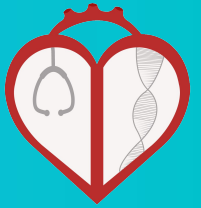




Anatomy Team
MED 439



MED439
KING SAUD UNIVERSITY

Development of the Kidney, Ureter, Bladder & Urethra

Renal Block - Lecture 2 & 4

Color index:

Important

In male's slides only

In female's slides only

notes

Extra information, explanation

Don't forget to check the [Editing File](#)



[@anatomy439](#)

Objectives:

Part (1) :

- Identify the embryological origin of kidneys & ureters.
- Differentiate between the 3 systems of kidneys during development.
- Describe the development of collecting & excretory parts of permanent kidney.
- Describe the fetal kidney & identify the pre- and postnatal changes that occur in the kidney.
- Enumerate the most common anomalies of kidneys & ureters.

Part (2) :

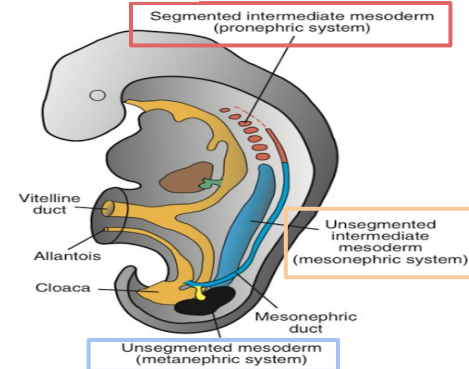
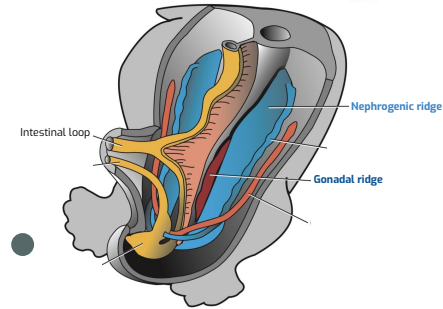
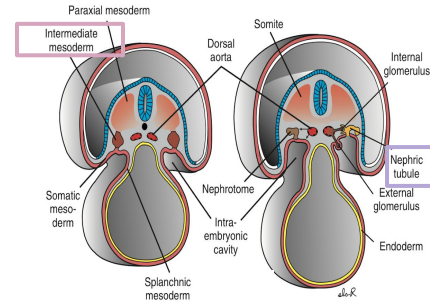
- Describe the cloaca and the formation of the urogenital sinus.
- Discuss the division of the urogenital sinus into various parts and name the adult organs that are derived from each part.
- Describe how the caudal parts of the mesonephric ducts and ureters are absorbed into the urogenital sinus and the significance of this embryonic event.
- Discuss the position of the urachus and its significance and fate.
- Describe the various anomalies concerned with the urinary bladder and urethra.

Development of the Kidney

The embryonic origin of kidney and ureters is from **intermediate mesoderm**

Intermediate mesoderm divides into:

- 1- **Nephrogenic ridge** (cord): forms **kidneys & ureters** (lateral)
- 2- **Gonadal ridge**: forms gonads (**testes or ovaries**) (medial)



01

Start of week 4

Pronephric system:

- Appears in cervical region
- Analogous to kidney of **fish**
- Formed of tubules & a duct
- **Not function in human**
- **Disappears**

02

End of week 4

Mesonephric system:

- Appears in thoracic & abdominal regions
- Analogous to kidney of **amphibians**
- Formed of tubules & a duct
- **Function temporarily**
- In male: forms genital duct
- In both sexes: forms ureteric bud

