OCR
Oxford Cambridge and RSA

Friday 15 October 2021 – Morning

A Level Biology A

H420/02 Biological diversity

Time allowed: 2 hours 15 minutes

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

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

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

First name(s) _____

Last name _____

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

INFORMATION
- The total mark for this paper is **100**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **28** pages.

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

SECTION A

You should spend a maximum of 20 minutes on this section.

Write your answer to each question in the box provided.

Answer **all** the questions.

1 Which of the options is a function of fibrous proteins?

A aids rigidity of membranes

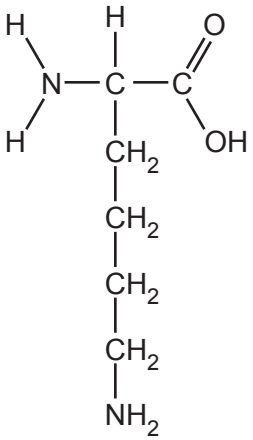
B involved in cell signalling

C provides elasticity in alveoli

D speeds up reactions

Your answer ☐ **[1]**

2 Which of the types of molecule is shown in the diagram?



A amino acid

B fatty acid

C nitrogenous base

D nucleotide

Your answer ☐ **[1]**

3 Which of the following processes is important in determining the overall body plan of an organism?

A endocytosis

B exocytosis

C meiosis

D mitosis

Your answer ☐ **[1]**

4 Genes are not expressed during cell division because chromosomes are more tightly wound around histone proteins than during interphase.

Which of the following shows the level at which gene expression is being controlled when DNA is more tightly wound during cell division?

A post-transcriptional

B post-translational

C transcriptional

D translational

Your answer ☐ **[1]**

5 Antibodies form part of the immune response.

Which of the following types of antibody bind to antigens on the surface of pathogens?

1 opsonins
2 agglutinins
3 anti-toxins

A 1, 2 and 3

B only 1 and 2

C only 2 and 3

D only 1

Your answer ☐ **[1]**

6 The primary immune response involves differentiation and clonal expansion of certain white blood cells.

Which of the following cells result from clonal expansion during the primary immune response?

1 plasma cells
2 B-memory cells
3 T-memory cells

A 1, 2 and 3

B only 1 and 2

C only 2 and 3

D only 1

Your answer ☐ **[1]**

7 Lupus is an autoimmune disease that affects the skin, joints and internal organs.

Which of the following is likely to be an effective treatment for lupus?

A immunosuppressant drugs

B injection of antibodies from someone who does not suffer from lupus

C somatic gene therapy

D vaccination

Your answer ☐ **[1]**

8 Lupus is a rare condition affecting approximately 0.025% of the population. However, 9 out of 10 sufferers are women.

The population of England and Wales in 2019 was approximately 64 million.

Which of the following estimates shows the number of men in England and Wales suffering from lupus?

A 160

B 1600

C 16 000

D 160 000

Your answer ☐ **[1]**

9 Which of the following substances is **not** required in DNA sequencing?

A DNA polymerase

B primers

C RNA nucleotides

D terminator bases

Your answer ☐ **[1]**

10 DNA fragments can be separated using gel electrophoresis.

Which of the following explains how gel electrophoresis is able to separate DNA fragments?

A DNA carries a negative charge and large fragments are pulled more strongly than small fragments towards the positive electrode.

B DNA carries a negative charge and small fragments are able to travel more quickly than large fragments towards the positive electrode.

C DNA carries a positive charge and large fragments are pulled more strongly than small fragments towards the negative electrode.

D DNA carries a positive charge and small fragments are able to travel more quickly than large fragments towards the negative electrode.

Your answer ☐ **[1]**

11 Gene sequencing has a number of uses.

Which of the following is **not** a use of gene sequencing?

A determining the amino acid sequence of a polypeptide

B the classification of newly-discovered organisms

C the polymerase chain reaction

D the selection of the correct vaccine in a disease outbreak

Your answer ☐ **[1]**

12 *Brassica rapa* is a plant that occurs in wild-type and dwarf varieties.

A student investigated the growth of *B. rapa*.

Seeds of both varieties were planted and the heights of stems were measured 20 days after planting.

The results are shown below.

