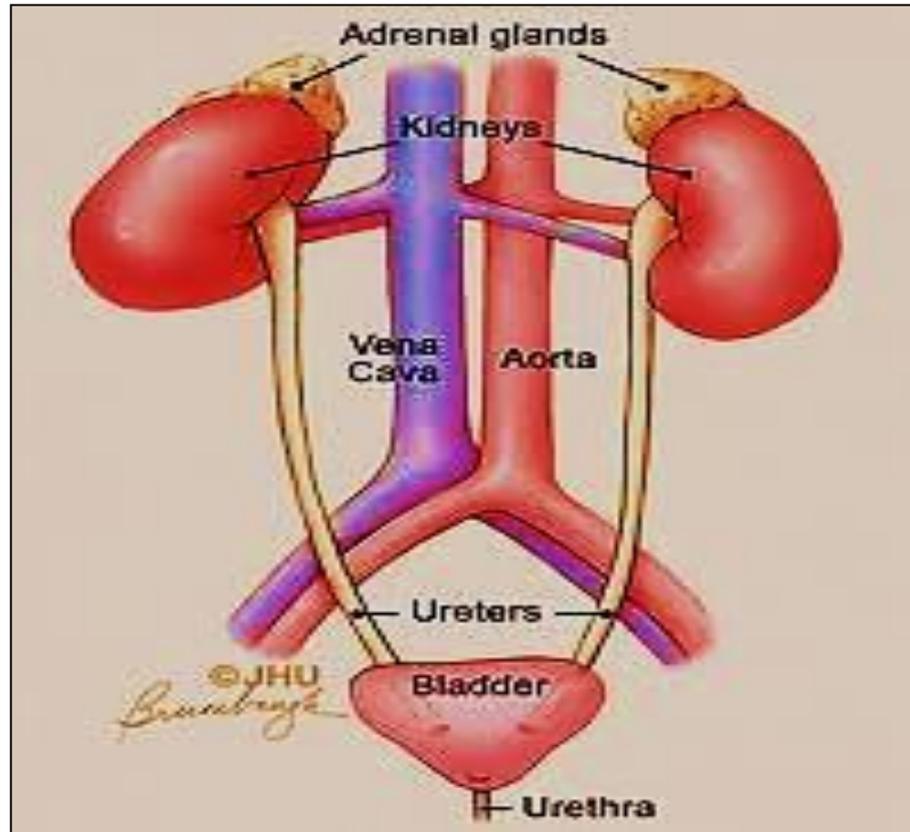


The Urinary System

The 3rd Year

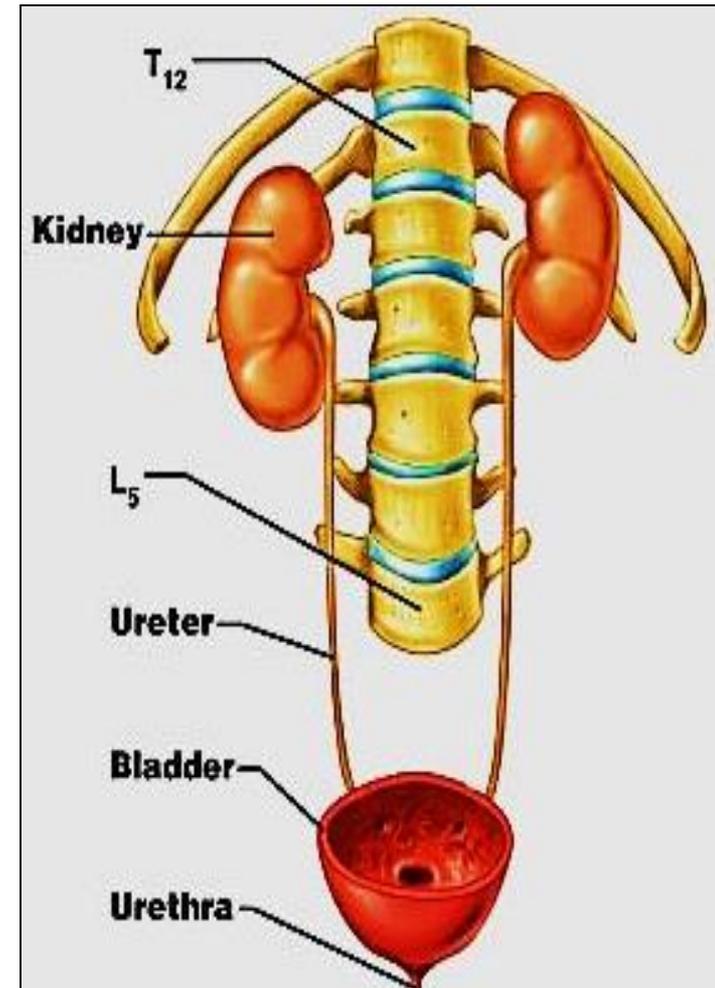


- The urinary system consists of:

- 2 kidneys (Filtrate blood)
- 2 ureters
- Urinary bladder
- Urethra

- Function:

- Removing waste & water from body
- Reabsorption of vital nutrients
- Maintain acid /base balance
- Help in control blood pressure
- Help in produce red blood cells (EPO Hormone)
- Produce Calcitriol (Vit. D) regulate Ca^+ → healthy bones



Kidneys

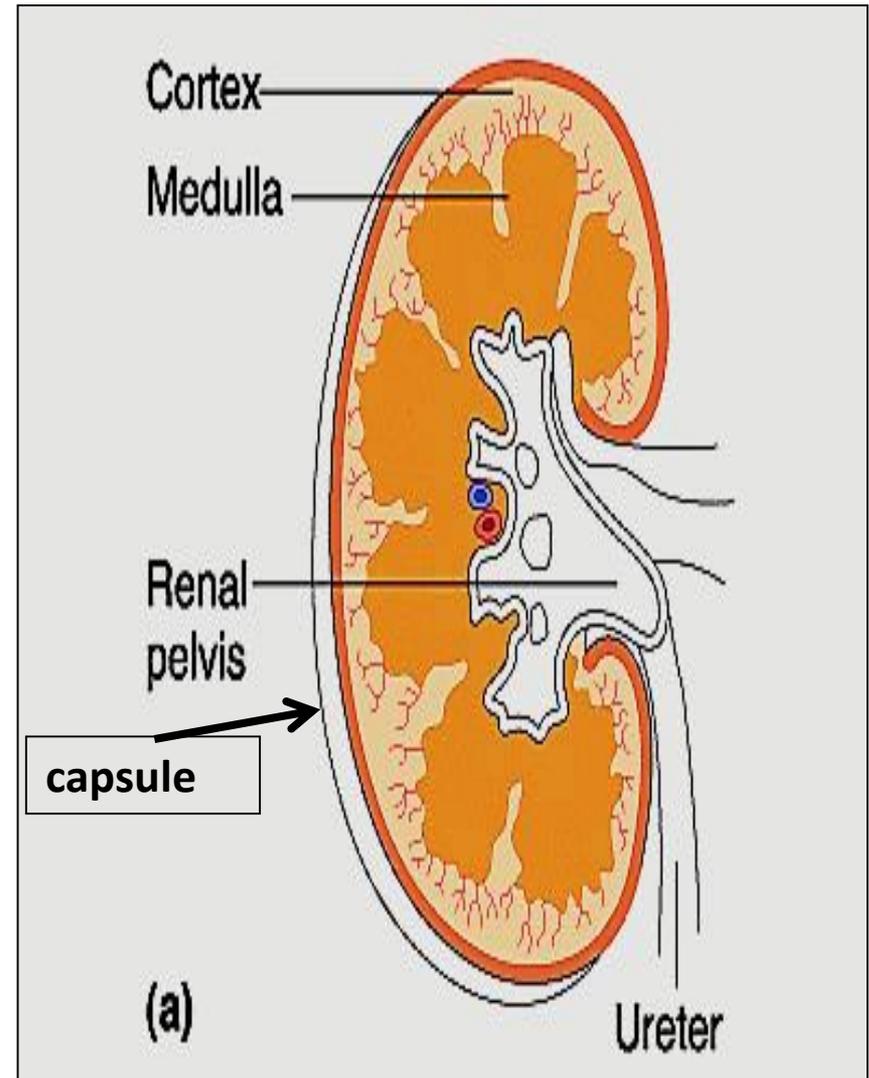
structure of the Kidney:

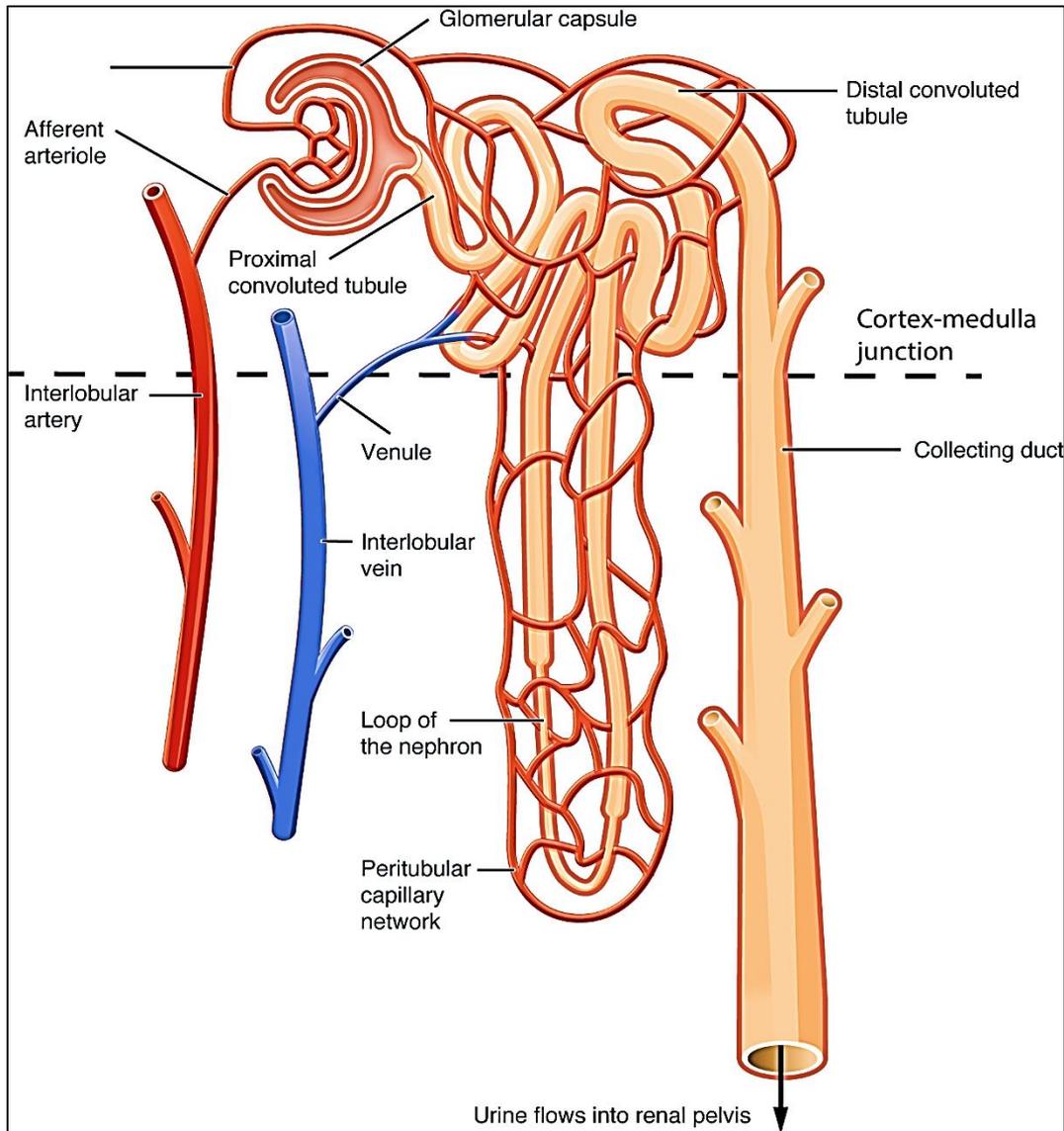
1. **Stroma** : capsule

2. **Parenchyma**:

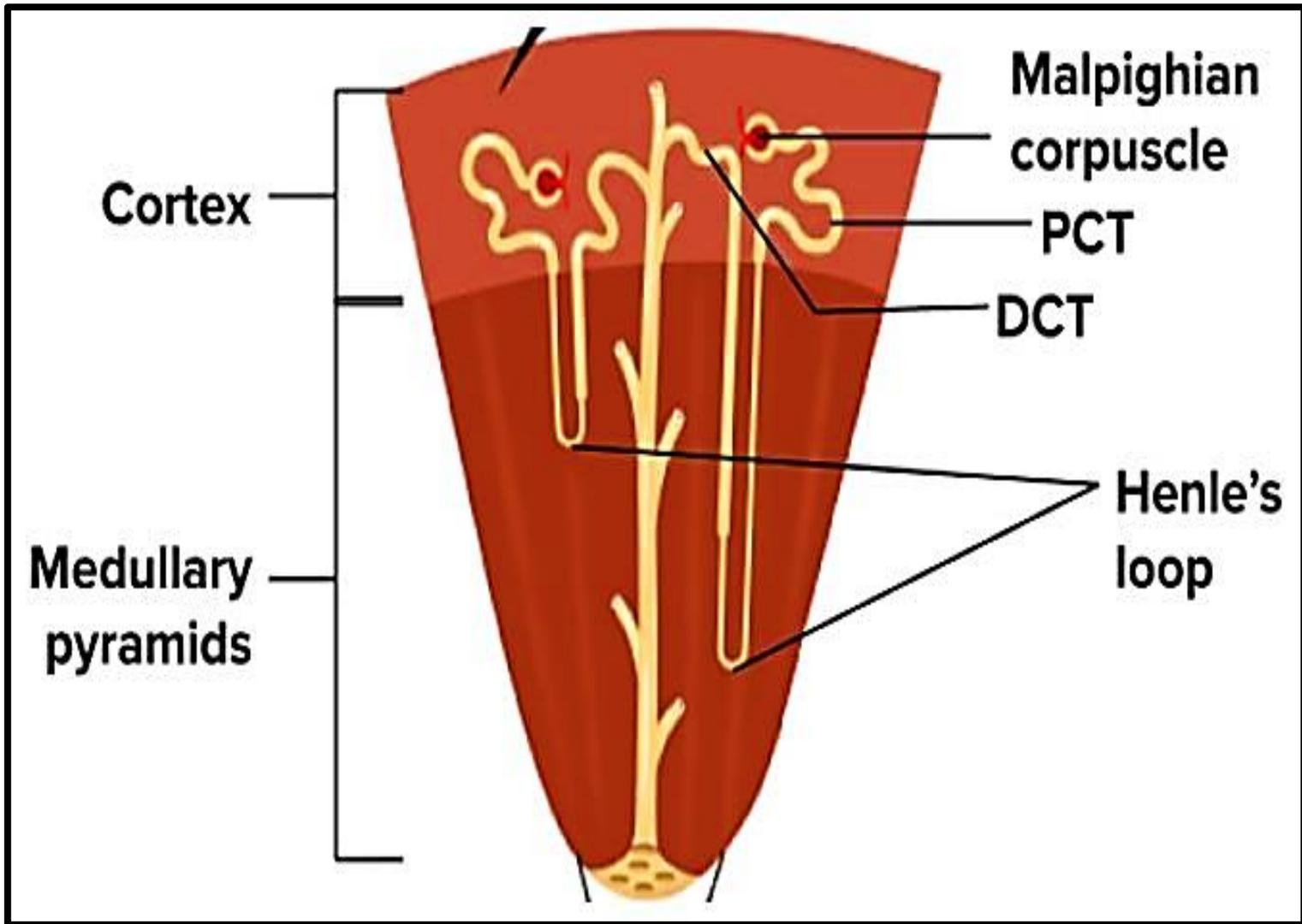
a. Cortex (outer part)

b. Medulla (inner part)

