



**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** for the question.

A correct answer scores 1, an incorrect answer scores 0.

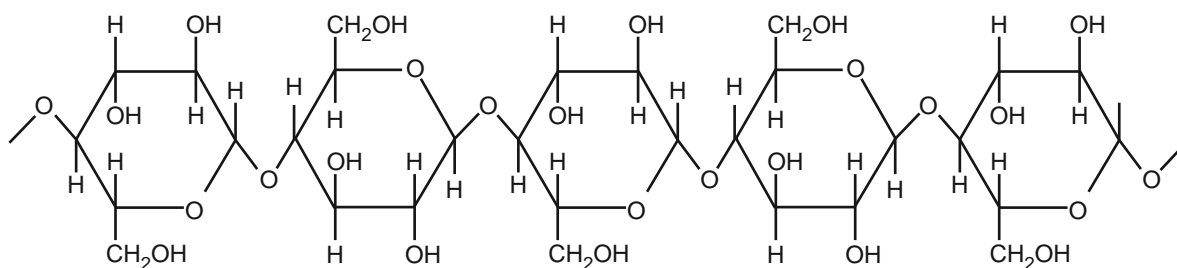
Marks will **not** be deducted for incorrect answers.

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

Use the following information to answer Questions 1 and 2.

Molecule A is a biomacromolecule.

A section of molecule A is shown below.

**Question 1**

In a cell, molecule A would

- A. act as an enzyme.
- B. contain genetic information.
- C. be synthesised from glucose molecules.
- D. transport information from the nucleus to the cytosol.

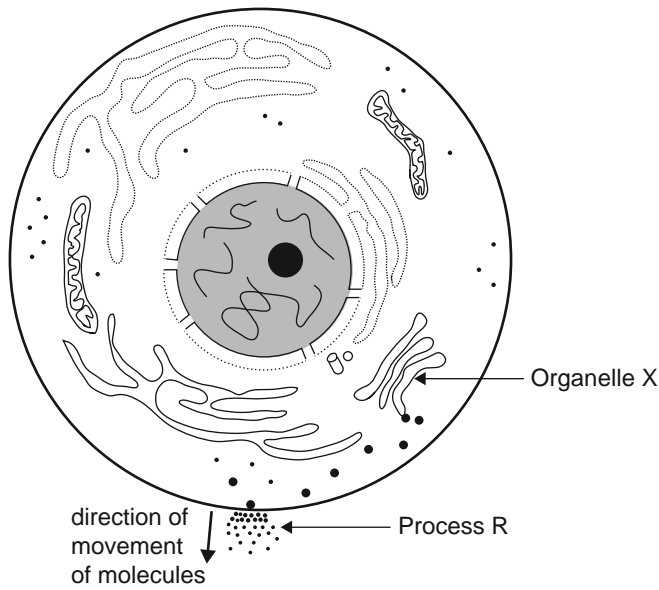
**Question 2**

When monomers are joined to form molecule A, which one of the following products is produced?

- A. carbon dioxide
- B. oxygen
- C. water
- D. ATP

Use the following information to answer Questions 3 and 4.

Consider the following cell diagram.



Source: www.cronodon.com

**Question 3**

Process R is an example of

- A. exocytosis.
- B. phagocytosis.
- C. pinocytosis.
- D. endocytosis.

**Question 4**

Organelle X

- A. is the site of cellular respiration.
- B. packages protein molecules for export from the cell.
- C. absorbs sunlight and produces carbohydrates.
- D. produces ribosomal RNA.

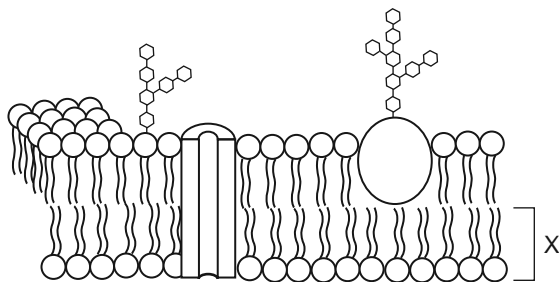
**Question 5**

The part of a molecule referred to as an anticodon can be found in

- A. DNA.
- B. transfer RNA.
- C. ribosomal RNA.
- D. messenger RNA.

**Question 6**

The diagram below shows the structure of a plasma membrane.



Source: www.cronodon.com

Structure X represents a molecule of

- A. phospholipid.
- B. glycoprotein.
- C. carbohydrate.
- D. cholesterol.

**Question 7**

During photosynthesis in chloroplasts, energy is used to split water, forming oxygen and hydrogen ions.

The splitting of water occurs

- A. in the stroma during the light-independent reaction.
- B. in the grana during the light-dependent reaction.
- C. on the membrane of the thylakoids during the light-independent reaction.
- D. on the surface of the outer chloroplast membrane during the light-dependent reaction.

**Question 8**

An increase in the atmospheric CO<sub>2</sub> level increases the rate of photosynthesis.

The rate of photosynthesis increases because

- A. the rate of the light-independent reactions on the thylakoid membranes of the chloroplasts increases.
- B. water loss from the leaf decreases, resulting in the availability of water for photosynthesis increasing.
- C. the increased CO<sub>2</sub> level lowers the pH inside the chloroplasts and increases the rate of enzyme-catalysed reactions.
- D. the rate of the light-independent reactions in the stroma increases with the increase in CO<sub>2</sub> level.

**Question 9**

In apoptosis

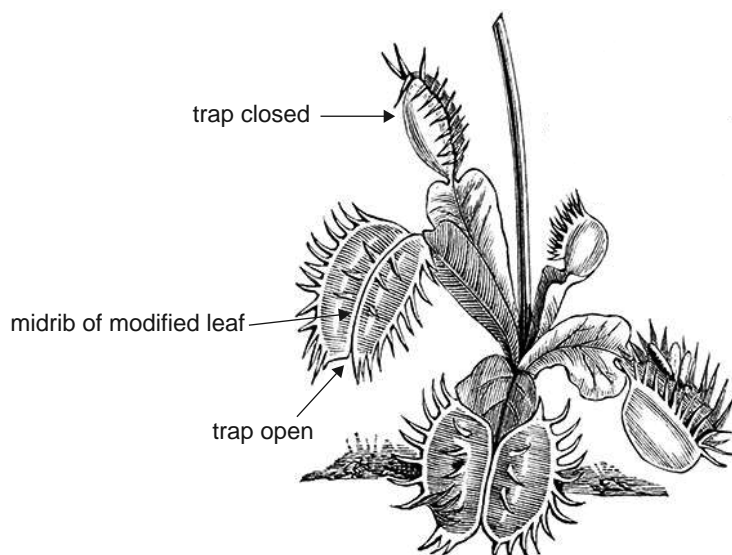
- A. a cell rapidly divides and releases antibodies.
- B. an inflammatory response is initiated by cell fragments.
- C. nuclear material and organelles are broken down.
- D. DNA is replicated.

**Question 10**

In the disease multiple sclerosis, the myelin sheath surrounding the axons of neurons is broken down. One of the symptoms of multiple sclerosis is weakening of the muscles.

A possible cause for this weakening could be

- A. the transmission of electrical impulses along the axons of neurons is slowed.
- B. the size of the electrical impulses travelling along the axons is smaller.
- C. neurotransmitter receptors on the muscle cells have become less sensitive.
- D. neurotransmitters are inhibited from travelling along the neurons.

**Question 11**

In some plants, a modified leaf forms an insect trap. 'Motor cells' are located along the midrib of the modified leaf. In their resting state, these cells are turgid and contain potassium ions at a concentration higher than the surrounding fluid. When the trap is triggered, potassium ions stream out of the motor cells through ion channels. The cells lose their turgidity. The pressure in the surrounding cells then causes the modified leaf to bend and so the trap closes.

