Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

0567776311

BIOLOGY **9700/41**

Paper 4 A Level Structured Questions **May/June 2021**

2 hours

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Section A: answer **all** questions.
- Section B: answer **one** question.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 100.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **24** pages. Any blank pages are indicated.

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Section A

Answer **all** questions.

1 **(a)** Photosynthesis is a complex process involving the transfer of light energy into chemical energy.

(i) Describe the role of photosynthetic pigments.

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..... [2]

(ii) Name the precise location in a chloroplast of photosynthetic pigments.

..... [1]

(iii) Name a practical technique to separate photosynthetic pigments.

..... [1]

(b) The rate of photosynthesis is affected by many environmental factors.

A student carried out an experiment to investigate the relationship between the concentration of carbon dioxide available to an aquatic plant, *Cabomba caroliniana*, and its rate of photosynthesis.

Fig. 1.1 shows the experimental set-up for this investigation.

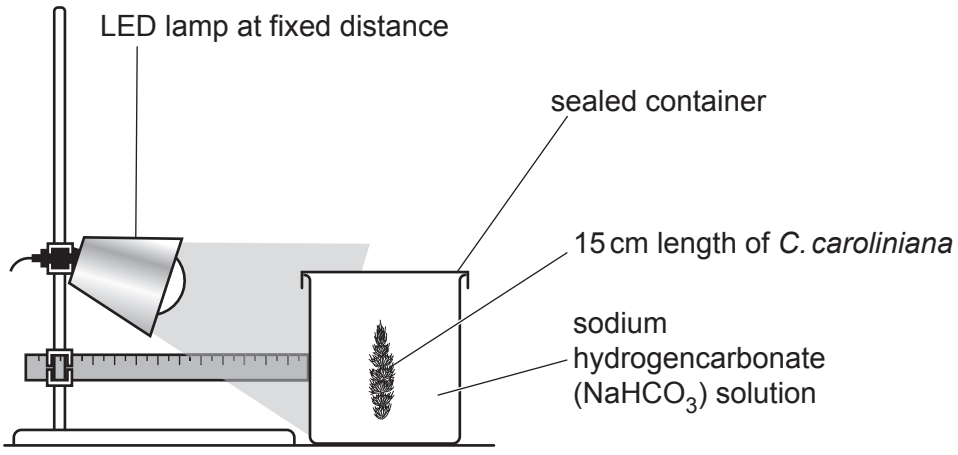


Fig. 1.1

- Sodium hydrogencarbonate solution was used as a source of carbon dioxide.
- The concentration of carbon dioxide was varied using six different concentrations of sodium hydrogencarbonate solution.
- All *C. caroliniana* plants were kept in the dark before the light was switched on at the start of the experiment.
- Five replicates were carried out at each concentration.
- The rate of photosynthesis was obtained by calculating the percentage change in dissolved oxygen concentration in the solution over five minutes.

Fig. 1.2 shows the results of the investigation.