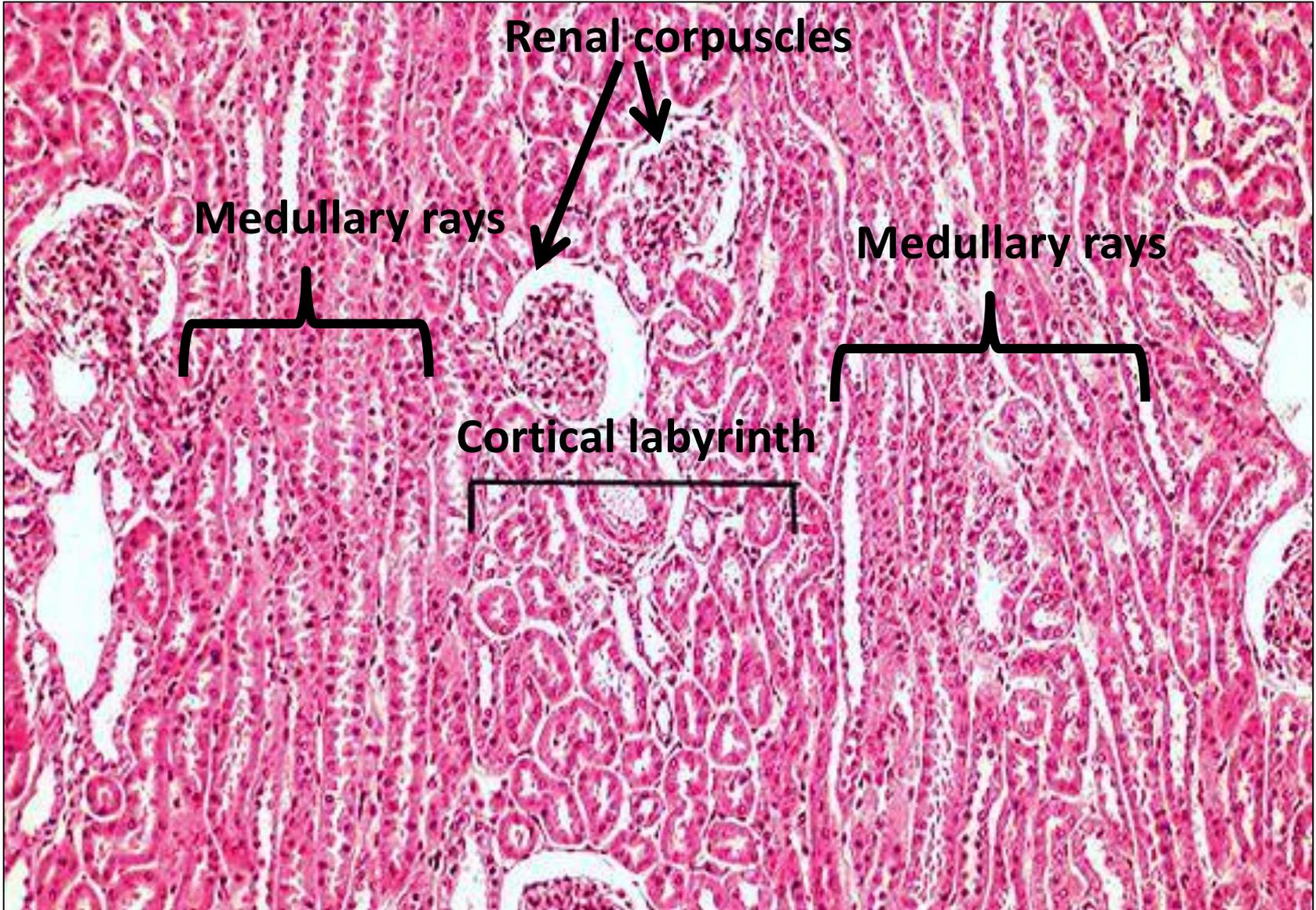




- Nephron is the microscopic structural and functional unit of the kidney that perform filtration of blood



Section in the kidney



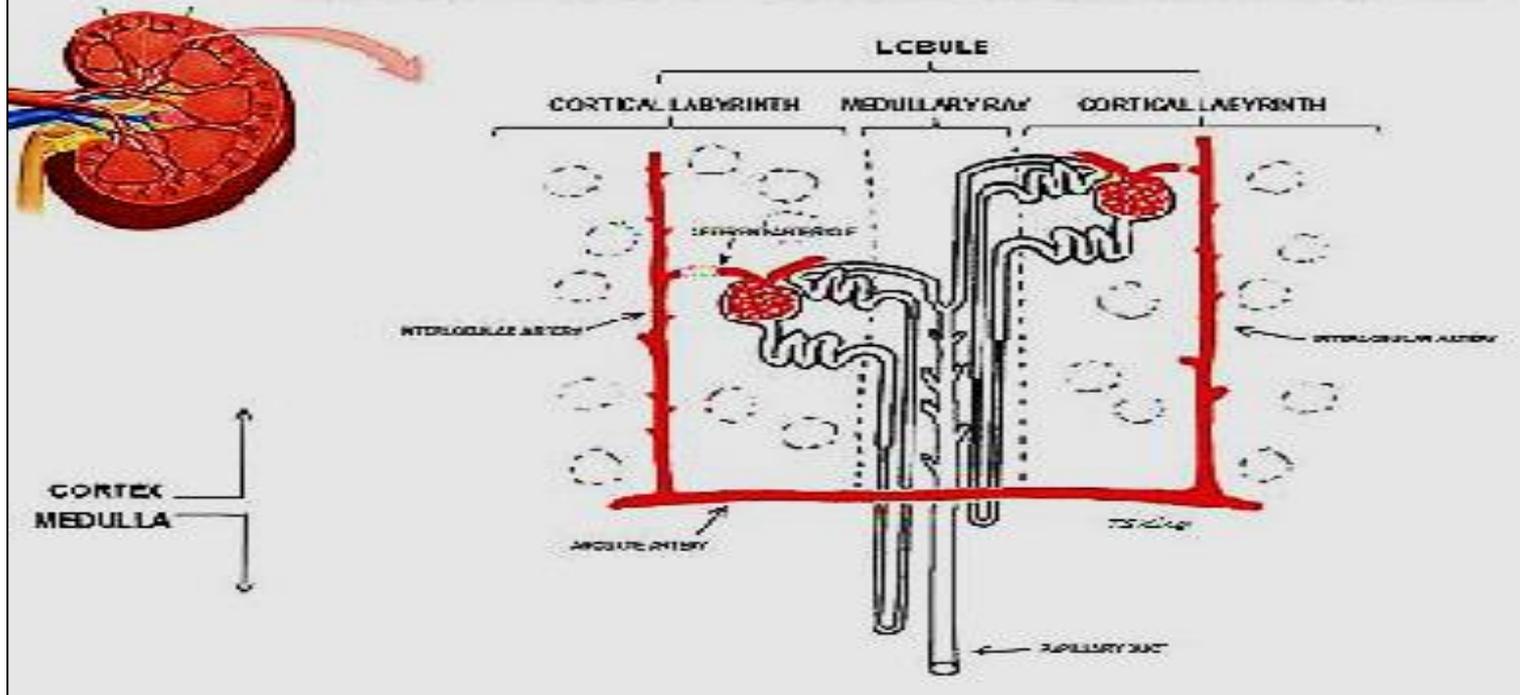
Cortex: contains

Cortical labyrinth + medullary rays + renal columns

- **Cortical labyrinth**: contains renal corpuscles and convoluted tubules.
- **Medullary rays**: are regions where parallel arrays of straight portions of **loop of Henle's + collecting ducts** travel perpendicular with the capsule (extend from the cortex to the medulla).
- A band of cortical labyrinth separates the medullary rays. Each medullary ray with 1/2 of the adjacent cortical labyrinth on either side is a **lobule**.

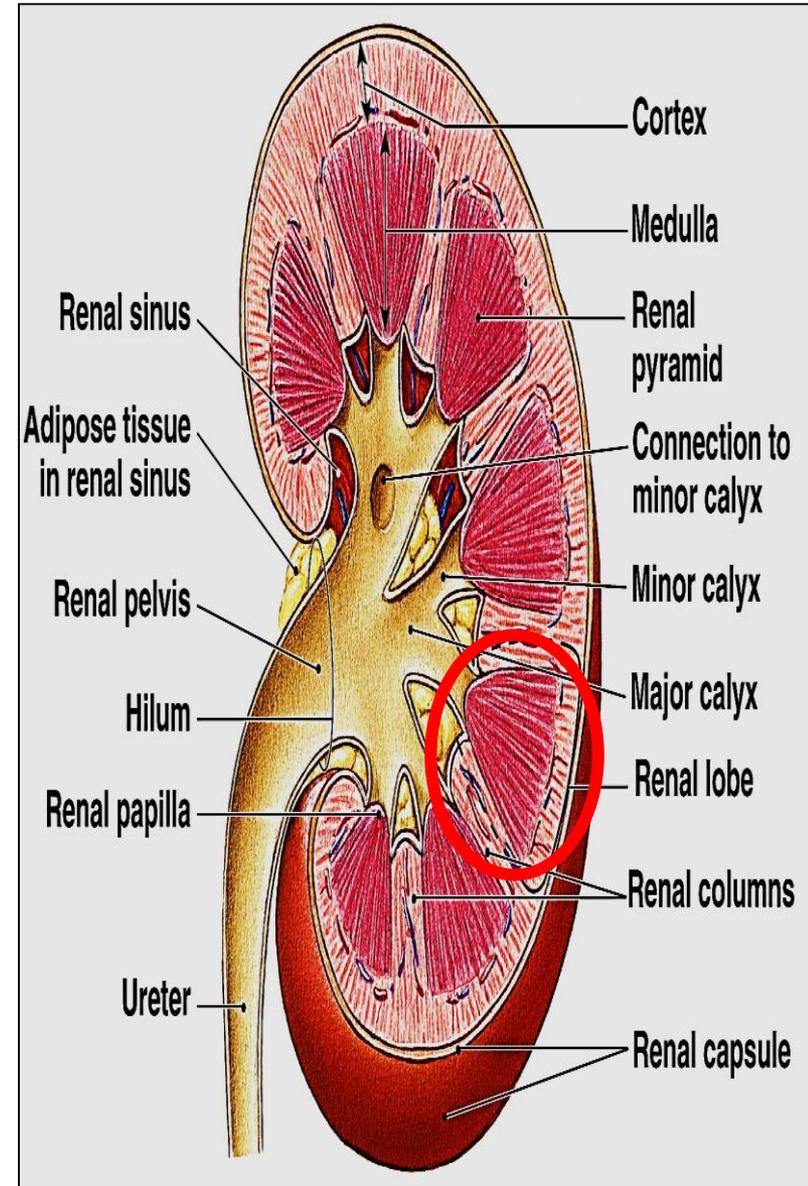
RENAL LOBULE

$\frac{1}{2}$ CORTICAL LABYRINTH + MEDULLARY RAY + $\frac{1}{2}$ CORTICAL LABYRINTH

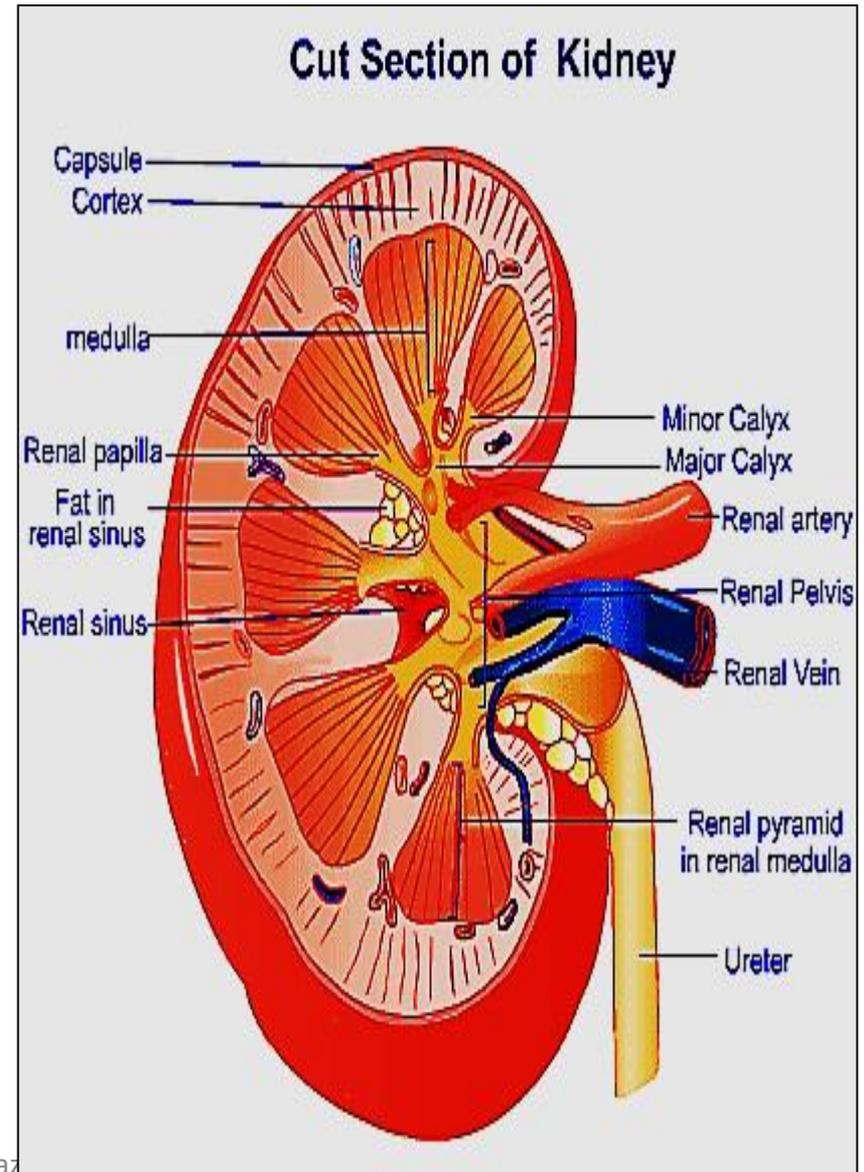


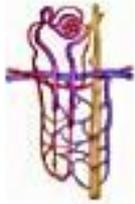
- Renal lobule defined within **cortex**
- The tissue between 2 interlobular arteries is defined as lobule.
- Interlobular arteries bisect Labyrinth.
- Thus a lobule consists of $\frac{1}{2}$ of labyrinth on one side of medullary ray & $\frac{1}{2}$ of labyrinth on the other side . Nephrons of that lobule drain in a single collecting duct

