1.6 Organisms Respond to Changes in their Environments: Test Pack

AQA 7402 · Calculator allowed · about 60 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 This question tests core vocabulary used to describe homeostatic control.

(a) Define homeostasis. **(1)**

(b) State what is meant by negative feedback. **(1)**

(c) State the general term for a cell or structure that detects a stimulus/change in a homeostatic system. **(1)**

(d) State the term for a structure that brings about a response to restore the normal level of a factor, e.g. a gland or a muscle. **(1)**

(Total for Question 1 is 4 marks)

© Revision Library | revisionlibrary.co.uk

2 This question tests key facts about blood glucose regulation and the kidney. For each part, identify the correct option.

(a) Which cells in the islets of Langerhans secrete insulin? **(1)**

- ☐ A) Alpha cells
- ☐ B) Beta cells
- ☐ C) Δ cells
- ☐ D) Acinar cells

(b) Which structure in the nephron is responsible for ultrafiltration of the blood? **(1)**

- ☐ A) The glomerulus and Bowman's capsule
- ☐ B) The loop of Henle
- ☐ C) The distal convoluted tubule
- ☐ D) The collecting duct

(c) Where is antidiuretic hormone (ADH) produced and released from? **(1)**

- ☐ A) Produced and released by the pancreas
- ☐ B) Produced in the hypothalamus, released from the posterior pituitary gland
- ☐ C) Produced and released by the adrenal cortex
- ☐ D) Produced in the liver, released by the kidney

(d) Which hormone or hormones raise blood glucose concentration by stimulating the breakdown of glycogen in the liver? Choose the option that names all of them. **(1)**

- ☐ A) Insulin
- ☐ B) Glucagon
- ☐ C) Adrenaline
- ☐ D) Both B and C

(Total for Question 2 is 4 marks)

© Revision Library | revisionlibrary.co.uk

3 The Pacinian corpuscle is a pressure receptor found deep in the skin, especially in the fingers and soles of the feet.

(a) Describe the structure of a Pacinian corpuscle. **(2)**

(b) Explain how pressure applied to the skin above a Pacinian corpuscle leads to the generation of a generator potential in the sensory neurone. **(4)**

(c) Explain why increasing the pressure applied to the corpuscle increases the frequency of action potentials passing along the sensory neurone, but does not change the size (amplitude) of each individual action potential. **(3)**

(Total for Question 3 is 9 marks)

© Revision Library | revisionlibrary.co.uk

4 Antidiuretic hormone (ADH) regulates the water potential of the blood by altering the permeability of the collecting duct to water. A dehydrated volunteer's plasma ADH concentration and urine concentration were monitored over several hours.

Time (hours)	Plasma ADH (arbitrary units)	Urine concentration (mosmol/kg)
0	2.0	300
2	5.5	620
4	8.0	900
6	4.0	550

(a) Explain how a fall in the water potential of the blood plasma (as in dehydration) leads to increased secretion of ADH. **(3)**

(b) Explain how increased ADH concentration causes the collecting duct to produce more concentrated urine. **(3)**

(c) Using the data, calculate the percentage increase in urine concentration between 0 and 4 hours. **(2)**

(d) Suggest why both plasma ADH concentration and urine concentration fall between 4 and 6 hours. **(1)**

(Total for Question 4 is 9 marks)

© Revision Library | revisionlibrary.co.uk

5 This final question draws together ideas about nervous and hormonal coordination in maintaining homeostasis in response to changing conditions.

(a) Compare nervous and hormonal (endocrine) communication in terms of the speed of response and the duration of effect, explaining why each is suited to a different type of homeostatic control. **(3)**

(b) During a sudden stressful event, adrenaline is released from the adrenal medulla under direct nervous stimulation via the sympathetic nervous system, producing effects (e.g. increased heart rate, raised blood glucose) within seconds. Explain why this rapid nervous stimulation of a hormone-secreting gland is advantageous for a 'fight or flight' response, compared with the normal (slower) hormonal feedback loop involving blood glucose concentration alone. **(3)**

(c) Both adrenaline and glucagon raise blood glucose concentration via the same second messenger, cAMP, acting on liver cells, yet they are released in response to different stimuli. Suggest three advantages to an organism of having two different hormones capable of producing the same overall effect on blood glucose. **(3)**

(Total for Question 5 is 9 marks)

© Revision Library | revisionlibrary.co.uk

6 The kidneys filter blood at the glomerulus to produce filtrate, and then reabsorb most of the filtered water and solutes as it passes along the nephron. In a healthy adult, the glomerular filtration rate (GFR) is approximately 125 cm^3 of filtrate produced per minute, but typical urine output is only about 1.0 cm^3 per minute.

