

Paper Reference(s) 9BI0/02
Pearson Edexcel Level 3 GCE

Biology B
Advanced

Total Marks

**PAPER 2: Advanced Physiology,
Evolution and Ecology**

Friday 13 June 2025 – Morning

Time: 1 hour 45 minutes

Question Paper

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

Surname					
Other names					
Centre Number					
Candidate Number					

**THIS DOCUMENT MUST BE
RETURNED TO PEARSON AT THE END
OF THE EXAMINATION**

YOU MUST HAVE

**Scientific calculator, writing and drawing
equipment, ruler**

YOU WILL BE GIVEN

Diagram Booklet

Turn over

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.

(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.

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 Look at the photograph for Question 1(a) in the Diagram Booklet. It shows part of a liver cell, as seen using an electron microscope. An outline image has also been provided in the Diagram Booklet.

**(a) Describe the roles of the labelled organelles in a liver cell.
(3 marks)**

Answer space continues on the next page.

1(a) continued.

(continued on the next page)

Turn over

1 continued.

(b) Hepatitis B is a DNA virus that infects liver cells. The DNA of the virus replicates inside liver cells.

**(i) Describe the process of DNA replication.
(3 marks)**

Answer space continues on the next page.

Turn over

1(b)(i) continued.

(continued on the next page)

Turn over

1(b) continued.

- (ii) The drug lamivudine is used to treat infections by the hepatitis B virus. It causes the production of altered nucleotides containing cytosine.**

Look at the diagrams for Question 1(b)(ii) in the Diagram Booklet. They show a normal nucleotide and an altered nucleotide.

Explain how lamivudine reduces replication of the hepatitis B virus in liver cells.

(2 marks)

Answer space begins on the next page.

Turn over

1(b)(ii) continued.

(Total for Question 1 = 8 marks)



Turn over

2 Look at the diagram for Question 2(a) in the Diagram Booklet. It shows the process of oogenesis.

**(a) (i) Which is the name of the cell labelled X?
(1 mark)**

- ☐ **A ovule**
- ☐ **B ovum**
- ☐ **C primary oocyte**
- ☐ **D secondary oocyte**

(continued on the next page)

2(a) continued.

(ii) Meiosis is involved in oogenesis.

**Describe the events of
prophase I during oogenesis.
(3 marks)**

Answer space continues on the next page.

Turn over

2(a)(ii) continued.

(continued on the next page)

Turn over

2(a) continued.

**(iii) Compare and contrast
the process of oogenesis
with spermatogenesis.
(3 marks)**

Answer space continues on the next page.

Turn over

2(a)(iii) continued.

(continued on the next page)

Turn over

2 continued.

(b) During in vitro fertilisation (IVF), oocytes are fertilised with sperm cells in a culture medium.

If more than one sperm cell fertilises an oocyte, the embryos do not develop.

Look at the graph for Question 2(b) in the Diagram Booklet. It shows the effect on the production of embryos that develop when different numbers of sperm cells are added to oocytes during IVF.

(continued on the next page)

Turn over

2(b) continued.

- (i) Calculate the number of sperm cells that need to be added to four oocytes so that 60% of embryos develop.
(1 mark)**

Answer space continues on the next page.

2(b)(i) continued.

Answer _____

(continued on the next page)

Turn over

2(b) continued.

(ii) Analyse the data to explain the effects of increasing the number of sperm cells per oocyte on the percentage of embryos that develop.

(2 marks)

Answer space continues on the next page.

Turn over

2(b)(ii) continued.

(Total for Question 2 = 10 marks)

3 Stress can change the heart rate of a person.

(a) Look at the diagram for Question 3(a) in the Diagram Booklet. It shows an ECG trace for a student at rest.

**(i) Which of the letters on this ECG trace represents the time when ventricular systole occurs?
(1 mark)**

☐ **A**

☐ **B**

☐ **C**

☐ **D**

(continued on the next page)

Turn over

3(a) continued.

