

Structured Questions: Paper 2

# 10.3 Gene Pools & Speciation

10.3.1 Gene Pools / 10.3.2 Evolution / 10.3.3 Speciation / 10.3.4 Polyploidy & Speciation / 10.3.5 Skills: Comparing Allele Frequencies Between Populations

Easy (5 questions)	/39
Medium (5 questions)	/47
Hard (5 questions)	/51
<b>Total Marks</b>	<b>/137</b>

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# Easy Questions

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

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**(1 mark)**

(b) The proportion of the times that an allele occurs within a gene pool is known as 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 lead to the presence of different phenotypes.

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

.....  
**(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)**

- 2 (a)** A population of guppies has two alleles for a specific gene as part of 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 from March to 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	

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**(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.

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**(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 allele frequency remained low over many generations and then decreased.

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

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**(2 marks)**

- 3 (a)** In the times before modern medicine, giving birth used to be a very dangerous time for women. There were often complications with the delivery that meant that babies were less likely to survive than they are today.

Babies that were very small when they were born were more likely to die during their infancy. Babies that were very large when they were born were more likely to be too difficult for the mothers to deliver on their own and could lead to fatal complications during their delivery.

State the type of selection that occurred during this time.

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**(1 mark)**

- (b)** In today's society, human evolution is exceptionally minimal in the majority of populations.

Suggest **two** reasons why human evolution 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 Berne, Indiana called the Amish. This community mixes very infrequently with the wider US population and tend to have children with people in their own 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.

Explain 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 into inheritance and genetics.

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(1 mark)

4 (a) What is the definition of a population?

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.....  
**(1 mark)**

(b) A population of beetles exists in an area of forest.

The beetle's outer shell that protects their wings is called an elytra. These can appear in different colours and patterns.

The beetles in the forest live mostly in leaf litter that is brown and green in colour.

They are hunted by predators such as birds.

Explain how the beetle population changed from having a large diversity of different elytra colours to having mostly brown and green.

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**(4 marks)**

(c) The humans that live near the forest build a road through the beetles' habitat.

The road is too wide for the beetles to cross, 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.

State the type of speciation that could occur in this instance, and describe how that speciation could occur.

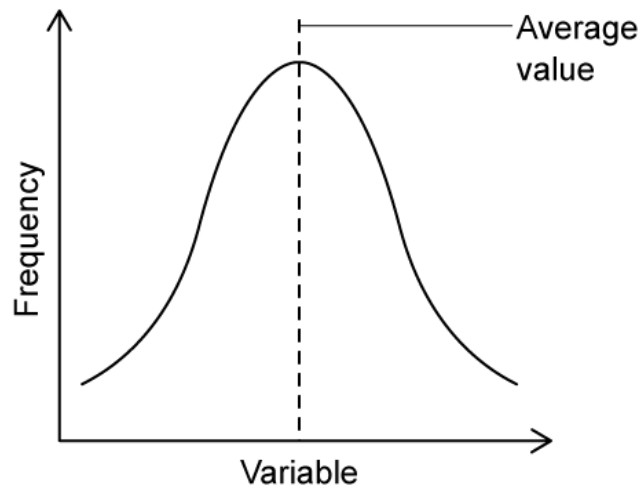
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(4 marks)



5 (a) One mark is available for clarity of communication throughout this question.

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 a population of bacteria could become resistant to a new type of antibiotic.

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**(5 marks)**

(c) Compare and contrast the processes of gradualism and punctuated equilibrium.

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**(5 marks)**

# Medium Questions

- 1 (a) Fur colour in rabbits (*Oryctolagus cuniculus*) is determined by four alleles, each with a varying degree of dominance. Allele **C** is responsible for a brown coat colour, allele **c<sup>ch</sup>** is responsible for a chinchilla coat colour, allele **c<sup>h</sup>** will produce a himalayan coat colour, while allele **c** will produce rabbits with a white coat colour.

Scientists investigated the frequency of the different alleles within a population of rabbits. Allele **C** had a frequency of 0.65, while allele **c<sup>ch</sup>** had a frequency of 0.25. Allele **c<sup>h</sup>** had a frequency that was twice that of allele **c**.

