Cambridge Pre-U

Cambridge International Examinations
Cambridge Pre-U Certificate

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

BIOLOGY (PRINCIPAL) **9790/02**

Paper 2 Long Answer **May/June 2015**

2 hours 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 or 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 **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.

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.

For Examiner's Use	
Section A	
Section B	
7	
8	
9	
Total	

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 **29** printed pages and **3** blank pages.

CAMBRIDGE International Examinations

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Section A

Answer **all** the questions.

You are advised to spend no more than 65 minutes on this section.

Data Analysis

1 In a study of kidney function, scientists investigated filtration of the blood. The site of ultrafiltration is shown in Fig. 1.1.

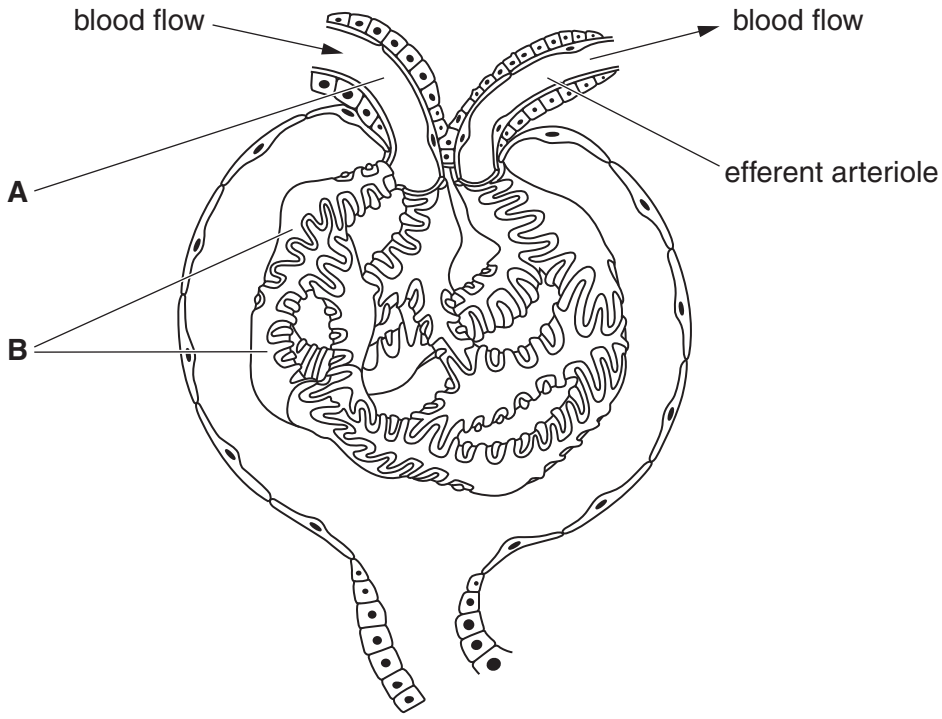

Fig. 1.1

(a) (i) Name the type of cells labelled **B** in Fig. 1.1.

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(ii) Suggest why it is important that the arteriole wall of **A** is thicker than the wall of the efferent arteriole.

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(b) The scientists measured the concentrations of several substances in three body fluids from healthy people:

- the blood of the renal artery
- the glomerular filtrate
- the urine.

The glomerular filtrate : plasma ratio of a substance is obtained by dividing its concentration in the glomerular filtrate by its concentration in the blood plasma. Values can be between 0.00 and 1.00.

Table 1.1 shows the results of this study together with the radius of each molecule or ion. Inulin was injected into the blood since it is not normally present in the blood plasma. It was included in this study because it can be used in determining filtration rates.

Table 1.1

substance	glomerular filtrate : plasma ratio	radius of one molecule or ion / nm
sodium ions	1.00	0.10
water	1.00	0.14
urea	1.00	0.16
glucose	1.00	0.36
inulin	0.98	1.48
albumin protein	0.00	3.55

(i) With reference to Fig. 1.1 and Table 1.1, comment on the results of this study.

