Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

0846723675

BIOLOGY **9700/42**

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.

Section A

Answer **all** questions.

1 **(a)** The enzyme alanine transaminase (ALT) is found in the liver. The function of ALT is to convert the amino acid α-ketoglutarate into another amino acid, glutamate.

Suggest why the liver may need to convert one amino acid into another.

.....

..... [1]

(b) Tumours can form in the liver.

Explain how a liver tumour develops.

.....

.....

..... [2]

(c) ALT can leak into the blood from liver tumour cells.

An increase in the concentration of ALT in the blood causes a decrease in the water potential of the blood.

State precisely the name **and** location of the cells where a change in the water potential of the blood would be detected.

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..... [1]

(d) Describe the homeostatic role of ADH when the water potential of the blood **decreases**.

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..... [5]

[Total: 9]

2 The summer squash plant, *Cucurbita pepo*, produces edible fruits that vary in shape.
Fig. 2.1 shows the fruits of three different varieties of squash plants.

Patty pan
(disc-shaped)

Di Nizza
(spherical)

Alfresco
(long)

Fig. 2.1

Fruit shape in squashes is controlled by two genes, **A/a** and **B/b**, that are located on different chromosomes.

- A disc-shaped fruit is produced when both dominant alleles, **A** and **B**, are present.
- A spherical fruit is produced when either allele **A** or allele **B** is present, but not if both **A** and **B** are present.
- A long fruit is produced when both allele **A** and allele **B** are absent.

(a) (i) Table 2.1 shows the possible genotypes of the Patty pan and Alfresco varieties.

Complete Table 2.1 to show the possible genotypes of the Di Nizza variety.

Table 2.1

variety	**possible genotypes**			
Patty pan (disc-shaped)	**AABB**	**AaBB**	**AABb**	**AaBb**
Di Nizza (spherical)	.....	.....	.....	.....
Alfresco (long)	**aabb**			

[1]

(ii) A gardener used pollen from a male flower of Alfresco to pollinate a female flower of Di Nizza. The gardener grew the seeds produced from this cross and found that half the offspring produced spherical fruits and half produced long fruits.

Draw **one** genetic diagram to explain this result.

parent genotypes

gametes

offspring genotypes

offspring phenotypes

[4]

(iii) The offspring show genetic variation with respect to fruit shape alleles.

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

process .....

stage of meiosis ..... [2]

(b) (i) Genetically modified (GM) summer squash plants with resistance to viral diseases have been grown in the USA since 1995.

Scientists have been concerned that viral resistance genes pass easily from GM squash plants to their wild relative, the Texas gourd, *Cucurbita texana*.

Explain why the possibility of gene flow from GM squash plants to the Texas gourd is a cause of social and environmental concern.

social .....

.....

.....

environmental .....

.....

.....

[2]

(ii) A study compared the survival of two different types of hybrids that were formed by cross-pollination between GM virus-resistant squash plants and wild Texas gourd plants:

- virus-resistant hybrids that had inherited the viral resistance gene
- non-resistant hybrids that had **not** inherited the viral resistance gene.

Viral disease outbreaks caused many of the non-resistant hybrids to die. Leaf-eating beetles then moved in larger numbers to the surviving healthy virus-resistant hybrids. The beetles carried a pathogenic bacterium *Erwinia* which was capable of killing the plants.

Fig. 2.2 compares infection with *Erwinia* in the virus-resistant hybrids and the non-resistant hybrids.

