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 [ ].

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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 .....

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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**.

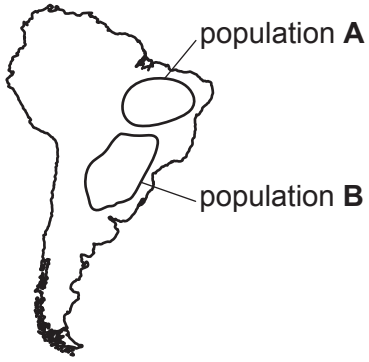


Fig. 3.1

- 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.

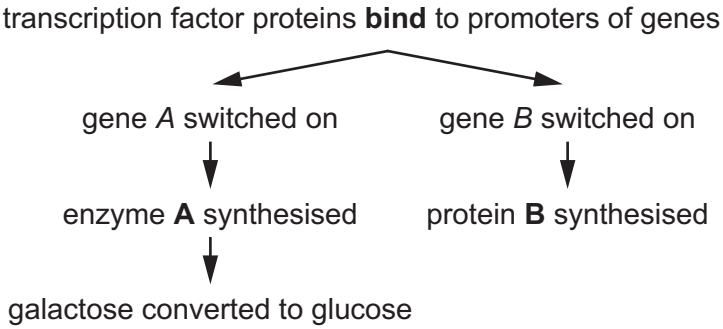


Fig. 5.1

(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.

.....

..... [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.

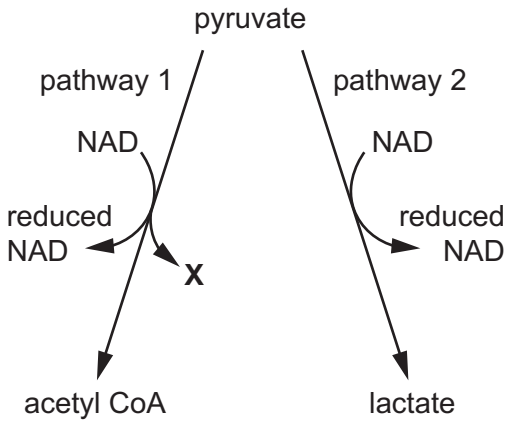


Fig. 6.1

(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.

.....

..... [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.

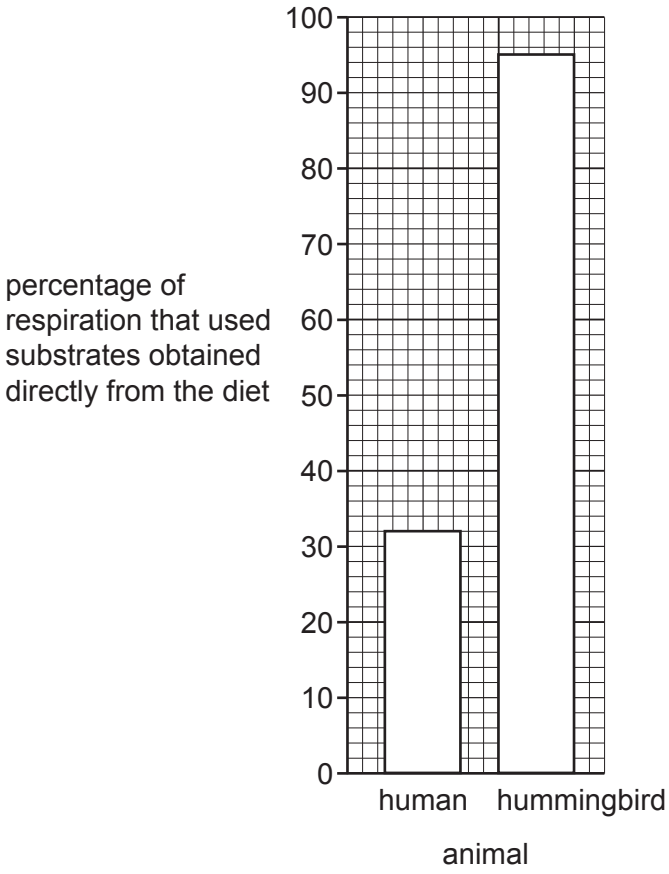


Fig. 6.3

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.

