



# Victorian Certificate of Education 2008

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## STUDENT NUMBER

Figures

Words


Letter

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# BIOLOGY

## Written examination 2

Monday 3 November 2008

Reading time: 9.00 am to 9.15 am (15 minutes)

Writing time: 9.15 am to 10.45 am (1 hour 30 minutes)

## QUESTION AND ANSWER BOOK

### Structure of book

<i>Section</i>	<i>Number of questions</i>	<i>Number of questions to be answered</i>	<i>Number of marks</i>
A	25	25	25
B	8	8	50
			Total 75

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners and rulers.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.
- No calculator is allowed in this examination.

#### Materials supplied

- Question and answer book of 23 pages.
- Answer sheet for multiple-choice questions.

#### Instructions

- Write your **student number** in the space provided above on this page.
- Check that your **name** and **student number** as printed on your answer sheet for multiple-choice questions are correct, **and** sign your name in the space provided 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.

**Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.**

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

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.

Choose the response that is **correct** for the question.

A correct answer scores 1, an incorrect answer scores 0.

Marks will **not** be deducted for incorrect answers.

No marks will be given if more than one answer is completed for any question.

*The following information relates to Questions 1 and 2.*

The following ultrasound image shows a fetus at the week 12 stage of development.



The area J surrounding the fetus contains amniotic fluid which includes skin cells from the fetus. A small sample of amniotic fluid can be extracted and the skin cells cultured. The following image is of a karyotype prepared from cultured skin cells of the baby in the photograph.

**Question 1**

The number of autosomes in this karyotype is

- A. 22
- B. 23
- C. 44
- D. 46

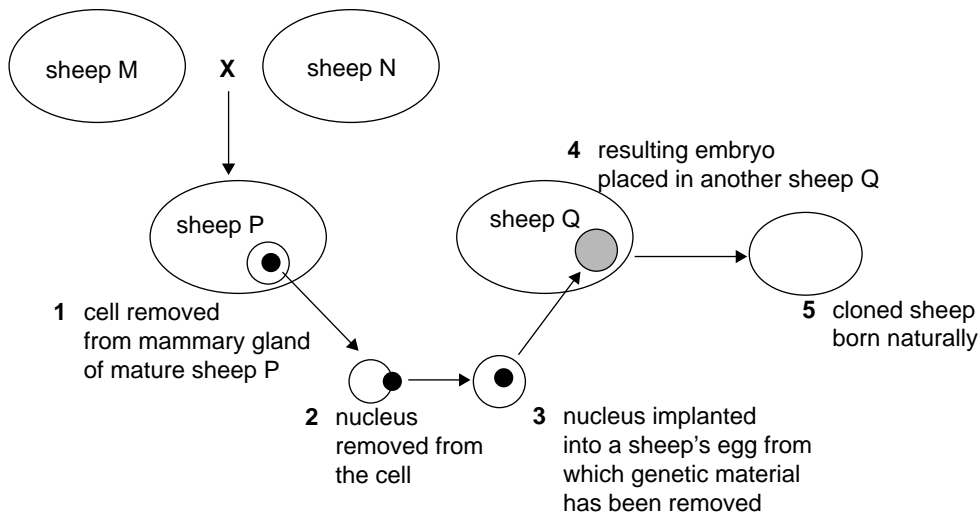
**Question 2**

Examination of the karyotype reveals that the baby

- A. is a male.
- B. has a defective allele.
- C. has an extra X chromosome.
- D. has three number 13 chromosomes.

**Question 3**

The following diagram summarises the steps involved in the production of a cloned sheep.



The chromosomes in the cells of the cloned sheep will be identical with those in the cells of

- A. sheep M.
- B. sheep N.
- C. sheep P.
- D. sheep Q.

**Question 4**

In sheep, white wool (B) is dominant to black wool (b). In 2005, a farmer with a flock of sheep containing a few black sheep decided to prevent all black sheep from breeding in the future. White sheep in the flock continued to reproduce in that year and the years that followed.

As a result of the farmer's action it is reasonable to predict that

- A. no black lambs were born in 2006 and beyond.
- B. black lambs were born in 2006 but none in the following years.
- C. the proportion of black lambs born in 2006 was the same as in previous years.
- D. the proportion of black lambs born would decline gradually in the years following 2005.

**Question 5**

Mitochondrial DNA

- A. is a linear molecule.
- B. is inherited only from the female parent.
- C. exists in mammalian cells but not plant cells.
- D. contains the same amount of uracil bases as adenine bases.

**Question 6**

When comparing normal meiosis in human males and females

- A. equal numbers of functional gametes are formed from each participating cell.
- B. each egg and sperm contain a single sex chromosome.
- C. each egg produced contains one more autosome than a sperm cell.
- D. all sperm contain the same kind and amount of DNA.

**Question 7**

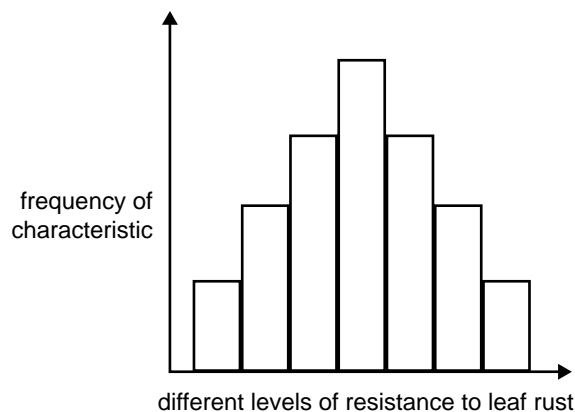
An amoeba only reproduces asexually.

Variation in an amoeba most commonly occurs through

- A. mutation.
- B. random fusion of gametes.
- C. chiasmata formation and crossing over.
- D. independent assortment of chromosomes.

