

(Renal Physiology 1)

Renal Functions and Basic Concepts

Dr Ahmad Ahmeda

aahmeda@ksu.edu.sa

We drip, drip, drip, all day and all night, three to four times more by day than by night, drip from the kidneys into the silent pool of the bladder, an underground dripping into an underground lake.

(Gustav Eckstein 1817)

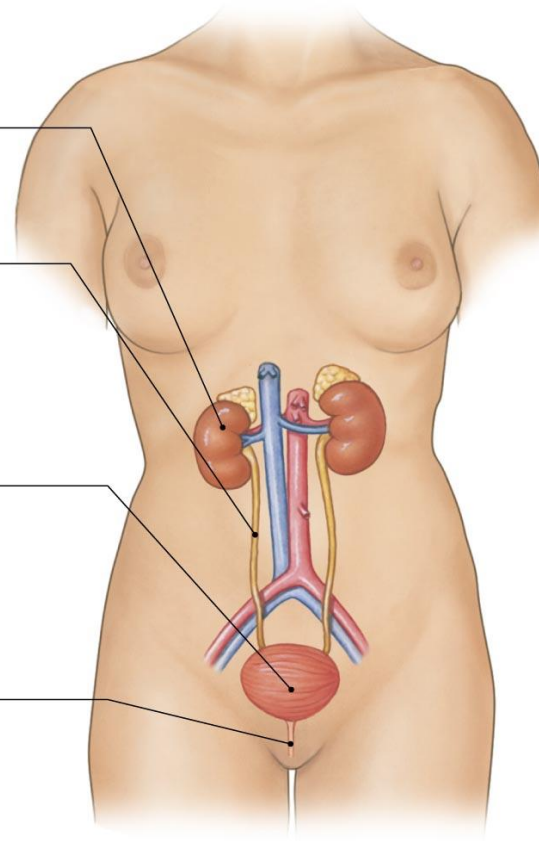
Urinary System Organs

Kidney
Produces urine

Ureter
Transports urine to the urinary bladder

Urinary bladder
Temporarily stores urine prior to elimination

Urethra
Conducts urine to exterior; in males, transports semen as well



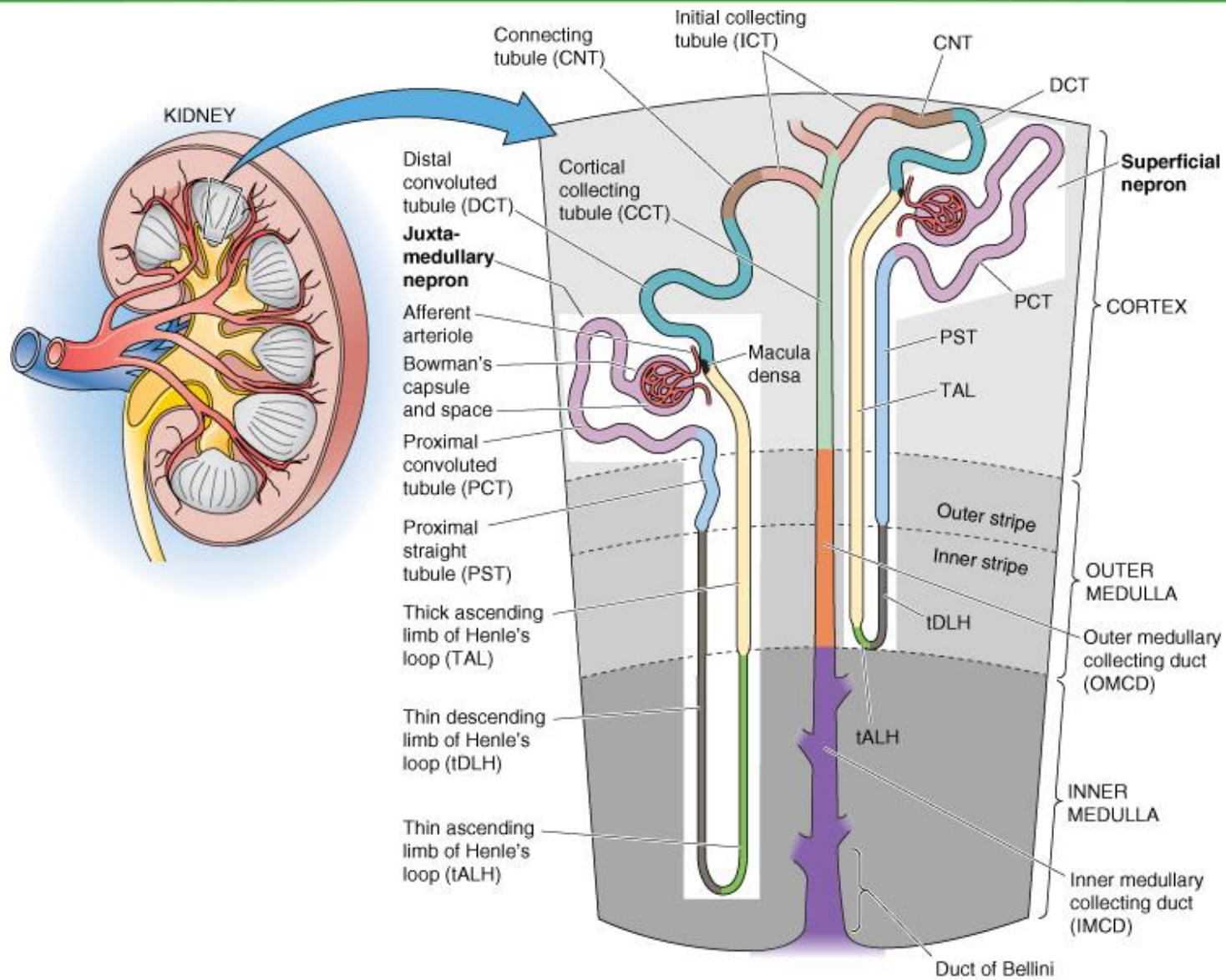
Anterior view

Kidney Functions

- 1) **Filter** 200 liters of blood daily, allowing toxins, metabolic wastes, and excess ions to leave the body in urine,
