

Biology B

Advanced

PAPER 3: General and Practical Principles in Biology

Total Marks

Wednesday 19 June 2024 – 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					

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.

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.

- 1 A student made a root tip squash to observe the stages of mitosis.**

(a) Name the region of the root tip where cells are actively dividing.

(1 mark)

(b) Give ONE reason for each of the following:

**(i) Treating the root tip with strong acid
(1 mark)**

(continued on the next page)

1(b) continued.

**(ii) Adding a stain to the root tip
(1 mark)**

**(iii) Pressing lightly on the coverslip
(1 mark)**

(continued on the next page)

1 continued.

- (c) Look at the diagram for Question 1(c) in the Diagram Booklet. It shows cells from a root tip squash.**

The total number of cells is 39

Calculate the mitotic index for this root tip squash.

Use the formula

$$\text{Mitotic index} = \frac{\text{number of cells in mitosis}}{\text{total number of cells}} \times 100$$

**Give your answer to ONE DECIMAL PLACE.
(2 marks)**

Answer _____

(Total for Question 1 = 6 marks)

- 2 The mammalian kidney contains over one million nephrons.**

One of their functions is to produce urine with a high concentration of urea.

- (a) Look at the diagram for Question 2(a) in the Diagram Booklet. It shows one nephron, collecting duct and some of the associated blood vessels.**

- (i) Explain how urea enters the nephron.
(2 marks)**

(continued on the next page)

Turn over

2(a) continued.

- (ii) In the region labelled *A*, sodium ions are actively pumped out of the nephron into the surrounding fluid.**

Explain how this movement of ions results in the formation of concentrated urine.

(3 marks)

Answer space continues on the next page.

2(a)(ii) continued.

(b) The concentration of urine varies between species of mammals.

Look at the graph for Question 2(b) in the Diagram Booklet. It shows the concentration of urine in kangaroo rats, camels and humans.

- (i) Determine the ratio of urine concentration for these three mammals.
(1 mark)**

Answer _____

(continued on the next page)

2(b) continued.

(ii) Kangaroo rats live in a desert habitat.

Explain ONE adaptation in the structure of a kangaroo rat kidney that enables it to produce very concentrated urine.

(2 marks)

(continued on the next page)

2(b) continued.

(iii) Kangaroo rats are endotherms.

**Give ONE behavioural adaptation that you would expect to see in kangaroo rats that helps them to conserve water in a hot desert.
(1 mark)**

(Total for Question 2 = 9 marks)

- 3 Beetroot (*Beta vulgaris*) is an edible plant. Look at the image for Question 3 in the Diagram Booklet. It shows a beetroot plant.**

The root cells contain a red pigment, betalain, in the vacuole.

- (a) (i) Draw a typical cell from a root, as seen using a light microscope.
Label THREE named membranes.
(2 marks)**

(continued on the next page)

Turn over

3(a) continued.

- (ii) Describe the structure of a membrane in a plant cell.
(2 marks)**

(continued on the next page)

3 continued.

(b) A group of students investigated the effect of temperature on membrane permeability using tissue from a beetroot. They used the following method.

- 1. Tubes containing 20 cm^3 of water were placed in water baths for 15 minutes at 20°C , 30°C , 40°C , 50°C and 60°C**
- 2. Cylinders were cut from the same beetroot using a standard cork borer, and these were cut into 1 cm lengths.**
- 3. Each piece was rinsed in water and then blotted dry, before being added to a tube in the water bath.**
- 4. After 20 minutes, a sample of the liquid was removed.**
- 5. The absorbance (amount of light absorbed by the red pigment) of each sample was measured using a colorimeter.**

(continued on the next page)

3(b) continued.

Look at the table for Question 3(b) in the Diagram Booklet. It shows the results.

- (i) Describe the relationship between temperature and absorbance, as shown by these results.
(2 marks)**

(continued on the next page)

3(b) continued.

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

(continued on the next page)

3 continued.

- (c) Group 1 results were excluded from the calculations of the means as they were so different from the other groups.**

**Identify FOUR errors this group may have made which would account for the difference in results.
(4 marks)**

Answer space continues on the next page.

