



University of Basra  
College of medicine

# The Urinary System

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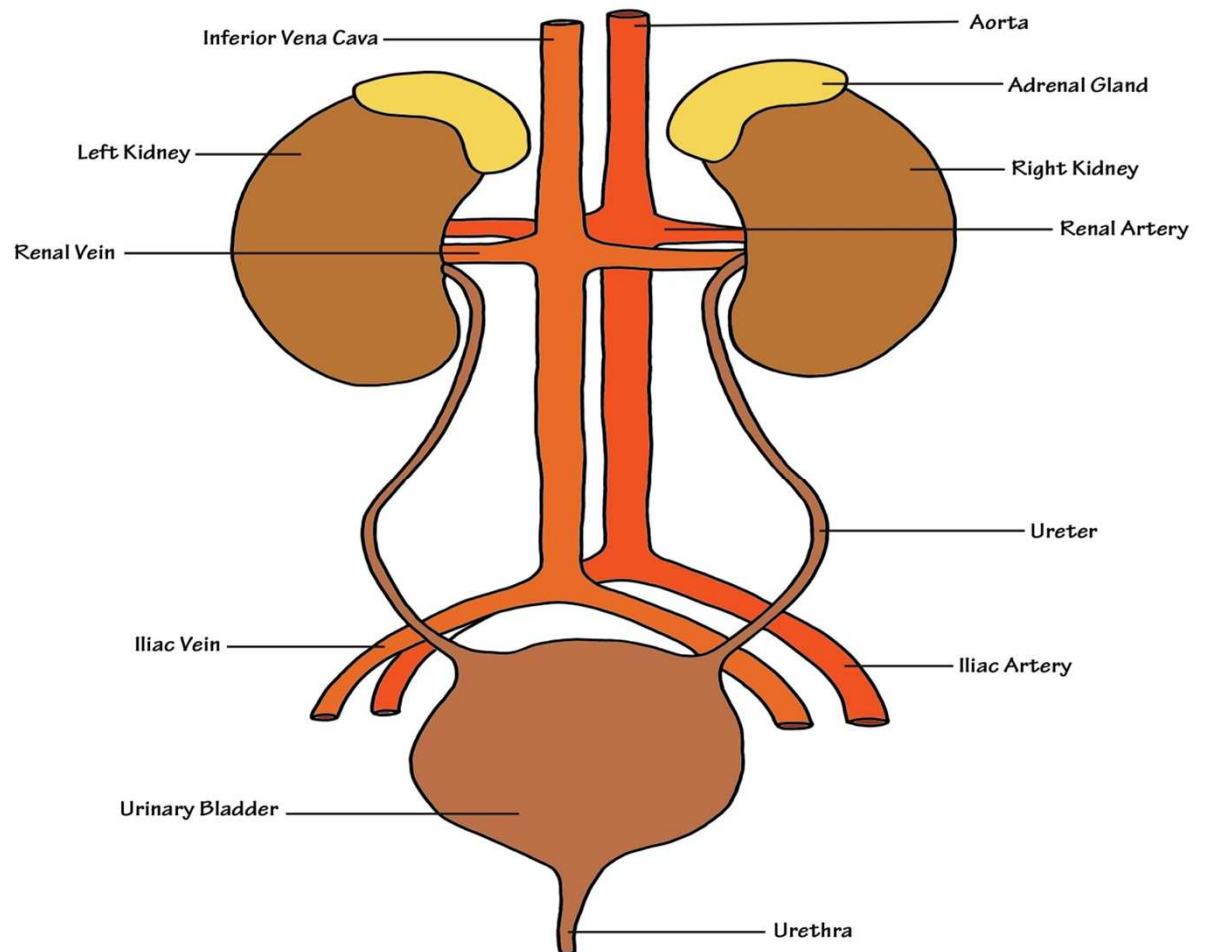
## Learning objective:

1. Structure and function and histological features of each component of the urinary system.
2. Blood filtration barrier.
3. Components of juxta-glomerular complex.

# The Urinary System

The urinary system consists of :

1. Paired kidneys.
2. Ureters.
3. Bladder
4. Urethra.



**Function** of this system:

- 1.Regulation of **water-electrolyte balance**, and **acid – base balance**.
- 2.Excretion of **metabolic wastes**.
- 3.Excretion of **bioactive** substances e.g many drugs.
- 4.Secretion of **renin**.
- 5.Secretion of **erythropoietin**.
6. Conversion of provitamine D to the active form of **vitamine D** (1,25 dihydroxyvitamin D)
- 7.**Gluconeogenesis**.

