# A-Level Biology

## Genetic Diversity and Natural Selection

### Question Paper

**Time available: 62 minutes**
**Marks available: 54 marks**

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**1.** The fruit fly is a species of small insect.

The fruit fly has a gene that codes for an enzyme called alcohol dehydrogenase (AD). AD catalyses the breakdown of alcohol when alcohol is in the insects' food.

The gene coding for AD has two alleles, **$AD^F$** and **$AD^S$**.

(a) The enzyme encoded by the **$AD^F$** allele catalyses the breakdown of alcohol **faster** than the enzyme encoded by the **$AD^S$** allele. Suggest why.

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**(3)**

A scientist took a random sample of adult fruit flies from a population. He measured the frequency of the **$AD^F$** allele in this sample (generation 0). He then:

- selected 100 of these insects at random and kept them in a container
- fed the insects food containing alcohol
- let the insects reproduce
- repeated these steps for 45 generations of fruit fly reproduction.

The scientist measured the frequency of the **$AD^F$** allele in the 45th generation.

(b) Suggest why the scientist took his sample from the population at random.

**(1)**

The table below shows the scientist's results.

| Generation of fruit fly reproduction | Frequency of $AD^F$ |
|---|---|
| 0 | 0.20 |
| 45 | 0.74 |

(c) Alcohol is toxic to fruit flies. Suggest and explain why the frequency of the **$AD^F$** allele changed during the 45 generations.

**(4)**

(d) Identify the type of selection investigated in the 45 generations of fruit fly reproduction.

Tick (✓) **one** box.

No selection ☐

Directional selection ☐

Random selection ☐

Stabilising selection ☐

**(1)**

**(Total 9 marks)**

**2.** A scientist investigated birth mass in a population of babies. She determined the birth mass ($b$) of babies and grouped this information into different ranges of birth mass.

Her results are shown in the table below.

