Insight Publications

# *INSIGHT*

***Trial Exam Paper***

# 2006

# BIOLOGY

## Written examination 2

**STUDENT NAME:**

## QUESTION AND ANSWER BOOK

*Reading time: 15 minutes*
*Writing time: 1 hour 30 minutes*

**Structure of book**

| *Section* | *Number of questions* | *Number of questions to be answered* | *Number of marks* | *Suggested times (minutes)* |
|---|---|---|---|---|
| **A** | 25 | 25 | 25 | 30 |
| **B** | 9 | 9 | 50 | 60 |
| | | | Total 75 | 90 |

- Students are permitted to bring the following items into the examination: pens, pencils, highlighters, erasers, sharpeners and rulers.
- Students are NOT permitted to bring sheets of paper or white out liquid/tape into the examination.
- Calculators are not permitted in this examination.

**Materials provided**
- The question and answer book of 25 pages.
- An answer sheet for multiple choice questions.

**Instructions**
- Write your **name** in the box provided and on the answer sheet for multiple-choice questions.
- You must answer the questions in English.

**At the end of the examination**
- Place the answer sheet for multiple choice questions in the front cover of the question and answer book.

**Students are NOT permitted to bring mobile phones or any other electronic devices into the 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** or that **best answers** the question.

1 mark will be awarded for a correct answer; no marks will be awarded for an incorrect answer.

Marks are **not** deducted for incorrect answers.

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

**Question 1**

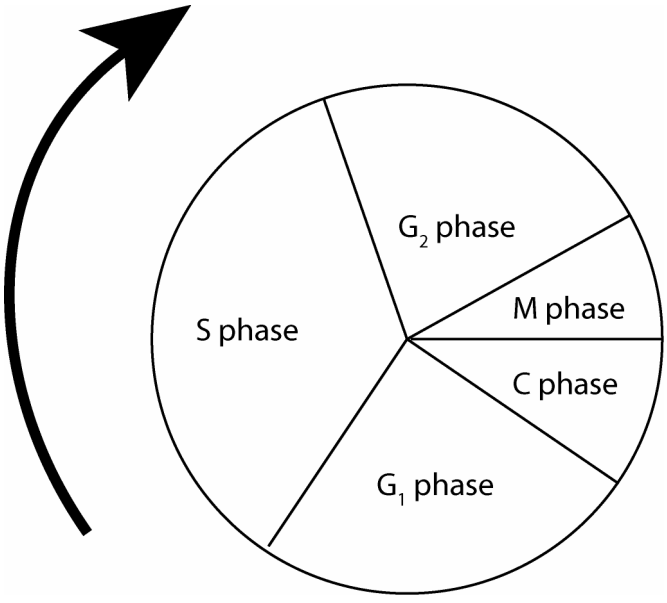
There are many levels of organisation in a chromosome. In eukaryotes, the DNA molecule coils around interacting proteins forming a supercoiled structure.

The name given to this supercoiled structure is

A. chromatin.
B. histone.
C. nucleosome.
D. centromere.

**Question 2**

The cell cycle describes the continuous sequence of events that takes place from one cell division to the next. The following diagram represents the life cycle of a cell.




The cell is most likely to be in interphase during phases

A. M, C and $G_1$.
B. $G_1$, S and $G_2$.
C. $G_1$ and $G_2$ only.
D. M and C only.

**Question 3**

The Cell Theory states that all cells are derived from pre-existing cells. Instructions for growth and development are passed from one generation of cells to the next through the processes of nuclear and cytoplasmic division. In many species, the instructions which determine their characteristics in successive generations are transferred in specialised cells known as gametes.

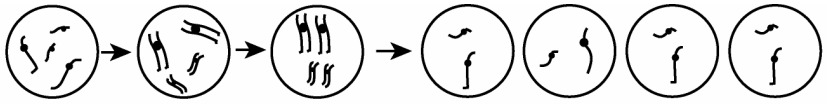
The process which gives rise to gametes is known as

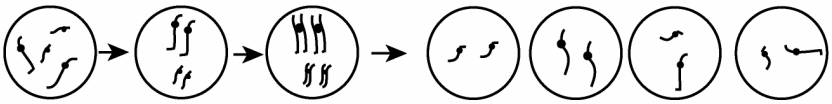
A. asexual reproduction.
B. sexual reproduction.
C. meiosis.
D. mitosis.

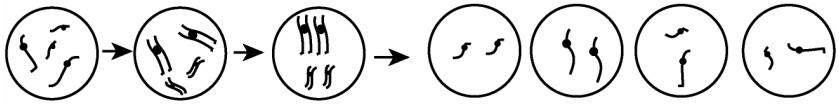
**Question 4**

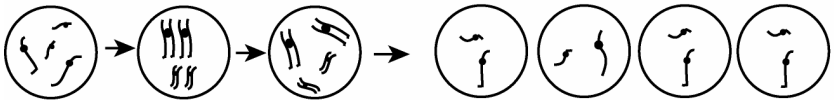
Meiosis is a cellular process which is also known as reductive division. During meiosis a very specific sequence of chromosome movements takes place to ensure that the resulting cells have all the genetic information they need to form a zygote.

Which of the following diagrams best summarises the correct sequence of events in meiosis?

