Student Name: _____

BIOLOGY

Unit 4 – Written examination 2

2008 Trial Examination

Reading Time: 15 minutes
Writing Time: 1 hour and 30 minutes

QUESTION AND ANSWER BOOK

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	25	25	25
B	7	7	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 permitted in this examination.

Materials supplied
- Question and answer book of 25 pages.

Instructions
- Print your name in the space provided on the top of this page.
- All written responses must be in English.

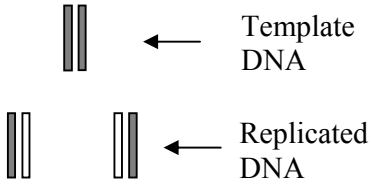
Students are NOT permitted to bring mobile phones and/or any other electronic devices into the examination room.

SECTION A- Multiple-choice questions

Instructions for Section A
Answer **all** questions. Choose the response that is **correct** for the question. A correct answer scores 1, an incorrect answer scores 0. Marks are **not** deducted for incorrect answers. If more than 1 answer is completed for any question, no mark will be given.

Question 1

The diagram below shows DNA before and after one cycle of replication.



This diagram is showing that DNA replication is:

A. Antiparallel

B. Redundant

C. Synthesised

D. Semi-conservative

Question 2

Which of the following events does not occur during DNA replication?

A. Okazaki fragments are spliced together by DNA ligase

B. The newly-synthesised strands are complementary to the parental strands

C. DNA polymerase synthesises both strands continuously

D. Helicase breaks the hydrogen bonds in the parental strand

Question 3

The diploid number of an onion is 16. A student makes a slide of onion epidermal cells and observes them with a microscope. One of the cells observed had been in the process of dividing. There were two noticeable groups of double-stranded chromosomes, which had been moving towards the "poles" of the cell. The stage of cell division being observed is most likely to be:

A. Metaphase I of meiosis

B. Metaphase of mitosis

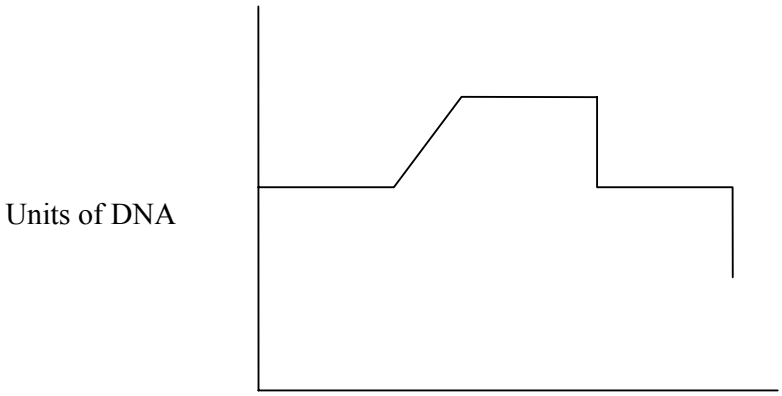
C. Anaphase I of meiosis

D. Anaphase II of meiosis

SECTION A - continued

Question 4

The following diagram represents changes to the amount of DNA present in a cell during cell division.



The most accurate interpretation of the diagram is:

A. One complete cycle of meiosis has occurred

B. One complete cycle of mitosis has occurred

C. Two complete cycles of meiosis have occurred

D. Two complete cycles of mitosis have occurred

Question 5

DNA sequences can be altered by point mutations including:

1) Additions
2) Substitutions
3) Deletions

Which one of the following options is most likely to cause a frameshift mutation?

A. 1 and 2

B. 2 and 3

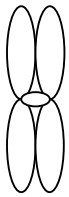
C. 1 and 3

D. 1, 2 and 3

SECTION A – continued
TURN OVER

Question 6

The diagram below shows a replicated chromosome taken from a cell during metaphase I of meiosis. It consists of two chromatids joined by a centromere.



