

Biology A (Salters Nuffield)
Advanced
PAPER 2: Energy, Exercise and Coordination

Total Marks

Friday 16 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

Scientific calculator, writing and drawing equipment

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.

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

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.

(continued on the next page)

INFORMATION continued.

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.

You may use a scientific calculator.

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 During growth, cells divide by mitosis. Many organisms also carry out meiosis to enable sexual reproduction.

**(a) (i) In which stage of cell division do spindle fibres attach to the centromeres?
(1 mark)**

- ☐ **A anaphase**
- ☐ **B interphase**
- ☐ **C metaphase**
- ☐ **D telophase**

(continued on the next page)

1(a) continued.

**(ii) In which stage of the cell division does the nuclear membrane start to break down?
(1 mark)**

- ☐ **A interphase**
- ☐ **B metaphase**
- ☐ **C prophase**
- ☐ **D telophase**

**(iii) In which stage of cell division are chromatids first visible when using a light microscope?
(1 mark)**

- ☐ **A interphase**
- ☐ **B metaphase**
- ☐ **C prophase**
- ☐ **D telophase**

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1 continued.

(b) Meiosis is involved in the production of sperm cells.

Crossing over during meiosis can result in genetic variation.

**Explain how crossing over can lead to genetic variation.
(3 marks)**

Answer space continues on the next page.

1(b) continued.

(Total for Question 1 = 6 marks)

2 It has been estimated that up to 90% of the cells present in a human are prokaryotic. This is due to prokaryotes being present on the skin surface and within the human body.

**(a) Which one of the following statements comparing prokaryotic DNA with human DNA is correct?
(1 mark)**

- ☐ **A prokaryotic DNA is linear and human DNA is circular**
- ☐ **B prokaryotic DNA is located in a membrane-bound nucleus**
- ☐ **C the base thymine is replaced by uracil in the prokaryotic DNA**
- ☐ **D the sugar in both eukaryotic and prokaryotic DNA is deoxyribose**

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2 continued.

(b) The lac operon is found in some prokaryotes.

**(i) Describe what is meant by the term OPERON.
(2 marks)**

(continued on the next page)

2(b) continued.

**(ii) Describe the effect of lactose on the
lac operon.
(3 marks)**

(Total for Question 2 = 6 marks)

3 Damage to the anterior cruciate ligament (ACL) is the most common major knee injury in football.

**(a) Which of the following describes the structure and function of a ligament?
(1 mark)**

- ☐ **A elastic and attaches bone to bone**
- ☐ **B elastic and attaches muscle to bone**
- ☐ **C non-elastic and attaches bone to bone**
- ☐ **D non-elastic and attaches muscle to bone**

(continued on the next page)

3 continued.

(b) Look at the graph for Question 3(b) in the Diagram Booklet. It shows the percentage of people in the UK who had ACL surgery from 2013 to 2018.

**Comment on the effect of age on the percentage of people who had ACL surgery from 2013 to 2018.
(3 marks)**

(continued on the next page)

3 continued.

- (c) Keyhole surgery or open surgery can be used to treat ACL damage.**

A study compared wound infections from these two types of surgery.

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

- (i) Complete the table to show the ratio of wound infections to number of open surgeries.**

**Give your answer to one significant figure.
(1 mark)**

(continued on the next page)

3(c) continued.

- (ii) Explain why there is a greater ratio of wound infections in open surgery compared with keyhole surgery.
(2 marks)**

(Total for Question 3 = 7 marks)

- 4 There are different types of genetic screening available.**

Each year, about 30 000 prenatal genetic screening tests are carried out.

- (a) Compare and contrast the use of pre-implantation genetic diagnosis (PGD) and amniocentesis.
(4 marks)**

(continued on the next page)

Turn over

4 continued.

**(b) Describe TWO different social issues related to the use of PGD.
(2 marks)**

(continued on the next page)

4 continued.

- (c) Genetic screening can be used to test for conditions such as cystic fibrosis.**

**Explain why cystic fibrosis affects digestion.
(3 marks)**

(Total for Question 4 = 9 marks)

5 The bacterium **Escherichia coli** (**E. coli**) makes up about 1% of the human gut flora. Some strains of this bacterium aid our digestion but some strains are pathogenic.

(a) The width of the **E. coli** DNA is 250 times smaller than the width of the bacterium.

An image of **E. coli**, at a magnification of 20 000, had a width of 10 mm.

Calculate the width of its DNA.

Give your answer in micrometres (μm) and in standard form.

(3 marks)

_____ μm

(continued on the next page)

Turn over

5 continued.

