

Paper Reference(s) 9BN0/02

Pearson Edexcel Level 3 GCE

Biology A (Salters Nuffield)

Advanced

PAPER 2: Energy, Exercise and Coordination

Friday 13 June 2025 – Morning

Time: 2 hours

Question Paper

Total Marks

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, ruler,
writing and drawing equipment**

YOU WILL BE GIVEN

Diagram Booklet

INSTRUCTIONS

Answer ALL questions.

**Show your working in any calculation
questions and include units in your
answer where appropriate.**

(continued on the next page)

Turn over

INSTRUCTIONS continued.

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.

You may use a scientific calculator.

(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 The pancreas is an organ found in the human body.**

The pancreas is made up of a number of different cell types including beta cells and acinar cells.

(a) Look at the diagram for Question 1(a) in the Diagram Booklet. It shows a beta cell from a human pancreas.

(continued on the next page)

1(a) continued.

- (i) Calculate the magnification of this diagram.
(2 marks)**

Answer _____

(continued on the next page)

Turn over

1(a) continued.

(ii) A student viewed the diagram and stated that the cell was undergoing mitosis.

Give TWO reasons why this statement is correct.

(2 marks)

Answer space begins and continues on the next 2 pages.

1(a)(ii) continued.

1 _____

Turn over

1(a)(ii) continued.

2 _____

(continued on the next page)

1 continued.

(b) Acinar cells produce the digestive enzyme elastase. Elastase is secreted from the acinar cells as a glycoprotein.

The polypeptide chain for elastase is formed on the ribosomes of the rER.

Describe how this polypeptide is processed to form a glycoprotein and then released from the cell.

(4 marks)

Answer space begins and continues on the next 2 pages.

Turn over

1(b) continued.

Turn over

1(b) continued.

(Total for Question 1 = 8 marks)

2 A spirometer can produce a trace used to study breathing.

(a) When using a spirometer, the same air is repeatedly inhaled and exhaled. Before the air is inhaled from the spirometer, it passes through soda lime to remove carbon dioxide.

Explain the effect on breathing if the inhaled air is NOT passed through soda lime.

(3 marks)

Answer space continues on the next 2 pages.

2(a) continued.

Turn over

2(a) continued.

(continued on the next page)

2 continued.

(b) A person at rest used a spirometer for 30 seconds. The person then exercised whilst using the same spirometer.

Look at the graph for Question 2(b) in the Diagram Booklet. The results are shown in the trace.

(continued on the next page)

2(b) continued.

(i) Which is the breathing rate at rest for this person?

(1 mark)

- ☐ **A 6 breaths per minute**
- ☐ **B 7 breaths per minute**
- ☐ **C 14 breaths per minute**
- ☐ **D 16 breaths per minute**

(continued on the next page)

2(b) continued.

(ii) The resting respiratory minute ventilation can be calculated using this trace, and the equation:

Resting respiratory minute volume = resting breathing rate (in breaths per minute) $\times$ Q

**Which is the value of Q?
(1 mark)**

☐ **A 0.5**

☐ **B 1.1**

☐ **C 14**

☐ **D 60**

2(b) continued.

(iii) Devise an investigation, using a spirometer, to find the change in the rate of oxygen uptake of a person during exercise compared with at rest.

(3 marks)

Answer space continues on the next 2 pages.

Turn over

2(b)(iii) continued.

Turn over

2(b)(iii) continued.

(Total for Question 2 = 8 marks)

Turn over

- 3 All cells have a cell surface membrane that allows some ions to move across.**

Look at the diagram for Question 3 in the Diagram Booklet. It shows the fluid mosaic model for the cell surface membrane.

(continued on the next page)

3 continued.

(a) The cell surface membrane also contains cholesterol.

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

It represents cholesterol.

Describe how the cholesterol is positioned within the phospholipid bilayer.

(2 marks)

Answer space continues on the next page.

Turn over

3(a) continued.

(continued on the next page)

Turn over

3 continued.

(b) An animal cell, containing proteins R, S and T in its cell surface membrane, was placed in a solution containing two ions, P and Q

The rate of uptake of both ions was measured as the cell was supplied with an increasing concentration of oxygen.

