Oxford Cambridge and RSA

Wednesday 21 June 2023 – Morning

A Level Biology A

H420/03 Unified biology

Time allowed: 1 hour 30 minutes

You can use:
- a scientific or graphical calculator
- a ruler (cm/mm)

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **24** pages.

ADVICE
- Read each question carefully before you start your answer.

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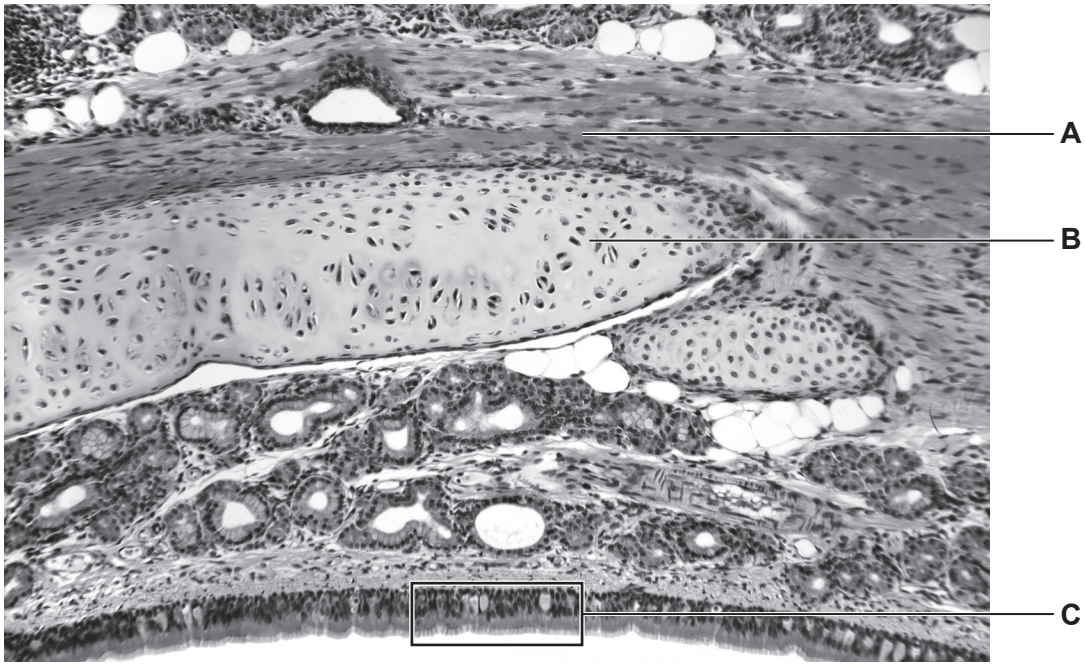
1 Cats are mammals.

(a) A light micrograph of a section through the trachea of a cat is shown in **Fig. 1.1**.

Fig. 1.1



(i) Name the tissues labelled **A** and **B** in **Fig. 1.1**.

A .....

B .....

[2]

(ii) Name the **two** types of cell in the box labelled **C** in **Fig. 1.1 and** outline their functions.

1 Name .....

Function .....

2 Name .....

Function .....

[2]

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(b) Alveoli increase the surface area to volume ratio (SA:V) in the lungs of cats and other mammals.

(i) An alveolus in the lung of a cat has:

- a spherical shape
- a diameter of 0.13 mm
- a surface area of 0.053 mm^2.

Calculate the SA:V of this alveolus.

Use the formula: volume of sphere = $\frac{4}{3}\pi r^3$

SA:V = ... **[3]**

(ii) Explain why the large SA:V of alveoli is an advantage to mammals.

