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CUET · BIOLOGY · CLASS XI · CODE 304

Excretory Products and their Elimination

CUET unit: Human Physiology → Excretory Products and their Elimination

By **UniDrill** · NCERT-grounded study material

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📌 Snapshot

- Establishes the three modes of nitrogenous excretion — ammonotelism, ureotelism and uricotelism — and links them to habitat and water economy.
- Builds a complete picture of the human urinary system from gross anatomy (kidney, ureter, bladder, urethra) down to the nephron and its blood supply (glomerulus, peritubular capillaries, vasa recta).
- Explains urine formation as a three-step process: glomerular filtration, tubular reabsorption and tubular secretion, with quantitative anchors (1100–1200 mL/min filtered, GFR 125 mL/min, 99% reabsorbed).
- Develops the counter-current mechanism (Henle's loop + vasa recta) that builds a 300 → 1200 mOsmol L^{-1} medullary gradient, allowing urine four times more concentrated than the initial filtrate.
- Covers hormonal regulation (ADH, Renin-Angiotensin, ANF, JGA), micturition reflex, accessory excretory organs (lungs, liver, skin) and clinical disorders (uraemia, dialysis, renal calculi, glomerulonephritis, transplantation).

📖 Detailed Notes

2.1 Core concepts

- Animals accumulate ammonia, urea, uric acid, CO_2, water and ions (Na^+, K^+, Cl^-, phosphate, sulphate) from metabolism or excess ingestion; these must be removed partially or totally (NCERT Ch. 16 intro, p. 205).
- Ammonia is the most toxic nitrogenous waste and needs large amounts of water to eliminate; uric acid is least toxic and can be excreted with minimal water loss (NCERT §intro, p. 205).
- **Ammonotelism** — excretion of ammonia by diffusion across body/gill surfaces as ammonium ions; seen in many bony fishes, aquatic amphibians and aquatic insects; kidneys play no significant role (NCERT §intro, p. 205).
- **Ureotelism** — ammonia is converted to urea in the liver and excreted by kidneys; seen in mammals, many terrestrial amphibians and marine fishes; some urea may be retained in kidney matrix for osmolarity (NCERT §intro, p. 205).
- **Uricotelism** — excretion of uric acid as pellet/paste; seen in reptiles, birds, land snails and insects, with minimum water loss (NCERT §intro, p. 205).

- Invertebrate/lower-chordate excretory structures: **Protonephridia (flame cells)** in Platyhelminthes (e.g., Planaria), rotifers, some annelids and Amphioxus — chiefly osmoregulation; **Nephridia** — tubular structures in earthworms and other annelids, remove nitrogenous wastes and balance fluid/ions; **Malpighian tubules** — most insects including cockroaches, do excretion and osmoregulation; **Antennal/green glands** — crustaceans like prawns (NCERT §intro, p. 206).
- Human excretory system consists of a pair of kidneys, a pair of ureters, a urinary bladder and a urethra (NCERT §16.1, p. 206).
- Kidneys are reddish brown, bean-shaped, situated between the last thoracic and third lumbar vertebrae on the dorsal abdominal wall; each kidney is 10–12 cm long, 5–7 cm wide, 2–3 cm thick, weighing 120–170 g (NCERT §16.1, p. 206).
- The inner concave surface bears a **hilum** through which ureter, blood vessels and nerves enter; inner to the hilum is the funnel-shaped **renal pelvis** with projections called **calyces** (NCERT §16.1, p. 206).
- The kidney has an outer **cortex** and an inner **medulla**; the medulla is divided into conical **medullary pyramids** that project into the calyces, while the cortex extends between pyramids as the **Columns of Bertini** (NCERT §16.1, pp. 206–207).
- Each kidney has nearly one million **nephrons**, the functional units; each nephron has a glomerulus and a renal tubule (NCERT §16.1, p. 207).
- The glomerulus is a tuft of capillaries from the afferent arteriole (branch of renal artery); blood leaves through the efferent arteriole (NCERT §16.1, p. 207).
- The renal tubule begins with a double-walled cup, **Bowman's capsule**, enclosing the glomerulus; glomerulus + Bowman's capsule = **malpighian body / renal corpuscle**; it continues into **PCT → Henle's loop (descending + ascending limbs) → DCT → collecting duct → renal pelvis** (NCERT §16.1, pp. 207–208).
- Malpighian corpuscle, PCT and DCT lie in the cortex; the loop of Henle dips into the medulla. **Cortical nephrons** have a short loop barely entering the medulla; **juxtamedullary nephrons** have a long loop running deep into the medulla (NCERT §16.1, p. 208).
- The efferent arteriole forms **peritubular capillaries** around the tubule; a U-shaped **vasa recta** runs parallel to the loop of Henle and is absent or highly reduced in cortical nephrons (NCERT §16.1, p. 208).
- Urine formation has three main processes — **glomerular filtration, reabsorption and secretion** (NCERT §16.2, p. 208).
- ~1100–1200 mL of blood is filtered per minute (~1/5 of cardiac output per ventricle); filtration occurs through endothelium of glomerular capillaries, basement membrane, and the **podocyte** epithelium of Bowman's capsule with **filtration slits/ slit pores**; everything except plasma proteins passes through — hence **ultrafiltration** (NCERT §16.2, p. 208).