.....

.....

..... [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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[Turn over

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BIOLOGY **9700/42**

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

2 hours

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INFORMATION

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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]

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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.

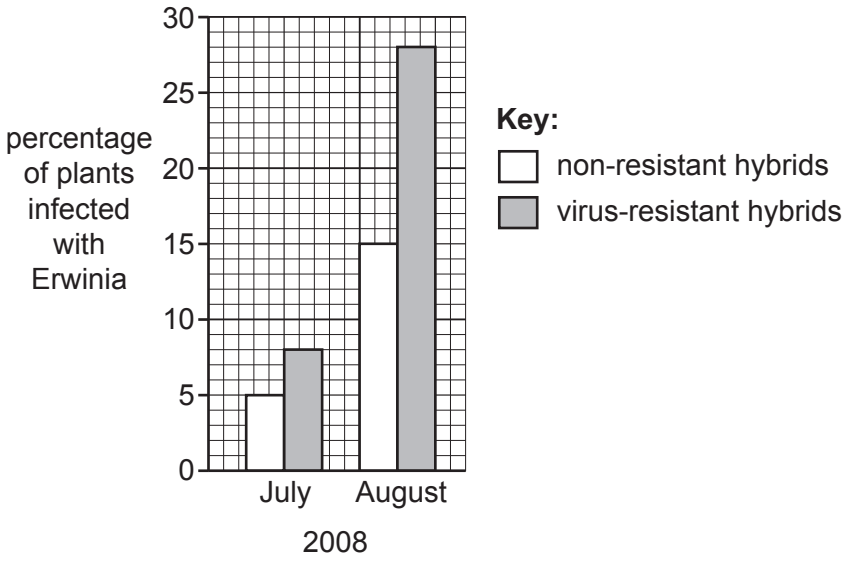


Fig. 2.2

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.

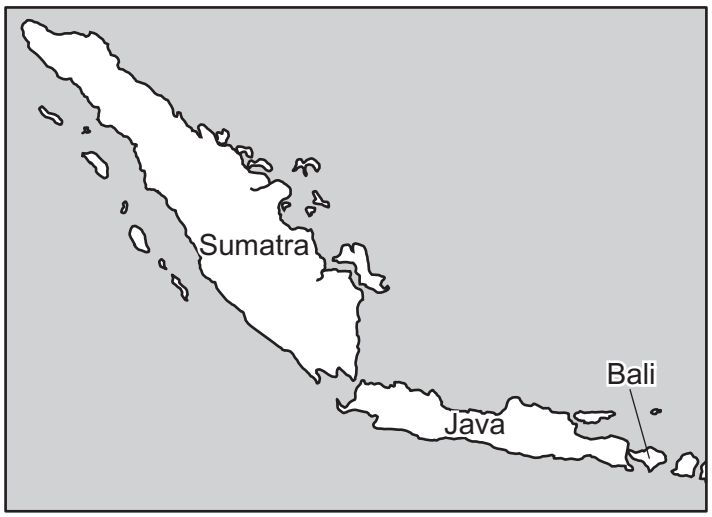


Fig. 3.1

- 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.

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(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.

.....

.....

.....

.....

..... [2]

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

.....

.....

..... [1]

[Total: 10]

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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.

.....

.....

.....

..... [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]

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(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.

.....

.....

.....

.....

..... [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.

.....

.....

.....

.....

.....

..... [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.

