No. 208

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

University Entrance, Bursaries and Scholarships Examination

BIOLOGY: 2000

QUESTION BOOKLET

Time allowed: Three hours
(Total marks: 200)

INSTRUCTIONS

Write your answers in the appropriate spaces in ANSWER BOOKLET No. 208/1 (purple cover).

This paper is divided into four sections. Answer **ALL** questions in Sections 1 to 3 and only **ONE** essay topic in Section 4.

Allocation of marks and suggested times you should allow for answering each section are as follows:

Section 1 – Animal Behaviour and Plant Responses (page 2)	50 marks;	45 minutes
Section 2 – Genetics and Evolution (page 7)	90 marks;	80 minutes
Section 3 – Contemporary Techniques in Molecular Biology or Biotechnology (page 15)	20 marks;	20 minutes
Section 4 – Contemporary Biological Issues – Essay Topics (page 17)	40 marks;	35 minutes

Check that this question booklet has all of pages 2 – 17 in the correct order and that none of these pages is blank.

YOU MAY KEEP THIS QUESTION BOOKLET AT THE END OF THE EXAMINATION

(Turn over

SECTION 1: ANIMAL BEHAVIOUR AND PLANT RESPONSES

(50 marks: 45 minutes)

Instructions: Answer all parts of all questions in this section. The space allocated in the Answer Booklet is a guide to the length, and in some cases, the format of the answers that are required.

QUESTION ONE (9 marks)

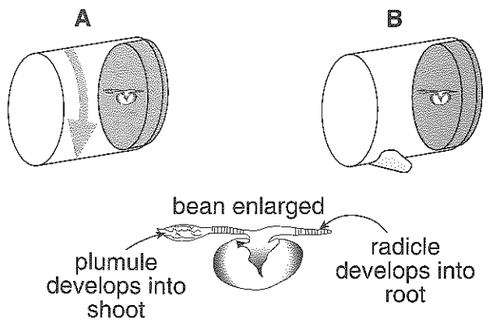
In plants grown in an environment in which light comes from one direction, the shoots grow towards the light.

(a) Name this growth response. (2 marks)

(b) What distinguishes a tropism from a nastic response? (1 mark)

Two newly-germinated bean seeds are attached to two separate clinostats (revolving wheels) as shown in the diagrams opposite.

Seed A is rotated continuously for 36 hours; seed B is left stationary. The experiment is carried out in darkness.



(c) On the diagrams in the Answer Booklet, draw in outline what each seedling will look like at the end of the 36 hours. (2 marks)

(d) In this experiment, what is the environmental stimulus to which:

(i) the plumule is responding?

(ii) the radicle is responding? (2 marks)

(e) Describe the **biological advantage** to the bean of both the plumule and radicle responses. (2 marks)

QUESTION TWO (13 marks)

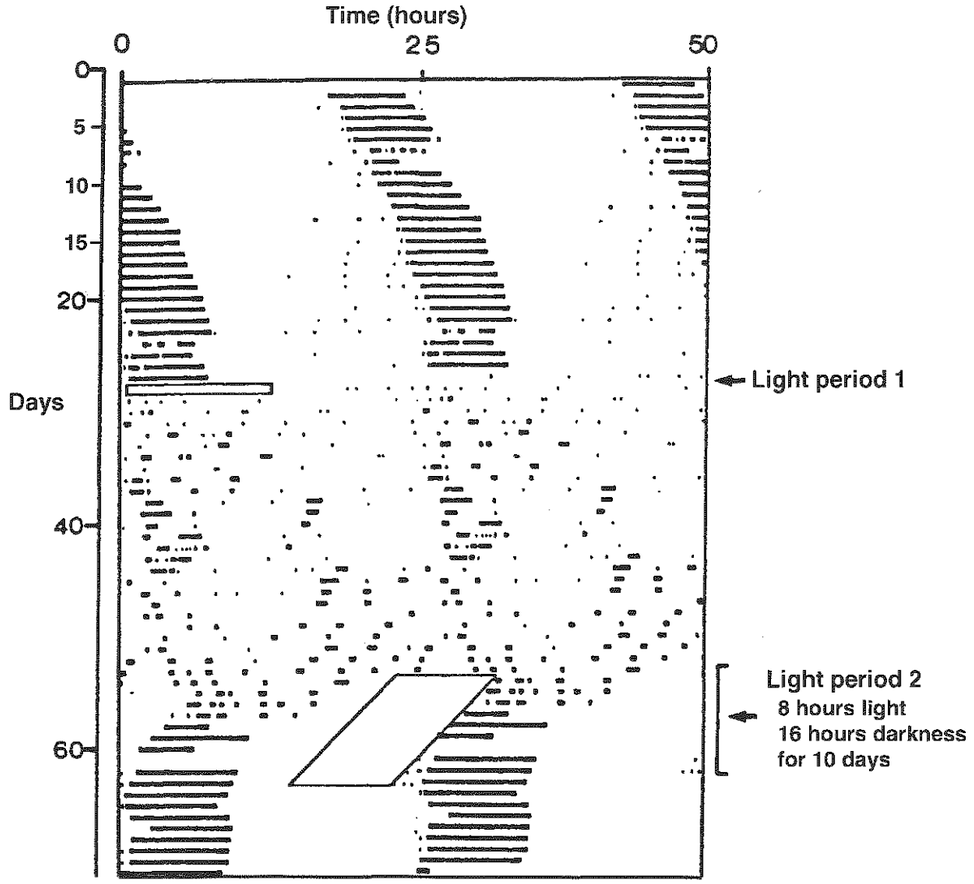
(a) In the table in your Answer Booklet match the example to the term listed.