It would be incorrect to conclude:

A. The chromatids will end up in different daughter cells

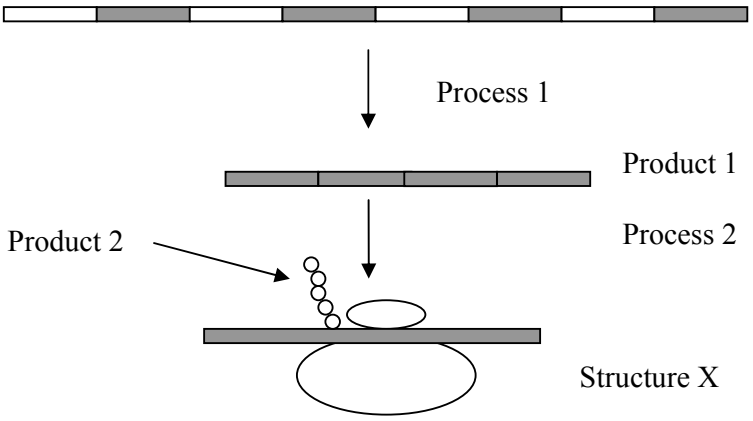
B. Both chromatids are genetically identical

C. Each chromatid consists of a single DNA molecule

D. The centromere will break during Anaphase II of meiosis

The following information relates to Questions 7 and 8.

The diagram below shows two of the stages which occur during protein synthesis in a eukaryotic cell.



Question 7

What is happening during process 1?

A. Gene splicing

B. Gene therapy

C. Intron removal

D. Intron ligation

Question 8

Process 2 is:

A. Transcription which occurs in the nucleus of the cell

B. Translation which occurs in the cytosol of the cell

C. Transcription which occurs in the cytosol of the cell

D. Translation which occurs in the nucleus of the cell

SECTION A – continued

The following information relates to Questions 9 and 10.

A woman with type A blood has several children by a man with type B blood. Their first child has type O blood.

Question 9

The number of phenotypes possible for any of their subsequent offspring is:

A. 1

B. 2

C. 3

D. 4

Question 10

What is the probability that any of their offspring will be homozygous and type B?

A. 0%

B. 25%

C. 50%

D. 100%

Question 11

Klinefelter's syndrome is a condition that occurs in men who have an extra X chromosome. They often don't make as much testosterone as other males, may have less facial and body hair and may also be less muscular. The effects of Klinefelter's syndrome may commence at any time after birth. Often it is not diagnosed until a male is in his teens.

The best tool for diagnosing Klinefelters syndrome would be:

A. Construct a pedigree chart

B. Analyse their level of oestrogen secretion

C. Perform DNA profiling

D. Complete karyotyping

Question 12

The most appropriate term used to describe the cause of Klinefelters syndrome is:

A. Non-disjunction

B. Aneuploidy

C. Polyploidy

D. Mutation

Question 13

The height of tobacco plants is governed by the expression of a series of genes at multiple loci in the plant's genome. This information can be interpreted to mean:

A. The genes causing this trait are linked

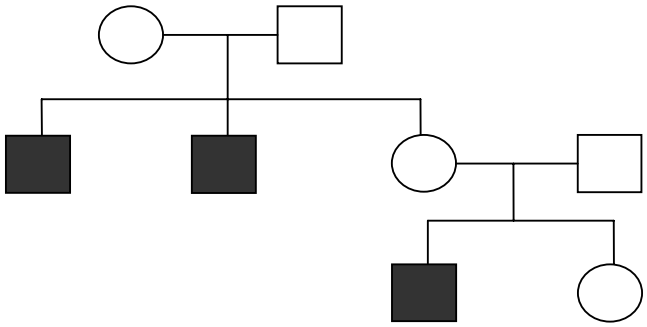
B. This is an example of polygenic inheritance

C. Some of the genes act as promoters

D. Discontinuous phenotypic variation would be expected

Question 14

The most likely pattern of inheritance in the pedigree chart below is:



A. X-linked recessive

B. X-linked dominant

C. Autosomal dominant

D. Autosomal recessive

Use the following information to answer Questions 15 and 16.

Flower colour in snapdragons is controlled by a single gene with two alleles: C^R, coding for red pigmentation, and C^W, coding for white pigmentation.

Question 15

A pure-breeding red flowering plant is crossed with a pure-breeding white flowering plant. All of the F_1 generation are pink. The mode of inheritance for this trait is:

A. Co-dominant inheritance

B. Monohybrid inheritance

C. Intermediate inheritance

D. Dihybrid inheritance

Question 16

Two members of the F_1 generation were crossed and the seeds planted. When the plants flowered, there was found to be 20 white, 20 pink and 60 red flowered plants.

From this data, it can be concluded that:

A. The frequency of the C^R allele is 0.6

B. The frequency of the C^W allele is 0.2

C. The frequency of the C^W allele is 0.4

D. The frequency of the C^W allele is 0.3

Use the following information to answer Questions 17 and 18.

