

SECTION A – Multiple-choice questions**Question 1**

Female green turtles, *Chelonia midas*, lay over 100 eggs at a time and bury them in the sand on beaches along Australia's tropical coastline before returning to the sea. If they are incubated at high temperatures (above 31°C) males hatch. If they are incubated at low temperatures (below 27°C) females hatch. At temperatures around 29°C about equal numbers of males and females hatch.

This example indicates that sex determination in the phenotype of green turtles is determined by

- A. genotype
- B. environment
- C. sex chromosomes
- D. genotype, environment and sex chromosomes

Question 2

The **polymerase chain reaction** (used in gene technology) and **DNA replication** (that occurs before cell division can take place) are similar because they

- A. are both semi-conservative
- B. involve replication of a target segment of a chromosome
- C. produce millions of copies
- D. use enzymes to separate the double helix

Question 3

Independent assortment or random segregation can occur during

- A. anaphase I of mitosis
- B. anaphase II of meiosis
- C. prophase I of meiosis
- D. metaphase I of mitosis

Information for Questions 4 and 5

The following figures have been determined in the analysis of the genome of a variety of organisms.

Organism	Base pairs (millions)	Number of genes
<i>E. coli</i> (bacteria)	4.6	4288
Yeast	12	6000
<i>C elegans</i> (nematode worm)	100	more than 19,000
Fruit fly	180	
<i>Homo sapiens</i> (humans)	3500	40 – 60 k

Question 4

From this information, and your knowledge, it can be stated that

- A. every gene must be made up of millions of base pairs
- B. some of the segments of base pairs are non-coding called exons
- C. the more complex an organism, the more genes will be present in its genome
- D. base pairs can occur in both DNA and RNA

Question 5

The base pairs of DNA include

- A. guanine – adenine
- B. cytosine – thymine
- C. adenine – thymine
- D. adenine – uracil

Question 6

Prokaryotes possess

- A. DNA in a chromosome
- B. RNA in plasmids
- C. no chromosomes
- D. DNA but no RNA

Information for Questions 7 and 8

The table below lists some of the amino acids and the base sequences on a messenger-RNA strand which code for them in protein synthesis.

Amino acid	mRNA code
tyrosine	UAU
alanine	GCA
phenylalanine	UUU
leucine	UUA
arginine	CGU
glycine	GGG
arginine	AGG

Question 7

The sequence of three bases in m-RNA is called

- A. a codon
- B. a triplet
- C. an anticodon
- D. an intron

Question 8

A DNA strand has the base sequence AAT CGC AAA TCC CGC ATA ATT TAG

If a single base deletion occurred after the sequence AAA, the name of the **fifth** amino acid in the polypeptide chain formed would be

- A. alanine
- B. leucine
- C. arginine
- D. glycine

Information for Questions 9, 10 and 11

The following table shows some of the possible sex chromosome patterns that determine maleness and femaleness for three different types of animals.

Sex chromosome pattern	Fruit fly	Chicken	Human
X	male		female
XX	female	male	female
XY	male	female	male
XXX	female		female
XXY			

Question 9

From this information it can be concluded that

- A. the pattern of sex determination in humans and chickens is the same
- B. the Y chromosome determines maleness in fruit flies
- C. a human with a pattern of XXY would be a female
- D. in chickens a chromosome pattern of XXX is male

Question 10

The abnormal number of sex chromosomes (X, XXX and XXY) that can sometimes occur in humans usually results from

- A. a gene mutation that occurs during gamete formation
- B. non-disjunction of homologous chromosomes during meiosis
- C. random assortment of chromosome pairs during meiosis
- D. a mistake in crossing-over resulting in translocation

Question 11

In domesticated chickens a gene which determines the colour of the feathers of certain breeds is located on the X chromosome. The Y chromosome does not carry a gene for feather colour as it is a smaller chromosome. The gene for feather colour has two alleles – F for silver feathers and f for gold feathers.

Using this information and the sex chromosome pattern for chickens shown in the previous table, which one of the following crosses could result in a gold feathered male chicken?

