UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

*6966527272036*

**BIOLOGY** **9700/41**

Paper 4 A2 Structured Questions **May/June 2011**

**2 hours**

Candidates answer on the Question Paper.

Additional Materials: Answer Paper available on request.

**READ THESE INSTRUCTIONS FIRST**

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black ink.
You may use a pencil for any diagrams, graphs, or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions in Section A and **one** question from Section B.
Circle the number of the Section B question you have answered in the grid below.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| **Section A** | |
| **1** | |
| **2** | |
| **3** | |
| **4** | |
| **5** | |
| **6** | |
| **7** | |
| **8** | |
| **Section B** | |
| **9 or 10** | |
| **Total** | |

This document consists of **23** printed pages, **3** lined pages and **2** blank pages.


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## Section A

For Examiner's Use

Answer **all** the questions.

**1** The polar bear, *Ursus maritimus*, lives in the Arctic regions of the USA, Canada, Norway and Russia. Polar bears move across the Arctic ice sheet to hunt prey such as seals.

Fig. 1.1 shows a polar bear.



**Fig. 1.1**

The area over which the Arctic ice sheet extends varies throughout the year.

Fig. 1.2 shows the variation in the extent of the Arctic ice sheet for the months of July to November for the years 1979 and 2009.

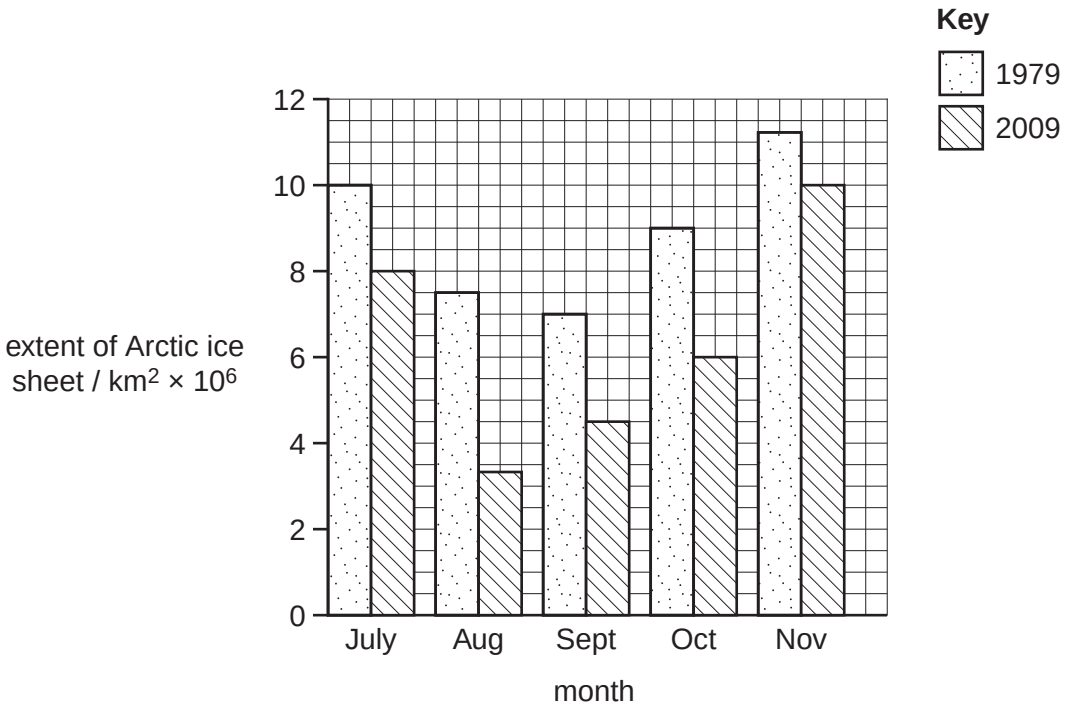



**Fig. 1.2**

**(a)** Calculate the percentage reduction in the area over which the ice sheet extends between 1979 and 2009 **for the month of September**.

*For Examiner's Use*

Give your answer to the **nearest whole number**.

Show your working.

answer ..... % [2]

**(b)** In 2008 the government of the USA classified *U. maritimus* as an endangered species because it is under threat of extinction.

Suggest what has caused *U. maritimus* to have become endangered.

