



NATIONAL SENIOR CERTIFICATE EXAMINATION
MAY 2021

LIFE SCIENCES: PAPER I

Time: 3 hours

200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 14 pages and a yellow Answer Booklet of 15 pages (i–xv). Please check that your question paper is complete. Detach the yellow Answer Booklet from the middle of the question paper. Remember to write your examination number in the blocks provided.
 2. This question paper consists of four questions.
 3. Question 1 must be answered in the yellow Answer Booklet provided.
 4. Questions 2, 3 and 4 must be answered in your Answer Book.
 5. Start **each question** on a **new** page.
 6. Read the questions carefully.
 7. Number the answers exactly as the questions are numbered.
 8. Use the total marks that can be awarded for each of Questions 1, 2, 3 and 4 as an indication of the detail required.
 9. It is in your own interest to write legibly and to present your work neatly.
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QUESTION 2

- 2.1 Read the extract below and use the information and your own knowledge to answer the questions that follow:

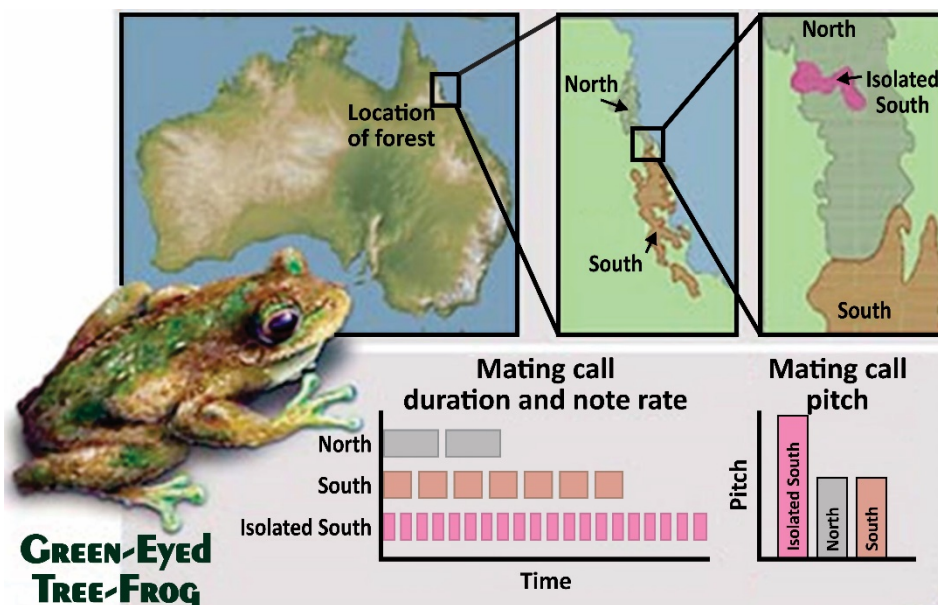
Picky female frogs drive evolution of new species in less than 8 000 years

"Female frogs in a tiny rainforest of Australia have driven the evolution of a new species", according to scientists from the University of Queensland, the University of California, Berkeley, and the Queensland Parks and Wildlife Service. The female frogs are highly selective in their choice of mate. The original population of tree frogs had become geographically separated into the northern and southern populations of tree frogs with the reduction of rainforest between 1 and 2 million years ago (see images below). A new species arose after the original two populations (the northern and southern populations) of the green-eyed tree frog re-established contact sometime during the last 8 000 years, resulting in three species of tree frog living in this rainforest today.

This speciation happened in the following manner. Although the mating calls of the northern and southern male frogs had become different from each other, the two groups could still interbreed. However, their hybrid offspring were less viable. In particular, the northern and southern groups had apparently changed enough during their million-year separation that offspring of southern females and northern males fail to develop beyond the tadpole/embryo stage.

