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Excretory Products and their Elimination Class 11 Notes | CBSE Biology Chapter 16

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Excretory Products and their Elimination Class 11 Notes | CBSE Biology Chapter 16

Excretory Products and their Elimination is Chapter 16 of CBSE Class 11 Biology — and one of the highest-yield chapters for NEET. It explains *how* your body removes nitrogenous wastes like ammonia, urea, and uric acid, and how the kidney — a master filter — keeps the chemistry of your blood perfectly balanced. Understand the nephron well and a whole block of physiology questions becomes easy marks.

By the end of these notes you will be able to compare ammonotelism, ureotelism, and uricotelism, label every part of the human excretory system and a nephron, trace urine formation step by step, explain the counter-current mechanism, and describe how ADH, RAAS, and ANF regulate kidney function. This is a high-weightage chapter — roughly 5–6 marks in boards and 2–3 NEET questions every year — and the foundation for understanding homeostasis.

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Key Concepts

1. Excretion and Why It Matters

Excretion is the process of removing harmful metabolic wastes — especially nitrogenous wastes — from the body. The breakdown of proteins and nucleic acids releases ammonia, which is highly toxic and must be removed or converted into a less harmful form.

Different animals excrete nitrogen in different chemical forms depending on how much water they can afford to lose. This single idea explains the three modes of excretion below.

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2. Modes of Excretion — Ammonotelism, Ureotelism, Uricotelism

The nitrogenous waste an animal produces depends mainly on its **habitat and water availability**.

Mode	Waste Excreted	Toxicity / Water Need	Examples
Ammonotelism	Ammonia (NH_3)	Most toxic; needs lots of water	Bony fishes, aquatic amphibians, aquatic insects
Ureotelism	Urea	Less toxic; moderate water	Mammals, terrestrial amphibians, marine fishes
Uricotelism	Uric acid	Least toxic; very little water lost	Reptiles, birds, insects, land snails

Key idea: Ammonia → urea → uric acid moves from most toxic / most water needed to least toxic / least water needed. Land animals that must save water excrete uric acid as a near-solid paste.

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3. Excretory Organs in Animals (Overview)

Before the kidney, simpler animals use simpler structures to remove wastes.

- **Protonephridia (flame cells):** Platyhelminthes (flatworms), rotifers — mainly osmoregulation.
- **Nephridia:** earthworms and other annelids — remove wastes and regulate fluid balance.
- **Malpighian tubules:** insects like cockroaches — remove nitrogenous wastes (uric acid).
- **Antennal (green) glands:** crustaceans like prawns.
- **Kidneys:** all vertebrates, including humans.

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4. Human Excretory System

The human excretory system consists of **one pair of kidneys, one pair of ureters, a urinary bladder, and a urethra**.

[DIAGRAM: Human excretory system — two bean-shaped kidneys, ureters carrying urine down to the urinary bladder, urethra opening out; renal artery and renal vein attached at the hilum.]

- **Kidneys** are reddish-brown, bean-shaped, located in the abdomen on either side of the vertebral column near the last two ribs.
- Each kidney has an outer **cortex** and inner **medulla**. The medulla is divided into conical **medullary pyramids** projecting into the **calyces**.
- The notch on the inner side is the **hilum**, through which the ureter, blood vessels, and nerves pass.
- Inner to the hilum is a funnel-shaped space, the **renal pelvis**, with projections called **calyces**.
- Each kidney has nearly **one million nephrons**, the structural and functional units.

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5. Structure of a Nephron

The **nephron** is the structural and functional unit of the kidney. Each nephron has two main parts — the **glomerulus** and the **renal tubule**.

[DIAGRAM: A nephron — Bowman's capsule enclosing the glomerulus (Malpighian body), leading to PCT, then the U-shaped loop of Henle (descending and ascending limbs), then DCT, opening into the collecting duct.]