**Question 8**

Members of a barley plant species show varying levels of partial resistance to the leaf rust, *Puccinia hordei*. The graph below shows the distribution of a population of barley plants with regard to this characteristic.



With respect to rust resistance, these plants show

- A. high mutation rates.
- B. polygenic inheritance.
- C. discontinuous variation.
- D. inheritance due to a single pair of alleles.

**Question 9**

In the following table, the information that is accurately presented is in row

	Cell	DNA arrangement	Gene product
A.	prokaryote	plasmid	DNA
B.	prokaryote	linear chromosome	protein
C.	eukaryote	plasmid	DNA
D.	eukaryote	linear chromosome	protein

**Question 10**

The highest level of genetic variation in mitochondrial DNA in modern-day humans occurs in African populations.

The most likely explanation is that

- A. *Homo sapiens* evolved in Africa.
- B. mitochondrial DNA has a higher mutation rate in African environments.
- C. gene flow occurred between *Homo sapiens* and other *Homo* species in Africa.
- D. natural selection does not operate on mitochondrial DNA in African environments.

**Question 11**

In his theory of evolution by natural selection, Darwin

- A. described the role of DNA as the material of inheritance.
- B. used evidence from Mendel's experiments on pea plants.
- C. stated that favourable alleles were passed on from parents to offspring.
- D. proposed that particular characteristics suit an organism to its environment.

**Question 12**

Two hominin (also called hominid) skull fragments were found in separate locations and each was associated with a number of artefacts. Skull X was dated and shown to be 100 000 years old, while skull Y was dated at 20 000 years old.

The artefacts most likely discovered with skull Y but not skull X would be

- A. fireplace fragments.
- B. stone tools for cutting.
- C. pigment used in rock paintings.
- D. bones from hunted animals.

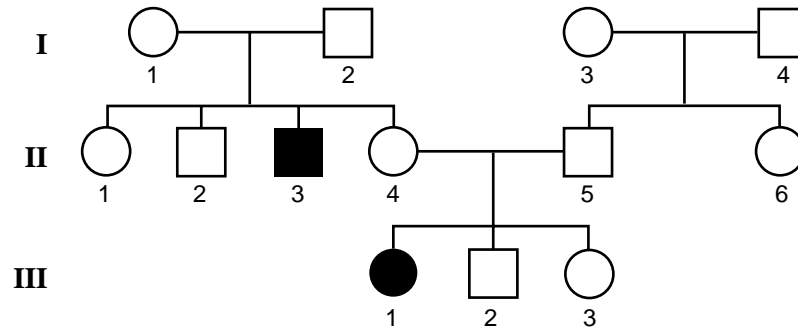
The following information relates to Questions 13 and 14.

Phenylketonuria (PKU) is a condition in which affected individuals fail to produce the enzyme phenylalanine hydroxylase. PKU is inherited as an autosomal recessive condition and the alleles involved are

P : normal production of the enzyme

p : lack of enzyme

The following pedigree shows a family in which two members have PKU.



### Question 13

In the pedigree shown, individuals that must be heterozygous for PKU include

- A. I-2
- B. I-4
- C. II-1
- D. II-6

### Question 14

The chance that individual III-3 is Pp with regard to the PKU locus is

- A.  $\frac{1}{3}$
- B.  $\frac{1}{2}$
- C.  $\frac{2}{3}$
- D.  $\frac{3}{4}$

*The following information relates to Questions 15 and 16.*

The following table shows a stratigraphic section of rock. Scientists found that fossils A and C had analogous structures.

Surface layer
Volcanic ash – no fossils found
Fossil D
Volcanic ash – no fossils found
Fossils A and C
Fossil B
Fossil A

**Question 15**

From the data it can be concluded that

- A. fossil A is less than 5 million years old.
- B. fossil D is the youngest fossil present.
- C. fossils A and C are closely related.
- D. fossil B is extinct.

**Question 16**

Fossils A and C both have limb-like appendages.

As they had analogous structures then they must have shared very similar

- A. DNA sequences.
- B. RNA sequences.
- C. habitats.
- D. selection pressures.

**Question 17**

Biologists have sequenced the genomes of many organisms. The number of genes found in organisms varies greatly. Some examples are listed in the table below.

Species of organism	Size of genome (approximate number of millions of base pairs)	Number of genes (approximate)
<i>Escherichia coli</i> (bacterium)	4.6	3 000
<i>C. elegans</i> (nematode worm)	100	20 621
<i>Fugu rubripes</i> (puffer fish)	365	38 000
<i>Mus musculus</i> (mouse)	3 000	22 000
<i>Homo sapiens</i> (human)	3 300	22 000
<i>Psilotum nudum</i> (whisk fern, a fern that grows in cracks in rocks)	250 000	unknown
<i>Arabidopsis thaliana</i> (flowering mustard plant)	100	28 000

From this data it can be concluded that

- A. larger organisms have larger genomes.
- B. puffer fish show greater genetic variety than *E. coli*.
- C. a nematode and flowering mustard plant have the same number of chromosomes.
- D. the larger the genome of an organism, the greater the number of proteins it produces.

**Question 18**

$\beta$ -cells in the human pancreas produce insulin. mRNA transcripts from these cells can be used to produce complementary (cDNA) copies of the active gene.

