Urogenital System

ANATOMY

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Number

5

Subject

Done By

Corrected by

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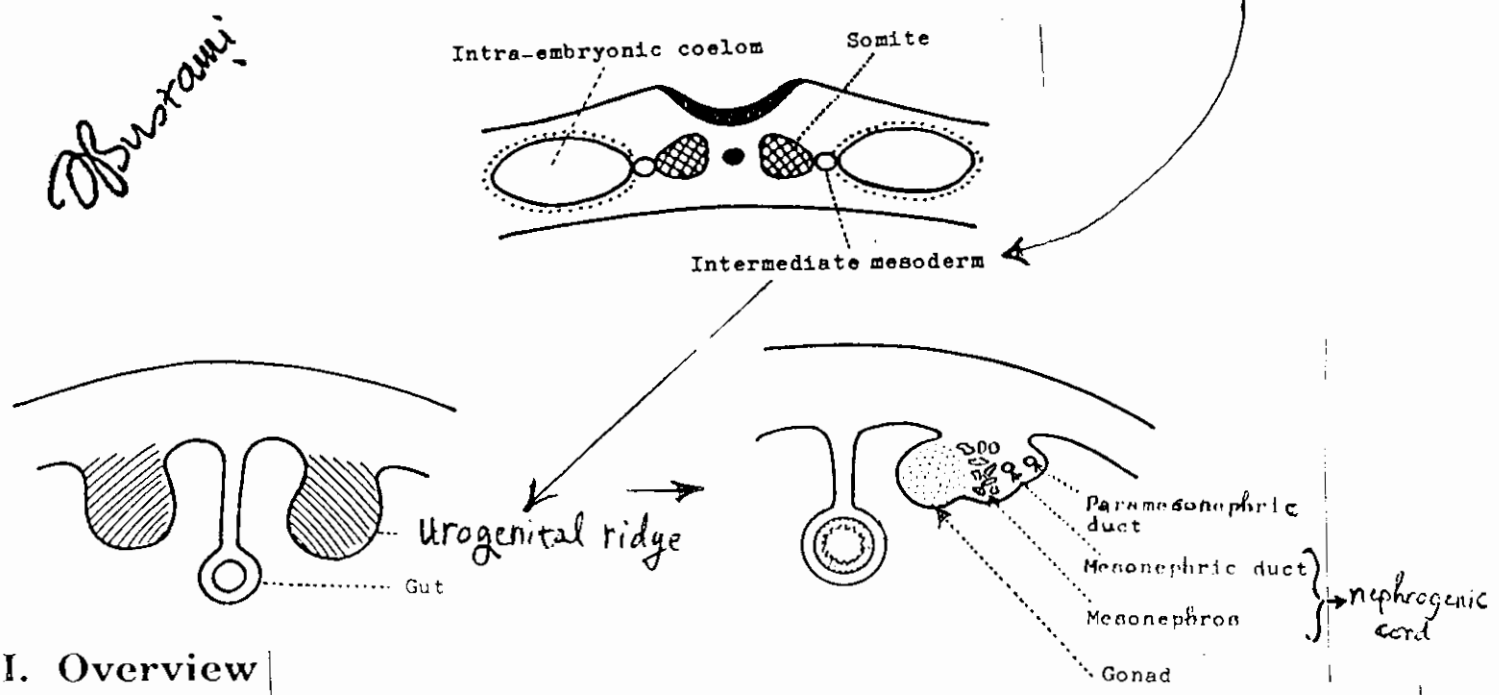
Urinary System



I. Overview

- The **intermediate mesoderm** forms a longitudinal elevation along the dorsal body wall, the **urogenital ridge**.
- Part of the urogenital ridge forms the **nephrogenic cord,** which gives rise to the urinary system.
- The nephrogenic cord develops into three sets of nephric structures: the **pronephros, mesonephros,** and **metanephros**.

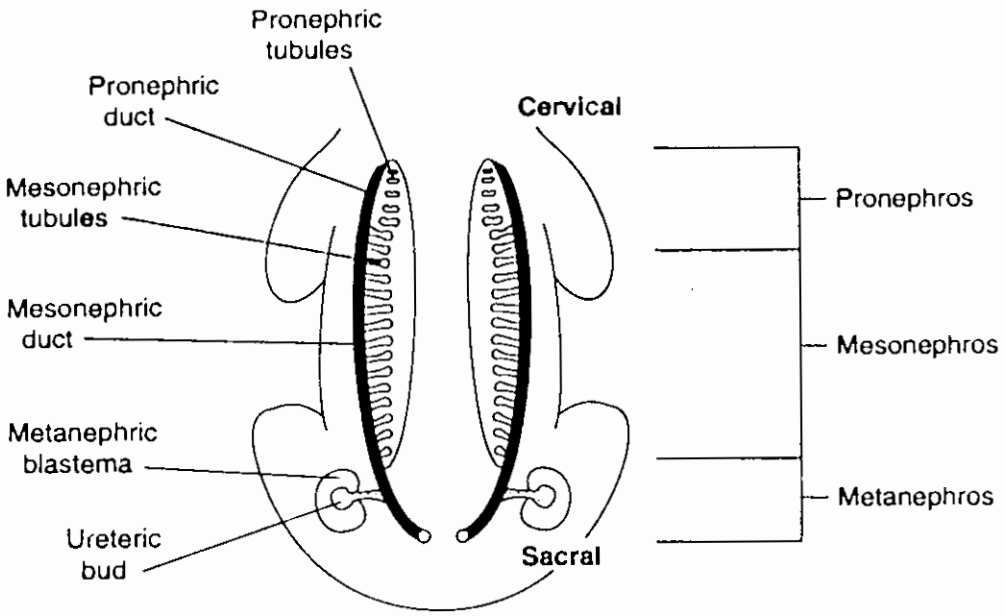


Figure 13-2. Frontal view of an embryo, depicting the pronephros, mesonephros, and metanephros. Note that nephric structures develop from cervical through sacral levels.

A. The pronephros (Figure 13-2)

- develops by the differentiation of mesoderm within the nephrogenic cord to form **pronephric tubules** and the **pronephric duct**.
- is the cranialmost nephric structure.
- is a transitory structure that regresses completely by week 5 of development and is not functional in humans.

B. The mesonephros (see Figure 13-2)

- –develops by the differentiation of mesoderm within the nephrogenic cord to form **mesonephric tubules** and the **mesonephric duct (wolffian duct)**.
- –is the middle nephric structure.
- –is partially transitory and is functional for a short period.
- –Most of the mesonephric tubules regress, but the mesonephric duct persists and opens into the urogenital sinus.

