Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

0874755085

BIOLOGY **9700/41**

Paper 4 A Level Structured Questions **May/June 2020**

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. Blank pages are indicated.

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Section A

Answer **all** questions.

1 **(a)** In mammals, the hormone ACTH is released from the anterior pituitary gland. ACTH stimulates the cells of the adrenal glands to synthesise the hormone cortisol. This is an example of cell signalling.

The main stages of cell signalling involving ACTH are similar to the main stages of cell signalling by adrenaline.

Describe the main stages of cell signalling involving ACTH.

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..... [5]

(b) If the concentration of cortisol in the blood increases above its set point, it will inhibit the production of ACTH by the anterior pituitary gland.

Name this type of homeostatic mechanism.

..... [1]

(c) The domestic dog, *Canis lupus familiaris*, is a mammal. A dog may develop a condition called Cushing's disease, which is a result of too much cortisol being secreted by the adrenal glands. The most common cause of this is an increased secretion of ACTH because of a tumour in the anterior pituitary gland.

Explain how a tumour develops.

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..... [2]

(d) One symptom of Cushing's disease in a dog is that the dog will want to drink much more than normal.

Suggest **one other** reason why a dog would want to drink much more than normal.

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..... [1]

[Total: 9]

2 The patty pan squash plant, *Cucurbita pepo*, produces edible fruits that vary in colour.

(a) The colour of the fruits is controlled by two genes, **A/a** and **B/b**, that occur on different chromosomes.

- Allele **A** produces a white fruit colour.
- Allele **a** does not produce a colour by itself but allows the colours coded by gene **B/b** to show in the phenotype.
- Allele **B** produces a yellow fruit colour.
- Allele **b** produces a green fruit colour.

In a dihybrid cross, an **AABB** plant was crossed with an **aabb** plant. All the resulting F1 plants produced white fruits.

The F1 plants were then crossed with each other to obtain the F2 generation.

(i) Complete Fig. 2.1 with the gametes produced by the F1 parents, the F2 genotypes and the F2 phenotypes.

State the ratio of fruit colours in the F2 offspring.

F1 parents: **AaBb** × **AaBb**

Fig. 2.1

ratio of fruit colours in F2 offspring .....
[4]

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(ii) Test crosses were carried out on two white-fruited plants, **P** and **Q**, from the F2 generation. Each of these plants had its female flowers pollinated with pollen from a green-fruited plant.

For plant **P**, half of the offspring were white and half were yellow.
For plant **Q**, half of the offspring were white and half were green.

Deduce the genotypes of plants **P** and **Q**.

plant **P** .....

plant **Q** .....

[2]

(iii) Plants **P** and **Q** show genetic variation with respect to fruit colour alleles.

Identify the process that occurred during meiosis in the F1 parents that produced this variation **and** the stage of meiosis at which it occurred.

process .....

stage of meiosis .....

[2]

(b) In 1994, two new varieties of squash were grown in the USA. Both varieties showed resistance to two viral diseases of squash plants.

- The variety 'Tigress' was developed by selective breeding.
- The variety 'Freedom II' was developed by adding genes for viral coat proteins to the squash genome.

(i) Identify, with reasons, the variety of squash that can be described as recombinant.

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..... [2]

(ii) Outline **one** social advantage and **one** social disadvantage of the recombinant squash variety compared to non-resistant squash varieties.

advantage .....

.....

disadvantage .....

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[2]

[Total: 12]

3 Cats are members of the Felidae family. Two genera of Felidae are *Leopardus* and *Panthera*.

(a) The genus *Leopardus* consists of species of wild cats that are small and spotted. In 2013, biologists investigated the evolution of *Leopardus tigrinus* in South America.

Fig. 3.1 shows the locations in South America of two populations of. *L. tigrinus*, population **A** and population **B**.

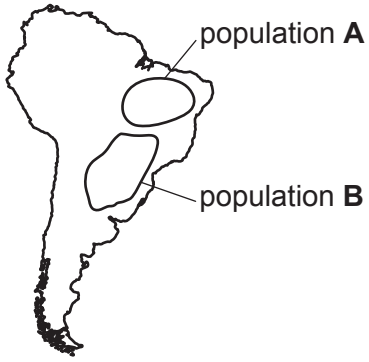


Fig. 3.1

- Population **A** lives in grassland and desert habitats and population **B** lives in forest habitats.
- The cats in population **A** have a lighter coat colour and a different pattern of spots from the cats in population **B**.
- Genetic analysis shows that population **A** is genetically distinct from population **B**.
- Population **B** has now been reclassified as a new species, *L. guttulus*.

(i) Define the term species.

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..... [2]

(ii) Explain how the two species, *L. tigrinus* and *L. guttulus*, have evolved from one original population in South America.

