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Student name

BIOLOGY
Unit 4
Trial Examination

QUESTION AND ANSWER BOOK

Total writing time: 1 hour 30 minutes

Structure of book

Section	Number of questions	Number of marks
A	25	25
B	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 allowed in this examination.

Materials supplied

- Question and answer book of 21 pages with a detachable answer sheet for multiple-choice questions inside the front cover.

Instructions

- Detach the answer sheet for multiple-choice questions during reading time.
- Write your **name** in the space provided above on this page and on the answer sheet for multiple-choice questions.
- All written responses should be in English.

At the end of the examination

- Place the answer sheet for multiple-choice questions inside the front cover of this book.

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SECTION A - Multiple Choice Questions

Specific instructions for Section A

This section consists of 25 questions. You should attempt **all** questions.

Each question has four possible correct answers. Only **one** answer for each question is correct. Select the answer that you believe is correct and indicate your choice on the Multiple Choice Answer Sheet by shading the letter that corresponds with your choice of the correct answer.

If you wish to change an answer, erase it and shade your new choice of letter.

Each question is worth **one** mark. **No** mark will be given if more than one answer is completed for any question. Marks will **not** be deducted for incorrect answers.

Question 1

The karyotype shown below is of a Down syndrome individual.

It is reasonable to state that Down Syndrome is due to:

A. excess DNA ligase producing an extra chromosome.
B. fusion of two sperm with one egg at fertilisation.
C. non-disjunction in the first cell division of the newly formed zygote.
D. non-disjunction of a parental chromosome during meiosis.

Question 2

The ABO blood group system in humans consists of the following alleles.

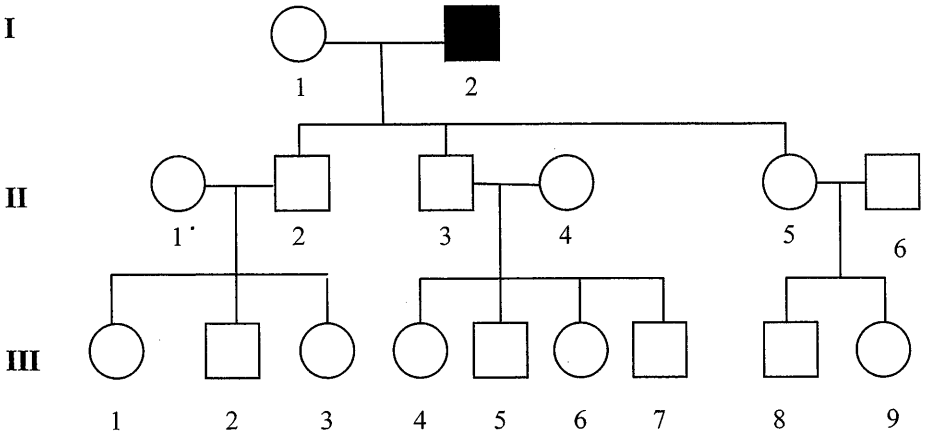
I^A
I^B
i

It is reasonable to state that:

A. the three alleles occupy three different loci on the same chromosome.
B. this is an example of polygenetic inheritance.
C. this results in 3 different phenotypes
D. I^A and I^B are co-dominant and i is recessive.

Question 3

One gene that is thought to be inherited via the Y chromosome is hairy ears. In the **incomplete pedigree** below, individual **I2** has the condition.

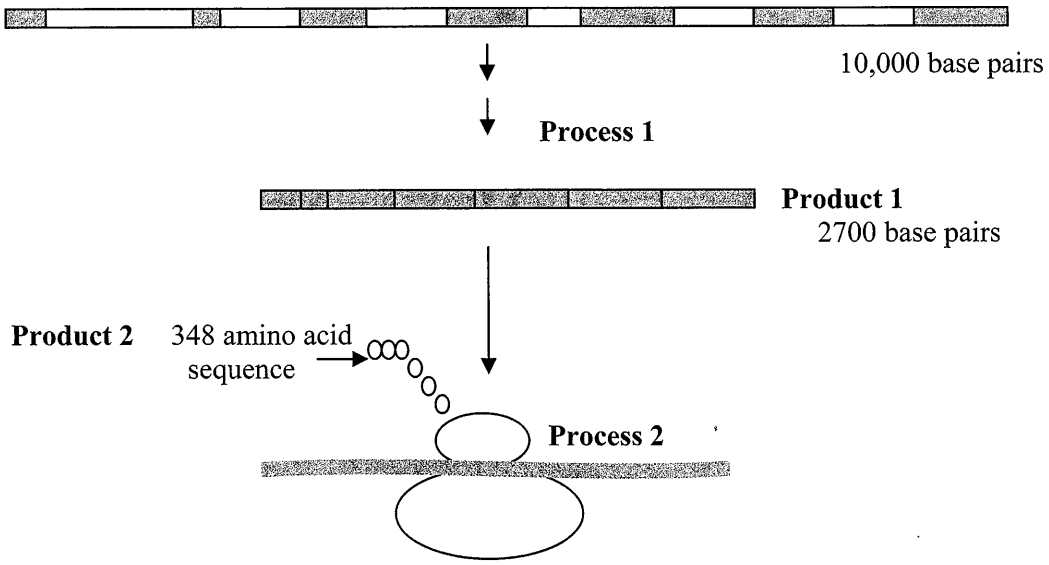


From this information it would be reasonable to state that individuals:

A. **II2**, **II3**, **II4**, will have the condition.
B. **II1**, **II5**, will have the condition.
C. **III2** has a 1 in 2 chance of having the condition.
D. **III2**, **III5** and **III7** will have the condition.

Question 4

The following diagram outlines the steps from gene to gene product.