- **Glomerulus:** a tuft of capillaries formed by the **afferent arteriole**; blood leaves through the **efferent arteriole**.
- **Bowman's capsule:** a double-walled cup enclosing the glomerulus. Together they form the **Malpighian body** or renal corpuscle.
- **Proximal Convoluted Tubule (PCT):** highly coiled, lined with brush-border (microvilli) for reabsorption.
- **Loop of Henle:** a U-shaped loop with a descending and an ascending limb, dipping into the medulla.
- **Distal Convoluted Tubule (DCT):** coiled tubule opening into the collecting duct.
- **Collecting Duct:** long ducts carrying urine through the medulla to the renal pelvis.

Two Types of Nephrons

- **Cortical nephrons:** majority; loop of Henle is short and barely enters the medulla.
- **Juxtamedullary nephrons:** fewer; loop of Henle is very long, running deep into the medulla — essential for concentrating urine.

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6. Urine Formation — Three Steps

Urine is formed in three sequential steps: **glomerular filtration, reabsorption, and secretion**.

(a) Glomerular Filtration

Blood is filtered under high pressure in the glomerulus across three layers (endothelium of capillaries, basement membrane, and the slit pores of podocytes). This is called **ultrafiltration** because everything except blood cells and proteins passes into the Bowman's capsule.

- The amount of filtrate formed by both kidneys per minute is the **Glomerular Filtration Rate (GFR) ≈ 125 mL/min** (about 180 litres/day).
- GFR is regulated by the **Juxtaglomerular Apparatus (JGA)**.

(b) Reabsorption

Nearly **99% of the filtrate is reabsorbed** back into the blood, so only about 1.5 litres of urine is released daily. Glucose, amino acids, and most water and ions are reabsorbed — mainly in the PCT.

(c) Secretion

Tubular cells **secrete** substances like H^+, K^+, and ammonia into the filtrate to maintain the ionic and acid-base balance of body fluids.

7. Function of the Tubules

Each part of the renal tubule has a specific role in fine-tuning the filtrate.

Region	Main Function
PCT	Reabsorbs ~70–80% of electrolytes and water; reabsorbs all glucose and amino acids; maintains pH by secreting H^+ and absorbing HCO_3^-
Descending limb of Henle	Permeable to water, impermeable to salts; filtrate becomes concentrated
Ascending limb of Henle	Impermeable to water, permeable to salts (NaCl); filtrate becomes dilute
DCT	Conditional reabsorption of Na^+ and water; secretes H^+, K^+, NH_3 to maintain pH and ionic balance
Collecting duct	Reabsorbs water (under ADH); concentrates urine; can reabsorb urea

8. Mechanism of Concentration of Filtrate — Counter-Current Mechanism

The kidney can make urine far more concentrated than blood. This depends on the **counter-current mechanism** set up by the loop of Henle and the **vasa recta** (the capillaries running parallel to the loop).

- The flow of filtrate in the two limbs of the loop is in **opposite directions**, forming a counter-current. Blood in the vasa recta also flows in a counter-current.
- NaCl and urea are exchanged so that an increasing **osmolarity gradient** is built up from the cortex (~300 mOsmol/L) towards the inner medulla (~1200 mOsmol/L).
- This gradient lets the collecting duct draw out water, producing concentrated (hypertonic) urine.

Key idea: The loop of Henle and vasa recta act as a counter-current multiplier and exchanger, maintaining the medullary gradient that makes water conservation possible.

9. Regulation of Kidney Function

Kidney activity is controlled by hormonal feedback through three main mechanisms.

(a) ADH (Vasopressin)

When body fluids become concentrated, osmoreceptors trigger release of **ADH** from the posterior pituitary. ADH increases water reabsorption from the DCT and collecting duct, reducing urine volume. (ADH also causes vasoconstriction, raising blood pressure.)