- 2) **Regulation** of water and electrolyte balance: Maintain the proper balance between water and salts, and acids and bases,
- 3) **Excretion** of bioactive substances (hormones and many foreign substances, especially drugs) that affects body function,
- 4) Regulation of arterial **blood pressure**: by production of renin (vasoactive substances) and regulate volume and chemical makeup of the blood,

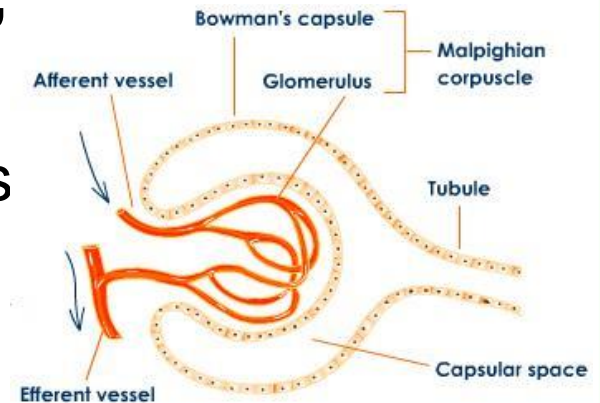
Kidney Functions

- 5) Regulation of red **blood cells production**: erythropoietin hormone to stimulate RBC production by bone marrow,
- 6) Regulation of **vitamin D production** : 25, cholecalciferol will be activated in the kidneys to 1,25 dihydrocholecalciferol D₃,
- 7) **Gluconeogenesis**: during prolonged fasting glucose can be synthesized in the liver and kidneys.