# 1. The kidney:

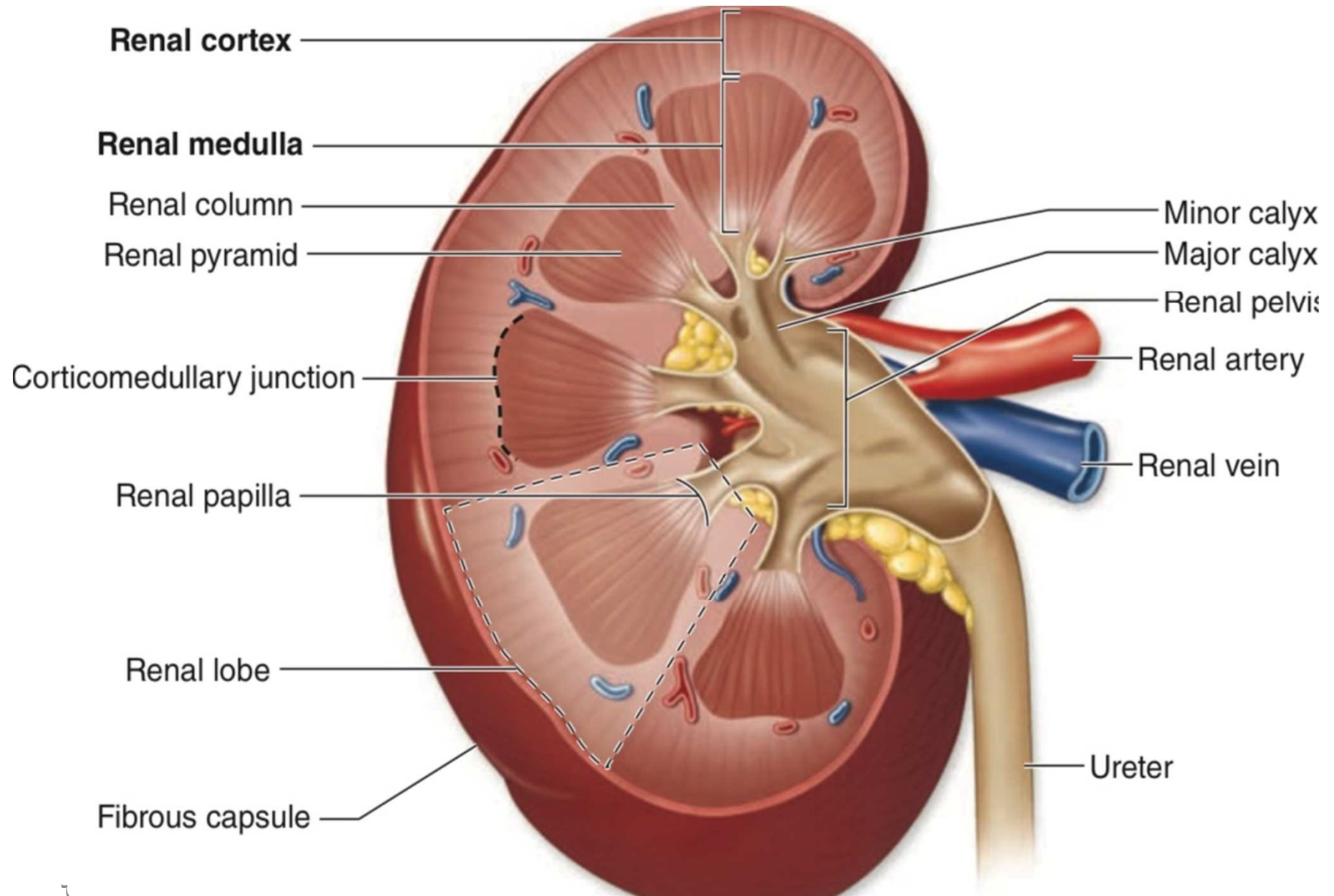
. It is a bean shaped organ with a 12 cm long , 6 cm wide ,2.5 cm width in adult.

. It has a concave medial border -**hilum**- where the nerves and blood vessels enter, ureter and blood vessels exit. And a convex lateral border.

. Within the hilum, the upper end of the ureter expand to form the **renal pelvis**, and divide into 2 or 3 **major calyces** , smaller branches - **minor calyces** - arise from each major calyx.

. The area around the renal pelvis and calyces are surrounded by **adipose tissue**.

# Structure of kidney



.The parenchyma of each kidney has an outer renal **cortex** , a darker stained region with many round corpuscles and tubule cross sections, , and an inner renal **medulla** consisting mostly of aligned renal tubules and ducts.

.The renal medulla consists of 8-15 conical structures called renal **pyramids**, all of their bases meeting the cortex( corticomedullary junction), and separated from each other by extension of cortex called renal **columns**.

Each pyramid plus cortical tissue at its base and extending along its sides constitute a renal **lobe**.

The tip of each pyramid – **renal papilla**- project into the minor calyx that collects urine formed by tubules in one renal lobe. Each kidney has 1-4 million functional units called **nephrons** , each consists of :

- 1. Renal corpuscle:** an initial dilated part enclosing a tuft of capillary loops and the site of blood filtration always located in the cortex.
- 2. Proximal tubules:** long convoluted , located in the cortex, with short straight part that enter the medulla.



