Excretory Products and their Elimination

OBJECTIVE TYPE QUESTIONS

Multiple Choice Questions (MCQs)

1. Select the group containing ammonotelic animals only.
(a) Earthworm, frog, turtle, pigeon
(b) Crocodile, earthworm, leech, bony fish
(c) Cockroach, land snail, prawn, toad
(d) Tapeworm, lizard, shark, leech

2. Malpighian corpuscles occur in _____.
(a) medulla (b) cortex
(c) pelvis (d) pyramid

3. Podocytes are the cells present in
(a) cortex of nephron
(b) inner wall of Bowman's capsule
(c) outer wall of Bowman's capsule
(d) wall of glomerular capillaries.

4. Urine formed in man is
(a) hypotonic (b) hypertonic
(c) isotonic (d) alkaline.

5. Reabsorption of chloride ions (Cl^-) from the glomerular filtrate, in the kidney tubule of mammal, is carried out by
(a) active transport
(b) diffusion
(c) osmosis
(d) brownian movement.

6. Uriniferous tubules are mainly concerned with
(a) concentration of urine
(b) passage of urine
(c) reabsorption of useful substances from glomerular filtrate
(d) removal of urea from blood.

7. Effective net filtration pressure in the glomerulus in kidney of man is about
(a) +75 mm Hg (b) +80 mm Hg
(c) +20 to 25 mm Hg (d) +50 mm Hg.

8. Sodium is reabsorbed in the collecting duct under the influence of
(a) antidiuretic hormone
(b) renin
(c) aldosterone
(d) both (a) and (b).

9. In _____ water is reabsorbed due to increasing osmolarity of interstitial fluid.
(a) ascending limb of Henle's Loop
(b) descending limb of Henle's Loop
(c) collecting duct
(d) proximal convoluted tubule

10. Match the column I with column II, and choose the correct combination from the options given below.

	Column I		**Column II**
A.	Water reabsorption	I.	Vasodilation
B.	ANF	II.	Adrenal cortex
C.	Angiotensin II	III.	ADH

(a) A-II, B-III, C-I (b) A-I, B-III, C-II
(c) A-III, B-I, C-II (d) A-I, B-II, C-III

11. Sebaceous glands eliminate
(a) sterols and hydrocarbons
(b) heavy metals
(c) glucose and amino acids
(d) none of these.

12. Angiotensinogen is a protein produced and secreted by
(a) juxtaglomerular (JG) cells
(b) macula densa cells
(c) endothelial cells in the blood vessels
(d) liver cells.

13. The function of renin is
(a) stimulation of corpus luteum
(b) vasodilation
(c) to reduce blood pressure
(d) degradation of angiotensinogen.

14. Which one of the following operates Renin Angiotensin Aldosterone System (RAAS)?
(a) JGA
(b) Bowman's capsule
(c) Loop of Henle
(d) ANF

15. A person has damaged renal tubules and produces scanty urine. He is not able to produce enough erythropoietin required for adequate RBC production and is thus suffering from anaemia. Identify the disorder from which he is suffering.
(a) Renal failure
(b) Diabetes insipidus
(c) Renal tubular acidosis
(d) Uremia

16. At a time about how much blood is passed through the artificial kidney?
(a) 1000 mL (b) 200 mL
(c) 500 mL (d) 400 mL

17. What will happen if one kidney is removed from the body of a human being?
(a) Death due to poisoning
(b) Uremia and death
(c) Stoppage of urination
(d) The person will survive and remain normal

18. Kidney stones are produced due to deposition of ____ and ____.
(a) silicates, uric acid
(b) minerals, water
(c) silicates, calcium carbonate
(d) uric acid, calcium oxalate

19. Match the column I with column II and select the correct option from the given codes.

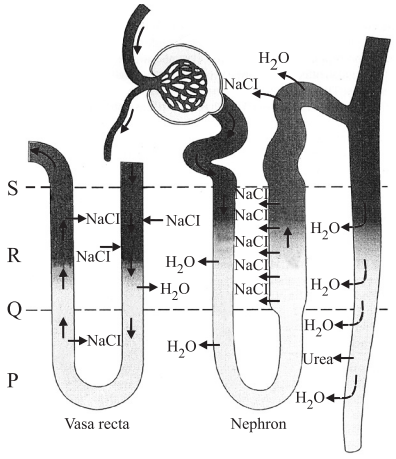
	Column I (Excretory structure)		**Column II (Organism)**
A.	Nephridia	1.	*Fasciola*
B.	Flame cells	2.	*Pheretima*
C.	General body surface	3.	*Periplaneta*
D.	Malpighian tubules	4.	*Hydra*

	A	**B**	**C**	**D**
(a)	2	1	4	3
(b)	1	2	3	4
(c)	3	4	1	2
(d)	4	3	2	1

20. What is not true about uricotelic animals?
(a) They are exemplify by reptiles, birds and insects, etc.
(b) They spend least amount of water for elimination of the excretory product.
(c) It is a most toxic excretory product needing prompt removal.
(d) Uric acid is almost insoluble and can be eliminated in solid state.

21. Which is not correct with respect to human kidney?
(a) The peripheral region is called cortex and central medulla.
(b) Malpighian corpuscles are present in the cortex region.
(c) Blood enters into glomerulus through efferent arterioles.
(d) The concave part of kidney is called hilum.

22. Refer to the given figure and select the correct option representing the osmolarity at P, Q, R and S.



	P ($mOsmolL^{-1}$)	**Q** ($mOsmolL^{-1}$)	**R** ($mOsmolL^{-1}$)	**S** ($mOsmolL^{-1}$)
(a)	1200	900	600	300
(b)	900	1200	300	600
(c)	300	600	900	1200
(d)	1200	300	900	600

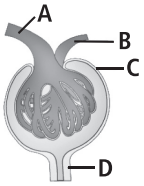
23. A fall in glomerular filtration rate (GFR) activates
(a) juxtaglomerular cells to release renin
(b) adrenal cortex to release aldosterone
(c) adrenal medulla to release adrenaline
(d) posterior pituitary to release vasopressin.

24. Deficiency of ADH leads to
(a) formation of copious quantity of dilute urine
(b) frequent micturition
(c) feeling insatiably thirsty
(d) all of these.

25. The location of kidney normally is between _____ thoracic vertebra and _____ lumbar vertebra.

(a) 8^{th} and 1^{st}, respectively
(b) 6^{th} and 1^{st}, respectively
(c) 10^{th} and 2^{nd}, respectively
(d) 12^{th} and 3^{rd}, respectively

26. Identify the labelled parts A to D in the given figure of the Malpighian body and select the correct option.



	A	B	C	D
(a)	Efferent arteriole	Afferent arteriole	Bowman's capsule	Proximal convoluted tubule
(b)	Afferent arteriole	Efferent arteriole	Renal corpuscle	Proximal convoluted tubule
(c)	Afferent arteriole	Efferent arteriole	Bowman's capsule	Proximal convoluted tubule
(d)	Afferent arteriole	Efferent arteriole	Bowman's capsule	Distal convoluted tubule

27. Consider the following statements each with one or two blanks.

(i) The ascending limb of loop of Henle is impermeable to (1) but allows transport of (2).
(ii) (3) and (4) play a significant role in producing a concentrated urine.
(iii) A fall in glomerular blood flow/glomerular blood pressure/GFR can activate the JG cells to release (5).

