Paper Reference(s)   9BI0/03
Pearson Edexcel Level 3 GCE

Biology B
Advanced
PAPER 3: General and Practical Principles in Biology

Wednesday 21 June 2023 – Morning

Time: 2 hours 30 minutes

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

Surname	
Other names	
Centre Number	
Candidate Number	

V71911A

Pearson

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 120.

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

(continued on the next page)

INFORMATION continued.

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.

1   Glucose is a monosaccharide.

(a) Look at the diagram for Question 1(a) in the Diagram Booklet. Complete the diagram to show the structure of beta-glucose.
(1 mark)

(continued on the next page)

1   continued.

(b) Glucose molecules can be joined
    to form the polysaccharides starch
    and cellulose.

    Give THREE differences between the
    structures of starch and cellulose.
    (3 marks)

Answer space continues on the next page.

_____

_____

_____

_____

_____

_____

1(b) continued.

_____

_____

_____

_____

_____

_____

_____

_____

_____

(continued on the next page)

1   continued.

(c) Explain how the properties of starch make it suitable as an energy store in cells.
(2 marks)

_____

_____

_____

_____

_____

_____

_____

(Total for Question 1 = 6 marks)

2 **Insects, such as locusts, can be dissected to show their gas exchange system.**

    (a) (i) **Look at the diagram for Question 2(a)(i) in the Diagram Booklet. It shows a dead locust.**

          Draw a line on this locust to show where you would cut through the exoskeleton to expose the gas exchange system.
          (1 mark)

(continued on the next page)

2(a) **continued.**

(ii) State why you would cover the dissected locust with water. (1 mark)

_____

_____

_____

_____

_____

(continued on the next page)

Turn over

2 continued.

(b) Look at the drawing for Question 2(b)(i) in the Diagram Booklet. It shows part of the dissected gas exchange system, as seen using a microscope.

(i) Name the structures labelled A and B.
(2 marks)

A _____

_____

B _____

_____

(continued on the next page)

2(b)   continued.

**(ii) Name the structure that
supplies oxygen directly to the
muscle tissue.
(1 mark)**

_____

_____

(continued on the next page)

2(b)   continued.

(iii) At the point labelled A, the structure is 0.9 mm in diameter.

Calculate the diameter of the structure at the point labelled X.

Give your answer to TWO decimal places.
(2 marks)

Answer _____ mm

(Total for Question 2 = 7 marks)

3   In genetic modification, DNA from one species is joined to DNA from another species, to form recombinant DNA.

This recombinant DNA is inserted into the host organism using a vector.

The diagram on the next page shows a simplified sequence of events in the formation of herbicide-resistant, genetically modified (GM) soya beans.

Herbicides are chemicals that kill plants. They can be used to kill unwanted plants, such as weeds.

(continued on the next page)

3   continued.

STEP A Plasmids are extracted from
A. tumefaciens bacteria

↓

STEP B Plasmids are cut using
an enzyme

↓

STEP C The gene for herbicide-
resistance is inserted into
the plasmids.

↓

STEP D Plasmids are returned to
A. tumefaciens bacteria

↓

STEP E A soya bean plant is
infected with the modified
A. tumefaciens bacteria

↓

STEP F Herbicide-resistant soya bean
plants are cloned from the
infected plant.

3   continued.

(a) (i) Name the enzyme used
         in STEP C.
         (1 mark)

_____

_____

(ii) Name the vector in this process.
      (1 mark)

_____

_____

(continued on the next page)

3   continued.

**(b) Explain why it is possible to clone
    many herbicide-resistant plants from
    one infected plant in STEP F.
    (2 marks)**

_____

_____

_____

_____

_____

_____

_____

(continued on the next page)

3   continued.

(c) Explain how herbicide resistance would improve the yield of GM soya bean plants compared to non-GM soya bean plants.
(3 marks)

Answer space continues on the next page.

_____

_____

_____

_____

_____

_____

_____

3(c)   continued.

_____

_____

_____

_____

_____

(Total for Question 3 = 7 marks)

4   When cereal grains germinate, stored starch is broken down by amylase.

(a) A student investigated the effect of gibberellin concentration on the production of amylase in cereal grains.

This method was used:

STEP 1   Dilute a stock solution of gibberellin to give five different concentrations.

STEP 2   Cut the cereal grains in half and discard the half containing the embryo.

STEP 3   Soak the remaining halves of the grains in sodium hypochlorite solution for five minutes.

STEP 4   Soak one grain in each of the gibberellin solutions for 24 hours.