Taking into consideration the opening and closing of the trap, which one of the following statements is true?

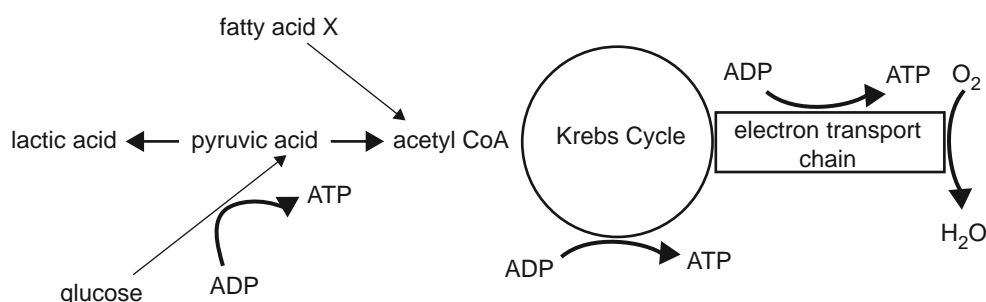
- A. When the trap is opening, potassium ions accumulate in the motor cells by diffusion.
- B. When the trap is opening, water accumulates in the motor cells by active transport.
- C. When the trap is closing, potassium ions leave the motor cells because of the pressure in the surrounding cells.
- D. When the trap is closing, water leaves the motor cells by osmosis.

**Question 12**

If there is insufficient glucose for cellular respiration, fatty acids can be changed to acetyl CoA. Each fatty acid X molecule produces eight molecules of acetyl CoA.

The diagram below summarises the pathways for the breakdown of fatty acid X and glucose.

The number of molecules produced in each step is **not** shown.

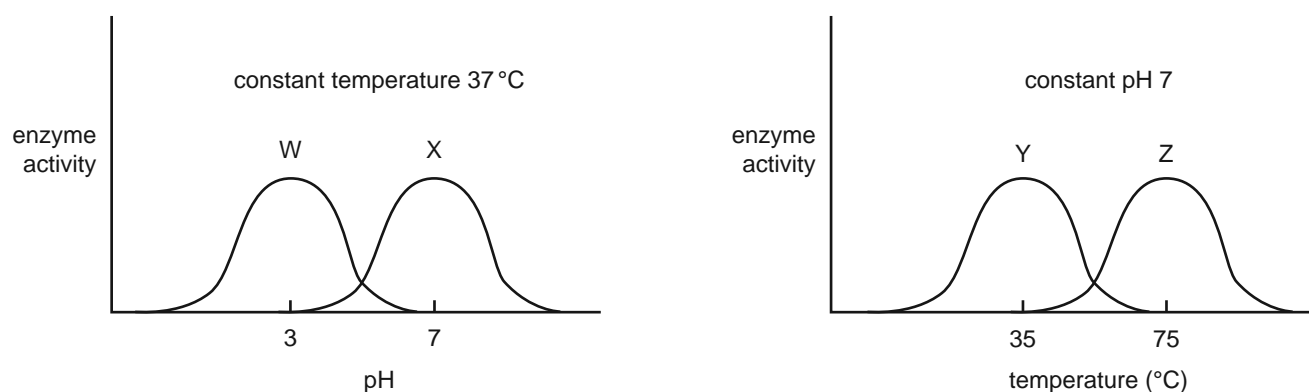


Referring to the information above and your knowledge of cellular respiration, which one of the following conclusions can be made?

- Most of the ATP is made in the Krebs Cycle.
- Pyruvic acid is converted to acetyl CoA under anaerobic conditions.
- No ATP can be formed from the breakdown of glucose under anaerobic conditions.
- One fatty acid X molecule produces more ATP in aerobic conditions than one glucose molecule does.

**Question 13**

The following graphs show the way four enzymes, W, X, Y and Z, change their activity in different pH and temperature situations.



Which one of the following statements about the activity of the four enzymes is true?

- At pH 7, enzyme Y is denatured at temperatures below 20 °C.
- Enzyme Z could be an intracellular human enzyme.
- At pH 3 and a temperature of 37 °C, the active site of enzyme W binds well with its substrate.
- At pH 3 and a temperature of 37 °C, enzyme X functions at its optimum.

**Question 14**

An example of 'self' material in an adult human female is

- A. pollen inhaled from flowers in her garden.
- B. sperm cells present in her reproductive tract.
- C. cells lining her nose and trachea.
- D. malarial parasites inside her red blood cells.

**Question 15**

The first line of defence against pathogens includes the

- A. activation of helper T cells.
- B. presence of acid in the stomach.
- C. release of histamine from mast cells.
- D. production of interferon from virus-infected cells.

**Question 16**

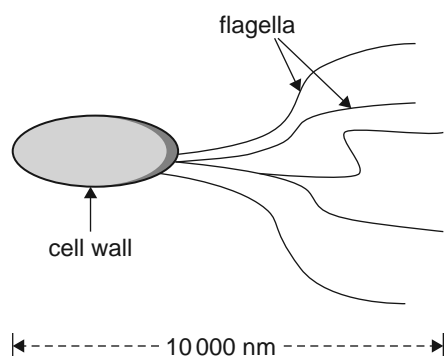
An example of a non-specific response by the immune system is

- A. phagocytes engulfing non-self material.
- B. cytotoxic T cells releasing chemicals into infected cells.
- C. production of memory T cells.
- D. cloning of B cells to produce plasma cells.

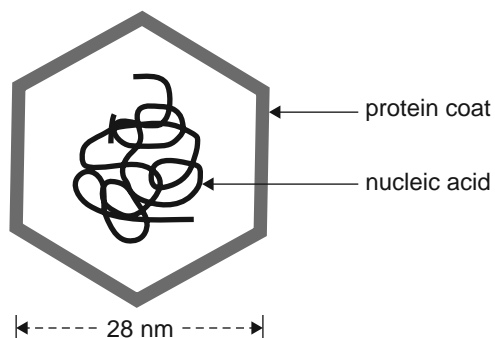
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**Question 17**

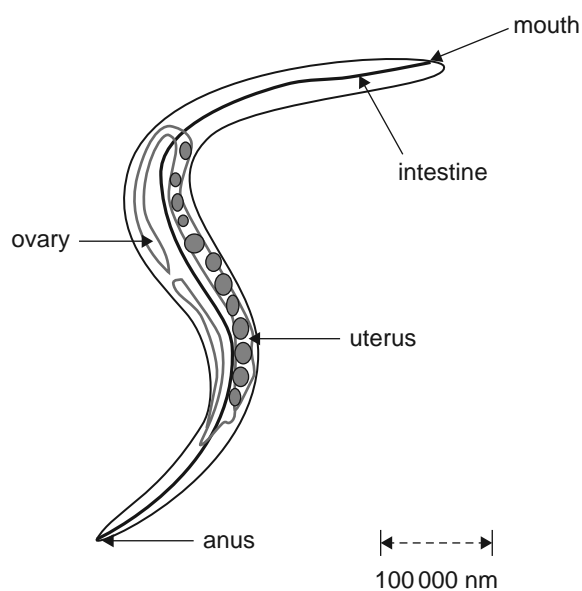
The following diagrams represent various types of plant and mammal pathogens. Their approximate size is indicated by a scale bar.