A. 

B. 

C. 

D. 

**Question 5**

All cells are programmed to divide, age and die, in a controlled manner within a given timeframe. Uncontrolled cell division leads to the accumulation of cancerous cells which form cancerous tissues. These tissues are either benign or malignant.

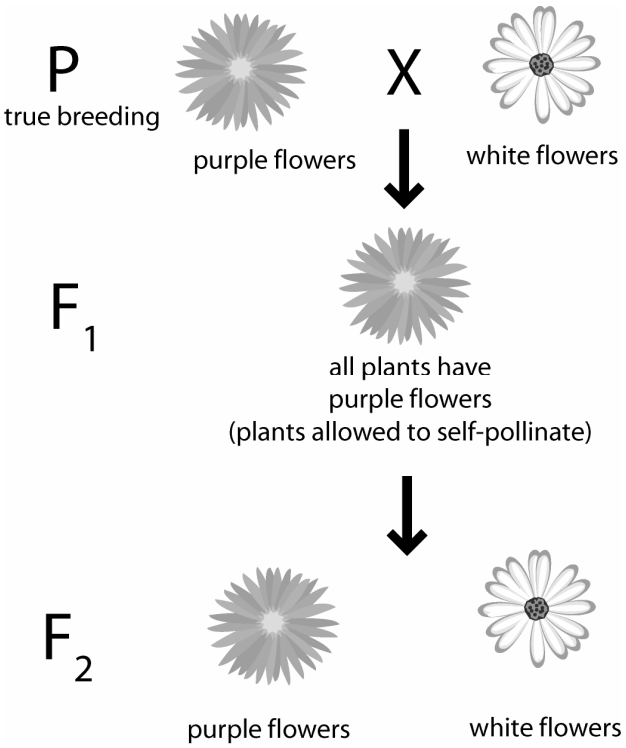
The process that normally results in the orderly, programmed death of cells is known as

A. pinocytosis.
B. apoptosis.
C. necrosis.
D. gametogenesis.

*Use the following information to answer Questions 6, 7 and 8.*

While studying mathematics at the University of Vienna, the Augustinian priest Gregor Mendel carried out some breeding experiments on pea plants. The results of his study have formed the basis of the study of heredity.

In his experiments Mendel tracked heritable characteristics for three generations. The following represents one such experiment.




**Question 6**

In the pea plants used in the experiment, flower colour is a characteristic that has no variable form. Flowers are either purple or white.

True-breeding pea plants are also known as

A. hybrids.
B. monohybrids.
C. heterozygous.
D. pure breeding.

**Question 7**

After allowing the $F_1$ purple-flowered pea plants to self-pollinate, Mendel discovered that the $F_2$ displayed a combination of purple-flowered pea plants and white-flowered pea plants.

These plants would have been produced in a ratio of

A. 3 purple : 1 white
B. 3 white : 1 purple
C. 1 white : 1 purple
D. 1 purple : 1 white

**Question 8**

If the genotype of pea plants that produce purple flowers is unknown, the most efficient way to determine the genotypes could be to cross a purple-flowered pea plant with

A. an $F_2$ generation purple-flowered pea plant.
B. an $F_1$ generation purple-flowered pea plant.
C. a P generation purple-flowered pea plant.
D. a P generation white-flowered pea plant.

**Question 9**

In humans there are four known blood groups. A person's blood group can be A, B, AB or O, where A and B indicate which antigens are found on the surface of the red blood cells. These four different blood groups result from various combinations of three different alleles of one gene.

The AB blood group occurs as a result of

A. incomplete dominance.
B. partial dominance.
C. codominance.
D. dominance.

**Question 10**

In populations, a single characteristic can be controlled by more than one gene. In humans, skin pigmentation is controlled by at least three different genes and is an example of polygenic inheritance.

With respect to skin pigmentation, the human population demonstrates

A. discontinuous variation.
B. continuous variation.
C. no variation.
D. temporal variation.

**Question 11**

The primary role of DNA in a cell is to determine what proteins the cell will make. RNA is a molecule that carries instructions from the DNA to the ribosomes where they are translated into proteins.

RNA differs from DNA in that it

A. contains a deoxyribose sugar.
B. is a shorter molecule than DNA.
C. contains thymine as one of its nucleotide bases.
D. is a double-stranded molecule.

**Question 12**

In the process of mRNA transcription, the part of the DNA to be copied is exposed. This strand is known as the template strand and the other strand of DNA

A. is known as the sense strand.
B. becomes the promoter.
C. has the same sequence as the mRNA (with T bases instead of U bases).
D. has the same sequence as the tRNA.

**Question 13**

Gene mutations occur as a result of changes in gene sequences and are usually detected and repaired by enzymes. A point mutation is one kind of gene mutation and can

A. involve the change of a single nucleotide base in a gene sequence.
B. involve the addition of one or two nucleotide bases in a gene sequence.
C. occur when a section of a chromosome breaks off and joins to another chromosome.
D. occur as a result of non-disjunction in meiosis.

**Question 14**

DNA replication is a very accurate process. Overall, mutations in individual genes are a rare occurrence. Certain environmental factors, known as mutagens, are capable of speeding up mutation rates.