(continued on the next page)   Turn over

4(a) **continued.**

    (i) **The stock solution of gibberellin has a concentration of $1\,g$ per dm^3.**

        Describe how you would dilute this stock solution to give a test solution of $300\,\mu g$ per dm^3.
        (2 marks)

Answer space continues on the next page.

_____

_____

_____

_____

_____

4(a)(ii) continued.

_____

_____

_____

(continued on the next page)

4(a)   continued.

> **(ii) State ONE reason for each of the following steps in the method. (2 marks)**

Answer space continues on the next page.

STEP 2

_____

_____

_____

_____

_____

(continued on the next page)

4(a)   continued.

STEP 3

_____

_____

_____

_____

(continued on the next page)

4   continued.

(b) The student completed the investigation using the following steps:

- the grains soaked in gibberellin solution were transferred to starch agar plates using forceps

- after 12 hours the surface of each plate was covered with iodine in potassium iodide solution, which was then poured away

- the diameter of the clear zone around each grain was measured.

(continued on the next page)

4(b)   continued.

   (i)   Describe how you would control ONE named abiotic variable and ONE named biotic variable.
   (2 marks)

Answer space continues on the next page.

Abiotic

_____

_____

_____

_____

_____

4(b)(i)   continued.

Biotic

_____

_____

_____

_____

_____

(continued on the next page)

4(b)   continued.

   (ii) Describe THREE further improvements to the method outlined in parts (a) and (b) that would improve the validity of the results.
   (3 marks)

Answer space continues on the next 2 pages.

_____

_____

_____

_____

_____

_____

4(b)(ii)   continued.

_____

_____

_____

_____

_____

_____

_____

_____

_____

4(b)(ii)   continued.

_____

_____

_____

(Total for Question 4 = 9 marks)

5 **(a)** **Bacteria are prokaryotes.**

(i) **Give TWO differences between the structures of a prokaryotic cell and a eukaryotic cell.**
(2 marks)

_____

_____

_____

_____

_____

_____

_____

(continued on the next page)

5(a)   continued.

(ii) Gram staining is often used to help identify bacteria.

A sample of bacteria from an infected person was tested by using Gram staining.

The bacteria stained red.

Explain why the bacteria stained red AND why this information is useful for treating the infected person.
(3 marks)

Answer space continues on the next page.

_____

_____

_____

_____

Turn over

5(a)(ii)   continued.

_____

_____

_____

_____

_____

_____

_____

_____

(continued on the next page)

5   continued.

(b) (i)   Describe the method used to isolate individual species from a mixed culture of bacteria in nutrient broth.
(4 marks)

Answer space continues on the next page.

_____

_____

_____

_____

_____

_____

_____

5(b)(i)   continued.

_____

_____

_____

_____

_____

_____

_____

_____

_____

(continued on the next page)

Turn over

5(b)   continued.

   (ii) Explain THREE precautions that
        would be taken to reduce the
        growth of pathogenic bacteria.
        (3 marks)

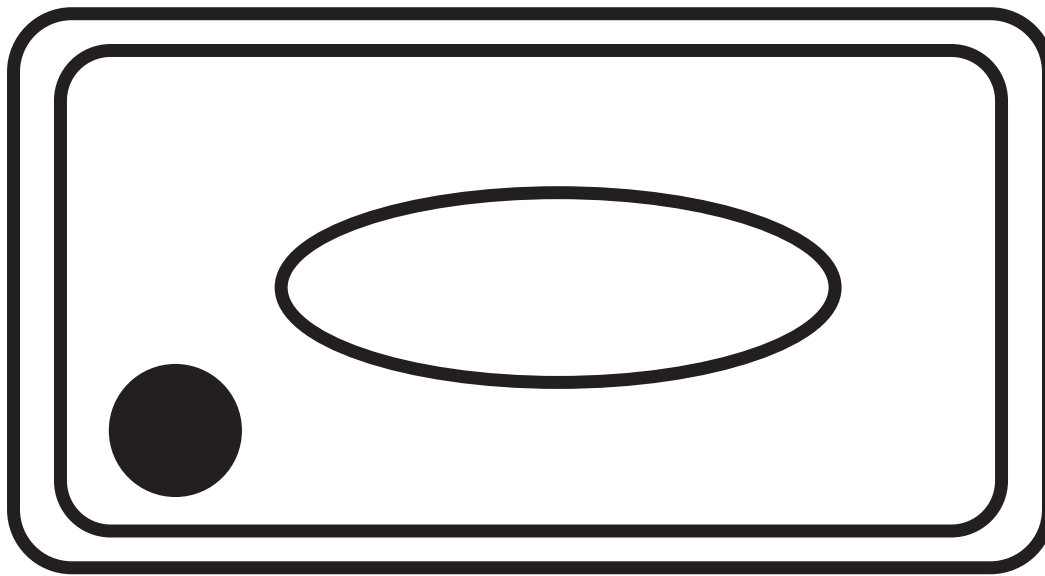Answer space continues on the next page.

