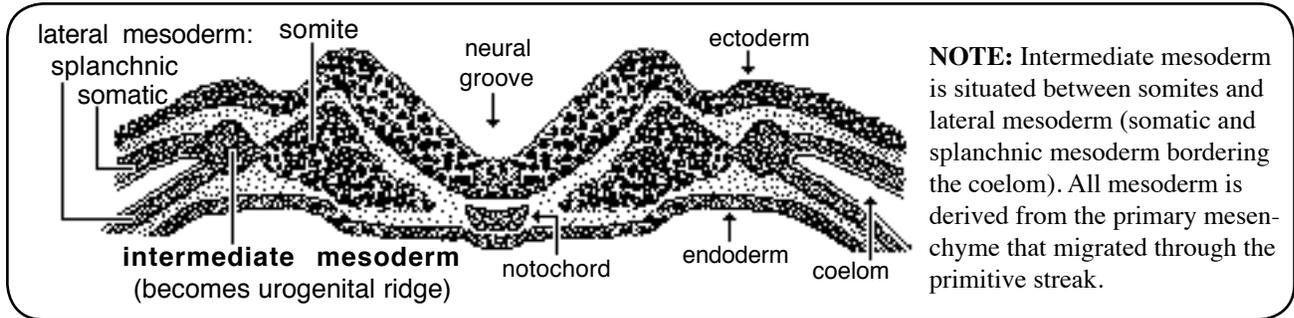


Urinary System

Intermediate mesoderm

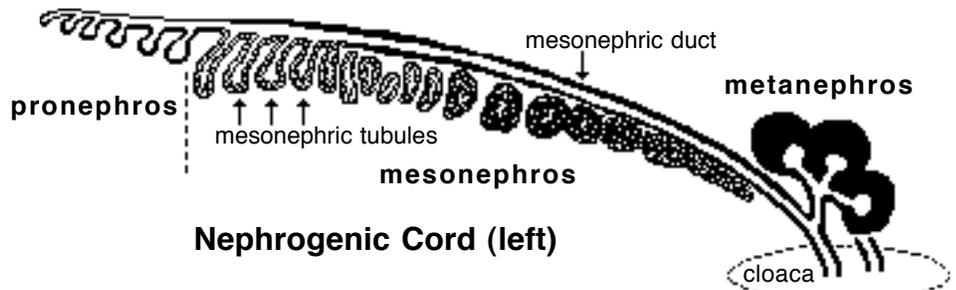


Intermediate mesoderm (plus adjacent mesothelium lining the coelom) forms a *urogenital ridge*, which consists of a laterally-positioned nephrogenic cord (that forms kidneys & ureter) and a medially-positioned gonadal ridge (for ovary/testis & female/male genital tract formation). Thus urinary & genital systems have a common embryonic origin; also, they share common ducts.

NOTE: Urine production essentially requires an increased capillary surface area (glomeruli), epithelial tubules to collect plasma filtrate and extract desirable constituents, and a duct system to convey urine away from the body.

Kidneys

Bilaterally, three kidneys develop from the nephrogenic cord. They develop chronologically in cranial-caudal sequence, and are designated pro—, meso—, and meta—, respectively.

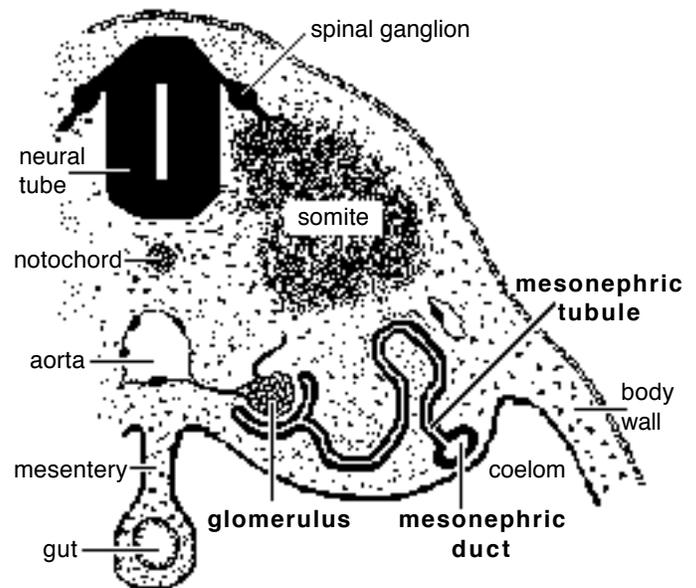


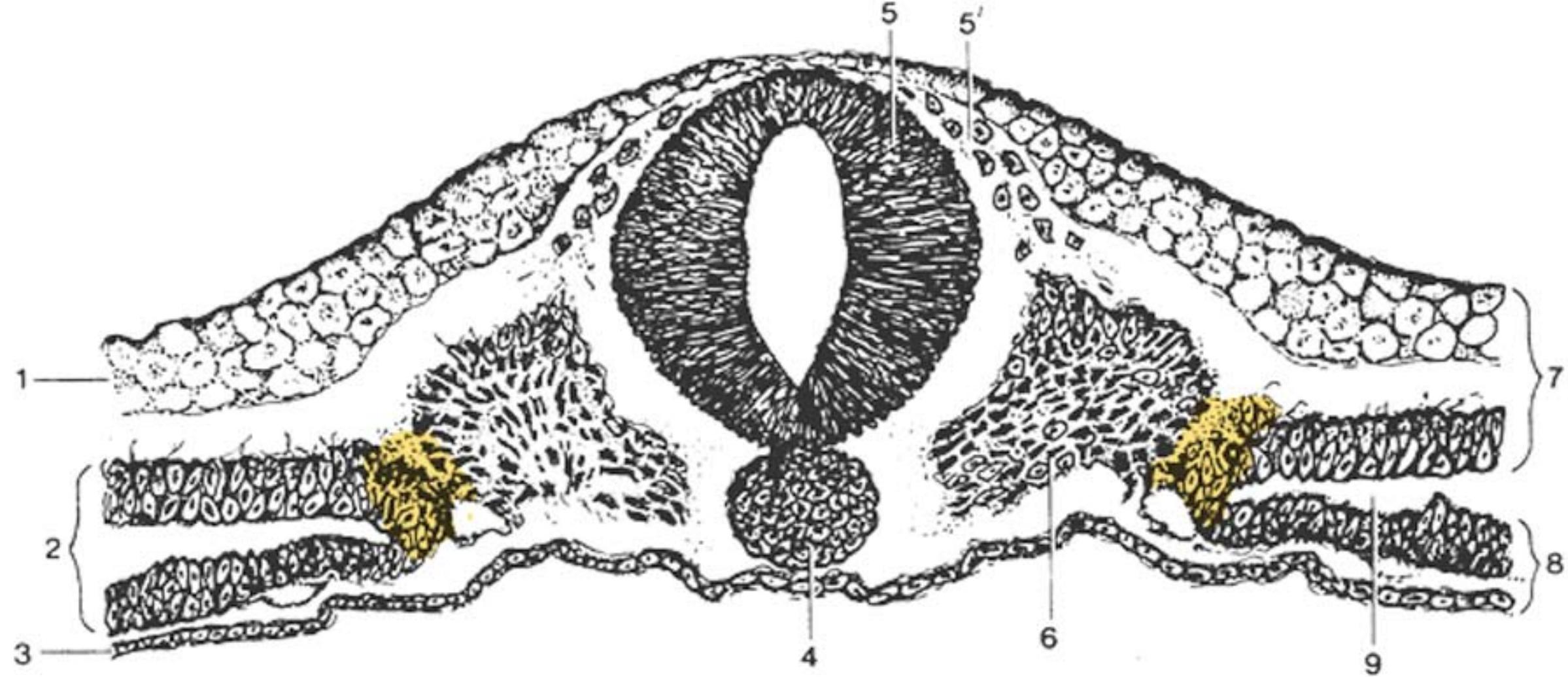
The pronephros and mesonephros develop similarly: the nephrogenic cord undergoes segmentation, segments become tubules, tubules drain into a duct & eventually tubules disintegrate.

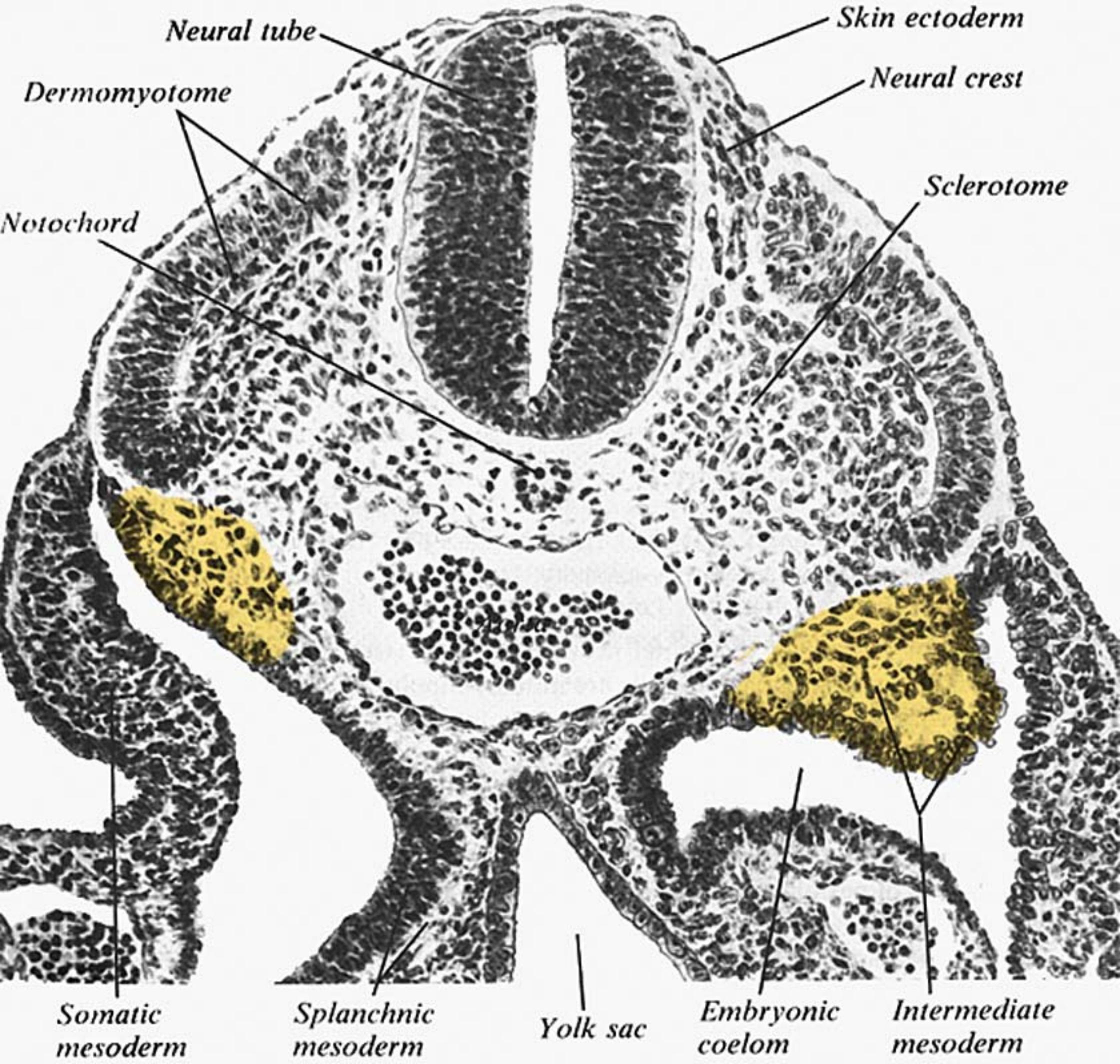
1] **Pronephros**—consists of (7-8) primitive tubules and a pronephric duct that grows caudally and terminates in the cloaca. The tubules soon degenerate, but the pronephric duct persists as the mesonephric duct. (The pronephros is not functional, except in sheep.)

