**ATAR HUMAN BIOLOGY – UNIT 4**

**TASK 8 – Evolutionary Mechanisms Investigation**

**NAME: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ WEIGHTING: 3 %**

**DUE DATE: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ MARK: \_\_\_\_\_\_ / = \_\_\_\_\_\_ %**

**Allele Frequencies and Sickle Cell Anaemia Investigation**

**Part A –** Carry out a practical investigation into how a selection pressure can influence a gene pool.

(1 lesson) *(12 marks)*

**Part B –**Processing and analysis of results from the practical investigation using knowledge of the Sickle Cell Anaemia Disease and Evolutionary Mechanisms studied. (1 lesson) *(25 marks)*

**Background**: Read the background information provided in the handout, Genetics of Sickle Cell Anaemia

**Introduction:** Allele frequency refers to how often an allele occurs in a population. Allele frequencies can change in a population over time, depending on the ‘selective pressure’ shaping that population. Predation, food availability, and disease are all examples of selective pressures.

**Evolution occurs when allele frequencies change in a population!**

In this activity, blue and black beads are used to represent two alleles of β globin. The BLACK beads represent gametes carrying the β globin A allele, and the BLUE beads represent gametes carrying the β globin S allele.

If an individual inherits two A alleles then they will have normal blood but will be susceptible to malaria.

An individual with two S alleles will have the Sickle Cell disease and will die young.

An individual with both the S and A alleles will be a carrier for the sickle cell disease but will be resistant to malaria.

In this investigation the imaginary Gene Pool you are monitoring exists in a region of Africa that is infested with malaria. You are going to simulating the effects of a high frequency of malaria on the allele frequencies of a population. You will be simulating the breeding patterns of humans by combining at random, the gametes that carry either the A allele or the S allele.

**Materials**: 75 Black beads, 25 blue beads, 5 containers (e.g. paper cups), one coin.

**Hypothesis**: What do you think will happen to the frequencies of the A and S alleles as a result of the presence of malaria? Formulate a hypothesis **and** explain your reasoning. *(4 marks)*

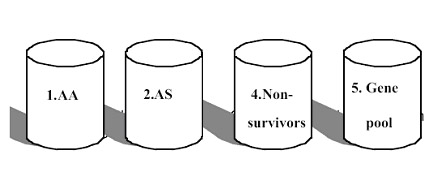
**Hypothesis:**

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**Method**

1. In pairs, collect your 100 beans, one coin and five containers.

2. Label the four containers with the following;



3. Place all the black and blue beads into the Gene pool container. Mix them up thoroughly.

4. Without looking, take out TWO beans from the gene pool. This is simulating the act of fertilisation to produce a new individual.

5. For every two beans chosen, your partner will flip a coin (or flipper) to determine whether the new individual is infected with malaria or not (grey box of table below).

Using the table below, the flip of the coin will determine in which container to put the two beans. Essentially you are deciding whether the individual lives or dies.

|  |  |  |  |
| --- | --- | --- | --- |
| **Genotype –**  **genetic make up** | **Phenotype –**  **sickle cell or not**  **reaction to malaria** | **Heads -**  **with malaria** | **Tails –**  **not infected with malaria** |
| AA (Black-Black) | No sickle cell disease  Susceptible to malaria | DIE  place in **non-survivors** | LIVE  place in **AA** |
| AS (Black-Blue) | No sickle cell disease  Resistant to malaria | LIVE  place in **AS** | LIVE  place in **AS** |
| SS (blue-blue) | Sickle cell disease | DIE  place in **non-survivors** | DIE  place in **non-survivors** |

6. Continue pairing up your beans in the same way until the gene pool is empty.

7. At the end record all your results. Draw up a table to record the numbers of A and S alleles left.

8. Now add these survivors back into the gene pool to produce the next generation; put all the beads from the survivor’s containers into the gene pool container. **Don’t touch the beads in the non-survivors container.**

9. Repeat the process for a second, third and fourth generation. Record all results in a table in the space below.

10. Combine all the results from the class. Collate and process these results by calculating the % Allele frequency in each generation. Put the results into a table and then present the results in a graph form.*(8 marks)*

**Analysis and Evaluation (6 Questions - 25 marks)**

1.Describe the trends and/or patterns in your data. (*3 marks)*

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2. Explain, using your knowledge of evolutionary mechanisms, the possible reasons for the trends shown in your data. *(4 marks)*

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3. Write a conclusion for this experiment. *(2 marks)*

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4. Discuss the reliability and validity of this investigation, include examples and reasoning for your comments. *(5 marks)*

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5. Sickle cell anaemia is a lethal recessive disease that scientists are working hard to eliminate from society as it is difficult to treat and expensive for the care of a sick individual. With embryo selection possible, the reality of eliminating Sickle Cell Disease from society is becoming increasingly possible.

Discuss the positives and negatives of eliminating the Sickle Cell allele from society. *(5 marks)*

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6. In America there is a much higher incidence of Sickle Cell Disease amongst African-Americans compared to people in America of other decent. In terms of evolutionary mechanisms describe how this is possible and discuss what factors would affect this allele frequency in the future. *(6 marks)*

*\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\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**Analysis and Evaluation (6 questions – 25 marks)**

1.Describe the trends and/or patterns in your data. *(3 marks)*

2. Explain, using your knowledge of evolutionary mechanisms, the possible reasons for the trends shown in your data. *(4 marks)*

3. Write a conclusion for this experiment. *(2 marks)*

4. Discuss the reliability and validity of this investigation, include examples and reasoning for your comments. *(5 marks)*

5. Sickle cell anaemia is a lethal recessive disease that scientists are working hard to eliminate from society as it is difficult to treat and expensive for the care of a sick individual. With embryo selection possible, the reality of eliminating Sickle Cell Disease from society is becoming increasingly possible.

