

UNIT –II HUMAN ANATOMY AND PHYSIOLOGY

II B--EXCRETORY PRODUCTS AND THEIR ELIMINATION

Very Short Answer Questions

1. Name the blood vessels that enter and exit the kidney?

A. **Renal artery** enters kidney and **renal vein** comes out of the kidney at hilum region of kidney.

2. What are renal pyramids and renal papillae?

A. **Renal pyramids** are the conical shaped medullary regions of kidney. Tips of the renal pyramids which open into pelvis are considered as **renal papillae**.

3. What are the columns of Bertin?

A. Extensions of the renal cortex among the renal pyramids in kidney are known as **Columns of Bertin**.

4. Name the structural and functional unit of kidney. What are the two main types of structural units in it?

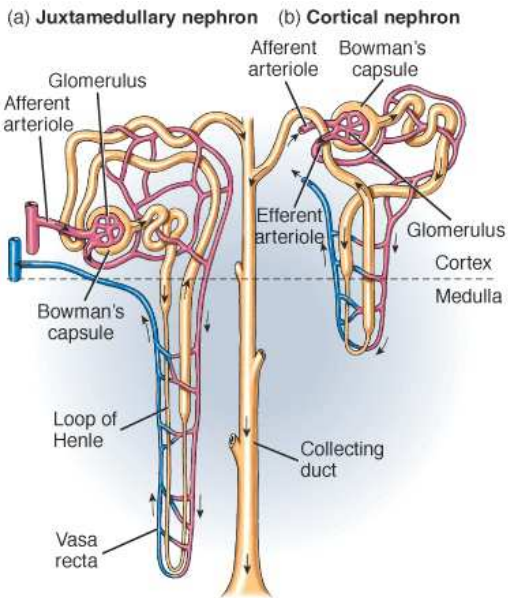
A. **Nephrons** are the structural and functional units of kidney.

The two main parts of nephron are:

(1) **Malphigian body (renal corpuscle)** and (2) **Convolutud tube**.

5. Distinguish between cortical and juxtamedullary nephrons?

A. * **Cortical nephrons** have renal corpuscle in the superficial renal cortex. They have shortest Loop of Henle extends only very little into the medulla. Vasa recta are absent.
* **Juxtamedullary nephrons** are located near the renal medulla. Loops of Henle are very long and run deep into the medulla. They have vasa recta.



6. Define glomerular filtration?

A. The method of filtration of blood, which occurs between glomerulus and lumen of the Bowman's capsule, due to difference in net pressure through 3 layered filtrate membrane is known as **glomerular filtration**.

The filtered fluid which collected in the Bowman's capsule is primary urine or glomerular filtrate. It is **hypotonic**.

7. Define Glomerular Filtration Rate (GFR)?

A. The amount of filtrate formed by both the kidneys, per minute is called **glomerular filtration rate** (GFR). GFR in a healthy individual is approximately 125 ml/1 minute.

8. What is meant by mandatory or obligatory reabsorption? In which parts of nephron does it occur?

A. In a healthy person, the GFR is 125 ml/1 minute or 180 liter per day.

About 85% of the filtrate formed is reabsorbed in a constant, unregulated fashion by the proximal convoluted tubule and descending limb of Henle's loop, called mandatory reabsorption.

9. Distinguish between juxtaglomerular cells and macula densa?

A. * The cells of the distal convoluted tubule are crowded in the region where distal convoluted tubule makes contact with afferent arteriole. These cells are known as Macula densa.

* Along side of macula densa, the wall of the afferent arteriole contains the modified smooth muscle fibers called juxtaglomerular cells.

10. What is juxtaglomerular apparatus?

A. Macula densa along with juxtaglomerular cells form juxtaglomerular apparatus which releases an enzyme called renin.

11. Distinguish between the enzyme renin and rennin?

A. **Renin:** Renin is an enzyme produced by the JG cells. This enzyme catalyses the conversion of angiotensinogen into angiotensin- I.

Rennin: Rennin is also an enzyme found in the gastric juice of infants. It acts on the milk protein casein in the presence of calcium ions and convert it into calcium paracaseinate and proteoses.

12. What is meant by the term osmoregulation?

A. The process of maintaining the quantity of water and dissolved solutes in balance is referred to as osmoregulation.

13. What is the role of atrial natriuretic peptide in the regulation of urine formation?

A. A large increase in blood volume promotes the release of atrial natriuretic peptide from the heart. Atrial natriuretic peptide decreases the absorption of water, Na^+ from proximal convoluted tubule.