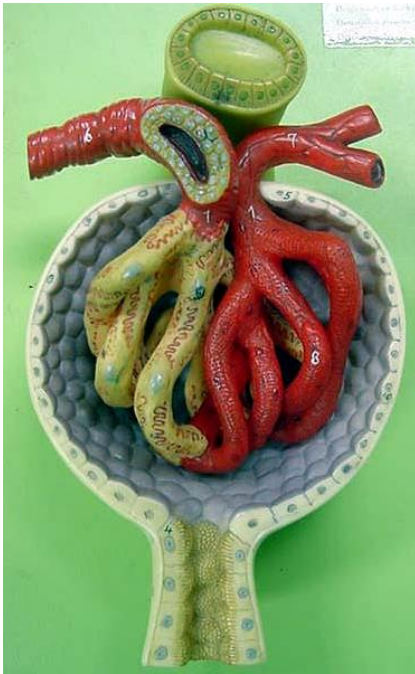


The Nephron

- Nephrons are the structural and functional units that form urine, consisting of:
 - **Glomerulus** – a tuft of capillaries associated with a renal tubule
 - **Glomerular (Bowman's) capsule** – blind, cup-shaped end of a renal tubule that completely surrounds the glomerulus



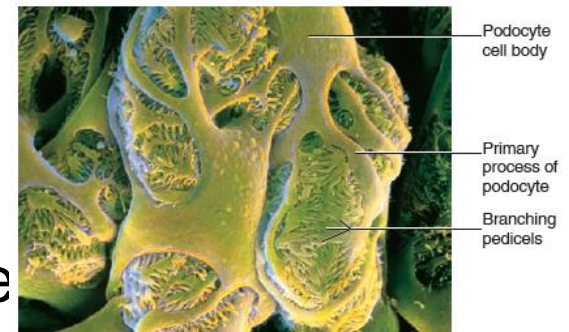
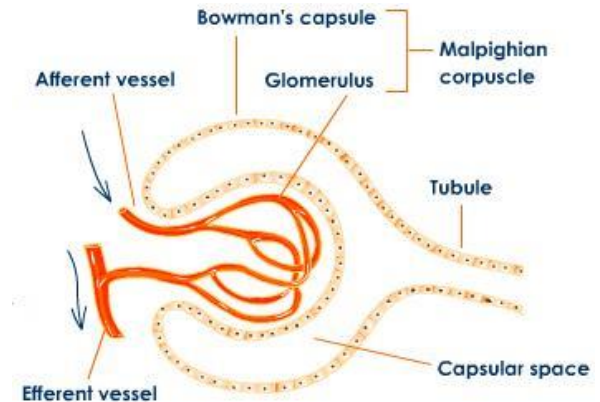
The Nephron