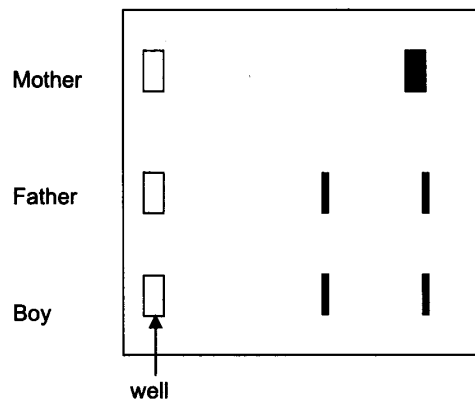
- A. a heterozygous silver male × silver female
- B. a homozygous silver male × silver female
- C. a heterozygous silver male × gold female
- D. a homozygous silver male × gold female

Information for Questions 12 and 13

A gel electrophoresis was carried out on DNA extracted from the white blood cells of a young boy to determine if he had inherited a gene for Huntington's disease (HD) and would therefore show symptoms of the disease later in life. HD is inherited as a dominant characteristic and will therefore be expressed if only one allele is inherited. The age of onset of the disease is often not until 20 – 40 years of age.

The HD allele is the result of a mutation which is called a 'stutter' as it results in the (CAG) code being repeated a large number of times. This means the DNA segment of the HD allele will be longer than the normal allele.

The following gel pattern was obtained for the boy and it is shown compared to the gel patterns of the DNA of his two parents.

**Question 12**

The DNA has

- A. moved from left to right as it is positive
- B. separated into bands as it is different weights
- C. formed bands of single molecules of DNA
- D. moved further if the segments are shorter

Question 13

The results indicate

- A. the father is a carrier of the HD allele
- B. the mother will develop HD later in her life
- C. the boy is heterozygous for the HD gene
- D. the boy inherited the HD allele from his mother

Information for Questions 14, 15 and 16

Cell division is controlled by genes and normally stops when enough cells have been made to perform a particular task. If these cells undergo a mutation they may form **oncogenes** or cancer-causing genes. In the mutated cells, cell division runs out of control and cells continue to divide and may form a tumour (for example, lung, breast or skin tumour).

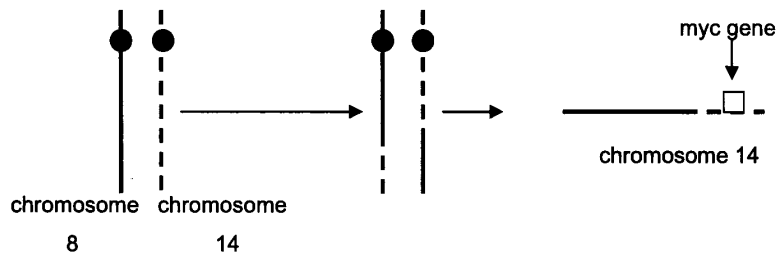
Question 14

Factors such as smoking, ultra-violet light and chemicals in the environment have been found to increase the rate of cancer. These factors are called

- A. malignants
- B. mutagens
- C. mitotic-stimulants
- D. malformations

Question 15

The mistake which leads to the mutation resulting in an oncogene called the *myc gene* in humans is shown in the following diagram. This gene is 'switched on' all the time and therefore encourages cells to divide indefinitely resulting in cancer tumours.



From the following choose the correct combination for the type of cell division when the above mutation would occur and the type of mutation.

	Type of cell division	Type of mutation
A.	meiosis	translocation
B.	meiosis	inversion
C.	mitosis	reversal
D.	mitosis	translocation