_____

_____

_____

_____

_____

_____

_____

_____

Turn over

5(b)(ii)   continued.

_____

_____

_____

_____

_____

(Total for Question 5 = 12 marks)

Turn over

6 **Water potential determines the direction of movement of water in and out of cells.**

(a) The diagram shows a plant cell.

The turgor pressure (P) of the cell is 400 kPa and the osmotic potential (π) is −500 kPa.

(continued on the next page)

6(a)   continued.

    (i) Calculate the water potential (ψ) of this cell.
        (1 mark)

Answer _____**kPa**

Turn over

6(a) **continued.**

(ii) Explain the direction of net movement of water for this plant cell when it is placed in a sucrose solution with a water potential (ψ) of –400 kPa.
(2 marks)

_____

_____

_____

_____

_____

_____

_____

Turn over

6   continued.

(b) A student carried out an investigation to determine the water potential of cells from a potato tuber, using a range of concentrations of sucrose solutions.

Cylinders of potato were cut using a cork borer, and the cylinders were then cut into discs.

The mass of each disc was recorded. One disc was placed in each sucrose solution and left for 12 hours. Each disc was then reweighed.

Look at the table for Question 6(b) and the grid for Question 6(b)(i) in the Diagram Booklet. The table shows the data collected.

(continued on the next page)

Turn over

6(b)   continued.

   (i) Plot a suitable graph of these results on the grid.

      Join the points with straight lines. (3 marks)

   (ii) Determine the concentration of sucrose solution that causes no change in mass, using your graph. (1 mark)

Answer _____ **mol dm^{-3}**

(continued on the next page)

Turn over

6(b) **continued.**

      (iii) **Evaluate whether the method used in this investigation would provide valid results for the water potential of potato cells.**
             (5 marks)

Answer space continues on the next 2 pages.

_____

_____

_____

_____

_____

_____

_____

6(b)(iii)   continued.

_____

_____

_____

_____

_____

_____

_____

_____

_____

6(b)(iii)   continued.

_____

_____

_____

(Total for Question 6 = 12 marks)

Turn over

7   Look at the drawing for Question 7 in the Diagram Booklet. It shows hedge woundwort (**Stachys sylvatica**).

This plant grows on the edge of woodlands and can be up to one metre in height.

A student investigated whether light intensity had an effect on the leaf area of hedge woundwort.

The student measured the area of 20 leaves from plants growing in full sun and 20 leaves from plants growing in shady conditions.

(continued on the next page)

Turn over

7 continued.

(a) (i) Give a suitable null hypothesis for this investigation.
(1 mark)

_____

_____

_____

_____

_____

(continued on the next page)

7(a) **continued.**

    (ii) **Devise a valid fieldwork method that the student could use to compare the leaf areas of the plants growing in full sunlight with the leaf areas of the plants growing in shady areas.**
(4 marks)

Answer space continues on the next page.

_____

_____

_____

_____

_____

_____

7(a)(ii)   continued.

_____

_____

_____

_____

_____

_____

_____

_____

_____

(continued on the next page)

Turn over

7   continued.

   (b) Look at the graphs for Question 7(b) in the Diagram Booklet. The student plotted histograms to display the data collected.

   (i)   The mean leaf area for leaves from plants in full sun is $27 \cdot 55\,cm^2$ with a standard deviation of $9 \cdot 62\,cm^2$.

   The mean leaf area for leaves from plants in shady conditions is $55 \cdot 50\,cm^2$ with a standard deviation of $13 \cdot 40\,cm^2$.

   Two standard deviations on either side of the mean will include 95% of the leaves.

   Determine the size range that would include 95% of leaves from plants in full sun, using the standard deviation value.
   (2 marks)

Answer space continues on the next page.

7(b)(i)   continued.

Answer _____ cm^2

(continued on the next page)

7(b)   continued.

(ii) The student analysed the data using a **t**-test.

Calculate the value of **t**.

Use the formula

$$t = \frac{(\bar{x}_A - \bar{x}_B)}{\sqrt{\dfrac{(S_A)^2}{n_A} + \dfrac{(S_B)^2}{n_B}}}$$

where:

$\bar{x}$ is the mean for each set of data

n is the number of samples in each set of data

S is the standard deviation for each set of data
(3 marks)

Answer space continues on the next page.

7(b)(ii)   continued.

