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Class	10th	Chapter	04
Subject	Biology	Board	Federal

CHAPTER 04: URINARY SYSTEM

Section I: Multiple Choice Questions

1. Nephron, the functional unit of kidney is composed of all of the following except:

A) Bowman's capsules B) loop of Henle C) glomerulus **D) ureter**

2. Osmoregulation involves:

A) active transport B) diffusion C) facilitated diffusion D) osmosis

3. Urine passes from bladder to the:

A) medulla **B) urethra** C) ureter D) cortex

4. Where is urea produced?

A) urinary bladder B) blood cells C) kidney **D) liver**

5. Which substance is present at a lower concentration in the renal artery than in the renal vein?

A) amino acid **B) carbon dioxide** C) glucose D) urea

6. In a kidney machine what must be at the same concentration in the dialysis fluid and in the blood?

A) glucose and salts B) protein C) urea D) water

7. The four structures listed are part of the human excretory system (1. bladder, 2. kidney, 3. ureter, 4. urethra). In which order does a molecule of urea pass through these structures?

A) 1 → 2 → 3 → 4 B) 1 → 4 → 3 → 2 C) 2 → 1 → 3 → 4 **D) 2 → 3 → 1 → 4**

8. In a kidney machine, which of the following passes from the blood to the dialysis fluid?

A) glucose B) plasma protein C) red blood cells **D) urea**

9. Which blood vessel carries blood with the lowest concentration of urea?

A) hepatic portal vein B) pulmonary vein **C) renal vein** D) vena cava

10. Lithotripsy is a procedure that breaks large kidney stones into smaller ones by using:

A) X-rays B) microwaves **C) sound waves** D) ultraviolet rays

11. Which row shows substances that are present in each of the structures of excretory system of a healthy human?

- Renal artery: salts, Renal vein: water, Ureter: protein, Urinary bladder: glucose
- **C) Renal artery: salts, Renal vein: water, Ureter: protein, Urinary bladder: glucose**
  (Wait, let's verify row C/D accurately from standard key: Renal artery has salts, Renal

*vein has water/glucose, Ureter has protein/urea, etc. Let's list the correct option row matching standard textbook keys: Option **C** or **D** depending on table layout; typically **C**)*

12. The filtration of waste takes place inside the kidneys in:

A) ureter B) urethra C) urinary bladder **D) nephron**

13. The function of glomerulus and Bowman's capsule of the nephron is to:

A) reabsorb water into the blood B) eliminate ammonia from the body

C) reabsorb salts and amino acids **D) filter the blood and capture the filtrate**

14. Evidence for glomerular filtration in the kidney could be obtained by comparing the sizes of the molecules present in Bowman's capsule with those in the:

A) afferent blood vessel B) collecting duct C) loop of Henle **D) proximal tubule**

Section II: Short Answer Questions

Q1. What is the role of urinary system in the body?

Answer: The primary role of the urinary system is osmoregulation and excretion. It regulates the volume and composition of body fluids (blood and tissue fluid) by removing metabolic nitrogenous wastes (like urea, uric acid, and creatinine) and balancing water, salt, and pH levels, thereby maintaining internal body stability (homeostasis).

Q2. Name the structures of urinary system.

Answer: The human urinary system consists of the following major structures:

1. **A pair of kidneys** (produce urine)
2. **A pair of ureters** (tubes carrying urine from kidneys to bladder)
3. **Urinary bladder** (temporary storage sac for urine)
4. **Urethra** (tube through which urine is expelled out of the body)

Q3. Write the functions of: kidney, ureter, urinary bladder, urethra, pelvis of kidney, capsule of kidney, dialysis.