(b) Renin-Angiotensin-Aldosterone System (RAAS)

A fall in blood pressure / volume is sensed by the JGA, which releases **renin**. Renin converts angiotensinogen to angiotensin I, then angiotensin II. Angiotensin II raises blood pressure and GFR, and stimulates the adrenal cortex to release **aldosterone**, which increases Na^+ and water reabsorption in the DCT.

(c) ANF (Atrial Natriuretic Factor)

When blood pressure rises, the atrial wall of the heart releases **ANF**, which causes vasodilation and reduces blood pressure. ANF acts as a check on the RAAS.

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10. Micturition

The release of urine from the urinary bladder is called **micturition**, and the nervous mechanism controlling it is the **micturition reflex**.

- Urine collects in the bladder; stretch receptors send signals to the CNS when it is full.
- The CNS triggers contraction of the bladder's smooth muscle and relaxation of the urethral sphincter, releasing urine.
- An adult human excretes about **1 to 1.5 litres of urine** per day; normal urine is light yellow (due to urochrome) and slightly acidic (pH ≈ 6).

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11. Role of Other Organs in Excretion

The kidneys are the chief excretory organs, but other organs help.

Organ	Substances Removed
Lungs	CO_2 and water vapour
Liver	Bile pigments (bilirubin, biliverdin), cholesterol, drugs, vitamins, degraded steroid hormones
Skin (sweat & sebaceous glands)	Sweat: NaCl, water, urea, lactic acid; Sebum: waxes, fatty acids, sterols

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12. Disorders of the Excretory System

Failure of kidney function leads to several disorders that are frequently tested.

- **Uremia:** accumulation of urea in the blood due to malfunctioning kidneys; highly harmful. Treated by **haemodialysis**.
- **Renal failure:** kidneys stop filtering blood, causing waste build-up.
- **Kidney stones (renal calculi):** insoluble crystals of calcium oxalate and other salts forming stony masses in the kidney.

- **Glomerulonephritis:** inflammation of the glomeruli of the kidney.

Haemodialysis and the Artificial Kidney

In dialysis, blood drained from an artery is cooled, mixed with anticoagulant (heparin), and passed through a coiled cellophane tube bathed in **dialysing fluid** that has the same composition as plasma but no nitrogenous wastes. Wastes diffuse out, the cleaned blood is given back through a vein after adding anti-heparin. A permanent cure is **kidney transplantation** from a matching donor.

Weightage in Board & Entrance Exams

Exam	Typical Weightage	Most-Tested Areas
CBSE Board (Class 11)	5–6 marks	Nephron structure, urine formation, modes of excretion, ADH/RAAS
NEET	2–3 questions	Counter-current mechanism, tubular function, regulation, disorders
Other Medical Entrances	1–2 questions	Ammonotelism vs ureotelism vs uricotelism, JGA, dialysis

[TABLE: Question-type split — VSA (1 mark): definitions, modes of excretion; SA (2–3 marks): nephron parts, urine formation steps, hormone roles; LA (5 marks): labelled nephron diagram, counter-current mechanism, regulation of kidney function.]

Important Definitions

Term	Definition
Excretion	Removal of toxic nitrogenous metabolic wastes from the body
Ammonotelism	Excretion of nitrogenous waste as ammonia (e.g., bony fishes)
Ureotelism	Excretion of nitrogenous waste as urea (e.g., mammals)
Uricotelism	Excretion of nitrogenous waste as uric acid (e.g., birds, reptiles, insects)
Nephron	The structural and functional unit of the kidney
Glomerular filtration (ultrafiltration)	Pressure filtration of blood in the glomerulus into Bowman's capsule
GFR	Glomerular filtration rate, ≈125 mL/min in a healthy person
Counter-current mechanism	Opposite flow in the loop of Henle and vasa recta that builds the medullary osmotic gradient
Micturition	The act of releasing urine from the urinary bladder
Uremia	Accumulation of urea in the blood due to kidney malfunction

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Solved Examples

Example 1

Why do aquatic animals like bony fishes excrete ammonia rather than urea?