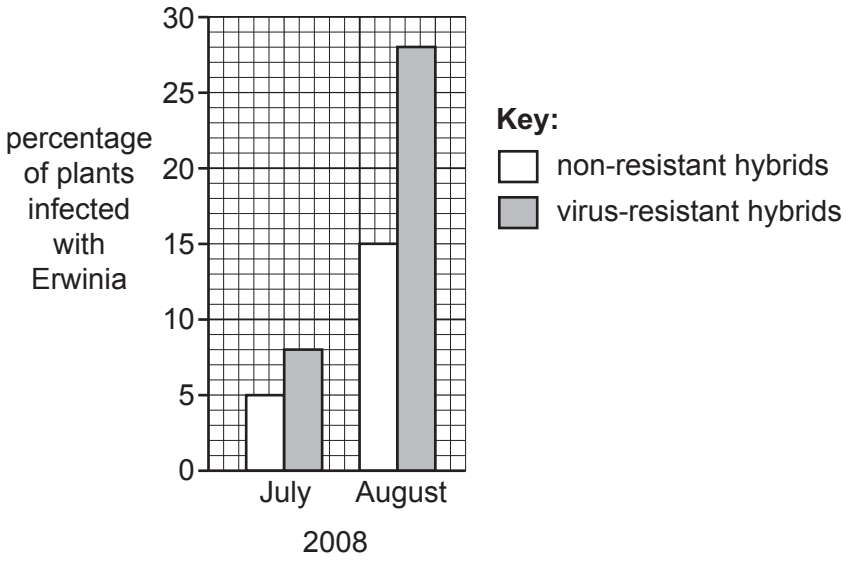

Fig. 2.2

Discuss whether these results provide support for the use of genetically modified organisms (GMOs) in food production.

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..... [2]

(iii) Suggest why the GM virus-resistant squashes grown by farmers rarely suffer infection by *Erwinia*.

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..... [1]

[Total: 12]

3 A subspecies is a genetically distinct population within a species that has some phenotypic differences from the rest of the species, but is not yet reproductively isolated.

Nine subspecies of the tiger, *Panthera tigris*, have been identified. Six of these subspecies are found on mainland Asia. Three of the subspecies originate from the Sunda Islands. These islands include Bali, Java and the large island of Sumatra.

Fig. 3.1 shows these three islands.

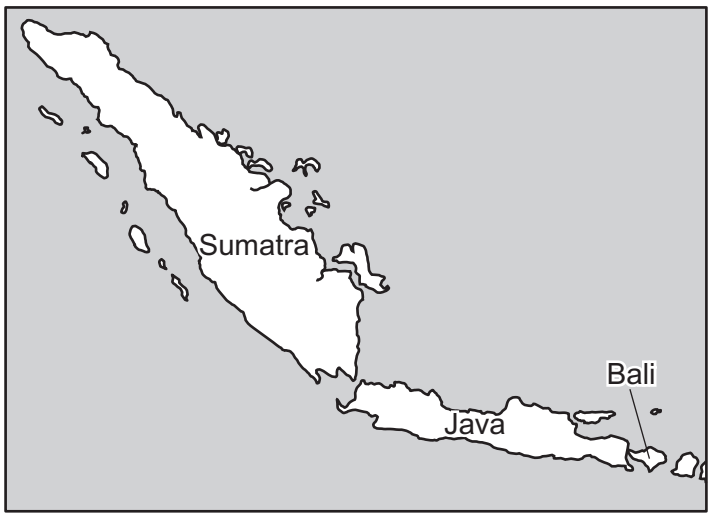

Fig. 3.1

- The Bali tiger, *Panthera tigris balica* (*P. t. balica*), became extinct in the 20th Century. The Bali tiger was found only on the island of Bali.
- The Javan tiger, *P. t. sondaica*, became extinct in the 20th Century. The Javan tiger was found only on the island of Java.
- The Sumatran tiger, *P. t. sumatrae*, lives only on Sumatra and is the closest living relative of Bali and Javan tigers.

20 000 years ago land bridges temporarily connected the Sunda Islands.

A recent study carried out a genetic analysis of the nine subspecies of tiger. Specific sections of mitochondrial DNA (mtDNA) that are useful in studies of evolution were amplified using PCR and compared to assess their evolutionary history.

- The source of DNA for the extinct subspecies came from museum specimens.
- mtDNA was extracted and polymerase chain reaction (PCR) carried out using primers based on specific sections of tiger mtDNA.
- The mtDNA sections for the three island subspecies were genetically distinct from the other six mainland subspecies.
- The mtDNA sections for the three island subspecies were all found to be very similar.

(a) Suggest **and** explain how the three subspecies of tiger on the Sunda Islands formed.

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..... [4]

(b) Explain why specific primers were used for the tiger mtDNA sections.

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..... [2]

(c) Describe **and** explain **one** characteristic of mtDNA that makes it more useful than using nuclear DNA to provide evidence of evolution.

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..... [2]

(d) Suggest **two** reasons why *P. t. balica* and *P. t. sondaica* became extinct.

