Cambridge Assessment International Education

# Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

*7252330661*

**BIOLOGY** **9700/42**

Paper 4 A Level Structured Questions **October/November 2025**

**2 hours**

You must answer on the question paper.

No additional materials are needed.

**INSTRUCTIONS**

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

**INFORMATION**

- The total mark for this paper is 100.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **28** pages. Any blank pages are indicated.


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**1** Rice, *Oryza sativa*, is a crop plant that has adapted to grow in flooded fields.

Fig. 1.1 outlines the effects on rice plants of growing in flooded fields.

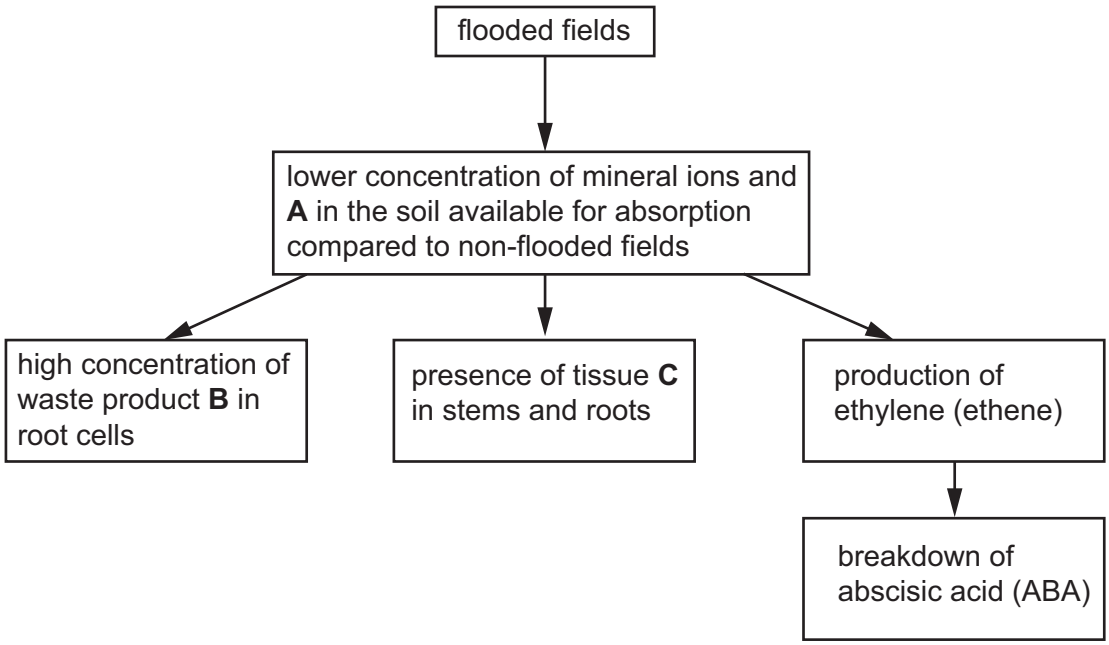



**Fig. 1.1**

**(a)** With reference to Fig. 1.1, name:

substance **A** .....

substance **B** .....

tissue **C** .....

[3]

**(b)** Describe how root cells respond to a high concentration of substance **B**.

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**(c)** Gibberellin is involved in the growth of stems in rice plants.

Fig. 1.2 shows the effect of gibberellin concentration on the length of stems in rice plants.