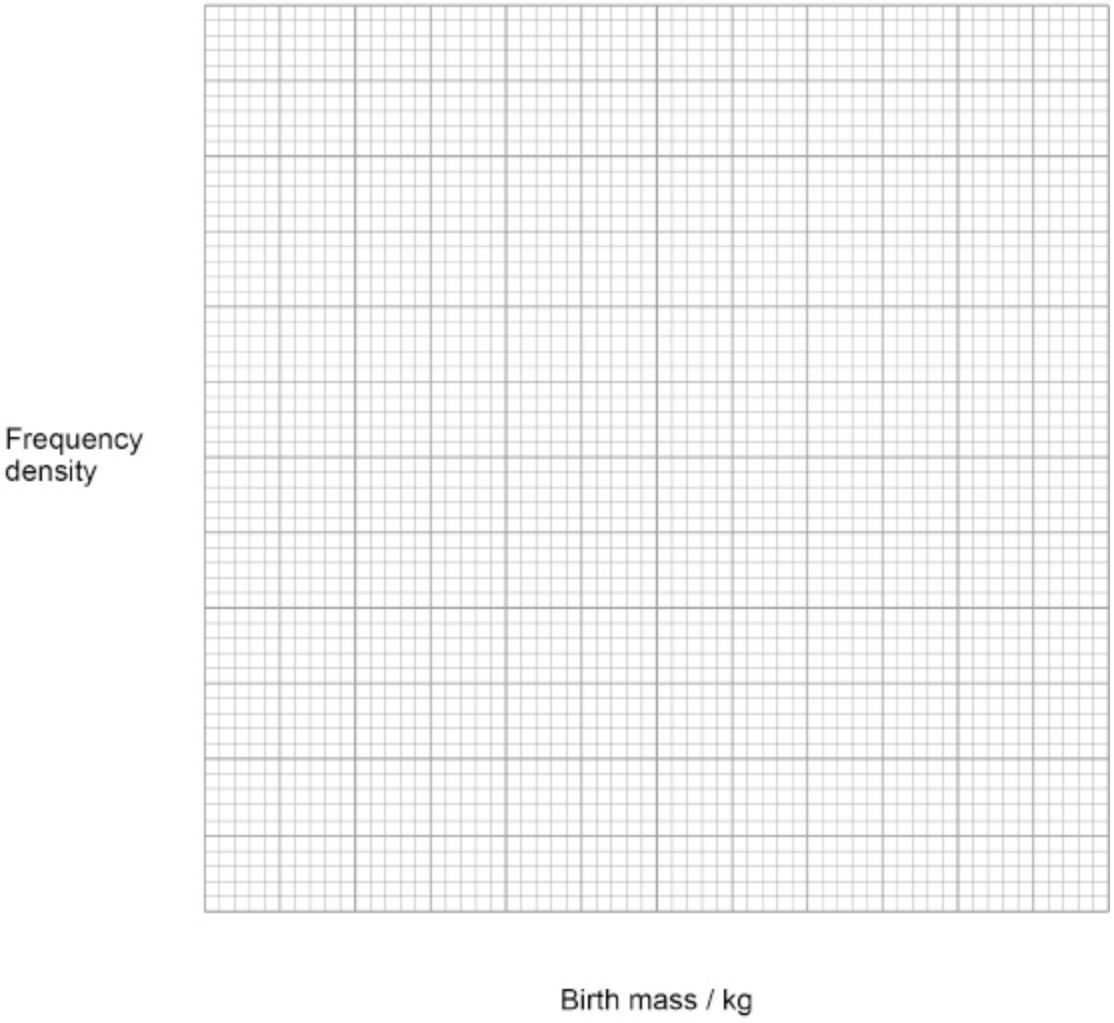
| **Birth mass *b* / kg** | **Range of mass / kg** | **Frequency density** |
|---|---|---|
| $0.0 < b \leqslant 2.0$ | 2.0 | 5 000 |
| $2.0 < b \leqslant 2.5$ | 0.5 | 20 000 |
| $2.5 < b \leqslant 3.0$ | 0.5 | 90 000 |
| $3.0 < b \leqslant 3.5$ | 0.5 | 260 000 |
| $3.5 < b \leqslant 4.5$ | 1.0 | 200 000 |
| $4.5 < b \leqslant 5.5$ | 1.0 | 20 000 |

Frequency density is calculated using this equation

$$\text{Frequency density} = \frac{\text{number of babies}}{\text{range of mass}}$$

(a) Draw, on **Figure 1**, a **suitable** chart to show the distribution of birth mass for this population of babies.

**Figure 1**




**(4)**

(b) Babies with birth mass less than 2.5 kg are classified as low birth mass.

Use information in the table above and the equation to calculate the number of babies born with low birth mass in this population.

