Q1.

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, $\mathbf{AD^F}$ and $\mathbf{AD^S}$.

(a) The enzyme encoded by the $\mathbf{AD^F}$ allele catalyses the breakdown of alcohol **faster**

than the enzyme encoded by the $\mathbf{AD^S}$ 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 $\mathbf{AD^F}$ 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 $\mathbf{AD^F}$ allele in the 45th generation.

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

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(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)

Q2.

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.

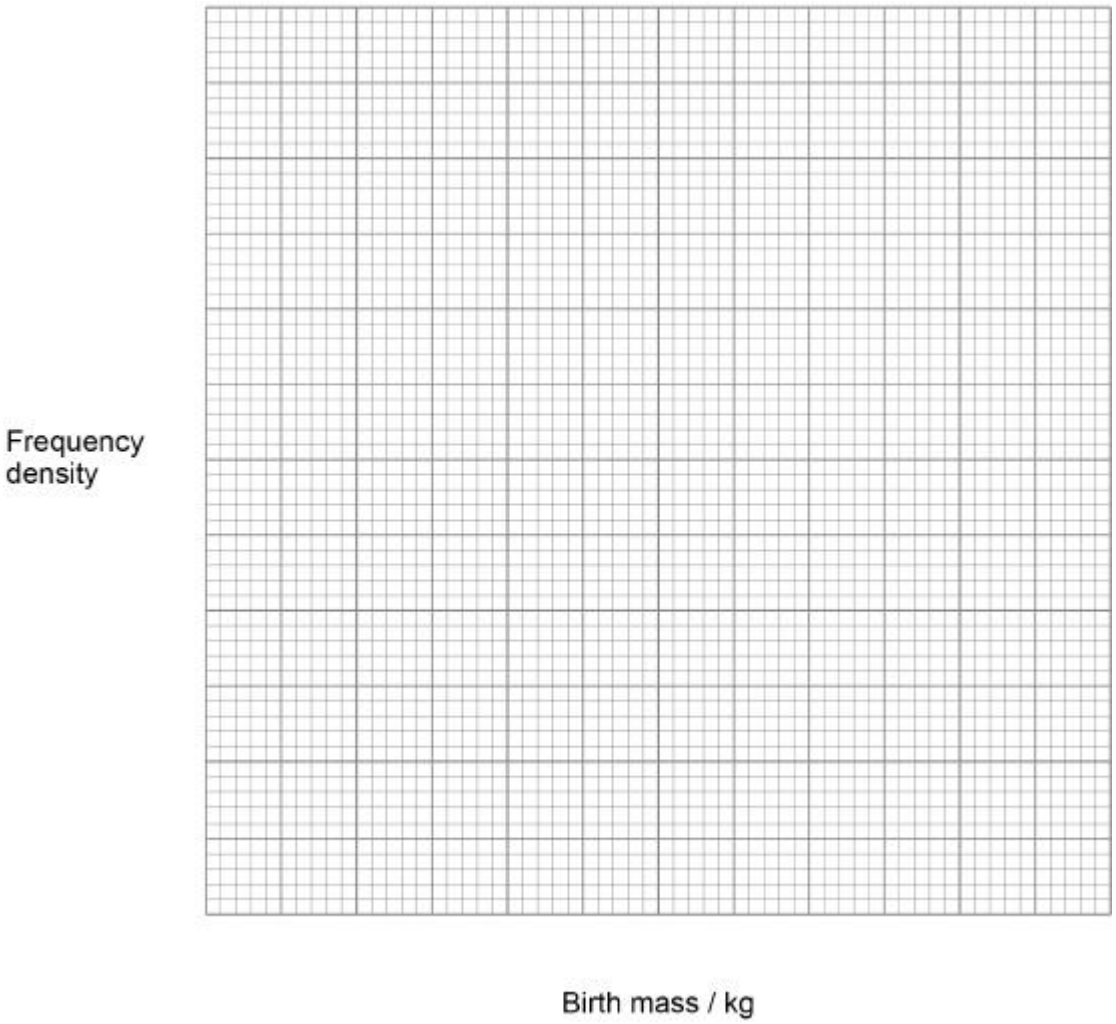
Birth mass *b* / kg	**Range of mass / kg**	**Frequency density**
$0.0 < b \leqslant 2.0$	2.0	5 000
$2.0 < b \leqslant 2.5$	0.5	20 000
$2.5 < b \leqslant 3.0$	0.5	90 000
$3.0 < b \leqslant 3.5$	0.5	260 000
$3.5 < b \leqslant 4.5$	1.0	200 000
$4.5 < b \leqslant 5.5$	1.0	20 000

