16 Excretory Products and Their Elimination

When we erase using an eraser, we use a plant product rubber. This rubber comes from rubber tree as we all know. Rubber tree is a tropical tree grown in large scale in Kerala. Rubber is a popular material that may be found in a variety of everyday goods. So, rubber is highly useful for us but it is a waste product of plants! This a basic example of excretion we see in our day-to-day life.

Topic Notes

- *Excretion, Excretory Products and Organs*

EXCRETION, EXCRETORY PRODUCTS AND ORGANS

1

TOPIC 1

MODES OF EXCRETION

Excretion is the process of removal of toxic nitrogenous metabolic wastes from the body of an organism produced due to the metabolism of protein and nucleic acids. The following are some of the benefits of excretion—maintaining ionic balance in body fluids and tissue, and maintaining the required proportion of water in your body. The toxic amount in the body rises, resulting in disorders.

The main nitrogenous wastes produced by animals are ammonia, urea, and uric acid. The most harmful type, ammonia, requires a significant amount of water for elimination, but uric acid, which is the least hazardous, can be eliminated with minimal water loss.

Major nitrogenous wastes in the body are:

S. No.	Ammonia	Urea	Uric acid
(1)	Most toxic nitrogenous waste.	Urea is less toxic than ammonia.	Least toxic nitrogenous waste.
(2)	Most of the Aquatic animals excrete ammonia.	Terrestrial animals excrete urea as their waste product.	Birds, insects and reptiles excrete uric acid.
(3)	Animals excreting ammonia are ammonotelic. Ammonia is excreted by diffusion across body surfaces / gill surfaces.	Animals excreting urea are ureotelic. Urea is excreted through kidneys.	Animals excreting uric acid are uricotelic. Uric acid is excreted in the form of a pellet or paste.
(4)	Process by which ammonia is excreted is ammonotelism.	Process by which urea is excreted is Ureotelism.	Process by which Uric acid is excreted is Uricotelism.

Types of kindeys

There are generally four types of kidney:

(1) **Archinephric kidney:** It is also believed that these are the ancestral kidney. It is present in the primitive vertebrate ancestor had this type of kidney. Such kidneys are today found in larvae of certain cyclostomes. Glomeruli are not present in some posterior tubules.

(2) **Pronephric kidney:** It appears as an embryonic functional kidney in fishes and amphibians generally. It is not functional in the embryonic life of the reptiles, birds and mammals. It is also called anterior kidney due to its position as it is present in the anterior position. Each tubule has a glomerulus.

(3) **Mesonephric kidney:** It is also called the middle kidney. In lamprey, most adult fishes and amphibians have these kidneys. Mesonephric kidney is functional in both embryos as well as adults. In reptiles aves and mammals it is functional in embryo and replaced by metanephric kidney in the adults. It consists of a large number of tubules which develop internal glomeruli enclosed in capsules forming malpighian bodies.

(4) **Metanephric kidney:** It is also known as posterior kidney. Tubules (nephrons) are very large in numbers. The glomeruli are very well developed. Metanephric kidneys are found in adult amniotes like reptiles, birds and mammals.

Important

➥ *Excretory Organs in different organisms:*

Animals /organisms	*Excretory organ*
Platyhelminthes	*Protonephridia with flame cells*
Annelids	*Metanephridia with nephrostomes*
Insects	*Malpighian tubules*
Crustaceans	*Antennal gland (green glands)*

Caution

Osmoregulation: It is a process that regulates the salt and water concentration of the body.

Example 1.1: Case Based:

Abhay visits a zoological park and also to an aquarium with his family. He saw very different species of animals. Being a biology student, Abhay was aware of different systems and their mechanisms in many animals. He shared his knowledge with his family and informed them about various forms of nitrogenous waste excreted by animals and their mechanisms of excretion.

(A) The mesonephric kidney can be found in which of the following organism?

(a) Reptilia (b) Amphibia

(c) Aves (d) All of these

(B) Vitamin which is excreted in large amounts in man's urine:

(a) Vitamin C (b) Vitamin K

(c) Vitamin D (d) Vitamin E

(C) How much amount of water does urine contain?

(D) What is the nitrogenous excretory product of aquatic reptiles?

(E) Assertion (A): Ammonia should be excreted out from the body as soon as possible after it is formed.

Reason (R): Ammonia is insoluble in water.

(a) Both A and R are true and R is the correct explanation of A.

(b) Both A and R are true and R is not the correct explanation of A.

(c) A is true but R is false.

(d) A is false but R is true.

Ans. (A) *(b) Amphibia*

Explanation: When the permanent kidney, the metanephros, is functional, the mesonephric kidney disappears in all mammalian species. It is mainly found in aquatic animals such as amphibians and it serves as their main excretory organ. While in the reptiles and aves, it serves as a temporary kidney.

(B) *(a) Vitamin C*

Explanation: Vitamin C is a water-soluble vitamin. Because of this property, it is excreted out in the urine.

(C) Urine is a liquid nitrogenous waste product produced due to protein and nucleic acid metabolism by the body. It comprises 91% to 96% water, it also contains a variety of solid and liquid components.

(D) Aquatic reptiles excrete urea as a nitrogenous waste product.

(E) *(c) A is true but R is false.*

Explanation: Ammonia is a form of basic nitrogenous protein catabolite that is highly soluble in water and extremely harmful to animals. As a result, its level in blood must be kept very low. Thus, ammonia should be eliminated from the body as quickly as it is produced. The animals require a considerable amount of water to excrete ammonia from their bodies. As a result, its removal in urine results in a significant loss of water from the body.

Role of Other Organs in Excretion

Other than the kidneys, there are a few more excretory organs that help in the removal of excretory wastes.

Lungs

The waste products of respiration are carbon dioxide and water. The CO_2 and some water (in vapour form) are removed by the lungs in expired air. Human lungs expel 400 mL of water in the form of water vapour each day and about 18 L of CO_2 per hour.

Liver

Liver cells degrade haemoglobin of worn-out red blood corpuscles into bile pigments like bilirubin and biliverdin. These pigments are carried by bile into the intestine and eliminated with the faeces. Liver also excretes cholesterol, steroid hormones, some vitamins, and many drugs. The liver deaminates undesirable amino acids and generates ammonia, which is rapidly coupled with CO_2 to produce urea in the urea cycle, which is then eliminated by the kidneys.

Skin

Sweat and sebaceous glands in the skin can remove certain chemicals from the body through their secretions.

(1) **Sweat Gland:** Sweat is an aqueous fluid consisting of NaCl, lactic acid, small amounts of urea, amino acids and glucose. Controlling

sweat loss is an example of homeostasis control in terms of body temperature regulation (*i.e.*, to facilitate a cooling effect on the body surface).

(2) **Sebaceous Gland:** Sterols, fatty acids, waxes and hydrocarbons are all removed by sebum from the sebaceous glands. This secretion is primarily responsible for the skin's protective oily covering.

Intestine

Epithelial cells of the intestine (colon) eliminate certain salts such as calcium, and iron with the faeces.

Salivary Glands

Salivary gland excretes substances like mercury, potassium iodide, lead and thiocyanate.

Example 1.2: Describe the role of liver, lungs and skin in excretion. **[NCERT]**

Ans. Lungs: Every day, the lungs eliminate a significant amount of carbon dioxide (18 litres) as well as a significant amount of water.

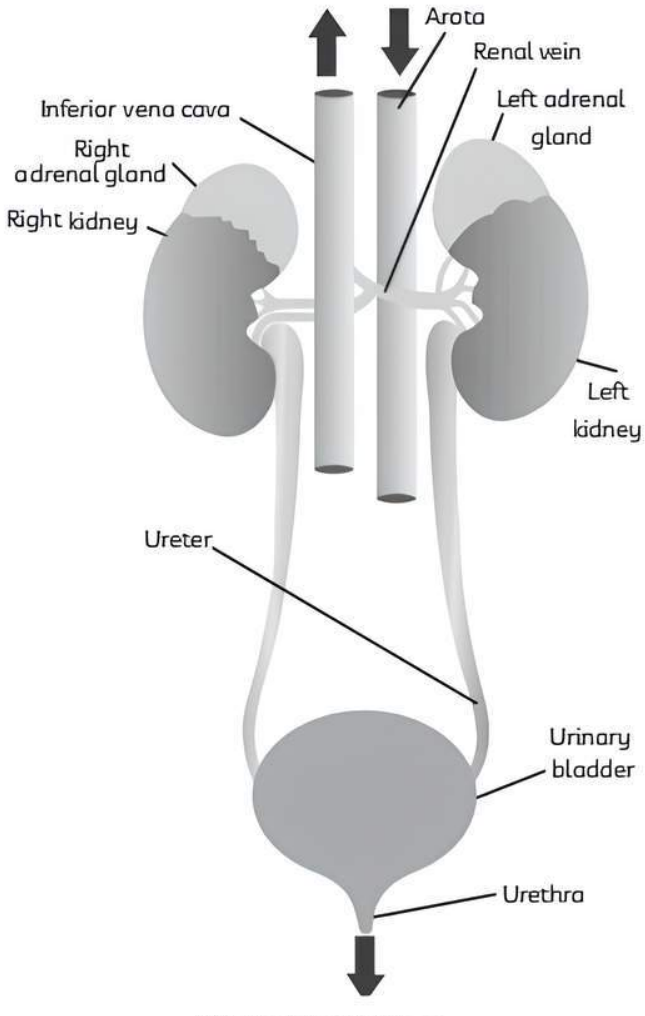
Liver: Bile, which contains bilirubin, biliverdin, degraded steroid hormones, vitamins, cholesterol, and drugs, are secreted by the liver. The majority of these chemicals are excreted together with digestive wastes.

