

Biology A (Salters Nuffield)

Advanced

PAPER 3: General and Practical Applications in Biology

Wednesday 19 June 2024 – Morning

Time: 2 hours

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

Surname					
Other names					
Centre Number					
Candidate Number					

YOU MUST HAVE

Ruler, writing and drawing equipment, scientific calculator and a copy of the scientific article adapted from the New Scientist and the Brazilian Journal of Medical and Biological Research (enclosed)

YOU WILL BE GIVEN

Diagram Booklet

INSTRUCTIONS

Answer ALL questions.

Show all your working out in calculations and include units where appropriate.

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 100.

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 questions 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.

- 1 One of the first plant species to colonise some habitats is thale cress (*Arabidopsis thaliana*).**

Look at the photograph for Question 1 in the Diagram Booklet. The plant hormone **IAA (auxin) is produced in the growing tips of plants such as thale cress.**

- (a) State what is meant by the term **colonisation of a habitat**.**

(1 mark)

(continued on the next page)

1 continued.

- (b) One role of **IAA** is to stimulate the phototropic response of shoots.

Describe how **IAA** causes a phototropic response in the shoots of a plant.

(3 marks)

Answer space continues on the next page.

1(b) continued.

(continued on the next page)

1 continued.

- (c) Another role of **IAA** is to stimulate the growth of lateral roots.

Look at the diagram for Question 1(c) in the Diagram Booklet. It shows the roots of thale cress.

One type of receptor for **IAA** is coded for by the **tir1** gene.

Scientists have investigated the effect of **IAA** on the growth of lateral roots in thale cress.

Plants homozygous for a normal **tir1** gene and plants homozygous for a mutation in the **tir1** gene were used in this investigation.

The plants were treated with different concentrations of **IAA**.

The mean number of lateral roots produced per mm of main root was recorded.

Look at the graph for Question 1(c) in the Diagram Booklet. It shows the results of this investigation.

(continued on the next page)

1(c) continued.

- (i) Explain why the scientists used plants homozygous for the normal and the mutant *tir1* gene in this investigation.
(2 marks)**

(continued on the next page)

1(c) continued.

- (ii) Calculate the percentage decrease in mean number of lateral roots for thale cress with the mutant **tir1** gene compared to thale cress with the normal **tir1** gene at **1.00 $\mu\text{mol dm}^{-3}$ of IAA.**
(1 mark)

Answer _____%

(continued on the next page)

1(c) continued.

(iii) Deduce the effect of the mutation in the *tir1* gene on the response of thale cress to IAA. (2 marks)

Answer space continues on the next page.

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Turn over

1(c)(iii) continued.

(Total for Question 1 = 9 marks)

- 2 Pathogenic bacteria can become resistant to antibiotics.

Methicillin-resistant **Staphylococcus aureus (MRSA)** is a bacterial pathogen that is resistant to many antibiotics.

Licochalcone **A** is a chemical isolated from the liquorice plant.

The antibacterial properties of licochalcone **A** have been investigated.

Look at the diagram for Question 2 in the Diagram Booklet. It shows the effect of licochalcone **A** on a bacterial lawn prepared using **MRSA**.

(continued on the next page)

2 continued.

- (a) Complete the table using information from the diagram.
(2 marks)

Mass of licochalcone A / μg	Diameter of clear zone / mm	Area of clear zone / mm^2
10	14.5	165
20	16.5	214
40	16.5	214
80		

(continued on the next page)

2 continued.

- (b) The bacteria used in this investigation are pathogenic.**

Describe how filter paper discs containing licochalcone **A can be safely placed on the bacterial lawn.**

(3 marks)

Answer space continues on the next page.

2(b) continued.

(continued on the next page)

2 continued.

- (c) Explain how an anomalous result could be identified for this investigation.
(2 marks)**

(Total for Question 2 = 7 marks)

3 Photosynthesis takes place in chloroplasts.

- (a) The light-dependent processes in photosynthesis can be investigated using the Hill reaction.**

Look at the graph for Question 3(a) in the Diagram Booklet. It shows the effect of three different herbicides, **A, **B** and **C**, on inhibition of the Hill reaction in isolated chloroplasts.**

- (i) State the location of the light-dependent reactions in chloroplasts.**
(1 mark)

(continued on the next page)

3(a) continued.

- (ii) Calculate the gradient of the slope for herbicide **A** at **50%** inhibition of the Hill reaction.**

**Give your answer to two significant figures.
(2 marks)**

Answer _____

(continued on the next page)

3(a) continued.

- (iii) Describe the role of chlorophyll in the light-dependent reactions of photosynthesis. (2 marks)**

(continued on the next page)

Turn over

3 continued.

(b) Describe the role of RUBISCO in the light-independent reactions of photosynthesis. (3 marks)

Answer space continues on the next page.

[illegible]

Turn over

3(b) continued.