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.

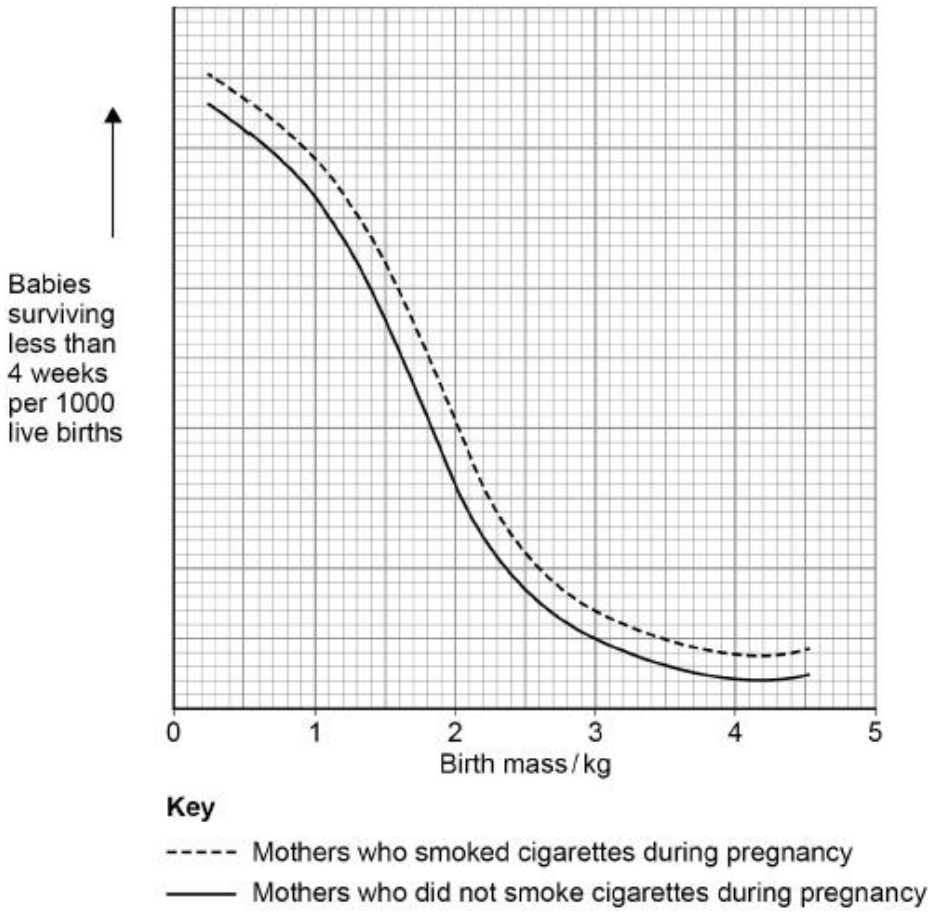
Show your working.

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)

Q3.

