Cambridge Assessment International Education

# Cambridge International AS & A Level

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

Paper 4 A Level Structured Questions **May/June 2022**

**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.

**1** The jaguar, *Panthera onca*, is a large cat that lives mainly in South America. The majority of jaguars have light brown fur with black spots, as shown in Fig. 1.1. Some jaguars have completely black fur, as shown in Fig. 1.2.

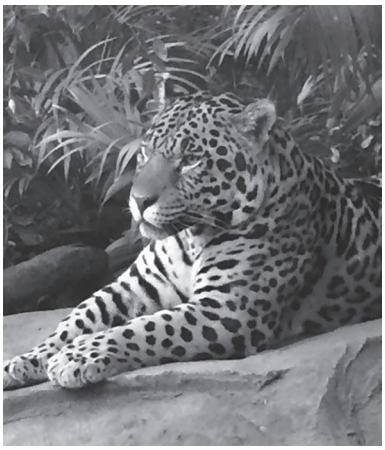

**Fig. 1.1**

**Fig. 1.2**

**(a)** The pigments involved in fur colour are produced as a result of biochemical pathways that take place in cells called melanocytes. These pathways are similar to those that occur in human melanocytes.

The melanocortin 1 receptor (MC1R) is located on the cell surface membrane of melanocytes and is coded for by the *MC1R* gene.

Fig. 1.3 outlines the processes that occur in jaguar melanocytes.

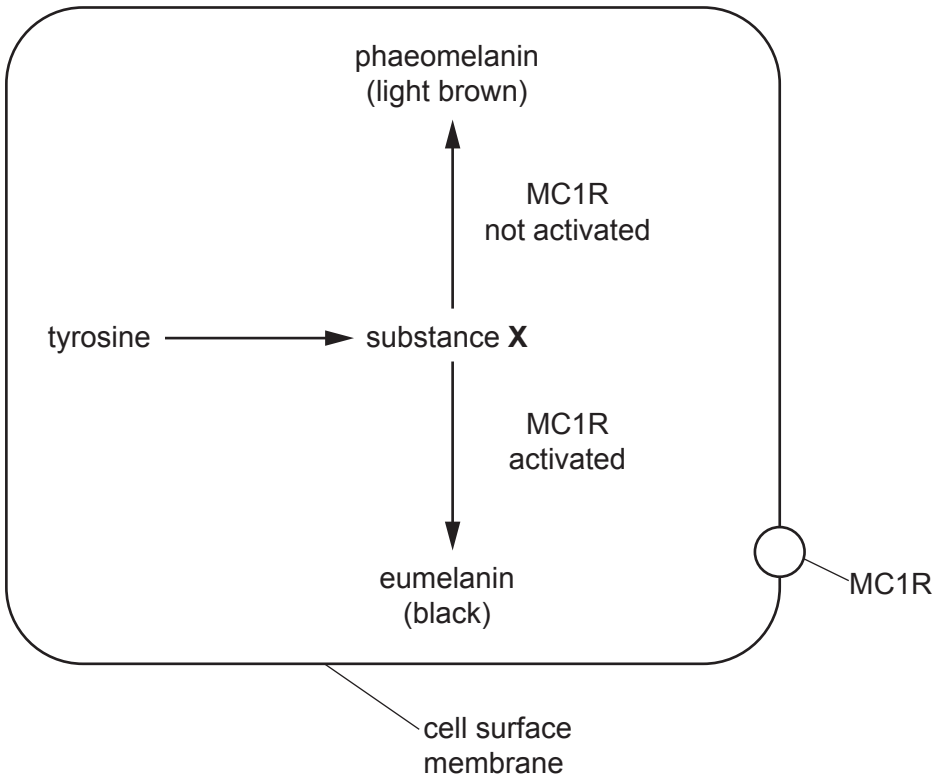


**Fig. 1.3**

**(i)** Name the substance represented by **X**.

..... [1]

**(ii)** When MC1R is activated a second messenger is produced in the cell.

Give an example of a second messenger.

..... [1]

**(iii)** Substance **X** is also produced in humans, but a mutation of the *TYR* gene can result in substance **X** not being produced.

Describe the phenotype of a person with this mutation.

