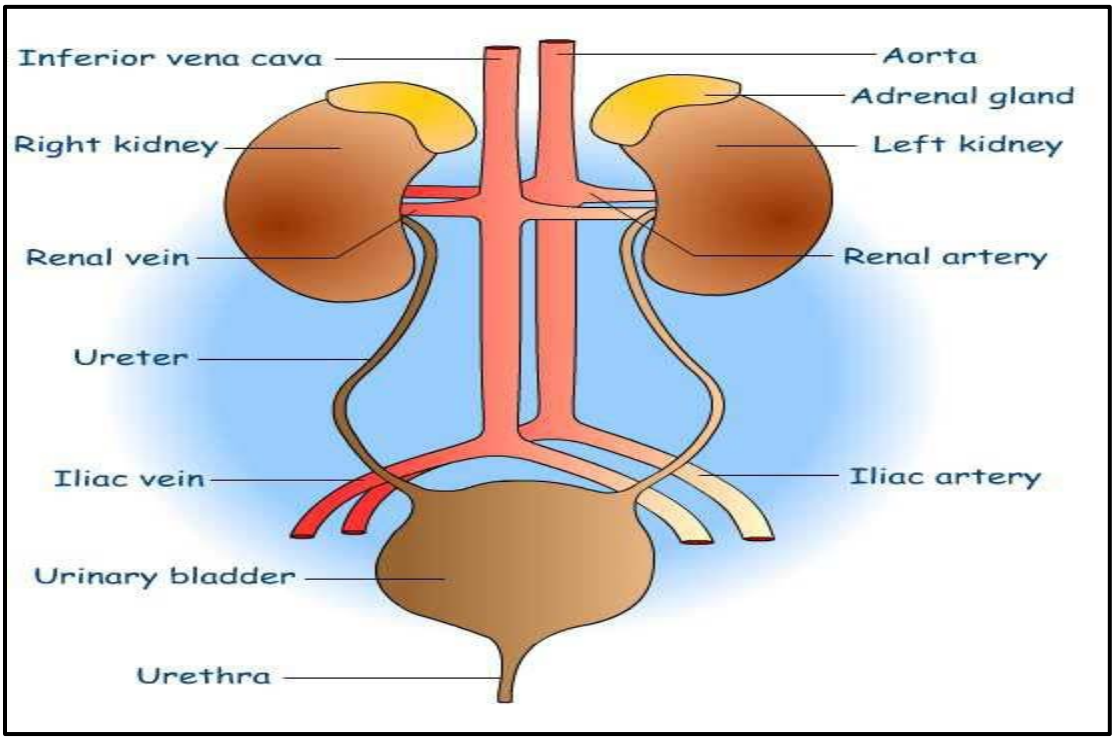
Urinary system

Excretion is the process by which the unwanted substances and metabolic wastes are eliminated from the body. Although various organs such as gastro intestinal (GI) tract, liver, skin and lungs are involved in removal of wastes from the body, their excretory capacity is limited. But, the renal system or urinary system has maximum capacity of excretory function.

Renal system includes:

1. A pair of kidneys
2. Ureters
3. Urinary bladder
4. Urethra.

Kidneys produce the urine. Ureters transport the urine to urinary bladder. Urinary bladder stores urine until it is voided (emptied). Urine is voided from bladder through urethra.



Urinary system

The Kidney

Kidney is a bean shaped organ, compound tubular gland, covered by a connective tissue capsule. There is a depression on the medial border of kidney called ***hilum***, through which renal artery, renal veins, nerves and ureter pass.

Kidneys perform several vital functions besides urine formation Thus, the functions of kidneys include:

1. Role of homeostasis

The primary function of kidneys is homeostasis. It is accomplished by the formation of urine. During the formation of urine, kidneys regulate various activities in the body, which are concerned with homeostasis such as:

i. Excretion of Waste Products.