Term	Example
1. Circadian	**A**. Hibernation in hedgehogs.
2. Circatidal	**B**. Some marine worms lay their eggs during the night of the full moon.
3. Circannual	**C**. Jet lag in humans.
4. Circalunar	**D**. Oysters open and close their shells twice in a 24-hour period.

(4 marks)

The following actogram shows an example of the activity rhythm for a New Zealand weta (*Hemideina sp.*). A solid line represents when the weta is active. The experiment was carried out in constant darkness except for two periods of light. These are shown by the open boxes (indicated by ⬅).

The results have been plotted on a 25-hour timescale to make it easier to see the rhythms.



The activity rhythm shown in the actogram is an endogenous rhythm.

(b) Name the **type** of endogenous rhythm shown here and give a **reason** for your answer. (2 marks)

(c) Describe TWO adaptive advantages to the weta of this type of rhythm. (2 marks)

(d) Explain why this rhythm is endogenous. (2 marks)

(Turn over

(e) State whether the **period** of the weta's activity rhythm over the first 20 days is **longer** or **shorter** than 24 hours. (1 mark)

(f) Describe the effect of the following light periods on the weta's activity:

(i) light period 1

(ii) light period 2. (2 marks)

QUESTION THREE (9 marks)

The term **pecking order** originates from studies of relationships among hens. The following set of data shows the interactions of six free-range hens.

Hens doing the pecking

Hens being pecked	A	B	C	D	E	F
A		0	11	12	10	21
B	8		10	7	5	7
C	0	0		0	0	0
D	0	0	18		11	13
E	0	0	8	6		29
F	0	0	22	0	0	

(a) Write the letters of the hens in order from **most** dominant to **least** dominant. (A working grid has been provided in the Answer Booklet to assist you.) (3 marks)

(b) Write down the **letter** of the hen that appears to be challenging for a higher position in the hierarchy. (1 mark)

(c) Hens are female. Name TWO factors besides being male or female that could influence an individual's position in the hierarchy. (2 marks)

(d) Many other bird species and most primates exhibit hierarchical behaviour. Give THREE advantages of this type of social organisation to either the group or the individual. (3 marks)

QUESTION FOUR (9 marks)

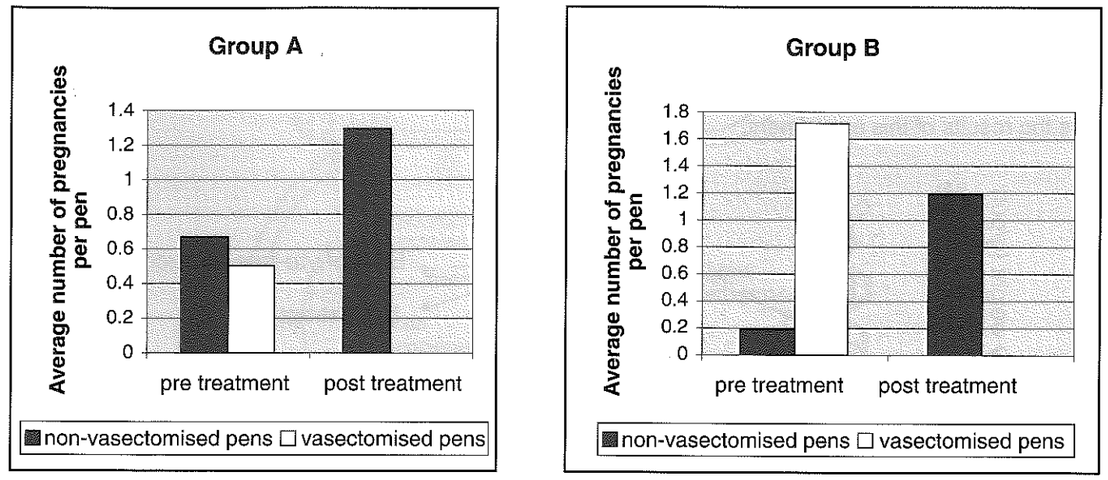
In many animal species the dominant males breed more successfully than subordinate males. Researchers carried out an experiment to see if this was true for the Australian brush tailed possum *(Trichosurus vulpecula)*. A number of wild adult possums were caught and divided into two experimental groups:

Group A – 5 pens each with one male and two females

Group B – 12 pens each with two males and two females.

In Group B the male possums were observed to determine which of the two males in each pen was dominant. Once this was established, seven of the dominant males were vasectomised (sterilised) along with two of the males in Group A. This occurred four months into the nine month breeding season. Female possums can become pregnant many times in one breeding season. The number of pregnancies over the breeding season was recorded.

The graphs below show the results collected.



Note: For Group A and Group B there were no pregnancies in the post-treatment vasectomised pens.

(a) What is the hypothesis that was being tested? (1 mark)

(b) Explain the purpose of the Group A animals. (1 mark)

(c) Why were the males not vasectomised at the start of the experiment? (1 mark)

(d) Describe TWO patterns shown in the graphs. (2 marks)

(e) What conclusion can be drawn from the results of this experiment? (2 marks)

(f) Explain the significance of the results in terms of the dominance hierarchy in male possums. (2 marks)

(Turn over

QUESTION FIVE (10 marks)

New Zealand farm pasture consists of a mixture of plants such as ryegrass and clover (a legume). Ryegrass is often found in a mutualistic relationship with an endophytic fungus. The ryegrass benefits from this relationship through increased drought tolerance, increased growth, and resistance to some insects. Toxins produced by the fungus however, may inhibit the growth of neighbouring plants such as clover.