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..... [2]

**(b)** The *MC1R* gene has two alleles and is located on an autosome.

- When two jaguars with light brown fur mate all the offspring have light brown fur.
- When two jaguars with black fur mate either all the offspring will have black fur or some offspring will have black fur and some will have light brown fur.

Using symbols, construct a genetic diagram to show how two jaguars with black fur can produce some offspring with black fur and some offspring with light brown fur.

[4]

[Total: 8]





**[Turn over**

**2** **(a)** Photosynthesis is affected by many environmental factors.

**(i)** Explain why light intensity can be a limiting factor in photosynthesis.

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..... [2]

**(ii)** The concentration of carbon dioxide ($CO_2$) can also be a limiting factor. It has an effect on the Calvin cycle in the light-independent stage of photosynthesis.

Ribulose bisphosphate (RuBP), triose phosphate (TP) and glycerate 3-phosphate (GP) are three important molecules in the Calvin cycle.

Fig. 2.1 shows how the concentration of GP changes when the concentration of $CO_2$ is reduced from 0.04% (atmospheric) to 0.008%.

Complete Fig. 2.1 by sketching the lines for RuBP and TP when the concentration of $CO_2$ is reduced from 0.04% to 0.008%.

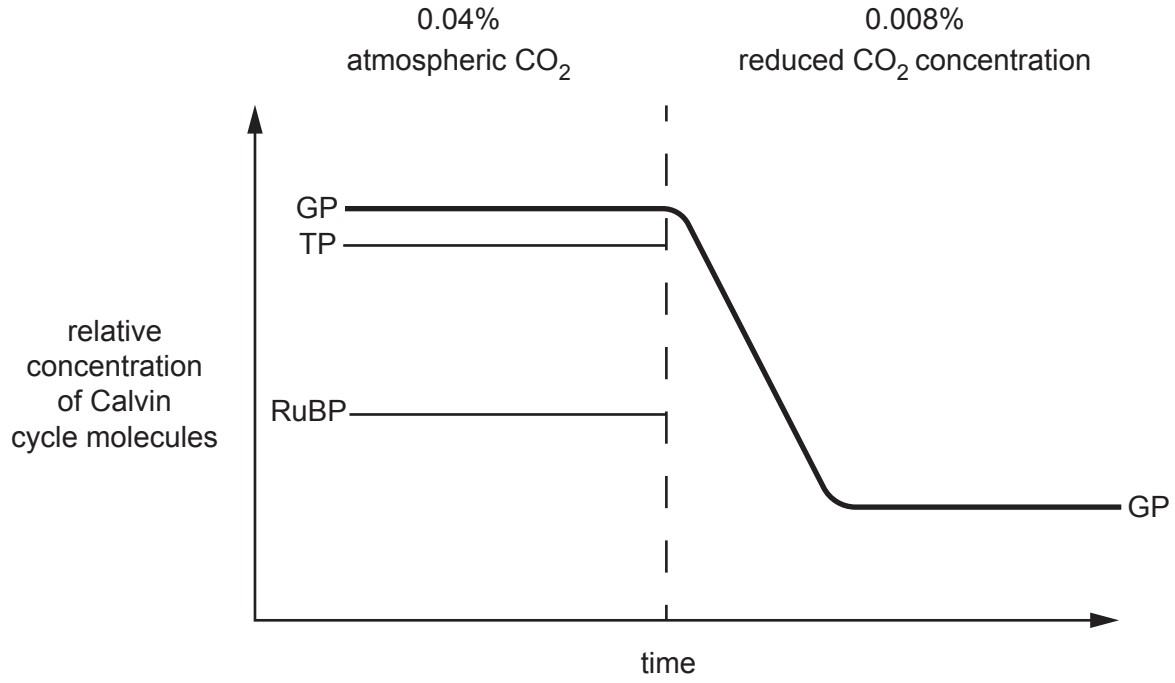


**Fig. 2.1** [2]

**(iii)** In very dry conditions, $CO_2$ concentration can become the main limiting factor of photosynthesis in plants.

Explain how very dry conditions cause $CO_2$ concentration to become the main limiting factor of photosynthesis in plants.

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**(b)** A factor that can limit the rate of photosynthesis is the rate of regeneration of RuBP.