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(ii) Sodium ions, urea and glucose have the same glomerular filtrate : plasma ratio but different concentrations in the blood plasma and urine, as shown in Table 1.2.

Table 1.2

substance	concentration in the blood plasma / mmol dm^{-3}	concentration in the urine / mmol dm^{-3}
sodium ions	140–150	50–130
urea	4–7	200–400
glucose	3.9–5.2	0.0

Explain the reasons for these differences.

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(c) One method used to determine the glomerular filtration rate (GFR) involves injecting an inulin solution into a vein. The rate at which inulin is filtered from the blood in the kidneys determines the rate at which it appears in the urine.

Inulin is a substance made by plants and is not normally a constituent of human blood.

(i) Suggest why inulin is suitable for determining the GFR.

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A person was injected with an inulin solution. Five minutes after the injection, a blood sample was taken and analysed to find the initial inulin concentration in the blood plasma. Sixty minutes after the injection, the urine produced in this time was collected and analysed to find the inulin concentration in the urine.

Table 1.3 shows the results of this investigation.

Table 1.3

initial concentration of inulin in the blood plasma / mg cm^{-3}	volume of urine collected 60 minutes after the injection of inulin / cm^3	concentration of inulin in the urine / mg cm^{-3}
0.25	54	3.5

(ii) Suggest why the blood sample was taken five minutes after the injection of inulin and not immediately after it was injected.

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(iii) Calculate the GFR, in cm^3 min^{-1}, using the following formula:

$$\text{GFR} = \frac{\text{concentration of inulin in urine in mg cm}^{-3} \times \text{urine formation rate in cm}^3\,\text{min}^{-1}}{\text{initial concentration of inulin in the blood plasma in mg cm}^{-3}}$$

GFR = ... cm^3 min^{-1} [2]

(d) Fig. 1.2 shows the relationship between the plasma solute concentration and the plasma ADH concentration.

A percentage plasma solute concentration of zero represents the mid-point of the normal range.

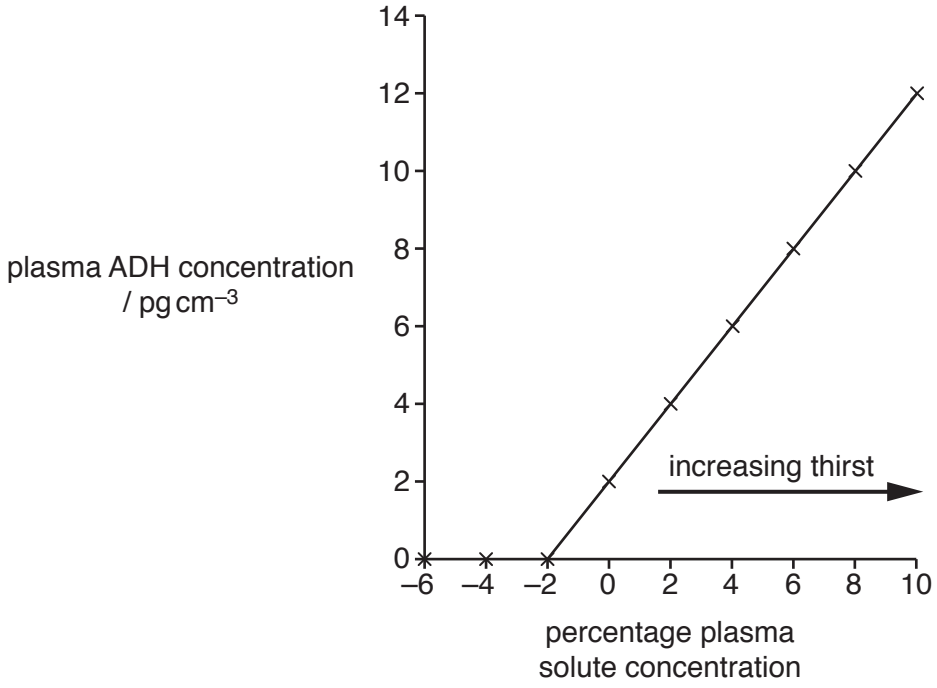

Fig. 1.2

Describe and explain the relationship between plasma solute concentration, ADH secretion and thirst in osmoregulation.

