

Development of the urinary system

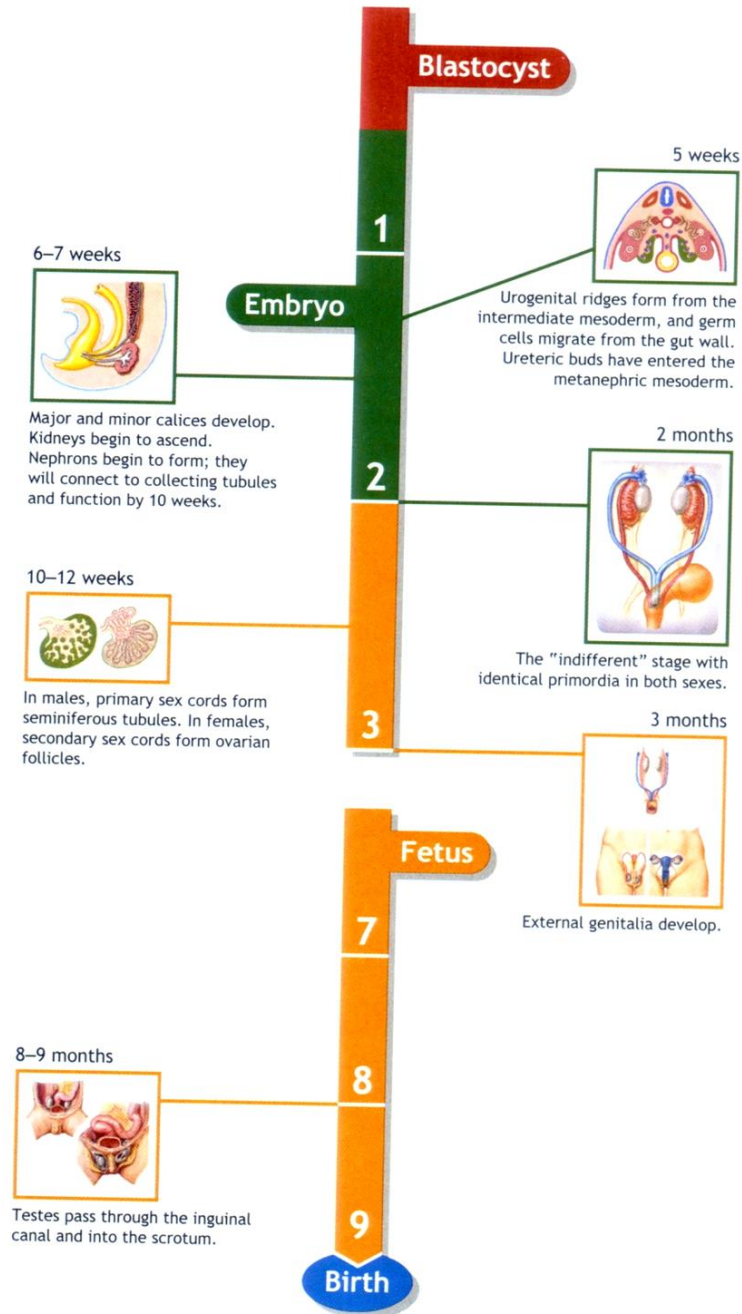
WSO

University of Hong Kong.

3 sets of kidneys developing in succession
(temporally and spatially) :

- Pronephros]
- Mesonephros]- Intermediate mesoderm
- Metanephros]

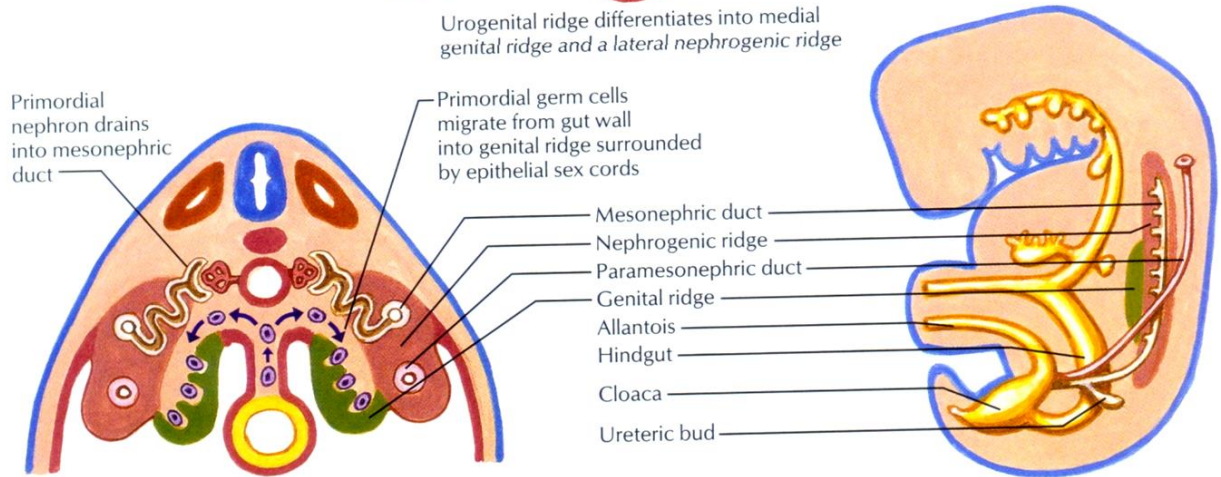
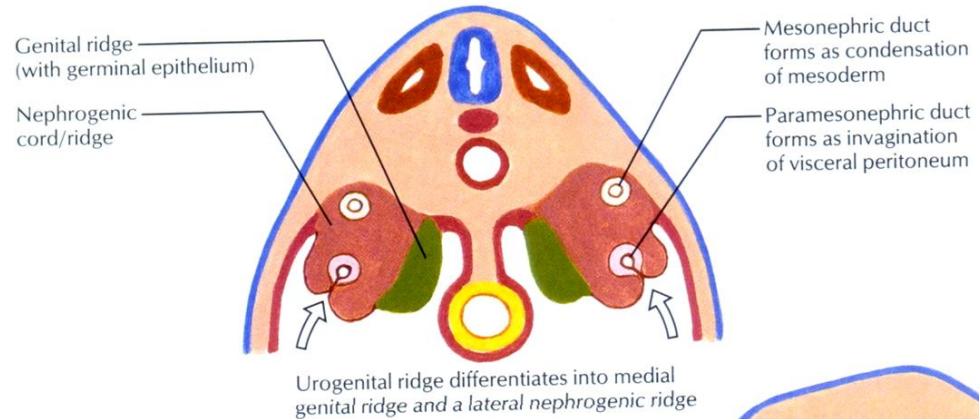
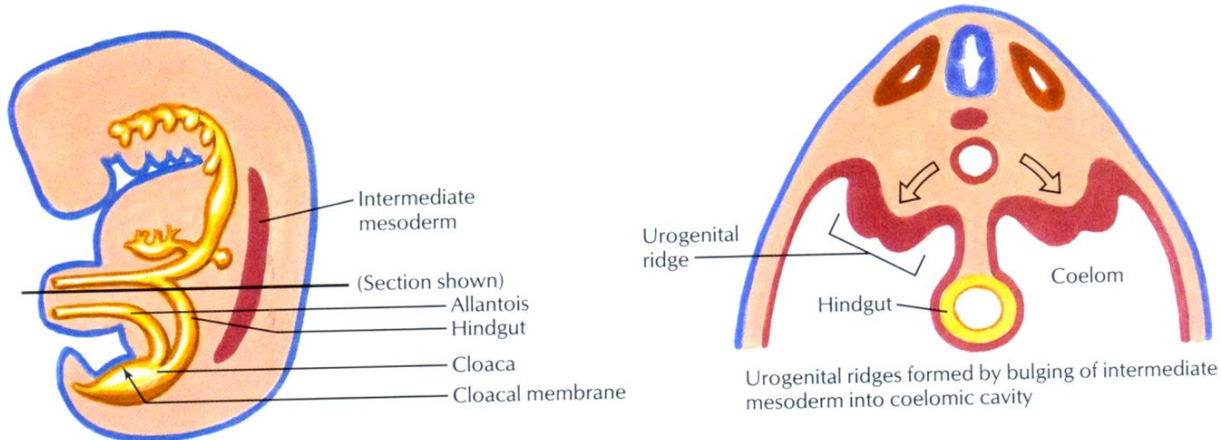
Prenatal Time Scale (Months)



Plan of Urinary System Development

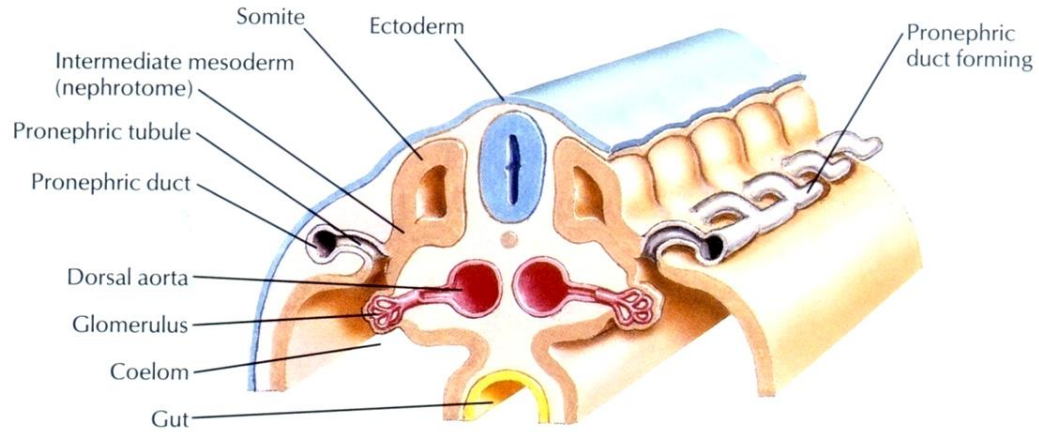
Pronephros, Mesonephros and Metanephros

- The intermediate mesoderm differentiate into nephrogenic tissue in the nephrogenic ridge lateral to the genital ridge. From cranial to caudal it forms three successive kidneys temporally and spatially.
- The *pronephros* never fully develops and quickly diminishes.
- The *mesonephros* is the first functional kidney with glomeruli, mesonephric tubules and mesonephric duct that drains embryonic urine into the cloaca.
- The *metanephros* becomes the permanent kidney. The metanephric ducts develops from a ureteric bud that grows from the caudal end of the mesonephric duct.