Sedoheptulose-1,7-bisphosphatase (SBPase) is an enzyme in the Calvin cycle that controls the rate of regeneration of RuBP. SBPase is coded for by the gene *SBPase*.

In an experiment, wheat plants were genetically modified to make more SBPase by introducing the *SBPase* gene from another grass species, *Brachypodium distachyon*. The resulting GM wheat plants were named Sox4.

- Wild type plants (not GM) and Sox4 plants were grown in a greenhouse.
- Light intensity, $CO_2$ concentration and temperature were kept constant.
- Mature plants were removed and dried to measure the biomass.

Fig. 2.2 shows the mean plant biomass for the wild type plants and GM Sox4 plants.

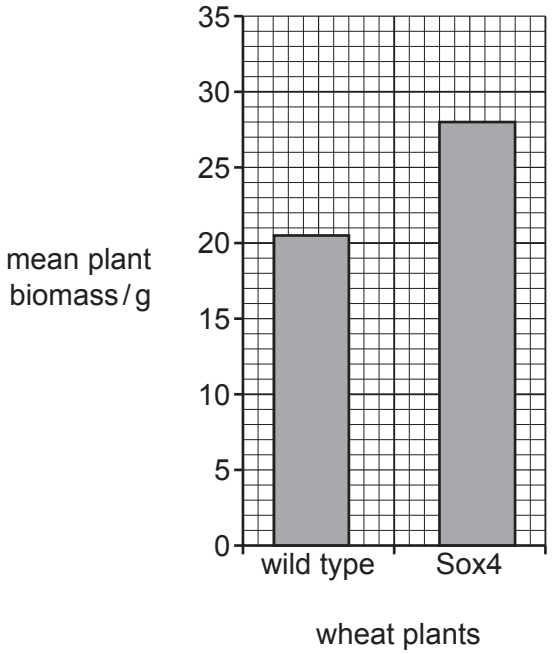


**Fig. 2.2**

**(i)** Calculate the percentage change in mean plant biomass when Sox4 plants are grown compared to wild type plants.

Show your working.

percentage change = ..... % [2]

**(ii)** Suggest **and** explain why Sox4 plants have a different mean plant biomass than wild type plants.

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**(iii)** Some soils may be deficient in nitrates.

Suggest how nitrate deficiency could limit the quantity of SBPase made by Sox4 plants.

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..... [2]

[Total: 15]

**3** Aerobic respiration occurs when oxygen is available. A much greater energy yield is obtained from aerobic respiration than from respiration in anaerobic conditions.

**(a)** Explain why the link reaction only occurs when oxygen is available.

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**(b)** Outline the stage of aerobic respiration that occurs in the cytoplasm of eukaryotic cells.

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[Total: 9]

**4** In 1973, a technique for genetic engineering was used for the first time. Recombinant DNA was made using a plasmid and this was successfully transferred into an organism.

In 2012, a new technique for genetic engineering, called gene editing, was developed.

**(a)** Table 4.1 lists some statements about the two genetic engineering techniques.

Complete Table 4.1 to compare the original genetic engineering technique using a plasmid vector with the newer technique of gene editing. For each row, place a tick (✓) in the correct column if the statement applies and leave a blank if the statement does not apply.

**Table 4.1**

| statement | genetic engineering using a plasmid | gene editing |
|---|---|---|
| It may cause the organism to produce a different protein. | | |
| It may cause a single base pair in a gene to be changed. | | |
| The success of the technique can be evaluated using marker genes. | | |
| It may use the CRISPR system. | | |
| It uses DNA ligase. | | |

[5]





**[Turn over**

**(b)** Cassava plants, *Manihot esculenta*, produce roots that have a high starch content. These roots are an important food source in tropical regions. The growth of cassava plants is reduced by competition from weeds.

Scientists used gene editing to develop two types of cassava plant with different mutations (changes to the DNA). The gene edited cassava plants showed resistance to the herbicide glyphosate. In susceptible plants, glyphosate prevents synthesis of three amino acids from a precursor molecule called shikimate.

Fig. 4.1 shows the concentration of shikimate in the wild type (not gene edited) and the two types of gene edited cassava plant after they were exposed to three different concentrations of glyphosate.