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..... [2]

(e) Suggest why *P. t. sumatrae* is still considered to be a member of the species *Panthera tigris*.

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..... [2]

[Total: 12]

4 Gene therapy can be used to treat some genetic disorders. An appropriate vector is chosen to carry the normal allele into the target cell. Three types of vectors commonly chosen are naked DNA, viruses and liposomes.

(a) A trial of gene therapy to treat cystic fibrosis used a viral vector. The viral vector caused a primary immune response with the production of memory cells.

Explain why the production of memory cells prevents the gene therapy from working in long-term chronic conditions such as cystic fibrosis.

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..... [3]

(b) With reference to the three types of vectors that are commonly used, discuss the challenges in choosing appropriate vectors for use in gene therapy.

Do **not** include problems associated with an immune response in your answer.

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..... [4]

(c) A trial was carried out to find a new vector for use in gene therapy.

The new vector was made from red blood cells taken from the person with the genetic disorder. The cells had most of their cytoplasmic content removed and were then broken up to make small spherical vectors.

Most of these vectors lacked the ability to bind to receptors on the target cells.

To solve this problem, genetically engineered stem cells taken from the person were used to form red blood cells. These red blood cells had membrane proteins that were complementary to the target cell receptors. The vectors that were produced were well-tolerated by the immune system.

(i) Explain why the vectors were well-tolerated by the immune system.

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..... [2]

(ii) Suggest why it is not possible to produce genetically engineered red blood cells, except by using genetically engineered stem cells.

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..... [1]

[Total: 10]

5 Yeast cells respond to changes in glucose concentration in their environment by using transcription factors to switch off genes.

When glucose is **present**:

- Mig1 transcription factors bind to the promoters of five genes
- Mig1 binding to the promoters stops (represses) transcription of these genes.

The genes that are repressed by Mig1 code for five enzymes that allow yeast cells to metabolise the sugar galactose when glucose is absent.

(a) Complete Table 5.1 to show **three chemical** differences between a transcription factor, such as Mig1, and a promoter.

Table 5.1

	transcription factor	**promoter**
difference 1		
difference 2		
difference 3		

[3]

(b) Mig1 binds to promoter sites with these features:

- 17 base pairs long
- includes a region of five repeating adenine-thymine pairs
- includes a region of six repeating cytosine-guanine pairs.

Promoter sites to which Mig1 binds are known as Mig1-binding promoter sites.

Bioinformatic techniques were used to analyse the yeast genome to look for sections of DNA that match these features. The information obtained for four chromosomes is shown in Table 5.2.

Table 5.2

yeast chromosome	chromosome size / base pairs	number of Mig1-binding promoter sites per chromosome
A	230 018	1
B	813 184	10
C	316 620	2
D	1 531 933	14

(i) Explain why bioinformatic techniques were used to obtain the information in Table 5.2.

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.....

.....

..... [2]

(ii) Identify, with a reason, the yeast cell chromosome that is **most likely** to include genes that code for enzymes that metabolise galactose.

.....

..... [1]

(iii) Mig1 binds to 27 promoters on these four chromosomes. Yeast cells also have other chromosomes where Mig1 binds to additional promoters.

Five different enzymes, coded by five genes, must be made for yeast cells to metabolise galactose.

Suggest reasons why an individual diploid yeast cell has a larger number of Mig1-binding promoter sites than the expected number of ten.

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..... [2]

(c) The repression of genes involved in galactose metabolism in yeast is similar to events at the *lac* operon in the bacterium *Escherichia coli*.

Explain how *E. coli* **represses** the production of proteins needed to metabolise lactose sugar.

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..... [3]

[Total: 11]

6 **(a)** Thyrotoxic myopathy (TM) is a neuromuscular disorder caused by overproduction of the thyroid hormone thyroxine. One of the main symptoms of TM is muscle fatigue.

Fig. 6.1 outlines the effects of overproduction of thyroxine on striated muscle.