Look at the graph for Question 3(b) in the Diagram Booklet. The results are shown.

(continued on the next page)

3(b) continued.

Only one of the proteins labelled R, S and T on the diagram on page 6 of the Diagram Booklet allows the uptake of ion P

This protein changes shape to move ion P

**Explain which protein allows the uptake of ion P
(4 marks)**

Answer space begins and continues on the next 2 pages.

Turn over

3(b) continued.

Turn over

3(b) continued.

(Total for Question 3 = 6 marks)

4 The human eye can detect both images and a change in light intensity.

(a) Describe the pathway taken by nerve impulses from sensory cells in the eye to the part of the brain that forms the images.

(3 marks)

Answer space continues on the next 2 pages.

Turn over

4(a) continued.

Turn over

4(a) continued.

(continued on the next page)

4 continued.

(b) The fovea is part of the retina.

**In one study, the mean density
of photosensitive cells in
the fovea was found to be
 $164\,000 \pm 24\,000 \text{ per mm}^2$**

**The mean radius of the fovea is
0.8 mm**

**Calculate the maximum number
of photosensitive cells present in
the fovea.**

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

Answer space begins on the next page.

Turn over

4(b) continued.

Answer _____

(continued on the next page)

4 continued.

(c) Look at the graph for Question 4(c) in the Diagram Booklet. It shows the relationship between light intensity and pupil diameter.

Explain the relationship shown in the graph.

(4 marks)

Answer space continues on the next 3 pages.

Turn over

4(c) continued.

Turn over

4(c) continued.

Turn over

4(c) continued.

(Total for Question 4 = 10 marks)

- 5 The Belgian Blue is a breed of cattle that contains a lot of muscle due to a mutation. The mutation affects cells called myoblasts.**

Look at the flow diagram for Question 5 in the Diagram Booklet. It shows some stages that lead to the production of excess muscle.

- (a) Look at the base sequence diagram for Question 5(a) in the Diagram Booklet. It shows 21 bases in one DNA strand of part of the myostatin gene.**

(continued on the next page)

5(a) continued.

(i) Which is the MAXIMUM number of DIFFERENT codons that there would be on the mRNA transcribed from this part of the gene?

(1 mark)

☐ **A 6**

☐ **B 7**

☐ **C 10**

☐ **D 21**

(continued on the next page)

Turn over

5(a) continued.

(ii) Look at the diagram for Question 5(a)(ii) in the Diagram Booklet. The bases shaded are deleted from one strand in the mutated gene (Stage 1).

The two strands of DNA are held together by hydrogen bonds.

There are two hydrogen bonds between adenine (A) and its complementary base and three between the other pair of bases.

(continued on the next page)

5(a)(ii) continued.

**Calculate the percentage reduction
in the number of hydrogen bonds
in this part of the myostatin gene
due to the mutation.**

**Give your answer to one
decimal place.**

(3 marks)

_____ %

(continued on the next page)

Turn over

5 continued.

**(b) Explain why myostatin produced from the mutated gene does not function (Stage 2).
(3 marks)**

Answer space continues on the next 2 pages.

Turn over

5(b) continued.

Turn over

5(b) continued.

(continued on the next page)

5 continued.

(c) Mitosis is involved in Stage 3.

Mitosis also has a number of other functions.

Which row is correct?

(1 mark)

(continued on the next page)

5(c) continued.

KEY

✗ = is not a function of mitosis

✓ = is a function of mitosis

Function		
	asexual reproduction	repair of cells
☐ A	✓	✓
☐ B	✓	✗
☐ C	✗	✓
☐ D	✗	✗

(continued on the next page)

Turn over

5 continued.

(d) Each muscle fibre (Stage 3) is a cell.

Which statement identifies a muscle fibre as a cell?

(1 mark)

- ☐ **A it contains cytoplasm in which organelles may be present**
- ☐ **B it has a cell wall containing actin**
- ☐ **C it has a nucleus that disappears in interphase**
- ☐ **D it has genetic material**

(Total for Question 5 = 9 marks)

Turn over

6 Antagonistic muscles interact to control the movement of the legs.

Sprinters need to respond rapidly to the starting signal in a race.

