

Homeostasis

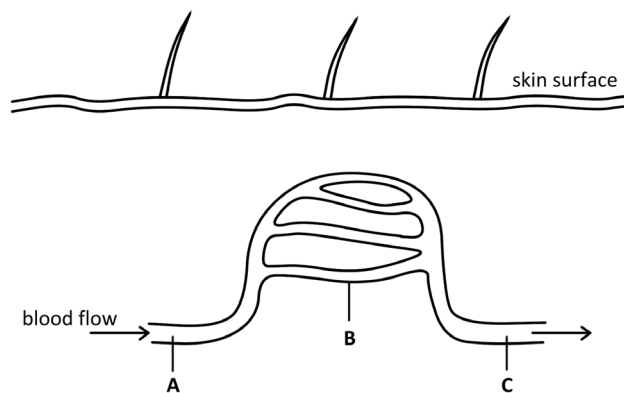
Mark Scheme



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1. Homeostasis is the maintenance of a stable internal environment in living organisms despite changes in external or internal conditions. Circle the letter of the correct answer for each question below.

- a) The figure below shows some arterioles close to the surface of the skin.



When vasoconstriction occurs at **A**, what will happen to the flow of blood through **B** and **C**?

D – is the only correct answer.	1 mark
	Total: 1 mark

- b) Which of the following scenarios would **least** likely trigger a significant release of ADH (antidiuretic hormone) from the pituitary gland?

C – is the only correct answer.	1 mark
	Total: 1 mark

- c) Which part of the brain coordinates the body's homeostasis response?

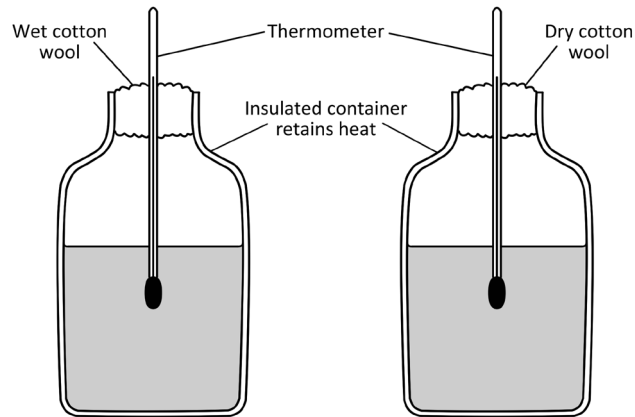
B – is the only correct answer.	1 mark
	Total: 1 mark

- d) Which part of the kidney nephron is affected by antidiuretic hormone (ADH)?

C – is the only correct answer.	1 mark
	Total: 1 mark

(Total for Question 1 is 4 marks)

2. A student set about investigating the effect of sweating on the temperature of the body. The student set up two beakers for the investigation as shown in the figure below.



- a) State **two** variables that would need to be controlled to ensure this investigation is valid.

Any two from the following:	
- Volume of water (in each container/flask). Allow: amount of water. - Initial / starting temperature of (the) water. Room temperature / ambient temperature / temperature of the surroundings. Amount / mass / surface area / thickness of cotton wool (used).	
	Total: 2 marks

The results of the student's investigation is shown in the table below.

Time (minutes)	Container 1 (°C)	Container 2 (°C)
0	100	100
5	72	93
10	60	85
15	45	74
20	33	65

- b) Calculate the mean temperature for container 1 during the investigation.

$(100 + 72 + 60 + 45 + 33) = 310$	1 mark
$310 \div 5 = 62\text{ (°C)}$	1 mark
	Total: 2 marks

- c) Calculate the range of temperature range for both container 1 and container 2.

Container 1 range: $100 - 33 = 67$	1 mark
Container 2 range: $100 - 65 = 35$	1 mark
	Total: 2 marks

- d) Explain how sweating helps to cool the body.

An explanation to include the following:	
Water / sweat evaporates (from the skin surface).	1 mark
Allow: sweat turns into a gas/vapour.	
(This process) requires energy / heat (which is taken) from the skin / body.	1 mark
Allow: heat energy is used to change state (of water).	
	Total: 2 marks

e) Why is it important to ensure that body temperature is kept within a narrow range?

An explanation to include the following:	
For enzymes to function (optimally / correctly) / prevent enzymes denaturing.	1 mark
Allow: enzymes have an optimum temperature.	
So that metabolic reactions / chemical reactions (in cells/body) can occur at an appropriate rate/ fastest rate.	1 mark
	Total: 2 marks

f) Explain how both vasoconstriction and vasodilation of arterioles in the skin contribute to the regulation of body temperature in humans.