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2 An investigation into a treatment for people who are infected with HIV was carried out involving a large number of people from over 70 countries. In September 1994, the patients began receiving a treatment called HAART (highly active antiretroviral therapy). They were monitored over the following years for helper-T cell counts and clinical outcomes. Data were analysed within six-month periods.

Fig. 2.1, opposite, shows the results of this investigation. The combined AIDS and death rate per six-month period is a measure of the number of patients who developed an illness characteristic of AIDS or who died.

(a) HIV infects helper-T cells. If the infection progresses, the number of helper-T cells decreases. This decrease may make people more susceptible to diseases.

Outline the part that helper-T cells play in the immune system.

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(b) The error bars on the lowest part of Fig. 2.1 are 95% confidence intervals.

Explain what is meant by 95% confidence intervals.

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(c) Suggest what might be concluded from the data in Fig. 2.1 about HAART as a means of controlling the consequences of HIV infection and comment on the validity and limitations of the data.

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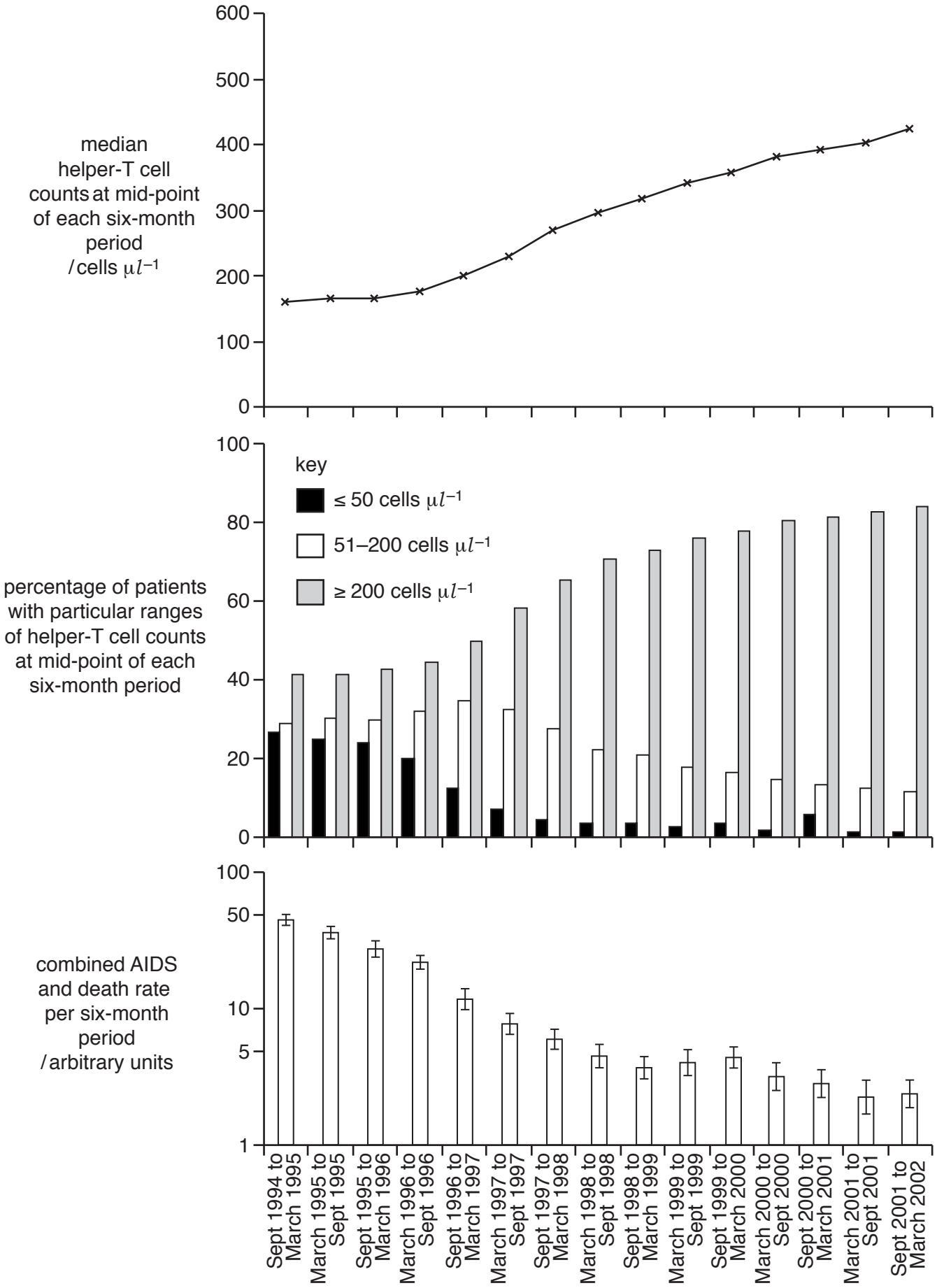

