Cambridge Pre-U

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
Cambridge International Level 3 Pre-U Certificate
Principal Subject

CANDIDATE NAME

CENTRE NUMBER | | | | | |

CANDIDATE NUMBER | | | | |

BIOLOGY **9790/03**

Paper 3 Long Answer **May/June 2011**

2 hours 30 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 a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

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

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

Section C
Answer **one** question.
Write your answer on the Question Paper. Separate answer paper will be available if required.

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.

For Examiner's Use	
1	
2	
3	
4	
Section B	
Section C	
Total	

This document consists of **19** printed pages and **1** blank page.

Section A

For Examiner's Use

Answer **all** the questions in the spaces provided.

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

1 Fig. 1.1 is an electronmicrograph of a differentiated human B-cell (plasma cell) in the process of producing antibodies.

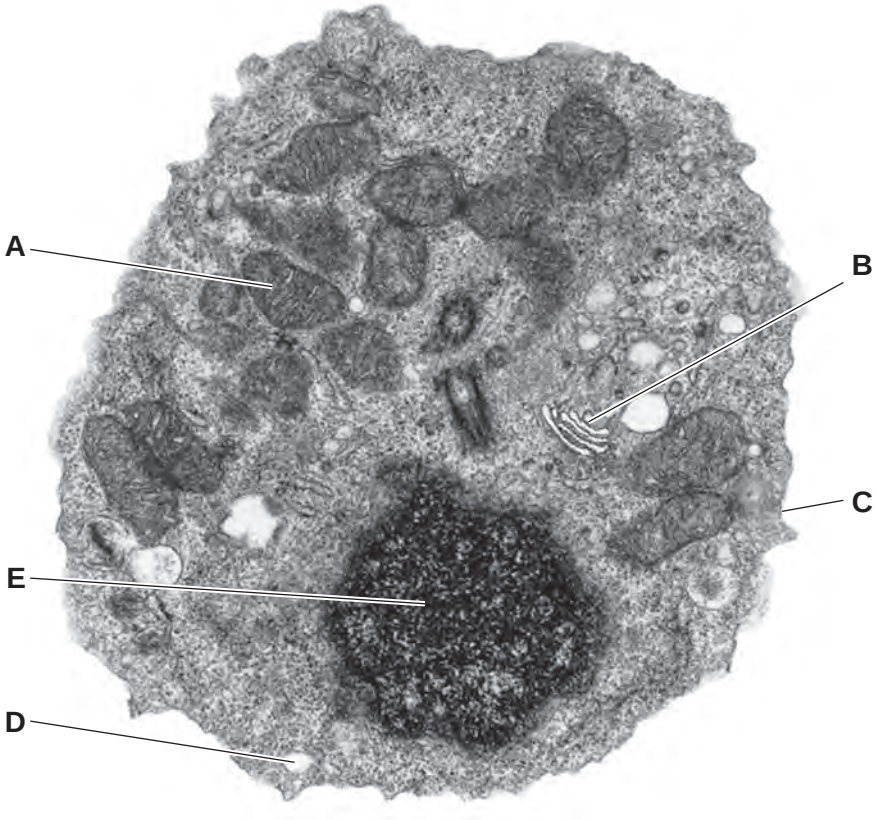

Fig. 1.1

(a) Name a part of the human body where B-cells

(i) are produced by division of stem cells,

.....[1]

(ii) produce antibodies.

.....[1]

(b) Name structures **A** and **B**.

A .....

B .....[2]

(c) Antibodies are proteins. With reference to structures **A** to **E**, outline the sequence of events that occur in the production and release of antibody proteins by differentiated B-cells (plasma cells).

For Examiner's Use

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[Total: 10]

2 Nitrogen is important in the synthesis of proteins.
Producing protein is an important aspect of plant growth.

(a) Name two types of nitrogen-containing organic molecules that are essential to enable a maize plant to produce proteins.

1 .....

2 ..... [2]

Protein production influences crop yield. The effects of nitrogen availability and plant density on yield of maize plants were investigated. Table 2.1 shows the results of this investigation.