Short Answer Type Questions

1. **Terrestrial animals are generally either ureotelic or uricotelic and not ammonotelic. Why?**

A. Ammonia is highly toxic and readily soluble in water, hence it should be eliminated from the body quickly in a very dilute solution.

Aquatic animals are surrounded by water, so water conservation is not a problem for them. In this manner, they are continuously eliminating ammonia.

On the other hand, terrestrial animals have to conserve water. They cannot waste water. So ammonia in diluted form can't be eliminated continuously. Since ammonia is highly toxic, it has to be converted to less toxic form, like urea or uric acid.

Urea is 1, 00,000 times less toxic than ammonia and requires less water for their excretion. Uric acid is less toxic than urea and being insoluble in water can be excreted as semi solid waste or pellets with very little water. This is the great advantage for animals with little access to water.

2. **Differentiate vertebrates on the basis of the nitrogenous waste products they excrete, giving example?**

A. Vertebrates are divided into three categories based on nitrogenous waste excretory products.

They are:

1) **Ammonotelic Animals:** The animals which excrete ammonia as nitrogenous waste products are called ammonotelic animals. These are aquatic organisms.

Ex: Some bony fishes

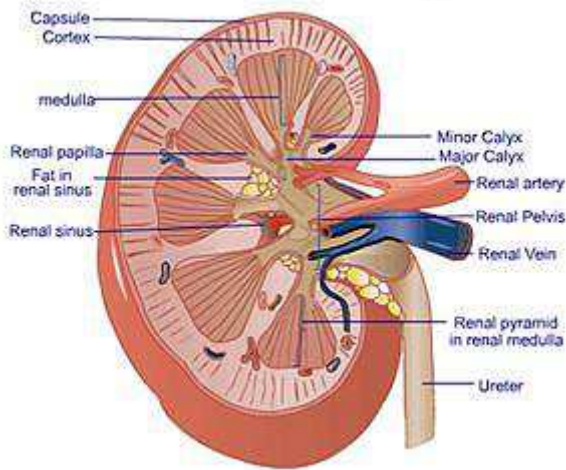
2) **Ureotelic Animals:** The animals which excrete urea as their chief nitrogenous waste are called ureotelic animals.

Ex: Earth worms, cartilaginous fishes, most of the amphibians and mammals

3) **Uricotelic Animals:** These animals excrete their nitrogenous waste products in the form of uric acid.

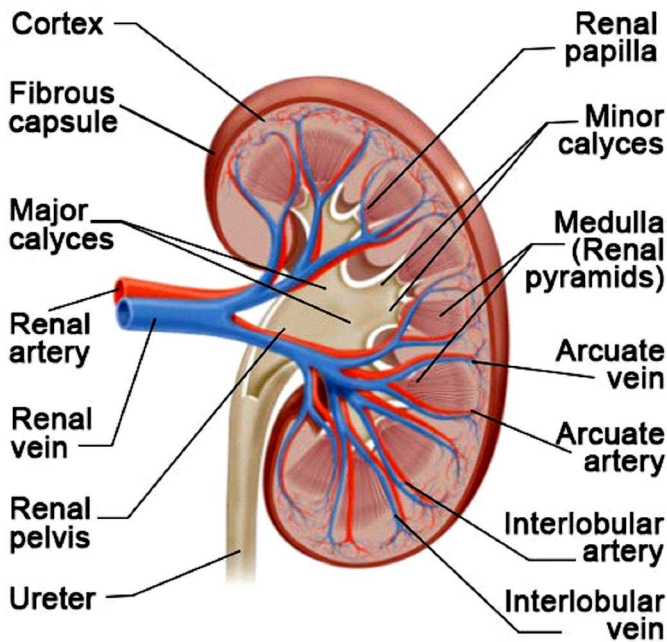
Ex: Reptiles, birds

3. Draw labeled diagram of the V.S. of kidney?



A.

4. Describe the internal structure of kidney of man?



- A.
- * Kidney is bean shaped structure, the outer surface of kidney is convex and inner surface is concave where it has a deep notch called hilum.
 - * Longitudinal sections of the human kidney show two distinct regions namely the outer cortex and the inner medulla.
 - * Medulla is divided into multiple cone shaped masses of tissue called renal pyramids.
 - * The renal pyramids are separated by the projections of the cortex called columns or Bertin.
 - * The tips of the pyramids are renal papilla.

