Regulatory hormones

Question Paper

Level	Pre U
Subject	Biology
Exam Board	Cambridge International Examinations
Topic	Animal physiology
Sub Topic	Regulatory hormones
Booklet	Question Paper

Time Allowed: **82 minutes**

Score: **/68**

Percentage: **/100**

Part - A

1 Lactate dehydrogenase (LDH) is an enzyme found in many organisms. Within the same organism, it can be found in different forms, called isoenzymes. The isoenzymes are structurally different but all catalyse the same reaction.

(a) (i) Fig. 21.1 shows a reaction catalysed by lactate dehydrogenase that occurs during anaerobic respiration in muscle tissue.

Complete Fig. 21.1 by identifying the compounds **A**, **B** and **C**.

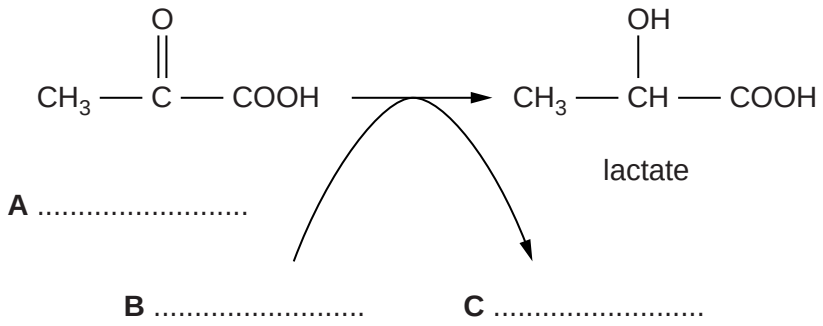

Fig. 21.1

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(ii) State where in the cell this reaction takes place.

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(iii) Explain the importance of this reaction in mammalian muscle tissue.

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Lactate dehydrogenase isoenzymes are globular proteins, each consisting of four polypeptides.

(b) Describe the structure of an enzyme, such as lactate dehydrogenase, and explain how this structure is suited to its role.

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Lactate dehydrogenase isoenzymes are made up of two types of polypeptide: polypeptide M, which is coded for by the *LDH-A* gene and polypeptide H, which is coded for by the *LDH-B* gene.

Table 21.1 shows the composition of different human lactate dehydrogenase isoenzymes and examples of tissues and organs where each can be found.

Table 21.1

isoenzyme	polypeptide composition of enzyme	example of isoenzyme location
LDH-1	HHHH	heart red blood cells
LDH-2	HHHM	heart red blood cells
LDH-3	HHMM	brain lungs
LDH-4	HMMM	kidneys placenta
LDH-5	MMMM	liver skeletal muscles

(c) With reference to Table 21.1, suggest how cells of different tissues of the same individual can produce different isoenzymes.

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(d) LDH can be present in blood plasma as a result of tissue damage.

Blood samples can be taken and tested to measure the concentrations of different LDH isoenzymes.

(i) This test can help in the diagnosis of heart attacks resulting from atheroma formation.

Explain how atheroma can lead to a heart attack.

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(ii) Suggest how a test for LDH isoenzymes can help in the diagnosis of different conditions.

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(e) The base sequences of the *LDH-A* and *LDH-B* genes and the sequences of the amino acids encoded by these genes were determined.

Fig. 21.2 shows the first ten amino acids of polypeptides M and H and the corresponding base sequences of one of the DNA strands of each gene.

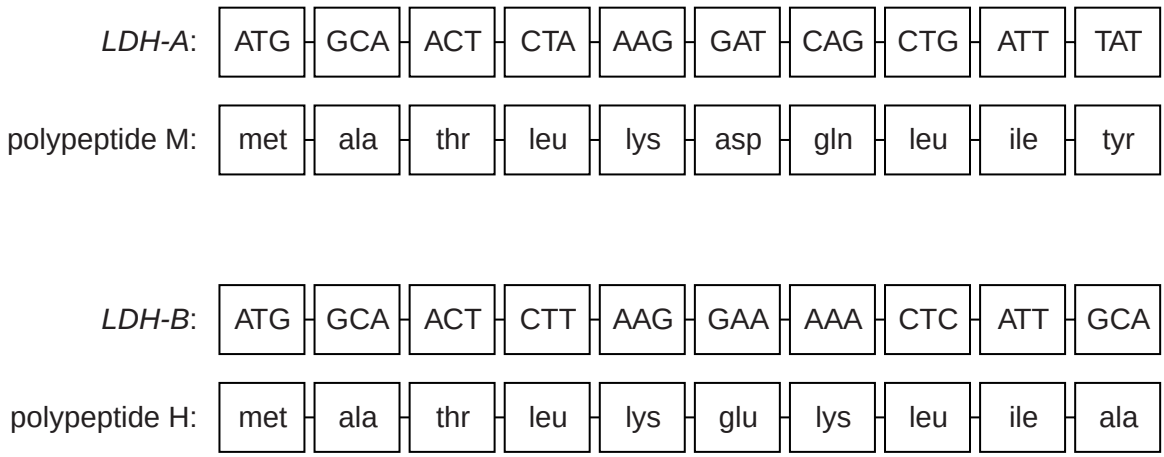

Fig. 21.2

Table 21.2 shows the genetic code (mRNA codons).

