



Victorian Certificate of Education

2007

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STUDENT NUMBER

Letter

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BIOLOGY

Written examination 2

Monday 5 November 2007

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	9	9	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.

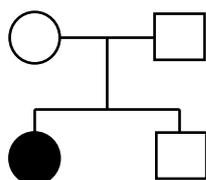
A correct answer scores 1, an incorrect answer scores 0.

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

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

Question 1

In the following pedigree the shaded individual has the trait under investigation.



The mode of inheritance of the trait is

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

Question 2

In mice, a gene influencing coat colour has three alleles.

They are

C	:	black coat
c^R	:	brown coat
c	:	white coat

Black coat is dominant to both brown and white coat. A mouse with the genotype $c^R c$ results in another coat colour known as fawn.

It is reasonable to predict that the cross

- A. $C c^R \times C c^R$ would result in all black mice.
- B. $c^R c^R \times c^R c$ would result in all brown mice.
- C. $c^R c^R \times c c$ would result in all fawn mice.
- D. $C c \times c c$ would result in all white mice.

Question 3

When comparing eukaryotic chromosomes with prokaryotic chromosomes, it is true that both

- A. exist in homologous pairs.
- B. are linear chromosomes.
- C. are situated within a nucleus.
- D. are made of double-stranded DNA molecules.

Question 4

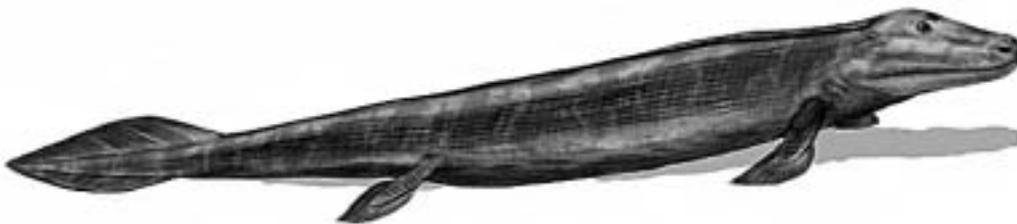
The edible pea (*Pisum sativum*) has a diploid number of 14. Specific cells in the ovary undergo meiosis to produce gametes.

The number of DNA molecules in one of these cells at the beginning of meiosis would be

- A. 7
- B. 14
- C. 21
- D. 28

Question 5

Biologists have suggested for a long time that reptiles evolved from fish-like ancestors. Recently, a 375 million-year-old fossil fish (*Tiktaalik roseae*) was found in Canada. This fossil had fins, scales and a lower jaw like those of a fish but had a crocodile-like skull, a mobile neck and forelimb bones resembling those of early reptiles.



Relative to fish and crocodiles, this rare *Tiktaalik* fossil represents an example of

- A. a transitional form.
- B. an index fossil.
- C. convergent evolution.
- D. coevolution.

Question 6

According to modern evolutionary theory, changes to genetic material in mammals can only be inherited by the next generation if

- A. they occur in somatic tissue.
- B. they occur in reproductive tissue.
- C. they make the species fitter.
- D. they make the individual fitter.