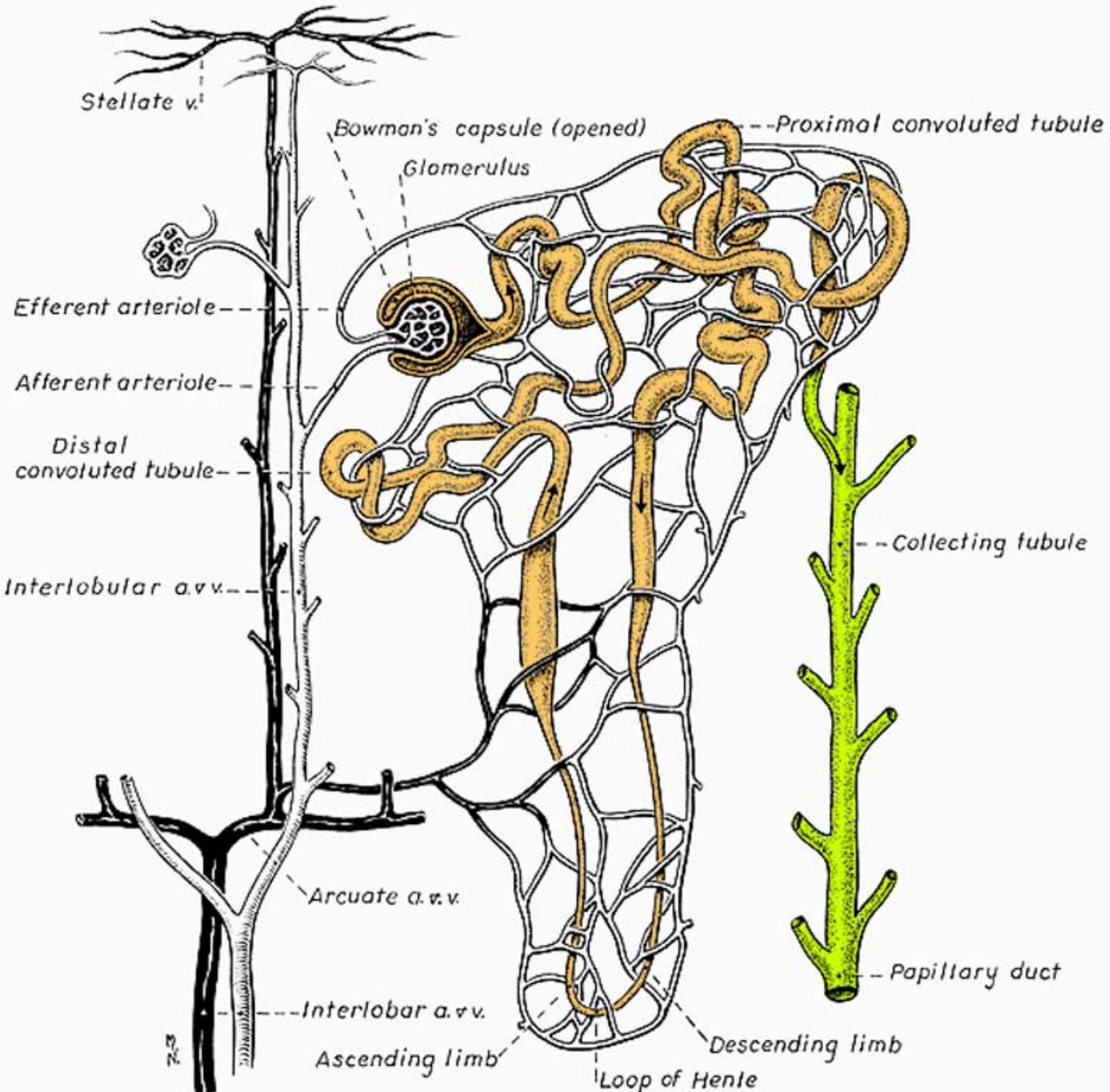
NOTE
The *mesonephros* is the functional kidney for fish and amphibians. The *metanephros* is the functional kidney of reptiles, birds, & mammals.

Although kidneys become functional *in-utero*, they are not essential because the placenta is capable of removing toxic agents from fetal blood.









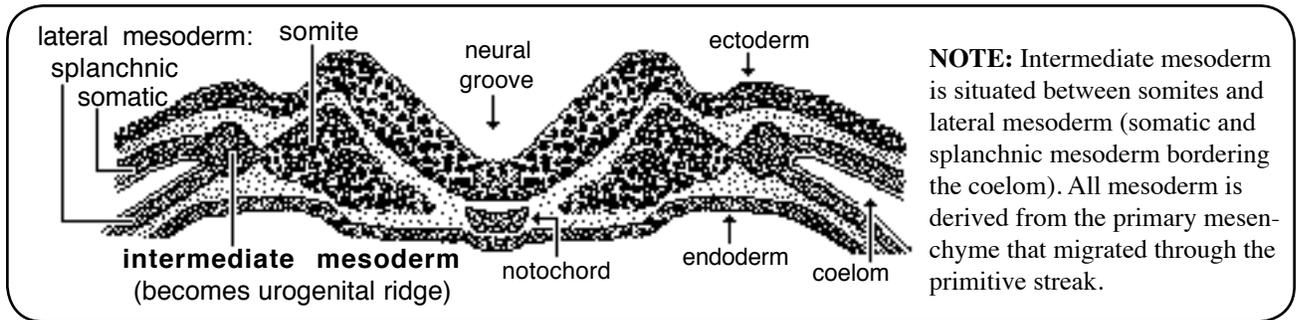
Nephros (Gr) = **Ren-** (Lat) = **Kidney** (Eng)

