Neap:

Trial Examination 2007

VCE Biology Unit 4

Written Examination

Question and Answer Booklet

Reading time 15 minutes
Writing time 1 hour 30 minutes

Student's Name: _____

Teacher's Name: _____

Structure of Booklet

Section	Number of questions	Number of questions to be answered	Number of marks
A	25	25	25
B	6	6	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 booklet of 18 pages.
Answer sheet for multiple-choice questions.

Instructions

Write your **name** and **teacher's name** on this booklet and in the space provided on the answer sheet for multiple-choice questions. All written responses should be in English.

At the end of the examination

Place the answer sheet for multiple-choice questions inside the front cover of this booklet and hand them in.

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

Students are advised that this is a trial examination only and cannot in any way guarantee the content or the format of the 2007 VCE Biology Unit 4 Written Examination.

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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

The position on a chromosome where a particular DNA sequence is located is called

A. the gene.
B. the locus.
C. the chromatid.
D. the allele.

Question 2

A DNA single-strand sequence is illustrated below.

3′ G G A T C C G A T 5′

The complementary DNA sequence to this strand is

A. 3′ C C T A G G C T A 5′
B. 5′ G G A U C C G A U 3′
C. 3′ C C U A G G C U A 5′
D. 5′ C C T A G G C T A 3′

Question 3

Chromosome number is reduced during meiosis because the process involves

A. a single cell division without any chromosome replication.
B. two cell divisions without any chromosome replication.
C. two cell divisions in which chromosome replication occurs once.
D. two cell divisions in which half of the chromosomes are destroyed.

Question 4

A cell containing 40 chromatids at the start of mitosis would produce cells containing

A. 5 chromosomes at the end of mitosis.
B. 10 chromosomes at the end of mitosis.
C. 20 chromosomes at the end of mitosis.
D. 40 chromosomes at the end of mitosis.

Question 5

A man with blood type A, whose father has blood type O, marries a woman with blood type B, whose mother has blood type O.

If the alleles for ABO blood type are $\mathbf{I^A}$ = A, $\mathbf{I^B}$ = B and **i** = O, the possible blood type(s) of their offspring is/are

A. A, B and AB only.
B. A and B only.
C. A, B, AB and O.
D. AB only.

Question 6

In humans, red–green colour blindness is controlled by a gene on the X chromosome.

A man and woman with normal colour vision marry. Both of their fathers were colour-blind.

The probability that their first child will be colour-blind is

A. 0
B. $\frac{1}{2}$
C. $\frac{1}{3}$
D. $\frac{1}{4}$

Use the following information to answer Questions 7 and 8.

In humans, widow's peak (**W**) is a dominant trait while a continuous hairline (**w**) is recessive. Short fingers (**S**) are also a dominant trait while long fingers (**s**) are recessive. The genes for these characteristics are inherited independently of one another.

A woman with a continuous hairline and short fingers and a man with a widow's peak and long fingers have three children. One child has a widow's peak and short fingers, one has a widow's peak and long fingers, and one has a continuous hairline and long fingers.

Question 7

The phenotype of a male with the genotype **Wwss** is

A. widow's peak and long fingers.
B. continuous hairline and short fingers.
C. continuous hairline and long fingers.
D. widow's peak and short fingers.

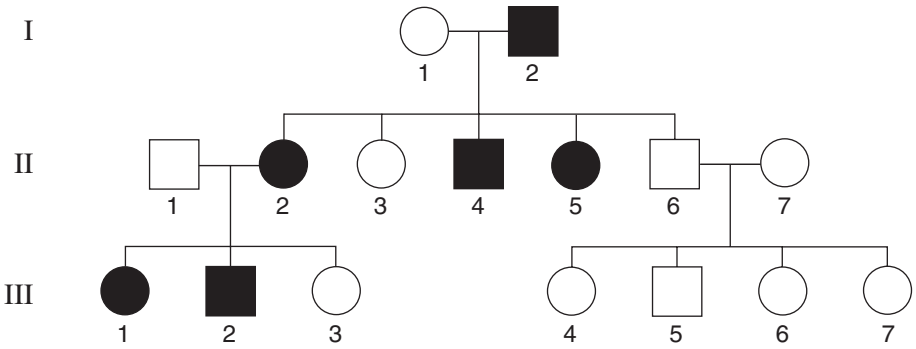
Question 8

The genotypes of the parents are

A. female **wwSS**; male **WWss**.
B. female **wwSs**; male **Wwss**.
C. female **wwSs**; male **WWss**.
D. female **WwSs**; male **WwSs**.