(Total for Question 3 = 8 marks)

- 4 Look at the photographs for Question 4 in the Diagram Booklet. They show two large marine animals, the great white shark and the humpback whale.**

A typical adult great white shark has a mass of approximately 600 kg

Adult humpback whales have a mass of approximately 140 000 kg

Look at the diagram for Question 4 in the Diagram Booklet. It shows the trophic levels for two marine communities, one that includes the great white shark and one that includes the humpback whale.

- (a) Explain why an area of ocean can support a greater biomass of humpback whales than of great white sharks.**
(3 marks)

Answer space continues on the next page.

4(a) continued.

(continued on the next page)

4 continued.

- (b) Phytoplankton are photosynthetic unicellular microorganisms.**

Phytoplankton are primary producers in aquatic ecosystems.

- (i) State the relationship between gross primary productivity and net primary productivity.
(1 mark)**

(continued on the next page)

4(b) continued.

- (ii) The concentration of oxygen in water (dissolved oxygen) can be measured using an oxygen probe.**

Explain how an oxygen probe could be used to estimate the effect of temperature on the gross primary productivity (GPP**) of phytoplankton.
(4 marks)**

Answer space continues on the next page.

4(b)(ii) continued.

[illegible]

(continued on the next page)

Turn over

4 continued.

- (c) Copepods are a group of zooplankton, small animals that feed on phytoplankton.**

In an experiment, the production of carbon dioxide and the uptake of oxygen by copepods was measured at 14°C and at 17°C

Look at the graph for Question 4(c) in the Diagram Booklet. The results of the experiment are shown in the graph.

- (i) Determine the mean ratio of carbon dioxide produced to oxygen consumed at 17°C
(1 mark)**

(continued on the next page)

4(c) continued.

- (ii) Deduce TWO conclusions from the results of this experiment.
(2 marks)**

(Total for Question 4 = 11 marks)

5 Human immune deficiency virus (HIV) can cause acquired immune deficiency syndrome (AIDS).

(a) Look at the diagram for Question 5(a) in the Diagram Booklet. It shows an HIV virus particle.

(i) State the role of gp120 in the life cycle of the HIV virus.
(1 mark)

(continued on the next page)

5(a) continued.

- (ii) Give a reason why there are proteins from the host cell in the lipid membrane surrounding the virus particle.
(1 mark)**

(continued on the next page)

5 continued.

- (b) During viral replication, virus **mRNA** molecules are translated into a virus polyprotein called gag. A polyprotein is a chain of smaller proteins.

This polyprotein is then split into individual proteins by the **HIV** protease.

Look at the diagram for Question 5(b) in the Diagram Booklet. It shows the individual proteins produced from the polyprotein by **HIV** protease.

Deduce how **HIV** protease can split the gag polyprotein into individual proteins.
(3 marks)

Answer space continues on the next page.

5(b) continued.

(continued on the next page)

5 continued.

- (c) **HIV** protease inhibitors are used in drugs to treat **HIV** infection.

In some individuals, the **HIV** has developed resistance to protease inhibitors.

Look at the graph for Question 5(c) in the Diagram Booklet. The graph shows the effect of polyprotein concentration on the initial rate of reaction of normal **HIV** protease and inhibitor-resistant **HIV** protease.

- (i) Calculate the initial rate of reaction in the inhibitor-resistant **HIV** protease for a polyprotein concentration of $7 \mu\text{mol dm}^{-3}$ (2 marks)

Answer space continues on the next page.

5(c)(i) continued.

Answer _____

(continued on the next page)

5(c) continued.

- (ii) Explain the importance of enzyme and substrate concentrations when comparing the initial rates of reaction of different enzymes.
(3 marks)**

Answer space continues on the next page.

5(c)(ii) continued.

(Total for Question 5 = 10 marks)

6 The drug **MDMA** (ecstasy) can cause damage to the brain.

(a) This damage can cause changes in behaviour. This drug affects serotonin synapses.

(i) Explain how **MDMA** changes the rate of transmission of nerve impulses across serotonin synapses.
(4 marks)

Answer space continues on the next page.

6(a)(i) continued.

(continued on the next page)

6(a) continued.

- (ii) The effect of **MDMA** on the behaviour of mice has been investigated.

Mice were provided with access to two buttons, an **MDMA** button and a control button.

When they pressed the **MDMA** button they received a dose of **MDMA**. When they pressed the control button they received a dose of salt solution.

The buttons were activated for one three-hour period each day.

Look at the graph for Question 6(a)(ii) in the Diagram Booklet. It shows the results of this experiment.

Determine the effect of **MDMA** on the number of button presses made by these mice.
(3 marks)

Answer space continues on the next page.

6(a)(ii) continued.

(continued on the next page)

6 continued.

- (b) **MDMA** is responsible for swelling of the brain resulting in death in some people.

