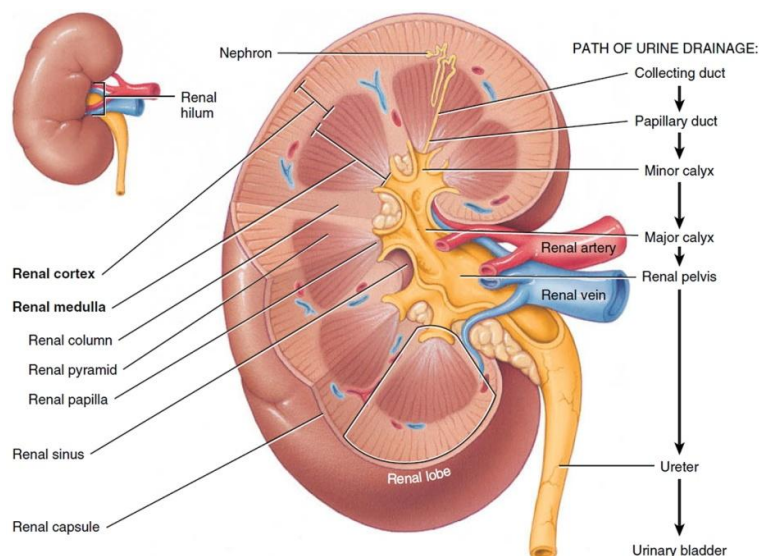


## Renal Physiology

### Functional Anatomy of the kidney :

- The two kidneys lie on the posterior wall of the abdomen, outside the peritoneal cavity.
- **Hilum** is a region on the medial side of each kidney through which renal artery and vein, lymphatics, nerve supply, and ureter pass.
- Each kidney is surrounded by a tough, fibrous capsule that protects its delicate inner structures.
- Each kidney has two major regions the outer **cortex** and the inner region is medulla. The medulla is divided into multiple cone-shaped masses of tissue called **renal pyramids**.
- Each pyramid terminates in the **papilla**, which projects into a funnel-shaped continuation of the upper end of the ureter called **renal pelvis**.
- Renal pelvis is divided into **minor calyces** (which collect urine from the tubules of each papilla) and **major calyces** which drain into the ureter.
- The walls of the calyces, pelvis, and ureter contain contractile elements that push the urine toward the bladder, where urine is stored until it is emptied by **micturition**



### Function of the kidney :

1. **Excretion of Metabolic Waste Products**, The kidneys are the primary means for eliminating waste products of metabolism, Foreign Chemicals, Drugs and metabolites that are no longer needed by the body :
  - urea (from the metabolism of amino acids)

- creatinine (from muscle creatine)
- uric acid (from nucleic acids)
- end products of hemoglobin breakdown (bilirubin)

## 2. **Regulatory function :**

- I. **Regulation of Water and Electrolyte Balances.:** kidneys have high capacity to change  $\text{Na}^+$  excretion in response to changes in  $\text{Na}^+$  intake is high. the same is done for water and for most other electrolytes, such as Cl, K, Ca, Mg, and Phosphate ions
- II. **Regulation of blood pressure :** Kidneys play an important role in the long-term regulation of arterial blood pressure by two ways:
  - Regulating the volume of extracellular fluid
  - Renin-angiotensin mechanism.
- III. **Regulation of Acid-Base Balance.**

## 3. **Endocrine function :** Hormones and peptides secreted by kidneys are:

- Erythropoietin (stimulating factor for erythropoiesis)
- Thrombopoietin : which stimulates the production of thrombocytes
- Renin
- Prostaglandins which affects renal blood flow
- Active vit D : Kidneys play a role in the regulation of blood calcium level by activating vitamin D (1,25 dihydroxycholecalciferol ) which is necessary for the absorption of calcium from intestine

## 4. **Gluconeogenesis :** during fasting can synthesize and release glucose into the blood, producing almost 20% of total body glucose.

