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# Friday 24 June 2022 – Morning

## A Level Biology A

**H420/03** Unified biology

**Time allowed: 1 hour 30 minutes**

**You can use:**
- a ruler (cm/mm)
- a scientific or graphical calculator

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

**INSTRUCTIONS**
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

**INFORMATION**
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **24** pages.

**ADVICE**
- Read each question carefully before you start your answer.

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Answer **all** the questions.

**1** The heart can be affected by a variety of disorders, some of which involve the immune system.

**(a)** **Fig. 1.1** shows the roles of three different types of antibody, labelled **R**, **S** and **T**.

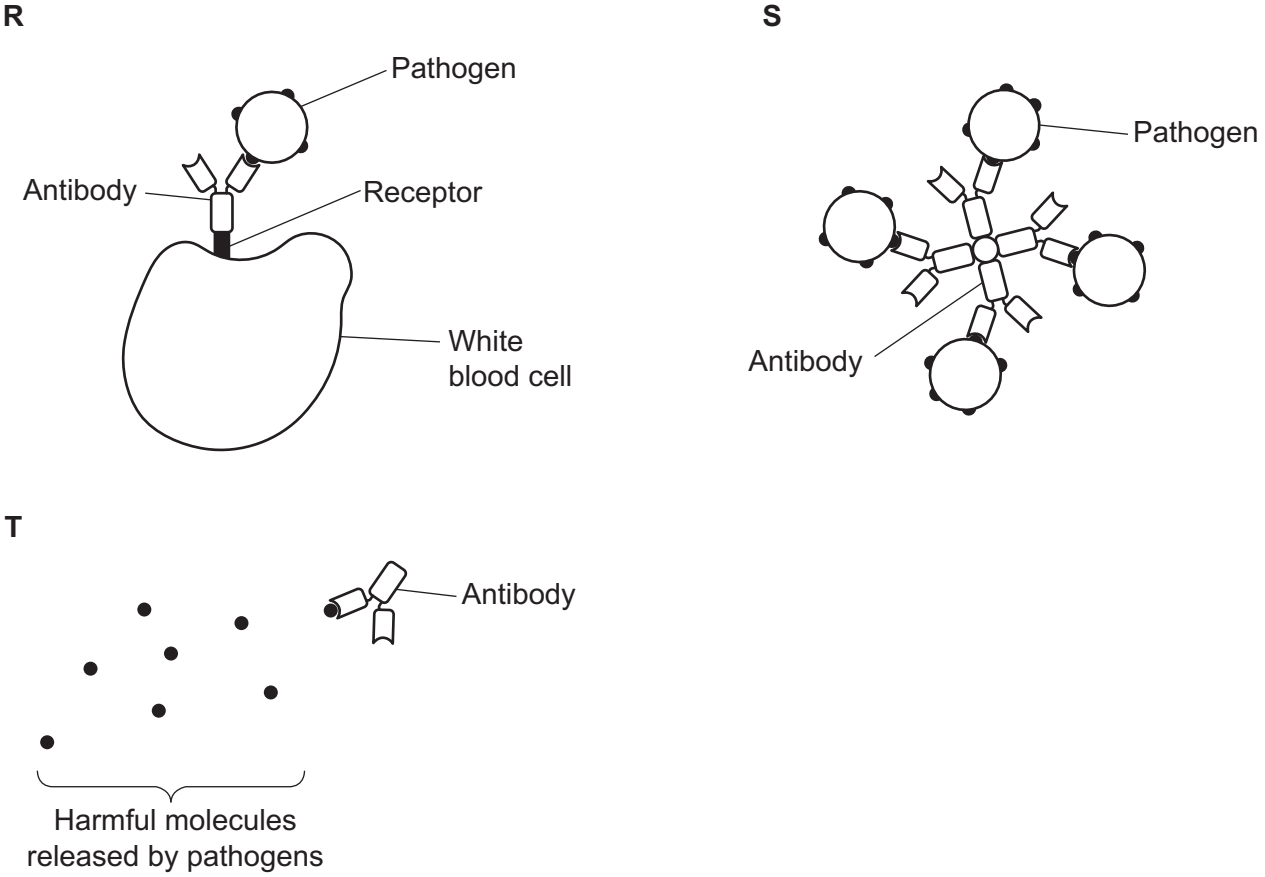



**Fig. 1.1**

State the names of the **three** different types of antibody shown in **Fig. 1.1**.