Variety	Height after 20 days (cm)						
	Individual plants						Mean
	1	2	3	4	5	6	
Wild-type	90.7	94.5	87.4	82.7	92.0	91.5	89.8
Dwarf	6.5	8.0	7.4	7.8	8.3	7.8	7.8

Which of the following correctly explains the student's results?

A variation in height between varieties is continuous and polygenic

B variation in height between varieties is discontinuous and controlled by one or two genes

C variation in height within varieties is continuous and controlled only by one or two genes

D variation in height within varieties is discontinuous and polygenic

Your answer ☐ **[1]**

13 Moving North from a large solitary tree in the school field, some students studied changes in plant species. They laid a tape measure due North from the base of the tree trunk and dropped a quadrat at 1 m intervals for 15 m.

Which of the following correctly describes the students' sampling method?

A arbitrary

B random

C stratified

D systematic

Your answer ☐ **[1]**

14 Which of the following best defines the term species richness?

A the distribution of species over an area

B the number of species in an area

C the relative abundance of each species in an area

D the relative number of individuals of a species in an area

Your answer ☐ **[1]**

15 Biodiversity can be considered at different levels.

An area of woodland habitat has a high Simpson's Index of Diversity.

Which of the following describes an area with a high Simpson's Index of Diversity?

A the area has a high genetic biodiversity

B the area has a high habitat biodiversity

C the area has a high species biodiversity

D the area is high in all levels of biodiversity

Your answer ☐ **[1]**

SECTION B

Answer **all** the questions.

16 DNA is a biological molecule that varies between individuals.

Sections of DNA code for proteins.

(a) **Fig. 16.1** shows the structure of part of a DNA molecule.

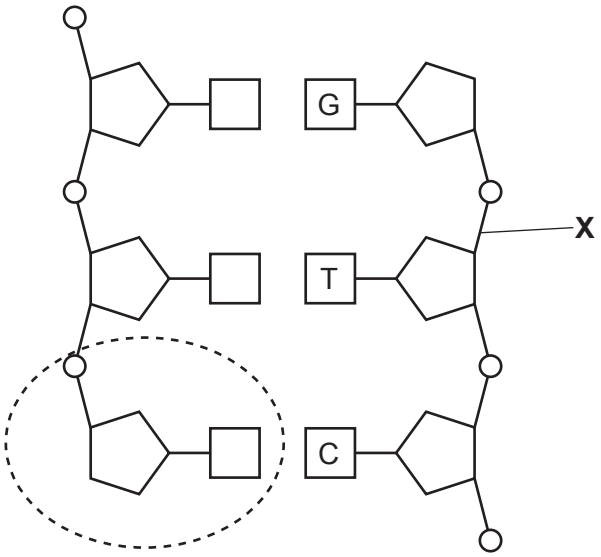


Fig. 16.1

(i) The circled region shows one nucleotide.

Name the components of **this** nucleotide.

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

(ii) State the name of the bond labelled **X** and the type of reaction that forms this bond.

Name .....

Type of reaction .....

[2]

(b) DNA profiling makes use of the fact that DNA varies between individuals.

(i) When creating a DNA profile, DNA is first extracted from a sample of tissue.

Outline the subsequent steps involved in producing a DNA profile.

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(ii) **Fig. 16.2** shows a DNA profile used to determine fatherhood in a paternity case.

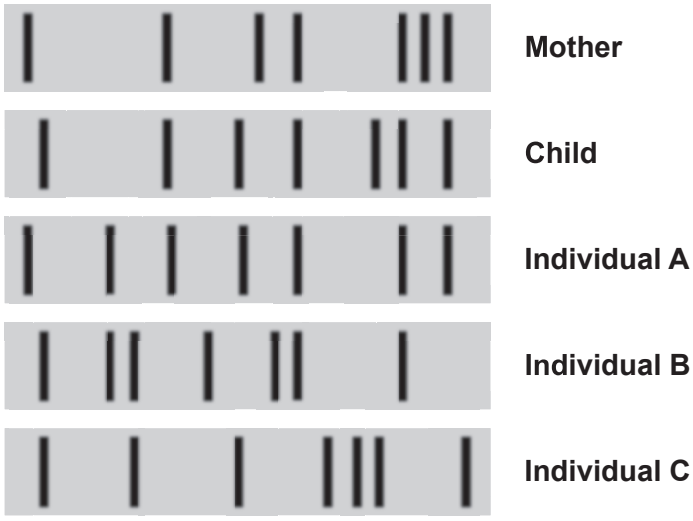

Fig. 16.2

Identify the individual who is most likely to be the child's father.

