

NCERT Exemplar Solutions of Class 11 Biology – Chapter 19: Excretory Products and their Elimination

LONG ANSWER TYPE QUESTIONS

1. Explain the mechanism of formation of concentrated urine in mammals.

Solution: Enhanced Explanation: The formation of concentrated urine involves the counter current mechanism in Henle's loop and vasa recta.

Detailed Mechanism:

Step 1: Henle's Loop – Counter current Multiplier

- **Descending limb:**
 - Permeable to water, impermeable to salts
 - Water moves out due to hypertonic medullary interstitium
 - Filtrate becomes progressively concentrated (300→1200 mOsm/L)
- **Ascending limb:**
 - Impermeable to water, actively transports NaCl out
 - Creates dilute filtrate (1200→100 mOsm/L)
 - Establishes osmotic gradient in medulla

Step 2: Vasa Recta - Countercurrent Exchanger

- **Descending vasa recta:** Blood becomes concentrated as it flows down
- **Ascending vasa recta:** Blood becomes diluted as it flows up
- **Net effect:** Maintains medullary gradient without washing it away

Step 3: Collecting Duct

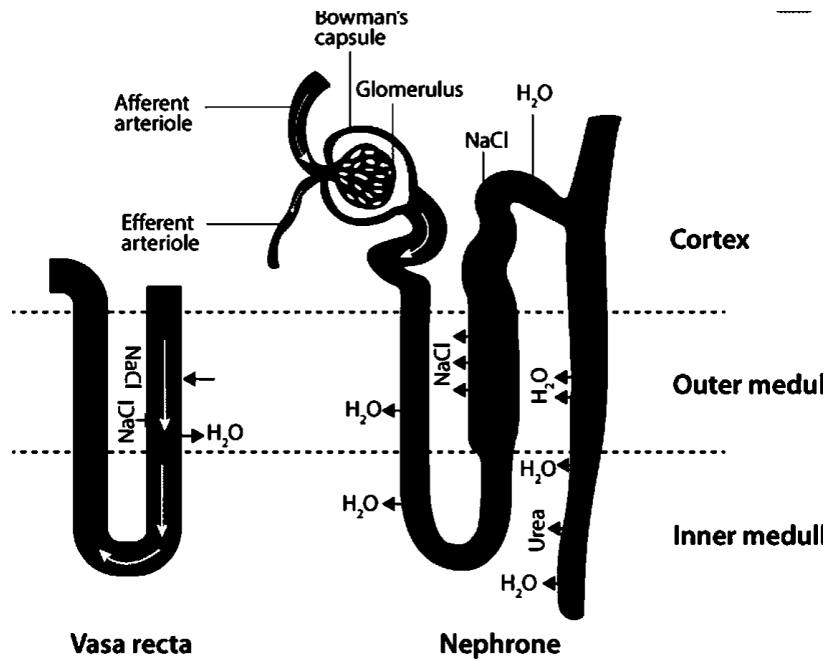
- **ADH presence:** High water permeability, water reabsorption
- **ADH absence:** Low water permeability, dilute urine
- **Urea recycling:** Urea contributes to medullary hypertonicity

Final Result: Urine can be concentrated up to 1200-1400 mOsm/L (4-5 times plasma concentration)

2. Draw a labelled diagram showing reabsorption and secretion of major substances at different parts of the nephron.

Solution: [The diagram showing the nephron with various substances being reabsorbed and secreted at different locations]

Enhanced Explanation:



Proximal Convoluted Tubule (PCT):

- **Reabsorption:** 65% water, 100% glucose, 100% amino acids, 70% NaCl, most HCO_3^-
- **Secretion:** H^+ , organic acids, drugs, toxins

Descending Limb of Henle:

- **Reabsorption:** Water only (permeable to water)
- **Secretion:** None

Ascending Limb of Henle:

- **Reabsorption:** 25% NaCl (active transport), impermeable to water
- **Secretion:** None

Distal Convoluted Tubule (DCT):

- **Reabsorption:** NaCl (5-10%), Ca^{2+} (PTH regulated)
- **Secretion:** K^+ , H^+ (aldosterone regulated)

Collecting Duct:

- **Reabsorption:** Water (ADH regulated), Na^+ (aldosterone regulated)
- **Secretion:** K^+ , H^+ , NH_3

3. Explain briefly, micturition and disorders of the excretory system.

Solution: Enhanced Explanation:

MICTURITION (Urination Process):

Neural Control:

1. **Filling phase:** Urine accumulates in bladder (up to 400-500 mL)
2. **Stretch receptors activated:** Detect bladder wall distension
3. **Afferent signals:** Sent to spinal cord and brain
4. **Micturition reflex:**

- Parasympathetic stimulation → Detrusor muscle contraction
- Somatic inhibition → Internal urethral sphincter relaxation
- Voluntary control → External urethral sphincter relaxation

