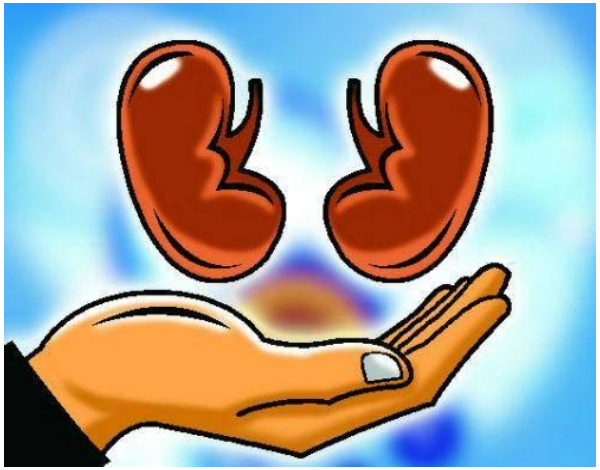


The functional anatomy of the urinary system

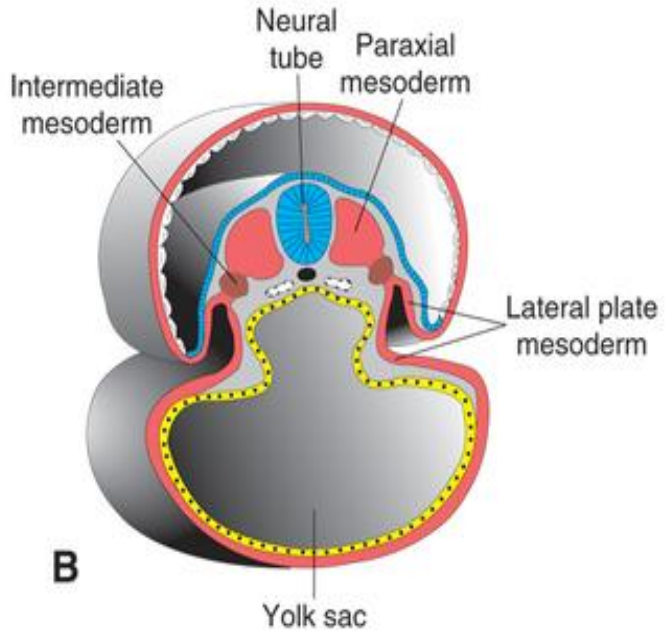
Human Anatomy Department
Dr. Anastasia Bendelic

Plan

- Development of the kidneys and their abnormalities
- Development of the urinary ways and their abnormalities
- Kidney – structure, topography, functions
- Ureter – structure, topography, function
- Urinary bladder – structure, topography, function
- Male and female urethra – structural peculiarities, functions

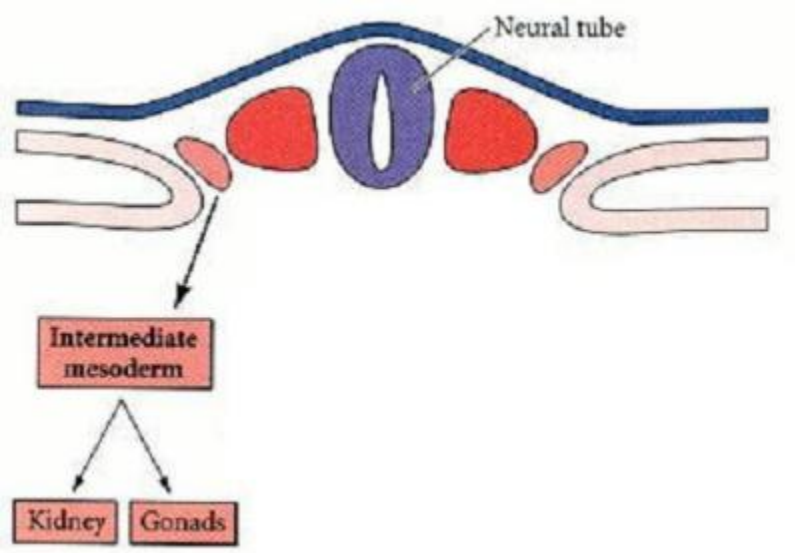
Kidney development

The kidney develop from ***intermediate mesoderm*** (or nephrogenic mesoderm).



Intermediate mesoderm

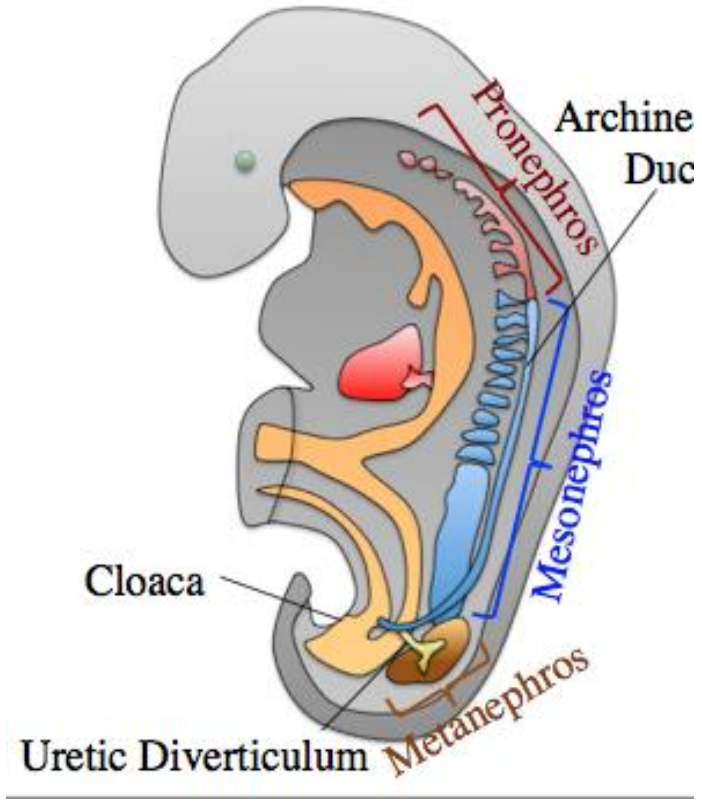
The ***intermediate mesoderm*** gives rise to the kidney and indifferent gonad.



Kidney development or nephrogenesis

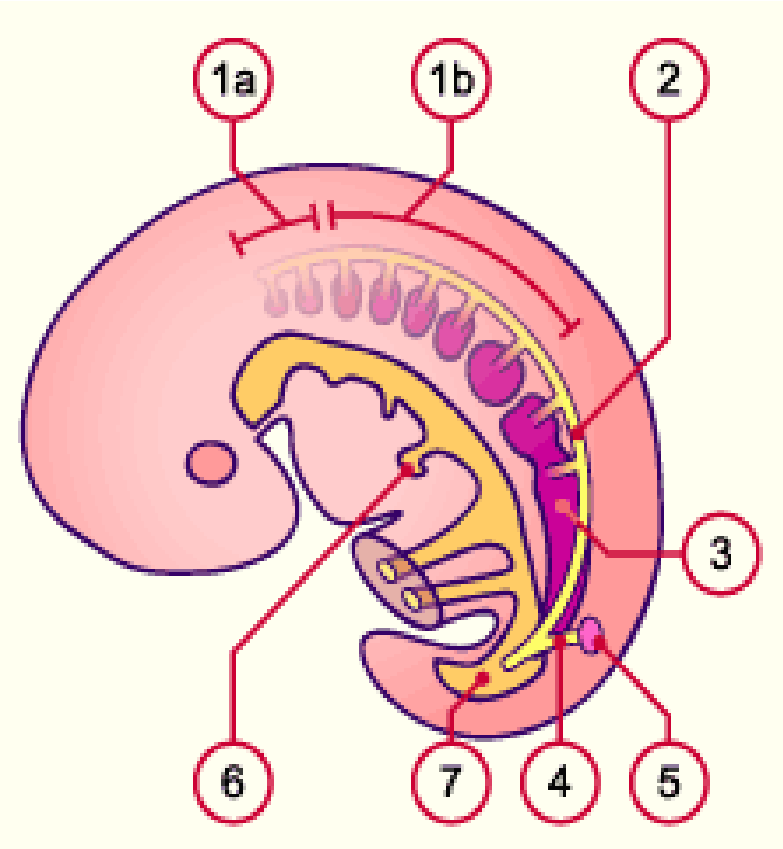
The development of the kidney includes a series of successive phases:

- ***Pronephros***;
- ***Mesonephros***;
- ***Metanephros***.

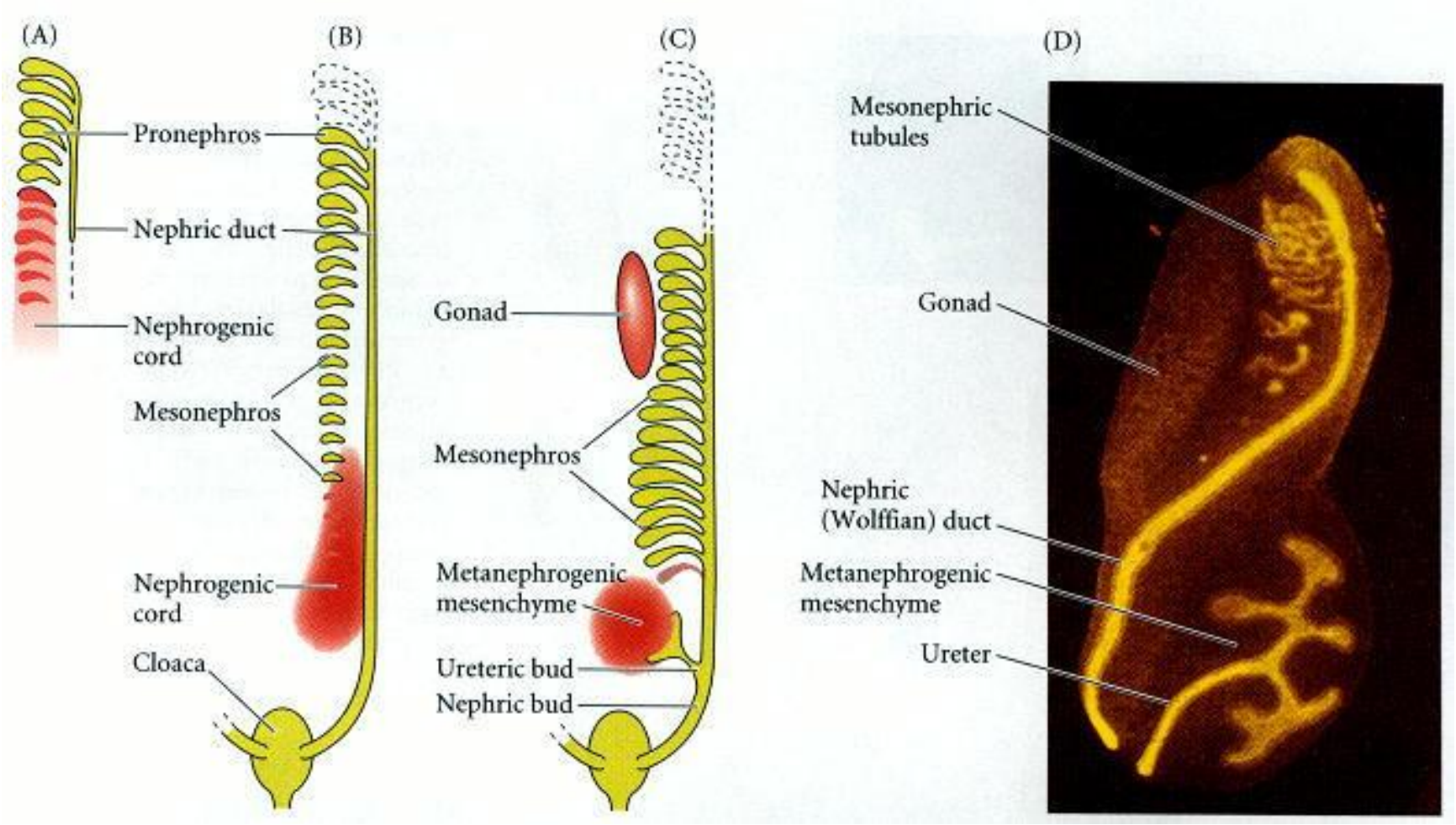


Kidney development or nephrogenesis

- ***Pronephros*** – pronephric tubules, pronephric duct;
- ***Mesonephros*** – mesonephric tubules, mesonephric duct or Wolffian duct;
- ***Metanephros*** – ureteric bud (or metanephric diverticulum), metanephric blastema.