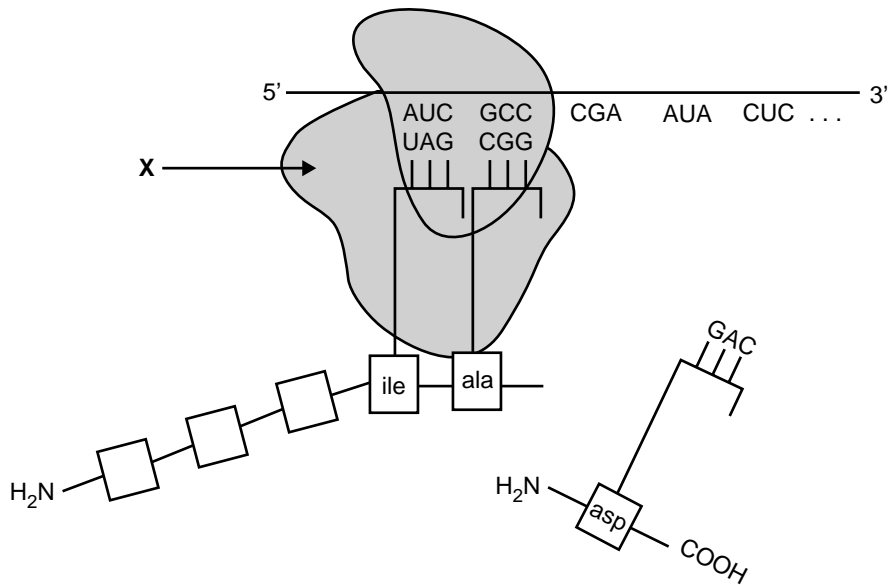
The enzyme needed to produce cDNA from an mRNA transcript is

- A. restriction endonuclease.
- B. reverse transcriptase.
- C. ligase.
- D. RNA polymerase.



**Question 19**

The diagram below shows part of the translation process of protein synthesis.

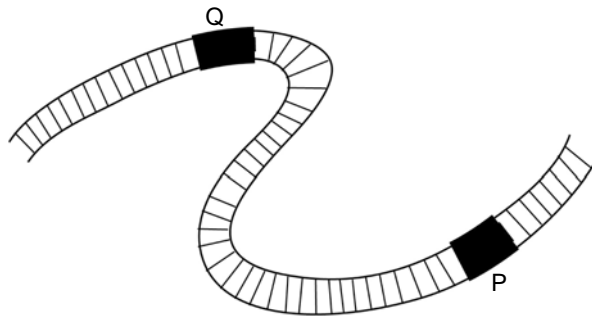


Structure **X** in the diagram contains

- A. messenger RNA.
- B. ribosomal RNA.
- C. transfer RNA.
- D. nuclear DNA.

**Question 20**

The genome of a small virus is depicted below, showing the positions of cutting sites (P and Q) for two restriction enzymes.



The length of DNA fragments obtained when using these restriction enzymes is shown in the table below.

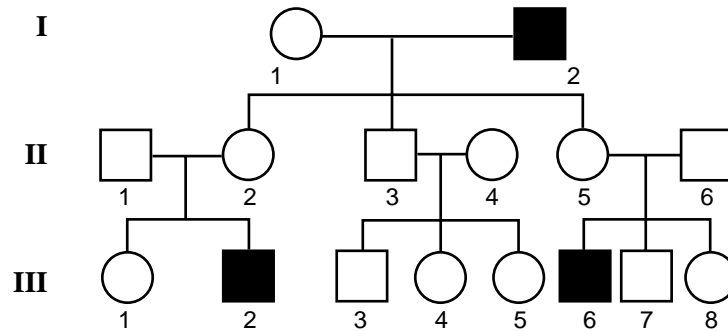
Cutting site	Restriction enzyme used	Length of DNA fragments obtained (kB)
Q	EcoR1	3, 7
P	BamH1	8, 2

If both EcoR1 and BamH1 are used together on this viral DNA, the length of fragments obtained would be

- A. 3, 8, 5, 2
- B. 7, 2, 1
- C. 3, 5, 2
- D. 3, 7, 8, 2

**Question 21**

Examine the following pedigree. Shaded individuals in the pedigree have a genetic disease. Individuals marrying into the family, that is individuals II-1, II-4 and II-6, have no history of the disease in their families.

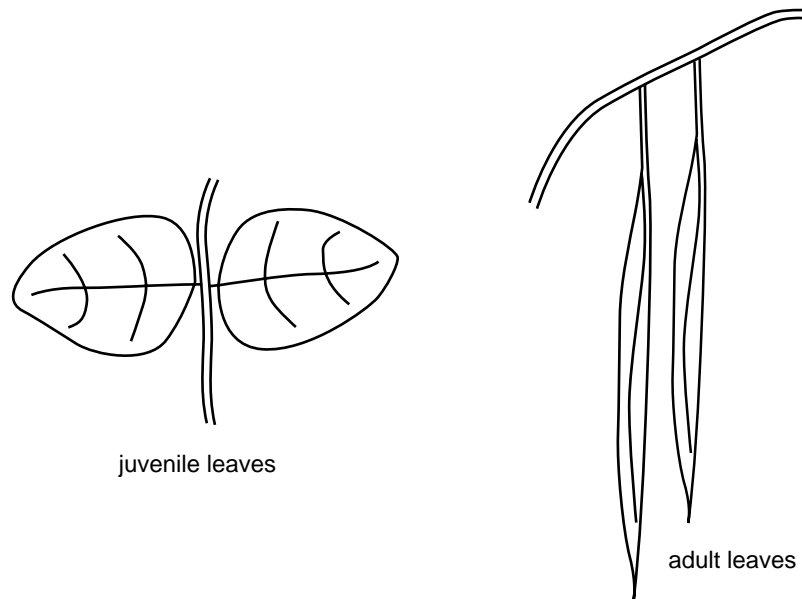


The mode of inheritance of the trait shown in the pedigree is most likely to be

- A. autosomal recessive.
- B. autosomal dominant.
- C. X-linked recessive.
- D. X-linked dominant.