Southern females that mated with southern males had healthy offspring and over several thousand years, this behaviour created a new reproductively isolated population – essentially a new species – that is unable to mate with either of the original northern and southern frog populations. The male frog mating call in the *new isolated south population* has changed significantly from both the northern and southern groups' calls. The calls of these male frogs had a higher pitch, were of shorter length and had a faster rate. (see graphs below)

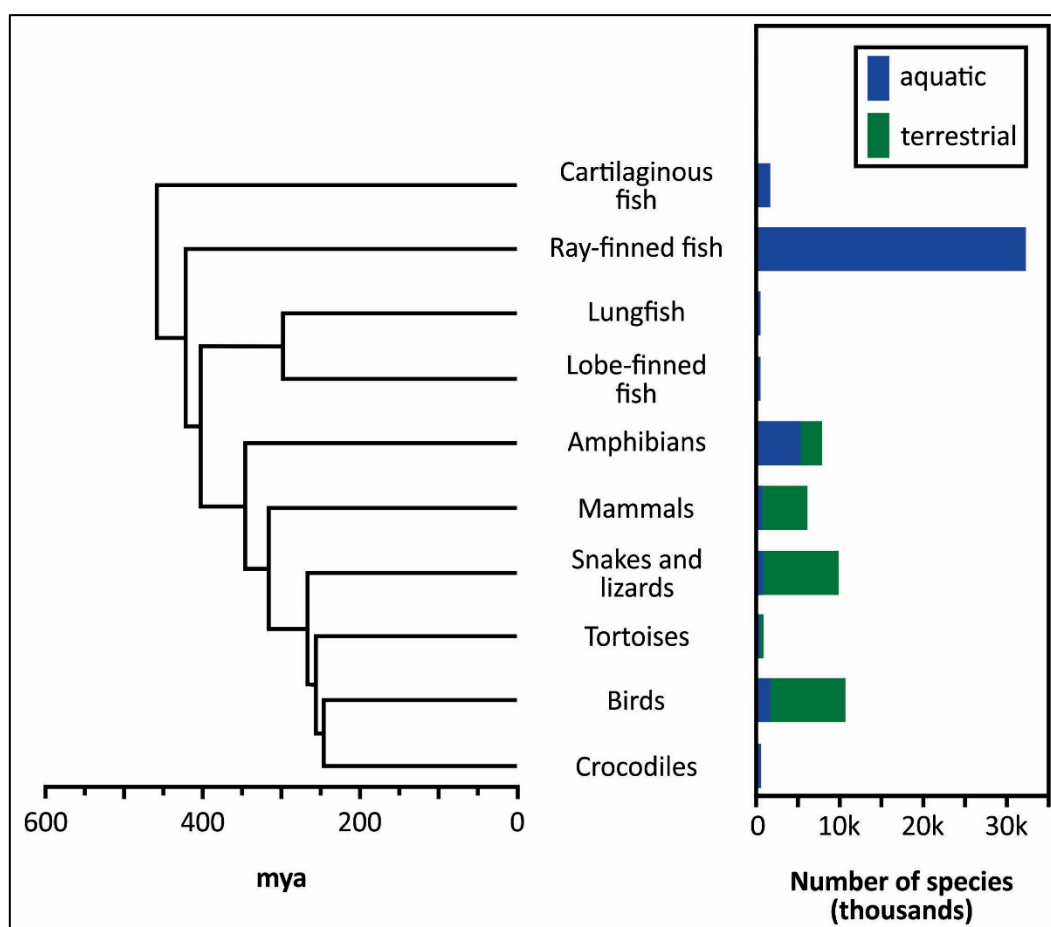
Location and mating calls of the Green-Eyed Tree frog populations in the rainforest of Australia.



[Adapted: <<https://www.berkeley.edu>>]

- 2.1.1 State TWO ways in which the mating call of the new isolated southern frog population differs from the north population of frogs. (2)
- 2.1.2 What type of speciation resulted in the new isolated southern frog species? Provide a reason for your answer. (2)
- 2.1.3 Suggest why the new isolated southern population of frogs could be considered a separate new species. (2)
- 2.1.4 Use the theory of natural selection to explain the changes seen in the mating calls of the new isolated southern male frogs. (5)
- 2.1.5 Discuss your understanding of the term *hybrid* in this source. (2)
- 2.1.6 Are the three different frog populations described in the text an example of convergent or divergent evolution? Explain your answer. (2)
- 2.1.7 Can the information in this article be considered reliable? Provide a well explained reason for your answer. (2)

- 2.2 Study the diagram of the phylogenetic tree of some vertebrates. Included in the diagram is the number of species in each vertebrate group as well as the number of species that live in aquatic (water) and in terrestrial (land) environments.



[Adapted: <<https://www.semanticscholar.org>>]

2.2.1 Refer to the diagram shown on the previous page and state whether the statements (a) to (f) are **true (T)** or **false (F)**.