C. The metanephros (see Figure 13-2)

- –develops from an outgrowth of the mesonephric duct, the **ureteric bud,** and from a condensation of mesoderm within the nephrogenic cord, the **metanephric blastema.**
- –is the caudalmost nephric structure.
- –begins to form at week 5 and is functional in the fetus at about week 10 of development.
- –develops into the **definitive adult kidney.**

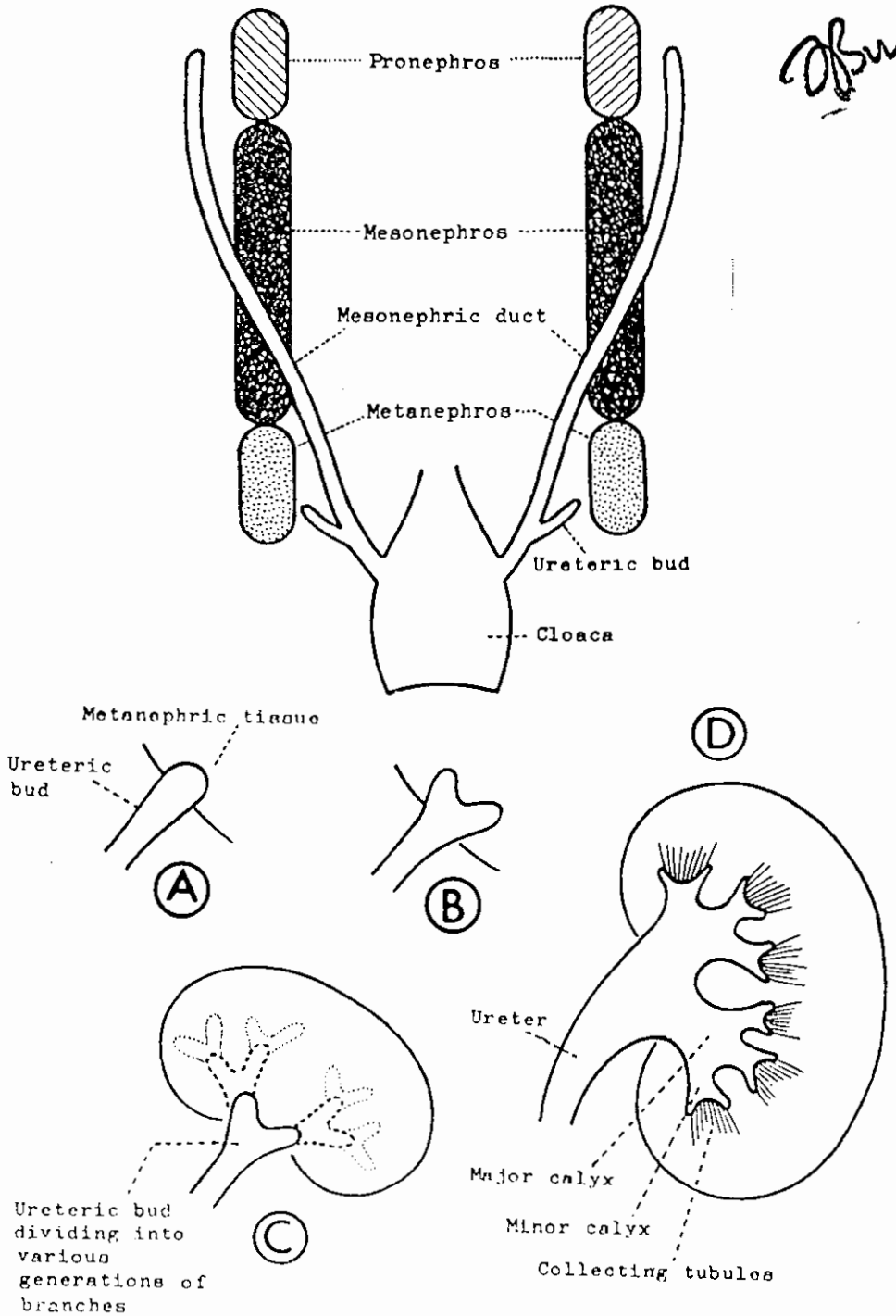


Fig. 16.7 Formation of collecting system of kidney.