### **functional unit of the kidney**

#### **Nephron:**

Each kidney in the human contains about 1 million nephrons, The kidney cannot regenerate new nephrons →with renal injury, disease, or normal aging, there is a gradual ↓ in nephron number.

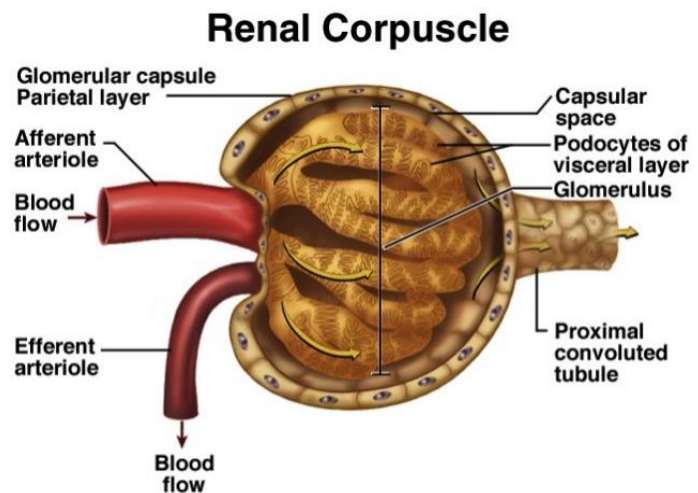
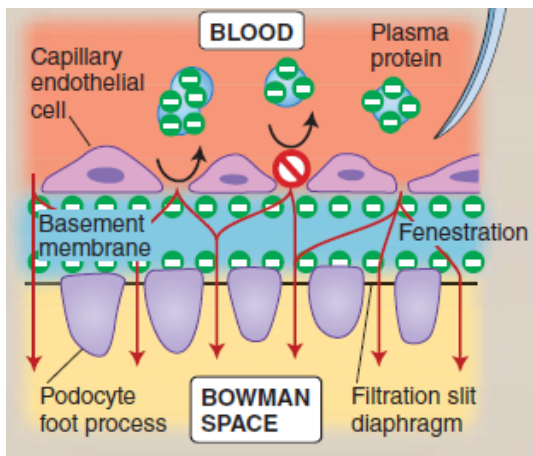
functions of the nephrons are :

- a) Glomerular filtration
- b) Tubular reabsorption
- c) Tubular secretion
- d) Excretion.

## Nephrons consist of renal corpuscle and renal tubule

### I. Renal corpuscle (Malpighian corpuscle) : site of filtration process

1. **Glomerulus** : is a tuft of glomerular capillaries through which large volume of fluid are filtered from the blood. it contains contractile cells which surround the glomerular capillaries called mesangial cells .They provide structural support and regulating blood flow through the glomerulus→ influence glomerular filtration rate. They also secrete prostaglandin and cytokines.
2. **Bowman's capsule**: is a capsular structure. it is the terminal dilation of renal tubule that encloses the glomerulus



### Filtering Membrane:

The membrane of the glomerulus consists of 3 main structures:

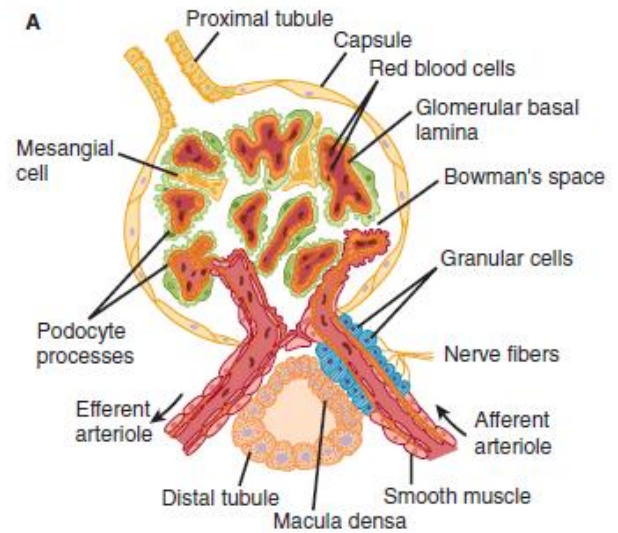
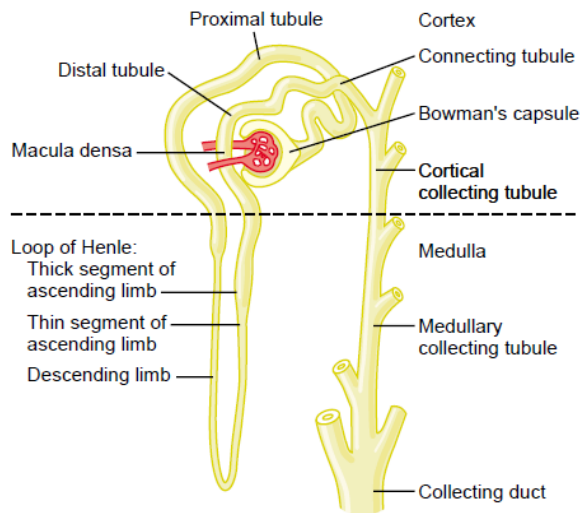
1. Capillary endothelial wall : have many fenestrations (pores) of 70 -90 nm in diameter . They prevent passage of blood cells
2. Glomerular basement membrane made up of a matrix of extracellular negatively charged proteins that repels proteins which carry a negative charge
3. Podocytes : Epithelial cell layer next to Bowman's space : the podocytes have foot processes ( cytoplasmic extensions of epithelial cells ) called **pedicles** . These pedicles interdigitate leaving small cleft like spaces in between (filtration **slit** ).

Around the capillaries is the mesangium, containing mesangial cells .

**Renal tubule** : is the Tubular portion of nephron ( continuation of Bowman capsule) It consists of three parts:

- **Proximal convoluted tubule (PCT)** : is the coiled portion arising from Bowman capsule.
- **Loop of Henle** : it connects PCT and DCT includes :
  - thin descending limb of loop of Henle
  - Ascending limb has thin and thick segment.
- **Distal convoluted tubule (DCT).**

**Note :** Renal corpuscle , PCT ,DCT lie in the renal cortex while loop of Henle extends into the renal medulla makes a hairpin then return to the renal cortex .



**Juxtaglomerular apparatus** : is a specialized renal structure that regulates arterial blood pressure and glomerular filtration rate . It consists of:

- I. **Macula densa** : are closely packed specialized cells of DCT that make contact with the afferent arteriole of its own renal corpuscle .They monitor the Na and Cl ion concentration of the fluid in the tubular lumen
- II. **Juxtaglomerular cells (granular cells)** : are modified smooth muscle cells in the wall of the afferent arteriole .They secrete rennin substance .
- III. **Extraglomerular mesangial cells** (between afferent and efferent arteriole).

### Collecting duct (CD) :

- several DCT drain into a **cortical collecting duct** which pass to the medulla → **medullary collecting duct** → form larger **papillary duct** that drain at the apex of renal pyramid ( renal papilla) into minor calyx
- Collecting ducts have two types of epithelial cells:
  - Principal or **P cells**: respond to **antidiuretic hormone(ADH) & Aldosteron**.
  - Intercalated or **I cells**: **secrete H ions. (acid -base balance )**

### Note:

- 3-4 minor calyces unite to form one major calyx. Each kidney has about 8 minor calyces and 2 to 3 major calyces.

### Types of nephrons:

Although each nephron has all the components, there are some differences, depending on how deep the nephron lies within the kidney:

1. Cortical nephrons
2. Juxtamedullary nephrons

Cortical nephron	Juxta medullary nephron
80 % of nephrons	20% of nephrons
Glomerulus locates in the superficial (outer)region of cortex	Glomerulus in the deeper (inner) part of the cortex close to the medulla
Has short loop of Henle that penetrate only into the outer medulla	Long loop of Henle that deep into inner medulla
blood supply to the tubule is peritubular capillaries	Vasa recta .
Urine formation	Concentration of urine and also urine formation