Which of the following outlines the diagram above?

	Process 1	Product 1	Process 2	Product 2
A.	transcription	mRNA	translation	polypeptide
B.	translation	mRNA	transcription	polypeptide
C.	translation	protein	transcription	protein
D.	transcription	protein	translation	polypeptide

Question 5

Plants from the genus *Melandrum* have male and female flowers on different individual plants. In these plants, sex determination follows the same pattern as in humans. An X-linked condition in these plants is lethal in homozygous females, whereas the same allele causes yellow-green blotches in males and is not lethal.
The alleles for the gene at this locus are:

X^l = lethal allele
X^L = normal allele

A heterozygous female is crossed with a yellow-green blotched male plant. The expected phenotypic ratios would be:

A. 1/3 normal males : 1/3 normal females : 1/3 yellow-green blotched males.
B. 1/4 yellow-green blotched females : 1/4 normal females : 1/4 yellow-green blotched males : 1/4 normal males.
C. 1/2 normal females : 1/2 normal males.
D. only normal males and no females.

Question 6

In cocker spaniel dogs red coat colour and spotted coat colour are both recessive autosomal traits. The alternative dominant alleles are black coat and solid colour.
The genes involves are:

Coat colour **B** – black
b – red

Coat pattern **S** – solid colour
s – spotted (colour on a white background)

A solid coloured male dog is mated to a solid coloured red female and they produce a litter of six pups that show the following coat colours and patterns:
- Two solid black
- Two solid red
- One black and white spotted
- One red and white spotted

The genotypes of the parents must be:

	Male	Female
A.	**BBSS**	**bbss**
B.	**BbSs**	**bbSs**
C.	**Bbss**	**bbSs**
D.	**BBss**	**bbSs**

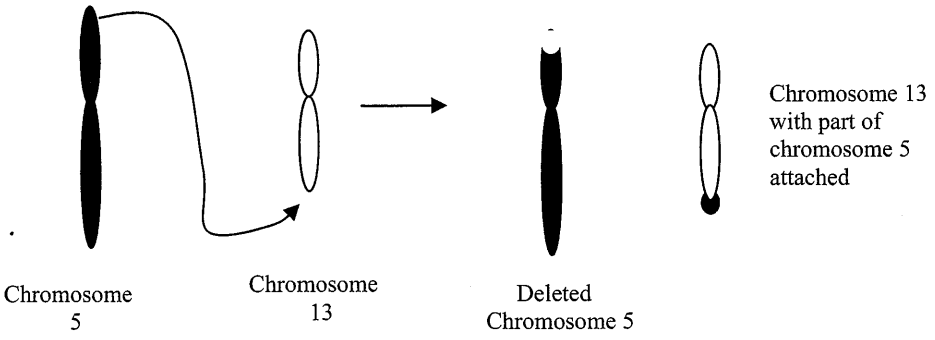
Question 7

The genetic code:

A. consists of a sequence of dideoxynucleotides.
B. may have more than one codon for each amino acid.
C. is made up of different codons that code only for amino acids.
D. is only found in prokaryotic and eukaryotic cells.

Questions 8 and 9 refer to the following information.

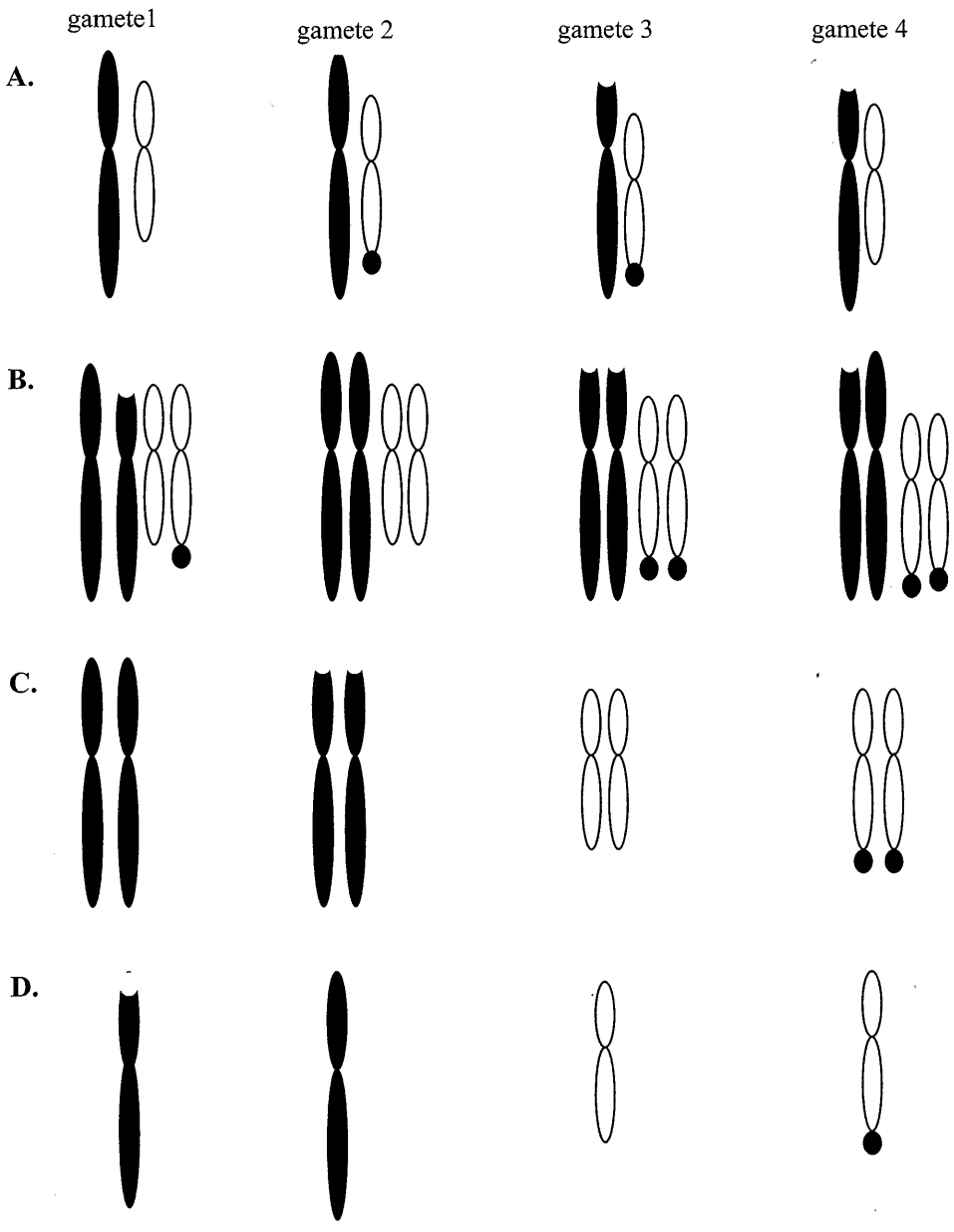
The mental retardation condition called Cri du Chat syndrome is due to a translocation of part of the short arm of chromosome 5 onto chromosome 13 as shown in the diagram below.



