Excretory products and their elimination

Different harmful substances are formed due to different metabolic reaction in the body. It includes, urea, uric acid, ammonia, carbon-dioxide, water, ions etc. The three-main nitrogenous waste are urea, ammonia and uric acid. Ammonia is the most toxic out of these. Animals excreting ammonia as nitrogenous waste are known as **ammonotelic**, for example, most bony fishes, aquatic amphibians etc. The excretion of ammonia occurs via diffusion. The organisms which excrete urea as nitrogenous waste, they are known as **ureotelic**. For example, mammals, amphibians etc. are ureotelic. Those organisms which excrete uric acid as nitrogenous waste, they are known as **uricotelic**, such as, reptiles, birds etc.

Excretory organs in variety of organisms

Different organisms have different excretory structures. *Amoeba* and *Paramecium* have contractile vacuole for excretion. Canal system is the excretory system found in sponges. Sponges have canal system for excretion. *Hydra* have coelenteron as excretory in function. Flame cells are found in Platyhelminthes. Nephridia are found in Annelids such as earthworm. Prawns have green glands for excretion. Malpighian tubules form the excretory system in insects.

Human excretory system

Human excretory system consists of a pair of kidneys, a pair of ureter, urinary bladder, and urethra.
Kidneys are bean shaped and lie in the abdominal cavity. The right kidney is placed slightly lower than the left kidney. The inner surface of the kidney is concave whereas outer surface of the kidney is convex. Towards the center of the inner concave surface of the kidney is a notch called hilum. Hilum is a point where Ureter, blood vessels and nerves enter. Inner to the hilum is a funnel-shaped space known as renal pelvis with projections known as calyces. Kidneys are divided into two regions- outer and inner. The outer part is known as the cortex and inner part is known as medulla. The medulla is divided into conical masses known as medullary pyramids. Extension of renal cortex which separates the pyramids is known as **column of Bertini.**

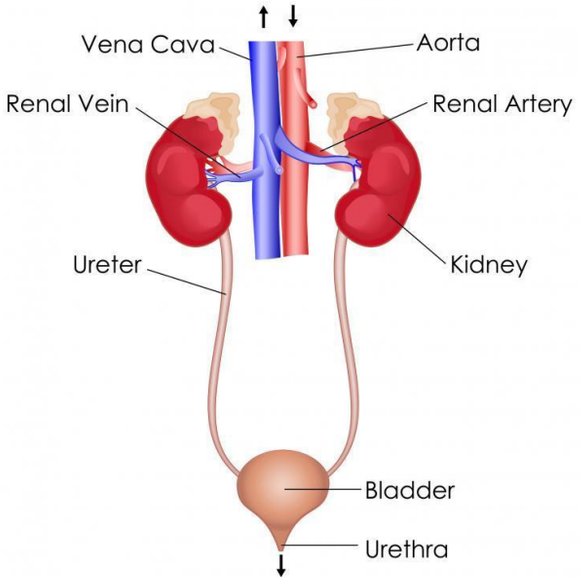

Fig. 1. Human excretory system

Nephrons are the structural functional unit of kidneys. Nephron consists of two major parts- renal corpuscle and renal tubule.

A tuft of the capillaries forms the glomerulus. Afferent arteriole brings blood into the glomerulus and leaves the efferent arteriole carries blood out of the glomerulus. Glomerulus is bound by a cup- shaped structure known as Bowman's capsule. Bowman's capsule together with glomerulus is known renal corpuscles or Malpighian body.