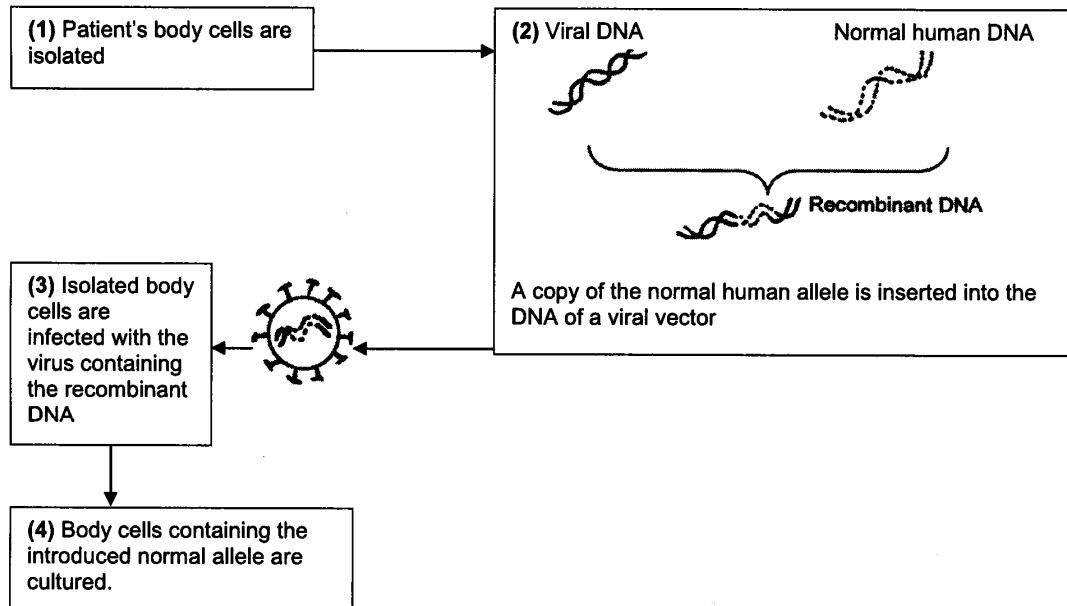
Question 16

Cells carrying oncogenes that encourage cells to survive and not die have now been discovered. One such gene called *Bcl-2* is usually inactivated by a *bim* protein in human cells. However if there is too much *Bcl-2* the mutated cells survive resulting in cancer. This type of cancer proliferation is due to a lack of

- A. gene expression
- B. gene activation
- C. lysis
- D. apoptosis

Information for Questions 17 and 18

Gene therapy is the gene technology used to correct or replace defective genes. It requires a **gene delivery system** – a way to deliver the gene into the patient’s cells. One such technique called **transfection** uses an infectious agent such as a virus. This method is briefly outlined below.



Question 17

Which of the following combinations is correct?

	Step (1) – cells used are	Step (2) uses the enzyme(s)	Step (4) is called/involves
A.	somatic	ligase	mitosis
B.	germ-line	restriction and ligase	meiosis
C.	somatic	restriction and ligase	cloning
D.	germ-line	restriction	fertilisation

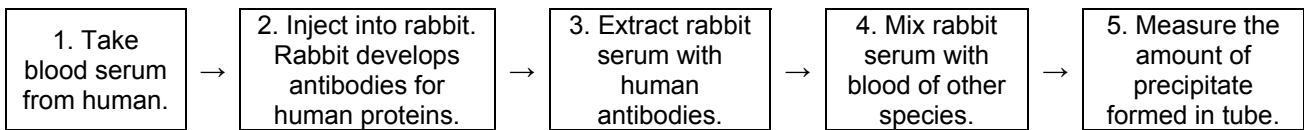
Question 18

Other types of gene delivery systems in human patients have used hypodermic needle injection and aerosols. A recent invention uses **ballistic DNA injection** in which plasmid DNA encoding for the gene of interest is coated on to microbeads and then ‘fired’ at target cells using gas pressure or a high voltage discharge from a **gene-gun**. One of the main advantages of this method would be