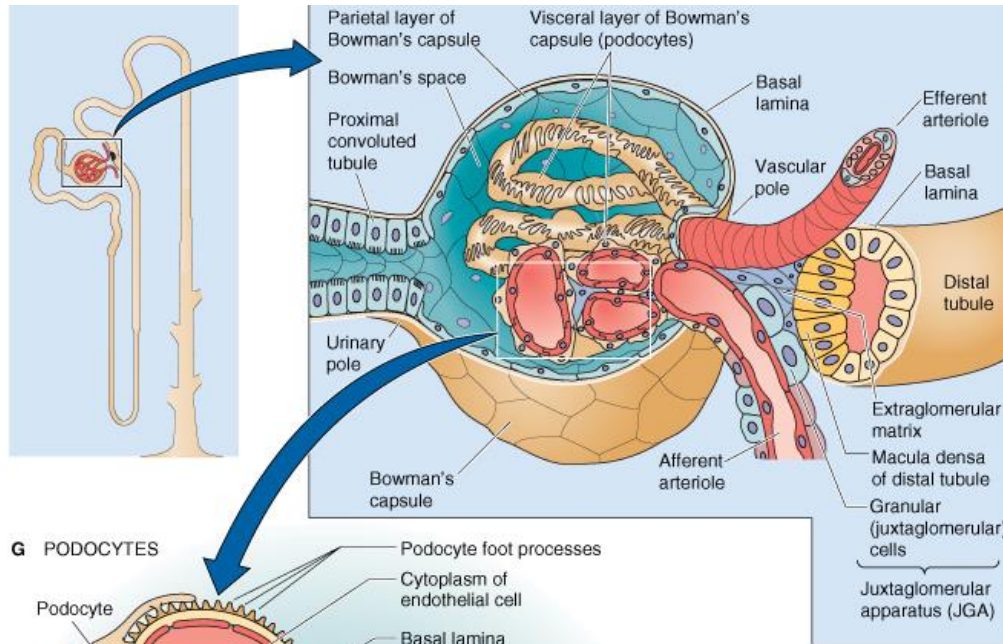


- **Renal corpuscle** – the glomerulus and its Bowman's capsule
- **Glomerular endothelium** – fenestrated epithelium that allows solute-rich, virtually protein-free filtrate to pass from the blood into the glomerular capsule

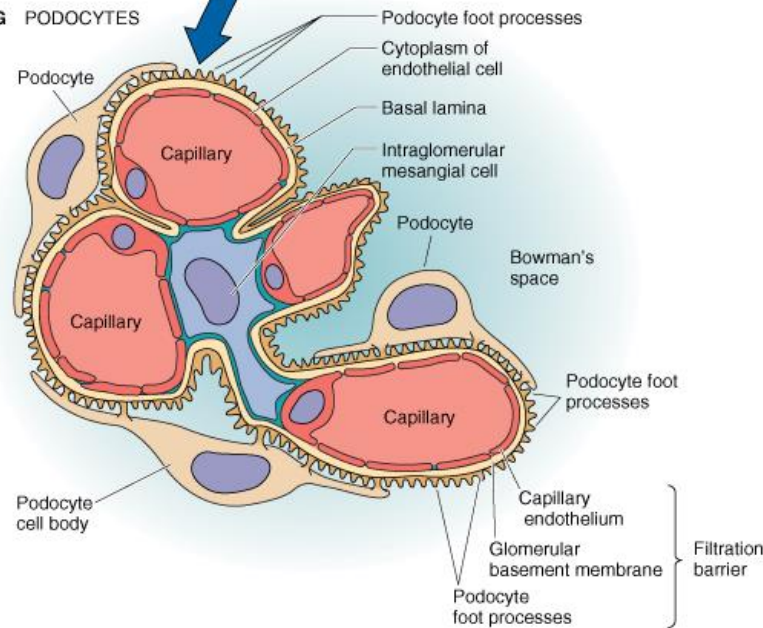
Anatomy of the Glomerular Capsule

- The external parietal layer is a structural layer
- The visceral layer consists of modified, branching epithelial **podocytes**
- Extensions of the octopus-like podocytes terminate in foot processes
- Filtration slits – openings between the foot processes that allow filtrate to pass into the capsular space





G **PODOCYTES**



Renal Tubule

- **Proximal convoluted tubule:** Has microvilli and mitochondria.
 - Reabsorbs water and solutes from filtrate and secretes substances into it.
- **Loop of Henle** – a hairpin-shaped loop of the renal tubule
 - Proximal part is similar to the proximal convoluted tubule.
 - Proximal part is followed by the thin segment and the thick segment.