Fig. 2.1

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(d) Nucleotide Analogue Reverse Transcriptase Inhibitor (NtARTi) drugs are used to treat HIV infection. These molecules resemble the four deoxynucleotides used to make DNA. However, each one lacks a hydroxyl group on the 3' carbon of the sugar. This means they are unable to join to the next nucleotide.

Describe the role of reverse transcriptase for the replication of the genetic material of HIV and suggest how NtARTi drugs prevent this.

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The Planning Task

3 A respirometer, such as that shown in Fig. 3.1, can be used to measure the rate of oxygen uptake by living organisms such as beetles.

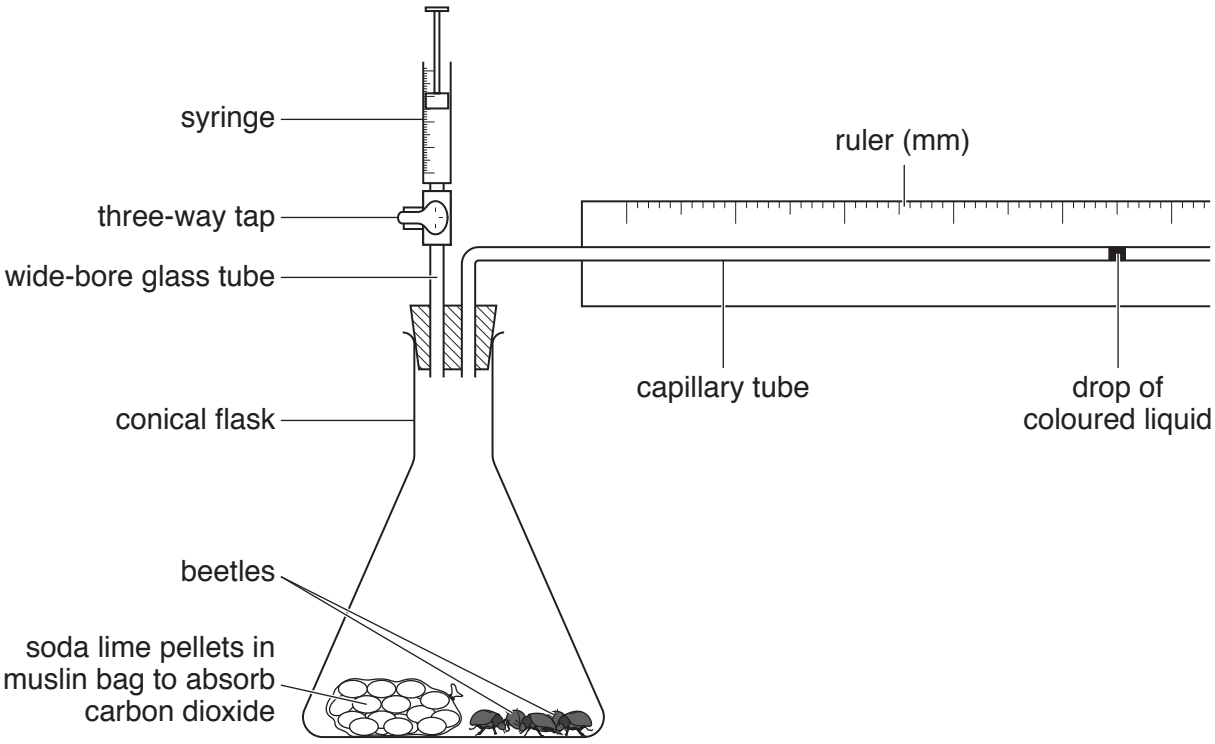

Fig. 3.1

The violet ground beetle, *Carabus violaceus*, and the arctic ground beetle, *C. odoratus*, are two closely related species of beetle. Arctic ground beetles live in colder climates than violet ground beetles.

Plan an investigation to compare the effect of temperature on the rate of oxygen uptake by violet ground beetles with that of arctic ground beetles.

You are provided with the following equipment and materials. Choose your equipment from this list. You may **not** use any additional equipment.

- living arctic and violet ground beetles
- simple respirometers, as shown in Fig. 3.1
- additional soda lime pellets in muslin bags
- additional coloured liquid for the respirometers
- thermostatically-controlled water-baths
- electronic timers