In an investigation, the response time for a group of athletes was studied.

Each athlete contracted a flexor muscle in the leg to hold a pedal down.

When a light was switched off, the athlete released the pedal.

The response time for the flexor muscle to fully relax was recorded.

(continued on the next page)

6 continued.

The investigation was repeated except the percentage muscle contraction needed to hold the pedal down was changed.

Look at the graph for Question 6 in the Diagram Booklet. The results are shown.

**(a) State the type of muscle that works antagonistically with a flexor muscle.
(1 mark)**

(continued on the next page)

Turn over

6 continued.

(b) The difference in the mean response time for the 25% contraction and the 50% contraction was significant at the 0·05 level.

Explain what is meant by this difference being significant at the 0·05 level.

(2 marks)

Answer space continues on the next page.

Turn over

6(b) continued.

(continued on the next page)

6 continued.

(c) Which is the relationship between the percentage muscle contraction needed to hold down the pedal and the response time?

(1 mark)

- ☐ **A exponential**
- ☐ **B linear**
- ☐ **C logarithmic**
- ☐ **D proportional**

(continued on the next page)

Turn over

6 continued.

***(d) When the investigation was carried out, it took time between the athlete seeing the light switch off and the flexor muscle being fully relaxed.**

Explain why there was a delay between the light being switched off and full relaxation of the flexor muscle in this investigation.

Use the results of the investigation and your own knowledge to answer this question.

(6 marks)

Answer space begins and continues on the next 5 pages.

Turn over

6(d) continued.

Turn over

6(d) continued.

Turn over

6(d) continued.

Turn over

6(d) continued.

Turn over

6(d) continued.

(Total for Question 6 = 10 marks)

7 Aerobic respiration in eukaryotic cells occurs in mitochondria.

(a) Look at the diagram for Question 7(a) in the Diagram Booklet. Complete the diagram of a mitochondrion to show the internal structure. Label each structure that is added.

(3 marks)

(continued on the next page)

7 continued.

(b) The matrix of a mitochondrion contains a range of enzymes.

Describe the role of enzymes in the link reaction.

(4 marks)

Answer space continues on the next 2 pages.

Turn over

7(b) continued.

Turn over

7(b) continued.

(continued on the next page)

7 continued.

**(c) Proton pumps are found
in mitochondria.**

**Explain the role of proton pumps in
aerobic respiration.**

(5 marks)

Answer space continues on the next 4 pages.

Turn over

7(c) continued.

Turn over

7(c) continued.

Turn over

7(c) continued.

Turn over

7(c) continued.

(Total for Question 7 = 12 marks)

8 Arabidopsis thaliana is a plant that uses phytochromes and auxin to respond to changes in the environment.

**(a) (i) State TWO ways that the active form of phytochrome (P_{FR}) can be converted to the inactive form (P_R)
(2 marks)**

Answer space begins and continues on the next 2 pages.

8(a)(i) continued.

1 _____

8(a)(i) continued.

2 _____

(continued on the next page)

8(a) continued.

(ii) Arabidopsis is known as a long-day plant.

Explain why Arabidopsis will flower when each day has 16 hours of light.

(3 marks)

Answer space continues on the next 2 pages.

Turn over

8(a)(ii) continued.

Turn over

8(a)(ii) continued.

(continued on the next page)

8 continued.

(b) Look at the diagram for Question 8(b) in the Diagram Booklet. Auxin is made by *Arabidopsis* using molecule Q and the enzymes TAA and YUC, as shown.

**(i) Which type of molecule is Q?
(1 mark)**

☐ **A amino acid**

☐ **B nucleic acid**

☐ **C nucleotide**

☐ **D protein**

(continued on the next page)

Turn over

8(b) continued.

***(ii) Phytochromes and auxin are involved in the response of *Arabidopsis* plants to the presence of other plants growing nearby.**

***Arabidopsis* plants grow taller if there are many neighbouring plants competing for sunlight.**

Look at the diagram for Question 8(b)(ii) in the Diagram Booklet. It shows some of the stages in this response.

(continued on the next page)

Turn over

8(b)(ii) continued.

