CHAPTER – 16

Excretory Products and Their Elimination

EXERCISES

2 Mark Questions

Q1:Define Glomerular Filtration Rate (GFR).

Answer:The amount of filtrate formed by the kidneys per minute is called glomerular filtration rate (GFR). It is approximately 125 mL/min. in a healthy person.

Q2:Indicate whether the following statements are true or false.
(a) Micturition is carried out by a reflex.
(b) ADH helps in water elimination, making the urine hypotonic.
(c) Protein-free fluid is filtered from blood plasma into the Bowman's capsule.

(d) Henle's loop plays an important role in concentrating the urine.

(e) Glucose is actively reabsorbed in the proximal convoluted tubule.

Answer: (a) True (b) False (c) True (d) True (e) True

Q3:What is meant by the term osmoregulation?

Answer: The regulation of water and solute contents of the body fluids by the kidney is called osmoregulation.

Q4:Match the items of column I with those of column II.

Column I	Column II
(a) Ammonotelism	**(i)Birds**
(b) Bowman's capsule	**(ii)Water reabsorption**
(c) Micturition	**(iii)Bony fish**
(d) Uricotelism	**(iv)Urinary bladder**
(e) ADH	**(v)Renal tubule**

Answer: (a) – (iii), (b) – (v), (c) – (iv), (d) – (i), (e) – (ii)

4 Mark Questions

Q1:Explain the autoregulatory mechanism of GFR.

Answer:The kidneys have built-in mechanisms for the regulation of glomerular filtration rate. One such efficient mechanism is carried out by juxta glomerular apparatus (JGA). JGA is a special sensitive 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 JG cells to release renin which can stimulate the glomerular blood flow and thereby the GFR back to normal.

Q2:Explain micturition.

Answer:The process of passing out urine from the urinary bladder is called micturition. Urine formed by the nephrons is ultimately carried to the urinary bladder where it is stored. This causes stretching of the wall of bladder that leads to the stimulation of stretch receptors on the walls of the bladder. This sends signal 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.

Q3:Terrestrialanimalsaregenerallyeitherureotelic or uricotelic, not ammoniotelic, why?

Answer:Ammoniotelic animals are aquatic animals that excrete ammonia which is highly soluble in water, thus large amount of water is also excreted. Terrestrial animals cannot afford to lose such large quantities of water from their bodies as they live in environment having water scarcity. They, therefore, excrete either urea (ureotelic) or uric acid (uricotelic) as these are less soluble in water.

Q4:Name the following.

(a) A chordate animal having flame cells as excretory structures.
(b) Cortical portions projecting between the medullary pyramids in the human kidney.
(c) A loop of capillary running parallel to the Henle's loop.

Answer: (a) Cephalochordate – Amphioxus

(b) Columns of Bertini
(c) Vasa recta

Q5:Fill in the gaps.
(a) Ascending limb of Henle's loop is_____to water whereas the descending limb is_____to it.
(b) Reabsorption of water from distal parts of the tubules is facilitated by hormone_____
(c) Dialysis fluid contains all the constituents as in plasma except_____
(d) A healthy adult human excretes (on an average)_____gm of urea/day.

Answer:
(a) Ascending limb of Henle's loop is impermeable to water whereas the descending limb is permeable to it.
(b) Reabsorption of water from distal parts of the tubules is facilitated by hormone ADH.
(c) Dialysis fluid contains all the constituents as in plasma except nitrogenous wastes.
(d) A healthy adult human excretes (on an average) 25 – 30 gm of urea/day.

7 Mark Questions

Q1:What is the significance of juxta glomerular apparatus (JGA) in kidney function?

Answer:Juxta glomerular apparatus (JGA) is a special sensitive region formed by cellular modifications in the distal convoluted tubule and the afferent arteriole at the location of their contact. The JGA plays a complex regulatory role. A fall in glomerular blood flow/ glomerular blood pressure/GFR can activate the JG cells to release renin which converts angiotensinogen in blood to angiotensin I and further to angiotensin II. Angiotensin II, being a powerful vasoconstrictor, increases the glomerular blood pressure and thereby GFR. Angiotensin II also activates the adrenal cortex to release aldosterone. Aldosterone causes reabsorption of Na+ and water from the distal parts of the tubule. This also leads to an increase in blood pressure and GFR.

Q2:Describe the role of liver, lungs and skin in excretion.

Answer:Other than the kidneys, lungs, liver and skin also help in the elimination of excretory wastes. Lungs remove large amounts of C02 (18 litres/day) and also significant quantities of water every day. Liver secretes bile which contains substances like bilirubin, biliverdin, cholesterol, degraded steroid hormones, vitamins and drugs. Most of these substances ultimately pass out along with digestive wastes. The sweat and sebaceous glands in the skin can eliminate certain substances through their secretions. Sweat produced by the sweat glands is a watery fluid containing NaCl, small amounts of urea, lactic acid etc. Sebaceous glands eliminate certain substances like sterols, hydrocarbons and waxes through sebum.