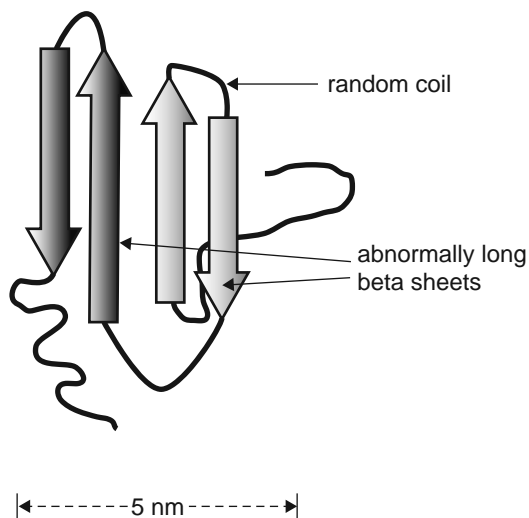
Pathogen W



Pathogen X



Pathogen Y



Pathogen Z

With respect to these pathogens, it would be reasonable to state that

- A. Z is a virus.
- B. both W and X are cellular.
- C. Y reproduces by binary fission.
- D. X reproduces by invading host-cell DNA.



*Use the following information to answer Questions 18 and 19.*

Australian scientists have grown a miniature mammalian kidney from stem cells taken from adult skin.

**Question 18**

In order to develop the technique above, it is essential to know how to

- A. remove a kidney from a developing embryo.
- B. insert kidney genes into skin-cell DNA.
- C. switch on the genes for kidney development.
- D. amplify DNA using a polymerase chain reaction.

**Question 19**

In the future, scientists aim to grow full-size kidneys for transplants in patients with kidney disease using the patient's own skin cells. This would overcome the problem of rejection of the transplanted kidney by the immune system.

Rejection of transplanted organs results mainly from an attack on the

- A. donor organ by the patient's memory B cells.
- B. donor organ by the patient's cytotoxic T cells.
- C. patient's immune cells by lymphocytes in the donated organ.
- D. patient's immune system by immunosuppressant drug treatment.

**Question 20**

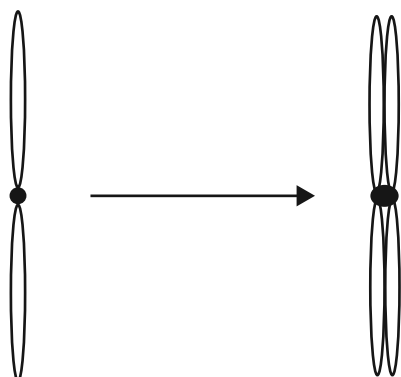
Which one of the following is a correct statement about mitosis?

- A. The spindle forms during prophase.
- B. Chromatids separate to opposite poles of the spindle during metaphase.
- C. Homologous chromosomes separate to opposite poles of the spindle during anaphase.
- D. Homologous chromosomes line up at the equator of the cell during telophase.

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**Question 21**

The diagram below represents an essential process in the production of new cells in a eukaryotic organism.



Which one of the following identifies the name of this process and its outcome?

	Name of process	Outcome of process
A.	binary fission	complementary strands
B.	cell division	sister chromatids
C.	transcription	proteins
D.	chromosomal replication	sister chromatids

*Use the following information to answer Questions 22 and 23.*

In populations of fruit flies, there are individuals that are resistant to the effects of insecticides. Insecticide-resistant fruit flies arose as a result of a mutation. In normal insecticide-susceptible fruit flies, a specific section of mRNA has the sequence GCU, whereas in the insecticide-resistant fruit flies, the sequence is UCU.

**Question 22**

Considering the mRNA sequence of the insecticide-resistant fruit flies, the corresponding sequence of nucleotides on the individual's DNA is

- A. AGA.
- B. AUA.
- C. CGA.
- D. TGT.

**Question 23**

This mutation is an example of a

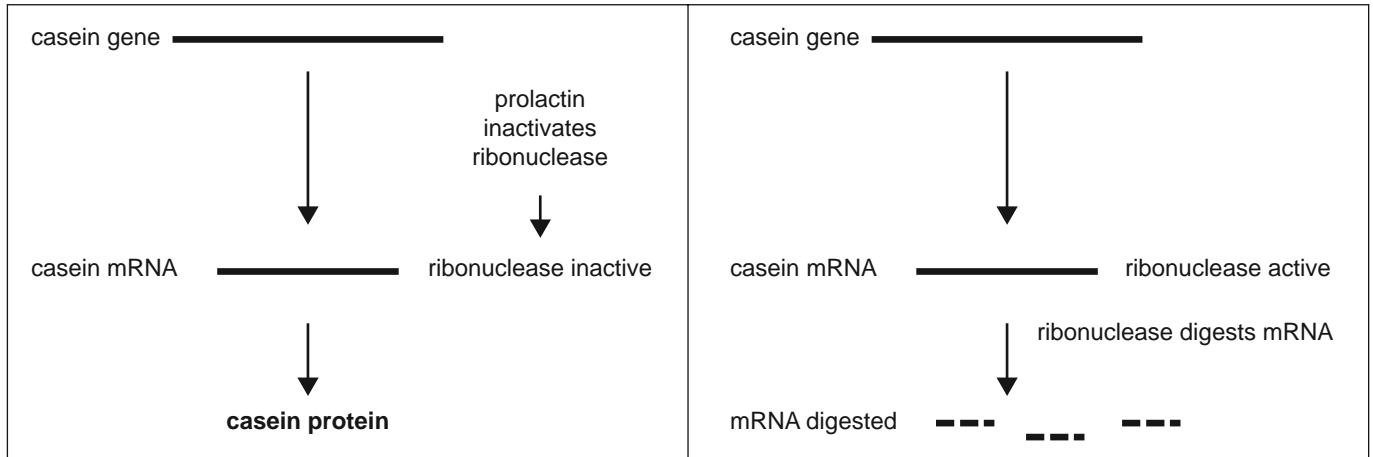
- A. chromosomal deletion during the formation of a gamete.
- B. nucleotide substitution during the formation of a gamete.
- C. chromosomal deletion during the formation of a somatic cell.
- D. nucleotide substitution during the formation of a somatic cell.

**Question 24**

Casein is a major protein found in mammalian milk.

When the mammals are producing milk, the pathway for the production of casein can be represented as shown in the diagram below on the left.

When the mammals are not producing milk, the pathway can be represented as shown in the diagram below on the right.



Which one of the following conclusions can be made from the information above?

- Ribonuclease has the effect of turning on the casein gene.
- Casein is a repressor protein for milk production in mammals.
- The hormone prolactin allows for the expression of the casein gene.
- Mammals produce milk only in the absence of the hormone prolactin.

**Question 25**

Plasmids of bacteria are used to transfer selected genes from one species to another.

The process can be represented as follows.

bacterial plasmid cut  $\rightarrow$  foreign gene and plasmid mixed  $\rightarrow$  plasmid with inserted foreign gene

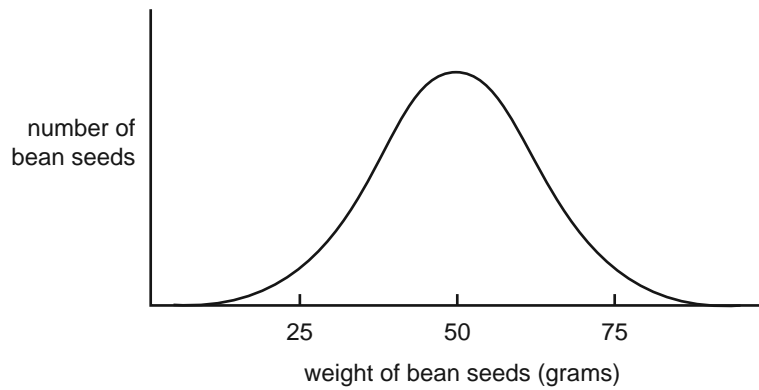
Enzymes are used to facilitate several of these steps.