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..... [3]

**(c)** *U. maritimus* is a eukaryote. Beneficial bacteria, which are prokaryotic cells, live in the gut of *U. maritimus*.

State three differences between the cells of *U. maritimus* and its gut bacteria.

1. .....

2. .....

3. ..... [3]

[Total: 8]

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**2** When gold is associated with mineral ores such as iron sulfide, the sulfides must be oxidised to release the gold particles. Since the mid 1990s, gold has been extracted from such ores by bioleaching.

Suitable bacteria oxidise iron sulfide to soluble iron sulfate, releasing $Fe^{3+}$ and $SO_4^{2-}$ ions. The reaction releases heat energy and temperatures within a heap of ore that is being bioleached (a bioheap) can reach 70 °C or higher.

Examples of bacteria used in this bioleaching are shown in Table 2.1.

**Table 2.1**

| example of bacterium | temperature range for growth / °C | activity | natural habitat |
|---|---|---|---|
| *Acidithiobacillus ferrooxidans* | 35 – 45 | oxidise iron and sulfur compounds | acid springs |
| *Sulfobacillus thermosulfidooxidans* | 45 – 65 | | |
| *Sulfolobus metallicus* | 65 – 95 | | |

**(a)** With reference to Table 2.1, suggest

**(i)** a natural habitat for organisms such as *S. thermosulfidooxidans* and *S. metallicus*

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..... [1]

**(ii)** why all three species of bacteria, rather than just one species, are mixed with ore in a bioheap.

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**(b)** The rate of oxidation of the iron in iron sulfide ore was compared in the presence and absence of *A. ferrooxidans* at pH 2.0.

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The results are shown in Fig. 2.1.

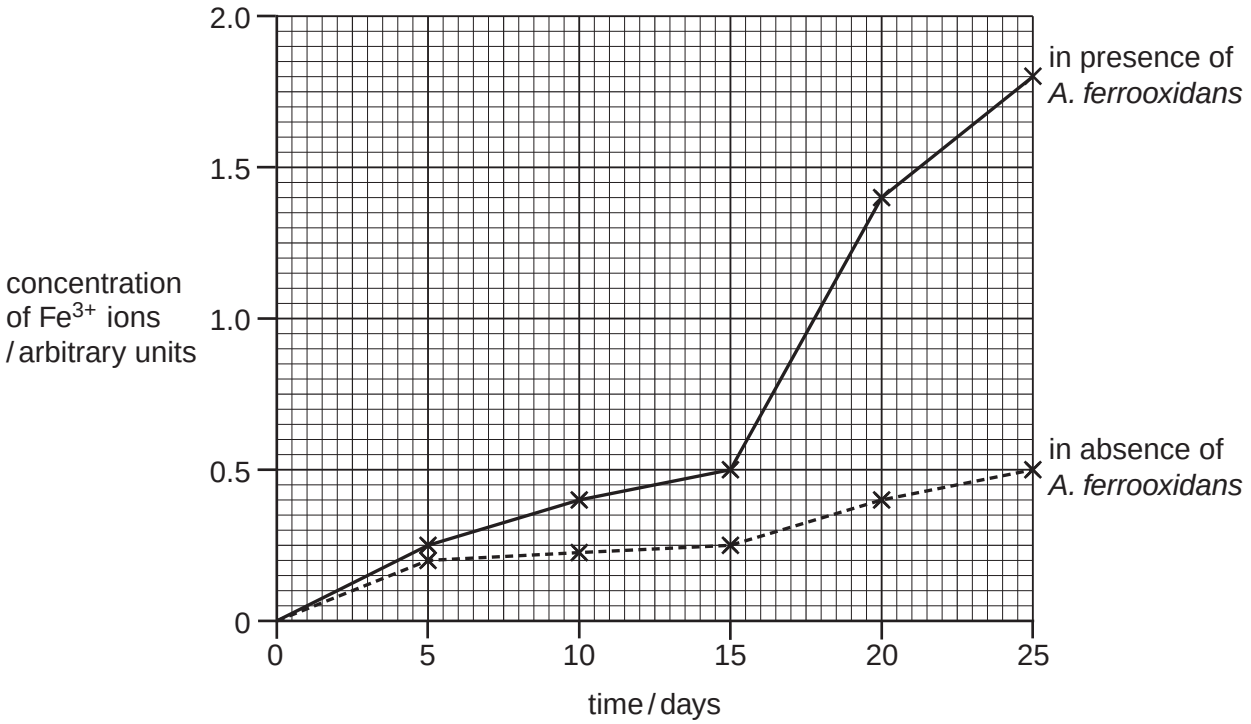



**Fig. 2.1**

**(i)** With reference to Fig. 2.1, describe the effect of *A. ferrooxidans* on the oxidation of the ore.

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**(ii)** Explain why bioleaching is now used on a large scale throughout the world.