Use the following information to answer Questions 9 and 10.

The following human pedigree examines a trait that is extremely rare in the community but has been prevalent in a family for over three generations.



Question 9

For the human pedigree above, the term which could describe the mode of inheritance of the trait indicated in black is

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

Question 10

It was found that the trait in the pedigree was autosomal recessive.

The number of individuals illustrated in the pedigree that are definitely heterozygous is

A. 5
B. 6
C. 7
D. 8

Use the following information to answer Questions 11–13.

The sequence below is a small section of mRNA transcribed from a gene.

5′ C G A U G U U C C A A G G G A U G C A U A A A G A G U A G C 3′

The table below is the complete table of codons and their respective amino acids.

second base in codon

first base in codon	U	C	A	G	third base in codon
U	UUU phe UUC UUA leu UUG	UCU UCC UCA ser UCG	UAU tyr UAC UAA stop UAG	UGU cys UGC UGA stop UGG trp	U C A G
C	CUU CUC CUA leu CUG	CCU CCC CCA pro CCG	CAU his CAC CAA gln CAG	CGU CGC CGA arg CGG	U C A G
A	AUU AUC AUA ileu AUG met	ACU ACC ACA thr ACG	AAU asn AAC AAA lys AAG	AGU ser AGC AGA arg AGG	U C A G
G	GUU GUC GUA val GUG	GCU GCC GCA ala GCG	GAU asp GAC GAA glu GAG	GGU GGC GGA gly GGG	U C A G

Question 11

The maximum number of amino acids found in the polypeptide coded for in the mRNA sequence above would be

A. 7
B. 10
C. 9
D. 8

Question 12

If the fifth codon in the mRNA sequence above was changed to UGA,

A. the translated product would be the same.
B. the translated product would be different by one amino acid.
C. the translated product would only be different after the change.
D. the translated product would be shorter.

