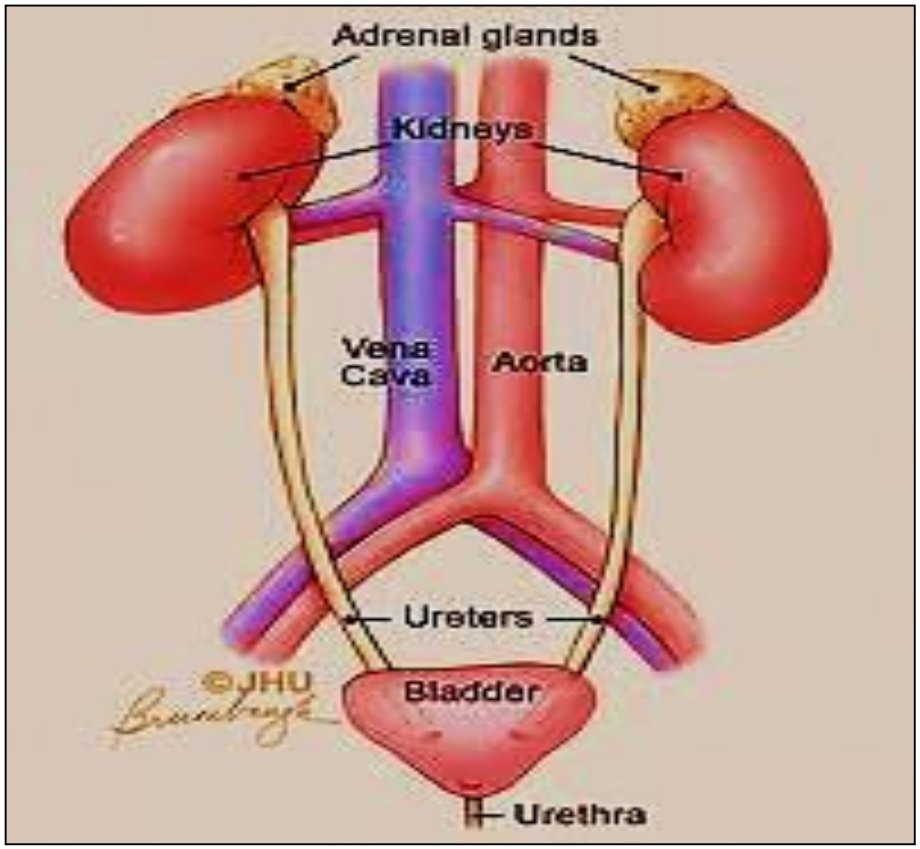
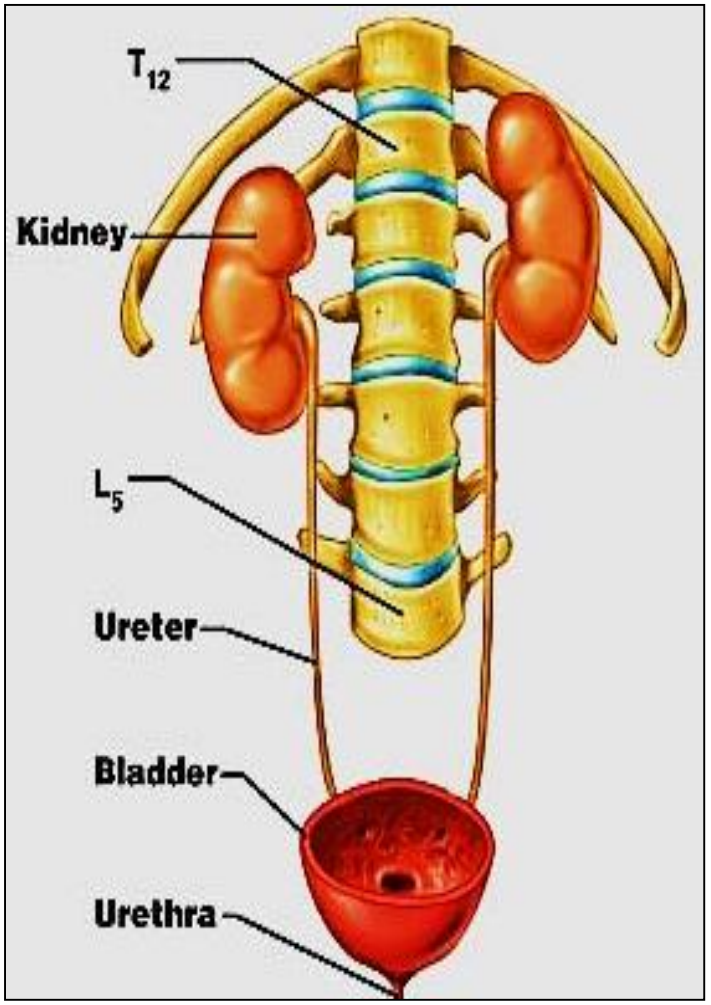
The Urinary System



- 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

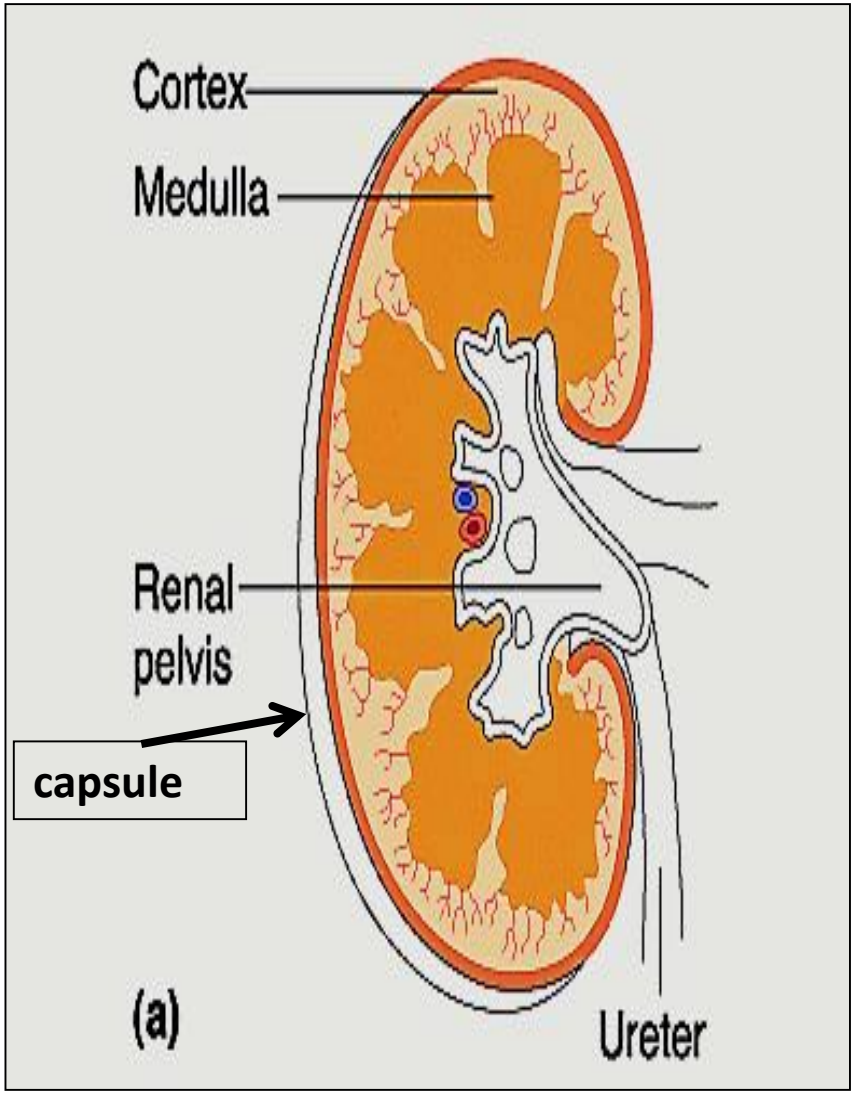
structure of the Kidney:

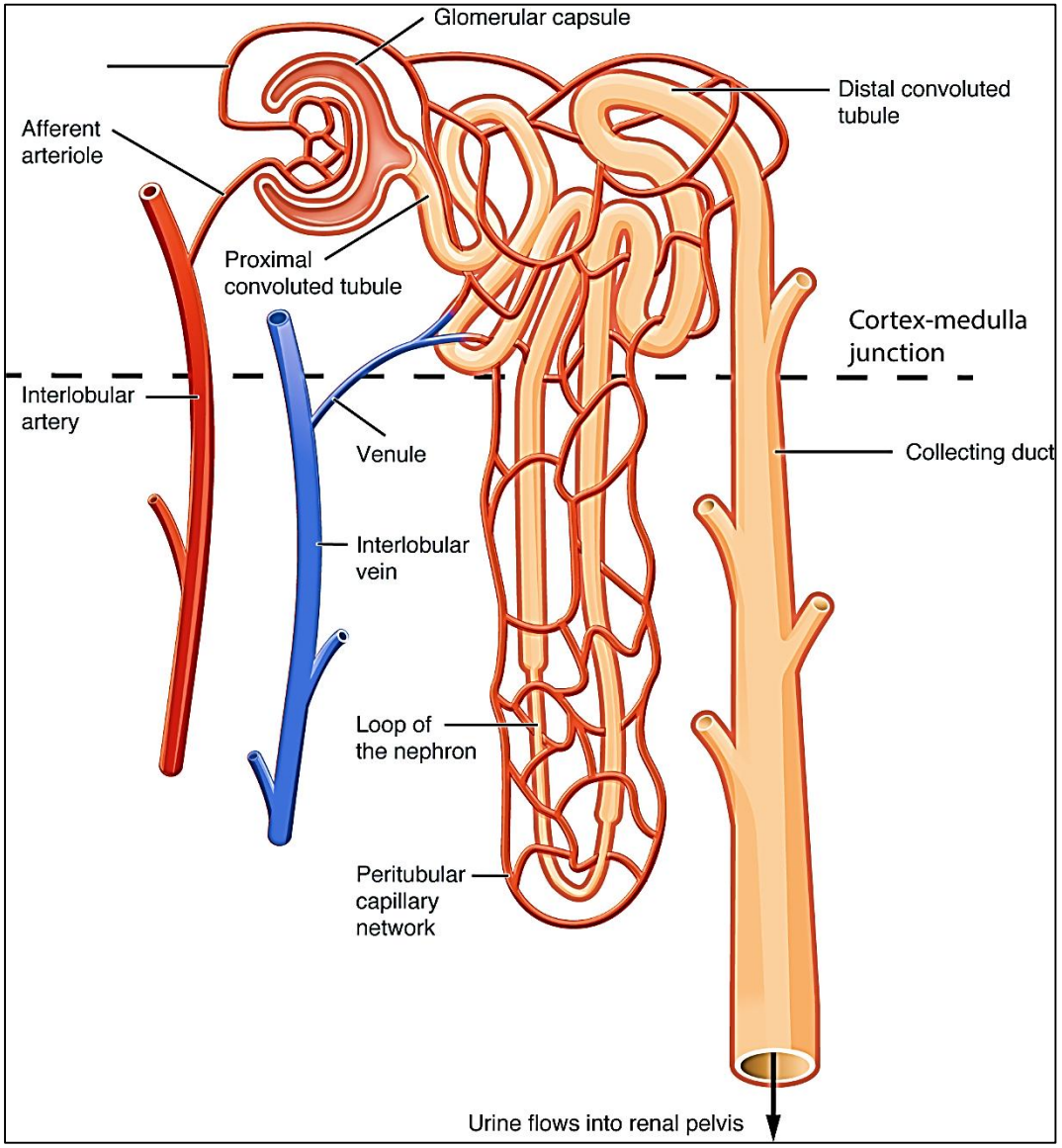
1. Stroma : capsule

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**

A- The nephron

- Each kidney contains 1- 1.4 million nephrons

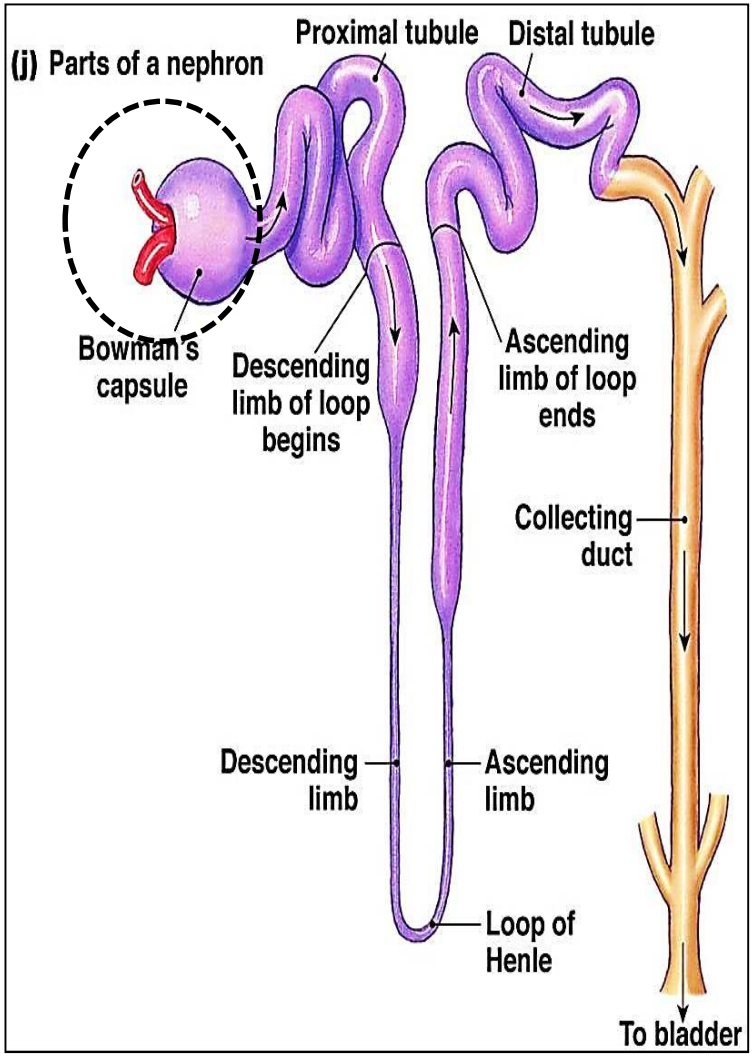
- Each nephron consists of:

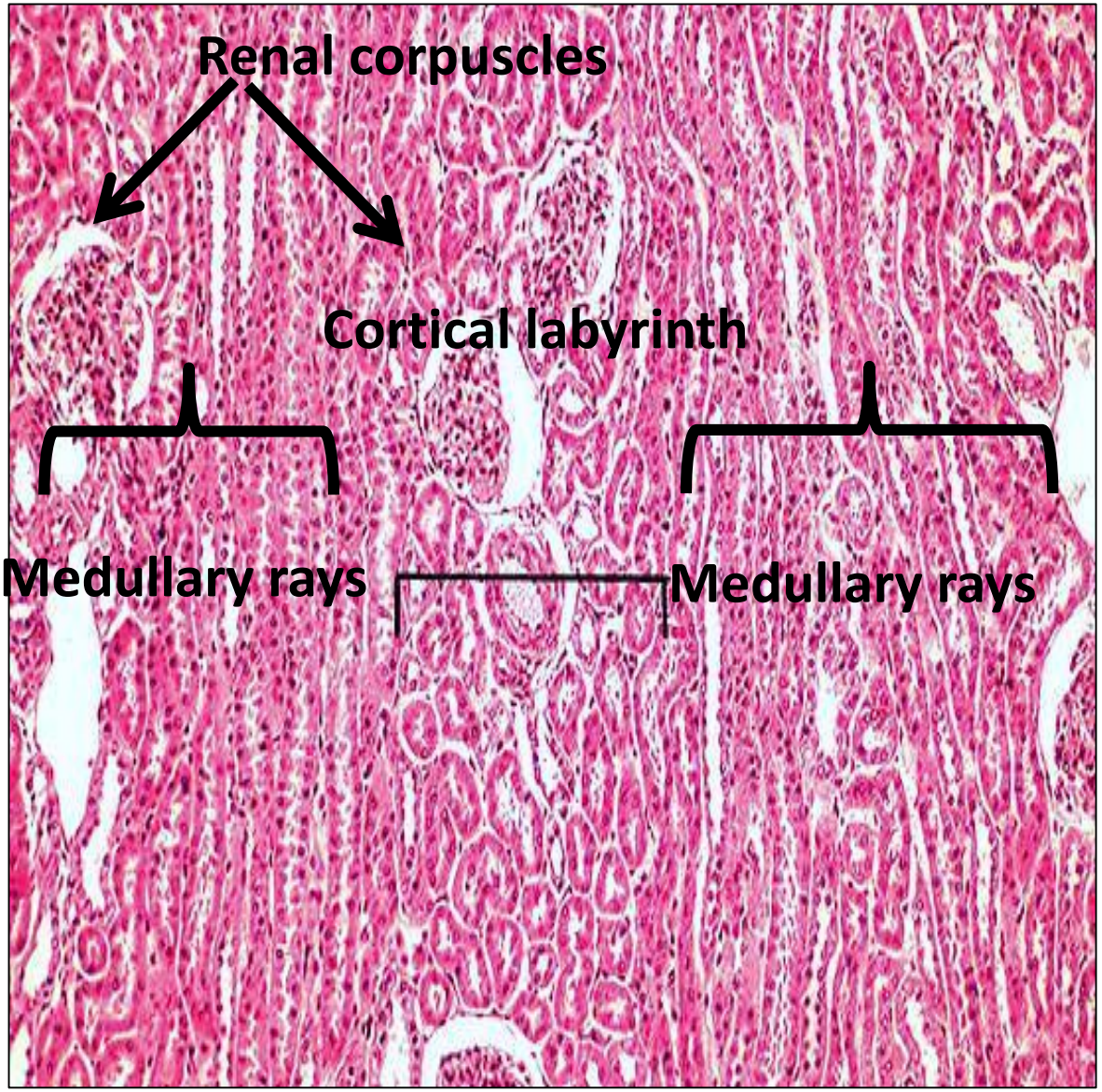
1- **Renal (malpigian) corpuscle**

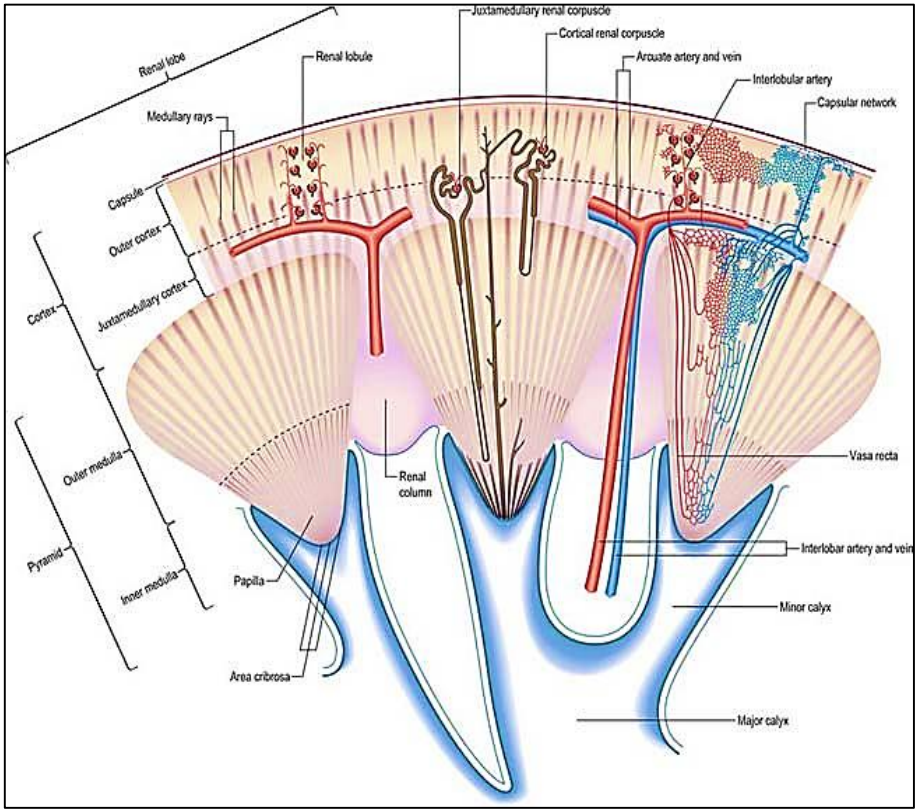
2- **Proximal convoluted tubule (PCT)**

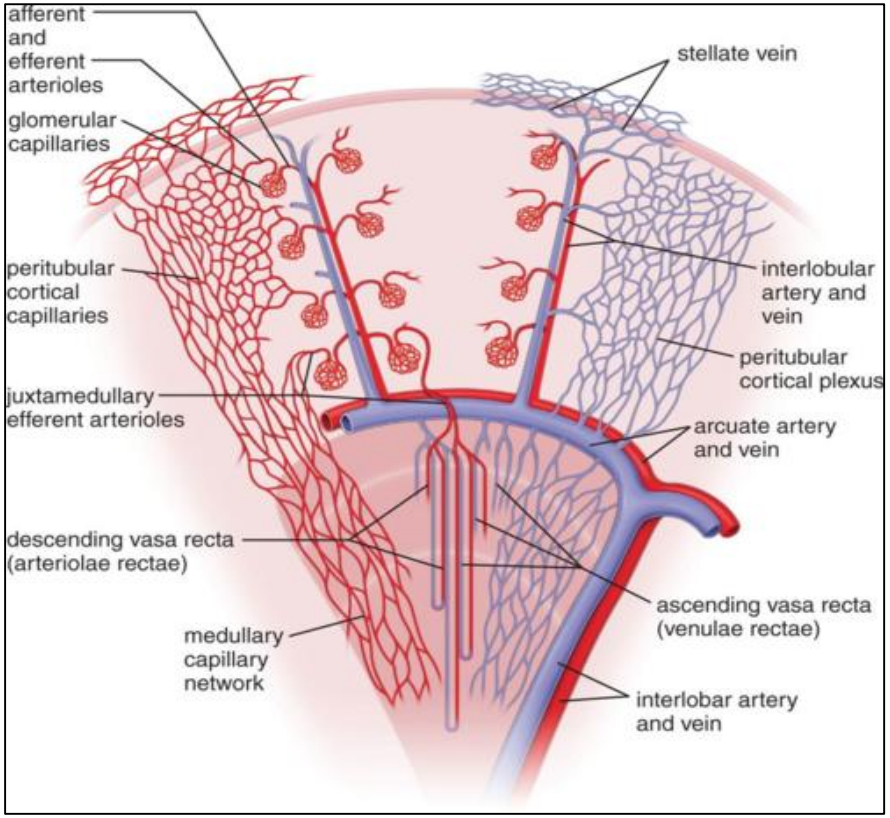
3- **Loop of Henle**

4- **Distal convoluted tubule (DCT)**




Renal corpuscles
Cortical labyrinth
Medullary rays
Medullary rays





Medullary rays and cortical labyrinth

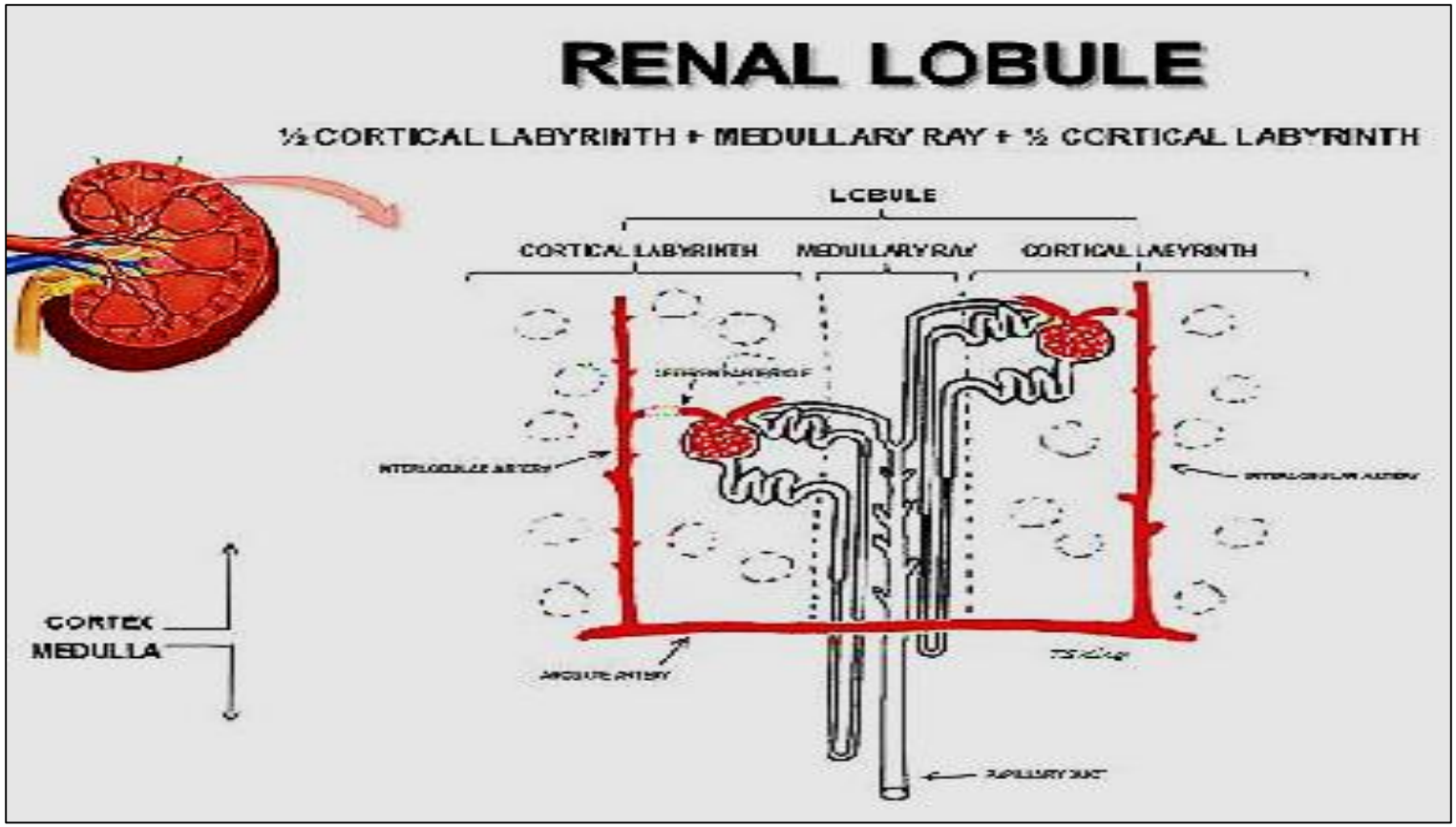
Cortex: contains

Cortical labyrinth , medullary rays , renal columns

- **Cortical labyrinth**: areas that contain renal corpuscles and convoluted tubules.

- **Medullary rays**: are regions where the straight segments of **loop of Henle's + collecting ducts** travel in radial fashion from medulla to cortex

- Bands of **cortical labyrinths** separate the areas of medullary rays. Each medullary ray with 1/2 of the adjacent cortical labyrinth on either side is a **lobule**.

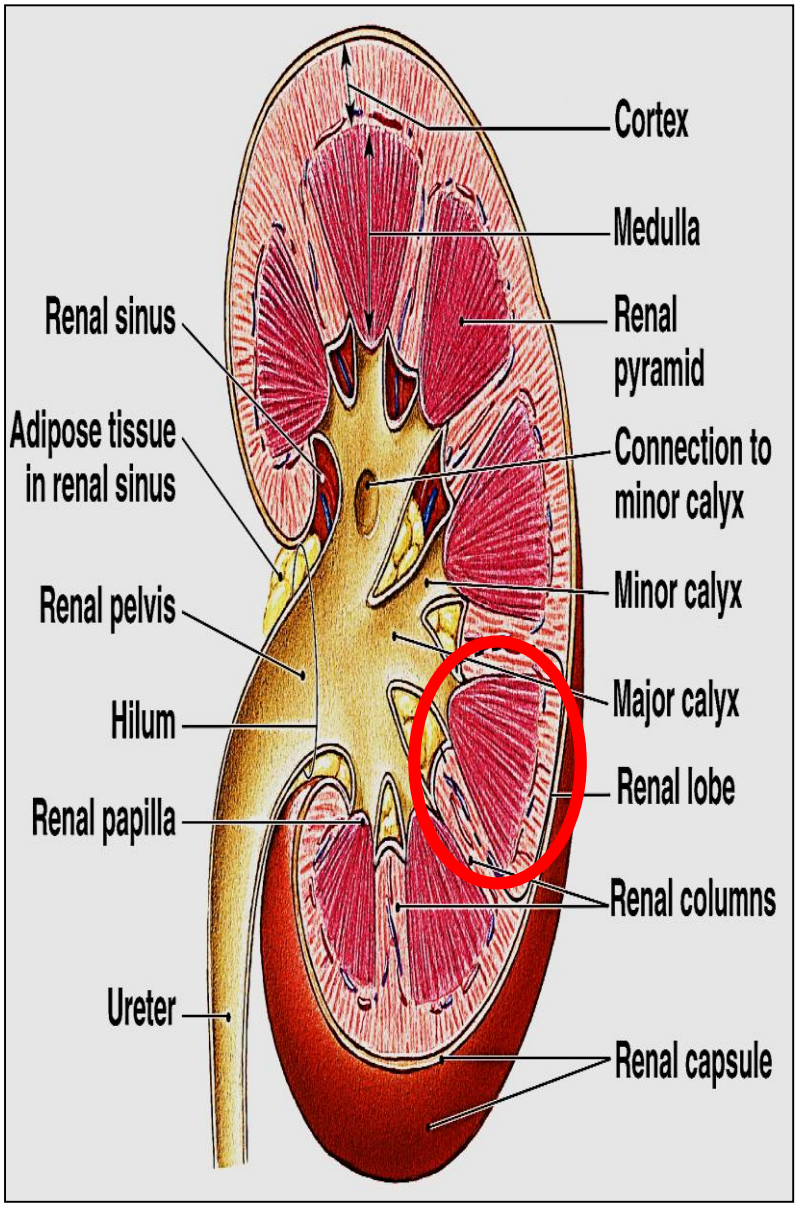


- **Renal lobule defined within cortex**
- **The tissue between 2 interlobular arteries is defined as lobule.**
- **Interlobular arteries bisect Labyrinth.**
- **Thus a lobule consists of ½ of labyrinth on one side of medullary ray & ½ of labyrinth on the other side . Nephrons of that lobule drain in 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

