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STUDENT NUMBER

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VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY



Victorian Certificate of Education 2001

BIOLOGY Written examination 2

Monday 5 November 2001

Reading time: 3.00 pm to 3.15 pm (15 minutes)

Writing time: 3.15 pm to 4.45 pm (1 hour 30 minutes)

QUESTION AND ANSWER BOOK

Structure of book

Section	Number of questions	Number of questions to be answered	Number of marks
A	24	24	24
B	8	8	51
Total			75

Materials

- Question and answer book of 24 pages.
- Answer sheet for multiple-choice questions.
- At least one pencil and an eraser.

Instructions

- Write your **student number** in the space provided on the cover of this book.
- Check that your **name** and **student number**, as printed on your answer sheet for multiple-choice questions, are correct, **and** sign your name to verify this.
- All written responses must be in English.

At the end of the examination

- Place the answer sheet for multiple-choice questions inside the front cover of this book.

SECTION A – Multiple-choice questions**Instructions for Section A**

Answer **all** questions.

All questions should be answered on the answer sheet for multiple-choice questions, in pencil.

You should spend approximately 30 minutes on this section.

A correct answer scores 1, an incorrect answer scores 0. Marks will **not** be deducted for incorrect answers. No mark will be given if more than one answer is completed for any question.

Question 1

The diploid number of the platypus is 52.

The number of chromosomes present in a somatic cell of a platypus is

- A. 13
- B. 26
- C. 52
- D. 104

Use the following information to answer Question 2.

In the following pedigree (Figure 1) individuals with an X-linked dominant trait are shaded.

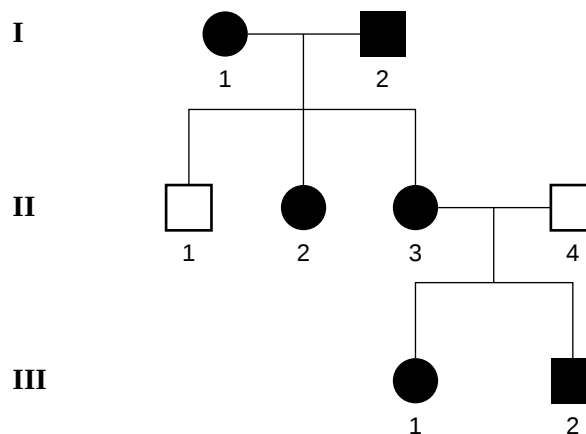


Figure 1

Question 2

From the information in the pedigree it is possible to conclude that an individual who is heterozygous is

- A. I – 1
- B. II – 1
- C. II – 3
- D. III – 2

Question 3

Mitosis occurs during growth of human tissues.

The number of chromosomes present in human cells before and after mitosis is best represented by

- A. $n \rightarrow n$
- B. $n \rightarrow 2n$
- C. $2n \rightarrow n$
- D. $2n \rightarrow 2n$

Question 4

In tomatoes the shape of the fruit is an inherited trait. In a cross between plants which are pure breeding for spherical fruit, and others which are pure breeding for oval fruit, all offspring have spherical fruit.

From this information you can conclude that

- A. a cross between tomatoes, each heterozygous, for spherical fruit, could produce offspring with two phenotypes.
- B. oval-shaped fruit is the dominant trait.
- C. any cross between tomatoes with spherical and oval fruit will produce offspring with one phenotype.
- D. all tomatoes with spherical fruit are homozygous.

Question 5

In gametes produced by meiosis in mammals the

- A. chromosomes in a gamete are identical to those in the parent cell.
- B. number of chromosomes in each gamete is half the number in the parent cell.
- C. amount of DNA in each gamete is the same as in the parent cell.
- D. number of alleles in each gamete is the same as in the parent cell.

Question 6

A trait such as egg size in chickens is polygenic.

This means that

- A. one gene locus with many alleles is involved.
- B. the population can be sorted into one or two phenotypic classes.
- C. the distribution of phenotypes is continuous.
- D. one gene locus with incomplete dominance is involved.

Use the following information to answer Question 7.

The colour of the exoskeleton of a beetle was known to be inherited. A series of four crosses between beetles with brown or green exoskeletons was performed. The genotype of each of the beetles involved in the cross was not known. The results are shown in Table 1 below.

Table 1

	Cross	Numbers of offspring of each phenotype	
		brown	green
Cross A	brown X green	12	11
Cross B	brown X brown	7	1
Cross C	brown X brown	18	0
Cross D	green X green	0	21

Question 7

It is possible to conclude from these results that the brown phenotype is dominant because

- A. approximately equal numbers of brown and green offspring are produced in Cross A.
- B. one green offspring is produced in Cross B.
- C. only brown offspring are produced in Cross C.
- D. only green offspring are produced in Cross D.

Use the following information to answer Question 8.

In peach plants the presence or absence of hairs on fruit and the colour of fruit flesh are under the control of two unlinked genes. The alleles of these two genes are as follows.

Hair on fruit: H hair present
 h no hair present

Fruit colour: W yellow flesh
 w white flesh

Question 8

In a test cross of plants, heterozygous at these two loci, it would be reasonable to expect that

- A. three quarters of the fruit would have hair.
- B. half of the fruit without hair would have white flesh.
- C. all of the fruit with hair would have yellow flesh.
- D. three quarters of the fruit would have white flesh.

Question 9

The sequences in a eukaryotic gene which are spliced out during processing of RNA and are not translated are called

- A. exons.
- B. codons.
- C. inclusions.
- D. introns.

Question 10

Polypeptide synthesis occurs at the

- A. nucleus.
- B. ribosomes.
- C. mitochondria.
- D. nucleolus.