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..... [5]

(b) Illegal trade threatens the survival of endangered species. Forensic tests can identify animal species from the DNA of their body parts, for example bones.

Cat species differ in the number of repeats of bases C and A (CA repeats) within one particular region of DNA, known as Ple46.

Table 3.1 shows the number of repeats in Ple46 for three endangered cat species.

Table 3.1

cat species	number of CA repeats in Ple46
Asiatic lion	22
Bengal tiger	7–8
leopard	14–15

(i) Gel electrophoresis is used to estimate the length of Ple46 in a sample of DNA to check whether the sample comes from one of the endangered cat species in Table 3.1.

Outline how gel electrophoresis is carried out to confirm whether the sample comes from one of these endangered cat species.

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..... [3]

(ii) Customs officials are responsible for checking whether animal body parts come from species on the CITES list of endangered species. Officials can now use a small DNA barcoding kit linked to a computer database to identify a species.

Suggest **two** advantages of using this method to identify a species.

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..... [2]

[Total: 12]

4 Mitochondrial complex I is a large enzyme complex that forms part of the electron transport chain. The enzyme is composed of many different polypeptides.

The genes coding for these polypeptides are located either in mitochondrial DNA (mtDNA) or in nuclear DNA. Mutations in these genes can lead to the production of an enzyme that does not function efficiently. This results in a disease known as mitochondrial complex I deficiency. If severe, this can lead to death in early childhood.

(a) Explain why people with mitochondrial complex I deficiency may have muscle weakness and difficulty with nervous coordination of movement.

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..... [2]

(b) When mitochondrial complex I deficiency is caused by mutation in mtDNA:

- a cell in an ovary produces gametes with different proportions of normal mitochondria and mitochondria that contain the mtDNA mutation (mutant mitochondria)
- a person has disease symptoms when the proportion of mutant mitochondria in their cells exceeds a certain threshold
- the severity of disease symptoms, and the age at which they appear, can vary greatly in the children of one woman.

In a family with a history of mitochondrial complex I deficiency that is caused by a mutation in a **nuclear** gene, the probability of a child inheriting the mutation can be predicted.

Suggest why, in families where mitochondrial complex I deficiency is caused by mtDNA mutation, it is **not** possible to predict the probability of a child inheriting the mutation.

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..... [3]

(c) Genetic screening can be carried out on people with symptoms of mitochondrial complex I deficiency.

Previously 7 mtDNA genes and 37 nuclear genes were sequenced. Some of the people tested did not have mutations in any of these genes. As a result, another gene was sequenced in these people and was found to be mutated.

This led to the suggestion that genetic screening should sequence a larger proportion of the genome for people suspected of having this disease.

Discuss the **ethical** reasons for and against sequencing a larger proportion of the genome for people suspected of having mitochondrial complex I deficiency.

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..... [3]

(d) One mutation linked to mitochondrial complex I deficiency is a base substitution. It causes the amino acid glycine to be replaced by the amino acid valine in a region of α helix in a protein that is important for the formation of mitochondrial complex I.

Glycine is a small amino acid with an R group of one hydrogen atom whereas valine has a larger and branched R group.

Predict how the change in amino acids would affect the structure of the protein.

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..... [2]

[Total: 10]

5 Yeast cells are unicellular eukaryotes. Yeast cells respond to changes in the concentrations of the sugars galactose and glucose by switching on genes using transcription factors.

Fig. 5.1 shows the events that occur when the sugar galactose is present and glucose is absent in the external environment.

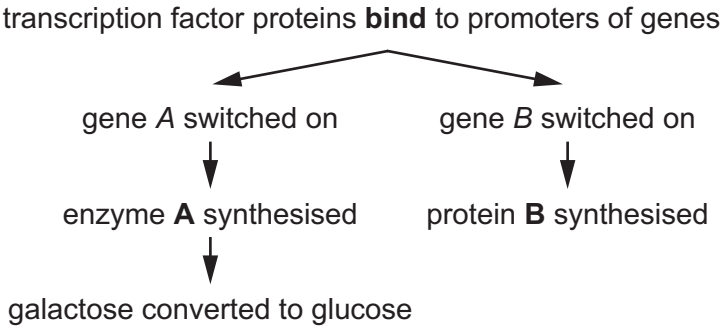


Fig. 5.1

(a) (i) Explain why enzyme **A** is described as an inducible enzyme.

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..... [3]

(ii) Protein **B** has a similar role to the protein coded for by gene *Y* of the *lac* operon.

Suggest a possible role for protein **B** that would allow yeast cells to make use of galactose.

