Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

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9092241844

BIOLOGY **9700/41**

Paper 4 A Level Structured Questions **October/November 2017**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

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

Section A
Answer **all** questions.

Section B
Answer **one** question.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

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.

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Section A

Answer **all** questions.

1 The St. Lawrence river in Canada has been identified as an area with very high biodiversity.

(a) Explain how the term biodiversity can be considered at different levels.

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(b) The St. Lawrence river is rich in species of aquatic mammals, especially whales.

In spring, thousands of whales swim from the Atlantic ocean up the St. Lawrence river. Thirteen different species of whale have been recorded. One of these is the blue whale, *Balaenoptera musculus*.

Fig. 1.1 is a diagram of a blue whale.

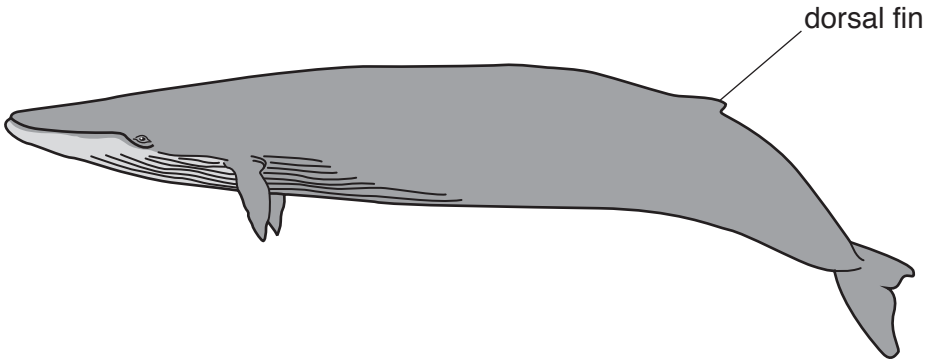


Fig. 1.1

Photographs of blue whales are analysed by computer so that individual whales can be identified and population abundance can be estimated. Each blue whale is different in colour and in the shape of dorsal fin. Different whales also have different patterns of scarring.

(i) State the **two** sources of phenotypic variation in the blue whale population.

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.....[1]

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(ii) Suggest **one** reason why it is difficult to measure the **actual** population size of the blue whale.

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.....[1]

(c) The St. Lawrence river runs through very busy industrial areas. It has many ports for cargo ships, a good fishing trade and many whale-watching boat trips for tourists.

Decades of whale hunting has caused a large decrease in whale population sizes. Since whale hunting was banned, whale populations have not recovered.

Seven of the thirteen whale species in the St. Lawrence river have been rated as endangered species.

Suggest **two** reasons why the populations of whales have not recovered since the ban on whale hunting.

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(d) Fat samples from under the skin of individual whales of several different species were taken. These were analysed and the concentrations of the toxins DDT and PCBs were measured.

Suggest why whales were found to have accumulated very high concentrations of DDT and PCBs in their fatty tissues.

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.....[2]

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[Turn over

(e) Algal blooms sometimes occur in the area of the Atlantic ocean near the St. Lawrence river. These result from rapid population growth of unicellular algae such as *Alexandrium tamarense*.

(i) *A. tamarense* produces saxitoxin, a neurotoxin that causes muscle paralysis by acting on voltage-gated sodium ion channels in neurones. Saxitoxin can kill whales.

Suggest how saxitoxin results in the death of a whale.

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.....[2]

(ii) Algae, such as *A. tamarense*, used to belong to the kingdom Plantae but are now classified in the kingdom Protoctista.

State **one** reason why *A. tamarense* is classified in the kingdom Protoctista and **not** in the kingdom Plantae.

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.....[1]

[Total: 11]

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2 The light dependent stage of photosynthesis in a suspension of isolated chloroplasts can be investigated using the Hill reaction.

Dichlorophenolindophenol (DCPIP) can be used to follow the process. DCPIP is a blue dye which turns colourless when it is reduced by accepting hydrogen and electrons.

oxidised DCPIP → reduced DCPIP
blue → colourless

(a) (i) The natural hydrogen acceptor in chloroplasts that is replaced by DCPIP in the Hill reaction is NADP. Reduced NADP is then used in the light independent stage of photosynthesis.

State the role of reduced NADP in the light independent stage.

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(ii) Predict **and** explain the effect on the concentration of RuBP in the chloroplasts if DCPIP becomes reduced instead of NADP.

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.....[1]

DCPIP can be used to investigate the effect of light wavelength on the rate of the light dependent stage of photosynthesis. One method is described here:

- Dip a small glass capillary tube into a beaker containing a suspension of isolated chloroplasts. Some of the chloroplast suspension will be drawn into tube **A**, forming a colour standard.
- Mix the rest of the chloroplast suspension with blue DCPIP solution. Dip a second capillary tube into this to draw up a sample, to form tube **B**.
- Store the chloroplast-DCPIP mixture for future use by wrapping the beaker in foil and covering it with a removable foil lid, as shown in Fig. 2.1.

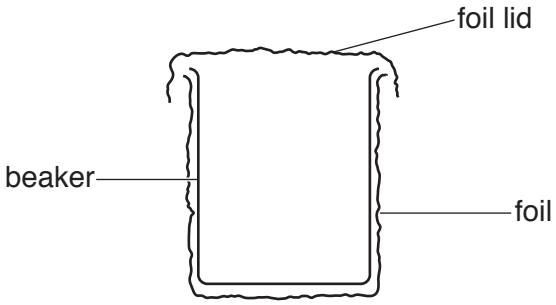


Fig. 2.1

- Place tube **A** and tube **B** on a white tile under a bench lamp placed 15 cm away and immediately cover them with a purple filter, as shown in Fig. 2.2.