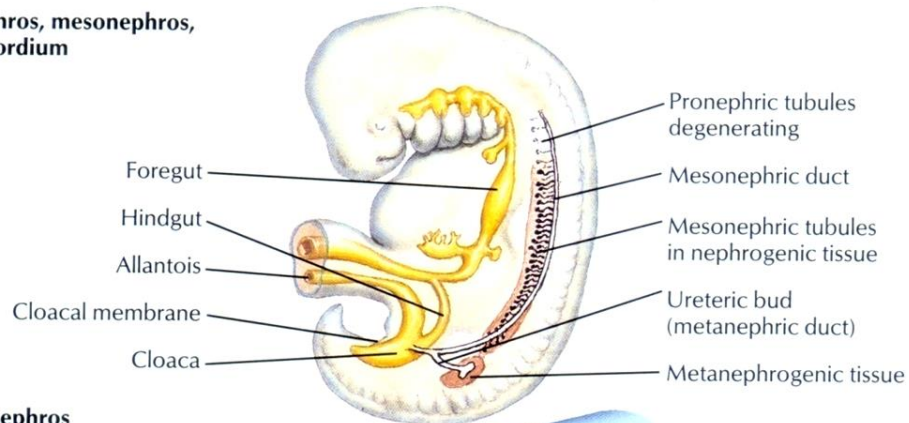


Pronephros

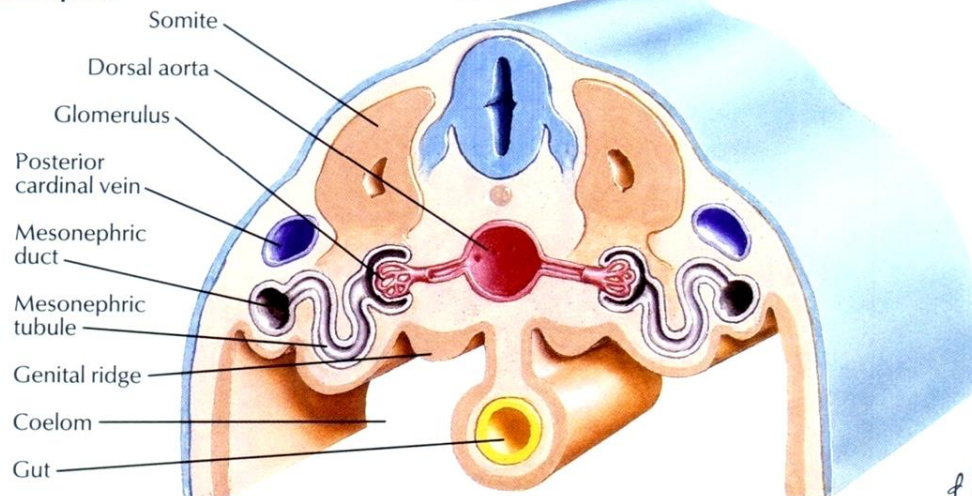
- 4th week
- At levels of somites 7-14 (cervical)
- Tubules open into coelomic cavity



Topography of pronephros, mesonephros, and metanephric primordium



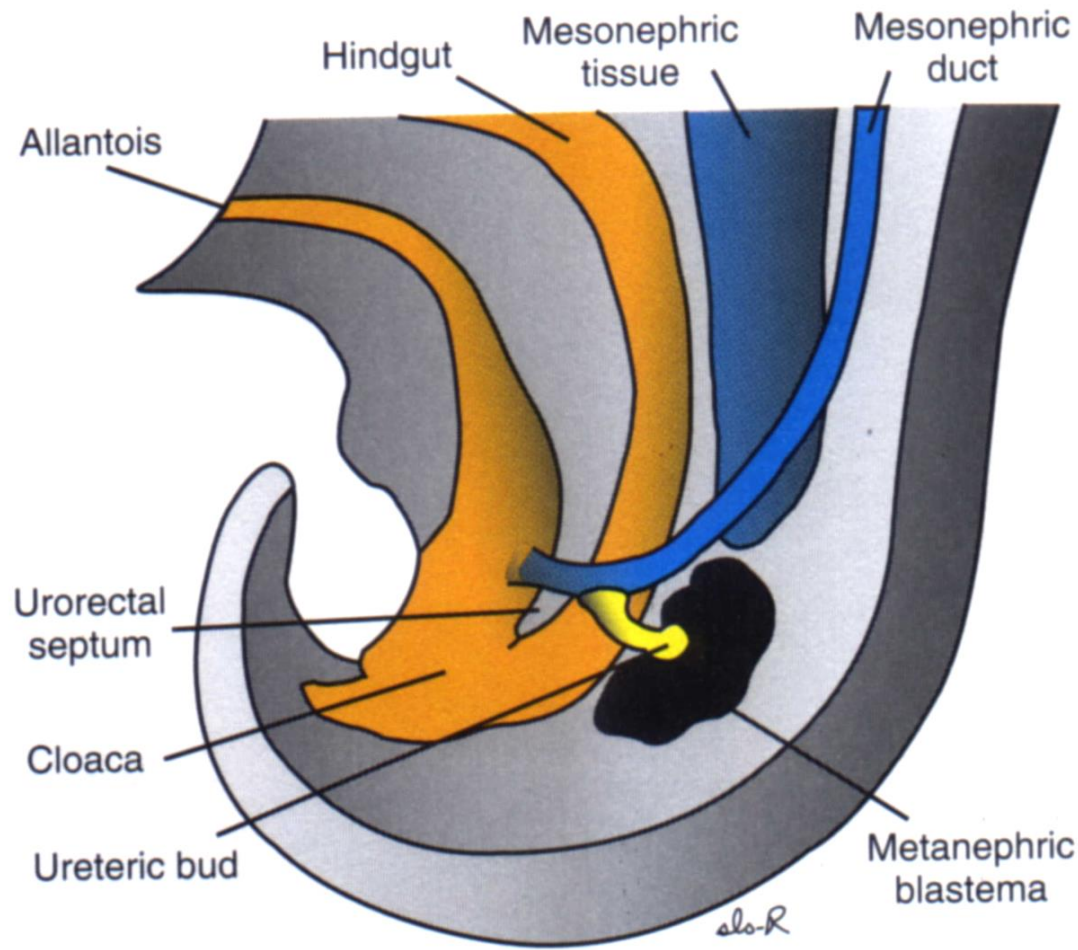
Section through mesonephros



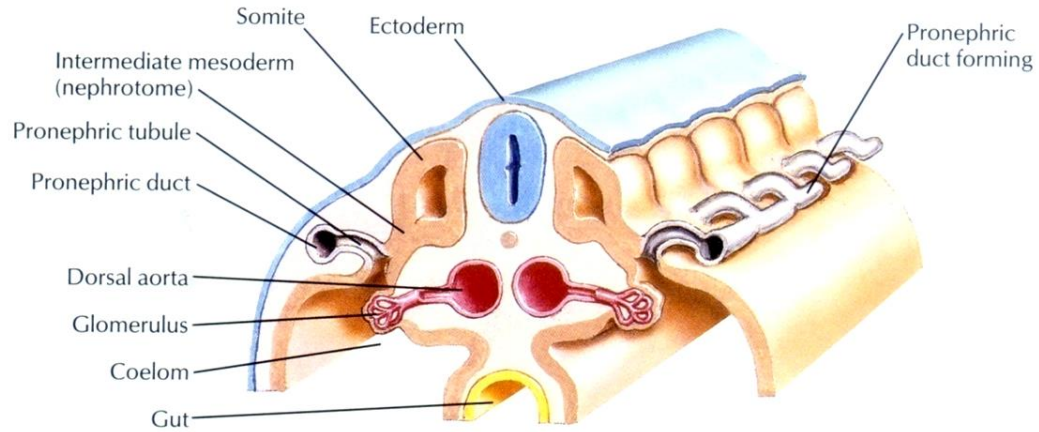
Mesonephros

- 4 - 5th week
- At levels of somites 14-26 (cervical to lumbar)
- Tubules 2-9 per segment differentiate to Bowman's capsule join to form mesonephric duct
- Mesonephros and ducts disappear by 16th week in **females**

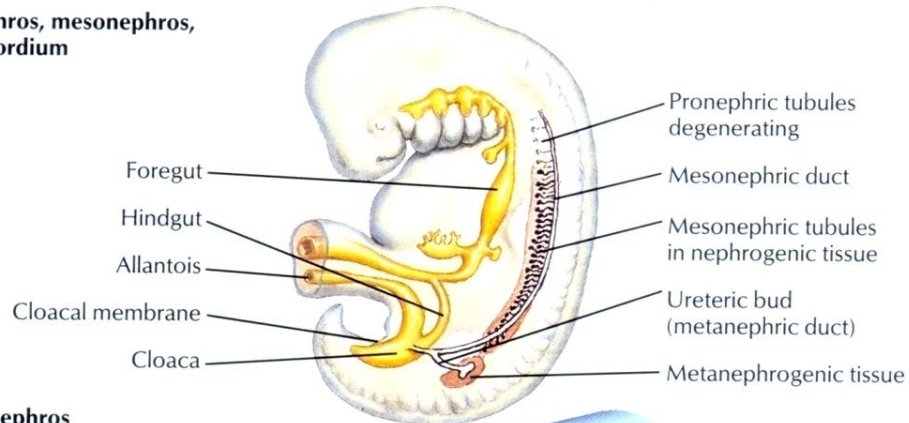
Mesonephric ducts persist in **males** as ductus deferens



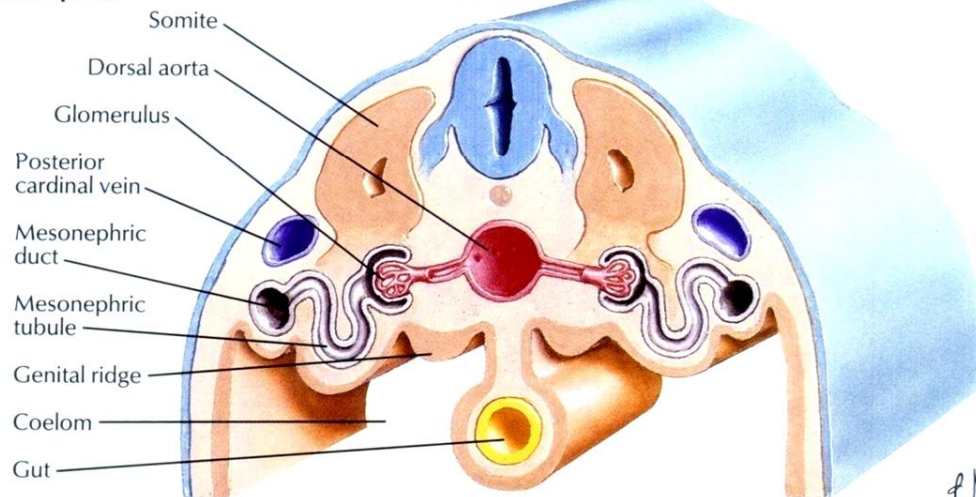
**Relation of the allantois, cloaca and the hindgut
at the end of the fifth week**



Topography of pronephros, mesonephros, and metanephric primordium



Section through mesonephros



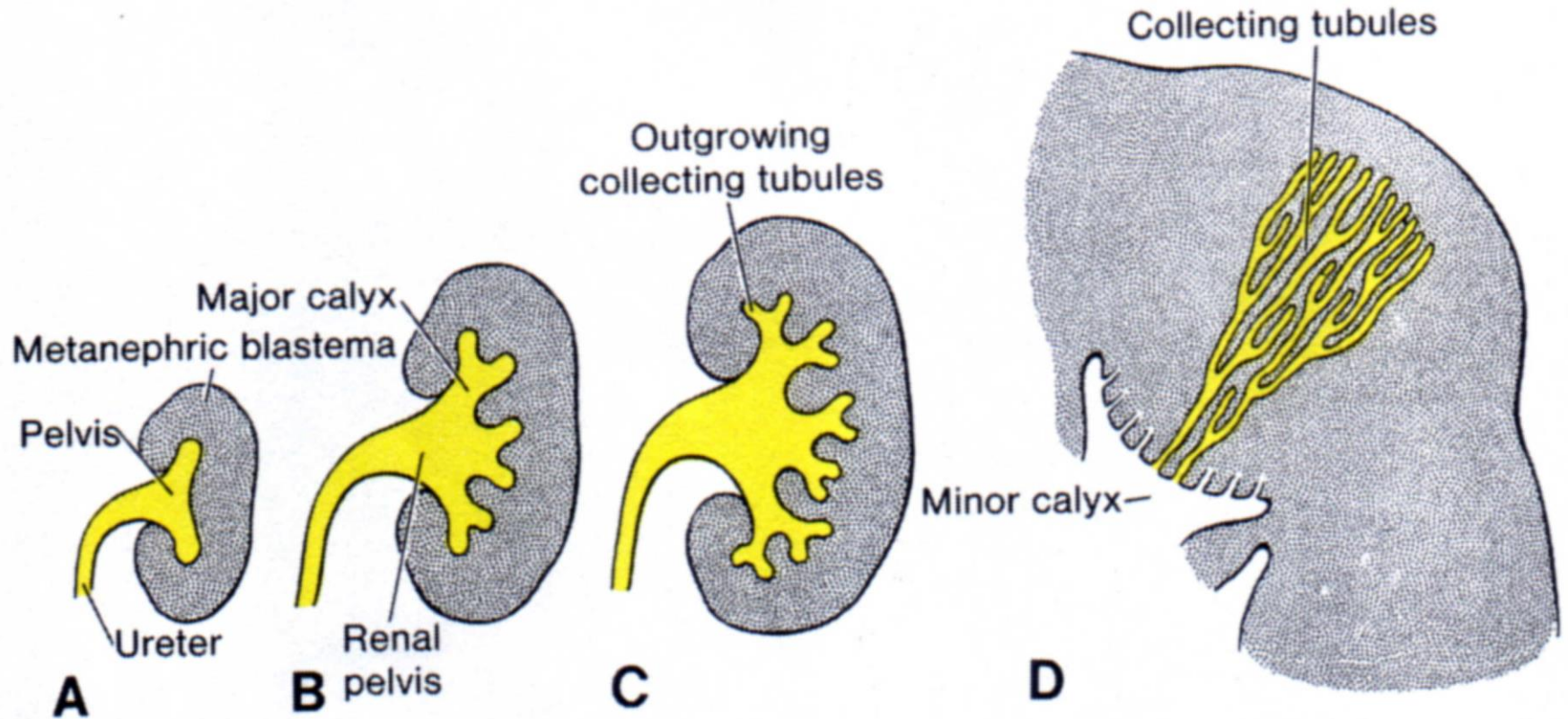
Metanephros (Permanent kidney)