- * Renal papilla projects into cup like calyces, formed by the funnel shaped pelvis, which continues out as the ureter. Ureter carries urine into urinary bladder.
- * In cortex and medulla, nearly one million nephrons are present. They are structural and functional units of kidney. They are embedded in the loose connective tissue of cortex and medulla.
- * In addition, kidney contains a network of blood capillaries, lymph sinuses and interstitial fluid in intra cellular spaces.
- * The kidney gets blood supply through renal artery and blood from kidney is carried out by renal vein.

5. Explain micturition?

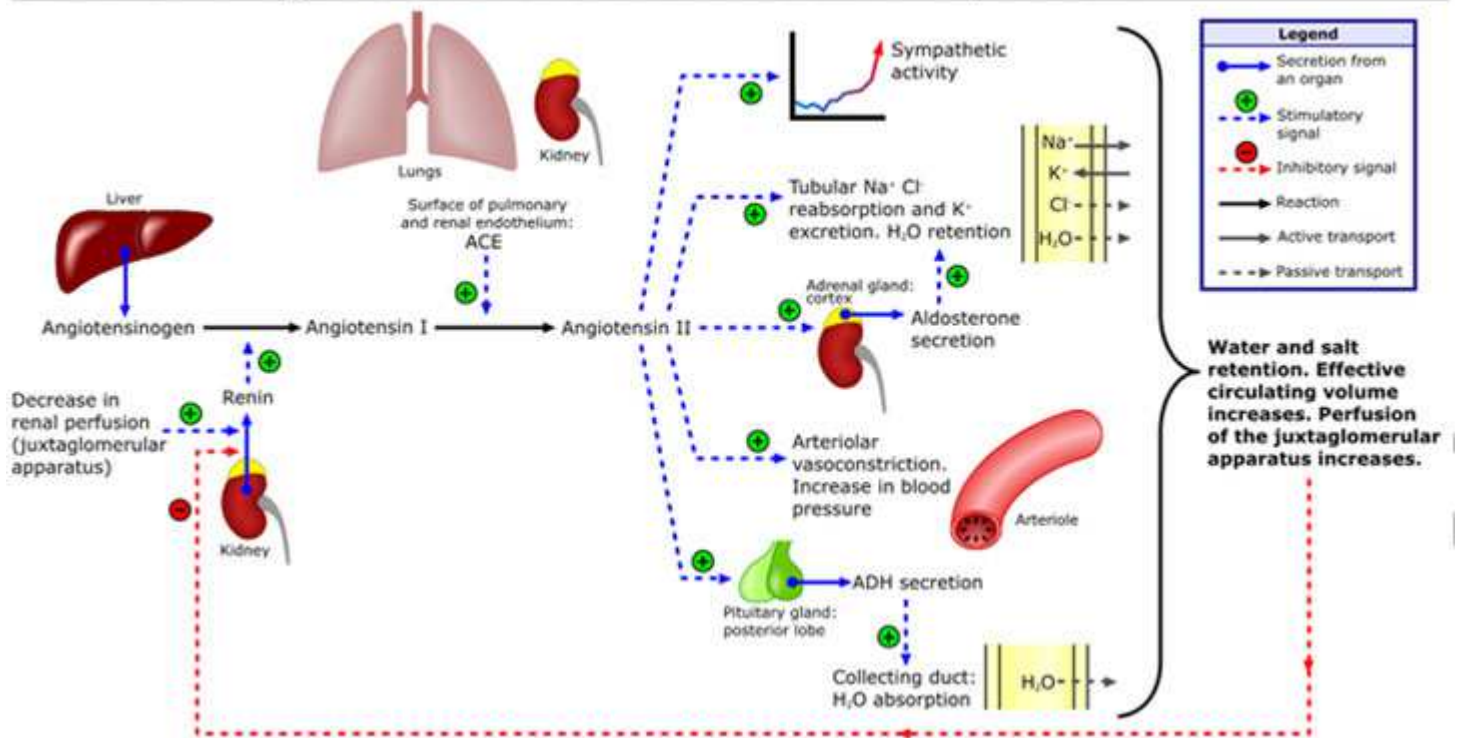
- A. The process of passing out of urine is called micturition and the neural mechanism involved is called micturition reflex.