Question 11

The genetic code

- A. has 64 codons all of which code for an amino acid.
- B. may have more than one amino acid for each codon.
- C. is read in groups of 4 bases.
- D. may have several codons for a single amino acid.

CONTINUED OVER PAGE

Use the following information to answer Question 12.

A 6 kb plasmid (a circular piece of DNA shown in Figure 2) was cut with the restriction enzyme *Eco*R1. The cut plasmid DNA was run on a gel.

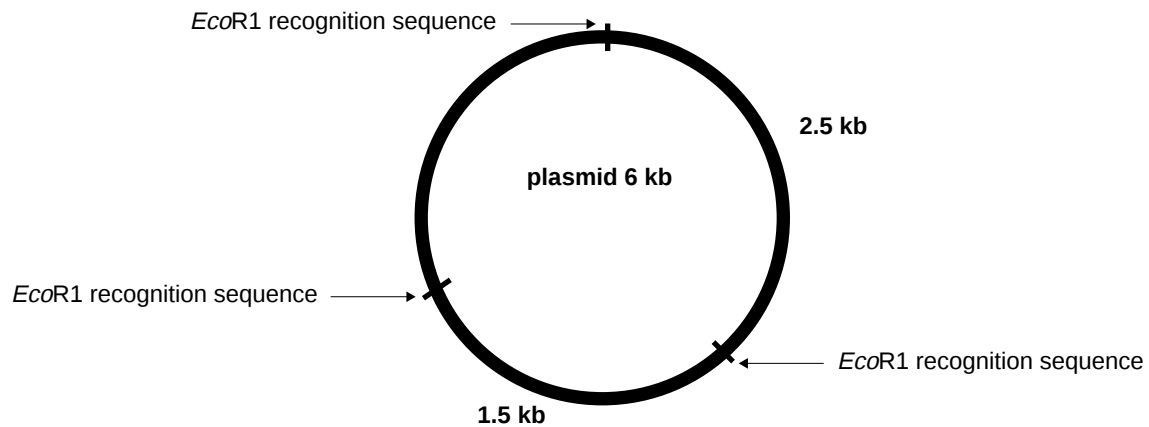
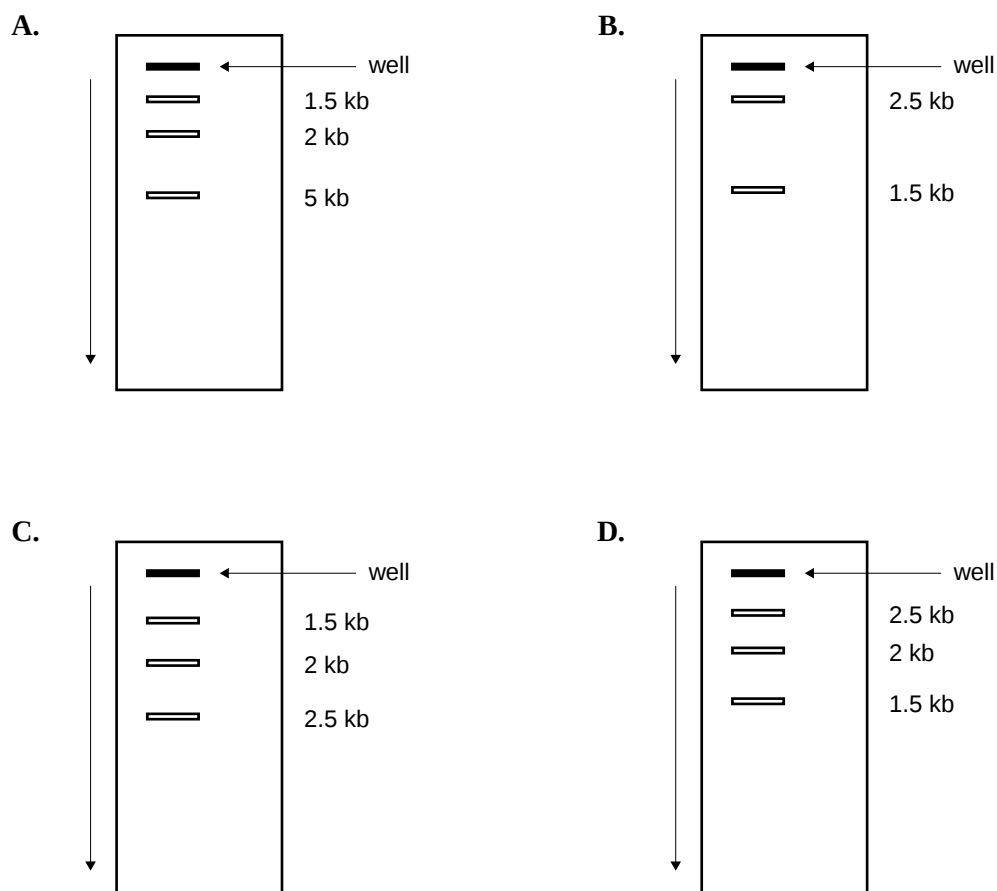


Figure 2

Question 12

The diagram which best illustrates the gel after electrophoresis of the digested plasmid is



Question 13

The base composition of the DNA of a particular bacterium was analysed. It was found that 18 per cent of the bases were adenine.

You could reasonably conclude that

- A. the DNA comprised 18 per cent adenine–thymine pairs.
- B. 32 per cent of the bases were cytosine.
- C. the DNA comprised 32 per cent of cytosine–guanine pairs.
- D. 36 per cent of the bases were thymine.

Use the following information to answer Question 14.

In the evolution of one species from another, chromosomal rearrangements can occur in which parts of or whole chromosomes become permanently attached to other chromosomes to form new chromosomal arrangements.