Renal Tubule

- **Distal convoluted tubule** (DCT) – Without microvilli that function more in secretion than reabsorption.
- **Connecting Tubules**

Two important cell types are found here:

- **Intercalated cells**

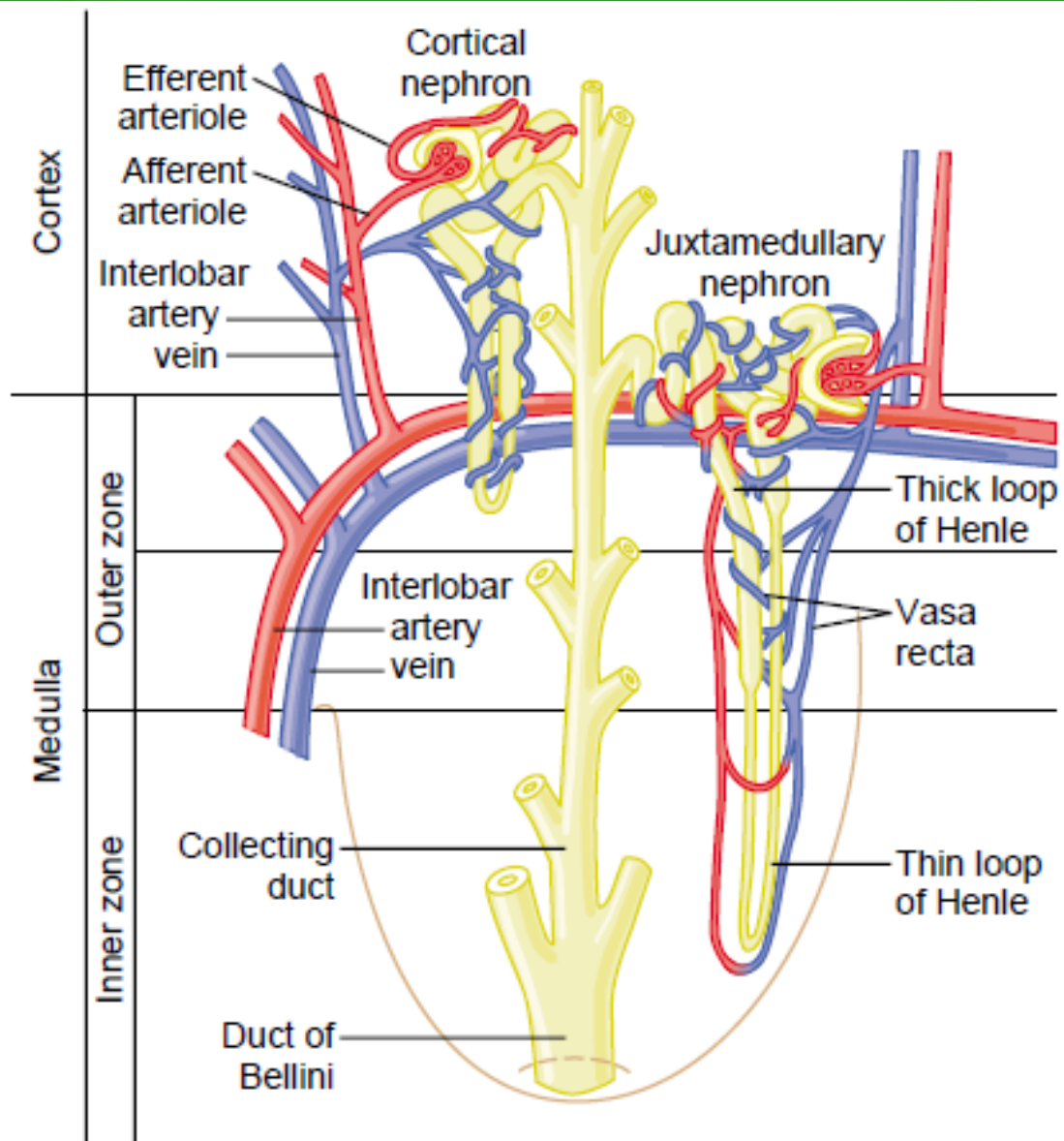
- Has a microvilli.
- Function in maintaining the acid-base balance of the body.

- **Principal cells**

- Without microvilli.
- Help maintain the body's water and salt balance.