- (a) The earliest vertebrates lived in an aquatic environment. (1)
- (b) Mammals have the greatest number of terrestrial species. (1)
- (c) There are 10 000 bird species. (1)
- (d) The lobe-finned fish diverged from the lungfish around 290 mya. (1)
- (e) Tortoises are more closely related to birds than to crocodiles. (1)
- (f) Amphibians have been present for 400 million years. (1)

2.2.2 Explain TWO lines of evidence that scientists can use to determine the evolutionary relatedness of the different groups of vertebrates. (4)

2.3 Doctors are now prescribing fewer antibiotics to reduce the evolution of antibiotic resistant bacteria. Using the example of antibiotic resistant bacteria, discuss how the theory of evolution can aid in understanding and solving this public health problem. (5)

2.4 An indication of the amount of genetic variation that occurs in any species is given by the percentage of heterozygous genes on the chromosomes of that species.

The table below shows the results of a study on the percentage of heterozygous genes at a number of different gene loci on the chromosomes of six different species.

Species	Heterozygous genes (%)
1. Human	6,7
2. Elephant seal	1
3. Horseshoe crab	5,7
4. Cheetah	0
5. Elephant	8,9
6. Fruit fly	12

2.4.1 Name the organism that has the greatest phenotypic variation. Give a reason for your answer. (2)

2.4.2 Name and describe a breeding method that could increase the percentage of heterozygous genotypes in a species. (2)

2.4.3 Explain why the breeding method you named in Question 2.4.2 that increases heterozygosity would be advantageous to a species. (2)

2.4.4 Which of the species is most likely to have undergone the Founder effect? Give a reason for your answer. (2)

[40]

QUESTION 3

- 3.1 Read the following text/source and use the information and your own knowledge to answer the questions that follow.

A scientist wanted to determine the population size of the Angulate tortoise on Robben Island, located 10 km off the coast of Cape Town. The tortoise population on Robben Island is considered a closed population. The mark-recapture method was considered suitable to determine an estimate for the population size.

The image below shows how the tortoises were marked during the study.



[Image: <www.researchgate.net>]

- 3.1.1 Identify ONE population parameter that will not apply to the Angulate tortoise. (1)
- 3.1.2 Name a precaution that should be taken when marking the tortoise to ensure reliable results. (1)
- 3.1.3 Name TWO density-dependent factors that could affect the growth of the tortoise population. (2)
- 3.1.4 The table below shows the data that the scientist collected during the study:

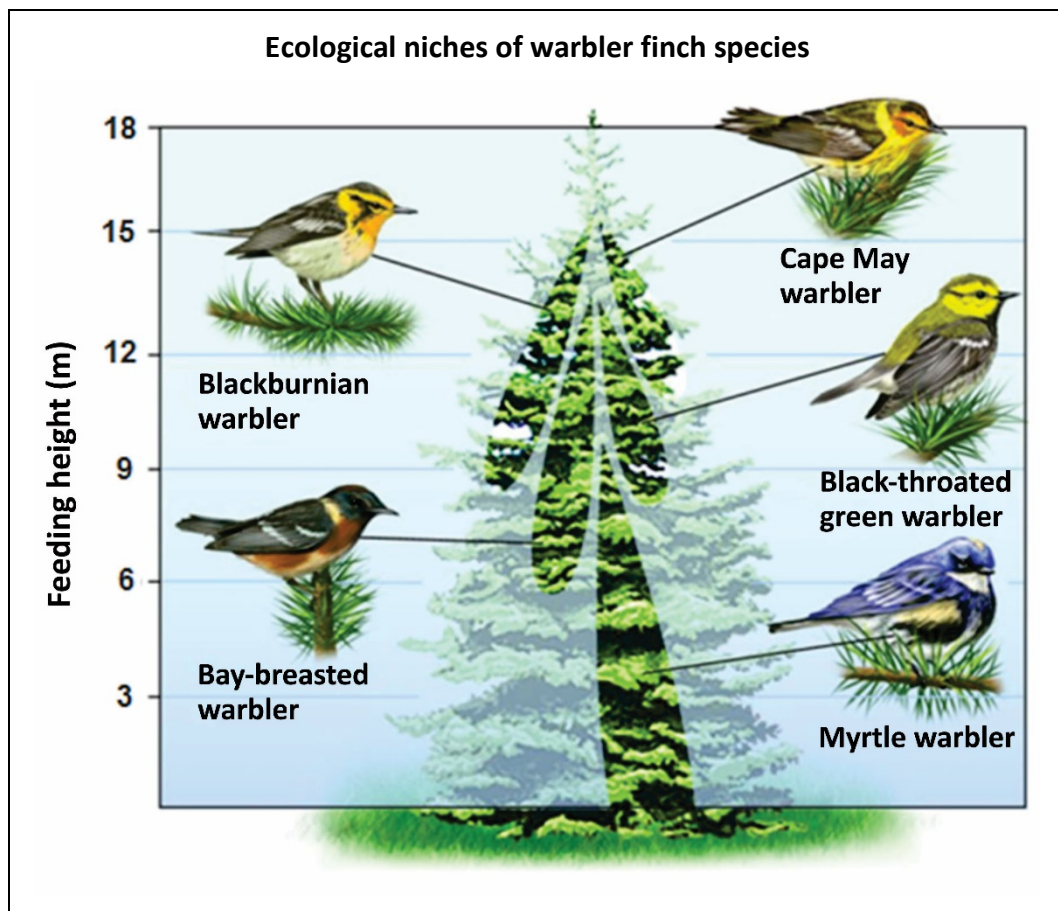
	Number of tortoises
First sampling session	
Number of tortoises captured and marked	37
Second sampling session	
Total number of tortoises captured	24
Number of tortoises originally marked	11