Answer:

- **Kidney:** Filters blood to remove nitrogenous wastes, excess water, and salts to form urine, and performs osmoregulation.
- **Ureter:** Transports urine peristaltically from the renal pelvis of each kidney down to the urinary bladder.
- **Urinary bladder:** A muscular sac that temporarily stores urine until it is voluntarily released from the body.
- **Urethra:** Conveys urine from the urinary bladder to the exterior of the body during micturition (urination).
- **Pelvis of kidney:** Acts as a funnel-shaped collecting space that gathers urine from the major calyces and channels it into the ureter.
- **Capsule of kidney (Renal capsule):** A tough, fibrous outermost connective tissue covering that protects the inner delicate functional tissues of the kidney.
- **Dialysis:** An artificial medical procedure (hemodialysis or peritoneal dialysis) used to filter and purify blood when the kidneys fail to function properly.

Q4. What materials are returned to the blood?

Answer: During tubular reabsorption in the nephron, useful components filtered out during glomerular filtration are reabsorbed back into the peritubular capillaries/blood. These include:

- Water (approx. 99%)
- Essential salts/ions (sodium, potassium, chloride, bicarbonate)
- Glucose and amino acids

Q5. What materials leave the body in urine?

Answer: Materials that are excreted from the body via urine include:

- Excess water
- Nitrogenous metabolic wastes (primarily urea, along with uric acid and creatinine)
- Excess mineral salts/ions (such as sodium, potassium, and phosphates)
- Toxins, drugs, and metabolic byproducts

Q6. Name the disorders of kidney.

Answer:

- **Kidney Stones (Renal Calculi):** Hard mineral and salt deposits formed inside the kidneys.
- **Kidney Failure (Renal Failure):** Progressive or sudden loss of kidney filtering capacity.

Q7. Write the causes of formation of kidney stone.

Answer: Kidney stones are caused by a combination of genetic and environmental factors that promote the precipitation and crystallization of salts in urine:

- Hypercalcemia or high concentrations of calcium, oxalate, and uric acid in urine.
- Dehydration or inadequate fluid intake.
- Urinary tract infections (UTIs) and metabolic abnormalities.
- A diet high in animal protein, sodium, or oxalate-rich foods.

Q8. Name the structures in the urinary system of man that is associated with each of these:

- **a. Urea formation:** Liver (produced here via the urea cycle and transported via blood to kidneys)
- **b. Urine formation:** Nephrons (inside the Kidneys)
- **c. Filtration:** Glomerulus (within the renal corpuscle of the nephron)
- **d. Reabsorption:** Renal tubules (Proximal convoluted tubule, loop of Henle, distal convoluted tubule)
- **e. Tubular secretion:** Renal tubules (distal and collecting tubules)
- **f. Temporary storage of urine:** Urinary bladder
- **g. Conduction of urine out of the body:** Urethra

Q9. The given diagram shows the structure of a human nephron. Trace the pathway of blood with the help of arrows (→) in the given diagram. ***(Note: Do NOT show pathway of the filtrate.)***

Answer: The pathway of blood flow through the nephron's vascular network is:

Renal Artery ⟶ Afferent Arterioles ⟶ Glomerulus ⟶ Efferent Arterioles ⟶ Peritubular Capillaries / Vasa Recta ⟶ Renal Vein

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Q10. Describe the kidney transplant.

Answer:

- **Definition:** Kidney transplant is a surgical procedure in which a healthy donor kidney (from a living or deceased donor) is implanted into a patient with end-stage renal failure (chronic kidney failure).
- **Procedure:** The failed kidneys are generally left in place unless they cause complications (like infection, high blood pressure, or pain). The donor kidney is placed in the lower abdomen, and its blood vessels (renal artery and vein) are stitched to the recipient's iliac blood vessels. The donor ureter is connected directly to the urinary bladder.
- **Complications & Success:** The recipient's immune system may recognize the new kidney as foreign and attempt to reject it. Therefore, immunosuppressive drugs must be taken for the rest of the patient's life to prevent organ rejection.

Q11. What is kidney failure and dialysis?

Answer:

- **Kidney Failure:** A medical condition in which both kidneys lose their ability to filter metabolic wastes, regulate fluid balance, and maintain electrolyte homeostasis effectively. It can be acute (sudden) or chronic (long-term/permanent).
- **Dialysis:** An artificial method of filtering blood to remove toxins, excess fluids, and waste products when the natural kidneys fail. There are two primary types:

1. **Hemodialysis:** Blood is pumped out of the body through an artificial machine containing a dialyzer (artificial kidney) with a semi-permeable membrane, where wastes diffuse out, and purified blood is returned to the body.
2. **Peritoneal Dialysis:** Dialysis fluid is introduced into the patient's abdominal cavity (peritoneal cavity), where the peritoneum acts as a natural semi-permeable membrane to filter wastes from blood vessels before the fluid is drained out.