- ice
- clamp stands with clamps
- pipettes and pipette fillers
- beakers of different sizes
- glass rods
- thermometers
- balance
- ruler
- plastic forceps

Your plan should:

- include a clear statement of the hypothesis or prediction
- explain the rationale for your hypothesis or prediction
- clearly outline the overall strategy
- identify the key variables
- give full details and explanations of the procedures that you would adopt to ensure that the results are as precise and repeatable as possible
- show how you would present and analyse your results
- include a brief risk assessment
- be written in clear scientific language.

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Section B

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

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

Case Study

4 A snail, *Cepaea nemoralis* (Fig. 4.1), occurs at sites in many parts of Britain. One of its main predators is the song thrush, *Turdus philomelos*, which hunts by sight. *C. nemoralis* has been widely used in biological research, particularly in genetics, ecology and evolution.

This snail provides an example of polymorphism. Within a population there are often several different forms, but they are all of the same species. The differences are accounted for by a small number of genes.

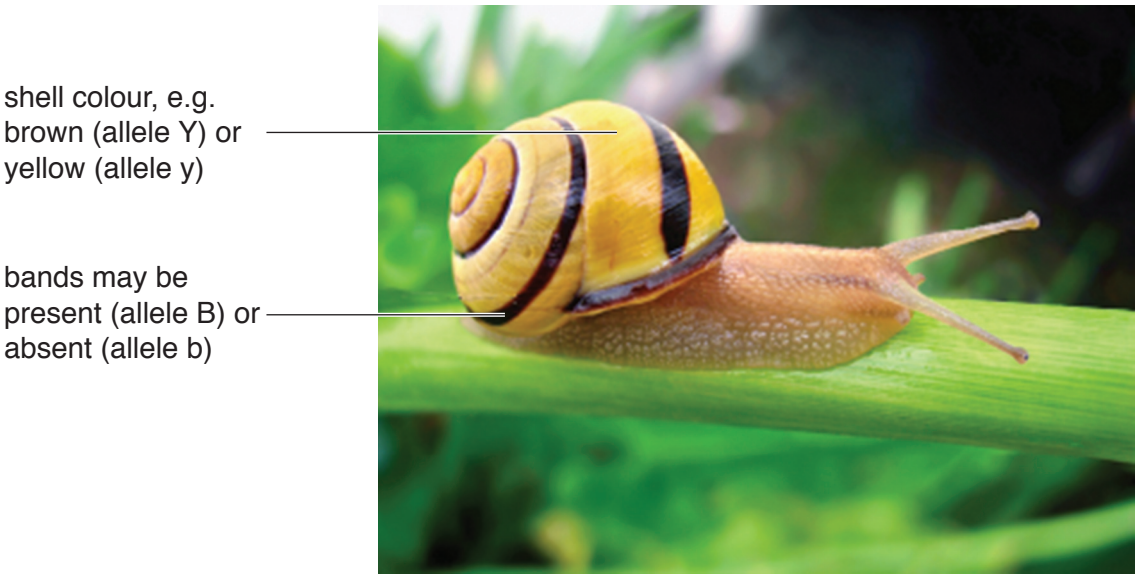

Fig. 4.1

(a) A geneticist crossed a banded, brown snail which was homozygous for both genes (BBYY) with an unbanded, yellow snail (bbyy).