Which one of the following shows the enzymes required for the first and last steps of the process?

	<b>Cuts plasmid</b>	<b>Inserts genes</b>
A.	restriction enzyme	DNA ligase
B.	restriction enzyme	DNA polymerase
C.	DNA ligase	DNA polymerase
D.	DNA polymerase	DNA ligase

**Question 26**

A student recorded the weight of over 10 000 bean seeds and graphically presented the data as shown below. The seeds came from bean plants grown in identical environmental conditions.

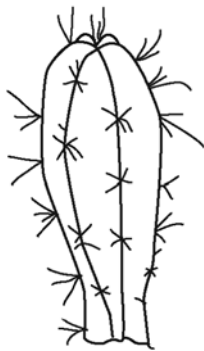


The seed weight varies because

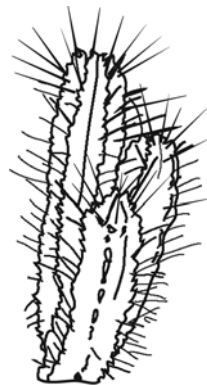
- A. all bean plants are homozygous for seed weight.
- B. many genes contribute to determining the weight of the seed.
- C. the bean plants grew in soil with similar moisture content.
- D. the bean plants grew at different temperatures.

**Question 27**

The American *Trichocereus macrogonus* and the South African *Euphorbia pentagona* are distantly related plants belonging to different families. Both plants live in dry regions. They both have thick, succulent stems to store water and spines for protection.



*Trichocereus macrogonus*



*Euphorbia pentagona*

not to scale

The similarity in form and function in *T. macrogonus* and *E. pentagona* is evidence of

- A. convergent evolution.
- B. divergent evolution.
- C. allopatric speciation.
- D. genetic drift.

**Question 28**

In humans, neurofibromatosis type 1 (NF-1) is an inherited disorder in which tumours of the nerve tissue form. NF-1 is an autosomal dominant trait.

A male with NF-1 has a child without the trait. The mother of the child does not have the trait.

The chance that the next child of these parents has NF-1 is

- A. zero.
- B. one in two.
- C. one in four.
- D. three in four.

*Use the following information to answer Questions 29–31.*

In a certain species of plant, the gene for stem colour assort independently to the gene for plant height.

The symbols for the alleles of the two genes are shown below.

Stem colour	Plant height
B: black	T: tall
b: red	t: dwarf

Plant 1 is a dwarf and has a black stem. Plant 1 has a parent that has a red stem.

Plant 2 is tall and has a black stem. Plant 2 has a parent that is a dwarf and has a red stem.

**Question 29**

The number of different genotypes that would be expected in the offspring of a cross between plant 1 and plant 2 is

- A. 2
- B. 4
- C. 6
- D. 8

**Question 30**

The number of different phenotypes that would be expected in the offspring of a cross between plant 1 and plant 2 is

- A. 2
- B. 4
- C. 6
- D. 8

**Question 31**

Plant 3 is tall and has a black stem. The phenotypes of the parents of plant 3 are unknown.

To determine the genotype of plant 3, it is best to cross it with a plant that is of a

- A. tall height and black stem colour.
- B. tall height and red stem colour.
- C. dwarf height and black stem colour.
- D. dwarf height and red stem colour.

**Question 32**

Flamingos are birds that live by lakes. The feather colour of flamingos may vary from white to pink to red. To investigate the inheritance of feather colour, a scientist performed the following crosses and recorded the feather colour of all the offspring when one year old. The diet of the offspring was also recorded.

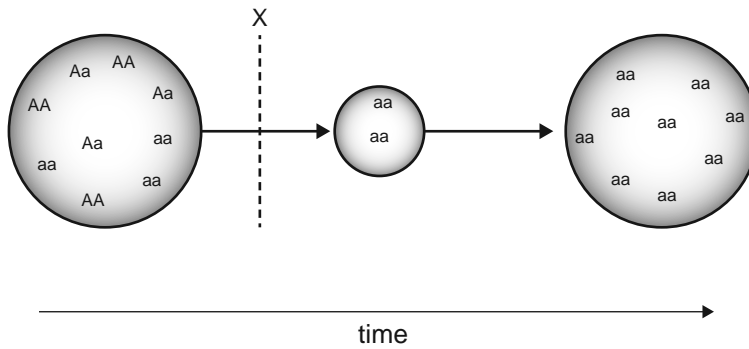
Cross	Feather colour of parents	Feather colour of all one-year-old offspring	Diet of offspring
1	white × white	white	aquatic plants
2	red × white	white	aquatic plants
3	white × white	pink	algae and crustaceans
4	red × white	pink	algae and crustaceans

Based on this information, a correct conclusion would be that

- A. both the parents in cross 1 must be homozygous for white feather colour.
- B. white feather colour is recessive to red feather colour.
- C. the feather colour of flamingos is influenced by their environment.
- D. two parents, both with pink feather colour, would produce one-year-old offspring with only pink feather colour.

**Question 33**

Consider the diagram below that models changes in allele frequencies for one trait in a population over two generations. The original population is shown on the left.

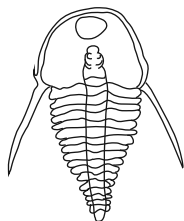


If the diagram above models the founder effect, then event X is

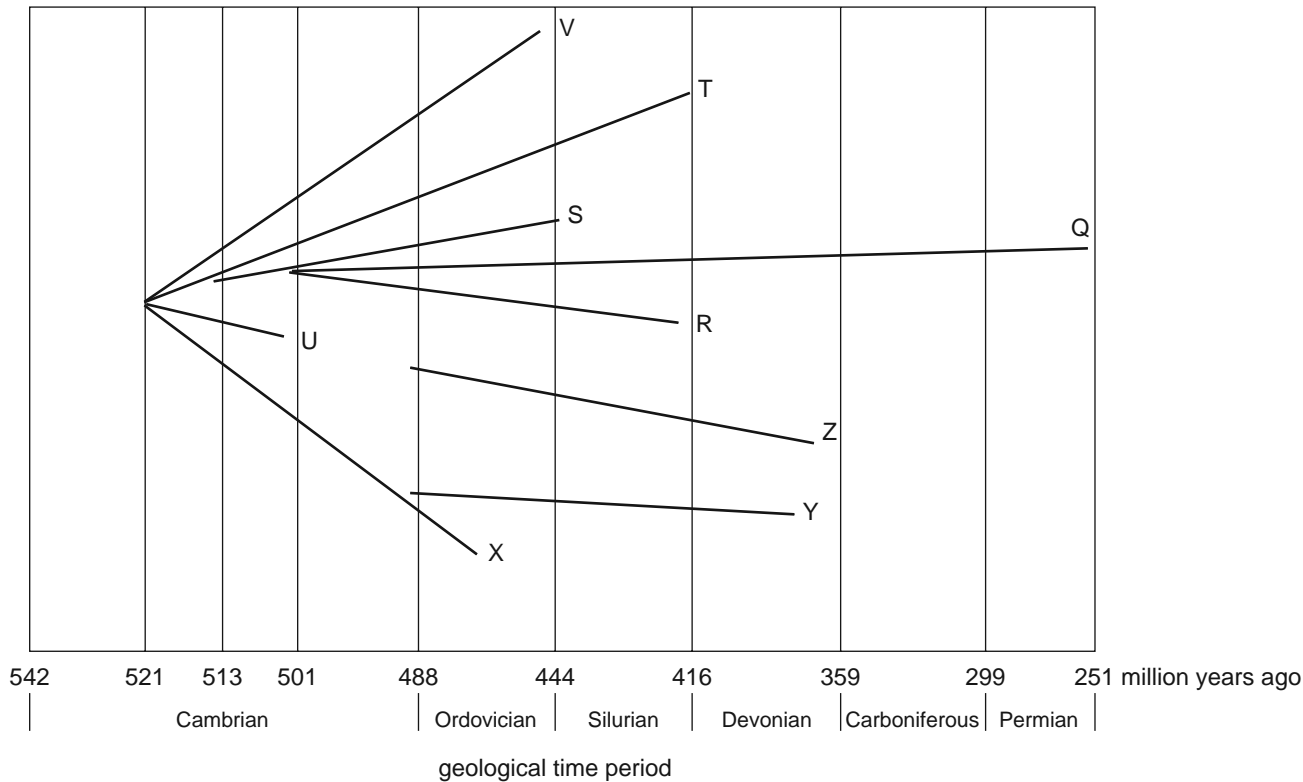
- A. migration.
- B. a natural disaster.
- C. random mating.
- D. a random assortment of alleles.