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SECTION III: EXTENSIVE ANSWER QUESTIONS

Q1. Describe human urinary system.

Introduction

The human urinary system (excretory system) is responsible for filtering metabolic waste products from the blood and maintaining osmotic balance (water and electrolyte balance) in the body.

Organs of the Human Urinary System

The human urinary system consists of four main components:

1. **A pair of Kidneys**
2. **A pair of Ureters**
3. **Urinary Bladder**
4. **Urethra**

Detailed Description of Components

1. Kidneys

- **Location & Structure:** Kidneys are dark red, bean-shaped organs located against the back wall of the abdominal cavity, on either side of the vertebral column, protected by the lower rib cage.
- **Dimensions:** Each kidney is about 10 cm long, 5 cm wide, and 4 cm thick.
- **Hilum:** The concave inner side of each kidney features a depression called the **hilum**, through which the ureter, renal artery, renal vein, nerves, and lymphatic vessels enter or exit.
- **Function:** Filters blood, removes nitrogenous wastes (urea, uric acid), regulates blood pressure, and performs osmoregulation.

2. Ureters

- **Structure:** Muscular tubes that arise from the renal pelvis of each kidney and extend downward to open into the urinary bladder.
- **Function:** Transport urine from the kidneys to the urinary bladder via rhythmic peristaltic contractions of their muscular walls.

3. Urinary Bladder

- **Structure:** A smooth, collapsible, hollow muscular sac located in the pelvic cavity.
- **Function:** Stores urine temporarily. It has a elastic muscular wall (detrusor muscle) that expands as it fills. An internal sphincter muscle at the neck of the bladder controls the voluntary release of urine.

4. Urethra

- **Structure:** A thin-walled tube leading from the floor of the urinary bladder to the exterior of the body.
- **Function:** Channels urine out of the body during urination (micturition). (In males, it also carries seminal fluid).

Q2. Relate the structure of the kidney with its function.

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Introduction

The functional structure of the kidney is divided into three distinct anatomical regions: the **Renal Cortex**, **Renal Medulla**, and **Renal Pelvis**. Each region contains specialized structures tailored to filtration, reabsorption, secretion, and urine collection.

Detailed Structural-Functional Relationship

Kidney Structure	Anatomical Features	Functional Significance
Renal Capsule	Outer tough, fibrous connective tissue membrane.	Protects inner kidney tissues against mechanical injury and bacterial infections.
Renal Cortex	Outer light red region containing renal corpuscles (glomerulus + Bowman's capsule) and convoluted tubules.	Facilitates **ultrafiltration** of blood under high hydrostatic pressure and extensive **tubular reabsorption**.
Renal Medulla	Inner reddish-brown region divided into 8–18 cone-shaped structures called **renal pyramids**.	Contains loops of Henle and collecting ducts that generate an osmotic gradient to **concentrate urine** and reabsorb water.
Renal Papilla	The pointed tip of each renal pyramid projecting into minor calyces.	Discharges formed urine from collecting ducts into the renal pelvis.
Renal Pelvis	Funnel-shaped expanded basin located at the hilum.	Collects urine draining from all renal pyramids and channels it into the ureter.

Q3. Describe the structure of nephron.

Introduction

The **nephron** is the structural and functional unit of the kidney. Each human kidney contains approximately 1 million nephrons.

A nephron consists of two main parts:

1. **Renal Corpuscle** (Malpighian Body)
2. **Renal Tubule**

Detailed Components of Nephron

1. Renal Corpuscle

The renal corpuscle is located in the cortex and performs ultrafiltration:

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- **Glomerulus:** A dense network of high-pressure capillaries branching from the afferent arteriole and merging into the efferent arteriole.
- **Bowman's Capsule:** A double-walled cup-shaped sac surrounding the glomerulus. Inner layer contains specialized epithelial cells called **podocytes** with filtration slits.