Which one of the following options correctly fills the blanks in any two of the statements?

(a) (1)-water, (2)-electrolytes, (5)-renin
(b) (3)-Henle's loop, (4)-vasa recta, (5)-angiotensin
(c) (1)-electrolytes, (2)-water, (3)-PCT, (4)-DCT
(d) (3)-Henle's loop, (4)-vasa recta, (5)-angiotensinogen

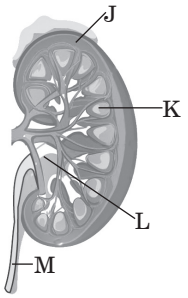
28. Which of the following statement is not scientifically correct?

(a) Left kidney is slightly higher than the right one.
(b) Columns of Bertini lie in between the pyramids.
(c) Renal vein contains more amount of excretory products than the renal artery.
(d) Hilum is the gateway for the kidney.

29. Condition which result from renal failure of kidney is known as

(a) uremia (b) enuresis
(c) diurea (d) haematuria.

30. Refer to the following diagram and identify the parts of a kidney indicated.



(a) J = nephron, K = pelvis, L = renal papilla, M = hilum
(b) J = medulla, K = nephron, L = pelvis, M = ureter
(c) J = cortex, K = medulla, L = calyx, M = pelvis
(d) J = cortex, K = medulla, L = pelvis, M = ureter

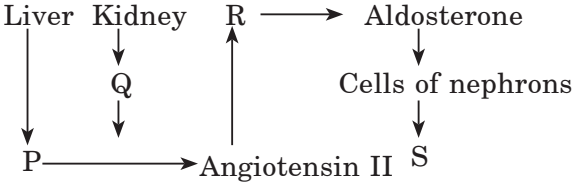
31. Diuresis is the condition in which

(a) the excretory volume of urine increases
(b) the excretory volume of urine decreases
(c) the kidneys fail to excrete urine
(d) the water balance of the body is disturbed.

32. Proximal convoluted tubule is lined by _____ cells.

(a) flattened
(b) columnar
(c) cuboidal with brush border
(d) simple rectangular

33. Identify P, Q, R, S and select the correct option.



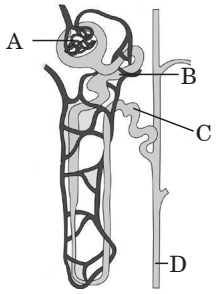
	P	Q	R	S
(a)	Angiotensin I	Renin	Adrenal cortex	Increased Na^+ reabsorption
(b)	Angiotensinogen	Renin	Adrenal cortex	Increased Na^+ reabsorption
(c)	Angiotensinogen	Renin	Adrenal medulla	Decreased Na^+ reabsorption
(d)	Angiotensin I	Renin	Adrenal cortex	Decreased Na^+ reabsorption

34. The kidney is expected to carry out all the functions except
(a) removal of excretory products
(b) maintenance of proper pH of body fluids
(c) blood pressure regulation
(d) production of antibodies and sustain immune system.

35. Excretion of nitrogenous waste product in a form of semi-solid paste occur in
(a) amniotes (b) desert animals
(c) ureotelic animals (d) uricotelic animals.

36. A crustacean lobster eliminates excretory matter from the body with the help of
(a) contractile vacuole (b) flame cells
(c) nephridia (d) none of these.

37. Refer to the given figure of nephron and select the correct option.

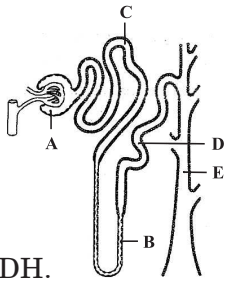


(a) A-glomerulus - a tuft of capillaries formed by afferent arteriole.
(b) B-PCT- only reabsorption of HCO_3^- and selective secretion of H^+ and K^+ occurs here.
(c) C-DCT - almost all glucose, amino acids, water, Na^+, K^+ and uric acid are absorbed here.
(d) D-Collecting duct-extends from the cortex of the kidney to the inner parts of medulla. Large amount of water is secreted in this region.

38. Mammals have
(a) opisthonephric kidneys and ureotelic excretion
(b) mesonephric kidneys and ureotelic excretion
(c) metanephric kidneys and ureotelic excretion
(d) metanephric kidneys and ammonotelic excretion.

39. A person diagnosed with inflammation of renal pelvis and the medullary tissue of the kidney, is suffering from
(a) renal calculi
(b) renal tubular acidosis
(c) renal failure
(d) pyelonephritis.

40. The given figure represents a single nephron from a mammalian kidney. Identify the labelled parts, match them with the functions (i-iv) and select the correct option.



(i) The site of ultrafiltration.
(ii) Particularly sensitive to ADH.
(iii) The main site for the reabsorption of glucose and amino acids.
(iv) Responsible for the maintenance of blood pH.
(a) (i)-A, (ii)-E, (iii)-C, (iv)-D
(b) (i)-A, (ii)-B, (iii)-C, (iv)-D
(c) (i)-B, (ii)-A, (iii)-C, (iv)-E
(d) (i)-E, (ii)-B, (iii)-D, (iv)-A

Case Based MCQs

Case I : Read the following passage and answer questions from 41 to 45 given below.

Excretion is the process of expelling of non-gaseous nitrogenous wastes like ammonia, urea, uric acid, etc, along with excess of water, salts and pigments out of the body. Animals maintain the ionic and acid-base balance of body by excreting wastes through organs like protonephridia, nephridia, malpighian tubules, green glands and kidneys. In humans, excretory system consist of one pair of kidneys, a pair of ureters, a urinary bladder and a urethra.

41. Select the correct set of animals which excrete ammonia.
(a) *Unio*, *Limnaea*, *Sycon*
(b) *Ascaris*, *Sycon*, *Asterias*
(c) Leech, *Pila*, *Helix*
(d) *Nereis*, Prawn, *Sycon*

42. Excretory structures present in *Amphioxus* is
(a) nephridia (b) protonephridia
(c) Malpighian tubule (d) green glands.

43. Select the incorrect statement regarding male urethra.

(A) It is much longer.
(B) It is not differentiated into regions.
(C) It carries only urine.
(D) It opens out at the tip of penis by urinogenital aperture.

(a) A and C (b) A and D
(c) B and C (d) B and D

44. Ureters, blood vessels, nerves enter or leave kidney through

(a) tubules (b) nephrons
(c) hilus (d) trigone.

45. Ureters carry urine from

(a) urethra to urinary bladder
(b) kidneys to urinary bladder
(c) urinary bladder to urethra
(d) urethra to kidney.

Case II : Read the following passage and answer questions from 46 to 50 given below.

Kidneys, filter unwanted substances from the blood and produce urine. Urine formation includes glomerular filtration, selective reabsorption and tubular secretion shown in the figure. These processes occurs in Malphigian corpuscle (Glomerulus and Bowman's Capsule) and renal tubules comprising proximal convoluted tubule, loop of Henle, distal convoluted tubule and collecting duct.

