

Model Answers: Medium

1a

a) i) The species of baleen whale that are genetically most similar are...

- Humpback and fin (whales); [1 mark]

a) ii) We can tell that these whales are most genetically similar because...

- They share the most recent common ancestor **OR** they separated into different species most recently (therefore their DNA will be most similar); [1 mark]

[Total: 2 marks]

Fig. 1 shows that humpback and Fin whales diverged from a common ancestor around 5 million years ago. This is more recent than the divergence of blue and sei whales which occurred almost 6 million years ago.

Species that share a more recent common ancestor will have DNA that is more similar. This is because it takes time for genetic changes to accumulate; the more recent the split into different species, the fewer changes will have occurred in their DNA.

1b

b) The process of natural selection leads to evolution as follows...

Any **five** of the following:

- There is genetic variation between individuals of a population; [1 mark]
- Environmental factors / selection pressures / named example of selection pressure will favour / provide a (selective) advantage to individuals with advantageous/favourable alleles; [1 mark]
- Those individuals will have a greater chance of surviving and reproducing **OR** those without the advantageous alleles will have a smaller chance of surviving and reproducing; [1 mark]
- Advantageous/favourable alleles will be passed to offspring **OR** disadvantageous/unfavourable alleles will not be passed to offspring; [1 mark]
- There will be a change in allele frequency in the population over time **OR** favourable/advantageous alleles will increase in frequency over time **OR** unfavourable/disadvantageous alleles will decrease in frequency over time; [1 mark]
- A large enough change in allele frequency / the gene pool can lead to reproductive/genetic isolation / the development/evolution of new species / speciation; [1 mark]

[Total: 5 marks]

This question requires to combine your knowledge of natural selection with that of evolution. The process of natural selection acting over long periods of time can lead to the development of new species.

1c

c) The benefit of analysing mitochondrial DNA is as follows...

Any **two** of the following:

- Mitochondrial DNA is circular **SO** there is no/limited crossing over / recombination of genes/DNA; [1 mark]
- Mutation is the only cause of change (in mitochondrial DNA) **SO** a molecular clock /

the passage of time can be estimated/calculated/calibrated (from fossils and carbon dating); [1 mark]

- Mutation rates (in mitochondrial DNA) are faster (than nuclear DNA **SO** more precise time/clock estimates can be made; [1 mark]
- Mitochondrial DNA passes from mother to daughter **SO** is useful for tracing (maternal) ancestry; [1 mark]
- Genes in the mitochondria code for proteins found in respiration **SO** are present in most living organisms (this is useful for comparison of different species); [1 mark]

[Total: 2 marks]

1d

d) A process other than natural selection leading to evolution is...

- Genetic drift; [1 mark]

[Total: 1 mark]

Evolution is the formation of new species when the allele frequencies of a population change sufficiently over time. While natural selection favours individuals with advantageous alleles, increasing the likelihood of their being passed on, sometimes alleles are passed on or not passed on simply due to chance. This is known as genetic drift, and has a much larger impact on allele frequencies in small populations than in large populations.

2a

a) Crop cultivation could result in speciation within the tortoise population in the following way...

Any **five** of the following:

- The original tortoise population will be separated / geographically isolated by crop/wheat fields (which act as a geographical barrier); [1 mark]
- The environmental conditions experienced in these separate habitats could differ / different selection pressures could be present in the separate habitats; [1 mark]
- Different alleles are selected for / increase the chance of survival (and reproduction) in the separate habitats **OR** genetic drift could act differently on the two separate populations over time; [1 mark]
- Genetic differences between the populations will accumulate over time; [1 mark]
- The populations become reproductively isolated from each other; [1 mark]
- This is known as allopatric speciation; [1 mark]

[Total: 5 marks]

When a physical barrier is involved in separating a population of individuals it is known as allopatric speciation. Different selection pressures or genetic drift events on both sides of the barrier will drive changes in allele frequencies until the two populations are genetically too different to reproduce successfully (they are unable to produce fertile offspring).

2b

b) i) The type of selection that is present in this population is...

- Disruptive (selection); [1 mark]

b) ii) The reason for this is that...

- There is selection against the average/middle sized tortoises in this population **OR** both extremes of tortoise body size / very large and very small tortoise body size are selected for; [1 mark]

[Total: 2 marks]

There would be an increase in the proportion of individuals with alleles for either very large or very small body size since they would have a selective advantage above tortoises with a medium body size. Over time this type of selection can lead to the formation of entirely new species within this population.

2c

c) This event would affect the new nature reserve tortoise in the following way...

Any **three** of the following:

- The new population has / is restarted with a reduced/small gene pool; [1 mark]
- The gene pool contains only/mostly alleles for the large phenotype **OR** gene pool does not contain (many) alleles for small phenotype; [1 mark]
- Most/all of the offspring from these individuals would inherit large body alleles **SO** would have the large phenotype; [1 mark]
- The population is small **SO** (any) small body alleles are likely to be lost by genetic drift; [1 mark]
- This is due to the bottleneck effect; [1 mark]

[Total: 3 marks]

The bottleneck effect can lead to sudden, large changes within the gene pool of a population and is usually driven by a dramatic event, such as the fire in this instance. The allele for the very small phenotype may have been eliminated from the population due to factors that were not related to natural selection.

2d

d) Small tortoises might appear in future generations of the rescued nature reserve population because...

- Some of the large tortoises may be heterozygous / may have the genotype Ll / may carry the recessive allele; [1 mark]
- A cross between two heterozygous individuals could lead to small offspring **OR** offspring of two heterozygous individuals may be homozygous recessive / have a genotype of ll; [1 mark]

[Total: 2 marks]

The presence of the recessive allele for small body size in the tortoises will be masked by the presence of the dominant allele for large body size in heterozygous individuals. When two heterozygous tortoises breed there will be a 25% change that a small sized tortoise will result from that cross.

LL × LL

	L	l
L	LL	Ll
l	Ll	ll

Large tortoises may have the heterozygous genotype [1 mark]

A heterozygous cross can lead to small offspring [1 mark]

3a

a) Natural selection could produce a population of earleaf acacias that is tolerant to low soil pH in the following way...

- One/some individuals in the original population have an allele/mutation that gives tolerance to low soil pH; [1 mark]
- Individuals that are tolerant to low soil pH are more likely to survive and reproduce in the new habitat; [1 mark]
- These individuals pass on the favourable allele(s) to their offspring / the next generation; [1 mark]
- There is an increase in the frequency of the allele(s) (that gives tolerance to low soil pH); [1 mark]

[Total: 4 marks]

The process of natural selection always occurs in a similar way; those with advantageous alleles for the particular environment will survive and reproduce to pass them on to the next generation, and the advantageous alleles increase in frequency in the population. Remember to adapt your answer to the specific example that is given.

3b

b) The month when each population had the highest flower density is:

Any **two** of the following:

- Normal acacias have their peak flowering time 60/65 days (after the beginning of the study) **WHILE** acid tolerant acacias have peak flowering at (around) 160/165/170 days (after the beginning of the study); [1 mark]
- Normal acacia begin flowering at day 0 and finish flowering by (around) day 100 **WHILE** acid tolerant acacias begin flowering at (around) day 95 and finish flowering by (around) day 185; [1 mark]
- There is a (very short) overlap in flowering times at (around) 95-100 days (after the start of the study); [1 mark]

Accept correctly identified months/dates in place of numbered days for any marking point.

[Total: 2 marks]

3c

c) The results in Fig.1 can lead to the formation of a new species of acacia because....

- The populations have different flowering times / only have a very short overlap in flowering time **SO** cannot interbreed / exchange genes / have gene flow; [1 mark]
- Each population experience different selection pressures / genetic drift; [1 mark]
- The populations become reproductively isolated from each other over time **OR** sympatric speciation occurs; [1 mark]

[Total: 3 marks]

Remember that sympatric speciation takes place with no geographical barrier. The difference in soil pH provided different ecological conditions for each population, which affected the flowering time of the population growing in low pH soils. This difference in flowering time prevented this population from exchanging genes with the surrounding acacia populations and prevented gene flow between them. As different selection pressures and genetic drift events act on each population they become genetically different, which will ultimately lead to reproductive isolation and a new species forming.

Note that it would also be technically correct to say that ecological separation prevents gene flow between the two populations, but as this information does not come from the data in Fig. 1 it cannot be credited as an answer here.

3d

d) The definition of a species is as follows..

- A group of organisms with similar morphological/physiological/biochemical/behavioural features; [1 mark]
- That are able to produce fertile offspring (when they breed) / are reproductively isolated from each other; [1 mark]

[Total: 2 marks]

The definition of the term species causes much debate amongst biologists and there are actually several different definitions used in different situations. The definition stated above is widely accepted and is the one that you will be expected to know.