Which of the following is **unlikely** to be a mutagen?

A. mustard gas
B. ultraviolet light
C. nitrous acid
D. polymerase

**Question 15**

While all cells in an individual organism contain the same DNA, the cells of the organism can be quite different in their structure and function. Cells do not necessarily express all the genes of their genome simultaneously.

The expression of genes is **not** dependent on

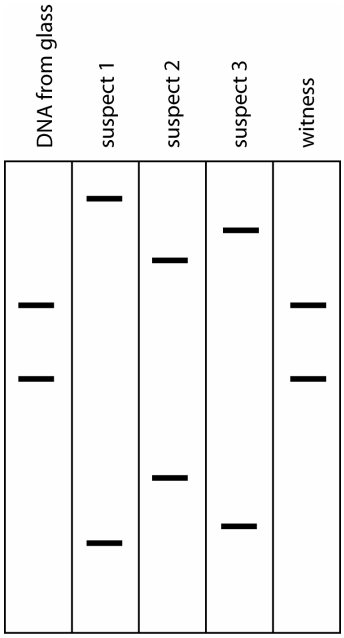
A. cell type.
B. the stage of cell development.
C. whether an organism is unicellular or multicellular.
D. extracellular and intracellular conditions.

*Use the following information to answer Questions 16, 17 and 18.*

A daring daytime smash and grab robbery is carried out on a large jewellery store. The front window is broken and the contents of the window display stolen. Three individuals are seen running from the scene but disappear quickly down a nearby laneway. One of the thieves must have been cut by the broken glass as there is quite an amount of blood found on the broken shards. The blood is swabbed in order to obtain DNA. The samples are processed but the crime remains unsolved as the suspects have not been identified.

Four months later, following the offer of a large reward, a witness comes forward and identifies three suspects. DNA samples are taken from the suspects and the witness and compared with the DNA samples collected at the time of the crime. DNA can be used to identify an individual through a technique known as DNA profiling. The technique relies on the fact that a person's DNA is constant from cell to cell and, consequently, their profile is the same, regardless of what cells are used to obtain the DNA.

The results of the DNA profile are shown in the table below.




**Question 16**

Constructing a DNA profile involves the use of two biotechnological techniques known as

A. electrophoresis and transformation.
B. PCR and electrophoresis.
C. PCR and transformation.
D. electrophoresis and DNA sequencing.

**Question 17**

A DNA profile has been created for all of the individuals involved at the crime scene and the profiles will then be compared with the

A. DNA of the store employees.
B. DNA of the witness.
C. DNA found on the glass.
D. DNA of the suspects.

**Question 18**

On the basis of the results of the DNA profile, the individual most likely to be convicted will be

A. suspect 1.
B. suspect 2.
C. suspect 3.
D. the witness.

**Question 19**

Fossils are the preserved remains of organisms that lived on Earth in the geological past. The discovery of fossils is thought to have initiated the development of ideas about evolution. Fossils are commonly found in rock and their age can be determined using various techniques.

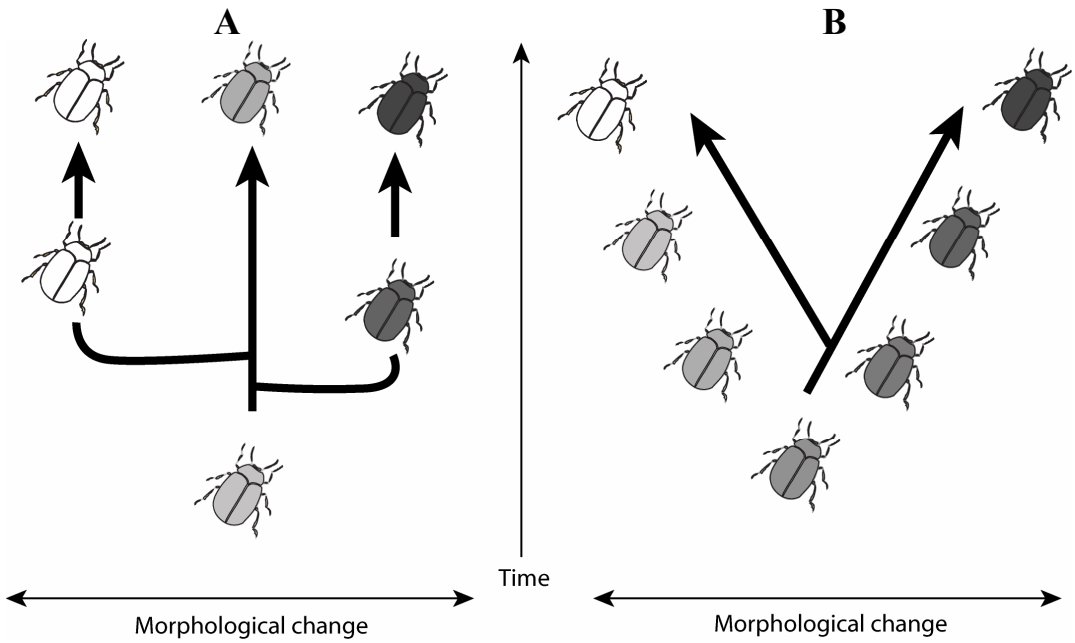
A reliable technique for dating fossils, known as absolute dating, assigns a numerical age to the fossil. Which of the following is **not** an example of an absolute dating technique?