For Examiner's Use

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..... [3]

**(c)** Gold-bearing sulfide ores often contain arsenic, which is potentially toxic to the bacteria used in bioleaching. However, arsenic-resistant strains of *A. ferrooxidans* have been found in some mines.

The activity of two strains of the bacterium, in the presence and absence of arsenic ions, is shown in Table 2.2.

**Table 2.2**

| | oxidation rate of iron in the ore / mg $dm^{-3}$ $h^{-1}$ | |
|---|---|---|
| strain of *A. ferrooxidans* | arsenic ions absent | arsenic ions present |
| 1 | 16 | 15 |
| 2 | 48 | 47 |

Describe the results shown in Table 2.2 **and** explain the role of natural selection in the evolution of arsenic-resistant bacteria.

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..... [4]

[Total: 14]

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**3** **(a)** Outline the technique of in-vitro fertilisation (IVF).

*For Examiner's Use*

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..... [4]

**(b)** For IVF to be successful, a sperm must have an undamaged plasma (cell surface) membrane, an intact acrosome (a sperm's large lysosome) and be capable of producing ATP for movement.

One method of assessing the quality of a sample of sperm is to mix it with three chemical probes that bind to specific components of the sperm. The probes fluoresce when the sperm are examined with a microscope using ultra-violet (UV) light, allowing their uptake to be determined.

The three probes fluoresce with different colours.

- Probe 1 combines with DNA and fluoresces red, but can enter a sperm only when its plasma membrane is damaged.
- Probe 2 combines with sugars in the acrosome and fluoresces yellow, but can enter the acrosome only when the acrosome membrane is damaged.
- Probe 3 combines with mitochondria and fluoresces bright green in sperm with active mitochondria and less brightly when the mitochondria are less active.

A sample of sperm was mixed with all three probes and examined using UV light.

Complete Table 3.1 by placing ticks (✓) in the appropriate boxes to describe the appearance of sperm that would be suitable for use in IVF.

**Table 3.1**

| | **appearance of sperm suitable for use in IVF** | | | |
|---|---|---|---|---|
| **target of probe** | red | yellow | green | colourless |
| DNA | | | | |
| acrosome | | | | |
| mitochondria | | | | |

[3]

**(c)** The technique of intracytoplasmic sperm injection (ICSI) involves injecting a single, chosen sperm into an oocyte. This technique is often used when standard IVF has failed.

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Researchers in Hawaii think that the acrosome of the sperm should be removed before the sperm is injected into the oocyte.

Suggest **one** reason why it might improve the success rate of ICSI to remove the acrosome before injecting a sperm into an oocyte.

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..... [1]

[Total: 8]

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**4** Almost 40% of adults with cystic fibrosis (CF) develop a form of diabetes known as cystic fibrosis-related diabetes (CFRD). This is thought to happen because the build-up of thick secretions in the pancreas destroys β cells.

**(a)** Explain how the destruction of β cells causes diabetes.

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**(b)** The bacterium *Pseudomonas aeruginosa* can cause chronic (long-lasting) lung infections. A person with CFRD is likely to have poorer lung function and a greater likelihood of having a chronic lung infection than a person who has CF but does **not** have CFRD.

An investigation was carried out to find out if the severity of damage to lung function in a person with CFRD is affected by

- their gender
- whether or not they have a chronic *P. aeruginosa* infection.

The investigators measured lung function by recording the maximum volume of air that can be expelled from the lungs in the first one second of a forced expiration. This is known as $FEV_1$. The lower the median $FEV_1$, the poorer the lung function.

Table 4.1 summarises the results of this investigation. All the 812 people in the study had cystic fibrosis.