- **The medulla** : consists of 8- 15 conical structures called **renal pyramids**
- The renal pyramids separated by cortical **C.T.** extensions called **renal columns (Bertin columns)** contain BV & renal tubules
- Each medullary pyramid + the cortical tissue at its base & along its sides form a **renal lobe**



- The apex of each pyramid is called **renal papillae**
- The renal papillae projects into a **minor calyx**
- 3-4 minor calyces join to form a **major calyx**, which empty into **renal pelvis**





URINARY SYSTEM



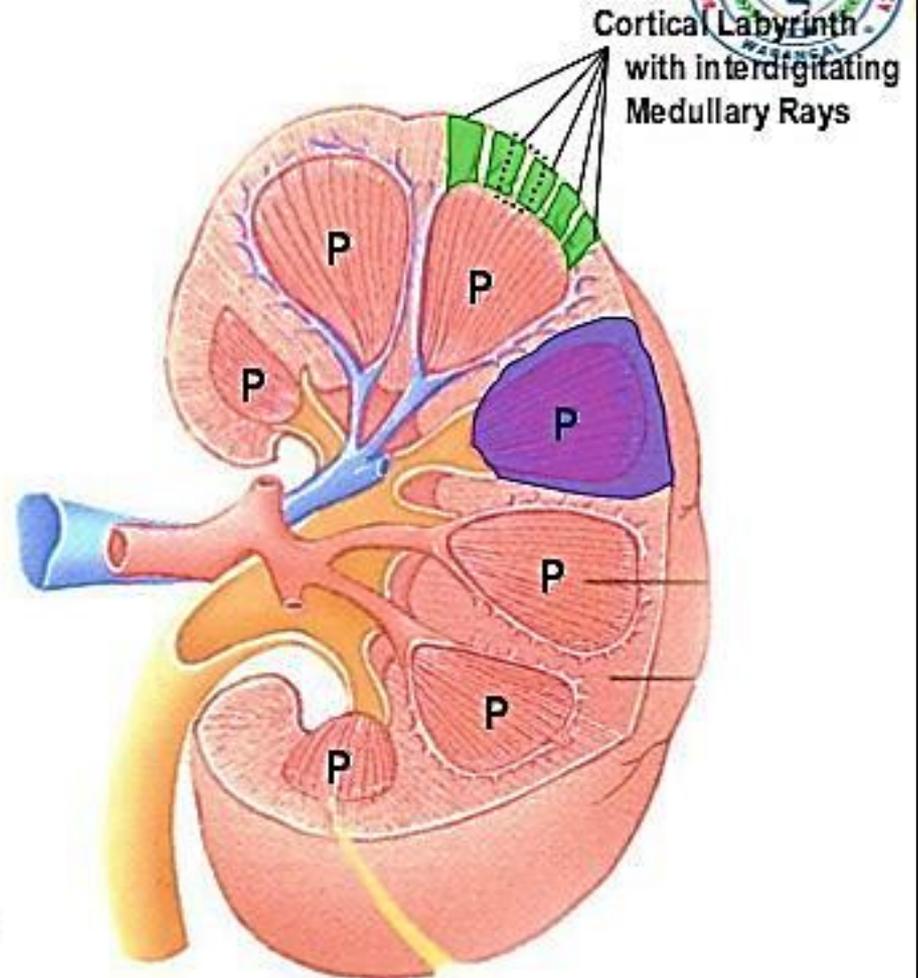
● KIDNEY (ORGANIZATION)

RENAL LOBE

- a single pyramid with its associated overlying cortex

RENAL LOBULE

- defined within cortex and involves a single medullary ray (central axis of lobule) with adjacent adjacent cortical labyrinth
- defined as a functional unit that consists of a collecting duct and all the nephrons that it drains



sudheerkumar kamarapu

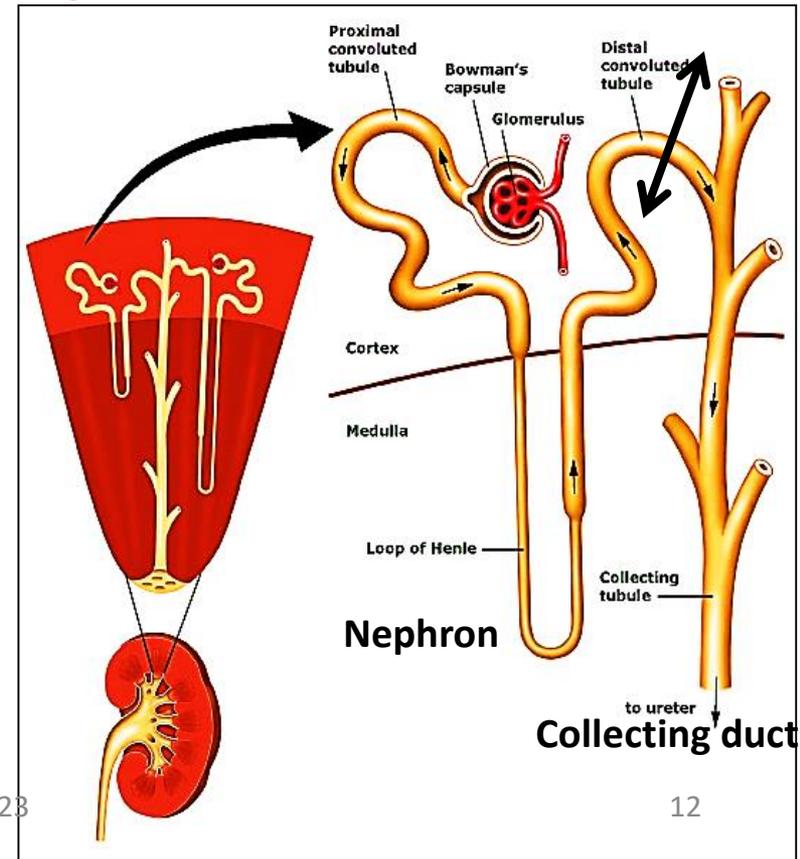
17

The uriniferous tubule

Consists of 2 parts: nephron + collecting duct

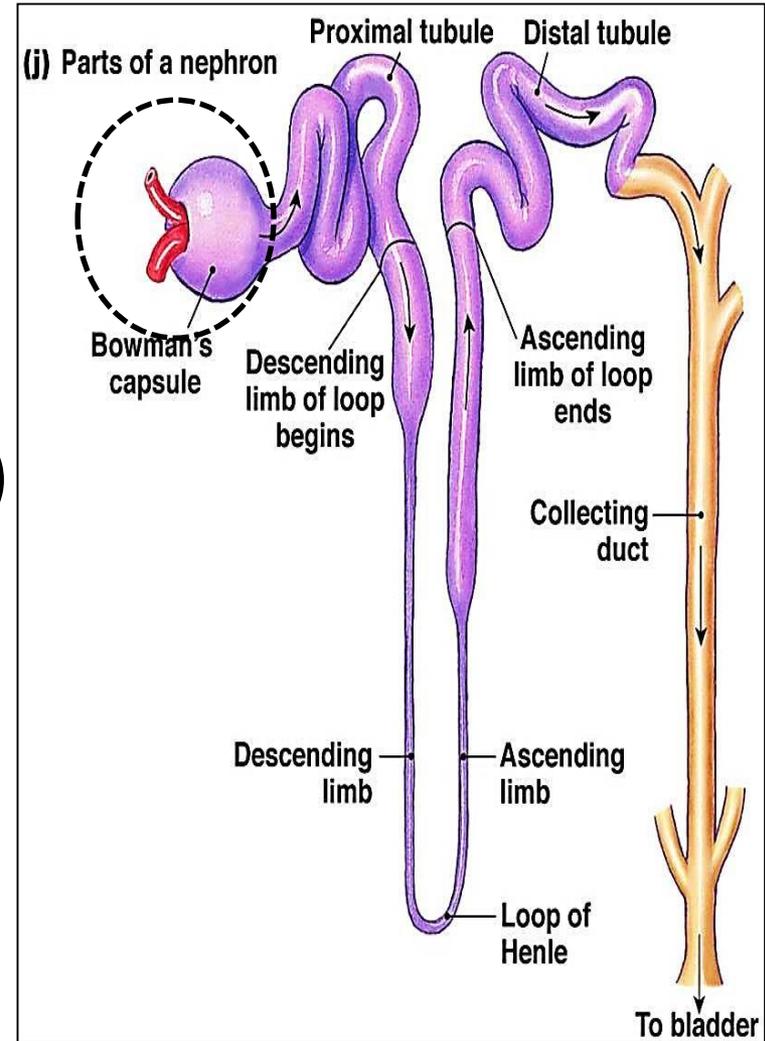
1- Nephron : the structural & functional unit of the kidney that filter blood → which **produce urine**

2- Collecting duct: concentrate & carries urine → to minor calyx



A- The nephron

- Each kidney contains 1- 1.4 million nephrons
- Each nephron consists of:
 - 1- **Renal (malpighian) corpuscle**
 - 2- **Proximal convoluted tubule (PCT)**
 - 3- **Loop of Henle**
 - 4- **Distal convoluted tubule (DCT)**

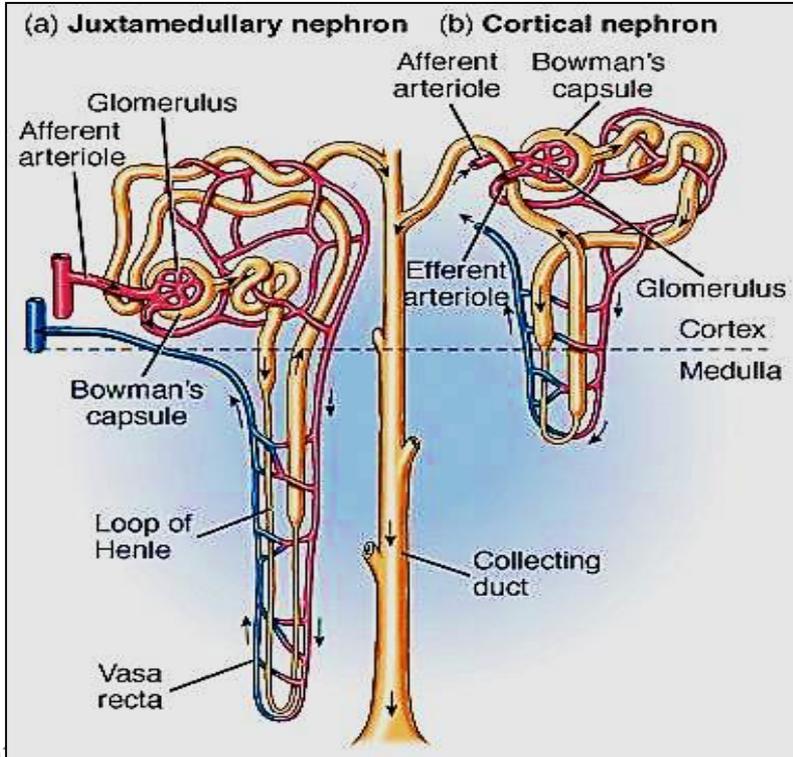


- Classification of nephrons:

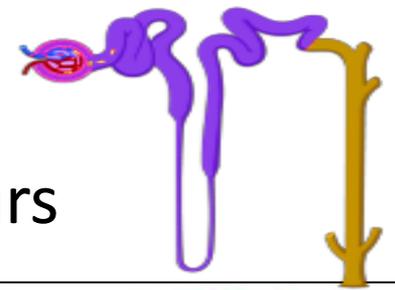
- Cortical nephrons: 85%, short loop of Henle, extend close to cortico-medullary junction

- Juxta-medullary nephron: has long Loop of Henle, extend deep in the medulla

They are responsible for setting up medullary osmotic gradient
→ production of concentrated hypertonic urine