(b) Meselson and Stahl used *E. coli* to investigate the nature of DNA replication.

They initially grew an *E. coli* population in a medium containing heavy nitrogen (^{15}N) until all the bacteria had DNA containing heavy nitrogen.

They then transferred the bacteria into a medium containing light nitrogen (^{14}N).

The bacteria were sampled after the first replication and after the second replication.

**(i) Look at the table for Question 5(b)(i) in the Diagram Booklet. Complete the table to show the expected DNA after *E.coli* had been grown in ^{14}N , for two possible types of DNA replication.
(3 marks)**

(continued on the next page)

5(b) continued.

- (ii) This study enabled Meselson and Stahl to show that DNA replication was semi-conservative rather than conservative.**

**Explain what is meant by the term semi-conservative DNA replication.
(2 marks)**

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5(b)(ii) continued.

(continued on the next page)

5 continued.

- (c) A pathogenic strain of this bacterium, **E. coli-STE**C, produces a toxin that reduces blood platelet concentration.

Explain how an E.coli-STEC infection increases the time taken for a blood clot to form.
(3 marks)

Answer space continues on the next page.

5(c) continued.

(Total for Question 5 = 11 marks)

6 Cellular respiration is a metabolic process essential for life.

(a) Look at the diagram for Question 6(a) in the Diagram Booklet. It represents part of aerobic respiration in a muscle cell.

**(i) Name two products, other than the three-carbon molecule (3C), that are formed by process J.
(1 mark)**

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6(a) continued.

- (ii) Describe what would happen to the three-carbon molecule (3C) if process K stopped.
(2 marks)**

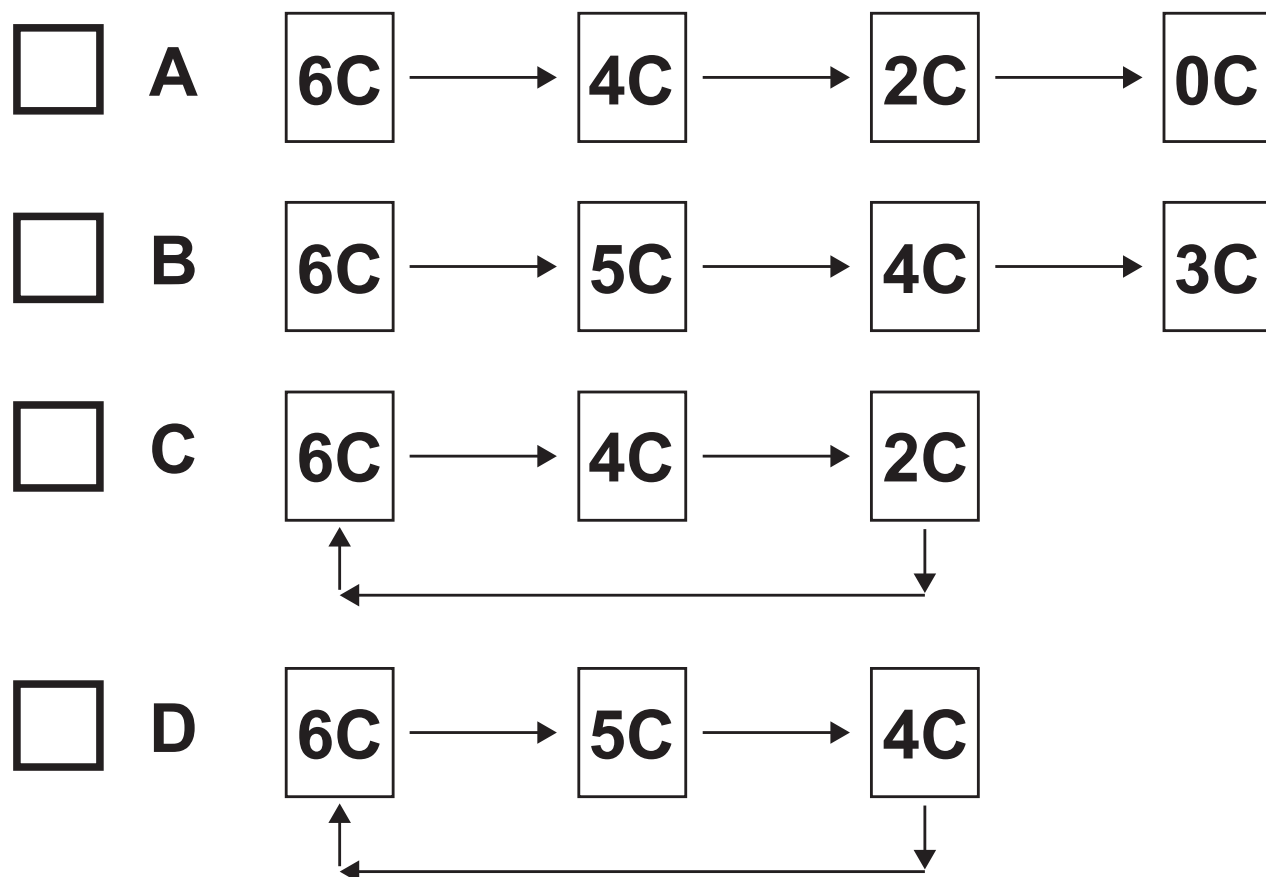
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6(a)(ii) continued.

