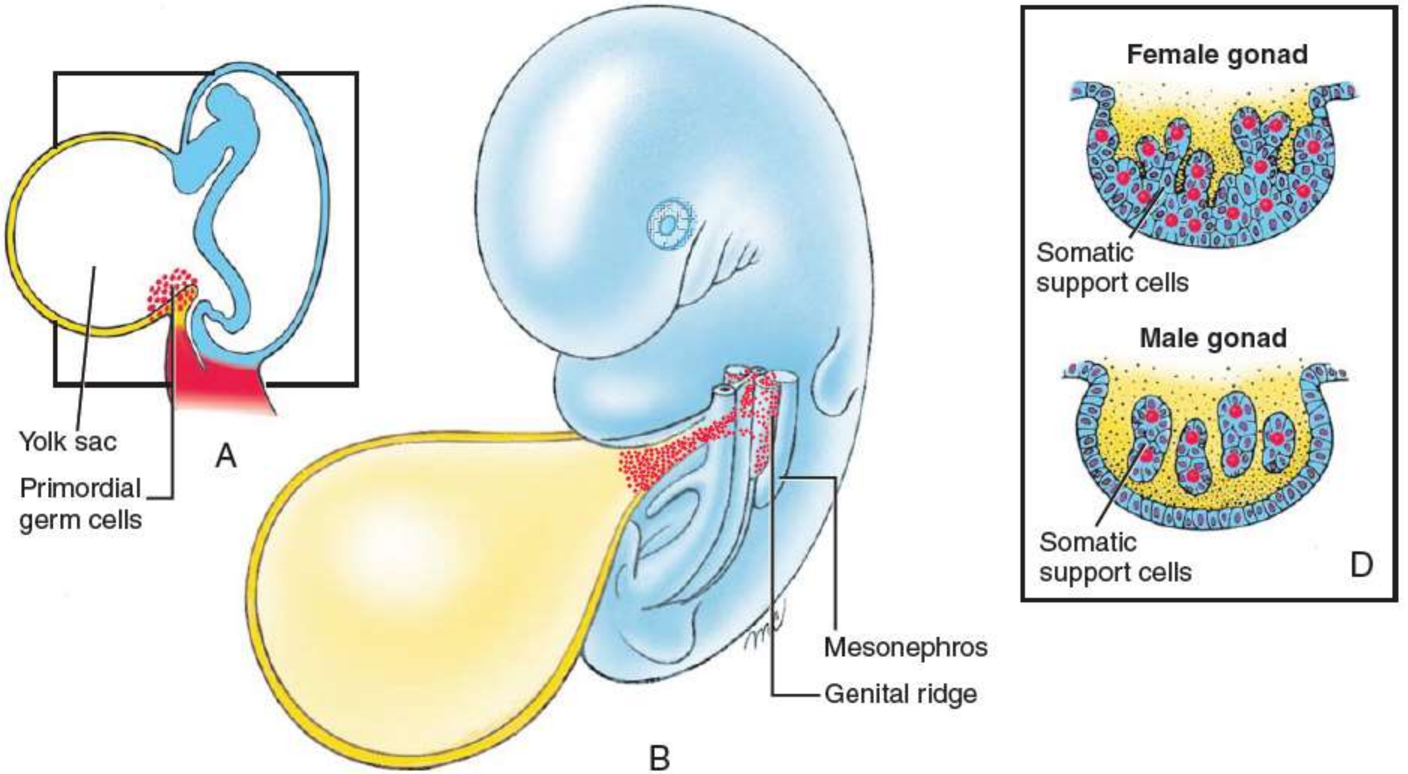


Figure 15-16. Formation of the genital ridges. *A*, *B*, During the 5th and 6th weeks, the genital ridges form in the posterior abdominal wall just medial to the developing mesonephroi in response to colonization by primordial germ cells migrating from the yolk sac. *C*, The primordial germ cells induce the coelomic epithelium lining the peritoneal cavity as well as cells of the mesonephros to proliferate and form the somatic support cells.

https://www.youtube.com/watch?v=MureNA-RSZM

The arrival of germ cells in the area just medial to the mesonephroi at the 10th thoracic segment induces cells of the mesonephros and adjacent coelomic epithelium to become somatic support cells that invest the germ cells.



TERATOMA FORMATION

Teratomas, tumors composed of tissues derived from all three germ layers, can be extragonadal or gonadal and are derived from PGCs. Sacrococcygeal teratomas are the most common tumors in newborns and occur in 1 in 20,000 to 70,000 births (see Fig. 1-1*C*). They occur four times more frequently in female newborns than in male newborns, and they represent about 3% of all childhood malignancies. Gonadal tumors are usually diagnosed after the onset of puberty. Both ovarian and testicular teratomas can form. The **pluripotency** (ability to form many cell types, not to be confused with **totipotency**, the ability to form *all* cell types) of teratomas is exhibited by their ability to give rise to a variety of definitive anatomic structures, including hair, teeth, pituitary gland, and even a fully formed eye.