46. Which of the following do not pass the lumen of Bowman's capsule during glomerular filtration?

(a) Creatinine (b) Glucose
(c) Water (d) Proteins

47. Which of the following hormone increases the reabsorption of Na^+ in PCT?

(a) Antidiuretic hormone
(b) Angiotensin II
(c) Aldosterone
(d) Atrial Natriuretic factor

48. Select the incorrect statement regarding mechanism of urine formation in human.

(a) The glomerular filtration rate is about 125 mL per minute.
(b) The ultrafiltration is opposed by the colloidal osmotic pressure of plasma.
(c) Aldosterone induces greater reabsorption of sodium.
(d) The counter current system contributes in diluting the urine.

49. Which of the following are reabsorbed in the proximal convoluted tubule ?

(a) Sulphates, sodium, chlorides
(b) Creatinine, phosphates, vitamins
(c) Sulphates, creatine, chlorides
(d) Bicarbonates, glucose, hormones

50. Kidneys help in the conservation of useful materials and excretion of wastes and therefore they receive 20% of the heart's output of blood (as much as the heart and brain combined). On a percentage basis, which substance is most completely reabsorbed by the kidneys?

(a) Water (b) Glucose
(c) Urea (d) Sodium

Assertion & Reasoning Based MCQs

For question numbers 51-60, two statements are given-one labelled Assertion and the other labelled Reason. Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.

(a) Both assertion and reason are true and reason is the correct explanation of assertion.
(b) Both assertion and reason are true but reason is not the correct explanation of assertion.
(c) Assertion is true but reason is false.
(d) Assertion is false but reason is true.

51. Assertion : When water has to be conserved in the body, ADH is released from the posterior pituitary.

Reason : ADH renders the walls of DCT and collecting duct and tubule impermeable to water.

52. Assertion : Sharks are said to be ammonotelic animals.

Reason : Sharks can retain considerable amounts of urea in their blood.

53. Assertion : Urinary bladder and ureters are lined by transitional epithelium.

Reason : Ureters carry the urine to urinary bladder where it is stored temporarily.

54. Assertion : The glomerular filtrate resembles the protein free plasma in composition and osmotic pressure.
Reason : The glomerular capillary wall and inner membrane of Bowman's capsule are impermeable to large molecules.

55. Assertion : Kidneys maintain the osmotic concentration of the blood.
Reason : Kidneys eliminate either hypotonic or hypertonic urine according to the need of the body.

56. Assertion : If human urine is allowed to stand for some time, it smells strongly of ammonia.
Reason : Main constituent of human urine is ammonia.

57. Assertion : Malpighian tubules are excretory organs in most of the insects.
Reason : Malpighian tubules help in the removal of nitrogenous wastes in cockroaches.

58. Assertion : During micturition, urine is prevented from flowing back into the ureters.
Reason : Urethral sphincters relax during micturition.

59. Assertion : Hemodialysis can save and prolong the life of uremic patients.
Reason : Waste products like urea are removed from the blood by the process of hemodialysis.

60. Assertion : Birds can considerably reduce water loss in the urine.
Reason : Birds store urine along with faeces in the cloaca.

SUBJECTIVE TYPE QUESTIONS

Very Short Answer Type Questions (VSA)

1. What are green glands? Where are they found?

2. Identify the structures :
(a) Funnel shaped space inside the kidney
(b) Projections into medulla.

3. How much amount of blood is filtered by the kidneys per minute?

4. Why is glomerular filtration also known as ultrafiltration?

5. Which part of loop of Henle is impermeable to water?

6. What are the two counter current systems that help in concentration of urine?

7. How is the hormone angiotensin II activated?

8. Which component of plasma is absent in dialysis fluid?

9. Which part of the body is connected to the dialyzer to withdraw blood for dialysis?

10. What is the value of glomerular filtration rate (GFR) in a healthy individual?

Short Answer Type Questions (SA-I)

11. What is the mode of excretion and form of nitrogenous wastes excreted in the following organisms?
(a) *Ascaris* (b) *Pila*
(c) Crocodiles (d) *Asterias*

12. What are the functions of collecting duct?

13. Give a brief description of
(a) Podocytes (b) Glomerulus

14. (a) What is meant by reabsorption in urine formation?
(b) Name the two modes of reabsorption.

15. How are the following materials reabsorbed in the proximal convoluted tubule?
(a) Glucose
(b) Amino acids
(c) Urea
(d) Chloride

16. What is the role played by NaCl and urea in the counter current mechanism?

17. What is the role played by renin in increasing the blood volume?

18. How is the back flow of urine into the ureters prevented?

19. What role sweat plays in our body?

20. Deficiency of antidiuretic hormone can cause diabetes. Justify.

Short Answer Type Questions (SA-II)

21. If a person is passing out dilute urine and suffering from fever and back pain, what is the most probable reason for this?

22. Mention the function of the following in regulation of kidney function.
(i) ADH (ii) ANF (iii) Renin

23. **(a)** What is the relationship between length of loop of Henle and concentration of urine?
(b) What is the maximum osmotic difference that can be created by the Na-K pump in the ascending limb of loop of Henle?

24. Why is skin an accessory excretory organ?

25. Fill in the blanks at (A), (B), (C), (D), (E) and (F) and complete the flow chart.

JG cells release (A), when there is fall in (B), or low availability of water in body.
↓
The released chemical converts (C) in the blood to angiotensin I and then to angiotensin II.
↓
Angiotensin II increases the blood pressure by constriction of (D).
↓
Angiotensin II also activates adrenal cortex to release (E).
↓
It causes reabsorption of Na^+ and water, causing rise in (F).

26. Glomerular filtration is autoregulated. Justify.

27. Describe the structure of Malpighian corpuscle with the help of a neatly labelled diagram.

28. The blood vessels and nephrons of kidney are deeply associated with each other. Justify.

29. What are the various functions performed by human kidneys?

30. What is the role of liver in excretion?

31. Comment upon the hormonal regulation of selective reabsorption.

32. Draw a labelled diagram of human excretory system.

33. Aquatic animals generally are ammonotelic in nature whereas terrestrial forms are not. Comment.

34. What are the factors that can affect the glomerular filtration rate (GFR)?

35. Differentiate among ammonotelic, ureotelic and uricotelic animals. Give two examples in each case.

Long Answer Type Questions (LA)

36. **(a)** With the help of a self explanatory flow chart, display the path followed by the blood in the kidney.
(b) Differentiate between descending and ascending limbs of loop of Henle.

37. What is the role played by following hormones in regulating the urine formation?
(a) Aldosterone
(b) Angiotensin II
(c) Atrial natriuretic factor

38. A person has been suffering from acute renal failure.
(a) What is the most appropriate way of treating him?
(b) Diagrammatically represent the procedure of the treatment.

39. List the different parts of the nephron's renal tubule along with their internal features.

40. Describe the structure of a human kidney with the help of a labelled diagram.

ANSWERS

OBJECTIVE TYPE QUESTIONS

1. (b) : Many aquatic animals like protozoans, sponges, cnidarians, coelenterates, liver fluke, leech, tapeworm, *Ascaris*, *Nereis*, earthworm, most aquatic arthropods, most aquatic molluscs, bony fishes, amphibian tadpole, tailed amphibians and crocodiles excrete ammonia.