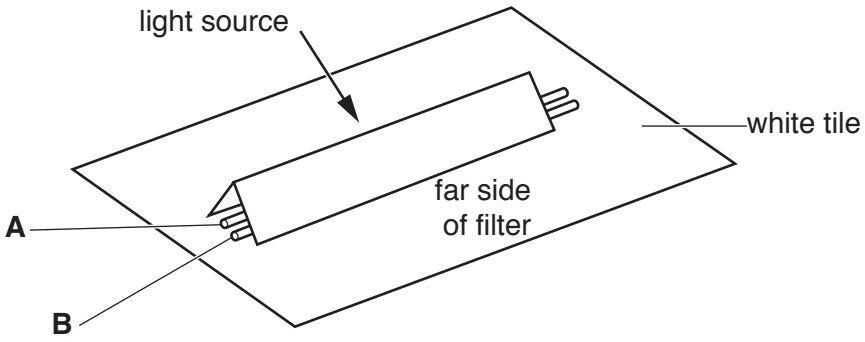


Fig. 2.2

- Measure the time for tube **B** to change colour to match that of tube **A**. This is the time taken for DCPIP to decolourise.
- Repeat four more times using the same tube **A** and a fresh tube **B**, placing the tubes under a different coloured filter each time.

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(b) Explain the reasons for:

the colour standard tube **A**

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covering the beaker containing the chloroplast-DCPIP mixture with foil.

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(c) Table 2.1 shows the results of the experiment.

Table 2.1

colour of filter	wavelength of light/nm	time taken to decolourise DCPIP/s	rate of light dependent stage of photosynthesis/s^{-1}
purple	425	37	27.0
blue	450	84	11.9
green	525	480	2.1
orange	625	45	.....
red	675	50	20.0

(i) Complete Table 2.1 by calculating the rate of the light dependent stage of photosynthesis for the orange wavelength, using the formula:

$$\text{rate} = \frac{1000}{t} \quad \text{where } t = \text{time in seconds.}$$ [1]

(ii) With reference to Table 2.1, describe **and** explain the effect of light wavelength on the rate of the light dependent stage of photosynthesis.

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[Total: 13]

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3 Fig. 3.1 shows a red squirrel, *Sciurus vulgaris*. This species is native to the British Isles, meaning it has lived there for at least 10 000 years. In the 1800s a related but slightly larger species, the grey squirrel, *Sciurus carolinensis*, was introduced from North America.



Fig. 3.1

A history of the interaction between red squirrels and grey squirrels includes these facts:

- Grey squirrels, which occupy a similar niche to red squirrels, expanded their range rapidly after introduction.
- Grey squirrels carry a virus that does not harm them, but which kills red squirrels.
- Red squirrels became extinct in many parts of the British Isles.
- Recently some areas have seen a reversal of this trend. There has been a decrease in numbers of grey squirrels. Red squirrels have re-colonised their former areas of habitat.
- This has happened in areas where protection of a native predator species, the pine marten, *Martes martes*, has resulted in an increase in the number of these predators.
- Analysis of pine marten faeces shows that they catch and eat many more grey squirrels than red squirrels.

(a) Use the information given to identify the causes of the extinction of red squirrels in many parts of the British Isles.

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(b) Describe how the level of molecular similarity between the two species, *S. vulgaris* and *S. carolinensis*, can be investigated.

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(c) Explain how the differing effect of pine marten predation on red and grey squirrel populations is due to natural selection and the separate evolution of each squirrel species.

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[Total: 8]

4 There are many different strains of the soil bacterium *Bacillus thuringiensis*. Each produces slightly different types of Cry-proteins, which are toxic to insects. Some types of cotton, known as Bt cotton, have been genetically modified to produce one of these proteins, Cry1Ac. This protein acts specifically to kill the larvae of butterflies and moths, including the cotton bollworm, *Helicoverpa zea*, a serious pest of cotton crops.

The genetically modified cotton contains a 'genetic package' that includes:

- the gene coding for Cry1Ac, the Bt protein
- a promoter
- a herbicide resistance gene that is used as a marker.

(a) (i) Suggest the advantages of using, in Bt cotton, the gene coding for Cry1Ac, rather than one of the genes coding for other types of the Cry-protein.

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(ii) Explain why a promoter is included in the genetic package.

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(iii) Suggest how the herbicide resistance gene can be used as a genetic marker.

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(b) Table 4.1 shows information about the cultivation of Bt cotton and non-GM cotton by farmers in India in 2002–2003.

Table 4.1

	Bt cotton	**non-GM cotton**
mean yield of cotton / kg ha^{-1}	264	196
seed cost / rupees ha^{-1}	629	196
insecticide cost / rupees ha^{-1}	503	851
net income / rupees ha^{-1}	2118	1253

(i) With reference to Table 4.1, compare the costs involved in growing Bt cotton with the costs involved in growing non-GM cotton.

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.....[2]

(ii) Table 4.1 shows that farmers who grow Bt cotton have a higher net income than those who grow non-GM cotton.

Use the information in the table to suggest **one** reason why some farmers in India choose to grow non-GM cotton, rather than Bt cotton.

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.....[1]

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(c) In one region of India, Andhra Pradesh, a severe drought in 2002–2003 meant that Bt cotton grew less well than other varieties of cotton that were better adapted for the conditions.

Suggest how a variety of Bt cotton that is better adapted to dry conditions could be produced from the existing varieties of Bt cotton, **without** using gene technology.

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[Total: 13]

5 **(a)** Explain the importance of the myelin sheath in the transmission of action potentials.

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(b) Acetylcholine is a neurotransmitter.

Describe the events that occur at a synapse that lead to the release of acetylcholine.

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[Total: 9]

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6 Chemiosmosis is the term used to describe the synthesis of ATP using a proton gradient across a membrane in a mitochondrion or chloroplast. It was first demonstrated by Peter Mitchell in 1961.

(a)
- In some of his experiments, Peter Mitchell used mitochondria that had been isolated from cells.
- The mitochondria were kept in liquid, in glass dishes, to which ADP, Pi and other substances were added.
- The temperature, pH and water potential were kept constant.
- After a period of time he checked for the presence of ATP.

The contents of some of the dishes are shown in the table below.

Complete the table using a tick (✓) if ATP was produced and a cross (✗) if no ATP was produced.

dish contents	ATP produced
mitochondria + ADP + Pi + acetyl CoA + oxygen	
mitochondria + ADP + Pi + acetyl CoA	
mitochondria + ADP + Pi + low concentration of protons (H^+)	
mitochondria + ADP + Pi + high concentration of protons (H^+)	

[2]

(b) Explain the consequences to a mitochondrion if the water potential of the liquid in the dishes is higher than the water potential of the mitochondrial matrix.

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(c) State the specific role of oxygen in the mitochondrion.