A. use of index fossils
B. radiometric dating
C. electron spin resonance
D. thermoluminescence

**Question 20**

Evolutionary trees commonly represent the descent of species from their ancestors as branches that sprout and diverge gradually, with each new species evolving continuously over long periods of time. However, palaeontologists rarely find gradual transitions of fossil forms of a species over time. In fact, species often appear suddenly as new forms. These new forms persist for some time and then disappear from the fossil record as suddenly as they appeared.

The diagram below is a representation of the two models of descent of species.




Which of the following is true of the diagram?

A. Model A represents the model of evolution known as gradualism.
B. Model A represents the model of evolution known as punctuated equilibrium.
C. Model B represents the model of evolution known as punctuated equilibrium.
D. Model A represents the model of evolution known as gradualism and model B represents the model of evolution known as punctuated equilibrium.

**Question 21**

Two populations of marsupial mice are separated from each other by an area heavily populated by humans. The two populations of mice are clearly different from each other and there are no individuals in either area which display characteristics of both populations.

It is reasonable to assume that

A. the two populations are two separate species.
B. the two populations could be the same species.
C. the two populations are the same species.
D. gene flow has occurred.

**Question 22**

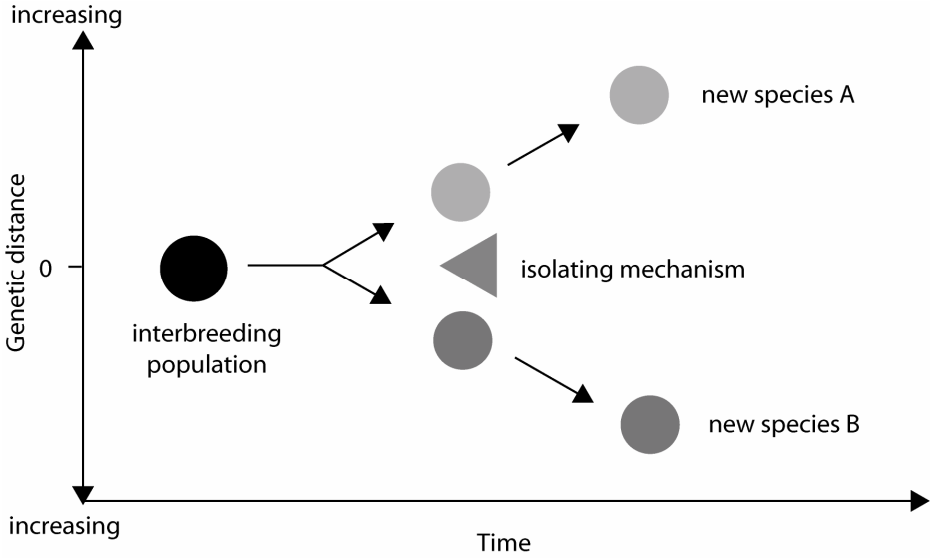
Chance events can cause allele frequencies in a population to change over time. When these random effects operate, the direction of the change is unpredictable and can differ from one generation to the next. The resultant pattern of change is known as genetic drift.

An example of genetic drift is

A. the loss of an allele from a population.
B. the sum of all variation in a population.
C. the phenotypic ratios in a population.
D. the interbreeding of two populations.

**Question 23**

Speciation is the process whereby a new species arises from a parent population. It occurs when the gene pool of the parent population is divided into two gene pools by an isolating mechanism. The two gene pools remain separate from each other and are no longer able to interbreed even when they are reunited.




Isolating mechanisms can operate before or after reproduction in individuals of a population. In animals, a post-reproductive isolating mechanism

A. prevents mating and prevents the production of offspring.
B. allows mating but prevents the production of offspring
C. allows mating but prevents the production of fertile offspring.
D. allows mating and allows the production of fertile offspring.

**Question 24**

Primates are grouped in the order of mammals that share common characteristics and include monkeys and apes. Hominids are the group of primates that

A. have tails.
B. possess semi-opposable thumbs.
C. show adaptations suited to arboreal life.
D. walk upright and have relatively large brains.

**Question 25**

Evidence from cave paintings near Lascaux in France suggest that the Cromagnon people, an early form of *Homo sapiens*, worked co-operatively in their hunting practices to exploit the game herds they pursued. The development of more complex social behaviours and cultural evolution in early humans was attributed to larger brain size and the acquisition of language.

Development of cultural evolution did **not** include

A. cultivation of crops.
B. burial of the dead.
C. hunting and gathering to obtain food.
D. religious rituals.

**END OF SECTION A**

## SECTION B – Short-answer questions

### Instructions for Section B

Answer this section in **pen**.

Answer all questions in the spaces provided.