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..... **[1]**

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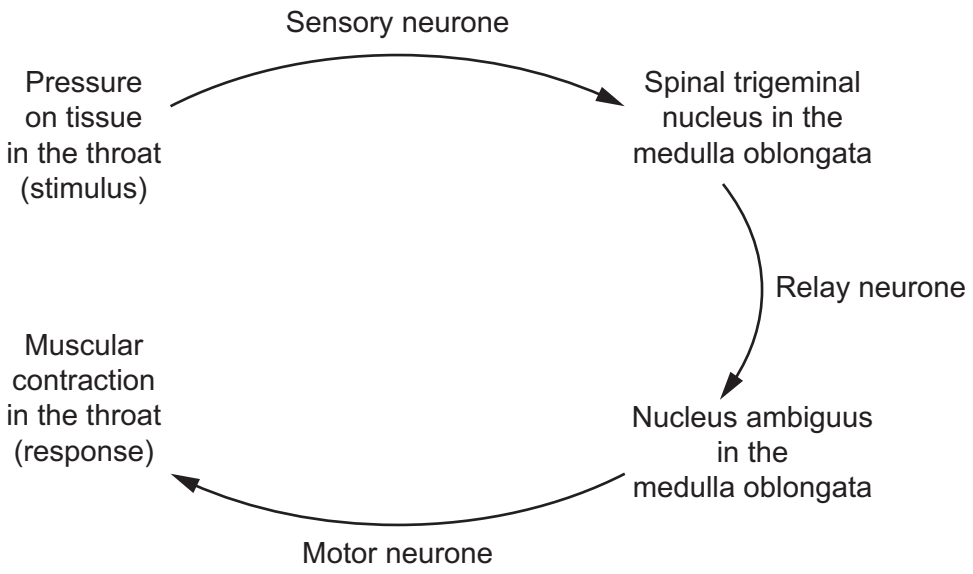
(c) The nervous system of a cat coordinates a response to stop objects becoming stuck in their throat.

Sensory receptors at the back of the throat detect the stimulus of a large piece of food or a ball of hair pressing on the tissue. The response is shown in **Fig. 1.2**.

Fig. 1.2



Explain **two** conclusions that can be drawn from **Fig. 1.2** about the type of nervous response shown.

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..... **[2]**

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2 Vitamins are molecules that are consumed in the diet of animals and have essential roles in the body.

(a) Thin layer chromatography (TLC) was used to separate a mixture of vitamins from a vitamin supplement tablet.

(i) Most vitamins are colourless.

Suggest **one** method for visualising the vitamins in TLC.

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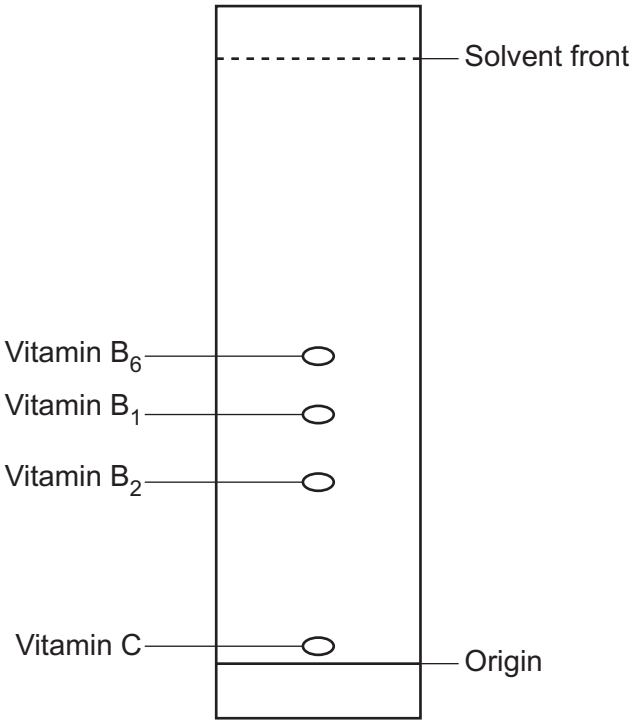
..... **[1]**

(ii) The results of the TLC are shown in the chromatogram in **Fig. 2.1**.

Fig. 2.1



Use **Fig. 2.1** to calculate the R_f value of vitamin B_2.