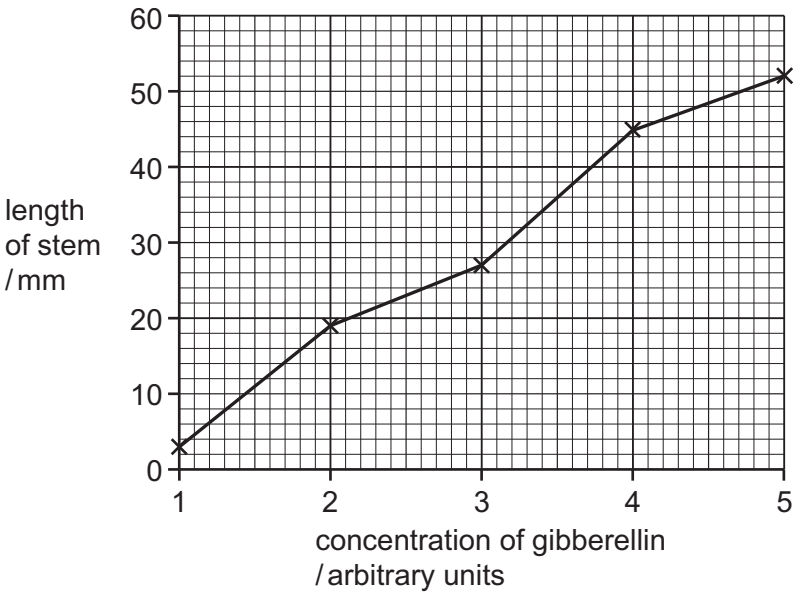



**Fig. 1.2**

**(i)** Describe the relationship shown in Fig. 1.2.

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**(ii)** ABA in rice plant cells inhibits the action of gibberellin.

With reference to Fig. 1.1 and Fig. 1.2, explain the importance of ethylene production for the growth of rice plants in flooded fields.

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**2** **(a)** Explain the terms gene, genotype and phenotype.

gene .....

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genotype .....

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phenotype .....

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[3]

**(b)** A monohybrid genetic cross can be carried out to produce an F1 and an F2 generation.

- Outline how a monohybrid genetic cross is carried out.
- State the expected percentage of each of the different offspring **genotypes** in the F2 generation.

Assume that the inheritance pattern is for autosomal dominant and recessive alleles.

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**Question 3 starts on page 6.**

**3** The *lac* operon is present in the genome of the bacterium *Escherichia coli*.

When glucose is **not** available, the presence of lactose in the extracellular environment leads to the expression of the genes of the *lac* operon. This leads to an increase in the uptake and metabolism of lactose.

When glucose **and** lactose are available in the extracellular medium, lactose is prevented from entering the bacterial cell.

Fig. 3.1 shows what happens when glucose enters a bacterial cell.

- Glucose enters the bacterial cell using a transport protein, **A**.
- **B** is an enzyme found in the cytoplasm of the bacterial cell.
- **B** catalyses the phosphorylation of glucose to produce glucose 6-phosphate.