Skin: Sebaceous glands and sweat glands present in skin can remove certain chemicals from the body through their secretions. Sweat is a watery fluid that contains NaCl, small amounts of urea, lactic acid, and other substances.

TOPIC 2

HUMAN EXCRETORY SYSTEM

In humans, the excretory system consists of a pair of kidneys, one pair of ureters, a urinary bladder and a urethra.



Human urinary system

Kidney

These are reddish-brown bean-shaped structures located near the dorsal inner wall of the abdominal cavity between the levels of the last thoracic and third lumbar vertebra. Human kidney is metanephric.

Location: On both sides of the diaphragm, the kidneys are situated underneath the diaphragm. Since the liver takes up more space on the right side, the right kidney is slightly lower and smaller than the left kidney. Kidneys are retroperitoneal in position.

One ureter arises from each kidney, and the two ureters obliquely open into the urinary bladder. Urinary bladder is a hollow, muscular sac-like structure which functions as a temporary storage organ of urine. The urethra is a membranous tube that emerges from the bladder's neck and transports urine to the exterior.

Important

➥ *An adult human kidney has a measurement of 10-12 cm in length while 5-7 cm in width and 2-3 cm in thickness, and 120-170 gm in average weight (i.e., 150 gm in males and about 135 gm in females).*

Structure of kidney

The structure of the kidney can be studied in different ways: exterior and interior structures.

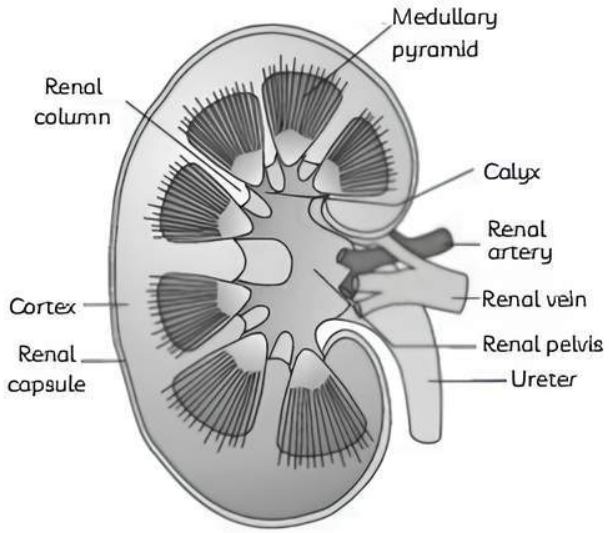
(1) The inner surface of each kidney is concave and the outer surface is convex. At the inner concave surface, a notch is presently called the hilum through which blood vessels (renal artery and renal vein) pass in and out of the kidneys along with the ureter and nerve supply.

(2) The kidney is surrounded by a layer of fibrous connective tissue, the renal capsule (innermost layer) which protects it from infection and injuries. Out to this capsule, there is a layer of fat, the adipose capsule, and another outer fibrous membrane, the renal fascia.

(3) Inside the kidney, two distinct areas are present the outer cortex and inner medulla. The medulla is divided into a few conical masses known as Medullary Pyramids projecting into the calyces. Each renal medullary pyramid ends into a structure called renal papilla.

(4) Column of Bertini: Column of Bertini refers to the cortex that extends between the pyramids as the renal column.

(5) The functional unit of each kidney is about one million of complex structures called nephrons.



Internal structure of kidney

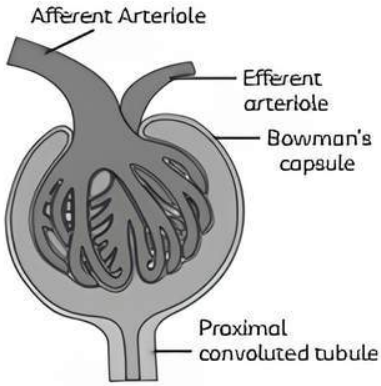
Structure of Nephron

Nephron is the structural and functional unit of the kidney. Renal corpuscle and Renal tubule are the two parts of a nephron. Glomerulus and Bowman's capsule are together named as Malpighian body or Renal corpuscles.

Glomerulus: It is the tuft of capillaries. The afferent arteriole, which supplies blood to the glomerulus, is short and wide, whereas the efferent arteriole, which takes blood away from the glomerulus, is narrow and long.

Bowman's capsule: Bowman's capsule is a cup-like structure with two walls surrounding the glomerulus. Exterior parietal wall of Bowman's capsule is made up of flattened (squamous) cells, while the interior visceral wall is made up of specialised cells called podocytes.

Renal tubules: The tubule has a relatively short neck present just below the glomerulus.



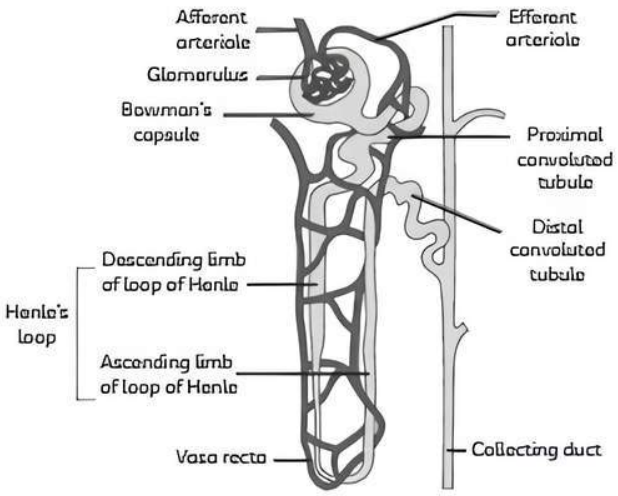
Malpighian body (Renal Corpuscle)

The renal tubule has three different regions just below the glomerulus:

(1) **Proximal convoluted tubule (PCT):** The tubules continue to form a highly coiled tubular part behind the neck and are restricted to the cortical portion of the kidney. It is lined by brush-bordered cuboidal epithelial cells. Tall microvilli (finger-like processes) at the free end of the cells are present which gives the appearance of brush-like.

(2) **Loop of Henle's:** It is a U-shaped hairpin-like loop with a descending limb terminating in the medulla and an ascending limb which returns back to the cortex.

(3) **Distal convoluted tubule (DCT):** The ascending limb extends as the distal convoluted tubule, a heavily coiled tubular area (DCT). Many nephrons' DCTs open into a straight tube known as a collecting duct, which converges and opens into the renal pelvis *via* medullary pyramids in the calyces.



Structure of nephron

Important

➥ *Afferent Arteriole: These are fine branches of renal artery which arise from the dorsal aorta. Afferent arteriole brings arterial blood to the renal capsules. Its blood contains a lot of nitrogenous waste materials.*

➥ *Efferent Arteriole: Efferent Arteriole arises from the glomerulus. It has a narrower diameter than afferent. The efferent arteriole divides to form the peritubular capillary network around the proximal and distal convoluted tubules of the nephrons. From the peritubular capillary network arise the capillaries of vasa recta which run parallel to the loops of Henle and the collecting ducts in the medulla. All the capillary networks join to form renal venules which join to form a renal vein that opens into the inferior vena cava. The blood that flows through it is low in waste materials.*

Example 1.3: Write the difference between Ascending Limb and Descending Limb of Henle's Loop.

Ans.

Ascending limb	Descending limb
It is impermeable to water but permeable to salts.	It is permeable to water, but impermeable to salts.
The ascending limb is thick than descending limb.	It is quite thin than ascending limb.
The fluid flow is in an upward direction.	The fluid flow is in a downward direction.

Types of Nephron

Based on their location in the Kidney, there are two types of Nephrons.

(1) **Cortical nephron:** The loop of Henle in the majority of nephrons is too short and extends only a small amount into the medulla; these nephrons are referred to as cortical nephrons. They form 85% of total nephrons.

(2) **Juxta-medullary nephron:** The Henles loop in some nephrons is too long and extends deep into the medulla. Such nephrons are juxta-medullary nephrons. They form 15% of total nephrons.

Ureters

The pelvis of each kidney is continued as a ureter and emerges out at hilum. Ureter is a long and muscular tube. Each ureter is about 25 to 30 cm in length. They are narrow, whitish, tubular structures, running backward along the abdominal wall to open into the urinary bladder. Ureters of both sides extend posteriorly and open into the urinary bladder. It is made up of transitional epithelium.

Urinary Bladder

In the pelvic cavity, it is a thin-walled, pear-shaped, white translucent sac. It serves as a temporary storage system for urine. Its inner lining is made up of transitional epithelium. Its muscular layer is well- developed and is called detrusor muscle.

Urethra

The membranous tube that transports urine to the outside is urethra. Except when urinating, the urethral sphincters keep the urethra closed. Its length differs in males and females. In females, urethra is short (about 4 cm in length) and carries urine only. It opens by urethral orifice (urinary aperture) in front of vaginal aperture. In males, urethra is much longer (about 20 cm in length) which opens out at the tip of penis by urinogenital aperture. Thus, the male urethra carries both urine as well as semen.

Urine Formation

Urine formation is of three major steps:

(1) Glomerular filtration
(2) Tubular reabsorption / selective reabsorption
(3) Tubular secretion

Glomerular filtration (Ultrafiltration)

The initial step in the formation of urine is the glomerular filtration of blood, that is carried out by the glomerulus. The kidney filters around 1100 to 1200 ml of blood per minute, which is one-fifth of the blood pumped by each ventricle of heart per minute. Blood is filtered *via* three layers due to glomerular capillary blood pressure: Endothelium of glomerular blood vessels, epithelium of Bowman's capsule, and the basement membrane between these two layers. Bowman's capsule epithelial cells are known as podocytes, and they are arranged in such a way that filtration slits are formed. Almost all plasma constituents, except proteins, pass through the lumen of Bowman's capsule after being filtered through these membranes. As a result, this procedure is considered as ultrafiltration. The amount of the filtrate formed by both kidneys per minute is called the glomerular filtration rate (GFR). In a normal person, GFR is about 125 ml per minute, *i.e.*, 180 litres per day.