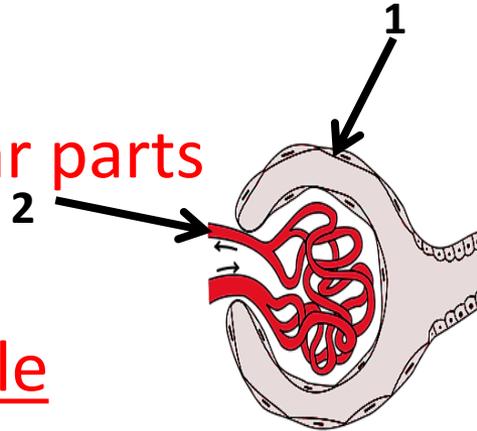


Renal (Malpighian) corpuscle



- Renal corpuscle is where blood filtration occurs
- it has 2 parts:

urinary & vascular parts



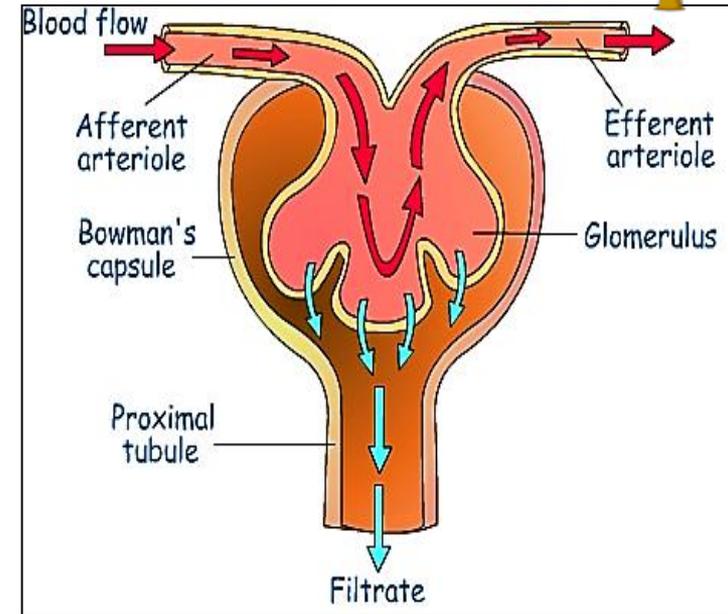
1 - Bowman's capsule

Double walled chamber has:

1. Inner/ visceral layer (podocytes)
2. Outer /parietal layer (simple squamous epithelium)

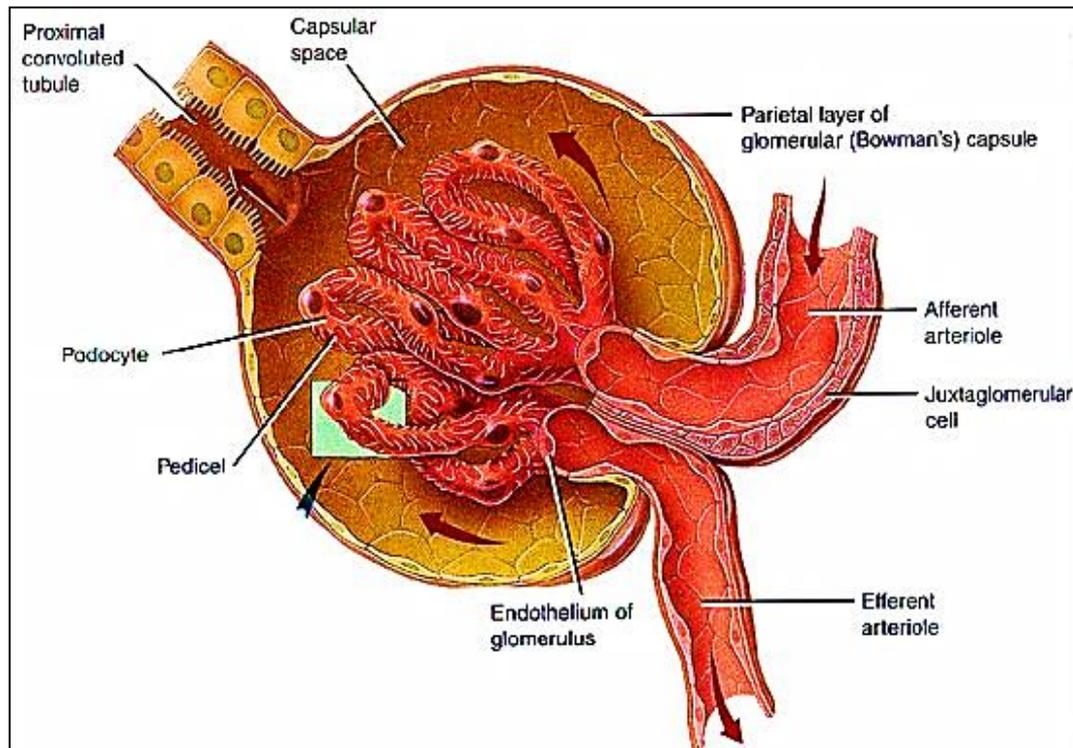
2- Glomerulus :

Tuft of capillaries, inside the capsule, supplied by afferent arteriole & drained by efferent arteriole

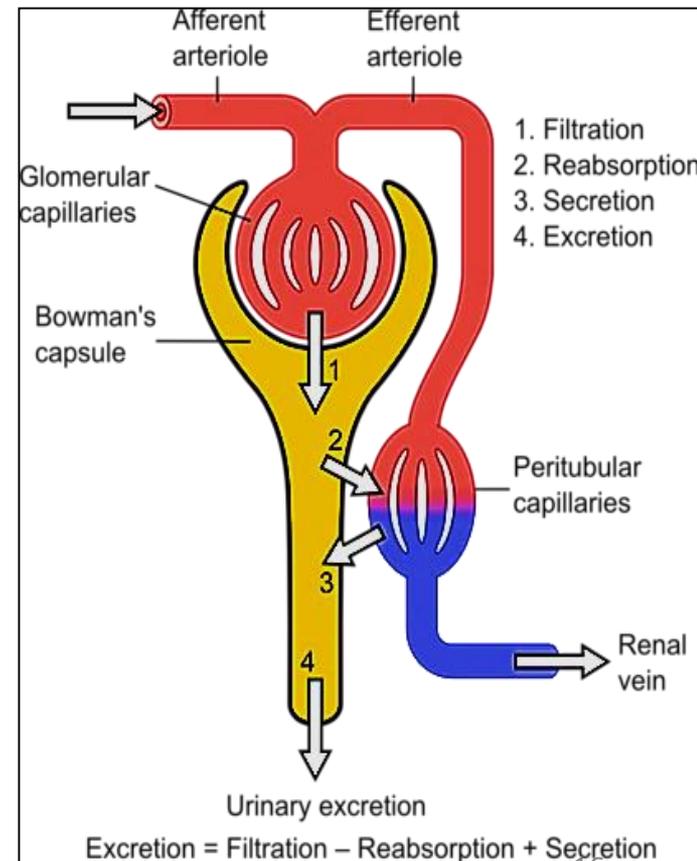


Glomerulus

- The prefiltered blood enter the glomerulus through afferent a & filtered blood exit through efferent a.
- The afferent arteriole has a **thicker media**, and **larger diameter** than the efferent one to create a high glomerular pressure → large quantities of filtrate

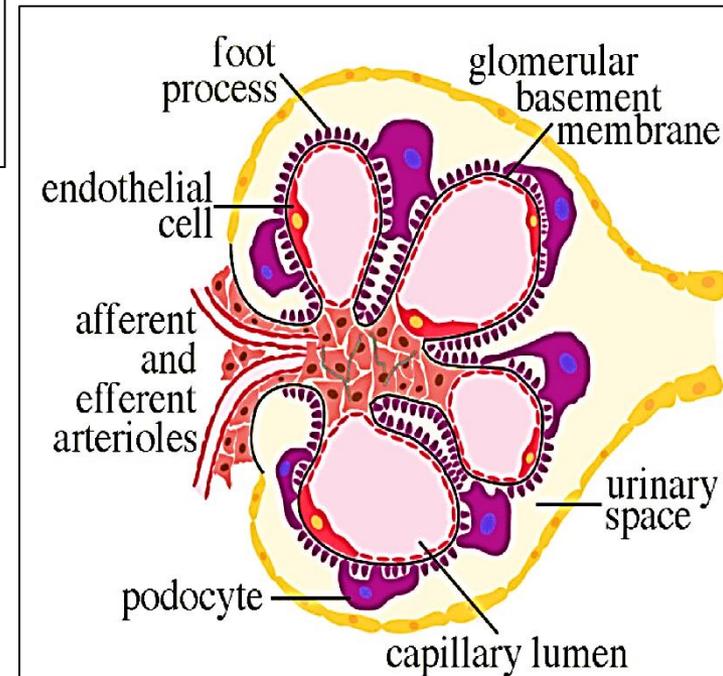
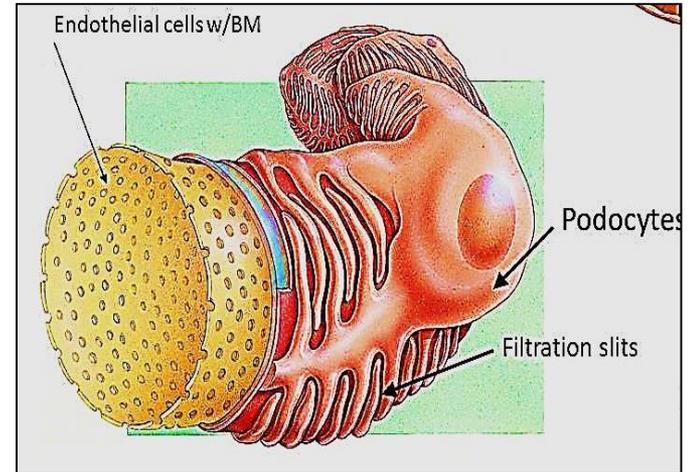


Prof Dr. Hala El-mazar 2023



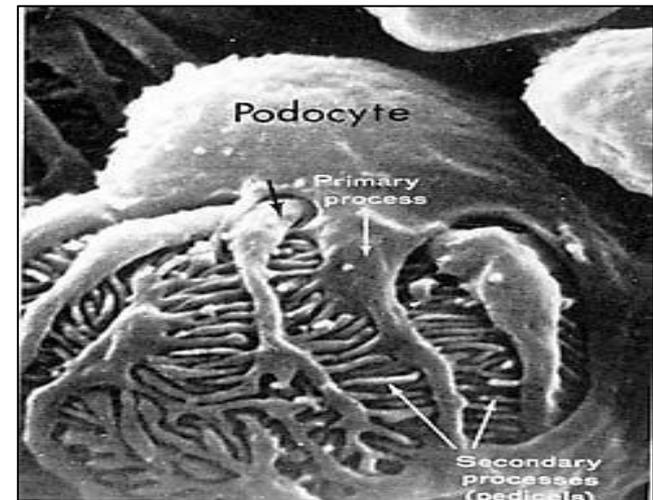
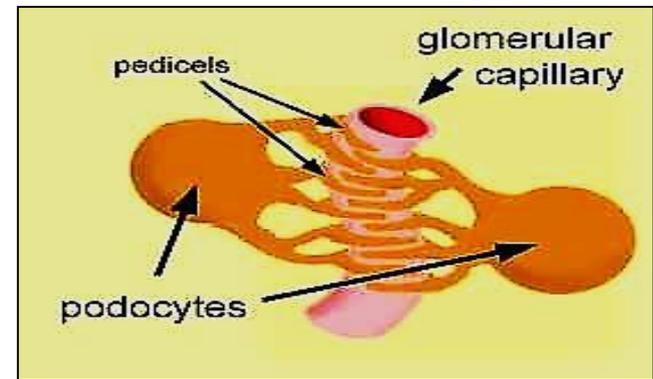
The wall of the glomerular capillaries is lined with fenestrated endothelial cells (70 – 100 nm), restrict the passage of blood cells & proteins with continuous basement membrane formed of type IV collagen (-ve charged) which repel portions (-ve charged) from escaping through (if Abs attack BM cause damage → **glomerulonephritis**

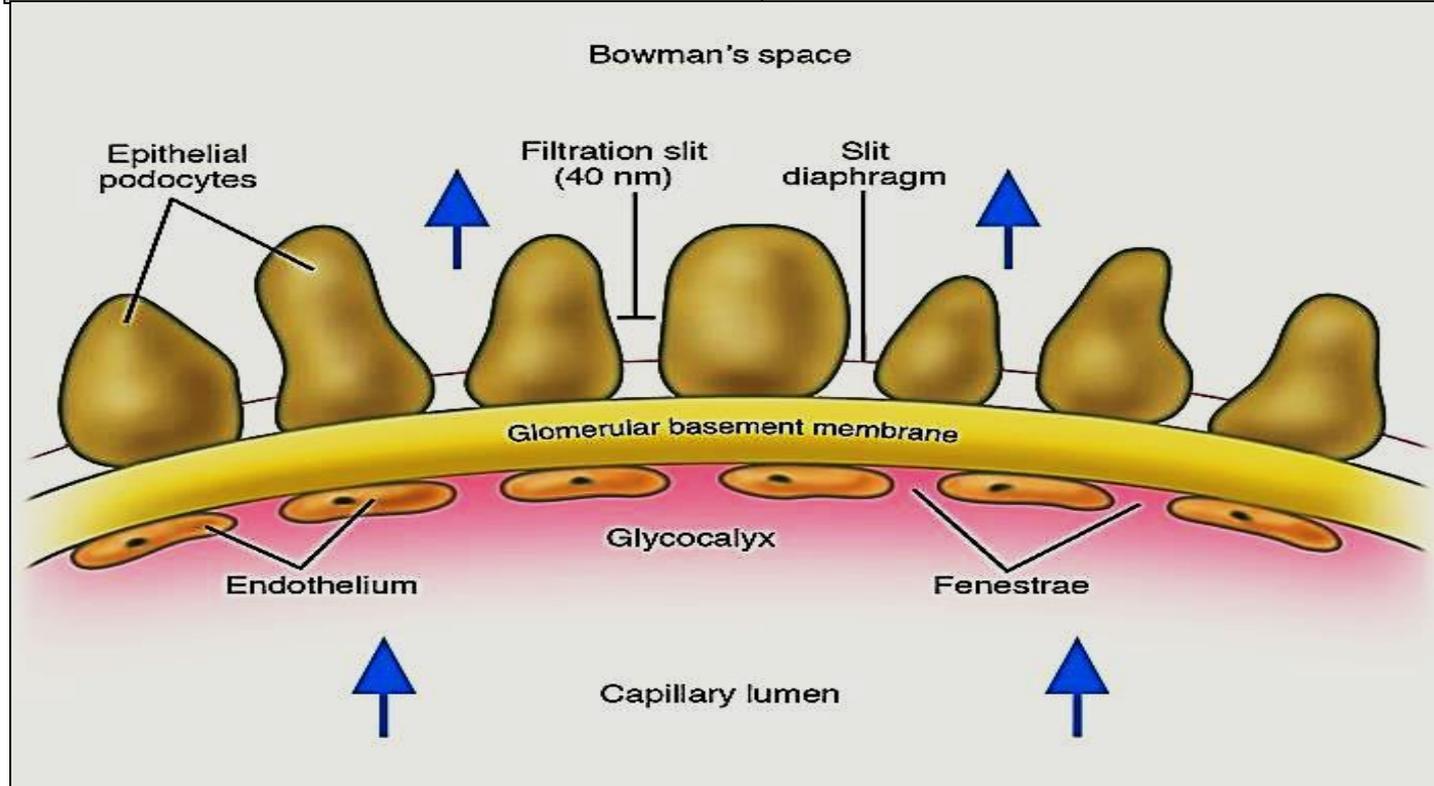
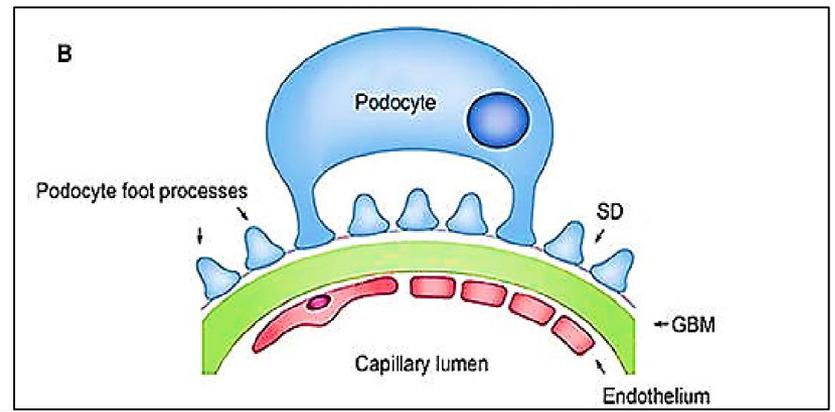
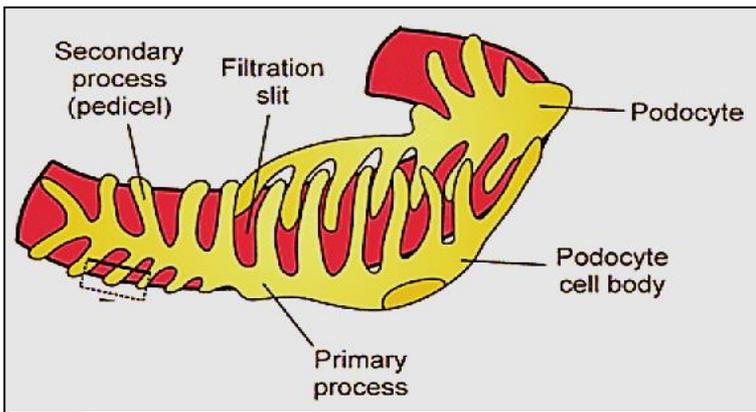
Bowman's capsule visceral layer is lined with special cells called **Podocytes**
Outer layer lined e simple squamous epithelium



