VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

Victorian Certificate of Education 2016

SUPERVISOR TO ATTACH PROCESSING LABEL HERE

STUDENT NUMBER | | | | | | | | | Letter |

BIOLOGY

Written examination

Friday 28 October 2016

Reading time: 9.00 am to 9.15 am (15 minutes)
Writing time: 9.15 am to 11.45 am (2 hours 30 minutes)

QUESTION AND ANSWER BOOK

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	40	40	40
B	11	11	70
			Total 110

- 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 correction fluid/tape.
- No calculator is allowed in this examination.

Materials supplied
- Question and answer book of 34 pages.
- Answer sheet for multiple-choice questions.

Instructions
- Write your **student number** in the space provided above on this page.
- Check that your **name** and **student number** as printed on your answer sheet for multiple-choice questions are correct, **and** sign your name in the space provided to verify this.
- All written responses must be in English.

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

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.

© VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY 2016

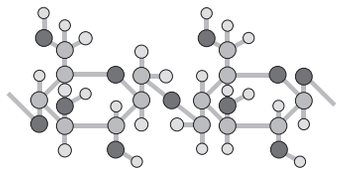
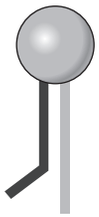
SECTION A – Multiple-choice questions

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 1–5.

The diagrams below represent three of the major macromolecule groups in living things.

		
Group A	Group B	Group C

Question 1

Synthesis of macromolecules from these groups involves

A. energy-generating condensation reactions requiring an input of water molecules.
B. energy-generating reactions requiring an input of carbon dioxide molecules.
C. energy-requiring condensation reactions with an output of water molecules.
D. energy-requiring reactions with an output of oxygen molecules.

Question 2

Starch, glycogen and cellulose are some examples of macromolecules from Group A.
Which one of the following would be true for these Group A macromolecules?

A. All three macromolecules are complex lipids and the monomer is lactose.
B. All three macromolecules are complex polymers and the monomer is ribose.
C. All three macromolecules are complex triglycerides and the monomer is fructose.
D. All three macromolecules are complex carbohydrates and the monomer is glucose.

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

Question 3

Each monomer of a macromolecule from Group B is made up of a

A. deoxyribose sugar, a phospholipid group and a nitrogen-containing base.

B. deoxyribose sugar, a phosphate group and a nitrogen-containing base.

C. ribose sugar, a phospholipid group and a nitrogen-containing base.

D. ribose sugar, a phosphate group and a glycerol backbone.

Question 4

A portion of one strand of a macromolecule from Group B has the sequence -CGATTCGGTTAA-

The complementary strand would be

A. -CGATTCGGTTAA-

B. -AATTGGCTTAGC-

C. -GCTAAGCCAATT-

D. -GCUAAGCCAAUU-

Question 5

If a sample of a macromolecule from Group C were chemically analysed, you would expect to find that it contains

A. amino acids and phosphate.

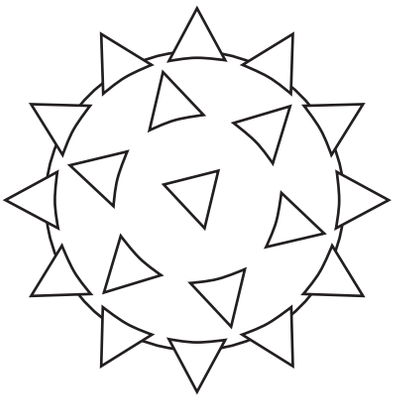
B. fatty acids and phosphate.

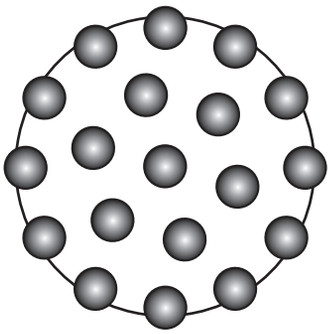
C. amino acids only.

