Insight Publications

INSIGHT
Trial Exam Paper

2007

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	8	8	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 23 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.

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.

AREA OF STUDY 1 – Heredity

Question 1

In humans, gametes are cells which pass on genetic information from parent to offspring. Gametes are normally haploid and arise from germ line cells. Germ line cells are

A. haploid.
B. diploid.
C. tetraploid.
D. polyploid.

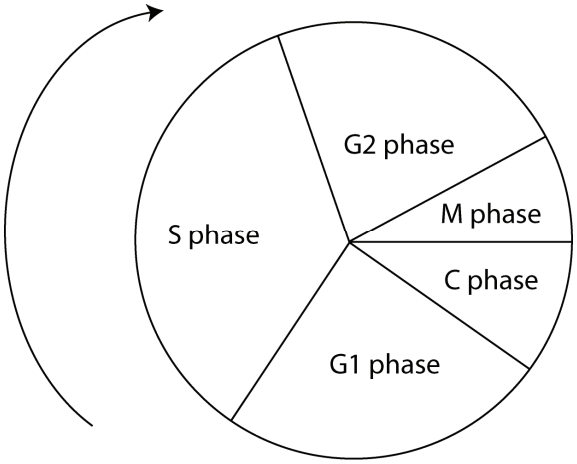
Question 2

The chromosomes in a human somatic cell can be arranged to form a karyotype. In a normal human male the chromosomes in a karyotype will be arranged into

A. 46 pairs of chromosomes, which include one large X chromosome and a smaller Y chromosome.
B. 44 pairs of chromosomes, which include one large X chromosome and a smaller Y chromosome.
C. 23 pairs of homologous chromosomes, including one large X chromosome and a smaller Y chromosome.
D. 22 pairs of homologous chromosomes and one large X chromosome and a smaller Y chromosome

Question 3

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.



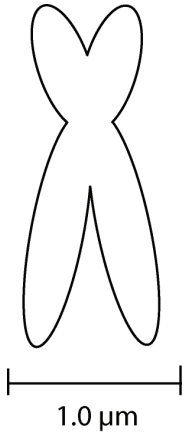
It would be expected that the mass of the cell would increase measurably during

A. S phase.
B. G1 phase.
C. G2 phase.
D. M and C phases.

Use the following information to answer Questions 4 and 5.

Question 4

When a eukaryote cell prepares to divide it, duplicates each of its chromosomes. The diagram shows a chromosome after duplication.



From the diagram, a duplicated chromosome consists of

A. a double-stranded chromosome which narrows at the centriole.
B. an homologous pair of chromosomes which narrow at the centromere.
C. two sister chromatids which narrow at the centromere.
D. two sister chromatids which narrow at the centriole.

Question 5

A duplicated chromosome viewed through a scanning electron microscope (SEM) shows a hairy appearance because each strand consists of a very long fibre which is folded and coiled in a compact arrangement. This fibre is

A. a DNA-protein complex known as chromatin.
B. also known as a nucleosome.
C. made up entirely of histones.
D. part of the troponin complex.

Question 6

In living organisms genes are regarded as the smallest physical unit of heredity. Different genes have

A. the same length open reading frame.
B. different nucleotide sequences.
C. the same number of nucleotides.
D. identical nucleotide sequences.

Question 7

Genes contain coded instructions for joining specific amino acids into proteins. Each segment of the coding region of a gene is known as the

A. exon.
B. intron.
C. promoter.
D. flanking region.

Question 8

After mating, two polled (hornless) cattle produced a calf with horns. It would be reasonable to conclude that

A. all horned × horned matings would produce only horned offspring.
B. all polled × polled matings would produce horned offspring.
C. the presence or absence of horns is a monogenic trait with three alleles.
D. horned is dominant to polled.

Use the following information to answer Questions 9 and 10.

Question 9

In guinea pigs, two genes and their alleles are

Gene for coat length	**L**	short
	l	long

Gene for coat colour	**B**	black
	b	white

These genes control two unrelated characteristics and therefore

A. are considered to be linked.
B. do not assort independently.
C. are found on homologous chromosomes.
D. assort independently.