**R** .....

**S** .....

**T** .....

**[3]**

**(b)** A condition called rheumatic heart disease can occur when a person's antibodies attack antigens on their own heart cells.

State the name of the **type** of disease represented by rheumatic heart disease.

..... **[1]**

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**(c)** **Fig. 1.2** shows two electrocardiogram (ECG) traces:

- an ECG of normal heart activity
- an ECG of a person with a type of heart disease




**Fig. 1.2**

Describe how the ECG trace of the heart with heart disease is different from the ECG trace of a normal heart.

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..... **[2]**

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**(d)** Gene therapy is a possible future treatment for heart disease.

The *AC6* gene codes for one form of the enzyme adenylyl cyclase.

Clinical trials have tested the effect of increasing levels of the *AC6* gene in heart cells.

**(i)** Suggest how using gene therapy to increase levels of the *AC6* gene in heart cells may improve heart function.

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..... **[2]**

**(ii)** State **one** method for inserting the *AC6* gene into the heart cells during gene therapy.

..... **[1]**

**(iii)** The results from gene therapy trials are published in peer-reviewed journals.

State why the results from gene therapy trials are published in journals.

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..... **[1]**

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**2** **(a)** **Fig. 2.1** shows a light micrograph of a blood smear.

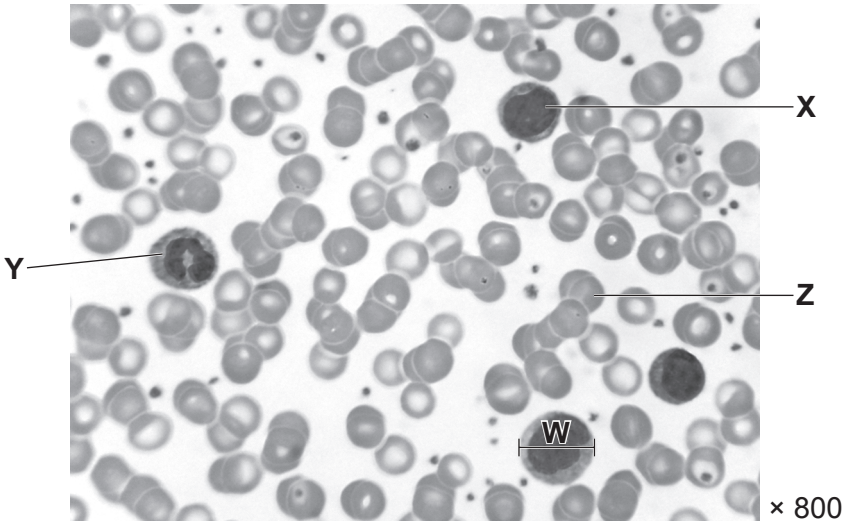



**Fig. 2.1**

**(i)** The cells labelled **X** and **Y** in **Fig. 2.1** are two different types of white blood cell.

Identify the types of white blood cell labelled **X** and **Y**.

**X** .....

**Y** .....

**[2]**

**(ii)** The blood cell labelled **Z** in **Fig. 2.1** contains a high concentration of haemoglobin.

Outline **two** other ways in which the blood cell labelled **Z** is adapted for its function.

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..... **[2]**

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**(iii)** The diameter of another blood cell is represented by the line **W** in **Fig. 2.1**.

The magnification used to produce **Fig. 2.1** was ×800.

Calculate the actual diameter, **W**, of the blood cell.

Give your answer in μm.

Diameter = ..... μm **[2]**

**(b)** Some white blood cells have a high concentration of lysosomes.

**(i)** State the role of lysosomes in white blood cells.

.....

..... **[1]**

**(ii)** A scientist calculated two values for the lysosomes in a white blood cell:

- mean volume of a lysosome = $6.5 \times 10^{-14}$ $cm^3$
- mean number of $H^+$ ions per lysosome = $1.3 \times 10^{-21}$ mol

Use these values to calculate the mean $H^+$ ion concentration per lysosome in this white blood cell.

Give your answer in mol $dm^{-3}$.

Mean $H^+$ ion concentration = ..... mol $dm^{-3}$ **[2]**

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**(iii)** The formula used to calculate pH is

$pH = -\log [H^+]$
where $[H^+]$ is $H^+$ ion concentration in mol $dm^{-3}$.

Use your answer from **part (ii)** to calculate the mean pH of the lysosomes in this white blood cell.