3(c) continued.

(Total for Question 3 = 12 marks)

- 4 Woodlice are crustaceans found in many gardens and woodland habitats.**

There are several species that are native to the UK and Ireland.

They obtain oxygen through gills, which are on their legs.

Look at the image for Question 4(a) in the Diagram Booklet. It shows one species of woodlouse, *Armadillidium vulgare*.

- (a) (i) Describe how you could measure the respiration rate of woodlice collected from a garden.
(5 marks)**

Answer space continues on the next page.

4(a)(i) continued.

[illegible]

(continued on the next page)

Turn over

4(a) continued.

- (ii) Identify ONE safety issue and ONE ethical issue involved in your method in part (a)(i) and state how you would minimise the effect of these.
(2 marks)**

Safety issue

Ethical issue

4 continued.

- (b) A student used a choice chamber to investigate the habitat preferences of woodlice.**

Look at the image for Question 4(b) in the Diagram Booklet. It shows a choice chamber.

Look at the diagram for Question 4(b) in the Diagram Booklet. It shows the conditions in each of the four sections.

Woodlice were able to move freely to all areas of the chamber.

The student suggested the hypothesis that woodlice show no habitat preference.

- Five woodlice were placed in each of the four sections and left to move.**
- The position of the woodlice was recorded after five minutes.**
- This was repeated three more times.**

(continued on the next page)

4(b) continued.

Look at the table for Question 4(b) in the Diagram Booklet. It shows the results obtained.

- (i) Explain which statistical test could be used to analyse these results.
(2 marks)**

(continued on the next page)

4(b) continued.

- (ii) The results suggest woodlice prefer some conditions to others.**

Explain why it is an advantage for them to live in these conditions.

(2 marks)

Answer space continues on the next page.

4(b)(ii) continued.

(continued on the next page)

4(b) continued.

- (iii) Describe THREE improvements that could be made to this investigation to ensure the conclusion is valid.**
(3 marks)

Answer space continues on the next page.

4(b)(iii) continued.

(Total for Question 4 = 14 marks)

5 Differences in water potential affect the direction of movement of water in and out of cells.

(a) The water potential of plant cells can be determined using plasmolysis.

A plant cell is plasmolysed when it loses water and the plasma membrane moves away from the cell wall. This can be observed when the cells are viewed with a light microscope.

A group of students used the following method to find the osmotic potential of cell sap in onion epidermal cells. The osmotic potential is equivalent to the concentration of the sucrose solution when **50% of cells are plasmolysed.**

(continued on the next page)

5(a) continued.

STEP 1: A stock sucrose solution of 0.8 mol dm^{-3} was diluted to make a range of concentrations.

STEP 2: A thin layer of onion epidermis was placed in 10 cm^3 of sucrose solution in each tube, and left for 20 minutes.

STEP 3: Each piece of onion epidermis was placed on a microscope slide covered with a drop of the sucrose solution in which it had been soaking, and a coverslip placed on top.

STEP 4: Using a microscope, the total number of cells in the field of view, and the total number that were plasmolysed, were counted.

STEP 5: The percentage of plasmolysed cells in each sucrose concentration was calculated.

(continued on the next page)

5(a) continued.

- (i) Describe how you would prepare **10 cm^3** of a solution of sucrose with a concentration of **0.6 mol dm^{-3}** from the stock solution.
(2 marks)

(continued on the next page)

5(a) continued.

- (ii) Look at the table and grid for Question 5(a)(ii) in the Diagram Booklet. The table shows the mean results.**

Plot a suitable graph to display these results.

Join the points with straight lines.

(3 marks)

- (iii) Determine the concentration of the cell sap of the onion epidermal cells, using your graph.**
(1 mark)

Answer _____ mol dm⁻³

(continued on the next page)

5(a) continued.

- (iv) Look at the conversion graph for Question 5(a)(iv) in the Diagram Booklet. It can be used to convert the concentration of cell sap into osmotic potential.**

Determine the osmotic potential of the cell sap of the onion epidermal cells.