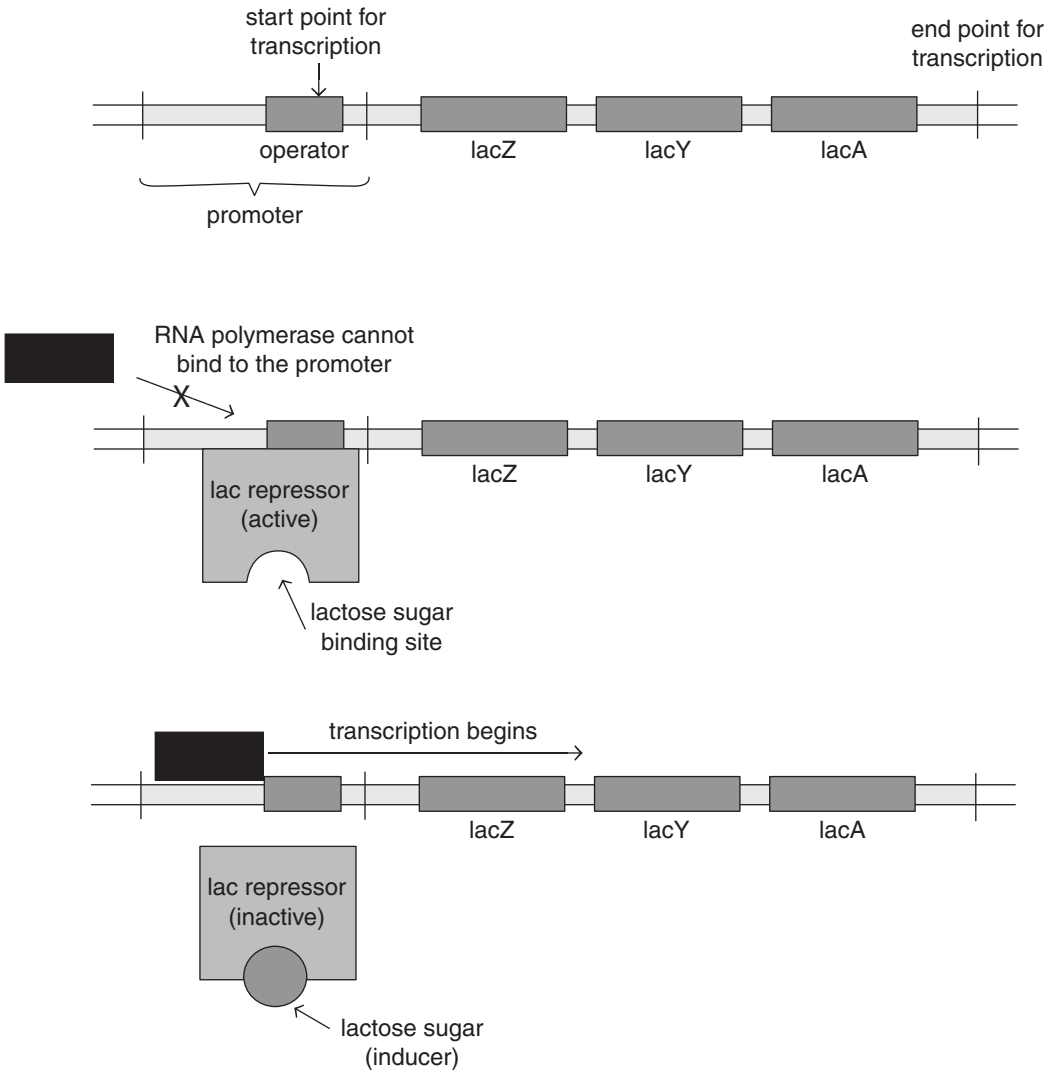
Question 13

Which of the following mRNA codes would provide a template for the same polypeptide as the original mRNA code?

A. 5′ C G C U G G U C C A A G G G A U G C A U A A A G A G U A G C 3′
B. 5′ C G C U G U U C U A A G G G A U G C A U A A A G A G U A G U 3′
C. 5′ C G G U G U U C G A A U G G A U G C A U A A A G A G U A G C 3′
D. 5′ C G A U G U U C C A A G G G A U G C A U A U A G A G U A G C 3′

Question 14

The following diagram summarises a well-researched bacterial DNA sequence called the lac operon. The genes on the operon are activated in the presence of lactose. Once activated, one of these genes (lacZ) is transcribed and an enzyme called lactase is produced which can then digest lactose.



RNA polymerase binding to the promoter will occur if

A. low amounts of lactose are around the gene.

B. high amounts of lactose are around the gene.

C. an active lac repressor is present.

D. lactose is not bound to the lac repressor.

Question 15

Which statement about frameshift mutation is **correct**?

A. It can only occur in non-coding regions of the genome.

B. It results in an amino acid sequence that is shorter in length.

C. It is caused by the insertion or deletion of DNA.

D. It changes the sequence of amino acids in the resulting protein, but does not change the sequence of nucleotides.

Question 16

A biologist collects a sample of fish from a stream. The fish are of the same species, but when the biologist measures the sample, she finds that their body sizes fall into two distinct groups: large and small.

Which explanation is most likely to account for this observation?

A. There are two species in the sample.
B. There is one species, but one size class is made up of males and the other is made up of females.
C. Body size in fish is the result of polygenic inheritance.
D. There is genetic drift.

Question 17

Consider the following pairs of structures.

I – A whale's flipper and a bat's wing.
II – A butterfly's wing and an eagle's wing.
III – A human's eye and a beetle's eye.

Which of the pairs represent homologous structures?

A. I only.
B. I, II and III.
C. I and II only.
D. II and III only.

Question 18

Consider the following statements about homologous structures.

I – Homologous structures indicate descent from a common ancestor.

II – Homologous structures can occur in pairs and contain the same sequence of genes.

III – Homologous structures are the result of convergent evolution.

Which statements are **correct**?

A. I and II only.
B. I, II and III.
C. I and III only.
D. I only.

Question 19

Which of the following is essential for allopatric speciation to occur?

A. Gene flow between populations must be restricted.
B. There must be a post-zygotic isolating mechanism.
C. Populations must live on islands.
D. Formerly isolated populations must never encounter each other again.

