17.2 Natural & Artificial Selection

Question Paper

Course	CIE A Level Biology
Section	17. Selection & Evolution
Topic	17.2 Natural & Artificial Selection
Difficulty	Hard

Time allowed: 50

Score: /36

Percentage: /100

Question 1a

Researchers investigated the extent to which the founder effect and natural selection affect evolutionary change.

Fig. 1 shows the brown anole lizard, *Anolis sagrei*. These lizards live on a number of Caribbean islands and feed on a variety of invertebrates and other small animals.

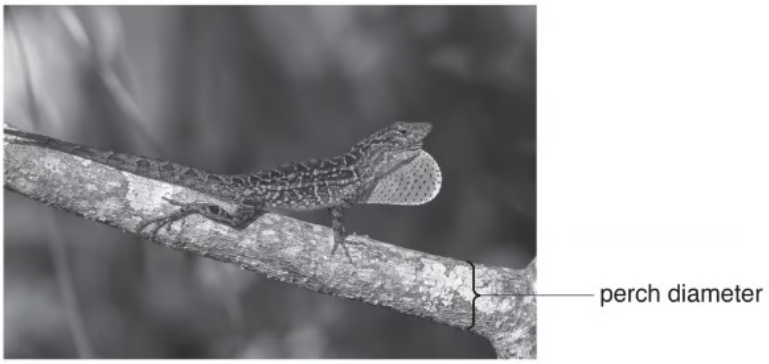

Fig. 1

A. sagrei spends a lot of time perching (resting) on, or moving along, branches of shrubs and trees. The width of the branch that *A. sagrei* perches on is known as the perch diameter, as labelled in Fig. 1.

There is a positive correlation between perch diameter and hind limb length of *A. sagrei.*

- Longer hind limbs allow *A. sagrei* to run faster on vegetation with a larger diameter
- Shorter hind limbs are needed to provide stability on vegetation of a smaller diameter

In 2004, a hurricane caused the death of all the *A. sagrei* lizards on seven islands.

In 2005, the researchers randomly collected seven male and seven female lizards from a source population on a nearby island. For each of the seven islands affected by the hurricane, a male and female lizard were mated and placed on each island. These islands formed the experimental founder islands where new populations of *A. sagrei* were successfully established from each founding pair.

Fig. 2 shows the difference in vegetation between the source island and the seven experimental founder islands.

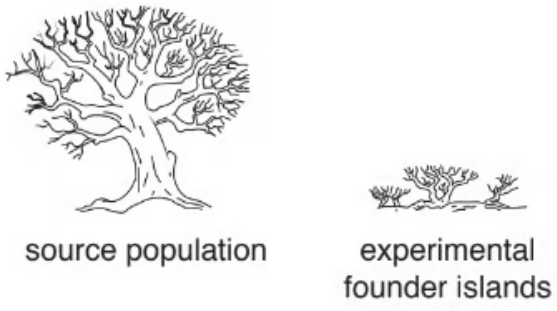

Fig. 2

(i)
Predict the effect of natural selection on mean hind limb length of *A. sagrei* on the seven experimental founder islands.

[1]

(ii)
Predict how collecting individuals at random for the seven founding pairs affects the mean hind limb length of *A. sagrei* on the different islands.

[1]

[2 marks]

Question 1b

Many generations of *A. sagrei* were produced over the four years after the introduction of the founding pairs.

Fig. 3 shows how the mean hind limb length of *A. sagrei* changed on the seven experimental islands and on the source island.

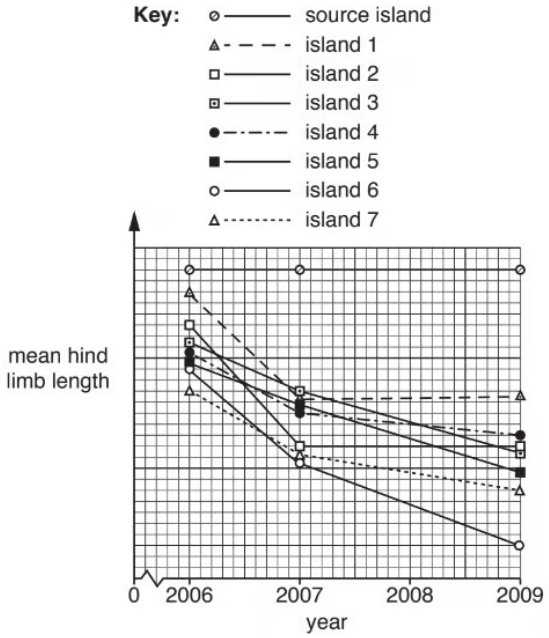

Fig. 3

With reference to Fig. 2 and Fig. 3, describe **and** suggest explanations for the results for the islands.

[5 marks]

Question 1c

In the investigation, one population of *A. sagrei* was established on each experimental founder island.

Outline how speciation may occur on the seven experimental founder islands.

[3 marks]

Question 1d

Speciation is one possible outcome for the experimental founder populations, but there is also a high risk that they may become extinct.