Tubular reabsorption

The second stage in the urine formation from filtrate is tubular reabsorption. In comparison to the volume of filtrate produced every day (180 L), the urine released is 1.5 L. It indicates that the renal tubules reabsorb up to 99% of the filtrate. As a result, the process is known as reabsorption. Epithelial cells present in the different segments of the nephrons perform this role either through passive or active mechanisms depending on the types of molecules being reabsorbed.

Nitrogenous wastes are absorbed passively. Reabsorption of water also occurs through passive transport in initial segments of nephron.

Glucose, amino acids and Na^+ are reabsorbed actively.

Tubular Secretion

It is also an essential step in the formation of urine. Tubular secretion removes certain substances from the blood that are not eliminated by filtration from the glomerular capillaries. It helps in the regulation of ionic and acid-base balance of body fluids by eliminating toxins such as foreign materials, ions (K^+, H^+, NH^+_4), and molecules (drugs) which have a high level of toxicity.

Glomerular Filtration Rate (GFR)

It is the amount of filtrate produced by both kidneys per minute. In a healthy human, it is around 125 mL per minute or 180 litres per day.

Auto regulatory mechanism of GFR

GFR is controlled by an inbuilt mechanism in the kidneys. The juxtaglomerular apparatus (JGA) is a specialised cellular structure found between the afferent and efferent arteriole which is close to the bowman's capsule. A decrease in GFR causes JGA cells to release renin, which raises glomerular blood flow and restores GFR to normal.

Functions of the Tubules

Water and various filtrate components of glomerular filtrate/primary urine are reabsorbed in distinct areas when it passes through the renal tubule. These are listed in the following order:

Proximal Convoluted Tubule (PCT)

The microvilli are simple cuboidal brush-border epithelium which present on the PCT epithelial cells and increases the surface area for reabsorption. The majority of the reabsorption process (65%) occurs within PCT. The absorption of HCO^-_3 from the filtrate is also increased by PCT. The pH and ionic balance of the bodily fluids are maintained by selective secretion of hydrogen ions, ammonia, and potassium ions. Nearly all of the essential nutrients and 70-80 % of electrolytes and water are reabsorbed by this segment.

Henle's Loop

Henle's loop has a minimum reabsorption rate, yet it is vital for maintaining the high osmolarity of the medullary interstitial fluid. Henle's loop has two parts that perform separate roles in osmoregulation, such as:

(1) **Descending Limb:** Because of the increasing osmolarity of the interstitial fluid, water is reabsorbed in descending limb, but sodium and other electrolytes are not reabsorbed. As the filtrate moves down, it becomes more concentrated.

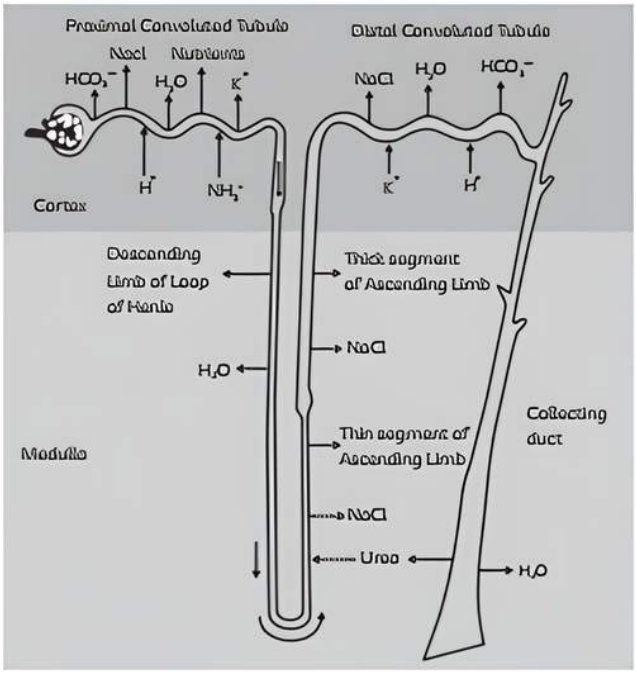
(2) **Ascending Limb:** This segment is impermeable to water, however, it is permeable to K^+, Cl^-, and Na^+, and only partly permeable to urea. As a result, Na^+, K^+, Mg^{2+}, and Cl^- are reabsorbed in ascending limb of the Henle's loop. As a result of the passage of electrolytes upto the medullary fluid, the concentrated filtrate becomes diluted as it passes upward.

Distal Convoluted Tubule (DCT)

In DCT conditional reabsorption of Na^+ and water takes place. Under the action of aldosterone, active reabsorption of Na^+ ions from the filtrate occurs. Under the effect of Antidiuretic Hormone (ADH), water is reabsorbed here. Potassium (K^+), hydrogen (H^+) ions, ammonium NH_4^+ ions, certain Cl^- (chloride) ions, and HCO^-_3 are all reabsorbed here with the related secretion. The pH of the blood and the sodium-potassium balance is also maintained. The filtrate is now isotonic to blood plasma.

Collecting Duct

This duct extends from renal cortex to the medulla's inner portions and is extremely permeable to water. Thus, under the influence of ADH, a significant amount of water is reabsorbed here, resulting in the formation of concentrated urine. Under the influence of aldosterone, sodium is also reabsorbed here. To maintain high osmolarity, the CT (Collecting Tubule) permits small amounts of urea to pass into the medullary interstitium. It also contributes to the maintenance of blood pH and ionic balance through the selective secretion of H^+ and K^+ ions. Therefore, the filtrate is now known as urine. As a result, urine is isotonic to the medullary fluid but hypertonic to the blood. By regulation of water levels, concentrations of important ions and other substances in the blood are controlled.



Example 1.5: What are the juxtaglomerular apparatus's position and function?

Ans. The distal convoluted tubule passes close to the Bowman's capsule between the afferent and efferent arterioles, forming this unique cellular apparatus called JGA. JGA cells release renin, a chemical that regulates blood pressure and renal blood flow, and consequently GFR.

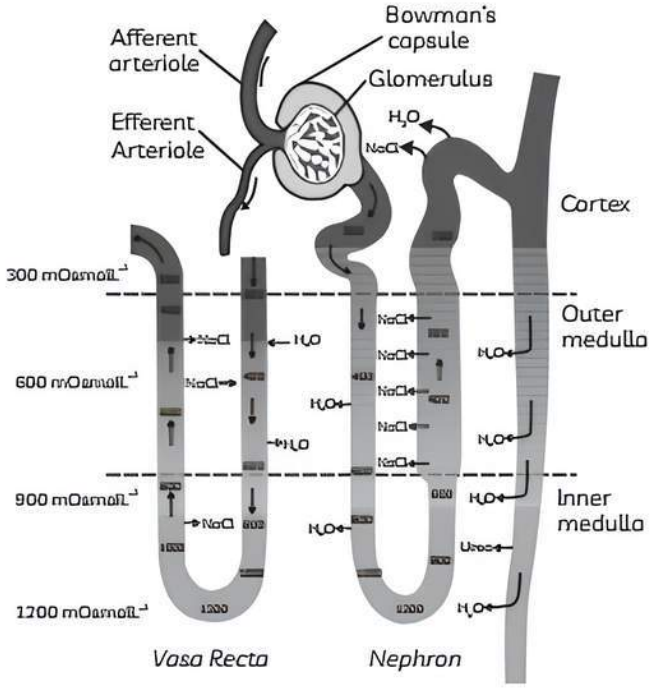
Counter-current Mechanism

The Henle's loop and the vasa recta are responsible of concentrating the filtrate (urine). They make up a mechanism known as the counter current mechanism. The flow of filtrate in the two limbs of the Henle loop and the flow of blood in the two limbs of the Vasa recta are in opposite directions, forming a counter-current system.

The following factors cause osmolarity to rise in the medullary interstitium:

(1) The proximity of the Henle's loop and the vasa recta.

(2) The counter-current system in both. The osmolarity in the cortex is around 300 msmol/L, while it is around 1200mOsmol/L in the medulla. NaCl and urea maintain this gradient. The loop of Henle maintains the NaCl interstitial gradient. If urea diffuses back into the ascending limb from the collecting duct, it is added to the interstitial fluid of the medulla. As a result of the counter-current process, a concentration gradient between the medullary interstitium and urine tubule is maintained. Human kidney can produce urine four times more concentrated than initial glomerular filtrate.



Diagrammatic representation of a nephron and vasa recta showing counter current mechanisms

Regulation of Kidney Functions

Regulation by hypothalamus

The osmoreceptors present in the blood vessels of hypothalamus are stimulated when the osmolarity increases above a set point of 300 msm/L and causing the hypothalamus to release antidiuretic hormone (ADH) from the posterior pituitary. To prevent diuresis, ADH signals the DCT and collecting duct to reabsorb water from the filtrate. It also promotes blood vessel constriction and increases blood pressure, which elevates GFR. In this situation, osmoreceptors also increase thirst.

Regulation by Renin Angiotensin-Aldosterone System

The Renin Angiotensin-Aldosterone System (RAAS) is a multi-hormonal system that operates JGA (RAAS). JGA releases renin, which transforms angiotensinogen in the blood into angiotensin I and ultimately angiotensin II when glomerular blood flow decreases. Angiotensin II is a potent vasoconstrictor that helps to sustain GFR by increasing glomerular blood pressure. It also causes the adrenal cortex to release aldosterone, which stimulates the reabsorption of Na^+ and H_2O from the DCT, resulting in a return to normal GFR.