(a) Calculate the volume of filtrate produced by the kidneys in 24 hours, in dm3, to 3 significant figures. **(2)**

(b) Given that typical urine output is 1.0 cm^3 per minute, calculate the percentage of the filtrate that is reabsorbed back into the blood as it passes along the nephron. **(3)**

(c) Explain why almost all of the glucose and amino acids in the filtrate are reabsorbed in the proximal convoluted tubule, but urea is only partially reabsorbed. **(3)**

(Total for Question 6 is 8 marks)

© Revision Library | revisionlibrary.co.uk

Mark scheme · 1.6 Organisms Respond to Changes in their Environments: Test Pack

Question 1

(a) the maintenance of a stable/constant internal environment, within set limits, despite external changes oe **B1**

(a) Answer: The maintenance of a stable internal environment within set limits despite external changes.

(b) a mechanism in which a change in a factor (from its normal/set level) brings about processes that return the factor back towards its normal level oe **B1**

(b) Answer: A mechanism in which a deviation from the normal level triggers a response that returns the level back towards normal.

(c) receptor **B1**

(c) Answer: Receptor.

(d) effector **B1**

(d) Answer: Effector.

Question 2

(a) B **B1**

(a) Answer: B

(b) A **B1**

(b) Answer: A

(c) B **B1**

(c) Answer: B

(d) D **B1**

(d) Answer: D

Question 3

(a) a sensory nerve ending wrapped in layers (lamellae) of connective tissue, separated by a gel/viscous fluid **B1**

(a) the lamellae/layers surround the end of a sensory neurone, which has stretch-mediated/mechanically-gated sodium ion channels in its membrane **B1**

(a) Answer: It consists of the end of a sensory neurone wrapped in concentric layers (lamellae) of connective tissue separated by gel, with stretch-mediated sodium channels in the neurone's membrane.

(b) pressure deforms/squashes the lamellae, which in turn deforms/stretches the membrane of the sensory neurone ending **B1**

(b) this stretching widens/opens the stretch-mediated sodium ion channels in the neurone membrane **B1**

(b) sodium ions diffuse into the neurone down their electrochemical gradient **B1**

(b) the influx of positive charge depolarises the membrane, producing a generator potential; if this reaches the threshold, it triggers an action potential in the sensory neurone **B1**

(b) Answer: Pressure deforms the lamellae and stretches the neurone membrane, opening stretch-mediated sodium channels; sodium ions diffuse in, depolarising the membrane and producing a generator potential which, if large enough, triggers an action potential.

(c) a greater pressure causes greater deformation of the lamellae/membrane, opening more stretch-mediated sodium channels and producing a larger generator potential **B1**

(c) a larger generator potential exceeds the threshold more often per unit time, generating more frequent action potentials (this is how stimulus intensity is coded) **B1**

(c) action potentials obey the all-or-nothing law: once the threshold is reached, an action potential of fixed size is always produced, so amplitude cannot vary with stimulus strength **B1**

(c) Answer: A greater pressure produces a bigger generator potential, which reaches the threshold more frequently, generating more action potentials per second; but because action potentials are all-or-nothing, each one is always the same size regardless of stimulus strength - stimulus intensity is coded by frequency, not amplitude.

© Revision Library | revisionlibrary.co.uk

Question 4

(a) osmoreceptors in the hypothalamus detect the fall in water potential of the blood oe **B1**

(a) the osmoreceptor cells lose water by osmosis and shrink, stimulating them to fire more frequently/generate more action potentials oe **B1**

(a) this stimulates neurosecretory cells in the hypothalamus to release more ADH from the posterior pituitary gland into the blood oe **B1**

(a) Answer: Osmoreceptors in the hypothalamus lose water and shrink when blood water potential falls, stimulating neurosecretory cells to release more ADH from the posterior pituitary.