Q3:Give a brief account of the counter current mechanism.

Answer:The kidneys have a special mechanism for concentrating the urine, it is called counter current mechanism. The mechanism is said to be a counter current mechanism because the out flow (in the ascending limb) of Henle's loop runs parallel to and in the opposite direction of the inflow (in the descending limb) and vasa recta. As the mechanism begins to function, the ascending limb of loop of Henle actively transports chloride and sodium ions out into the vasa recta from where it is secreted into the interstitial fluid. As a result the interstitial fluid around the loop of Henle contains large quantities of NaCl. The filtrate passes from the ascending limb of loop of Henle and enters a collecting duct. The collecting duct passes adjacent to the loop of Henle where the interstitial fluid contains large amounts of NaCl. The high osmotic pressure created by NaCl causes water to diffuse out of the collecting duct in the interstitial fluid and eventually to the blood of vasa recta. The filtrate becomes greatly concentrated and is now called urine. A similar counter current mechanism, operates between the interstitial fluid and blood passing through the vasa recta. As the blood capillary runs along the ascending limb of loop of Henle, NaCl diffuses out of the blood. The direction is reversed as the blood capillary passes along the descending limb of Henle. The blood flows in the vasa recta around the loop of Henle from ascending to the descending side while the fluid passing through the loop of Henle goes in the opposite direction. The arrangement helps to maintain the concentration gradient of NaCl.

The 'overall function of counter current mechanism is to concentrate sodium

chloride in the interstitial fluid and thereby cause water to diffuse out of the collecting ducts and concentrate the urine.

Multiple Choice Questions

1. **_____ is considered as the basic functional unit of the human kidney**

    1. Exon
    2. Nephron
    3. Cilia
    4. Neuron

Answer: Nephron

2. **The Krebs-Henseleit cycle is a sequence of biochemical reactions that take place in _____**
    1. Brain
    2. Liver
    3. Urinary bladder
    4. Lungs

Answer: Liver

3. **Bowman capsule is located in _____**
    1. Cortex
    2. Henle's loop
    3. Bladder
    4. None of the above

Answer: Cortex

4. **The _____ is the point where two or three major renal calyces join together.**
    1. Renal pelvis
    2. Urethra
    3. Bowman's capsule
    4. None of the above

Answer: Renal pelvis

5. **_____ are tubes made up of smooth muscle fibres that transport urine to the bladder from the kidneys**
    1. Renal Papilla
    2. Urethra
    3. Ureters
    4. None of the above

Answer: Ureters

6. **Nitrogenous wastes excreted through urine in humans is**
    1. Trimethylamine oxide
    2. Ammonia
    3. Uric Acid
    4. Urea

Answer: Urea

7. **_____ is a distensible, hollow, muscular sac located in the pelvis, just behind the pubic bone.**
    1. Bowman's capsule
    2. Urinary bladder
    3. Ureter

4. None of the above

Answer: Urinary bladder

8. **The _____ synthesizes most of the excretory compound in humans and is eliminated through _____**
    1. Liver, Urine
    2. Kidneys, Urine
    3. Liver, Bile juice
    4. None of the above

Answer: Liver, Urine

9. **_____ is responsible for the recovery of water and sodium chloride from the urine.**
    1. Bowman's capsule
    2. Ureter
    3. Loop of Henle
    4. None of the above