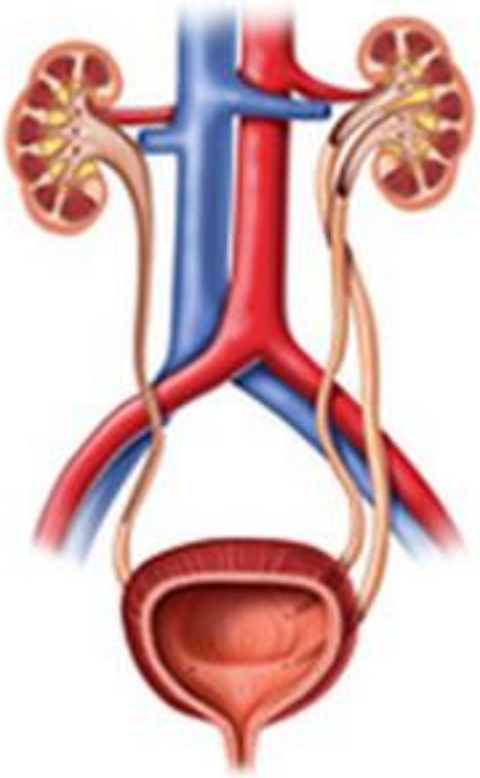
Kidney development or nephrogenesis

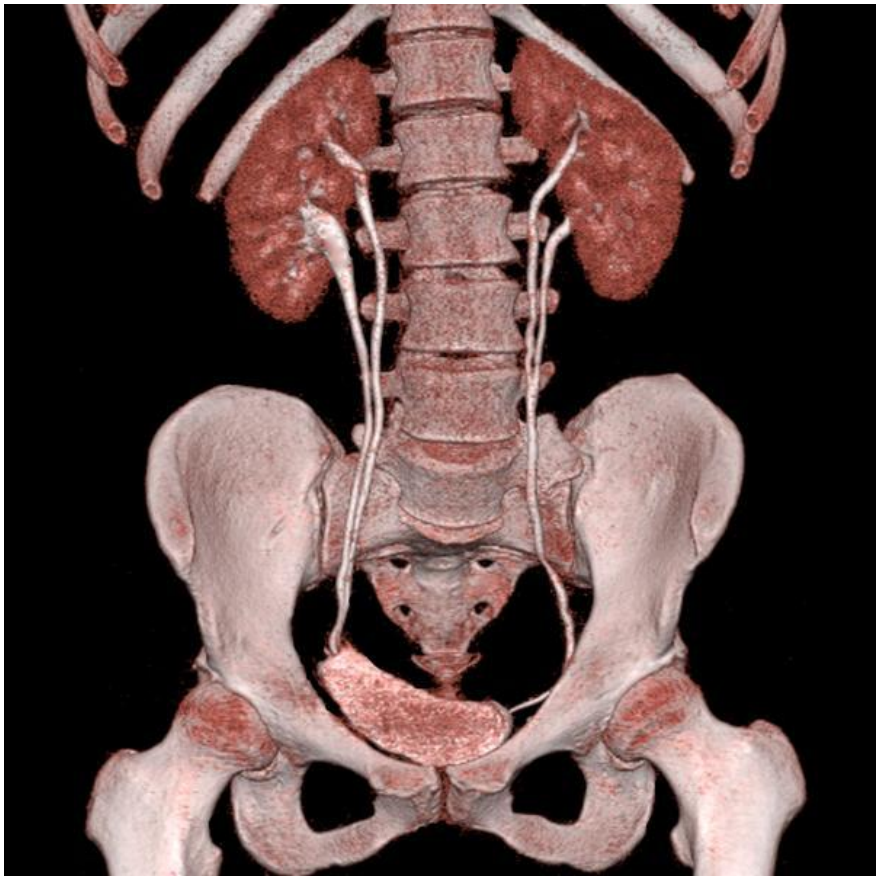


Abnormalities

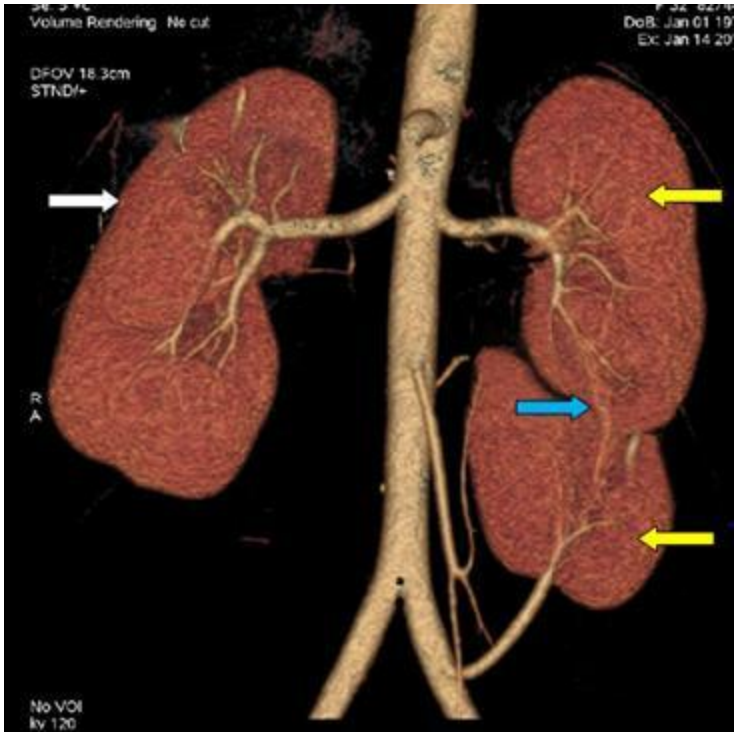
- ***Bifid renal pelvis*** and ***ureter*** result from division of the metanephric diverticulum (ureteric bud). It may be unilateral or bilateral.
- ***Retrocaval ureter*** passes posterior to the inferior vena cava.
- ***Supernumerary kidney*** develops as a result of splitting of the metanepfric blastema.
- ***Renal agenesis –*** ureteric bud fails to develop.
- ***Horseshoe kidney*** – the inferior poles of the kidney are fused.
- ***Multichystic dysplastic kidney*** is characterized by presence of multiple, non-communicating cysts.
- ***Ectopic pelvic kidney*** fails to climb towards its normal position.