Regulation by heart (ANF)

Atrial natriuretic factor is antagonistic to RAAS. ANF is released from the wall of atria of the heart. The release of atrial natriuretic factor (ANF) is due to an increase in blood volume and pressure to the atria of the heart. It causes vasodilation and thus decreases blood pressure. Thus dilute urine is produced.

Urine

A healthy adult man passes around 1-1.5 litres of urine every day.

Composition

Water makes up 95% of urine, other substances are only about 5%. Organic substances like urea, creatinine, creatine, ammonia, uric acid, hippuric acid, oxalic acid, amino acids, vitamins, hormones and enzymes. The inorganic substances like chloride, phosphate, sulphate, potassium, sodium, calcium magnesium, iodine, arsenic and lead etc. and other substances make up the remaining 3%. Due to the pigment urochrome formed by the breakdown of haemoglobin, the colour of urine is pale yellow. The pH ranges between 4.5-8.2 with an average of pH 6.0. (*i.e.*, slightly acidic). It has a strong ammonia-like odour. 25-30 gm of urea is excreted out daily.

Example 1.6: Case Based:

For a survey on kidney failure, some students visited hospitals in their area. They met different people with different kidney disorders. During this survey, they found that most of the kidney failure is due to improper filtration and disturbed filtration mechanism. On the basis of this answer the related questions given below:

(A) What will happen to the glomerular filtration if the afferent renal arteriole is decreased in diameter and efferent renal arteriole increases in diameter?
(a) Be faster
(b) Be slower
(c) Take place at the same speed
(d) No effect will be seen

(B) Which of the following is completely reabsorbed in renal tubules?
(a) Sodium (b) Water
(c) Potassium (d) Glucose

(C) Name the hormone which improves the water permeability in Distal tubule.

(D) Which is an important factor of the renin-angiotensinogen-aldosterone system?

(E) Assertion (A): The osmotic concentration of the blood is maintained by the kidneys.
Reason (R): According to the body's needs, the kidneys remove hypotonic or hypertonic urine.
(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true and R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

Ans. (A) *(b) Be slower*

Explanation: Glomerular filtration is affected and becomes extremely slow when the diameter of the efferent arteriole exceeds that of the afferent arteriole.

(B) *(d) Glucose*

Explanation: The glucose transporter reabsorbs the glucose filtered out of the glomerular filtrate. Because there is no glucose in the urine of a healthy person, almost all of the glucose is reabsorbed from the glomerular filtrate.

(C) ADH - Antidiuretic Hormone. This hormone is released from the posterior pituitary or neurohypophysis.

(D) Juxtaglomerular apparatus (JGA)

(E) *(a) Both A and R are true and R is the correct explanation of A.*

Explanation: The kidneys are responsible for controlling blood concentration and osmotic pressure. When an animal's water intake is high, the urine excreted must be hypotonic, that is, dilute and lower in osmotic pressure than their blood, in order to remove the excess water. When there is a risk of excessive water loss from the body, the urine must be hypertonic, *i.e.* more concentrated and higher in osmotic pressure than the blood, in order to reduce water loss through urine.

TOPIC 3

DISORDERS OF THE EXCRETORY SYSTEM

Kidney dysfunction can result in a variety of excretory system problems such as:

Uremia

The presence of an excessive amount of urea in the blood is called uremia. Urea is extremely dangerous because it poisons cells at high concentrations and can cause kidney failure.

Failure of the Kidneys (Renal Failure)

Renal or kidney failure is the partial or complete inability of the kidneys to perform excretory and salt-water regulating activities.

Renal Calculi

It is the formation of a stone or an insoluble mass of crystallised salts (calcium, magnesium, phosphates, and oxalates, for example).

Glomerulonephritis

It is the inflammation of the kidney's glomeruli. A hemodialyzer (artificial kidney) is an equipment that filters a person's blood (to eliminate urea and other nitrogenous wastes) when their kidneys are destroyed.

Diabetes Insipidus

When the kidneys are unable to save water while filtering blood, a rare illness called diabetes insipidus develops. This form of diabetes is different than diabetes mellitus (sugar diabetes). Despite their origins and treatments differing, both types of diabetes are linked to frequent urination.

A deficiency of antidiuretic hormone (ADH), also known as vasopressin, which prevents dehydration, or the kidney's inability to react to ADH, is the main cause of diabetes insipidus.

Important

➥ *Central diabetes insipidus is the term used to describe diabetes insipidus that results from a deficiency in ADH. Damage to the hypothalamus or pituitary gland may be the cause of this disease.*

➥ *Nephrogenic diabetes insipidus, which may be hereditary, is the term used when the condition is brought on by the kidneys' inability to react to ADH.*

TOPIC 4

ARTIFICIAL KIDNEY (HAEMODIALYSIS) AND KIDNEY TRANSPLANT

Artificial Kidney and Dialysis

Dialysis is an artificial process for removing extra fluid and waste from the body. It is accomplished with the aid of a **dialyzer** or **artificial kidney**.

Haemodialysis is the process which is done with the help of a dialyzer. Haemodialysis is often known as renal replacement therapy.

A kidney will filter a hundred and eighty litres of blood each day. If the kidneys don't seem to be functioning properly, waste starts accumulating within the blood. This leads to coma and even death. To cure this, the patient is subjected to dialysis.

The process of dialysis maintains the body balance in the following ways:

(1) It controls blood pressure.

(2) It removes excess water and metabolic wastes from the body.

(3) It prevents chemicals like $K^{\oplus}$, $Na^{\oplus}$ and bicarbonates from reaching harmful levels.

Dialysis is employed for individuals with a critical kidney disorder such as grave kidney damage, previously severe renal failure, etc. This treatment might continue for months or years since most kidney failures are irreversible.

Process of Dialysis

(1) A dialyzer is used to filter arterial blood, which is then returned to the body through a vein during the dialysis procedure. During the blood's passage through the machine, heparin is employed as an anticoagulant.

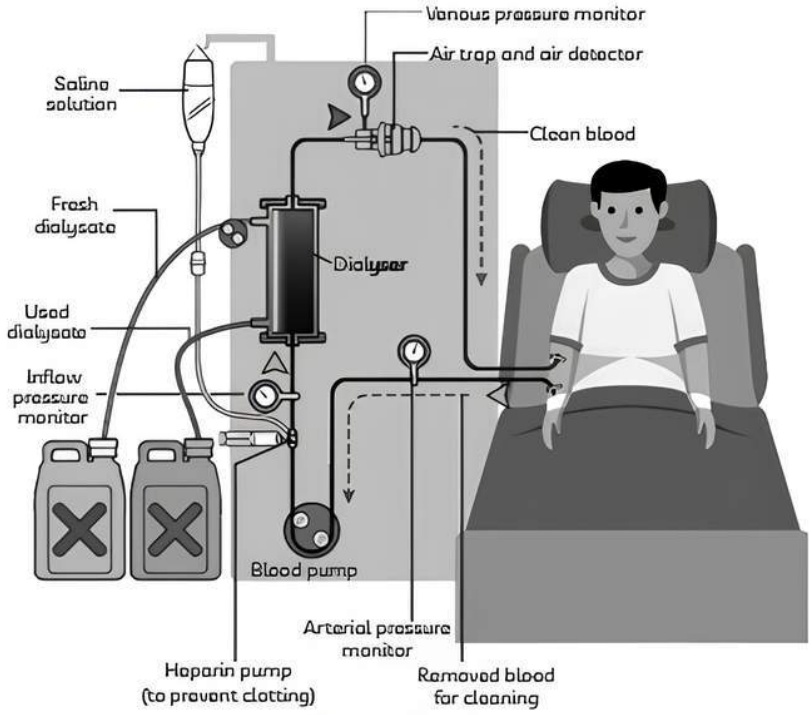
(2) The hemofilter, which is located inside the dialyzer and has microscopic channels placed between two cellophane membranes, is where the blood passes through the dialyzer. These membranes have pores.

(3) These membranes' exterior surfaces are submerged in dialysate, a dialyzing fluid. Fresh dialysate is continuously added to replace the used dialysate.

(4) By way of the concentration gradient, urea, phosphate, creatinine, and other undesirable components of the blood enter the dialysate. The dialysate's constituents that the body requires diffuse into the blood.

(5) Almost all substances, with the exception of plasma proteins, are exchanged between the blood and dialysate through cellophane membranes.

(6) Additionally, the dialysis machine features a number of blood pumps with pressure monitors that make it simple for the patient's blood to flow from them to the machine and back again. Moreover, it contains pumps for the drainage of spent dialysate and the flow of fresh dialysate.



Process of dialysis

Kidney Transplant

In a kidney transplant, a healthy kidney from a living or deceased donor is surgically implanted into a patient whose kidneys are no longer functioning correctly.

This procedure is mainly performed on people who are suffering from end-stage renal disease or chronic kidney disease (when the kidneys have lost about 90% of their ability to function normally).

Before the process of a kidney transplant, several tests such as blood typing, tissue typing, crossmatch, etc. are performed to evaluate whether a donor kidney will be a good match for the patient or not.

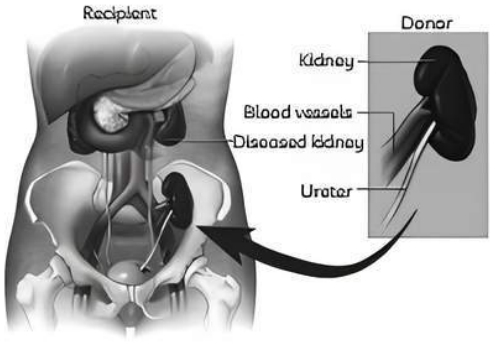
Process of kidney transplant

(1) General anaesthesia is used during kidney transplant surgeries. Throughout the procedure, the surgical team keeps an eye on the patient's heart rate, blood pressure, and blood oxygen level.

