Rewarding Learning

ADVANCED
General Certificate of Education
2019

Centre Number

Candidate Number

Biology

Assessment Unit A2 2
assessing
Biochemistry, Genetics and Evolutionary Trends

[ABY21]

ABY21

THURSDAY 13 JUNE, MORNING

TIME

2 hours 15 minutes.

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.

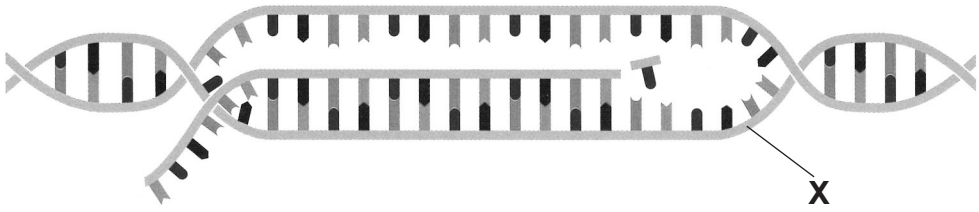
INFORMATION FOR CANDIDATES

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 provided for use with this paper.

12036

Section A

1 The process of transcription is represented by the diagram below.



(a) Identify the strand labelled **X**.

X _____ [1]

(b) State the number of bases in the section of mRNA shown.

_____ [1]

(c) Outline the role of RNA polymerase in transcription.

_____

_____

_____ [1]

(d) Name the part of the cell where transcription takes place.

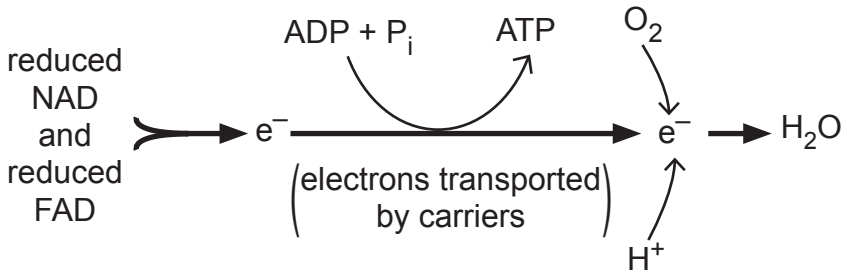
_____ [1]

2 **(a)** The main stages in the aerobic respiration of glucose are listed in the table below. Complete the table to show the net number of ATP molecules produced during each stage for each molecule of glucose respired.

Stage	Net number of ATPs produced
Glycolysis	
Link reaction	
Krebs cycle	
Electron transport chain	

[2]

(b) The diagram below summarises the electron transport chain.



(i) Name the part of the mitochondrion where the electron transport chain occurs.

_____ [1]

[Turn over

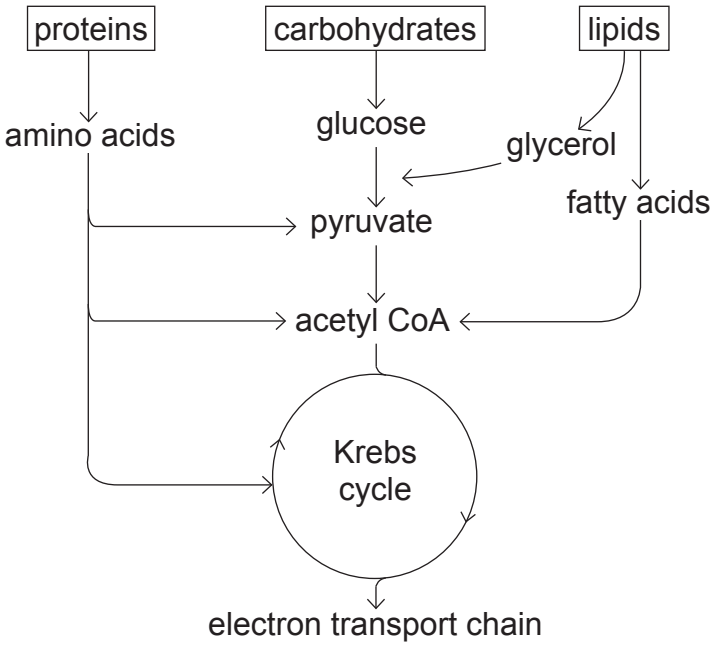
(ii) Explain how the transfer of electrons along the electron transport chain leads to the production of ATP.

[3]

(iii) The respiratory poison cyanide inhibits the enzyme cytochrome oxidase. Explain fully why this prevents the functioning of the electron transport chain.

[2]

(c) The diagram below shows the respiratory pathways involved during the respiration of proteins, carbohydrates and lipids.



Using the information provided and your knowledge of aerobic and anaerobic respiration, suggest and explain why carbohydrate is the preferred respiratory substrate of most organisms.

_____

_____

_____

_____

_____

_____ [2]

[Turn over

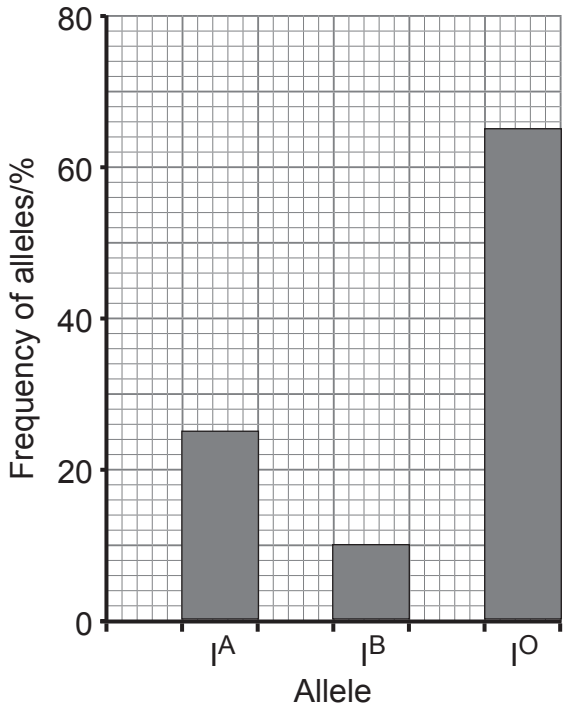
3 Variation is an important feature of populations that reproduce sexually.

(a) State **two** features of sexual reproduction that increase variation.

1. _____

2. _____ [2]

The bar chart below shows the approximate frequency of the different human blood group alleles (ABO system) in many European populations.



(b) Allele polymorphism can be said to exist for a gene if the variation at that gene locus cannot be explained by recent mutation alone. State how the graph shows that this gene for human blood groups is polymorphic.

_____

_____

_____ [1]

(c) An investigation was carried out to determine blood group allele frequencies in different geographical regions. The blood group alleles of 1000 people from a European country and 1000 people from an African country were identified. The results are shown in the table below.

	Frequency of blood group alleles		
	I^A	I^B	I^O
European country	460	210	1330
African country	298	198	1504

(i) State **one** way in which the blood group allele data is similar for the two countries.

_____

_____

_____ [1]

[Turn over

A variation of the chi-squared (χ^2) test can be used to check if the difference between the European and African data is statistically significant.

(ii) Complete the table below to calculate the χ^2 for this data.

Blood group allele	Allele frequency		Differences	Differences^2	Differences^2 / European allele frequency
	European country	African country			
I^A	460	298	162	26244	57.05
I^B	210	198	12	144	0.69
I^O	1330	1504			

χ^2 _____ [1]

(iii) On the basis of the calculated χ^2 value, state the following:

- the degrees of freedom for the test _____
- the probability value _____ [2]

(iv) What can be concluded from this statistical test?

_____

_____

_____ [1]

(v) Suggest a possible reason for differences in blood group allele frequencies in different geographical regions.

_____

_____

_____ [1]

4 **(a)** Genetically modified (GM) bacteria, yeasts and viruses have a range of biological uses.

(i) Restriction endonucleases have an important function in the production of GM bacteria. State **one** function of restriction endonucleases in this role.

_____

_____

_____ [1]

(ii) State **one** use of GM viruses.

_____

_____ [1]

(b) The global cultivation of GM crop plants has steadily increased in recent years. In 1995, they covered an area of approximately 17 000 km^2. In 2015, this had increased to approximately 1 800 000 km^2.

(i) Calculate the percentage increase in the area used to grow GM crops between 1995 and 2015. Give your answer to **two significant figures**.

(Show your working.)

_____% [2]

[Turn over

Many countries including the USA, Brazil, Argentina and India produce considerable amounts of GM crops. However, in Europe there is significant opposition to growing and using GM crops.

Most of the GM crops grown in Europe are used for animal feed or other uses that do not involve direct human consumption.

(ii) Suggest why most GM crops in Europe are used for animal feed or other uses that do not involve direct human consumption.

_____

_____

_____ [1]

(c) In order to produce a GM crop plant, the desirable gene is inserted into small sections of plant tissue. These can develop and grow into a mature plant, a technique known as tissue culture.

(i) Suggest and explain why the desirable gene is inserted into small sections of tissue rather than into mature plants.

_____

_____

_____

_____

_____

_____ [2]

In order to identify which plant tissue sections have incorporated the desirable gene, a marker gene is added. An example of such a marker gene in GM plants is a gene for herbicide tolerance (resistance), which can be used in a similar way to antibiotic resistance genes in GM bacteria.

(ii) Explain how, after the herbicide tolerance gene is inserted, researchers identify those tissue sections which have successfully incorporated the desirable gene.

_____

_____

_____

_____

_____

_____ [2]

The technique described above involves use of a vector to deliver genetic material into plant cells. However, scientists can also use techniques to directly manipulate plant genomes, reducing the need for herbicide tolerance genes as markers.

(iii) Suggest **two** advantages in directly manipulating plant genomes, rather than using a vector gene transfer technique.

1. _____

_____

2. _____

_____ [2]

[Turn over

(d) Some GM crops can grow in otherwise unfavourable environments, such as very dry soil.

(i) Suggest and explain a benefit of being able to grow GM crops in very dry soil.

_____

_____

_____

_____

_____ [2]

(ii) Suggest **one** disadvantage of growing GM crops in these environments.

_____

_____

_____ [1]

5 **(a)** Batten disease is a very rare, life-limiting genetic condition that usually causes death of individuals in their late teens or early twenties. It is an autosomal recessive disorder.

(i) Using a genetic diagram, show the ratio of phenotypes in the offspring of two individuals, who are both heterozygous for the condition. Use **B** for the dominant allele and **b** for the recessive allele.

[2]

(ii) Explain why the Hardy–Weinberg equation could **not** be used to predict the percentage of Batten disease-causing alleles in a population.

_____

_____

_____ [1]

[Turn over

(b) Haemophilia is another relatively rare genetic condition in humans in which the blood fails to clot properly. The gene for haemophilia is located on the X chromosome, making haemophilia a sex-linked condition. The allele for haemophilia is recessive to the normal allele.

(i) Describe what is meant by the term 'sex-linked condition'.

_____

_____ [1]

The genotype for a female without the haemophilia allele can be represented as $\mathbf{X^HX^H}$.

(ii) Using the genotype format shown, give all the possible genotypes of individuals with haemophilia.

_____ [1]

(iii) Using the information provided, explain why there are very few females with haemophilia.

_____

_____

_____

_____

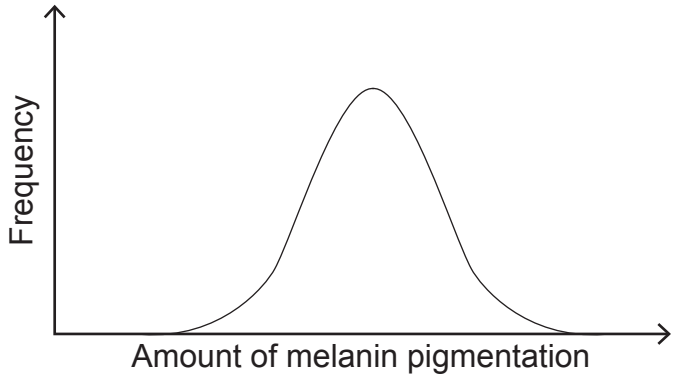
_____ [2]

(c) Determine the gametes produced in a cross between a male with haemophilia and who does not carry the Batten disease allele and a female heterozygous for each of haemophilia and Batten disease.

Male _____

Female _____ [2]

(d) Melanin is a pigment in human skin. The amount of melanin pigmentation varies considerably. The graph below shows the frequency of individuals with different amounts of melanin pigmentation in the human population.



(i) Suggest and explain the genetic basis of the pattern shown.

_____

_____

_____

_____

_____

_____ [2]

(ii) Suggest **one** reason why the amount of pigmentation in an individual's skin can change over time.

_____

_____

_____ [1]

[Turn over

6 **(a)** Although most human cells contain the full genome, in any one cell only a relatively small number of genes are expressed (actively code for protein molecules).

This regulation of gene expression is commonly under epigenetic control.

(i) Define the term 'epigenetics'.

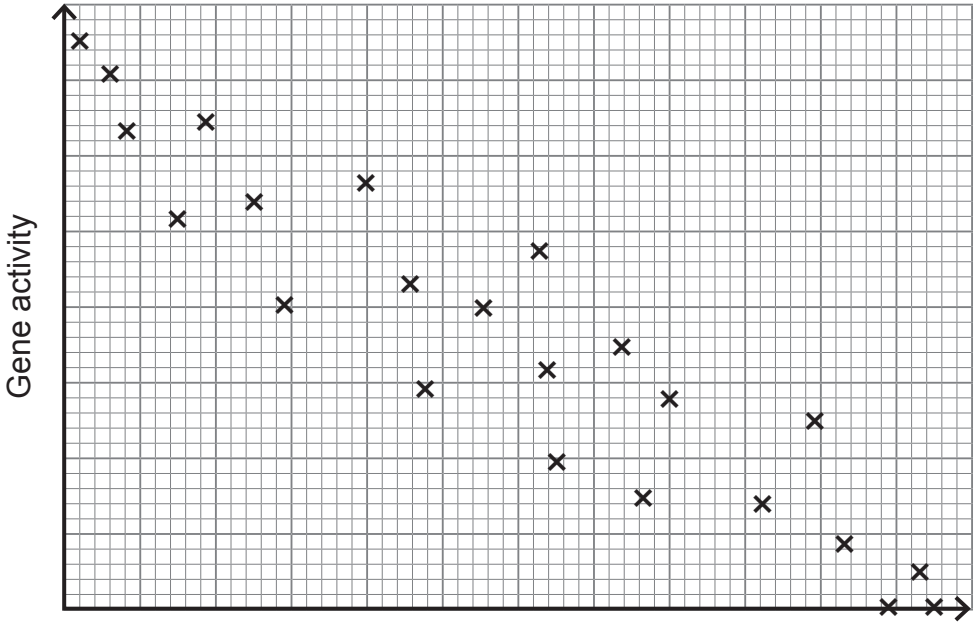
_____

_____

_____ [1]

Methylation is an epigenetic mechanism which involves methyl groups (CH_3) being attached to DNA sequences where a C base is immediately followed by a G base.

The graph below shows the relationship between the percentage of CG sequences with methyl groups attached in one gene and the activity of that gene (the number of protein molecules produced over time) in different parts of the body.



(ii) Using the information provided, describe how methylation affects gene expression.

_____

_____

_____

_____

_____

_____

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_____

_____

_____ [4]

(iii) Name **one** other type of epigenetic modification.

_____ [1]

(iv) Describe and explain the advantage of controlling gene expression to an organism.

_____

_____

_____

_____

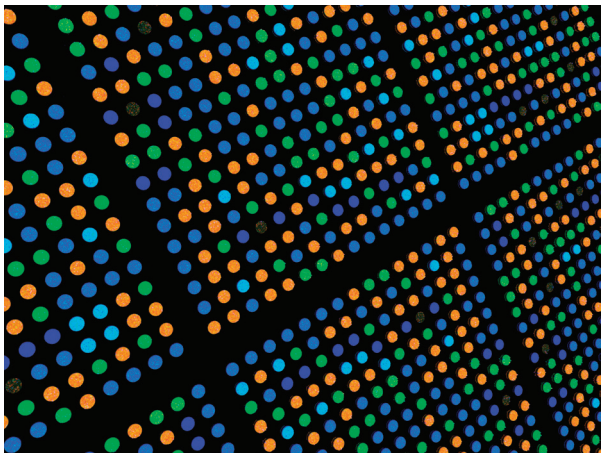
_____

_____ [2]

[Turn over

(b) Gene expression can be investigated using microarrays. Part of a microarray is shown in the photograph below.

Each microscopic 'well' (spot of colour in the photograph) contains a different sequence of single-stranded DNA bound to its surface.



© Pasieka / Science Photo Library

Researchers investigating gene expression extracted all the messenger RNA (mRNA) from liver cells.

(i) Explain why mRNA was used to investigate gene expression.

_____

_____

_____ [1]

(ii) Explain how a microarray as described opposite could be used to investigate the genes which were being expressed by the liver cells.

_____

_____

_____

_____

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_____

_____

_____ [3]

[Turn over

7 Speciation, the process by which new species are formed, is relatively common on isolated volcanic islands.

(a) Define the term 'species'.

_____

_____

_____ [1]

(b) The Hawaiian Islands are a group of volcanic islands in the Pacific Ocean. As volcanic islands, they were devoid of life when formed. Although small, each of the islands has a wide range of ecological habitats, including rocky shore, grassland, woodland and mountain. Relatively recent lava flows have sub-divided many of the habitats such as woodland into isolated sections.

The islands are home to over 500 species of the insect genus *Drosophila* (fruit flies). Over 85% of the species is endemic to a particular island, which means that the species is only found on that particular island.

Drosophila are poor fliers. It is thought that all the *Drosophila* species found on these islands evolved from one species (or a very small number of species) that reached the islands millions of years ago, possibly on driftwood.

(i) Using the information provided, describe and explain **two** factors that would have contributed to the process of allopatric speciation of *Drosophila* on one particular island.

_____

_____

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_____

_____

_____

_____ [4]

[Turn over

(ii) Each of the Hawaiian Islands was formed at a different time. The older the island, the more endemic species of *Drosophila* on that island.

Suggest an explanation for this.

[3]

(c) Insects, in general, are the most successful animal group in terms of number of species. Explain why.

[2]

8 **(a)** Ferns are regarded as being more highly evolved than mosses in terms of their adaptations to terrestrial life. Unlike mosses, they possess vascular tissue which provides both a mechanism for water transport and support.

(i) Apart from the presence of vascular tissue, state **one** other way in which ferns are better adapted to terrestrial life than mosses. Explain your answer.

_____

_____

_____

_____ [2]

(ii) State how the xylem in vascular tissue provides support in plants.

_____

_____

_____

_____ [2]

(b) Angiosperms also possess vascular tissue. Woody angiosperms (trees) are able to increase the thickness of their stems, as they increase in height. They can do this as they have a layer of dividing cells down the stem (in addition to the dividing cells at root and shoot tips). This layer of dividing cells lies between the phloem and xylem in vascular bundles.

Ferns do not possess this dividing layer running down their stems and therefore they cannot significantly increase their thickness as they grow in height.

The table overleaf shows the height and maximum stem width of 10 trees and 10 ferns, randomly sampled in the same woodland. The height to width ratio was also calculated.

To reduce the number of variables involved, only one tree species and one fern species were sampled.

[Turn over

The data is shown in the table below.

Sample number	Fern			Tree		
	Height/m	Stem width/m	Height: width ratio	Height/m	Stem width/m	Height: width ratio
1	1.1	0.012	92:1	11.7	0.293	40:1
2	0.7	0.013	54:1	10.4	0.274	38:1
3	1.0	0.012	83:1	9.4	0.254	37:1
4	0.6	0.010	60:1	12.6	0.323	39:1
5	0.8	0.012	67:1	14.4	0.345	42:1
6	1.1	0.012	92:1	9.7	0.252	38:1
7	0.6	0.010	60:1	7.7	0.177	44:1
8	0.4	0.010	40:1	13.4	0.311	43:1
9	1.2	0.011	109:1	8.6	0.205	42:1
10	1.0	0.010	100:1	8.1	0.221	37:1

(i) It can be concluded from the data that the tree species has a greater stem width. State **three** other conclusions that can be drawn from this data.

_____

_____

_____

_____

_____

_____

_____

_____

_____ [3]

(ii) Using the information provided, suggest and explain **one** benefit of trees being able to increase their width.

_____

_____

_____

_____

_____

_____ [2]

(c) Kingdom Animalia also shows evolutionary development in methods of support as the phyla become more complex. State **one** similarity and **one** difference in methods of support between the Cnidaria and Annelida.

Similarity _____

_____

_____

Difference _____

_____

_____ [2]

Section B

Quality of written communication will be assessed in this section.

9 **(a)** Describe and explain how plants use light energy to make glucose. [12]

As light is essential for the growth of plants, most plants are adapted by having leaves that can trap as much light as possible.

(b) With reference to factors which limit the rate of photosynthesis, suggest why leaves in shady positions are often broad and thin and darker in colour, while those near the top of the canopy have a greater stomatal density. [6]

(a) Describe and explain how plants use light energy to make glucose.

[Turn over

(b) With reference to factors which limit the rate of photosynthesis, suggest why leaves in shady positions are often broad and thin and darker in colour, while those near the top of the canopy have a greater stomatal density.

[Turn over

THIS IS THE END OF THE QUESTION PAPER

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For Examiner's use only	
Question Number	Marks
1	
2	
3	
4	
5	
6	
7	
8	
9	
Total Marks	

Examiner Number