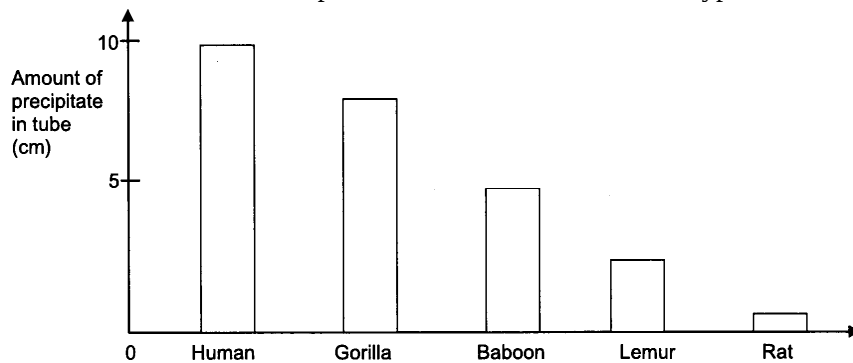
- A. plasmids are readily available in bacteria
- B. the target cells will not be damaged
- C. many patients react adversely to the hypodermic needle injections
- D. the precise target cells can be injected

Question 19

Immunological studies provide a method of indirectly estimating the degree of similarity of proteins in different species; the greater the difference in proteins, the more distant the evolutionary relationship. The method for immunological comparison is briefly outlined below.



The following results were obtained from samples of blood from five different types of animal.



The results indicate that

- A. the more similar the blood sample to the original human blood, the less the reaction
- B. the rat and lemur blood show more recognition of anti-human antibodies than that of the gorilla and baboon
- C. when anti-human antibodies are added to human blood there is a low degree of affinity
- D. the closer the evolutionary relationship, the more precipitate formed

Question 20

Which of the following is **essential** for allopatric speciation to take place?

- A. a high mutation rate
- B. abundant variation in the population
- C. a physical barrier
- D. a migrating population

Question 21

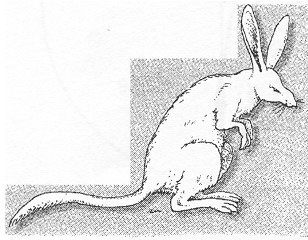
Marsupials were initially distributed throughout the super-continent of Gondwana. When Gondwana separated, 100 million years ago, and the placentals developed, the placentals displaced the marsupials in most habitats around the world. However, in Australia marsupials evolved into a wide variety of forms. This was mainly because

- A. Australia is an island
- B. there is a wide variety of ecological habitats
- C. there was competition with placentals
- D. humans had killed off most of the placentals

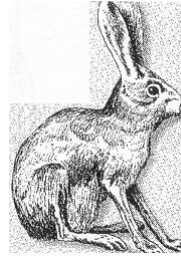
Question 22

Many of the Australian marsupial mammals have a remarkable resemblance to placental mammals which live in ecologically similar habitats in North America. This can be seen as follows when comparing –

Long-eared bandicoot



Jack rabbit



The long ears, strong hind limbs, snout and whiskers of these two species are called

- A. analogous structures
- B. convergent structures
- C. homologous structures
- D. divergent structures

Question 23

Populations are groups of interbreeding individuals of the same species occupying the same habitat at the same time. However, within each population there are breeding sub-units. These are sometimes called **demes**. Individuals within a deme tend to breed with each other more often than they do with individuals of other demes. Which of the following is correct about such populations?

- A. The members of each deme are part of a different gene pool.
- B. The flow of genes between separate demes may slow down or even cease.
- C. All the demes will evolve in the same direction.
- D. The demes will continue to be the one species.

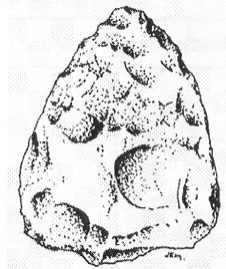
Question 24

Human evolution occurred over millions of years. The change from being a nomadic scavenger to a hunter-gatherer and then the development of agriculture took place in a series of small steps over a very long time. A few human societies, including the Australian aborigines, were still at this stage until very recently (last century). This is an example of

- A. biological evolution
- B. cultural evolution
- C. divergent evolution
- D. convergent evolution

Question 25

The following is a diagram of a hand-axe found in a fossil dig in Le Moustier in France. This more refined method of making tools allowed finer workmanship than that seen earlier in crude pebble or rock tools.