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(d) Name the enzyme used to produce ATP in chemiosmosis.

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[Turn over

(e) Describe the role of the inner mitochondrial membrane (crista) in chemiosmosis.

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[Total: 10]

7 **(a)** Galactosaemia is a rare genetic disease in which the build-up of the monosaccharide galactose can result in an enlarged liver, kidney failure and brain damage. Galactose is produced in the body from the digestion of the sugar lactose, found in milk.

Galactosaemia is caused by a recessive mutation of the *GALT* gene. The normal dominant allele codes for an enzyme which converts galactose to glucose.

(i) Suggest how a person with galactosaemia can minimise damage to the liver, kidney and brain.

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(ii) Explain how a mutation in the *GALT* gene could result in a change in the enzyme responsible for the metabolism of galactose.

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(b) If the phenotypes of parents are known, the probabilities of having a child with galactosaemia, an unaffected child (healthy, not a carrier) or a child who is a carrier can be calculated.

Complete Table 7.1 to show the results of these calculations.

Table 7.1

parent 1	parent 2	percentage probability of having a child with galactosaemia	percentage probability of having an unaffected child	percentage probability of having a child who is a carrier
unaffected	carrier	0	50	50
carrier	carrier	.....	.....	.....
unaffected	has galactosaemia	.....	.....	.....
carrier	has galactosaemia	50	0	50

[2]

(c) Testing for galactosaemia is usually carried out on newborn babies, although it is possible to carry out the test on a foetus.

Explain how the presence of galactosaemia in a foetus may be determined.

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.....[2]

[Total: 9]

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[Turn over

8 **(a)** Homeostasis in mammals involves negative feedback mechanisms.

Outline how a negative feedback mechanism works.

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(b) Fig. 8.1 is a diagram summarising the role of the nervous and endocrine systems in the control of blood glucose concentration.

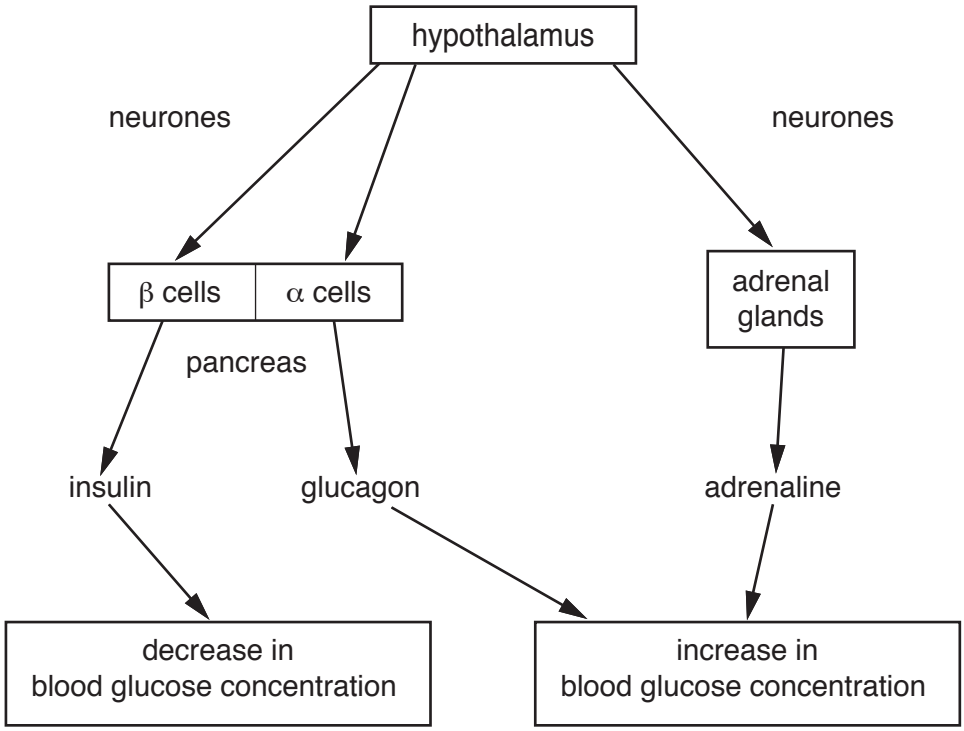


Fig. 8.1

With reference to Fig. 8.1, describe the role of the **nervous system** in the control of blood glucose concentration.

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(c) If the core temperature of the human body falls, the hypothalamus sends impulses to activate several physiological responses, some of which are listed below.

For each one, state how it would help to bring the core temperature back to normal.

vasoconstriction .....

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shivering .....

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increasing secretion of adrenaline .....

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.....[4]

[Total: 12]

Section B

Answer **one** question.

9 **(a)** Explain how rice is adapted to grow with its roots submerged in water. [6]

(b) Explain how the leaves of maize or sorghum are able to maximise carbon dioxide fixation at high temperatures. [9]

[Total: 15]

10 **(a)** Describe the types of gene mutation that can occur **and** explain how some mutations can lead to a shortened polypeptide. [6]

(b) Outline the effects of the mutant sickle cell allele on the phenotype of a person with sickle cell anaemia. [9]

[Total: 15]

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5530411636

BIOLOGY **9700/42**

Paper 4 A Level Structured Questions **October/November 2017**

2 hours

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Section A

Answer **all** questions.

1 Fig. 1.1 shows a snow leopard, *Panthera uncia*. The habitat of the snow leopard is the high mountains of Central Asia.



Fig. 1.1

Snow leopards usually live and hunt alone. Their main prey is grazing herbivores, such as wild sheep and wild goats. They will also hunt domesticated animals and livestock.

The number of snow leopards has decreased dramatically in the last 40 years.

(a) (i) Predict the consequences to the ecosystem if the number of snow leopards continues to decrease.

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(ii) In 2003, the total number of snow leopards was estimated to be between 4080 and 6590.

Suggest **one** reason why the actual number of snow leopards in 2003 may have been higher than the estimated number.

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.....[1]

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(b) The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is an agreement between the governments of most countries.

The snow leopard is endangered and is listed on this agreement.

Describe the actions taken by participating governments that help to conserve endangered animals, such as the snow leopard.

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(c) State how a decrease in the number of snow leopards will affect the genetic diversity of the species.

Outline the possible future consequences of this change in genetic diversity.