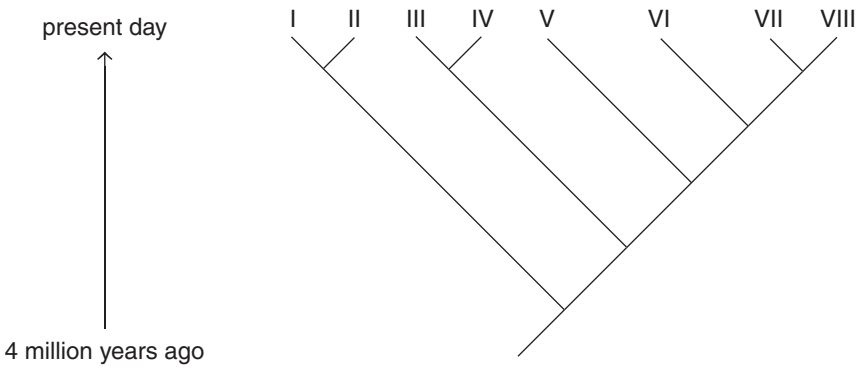
Question 20

Which of the following was a central point in Darwin's theory of evolution by natural selection?

A. The biological structures that an organism is most likely to inherit from its parents are those that have become better suited to the environment through constant use.
B. Mutations occur to help future generations adapt to their environment.
C. Phenotypic variation between individuals of the same species affects their chances of surviving and reproducing in their habitat.
D. Genes change in order to help organisms cope with problems encountered within their environment.

Question 21

A monophyletic group is defined as a recent common ancestor and all of its descendants. The cladogram (branch diagram) below depicts the relationships between eight species (I to VIII).



Which of the following groupings of species form part of a monophyletic group?

A. I, II and III

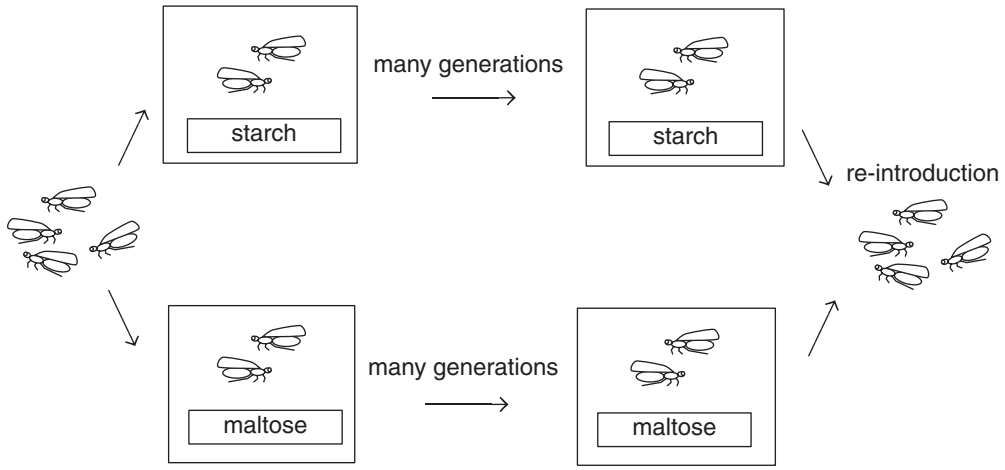
B. III, IV and V

C. III, IV, V, VI and VIII

D. VI, VII and VIII

Question 22

A student took 1000 fruit flies of the same species from a population and divided them into two equal populations living in different cages. One of the populations lived on maltose-based food, and the other population lived on starch-based food. After many generations, the two populations of flies were reintroduced to each other. The flies were then tested to see which flies they preferred to mate with. The experimental procedure is shown in the diagram below.



The 'maltose flies' preferred to breed with other 'maltose flies', although if 'maltose flies' were not available, they would breed with 'starch flies'. Similarly, 'starch flies' preferred to breed with other 'starch flies', but they would still mate with 'maltose flies'.

From these results, it was reasonable for the student to conclude that

A. two new species of fruit flies had evolved.

B. reproductive isolation had begun to occur as a result of the geographic isolation of the two populations.

C. the flies had undergone genetic drift and could not produce viable gametes.

D. the flies had evolved different reproductive organs due to their different diets and this was preventing them from interbreeding.

Question 23

Using your knowledge of the skeletal structure of the great apes, which of the following features of the skeleton supports the human as the only bipedal ape?

A. The human's skull sits on a vertical vertebral column allowing the eyes to face forward, suggesting that the human needs to stand upright to move.

B. The human's arm-to-leg ratio is larger than the other apes, suggesting that the arms are not used for locomotion.

C. The human's skull is larger, illustrating a greater brain capacity to achieve bipedal movement.

D. The human's jaw is smaller, suggesting an omnivorous diet, which could only occur if the human is bipedal.

Question 24

The entire human genome has now been mapped. This was only possible because of refinement and modification of techniques that originally suggested that the map would take over 100 years to achieve.