Justify your answer.

Individual .....

Justification .....

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

(iii) DNA profiling can be used in cases of paternity and forensics.

State **one** other use of DNA profiling.

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

(c) DNA codes for proteins within the cell. Some regions of DNA are described as non-coding.

(i) Explain why some regions of DNA can be described as 'non-coding'.

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

(ii) Non-coding regions of DNA show more variation than coding regions. This makes non-coding regions useful in DNA profiling.

Suggest why non-coding regions of DNA show more variation.

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

(d) DNA sequencing has allowed scientists to create a strain of *Escherichia coli* bacteria with an entirely artificial genome.

Complete the passage using the most appropriate words.

The creation of an organism with an artificial genome is known as .....

biology. The bacterium created has been classified in the genus .....

However, the classification of this organism is problematic because the basis of classification

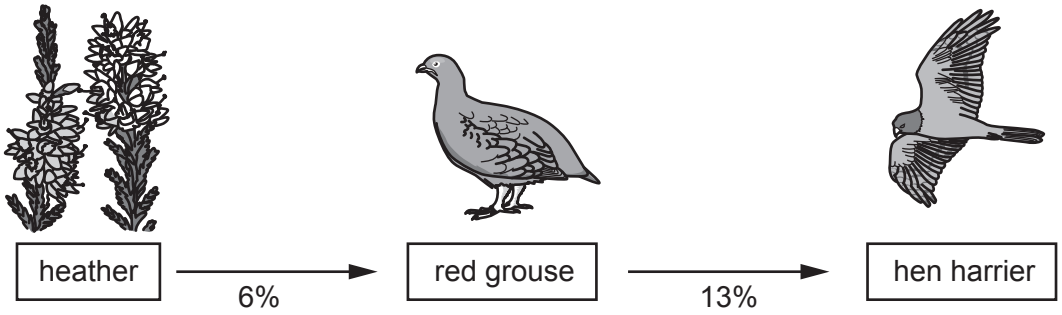
is ..... .

[3]

17 Heather is a plant with a woody stem that grows on upland areas of the UK such as the North York Moors. These areas are often described as heather moorland.

Heather moorland is a habitat that is relatively common in the UK but rare elsewhere in the world.

The diagram shows an example of biomass transfer in a heather moorland ecosystem.



The numbers below the arrows represent the percentage of biomass transferred to the species shown in the next trophic level.

(a) Sunlight that can potentially be used in photosynthesis by green plants such as heather is called photosynthetically active radiation (PAR).

(i) In one year, 8.94×10^9 kJ m^{-2} of PAR fell on an area of heather moorland.

The heather plants then converted 9.08×10^7 kJ m^{-2} of this energy into biomass.

Calculate the energy in the PAR that the heather did **not** convert into biomass.

Energy = ... kJ m^{-2} **[2]**

(ii) Scientists were able to estimate the increase in biomass in heather plants in one year.

Suggest how the increase in biomass over time in a plant such as heather could be determined experimentally.

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

(iii) Some of the solar radiation that falls on the leaves of plants is reflected. Some solar radiation is of a wavelength that is not suitable for use in photosynthesis.

List **one** other reason why much of the PAR is not used by the plant in the production of biomass.

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

(iv) Suggest and explain why the percentage of biomass transferred between heather and grouse is smaller than the percentage of biomass transferred between grouse and hen harrier.

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

(b) The hen harrier is the top predator on heather moorland in the UK.

Scientists are concerned about a recent decrease in the population of hen harriers.

The current estimate of the hen harrier population in the UK is 545 pairs. This represents 71% of the estimated population in 2004.

(i) Calculate the estimated population of UK hen harriers in 2004.

Estimated population = ... pairs **[2]**

(ii) Since 2004, the population of red grouse in the UK has been relatively stable and it is not thought that the population has been affected by changes in climate.

Suggest an explanation for the decrease in hen harrier numbers since 2004.

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

(c) Heather moorland in the UK is managed in an attempt to conserve the habitat. One of the procedures carried out as part of this management is regular burning of the moorland. Small areas are burnt in the winter and new shoots begin to grow the following year. This helps to maintain a variety of heights of heather plants, and prevents the growth of other larger species of plant.

