37.1 Homeostasis

Name: _____ Class: _____ Date: _____ **Total: 26 marks**

KEY WORDS homeostasis • negative feedback • insulin • glucagon • vasodilation • ultrafiltration

Objective

Build the skills to answer exam questions on **homeostasis** : negative feedback, control of blood glucose, diabetes and body temperature.

You must be able to:

- explain homeostasis and negative feedback with a stimulus–receptor–effector loop
- explain the control of blood glucose by insulin and glucagon, and compare type 1 and type 2 diabetes
- explain thermoregulation by the hypothalamus: vasodilation, vasoconstriction, sweating and shivering
- interpret glucose tolerance and temperature data
- explain osmoregulation by the kidney: ultrafiltration, selective reabsorption, the loop of Henle and ADH

1 Key knowledge and worked examples

■ Homeostasis

Homeostasis keeps internal conditions (blood glucose, body temperature, water balance, blood pH) within narrow limits. **Negative feedback:** a change from the set point is detected by **receptors**, and **effectors** bring the value back.

blood glucose	detected by	hormone	effect
too high (after a meal)	β cells in the pancreas	**insulin**	cells take up glucose; liver and muscle store it as **glycogen**
too low (fasting, exercise)	α cells in the pancreas	**glucagon**	liver breaks glycogen down to glucose

Type 1 diabetes: the immune system destroys β cells, so little insulin is made; treated with insulin injections. **Type 2 diabetes:** cells respond less to insulin; linked to diet, obesity and lack of exercise; treated with diet, exercise and drugs.

Thermoregulation (set point about 37 °C): the **hypothalamus** receives information from thermoreceptors.

- **too hot: vasodilation** of skin arterioles (more heat lost from the skin), **sweating** (evaporation removes heat).
- **too cold: vasoconstriction**, **shivering** (muscle contractions release heat), hair erection, and **thyroxine** raises the metabolic rate; brown fat releases heat in babies.

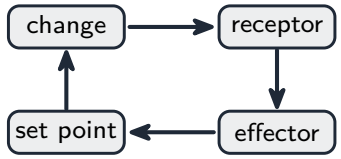
HL: the **kidney** filters blood in the **glomerulus** (**ultrafiltration**: high pressure pushes small molecules into the Bowman's capsule; proteins and cells stay). The **proximal convoluted tubule** reabsorbs all glucose, most water and ions (**selective reabsorption**, using active transport; microvilli and many mitochondria). The **loop of Henle** pumps Na^+ into the medulla, making it salty. **ADH** from the pituitary, released when the blood is too concentrated, makes the **collecting duct** more permeable to water (more aquaporins), so more water is reabsorbed and urine is concentrated.

Worked example. Blood glucose rises from 5.0 to 8.5 mmol dm^{-3} after a meal: an increase of $\frac{3.5}{5.0} \times 100 = \mathbf{70}\%$.

Answer shapes: change → receptor → hormone or nerve → effector → effect → value returns (negative feedback).

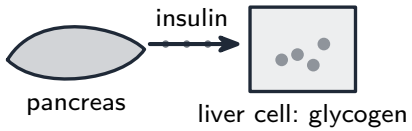
2 Practice

2.1 Outline what is meant by negative feedback. [2]

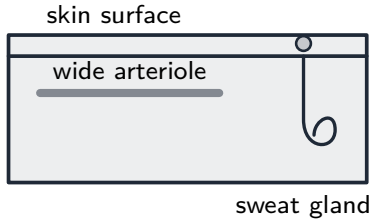


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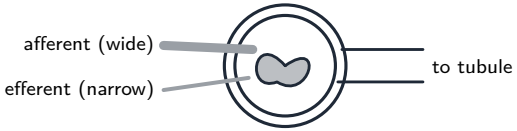
2.2 Explain how blood glucose concentration is lowered after a meal. [3]



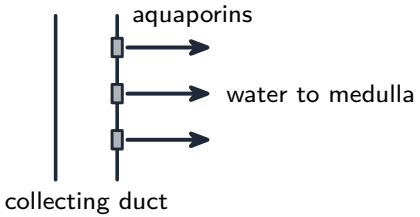
2.3 Explain how the skin helps to cool the body on a hot day. [3]



2.4 Explain how the structure of the glomerulus and Bowman's capsule allows ultrafiltration. [3]

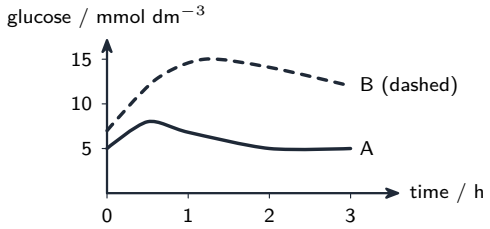


2.5 Explain how ADH reduces water loss when a person is dehydrated. [3]



3 Exam-style questions

3.1 The graph shows blood glucose in two people after each drank 75 g of glucose at time 0.



(a) State the maximum blood glucose of person B. [1]

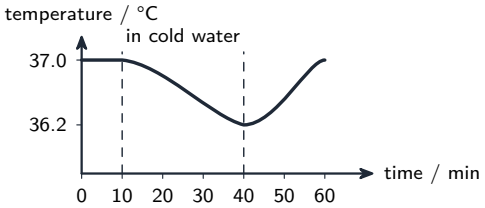
(b) Describe the results for person A. [2]

(c) Suggest, with a reason, which person has diabetes. [1]

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(d) Explain one difference in the cause of type 1 and type 2 diabetes. [2]

3.2 The graph shows the core temperature of a swimmer who enters cold water at 10 minutes and leaves it at 40 minutes.



(a) Calculate the fall in core temperature. [1]

(b) Name the part of the brain that detects the change. [1]

(c) Explain two responses that reduce heat loss or increase heat production. [4]

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Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

a change from the set point is detected; the response reverses the change, bringing the value back to the set point

2.2

β cells in the pancreas detect the high glucose concentration; they release insulin; insulin makes cells take up glucose, and the liver and muscles convert it to glycogen

2.3

arterioles in the skin dilate (vasodilation); more blood flows near the surface and more heat is lost by radiation; sweat glands release sweat, and its evaporation removes heat

2.4

the efferent arteriole is narrower than the afferent, so blood pressure in the glomerulus is high; the capillary walls have pores and the basement membrane acts as a filter; small molecules such as water, glucose and urea pass into the capsule, while proteins and blood cells stay

2.5

the hypothalamus detects the concentrated blood and the pituitary releases ADH; ADH makes the collecting duct more permeable to water by adding aquaporins; more water is reabsorbed into the blood, so a small volume of concentrated urine is made

3.1

(a) 15 mmol dm^{-3}

(b) rises from 5 to a peak of about 8 mmol dm^{-3} at about 0.5 h; falls back to 5 mmol dm^{-3} by about 2 h

(c) B, because glucose rises much higher and stays high / does not return to normal

(d) type 1: β cells are destroyed, so little or no insulin is made; type 2: insulin is made but target cells respond less to it

3.2

(a) $37.0 - 36.2 = \mathbf{0.8}$ °C

(b) hypothalamus

(c) any two, each response with its explanation: vasoconstriction of skin arterioles, so less blood reaches the surface and less heat is lost; shivering, rapid muscle contractions whose respiration releases heat; more thyroxine raises the metabolic rate; hair erection traps air as insulation

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