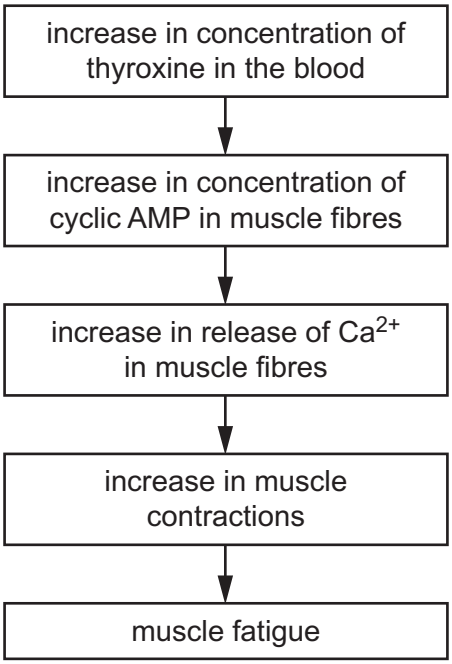


Fig. 6.1

(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]

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(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.

.....

.....

.....

..... [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.

.....

.....

.....

.....

.....

..... [3]

[Total: 11]

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

.....

.....

.....

.....

..... [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]

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(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.

.....

.....

.....

.....

.....

.....

.....

..... [4]

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

.....

.....

.....

.....

..... [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]

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

Outline how viruses are classified.

.....

.....

.....

..... [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]

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BIOLOGY **9700/43**

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 The courgette plant, *Cucurbita pepo*, produces edible fruits that vary in colour and shape.

Fruit colour in courgettes is controlled by the gene **A/a**.
Fruit shape in courgettes is controlled by the gene **B/b**.

- A yellow fruit is produced when the dominant allele **A** is present.
- A round fruit is produced when the dominant allele **B** is present.

Genes **A/a** and **B/b** occur on different chromosomes.

Table 1.1 shows the genotypes and phenotypes of four different varieties of courgette with respect to their fruit colour and shape.

Table 1.1

name of variety	genotype	fruit colour	fruit shape
Defender	**aabb**	green	long
Floridor	**AABB**	yellow	round
Golden Dawn	**AAbb**	yellow	long
Tondo di Piacenza	**aaBB**	green	round

(a) (i) The varieties Golden Dawn and Tondo di Piacenza were grown in the same garden and cross-pollination occurred between them. The gardener grew these cross-pollinated F1 seeds into plants that formed fruits.

The gardener did not know the genotypes of the parent plants and did not know that cross-pollination had occurred.

State the phenotype of the fruits of the F1 plants **and** explain why it was unexpected for the gardener.

.....

.....

.....

..... [2]

(ii) The gardener crossed two of these F1 plants.

Complete Fig. 1.1 with the F1 gametes, F2 genotypes and F2 phenotypes.

State the ratio of fruit phenotypes in the F2 offspring.

Fig. 1.1

ratio of fruit phenotypes ..... [4]

(b) Watermelons, *Citrullus lanatus*, are plants in the same family as courgettes. They produce large round edible fruits that usually contain many hard seeds. Seeds are the structures formed when the male and female gametes fuse at fertilisation.

In the 1990s a triploid (3n) watermelon plant was developed. To produce the triploid watermelon plant, a normal diploid parent plant (2n = 22) was crossed with an artificially created tetraploid plant (4n = 44).

Triploid watermelon plants develop edible fruits but these are sterile and do not contain seeds, making them more enjoyable to eat.

Explain why the fruits of the triploid plants are sterile and do not contain seeds.

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..... [3]

(c) (i) Watermelons are attacked by watermelon mosaic virus (WMV).
In 1965, a WMV-resistant plant in the same family, *Cucurbita ecuadorensis* (2n = 40), was found growing wild in South America.

State why a WMV-resistant variety of watermelon cannot be obtained by breeding *Cucurbita ecuadorensis* with a normal diploid watermelon.

.....

..... [1]

(ii) Outline how the WMV-resistant trait of *Cucurbita ecuadorensis* could be transferred to watermelon plants.