**Question 1**

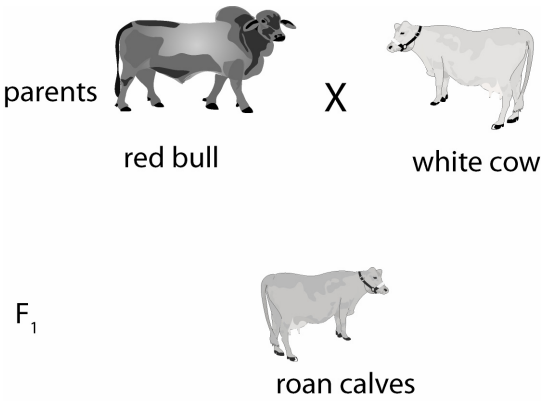
In shorthorn cattle, coat colour is determined by one gene with two alleles.

**a.** What is an allele?

_____

1 mark

The symbols for the alleles are red ($C^R$) and white ($C^W$). When pure breeding red cattle are crossed with pure breeding white cattle, the $F_1$ offspring have roan coats ($C^RC^W$) which have a mixture of red and white hair. The genotype $C^RC^W$ exhibits codominance in the phenotype.




**b.** What is meant by codominance?

_____

1 mark

The $F_1$ offspring are crossed.

**c.** **i.** What are the expected phenotypes for coat colour in the $F_2$?

_____

**ii.** What are the genotypes expected for coat colour in the $F_2$?

_____

1 + 1 = 2 marks

**d.** What is the expected ratio for genotype and phenotype in the $F_2$?

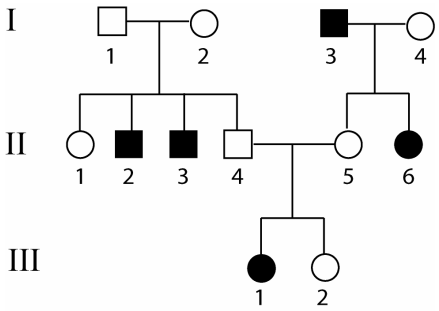
_____

1 mark

Total 5 marks

**Question 2**

In humans, earlobes can be attached or free. Earlobe attachment in a family was investigated over three generations and the data is recorded in the pedigree below. The shaded individuals have attached earlobes.




**a.** **i.** Is the attachment of earlobes a dominant or recessive trait?

_____

**ii.** Using the pedigree, explain the reason for your choice.

_____

_____

**iii.** Assign suitable allele symbols for this condition.

_____

1 + 1 + 1 = 3 marks

**b.** What is the genotype of individual II-1?

_____

1 mark

**c.** **i.** Use a Punnett square to demonstrate the outcome of a cross between individual II-4 and individual II-5.

**ii.** What is the probability that their third child will be homozygous for free earlobes?

_____

2 + 1 = 3 marks

Total 7 marks

**SECTION B** – continued

**Question 3**

Fragile X syndrome occurs in 1 in 1 500 male births and 1 in 2 500 female births. The mutation is often visibly expressed on the X chromosome and is due to an over-duplication of three nucleotides in the FMR-1 gene. In contrast with the normal 30 repeats of the CCG trinucleotide, individuals with fragile X syndrome can have 700 or more repeats within their allele.

**a.** What is the name given to the position of a gene on a chromosome?

_____

1 mark

**b.** What is the term used to describe genes found on the X chromosome?

_____

1 mark

**c.** Why is a male more likely to have fragile X syndrome than a female?

_____

_____

_____

2 marks

Mutations occur in all organisms and can be somatic or germline in their nature.

**d.** What is the difference between somatic and germline mutations?

_____

_____

_____

_____

2 marks

Total 6 marks

**Question 4**

Sickle-cell disease is an inherited blood condition. It is caused by the substitution of a single amino acid in the haemoglobin protein of red blood cells. Instead of normal beta haemoglobin, abnormal haemoglobin S (HbS) is produced. There are two alleles for the beta haemoglobin gene HbA (normal) and HbS (defective). When the oxygen content of an affected individual's blood is low, the HbS crystallises, deforming the red blood cells to a sickle shape. The inability to transport sufficient oxygen leads to tiredness, kidney or heart failure and children with the condition usually die by the age of 10 if it is left untreated.

**a.** What is another type of point mutation that is not caused by a substitution?

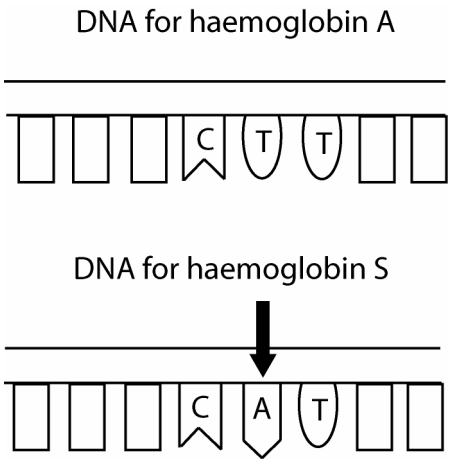
_____

1 mark

Use the table of part of the genetic code (below) to answer parts **b** to **d**.