(2) The new kidney is inserted into the body through an incision made by the surgeon in the lower portion of one side of the abdomen. Patients' kidneys are left in place unless they are producing issues like high blood pressure, kidney stones, discomfort, or infection.

(3) Just over one of the legs, in the lower region of the abdomen, are blood veins to which the new kidney's blood vessels are connected.

(4) The bladder is attached to the ureter of the new kidney, which is the tube that connects the kidney with the bladder.



Kidney transplant

Example 1.7: What method uses artificial kidneys?

Ans. Hemodialysis is a procedure that uses an artificial kidney to eliminate waste products from the body. Purified blood is pumped back into the body after being removed from a dialysis solution by a series of semi-permeable membranes.

Example 1.8: Kidney transplantation is better in comparison to dialysis. Justify the statement.

Ans. Despite being a life-saving procedure, dialysis only performs around 10% of the functions of a healthy kidney. Because of its impact on the body, dialysis can also cause other health problems. With a kidney transplant, patients often live 10 to 15 years longer than they would if they continued on dialysis. And the majority of people claim that transplantation significantly improves their quality of life in contrast. Hence, kidney transplantation is a much better procedure in comparison to dialysis.

OBJECTIVE Type Questions

[1 mark]

1. Filtration of the blood takes place in:

(a) PCT (b) DCT

(c) Collecting ducts (d) Malpighian body

[NCERT Exemplar]

Ans. *(d) Malpighian body*

Explanation: The driving force that drives filtrate out of the capillaries and into the slits in the nephron is the force of hydrostatic pressure present in the glomerulus (that is, the force of pressure exerted from the pressure of the blood vessels itself). Thus, the malpighian body is responsible for blood filtration.

2. The Ornithine cycle is responsible for the formation of:

(a) $C_5H_4N_4$ (b) $C_5H_4N_4O_3$

(c) $[(NH_2)_2CO]$ (d) NH_3

Ans. *(c) $[(NH_2)_2CO]$*

Explanation: The urea cycle is also known as the ornithine cycle. The formation of urea from ammonia is the urea cycle. Urea has the chemical formula $[(NH_2)_2CO]$. Ammonia is NH_3. Purine is $C_5H_4N_4$. Uric acid is represented by the formula $C_5H_4N_4O_3$.

Related Theory

The ornithine cycle (also known as the urea cycle) is a series of biochemical pathway that converts ammonia (NH_3) into urea $(NH_2)_2CO$. In ureotelic species, this cycle occurs. The urea cycle transforms extremely toxic ammonia into urea, which is then excreted.

3. Which of the following pair is correctly matched?

(a) Humerus - hind leg

(b) Sebum - sexual attraction

(c) Saliva - sense of food taste

(d) Sweat - temperature regulation

Ans. *(d) Sweat - temperature regulation*

Explanation: Sweat is primarily made up of water, however, it also contains salts. Its main function is to regulate body temperature. The skin temperature cools when the water in sweat evaporates.

4. Statement A: As the concentrated filtrate passes upward in the descending limb of the loop of Henle, it gets diluted.

Statement B: Ascending limb allows the passage of electrolytes actively or passively the medullary fluid.

(a) Both A and B are correct.
(b) Both A and B are incorrect.
(c) Only A is correct.
(d) Only B is correct.

Ans. *(d) Only B is correct.*

Explanation: The amount of reabsorption is minimal in Henle's loop. However, this area is crucial in ensuring that the medullary interstitial fluid is kept at high osmolarity. Water can pass through the descending limb of the Henle loop, but electrolytes are essentially impermeable. As it descends, this concentrates the filtrate. Although the ascending limb is impermeable to water, it allows for active or passive movement of electrolytes. As a result, electrolytes moving into the medullary fluid dilute the concentrated filtrate as it passes upward. As a result, the Henle loop's hairpin bend between the ascending and descending limbs is where the filtrate is most concentrated.

5. Excretory products of mammalian embryo are eliminated by:

(a) Amniotic fluid **(b) Ureters**
(c) Placenta **(d) Allantois**

Ans. *(c) Placenta*

Explanation: The placenta removes the excretory products of the mammalian embryo. During pregnancy, it is an organ linked to the womb's lining that transports oxygen and nutrients from the mother's blood to the baby *via* placenta.

6. Which one of the following statements is incorrect?

(a) Birds and land snails are uricotelic animals.
(b) Mammals and frogs are ureotelic animals.
(c) Aquatic amphibians and aquatic insects are ammonotelic animals.
(d) Birds and reptiles are ureotelic.

[NCERT Exemplar]

Ans. *(d) Birds and reptiles are ureotelic*

Explanation: Uricotelic animals are reptiles (snakes and lizards), birds, land snails, and insects that eliminate nitrogenous wastes in the form of uric acid as a pellet or paste with minimal water loss.

7. The kidneys are situated in:

(a) pelvic cavity **(b) thoracic cavity**
(c) body cavity **(d) abdominal cavity**

Ans. *(d) abdominal cavity*

Explanation: Along with digestive organs, kidneys are located in the abdominal cavity.

Related Theory

The brain and spinal cord are situated in the dorsal body cavity. The bladder and reproductive organs are located in the pelvic cavity, a part of ventral body cavity.

8. Which of the following can be cured by hemodialysis?

(a) Uremia
(b) Renal calculi
(c) Acute Glomerulonephritis
(d) All of the above

Ans. *(a) Uremia*

Explanation: Toxins accumulated in blood, cause uremia. When kidneys stop filtering toxins out through urine, it causes uremia. The kidneys get severely damaged in Uremia. Dialysis is the most common treatment for uremia. Dialysis is when wastes, excess fluids, and toxins are removed from the bloodstream artificially.

Related Theory

Hemodialysis is a blood-cleaning procedure that uses a dialysis machine and a filter (artificial kidney), or dialyzer. The dialyzer, commonly known as a filter, is divided into two sections: One for patient blood and the other for dialysate, a cleansing solution. A small membrane separates these two components. Blood cells, proteins, and other important substances can not cross past the barrier, so they stay in patients' blood. Smaller waste substances in the blood, such as urea, creatinine, potassium, and excess fluid, pass through the membrane and are washed away.

Caution

Students must remember that glomerulonephritis is also treated with dialysis but acute glomerulonephritis is cured naturally by changing diet. Haemodialysis is a type of dialysis treatment which is specifically used for treating Uremia.

9. What happens when the glomerular filtration rate falls?

(a) Repression of juxta glomerular cell
(b) Release of renin
(c) Activation of podocyte
(d) None of the above

Ans. *(b) Release of renin*

Explanation: When the rate of GFR decreases, the juxtaglomerular cells become activated, releasing the renin hormone, which stimulates glomerular blood flow and therefore normalises the GFR level.

10. The ureter, nerves and blood vessels, enter the kidney *via*:

(a) Calyces **(b) Cortex**
(c) Capsule **(d) Hilum**

Ans. *(d) Hilum*

Explanation: Hilum is the concave area (notch) on the inner side of the kidney where nerves and blood vessels enter and exit the kidney; it is also the area from where the ureters exit.

11. The major amount of water and salts are reabsorbed by the body in:

(a) Bowman's capsule
(b) DCT and PCT
(c) PCT
(d) DCT

Ans. *(c) PCT*

Explanation: The majority of reabsorption takes place in the proximal convoluted tubule. In the proximal convoluted tubule, around 70-80 per cent of electrolytes and water are reabsorbed and returned back to the circulation.

12. In glycosuria, urine contains an abnormal amount of:

(a) Amino acids **(b) Glucose**
(c) Epithelial cells **(d) Inorganic ions**

Ans. *(b) Glucose*

Explanation: The condition in which an abnormal amount of amino acid is found in urine is aminoaciduria and the condition in which glucose is present in abnormal amounts in urine is glycosuria.

13. ..... are the major excretory organs in Mosquito.

(a) Nephrons
(b) Flame cells
(c) Malpighian tubules
(d) Nephridia

Ans. *(c) Malpighian tubules*

Explanation: Chief excretory structures in mosquito are Malpighian tubules and hindgut.

Caution

Students usually get confused here and mark wrong answers Flame cells are excretory organs of freshwater invertebrates, including Platyhelminthes. Nephrons and nephridia are excretory organs for humans and annelids, respectively.

14. The notch on medial side of the kidney is referred to as:

(a) Pyramid **(b) Pelvis**
(c) Ureter **(d) Hilum**

Ans. *(d) Hilum*

Explanation: The hilum is a notch on the kidney's medial concave border from where the renal artery enters and the renal vein leaves.

15. In vertebrates, the formation of hyperosmotic (concentrated) urine is mostly dependent on:

(a) Capillary network forming glomerulus
(b) Length of Henle's loop
(c) PCT length
(d) Bowman's capsule area

Ans. *(b) Length of Henle's loop*

Explanation: The loop of Henle is responsible for the kidney's ability to produce urine that is hypertonic to blood plasma. The Henle's loop does not directly concentrate urine; instead, it acts as a counter-current multiplier that creates a concentration gradient in the surrounding interstitial medulla.