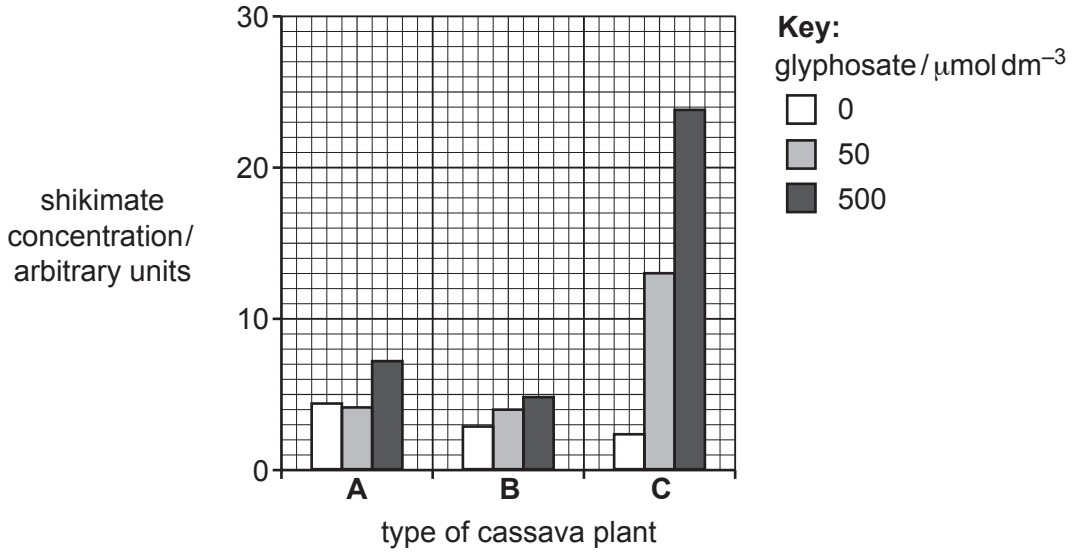


**Fig. 4.1**

**(i)** Identify the letter in Fig. 4.1 that represents the wild type cassava plant.

..... [1]

**(ii)** Explain the social benefit of this example of gene editing.

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..... [3]

[Total: 9]

**5** Bison are a type of large wild cattle. Ancestors of modern bison appeared in Asia 2.5 million years ago. This ancestral bison species increased its range into Europe and North America.

While the ancestral species is now extinct, its descendants include *Bison bonasus*, the European bison, and *Bison bison*, the American bison.

Fig. 5.1 shows an American bison.

**Fig. 5.1**

**(a)** After the end of the last ice age, populations of the ancestral bison were separated by sea and by forests that were not suitable as habitats. The separation resulted in the evolution of the European bison and the American bison.

Explain how this separation resulted in the evolution of the two bison species.

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**(b)** Table 5.1 compares features of European bison and American bison.

**Table 5.1**

| feature | European bison, *B. bonasus* | American bison, *B. bison* |
|---|---|---|
| type of food | grass and higher vegetation such as leaves of bushes and trees | grass and low vegetation |
| height / m | 2.1 | 2.0 |
| maximum mass / kg | 1000 | 1270 |

Assess the relative importance of natural selection and genetic drift in producing the different heights and masses of the two species of bison.

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**(c)** The European bison has a nuclear genome that is very similar to that of the American bison. The European bison has a mitochondrial genome that is more similar to that of wild cattle of the genus *Bos* than to the American bison.

Discuss what this implies about the evolutionary history of the European bison.

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**(d)** Outline how practical techniques could be used to test the hypothesis that farmed cattle are closely related to European bison.

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[Total: 14]

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**6** **(a)** Gibberellin is a plant hormone that has an important role in seed germination.

Fig. 6.1 is a diagram of a section through a barley seed (grain).