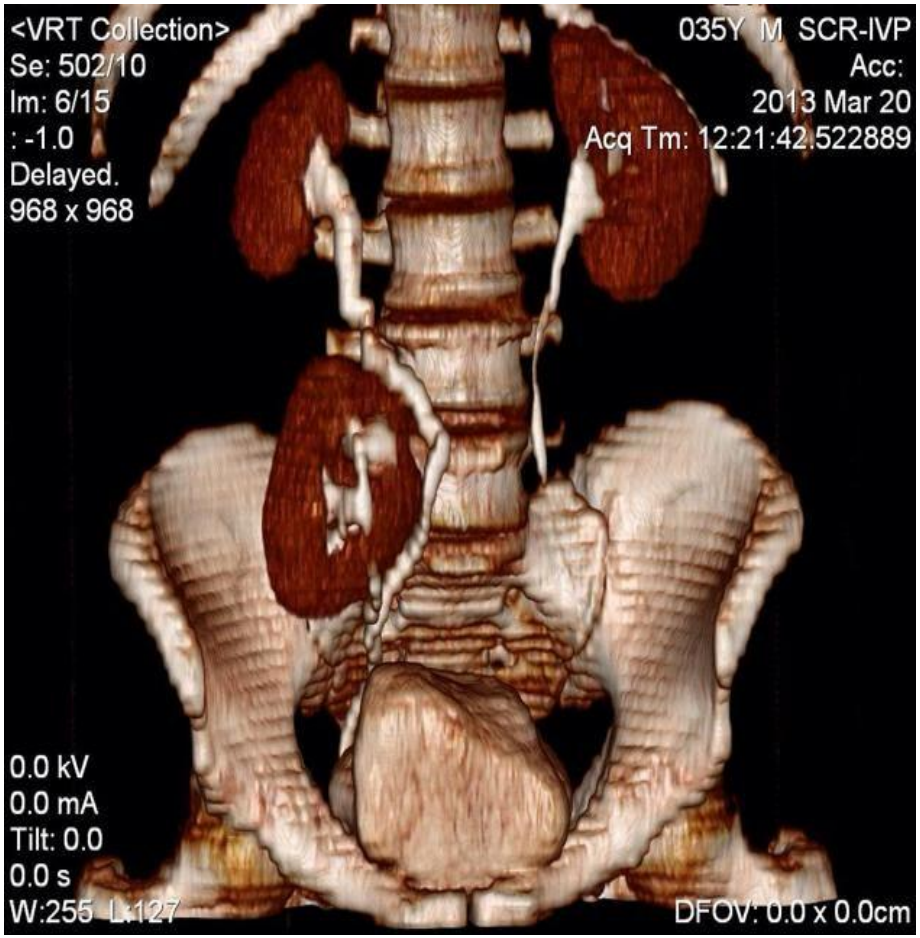
Double and bifid ureter





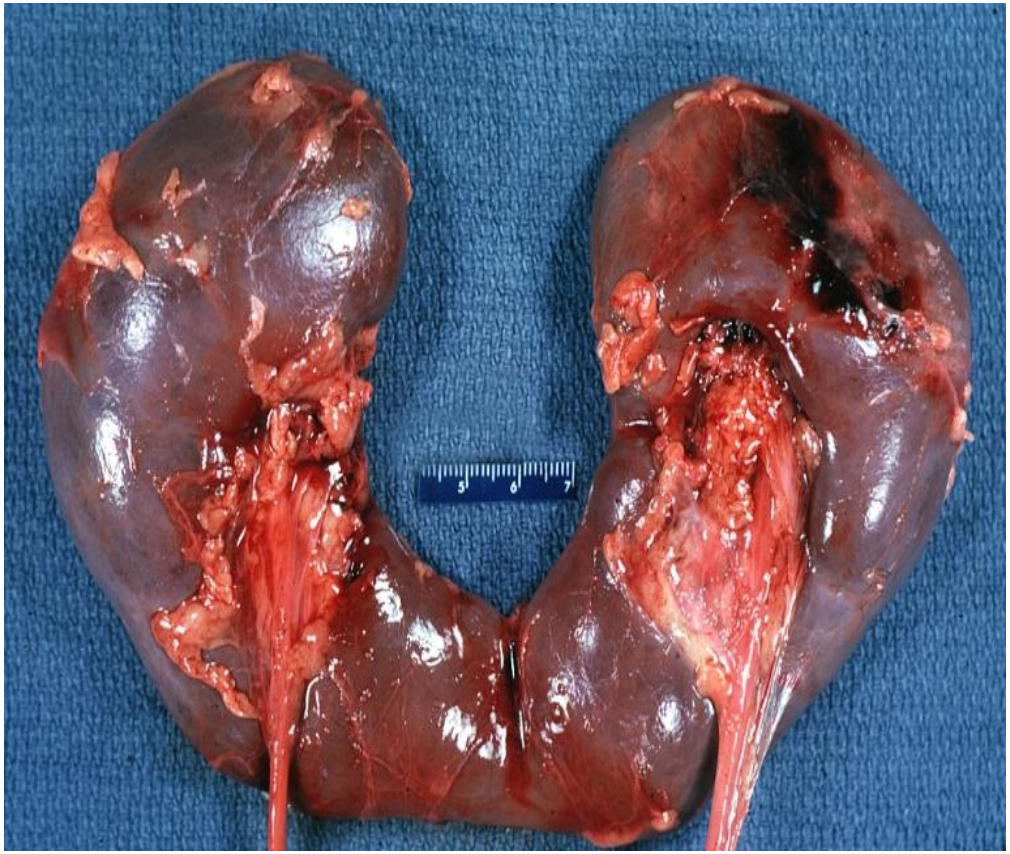
Supernumerary kidneys

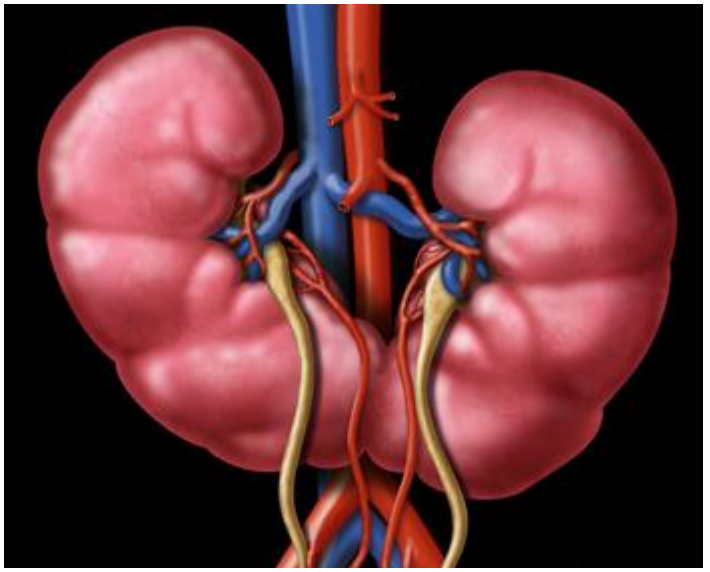




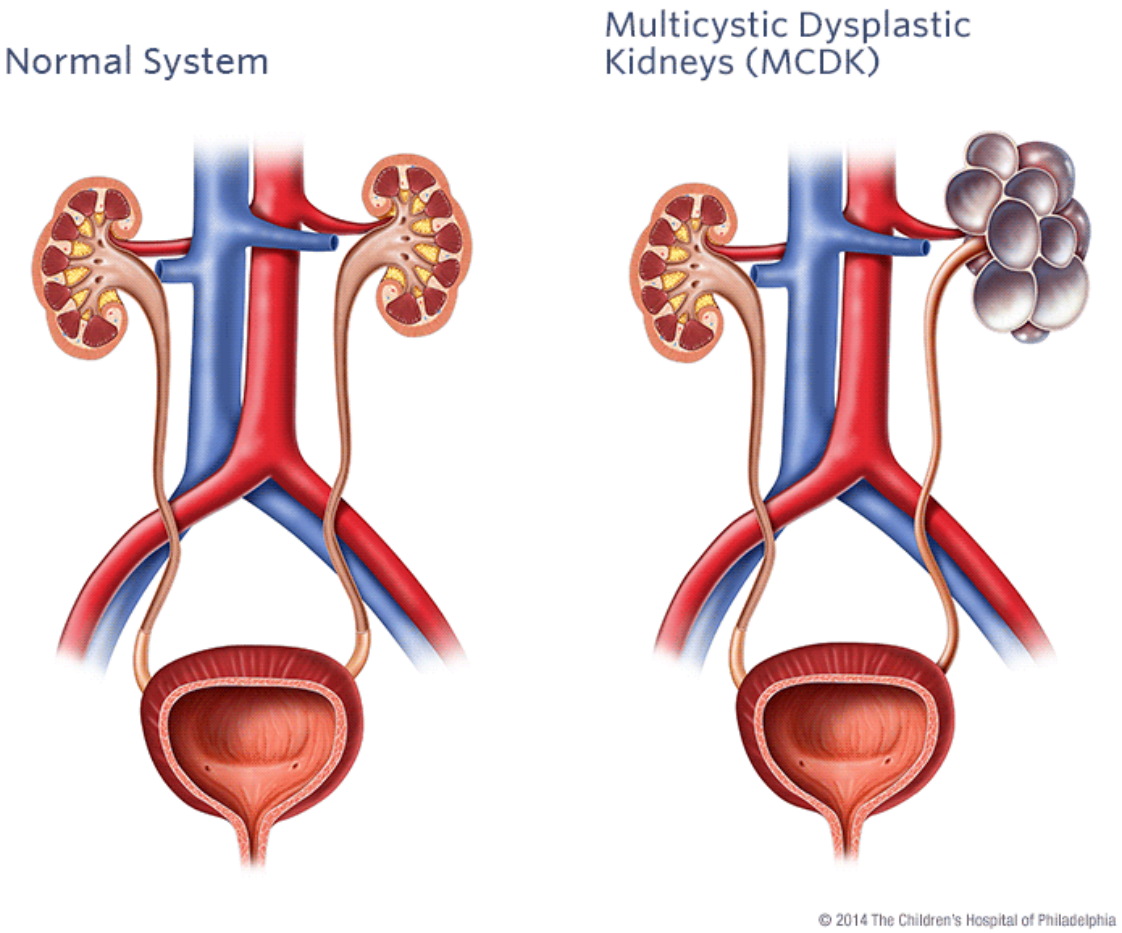
Unilateral renal agenesis

Horseshoe kidney

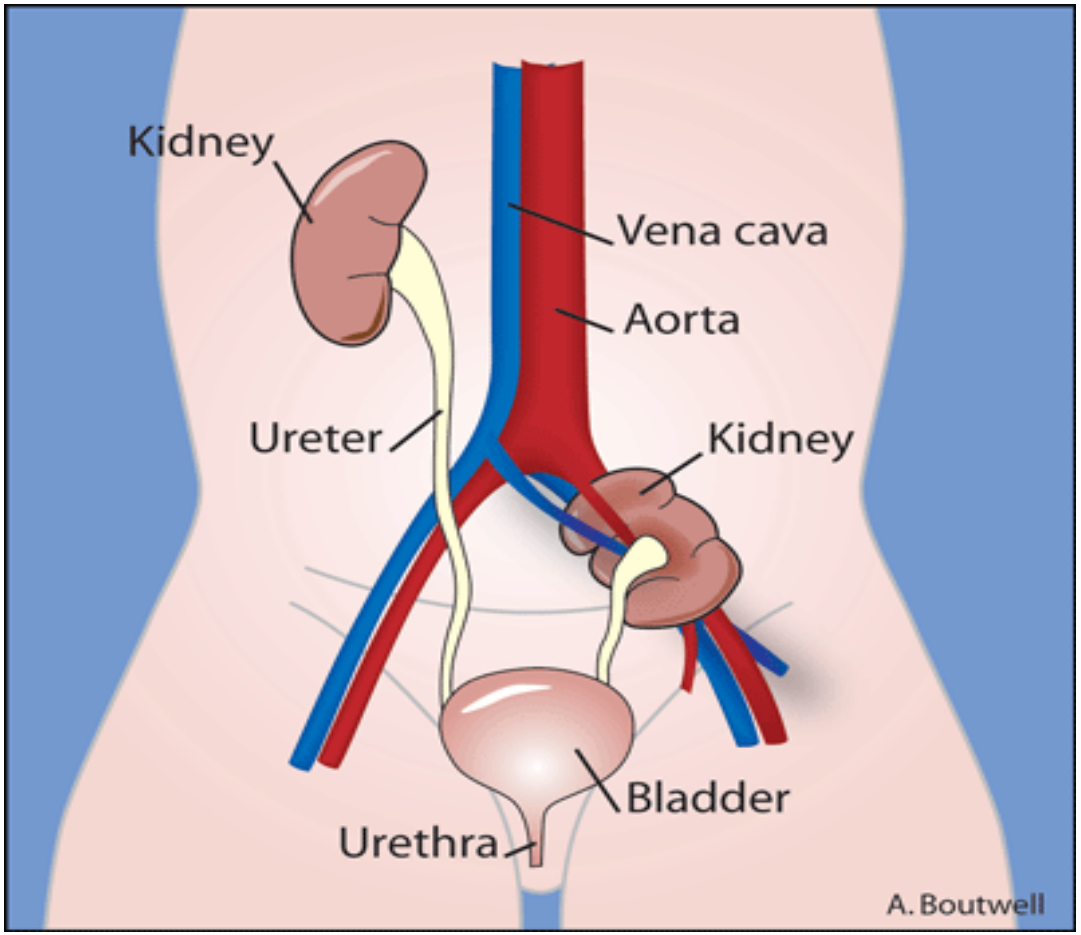




Multicystic dysplastic kidney

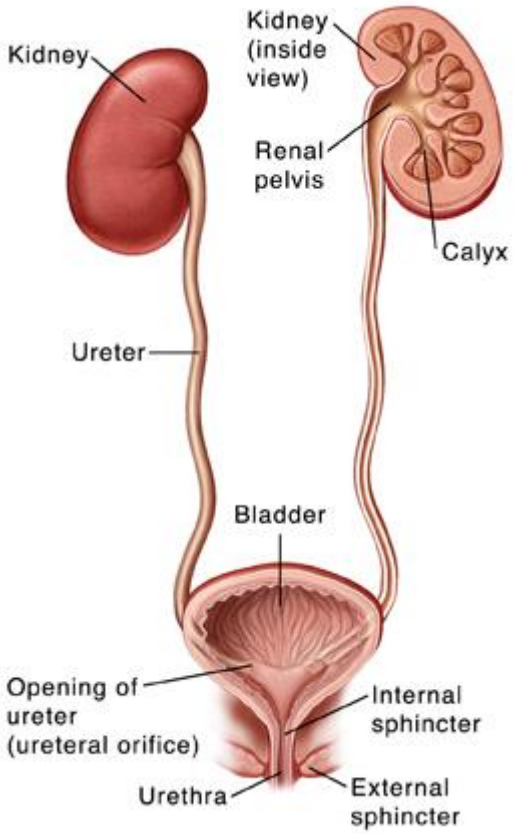


Ectopic pelvic kidney



Urinary system consists of:

- ***Kidneys*** which produce urine;
- ***Ureters*** which carry urine from the kidneys;
- ***Urinary bladder*** which temporarily stores urine;
- ***Urethra*** which conducts urine from the urinary bladder to the exterior.