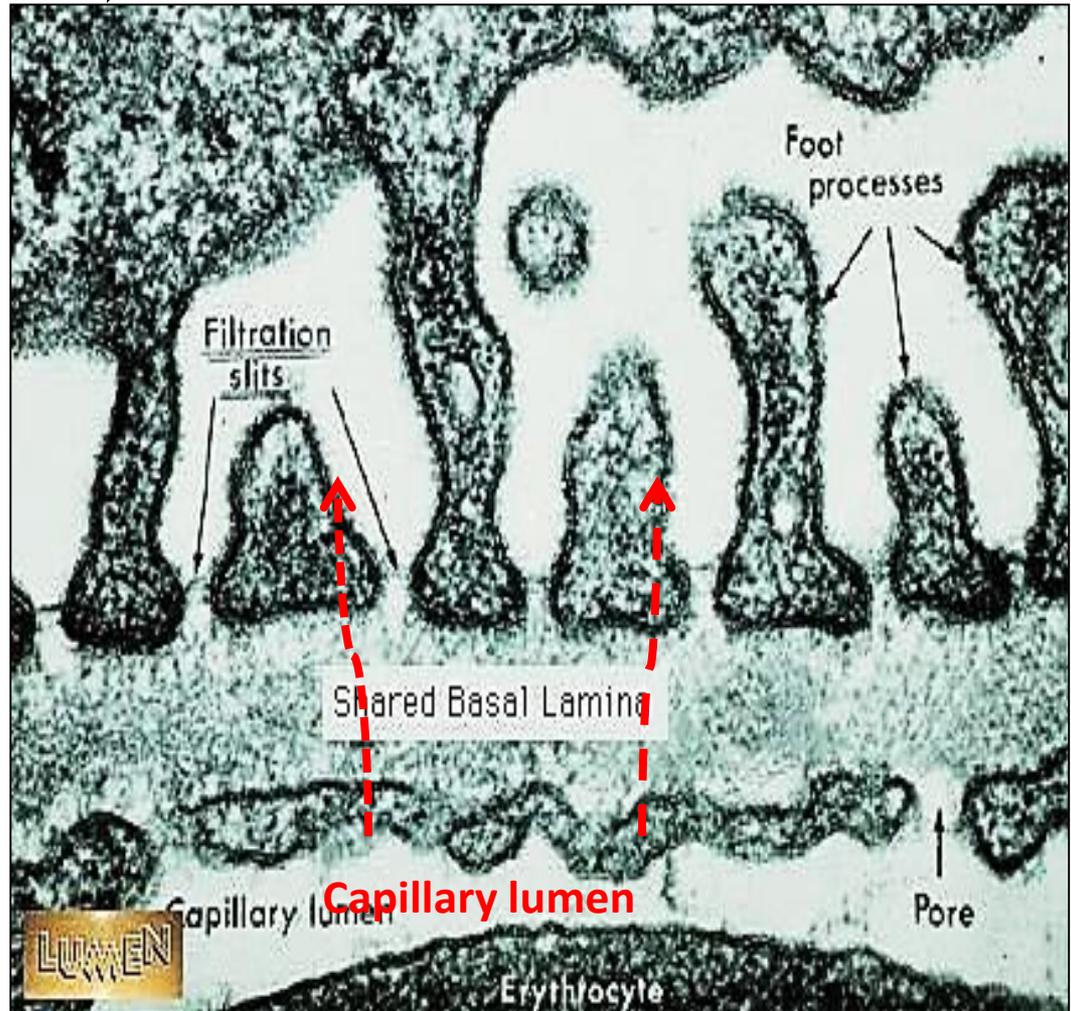
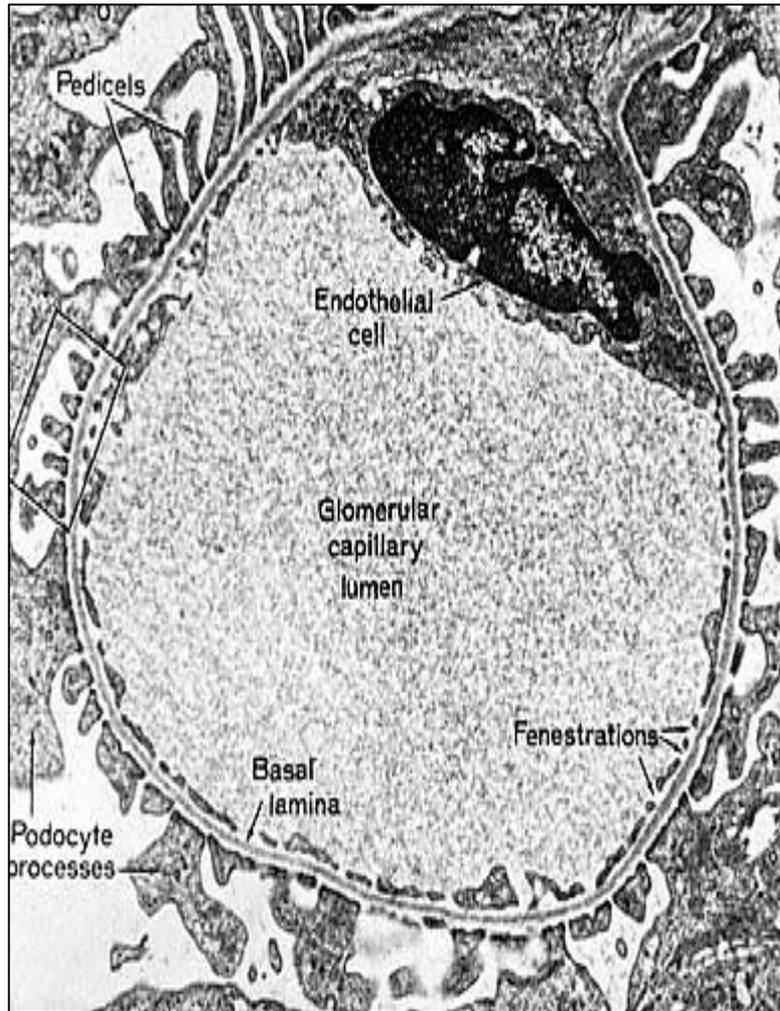
Podocytes

- They are flattened cells with several primary processes
- Each 1ry process send numerous 2ry process (**pedicles**)
- Encircle the underlying bl. capillary
- **2ry process interdigitate** with each other
- Forming minute spaces in-between called **filtration slits** closed by semipermeable **diaphragm (10- 40 nm)**
- they comprise the main filtration barrier in the glomerulus they also express vit D receptors

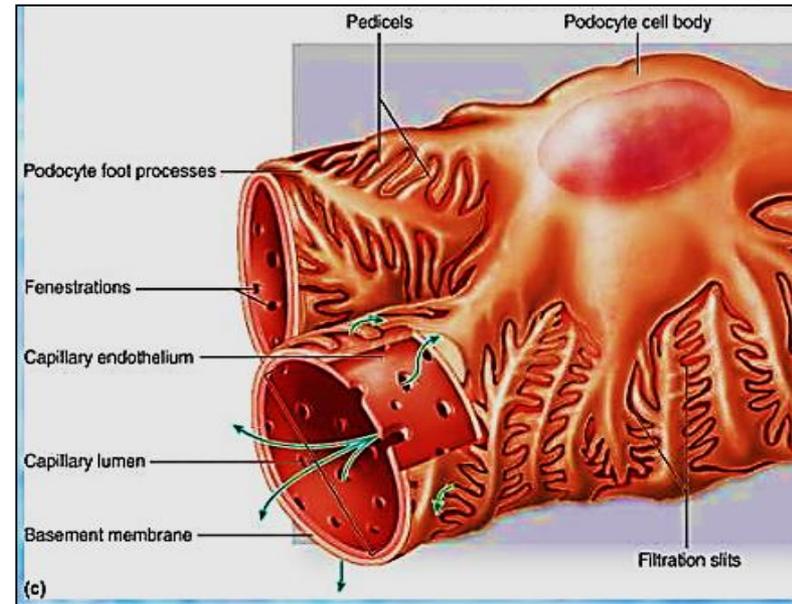




Filtration slits & slit diaphragm

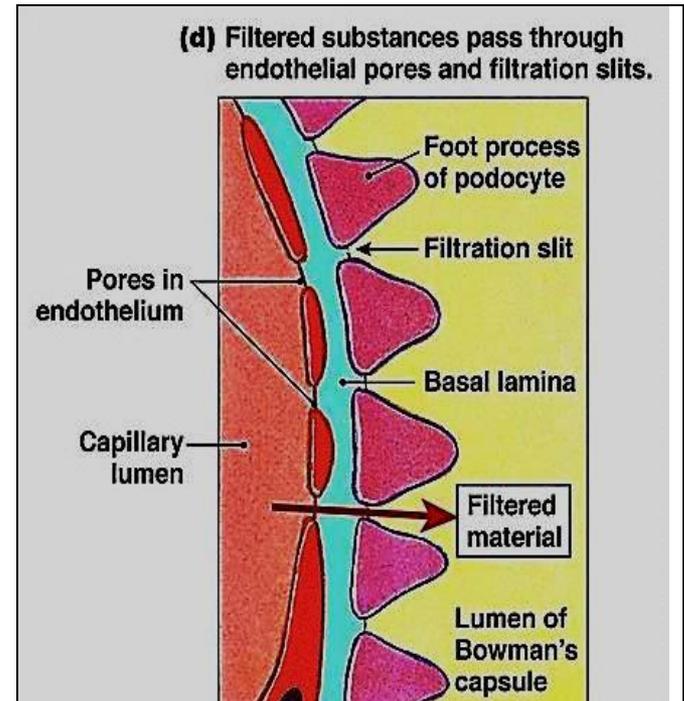


- The cytoplasm of Podocytes contains ↑free ribosomes, rER, Mitochondria , Golgi, **actin microfilaments** (contractility).