16. Statement A: Excessive loss of fluid from body stimulates the release of TSH.

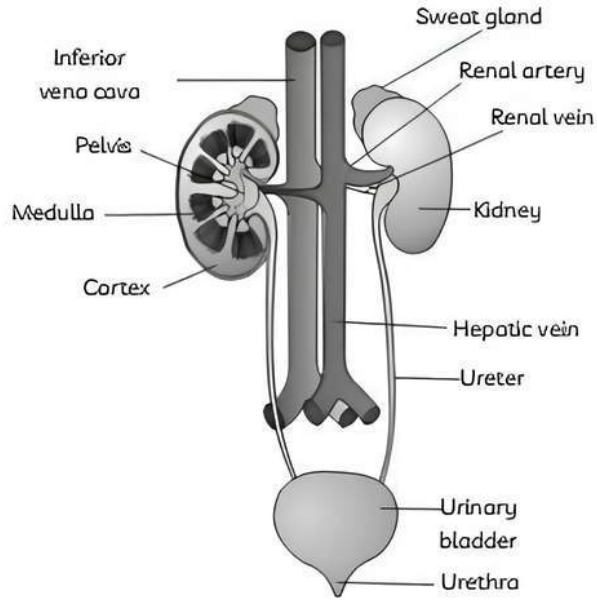
Statement B: TSH facilitates water reabsorption from latter parts of the tubule, thereby preventing diuresis.

(a) Both A and B are correct.
(b) Both A and B are incorrect.
(c) Only A is correct.
(d) Only B is correct.

Ans. *(b) Both A and B are incorrect.*

Explanation: These receptors can be activated by an excessive loss of bodily fluid, which prompts the hypothalamus to release vasopressin or antidiuretic hormone (ADH) from the neurohypophysis. ADH makes it easier for water to be reabsorbed from the tubule's later sections (the collecting duct and distal convoluted tubule), which prevents diuresis. Osmoreceptors can be turned off and the release of ADH can be suppressed with an increase in bodily fluid content, completing the feedback loop. ADH primarily affects the kidney's collecting ducts, where it increases the reabsorption of water.

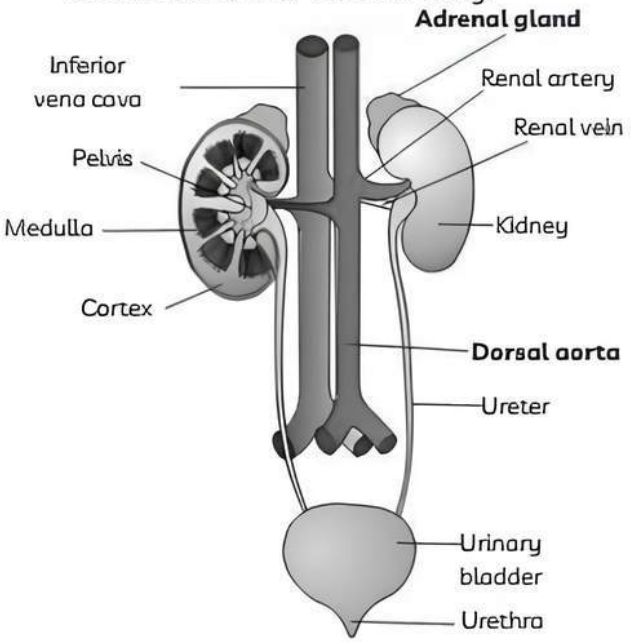
17. Which of the following is incorrectly marked in the given diagram?



(a) Renal artery and inferior vena cava
(b) Hepatic portal vein and sebaceous gland
(c) Dorsal aorta and ureter
(d) Urinary bladder and urethra

Ans. *(b) Hepatic portal vein and sebaceous gland*

Explanation: The given diagram represents the human urinary system. The human urinary system is a complex excretory system which is responsible for the concentration of urine and elimination of urea from the body.



Human urinary system

Assertion-Reason (A-R)

Given below are two statements labelled as Assertion (A) and Reason (R). Select the most appropriate answer from the options given below:

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true and R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

18. **Assertion (A):** Whales and seals are considered ureotelic animals.
Reason (R): It is due to the fact that urea is the major nitrogenous waste product in whales and seals.

Ans. *(a) Both A and R are true and R is the correct explanation of A.*

Explanation: Removal of nitrogenous waste product in the form of urea, is known as ureotelism and the organisms are called ureotelic. Because urea is the main nitrogenous waste product of aquatic mammals like whales and seals, they are known as ureotelic animals.

Caution

Ammonia is the most basic nitrogen catabolite of protein, but because it is very toxic to mammals, its content in the blood should be very low.

19. **Assertion (A):** When human urine is let to stand for a long time, it has a strong ammonia odour.
Reason (R): Ammonia is the main component in human urine.

Ans. *(c) A is true but R is false.*

Explanation: Though urea is the main nitrogenous component of human urine, a minor quantity of ammonia is also present in it. When urine is allowed to remain for an extended period of time, bacterial breakdown occurs, resulting in the creation of ammonia from urine, which has a distinct odour.

20. **Assertion (A):** The vasa recta is not present or highly diminished in cortical nephrons.
Reason (R): The main concern of cortical nephrons is urine concentration.

Ans. *(c) A is true but R is false.*

Explanation: Cortical nephrons are located in the renal cortex and have a short Henle's loop with no vasa recta. Hence, they are not included in urine concentration. When the water supply is normal, they regulate plasma volume.

21. **Assertion (A):** Comparative to uric acid urea is a more toxic excretory substance.
Reason (B): Birds and insects are uricotelic animals.

[Delhi Gov. QB 2022]

Ans. *(b) Both A and R are true and R is not the correct explanation of A.*

Explanation: Uricotelic organisms are those that emit uric acid as a nitrogenous waste product. Uric acid excretion is the least hazardous as compared to the other two ammonia and urea, thus requiring the least water.

Insects, land snails, birds, and most reptiles which must conserve water, are uricotelic.

CASE BASED Questions (CBQs)

[**4** & **5** marks]

Read the following passages and answer the questions that follow:

22. *Master Mahrishi Shukla was born with bilateral refluxing ureters (part of urine goes back to the kidney instead of coming out of natural passage). He was diagnosed as suffering from high blood pressure and kidney failure at 8 years of age. He was started on maintenance haemodialysis under care of a nephrologist. He had difficulty controlling blood pressure, for which he was hospitalised 8 times. Once he needed ventilatory support due to flash pulmonary edema and convulsions needing anaesthetic agents to control convulsion.*

His father decided to donate a kidney but family finances were not sufficient to pay for a kidney transplant.

(A) Structure that covers the kidneys is:

(a) calyx **(b) renal fascia**

(c) renal pyramid **(d) hilum**

(B) The given three major hormones are secreted by the kidneys. Match them with their correct functions.

Hormone	Function
(A) Renin	(i) Helps in the absorption of calcium in the intestines.
(B) Calcitriol	(ii) Released in response to hypoxia.
(C) Erythropoietin	(iii) Controls blood pressure by regulation of angiotensin and aldosterone.

Codes:

(a) (A) – (i), (B) – (ii), (C) – (iii)

(b) (A) – (iii), (B) – (i), (C) – (ii)

(c) (A) – (i), (B) – (iii), (C) – (ii)

(d) (A) – (ii), (B) – (i), (C) – (iii)

(C) Which of the following is not a function of kidneys?

(a) Filter blood

(b) Removal of metabolic waste

(c) Reabsorption

(d) None of the above

(D) What is the kidney's shape?

(a) The organ is oval in shape.

(b) It's a bean-shaped organ.

(c) It has a rectangular shape.

(d) It does not have a fixed shape.

(E) When a person is put on dialysis, he suffers from:

(a) Cardiovascular disease

(b) Kidney disease

(c) Respiratory issue

(d) None of the examples given

Ans. (A) *(b) renal fascia*

Explanation: Each kidney is secured in position by connective tissue called renal fascia and is protected by perirenal fat (thick layer of adipose tissue). Each kidney is surrounded with a thick, fibrous connective tissue renal capsule that provides support for the soft tissues inside.

⚠ Caution

➥ *Some students may select the option (a) as calyx covers the renal papilla but the whole kidney is surrounded by fibrous capsule renal fascia.*

(B) *(b) (A) – (iii), (B) – (i), (C) – (ii)*

Explanation: The kidneys secrete three different types of hormones: erythropoietin, renin and calcitriol (1, 25-dihydroxycholecalciferol).

(1) **Erythropoietin** is the peptide hormone secreted by the juxtaglomerular cells of the kidney. This hormone releases in response to hypoxia (insufficient oxygen supply to the tissues). It stimulates the formation of RBCs from the hematopoietic stem cells in the bone marrow.

(2) **Renin** is also a peptide hormone and it is secreted by the juxtaglomerular cells of the kidney. This hormone has enzymatic activity and it controls blood pressure by regulatng of angiotensin and aldosterone.

(3) **Calcitriol** is a steroid hormone synthesized by the cells of the proximal tubules of the nephrons. This hormone is the active form of vitamin D. It helps in the formation of calcium-binding protein thereby increasing the intestinal absorption of calcium. Thus, it plays an important role in the bone formation.

(C) *(d) None of the above*

Explanation: The functions of kidneys are described as follows:

(1) The major function performed by the kidneys is to filter the blood for urine formation.

(2) It removes the metabolic wastes like urea and uric acid from the blood and helps in their excretion through the urine.

(3) By reabsorbing bicarbonate from urine and releasing hydrogen ions and acid ions into the urine, it keeps the body's acid-base balance in check.

(4) By collaborating with the pituitary gland, it also regulates the body's levels of salt and water stablility.

(D) *(b) It's a bean-shaped organ.*

Explanation: Kidneys are reddish-brown bean-shaped structures located near the dorsal inner wall of the abdominal cavity between the levels of the last thoracic and third lumbar vertebra. Human kidney is metanephric.

(E) *(b) Kidney disease*

Explanation: Dialysis is employed for individuals with a critical kidney disorder such as grave kidney damage, previously severe renal failure, etc. Dialysis is an artificial process for removing extra fluid and waste from the body. This technique is accomplished with the aid of a dialyzer or artificial kidney.