Use your answer to (b)(iii) and the conversion graph.

(1 mark)

Answer _____ kPa

(continued on the next page)

5(a) continued.

- (v) Write the equation that is used to calculate the water potential of a plant cell.
(1 mark)**

- (vi) State the water potential of the cell sap of the onion epidermal cells when **50%** of the cells are plasmolysed.
(1 mark)**

Answer _____ **kPa**

(continued on the next page)

5 continued.

(b) The students modified the method and repeated the investigation.

The changes are shown in emphasised font.

STEP 2: all pieces of onion epidermis were cut from a single onion.

STEP 2: tubes containing sucrose solution and onion epidermis layers were left in a thermostatically controlled water bath for 20 minutes.

STEP 4: the total number of cells in the field of view, and the number that were plasmolysed were counted. This was repeated twice for each of the sucrose concentrations.

Explain why each of these changes are likely to improve the validity of this investigation.

(3 marks)

Answer space continues on the next page.

5(b) continued.

(Total for Question 5 = 12 marks)

- 6 Duckweed, *Lemna minor*, is a small plant that floats on the surface of freshwater ponds.**

Each plant consists of a frond, which contains photosynthetic pigments, and a root which absorbs inorganic ions from the water.

Look at the diagram for Question 6 in the Diagram Booklet. It shows duckweed plants.

Duckweed typically reproduces asexually by budding, to produce daughter plants. In ideal conditions, the doubling time is around 3 days.

A student investigated the effect of changing the wavelength of light on the time taken for the number of duckweed plants to double.

- **Ten duckweed plants were added to a tank containing 3 dm^3 of water with dissolved inorganic ions. The temperature was maintained at 10°C**
- **A lamp with no filter was placed at a known distance from the tank.**
- **The total number of plants were counted at intervals of 3 days.**
- **The investigation was repeated with a red filter over the lamp and then again with a blue filter over the lamp.**

(continued on the next page)

Turn over

6 continued.

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

- (a) (i) Explain the results of this investigation.
(2 marks)**

(continued on the next page)

6(a) continued.

- (ii) The shortest time for the number of plants to double was more than 3 days.**

Give TWO ways of reducing the time taken for the number of plants to double.

(2 marks)

1 _____

2 _____

(continued on the next page)

6(a) continued.

- (iii) Give ONE reason why the results may not be accurate.
(1 mark)**

(continued on the next page)

6(a) continued.

- (iv) Describe a method that could be used to measure the growth of the plants more accurately.
(2 marks)**

(continued on the next page)

6 continued.

- (b) In another investigation, the student grew duckweed plants in water containing a fertiliser.**

The fertiliser contained nitrate, phosphate and magnesium ions.

Three concentrations of the fertiliser were used, with all other conditions kept constant.

Look at the graph for Question 6(b) in the Diagram Booklet. It shows the results of this investigation.

**Explain the effect of increasing fertiliser concentration on the growth of these plants.
(3 marks)**

Answer space continues on the next page.

Turn over

6(b) continued.

(continued on the next page)

6 continued.

- (c) It has been suggested that duckweed could be grown in water polluted with organic waste from cows.**

These plants could be processed to make feed for poultry and cattle.

**Analyse the information to comment on this suggestion.
(4 marks)**

Answer space continues on the next page.

Turn over

6(c) continued.

(Total for Question 6 = 14 marks)

- 7 Turmeric is a spice made from the root of the plant *Curcuma longa*.**

It has been used in traditional medicine for many years.

- (a) A student investigated the antibacterial properties of turmeric.**

The student suggested the hypothesis:

An extract made from turmeric root will reduce the growth of bacteria.

**Devise a valid method to test this hypothesis.
(6 marks)**

Answer space continues on the next 2 pages.

7(a) continued.

[illegible]

Turn over

7(a) continued.

(continued on the next page)

7 continued.

- (b) Curcumin is an organic compound found in the spice turmeric and may be used to treat joint pain.**

In 2019, a trial compared the treatment of joint pain with curcumin and Drug A. Joint pain is due to inflammation and can lead to immobility.