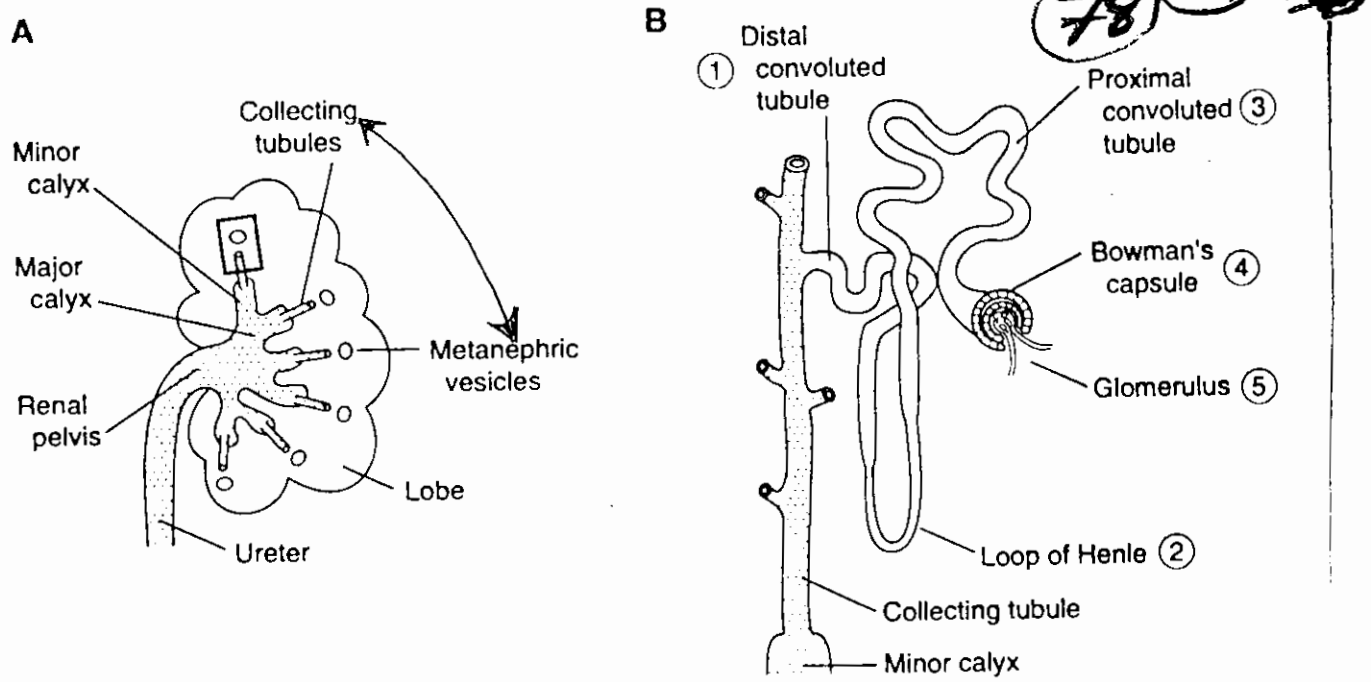


Figure 13-3. (*A*) Lateral view of a fetal kidney. *Stippled area* indicates structures formed from the ureteric bud. Note the lobulated appearance of a fetal kidney. The lobulation disappears during infancy as the kidney grows through elongation of the proximal convoluted tubules and loops of Henle. (*B*) Enlarged view of the *rectangle* shown in *A*, illustrating a collecting tubule (*stippled*) derived from the ureteric bud and those structures derived from the metanephric vesicle. Structures numbered *1–5* make up a nephron.

II. Development of the Kidneys

A. Further development of the metanephros (Figure 13-3)

–The ureteric bud initially penetrates the metanephric blastema and then undergoes repeated divisions to form the **ureters, renal pelvis, major calyces, minor calyces,** and **collecting tubules**.

–The inductive influence of the collecting tubules causes the formation of **metanephric vesicles,** which are critical to nephron formation.

1. Nephron formation

–The metanephric vesicles differentiate into the **distal convoluted tubule, loop of Henle, proximal convoluted tubule,** and **Bowman's capsule**.

–Tufts of capillaries (**glomeruli**) protrude into Bowman's capsule.

–These structures—distal convoluted tubule, loop of Henle, proximal convoluted tubule, Bowman's capsule, and glomerulus—make up a **nephron**.

–Nephron formation is complete at birth, but functional maturation of nephrons continues throughout infancy.

–The fetal kidney is divided into **lobes** in contrast to the definitive adult kidney.

2. Tissue sources

–The **transitional epithelium** lining the ureter, pelvis, major calyx, and minor calyx and the **simple cuboidal epithelium** lining the collecting tubules are derived from **mesoderm of the ureteric bud**.

–The **simple cuboidal epithelium** lining the distal convoluted tubule, the **simple squamous epithelium** lining the loop of Henle, the **simple columnar epithelium** lining the proximal convoluted tubule, and the **podocytes and simple squamous epithelium** lining Bowman's capsule are derived from **mesoderm of the metanephric vesicle**.

(B) Differentiation of the metanephric cap (blastema) and the formation of the nephrons (excretory units of the kindey) :

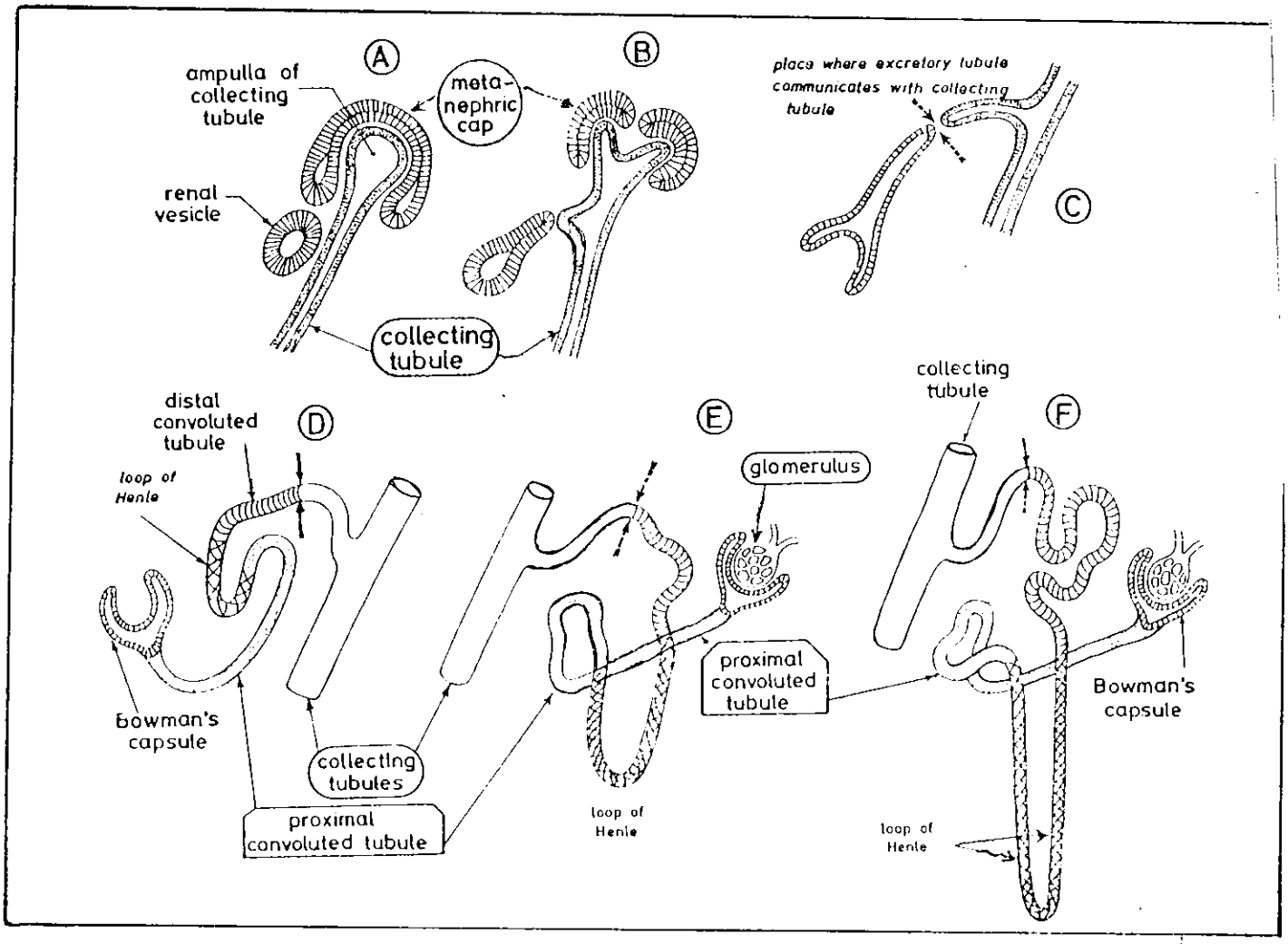
While the ureteric bud and its subdivisions (ramifications) are penetrating the metanephric cap, the upper end of each newly-formed subdivision (tubule) of the ureteric bud becomes covered by a tissue cap. In this way the tissue of the metanephric cap becomes subdivided into many small spherical masses which surround the free ends of the collecting tubules (which arise from the ureteric bud).