Urine is formed by the nephrons is ultimately carried to the urinary bladder where it is stored till a voluntary signal is given by the central nervous system (CNS). This signal is initiated by the stretching of the urinary bladder as it gets filled with urine. In response, the stretch receptors on the walls of the bladder send signals to the CNS. The CNS passes on motor messages to initiate the contraction of smooth muscles of the bladder and simultaneous relaxation of the urethral sphincter, causing the release of urine.

6. What is the significance of juxtaglomerular apparatus (JGA) in kidney function?

- A. Macula dense together with JG cells forms juxtaglomerular apparatus (JAG). JAG plays a complex regulating role. A fall in glomerular blood flow or glomerular blood pressure or GFR can activate JG cells to release an enzyme called renin into the blood. This, catalyses the conversion of angiotensinogen into angiotensin – I which is further converted into angiotensin – II by angiotensin converting enzyme. Angiotensin – II, being a powerful vasoconstrictor increase the glomerular blood pressure and there by GFR. Angiotensin – II also activates the adrenal cortex to release aldosterone. Aldosterone causes reabsorption of Na^+ and water from distal convoluted tubule and collecting duct, to reduce loss through urine and also to promote secretion of K^+ ions into distal convoluted tubule and collecting duct. It leads to increase in the blood pressure and GFR. This complex mechanism is generally known as renin – angiotensin – aldosterone system (RAAS).

Renin-angiotensin-aldosterone system



7. Give a brief account of the counter current mechanism?

A. Mammals have the ability to produce concentrated urine. The Henle's loop and vasa recta play an important role in this. The flow of the renal filtrate in the two limbs of Henle's loop is in opposite directions and thus form counter current. The flow of blood through vasa recta is also in counter current pattern. The proximity between the Henle's loop and vasa recta, as well as the counter currents of renal fluid and blood in them help in maintaining an increasing osmolarity towards the inner medullar interstitium. This gradient is mainly caused by NaCl and urea. NaCl passes out the ascending limb of Henle's loop, and it enters the blood of the descending limb of vasa recta. NaCl is returned to the interstitium from the ascending portion of the vasa recta. Similarly small amounts of urea enter the thin segment of ascending limb of Henle's loop which is transported back to the interstitium, from the collecting duct. Transport of these substances facilitated by the special arrangement of Henle's loop and vasa recta is called the counter current mechanism.

This mechanism helps to maintain a concentration gradient in the medullary interstitium. Presence of such interstitium gradient helps easy passage of water from the collecting duct, there by concentrating the urine.