**Question 22**

Australian *Eucalyptus* trees characteristically have two types of leaves, a juvenile (young) form and an adult form. The juvenile leaves are held horizontally and are relatively large and broad, while the adult leaves hang vertically and are long and narrow. Typical juvenile and adult leaves are shown below.



A selection pressure which is likely to have had the greatest influence on the evolution of the juvenile leaf shape and position would be

- A. competition for light.
- B. unpredictable rainfall.
- C. browsing by herbivores.
- D. high ambient temperatures.

**Question 23**

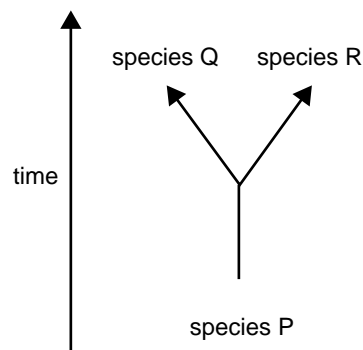
*Lucilia cuprina*, the sheep blowfly, lays its eggs in wounds and the wet fleece of sheep. The larvae hatch and burrow into the sheep's skin, causing distress, reduced wool production and sometimes death. Particular chemicals were used in the past to control the *L. cuprina* but these became less effective as sheep blowfly developed a resistance to the chemicals.

The cause of the increased resistance to the chemicals was most likely due to

- A. farmers successively reducing the levels of insecticide applied to sheep.
- B. the insecticide producing a change in a gene which enhanced the survival of the blowfly.
- C. a chance mutation in a blowfly gene conferring a survival advantage in the chemical environment.
- D. the insecticide producing a change in phenotype which enhanced reproduction of the blowfly.

**Question 24**

Consider the following diagram that represents one type of evolution.



It may be concluded that

- A. species Q and R could be the result of parallel evolution.
- B. species Q and R could be the result of convergent evolution.
- C. species P would appear in the fossil record later than species R.
- D. species Q and R could have arisen through a process of allopatric speciation.

**Question 25**

Since the introduction of the poisonous cane toad to Australia in 1935, there has been an increase in the ratio of body length to head size in two species of snakes, the Red-bellied Black Snake and the Green Tree Snake.

A smaller headed snake cannot consume a large prey item, and so cannot swallow a large cane toad that has sufficient toxin to kill the snake.

The rapid evolution of body dimensions in the Red-bellied Black Snake and the Green Tree Snake most likely came about because

- A. cane toad toxin reduced the head size of the snakes.
- B. even small cane toads contain enough toxin to kill a long-bodied snake.
- C. smaller headed snakes are better at catching cane toads than large headed snakes.
- D. larger headed snakes were killed by the levels of toxin ingested when they ate a large cane toad.

**SECTION B – Short answer questions**

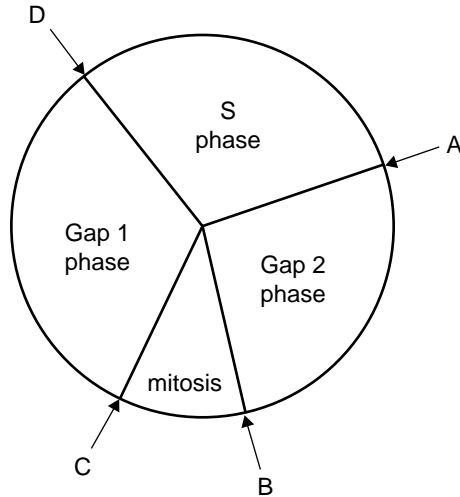
**Instructions for Section B**

Answer this section in pen.

Answer **all** questions in the spaces provided.

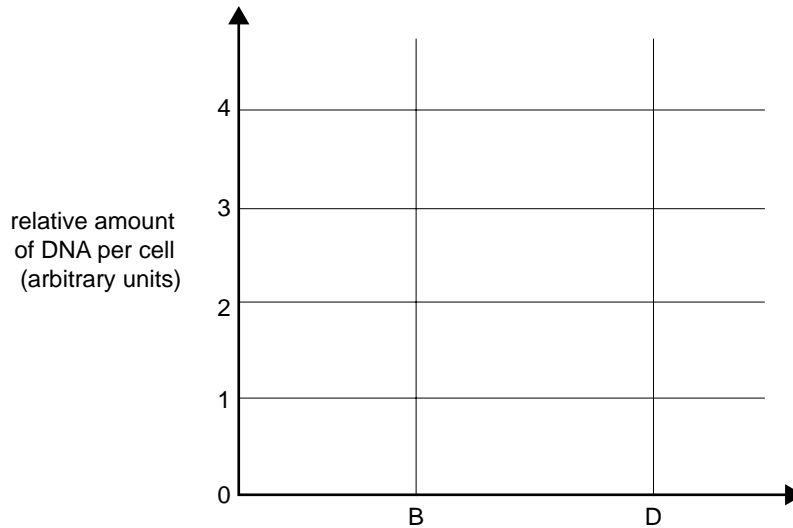
**Question 1**

When a cell replicates it goes through a series of events that can be summarised by the following diagram. The cycle moves in a clockwise direction and includes mitosis. Note four points, labelled A, B, C and D.