R_f = ... **[2]**

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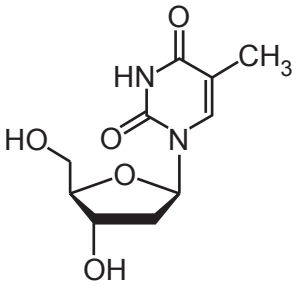
(b) Vitamin B_9 is needed for the synthesis of molecule **D**, shown in **Fig. 2.2**.

Fig. 2.2



Molecule **D**

Molecule **D** is a component in the structure of DNA.

A deficiency of vitamin B_9 in the diet can cause interphase to stop in some cells.

Use **Fig. 2.2** to explain why a deficiency of vitamin B_9 can cause interphase to stop.

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..... **[2]**

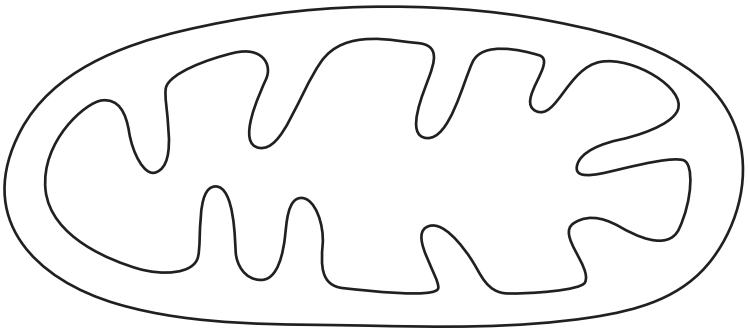
(c) Vitamin B_2 is used by the body to make FAD. Vitamin B_3 is used by the body to make NAD.

(i) A mitochondrion is shown in **Fig. 2.3**.

Label **Fig. 2.3** to show the locations where FAD gains H atoms and where FAD releases H atoms during respiration.

- Use the letter **E** to show where FAD gains H atoms.
- Use the letter **F** to show where FAD releases H atoms.

Fig. 2.3



[2]

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(ii) The table lists features that are correct for FAD, NAD, both or neither.

Complete the table by adding a tick (✓) to a box where the feature is correct and a cross (✗) where the feature is incorrect. You should add either a tick or a cross to every box in the table.

Feature	**FAD**	**NAD**
Is a prosthetic group		
Is reduced in the link reaction		
Oxidises molecules in the electron transport chain		

[2]

(iii) ATP is produced in respiration. Some of these molecules of ATP are used to release energy for processes in respiration. For example, ATP is used in the early stages of glycolysis.

Suggest **one other** way in which ATP contributes to the process of respiration.

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..... **[1]**

(d) Vitamin C affects the activity of enzymes in different ways.

(i) Vitamin C acts as a coenzyme for several enzymes in the synthesis of collagen.

Outline the role of coenzymes in biological reactions.

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..... **[2]**

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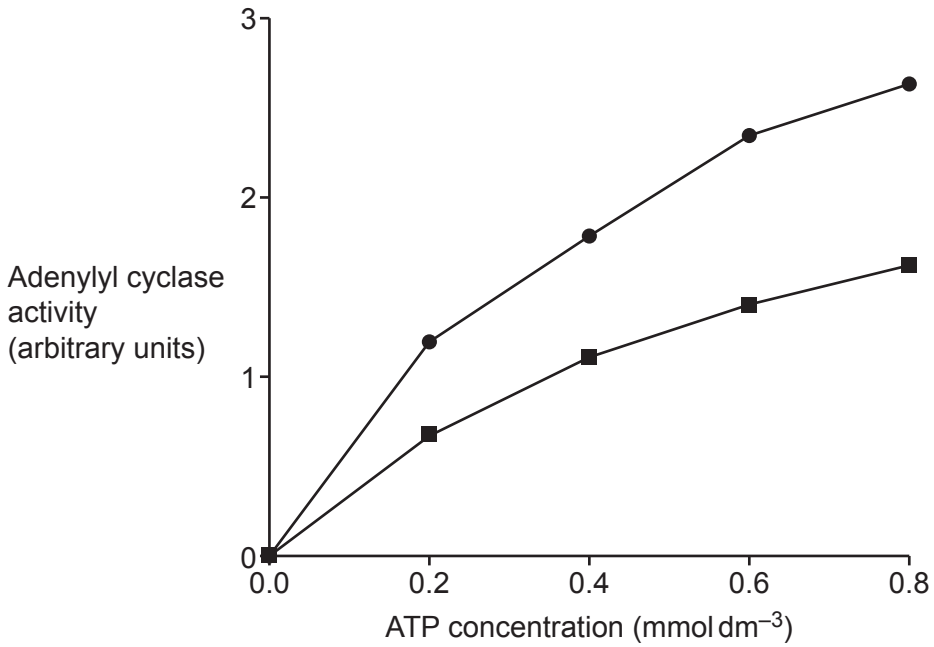
(ii) A scientist investigates the effect of vitamin C on the activity of the enzyme adenylyl cyclase.