2 sources (a) ureteric bud
 (b) metanephric blastema

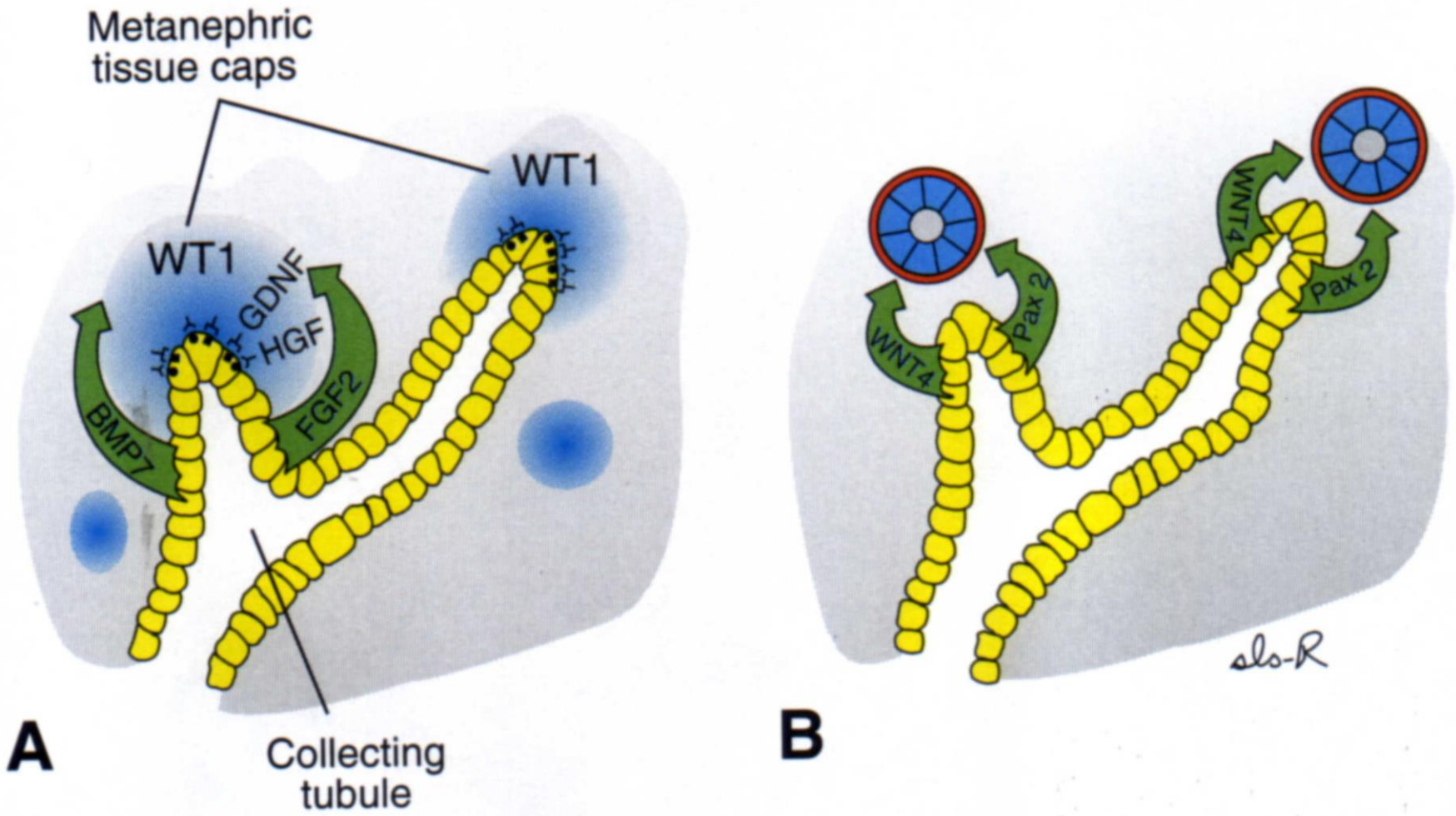
2nd month

- Ureteric bud (*giving rise to drainage system*)
- Outgrowth from mesonephric duct giving rise to ureter
- 1st - 4th order : major & minor calyces
- 5th order : papillary duct
- 6th – 14th order : collecting tubule

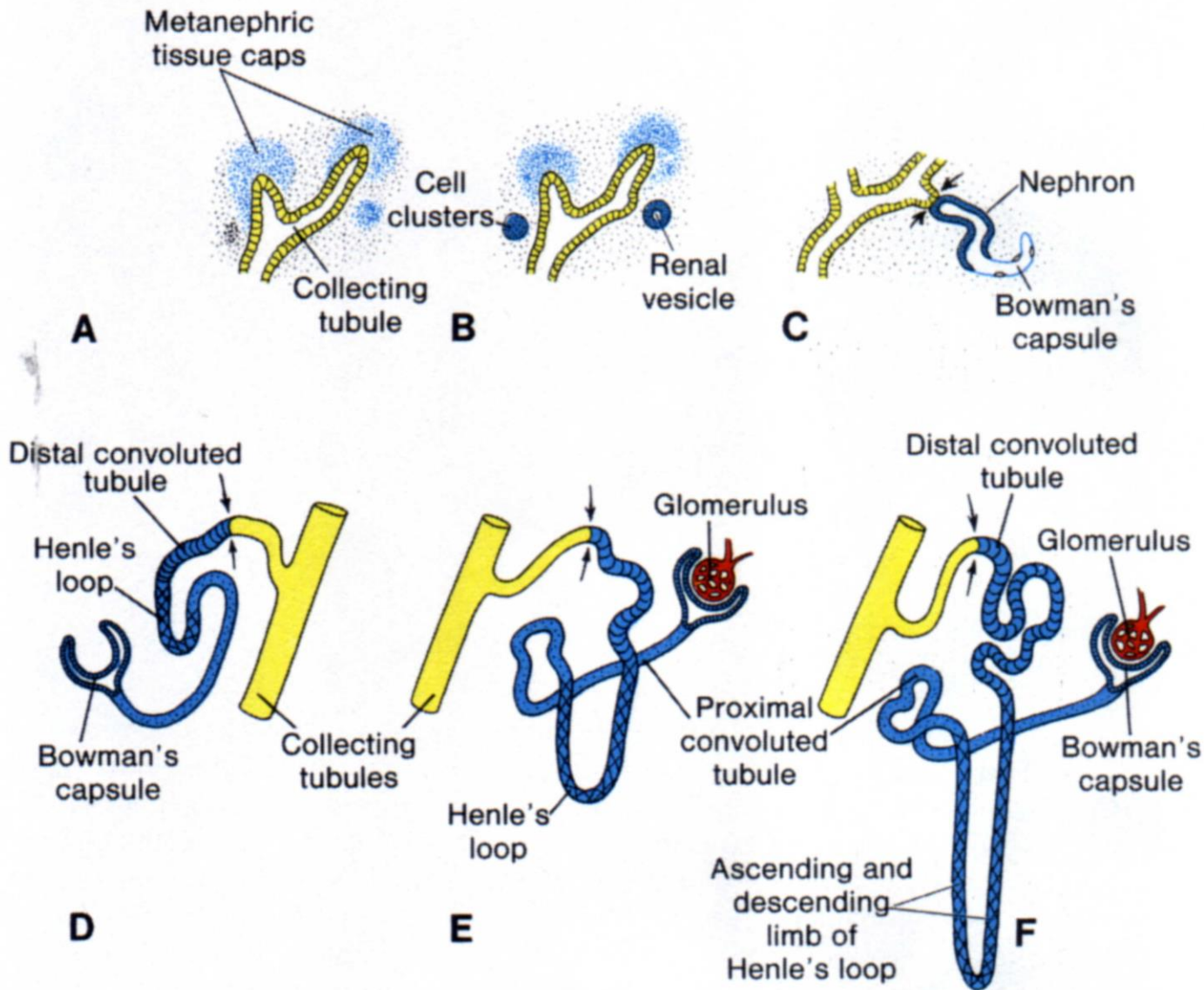
- **Metanephric blastema** (*giving rise to the nephron units*)
 - Vesicle lined by epithelium
 - Elongation of vesicles into S-shaped blind tubules
 - Differentiate into:
 - Bowman's capsule
 - Proximal convoluted tubule
 - Loop of Henle's
 - Distal convoluted tubule
 - Canalize with collecting duct



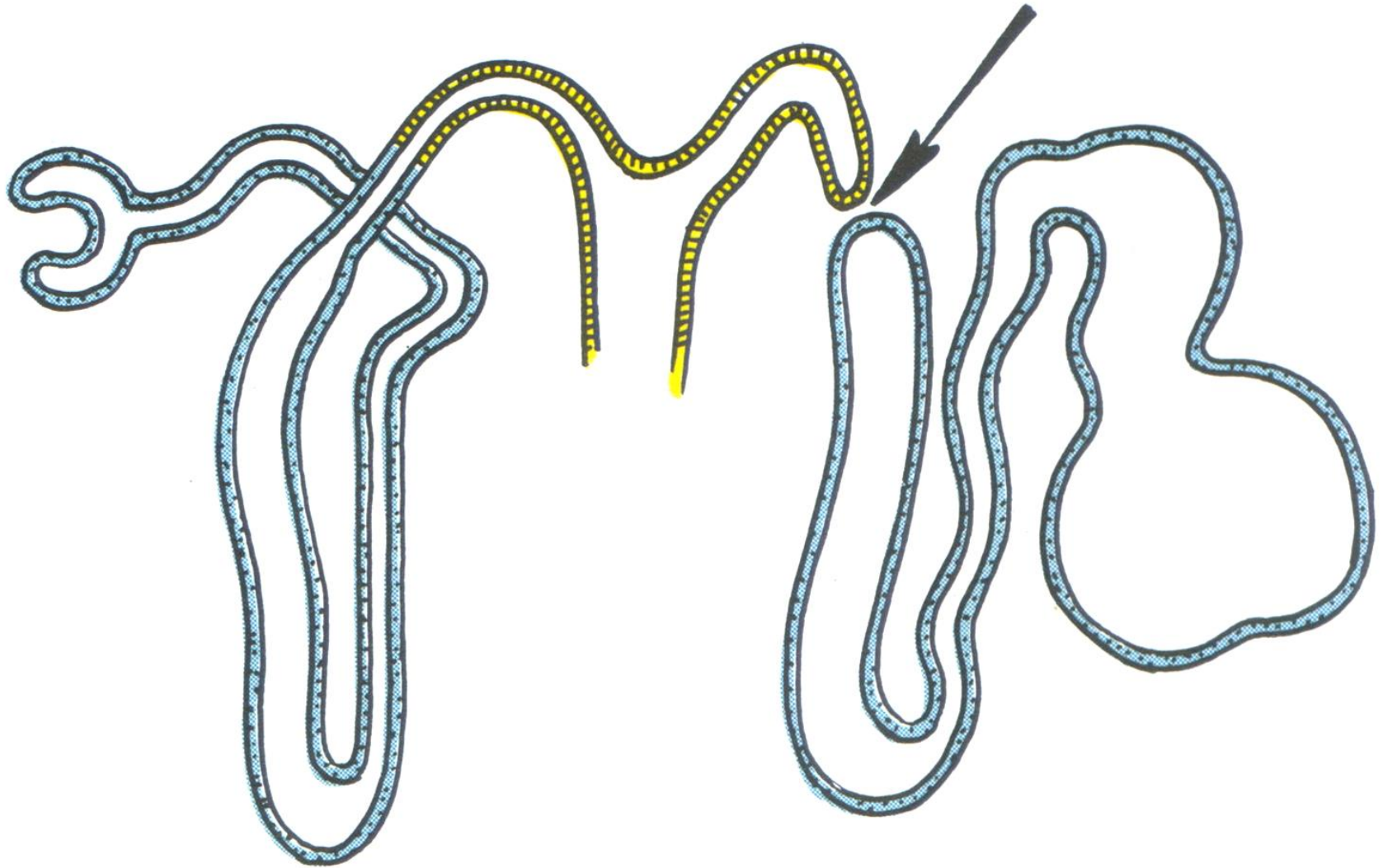
Development of the renal pelvis, calyces and collecting tubules of the metanephros