**3. Loop of henle** : lies in the medulla , it has :

a. thin **descending** limb.

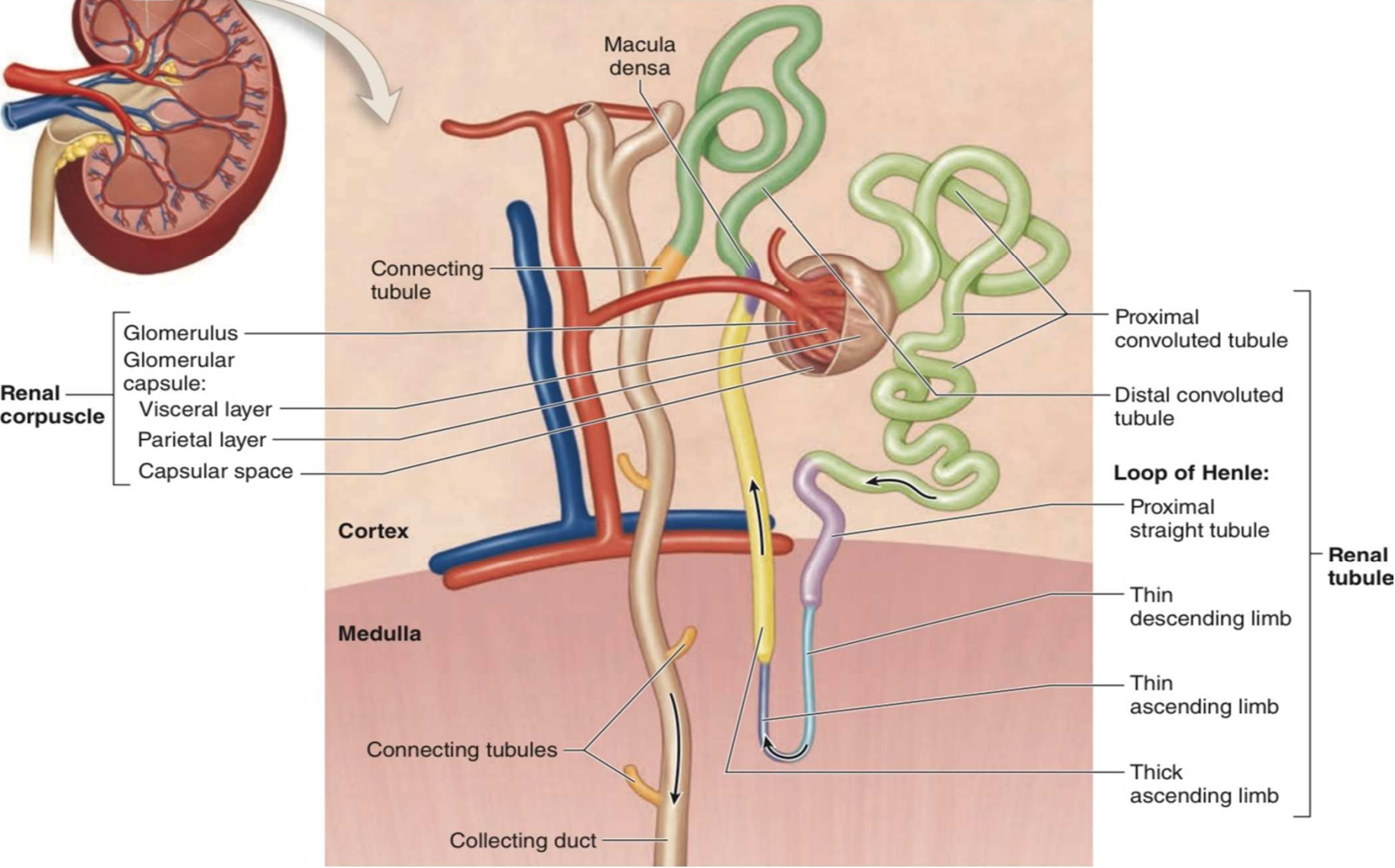
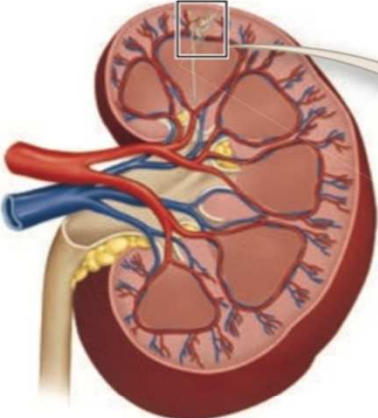
b. thin **ascending** limb.

**4. Distal tubule** : thick straight part extend from the loop of henle back into the cortex and a convoluted part completely in the cortex.

**5. Connecting tubules**: a short minor part linking the nephron to collecting ducts.

.Connecting tubules from several nephrons merge to form **collecting tubules**, that then merge as larger **collecting ducts** that converge in the renal papilla where they deliver urine to the minor calyx.