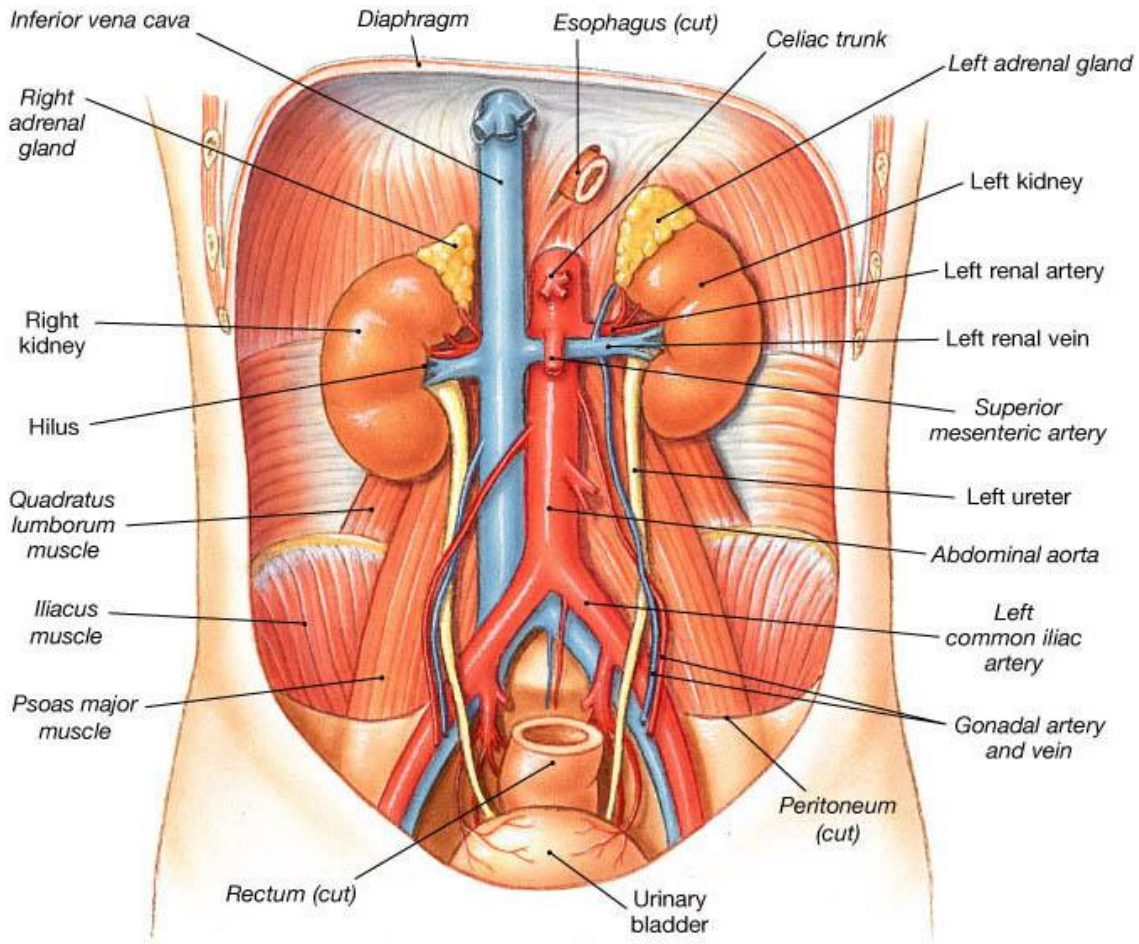
Kidney (ren, nephros)

The kidneys remove the excess water, salts and wastes of the protein metabolism and form the urine.

They lie ***retroperitoneally*** on the posterior abdominal wall on each side of the vertebral column at the level of ***T12 – L3 vertebrae***.

The right kidney lies slightly inferior to the left kidney, owing to its relationship to the liver.

Kidney (ren, nephros)



(a) Anterior view

Kidney is bean-shaped and has:

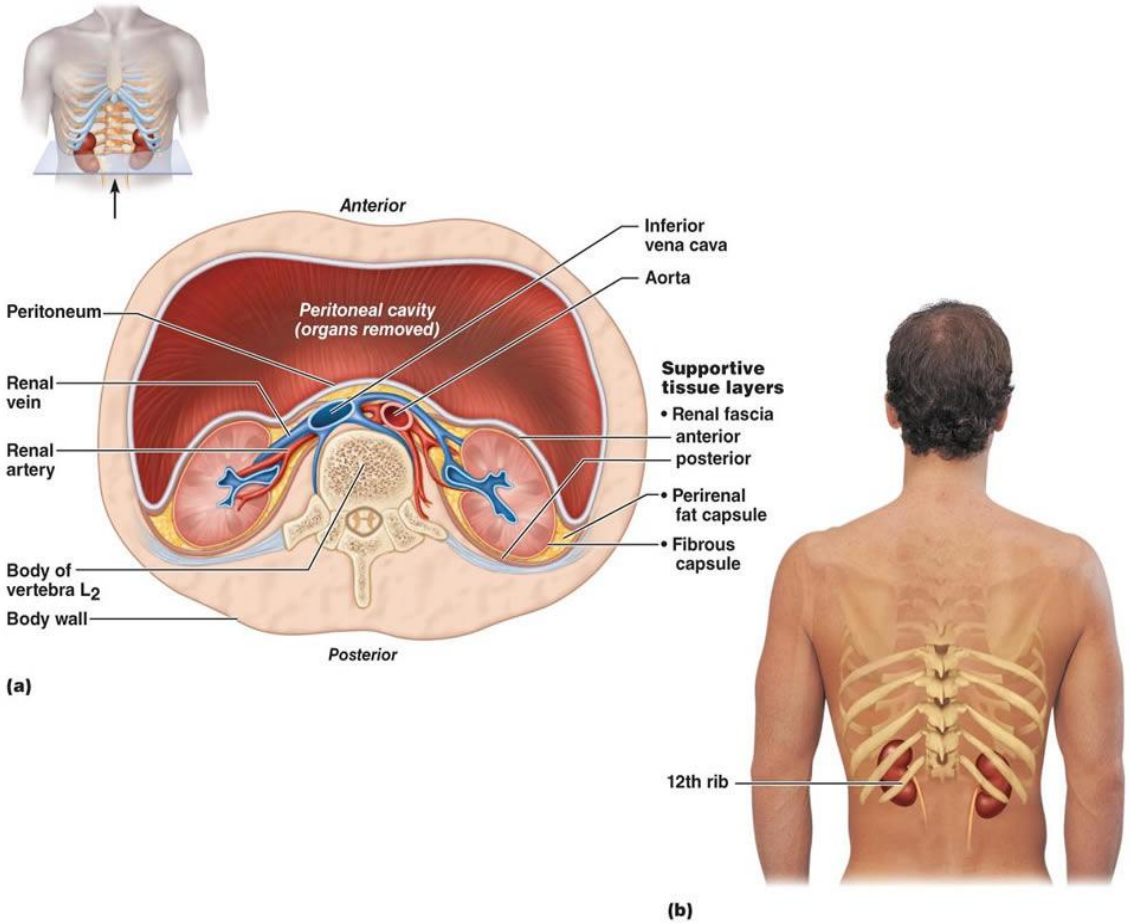
- two ***surfaces***: ***anterior*** and ***posterior***;
- two ***borders***: ***medial*** and ***lateral***;
- two ends (or ***poles***): ***superior*** and ***inferior***.

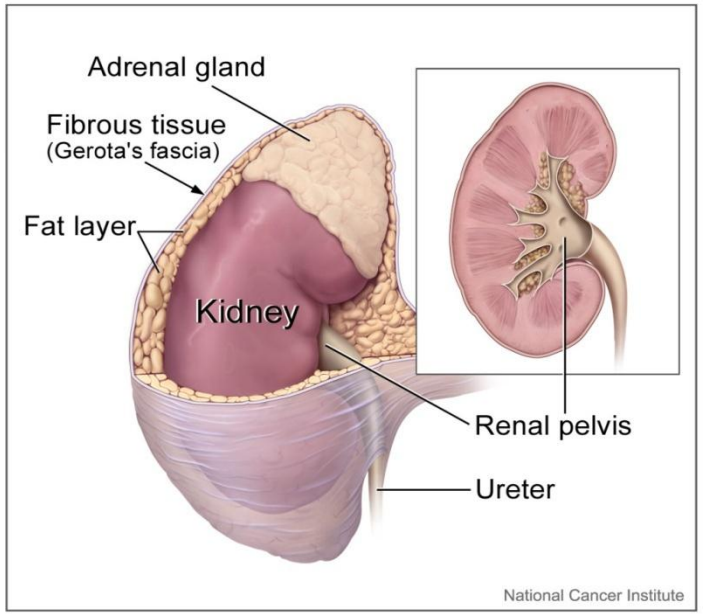
On the medial border the ***renal hilum*** is located, where the *renal artery* enters, and *renal vein* and *renal pelvis* (or ureter) leave the renal sinus.

Fixation apparatus of kidney:

- ***Renal*** (muscular) ***bed*** (or seat);
- ***Renal pedicle*** (renal artery, renal vein, ureter);
- ***Renal capsules*** (fibrous and adipose capsules);
- ***Renal fascia*** or Gerota`s fascia (consits of prerenal and retrorenal laminae);
- ***Peritoneum***;
- ***Intra-abdominal pressure***.

Fixation apparatus of kidney:

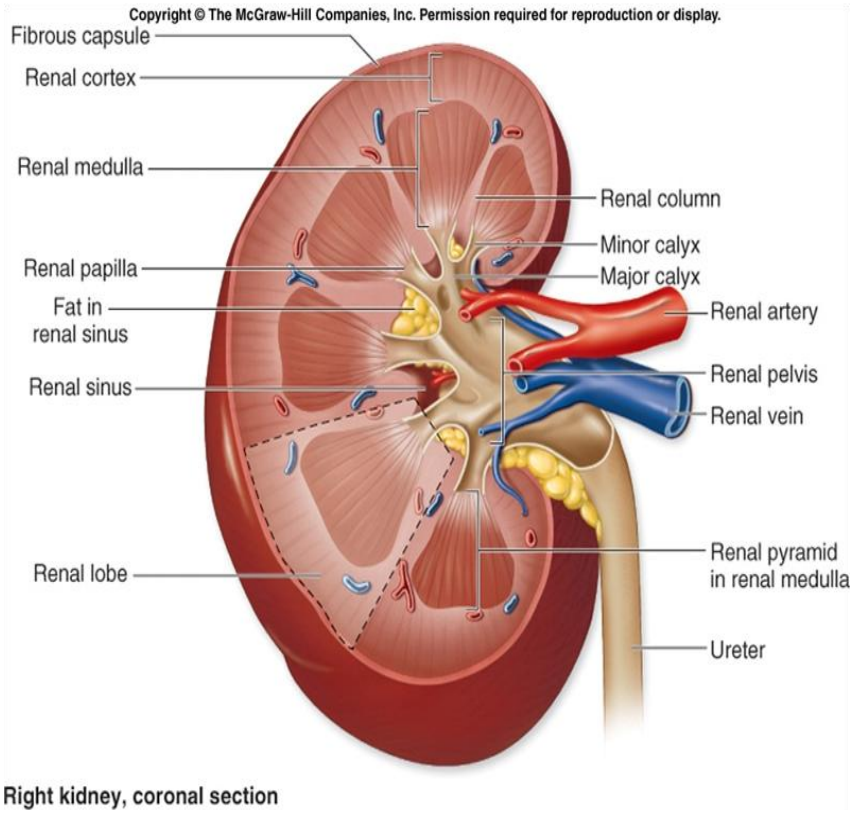




Internal (macro-microscopic) structure of kidney

1. **Renal parenchyma:**
   - ***Renal cortex*** – outer layer of kidney;
   - ***Renal medulla*** – inner layer of kidney arranged into the ***pyramids***.