2. (b) : The Malpighian corpuscles are situated in the cortical region of the kidney.

3. (b) : The inner visceral layer of Bowman's capsule consists of special type of cells called podocytes.

4. (b) : The main function of counter-current mechanism is to concentrate NaCl in interstitial fluid and cause water to diffuse out of collecting ducts. As a result, hypertonic urine is produced in human being.

5. (b) : Chloride ions, urea and other solutes from filtrate are reabsorbed by diffusion.

6. (d) : Nephrons or uriniferous tubules are mainly concerned with removal of urea from blood.

7. (c)

8. (c) : Sodium is reabsorbed in the collecting duct under the influence of aldosterone.

9. (b) : In descending limb of Henle's loop, water is reabsorbed due to increasing osmolarity of interstitial fluid.

10. (c)

11. (a) : Sebaceous glands eliminate certain substances like sterols, hydrocarbons and waxes through sebum.

12. (d) : Angiotensinogen is synthesised and secreted mainly by the liver cells.

13. (d) : Renin converts angiotensinogen into angiotensin II in the blood.

14. (a) : JGA (Juxtaglomerular apparatus) operates a multihormonal Renin Angiotensin Aldosterone system (RAAS).

15. (a) : The person is suffering from renal failure.

16. (c) : Hemodialysis saves and prolongs the life of many patients. At a time about 500 mL of blood is passed through the artificial kidney.

17. (d) : If one kidney is removed from the body, the person will survive and remain normal because kidney enlarges in size to perform extra work of missing kidney (compensatory hypertrophy).

18. (d) : Kidney stones are produced due to deposition of uric acid and calcium oxalate.

19. (a)

20. (c) : Uric acid molecule is more complex and needs far more energy in its synthesis from ammonia than urea molecule. However, (i) it is much less toxic than both ammonia and urea and (ii) it is almost insoluble and can be eliminated from the body in nearly a solid state, thus saving water. (1 g of uric acid excretion needs only 10 mL of water). Therefore, excretion of uric acid is advantageous for the animals which have to conserve water for their survival. It is excreted by insects, some land crustaceans (*Oniscus*), land snails (*Helix*), land reptiles (snakes, turtles) and birds.

21. (c) : Blood enters into glomerulus through afferent arterioles.

22. (a)

23. (a) : A fall in GFR can stimulate the JG cells to release renin which can stimulate the glomerular blood flow and thereby the GFR comes back to normal.

24. (d) : Too little ADH in your blood may be caused by compulsive water drinking or low blood serum osmolality, which is the concentration of particles in your blood. A rare water metabolism disorder called central diabetes insipidus is sometimes the cause of ADH deficiency. Central diabetes insipidus is marked by a decrease in either the production of ADH by your hypothalamus or the release of ADH from your pituitary gland. Common symptoms include excessive urination, which is called polyuria, followed by extreme thirst, which is called polydipsia.

25. (d) : The kidneys are located high in the abdominal cavity and against its back wall. They are found on either side of the backbone (the vertebral or spinal column), between the levels of the 12^{th} thoracic and 3^{rd} lumbar vertebrae.

26. (c) **27. (a)** **28. (c)**

29. (a) : In case of uremia, there are high concentrations of non-protein nitrogens which include urea, uric acid, creatinine and a few less important compounds. Urea accumulation in blood is comparatively high in uremia. In such patients, urea can be removed by a process called haemodialysis.

30. (d)

31. (a) : Certain substances such as tea, coffee and alcohol, increase urine output. These are said to be diuretic and the condition is called diuresis.

32. (c) : The Bowman's capsule leads into the proximal convoluted tubule that is lined by cuboidal epithelial cells bearing a brush border of tall microvilli (finger - like processes) at free end which increase the surface area. The cells have numerous mitochondria near the basolateral surface, which allows the reabsorption of salts by active transport.

33. (b) : A reduction in the Na^+ level in the interstitial fluid stimulates specialised cells (JG cells) in the afferent arterioles of the kidney cortex to form a protein called renin. Renin serves as an enzyme in the conversion of the plasma protein angiotensinogen (produced by liver) into angiotensin I

and further to angiostensin II. The latter, being a powerful vasoconstrictor, increase the glomerular blood pressure and thereby GFR. Angiotensin II stimulates the adrenal cortex to produce aldosterone which acts on the cells of the collecting ducts and increase the rate of reabsorption of Na^+. Reabsorption of Na^+ brings about the uptake of an osmotically equivalent amount of water. Absorption of sodium and water increases blood volume and pressure. Thus the Renin-Angiotensin-Aldosterone System (RAAS) maintains homeostasis.

34. (d)

35. (d) : Excretion of nitrogenous waste product in semi-solid form is found in uricotelic animals.

36. (d) : Two different excretory organs are found among crustaceans: the antennal gland and the maxillary gland. Both have the same basic structure : an end sac and a convoluted duct that may expand into a bladder before opening to the outside. In most adult crustaceans, only one or the other gland functions. The functional gland may change during the life cycle.

37. (a) **38. (c)** **39. (d)**

40. (a) : Malpighian corpuscle (A) is the site of ultrafiltration. A considerable amount of water is reabsorbed in the collecting duct (E) under the influence of ADH. Proximal convoluted tubule (C) is the main site for the reabsorption of glucose and amino acids. In distal convoluted tubule (D), both hydrogen ions and ammonium ions are secreted, thus it maintains blood pH.

41. (d) : *Nereis*, *Sycon*, Leech, *Pila* and Prawn are ammonotelic *Unio*, *Asterias* and *Limnaea* are aminotelic and *Ascaris* is an ureotelic organism.

42. (b) : *Amphioxus* has protonephridia or flame cells for excretion.

43. (c) : Male urethra is differentiated into three regions : prostatic (3-4 cm), membranous (1 cm) and penial (15 cm) and it carries both urine and semen.

44. (c) : Blood vessels, lymph vessels, nerves and ureter enter or leave the kidney through the hilus.

45. (b) : Ureter is long, narrow and tubular structure arise from the kidney to the urinary bladder. It is about 25 to 30 cm in length.

46. (d) : Blood is filtered so finely through the membranes of glomerulus, that almost all the constituents of the plasma except the proteins, pass onto the lumen of the Bowman's capsule.

47. (b) : Renin enzyme secreted by the juxtaglomerular cells of the kidney converts angiotensinogen into angiotensin I which is further converted into angiotensin II by an enzyme angiotensin-converting enzyme. Angiotensin II works as a hormone which induces the proximal convoluted tubules to reabsorb more NaCl and water.

48. (d) : The counter current mechanism helps to concentrate the filtrate which occurs in loop of Henle and vasa recta in the medulla region of the kidney.

49. (d) : About 65 percent of glomerular filtrate is normally reabsorbed in the proximal convoluted tubule. Glucose, amino acids, vitamins, hormones, sodium, potassium, chlorides, phosphates, bicarbonates, water and some urea from the filtrate are generally absorbed by the PCT.

50. (b) : Glucose is 100 per cent reabsorbed and thus a healthy person will excrete no glucose in the urine. Sodium and water are usually over 99 percent reabsorbed. Urea is the main excretory product formed as a result of protein breakdown.