Give your answer to **2** significant figures.

pH = ..... **[1]**

**(iv)** The scientist stained the lysosomes in a sample of living white blood cells.

The table shows the properties of five stains, **A** to **E**.

| Stain | Properties |
|---|---|
| **A** | Suitable to stain alkaline components.<br>Taken up by active cells. |
| **B** | Suitable to stain acidic components.<br>Taken up by active cells. |
| **C** | Suitable to stain neutral components.<br>Taken up by active cells. |
| **D** | Suitable to stain alkaline components.<br>Can be used to stain fixed sections of tissue. |
| **E** | Suitable to stain acidic components.<br>Can be used to stain fixed sections of tissue. |

Select the most appropriate stain for the scientist to use, based on your answer from **part (iii)**.

..... **[1]**

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**(c)** Differential staining can be used to distinguish between bacteria with thick cell walls and bacteria with thin cell walls.

Four substances are used when differentially staining bacteria:

- Crystal violet, which stains bacteria purple.
- Safranin, which stains bacteria pink but is not visible in the presence of crystal violet.
- Alcohol, which removes fixed stains from bacteria with thin cell walls.
- Iodide solution, which fixes crystal violet to bacterial cells.

Suggest a practical procedure for staining a slide that would allow thin-walled bacteria to be differentiated from thick-walled bacteria.

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..... **[2]**

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**(d)** **Fig. 2.2** shows stained tissue that includes two different blood vessels, labelled **L** and **M**, and a substance labelled **N**.

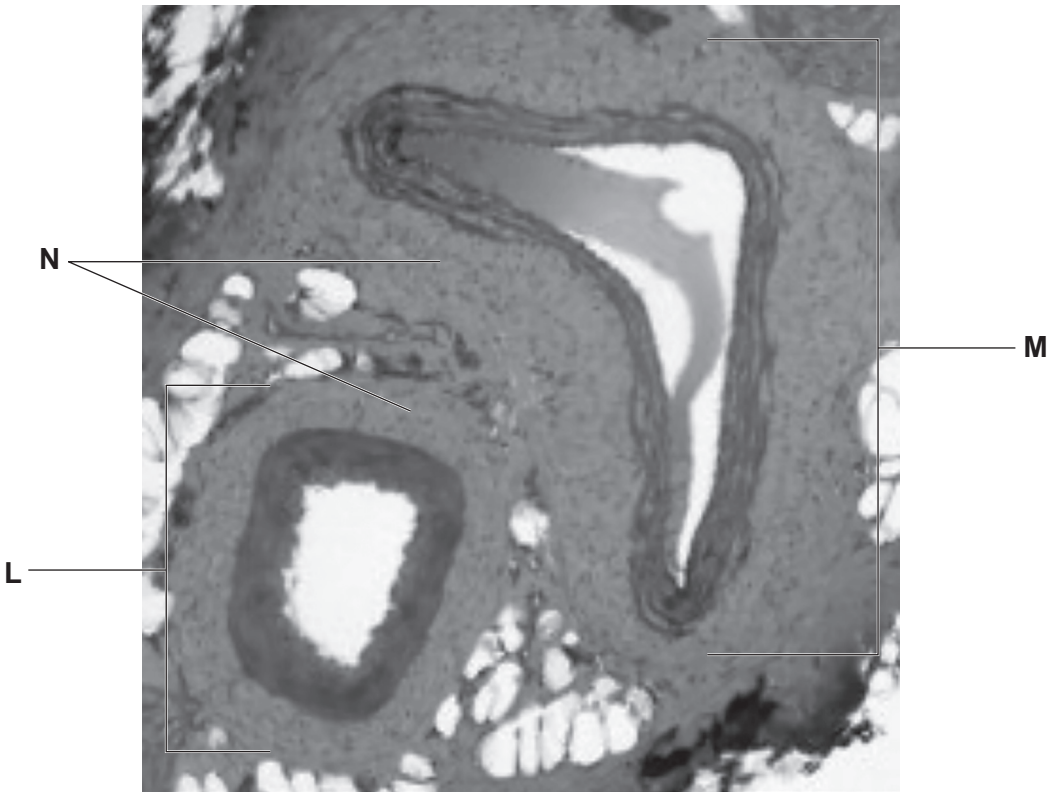



**Fig. 2.2**

**(i)** State whether **L** is an artery or a vein **and** give **two** pieces of evidence from **Fig. 2.2** that allow you to reach your decision.

**L** .....

Evidence 1 .....

.....

Evidence 2 .....

.....