Calculate the frequency of allele **c<sup>h</sup>**.

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**(2 marks)**

- (b) The habitat of this rabbit population changed and white coat colour became better camouflage from predators.

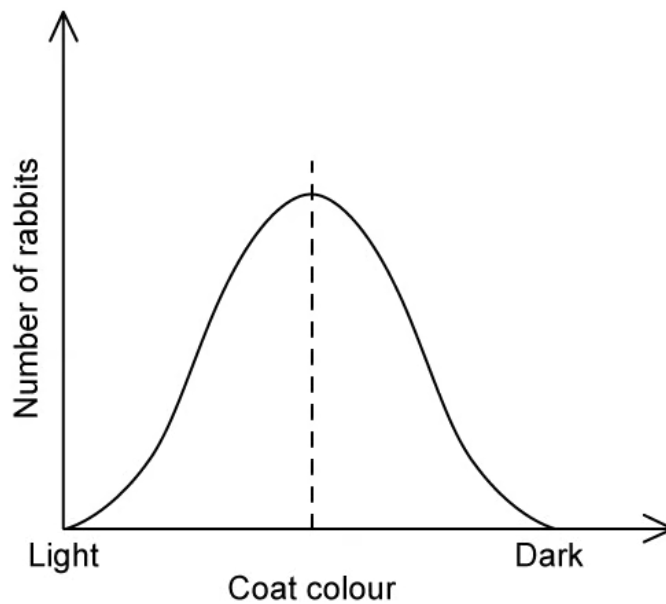
Explain the effect this would have on the allele frequency of the population over time.

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**(2 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.

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**(2 marks)**

- (d)** After several generations, the rabbit population showed many phenotypic changes from other rabbit populations in nearby habitats.

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

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**(2 marks)**

**2 (a)** Renosterveld is a type of vegetation that is part of South Africa's Fynbos Biome 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 the remaining pockets of natural vegetation.

Explain how the cultivation of crops could result in speciation within a population of geometric tortoises over time.

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**(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 away under shrubs from aerial predators, such as peregrine falcons (*Falco peregrinus*), while large individuals have the advantage of having shells that make it difficult for aerial predators to get a secure grip on them.

State, with a reason, the type of selection that is at work in this population.

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**(2 marks)**

- (c) A very large fire swept through the habitat of the tortoise population, destroying all the vegetation. Only ten tortoises (all with the small phenotype) near the edge of the vegetation managed to escape the blaze. They 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 that would result from these individuals.

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**(2 marks)**

**3 (a)** Mining for gold produces waste rocks and mine tailings, which contain sulphur 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 acacias (*Acacia auriculiformis*) surviving in the acidic soil. They typically occur in more neutral or alkaline soils.

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

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**(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*.

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**(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.