# A nephron and its parts



# Blood circulation of the kidney

.Renal vasculature is a large, well organized and closely associated with all the elements of the nephron.

.Each kidney **renal artery** divide into two **segmental** arteries at the hilum.

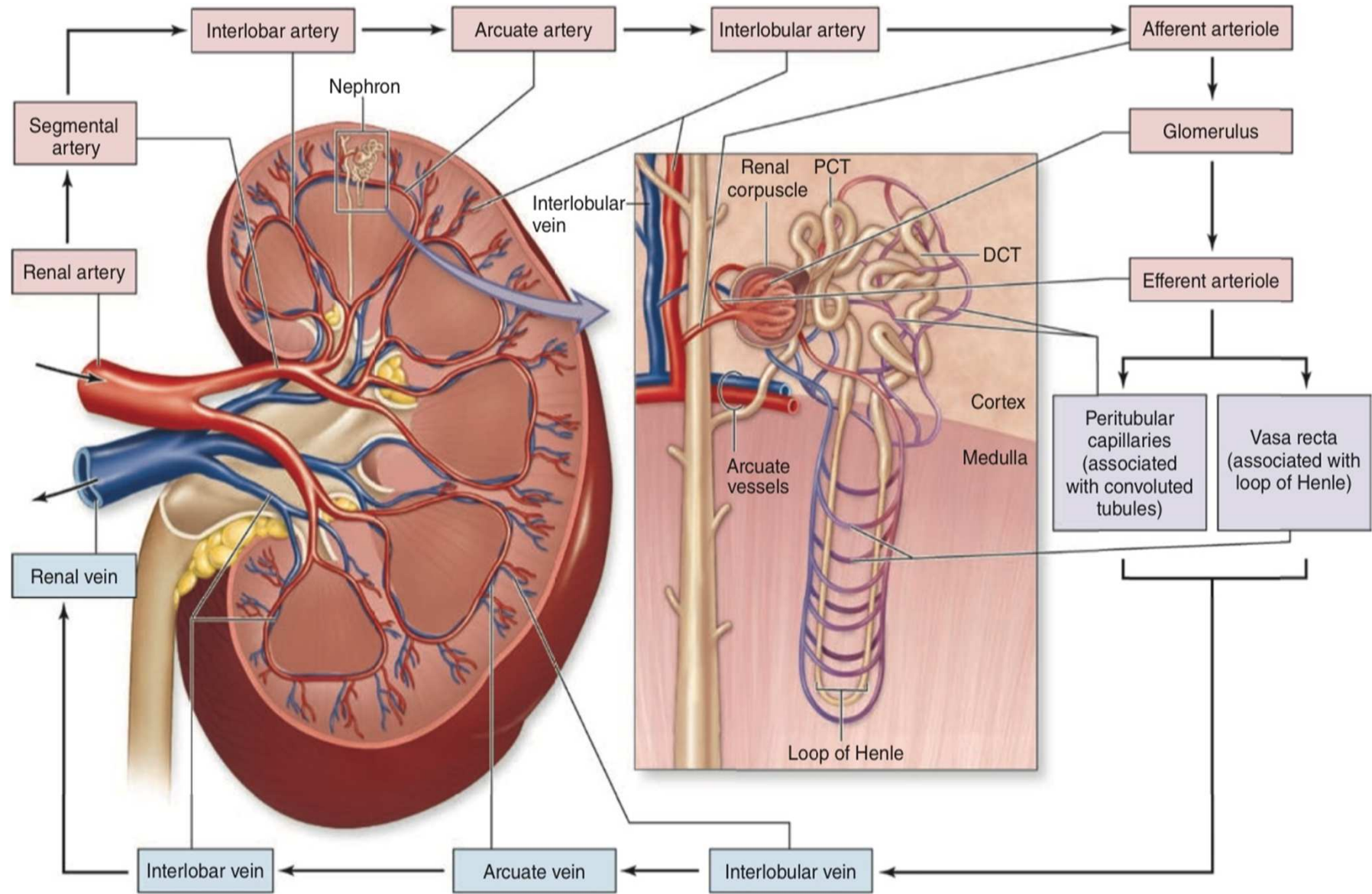
These will branch further into the **interlobar** arteries , which extend between the renal pyramids, they divide to form the **arcuate** arteries ( run at the base of each pyramid).

.Smaller **interlobular** arteries radiate from arcuate arteries. From the interlobular arteries arise the microvascular **afferent arterioles** that divide and form plexus of **capillary** loops - **glomerulus**- each located within a renal corpuscle.

.Blood leave the glomerulus via **efferent arterioles** , which branch again to form another capillary network - **peritubular capillaries**- distributed profusely in the cortex.

In The juxtaglomerular corpuscles near the medulla ,the efferent arterioles instead will form tassel-like bundles of capillaries called **vasa recta** ( penetrate deep in the medulla in association with collecting ducts and loop of henle).