Each of these spherical masses of metanephric tissue develops into a small **renal vesicle** which will develop into an *excretory tubule* called the **"nephron".**

One end of the nephron becomes invaginated to form the *Bowman's capsule* while the other end opens into one of the collecting tubules thus forming a free connection from the nephron (= excretory tubule) to the collecting tubule.

The nephrons become longer and each one gives rise to three segments : (a) *a proximal convoluted tubule*, (b) *a loop of Henle*, and (c) *a distal convoluted tubule*.

The first group of nephrons to appear are temporary; degenerate and finally disappear.



Various stages in the development of the metanephric tissue. The arrows show the place where the collecting tubules become connected to the excretory tubules.

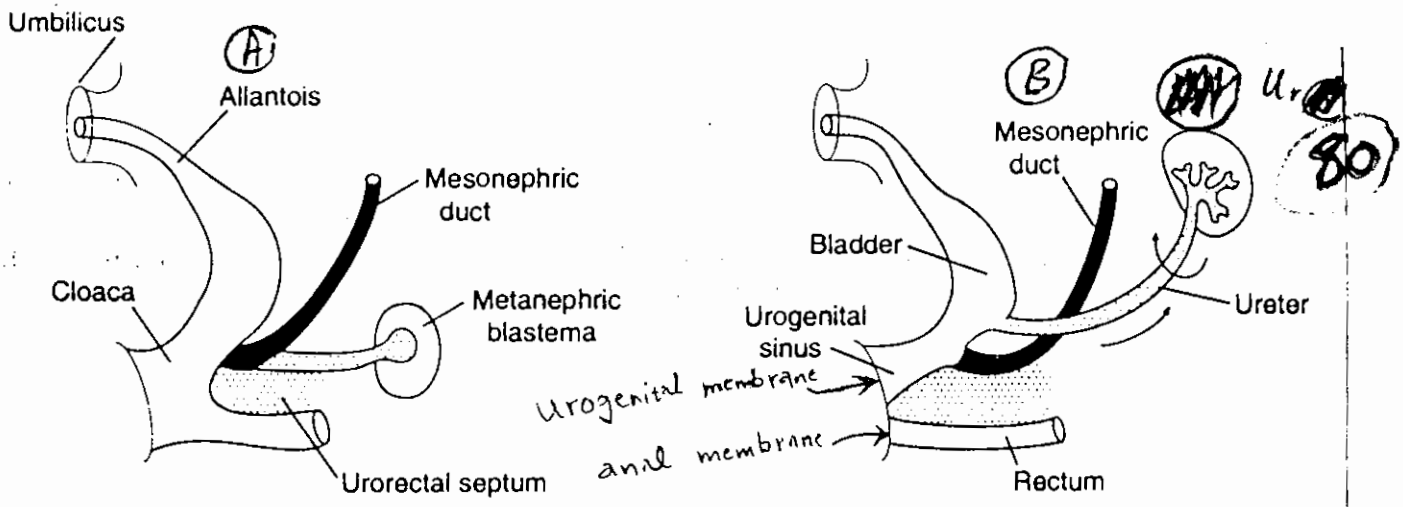


Figure 13-4. Lateral views depicting the formation of the bladder from the upper part of the urogenital sinus at week 4 (*A*) and week 7 (*B*). Note that the mesonephric duct and ureteric bud separate and obtain their own opening. The urorectal septum partitions the cloaca to form the hindgut and urogenital sinus.

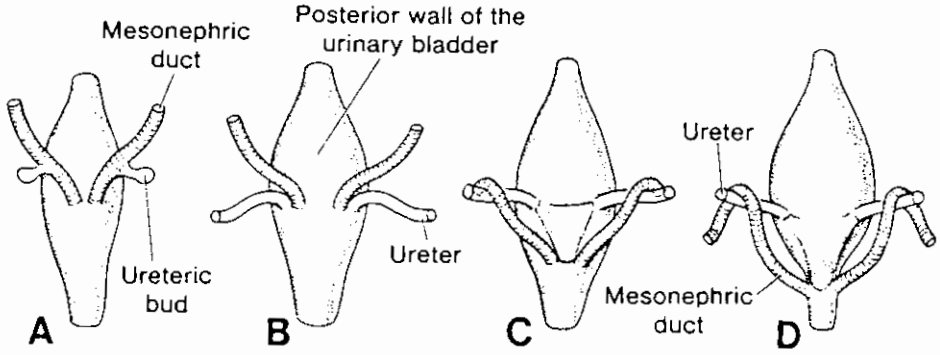


Figure 15-12. Dorsal view of the bladder to show the relationship of the ureters and mesonephric ducts during development. Initially the ureter is formed by an outgrowth of the mesonephric duct, but with time it obtains a separate entrance into the urinary bladder. Note the trigone of the bladder, formed by incorporation of the mesonephric ducts.

Development of the **bladder** *and* **urethra**

The lower part of the hindgut is expanded to form the **cloaca.**

During the 4th to 7th weeks the cloaca is subdivided into 2 *parts* :

(a)	The **ano-rectal canal**	behind
(b)	The **primitive uro-genital sinus** ..	in front

The division of the cloaca into its 2 subdivisions occurs because a fold called a *uro-rectal septum* arises in the angle between the allantois and the hindgut and grows caudally until it fuses with the cloacal membrane.

In this way the cloaca is divided into the ano-rectal canal and the primitive urogenital sinus and the cloacal membrane is divided into (a) the **uro-genital membrane**.. in front

(b) the **anal membrane** ..... behind

Further changes in the "primitive" uro-genital sinus

The uro-genital sinus is the anterior part of the cloaca; a constriction appears in it at the place of the entrance of the openings of the mesonephric ducts; this constriction divides the uro-gential sinus into 2 parts : *upper* and *lower*.

(a) The *upper* part is called the **vesico-urethral canal** and lies above the entrance of the mesonephric ducts.