03

Week 5

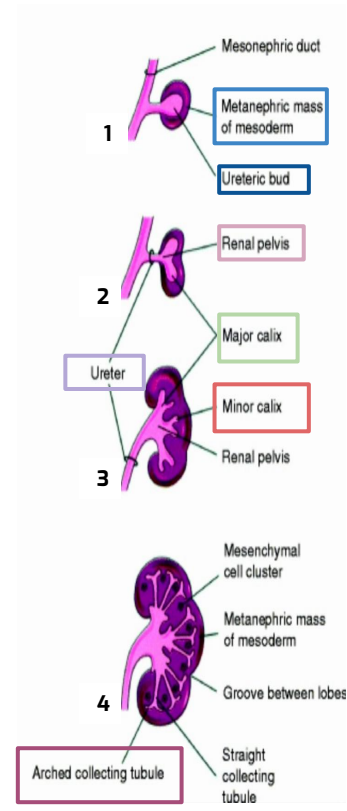
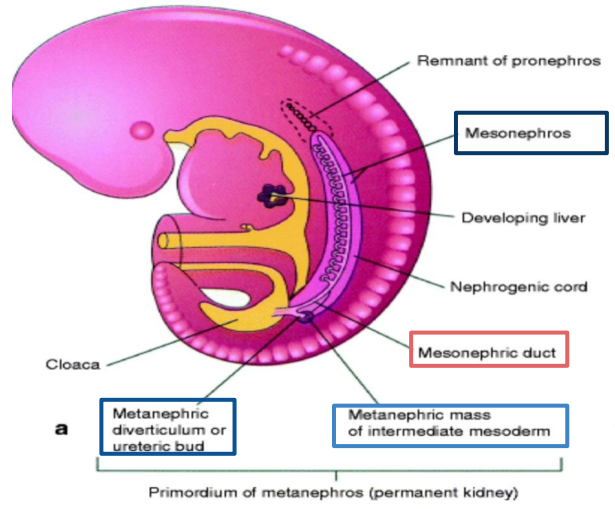
Metanephric system:

- Appears pelvis
- **Starts to function at the 9th Week**

Metanephros (Permanent Kidney)

Formed of 2 origins

- Ureteric bud**
(derived from **mesonephric duct**)
gives **collecting part** of kidney
- Metanephric blastema(mass)**
(derived from **nephrogenic cord**)
gives **excretory part** of kidney

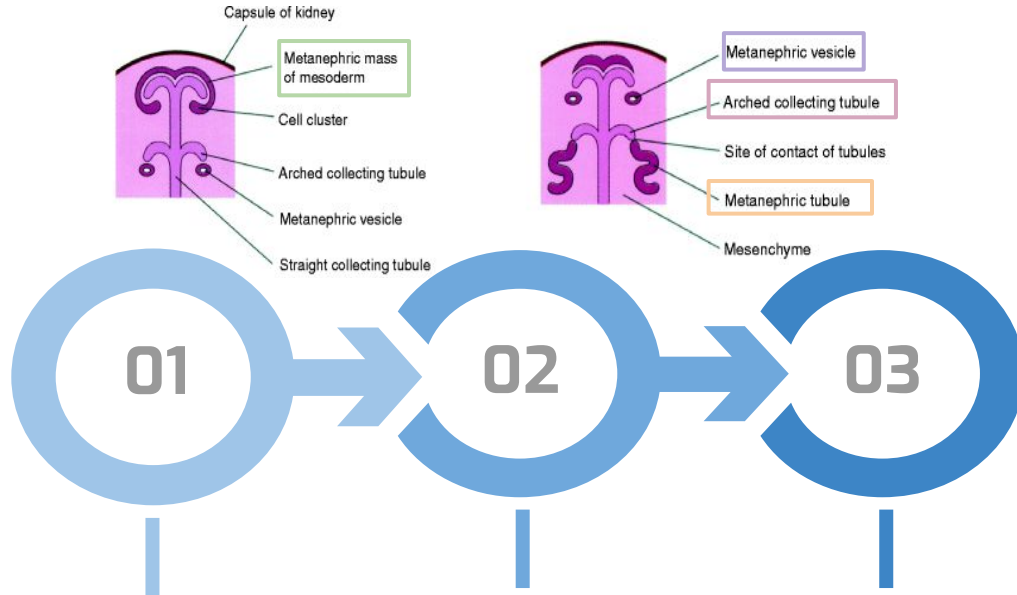


Collecting part

- 1** Ureteric bud elongates & penetrates **metanephric mass**
- 2** Stalk of ureteric bud forms **ureter** & cranial end forms **renal pelvis**.
- 3** Branching of renal pelvis gives 3 **major calyces**. Branching of major calyces gives **minor calyces**.
- 4** Continuous branching gives straight then **arched collecting tubules**

Metanephros (Permanent Kidney)

Excretory part



Each **arched collecting tubule** is surrounded by a **cap of metanephric mass**

The metanephric cap forms the **metanephric vesicle**, which is elongates to form an **S-shaped metanephric tubule**.