51. (c) : The permeability of the distal convoluted tubule (DCT) and the collecting duct is under the control of a hormone released by the posterior pituitary called vasopressin or antidiuretic hormone (ADH). When water content in the body is low, and therefore, has to be conserved, ADH is released from the posterior pituitary which makes the walls of the DCT and collecting duct permeable to water. The surrounding tissue is hypertonic due to active reabsorption of Na^+ into it and due to the retention of Na^+ and urea by the counter - current system of vasa recta. So, water is progessively reabsorbed from the filtrate flowing along the DCT and collecting duct into the surrounding hypertonic tissue and the peritubular capillaries.

52. (d) : Sharks are not ammonotelic, but they are ureotelic animals. Ammonotelic animals excrete ammonia as major nitrogenous waste product. For example-bony fishes, many aquatic invertebrates and aquatic amphibians whereas ureotelic animals excrete urea instead of ammonia as the major nitrogenous waste product. Ureotelic animals include man and all other mammals, aquatic mammals like whales and seals, toads and frogs, cartilaginous fishes such as sharks and sting rays. Sharks need to avoid water loss from body, thus they cannot excrete ammonia, as it requires enough water to be eliminated. Sharks can retain so much urea in their blood that their blood osmotic pressure approaches that of sea water. This minimises water loss from their body to the concentrated saline water of the sea.

53. (b) : Urinary bladder and ureters of excretory system are lined by transitional epithelium because it is a stretchable epithelium, hence the urinary bladder and ureters may be considerably stretched without getting torn when they are filled with urine. Ureters are thin muscular tubes which emerge from the hilum of each kidney. Urine enters the ureters from the renal pelvis and is conducted along the ureters by peristaltic waves on their walls. Ureters from both the kidneys finally open into urinary bladder which is a hollow muscular sac. In this way urine from both the kidneys is drained into the urinary bladder which stores it temporarily.

Besides functioning as a temporary reservoir of urine, the urinary bladder also evacuates the urine by the process of micturition at suitable intervals.

54. (b) : Glomerular filtrate is the protein free fluid which is filtered from the blood of glomerular capillaries to the lumen of the Bowman's capsule. This process is called glomerular filtration. About $1/5^{th}$ of the cardiac output is received by kidneys for filtration in a minute. The filtration occurs across the membrane made of the glomerular capillary wall and the inner membrane of the Bowman's capsule. The pores of this filtering membrane are impermeable to large molecules or particles. Large particles like blood cells and protein macromolecules do not normally enter into the glomerular filtrate. But smaller molecules like glucose, urea, creatinine, amino acids and mineral salts are filtered into the Bowman's capsule in concentrations more or less similar to their respective concentrations in the plasma. The filtrate therefore almost resembles the protein free plasma in composition and osmotic pressure.

55. (a) : Kidneys play an essential role in maintaining the concentration and osmotic pressure (osmoconcentration) of blood. When water intake of an animal is very high, the excreted urine will be hypotonic i.e., dilute and lower in osmotic pressure than their blood in order to remove the excess of water. Contrary to this, when there is a threat of excessive water loss from the body; the excreted urine will be hypertonic *i.e.* more concentrated and higher in osmotic pressure than their blood in order to reduce the loss of water with urine. In this way, the osmotic concentration of the blood is maintained.

56. (c) : Urea is the chief nitrogenous constituent of human urine, though it possesses small amount of ammonia. But when the urine is allowed to stand for sometime, bacterial degradation occurs and it leads to the production of ammonia from urea. And thus smells strongly.

$$NH_2 - CO - NH_2 \xrightarrow[\text{degradation}]{\text{Bacterial}} NH_3 \uparrow + CO_2$$

57. (b) : Malpighian tubules are the excretory structures of most insects including cockroaches. They help in the removal of nitrogenous wastes and osmoregulation.

58. (b) : The expulsion of urine from urinary bladder is called micturition. When enough urine has accumulated in the bladder to distend the bladder and raise its pressure sufficiently, a spontaneous nervous activity (reflex) is initiated; this causes the smooth muscles on the bladder wall to contract and the urethral sphincters, which guard the urethra, to relax. Urine consequently flows from the bladder through the urethra to the exterior. But it is prevented from flowing back into the ureters, because the terminal part of each ureter passes obliquely through the bladder wall and is consequently closed due to compression by the contracting bladder muscles.

59. (a) : The blood urea level rises abnormally in patients suffering from renal failures i.e., uremia. In uremic patients, an artificial kidney is used for removing accumulated waste products like urea from the blood by a process called hemodialysis.

60. (b) : Birds cannot excrete urine as hypertonic as the mammalian urine, still these animals can considerably reduce water loss in the urine, because their principle nitrogenous waste product happens to be insoluble uric acid. In birds, ureters and rectum open into a sac called the cloaca which stores both urine and faeces. Large volume of water can be reabsorbed from the urine in the cloaca, because uric acid does not require much water to be excreted. Consequently, the urine volume ultimately becomes very little, just sufficient to sweep away the insoluble uric acid from the cloaca.

SUBJECTIVE TYPE QUESTIONS

1. Green glands are structures involved in excretion. They are found in prawns (crustaceans).

2. (a) Renal pelvis

(b) Calyces

3. On an average, 1100 to 1200 mL of blood is filtered by the kidneys per minute.

4. Ultrafiltration is filtration under pressure. Glomerular filtration is also called ultrafiltration due to the high blood pressure in the glomerular capillaries that allows continuous process of filtration through the semi-permeable glomerular capillaries.

5. Ascending limb of loop of Henle.

6. The two counter current systems are glomerular filtrate in the Henle's loop and blood in the vasa recta that flow in opposite directions.

7. Enzyme called renin is secreted by juxtaglomerular cells which converts angiotensinogen to angiotensin I which is further converted into angiotensin II.

8. Nitrogenous wastes are absent in the dialysis fluid.

9. Radial artery

10. Approximately 125 mL/minute, *i.e.*, 180 litres per day.

11. (a) *Ascaris* - Dual excretion, *i.e.*, both ureotelic and ammonotelic. Wastes are ammonia (in water) and urea (on land).

(b) *Pila* - Ammonotelic, waste product is ammonia.

(c) Crocodiles - Ammonotelic, waste product is ammonia.

(d) *Asterias* - Aminotelic, excretes amino acids.

12. The collecting duct has important functions in regulating the composition of urine, as water, ions and nutrients are reabsorbed from the filtrate in the nephron tubules and collecting ducts. This reabsorption prevents the loss of useful

nutrients, ions, and water, and provides an opportunity for tubule cells to regulate the composition of blood and the body fluids by maintaining their pH and ionic balance due to selective secretion of H^+ and K^+ ions.

13. (a) Podocytes are specialised cells found in the epithelium of visceral layer of glomerular membrane. They have foot like processes called the pedicels, hence called so. The space between the pedicels are called slit pores through which filtration occurs.

(b) Glomerulus is a capillary network within the Bowman's capsules. Blood enters glomerular capillaries through afferent arterioles and leaves through efferent arterioles. The diameter of afferent arteriole is much more than that of efferent arteriole.

14. (a) Reabsorption is the process by which most of the substances from the glomerular filtrate are reabsorbed by the nephron.

(b) Active and passive mechanism.