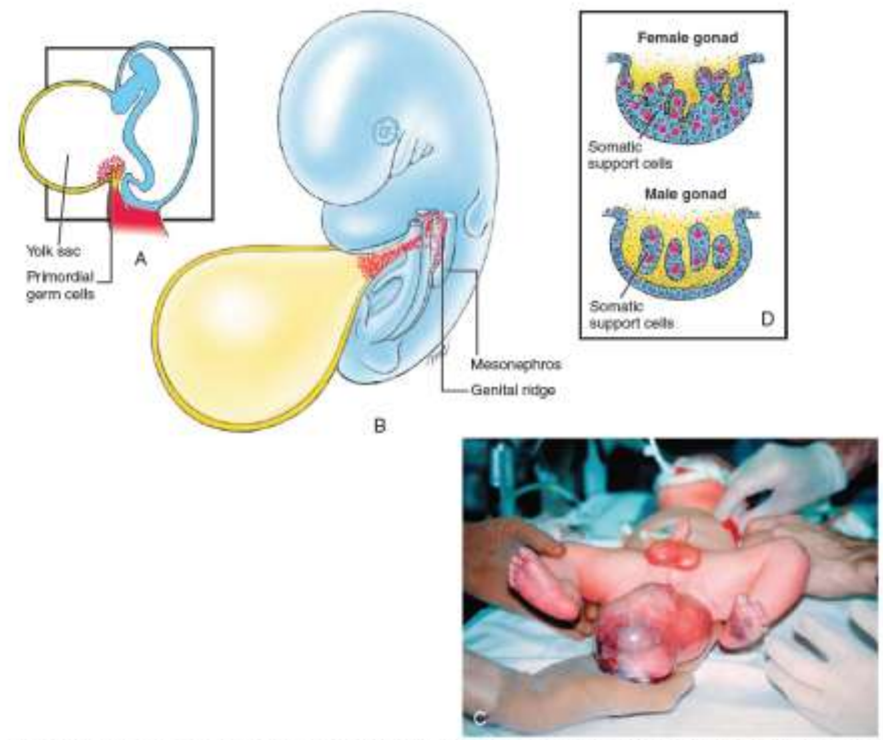


Figure 1-1. *A*, Primordial germ cells (PGCs) reside in the endodermal layer of the caudal side of the yolk sac during 4 to 6 weeks of development and then migrate to the dorsal body wall. *B*, Between 6 and 12 weeks, PGCs stimulate formation of the genital ridges. *C*, Infant with a large sacrococcygeal teratoma. *D*, Somatic support cells differentiate and invest PGCs. In females, somatic support cells become ovarian follicle cells; in males, somatic support cells become Sertoli cells of the seminiferous tubules.

Somatic support cells will differentiate into Sertoli cells in the male and follicle cells (or granulosa cells) in the female. During the same period, a new pair of ducts, the **müllerian (paramesonephric) ducts**, form in the dorsal body wall just lateral to the mesonephric ducts.

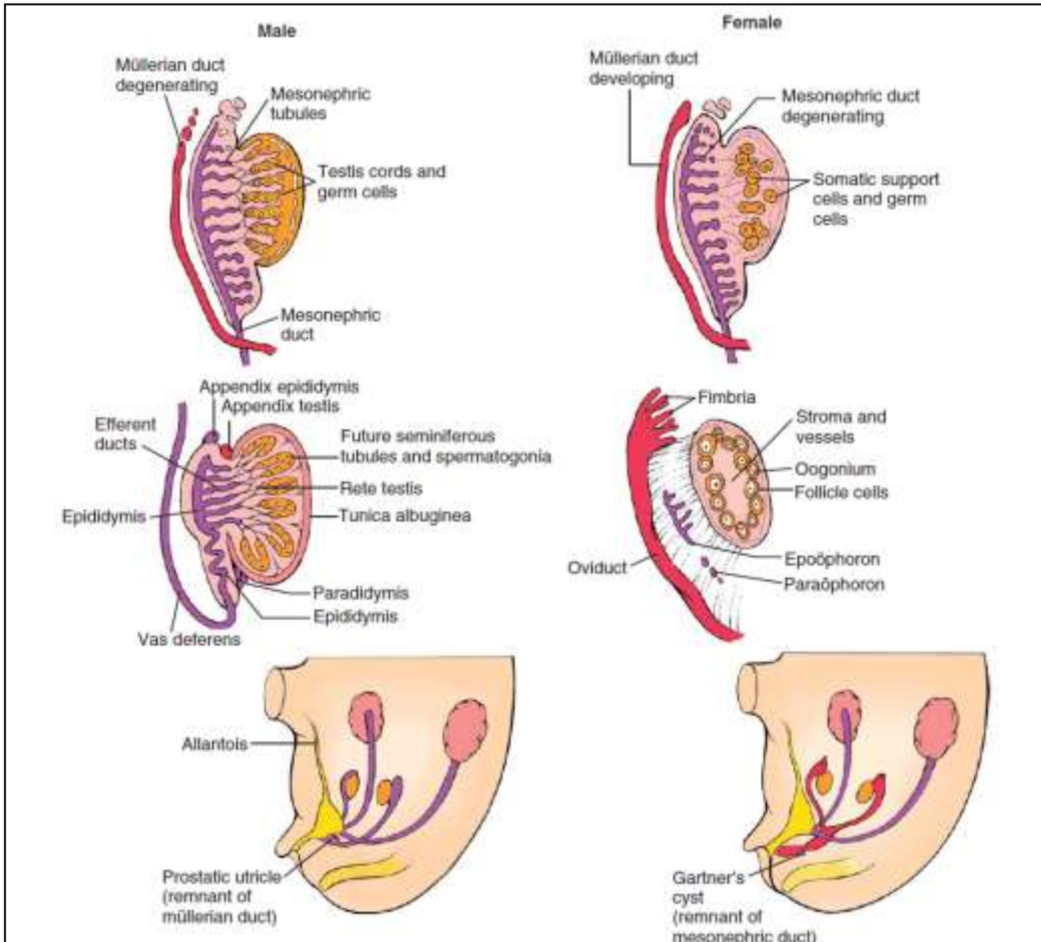


Figure 15-19. Comparison of human male and female gonadal development at the tissue level. The male and female genital systems are virtually identical through the 7th week. In the male, SRY protein produced by the pre-Sertoli cells causes the somatic support cells to differentiate into Sertoli cells. Sertoli cells, together with myoepithelial precursor cells, then organize into testis cords and rete testis tubules. AMH produced by the Sertoli cells causes the müllerian ducts to regress. Leydig cells also develop, which in turn produce testosterone, the hormone that stimulates development of the male genital duct system.