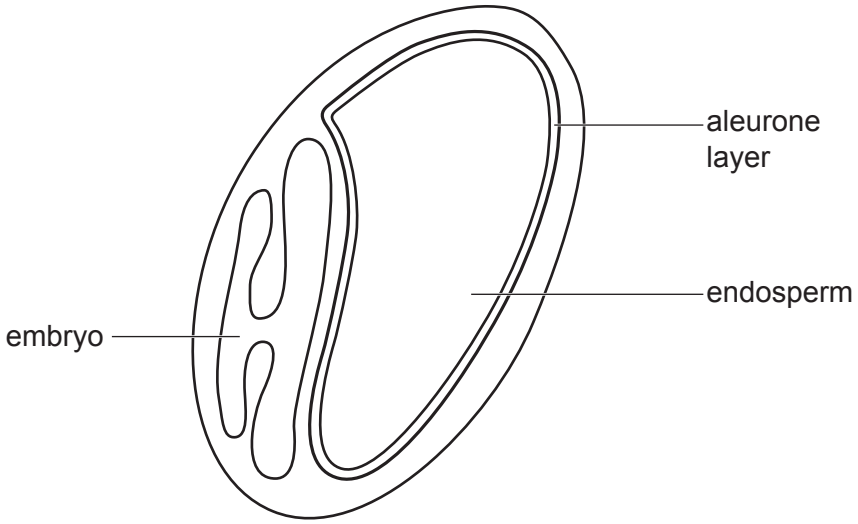


**Fig. 6.1**

On Fig. 6.1:

- Draw **one** arrow, labelled **G**, to show the movement of gibberellin during germination.
- Draw **one** arrow, labelled **A**, to show the movement of amylase during germination.

[2]

**(b)** Outline the role of amylase in seed germination.

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**(c)** The germination of three groups of seeds of the plant *Penstemon digitalis* was investigated.

The seeds were soaked for 24 hours in distilled water or in a solution of gibberellin. They were then sown on filter paper in dishes and kept moist for 10 days.

Fig. 6.2 shows the results for each group.