(i) Predict the genotype(s) and phenotype(s) of the offspring of this cross.

genotype(s) .....

phenotype(s) .....

[1]

(ii) The geneticist then crossed the offspring from this cross with unbanded, yellow snails.

In the space below, use a genetic diagram to explain why the geneticist expected the result to be a 1 : 1 : 1 : 1 ratio for the four expected phenotypes.

[3]

(iii) Table 4.1 shows the observed and expected numbers of snails of each phenotype resulting from the cross in **(a) (ii)**.

Table 4.1

phenotype	observed	expected
banded, brown	18	31
unbanded, brown	45	31
banded, yellow	44	31
unbanded, yellow	17	31

Explain how the *expected results* were calculated.

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(b) A chi-squared (χ^2) test comparing the ratio of the expected results with that of the observed results gave a value of 23.55. Using Table 4.2, which is a small extract from a table of χ^2 values, interpret the result of the chi-squared test.

Table 4.2

	probability, *p*				
degrees of freedom	**0.20**	**0.10**	**0.05**	**0.01**	**0.001**
1	1.64	2.71	3.84	6.63	10.83
2	3.22	4.61	5.99	9.21	13.82
3	4.64	6.25	7.81	11.34	16.27
4	5.99	7.78	9.49	13.28	18.47
5	7.29	9.24	11.07	15.09	20.52

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(c) Use your knowledge of meiosis to discuss the results shown in parts **(a)** and **(b)**, and suggest an explanation for the observed results in Table 4.1.

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[Total: 13]

5 The polymorphism in *C. nemoralis* includes snails with shells that are pink, as well as the yellow and brown colours seen in question **4**.

- Snails with many dark bands and snails with a brown shell colour are classed as 'dark-coloured'.
- Unbanded snails with a pink or yellow shell colour are classed as 'light-coloured'.

Fig. 5.1 shows the results of an experiment comparing dark- and light-coloured snails. Electronic temperature sensors recorded the temperature inside the shells of the snails. At the start of the experiment the snails had not emerged from their shells. After 10 minutes the snails were exposed to strong sunlight for a 30-minute period.

The mean time taken for the snails of each colour class to emerge from their shells to feed was measured. Dark-coloured snails emerged after 20.2 minutes of sunlight exposure but light-coloured snails took 29.9 minutes to emerge. This difference was statistically significant at $p \leq 0.05$.