(b) The *lower* part is called the **"defintive" uro-gential sinus** and lies below the level of the entrance of the mesonephric ducts.

- The **vesico-urethral canal** will give rise to
  (a) **urinary bladder**
  (b) **upper part of prostatic urethra**

Subdivisions of → CLOACA

Rectum (ano-rectal canal)

Primitive urogenital sinus

Vesico-urethral canal

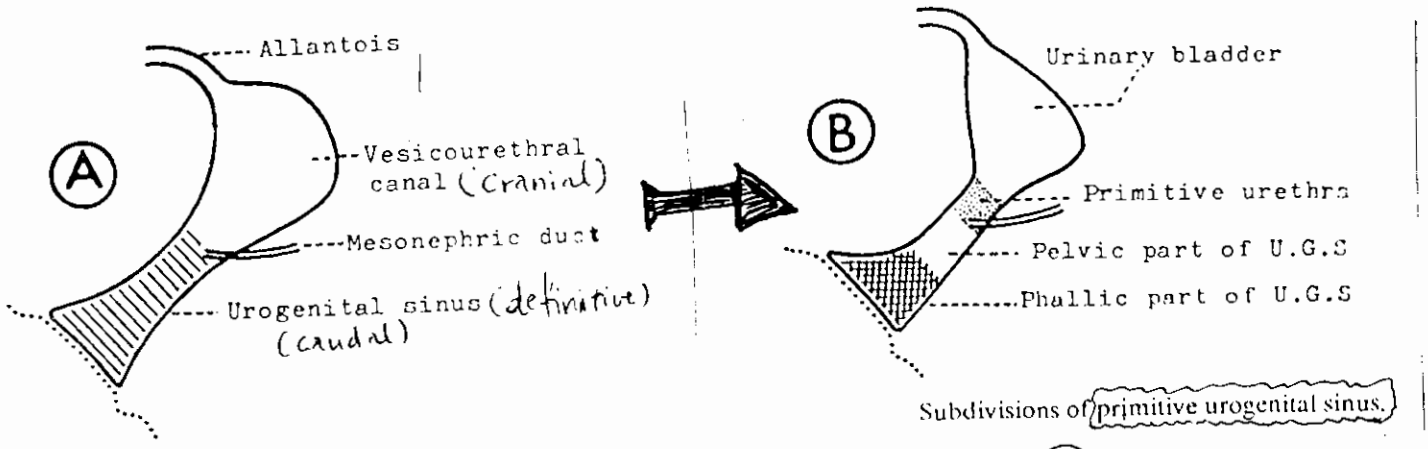
Definitive urogenital sinus

Urinary bladder

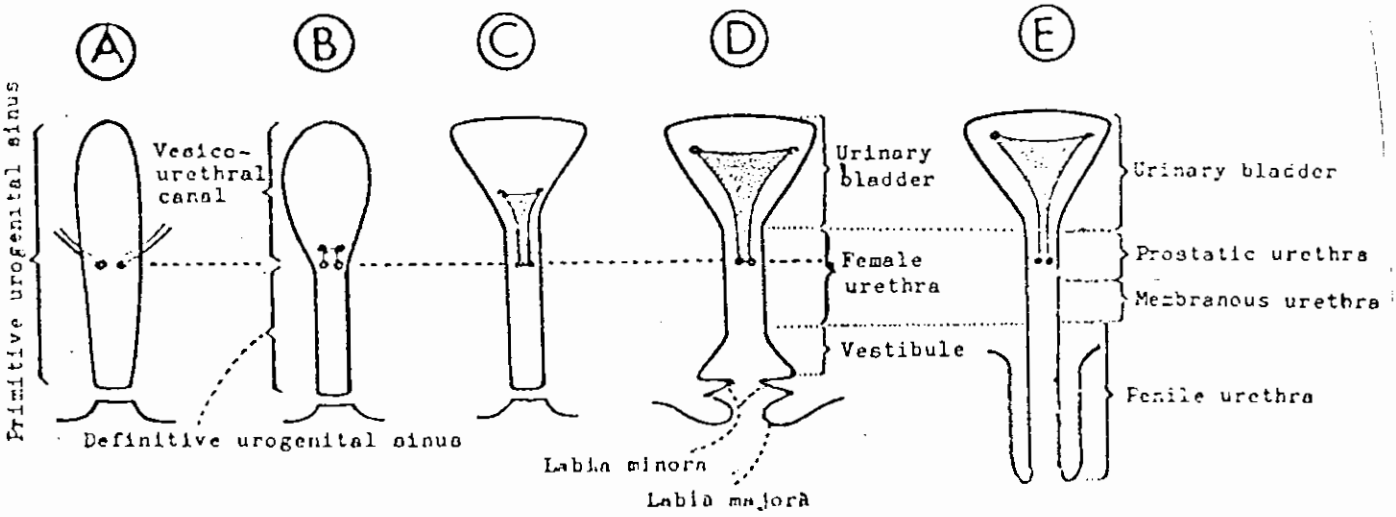
Primitive urethra

Pelvic part

Phallic part



Subdivisions of primitive urogenital sinus.



Development of the urethra.

What is the fate of the definitive uro-genital sinus ?

- The fate of the "**definitive uro-genital sinus** differs very much in the 2 sexes :

(i) In the **male** it consists of 2 parts :

(a) a small **upper pelvic part** ⇨ (1) **lower part of prostatic urethra** (2) **membranous urethra**

(b) a long **lower phallic part** ⇨ **penile urethra**

Remember : terminal part of Penile Urethra (in the glans) → derived from ectoderm

(ii) In the **female** the definitive uro-genital sinus forms: (a) a small part of the urethra (b) the lower 1/3 of the vagina (c) the vestibule.

III. Development of the Urinary Bladder (Figure 13-4)

–The urinary bladder is formed from the upper end of the urogenital sinus, which is continuous with the allantois.

–The allantois becomes a fibrous cord, the **urachus** (**median umbilical ligament** in the adult).

–The lower ends of the mesonephric ducts become incorporated into the posterior wall of the bladder at the **trigone**.

–The mesonephric ducts eventually open into the urogenital sinus below the bladder.

–The **transitional epithelium** lining the urinary bladder is derived from endoderm because of its etiology from the urogenital sinus and gut tube. The **transitional epithelium** lining the ureters, renal pelvis, and major and minor calyces is derived from mesoderm because of its etiology from the ureteric bud.