Marking guidance		
Level	Marks	Descriptor
Level 1	1 - 2	A basic or limited explanation is provided, demonstrating a partial understanding. Statements about vasoconstriction and/or vasodilation are made, but the link to temperature regulation is weak or unclear. Only one process is described, and/or the description contains significant inaccuracies or omissions
Level 2	3 - 4	A generally correct explanation is provided, demonstrating some understanding of how vasoconstriction and vasodilation contribute to temperature regulation. Either: Both processes are described, but one or both may lack some detail or clarity in linking arteriole changes to blood flow and heat exchange. One process is explained well, but the other is described with less detail or some inaccuracies
Level 3	5 - 6	A detailed and coherent explanation is provided, demonstrating a clear understanding of how both vasoconstriction and vasodilation of arterioles in the skin contribute to temperature regulation. The mechanisms of both processes are accurately described, clearly linking changes in arteriole diameter to blood flow near the skin surface, and consequently to heat loss or conservation

Indicative content:	
General points: • Body temperature needs to be regulated / kept constant / homeostasis. • Blood transports / carries heat / thermal energy. • Arterioles are (small) blood vessels (in the skin / leading to capillaries). • (Smooth) muscles in the walls of arterioles can contract or relax. Vasodilation (when the body is too hot): • Arterioles (supplying skin capillaries / near skin surface) dilate / widen. • (Smooth) muscles in arteriole walls relax. • More blood flows through arterioles / to capillaries near the skin surface. • (This means) more blood is closer to the (skin) surface. • Increases heat loss from the blood (to the environment). • Heat lost by radiation / convection / conduction. • Helps to cool the body down / lower body temperature.	

Vasoconstriction (when the body is too cold): • Arterioles (supplying skin capillaries / near skin surface) constrict / narrow. • (Smooth) muscles in arteriole walls contract. • Less blood flows through arterioles / to capillaries near the skin surface. • (This means) less blood is closer to the (skin) surface. • Reduces heat loss from the blood (to the environment). • Conserves heat / keeps core body warm. • Helps to prevent further heat loss / maintain core body temperature. Regulation aspect: • These processes are part of a negative feedback mechanism. • Response to changes in blood/body temperature detected by the thermoregulatory centre (in the brain)	
	Total: 6 marks

(Total for Question 2 is 16 marks)

3. This question is about glucoregulation.

a) Identify the organ shown above.

Pancreas.	1 mark
	Total: 1 mark

b) Name the **two** hormones that this organ produces that are involved in glucoregulation.

1 mark for each correct hormone.	
Insulin.	1 mark
Glucagon.	1 mark
	Total: 2 marks

c) Explain why it is important for the body to maintain a stable blood glucose concentration.

An explanation to include three of the following:	
To ensure a (constant / reliable) supply of glucose to cells,	1 mark
For respiration (to occur efficiently / at an appropriate rate).	1 mark
If blood glucose is too low, cells (especially brain cells) will not have enough glucose / energy (for normal function / respiration)	1 mark
If blood glucose is too high, it can lower the water potential of the blood / tissue fluid.	1 mark
To prevent glucose being lost in the urine (if levels are too high).	1 mark
	Total: 3 marks

- d) Describe the chemical test that doctors could use in the present to test for glucose in a sample of urine.

An explanation to include the following:	
Add <u>Benedict's solution</u> / reagent (to the urine sample)	1 mark
<u>Heat</u> (the mixture / solution)	1 mark
(A positive result is a) colour change from blue to green / yellow / orange / (brick) red.	1 mark
	Total: 3 marks

The doctor suspects their patient has type 2 diabetes.

- e) State the cause of type 2 diabetes and suggest **two** ways it can be treated.

An explanation to include the following:	
Cause: Body cells / liver cells / muscle cells <u>become resistant</u> / less responsive / do not respond (effectively) to insulin.	1 mark
Treatment: (any two from the following) • (Eating a) healthy / balanced / controlled diet. • Regular exercise • Losing weight (if overweight / obese) • Medication / drugs / tablets (to lower blood glucose / increase insulin sensitivity / help pancreas produce more insulin).	2 marks
	Total: 3 marks

- f) Describe the roles of the pancreas and the liver in maintaining stable blood glucose levels in the body.