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..... [2]

[Total:12]

2 **(a)** Diabetes insipidus (DI) is a condition in humans that causes a person to have an excessive thirst, which leads to increased drinking. One form of DI is caused by a tumour in the region of the hypothalamus concerned with osmoregulation.

(i) Explain how a tumour develops in the hypothalamus.

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..... [2]

(ii) Suggest how a tumour in the hypothalamus can lead to a person producing a large volume of dilute urine.

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..... [3]

(b) The nervous and endocrine systems of a mammal co-ordinate responses to changes in the internal and external environment. Table 2.1 compares some features of the nervous and endocrine systems.

Complete Table 2.1.

Table 2.1

feature	nervous system	endocrine system
signal	impulse	.....
method of transmission of signal	.....	in blood
type of communication	.....	chemical
duration of effect	.....	.....

[4]

[Total: 9]

3 (a) The collared flycatcher, *Ficedula albicollis*, and the pied flycatcher, *F. hypoleuca* are two closely related species of bird. DNA analysis has shown that speciation from a common ancestor occurred approximately 1 million years ago.

A study was carried out on the island of Öland, Sweden. In Öland, the breeding areas of the two bird species overlap and small numbers of hybrid flycatchers are produced.

- Birds were captured and their DNA was analysed to identify whether each bird was *F. albicollis, F. hypoleuca* or a hybrid.
- Sperm samples were taken from the male birds.

Table 3.1 shows the percentage of males of each bird type with normal sperm.

Table 3.1

bird type	percentage of males with normal sperm
F. albicollis	68
F. hypoleuca	78
male hybrid	0

- The researchers observed that female birds mostly choose mates of their own species based on plumage (feathers) and song.
- Hybrid flycatchers are produced when female *F. albicollis* mate with male *F. hypoleuca* that have a song that is similar to *F. albicollis*.
- Analysis showed that all female hybrids were sterile.

The group of eggs a female bird lays at a single time in its nest is called a clutch. The offspring in the nest are looked after by a male-female pair. Sometimes the male in the male-female pair does not provide the sperm that fertilise the eggs of the female.

Table 3.2 shows:

- the percentage of clutches with eggs that hatched
- the percentage of extra-pair nestlings (offspring in the nest fathered by a male that was different from the male of the male-female pair).

Table 3.2

parents of nest		percentage of clutches with eggs that hatched	percentage of extra-pair nestlings
male	female		
F. albicollis	*F. albicollis*	94.5	17.2
F. hypoleuca	*F. hypoleuca*	89.3	22.4
hybrid	*F. albicollis* or *F. hypoleuca*	38.0	100.0

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(i) Discuss the pre-zygotic and post-zygotic isolating mechanisms that maintain *F. albicollis* and *F. hypoleuca* as separate species.

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..... [4]

(ii) Explain how the two species *F. albicollis* and *F. hypoleuca* could have evolved from one original ancestral population.

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..... [5]

(b) A single-nucleotide polymorphism (SNP) is caused by a base pair substitution mutation in a specific region of DNA.

One method of identifying whether two individuals have the same SNP is to:

- use a specific primer and polymerase chain reaction (PCR)
- add a restriction enzyme
- carry out gel electrophoresis
- stain with a dye to compare banding patterns.

(i) Explain why:

a specific primer is used

.....

.....

.....

a restriction enzyme is added

.....

.....

.....

gel electrophoresis is carried out.

.....

.....

.....

.....

[3]

(ii) The method of identifying whether two individuals have the same SNP method was carried out to compare species **A** and species **B**.

Fig. 3.1 shows the banding patterns that were observed.