nephron (n.) = functional unit of the kidney

renal (adj.), e.g., renal cortex; renal medulla

Urinary System

Intermediate mesoderm

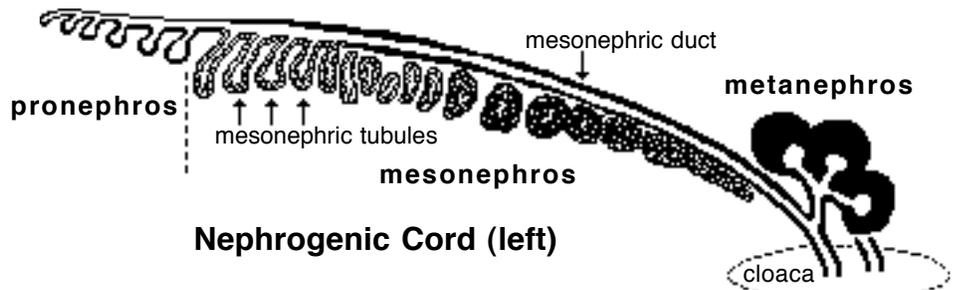


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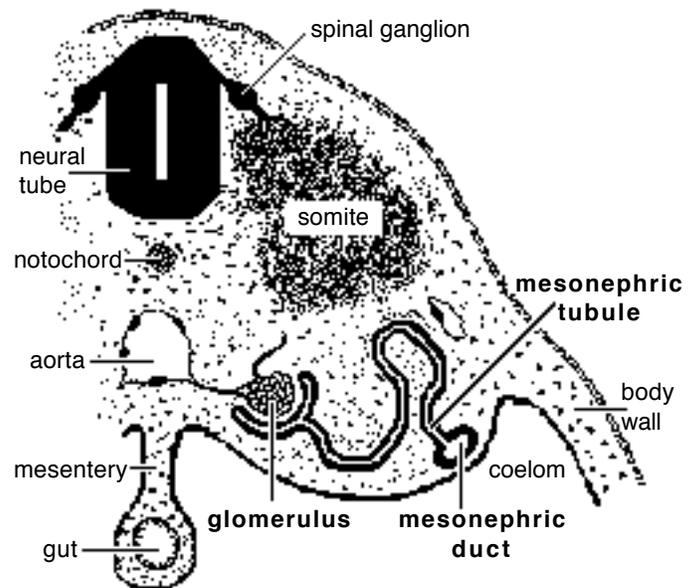
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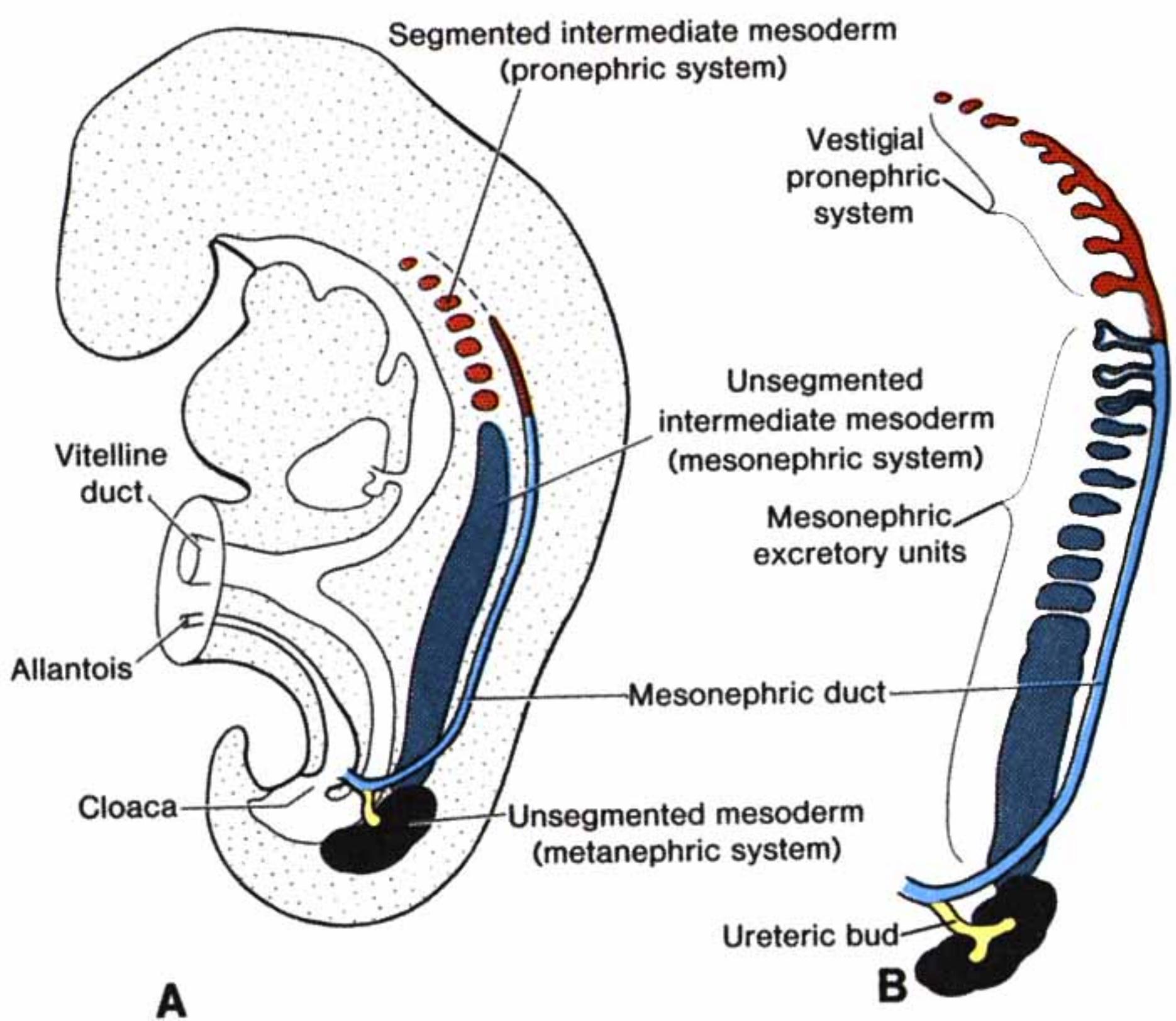
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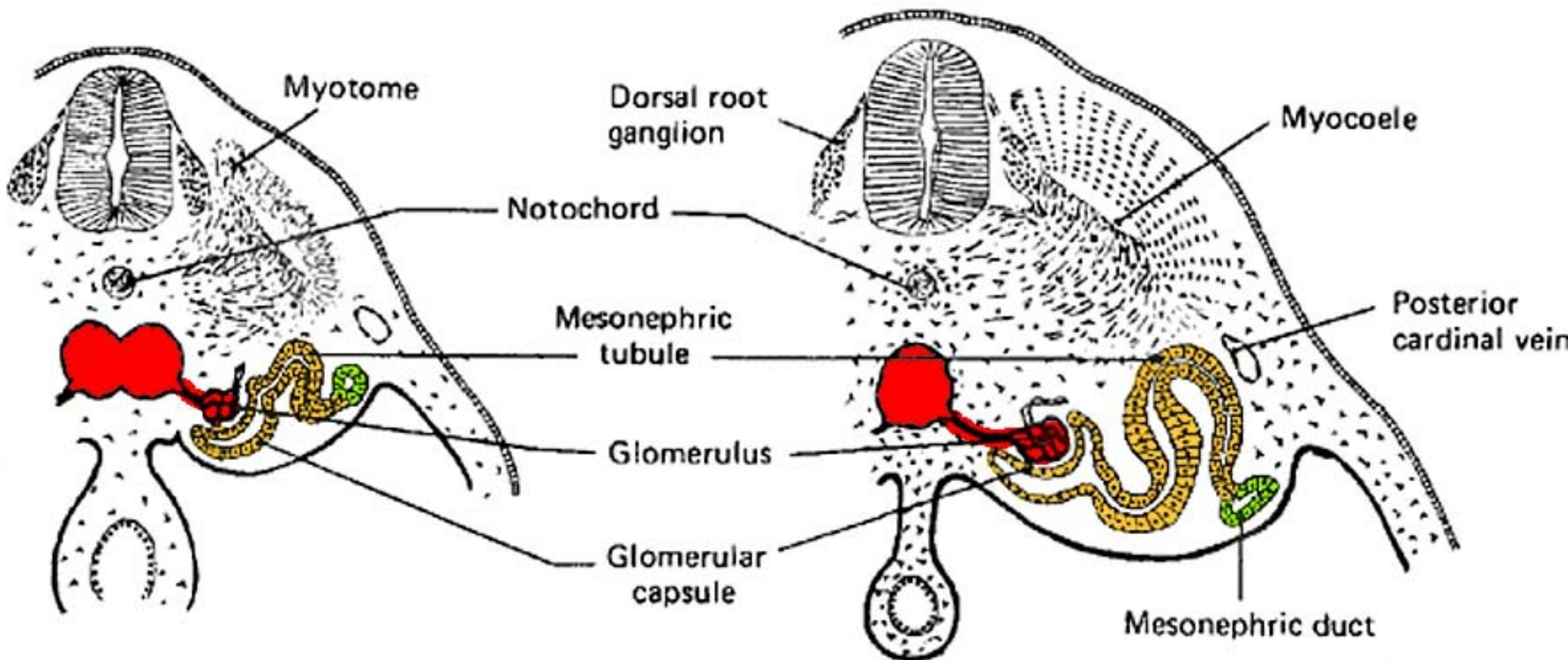
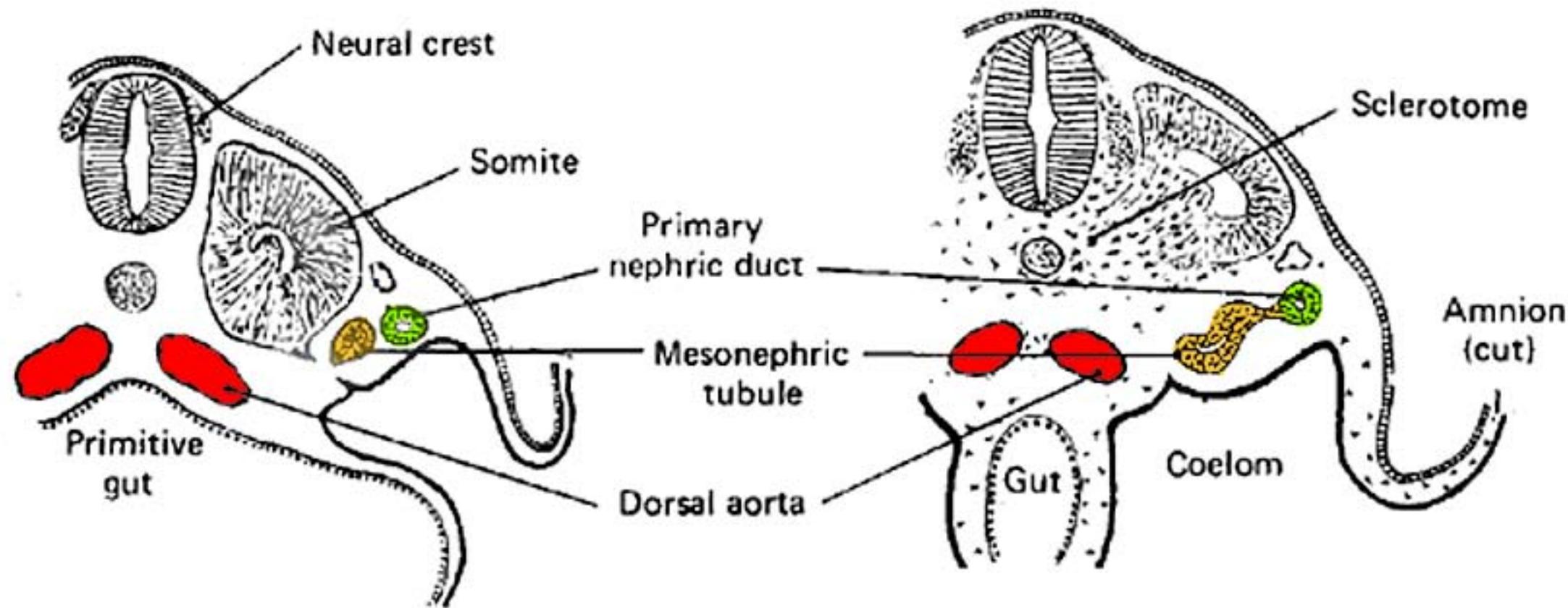
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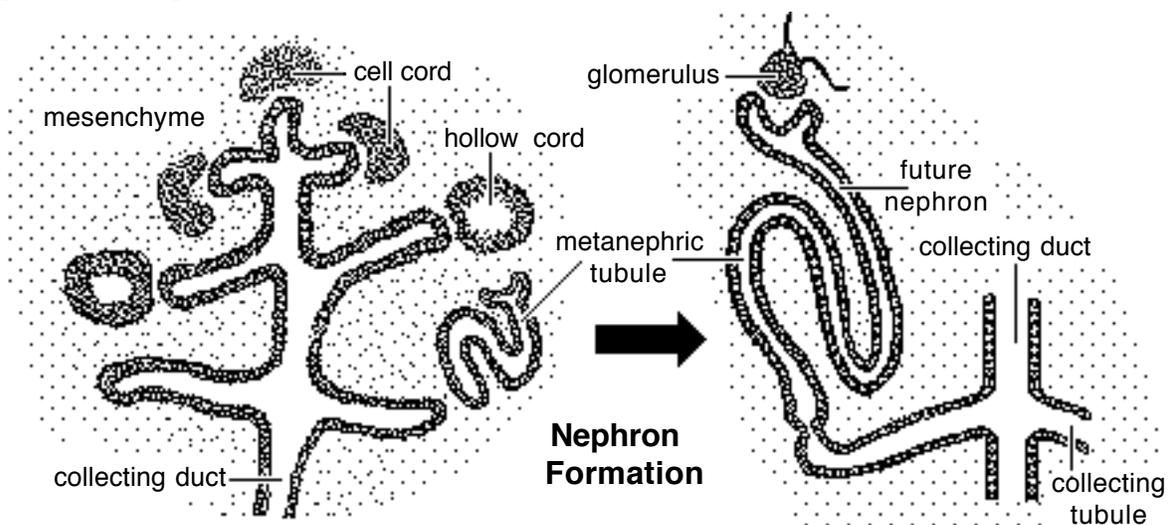
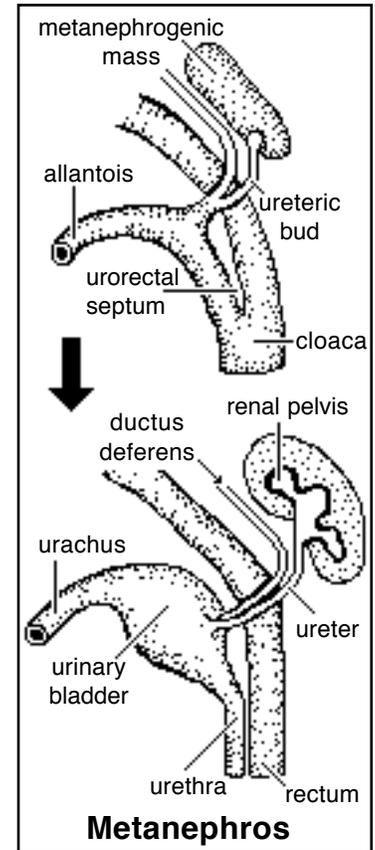
2] **Mesonephros**—consists of (70-80) tubules induced to form by the mesonephric duct (former pronephric duct). One end of each tubule surrounds a vascular proliferation (glomerulus) produced by a branch of dorsal aorta. The other end of the tubule communicates with the mesonephric duct. The mesonephros eventually degenerates, but a few tubules that become incorporated within the testis and the mesonephric duct becomes epididymis/ductus deferens in the male. (Functional development of the mesonephros is inversely related to the numbers of tissue layers in the placenta, among species.)

3] **Metanephros**—becomes the adult kidney and ureter of mammals, birds, and reptiles. The metanephros originates in the pelvic region and “ascends” cranially into the abdomen by differential growth. The kidney is lobulated initially and subsequently becomes smooth in most species. The metanephros originates from two sources:

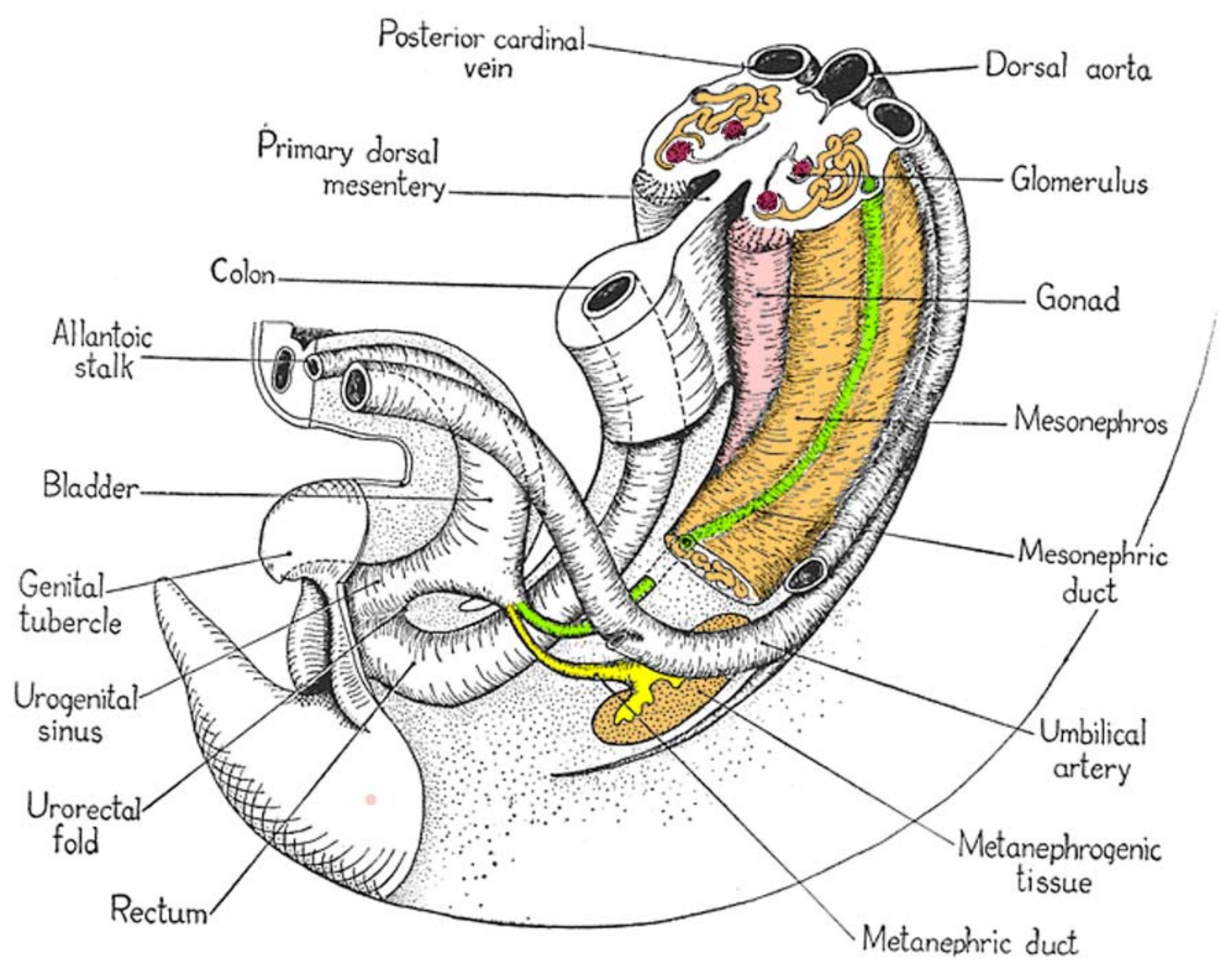
- a *ureteric bud* (induced by neural tube) grows out of the mesonephric duct in the region of the cloaca; the bud eventually develops into the ureter, renal pelvis, and numerous collecting ducts;
- *metanephrogenic mass*, which is the caudal region of the nephrogenic cord. Note: When the ureteric bud grows into the mesoderm, it induces the metanephrogenic mass to develop; in turn, the mass induces the cranial end of the ureteric bud to differentiate into renal pelvis and collecting tubules—these, in turn, induce the metanephrogenic mass cells to form nephrons.