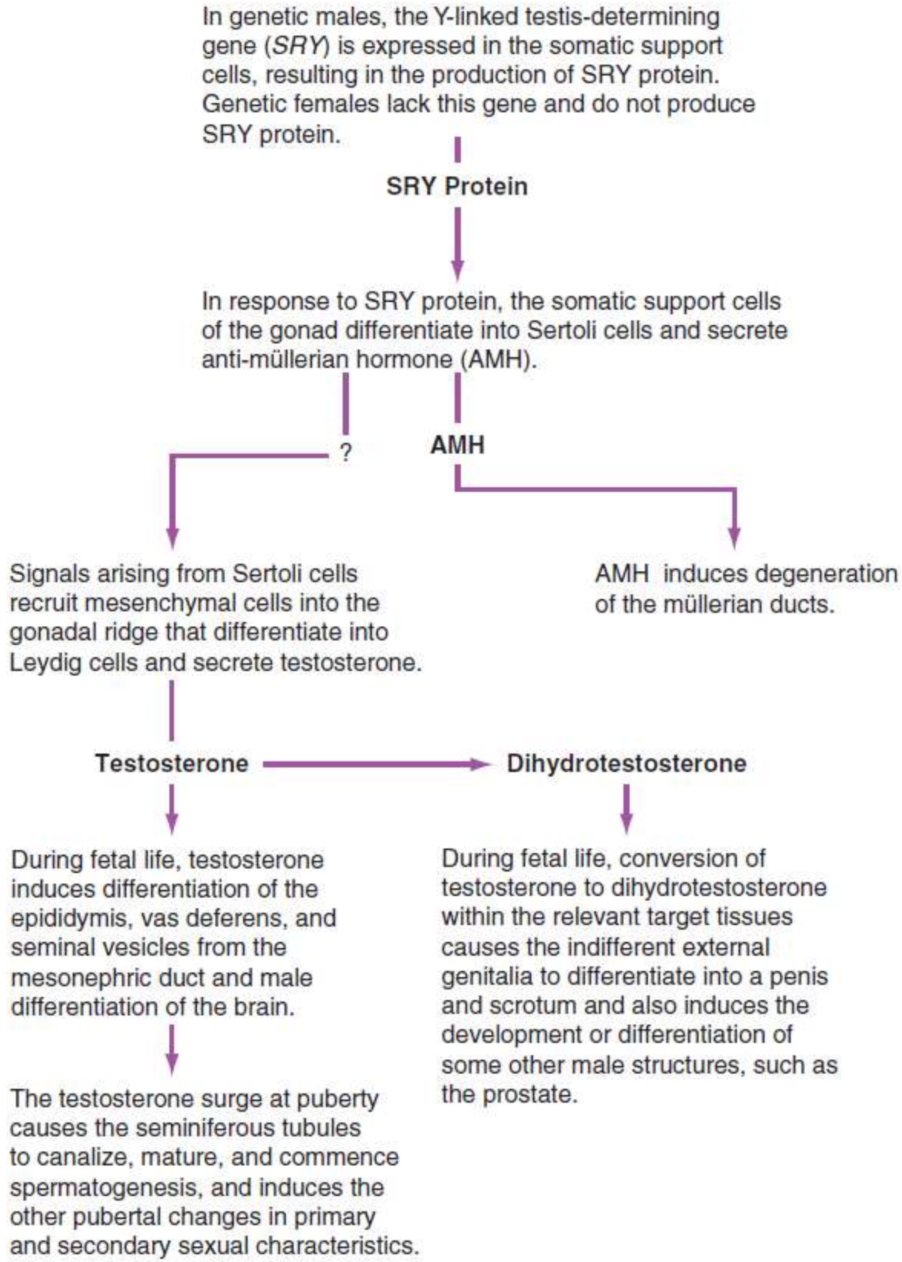
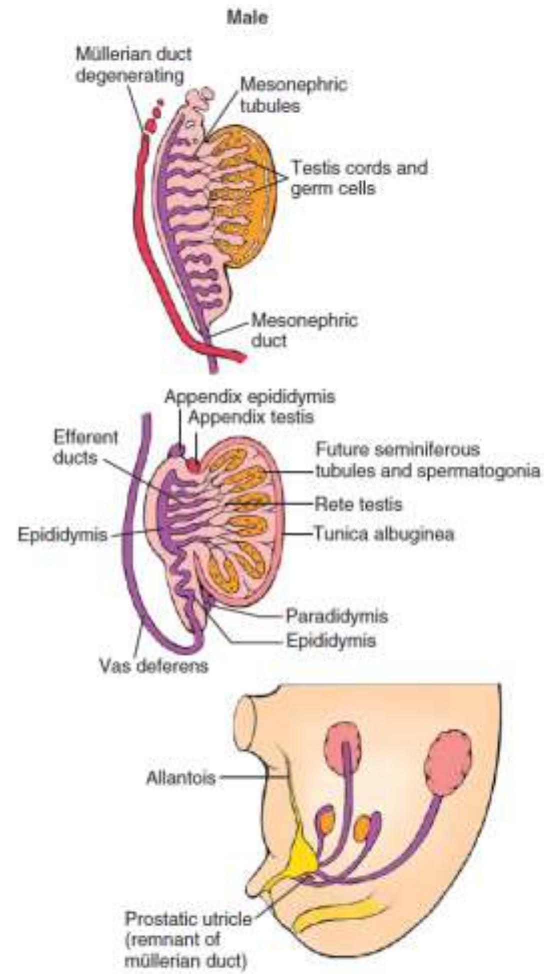
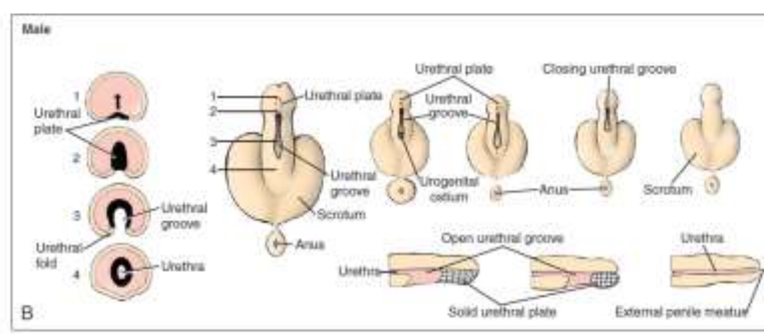