Kidneys excrete the unwanted waste products which are formed during metabolic activities:

a. Urea – end product of amino acid metabolism.

b. Uric acid – end product of nucleic acid metabolism.

c. Creatinine – end product of metabolism in muscles.

d. Bilirubin – end product of hemoglobin degradation.

e. Products of metabolism of other substances

f. Harmful foreign chemical substances like toxins, drugs, heavy metals, pesticides, etc.

ii. Maintenance of Water Balance

Kidneys maintain the water balance in the body by conserving water when it is decreased and excreting water when it is excess in the body.

iii. Maintenance of Electrolyte Balance

Maintenance of electrolyte balance, especially sodium is in relation to water balance. Kidneys retain sodium if the osmolarity of body water decreases and eliminate sodium when osmolarity increases.

iv. Maintenance of Acid–Base Balance

The kidneys contribute to acid-base regulation, along with the lungs and body fluid buffers, by excreting acids and by regulating the body fluid buffer stores. The kidneys are the only means of eliminating from the body certain types of acids, such as sulfuric acid and phosphoric acid, generated by the metabolism of proteins.

2. Hemopoietic function

Kidneys stimulate the production of erythrocytes by secreting ***erythropoietin***, which stimulates the production of red blood cells by *hematopoietic stem cells* in the bone marrow. Erythropoietin is the important stimulating factor for erythropoiesis. Kidney also secretes another factor called ***thrombopoietin***, which stimulates the production of thrombocytes.

3. Endocrine function

Kidneys secrete many hormonal substances in addition to erythropoietin and thrombopoietin. The hormones secreted by kidneys are:

i. Erythropoietin
ii. Thrombopoietin
iii. Renin
iv. 1, 25-dihydroxycholecalciferol (calcitriol)
v. Prostaglandins.

4. Regulation of blood pressure

Kidneys play an important role in long-term regulation of arterial blood pressure by excreting variable amounts of sodium and water. The kidneys also contribute to short-term arterial pressure regulation by secreting hormones and vasoactive factors.

5. Regulation of blood calcium level

Kidneys play a role in the regulation of blood calcium level by producing the active form of vitamin D 1,25-dihydroxyvitamin D3 (calcitriol), by hydroxylating this vitamin. Calcitriol is essential for normal calcium deposition in bone and for calcium reabsorption by the gastrointestinal tract.

6. Glucose Synthesis (gluconeogenesis)

The kidneys synthesize glucose from amino acids and other precursors during prolonged fasting, a process referred to as gluconeogenesis. The kidneys' capacity to add glucose to the blood during prolonged periods of fasting rivals that of the liver.

The components of kidney are arranged in three layers:

1. Outer Cortex

Cortex is dark and granular in appearance. It contains renal corpuscles and convoluted tubules. At intervals, cortical tissue penetrates medulla in the form of columns, which are called renal columns or columns of Bertini.