(continued on the next page)

6(a) continued.

(iii) Which one of the following represents process L?
(1 mark)



(b) Respiration in maggots is similar to respiration in humans.

Look at the diagram for Question 6(b) in the Diagram Booklet. In an investigation, three maggots were placed in a respirometer as shown.

The maggots respired aerobically for 20 minutes in this respirometer.

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6(b) continued.

**Explain why the coloured liquid moved to the left during the 20 minutes of this investigation.
(2 marks)**

(continued on the next page)

6 continued.

- (c) Devise an investigation, using a respirometer, to find the optimum temperature for respiration in maggots.
(5 marks)**

Answer space continues on the next page.

Turn over

6(c) continued.

(Total for Question 6 = 11 marks)

7 Muscles and eyes are examples of organs found in the human body.

(a) Look at the table for Question 7(a) in the Diagram Booklet. Skeletal muscle tissue contains several types of muscle fibre that have different properties. Two of these are shown in the table.

The proportion of type I and type II muscle fibres in the skeletal muscle of long distance runners and sprinters is different.

Explain the advantages for long distance runners of having both type I and type II muscle fibres, but not in equal quantities.

(5 marks)

Answer space continues on the next page.

7(a) continued.

[illegible]

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Turn over

7 continued.

- (b) Some people can have a recessive genetic condition of the eye due to a non-functional gene.**

Genetically modified viruses can be used to treat these people by introducing a functional version of the gene into the cells of the eye.

- (i) A student made three statements about this treatment:**

- ligase would be used to cut open the viral plasmid**
- a restriction enzyme would be used to add the functional gene to the genome of a person with the condition**
- the functional gene would act as the vector.**

**How many of these statements are correct?
(1 mark)**

☐ **A none**

☐ **B 1**

☐ **C 2**

☐ **D 3**

7(b) continued.

- (ii) EcoR1 is an enzyme that can be used in the process of genetic modification.**

This enzyme hydrolyses bonds in DNA producing sticky ends.

Look at the diagram for Question 7(b)(ii) in the Diagram Booklet. It shows a fragment of DNA cut out of a much longer sample of DNA. Not all of the bases in the double-stranded section are shown.

How many phosphodiester bonds were hydrolysed in the production of this fragment of DNA?

(1 mark)

☐ **A 2**

☐ **B 4**

☐ **C 8**

☐ **D 16**

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Turn over

7(b) continued.

- (iii) Explain why a person successfully treated using a genetically modified virus may still have a child with this recessive condition.
(3 marks)**

Answer space continues on the next page.

7(b)(iii) continued.

(continued on the next page)

7 continued.

- (c) The ability to produce personalised medicines is one outcome of the human genome project (HGP).**

Which one of the following allows the development of personalised medicines?

(1 mark)

- ☐ **A differences in the genome between people**
- ☐ **B medicines having the same effects on people**
- ☐ **C similarities in the genome between people**
- ☐ **D the genome does not affect the activity of medicines**

(Total for Question 7 = 11 marks)

8 The nervous system contains different types of cell including neurones and Schwann cells.

(a) Mitochondria in the cytoplasm of neurones synthesise adenosine triphosphate (ATP).

Explain the role of ATP in the transmission of impulses along neurones.

(2 marks)

(continued on the next page)

8 continued.

- (b) Mitochondria move along the length of the axon in the cytoplasm.**

The axon cytoplasm contains actin along its length. There is myosin on the surface of the mitochondria.

- (i) Explain how the myosin head could move mitochondria along the axon.
(3 marks)**

Answer space continues on the next page.

Turn over

8(b)(i) continued.

(continued on the next page)

8(b) continued.

- (ii) In an axon that is 9 cm long, the speed of mitochondrial movement was recorded as $0.5\mu\text{m s}^{-1}$.**

**Calculate the time it would take a mitochondrion to move the length of this axon. Give your answer in hours.
(2 marks)**

_____ hours

(continued on the next page)

8 continued.