This capacity for humans to improve their inventions for the betterment of the human race is an example of

A. behavioural evolution.

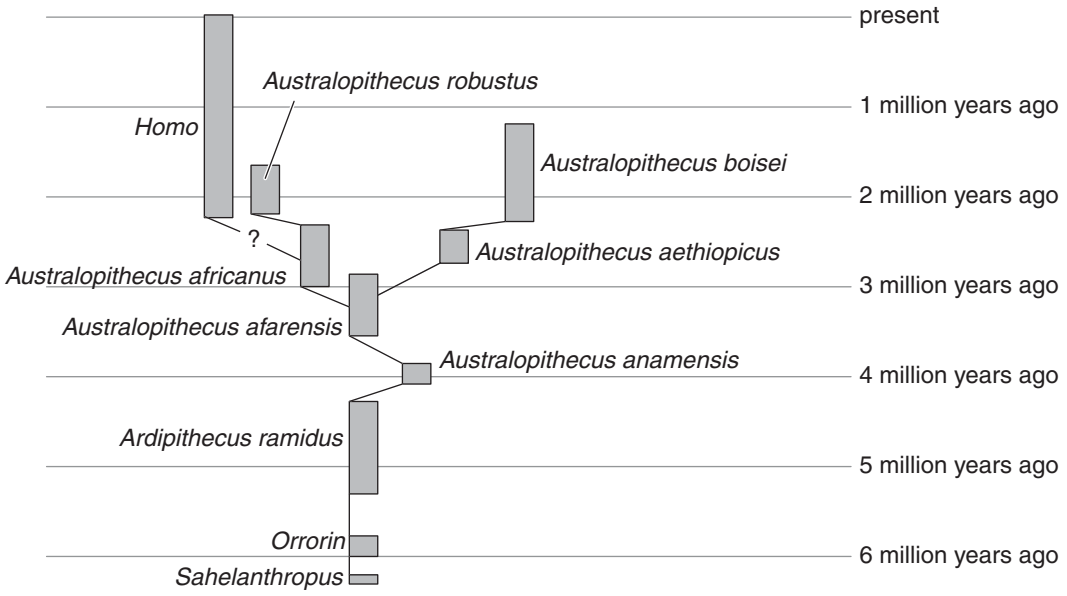
B. cultural evolution.

C. technological evolution.

D. structural evolution.

Question 25

The following graph is of the evolutionary line leading towards the *Homo* genus from the ancestral *Sahelanthropus*. The length of the thick lines indicates the time period that the particular group existed for.



According to the graph, *Ardipithecus ramidus* existed for

A. 4.25 million years.

B. 5.25 million years.

C. 1 million years.

D. 4.75 million years.

SECTION B: SHORT-ANSWER QUESTIONS

Instructions for Section B

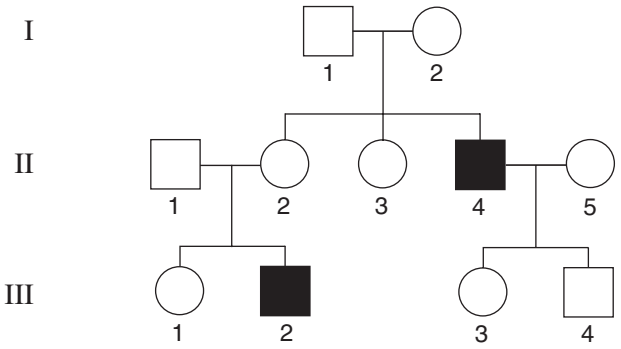
Answer this section in pen.

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

Question 1

Duchenne muscular dystrophy (DMD) is a sex-linked recessive disorder that usually affects only males. This disorder leads to the wasting away of muscle tissue, usually leading to the death of sufferers before they reach 20 years of age.

The pedigree below shows the inheritance pattern of DMD where shaded individuals express this disorder.



a. What evidence from the pedigree suggests that this disorder is a recessive trait? Explain.

_____

_____

1 mark

b. **i.** Assign allelic symbols for DMD.

_____

ii. What is the genotype of individual II–4?

_____

iii. State the probability that individuals II–1 and II–2's next child will have DMD.

_____

1 + 1 + 1 = 3 marks

c. If individual II–3 marries a normal male, what advice should a genetic counsellor give as to the chance of them conceiving a DMD child?