For Examiner's Use

**Table 4.1**

| | without chronic *P. aeruginosa* infection | | | | with chronic *P. aeruginosa* infection | | | |
|---|---|---|---|---|---|---|---|---|
| | male | | female | | male | | female | |
| | with CFRD | without CFRD | with CFRD | without CFRD | with CFRD | without CFRD | with CRFD | without CFRD |
| **number of people** | 44 | 110 | 52 | 93 | 106 | 166 | 121 | 120 |
| **$FEV_1$** | 71.1 | 71.4 | 53.6 | 73.6 | 49.0 | 59.0 | 42.0 | 61.0 |

With reference to Table 4.1

**(i)** discuss whether or not there appears to be a positive correlation between having a chronic *P. aeruginosa* infection and having CFRD

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..... [2]

**(ii)** calculate the percentage difference between the $FEV_1$ of males and females without CFRD and without *P. aeruginosa* infection.

Show your working

answer ..... % [2]

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**(iii)** outline the conclusions that can be drawn concerning the relationship between gender and the severity of lung damage in a person with CFRD and with *P. aeruginosa* infection.

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**(c)** In a person with CF, damage to lung function and the increased likelihood of chronic infections are the result of the secretion of thick mucus.

Explain why thick mucus is secreted in the lungs of a person with CF.

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..... [4]

[Total: 15]

For Examiner's Use

**5** Both sorghum and maize are important food crops in dry regions of the world, but sorghum is able to produce higher yields than maize in very dry conditions.

This is partly because sorghum plants have a smaller leaf area than maize, and also because sorghum leaves have rows of motor cells along the midrib of the upper surface of the leaf, allowing the leaves to roll up.

**(a)** Explain how **these two** features adapt sorghum plants for growth in very dry conditions.

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..... [3]

**(b)** Sorghum is a staple food in Africa, but the major storage protein that it contains, kaffirin, is not easily digested by protease enzymes. The main cause of this is cross-linking between kaffirin molecules.

The digestibility of the protein in five varieties of sorghum was measured when raw, and after cooking. Digestibility was measured as the percentage of the protein that would be broken down to amino acids during digestion.

The results are shown in Fig. 5.1.

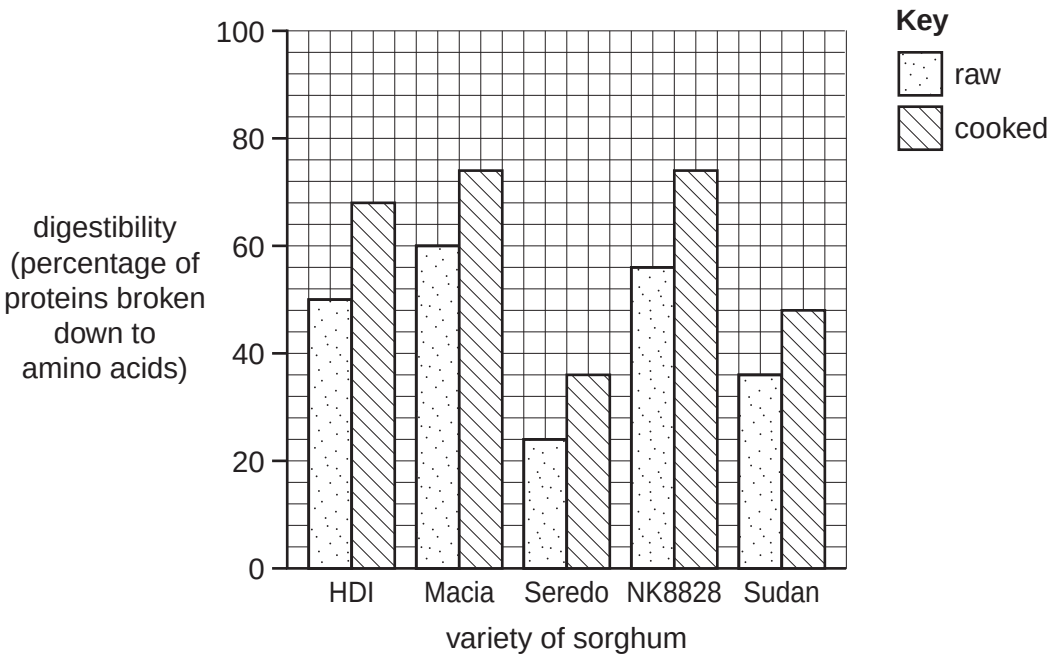



**Fig. 5.1**

With reference to Fig. 5.1

*For Examiner's Use*

**(i)** compare the digestibility of raw and cooked sorghum protein

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..... [2]

**(ii)** using your knowledge of protein structure and enzyme activity, suggest reasons for the differences you have described in **(i)**.