Adenylyl cyclase catalyses the conversion of ATP to cAMP.

The scientist measures the activity of adenylyl cyclase without vitamin C and with 1 mmol dm^{-3} of vitamin C.

The scientist's results are shown in **Fig. 2.4**.

Fig. 2.4



Key: —●— Without vitamin C

—■— 1 mmol dm^{-3} vitamin C

Explain what can be concluded from the results in **Fig. 2.4** about the effect of vitamin C on the activity of adenylyl cyclase.

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..... **[2]**

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3 Genetic modification and selective breeding can be used to improve the characteristics of crop plants, such as maize.

(a) In high light intensity, photosystem II absorbs excess light energy.

A process called nonphotochemical quenching (NPQ) converts the excess light to heat energy.

NPQ can continue when light intensity is no longer in excess. This makes photosynthesis inefficient.

Scientists genetically modified (GM) crop plants to limit NPQ.

The scientists exposed unmodified plants and GM plants to a period of high light intensity followed by lower light intensity. The scientists then compared the rate of NPQ and the rate of carbon dioxide (CO_2) fixation in unmodified plants and GM plants.

Some of the results are shown in the table.

Time after decrease in light intensity (s)	**Rate of NPQ (arbitrary units)**		**Rate of CO_2 fixation (mmol CO_2 m^{-2} s^{-1})**	
	Unmodified plant	GM plant	Unmodified plant	GM plant
0	1.00	1.00	26	26
150	0.35	0.25	11.5	13.2

(i) State **one** dependent variable in this investigation.

..... **[1]**

(ii) Explain the effect of genetic modification on the rate of CO_2 fixation after 150 seconds of low light intensity.

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..... **[2]**

(iii) Often a single company holds the patent for a GM crop plant.

Suggest a potential ethical issue that may exist if one company holds the patent for a GM crop plant.

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..... **[1]**

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(b) Humans have been selectively breeding maize as a crop plant for thousands of years, which has resulted in many different varieties of maize.

Different varieties of maize have different genomes.

Describe how bioinformatics and computational biology can be used to compare the genomes of different varieties of maize.

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..... **[3]**

(c) Two characteristics that farmers have selectively bred in maize are colour and kernel (fruit) shape.

Colour is determined by a gene with two alleles:

- Allele **A** is dominant and results in a purple colour.
- Allele **a** is recessive and results in a yellow colour.

Kernel shape is determined by a gene with two alleles:

- Allele **B** is dominant and results in a smooth shape.
- Allele **b** is recessive and results in a wrinkled shape.

The two genes are found on different chromosomes.

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Two maize plants are crossed.

- One parent plant is purple and smooth and heterozygous for both genes.
- One parent plant is yellow and smooth and heterozygous for gene **B/b**.

Complete the answer lines below to show this genetic cross.

Parental genotypes: ..... × .....

Gametes: .....

Expected offspring phenotypes: .....

.....

Expected phenotypic ratio: .....

[4]

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4 The Convention on International Trade in Endangered Species (CITES) came into effect in 1975.

(a)* **Fig. 4.1** shows the percentage of species threatened with extinction that have been protected under CITES.