The metanephrogenic mass forms nephrons in the following manner:

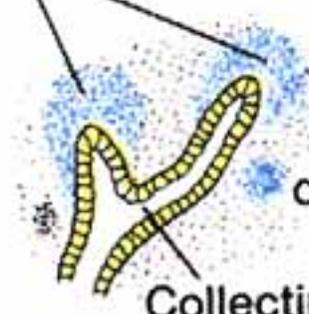
- adjacent to collecting tubules, mesodermal cells proliferate to form cell cords; the cords canalize and elongate, becoming S-shaped metanephric tubules and eventually nephrons;
- one end of each metanephric tubule establishes communication with a collecting tubule; the other end of the tubule expands to surround a capillary glomerulus (forming a glomerular capsule);
- between the two ends, each metanephric tubule differentiates into the regions characteristic of a nephron (proximal segment, thin loop, & distal segment)



NOTE: Nephrons develop from deep to superficial in the kidney. Many of the early nephrons subsequently degenerate as a normal occurrence. Nephrons continue to form and mature postnatally (except in the bovine); thereafter, nephrons cannot be replaced if they are damaged.

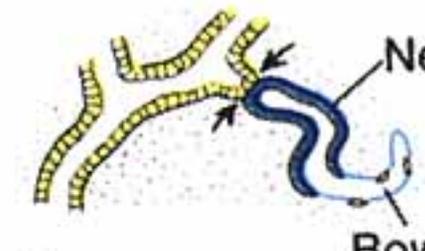
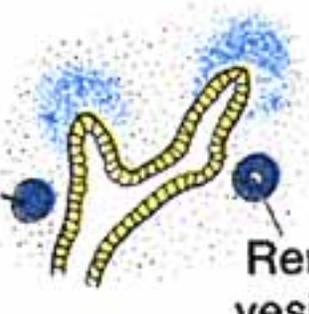


Metanephric tissue caps



Cell clusters

Renal vesicle



A

B

C

Distal convoluted tubule

Henle's loop

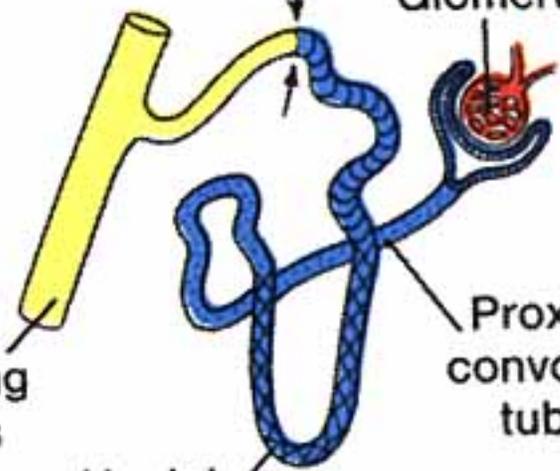
Bowman's capsule

Collecting tubules



Glomerulus

Henle's loop



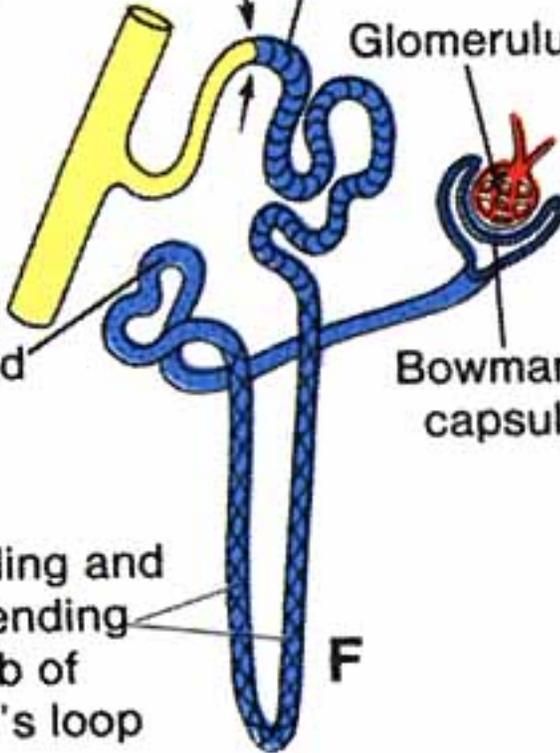
Proximal convoluted tubule

Distal convoluted tubule

Glomerulus

Bowman's capsule

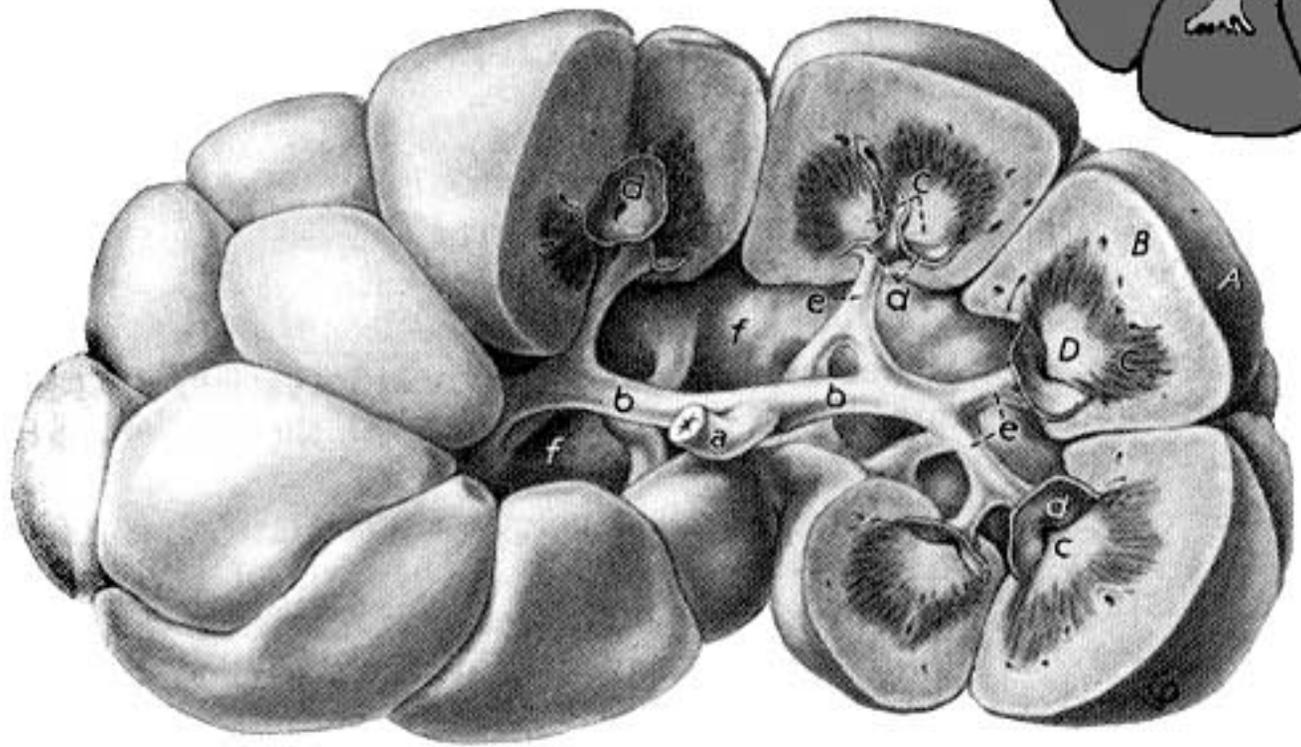
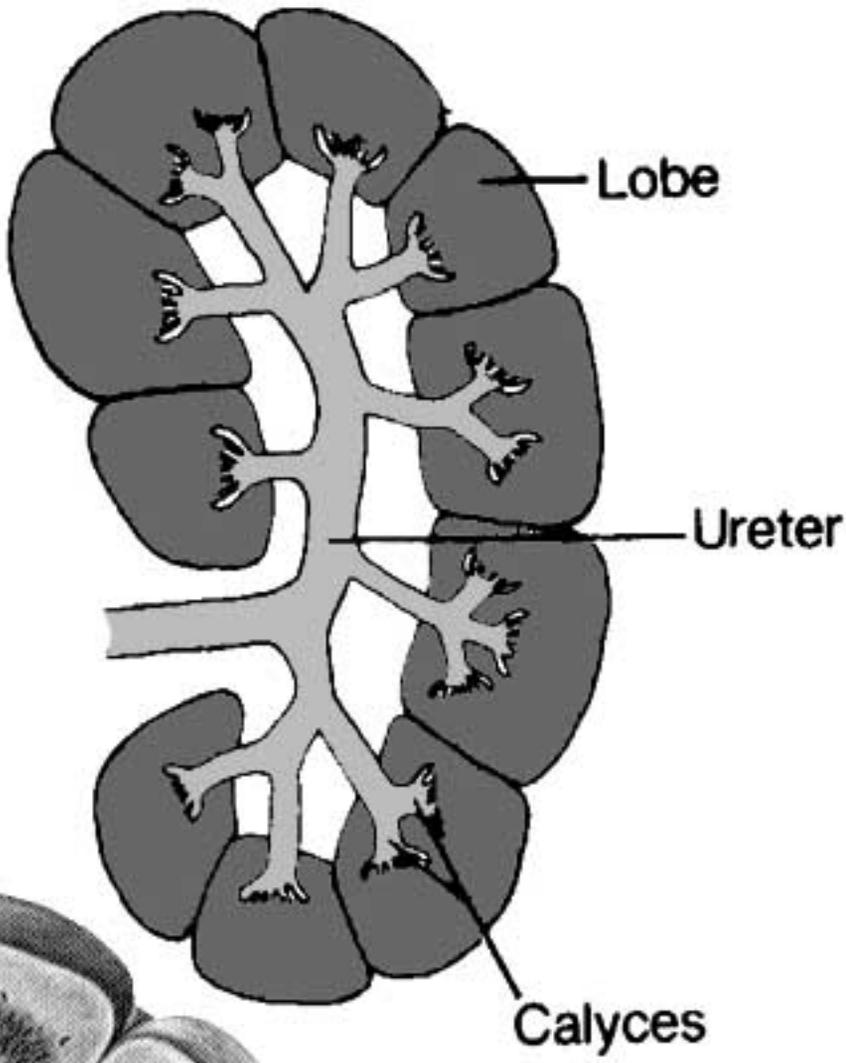
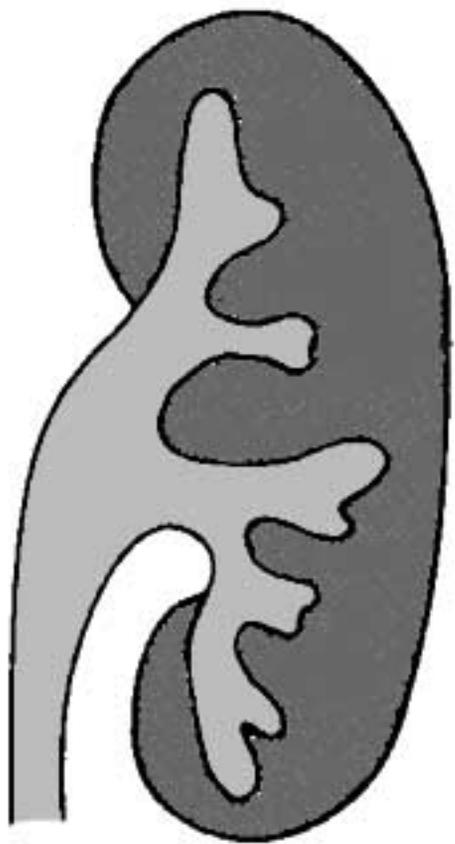
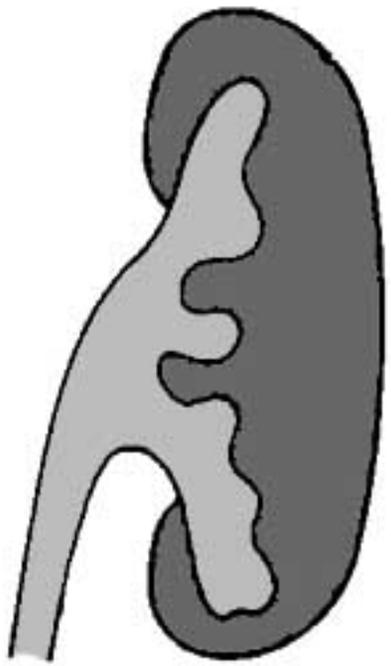
Ascending and descending limb of Henle's loop