- (ii) Describe how myogenic stimulation maintains the heart rate of the student when at rest.
(3 marks)**

Answer space continues on the next page.

Turn over

3(a)(ii) continued.

(continued on the next page)

Turn over

3 continued.

(b) Scientists investigated the effect of an anti-anxiety drug on the change in heart rate of a student after a sudden fright.

In this investigation:

- **The resting heart rate of the student was measured.**
- **The student was given a sudden, unexpected fright and their heart rate was measured again.**
- **This was repeated four more times.**

(continued on the next page)

Turn over

3(b) continued.

- **The investigation was then repeated after the student had taken the anti-anxiety drug.**

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

- (i) The mean volume of blood pumped around the body in one minute after a fright without the anti-anxiety drug is 18 dm^3**

The stroke volume of the student's heart was 150 cm^3

(continued on the next page)

3(b)(i) continued.

Calculate the mean volume of blood pumped around the body in one minute after a fright, when taking the anti-anxiety drug.

Give your answer in dm^3 and to the nearest whole number.

(2 marks)

Answer space continues on the next page.

3(b)(i) continued.

Answer _____ dm³

(continued on the next page)

3(b) continued.

(ii) The anti-anxiety drug has a similar shape to noradrenaline.

Analyse the data to comment on the results of this investigation.

(4 marks)

Answer space continues on the next 2 pages.

Turn over

3(b)(ii) continued.

Turn over

3(b)(ii) continued.

(Total for Question 3 = 10 marks)

- 4 Sickle cell anaemia is a condition caused by a mutation and a change in the structure of haemoglobin.**

Look at the diagram for Question 4(a) in the Diagram Booklet. It shows the changes that occur in the **DNA sequence and the amino acid sequence for this condition.**

(continued on the next page)

4 continued.

**(a) (i) Which type of bond is used when forming both the secondary structure and tertiary structure of proteins?
(1 mark)**

- ☐ **A disulfide**
- ☐ **B hydrogen**
- ☐ **C ionic**
- ☐ **D peptide**

(continued on the next page)

Turn over

4(a) continued.

(ii) Which type of mutation has occurred to produce the allele for sickle cell anaemia?

(1 mark)

- ☐ **A insertion**
- ☐ **B deletion**
- ☐ **C substitution**
- ☐ **D translocation**

(continued on the next page)

4(a) continued.

(iii) Glutamate is a charged, polar amino acid. It is located on the outer surface of unaffected haemoglobin molecules.

Look at the diagram for Question 4(a)(iii) in the Diagram Booklet. It shows the structure of the amino acids glutamate and valine.

Explain why the mutation in sickle cell anaemia causes haemoglobin molecules to bind together.

(2 marks)

Answer space begins on the next page.

Turn over

4(a)(iii) continued.

(continued on the next page)

Turn over

4 continued.

(b) Look at the graph for Question 4(b) in the Diagram Booklet. It shows the range of oxygen dissociation curves for haemoglobin taken from people who do not have sickle cell anaemia (unaffected) and from people with sickle cell anaemia (affected).

The shaded areas represent the ranges for each blood sample.

(continued on the next page)

4(b) continued.

- (i) Compare and contrast the properties of haemoglobin from these two groups of people.
(2 marks)**

Answer space continues on the next page.

Turn over

4(b)(i) continued.

(continued on the next page)

4(b) continued.

(ii) There is only one known allele that causes sickle cell anaemia.

State how the graph suggests that other genes affect the phenotype of people affected by sickle cell anaemia.

(1 mark)

Answer space continues on the next page.

Turn over

4(b)(ii) continued.

(continued on the next page)

4(b) continued.

**(iii) Explain why the oxygen dissociation curve for people with sickle cell anaemia means that they have difficulty exercising.
(3 marks)**

Answer space continues on the next page.

Turn over

4(b)(iii) continued.

(Total for Question 4 = 10 marks)

Turn over

5 Auxin is a plant growth substance.

(a) Which of the following are functions of auxin?