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(d) In 1775 the snow leopard was classified as the only species in the genus *Uncia* and was known as *Uncia uncia*.

More recently, new techniques showed similarities to the tiger, *Panthera tigris*, and so in 2006 the snow leopard was reclassified in the genus *Panthera*.

Suggest the type of evidence used to classify the snow leopard in 1775.

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.....[2]

[Total: 11]

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[Turn over

2 The light dependent stage of photosynthesis in a suspension of isolated chloroplasts can be investigated using the Hill reaction.

Dichlorophenolindophenol (DCPIP) can be used to follow the process. DCPIP is a blue dye which turns colourless when it is reduced by accepting hydrogen and electrons.

oxidised DCPIP → reduced DCPIP
blue → colourless

(a) (i) DCPIP is an artificial hydrogen acceptor that can be used in the Hill reaction.

Name the natural hydrogen acceptor found in chloroplasts that is replaced by DCPIP in the Hill reaction.

.....[1]

(ii) Outline the way in which hydrogen is made available to reduce the hydrogen acceptor in the light dependent stage of photosynthesis.

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.....[2]

(b) A suspension of isolated chloroplasts for measuring the rate of the Hill reaction can be prepared by carrying out the following steps:

- prepare buffer solution with the same water potential as the stroma of chloroplasts
- liquidise (homogenise) spinach leaves in ice cold buffer solution
- filter the liquid and obtain the filtrate
- centrifuge the filtrate to obtain a pellet of chloroplasts
- add the chloroplast pellet to fresh buffer solution in a beaker and mix to obtain a suspension.

Explain the reason for:

(i) keeping the temperature very low

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.....[2]

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(ii) using a buffer solution

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(iii) using a solution of the same water potential as the stroma of chloroplasts.

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.....[2]

(c) An experiment was carried out to measure the time taken for decolourisation of DCPIP mixed with a suspension of chloroplasts.

The results are shown in Table 2.1.

Table 2.1

replicate	time taken for DCPIP to decolourise/s	rate/s^{-1}
1	38	
2	43	
3	48	
mean	.....	.....

Complete Table 2.1 by calculating:

(i) for the three replicates, the mean time taken for the DCPIP to decolourise [1]

(ii) the mean rate using the formula:

$$\text{rate} = \frac{1000}{t}$$ where t = time in seconds. [1]

(iii) The time taken to decolourise DCPIP was measured at a range of light intensities.

State **and** explain the expected relationship between light intensity and time taken to decolourise DCPIP.

expected relationship .....

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explanation .....

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.....[4]

[Total: 15]

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3 Fig. 3.1 shows a male red deer, *Cervus elaphus*. Red deer are herbivores, browsing on low vegetation in forests and on waste land.



Fig. 3.1

A history of wild red deer on the western European island of Ireland includes these facts:

- Red deer have lived in Ireland for at least 12 000 years.
- Originally red deer could cross from the neighbouring island of Great Britain to Ireland over a land connection.
- A rise in sea levels at the end of the last Ice Age removed this land connection, separating the red deer on the two islands.

- In the 1800s the number of red deer in Ireland decreased sharply after the main food crop for the human population failed for several consecutive years.
- In the 1900s this decrease in the number of red deer continued as large areas of waste land were drained for agriculture.

- By 1960 red deer were nearly extinct in Ireland, restricted to one population, **A**, of 60 individuals.
- Since then protection has allowed population **A** to increase to over 600 red deer.
- Several new red deer populations, **B**, **C** and **D**, have also been established in different parts of Ireland from individuals brought from Great Britain.

(a) Use the information given to identify **two** causes of extinction that may have threatened the survival of red deer in Ireland.

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.....[2]

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(b) Describe how the level of molecular similarity between the red deer in population **A** and population **B** can be investigated.

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(c) Explain why some red deer in population **A** show unique molecular features that are not found in any of the red deer of populations **B**, **C** and **D**.

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[Total: 8]

4 **(a)** The body temperature of a human is maintained at its set point of approximately 37 °C. If it rises above this temperature, physiological responses begin to return the temperature to its set point. Two of these responses are vasodilation and sweating.

Explain how vasodilation and sweating help to return the body temperature to its set point.

vasodilation .....

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sweating .....

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.....[4]

(b) Diabetes mellitus is a disease where the pancreas is not able to secrete sufficient insulin.

The symptoms of diabetes mellitus include a tendency to drink a lot of water and a loss of body mass.

Suggest why these symptoms occur.

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.....[4]

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(c) A person with diabetes mellitus can use a biosensor to measure the concentration of glucose in their blood.

(i) Outline how a glucose biosensor works.

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(ii) Suggest **one** advantage of using a biosensor rather than a dip stick.

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[Total: 12]

5 Huntington's disease is caused by a dominant allele of the gene that codes for the production of the huntingtin protein. This protein affects the development of many different tissues, including brain tissue.

- The Huntington allele contains several repeats of the base sequence CAG, which codes for glutamine.
- This results in a polyglutamine section in the synthesised protein.
- A gene with more than 39 CAG repeats produces a protein that does not fold properly and does not function.

- Symptoms of Huntington's disease usually first appear between the ages of 30 and 45 years.
- There is no treatment for the disease, which is progressive and always fatal.
- Some people with between 27 and 35 CAG repeats do not develop the disease, but may still pass on the Huntington allele to their children, who may develop the disease as the number of repeats tends to increase when gametes are produced.

(a) (i) The amino acid sequences on either side of the polyglutamine section of the huntingtin protein are not changed by the presence of the CAG repeats in the Huntington allele.

Explain why this is so.

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(ii) With reference to the information given, explain why Huntington's disease cannot be treated with gene therapy.

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(b) Young people who have a parent with Huntington's disease can choose to be screened for the presence of the Huntington allele.

(i) State the probability that a young person who has **one** parent with Huntington's disease will inherit the Huntington allele.

.....[1]

(ii) Suggest **one** advantage and **one** disadvantage of screening for Huntington's disease before any symptoms occur.

advantage .....

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disadvantage .....

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.....[2]

(c) A couple, in which one partner has the Huntington allele, may choose to use IVF (*in vitro* fertilisation) to have a child.