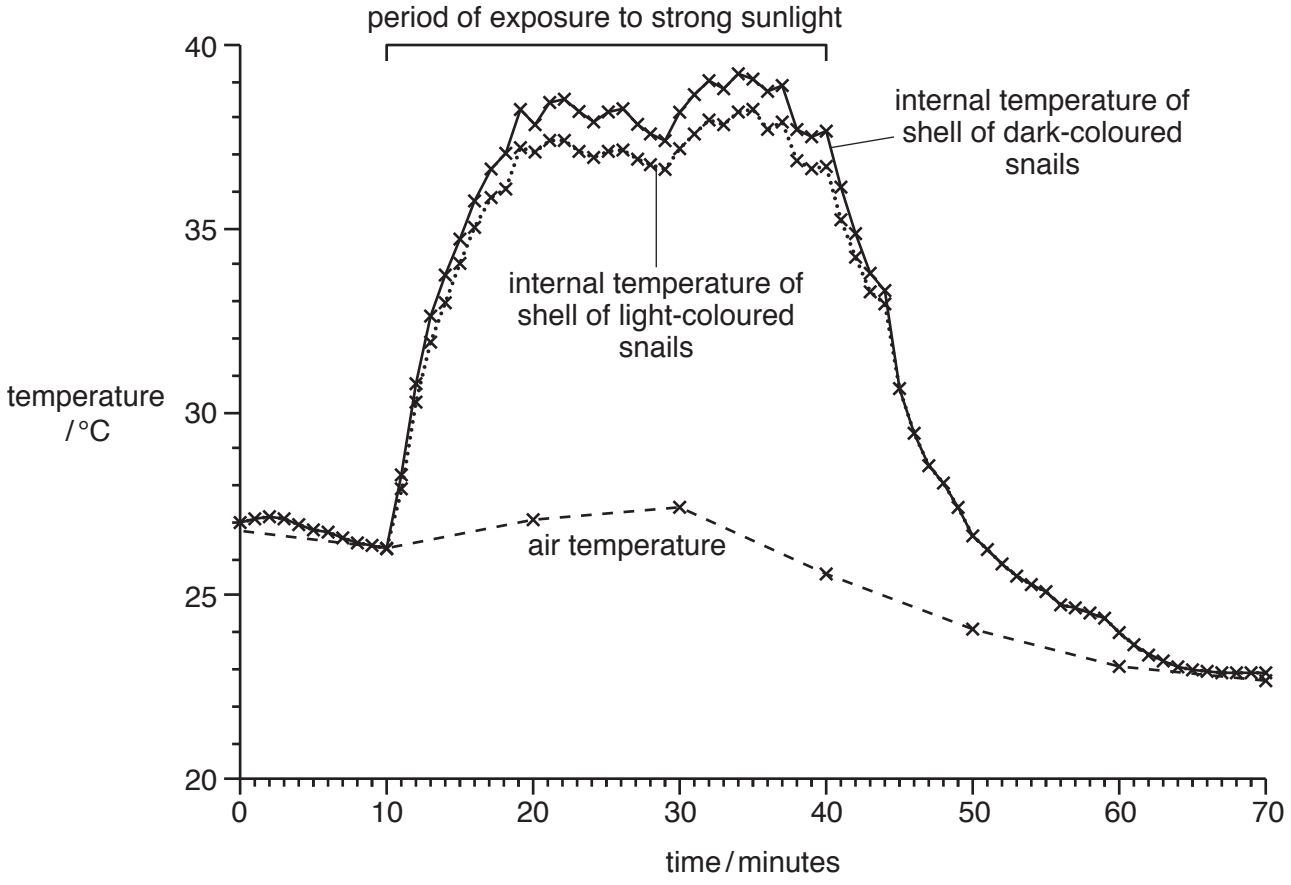

Fig. 5.1

State the conclusions that can be drawn from the results and their significance to the survival of the snails.