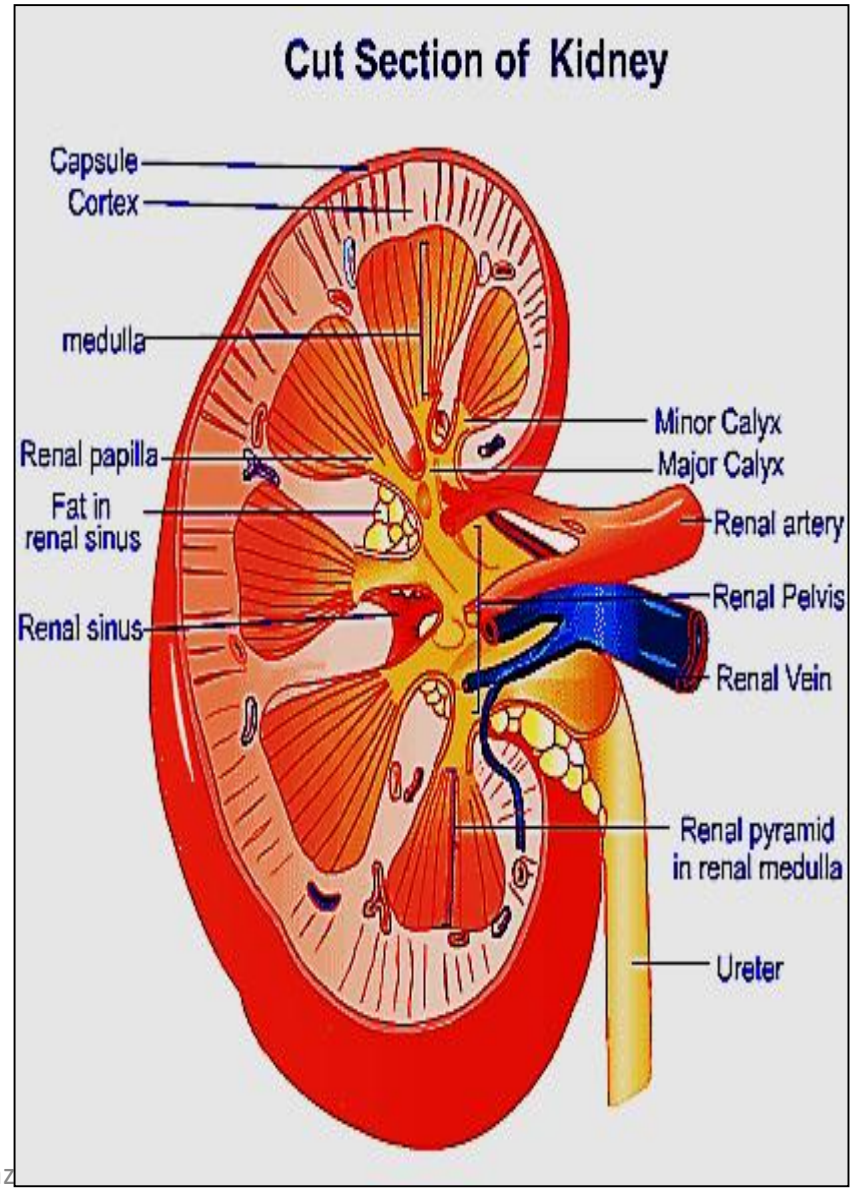
- Each medullary pyramid + the cortical tissue at its base & along its sides form a **renal lobe**



- 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

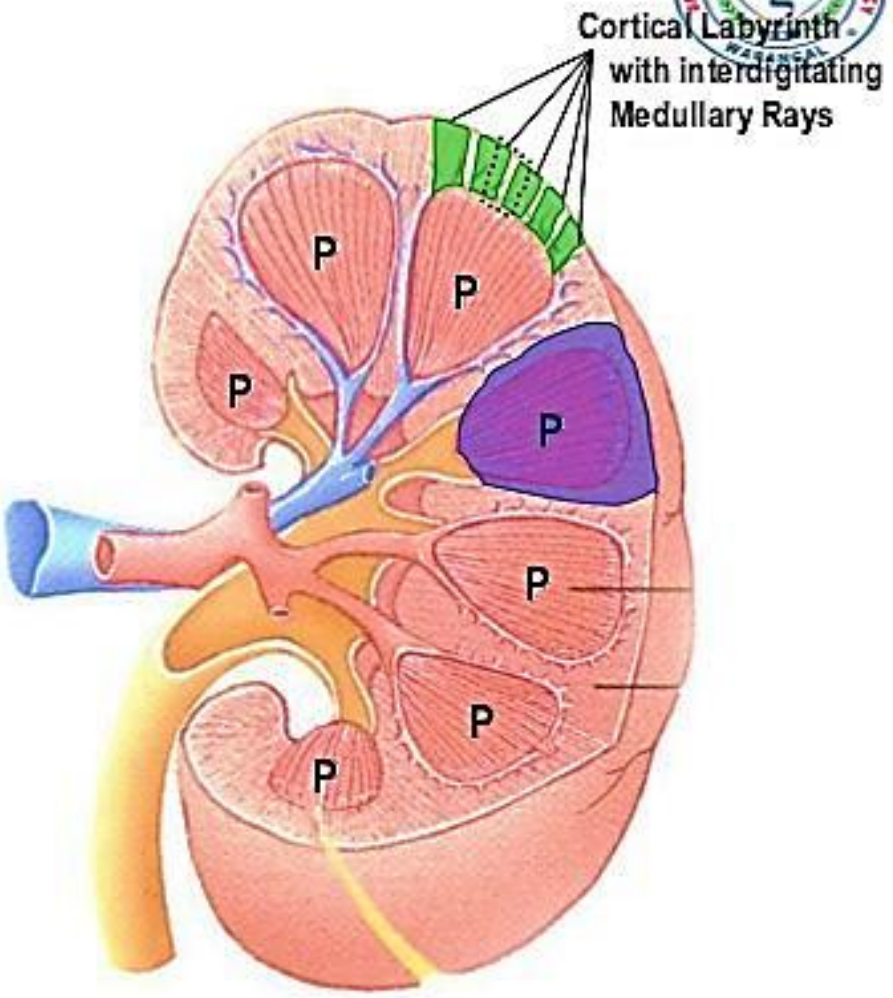
- **KIDNEY (ORGANIZATION)**

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

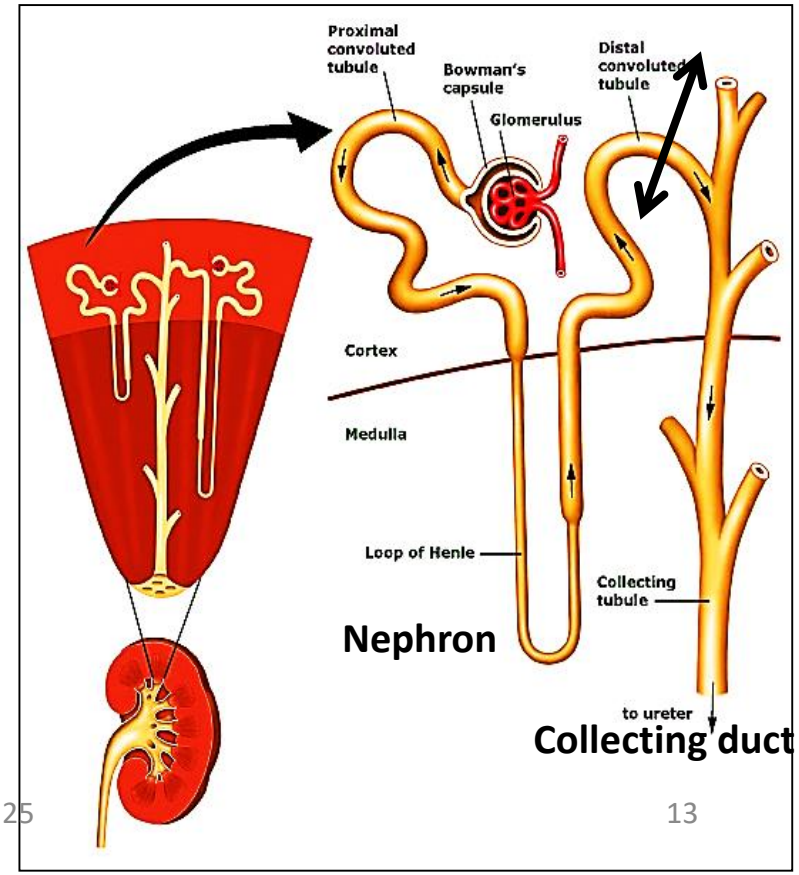
17

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

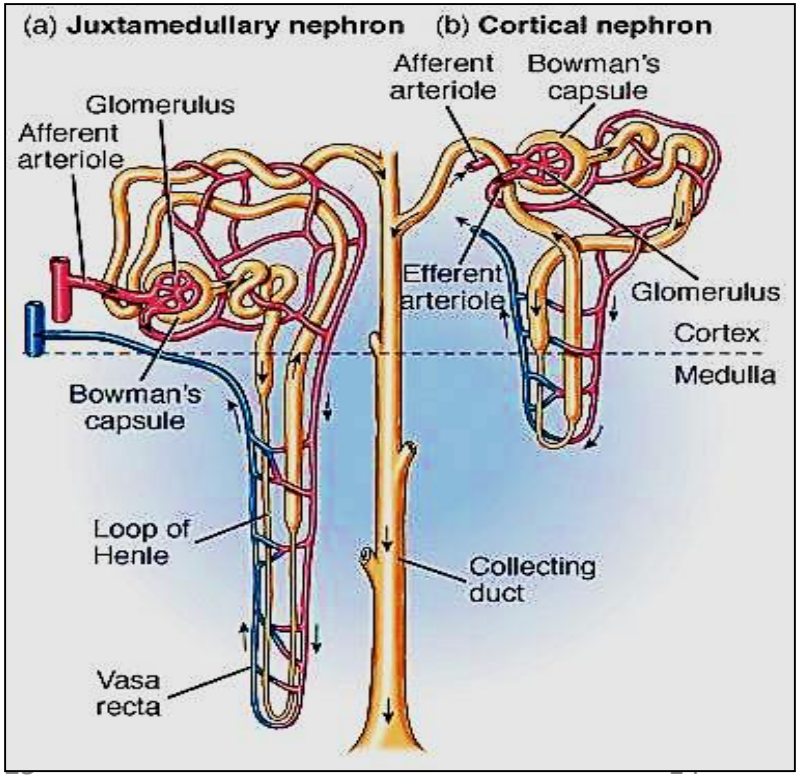


- **Classification of nephrons:**

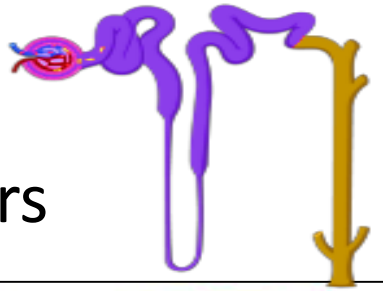
➢ Cortical nephrons: 85%, short loop of Henle, extend close to cortico-medullary junction

➢ 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

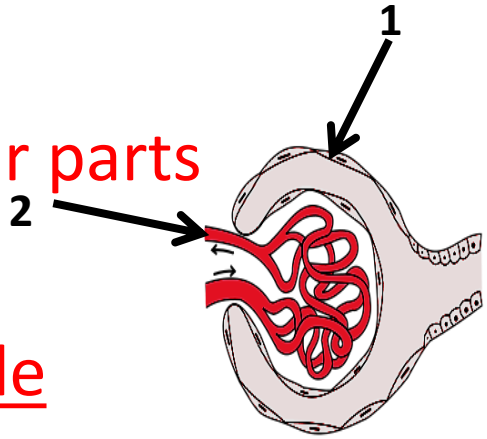


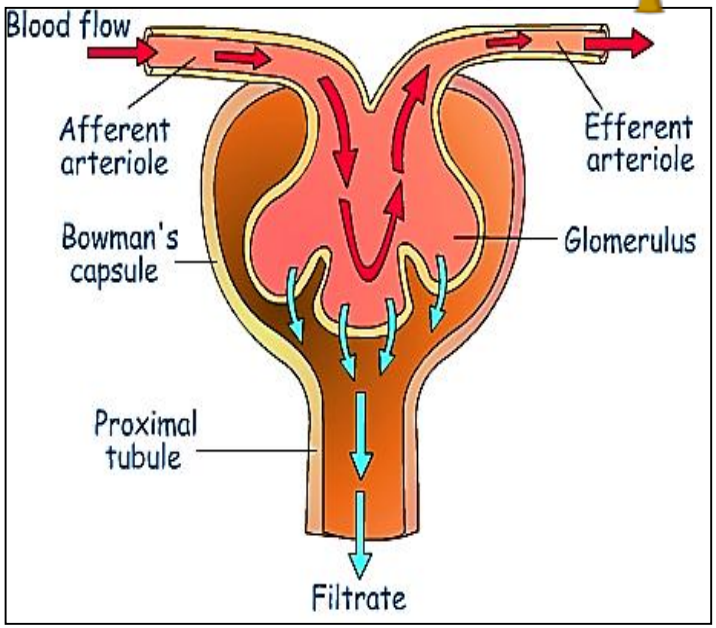
Renal (Malpigian) corpuscle



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

  urinary & vascular parts





1 - Bowman's capsule

Double walled chamber has:

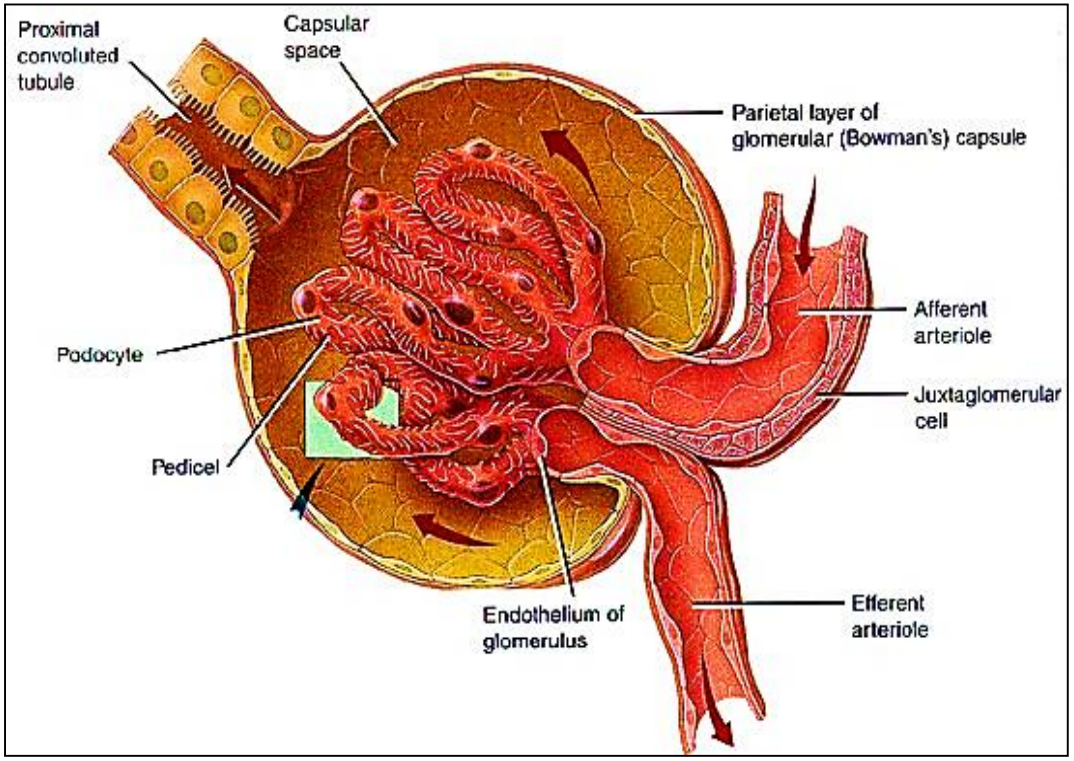
1. Inner/ visceral layer (podocytes)
2. Outer /parietal layer (simple squamous epithelium)

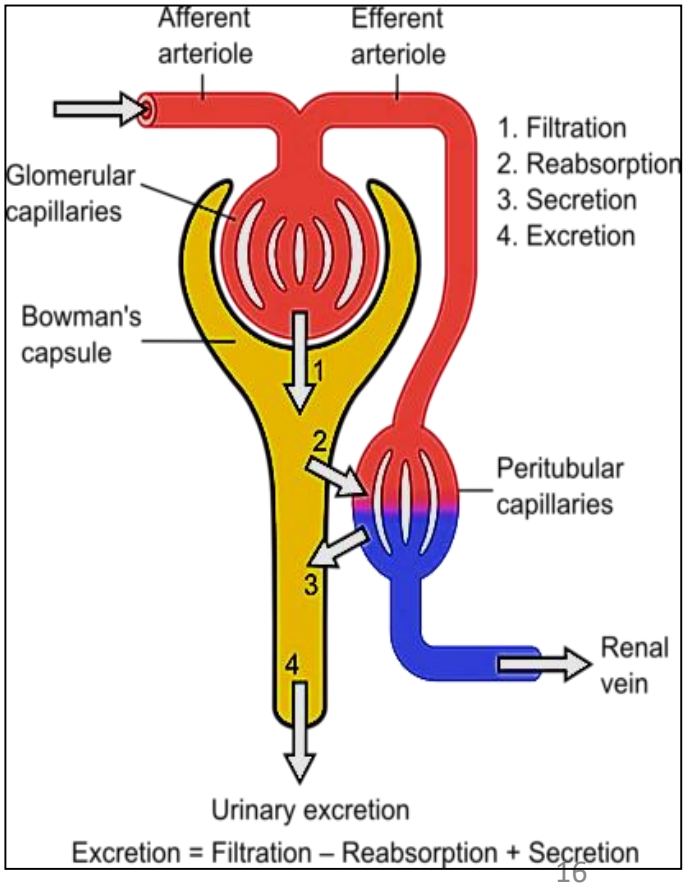
2- Glomerulus :

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

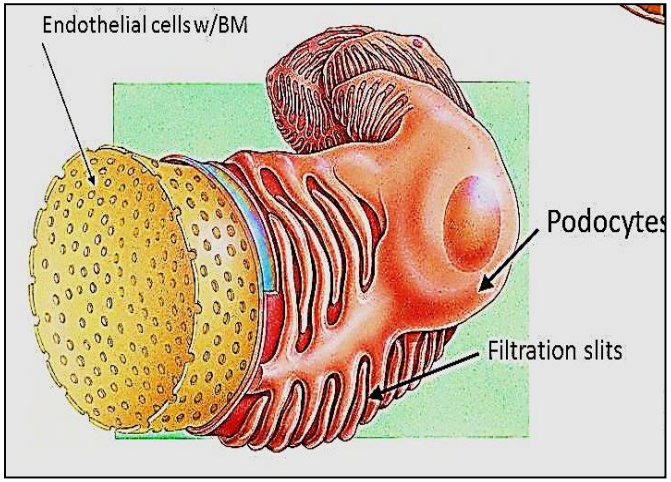
Glomerulus

- **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**

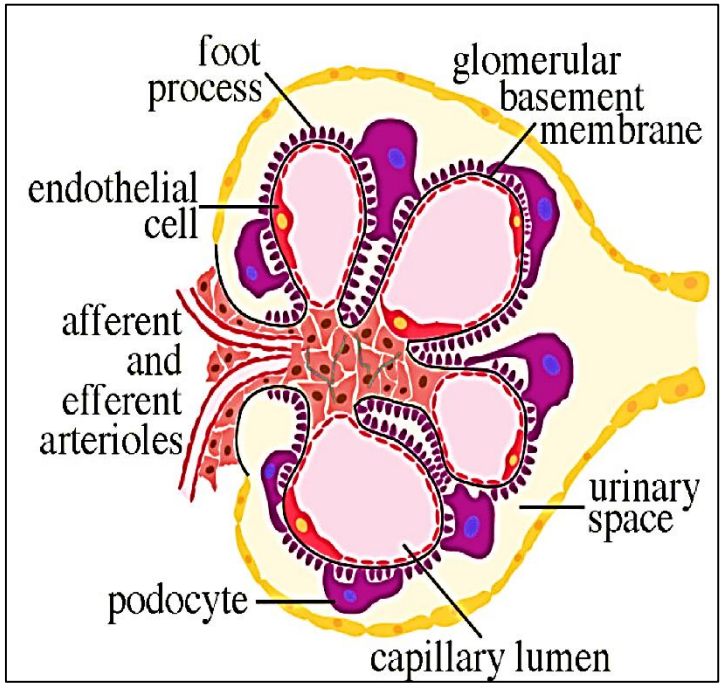




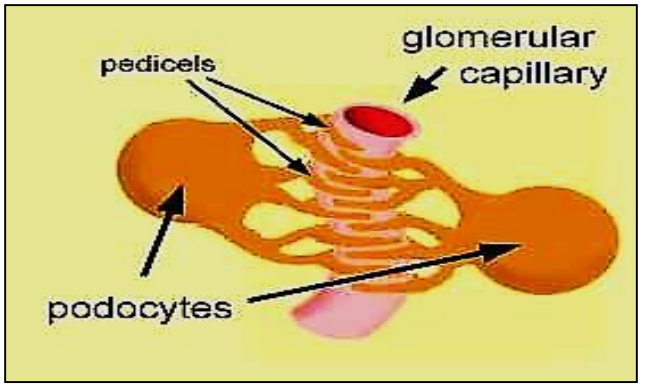
The wall of the glomerular capillaries is lined with fenestrated endothelial cells (70 – 100 nm), restrict the passage of blood cells & proteins
with continuous basement membrane formed of type IV collagen (-ve charged) which repel portions (-ve charged) from escaping through (if Abs attack BM cause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



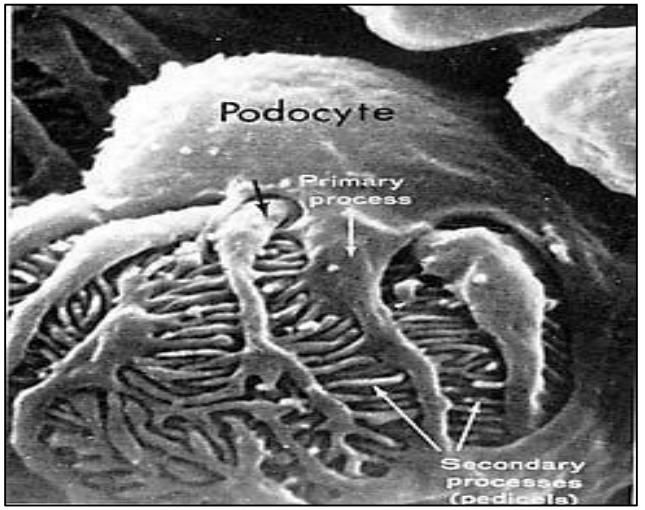
Bowman's capsule visceral layer is lined with special cells called
Podocytes
Outer layer lined e simple squamous epithelium



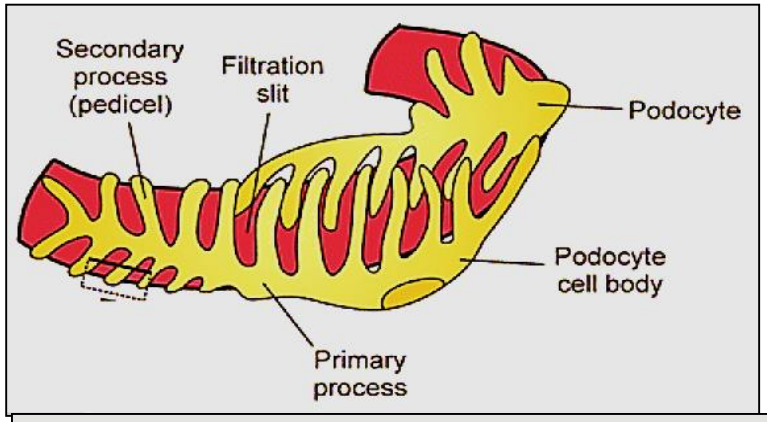
Podocytes

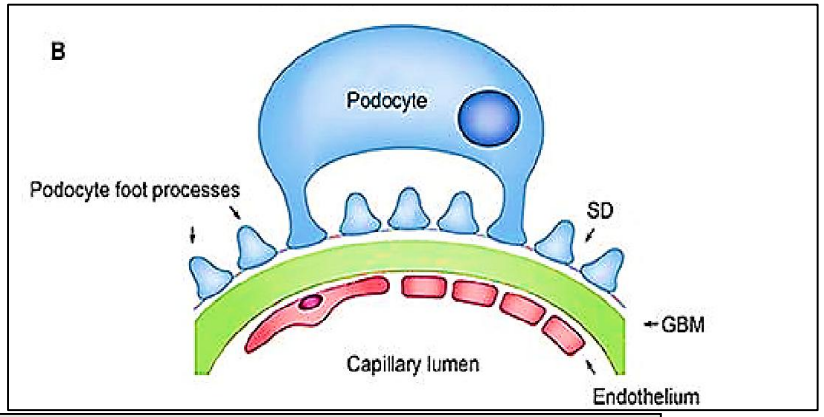


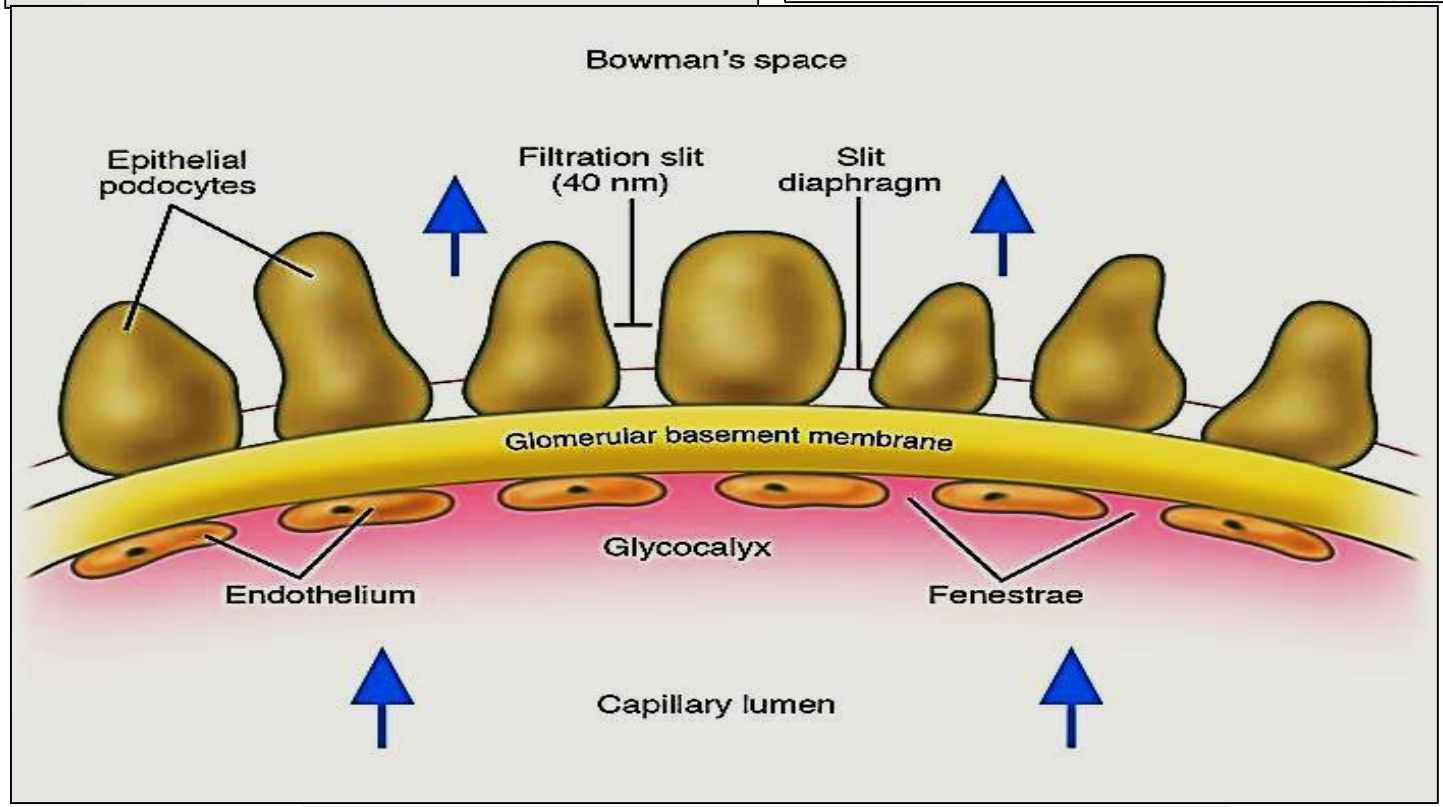
- They are flattened cells with several primary processes
- Each 1ry process send numerous 2ry process (**pedicles**)
- Encircle the underlying bl. capillary
- 2ry process interdigitate with each other