In the vinegar fly, *Drosophila*, chromosomal rearrangements have occurred in the evolution of *D. melanogaster* and *D. persimilis* from the ancestral form *D. virilis*. The changes are outlined below in Figure 3.

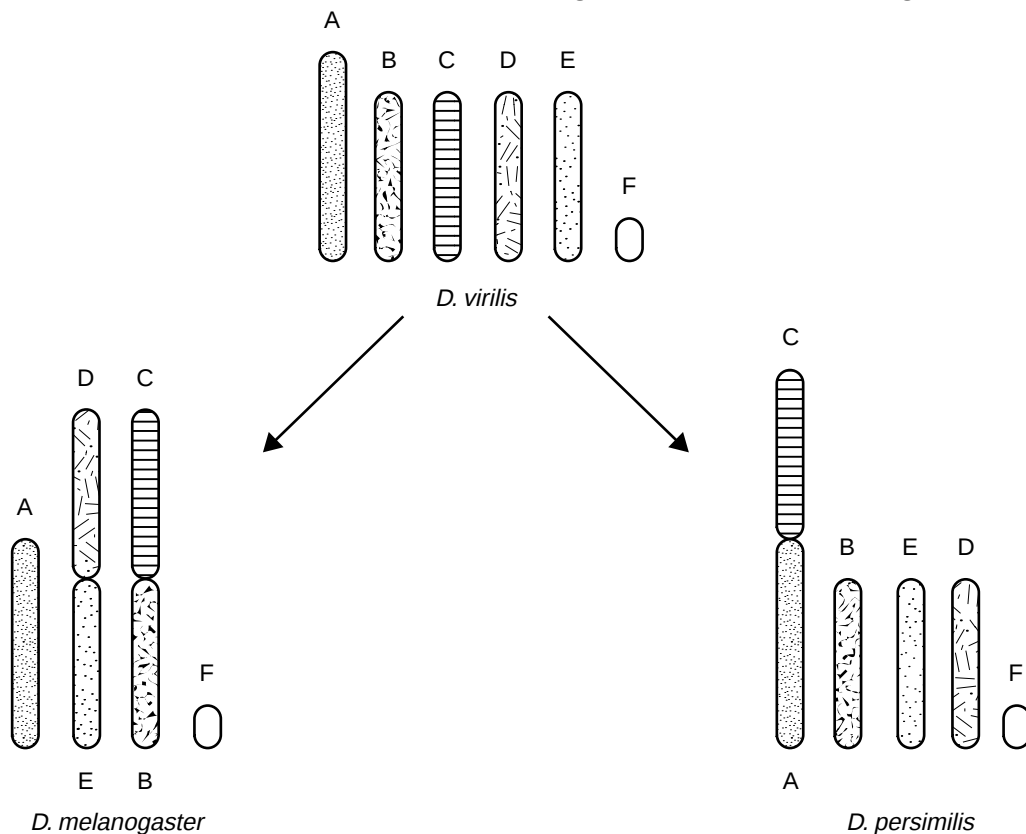


Figure 3

Only the haploid set of chromosomes is shown for each species. The letters A to F indicate the chromosomes in the ancestral species and the ways in which they have been rearranged in the two new species.

Question 14

You could reasonably conclude that

- A. there have been two new chromosomal combinations in the evolution of *D. melanogaster*.
- B. the diploid number of each of the three species is the same.
- C. no other species of *Drosophila* would show chromosomal rearrangements.
- D. in the evolution of *D. persimilis* each chromosome of *D. virilis* has been rearranged.

Question 15

Over the years there has been an increase in the number of strains of *Staphylococcus aureus* which are resistant to penicillin. The increase in the frequency of resistance has developed as a consequence of natural selection. This means that

- A. resistance to penicillin developed in nonresistant *Staphylococcus aureus* after exposure to penicillin.
- B. no resistant bacteria existed in the population before penicillin was used.
- C. penicillin caused a mutation in *Staphylococcus aureus* which made the bacteria resistant to penicillin.
- D. resistance to penicillin is an inherited trait in *Staphylococcus aureus*.

Use the following information to answer Question 16.

The following diagram (Figure 4) shows the evolutionary relationships in a number of species.

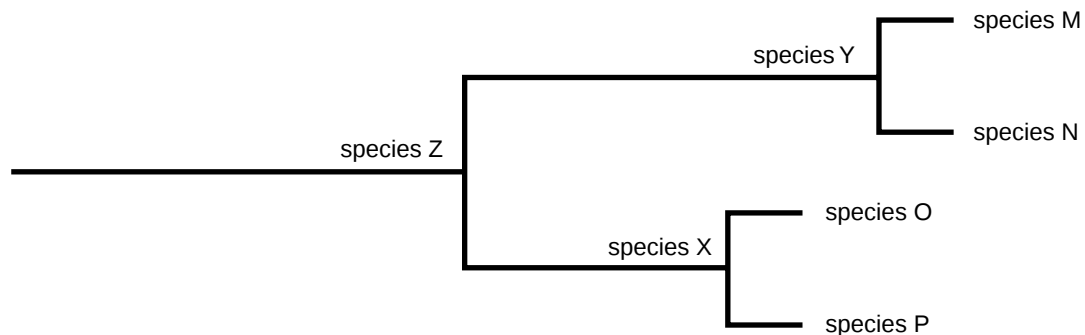


Figure 4

Question 16

This diagram indicates that

- A. species N and O are the most closely related species shown.
- B. species Y is the most recent common ancestor of species M and N.
- C. species X is a common ancestor to species M, N, O and P.
- D. species Z is the most recent common ancestor of species O and P.

Question 17

Selection operating over time on a population is likely to result in

- A. extinction.
- B. changes in allele frequencies.
- C. genetic drift.
- D. mutations.