- Using the scientist's data in the table, calculate the size of the Angulate tortoise population on Robben Island. Show all working and express your answer as a whole number. (2)

3.1.5 A different method of sampling populations in an ecological study is to use a quadrat.

- (a) Explain why a biologist may select the quadrat sampling method rather than mark-recapture for a particular population. (2)
- (b) Explain why a system of random sampling must be adopted with the quadrat method in determining population size. (2)

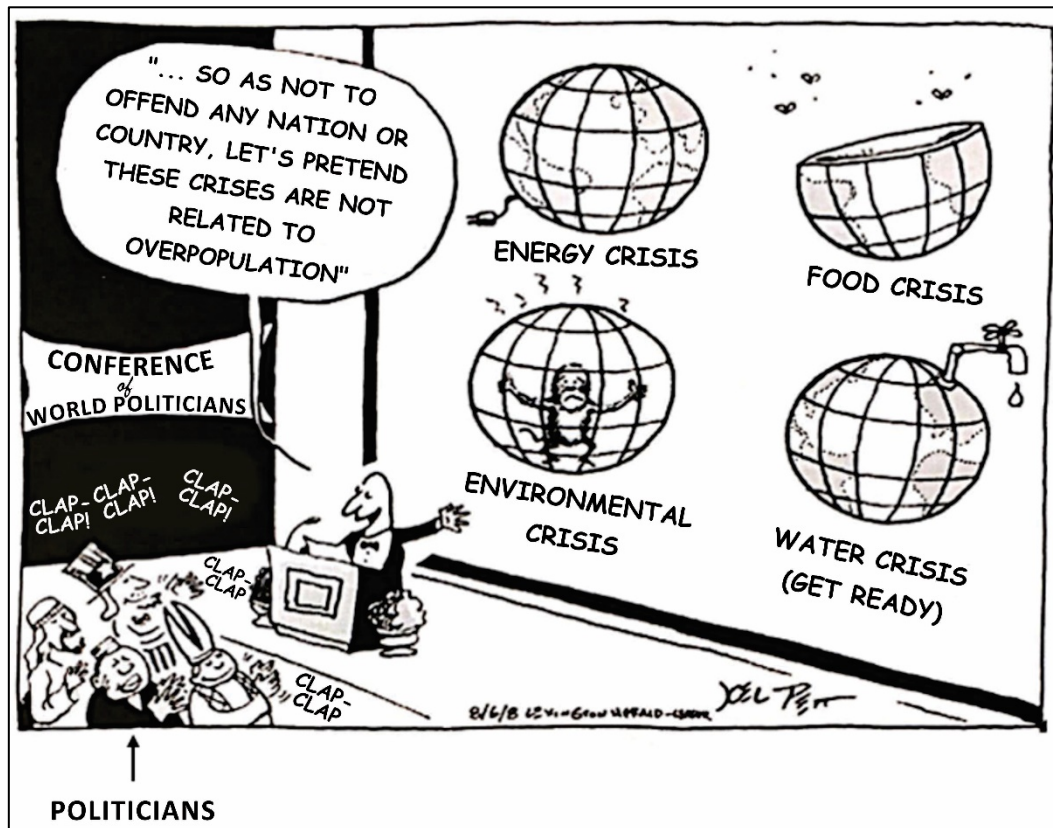
3.2 In North America, different species of warbler finch use fir trees as their habitat. Each warbler finch species occupies a different part of the tree as its ecological niche.