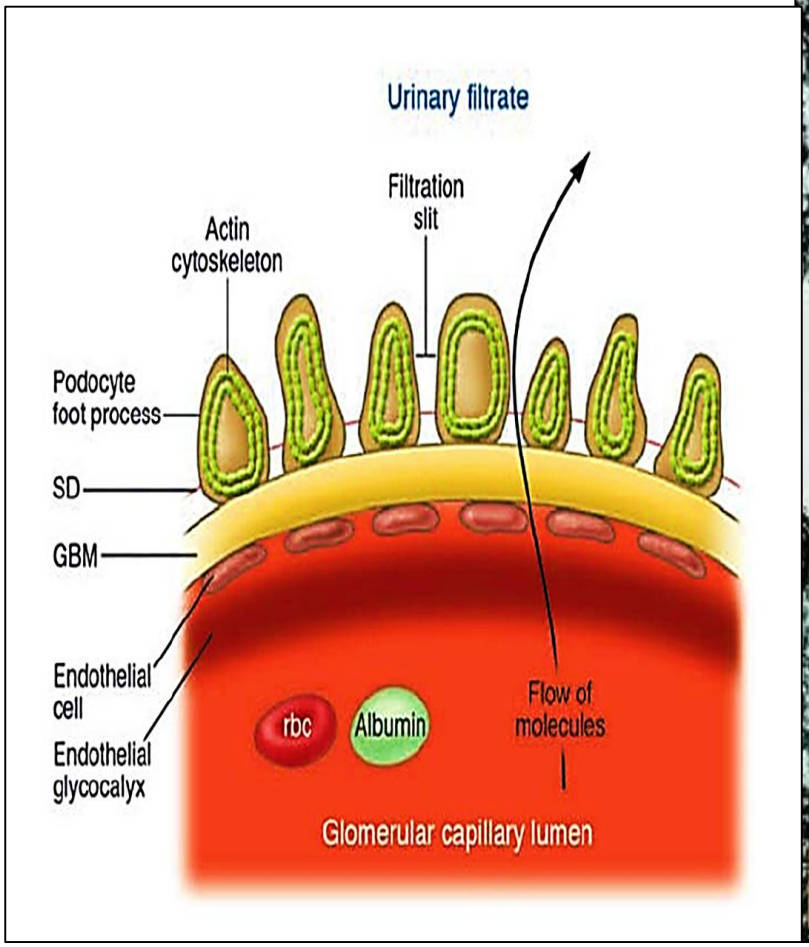
- Forming minute spaces in-between called **filtration slits** closed by semipermeable diaphragm (10- 40 nm)
- they comprise the main filtration barrier in the glomerulus they also express vit D receptors

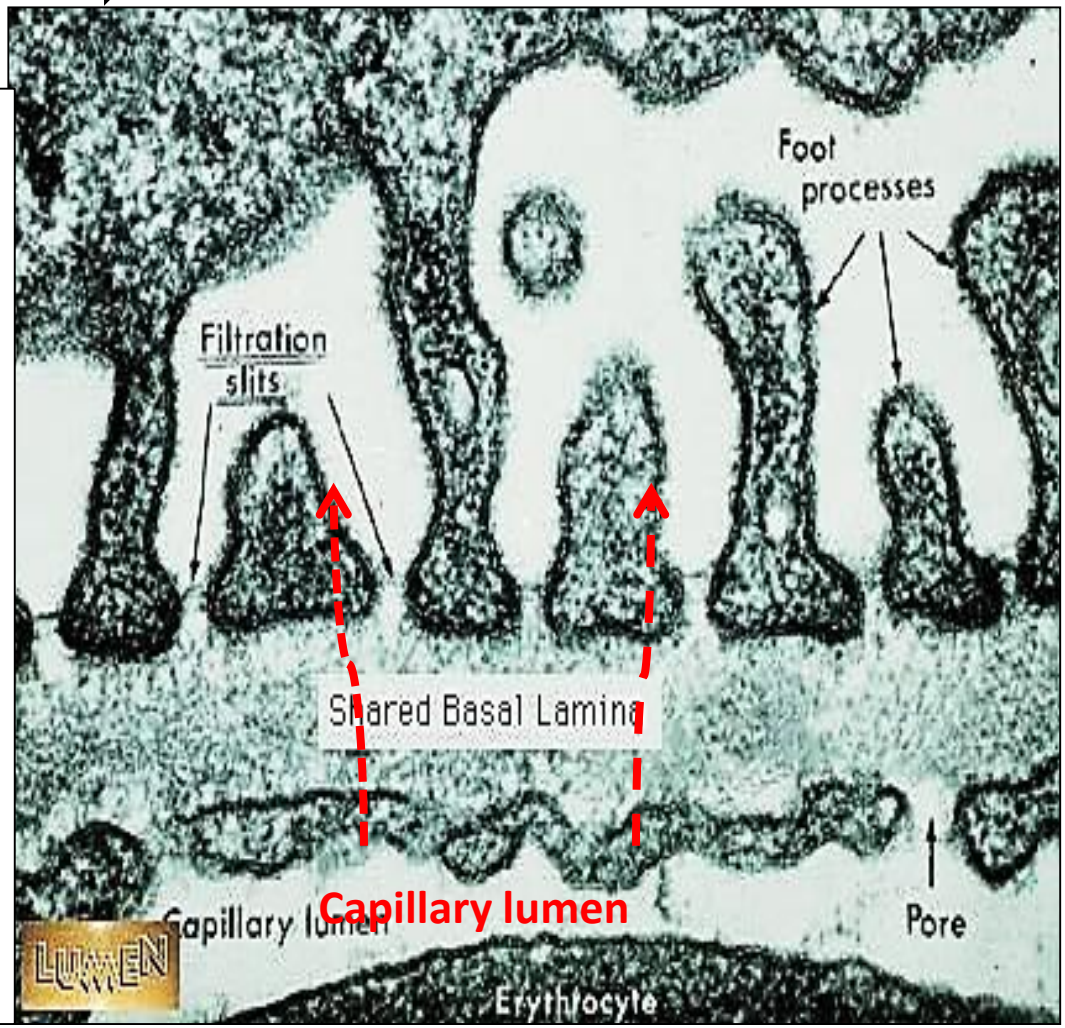




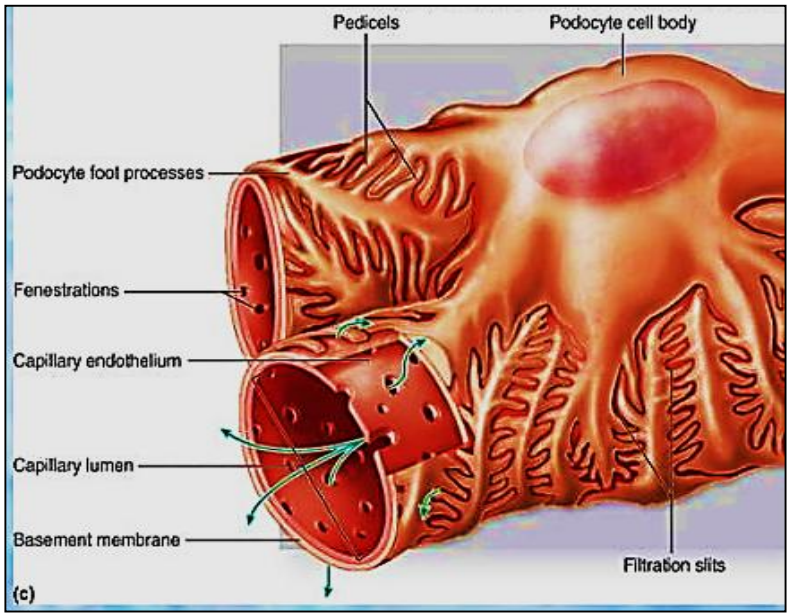


Filtration slits & slit diaphragm


Urinary filtrate
Filtration slit
Actin cytoskeleton
Podocyte foot process
SD
GBM
Endothelial cell
Endothelial glycocalyx
rbc
Albumin
Flow of molecules
Glomerular capillary lumen


Foot processes
Filtration slits
Shared Basal Lamina
Capillary lumen
Pore
LUMEN
Erythrocyte

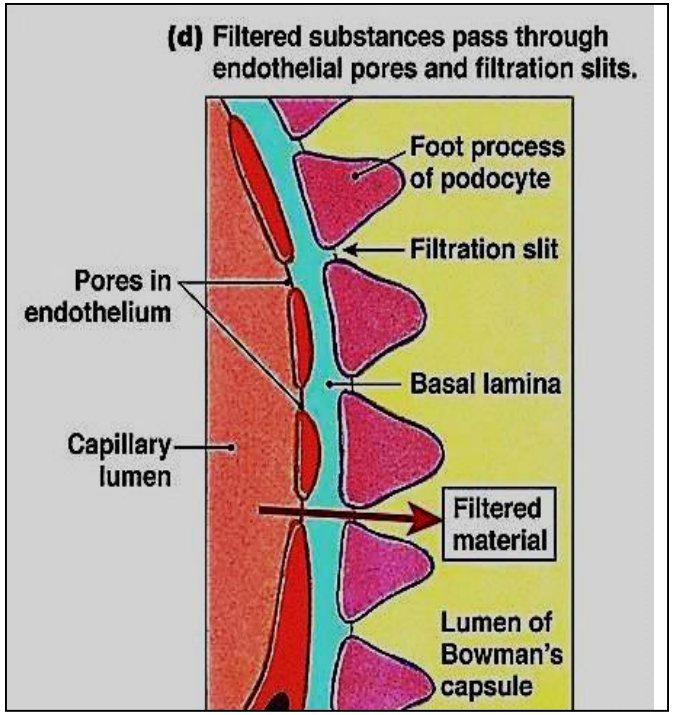
- The cytoplasm of Podocytes contains ↑free ribosomes, rER, Mitochondria , Golgi, **actin microfilaments** (contractility).



Function of podocyte:

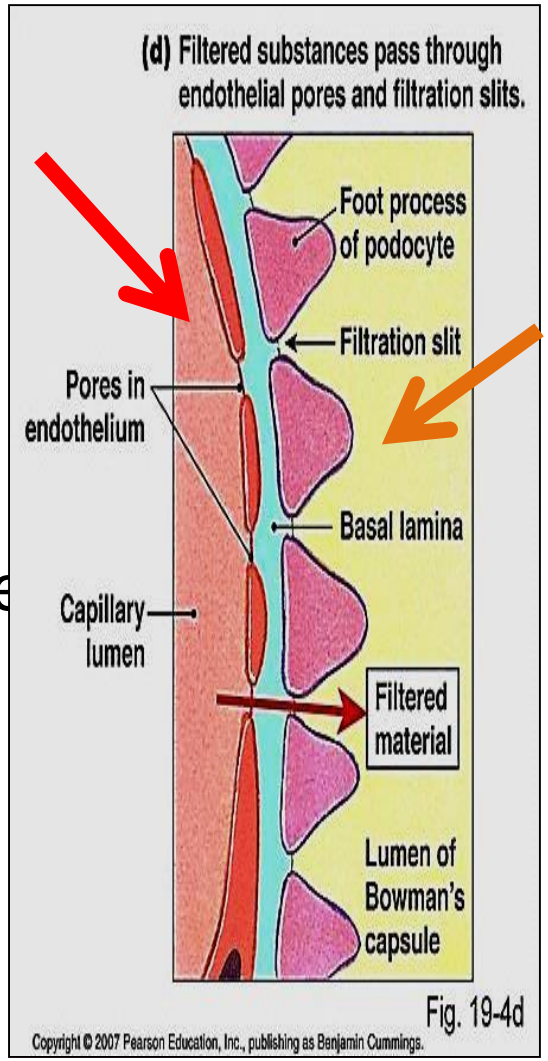
1- formation of blood renal barrier

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:

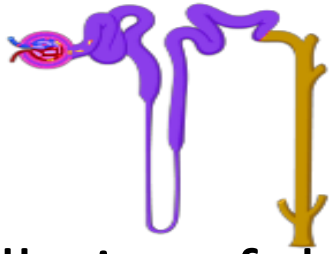
1- Glomerular endothelium (**fenestrated**)

2- Basement m. shared between Podocytes

& endothelial cells (continuous & -ve charge

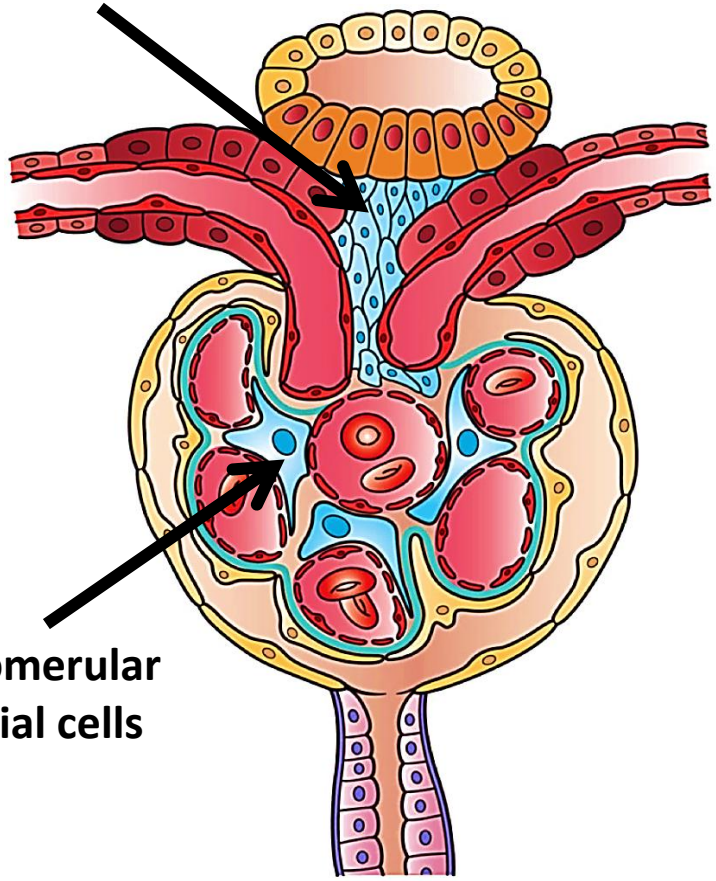
3- Filtration slit diaphragms

Mesangial cells



- Specialized cells found around glomerular capillaries of the kidney

- They are 2 types:



1- Intra -glomerular :

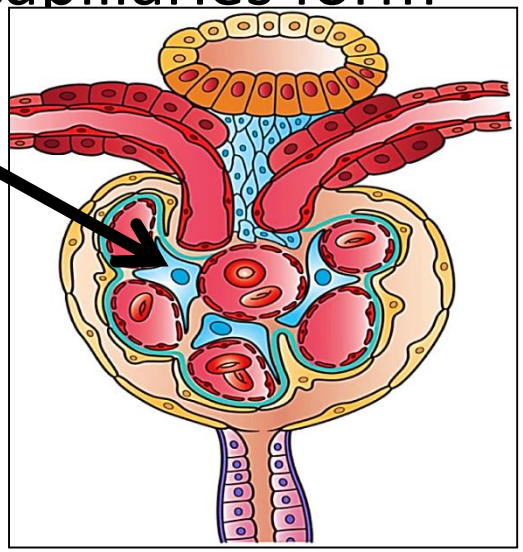
located along glomerular capillaries within renal corpuscle