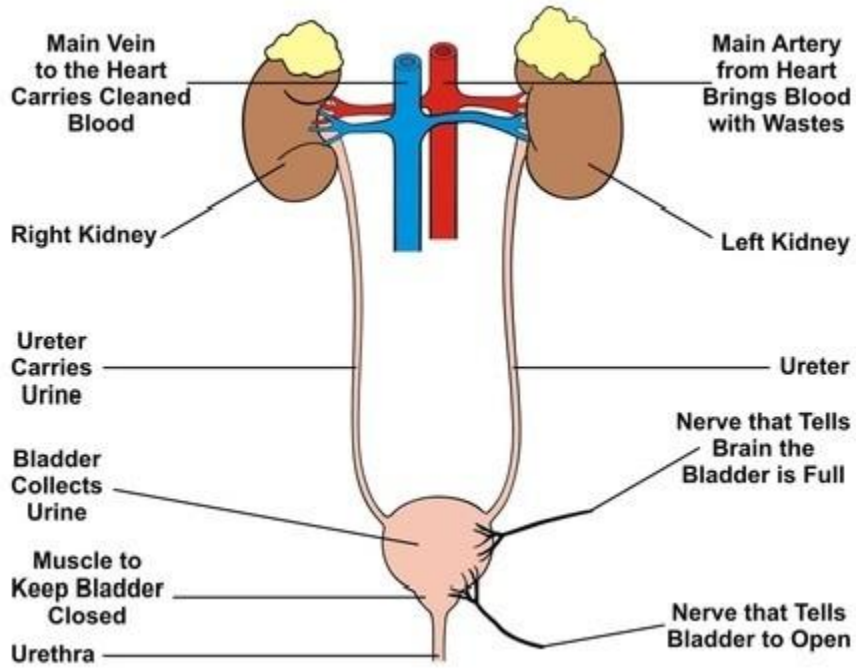
Answer: Loop of Henle

10. **The _____ are kidney tissues that are shaped like cones.**
    1. Renal pyramids
    2. Renal pelvis
    3. Renal calculi
    4. Renal vasculitis