Look at the diagram for Question 6(b) in the Diagram Booklet. It shows how **MDMA** can cause brain swelling and death in some people.

Brain cells regulate their volume using active transport of sodium ions.

- (i) State what is meant by **ACTIVE TRANSPORT**.
(2 marks)

(continued on the next page)

6(b) continued.

**(ii) Explain how the active transport of sodium ions can regulate brain cell volume.
(3 marks)**

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6(b)(ii) continued.

(continued on the next page)

6(b) continued.

**(iii) Explain why swelling of the brain cells will result in vasoconstriction.
(2 marks)**

(continued on the next page)

6(b) continued.

- (iv) Explain why vasoconstriction will result in the death of brain cells.
(2 marks)**

(Total for Question 6 = 16 marks)

- *7 Sports injuries can be treated to reduce pain caused by muscle cramp.**

Ice massage, ice pack and cold-water immersion are three different types of treatment.

The compound action potential (CAP) is a measure of the sum of all action potentials in a muscle.

In one investigation, the effects of these treatments on the CAP in a leg muscle were investigated.

Look at the diagram for Question 7 in the Diagram Booklet. It shows the latency, duration and amplitude for a CAP.

- **Latency is the time taken from application of stimulus to the start of a CAP**
- **Duration is the length of time the CAP shows depolarisation**
- **Amplitude is the sum of depolarisation of all individual action potentials in the CAP**
- **Conduction velocity is the mean speed at which the CAP travels along the neurones.**

(continued on the next page)

7 continued.

Look at the graphs for Question 7 in the Diagram Booklet. The effects of the different treatments on the CAP for motor and sensory neurones are shown in the graphs.

Assess the effect of different cold treatments on nerve conduction and the reduction of pain caused by muscle cramp.

**Use all the information provided in the question as well as your own knowledge and understanding.
(9 marks)**

Answer space continues on the next 3 pages.

7 continued.

[illegible]

Turn over

7 continued.

[illegible]

Turn over

7 continued.

(Total for Question 7 = 9 marks)

- 8 The scientific article you have studied was adapted from the **New Scientist** and the **Brazilian Journal of Medical and Biological Research**.

Use the information from the scientific articles and your own knowledge to answer the following questions.

- (a) Explain why analysis of the amino acid sequence of the eye lens proteins can be used to determine the phylogenetic relationship of different sloths (Box 1).
(3 marks)

Answer space continues on the next page.

8(a) continued.

(continued on the next page)

8 continued.

- (b) Describe how the algae living on the hair of sloths can be shown to belong to one of four phyla (Box 2). (4 marks)**

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8(b) continued.

(continued on the next page)

8 continued.

(c) Describe how a spirometer could be used to estimate the metabolic rate of a sloth (paragraph 5). (4 marks)

Answer space continues on the next page.

[illegible]

Turn over

8(c) continued.

(continued on the next page)

8 continued.

- (d) Explain how the presence of different antibodies can be used to show that some viruses are specific to sloths and some are incidental (Box 3). (3 marks)**

Answer space continues on the next page.

8(d) continued.

(continued on the next page)

8 continued.

- (e) Sloths have ‘the longest digestive process on record for a plant-eating mammal’ (paragraph 7).**

Deduce the advantage to the sloth of a slow digestive process.

(2 marks)

(continued on the next page)

8 continued.

- (f) Explain why 'maintaining a core body temperature is energetically expensive' for a sloth (paragraphs 8 and 9).
(3 marks)**

Answer space continues on the next page.

8(f) continued.

(g) Sloths can warm up by climbing higher up into the canopy (paragraph 9).

**State the type of adaptation that this represents.
(1 mark)**

(continued on the next page)

8 continued.

- (h) Sloths spend a lot of time hanging upside down – ‘constant grip is made possible by a lattice of tendons in the hands and feet that draw the digits closed’ (paragraph 10).**

**Explain the advantage of using a lattice of tendons to draw the digits closed.
(3 marks)**

Answer space continues on the next page.

8(h) continued.

(continued on the next page)

8 continued.

- (i) Sloth muscles 'contain a unique set of enzymes that confers tolerance to heavy accumulations of lactic acid' (paragraph 12).**

Deduce how the enzymes in sloth muscles will differ from those in human muscles.

(2 marks)

(continued on the next page)

8 continued.

- (j) Sloths carry a ‘community of commensal beetles, mites and moths’.**

**Explain what is meant by this phrase (Box 4).
(2 marks)**

Answer space continues on the next page.

Turn over

8(j) continued.

(continued on the next page)

8 continued.

- (k) Describe how sympatric speciation could have occurred in the moths living on sloths (Box 4). (3 marks)**

Answer space continues on the next page.

[illegible]

Turn over

8(k) continued.

(Total for Question 8 = 30 marks)

TOTAL FOR PAPER = 100 MARKS
END OF PAPER