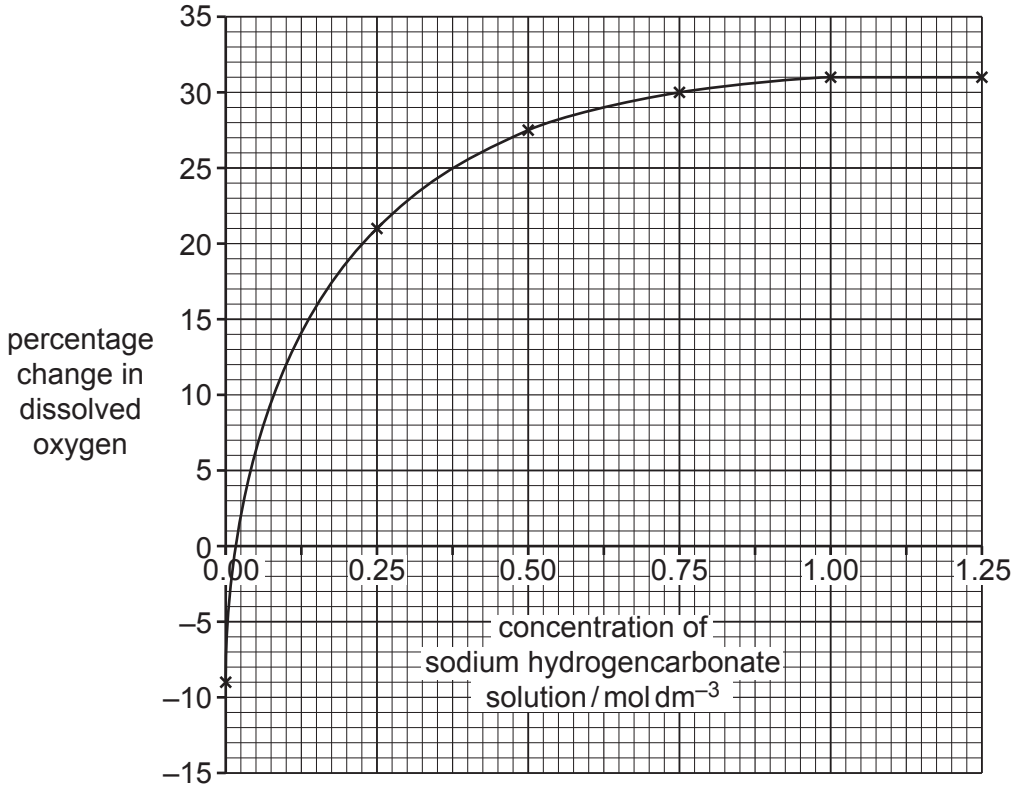


Fig. 1.2

(i) With reference to Fig. 1.2, explain the pattern of results obtained between 0.25 mol dm^{-3} and 1.25 mol dm^{-3} of sodium hydrogencarbonate solution.

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..... [3]

(ii) The percentage change in dissolved oxygen for *C. caroliniana* at 0.00 mol dm^{-3} of sodium hydrogencarbonate solution is negative.

Suggest reasons for this negative value.

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..... [2]

(iii) To minimise temperature changes, the student decided to use an LED lamp as a light source. LED lamps release very little heat energy.

Explain the importance of minimising temperature changes in this experiment.

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..... [3]

[Total: 12]

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2 **(a)** All organisms respire to release energy from energy-rich molecules such as glucose.

(i) Anabolic reactions **use** energy.

State **two** examples of anabolic reactions occurring in living organisms.

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..... [2]

(ii) Describe **and** explain the use of ATP in glycolysis.

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..... [3]

(b) Some factory workers in the early 20th century were exposed to chemical X and experienced serious side-effects.

Some of the effects of exposure to chemical X are:

- decreased production of ATP
- increased lipid metabolism, with weight loss
- increased production of pyruvate and lactate
- excess heat energy release, causing an increase in body temperature, which can be fatal.

Chemical X increases the permeability of the inner mitochondrial membrane to protons (hydrogen ions), causing some protons to leak out into the matrix.

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(i) Explain why people exposed to chemical X show:

- decreased production of ATP
- increased lipid metabolism.

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..... [3]

(ii) Suggest **and** explain why chemical X causes increased production of pyruvate and lactate.

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..... [2]

(iii) Suggest why excess heat energy is released.

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..... [1]

[Total: 11]

3 In 2014, scientists published a phylogenetic (evolutionary) tree diagram showing how and when different groups of insects developed from ancestral groups.

To construct the diagram, the scientists compared nucleotide **and** amino acid sequence data for 1478 genes from each of 103 different insect species. The 103 species represented all 32 orders of the class Insecta.

The data were used to arrange the species in related groups according to their degree of molecular similarity and to track how sequences changed over time.

(a) (i) Outline **three** ways in which the members of a species are similar.

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..... [3]

(ii) Organisms are classified in a hierarchical system of taxonomic units.

Name the domain and kingdom to which insects belong.

domain .....

kingdom .....

[2]

(iii) Explain why a phylogenetic tree diagram is useful for classifying insect species.

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..... [2]

(b) For this study, new software for processing large quantities of data was developed.

(i) Calculate the total number of sequences that were compared, considering both the nucleotide and amino acid sequences for each gene.

..... [1]

(ii) Explain why this study needs to make use of bioinformatic techniques.

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..... [3]

[Total: 11]

4 **(a)** Genetic engineering involves the manipulation of naturally occurring enzymes and processes.

List the enzymes used in genetic engineering (genetic modification) **and** outline their roles in natural processes.

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..... [5]

(b) Genetically modified organisms (GMOs) include crop plants. Genetically modified (GM) crop plants have been grown in North America in increasing quantities since 1996. They are now grown in many areas of the world and are eaten by millions of people and farm animals.

Table 4.1 compares the area of land used to grow GM crop plants on six continents in 2013.

Table 4.1

continent	**area of land used to grow GM crop plants / million hectares**	**edible GM crop plants grown**
Africa	3.5	maize, soybean
Asia	19.1	maize, papaya, tomato
Australasia	0.6	canola
Europe	0.2	maize
North America	81.1	canola, maize, papaya, soybean, squash, sugar beet
South America	70.9	canola, maize, soybean

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(i) Suggest how North America and South America benefit from growing large areas of GM crop plants rather than non-GM crop plants.