In a species of plant, the pigmentation of the seed coat depends on the action of two different, unlinked genes. One gene codes for pigment colour, with green (G) being dominant to brown (g). The second gene has two alleles: (I) inhibits the expression of the first coat colour gene (resulting in a lack of pigmentation) and (i) allows it to be expressed.

Question 17

Which of the following statements is correct?

A. A green-seeded plant must be homozygous for both genes

B. A brown-seeded plant must be homozygous for both genes

C. A plant heterozygous for both genes will be green

D. A plant with a coloured seed must be homozygous for the (I) allele

Question 18

If two heterozygous parents are crossed, the probability of the offspring having coloured seeds is expected to be:

A. $\frac{9}{16}$

B. $\frac{1}{4}$

C. $\frac{3}{16}$

D. $\frac{1}{16}$

Question 19

A single droplet of blood is located at a crime scene. Enough DNA can be obtained to perform DNA profiling by performing:

A. Polymerase chain reaction

B. Electrophoresis

C. DNA sequencing

D. DNA synthesis

Question 20

Genetic drift can play a role in altering allele frequencies in a population over a period of time. The impact of genetic drift is most likely to be observed when:

A. The population is small in size

B. Selection pressures are in operation

C. A mutation occurs

D. New individuals enter the population

Question 21

A variety of animals (including green tree snakes, spider monkeys and the arboreal salamander) all have prehensile tails. This is an example of:

A. Allopatric speciation

B. Homologous structures

C. Convergent evolution

D. Genetic drift

Question 22

Platynereis dumerilii is a small marine worm which has not changed significantly in millions of years. It is uncommon to find fossilised remains of soft bodied animals such as this because:

A. Soft tissues decompose rather than fossilise

B. The fossil record is incomplete

C. They were present in low numbers

D. They lived in inappropriate conditions for fossilisation to occur

Question 23

Adaptive radiation is a form of evolution where a single ancestral species rapidly diverges, producing many different species and filling a range of ecological niches. Which of the following situations would not promote adaptive radiation?

A. Mass extinctions

B. Colonisation of an isolated ecosystem

C. A catastrophic event

D. An increase in population size

SECTION A – continued

Question 24
The diagram below represents some undisturbed layers of sedimentary rock

Species A
Species A and B
Species C
Species D
Species E

What assumptions can be made from this data?

A. Species D is the ancestor of species C

B. Species C existed before species D

C. Species B was the least abundant

D. Species A is the most recent

Question 25
A scientist locates a primate skull. Which of the following features could be used to determine if the organism was bipedal or not?

A. The presence of large supraorbital brow ridges

B. The position of the foramen magnum

C. The presence of large canine teeth

D. The size of the brain case

END OF SECTION A
TURN OVER

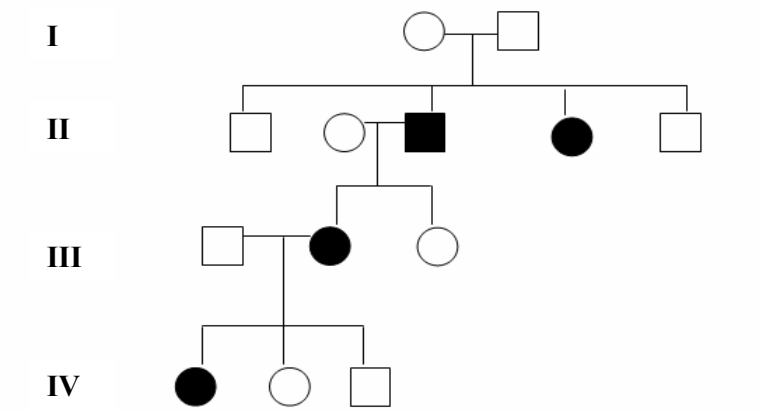
SECTION B- Short-answer questions

Instructions for Section B
Answer all questions in the spaces provided.

Question 1

Friedreich ataxia (FRDA) is a disease that causes progressive damage to the nervous system. Symptoms include: difficulty in walking, slurred speech, foot deformities and heart conditions (such as cardiomyopathy, myocarditis, tachycardia) and heart failure. This condition is ultimately fatal, with affected individuals often dying before the age of 30. There is no known cure.

a. Identify the mode of inheritance for this condition. Use the data from the pedigree chart to support your answer.



2 marks

SECTION B - Question 1- continued

b. Individual IV-3 marries a woman who develops FRDA. What is the probability that their first child will be a male with FRDA?

1 mark

c. The inheritance of FRDA has been found to be a polymorphic condition. What does this mean?