Fig. 4.1

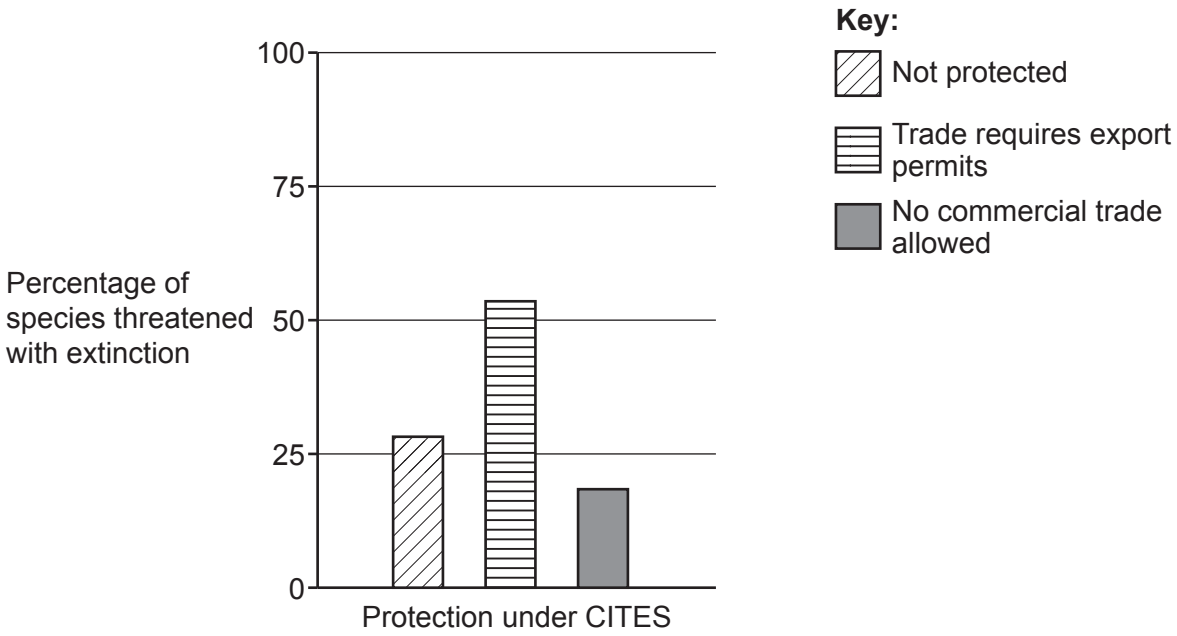
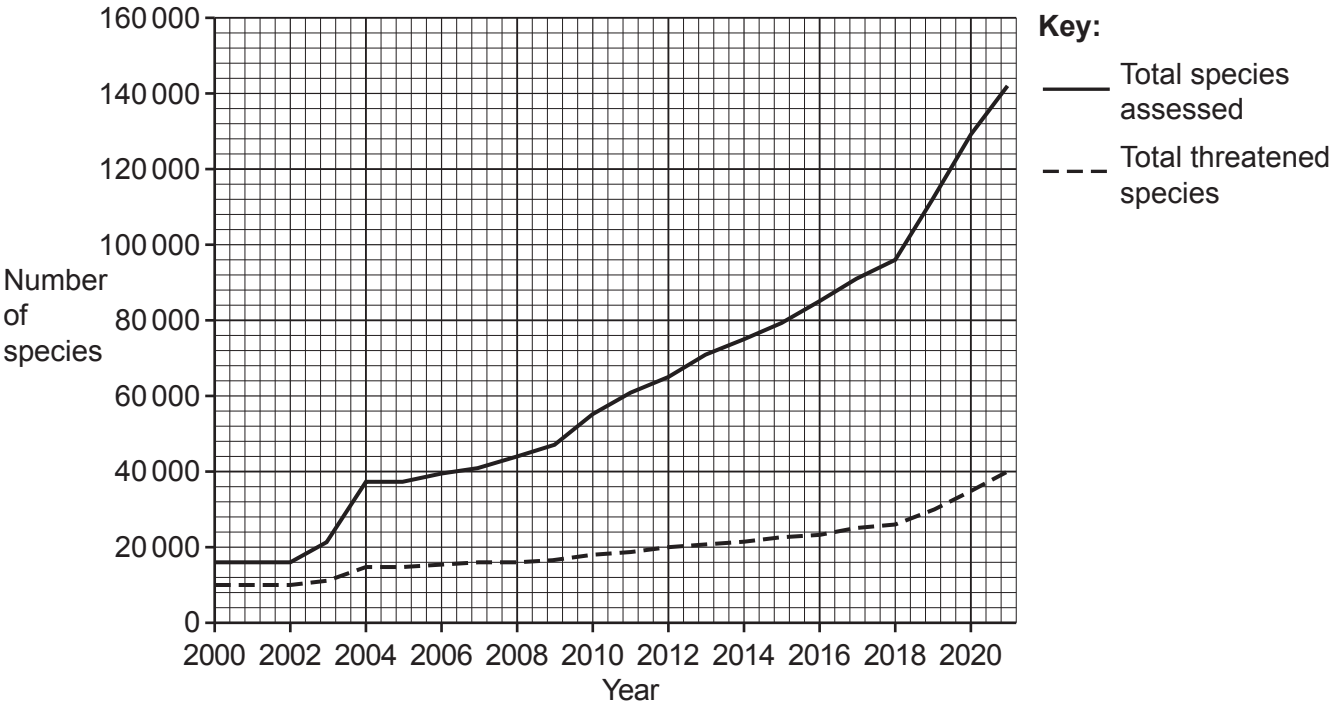