Explain how neighbouring plants competing for light result in *Arabidopsis* plants growing taller.

Use the information provided and your own knowledge to answer the question.

(6 marks)

Answer space continues on the next 4 pages.

Turn over

8(b)(ii) continued.

Turn over

8(b)(ii) continued.

Turn over

8(b)(ii) continued.

Turn over

8(b)(ii) continued.

(Total for Question 8 = 12 marks)

- 9 Look at the picture for Question 9 in the Diagram Booklet. It shows a thylacine (Tasmanian tiger), a mammal believed to have become extinct during the twentieth century.**

Some scientists are hoping to produce living thylacines. The scientists are planning to use preserved thylacine DNA, stem cells from closely-related species and gene technology.

(continued on the next page)

9 continued.

(a) (i) Describe how stem cells can be made to differentiate into different specialised cells.

(4 marks)

Answer space continues on the next 2 pages.

Turn over

9(a)(i) continued.

Turn over

9(a)(i) continued.

(continued on the next page)

9(a) continued.

- (ii) Explain why the scientists
plan to use stem cells from
closely-related species.
(2 marks)**

Answer space continues on the next page.

Turn over

9(a)(ii) continued.

(continued on the next page)

9(a) continued.

**(iii) Explain ONE reason for using stem cells from more than one individual of the same species to produce a population of thylacines that can survive for a long time.
(2 marks)**

Answer space continues on the next page.

Turn over

9(a)(iii) continued.

(continued on the next page)

9 continued.

(b) Gene technology uses restriction enzymes and ligases.

**(i) Which type of bond is hydrolysed by a restriction enzyme during gene technology?
(1 mark)**

☐ **A ester**

☐ **B hydrogen**

☐ **C peptide**

☐ **D phosphodiester**

(continued on the next page)

Turn over

9(b) continued.

- (ii) Determine the number of condensation reactions that occur when ligase joins a single gene to a bacterial plasmid.
(3 marks)**

Answer space continues on the next 2 pages.

Turn over

9(b)(ii) continued.

Turn over

9(b)(ii) continued.

(Total for Question 9 = 12 marks)

10 Angina is a painful condition caused by a narrowing of the coronary arteries that supply heart muscle with oxygen.

This narrowing can be caused by atheroma partially blocking the artery lumen.

**(a) (i) Which structure supplies the coronary artery with oxygenated blood?
(1 mark)**

☐ **A aorta**

☐ **B left atrium**

☐ **C pulmonary artery**

☐ **D right ventricle**

10(a) continued.

(ii) Explain why angina is likely to be more painful during exercise than when at rest.

(3 marks)

Answer space continues on the next 2 pages.

Turn over

10(a)(ii) continued.

Turn over

10(a)(ii) continued.

(continued on the next page)

Turn over

10(a) continued.

(iii) Describe the events that occur in a coronary artery that lead to the formation of an atheroma.

(3 marks)

Answer space continues on the next page.

Turn over

10(a)(iii) continued.

(continued on the next page)

10 continued.

(b) Angina can lead to a raised heart rate.

Look at the picture for Question 10(b) in the Diagram Booklet. A substance found in a plant, Roselle (*Hibiscus sabdariffa*), has been shown to reduce heart rate in humans.

In humans, this substance was effective at a dose of 15 mg kg^{-1} of human body mass.

(continued on the next page)

Turn over

10(b) continued.

**(i) Why was the substance given at a dose of 15 mg kg^{-1} of human body mass and not just at 15 mg ?
(1 mark)**

- ☐ **A so each person is given the same mass of substance**
- ☐ **B so the data is more precise**
- ☐ **C to allow a valid comparison between humans**
- ☐ **D to control the dependent variable**

(continued on the next page)

Turn over

10(b) continued.

- (ii) Devise an investigation to find the mean minimum concentration of this substance that will lower the heart rate in *Daphnia*.
(5 marks)**

Answer space continues on the next 3 pages.

Turn over

10(b)(ii) continued.

Turn over

10(b)(ii) continued.

Turn over

10(b)(ii) continued.

(Total for Question 10 = 13 marks)

TOTAL FOR PAPER = 100 MARKS

END OF PAPER