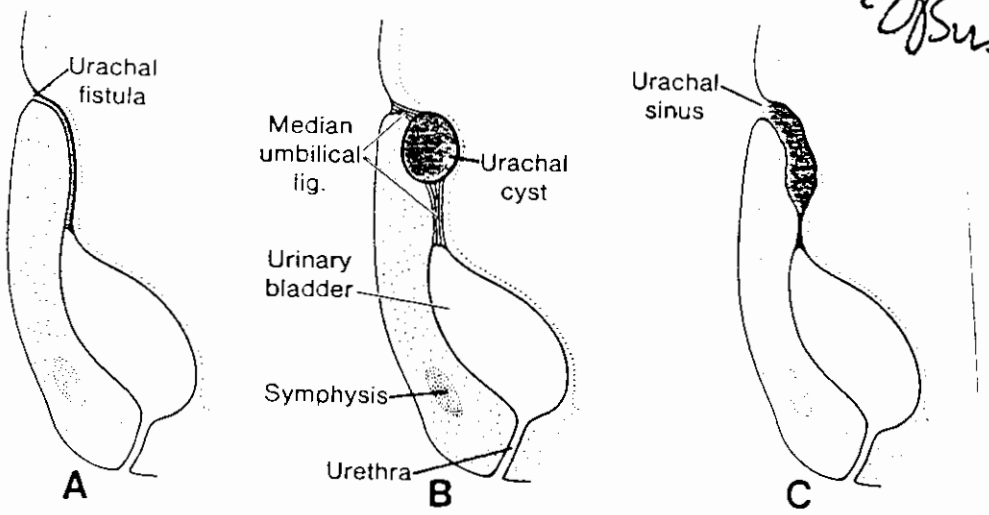


Figure 15-13. A, Urachal fistula. B, Urachal cyst. C, Urachal sinus. The sinus may or may not be in open communication with the urinary bladder.

Congenital abnormalities of the urachus (allantois)

Normally, the allantois obliterates to form a fibrous urachus which in the adult is the median umbilical ligament.

A. Urachal fistula results from persisting allantois, which extends from the urinary bladder to the umbilicus. Urine may drain from the umbilicus (Fig. 17-7).

B. Urachal sinus results from a persistent proximal or distal allantois.

C. Remnants of the allantois may persist and give rise to urachal cysts.

IV. Development of the Female Urethra (Figure 13-5)

–The female urethra is formed from the lower end of the urogenital sinus.
–develops endodermal outgrowths into the surrounding mesoderm to form the **urethral glands** and **paraurethral glands**.
–ends at the **vestibule of the vagina,** which also forms from the urogenital sinus. The vestibule of the vagina develops endodermal outgrowths into the surrounding mesoderm to form the **greater vestibular glands**.
–The **transitional epithelium** and **stratified squamous epithelium** lining the female urethra are derived from **endoderm**.

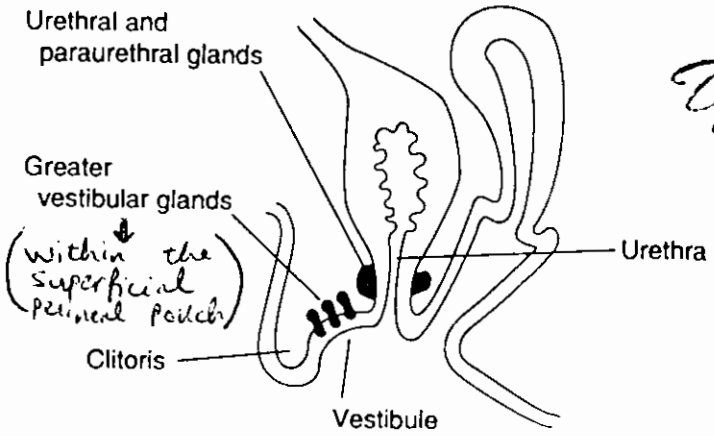


Figure 13-5. Diagram depicting the female urethra.

V. Development of the Male Urethra (Figure 13-6)

A. Prostatic urethra, membranous urethra, and proximal part of penile urethra

–These parts of the urethra are formed from the lower end of the urogenital sinus.

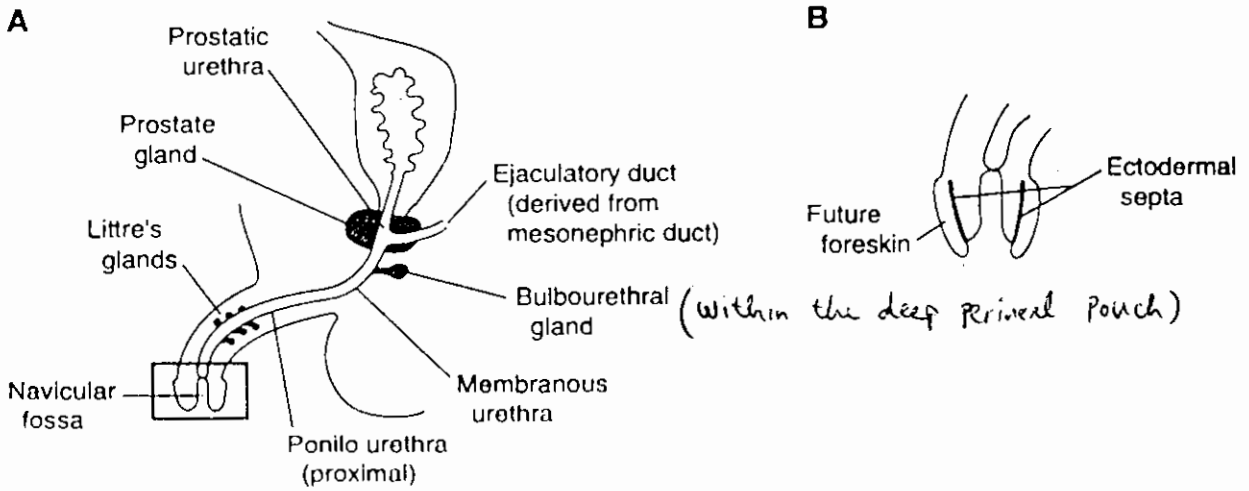


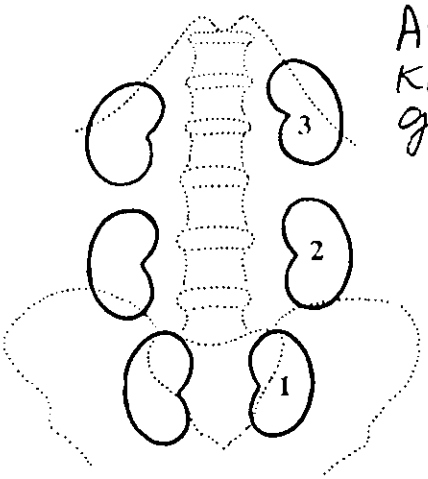
Figure 13-6. (*A*) Diagram depicting the male urethra. Note that the ejaculatory duct, which is derived from the mesonephric duct, opens into the prostatic urethra. (*B*) Enlarged view of box in *A*, showing the formation of the foreskin.