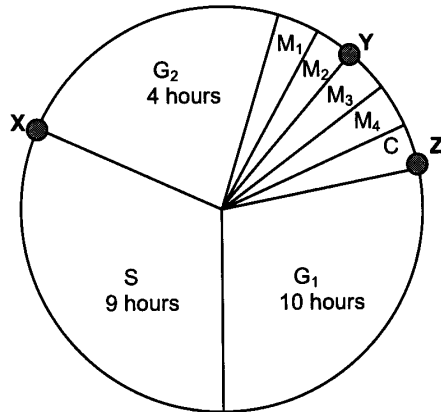
The approximate time when such stone hand-axes would have been made would be

- A. 6 million years ago
- B. 2 million years ago
- C. 1 million years ago
- D. 10 000 years ago

SECTION B – Short-answer questions

Question 1

The cell cycle is the period of time for a newly formed somatic cell to grow, prepare for division, and undergo nuclear division, followed by cell division into two daughter cells identical to each other and to the parent cell. This can be represented by the following diagram which includes the approximate time spent in each stage.



$M_1 - C = 1$ hour.

Note: time periods not shown to scale

M_1 , M_2 , M_3 and M_4 are the stages of cell division occurring in this cycle.

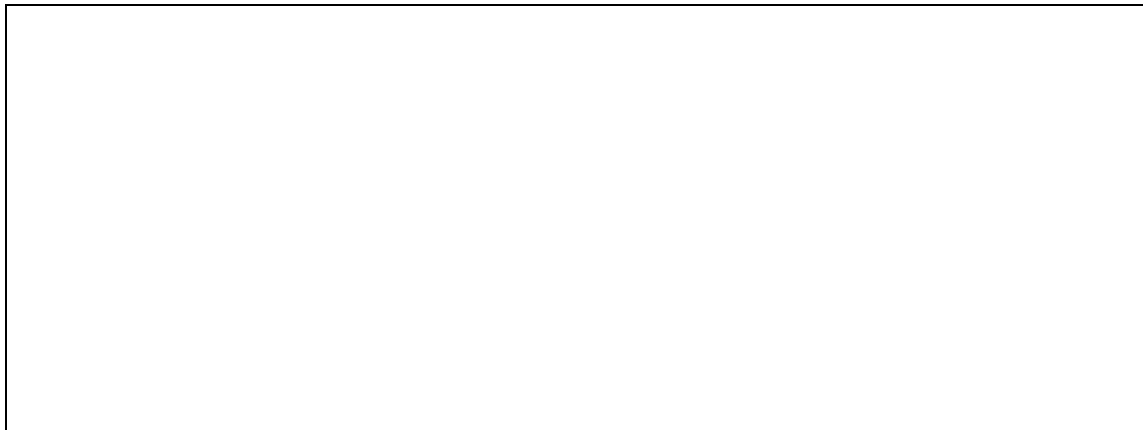
- a. i. What type of cell division is involved in this cycle?

_____ 1 mark

- ii. From the diagram write down the letters of the stages which would be included in interphase.

_____ 1 mark

- b. In the following space **draw** and **label** an insect cell with a diploid number of $2n = 4$ at stage M_3 .



2 marks

- c. If a newly-formed somatic cell of the insect in **b.** contained 3.6 picograms of DNA (10^6 picograms = 1 mg), determine how much DNA would be at each of the following points on the diagram. For each explain the answer given.

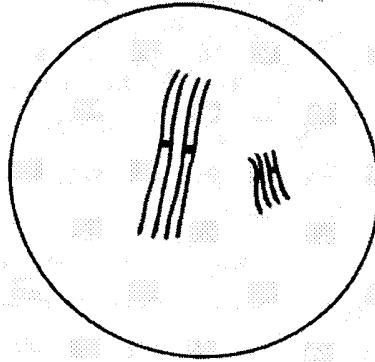
- i. X _____

- ii. Y _____

iii. Z _____

3 marks

A student examined some tissue from the same insect and observed the following cell.