Any embryos obtained from the IVF procedure can be screened in the following way:

- carry out an embryo biopsy
- use PCR
- test for the presence of the Huntington allele
- only implant embryos that do not contain the Huntington allele.

(i) State what is meant by the term *embryo biopsy*.

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.....[1]

(ii) Explain why PCR is used in this procedure.

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(iii) Outline **two** social or ethical implications of screening embryos in this way.

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[Total: 13]

6 Cloves are the aromatic flower buds of the tree *Syzygium aromaticum*. Eugenol is a drug extracted from cloves.

Eugenol affects the movement of sodium ions through the cell surface membranes of sensory neurones.

(a) Fig. 6.1 shows the effect of eugenol concentration on the percentage decrease in sodium ion movement.

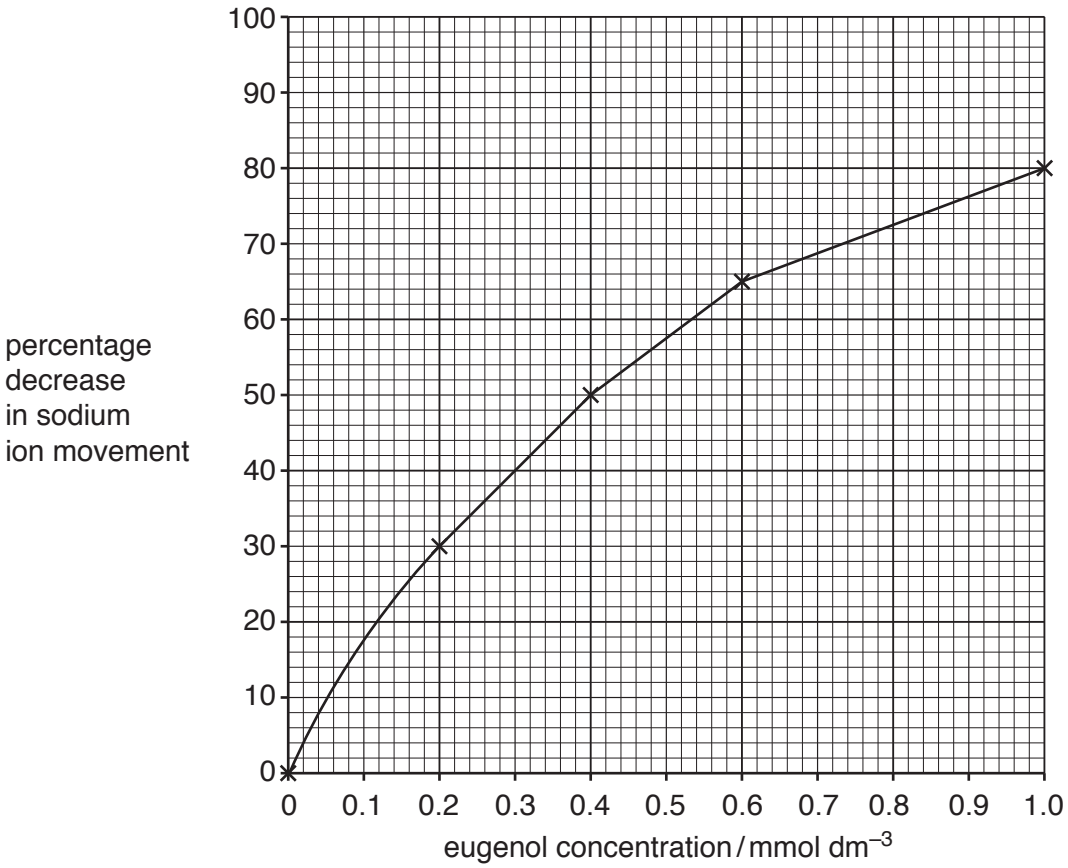


Fig. 6.1

(i) Describe the effect of eugenol concentration on the percentage decrease in sodium ion movement.

.....

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.....

.....[2]

(ii) Using Fig. 6.1, determine the percentage decrease in sodium ion movement at a eugenol concentration of 0.5 mmol dm^{-3}.

percentage decrease ..... % [1]

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(b) Eugenol can be used to relieve the pain of toothache by putting it onto the affected tooth and gum.

Suggest **and** explain how the action of eugenol may reduce pain.

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.....[5]

[Total: 8]

7 **(a)** In respiration, most ATP is synthesised during oxidative phosphorylation. Some ATP is made by substrate-linked reactions in glycolysis and Krebs cycle.

Describe how ATP is made by substrate-linked reactions.

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.....[2]

(b) Lipids can be metabolised to provide ATP.

- The enzyme lipase hydrolyses lipids to glycerol and fatty acids.
- The hydrocarbon chain of the fatty acid breaks down into smaller, 2C compounds.
- Each 2C compound reacts with coenzyme A to form acetyl coenzyme A.

(i) Name the covalent bond in lipids that is hydrolysed by lipase.

.....[1]

(ii) State the role of acetyl coenzyme A in respiration.

.....[1]

(iii) Explain why lipids have a higher energy value than carbohydrates.

.....

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.....[2]

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(c) The respiratory quotient, RQ, is used to show which substrate is being metabolised by cells. It can be determined using the equation below.

$$RQ = \frac{\text{molecules of carbon dioxide released}}{\text{molecules of oxygen taken in}}$$

Lauric acid is a saturated fatty acid found in coconuts and has a chain of 12 carbon atoms.

(i) Complete the equation below which outlines the aerobic respiration of lauric acid.

$C_{12}H_{24}O_2 + \ldots\ldots O_2 \longrightarrow 12CO_2 + 12H_2O$ [1]

(ii) Calculate the RQ value for lauric acid.

Show your working. Give your answer to 2 decimal places.

answer = ...[2]

[Total: 9]

8 **(a)** The sweet pea, *Lathyrus odoratus*, is a flowering plant that grows in many parts of Europe. The inheritance of flower colour and shape of pollen grains is controlled by genes that display autosomal linkage.

Explain what is meant by *autosomal linkage*.

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.....[2]

(b) In sweet peas, the allele for purple flowers is dominant to the allele for red flowers and the allele for long pollen grains is dominant to the allele for round pollen grains.

A sweet pea plant that is heterozygous for both purple flowers and long pollen grains is crossed with a sweet pea plant with red flowers and round pollen grains. The results of this cross are shown in Table 8.1.