15. (a) Glucose - Active transport
(b) Amino acid - Active transport
(c) Urea - Diffusion
(d) Chloride - Diffusion

16. NaCl and urea help to maintain the gradient for osmolarity of 300 $mOsmolL^{-1}$ in the cortex to about 1200 $mOsmolL^{-1}$ in the inner medulla. The increased concentration of NaCl and urea in the interstitial fluid draws out water by osmosis thus concentrating the urine.

17. Renin initiates a series of chemical reactions that ultimately result in the formation of angiotensin II. It increases blood volume in two ways : Firstly, it induces the proximal convoluted tubules to reabsorb more NaCl and water and secondly it stimulates the adrenal glands to release a hormone, called aldosterone that induces the distal convoluted tubule to absorb more Na^+ and water.

18. The back flow of urine into the ureters is prevented because the terminal part of each ureter passes obliquely through the bladder wall and closed due to compression by the contracting bladder muscles.

19. Sweat provides a cooling effect to our body when it gets evaporated. It also helps in excretion of NaCl, small amounts of urea, lactic acid, etc.

20. Antidiuretic hormone facilitates absorption of water from distal part of tubules. Its deficiency may cause passing of excessive dilute urine and intense thirst. This condition is known as diabetes insipidus.

21. The person is suffering from pyelonephritis. It is an inflammation of the renal pelvis and the medullary tissue of the kidney. This disease is usually caused by bacteria that reach the kidney by way of the urethra and ureter. It usually affects countercurrent mechanism in the medulla. Affected person has inability to concentrate his urine. Symptoms of this disease are frequent and painful urination, fever and back pain.

22. The following play an important role in the functioning of kidneys–

(i) ADH : Antidiuretic hormone (ADH) is secreted by hypothalamus of the brain and released into the blood from the posterior lobe of the pituitary gland. The release of ADH is triggered when osmoreceptors in the hypothalamus detect an increase in the osmolarity of the blood above a set point of 300 $mosmL^{-1}$. In this situation, the osmoreceptor cells also promote thirst. It increases the reabsorption of water in the DCT and collecting duct.

(ii) ANF : Atrial natriuretic factor is another hormone which opposes the regulation by RAAS. The walls of the atria of the heart release ANF in response to an increase in blood volume and pressure. ANF inhibits release of renin from the JGA and thereby inhibits NaCl reabsorption by the collecting duct and reduces aldosterone release from the adrenal gland.

Thus ADH and ANF regulate the function of the kidneys. As a result, they control body fluid osmolarity, salt concentration, blood pressure and blood volume.

(iii) Renin : The smooth muscle cells of both the afferent and efferent arterioles are swollen and contain dark granules. These cells are called juxtaglomerular cells. The granules are composed mainly of inactive renin. It means renin is secreted by juxtaglomerular cells. Renin converts angiotensinogen into angiotensin I and further to angiotensin II. The latter increases blood pressure. It also stimulates the secretion of aldosterone by the adrenal cortex thus inducing the reabsorption of sodium ions by the DCT and that of water through collecting ducts.

23. (a) In different mammals, the concentration of urine is directly related to the length of loop of Henle. The function of the loop of Henle is to conserve water. More the length of loop of Henle more is absorption of water and this results in more concentrated urine.

(b) The thick part of the ascending limb of loop of Henle is virtually impermeable to water, but large amounts of sodium, chloride, potassium, and other ions are actively transported from the tubule into the medullary interstitium. Therefore, fluid in the thick ascending limb of the loop of Henle becomes very dilute, falling to a concentration of about 100 mOsmol/l.

24. Skin plays a major role in excretion. It helps the body to get rid of excess of water, salts and waste such as ammonia in aquatic animals. The mammalian skin possesses sweat glands and sebaceous glands that play excretory roles. The secretion of sweat glands (sweat) is an aqueous fluid containing sodium chloride, lactic acid, urea, amino acids and glucose. Control of sweat lost is an example of homeostatic control for regulating the body temperature according to the variation in the ambient temperature.

Sebum from sebaceous glands eliminates sterols, fatty acids and some other hydrocarbons. They are mainly meant for lubrication of hair and skin, but some constituents are concerned with excretion like waxes and sterols.

25. (A) - Renin
(B) - Glomerular filtration rate
(C) - Angiotensinogen
(D) - Arterioles
(E) - Aldosterone
(F) - Blood volume

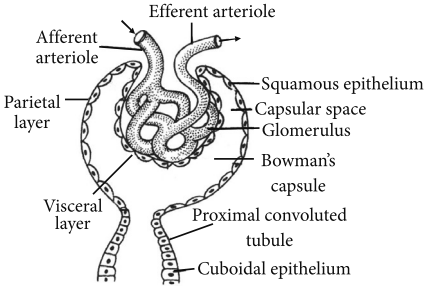
26. Glomerular filtration is autoregulated by the following mechanisms:

(i) Myogenic mechanism : An increase in blood pressure increases blood flow to the glomerulus by stretching afferent arteriole. When the wall of the arteriole contracts, the diameter of the afferent arteriole is reduced that increases the flow of blood.

(ii) Juxtaglomerular mechanism : Juxtaglomerular apparatus (JGA) cells secrete enzymes like renin that modulate blood pressure and thus renal blood flow. This also regulates GFR.

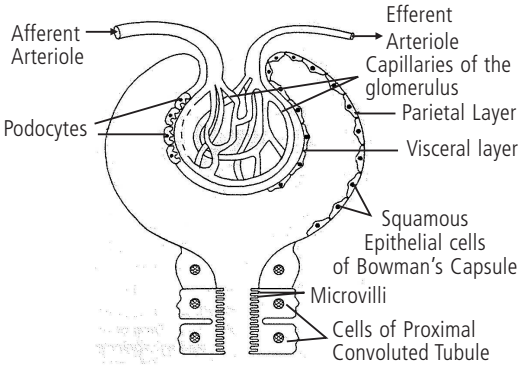
(iii) Neural control : Blood vessels of the kidney are innervated by nerve fibres of sympathetic neural system. When activated, the nerve fibres bring about constriction of renal arteries and cause decrease in renal flow and GFR.

27. The diagram of Malpighian corpuscle is as follows:



The Malpighian Corpuscle (= Renal corpuscle; fig.): It comprises glomerulus and Bowman's capsule.

(i) Glomerulus : It is a tuft of capillaries. This capillary network consists of a complex *anastomosing plexus* of vessels and not of independent capillary loops. Blood enters the glomerulus through an afferent arteriole and leaves it through an efferent arteriole. Glomerular filtration takes place in the glomerulus.



(ii) Bowman's Capsule (= Glomerular capsule) : It is a double layered cup-shaped structure. The lumen of the capsule is continuous with the narrow lumen of the renal tubule. The two layers of the Bowman's capsule are outer parietal layer and inner visceral layer. The visceral layer surrounds the glomerulus and is composed of special type of cell, the podocytes.

28. There is an intimate association between the blood vessels and the nephrons of the kidney. This association permits both extensive filtration from the blood and selective reabsorption back into the blood.

After entering each kidney, the renal artery branches repeatedly, forming smaller and smaller arteries, until tiny arterioles reach each of the 1 million nephrons. An afferent arteriole delivers blood to the glomerulus for filtration, an efferent arterioles drains filtered blood away from the same glomerulus.