This trial involved 139 patients aged 38 to 65, who had been taking anti-inflammatory medication to combat pain for at least three months. These patients were randomly assigned into two groups.

- One group was given 50 mg of Drug A (an anti-inflammatory drug which is an existing treatment for knee pain) twice a day for 28 days.**
- The other group was given 500 mg of curcumin three times a day for 28 days.**

At the end of the trial, patients were asked to rate their pain on a scale of 0 to 100. The scientists also collected data about side effects, weight loss and overall outcomes.

Patients who had liver or kidney disease, heart disease, bronchitis or stomach ulcers were excluded from the trial.

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

7(b) continued.

Analyse the data to discuss the suggestion that curcumin should be used to replace Drug A as a treatment for knee pain.

Use information about the design of this trial AND the results to support your answer.

(6 marks)

Answer space continues on the next 2 pages.

7(b) continued.

[illegible]

Turn over

7(b) continued.

(Total for Question 7 = 12 marks)

- 8 Look at the photograph for Question 8 in the Diagram Booklet. It shows a celandine plant, **Ficaria verna**, that is commonly found in woodlands in the UK.

A student noticed that many of these plants grew in a mature beech woodland, but seemed to be less abundant as the distance from a path increased.

The student investigated the distribution of celandine using this method:

- set up a transect at **90°** to the path (transect 1)
- at 1 metre intervals along the transect, place a tape parallel to the path
- record the presence or absence of celandine every **25 cm** along the tape
- repeat for two more transects in the woodland (transects 2 and 3).

Look at the diagram for Question 8 in the Diagram Booklet. It shows the arrangement of the transect and the tape.

(continued on the next page)

8 continued.

- (a) Give a null hypothesis for this investigation.
(1 mark)**

- (b) Look at Table 1 for Question 8(b) in the
Diagram Booklet. It shows the results collected.**

**Look at Table 2 for Question 8(b) in
the Diagram Booklet. It shows how the
student analysed this data to calculate the
Spearman's Rank correlation coefficient.**

(continued on the next page)

8(b) continued.

(i) Calculate the correlation coefficient, r_s

Use the formula:

$$r_s = 1 - \frac{6 \sum d^2}{n(n^2 - 1)}$$

Where:

$\sum$ = the sum of

d = the difference between each pair of ranks

n = the size of the sample
(number of pairs of values)

Give your answer to
THREE SIGNIFICANT FIGURES.
(3 marks)

Answer _____

8(b) continued.

- (ii) Look at Table 1 for Question 8(b)(ii) in the Diagram Booklet. It shows some critical values for this correlation coefficient.**

Analyse the data to explain the conclusion that can be drawn from this investigation.

Use the table of critical values and your calculated correlation coefficient.

(3 marks)

Answer space continues on the next page.

8(b)(ii) continued.

**(c) (i) Name ONE abiotic factor that might influence the distribution of celandine plants.
(1 mark)**

(continued on the next page)

8(c) continued.

- (ii) Describe a method that could be used to measure how this abiotic factor changes along the transect.**
(3 marks)

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.

8(c) continued.

- (iii) Explain why the factor you have chosen would change along the transect AND how this affects the growth of celandine plants.
(3 marks)**

Answer space continues on the next page.

8(c)(iii) continued.

(Total for Question 8 = 14 marks)

- 9 Peppered moths, **Biston betularia**, are found in many parts of the UK. Two forms of this species are found, a light form and a dark form.

Peppered moths sometimes rest on tree trunks during the day. In rural areas with clean air, the tree trunks are often covered with lichen. In industrial areas the trees have less lichen on them due to air pollution.

Look at the images for Question 9 in the Diagram Booklet. They show both forms resting on tree trunks.

Peppered moths are often preyed on by birds.

- (a) Until 1848, light peppered moths were the only form recorded.

In 1848, a single darker form of the moth was observed in an industrial area in the north-west of England.

In 1895, **98%** of peppered moths in this industrial area were the dark form.

Explain how natural selection could have led to these changes.

(4 marks)

Answer space continues on the next 2 pages.