Table 8.1

offspring phenotype	percentage of offspring
purple flowers, long pollen grains	44
red flowers, round pollen grains	44
purple flowers, round pollen grains	6
red flowers, long pollen grains	6

Describe **and** explain the results shown in Table 8.1.

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.....[4]

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(c) Different alleles affecting flower colour in the sweet pea plant are the result of gene mutations.

State how a gene mutation may occur.

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.....[3]

[Total: 9]

Section B

Answer **one** question.

9 **(a)** Describe how the structure of a mitochondrion is related to its function. [8]

(b) Describe respiration in anaerobic conditions in mammalian liver cells **and** describe how this differs in yeast cells. [7]

[Total: 15]

10 **(a)** Explain how meiosis can lead to genetic variation. [8]

(b) Explain how the presence of a mutant allele can result in albinism. [7]

[Total: 15]

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BIOLOGY **9700/43**

Paper 4 A Level Structured Questions **October/November 2017**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

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 pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.

Section B
Answer **one** question.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

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.

This document consists of **21** printed pages and **3** lined pages.

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CAMBRIDGE International Examinations

Section A

Answer **all** questions.

1 The St. Lawrence river in Canada has been identified as an area with very high biodiversity.

(a) Explain how the term biodiversity can be considered at different levels.

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.....[2]

(b) The St. Lawrence river is rich in species of aquatic mammals, especially whales.

In spring, thousands of whales swim from the Atlantic ocean up the St. Lawrence river. Thirteen different species of whale have been recorded. One of these is the blue whale, *Balaenoptera musculus*.

Fig. 1.1 is a diagram of a blue whale.

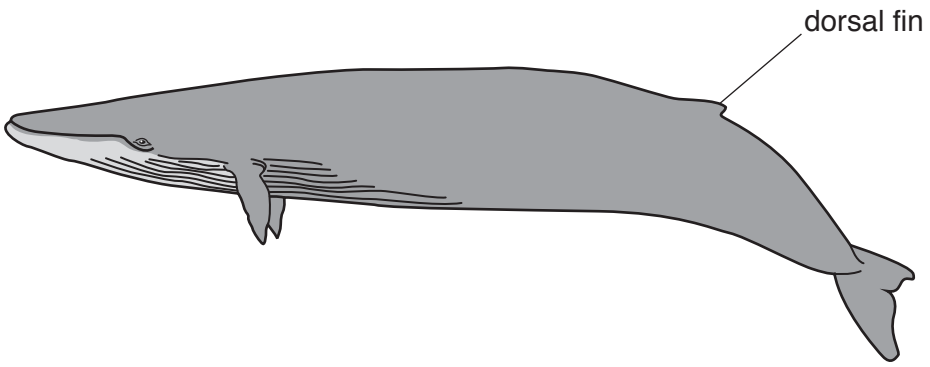


Fig. 1.1

Photographs of blue whales are analysed by computer so that individual whales can be identified and population abundance can be estimated. Each blue whale is different in colour and in the shape of dorsal fin. Different whales also have different patterns of scarring.

(i) State the **two** sources of phenotypic variation in the blue whale population.

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.....[1]

(ii) Suggest **one** reason why it is difficult to measure the **actual** population size of the blue whale.

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.....[1]

(c) The St. Lawrence river runs through very busy industrial areas. It has many ports for cargo ships, a good fishing trade and many whale-watching boat trips for tourists.

Decades of whale hunting has caused a large decrease in whale population sizes. Since whale hunting was banned, whale populations have not recovered.

Seven of the thirteen whale species in the St. Lawrence river have been rated as endangered species.

Suggest **two** reasons why the populations of whales have not recovered since the ban on whale hunting.

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.....[2]

(d) Fat samples from under the skin of individual whales of several different species were taken. These were analysed and the concentrations of the toxins DDT and PCBs were measured.

Suggest why whales were found to have accumulated very high concentrations of DDT and PCBs in their fatty tissues.

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.....[2]

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[Turn over

(e) Algal blooms sometimes occur in the area of the Atlantic ocean near the St. Lawrence river. These result from rapid population growth of unicellular algae such as *Alexandrium tamarense*.

(i) *A. tamarense* produces saxitoxin, a neurotoxin that causes muscle paralysis by acting on voltage-gated sodium ion channels in neurones. Saxitoxin can kill whales.

Suggest how saxitoxin results in the death of a whale.

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.....[2]

(ii) Algae, such as *A. tamarense*, used to belong to the kingdom Plantae but are now classified in the kingdom Protoctista.

State **one** reason why *A. tamarense* is classified in the kingdom Protoctista and **not** in the kingdom Plantae.

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.....[1]

[Total: 11]

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2 The light dependent stage of photosynthesis in a suspension of isolated chloroplasts can be investigated using the Hill reaction.

Dichlorophenolindophenol (DCPIP) can be used to follow the process. DCPIP is a blue dye which turns colourless when it is reduced by accepting hydrogen and electrons.

oxidised DCPIP → reduced DCPIP
blue → colourless

(a) (i) The natural hydrogen acceptor in chloroplasts that is replaced by DCPIP in the Hill reaction is NADP. Reduced NADP is then used in the light independent stage of photosynthesis.

State the role of reduced NADP in the light independent stage.

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.....[2]

(ii) Predict **and** explain the effect on the concentration of RuBP in the chloroplasts if DCPIP becomes reduced instead of NADP.

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.....[1]

DCPIP can be used to investigate the effect of light wavelength on the rate of the light dependent stage of photosynthesis. One method is described here:

- Dip a small glass capillary tube into a beaker containing a suspension of isolated chloroplasts. Some of the chloroplast suspension will be drawn into tube **A**, forming a colour standard.
- Mix the rest of the chloroplast suspension with blue DCPIP solution. Dip a second capillary tube into this to draw up a sample, to form tube **B**.
- Store the chloroplast-DCPIP mixture for future use by wrapping the beaker in foil and covering it with a removable foil lid, as shown in Fig. 2.1.

