

Excretion and Homeostasis

Matthew Williams • Biology • May 9, 2026

Excretion and Homeostasis

The body constantly produces waste products from its chemical reactions. Excretion removes these before they accumulate to toxic levels. At the same time, the body maintains a stable internal environment — a process called homeostasis.

Excretion vs Egestion

These two terms are often confused:

Term	Meaning	Example
Excretion	removal of metabolic waste products produced inside the body	urea in urine, CO ₂ in exhaled air
Egestion	removal of undigested food that was never absorbed	faeces

Faeces is **not** simply an excretory product — it largely consists of undigested material. However, it does contain **bilirubin**, which is a genuine excretory product: it is formed in the liver from the breakdown of haemoglobin in old red blood cells and is excreted via bile into the gut, giving faeces their brown colour.

Metabolic Wastes and Where They Leave

Waste product	Produced by	Organ of excretion
Carbon dioxide	aerobic respiration in all cells	lungs (exhaled)
Water	aerobic respiration; various metabolic reactions	kidneys (urine), lungs, skin
Urea	deamination of excess amino acids in the liver	kidneys (urine)

Urea formation: When the body has more amino acids than it needs, the liver removes the nitrogen-containing amino group (deamination), converts it to ammonia, then combines it with CO₂ to form urea. Urea passes into the blood and is filtered by the kidneys.

Excretion in Plants

Plants also produce metabolic wastes and have their own methods of dealing with them:

Method	How it works
Leaf fall	waste products (e.g. calcium oxalate, tannins) accumulate in leaves; entire leaves shed seasonally
Loss of bark	some waste compounds stored in bark, which peels away over time
Storage	some wastes (e.g. resins, tannins) are locked in non-living heartwood or vacuoles where they cannot harm the plant

Plants also release CO₂ (from respiration) and O₂ (from photosynthesis) through stomata — gases are exchanged, not strictly stored as waste.

The Urinary System and Kidney Structure

The kidneys filter blood, regulate water balance, and excrete urea in urine.

Urine passes from kidneys → ureters → bladder → urethra (out of the body).

Each kidney has:

- **cortex** — outer region; contains glomeruli and Bowman's capsules
- **medulla** — inner region; contains loops of Henle and collecting ducts
- **pelvis** — central space where urine collects before draining into the ureter

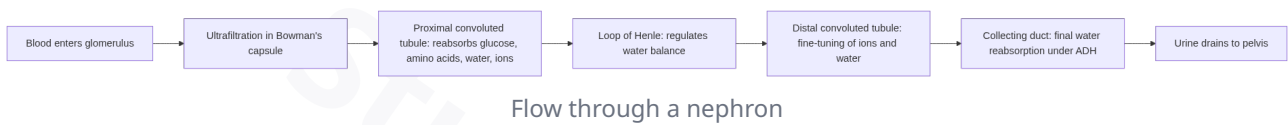
Cross-section of a kidney

- | | |
|------------------------|--------------------------------|
| 1. Renal pyramid | 9. Fibrous capsule (inferior) |
| 2. Interlobular artery | 10. Fibrous capsule (superior) |
| 3. Renal artery | 11. Interlobular vein |
| 4. Renal vein | 12. Nephron |
| 5. Renal hilum | 13. Minor calyx |
| 6. Renal pelvis | 14. Major calyx |
| 7. Ureter | 15. Renal papilla |
| 8. Minor calyx | 16. Renal column |

The Nephron

The nephron is the functional unit of the kidney. Each kidney contains about one million nephrons. The nephron filters blood and selectively recovers useful substances.

Structure of a nephron	
1. Interlobular artery	7. Efferent arteriole
2. Afferent arteriole	8. Proximal convoluted tubule
3. Juxtaglomerular apparatus	9. Loop of Henle
4. Renal corpuscle	10. Distal convoluted tubule
5. Glomerulus	11. Connecting tubule
6. Bowman's capsule	12. Interlobular vein



Ultrafiltration

Blood enters the glomerulus (a tight knot of capillaries inside the Bowman's capsule) under high pressure. Small molecules are forced out of the blood into the Bowman's capsule. Large molecules (proteins, red blood cells) are too big to pass through and stay in the blood.