# Blood supply of the kidney



# Renal function: filtration ,secretion and absorption

. All the major functions of the kidney – the removal of metabolic waste products and excess water and electrolytes from the blood - is performed by **specialized epithelial cells** of the nephrons and collecting system.

Renal function include the following activities:

**1. Filtration:** water and solutes in the blood leave the vascular system and enter the lumen of the nephron.

**2. Tubular secretion :** substances move from epithelial cells of tubules into the lumens.

**3. Tubular reabsorption :** substances move from the tubular lumen across the epithelium into the interstitium and surrounding capillaries.



# Renal corpuscles and blood filtration

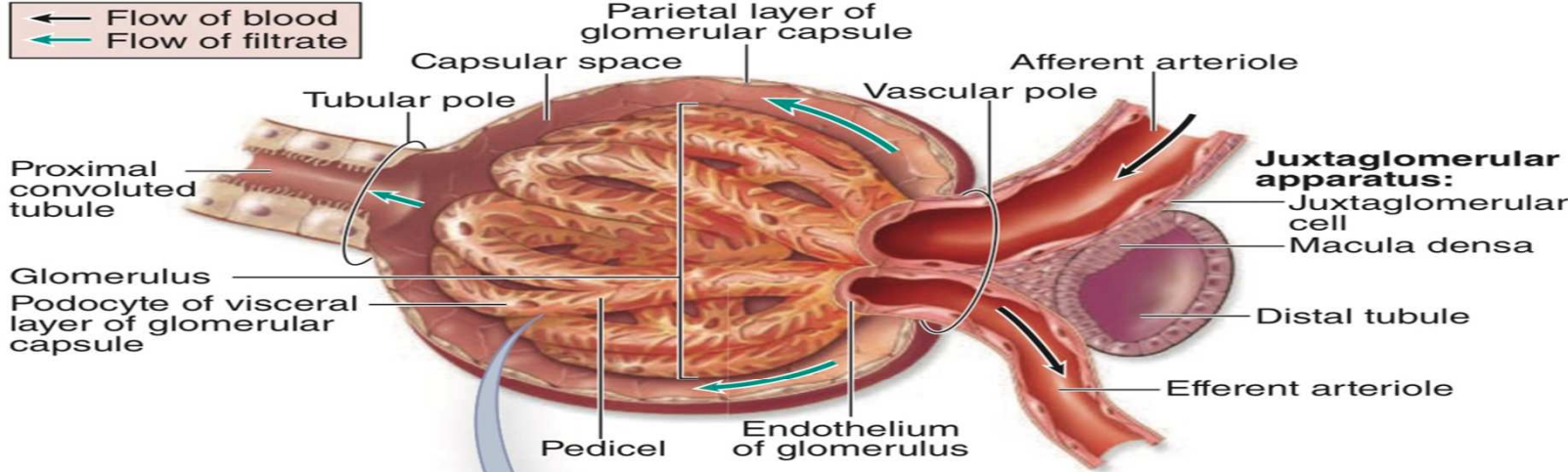
- . At the beginning of each nephron , a 200  $\mu\text{m}$  corpuscle, containing tuft of **glomerular capillaries** , surrounded by double walled epithelial capsule – **bowman capsule**-

.The **visceral layer** of the capsule closely envelop the glomerular capillaries , which are finely fenestrated.