Table 2.1

density / number of maize plants per m^2	mean yield of grain / g m^{-2}	mean yield of grain per plant / g	mean yield of grain / g m^{-2}	mean yield of grain per plant / g
	high nitrogen availability		low nitrogen availability	
4	811	203	477	119
8	1254	157	674	84
12	1309	109	635	53
16	1376	86	531	33
20	1444	72	498	25
24	1297	54	383	16

(b) With reference to Table 2.1, describe the patterns shown in the data **and** suggest possible explanations for them.

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[Total: 7]

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3 Fig. 3.1 shows diagrams of the circulatory systems of three groups of vertebrate: fish, amphibians and mammals.

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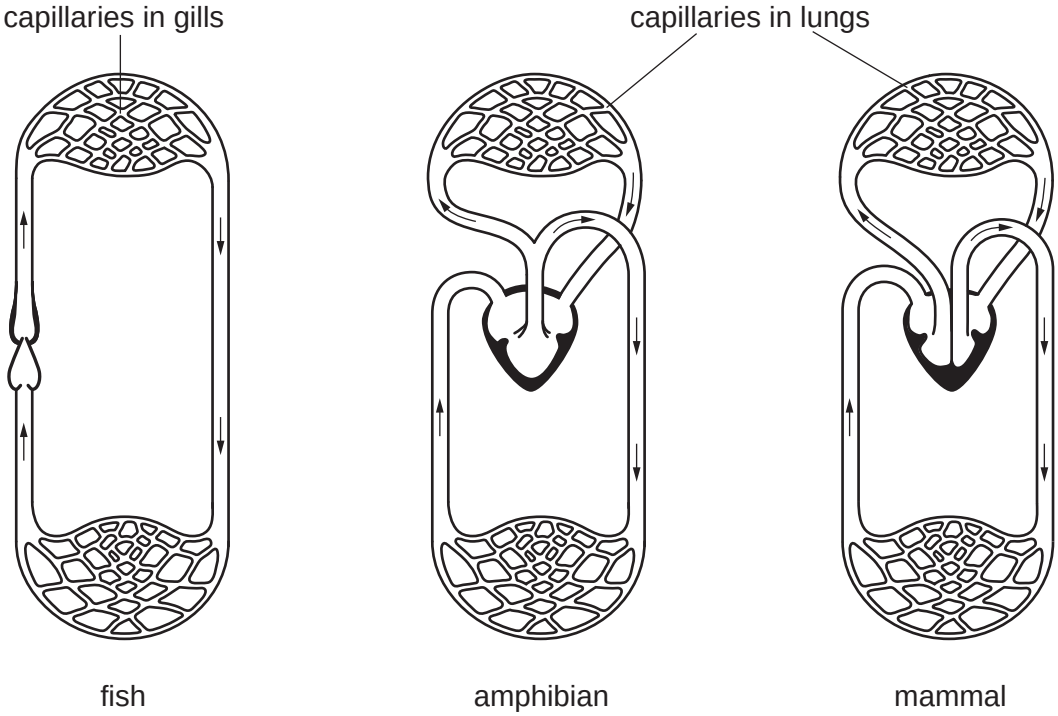

Fig. 3.1

(a) State three ways in which the circulatory systems shown in Fig. 3.1 are similar.

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(b) State **and** explain the advantages to a mammal of the circulatory system shown in Fig. 3.1 in comparison to the circulatory systems of fish and amphibians.

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[Total: 10]

4 Fig. 4.1 and Fig. 4.2 show the effects of leaf temperature and light intensity on the rate of photosynthesis in a leaf of the plant *Atriplex patula.* This plant grows in temperate regions.

All measurements were made at atmospheric carbon dioxide concentration and show results at two different concentrations of oxygen.

All measurements in Fig. 4.1 were taken at a light intensity of $300\,J\,m^{-2}\,s^{-1}$. All measurements in Fig. 4.2 were taken at 27 °C.