Children that inherit the deleted chromosome 5 from a parent show the Cri du Chat syndrome. The parent with a balanced translocation does not show any symptoms.

Question 8

A woman has this translocation. The gametes that would be formed by this individual could contain the following chromosomes:



Question 9

The woman shown above has a child to a man who does not have this translocation. The chance that this child has inherited the Cri du Chat syndrome would be:

A. 100 %
B. 75 %
C. 25 %
D. 50 %

Question 10

Mutations can result in genetic diseases. One such mutation occurs in the β globulin gene, part of which is shown below.

Normal β globulin							
Codon number	36	37	38	39	40	41....	
mRNA	CCU	UGG	ACC	CAG	AGG	UUC	UUC
amino acid	pro	trp	thr	gln	arg	phen	phen

mutated β globulin						
Codon number	36	37	38	39	40	41....
mRNA	CCU	UGG	ACC	AGA	GGU	UCU
amino acid	pro	trp	thr	arg	gly	ser

The above mutation could be due to:

A. deletion of the triplet CAG.
B. formation of a stop codon.
C. change of C to A therefore changing gln to arg.
D. deletion of C causing a frame shift.

Question 11

Examples of the process of apoptosis would include:

A. necrosis of bacterial infected tissue.
B. destruction of T cells after infection has passed.
C. destruction of webbing between the toes in the developing foetus.
D. mitosis of cancer cells.