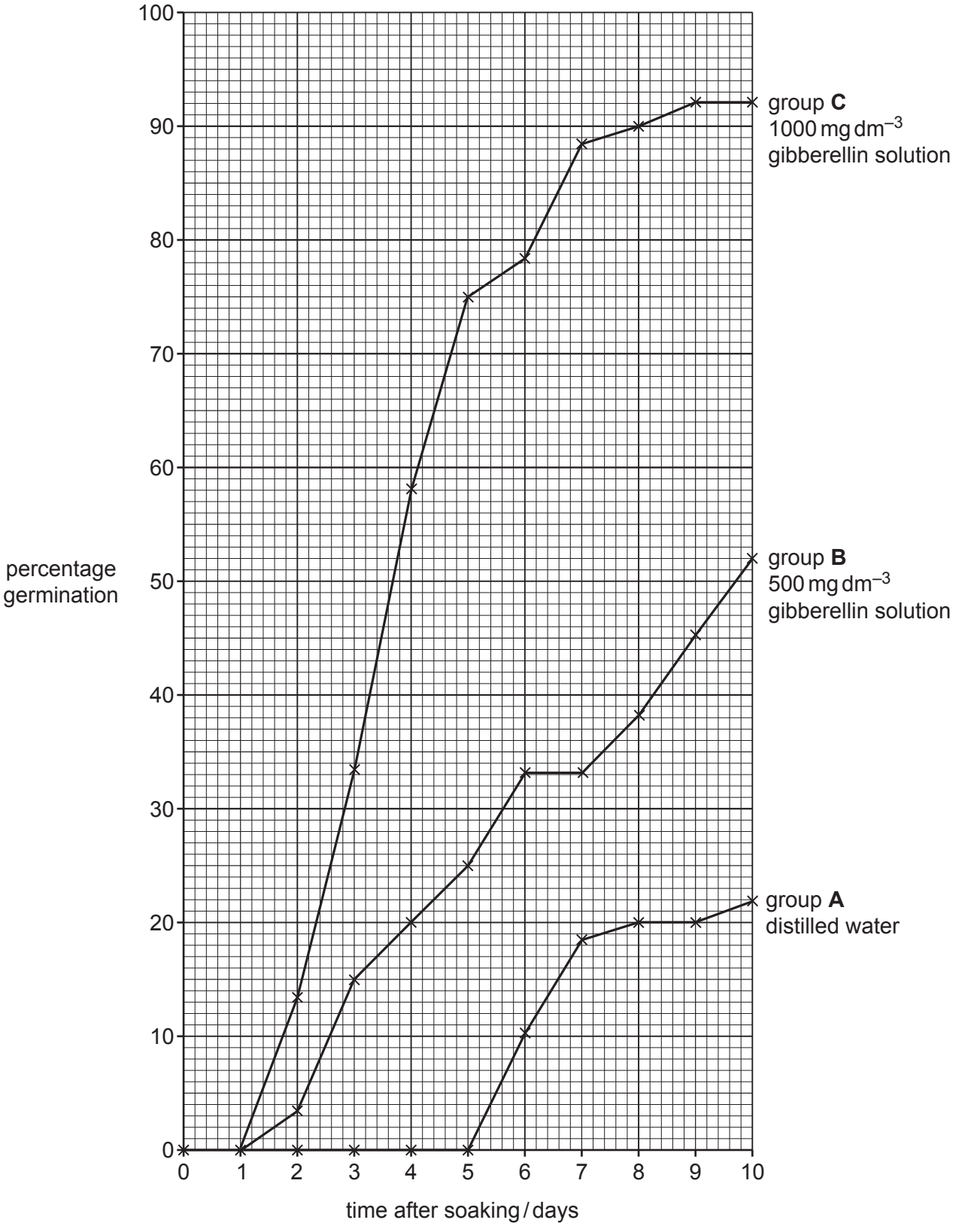


**Fig. 6.2**

Describe the results shown in Fig. 6.2.

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[Total: 9]

**7** The bacterium, *Escherichia coli*, can use glucose or disaccharides, such as lactose, in its metabolism. Lactose needs to be hydrolysed by the enzyme β-galactosidase to form glucose and galactose, which can then be used by *E. coli*.

The production of β-galactosidase is controlled by a length of DNA called the *lac* operon.

**(a)** Fig. 7.1 shows the *lac* operon when lactose is **absent**.

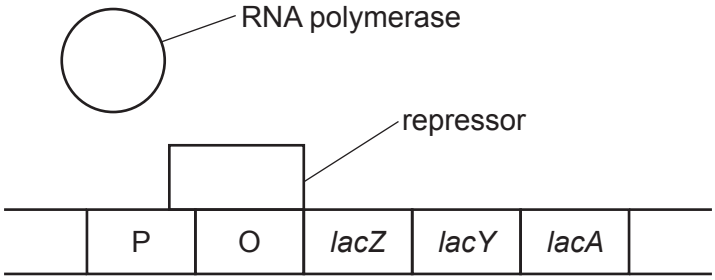


**Fig. 7.1**

On Fig. 7.2, draw the positions of RNA polymerase and the repressor molecule when lactose is **present**.

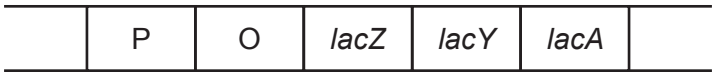


**Fig. 7.2** [2]

**(b)** The protein coded for by *lacY* is not involved in the control of gene expression.

**(i)** Name the type of gene represented by *lacY*.

..... [1]

**(ii)** Name the protein product coded for by *lacY* **and** state the precise role of this protein.

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..... [2]

**(c)** In an investigation into the growth of *E. coli*, a sample of the bacterium was grown in a medium that contained limited concentrations of glucose and lactose. The population size of *E. coli* was measured at regular intervals.

Fig. 7.3 shows the population growth curve obtained for this investigation.

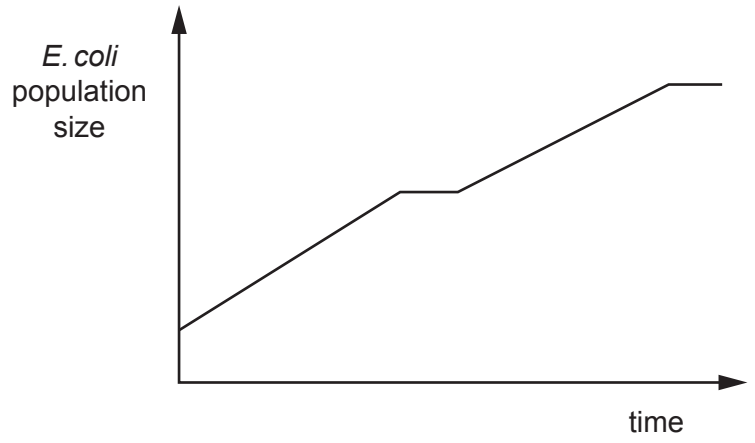


**Fig. 7.3**

Describe **and** suggest explanations for the population growth curve shown in Fig. 7.3.