Process: Coordinated contraction of bladder wall with relaxation of sphincters

DISORDERS OF EXCRETORY SYSTEM:

1. Glomerulonephritis

- **Definition:** Inflammation of glomeruli
- **Causes:** Infections (streptococcal), autoimmune diseases
- **Symptoms:** Hematuria, proteinuria, hypertension, edema
- **Treatment:** Anti-inflammatory drugs, immunosuppressants

2. Uremia

- **Definition:** Accumulation of urea and toxins in blood
- **Causes:** Kidney failure, severe dehydration
- **Symptoms:** Nausea, confusion, fatigue, uremic frost
- **Treatment:** Dialysis, kidney transplantation

3. Renal Calculi (Kidney Stones)

- **Definition:** Crystalline deposits in kidney/urinary tract
- **Composition:** Calcium oxalate (80%), uric acid, struvite
- **Symptoms:** Severe pain, hematuria, nausea
- **Treatment:** Hydration, lithotripsy, surgical removal

4. Additional Disorders:

- **Polycystic kidney disease:** Genetic disorder with cyst formation
- **Nephrotic syndrome:** Massive proteinuria and hypoalbuminemia
- **Acute tubular necrosis:** Kidney damage from toxins or ischemia

4. How does tubular secretion help in maintaining ionic and acid-base balance in body fluids?

Solution: Enhanced Explanation: Tubular secretion is crucial for maintaining homeostasis through active transport of substances from blood to urine.

IONIC BALANCE REGULATION:

Sodium Balance:

- **DCT and Collecting Duct:** Aldosterone-regulated Na^+ reabsorption
- **Fine-tuning:** Adjusts Na^+ excretion based on body needs
- **Clinical significance:** Maintains blood pressure and fluid volume

Potassium Balance:

- **Principal cells:** K^+ secretion in DCT and collecting duct
- **Aldosterone effect:** Increases K^+ secretion when Na^+ is retained
- **Dietary adjustment:** High K^+ diet → increased secretion

Calcium and Phosphate:

- **DCT:** PTH-regulated Ca^{2+} reabsorption
- **Phosphate excretion:** Maintains Ca^{2+} - PO_4^{3-} balance

ACID-BASE BALANCE REGULATION:

Hydrogen Ion Secretion:

- **PCT:** H^+ secretion coupled with HCO_3^- reabsorption
- **DCT and Collecting Duct:** Fine-tuning of H^+ secretion
- **Buffer systems:** Phosphate and ammonia buffer systems

Bicarbonate Handling:

- **Reabsorption:** 99.9% of filtered HCO_3^- reabsorbed
- **Generation:** New HCO_3^- produced during H^+ secretion

Ammonia Production:

- **PCT cells:** Glutamine \rightarrow $2NH_3$ + glucose
- **NH_3/NH_4^+ buffer system:** Major urinary buffer (pH 4.5-8.0)

Clinical Importance:

- **Respiratory acidosis:** Increased H^+ secretion, HCO_3^- retention
- **Metabolic alkalosis:** Decreased H^+ secretion, increased HCO_3^- excretion

5. The glomerular filtrate in the loop of Henle gets concentrated in the descending and then gets diluted in the ascending limbs. Explain.

Solution: Enhanced Explanation: The concentration changes in Henle's loop are due to differential permeability and active transport mechanisms.

DESCENDING LIMB - CONCENTRATION:

Permeability characteristics:

- **Water permeable:** Contains aquaporin-1 water channels
- **Salt impermeable:** No significant NaCl transport
- **Urea permeable:** Allows urea equilibration

Concentration mechanism:

- **Initial filtrate:** 300 mOsm/L (isotonic with plasma)
- **Progressive concentration:** As it descends through hypertonic medulla
- **Maximum concentration:** 1200 mOsm/L at the bend
- **Driving force:** Osmotic gradient created by ascending limb

ASCENDING LIMB - DILUTION:

Permeability characteristics:

- **Water impermeable:** Lacks aquaporin channels
- **Active NaCl transport:** $Na^+ - K^+ - 2Cl^-$ co-transporters in thick ascending limb
- **Passive transport:** Thin ascending limb (NaCl diffusion)

Dilution mechanism:

- **Salt removal:** Active transport of NaCl into interstitium
- **Water retention:** Cannot follow due to impermeability
- **Progressive dilution:** 1200 \rightarrow 100 mOsm/L
- **Hypotonic filtrate:** Enters DCT at \sim 100 mOsm/L

FUNCTIONAL SIGNIFICANCE:

- **Energy requirement:** ATP needed for active transport in ascending limb

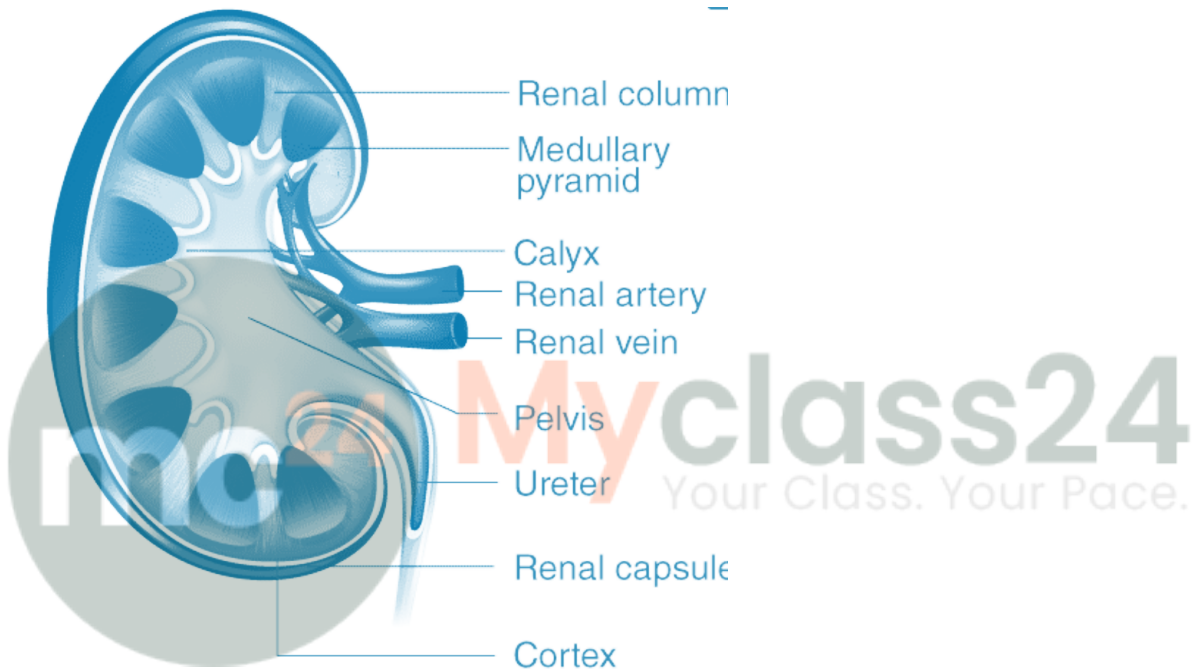
- **Gradient establishment:** Creates the medullary hypertonicity
- **Urine concentration:** Enables variable urine concentration based on body needs
- **Evolutionary advantage:** Water conservation in terrestrial mammals

CLINICAL CORRELATIONS:

- **Loop diuretics:** Block $\text{Na}^+ - \text{K}^+ - 2\text{Cl}^-$ transporters \rightarrow increased urine output
- **Diabetes insipidus:** Normal loop function but impaired water reabsorption in collecting duct
- **Chronic kidney disease:** Impaired concentrating ability due to nephron loss

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

Solution: [The diagram of human kidney structure with labeled parts]



Enhanced Explanation:

EXTERNAL ANATOMY:

- **Shape:** Bean-shaped organs, ~12 cm length
- **Location:** Retroperitoneal, between T12-L3 vertebrae
- **Coverings:**
 - Renal capsule (innermost)
 - Adipose capsule (middle)
 - Renal fascia (outermost)

INTERNAL STRUCTURE:

Cortex:

- **Location:** Outer region
- **Color:** Reddish-brown (rich blood supply)
- **Contents:** Renal corpuscles, PCT, DCT
- **Renal columns:** Cortical extensions between pyramids

Medulla:

- **Structure:** 8-12 conical medullary pyramids
- **Contents:** Henle's loops, collecting ducts, vasa recta
- **Renal papilla:** Apex of pyramid projecting into calyx

Renal Pelvis and Calyces:

- **Minor calyces:** Cup-shaped structures receiving urine from papillae
- **Major calyces:** Formed by fusion of minor calyces
- **Renal pelvis:** Funnel-shaped space formed by major calyces
- **Function:** Collect and channel urine to ureter

BLOOD SUPPLY:

- **Renal artery:** Branches from abdominal aorta
- **Segmental arteries:** 5 branches within kidney
- **Interlobar arteries:** Between pyramids
- **Arcuate arteries:** At cortico-medullary junction
- **Interlobular arteries:** Into cortex
- **Afferent arterioles:** To glomeruli

NEPHRON DISTRIBUTION:

- **Cortical nephrons:** 85% of nephrons, short Henle's loops
- **Juxtamedullary nephrons:** 15% of nephrons, long Henle's loops extending deep into medulla
- **Function:** Juxtamedullary nephrons crucial for urine concentration

CLINICAL ANATOMY:

- **Hilum:** Entry/exit point for vessels, ureter, nerves
- **Renal sinus:** Space containing pelvis, calyces, vessels
- **Kidney stones:** Can lodge in renal pelvis or ureter
- **Hydronephrosis:** Dilation due to urine retention