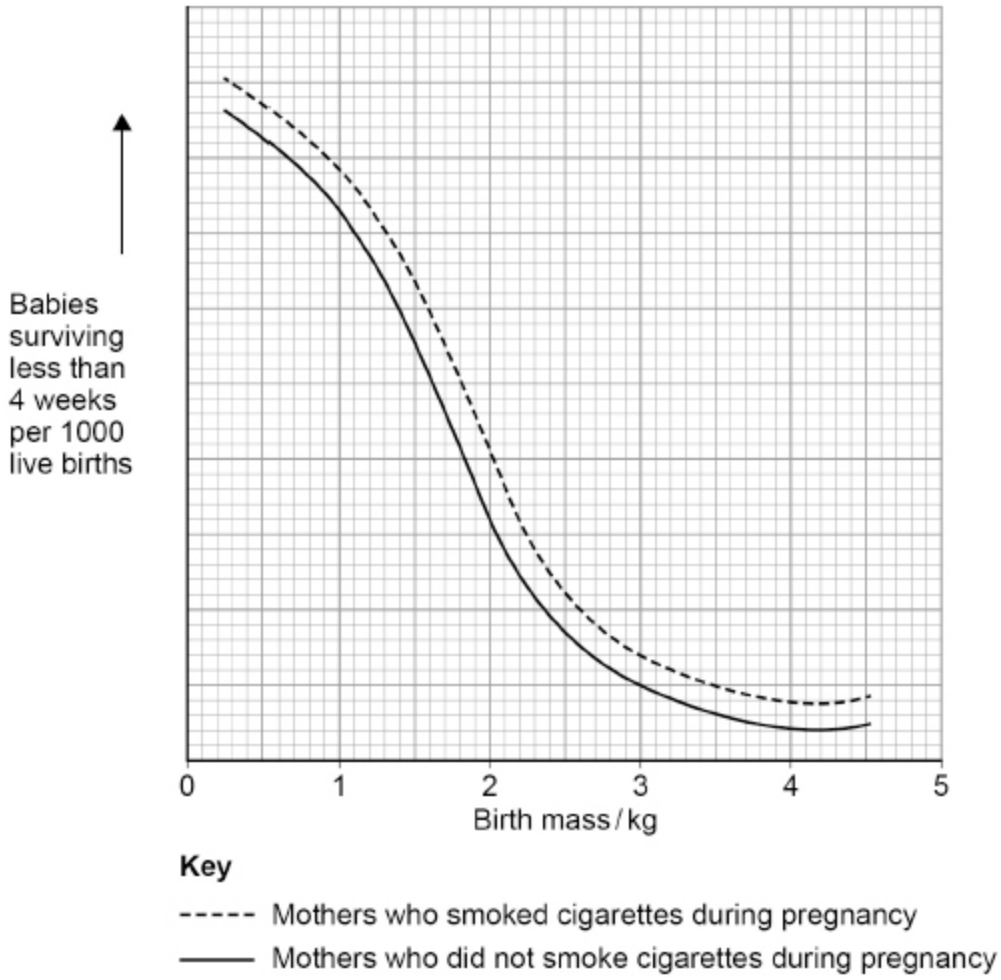
Show your working.

Answer _____

**(2)**

The scientist also measured the relationship between birth mass and babies surviving less than 4 weeks. She determined if the mothers of these babies smoked cigarettes during pregnancy. Her results are shown in **Figure 2**.

**Figure 2**




(c) State **three** conclusions that can be drawn from the data in **Figure 2**.

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2 _____

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3. _____

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**(3)**

**(Total 9 marks)**

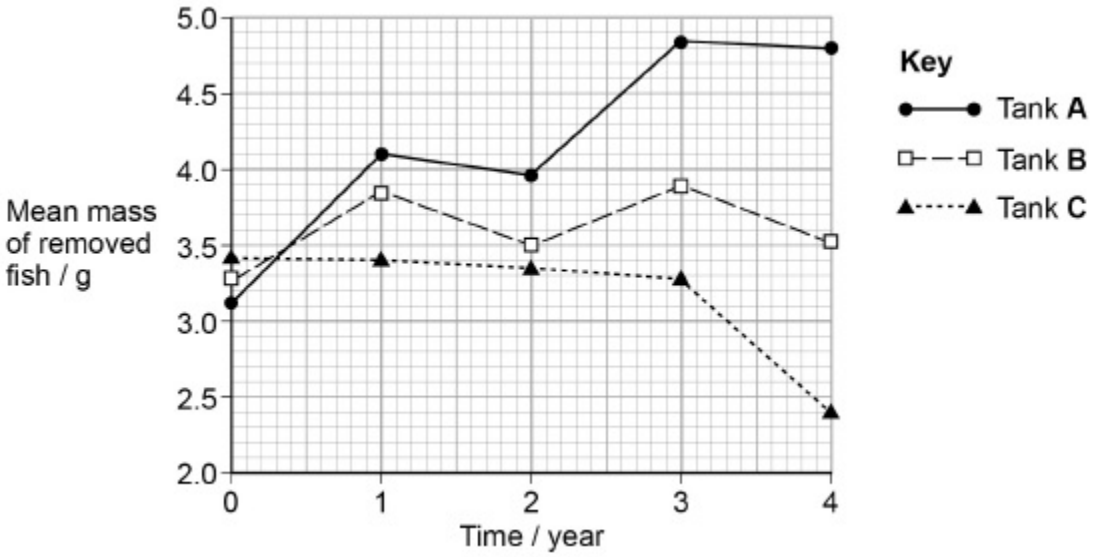
**3.** Scientists investigated changes in the mass of fish from three populations of the same species. The fish they used had a life cycle of one year.

