

***Human Biology ATAR – Task 11: Science Inquiry***

***The genetic of sickle anaemia (5%)***

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| --- | --- | --- | --- |
| Name: MARKING KEY | | | |
| Time allowed: 1 Lesson | | | |
| **Section** | Your Mark | Marks available | Percentage of Investigation |
| Research questions |  | 20 | 100% |

**Declaration of Authenticity**

I (Student Name) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ declare that this work is my own and I have not plagiarised from any source.

Signature:  
  
Date:

1. Write down the genotype of a person with (2 marks)
   1. Sickle-cell anaemia HbS HbS
   2. Sickle-cell trait HbA HbS

*The gene that brings about the formation of sickle cell haemoglobin is rare in most human populations. In some parts of Africa, however, the sickle cell trait is found in as much as 40 per cent of the population*.

1. When a heterozygous individual mates with another heterozygous individual, what is the percentage of the offspring that would be expected to be homozygous for the Sickle-cell Anaemia? Show all working (punnet square) (3 marks)

Cross: HbA HbS X HbA HbS 1 mark

|  |  |  |
| --- | --- | --- |
|  | HbA | HbS |
| HbA | HbA HbA  normal | HbA HbS  trait |
| HbS | HbA HbS  trait | HbS HbS  anaemia |

1 mark

25% homozygous for Sickle-cell Anaemia – 1 mark

1. What effect would you expect the death of children with Sickle-cell anaemia to have on the frequency of the gene for sickling in any population? (1 mark)

The death of children with Sickle-cell Anaemia will reduce the frequency of the gene for sickling, this removes the from trait the gene pool

1. Which would you expect to leave more children surviving into adulthood - couples mating who both have Sickle-cell trait *(heterozygous individuals)* or couples mating who both have normal red blood cells? Why? Show evidence to support your argument (3 marks)

|  |  |  |
| --- | --- | --- |
|  | HbA | HbS |
| HbA | HbA HbA  normal | HbA HbS  trait |
| HbS | HbA HbS  trait | HbS HbS  anaemia |

Couple both with Sickle-cell Trait – produce

25% normal

50% with the trait

25% with anaemia – generally die in childhood

( 1 mark)

|  |  |  |
| --- | --- | --- |
|  | HbA | HbA |
| HbA | HbA HbA  normal | HbA HbA  normal |
| HbA | HbA HbA  normal | HbA HbA  normal |

100% normal

Hence the offspring of the normal cross will have more chance of reaching adulthood (100%) (1 mark)

than the heterozygous cross where 75% will reach adulthood (1 mark)

*There is no evidence that the frequency of the gene for sickling is becoming less in African populations. Therefore a biological problem arises: how can the gene for sickling be so great when natural selection works so strongly against the gene? Biologists have developed at least three hypotheses to account for the high frequency of the sickling gene in African populations. One involves mutation rates, a second involves fertility and a third involves resistance to disease.*

*Through genetic reasoning and mathematical techniques, it is possible to calculate the rate at which genes are lost from the population gene pool by natural selection. This rate has been found to be 100 times the average rate of mutation at any one place on a gene in human chromosomes.*

1. Does this finding support or not support the *mutation rates* hypothesis? Explain.

(2 marks)

Not supported – the rate that genes are lost from the population is 100 times average mutation rate, hence does not explain how the gene for sickling is not reducing

1. Does this finding support or not support the *fertility* hypothesis? Explain (2 marks)

Not supported – no evidence people with Sickle-cell trait produce more children that those with normal haemoglobin implies that fertility is not a factor.

*As data on sickling was collected, the frequencies of the Sickle-cell trait in various populations were plotted on maps. It became clear that the gene is most common in a belt extending across Central and West Africa. In the same region, malaria and hookworm are common diseases. Malarial parasites multiply inside red blood cells; hookworms feed on the lining of the intestines.*

1. Which of the two diseases would be most likely to be associated with sickling? Explain. (2 marks)

Malaria as the parasites (cause of transmission) multiply inside red blood cells.

*The present frequency of Sickle-cell trait in parts of Africa from which the ancestors of African Americans came indicates that the early African American population contained about 22 per cent sicklers.*

1. How would mixing with the European population have caused this frequency to change? Use a punnet square to demonstrate how this happens (3 marks)

So, percentage sicklers has gone from ~40% to ~22% in parts of Africa. By mixing with European populations, the frequency of sicklers will decrease as the introduction of more ‘normal’ genes (assumption that Europeans are all normal) will ‘dilute’ the sickle cell genes and they will disappear from the gene pool (1)

|  |  |  |
| --- | --- | --- |
|  | HbA | HbA |
| HbA | HbA HbA  normal | HbA HbA  normal |
| HbS | HbA HbS  trait | HbS HbA  trait |

Hence: this cross produced 50% sicklers

In a heterozygous cross, at least 75% have at least one sickle cell gene/trait or anaemia

Gene frequency decreases as individuals with anaemia leave the population which they would get from heterozygous crosses (1)

(1)

*In the United States of America, control measures have almost eliminated the transmitter of Malaria - the Anopheles mosquito.*

1. Recalling that an individual homozygous for sickling usually dies before reaching reproductive age, what would you expect to happen to the frequency of the gene for sickling in the United States. Why? (2 marks)

When an individual homozygous for sickling dies, genes are removed from the gene pool, hence the frequency of the gene for sickling will decrease.