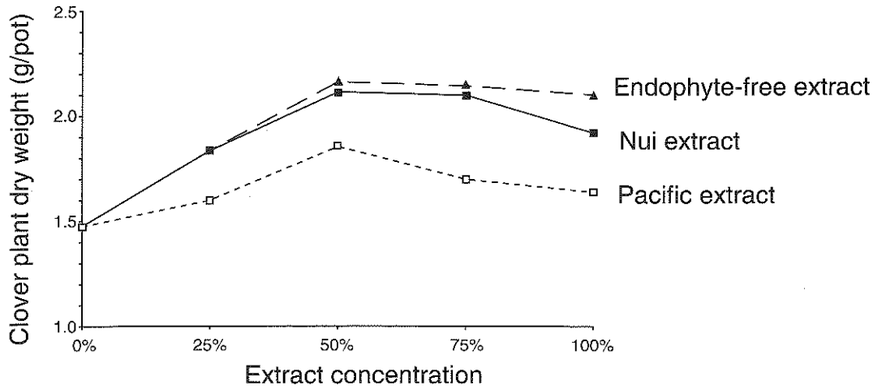
(a) What is the term used to describe the effect on neighbouring plants of the toxins produced by the fungus? (1 mark)

(b) Suggest how the fungus might benefit from its relationship with the ryegrass. (1 mark)

(c) What does **endophytic** suggest about the ecological niche of the fungus? (1 mark)

Experiments have been carried out to determine if the type of ryegrass cultivar affects the growth of clover.

Leaves from two ryegrass cultivars, Pacific and Nui, both infected with fungus, were left to soak in distilled water for 48 hours. The resulting leaf extracts (100%) were diluted to provide concentrations of 75, 50, and 25%. These extracts are labelled Pacific extract and Nui extract on the graph. Distilled water provided a 0% concentration. A third leaf extract was made from Nui and Pacific cultivars **not** infected with the endophytic fungus. These extracts were applied to clover plants growing in pots in a glasshouse. The following graph shows the results of this experiment.



(d) Using the information in the graph, describe the effect of each of the following factors on clover growth:

(i) endophyte-infected ryegrass

(ii) ryegrass cultivar. (2 marks)

(e) Suggest a reason why, for all treatments, clover growth was higher at the 25 – 100% extract concentrations compared with 0%. (2 marks)

(f) Give ONE reason why clover is important as a pasture plant in New Zealand. (1 mark)

(g) Explain the importance of these experimental findings for clover growth and feed quality for animal production. (2 marks)

SECTION 2: GENETICS AND EVOLUTION

(90 marks: 80 minutes)

Instructions: Answer all parts of all questions in this section. The space allocated in the Answer Booklet is a guide to the length, and in some cases, the format of the answers that are required.

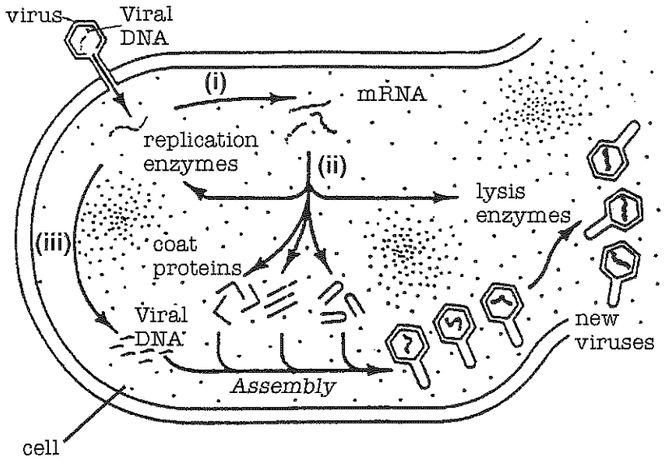
QUESTION ONE (10 marks)

(a) Describe the process of DNA replication. (3 marks)

(b) DNA replication is described as a semi-conservative process. Explain what is meant by **semi-conservative**. (1 mark)

Viruses reproduce by injecting their genetic material into a cell. Once inside the cell the viral genetic material takes over the cell's metabolic reactions and uses them to make viral DNA and proteins to produce new viral particles.

The following diagram represents this process.



(c) Give the name of each of the processes being carried out at steps (i), (ii) and (iii) in the diagram. (3 marks)

Many soil bacteria have evolved restriction enzymes, which are used as a defence mechanism against viruses. The enzymes are able to cut the viral DNA as soon as it enters the cell.

(d) Give THREE ways in which cutting the viral DNA can prevent the viral DNA from being replicated. (3 marks)

QUESTION TWO (7 marks)

Down's Syndrome is a human condition caused by a chromosome abnormality. Affected individuals are generally trisomic for chromosome 21. This is an example of aneuploidy.

(a) Give the total chromosome number of an individual with trisomic Down's Syndrome. (1 mark)

(b) Explain what causes aneuploidy. (1 mark)

Another type of chromosomal mutation can result in changes to the original sequence of genes on the chromosome. The letters on the diagram below represent the position of genes along a chromosome.