What is filtered into the capsule: water, glucose, urea, mineral ions, amino acids.

Selective Reabsorption

As the filtrate travels along the nephron, useful substances are recovered back into the blood:

Substance	Reabsorbed?	How
Glucose	completely (if blood glucose is normal)	active transport in proximal tubule
Amino acids	yes	active transport in proximal tubule
Water	most of it	osmosis throughout; amount adjusted by ADH
Urea	small amount	mostly remains in urine
Mineral ions	adjusted according to body's needs	active transport

The remaining fluid is urine — mostly water, urea, and mineral salts.

Osmoregulation and ADH

Osmoregulation is the control of the water concentration of body fluids. This is critical because cells shrink or swell if the surrounding fluid concentration changes.

The hypothalamus monitors blood water concentration and controls the release of **ADH (antidiuretic hormone)** from the pituitary gland.

Blood water concentration	ADH released	Effect on kidney	Urine produced
Too low (blood too concentrated)	more ADH	collecting duct becomes more permeable to water; more water reabsorbed	small volume, concentrated urine
Too high (blood too dilute)	less ADH	collecting duct less permeable; less water reabsorbed	large volume, dilute urine

This is a **negative feedback** mechanism — the response opposes the change, returning the system toward normal.

Exam Tip

On a hot day with heavy sweating, you lose water through your skin. Blood becomes more concentrated 'more ADH released 'kidneys retain more water 'small volume of concentrated (dark) urine is produced. Drinking more water reverses this.

Kidney Failure and Dialysis

If the kidneys fail, urea and other wastes accumulate in the blood to toxic levels. Treatment options:

- **Dialysis (haemodialysis)** — blood is passed through a machine containing a selectively permeable membrane bathed in dialysis fluid. Urea and excess ions diffuse out of the blood across the membrane; glucose, useful salts, and blood cells are retained. The patient typically needs dialysis several times per week.
- **Kidney transplant** — a healthier long-term solution; donor organ must be well-matched to avoid rejection.

The Skin

The skin has two main layers:

- **Epidermis** — outer layer; tough, protective; contains melanocytes that produce **melanin** (pigment responsible for skin, hair, and eye colour)
- **Dermis** — deeper layer; contains blood capillaries, sweat glands, hair follicles, sense receptors, and fat cells

Labelled diagram of skin showing epidermis, dermis, hair follicle, sweat gland, blood capillaries, and nerve endings

Functions of the skin

- protection against pathogens, dehydration, UV radiation, and physical damage
- temperature regulation
- sensation (touch, pressure, pain, temperature)
- vitamin D synthesis (using sunlight)
- minor excretion of salts and urea in sweat

Melanin and UV Protection

Melanin absorbs UV radiation from sunlight, protecting the DNA in skin cells from damage that can lead to skin cancer. The more melanin in the skin, the darker the complexion. Production increases with UV exposure (tanning).

SPF (Sun Protection Factor) is a measure of how well a sunscreen blocks UV radiation. An SPF of 30 blocks about 97% of UVB rays. SPF is relevant because UV radiation can cause sunburn, premature skin ageing, and skin cancer — particularly in individuals with lower melanin levels.