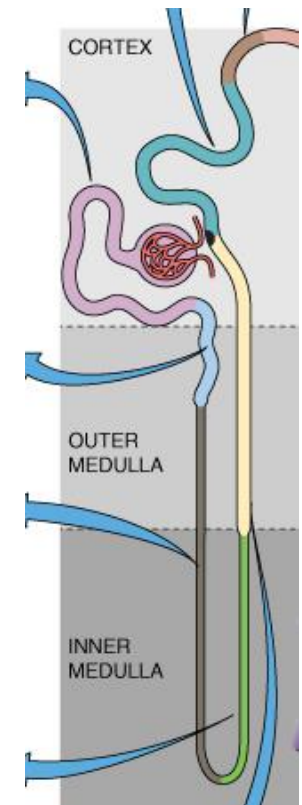
Types of Nephrons

- **Cortical nephrons** – 85% of nephrons; located in the cortex
- **Juxtamedullary nephrons:**
 - Are located at the cortex-medulla junction
 - Have loops of Henle that deeply invade the medulla
 - Have extensive thin segments
 - Are involved in the production of concentrated urine



Juxtaglomerular Apparatus (JGA)

- Where the distal tubule lies against the afferent (sometimes efferent) arteriole
- Arteriole walls have juxtaglomerular (JG) cells
 - Enlarged, smooth muscle cells
 - Have secretory granules containing renin
 - Act as mechanoreceptors



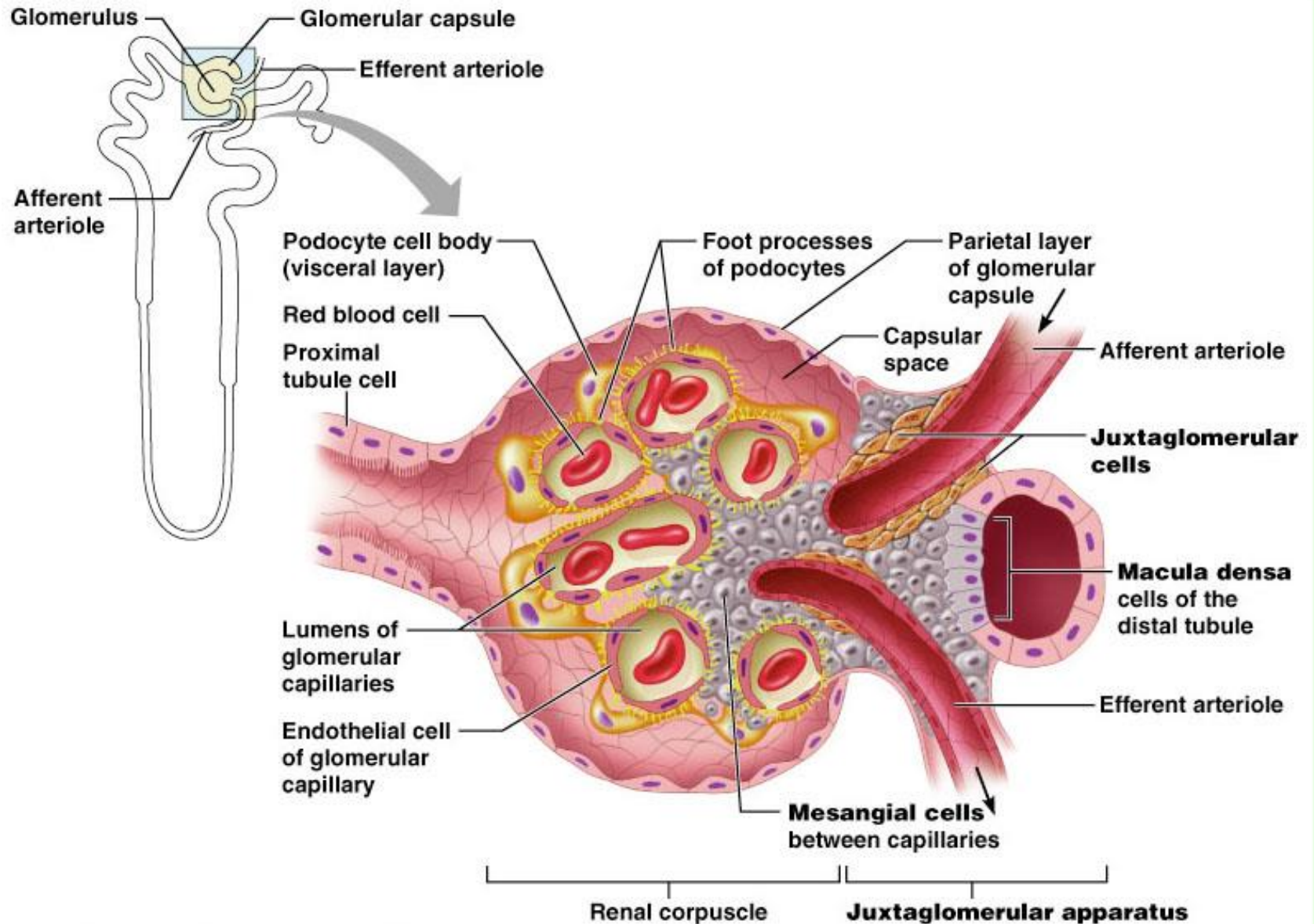
Juxtaglomerular Apparatus (JGA)