Function of podocyte:

- 1- formation of blood renal barrier
- 2- Renewal of glomerular basement membrane (GBM)

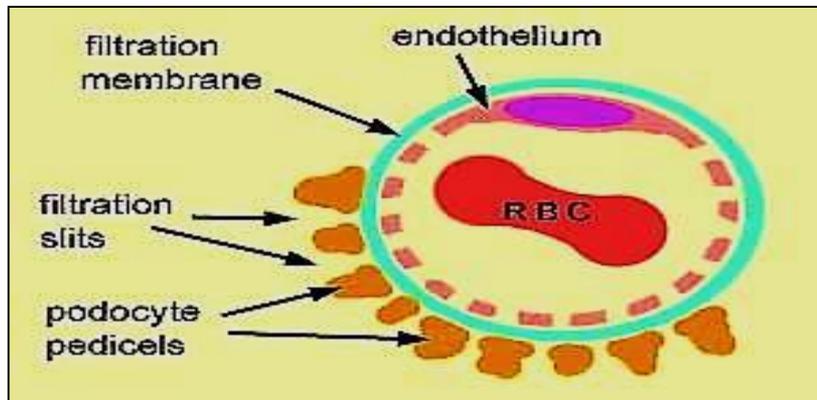


Blood Renal Barrier

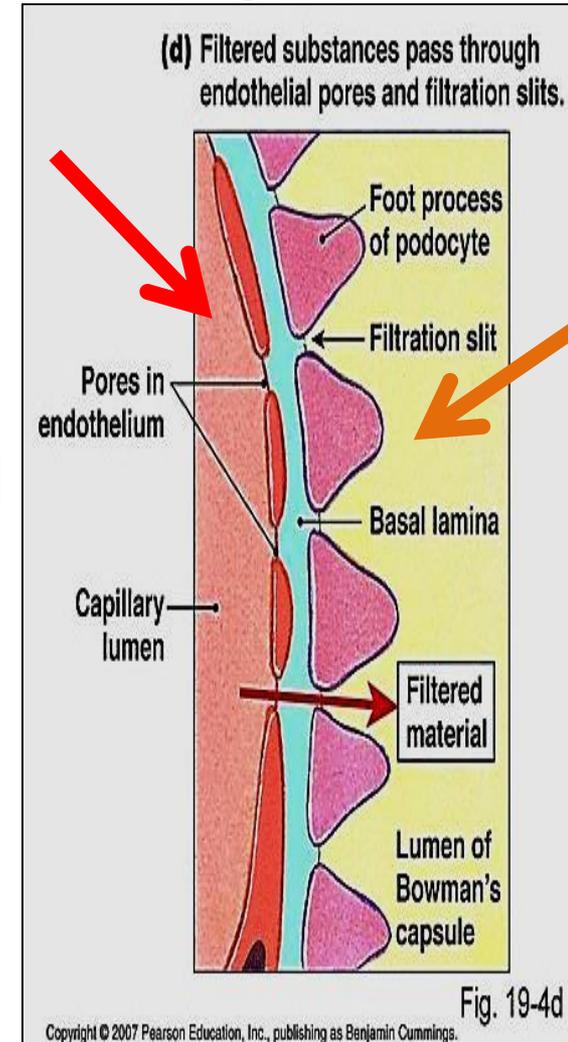
Barrier that separate blood inside glomerular capillaries from glomerular filtrate inside Bowman's space & through which filtration of blood occur

Formed of 3 layers:

- 1- Glomerular endothelium (fenestrated)
- 2- Basement m. (continuous & -ve charged)
- 3- Filtration slit diaphragms



023



Mesangial cells



- Specialized cells found around glomerular capillaries of the kidney

- They are 2 types:

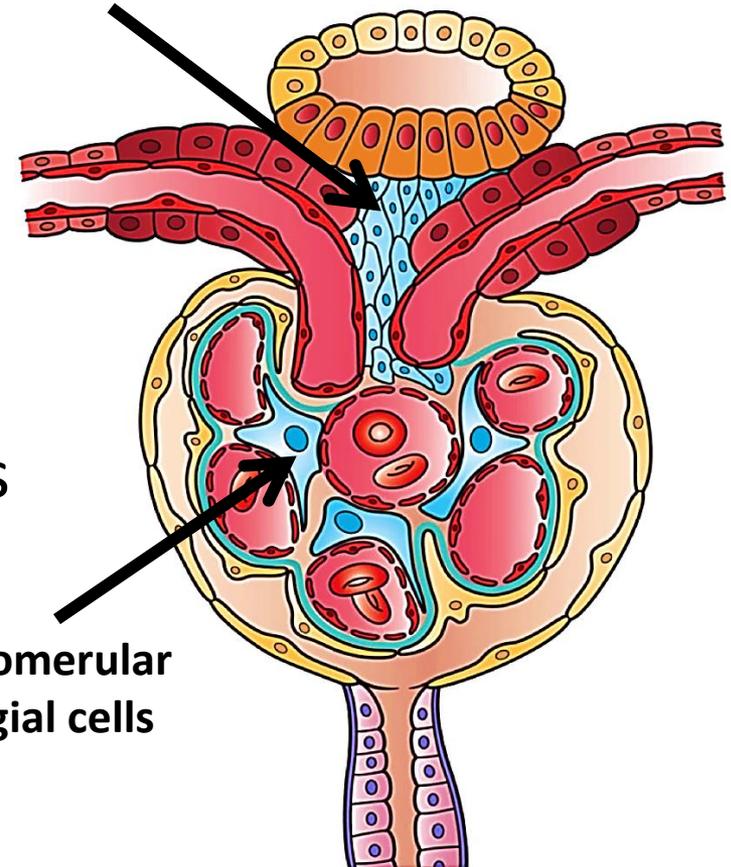
1- Intra -glomerular :

located along glomerular capillaries
within renal corpuscle

2- Extra-glomerular (Lacis cells) :

located at the vascular pole

Extra-glomerular mesangial cells



Intra-glomerular mesangial cells

Intra-glomerular mesangial cells:

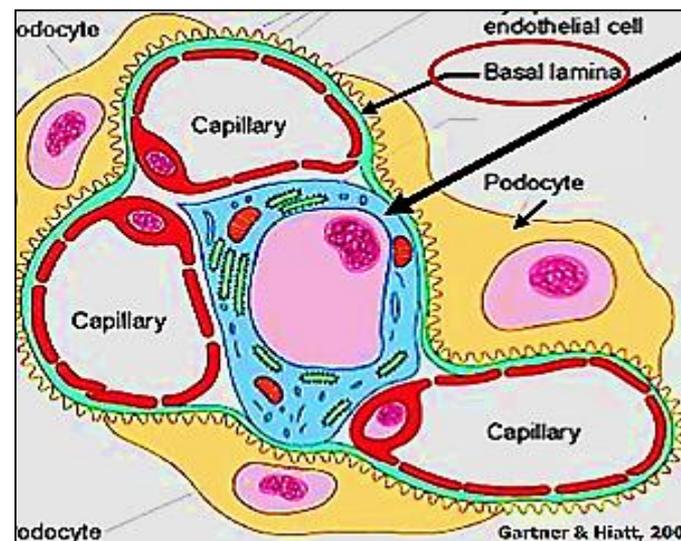
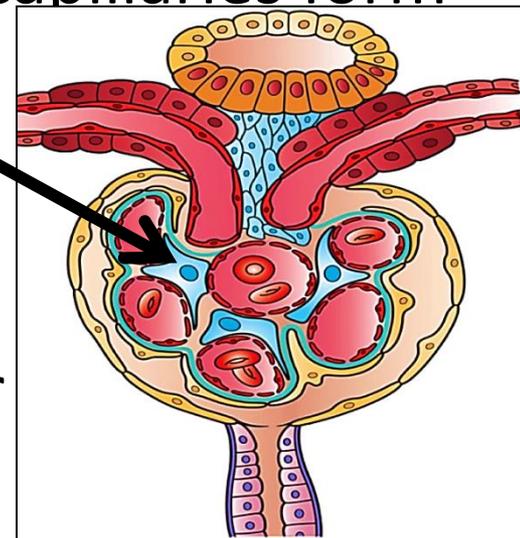
Specialized **pericytes** located between the endothelial cells & the basement membrane of glomerular capillaries form **mesangium**

Function:

1- Filtration: regulate bl. flow of glomerular capillaries by their contractile activity → control GFR

2- Structural support to glomerulus

3- Phagocytosis & renewal of BM

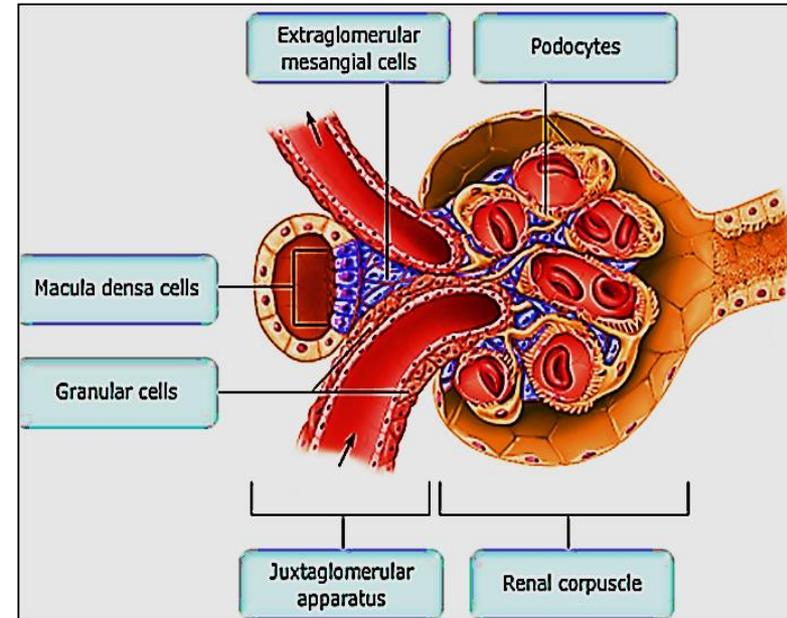


Extra-glomerular mesangial cells (Lacis cells):

Specialized **smooth ms cells** found outside the glomerulus , at the vascular end

Function:

1- Role in regulation of bl flow to kidney & systemic bl. pressure via Renin-Angiotensin-Aldosterone system



2- Part of **Juxta-glomerular apparatus**, together with macula densa & granular cells

3- may play role in secretion of erythropoietin Hormone.

Juxtaglomerular apparatus

- Located at the vascular end of renal corpuscle

- Consists of 3 components:

1- *Macula densa*

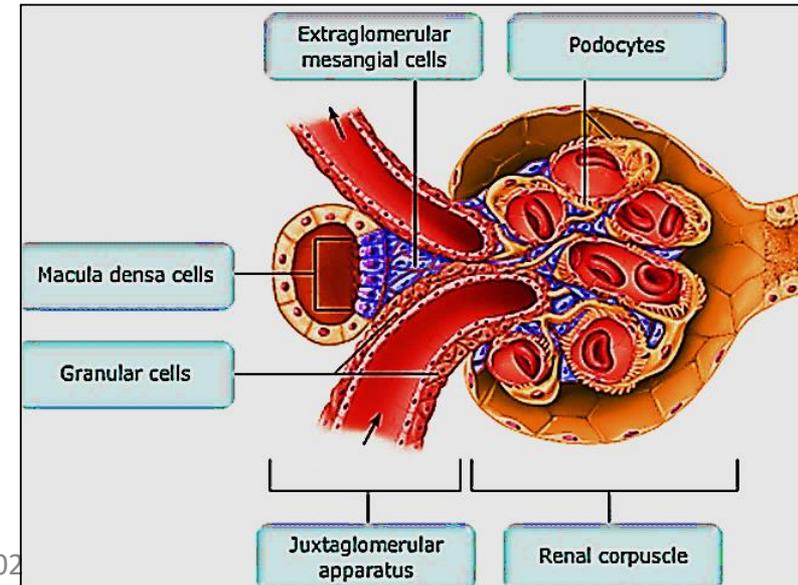
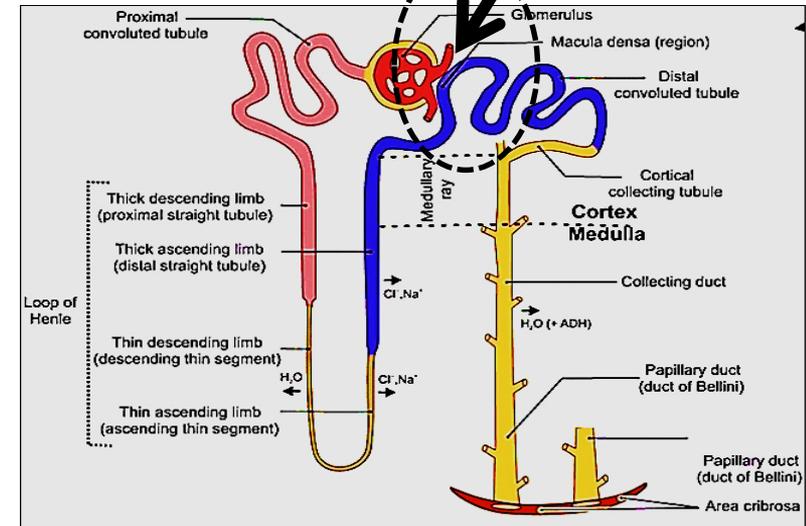
(lining of distal convoluted T.)

2- *Granular (juxtaglomerular) cells*

(wall of afferent arteriole)

3- *Lacis cells*

(Extra-glomerular mesangial cells)

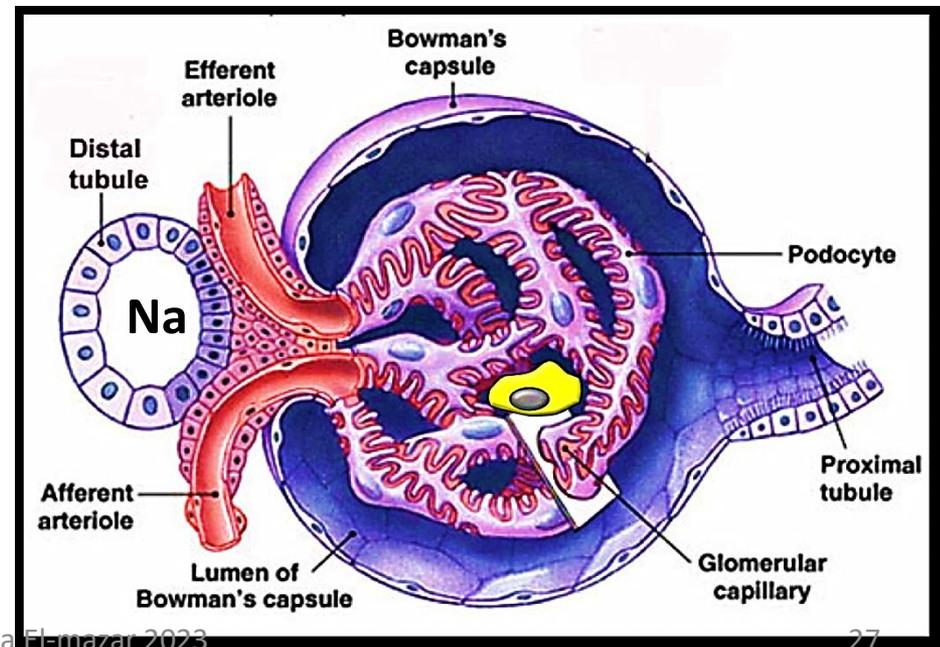


1- Macula densa (NaCl):

1. The part of DCT the fits between the aff. & eff. Arterioles
Cells ↑ in length → become columnar
2. The nuclei of cells become **apical**, deeply stained & closely packed appear as dark spots
3. Golgi complex is **infra-nuclear** (basal)
4. **Basement membrane is lost**, so these cells are in contact with granular cells

- **Function:**

Act as **osmoreceptors** that monitor the level of Na^+ ions of the filtrate in the lumen of DCT