The tubule lengthens to form: **proximal & distal convoluted tubules + loop of Henle**
The end of each tubule forms **glomerular (Bowman's) capsule**. Which is then invaginated by capillaries (**glomerulus**)

The Nephron

It's the functional units of the kidney

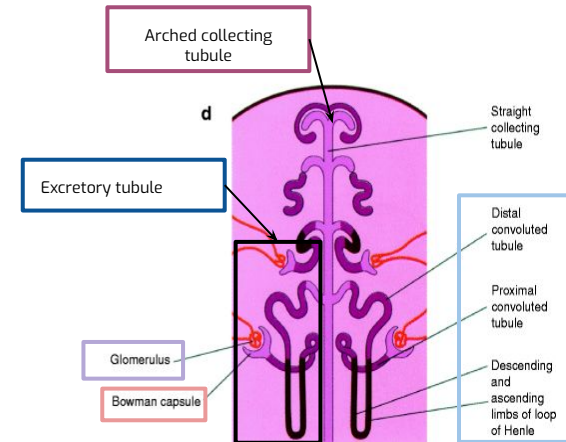
The nephron is formed by fusion of:

1. **Excretory tubule** formed of metanephric mass (cap).
2. **Arched collecting tubule** formed of ureteric bud.

At full term, each kidney contains:

800000 - 1000000 nephrons.

(The nephrons' number is permanent because they can't be replaced nor regenerated. But they can decrease in number due to any pathological reasons)



Changes In The Fetal Kidney

By week 9

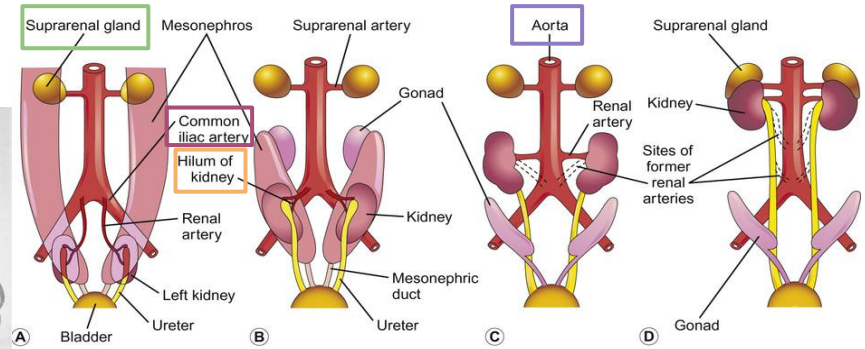
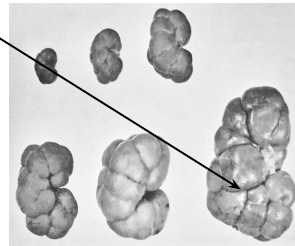
- **Change in position:** The kidney ascends from pelvis to abdomen & attains its adult position, **caudal to suprarenal gland**.
- **Change in blood supply:** As the kidney ascends, its blood supply changes from **renal branches of common iliac arteries** into **renal branches of abdominal aorta**.
- **Rotation:** Initially, **hilum** (site of entry & exit of vessels & nerves) is **ventral** then rotates medially about 90° & becomes **medial**.
- **Glomerular filtration begins** (Start of function).
- Kidney is subdivided into **lobes** that are visible externally

As a result:

At 9th week, kidney attains its adult position & receives its supply from renal artery, its hilum is rotated medially.

dr. note:

The only organ that ascends during development while the rest of the organs descend ex: Diaphragm



In full term (end of fetal period)

- Lobulation diminishes at the end of fetal period.
- Nephron formation is **complete at birth**.

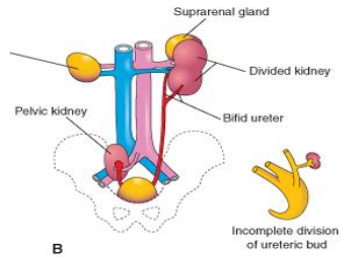
After birth

- **Increase in size:** due to elongation of tubules and increase in connective tissue between tubules (**not** due to increase in number of nephrons)
- Disappearance of kidney lobulation (usually disappears by the end of the first postnatal year)

Anomalies Of Kidney Development

Pelvic kidney:

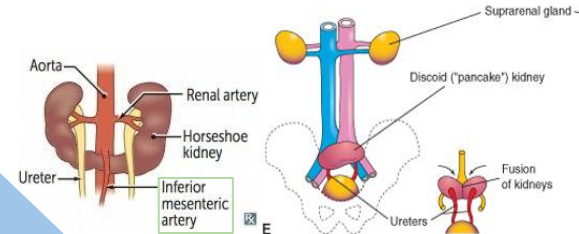
Failure of ascent of one kidney (ureter is short).
(The kidney is non-functional)