Answer _____

Turn over

7(b) **continued.**

    (iii) **Look at the table for Question 7(b)(iii) in the Diagram Booklet. It shows the critical values of t for different degrees of freedom.**

          Comment on the results of this investigation.

          Use the information in the table to support your answer.
          (3 marks)

Answer space continues on the next page.

_____

_____

_____

_____

_____

7(b)(iii)   continued.

_____

_____

_____

_____

_____

_____

_____

_____

_____

(Total for Question 7 = 13 marks)

Turn over

8   Haemoglobin transports oxygen around the human body.

(a) (i)   Explain how the structure of haemoglobin enables it to combine with oxygen in the blood vessels of the lungs.
(3 marks)

Answer space continues on the next page.

_____

_____

_____

_____

_____

_____

_____

8(a)(i)   continued.

_____

_____

_____

_____

_____

(continued on the next page)

8(a) continued.

(ii) The partial pressure of carbon dioxide affects how readily haemoglobin picks up and releases oxygen.

Look at the graph for Question 8(a)(ii) in the Diagram Booklet. It shows an oxygen dissociation curve for haemoglobin in blood in the lungs.

The oxygen dissociation curve for haemoglobin in blood in the tissues of respiring muscle is different.

Sketch this curve onto the axes. (1 mark)

Turn over

8(a) **continued.**

(iii) **Explain the advantage of this change in the position of the oxygen dissociation curve.**
(2 marks)

_____

_____

_____

_____

_____

_____

_____

8   continued.

(b) Beta thalassaemia is an inherited condition affecting the gene for beta-globin (HBB gene).

People with beta thalassaemia have less or no beta-globin.

The most common form is a recessive condition caused by a mutation in the HBB gene.

(continued on the next page)

8(b) **continued.**

(i) **State the probability that two parents who are heterozygous for this condition would have a child who has beta thalassaemia.**
(1 mark)

_____

_____

_____

_____

_____

(continued on the next page)

Turn over

8(b)   continued.

(ii) Explain why a person who is heterozygous does not show the symptoms of beta thalassaemia. (2 marks)

_____

_____

_____

_____

_____

_____

_____

_____

(continued on the next page)   **Turn over**

8 continued.

(c) Overall, the proportion of people with beta thalassaemia is 30 in 1000.

In some parts of the world it is much higher.

In one Mediterranean island, 280 in 1000 people have beta thalassaemia.

(i) Calculate the probability that a person on this island is heterozygous for beta thalassaemia.

Use the Hardy–Weinberg equation

$$p^2 + 2pq + q^2 = 1$$

Give your answer to two significant figures.
(3 marks)

Answer space continues on the next page.

8(c)(i)   continued.

Answer _____

(continued on the next page)   **Turn over**

8(c)   continued.

(ii) Give TWO reasons why this value may not be accurate.
(2 marks)

_____

_____

_____

_____

_____

_____

_____

_____

(Total for Question 8 = 14 marks)

Turn over

9 **Coronary heart disease is a major cause of death in Europe.**

    (a) Explain how atherosclerosis can cause coronary heart disease and can lead to death.
    (4 marks)

Answer space continues on the next page.

_____

_____

_____

_____

_____

_____

_____

9(a) continued.

_____

_____

_____

_____

_____

_____

_____

_____

(continued on the next page)

Turn over

9   continued.

*(b) Look at the table and the graph for Question 9(b) in the Diagram Booklet. The table shows the change in the number of deaths from coronary heart disease in males and females in some European countries, and the whole of Europe, between 1990 and 2019.

The graph shows the number of deaths of males, per 100 000, from coronary heart disease in the UK from 1979 to 2013.

It has been suggested that the change in deaths from coronary heart disease in the UK is due to improved lifestyle choices, and that coronary heart disease could be reduced to almost zero in the UK if people made better choices.

(continued on the next page)

9(b) continued.

Discuss the validity of this suggestion.

Use the data and your own knowledge to support your answer. (9 marks)

Answer space continues on the next 5 pages.

_____

_____

_____

_____

_____

_____

Turn over

9(b)   continued.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Turn over

9(b)   continued.

_____

_____

_____

_____

_____

_____

_____

_____

_____

9(b)   continued.

_____

Turn over

9(b)   continued.

_____

_____

_____

_____

_____

_____

_____

_____

_____

9(b)   continued.

_____

_____

_____

_____

_____

_____

_____

_____

_____

Turn over

9(b)   continued.

_____

_____

_____

_____

_____

_____

_____

(Total for Question 9 = 13 marks)

10 Five groups of students used respirometers to investigate the rate of aerobic respiration by maggots.

Look at the diagram and the table for Question 10 in the Diagram Booklet. The diagram shows the type of respirometer used.