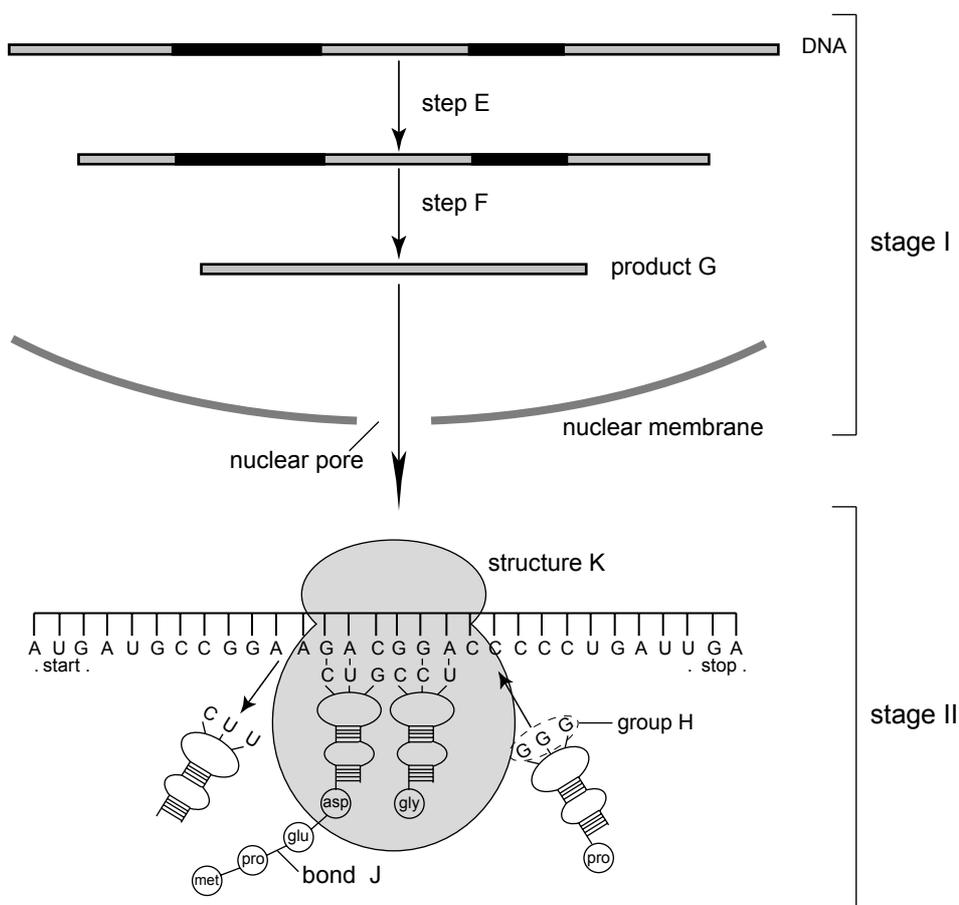
Question 7

Comparison of sequences in mitochondrial DNA is often used to establish the degree of relatedness between organisms and thus to suggest evolutionary relationships, particularly in complex, higher-level organisms. Mitochondrial DNA is used because it

- A. is only inherited in males.
- B. has more genes than nuclear DNA.
- C. mutates more slowly than nuclear DNA.
- D. contains different nitrogen bases from those found in nuclear DNA.

The following information relates to Questions 8, 9 and 10.

The following diagram outlines the production of protein in a cell when DNA is activated.



Question 8

At stage I, the DNA molecule involved has the base sequence

- A. TACTACGGCCTCCTGCCTGGGGGACTAACT
- B. TACTACGGCCTTCTGCCTCCCGGACTAACT
- C. TACTACGGCCTTCTGCCTGGGGGACTAACT
- D. TACTACGGCCTTCTGTTTGGGGGACTAACT

Question 9

In stage I

- A. step E represents translation.
- B. removal of exons occurs at step F.
- C. product G is the initial mRNA produced.
- D. the enzyme RNA polymerase is active.

Question 10

In stage II

- A. structure K is made of tRNA.
- B. the three bases of group H form an anticodon.
- C. bond J represents a hydrogen bond.
- D. the mRNA shown will code for a protein containing 10 amino acids.

Question 11

The relationship between genome and organism is equivalent to the relationship between _____ and population.

- A. species
- B. gene pool
- C. gene
- D. allele

Question 12

The normal order of development of features in an embryo is determined by gene sequences. The relevant groups of genes have been studied extensively in insects and chordates. These groups of genes are responsible for directing the sequential embryonic development of the head, thorax, limbs and wings of insects and the head, thorax and limbs in chordates.

In the summary below, gene activity starts at the left and continues in sequence to the right. The action of each gene in the group promotes the action of the subsequent gene.

In insects

head develops → gene 1	thorax develops → gene 3	legs develop → gene 4	abdomen develops gene 7
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In chordates

head develops → gene 1	thorax develops → gene 4	limbs develop → gene 8	digits develop gene 13
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The above information suggests that if the action of a particular gene in a sequence was blocked

- A. an abnormal insect could develop possessing a head but no legs.
- B. an abnormal insect could develop possessing a thorax and legs but no head.
- C. an abnormal chordate could develop with a thorax but no head.
- D. an abnormal chordate could develop possessing digits but no legs.

Question 13

The action of apoptosis

- A. causes the production of new cells.
- B. is only initiated by signals exterior to a cell.
- C. involves the reuse of all parts of a dead cell.
- D. can involve the death of perfectly healthy cells.

Question 14

New alleles arise in a sexually reproducing population by

- A. mutations in DNA sequences prior to meiosis.
- B. random fertilisation of gametes during reproduction.
- C. random assortment of homologous chromosomes during meiosis.
- D. exchange of chromatin between homologous chromosomes during meiosis.

Question 15

Two gene loci in an organism have the following alleles.

Gene locus one : *T and t*

Gene locus two : *P and p*

An organism showing both dominant traits, but with unknown genotype, is represented by *T- P-*.

An appropriate test cross to establish the genotype of such an organism would be

- A. *T- P-* x *tt pp*
- B. *T- P-* x *tt Pp*
- C. *T- P-* x *Tt PP*
- D. *T- P-* x *TT PP*

Question 16

For allele frequencies to remain constant in a population it is essential that

- A. mutations occur.
- B. genetic drift occurs.
- C. mating occurs at random in the population.
- D. there is regular migration into the population.

Question 17

Lactase is an enzyme in humans which breaks down lactose, one of the sugars in milk. Milk is a safe and nutritious food which is readily available year-round. Although most adults around the world lose the ability to produce lactase as they mature, more than 90% of Europeans have a lactase-producing allele which remains active into adulthood.

Scientists analysed DNA in bone samples from a number of Neolithic Europeans (dated between 5840 BC and 5000 BC) and found that none of them had the adult lactase allele.

The most likely explanation for this data is that

- A. the adult lactase-producing allele which remains active into adulthood arose millions of years ago in ancestors of modern humans.
- B. possession of the adult lactase-producing allele which remains active into adulthood confers a significant evolutionary advantage.
- C. the adult lactase-producing allele which remains active into adulthood did not arise in Europe.
- D. modern Europeans are not descended from the Neolithic Europeans tested.

Question 18

Excavations at a fossil site uncovered a layer of ancient flood debris. The layer consisted of stones and sand, mixed with fossilised plant and animal remains. The debris had been deposited in a rocky river valley and then covered with fine sandy sediment which was dated to approximately 10 million years ago.