Genes involved in the differentiation of the kidney



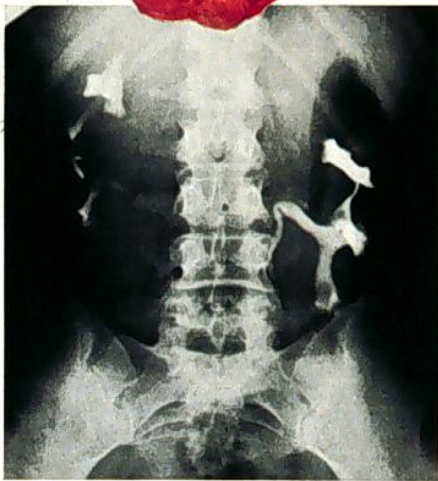
Differentiation of the nephron unit



Formation of cyst in the metanephric kidney



POLYCYSTIC KIDNEY:
SURFACE ASPECT



INTRAVENOUS PYELOGRAM: BILATERAL
POLYCYSTIC DISEASE



KIDNEY
SECTIONED

Polycystic kidney disease:

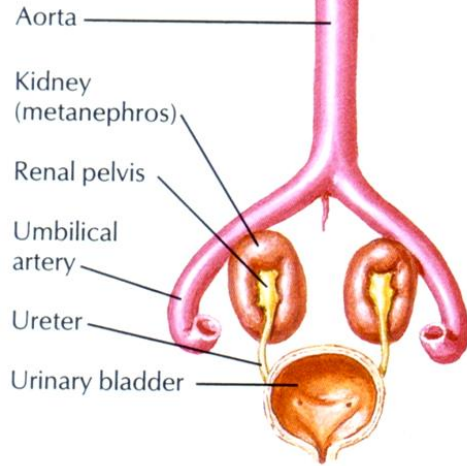
- 1-2:1000 births
- Inheritable disease , most cases are caused by dominant gene
- Involves ~5% nephrons

Rotation of kidneys:

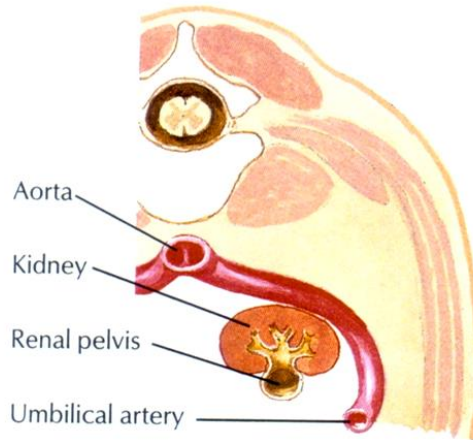
- **Hilum of kidney faces ventrally**
 - **Rotates 90°**
- **Hilum directed medially**

Apparent "ascent and rotation" of the kidneys in embryological development

6 weeks

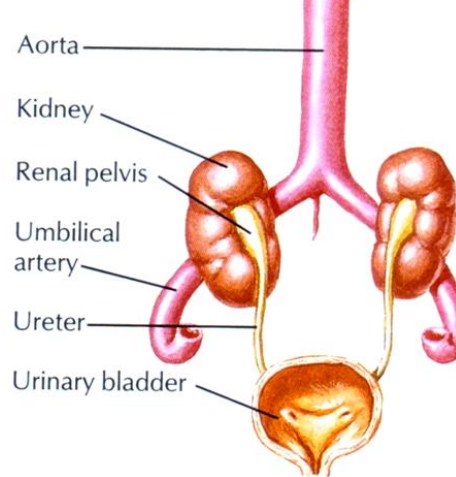


Frontal view

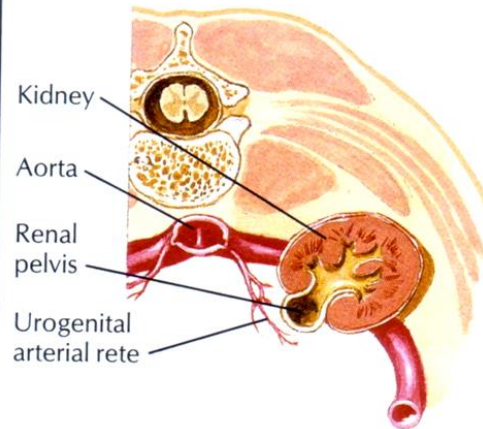


Cross section

7 weeks

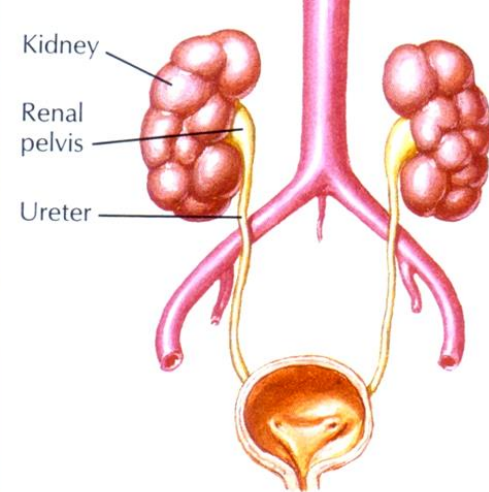


Frontal view

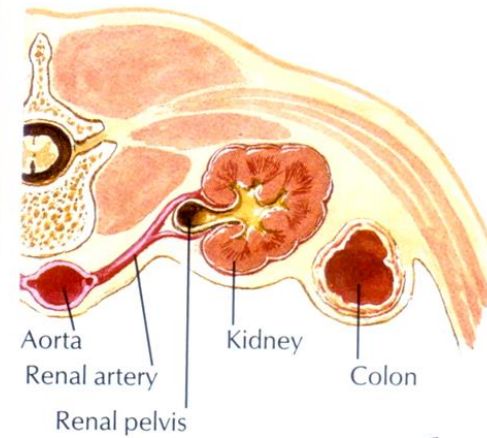


Cross section

9 weeks



Frontal view



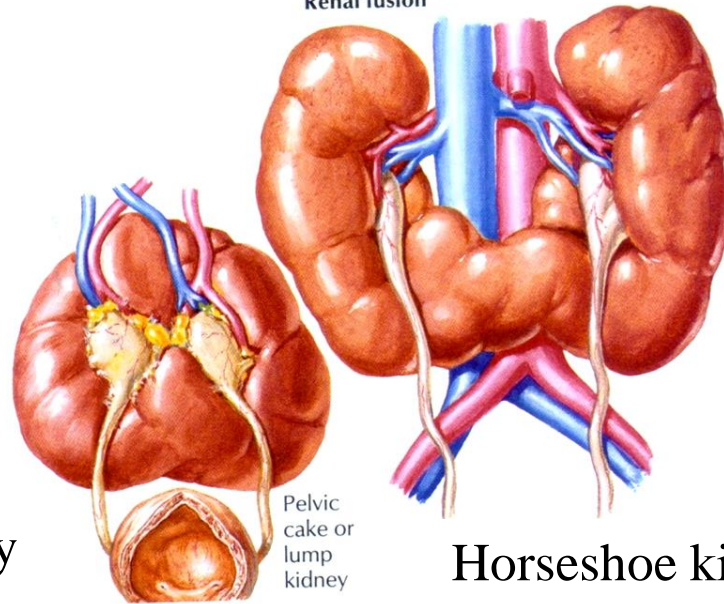
Cross section

Ascend and blood supply

- **Metanephros**: a pelvic organ; arterial supply from middle sacral arteries
 - Growth of lumbo-sacral region
 - Growth of ureter
- “**Ascend**”: to lumbar region (L2); arterial supply from upper lumbar arteries.

Right lobe of liver prevents right kidney to ascend as far as that on the left.