(b) ADH binds to receptors on the cell-surface membrane of collecting duct cells oe **B1**

(b) this causes vesicles containing aquaporins (water channel proteins) to fuse with the cell-surface membrane, increasing the number of aquaporins present oe **B1**

(b) this increases the permeability of the collecting duct to water, so more water is reabsorbed by osmosis (into the blood, down the gradient created by the medulla), producing a smaller volume of more concentrated urine oe **B1**

(b) Answer: ADH causes more aquaporins to be inserted into the collecting duct cell membrane, increasing its permeability to water so more water is reabsorbed by osmosis, giving a smaller volume of more concentrated urine.

(c) correct substitution: (900 - 300)/300 x 100 **M1**

(c) 200% cao **A1**

(c) Answer: 200%

(d) the volunteer is likely to have drunk water (or the negative feedback response has restored blood water potential towards normal), reducing the stimulus for ADH release, so less ADH is secreted and less water is reabsorbed, producing more dilute urine oe **B1**

(d) Answer: The volunteer probably drank water, raising blood water potential back towards normal, reducing the stimulus for ADH release and allowing more dilute urine to be produced.

Question 5

(a) nervous communication is very fast (impulses travel rapidly along neurones) and short-lived, suiting responses that must occur immediately, such as antagonistic effector control of heart rate or thermoregulation oe **B1**

(a) hormonal communication is comparatively slow (hormones travel in the blood to target cells) but long-lasting, suiting responses that need to be sustained over a longer period, such as blood glucose regulation oe **B1**

(a) a valid supporting comparison, e.g. nervous responses act on specific, localised effectors via a synapse, whereas hormones act on any cell with the complementary receptor, giving a more widespread but less precisely localised effect oe **B1**

(a) Answer: Nervous responses are fast and short-lived, suiting immediate adjustments (e.g. heart rate); hormonal responses are slower but longer-lasting, suiting sustained regulation (e.g. blood glucose); hormones also act more widely on any responsive cell, while nerve impulses act on specific, localised effectors.

(b) the normal hormonal feedback loop for glucagon relies on a fall in blood glucose concentration to trigger a response, which takes time to develop and detect oe **B1**

(b) direct nervous stimulation of the adrenal medulla allows adrenaline release to be triggered immediately by the brain's perception of a threat, before any change in blood glucose has occurred oe **B1**

(b) this anticipatory response ensures blood glucose (and other resources, e.g. oxygen delivery via increased heart rate) is already being mobilised by the time it is needed for a rapid physical response, which is critical in a genuine emergency oe **B1**

(b) Answer: Nervous stimulation lets adrenaline be released immediately in anticipation of a threat, before blood glucose has actually fallen, mobilising energy resources faster than the slower glucagon feedback loop could, which is critical for a rapid fight-or-flight response.

(c) having two hormones allows blood glucose to be raised in response to two different types of stimulus: a genuine fall in blood glucose (glucagon) and an anticipated increase in demand due to stress/exercise (adrenaline), oe **B1**

(c) this provides redundancy/back-up, so that if one signalling pathway is impaired, the other can still help raise blood glucose when needed oe **B1**

(c) it allows a graded and more precisely appropriate response, since the two hormones can act together or independently depending on the situation, giving finer control than a single hormone alone oe **B1**

(c) Answer: Two hormones allow blood glucose to be raised in response to different situations (falling glucose versus anticipated stress), provide a degree of redundancy if one pathway is impaired, and allow more finely graded control than a single hormone could provide.

© Revision Library | revisionlibrary.co.uk

Question 6

(a) 125 x 60 x 24 = 180000 cm^3 **M1**

(a) 180 dm3, cao **A1**

(a) Answer: 180 dm3

(b) reabsorbed per minute = 125 - 1.0 = 124 cm^3 **M1**

(b) percentage reabsorbed = 124/125 x 100 **M1**

(b) 99.2%, awrt **A1**

(b) Answer: 99.2%

(c) glucose and amino acids are actively/selectively reabsorbed by specific co-transporter proteins in the proximal convoluted tubule wall, which the cell has in sufficient number to reabsorb essentially all of the useful solute present under normal conditions oe **B1**

(c) urea is a waste product with no specific reabsorption mechanism/no specific transporter protein oe **B1**

(c) urea only re-enters the blood by diffusion down its concentration gradient (as water reabsorption concentrates it in the tubule), so only some of it is reabsorbed, and most passes out in the urine oe **B1**

(c) Answer: Glucose and amino acids are actively reabsorbed via specific co-transporters, so almost all is recovered; urea has no specific transporter and only diffuses back passively, so only part of it is reabsorbed and most remains in the urine.

© Revision Library | revisionlibrary.co.uk