SUPERVISOR TO ATTACH PROCESSING LABEL HERE

STUDENT NUMBER

									Letter
Figures									
Words									

Victorian Certificate of Education 1997

BIOLOGY

Common Assessment Task 3: Written examination

Monday 3 November 1997: 3.00 pm to 4.45 pm
Reading time: 3.00 pm to 3.15 pm
Writing time: 3.15 pm to 4.45 pm
Total writing time: 1 hour 30 minutes

QUESTION AND ANSWER BOOK

Structure of book

Number of articles	*Number of questions in each article*	*Number of questions to be answered*
8	1	8

Directions to students

Materials
Question and answer book of 23 pages.

The task
Please ensure that you write your **student number** in the space provided on the cover of this book.
Answer **all** questions.
Write your answers in the spaces provided in this question and answer book.
The marks for each question give you an idea of how much time you should spend, and how much information you should provide. There is a total of 75 marks available.
All responses must be in ink or ball point pen.
All written responses should be in English.

At the end of the task
Hand in this question and answer book.

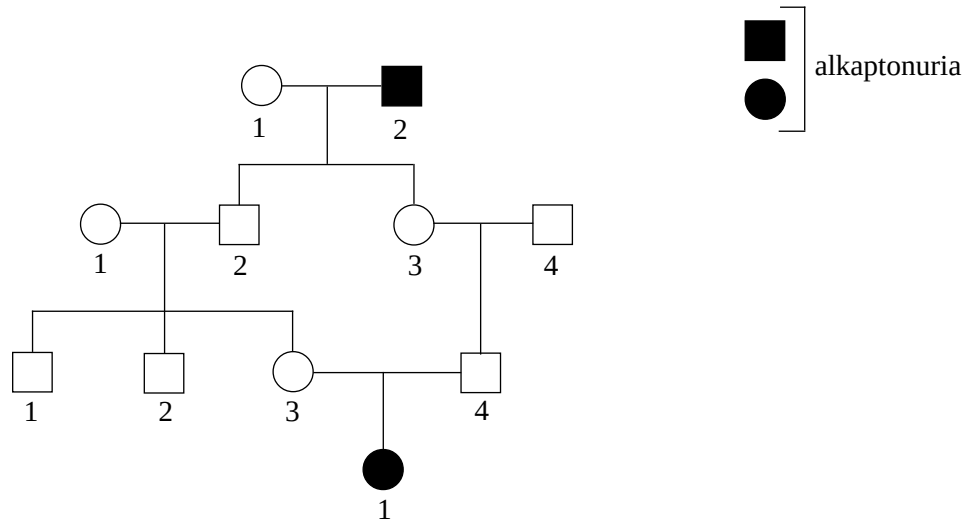
Students should attempt all parts of all questions

Article 1

Genes in biochemical pathways

In humans, **alkaptonuria** is an inherited disease resulting from a block in a metabolic pathway. The pedigree of a family in which this disease is present is displayed in Figure 1.

Figure 1



Question 1

a. **i.** Using the information in Figure 1, state whether alkaptonuria is dominant or recessive.

_____

1 mark

ii. What evidence from the pedigree supports your answer to question **1a.i.**?

_____

_____

_____

1 mark

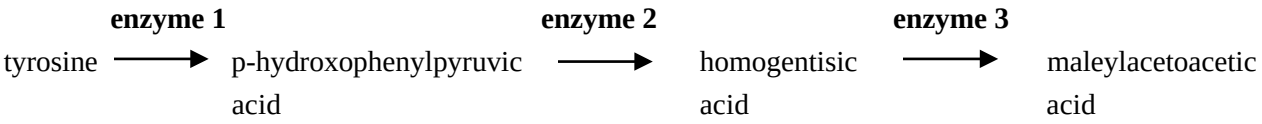
b. If individuals **III**–3 and **III**–4 shown in Figure 1 have another child, what is the probability that this child will have alkaptonuria? Show all the necessary working.

Working space

Probability _____

3 marks

Tests on the urine of humans with alkaptonuria indicate high levels of homogentisic acid. Homogentisic acid is one of the compounds produced in the metabolic pathway in which the amino acid tyrosine is broken down. Part of the metabolic pathway is shown below.