Use the following information to answer Questions 34–37.

Trilobites existed from the Early Cambrian period (521 million years ago) until the end of the Permian period (251 million years ago). The chart below, based on fossil evidence, shows the phylogeny of some trilobite orders present in Earth’s oceans over this time.



A trilobite fossil  
order: Ptychopariida



**Question 34**

Trilobite fossils in a particular layer of rock were used to date a fossil shell in the same layer. A palaeontologist dated the fossil shell to 328–359 million years old.

It is most likely that the trilobite fossils present were of the order

- A. Y.
- B. U.
- C. Q.
- D. T.

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**Question 35**

The absolute age of the trilobite fossils was most likely determined by using

- A. carbon dating.
- B. transition fossils.
- C. index fossils.
- D. potassium-argon dating.

**Question 36**

The geological time periods shown on the chart differ in duration because the time periods reflect

- A. the diversity of fossils and mass extinction events.
- B. the absence of trilobite fossils in the Late Cambrian period.
- C. different rates of radioactive decay.
- D. different rates of fossilisation.

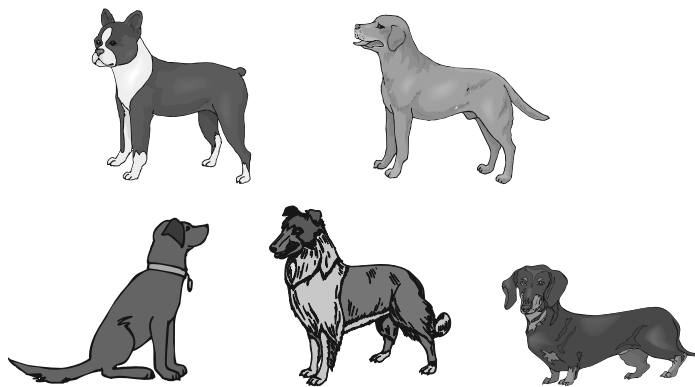
**Question 37**

The chance of a trilobite becoming fossilised is increased by

- A. slow burial of its remains in dry sediment.
- B. large temperature variations in the sediment containing its remains.
- C. the presence of hard body parts.
- D. the presence of scavengers at the time of its death.

**Question 38**

The diagram below shows five different breeds of dog that now exist within the *Canis lupus familiaris* species.



The development of variant breeds within *Canis lupus familiaris* is an example of

- A. natural selection occurring in geographically isolated populations.
- B. gene-transfer technology transforming the genotype of a species.
- C. convergent evolution occurring in a range of similar habitats.
- D. human intervention through artificial selection.

Use the following information to answer Questions 39 and 40.

A hominin species, *Homo floresiensis*, was identified from fossils found on an isolated Indonesian island. These fossils were dated to be 18 000 years old.

The adult skull of this upright bipedal hominin had a cranial volume less than one-third of the average cranial volume of a modern adult human. It had harder, thicker eyebrow ridges than *Homo sapiens*, a sharply sloping forehead and no chin.

*H. floresiensis* was just over one metre tall and their arm-to-leg ratio was slightly larger than modern humans. They weighed approximately 16 kg.

The fossils were found in sediment that also contained stone tools and fireplaces for cooking. The fireplaces contained the burnt bones of animals, each animal weighing more than 350 kg. The stone tools included blades, spearheads, and cutting and chopping tools.

### Question 39

The above evidence and current theories of hominin evolution indicate that

- A. the very small stature of *H. floresiensis* is unexpected in a species that is geographically isolated on a small island.
- B. *H. floresiensis* was a species that showed considerable social cooperation and methods for passing on knowledge.
- C. the sloping forehead and absence of chin of members of the *H. floresiensis* species suggest they were members of the first migration of hominins into Australia over 50 000 years ago.
- D. the skull shape and size of *H. floresiensis* suggest a close relationship to the *Homo neanderthalensis* species.

### Question 40

The fossils of *H. floresiensis* showed that they had opposable thumbs.

The development of an opposable thumb in primate evolution

- A. is used to distinguish members of the genus *Homo* from the other great apes.
- B. was a necessary step in the development of bipedalism in hominins.
- C. was an important anatomical development that assisted tool-making in hominins.
- D. is a significant factor in determining the arm-to-leg ratio of modern humans.

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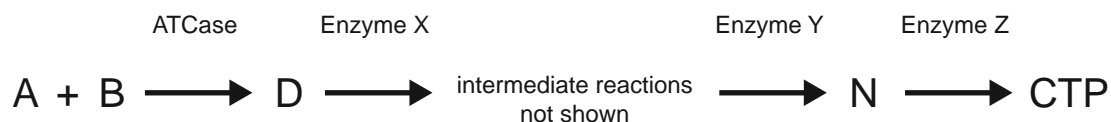
**SECTION B – Short-answer questions****Instructions for Section B**

Answer **all** questions in the spaces provided. Write using black or blue pen.

**Question 1** (6 marks)

CTP is a substance used by cells to make RNA. The cell initially synthesises CTP using a metabolic pathway starting with the amino acid aspartane (A) and another complex molecule (B).

The pathway for making CTP is represented below. The enzyme involved in the first step of the pathway is called ATCase.



- a. What is the role of ATCase? Explain how it performs this role.

2 marks

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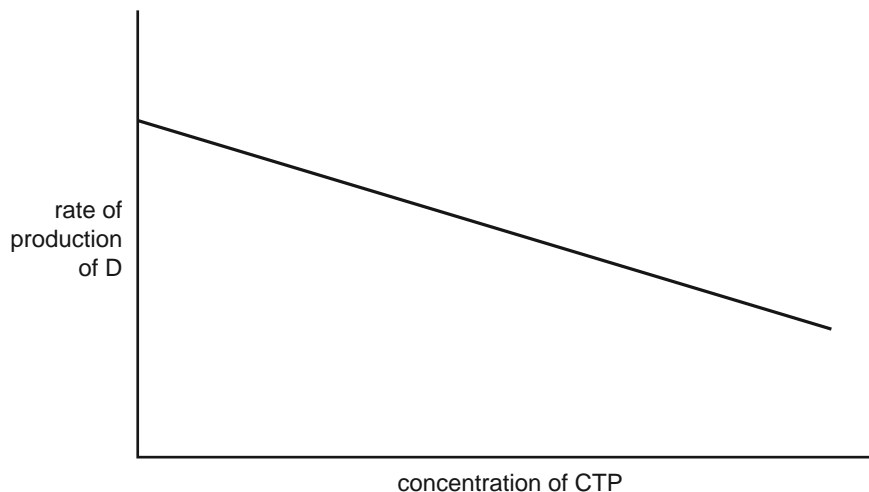
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The graph below shows the change in the rate of production of D in solutions with different concentrations of CTP, keeping all other variables constant.