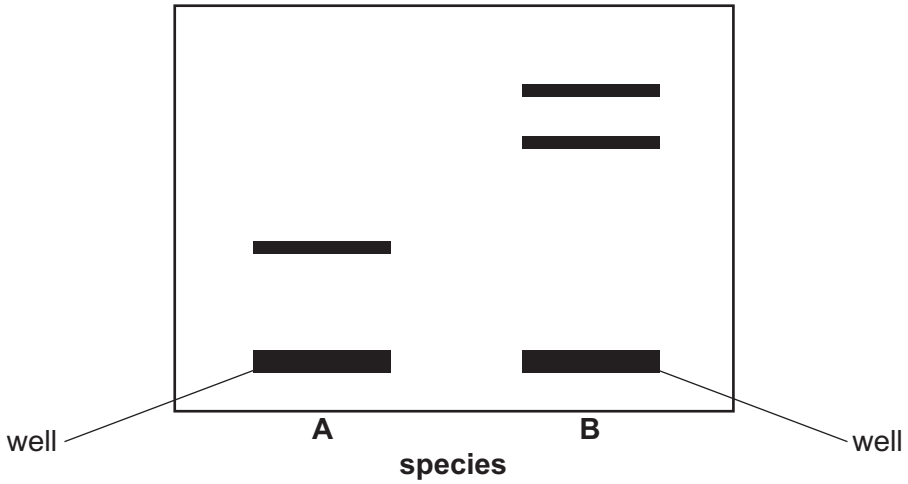


Fig. 3.1

Describe **and** suggest an explanation for the results obtained in Fig. 3.1.

.....

.....

.....

..... [2]

[Total: 14]

4 Lung epithelial cells have a thin layer of watery mucus on their surface.

The normal allele of the *CFTR* gene codes for a transport protein that transports chloride ions out of epithelial cells.

Fig. 4.1 is a diagram of part of the cell surface membrane and the mucus layer of an epithelial cell with normal CFTR proteins.

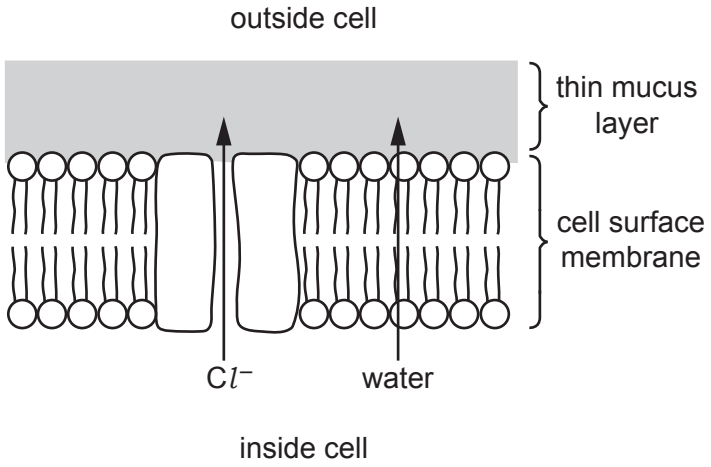


Fig. 4.1

Cystic fibrosis (CF) is a genetic disorder caused by having two recessive alleles of *CFTR*. In severe cases of CF, the transport proteins are not added to the cell surface membrane. This causes the mucus layer to be thick and sticky.

(a) Explain why the absence of CFTR proteins will cause the mucus layer to be thick and sticky.

.....

.....

.....

.....

..... [2]

(b) The probability of a baby having CF when both parents are heterozygous carriers for CF is 25%.

It is possible to carry out prenatal screening to check for CF by using one of these tests:

- amniocentesis, using cells from the amniotic fluid
- chorionic villus sampling, using cells from the placenta.

Both tests slightly increase the probability of the pregnancy failing (miscarriage).

Outline the advantages of carrying out prenatal screening for CF.

.....

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..... [3]

(c) Embryos produced by IVF may be screened for genetic abnormalities:
- to test for a specific genetic disease, such as cystic fibrosis
- to check whether there is an abnormal number of chromosomes present.

To improve the success of implantation and pregnancy, only embryos without any form of genetic abnormality are transferred to the woman's uterus.