Explain why the experimental founder populations are at high risk of extinction.

[3 marks]

Question 2a

Artificial insemination (AI) is one method used in assisted reproduction programmes for large mammals.

For many years, horse breeders have collected semen samples from male horses and used these to inseminate female horses. Success rates have been good. However, due to the sample containing live sperm cells, the process needed to be carried out quickly.

New technologies exist to allow horse semen to be frozen in small plastic straws. Semen samples can now be stored for many years and transported all over the world.

- Each 0.5 cm^3 straw can hold 7.5×10^7 sperm cells.
- A typical sample of horse semen contains 7.5×10^9 sperm cells.

(i)
Calculate the volume of a typical horse semen sample.

[1]

(ii)
To inseminate one female horse, 5.0×10^8 sperm cells are needed.

Calculate the minimum number of straws needed to carry out this process.

[1]

[2 marks]

Question 2b

The semen from a horse is analysed by technicians to determine its quality before the horse is accepted onto the assisted reproduction programme.

Technicians use microscopy to look at the appearance and motility of the sperm cells and to estimate the sperm count.

Fig.1 shows the surface view of a haemocytometer used to estimate the number of sperm cells in a sample.

Each number represents a sperm cell which was counted in the sample.

Each star (*) represents a sperm cell **not** counted in the sample.

The depth of the haemocytometer is 0.1mm.

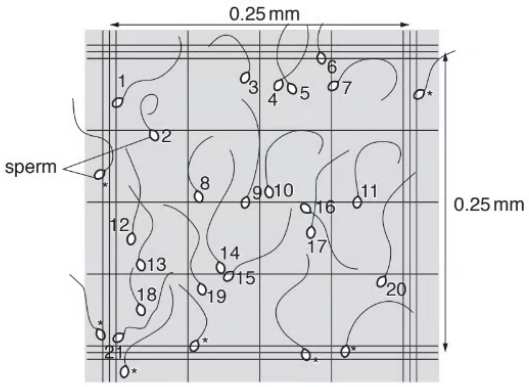

Fig. 1

Suggest how this apparatus could be used to estimate the number of sperm cells per cm^3 of semen **and** describe how the technician decided which sperm cells to include in the count.

[4 marks]

Question 2c

To ensure that the sperm cells remain viable after they have been frozen, a solution is added to the sample **before** freezing the semen in the straws.

The solution contains:

- a sugar
- a buffer to maintain pH
- antibiotics.

Explain why it is necessary for the solution to contain these three substances.

[3 marks]

Question 3a

Researchers have found evidence of natural selection in humans.

- Originally, in human populations it was only babies and children that needed to digest the milk sugar, lactose. The gene coding for the enzyme lactase (*LCT gene*) was switched off before adulthood.
- Today, in many populations, some adult individuals have lactose intolerance, which means they cannot digest lactose. Lactose intolerance leads to side-effects such as abdominal pain after eating food containing lactose.
- A mutation has been identified that keeps the *LCT gene* switched on. An adult who has this mutation is able to digest lactose. This is called lactose persistence.
- Lactose persistence increased in populations in Europe several thousand years ago.
- The increase in lactose persistence in Europe coincided with an increase in farming of cows for milk.

(i)

Natural selection has caused this increase in lactose persistence.

State the type of selection that has caused this increase.

[1]

(ii)

Explain why there was selection for lactose persistence in humans several thousand years ago.

[3]

[4 marks]

Question 3b

Lactose intolerance and lactose persistence were investigated in a test population in Europe.

The mutation which causes lactose persistence is in a regulatory gene (**T/t**).

- People with lactose intolerance have the genotype **tt**.
- People with lactose persistence have the genotypes **TT** and **Tt**.
- 166 people were tested for their genotype.
- 58 people were found to have lactose intolerance.

(i)

The Hardy–Weinberg principle can be used to calculate allele, genotype and phenotype frequencies in populations.

The Hardy–Weinberg equations are shown in Fig.1:

$$p + q = 1$$
$$p^2 + 2pq + q^2 = 1$$

Fig. 1

Calculate the frequency of allele **T**.

Show your working.

[3]

(ii)

When the calculated phenotype frequencies were compared to those in the general population in Europe, it was found that the percentage of people with lactose intolerance in this test population was much higher than in the general population.

Suggest **two** reasons why the percentage of people with lactose intolerance was much higher in the test population than in the general population.

[5 marks]

Question 3c

In eukaryotes, gene expression is controlled by transcription factors, coded for by regulatory genes.

(i)

Outline ways in which transcription factors carry out their role.

[2]

(ii)

It is estimated that 2% of human DNA consists of genes coding for proteins (structural genes). Of the remaining 98%, some of the DNA consists of regulatory genes and control sequences that together control gene expression.

State **one** type of control sequence found in human DNA.

[1]

(iii)

A study of human evolution identified the location of mutations that result in a change in human phenotype. The study found most examples of mutations had occurred in regulatory genes, not structural genes.

Suggest **and** explain why most changes in human phenotype are due to mutations in regulatory genes.

[2]

[5 marks]