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..... [3]

[Total: 8]

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**6** Canavan disease is a non sex-linked inherited condition that causes progressive damage to neurones of the brain. Symptoms of the condition include a loss of motor skills and mental retardation. The symptoms appear in early infancy and many children with this condition die by the age of four years.

*For Examiner's Use*

People with Canavan disease lack an enzyme called aspartoacylase which breaks down N-acetyl aspartate. The build up of N-acetyl aspartate can interfere with the formation of the myelin sheath, particularly in neurones of the brain.

**(a)** Enzymes such as aspartoacylase display specificity.

Outline what is meant by *specificity* of an enzyme.

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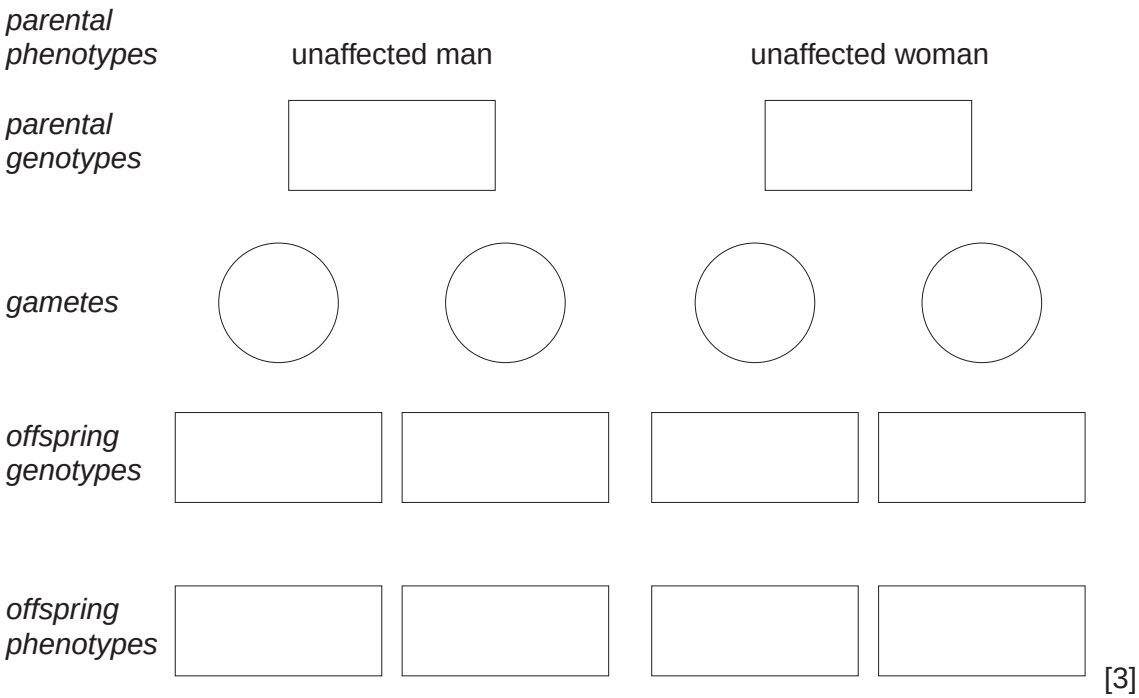
..... [2]

**(b)** Complete the genetic diagram below to show how an unaffected man and an unaffected woman could produce a child with Canavan disease.

*key to symbols*

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[3]

**(c)** Explain the importance of the myelin sheath in the functioning of a neurone.

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..... [3]

[Total: 8]

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**Question 7 starts on page 17**

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**7** **(a)** Complete the following passage about ATP by writing in the missing words.

*For Examiner's Use*

All living organisms use energy. The most common immediate source of energy is adenosine triphosphate (ATP) which is used in every cell for the movement of ions against a concentration gradient, known as ..... .

ATP is known as the universal currency of energy.

ATP is a phosphorylated nucleotide which is known as a 'high energy' molecule. It is made of an organic base, adenine, a 5 carbon sugar named ..... and three phosphate groups. ATP is very soluble in ..... and easily transported within the cell. The removal of the outer phosphate group by the process of ..... releases energy. The energy released as a result of this reaction can be channelled directly into other reactions in the cell.