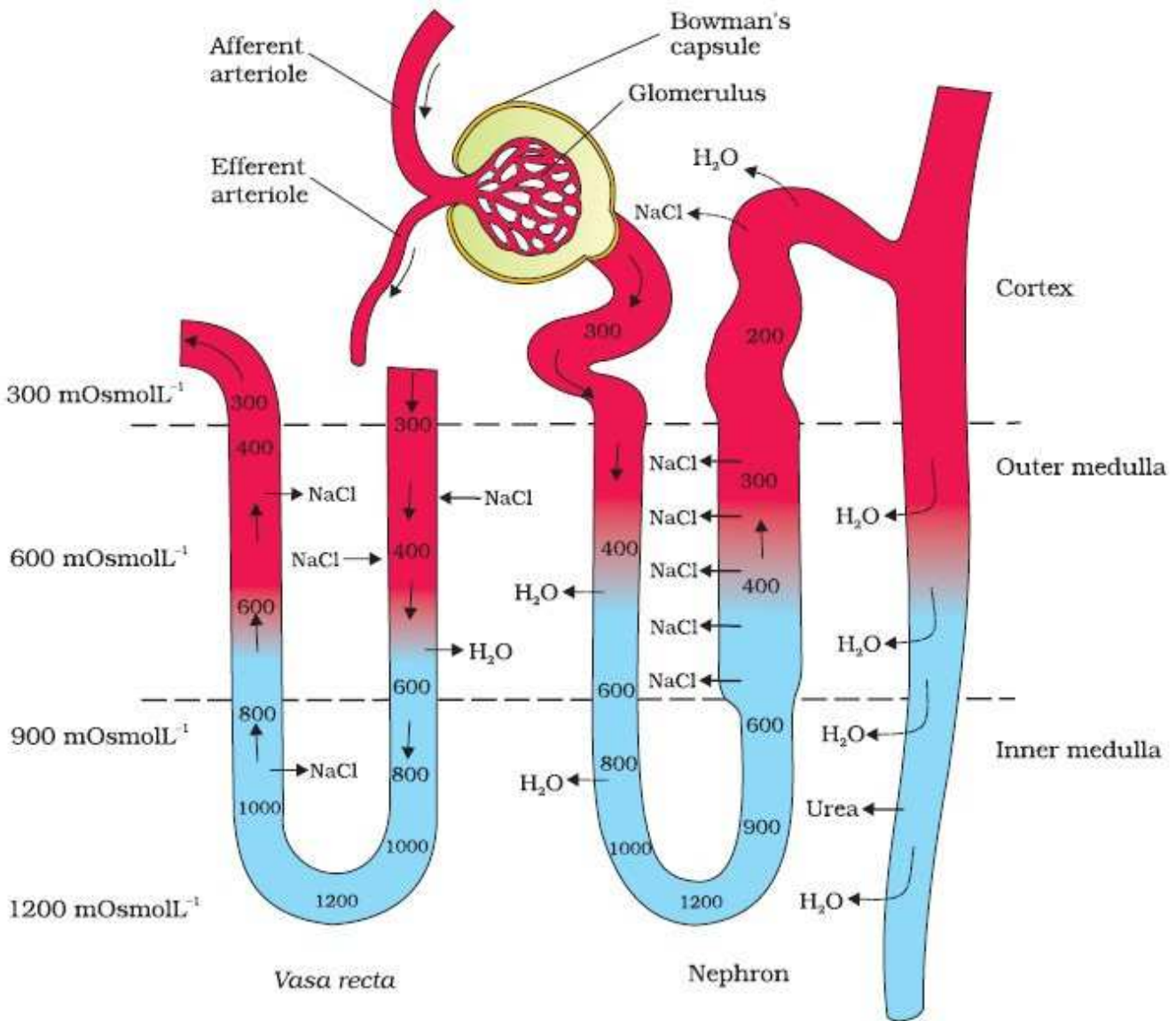


Figure 6. Diagrammatic representation of a nephron and *vasa recta* showing counter current mechanisms

8. Explain the auto regulatory mechanism of GFR?

- A. **Auto Regulation of GFR:** The kidneys have built in mechanism for the regulation of glomerular filtration rate. One such efficient mechanism is carried out by juxtaglomerular apparatus. Juxtaglomerular apparatus is a special region formed by cellular modifications in the distal convoluted tubule and the afferent arteriole at the location of their contact. A fall in GFR can activate the juxtaglomerular cells to release an enzyme called renin, which catalyses the conversion of angiotensinogen into angiotensin – I and further converted to angiotensin – II by action of an enzyme angiotensin converting enzyme. Angiotensin – II stimulates the adrenal cortex to secrete aldosterone. Aldosterone causes reabsorption of Na^+ and water from DCT and collecting duct to reduce loss through urine and also promotes the

secretion of K^+ ions into the DCT and CD (collecting duct). It leads to increase in the blood pressure and GFR.

9. Describe the role of liver, lungs and skin in excretion?

A. In addition to the kidneys, liver, lungs and skin also plays an important role in elimination of excretory wastes.

a) Liver: Liver is the largest gland in our body, secretes bile, containing substances, like bilirubin, biliverdin, cholesterol, degraded steroid hormones, vitamins and drugs. Most of these substances ultimately pass out along with digestive wastes.

b) Lungs: Lungs remove large amounts of CO_2 (18 liters 1 day), various, volatile materials and significant quantities of water.

c) Skin: Human skin possesses two types of glands namely sweat and sebaceous glands for the elimination of certain substances through their secretions.

* Sweat produced by the sweat glands is a watery fluid containing NaCl, small amount of urea, lactic acid, etc.

* Sebaceous glands eliminate certain substances like sterols, hydrocarbons and waxes through sebum. This secretion provides a protective oily covering for the skin.