- **Glomerular Filtration Rate (GFR)** in a healthy human ≈ **125 mL/min**, i.e., 180 L/day; the **juxtaglomerular apparatus (JGA)** — at the contact of DCT and afferent arteriole — regulates GFR by releasing **renin** when GFR falls (NCERT §16.2, p. 209).
- ~99% of the 180 L/day filtrate is reabsorbed; glucose, amino acids, Na^+ are actively reabsorbed, nitrogenous wastes by passive transport, and water passively in initial segments (NCERT §16.2, p. 209).
- Tubular cells secrete H^+, K^+ and ammonia into the filtrate to maintain ionic and acid-base balance (NCERT §16.2, p. 209).
- **PCT** — simple cuboidal brush-border epithelium reabsorbs nearly all essential nutrients and 70–80% of electrolytes and water; secretes H^+, NH_3 and absorbs HCO_3^- (NCERT §16.3, p. 209).
- **Henle's loop** — descending limb is permeable to water but almost impermeable to electrolytes (filtrate gets concentrated); ascending limb is impermeable to water but transports electrolytes (filtrate gets diluted); minimum reabsorption in ascending limb; maintains the high osmolarity of medullary interstitial fluid (NCERT §16.3, p. 209).
- **DCT** — conditional reabsorption of Na^+ and water; reabsorbs HCO_3^-; secretes H^+, K^+ and NH_3 (NCERT §16.3, p. 209).
- **Collecting duct** — extends from cortex to inner medulla; reabsorbs large amounts of water to give concentrated urine; allows small amount of urea into medullary interstitium to maintain osmolarity; secretes H^+ and K^+ (NCERT §16.3, p. 210).
- **Counter-current mechanism** — the two limbs of Henle's loop, and the two limbs of vasa recta, carry fluid in opposite directions; their proximity maintains an interstitial osmolar gradient from ~**300 mOsmol L^{-1}** in the cortex to ~**1200 mOsmol L^{-1}** in the inner medulla, due mainly to **NaCl and urea**; human kidneys can produce urine nearly **four times** as concentrated as the initial filtrate (NCERT §16.4, pp. 210–212).
- Regulation involves the hypothalamus, JGA and (partly) the heart. **Osmoreceptors** detect fall in blood/body fluid volume, triggering release of **ADH (vasopressin)** from the neurohypophysis; ADH facilitates water reabsorption from later tubular segments (preventing diuresis) and also raises blood pressure by vasoconstriction (NCERT §16.5, p. 212).
- **Renin-Angiotensin mechanism** — fall in glomerular blood flow/pressure/GFR triggers JG cells to release renin; renin converts angiotensinogen → angiotensin I → angiotensin II (powerful vasoconstrictor) raising glomerular BP and GFR; angiotensin II also stimulates the adrenal cortex to release **aldosterone**, which causes Na^+ and water reabsorption at distal tubule (NCERT §16.5, p. 212).
- **Atrial Natriuretic Factor (ANF)** is released when atrial blood flow increases; it causes vasodilation, lowering BP, and thus acts as a check on the renin-angiotensin mechanism (NCERT §16.5, p. 212).

- **Micturition** — urine is stored in the urinary bladder; stretching activates stretch receptors that signal the CNS; CNS triggers bladder contraction and urethral sphincter relaxation, releasing urine. The neural process is the **micturition reflex** (NCERT §16.6, pp. 212–213).
- Adult humans excrete 1–1.5 L of urine/day; urine is light yellow, slightly acidic (pH ~6.0), with a characteristic odour; ~25–30 g of urea per day; presence of glucose (**glycosuria**) or ketone bodies (**ketonuria**) indicates diabetes mellitus (NCERT §16.6, p. 213).
- **Other excretory organs** — Lungs remove ~200 mL/min of CO_2 and significant water; Liver secretes bile-containing bilirubin, biliverdin, cholesterol, degraded steroid hormones, vitamins and drugs (mostly leave with digestive wastes); Sweat (NaCl, urea, lactic acid) is mainly for cooling but aids excretion; Sebaceous glands eliminate sterols, hydrocarbons, waxes via sebum; small amounts of nitrogenous wastes are eliminated through saliva (NCERT §16.7, p. 213).
- **Disorders** — **Uraemia**: accumulation of urea in blood; treated by **haemodialysis** through an **artificial kidney** (coiled cellophane tube in dialysing fluid of plasma-like composition without nitrogenous wastes; heparin added before, anti-heparin after). **Kidney transplantation** corrects acute renal failure — donor preferably a close relative to reduce rejection. **Renal calculi** — stones/insoluble crystallised salts (e.g., oxalates) in the kidney. **Glomerulonephritis** — inflammation of glomeruli (NCERT §16.8, pp. 213–214).