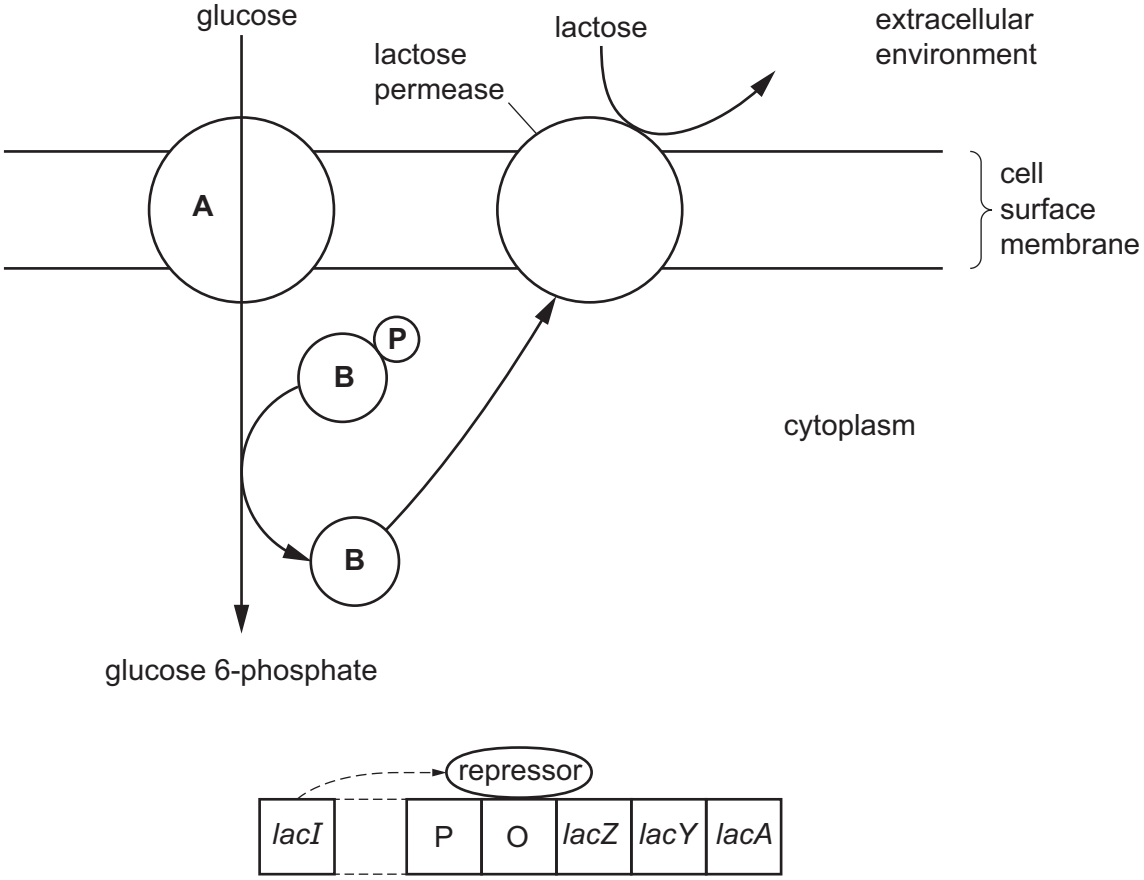






**Fig. 3.1**

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**(a) (i)** With reference to Fig. 3.1, suggest **and** explain how the presence of glucose in the extracellular environment prevents lactose entering the bacterial cell.

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**(ii)** Suggest the advantages for the bacterial cell in preventing the entry of lactose when glucose is present in the extracellular environment.

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**(iii)** The glucose 6-phosphate in the cytoplasm of the bacterial cell is used to produce fructose 1,6-bisphosphate.

Fructose 1,6-bisphosphate is used in glycolysis.

Outline the events that occur in glycolysis following the production of fructose 1,6-bisphosphate.

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**(b)** *E. coli* is present in the gut (intestines) of young mammals.

The diet of young mammals contains lactose which is present in the milk they consume.

Scientists carried out an experiment using *E. coli* with a *lac* operon ($lac^+$ *E. coli*) and *E. coli* without a *lac* operon ($lac^-$ *E. coli*).

The experiment was carried out to determine whether the presence of a *lac* operon gives *E. coli* a selective advantage.

- Equal numbers of $lac^+$ *E. coli* and $lac^-$ *E. coli* were given to 8 mice to allow the bacteria to colonise the gut.
- On day 0, 50% of the *E. coli* in the gut of each mouse were $lac^+$ *E. coli.*
- 4 mice were fed a standard diet that included lactose.
- 4 mice were fed a standard diet without lactose.
- The percentage of $lac^+$ *E. coli* that were in the gut of each mouse was determined every day for 6 days.

The results are shown in Fig. 3.2.