Question 18

When populations of the same species live in different habitats, after many generations, differences in their characteristics will have evolved.

This is an example of

- A. divergent evolution.
- B. parallel evolution.
- C. gene flow.
- D. convergent evolution.

Use the following information to answer Question 19.

Fossil evidence for four groups of marine organisms has been compiled into the diagram below (Figure 5). The width of each shaded area indicates the number of different species in each group at a given time.

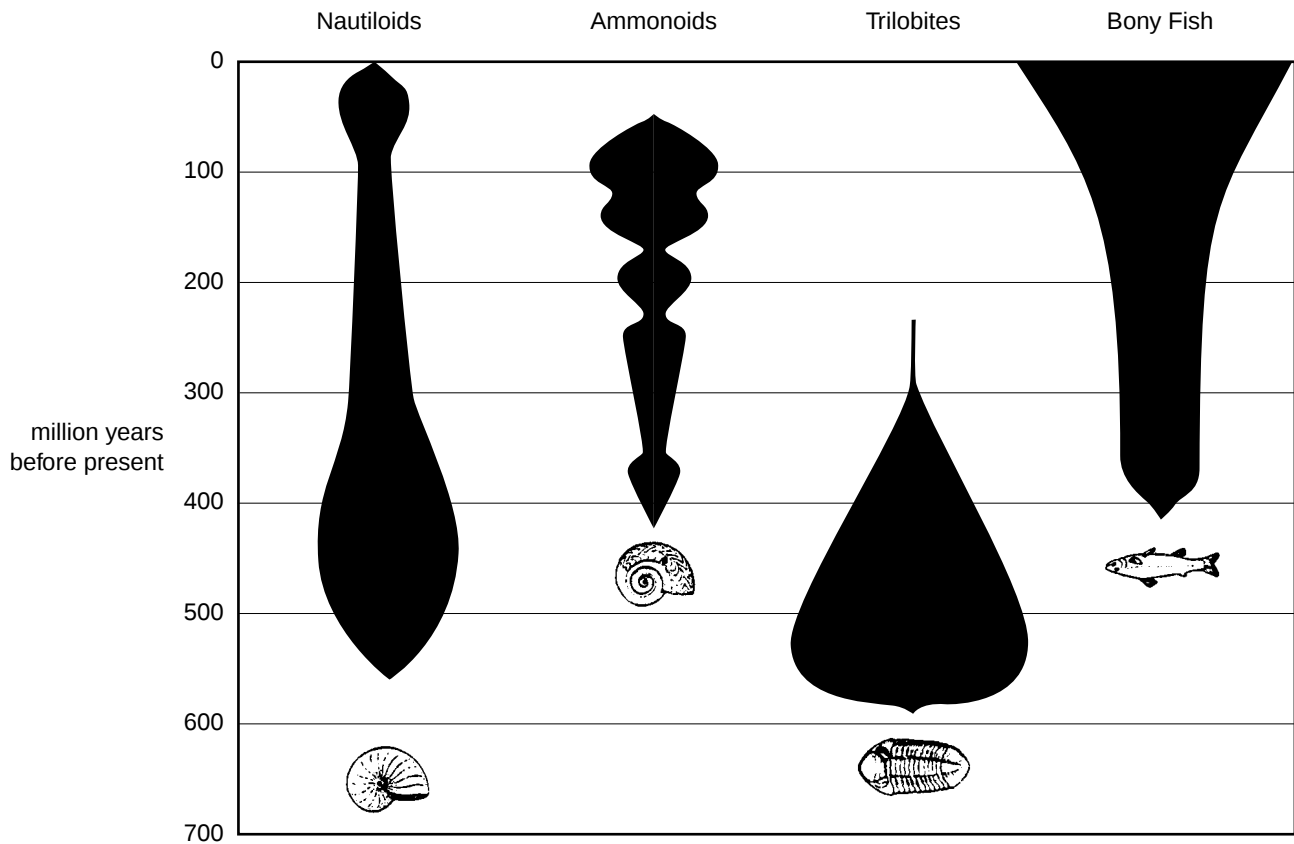


Figure 5

Question 19

This data indicates that

- A. ammonoids are the most ancient species.
- B. the number of ammonoid species decreased twice in the fossil history before they died out.
- C. 500 million years ago, the trilobites had the greatest number of different species.
- D. trilobites became extinct before the bony fish entered the fossil record.

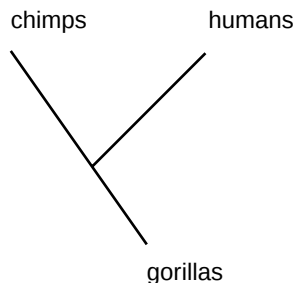
Use the following information to answer Question 20.

The common ancestor of modern apes and humans lived about 8 million years ago. The evolutionary line leading to gorillas diverged from the common ancestor about 7 million years ago. The most recent common ancestor of the chimpanzee and human occurred about 2 million years ago.

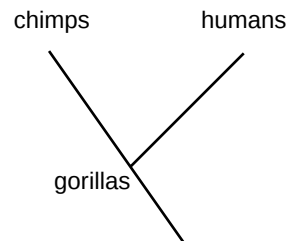
Question 20

The diagram which best represents the evolution of these three species is

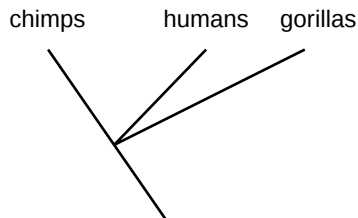
A.



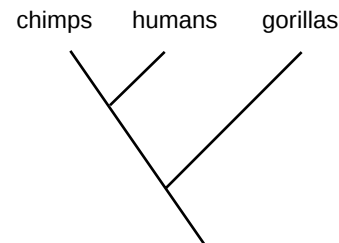
B.