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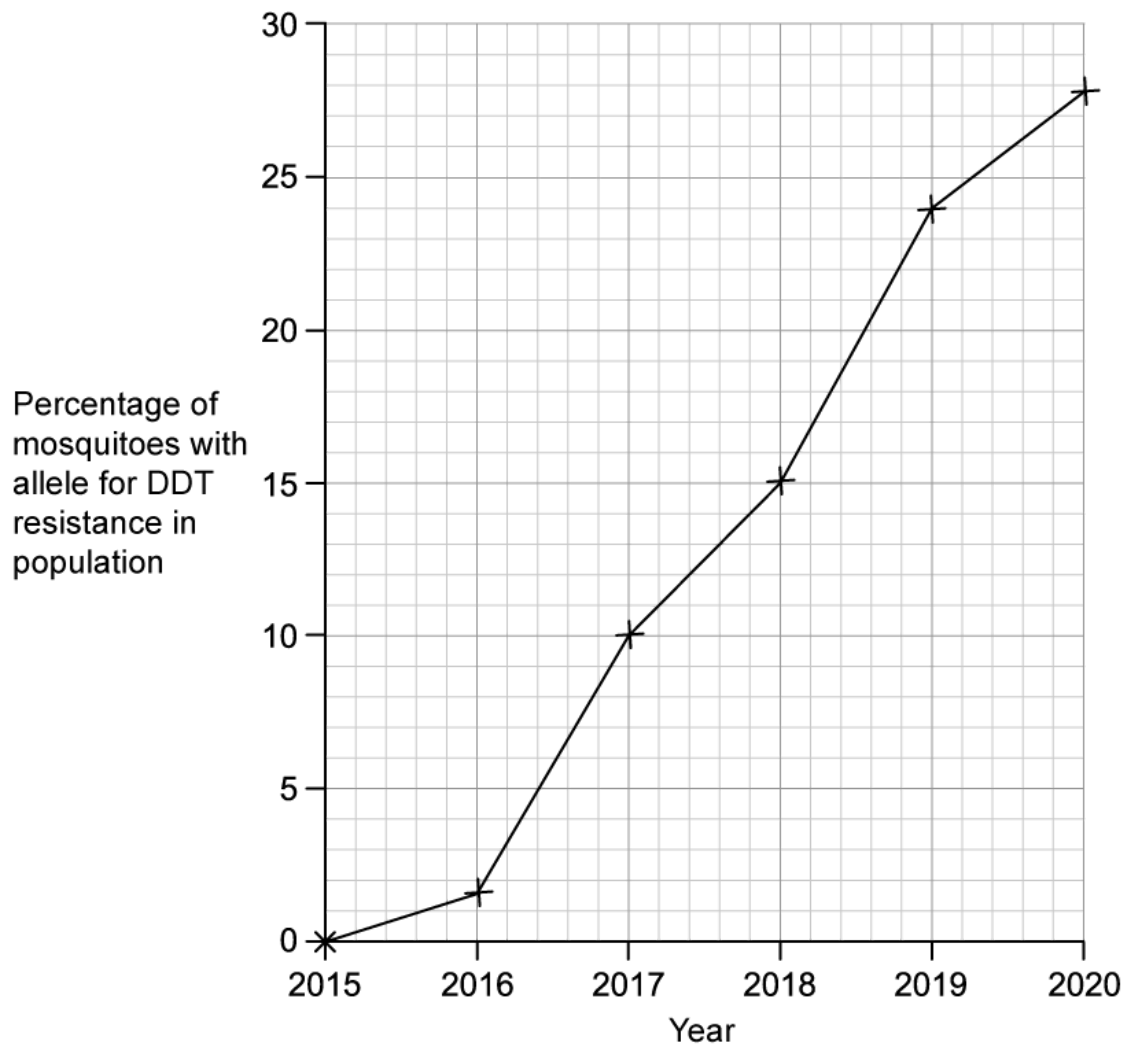
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(2 marks)



- 4 (a)** Mosquitoes spread a disease called malaria. DDT is a pesticide used to kill mosquitoes. DDT is used in many countries in Africa to try 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 (in Africa) over 5 years.

The graph below shows the biologists' results.



Explain the results shown by the graph.

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**(3 marks)**

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

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(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 allele frequency for DDT resistance over time.

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(2 marks)

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

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(1 mark)

**5 (a)** *One mark is available for clarity of communication throughout this question.*

Outline the theory of gradualism to explain the emergence of new species and include in your answer how the fossil record can support this theory.

