

URINARY SYSTEM

STRUCTURE AND FUNCTION OF NEPHRONS

The nephron

- The structural and functional unit of the kidney.
- 2 millions in each kidney
- Responsible for urine production

Consists of :

1- Renal corpuscle contains the glomerulus surrounded by a double layer of Bowman's capsule.

2- Long tubular part that includes

A. Proximal thick segment (proximal convoluted tubule and proximal straight tubule)

B. Thin segment (thin part of the loop of Henle)

C. Distal thick segment (distal straight tubule and distal convoluted tubule).

D. Collecting tubule that opens at the renal papilla.

The filtration apparatus of the kidney consists of the

1. Glomerular endothelium

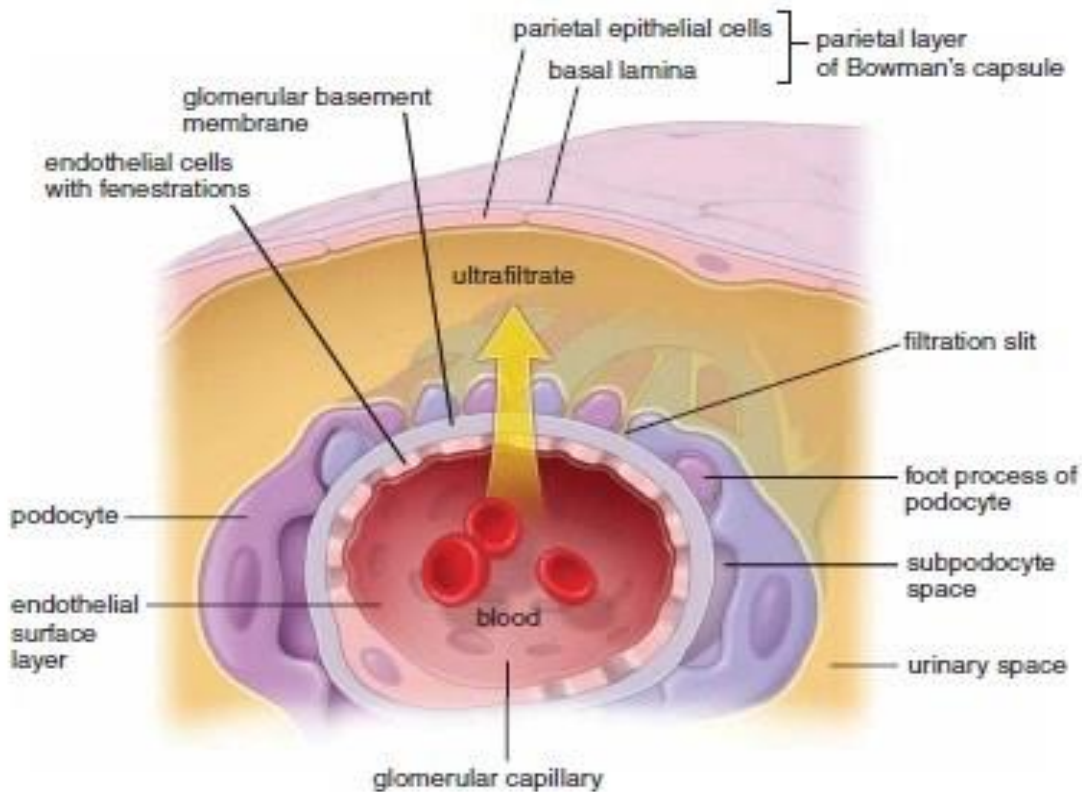
2. Glomerular basement membrane (GBM): acts as a physical barrier and an ion-selective filter

3. Bowman's capsule **podocytes**: extend their processes around the capillaries which interdigitate with other processes of the neighboring podocytes. The spaces between the interdigitating foot processes form **filtration slits** that are covered by the **filtration slit diaphragm**.

The juxtaglomerular apparatus includes

- 1- **Macula densa** (monitors Na concentration in tubular fluid)
- 2- **Juxtaglomerular cells** (secrete renin)
- 3- **Extraglomerular mesangial cells**

It regulates blood pressure by activating the **renin-angiotensin-aldosterone system (RAAS)**.



KIDNEY TUBULE FUNCTION

The **glomerular ultra-filtrate** from the Bowman's capsule passes through a series of tubules and collecting ducts lined by epithelial cells that secrete and absorb various substances to produce the final urine.

1- Proximal convoluted tubule

- Receives the glomerular ultrafiltrate from the Bowman's capsule.
- The initial and major site for **reabsorption** of:
 - Glucose
 - Amino acids
 - Polypeptides
 - Water
 - Electrolytes.

2- Loop of Henle: concentrates the ultrafiltrate

- The descending limb (highly permeable to water)
- Ascending limb (highly permeable to Na₊ and Cl₋).

3- Distal straight tubule (thick ascending limb) ascends back into the cortex to reach the vicinity of its renal corpuscle, where it makes contact with the afferent arteriole. In this area, the epithelial cells of the tubule form the **macula densa**.

4- The distal convoluted tubule involved in reabsorption of:

- Sodium
- Bicarbonate
- Ammonium
- Chloride

5- Distal Convoluted tubules empties into the cortical collecting duct that lies in the medullary ray. They further adjust the concentration of Na₊ and K₊ in the ultrafiltrate.

- The medullary **collecting duct** is lined by cuboidal cells, with a transition to columnar cells as the duct increases in size.

- The collecting ducts possess aquaporins and antidiuretic hormone (ADH)–regulated water channels that regulate water reabsorption.
- The collecting ducts open at the renal papilla, and the modified ultrafiltrate, now called urine, flows sequentially via the excretory passages.

URETER, URINARY BLADDER, AND URETHRA

- All excretory passages for urine, except the urethra, have the same general organization:
- They are lined by a mucosa containing transitional epithelium (urothelium) and have a smooth muscle layer and a connective tissue adventitia (or serosa).
- Transitional epithelium is a specialized stratified epithelium with large dome-shaped (umbrella) cells that bulge into the lumen.

1- The ureter conducts urine from the renal pelvis to the urinary bladder and it is lined by transitional epithelium, underlying smooth muscle arranged in three distinct layers, and connective tissue adventitia.

2- The urinary bladder is also lined by transitional epithelium and possesses many mucosal folds, except in the trigone region. Its muscular wall is thick and well developed and forms the detrusor muscle.

3- The urethra conveys urine from the urinary bladder to the external urethral orifice.

A. The female urethra is short and lined by:

1. Transitional epithelium (upper half)
2. Pseudostratified columnar epithelium (lower half)
3. Stratified squamous epithelium (before its termination).

B. The male urethra is much longer than the female and is divided into three regions:

1. The prostatic urethra (lined by transitional epithelium)
2. Short membranous urethra that pierces the external urethral sphincter (lined by stratified or pseudostratified columnar epithelium)
3. Penile urethra (lined by pseudostratified columnar epithelium)