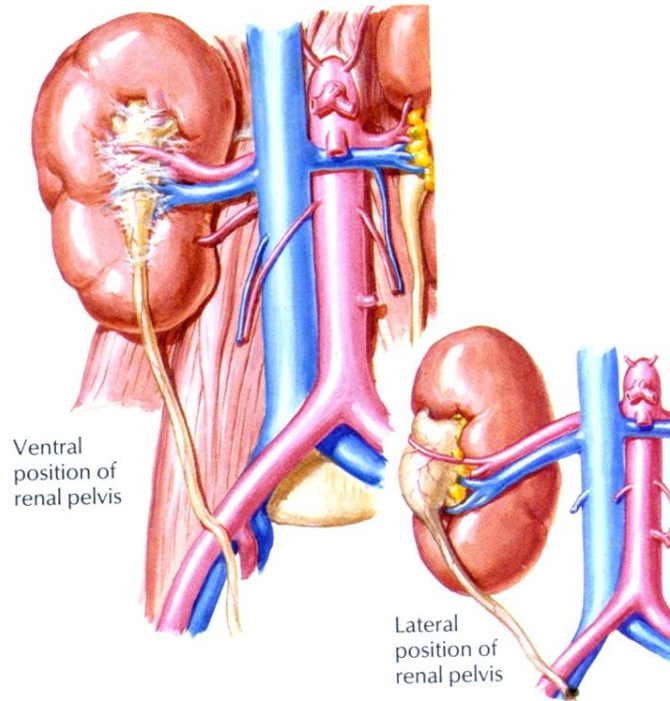
Renal fusion



Rosette kidney

Horseshoe kidney

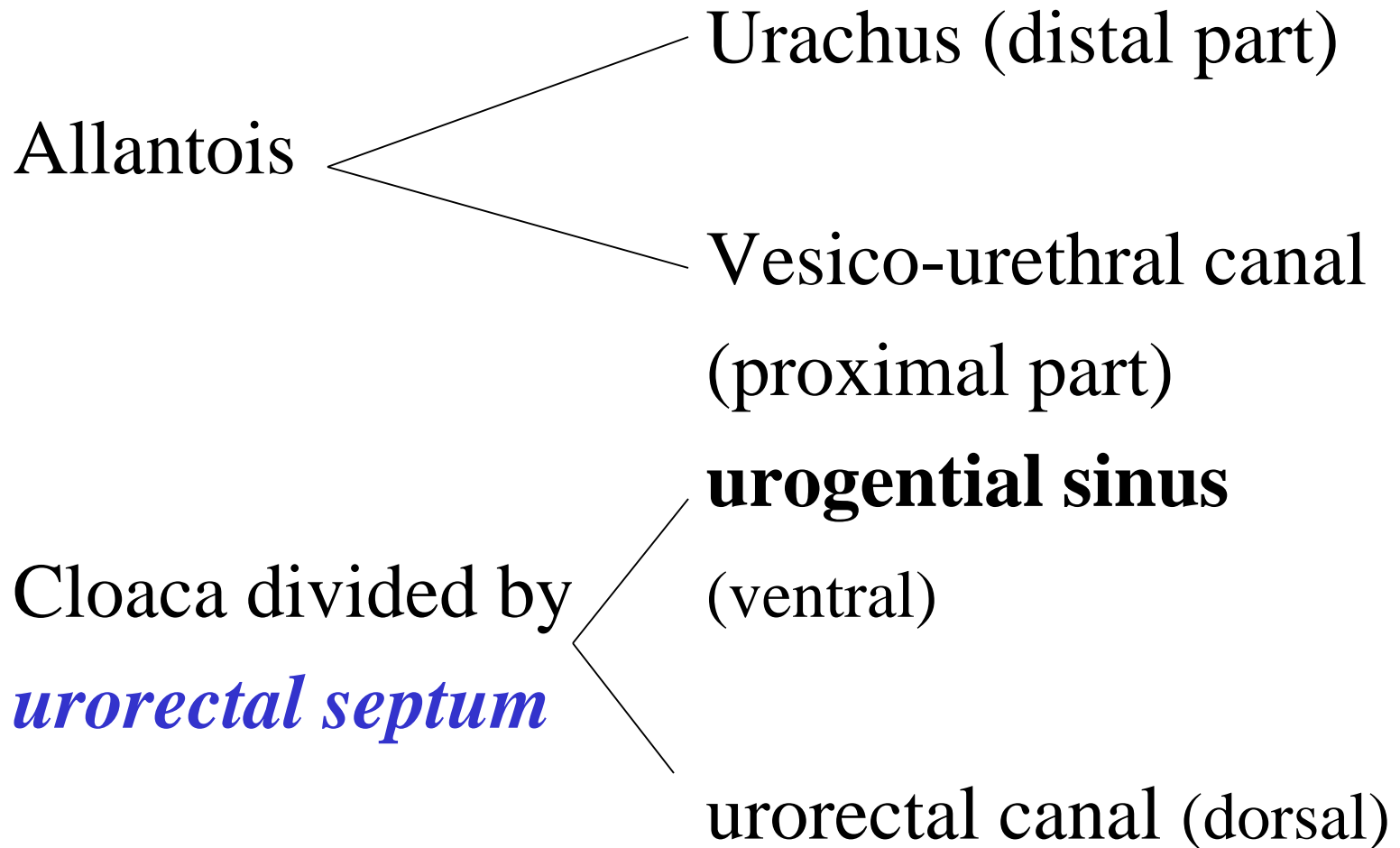
Anomalies of renal rotation

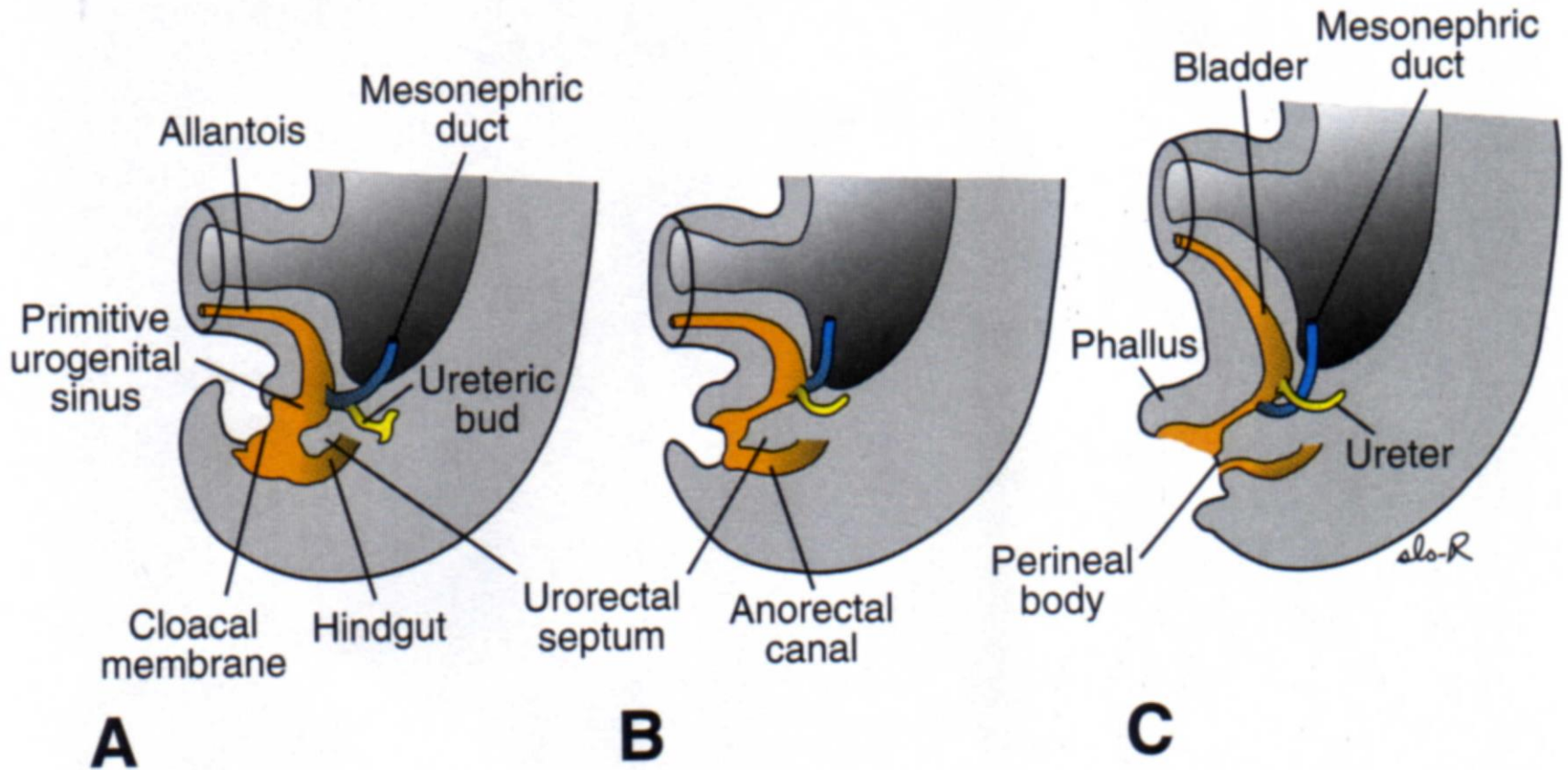


Ventral position of renal pelvis

Lateral position of renal pelvis

Urinary bladder:

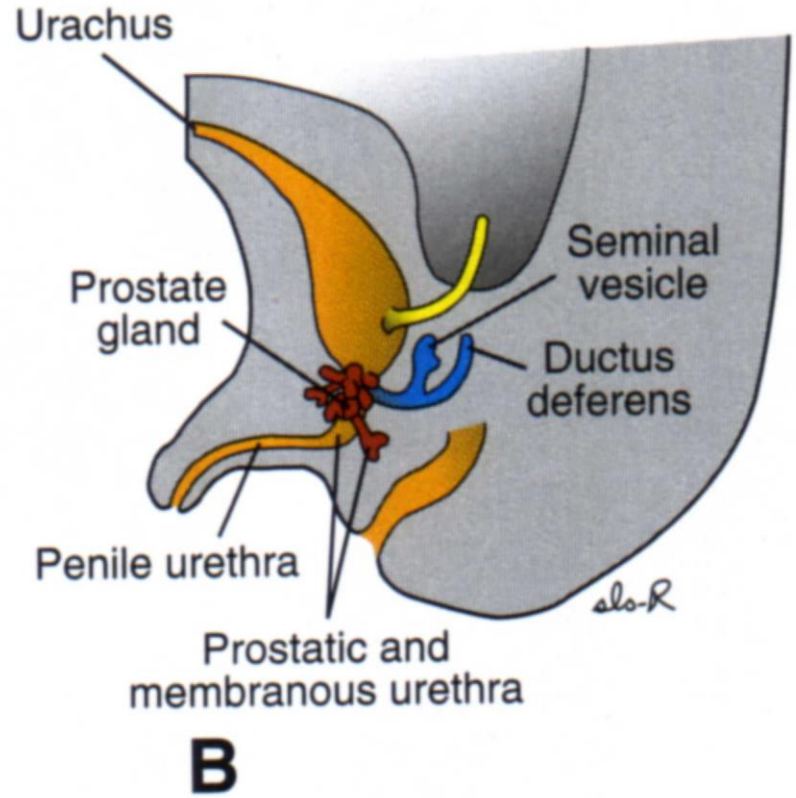
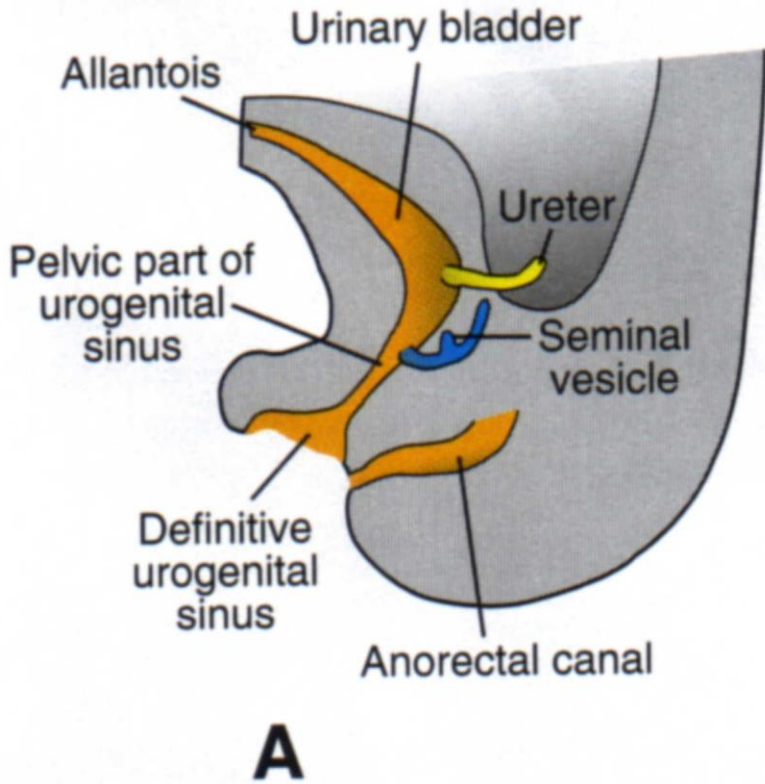




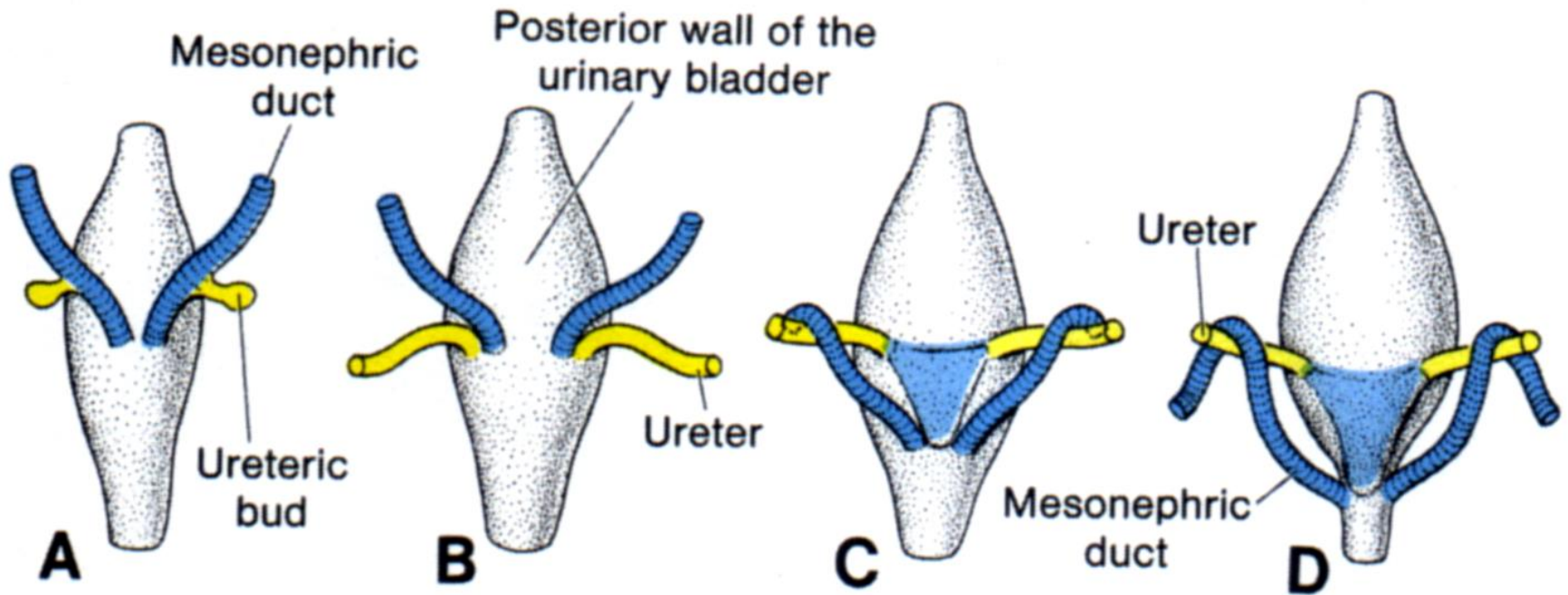
Division of the cloaca into the urogenital sinus and anorectal canal.