Each step in the metabolic pathway is catalysed by an enzyme. Alkaptonuria is the result of a defect in the production of one of these enzymes.

c. **i.** Alkaptonuria results from a defect in the production of which enzyme – **1**, **2** or **3**?

_____

1 mark

ii. Explain your answer to **1c.i.**

_____

_____

_____

_____

1 mark

d. Investigations of the DNA of humans with a defect in the production of a particular enzyme have shown that the defect may be the result of a deletion of a single base in the DNA coding for that enzyme.

With the aid of diagrams use the sequence of DNA shown below, and the section of the genetic code given in Figure 2, to explain how a deletion of a single base in DNA could change the amino acid sequence of an enzyme.

DNA sequence

3′.....A G A G A G T A G C ....5′

Figure 2

Part of the genetic code

mRNA	Amino acid	mRNA	Amino acid
UUU	phe	UCU	ser
UUC	phe	UCC	ser
UUA	phe	UCA	ser
UUG	phe	UCG	ser
CUU	leu	CCU	pro
CUC	leu	CCC	pro
CUA	leu	CCA	pro
CUG	leu	CCG	pro
AUU	iso	ACU	thr
AUC	iso	ACC	thr
AUA	iso	ACA	thr
AUG	met	ACG	thr

3 marks

Total 10 marks

TURN OVER

Article 2

Zebras, donkeys and zonkeys

A few unusual hybrids have been formed when different species, kept together in captivity, mate and produce offspring. One such unusual event produced a zonkey. A male zebra mated with a female donkey to produce a hybrid animal called a zonkey. The zonkey had phenotypic features of both parents. The scientists explained that they would be able to confirm whether the new offspring was a donkey or a zonkey by taking a sample of blood from the animal and preparing a karyotype. It is known that the diploid number of the donkey, *Equus asinus,* is 62 and the diploid number of the zebra, *Equus quagga*, is 44.

Question 2

a. How many chromosomes would be present in the egg of the donkey?

_____

1 mark

b. Name the type of cell division involved in the formation of the egg of the donkey.

_____

1 mark

c. **i.** How many chromosomes would be present in the somatic tissue of a true ‘zonkey’?

_____

1 mark

ii. Explain how you worked out the chromosome number you have given as an answer to **2c.i.**

_____

_____

_____

1 mark

The scientists stated that even if the offspring were a true zonkey it would be unlikely to produce offspring because of problems with gamete formation.

d. Explain why there would be problems with **gamete** formation in a zonkey.

_____

_____

_____

_____

_____

2 marks

Total 6 marks

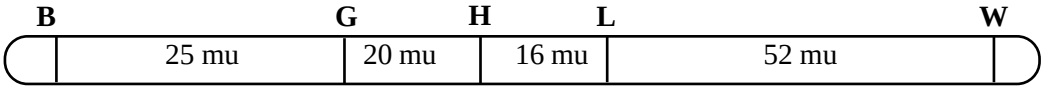
Article 3

Inheritance in the tomato

A plant which has been extensively studied by geneticists is the tomato, *Lycopersicum esculentum.*

The diagram in Figure 3 shows the position of five of the gene loci mapped to chromosome number 5 in the tomato. Several genes are identified on the chromosome and the map units separating each locus are indicated.

Figure 3



mu = map units

Question 3

a. What is the significance of linkage between two gene loci to the segregation of alleles at these loci?

_____

_____

_____

1 mark

b. During meiosis, homologous chromosomes synapse and crossing over may occur.

i. Which pair of gene loci shown in Figure 3 is likely to have the highest frequency of crossing over during meiosis?

_____

1 mark

ii. Explain your reasoning for choosing these two gene loci.

_____

_____

1 mark

c. Plants homozygous for the hairy, purple stem phenotype were crossed with hairless, green stem plants. Using the allele symbols given below, show the genotype and phenotype of the F_1 of this cross.

Gene H	H	Hairy stem
	h	hairless stem
Gene G	G	Purple stem
	g	green stem

Working space

genotype _____

phenotype _____

2 marks

d. A test cross using the F_1 offspring and a hairless, green stem tomato plant was performed. Figure 4 represents details of the offspring which resulted from this cross.

Complete the table in Figure 4 by filling in the appropriate information in the **four** empty spaces.