D

E

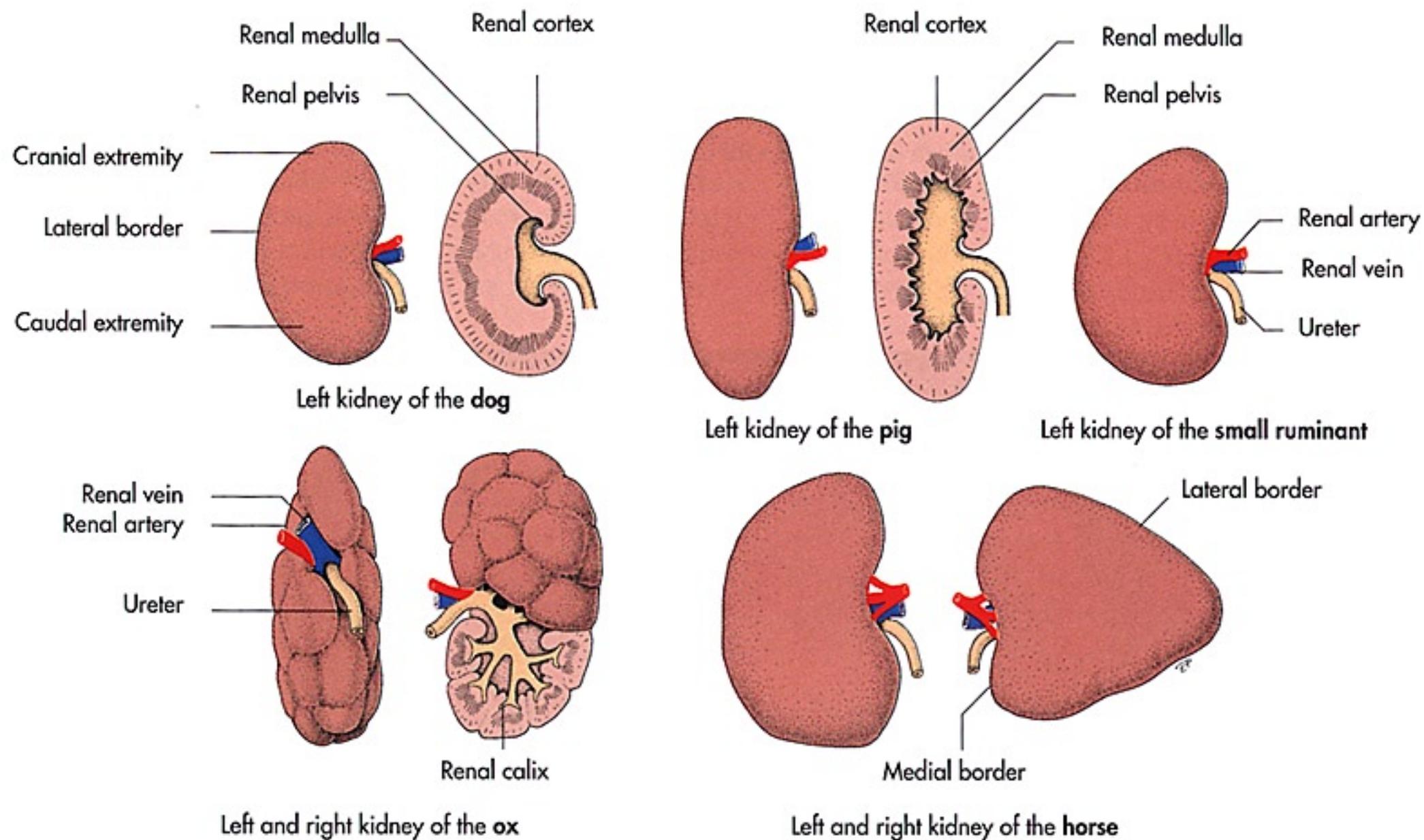
F



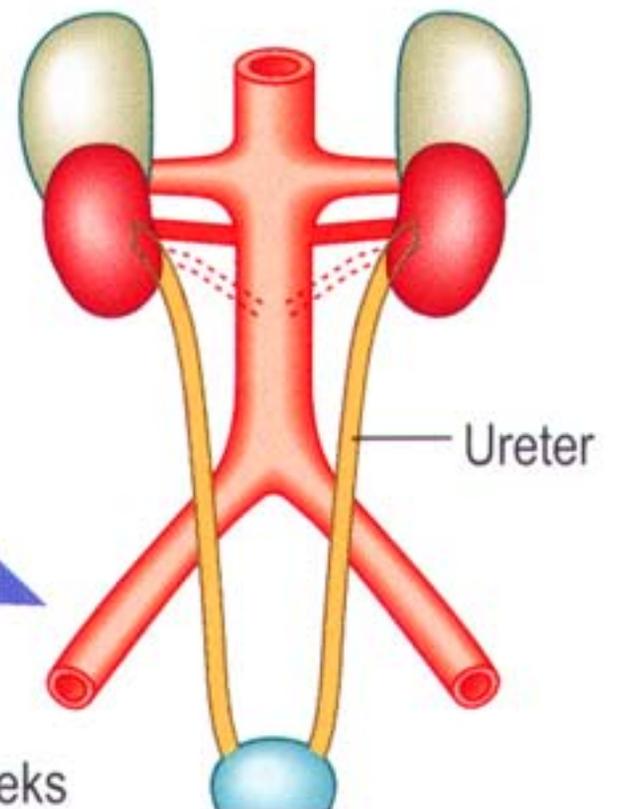
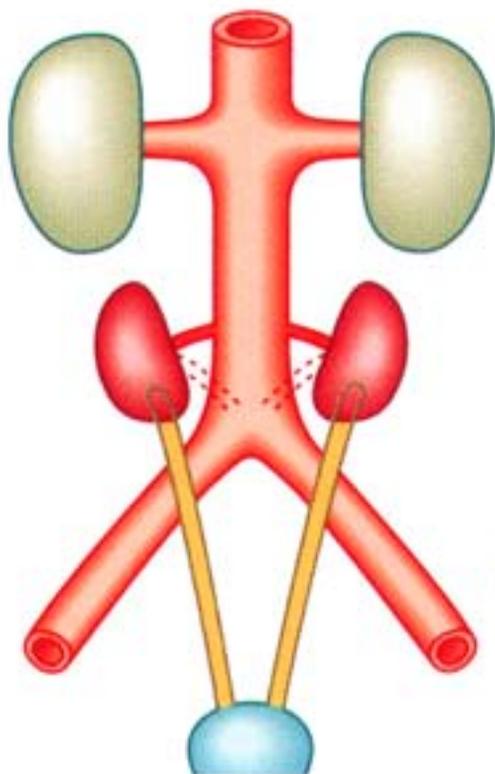
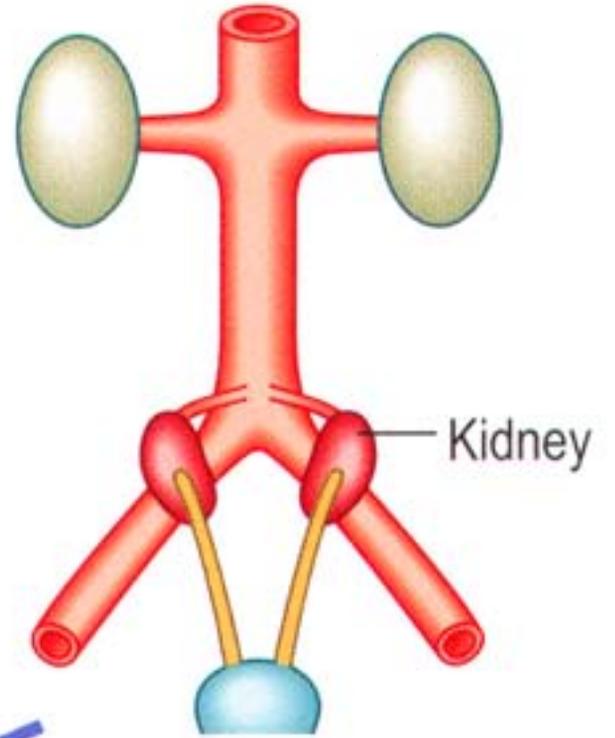
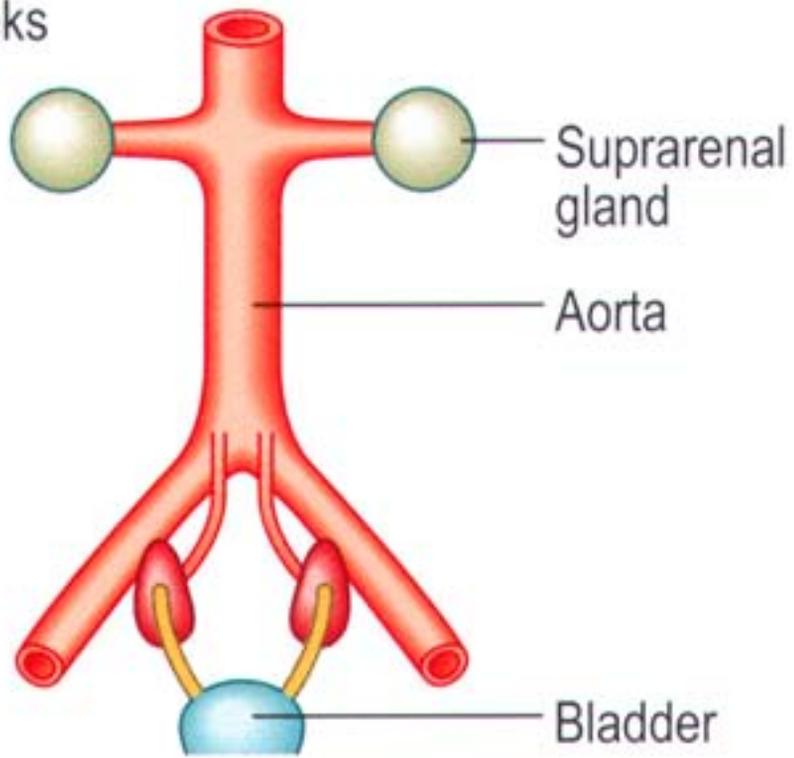
**Bovine
Kidney**