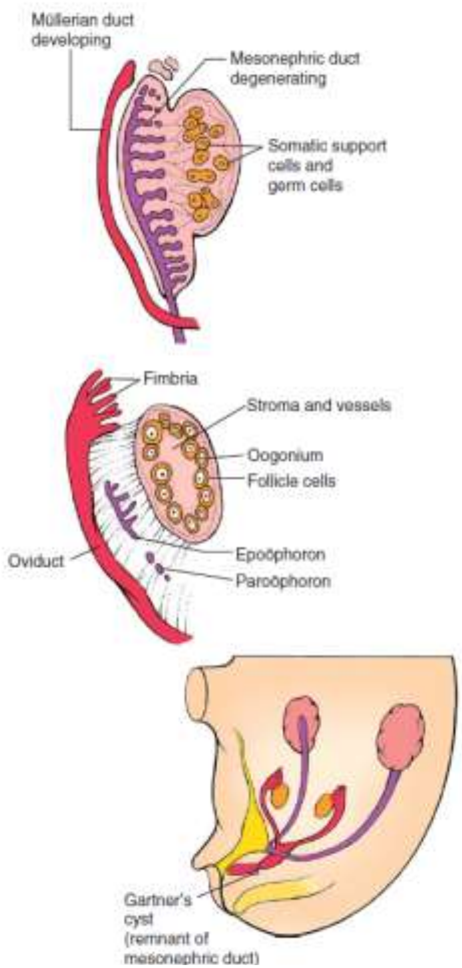
Figure 15-18. Summary of the differentiation cascade of the male genital system development.

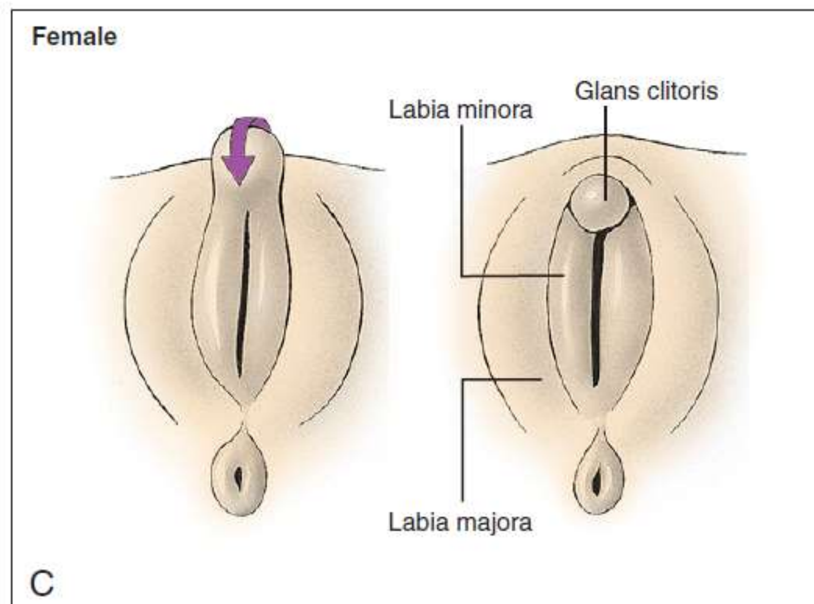
Differentiating Sertoli cells then envelop the germ cells and together with the myoepithelial cells organize into testis cords (future seminiferous tubules). The deepest portions of the somatic support cells in the developing gonad, which do not contain germ cells, differentiate into the rete testis. The rete testis connects with a limited number of mesonephric tubules and canalizes at puberty to form conduits connecting the seminiferous tubules to the mesonephric duct. These nephric tubules become the efferent ductules of the testes, and the mesonephric ducts become the vasa deferentia (singular, vas deferens). The müllerian ducts degenerate. During the 3rd month, the distal vas deferens sprouts the seminal vesicle, and the prostate and bulbourethral glands grow from the adjacent pelvic urethra. Simultaneously, the indifferent external genitalia (consisting of paired urogenital and labioscrotal folds on either side of the urogenital plate and an anterior genital tubercle) differentiate into the penis and scrotum.





Because genetic females lack a Y chromosome, they do not produce SRY protein. Hence, the somatic support cells do not form Sertoli cells but rather differentiate into follicle cells that surround the germ cells to form **primordial follicles** of the ovary. The mesonephric ducts degenerate, and the müllerian ducts become the genital ducts. The proximal portions of the müllerian ducts become the **fallopian tubes** (or **oviducts**). Fusion of the distal portions of the ducts gives rise to the **uterus** and possible contributions to the cranial **vagina**; the caudal portion of the vagina is thought to develop from a pair of endodermal **sinuvaginal** bulbs that develop from the posterior wall of the urogenital sinus. The indifferent external genitalia develop into the female external genitalia: the **clitoris** and the paired **labia majora** and **minora**.