2- Extra-glomerular (Lacis cells) :

located at the vascular pole

Intra-glomerular mesangial cells:

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

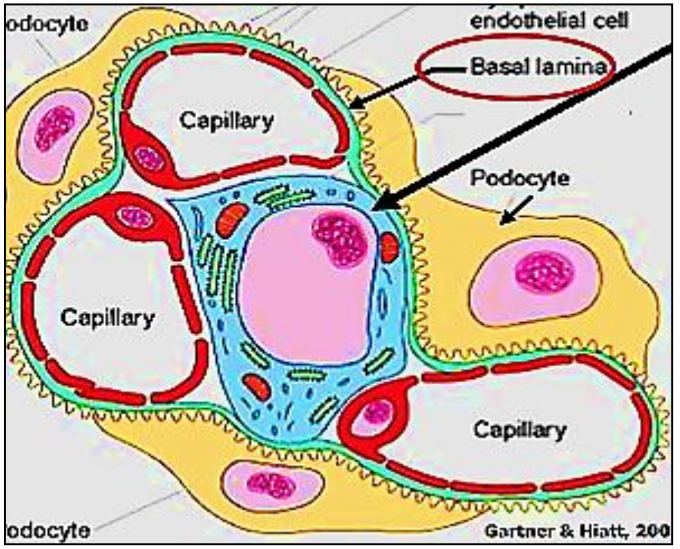


Function:

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

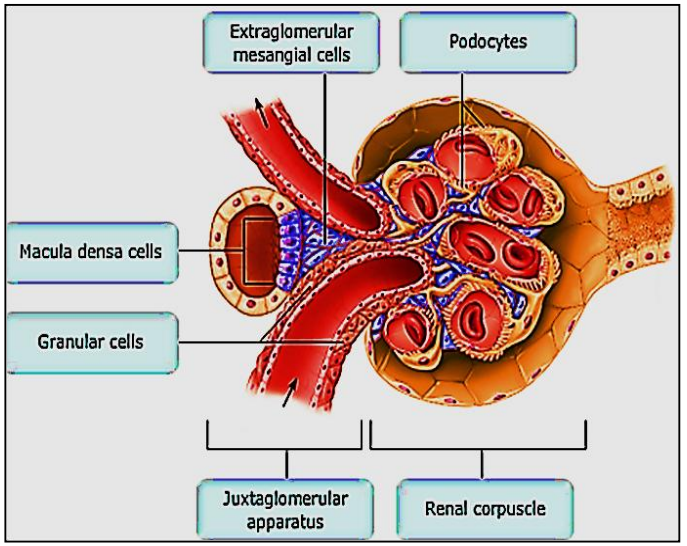
2- Structural support to glomerulus

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- Signal transmission. play Role in Renin-Angiotensin-Aldosterone system

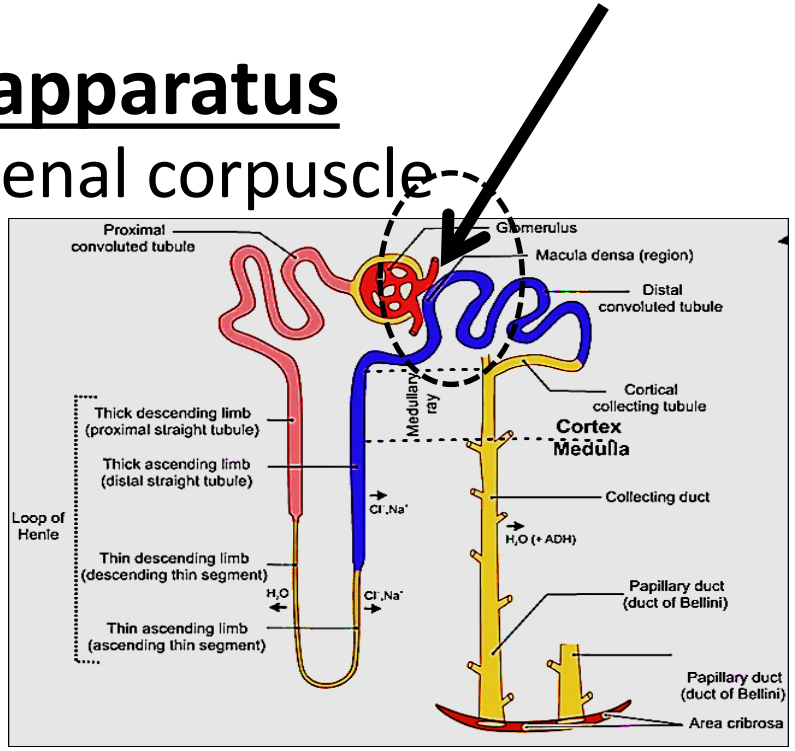
2- Part of **Juxta-glomerular apparatus**, together with macula densa & granular cells

3- may play role in secretion of erythropoietin Hormone.

These cells are Oxygen sensory. Main source of this H is **peritubular interstitial cells**

Juxtaglomerular apparatus

- Located at the vascular end of renal corpuscle



- **Consists of 3 components:**

1- *Macula densa*

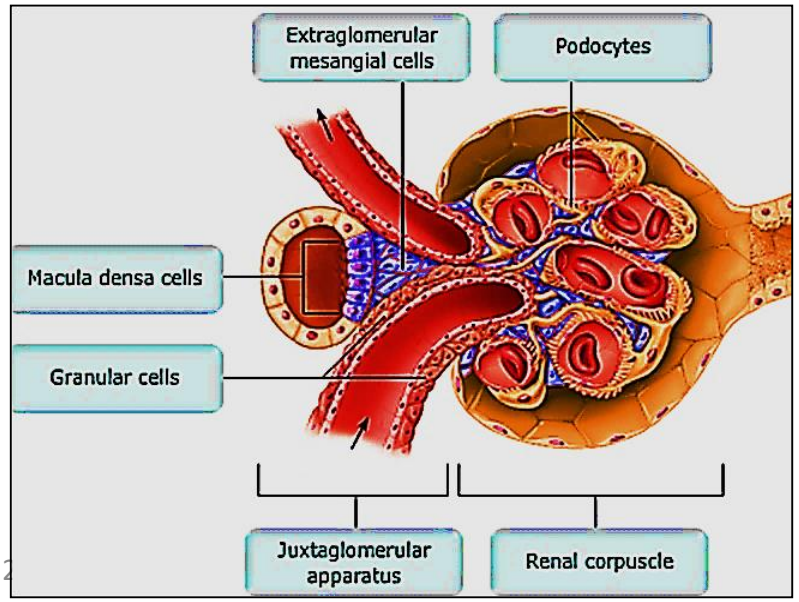
(lining of distal convoluted T.)

2- *Granular (juxtaglomerular)cells*

(wall of afferent arteriole)

3- *Lacis cells*

(Extra-glomerular mesangial cells)

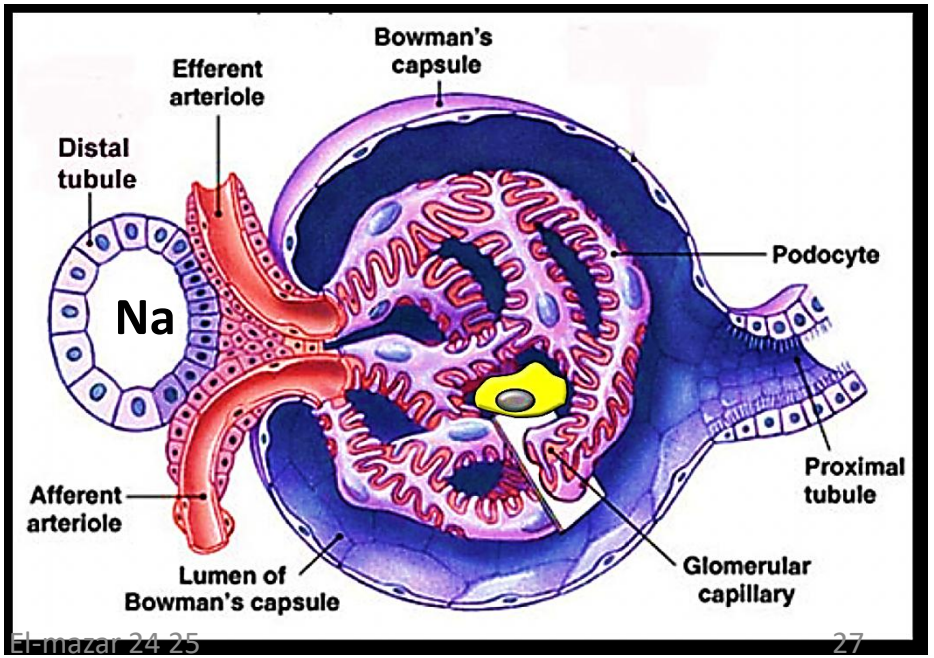


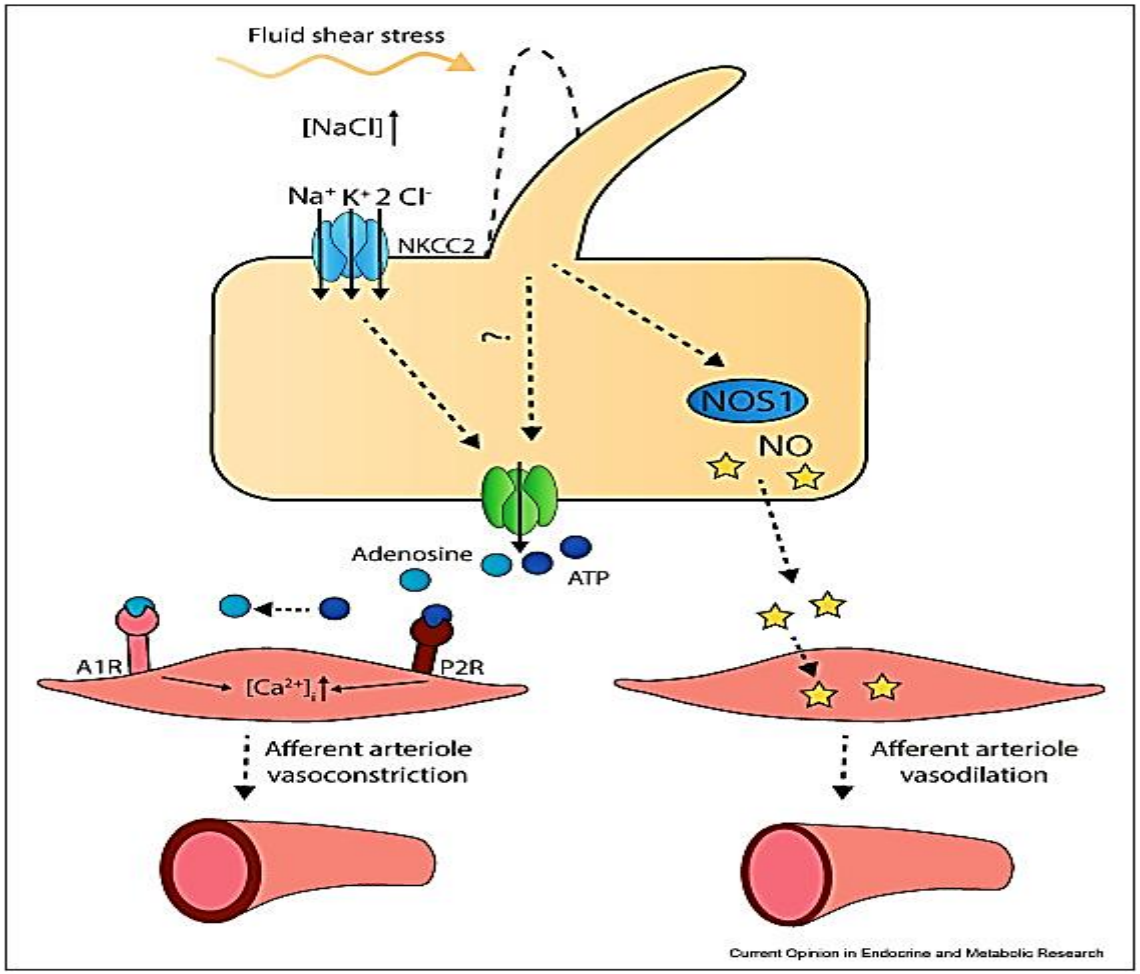
1- Macula densa (Nacl):

1. The part of **DCT** the fits between the aff. & eff. Arterioles Cells become tall columnar
2. The nuclei of cells become, deeply stained & closely packed appear as dark spots
3. 1ry cilia , single non motile project extend from their surface to detect any osmotic changes lumen

- **Function**:

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





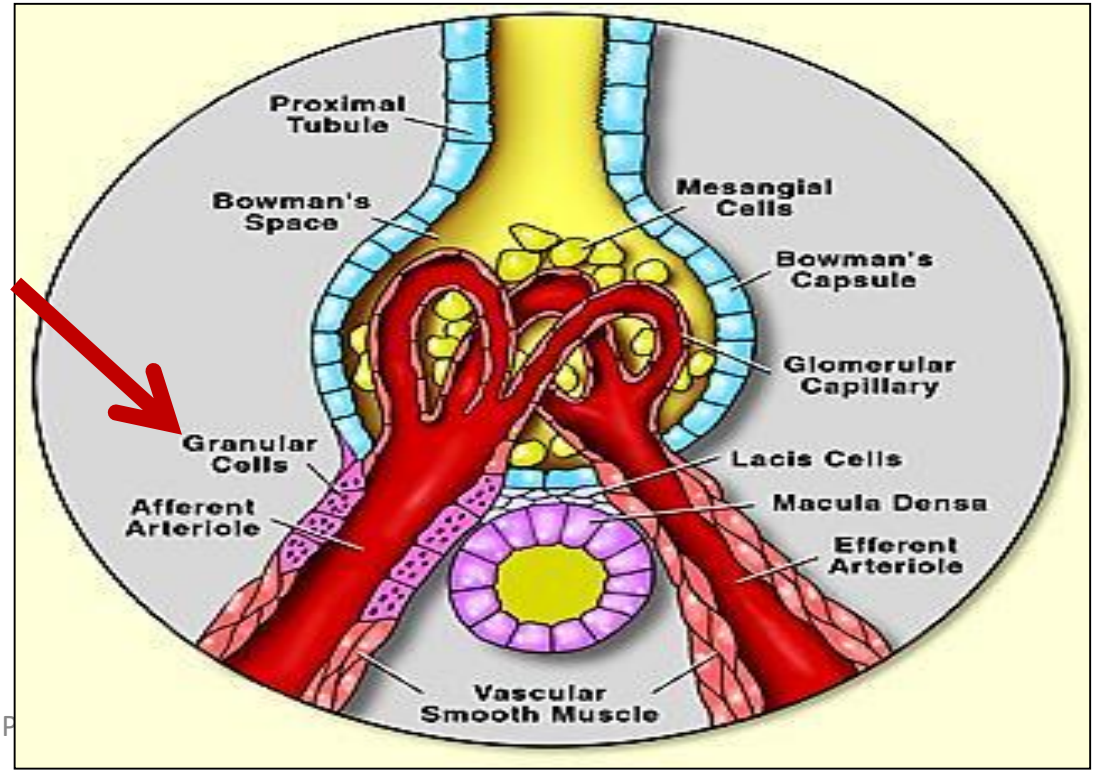
Osmoreceptors cells of macula densa

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**



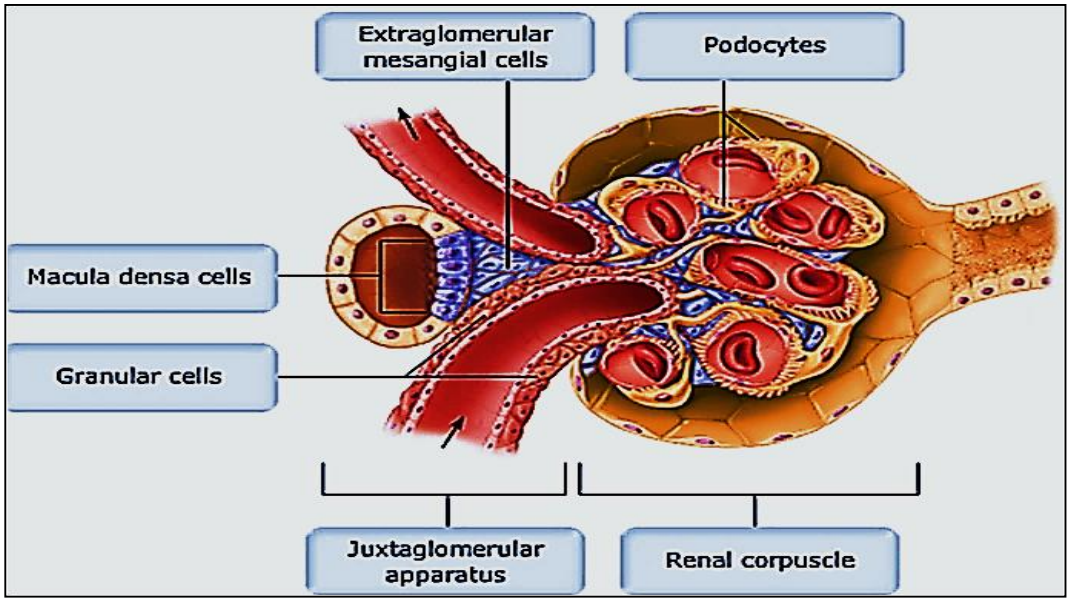
3- Extraglomerular mesangial cells (Lacis cells):

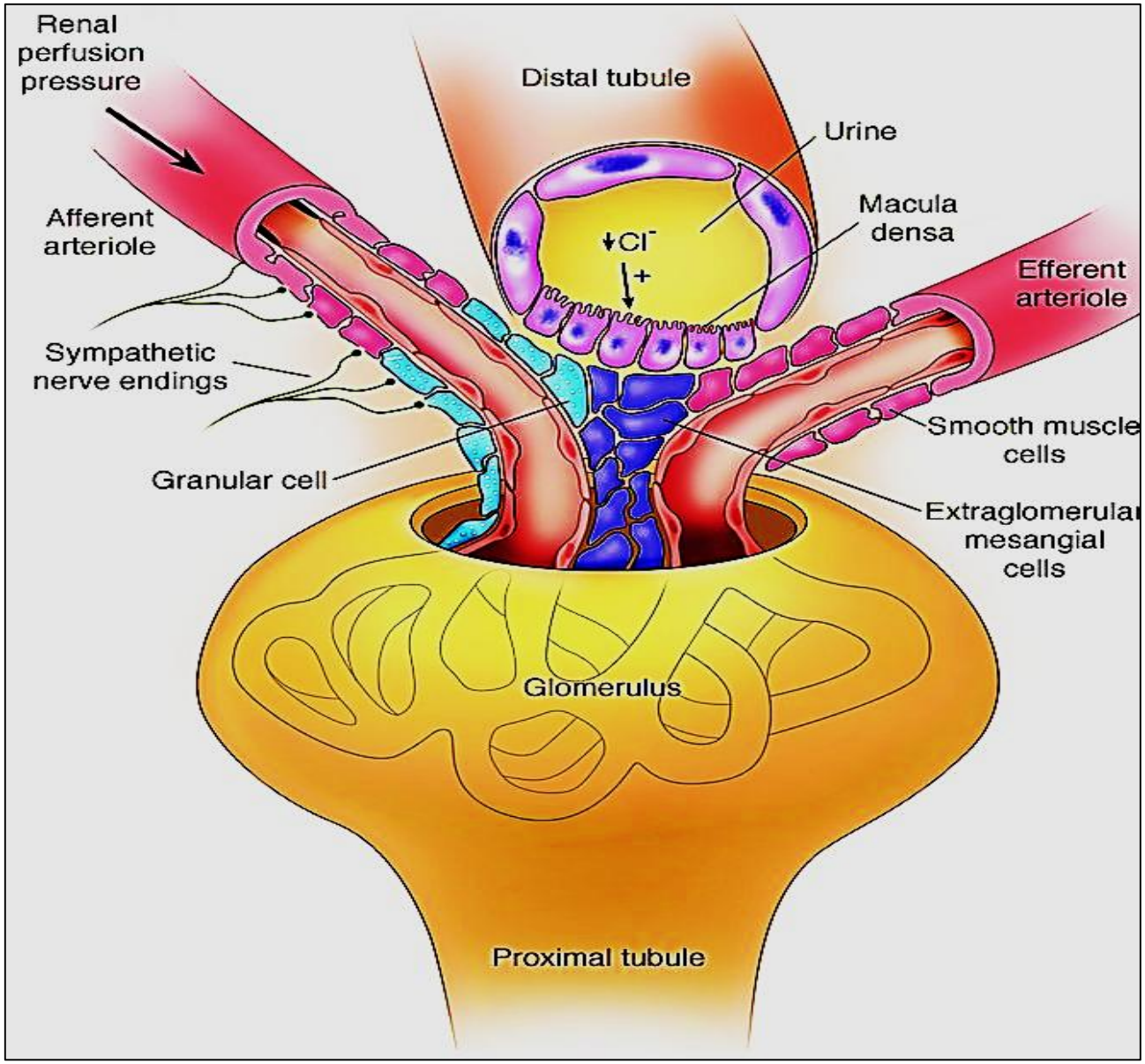
- Small pale stained cells occupy the space between the afferent arteriole, eff. arteriole & macula densa

Function:

a) Supportive

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

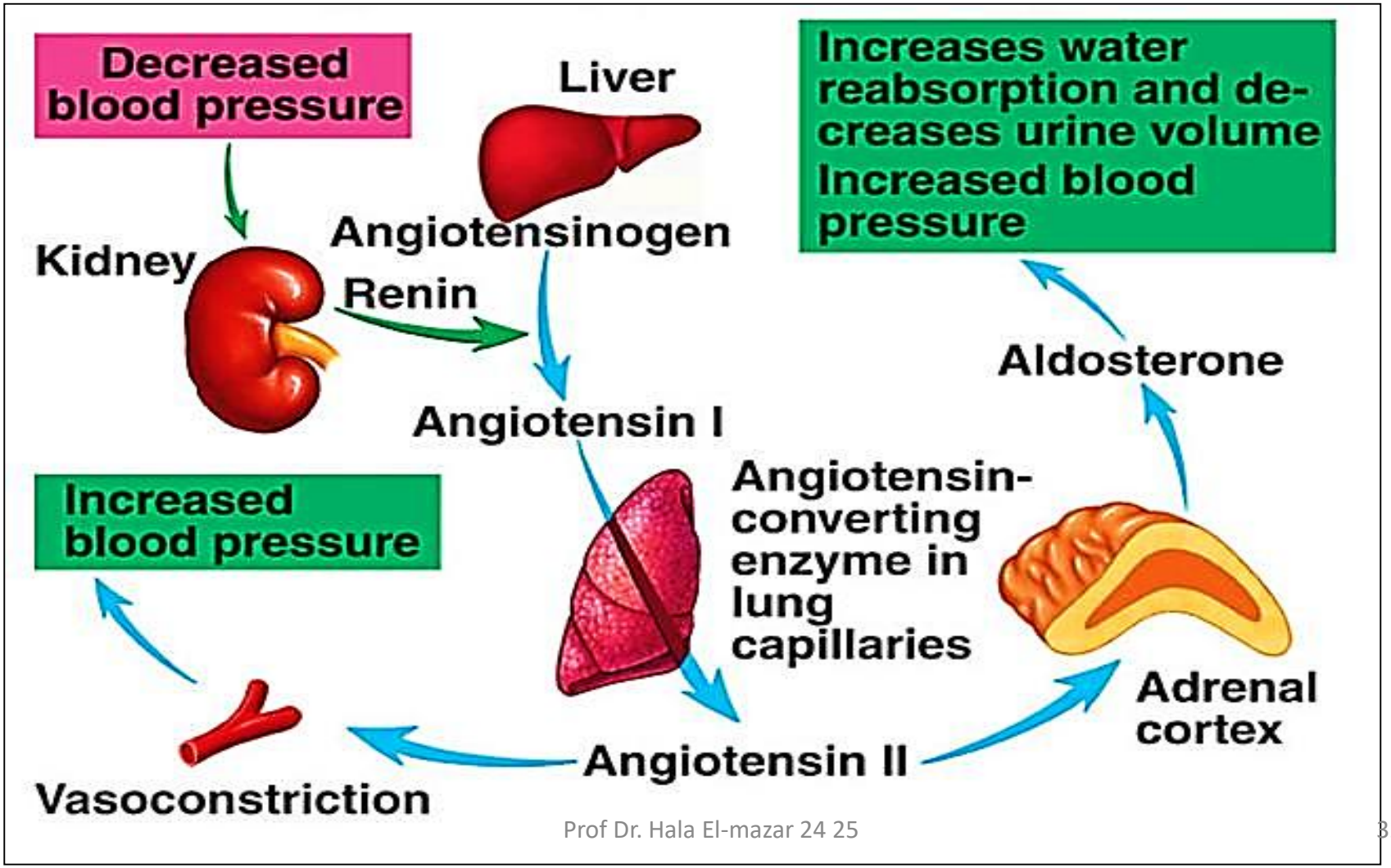




Juxta glomerular apparatus

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:

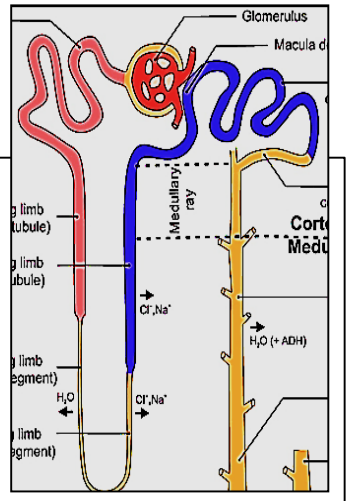
- potent vasoconstrictor
- ++ release of Aldosterone from adrenal cortex & ADH from posterior pituitary

➢ Aldosterone promotes reabsorption of Nacl by DCT

➢ ADH promotes water reabsorption from collecting tubules

Both will cause ↑ blood pressure

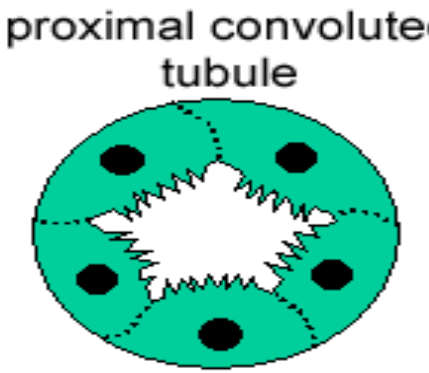
Proximal & distal convoluted tubules



PCT

Longer+ narrow lumen

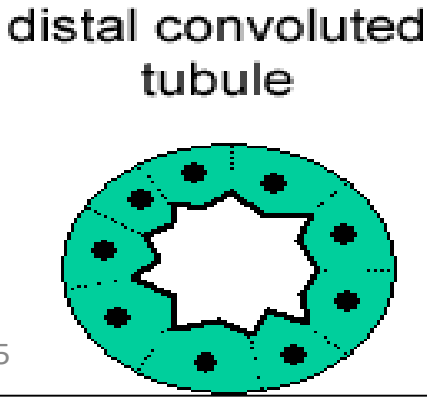
- Lined e 3-5 cells
- Ill-defined cell borders
- **apical brush border**
- **Reabsorption** of water (Na^+ pump), sugar , amino acids
- **Secretion** of some metabolites (penicillin , dyes, ammonia)
- Cells express Vit. D receptors



DCT

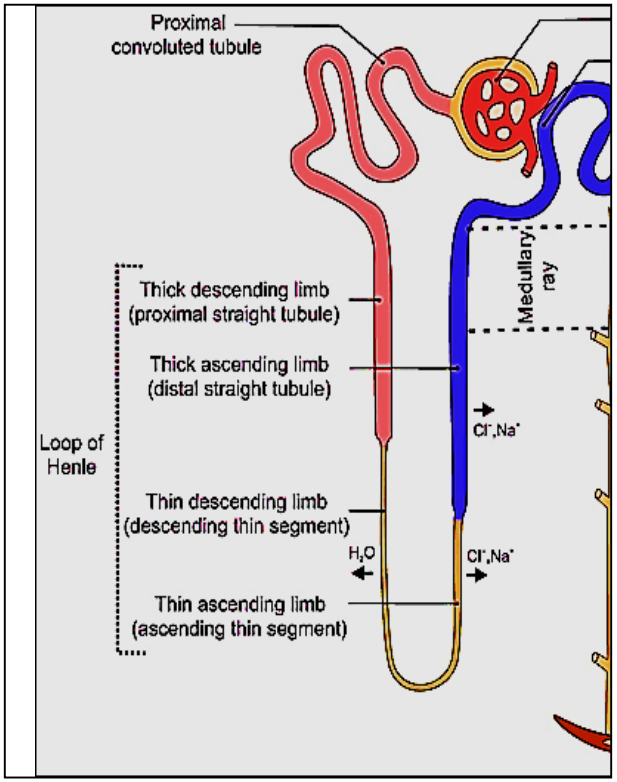
Shorter + wide lumen

- Lined e 5-8 cells
- clear cell borders
- **No brush border**
- Reabsorption of water under effect of Aldosterone
- Cells express Vit. D receptors