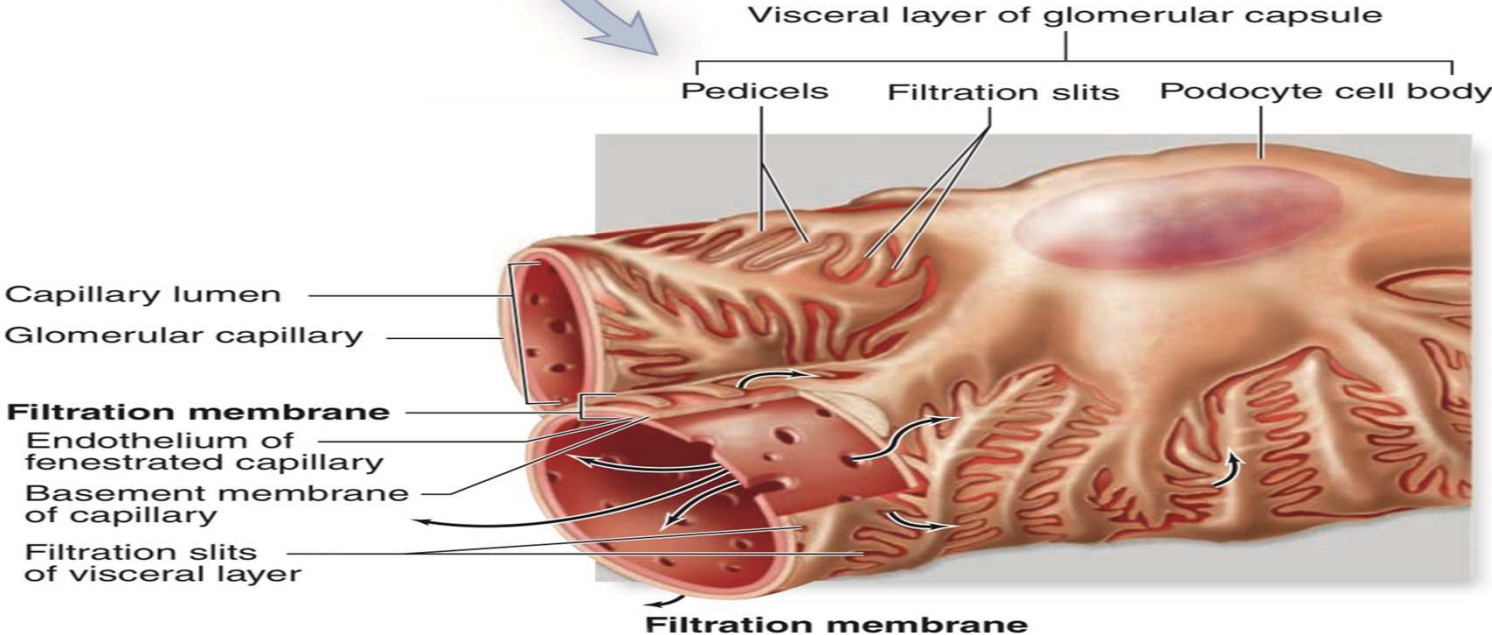
.The outer layer – **parietal layer** – form the surface of the capsule , between the two layers is the capsular ( urinary ) space , which receive the urine filtered through the capillary wall of the visceral layer.



# Renal corpuscle



## Renal corpuscle



Each corpuscle has a vascular pole and a tubular pole.

The **parietal layer** : consist of **simple squamous** epithelium , which change to simple cuboidal at the tubular pole.

The **visceral layer** : has unusual epithelial stellate cells -**podocytes** - together with the capillary endothelial cells compose the apparatus of the renal filtration.

. Each podocyte extend several primary processes , each of which give rise to many secondary parallel interdigitating processes ( **pedicels**) which cover most of the capillary surface. Between these pedicels , elongated spaces - **filtration slits**- form ( 25- 30 nm).