(c) Redraw the chromosome diagrams in the Answer Booklet to show the result of the mutations named below:

(i) duplication

(ii) inversion. (2 marks)

(d) Give THREE reasons why a point or gene mutation is less likely to have a major impact on an organism compared with a chromosomal mutation. (3 marks)

QUESTION THREE (10 marks)

Flower colour in some plants is controlled by two unlinked genes, **F** and **H**. Gene **F** controls the production of a red pigment from a colourless substrate. Gene **H** controls the conversion of the red pigment to a purple pigment. In plants that are homozygous recessive **ff** the second gene cannot be expressed and the flowers are white.

(a) Define **unlinked genes**. (1 mark)

(b) What type of gene-gene interaction is shown by flower colour in this example? (1 mark)

(c) In a cross between two plants, **FfHh** and **FfHh**, give the:

(i) phenotype of the parents (1 mark)

(ii) flower colours of the offspring and their expected ratios. Show your working. (3 marks)

(d) A plant with white flowers is crossed with a plant producing purple flowers. The flower colours of the offspring were found to show this ratio:

1 purple : 2 white : 1 red

(i) What is the likely genotype of the purple-flowered parent? (1 mark)

(ii) What is the likely genotype of the white parent? (1 mark)

(iii) Give all the possible genotypes of the white offspring. (2 marks)

QUESTION FOUR (5 marks)

The human ABO blood groups are an example of multiple alleles, where three or more alleles occur at a gene locus. The allele **i** is recessive and the alleles I^A and I^B are co-dominant.

(a) What does the term **co-dominant** refer to? (1 mark)

(b) A couple have four children. Two children have blood group **O**, the other two children have blood group **A**. Give the most likely **genotypes** and **phenotypes** for the parents. (2 marks)

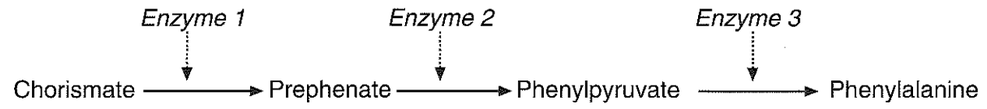
(c) A mother has blood group **AB**, the father is group **A**. What is the probability of their first child having blood group **AB** if the father is:

(i) homozygous?

(ii) heterozygous? (2 marks)

QUESTION FIVE (8 marks)

The following diagram shows part of the metabolic pathway involved in the biosynthesis of the essential amino acid phenylalanine.



(a) Define **metabolic pathway**. (1 mark)

(b) A point mutation can result in Enzyme 1 **not** being produced. As a result of this:

(i) which chemical(s) would be present in excess?

(ii) which chemical(s) would be absent? (2 marks)

(c) Suggest a possible consequence to an animal if this metabolic pathway fails to operate. (1 mark)

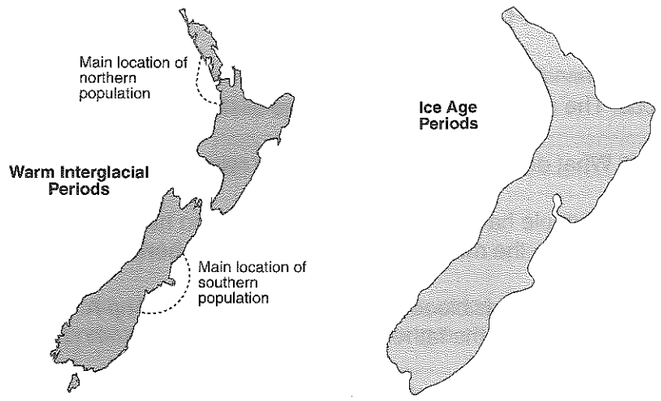
(d) Explain how DNA controls the functioning of a cell as it carries out its life processes. Support your answer using the above metabolic pathway as an example. (4 marks)

(Turn over

QUESTION SIX (9 marks)

Hector's dolphin is the world's rarest dolphin and is found only in New Zealand waters.

Recent DNA studies have shown that the northern population is genetically different from the southern population (see map). The differences are significant enough for the two populations to be classified as sub-species. Given enough time it is possible that they will become separate species.



(a) Explain how the ice ages could have isolated the two populations. (1 mark)

(b) What **type** of speciation do these two sub-species of Hector's dolphin illustrate? (1 mark)

Isolation is now preventing gene flow between the two populations.

(c) Define **gene flow**. (1 mark)

(d) What must happen if these two sub-species are to evolve into different species? (2 marks)

(e) List the probable sequence of events that led to the formation of the two sub-species of Hector's dolphin. (4 marks)

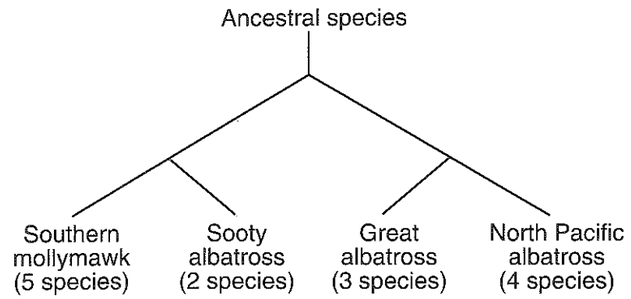
QUESTION SEVEN (5 marks)

Early taxonomists originally classified the New Zealand Grey Warbler into the same family as warblers found in the Northern Hemisphere, due to their similarities in bill (beak) shape and feeding behaviour. As a result of recent DNA analysis, the New Zealand Grey Warbler has now been reclassified into a genetically unrelated group.