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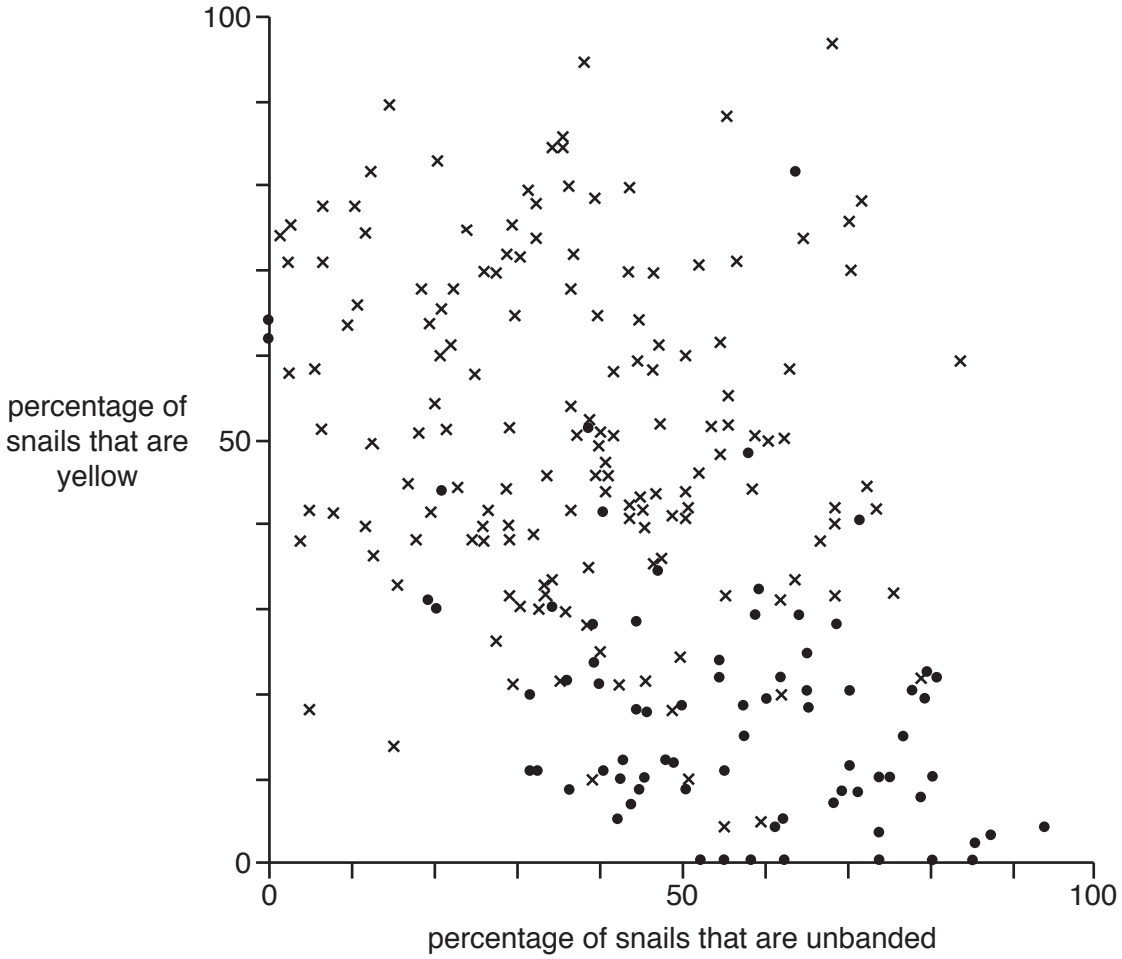
6 In a study of *C. nemoralis* at many sites in woodland habitat and open grassland habitat, the percentage of snails with different types of shell was calculated. At each site:

- the percentage of snails that had unbanded shells, of any colour, was recorded
- the percentage of yellow snails, whether or not they were banded, was recorded.

Fig. 6.1 shows the results.



key

- woodland site
- × open grassland site

Fig. 6.1

(a) (i) With reference to Fig. 6.1, describe how habitat affects shell colour and banding.

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(ii) The genotype for yellow shell colour is homozygous recessive. In many of the sites, yellow is the most common phenotype.

Suggest how the recessive phenotype can become the most common.

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(b) A student carried out a project to study changes in the proportion of different forms of *C. nemoralis* at a particular site over time. The snails differed in shell colour (yellow, pink and brown). Historic data for the site, collected in 1960, were available for comparison. The student marked out a study area corresponding as closely as possible to that of the 1960 study and sampled the 2013 population, obtaining the results presented in Table 6.1.

Table 6.1

phenotype	percentage of snails	
	1960 sample	2013 sample
brown, banded	7	2
brown, unbanded	45	22
pink, banded	37	22
pink, unbanded	5	17
yellow, banded	6	37
yellow, unbanded	0	0

(i) Summarise the changes in this snail population between 1960 and 2013.

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(ii) Suggest ways in which the habitat might have changed to account for the changes shown in Table 6.1.

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(c) Discuss the factors that contribute to maintaining polymorphism in *C. nemoralis*.

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[Total: 12]

[Total for Section B: 30]

Section C

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

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

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

7 Contrast the phylogenetic (cladistic) system with the phenetic system of classification of living organisms, and discuss to what extent each is useful to the study of biology and its practical application.

8 Summarise how cells produce ATP and discuss why life would be impossible without ATP.

9 Describe the modes of action of insulin and glucagon in the regulation of blood glucose concentration. Explain how disruption of this homeostatic mechanism leads to type 2 diabetes.

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