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..... [3]

(ii) Only a small area of land is used to grow GM crop plants in Europe. This is mainly because most of Europe uses a 'precautionary principle'. The precautionary principle prevents GM crop plants being grown if there is a possible risk of harm to human health or to the environment, even if there is no proof of harm.

Many European citizens have concerns about the safety of eating GM food, but Europe imports large quantities of GM maize and GM soybean to feed farm animals.

Use this information and Table 4.1 to deduce two arguments **in favour of** growing more GM crop plants in Europe.

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2 .....

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[2]

(iii) Explain why the data in Table 4.1 are not enough to calculate the extent to which different continents have replaced traditional crop plants with GM versions.

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..... [2]

[Total: 12]

5 **(a)** Nerves consist of bundles of different types of neurones.

Fig. 5.1 shows the mean transmission speed of impulses for three types of sensory neurone, **C**, **A$^{\delta}$** and **A$^{\beta}$**.

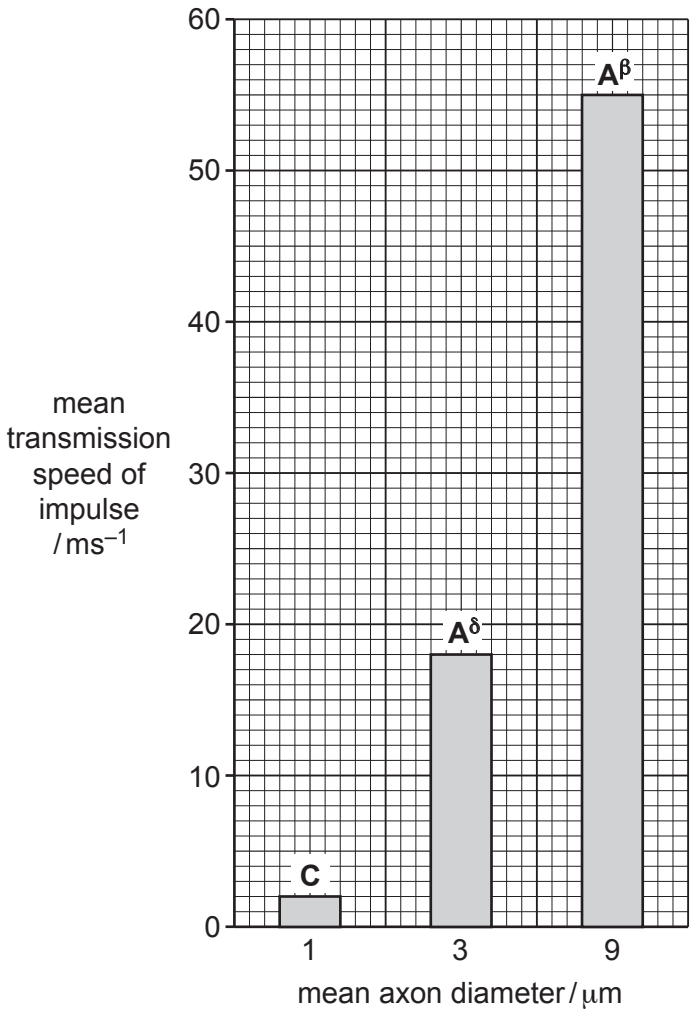


Fig. 5.1

- Impulses from pain receptors in the skin are sent along sensory neurones **C** and **A$^{\delta}$**.
- Sensory neurones **C** and **A$^{\delta}$** synapse in the spinal cord with relay neurones known as projection neurones.
- Projection neurones send impulses to the part of the brain that perceives pain.

- Impulses from touch receptors in the skin pass along sensory neurones **A$^{\beta}$**, which can also synapse with the projection neurones in the spinal cord.

- Sensory neurones **A$^{\delta}$** and **A$^{\beta}$** are myelinated.
- Sensory neurones **C** are unmyelinated.

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(i) Describe the results shown in Fig. 5.1 **and** suggest explanations for these results.

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..... [3]

(ii) Gently rubbing a damaged area of skin can reduce the perception of pain.

Suggest an explanation for this.

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..... [1]

(b) Back pain in humans can be reduced by using a transcutaneous electrical nerve stimulation (TENS) machine.

A TENS machine uses electrical impulses to stimulate nerve endings near the site of the pain.

It is thought that TENS triggers the release of natural painkillers called endorphins at synapses.

Fig. 5.2 shows synapses in a pain pathway.