(a) Give the term that describes two genetically unrelated groups that over time evolve similar adaptations. (1 mark)

(b) Give a reason why the New Zealand Grey Warbler and the Northern Hemisphere Warbler, although genetically unrelated, have evolved similar adaptations for feeding. (1 mark)

Seabirds such as the albatross, mollymawk, titi and petrel make up at least half of the native bird species in New Zealand. The following diagram shows the relationship between the four main albatross groups.



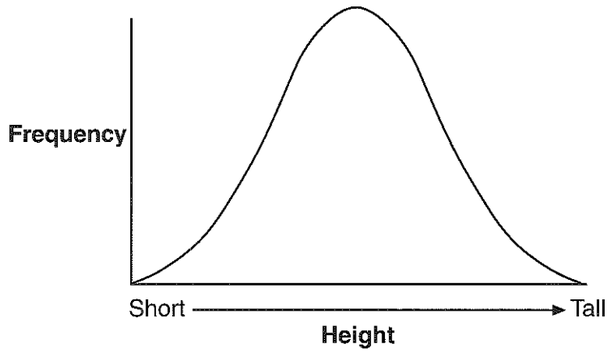
(c) Name the evolutionary pattern illustrated in the albatross group. (1 mark)

One major characteristic of this group is the amount of time they spend out at sea, only returning to land to breed. The sea is a rather uniform habitat, yet there are many hundreds of different sea bird species alive today.

(d) Suggest TWO factors that could have produced different ecological niches and/or prevented gene flow, thus allowing speciation to occur in this group of birds. (2 marks)

QUESTION EIGHT (6 marks)

Height in humans is an example of continuous variation and can be represented by the graph below.



A research study carried out in a European country last year found that childless men are on average 4 cm shorter than men who are fathers. This suggests that taller men are reproductively more successful than shorter men.

(a) Give ONE way in which genetic variation as seen in the height of humans may have arisen. (1 mark)

(b) Environmental factors can affect the achievement of genetic potential. Name TWO environmental factors that may prevent men and women from reaching their full height potential. (2 marks)

(Turn over

(c) Based on the suggestion from the research study, sketch a graph on the axes provided in the Answer Booklet, showing what the expected height distribution of men in this European country would look like in 200 years time. (1 mark)

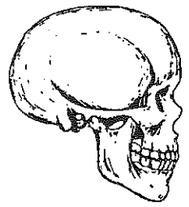
(d) Give ONE change to the allele frequency in the gene pool in this European country that would be expected after several generations. (1 mark)

(e) Name a process acting on the gene pool of men in this European country that may ensure that the height distribution remains the same as it is now. (1 mark)

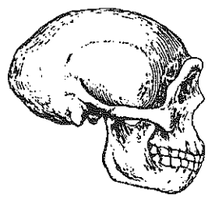
QUESTION NINE (12 marks)

Use the information in the diagrams below to answer questions (a) to (c).
Note: *The skulls are not drawn to the same scale.*

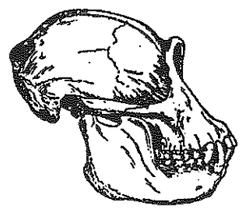
Homo sapiens



Homo erectus



Chimpanzee



(a) Identify a physical characteristic that the *Homo erectus* skull has in common with the chimpanzee skull, thus illustrating a common ancestry. (1 mark)

(b) What physical characteristic does the *Homo erectus* skull have in common with the skull of the modern human, which shows that *H. erectus* is likely to be an ancestor of the modern human? (1 mark)

(c) Identify ONE major change in the cranium that has occurred between *Homo erectus* and modern humans and explain its significance for human evolution. (2 marks)

The change from **quadrupedal** walking to **bipedal** walking required major changes to the skeleton.

(d) For each of the following skeletal features, describe the change and explain how it assisted bipedalism:

(i) skull

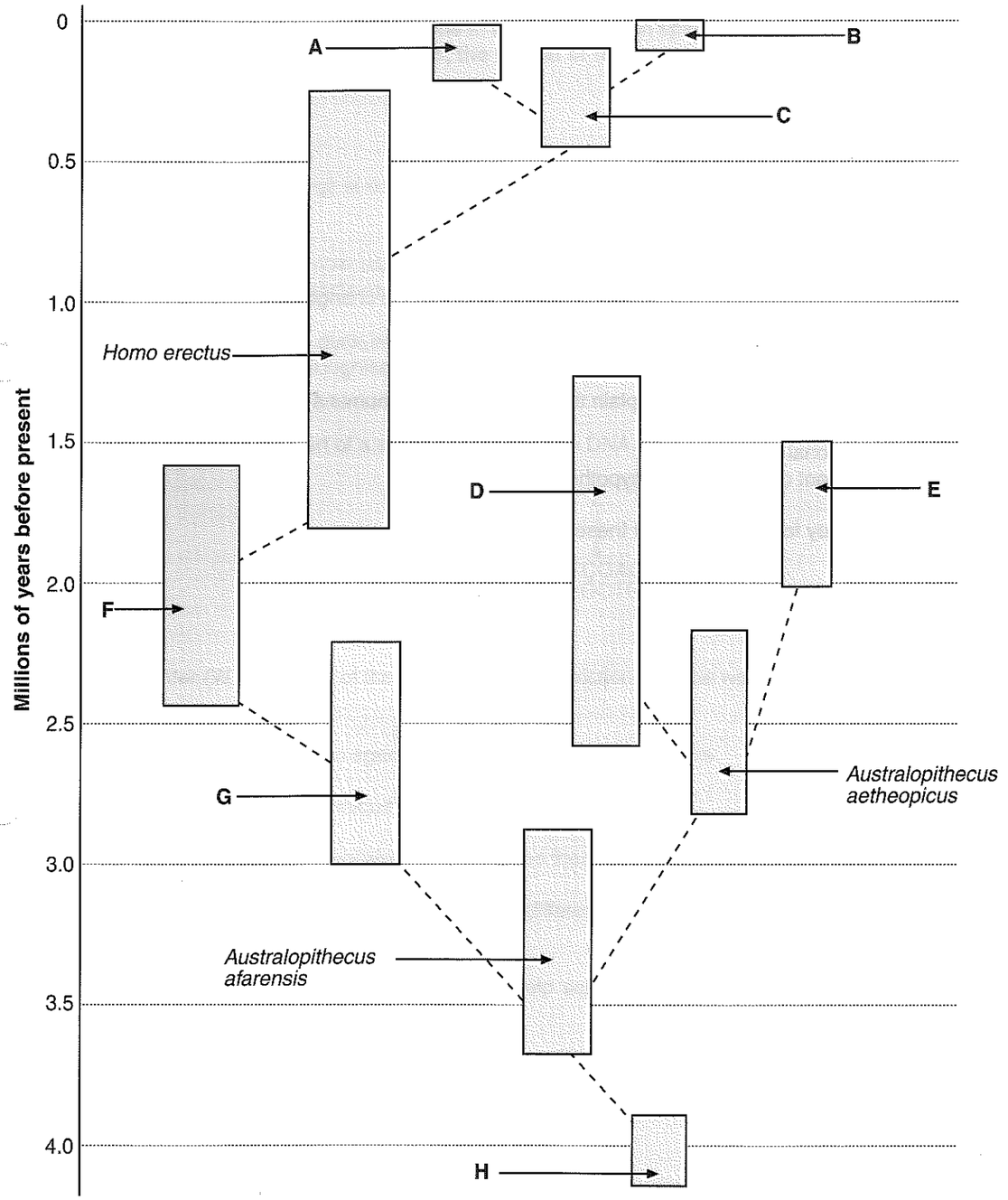
(ii) rib cage

(iii) spine

(iv) pelvis. (8 marks)

QUESTION TEN (18 marks)

The diagram below shows a commonly accepted model for Human Evolution. After studying the diagram, answer the questions on page 14.



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(c) Based on the suggestion from the research study, sketch a graph on the axes provided in the Answer Booklet, showing what the expected height distribution of men in this European country would look like in 200 years time. (1 mark)

(d) Give ONE change to the allele frequency in the gene pool in this European country that would be expected after several generations. (1 mark)

(e) Name a process acting on the gene pool of men in this European country that may ensure that the height distribution remains the same as it is now. (1 mark)

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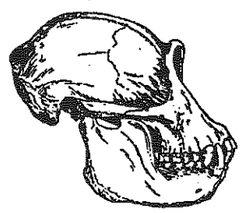
Homo erectus

Chimpanzee



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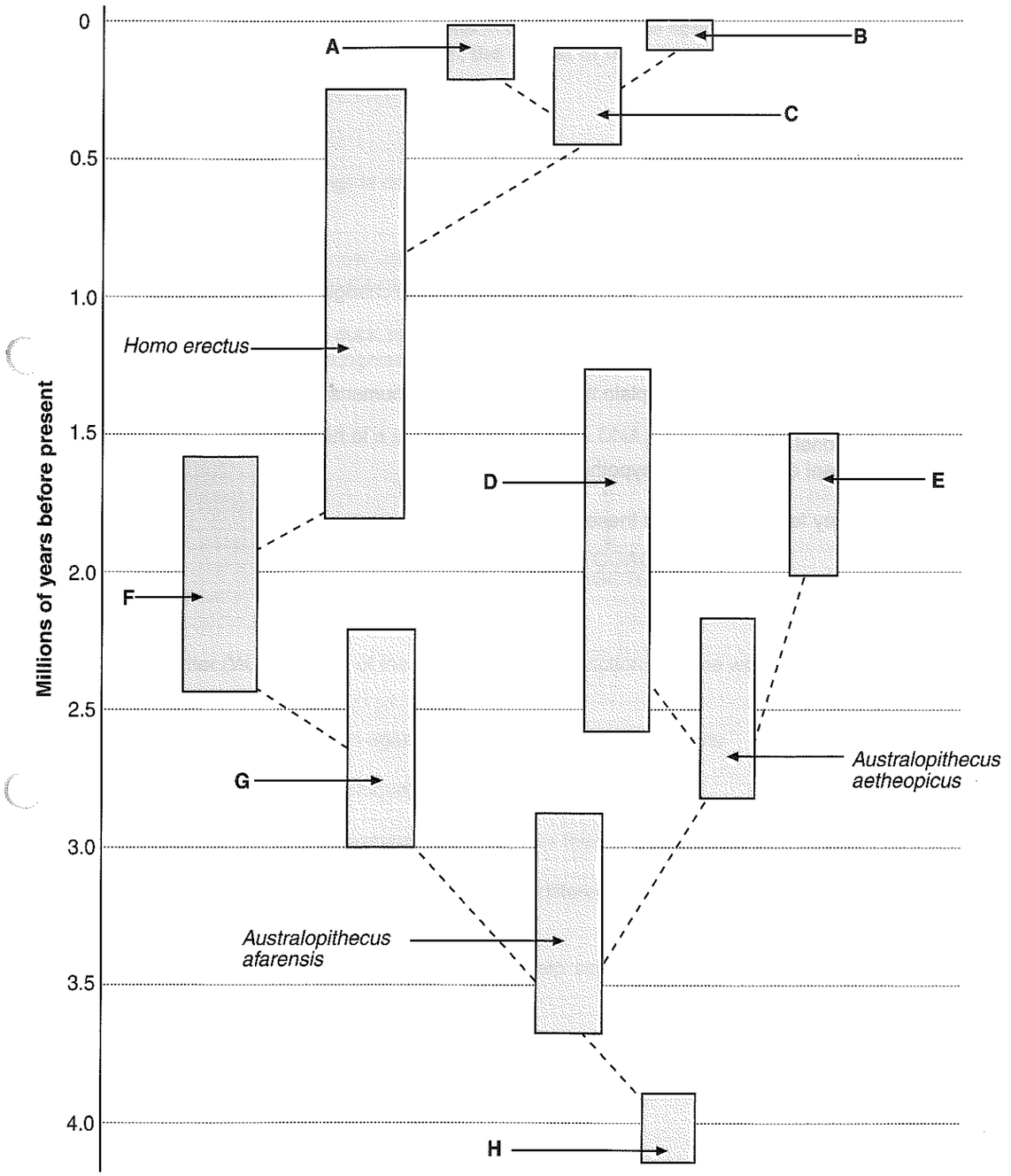