[Source: <<https://allyouneedisbiology.wordpress.com>>]

- 3.2.1 How does the example of warbler finches in fir trees depict interspecific competition? (1)
- 3.2.2 Explain why different ecological niches are important for the survival of all the finch species. (3)
- 3.2.3 Describe, using a named example, how co-existence that is seen in large herbivores in the African Savannah, reduces competition. (3)

- 3.3 Study the cartoon below and answer the question based on your observations.



[Adapted from: <<https://www.worldpopulationbalance.org>>]

Discuss the message that the cartoonist is conveying regarding human population growth.

(4)

- 3.4 In November 1974 in Ethiopia, the skeleton of a small hominid named Lucy was found. The skeleton was around 40% complete and at the time of the discovery, the most complete early hominid known.



- 3.4.1 Provide the scientific name of Lucy. (1)
- 3.4.2 Suggest why a palaeontologist who studies hominid fossils needs to be an expert in human anatomy. (3)
- 3.4.3 List FOUR skeletal features that a palaeontologist would include in a checklist required to identify if Lucy was bipedal. (4)
- 3.4.4 Anyone is allowed to download and print out casts from educational institutions of Lucy's bones on 3D printers. Suggest how this could promote the understanding of Hominid evolution within the general public. (3)

- 3.5 Read the text below and use the information and your own knowledge to answer the questions that follow:

Did a fall from a tree kill Lucy?

A group of researchers at the University of Texas have hypothesised that Lucy died after falling from a tree. They conducted CT scans of each of Lucy's bones over an eight-year period. The scientists then analysed the 35 000 digital slices that the scans generated. The scans revealed fractures that took place in living bone tissue indicating that these happened before her death.

Nine orthopaedic surgeons who were shown the scans agreed that the fractures were caused by a fall from a considerable height.

Studies of fossilised mammals and pollen, and the geology of the environment where Lucy was found, indicated that the area was grass covered woodland with plenty of large trees.

An image from a video animation depicting a hypothetical scenario for Lucy's fall out of a tree



[Adapted: <<https://anthropology.net>>]

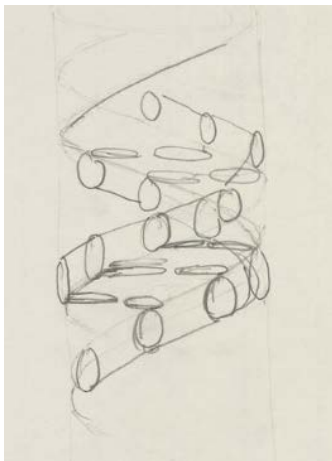
- 3.5.1 Suggest TWO reasons why Lucy would be climbing trees. (2)
- 3.5.2 List TWO pieces of evidence used by the researchers at the University of Texas to support their hypothesis. (2)
- 3.5.3 Some scientists are not convinced that the evidence put forward by the researchers from the University of Texas suggests that Lucy died from a fall. Do you think it is important that scientists should question new hypotheses and findings? Support your answer by providing good scientific reasoning. (4)

[40]

QUESTION 4

- 4.1 In 1953, James Watson and Francis Crick discovered the structure of DNA. Earlier, in 1950, Erwin Chargaff and his team had demonstrated that the amounts of the nitrogen bases, adenine and thymine, are equal. The other two DNA nitrogenous base amounts are also equal.

Sketch by Francis Crick of the DNA structure



[Source: <www.wdl.org>]

- 4.1.1 Identify TWO visible features on the simple sketch of DNA above that could be used to describe its structure. (2)
- 4.1.2 Samples from an ill person showed two different kinds of nucleic acids in their cells – both their human DNA and the RNA of viral nucleic acids. The results of the percentage of nitrogen bases for the nucleic acids in the samples are shown in the table below.

Use the information and your own knowledge to answer the questions.