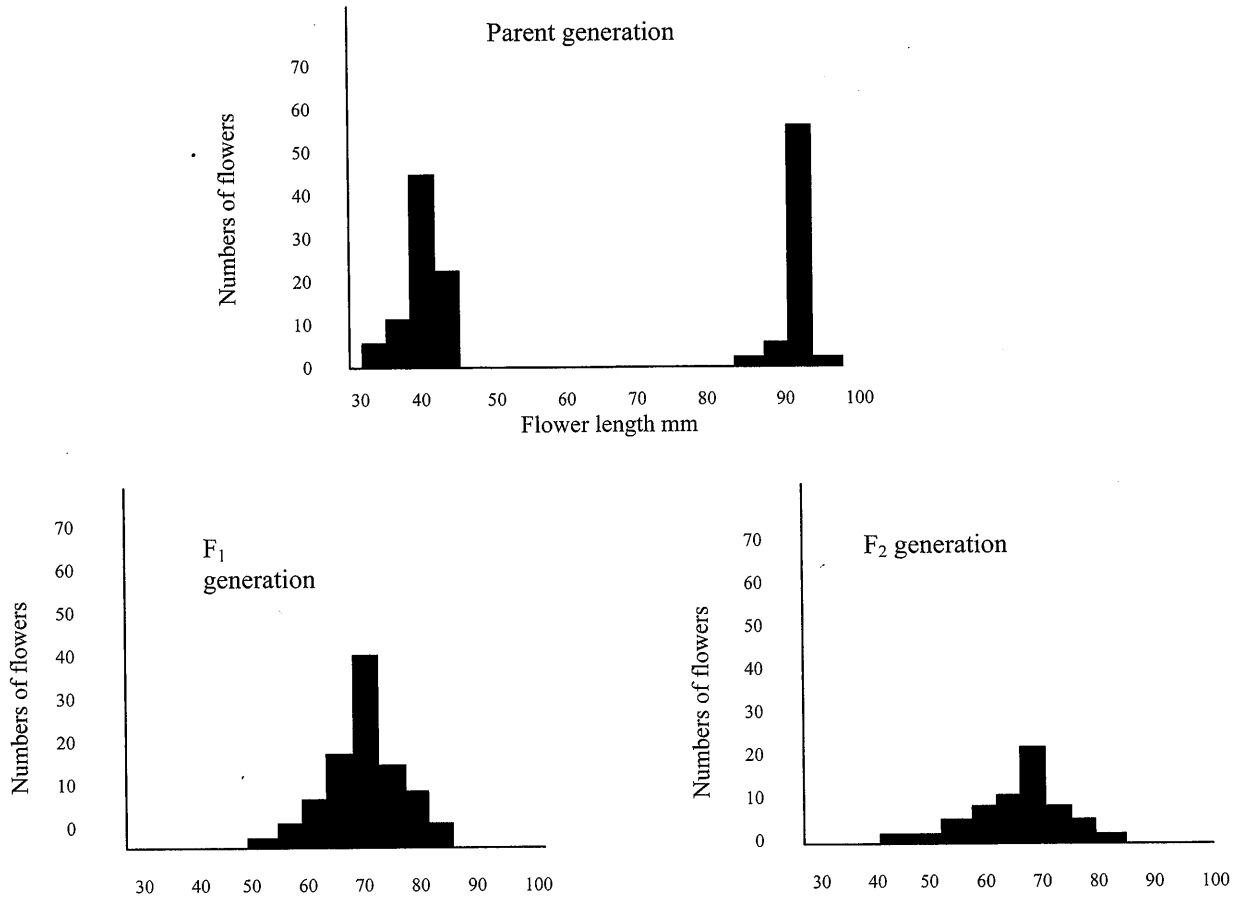
Question 12

Male lions, when they mature, leave the pride where they were born and take over another pride where they mate with the females. This is an example of:

A. genetic drift
B. founder effect
C. gene flow
D. natural selection

Question 13

The tobacco plant *Nicotiania longiflora* shows a variety of flower lengths. Scientists investigating the genetics of this characteristic crossed pure breeding short flowers with an average length of 40.5mm with pure breeding long flowers with an average flower length of 93.3mm. The graphs below show flower lengths of the parent generation, the F_1 generation and the F_2 generation.



The F_2 generation pattern of inheritance shows that:

A. height is controlled by one gene with 2 different alleles.
B. height is controlled by 2 different genes on the same chromosome.
C. height is controlled by more than one gene on different chromosomes.
D. height is controlled by the environment of the plant.

Question 14

In tomato plants tall (**T**) is dominant to short (**t**) and hairy stem (**H**) is dominant to hairless (**h**). Some tomato plants were crossed and the **F_1** progeny were counted. The results are shown in the table below.

Phenotype	Number of plants
Tall hairy	118
Short hairless	121
Tall hairless	112
Short hairy	109

The genotypes of the parent plants must be:

A. **TtHh** and **TtHh**
B. **TTHH** and **tthh**
C. **TtHh** and **tthh**
D. **TThh** and **ttHH**

Question 15

Soybeans can exist in three different colours due to co-dominant alleles according to the following:

C^GC^G	golden colour
C^GC^D	light green colour
C^DC^D	dark green colour

Investigation of 200 plants grown in an isolated field found the following numbers of plants.

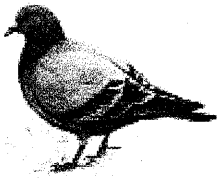
Genotype	Number of plants
C^GC^G	2
C^GC^D	36
C^DC^D	162

From this data it would be reasonable to state that the frequency of the C^G allele and the C^D allele would be:

	C^G	C^D
A.	0.1	0.9
B.	0.05	0.95
C.	0.38	0.62
D.	0.5	0.45

Question 16

Fancy breeds of pigeons have all come from the rock dove, which is found in most cities in the world.



Rock dove

example of a Fancy pigeon

The development of the fancy pigeons is an example of:

A. natural selection.
B. selective breeding.
C. the founder effect.
D. genetic drift.

Question 17

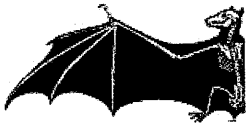
The theory of evolution can be supported by direct evidence. Which of the following alternatives is **not** an example of direct evidence to support evolution?

A. fossils.
B. resistance of bacteria to antibiotics.
C. increased pesticide resistance in insects.
D. observed allele frequency changes in populations.

Question 18

wing of an insect

wing of a bird



wing of a bat

The diagrams above show the wings of various animals. It is reasonable to state that the structures represented:

A. are homologous structures
B. are analogous structures.
C. show adaptive radiation.
D. indicate that these animals are closely related.

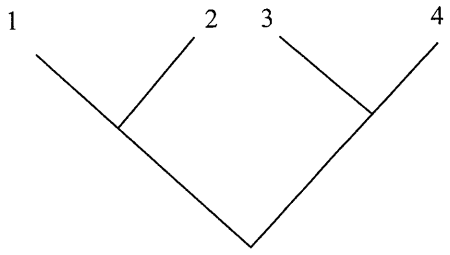
Question 19

X-rays, ultra violet light and radioactive substances can all change the chemical nature of DNA. These agents are all classified as:

A. enzymes
B. mutagens
C. growth regulators
D. DNA toxins

Question 20

The following is a cladogram showing the relationship between 4 different species.



It would be reasonable to state that:

A. **1** is the most recently evolved species.
B. **2** and **3** are more closely related than **1** and **4**.
C. **1** and **2** are more closely related than **1** and **3**.
D. **3** and **4** are more closely related than **1** and **2**.

Question 21

Convergent evolution:

A. is responsible for the similarity in the phenotype of non-related species.
B. is also known as allopatric speciation.
C. is responsible for the development of homologous structures.
D. results in the evolution of two species that are interdependent.

Question 22

In 1975 a strain of *Flavobacteria* was discovered living in waste water coming from a factory producing nylon. This bacterium was able to break down the nylon molecule. Nylon is a man-made fabric that was developed in 1936. It would be reasonable to state that:

A. the gene governing nylon breakdown always existed in these bacteria but was only discovered in 1975.
B. there was a mutation in these bacteria enabling them to be able to break down nylon.
C. genetic drift caused the bacteria to adapt.
D. the presence of nylon caused the bacteria to mutate.