A new double screening method was trialled where a single embryo biopsy was taken and used to test for a specific genetic disease **and** to check the number of chromosomes.
In the trial, 1122 embryos were tested using this double screening method.

In the trial, of the 1122 embryos tested:
- 50.6% did not have a genetic disease
- 27.5% did not have a genetic disease **and** did not have an abnormal number of chromosomes (normal embryos).

Only normal embryos were transferred into the women. The percentage of embryo transfers that resulted in pregnancy was calculated.

The results of the trial using double screening of a single biopsy were compared to the results of IVF procedures that used standard screening methods, as shown in Table 4.1.

Table 4.1

IVF method	percentage of embryo transfers that resulted in pregnancy
IVF with standard screening	32
IVF with double screening	49

Using the data in Table 4.1, discuss the social **and** ethical considerations of double screening for cystic fibrosis and chromosomal abnormalities in a single biopsy.

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..... [3]

[Total: 8]

5 Yeast cells are unicellular eukaryotes that respond to the presence and absence of different sugars by switching genes on or off. One example of this is summarised in Fig. 5.1.

If glucose is **present**, a sequence of events occurs.
- Yeast cells metabolise glucose using constitutively expressed enzymes.
- Mig1 transcription factor (**A**) binds to promoter **B**.
- This stops transcription of gene **C**.
- Production of enzyme **D** stops.

If galactose is present and glucose is **absent**, a different sequence of events occurs.
- The Msn2 transcription factor (**E**) binds to promoter **B**.
- This activates transcription of gene **C**.
- Enzyme **D** is produced and helps convert galactose to glucose.

Gene **F** codes for the Mig1 transcription factor, **A**.
Gene **G** codes for the Msn2 transcription factor, **E**.

Fig. 5.1

(a) (i) With reference to Fig. 5.1, identify **one** letter corresponding to:

a structural gene .....

a control (regulatory) sequence .....

a repressor molecule .....

[3]

(ii) Explain why enzyme **D** is described as inducible.

.....

.....

.....

.....

.....

..... [2]

(b) Scientists have produced genetically engineered yeast cells. The gene coding for Mig1 transcription factor and the marker gene coding for green fluorescent protein (GFP) are transcribed together to produce a single mRNA molecule.

The resulting Mig1 transcription factor proteins contain a GFP region as part of their structure and are called tagged Mig1 molecules. These tagged Mig1 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 Mig1 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 Mig1 molecules present		
	cytoplasm	nucleus	total
glucose absent	1156	176	1332
glucose present	580	226	806

(i) Calculate the percentage of Mig1 molecules in the nucleus when glucose is **present**.

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

..... % [2]

(ii) When glucose is **absent**, 13% of the available Mig1 molecules are present inside the nucleus.

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

.....

.....

.....

..... [2]

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(c) Yeast cells are unable to take in and metabolise the disaccharide sugar lactose.

Some strains of yeast have been genetically engineered to overcome this, by inserting two genes from the bacterium *Escherichia coli* into yeast cells.

Name the **two** bacterial genes that have been inserted into the yeast cells.

.....

..... [2]

[Total: 11]

6 **(a)** Structures and compounds involved in the light dependent stage of photosynthesis are listed, **A** to **J**.

A – thylakoid membrane

B – starch grain

C – chlorophyll a

D – chlorophyll b

E – water

F – NADP

G – electron

H – proton

I – ATP

J – chloroplast envelope

Complete Table 6.1 by matching each description with **one** letter chosen from **A** to **J** to show the correct structure or compound.

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

Table 6.1

description	letter
accessory pigment	
location of ATP synthase	
acts as reaction centre	
transports hydrogen atoms	
diffuses through ATP synthase	
broken down in photolysis	

[6]

(b) GP (PGA) and TP (triose phosphate) are intermediates of the Calvin cycle of the light independent stage. Some GP and TP are used for the synthesis of organic compounds.

(i) Name a polysaccharide synthesised as a result of TP production.