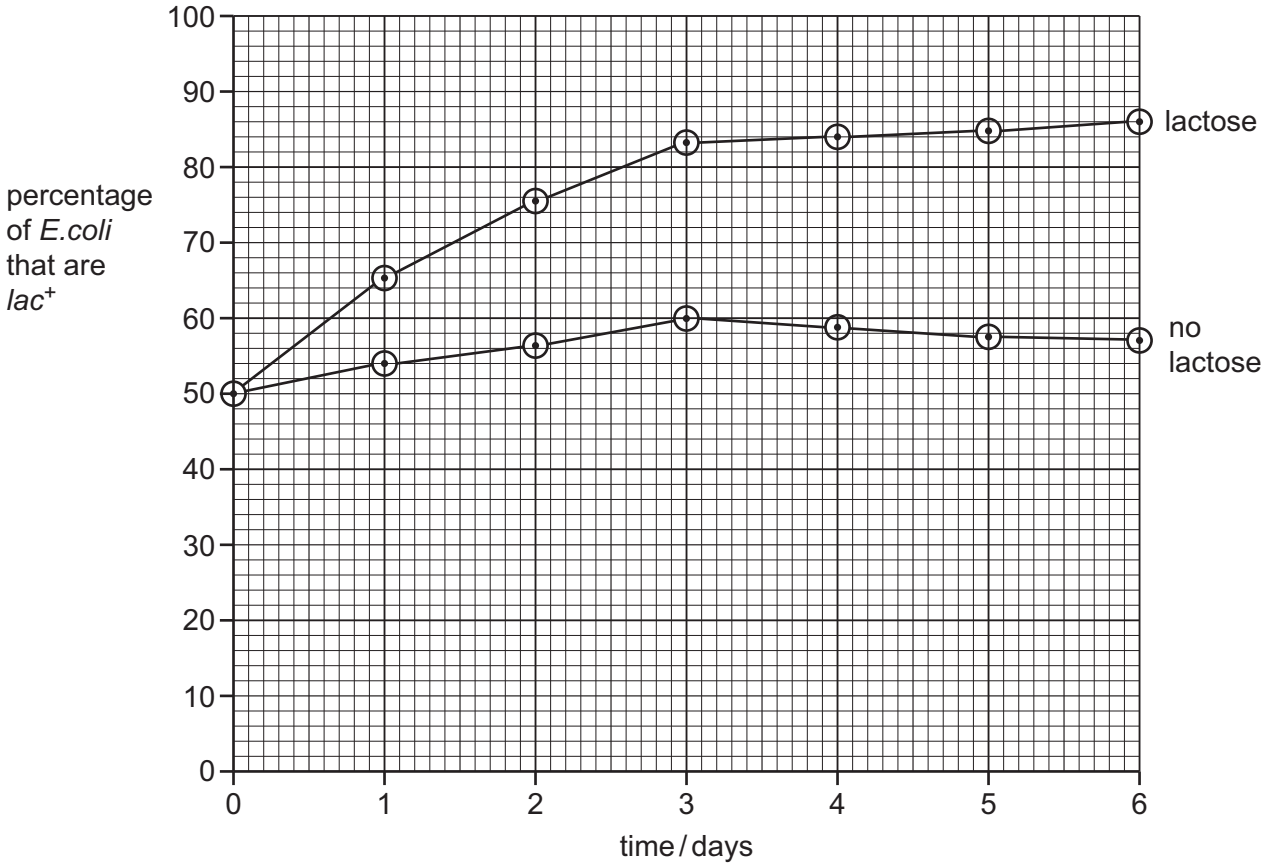



**Fig. 3.2**

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**(i)** With reference to Fig. 3.2, describe the effect of the different diets on the percentage of *E. coli* that are *lac*$^+$.

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**(ii)** The scientists concluded that *lac*$^+$ *E. coli* had a selective advantage when colonising the gut, but only in the presence of lactose.

Suggest why the presence of lactose caused *lac*$^+$ *E. coli* to have a selective advantage.

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**4** The evolution of antibiotic resistance in bacteria has occurred as a result of natural selection.

**(a)** Name **two** ways in which a bacterium can become resistant to an antibiotic.

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**(b)** The World Health Organisation regularly analyses bacterial DNA sequence data.

Suggest **one** way in which this contributes to solving the problem of antibiotic resistance in bacteria.

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**(c)** Some infectious bacterial diseases are treated with the antibiotic streptomycin.

If a person does **not** finish the prescribed course of streptomycin, bacteria are more likely to become resistant to the antibiotic.

Explain why a streptomycin-resistant strain of bacteria is more likely to develop as a result of natural selection when a person does **not** complete the prescribed course of antibiotics.

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**Question 5 starts on page 12.**

**5** Metachromatic leukodystrophy (MLD) is a genetic disease that affects the nervous system.

MLD is caused by mutations in the *ARSA* gene located on chromosome 22. The *ARSA* gene, which is 3150 base pairs (bp) in length, includes 8 exons and is shown in Fig. 5.1.

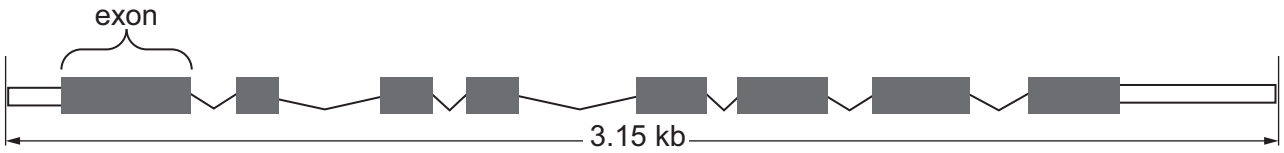



**Fig. 5.1**

A genetic test using DNA sequencing is available to identify mutations associated with MLD in the *ARSA* gene. The sequencing method can only work if a DNA fragment size is less than 1000 bp.