***(c) Look at the table for Question 8(c) in the Diagram Booklet. It shows the proportion of two components found in the cell surface membrane of two cells of the nervous system.**

Discuss the relative importance of lipids and proteins in the cell surface membranes of motor neurones and Schwann cells.

(6 marks)

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8(c) continued.

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8(c) continued.

(Total for Question 8 = 13 marks)

- 9 Many organisms contain photosensitive pigments. Humans have the photosensitive pigment rhodopsin in the eye. Plants have a photosensitive pigment called phytochrome.**
- (a) Retinitis pigmentosa (RP) is a genetic condition that can be caused by a dominant allele. It affects the functioning of rhodopsin.**
- (i) Look at the diagram for Question 9(a)(i) in the Diagram Booklet. The family pedigree shows the inheritance of this condition in one family.**

It is possible to determine genotypes of some individuals from a family pedigree diagram.

**How many members of this family can have their genotype for RP determined from this diagram?
(1 mark)**

- ☐ **A 3**
- ☐ **B 7**
- ☐ **C 9**
- ☐ **D 10**

(continued on the next page)

9(a) continued.

- (ii) Rhodopsin is made of protein and retinal. The structure of rhodopsin can be studied by measuring the ratio of light absorbed at 280 nm and at 500 nm.**

Look at the table for Question 9(a)(ii) in the Diagram Booklet. It shows the absorbance ratio of the rhodopsin from two people, one with RP and one without.

Explain why a gene mutation causes the difference in the absorbance ratio for a person with RP.

(3 marks)

Answer space continues on the next page.

9(a)(ii) continued.

(continued on the next page)

9 continued.

(b) Rod cells form synapses with bipolar neurones.

**Describe how movement of sodium ions in a rod cell affects depolarisation in a bipolar neurone.
(4 marks)**

Answer space continues on the next page.

9(b) continued.

(continued on the next page)

9 continued.

(c) Some plants only flower when the days are long and the nights are short. They are known as long-day plants.

**(i) Describe the role of the photosensitive pigment phytochrome in the flowering of long-day plants.
(2 marks)**

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Turn over

9(c) continued.

- (ii) Devise an investigation to find out if a species of plant is a long-day plant or a short-day plant.
(3 marks)**

Answer space continues on the next page.

Turn over

9(c)(ii) continued.

(Total for Question 9 = 13 marks)

10 Doctors believe that about 28% of the adult population in the UK are obese. This can lead to a number of health-related conditions including coronary heart disease.

(a) Food packaging often contains nutritional information.

Look at the table for Question 10(a) in the Diagram Booklet. It shows some nutritional information about chocolate biscuits.

**(i) Calculate the percentage of fat present in the biscuits that contains carbon to carbon double bonds.
(1 mark)**

_____ %

(continued on the next page)

Turn over

10(a) continued.

- (ii) Calculate the number of biscuits needed to exceed the recommended daily intake (RI) for sugar.
(2 marks)**

Answer _____

(continued on the next page)

10(a) continued.

- (iii) The energy content for four biscuits and the percentage of total recommended daily intake can be used to calculate a recommended daily intake.**

Calculate the daily recommended intake of energy from the data in the table. Give your answer in joules and in standard form.

(2 marks)

_____ J

(continued on the next page)

10 continued.

- (b) The Million Women Study was set up in 1996 and considered aspects of the health of UK women.**

Using data from this study, scientists investigated the effects of various factors on coronary heart disease (CHD).

The scientists selected one million women who had not had CHD before the study started.

The women provided information on the following:

- BMI**
- smoking habits**
- alcohol intake**
- level of physical activity**
- age at the start of the investigation.**

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10(b) continued.

The women were monitored for five years and the development of CHD was recorded. The data were used to estimate the likelihood of any woman developing CHD.

Look at the table for Question 10(b) in the Diagram Booklet. It shows the effect of age and BMI on the development of CHD in women.

- (i) Describe the effect of age and BMI on the development of CHD in women.
(2 marks)**

Answer space continues on the next page.

10(b)(i) continued.

(continued on the next page)

10(b) continued.

- *(ii) Look at the graphs for Question 10(b)(ii) in the Diagram Booklet. They show the effect of three different lifestyle factors on the development of CHD in women.**

Evaluate the information provided in the table and graphs to determine which factors are most likely to increase the risk of CHD in women.

(6 marks)

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Turn over

10(b)(ii) continued.

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10(b)(ii) continued.

(Total for Question 10 = 13 marks)

TOTAL FOR PAPER = 100 MARKS
END OF PAPER