**[2]**

**(ii)** State the substance labelled **N**.

..... **[1]**

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**3** **(a)** A student wrote a method for taking a cutting to clone a plant:

- Select a stem with many flowers and leaves.
- Make a slanting cut in the stem, below some leaves.
- Dip the cut stem in rooting powder.
- Plant the cutting in watered compost.

Describe and explain how the student's procedure could be improved.

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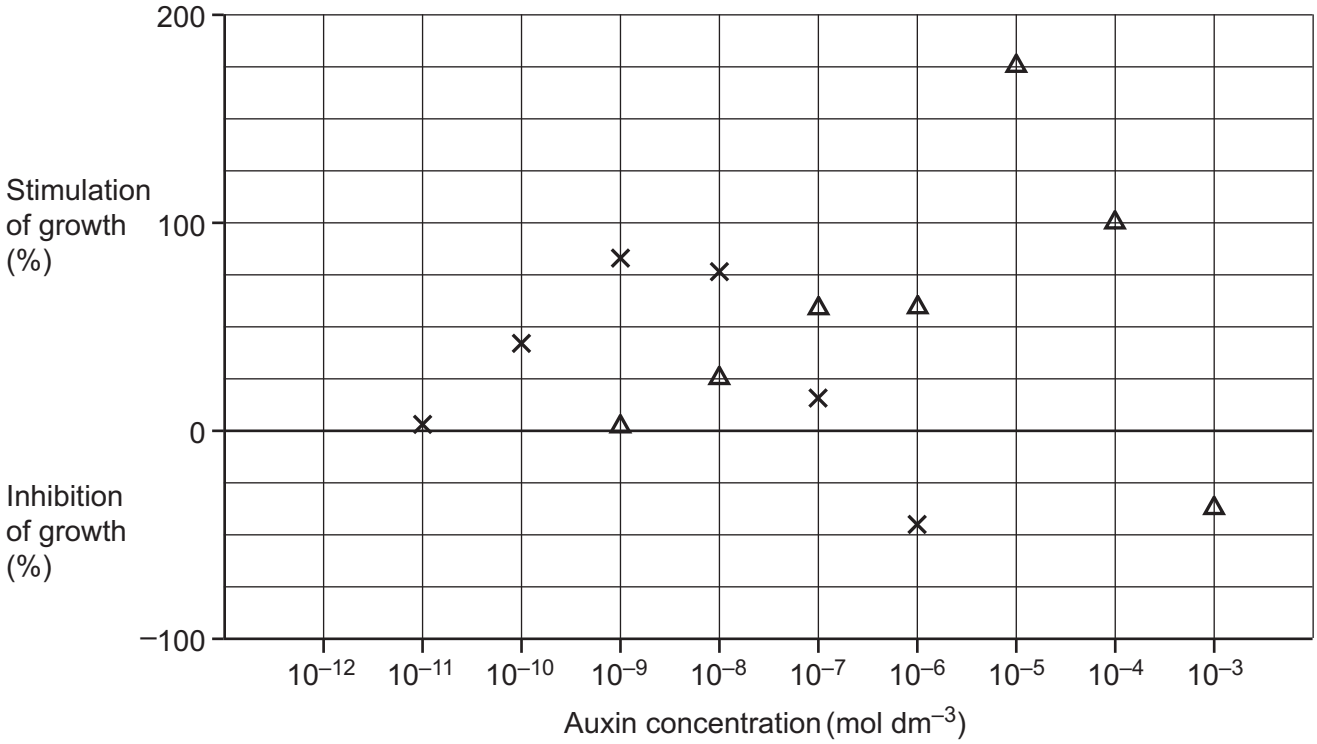
**(b)** The student investigated the effect of auxin concentration on the growth of shoots.

The student applied different concentrations of auxin to the apical shoot and the lateral shoots.

The student measured the percentage of growth stimulation or inhibition compared to normal.

Normal growth was represented by 0%.

The student's results are shown in the graph.




**Key:** × = lateral shoots

Δ = apical shoot

**(i)** Use the graph to estimate the auxin concentration at which inhibition of lateral shoots is 100%.

Auxin concentration = ..... mol dm$^{-3}$ **[1]**

**(ii)** The student identified a possible anomaly in their results: the data point for the apical shoot receiving $10^{-6}$ mol dm$^{-3}$ of auxin.

State what the student could do to determine whether this data point was an anomaly.

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..... **[1]**

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**(iii)** Using the graph, describe the conclusions that can be drawn about the role of different auxin concentrations in the control of apical dominance.