Question 10

Guinea pigs with the genotype **LlBb** will have

A. long, white-haired coats.
B. long, black-haired coats.
C. short, white-haired coats.
D. short, black-haired coats.

Question 11

An anticodon is a triplet sequence of bases found on a

A. mRNA molecule.
B. template strand of DNA.
C. tRNA molecule.
D. rRNA molecule.

Use the following information to answer Questions 12 and 13.

The sequence of bases in the template strand of a piece of DNA is

A A G T C C A T G G A C

Question 12

The sequence of bases in the complementary strand of the same piece of DNA would be

A. A A G T C C A T G G A C
B. C C T G A A C G T T C A
C. U U C A G G U A C C U G
D. T T C A G G T A C C T G

Question 13

The base sequence of the mRNA produced from this piece of DNA would be

A. T T C A G G T A C C T G
B. U U C A G G U A C C U G
C. A A G U C C A U G G A C
D. A A G T C C A T G G A C

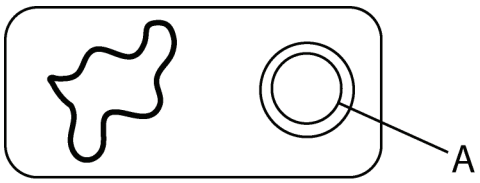
Question 14

During embryonic development there are active genes that control the expression of structural genes thus ensuring that body parts are built in the correct positions. These genes are known as

A. homeotic genes.
B. structural genes.
C. regulator genes.
D. functioning genes.

Question 15

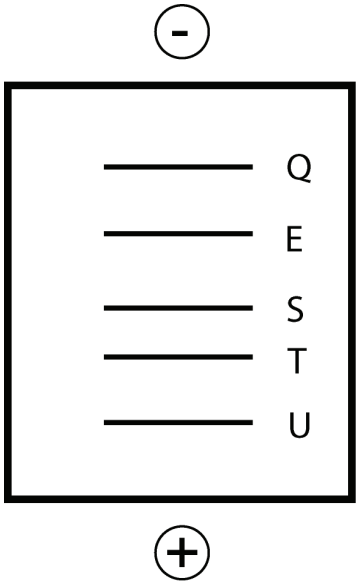
The diagram represents a bacterial cell. The structure labelled **A** found in many bacterial cells is known as a



A. primer.
B. promoter.
C. probe.
D. plasmid.

Use the following information to answer Questions 16 and 17.

A segment of linear DNA was isolated and cut using a restriction enzyme. The fragments of DNA were then placed in a gel and separated by electrophoresis. The diagram below shows the gel and fragments at the end of electrophoresis.



Question 16

Prior to cutting with the restriction enzyme, the segment of DNA has

A. eight recognition sites.
B. five recognition sites.
C. four recognition sites.
D. three recognition sites.

Question 17

Of the fragments obtained in the gel, which is the largest fragment?

A. Fragment Q is the largest.
B. Fragment S is the largest.
C. Fragment U is the largest.
D. All fragments are the same size.

Question 18

Seed mass is a phenotype shown in bean plants. It has been demonstrated that on occasions heavy parental (P) seeds can produce F1 plants with seeds of lighter mass than normal. In addition these lighter seeds demonstrate a range of masses. This can be explained by the fact that seed mass is an example of

A. genetic drift.
B. discontinuous variation.
C. polygenic inheritance.
D. monogenic inheritance.

Use the following information to answer Questions 19 and 20.

In shorthorn cattle, coat colour is controlled by a gene with the alleles **R** (red hair) and **r** (white hair). A heterozygous cow will have a roan coat (mixture of both red hairs and white hairs). A population of one hundred cows was sampled to investigate coat colour. The results are shown in the table.

genotype based on coat colour	**RR**	**Rr**	**rr**
number of cows of each genotype	80	10	10

Question 19

The relationship that best describes this expression of alleles is

A. complete dominance.
B. incomplete dominance.
C. co-dominance.
D. partial dominance.

Question 20

From the data above, it is possible to conclude that

A. there is a total of 100 alleles in this population.
B. the frequency of the **R** allele is 0.9.
C. the frequency of the **r** allele is 0.3.
D. the total number of **r** alleles is 30.