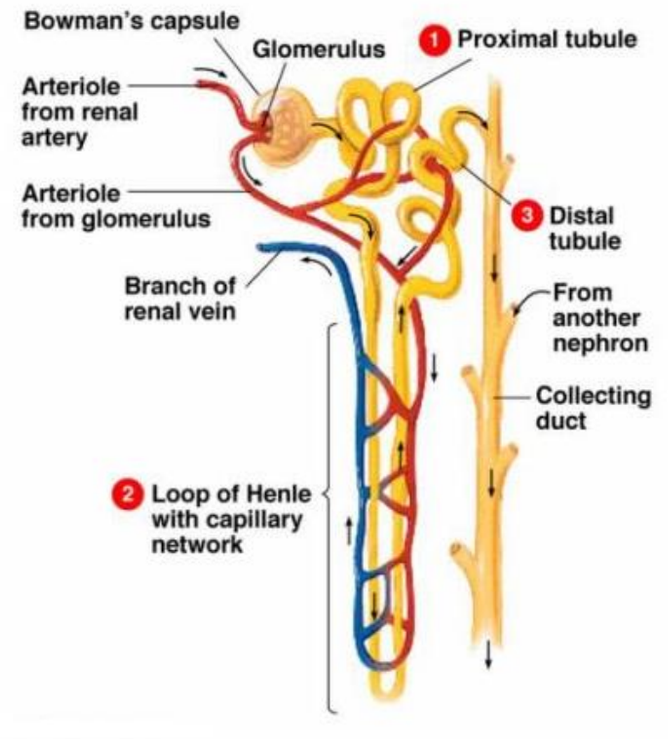

Fig. 2. Structure of the nephrons

The tubule extends to form a highly coiled structure known as proximal convoluted tubule (PCT). The next part of the tubule is Henle's loop. Henle's loop consists of ascending and descending limb. The ascending limb extends to form distal convoluted tubule (DCT). The DCT then opens into collecting duct.

Cortical nephrons and medullary nephrons are the two main types of nephrons. When loop of Henle is too short and only small part of it is found in medulla, it is known as **cortical nephrons**. When loop of Henle is long and spreads into the medulla, they are known as **medullary nephrons**.

Urine formation

The three main steps of urine formation are glomerular filtration, tubular reabsorption, and secretion.

Glomerular filtration begins when blood enter the glomerulus through afferent arteriole. Water and nitrogenous waste move into the glomerulus and blood cells, proteins exit the glomerulus through efferent arteriole. On an average, kidney filters about 1100 ml to 1200 ml of blood per minute. The glomerular capillary blood pressure causes filtration of blood through 3 different layers. The first layer is known as **endothelium** that surround the glomerular blood vessels, the other is **epithelium** of Bowman's capsule and a **basement membrane** is present between the two layers. The epithelial cells present in the Bowman's capsule are known as **podocytes** which are arranged in an intricate manner to leave some minute spaces called slit pores or filtration slits.

Glomerular filtration rate is defined as the amount of filtrate produced by the kidneys per minute.

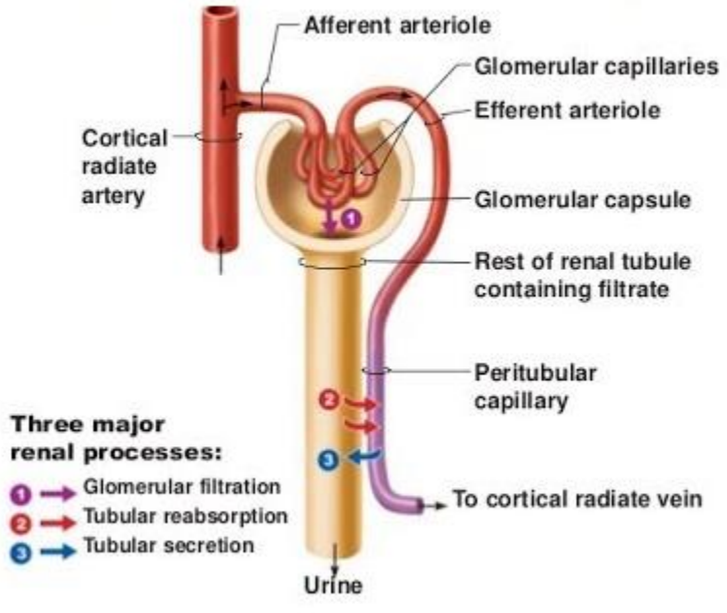

Fig. 3. Steps of urine formation

Tubular reabsorption involves the absorption of required molecules or ions such as sodium ions, glucose, amino acids etc. Some of the substances are absorbed actively and some are absorbed passively. Glucose and amino acids are absorbed actively whereas water is absorbed passively.

The last step of urine formation is secretion. Potassium ions, hydrogen ions, ammonia are secreted out to maintain the ionic and acid balance of the body fluids.