_____

_____

_____

_____

2 marks

d. DMD is caused by the absence of functioning dystrophin (a protein comprising 3700 amino acids) which leads to the degradation of muscle fibres. In 75% of DMD sufferers, a small, abnormal, dysfunctional dystrophin protein (comprising 2500 amino acids) is formed. The faulty DMD gene is missing an exon.

i. What is an exon?

_____

ii. Explain how the removal of an exon could lead to a small, abnormal dystrophin protein.

_____

_____

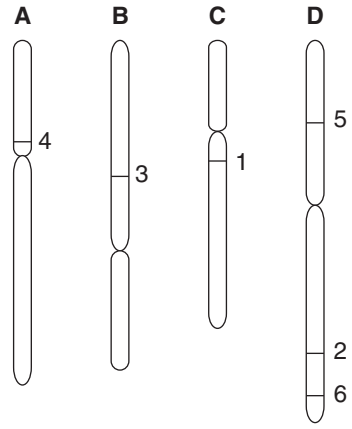
_____

_____

1 + 2 = 3 marks
Total 9 marks

Question 2

The diagram below shows four chromosomes (labelled A–D) from one species of *Arabidopsis*. (*Arabidopsis* is the genus of plants that includes cabbages.) The diagram illustrates the location of several genes (labelled 1–6) on the chromosomes. These genes code for a group of enzymes that are called XTH proteins. These genes have been extensively researched and have provided evolutionary evidence for various members of this plant genus.



a. **i.** Which genes (1–6) are linked?

_____

ii. Which two genes (1–6) are most likely to be inherited together?

_____

iii. How many molecules of DNA are illustrated in the diagram above?

_____

1 + 1 + 1 = 3 marks

b. Consider a **diploid** plant from this genus that has a cell undergoing meiosis.
Draw a labelled diagram of the chromosomes (A and B only) as they would appear in prophase I.

2 marks

c. **i.** If the plant was heterozygous for all six genes illustrated in the four chromosomes, how many different allele combinations would be possible as a result of meiosis if no crossing-over occurred?

_____

ii. Describe how another allele combination could occur if cross-over did occur (consider only chromosome D).

_____

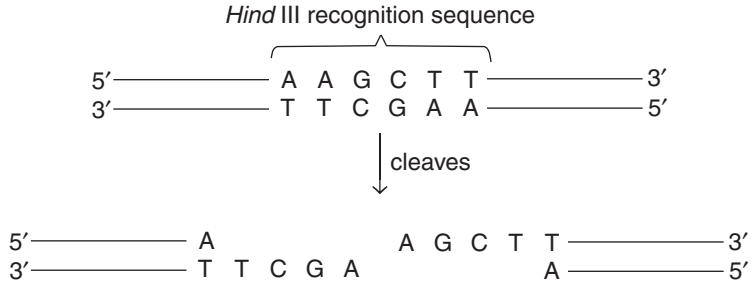
_____

_____

1 + 1 = 2 marks
Total 7 marks

Question 3

Hind III is a restriction enzyme derived from the bacterium *Haemophilus influenzae*. The diagram below shows the effect of this enzyme on DNA.



a. A plasmid to be used in genetic modification contains this recognition sequence at five locations.
If the plasmid was digested with *Hind* III, how many fragments of DNA would be formed?

_____

1 mark

An autosomal recessive inherited disorder runs in the Jones family. An allele specifying the production of a normal protein (**R**) is 160 kbp in length and has a recognition sequence for *Hind* III halfway along its length. The mutant allele (**r**) has a second restriction site, 60 kbp beyond the midway point of the gene.

b. Describe the DNA fragments resulting from

i. the restriction of the normal allele by *Hind* III.

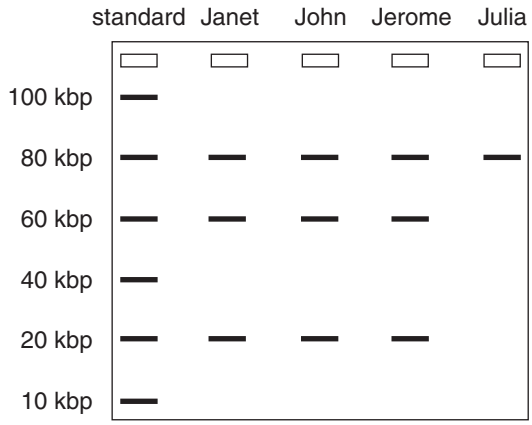
_____

ii. the restriction of the mutant allele by *Hind* III.