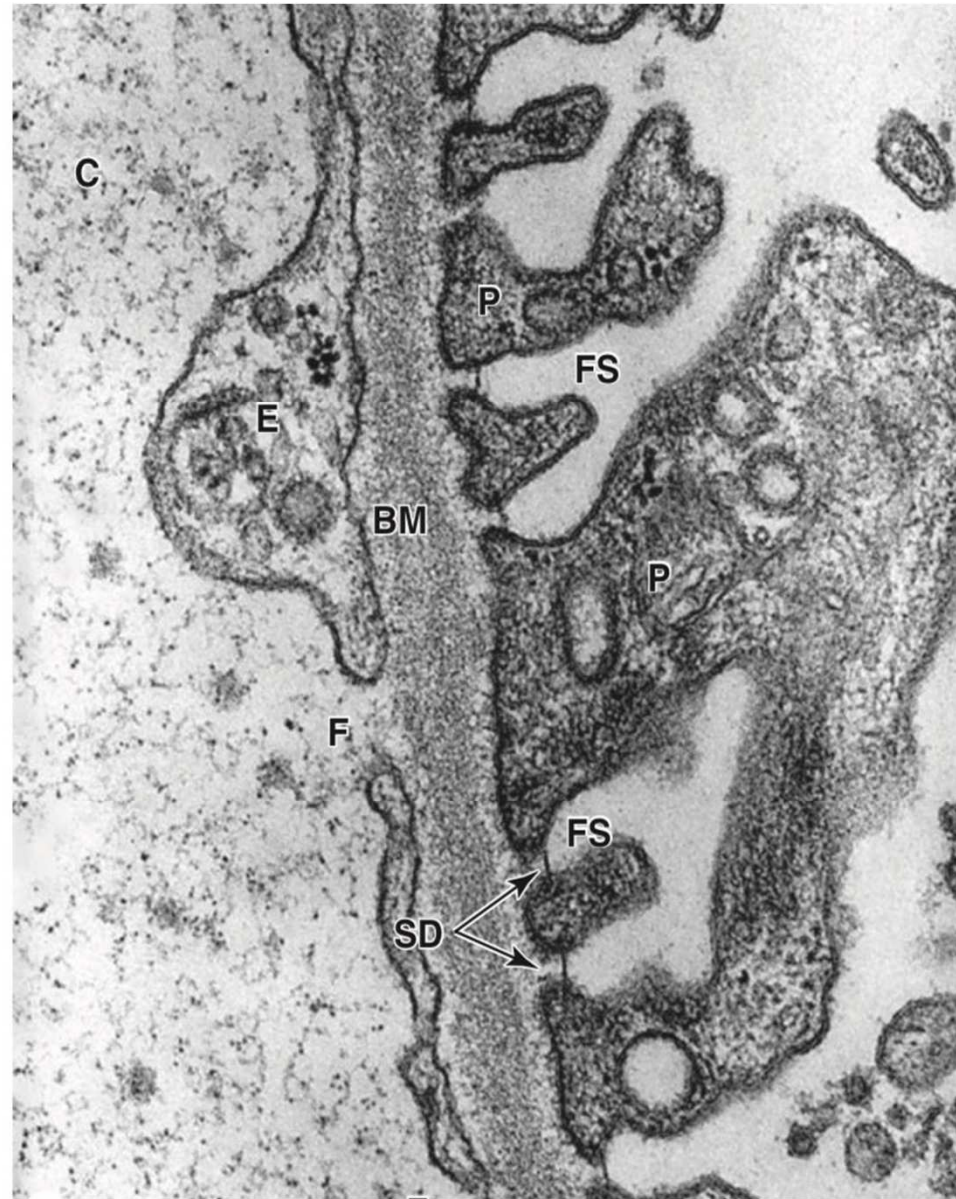
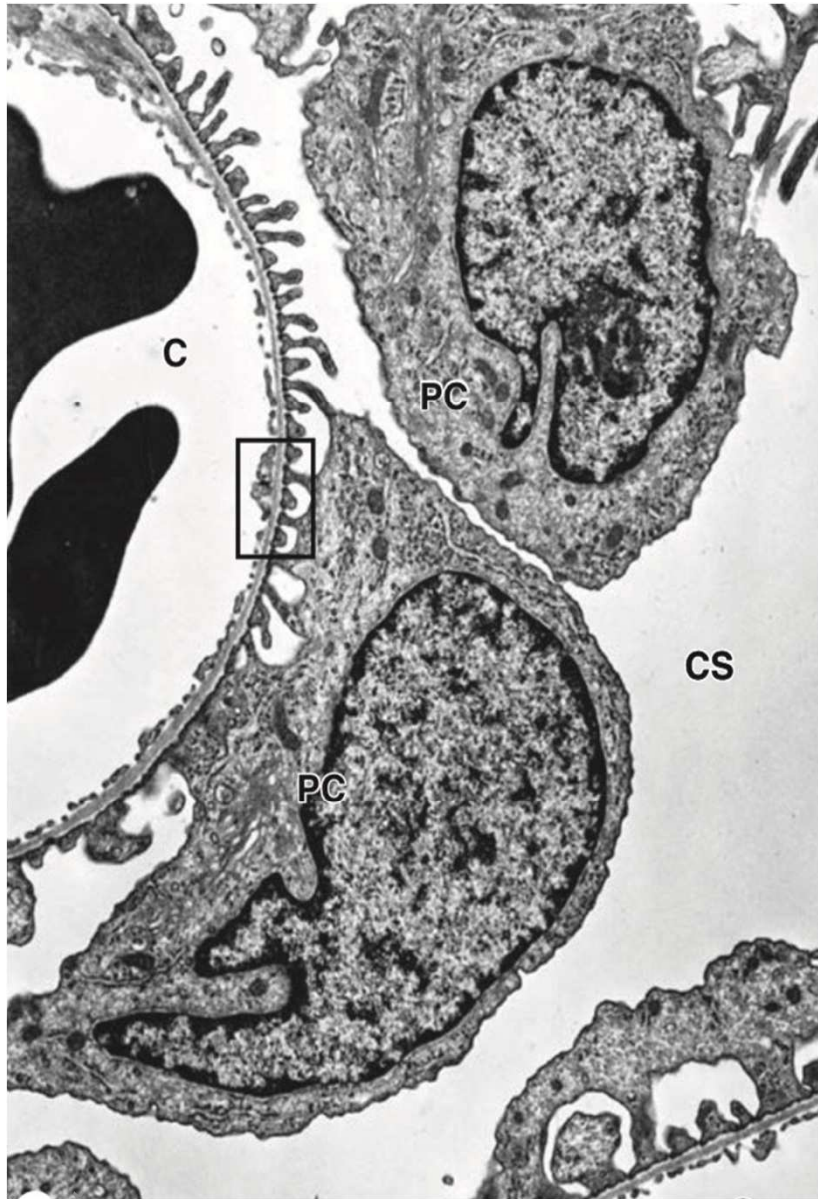
Bridging the slit pores are zipper like **slit diaphragms** ( tight junctions composed of nephrins and other proteins , glycoproteins and proteoglycans) projecting from the cell membrane of each side of the filtration slit.

Between the highly fenestrated endothelial cells of the glomerular capillaries and the covering podocytes is the thick glomerular basement membrane (**GBM**).