1

Horseshoe kidney:

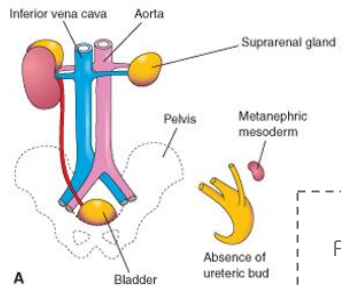
The poles of both kidneys (usually the lower poles) fuse:
The kidneys have a lower position than normal but have normal function. The blood supply to the large intestine will be affected if the kidney become above the inferior mesenteric arteries (starting from left third of transverse colon)



2

Unilateral renal agenesis:

Due to absence of one ureteric bud
It can be bilateral which is fatal



3

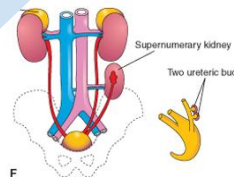
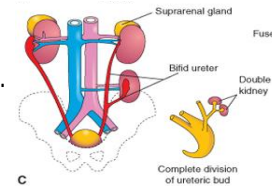
Agenesis means:

Failure of an organ to develop due to the absence of primordial tissue

4

Supernumerary kidney:

Due to development of 2 ureteric buds.
Two kidneys with one ureter



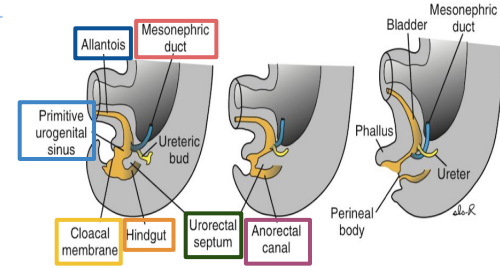
F

Right side: Malrotation of kidney.
Left side: Bifid ureter & supernumerary kidney.
Two kidneys with two separate ureters

Development of the Urinary Bladder & Urethra

Development Of Urinary Bladder & Urethra

- The cloaca is the dilated terminal part of the **hind gut**.
- It is endodermal lined cavity , developed from endoderm.
- It receives the **allantois** (anteriorly) and the (2) mesonephric ducts (Laterally on both sides)
- Its floor is closed by the **cloacal membrane**.
- A mesodermal **urorectal septum** divides the cloaca and the cloacal membrane.



Urorectal septum	
Cloaca	
<p>Ventral part (Primitive urogenital sinus) communicates with the allantois and the mesonephric ducts. Its floor is the urogenital membrane.</p>	<p>Dorsal part The anorectal canal, that forms the rectum and upper part of anal canal. Its floor is the anal membrane.</p>
<p>Primitive urogenital sinus</p> <p>Cranial (vesical part) forms most of the bladder and continuous with the allantois. Middle (pelvic part) forms main part of male urethra (prostatic & membranous part) & entire female urethra. Caudal (phallic part) grows towards genital tubercle & shares in the formation of the male urethra (give rise to the penile "spongy" part of the male urethra)</p>	<p>Primitive urogenital sinus</p> <ul style="list-style-type: none"> Allantois Vesical part Pelvic part Phallic part Dorsal part

Urinary Bladder

01

It develops mainly from the vesical part of the **urogenital sinus**.

02

The **trigone** is derived from the absorbed caudal ends of the **Mesonephric ducts**.

03

The epithelium is endodermal in origin.

04

The other layers are derived from the splanchnic mesoderm

05

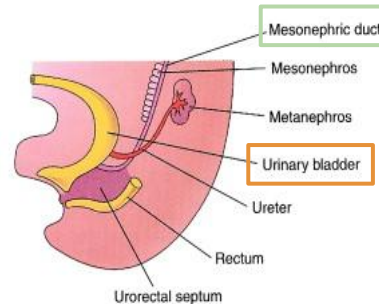
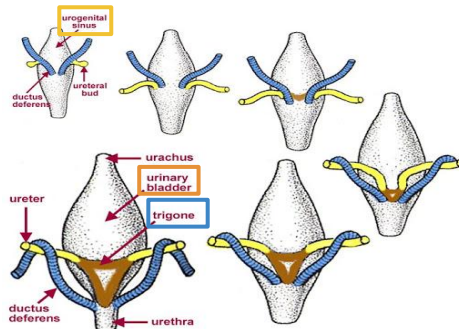
The allantois is at first continues with the bladder, then it becomes a thick fibrous cord called **urachus** which extends from apex of the **bladder** to the umbilicus. At birth it is represented by the median umbilical ligament.