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

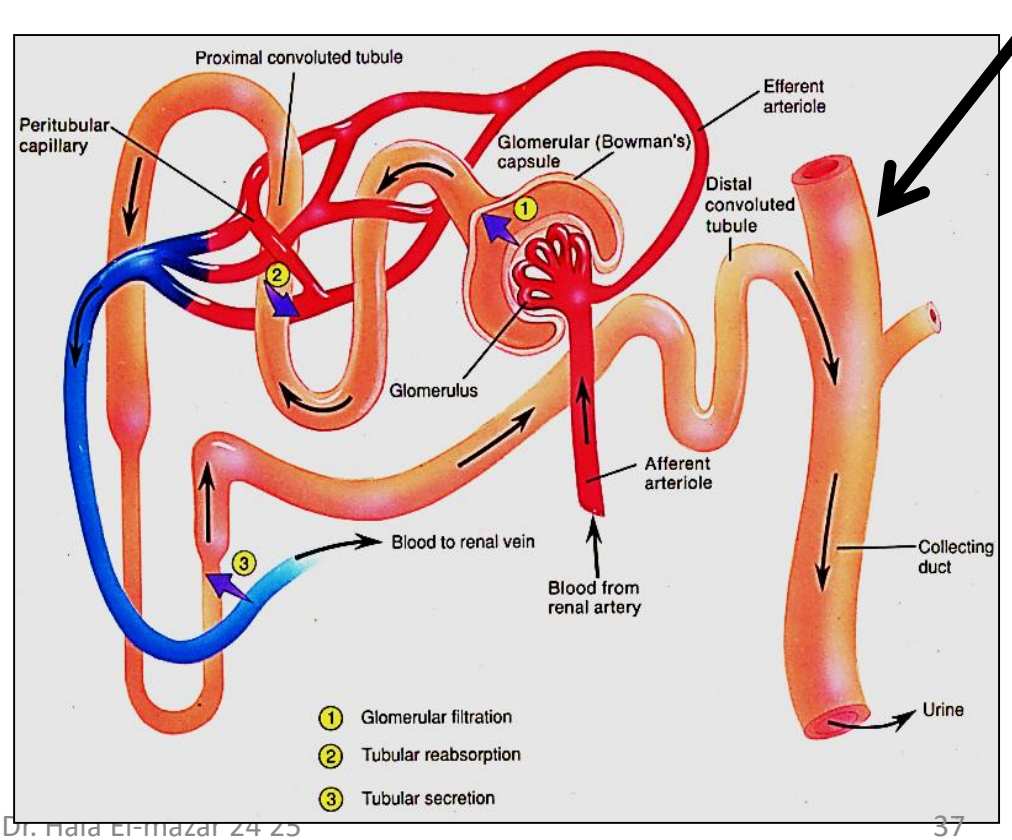
- The excretory portion of renal tubules, under **ADH**

- Lined with simple cuboidal epithelium. Each 6-8 collecting ducts drain into →tips of medullary pyramid

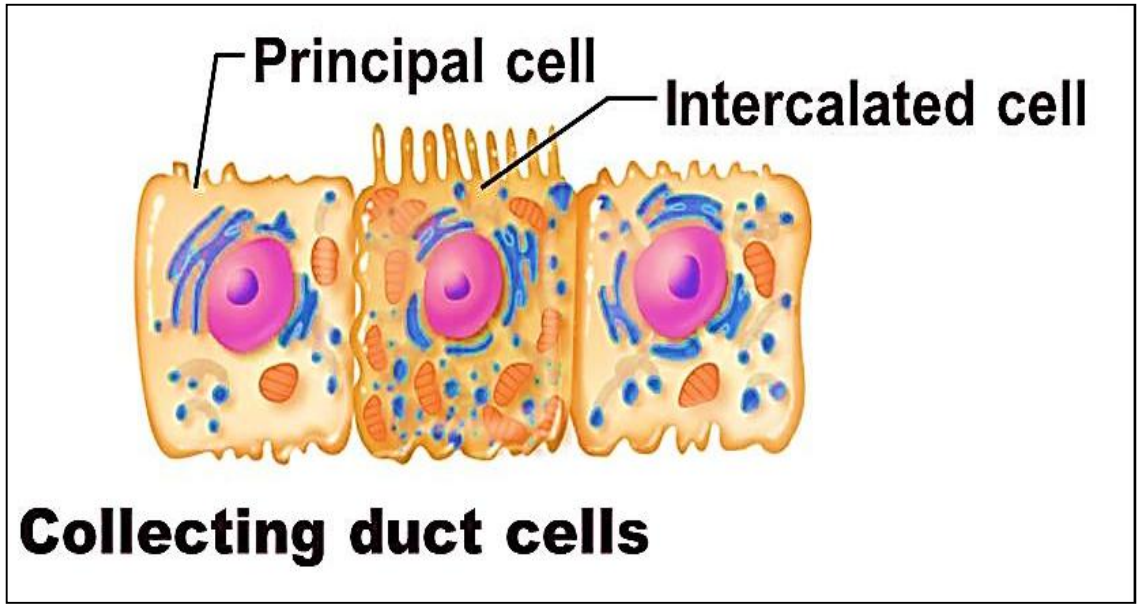
- 2 types of cells line collecting tubules

a) Principle cells

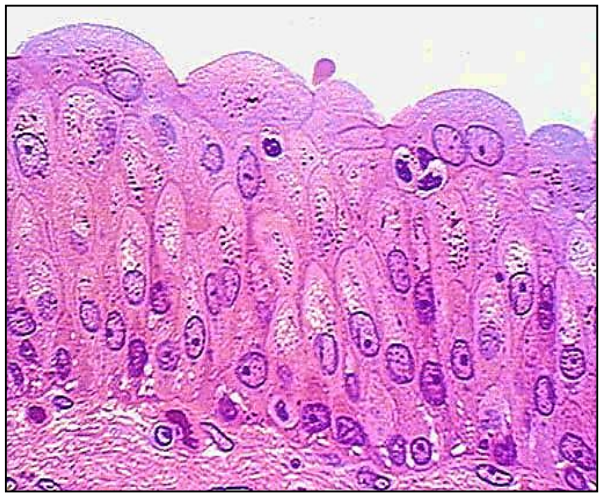
b) Intercalated cells



Principle cells	Intercalate cells
• Numerous • **Very sensitive to ADH →** • Responsible for the ability of collecting tubules to **concentrate urine** • **Reabsorbe water** • Reabsorb Na & secrete K	• 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 - Musculosa – adventitia

Mucosa:

Transitional epithelium + CT lamina propria

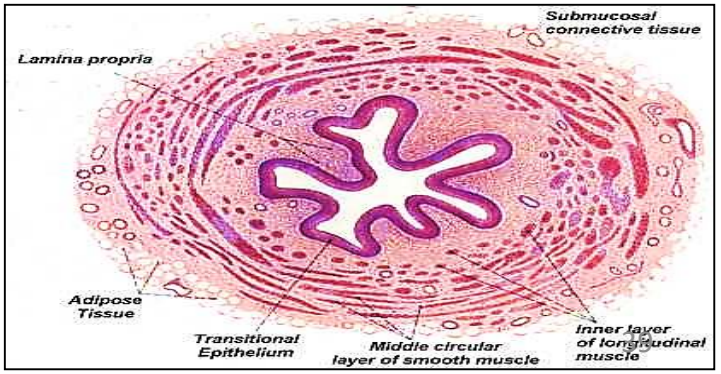
Musculosa:

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.)

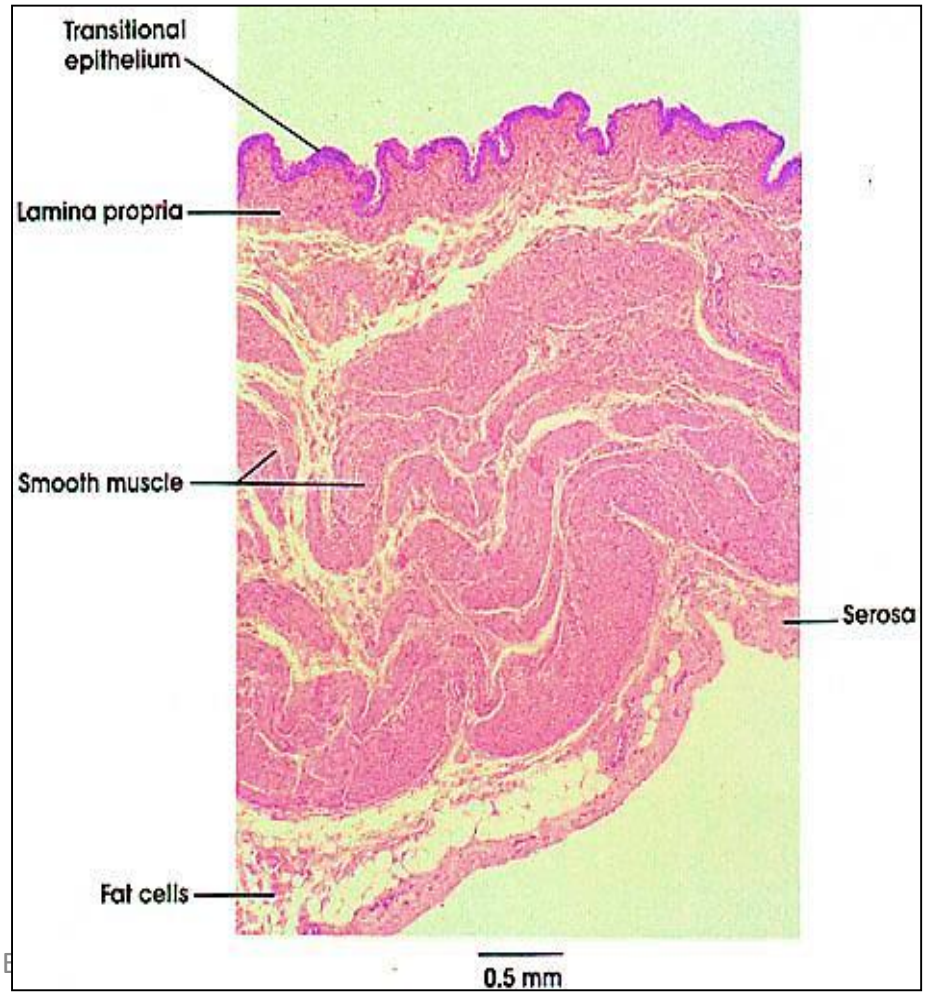
At the neck of bladder ,

the *middle circular* form→

internal urethral sphincter

serosa:

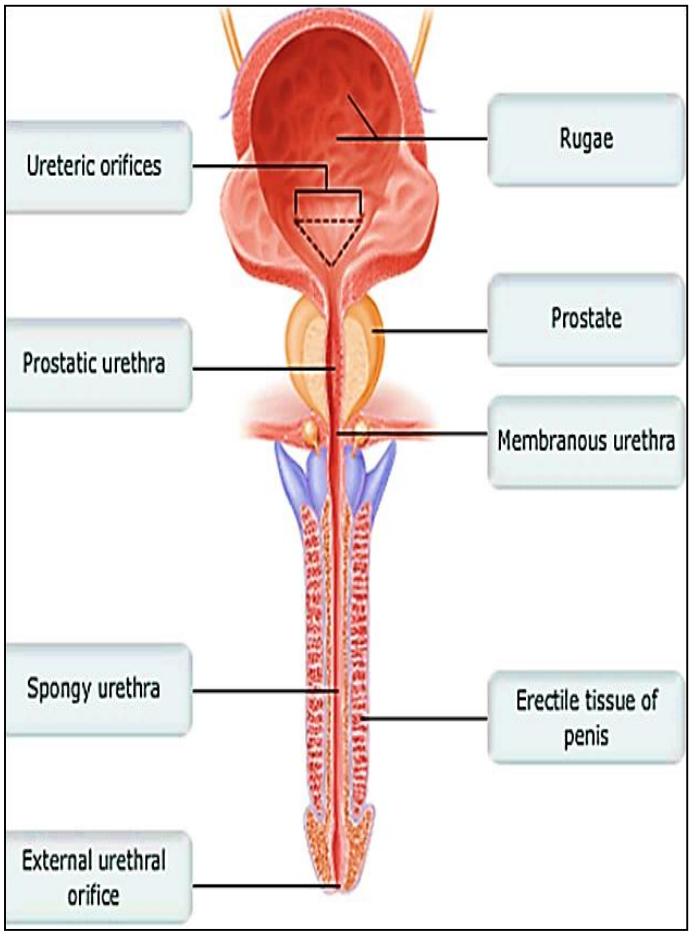
Loose areolar CT



urethra

A-Male urethra

Prostatic – membranous – penile



Prostatic urethra:

- Lined e **transitional** epithelium

Membranous urethra:

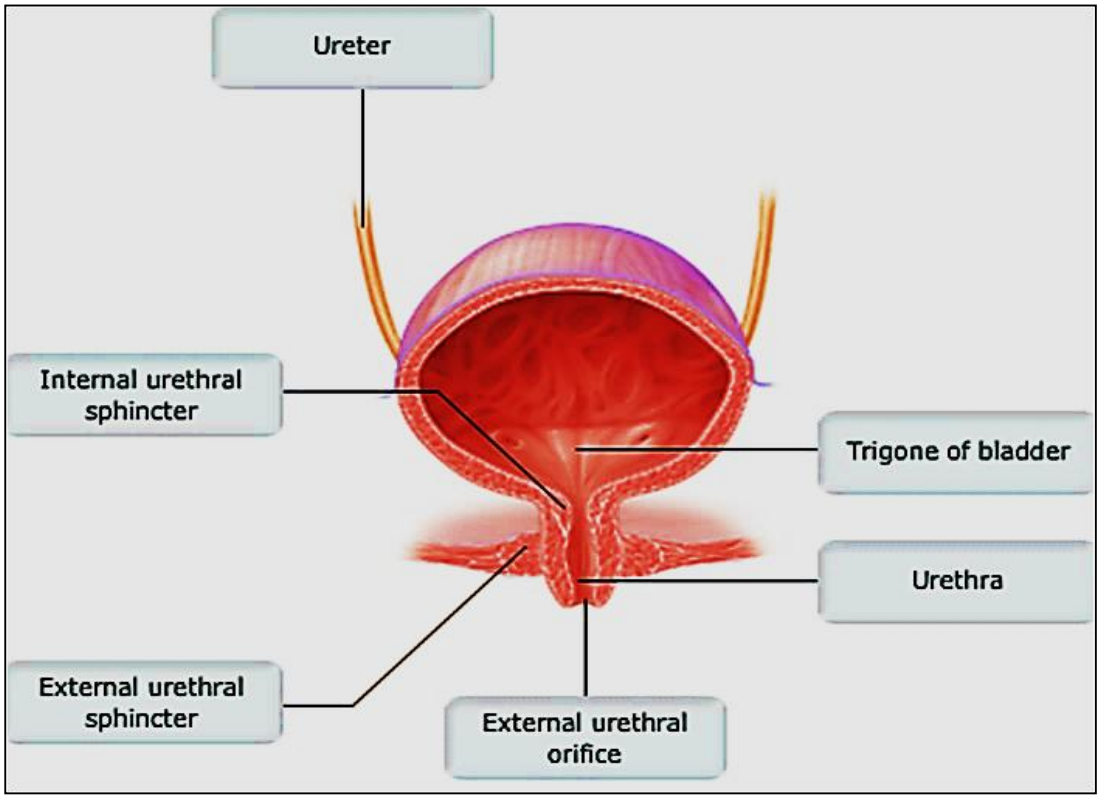
- Lined e **stratified columnar** epithe

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