10. Name the following?

a) A chordate animal having protonephridial type excretory structures

Cephalochordate

b) Cortical portions projecting between the medullary pyramids in the human kidney

Columns of Bertin

c) Capillary network paralleling the loop of Henle Vasa recta

d) A non chordate animal having green glands as excretory structures..... Crustaceans

Long Answer Questions

1. Describe the excretory system of man, giving the structure of a nephron?

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

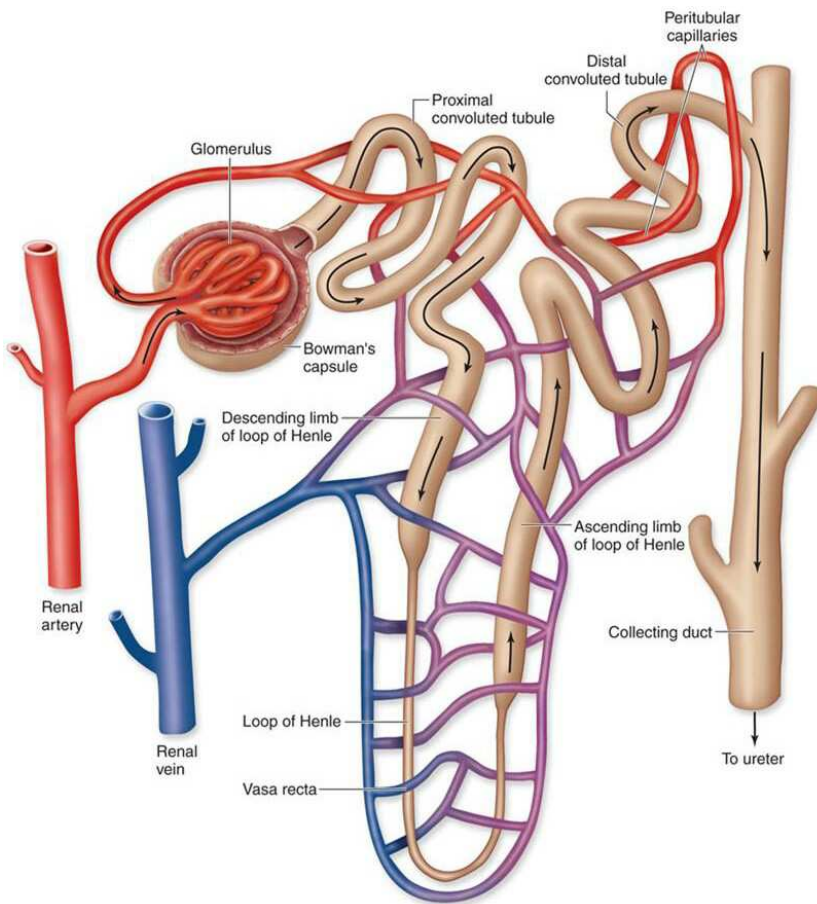
Kidneys: Kidneys are reddish brown, bean shaped structures, situated on either side of the vertebral column between the levels of last thoracic and third lumbar vertebrae in a retroperitoneal position. The right kidney is slightly lower than the left one due to the presence of liver.

The outer surface of the kidney is convex and the inner surface is concave, where it has a deep notch called hilum, the point at which the renal artery and nerves enter and renal vein and ureter leave. Each kidney is surrounded by a tough, fibrous tissue, called renal capsule.

Ureter: These are slender whitish tubes, which emerges from the pelvis of the kidney. The ureter run down and opens into the urinary bladder.

Urinary bladder: Urinary bladder is a pear shaped like muscular organ. It temporarily stores the urine, situated in the lower abdominal cavity. The neck of the bladder leads into the urethra. Urethra opens near the vaginal orifice in the female and through the penis in the male.

Structure of Nephron: Each kidney has nearly one million nephrons. These are structural and functional units of kidney, embedded in the loose connective tissue of cortex and medulla. Nephron consists of malphigian body and renal tubule.



I) Malpighian Body: It begins in the cortex of the kidney. It contains Bowman's capsule and glomerulus.

a) Bowman's Capsule: It is a thin walled, double layered cup. The inner wall of the Bowman's capsule has certain unique cells called podocytes.

b) Glomerulus: It is a dense network of capillaries in the cup of Bowman's capsule. Afferent arteriole of renal artery enters the cavity of Bowman's capsule and split into five branches. They unite and come out of the Bowman's capsule as an afferent arteriole.

The podocytes of inner wall of Bowman's capsule wrap around each capillary. The podocytes are arranged in an intricate manner so as to leaves some minute spaces called filtration slits. The endothelium cells of capillaries have numerous pores called fenestrations.