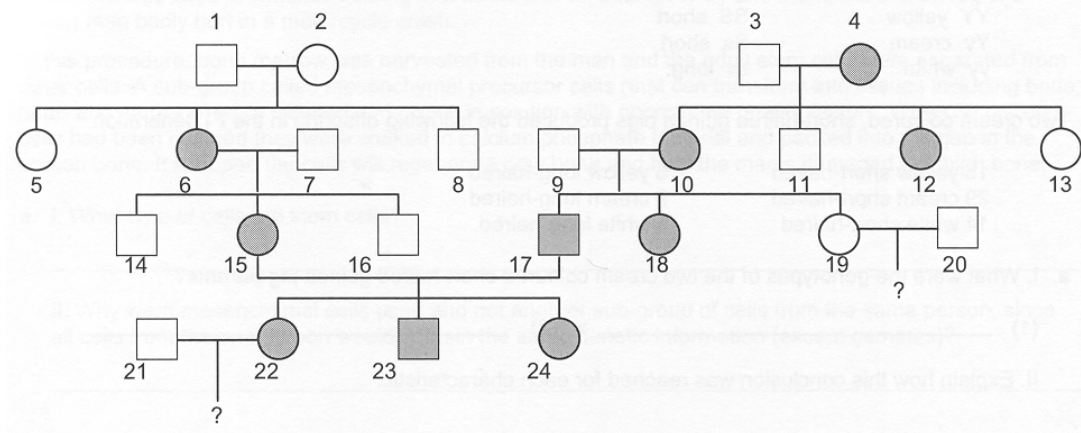
d. Could this cell be from the same tissue as the cell referred to in the previous cell cycle diagram? Explain.

2 marks

Total 8 marks

Question 2

The following is a pedigree for myopia (near sightedness) in which individuals with this condition are shaded.



a. Is the inheritance of myopia dominant or recessive? **Circle** one part of the pedigree which provides evidence to support your decision and briefly explain.

2 marks

- b. Draw a **box** around part of the pedigree which provides evidence to indicate that myopia is inherited as an autosomal not a sex-linked characteristic. Briefly explain.

2 marks

- c. Female (24) said there was a much greater change of her sister (22) having children with myopia than her auntie (19) as her sister had myopia herself. Assuming both the husbands (20) and (21) had no previous family history of the condition, do you agree with her? Assign appropriate allele symbols and show all working in the space provided.

2 marks

Total 6 marks

Question 3

Guinea pig hair is under the control of many genes, among them the genes for colour and length. The possible genotypes and their associated phenotypes for these two genes are:

YY	yellow	SS	short
Yy	cream	Ss	short
yy	white	ss	long

Two cream coloured, short-haired guinea pigs produced the following offspring in the F₁ generation.

15 yellow short-haired	5 yellow long-haired
29 cream short-haired	9 cream long-haired
14 white short-haired	5 white long-haired

- a. i. What were the genotypes of the two cream coloured short-haired guinea pig parents?

(1) _____ × (2) _____

- ii. Explain how this conclusion was reached for each characteristic.

1 + 2 = 3 marks

- b. i. If a guinea pig breeder purchased a white short-haired guinea pig from the pet shop, give the genotypes of the cross she could carry out to determine if the guinea pig she bought was **pure breeding** short-haired?

- ii. Suggest another factor which may have caused the white hair of the guinea pig.

1 + 1 = 2 marks

Total 5 marks

Question 4

A radical new procedure in stem-cell technology was performed in Melbourne in 2006. It was the first time in the world a patient's own stem cells had been used to make identical cells for replacement healing. The procedure was used to simulate healing of a fracture in an attempt to try and mend the broken leg of a young man badly hurt in a motorcycle crash.

In this procedure, bone marrow was harvested from the man and the adult stem cells were separated from other cells. A sub-group called mesenchymal precursor cells (that can transform into tissues including bone, heart and cartilage) were isolated and grown in solution with appropriate growth factors. When 30 million cells had been cultured they were soaked in calcium phosphate material and packed into the gap in the broken bone. It is hoped the cells will regenerate new bone and heal the man's damaged left thigh bone.

a. i. What type of cells are stem cells?

ii. Why were mesenchymal cells used and not another sub-group of cells from the same person, since all cells from the one person would contain the same genetic information (Except gametes)?

1 + 1 = 2 marks

b. What is cell regeneration and how does it occur?