1 mark

d. The most common mutation which causes FRDA is a large area containing many copies of a GAA triplet-repeat (referred to as GAA-TR) sequence in the first intron of the FRDA gene. What effect will this mutation have on the protein? Explain your answer.

2 marks

SECTION B - Question 1- continued
TURN OVER

e. The normal allele contains 50 to 60 GAA repeats, whereas the mutant allele contains between 100 and 1700 repeats. Based on this information, identify a molecular biology technique which could be used to diagnose this condition. Explain how you could determine the difference between a normal allele and a mutant allele.

2 marks
Total 8 marks

SECTION B - continued

Question 2
The information below shows the sequence of the leading strand of a fragment of DNA. The desired gene is highlighted in bold. A table showing the recognition sequences for a range of restriction enzymes has been provided underneath.

5'GTCAGGATTGACCCCTCCCAAGCTTGTATGTTTTCAGCTGTCCAAATC**GAATTC**
GGAGGCTTTTATGTGGTTCGTTCTTATTACCCTTCTGTGAATGTCACGC
TGACGAATACCTTCGGTTCGTAACCCCTAACTCTTTCTCATTTACGGTG
TTCGGATTATCGTCCAAATTCTGGAGCTAGGGAGTTTCAGTTTCAGTTT
TATTAGAATTCGACAGCTGCATCAAGCTTCTTGGAAGAGATTCTGGTAACGGTT
A3'

EcoRI	5'GAATTC 3'CTTAAG	5'---G AATTC---3' 3'---CTTAA G---5'
BamHI	5'GGATCC 3'CCTAGG	5'---G GATCC---3' 3'---CCTAG G---5'
HindIII	5'AAGCTT 3'TTCGAA	5'---A AGCTT---3' 3'---TTCGA A---5'
AluI	5'AGCT 3'TCGA	5'---AG CT---3' 3'---TC GA---5'
HaeIII	5'GGCC 3'CCGG	5'---GG CC---3' 3'---CC GG---5'
MboI	5'GATC 3'CTAG	5'---GA TC---3' 3'---CT AG---5'

a. Identify which restriction enzyme would be the most appropriate choice for cutting out the desired gene.

_____

1 mark

SECTION B-Question 2-continued
TURN OVER

b. Provide two reasons to justify your choice.

2 marks

c. Once the gene has been removed, it can be inserted into a bacterial plasmid. Identify the enzyme that enables the gene to be annealed into the plasmid.

1 mark

d. At the same time, another gene is inserted into the same plasmid. This gene enables the bacteria to produce a protein which provides the bacteria with resistance to the antibiotic ampicillin. What is the purpose of this second, inserted gene?

1 mark

e. It is possible for the bacteria to produce the protein coded for by the inserted gene because the genetic code is universal. Explain what this means.

1 mark

Total 6 marks

SECTION B-continued

Question 3

Thomas Hunt Morgan was a scientist who studied the inheritance patterns of specific traits in *Drosophila melanogaster* (fruit flies). When he crossed pure breeding flies with grey bodies and long wings with pure breeding flies with black bodies and vestigial wings, all of the F_1 generation had grey bodies and long wings.

a. He then performed a test cross using one of the F_1 generation and a pure breeding fly which had a black body and vestigial wings. Use your own allele symbols to show the expected outcome of this cross. Include the genotypic and phenotypic ratios in your answer.

3 marks

When the test cross was performed the following results were obtained.

PHENOTYPE	NUMBER OF FLIES
Grey body, long wings	1339
Grey body, vestigial wings	151
Black body, long wings	147
Black body, vestigial wings	1205

b. Identify two pieces of information provided, which proves this is an example of a dihybrid cross.

2 marks

SECTION B-Question 3-continued

TURN OVER

c. Are the genes for these traits linked or independently assorted? Use the data to support your answer.

2 marks

d. Identify the type of cell division responsible for these results.

1 mark

Total 8 marks

Question 4

The first appearance of a cat-like ancestor, known as *Proailurus*, has been dated as occurring more than 30 million years ago. Approximately 26 million years ago, a divergence occurred, with sabre-toothed cats developing along one line, and other cats, known as "true cats", along another.

A species of true cat known as *Miracinonyx* originated in North America about 4 million years ago. It appears to be the common ancestor of many large cats, including the cheetah (*Acinonyx jubatus*), now found in Africa. and the cougar *(Felis concolor*), now found in the Americas.