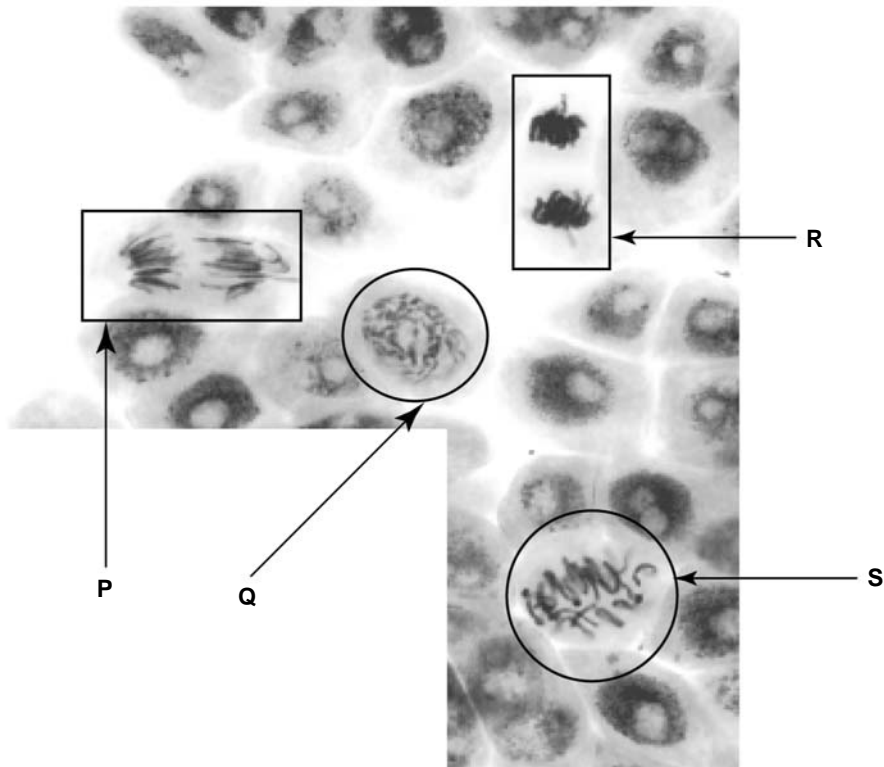
Given that two cells are formed as a result of replication, a cell must replicate its DNA during the cycle.

- a. Using crosses, mark on the graph below the relative amount of DNA present at each of the points B and D in the cycle.



1 mark

The following photograph shows a group of cells, some of which are replicating by mitosis. The letters P, Q, R and S indicate cells that are at different points in the cell cycle.



- b. Starting with the cell closest to the beginning of mitosis, arrange the letters P, Q, R and S in the order in which they would occur during the cell cycle.

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1 mark

If a serious error has occurred during mitosis, the daughter cells may not survive to complete the cell cycle.

- c. Name the process by which such cells are destroyed.

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1 mark

Meiosis is another form of cell division. A student claimed that there was no significant difference between mitosis and meiosis.

- d. Identify one significant feature of meiosis and explain how it indicates that it is a different process from mitosis.

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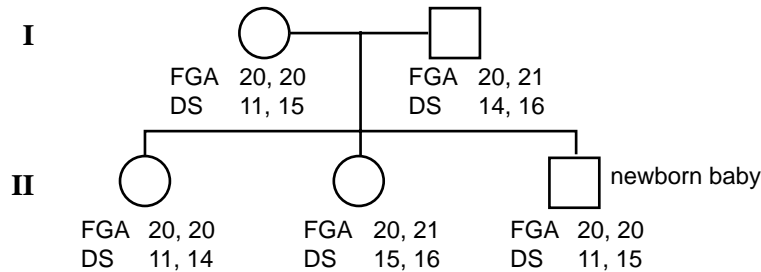
2 marks

Total 5 marks

**Question 2**

Some gene loci have several alternative alleles. With these gene loci, the DNA profile of an individual may be given in terms of the relative sizes of the alleles. For example, gene locus THO has three alleles that are called THO 7, THO 9 and THO 10.

In a maternity hospital, a mother claimed that she had accidentally been given the wrong baby boy. A DNA analysis of two gene loci, locus FGA and locus DS, was carried out on members of the family and the results are included in the following pedigree. Assume that no mutation involving these two loci has occurred in the family.



- a. Does the data support the mother’s claim that she has been given the wrong baby boy? Give reasons to support your answer.

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2 marks

Many trials involving the technique of gene therapy have been carried out in humans, with varying success.

- b. What is the aim of gene therapy?

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1 mark

The technique of gene therapy also involves the use of vectors.

- c. Name one agent that could act as a vector in gene therapy.

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1 mark

In 1999, during a gene therapy trial for a particular enzyme deficiency, a young man died from multiple organ failures four days after starting the treatment. He was in excellent health before participating in the trial.

- d. Suggest one event that could have occurred within the young man as a result of him receiving gene therapy that resulted in his death.

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1 mark

Total 5 marks

**SECTION B** – continued

**Question 3**

Many gene loci are involved in determining blood groups.

One gene, the ABO gene, is responsible for the ABO blood groups. This gene locus has the alleles

**I<sup>A</sup>** : A antigen produced

**I<sup>B</sup>** : B antigen produced

**i** : no antigen produced

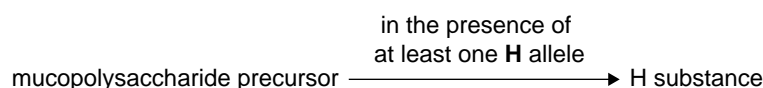
There are four phenotypes, called blood groups, in this system. They are A, B, AB and O.

- a. Complete the following table using the allele symbols given above.

Blood group	Possible genotypes
B	
AB	

2 marks

Another gene associated with blood groups has the alleles **H** (H substance) and **h** (lack of H substance). The pathway involved can be summarised as follows.

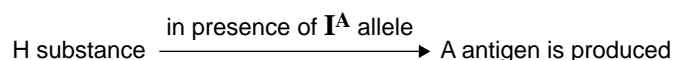


- b. Write the genotype of an individual who fails to produce H substance.

1 mark

H substance is the substrate for the production of the antigens associated with the ABO blood group.

For example



- c. To which blood group would a person with the genotype **hh I<sup>A</sup>I<sup>B</sup>** be assigned after routine blood-group testing?

1 mark

H substance is also called H antigen. The H antigen and antigens of the ABO blood-group system are also found in some body fluids, for example in saliva.