Marking guidance		
Level	Marks	Descriptor
Level 1	1 - 2	A basic or limited description is provided, demonstrating partial understanding. Simple statements are made about the pancreas producing hormones and/or the liver storing glucose, but the links to blood glucose regulation or the specific actions are weak or unclear. Only the role of one organ is mentioned, or the description contains significant inaccuracies or omissions
Level 2	3 - 4	A generally correct description is provided, demonstrating some understanding of the roles of the pancreas and liver. Either: The roles of both organs are described, but one or both descriptions may lack some detail or clarity, particularly in how the liver responds to specific hormones.
Level 3	5 - 6	A detailed and coherent description is provided, demonstrating a clear understanding of the distinct but coordinated roles of both the pancreas and the liver in blood glucose regulation. The response accurately describes how the pancreas detects glucose levels and releases appropriate hormones (insulin and glucagon), and how the liver responds to these hormones to either store or release glucose. The description clearly <u>links</u> these actions to the maintenance of stable blood glucose levels.

Indicative content:	
Pancreas: If blood glucose is too high: Pancreas / (β / beta) cells in pancreas produce / release insulin. If blood glucose is too low: Pancreas / (α / alpha) cells in pancreas produce / release glucagon. Liver (as a target organ): In response to insulin (when blood glucose is high): Insulin travels in the blood to the liver. (Insulin causes) liver cells to take up glucose from the blood. (Insulin causes) liver to convert glucose into glycogen (for storage). This lowers blood glucose concentration (back to normal). In response to glucagon (when blood glucose is low): Glucagon travels in the blood to the liver. (Glucagon causes) liver to convert stored glycogen back into glucose. Glucose is released from the liver into the blood. This raises blood glucose concentration (back to normal). General points for higher levels: Coordinated action of pancreas and liver. Negative feedback mechanism (implied by corrective actions).	
	Total: 6 marks

(Total for Question 3 is 16 marks)

4. The figure below shows a section of human skin.

a) What is the term given to the raising of hair follicles in the skin.

Piloerection.	1 mark
	Total: 1 mark

b) Explain how this process of works and how it contributes to maintaining body temperature. Include in your answer an explanation of when and why this process occurs in response to changes in skin temperature.

Marking guidance		
Level	Marks	Descriptor
Level 1	1 - 2	A basic or limited explanation is provided, demonstrating partial understanding. The response may state that hairs stand up in the cold but provides a limited or unclear explanation of the mechanism.
Level 2	3 - 4	A generally correct explanation is provided, demonstrating some understanding. The mechanism of hair erection is described, and its role in trapping air is mentioned. The link to reducing heat loss and occurring in cold conditions is present.
Level 3	5 - 6	A detailed and coherent explanation is provided, demonstrating a clear understanding of the entire process. The mechanism involving erector muscle contraction is accurately described. The role in trapping an insulating layer of air to reduce heat loss is clearly explained.

Indicative content:	
When and Why (Stimulus and Purpose): - Occurs when the body / skin temperature is low / person is cold. - It is a response to reduce heat loss / conserve body heat / keep the body warm. How it Works (Mechanism): (Tiny) erector muscles / hair erector muscles / arrector pili muscles (are attached to hair follicles). - These muscles contract. - This pulls the hair(s) upright / causes hairs to stand on end. Contribution to Maintaining Body Temperature (Function): - Hairs standing on end trap a layer of air next to the skin. - Air is a poor conductor of heat / (good) insulator. - This trapped layer of air reduces heat loss from the skin to the environment. - Reduces heat loss by convection (and radiation to a lesser extent). (This response is more effective in animals with more fur/hair than humans).	
	Total: 6 marks

The skin is also involved in the process of sweating, which helps regulate body temperature.

c) Explain how sweating contributes to maintaining the temperature of the body.

An explanation to include the following:	
(Sweat glands release) sweat / water onto the skin surface.	1 mark
Water / sweat evaporates (from the skin surface).	1 mark
Allow: sweat turns into a gas / vapour.	
(Evaporation) requires energy / heat, which is taken from the skin / body, (therefore cooling it).	1 mark
Allow: heat energy is used to change state (of water).	
	Total: 3 marks

d) Which region of the brain is involved with coordinating responses in homeostasis.

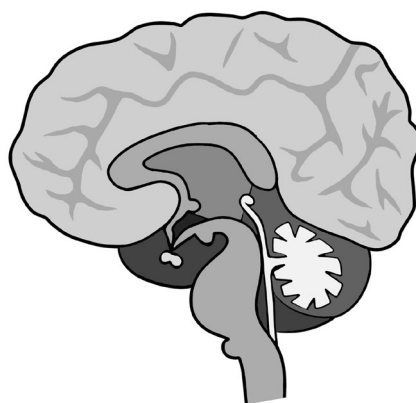
Hypothalamus.	1 mark
	Total: 1 mark

e) Explain why is it important to maintain body temperature within a narrow range.