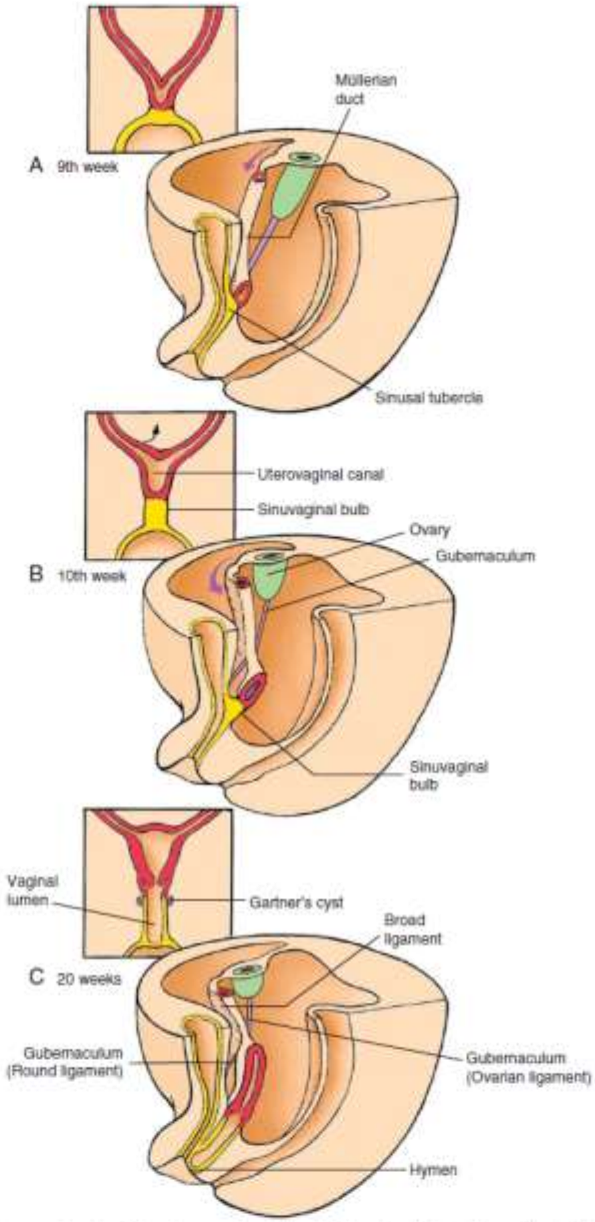


Figure 15-28. Formation of the uterus and vagina. *A*, The uterus and cranial end of the vagina begin to form as the müllerian ducts fuse together near their attachment to the posterior wall of the urogenital sinus. *B*, *C*, The ducts then zip together in a cranial direction between the 3rd and 5th months. As the müllerian ducts are pulled away from the posterior body wall, they drag a fold of peritoneal membrane with them, forming the broad ligaments of the uterus. *A-C*, The caudal end of the vagina is thought to form from the sinuvaginal bulbs on the posterior wall of the urogenital sinus.

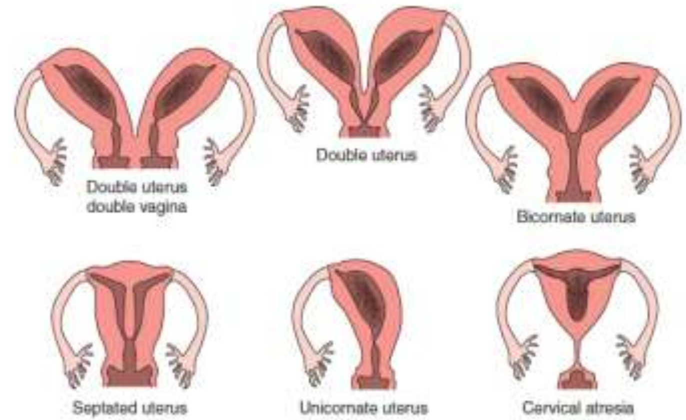


Figure 15-29. Anomalies of the uterus and vagina. Many anomalies related to the development of the uterus and vagina are attributable to abnormal fusion or regression of the caudal portion of the müllerian duct.