- b. i. Using the information in the graph, state what is happening to the rate of production of D as the concentration of CTP increases.

1 mark

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- ii. CTP changes the quaternary structure of the enzyme ATCase.

Use this information to explain at a molecular level how the production of CTP is regulated within a cell.

3 marks

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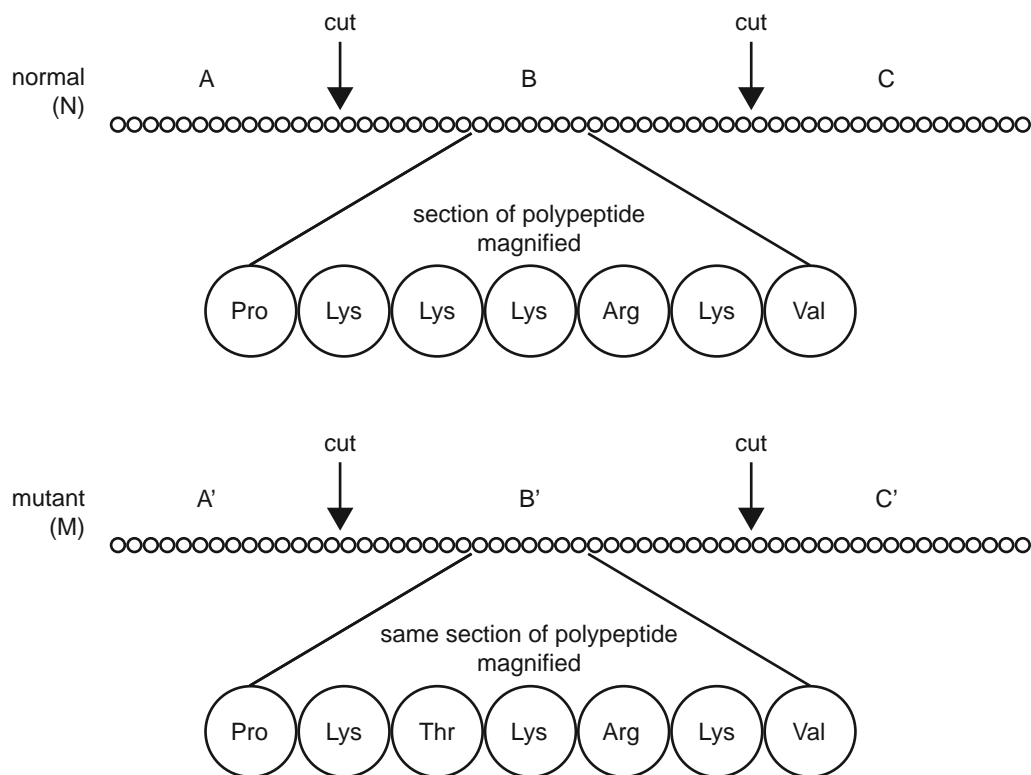
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**Question 2** (5 marks)

Scientists have investigated how the nucleus accumulates the enzymes that it needs to function. They found a possible answer while studying a particular mutant form of the SV40 virus. A mutant polypeptide produced by this virus was not able to get into the host cell's nucleus in the way that the normal (non-mutant) form did.

The polypeptides for the normal (N) form and the mutant (M) form are shown below. A sequence of seven amino acids from the middle of the polypeptides is also shown below.



Both the normal and mutant forms of the polypeptides were cut into three smaller chains – A, B and C (A', B' and C') – as shown above. Each polypeptide was put into a cell and then its accumulation in the nucleus was measured. The table below shows the results of the experiment.

Polypeptide	Accumulates in nucleus
N	yes
M	no
A	no
B	yes
C	no
A'	no
B'	no
C'	no

- a. Based on the results in the table, scientists proposed the hypothesis that the sequence of seven amino acids, Pro-Lys-Lys-Lys-Arg-Lys-Val, enabled the polypeptide to cross the nuclear membrane and accumulate in the nucleus.

What evidence supports this hypothesis?

2 marks

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- b. Scientists can make polypeptides with any sequence of amino acids. They also have techniques for inserting these polypeptides into the cytoplasm of cells. One scientist predicted it was the presence of lysine (Lys) in the third position of the amino acid sequence that enabled the polypeptide to accumulate in the nucleus. She designed a controlled experiment to test her prediction. She used a large sample of identical cells. All cells were kept under the same environmental conditions.

Outline the other steps the scientist took to complete her experiment.

3 marks

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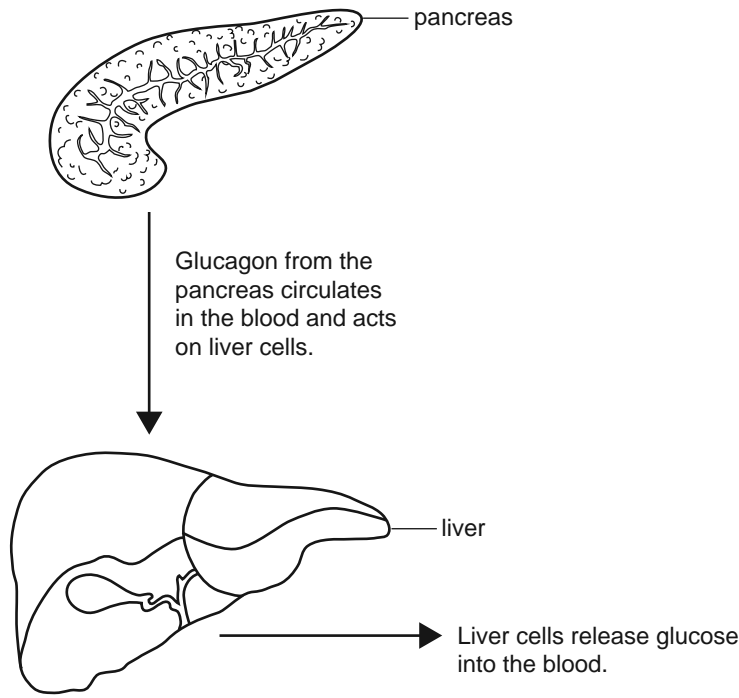
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**Question 3** (6 marks)

After exercise, low levels of blood glucose can result in the release of glucagon (a hydrophilic hormone) from the pancreas. One site of glucagon activity is liver cells, where it causes a process called glycogenolysis to occur. In this process, stored glycogen is broken down and glucose is released into the blood stream.



- a. Describe how hydrophilic hormones, such as glucagon, stimulate a metabolic process, such as glycogenolysis, inside a cell.

2 marks

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When glycogenolysis occurs in a cell, the concentration of glucose in the cytosol increases. Glucose passes through the plasma membrane by facilitated diffusion.

b. Explain how the facilitated diffusion of glucose occurs.

2 marks

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Muscle cells in the heart contract and relax more rapidly during exercise and require a constant supply of energy.

c. Which organelle would you expect to see in large numbers in heart muscle cells to supply this energy? Explain your response.

2 marks

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**SECTION B** – continued  
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**Question 4** (7 marks)

a. Define the term 'pathogen'.