Figure 4

Genotype		$\frac{Hg}{hg}$	$\frac{hG}{hg}$	
Phenotype	Hairy, Purple stem		hairless, Purple stem	
Number of offspring	39	11	9	41

2 marks

e. The results shown in Figure 4 confirm that the two loci, Hairy/hairless and Purple/green are linked.

i. What feature of the results shown in Figure 4 indicates that the Hairy/hairless gene and the Purple/green gene are linked?

_____

_____

1 mark

ii. If the Hairy/hairless gene and the Purple/green gene loci had **not** been linked, what phenotypes and in what ratio would you expect to see in the offspring of the test cross of the F_1?

_____

_____

2 marks

Total 10 marks

Article 4

Tackling a weighty problem

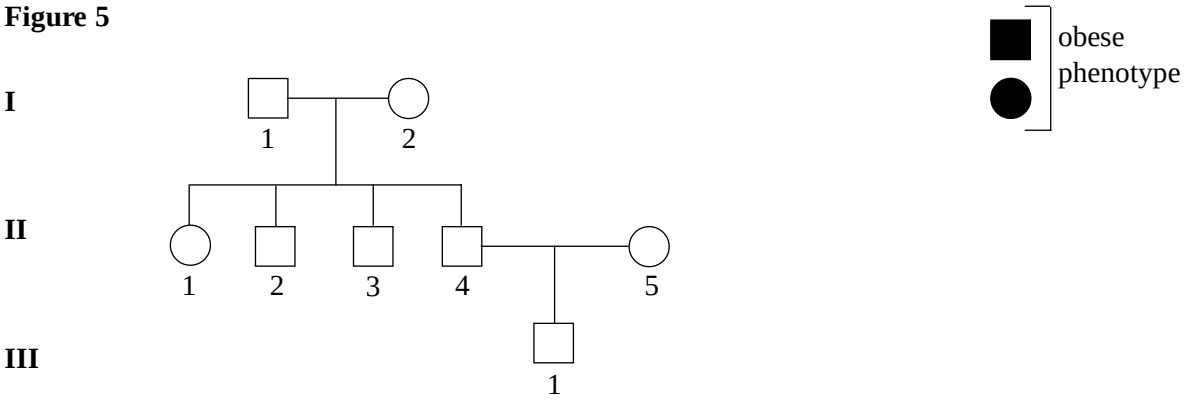
Obesity in mice is an excess of body fat which may result from a mutation in a single gene. One of the most intensively studied mutations is in the **obese** gene. Mice homozygous for this autosomal mutation overeat, and have a notably obese phenotype by one month of age.

Question 4

a. Figure 5 is an **incomplete** pedigree demonstrating the inheritance of the obese phenotype.

By **shading** only **one** symbol, complete the pedigree so that it demonstrates that the inheritance of this form of obesity can be **only** autosomal recessive.

Figure 5



1 mark

b. Suggest **one** feature of your completed pedigree which **eliminates** X-linked recessive inheritance of the **obese** mutation.

_____

_____

_____

1 mark

The sequence of bases in the DNA of the **obese** gene was determined in 1995. It was found that the base sequence encoded a 4.5 kilobase (4500 bases) messenger RNA (mRNA). From this mRNA a protein of approximately 167 amino acids is translated.

c. Name **two** structural differences between DNA and messenger RNA.

Structural difference 1 _____

_____

Structural difference 2 _____

_____

2 marks

d. During the translation of the mRNA into a protein, a second type of RNA is involved.

i. Name this other type of RNA.

_____

1 mark

ii. Describe the role of this other RNA in translation.

_____

_____

_____

_____

2 marks

CONTINUED OVER PAGE

A section of the mRNA of the normal **obese** allele sequence is shown aligned with the mRNA sequence of the mutant **obese** allele in Figure 6. The mutation appears as a change in the mRNA sequence coding for the amino acid arginine.

Figure 6

amino acid sequence of the normal allele	glutamic acid	asparagine	leucine	arginine	aspartic acid	leucine
mRNA normal allele	GAG	AAU	CUC	**C**GA	GAC	CUC
mRNA mutant allele	GAG	AAU	CUC	**U**GA	GAC	CUC

e. **i.** What does the letter **C** represent in the mRNA sequence?