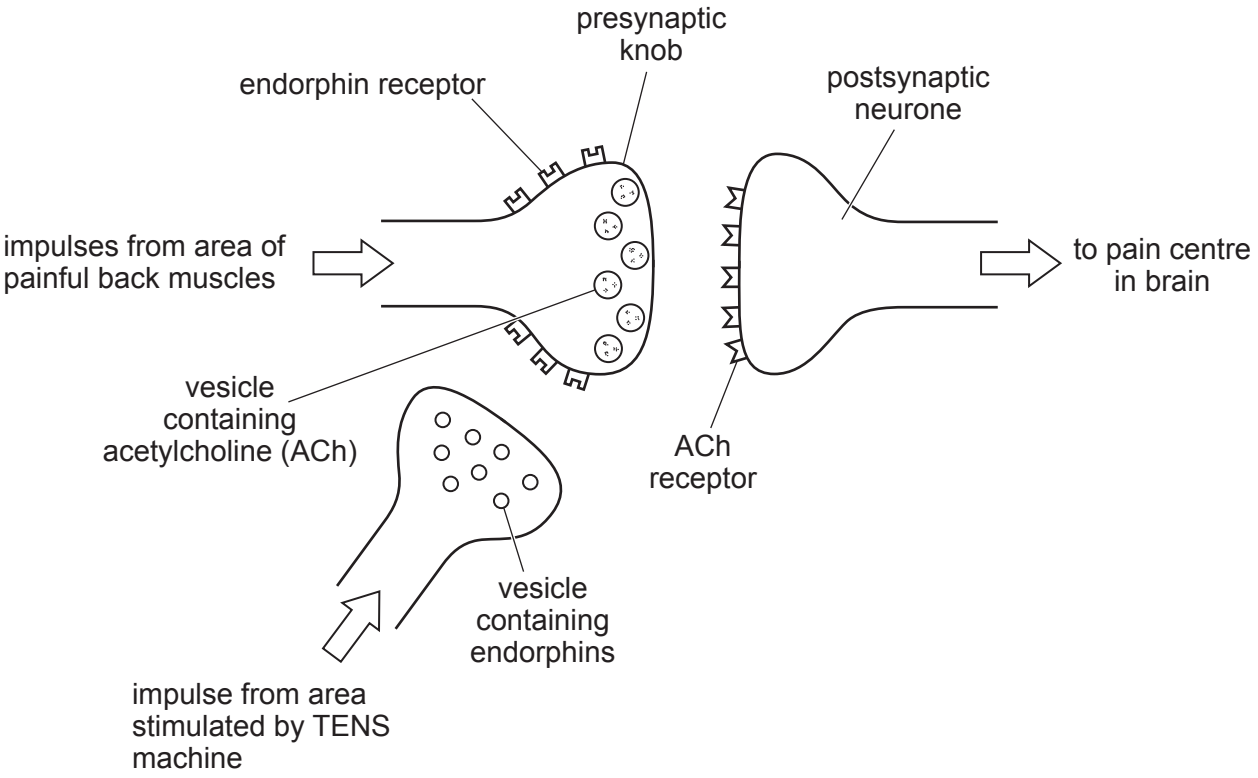


Fig. 5.2

(i) Suggest **and** explain how endorphins may act to reduce pain.

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..... [4]

(ii) Suggest **one disadvantage** of using pharmaceutical drugs for reducing pain compared to using TENS.

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[Total: 9]

6 **(a)** Thermoregulation is the control of the core temperature of the body.

Thermoreceptors send information about a change in core temperature to the hypothalamus. The hypothalamus controls the core temperature by sending impulses to activate several physiological responses.

Table 6.1 lists physiological responses to a **decrease** in core temperature.

Complete Table 6.1 to explain how each response contributes to maintaining a core temperature within narrow limits.

Table 6.1

response	explanation
blood vessels near the surface of the skin constrict (narrow)	....
shivering occurs	....
hairs rise	....
reduction in the production of sweat	....

[4]

(b) Animals can also use behaviour to adapt to temperature changes.

Suggest why some animals curl up their bodies in cold weather.

.....

..... [1]

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(c) The Sitatunga deer, *Tragelaphus spekii*, and the Nile monitor lizard, *Varanus niloticus*, live in Africa.

Fig. 6.1 shows a Sitatunga and Fig. 6.2 shows a Nile monitor.



Fig. 6.1



Fig. 6.2

An investigation was carried out to measure the core temperature of the Sitatunga and the Nile monitor as the environmental temperature was increased.

The results are shown in Fig. 6.3.