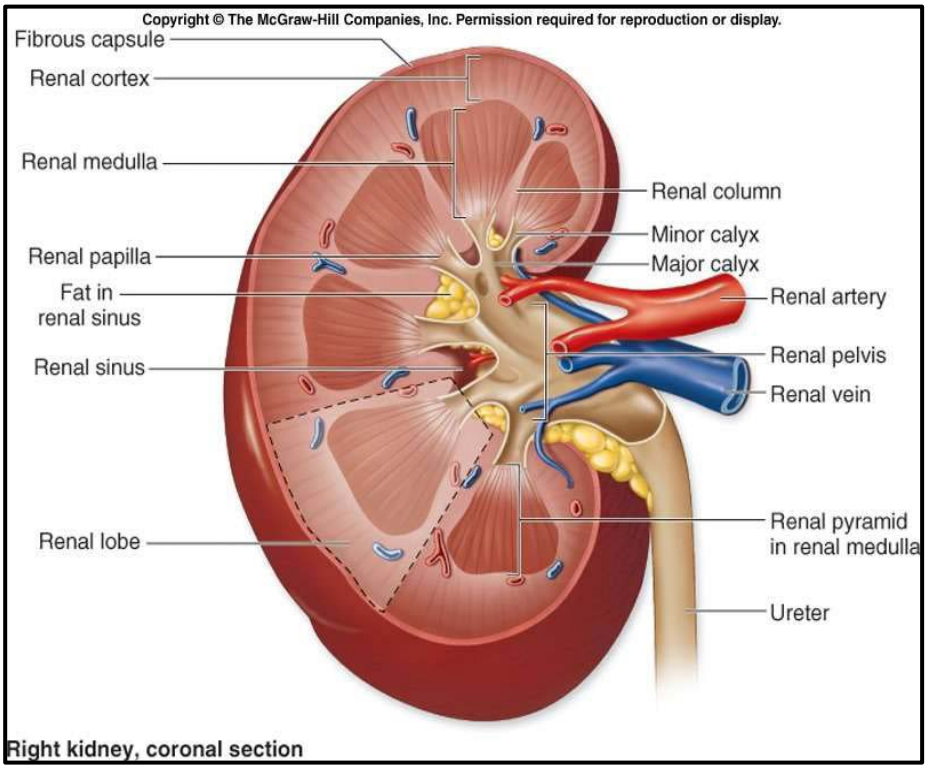
2. Inner Medulla

Medulla contains tubular and vascular structures arranged in parallel radial lines. It is divided into 8 to 18 ***medullary*** or ***Malpighian pyramids***.

3. *Renal Sinus*

Renal sinus consists of the following structures:

i. Renal pelvis: Upper expanded part of ureter.
ii. Subdivisions of pelvis –major calyces and minor calyces.
iii. Branches of nerves, arteries and veins.
iv. Loose connective tissues and fat.



Parenchyma of kidney

It is made up of tubular structures called ***uriniferous tubules***, which are of two types:

1. **Terminal or secretary tubules called nephrons**, which are concerned with formation of urine

2. **Collecting ducts or tubules** which are concerned with transport of urine from nephrons to pelvis of ureter. The collecting ducts unite to form ***ducts of Belini***, which open into minor calyces through papilla.

Nephron and Juxtaglomerular Apparatus

Nephron is defined as the structural and functional unit of kidney. Each kidney consists of 1 to 1.3 million of nephrons. The kidney cannot regenerate new nephrons. Therefore, with renal injury, disease, or normal aging, the number of nephrons gradually decreases. After age 40 years, the number of functioning nephrons usually decreases about 10 percent every 10 years.

Each nephron is formed by two parts:

1. A blind end called ***renal corpuscle*** or ***Malpighian corpuscle***
2. A tubular portion called ***renal tubule.***

Renal corpuscle

The renal corpuscle is also known as Malpighian corpuscle. It is a spheroidal and slightly flattened structure with a diameter of about 200 μ. The function of the renal corpuscle is the filtration of blood which forms the first phase of urine formation.

Renal corpuscle is situated in the cortex of the kidney either near the periphery or near the medulla. Based on the situation of renal corpuscle, the nephrons are classified into two types:

1. Cortical Nephrons or superficial nephrons

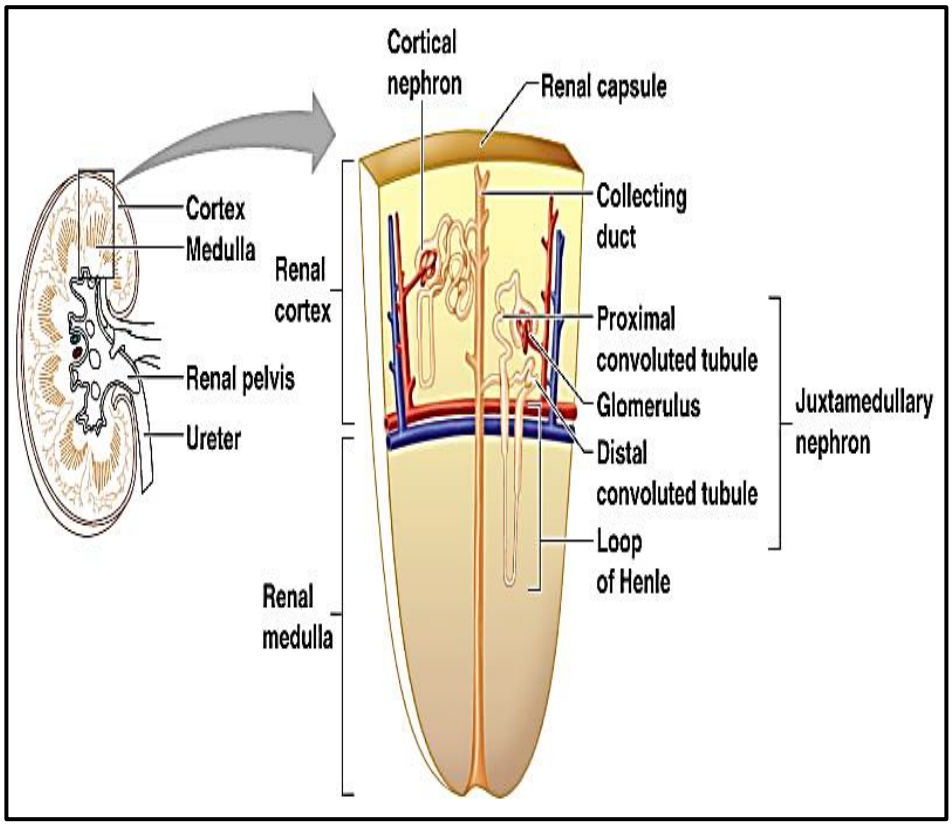
Cortical nephrons are the nephrons, which have their corpuscles in the outer cortex of the kidney near the periphery. In human kidneys 85% nephrons are cortical nephrons.