_____

1 mark

ii. What base in DNA is complementary to uracil in mRNA? (Write the full name of the base.)

_____

1 mark

iii. What is the name given to the three bases in mRNA which code for an amino acid?

_____

1 mark

The base change which leads to the mutant **obese** allele is shown in Figure 6 as a change in the mRNA sequence.

f. What was the original base change in the DNA strand of the mutant allele which was transcribed to form this mRNA?

_____

1 mark

g. Use the information in the section of the genetic code shown in Figure 7 to explain the consequence of this mutation on the translation of the section of polypeptide shown in Figure 6.

Figure 7

UAU	tyrosine	UGU	cysteine
UAC	tyrosine	UGC	cysteine
UAA	stop	UGA	stop
UAG	stop	UGG	tryptophan
CAU	histidine	CGU	arginine
CAC	histidine	CGC	arginine
CAA	glycine	CGA	arginine
CAG	glycine	CGG	arginine

1 mark

There is the possibility that obesity in mice may be the result of polygenic inheritance.

h. Explain what is meant by the phrase **polygenic inheritance**.

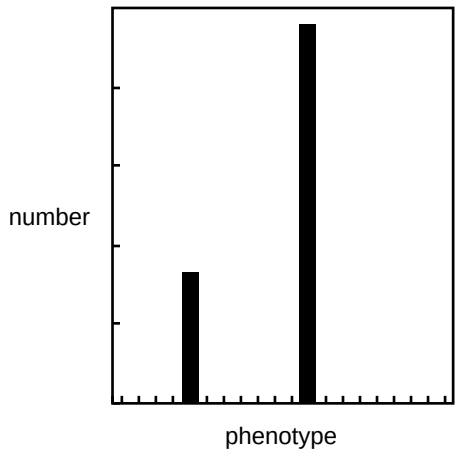
1 mark

i. Suggest another trait in mice which might be the result of polygenic inheritance.

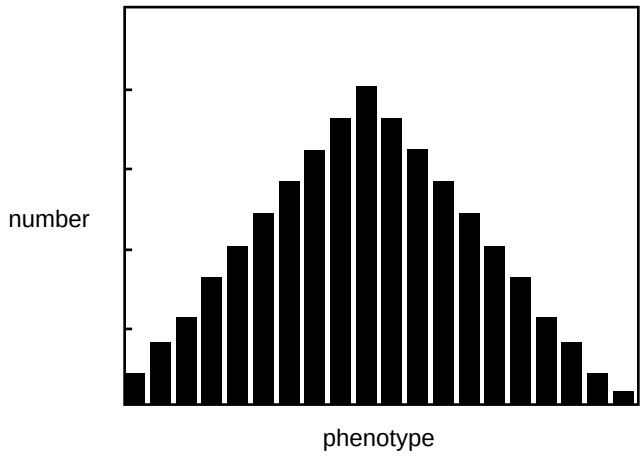
1 mark

Graphs A and B represent the distribution of phenotypes in a population for either a polygenic trait or a trait which is the result of a single gene with two alleles.

Graph A



Graph B



j. **i.** Which graph, A or B, represents the distribution of phenotypes for a polygenic trait?

Graph _____

1 mark

ii. Explain your answer to **4j.i.**

_____

_____

1 mark

Total 16 marks

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Article 5

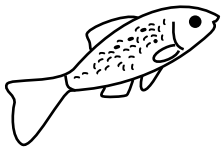
Natural selection made visible

Guppies, *Poecilia reticulata,* are small, active freshwater fish. Scientists have studied populations of guppies living in streams. In some of these streams, referred to as **dangerous streams**, guppies are found with predatory fish. These predatory fish eat guppies. In the dangerous streams, male guppies have small spots whose colours blend with the sand on the stream bed. In other streams, referred to as **safe streams**, the predatory fish are absent. In safe streams the male guppies have brightly coloured spots. See Figure 8.

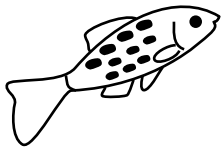
The scientists suggested that the colour of the spots shown by the males in dangerous streams may be the result of natural selection.