1 mark

c. Why was it preferable to use stem cells from the patient rather than a donor?

1 mark

This type of technology is called **therapeutic stem cell cloning**. Possible applications could range from blood vessel replacement to skin, bone, tendon and cartilage repair to the treatment of degenerative nerve tissues. The best source of stem cells is from very early embryos, although adult tissues can be used, as seen in the bone-healing technique above.

d. Why would it be preferable to use stem cells from very early embryos?

1 mark

Therapeutic stem cell cloning using very early embryos is just being developed. Despite its enormous medical potential, it is still banned in some countries.

e. Briefly discuss one major ethical issue involved in using this procedure.

1 mark

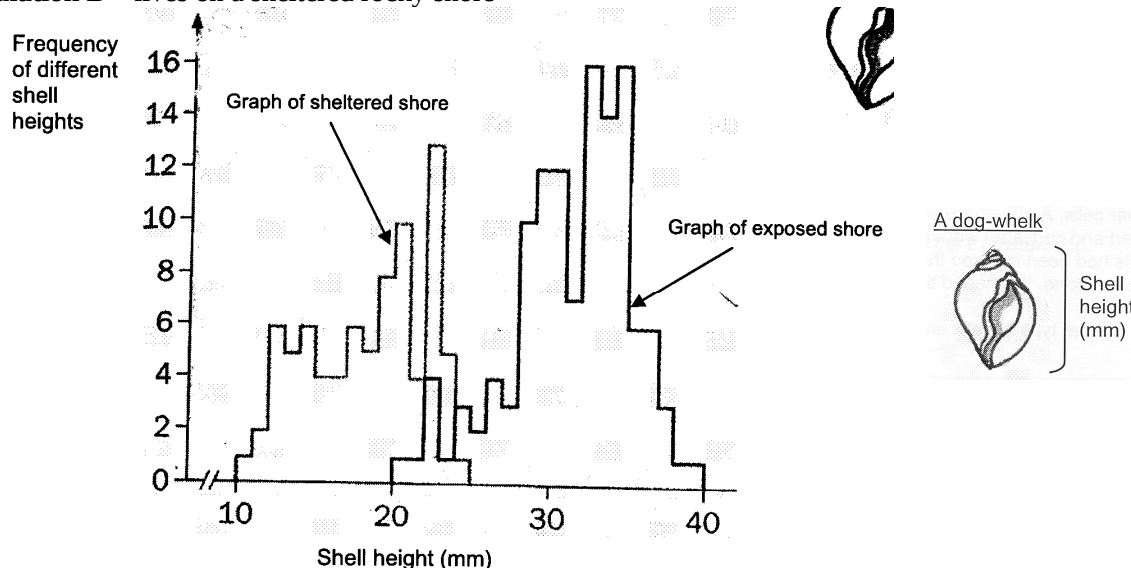
Total 6 marks

Question 5

The dog-whelk is a mollusc (soft-bodied animal living in a shell) found on the rocky shores around England. The following graphs show the variation in shell height in two different populations of dog-whelks.

Population A – lives on a rocky shore and was exposed to strong wave action

Population B – lives on a sheltered rocky shore



- a. i. By studying the shape of the graphs, what type of variation is shown in the two dog-whelk populations?

- ii. This pattern of variation suggests the characteristic of shell height is the result of polygenic inheritance. Explain what is meant by the phrase **polygenic inheritance**.

- iii. Suggest another trait or feature of dog-whelks which could result from polygenic inheritance.

1 + 1 + 1 = 3 marks

In a further investigation it was found that dog-whelks Population B (sheltered shore) had much thicker shells than those in Population A. On the sheltered shore there were more crabs, which are predators of dog-whelks, eating the soft body out of the shell.

- b. i. What process could have led to the difference in shell thickness of these two populations?

- ii. Briefly explain how the thicker shells in population B could have come about.

1 + 3 = 4 marks
Total 7 marks

Question 6

Many zoos worldwide are now involved in captive breeding programs. At Melbourne Zoo giraffes, gorillas and orangutans have been used for such programs; however, a major problem was encountered with the offspring of the giraffes being born with deformed feet.