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**(c)** Another student plans to investigate the effect of gibberellin concentration on the rate of stem elongation in the pea plant, *Pisum sativum*.

**(i)** Suggest appropriate units for the dependent variable in this investigation.

..... **[1]**

**(ii)*** The student has access to standard laboratory equipment and planting materials.

Outline a method that the student could use to investigate the effect of gibberellin concentration on stem elongation in *P. sativum*.

In your answer, you should include details of an appropriate statistical test for this investigation.

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..... **[6]**

Additional answer space if required.

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**(d)** A friend of the student had an apple tree in their garden. The friend asked the student if there was a way to ripen the fruit on the apple tree more quickly so that it would be ready to eat within a few days.

The student gave this advice:

'You should spray the tree with ethene.'

Evaluate whether acting on the student's advice would produce fruit that was ready to eat within a few days.

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..... **[3]**

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**4** The sea sponge, *Aplysina aerophoba*, and the zebra shark, *Stegostoma fasciatum*, are both animals.

**(a)** *A. aerophoba* does not have an internal circulatory system. Instead, it filters food and oxygen from the surrounding water, as shown in **Fig. 4.1**.

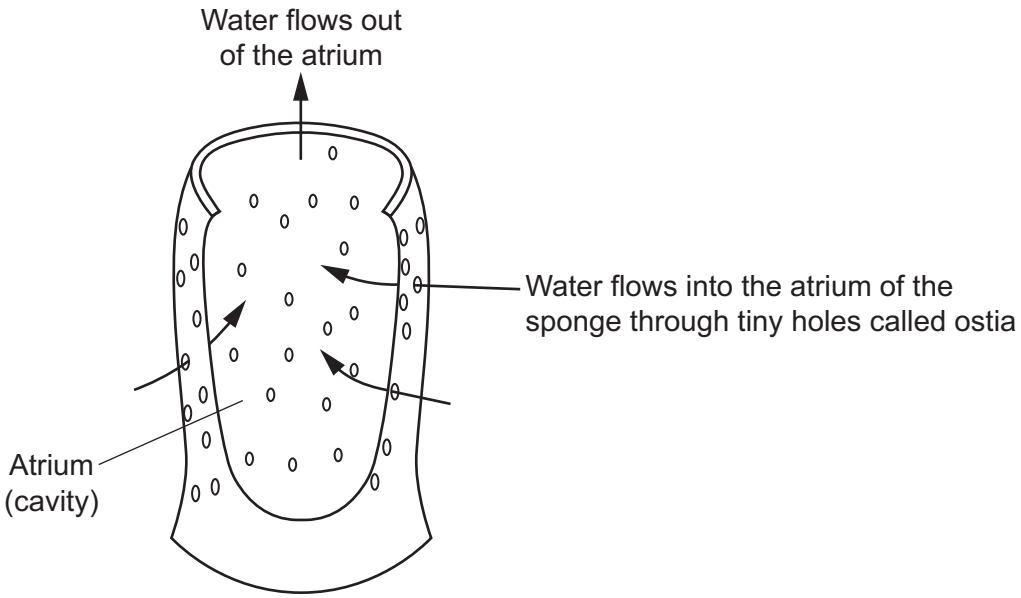



**Fig. 4.1**

**(i)** Suggest why *A. aerophoba* does not need a circulatory system.

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..... **[1]**

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**(ii)** A diagram of the circulatory system of *S. fasciatum* is shown in **Fig. 4.2**.

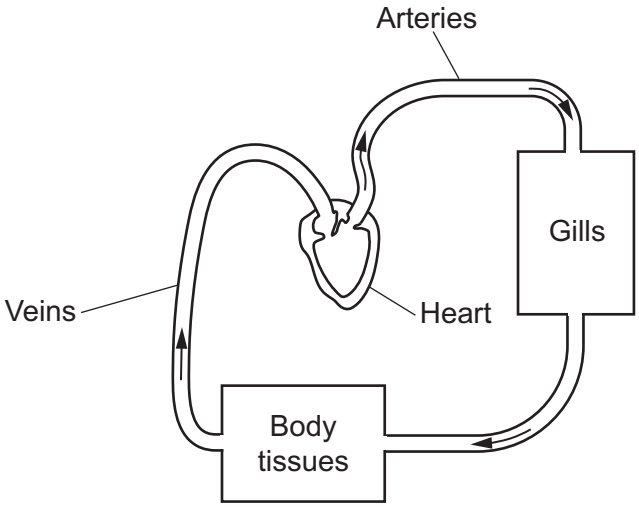



**Fig. 4.2**

Describe the type of circulatory system that *S. fasciatum* has.