1 mark

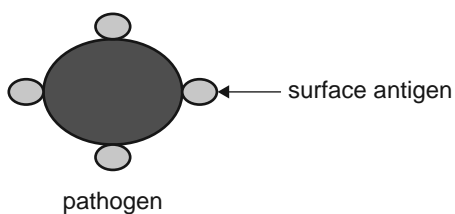
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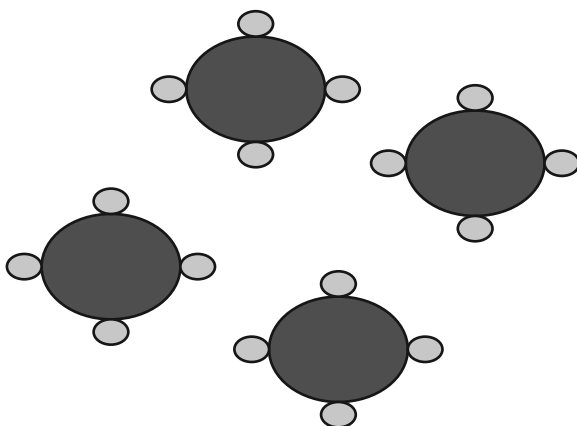
The diagram below shows a generalised pathogen with antigens on its surface. The immune system responds to antigens by making antibodies.



b. Draw an antibody that would be effective against this pathogen. Label the different parts of the antibody.

2 marks

One way that antibodies work is by forming antigen–antibody complexes.  
The diagram below shows four pathogens.



- c. i. Illustrate on the diagram **above** how the antigen–antibody complex forms, using at least **four** antibodies in your drawing. 2 marks
- ii. Explain how an antigen–antibody complex provides protection against these pathogens. 2 marks

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**Question 5** (6 marks)

The RhD antigen is a protein found on red blood cells in humans. The presence of the protein is genetically controlled. Possible phenotypes and genotypes with respect to this trait are shown in the table below.

Genotype	Phenotype	RhD antigens on red blood cells
DD	Rhesus positive	present
Dd	Rhesus positive	present
dd	Rhesus negative	absent

- a. With reference to the father's possible phenotype(s) and genotype(s), explain how a Rhesus-negative mother could be pregnant with a Rhesus-positive fetus.

2 marks

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Hemolytic disease of the newborn (HDN) can occur if a Rhesus-negative mother is pregnant with a Rhesus-positive fetus. During pregnancy and birth, some fetal blood cells may enter the mother's bloodstream. The mother makes antibodies against the fetal RhD antigens. This is usually not a problem until there is a second pregnancy with a Rhesus-positive fetus. RhD antibodies made by the mother then cross the placenta, resulting in the possible death of the newborn.

- b. Explain, by referring to the immune response, why the fetus in a second pregnancy is at far greater risk of HDN than the first Rhesus-positive fetus.

2 marks

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A treatment called immunoprophylaxis has reduced the incidence of newborn death due to HDN. In this treatment, the Rhesus-negative mother receives injections of RhD antibodies with her first Rhesus-positive pregnancy and again at the birth.

- c. Would you consider this treatment to be an active or a passive form of immunotherapy? Explain your response.

2 marks

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**SECTION B – continued**  
**TURN OVER**

**Question 6** (4 marks)

Beehives consist of up to 40 000 honey bees. The majority of these bees are female worker bees. There is only one queen bee. She is a diploid female ( $2n = 32$ ) and she is the bee that lays the eggs for the colony. The queen bee lays two different types of eggs:

- Type 1 – Those eggs that have been fertilised by sperm give rise to females that become either worker bees or other queen bees.
- Type 2 – Those eggs that have not been fertilised by sperm give rise to male drone bees.

**a.** How many chromosomes are there in the somatic cells of the following bees?

1 mark

Female worker bee \_\_\_\_\_

Male drone bee \_\_\_\_\_

**b.** Even though they come from unfertilised eggs, male drone bees show genotypic variation.

Describe how this can occur.

2 marks

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**c.** Explain an advantage that genetic variation brings to a species.

1 mark

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**Question 7** (5 marks)

Scientists studying the nucleus of the fruit fly *Drosophila melanogaster* observed distinct types of nucleic acid chains.

These scientists noticed that one type of nucleic acid chain was able to pass through the nuclear membrane and move to a ribosome. After the nucleic acid chain attaches to the ribosome, a polymer is produced.

- a. Describe the steps occurring at the ribosome that resulted in the production of the polymer. 3 marks

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- b. One particular length of nucleic acid chain passed through the nuclear membrane and coded for the production of a polymer that was 90 monomers long.

How many nucleotide bases on the nucleic acid chain were involved in the coding for this polymer?  
Explain your response.

2 marks

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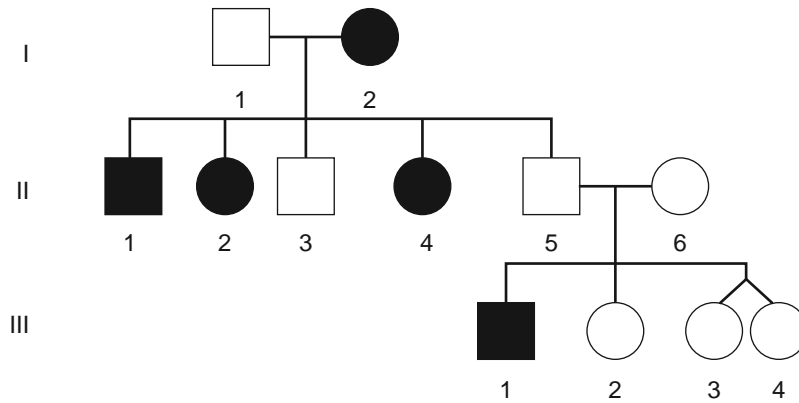
**Question 8** (6 marks)

Hereditary hypophosphatemic rickets (HHR) is a human disorder related to low levels of phosphate in the blood. HHR follows an X-linked dominant mode of inheritance. A male with HHR has six children – three boys and three girls. The mother of the children does not have HHR.

- a. Draw a pedigree in the space below to show the information above and shade all individuals who will have HHR.

1 mark

In another family, a **different trait** occurs in some individuals, as shown in the pedigree below.



- b. Determine the mode of inheritance of this different trait and give two reasons to support your response.

3 marks

Mode of inheritance \_\_\_\_\_

\_\_\_\_\_

Reason 1 \_\_\_\_\_

\_\_\_\_\_

Reason 2 \_\_\_\_\_

\_\_\_\_\_



- c. Consider the identical twins, individuals III-3 and III-4. Neither individual has the different trait. A study of many other traits expressed by these two individuals when they were aged 20 was carried out.

What would the findings of such a study reveal? Explain.

2 marks

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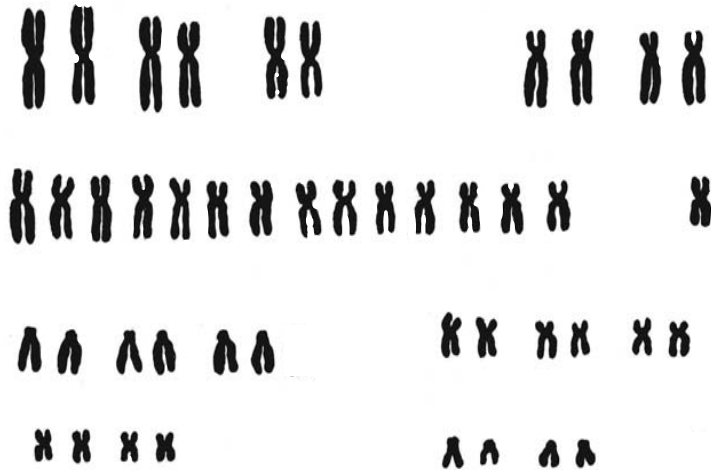
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**SECTION B – continued**  
**TURN OVER**

**Question 9** (5 marks)

Consider the following human karyotype.



- a. Name the two types of macromolecules that would be found in the structures in the karyotype.

Macromolecule 1 \_\_\_\_\_

Macromolecule 2 \_\_\_\_\_

Draw **two** labelled diagrams in the space below to illustrate the general structure of the monomers of each macromolecule named.