The scientists set up three fish tanks, each containing a separate population. Each year the scientists removed all the fish from each tank and determined the mean mass of the fish removed. They then put back 10% of each population in the following way.

Tank **A** – put back only the largest fish.
Tank **B** – put back fish at random.
Tank **C** – put back only the smallest fish.

During each year the fish were left to grow and reproduce.

The scientists' results are shown in the graph.




(a) What type of selection were the scientists modelling in this investigation by putting back only the largest or only the smallest fish in Tank **A** and Tank **C**? Give a reason why.

Type of selection _____

Reason _____

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**(2)**

(b) Explain the purpose of Tank **B**.

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**(2)**

(c) Calculate the ratio of the mean mass of fish removed from Tank **A** to the mean mass of fish removed from Tank **C** at 1 year **and** at 4 years.

How much greater is the ratio at 4 years compared with the ratio at 1 year?

Ratio at 1 year = _____

Ratio at 4 years = _____

How much greater at 4 years = _____

**(2)**

(d) Sea fishing is regulated in law. The size of the mesh used in some fishing nets is controlled so that small fish can escape but large fish are captured. This regulation is designed to protect populations of wild fish.

Using all the information in this question, evaluate whether the scientists' investigation supports the use of these types of nets in sea fishing.

**(3)**

**(Total 9 marks)**

**4.** (a) What is the name of a position of a gene on a chromosome?

**(1)**

(b) What is meant by genetic diversity?

**(1)**

A geneticist investigated genetic diversity in four different breeds of dog. She compared DNA base sequences of the same genes from a large number of dogs from each breed.

The geneticist calculated the mean genetic diversity for each breed of dog. The value of this mean was between 0 and 1.

- A mean value of 1 shows maximum genetic diversity.
- A mean value of 0 shows no genetic diversity.

Her results are shown in the table

| **Breed of dog** | **Mean genetic diversity** | **Standard deviation** |
|---|---|---|
| Airedale terrier | 0.51 | ± 0.03 |
| Bull terrier | 0.38 | ± 0.02 |
| Jack Russell terrier | 0.76 | ± 0.01 |
| Miniature terrier | 0.47 | ± 0.02 |

(c) What do these data show about the differences in genetic diversity between these breeds of dog?

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**(3)**

(d) Miniature terriers were first bred from bull terriers in the 19th century.

Suggest **one** explanation for the observed difference in genetic diversity between miniature terriers and bull terriers.