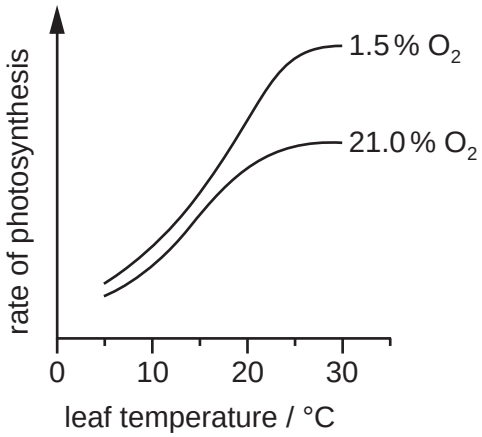

Fig. 4.1

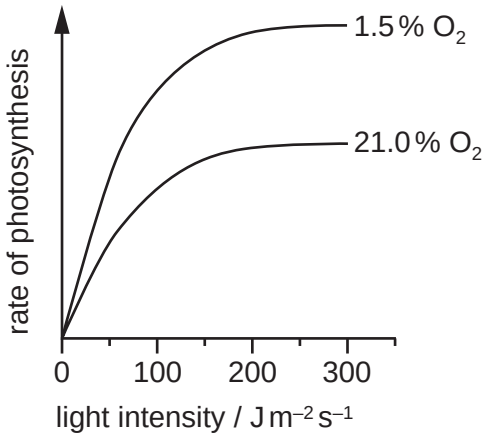

Fig. 4.2

(a) In Fig. 4.2 the units used for light intensity are $J\,m^{-2}\,s^{-1}$. State the meaning of these abbreviations in words.

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(b) With reference to Fig. 4.1, compare and contrast the effects of leaf temperature on the rate of photosynthesis at oxygen concentrations of 21.0 % and 1.5 %.

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(c) Why was the experiment on the effect of leaf temperature (Fig. 4.1) carried out in conditions of light saturation?

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(d) In certain conditions, oxygen exerts a significant inhibitory effect on photosynthesis in *A. patula*.

With reference to Fig. 4.1 and Fig. 4.2, state what these conditions might be.

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(e) Explain, with reference to reactions within the light-independent stage of photosynthesis and the data provided, how oxygen inhibits photosynthesis in *A. patula*.

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[Total: 13]

Section B

Read the passage carefully and answer **all** the questions in the spaces provided.

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

Mitochondrial Eve: the mother of us all?

In 1987, Cann, Stoneking and Wilson published the results of research which led them to suggest that all modern humans, of whatever race, are descended from one woman, Mitochondrial Eve, who lived in Africa between 150 000 to 200 000 years ago. This extraordinary claim, which remains controversial, was based on analysis of mitochondrial DNA (mtDNA) of 157 people chosen to represent all existing racial groups. In 2000, Ingman and his co-workers carried out a similar study based on a sample of 53 people of different races using improved techniques and arrived at a similar conclusion.

The investigation was carried out by studying the nucleotide sequence of DNA of the mitochondria of each person. mtDNA consists of a circle of DNA made up of about 37 genes concerned with the production of proteins, including cytochrome c oxidase and NADH dehydrogenase. Features of mtDNA which make it particularly important in this type of study include:

- higher mutation rate than chromosomal DNA,
- little or no genetic recombination,
- humans, male or female, derive all their mitochondria from their mother through the cytoplasm of the ovum.

The figure of between 150 000 and 200 000 years ago is derived by means of a method of calculation known as the Molecular Clock Hypothesis. This is based on the average rate of mutation of DNA over time and the idea that the greater the difference in nucleotide sequence, the longer ago it was that individuals shared a common ancestor. The molecular clock can be calibrated by comparing the differences in nucleotide sequence between similar species whose date of speciation can be calculated independently from fossil evidence.

Mitochondrial Eve was a modern human, *Homo sapiens*, like yourself. When her descendants arrived in Europe over 40 000 years ago they found a population of another human-like animal already present, now known as Neanderthals. By about 30 000 years ago, the Neanderthals had become extinct.

A question which interests many people is ‘were the Neanderthals and *H. sapiens* separate species – or just slightly different races of the same species?’

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5 **(a)** Name **and** outline the theory which accounts for the existence of mitochondria in eukaryotic cells.

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(b) Suggest why it is biologically important that mtDNA includes genes for cytochrome c oxidase and NADH dehydrogenase.

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(c) Suggest how all the mitochondria in a male muscle cell derive from the mitochondria of his mother.

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(d) mtDNA is a group of genes which is transmitted to both male and female offspring.

How may a group of genes be transmitted **only** to male offspring?

.....[1]

[Total: 10]

6 In 2000, Geisert and his co-workers carried out research on mtDNA. They analysed the nucleotide sequence of the mtDNA of

- 994 modern humans (including a range of racial groups)
- one Neanderthal fossil
- nine chimpanzees.