23. *A man has symptoms like pain while passing urine through the urinary tract and pain in the lower back. Later he was diagnosed with kidney stones. A kidney stone affects one out of every 10 people at some point in their lives. These stones are mineral and acid salt deposits that clump together in concentrated urine but they rarely cause long-term damage. Severe pain, usually in the side of the abdomen, is the most prevalent symptom, which is frequently accompanied by nausea.*

(A) Mention the causes of kidney stones.

(B) Write any four symptoms of kidney stones are observed in starting?

(C) Write the names of the diagnostic approaches for kidney stones. Mention any four.

Ans. (A) Majority of stones are formed as a result of a mix of genetics and environmental influences. High calcium levels in the urine, obesity, some meals, certain drugs, calcium supplements, gout, hyperparathyroidism and not drinking enough water are all risk factors. When the concentration of minerals in urine is too high, stones form in the kidney.

(B) Symptoms of kidney stones observed in starting are:

(1) Back, belly, or side pain is common.

(2) During urinating, patients may experience pain or a burning sensation.

(3) Urine with blood in it.

(4) Urine that is cloudy or stinky.

(5) Nausea and vomiting are common side effects. *(Any four)*

(C) Kidney stones are diagnosed by the doctor through various diagnostic approaches such as:

(1) Imaging Tests

(2) Kidney Stone Analysis

(3) Urinalysis

(4) Blood Chemistry Screen

(5) Kidney Ultrasound *(Any four)*

Related Theory

- *Imaging tests include X-rays, ultrasound and CT Scans. The exact size and location of the stone are correctly detected through these imaging tests.*
- *In the kidney stone analysis technique, the patient is asked to pass a stone through urine and collect it using a kidney stone strainer. It then has to be provided to a laboratory for further chemical testing.*
- *Urinalysis is a technique of collecting a sample of 30-60 mL of urine and then it is tested for the presence of bacteria and harmful micro-organisms. Not only kidney stones but any irregularities or impairment can be detected through urinalysis.*
- *Blood chemistry screen or blood fasting test is done to ascertain levels of calcium, electrolytes and other substances responsible for causing kidney stones.*
- *Kidney ultrasound is done with the help of an ultrasound machine which uses sound waves for creating images of the stones, cysts or other irregularities in the kidney on the screen.*

VERY SHORT ANSWER Type Questions (VSA)

[1 mark]

24. The mechanism of concentration of filtrate is also known as a counter-current mechanism. Justify the statement. [Delhi Gov. QB 2022]

Ans. In the ascending limb, the outflow runs parallel to and in the opposite direction of the inflow in the descending limb.

25. Urine produced in the ..... passes through the ..... into the ..... where it is stored until it is released through the [Diksha]

Ans. Kidneys, Ureters, Urinary bladder, Urethra.

26. Name the region in which filtration occurs.

Ans. Glomerular is the region of nephron where filtration occurs.

27. What is the excretory product of the kidneys of reptiles? [NCERT Exemplar]

Ans. Excretory product in reptiles is uric acid. Because reptiles are uricotelic organisms.

28. Write the correct words.

The excretory system of human beings includes a pair of ..... a pair of ureters, a ..... and a urethra. [Diksha]

Ans. Kidneys, Urinary Bladder.

29. What is ultrafiltration of the kidney?

Ans. Ultrafiltration is the filtration of blood which occurs in the glomerulus.

30. Identify the glands that accomplish the excretory function in prawns.

Ans. Antennal glands or green glands perform the function of excretion in prawns.

SHORT ANSWER Type-I Questions (SA-I)

[2 marks]

31. Mark the odd ones as each of the following:

(A) Renal pelvis, medullary pyramid, renal cortex, ureter.

(B) Afferent arteriole, Henle's loop, vasa recta, efferent arteriole.

(C) Glomerular filtration, antidiuretic hormone, hypertonic urine, collecting duct.

(D) Proximal convoluted tubule, distal convoluted tubule, Henle's loop renal corpuscle. [Delhi Gov. QB 2022]

Ans. (A) Ureter

(B) Henle's loop

(C) Glomerular filtration

(D) Renal corpuscle

32. Why is it essential to eliminate waste products by excretion?

Ans. Since all waste products are harmful and toxic, it is essential and necessary to eliminate them from the body. They have a damaging effect on the body.

33. Name the products excreted by lungs and skin.

Ans. Products excreted by lungs are carbon dioxide and water vapour.

Products excreted by lungs are urea, water, a few salts, etc.

34. Comment upon the hormonal regulation of selective reabsorption.

[NCERT Exemplar]

Ans. Low blood volume and an increase in osmolarity of blood activate osmoreceptors which are present in hypothalamus. When the body loses excess fluid, these receptors are also activated, causing the hypothalamus to release antidiuretic hormone (ADH) or vasopressin. ADH prevents diuresis by facilitating water reabsorption from the distal convoluted tubule and collecting duct.

35. Mention the chemicals that exit from tubules to keep the medullary interstitium at a constant concentration gradient.

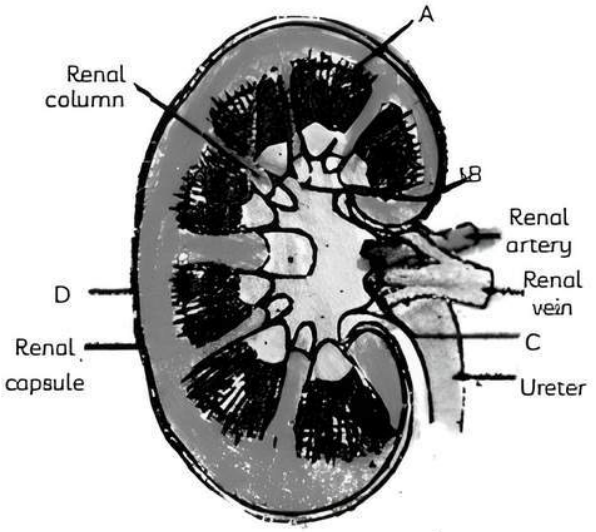
Ans. Sodium chloride (NaCl), water, and urea (containing H^+, K^+, and NH^{3+}) are the primary chemicals that exit tubules to maintain such a gradient.

36. The following abbreviations stand for?

(A) ANF
(B) GFR
(C) DCT
(D) ADH

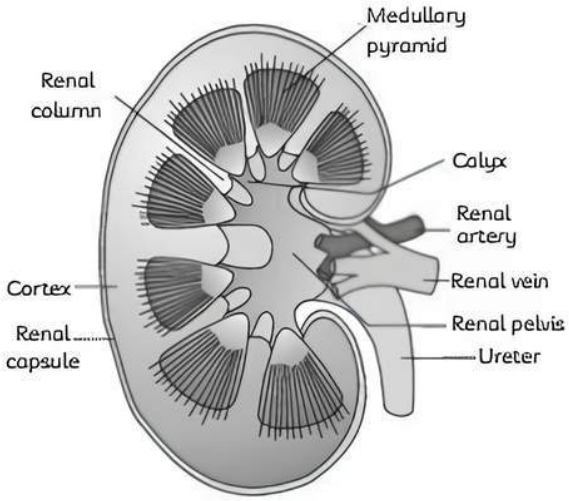
Ans. (A) **ANF:** Atrial natriuretic factor
(B) **GFR:** Glomerular filtration rate
(C) **DCT:** Distal convoluted tubule
(D) **ADH:** Antidiuretic hormone

37. In the following diagram of a longitudinal section of the kidney. Identify the labelled parts A, B, C and D respectively.

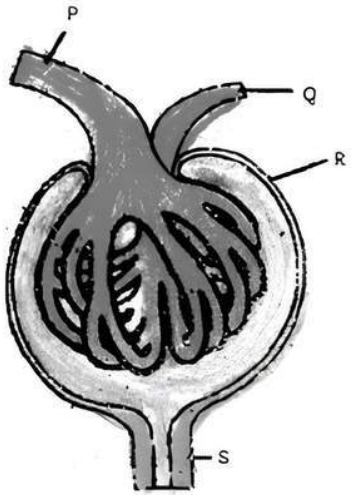


[Delhi Gov. QB 2022]

Ans A- Medullary pyramid
B- Calyx
C- Renal pelvis
D- Cortex

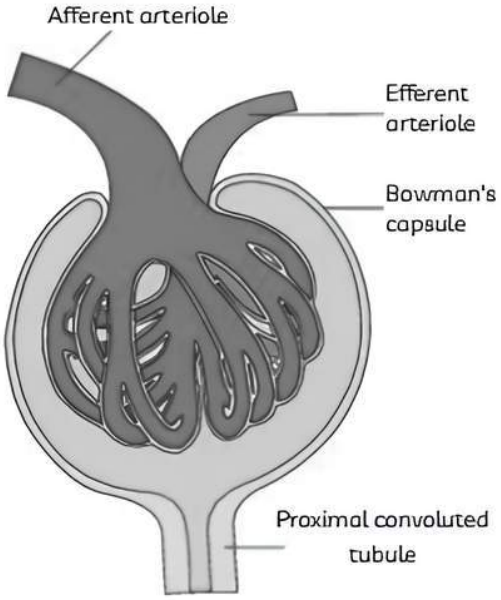


38. In the diagram showing the malpighian body (renal corpuscle). Identify the labelled P, Q, R and S.



[Delhi Gov. QB 2022]

Ans. P- Afferent arteriole
Q- Efferent arteriole
R- Bowman's capsule
S- Proximal convoluted tubule



SHORT ANSWER Type-II Questions (SA-II)

[3 marks]

39. What is dialysis? Explain the purpose of this technique. [NCERT Exemplar]

Ans. Kidneys are essential for survival. Several factors, such as infections, injury, or restricted blood flow to the kidneys, reduce kidney's activity. This causes the body to accumulate poisonous wastes, which can eventually lead to death.