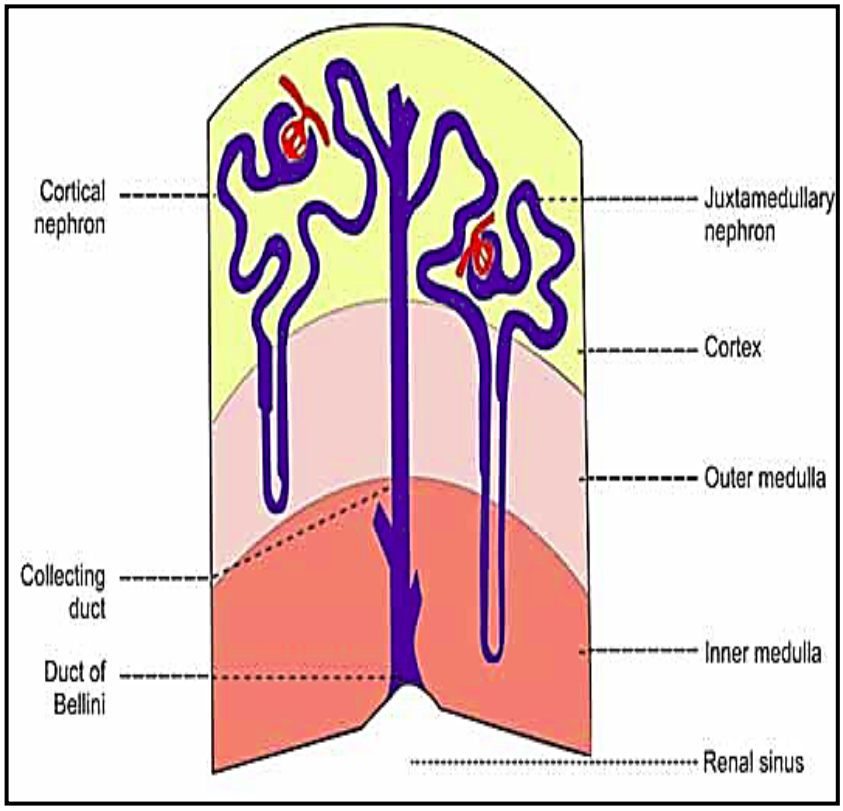
2. Juxtamedullary Nephrons

Juxtamedullary nephrons are the nephrons which have their corpuscles in the inner cortex near medulla or corticomedullary junction.

Features of two types of nephron

Features	Cortical nephron	Juxtamedullary nephrons
Situation of renal corpuscle	Outer cortex near the periphery	Inner cortex near medulla
Loop of Henle	Short	Long
	Hairpin bend penetrates only up to outer zone of medulla	Hairpin bend penetrates up to the inner zone of medulla
Function	Formation of urine	Mainly the concentration of urine and formation of urine





Structure and Types of Nephron