D. glucose.

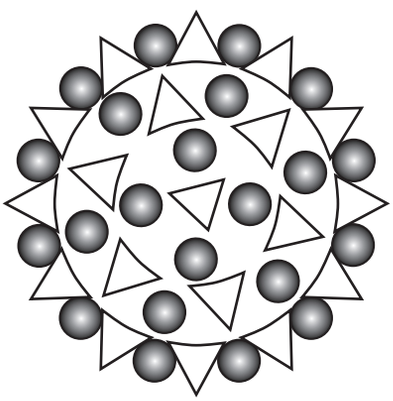
Question 6

Many eukaryotic cells have proteins as part of their plasma membranes. An experiment was performed on two different animal cells. The diagrams below show the positions and shapes of two proteins on the plasma membranes of the two different cells.





These cells were then fused. After one hour, the plasma membrane of the resulting living cell was observed. The changed positions of the proteins are shown below.



The redistribution of proteins on the plasma membrane can be explained by

A. the fluid mosaic model.

B. movement due to osmosis.

C. the presence of cholesterol in the plasma membrane.

D. the active transport of proteins across the plasma membrane.

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

Question 7

In animal cells, tight junctions are multi-protein complexes that mediate cell-to-cell adhesion and regulate transport through the extracellular matrix. Proteins that form these complexes are made within the cell.

One pathway for the production of protein for these junctions is

A. nucleus – ribosome – Golgi apparatus – vesicle – endoplasmic reticulum.

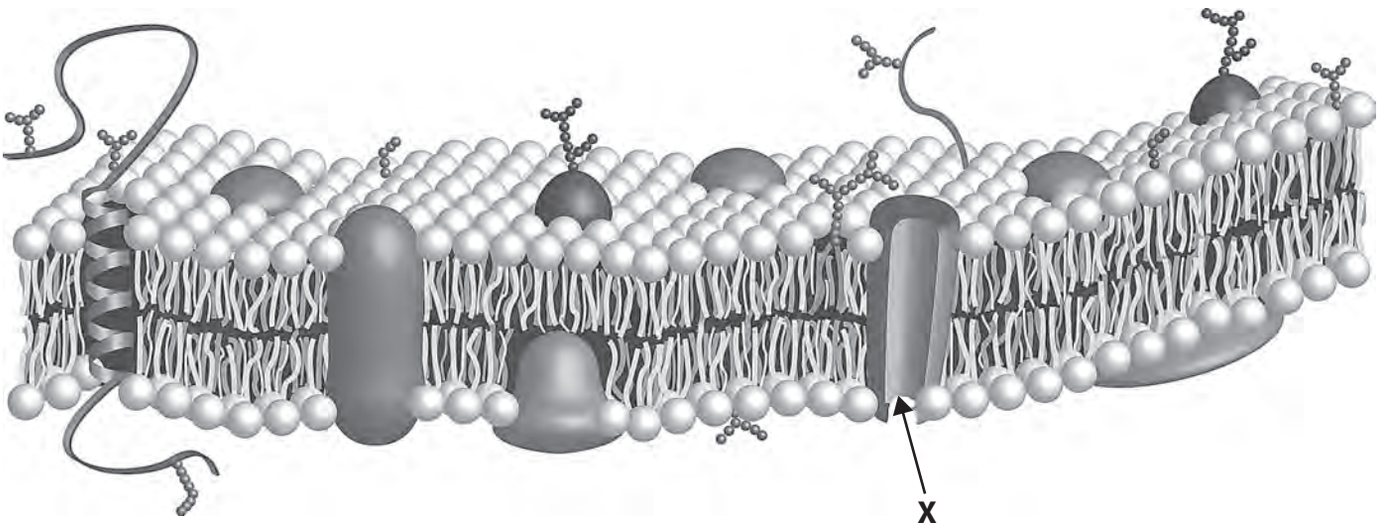
B. nucleus – ribosome – endoplasmic reticulum – vesicle – Golgi apparatus.

C. nucleus – vesicle – endoplasmic reticulum – Golgi apparatus – ribosome.

D. nucleus – vesicle – Golgi apparatus – ribosome – endoplasmic reticulum.

Question 8

Consider the following diagram of a plasma membrane.