Trigone of bladder:

- Formed from dilatation of mesonephric ducts (epithelium – mesodermal in origin)
- Later overgrown by surrounding epithelium from cloaca and allantois (endodermal in origin).



Development of the urogenital sinus in the male



Dorsal view of the bladder showing the relation of the ureters and mesonephric ducts during development

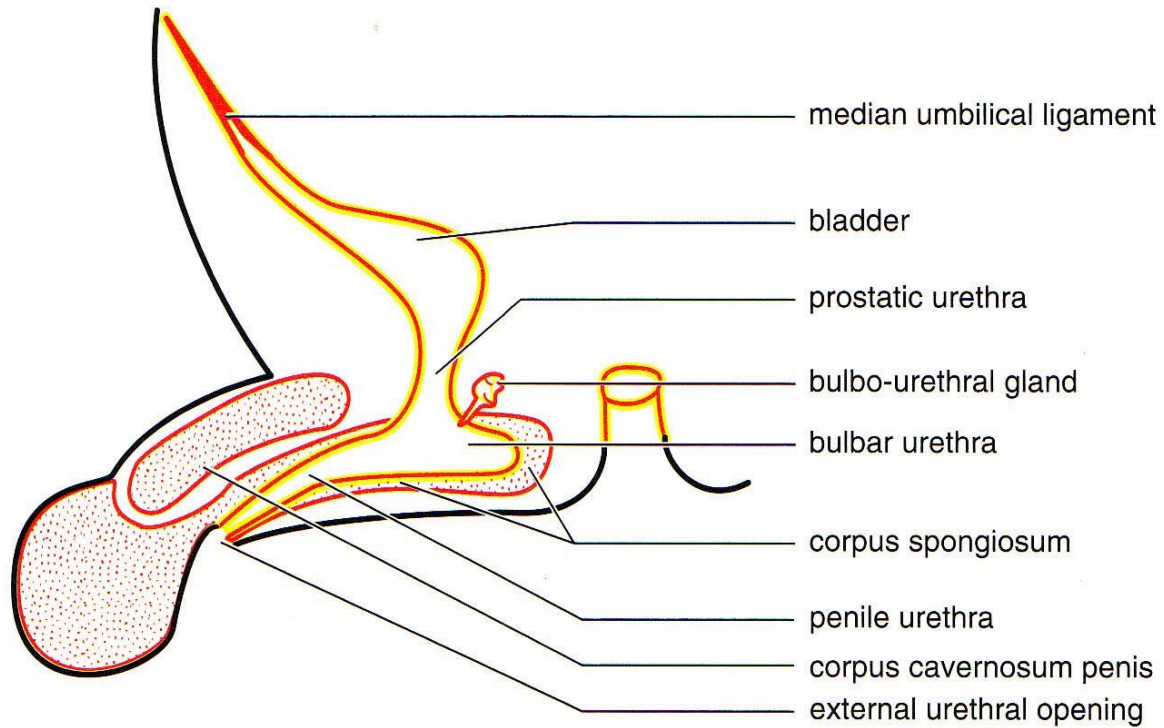
Urethra:

Female urethra

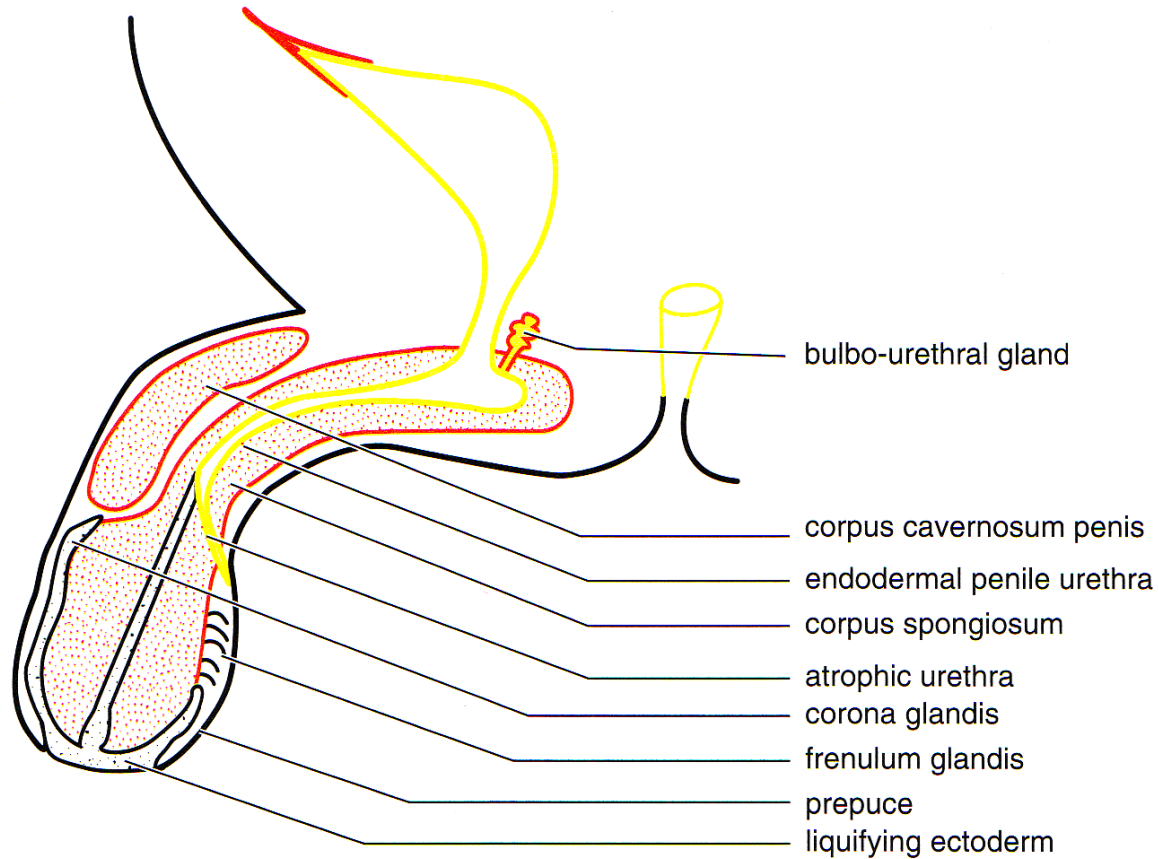
- Neck of primitive bladder elongates to form the whole urethra

Male urethra:

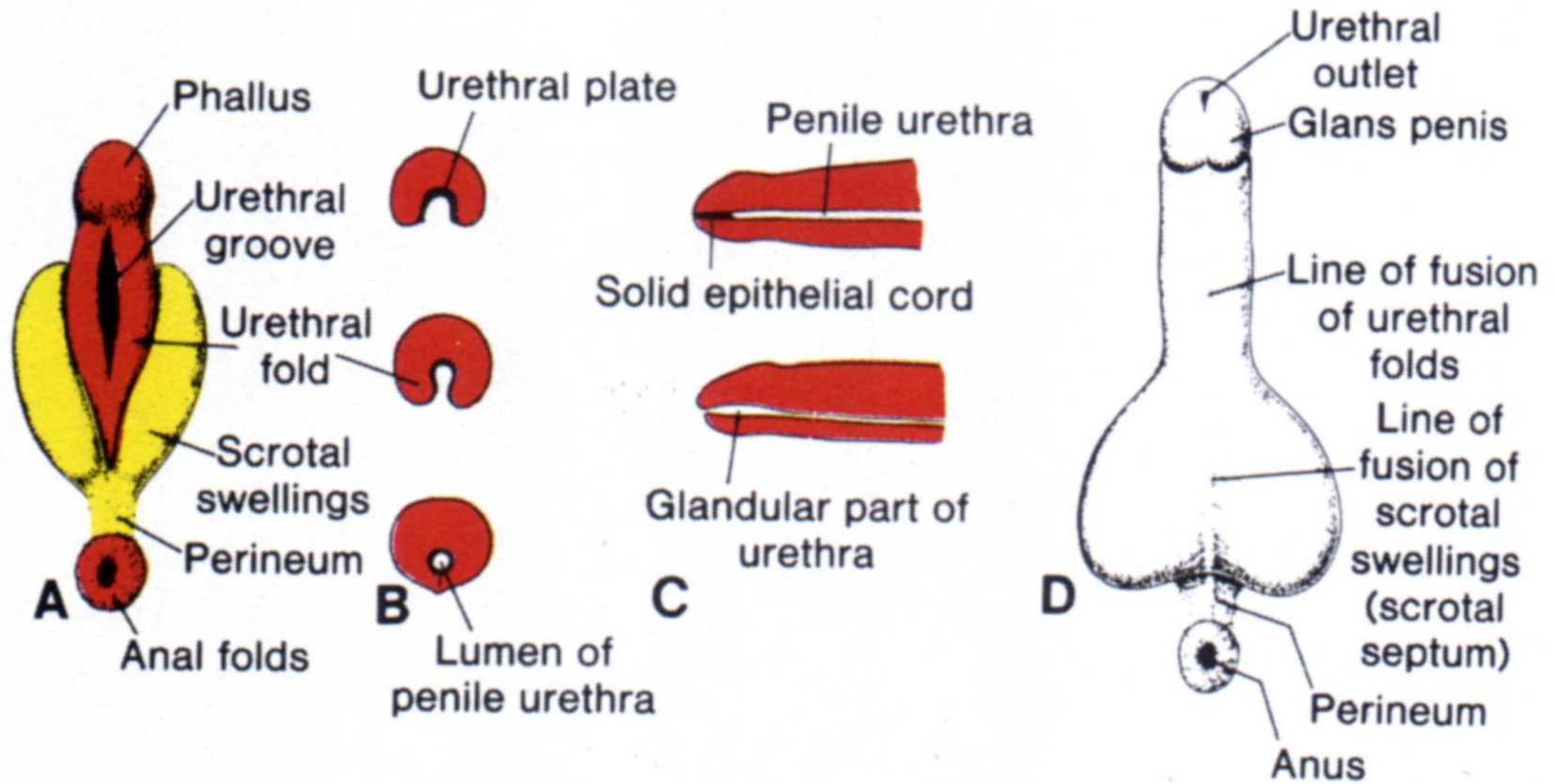
- Prostatic urethra – proximal part from mesonephric duct; distal part from urogenital sinus
- Membranous urethra – urogenital sinus
- Penile urethra – urogenital sinus enclosed by urethral fold
- Glans urethra – ingrowth of ectodermal cord and then canalize



Penis at 4 months - growth and fusion of urethral fold formed a penile urethra and a physiological hypospadias



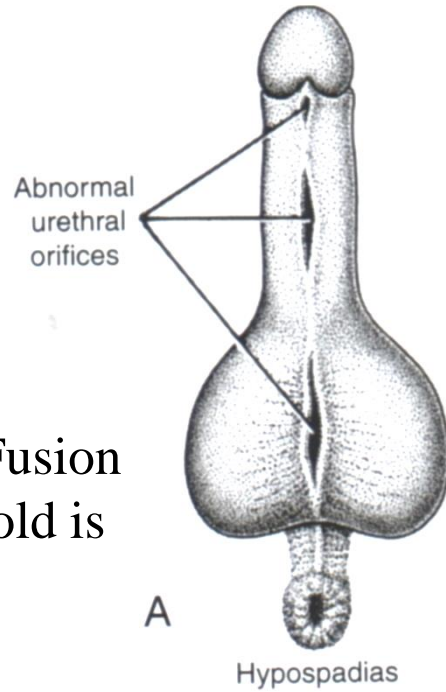
**Penis at 6 months – ingrowth of ectodermal tissue
form the glans penis**



