



Rewarding Learning

ADVANCED
General Certificate of Education

Centre Number

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Candidate Number

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Biology

Assessment Unit A2 2

assessing

Biochemistry, Genetics and
Evolutionary Trends



[ABY21]

ABY21

Assessment

Assessment Level of Control:

Tick the relevant box (✓)

TIME

2 hours 15 minutes.

Controlled Conditions	
Other	

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen.**

Answer **all nine** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100. Section A carries 82 marks. Section B carries 18 marks. Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

You are reminded of the need for good English and clear presentation in your answers.

Use accurate scientific terminology in all answers.

You should spend approximately **25 minutes** on Section B.

You are expected to answer Section B in continuous prose.

Quality of written communication will be assessed in Section B.

Statistics Sheets are **not** required for use with this paper.

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40ABY2101

Section A

1 (a) Kingdom Animalia can be divided into phyla. Using the key shown, identify the animal phyla **A–E** and write the answers in the table below.

1. Bilaterally symmetrical – go to 2
Not bilaterally symmetrical – phylum **D**
2. Body segmented – go to 3
Body not segmented – phylum **A**
3. Possess jointed limbs **and** a fixed number of externally visible metameric segments – phylum **E**
Do not possess jointed limbs **and** a fixed number of externally visible metameric segments – go to 4
4. Supported by a hydrostatic skeleton – phylum **B**
Supported by spinal column – phylum **C**

	Phylum
A	
B	
C	
D	
E	

[3]



(b) Phyla that have a 'one-way' gut (with both mouth and anus) are regarded as having more highly evolved digestive systems than phyla with only one opening to the gut.

(i) Name **three** phyla that possess a 'one-way' gut.

_____ [1]

(ii) State **two** advantages of having a 'one-way' gut rather than a digestive system with only one opening.

1. _____

2. _____ [2]

[Turn over



- 2 (a) The Polymerase Chain Reaction (PCR) is a technique that can produce many copies of sections of DNA in a very short time.

The first stage in the process is heating the DNA to around 95°C.

- (i) Explain precisely what happens during this stage.

[1]

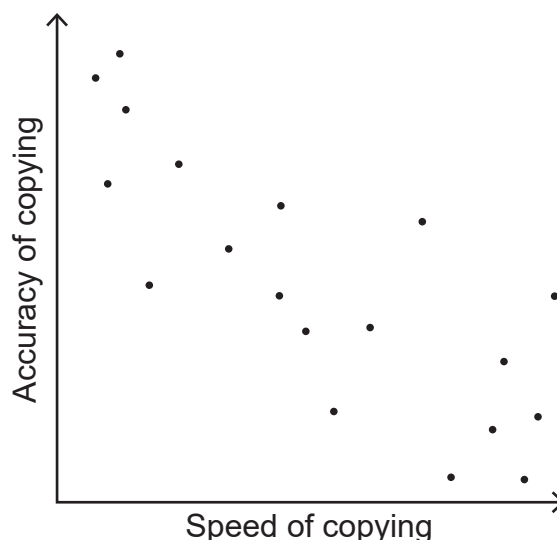
Following initial heating, the DNA is cooled to allow primers to bind.

- (ii) Give **one** reason why primers are necessary in PCR.

[1]

- (b) A thermostable DNA polymerase enzyme is used in PCR to copy the desired section of DNA. Many different types of thermostable DNA polymerase are available, each with slightly different properties.

For example, an enzyme called *Taq* polymerase can copy DNA quickly but has a relatively high error rate (around one incorrect base in every 10 000 base pairs). The scatter graph below shows the speed of copying and the accuracy of 19 different types of DNA polymerase enzymes. (Each point represents a different type of DNA polymerase.)



(i) Describe the trend shown in the graph.

[1]

(ii) PCR is used in amplifying DNA evidence from crime scenes for use in criminal investigations. Circle **one** DNA polymerase enzyme in the graph that would be suitable for this purpose.

[1]

(iii) Using the information provided, suggest why *Taq* polymerase is mainly used for amplifying **short** sections of DNA.

[1]

(c) PCR is normally used after identification and isolation of a section of DNA of interest.

(i) Describe how DNA probes can be used to identify a section of DNA.

[2]

[Turn over



- (ii) When using DNA probes, it is essential that the target DNA is separated into single strands. Explain precisely why this is necessary.

[1]



3 The light-dependent stage of photosynthesis results in the production of NADPH and ATP, products that are essential for the light-independent stage.

(a) State precisely where the light-dependent stage of photosynthesis takes place in plant cells.

_____ [1]

(b) Photoactivation involves the release of electrons from pigments in photosystem II (PSII) and photosystem I (PSI).

Describe fully the role of the electrons emitted from PSII and PSI pigments in the light-dependent reaction.

PSII _____

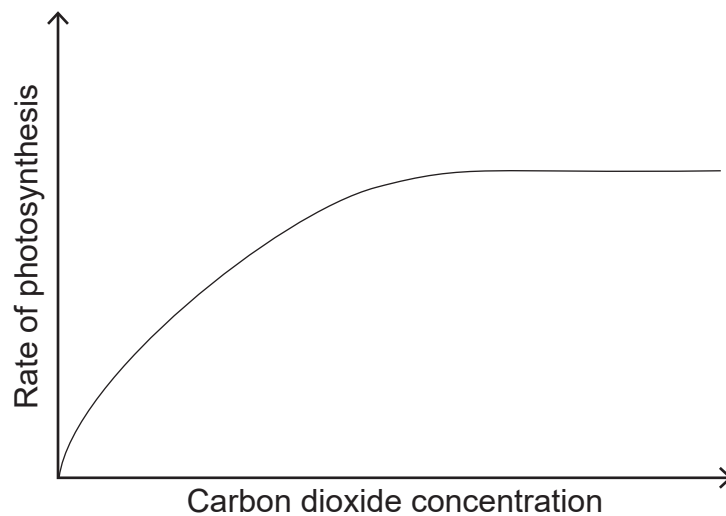
PSI _____

_____ [4]

[Turn over



- (c) The graph below shows the effect of carbon dioxide concentration on the rate of photosynthesis.



Describe the trend shown in the graph and use your knowledge of the biochemistry of photosynthesis to explain this trend.

[3]



(d) In many plant species, stomatal opening is affected by carbon dioxide concentration. For example, if carbon dioxide concentration within the leaf falls below a certain level, the stomatal pore size increases (stomata open more fully). Conversely, if carbon dioxide concentration within the leaf rises above a certain level, the stomatal pore size decreases.

(i) Suggest an advantage of decreasing stomatal pore size when carbon dioxide concentration within the leaf rises.

[2]

(ii) The leaf has carbon dioxide sensors which monitor changes in carbon dioxide concentrations. There is evidence to suggest that these are found within the mesophyll, rather than on the leaf surface. Suggest an advantage of these sensors being within the mesophyll.

[1]

(e) There is some evidence that the mean number of stomata per unit leaf area has decreased slightly over the last 100 years in many plant species. Suggest a possible reason for this.

[1]

[Turn over



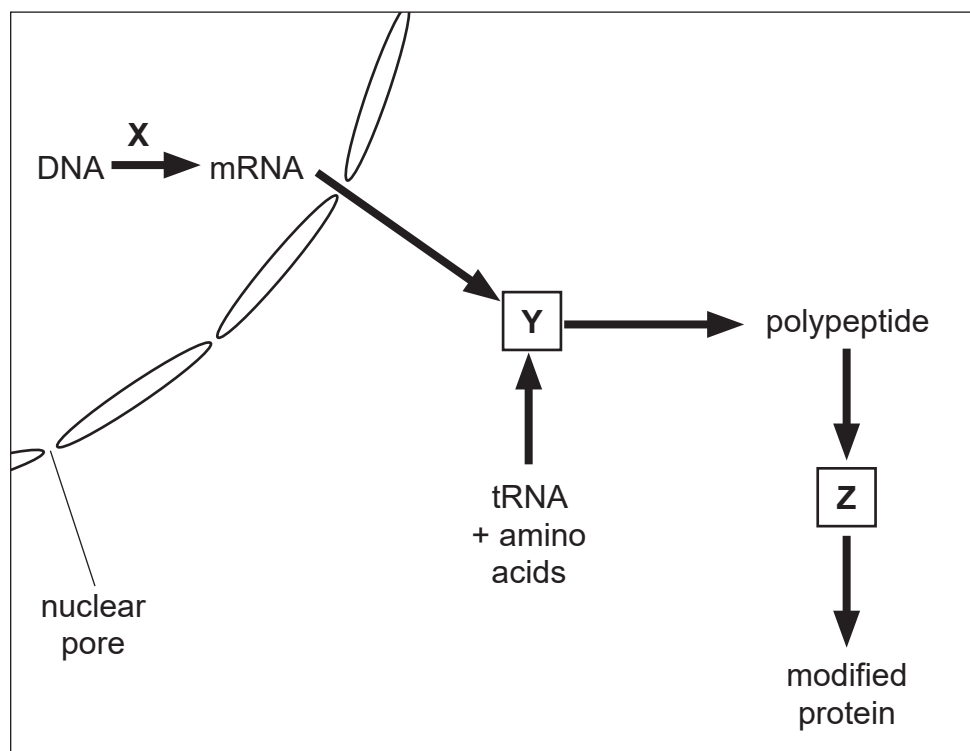
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40ABY2110

- 4 (a) The diagram below represents the parts of a cell involved in protein production.



Using the diagram and your knowledge:

- (i) Give **one** piece of evidence which indicates that the cell shown does not represent a prokaryotic cell.

_____ [1]

- (ii) Identify process **X** and organelles **Y** and **Z**.

X _____

Y _____

Z _____

[3]

[Turn over



(b) The table below shows the amino acids coded for by mRNA codons.

		second base in codon					
		U	C	A	G		
first base in codon	U	phenylalanine phenylalanine leucine leucine	serine serine serine serine	tyrosine tyrosine stop stop	cysteine cysteine stop tryptophan	U C A G	third base in codon
	C	leucine leucine leucine leucine	proline proline proline proline	histidine histidine glutamine glutamine	arginine arginine arginine arginine	U C A G	
	A	isoleucine isoleucine isoleucine methionine and start	threonine threonine threonine threonine	asparagine asparagine lysine lysine	serine serine arginine arginine	U C A G	
	G	valine valine valine valine	alanine alanine alanine alanine	aspartate aspartate glutamate glutamate	glycine glycine glycine glycine	U C A G	

- (i) Using the table, identify the sequence of amino acids coded for by a DNA sequence of ATAGGGCAG.

_____ [2]



- (ii) Using the table, explain the possible consequence(s) arising from a substitution mutation involving the third base in the base sequence shown (represented as **X** in the sequence below).

AT**X**GGGCAG

[2]



- (c) By 1960 it was understood that DNA was the molecule that codes for protein, but the number of bases required to code for each amino acid was not yet known.

Two scientists, Sydney Brenner and Francis Crick, carried out an investigation which was crucial to our understanding of how DNA codes for amino acids. By adding or removing a known number of base pairs in DNA, they were able to study the effects of this on the polypeptide produced. Their results are summarised in the table below.

Number of base pairs changed	Bases – added or deleted	Result of mutation (degree of change to amino acids produced beyond point of mutation)
1	added	major change
1	deleted	major change
2	added	major change
2	deleted	major change
3	added	no change
3	deleted	no change

State the conclusion that Brenner and Crick were able to draw from this investigation and explain the results shown.

[4]



5 (a) When trees are cut down in a wood, the resulting succession normally involves changes in the relative proportions of moss, fern and angiosperm (including tree) species.

(i) Apart from the presence of chlorophyll and chloroplasts, state **one** way in which the structure of moss, fern and angiosperm cells differs from that of fungal and animal cells.

_____ [1]

In an investigation of succession following the complete above-ground removal of the trees in a deciduous woodland, the estimated percentage biomass of mosses, ferns and angiosperms was recorded over time.

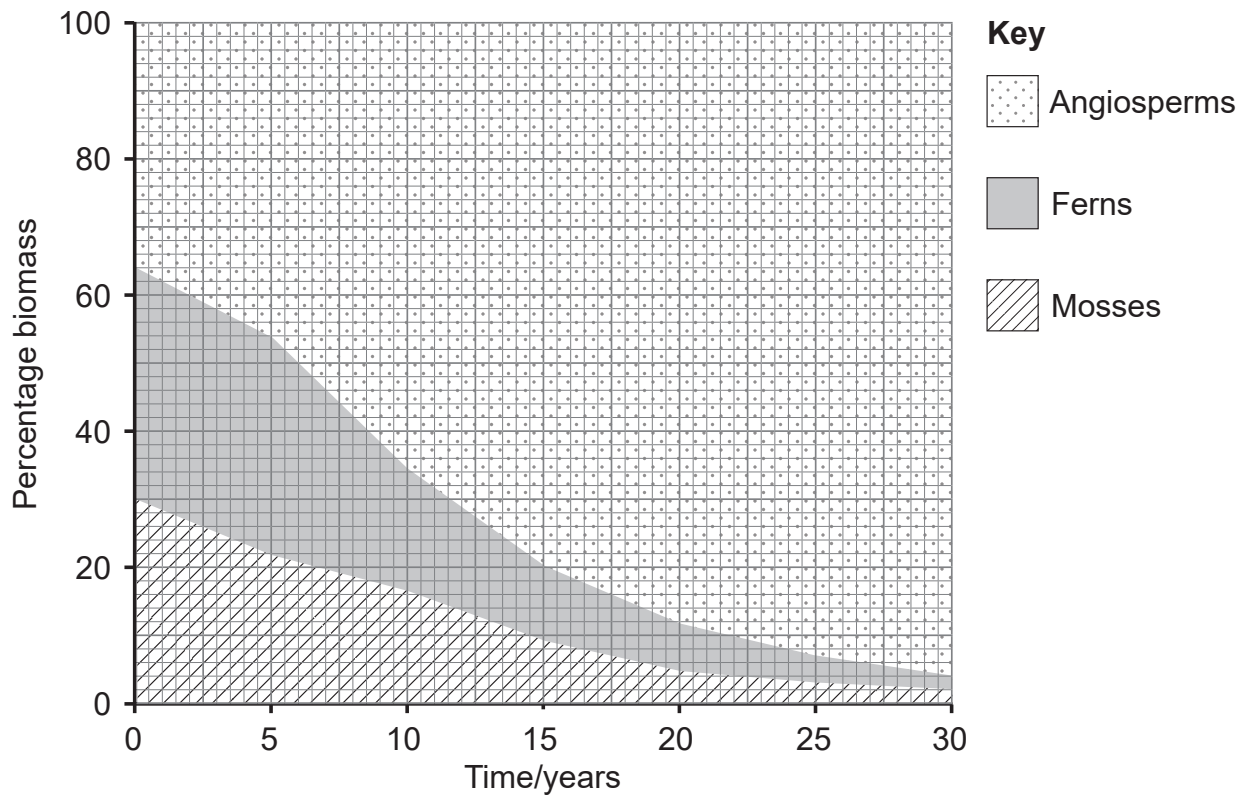
(ii) Suggest reasons why **estimated** values of biomass were used.

_____ [2]

[Turn over]



The results of the investigation following the complete above-ground removal of the trees are shown in the graph below.



(iii) Calculate the percentage of the total biomass that is ferns at five years.

_____ % [1]



[4]

[Turn over

- (b) In terms of adaptation to terrestrial life, the following evolutionary sequence exists:

mosses → ferns → angiosperms

- (i) State **one** way in which ferns are better adapted to terrestrial life than mosses. Explain your answer.

Adaptation _____

Explanation _____

_____ [2]

- (ii) State **one** way in which angiosperms are better adapted to terrestrial life than ferns. Explain your answer.

Adaptation _____

Explanation _____

_____ [2]





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6 In recent decades, the genomes of many species have been sequenced. Scientists believe that this has the potential to bring huge medical benefits.

(a) Genome sequencing has enabled the identification of single nucleotide polymorphisms (SNPs) and microsatellite repeat sequences (MRSs) associated with particular medical conditions.

(i) Define the term 'single nucleotide polymorphism'.

[1]

(ii) Name the type of mutation that produces SNPs.

[1]

Huntington's disease is linked to an MRS in a particular gene. The sequence which repeats is CAG. In an investigation, ten individuals with a history of Huntington's disease in their families had the sequence of this gene analysed. The results are shown in the table below.

Individual	Number of CAG repeats in MRS	Developed Huntington's disease	Age at diagnosis/years
1	14	no	—
2	32	no	—
3	38	yes	42
4	54	yes	24
5	17	no	—
6	63	yes	18
7	10	no	—
8	33	no	—
9	40	yes	40
10	49	yes	30



(iii) Comment on the results shown.

[3]

(iv) Some of the technology used in genome sequencing has allowed commercial companies to develop genotype testing services/genome sequencing services for individuals.

An increasing number of people are now using these services. However, not everyone is in favour of doing this. Suggest **one** argument against an individual choosing to have his or her genome sequenced.

[1]

[Turn over]



- (b) Greater understanding of the human genome has led to the development of personalised medicine in which the most suitable treatment or drugs are matched to an individual's genome.

(i) Give **one** benefit of the use of personalised medicine.

[1]

(ii) However, for many medical conditions, progress in the use of personalised medicine has been slower than anticipated. Suggest **one** reason for this.

[1]

- (c) Advances in technology have allowed the genomes of extinct species to be sequenced. For example, the genome of Neanderthals (*Homo neanderthalensis*) has been sequenced. Neanderthals lived approximately 300 000 to 30 000 years ago. DNA from bone was used but sequencing Neanderthal DNA proved much more difficult than sequencing modern DNA.

Suggest **one** reason why it proved difficult to sequence the Neanderthal DNA.

[1]





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[Turn over



40ABY2123

- 7 (a) Mendel's first law of inheritance is known as 'the law of segregation of factors'. Explain the meaning of this law with respect to monohybrid inheritance.

[1]

- (b) The human diploid chromosome number is 46. With reference to autosomes and sex chromosomes, describe the chromosomal make-up of a normal female gamete.

[1]

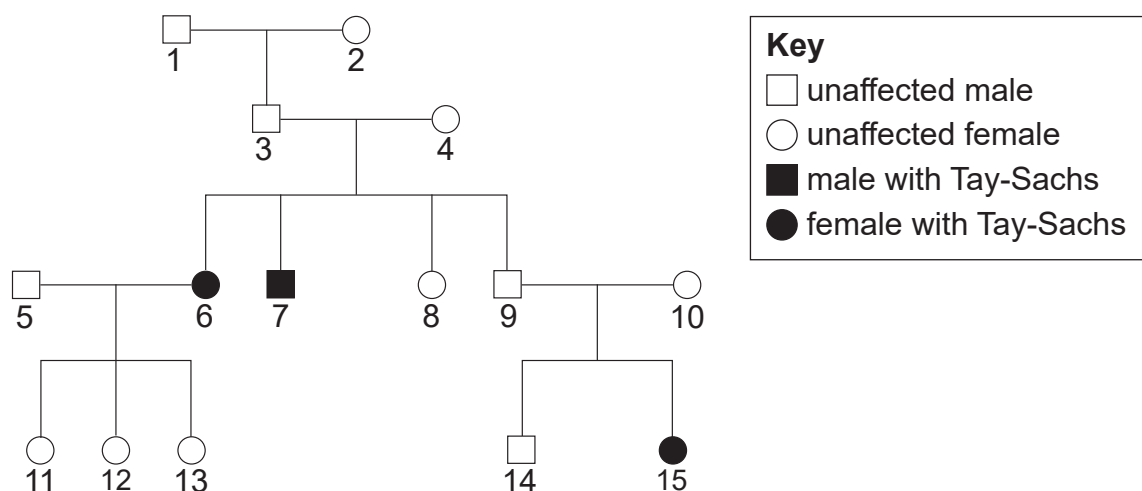
- (c) The inheritance of traits in humans can be described as:

- autosomal recessive
- autosomal dominant
- sex-linked recessive
- sex-linked dominant

Examination of pedigree diagrams can allow the type of inheritance to be determined.



Tay-Sachs disease is a human disease caused by a mutation in one gene. The inheritance of Tay-Sachs disease in a family group is shown in the pedigree diagram below.



- (i) Identify the most likely genotypes of individuals **4** and **5**.
(You should only choose symbols from the list: T, t, X^T , X^t or Y.)

4 _____

5 _____

[2]

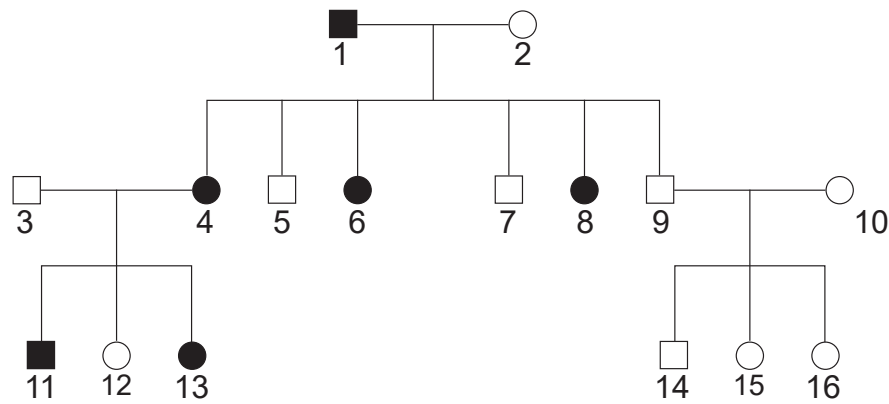
- (ii) Using the pedigree diagram and your knowledge, calculate the probability of individuals **9** and **10** having a son who does **not** have Tay-Sachs disease.

_____ [1]

[Turn over]



Fragile X syndrome is another human disease caused by a mutation in one gene. The pedigree diagram below represents how Fragile X syndrome can be inherited in humans.



Key

- unaffected male
- unaffected female
- male with Fragile X syndrome
- female with Fragile X syndrome

- (iii) The diagram suggests that fathers with Fragile X syndrome do not pass the condition on to their sons. Using the diagram and your knowledge, suggest an explanation for there being no father-to-son transmission of the condition.

[2]



- (iv) Identify the type of inheritance shown by Fragile X syndrome, from those listed at the start of question 7 part (c).

_____ [1]

- (v) Although the pedigree diagram provides an example of how Fragile X syndrome was inherited in one family, the presence of Fragile X syndrome in some individuals cannot be explained by genetic inheritance.

Suggest an explanation for this.

_____ [1]

- (d) Approximately 1 in 17 000 individuals have the inherited autosomal recessive disorder albinism.

Using the Hardy-Weinberg equation, calculate the percentage of people who are heterozygous for the albinism allele.

(Show your working.)

_____ % [3]

[Turn over]



- 8 The Tristan albatross (*Diomedea dabbenena*) is one of a number of bird species at risk of extinction in Gough Island, a small and very remote island in the South Atlantic. The albatross is only found on Gough Island and a few small neighbouring islands. Gough Island is a UNESCO World Heritage Site due to its importance as a bird sanctuary, with over 10 million nesting birds.

Mice were introduced to Gough Island from visiting ships and are now predators of albatross eggs and young chicks. Before their introduction, there were no predators of Tristan albatrosses on the island. The albatrosses had not evolved the behaviours necessary to avoid predation by the introduced mice, and the species is now critically endangered as a result. The Tristan albatross is particularly at risk as its nests are in small burrows in the ground which are easily accessible to mice. The albatrosses only breed every other year, another factor which has contributed to their population decline.

Although eggs and young chicks are not a 'natural' food of mice (they have a preference for grain, seeds, fruits and sometimes other animals such as earthworms and small insects), the lack of resources on the small island eventually led to the mice feeding on the eggs and chicks.

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Article "The impacts of introduced House Mice on the breeding success of nesting seabirds on Gough Island" by Anthony Caravaggi, Richard J. Cuthbert, Peter G. Ryan, John Cooper, Alexander L Bond. <http://doi.org/10.1111/ibi.12664>

- (a) (i) In terms of natural selection, describe what is meant by the term 'fitness'.

[1]



-
-
-
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-
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-
-
-
-
-
- [4]

[4]

- Suggest an explanation for the greater predation during winter.

[1]

[1]

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40ABY2129

- (iv) The mice on the island are up to 50% larger than mice of the same species found in non-island habitats. Suggest a reason for this.

[1]

- (b) The table below contains data resulting from an investigation into the mass of another rodent species, both on an island and on the closest mainland.

Sample site	Sample size	Mean mass/g	Standard deviation/g	Range/g
Island	20	360	± 72	264 (560–296)
Mainland	20	303	± 58	325 (510–185)

- (i) In terms of statistics, compare and contrast the **terms** standard deviation and range.

[3]



(ii) Explain why standard deviation is a more useful value than range.

[1]



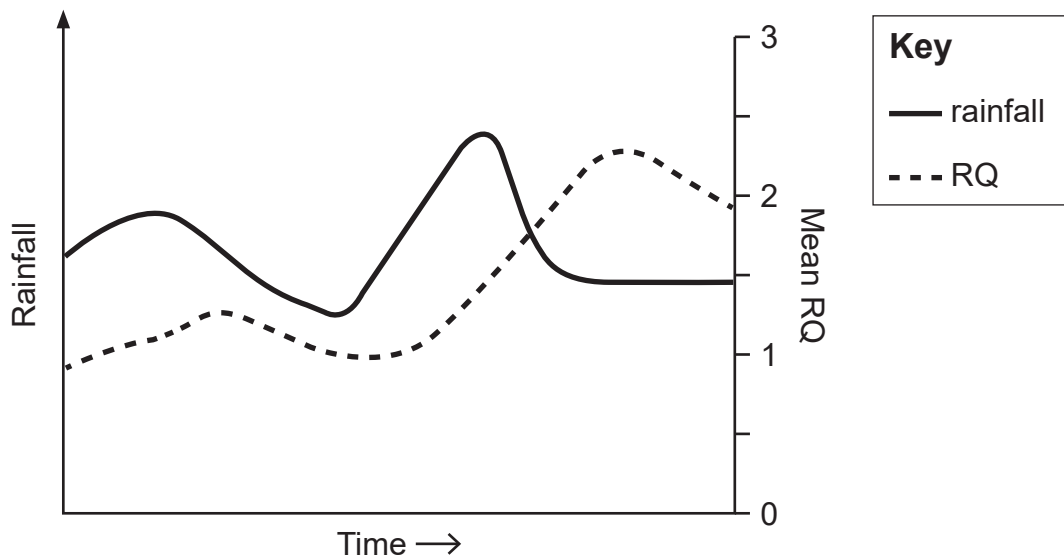
Section B

Quality of written communication will be assessed in this section.

- 9 Respiration is a biochemical process in cells in which energy is released and used to form ATP. In typical eukaryotic cells, most ATP is produced within mitochondria.

- (a) Outline the structure of a mitochondrion and describe in detail the stages of respiration that take place within mitochondria. [12]

The graph below shows rainfall patterns over a period of time in a meadow. The mean RQ values in the cells of the roots of a plant species in the meadow over the same period are also shown.



- (b) Outline the process of anaerobic respiration in plants and suggest an explanation for the results shown in the graph. [6]



[illegible]

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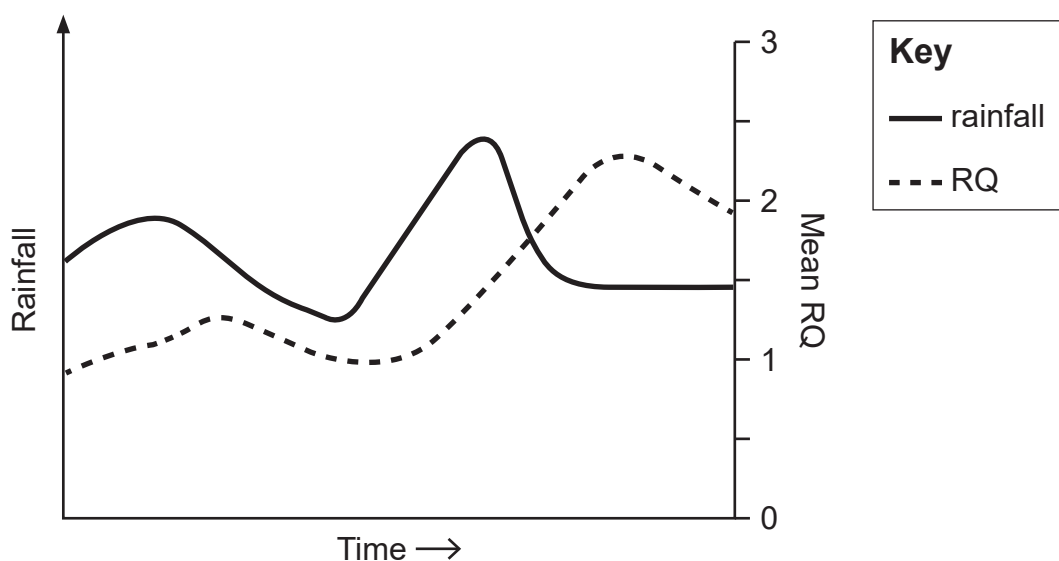
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40ABY2135

The graph below shows rainfall patterns over a period of time in a meadow. The mean RQ values in the cells of the roots of a plant species in the meadow over the same period are also shown.



- (b) Outline the process of anaerobic respiration in plants and suggest an explanation for the results shown in the graph.





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Examiner Number

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