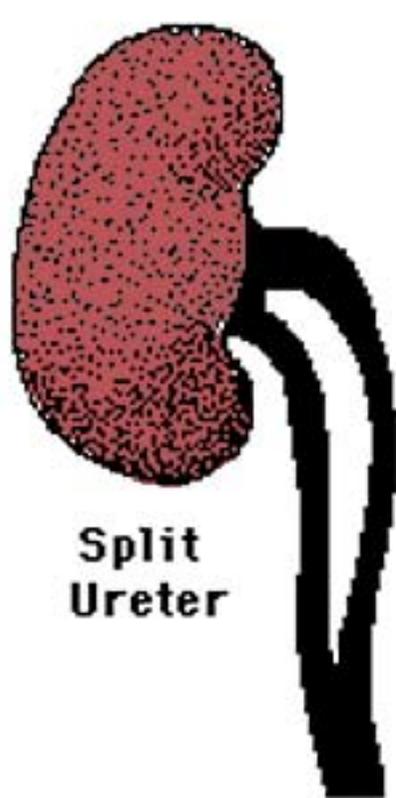
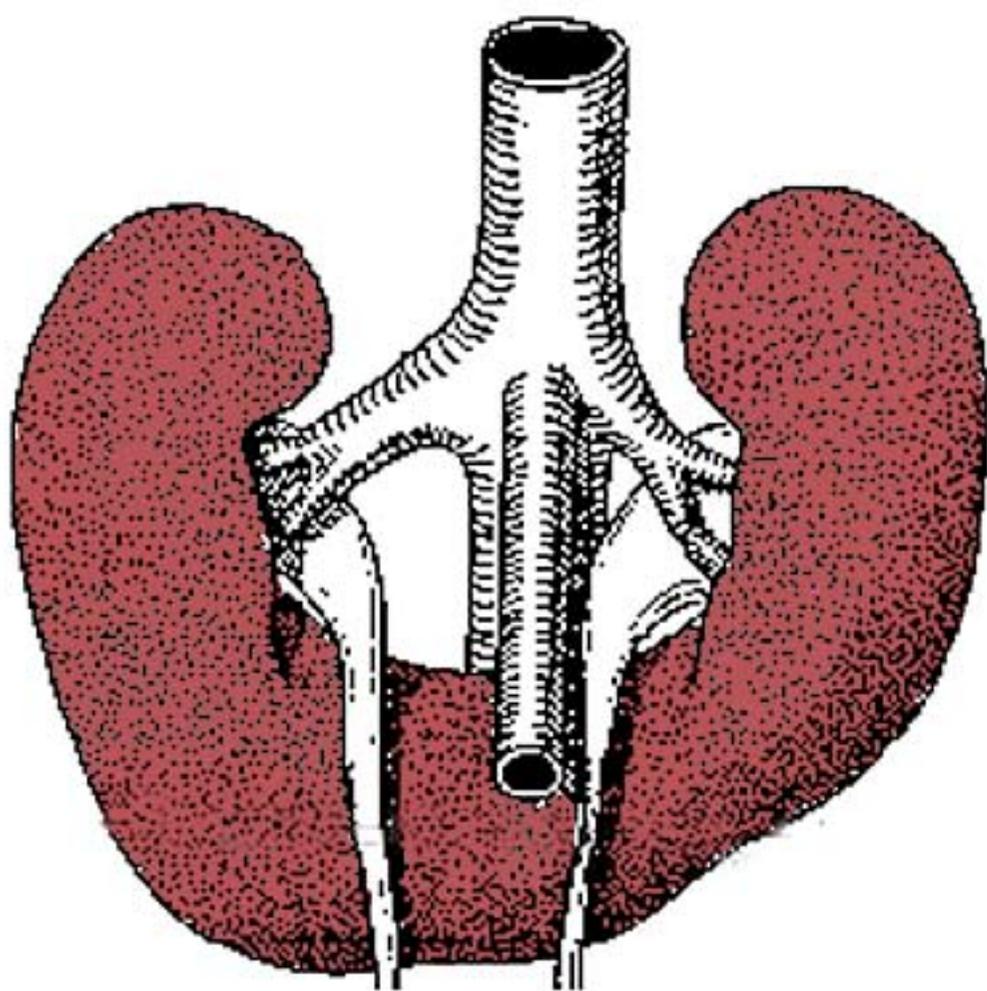


Bovine Renal Calyces

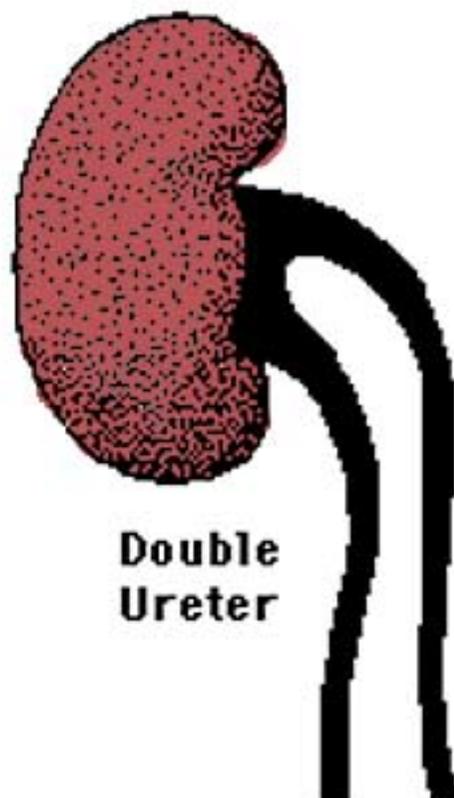


6 Weeks

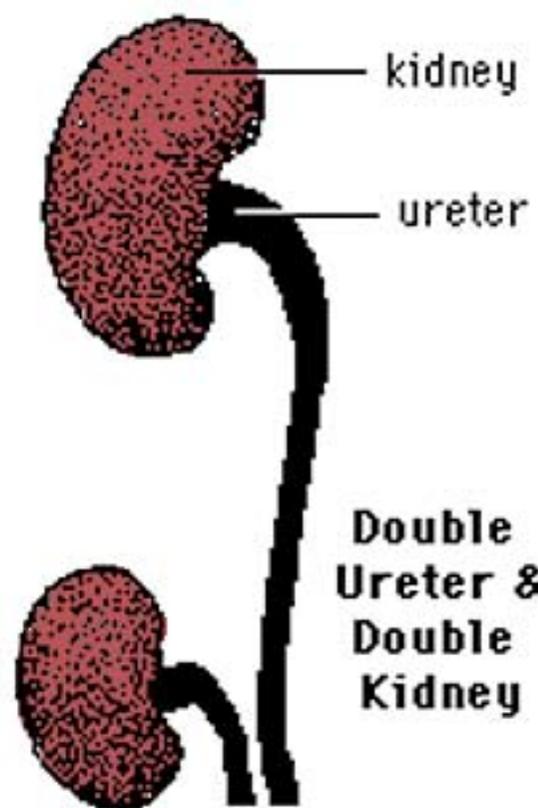




Split Ureter



Double Ureter



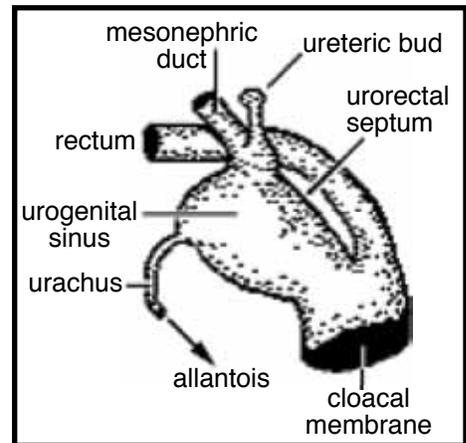
Double Ureter & Double Kidney

**Three Variations of Double Ureter
(left side, dorsal view)**

Urinary Bladder and Urethra

A urorectal septum divides the *cloaca* into, dorsally, a rectum & anal canal and, ventrally, a **urogenital sinus**. The urorectal septum also divides the cloacal membrane into an anal membrane and a urogenital membrane. The membranes subsequently degenerate, resulting in an anus and urogenital orifice, respectively.

Cranially, the urogenital sinus connects to the **urachus**, which is the intra-embryonic stalk of the allantois. The sinus may be divided into a pelvic (cranial) region and a phallic (caudal) region.



Urinary bladder develops from expansion of the cranial end of the urogenital sinus, including the adjacent portion of the urachus. The expansion incorporates both the mesonephric duct (future ductus deferens) and ureter into the dorsal wall of the urogenital sinus, each with a separate opening. Differential growth of the dorsal wall results in mesonephric duct and ureter openings being switched cranio-caudally, creating a trigone region that anchors the ureters to the bladder & urethra. (The bladder trigone region originates from mesoderm. The rest of the bladder is derived from endoderm.)

Urethra develops from the urogenital sinus. The development is gender specific:

In females, the mid region of the urogenital sinus becomes urethra. (The caudal region of the urogenital sinus become vestibule. The vagina arises as an outgrowth of the vestibule.)

In males, the pelvic urethra develops from the mid region of the urogenital sinus and the penile urethra develops from elongation of the caudal end of the urogenital sinus.

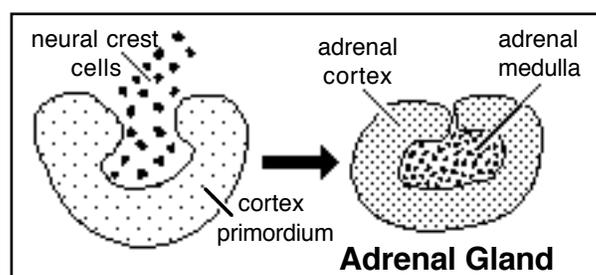
NOTE: In the fetus, urine is discharged into the allantoic cavity through the urachus and into the amniotic cavity through the urogenital orifice.