C.



D.



Question 21

In comparison with an adult fossil hominid, *Australopithecus*, the skeleton of *Homo sapiens* would show

- A. more digits on the hands and feet.
- B. more prominent brow ridges.
- C. a reduced number of ribs.
- D. proportionally smaller teeth.

Question 22

Marsupials are found in South America, Australia and New Guinea.

This distribution is consistent with the idea that marsupials have a common evolutionary origin because

- A. similar habitats are found in these regions.
- B. other types of mammals are not found naturally in these regions.
- C. these regions were once joined together as a single landmass.
- D. land bridges have connected these regions to Asia and North America in the past.

Question 23

Over the last 200 years, many species of animals have become extinct.

One reason for such extinctions has been

- A. major climate change.
- B. habitat destruction by humans.
- C. extraterrestrial impacts; for example, meteors.
- D. the evolution of new groups of vertebrates.

Use the following information to answer Question 24.

The graph below (Figure 6) shows changes in the approximate number of families of marine animals over the past 500 million years.

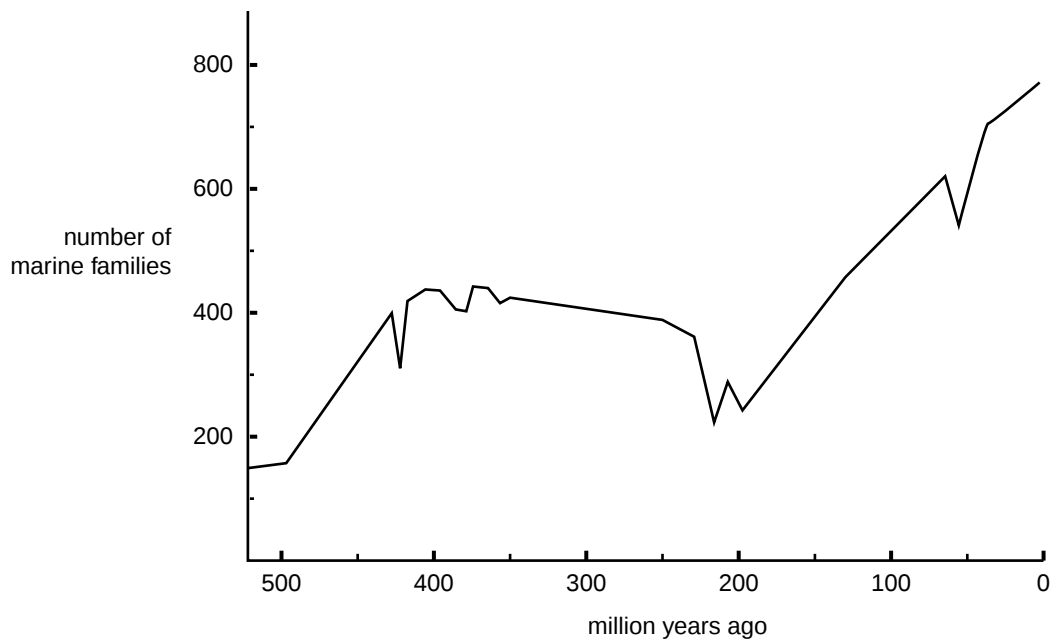


Figure 6

Question 24

The greatest episodes of extinction in these groups occurred at approximately

- A. 490, 180 and 50 million years ago.
- B. 430, 230 and 60 million years ago.
- C. 570, 370 and 130 million years ago.
- D. 510 and 210 million years ago.

SECTION B – Short-answer questions**Instructions for Section B**

Answer **all** questions. You should spend approximately 60 minutes on this section.

Question 1

Feather colour pattern in a species of duck is determined by one gene with three alleles.

- a.** What is an allele?

1 mark

The symbols for the three alleles are F^H , F^I and f . The genotype $F^H F^I$ exhibits codominance in the phenotype.

- b.** Explain what is meant by codominance.

1 mark

In a population of this species of duck all three alleles can be found.

- c.** **i.** How many different phenotypes would you expect for feather colour pattern?

- ii.** How many different genotypes would you expect for feather colour pattern?

1 + 1 = 2 marks

In humans, a biochemical disorder known as Tyrosinosis has been investigated.

Figure 7 below shows the inheritance of Tyrosinosis, in one family. The gene for Tyrosinosis is located on an autosome.

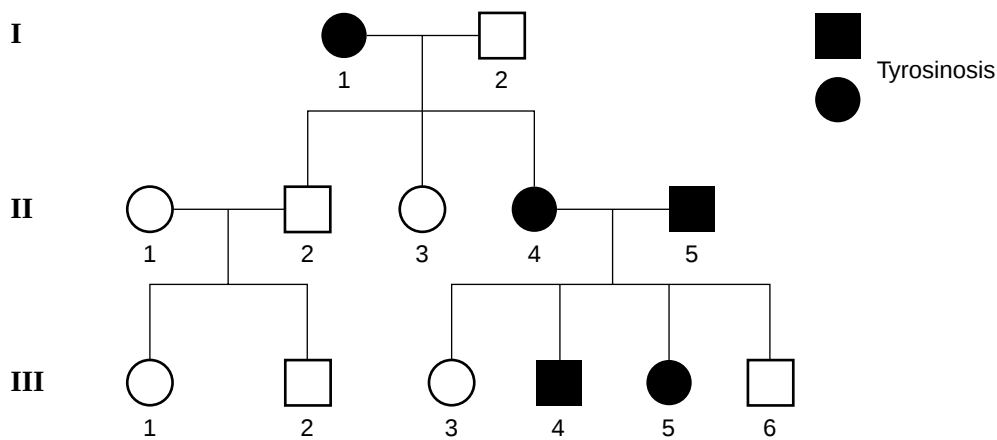


Figure 7

- d. i.** Is Tyrosinosis a dominant or a recessive trait?