06

After absorption of the **mesonephric ducts** to form the **trigone**, the ureters open separately in the **bladder**.

07

In infants and children the **bladder** is an abdominal organ. It starts to enter the greater pelvis at about 6 years and becomes a pelvic organ after puberty.

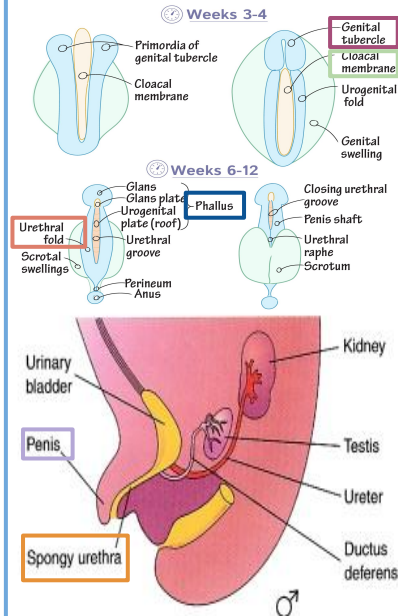


Urethra

- **Indifferent stage:** "it's Called so because we cannot differentiate if the fetus was a male or a female"
 - The genital tubercle (mesenchymal elevation) develops at the cranial end of the **cloacal membrane**.
 - Two urethral folds, develop on either side of the **urogenital membrane**. Forms the phallic part of the urogenital sinus.
 - Laterally two labioscrotal, (cloacal) folds develop on either side of the **urethral folds**.

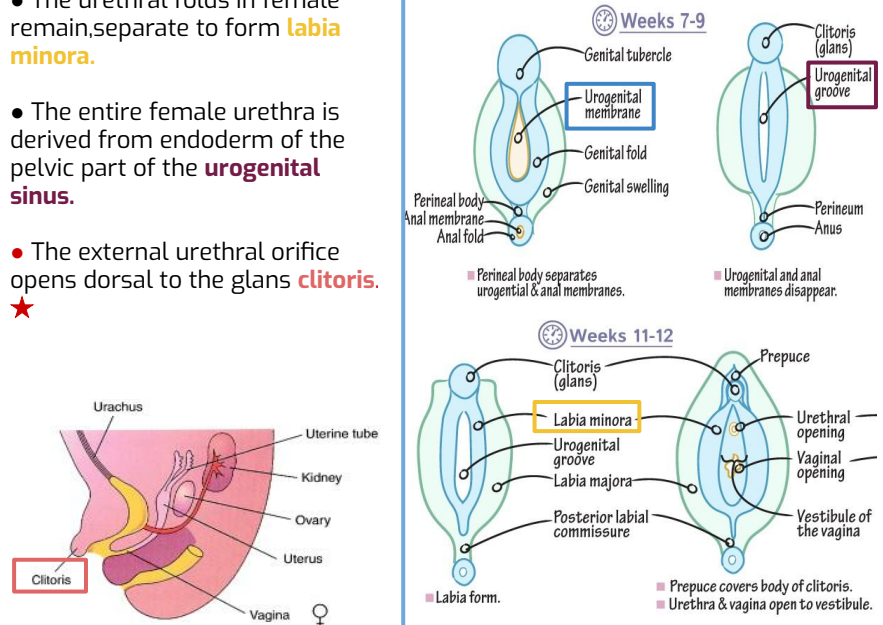
Male Urethra

- The urethral folds in male fuse with each other to close the penile urethra. (**spongy urethra is formed by tubularization of the urethral folds**)
- Most of the male urethra (prostatic, membranous and spongy parts) is derived from endoderm of the pelvic and phallic parts of **urogenital sinus**.
- The **genital tubercle** elongates forming the **phallus**, which is the precursor of the **penis**.
- The distal (terminal) part of male urethra in glans penis starts as **ectodermal solid cord** that grows towards the root of **penis** to meet the **spongy urethra**, later it canalizes.