..... [1]

(ii) Name the additional element that is required for the production of amino acids from Calvin cycle intermediates.

..... [1]

[Total: 8]

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7 **(a)** Fig. 7.1 shows part of the process of respiration in a mitochondrion.

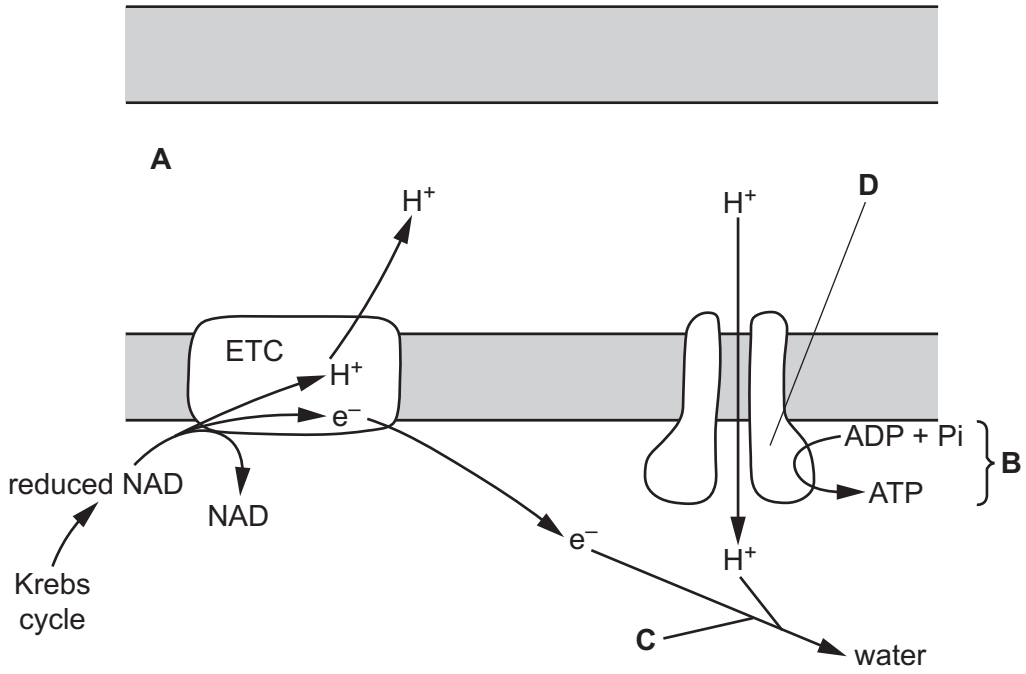


Fig. 7.1

(i) With reference to Fig. 7.1, name:

area **A** .....

process **B** .....

substance **C** .....

[3]

(ii) State the type of chemical compound that is represented by **D**.

..... [1]

(iii) State the process by which ATP can be synthesised directly during glycolysis or the Krebs cycle.

..... [1]

The elephant seal, *Mirounga angustirostris*, spends most of its life in the ocean.

Fig. 7.2 is an elephant seal.



Fig. 7.2

(b) Elephant seals can stay underwater for up to two hours. During this time, respiration continues.

Fig. 7.3 shows the mass of blood in the body, as a percentage of total body mass, for the elephant seal and for three other mammals.