- d. Complete the following table.

Genotype	Antigens appearing in saliva
<b>Hh I<sup>A</sup>I<sup>A</sup></b>	
<b>HH ii</b>	

2 marks

Total 6 marks

**Question 4**

In the late 1950s, a series of nuclear tests involving the detonation of hydrogen bombs was carried out in the mid-Pacific Ocean. Witnesses of these tests included 500 New Zealand sailors.

Since the tests, the New Zealand sailors have claimed that their lives have been affected because, as a direct result of radioactivity from the tests, a number of genetic disorders have appeared among them and their offspring.

In the year 2000, the New Zealand veterans commissioned research to assess DNA damage that they may have.

- a. Describe three factors that scientists would need to consider in the design of their research.

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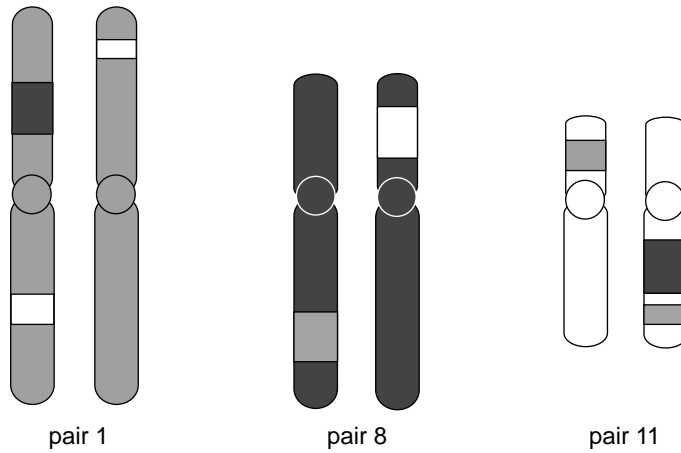
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3 marks



The chromosomes of men who participated in the study were examined. Each homologous pair of chromosomes was stained with a specific colour. This technique meant that segments of chromosomes that have moved between non-homologous chromosomes can be readily identified. The following diagram shows the result for three homologous pairs of chromosomes from veteran X.



- b. i.** Assume that you are veteran X. Use the data to present an argument supporting your claim that you have genetic defects that adversely impact on your health.

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- ii.** Explain how the results for veteran X could lead to an increase in genetic disorders in his children and grandchildren.

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2 + 2 = 4 marks

- c.** One individual claimed the chromosomal changes observed in veteran X were mutations involving a single base pair on each chromosome. Explain whether you agree or disagree with this individual.

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1 mark

Total 8 marks

**Question 5**

Three different kinds of plants, a cactus, euphorbia and milkweed, have similar adaptations for growing in desert environments. They all have long, fleshy stems for water storage, protective spines and reduced leaves. Both the euphorbia and milkweed plants are believed to have evolved from leafy plants adapted to more temperate climates. They share a more recent ancestor than either one does to a cactus.

- a. Draw an evolutionary tree (also called phylogenetic tree or cladogram) to demonstrate this relationship.

1 mark

- b. Name the process by which the ancestral leafy euphorbia plant could have given rise to the desert-adapted species described above.

1 mark

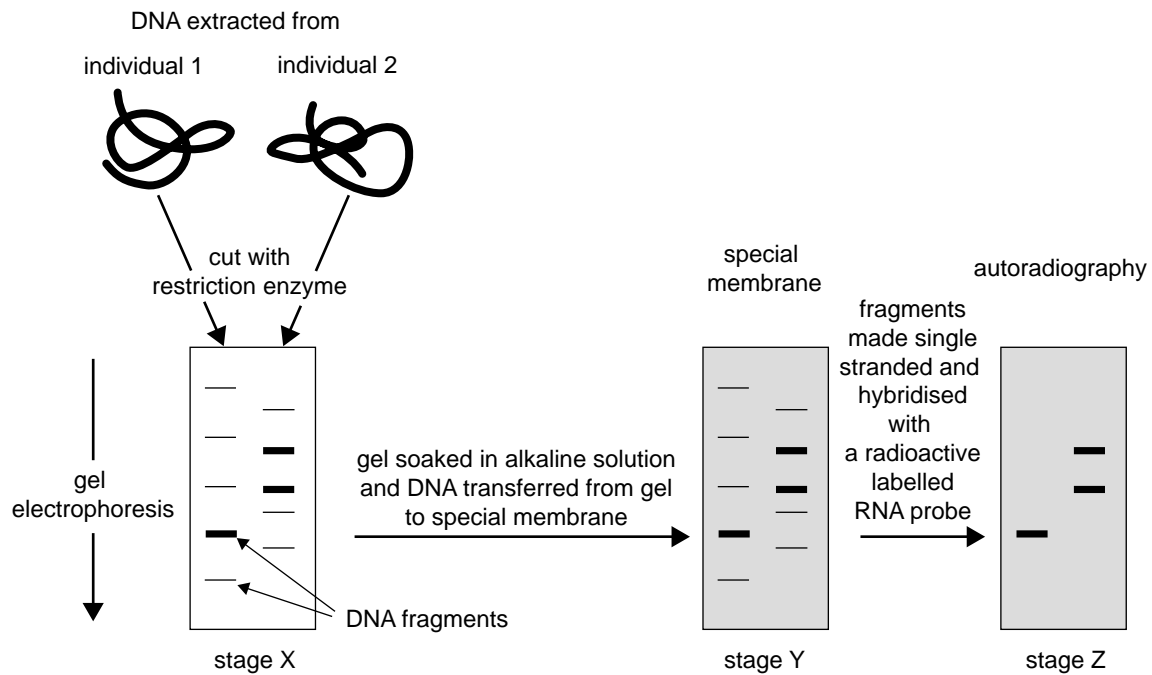
- c. What is a possible explanation for there being so few cactus fossils?