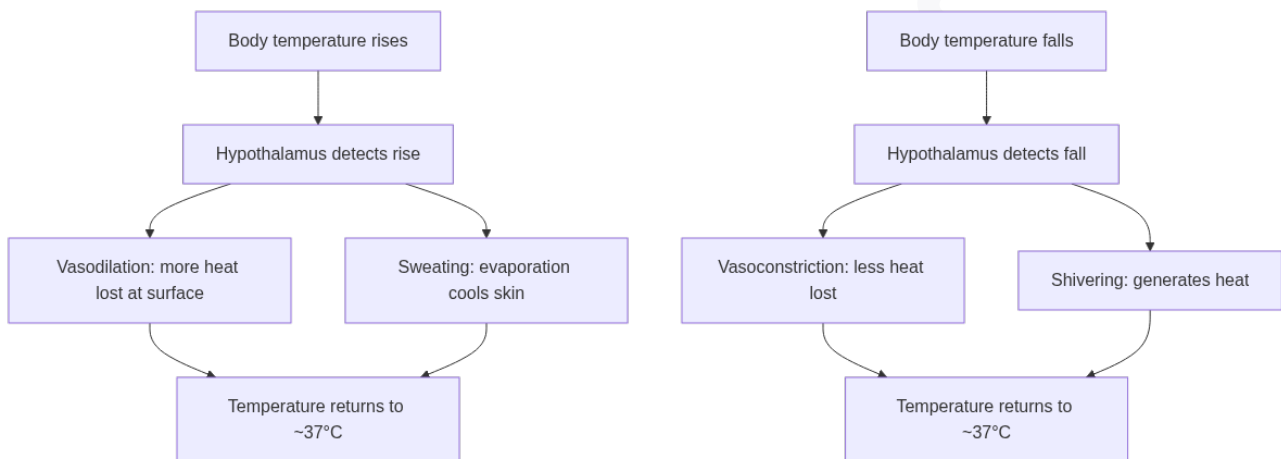
Skin bleaching refers to the use of chemical agents (e.g. hydroquinone, mercury compounds) to reduce melanin production, lightening skin tone. While widely practised in some Caribbean communities, skin bleaching carries significant health risks: mercury is toxic to the kidneys and nervous system, and reduced melanin leaves the skin more vulnerable to UV damage and skin cancer.

Temperature Regulation

The body maintains core temperature at about 37°C — the optimum for enzyme activity.

The **hypothalamus** acts as the thermostat, detecting temperature changes in the blood and sending signals to effectors in the skin.

Response	When	Mechanism
Vasodilation	too hot	blood capillaries near skin surface widen; more blood flows through; heat lost by radiation
Vasoconstriction	too cold	capillaries narrow; less blood near surface; heat retained
Sweating	too hot	sweat glands secrete water and salts onto skin; evaporation carries away heat
Shivering	too cold	rapid involuntary muscle contractions; friction generates heat
Piloerection	too cold	hair erector muscles raise hairs; traps layer of air as insulation (more effective in furry animals than in humans)



Temperature regulation by negative feedback

Remember

Vasodilation and vasoconstriction change how much blood flows near the skin surface, not whether blood flows to the skin. The capillaries open or narrow; the blood volume in the body does not change.

PRACTICE — EXCRETION AND HOMEOSTASIS**Excretion**

Removal of metabolic waste products made inside the body, such as urea and CO₂,

Egestion

Removal of undigested food from the body as faeces; not the same as excretion.

Urea

A nitrogenous waste product formed in the liver from the deamination of excess amino acids.

Nephron

The functional unit of the kidney; performs ultrafiltration and selective reabsorption.

Ultrafiltration

Forcing small molecules from blood into the Bowman's capsule under high pressure.

Selective reabsorption

Recovery of useful substances (glucose, amino acids, water) from the filtrate back into the blood.

ADH

Antidiuretic hormone; released by the pituitary; increases water reabsorption in the collecting duct.

Osmoregulation

Control of the water concentration of body fluids.

Negative feedback

A control mechanism in which the response opposes and corrects a change from the set point; used in all homeostatic systems.

Positive feedback

A control mechanism in which the response amplifies the original change, driving a process to completion; examples include childbirth contractions and blood clotting.

Vasodilation

Widening of blood capillaries near the skin surface; increases heat loss.

Vasoconstriction

Narrowing of blood capillaries near the skin surface; reduces heat loss.

Homeostasis

Maintenance of a stable internal environment despite changes in the external environment.

Bilirubin

A metabolic waste product from haemoglobin breakdown; excreted via bile into the gut; gives faeces their brown colour.

Dialysis

A process in which blood is filtered through a selectively permeable membrane to remove urea and excess substances when the kidneys fail.

Melanin

A pigment produced in the epidermis that absorbs UV radiation, protecting skin cell DNA from damage.

SPF

Sun Protection Factor; a measure of how well a sunscreen blocks UV radiation; higher SPF = greater protection.