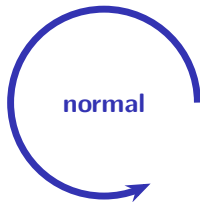


Homeostasis

A-Level Biology ■ Topic 14

A-Level Biology



What we will cover

- 1 Negative feedback
- 2 The kidney
- 3 The nephron
- 4 Osmoregulation & ADH
- 5 Blood glucose
- 6 Stomata



glucose kept in narrow limits



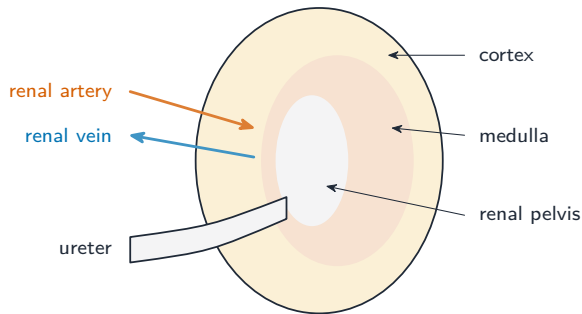
Negative feedback

A change is detected, and the response **reverses** it – keeping the factor near a set point. That is **homeostasis** .

Positive feedback increases the change (oxytocin in labour). It is rare, and it does not give a stable internal environment.



The kidney

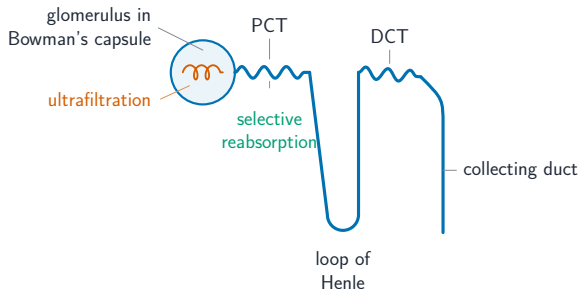


The **kidney** cleans the blood and controls its water.

- **cortex & medulla** clean the blood
- urine collects in the **renal pelvis**

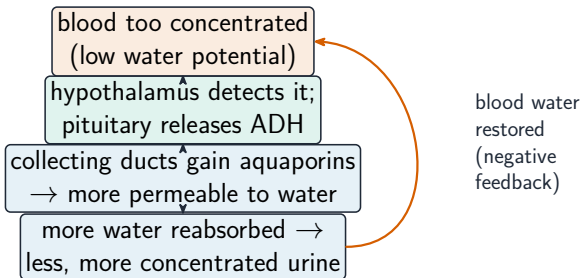
The liver makes **urea** from excess amino acids (**deamination**).

The nephron and making urine



- **ultrafiltration (Bowman's capsule)** – pressure pushes out small molecules; cells & proteins stay
- **selective reabsorption (proximal tubule)** – glucose & water taken back

Osmoregulation and ADH



The **hypothalamus** detects the blood's **water potential** .

If too concentrated, the pituitary releases **ADH** – the **collecting ducts** reabsorb more water, so less, concentrated urine is made.

ADH, and what it changes

The detector

Osmoreceptors in the hypothalamus sense the water potential of the blood.

The hormone

When the blood is too concentrated, the **pituitary gland** releases **antidiuretic hormone** (ADH).

The effect

ADH makes the collecting duct wall more permeable to water – aquaporins are inserted – so more water returns to the blood and the urine is small and concentrated.

The feedback

Blood water potential rises, the osmoreceptors quieten, ADH release falls. Negative feedback, in one loop.

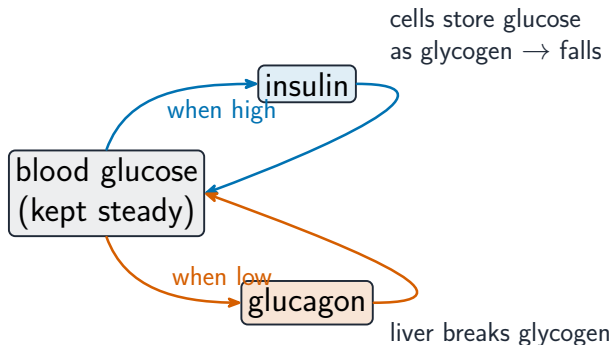
ADH changes a *permeability*, not a pump. The water still moves down its own gradient.