A certain proportion of this energy is lost as ..... .

ATP is continually broken down and is reformed at a fast rate by the process of respiration. [5]

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**[Turn over**

**(b)** During a sporting event an athlete may have to carry out anaerobic respiration in addition to aerobic respiration to produce sufficient ATP.

*For Examiner's Use*

Fig. 7.1 outlines both processes in a muscle cell and shows how a liver cell is linked to these processes.

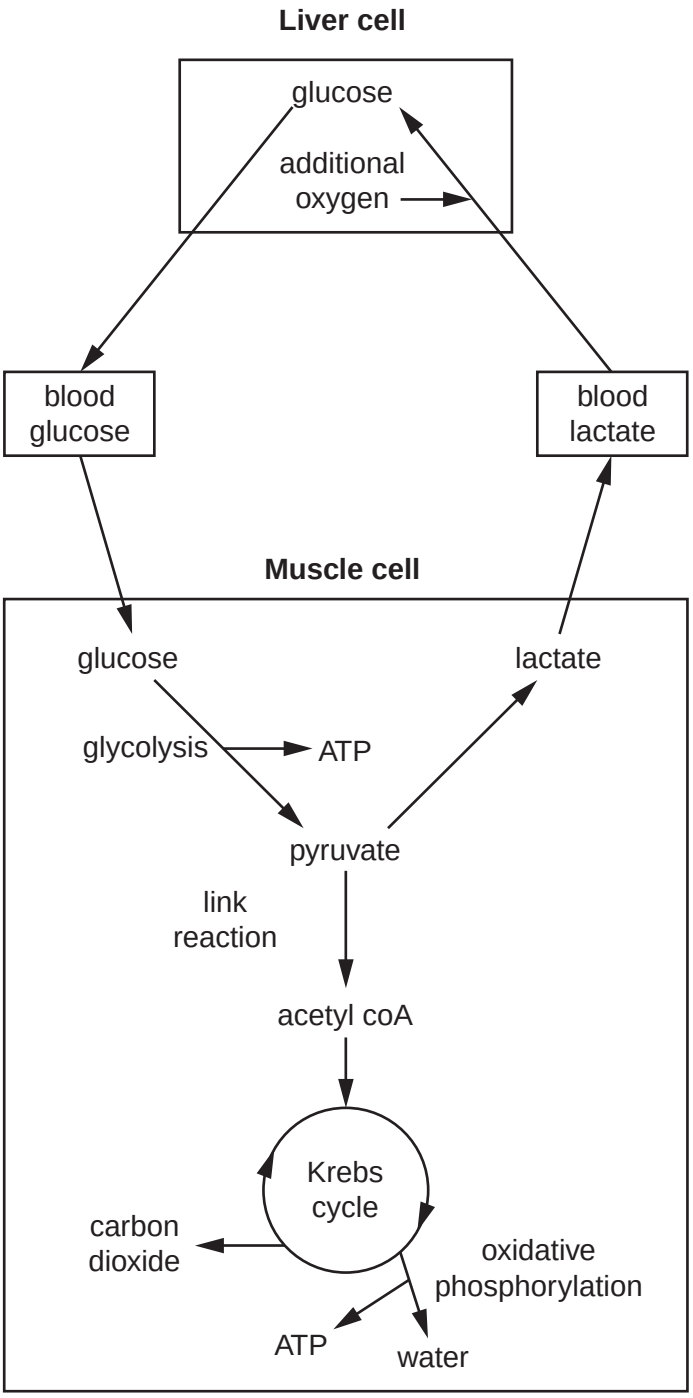



**Fig. 7.1**

You may refer to Fig. 7.1 in answering questions **(i)** to **(v)** below.

*For Examiner's Use*

**(i)** Glucose produced in the liver cell can be released into the blood to maintain blood glucose concentration.

State one use of glucose **within** the liver cell.

.....

..... [1]

**(ii)** Suggest why anaerobic respiration is said to be less efficient than aerobic respiration.

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..... [2]

**(iii)** Complete the table to indicate, within the muscle cell, the precise locations of glycolysis, the link reaction, the Krebs cycle and oxidative phosphorylation.

| process | precise location |
|---|---|
| glycolysis | |
| link reaction | |
| Krebs cycle | |
| oxidative phosphorylation | |

[4]

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**(iv)** Glucose is phosphorylated at the start of glycolysis in the muscle cell.