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[Total: 9]

**8** The role of sensory receptor cells in mammals is to detect stimuli and generate action potentials in sensory neurones.

Human taste buds on the tongue contain chemoreceptor cells. Different chemoreceptor cells respond to different chemical stimuli.

Fig. 8.1 is a diagram of chemoreceptor cells in a taste bud.

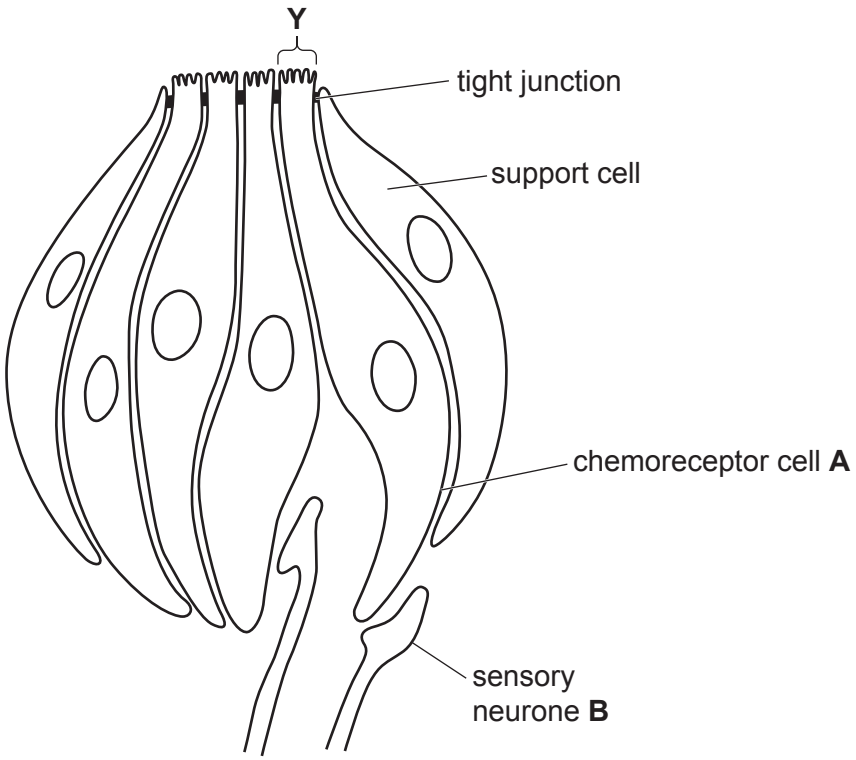


**Fig. 8.1**

**(a)** Name the structures in the region **Y**.

..... [1]

**(b)** Suggest a reason for the tight junctions between the chemoreceptor cells.

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..... [1]

**(c)** Chemoreceptor cell **A** responds to sodium ions ($Na^+$) in salt.

Describe how the contact of cell **A** with $Na^+$ can result in an action potential in sensory neurone **B**.

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..... [7]

[Total: 9]

**9** **(a)** Ultrafiltration in the kidney takes place between the glomerulus and the Bowman's capsule. The afferent blood vessel carrying blood to the glomerulus has a wider lumen than the efferent blood vessel.

Explain why the lumen of the afferent blood vessel needs to be wider than the lumen of the efferent blood vessel.