- ii.** From the pedigree, what conclusive evidence justifies your answer?

1 + 1 = 2 marks

- e. i.** Write appropriate symbols for the alleles for the biochemical disorder.

Allelic symbols _____

- ii.** Use these symbols to indicate the genotypes of the following individuals.

Individual I – 1 _____

Individual III – 6 _____

1 + 1 = 2 marks

- f.** Individuals II – 4 and II – 5 have another child. What is the chance that the child will have the biochemical disorder?

1 mark

Total 9 marks

Question 2

In maize, *Zea mays*, the endosperm in seeds may be sugary or starchy. This trait is under the control of a single gene.

A farmer crossed two plants, each heterozygous, for the trait. Figure 8 below shows a typical portion of one of the cobs produced as a result of this cross.

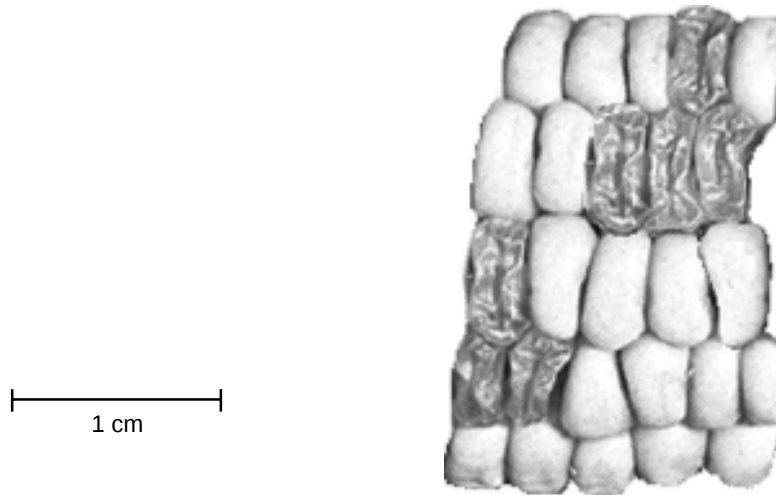


Figure 8

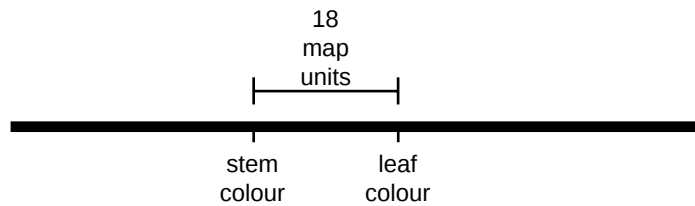
In the cob, each seed (often called a kernel) represents an offspring of the mating. A seed with a starchy endosperm is paler and more rounded than a seed with a sugary endosperm.

- a. i. Which phenotype, sugary endosperm or starchy endosperm, is the dominant phenotype?

- ii. Explain your answer to part a.i.

1 + 2 = 3 marks

Part of the chromosome map for chromosome number 10 in maize is



The genes and their alleles are

Stem colour **G** : green stem
g : yellow stem

Leaf colour **L** : red leaf
l : green leaf

A plant (plant X), heterozygous at the two gene loci, was crossed with a plant homozygous recessive for each trait (plant Y). The number of each kind of phenotype obtained in the offspring of the cross is given in Table 2 below.

Table 2

Phenotype of offspring	yellow stem red leaf	yellow stem green leaf	green stem red leaf	green stem green leaf
Number of offspring	84	18	18	80

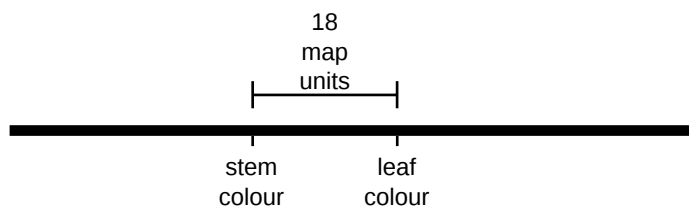
b. What was the genotype of each parent in the cross? Make sure that you show the linkage relationship in the way you present your answer.

i. Plant X _____

ii. Plant Y _____

2 + 1 = 3 marks

c. Another gene (**W**) on maize chromosome 10 shows 12 per cent recombination with the leaf colour gene. On the diagram of the chromosome below, mark two possible positions for the **W** gene.



2 marks

Total 8 marks

SECTION B – continued
TURN OVER

Question 3

In cats, a gene for fur colour has the alternative alleles

- F** : black and white patches of fur
f : black fur

The three possible genotypes and their phenotypes are

- FF** : lots of white with very small patches of black
Ff : approximately equal areas of black and white
ff : all black

Some white fur can also appear on a cat if there has been environmental damage to the pigment cells during development.

A cat breeder mated two black cats and was surprised to find one black and white male kitten within a litter of three kittens. It was important for the cat breeder to know if the black and white male kitten had arisen as a result of a mutation or as a result of environmental damage during development.

- a.** What cross could the breeder carry out to determine the cause of the white on the black and white male kitten?

1 mark

- b.** What results from the cross described in **a.** would you expect if the white on the black and white male kitten was genetically determined? Show the genotypes of the parents and the offspring of your cross in the answer.

2 marks

- c.** What results from the cross described in **a.** would you expect if the white on the black and white male kitten, was due to environmental damage during development? Show the genotypes of the parents and the offspring of your cross in the answer.