Figure 8

male guppy from a dangerous stream
(spots blend with sand)



male guppy from a safe stream
(spots brightly coloured)



Question 5

a. From the information given, name a selective pressure on the male guppies in the dangerous streams.

_____

1 mark

b. Suggest **one** reason why the male guppies in the safe streams have brightly coloured spots.

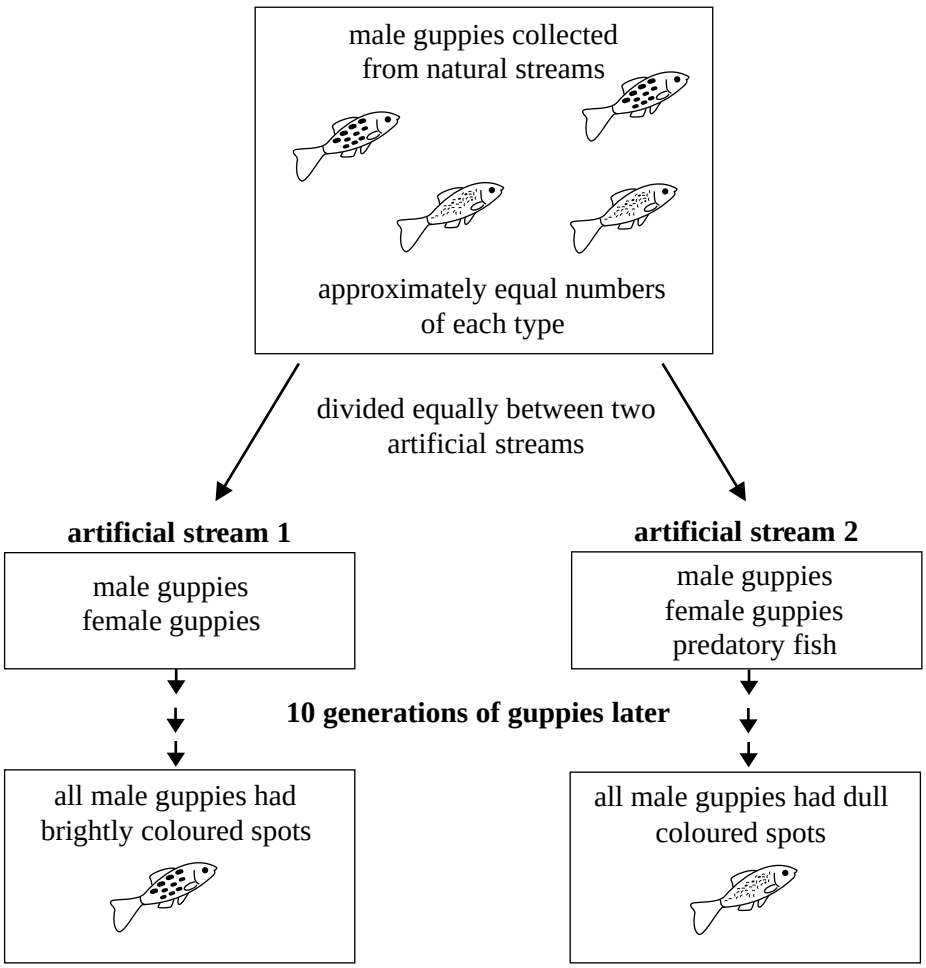
_____

_____

1 mark

Scientists wanted to test the hypothesis that the colour of the spots of male guppies in dangerous streams is due to natural selection. Two identical artificial streams were built in a laboratory. A large number of male guppies were collected and divided into two equal groups. Figure 9 summarises the experiment in the laboratory.

Figure 9



c. Describe the important steps in the process that has occurred in artificial stream 2 which results in the changes in the male guppy population over the 10 generations of the experiment.

4 marks

d. When designing the artificial streams in the laboratory, the scientists made streams with similar conditions to those occurring in the wild. Name **one** factor they would need to take into account when designing their artificial streams.

_____

_____

1 mark

At a later date a similar experiment was carried out in the wild. Two hundred male guppies were moved from **dangerous streams** to **safe streams** two kilometres away. Within a year (20 generations), most male descendants of those 200 guppies had brightly coloured spots when compared with guppies in the **dangerous streams**.

e. Why did the scientists carry out the experiment in the wild?