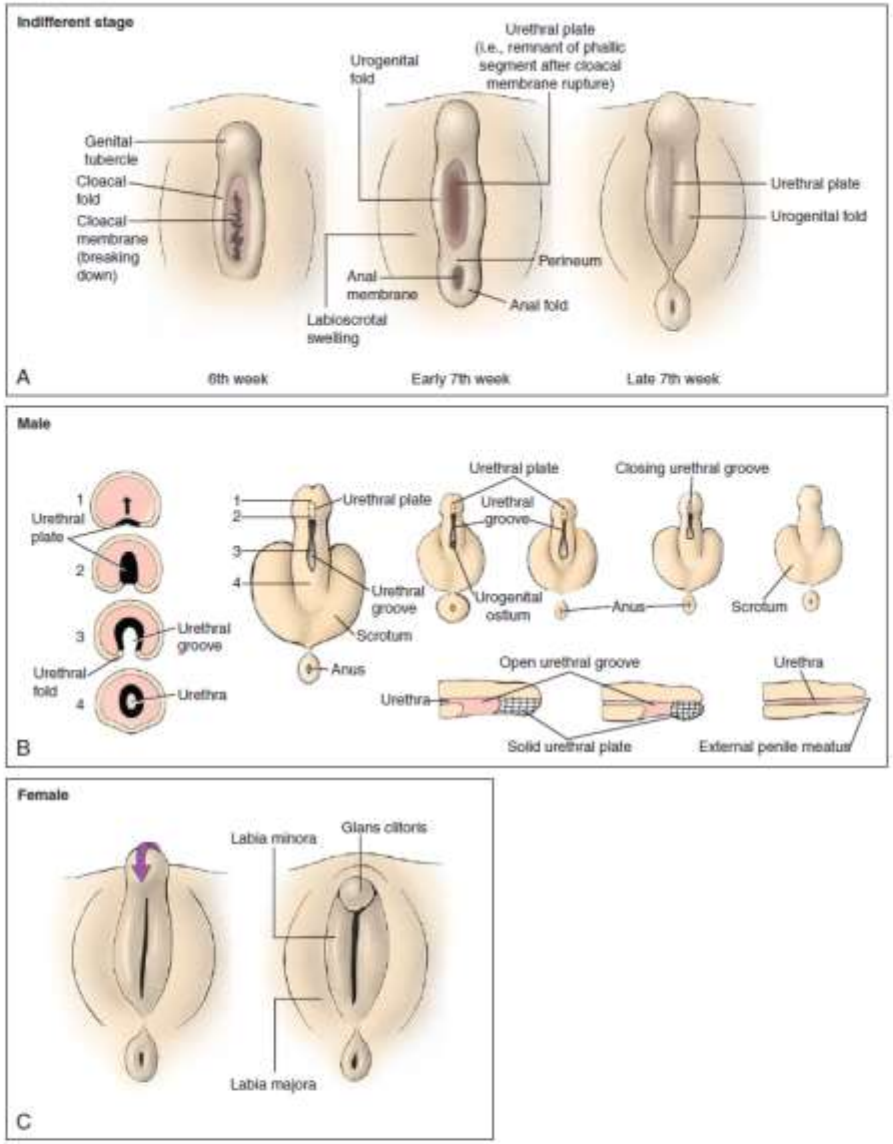


Figure 15-31. Formation of the external genitalia in males and females. *A*, The external genitalia form from a pair of labioscrotal folds, a pair of urogenital folds, and an anterior genital tubercle. Male and female genitalia are morphologically indistinguishable at this stage. *B*, In males, the urogenital folds fuse and the genital tubercle elongates to form the shaft and glans of the penis. Fusion of the urethral folds encloses the phallic portion of the urogenital sinus to form the penile urethra. The distal urethra is formed by canalization of a solid endodermal extension of the urethral plate into the glans. The labioscrotal folds fuse to form the scrotum. *C*, In females, the genital tubercle bends inferiorly to form the clitoris, and the urogenital folds remain separated to form the labia minora. The labioscrotal folds form the labia majora.

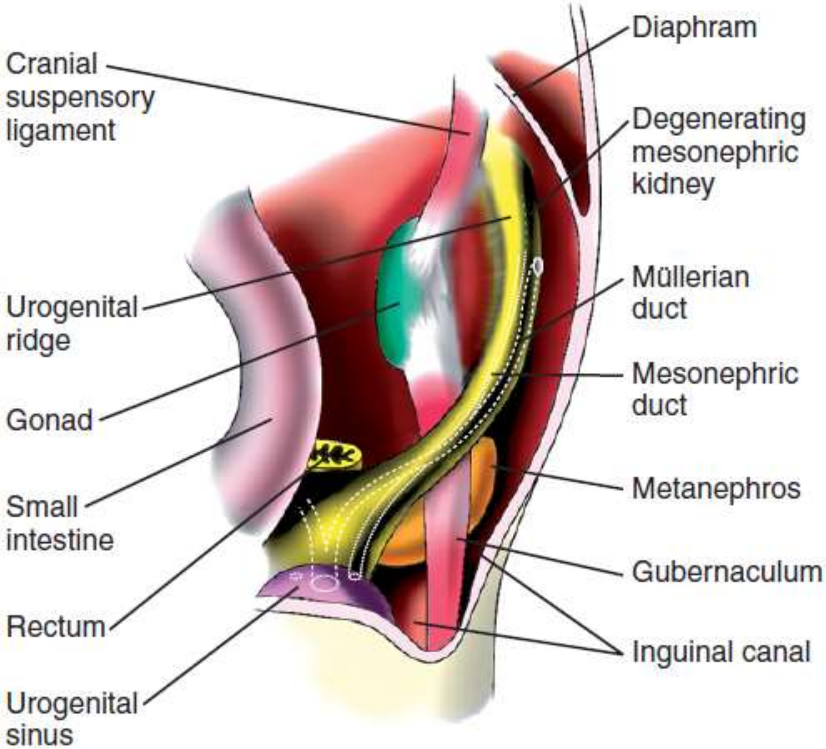
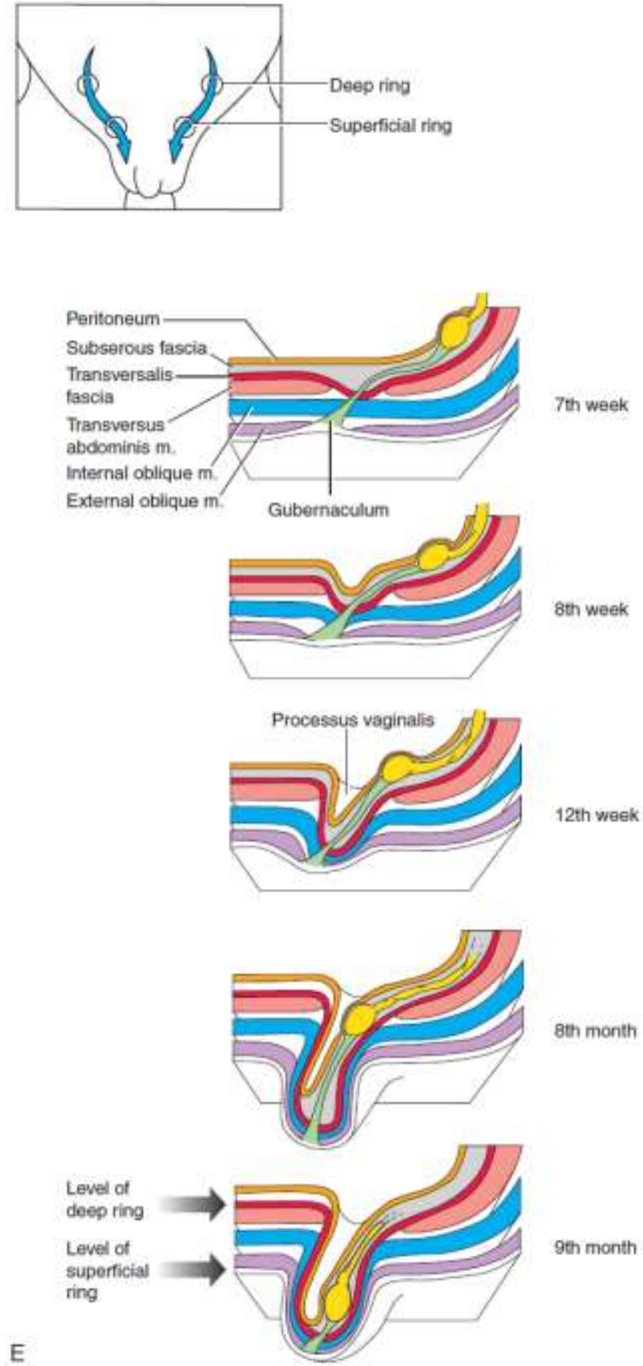


Figure 15-34. At the indifferent gonad stage, two ligaments, a cranial suspensory ligament and the gubernaculum, anchor the mesonephric-gonadal complex. The cranial suspensory ligament runs from the cranial portion of the mesonephric-gonadal complex to the diaphragm. The gubernaculum is attached to the caudal portion of the gonad and extends to the peritoneal floor, where it is attached to the fascia between the developing external and internal oblique abdominal muscles in the region of the labioscrotal swellings.