In this situation it is true that

- A. the fossils are less than 10 million years old.
- B. the rocks of the valley walls are younger than the fossils.
- C. the plants and animals lived in the same habitat.
- D. the stones mixed with the fossils cannot be younger than the fossils.

Question 19

Traces of starch from wild barley (*Hordem*) and wheat (*Triticum*) species were found on a 23 000-year-old seed-grinding stone used by ancient humans in Israel.

The method which would have been used to date these ancient starch grains is

- A. radioactive carbon-14 dating.
- B. radioactive uranium-235 dating.
- C. relative dating by comparing rock strata.
- D. the use of a molecular clock.

Question 20

Domestic dogs vary greatly in adult size. All dog breeds have the IGF-1 gene coding for a hormone which promotes growth to adolescence. Scientists have discovered that all small dog breeds have an allele, called S, of another gene close to IGF-1.

The best hypothesis to explain the size range in dogs is that

- A. the gene product of the S allele is a promoter of IGF-1.
- B. IGF-1 is the only gene controlling growth in dogs.
- C. when S is translated its product inhibits IGF-1 gene expression.
- D. large breeds cannot produce a transcript of the IGF-1 gene.

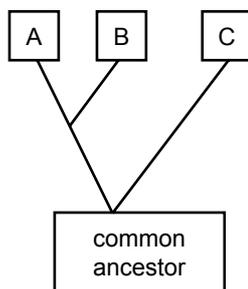
Question 21

Cytochrome-c is a protein found in most organisms. The amino acid sequence of this protein varies between species. The numbers of differences in the amino acid sequences in the protein of cytochrome-c between three species of chordate A, B and C are shown in the table below.

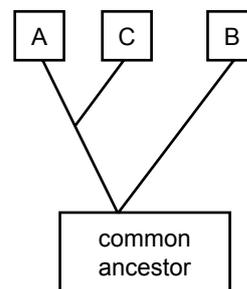
	Species B	Species C
Species A	11	3
Species B		10

Based on this evidence, the phylogenetic tree that best represents the possible evolutionary relationships between the three species is

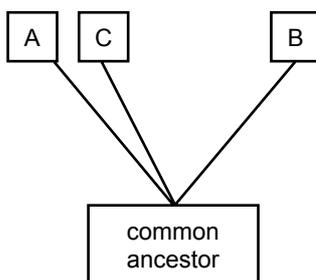
A.



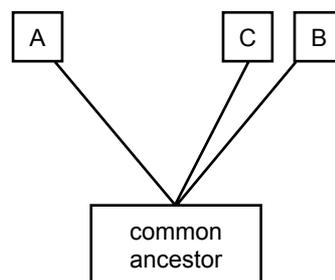
B.



C.