Question 21

In a population of living organisms, allele frequencies can change over time. The change in allele frequencies is **not** due to

A. random mating.
B. chance.
C. migration.
D. selection.

Question 22

Mitochondrial DNA (mtDNA) can be used to trace the evolutionary history of a species. A characteristic of mtDNA **not** used to distinguish it from nuclear DNA is

A. lack of recombination.
B. descent through the maternal line.
C. high copy number.
D. molecular structure.

Question 23

Carbon-14 (^{14}C) dating is used to estimate the age of fossilised organic material up to the age of 60 000 years. In comparison, electron spin resonance (ESR)

A. relies on radioactive decay in order to make its estimation of fossil age.

B. is used to estimate the age of material more than one million years old.

C. determines the alignment of the Earth's magnetic field at the time when the sample was last heated above a critical level.

D. measures the microwave energy absorbed by samples exposed to radiant energy in the distant past.

Question 24

The evolution of bipedal locomotion in early hominins was accompanied by significant modifications in the skeleton. One of the characteristics **not** associated with bipedal locomotion is the

A. shape and positioning of the shoulder blades.

B. arrangement of the femur and tibia.

C. structure and shape of the pelvis and hip bone.

D. position of the foramen magnum.

Question 25

The origin of the human species is thought to have been in Africa. Rather than evolving in a simple linear progression, the hominin line has been shown to have emerged in a branching manner with several different hominin species coexisting. Despite this, it has been determined that the hominin species appeared in the fossil record from oldest to most recent in the following order

A. *A. anamensis, A. africanus, H. sapiens, H. habilis*.

B. *A. afarensis, A. africanus, H. habilis, H. heidelbergensis*.

C. *H. sapiens, H. habilis, A. africanus, A. ramidus*.

D. *A. ramidus, H. rudolfensis, A. africanus, H. heidelbergensis*.

END OF SECTION A
TURN OVER

SECTION B – Short-answer questions

Instructions for Section B

Answer this section in **pen**.

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

Question 1

In cats the ability to produce a tail is genetically controlled by a single gene. The gene which controls the development of a tail in Manx cats has the following alleles:

$\mathbf{M}^{L}$ – taillessness **M** – normal tail

It is known that tailless Manx cats are heterozygous ($\mathbf{M}^{L}\mathbf{M}$) and carry a recessive allele for normal tail.

a. What would be the genotype of a cat with a normal tail?

_____

1 mark

A cross is made between a Manx cat and a cat with a normal tail.

b. What genotypic ratio and phenotypic ratio would be expected in the offspring of the cross between these two cats? Ensure that the correct allelic symbols are used.

_____

_____

_____

_____

_____

3 marks

A research group studying inheritance patterns performed a large number of crosses with the Manx offspring from the initial cross. They found that their crosses always produced offspring in a ratio of two Manx cats to one normal tailed cat (2 Manx: 1 normal)

c. What is the most likely explanation for this result?

_____

_____

_____

1 mark

Huntington's disease is a degenerative medical condition which affects adult humans, usually between the ages of 35–45 years. It is characterised by deterioration of the nervous system and is fatal.

d. Why does Huntington's disease persist in the human population if it is fatal?

_____

_____

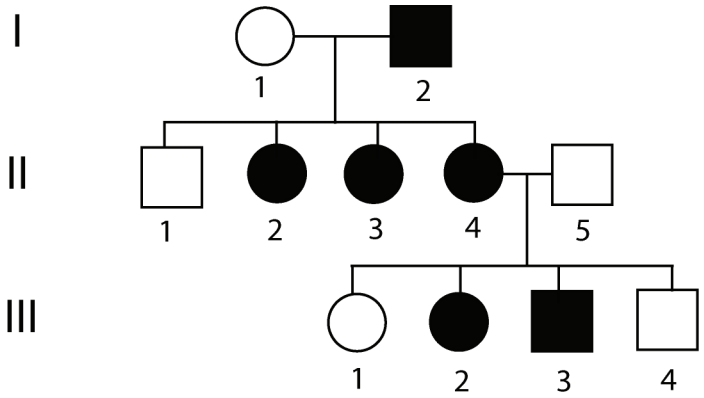
_____

2 marks
Total 7 marks

CONTINUED
PLEASE TURN OVER

Question 2

Vitamin D-resistant rickets is an inherited condition controlled by the HYP gene and is expressed even if an individual has only one copy of the allele present. The following pedigree shows a portion of a family in which some of the members have rickets. The shaded individuals on the pedigree have rickets.



a. What is the most likely form of inheritance shown? Support your response by referring directly to the pedigree.