2 marks

Total 5 marks

Question 4

One form of osteoarthritis in humans is believed to be the result of a mutation in the DNA of the Type II Collagen Alpha 1 gene (COL2A1).

A small region of the mRNA coded by this DNA of both the mutant COL2A1 allele and the normal COL2A1 allele is shown below (Figure 9).

	mRNA						
Normal sequence of COL2A1	AAG	AUG	GUC	CGU	CUG	GAC	CUG....
Mutant sequence of COL2A1	AAG	AUG	GUC	UGU	CUG	GAC	CUG....

Figure 9

- a. What feature of the sequences shown in Figure 9 indicates that it is mRNA and not DNA?

1 mark

- b. What base substitution would have occurred in the template strand of DNA resulting in this change in the mRNA?

1 mark

mRNA	Amino Acid	mRNA	Amino Acid
UUU	phe	UGU	cys
UUC	phe	UGC	cys
UUA	phe	UGA	stop
UUG	phe	UGG	tryp
CUU	leu	CGU	arg
CUC	leu	CGC	arg
CUA	leu	CGA	arg
CUG	leu	CGG	arg
AUU	iso	AGU	gly
AUC	iso	AGC	gly
AUA	iso	AGA	gly
AUG	met	AGG	gly

Figure 10 Part of the genetic code

- c. Using the information in the genetic code in Figure 10, describe the effect of the mutation on the amino acid sequence which would be produced from this mRNA.

1 mark

- d. i.** What term is used to describe the production of RNA from DNA?

- ii.** Outline the steps which take place during the process named in **d.i.**

1 + 3 = 4 marks

When a gene such as COL2A1 is studied in the laboratory, restriction enzymes or endonucleases are used in the manipulation of the DNA.

- e.** Restriction enzymes cut DNA. Describe two other features of a restriction enzyme.

2 marks

Another mutation studied is the result of a deletion of 3 bases in the DNA of the gene.

The pedigree below (Figure 11) shows a family in which this autosomal recessive mutation is inherited.

The genotype of an individual can be determined by techniques which include a form of gel electrophoresis which can separate very small differences in the size of a piece of DNA.

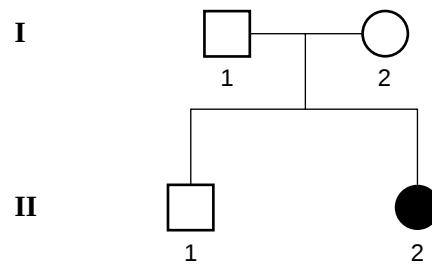
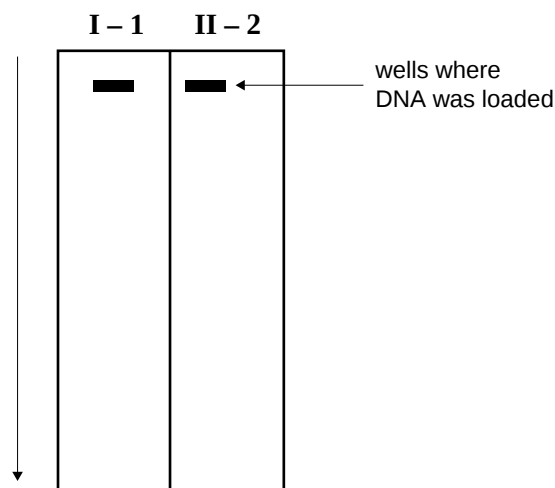


Figure 11

- f. Using the diagram of the gel (below) as a starting point, show the pattern of bands expected on the gel for I – 1 and II – 2.



2 marks

Total 11 marks

Question 5

Thirteen species of Darwin's finches occur on the Galápagos Islands, a group of about 30 islands 1000 km off the west coast of South America. The habitat varies widely between these islands. The finch species are found nowhere else in the world and are thought to have evolved from a single common ancestor.

- a. What conditions within the Galápagos group of islands are suitable for the speciation of the finches?

2 marks

- b. Within the Galápagos group the one finch species may be found on a number of islands. Explain how this could have occurred.

1 mark

- c. On the Galápagos Islands one species of finch, *Geospiza fortis*, is a seed eater. In 1977 a drought resulted in a shortage of seeds and only the largest individuals with strong beaks for cracking larger seeds were favoured. Over the next several generations the average body size of this species of finch increased. What term is given to the process described here?

1 mark

Total 4 marks

Question 6

Adalia bipunctata (ladybird beetles) are either red or black in any given population. The graph below (Figure 12) shows the percentage of black ladybird beetles in the ladybird beetle population, identified in a particular area over four years.

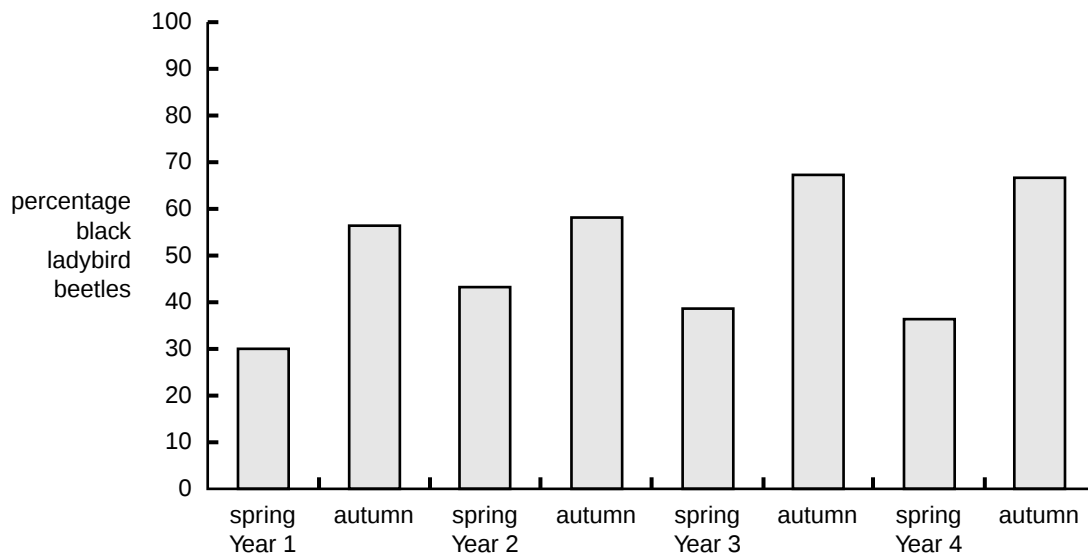


Figure 12

- a. Which form of ladybird beetle is more common in the population in spring?