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..... [1]

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Scientists produced genetically engineered yeast cells. The gene coding for Msn2 transcription factor proteins and the marker gene coding for green fluorescent protein (GFP) are transcribed together to produce a single mRNA molecule.

The resulting Msn2 transcription factor proteins contain a GFP region as part of their structure and are called tagged Msn2 molecules. These tagged Msn2 molecules show up as green fluorescent spots when viewed using a microscope with a very high resolution.

An investigation was carried out to compare the distribution of tagged Msn2 molecules in yeast cells, when glucose is absent and when glucose is present.

The results are shown in Table 5.1.

Table 5.1

glucose availability	mean number of tagged Msn2 molecules present		
	cytoplasm	nucleus	total
glucose absent	3263	2012	5275
glucose present	1755	632	2387

(b) (i) Calculate the percentage of Msn2 molecules in the cell that are located inside the nucleus, when glucose is **absent**.

Show your working and write your answer to **two** significant figures.

..... % [2]

(ii) When glucose is **present**, 26% of Msn2 molecules in the cell are located inside the nucleus.

Suggest why this figure is different from your answer to **(i)**.

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..... [2]

(c) Another method of tagging molecules with a fluorescent colour is to use monoclonal antibodies that have GFP attached. These monoclonal antibodies bind specifically to the molecule of interest. This is called immunofluorescent tagging.

Suggest reasons why immunofluorescent tagging is **not** a suitable choice for this investigation.

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..... [3]

[Total: 11]

6 **(a)** At the end of glycolysis in mammalian muscle tissue, pyruvate is formed. Pyruvate can be further metabolised along two different pathways, pathway 1 and pathway 2.

Fig. 6.1 outlines the two pathways.

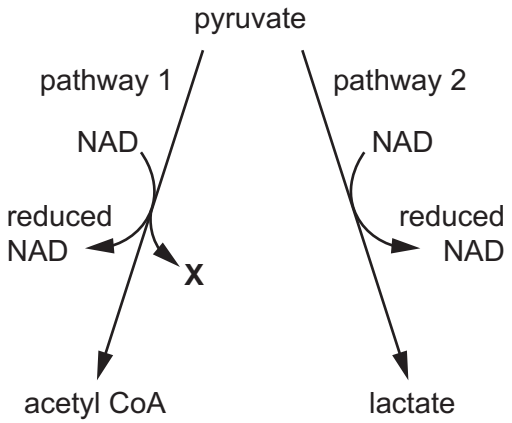


Fig. 6.1

(i) State the condition under which pyruvate would be metabolised along pathway 2.

..... [1]

(ii) Name compound **X**.

..... [1]

(iii) Name the two **types** of reaction that are involved in pathway 1.

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..... [2]

(iv) Suggest a cell in a mammal that **cannot** carry out pathway 1.

Give a reason for your answer.

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..... [2]

(v) ATP is synthesised during glycolysis.

Name the process by which ATP is synthesised.

..... [1]

(b) The rufous hummingbird, *Selasphorus rufus*, feeds on the nectar produced by flowers. Nectar is a liquid containing sugars. Hummingbirds hover to maintain a position next to a flower while they feed. This requires a lot of energy.

Fig. 6.2 is a rufous hummingbird.



Fig. 6.2

Hummingbirds that have not fed for some time have a respiratory quotient (RQ) value of 0.7. After feeding their RQ value is 1.0.

(i) Define the term *respiratory quotient*.

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..... [2]

(ii) Explain why a hummingbird that has not fed for some time has an RQ value of 0.7, while a hummingbird that has fed has an RQ value of 1.0.

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..... [2]

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(iii) When animals exercise they can respire substrates obtained directly from their diet, as well as respiring substrates from energy stores.

An investigation worked out the percentage of respiration that used substrates obtained directly from the diet of humans and hummingbirds as they exercised.

Fig. 6.3 shows the results of this investigation.