The efferent arteriole connects to a second network of capillaries, the peritubular capillaries, which are closely associated with the nephron tubule. It is into these peritubular capillaries that water, ions and nutrients are reabsorbed from the filtrate in the nephron tubule. From the peritubular capillary network arise the capillaries of vasa recta, which extend parallel to the loops of Henle and the collecting ducts in the medulla. The vasa recta consist of descending capillaries and ascending capillaries. All the capillary networks join to form renal venules which join to form a renal vein that opens into the inferior vena cava.

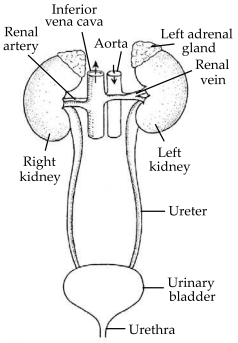
29. The various functions of human kidney are :
(i) Osmoregulation
(ii) Elimination of nitrogenous wastes
(iii) Maintenance of pH
(iv) Maintenance of salt contents
(v) Removal of other substances such as toxic substances, drugs, pigments, excess vitamins from the blood
(vi) Maintenance of blood pressure
(vii) Secretion of renin
(viii) Erythropoietin production
(ix) Homeostasis.

30. Urea is formed in the liver which is eliminated through kidneys. Liver cells also degrade the haemoglobin of worn out red blood corpuscles into bile pigments (bilirubin and biliverdin). Liver cells also excrete cholesterol, certain products of steroid hormones, some vitamins and many drugs. Liver secretes these substances in the bile. The bile carries these substances to the intestine and are passed out with faeces.

31. An excessive loss of fluid from the body can activate the osmoreceptors present in the body which further stimulate the hypothalamus to release antidiuretic hormone (ADH) from the neurohypophysis. ADH facilitates water reabsorption in distal convoluted tubule and collecting duct. An increase in body fluid volume can switch off the osmoreceptors and suppress the ADH release to complete the feedback.

Angiotensin II also activates the adrenal cortex to release aldosterone. This hormone causes reabsorption of Na^+ and water from the distal parts of the tubule.

32. The diagram of human excretory system is as follows:



33. Aquatic animals like bony fishes, aquatic amphibians and aquatic insects excrete ammonia, *i.e.,* they are ammonotelic in nature. This is because ammonia is highly toxic and is readily soluble in water. It is generally excreted by diffusion across body surfaces or through gill surfaces (in fish) as ammonium ions. Excretion of nitrogenous wastes in the form of ammonia requires a lot of water. Terrestrial animals cannot afford to lose so much of water, thus they convert ammonia into urea or uric acid which are less toxic and can be stored in body for longer.

Terrestrial amphibians and mammals mainly excrete urea and are called ureotelic animals while reptiles, birds, land snails excrete uric acid and are called uricotelic animals. Urea and uric acid are less soluble in water and can be excreted with lesser loss of water. Thus, terrestrial adaptation necessitated the production of urea and uric acid for conservation of water.

34. The factors that can affect the glomerular filtration rate (GFR) are:

(i) It increases with increase in renal blood flow.

(ii) An increase in glomerular capillary hydrostatic pressure can increase glomerular filtration rate.

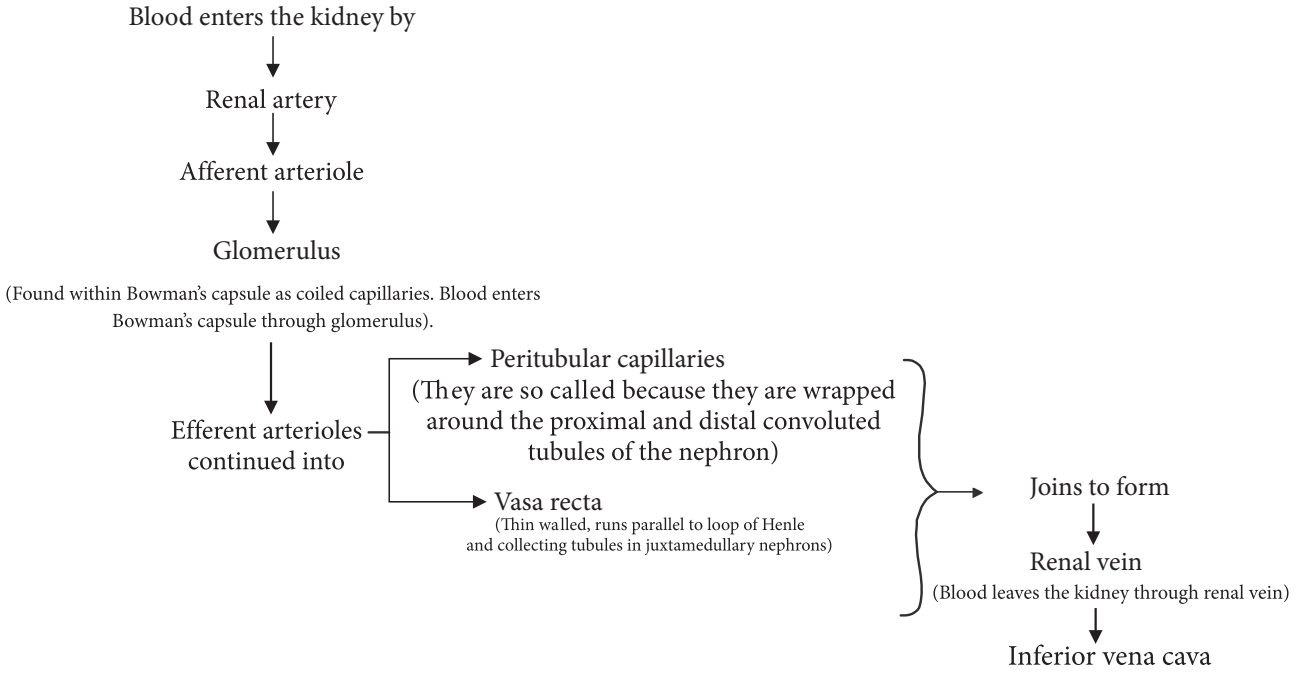
(iii) Increase in systemic blood pressure can increase GFR.

(iv) Increase in constriction of afferent and/or efferent arteriole increases GFR.

35. Differences among ammonotelic, ureotelic and uricotelic is given below :

Features	Ammonotelic	Ureotelic	Uricotelic
Mode of excretion	Ammonotelism	Ureotelism	Uricotelism
Excretory products	Ammonia, (formed by deamination of amino acids in liver).	Urea (formed by detoxification of amino acid in liver).	Uric acid (mainly formed from purines in liver cells but formed in Malpighian tubules in insects.
Toxicity	Ammonia is highly toxic (hence can't be stored in body).	Less toxic and stored for longer time.	Insoluble in water and least toxic. Stored in body for long time.
Water requirement	Needs more water for excretion. Suitable to aquatic animals.	Being a small molecule, urea can be filtered easily in the kidney.	Requires little water for elimination. Suitable for terrestrial animals and those having shelled eggs.
Examples	Protozoans, protists, sponges, cnidarians, liver fluke, tapeworm, *Ascaris*, *Nereis*, *leech*, *Pila*, bony fishes.	*Ascaris*, cartilaginous fishes, frogs and toads, turtles, alligators, all mammals, etc.	Insects, land snails, reptiles, crustaceans, birds, etc.