9(a) 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.

Turn over

9(a) continued.

(continued on the next page)

9 continued.

***(b) Scientists have carried out several investigations to explain changes in the peppered moth populations.**

INVESTIGATION 1: scientists placed both forms of the moths onto tree trunks in industrial and rural areas. They recorded the number of each type of moth eaten by birds.

The scientists found that on lichen-covered trunks, birds were twice as likely to eat dark moths as light moths.

INVESTIGATION 2: scientists released marked peppered moths in an industrial area and in a rural area.

A few days later they trapped moths and calculated the percentage of trapped moths that were marked (recaptured moths). Look at the table for Question 9(b) in the Diagram Booklet. It shows the results.

INVESTIGATION 3: scientists collected data about the proportions of light and dark moths in different parts of England and Scotland in the 1950s and in the 1970s.

Look at the maps for Question 9(b) in the Diagram Booklet. They show the results.

(continued on the next page)

Turn over

9(b) continued.

INVESTIGATION 3 found that in the 1970s there was a higher proportion of light moths than dark moths in areas that were once industrial, but the amount of lichen growing on tree trunks had not changed significantly.

Recent investigations have provided new evidence for the changes in the proportions of peppered moth:

- **peppered moths do not typically rest on tree trunks during the day, but are more likely to rest on the underside of high branches**
- **the main predators of peppered moths are bats, not birds.**

It has been suggested that the change in proportions of peppered moth forms is an example of natural selection.

**Discuss the validity of this suggestion.
(9 marks)**

Answer space continues on the next 5 pages.

9(b) continued.

[illegible]

Turn over

9(b) continued.

[illegible]

Turn over

9(b) continued.

[illegible]

Turn over

9(b) continued.

[illegible]

Turn over

9(b) continued.

(Total for Question 9 = 13 marks)

- 10 During respiration, yeast cells break down sugars to produce carbon dioxide and ethanol.**

The respiration rate of yeast is affected by several factors. It can be estimated by measuring the rate of production of carbon dioxide gas.

- (a) Scientists measured the rate of respiration of yeast using the sugar sucrose as a substrate.**

This was repeated using the sugar lactose with and without lactase.

Lactase is an enzyme that hydrolyses lactose.

The same concentrations of both sugars were used and the suspensions were incubated at 30°C

Look at the graph for Question 10(a) in the Diagram Booklet. It shows the results.

(continued on the next page)

10(a) continued.

- (i) Calculate the initial rate of respiration of yeast with sucrose.
(1 mark)**

Answer _____ **cm³ min⁻¹**

- (ii) Explain the results for sucrose compared with LACTOSE WITHOUT LACTASE.
(3 marks)**

Answer space continues on the next page.

Turn over

10(a)(ii) continued.

[illegible]

(continued on the next page)

10(a) continued.

- (iii) Explain the effect of LACTASE on the respiration rate of yeast during the first 400 minutes.
(3 marks)**

Answer space continues on the next page.

10(a)(iii) continued.

(continued on the next page)

10 continued.

- (b) The experiment with sucrose was repeated at a temperature 10°C lower.**

All other variables remained the same.

Explain the effect of this temperature change on the rate of respiration of yeast.

(3 marks)

Answer space continues on the next page.

Turn over

10(b) continued.

(continued on the next page)

10 continued.

- (c) The effect of changing the concentration of yeast on the rate of respiration was also investigated.**

Two yeast suspensions were made by adding different masses of yeast to 100 cm^3 of water containing 20 g of sucrose.

Look at the graph for Question 10(c) in the Diagram Booklet. It shows the results for a suspension containing 7.0 g of yeast.

- (i) Sketch a line on this graph to show the expected results for a suspension containing 3.5 g of yeast.**
(1 mark)

(continued on the next page)

10(c) continued.

- (ii) Explain the effect of the concentration of yeast on the volume of carbon dioxide produced in this investigation.
(3 marks)**

Answer space continues on the next page.

10(c)(ii) continued.

(Total for Question 10 = 14 marks)

TOTAL FOR PAPER = 120 MARKS
END OF PAPER