Suggest why this phosphorylated glucose does **not** diffuse out of the cell into the surrounding tissue fluid.

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..... [2]

**(v)** Additional oxygen is required in the metabolic pathways involved in the conversion of lactate to glucose.

State the term given to this additional oxygen.

..... [1]

[Total: 15]

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**Question 8 starts on page 22**

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**8** The hedgehog, *Erinaceus europaeus*, is a small carnivorous mammal native to Northern Europe.

Fig. 8.1 shows a hedgehog.



**Fig. 8.1**

Hedgehogs were introduced onto a small group of islands off the west coast of Scotland in 1974. The hedgehog population has increased so that there are now over 5000 breeding pairs. These hedgehogs have no natural predators on these islands and their diet consists mainly of bird's eggs.

Fig. 8.2 shows the hedgehog population density in the year 2000**.**

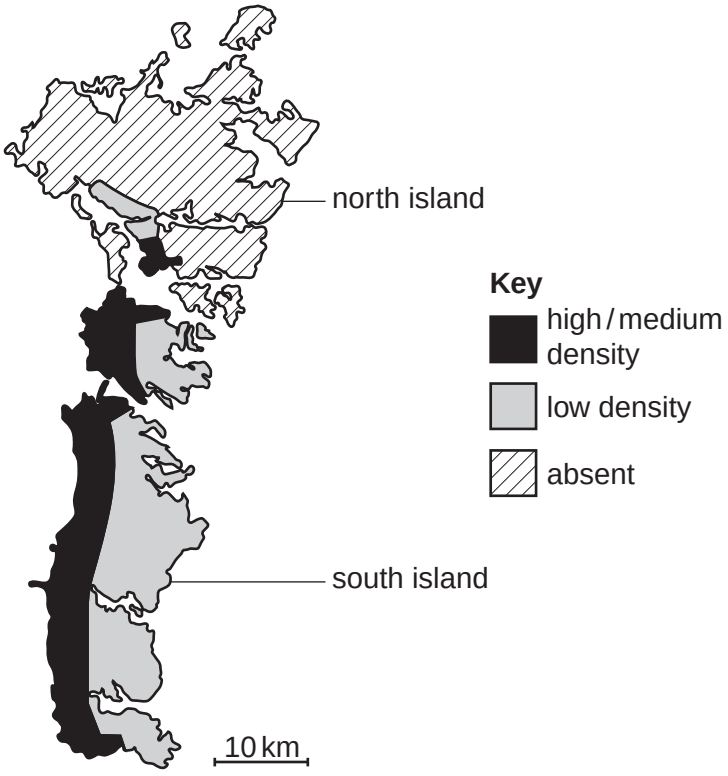



**Fig. 8.2**

Table 8.1 shows the changes in the populations of the species of birds from 1983 to 2000.

*For Examiner's Use*

**Table 8.1**

| | **breeding pairs in 1983** | **breeding pairs in 2000** | **% change in population** |
|---|---|---|---|
| **north island** | | | |
| oystercatcher | 928 | 1122 | +21 |
| lapwing | 1104 | 1364 | +24 |
| redshank | 486 | 733 | +51 |
| **south island** | | | |
| oystercatcher | 907 | 1403 | +55 |
| lapwing | 1869 | 1287 | –31 |
| redshank | 1288 | 760 | –41 |

**(a)** Using Fig. 8.2 and Table 8.1, describe the relationship between the hedgehog population density and the changes in the populations of **lapwings** and **redshanks**.

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..... [3]

**(b)** Suggest an explanation for the increase in the oystercatcher population on the south island, despite the increase in the hedgehog population.

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..... [2]

**(c)** Explain why the population of hedgehogs on one of these islands may eventually become a different species from that on mainland Scotland.

*For Examiner's Use*

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..... [4]

[Total: 9]

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## Section B

Answer **one** question.

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**9** **(a)** Outline the ways in which the endocrine **and** nervous systems carry out their roles in control and coordination in animals. [8]

**(b)** Describe the part played by auxins in apical dominance in a plant shoot. [7]

[Total: 15]

**10** **(a)** Describe how non-cyclic photophosphorylation produces ATP and reduced NADP. [9]

**(b)** Outline the steps of the Calvin cycle. [6]

[Total: 15]

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