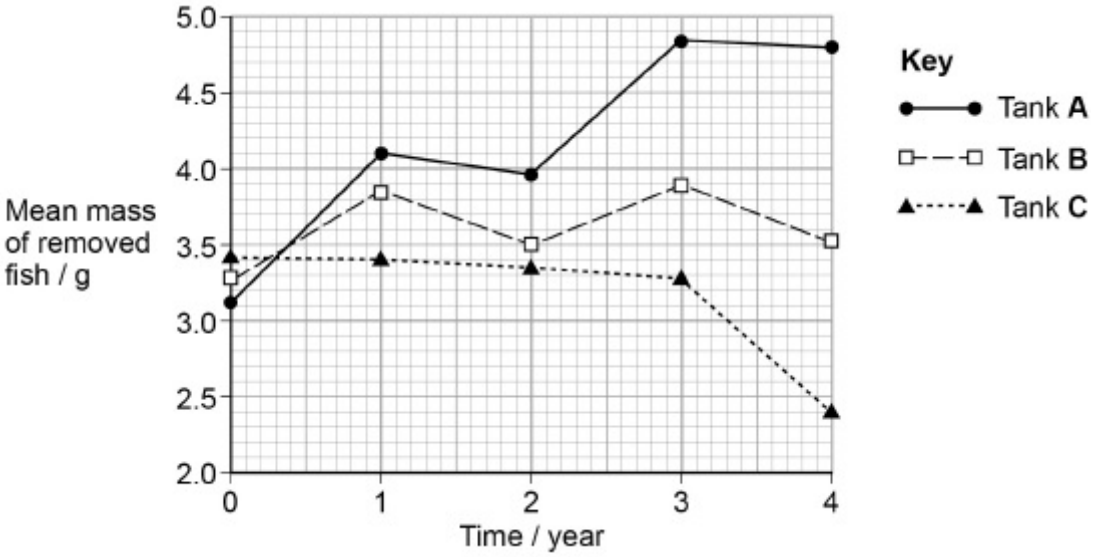
Scientists investigated changes in the mass of fish from three populations of the same species. The fish they used had a life cycle of one year.

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)

Q4.

(a) A student used a dilution series to investigate the number of cells present in a liquid culture of bacteria.

Describe how he made a 1 in 10 dilution and then used **this** to make a 1 in 1000 dilution of the original liquid culture of bacteria.

(3)

(b) Using an optical microscope, the student determined there were 15 cells in 0.004 mm^3 of the 1 in 1000 dilution of the culture.

Calculate the number of cells in 1 cm^3 of undiluted liquid culture.

Answer = _____ Number of cells

(2)

(c) The student looked at cells in the 1 in 10 dilution during his preliminary work. He decided **not** to use this dilution to determine the number of cells in the undiluted liquid culture.

Suggest an explanation for the student's decision.

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(2)

(d) On some farms, animals are routinely given antibiotics in their food.

Scientists investigated whether these farm animals had antibiotic-resistant bacteria in their intestines. They tested the bacteria for resistance to two antibiotics, tetracycline and streptomycin.

Their results are shown in the table.

Antibiotic	**Percentage of antibiotic-resistant bacteria**
Tetracycline	29
Streptomycin	13

Suggest and explain **one** reason why bacteria resistant to tetracycline are more common than bacteria resistant to streptomycin in these farm animals.

(2)

(e) In recent years, these farm animals have not been given tetracycline in their food. Despite this, the percentage of bacteria resistant to tetracycline has remained constant.

Suggest **one** reason why.

(1)

(Total 10 marks)

Q5.

Lactose is the main sugar in milk and is hydrolysed by the enzyme lactase. Lactase is essential to newborn mammals as milk is their only source of food. Most mammals stop producing lactase when they start feeding on other food sources. Humans are an exception to this because some continue to produce lactase as adults. The ability to continue producing lactase is known as lactase persistence (LP) and is controlled by a dominant allele. A number of hypotheses based on different selection pressures have been put forward to explain LP in humans.

(a) One hypothesis for LP in humans suggests that the selective pressure was related to some human populations farming cattle as a source of milk.

Describe how farming cattle as a source of milk could have led to an increase in LP.

(4)

(b) Use the information provided to explain why the number of people showing LP would **rapidly** increase once selection for this condition had been established.

(2)

(c) Lactase persistence is caused by a mutation in DNA. This mutation does not occur in the gene coding for lactase.

Suggest and explain how this mutation causes LP.

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(2)

(Total 8 marks)