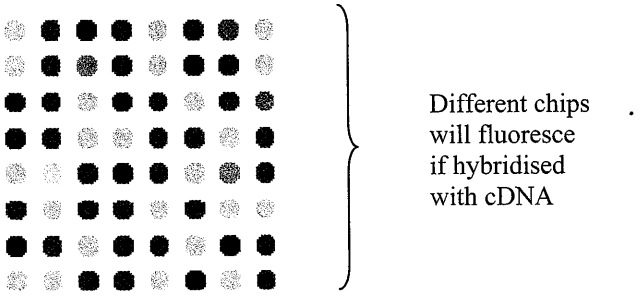
Question 23

Bipedalism is a characteristic of early hominins. Scientists examining fossil skeletons can make inferences about the individual being capable of bipedalism by:

A. examining the development of the clavicle (shoulder blade).
B. examining the size of the skull.
C. examining the position of the foramen magnum in the skull.
D. examining if the rib-cage gradually sloped in or out.

Question 24

A French company is using DNA chip or DNA array technology to test drinking water for disease-causing bacteria. The DNA chips are made with gene sequences from a variety of disease-causing bacteria. Bacteria are first isolated from the sample of water and their mRNA is extracted. This mRNA is converted to cDNA. The different DNAs are labelled with different fluorescent dyes. The labelled DNA is incubated with the specific DNA chips as shown in the diagram below. If the DNA chip from the disease-causing bacteria hybridises with the DNA from any bacteria from the sample then those bacteria are the disease-causing bacteria.



In order for this procedure to work:

A. the cDNA must be single-stranded and the DNA chip double-stranded.
B. the DNA chip must be single-stranded and the cDNA double-stranded.
C. both the cDNA and the DNA chip must be singe-stranded
D. both the cDNA and the DNA chip must be double-stranded.

Question 25

cDNA is constructed from mRNA by the use of the enzyme:

A. DNA polymerase
B. DNA ligase
C. RNA polymerase
D. reverse transcriptase

END OF SECTION A

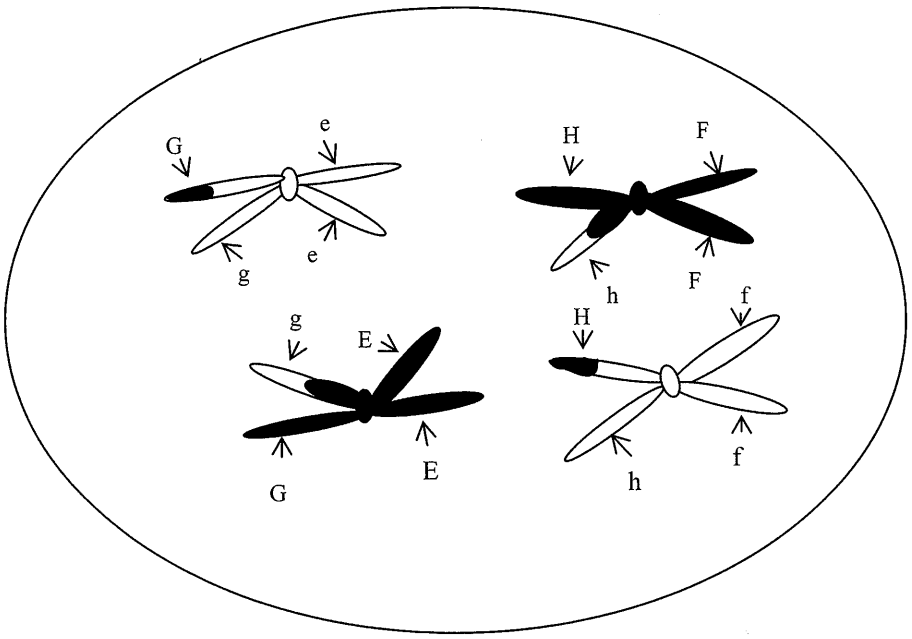
SECTION B - Short Answer Questions

Specific instructions for Section B

This section consists of 7 questions. There are 50 marks in total for this section.
Write your responses in the spaces provided. You should attempt **all** questions. Please write your responses in **blue** or **black ink**.

Question 1

The diagram below shows four chromosomes in a phase of cell division in an animal tissue. The letters represent alleles of genes on the chromosomes



a Name the type of cell division depicted in the diagram above. Explain your answer.

(2 marks)

b What is the genotype of the cell shown above?

(1 mark)

c Give **two** possible genotype(s) of the cells formed from this cell division.

(2 marks)

Total 5 marks

Question 2

In the disease sickle cell anaemia, a thymine base replaces an adenine base in the β globulin gene in chromosome 11. Those individuals that are heterozygous are carriers, while those that are homozygous for the sickle cell allele have the condition of sickle cell anaemia.

Normal β globulin CCTGAGG Sickle cell CCTGTGG

a What type of mutation results in an individual having sickle cell anaemia?

_____

(1 mark)

Mutations that cause genetic diseases such as sickle cell anaemia can sometimes be diagnosed using enzymes that cut the DNA at specific restriction sites. The enzyme MstII recognises the sequence CCTNAGG, where N is any nucleotide. MstII cuts the DNA as shown to create "sticky ends".

↓
CCTGAGG

b Draw the double stranded section of DNA to show how sticky ends would be produced.

_____

_____

(1 mark)

c How does the mutation in sickle cell anaemia affect the action of MstII?

