

Biology A (Salters Nuffield)

Advanced

Paper 3: General and Practical Applications in Biology

Wednesday 21 June 2023 – 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 Scientific American (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
– 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.

You may use a scientific calculator.

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.

Turn over

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 The heart pumps blood around the circulation system.

- (a) Explain why many animals need a heart AND circulation system.
(2 marks)**

(continued on the next page)

1 continued.

- (b) If the heart of an animal is removed from its body, the heart will continue to beat for a period of time.**

The left atrium stops contracting if it is separated from the rest of the heart.

However, the right atrium and the rest of the heart will continue to beat.

Eventually, the right atrium and the rest of the heart will also stop beating.

- (i) Give a reason why the heart will continue to beat after being removed from the body.
(1 mark)**

(continued on the next page)

1(b) continued.

- (ii) Explain why the left atrium stops beating when it is separated from the right atrium. (2 marks)**

(continued on the next page)

1(b) continued.

- (iii) Explain why the right atrium and the rest of the heart eventually stop beating.
(2 marks)**

(Total for Question 1 = 7 marks)

- 2 White blood cells are involved in the non-specific and specific immune responses.**

Neutrophils and monocytes are two types of white blood cell.

Look at Table 1 for Question 2(a) in the Diagram Booklet. The table provides information about the neutrophils and monocytes of one individual.

- (a) Complete the table to show the volume of each neutrophil.
(2 marks)**

(continued on the next page)

2 continued.

Look at Table 2 for Question 2(b) in the Diagram Booklet.

(b) The table shows some properties of neutrophils and monocytes.

Activated monocytes are called macrophages.

**(i) State what is meant by the term phagocytosis.
(1 mark)**

(continued on the next page)

2(b) continued.

**(ii) Explain why monocytes play a role in the antigen specific immune response to viruses but neutrophils do not.
(3 marks)**

[illegible]

(Total for Question 2 = 6 marks)

Look at Image 1 for Question 3(a) in the Diagram Booklet.

- 3 The photograph shows a three-spined stickleback (*Gasterosteus aculeatus*).

This fish feeds on small invertebrates such as the brine shrimp (*Artemia salina*).

- (a) Calculate the length of the stickleback between lines A and B.

Give your answer to two significant figures.
(1 mark)

Answer _____ mm

(continued on the next page)

3 continued.

Look at Diagram 1 and 2 for Question 3(b) in the Diagram Booklet.

- (b) An investigation studied the food biting response of the three-spined stickleback.**

Individual fish were allowed to acclimatise in their own tanks.

A glass tube containing several live brine shrimps was placed in the middle of the tank, as shown in the diagram.

The stickleback tried to bite the brine shrimps in the tube.

The number of bites made by the stickleback was recorded each minute for 10 minutes.

The graph shows the results of this investigation.

- (i) Calculate the percentage decrease in the number of bite responses from 1 to 6 minutes.
(2 marks)**

Answer _____

(continued on the next page)

Turn over

3(b) continued.

**(ii) Explain the results of this investigation.
(3 marks)**

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Turn over

3 continued.

- (c) Adult male sticklebacks develop a red throat during the breeding season.**

The male of a breeding pair of sticklebacks will attack a competing male in order to drive it away.

Devise an investigation to determine the effect of the presence of a competing male on the attack response of the male stickleback.

(4 marks)

Answer space continues on the next page.

Turn over

3(c) continued.

(Total for Question 3 = 10 marks)

Look at Diagram 3 for Question 4 in the Diagram Booklet.

- 4 The effect of environmental temperature and exercise on the rate of sweating was studied.

The graph shows the results for one person.

- (a) Explain the importance of the dipole nature of water in sweating.
(2 marks)

(continued on the next page)

Turn over

4 continued.

**(b) Comment on the results of this study.
(4 marks)**

Answer space continues on the next page.

[illegible]

Turn over

4(b) continued.

(continued on the next page)

4 continued.

- (c) Describe how the production of sweat is controlled during exercise in humans.
(4 marks)**

Answer space continues on the next page.

4(c) continued.

(Total for Question 4 = 10 marks)

- 5 People with diabetes can suffer from a condition called diabetic peripheral neuropathy (DPN).**

In DPN, peripheral nerves become damaged, affecting the transmission of nerve impulses.