- **Macula densa**
 - Tall, closely packed distal tubule cells
 - Lie adjacent to JG cells
 - Function as chemoreceptors or osmoreceptors
 - The cells of the macula densa are sensitive to the ionic content and water volume of the fluid in the tubule
 - produce molecular signals that promote renin secretion by the juxtaglomerular cells

Juxtaglomerular Apparatus (JGA)

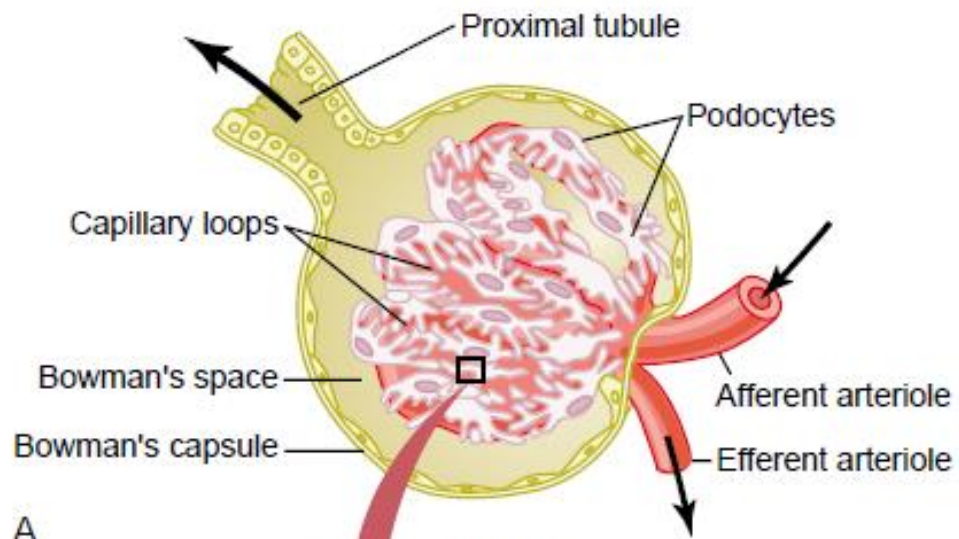
- **Mesangial cells**

- Have phagocytic and contractile properties
- Influence capillary filtration
- Intraglomerular mesangial cells provide structural support and regulate blood flow of the glomerular capillaries by their contractile activity