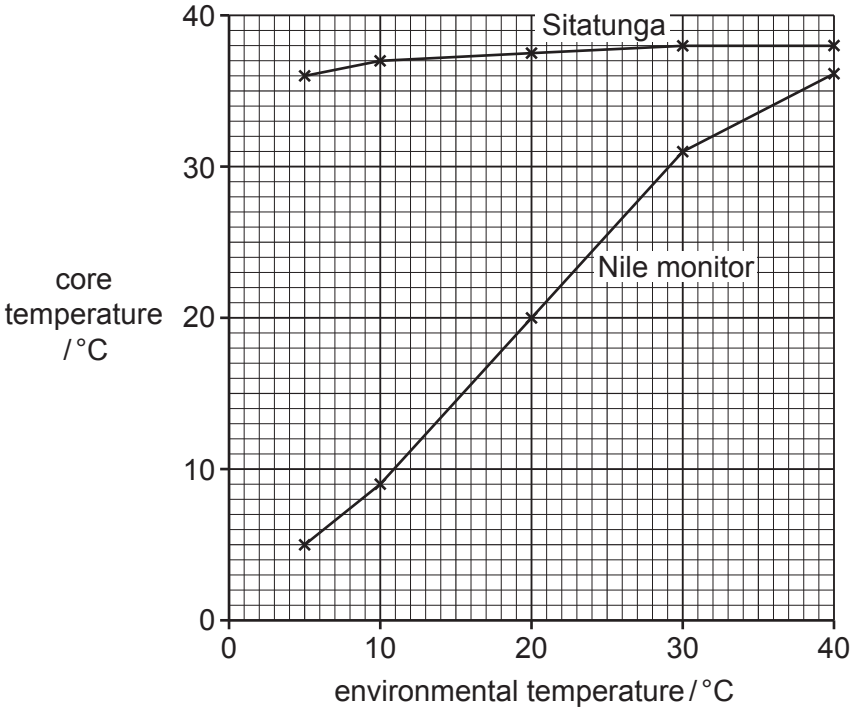


Fig. 6.3

(i) Describe the results shown in Fig. 6.3.

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..... [3]

(ii) When the environmental temperature is low, Nile monitors are relatively inactive.

Suggest **one** disadvantage to the Nile monitor of being inactive.

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..... [1]

(d) Thermoregulation relies on negative feedback.

Explain what is meant by negative feedback.

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..... [3]

[Total: 12]

7 People vary in which molecules are present on the surface of their red blood cells. For example, in the ABO blood group system, people may be categorised into one of four blood groups: A, B, AB and O.

A single gene, ***I***, with three alleles, determines these blood groups. Gene ***I*** is an example of a gene with multiple alleles.

- Alleles $\mathbf{I^A}$ and $\mathbf{I^B}$ are codominant.
- Allele $\mathbf{I^o}$ is recessive to alleles $\mathbf{I^A}$ and $\mathbf{I^B}$.

(a) Explain what is meant by codominant and recessive.

codominant .....

.....

recessive .....

.....

[3]

(b) Table 7.1 shows a cross between a person with blood group A and a person with blood group B.

Complete Table 7.1.

Table 7.1

parental phenotype (blood group)	A		B	
parental genotype	$\mathbf{I^A I^o}$		$\mathbf{I^B I^o}$	
gametes	.....	.....	.....	.....
offspring genotype	.....	.....	.....	.....
offspring phenotype (blood group)	.....	.....	.....	.....

[3]

(c) Haemophilia is a blood condition where bleeding continues for a long period of time after a blood vessel has been damaged.

A person with haemophilia has a mutation in a gene on the X chromosome, which results in the lack of a blood clotting factor.

Explain why a man who has haemophilia cannot pass the condition to his male offspring.

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..... [3]

[Total: 9]

8 **(a)** Humans use selective breeding to improve the features of crop plants and domestic animals.

(i) State another term for selective breeding.

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(ii) Describe how selective breeding can be used to improve the milk yield of dairy cattle.

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..... [5]

(b) Explain what is meant by disruptive selection.

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..... [3]

[Total: 9]

Section B

Answer **one** question.

9 **(a)** Describe how you would carry out an investigation to calculate the effect of substrate concentration on the rate of respiration of yeast in anaerobic conditions using a redox indicator, such as DCPIP or methylene blue. [8]

(b) Compare respiration in anaerobic conditions in mammalian tissue and in yeast cells. [7]

[Total: 15]

10 **(a)** Explain how speciation can occur due to geographical separation. [8]

(b) Using examples, explain why species may become extinct. [7]

[Total: 15]

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[Turn over

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