_____

1 + 1 = 2 marks

The parents in the Jones family, Janet and John, decided to have themselves and their two children, Jerome and Julia, screened for the disease. Their DNA samples were digested with *Hind* III and separated using gel electrophoresis. The gel was then treated with a gene probe to detect DNA contained in the gene. The distribution of DNA fragments on the resulting gel is shown below.



c. **i.** After digestion with *Hind* III, describe how gel electrophoresis enables a band pattern to appear on the gel.

_____

_____

_____

_____

ii. What is a 'gene probe'?

_____

_____

iii. Explain the purpose of the standard DNA.

_____

_____

2 + 1 + 1 = 4 marks

d. Which individual(s) carry at least one copy of the mutant allele, **r**? Explain.

_____

_____

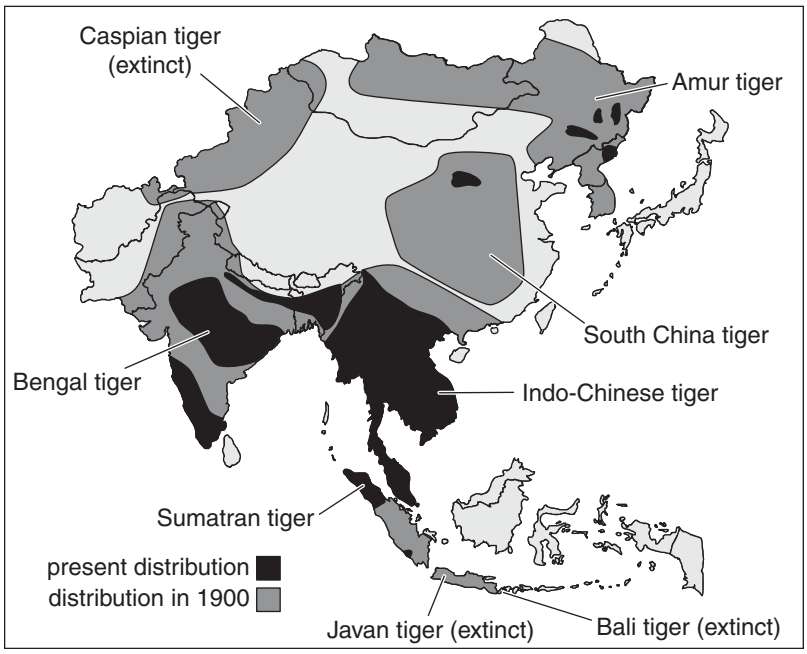
2 marks

Total 9 marks

Question 4

Tigers (*Panthera tigris*) are mammals of the Felidae family and are the largest and heaviest cats in the world. There are eight recognised sub-species of tiger, three of which are extinct and one of which (the South China tiger) is almost certain to become so in the near future.

Past and present distribution of the tiger



Data in this map sourced from the Global Tiger Patrol website. http://www.globaltigerpatrol.co.uk/AbouttheTiger.asp. Used with permission.

Tigers were once widespread across Asia. However, tigers now occur only in scattered populations as illustrated in the distribution map above. Numbers are thought to have fallen since the turn of the twentieth century from perhaps 100 000 to the present estimate of below 2500 mature breeding individuals, with no sub-population containing more than 250 mature breeding individuals. The South China tiger is on the verge of extinction, and the Chinese population of the Amur (Siberian) tiger is in a critical state, although 360–406 individuals are estimated to survive in neighbouring parts of Russia.

a. Describe two ways in which human activity threatens the tiger with extinction.

_____

1 mark

White tigers occur in all sub-species. Indeed, white fur is the most common phenotype in populations of Amur (Siberian) tigers. White adults are relatively rare in other tiger populations, with most individuals being orange. Amur (Siberian) tigers are also generally larger than tigers of other sub-species.

b. Describe the process by which Siberian tigers have evolved to become predominantly large and white.

_____

_____

_____

_____

_____

3 marks

c. What is the most likely explanation for the dispersal of the Sumatran sub-species from the Asian mainland to Sumatra (or in the opposite direction)?

_____

_____

1 mark

A genetic analysis of the same specific region of mitochondrial DNA from tigers in six distinct sub-species (a total of 100 animals) is shown in the table below.