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**(4 marks)**

**(b)** Explain how polyploidy can lead to the formation of new species.

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**(4 marks)**

**(c)** Describe the process of evolution by natural selection.

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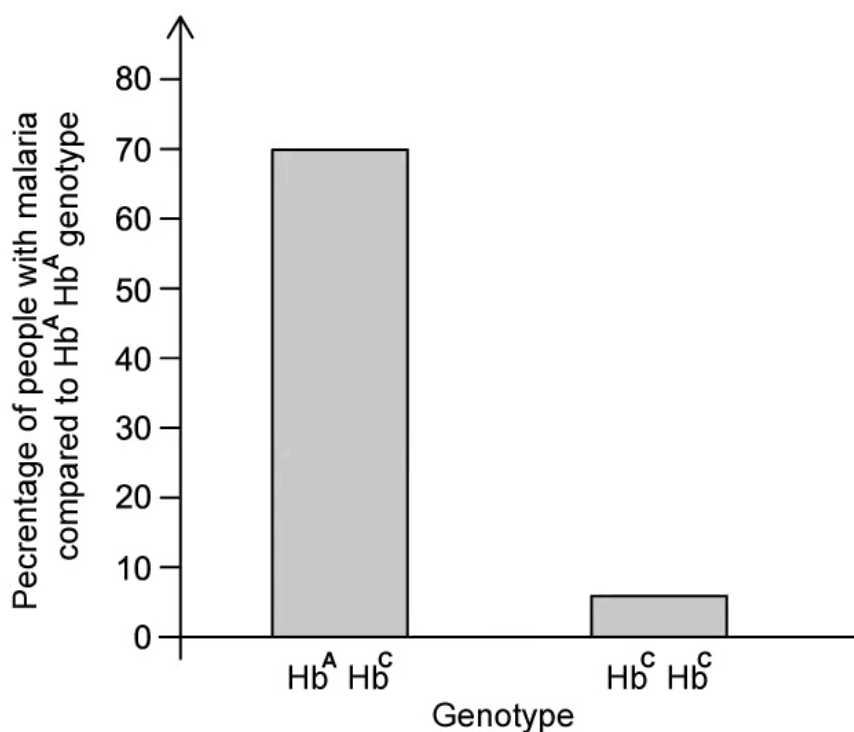
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**(7 marks)**

# Hard Questions

1 (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<sup>A</sup>**. In the West African country of Burkina Faso, 20% of people are heterozygous for a different allele, **Hb<sup>C</sup>**, which has no effect on their health. People homozygous for **Hb<sup>C</sup>** suffer a very mild anaemia. The graph below shows how the **Hb<sup>C</sup>** allele affects the chance of getting malaria.



The **Hb<sup>C</sup>** allele is increasing in frequency in parts of Africa, such as Burkina Faso.

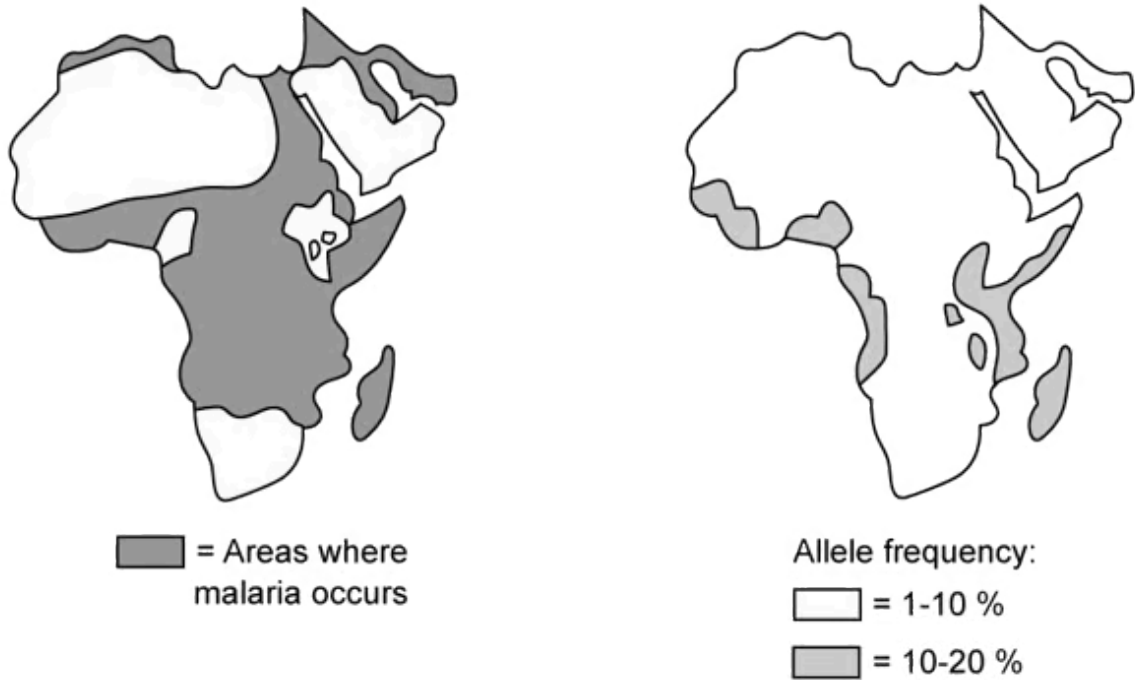
Suggest an explanation for this.