(a) On page 15 in the Answer Booklet there is a table which includes a list of hominid species. Complete the table with the appropriate letters from the diagram on page 13 of this booklet. (4 marks)

(b) For each of the hominid species listed below, give ONE significant cultural or biological development that occurred during that species' time span and describe the evolutionary significance the development gave to that species.

(i) *Australopithecus anamensis*

(ii) *Homo habilis*

(iii) *Homo erectus*

(iv) *Homo neanderthalensis.* (8 marks)

(c) Describe FOUR ways in which the lifestyle of *Homo sapiens* was changed by the domestication of plants and animals. (4 marks)

Two scientific theories currently exist to explain the origin of modern humans *(Homo sapiens)*.

1. The multi-regional hypothesis.
2. The replacement or Out of Africa hypothesis.

(d) Describe ONE key feature of each of these hypotheses. (2 marks)

SECTION 3: CONTEMPORARY TECHNIQUES IN MOLECULAR BIOLOGY OR BIOTECHNOLOGY

(20 marks: 20 minutes)

Instructions: Answer all parts of all questions in this section. The space allocated in the Answer Booklet is a guide to the length, and in some cases, the format of the answers that are required.

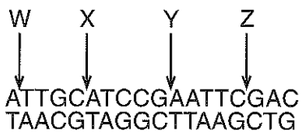
QUESTION ONE (10 marks)

DNA profiling (DNA fingerprinting) is commonly used in criminal investigations and in determining paternity cases.

Scientists in New Zealand are now using this process to provide information on the mating and breeding behaviour of some of New Zealand's native birds such as the blue duck.

(a) When DNA profiling a blue duck, restriction enzymes are used to cut the DNA at specific sites. How does each restriction enzyme recognise the correct site to cut? (1 mark)

The following diagram shows part of a sequence of bases in DNA.



(b) Give the letter (W, X, Y or Z) of the position that a restriction enzyme would cut to produce a sticky end fragment. (1 mark)

The cut DNA is then run through an agarose gel to separate the fragments.

(c) What is the name of this technique? (1 mark)

(d) State the property of DNA fragments which causes them to move along the gel. (1 mark)

(e) Explain why the DNA fragments will be located at different positions along the length of the gel at the end of the process. (1 mark)

(f) Describe how DNA profiling can be used to help scientists study the mating and breeding of the blue duck. (2 marks)

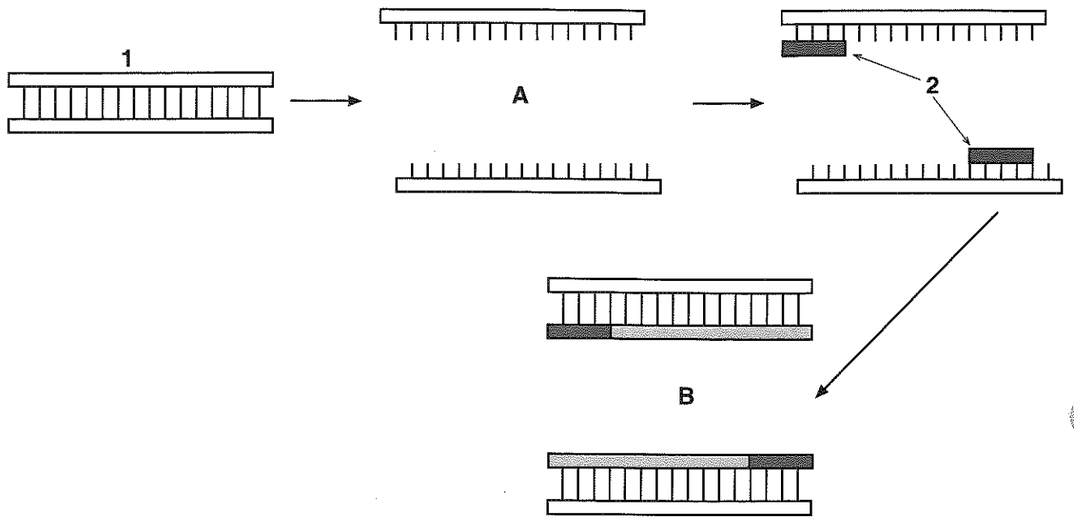
Restriction enzymes are used in other processes such as transformation to produce a transgenic organism.