Tiger population	Number of animals in sample	Total number of different alleles in the sub-species	Alleles unique to the sub-species (%)
Sumatran	16	108	10.2
Indo-Chinese (from Vietnam, Cambodia and Thailand)	30	130	14.6
Indo-Chinese (from Malaya)	22	108	2.8
Amur (Siberian)	13	104	2.9
South China	4	66	1.5
Bengal	15	106	11.3

Data in this table sourced from Luo SJ, Kim JH, Johnson WE, van der Walt J, Martenson J, Yuhki N, Miquelle DG, Uphyrkina O, Goodrich JM, Quigley HB, Tilson R, Brady G, Martelli P, Subramaniam V, McDougal C, Hean S, Huang SQ, Pan W, Karanth UK, Sunquist M, Smith JDL & O'Brien SJ 2004, 'Phylogeography and genetic ancestry of tigers (*Panthera tigris*)' *PLoS Biology*, vol. 2. http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=534810. Used with permission.

d. Which sub-species appears to be entering a genetic bottleneck? Support your answer with data from the table.

_____

_____

2 marks

e. Scientists have recently suggested that the so-called Indo-Chinese sub-species should be divided into two groups: a northern Indo-Chinese sub-species and a peninsular-Malayan sub-species. Explain how data from the table could be used to support this argument.

_____

_____

_____

2 marks

Analysis of the tigers' mitochondrial DNA revealed that all tigers diverged from a common ancestor that lived 72 000–108 000 years ago.

f. Explain why so many different tiger sub-species have arisen in such a short period of time.

_____

_____

_____

1 mark

g. Why was mitochondrial DNA, instead of chromosomal DNA, used to measure the evolutionary relationships between tiger sub-species?

_____

_____

1 mark

Total 11 marks

Question 5

Fossils of bony fish (class **Osteichthyes**) are relatively common.

a. Define a 'fossil'.

_____

_____

1 mark

b. **i.** Give two reasons why the remains of bony fish are relatively common in the fossil record.

_____

_____

_____

ii. In some countries, bony fish have been used as **index fossils**.

Explain how index fossils can be used in the relative dating of rocks.

_____

_____

_____

2 + 1 = 3 marks

There are two sub-classes of bony fish: the **Actinopterygii** (ray-finned fish) and the **Sarcopterygii** (lobe-finned fish). The following table shows the ages of some rocks in which fossils of some Sarcopterygian fish have been found.

Fish	Location of rock	Age
Osteolepis	Scotland	395 million years
Dipterus	Scotland	350 million years
Latimeria chalumnae	Mozambique	80 million years
Neoceratodus	Northern New South Wales	100 million years

c. Describe how the ages of these rocks would have been determined by absolute dating.

_____

_____

_____

2 marks

Today's Sarcopterygians are represented by the Crossopterygians (coelacanths) and the Dipnoans (true lungfishes). Sarcopterygians have a fleshy lobe at the base of their fins that is leg-like in appearance. Only a single genus of coelacanth survives. The lungfish are more widespread.

The 'lung' of a lungfish is a modified swim bladder. In most fish the swim bladder is used for buoyancy in swimming, but in the lungfish it also absorbs oxygen and removes carbon dioxide. African and South American lungfish are able to survive drought by burrowing into the mud and breathing air through their swim bladder instead of through their gills.

d. Intermediate forms are one of the key predictions of the theory of evolution, which stipulates that species evolve through a process of natural selection. Many scientists believe that Sarcopterygian fish represent intermediate forms in the evolution of Amphibians (e.g. frogs and toads) from bony fish.

Explain how the features of the lungfish support this idea.

_____

_____

_____

_____

2 marks

Total 8 marks

Question 6

Gene technologists seem to be making new discoveries on a regular basis. The general public often have the perception that this kind of science is moving far too quickly. However with careful and educated discussion, the correct decisions on how to best utilise these technologies are being made.

a. Use your biological knowledge to discuss the genetic accuracy of the following statements.

i. "Gene therapy replaces a 'faulty' form of a gene with the 'normal' form of the gene giving the cell the capacity to express a particular protein."

_____

_____

_____

ii. "Cloning technology places the nucleus of a differentiated cell into an enucleated (the nucleus has been removed) ovum. The clone possesses a genetically identical genome to the clone 'parent', but the age of the clone will be the same as the parent clone."

_____

_____

_____

2 + 2 = 4 marks

b. Discuss one biological reason why we should proceed with one of the technologies outlined in part **a.** and one biological reason why we should **not** proceed with it.

_____

_____

_____

_____

2 marks

Total 6 marks

END OF QUESTION AND ANSWER BOOKLET