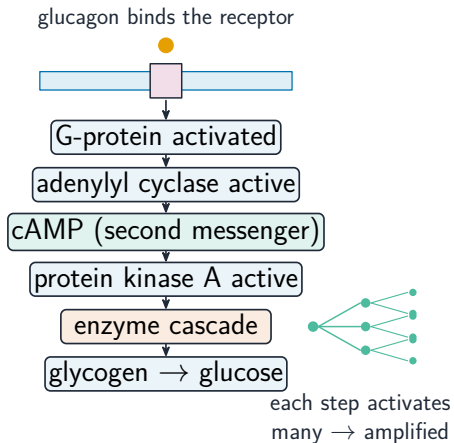
Controlling blood glucose

Two hormones work against each other:

- high glucose → **insulin** stores it as **glycogen**
- low glucose → **glucagon** breaks glycogen back to glucose



Cell signalling: the glucagon cascade



Glucagon binds a receptor → **G-protein** G → **cAMP** (a **second messenger**) → an **enzyme cascade**.

Each step switches on **many** of the next, so the signal is greatly **amplified**.

One hormone, an amplified answer

1. Binding

Glucagon binds a receptor on the liver cell surface, causing a **conformational change** – a change in the receptor's shape.

2. G-protein

That activates a **G-protein** G , which switches on the enzyme **adenylyl cyclase**.

3. Second messenger

Adenylyl cyclase makes a **second messenger** inside the cell: **cyclic AMP** (cAMP).

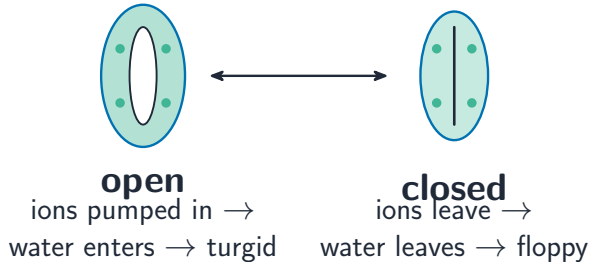
4. Enzyme cascade

cAMP activates **protein kinase A** A , which starts an **enzyme cascade** – each enzyme switching on the next by **phosphorylation**.

The point of the cascade is **amplification**: a few hormone molecules outside end in millions of glucose molecules released.



Stomata and guard cells



Guard cells open a **stoma** by taking in water (turgid) and close it by losing water. Under water stress, **abscisic acid** closes the stomata to save water.

Stomata: balancing two needs

stomata

pores in a leaf, opened and closed by guard cells

the conflict

letting in **carbon dioxide** for photosynthesis, against losing water by transpiration

opening

active transport pumps K^+ into the guard cells, water follows by osmosis, and the turgid cells bow apart

aquaporins

channel proteins that let that water move quickly

closing

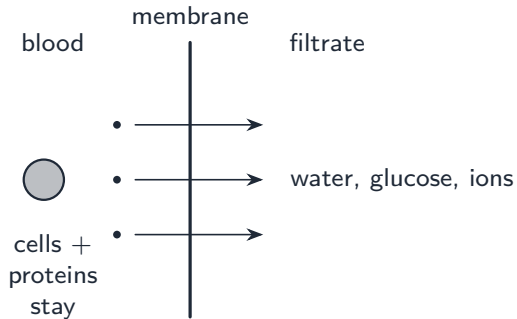
ADH 's plant counterpart **abscisic acid** is released in drought and triggers closure

calcium ions

act as the second messenger inside the guard cell during that response

Guard cells work by **changing their own water potential** deliberately – the only cells in the plant that do.

Making urine



Ultrafiltration keeps blood cells and proteins in the blood

The kidney's structure, and measuring glucose

the fibrous capsule

the tough outer covering

the cortex

the outer region, holding the glomeruli and convoluted tubules

the medulla

the inner region, holding the loops of Henle and collecting ducts

the pelvis

where urine collects before the ureter

test strips and biosensors

measure glucose in blood or urine using **glucose oxidase** and **peroxidase**

why enzymes

they are **specific** to glucose, so no other sugar in the sample gives a reading

Specificity is the whole reason a biosensor works. A chemical test that reacted with any reducing sugar could not diagnose diabetes.