(g) What is a **transgenic organism**? (1 mark)

(h) Explain how restriction enzymes are used in producing a transgenic organism. (2 marks)

QUESTION TWO (10 marks)

(a) The diagram below shows the steps in the Polymerase Chain Reaction (PCR).



(i) Give the name of molecule **1**.

(ii) What is the function of molecule **2**?

(iii) Describe what has happened at each of **A** and **B**. (4 marks)

(b) Describe the importance of temperature in the PCR process. (2 marks)

(c) PCR can be used to produce many copies of a desirable gene. List TWO advantages of using PCR to do this **compared** with gene cloning using bacteria. (2 marks)

Forensic scientists often use PCR before they carry out DNA profiling.

(d) Why is PCR particularly useful in forensic science? (1 mark)

(e) What must the forensic scientist avoid when using PCR to ensure the evidence is admissible in court? (1 mark)

SECTION 4: CONTEMPORARY BIOLOGICAL ISSUES – ESSAY TOPICS

(40 marks: 35 minutes)

INSTRUCTIONS

1. *Write an essay on ONE of the topics listed below.*
2. *You should write about 500 words in total (2-3 pages). The space in your Answer Booklet is more than adequate and should not be exceeded.*
3. *A space has been provided in your Answer Booklet for you to plan your essay. This plan will not be marked.*
4. *Marks will be awarded for:*
   - *presenting an essay that answers the question* *(30 marks)*
   - *communicating knowledge and ideas logically and clearly.* *(10 marks)*

   (Total = 40 marks)

LIST OF TOPICS

EITHER:

1. Biological Control

"In the search for alternatives to chemical sprays, biological control is often presented as the best alternative approach for pest control." Natural Pest Control, 1986.

With respect to an organism that is **EITHER a pest OR a weed** in New Zealand*, describe the biological reasons for your organism becoming a problem. Discuss the issues that have led to a search for alternatives to chemical sprays. Describe the biological methods currently used to control your pest or weed and present your reasoned opinion about whether biological control is the best approach for your organism.

OR:

2. Biodiversity in Aquatic Environments

"Unless a fifth of the world's oceans are protected, many marine ecosystems and fish stocks will be in serious trouble." New Scientist, 30 August 1997.

This quotation reflects concepts that can be applied to **EITHER freshwater OR coastal marine environments**. Discuss the relevance of this quotation to the methods used in the conservation of biological diversity of indigenous species in a named New Zealand* aquatic environment. Give your reasoned opinion on the suitability of the methods used to ensure biological diversity within aquatic environments. Discuss the ethical and social implications of protecting this aquatic environment.

OR:

3. Genetically Modified Organisms

"Genetic engineering seems fine as long as scientists don't cross ethical lines. It is fine if it helps save lives, not fine in our foods." New Zealand Herald, 17 May 1999.

With respect to **EITHER plant crops OR farm animals** in New Zealand*, describe the biological development and use of genetically modified organisms. Discuss the likely ethical lines referred to in the quote. This year the New Zealand Government set up a Royal Commission on Genetic Modification. Describe the issues that the Commission needs to consider and give your reasoned opinion about what the best outcome would be for New Zealand.

*Candidates who attend a Pacific Island school may write about an example from their own country.

Acknowledgements

SECTION 1

Page 3 Modelling the circadian system of the Weta *Hemideina thoracica*, (Orthoptera: Stenopelmatidae) R.D. Lewis, *Journal of the Royal Society of New Zealand*, Vol. 24, page 412, 1994.

Page 5 Adapted from Social dominance and breeding success in captive brushtail possums, *Trichosurus vulpecula*, S.E. Jolly et al, *New Zealand Journal of Zoology*, Vol. 26, pages 21 – 25, 1999.

Page 6 Adapted from Allelopathic effects of endophyte-infected perennial ryegrass extracts on white clover seedlings, B.L. Sutherland et al, *New Zealand Journal of Agricultural Research*, Vol. 42, pages 19–26, 1999.

SECTION 2

Page 7 *University of Waikato Department of Biological Science Laboratory Manual: Course 0770.101A Cellular and Molecular Biology*, page 10.8, University of Waikato, 1997.

Page 10 Ice Age Map of New Zealand adapted from *Year 13 Biology 1999 Student Resource and Activity Manual*, Richard Allan and Tracey Greenwood, page 220, Biozone, 1999.

Grey Warbler drawing from *Bush and High Country Birds of New Zealand*, Elaine Power, page 24, David Bateman, 1988.

Page 11 Albatross family tree based on *Examples of Evolution in New Zealand*, Adrian Patterson and Peter E. Smith, page 35, Lincoln University, 1998.

SECTION 4

Page 17 Biological control quote from *Natural Pest Control A New Zealand Guide for Home Gardeners and Small Farmers*, Bruce Chapman and David Penman, page 22, Reed Methuen, 1986.

Biodiversity quote from *New Scientist*, 30 August, 1997.

Genetic engineering quote from *New Zealand Herald*, 17 May, 1999.