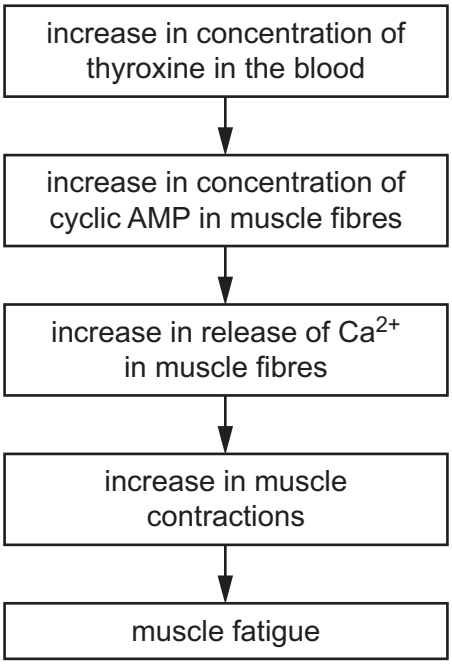

Fig. 6.1

(i) The concentration of thyroxine in the blood usually fluctuates around a set point.

Name the mechanism that keeps the concentration of thyroxine in the blood close to its set point.

..... [1]

(ii) Name the part of the striated muscle fibre that releases Ca^{2+}.

..... [1]

(iii) Describe the role of Ca^{2+}, troponin and tropomyosin in the contraction of striated muscle.

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..... [4]

(iv) Cyclic AMP (cAMP) is also involved in the response of liver cells to glucagon.

Describe the role of cAMP in the response of liver cells to glucagon.

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.....

..... [2]

(b) An increase in the concentration of thyroxine in the blood can lead to a condition called insulin resistance (IR). IR decreases the sensitivity to insulin of target cells, such as muscle and liver cells.

Suggest how decreased sensitivity to insulin affects target cells.

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..... [3]

[Total: 11]

7 **(a)** Define the term respiratory quotient (RQ).

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..... [2]

(b) Fig. 7.1 summarises the respiration of an organic substance, **A**, in aerobic conditions.

(i) Complete Fig. 7.1 in the spaces provided.

$C_{18}H_{32}O_2$ + ...O_2 ⟶ ..... CO_2 + $16H_2O$

substance **A**

Fig. 7.1 [2]

(ii) Calculate the RQ for substance **A**.

Write your answer to **two** decimal places.

RQ = ... [1]

(iii) Use your calculated RQ value to suggest the group of compounds to which substance **A** belongs.

..... [1]

(c) Dinitrophenol (DNP) is a compound used in the production of a number of products, including chemical dyes, insecticides and wood preservers. People who work in factories with DNP are at risk of exposure if they do not follow health and safety guidelines.

DNP is a molecule that can transport protons across the inner mitochondrial membrane, allowing protons to leak out of the intermembrane space.

(i) Suggest **and** explain the effects of DNP on aerobic respiration in human cells.

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..... [4]

(ii) Suggest **two** symptoms that may be experienced by people after exposure to DNP for several months.

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..... [2]

[Total: 12]

8 **(a)** Most organisms are classified according to a taxonomic hierarchy.

The hierarchy is shown in Fig. 8.1 but the group names are not in the correct order.

1 – kingdom

2 – order

3 – genus

4 – family

5 – domain

6 – class

7 – species

8 – phylum

Fig. 8.1

Complete Table 8.1 by writing the numbers in the correct order.

Table 8.1

5	.....	.....	.....	.....	.....	.....	**7**

[2]

(b) Members of the Eukarya domain share similar features but will also have several differences.

Complete Table 8.2 by stating the differences between the kingdoms Fungi and Plantae.

Table 8.2

	Fungi	Plantae
type of nutrition	.....	.....
storage polysaccharide	.....	.....
main component of cell wall	.....	.....

[3]

(c) Name the domain that contains organisms with a peptidoglycan cell wall.

..... [1]

(d) Viruses are not included in the three domain classification.

Outline how viruses are classified.

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..... [2]

[Total: 8]

Section B

Answer **one** question.

9 **(a)** Describe how gel electrophoresis is used to distinguish between two alleles of a gene. [9]

(b) Outline the advantages of screening for the presence of mutations of the genes for breast cancer, *BRCA1* and *BRCA2*. [6]

[Total: 15]

10 **(a)** Describe the role of chloroplast pigments in light absorption. [7]

(b) Outline how the Calvin cycle produces triose phosphate **and** outline the conversion of triose phosphate into amino acids. [8]

[Total: 15]

[Turn over

[Turn over