Along one nephron, in order

Glomerulus and capsule

Each kidney holds about a million **nephrons** . Blood in the **glomerulus** is under high pressure, so water and small molecules – glucose, ions, urea – are pushed into the **Bowman's capsule** as the **filtrate** .

Proximal tubule

The **proximal convoluted tubule** reabsorbs all the glucose and most of the ions and water.

Loop of Henle

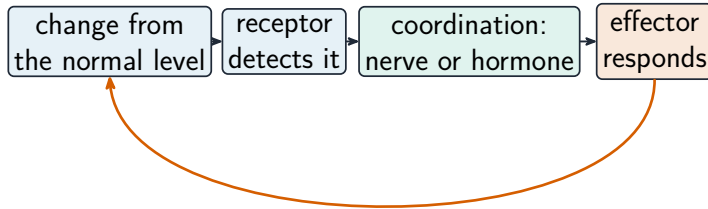
The **loop of Henle** builds a salt gradient in the medulla – the pump that makes concentrated urine possible.

Distal tubule and duct

The **distal convoluted tubule** fine-tunes ions and pH; the **collecting duct** sets the final water content.

The tubule wall is built for the job: **microvilli** for surface area, and many **mitochondria** to power the **active transport** .

The principles of homeostasis



the response pushes the level back to normal (negative feedback)

Negative feedback: a receptor detects a change and an effector corrects it, returning to normal

What homeostasis is, and the parts it needs

homeostasis

keeping conditions inside the body **steady** even when the outside changes

what is held steady

temperature, blood glucose, water potential, pH and ion **concentration**

a receptor

detects the change from the set point

a coordination system

carries the message – either the **nervous system** using nerve signals, or the **endocrine system** using hormones in the blood

an effector

brings about the correction – a muscle or a gland

negative feedback

the correction *reverses* the change, so the value returns toward the set point

Positive feedback amplifies instead, which is why it is rare in the body and used only for events that must run to completion – childbirth, the action potential.

The principles of homeostasis, continued



Sweating cools the body – part of temperature homeostasis, with the skin as the effector

Exam tips

- Frame every answer as **negative feedback**: receptor → coordinator → effector → correction; name each part.
- **Blood glucose**: insulin lowers it (uptake, glycogenesis), glucagon raises it (glycogenolysis) – explain through cell signalling.
- **Kidney**: know ultrafiltration (Bowman's capsule), selective reabsorption (proximal tubule) and the role of **ADH** in osmoregulation.
- **Stomata** open when guard cells become turgid (K^+ enters, water follows).



Worked example – controlling blood glucose

Explain how blood glucose returns to normal after a meal.

- Glucose rises above the set point. β cells in the islets of Langerhans detect it.
- They secrete **insulin**, which binds receptors on liver and muscle cells.
- More **GLUT4** transporters move into the membrane, and glucose $\rightarrow$ **glycogen** (glycogenesis).
- Blood glucose falls $\Rightarrow$ less insulin secreted: **negative feedback**.

Name the **detector** (β cell), the **signal** (insulin) and the **effector** (liver). Insulin **lowers**, glucagon **raises** – both from the pancreas.

Topic 14 – key takeaways

1

Negative feedback

receptor detects, effector corrects

2

Nephron

ultrafiltration then selective reabsorption

3

Osmoregulation

ADH makes ducts reabsorb more water

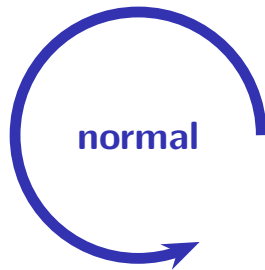
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Blood glucose

insulin vs glucagon; cascade amplifies

Check yourself

- 1 Where in the nephron does ultrafiltration happen?
- 2 Which hormone makes collecting ducts reabsorb water?
- 3 Which hormone lowers blood glucose?
- 4 What is cAMP called in cell signalling?



Answers 1. the Bowman's capsule 2. ADH 3. insulin 4. a second messenger