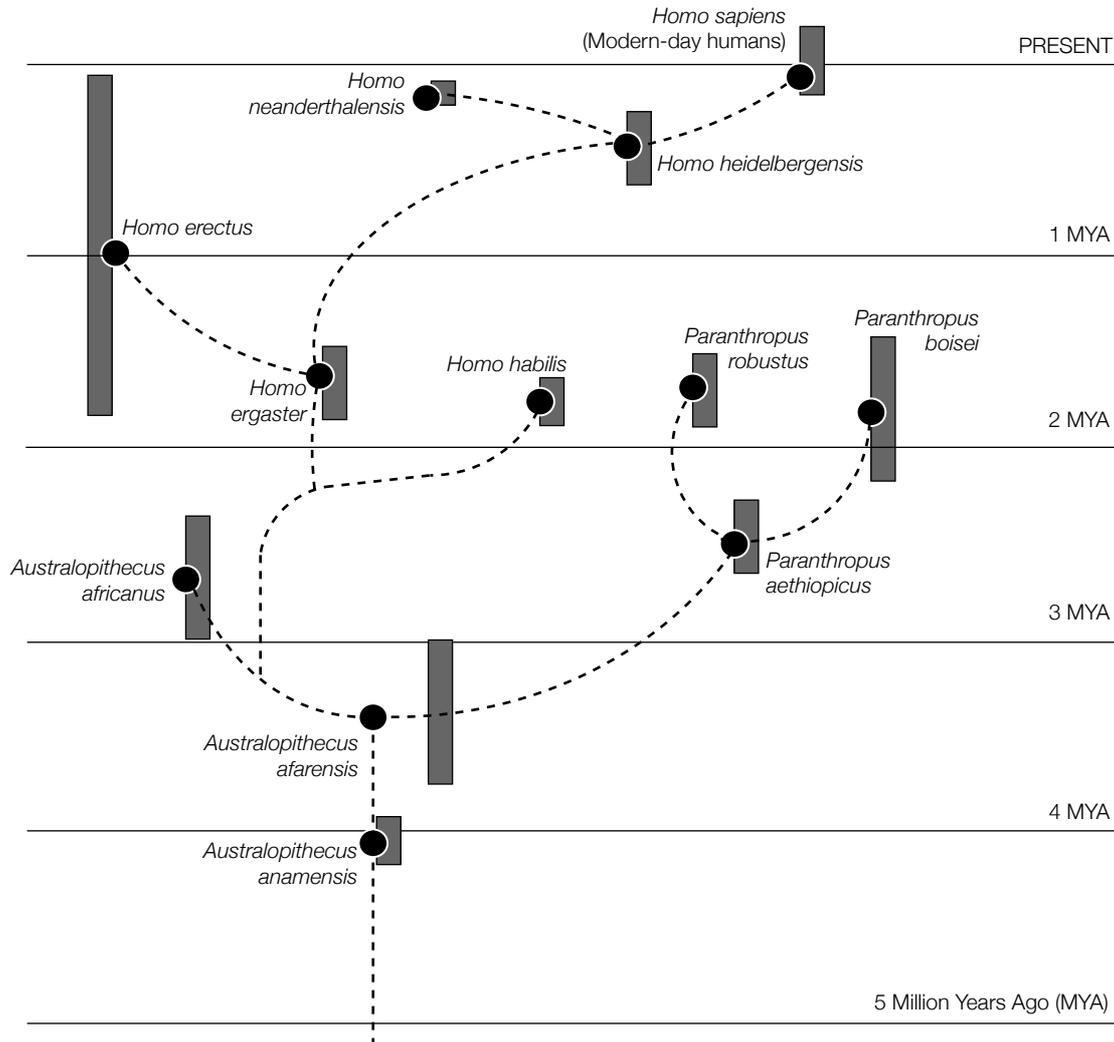


D.



Question 22

This diagram illustrates one interpretation of the origin of humans. The dotted lines indicate possible evolutionary relationships, and the vertical bars show the period from which fossils are known for each species.



This diagram suggests that

- A. *Homo habilis* is an ancestor of modern humans.
- B. *Homo sapiens* is descended from *Paranthropus aethiopicus*.
- C. *Homo erectus* became extinct before modern humans appeared.
- D. *Australopithecus* species may have given rise to modern humans.

Question 23

In maize plants, two gene loci on different chromosomes have the following alleles.

Gene locus one	Gene locus two
<i>R</i> : green stems	<i>D</i> : normal height
<i>r</i> : red stems	<i>d</i> : dwarf plants

The following cross was carried out and the seeds collected.

$$Rr Dd \times Rr Dd$$

1600 of the seeds were grown to examine the phenotypes of the offspring.

It would be reasonable to expect that among the offspring approximately

- A. 100 offspring would be homozygous at both gene loci.
- B. 600 of the offspring will have green stems and be of normal height.
- C. $\frac{2}{3}$ of the green stem, dwarf offspring will be heterozygous at gene locus one.
- D. $\frac{1}{3}$ of the red stem, normal height offspring will be heterozygous at both gene loci.

Question 24

Complex social activities require articulate speech. Evidence found with early *Homo* fossils suggests that this genus was the first to use articulate speech.

This suggestion would be best supported by evidence of

- A. burial ceremonies.
- B. use of stone tools.
- C. living in groups.
- D. organised hunting of prey.

Question 25

A soil bacterium (*Agrobacterium tumefaciens*) infects roses and fruit trees, stunting their growth. A similar bacterium (*A. radiobacter*) was genetically modified to include a plasmid gene coding for an antibiotic lethal to *A. tumefaciens*. *A. radiobacter* has a gene giving resistance to this antibiotic. A transfer gene located on the plasmid enables insertion of the modified gene into *A. radiobacter*.

Suspensions of genetically modified bacteria are applied to the soil around plants.

For this treatment to be successful, genetic modification of *A. radiobacter* would need to include

- A. removal of all plasmids.
- B. removal of the antibiotic gene.
- C. destruction of the antibiotic resistance gene.
- D. removal of the plasmid transfer gene.

SECTION B – Short answer questions

Instructions for Section B

Answer this section in pen.

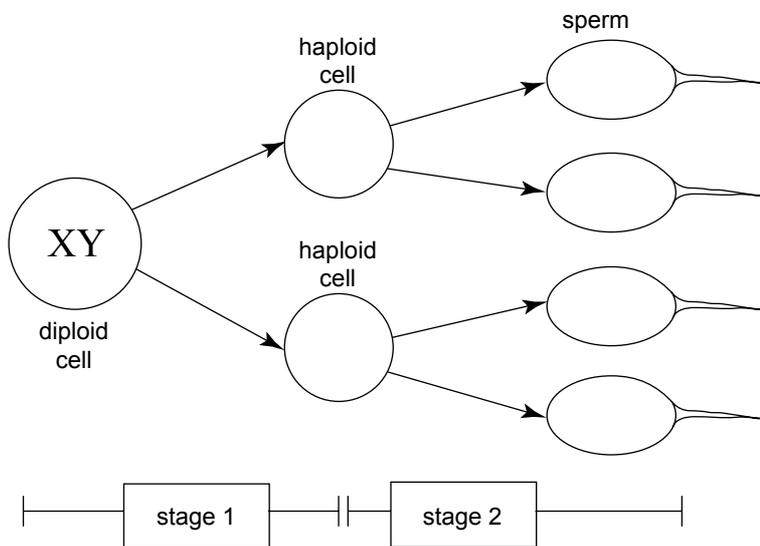
Answer **all** questions in the spaces provided.

Question 1

a. Name the process by which gametes are produced in humans.