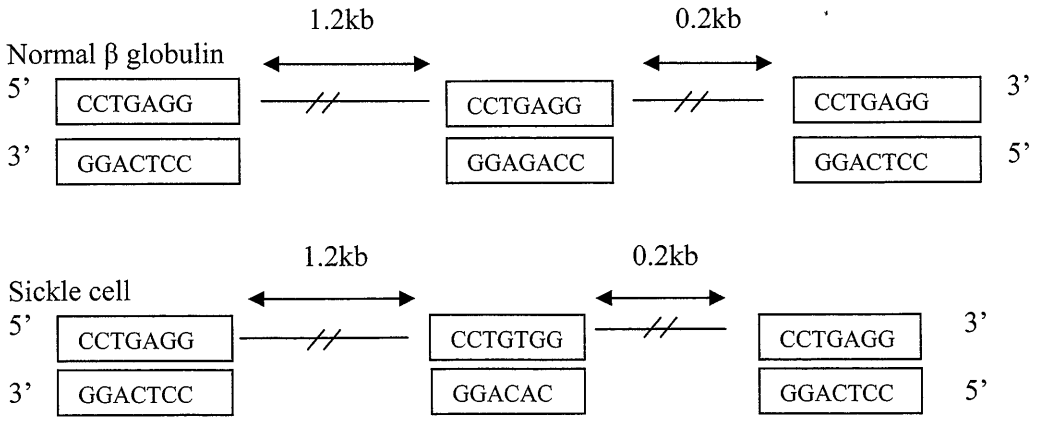
_____

_____

_____

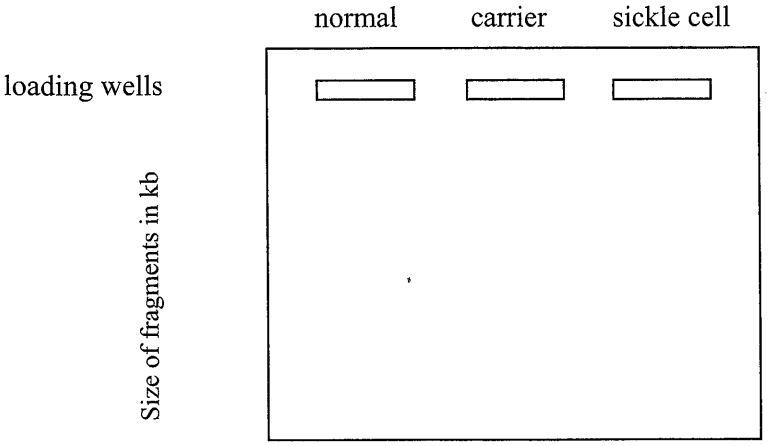
(2 marks)

In both normal β globulin and sickle cell there are restriction sites recognised by MstII at 1.2kb upstream in the 5' flanking region and at 0.2kb downstream at the 3' end as shown in the diagram below.



After treating DNA with MstII the DNA can be run on a gel electrophoresis to distinguish between a normal individual, a carrier of sickle cell and an individual with sickle cell anaemia.

d Complete the diagram below to show the pattern showed by the different individuals. Include the size of the expected DNA fragments in kilobases at the side.

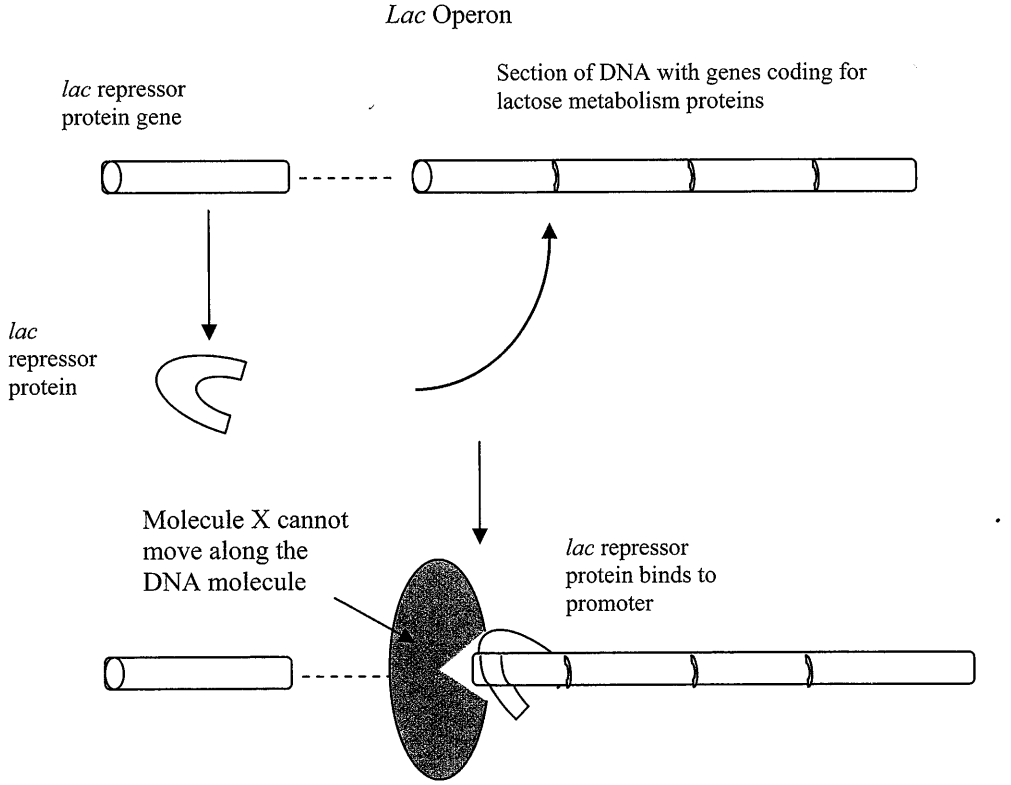


(3 marks)

Total 7 marks

Question 3

In prokaryotic cells regulatory genes and structural genes are next to each other forming an arrangement known as an operon. One such operon in the bacteria *E.coli* controls lactose metabolism. *E.coli* can use lactose as an energy source when it is present in the medium on which it is growing. If lactose is not present the regulatory gene produces a *lac* repressor protein that prevents the genes needed for lactose metabolism from being switched on. The diagram below outlines the procedure.



a Where in the cell of a prokaryote would you expect to find these operons?