GBM is the most important part of filtration barrier that separate the blood and capsular space , and formed by fusion of the capillary and podocyte basal laminae.



An electron microscope image of the glomerular filtration barrier

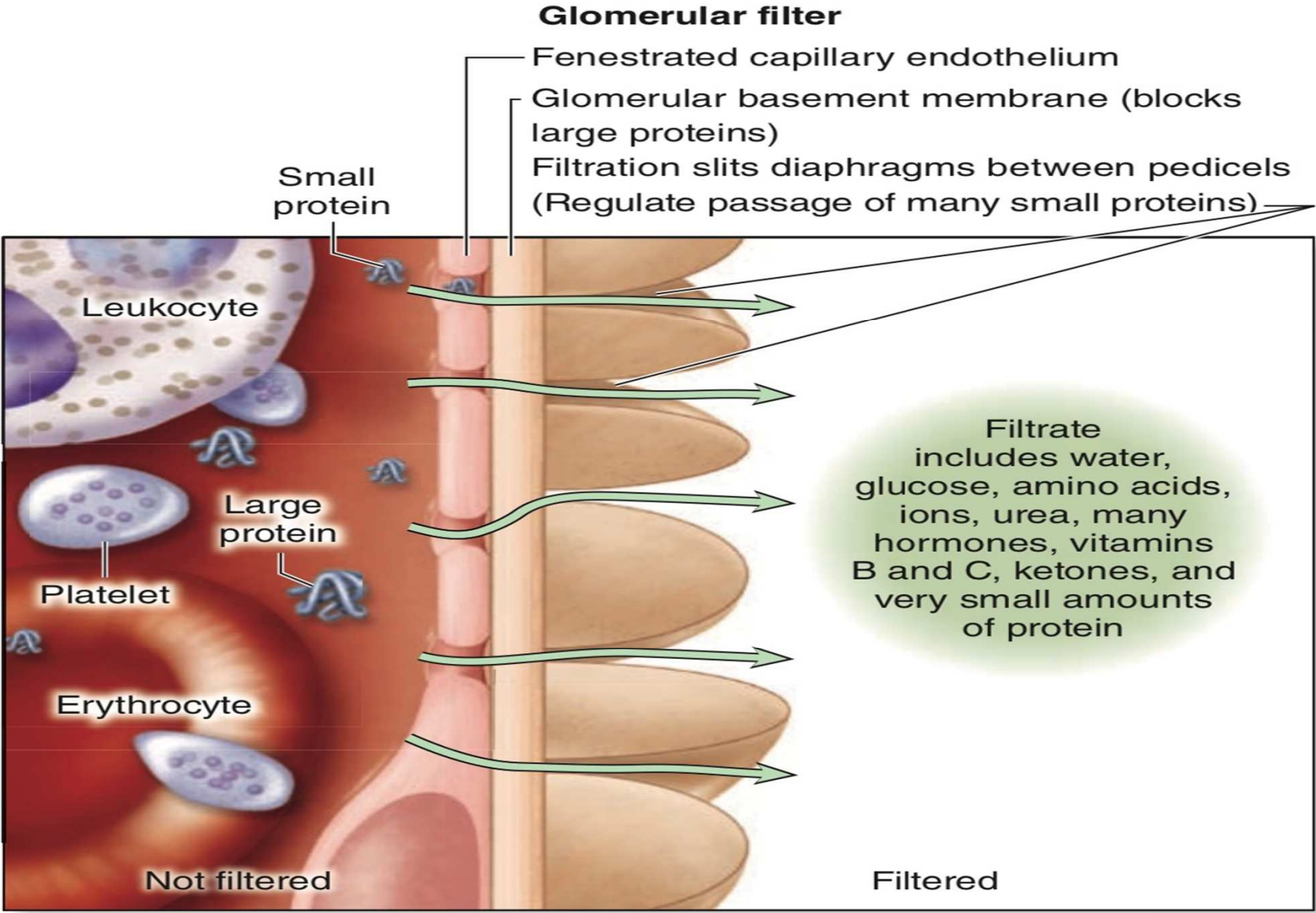


The **filtration** occurs through these structures:

1. the fenestrations of the capillary endothelium which block the blood and platelets.
2. GBM which restricts larger proteins and most organic anions.
3. the filtration slit diaphragms which restrict some small proteins and organic anions.

.Normally 20% of plasma entering a glomerulus is filtered into the capsular space. The glomerular filter blocks most plasma proteins.

# Glomerular filtration barrier



Substances filtered by filtration membrane



Renal corpuscles also contains **mesangial cells** , together with surrounding matrix they comprise the **mesangium**( fill gaps between capillaries that lack podocytes)

### Function of the mesangium:

1. Physical support.
2. Contractions of mesangial cells in response to blood pressure changes help to maintain an optimal filtration rate.
3. Phagocytosis of protein aggregates adhering to the glomerular filter.
4. Secretion of several cytokines and PGs.