Function of the tubules

Proximal convoluted tubules (PCT) is lined by simple cuboidal brush border epithelium. This type of epithelium helps in providing increased surface area for reabsorption. Most of the electrolytes and water are reabsorbed in PCT. It helps to maintaining the pH and ionic balance of the body fluids by secretion of hydrogen ions, potassium ions, ammonium ions into the filtrate.

Henle's loop, is very important in maintaining the osmolarity of the fluid. Very less reabsorption occurs in ascending limb. It is impermeable to water, but permeable to electrolyte. Descending limb absorbs most of the water, making the filtrate concentrated. Descending limb is almost impermeable to any electrolyte. So, different part of Henle's loop reabsorb differently.

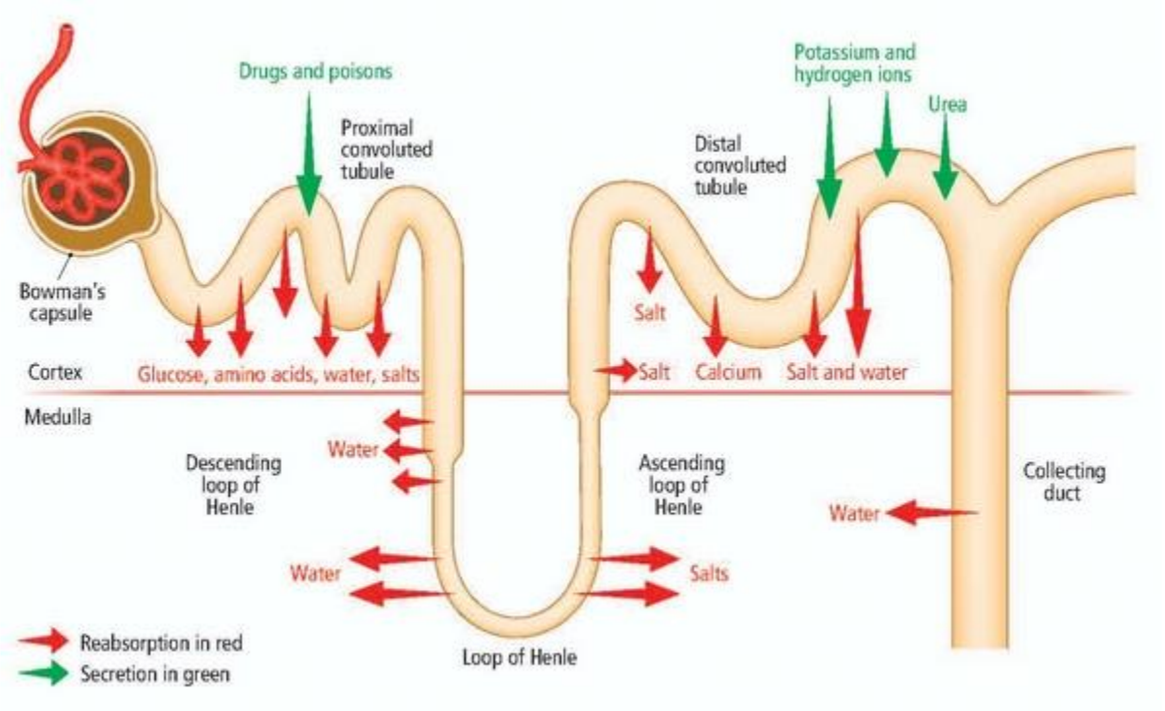

Fig. 4. Function of the tubules

In Distal convoluted tubule, the reabsorption of water, sodium ions and bicarbonate ions occur whereas secretion of potassium ions and hydrogen ions occurs to maintain the ionic balance of the fluid.

Collecting duct, reabsorbs large amount of water to make the urine concentrated. Secretion of hydrogen ions and potassium ions also takes place in collecting duct. It maintains the ionic balance and pH of blood.

Regulation of kidney function

There main parts are involved in kidney regulation- hypothalamus, juxtaglomerular apparatus (JGA) and heart. Any change in the blood volume, ionic balance triggers the osmoreceptors in the body. This stimulates the hypothalamus to secrete antidiuretic hormone (ADH), which is also known as **vasopressin**. This helps in the reabsorption of water from the tubules. This increases the blood volume and switch off the osmoreceptors through negative feedback mechanism.

