Question	Answers			Extra information	Mark	AO Spec reference
1(a)(i)	**Physiological response**	**Warming effect**	**Cooling effect**	One mark per correct row	4	AO1 5.1.1(d)
	hairs lying flat on skin		✓			
	shivering	✓				
	reduced metabolic rate in the liver		✓			
	increase in sweating		✓			
1(a)(ii)	Any three from: reduces body temperature ✓ arterioles (near skin surface) widen ✓ more blood flows through capillaries (near skin surface) ✓ more heat radiated from skin surface ✓			Accept limits further increase in body temperature	3 max	AO1 5.1.1(d)
1(b)(i)	(peripheral temperature receptors in) skin ✓ (temperature-sensitive neurones in) hypothalamus ✓				2	AO1 5.1.1(d)
1(b)(ii)	Any three from: sweat glands ✓ erector pili muscles ✓ skeletal muscle ✓ sphincter muscles (controlling arteriole constriction and dilation) ✓ adrenal glands ✓ cardiac muscle ✓			Accept arrector pili muscles	3 max	AO1 5.1.1(d)

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Question	Answers	Extra information	Mark	AO Spec reference
1(b)(iii)	Any four from: maintains core body temperature ✔ within a narrow range / near set point / near 37 °C ✔ thermoregulatory centre / temperature-sensitive neurones / temperature receptors detect temperature change ✔ *idea of* stimulates nervous system / endocrine system response ✔ negative feedback ✔ to reverse / limit change in temperature ✔	Accept (blood) temperature returns to set point	4 max	AO1 5.1.1(d)
1(c)	surface area ✔ respiration ✔ conduction ✔		3	AO1 5.1.1(d)
2(a)	*idea of* respond to changes in the (internal or external) environment ✔ **OR** to coordinate the activities of different organs ✔	Accept a described example Accept a described example	1 max	AO1 5.1.1(a)
2(b)	Any five from: *agree* animals have a nervous system **and** plants do not ✔ animals have blood vessels (to transport hormones) **and** plants do not ✔ animals have glands **and** plants do not ✔ *disagree* both use hormones ✔ both have target cells / receptors on cells ✔ both produce cellular / genetic changes ✔	Accept most plant cells can produce hormones	5 max	AO3 3.1.2(a) 5.1.1(a) 5.1.3(b) 5.1.4(a) 5.1.4(b) 5.1.5(b)

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Question	Answers	Extra information	Mark	AO Spec reference
2(c)	<table><tr><th>Example of homeostasis</th><th>Receptor</th><th>Effector</th></tr><tr><td>control of water potential</td><td>osmoreceptor</td><td>(posterior) pituitary gland / collecting duct</td></tr><tr><td>control of heart rate</td><td>chemoreceptor / pH receptor / baroreceptor / pressure receptor</td><td>cardiac / heart , muscle</td></tr><tr><td>body temperature regulation</td><td>thermoreceptor / temperature receptor</td><td>sweat glands / erector pili muscles / skeletal muscle / sphincter muscles / adrenal glands / cardiac muscle</td></tr></table>	One mark per correct box	6	AO1 5.1.1(c) 5.1.2(d) 5.1.5(k)
3(a)	**Level 3 (5–6 marks)** Outlines the events in the regulation of blood glucose concentration, with no/few errors and a clear understanding of negative feedback. *There is a well-developed line of reasoning, which is clear and logically-structured and uses scientific terminology at an appropriate level. All the information presented is relevant and forms a continuous narrative.* **Level 2 (3–4 marks)** Outlines the events in the regulation of blood glucose concentration, with some errors or omissions. *There is a line of reasoning presented with some structure and use of appropriate scientific language. The information presented is mostly relevant.* **Level 1 (1–2 marks)** Outlines aspects of the regulation of blood glucose concentration, with major errors or omissions.	**Indicative content**: • reference to blood glucose concentration set point • understanding/clear description of the concept of negative feedback • detection of changes in blood glucose concentration in pancreatic cells • description of negative feedback when blood glucose is too low (e.g., glucagon release and effects in liver cells, such as glycogenolysis)	6	AO1 5.1.1(c) 5.1.4(d)