–The **transitional epithelium** and **stratified columnar epithelium** lining these parts of the urethra are derived from **endoderm**.

1. The **prostatic urethra** develops endodermal outgrowths into the surrounding mesoderm to form the **prostate gland**.
2. The **membranous urethra** develops endodermal outgrowths into the surrounding mesoderm to form the **bulbourethral glands**.
3. The **proximal part of the penile urethra** develops endodermal outgrowths into the surrounding mesoderm to form **Littre's glands**.

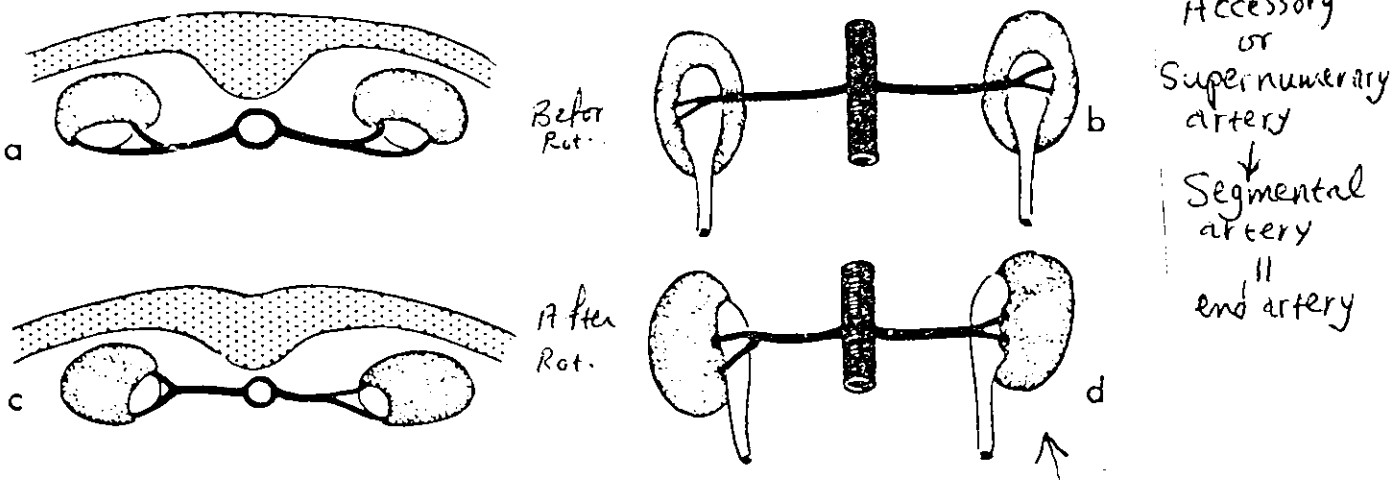
B. Distal part of the penile urethra

- –is formed from an ingrowth of surface ectoderm called the **glandular plate**.
- –The glandular plate joins the membranous urethra and becomes canalized to form the **navicular fossa**.
- –Ectodermal septa appear lateral to the navicular fossa and become canalized to form the **foreskin**.
- –The **stratified squamous epithelium** lining this part of the urethra is derived from **ectoderm**.



Ascent of the Kidney from the groin to the loin

Fig. 16.8 Ascent of kidney.



B. Relative ascent of the kidneys

- –The fetal metanephros is located in the sacral region, whereas the definitive adult kidney is located in the **upper lumbar region**.
- –The change in location results from a disproportionate growth of the embryo caudal to the metanephros.
- –During the relative ascent, the kidneys rotate 90° medially, causing the hilum to orientate medially instead of ventrally.

C. Blood supply of the kidneys

- –changes as the metanephros undergoes its relative ascent.
- –The metanephros will receive its blood supply from arteries at progressively higher levels until the definitive **renal arteries** develop at L2.
- –Arteries formed during the ascent may persist and are called **supernumerary arteries**.
- –Supernumerary arteries are **end arteries**; therefore, any damage to them will result in necrosis of kidney parenchyma.

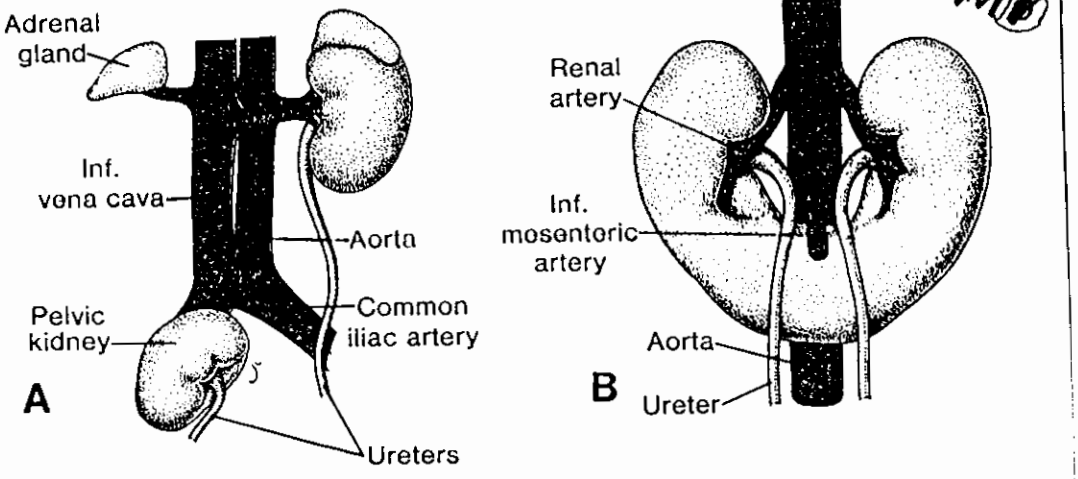


Figure 15-9. A, Unilateral pelvic kidney. Note the position of the adrenal gland on the affected side. B, Horseshoe kidney, ventral view. Note the position of the inferior mesenteric artery.

VII. Clinical Considerations

A. Renal agenesis

–occurs when the **ureteric bud fails to develop,** thereby eliminating the induction of metanephric vesicles and nephron formation.