_____

_____

_____

_____

2 marks

b. What is the genotype of individual **II-4**?

_____

1 mark

c. i. Use a Punnett square to demonstrate the outcome of a cross between individual **III-3** and an unrelated heterozygous affected female.

2 marks

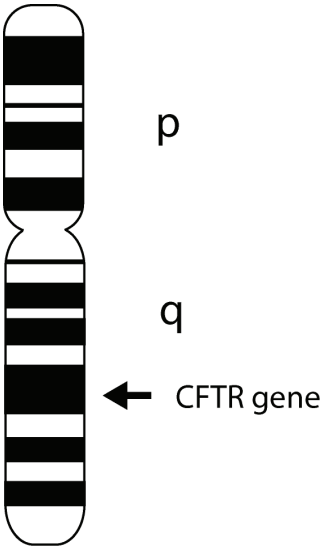
c. ii. What is the probability that the couple will produce a son who does not have Vitamin D-resistant rickets? Show your working.

_____

1 mark
Total 6 marks

Question 3

Cystic fibrosis (CF) is an inherited disorder caused by a mutation of the cystic fibrosis transmembrane conductance regulator (CFTR) gene and in Australia occurs in approximately 1 in 2000 Caucasian births, with a carrier frequency of 4%. The CFTR gene is located on chromosome 7 and produces a protein (CFTR) that binds to cell membranes and acts as a channel to regulate the transport of chloride ions out of cells.



Individuals with CF demonstrate defective transport of chloride ions and secrete thick mucus which collects in and blocks airways and pancreatic ducts. Signs of CF include production of salty sweat, blockage and infection of airways and lungs, heart complications and malabsorption from the digestive tract. Individuals who are heterozygous for this mutation are not symptomatic for the condition.

a. What form of inheritance is CF?

_____

1 mark

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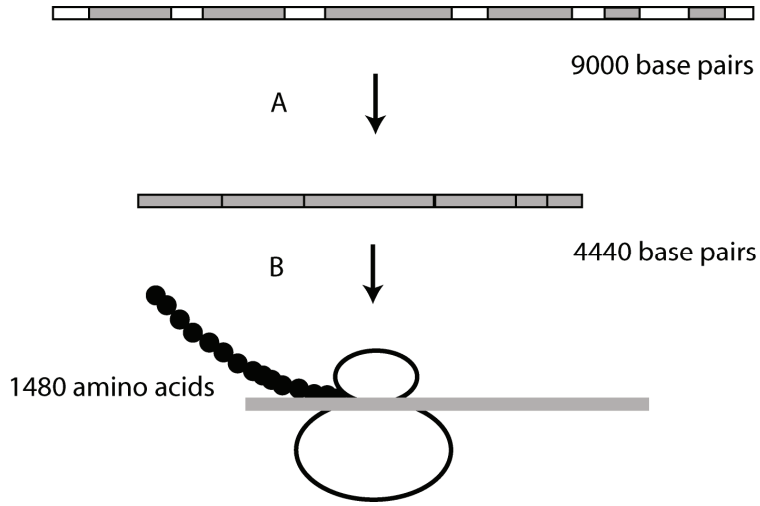
PLEASE TURN OVER

The normal form of CFTR is made up of a chain of 1480 amino acids with more than 500 mutations of the CFTR gene having been described. The following diagram outlines the steps associated with the production of CFTR.



b. i. What is the name of the process that occurs at A?

_____

1 mark

b. ii. What occurs between processes A and B to reduce the number of base pairs from 9000 to 4440 base pairs?