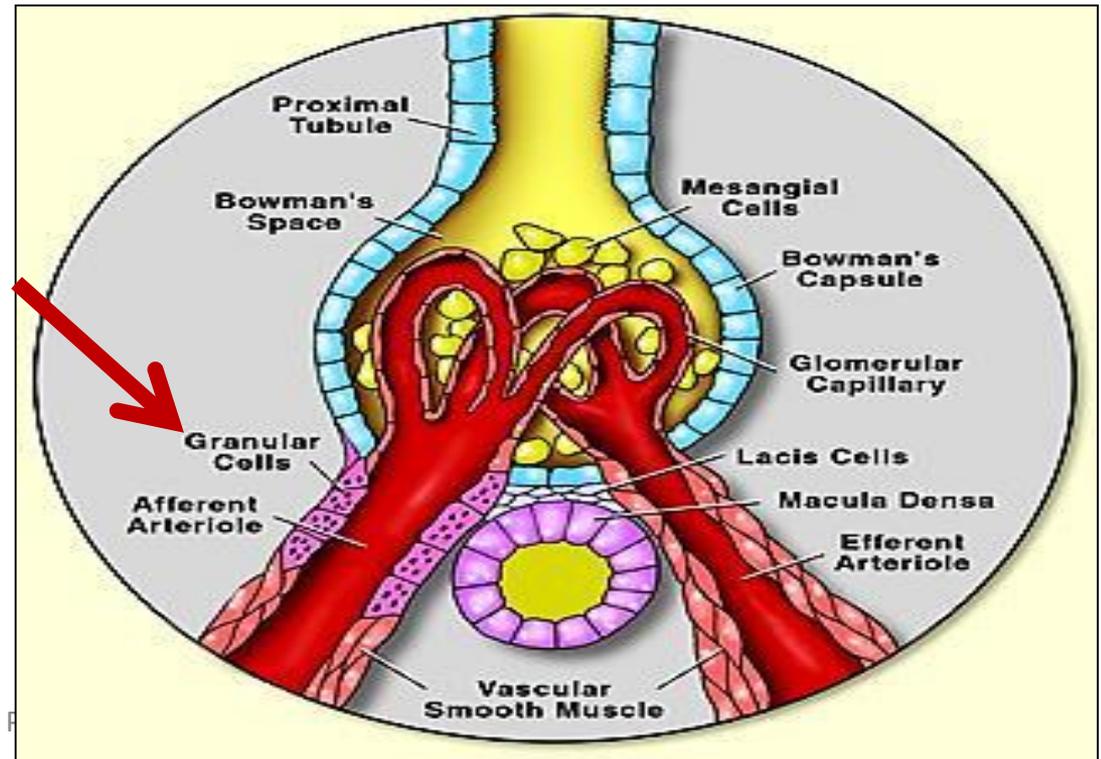


2- Juxtaglomerular cells (granular) cells:

- **Modified smooth muscle cells** present in the tunica media of the afferent arteriole
- Nuclei of cells become rounded instead of being elongated
- Cytoplasm contain secretory granules contain **Renin H**

Function:

Secrete **Renin H**

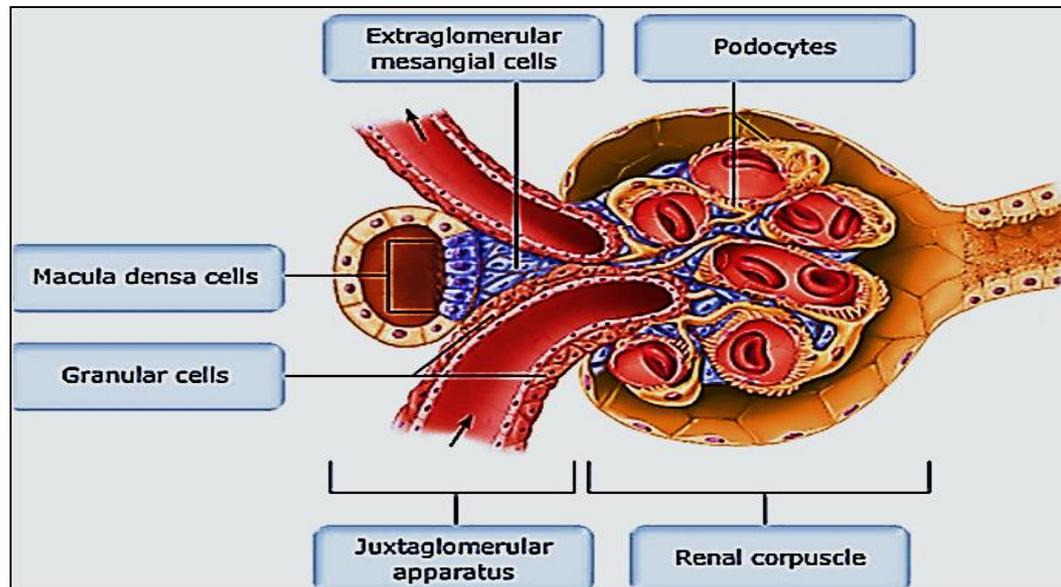


3- Extraglomerular mesangial cells (Lacis cells):

- Small pale stained cells occupy the space between the afferent arteriole, eff. arteriole & macula densa

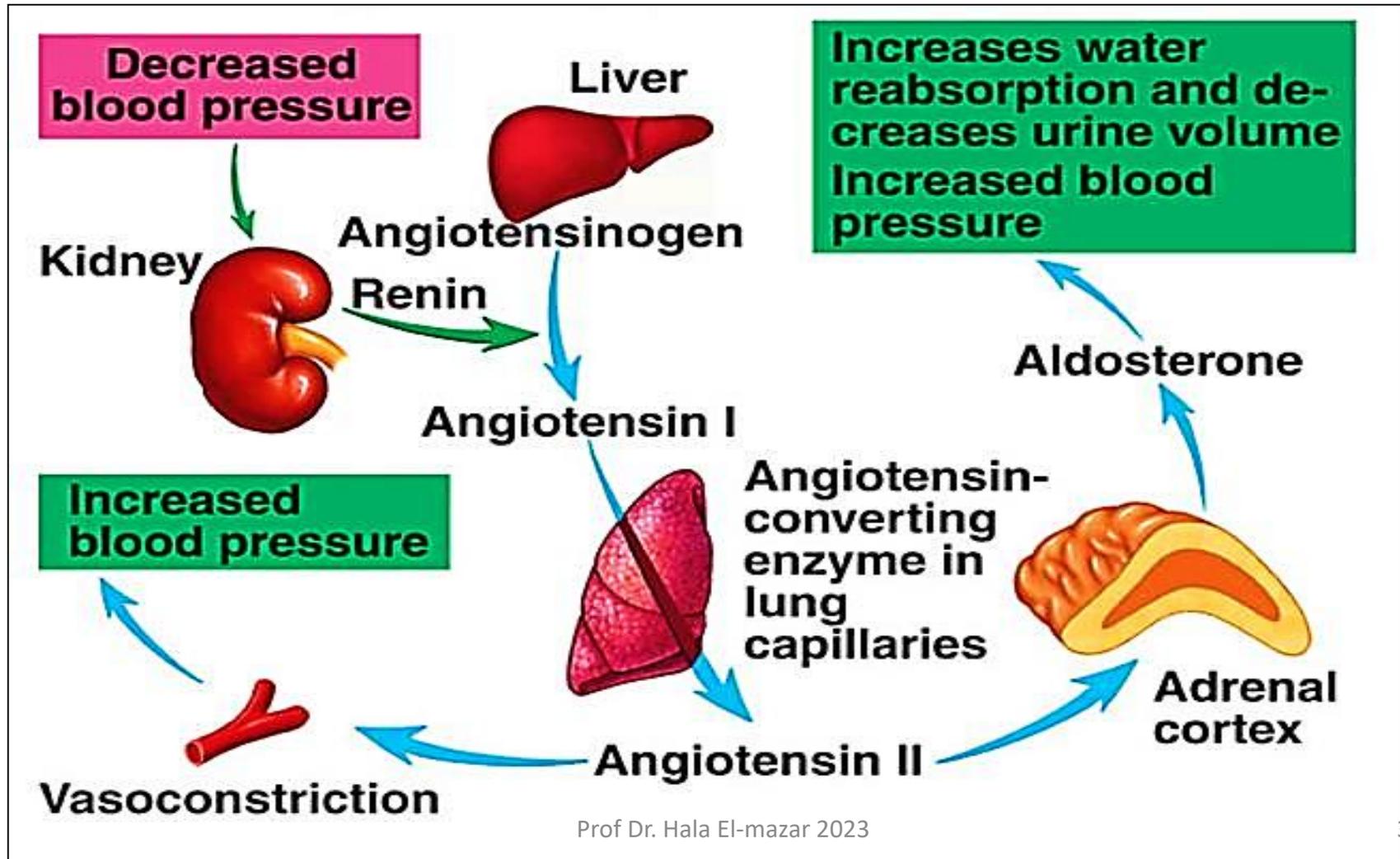
Function:

- a) Supportive
- b) Transmit signals from macula densa → glomerulus → vasoconstriction of blood vessels



Function of Juxtaglomerular apparatus:

- Regulation of glomerular filtrate rate & blood pressure through the Renin-angiotensin – Aldosterone system



Mechanism of Renin- angiotensin – aldosterone

- Drop in blood pressure or blood volume
- → ↓ volume of glomerular filtrate
- → ↓ Na & Cl concentration In DCT.
- → Macula densa monitor these changes
- → ++ JG cells → Renin
- → changes angiotensinogen in blood (formed by liver)→ angiotensin I → lung (has ACE) → angiotensin II

Angiotensin II is:

- potent vasoconstrictor
 - ++ release of Aldosterone from adrenal cortex & ADH from posterior pituitary
- **Aldosterone** promotes reabsorption of NaCl by DCT
- **ADH** promotes water reabsorption from collecting tubules
- Both will cause ↑ blood pressure**

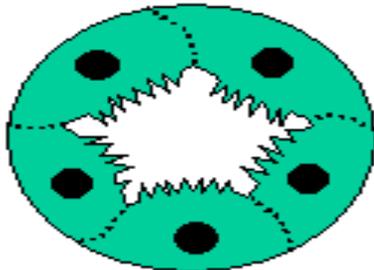
Proximal & distal convoluted tubules

PCT

Longer+ narrow lumen

- Lined e 3-5 cells
- Ill-defined cell borders
- **apical brush border**
- **Reabsorption** of water (Na^+ pump), sugar , amino acids
- **Secrtion** of some metabolites (penicillin , dyes, ammonia)

proximal convoluted tubule

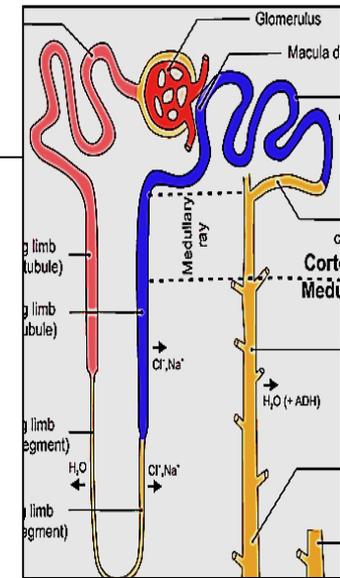
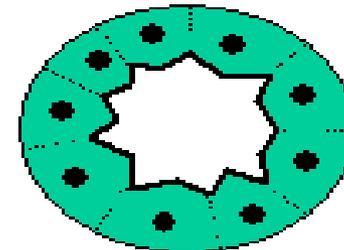


DCT

Shorter + wide lumen

- Lined e 5-8 cells
- clear cell borders
- **No brush border**
- Reabsorption of water under effect of Aldosterone

distal convoluted tubule



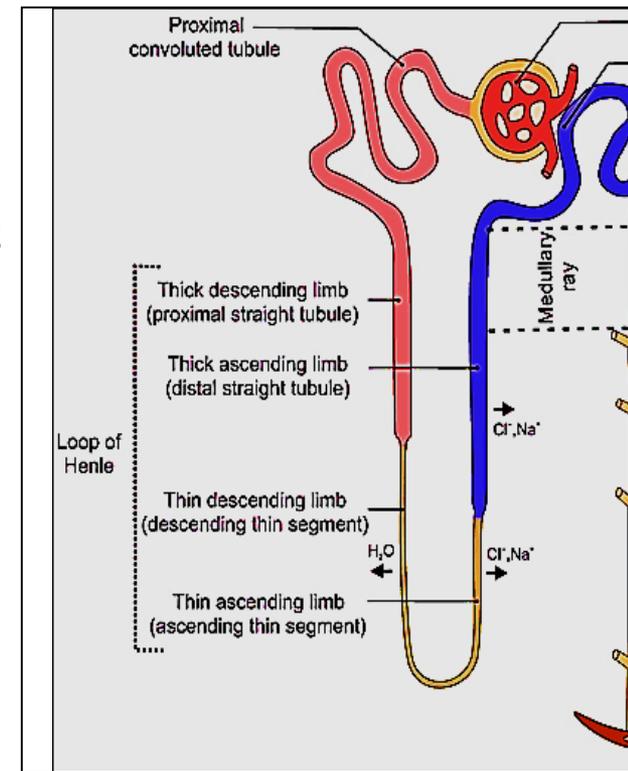
Loop of Henle

- Variable in length
- Thin segment: lined by simple squamous
- Thick segment: lined by simple cubical
- It descend from cortex to medulla

Function:

Create concentration gradient in the medulla of kidney → produce hypertonic urine

- The **descending limb** has ↑ permeability to water, ↓ permeability to ions
- The **ascending limb** is permeable to ions. impermeable to water.