An explanation to include the following:	
For enzymes to function (optimally / correctly) / prevent enzymes denaturing.	1 mark
Allow: enzymes have an optimum temperature.	
So that metabolic reactions / chemical reactions (in cells/body) can occur at an appropriate rate/ fastest rate.	1 mark
	Total: 2 marks

(Total for Question 4 is 13 marks)

5. The figure below shows a section through the brain.



a) What part of the brain regulates homeostasis, particularly in relation to osmoregulation?

Hypothalamus.	1 mark
	Total: 1 mark

b) Name the hormone produced by this part of the brain that affects the kidney.

Anti diuretic hormone.	1 mark
	Total: 1 mark

c) Describe how the kidney responds to high and low levels of this hormone and give the effect this would have on the production of urine.

Marking guidance		
Level	Marks	Descriptor
Level 1	1 - 2	A basic or limited description is provided. The response may mention ADH affecting water levels or urine but with a weak or unclear link to kidney action or specific effects on urine volume/concentration. Only one scenario (high or low ADH) might be addressed.
Level 2	3 - 4	A generally correct description is provided. The response describes the kidney's response to high and low ADH levels, and the effect on urine production. However, the explanation of how changes in permeability lead to changes in water reabsorption might be less detailed, or the description of urine volume/concentration might be incomplete for one or both scenarios.
Level 3	5 - 6	A detailed and coherent description is provided for both high and low levels of ADH. The response accurately explains how the kidney (specifically the collecting ducts) responds to changes in ADH levels by altering its permeability to water. This is clearly <u>linked</u> to the amount of water reabsorbed and the resultant changes in both the volume and concentration of urine produced in each scenario (high ADH and low ADH).

Indicative content:	
General Point: - ADH (Anti-diuretic Hormone) is involved in osmoregulation / controlling blood water potential / water balance. - ADH acts on the kidney tubules / collecting ducts. High levels of ADH (e.g., when blood water potential is low / dehydrated): - More ADH is released (from the pituitary gland). - ADH travels in the blood to the kidneys.	

Kidney response: ADH causes the walls of the collecting ducts (and distal tubules) to become more permeable to water. Effect on urine production: More water is reabsorbed from the filtrate (in the collecting ducts) back into the blood (by osmosis). - This results in a small(er) volume of urine. - The urine produced is more concentrated / darker yellow. Low levels of ADH (e.g., when blood water potential is high / well-hydrated): (Less / No) ADH is released (from the pituitary gland). Kidney response: The walls of the collecting ducts are less permeable to water. Effect on urine production: Less water is reabsorbed from the filtrate (in the collecting ducts) back into the blood. - This results in a large(r) volume of urine. - The urine produced is more dilute / paler yellow.	
	Total: 6 marks

d) Identify each of these cells and explain in terms of osmosis, how each cell has arrived in its current condition.

An explanation to include the following:	
1 mark for correctly identifying all three states.	1 mark
Cell 1: <u>Crenated</u>. Do not accept shrivelled. One mark for explaining Cell 1: Placed in a hypertonic solution / solution with a lower water potential (than the cell cytoplasm). Water moves out of the cell by osmosis (down the water potential gradient).	1 mark
Cell 2: <u>Normal</u>. One mark for explaining Cell 2: Placed in an isotonic solution / solution with the same water potential (as the cell cytoplasm). There is no net movement of water by osmosis / water moves in and out at equal rates.	1 mark
Cell 3: <u>Burst / lysed. Accept lysis has happened</u>. One mark for explaining Cell 3: Placed in a hypotonic solution / solution with a higher water potential (than the cell cytoplasm). Water moves into the cell by osmosis (down the water potential gradient), (causing it to swell and burst as it has no cell wall).	1 mark
	Total: 4 marks

e) Explain why maintaining osmoregulation is crucial for animal cells.

Award one mark for each of the following points, up to a maximum of 4 marks:	
Prevents cells from taking in too much water (by osmosis) if the external environment is hypotonic / has a higher water potential.	1 mark
(This is important because) animal cells lack a cell wall and can burst / lyse if they swell too much.	1 mark
Prevents cells from losing too much water (by osmosis) if the external environment is hypertonic / has a lower water potential	1 mark
(This is important because) if cells lose too much water they shrink / crenate, which can disrupt cell processes / metabolic reactions / enzyme function.	1 mark
(Therefore, osmoregulation) maintains a stable internal environment / water potential / solute concentration within the cell.	1 mark
(This allows) optimal conditions for metabolic reactions / enzyme activity.	1 mark
	Total: 4 marks

f) State why plant cells are not as affected by changes in water concentration compared to animal cells.

Plant cells have <u>a cell wall</u> which provides support / prevents bursting.	1 mark
	Total: 1 mark

(Total for Question 5 is 17 marks)