_____

_____

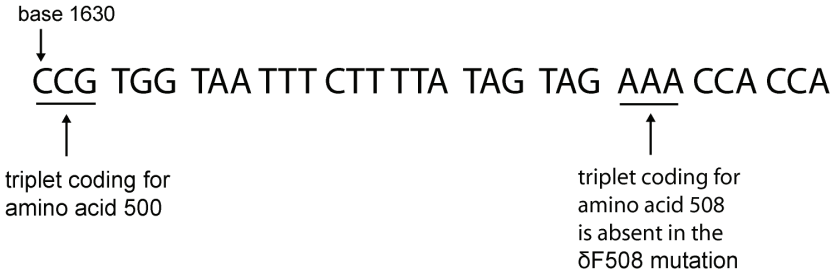
1 mark

b. iii. What is the name of the process that occurs at B?

_____

1 mark

A common mutation known as the δF508 is associated with the 508th triplet in the DNA sequence of the CFTR gene and causes the absence of CFTR from its correct position in the cell membrane. Part of the DNA sequence that codes for CFTR is presented below.



c. What type of mutation occurs at the 508th amino acid position?

_____

1 mark

SECTION B – Question 3 – continued

CF in humans has been investigated using 'knockout' mice. Experiments with knockout mice demonstrated that when copies of the normal CF gene were transferred into cells lining their airways, their symptoms of CF were reduced.

d. What is a knockout mouse?

_____

_____

1 mark

As a result of the studies using knockout mice, clinical trials for human individuals with CF commenced. Normal CFTR genes were isolated and introduced to patients using adenoviruses (which were piped directly into lungs) and liposomes (which were inhaled as an aerosol). The human clinical trials have only shown a 25% correction of CF, with short-lived effects and in the case of the adenovirus, the death of one patient.

e. i. What other general name is given to adenoviruses and liposomes in gene therapy?

_____

1 mark

e. ii. What is a liposome and how does it deliver a normal CFTR gene to a cell?

_____

_____

_____

_____

2 marks

f. Why are the effects of gene therapy for CF so temporary?

_____

_____

1 mark
Total 10 marks

Question 4

Malaria is a disease which is caused by a protozoan from the genus *Plasmodium*. There are many forms of malaria, the most severe of which is caused by *Plasmodium falciparum*. Humans become infected if they are bitten by a female *Anopheles* mosquito which is carrying sporozoites in its salivary glands. The sporozoites enter the blood of the victim and infect the liver where they form merozoites. The merozoites leave the liver, enter red blood cells and reproduce by mitosis. Infected red blood cells eventually rupture and large numbers of the malarial parasite are released, along with their metabolic wastes, into the bloodstream. This results in the symptoms of chills, shaking and burning fever which are associated with malaria. The released parasites can then go on to infect more red blood cells. Drugs are available to treat malaria; however, a complete cure is difficult because the parasite is capable of remaining dormant in the liver for many years.

Travellers to countries where malaria is prevalent are advised to take anti-malarial drugs before, during and after their visit; however, this is no longer a guarantee against infection.

a. i. Why might anti-malarial drugs no longer be successful in preventing malarial infection?

_____

1 mark

a. ii. Apart from the fact that travellers could be infected with malaria, identify another serious consequence of ineffective anti-malarial drugs.

_____

1 mark

Control of malaria has become very difficult and much research has been directed towards finding a successful strategy that will eradicate the disease. Recently scientific trials have resulted in the production of transgenic mosquitoes which cannot pass on malaria.

b. What is the difference between a genetically modified organism and a transgenic organism?

_____

_____

_____

2 marks

c. What are two techniques that might be used to develop transgenic organisms?

_____

_____

1 mark

In a study using transgenic mosquitoes, researchers combined equal numbers of transgenic and wild-type mosquitoes which were fed on malaria-infected mice. The mice were infected with *Plasmodium* – the parasite that causes malaria in humans. After nine generations, the number of mosquitoes in the two populations was compared.

	Generation 1	**Generation 9**
Transgenic mosquitoes	0.5	0.7
Wild-type mosquitoes	0.5	0.3

d. i. What is being described by the numerical value attributed to the transgenic and the wild-type mosquitoes at Generation 9?

_____

1 mark

d. ii. Identify one factor that might have contributed to the greater proportion of the transgenic mosquitoes.