II) Renal Tubule: It is narrow, delicate tubule arises from the posterior part of Bowman's capsule known as neck. It opens into along narrow convoluted tubule with three parts like proximal convoluted tubule, Loop of Henle and Distal convoluted tubule.

a) Proximal convoluted Tubule: It is a lined by simple cuboidal epithelium with brush border to increase area of absorpion.

b) Loop of Henle: It is a hairpin like tubule present in medulla region. It consists of a descending limb and an ascending limb. The proximal part of the ascending limb is thin and the distal part is thick. The thick ascending limb continuous into the distal convoluted tubule.

c) Distal Convoluted Tubule (DCT): It is present in cortex. It is lined by simple cuboidal epithelium. The DCT continuous as the initial collecting duct in the cortex.

Collecting System: Some initial collecting ducts unite to form straight collecting duct, which passé through the medullary pyramid. In the medulla, the tubes of each pyramid join and form duct of Bellini, which finally opens into tip of the renal papilla.

Capillary Network of Nephron: The efferent arteriole emerging from the glomerulus forms a fine capillary network called the peritubular capillaries, around the renal tubule. The portion of the peritubular capillaries that surrounds the loop of Henle is called the vasa recta. The vasa recta is absent or highly reduced in the cortical nephrons. The juxtamedullary nephrons possess well developed vasa recta.

2. Explain the physiology of urine formation?

A. The formation of urine involves three main processes namely

- 1) Glomerular filtration
- 2) Selective reabsorption
- 3) Tubular secretion

1) Glomerular Filtration: It is first step in urine formation. The process of filtration of blood, which occurs between glomerulus and lumen of the Bowman's capsule due to difference in net pressure, is called glomerular filtration.

The hydrostatic pressure of blood while flowing in the glomerulus is 60mm Hg. It is opposed by glomerular colloidal osmotic pressure of 32mm Hg and Bowman's capsule hydrostatic pressure of 18mm Hg.

The net filtrate pressure is 10mm Hg ($60 - 32 + 18 = 10$). This causes the filtration of blood through the 3 layered filtrate membrane formed by endothelium cells of glomerular capillary together with the basement membrane and podocytes of the Bowman's cup. By the result of glomerular filtration primary urine or renal fluid is collected in lumen of the Bowman's capsule.

The primary urine contains almost all the constituents of plasma, except the proteins. The primary urine is hypotonic to the cortical fluid; it passes into the next part of renal tubule.

2) Selective Reabsorption: During the process of glomerular filtration 125 ml/minute of primary urine is formed. Nearly 99% of which and essential substances are reabsorbed by renal tubules called selective reabsorption. About 85% of filtrate formed (primary urine) is reabsorbed in a constant unregulated manner called obligatory reabsorption.

3) Tubular Secretion: During the formation of urine, the tubular cells secrete substances such as H^+ , K^+ and NH_3^+ into the filtrate/ Tubular secretion is also an important step in the formation of urine as it helps in maintenance of ionic and acid base balance of the body fluids.

Mechanism of selective reabsorption and secretion takes place in different parts of nephrons.

a) In the Proximal Convoluted Tubule: Nearly all the essential nutrients and 70 – 80% of electrolytes and water are reabsorbed by this segment.

Na^+ , glucose, amino acids, Cl^- and other essential substances are reabsorbed into blood. PCT also helps to maintain the pH and ionic balance of body fluids by selective secretion of H^+ and NH_3 into the filtrate and by the absorption of HCO_3^- from it.

b) In the Henle's Loop: Reabsorption in this segment is minimum.