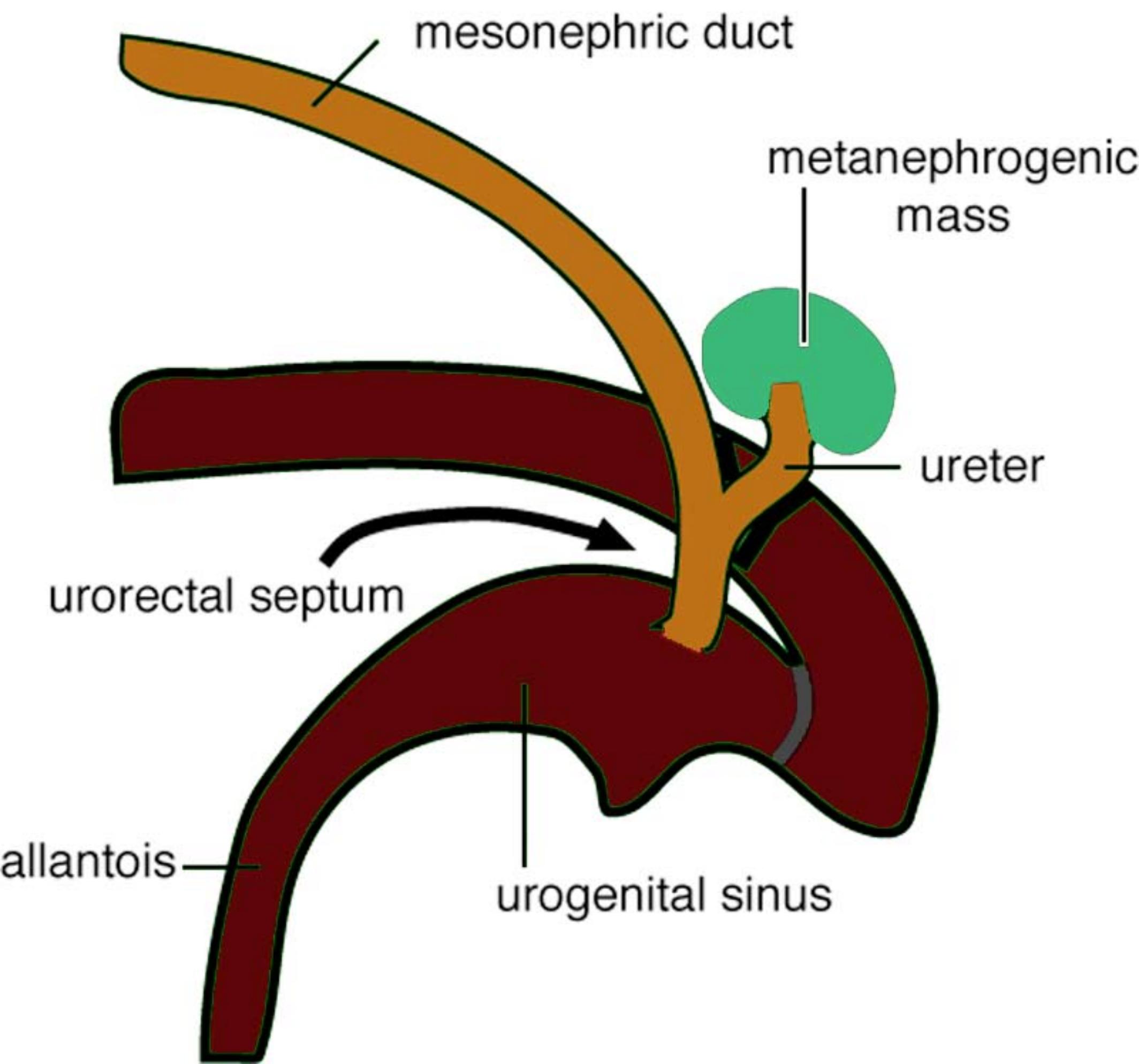
Abnormalities of development include:

- Hydronephrosis (cystic/polycystic kidneys) may result from ureteric atresia or from failure of nephrons to communicate with collecting tubules.
- Patent urachus (urachal fistula) results from a failure of the allantoic stalk to close at birth. Also, vesicourachal diverticulum (urachus persisting as a blind pouch) is a source of chronic cystitis.
- Ectopic ureter, where the ureter opens into the urethra or vagina instead of the bladder, is a source of incontinence because urine is deposited beyond urinary sphincters.

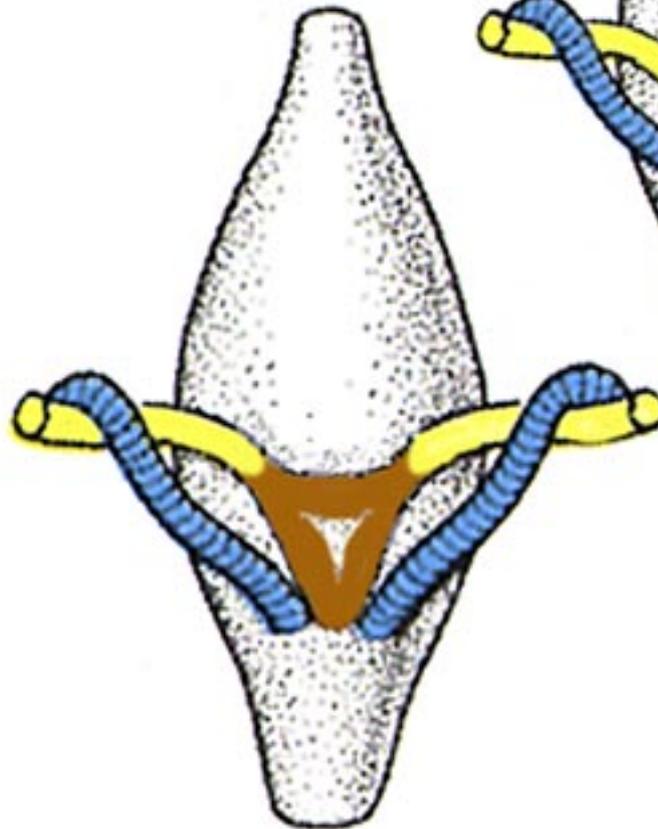
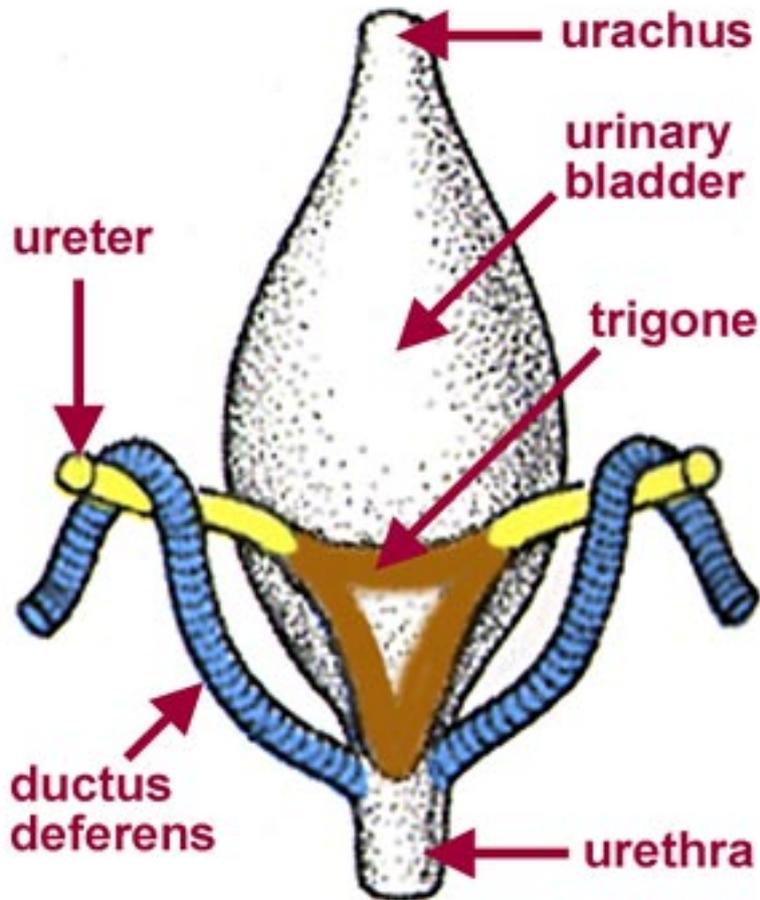
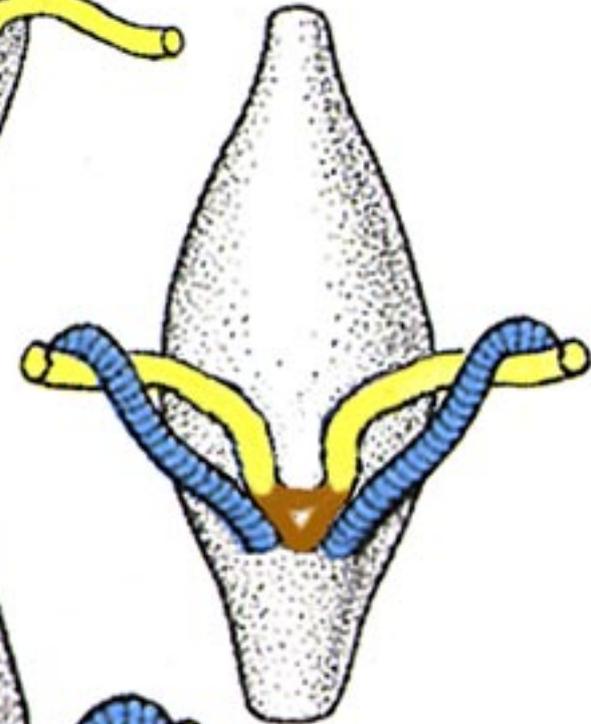
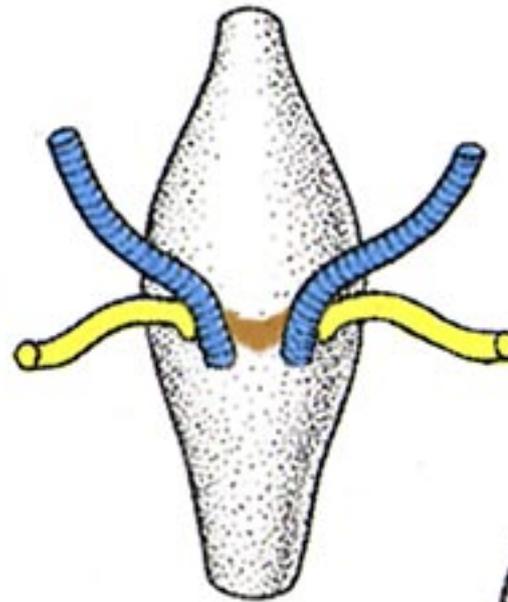
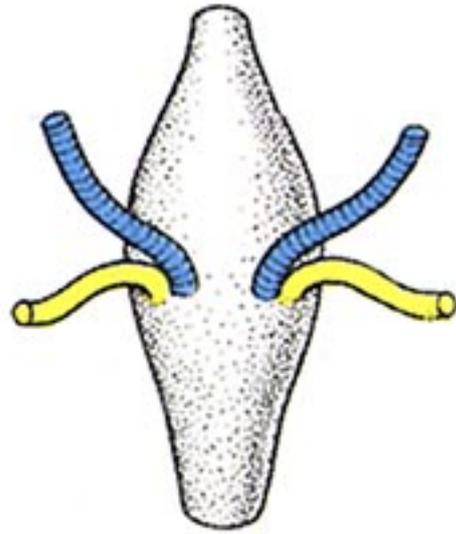
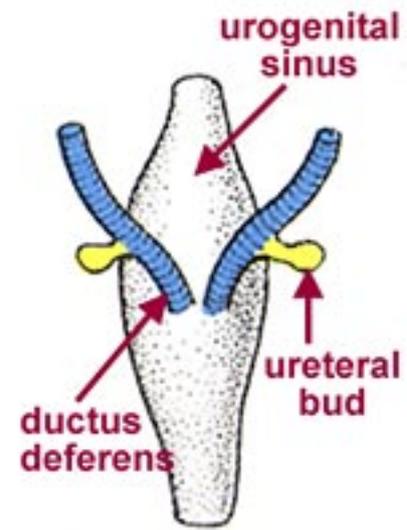
Adrenal Cortex