Fig. 4.2 shows the number of species assessed and the number of species categorised as threatened with extinction by the International Union for Conservation of Nature (IUCN) each year.

Fig. 4.2



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The aim of CITES is to monitor and regulate the international trade of threatened species to prevent extinctions.

Using the data in **Fig. 4.1** and **Fig. 4.2**, evaluate how successful CITES has been in achieving its aim.

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Additional answer space if required.

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(b) The kakapo, shown in **Fig. 4.3**, is an endangered species of flightless bird that lives in New Zealand. The population size of kakapos has experienced a large decrease over the past few hundred years. There are now fewer than 250 kakapos living in the wild.

Fig. 4.3

(i) State the term for a large decrease in population size that reduces the gene pool.

..... **[1]**

(ii) Adaptations can be categorised into three different types:
- anatomical
- behavioural
- physiological.

The table lists four traits that kakapos have evolved.

Complete the table by naming the type of adaptation represented by each of the four kakapo traits.

Kakapo trait	**Type of adaptation**
Active at night to avoid predators	
Green feathers that camouflage with its surroundings	
Slow digestion to extract nutrients from a high-fibre, low-protein diet	
Strong beak and claws to climb trees	

[2]

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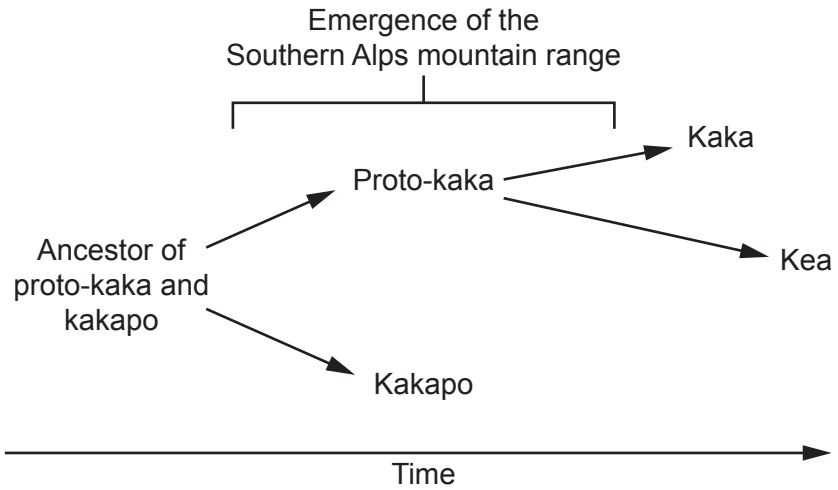
(iii) The kakapo and two other species of bird, the kaka and the kea, evolved from a common ancestor approximately 70 million years ago.