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..... [2]

**(b)** Fig. 9.1 is a diagram of part of the glomerulus and Bowman's capsule.

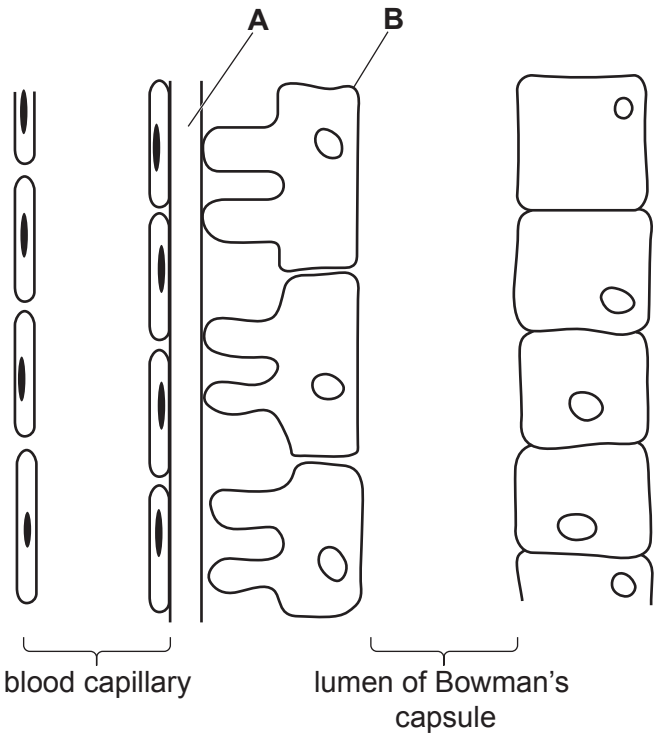


**Fig. 9.1**

**(i)** Name **A** and **B**.

**A** .....

**B** .....

[2]

**(ii)** Describe the roles of **A** and **B** in the formation of the glomerular filtrate.

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..... [3]

[Total: 7]

**10** The African penguin, *Spheniscus demersus*, lives along the coast of South Africa.

Fig. 10.1 shows two African penguins.

**Fig. 10.1**

**(a)** One way of estimating the size of a population of African penguins is to use the mark-release-recapture method.

Suggest **three** assumptions that must be made for the mark-release-recapture method to be valid.

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..... [3]

**(b)** The International Union for the Conservation of Nature (IUCN) Red List of Threatened Species has categorised the African penguin as endangered and could become extinct.

Suggest reasons why the African penguin has become endangered and could become extinct.

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..... [3]

**(c)** Fig. 10.2 shows the estimated numbers of African penguins in the years of 1800, 1900 and 2000.

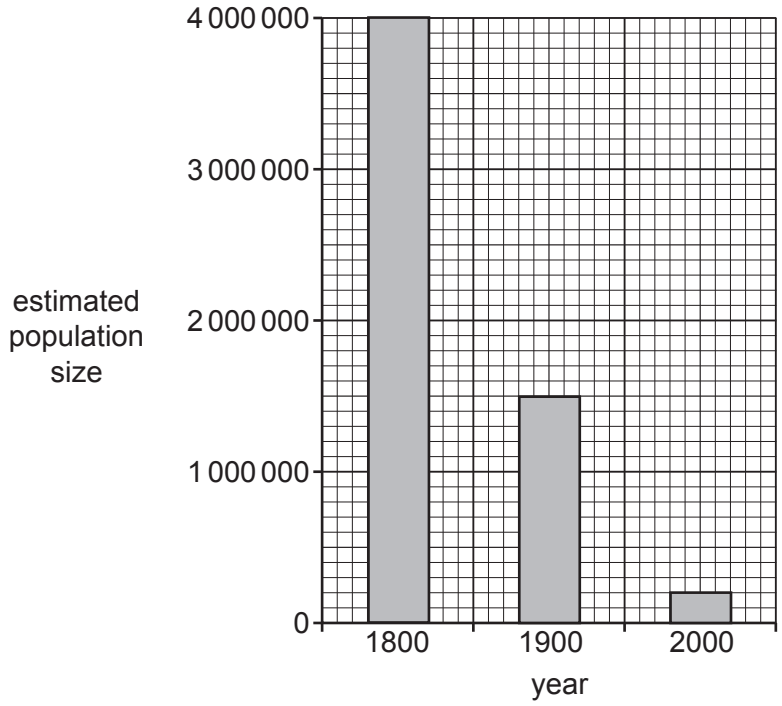


**Fig. 10.2**

Calculate the mean yearly decrease in population size of the African penguin between 1900 and 2000.

answer = ..... $yr^{-1}$ [1]

**(d)** The African penguin is a member of the kingdom Animalia.

Outline the characteristic features of the kingdom Animalia.

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[Total: 11]

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