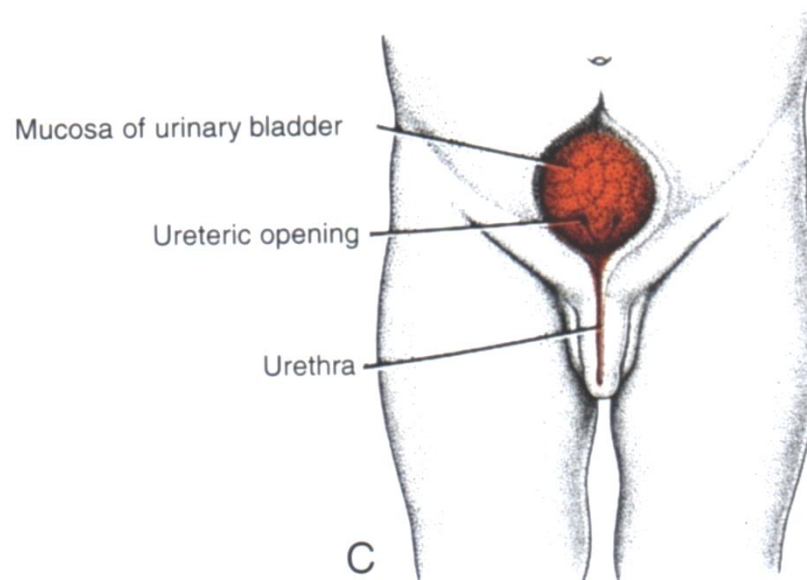
Development of the male urethra

Hypospadias - Fusion of the urethral fold is incomplete

(ventral aspect)

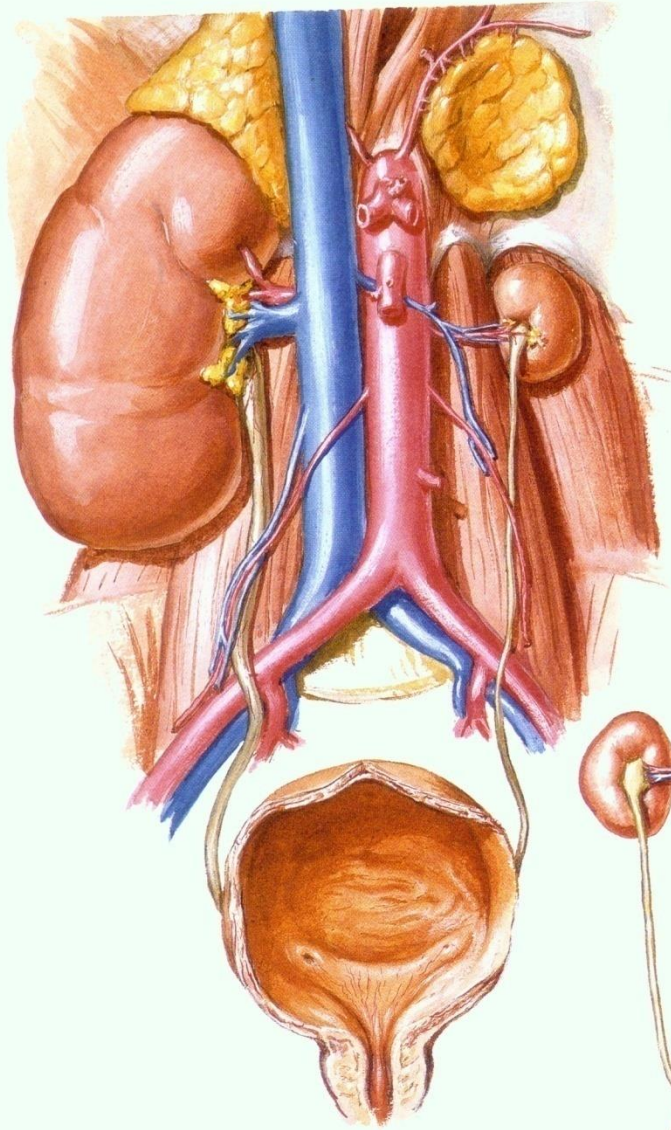


Epispadias associated with exstrophy of bladder



Congenital anomalies

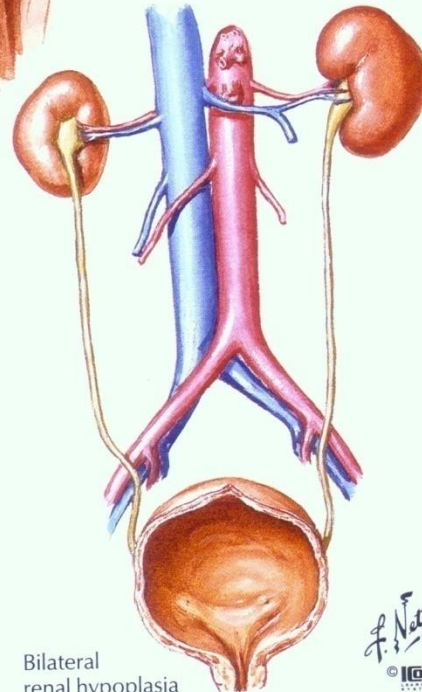
- *Anomalies in kidney development*
 - Renal agenesis
 - Renal cysts – polycystic or solitary cyst
 - Pelvic kidney
 - Horseshoe kidney
 - Rosette kidney
 - Unilateral double kidney
 - Aberrant renal arteries



Left unilateral hypoplasia of the kidney with narrow but patent ureter; both suprarenal glands present

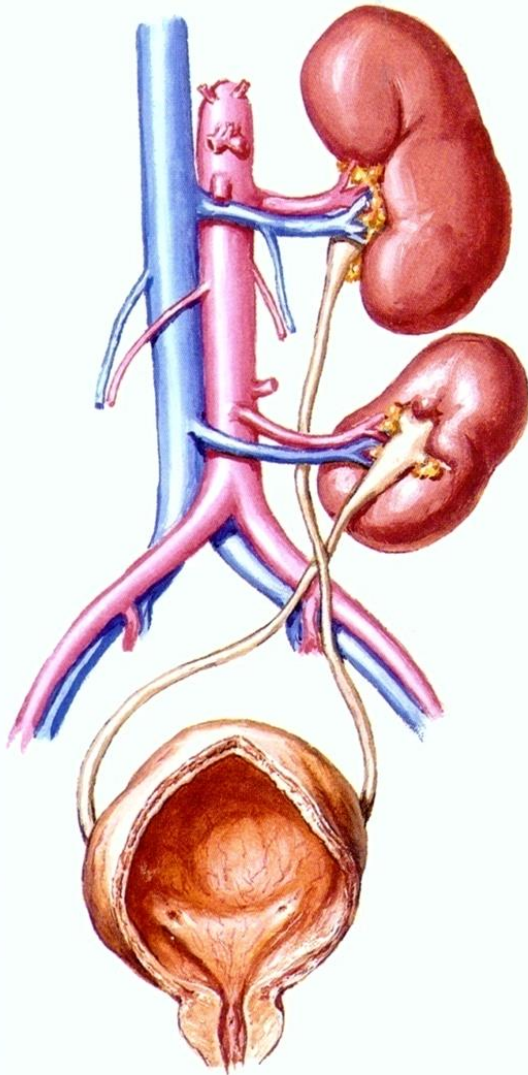


Persistent fetal lobulation

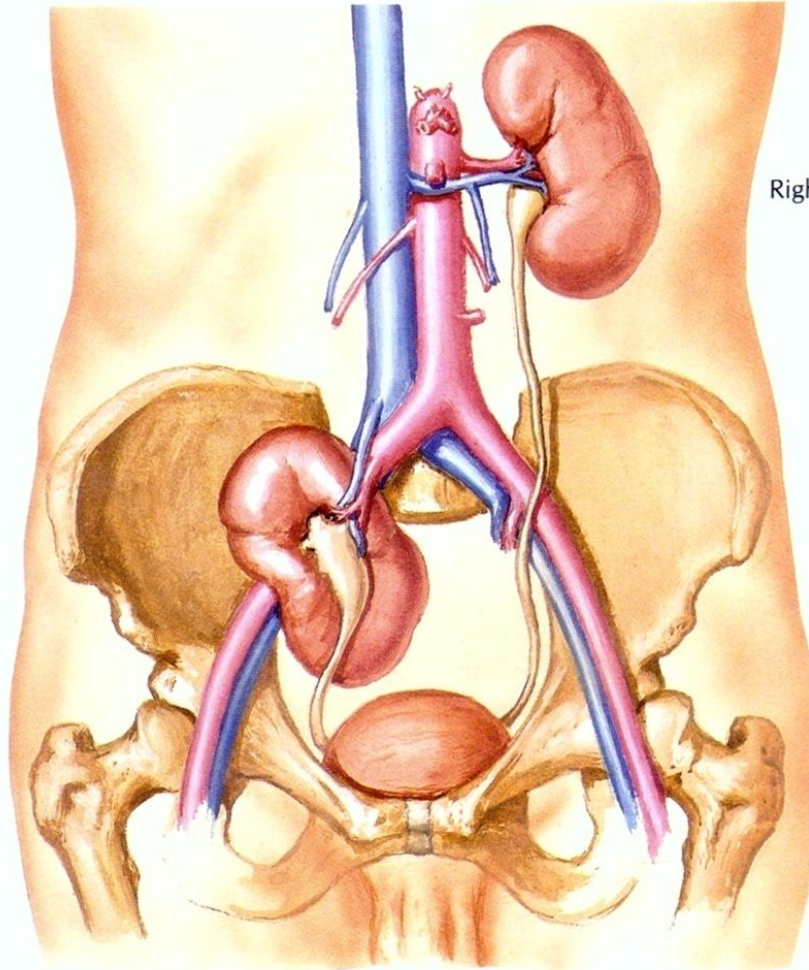


Bilateral renal hypoplasia

Ectopia of the kidney



Crossed ectopia of the right kidney



Right pelvic kidney

Congenital anomalies

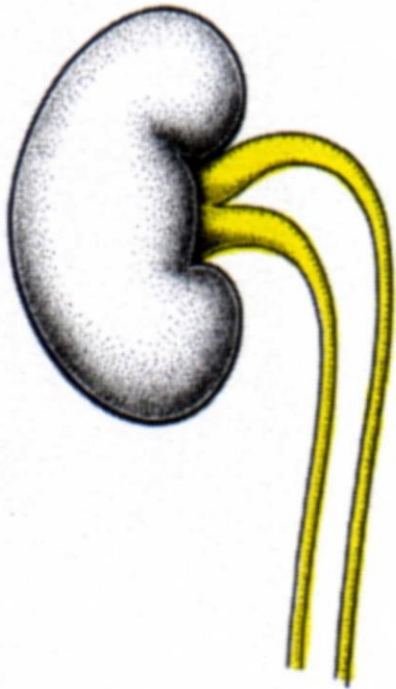
Ureter

- Double pelvis of ureter
- Bifid ureter
- Ectopic ureteric orifice
- Postcaval ureter
- Atresia of ureter

Bladder

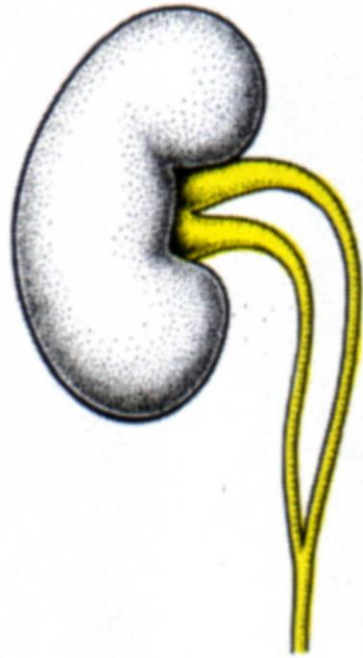
- Exstrophy of bladder
- Patent urachus (urachal fistula, urachal cyst or urachal sinus)