1. inhibiting lateral shoot growth

2. stimulating the elongation of cells in plant stems

3. stimulating flowering
(1 mark)

☐ **A 1 and 2**

☐ **B 1, 2 and 3**

☐ **C 1 and 3**

☐ **D 2 and 3**

5 continued.

(b) In an investigation, wheat seedlings were exposed to different concentrations of auxin.

The mean lengths of the roots and the mean dry biomass of the seedlings were calculated.

Look at the graphs for Question 5(b) in the Diagram Booklet. They show the results of this investigation.

(continued on the next page)

5(b) continued.

- (i) Calculate the percentage increase in mean root length when given an auxin concentration of $10^{-4} \mu\text{mol dm}^{-3}$ compared with no auxin.**

Give your answer to the nearest whole number.

(1 mark)

Answer space continues on the next page.

5(b)(i) continued.

Answer _____

(continued on the next page)

5(b) continued.

(ii) Analyse the data to discuss the effects of auxin on the growth of wheat seedlings.

(4 marks)

Answer space continues on the next 2 pages.

Turn over

5(b)(ii) continued.

Turn over

5(b)(ii) continued.

(Total for Question 5 = 6 marks)

6 Look at the photograph for Question 6(a) in the Diagram Booklet. It shows a brown rat, *Rattus norvegicus*. An outline image has also been provided in the Diagram Booklet.

(a) The classification hierarchy for the brown rat is:

- **Domain: Eukarya**
- **Kingdom: Animalia**
- **Phylum: Chordata**
- **Mammalia**
- **Rodentia**
- **Muridae**
- **Genus: Rattus**
- **Species: norvegicus.**

6(a) continued.

- (i) Look at the table for Question 6(a)(i) in the Diagram Booklet. Which family, order and class does the brown rat belong to?
(1 mark)**

☐ **A**

☐ **B**

☐ **C**

☐ **D**

(continued on the next page)

Turn over

6(a) continued.

- (ii) State ONE method that scientists use to determine the evolutionary relationships of the brown rat compared with other species.
(1 mark)**

(continued on the next page)

Turn over

6 continued.

(b) Warfarin is a poison that is often used to control brown rat populations.

In areas where large amounts of warfarin have been used, many rats have developed resistance to warfarin.

(continued on the next page)

6(b) continued.

**Three genotypes occur in
rat populations:**

**$W^N W^N$ – rats that are not resistant
to warfarin**

**$W^R W^R$ – rats that are resistant to
warfarin but require large
amounts of vitamin **K** in
their diet to survive**

**$W^N W^R$ – rats that are resistant to
warfarin and **DO NOT**
require large amounts of
vitamin **K** to survive.**

(continued on the next page)

Turn over

6(b) continued.

After the introduction of warfarin, scientists determined the change in numbers of rats that were resistant to warfarin, and the number that were not resistant to warfarin.

Look at the table for Question 6(b) in the Diagram Booklet. It shows their results.

(continued on the next page)

6(b) continued.

- (i) Calculate the expected number of rats that would be resistant to warfarin but DO NOT require large amounts of vitamin K to survive, before warfarin was used.**

Use the Hardy-Weinberg equation

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

(3 marks)

Answer space continues on the next page.

6(b)(i) continued.

Answer _____

(continued on the next page)

Turn over

6(b) continued.

- (ii) Explain why, after two years,
there is a change in the number
of rats that are resistant
to warfarin.
(2 marks)**

Answer space continues on the next page.

Turn over

6(b)(ii) continued.

(continued on the next page)

6(b) continued.

(iii) Warfarin is highly toxic to rats that have no resistance.

Explain why, after five years, there are still many rats that are not resistant to warfarin.

(2 marks)

Answer space continues on the next page.

Turn over

6(b)(iii) continued.

(Total for Question 6 = 9 marks)

- 7 Inulin is a polysaccharide made of fructose that is used as a storage molecule by some plant species.**

Look at the diagram for Question 7(a) in the Diagram Booklet. It shows part of a molecule of inulin.