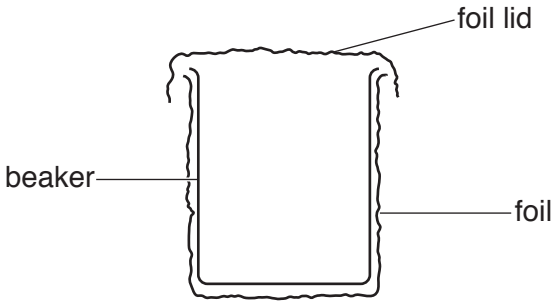


Fig. 2.1

- Place tube **A** and tube **B** on a white tile under a bench lamp placed 15 cm away and immediately cover them with a purple filter, as shown in Fig. 2.2.

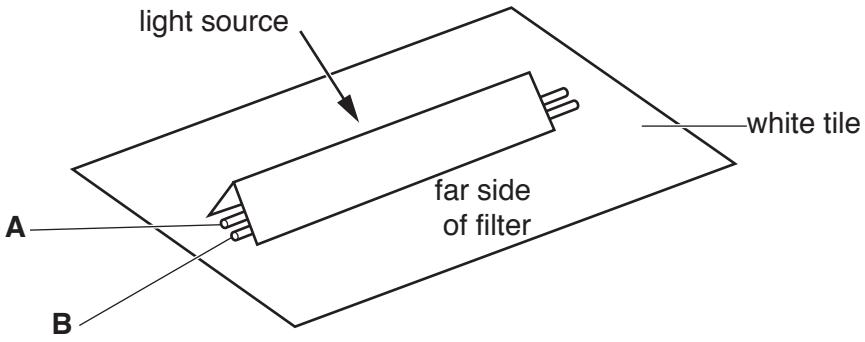


Fig. 2.2

- Measure the time for tube **B** to change colour to match that of tube **A**. This is the time taken for DCPIP to decolourise.
- Repeat four more times using the same tube **A** and a fresh tube **B**, placing the tubes under a different coloured filter each time.

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(b) Explain the reasons for:

the colour standard tube **A**

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covering the beaker containing the chloroplast-DCPIP mixture with foil.

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(c) Table 2.1 shows the results of the experiment.

Table 2.1

colour of filter	wavelength of light/nm	time taken to decolourise DCPIP/s	rate of light dependent stage of photosynthesis/s^{-1}
purple	425	37	27.0
blue	450	84	11.9
green	525	480	2.1
orange	625	45	.....
red	675	50	20.0

(i) Complete Table 2.1 by calculating the rate of the light dependent stage of photosynthesis for the orange wavelength, using the formula:

$$\text{rate} = \frac{1000}{t} \quad \text{where } t = \text{time in seconds.}$$ [1]

(ii) With reference to Table 2.1, describe **and** explain the effect of light wavelength on the rate of the light dependent stage of photosynthesis.

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[Total: 13]

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3 Fig. 3.1 shows a red squirrel, *Sciurus vulgaris*. This species is native to the British Isles, meaning it has lived there for at least 10 000 years. In the 1800s a related but slightly larger species, the grey squirrel, *Sciurus carolinensis*, was introduced from North America.



Fig. 3.1

A history of the interaction between red squirrels and grey squirrels includes these facts:

- Grey squirrels, which occupy a similar niche to red squirrels, expanded their range rapidly after introduction.
- Grey squirrels carry a virus that does not harm them, but which kills red squirrels.
- Red squirrels became extinct in many parts of the British Isles.
- Recently some areas have seen a reversal of this trend. There has been a decrease in numbers of grey squirrels. Red squirrels have re-colonised their former areas of habitat.
- This has happened in areas where protection of a native predator species, the pine marten, *Martes martes*, has resulted in an increase in the number of these predators.
- Analysis of pine marten faeces shows that they catch and eat many more grey squirrels than red squirrels.

(a) Use the information given to identify the causes of the extinction of red squirrels in many parts of the British Isles.

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(b) Describe how the level of molecular similarity between the two species, *S. vulgaris* and *S. carolinensis*, can be investigated.

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(c) Explain how the differing effect of pine marten predation on red and grey squirrel populations is due to natural selection and the separate evolution of each squirrel species.

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[Total: 8]

4 There are many different strains of the soil bacterium *Bacillus thuringiensis*. Each produces slightly different types of Cry-proteins, which are toxic to insects. Some types of cotton, known as Bt cotton, have been genetically modified to produce one of these proteins, Cry1Ac. This protein acts specifically to kill the larvae of butterflies and moths, including the cotton bollworm, *Helicoverpa zea*, a serious pest of cotton crops.

The genetically modified cotton contains a 'genetic package' that includes:

- the gene coding for Cry1Ac, the Bt protein
- a promoter
- a herbicide resistance gene that is used as a marker.

(a) (i) Suggest the advantages of using, in Bt cotton, the gene coding for Cry1Ac, rather than one of the genes coding for other types of the Cry-protein.

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(ii) Explain why a promoter is included in the genetic package.

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(iii) Suggest how the herbicide resistance gene can be used as a genetic marker.

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(b) Table 4.1 shows information about the cultivation of Bt cotton and non-GM cotton by farmers in India in 2002–2003.

Table 4.1

	Bt cotton	**non-GM cotton**
mean yield of cotton / kg ha^{-1}	264	196
seed cost / rupees ha^{-1}	629	196
insecticide cost / rupees ha^{-1}	503	851
net income / rupees ha^{-1}	2118	1253

(i) With reference to Table 4.1, compare the costs involved in growing Bt cotton with the costs involved in growing non-GM cotton.

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.....[2]

(ii) Table 4.1 shows that farmers who grow Bt cotton have a higher net income than those who grow non-GM cotton.

Use the information in the table to suggest **one** reason why some farmers in India choose to grow non-GM cotton, rather than Bt cotton.

.....

.....[1]

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(c) In one region of India, Andhra Pradesh, a severe drought in 2002–2003 meant that Bt cotton grew less well than other varieties of cotton that were better adapted for the conditions.

Suggest how a variety of Bt cotton that is better adapted to dry conditions could be produced from the existing varieties of Bt cotton, **without** using gene technology.

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[Total: 13]

5 **(a)** Explain the importance of the myelin sheath in the transmission of action potentials.

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(b) Acetylcholine is a neurotransmitter.

Describe the events that occur at a synapse that lead to the release of acetylcholine.

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[Total: 9]

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6 Chemiosmosis is the term used to describe the synthesis of ATP using a proton gradient across a membrane in a mitochondrion or chloroplast. It was first demonstrated by Peter Mitchell in 1961.