The Ice Age made it possible for *Miracinonyx* to migrate across continents. The result was several ancestral forms of the modern cheetah, such as the giant cheetah, (*Acinonyx pardensis)*, found in China, southern Europe and India, and intermediate-sized cheetahs, (*Acinonyx intermedius)* which had a range that extended from Africa to China.

a. Suggest one reason why all species of cheetah, with the exception of the modern cheetah, became extinct.

1 mark

SECTION B-Question 4-continued

b. Suggest a technique of absolute dating which could be used to establish the date of a *Proailurus* fossil.

1 mark

Rejection is the normal response to a tissue transplant. A study was conducted by performing skin transplants on domestic house cats and cheetahs. The biologists found that the 14 house cats tested all rejected a skin graft from an unrelated cat within two weeks. Of the 14 cheetahs that received skin grafts from an unrelated cheetah, only 3 rejected the grafts, and these rejections took longer than 40 days to occur.

c. What conclusions can be drawn about genetic variation between the cheetahs being tested? Use evidence to support your answer.

2 marks

Inbreeding depression is caused by excess inbreeding, with the most common symptom being reproductive failure. In the late 1970's, Dr. David Wildt conducted a study designed to test inbreeding depression in the captive cheetah population in several American Zoos. He collected sperm samples from a number of cheetahs and examined them under a microscope. He found that about 70 percent of the sperm were abnormal and deformed, with many having bent or coiled tails, which would prevent them from penetrating and fertilizing a female's egg.

His hypothesis was the abnormal sperm were due to inbreeding and stressful conditions at the zoos. This hypothesis was later disproved.

d. What evidence could be used to disprove this hypothesis?

1 mark

SECTION B-Question 4-continued
TURN OVER

Cheetahs are the only large cats that are unable to sheath their claws, which gives them extra traction for running. They also have unusually broad nasal passages, which help the cheetah take in a large supply of oxygen while running, a light-boned frame and an extremely flexible spine.

e. What is the process that has caused the cheetahs to evolve in this way? Describe how this process shaped the evolution of cheetahs, resulting in their current form.

3 marks

Total 8 marks

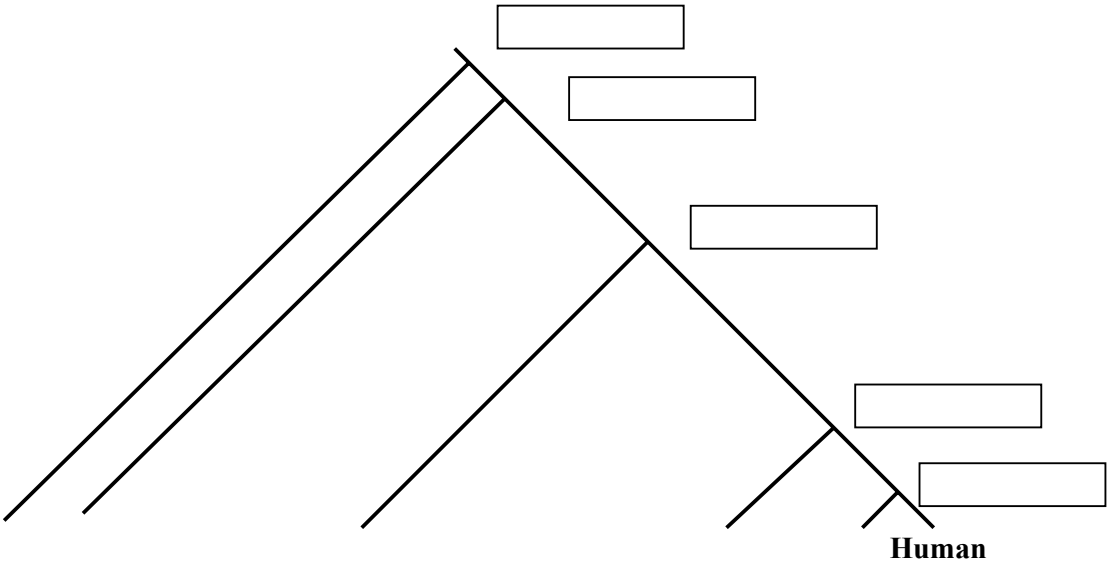
Question 5
One of the ways of determining ancestry is to compare the similarity of amino acid sequences of proteins in different species.

The table below shows the number of differences between a human protein sequence and that of other species.