The evolutionary timeline of the three species is shown in **Fig. 4.4**.

Fig. 4.4



- The kakapo cannot fly. It forages for leaves and roots on the ground in forests and grasslands.
- The kaka can fly. It eats seeds, fruit, and occasionally the eggs of other birds in forest habitats.
- The kea can fly. It eats plants, larvae and other small animals. It lives in mountainous forest habitats.
- All three species live on the South Island of New Zealand and had overlapping ranges until the population size of kakapos started to decrease. Populations of kakas also live on the North Island of New Zealand.

A student studied the information and suggested that all three species evolved by sympatric speciation.

Evaluate the student's conclusion.

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(iv) New Zealand has a high species biodiversity compared to many countries.

Species biodiversity includes the concepts of species richness and species evenness.

Explain the difference between species richness and species evenness.

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..... **[2]**

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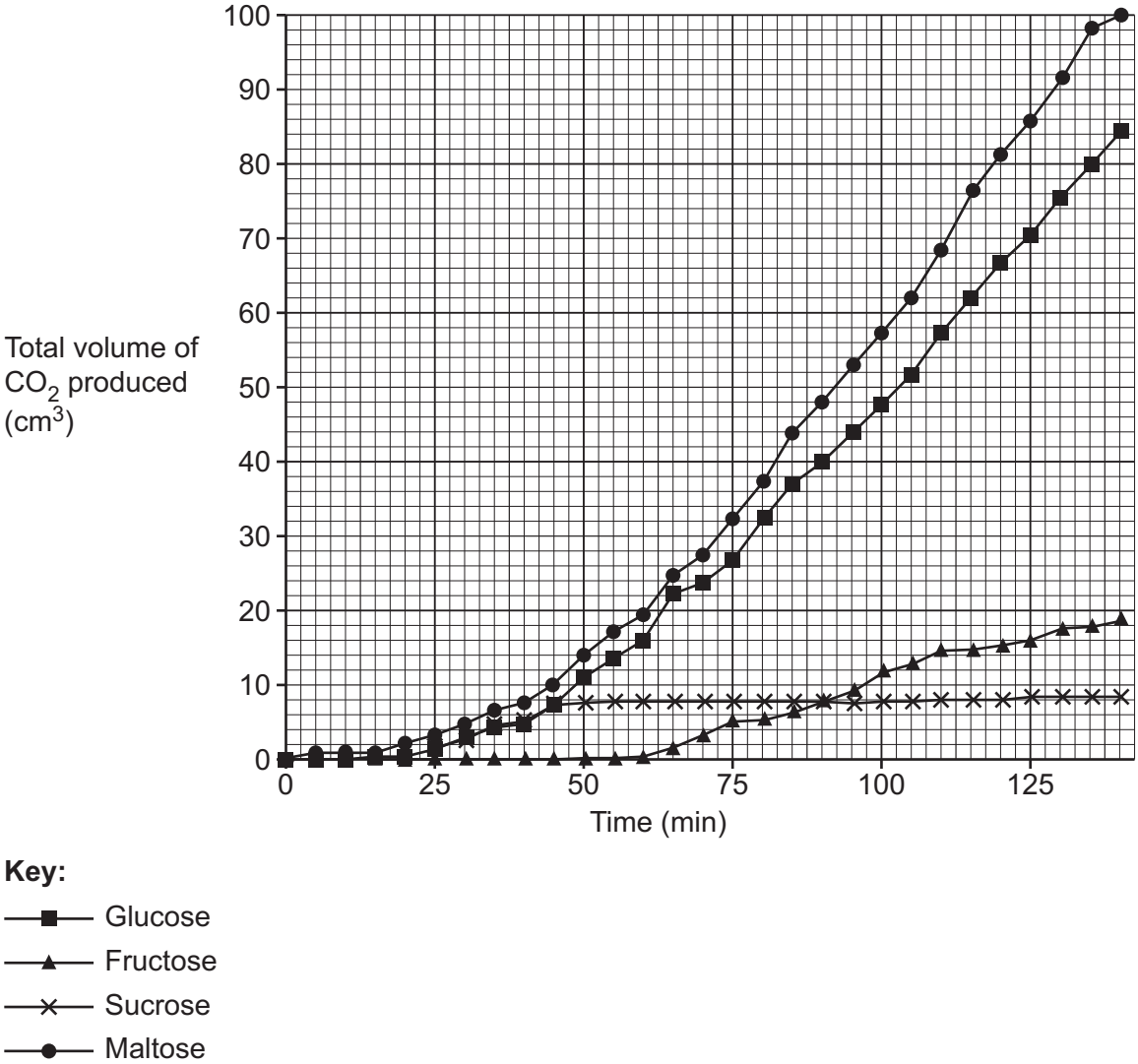
5 Yeast can respire aerobically or anaerobically.