1 mark

Total 3 marks

**Question 6**

RFLP (Restriction Fragment Length Polymorphism) analysis is commonly used to determine genetic variation between individuals. The procedure is summarised below.



In this procedure, scientists select a particular restriction enzyme from an available range.

a. Explain the reason for their choice.

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1 mark

Electrophoresis uses electrical current to sort DNA fragments.

b. i. Describe one characteristic of this sorting process.

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ii. Explain why the DNA of each individual produces a different pattern of fragments after gel electrophoresis, even when the same restriction enzyme is used.

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1 + 1 = 2 marks

Examine stages Y and Z.

c. Describe, at the molecular level, what is meant by the term 'hybridised'. Why is it necessary to carry out hybridisation?

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2 marks

Total 5 marks

**Question 7**

The relatively abundant Green-eyed Tree Frog (*Litoria genimaculata*) inhabits tropical rainforest in Far North Queensland. There are two main populations, a north and a south population.

*L. genimaculata* has a green crescent across its upper eye and a ridge along the back of its limbs. It has mottled colouring and can vary from light brown and green, to grey with reddish blotches.

- a. State a phenotypic characteristic of *L. genimaculata* and suggest a possible selection pressure acting on this characteristic.

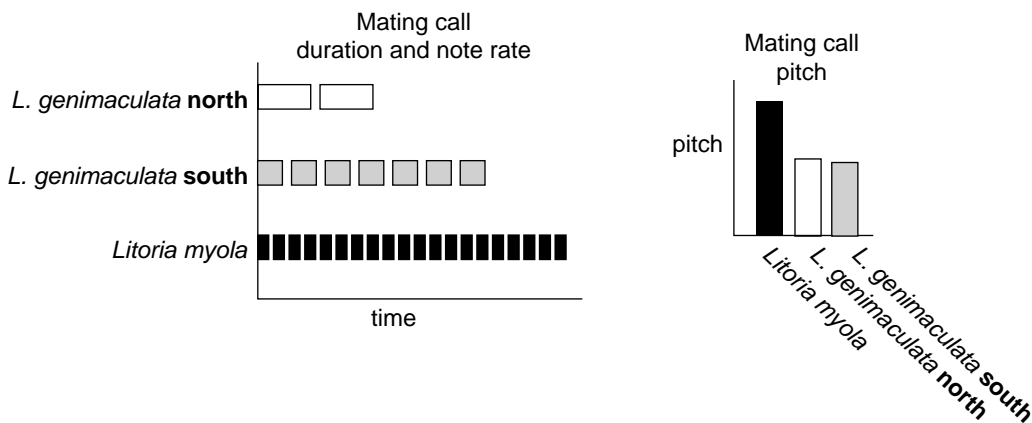
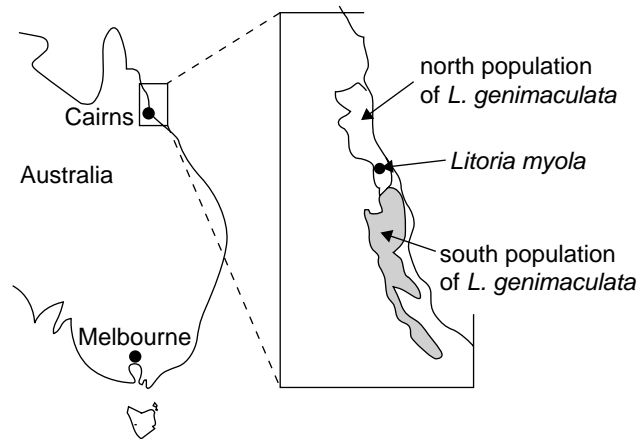
Phenotypic characteristic \_\_\_\_\_

Selection pressure \_\_\_\_\_

1 mark

The critically endangered Kuranda Tree Frog, *Litoria myola*, is found in very small populations in isolated fragments of wet tropical rainforest near Cairns in Queensland. The two species, *L. myola* and *L. genimaculata*, are very similar in appearance, although the male *L. genimaculata* is larger than the male *L. myola*. Biologists have also found that their mating calls differ markedly. There is some overlap between the ranges of these three frog groups.

The following diagrams show the distribution of the frogs, and the characteristics of their calls.



- b. Examine the data in the graphs and describe **two** differences between the mating calls of *L. myola* and *L. genimaculata*.

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2 marks

Scientists now believe that *L. myola* evolved from the *L. genimaculata* about 8000 years ago. It is proposed that a population of Green-eyed Tree Frogs became isolated due to changing climate conditions.

- c. Suggest how changing climate conditions could have isolated small populations of rainforest frogs.

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1 mark

- d. What is one type of evidence that biologists could use to estimate an approximate date of divergence of these two species?

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1 mark

- e. Describe how *L. myola* could have evolved from *L. genimaculata*. (Use the terms 'allele frequency' and 'gene flow' in your answer.)

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3 marks

In northern areas, where the distributions of the two species overlap, a few hybrid offspring (1.4% of the population) have been observed, resulting from matings between the two species. Biologists wish to establish whether or not the Green-eyed and Kuranda Tree Frogs are, in fact, distinct species.

- f. How could biologists determine this experimentally?