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..... **[2]**

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**(b)** Both *A. aerophoba* and *S. fasciatum* reproduce sexually, but under particular conditions they are both able to reproduce asexually.

In asexual reproduction in *A. aerophoba*:
- clumps of diploid cells detach from the body of the sponge
- the cells reattach to a surface and grow into new, adult sponges.

In asexual reproduction in *S. fasciatum*:
- meiosis occurs in a female
- two of the haploid cells produced by meiosis fuse to form a diploid cell
- the diploid cell develops into a new shark.

A student stated, 'When they reproduce asexually, both animals produce clones of themselves.'.

Evaluate the student's statement.

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**(c)*** Humans can produce artificial clones of animals.

Describe **two** methods for producing artificial clones of animals.

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Additional answer space if required.

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**5** DNA must be extracted from cells before it can be analysed.

**(a)** The sentences describe how DNA is extracted from a sample of tissue.

Complete the sentences using the most appropriate words or phrases.

Detergent is used to break down ..... . Proteins,

such as histones, surrounding DNA can be hydrolysed by the addition of

..... . The DNA is precipitated from solution by adding

..... .

**[3]**

**(b)** DNA analysis can be used to assess genetic biodiversity within populations.

A scientist assessed genetic biodiversity in four populations, **A** to **D**, of yellow horn, which is a small tree. They used two measures of genetic biodiversity:

- the percentage of polymorphic gene loci
- observed heterozygosity (the proportion of heterozygous loci in a population)

and analysed 23 gene loci in each individual tree they sampled.

The results are shown in the table.

| Population | Number of trees sampled | Percentage of polymorphic loci | Observed heterozygosity |
|---|---|---|---|
| **A** | 6 | 86.96 | 0.68 |
| **B** | 16 | 100.00 | 0.66 |
| **C** | 6 | 91.30 | 0.63 |
| **D** | 6 | 100.00 | 0.80 |

Another scientist stated that these results may not allow an accurate assessment of genetic biodiversity in these four populations.

Identify **two** pieces of evidence that support this scientist's evaluation.

1 .....

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2 .....

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**[2]**

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**(c)** The Hardy-Weinberg principle can be used to calculate allele and genotype frequencies in populations.

The common morning glory plant, *Ipomoea purpurea*, has a range of flower colours.

Two colours, purple and pink, are determined by a single gene.

The allele, **F**, coding for purple flowers is dominant to the allele, **f**, coding for pink flowers.

A field contained 600 *I. purpurea* plants, 150 of which had pink flowers.

Using the Hardy-Weinberg principle, calculate the number of plants that had a homozygous dominant (FF) genotype.

Use the equations:

$p + q = 1$

$p^2 + 2pq + q^2 = 1$

Number of plants with genotype FF = ..... **[2]**

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**6** Haemoglobin is an important protein in many animals, including humans.

**(a)** Sickle cell disease (SCD) is a disease caused by the production of abnormal haemoglobin.

A treatment for SCD is based on a technique called CRISPR gene editing and allows SCD patients to begin production of fetal haemoglobin.

The treatment has the following steps:

- Bone marrow stem cells are removed from the patient with SCD.
- An enzyme called Cas9 is added to the stem cells.
- Cas9 deletes bases from the *BCL11A* gene.
- The *BCL11A* gene usually switches off the fetal haemoglobin gene in adults.
- The gene-edited stem cells are placed back in the patient.
- The patient can now produce fetal haemoglobin.

This CRISPR gene editing method is different from traditional genetic engineering, which uses restriction enzymes and plasmids.

Describe the similarities and other differences between CRISPR gene editing and traditional genetic engineering methods.

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..... **[4]**

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**(b)** Haemoglobin plays a crucial role in transporting oxygen in animals. Several ions also have roles in oxygen transport.

Three ions are listed in the table below.

Place ticks (✓) in the correct boxes to indicate which properties and features are true for each ion.

| Ion | Has a negative charge | Binds to haemoglobin | A product of the dissociation of carbonic acid | Involved in the chloride shift |
|---|---|---|---|---|
| **Hydrogen** | | | | |
| **Hydrogencarbonate** | | | | |
| **Chloride** | | | | |

**[3]**

**END OF QUESTION PAPER**

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## ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

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