- a. i. What are captive breeding programs?

- ii. Why would zoos choose to be involved in such programs?

1 + 1 = 2 marks

- b. i. From the results of the giraffe breeding program, what inference can be made about the genetic background of the breeding parents of the offspring with deformed feet?

- ii. If a giraffe was to be 'imported' from another zoo, to be a breeding parent, what would be a most important feature in choosing that giraffe?

1 + 1 = 2 marks

- c. Some zoos choose not to 'import' animals but instead use 'imported' sperm samples for artificial insemination. Suggest **two** advantage of this method.

(1) _____

(2) _____

2 marks

- d. In what way is selective breeding, as used in zoos, similar to natural selection in terms of the effect on the gene pool?

1 mark

Total 7 marks

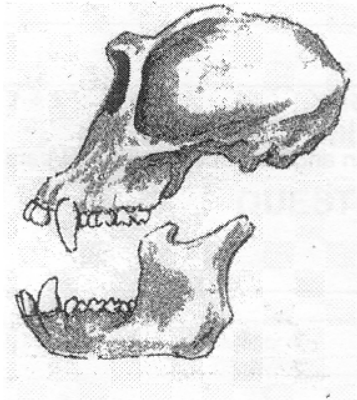
Question 7

In 1924 in a limestone quarry in Tuang, South Africa, a remarkable fossil was discovered in the rock, a skull (including the brain case and lower jaw) and a petrified replica of the brain. Professor Raymond Dart concluded that the 'Tuang child', as it was called, was a juvenile of an extinct race, intermediate between living apes and humans. He classified it as a new species *Australopithecus africanus*. After extensive examination he concluded that the 'Tuang child' walked upright.

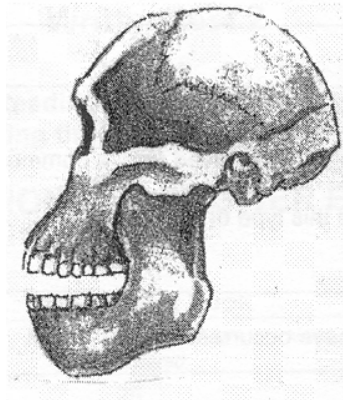
- a. Suggest the evidence from the structure of the skull that would have led Dart to conclude that the 'Tuang child' walked upright.

1 mark

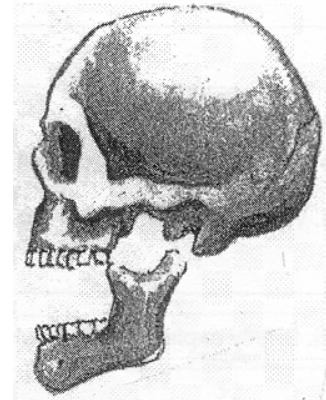
Study the following three skulls and lower jaws.



Chimpanzee



Australopithecus africanus
(like 'Tuang child', but adult skull)



Human

- b. Describe two other features from the skull and lower jaw (apart from that used in a.) which suggest the 'Tuang child' was a possible ancestor of the human species.

- i. _____

 ii. _____

2 marks

The 'Tuang child' was the first hominid fossil to be discovered in Africa and provided the earliest possible clues to possible ancestors of the human species.

- c. i. What is a hominid?

- ii. Give the names of two other hominids (living or extinct).

1 + 1 = 2 marks

Quarrying for limestone has destroyed the area where the fossil was found so its age could not be determined using evidence from the quarry. However, it has been dated at 2.2 million years old.

- d. i. What is the type of rock, in which fossils are often found, like the limestone of the Tuang quarry?

- ii. With no quarry left, after extensive mining, briefly explain how the absolute age of the 'Tuang child' would have been determined.

1 + 1 = 2 marks

Apes and humans are thought to have evolved from a common ancestor about 6 million years ago.

e. i. What term is used to describe this type of evolution?

ii. Briefly explain how it would have occurred.

1 + 2 = 3 marks

Total 10 marks

END OF QUESTION AND ANSWER BOOKLET