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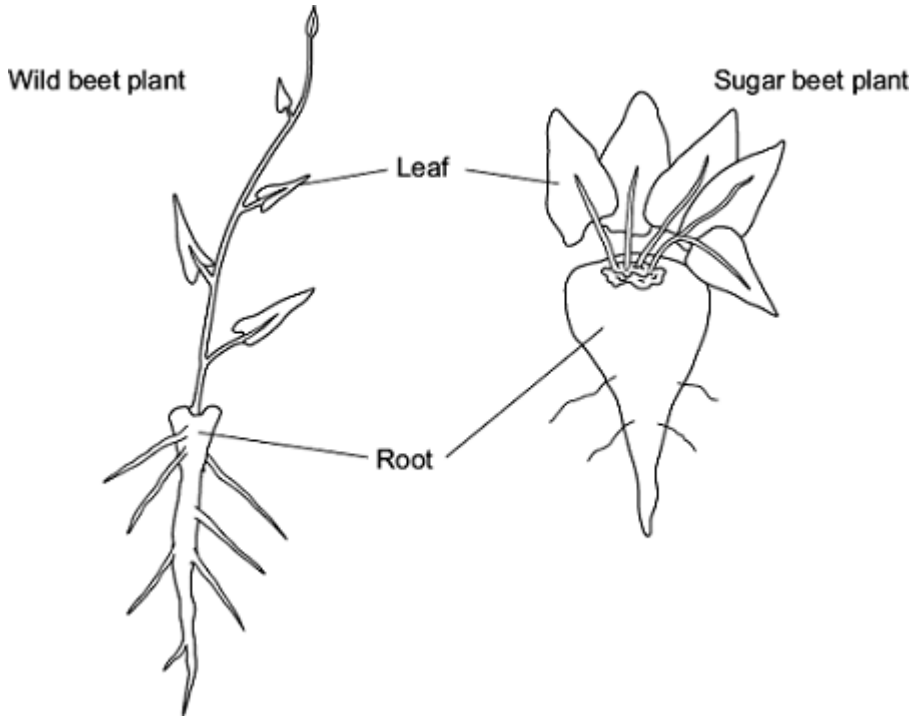
**(2)**

**(Total 7 marks)**

**5.** Sugar beet is a crop grown for the sugar stored in its root. The sugar is produced by photosynthesis in the leaves of the plant. Plant breeders selected high-yielding wild beet plants. They used these plants to produce a strain of sugar beet to grow as a crop.

The drawings show a wild beet plant and a sugar beet plant. The drawings are to the same scale.




(a) Use the drawings to describe **two** ways in which a sugar beet plant is different from a wild beet plant.

Explain how each of these differences would give an increased yield of sugar.

Difference 1 _____

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Explanation _____

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Difference 2 _____

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Explanation _____

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**(4)**

(b) Sugar beet plants have been selected for a faster rate of growth.

Suggest how the faster rate of growth may increase profit for a farmer.

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**(1)**

(c) Describe and explain how selection will have affected the genetic diversity of sugar beet.

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**(2)**

**(Total 7 marks)**

**6.**

(a) Explain what is meant by genetic diversity.

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**(1)**

(b) Apart from genetic factors what other type of factor causes variation within a species?

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**(1)**

(c) The spotted owl is a bird. Numbers of spotted owls have decreased over the past 50 years. Explain how this decrease may affect genetic diversity.

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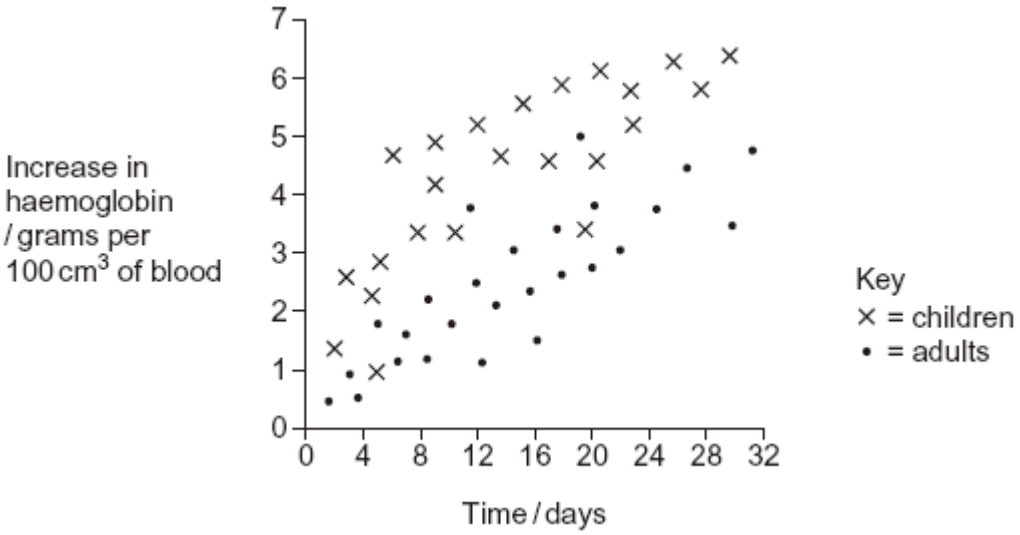
**(2)**