Female Urethra

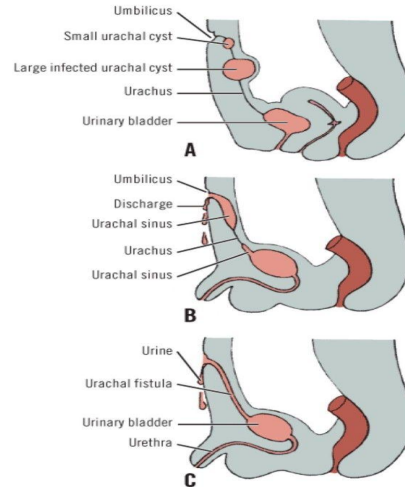
- The urethral folds in female remain separate to form **labia minora**.
- The entire female urethra is derived from endoderm of the pelvic part of the **urogenital sinus**.
- The external urethral orifice opens dorsal to the glans **clitoris**. ★



Anomalies Of Urinary Bladder & Urethra Development

Urachal Anomalies

- A. **Urachal cyst**
Persistence or remnant of epithelial lining of urachus
- B. **Urachal sinus**
Discharge serous fluid from the umbilicus.
- C. **Urachal fistula.**
The entire urachus remains patent and allows urine to escape from the umbilicus.



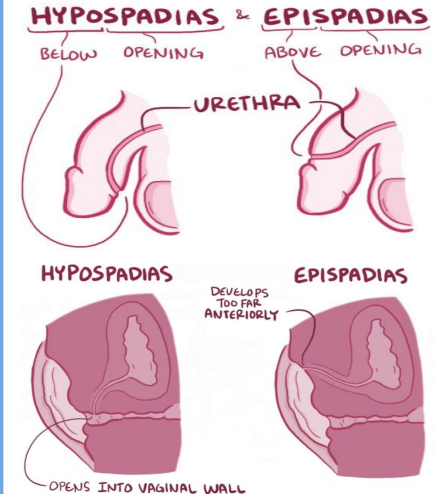
Urethral Anomalies

Hypospadias :

Is the most common anomaly, with incomplete fusion of the urethral folds, and abnormal openings of the urethra occur along the ventral (inferior) aspect of the penis.

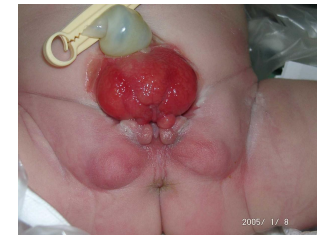
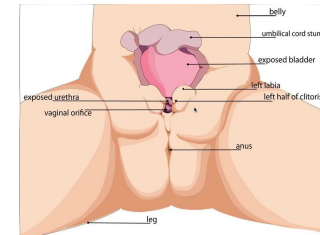
Epispadias :

Is a rare abnormality, in which the urethral meatus is found on the dorsum of penis, it is most often associated with exstrophy of the bladder.



Exstrophy of the bladder (Ectopia vesicae)

Exposure of the posterior wall of the bladder due to a defect in the anterior abdominal wall and anterior wall of the bladder. Bladder exstrophy is a congenital abnormality that occurs when the skin over the lower abdominal wall does not form properly. The bladder is open and exposed on the outside of the abdomen; it is associated with epispadias. In epispadias, the urethral meatus is found on the dorsum of the penis.



Summary

Kidneys & ureters

- ◇ Originates from nephrogenic ridge (cord) of intermediate mesoderm.
- ◇ During development, 3 systems appear:
 1. **Pronephric**: in cervical region, not function.
 2. **Mesonephric**: in thorax & abdomen, function temporarily, mesonephric duct gives ureteric bud.
 3. **Metanephric**: in pelvis, permanent kidney.
- ◇ Ureteric bud gives: ureter + collecting part of kidney (calyces, straight & arched collecting tubules).
- ◇ Metanephric mass gives: excretory part of kidney (Bowman capsule, proximal & distal convoluted tubules, loop of Henle).

At 9th week



- Glomerular filtration begins.
- Kidney attains its adult position.
- Kidney receives its arterial supply from aorta.
- Kidney completes rotation.

At full term



- Nephron formation is complete.
- Lobulation of kidney diminishes

After birth



- Lobulation of kidney disappears.
- Kidney increases in size due to elongation of existing tubules not due to increase in number of nephrons.