(a)
- In some of his experiments, Peter Mitchell used mitochondria that had been isolated from cells.
- The mitochondria were kept in liquid, in glass dishes, to which ADP, Pi and other substances were added.
- The temperature, pH and water potential were kept constant.
- After a period of time he checked for the presence of ATP.

The contents of some of the dishes are shown in the table below.

Complete the table using a tick (✓) if ATP was produced and a cross (✗) if no ATP was produced.

dish contents	ATP produced
mitochondria + ADP + Pi + acetyl CoA + oxygen	
mitochondria + ADP + Pi + acetyl CoA	
mitochondria + ADP + Pi + low concentration of protons (H^+)	
mitochondria + ADP + Pi + high concentration of protons (H^+)	

[2]

(b) Explain the consequences to a mitochondrion if the water potential of the liquid in the dishes is higher than the water potential of the mitochondrial matrix.

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.....[2]

(c) State the specific role of oxygen in the mitochondrion.

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.....[1]

(d) Name the enzyme used to produce ATP in chemiosmosis.

.....[1]

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[Turn over

(e) Describe the role of the inner mitochondrial membrane (crista) in chemiosmosis.

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.....[4]

[Total: 10]

7 **(a)** Galactosaemia is a rare genetic disease in which the build-up of the monosaccharide galactose can result in an enlarged liver, kidney failure and brain damage. Galactose is produced in the body from the digestion of the sugar lactose, found in milk.

Galactosaemia is caused by a recessive mutation of the *GALT* gene. The normal dominant allele codes for an enzyme which converts galactose to glucose.

(i) Suggest how a person with galactosaemia can minimise damage to the liver, kidney and brain.

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.....[1]

(ii) Explain how a mutation in the *GALT* gene could result in a change in the enzyme responsible for the metabolism of galactose.

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.....[4]

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(b) If the phenotypes of parents are known, the probabilities of having a child with galactosaemia, an unaffected child (healthy, not a carrier) or a child who is a carrier can be calculated.

Complete Table 7.1 to show the results of these calculations.

Table 7.1

parent 1	parent 2	percentage probability of having a child with galactosaemia	percentage probability of having an unaffected child	percentage probability of having a child who is a carrier
unaffected	carrier	0	50	50
carrier	carrier	.....	.....	.....
unaffected	has galactosaemia	.....	.....	.....
carrier	has galactosaemia	50	0	50

[2]

(c) Testing for galactosaemia is usually carried out on newborn babies, although it is possible to carry out the test on a foetus.

Explain how the presence of galactosaemia in a foetus may be determined.

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.....[2]

[Total: 9]

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[Turn over

8 **(a)** Homeostasis in mammals involves negative feedback mechanisms.

Outline how a negative feedback mechanism works.

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(b) Fig. 8.1 is a diagram summarising the role of the nervous and endocrine systems in the control of blood glucose concentration.

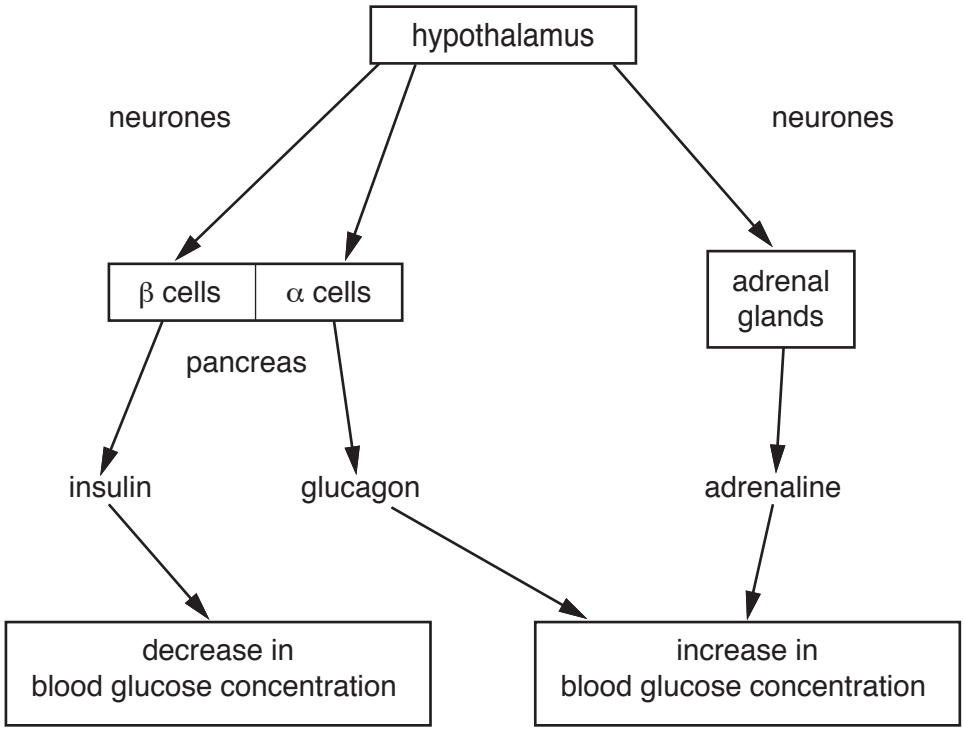


Fig. 8.1

With reference to Fig. 8.1, describe the role of the **nervous system** in the control of blood glucose concentration.

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.....[4]

(c) If the core temperature of the human body falls, the hypothalamus sends impulses to activate several physiological responses, some of which are listed below.

For each one, state how it would help to bring the core temperature back to normal.

vasoconstriction .....

.....

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shivering .....

.....

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increasing secretion of adrenaline .....

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.....[4]

[Total: 12]

Section B

Answer **one** question.

9 **(a)** Explain how rice is adapted to grow with its roots submerged in water. [6]

(b) Explain how the leaves of maize or sorghum are able to maximise carbon dioxide fixation at high temperatures. [9]

[Total: 15]

10 **(a)** Describe the types of gene mutation that can occur **and** explain how some mutations can lead to a shortened polypeptide. [6]

(b) Outline the effects of the mutant sickle cell allele on the phenotype of a person with sickle cell anaemia. [9]

[Total: 15]

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