2. Renal Tubule

A long, coiled tube extending from Bowman's capsule:

- **Proximal Convoluted Tubule (PCT):** Located in the cortex; lined with microvilli (brush border) to maximize surface area for maximum selective reabsorption.
- **Loop of Henle:** A U-shaped hairpin loop extending down into the medulla:
  - *Descending Limb:* Thin wall, highly permeable to water, impermeable to solutes.
  - *Ascending Limb:* Thick wall, active transport of Na^+ and Cl^-, impermeable to water.
- **Distal Convoluted Tubule (DCT):** Located in the renal cortex; performs selective secretion and hormonally-controlled salt/water reabsorption.
- **Collecting Duct:** Receives urine from multiple DCTs of adjacent nephrons, passes down through the renal medulla, and empties into the renal pelvis.

Q4. Explain the process of urine formation in human.

Introduction

Urine formation takes place in the nephron through **three main processes**:

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+-------------------------------------------------------------+
|              STEPS OF URINE FORMATION                       |
+-------------------------------------------------------------+
| 1. Pressure / Ultrafiltration (at Glomerulus into Bowman's) |
| 2. Selective Reabsorption  (at PCT, Loop of Henle, DCT, Duct) |
| 3. Tubular Secretion       (at DCT & Collecting Duct)       |
+-------------------------------------------------------------+
```

Detailed Steps

1. Glomerular Filtration (Ultrafiltration)

- **Site:** Glomerulus and Bowman's capsule.
- **Mechanism:** Blood enters the glomerulus under high hydrostatic pressure via the wide afferent arteriole and exits through the narrower efferent arteriole.
- **Outcome:** Water, glucose, amino acids, urea, uric acid, and mineral salts are forced across the capillary walls into Bowman's capsule, forming **glomerular filtrate**. Blood cells and large plasma proteins remain in blood capillaries.

2. Selective Reabsorption

- **Site:** PCT, Loop of Henle, DCT, and Collecting Duct.
- **Mechanism:** About 99% of the glomerular filtrate volume is reabsorbed into peritubular capillaries:
  - **PCT:** 100% of glucose and amino acids, and ~65–70% of water and Na^+ are reabsorbed by active transport and osmosis.

- **Loop of Henle:** Creates a hypertonic medullary interstitium; descending limb reabsorbs water, ascending limb actively reabsorbs Na^+ and Cl^-.
- **DCT & Collecting Duct:** Water reabsorption is fine-tuned under the control of **Anti-Diuretic Hormone (ADH)**, while Na^+ reabsorption is controlled by **Aldosterone**.

3. Tubular Secretion

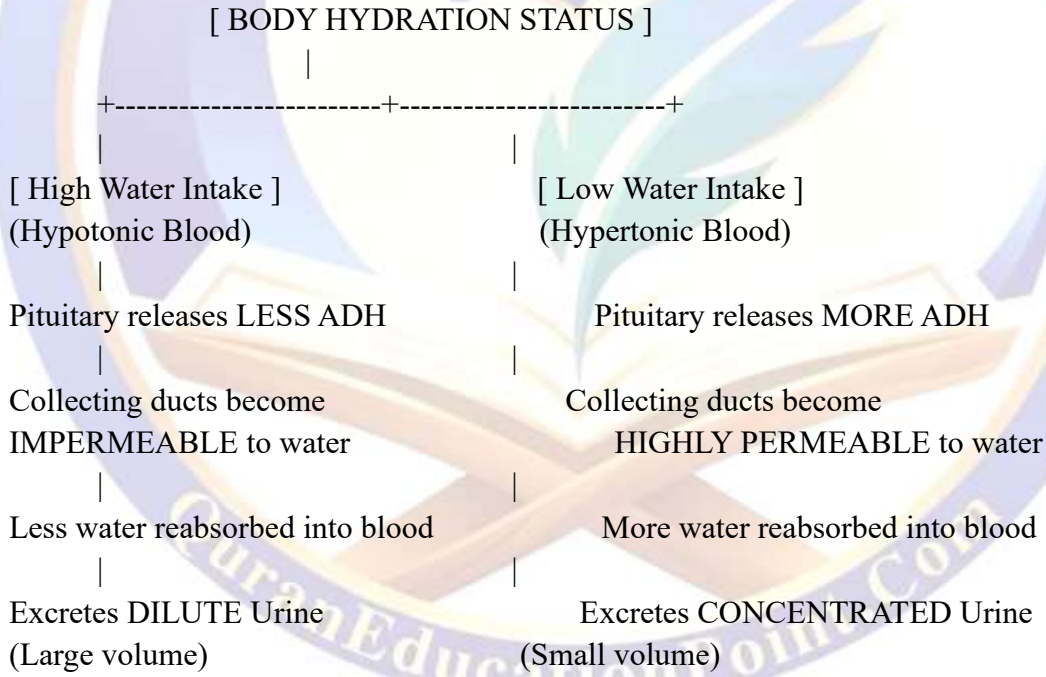
- **Site:** Proximal and Distal Convoluted Tubules.
- **Mechanism:** Epithelial cells of tubules actively transport metabolic wastes directly from peritubular capillaries into the tubular lumen:
  - Secretes H^+, K^+, NH_4^+, creatinine, and drug metabolites.
- **Function:** Maintains normal blood pH ($\approx 7.35 - 7.45$) and electrolyte balance.

Q5. Describe the osmoregulatory function of kidney.

Introduction

Osmoregulation is the maintenance of optimal balance of water and solute (salt) concentrations in body fluids. The kidney regulates urine concentration based on the hydration status of the body.