_____

1 mark
Total 7 marks

CONTINUED
PLEASE TURN OVER

Question 5

Neofelis diardi, also known as the Bornean clouded leopard, lives on the South-east Asian islands of Borneo and Sumatra and has been identified as a new species of leopard. Clouded leopards were first documented in 1821 and *Neofelis nebulosa* is the species found on the South-east Asian mainland. Until recently the mainland and island animal were thought to have been the same species, however DNA tests highlighting around 40 nucleotide differences between the two species (lions and leopards have 56 nucleotide differences) suggest the two species separated 1.4 million years ago. Results from the genetic study are also supported by separate research based mainly on fur patterns and colouration of skins. The new clouded leopard species is generally darker than the mainland species, has small cloud markings, many distinct spots within the cloud markings, greyer fur and a double dorsal stripe. Clouded leopards from the mainland have large clouds on their skin with fewer, often faint, spots within the cloud markings and they are lighter in colour, with a tendency toward tawny-coloured fur and a partial double dorsal stripe.

a. How could the ancestors of the Bornean leopard have arrived in Borneo and Sumatra from the South-east Asian mainland?

_____

1 mark

b. What kind of speciation has occurred in the clouded leopard?

_____

1 mark

c. Explain how the differences between the two populations of clouded leopard have come about.

_____

_____

_____

_____

_____

_____

_____

_____

2 marks

d. What form of evolution has occurred in the speciation of the Bornean leopard?

_____

1 mark
Total 5 marks

Question 6

Proteins are biological molecules, the basic unit of which is an amino acid. The production of all proteins is genetically controlled and any difference in the sequence of amino acids is indicative of a change in DNA sequence.

The following table shows the number of differences that exist in the amino acid sequence of the beta chain of haemoglobin in humans and other vertebrates. Haemoglobin is the protein in red blood cells that is responsible for oxygen transport. In adults, the haemoglobin molecule is comprised of four polypeptide chains, 2 alpha chains consisting of 141 amino acids and 2 beta chains consisting of 146 amino acids.

Vertebrate	No. of amino acids different from humans
gorilla	1
gibbon	3
rhesus monkey	8
mouse	27
chicken	45
frog	67

a. Which vertebrate is most closely related to humans?

_____

1 mark

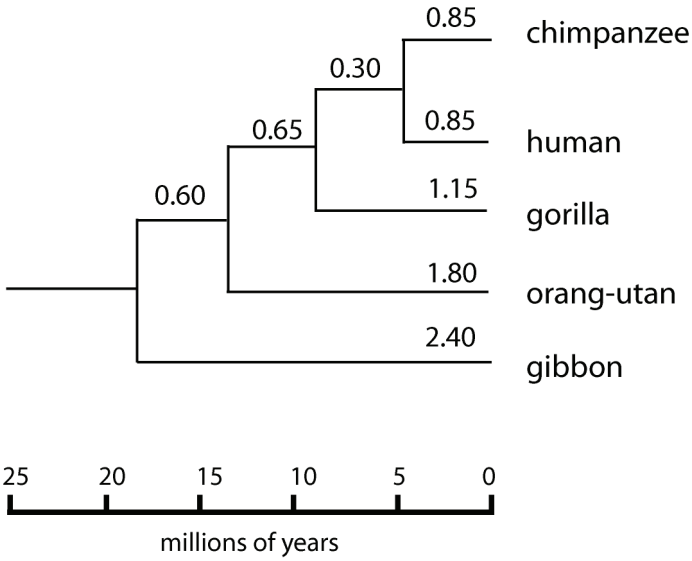
b. Why can the comparison of amino acid differences in proteins be used to determine how closely different vertebrates are related?

_____

_____

1 mark

The following diagram is an evolutionary tree showing the inferred relationships between groups of primates based on DNA hybridisation evidence.



c. How can DNA hybridisation provide a measure of genetic relatedness between species?

_____

_____

_____

2 marks

From the diagram it is possible to infer that the gibbon line diverged around 20 million years ago. After completion of the DNA–DNA hybridisation and in order to be more certain about time scales, it is essential to calibrate the evolutionary tree against some other measure.