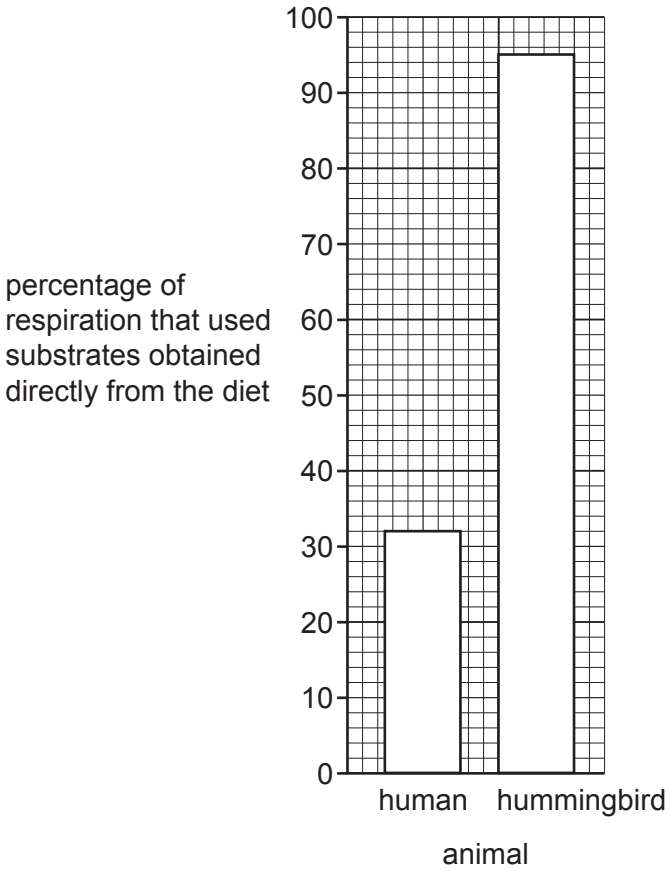


Fig. 6.3

Fig. 6.3 shows that hummingbirds have a higher percentage of respiration that uses substrates obtained directly from the diet.

Calculate how many times greater this figure is for hummingbirds compared to humans.

Show your working and write your answer to **two** decimal places.

answer = ... [2]

(iv) Suggest the benefits to a hummingbird of obtaining most of its respiratory substrates from its diet while exercising.

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..... [2]

[Total: 15]

7 **(a)** Structures, processes and compounds involved in photosynthesis in C4 plants include:

A – carbon dioxide

B – phosphorylation

C – palisade cells

D – PEP carboxylase

E – rubisco

F – malate

G – RuBP

H – mesophyll cells

I – guard cells

J – photorespiration

K – photolysis

L – oxaloacetate

M – ATP synthase

N – chlorophyll

Complete Table 7.1 by matching each description with **one** letter chosen from **A** to **N** to show the correct structure, process or compound.

You may use each number once, more than once or not at all.

Table 7.1

description	letter
enzyme with a high optimum temperature	
enzyme in bundle sheath cells	
process that slows down the rate of photosynthesis	
compound that releases carbon dioxide into bundle sheath cells	
cells that stop oxygen reaching bundle sheath cells	

[5]

(b) Some plants, such as rice, are adapted to grow when partially submerged in water.

Describe **and** explain the adaptations that allow rice plants to survive in waterlogged fields.

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..... [3]

[Total: 8]

8 **(a)** Sampling is used to find out the variety of species in an ecosystem and the size of the population of each species.

A study was carried out to investigate the biodiversity of two fields, **A** and **B**.

Field **A** had **not** been used for growing crops for 10 years. Field **B** had been used for growing crops until one year before the study. Random sampling was carried out.

Describe how random sampling could be carried out on plant species in the two fields.

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..... [4]

(b) Table 8.1 shows the results of the sampling of field **A**.

Table 8.1

species	number of individuals (n)
Scabiosa columbaria	13
Centaurea centaurium	15
Primula veris	26
Trifolium pratense	36
Leucanthemum vulgare	11
Silybum marianum	5
Anacamptis morio	8
total number of individuals (N)	114

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Simpson's Index of Diversity (D) is a value of the species diversity in an area.

The formula for this is:

$$D = 1 - \left(\sum \left(\frac{n}{N} \right)^2 \right)$$

$\sum$ = sum of
n = number of individuals of a species
N = number of individuals of all species

(i) Complete Table 8.2 for *Primula veris*.

Table 8.2

species	n	$\frac{n}{N}$	$\left[\frac{n}{N}\right]^2$
Scabiosa columbaria	13	0.11	0.01
Centaurea centaurium	15	0.13	0.02
Primula veris	26	.....	.....
Trifolium pratense	36	0.32	0.10
Leucanthemum vulgare	11	0.10	0.01
Silybum marianum	5	0.04	0.00
Anacamptis morio	8	0.07	0.00

[1]

(ii) Use the data in Table 8.2 to calculate Simpson's Index of Diversity (D) for field **A**.

Show your working and write your answer to **two** decimal places.

D = ... [2]

(iii) The value of D for field **B** was 0.45.

Comment on the values of D for both fields.

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..... [1]

[Total: 8]

Section B

Answer **one** question.

9 **(a)** Describe how the polymerase chain reaction is used to clone and amplify DNA. [8]

(b) Explain the advantages of using recombinant DNA techniques to produce human proteins, such as factor VIII or adenosine deaminase. [7]

[Total: 15]

10 **(a)** Describe the ultrastructure of a striated muscle fibre. [8]

(b) Explain how auxin causes plant cells to elongate. [7]

[Total: 15]

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