Question	Answers	Extra information	Mark	AO Spec reference
	The information is communicated with only a little structure. Communication is hampered by the inappropriate use of technical terms. **0 marks** No response or no response worthy of credit.	• description of negative feedback when blood glucose is too high (e.g., insulin release and effects in liver cells, such as glycogenesis)		
3(b)	Any three from: *idea that* water potential will change due to environmental conditions / food intake / water intake / metabolism ✓ *idea that* any deviation away from set point is reversed by negative feedback ✓ correct ref. to osmoreceptors / hypothalamus / ADH / collecting duct ✓ *idea that* negative feedback causes overshoot beyond set point ✓		3 max	AO19 5.1.1(c) 5.1.2(d)
3(c)	Any three from: *idea that* positive feedback enhances the effect of the original stimulus ✓ diffusion of Na^+ ions into neurone ✓ opens voltage-gated Na^+ ion channels ✓ (so that) more Na^+ ions enter ✓		3 max	AO2 5.1.1(c) 5.1.3(c)
4(a)	Any two from: paracrine signalling does not require transport in blood vessels ✓ *idea that* endocrine signalling works over longer distances ✓ endocrine signalling uses hormones ✓ both use receptors on target cells ✓	Accept reverse arguments	2 max	AO2 5.1.1(b) 5.1.4(a)
4(b)	**Level 3 (5–6 marks)** A detailed outline of cell signalling in the immune system, with no/few errors or omissions. *There is a well-developed line of reasoning, which is clear and logically-structured and uses scientific terminology at an appropriate level. All the information presented is relevant and forms a continuous narrative.*	**Indicative content**: • mast cells release histamines for inflammatory response • cytokines / interferons / interleukins • attraction of phagocytes to wound/infection sites	6	AO1 4.1.1(e) 4.1.1(f) 4.1.1(g) 5.1.1(b)

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Question	Answers	Extra information	Mark	AO Spec reference
	Level 2 (3–4 marks) An outline of cell signalling in the immune system, with some errors or omissions. *There is a line of reasoning presented with some structure and use of appropriate scientific language. The information presented is mostly relevant.* **Level 1 (1–2 marks)** Outlines aspects of cell signalling in the immune system, with major errors or omissions. *The information is communicated with only a little structure. Communication is hampered by the inappropriate use of technical terms.* **0 marks** No response or no response worthy of credit	• phagocyte / macrophage / antigen-presenting cell signalling • stimulation of proliferation and differentiation of B and T cells stimulation of killer T cell activity		
5(a)(i)	generates heat internally ✓ stable core body temperature (at high environmental temperatures) ✓		2	AO2 5.1.1(d)
5(a)(ii)	lack of fur ✓ *idea of* reliance on behavioural responses ✓ core body temperature can vary (at low environmental temperatures) ✓		3	AO2 5.1.1(d)
6(a)	*idea of* standardised temperature measurement procedure ✓ use thermometer with , high resolution / low uncertainty ✓ take repeat readings / increase sample sizes ✓	e.g., tympanic measurement of core temperature tends to be more accurate than oral or axillary measurements. All students would need to use the same measurement (preferably tympanic).	3	AO3 5.1.1(d)

Question	Answers	Extra information	Mark	AO Spec reference
		NOTE: Repeats (or increasing sample sizes) may reduce the impact of random measurement errors and increase the accuracy of the mean value.		
6(b)(i)	1.480 ✓ ✓ ✓ ✓	ALLOW three marks $\sigma^2 = 0.0144$ and 0.0484 $\left(\dfrac{0.0144}{13}\right) + \left(\dfrac{0.0484}{14}\right) = 0.004564834$ ✓ $\sqrt{0.004564834} = 0.06756356$ ✓ $\dfrac{0.1}{0.06756356} = 1.480$ ✓ Award 4 marks for correct final answer Accept 1.48 or any correct rounding of calculator value. Allow errors carried forward If the final answer is incorrect, award one mark for each step of the working, up to a maximum of 3 marks	4	AO2 5.1.1(d)

Question	Answers	Extra information	Mark	AO Spec reference
6(b)(ii)	no significant difference between the means of the two groups ✓ (greater than) 95% probability that the differences are due to chance ✓	Accept reverse arguments if the calculated value in **6(b)(i)** is greater than 2.06 Accept (less than) 5% probability that the differences are due to chance	2	AO3 5.1.1(d)

Skills box answers

Question	Answer
1	$kJ\,m^{-2}\,year^{-1}$ or $kJ\,ha^{-1}\,year^{-1}$
2(a)	5.50%
2(b)	60.3%
2(c)	16.7%
3	percentage efficiency increases from 10% to 48%
4	the efficiency of energy transferred would increase, which is a positive; however, fish provide a good source of protein which may be missing in algae;