The test involves a number of different stages:

- Genomic DNA is extracted from a blood sample.
- Polymerase chain reaction (PCR) using 5 pairs of primers selects 5 different DNA fragments of the *ARSA* gene.
- Gel electrophoresis is carried out on the DNA fragments.
- The DNA fragments are sequenced and analysed for mutations.

Table 5.1 shows the length of the DNA fragments and the exons present in each DNA fragment.

**Table 5.1**

| fragment number | DNA fragment length / bp | exons in DNA fragment |
|---|---|---|
| 1 | 405 | 1 |
| 2 | 737 | 1-2 |
| 3 | 706 | 2-4 |
| 4 | 860 | 5-7 |
| 5 | 916 | 7-8 |

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**(a)** Genomic DNA and primers are added to the PCR machine.

Name **two** other substances that are added to the PCR machine, **and** explain why each substance is added.

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**(b)** Gel electrophoresis is carried out on the 5 different DNA fragments produced as a result of PCR. Each DNA fragment is put into a loading well on the gel.

The final lane on the electrophoresis gel contains a DNA ladder of known lengths of DNA.

Fig. 5.2 shows the results of the gel electrophoresis.

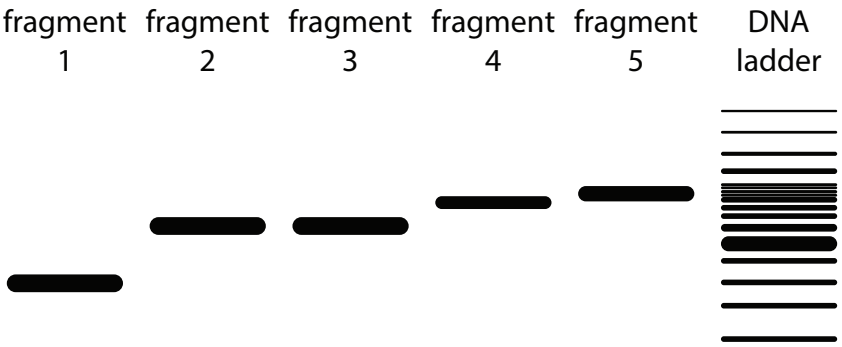



**Fig. 5.2**

**(i)** Suggest the role of the DNA ladder.

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**(ii)** In the genetic test for MLD, PCR and gel electrophoresis are carried out before DNA sequencing.

Suggest **and** explain reasons why PCR and gel electrophoresis are carried out before DNA sequencing.

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**(c)** Calculate the number of copies of DNA that are obtained if PCR is run for 35 cycles.

Assume that there is only 1 copy of DNA at the start of PCR.

Give your answer in standard form to **two** significant figures.

number of copies .....

[1]

**(d)** MLD is a rare autosomal recessive disease. It is estimated that there is one case of MLD in every 40 000 births worldwide. Children with MLD have a reduced life expectancy.

- MLD is a degenerative disease that causes severe disability.
- Before 2022, there was no known cure for MLD and the only treatment for symptoms was to provide pain relief.

A new gene therapy treatment known as Libmeldy® became available in a number of countries in 2022. The treatment must start before symptoms are present. Although the treatment may provide a cure for MLD, a single dose is extremely expensive.

Blood samples from newborn babies are screened for a number of rare genetic diseases (neonatal screening) in most countries of the world, but none include screening for MLD.

Discuss the social and ethical considerations of including screening for MLD when carrying out neonatal screening in a country where gene therapy for MLD is available.

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[Total: 14]

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**6** **(a)** Phosphoinositide 3-kinase (PI3K) and protein kinase B (PKB) are enzymes involved in the regulation of blood glucose concentration.

Fig. 6.1 shows a cell-signalling pathway involving insulin, PI3K and PKB in a muscle cell.