1 mark

- b. Identify one selection pressure which may occur in spring and explain how this selection pressure accounts for the difference in the frequency of the two differently coloured ladybird beetles.

2 marks

Total 3 marks

Question 7

In the early 1860s two unusual fossils were discovered in a limestone quarry in Bavaria. The first was that of a feather and the second was a small skeleton with impressions of feathers. The organism represented by these specimens was named *Archaeopteryx*. It is thought by many scientists to be the oldest recorded bird (about 150 million years old).

- a. How could scientists in the 1860s have estimated the relative age of these fossils?

1 mark

- b. There are fewer than 10 specimens of *Archaeopteryx* known today. Some of the specimens are incomplete and lack distinct feather impressions.

- i. Give one possible reason why fossils of *Archaeopteryx* are rare.

- ii. Give one possible reason why some of the *Archaeopteryx* fossils are incomplete.

1 + 1 = 2 marks

Modern birds are thought by many scientists to have evolved from a group of dinosaurs called theropods. Fossils of *Archaeopteryx* and another fossil species, *Rahona*, show a mixture of characteristics of modern birds and theropods. The diagrams below (Figure 13) show two possible views of the evolution of these organisms.

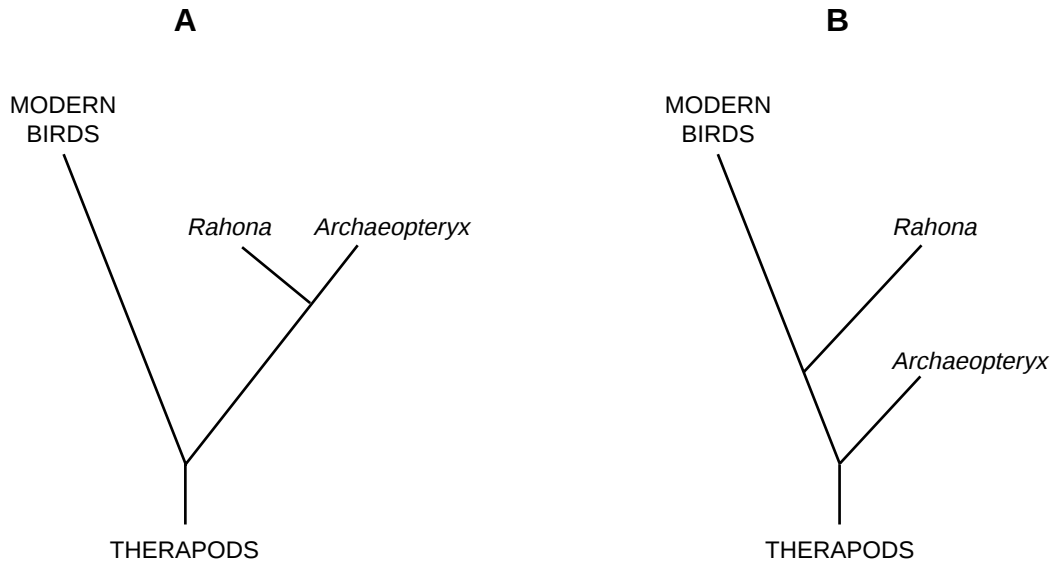


Figure 13

- c. Explain which diagram (A or B) suggests that modern birds are more closely related to *Rahona* than they are to *Archaeopteryx*.

2 marks

Flight evolved in both birds and pterosaurs (an extinct reptile group). While both of these groups had wings their wing structures were very different. The wings of pterosaurs were made up of the arm and a very long 4th digit (finger) which supported a flying membrane. This membrane was supported by modified scales. However, bird wings are made up of the whole arm with a reduced number of digits. Flight is accomplished with feathers rather than a flight membrane.

- d. Explain whether the wings of birds and pterosaurs are analogous or homologous structures.

2 marks

Total 7 marks

SECTION B – continued
TURN OVER

Question 8

The yellow monkey flower, *Mimulus guttatus*, has a single gene which affects the reproductive rate of mature plants and the amount of chlorophyll in the leaves. The gene has two alleles: G and g. The genotypes and associated phenotypes are listed below.

Genotype	GG	Gg	gg
Phenotype	- normal amount of chlorophyll in leaves - high rate of reproduction	- leaves with white (chlorophyll-free) streaks which do not affect survival - higher reproductive rate than GG individuals	lack chlorophyll and die before maturity or early in development

- a. Individuals with the genotype **gg** cannot pass their alleles on to the next generation. In large populations of the yellow monkey flower, however, the allele **g** has been maintained at a relatively high level over a long period of time. Explain.

2 marks

- b. When comparing smaller isolated populations of the yellow monkey flower, the frequency of the **g** allele can vary from zero in some populations to relatively high levels in others. Give one explanation for this observed variation in allele frequency between small populations.

2 marks

Total 4 marks

END OF QUESTION AND ANSWER BOOK