_____

_____

1 mark

Total 8 marks

Article 6

Global cooling and speciation

Why do tropical rainforests contain so many species? One theory is that climatic change is the driving force. There have been extended periods in the last 100 000 years when the earth's climate became cool and dry. During these periods of severe global cooling the large rainforests broke into smaller, separate rainforests. Populations of plants and animals in the separate rainforests then began to diversify into new species.

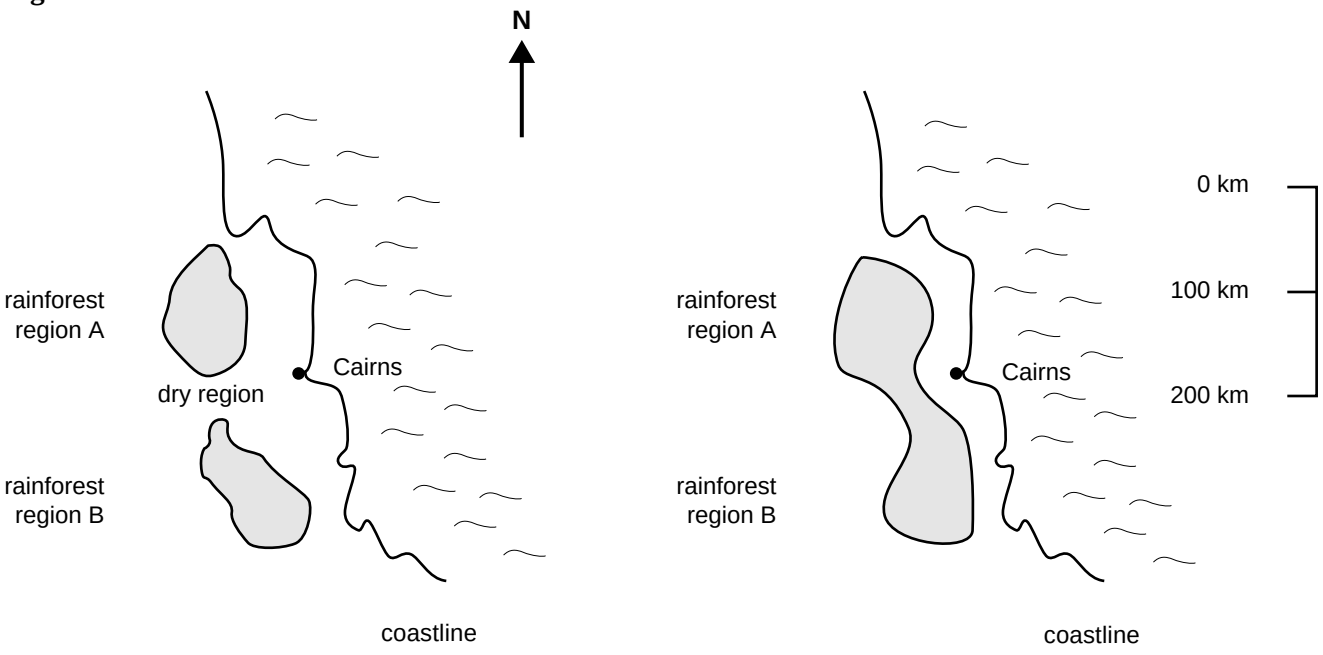
Question 6

a. Explain how separation of regions of rainforest may be important for one rainforest species to diversify into several new species.

2 marks

Australian scientists have found genetic evidence to support the view that climatic change is important in speciation. Their study included three bird species and one lizard species living in two areas of rainforest in northeastern Australia. During the last extended period of severe global cooling 18 000 years ago, these two areas of the original rainforest became separated by a dry region (Figure 10a).

Figure 10



a. Rainforest areas existing during the last period of global cooling and drying, 18 000 years ago

b. Present day rainforest areas of northeastern Australia

For their study, the scientists considered the present day species to consist of two populations: one population living in rainforest region A (north of Cairns) and the other population living in rainforest region B (south of Cairns). For each species, the scientists sampled cells from many individuals in both populations, isolated DNA from these cells, and compared the base sequence for the cytochrome b gene. This gene accumulates mutations at a steady and relatively rapid rate, and can be used to study evolutionary relationships between species.

b. Describe the relationship the scientists assumed between the accumulation of mutations and the evolutionary relationships between species.

