

Biology B

Advanced

PAPER 2: Advanced Physiology, Evolution and Ecology

Friday 16 June 2023 – Morning

Time: 1 hour 45 minutes

Total Marks

In the boxes below, write your name, centre number and candidate number.

Surname					
Other names					
Centre Number					
Candidate Number					

YOU MUST HAVE

Scientific calculator, writing and drawing equipment, ruler

YOU WILL BE GIVEN

Diagram Booklet

INSTRUCTIONS

Answer ALL questions.

Answer the questions in the spaces provided in this Question Paper or in the separate Diagram Booklet – there may be more space than you need.

INFORMATION

The total mark for this paper is 90.

The marks for EACH question are shown in brackets – use this as a guide as to how much time to spend on each question.

In question(s) marked with an ASTERISK (*), marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.

There may be spare copies of some diagrams.

ADVICE

Read each question carefully before you start to answer it.

Try to answer every question.

Check your answers if you have time at the end.

Answer ALL questions. Write your answers in the spaces provided.

Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Carbohydrates and proteins are important biological molecules.

(a) Look at the diagrams for Question 1(a) in the Diagram Booklet. They show some of the bonds found in biological molecules.

**(i) Which one of the letters shows a bond that joins glucose molecules together in a disaccharide?
(1 mark)**

☐ A W

☐ B X

☐ C Y

☐ D Z

(continued on the next page)

Turn over

1(a) continued.

**(ii) Which letters show bonds that hold together the tertiary structure of a protein?
(1 mark)**

☐ **A V and X**

☐ **B V and Z**

☐ **C W and Y**

☐ **D W and Z**

**(iii) Which letter shows a bond that holds together cellulose molecules within a cellulose microfibril?
(1 mark)**

☐ **A V**

☐ **B W**

☐ **C X**

☐ **D Y**

(continued on the next page)

Turn over

1 continued.

- (b) Raw egg white is a liquid containing dissolved ovalbumin, a globular protein.**

Ovalbumin has some amino acids with polar R-groups and some amino acids with non-polar R-groups.

If raw egg white is heated to a temperature above 70 °C, it irreversibly changes into a solid.

Look at the diagram for Question 1(b) in the Diagram Booklet. It shows how the structure of ovalbumin changes when heated.

Explain why heating ovalbumin to temperatures above 70 °C causes egg white to change from a liquid into a solid.

(3 marks)

Answer space continues on the next 2 pages.

1(b) continued.

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Turn over

1(b) continued.

(Total for Question 1 = 6 marks)

2 Bromelain is a protease enzyme in pineapple juice.

- (a) Look at the graphs for Question 2(a) in the Diagram Booklet. Which graph shows the energy changes that occur in a typical enzyme catalysed reaction?
(1 mark)**

☐ **A W**

☐ **B X**

☐ **C Y**

☐ **D Z**

(continued on the next page)

2 continued.

(b) A student investigated the digestion of gelatine protein by pineapple juice.

This is the method used.

STEP 1: Make a solid disc of gelatine protein, with a depth of 1 cm, in a Petri dish.

STEP 2: Cut out a circular well with a diameter of 2 cm in the centre of the disc.

STEP 3: Fill the well with pineapple juice.

STEP 4: Incubate the dish for one hour at 37 °C.

STEP 5: Measure the diameter of the area that has been digested by the bromelain enzyme.

(continued on the next page)

2(b) continued.

Look at the diagram for Question 2(b) in the Diagram Booklet. It shows a gelatine disc before and after incubation with the pineapple juice.

The diameter of the circular area that had been digested after one hour was 6 cm.

Calculate the volume of gelatine that had been digested.

**Give your answer, in mm³, to two significant figures.
(3 marks)**

Volume of a cylinder = $\pi r^2 l$

$\pi = 3.14$

Answer _____ mm³

2 continued.

(c) Bromelain also digests other proteins.

The student also investigated the effects of changing the concentration of a soluble protein, and the addition of copper sulfate on the rate of digestion of this soluble protein by bromelain.

Look at the graph for Question 2(c) in the Diagram Booklet. The results are shown.

(i) Explain the effect of increasing substrate concentration on the rate of digestion of the soluble protein.

(2 marks)

Answer space continues on the next page.

2(c)(i) continued.

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2(c) continued.

**(ii) Explain the effect of copper sulfate on the rate of digestion of the soluble protein.
(2 marks)**

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(Total for Question 2 = 8 marks)

- 3 Look at the photograph for Question 3(a) in the Diagram Booklet. It shows part of a testis, as seen using a light microscope.**

(a) The cell labelled X is a primary spermatocyte.

**(i) At which stage of cell division is cell X?
(1 mark)**

- ☐ **A prophase I of meiosis**
- ☐ **B prophase II of meiosis**
- ☐ **C prophase I of mitosis**
- ☐ **D prophase II of mitosis**

(continued on the next page)

3(a) continued.

(ii) In the photograph, cell X has a width of 0.8 cm.

The magnification of the photograph is $\times 1500$.

Calculate the actual width, in micrometres (μm), of cell X.

**Give your answer to one decimal place.
(2 marks)**

Answer _____ μm

(continued on the next page)

3 continued.

- (b) Some pregnancies do not develop to full term, so no baby is born.**

Damage to the DNA of sperm is thought to be one cause of pregnancies not developing to full term.

Scientists investigated if there is an association between the production of sperm with damaged DNA and the risk of pregnancies not developing to full term.

The percentage of sperm cells with DNA damage was determined for 130 men where there was a history of pregnancies not developing to full term.

The percentage of sperm cells with DNA damage was measured for 78 men where pregnancies developed to full term.

Look at the graphs for Question 3(b) in the Diagram Booklet. They show the results of this investigation.

(continued on the next page)

3(b) continued.

- (i) Calculate the number of men with partners that have a history of pregnancies not developing to full term that had 25% or less of sperm with DNA damage.
(1 mark)**

Answer _____

(continued on the next page)

3(b) continued.

- (ii) The scientists concluded that having more than 25% of sperm with damaged DNA leads to a high risk of pregnancies not developing to full term.**

**Analyse the data to evaluate this conclusion.
(4 marks)**

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3(b)(ii) continued.

This image shows a blank sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

(Total for Question 3 = 8 marks)

- 4 Saltmarshes are coastal habitats where silt (mud) is deposited. Saltmarshes are colonised by different species of plants and are regularly flooded with seawater.**

Look at the photograph for Question 4(a) in the Diagram Booklet. It shows an area of salt marsh.

(a) Conditions close to the sea are very windy.

- (i) Which row in the table causes the highest rate of transpiration from a plant?
(1 mark)**

	Temperature	Wind speed	Air humidity
<input type="checkbox"/> A	high	high	high
<input type="checkbox"/> B	high	high	low
<input type="checkbox"/> C	high	low	high
<input type="checkbox"/> D	low	high	low

(continued on the next page)

4(a) continued.

- (ii) Samphire is one of the few plants that can grow in the areas close to the sea. Samphire plants have very small leaves and swollen stems.**

Look at the diagrams for Question 4(a)(ii) in the Diagram Booklet. They show a samphire plant and a cross section through the stem of a samphire plant.

**Explain how samphire is adapted to grow in areas of saltmarshes closest to the sea.
(4 marks)**

Answer space continues on the next page.

4(a)(ii) continued.

(continued on the next page)

4 continued.

(b) A group of students investigated succession in a saltmarsh.

The students measured several factors at 5 m intervals along a transect, starting at the edge of the sea.

The factors measured were:

- ACFOR scales for samphire, sea lavender, and scurvy grass**
- index of diversity of all plant species**
- percentage of silt (mud) made up of organic material.**

(continued on the next page)

4(b) continued.

Look at the table for Question 4(b) in the Diagram Booklet. The results are shown.

- (i) Give TWO limitations of using ACFOR scales to compare the distribution of different plant species.
(2 marks)**

(continued on the next page)

4(b) continued.

- (ii) Saltmarshes are produced by deposits of silt (mud) from rivers.**

As the distance from the sea increases, the age of the saltmarsh increases.

**Explain the changes in distribution of the species as distance from the sea increases.
(4 marks)**

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4(b)(ii) continued.

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(Total for Question 4 = 11 marks)

5 The human retina contains photoreceptors called rod cells and cone cells.

**(a) (i) Which of the following occur in the rod cell when it is stimulated by light?
(1 mark)**

- 1 rhodopsin breaks down into retinal and opsin**
- 2 there is a decrease in the release of neurotransmitter molecules**
- 3 there is more diffusion of sodium ions into the rod cell**

☐ **A 1 and 2**

☐ **B 1 and 3**

☐ **C 1, 2 and 3**

☐ **D 2 and 3**

(continued on the next page)

5(a) continued.

- (ii) Explain why the centre of the retina is less sensitive to low intensity light than the outer areas.
(2 marks)**

(continued on the next page)

Turn over

5 continued.

- (b) Red-green colour blindness is a sex-linked genetic condition. People with this condition are unable to detect differences between red and green colours.**

Look at the pedigree diagram for Question 5(b) in the Diagram Booklet. It shows the inheritance of red-green colour blindness in a family.

The allele for red-green colour blindness, X^r , is recessive to the allele for colour vision, X^R .

- (i) How many of the individuals in the family must have a genotype of $X^R X^r$?
(1 mark)**

☐ **A 2**

☐ **B 3**

☐ **C 4**

☐ **D 5**

(continued on the next page)

5(b) continued.

- (ii) Explain how this pedigree diagram demonstrates that red-green colour blindness is caused by a recessive allele.
(2 marks)**

(continued on the next page)

5 continued.

(c) Pingelap is an isolated island in the Pacific Ocean.

On Pingelap, between 4% and 10% of the population has a condition called achromatopsia. This means that they are unable to see any colour.

In most other countries, the incidence of achromatopsia is around 0.003%.

(i) Look at the pedigree diagram for Question 5(c)(i) in the Diagram Booklet. It shows the people who are and are not affected with achromatopsia in a family.

Deduce how achromatopsia is inherited.

Use the information in the pedigree diagram to support your answer.

(3 marks)

Answer space continues on the next page.

Turn over

5(c)(i) continued.

(continued on the next page)

5(c) continued.

- (ii) In 1755, a tsunami reduced the population to 20 people and there has been little immigration to the island.**

In 2022, the human population of Pingelap was approximately 250.

**Explain why the incidence of achromatopsia is higher in Pingelap than in other countries.
(2 marks)**

Answer space continues on the next page.

5(c)(ii) continued.

(Total for Question 5 = 11 marks)

6 Look at the diagram for Question 6(a) in the Diagram Booklet. It shows an action potential in a neurone.

**(a) (i) Which of the following causes the change in potential between X and Y?
(1 mark)**

- ☐ **A movement of calcium ions out of the neurone**
- ☐ **B movement of potassium ions out of the neurone**
- ☐ **C movement of sodium ions into the neurone**
- ☐ **D movement of sodium ions out of the neurone**

(continued on the next page)

6(a) continued.

- (ii) Explain how membrane proteins cause the change in potential between Y and Z.
(2 marks)**

(continued on the next page)

6 continued.

(b) Look at the photograph for Question 6(b) in the Diagram Booklet. It shows an African crested rat.

This rat has several adaptations to prevent it being eaten by predators.

These adaptations include:

- **The rat chews the bark of a tree called the arrow tree. The bark of this tree contains a poison called ouabain.**
- **The rat rubs the poison onto its fur, which is hollow to absorb the poison.**
- **The rat produces proteins in its saliva that prevent the ouabain harming it.**

(continued on the next page)

6(b) continued.

**(i) Which types of adaptation has the rat evolved?
(1 mark)**

1 anatomical

2 behavioural

3 physiological

☐ **A 1 and 2**

☐ **B 1, 2 and 3**

☐ **C 1 and 3**

☐ **D 2 and 3**

(continued on the next page)

6(b) continued.

- (ii) Ouabain inhibits sodium–potassium exchange pumps.**

Look at the diagram for Question 6(b)(ii) in the Diagram Booklet. It shows the effect of ouabain on the potential difference across a motor neurone membrane.

**Explain how ouabain prevents the transmission of nerve impulses.
(3 marks)**

Answer space continues on the next page.

6(b)(ii) continued.

(Total for Question 6 = 7 marks)

- 7 Scientists investigated the role of ex-situ conservation of plant species on genetic biodiversity.

The scientists investigated the variability of DNA sequences of 30 different genes for a number of species of plants in seed banks and in the wild.

- (a) (i) Which row gives correct statements about the genetic code in eukaryotes?
(1 mark)

	Overlapping	Degenerate	Contains introns in genes
<input type="checkbox"/> A	yes	yes	yes
<input type="checkbox"/> B	yes	no	yes
<input type="checkbox"/> C	no	yes	no
<input type="checkbox"/> D	no	yes	yes

(continued on the next page)

7(a) continued.

- (ii) Explain why the DNA sequences of genes are more variable than the sequences of amino acids in the proteins coded for by these genes.
(2 marks)**

(continued on the next page)

7(a) continued.

- (iii) Describe how the scientists could use technology to find out whether gene sequences of two species are similar.
(2 marks)**

(continued on the next page)

7 continued.

***(b) The scientists measured the mean genetic diversity of species in the wild and the mean genetic diversity of the same species in seed banks.**

The species examined included:

- trees**
- non-woody species of plant**
- plant species classed as endangered**
- plant species classed as not endangered**
- plants of economic importance that are harvested by people.**

(continued on the next page)

7(b) continued.

The scientists also measured the mean number of differences in the DNA sequences of the seeds that had been stored for different lengths of time compared with plants in the wild.

Look at the graphs for Question 7(b) in the Diagram Booklet. They show the results.

**Error bars represent ± 1 standard deviation
 n = number of different species**

**Analyse the data to discuss the results of this investigation.
(6 marks)**

Answer space continues on the next 3 pages.

7(b) continued.

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Turn over

7(b) continued.

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7(b) continued.

(Total for Question 7 = 11 marks)

- 8 (a) Explain why a double circulatory system enables mammals to have a high metabolic rate.
(2 marks)

(continued on the next page)

8 continued.

- (b) Abnormal heart rhythms can be identified in ECG traces.**

Look at the diagram for Question 8(b) in the Diagram Booklet. It shows ECG traces of a person with a regular, healthy heart rhythm and a person with an abnormal heart rhythm.

- (i) Calculate the heart rate, in beats per minute, of the person with an abnormal heart rate.**

**Give your answer to the nearest whole number.
(2 marks)**

Answer _____ beats per minute

8(b) continued.

- (ii) Explain how the ECG traces show this abnormal heart rhythm is due to damage to the septum in the centre of the heart between the left and right sides.
(2 marks)**

Answer space continues on the next page.

8(b)(ii) continued.

(continued on the next page)

8(b) continued.

(iii) Bradycardia is a heart condition that results in a heart rate that is slower than normal.

Atropine is a drug that can be used to treat some forms of bradycardia.

Atropine is a competitive inhibitor of acetylcholine.

**Explain why atropine will lead to an increase in heart rate.
(3 marks)**

Answer space continues on the next page.

8(b)(iii) continued.

(continued on the next page)

8(b) continued.

- (iv) Describe how exercise leads to the stimulation of the cardiac centre in the medulla oblongata.
(4 marks)**

Answer space continues on the next page.

8(b)(iv) continued.

(Total for Question 8 = 13 marks)

- 9 Phytoplankton are producer organisms in marine ecosystems.**

Zooplankton are small animals that live in the surface waters of the oceans.

The diagram shows a food chain for the South Atlantic Ocean.

**phytoplankton → zooplankton → sardine →
common seal → orca**

Look at the diagrams for Question 9(a) in the Diagram Booklet. They show ecological pyramids for this food chain.

- (a) Comment on the shapes of these three ecological pyramids.
(3 marks)**

Answer space continues on the next page.

9(a) continued.

(continued on the next page)

9 continued.

- (b) Look at the diagram for Question 9(b) in the Diagram Booklet. It shows the flow of energy through this food chain.**

All values are measured in $\text{kJ m}^{-3} \text{yr}^{-1}$

- (i) Calculate the percentage efficiency of energy transfer between the phytoplankton and the zooplankton.**

Give your answer to the nearest whole number.

(2 marks)

Answer _____ %

(continued on the next page)

Turn over

9(b) continued.

(ii) Common seals and orcas are endotherms.

Sardines are ectotherms.

Explain why the transfer of energy from sardines to orcas is less efficient than the transfer of energy from zooplankton to common seals.

(3 marks)

Answer space continues on the next page.

Turn over

9(b)(ii) continued.

(continued on the next page)

9 continued.

- (c) Scientists investigated the impact of global warming on marine productivity.**

They determined the effect of temperature and light intensity on the net primary productivity (NPP) of phytoplankton.

Phytoplankton were exposed to different light intensities at three different temperatures for one month. After one month, the scientists measured the increase in dry biomass of phytoplankton.

Look at the table for Question 9(c) in the Diagram Booklet. The results are shown.

- (i) State what is meant by the term net primary productivity (NPP).
(1 mark)**

(continued on the next page)

9(c) continued.

***(ii) Some effects of global warming include the following:**

- **Atmospheric carbon dioxide could cause an increase in temperature.**
- **Increased atmospheric temperature could increase cloud cover.**
- **Increased ocean temperature could reduce the movement of nutrients such as nitrates from the seabed to the surface water.**
- **The scientists concluded that if the use of fossil fuels is not reduced, there will be a fall in populations of orcas in the South Atlantic Oceans.**
- **Analyse the data in the table and the information given to discuss this conclusion.**

(6 marks)

Answer space continues on the next 2 pages.

Turn over

9(c)(ii) continued.

9(c)(ii) continued.

(Total for Question 9 = 15 marks)

TOTAL FOR PAPER = 90 MARKS
END OF PAPER