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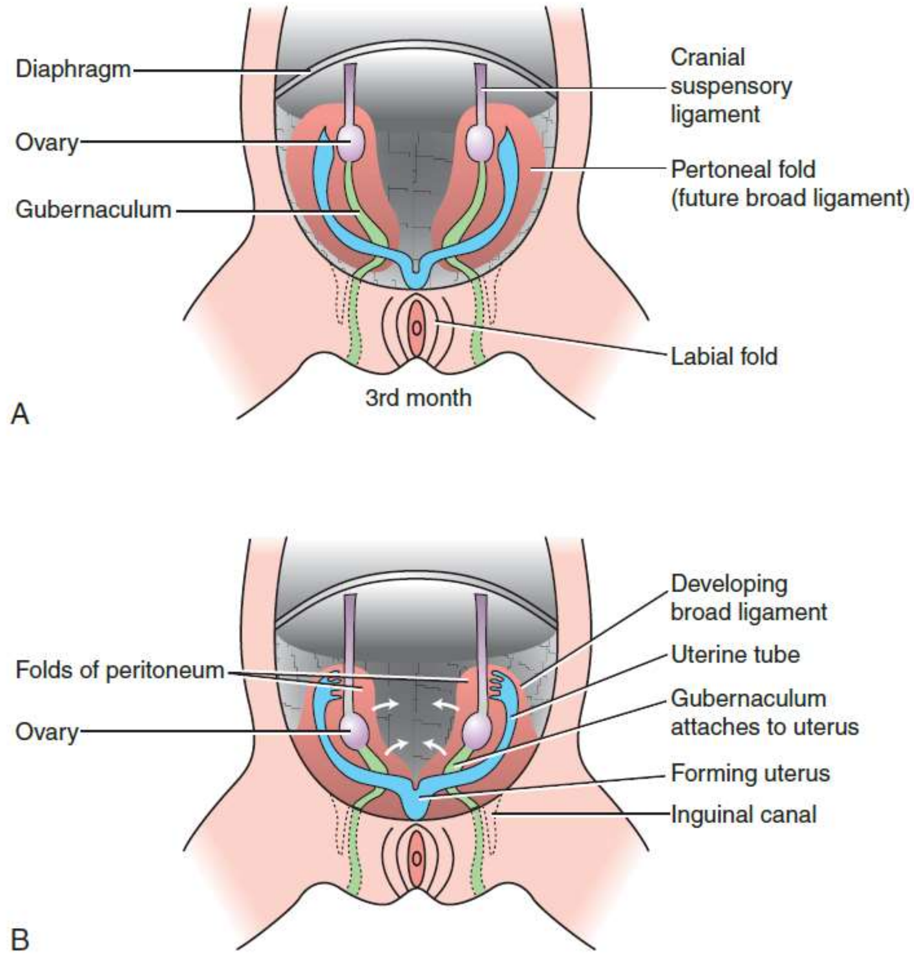
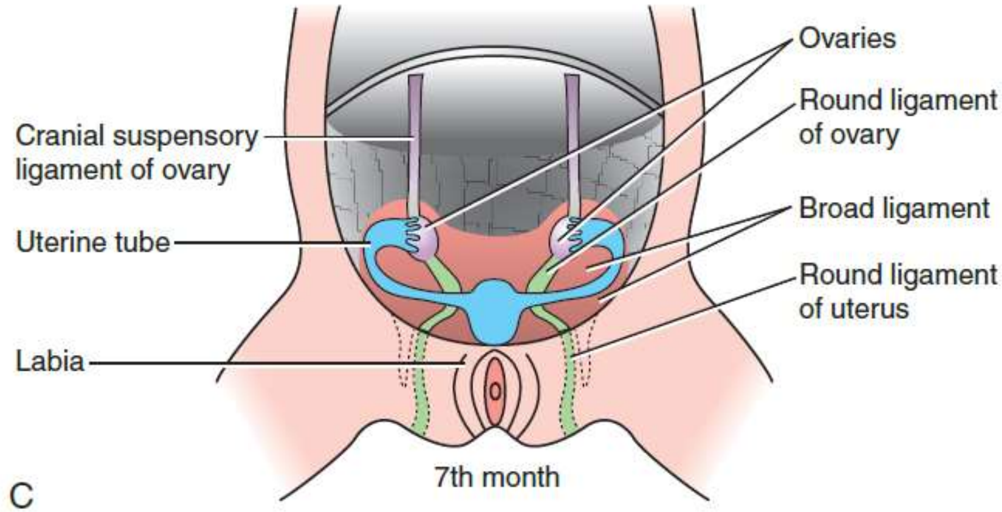


Figure 15-38. *A*, *B*, In females, the gubernaculum does not swell or shorten. Nevertheless, the ovaries still descend to some extent during the 3rd month and are swept out into a peritoneal fold called the broad ligament of the uterus (see Fig. 15-28). This translocation occurs because the gubernaculum becomes attached to the developing müllerian ducts. As the müllerian ducts zip together from their caudal ends, they sweep out the broad ligaments and simultaneously pull the ovaries into these peritoneal folds. As a consequence, the remnant of the female gubernaculum connects the labia majora with the wall of the uterus and is then reflected laterally, attaching to the ovary.