1. Unilateral renal agenesis

–is relatively common; therefore, a physician should never assume a patient has two kidneys.
–is more common in males.
–is asymptomatic and compatible with life because the remaining kidney hypertrophies.

2. Bilateral renal agenesis

–is relatively uncommon.
–causes oligohydramnios during pregnancy, which allows the uterine wall to compress the fetus, resulting in **Potter syndrome** (deformed limbs, wrinkly skin, and abnormal facial appearance).
–is incompatible with life unless a suitable donor is available for kidney transplant.

B. Pelvic kidney

–is an ectopic kidney that occurs when one or both kidneys fail to ascend and therefore remain in the pelvis or lower lumbar area.
–In some cases, two pelvic kidneys fuse to form a solid mass, commonly called a **pancake kidney**.

C. Horseshoe kidney

–occurs when the **inferior poles of the kidneys fuse**.
–Normal ascent of the kidneys is arrested because the fused portion gets trapped behind the inferior mesenteric artery.

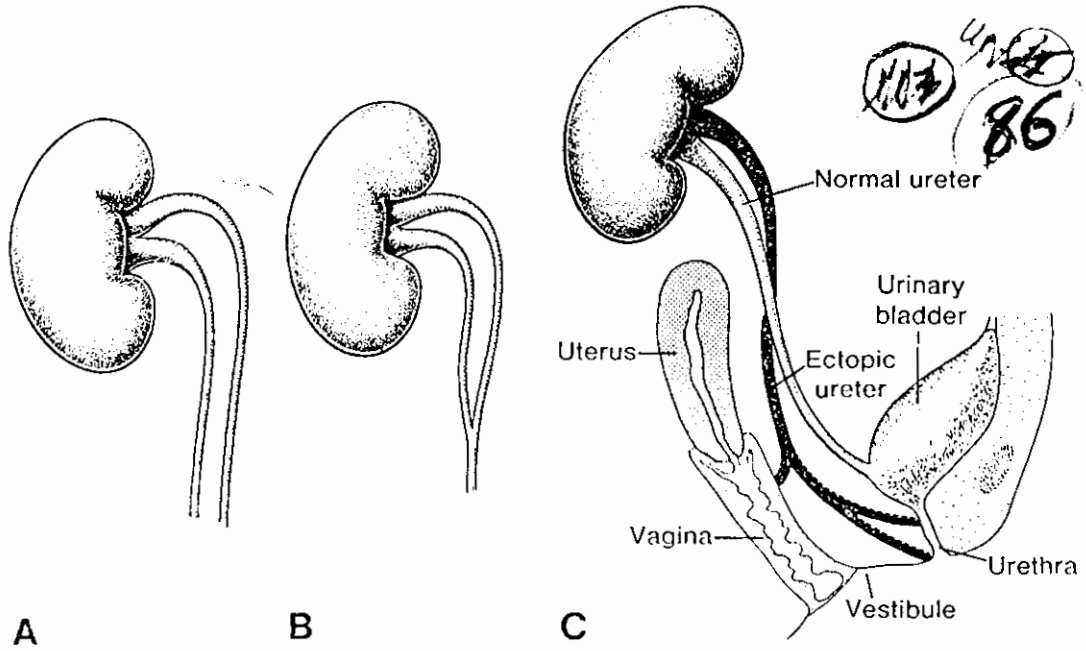


Figure 15-7. A and B, Complete and partial double ureter. C, Possible sites of ectopic ureteral openings in the vagina, urethra, and vestibule.

D. Duplication of the urinary tract

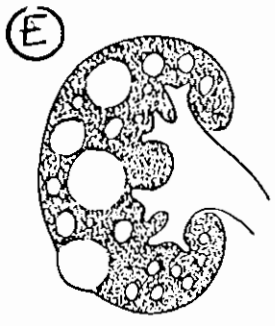
- –occurs when the **ureteric bud prematurely divides** before penetrating the metanephric blastema.
- –results in either a double kidney or duplicated ureter and renal pelvis.

E. Polycystic disease of the kidneys

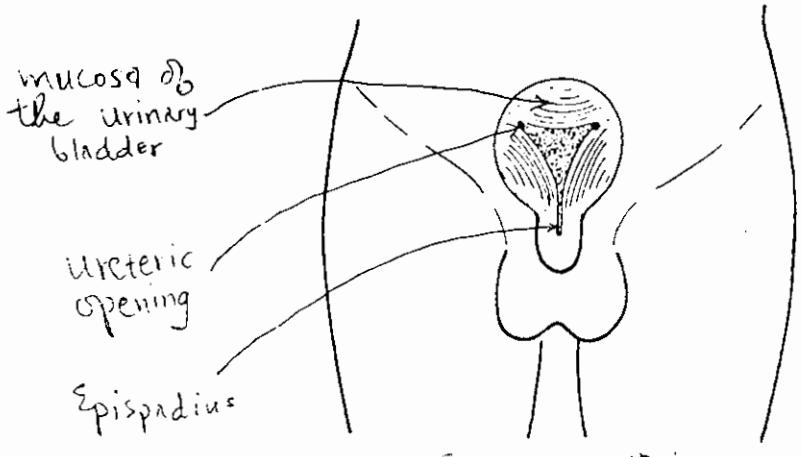
- –occurs when the **loops of Henle dilate,** forming large cysts that severely compromise kidney function.
- –is a relatively common hereditary disease.
- –is associated clinically with cysts of the liver, pancreas, and lungs.
- –Treatment includes dialysis and kidney transplant.

F. Exstrophy of the bladder (Ectopia vesicae)

- –occurs when the posterior wall of the urinary bladder is exposed to the exterior.
- –is caused by a failure of the anterior abdominal wall and anterior wall of the bladder to develop properly.
- –is associated clinically with urine drainage to the exterior and **epispadias.**
- –Surgical reconstruction is difficult and prolonged.



Polycystic Kidney
(Non-Union theory)
collecting & excretory tubules fail to join



Ectopia Vesicae

Section of the Kidney showing multiple cysts characteristic of Polycystic Kidney

Congenital Polycystic Kidney

→ Autosomal recessive polycystic Kidney disease ←

- → occurs in 1/5,000 births
- → cysts form from collecting ducts
- → Kidney becomes very large
- → Renal failure in infancy or childhood

→ Autosomal dominant polycystic Kidney disease

- → occurs in 1/5,000 – 1/~~10~~,000 births
- → cysts form from all segments of the nephron
- → do not cause renal failure until adulthood
- → more common but less progressive than the Autosomal recessive disease

Illustrate