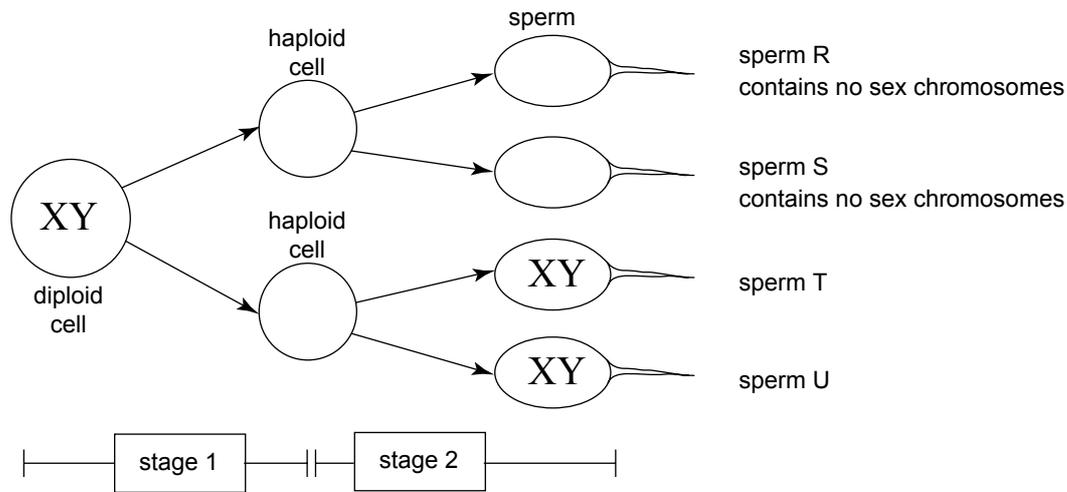
1 mark

b. Use the symbols X and Y to complete the diagram below to show how the sex chromosomes behave during meiosis in a human male.



1 mark

Sometimes a mistake occurs in sperm production resulting in sperm which carry an extra X chromosome or an extra Y chromosome. Part of such a process is shown in the diagram below. Note that only the sex chromosomes are shown.



- c. Describe the mistake in the process that led to the production of abnormal sperm.

1 mark

- d. If sperm T fertilised a normal ovum, what would be the diploid number of the resulting zygote?

1 mark

- e. One kind of error in sperm production has been shown in the diagram above. In another kind of error, sperm are produced carrying XX or YY chromosomes. Explain how this could occur.

1 mark

Total 5 marks

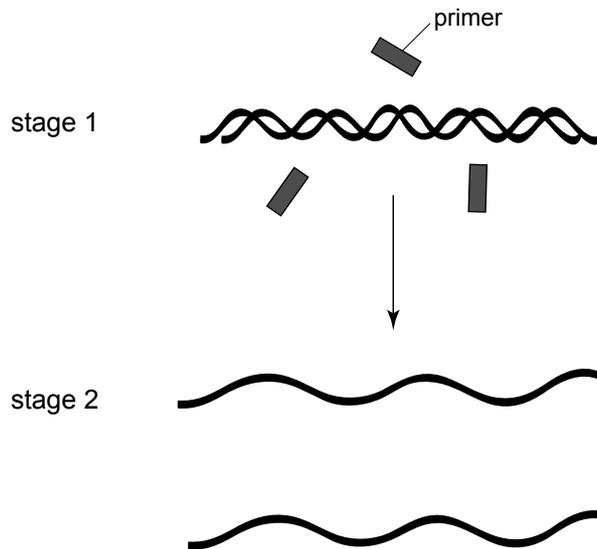
Question 2

Victoria Police forensic scientists conduct DNA profiling using samples taken from crime scenes. Traces of DNA of less than 1 nanogram can be amplified and then profiled.

- a. Name the process which is used to amplify the DNA.

1 mark

Below is a diagram showing part of this process.



- b. What must be done between stages 1 and 2 to separate the strands of the DNA molecule?

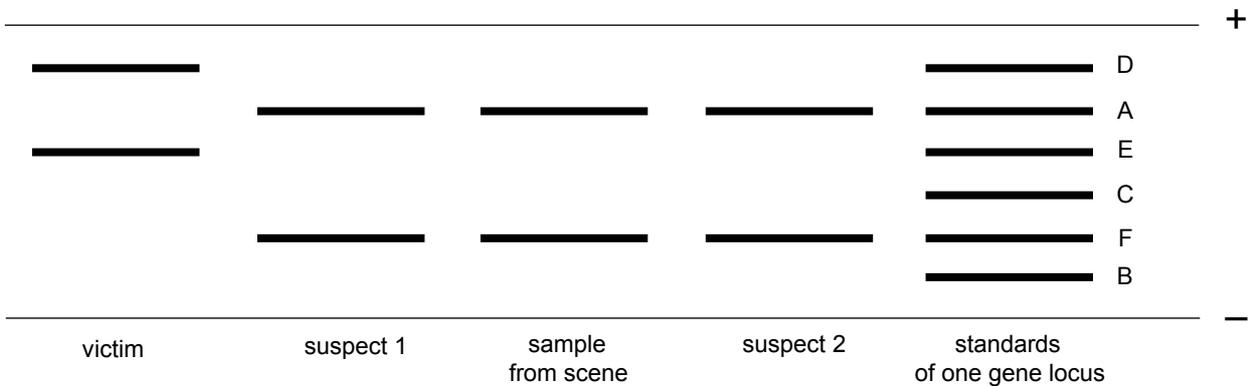
1 mark

- c. Complete and label the diagram at stage 2.