Discuss the positives and negatives of eliminating the Sickle Cell allele from society. *(5 marks)*

6. In America there is a much higher incidence of Sickle Cell Disease amongst African-Americans compared to people in America of other decent. In terms of evolutionary mechanisms describe how this is possible and discuss what factors would affect this allele frequency in the future. *(6 marks)*

**Mark scheme**

**Hypothesis**: What do you think will happen to the frequencies of the A and S alleles as a result of the presence of malaria? Formulate a hypothesis **and** explain your reasoning. *(4 marks)*

|  |  |
| --- | --- |
| **Description** | **Marks** |
| *If malaria is present*  *then the number of A & S alleles will stay relatively constant* | 1-2 |
| *Then any two of the following:* | |
| *Malaria provides a selection advantage for carriers of sickle cell anaemia* | 1 |
| *Therefore carriers will survive breed and pass on alleles keeping the sickle cell allele frequency the same* | 1 |
| *Not all the normal individuals will die of malaria so A allele frequency will also remain constant* | 1 |
|  | **Total 4** |

**Table – 3 marks**

|  |  |
| --- | --- |
| **Description** | **Marks** |
| *Table should be headed appropriately* | 1 |
| *Should be neatly drawn, correct* | 1 |
| *Averages calculated correctly* | 1 |
|  | **Total 3** |

**Graph – 5 marks**

|  |  |
| --- | --- |
| **Description** | **Marks** |
| *Title including independent and dependent variables eg graph to show how malaria affects the allele frequencies of A and S alleles over generations* | 1 |
| *Axis labelled correctly with units* | 1 |
| *Scales correct* | 1 |
| *Points plotted correctly* | 1 |
| *key* | 1 |
|  | **Total 5** |

1.Describe the trends and/or patterns in your data. *(3 marks)*

|  |  |
| --- | --- |
| **Description** | **Marks** |
| *Describe pattern for A allele* |  |
| *describe pattern for S allele* |  |
| *describes connection between two alleles* |  |
|  | **Total 3** |

2. Explain, using your knowledge of evolutionary mechanisms, the possible reasons for the trends shown in your data. *(4 marks)*

|  |  |
| --- | --- |
| **Description** | **Marks** |
| *Number of A alleles removed from gene pool due to death by malaria* | 1 |
| *Half/some of the people with AA survive keeping the A alleles frequency higher than S* | 1 |
| *People with sickle cell die and remove alleles from gene pool* | 1 |
| *Heterozygous survive because of selection advantage* | 1 |
| *Number of A and S alleles going to next generation remain relatively even* | 1 |
|  | **Total 4** |

3. Write a conclusion for this experiment. *(2 marks)*

|  |  |
| --- | --- |
| **Description** | **Marks** |
| *Being a carrier for sickle cell increases chances of survival in a malaria region* | 1 |
| *which enables the frequencies of both alleles to remain relatively constant* | 1 |
| *Data (1)linked to hypothesis(1) – appropriate to student data* |  |
|  | **Total 2** |

4. Discuss the reliability and validity of this investigation, include examples and reasoning for your comments. *(5 marks)*

|  |  |
| --- | --- |
| **Description** | **Marks** |
| *tested what it was supposed to – so valid* | 1 |
| *showed how a selection advantage had an effect on a gene pool - reason* | 1 |
| Reasoning as to why not reliable eg: | |
| *the gene pool was not a true reflection of a real life gene pool* | Max 3 |
| *not births occurred so population continually reduced* |
| *50% chance of dying from malaria did not take into account any medical intervention/very high* |
| *Did not take into account any other factors that would affect survival such as food etc* |
|  | **Total 5** |

5. Sickle cell anaemia is a lethal recessive disease that scientists are working hard to eliminate from society as it is difficult to treat and expensive for the care of a sick individual. With embryo selection possible, the reality of eliminating Sickle Cell Disease from society is becoming increasingly possible.

Discuss the positives and negatives of eliminating the Sickle Cell allele from society. *(5 marks)*

|  |  |
| --- | --- |
| **Description** | **Marks** |
| *Positives eg:* | |
| *less people likely to inherit condition and suffer* | 1 -3 |
| *reduced medical costs on society* |
| *More productive at work as not many people suffering and being tired all the time* |
| *Negatives eg:* | |
| *If malaria comes back to the region more people will die of condition as less carriers* | 1 - 3 |
| *Mutation could come back so spending all money eliminating it waste of time* |
| *Disease can be helpful if carrier and can be treated now so symptoms not as bad* |
|  | **Max 5** |

6. In America there is a much higher incidence of Sickle Cell Disease amongst African-Americans compared to people in America of other decent. In terms of evolutionary mechanisms describe how this is possible and discuss what factors would affect this allele frequency in the future. *(6 marks)*

|  |  |
| --- | --- |
| **Description** | **Marks** |
| *Founder population had high incidence of sickle cell allele* | 1 - 6 |
| *Due to providing selection advantage in their home country* |
| *Brought to America as slaves so were a small, isolated population* |
| *Random genetic drift responsible for maintaining the high incidence of alleles even though no selection advantage* |
| *No population wide spread in the general community, gene pool much larger so alleles frequency much less* |
| *Less chance of heterozygous meeting so frequency of allele will reduce much quicker* |
| *People with condition will still die and remove alleles from gene pool or technology will help couples have offspring without sickle cell reducing the allele frequency in gene pool* |
|  | **Total 6** |