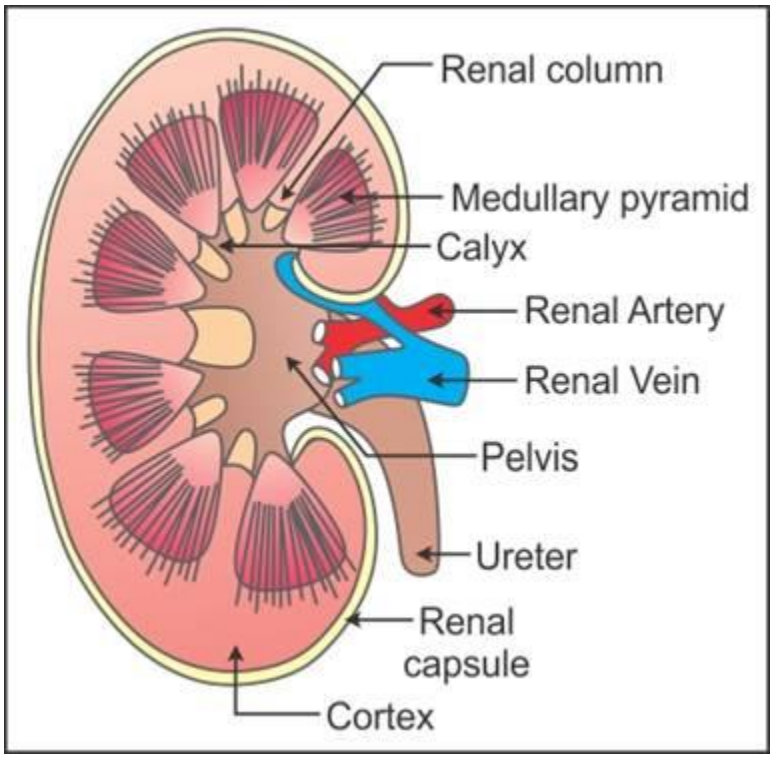
Answer: Renal pyramids

DIAGRAMS

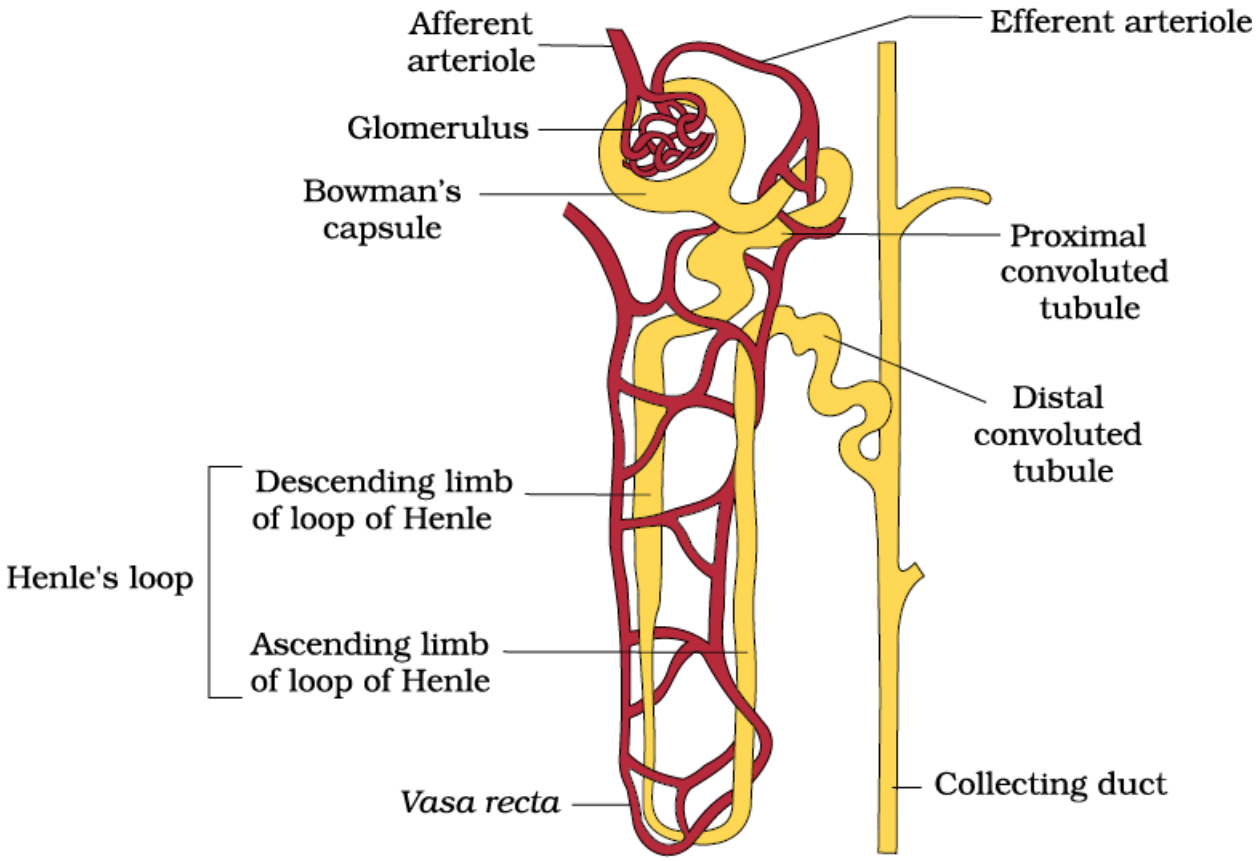
Human Urinary system



Longitudinal section (Diagrammatic) of Kidney



A diagrammatic representation of a nephron showing blood vessels, duct and tubule



SUMMARY

Many nitrogen containing substances, ions, CO2, water, etc., that accumulate in the body have to be eliminated. Nature of nitrogenous wastes formed and their excretion vary among animals, mainly depending on the habitat (availability of water). Ammonia, urea and uric acid are the major nitrogenous wastes excreted. Protonephridia, nephridia, malpighian tubules, green glands and the kidneys are the common excretory organs in animals. They not only eliminate nitrogenous wastes but also help in the maintenance of ionic and acid-base balance of body fluids. In humans, the excretory system consists of one pair of kidneys, a pair of ureters, a urinary bladder and a urethra. Each kidney has over a million tubular structures called nephrons. Nephron is the functional unit of kidney and has two portions –

glomerulus and renal tubule. Glomerulus is a tuft of capillaries formed from afferent arterioles, fine branches of renal artery. The renal tubule starts with a double walled Bowman's capsule and is further differentiated into a proximal convoluted tubule (PCT), Henle's loop (HL) and distal convoluted tubule (DCT). The DCTs of many nephrons join to a common collecting duct many of which ultimately open into the renal pelvis through the medullary pyramids. The Bowman's capsule encloses the glomerulus to form Malpighian or renal corpuscle. Urine formation involves three main processes, i.e., filtration, reabsorption and secretion. Filtration is a non-selective process performed by the glomerulus using the glomerular capillary blood pressure. About 1200 ml of blood is filtered by the glomerulus per minute to form 125 ml of filtrate in the Bowman's capsule per minute (GFR). JGA, a specialised portion of the nephrons, plays a significant role in the regulation of GFR. Nearly 99 per cent reabsorption of the filtrate takes place through different parts of the nephrons. PCT is the major site of reabsorption and selective secretion. HL primarily helps to maintain osmolar gradient (300 mOsmolL–1 -1200 mOsmolL–1) within the kidney interstitium. DCT and collecting duct allow extensive reabsorption of water and certain electrolytes, which help in osmoregulation: H^+, K^+ and NH_3 could be secreted into the filtrate by the tubules to maintain the ionic balance and pH of body fluids. A counter current mechanism operates between the two limbs of the loop of Henle and those of vasa recta (capillary parallel to Henle's loop). The filtrate gets concentrated as it moves down the descending limb but is diluted by the ascending limb. Electrolytes and urea are retained in the interstitium by this arrangement. DCT and collecting duct concentrate the filtrate about four times, i.e., from 300 mOsmolL–1 to 1200 mOsmolL–1, an excellent mechanism of conservation of water. Urine is stored in the urinary bladder till a voluntary signal from CNS carries out its release through urethra, i.e., micturition. Skin, lungs and liver also assist in excretion.