2.2 Definitions to memorise

Term	Definition	Page
Ammonotelism	Excretion of ammonia (most toxic, needs much water); bony fish, aquatic amphibians, aquatic insects	205
Ureotelism	Conversion of NH_3 → urea in liver, excretion by kidneys; mammals, terrestrial amphibians, marine fishes	205
Uricotelism	Excretion of uric acid as pellet/paste with minimum water loss; reptiles, birds, land snails, insects	205
Protonephridia	Flame-cell excretory structures in Platyhelminthes, rotifers, some annelids, Amphioxus; mainly osmoregulation	206
Malpighian tubules	Excretory structures of most insects (e.g., cockroach); excretion + osmoregulation	206
Antennal / green glands	Excretory structures of crustaceans (e.g., prawn)	206
Hilum	Notch in inner concave kidney surface where ureter, vessels, nerves enter	206
Columns of Bertini	Cortical extensions between medullary pyramids	207
Nephron	Functional unit of kidney (~1 million per kidney); glomerulus + renal tubule	207

Term	Definition	Page
Malpighian body / renal corpuscle	Glomerulus together with Bowman's capsule	207
Cortical nephron	Nephron with a short loop of Henle barely entering medulla; vasa recta reduced/absent	208
Juxtamedullary nephron	Nephron with a long loop of Henle running deep into medulla; well-developed vasa recta	208
Ultrafiltration	Fine filtration across glomerular endothelium, basement membrane and podocyte slit pores; everything but proteins passes	208
Glomerular Filtration Rate (GFR)	Volume of filtrate formed per minute by the kidneys; ~125 mL/min in a healthy adult	209
Juxtaglomerular apparatus (JGA)	Sensitive region at contact of DCT and afferent arteriole; releases renin to restore GFR	209
Counter-current mechanism	Opposite-direction flow in Henle's loop and vasa recta that maintains medullary osmolar gradient (300 → 1200 mOsmol L^{-1})	211
ADH (vasopressin)	Neurohypophyseal hormone that promotes water reabsorption in later tubules; vasoconstrictor	212
Renin-Angiotensin mechanism	JGA → renin → angiotensin I → angiotensin II → vasoconstriction + aldosterone → ↑BP, ↑GFR	212
ANF	Atrial Natriuretic Factor; vasodilator from heart atria; checks renin-angiotensin	212
Micturition	CNS-controlled voluntary release of urine via bladder contraction + sphincter relaxation	213
Glycosuria / Ketonuria	Glucose / ketone bodies in urine; indicative of diabetes mellitus	213
Uraemia	Accumulation of urea in blood due to kidney malfunction	213
Haemodialysis	Removal of urea using an artificial kidney with cellophane tube + dialysing fluid (heparin in, anti-heparin out)	213–214
Renal calculi	Insoluble mass of crystallised salts (e.g., oxalates) in kidney	214
Glomerulonephritis	Inflammation of glomeruli of kidney	214

2.3 Diagrams / processes to remember

- **Figure 16.1 (p. 206)** — Human urinary system: kidneys, renal artery/vein, ureters, urinary bladder, urethra, dorsal aorta, inferior vena cava and adrenal gland.
- **Figure 16.2 (p. 207)** — Longitudinal section of kidney: cortex, medulla, medullary pyramids, renal columns (Bertini), calyx, renal pelvis, hilum.

- **Figure 16.3 (p. 207)** — Nephron with blood supply: afferent and efferent arterioles, glomerulus, Bowman's capsule, PCT, descending and ascending limbs of loop of Henle, DCT, collecting duct, vasa recta.
- **Figure 16.4 (p. 208)** — Malpighian body / renal corpuscle (Bowman's capsule enclosing glomerulus).
- **Figure 16.5 (p. 210)** — Sites of reabsorption and secretion: HCO_3^-, NaCl, water, K^+, H^+, NH_3, nutrients, urea — across PCT, loop of Henle, DCT and collecting duct.
- **Figure 16.6 (p. 211)** — Counter-current mechanism: numerical osmolarity values (300 → 1200 mOsmol L^{-1}), NaCl and urea movements between vasa recta, Henle's loop and collecting duct.