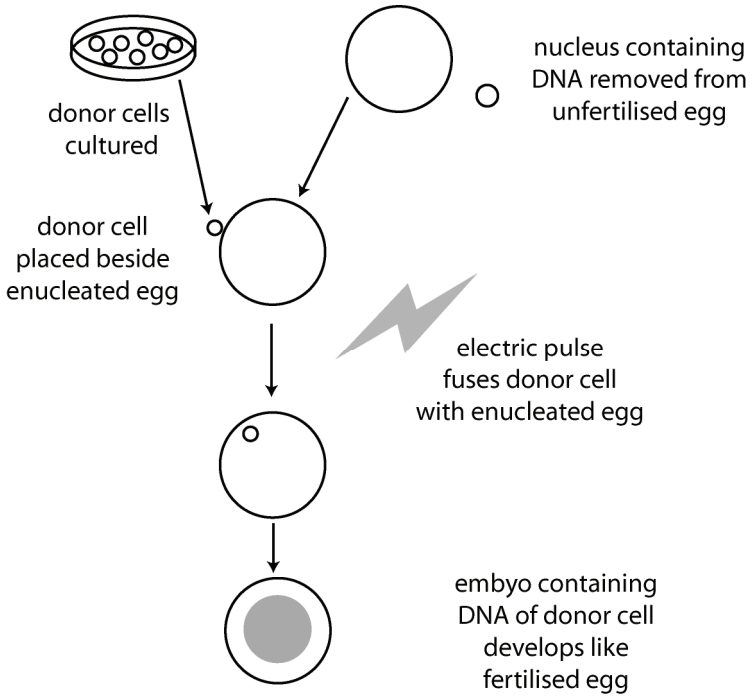
d. In order to identify a time scale for this evolutionary tree, what other form of evidence would be used for calibration?

_____

1 mark
Total 5 marks

Question 7

Cloning is the process of producing genetically identical organisms from one parent. There are two known techniques for cloning an organism. The following diagram outlines the technique used to produce the Afghan hound 'Snuppy' (named after the **S**eoul **N**ational **U**niversity p**uppy**), the first dog to be artificially cloned from the ear cell of a 3-year-old Afghan hound.



a. i. What is the name of the reproductive cloning technique shown in the diagram?

_____

1 mark

a. ii. Explain how the technique you have identified in **7ai.** differs from therapeutic cloning.

_____

_____

_____

1 mark

a. iii. How might the application of therapeutic cloning affect the evolutionary process?

_____

_____

_____

1 mark

In order to produce Snuppy, 123 embryos were implanted into surrogate females, only three embryos survived. Of these embryos one died just prior to birth, another died soon after birth and the third was the only survivor – Snuppy. Clearly the success of live births from cloning is not high.

b. What is another disadvantage associated with this cloning technique?

_____

1 mark

It has been hypothesised that animals cloned from adult somatic cells will age more rapidly than those which have been cloned from younger somatic cells.

c. Why might animals cloned from adult somatic cells age more rapidly?

_____

_____

1 mark
Total 5 marks

Question 8

Over time, human populations have been affected by change which has resulted in the variations observable between different indigenous populations. Biological evolution is one type of change that has occurred in the human population and has affected inherited phenotypes.

a. What is the name given to the process through which biological evolution occurs and what is its outcome?

_____

_____

1 mark

In humans, the ability to digest lactose, a sugar found in milk, is due to the presence of an enzyme. Individuals who can digest lactose are considered to be 'lactose tolerant' while those who cannot are 'lactose intolerant'. Mammals are usually lactose tolerant, with humans showing tolerance up to the age of four years. Beyond this age however, lactose intolerance becomes increasingly common. Lactose intolerance results in abdominal cramps, bloating and diarrhoea and occurs soon after consuming fresh milk or fresh milk products.

b. Is the human population monomorphic or polymorphic in terms of its ability to digest lactose? Explain your answer.

_____

_____

1 mark

c. Humans have not always been lactose tolerant. What is the most likely cause of lactose tolerance?

_____

1 mark

Domestication of wild cattle occurred as the first human communities established agricultural practices.

d. At this time, would one of the phenotypes have been at a selective advantage? Explain your answer.

_____

_____

_____

2 marks
Total 5 marks

END OF QUESTION AND ANSWER BOOK