

# 10.3 Gene Pools & Speciation

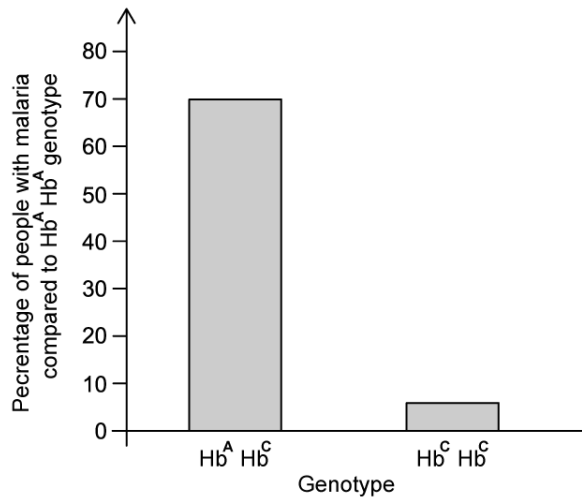
## Question Paper

Course	DP IB Biology
Section	10. Genetics & Evolution (HL Only)
Topic	10.3 Gene Pools & Speciation
Difficulty	Hard

**Time allowed:** 70  
**Score:** /53  
**Percentage:** /100

**Question 1a**

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.

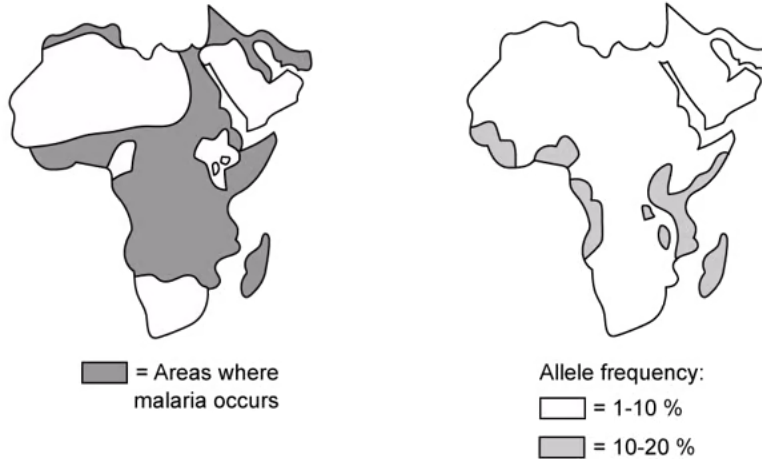
[2 marks]

[2 marks]

**Question 1b**

b)

The image below shows the prevalence of malaria and the frequency of the  $Hb^C$  allele. Those individuals homozygous with  $Hb^C Hb^C$  develop mild anaemia. Scientists concluded that the  $Hb^C$  allele is more prevalent in areas with higher risk of mortality from malaria.



Use the information in part (a) to evaluate their conclusion.

[3 marks]

[3 marks]

**Question 1c**

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.

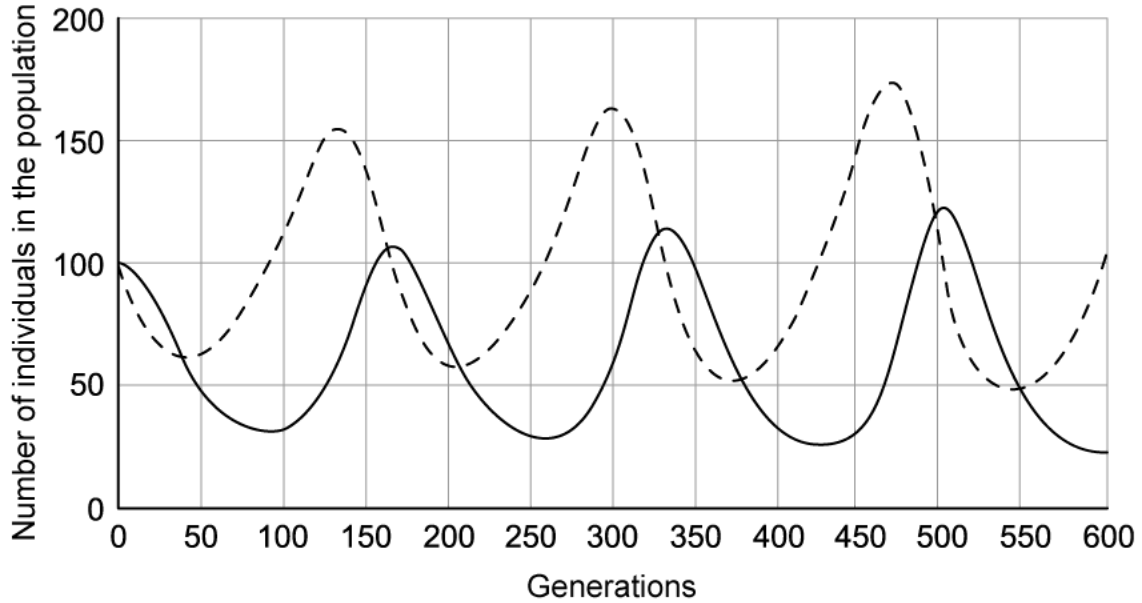
Calculate the frequency of the  $Hb^C$  allele in the village.