2. **Renal sinus**



Right kidney, coronal section

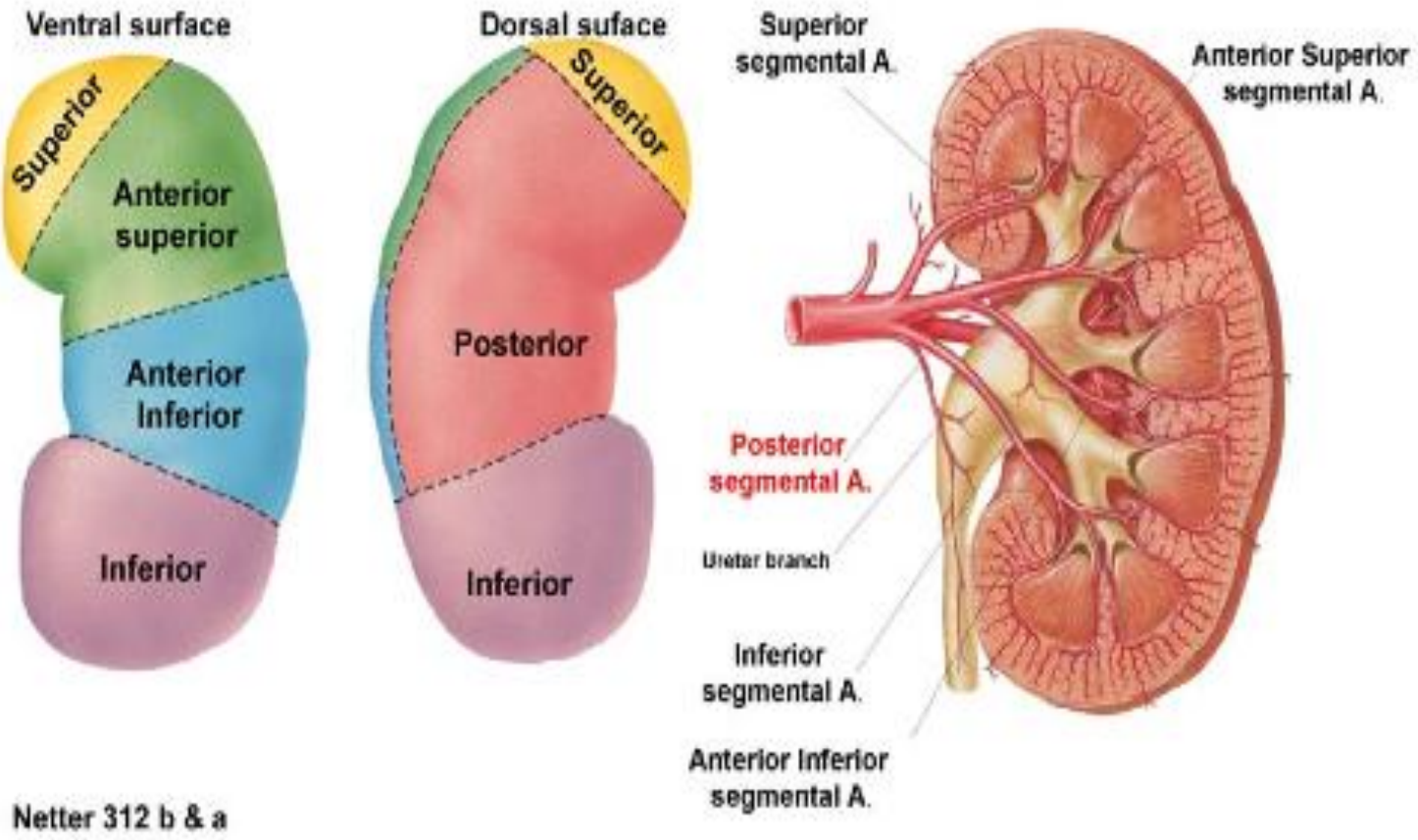
Internal (macro-microscopic) structure of kidney

- ***Renal lobe*** comprises a renal pyramid as well as renal cortex which surrounds it.
- ***Renal segment*** consists of 2 – 3 renal lobes.

There are 5 renal segments:

1. *superior segment;*
2. *inferior segment;*
3. *anterior superior segment;*
4. *anterior inferior segment;*
5. *posterior segment.*

Segmental structure of the kidney



Netter 312 b & a

Nephron – functional and structural unit of kidney

There are about 1.000.000 nephrons in each human kidney.

Each ***nephron*** consists of two parts:

- ***Renal corpuscle***, producing primary urine (150-180 l/ 24 hours);
- ***Renal tubule***, producing secondary urine (1,5 -2 l/ 24 hours).

Nephron – functional and structural unit of kidney

- ***Renal corpuscle*** comprises:

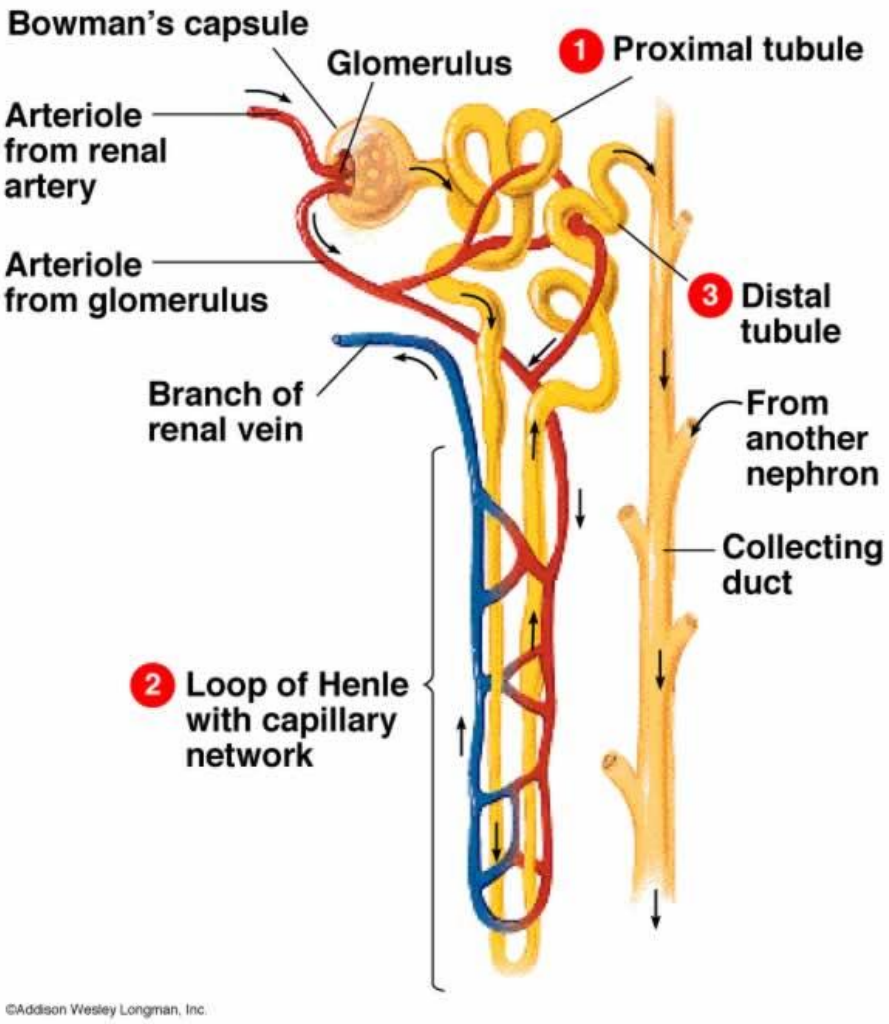
1. *glomerulus* (a network of capillaries);
2. *Bowman`s capsule or glomerular capsule.*

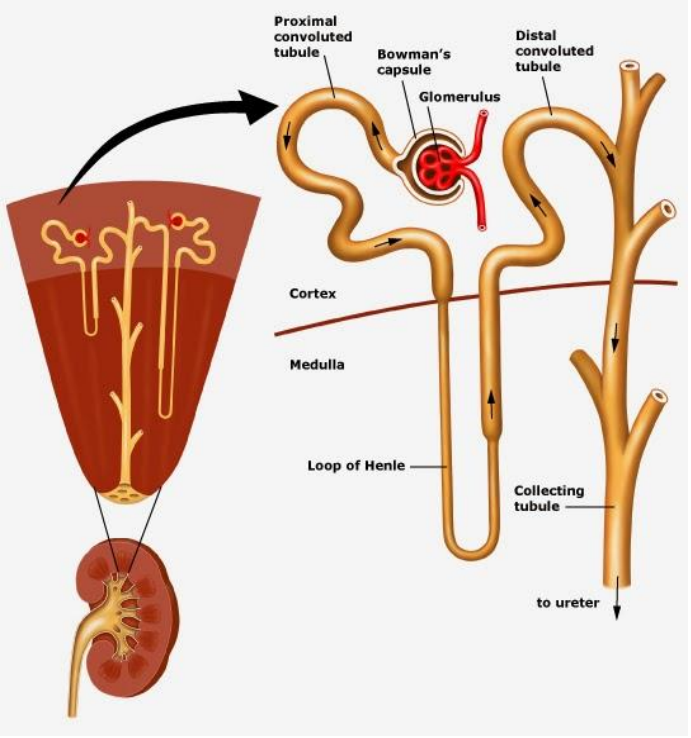
- ***Renal tubule*** consists of:

1. proximal convoluted tubule;
2. loop of Henle;
3. distal convoluted tubule.

The final urine is conveyed through the ***collecting ducts, papillary ducts*** into the renal calyces and pelvis.

Nephron – functional and structural unit of kidney





Nephron – functional and structural unit of kidney

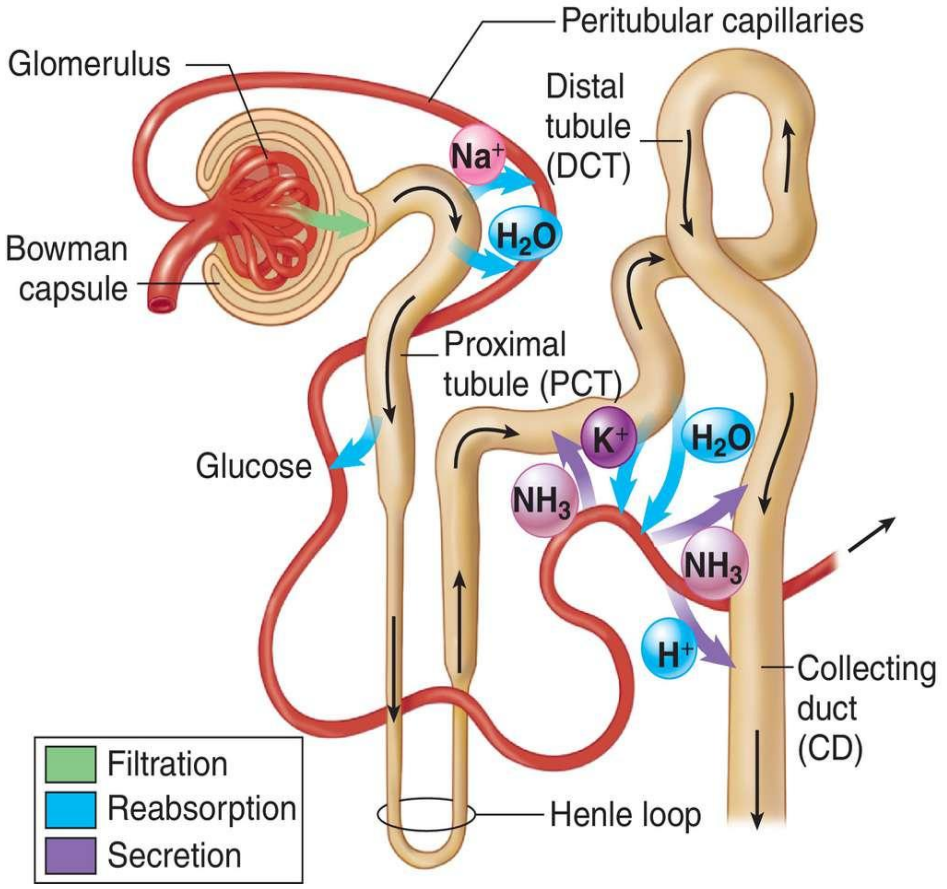
There are two kind of nephrons:

- ***Cortical nephrons*** (80%), which have short loops of Henle;
- ***Juxtamedullary nephrons*** (20%) have long loops of Henle, that extend deep into the renal medulla.

