Model Answers: Medium

1a

a) The purpose of the islands without snakes was…

- (To serve) as a control; [1 mark]
- To demonstrate that the claw length (of the mice) remained unchanged in the absence of snakes **OR** to demonstrate that the presence of snakes (and not any other variable) led to an increase in claw length; [1 mark]

[Total: 2 marks]

In scientific investigations, the control is the test group that does not receive treatment. Without the control group there would be nothing to compare the treatment group to, and therefore no way of being sure that the change observed in the dependent variable (in this case the claw length of the mice) is due to the experimental treatment (the presence of snakes).

1b

b) A mutation could lead to a change in claw length by…

- (A mutation) changes the base sequence / triplet code (of DNA); [1 mark]
- (A mutation) may result in a new allele; [1 mark]
- The new allele codes for a different protein / a protein with an altered structure (which affects the growth/length of the claws); [1 mark]

[Total: 3 marks]

1c

c) i) The type of selection that occurred on the snake infested islands was…

- Directional (selection); [1 mark]

c) ii) The reason for this is that…

- The allele frequency for long claws increased over time / there was selection pressure for long claws **OR** allele frequency for short claws decreased over time / there was selection against short claws; [1 mark]

[Total: 2 marks]

With directional selection, there is a gradual change in the allele frequency of a population over time that causes the phenotype to shift in a single direction. This typically occurs when there is a change in the environment (e.g. introduction of snakes) or when a new advantageous allele appears in the population.

1d

d) The effect of the introduction of snakes on an island without trees would be…

Any **three** of the following:

- Claw length would decrease / claws would become shorter (over time); [1 mark]
- Mice with short claws have a (selective) advantage as they can run faster (than snakes) **OR** mice with long claws have a (selective) disadvantage as they would be too slow to escape (from snakes); [1 mark]
- Mice with short claws are more likely to survive and reproduce **SO** passing on the allele for short claws **OR** mice with long claws are less likely to survive and reproduce **SO** will not pass on the allele for long claws; [1 mark]
- The short claw allele will increase in frequency **OR** the long claw allele will decrease in frequency; [1 mark]

[Total: 3 marks]

This question requires you to describe the process of natural selection while applying it to the example that is given. Mice with short claws will have an advantage over those with long claws that cannot run as fast. Short claw mice will have a greater chance of surviving and reproducing. The **allele** for short claws will be passed down to their offspring leading to a change in allele **frequency** in favour of short claws over time.

2a

a) The process that is affecting the allele frequency of the mango tilapia population is:

- (The) bottleneck effect / population bottleneck; [1 mark]

[Total: 1 mark]

2b

b) The effect of the bottleneck effect would be...

Any **two** of the following:

- It reduces the genetic diversity in the population **OR** alleles are lost from the population (due to the reduction in population size) **OR** the gene pool within a population shrinks/gets smaller; [1 mark]
- This makes the species less able to respond to environmental changes **OR** increases the risk of (local) extinction of the population; [1 mark]
- Inbreeding will occur; [1 mark]

[Total: 2 marks]

Genetic diversity is important as it increases the resilience of a population to environmental changes. The lack of genetic diversity that results from the bottleneck effect makes populations more susceptible to extinction if there is a change in their environment.