[2 marks]

[2 marks]

**Question 2a**

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



**Key:** - - - = Rabbits    — = Wolves

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.

[4 marks]

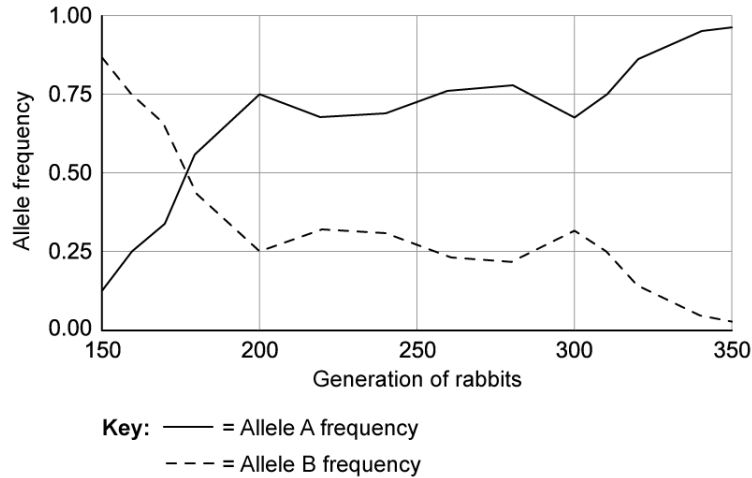
[4 marks]

**Question 2b**

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**).



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 marks]

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 marks]

[4 marks]

### Question 2c

b)  
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.

[1 mark]

[1 mark]

### Question 3a

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.

[4 marks]

[4 marks]

### Question 3b

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

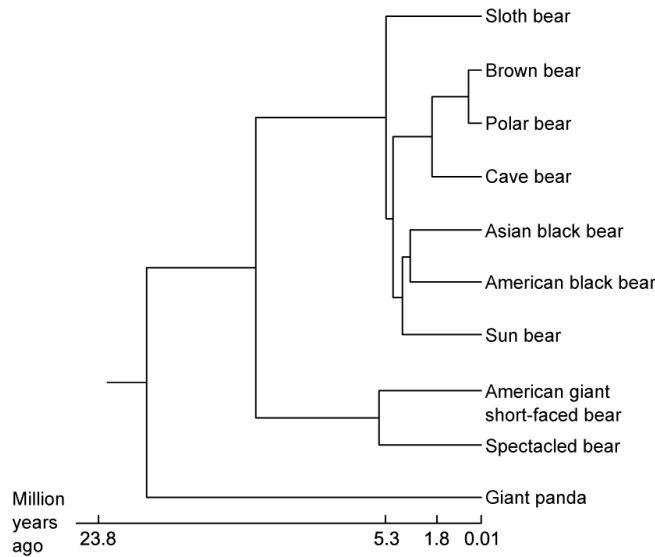
Suggest how scientists know about their evolutionary past.

[2 marks]

[2 marks]

**Question 3c**

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 mark]

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 a "rapid radiation".

[2 marks]

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 mark]

[4 marks]

**Question 4a**

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.

**[3 marks]****[3 marks]**



**Question 4b**

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 represent the diploid species, 4n represents the tetraploid species, and >4n represents the species with more than four sets of chromosomes.

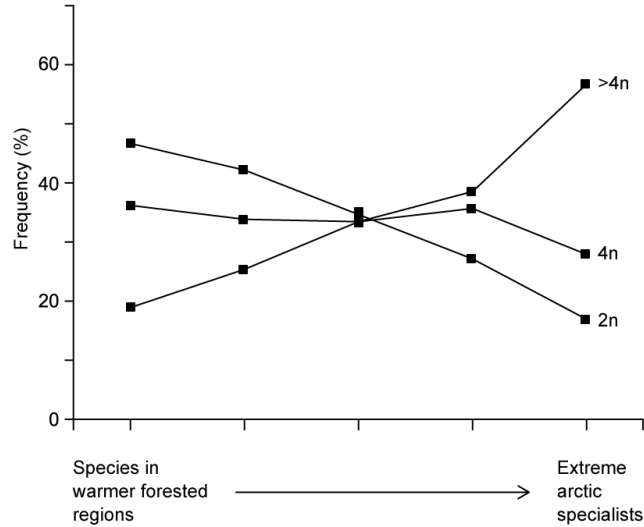


Figure taken from Brochmann et al. 2004

Describe the trends shown in this figure.

[4 marks]

[4 marks]

### Question 4c

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".

[3 marks]

[3 marks]

### Question 4d

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.

[2 marks]

[2 marks]

### Question 5a

*One mark is available for clarity of communication throughout this question.*

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]

[3 marks]

## Question 5b

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.

[5 marks]

[5 marks]

**Question 5c**

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.

**[7 marks]****[7 marks]**