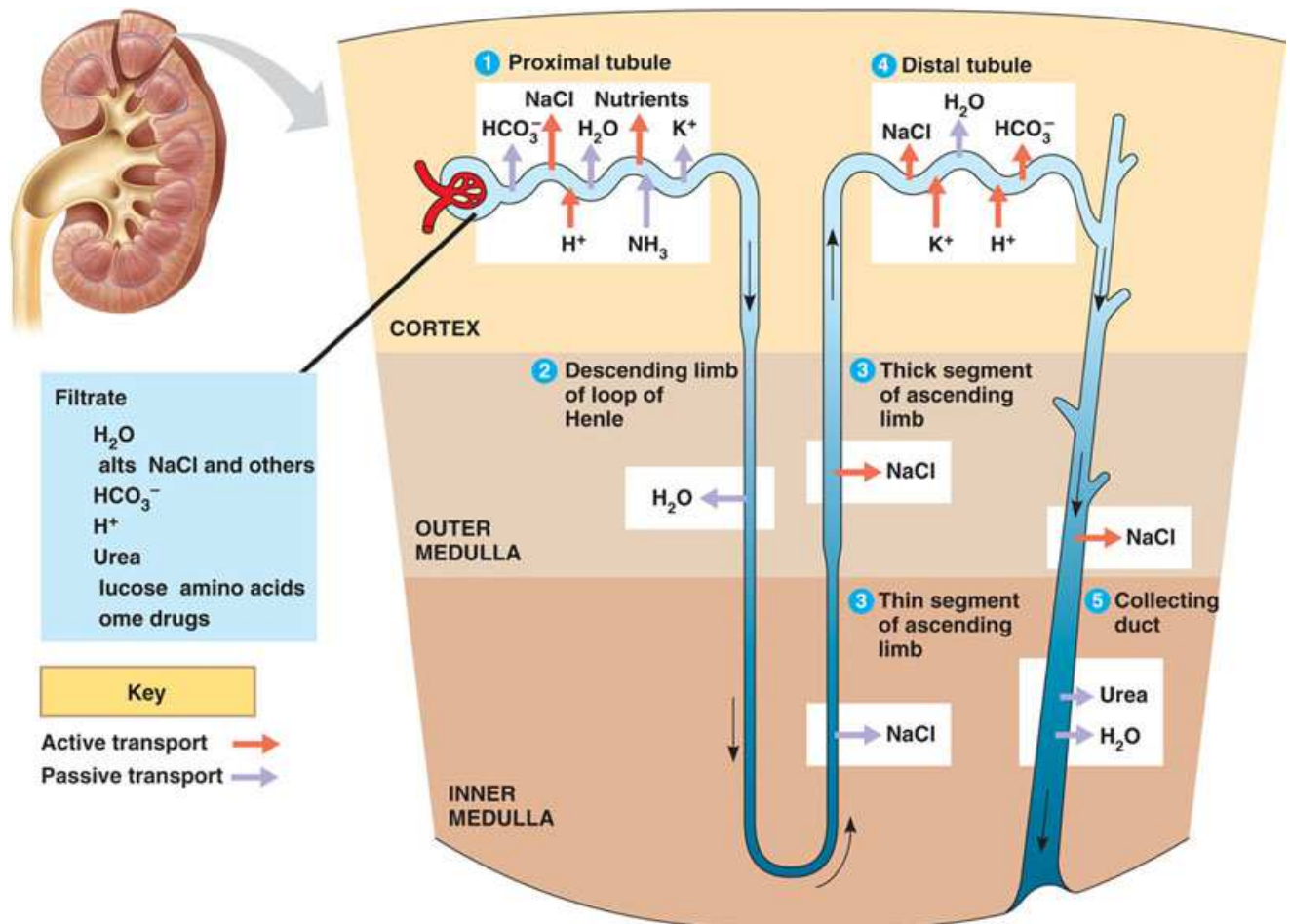
- * The descending loop of Henle is permeable to water and almost impermeable to electrolytes results the filtrate.
- * The ascending limb has two specialized regions, a proximal thin segment in which NaCl diffuses out into interstitial fluid passively, and distal thick segment, in which NaCl is actively pumped out.

The ascending limb is impermeable to water. Thus the filtrate becomes progressively more dilute as it moves up to the cortex i.e., towards the DCT.

In the distal convoluted tubule (DCT): It is permeable to water and ions. The reabsorption of water is variable depending on several conditions and is regulated by ADH. DCT is also capable of reabsorption of HCO_3^- and selective secretion of H^+ and K^+ ions and NH_3^+ into DCT from peritubular network, to maintain the pH and sodium – potassium balance in the blood.

In the Collecting Duct (CD): Considerable amount of water could be reabsorbed from this region to produce concentrated urine. This segment allows passage of small amount of urea to medullary interstitium to keep up its osmolarity. It also plays a role in the maintenance of pH and ionic balance of blood by the selective secretion of H^+ and K^+ ions.

The renal fluid after the process of facultative reabsorption in the CD, influenced by ADH, constitutes the urine that is sent out. Urine in the CD is hypertonic to the plasma of blood.



Saks