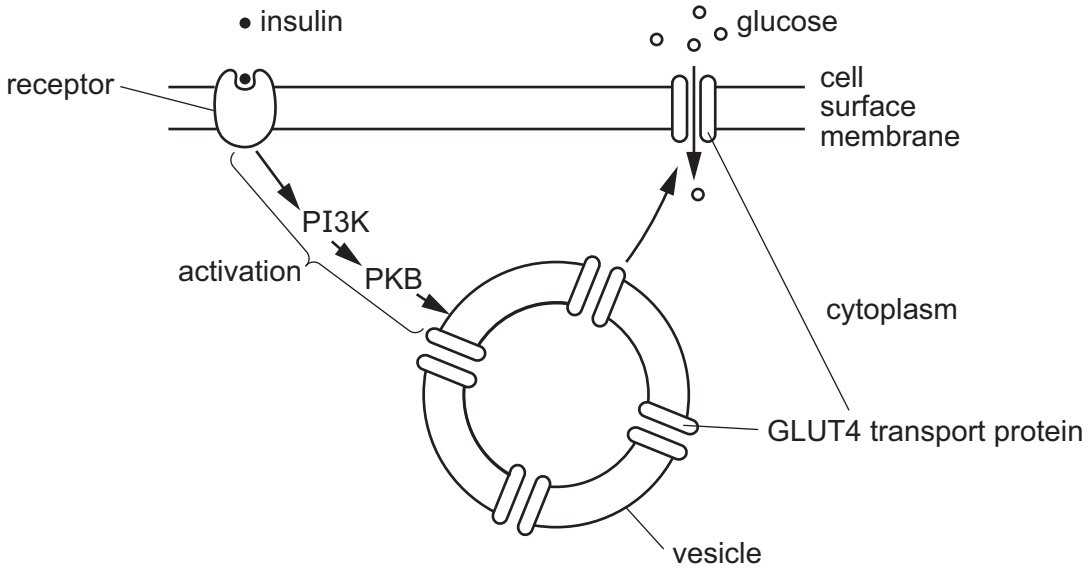



**Fig. 6.1**

Type 2 diabetes mellitus is a common disease. Some people with type 2 diabetes have a low concentration of PI3K in their muscle cells and cannot maintain their blood glucose concentration within normal limits.

With reference to Fig. 6.1, suggest why a low concentration of PI3K can lead to type 2 diabetes.

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**(b)** Describe how a biosensor can be used to measure blood glucose concentration.

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**7** **(a)** The Venus fly trap, *Dionaea muscipula*, is a plant that can capture insects. Each leaf of a Venus fly trap is modified to form 2 lobes.

Fig. 7.1 shows how the leaf of a Venus fly trap appears folded (closed) when an insect has been captured.



**Fig. 7.1**

**(i)** Suggest a reason why the Venus fly trap needs to capture insects, even though it carries out photosynthesis.

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**(ii)** The leaves are specialised to form 2 lobes. The lobes are red on the upper surface.

Suggest why the lobes are red.

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**(iii)** The lobes have sensory hairs. Touching 1 sensory hair will **not** cause a response by the leaf. At least 2 sensory hairs need to be touched within 20 seconds to cause a response in the leaves.

State the advantage to the plant of producing a response only when 2 sensory hairs are touched within 20 seconds.

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**(iv)** When an insect has been trapped, the leaves have to remain closed for a number of days.

Suggest why this needs to happen.

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**(b)** Action potentials are produced by the Venus fly trap during the closure of a leaf. Each action potential is also associated with a refractory period. This is similar to the action potential and refractory period observed in a mammalian neurone during nerve impulse transmission.

Explain the role played by the refractory period in the transmission of an impulse in a mammalian neurone.

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**8** **(a)** Palm oil is the most widely used vegetable oil. It is obtained from the African oil palm, *Elaeis guineensis*. Oil palms are the highest yielding vegetable oil crop, needing only 10% of the land area required by other crops to produce the same quantity of oil.

On the island of Borneo, tropical rainforests are cut down and cleared to create oil palm plantations. This has a large effect on biodiversity.

The Bornean orangutan, *Pongo pygmaeus,* is only found on the island of Borneo and is classified as critically endangered on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species™.

Fig. 8.1 shows Bornean orangutans.



**Fig. 8.1**

Suggest ways in which the Bornean orangutan may be conserved.

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**(b)** Biodiversity can be assessed at different levels.