**(Total 4 marks)**

**7.** (a) Haemoglobin contains iron. One type of anaemia is caused by a lack of iron. This type of anaemia can be treated by taking tablets containing iron. A number of patients were given a daily dose of 120 mg of iron. **Figure 1** shows the effect of this treatment on the increase in the concentration of haemoglobin in their red blood cells.

**Figure 1**




(i) Give **one** difference in the response of adults and children to this treatment.

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**(1)**

(ii) You could use the graph to predict the effect of this treatment on the increase in haemoglobin content of an adult after 40 days. Explain how.

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**(2)**

(iii) Haemoglobin has a quaternary structure. Explain what is meant by a quaternary structure.

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**(1)**

(b) (i) Pernicious anaemia is another type of anaemia. One method of identifying pernicious anaemia is to measure the diameter of the red blood cells in a sample of blood that has been diluted with an isotonic salt solution. Explain why an isotonic salt solution is used to dilute the blood sample.

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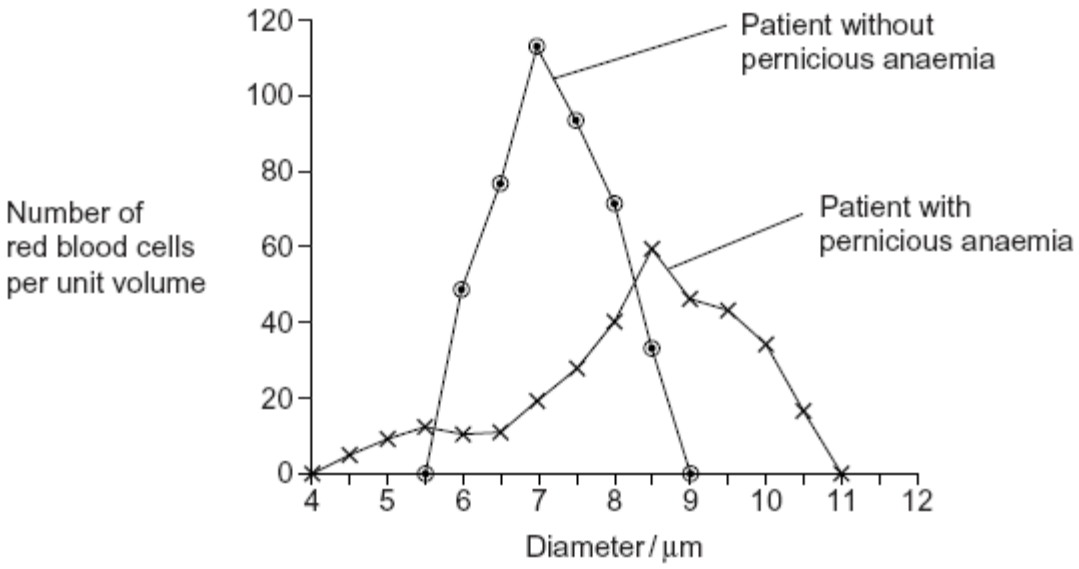
**(3)**

(ii) A technician compared the red blood cells in two blood samples of equal volume. One sample was from a patient with pernicious anaemia, the other was from a patient who did not have pernicious anaemia. **Figure 2** shows some of the results she obtained.

**Figure 2**




Describe **two** differences between the blood samples.

1. _____

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2. _____

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**(2)**

**(Total 9 marks)**