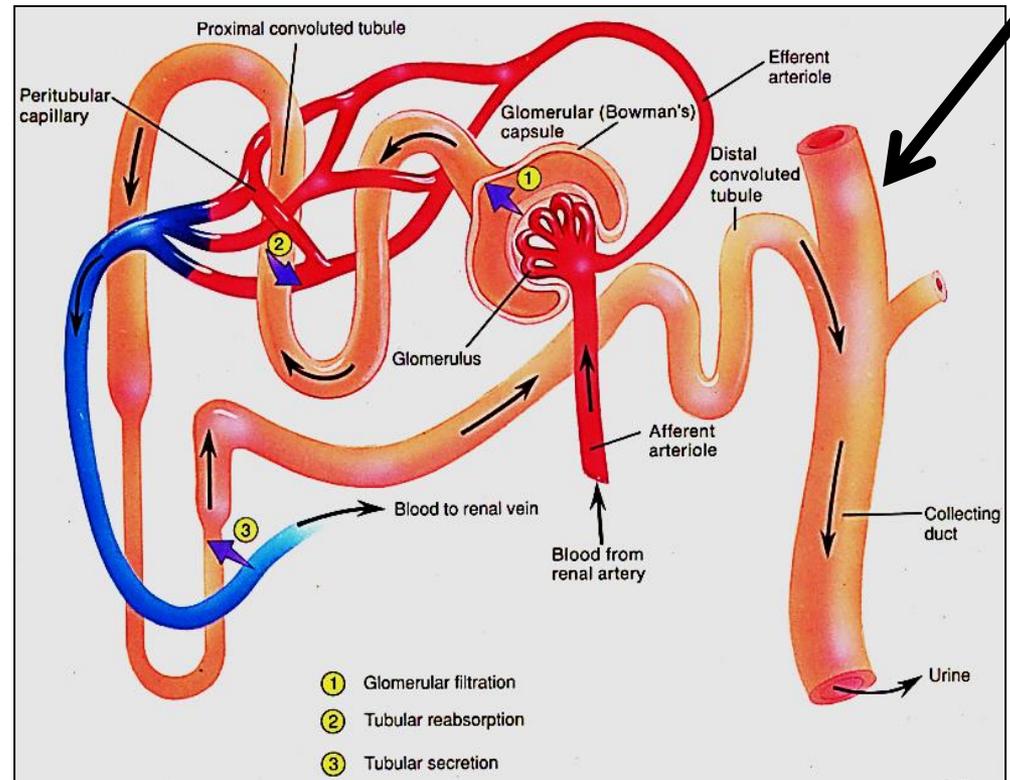


The collecting ducts

- The excretory portion of renal tubules, under **ADH**
- Lined with simple cuboidal epithelium. Each 6-8 collecting ducts drain into → tips of medullary pyramid

- 2 types of cells line collecting tubules

- a) Principle cells
- b) Intercalated cells



Principle cells

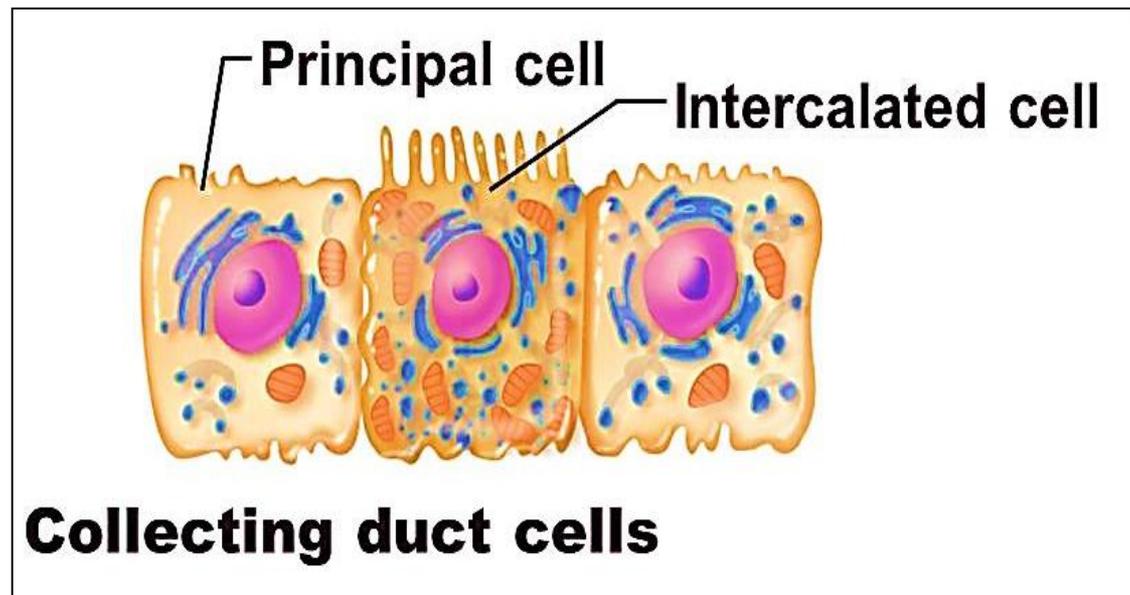
- Numerous
- **Very sensitive to ADH** →
- Responsible for the ability of collecting tubules to **concentrate urine**
- Reabsorb Na & secrete K

Intercalate cells

- Few, have apical microfolds
- 2 types alpha & Beta
- **Regulate acid- base balance**

Alpha → H^+ ion → acid urine

Beta → HCO_3^- → alkaline urine



ureters

Muscular tube formed wall is formed of :

Mucosa - Muscularosa – adventitia

Mucosa:

Transitional epithelium + CT lamina propria

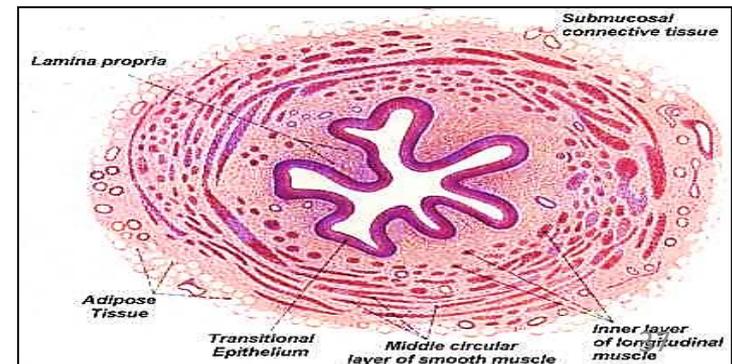
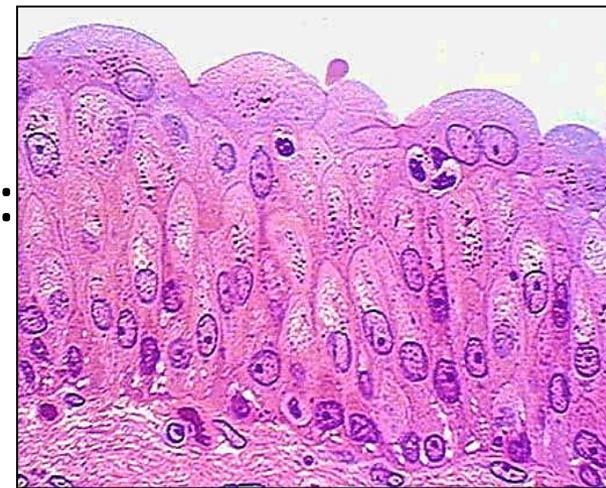
Muscularosa:

Upper 2/3 of ureter: inner longitudinal & outer circular

Lower 1/3 of ureter: additional outer longitudinal

Adventitia

Loose areolar CT



Urinary bladder

Mucosa:

Transitional epith. + lamina propria

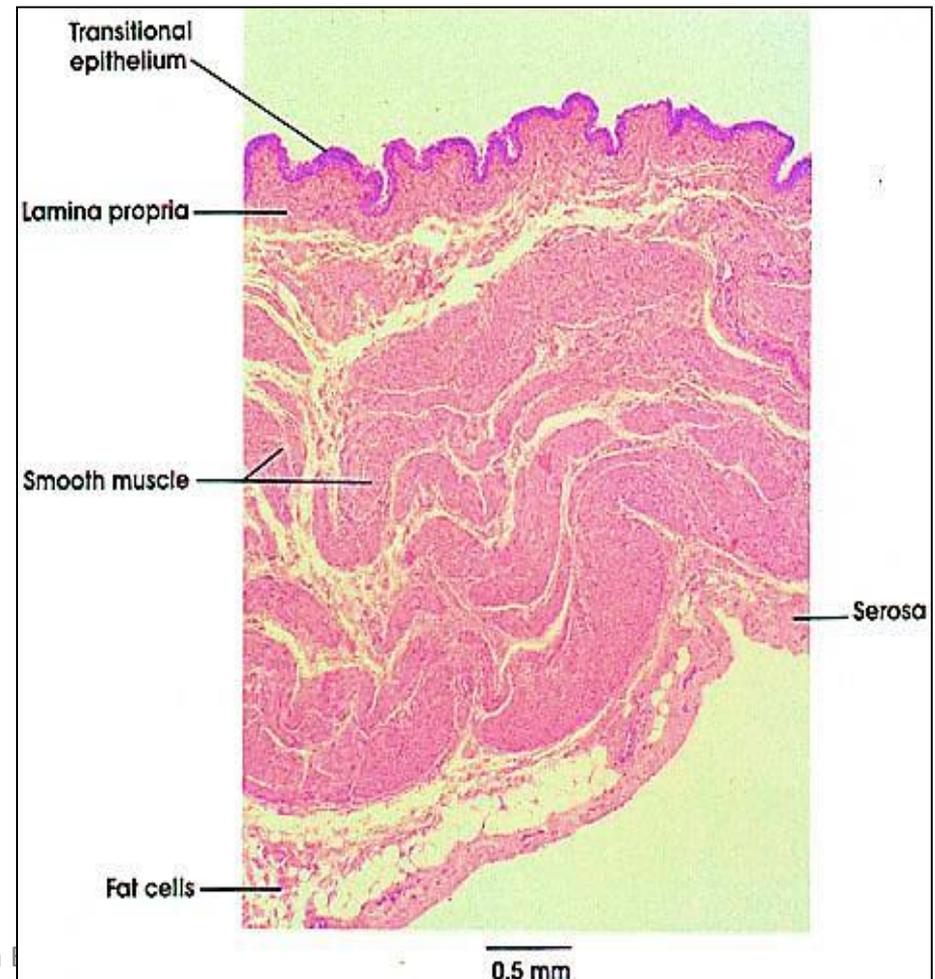
Musculosa:

IL , MC & OL (detrusor ms.)

At the neck of bladder ,
the *middle circular* form →
internal urethral sphincter

Serosa:

Loose areolar CT



urethra

A-Male urethra

Prostatic – membranous – penile

Prostatic urethra:

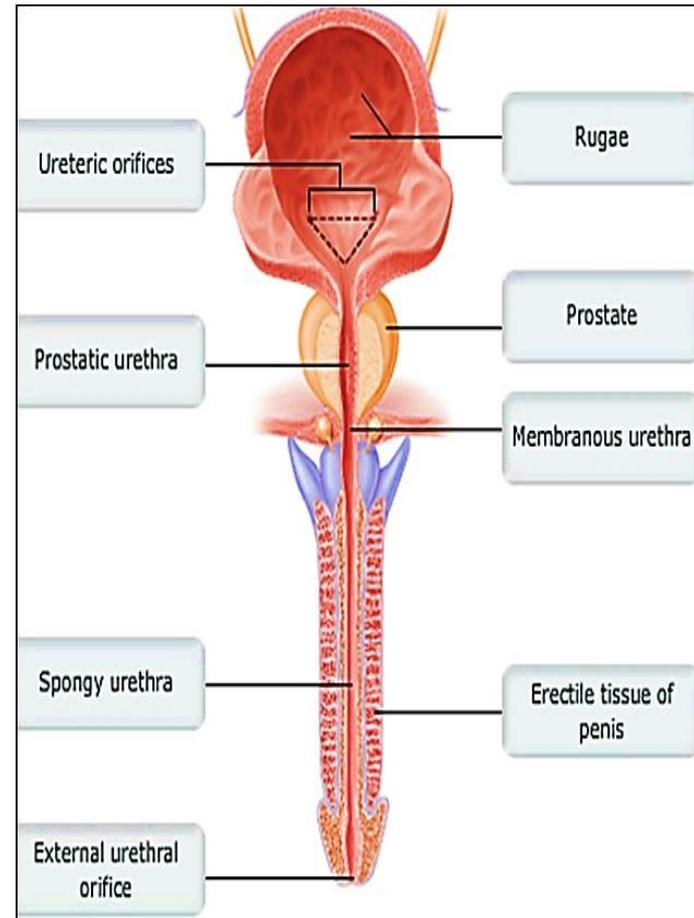
- Lined e **transitional** epithelium

Membranous urethra:

- Lined e **stratified columnar** epithe

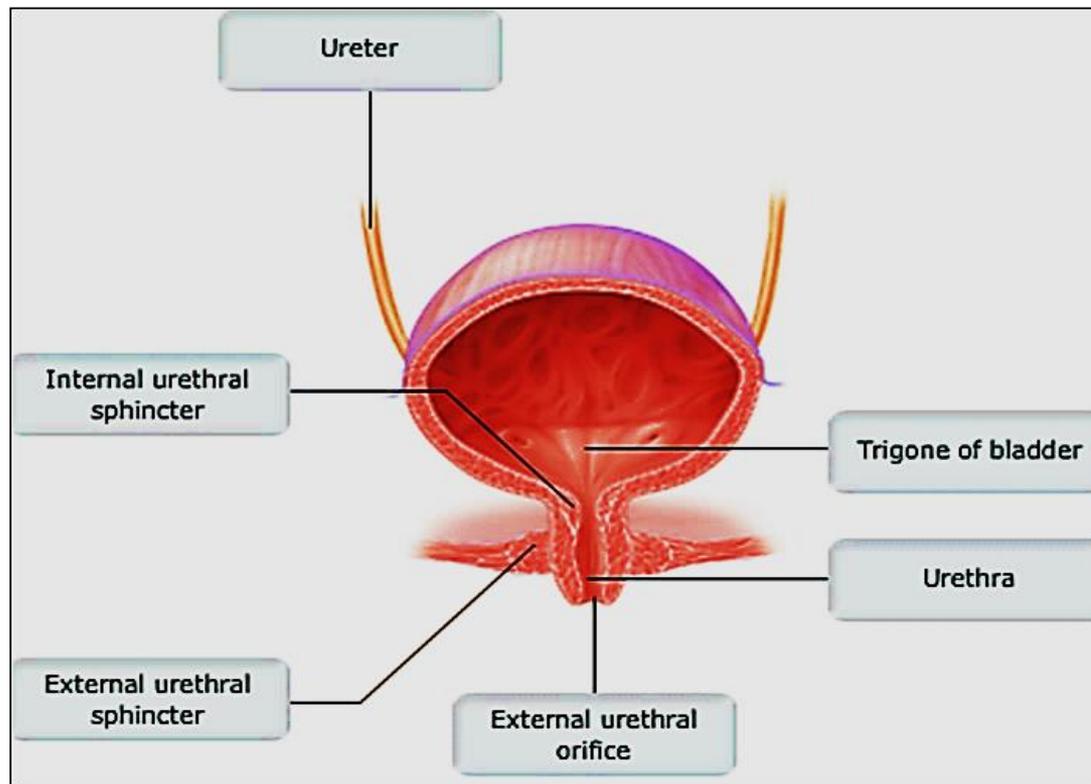
Penile urethra:

- Lined e **stratified columnar** epith which → **stratified squamous** in its distal part (fossa navicularis)



B- Female urethra

- Short straight tube
- Lined with **transitional** epithelium, then **stratified squamous** at its distal part



Thank you