36. (a) The flow of blood in the kidneys can be represented as:



(b) Differences between descending limb and ascending limb of loop of Henle are :

	Descending limb of loop of Henle	Ascending limb of loop of Henle
(i)	Thin walled.	Thick walled.
(ii)	Freely permeable to water.	Impermeable to water.
(iii)	5% of water is drawn out of the filtrate by vasa rectae (reabsorbed).	Water is not reabsorbed.
(iv)	Sodium and other solutes not reabsorbed.	Sodium, potassium, calcium, etc., are reabsorbed.
(v)	Nephric filtrate becomes hypertonic due to loss of water.	Nephric filtrate becomes hypotonic due to loss of solute.
(vi)	It is the first part of loop of Henle that gets isotonic filtrate from PCT.	It is the second part of loop of Henle and passes hypotonic filtrate to DCT.

37. (a) Aldosterone is a hormone secreted by the outer layer of the adrenal gland (cortex part), a gland which is situated above the kidneys. The release of aldosterone is controlled by low levels of sodium in body.

When aldosterone is present in the blood, more Na^+ from the filtrate is reabsorbed by the epithelial cells of the collecting duct. Retaining Na^+, raises the osmotic pressure of the blood and reduces water loss from the body. When aldosterone is absent, some Na^+ remains in the filtrate and is excreted with the urine.

(b) As blood pressure decreases, the cells of juxtaglomerular apparatus release an enzyme renin and activate the Renin-Angiotensin-Aldosterone pathway (RAAS). Renin converts angiotensinogen into angiotensin I and then converts angiotensin I into angiotensin II, a peptide hormone that is the active form. Angiotensin II has the following effects:

- Increases the release of aldosterone
- Raises blood pressure directly by constricting blood vessels
- Stimulates sodium reabsorption by the distal convoluted tubules.

These changes assist in restoring extracellular fluid volume and in stabilising blood pressure.

(c) Atrial natriuretic factor (ANF) a peptide hormone produced by the atria of heart, increases sodium excretion and decreases blood pressure and blood volume. ANF is released into the bloodstream in response to stretching of the atrial muscle cells by increased blood volume.

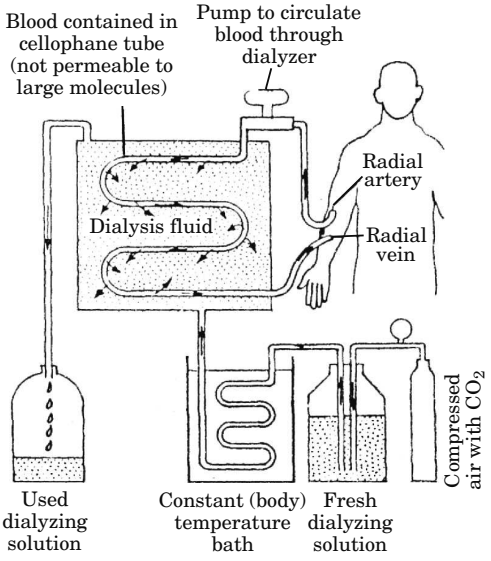
ANF has the following physiological effects:

- Inhibits the release of renin from JGA.
- Inhibits the collecting ducts from reabsorbing sodium, both directly and indirectly (by inhibiting aldosterone secretion).

38. (a) When the kidneys are completely damaged and do not function, the patient often receives haemodialysis (treatment with an artificial kidney). Haemodialysis is the separation of certain substances from blood by use of a selectively permeable membrane. The pores in the membrane allow some substances to pass through, however, prevent others. The patient is connected to the machine by a tube attached to the radial artery. Blood from the artery is pumped into a tube that runs through the dialyzer. The dialyzer is

filled with dialysis fluid which contains the same quantities of electolytes and nutrients as normal plasma but contains no waste products. The cellophane tube (a tube bounded by thin membrane) is kept in the dialysis fluid. The membrane of the cellophane tube is impermeable to blood cells and proteins but permeable to urea, uric acid, creatinine and mineral ions. So, these wastes diffuse from the blood to the dialysis fluid across the cellophane membrane. Thus, the blood is cleared of nitrogenous waste products without losing plasma proteins. Such a process of separating small solutes from macromolecular colloids with the help of a selectively permeable membrane is called dialysis. Now the blood is returned to the patient's body through a vein usually the radial vein. Haemodialysis saves and prolongs the life of many patients.

(b) A schematic diagram to show the working of an artificial kidney is :



39. The renal tubule consists of the following parts:

(i) Proximal convoluted tubule (PCT): The Bowman's capsule leads into the proximal convoluted tubule that is lined by cuboidal epithelium which has a brush border of microvilli at the free end for increasing the surface area. The basolateral surface of these cells have number of mitochondria for the reabsorption of salts by active transport.

(ii) Loop of Henle : It starts from the PCT with its major part in the medulla. It has an ascending and a descending limb. The descending limb is continuous with the PCT having the upper part with the same diameter but as it descends further, it narrows down. The upper part has cuboidal epithelium but the cells have less microvilli and mitochondria as compared to PCT. The narrow segment also called the thin segment has flat epithelial cells with thinly scattered microvilli and very few mitochondria. The ascending limb also has thick and thin segments. The thick segment of ascending limb is lined by cuboidal epithelial cells with short apical microvilli and numerous mitochondria.

(iii) Distal convoluted tubule (DCT) : The thick segment of ascending limb of loop of Henle is continuous with the DCT that lies in the cortex. It is lined by cuboidal cells that have few, small and irregularly spaced microvilli. The distal convoluted tubule joins the collecting duct on the other hand.

40. Human excretory system consists of a pair of kidneys, a pair of ureters, urinary bladder and urethra.

Kidneys are reddish brown, bean shaped structures, situated between the last thoracic and third lumbar vertebra close to the dorsal inner wall of abdominal cavity.

The kidneys are covered by a layer of fibrous connective tissue, the renal capsule. Outside the capsule, is a layer of fat, the adipose capsule, followed by a fibrous membrane, the renal fascia. The renal capsule, adipose capsule and renal fascia constitute the protective coats of kidneys. Towards the centre of the inner concave surface of the kidney, is a notch called hilus or hilum. Blood vessels, lymph vessels, nerves and ureters enter or leave the kidney through hilus.

There are two distinct zones in kidney–an outer, darker, renal cortex and an inner, lighter renal medulla which is made of 15-16 conical subdivisions called renal pyramids. The cortex extends in between medullary pyramids as renal columns, called columns of Bertini.

Ureters are narrow, tubular structures composed of transitional epithelium, about 25-30 cm long and run backward along the abdominal wall to open into urinary bladder. Ureters carry urine from the kidneys to the urinary bladder. Urinary bladder is muscular, pear shaped, sac-like structure lying in the pelvic cavity. Its inner lining is formed of transitional epithelium and muscular layer is called detrusor muscle. Urinary bladder stores urine temporarily. Urethra in males carries both urine and semen but, in females it carries only urine.

Diagrammatic representation of human kidney is as follows: