

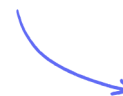
Structured Questions

Natural Selection

Natural Selection & Evolution / Selection Pressures / Selection Pressures: Skills / Gene Pools (HL) / Allele Frequencies: Skills (HL) / Types of Natural Selection (HL) / Hardy-Weinberg Principle (HL) / Artificial Selection (HL)

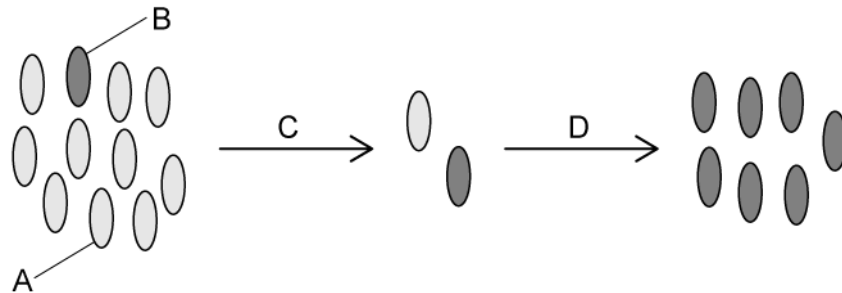
Easy (7 questions)	/44
Medium (7 questions)	/62
Hard (8 questions)	/62
Total Marks	/168

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Easy Questions

1 (a) The following diagram illustrates the development of antibiotic resistance in bacteria.



Annotate the bacteria labelled **A** and **B**.

(2 marks)

(b) State the selection pressure that is applied at **C**.

(1 mark)

(c) The mutation for antibiotic resistance is passed on to other bacteria at point **D**.

List **one** of the processes by which this could occur.

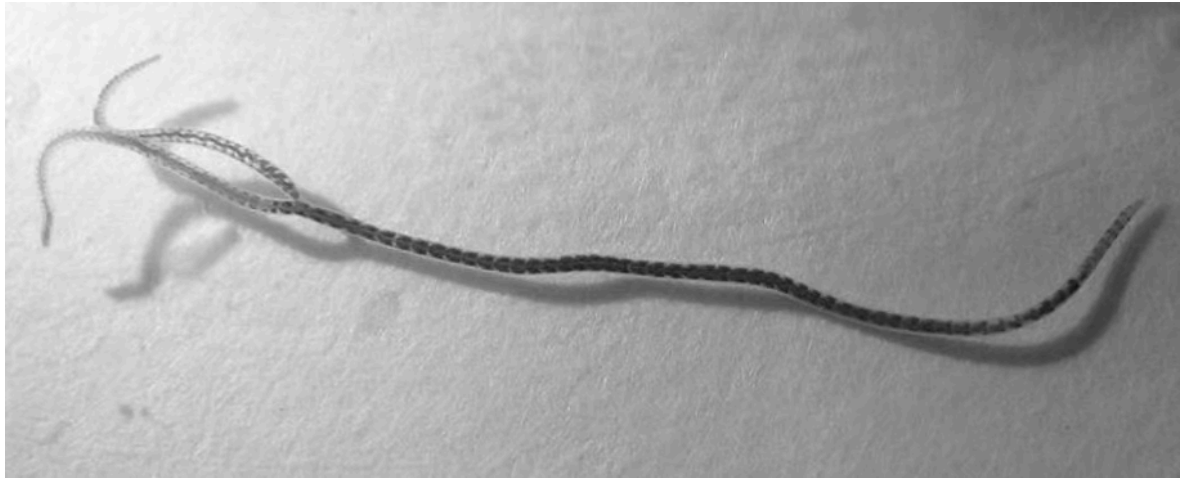
(1 mark)

(d) State **one** strategy that could be used to reduce the rate at which resistance evolves in bacteria.

(1 mark)

2 (a) The blackworm (*Lumbriculus variegatus*) is a species of worm native to North America and Europe. Blackworm habitat includes marshes, swamps and ponds, and they are a popular food source for fish kept in aquariums.

Each body segment is able to regenerate into a complete individual, and sexual reproduction in blackworms is very rare.



Dvortygirl, CC BY-SA 3.0, via [Wikimedia Commons](#)

(i) State the main source of variation in a blackworm population.

[1]

(ii) List **two** other sources of variation in other species.

[2]

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(3 marks)

(b) The blackworm in the image in part a) has grown a second tail. Its ability to regenerate body parts can be considered a useful adaptation.

(i) Define the term 'adaptation'.

[1]

(ii) Suggest **one** role of the regeneration abilities of the blackworm.

[1]

(2 marks)

3 (a) Define the term **gene pool**.

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(1 mark)

(b) The number of alleles of one type that occur within a gene pool, expressed as a proportion of the total alleles, is the allele frequency.

State and explain **one** reason why the frequency of an allele might change over time.

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(2 marks)

(c) Different alleles in a population result in different phenotypes.

State why it is easier to calculate a phenotype frequency than an allele frequency.

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(1 mark)

(d) In a population of cattle 12 individuals are white, 15 are red, and 28 are roan.

Calculate the frequency of the red phenotype.

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(2 marks)

- 4 (a)** A population of guppies has two alleles of a specific gene in its gene pool. The frequencies of the alleles are shown in the table below.

A mutation occurs in the population that leads to the formation of a new allele for the gene.

Complete the table below with the allele frequencies of the new allele between March and July.

Month	Frequency of allele 1	Frequency of allele 2	Frequency of new allele
January	0.81	0.19	0
February	0.78	0.22	0
March	0.77	0.21	
April	0.65	0.27	
May	0.51	0.34	
June	0.43	0.33	
July	0.40	0.24	

(1 mark)

- (b)** The new allele was a dominant allele that provided the guppies with a survival advantage within their population.

Predict what will happen to the frequencies of all three alleles for the next five months, from August to December.

(2 marks)

- (c) A few individuals with the mutated allele from the original population travelled to a new area and merged with a different population of guppies.

In the new population the frequency of the new allele remained low over many generations and then decreased.

Suggest a reason for the difference in the frequency of the new allele between the population in part a) and this new population.

(2 marks)

5 (a) Head circumference in newborn babies is an example of selection in human populations:

- Babies that are very small at birth have reduced survival chances due to developmental difficulties or infection
- Babies that are very large at birth have reduced survival chances due to fatal complications during childbirth

State the type of selection that is likely to be acting on head circumference in human babies.

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(1 mark)

(b) Selection acting on modern day humans is minimal in the majority of populations.

Suggest **two** reasons why selection is minimal in the majority of populations.

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(2 marks)

(c) A scientific study was carried out in 2017 on a small community of people in Indiana known as the Amish. This community mixes very infrequently with the wider US population and children are most often born to parents within the community.

The study found that a large number of individuals in their community possessed a mutated allele that increased their life expectancy by ten years on average.

Suggest why this allele is found in much higher percentages in this community compared to the rest of the US population.

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(2 marks)

(d) Isolated groups, such as the Amish, make excellent subjects for scientific study.

Suggest **one** reason why scientists often focus on isolated groups for studies on inheritance and genetics.

(1 mark)

6 (a) Define the term **population**.

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(1 mark)

(b) A population of beetles lives in leaf litter on a forest floor. The beetles are predated on by various species of small birds and rodents.

The beetles have an outer wing case that protect their wings, known as an elytra, which occurs in different colours.

Explain how the beetle population could have evolved from having a large diversity elytra colours to having mostly brown and green.

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(4 marks)

(c) A road was built through the forest in which the beetles lived, causing the two populations to become isolated from each other.

On one side of the road, the leaf litter is cleared and a population of plants with red berries starts to colonise the area.

(i) State the type of speciation that could occur in this instance.

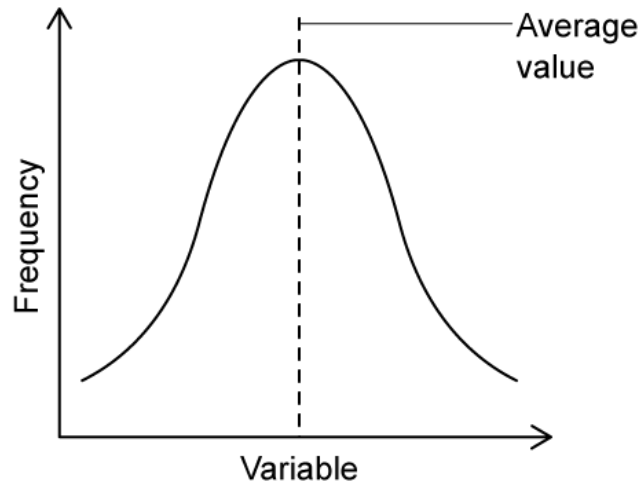
[1]

(ii) Describe how the speciation named in part (i) could occur.

[3]
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(5 marks)

7 (a) The image below shows a normal distribution curve.



Sketch three graphs to show how this normal distribution curve would change if the population is exposed to directional selection, stabilising selection, and disruptive selection.

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(3 marks)

(b) Explain how natural selection could enable a population of bacteria to become resistant to an antibiotic.

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(4 marks)

Medium Questions

- 1 (a)** A group of biologists conducted an investigation on a remote archipelago (a collection of islands) in the Pacific Ocean. A species of mouse lives on these islands without any natural predators. The biologists measured the claw length of a large number of these mice.

On half of the islands a species of snake was accidentally introduced that preys on the mice but that cannot climb trees. Several years after the snakes were introduced the biologists returned and found that on the islands with snakes, the claw length of the mice had changed. Some had shorter claws, enabling them to run faster, while others had longer claws, enabling them to climb trees.

Suggest the benefit to the scientists' investigation of there being islands without any snakes present.

(2 marks)

- (b)** The evolution of long claws in the mice in part (a) was made possible by a mutation in the gene controlling claw length.

Explain how a mutation could lead to a change in claw length.

(3 marks)

- (c)** When the biologists conducted the investigation in part (a), flooding of the islands was very rare. Now, due to climate change, flooding of the islands occurs more regularly. This flooding can regularly wipe out large numbers of ground-living species.

Using this information and the information from part (a), explain how the claw length of the mice on the islands are likely to be changing now.

(3 marks)

2 (a) Outline the equivalent features of selective breeding and evolution by natural selection.

(5 marks)

(b) Explain how natural selection can account for the development of antibiotic resistant bacterial strains.

(7 marks)

3 (a) Fur colour in rabbits (*Oryctolagus cuniculus*) is determined by four alleles, each with a varying degree of dominance.

- Allele **C** = brown
- Allele **c^{ch}** = chinchilla
- Allele **c^h** = himalayan
- Allele **c** = white

Scientists investigated the frequency of the different alleles within a population of rabbits. Allele **C** had a frequency of 0.65 while allele **c^{ch}** had a frequency of 0.25. Allele **c^h** had a frequency that was twice that of allele **c**.

Calculate the frequency of allele **c^h**.

(2 marks)

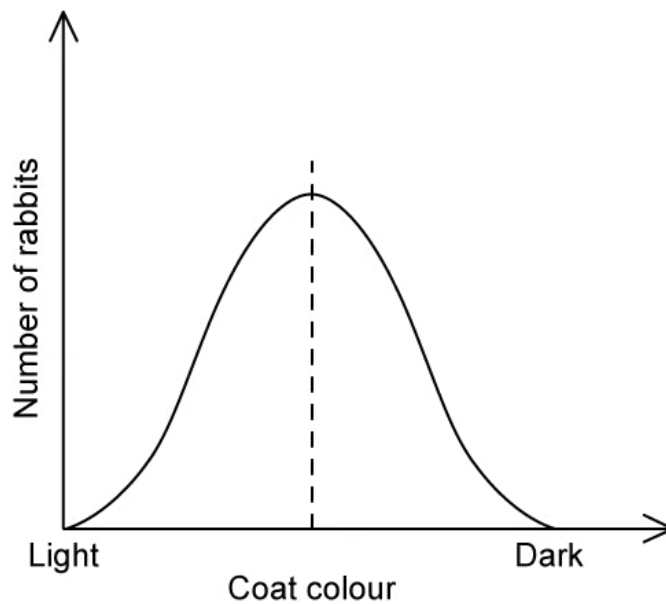
(b) The habitat of this rabbit population changed:

- Temperatures dropped
- Snowfall became more frequent

Explain the effect that this would have on the allele frequencies in the rabbit population over time.

(3 marks)

(c) The following graph shows the distribution of coat colour within the rabbit population before the environment changed.



State, with a reason, the type of selection that would be observed **after** the environment changed.

(2 marks)

- (d)** After several generations the rabbit population accumulated several phenotypic differences to other rabbit populations in nearby habitats.

Explain how scientists could determine whether rabbits from these populations still belong to the same species.

(2 marks)

4 (a) Renosterveld is a type of vegetation that is part of South Africa's fynbos biome and is found within the Cape Floristic Region. Renosterveld is characterised by a variety of species of shrubs and grasses that grow in relatively fertile soil, which make the areas where they grow popular for cultivating crops, such as wheat. Renosterveld is home to the endangered geometric tortoise (*Psammobates geometricus*), which survives in pockets of natural vegetation.

Wheat crops are cultivated in fields which are securely fenced, preventing the movement of some animals between the natural vegetation and crop fields.

Explain how the cultivation of crops in this region could result in speciation in geometric tortoises over time.

(4 marks)

(b) Scientists investigated one of these tortoise populations and discovered that most individuals were either very large or very small. Very small individuals have the advantage of being able to hide under shrubs from aerial predators, while large individuals have larger shells that make it difficult for aerial predators to get a secure grip on them.

State, with a reason, the type of selection that will be occurring in this population.

(2 marks)

- (c) A fire swept through the habitat of the tortoise population, destroying all the vegetation. Only ten tortoises near the edge of the vegetation managed to escape the blaze; all of these individuals had the small phenotype.

The surviving tortoises were rescued by volunteers at a reptile sanctuary and released into a small nature reserve where no other geometric tortoises occurred.

Explain the effect that this event would have on the new tortoise population in the nature reserve.

(2 marks)

- 5 (a)** Mining for gold produces waste rocks and mine tailings, which contain sulfur-bearing minerals. When surface water and shallow groundwater come into contact with these minerals, a chemical reaction occurs which produces sulfuric acid. This process is known as acid mine drainage and it can lower the soil pH to a level where very few plants can survive.

Environmentalists studied the area around an abandoned gold mine and discovered a few specimens of earleaf acacia (*Acacia auriculiformis*) surviving in the acidic soil. This species typically occurs in more neutral or alkaline soils.

Explain how natural selection could produce a population of *Acacia auriculiformis* that would be tolerant of the acidic soil found around the mine shaft.

(4 marks)

- (b)** The scientists found that individuals from the population of *Acacia auriculiformis* that are tolerant to low soil pH flowered at a different time to individuals from the population of *Acacia auriculiformis* growing in the surrounding habitat, which were not tolerant to low soil pH.

Identify, with a reason, the type of speciation that could occur between the two populations of *Acacia auriculiformis*.

(2 marks)

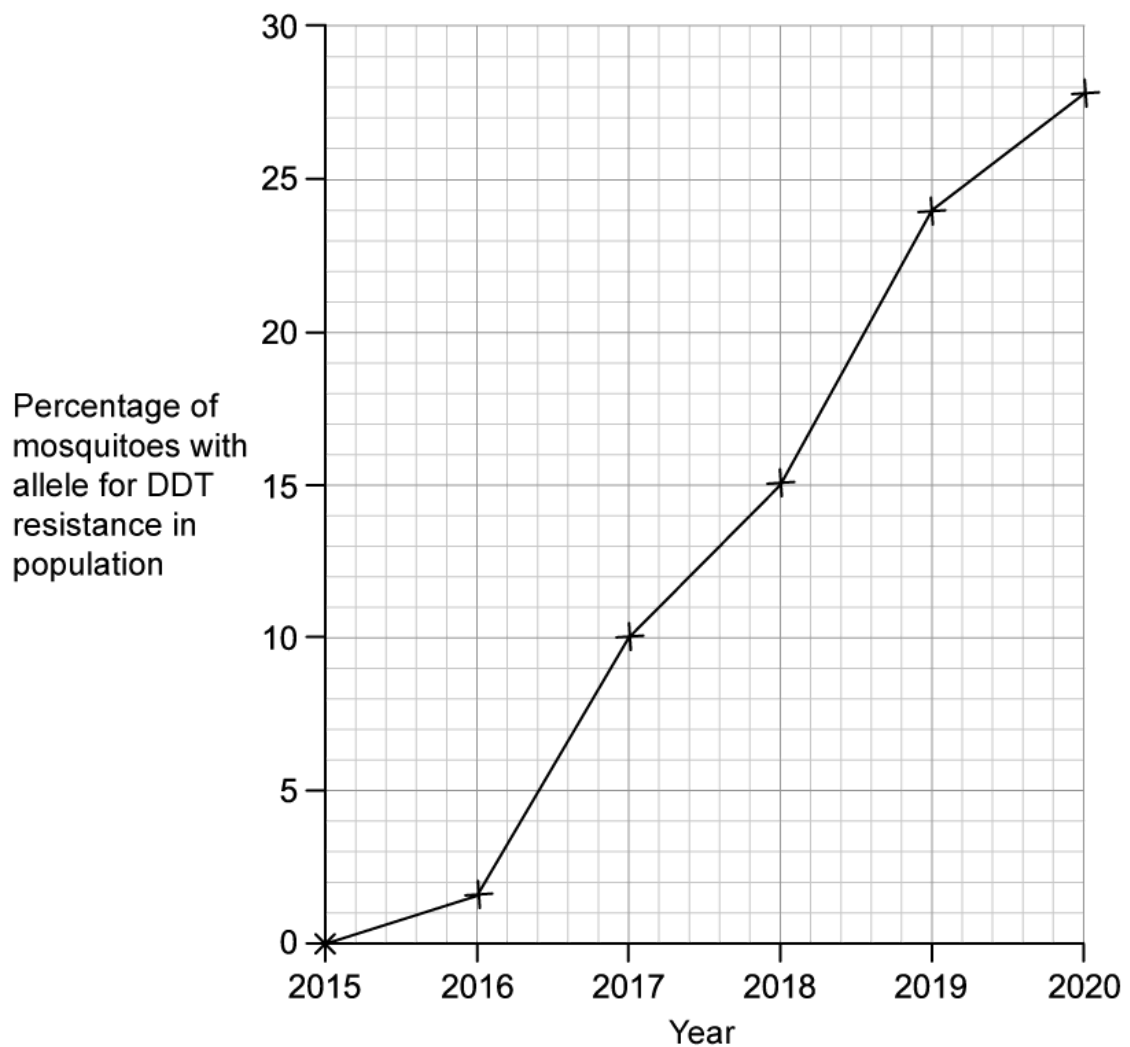
- (c)** State, with a reason, whether the population of *Acacia auriculiformis* that are tolerant to low soil pH could be considered a stable gene pool.

(2 marks)

6 (a) Mosquitoes spread a disease called malaria. DDT is a pesticide used to kill mosquitoes; it is used in many countries in Africa to control the spread of malaria.

Some mosquitoes have an allele that gives them resistance to DDT. A group of biologists studied how frequently this allele occurred in a population of mosquitoes in Uganda over 5 years.

The graph below shows the biologists' results.



Explain the results shown in the graph.

(3 marks)

(b) Calculate the percentage increase in the percentage of mosquitoes that have the allele for DDT resistance from 2017 to 2020.

(2 marks)

(c) Due to the increase in DDT resistance in mosquitoes, many African countries now use alternative pesticides such as pyrethroids, instead of DDT, to control the spread of malaria.

Explain the effect this may have on the frequency of the allele for DDT resistance over time.

(2 marks)

(d) Describe the effect of stabilising selection on a population.

(2 marks)

7 (a) Describe the process of evolution by natural selection.

(6 marks)

(b) Outline why some areas of the human genome are more susceptible to detrimental mutations than others.

(2 marks)

Hard Questions

- 1 Outline how artificial selection has led to the domestication of wolves over many years to result in the domestic dogs of the modern day.

(3 marks)

2 (a) Natural selection would not be possible without the presence of variation within a species.

Explain how variation allows natural selection to occur.

(3 marks)

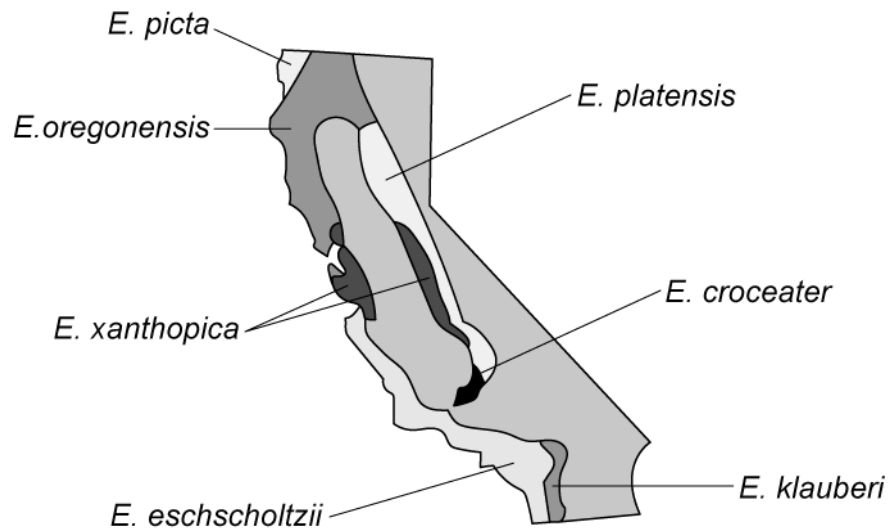
(b) Mutation, meiosis and sexual reproduction are all sources of genetic variation.

Outline the way in which each of these factors contributes to variation within a species.

(5 marks)

- 3 (a)** *Ensatina* is the genus name for a group of lungless salamanders (a type of amphibian) that occur in certain regions of the USA. Seven subspecies have been identified across California, each of which shows slight differences in colouration. Some scientists argue that the *Ensatina* populations represents different species rather than varieties within a single species. This is due to the fact that some of the populations are not able to successfully interbreed.

The map below shows the distribution of the subspecies of *Ensatina* salamanders across California.



Explain the process that could have resulted in the slight variations in colouration between different *Ensatina* subspecies.

(3 marks)

- (b)** Some of the adjacent subspecies of *Ensatina* can successfully breed with one another, but the western subspecies *E. eschscholtzii* cannot interbreed with the eastern subspecies *E. klauberi*.

Based on the information provided, evaluate the claim made by some scientists that the different subspecies of *Ensatina* should be classified as separate species.

(2 marks)

4 (a) The turtle-headed sea snake, *Emydocephalus annulatus*, can be found in waters off the coast of Australia, New Zealand and New Caledonia. These snakes usually have banded patterns of white with dark rings, although some individuals exhibit a single dark colour with no banded patterns. The dark parts of the skin contains a high concentration of the pigment melanin, which binds to certain trace elements present in the water. These trace elements are removed from the body when the snake sloughs off the skin. It was found that melanic sea snakes will slough off the skin more frequently than those with banded colouration.

Scientists studied the frequency of melanic sea snakes from several sites in waters surrounding urban-industrial areas and waters from non urban-industrial areas. The results are shown in the table below.

Site	Melanic sea snakes in urban-industrial waters / %	Melanic sea snakes in non urban-industrial waters / %
A	78	23
B	95	0
C	64	14
D	92	2
E	98	7

Calculate the percentage difference in the mean frequency of melanic snakes found in urban-industrial waters and those that were present in non urban-industrial waters.

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(3 marks)

(b) Suggest a possible explanation for the results shown in part a).

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(2 marks)

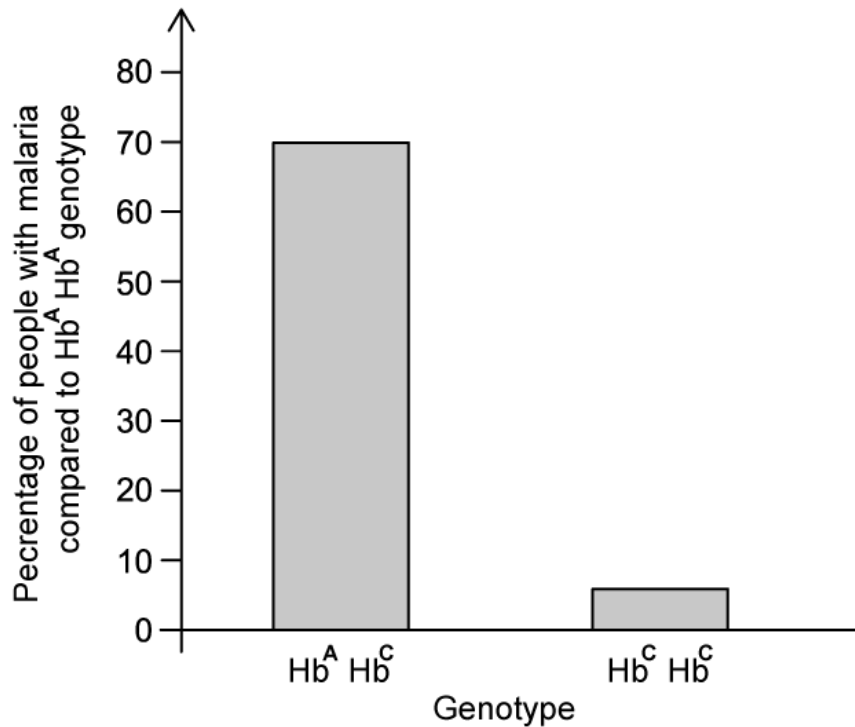
(c) Based on the information provided in part a), deduce the adaptive advantage of melanism to turtle-headed sea snakes.

(3 marks)

- 5 (a) Malaria is caused by a parasite that attacks red blood cells, producing repeated bouts of serious illness and often causing death.

The allele for normal haemoglobin in red cells is **Hb^A**. In the West African country of Burkina Faso, 20% of people are heterozygous for a different allele, **Hb^C**, which has no effect on their health.

People homozygous for **Hb^C** suffer a very mild anaemia. The graph below shows how the **Hb^C** allele affects the chance of getting malaria.



The **Hb^C** allele is increasing in frequency in parts of Africa, such as Burkina Faso.

Suggest an explanation for this.

(2 marks)

- (b) The image below shows the prevalence of malaria and the frequency of the **Hb^C** allele.



■ = Areas where malaria occurs



Allele frequency:

□ = 1-10 %

■ = 10-20 %

Scientists concluded that the **Hb^C** allele is more prevalent in areas with a higher risk of mortality from malaria.

Use the information provided to evaluate this conclusion.

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(3 marks)

- (c) In a village with a population of 500 there were 8 people who were homozygous for the normal adult haemoglobin allele and 96 who were heterozygous.

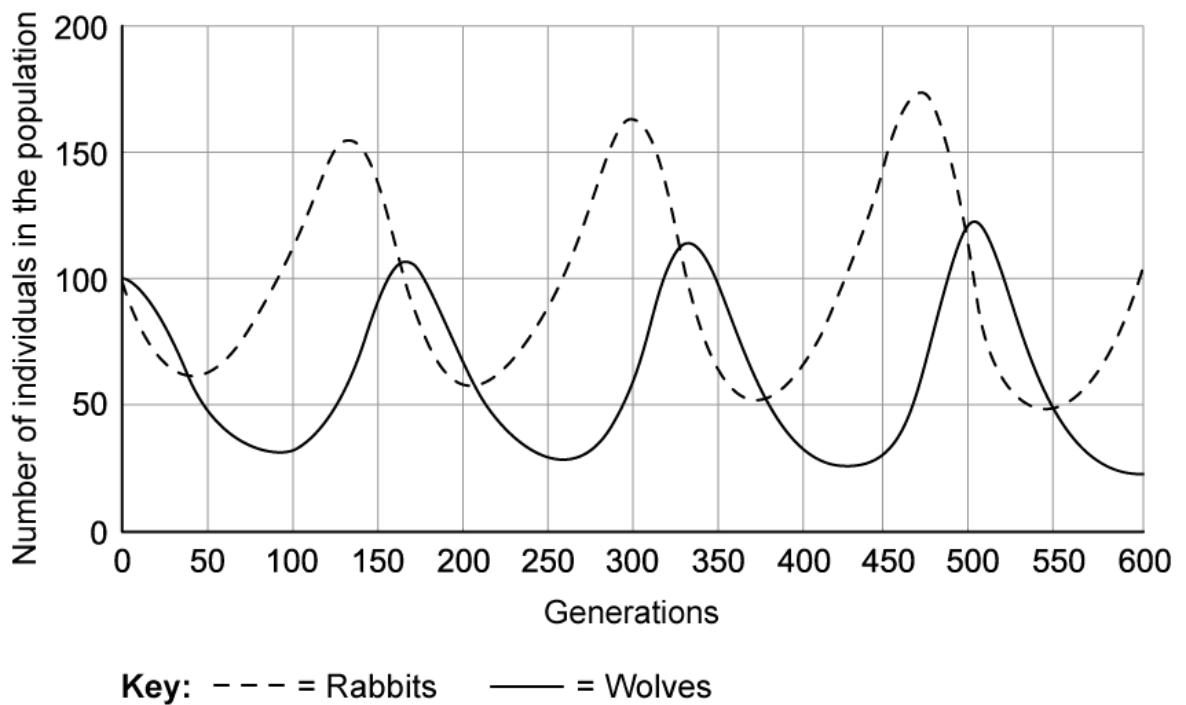
Calculate the frequency of the **Hb^C** allele in the village.

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(2 marks)

6 (a) The graph below shows the population sizes of a rabbit and a wolf population over many generations.



Explain the data in the graph for rabbit and wolf populations over the first 300 generations.

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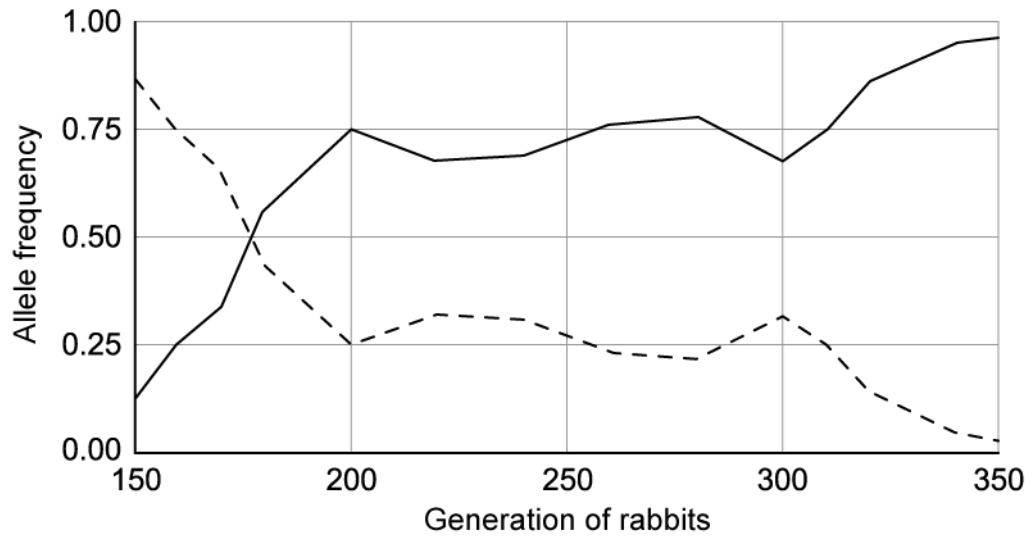
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(4 marks)

(b) During the time period of the study a new allele emerged in the rabbit population.

The graph below shows how the frequency of this new allele (allele **A**) changed over several generations in relation to the existing allele (allele **B**).



Key: — = Allele A frequency
 - - - = Allele B frequency

- (i) Use information from both graphs to suggest a reason for the change in frequency of allele A from generation 150 to 200.

[2]

- (ii) Using the graph above and the graph from part (a), suggest a reason for the change in allele frequency for allele A from generation 200 to 300.

[2]

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(4 marks)

- (c) At generation 350 in the graph shown in part b) the frequency of allele A is high, but never 100%.

State **one** reason why it is not beneficial for this population to have one allele at 100% frequency.

(1 mark)

7 (a) During extended periods of low global temperatures, known as ice ages, the European black bear populations changed from having a small body mass to having a much larger one.

Explain the concept of directional selection using the example of black bear body mass during an ice age.

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(4 marks)

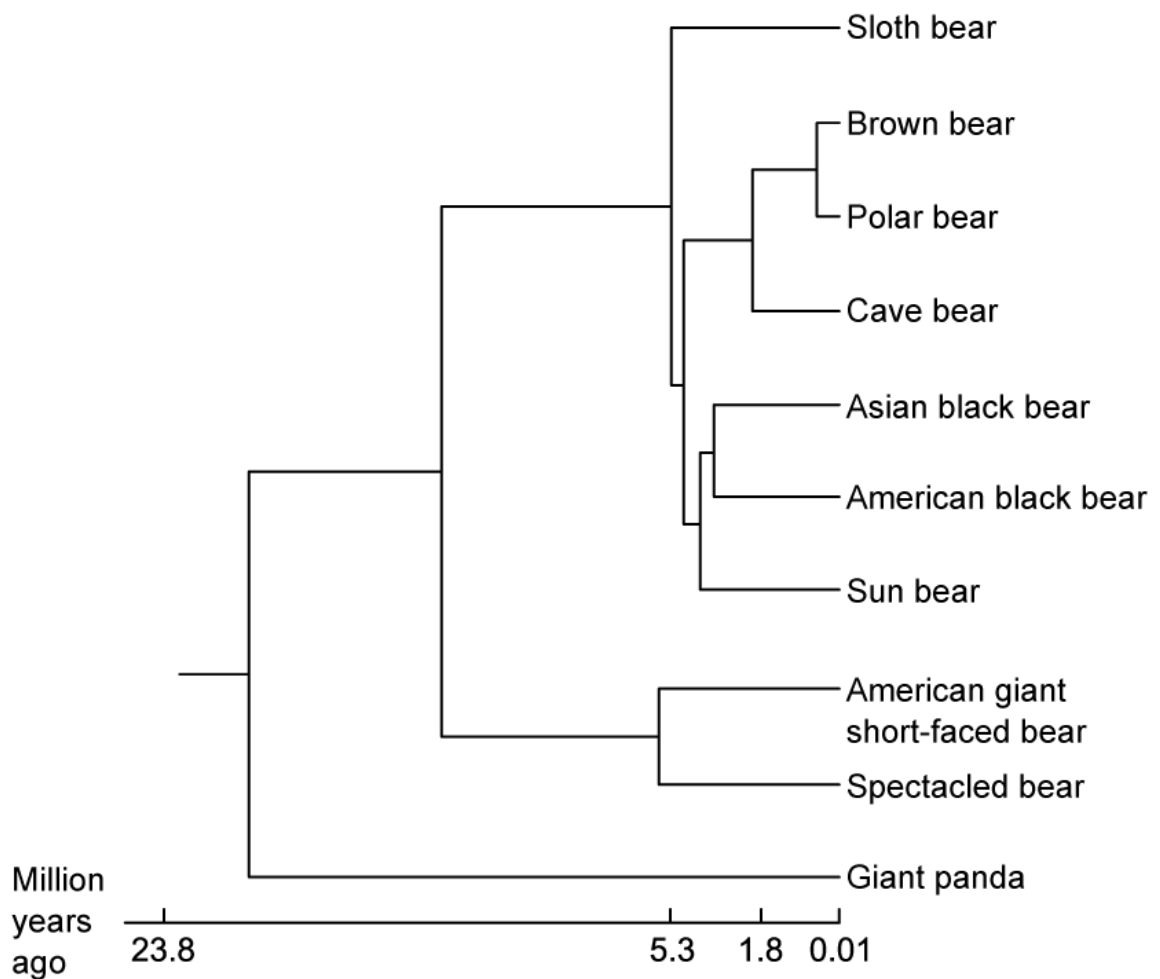
(b) The evolution of Black bear body mass happened on Earth thousands of years ago.

Suggest how scientists know about their evolutionary past.

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(1 mark)

(c) The tree below is taken from a 2008 study of the mitochondrial DNA of bears.



- (i) Suggest how scientists determined the relationships between the bear species.

[1]

- (ii) The scientists who wrote this study, Krause *et al.*, stated that there was evidence for a "rapid radiation" of bears 5 million years ago.

Describe the evidence from the figure that supports the idea of "rapid radiation".

[2]

- (iii) Brown bears and polar bears share a recent common ancestor according to this tree.

Suggest **one** cause of the speciation event that occurred between the ancestors of brown bears and polar bears.

[1]

(4 marks)

8 (a) A student describes a gene pool as "all the genes that can be found in a particular species".

Explain why the student's definition is incorrect.

(3 marks)

(b) The evolution of some species can be driven by female mating preferences, e.g. in a species of bird called the long-tailed widowbird, females have a preference for males with long tails. The long tails of male widowbirds have evolved from short-tailed ancestors despite being heavy and limiting male flying ability.

Discuss the selection process that has resulted in long tails in male widowbirds.

(5 marks)

(c) Since the first human genome was sequenced in 2003, scientists have spent a lot of time studying human genomes around the world.

The study of the human genome has involved measuring the frequencies of different alleles in different populations around the world.

Explain some of the reasons for studying and comparing allele frequencies in different human populations, as well as some of the limitations of this process.

(5 marks)