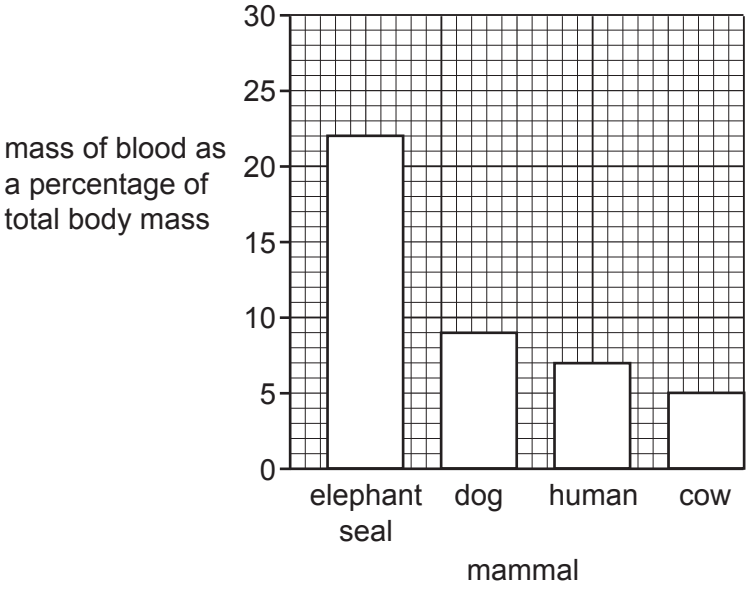


Fig. 7.3

(i) Fig. 7.3 shows that elephant seals have a higher mass of blood as a percentage of total body mass than humans.

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

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

answer ..... [2]

(ii) Suggest why an elephant seal needs such a large mass of blood as a percentage of total body mass.

.....

.....

.....

.....

..... [2]

(c) Elephant seals have a very thick layer of adipose tissue under their skin. Adipose cells are rich in fat molecules.

Suggest why 1 g of fat will produce more ATP than 1 g of carbohydrate as a respiratory substrate in aerobic respiration.

.....

.....

.....

.....

.....

..... [2]

(d) (i) Adipose tissue plays an important role in thermoregulation in elephant seals.

State the role of adipose tissue in thermoregulation.

..... [1]

(ii) The hypothalamus in the brain is the control centre for thermoregulation.

Outline how a change in temperature of the external environment results in an impulse arriving at the hypothalamus.

.....

.....

.....

..... [2]

(iii) When the blood temperature of a mammal decreases, one response is that its body secretes more adrenaline.

Suggest how an increase in adrenaline results in an increase in blood temperature.

.....

.....

.....

..... [2]

[Total: 16]

8 **(a)** Sampling can be used to find the distribution and abundance of species in an area.

Students sampled a rocky shore from a high tide area to a low tide area. They decided to use a belt transect.

Describe how you would carry out a belt transect to assess the distribution and abundance of organisms in an area.

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..... [5]

(b) The results of an ecological investigation may suggest that there is a relationship between two variables, for example the abundance of a plant species and light intensity.

Scattergraphs can be drawn between the two variables.

(i) Fig. 8.1 shows three scattergraphs, **A**, **B** and **C**.

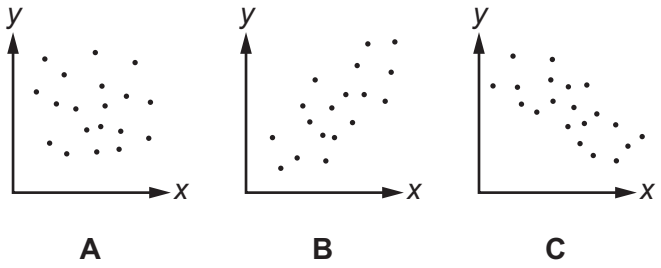


Fig. 8.1

State which scattergraphs show a relationship between the two variables, *x* and *y*.

..... [1]

(ii) Name a statistical test you would carry out to assess the strength of any relationship between two variables.

..... [1]

[Total: 7]

Section B

Answer **one** question.

9 **(a)** Using named examples, describe **and** explain the differences between continuous variation and discontinuous variation. [8]

(b) Outline how selective breeding (artificial selection) has improved the yield of crops, such as wheat and maize.

[7]

[Total: 15]

10 **(a)** Describe **and** explain how the stimulation of sensory hair cells of a Venus fly trap plant leads to an insect being trapped. [8]

(b) Explain what is meant by the term *homeostasis* **and** describe the principles of homeostasis in mammals. [7]

[Total: 15]

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