Urinary bladder

- ◇ It develops mainly from the vesical part of the urogenital sinus.
- ◇ The allantois is at first continues with the bladder, then it becomes a thick fibrous cord called urachus which extends from apex of the bladder to the umbilicus.
- ◇ The epithelium is endodermal in origin, of the urogenital sinus.
- ◇ The other layers are derived from the splanchnic mesoderm.
- ◇ After absorption of the mesonephric ducts to form the trigone, the ureters open separately in the bladder.
- ◇ Bladder exstrophy is a congenital abnormality that occurs when the skin over the lower abdominal wall does not form properly. The bladder is open and exposed on the outside of the abdomen; it is associated with epispadias.
- ◇ In epispadias, the urethral meatus is found on the dorsum of the penis.

Urethra

- ◇ The genital tubercle develops at the cranial end of the cloacal membrane.
- ◇ **Male Urethra**
 - ◇ The urethral folds in male fuse with each other
 - ◇ Most of the male urethra derived from endoderm of the pelvic and phallic parts of urogenital sinus
- ◇ **Female Urethra**
 - ◇ The urethral folds in female remain separate.
 - ◇ The entire female urethra is derived from endoderm of the pelvic part of the urogenital sinus.

MCQ

Q1: Which one of the following events happens by the end of the 9th week?

- A. Nephron formation is complete
- B. Disappearance of kidney lobulation
- C. Kidney attains its adult position
- D. Metanephric system appears

Q4: Failure of one kidney to develop is due to

- A. Absence of one ureteric bud
- B. Malrotation during development
- C. Failure of kidney to ascend
- D. Development of two ureteric buds

Q2: Which one of the following structures is a derivative of the metanephric mass?

- A. Ureter
- B. Collecting tubule
- C. Glomerulus
- D. Proximal convoluted tubule

Q5: The urinary bladder is mainly developed from :

- A. Vesical part of the urogenital sinus.
- B. Pelvic part of the urogenital sinus.
- C. Pallic Part Of The Urogenital Sinus.
- D. Allantois

Q3: Which one of the following best describes the adult kidney?

- A. An additional number of nephrons develops after birth
- B. lies inferior to the adrenal glands
- C. Lobulations are visible
- D. Is supplied by branches of the common iliac arteries

Q6: Which one of the following forms the entire female urethra ?

- A. Genital tubercle.
- B. Allantois
- C. Vesical part of the urogenital sinus.
- D. Pelvic part of the urogenital sinus.

MCQ

Q7: The trigone of the urinary bladder is developed from :

- A. Paramesonephric ducts.
- B. Mesonephric ducts.
- C. Allantois
- D. Urogenital sinus.

Q10: Metanephric system starts functioning at the

- A. 5th week
- B. 4th week
- C. 9th week
- D. 10th week

Q8: The urethra in glans penis is developed from :

- A. The vesical part of urogenital sinus.
- B. The pelvic part of urogenital sinus.
- C. The ectoderm.
- D. The splanchnic mesoderm.

Q11: lobulation of the kidney diminishes at:

- A. 9th week
- B. 4th week
- C. 5th week
- D. At full term

Q9: The kidney and ureters arise from

- A. Proximal mesoderm
- B. Intermediate mesoderm
- C. Lateral mesoderm
- D. Ectoderm

Q12: Which type of Urachal anomalies is defined by "discharge serous fluid from the umbilicus"

- A. Urachal sinus
- B. Urachal fistula
- C. Urachal cyst
- D. None of the above

SAQ :

1 : List the anomalies of kidney development.

2 : List the urachal anomalies.

3 : List the urethral anomalies.

4: List the systems that appear during the development of the kidney and ureter.

SAQ Answers :

1:

- Pelvic kidney
- Horseshoe kidney
- Unilateral renal agenesis
- Supernumerary kidney
- Right side: malrotation of kidney
- Left side: bifid ureter & supernumerary kidney

2:

- A. Urachal cyst persistence or remnant of epithelial lining of urachus
- B. Urachal sinus, discharge serous fluid from the umbilicus.
- C. Urachal fistula, the entire urachus remains patent and allows urine to escape from the umbilicus.

3:

- Hypospadias : is the most common anomaly, with incomplete fusion of the urethral folds, and abnormal openings of the urethra occur along the ventral (inferior) aspect of the penis.
- Epispadias : is a rare abnormality, in which the urethral meatus is found on the dorsum of penis, it is most often associated with exstrophy of the bladder

4:

- Pronephric: in cervical region
- Mesonephric: in thorax & abdomen
- Metanephric: in pelvis

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