4 marks

- b. Explain whether this individual's karyotype is the same as, or different from, a normal human karyotype.

1 mark

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

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**SECTION B – continued**  
**TURN OVER**

**Question 10** (4 marks)

In birds, the sex chromosomes of males are of equal length and are referred to as the ZZ chromosomes. Female birds have sex chromosomes of unequal length that are referred to as the ZW chromosomes.

A gene for head feather colour in a bird is found on the Z chromosome. The W chromosome does not contain a copy of this gene. Red head feathers are dominant to black head feathers.

allele symbols:    red head feathers: R        black head feathers: r

A cross between a heterozygous male with red head feathers and a female with black head feathers was carried out.

- a. Predict the resulting offspring. Show all working, including genotypes of parents, genotypes and phenotypes of offspring, and ratios where appropriate.

2 marks

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The gene for the colour of the breast feathers in these same birds is found on an autosome. There are three alleles for this gene.

allele symbols:      purple: B      lilac:  $b^l$       white: b

White breast feathers are recessive to both purple and lilac breast feathers.

Purple breast feathers are dominant to lilac breast feathers.

The following cross was carried out.

phenotypes of parents:    male with purple breast feathers × female with lilac breast feathers

genotypes of parents:                      Bb                                       $b^l b$

- b. Predict the resulting offspring. Show all working, including genotypes and phenotypes of offspring, and ratios where appropriate.

2 marks

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**Question 11** (9 marks)

In 1991, the body of a man was found frozen beneath a glacier in Italy. Researchers named him Ötzi. It was determined that Ötzi died 5300 years ago and that his body is the oldest mummified human body ever found. Scientists have successfully extracted DNA from the nucleus of his frozen cells.

- a. Describe the process scientists would use on a small sample of Ötzi’s DNA to obtain larger quantities of identical DNA. 3 marks

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Using gel electrophoresis, scientists discovered that there were four different types of blood on Ötzi’s clothes. Their results were as follows.

Ötzi’s blood taken from his blood vessels	Blood sample 1 from Ötzi’s clothes	Blood sample 2 from Ötzi’s clothes	Blood sample 3 from Ötzi’s clothes	Blood sample 4 from Ötzi’s clothes
—		—	—	
	—			—
—	—		—	—
—			—	
	—	—		—
		—		
		—		—

- b. i. Which blood sample on Ötzi's clothes belongs to Ötzi? 1 mark

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- ii. Propose **one** hypothesis that would explain the presence of the other blood samples on Ötzi's clothes. 1 mark

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- c. Analysis of mammalian proteins provides evidence of evolutionary relationships.  
Explain how amino acid differences in a protein can indicate evolutionary relationships. 2 marks

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- d. The development of bipedalism in hominins is believed to have had a very significant effect on human evolution.  
Describe **two** effects of bipedalism on hominin behaviour. 2 marks

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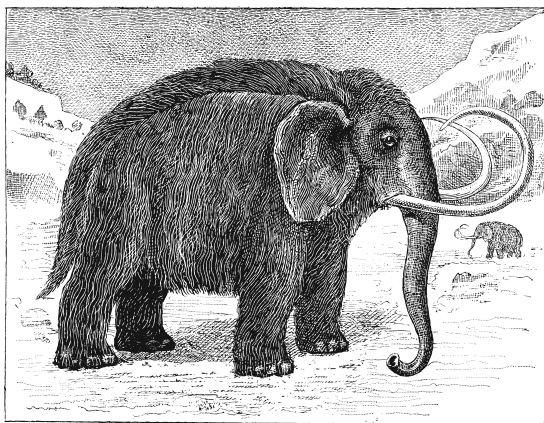
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**Question 12** (7 marks)

Source: Morphart Creation/shutterstock.com

The extinct woolly mammoth, *Mammuthus primigenius*, was closely related and similar in size to present-day elephants. It was herbivorous and highly adapted to very cold climates, with a dense undercoat and small, fur-lined ears. The table below shows information about woolly mammoths inferred from extensive fossil evidence.

Number of years ago	Event	Abundance of mammoths
200 000	woolly mammoths first appeared in north-east Siberia and later spread to Europe, Asia and North America	very high
120 000–100 000	climate warmed	moderate
100 000	climate cooled again	
15 000	first evidence of human hunting: spear found in mammoth vertebrae	low
14 000–10 000	mammoths extinct in North America, Europe and most of northern Asia	very low, found only in Siberia
3900	last woolly mammoth died on an island off the coast of Siberia	non-existent

- a. Define the term 'selection pressure' and, based on the information provided, give an example of a selection pressure on woolly mammoths.

2 marks

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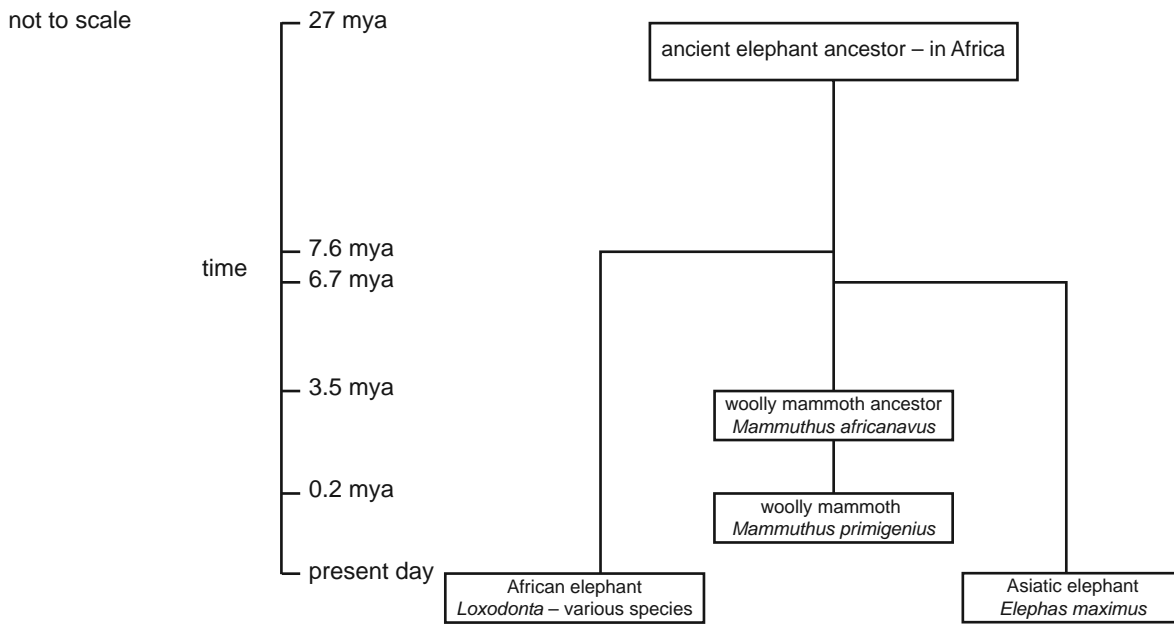
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It has been suggested that elephant-like ancestors of the woolly mammoth left Africa 3.5 million years ago (mya) and lived in Central Europe. The chart below shows a summarised phylogenetic tree based on mitochondrial and chromosomal DNA from fossils and living elephants.



- b. i. Explain how the woolly mammoth *M. primigenius* probably arose from the woolly mammoth ancestor *M. africanavus*.

3 marks

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- ii. Suggest how it could be possible for *M. primigenius* to have arisen so recently (0.2 mya) yet now be extinct, while the Asiatic elephant, *E. maximus*, has been present for over 6 million years.

2 marks

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