**second base**

| first base | U | | C | | A | | G | | third base |
|---|---|---|---|---|---|---|---|---|---|
| **U** | UUU | phenylalanine | UCU | serine | UAU | tyrosine | UGU | cysteine | **U** |
| | UUC | phenylalanine | UCC | serine | UAC | tyrosine | UGC | cysteine | **C** |
| | UUA | leucine | UCA | serine | UAA | stop | UGA | stop | **A** |
| | UUG | leucine | UCG | serine | UAG | stop | UGG | trypotophan | **G** |
| **C** | CUU | leucine | CCU | proline | CAU | histidine | CGU | arginine | **U** |
| | CUC | leucine | CCC | proline | CAC | histidine | CGC | arginine | **C** |
| | CUA | leucine | CCA | proline | CAA | glutamine | CGA | arginine | **A** |
| | CUG | leucine | CCG | proline | CAG | glutamine | CGG | arginine | **G** |
| **A** | AUU | isoleucine | ACU | threonine | AAU | asparagine | AGU | serine | **U** |
| | AUC | isoleucine | ACC | threonine | AAC | asparagine | AGC | serine | **C** |
| | AUA | isoleucine | ACA | threonine | AAA | lysine | AGA | arginine | **A** |
| | AUG | methionine/start | ACG | threonine | AAG | lysine | AGG | arginine | **G** |
| **G** | GUU | valine | GCU | alanine | GAU | aspartic acid | GGU | glycine | **U** |
| | GUC | valine | GCC | alanine | GAC | aspartic acid | GGC | glycine | **C** |
| | GUA | valine | GCA | alanine | GAA | glutamic acid | GGA | glycine | **A** |
| | GUG | valine | GCG | alanine | GAG | glutamic acid | GGG | glycine | **G** |




**b.** What amino acid is normally produced in haemoglobin A?

_____

1 mark

**c.** What is the mRNA triplet transcribed from the DNA from the HbS gene?

_____

1 mark

**d.** What amino acid is produced after the point mutation?

_____

1 mark

Total 4 marks

**CONTINUED**
**PLEASE TURN OVER**

**Question 5**

The condition severe combined immunodeficiency (SCID) is caused by a defective gene which disrupts the functioning of the B and T cells of the immune system. Children affected by SCID must live in completely sterile environments due to their susceptibility to disease and infection. The condition has been successfully treated by gene therapy.

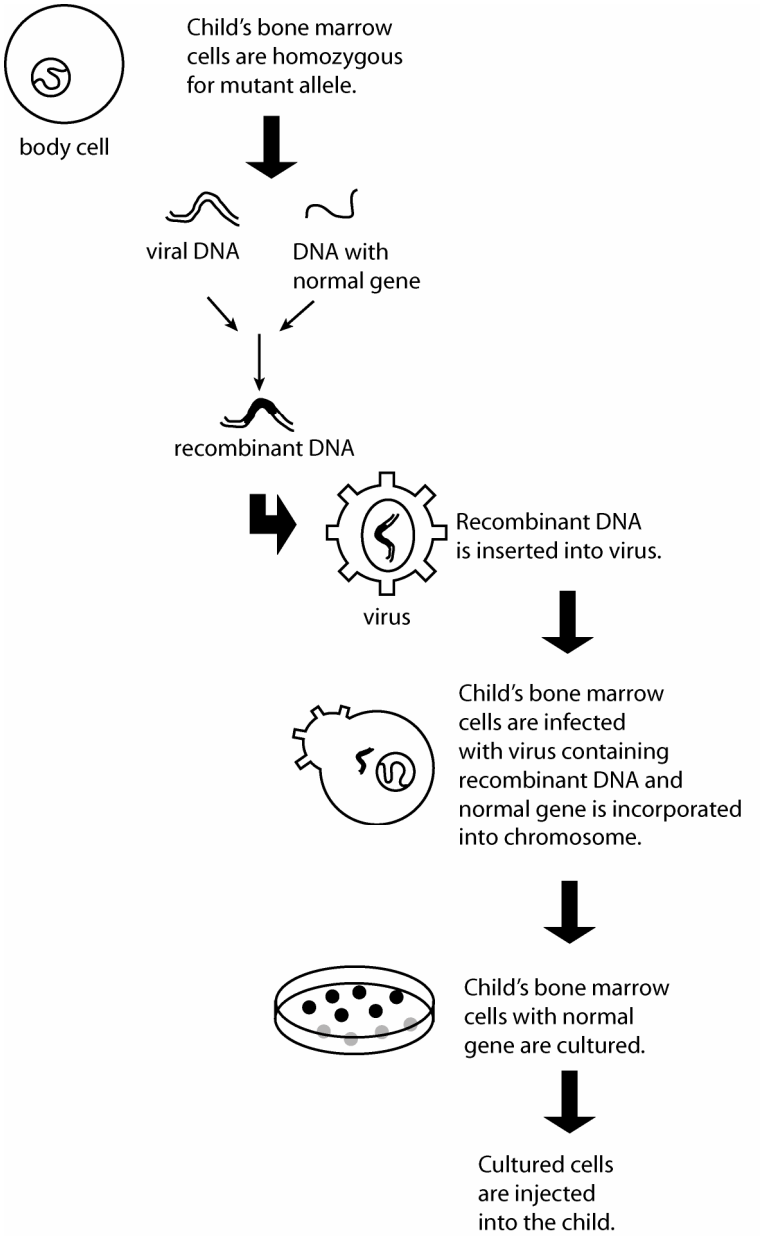
**a.** What is gene therapy?

_____

_____

1 mark

The diagram below outlines the process of gene therapy for SCID.