2 marks

Small pieces of DNA of differing length can be compared to determine whether or not a sample could have come from a particular person. In a case, samples of DNA from the victim and the crime scene were compared with samples from two suspects.

The DNA samples were treated with restriction enzymes, amplified and run through gel electrophoresis. The results for one gene locus are shown in the diagram below.



d. Draw an arrow on the right-hand side of the diagram to indicate the direction of movement of the DNA fragments.

1 mark

e. What do the standards consist of, and what is their purpose?

2 marks

f. From these results, give a conclusion which could be drawn about the sample taken from the crime scene.

1 mark

g. What further action would you recommend to the forensic scientists investigating this case?

1 mark

Total 9 marks

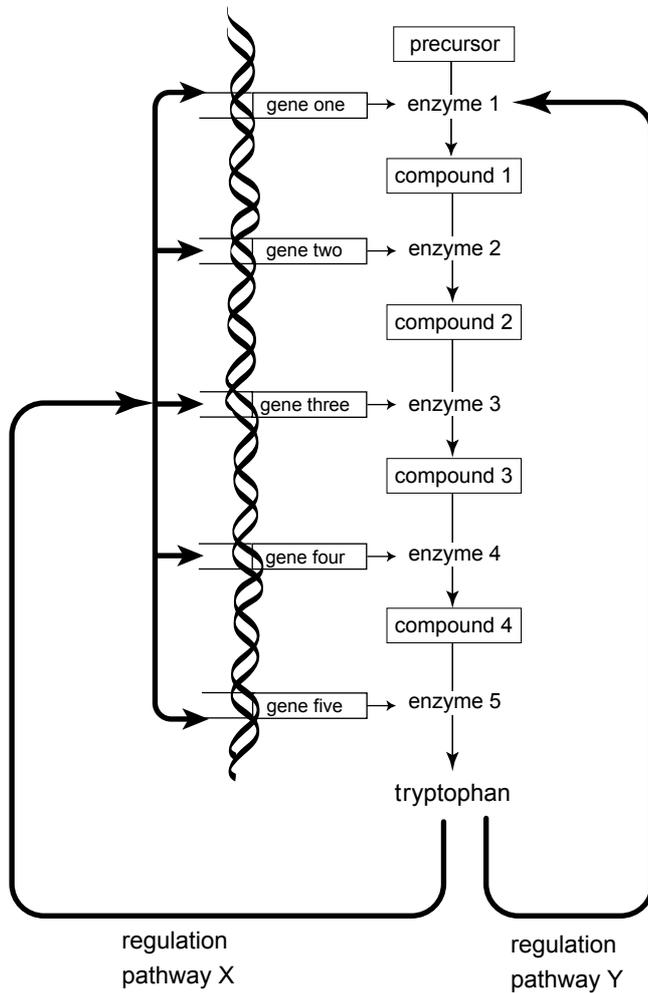
Question 3

a. Explain what is meant by gene regulation.

1 mark

Bacteria require amino acids to produce proteins. For example, bacteria in a human intestine may absorb amino acids from digested food, but at times there may be a deficiency of a particular amino acid. If this is the case, the bacteria will produce the necessary amino acid themselves.

The diagram below is a regulation system in a bacterial cell involving the production of the amino acid tryptophan. Note that there are two pathways (X and Y). Tryptophan is the regulatory compound in these two pathways and acts as a repressor in both.



b. Describe the immediate outcome when tryptophan activates pathway X.

1 mark

- c. Describe the immediate outcome when tryptophan activates pathway Y.

1 mark

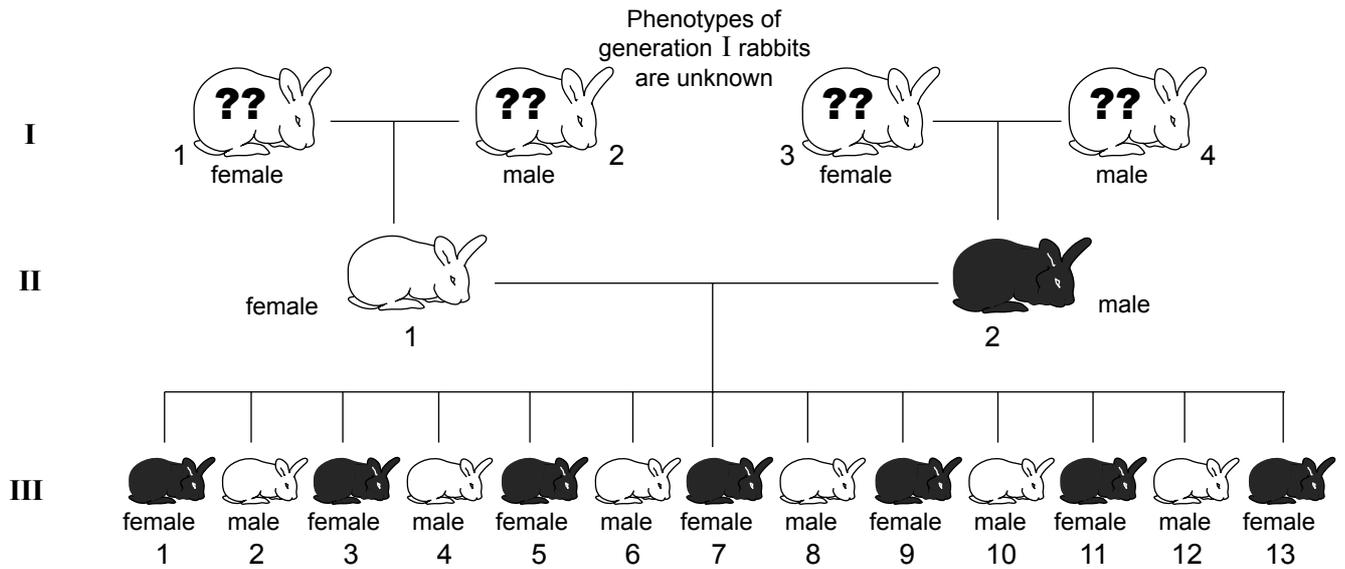
- d. Suggest how the action of tryptophan as a repressor in this system could be of selective advantage to a bacterial cell in the digestive tract.