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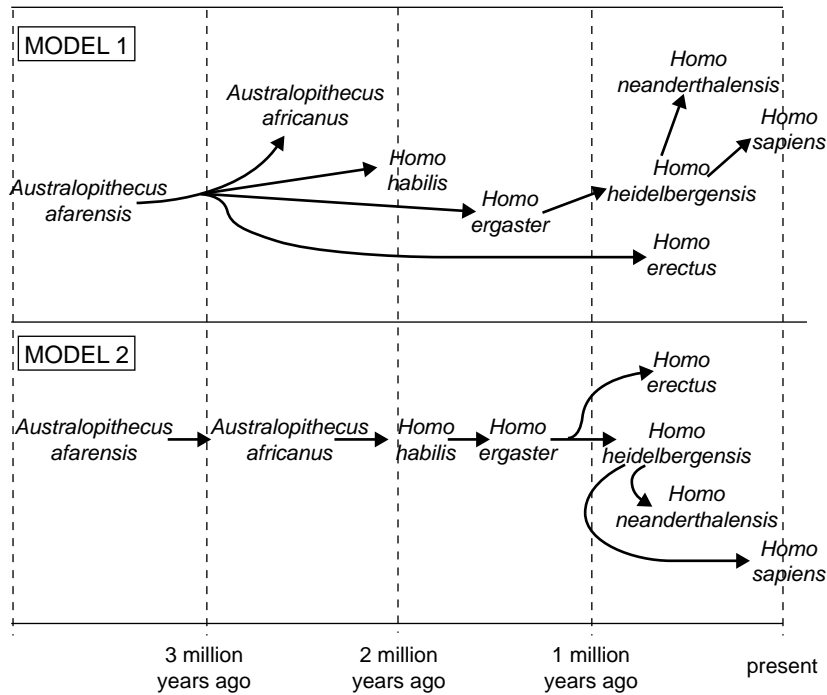
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1 mark

Total 9 marks

**Question 8**

Two paleoanthropologists each used fossil data to draw a model of the human evolutionary tree. The two models they produced are shown below.



a. Explain how it is possible that the paleoanthropologists produced different models for the human evolutionary tree.

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1 mark

b. i. State one feature of agreement between the models.

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ii. State one feature of conflict between the models.

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1 + 1 = 2 marks

c. Give **two** structural features that would distinguish between the fossils of *Homo erectus* and *Australopithecus afarensis*.

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2 marks

Evidence suggests that *Homo sapiens* and *Homo neanderthalensis* were living in the same areas some 30 000 years ago, but did not interbreed.

d. Give one reason why interbreeding might not have occurred.

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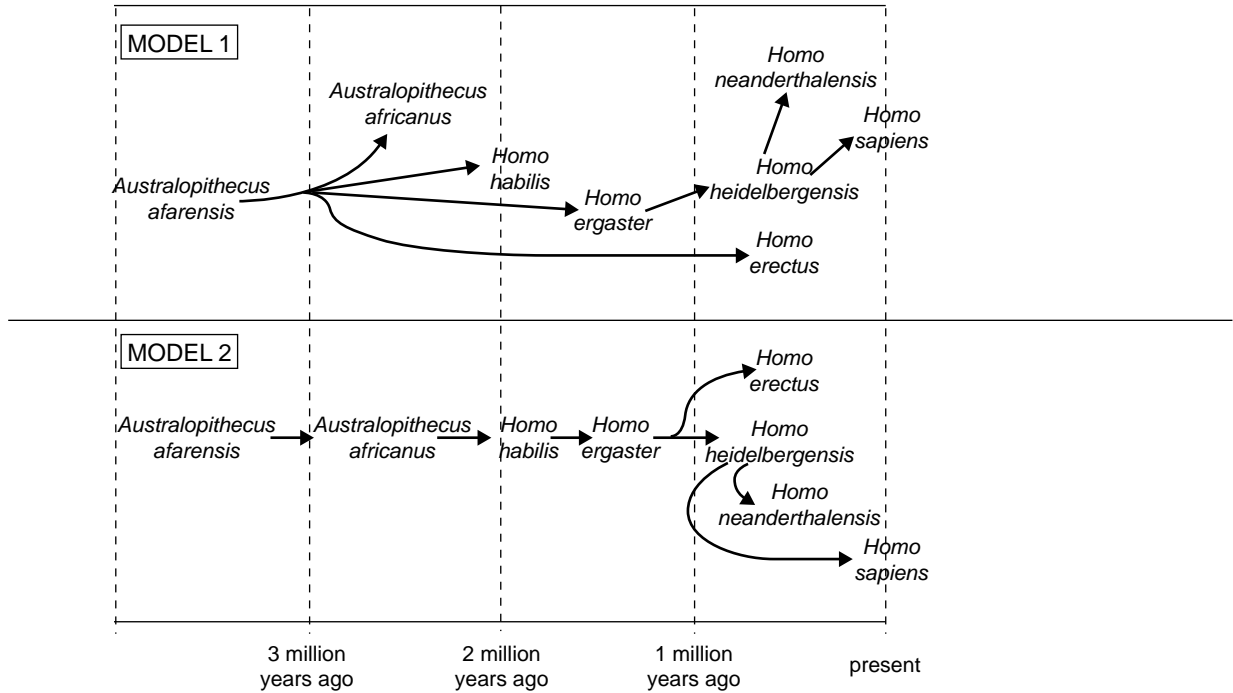


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1 mark

Scientists have recently discovered a tiny fossil skull in Indonesia. It has been named *Homo floresiensis* (the hobbit) and dated to the time our own ancestors were colonising the world. Some scientists believe *Homo floresiensis* evolved from *Homo erectus*. Fossils of *Homo erectus* have also been discovered in Indonesia.

e. Modify **one** of the models below to include *Homo floresiensis*.



1 mark

There is still some debate about what the hobbit is. Two explanations have been proposed.

**Explanation 1** – The hobbit belongs to a species of small-brained dwarf humans.

**Explanation 2** – The hobbit is a Stone Age *Homo sapiens* with a disease that stunts brain development.

f. i. Suggest one piece of evidence that would support explanation 1.

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ii. Suggest one piece of evidence that would support explanation 2.

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1 + 1 = 2 marks

Total 9 marks