1 mark

Figure 11 summarises the scientists' findings.

Figure 11

		Degree of difference in cytochrome b gene		
		Within rainforest region A	**Within rainforest region B**	**Between rainforest region A and rainforest region B**
Birds	grey headed robin	0%	0%	1.4%
	chowchilla	0%	0%	2.4%
	scrubwren	0%	0%	0%
Lizard	prickly skink	0%	0%	6%

c. Explain how the data in Figure 11 support the hypothesis that global cooling contributed to the diversity within species.

2 marks

d. Suggest why there is a much greater difference between the cytochrome b gene of the prickly skinks from rainforest region A and rainforest region B compared with the other species listed in Figure 11.

1 mark

The scientists were puzzled by the lack of difference in the base sequence of the cytochrome b gene between the two populations of the scrubwren. One suggestion is that the scrubwren population in rainforest region A became extinct during the last cool dry period 18 000 years ago.

e. Explain how this extinction during the last cool dry period could explain the lack of diversity in the present day scrubwren population in the rainforest of northeastern Australia.

2 marks

Total 8 marks

Article 7

When is a bat like a primate?

Bats, order *Chiroptera,* are unusual mammals because they can fly. The muscles and skeleton of the wing of all bats are similar, and are used to distinguish bats from other mammals. Bats are divided into two suborders: suborder *Megachiroptera,* the large fruit bats, and suborder *Microchiroptera,* the small insectivorous bats.

The traditional view is that the two suborders of bats have evolved from a common ancestor.

Question 7

a. Suggest a reason for this view.

_____

_____

1 mark

This traditional view is now being challenged. Recently, a team of biologists has looked at the proteins in the blood of a selection of species from the two groups of bats and the primates. They have found more similarity between the blood proteins of *Megachiroptera* and primate, than between the blood proteins of the two suborders of bats.

b. Suggest **two** conclusions that may be made from this recent data about the evolutionary history of bats.

Conclusion one _____

_____

Conclusion two _____

_____

2 marks

c. Explain why the biologists believed that a study of blood proteins would provide useful additional data to assist them in working out the evolutionary relationships.

_____

_____

_____

_____

_____

2 marks

d. If this new evidence based on blood proteins is accepted, how could you explain the similar wing muscles and skeleton in the two suborders of bats?

2 marks

Total 7 marks

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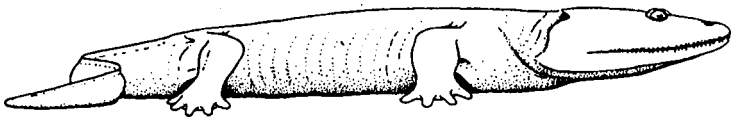
Article 8

Fossil in a wall

While cleaning mud from his garden wall, a Sydney resident discovered a black shape embedded in one of the large sandstone boulders. This black shape turned out to be an excellently preserved fossil. The fossil was dated as being 220 million years old. The fossil is believed to be a brachiopid, a member of the Temnospondyl family of amphibians.

Scientists have made a sketch of what they believe the animal would have looked like. See Figure 12.

Figure 12



The amphibian measured approximately two metres in length and had evidence of what might have been gill structures.

Question 8

a. **i.** The scientists chose not to use carbon dating to age this fossil. Explain why carbon dating was not appropriate in this case.

_____

_____

1 mark

ii. Suggest a suitable method for dating the brachiopid fossil.

_____

_____

1 mark

b. Suggest **two** pieces of evidence used by the scientist to conclude that the brachiopid lived in water.

Evidence one _____

_____

Evidence two _____

_____

2 marks

c. State **two** pieces of evidence that the scientists could use to decide that the brachiopid ate animals.

Evidence one _____

_____

Evidence two _____

_____

2 marks

d. Describe the conditions that would have been necessary for fossilisation of the brachiopid.

_____

_____

_____

_____

_____

_____

2 marks

Homologous structures are used to place animals such as the brachiopid on the evolutionary tree.

e. What are homologous structures? Use an example to explain your answer.

_____

_____

_____

_____

_____

_____

2 marks

Total 10 marks

TOTAL 75 marks

END OF QUESTION AND ANSWER BOOK