2 marks

Total 5 marks

Question 4

The pedigree below represents a family of rabbits. The shaded rabbits have an inherited disease. The phenotypes of rabbits I-1, I-2, I-3 and I-4 are not known.



On the basis of the offspring produced by II-1 and II-2 it has been suggested that the disease is inherited as an X-linked dominant characteristic.

- a. What evidence from generations II and III supports the suggestion made about the mode of inheritance of the disease?

1 mark

- b. If the mode of inheritance suggested is correct, complete the table below to show the possible phenotypes and genotypes of rabbits I-1, I-2, I-3 and I-4. For each rabbit's phenotype, select from
- has the disease
 - does not have the disease
 - impossible to tell from the information given.

Use the following symbols to represent the alleles involved: X^D , X^d , Y.

	i. Phenotype	ii. Possible genotype(s)
rabbit I-1		
rabbit I-2		
rabbit I-3		
rabbit I-4		

4 marks

Assume each female in generation III was mated to a male from the same litter.

- c. What genotypic and phenotypic ratios would you expect in the offspring?

2 marks

Total 7 marks

Question 5

Eastern tiger snakes (*Notechi scutatus*) living on desolate islands off mainland Australia have longer jaws than the mainland populations of snakes. The diet of island snakes includes large prey, such as seagull chicks, while the diet of the mainland snakes consists of small prey, such as frogs and mice.

Researchers set up experiments using baby snakes from both locations. Snakes were fed either large or small mice over several months, until they reached maturity. The method and results are indicated in the table below.

	experiment 1		experiment 2	
	group A island snakes	group B island snakes	group C mainland snakes	group D mainland snakes
Length of eastern tiger snakes' jaws at birth	long	long	normal	normal
Type of prey given over several months	small mice	large mice	small mice	large mice
Length of eastern tiger snakes' jaws at maturity	normal	long	normal	normal

- a. What were the researchers investigating in these experiments?

1 mark

- b. What was the independent variable in experiment 1?

1 mark

- c. What evidence from the results suggests that the size of eastern tiger snakes' jaws is

- i. a genetically inherited trait

- ii. affected by environmental factors?

1 + 1 = 2 marks

At present the island and mainland populations are both classified as the same species.

It has been proposed that the two populations of snakes may eventually evolve into two separate species.

- d.** Outline the steps involved in the process of speciation, with particular reference to the snakes in the two populations. You may use a labelled diagram or flow chart to illustrate your answer.

3 marks

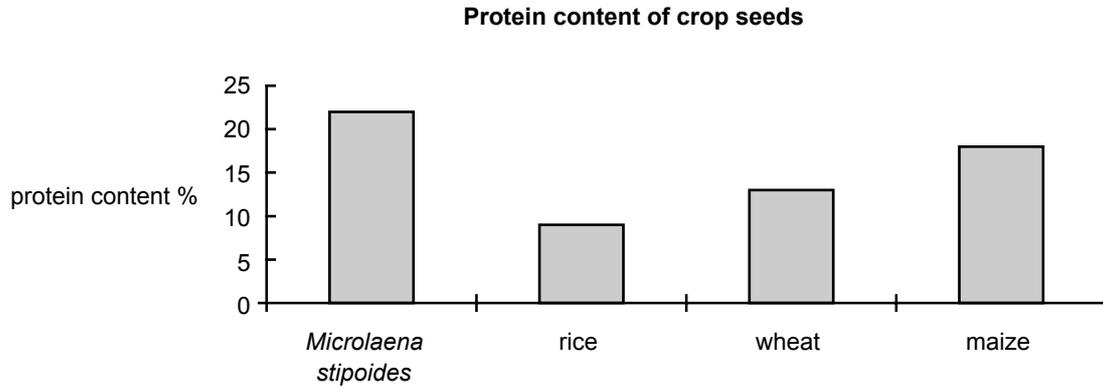
Total 7 marks

Question 6

Australian agricultural biologists are currently researching weeping rice grass (*Microlaena stipoides*), a deep-rooted native relative of rice. Their aim is to produce drought-tolerant grain crops, pasture grass for livestock and domestic lawns.

M. stipoides thrives in a variety of soil types from coastal to mountain habitats. It does not spread in an uncontrolled way as many introduced grasses do. It requires less fertiliser and liming of soil than introduced crop species.

At present *M. stipoides* 'seed is only half the size of domestic rice.



- a. The seed size trait is most likely to be polygenic. What is a polygenic trait?

1 mark

A researcher stated that weeping rice grass has not undergone selection or breeding for larger seed size.