ORGANISM	NUMBER OF DIFFERENCES
Shark	85
Dolphin	8
House cat	21
Chimpanzee	1
Goldfish	78

.

a. Use the information above to complete the cladogram below. Write the species name into the boxes provided.



2 marks

SECTION B-Question 5-continued
TURN OVER

b. Sharks and dolphins both have similar streamlined shapes. What kind of evolution has caused the phenotypic similarities between the two species? Use the data provided to support your answer.

2 marks
Total 4 marks

Question 6
All living humans have mitochondrial DNA (mtDNA), which can be traced back to a single female known as Mitochondrial Eve, who is supposed to have existed approximately 140,000 years ago. The analysis of mtDNA is based on the assumptions that mtDNA is passed down through the matrilineal (female) line.

Scientists have tested mtDNA from individuals taken from all over the world and used that data to trace ancestry back to Mitochondrial Eve. They then constructed a phylogenetic tree showing how all of the modern races diverge from that single point. Indigenous Africans were found to diverge first, and all other races have been found to branch off from the African lineage.

a. Which theory of human evolution does this information support?

1 mark

b. Why is it unlikely that mitochondrial eve was the only female of the species alive at that time?

1 mark

c. Identify one reason why mtDNA from all other females of the time has been lost.

1 mark

SECTION B-Question 6-continued

d. Explain why mtDNA is more useful for tracing ancestry than nuclear DNA.

1 mark

An alternative view of human evolution rests on evidence that *Homo* genus individuals have been present in Asia, as well as in Africa, for similar periods of time. It proposes that the transformation of archaic to anatomically modern humans occurred in parallel in both of these areas, ultimately resulting in the single modern species *Homo sapiens* being found worldwide.

e. The earliest point of divergence for the Asian populations has been found to be approximately 90,000 years ago. Does this support or disprove this theory? Use the data supplied to justify your answer.

2 marks

SECTION B-Question 6-continued
TURN OVER

f. When mitochondrial DNA was mapped, there were 133 distinct forms found (many of these are region-specific). If hybridisation had occurred between individuals existing in Asia and those emerging from Africa, would you expect to find the greatest amount of mtDNA diversity in the modern African population or the modern Asian population? Justify your answer.

2 marks

g. Archaeologists have found evidence of the use of complex knife blades in Africa. At the same time, less complex flint knife blades were being used in other regions of the world. Identify the type of evolution that enables knowledge about the construction of tools to be passed from one generation to another.

1 mark

Wheat grains are attached to stalks by a structure called a rachis. Ancestral forms of wheat had a brittle rachis, causing a condition called shatter head, which allowed the dispersal of seeds if touched or blown by wind. Domesticated wheat has a tough rachis, preventing seed dispersal. All available information indicates that this phenotypic change occurred in a period of approximately 300 years, between 10,000 and 9,700 years ago

h. What process has caused the phenotypic differences between wild wheat and domesticated wheat? Use the information provided to support your answer.

2 marks

Total 11 marks

SECTION B-continued

TURN OVER

Question 7
Gene therapy is a method of delivering correctly functioning genes to individuals with adverse mutations.

Haemophilia B is an X-linked recessive condition. Affected individuals have a defective gene for a protein known as factor IX, which has an important role in helping blood to clot. Sufferers of this condition need regular injections of factor IX to prevent excessive bleeding.

A medical facility recently conducted a small initial trial, where an adenovirus was used to carry the gene which codes for the correct production of factor IX into the existing body cells of three affected individuals. Two of these individuals subsequently produced small amounts of factor IX, at levels between 0.5 and 1% of the level produced by unaffected individuals. One man's requirement for factor IX diminished by 80%, and another by 50%.

a. Would it be biologically correct to state that the normal gene coding for factor IX has replaced the faulty copy of the gene? Explain your answer.

1 mark

b. Is the case outlined above an example of germ line or somatic gene therapy? Use the information provided to support your answer.

2 marks

SECTION B-Question 7-continued

c. There have been both successes and failures using gene therapy, both of which promote ethical and moral debates. The worst of the failures was the subsequent death of a teenager undergoing therapy for a condition caused by ornithine transcarbamylase deficiency, an X-linked recessive trait.

Identify one technical issue which needs to be overcome for gene therapy to be successful.

1 mark

d. Haemophilia B is a monogenic trait and Type 1 Diabetes is a polygenic trait. Briefly explain why somatic gene therapy is not a viable option for sufferers of Type 1 Diabetes.

1 mark

Total 5 marks

END OF QUESTION AND ANSWER BOOK