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(2 marks)

(b) The image below shows the prevalence of malaria and the frequency of the **Hb<sup>c</sup>** allele. Those individuals homozygous with **Hb<sup>c</sup> Hb<sup>c</sup>** develop mild anaemia. Scientists concluded that the **Hb<sup>c</sup>** allele is more prevalent in areas with higher risk of mortality from malaria.



Use the information in part (a) to evaluate their 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 sickle-cell allele and 96 who were heterozygous.

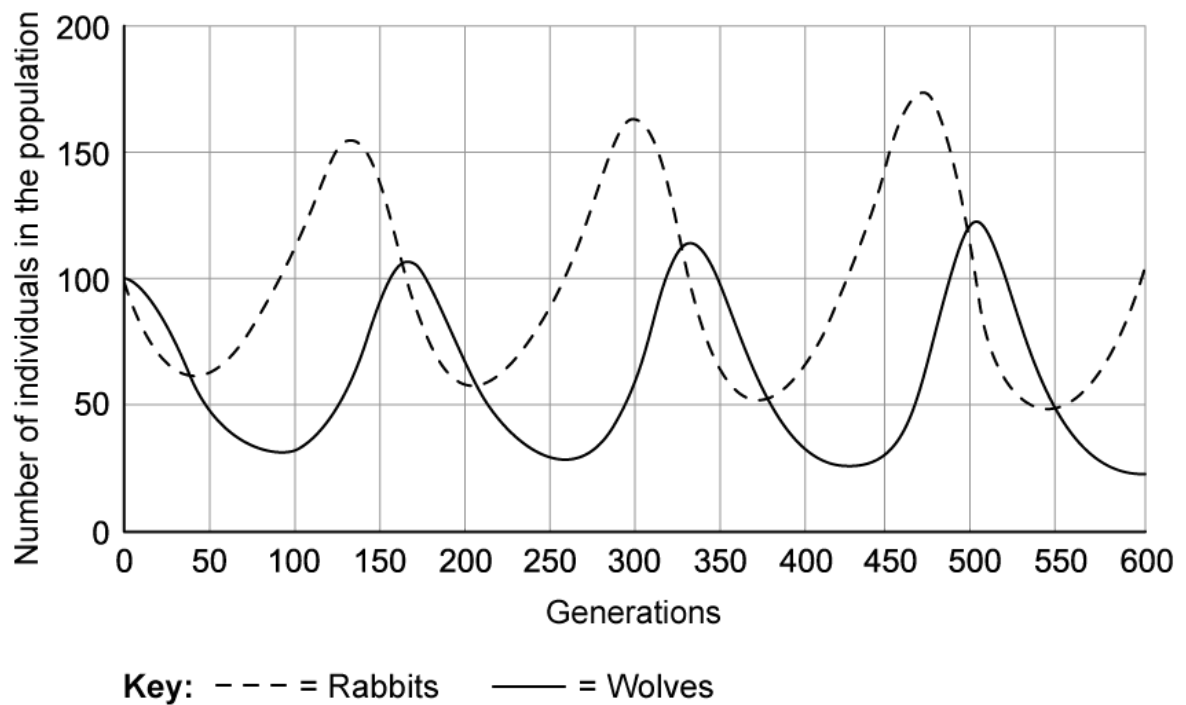
Calculate the frequency of the **Hb<sup>c</sup>** allele in the village.

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.....

**(2 marks)**

- 2 (a) The graph below shows the population numbers of a rabbit and wolf population over a series of generations.