Table 21.2

first position	second position				third position
	U	C	A	G	
U	phe	ser	tyr	cys	U
	phe	ser	tyr	cys	C
	leu	ser	STOP	STOP	A
	leu	ser	STOP	trp	G
C	leu	pro	his	arg	U
	leu	pro	his	arg	C
	leu	pro	gln	arg	A
	leu	pro	gln	arg	G
A	ile	thr	asn	ser	U
	ile	thr	asn	ser	C
	ile	thr	lys	arg	A
	met	thr	lys	arg	G
G	val	ala	asp	gly	U
	val	ala	asp	gly	C
	val	ala	glu	gly	A
	val	ala	glu	gly	G

Comment on the sequences shown in Fig. 21.2. You may refer to Table 21.2.

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[Total: 26]

Part - B

Type 2 diabetes – the growing threat

Diabetes mellitus currently affects at least 2.5 million people in the UK and is a condition in which the body is unable to maintain a normal blood glucose concentration. Many people who have no experience of diabetes think that the more common form is type 1, requiring insulin injections. Yet this is not the case. By far the more common is type 2, which represents approximately 85–90% of cases, and is on the increase. Originally thought of as affecting older people it is becoming increasingly common among the young. It is thought that obesity is an important risk factor. There is no entirely successful way of treating type 2 diabetes although it can be managed by control of diet, appropriate exercise and the use of medication.

Those with the condition, at least initially, produce insulin normally but certain body cells develop insulin resistance. This means that they do not respond to the hormone by taking up glucose from the blood rapidly enough to maintain a normal blood glucose concentration. The permeability of cell membranes is dependent on the presence of transporter protein molecules. Table 1.1 provides information about two types of such transporters, GLUT and SGLT. Table 1.1 distinguishes four types (isoforms) of GLUT.

Table 1.1

transporter group	type of mechanism	isoform	mainly present in	further information
GLUT (glucose transporters)	facilitated diffusion	GLUT1	cells	low-level basal glucose uptake required to sustain respiration
		GLUT2	cells in small intestine lining, in the liver and in cells of kidney tubules	in the kidney tubule these transport glucose from cells lining the nephron into capillaries
		GLUT3	neu	probably main glucose transporter in neurones
		GLUT4	adipose cells and striated muscle cells (skeletal and cardiac)	insulin-controlled glucose transporter
SGLT (sodium-glucose linked transporters)	secondary active transport along sodium gradient		cells lining the proximal tubule of nephrons	transport glucose directly from glomerular filtrate into cells lining nephron

Insulin is produced by the β cells of the islets of Langerhans within the pancreas. When the insulin concentration of the blood is low, GLUT4 molecules are removed from the cell membranes of adipose cells and skeletal muscle cells into vesicles in the cytoplasm. Except in the case of type 2 diabetes, an increase in blood insulin concentration means that insulin combines with specific sites on the cell surface membrane. This causes the GLUT4 molecules to be restored to the membrane, making it permeable to glucose. When blood insulin concentration falls, the GLUT4 molecules are removed from the membrane into cytoplasmic vesicles again.

On the onset of type 2 diabetes the patient's cells become insulin-resistant. Initially the pancreas responds by producing extra insulin. This only partially alleviates the problem of insulin resistance and, in time, overworking of the pancreatic β cells leads to their death and subsequently a reduction in insulin production. At this stage the patient may need to receive insulin injections, although this offers only a partial solution.

2 **(a)** After a meal, blood glucose concentration rises above the target concentration (4.5–5.5 mmol dm^{-3}) at which it is normally maintained by homeostasis.

With the help of Table 1.1, outline how the glucose concentration is reduced to normal in a person who does not have diabetes.

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(b) In the space below draw a simple, labelled diagram showing how protein transporter molecules may form part of a cell surface membrane.

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(c) Explain how the uptake of glucose by cells in the proximal convoluted tubule differs from its uptake by liver cells.

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(d) **(i)** Suggest a mechanism by which the glucose transporter GLUT4 is restored to the membrane when insulin binds to the cell surface membrane.

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(ii) To what extent might the removal of GLUT4 from a muscle cell surface membrane render it impermeable to glucose?

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[Total: 12]

3 ‘In multicellular organisms the body can only function properly when the cells are in constant communication with each other.’

Explain how this is true for humans with reference to the endocrine system.

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