- b. What might be the advantage of breeding this species for larger seed size?

1 mark

- c. If you were a farmer involved in a systematic breeding program, outline the steps you should take to develop a variety of weeping rice grass with large seeds.

2 marks
Total 4 marks

Question 7

A complete skeleton of *Thylacoleo carnifex*, a huge marsupial ‘lion’, was found in a cave in the Nullarbor Plain. Further exploration uncovered more specimens of *Thylacoleo* as well as other extinct mammals, some previously unknown to science.

The specimens of *Thylacoleo* were dated to be between 100 000 and 200 000 years old.

In attempting to date the other mammal specimens, scientists had a range of methods available.

- a. Describe a relative dating technique which could be used to date the extinct mammals.

1 mark



Thylacoleo skull

Thylacoleo had powerful jaws with only two types of teeth—one type for killing and one type for slicing meat. It had short, strong limbs and opposable thumbs with prominent claws. It has been compared with large placental carnivores such as lions.

- b. What kind of evolution has produced similar characteristics in *Thylacoleo* and lions?

1 mark

- c. Describe two methods by which *Thylacoleo* is likely to have obtained its food, and state the evidence that supports your answers.

	method	evidence
i.		
ii.		

2 marks

Total 4 marks

Question 8

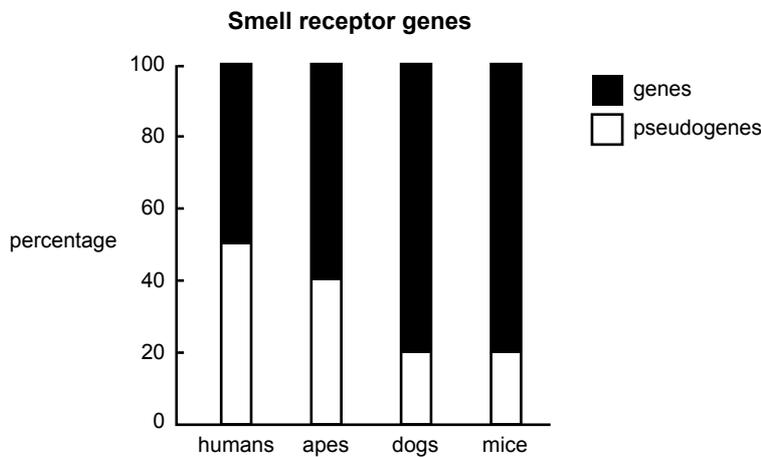
Pseudogenes are the remains of broken genes which are unable to function and can be considered to be genetic fossils. Some are relics of genes lost through evolution while others reflect an earlier version of a present functional gene. Pseudogenes are able to accumulate all kinds of mutations.

The gene G in mice makes an enzyme that helps synthesise vitamin C, but this gene became faulty in primates more than 40 million years ago and is now a pseudogene in humans.

- a. What is one possible consequence of the loss of gene G in primates?

1 mark

In mammals, more than one thousand genes coding for smell receptors have been identified. Individual species vary in the proportion of these genes that have become pseudogenes, and humans have fewer than 500 functional genes coding for smell receptors. The majority of these genes are still functional genes in rats and mice.



- b. From the graph, what can be concluded about the importance of smell to the survival of these four groups?

1 mark

- c. Mice and dogs can only distinguish shades of grey, while some apes and monkeys are able to distinguish colours. Would you expect to find any change in the numbers of smell pseudogenes in apes and monkeys able to distinguish colours? Explain why.

1 mark

- d. Why are pseudogenes able to accumulate mutations that do not exist in functional genes?

2 marks

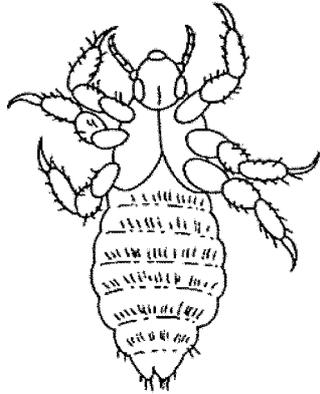
Total 5 marks

SECTION B – continued

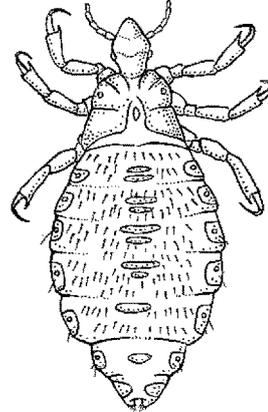
Question 9

There are two varieties of lice which live on humans: body lice which only live in clothing but feed on the body, and head lice which only live in hair and feed on the scalp.

It is not known when humans began wearing clothes. It is difficult to find evidence of cultural evolution in early humans as changes in behaviour are rarely reflected in physical changes visible in fossils. However, indirect evidence can be found.



head louse *Pediculus humanus capitis*



body louse *Pediculus humanus corporis*

A scientist used DNA hybridisation to measure differences between the DNA of head lice and body lice. He estimated that the two groups diverged about 72 000 years ago.

- a. Explain how DNA hybridisation can be used to determine evolutionary relationships.

2 marks

- b. A scientist claimed to have found other evidence showing the time at which humans began wearing clothes. What might this evidence have been?

1 mark

- c. Explain a possible advantage for lice of living in clothing.

1 mark

Total 4 marks