In this population the wolves act as predators for the rabbits, and have very few alternative food sources.

Explain the changes in the number of rabbits and wolves over the first 300 generations.

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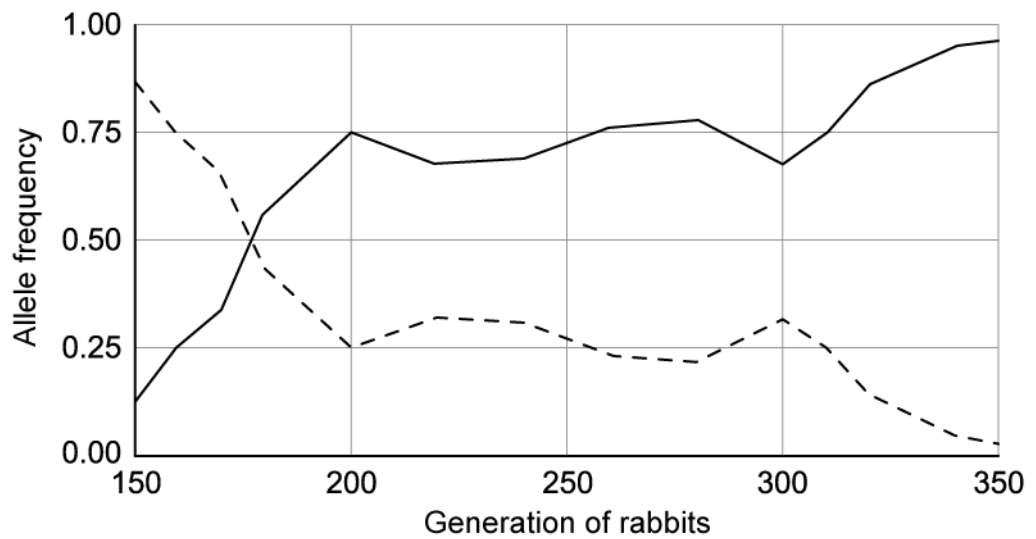
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(4 marks)

- (b) During the period of time studied a new allele emerged in the population of rabbits.

The graph below shows how the frequency of this new allele (**Allele A**) changed over several generations versus its counterpart allele (**Allele B**).



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

- (i) The generation span shown on the x axis of this graph corresponds to the generations shown in the graph from part (a).

Using the graph above and the graph from part (a), suggest a reason for the change in allele frequency for 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 the frequency of allele A (shown on the graph in part (b)) is high, but never 100%.

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

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(1 mark)



**3 (a)** In the Earth's history, there have been periods where the global temperatures have been very low. These periods can be titled as an 'ice age' or a 'glacial age'.

During these periods, the European black bear populations changed from having a small body mass to having a much larger one.