- (a) (i) The inulin molecule in the diagram contains fructose.**

Which of these carbohydrates also contain fructose?

(1 mark)

- ☐ **A lactose, maltose, and sucrose**
- ☐ **B lactose and sucrose**
- ☐ **C maltose and sucrose**
- ☐ **D sucrose**

7(a) continued.

**(ii) Which is the name of the chemical bond that joins the monosaccharides in inulin?
(1 mark)**

- ☐ **A ester**
- ☐ **B glycosidic**
- ☐ **C hydrogen**
- ☐ **D peptide**

(continued on the next page)

7(a) continued.

(iii) Fructose has the same molecular formula as glucose.

Which is the molecular formula of a molecule of inulin consisting of four fructose sugars?

(1 mark)

☐ **A $\text{C}_{24}\text{H}_{42}\text{O}_{21}$**

☐ **B $\text{C}_{24}\text{H}_{44}\text{O}_{22}$**

☐ **C $\text{C}_{24}\text{H}_{48}\text{O}_{21}$**

☐ **D $\text{C}_{24}\text{H}_{48}\text{O}_{24}$**

(continued on the next page)

Turn over

7 continued.

(b) The number of fructose molecules in inulin can vary from 10 to 70

Inulin with high numbers of fructose molecules is less soluble in water.

(i) Look at the diagram for Question 7(b)(i) in the Diagram Booklet. It shows three plant cells with different water potentials.

Draw arrows on the diagram to show the direction of water movement between the cells.

(1 mark)

(continued on the next page)

Turn over

7(b) continued.

(ii) Explain why some plant species make inulin with fewer fructose molecules in dry weather and inulin with more fructose molecules in wet weather.

(2 marks)

Answer space continues on the next page.

Turn over

7(b)(ii) continued.

(continued on the next page)

7 continued.

(c) Inulin is used to measure the rate of filtration by the kidneys.

A saline solution containing inulin is injected into the vein of a patient.

The concentration of inulin in the blood plasma is then measured over time.

The rate of filtration is a measure of the maximum rate that inulin is removed from the blood by the kidneys.

Look at the graph for Question 7(c)(i) in the Diagram Booklet. It shows the concentration of inulin in the blood plasma after an injection of 5 g of inulin.

7(c) continued.

- (i) Calculate the maximum rate that the inulin is removed from the blood.**

**Give your answer to two decimal places with appropriate units.
(2 marks)**

Answer space continues on the next page.

7(c)(i) continued.

Answer _____

(continued on the next page)

Turn over

7(c) continued.

- (ii) Explain how inulin passes
from the blood plasma into the
proximal convoluted tubule of
a nephron.
(2 marks)**

Answer space continues on the next page.

Turn over

7(c)(ii) continued.

(continued on the next page)

7(c) continued.

**(iii) Explain why all the inulin is
released into the urine.
(2 marks)**

Answer space continues on the next page.

Turn over

7(c)(iii) continued.

(Total for Question 7 = 12 marks)

- 8 Look at the diagram for Question 8 in the Diagram Booklet. It shows a grouse on a heather moor. Heather moors are areas of countryside that are dominated by heather plants.**

Heather moors are habitats for a variety of plants and animals. They are also used for sheep farming and as areas to raise grouse.

The net primary productivity (NPP) of a heather moor decreases with the age of the heather plants.

(continued on the next page)

8 continued.

(a) Which of the following is the correct formula to calculate **NPP**?
(1 mark)

- ☐ A **NPP = gross primary productivity (GPP) – respiration**
- ☐ B **NPP = gross primary productivity (GPP) + respiration**
- ☐ C **NPP = gross primary productivity (GPP) + photosynthesis**
- ☐ D **NPP = gross primary productivity (GPP) – photosynthesis**

(continued on the next page)

Turn over

8 continued.