Mechanisms of Osmoregulation



Detailed Regulatory Pathways

1. When Water is in Excess (Overhydration)

- Blood plasma osmotic pressure decreases (blood becomes hypotonic).
- Osmoreceptors in the hypothalamus detect high fluid volume and signal the posterior pituitary gland to **inhibit ADH release**.
- Tubule walls (DCT and collecting ducts) remain **impermeable to water**.
- Less water is reabsorbed back into the blood.

- **Result:** Large volume of **dilute (hypotonic) urine** is produced.

2. When Water is Scarce (Dehydration / Sweating)

- Blood plasma osmotic pressure increases (blood becomes hypertonic).
- Hypothalamus stimulates posterior pituitary gland to **secrete ADH (Vasopressin)** into the blood.
- ADH increases the **permeability of DCT and collecting ducts** to water by inserting aquaporin channels.
- Large amounts of water are reabsorbed back into the peritubular capillaries.
- **Result:** Small volume of **concentrated (hypertonic) urine** is excreted.

Q6. Discuss the kidney stones and its treatment.

1. Definition

Kidney stones (**Renal Calculi**) are insoluble hard crystalline mineral and salt deposits that form inside the renal pelvis or calyces when solutes precipitate out of urine.

2. Causes & Risk Factors

- **Hypercalcemia & Hyperoxaluria:** Excess levels of calcium or oxalate in blood/urine.
- **Dehydration:** Inadequate fluid consumption leads to concentrated urine.
- **Dietary Factors:** Excessive consumption of animal protein, sodium, alcohol, or oxalate-rich foods (spinach, tomatoes).
- **Infections:** Recurrent urinary tract infections (UTIs).

3. Symptoms

- Severe, sharp back/flank pain below the ribs (renal colic) radiating to the lower abdomen and groin.
- Painful or burning urination (dysuria).
- Blood in urine (hematuria).
- Nausea, vomiting, fever, and chills (if infected).

4. Treatments

A. Non-Surgical Treatments

- **High Fluid Intake:** Drinking 3 to 4 liters of water daily helps flush out small stones (< 5 mm).
- **Medications:** Painkillers (analgesics) and alpha-blockers to relax ureter muscles.

B. Lithotripsy (Extracorporeal Shock Wave Lithotripsy - ESWL)

- High-energy **ultrasonic/sound waves** or shock waves are focused from outside the body directly onto the kidney stone.
- The shock waves break the stone into tiny sand-like particles.
- The fragments pass out naturally through the body via urine.

C. Surgical Treatments

- **Percutaneous Nephrolithotomy (PCNL):** A small incision in the back to insert a scope and break/remove large stones.

- **Ureteroscopy:** A thin scope passed through the urethra and bladder into the ureter to remove stuck stones.
- **Open Surgery:** Performed rarely for very large, complex stones.

Q7. Describe the following two types of Dialysis: a. Haemodialysis b. Peritoneal Dialysis

Introduction

Dialysis is an artificial technique used to remove waste products and excess fluids from the blood when the kidneys can no longer perform their function (kidney failure).

a. Haemodialysis

- **Mechanism:** Blood is pumped outside the body through an artificial machine containing a **dialyzer** ("artificial kidney").
- **Procedure:**