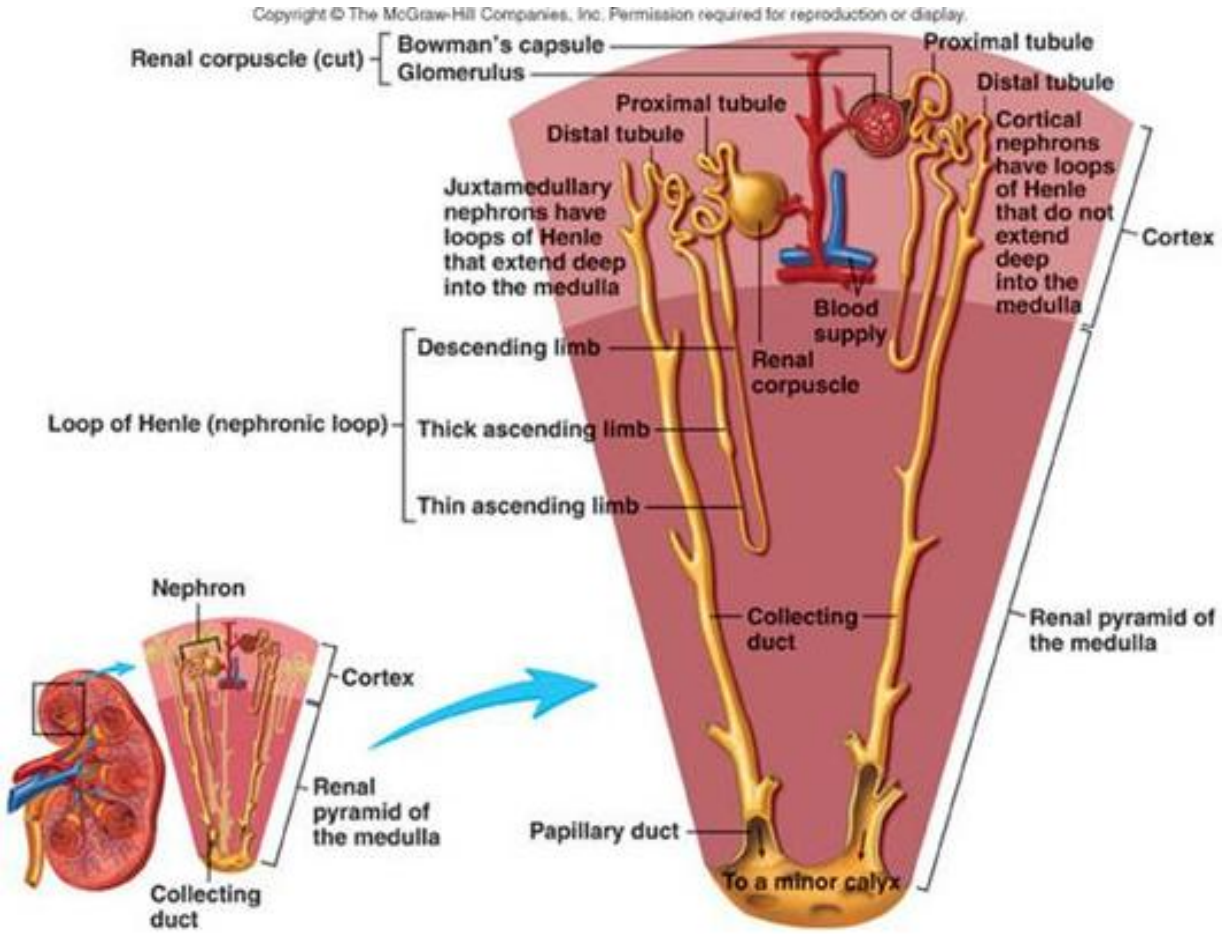
Urine formation

The three processes of urine formation are, as follows:

- (glomerular) ***filtration***,
- (tubular) ***reabsorption*** ,
- (tubular) ***secretion***.



Nephron – functional and structural unit of kidney

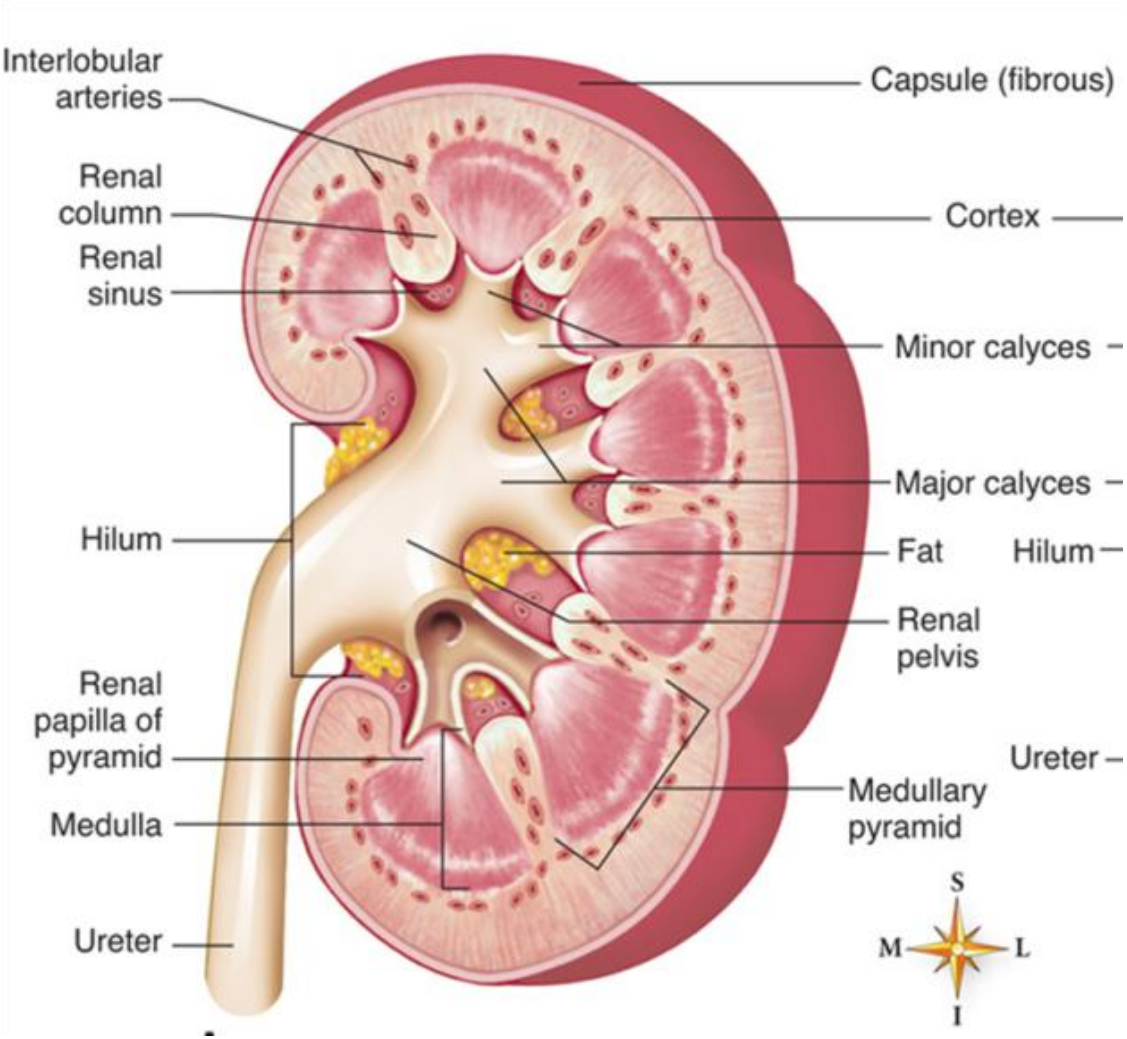


Renal sinus

The ***renal sinus*** is a space of within the kidney, which is occupied by:

- ***minor renal calyces***,
- ***major renal calyces***;
- ***renal pelvis***;
- *vessels*;
- *nerves*;
- variable amount of fat.

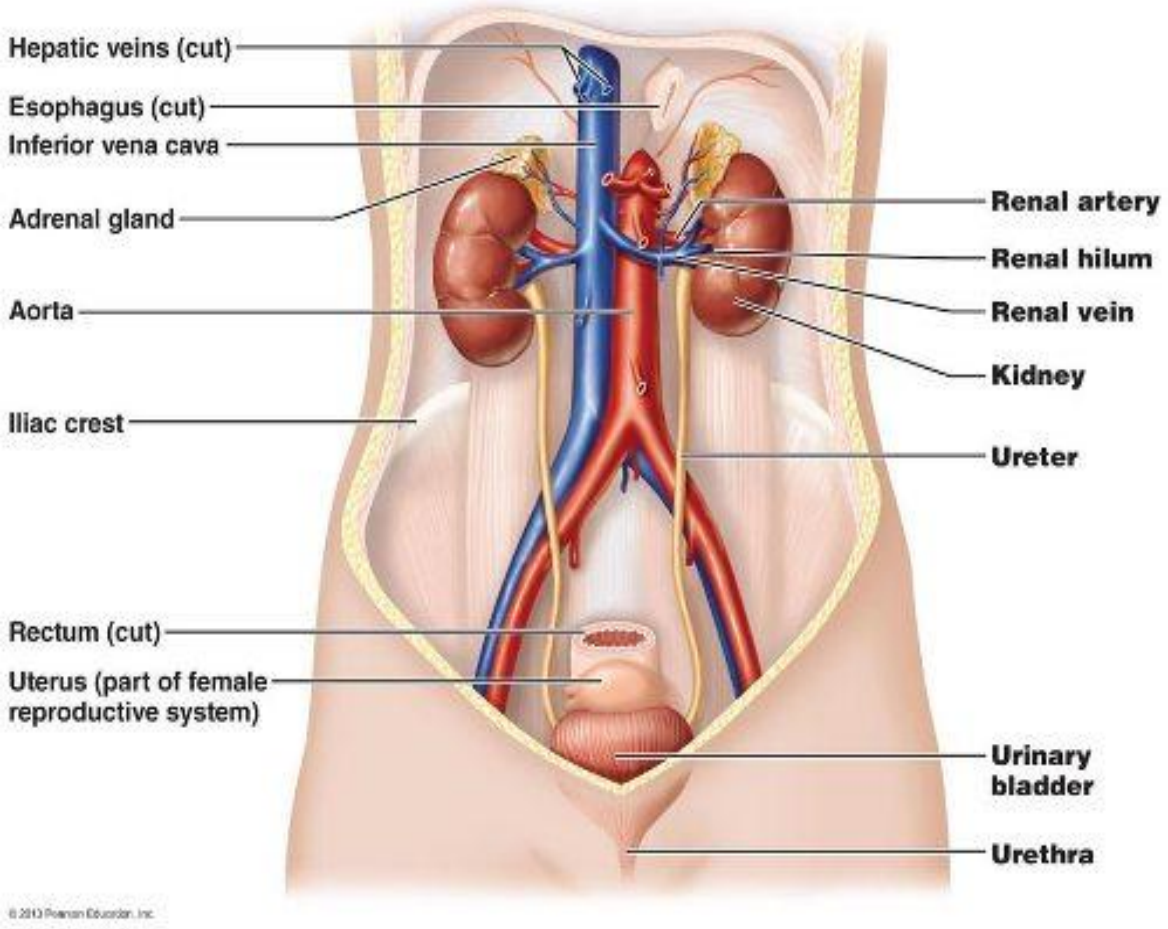
Renal sinus


Interlobular arteries
Renal column
Renal sinus
Hilum
Renal papilla of pyramid
Medulla
Ureter
Capsule (fibrous)
Cortex
Minor calyces
Major calyces
Fat
Hilum
Renal pelvis
Ureter
Medullary pyramid
S
M
L
I

Ureters

- muscular tubes, which connect the kidneys to the urinary bladder;
- have 3 parts: ***abdominal, pelvic, intramural*** (or *intravesical*);
- their walls consist of 4 layers: *mucosa, submucosa, muscular* and *adventitious coats*.

Ureters


Hepatic veins (cut)
Esophagus (cut)
Inferior vena cava
Adrenal gland
Aorta
Iliac crest
Rectum (cut)
Uterus (part of female reproductive system)
Renal artery
Renal hilum
Renal vein
Kidney
Ureter
Urinary bladder
Urethra

Urinary bladder

- when empty, the adult urinary bladder is located in the pelvic cavity;
- In infants and young children is in the abdominal cavity even empty;
- it is separated from the pubic bones by the *retropubic space* (of Retzius);
- its neck is held firmly by the *puboprostatic ligament* in males and *pubovesical ligament* in females.

Urinary bladder

- It has 4 parts:

a) ***apex of the bladder;***
b) ***body of the bladder;***
c) ***fundus of the bladder;***
d) ***neck of the bladder.***

- The *ureteric orifices* and the *internal urethral orifice* are at the angles of the **trigone of the bladder.**

Urinary bladder

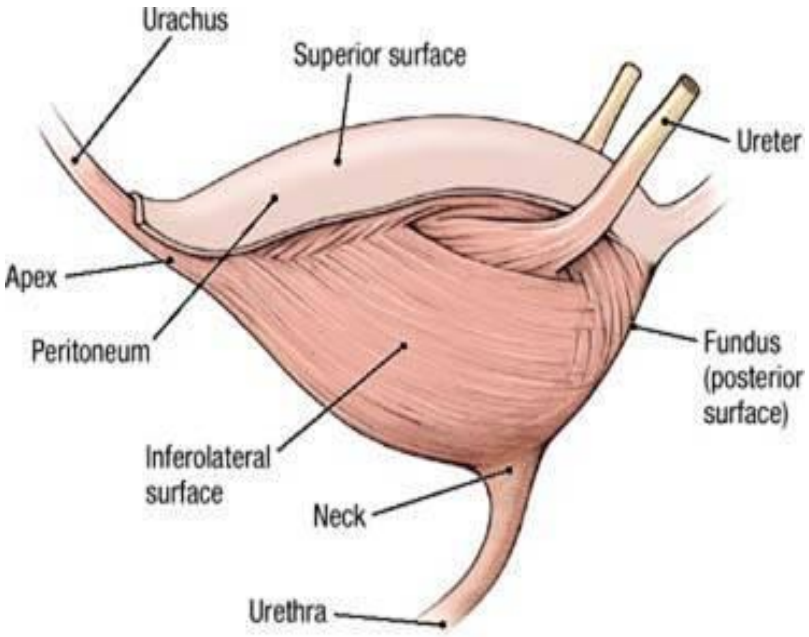


Figure 5.33. Parts of the urinary bladder in the female.

Urinary bladder

- Its walls consists of:

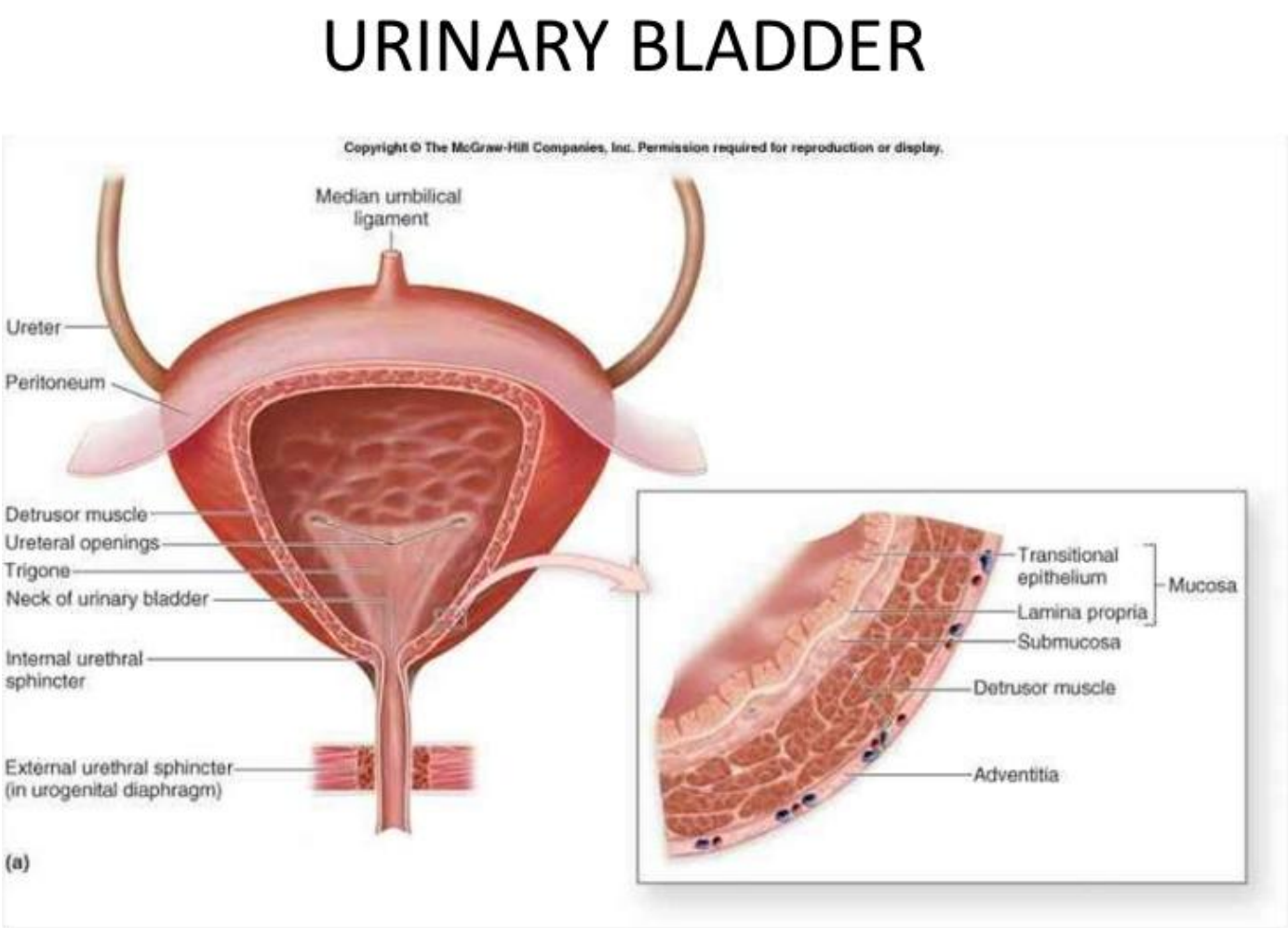
a) ***Mucosa***, which forms the folds, except of the trigone of the bladder;

b) ***Submucosa,*** absent at the level of the trigone;

c) ***Muscular coat*** which forms the *detrusor muscle* and *internal uretheral sphincter*;

d) ***Serous coat*** (visceral peritoneum).

Urinary bladder

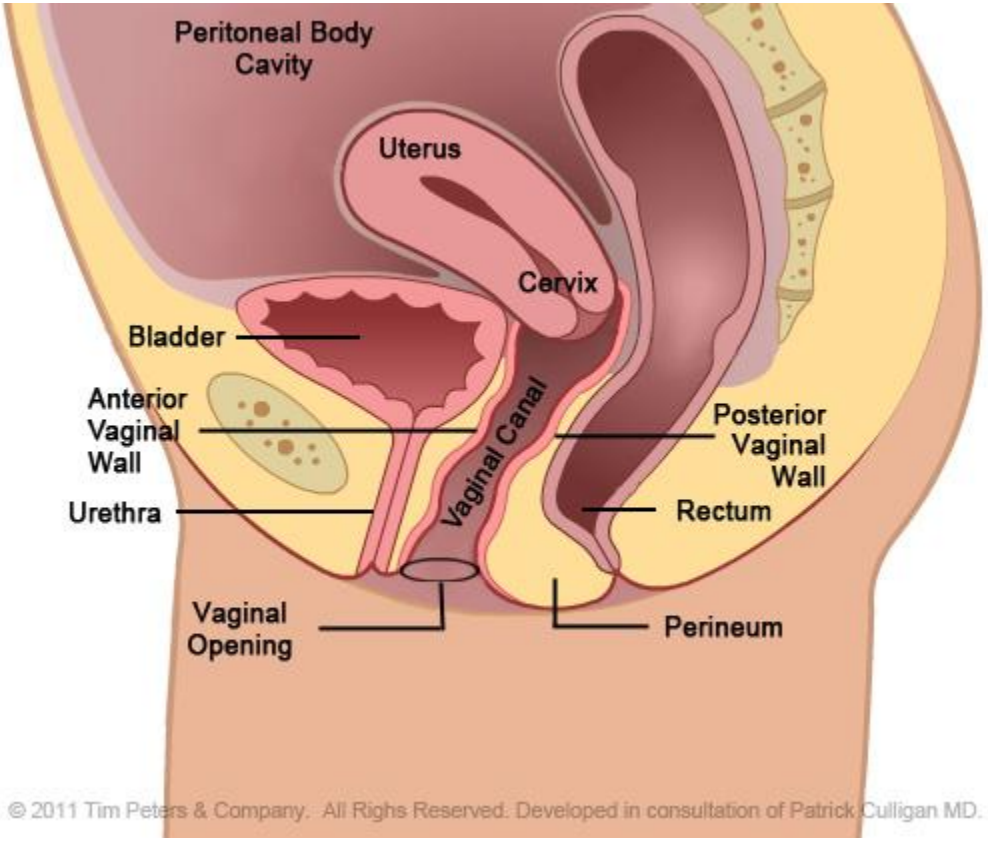


Female urethra

- It is a short fibromuscular tube (3 - 5 cm).
- It lies anterior to the vagina.
- It begins at the neck of the urinary bladder by the *internal urethral orifice* (or ostium).
- It opens into the vestibule of vagina by the *external urethral orifice* (or ostium).
- It has two parts:

1. ***intramural part*** (corresponds with the neck of bladder);
2. ***perineal part*** (which pierces the urogenital diaphragm of perineum).