Sample	Nitrogen bases (%)				
	A	T	G	C	U
1	22,1	22,1	27,9	27,9	0
2	24	0	36	27	13

- (a) Which sample contains the human DNA? Explain your answer. (3)
- (b) Name the nitrogenous base represented by "C". (1)
- (c) Draw a simple labelled diagram to show the components that make up ONE nucleotide in DNA. (3)
- (d) State ONE way in which RNA differs in structure from DNA. (1)

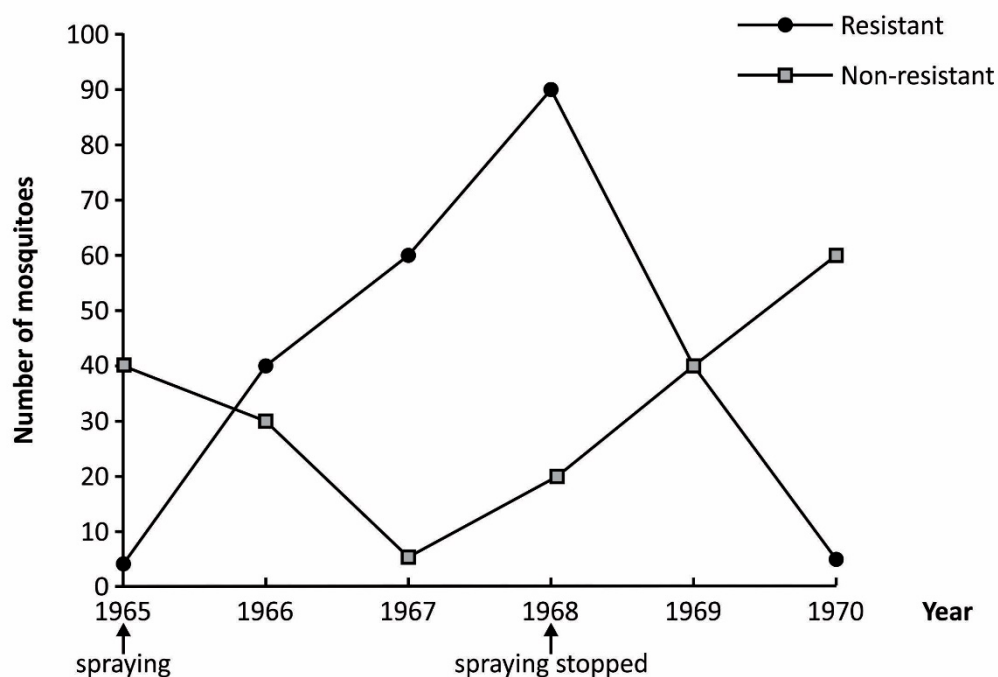
4.2 Read the information below on insecticide resistance and answer the questions.

In the 1960s an insecticide, DDT, was widely used to control insect pest populations.

The graph below shows the number of mosquitoes of 2 phenotypes:

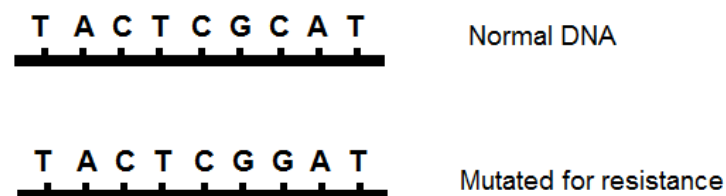
- those resistant to DDT
- those non-resistant to DDT

Scientists collected this data from 1965, when DDT was first used, through to 1970. Spraying with DDT was stopped in 1968.



Scientists have narrowed down how the mosquitoes develop resistance to DDT. They have found that resistant mosquitoes have a single mutation in the gene named *GSTe2*. This mutation makes insects produce a protein that helps the breakdown of DDT so that it is no longer toxic.