Dialysis technique (an artificial process for removing extra fluid and waste from the body which is accomplished with the aid of a dialyzer or artificial kidney) can be used in this situation.

Hemodialysis is the process of removing excess water, solutes, and toxins from the blood in people whose natural kidneys have lost the ability to do so.

The concentration gradient of the materials to be removed is created in a series of semipermeable tubules. Osmosis causes waste substances to exit the blood.

40. What could be done if the newly transplanted kidney is rejected by the body?

Ans. Rejection indicates that the immune system has recognized the new kidney as foreign tissue and is attempting to eliminate it. The first priority is to prevent rejection with immune-suppressing medication. A change in kidney function (an increase in creatinine, a waste product) measured by a blood test is the most common sign of rejection. This is why, for the first three months after transplantation, patients should have gone through frequent blood tests, followed by regular tests. If a kidney biopsy and ultrasound confirm the rejection episode, the transplant team will either increase the amount of anti-rejection medication or prescribe a different anti-rejection drug combination. We can successfully reverse most rejection episodes with medicine if we detect them early enough. However, if the episode is severe, the new kidney's overall life span may be shortened.

41. Dheeraj is a 50-year-old man who lives in Shyamnagar. He is suffering from uremia and pyelonephritis. Explain both the situations.

Ans. Uremia: Uremia is a condition in which there is a high concentration of urea, uric acid, creatinine, and other substances in the blood. Urea accumulation is high in the blood which is removed by haemodialysis.

Pyelonephritis: It is a condition in which there is inflammation of renal pelvis and medullary tissues. It has an impact on the anti-current mechanism. Frequent urination, fever, and lumbar pain are the most common symptoms.

42. Mention the role of Renin-Angiotensin in kidney regulation.

Ans. Angiotensinogen is converted to Angiotensin I, which is then converted to Angiotensin II by Renin. The vasoconstrictor angiotensin II is very efficient. It enhances glomerular filtration rate by increasing blood flow to the glomerulus. Angiotensin II also activates adrenal cortex to release aldosterone which causes reabsorption of Na^+ and water from distal part of the tubule. This causes an increase in blood volume, then blood pressure and then GFR.

43. State true or false giving reason.

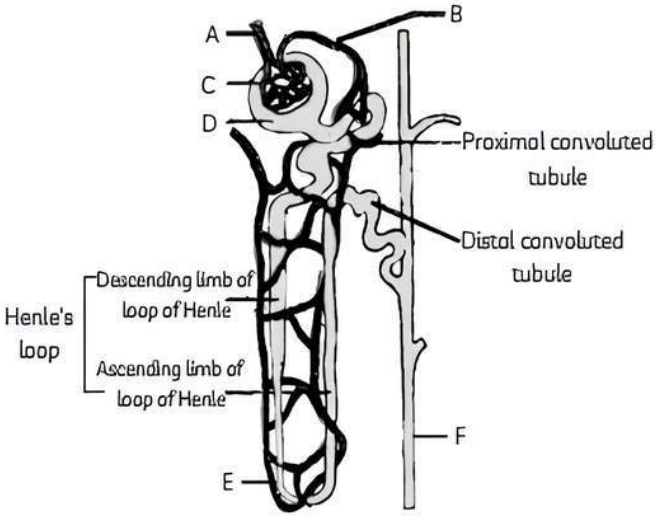
(A) ADH aids in the removal of water by making the urine hypotonic.

(B) The Henle's loop is an important part of the urine concentration process.

Ans. (A) False; ADH is a hormone which regulates the amount of water in the body. It is a small peptide hormone which regulates the body's retention of water.

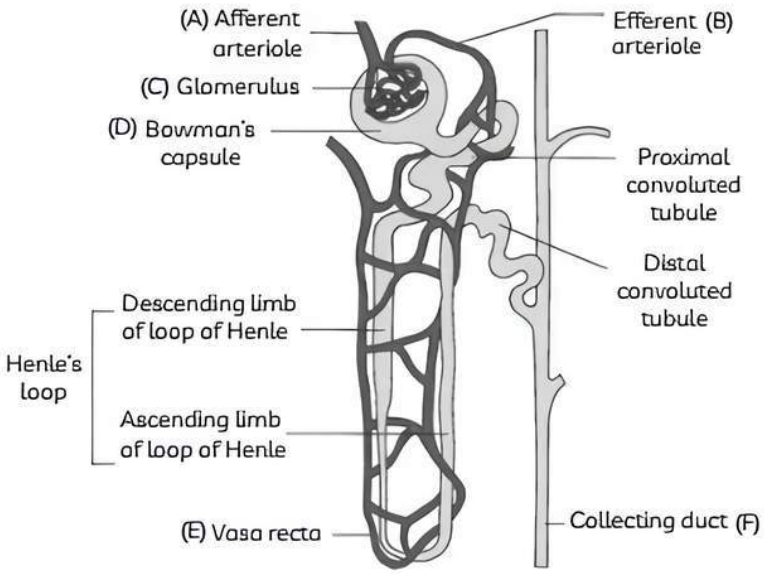
(B) True; it indeed is an important part of the urine concentration process.

44. In the following diagram shows structure of a nephron. Identify labelled parts A, B, C, D, E and F.



[Delhi Gov. QB 2022]

Ans.



LONG ANSWER Type Questions (LA)

[4 & 5 marks]

45. Explain the structure of the renal corpuscle along with its functions.

Ans. Glomerulus and Bowman's capsule together constitute the renal corpuscle or malpighian body. It is the organ where filtration and formation of glomerular filtrate occurs. This is called ultrafiltration. Nephrons are the functional units of the kidney. Each kidney has one million nephrons.

The nephron is a thin, long, and twisted tubular structure. Bowman's capsule is an upturned capsule that starts the tubule of nephron. A tuft of capillaries is present in Bowman's capsule called glomerulus. The renal corpuscle, often known as a globular body, is made up of the Bowman's capsule and the glomerulus. Blood enters into the glomerular capillaries by afferent arterioles, and blood exits the glomerulus by efferent arterioles.

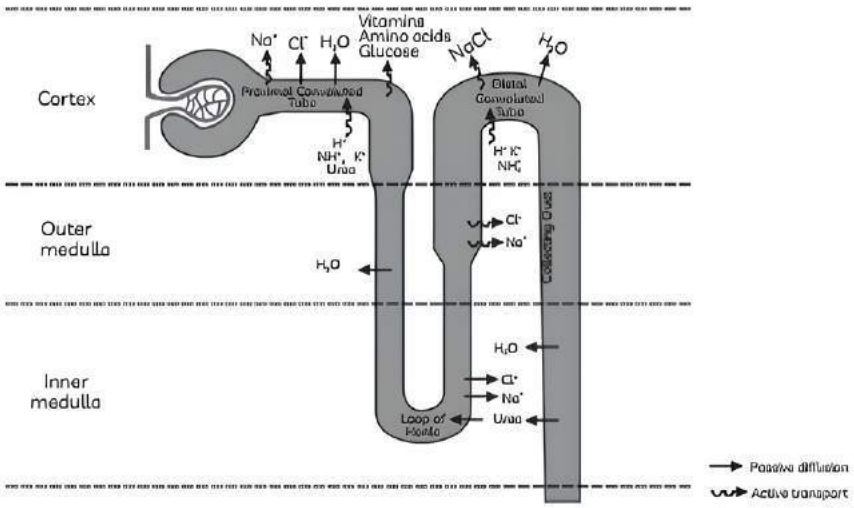
A nephron is made up of three parts: proximal convoluted tubule, Henle's hoop and Distal nephron convoluted tubule.

PCT (Proximal Convoluted Tubule) is a lengthy, densely coiled tubule-like structure that arises from the Bowman's capsule's neck. It then loops in a Henle's loop part of the tubule into a thin-walled straight tubule. The ascending limb is long and slim, whereas the descending limb is short and narrow. Henle's loop is followed by DCT, another twisted tubule segment (Distal convoluted tubule). Near the DCT's end a tiny, straight tubule is present, called the collecting duct. The collecting duct descends to the medulla, carrying the collected urine to the medulla.

The larger ducts of Bellini are formed when the collecting ducts unite in the medulla. These ducts pass through the renal pyramids before opening in the renal pelvis. The efferent arteriole divides to form a peritubular capillary network around proximal and distal convoluted tubule. This peritubular capillary also forms vasa recta which runs parallel to loops of Henle and collecting ducts in the medulla. They help in maintaining renal osmotic pressure by assisting in the retention of reabsorbed ions.

46. Draw a labelled diagram showing reabsorption and secretion of major substances in different parts of the nephron. [NCERT Exemplar]

Ans.



Nephron and the Urine Formation Process

47. What role does the juxtaglomerular apparatus (JGA) play in kidney function?

Ans. The juxtaglomerular apparatus is a sensitive zone developed by cellular changes in the DCT region and the afferent arteriole at the point where they connect.

Significance:

(1) The renin-angiotensin-aldosterone system is involved (RAAS) in its mechanism.

(2) The juxtaglomerular apparatus stimulates when the glomerular filtration rate drops, causing renin secretion.

(3) Renin is a protein that transforms a peptide, such as an angiotensinogen into angiotensin.

(4) Angiotensin II is a hormone that increases GFR and blood flow in three ways:

(i) Increasing the glomerular pressure by narrowing the efferent arterioles.

(ii) Activating the PCT's walls in order to reabsorb more water and NaCl.

(iii) The adrenal gland secretes aldosterone, which aids in the reabsorption of water and sodium in the DCT.

(5) Blood volume and blood pressure rise as a result. Pee volume and hypertonic urine both decrease.