Outline the main levels at which biodiversity can be assessed.

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**(c)** The biodiversity of a habitat can be measured by calculating Simpson's index of diversity (*D*).

The formula for Simpson's index of diversity (*D*) is:

$$D = 1 - \left(\Sigma\left(\frac{n}{N}\right)^2\right)$$

Key to symbols:

$n$ = number of individuals of each type present in the sample

$N$ = the total number of all individuals of all types present in the sample

A survey of shrubs and trees in a temperate woodland was carried out. The results are shown in Table 8.1.

**Table 8.1**

| **common name** | $n$ | $\frac{n}{N}$ | $\left(\frac{n}{N}\right)^2$ |
|---|---|---|---|
| maple | 807 | 0.196 | 0.0384 |
| alder | 6 | 0.001 | 0.0000 |
| hazel | 1856 | 0.451 | ..... |
| hawthorn | 82 | 0.020 | 0.0004 |
| blackthorn | 40 | 0.010 | 0.0001 |
| willow | 101 | 0.025 | 0.0006 |
| birch | 78 | 0.019 | 0.0004 |
| wild rose | 84 | 0.020 | 0.0004 |
| oak | 1036 | 0.252 | 0.0635 |
| dogwood | 29 | 0.007 | 0.0000 |
| $N$ = | 4119 | Total = | ..... |

**(i)** Complete Table 8.1. [2]

**(ii)** Calculate the value for Simpson's index of diversity (*D*).

*D* = .....
[1]

**(iii)** Using your value for *D*, comment on the biodiversity of this temperate woodland.

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**9** **(a)** Fig. 9.1 shows an absorption spectrum for chlorophyll *a* and the corresponding action spectrum for a species of plant.

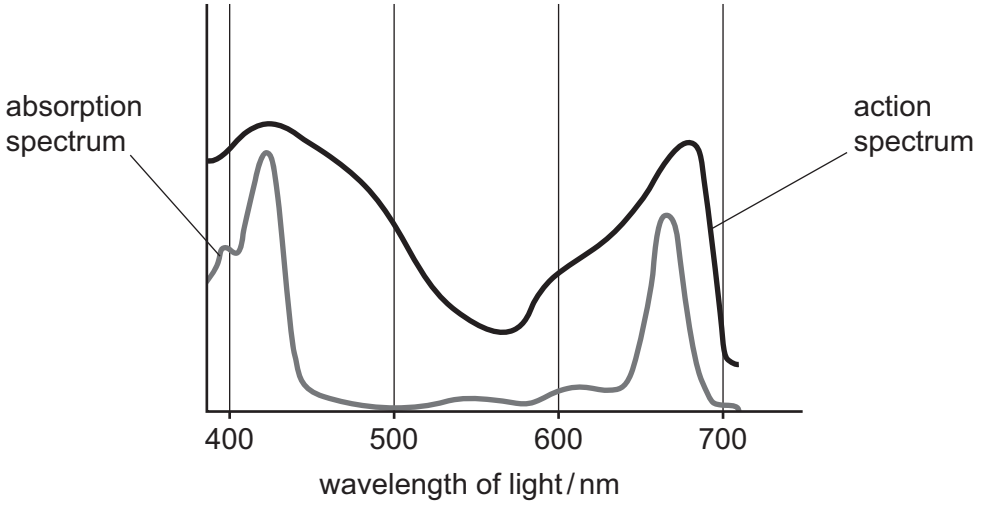



**Fig. 9.1**

**(i)** Explain what is meant by an absorption spectrum and an action spectrum.

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**(ii)** Suggest **and** explain why the curve shown in Fig. 9.1 for the absorption spectrum is different from the curve for the action spectrum for wavelengths of light between 450 nm and 550 nm.

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**(b)** Scientists investigated the effect of temperature on the rate of photosynthesis **and** the rate of respiration of the trailing azalea, *Kalmia procumbens*, at a high light intensity.

Fig. 9.2 shows the results of this investigation.