    1. Blood is taken from an arterial access (AV fistula/graft) in the patient's arm.
    2. Blood flows through long, thin semi-permeable cellophane tubes submerged inside **dialysis fluid (dialysate)**.
    3. Dialysate contains optimal concentrations of glucose, water, and essential salts, but **no urea/uric acid**.
    4. Wastes (urea, creatinine, excess salts) move out of the blood into dialysate by **diffusion**.
    5. Cleansed blood is warmed, monitored, and returned to the body through a vein.
- **Frequency:** Performed at a dialysis center 3 times a week, taking 3–5 hours per session.

b. Peritoneal Dialysis

- **Mechanism:** Uses the patient's own **peritoneum** (abdominal lining) as a natural semi-permeable membrane.
- **Procedure:**
    1. A soft plastic tube (catheter) is surgically implanted into the lower abdominal cavity (peritoneal cavity).
    2. **Dialysis fluid** is infused through the catheter into the peritoneal cavity.
    3. Wastes and excess fluid diffuse across blood vessels lining the peritoneum into the dialysis fluid.
    4. After a dwell time of a few hours, the fluid is drained out and replaced with fresh dialysate.
- **Frequency:** Can be performed at home daily (either manually 3–4 times daily or automatically overnight using a cycler).

Q8. Outline the causes of kidney failure and its treatment.

1. Causes of Kidney Failure

Kidney failure (End-Stage Renal Failure) occurs due to the progressive decline or sudden shutdown of renal function:

- **Diabetes Mellitus:** Diabetic nephropathy damages glomeruli due to chronic high blood sugar.

- **Hypertension (High Blood Pressure):** Uncontrolled high pressure damages small renal blood vessels.
- **Glomerulonephritis:** Inflammation of glomeruli caused by autoimmune reactions or bacterial infections.
- **Long-term Drug Toxicity:** Chronic overuse of non-steroidal anti-inflammatory drugs (NSAIDs) or certain antibiotics.
- **Polycystic Kidney Disease (PKD):** Genetic disorder causing fluid-filled cysts to replace kidney tissue.
- **Urinary Tract Obstructions:** Prolonged blockage by large kidney stones or enlarged prostate.

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2. Treatments for Kidney Failure

Option A: Dialysis (Artificial Support)

- **Hemodialysis:** Removes wastes artificially via blood filtration through a dialyzer machine 3 times per week.
- **Peritoneal Dialysis:** Removes wastes using peritoneal cavity fluid exchange daily.
- *Note:* Dialysis acts as a temporary management system but does not cure kidney disease completely.

Option B: Kidney Transplantation (Permanent Solution)

- **Definition:** Surgical replacement of a failed kidney with a healthy, functioning kidney from a living or deceased donor.
- **Matching:** Donor and recipient blood groups and Tissue (HLA) matching must be compatible to minimize rejection risk.
- **Procedure:** The donor kidney is grafted into the lower abdomen, connecting the renal artery and vein to the recipient's iliac blood vessels, and the donor ureter to the bladder.
- **Post-Operative Care:** Recipient must take lifelong **immunosuppressive drugs** to prevent immune rejection of the foreign organ.

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