Peripheral nerves are nerves that connect the central nervous system to all parts of the body. These nerves are formed from bundles of axons.

Look at Diagram 4 for Question 5 in the Diagram Booklet. It shows the structure of a peripheral nerve.

(a) Each axon is surrounded by a myelin sheath.

- (i) Name the type of cell that forms the myelin sheath.**

(1 mark)

(continued on the next page)

5(a) continued.

- (ii) Describe the role of myelination in the conduction of a nerve impulse.
(2 marks)**

(continued on the next page)

5(a) continued.

- (iii) Describe the role of ion channels in the conduction of a nerve impulse.
(5 marks)**

Answer space continues on the next page.

5(a)(iii) continued.

(continued on the next page)

5 continued.

- (b) During the early stages of DPN, individuals suffer from nerve pain.**

Eventually, the damage results in nerves dying and complete loss of sensation.

Several factors have been linked to an increased risk of DPN in individuals with diabetes.

Look at Table 3 for Question 5(b) in the Diagram Booklet. The table lists some of these risk factors for DPN.

(continued on the next page)

5(b) continued.

- (i) The information in the table can be used to estimate the increase in risk of developing DPN for an individual with diabetes.**

Individual A is a diabetic who smokes and has high triglycerides.

Individual B is a diabetic who smokes and has a high LDL to HDL ratio.

**Calculate the ratio of the increase in percentage risk for individuals A and B.
(1 mark)**

Ratio _____

(continued on the next page)

5(b) continued.

- (ii) Explain why these risk factors can cause peripheral nerve cells to die.
(3 marks)**

Answer space continues on the next page.

5(b)(ii) continued.

(Total for Question 5 = 12 marks)

- 6 The zebrafish (*Danio rerio*) has been studied as a model for vertebrate development.**

Zebrafish have a variety of types of stripes and fin shape phenotypes.

Wild type zebrafish are homozygous for the black stripe and short fin phenotypes.

Look at Image 2 for Question 6 in the Diagram Booklet. It shows a wild type zebrafish.

- (a) The black stripes of zebrafish are produced by cells called melanophores.**

Melanophores produce a black pigment called melanin.

**Explain how a specialised cell such as a melanophore is produced from a stem cell.
(3 marks)**

Answer space continues on the next page.

6(a) continued.

(continued on the next page)

6 continued.

- (b) Zebrafish with different phenotypes have been produced by introducing gene mutations into the zebrafish genome.**

Look at Table 4 for Question 6 in the Diagram Booklet. Two of these phenotypes, spots and long fin, are described in the table.

In an investigation, the inheritance of these two phenotypes was studied.

In cross 1, one parent was homozygous for stripes and the other parent was homozygous for spots.

In cross 2, one parent was homozygous for short fins and the other parent was homozygous for long fins.

Look at Table 5 for Question 6 in the Diagram Booklet. The table shows the results of this investigation.

(continued on the next page)

6(b) continued.

- (i) State what is meant by the term gene mutation.
(1 mark)**

- (ii) Deduce the pattern of inheritance of the spots and long fin phenotypes.
(2 marks)**

(continued on the next page)

6 continued.

- (c) Melanin pattern (stripes or spots) and fin length (long or short) are controlled by different genes.**

Parents heterozygous for both these genes (DdNn) were crossed.

Look at Table 6 for Question 6(c)(i) in the Diagram Booklet. The table shows the expected genotypes of the parental gametes and the genotypes and phenotypes of the offspring.

The expected genotypes and phenotypes assume that genes for spots and long fins are inherited independently of each other.

- (i) Complete the table by filling in the missing genotypes and phenotypes.
(2 marks)**

(continued on the next page)

6(c) continued.

- (ii) Look at Table 7 for Question 6(c)(ii) in the Diagram Booklet. The table contains the observed and expected results of this cross.**

**Calculate a value for chi squared (χ^2).
(3 marks)**

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

Answer _____

(continued on the next page)

Turn over

6(c) continued.

(iii) Look at Table 8 for Question 6(c)(iii) in the Diagram Booklet. Some critical values for the chi squared test (χ^2) are given in the table.

State a conclusion that can be drawn from the results of this cross.