(b) As heather plants age, the ratio of leaf area to area of woody stem changes.

A student investigated the relationship between the age of heather plants and the ratio of leaf area : woody stem area.

Look at the table for Question 8(b) in the Diagram Booklet. The student carried out a Spearman's rank correlation test using the data in the table.

(continued on the next page)

Turn over

8(b) continued.

- (i) Calculate the missing values to complete the table. Write your answers in the table.**

(2 marks)

- (ii) Calculate the Spearman's rank correlation coefficient for the data in the table. Use the formula**

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

(3 marks)

Answer space begins on the next page.

8(b)(ii) continued.

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

Answer _____

(continued on the next page)

8(b) continued.

**(iii) Look at the table for
Question 8(b)(iii) in the Diagram
Booklet. It gives some critical
values for the Spearman's rank
correlation coefficient.**

**Comment on the relationship
between the age of the heather
and the ratio of leaf area to
woody stem area.**

**Use your calculated value of
Spearman's rank correlation
coefficient and the table.**

(3 marks)

**Answer space begins and continues on the
next 2 pages.**

Turn over

8(b)(iii) continued.

Turn over

8(b)(iii) continued.

(continued on the next page)

8 continued.

***(c) Farmers manage heather moors by burning the heather every 10 years. This removes older heather and allows younger plants to grow.**

Managing heather moors by burning is controversial.

It has been suggested that instead of burning the heather, the moors should be left to return to nature as part of a rewilding strategy.

Rewilding strategies aim to return areas of farmland to the original ecosystems that existed before the heather moors.

8(c) continued.

Several factors have to be considered before a decision on rewilding is made.

- **The heather moors are areas of peat containing dead organic waste that decomposes very slowly.**
- **Heather moors are an area of income for farmers.**
- **Over time, heather becomes very dominant and lies flat over the ground, blocking light.**

(continued on the next page)

Turn over

8(c) continued.

- **A variety of small species of plants live around areas of older heather.**
- **Heather seeds need to be heated to germinate efficiently.**
- **Some endangered species consume grouse.**
- **Grouse are raised by humans for profit.**
- **Heather moors have been managed for many years and many species that lived in the area are now extinct.**

(continued on the next page)

Turn over

8(c) continued.

Analyse all the information in the question to discuss the effects of rewilding the moors compared with management by burning.

(6 marks)

Answer space continues on the next 3 pages.

Turn over

8(c) continued.

Turn over

8(c) continued.

Turn over

8(c) continued.

(Total for Question 8 = 15 marks)

9 Look at the diagram for Question 9(a)(i) in the Diagram Booklet. It shows a section through the central area of a human retina.

(a) (i) Draw an arrow on the left of the diagram to show the direction that light travels through the retina.

(1 mark)

(ii) Describe how light absorbed by rhodopsin in a rod cell leads to a change in release of neurotransmitter from the rod cell.

(3 marks)

Answer space begins and continues on the next 2 pages.

9(a)(ii) continued.

Turn over

9(a)(ii) continued.

(continued on the next page)

9 continued.

***(b) A student investigated the retinal structures of different mammals.**

The student collected information about:

- **the structure of the retina of the cat (a predator that hunts at night)**
- **the distribution of rods and cones in the retina of humans and cats**
- **the total number of rods and cones in the retinas of species active in the day and species active at night.**

(continued on the next page)

Turn over

9(b) continued.

Look at the diagram for Question 9(b) in the Diagram Booklet. It shows part of the retina of a cat.

Look at Table 1 and Table 2 for Question 9(b) in the Diagram Booklet. They show some of the data collected by the student.

Discuss how the retinas of animals are adapted to their activity at different times of the day.

(6 marks)

Answer space continues on the next 4 pages.

Turn over

9(b) continued.

Turn over

9(b) continued.

Turn over

9(b) continued.

Turn over

9(b) continued.

(Total for Question 9 = 10 marks)

TOTAL FOR PAPER = 90 MARKS

END OF PAPER