2.4 Common confusions / NTA trap points

- **Toxicity vs water economy direction:** Ammonia > urea > uric acid in toxicity, but ammonia needs the most water and uric acid the least — students often invert one of the two scales.
- **Cortical vs juxtamedullary nephrons:** Vasa recta is well-developed in **juxtamedullary** nephrons and absent/reduced in **cortical** nephrons — NTA flips this regularly.
- **Loop of Henle permeability:** Descending limb is permeable to water (impermeable to salts); ascending limb is the opposite — confusing the limbs is a classic distractor.
- **GFR figures:** 1100–1200 mL/min is the **blood filtered**, while 125 mL/min is the **filtrate formed** (GFR) — NTA tests both numbers in the same MCQ.
- **ADH effect:** ADH causes water **reabsorption** (producing concentrated/hypertonic urine), it does **not** promote water elimination or hypotonic urine — Exercise Q3(b) tests this trap directly.
- **Renin vs renal calculi vs glomerulonephritis** — three different "renal" words; renin is a JGA enzyme, calculi are stones, glomerulonephritis is glomerular inflammation.
- **PCT vs DCT** — PCT reabsorbs ~70–80% of electrolytes & water (obligate); DCT performs conditional water reabsorption under ADH and aldosterone control.
- **Micturition reflex** — initiated by stretch receptors in the bladder wall when filled with ~300 mL urine; controlled by the CNS via pelvic nerves (NCERT §16.5, p. 305).

2.5 Quick comparison table — excretion at a glance

#	Item	Value / Detail	Page
1	Excretory product — humans	Urea (ureotelic)	299
2	Ureotelic animals	Mammals, marine fish, amphibians	299
3	Ammonotelic animals	Bony fish, aquatic amphibians, aquatic insects	299

#	Item	Value / Detail	Page
4	Uricotelic animals	Reptiles, birds, land snails, insects	299
5	Nephron number per kidney	~1 million	300
6	Nephron types	Cortical (85%), juxtamedullary (15%)	300
7	GFR	125 mL/min ≈ 180 L/day	302
8	Blood filtered	1100–1200 mL/min	302
9	Urine output	~1.5 L/day	304
10	Urine composition	Urea (25–30 g/day), uric acid, creatinine, Na+, K+	304
11	Descending limb	Permeable to water	303
12	Ascending limb	Impermeable to water; reabsorbs salts	303
13	ADH source / target	Posterior pituitary / DCT-collecting duct	304
14	RAAS sequence	Renin → angiotensinogen → angiotensin I → II → aldosterone	304
15	Diuresis vs dialysis	Diuresis = increased urine output; dialysis = artificial blood filtration	305

🎯 Practice MCQs

Q1. Which of the following groups of animals is correctly matched with its mode of nitrogenous excretion?

A. Bony fish — uricotelic

B. Mammals — ammonotelic

C. Reptiles and birds — uricotelic

D. Aquatic amphibians — ureotelic

Q2. The excretory structures of Platyhelminthes (e.g., *Planaria*) are:

A. Nephridia

B. Malpighian tubules

C. Protonephridia (flame cells)

D. Antennal glands

Q3. Match the items in Column I with those in Column II and select the correct option. | Column I | Column II | |---|---| | (a) Columns of Bertini | (i) Filtrate concentration | | (b) Vasa recta | (ii) Cortical extensions between pyramids | | (c) Loop of Henle | (iii) U-shaped capillary parallel to Henle's loop | | (d) Bowman's capsule | (iv) Encloses glomerulus |

A. a–ii, b–iii, c–i, d–iv

B. a–iii, b–ii, c–iv, d–i

C. a–i, b–iv, c–ii, d–iii

D. a–iv, b–i, c–iii, d–ii

📊 PYQ Alignment

This chapter is a near-certain source of 6–8 MCQs each year on the CUET (UG) Biology paper, with NTA favouring quantitative recall (GFR 125 mL/min, 1200 mOsmol L^{-1} medullary gradient, 99% reabsorption, 25–30 g urea/day), nephron-segment functions (PCT vs Henle vs DCT vs collecting duct), counter-current/vasa-recta mechanics, hormonal regulation (ADH, renin-angiotensin-aldosterone, ANF) and disorder definitions (uraemia, dialysis, renal calculi, glomerulonephritis), often as assertion-reason or "incorrect statement" questions.

Excretory Products and their Elimination appeared in CUET (UG) Biology across 1 cycle(s) — 1 question(s) total. The questions below were extracted from official CUET (UG) papers and matched to this chapter by topic. See `/pyq/biology` for the full PYQ archive.

CUET 2024 — Actual PYQs from this chapter

Q.11 (CUET 2024) Which statements are incorrect with respect to nucleotides? (A) Purines and pyrimidines are nitrogenous bases (B) Nucleotides are non-enzymatic molecules (C) Phosphate group linked to 5′ C by phosphoester bond (D) RNA has additional –OH at 2′ position (E) Thymine is a pyrimidine Options given.

- A)
- B)
- C)
- D)

Tests: aligns with chapter content Answer: Not in extracted key — verify against official NTA key