Once they knew the nucleotide sequences of each of these samples of mtDNA they compared each of these sequences with each of the 994 modern human nucleotide sequences. In this way they were able to make human to human, Neanderthal to human and chimpanzee to human comparisons. The number of differences in the nucleotide sequence for each comparison was then recorded. The differences in mtDNA were quite small – no more than a few nucleotide bases – and relatively neutral in terms of evolution.

The results of these comparisons are shown in Fig. 6.1.

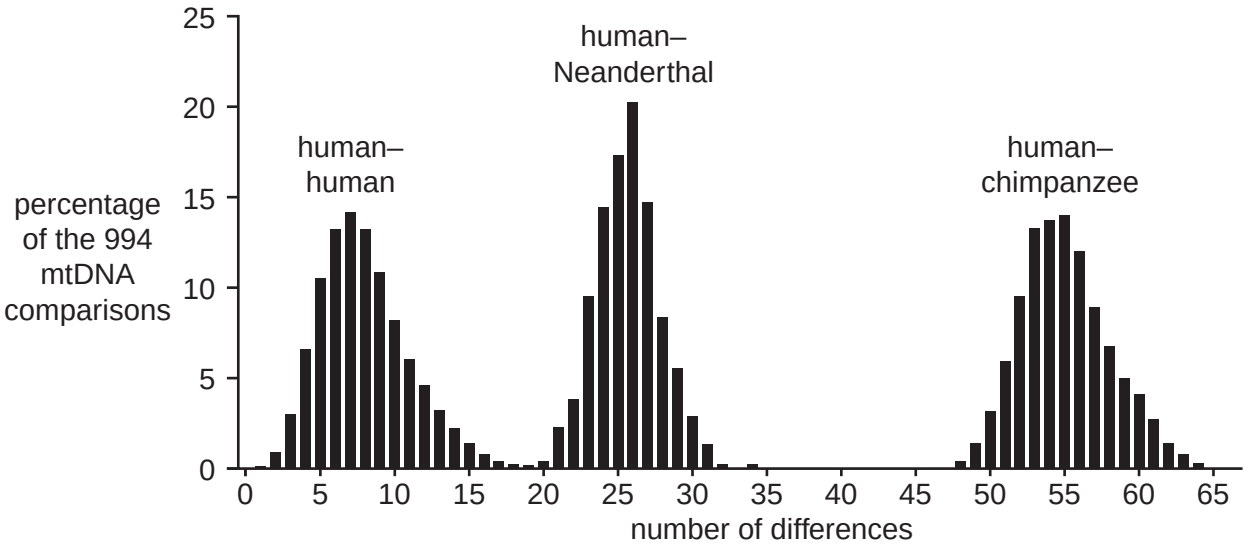

Fig. 6.1

(a) Neanderthal mtDNA is very difficult to obtain. In the case of the specimen referred to in Fig. 6.1, only very small quantities were available.

Suggest how the researchers were able to copy many times the few available Neanderthal mtDNA molecules to provide enough mtDNA to carry out their analyses.

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(b) Suggest why the higher mutation rate and the virtual absence of recombination make mtDNA more useful in tracing ancestry over many generations than the chromosomal DNA of eukaryotic cells.

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(c) Comment on the information given in Fig. 6.1.

You may wish to include potential conclusions, discussion or evaluation in your comments.

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[Total: 11]

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7 **(a)** The text in question 6 states that the changes in mtDNA were 'relatively neutral in terms of evolution'.

Explain what is meant by this statement.

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.....[2]

(b) mtDNA evidence alone is unlikely to be enough to determine whether Neanderthals and modern humans are of the same or of different species.

Suggest what further information would help to resolve this question.

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(c) Suggest what might have been the circumstances which led to one woman giving rise to the whole modern human race.

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[Total: 9]

Section C

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

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

Credit will be given for answers that draw from a wide range of syllabus material and also for evidence of reading around the subject.

8 Discuss how an understanding of ecosystems can contribute to the goal of sustainable development of human populations.

9 '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.

10 Discuss the issues raised for biologists if life were shown to exist, or to have existed in the past, on Mars.

[Total: 30]

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