**b.** **i.** What is the role of the virus in this process?

_____

**ii.** Why is a virus well suited to this role?

_____

_____

1 + 2 = 3 marks

In gene therapy for SCID, bone marrow cells are harvested, cultured and injected back into the child, who then produces functional B and T cells. The desired outcome is that the child demonstrates a normal immune response and remains healthy.

**c.** Why are bone marrow cells ideal for use in gene therapy?

_____

_____

2 marks

**d.** What is a limitation associated with the use of gene therapy?

_____

_____

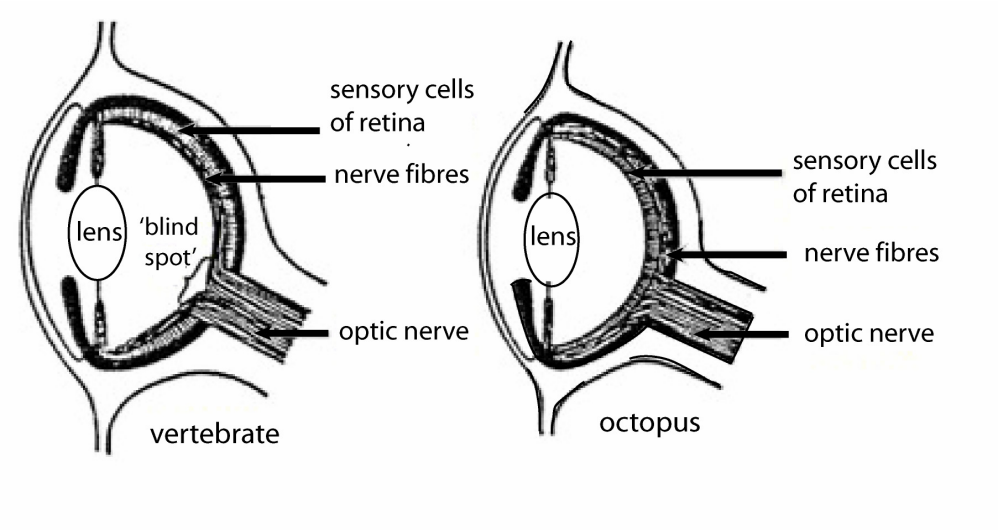
_____

2 marks

Total 8 marks

**Question 6**

The vertebrate eye and the octopus eye appear to be very similar in their structure and function. In the octopus eye, the sensory cells lie in front of the nerve fibres. The vertebrate eye however has an inverted retina which means that the sensory cells of the retina lie behind the nerve fibres. Consequently, the vertebrate eye has a blind spot where the optic nerve emerges from it.




**a.** **i.** What is the term used to describe these similar structures?

_____

**ii.** What is the meaning of this term?

_____

_____

_____

1 + 2 = 3 marks

**b.** What pattern of evolution is demonstrated by these structures?

_____

1 mark

The platypus and the echidna are monotremes currently found only in Australia. Fossils of the ancestor of these animals have been found in Australia in Cretaceous rocks (138 million years BP – 65 million years BP). In Patagonia, South America, rocks formed from Palaeocene sediments (65 million years BP – 54 million years BP) revealed an upper right molar which bore close similarities to the tooth of the ancestral platypus, *Obdurodon*, which was present in Oligocene–Miocene deposits (40 million years BP – 23 million years BP) in Australia. The fine structure of the enamel and ridge patterns of the teeth in the Patagonian and Australian fossils were similar. South America and Australia were joined as part of one landmass which separated in the Cretaceous period (146 million years BP – 65 million years BP).