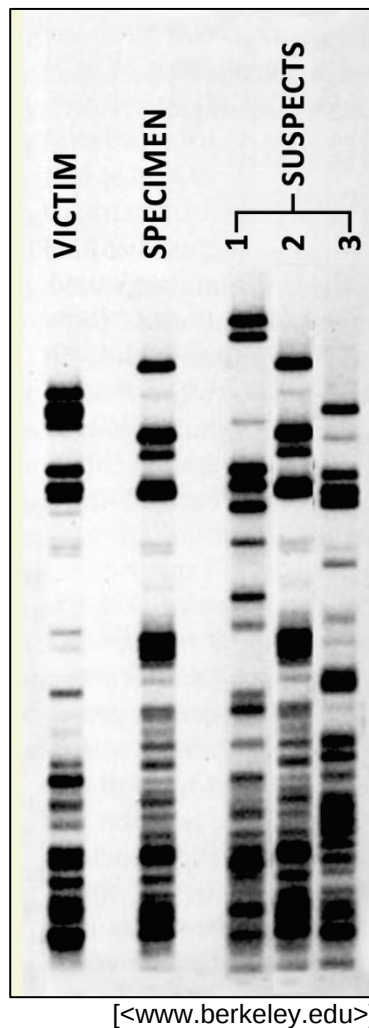
The normal DNA segment and the mutated DNA segment in the *GSTe2* gene are shown below:



[Adapted from: Victoria Certification of Education. 2004. Biology exam <www.vcaa.vic.edu.au>]
 [Source: <www.sciencedaily.com>]

- 4.2.1 Identify the dependent variable in the graph. (1)
- 4.2.2 In which year did the scientists collect the highest number of resistant mosquitoes? (1)
- 4.2.3 What can the scientists conclude about the effect of DDT on the number and phenotype of mosquitoes during the period that DDT was being sprayed? (3)
- 4.2.4 Refer to the normal DNA strand shown in the source.
- (a) Describe clearly the process during which the 'Normal DNA' strand is transcribed into mRNA. (4)
 - (b) Provide the mRNA strand that would be transcribed from the normal DNA strand during protein synthesis. (3)
- 4.2.5 Refer to the mutated DNA strand.
- (a) Identify the type of point mutation that occurred. (1)
 - (b) Explain why this mutation would result in the synthesis of a different protein that provides DDT resistance. (2)

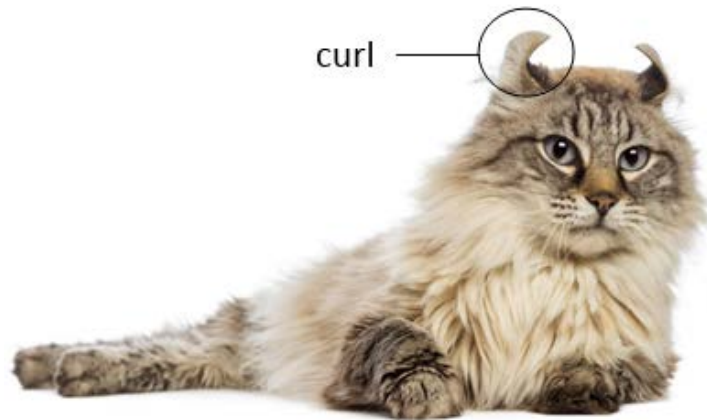
- 4.3 At a crime scene a forensic scientist found a small specimen of blood which was not from the victim. DNA was also extracted from the blood samples of the victim and three suspects and the DNA profiles were produced and can be seen below.



- 4.3.1 Identify the suspect that most likely committed the crime. (1)
- 4.3.2 The forensic scientist only found a small specimen of blood.
- (a) What procedure does the forensic scientist perform to ensure there is enough DNA for analysis? (1)
- (b) Which cells in the blood sample would be used to obtain DNA? (1)
- 4.3.3 Suggest TWO reasons why using only a DNA profile in identifying the person who committed the crime may not be reliable. (2)
- 4.3.4 Name one other use for a DNA profile. (1)

- 4.4 Read the information on the breeding of the American Curl cat below and answer the questions that follow.

The American Curl cat is a relatively new breed originating in the 1980s by selective breeding. The trait is a result of a natural mutation that causes distinctively curled ears. A single gene with two alleles codes for the ear-shape trait. The dominant allele (**R**) codes for curled ears, and the recessive allele (**r**) codes for straight ears.



[Image source: <<https://www.omlet.co.uk>>]

- 4.4.1 Differentiate between the terms *allele* and *gene*. (2)
- 4.4.2 From the source, select a term/phrase that describes *artificial selection*. (1)
- 4.4.3 A heterozygous male curl-eared cat is crossed with a heterozygous female curl-eared cat.

Using a punnet diagram, determine the expected genotypic and phenotypic ratios of the offspring that result from the cross.

(6)
[40]

Total: 200 marks