Answer: Ammonia is highly soluble and easily diffuses out across gill surfaces into the surrounding water. Since these animals live in water, they can afford the large water loss needed to flush out toxic ammonia, so they are **ammonotelic**.

Example 2

If the GFR is 125 mL/min, calculate the approximate volume of filtrate formed by both kidneys in a day.

Answer: Volume per day = 125 × 60 × 24 = 180,000 mL = **180 litres/day**. Of this, about 99% is reabsorbed, so only ~1.5 litres is excreted as urine.

Example 3

A person's urine tests positive for glucose. Where in the nephron has reabsorption failed, and what is the condition called?

Answer: Normally all glucose is reabsorbed in the **PCT**. Glucose in urine (**glycosuria**) indicates the filtered glucose has exceeded the reabsorptive capacity, as in diabetes mellitus.

Example 4

Name the hormone that increases facultative reabsorption of water and the part of the nephron it acts on.

Answer: ADH (vasopressin) increases water reabsorption, acting mainly on the **DCT and collecting duct**, producing concentrated urine.

Example 5

Which part of the loop of Henle is permeable to water but not to salts, and why is this important?

Answer: The **descending limb** is permeable to water but impermeable to salts. Water moves out, concentrating the filtrate — a key step in building the medullary concentration gradient.

Example 6

A patient with kidney failure shows high urea in blood. Name the condition and the treatment used to remove the waste.

Answer: The condition is **uremia**. It is treated by **haemodialysis** using an artificial kidney; a permanent cure is kidney transplantation.

Important Questions for Board Exams

1-Mark Questions (VSA)

1. Define the term excretion.
2. Name the nitrogenous waste excreted by birds and reptiles.
3. What is the structural and functional unit of the kidney?
4. What is the normal GFR value in a healthy person?
5. Name the hormone secreted by the JGA cells when blood pressure falls.

2–3-Mark Questions (SA)

1. Differentiate between ammonotelism, ureotelism, and uricotelism with examples.
2. Describe the three steps involved in the formation of urine.
3. Explain the role of ADH in the regulation of kidney function.
4. What is the counter-current mechanism? Name the structures involved.

5-Mark Questions (LA)

1. Draw a labelled diagram of a nephron and describe the structure of its different parts.
2. Explain the mechanism of concentration of the filtrate, highlighting the role of the loop of Henle and vasa recta.
3. Describe how the kidney function is regulated by ADH, the RAAS, and ANF.

Quick Revision Points

- Excretion removes nitrogenous wastes; toxicity order: ammonia > urea > uric acid
- Ammonotelic (fishes) → ureotelic (mammals) → uricotelic (birds, reptiles, insects)
- Human excretory system: 2 kidneys, 2 ureters, 1 bladder, 1 urethra
- Each kidney has ~1 million nephrons; cortex + medulla (pyramids, calyces, pelvis)
- Nephron: glomerulus + Bowman's capsule (Malpighian body) → PCT → loop of Henle → DCT → collecting duct
- Urine formation: glomerular filtration (ultrafiltration) → reabsorption (~99%) → secretion
- GFR ≈ 125 mL/min (~180 L/day); regulated by JGA
- Counter-current mechanism: loop of Henle + vasa recta build medullary gradient (300 → 1200 mOsmol/L)
- Regulation: ADH (water reabsorption), RAAS (renin → angiotensin II → aldosterone), ANF (lowers BP)
- Micturition: reflex release of ~1–1.5 L urine/day; pH ≈ 6, yellow due to urochrome
- Other organs: lungs (CO_2), liver (bile pigments), skin (sweat, sebum)
- Disorders: uremia, renal failure, kidney stones, glomerulonephritis; treated by dialysis / transplant

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Next Chapter: Chapter 17 — Breathing and Exchange of Gases