Cambridge Pre-U

Cambridge International Examinations
Cambridge Pre-U Certificate

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

0123456789

BIOLOGY (PRINCIPAL) **9790/03**

Paper 3 Case Study and Synoptic Essay **For Examination from 2016**

SPECIMEN PAPER

1 hour 45 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams and graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.
Write your answers in the spaces provided on the Question Paper.

Section B
Answer **one** question.
Write your answers on the Question Paper.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

The syllabus is approved for use in England, Wales and Northern Ireland as a Cambridge International Level 3 Pre-U Certificate.

This document consists of **11** printed pages and **1** blank page.

CAMBRIDGE International Examinations

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Section A – Case Study

Read the passage carefully and answer **all** the questions.

You are advised to spend no more than 50 minutes on this section.

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	all 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	neurones	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.

1 **(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.

[4]

(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]

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2 Table 2.1 presents the results of an experiment comparing rates of glucose production by a group of people with type 2 diabetes and a control group without the condition, during 23 hours of fasting.

Table 2.1

	rate of glucose production per unit body mass / μmol kg^{-1} min^{-1}		significance level
	patients with type 2 diabetes	control group	
total glucose production	11.1 ± 0.6	8.9 ± 0.5	$p < 0.05$
glucose from hydrolysis of glycogen in the liver	1.3 ± 0.2	2.8 ± 0.7	$p < 0.05$
glucose from gluconeogenesis	9.8 ± 0.7	6.1 ± 0.5	$p < 0.01$

(a) Discuss the conclusions which can be drawn from the data in Table 2.1.

[6]

(b) In individuals without diabetes, the blood glucose concentration in the renal vein is only slightly lower than in the renal artery.

Explain why one might expect the glucose concentration of the blood in the renal vein to be much **lower** than in the renal artery **and** suggest why, in fact, the concentrations are almost identical.

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[Total: 10]

3 It is possible to restore insulin secretion in a diabetic patient by transplanting a pancreas or isolated islets of Langerhans, but limited donor organs and risks involved restrict these therapies to a small proportion of people with diabetes. Recent experiments suggest that it may, in future, be possible to treat diabetes with adult stem cells from the patient's own bone marrow.

Explain why such an approach, once perfected, is more likely to offer, at least initially, a treatment for type 1 rather than type 2 diabetes **and** discuss why this approach may be preferable to the use of transplants or embryonic stem cells.

[8]

[Total: 8]

[Total for Section A: 30]

Section B – Synoptic Essay

Answer **one** question on the lined paper that follows.

You are advised to spend no more than 50 minutes on this section.

Choose **one** question from question 4, question 5 or question 6.

4 'There is no evolutionary advantage in being multicellular'.

Discuss this view.

5 All living organisms need to synthesise ATP. Explain the similarities and differences between organisms in the ways in which this is achieved.

6 Why do people get heart disease and what should be done about it?

Your answer should draw from a wide range of syllabus material and also demonstrate evidence of reading around the subject. [30]

[Total for Section B: 30]