Ventral body wall defect, the urinary bladder mucosa is exposed



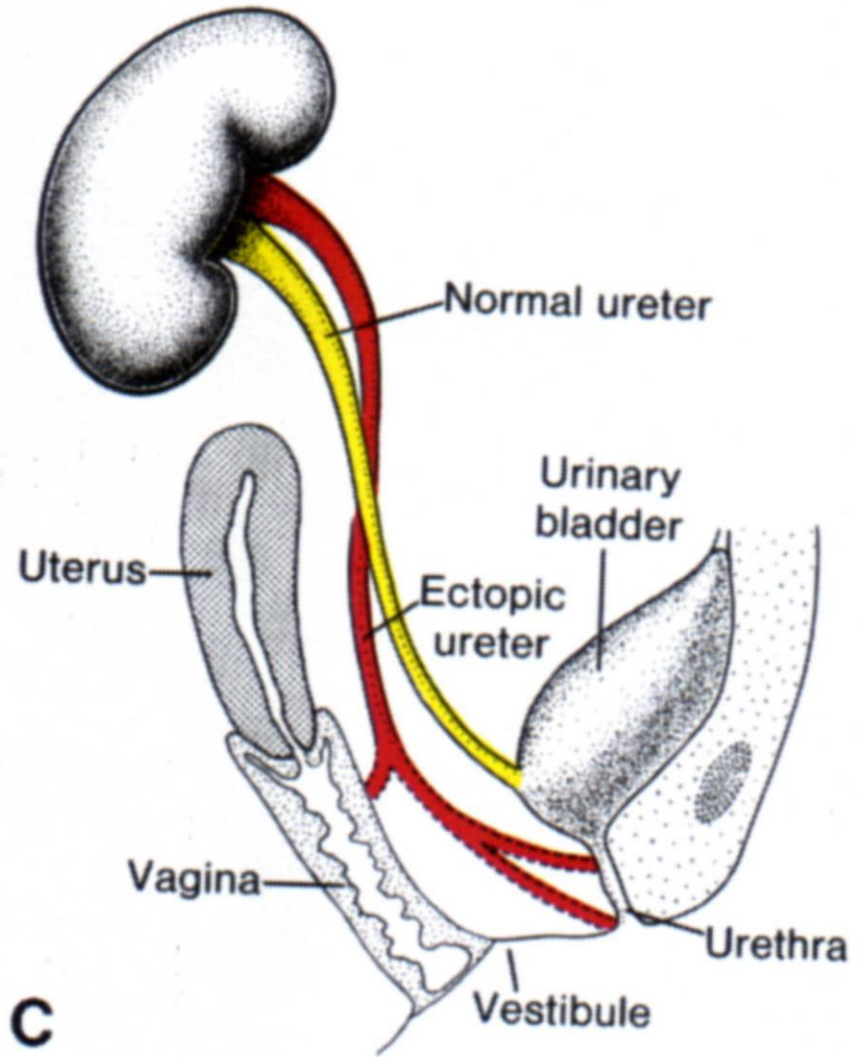
A

**Complete
double ureter**



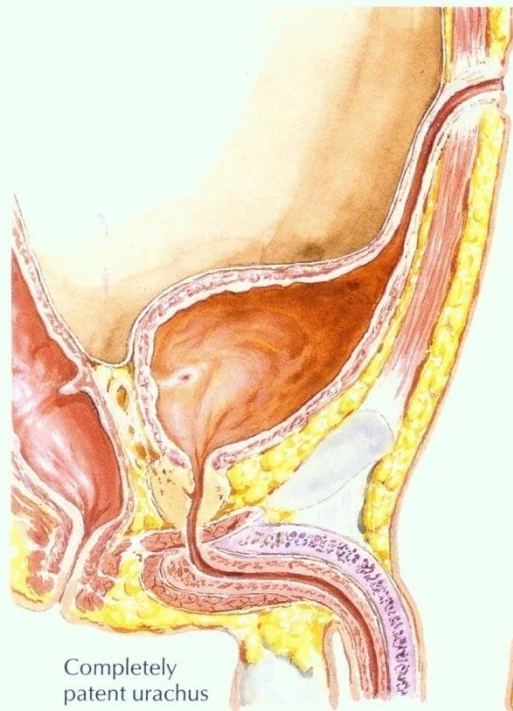
B

**Partial
double ureter**

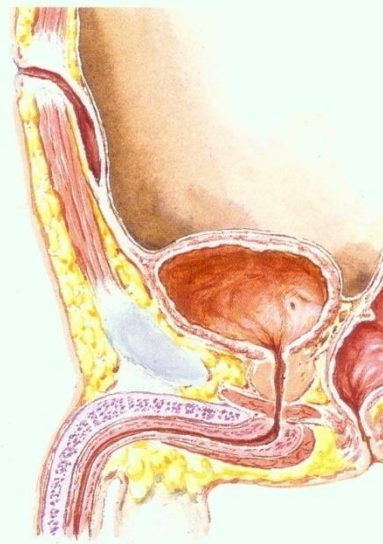


C

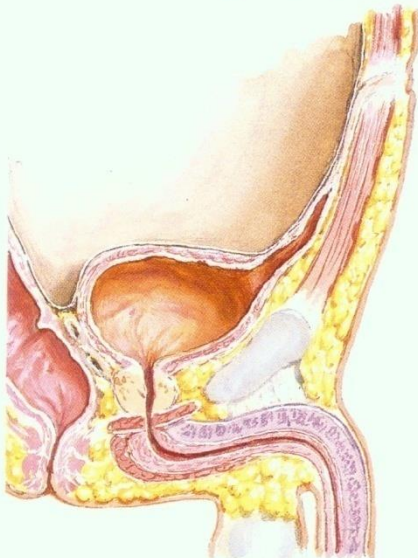
**Sites of ectopic
ureter openings**



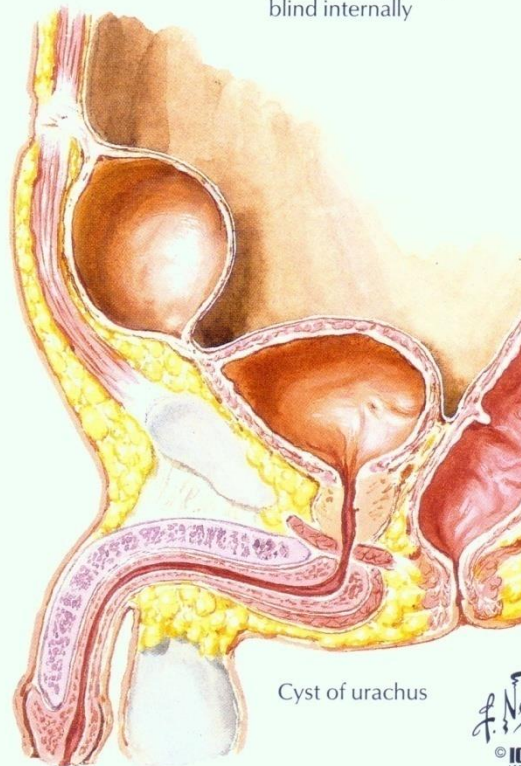
Completely patent urachus



Partially patent urachus; opening externally, blind internally



Partially patent urachus; opening internally, blind externally



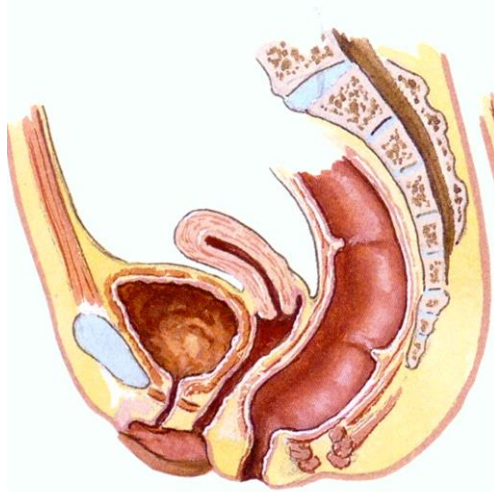
Cyst of urachus

Congenital anomalies

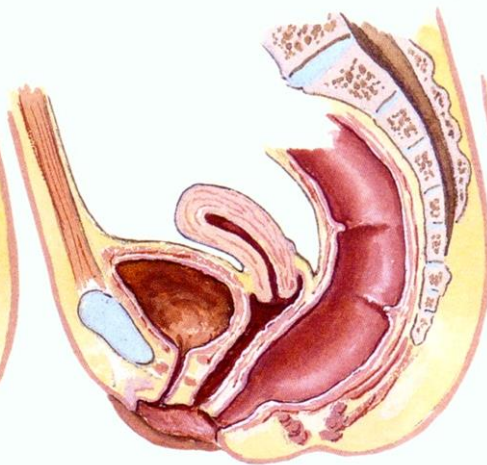
Urethra

- Meatus stenosis
- Posterior urethral valves
- Urethral stenosis
- Hypospadias
- epispadias

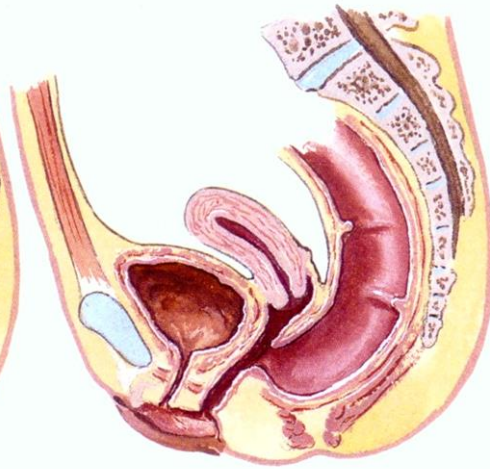
Fistulas resulting from the incomplete division of the cloaca



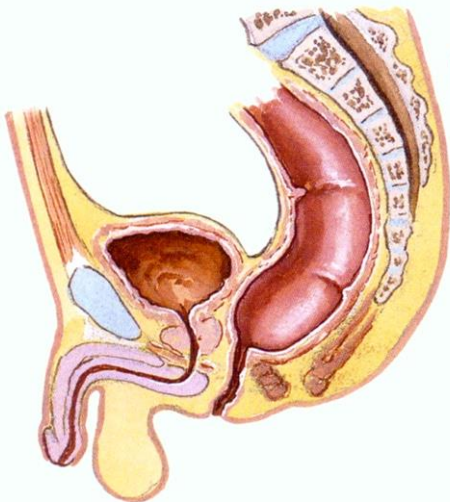
Rectoperineal



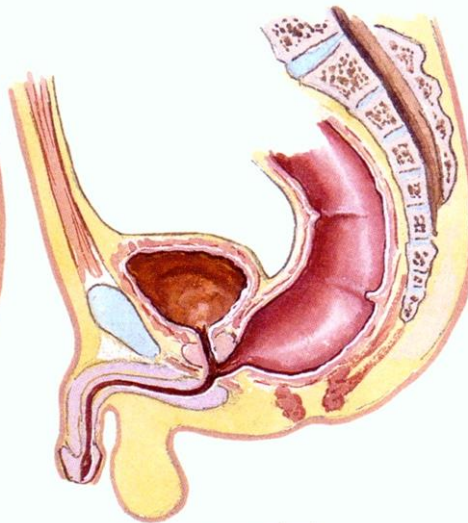
Rectovestibular



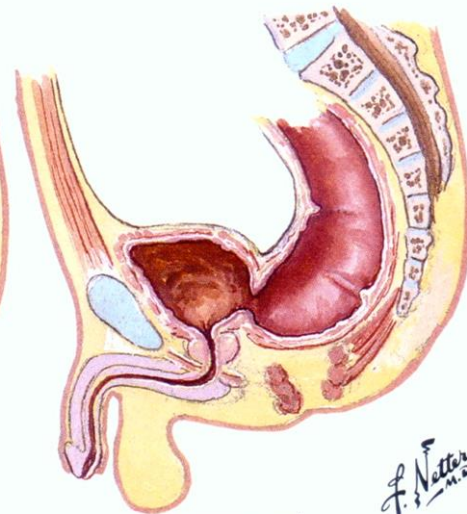
Rectovaginal



Rectoperineal



Rectourethral



Rectovesical

F. Netter
M.D.
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References:

- Cochard LR (2002) Netter's Atlas of Human Embryology.
- Sadler TW (2004) Langman's Medical Embryology 9th edition.