(i) State why the management of heather moorland is known as *in situ* conservation.

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

(ii) Apart from regular burning, suggest another procedure that could be carried out to conserve the heather moorland habitat.

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

(d)* In a newly-available area of land, the communities change over time. The process of change is known as succession.

Outline the process of primary succession **and** explain why heather moorland is an example of deflected succession.

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Additional answer space if required.

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18 Cells are surrounded by a plasma membrane that contains phospholipids.

(a) Explain how the structure of phospholipid molecules allows for the formation of plasma membranes.

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

(b) The permeability of plasma membranes can be investigated using beetroot.

Beetroot cells contain a red pigment. The red pigment leaks out of the cells only when the plasma membrane has become damaged.

Some students investigated the effect of pH on the permeability of plasma membranes in beetroot cells.

The students used a valid method for the investigation, which is outlined below:

- Equal-sized disks of beetroot were cut.
- The disks were each immersed in an equal volume of buffer solution.
- After a set time, the solution was stirred and the absorbance measured using a colorimeter.
- The procedure was replicated three times in each of six different pH buffers.

The students recorded their results in the format shown below.

pH2 – 80%, 78%, 78%: average = 78.67%
pH3 – 61%, 60%, 60%: average = 60.33%
pH4 – 19%, 23%, 22%: average = 21.33%
pH5 – 9%, 10%, 11%: average = 10 %
pH6 – 0%, 0%, 0%: average = 0
pH7 – 0%, 0%, 0%: average = 0

(i) Present the students' results in an appropriate table in the space below.

[4]

(ii) The students concluded that the red pigment began to leak out of the beetroot cells at any pH below pH6.

Suggest and explain why a low pH might cause the red pigment to leak out of the beetroot cells.

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

(iii) Outline how the students could modify their investigation to get a more accurate value for the pH at which the red pigment begins to leak out of the beetroot cells.

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

19 The inheritance of some alleles depends on the sex of the individual.

(a) In birds, sex is determined by a combination of **Z** and **W** chromosomes.

Male birds have two **Z** chromosomes and female birds have one **Z** chromosome and one **W** chromosome.

(i) The chromosomes used to determine sex inheritance are given different letters in birds and mammals.

Identify one **other** way in which the sex determination in birds is different from sex determination in mammals.

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

(ii) A pigeon is a bird. The colour of pigeon feathers is determined by a single gene on the **Z** chromosome.

The feather colour gene has three alleles.
$\mathbf{Z^A}$ = red
$\mathbf{Z^B}$ = blue
$\mathbf{Z^b}$ = brown

$\mathbf{Z^A}$ is dominant to $\mathbf{Z^B}$ and $\mathbf{Z^b}$
$\mathbf{Z^B}$ is dominant to $\mathbf{Z^b}$

The **W** chromosome contains no gene for feather colour.

A pigeon with the genotype $\mathbf{Z^A\ Z^b}$ was crossed with a pigeon with genotype $\mathbf{Z^BW}$.

Complete the answer lines below to show this genetic cross.

Parent genotypes: $\mathbf{Z^A\ Z^b}$ × $\mathbf{Z^BW}$

Parent phenotypes: ....

Gametes: ....

Offspring genotypes: .....

Offspring phenotypes: .....

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[4]

(b) Haemophilia in humans is a sex-linked disorder.

The recessive haemophilia allele is carried on the **X** chromosome.

Females who carry the recessive allele for haemophilia on one of their sex chromosomes do not show any symptoms.

A female who was a carrier of the haemophilia allele and a male who did not have the haemophilia allele had nine children. The expected ratio of phenotypes in the children of this couple would be 2 healthy females : 1 healthy male : 1 male with haemophilia.

(i) A student performed a chi squared calculation on the phenotypes of the actual nine children.

Part of the calculation is shown in **Table 19.1**.

Phenotypes	**Observed number (O)**	**Expected number (E)**	**O–E**	**$(O–E)^2$**	**$\frac{(O–E)^2}{E}$**
Healthy female			0.5	0.25	0.056
Healthy male			0.75	0.56	0.249
Haemophilia male			–1.25	1.56	0.693
				χ^2 =	0.998

Table 19.1

Complete the table by filling in the columns for the observed and expected numbers.

[Answer on Table 19.1] **[2]**

(ii) **Table 19.2** shows part of a statistical table for the chi squared test.

p%	**99**	**95**	**90**	**10**	**5.0**	**1.0**	**0.5**
v = **1**	.0001	.0039	.0158	2.706	3.841	6.635	7.879
2	.0201	0.103	0.211	4.605	5.991	9.210	10.60
3	0.115	0.352	0.584	6.251	7.815	11.34	12.84
4	0.297	0.711	1.064	7.779	9.488	13.28	14.86
5	0.554	1.145	1.610	9.236	11.07	15.09	16.75
6	0.872	1.635	2.204	10.64	12.59	16.81	18.55
7	1.239	2.167	2.833	12.02	14.07	18.48	20.28
8	1.646	2.733	3.490	13.36	15.51	20.09	21.95
9	2.088	3.325	4.168	14.68	16.92	21.67	23.59

Table 19.2

Identify the critical value for the chi squared test in part **(i)**.

Critical value = ... **[1]**

(iii) The calculated value for χ^2 was below the critical value.

The student concluded that their expected ratio of 2 : 1 : 1 was incorrect and should be rejected.

Evaluate the student's conclusion.

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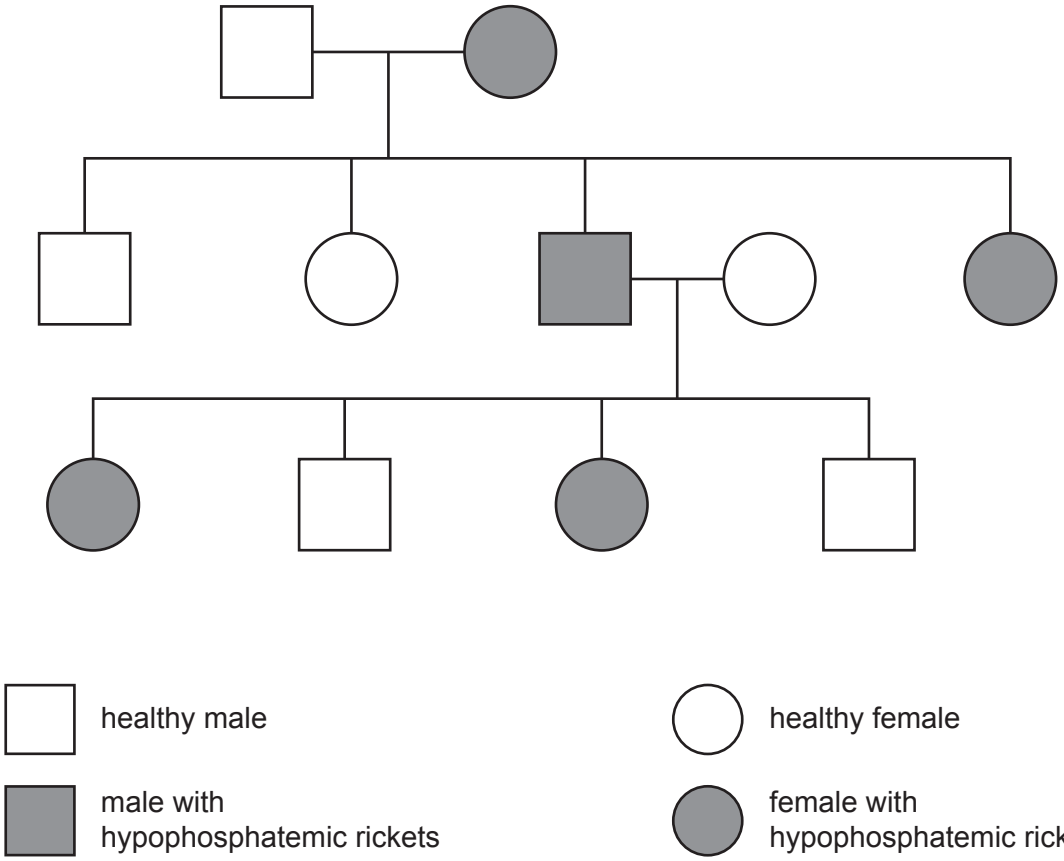
..... **[2]**

(c) Hypophosphatemic rickets is a sex-linked condition.

The diagram shows the occurrence of hypophosphatemic rickets in a single family.



What conclusions can be drawn about the inheritance of hypophosphatemic rickets?

Explain your answer.

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

20 Charles Darwin visited the Galapagos Islands in the 1820s. The organisms living on the Galapagos Islands provided Darwin with evidence that helped him to develop his theory of evolution by natural selection.

(a) Finches are small birds that are common on the Galapagos Islands.

The variation in the sizes of beak of the various Galapagos finch species provided evidence for evolution by natural selection.

Scientists recently studied the beak sizes of two species of Galapagos finch living on the same island, *Geospiza fuliginosa* and *Geospiza fortis*.

Beak size is an overall measurement that includes length, depth and width. The arbitrary units are relative to the average of all of the individual birds measured.

Some of the scientists' results are shown in **Fig. 20.1**.

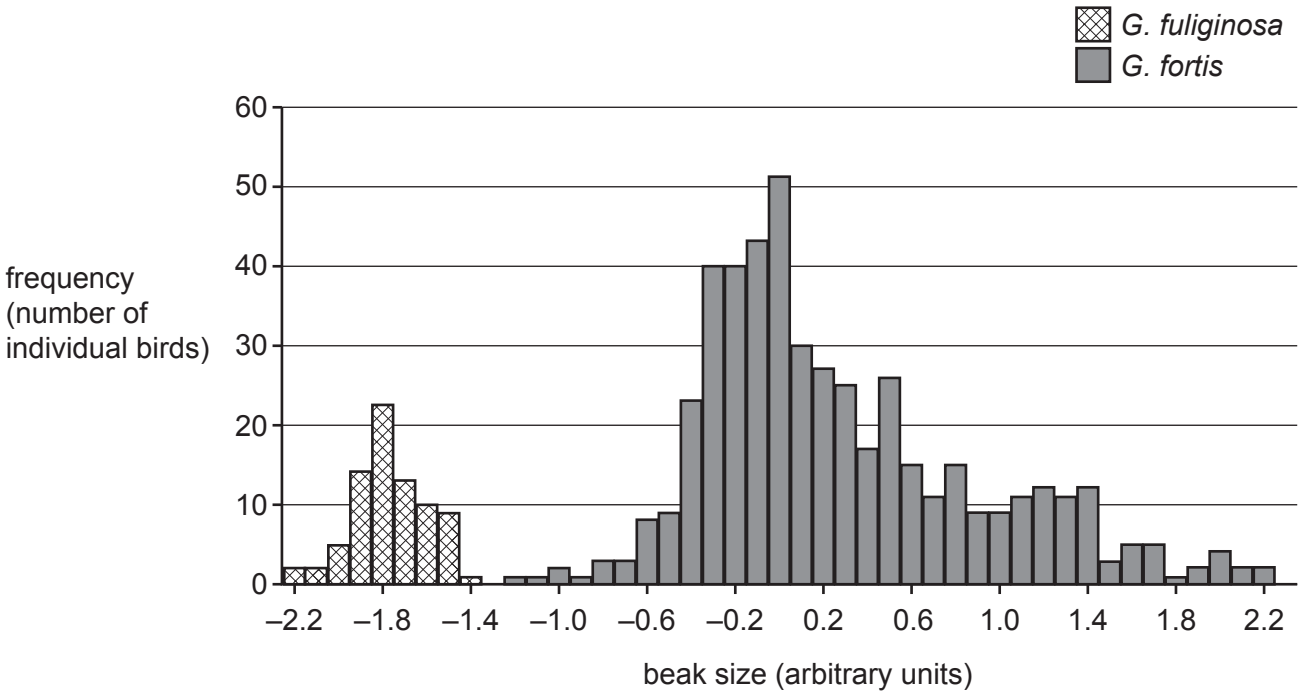

Fig. 20.1

(i) Identify the modal beak size of *G. fuliginosa*.

Size = ... arbitrary units **[1]**

(ii) Calculate the range of *G. fuliginosa* beak size as a proportion of the range of *G. fortis* beak size.

Give your answer to **2** significant figures.

Proportion = ... **[2]**

(iii) The scientists concluded that the data showed evidence of disruptive selection in the population of *G. fortis*. In disruptive selection, extreme phenotypes are selected for and average phenotypes selected against.

Evaluate the conclusion that disruptive selection is occurring in *G. fortis*.

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

(b) The *G. fortis* all live in the same location. If disruptive selection is occurring in the *G. fortis* population, it is possible that speciation might occur.

(i) Name the type of speciation that occurs when two populations live in the same location.

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

(ii) Suggest how *G. fortis* with large beaks could become reproductively isolated from *G. fortis* with small beaks despite living in the same location.

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

(iii) Comparing anatomy between species such as beak size in finches can be used to provide evidence to support the theory of evolution by natural selection.

Describe how DNA can be used to provide evidence to support the theory of evolution by natural selection.

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

(c)* In the 1970s, another group of scientists studied beak sizes in one species of finch on Daphne Island, one of the Galapagos Islands. The study lasted three years. The results are shown in **Fig. 20.2**.

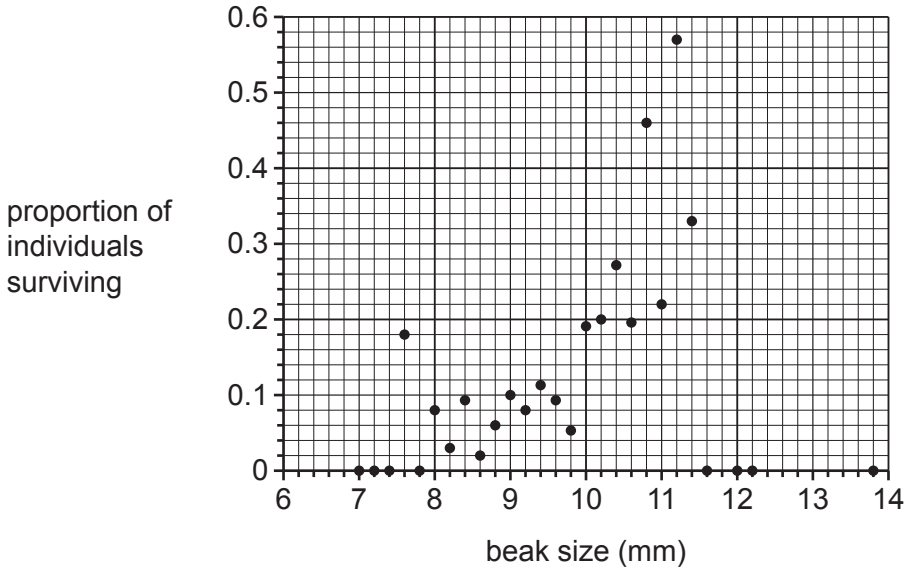

Fig. 20.2

The results suggested that stabilising selection was occurring within this population of finches.

With reference to **Fig. 20.2**, explain the effect of stabilising selection on beak size on Daphne Island. **[6]**

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Additional answer space if required.

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(d) Alfred Russel Wallace is another important figure in the understanding of evolution.

Outline the way in which Wallace contributed to the acceptance of Darwin's theory of natural selection by the wider scientific community.

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

21 Plants have the ability to propagate themselves naturally by cloning. This ability is used by humans commercially when carrying out tissue culture.

(a) Strawberry plants produce clones using runners. This is an example of natural cloning.

State **one** other method of natural cloning in plants.

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

(b) Name the type of plant tissue from which natural clones are produced.

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

(c) Tissue culture greatly increases the number of cloned plants that can be produced from a single parent plant.

Outline how it is possible to produce many clones from a single original parent plant.

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

(d) Pineapples are plants that can be cloned by tissue culture.

Plant hormones are used during the tissue culture process. One of these plant hormones is known as BAP.

The table below shows the effect of the concentration of BAP on the length of pineapple shoots.

BAP concentration ($mg\,dm^{-3}$)	Mean shoot length (mm)
0	33.8
1	27.5
2	23.6
3	30.8
4	37.0
5	49.9
6	26.4
7	22.3

(i) Calculate the percentage increase in mean shoot length caused by adding 5 mg dm^{-3} BAP.

Give your answer to **2** significant figures.

Percentage increase = ... % **[2]**

(ii) The valid investigation that generated the results shown above featured an independent variable, a dependent variable and several controlled variables.

State the independent and dependent variables and suggest **two** appropriate controlled variables.

Independent variable .....

Dependent variable .....

Controlled variables

1 .....

2 .....

[3]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

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