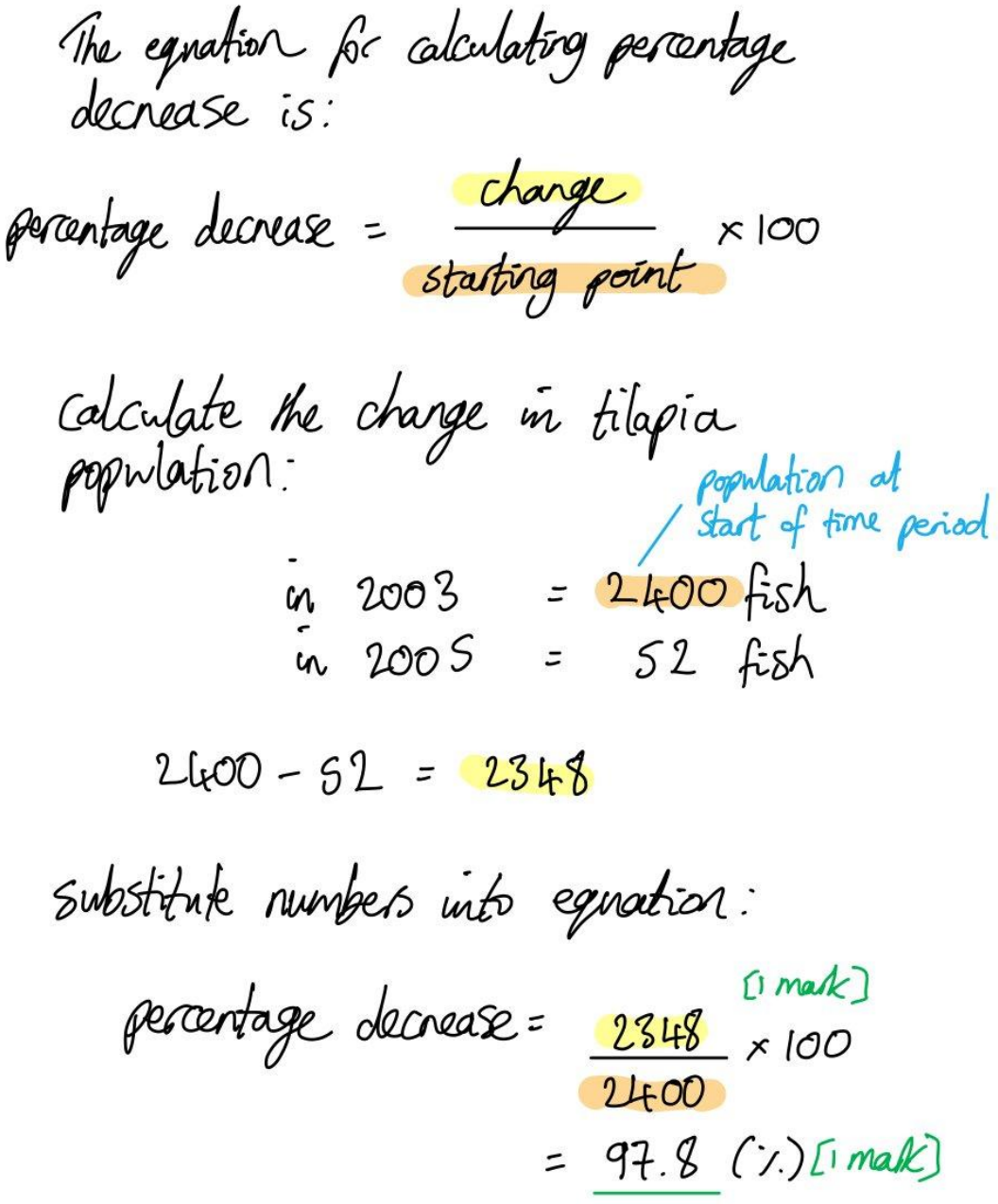
2c

c) The percentage decrease in tilapia numbers can be calculated as follows...

- 2348 ÷ 2400; [1 mark]
- 97.8 (%); [1 mark]

Full marks awarded for the correct answer in the absence of other calculations.

[Total: 2 marks]



2d

d) The introduction of predatory fish that mainly prey on mango tilapia of medium body size would have the following effect...

Any **four** of the following:

- There would be an increase in small **and** large sized tilapia **OR** there would be a decrease in medium sized tilapia; [1 mark]
- Due to disruptive selection; [1 mark]
- Small **and** large sized tilapia would have a higher probability of surviving and reproducing / they would have increased fitness **OR** medium sized tilapia would have a lower probability of surviving and reproducing / they would have decreased fitness; [1 mark]
- The alleles for small and large body size would be passed on (to their

offspring) **OR** the alleles for medium body size would not be passed on (to offspring); [1 mark]

- the allele frequency of small and large alleles would increase / the small and large alleles would increase in frequency (in the population) **OR** the allele frequency of medium alleles would decrease / the medium alleles would decrease in frequency (in the population); [1 mark]

[Total: 4 marks]

Since there is a selection pressure against tilapia with an intermediate body size this would be an example of disruptive selection. Those with small or large body sizes would have a selective advantage and would have a higher chance of surviving long enough to reproduce and pass their small or large alleles on to their offspring. Over time there would be an increase in small and large allele frequencies and in the proportion of tilapia that fall into the two extreme categories for body size.

3a

a) The trend in antibiotic resistance that can be observed in Fig. 1 shows...

Any **four** of the following:

- There was an overall increase in antibiotic resistance observed in both Greece and Italy; [1 mark]
- Resistance levels are higher in Greece than in Italy; [1 mark]
- Greece had a decrease in antibiotic resistance between 2007 and 2008 **AND** 2011 and 2012; [1 mark]
- Antibiotic resistance was low in Italy until 2009, after which there was a (steep) increase **OR** antibiotic resistance in Italy did not start to increase until 2009; [1 mark]
- Data points correctly quoted to support any of the above statements (e.g. mark points 1 or 2 could be supported by 'resistance in Greece increases from 31% in 2006 to 59% in 2013 and resistance in Italy increases from 1% in 2006 to 32% in 2013'); [1 mark]

[Total: 4 marks]

When asked to describe trends in data, remember to discuss whether there was an overall increase or decrease observed. Mention anything that stands out, such increases or decreases that do not fit the overall trend. or a levelling off in the data. Quoting data points from the graph to support your descriptions will always be worth at least one mark.

3b

b) The widespread use of antibiotics can lead to the development of antibiotic resistance in bacteria in the following ways:

Any **three** of the following:

- Alleles that give resistance to antibiotics are present (at random) / (random) mutation gives rise to antibiotic resistance alleles (in bacterial populations; [1 mark]
- Antibiotics act as a selection pressure for resistant bacteria / select bacteria with resistance (alleles); [1 mark]
- These bacteria are more likely to survive and reproduce **SO** passes the resistant alleles on to their offspring **OR** non-resistant bacteria are killed and do not reproduce **SO** does not pass on their alleles; [1 mark]
- The resistance alleles become more frequent / increase in frequency in the

population; [1 mark]

Reject *any answer point that suggests that antibiotic use causes antibiotic resistance*

[Total: 3 marks]

3c

c) Antibiotic resistance can be transferred between different species of bacteria in the following way…

Any **two** of the following:

- Alleles for antibiotic resistance can be found on plasmids; [1 mark]
- Plasmids can be transferred between bacteria (of different species); [1 mark]
- (This mechanism is known as) horizontal gene transfer; [1 mark]

[Total: 2 marks]

4a

a) The allele frequencies for the tomato population can be calculated as follows…

- q = 0.45; [1 mark]
- p = 1 - 0.45; [1 mark]
- p = 0.55; [1 mark]

Full marks can be awarded for the correct answers for p and q in the absence of other calculations.

[Total: 3 marks]

Allele frequencies:

$$p + q = 1$$

- p: dominant (B)
- q: recessive (b)

Genotype frequencies:

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

- p^2: homozygous dominant (BB)
- $2pq$: heterozygous (Bb)
- q^2: homozygous recessive (bb)

In Hardy-Weinberg questions, start by working out what information the question provides:

In tomato plants the gene that codes for stem colour has two alleles. Allele **B** codes for a purple stem, while allele **b** codes for a green stem in tomato plants. A farmer growing tomatoes in a greenhouse, noticed that about 20% of the tomatoes had green stems.

This is the homozygous recessive genotype so is represented by q^2

$q^2 = 20\% = 0.2$ — convert to a proportion

Next, work out what the question is asking you to calculate:

Calculate the allele frequencies in this population.

These are represented by p and q

use q^2 to calculate q:

$q^2 = 0.2$

$q = \sqrt{0.2}$ — the square root of $q^2 = q$

$= 0.45$ [1 mark]

use q to calculate p:

$p = 1 - q$ — $p + q = 1$

$= 1 - 0.45$ [1 mark]

$= 0.55$ [1 mark]

4b

b) The Hardy-Weinberg principle would not apply to the tomato population because....

- There is a selection pressure against the purple-stemmed tomato plants / (artificial) selection is acting on the population (by the farmer); [1 mark]
- Non-random mating is occurring / only green stemmed tomato plants are allowed to reproduce; [1 mark]

[Total: 2 marks]

Hardy-Weinberg assumptions about selection and non-random mating are not being met here and there will be a change in the allele frequencies in this population. This means that

the Hardy-Weinberg principle, and therefore equations, will not apply to this population.

4c

c) The homozygous recessive individuals can be recognised in the tomato population because…

- The tomato plants with genotypes BB/homozygous dominant and Bb/heterozygous will have the same phenotype **OR** purple stemmed tomatoes can be homozygous dominant or heterozygous; [1 mark]
- This is because the dominant allele (B) will mask the presence of the recessive allele (b) in (the phenotype of) heterozygous individuals **OR** the recessive allele (b) will not be expressed (in the phenotype of) heterozygous individuals; [1 mark]

[Total: 2 marks]

4d

d) The proportion of heterozygous individuals can be calculated as follows:

- 2 x 0.55 x 0.45 **OR** 0.495; [1 mark]
- 0.5; [1 mark]

Full marks awarded for the correct answer in absence of other calculations.

[Total: 2 marks]

The frequency of heterozygous individuals is represented by:

$2pq$

from part a)

$p = 0.55$

$q = 0.45$

Calculate $2pq$:

$2pq = 2 \times 0.55 \times 0.45$ OR [1 mark]

$= 0.495$

$= 0.5$ [1 mark]

5a

a) Artificial selection resulted in the development of Dorper sheep as follows...

Any **four** of the following:

- Humans selected (individuals showing) desired characteristics of high fertility in Dorset Horn sheep **AND** (fast growth and) heat/aridity tolerance in Blackhead Persian sheep; [1 mark]
- (They) bred Dorset Horn and Blackhead Persian / the two breeds of sheep together; [1 mark]
- The offspring that displayed the desired characteristics (of fast growth rate, high fertility, and tolerance to heat/arid conditions) were bred together; [1 mark]
- This process was repeated over many generations; [1 mark]
- The desired alleles increase in frequency in the population; [1 mark]

[Total: 4 marks]

In artificial selection humans act as the selective agent instead of selection pressures in

nature. By selecting and crossbreeding individuals with the desired characteristics over many generations a new breed is established. Most individuals in that population will display the favourable characteristics that were chosen due to the high frequency of the desired alleles.

5b

b) Other characteristics that may be selected for in sheep include...

Any **two** of the following:

- Docility / good natured personality; [1 mark]
- High quality wool / fast wool growth; [1 mark]
- High quality / fast meat production; [1 mark]
- Disease resistance; [1 mark]

[Total: 2 marks]

5c

c) The negative impacts of inbreeding include the following...

Any **two** of the following:

- (It may lead to) inbreeding depression **OR** a lack of hybrid vigour; [1 mark]
- There is a greater chance that harmful recessive alleles will be inherited together / expressed; [1 mark]
- There will be less genetic variation **OR** no new alleles will be introduced into the population; [1 mark]

[Total: 2 marks]

6a

a) Environmental factors that may prevent further increases in the size of red deer populations include.....

Any **three** of the following:

- Predation; [1 mark]
- Competition for food / decrease in food availability; [1 mark]
- Disease; [1 mark]
- Habitat loss/reduction / lack of breeding sites; [1 mark]
- Pesticide/herbicide use; [1 mark]
- Climate change; [1 mark]

[Total: 3 marks]

6b

b) i) A curve drawn on Fig. 3 to show the pattern of variation of body mass in this red deer population after many years of a selection pressure acting against red deer of low body mass would have the following appearance...

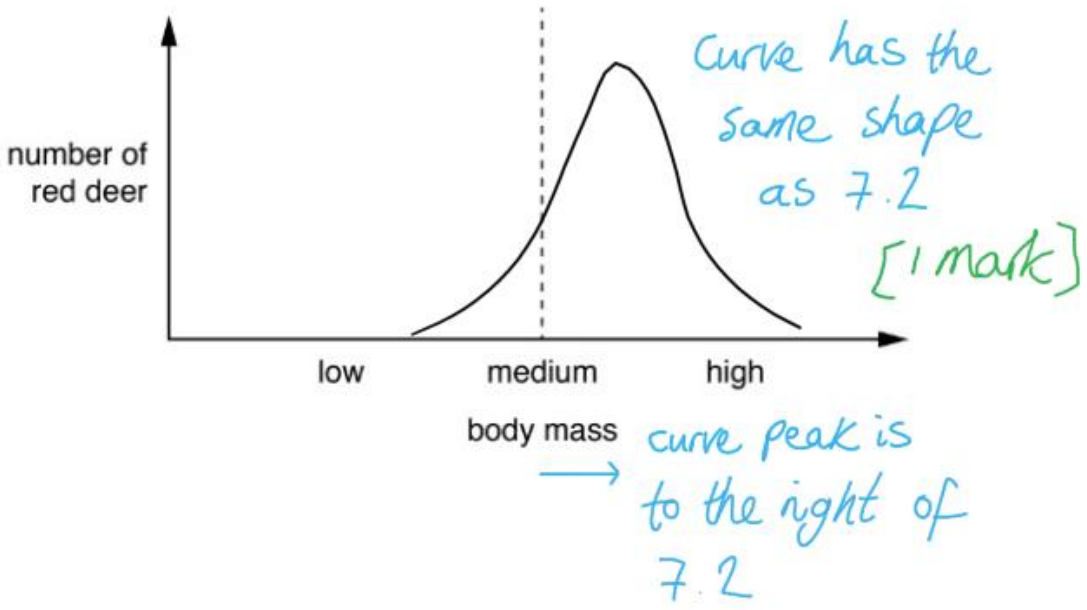
- A curve that has the same shape as that shown in Fig. 2 **AND** that is further to the right; [1 mark]

b) ii) The type of force of natural selection that is acting on this population is...

- Directional (selection); [1 mark]

[Total: 2 marks]

i) The curve should be drawn as follows...



ii) Selection acting against deer of low body mass (e.g. a predator that picks off smaller, weaker individuals) would mean that larger individuals are more likely to survive, reproduce, and pass on their alleles for large body mass. Over time these large-body alleles would become more frequent in the population and the average body size in the population would increase; this is an example of directional selection.

6c

c) i) A curve drawn on Fig. 4 to show the pattern of variation of body mass in this red deer population after many years of a selection pressure acting against red deer of medium body mass would have the following appearance…

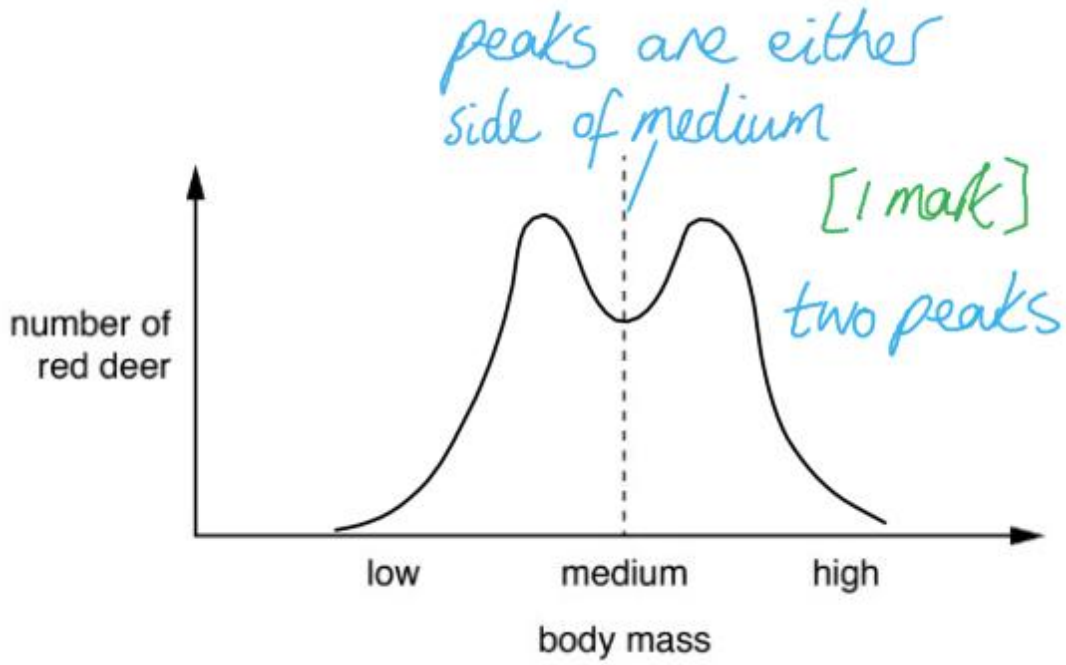
- A curve that has two peaks **AND** the peaks are either side of the medium value; [1 mark]

c) ii) The type of force of natural selection that is acting on this population is…

- Disruptive (selection); [1 mark]

[Total: 2 marks]

i) The curve should be drawn as follows…



ii) Selection acting against deer of medium body mass (e.g. human hunters might decide to avoid killing the smallest deer due to their lack of meat, and to leave the alleles of the largest, most impressive deer in the gene pool) would mean that deer that are either smaller than average or larger than average are more likely to survive, reproduce, and pass on their small-body or large-body alleles. Small-body and large-body alleles will increase in frequency in the population and there will be an increase in the number of individuals with these extremes of body size in the population.