_____

(1 mark)

b Why do organisms need to regulate the expression of their genes?

(1 mark)

c Molecule **X** attaches to part of the DNA molecule. Name molecule X.

(1 mark)

d What process is being prevented by molecule X being prevented from moving along the DNA molecule?

(1 mark)

When lactose is present in the media, the lactose binds to the repressor molecule and alters its configuration.

e Outline how altering the configuration of the *lac* repressor protein enables the bacteria to metabolise lactose.

(3 marks)

Total 7 marks

Question 4

Agrobacterium tumefaciens is a species of bacteria that causes crown gall disease, a tumerous outgrowth on the growing tips of plants. The bacterium enters the plant through small cuts and once inside the plant cell a DNA sequence from the bacterium integrates into the plant's DNA. The inserted DNA causes the plant cells to reproduce quickly and to form a tumour and to synthesise nutrients needed by the bacteria. The DNA inserted into the pant DNA is carried on a large plasmid, the T_i plasmid.

a What is a plasmid?

_____

(1 mark)

Scientists have used this mechanism shown by *Agrobacterium tumefaciens* in order to genetically modify particular plants.

b Outline the steps demonstrating how scientists might use the Agrobacterium plasmid to create a crop plant that is resistant to a herbicide.

_____

_____

_____

_____

_____

_____

(3 marks)

Total 4 marks

Question 5

Diatoms are a unique form of algae that have a hard silica shell. The diatom shell, called a frustule, is different for each species, so you can identify them through a microscope. The study of fossilised diatoms in the USA led to the discovery of the evolution of a new species of diatom.

a Give **two** reasons why diatoms are easily fossilised.

_____

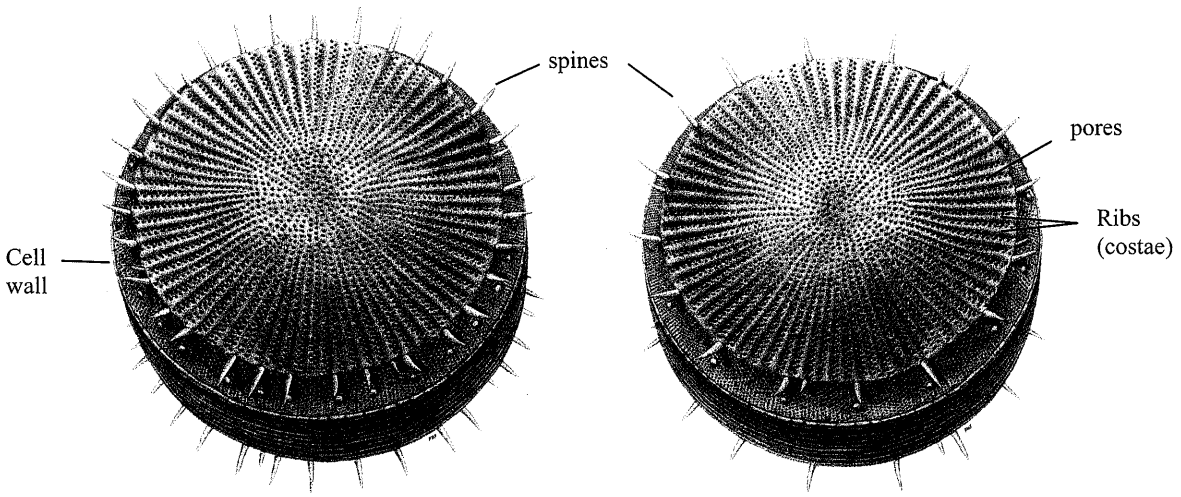
_____

_____

_____

(2 marks)

The diatom *Stephanodiscus niagare* is very common over the whole of the USA.
In Yellowstone National Park in the USA where there are many hot sulphur lakes, there is a unique species of the genus *Stephanodiscus* named *Stephanodiscus yellowstonesis,* found only in Lake Yellowstone. Lake Yellowstone formed after the last Ice Age 14,000 years ago. Ever since then diatoms have lived and died in the lake. Their sinking skeletons have built up fossil deposits many metres thick, creating a unique time–line.



Stephanodiscus niagare *Stephanodiscus yellowstonesis*

Scientists have taken core samples of mud from below the lake in Yellowstone representing different times and examined them for fossils of *Stephanodiscus* diatoms. The climate of Yellowstone National park 14,000 years ago was cooler and wetter compared to today. The table below shows the change in *Stephanodiscus* over time.

Date of core sample	Diatom Species
Present	*Stephanodiscus yellowstonesis*
2000 years ago	*Stephanodiscus yellowstonesis*
4000 years ago	*Stephanodiscus yellowstonesis*
6000 years ago	*Stephanodiscus yellowstonesis*
8000 years ago	*Stephanodiscus yellowstonesis*
10,000 years ago	*Stephanodiscus yellowstonesis*
12,000 years ago	*Stephanodiscus (transitional)*
14,000 years ago	*Stephanodiscus niagare-like ancestor*

b Using the diagrams above, suggest how scientists might distinguish one species of diatom from another.

_____

(1 mark)

This is an example of phyletic evolution.

c What is phyletic evolution?

_____

_____

(1 mark)

d The fossils found 12,000 years ago are considered transitional fossils. What are transitional fossils?

_____

(1 mark)

e Outline how the change in *Stephanodiscus* in Yellowstone National Park has come about.

_____

_____

_____

(2 marks)

f How did scientists decide that there is now a new species of *Stephanodiscus*?

_____

(1 mark)

Total 8 marks

Question 6

African cheetah (*Acinonyx jubatus*) is an endangered species as it shows very little genetic diversity as distinct from other large cats such as lions.

a What is genetic diversity?