Female urethra

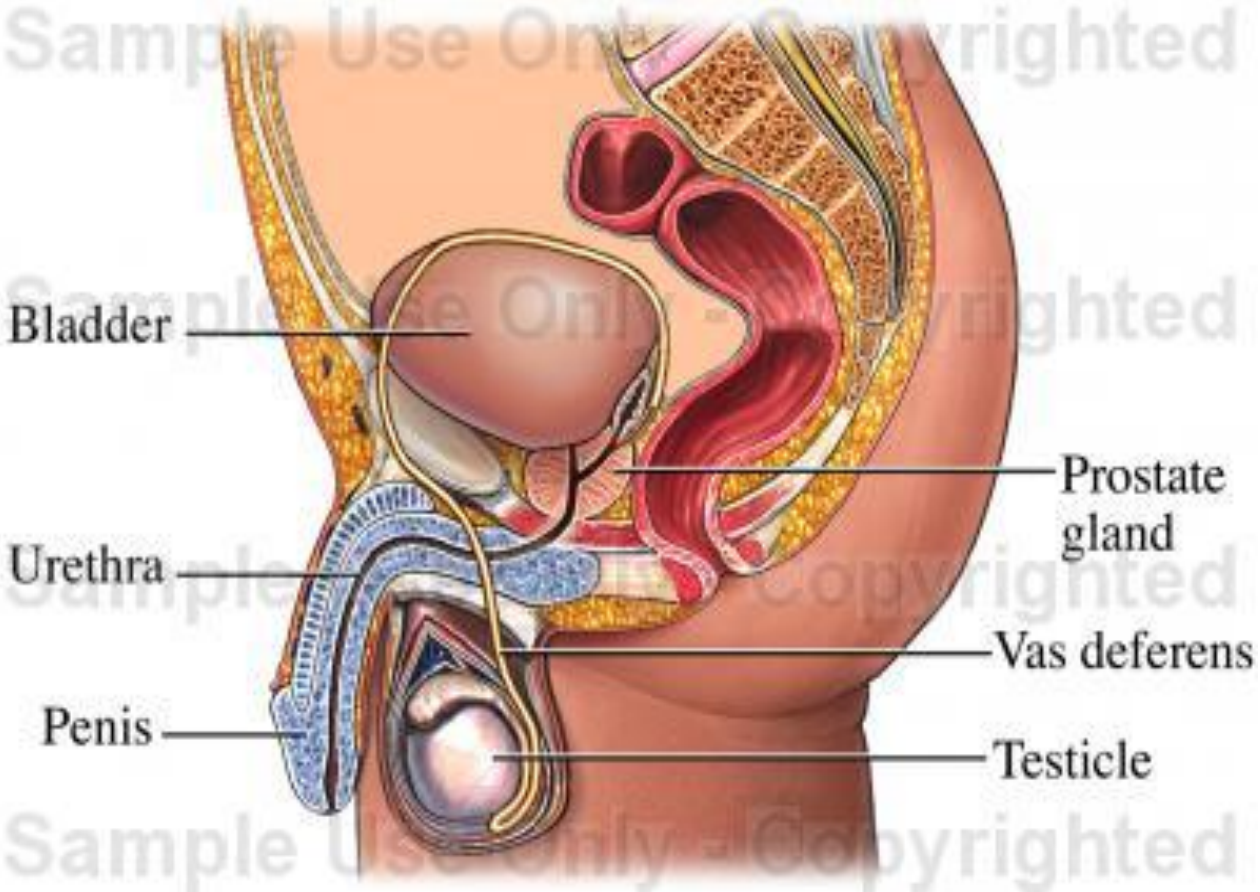


Male urethra

- It is a fibromuscular tube that begins at the neck of the urinary bladder (*internal urethral orifice*) and ends at the level of the glands penis (*external urethral orifice*).
- It is significantly longer in males than females (20 cm).
- It consists of four parts:

1. ***preprostatic*** (or ***intramural***) ***part*** (0,5 cm);
2. ***prostatic part*** (3 cm);
3. ***membranous part*** (1 cm);
4. ***spongy part*** (16 cm).

Male urethra



Urethra

- It is a passageway for urine.
- It serves an additional purpose in men, as it is also utilized as a passageway for semen during ejaculation.

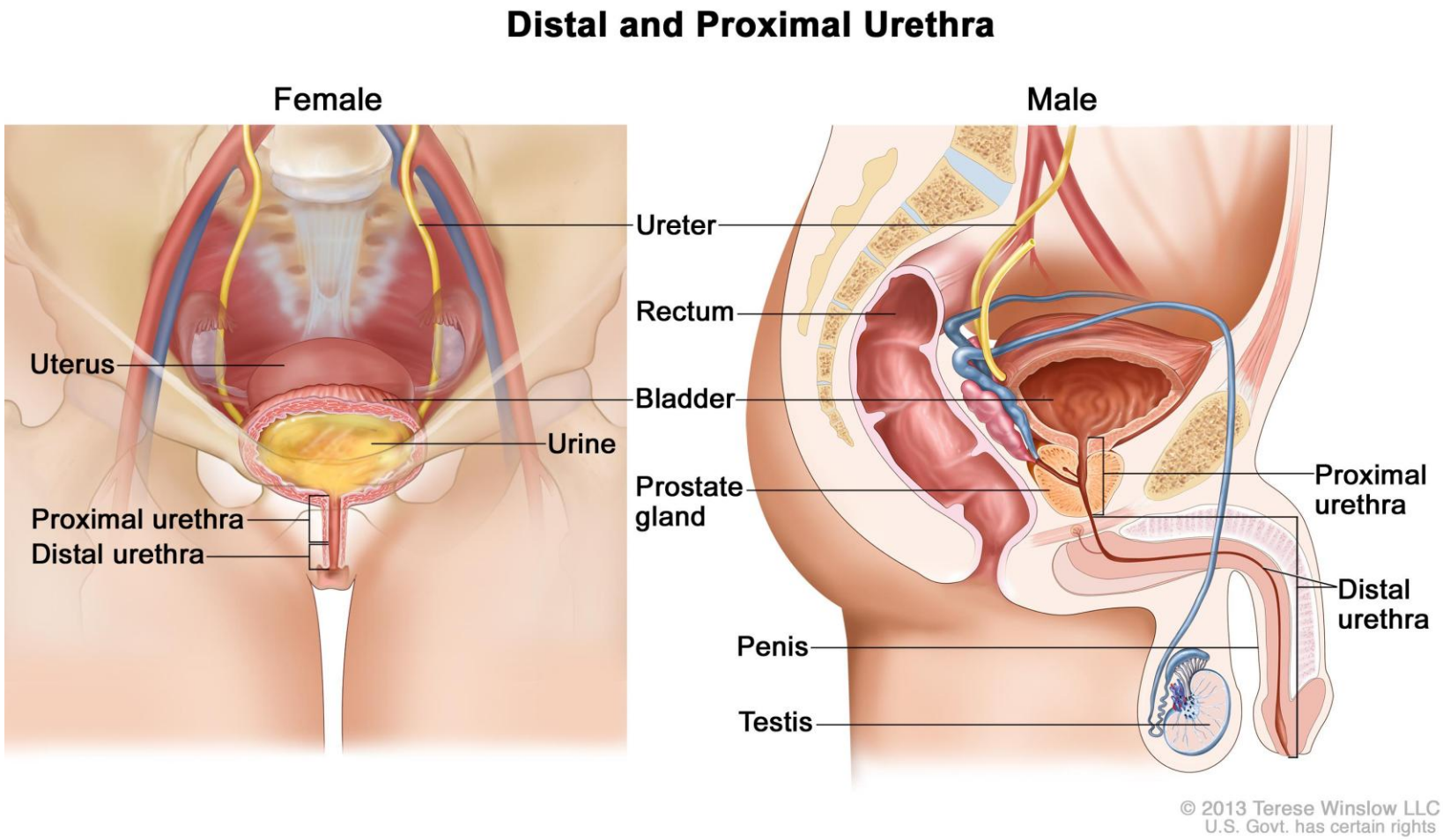
Male urethra:

1. anterior urethra;
2. posterior urethra.

Male urethra:

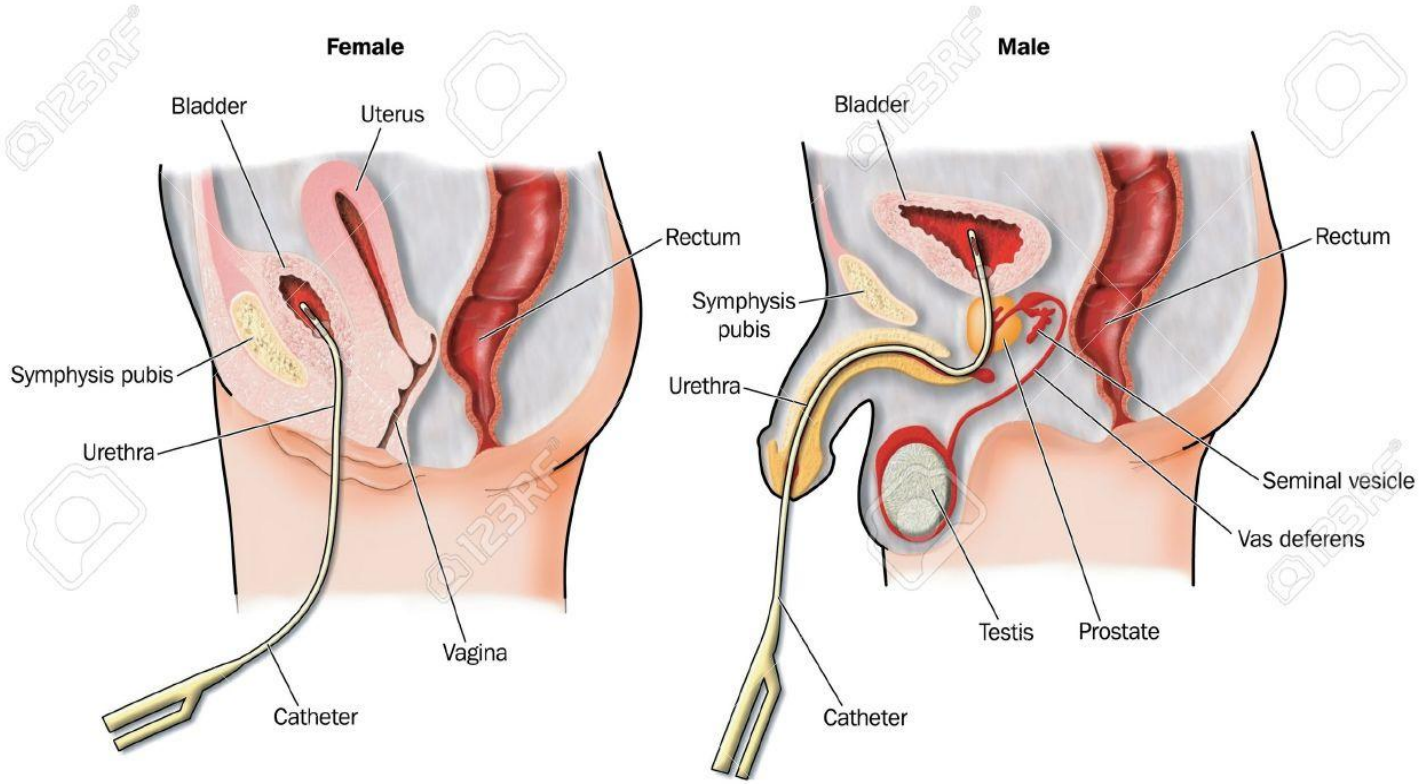
1. fixed part (pelvic part):
2. mobile part (penile part).

Urethra, gender differences



Urethral catheterization

It is done to remove urine from a person who is unable to micturate.



Urinary system