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

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**(4 marks)**

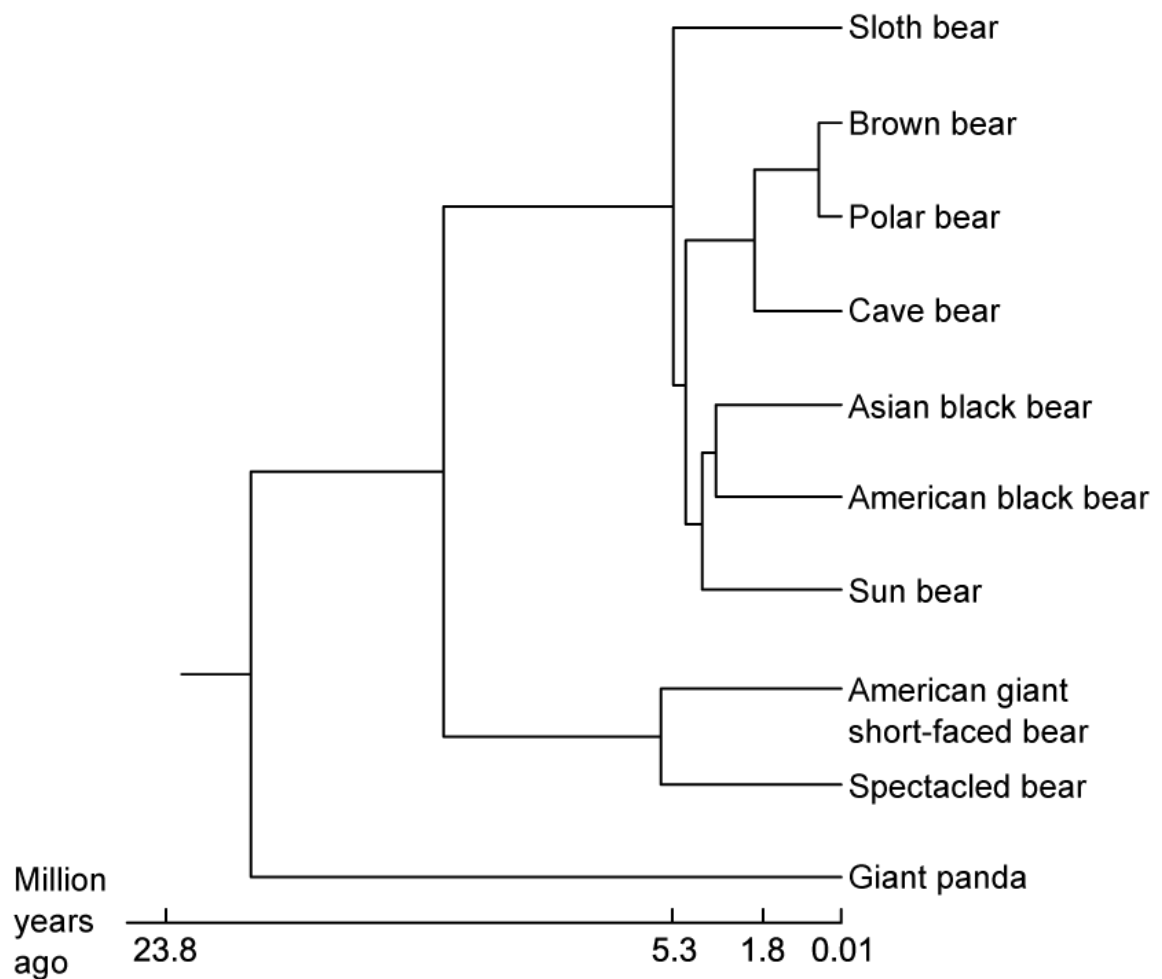
**(b)** These events happened on Earth thousands of years ago, and the black bears no longer exist in Europe.

Suggest how scientists know about their evolutionary past.

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**(1 mark)**

**(c)** The phylogenetic tree below is taken from a 2008 study of the mitochondrial DNA (mtDNA) of bears and shows their evolutionary history.



- (i) Suggest the method the scientists used to identify which of the bears were most closely related to each other. [1]
- (ii) The scientists who wrote this study, Krause *et al.*, described the findings as proving that there was a "rapid radiation" of bears 5 million years ago. Describe the evidence from the figure that supports the idea of "rapid radiation". [2]
- (iii) The brown bears and polar bears have only recently speciated when compared to the rest of the phylogenetic tree. Suggest **one** cause of this speciation event. [1]

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**(4 marks)**

4 (a) When a polyploidy event occurs that causes speciation, is this more likely to be an example of gradualism or punctuated equilibrium? Explain your answer.

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(2 marks)

(b) Plants that exist in the most northern regions of the world, such as Svalbard, have been extensively studied to identify their ploidy.

The figure below shows the ploidy levels of 1719 species that were studied in different regions, ranging from warmer forested regions, north into the extreme arctic desert.  $2n$  represents the diploid species,  $4n$  represents the tetraploid species, and  $>4n$  represents the species with more than four sets of chromosomes.