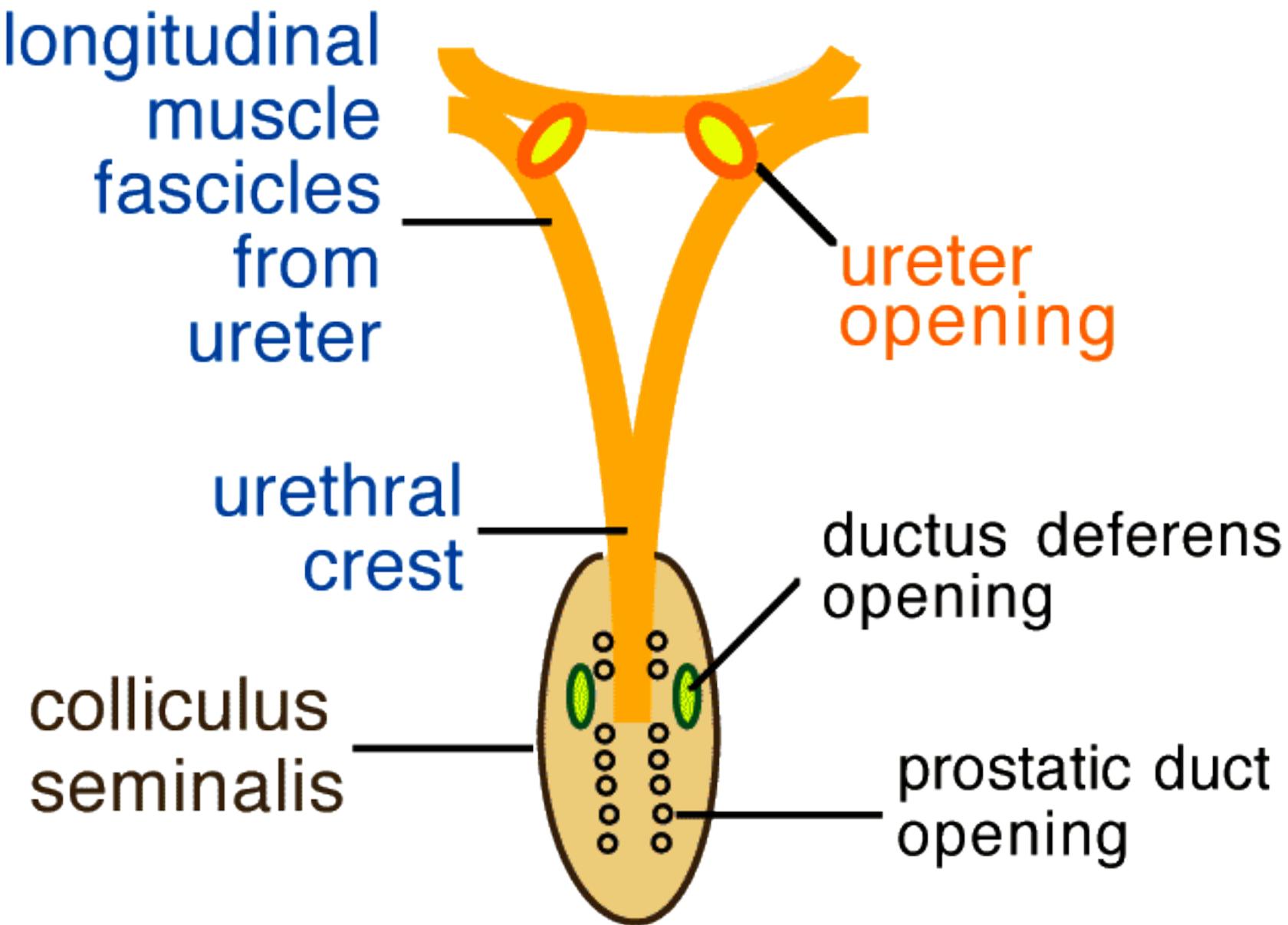
The adrenal gland consists of an adrenal medulla and an adrenal cortex that are embryologically, histologically, and functionally different, even though they are combined grossly. The adrenal medulla is derived from neural crest (ectoderm). The adrenal cortex arises from cells of mesonephric tubules that dissociate and migrate to the location of the adrenal gland when the mesonephros degenerates.





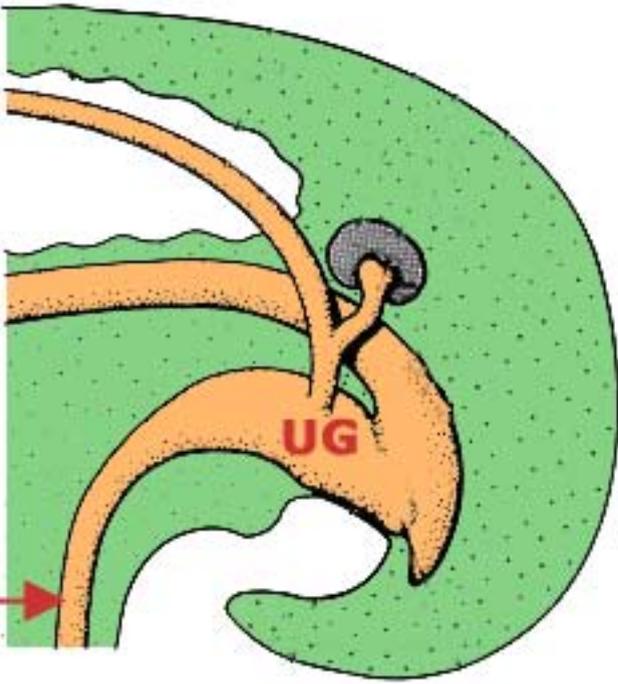






TRIGONE

(internal dorsal wall of bladder neck and prostatic urethra of male dog)



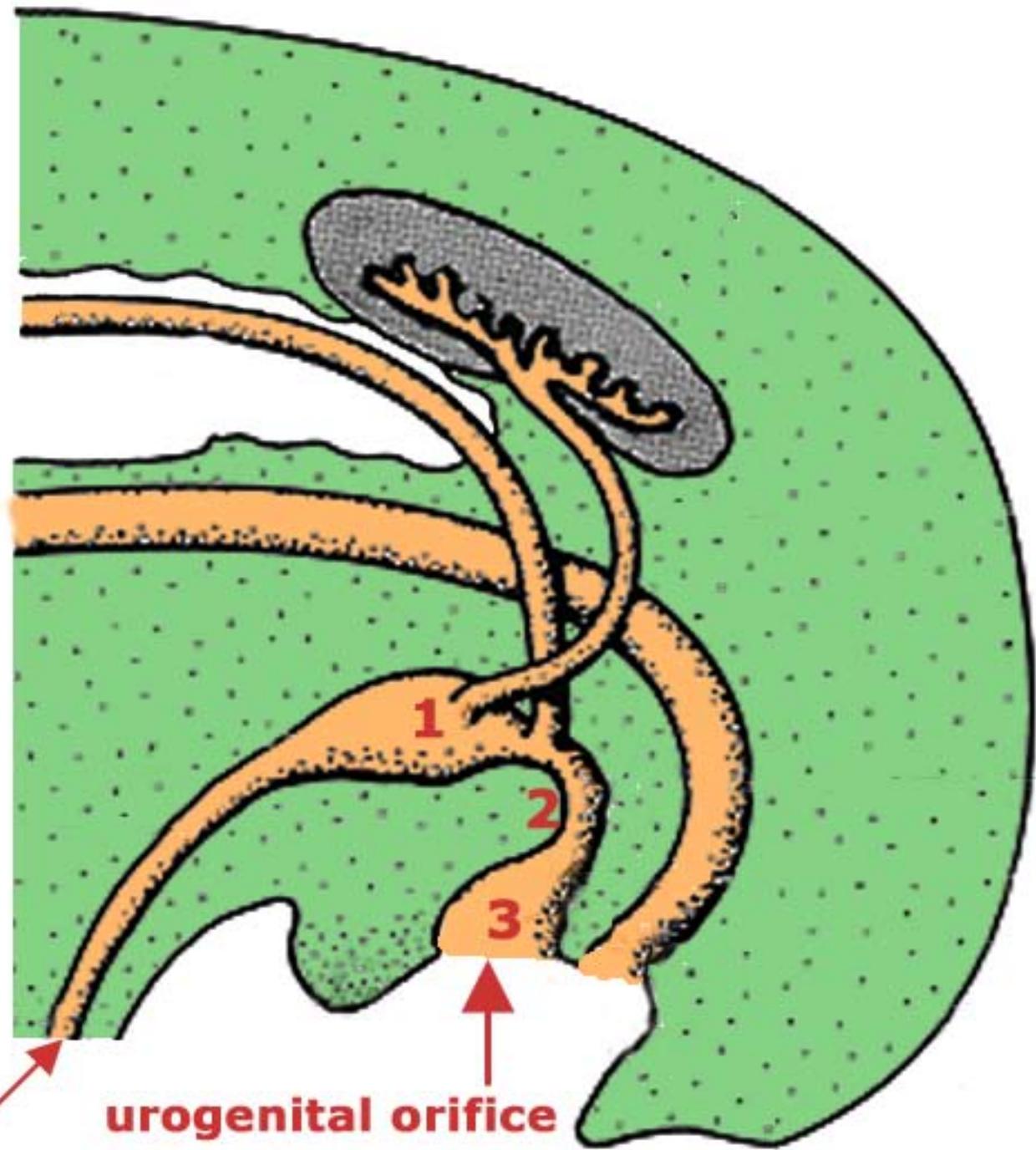
allantois →

UG

Urogenital Sinus (UG)
Male **Female**

- 1. urinary bladder**
- 2. pelvic urethra**
- 3. penile urethra**

- urinary bladder**
- urethra**
- vestibule**



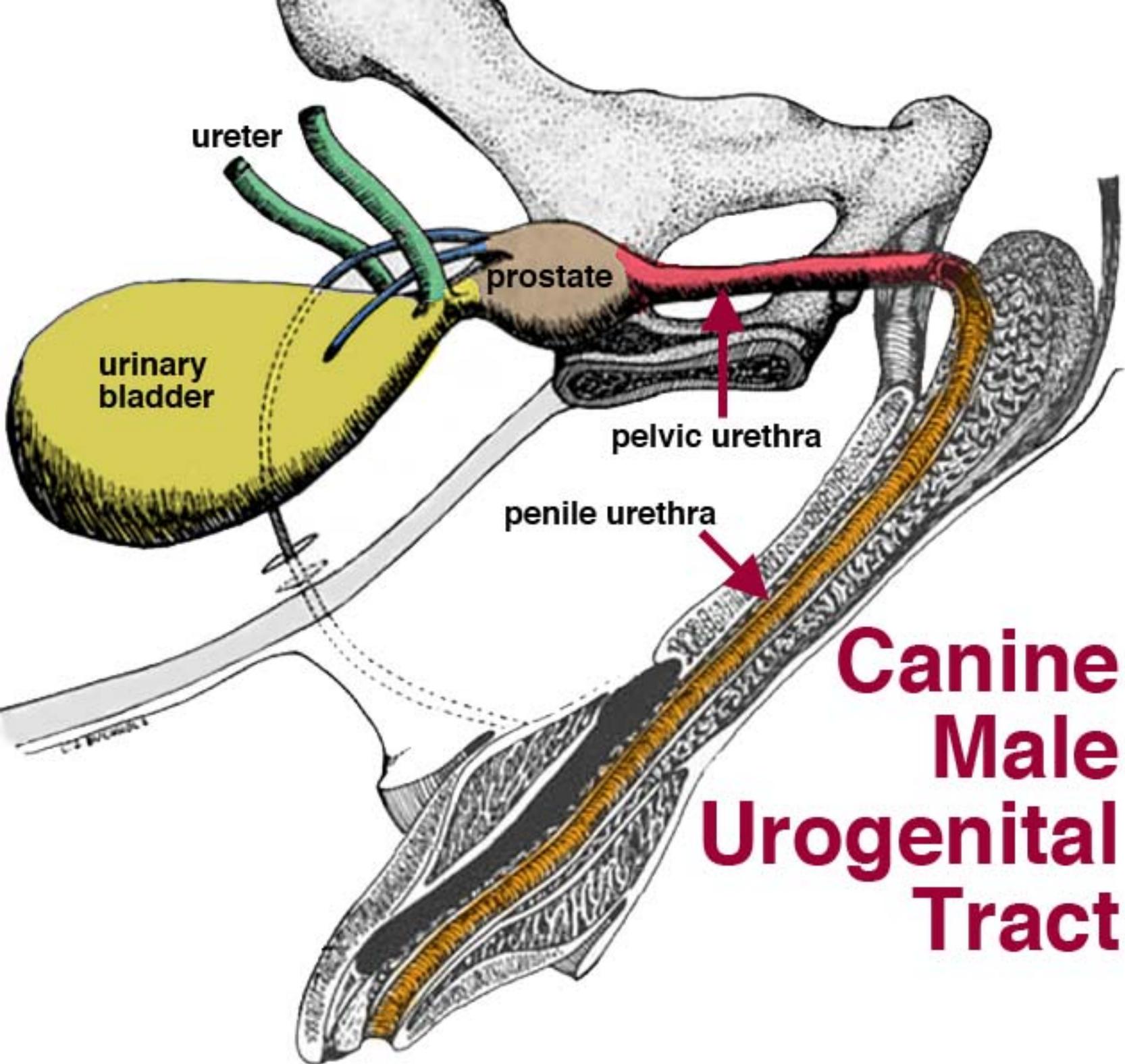
urachus →

urogenital orifice

1

2

3



ureter

urinary bladder

prostate

pelvic urethra

penile urethra

**Canine
Male
Urogenital
Tract**