_____

_____

(1 mark)

b What is the most likely cause of this lack of genetic diversity in the cheetah population?

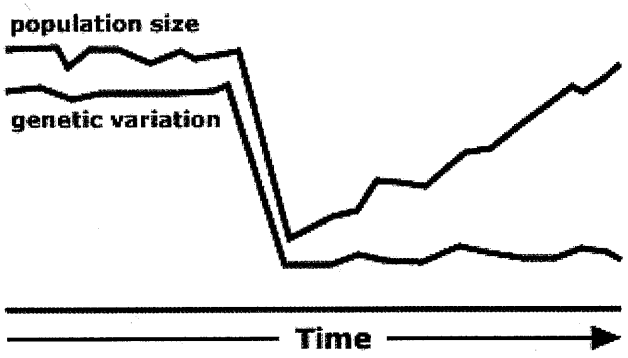
_____

_____

_____

(1 mark)

The following graph shows population and genetic variation.



c **i** Explain the rapid increase in population size on the right-hand side of the graph.

_____

_____

_____

(2 marks)

ii Why does the genetic variation not increase as rapidly?

_____

_____

(1 mark)

In 1982 captive lions and cheetahs were exposed to the deadly feline infectious peritonitis virus. This virus killed 50% of the cheetah population but few lions showed any symptoms, despite tests confirming they had been infected.

d Suggest a reason for this observation.

_____

_____

(1 mark)

Often when a species has decreased its population numbers it can be susceptible to genetic drift.

e What is genetic drift?

_____

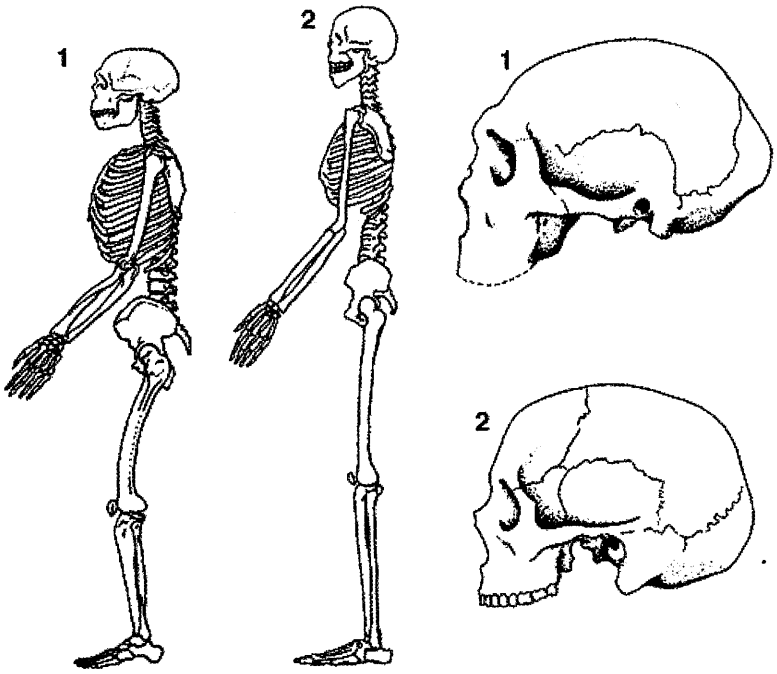
_____

(1 mark)

Total 7 marks

Question 7

Homo neanderthalensis and *Homo sapiens* co-existed in Europe for tens of thousands of years.



a Which skull above is *Homo neanderthalensis*? Explain your choice.

_____

_____

(2 marks)

b Is *Homo neanderthalensis* considered to be an ancestor of *Homo sapiens*? Explain your answer.

_____

_____

(1 mark)

During this period of co-existence in Europe the weather had become very cold. Both *Homo neanderthalensis* and *Homo sapiens* used animal skins to clothe themselves.

c Which species, *Homo neanderthalensis* or *Homo sapiens,* is better adapted to the cold? Explain your answer.

_____

_____

_____

(2 marks)

Homo neanderthalensis existed in small groups with little interaction between these groups. Recent discoveries have shown that some carefully carved almost identical artefacts have been found in different groups of *Homo sapiens.*

d What does this suggest about the different groups of *Homo sapiens*?

_____

_____

(1 mark)

Homo neanderthalensis died out about 28,000 years ago and *Homo sapiens* are the only representatives of the genus *Homo*. *Homo neanderthalensis* made tools and were good hunters and were physically stronger than *Homo sapiens.*

e Suggest why *Homo sapiens* came to populate the planet rather than *Homo neanderthalensis.*

_____

_____

_____

(2 marks)

In 2008 archaeologists uncovered a finger bone in the Denisova cave in Siberia. This Denisova hominin lived about 41,000 years ago. Mitochondrial DNA (mtDNA) was extracted first and compared with modern human mtDNA.

f Give **two** advantages of using mtDNA.

_____

_____

(2 marks)

The Denisova hominin differs from modern human DNA by 385 nucleotide bases out of a possible 16 500 whereas *Homo neanderthalensis* differs by 202 nucleotide bases. Anthropologists believe that hominins left Africa in waves of migration firstly *Homo erectus* about 1.9 million years ago, then *Homo neanderthalensis* between 300,000 and 500,000 years ago and finally *Homo sapiens* about 70,000 years ago.

g What does the mtDNA evidence suggest about the relationship between *Homo sapiens* and the Denisova hominin and their migration out of Africa?

_____

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(2 marks)

Total 12 marks

END OF EXAMINATION

Acknowledgements

www.ucl.ac.uk/~ucbhjow/bmsi/bmsi_7.html
rspb.org.uk
chennaiclassic.com
http://www.examplesof.com/language/homologous structure.html
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