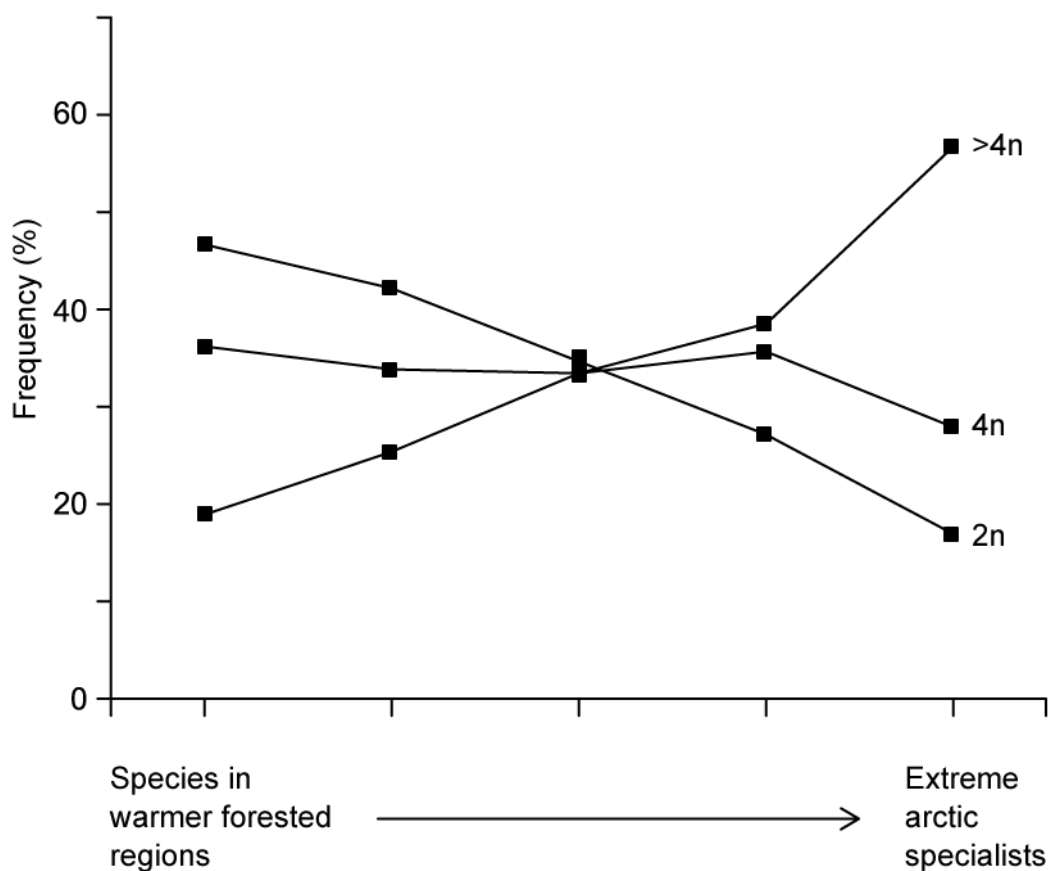


Figure taken from Brochmann *et al.* 2004

Describe the trends shown in this figure.

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**(4 marks)**

- (c)** The scientists concluded from this study that polyploidy was more common in species of plants adapted for extreme cold environments because it helps to "buffer against inbreeding".

Suggest why inbreeding is so common with these types of plants, and explain why polyploidy "acts as a buffer".

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**(3 marks)**

- (d)** A second suggestion for the reason behind the increased ploidy in arctic flora is that it increases hybrid vigour.

Define the term hybrid vigour.

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**(2 marks)**

**5 (a)** *One mark is available for clarity of communication throughout this question.*

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.

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**(3 marks)**

**(b)** The evolution of some species can be driven by female preferences.

This has occurred in a species of birds called the long-tailed widowbird. The ancestors of the long-tailed widowbird had very short tails. This changed when females developed a behaviour causing them to preferentially mate with the males with the longest tails. However, if their tail is too long the male is weighed down by it and cannot fly, causing it to die prematurely.

Describe the type of selection that has occurred to the long-tailed widowbird.

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**(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.

One aspect of genome study that scientists can learn a lot from is the study of the frequencies of different alleles in different populations around the world.

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

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**(7 marks)**