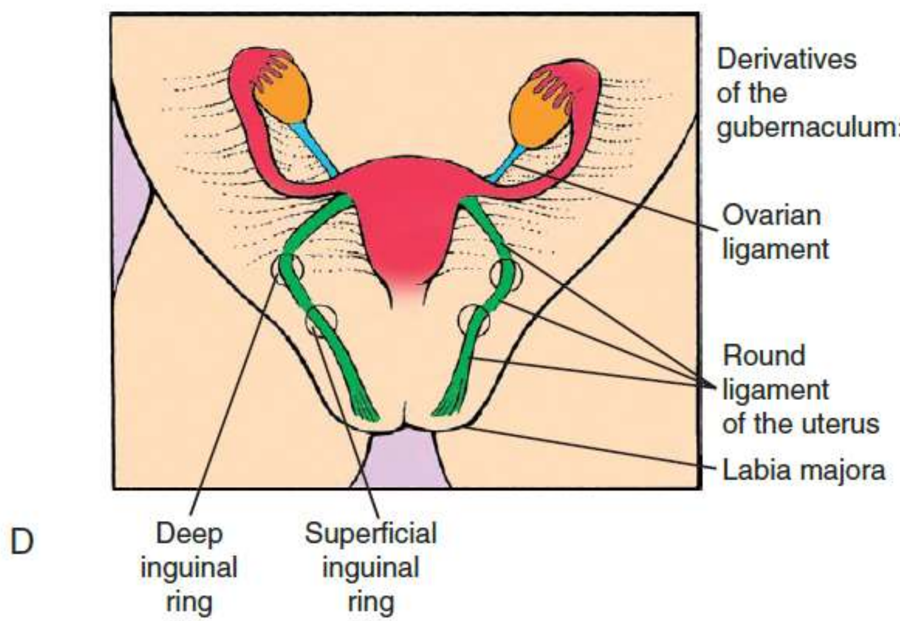


Figure 15-38. cont'd, *C*, Completly formed broad ligament containing ovaries and ovarian round ligament. *D*, The round ligament of the uterus (remnant of the gubernaculum) exits the abdominal cavity via the deep and superficial inguinal rings and connects to the base of the labia majora.

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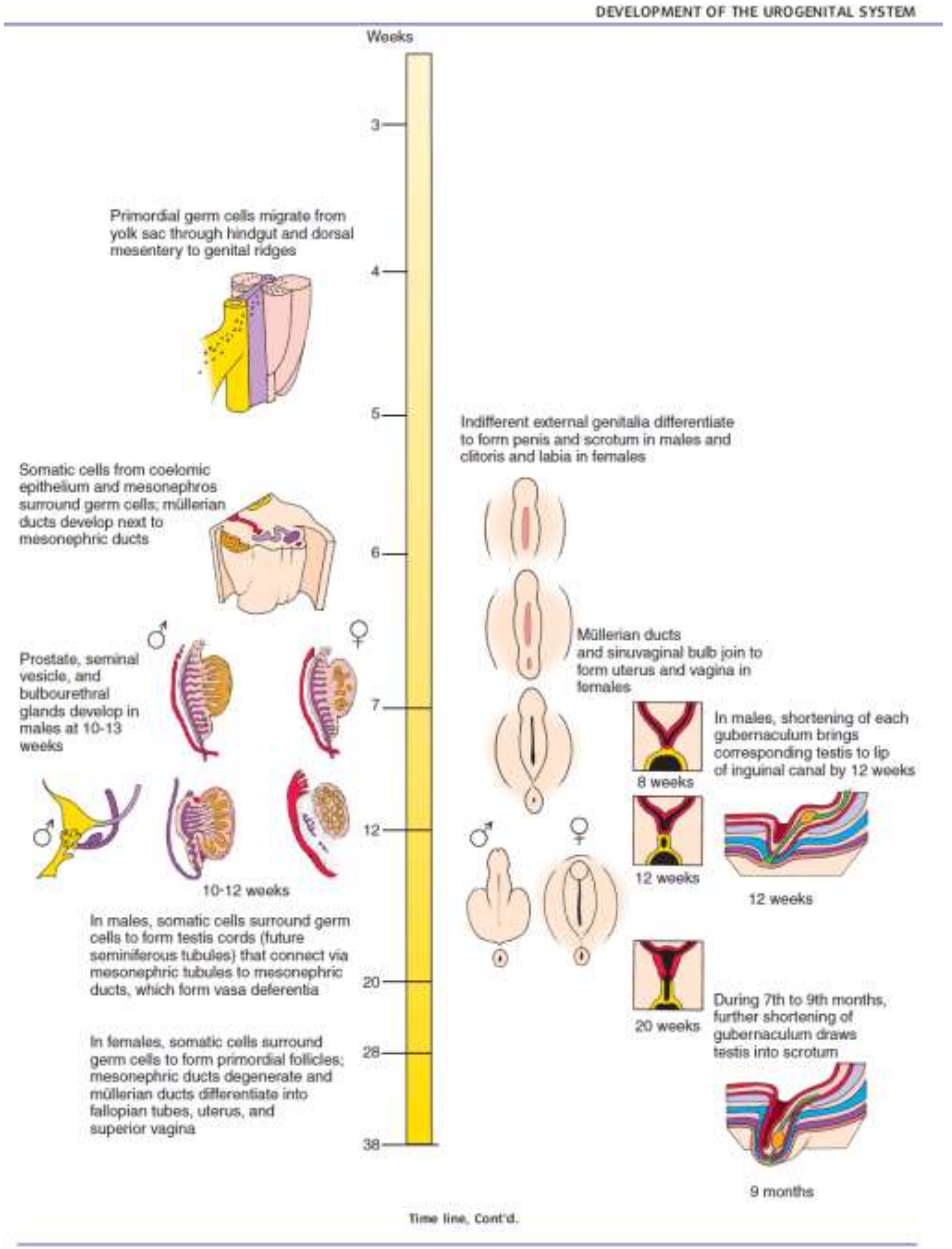

Thank you for attention!

References:

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