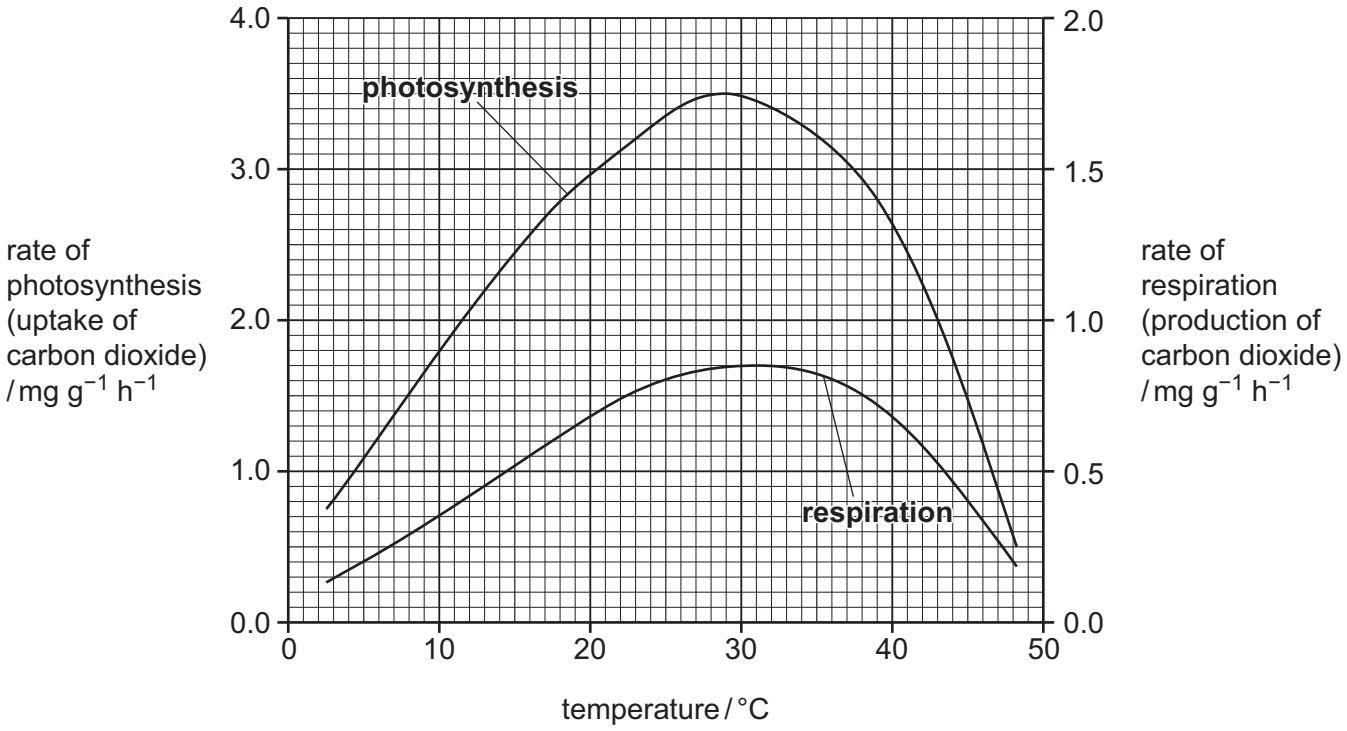



**Fig. 9.2**

**(i)** With reference to Fig. 9.2, describe **and** explain the effect of temperature on the rate of **photosynthesis** for *K. procumbens*.

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**(ii)** The rate of photosynthesis in this investigation was obtained by measuring the uptake of carbon dioxide from the atmosphere. It did **not** take into account the use of carbon dioxide produced by respiration.

Using Fig. 9.2, calculate the rate of photosynthesis at 20 °C when the carbon dioxide produced by respiration is taken into account.

rate of photosynthesis .....
[2]

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**10 (a)** Nerve impulses can be transmitted along a myelinated motor neurone to a neuromuscular junction at fast speeds of up to $100\,m\,s^{-1}$.

Outline how a transmission speed of $100\,m\,s^{-1}$ is achieved by the neurone.

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**(b)** When a nerve impulse reaches the neuromuscular junction, acetylcholine is released and diffuses to the sarcolemma.

Describe how the release of acetylcholine can result in the binding of calcium ions to troponin in the sarcomere.

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**(c)** Muscle contraction can be affected by a low blood glucose concentration.

Suggest how a low blood glucose concentration would affect the functioning of the sarcomere.

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