**c.** What conclusions can be drawn about the fossils found in South America and in Australia?

_____

_____

_____

_____

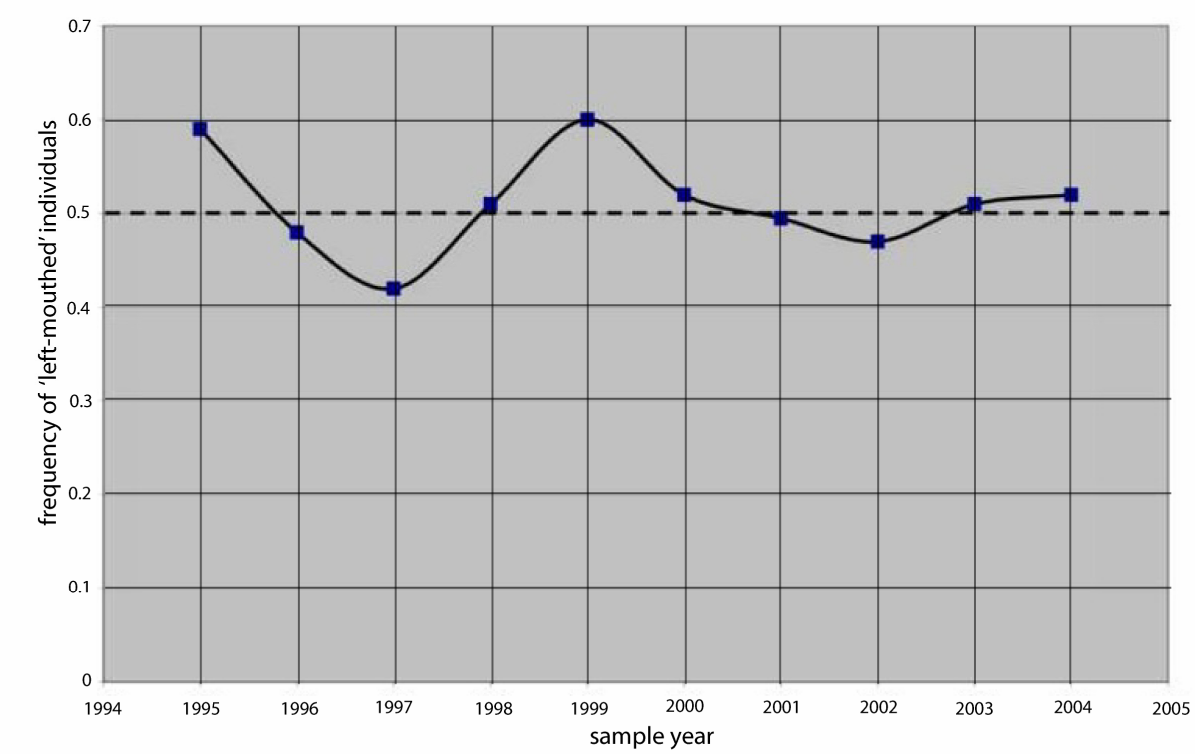
2 marks

Total 6 marks

**CONTINUED**
**PLEASE TURN OVER**

**Question 7**

*Perissodus microlepis* is a small cichlid fish that lives in Lake Tanganyika in Africa. This fish feeds on the scales of other fish by approaching their prey from behind to snatch scales from the flanks of their prey with their mouth. *P. microlepis* has an asymmetrical mouth which is oriented either towards the right or the left and they attack their prey from opposite sides, according to the position of their mouth. The 'right-mouthed' and 'left-mouthed' morphs occur in approximately equal numbers among individuals in a population. A 10-year study of 'left-mouthed' individuals recorded slight variations in relative frequencies. This trait is determined by simple Mendelian inheritance and is an example of a balanced polymorphism.




**a.** What is a polymorphism?

_____

_____

1 mark

**b.** On the graph above, plot the likely frequencies of 'right-mouthed' individuals over the 10-year interval.

1 mark

A hypothesis was proposed:

The fish, which *P. microlepis* preys upon, guard more effectively against attack from either the left side or the right side, depending on which *P. microlepis* morph is more common at the time.

**c. i.** What mechanism is contributing to the balance of the cichlid population?

_____

**ii.** Explain how this mechanism operates for *P. microlepis*.

_____

_____

_____

1 + 2 = 3 marks

Total 5 marks

**CONTINUED**
**PLEASE TURN OVER**

**Question 8**

An amniote is a vertebrate that develops a fluid-filled sac around an embryo. Amniotes are thought to have arisen from cotylosaurs. The fossil record provides no records of fluid-filled sacs surrounding developing foetuses. However, it is generally accepted that they evolved in the late Carboniferous period and were associated with the independence of amniotes from the water. The following table compares the estimated numbers of mutational changes (base substitutions) in the gene that encodes the respiratory protein, cytochrome *c*.

| | | | | | |
|---|---|---|---|---|---|
| pigeon | 0 | | | | |
| duck | 4.5 | 0 | | | |
| chicken | 5.4 | 0.9 | 0 | | |
| penguin | 5.5 | 1.0 | 0.1 | 0 | |
| turtle | 2.1 | 2.4 | 3.3 | 3.4 | 0 |
| | pigeon | duck | chicken | penguin | turtle |

**a.** Which species diverged most recently from the pigeon?

_____

1 mark

**b.** What conclusion can be drawn about the presence of cytochrome *c* in all the amniotes listed?

_____

1 mark

**c.** Use the data from the table above to construct an evolutionary tree which demonstrates the evolutionary relationship between the pigeon, duck and penguin.

2 marks

Total 4 marks

**Question 9**

There have been many human fossils found in Australia since 1884. Radiocarbon dating was used to date some of the skeletons and they were found to range in age from 9 000 years to 29 000 years.

| Fossil location | Age (years) |
|---|---|
| Lake Mungo (New South Wales) | 26 000–29 000 |
| Keilor (Victoria) | 13 000 |
| Kow Swamp (Victoria) | 9 000–13 000 |
| Talgai (Queensland) | 9 000–11 000 |

Radiocarbon dating is suitable for fossil samples up to a particular age, beyond which it is difficult to accurately determine the level of carbon-14.

**a. i.** What principle does radiometric dating depend upon?

_____

_____

**ii.** What alternative dating method would be appropriate for ageing these fossils?

_____

_____

1 + 1 = 2 marks

There were structural differences observed in the fossil skulls from these areas.

**b.** Suggest two explanations for the differences in these skulls.

Explanation 1 _____

_____

Explanation 2 _____

_____

2 marks

Fossil evidence indicates that the earliest human inhabitants arrived in Australia about 60 000 years ago. These inhabitants are most likely to have migrated from South-East Asia.

**c.** How did the first inhabitants get to Australia from South-East Asia?

_____

_____

1 mark

Total 5 marks

**END OF QUESTION AND ANSWER BOOK**