Maggots were placed in the boiling tube and the 3-way tap was closed.

The distance the coloured liquid had moved was measured after 15 minutes.

The rate of oxygen uptake was calculated.

The table shows the results obtained.

10 continued.

(a) The rate of aerobic respiration was determined as the oxygen uptake calculated in mm^3 per minute per gram.

State the TWO additional measurements that you would make to calculate the rate using these units. (2 marks)

_____

_____

_____

_____

_____

_____

_____

10 continued.

(b) Justify TWO improvements that would ensure the validity of this investigation.
(2 marks)

_____

_____

_____

_____

_____

_____

_____

(continued on the next page)

10 continued.

(c) (i) For enzyme-controlled reactions, a 10°C rise in temperature will double the rate of reaction.

Predict the mean rate of oxygen uptake if the water bath had been set at 5°C.
(1 mark)

Answer _____

$mm^3\,min^{-1}\,g^{-1}$

(continued on the next page)

10(c)   continued.

   (ii) Explain why decreasing the
         temperature affects the rate of
         respiration of maggots.
         (2 marks)

_____

_____

_____

_____

_____

_____

_____

(continued on the next page)

10 continued.

**(d) Describe the role of oxygen in the formation of ATP during aerobic respiration.
(3 marks)**

_____

_____

_____

_____

_____

_____

_____

_____

(Total for Question 10 = 10 marks)

Turn over

11 Citizen science involves members of the public collecting scientific data.

In 2019 and 2020, a citizen science project was carried out in the UK to investigate the numbers of flowers of wild plant species found in lawns.

Volunteers across the UK were asked to survey their own lawns to find out which wild flowering plants were growing there.

Participants were asked to mark out a one metre-squared area on their lawn, chosen at random, and count the number of flowers of each species within this area.

In 2020, the data were recorded from over 9 000 one metre-squared areas.

Look at the table for Question 11 in the Diagram Booklet. It shows data for the five most commonly recorded wild plant species in 2020.

(continued on the next page)   **Turn over**

11 continued.

(a) Scientists who analysed the data suggested that the unusually warm weather in Spring 2020 might be responsible for the change in the numbers of flowers recorded in 2020 compared to 2019.

(i) Name ONE factor, other than temperature, that could cause the change in the numbers of flowers of these five species.
(1 mark)

_____

_____

(continued on the next page)

Turn over

11(a) continued.

    (ii) The scientists concluded that for all species recorded, the number of flowers of wild plants in lawns decreased 19% in 2020 compared to 2019.

        Evaluate the method of data collection in this survey.
(5 marks)

Answer space continues on the next 2 pages.

_____

_____

_____

_____

_____

_____

11(a)(ii) continued.

_____

_____

_____

_____

_____

_____

_____

_____

_____

11(a)(ii)   continued.

_____

_____

_____

_____

(continued on the next page)

11 continued.

(b) The table shows the total data collected in one quadrat placed on a lawn.

Wild plant species	Total number of flowers recorded
Daisy	11
Dandelion	8
Cat's-ear	14
Selfheal	2

(i) Calculate the biodiversity index (D) for the quadrat, using the data in the table.

Use the formula

$$D = \frac{N(N-1)}{\Sigma n(n-1)}$$

(3 marks)

Answer space continues on the next page.

Turn over

11(b)(i)   continued.

Answer _____

(continued on the next page)

11(b) **continued.**

(ii) Describe TWO improvements which should be made to the method to give a more accurate measure of the biodiversity index for this quadrat.
(2 marks)

_____

_____

_____

_____

_____

_____

_____

(continued on the next page)

Turn over

11   continued.

(c) (i) Bees feed on nectar in flowers.

The mean mass of nectar sugar produced per square metre of lawn was calculated for 2019 and 2020.

Scientists then calculated the mean number of bees per square metre that could be supported by the nectar.

Look at the table for Question 11(c)(i) in the Diagram Booklet. The table shows the data.

Calculate the mean number of bees supported per square metre of lawn in 2020.
(2 marks)

Answer space continues on the next page.

11(c)(i)   continued.

Answer _____

11(c)   continued.

(ii) Bees are important pollinators of a variety of plants.

Explain the possible short-term AND long-term consequences of the decline in flowers of wild plant species in lawns in 2020. (4 marks)

Answer space continues on the next page.

_____

_____

_____

_____

_____

_____

11(c)(ii)   continued.

_____

_____

_____

_____

_____

_____

_____

_____

(Total for Question 11 = 17 marks)

TOTAL FOR PAPER = 120 MARKS
END OF PAPER