The juxtaglomerular apparatus is activated during fall in glomerular blood pressure. Juxtaglomerular cells then release an enzyme known as renin, which converts angiotensinogen in blood to **angiotensin I** which gets further transformed to **angiotensin II**. Angiotensin II is an effective vasoconstrictor, so it increases the glomerular blood pressure. Angiotensin II also acts on adrenal cortex to release hormone, **aldosterone** to increase sodium ion and water reabsorption from the distal tubules. This mechanism is known as **renin-angiotensin mechanism.**

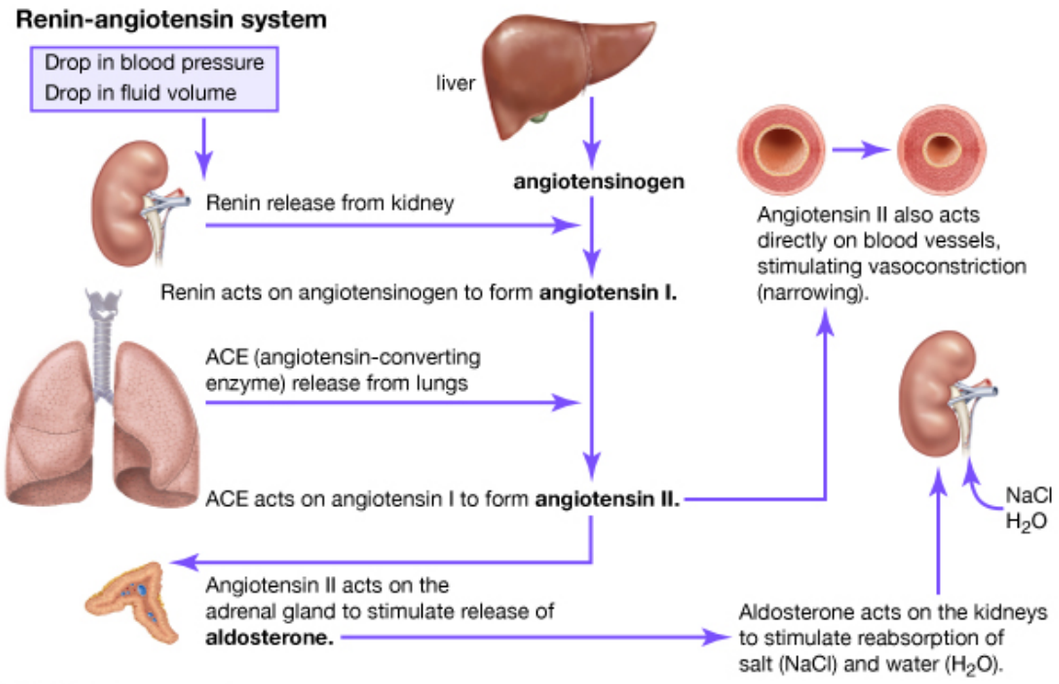

Fig. 5. Regulation of kidney function by renin-angiotensin-aldosterone system

Heart releases a polypeptide hormone known as **atrial natriuretic factor (ANF)** which causes vasodilation to decrease the blood pressure. It acts as a negative feedback mechanism for renin-angiotensin mechanism.

Micturition: It is the process of release of urine from the body. It is controlled by the CNS through various neural mechanisms.

Other Organs in Excretion: Lungs, kidneys, liver and skin function to eliminate wastes like carbon dioxide, toxic substances, urea, etc.

Disorders of the excretory system:

Uremia: Accumulation of urea in blood due to malfunctioning of kidneys.

Acute renal failure: One or both kidneys completely fail and are unable to function due to various reasons.

Renal calculi: Insoluble kidney stones formed as a result of accumulation of insoluble crystals like oxalates.

Glomerulonephritis: Inflammation of glomerulus.

Hemodialysis can be done to remove excess urea from blood in cases of malfunctioning of kidney. Blood is taken out of the body through cellophane tubules and dialyzed against an isotonic liquid so as to remove wastes and the filtered blood is pumped back into the body.