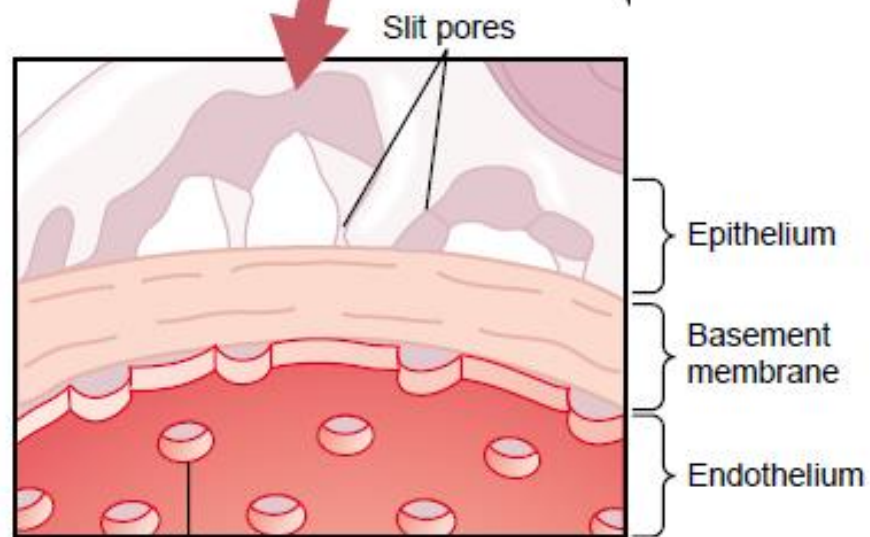


Filtration Membrane

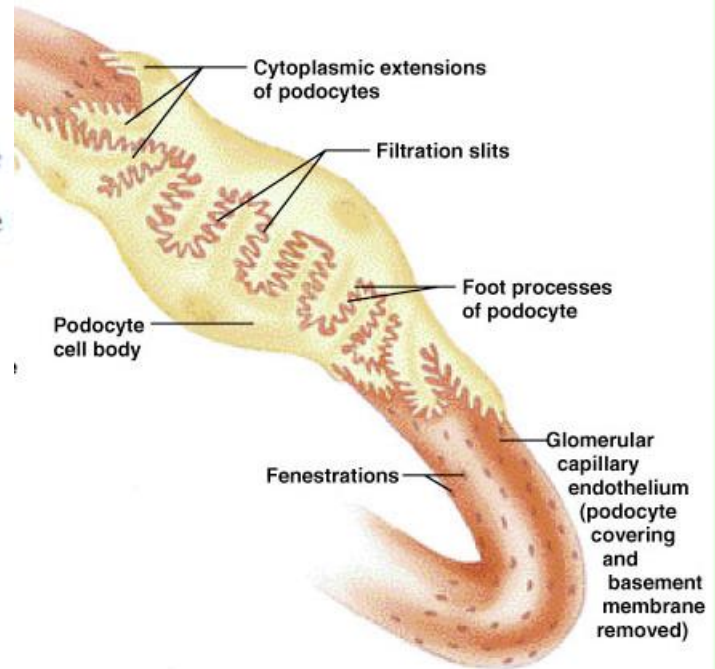
- Filter that lies between the blood and the interior of the glomerular capsule
- It is composed of three layers
 - Fenestrated endothelium of the glomerular capillaries (Pores are 50-100 nm in diameter)
 - Visceral membrane of the glomerular capsule (podocytes)
 - Basement membrane composed of fused basal laminae of the other layers.



A



B



Filtration Membrane

- Glomerular filtration membrane is highly permeable to water and small molecules (less than 10.000 MW)
- Large molecules (more than 70.000 MW especially proteins are not filtered due to their large size and negative electrical charge because their passage is repulsed by negatively charged glycoproteins present on endothelial pores, basement membrane and podocytes.

Composition of Glomerular Filtration

- Glomerular Filtrate has almost the same composition as that of plasma, except that it has no significant amount of proteins (it has about 0.003%)
- It is less than 1/2000 protein as compared with plasma.