(2 marks)

(Total for Question 6 = 13 marks)

7 Tuberculosis is an infectious disease caused by the bacterium **Mycobacterium tuberculosis**.

(a) Describe how **M. tuberculosis** bacteria evade the immune system.
(2 marks)

(continued on the next page)

7 continued.

(b) The transcription factor STAT3 is involved in regulating the activity of macrophages and T cells.

**(i) State what is meant by the term transcription factor.
(1 mark)**

(continued on the next page)

7(b) continued.

- *(ii) The gene for STAT3 can have alternative bases at two sites, SNP1 and SNP2.**

The base at SNP1 is either A or G and the base at SNP2 is either T or C.

The SNP1 and SNP2 sites are in the introns of the STAT3 gene.

In one investigation, the association of different bases at these two SNP sites with tuberculosis (TB) infection was studied.

Look at Table 9 and Diagram 5 for Question 7(b)(ii) in the Diagram Booklet. The table and graph show some of the results of this investigation.

In a second investigation, white blood cells with different SNP1 genotypes were grown in culture with cells infected with Mycobacteria.

After three days the number of surviving bacterial cells was determined.

(continued on the next page)

7(b)(ii) continued.

Look at Diagram 5 for Question 7(b)(ii) in the Diagram Booklet. The graph shows the results of the second investigation.

Evaluate the role of the different STAT alleles in tuberculosis infections.

(9 marks)

Answer space continues on the next 3 pages.

7(b)(ii) continued.

[illegible]

Turn over

7(b)(ii) continued.

[illegible]

7(b)(ii) continued.

[illegible]

(Total for Question 7 = 12 marks)

Turn over

- 8 Look at the article for Question 8 in the Text Booklet. The scientific article you have studied is adapted from a chapter in the book *Oxygen*.**

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

- (a) The mass of ‘carbon turned into sugars by photosynthesis’ is a measure of the gross productivity of photosynthetic organisms (paragraph 2).**

Write an equation that describes the relationship between total carbon turned into sugar and the carbon turned into sugar that becomes available to primary consumers.

(1 mark)

- (b) Name one product, other than ATP and oxygen, produced by the light dependent reactions of photosynthesis (paragraph 4).**

(1 mark)

(continued on the next page)

Turn over

8 continued.

- (c) Explain why cells use 'chemical energy in the form of ATP' (paragraphs 4 and 5).
(3 marks)**

(continued on the next page)

Turn over

8 continued.

- (d) Describe how 'plant photosynthesis converts carbon dioxide from the air into simple organic molecules' (paragraph 5).
(4 marks)**

Answer space continues on the next page.

8(d) continued

(continued on the next page)

8 continued.

- (e) Devise an investigation to show that in chloroplasts, the oxygen for photosynthesis comes from water and not carbon dioxide (paragraphs 6 and 7).
(4 marks)**

Answer space continues on the next page.

Turn over

8(e) continued.

[illegible]

(continued on the next page)

Turn over

8 continued.

- (f) Explain how chloroplasts are adapted for their role in photosynthesis (paragraphs 9 and 10).
(4 marks)**

Answer space continues on the next page.

8(f) continued.

(continued on the next page)

8 continued.

- (g) Explain how energy of the electrons passed along an electron transport chain 'is used to power the synthesis of ATP' (paragraph 10).
(3 marks)**

Answer space continues on the next page.

8(g) continued.

(continued on the next page)

8 continued.

- (h) Explain how ‘tiny changes’ in chlorophyll molecules could result in a change in the wavelength of light absorbed (paragraphs 12 and 13).
(3 marks)**

Answer space continues on the next page.

8(h) continued.

(continued on the next page)

8 continued.

- (i) The structure of the oxygen-evolving complex is similar to that of catalase, 'it looks as if it evolved from two catalase enzymes lashed together' (paragraph 17).**

**Explain how proteomics and genomics could be used to support the suggestion that the oxygen-evolving complex evolved from catalase.
(4 marks)**

Answer space continues on the next page.

8(i) continued.

- (j) Look at Diagram 7 for Question 8(j) in the Diagram Booklet. Sketch a graph to compare the effect of substrate concentration on the rate of reaction of catalase and peroxidase (paragraphs 19 and 20).**

**Include suitable units in the labels for each axis.
(3 marks)**

(Total for Question 8 = 30 marks)

**TOTAL FOR PAPER = 100 MARKS
END OF PAPER**