(a) A student investigated how the type of respiratory substrate affects the rate of aerobic respiration in yeast.

Four different populations of yeast were provided with fructose, glucose, maltose or sucrose as a respiratory substrate. The student measured the CO_2 produced by each population over 150 minutes.

The student's results are shown in **Fig. 5.1**.

Fig. 5.1



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(i) Compare CO_2 production when the substrate is glucose and CO_2 production when the substrate is maltose.

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(ii) The student wrote a note:

'The CO_2 production with fructose is approximately the same as the CO_2 production with sucrose'.

Explain whether you agree with the student's note.

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..... **[2]**

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(b) A student plans to compare the rate of anaerobic respiration in two species of yeast.

(i) The student uses glucose as the respiratory substrate in their experiment.

The student produces a 0.01 mol dm^{-3} glucose solution for each yeast population. This is the method that they use to produce each 0.01 mol dm^{-3} glucose solution:

- Make two 10-fold dilutions from a 1.0 mol dm^{-3} stock solution.
- In each dilution, use a measuring cylinder to measure the volume of water and a dropping pipette to transfer the glucose solutions.

Suggest **two** ways in which the student can reduce the percentage error in their measurements when producing the glucose solutions.

1 .....

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2 .....

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[2]

(ii) Complete the sentences using appropriate words or phrases.

This is the method that the student uses in their experiment:

- To avoid contamination, place the yeast in glucose solutions that are produced using ..... water.
- Culture each species of yeast in different flasks.
- Ensure anaerobic conditions by using a ..... flask.
- Use the rate of CO_2 production as a measure of respiration rate.
- Standardise all other variables.
- Repeat the measurements with 10 populations from each species and calculate two means and two ..... .
- Analyse the data using a Student's *t*-test.

[3]

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6* Homeobox genes, including Hox genes, code for transcription factors and regulate the expression of structural genes.

Describe the general roles of homeobox genes in the human body **and** suggest the roles of these genes in the development of the brain.

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Additional answer space if required.

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7 Organisms are classified into three domains: Archaea, Bacteria and Eukarya.

Scientists have compared the structures of molecules, such as DNA polymerase and helicase, and organelles in the three domains.

(a) The table shows a comparison of some features of the three domains.

Feature	**Archaea**	**Bacteria**	**Eukarya**
Type of DNA polymerase	SFB and SFD	SFA and SFC	SFB
Type of helicase	SF1 and SF2	SF1 and SF2	SF1 and SF2
Histone proteins	Present	Absent	Present
Size of ribosomes	70S	70S	80S
Mitochondria	Absent	Absent	Present

Explain what conclusions can be drawn from the table about which two domains are most closely related.

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..... **[3]**

(b) State the roles of DNA polymerase and helicase in cells.

DNA polymerase .....

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Helicase .....

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[2]

END OF QUESTION PAPER

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ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

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