Source: magnetix/Shutterstock.com

The structure labelled 'X' is a

A. protein channel.

B. cholesterol molecule.

C. glycoprotein molecule.

D. phospholipid molecule.

Question 9

ATP is important in living cells as it

A. is required for osmosis.

B. provides a supply of usable energy for the cell.

C. provides one of the building blocks for lipid synthesis.

D. is an important structural component of the plasma membrane.

Question 10

Plants grown in light were supplied with water containing radioactive oxygen atoms. After four hours, an analysis of the chemicals in and around the plants was undertaken.

Which one of the following would contain the radioactive oxygen atoms after four hours?

A. protein

B. glucose

C. oxygen gas

D. carbon dioxide gas

Question 11

Which one of the following statements about photosynthesis in chloroplasts is correct?

A. The grana are the site of the light-independent stage.

B. Chlorophyll found in the stroma traps light for use during the light-dependent stage.

C. The light-dependent stage produces ATP for use during the light-independent stage.

D. The light-independent stage captures carbon dioxide for use during the light-dependent stage to produce glucose.

Question 12

In a prokaryotic cell undergoing binary fission

A. a circular molecule of DNA is replicated.

B. a nuclear membrane is synthesised.

C. spindle proteins are formed.

D. a cell plate is formed.

Question 13

A cell divides to produce gametes.

This process will

A. supply cells for the replacement of damaged tissue.

B. produce cells that are genetically identical.

C. involve one nuclear division.

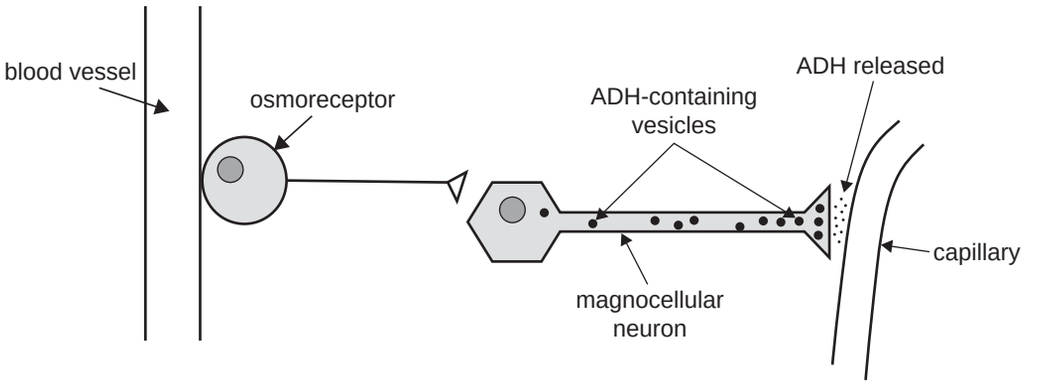
D. produce haploid cells.

DO NOT WRITE IN THIS AREA

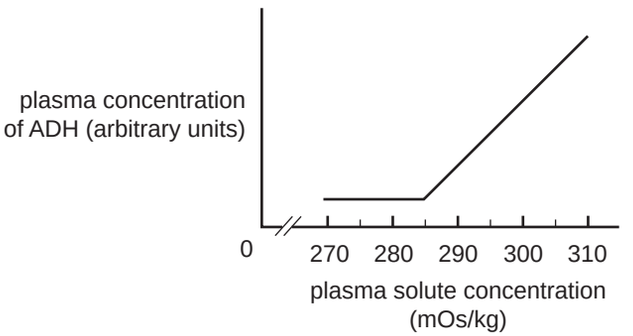
DO NOT WRITE IN THIS AREA

Question 14

Antidiuretic hormone (ADH) is a hormone involved in the regulation of blood plasma solute concentration. Osmoreceptors detect changes in blood plasma solute concentration and stimulate magnocellular neurons. Magnocellular neurons are special neurons that synthesise ADH, storing ADH in vesicles until stimulated to release it. ADH diffuses across a gap and into a capillary. This process is shown in the diagram below.



The graph below shows the concentration of ADH in the blood at different plasma solute concentrations.



Based on the information given and your own knowledge, which one of the following is a correct statement?

A. At plasma solute concentrations below 285 mOs/kg, nerve electrical impulses from the osmoreceptor are too small in magnitude to trigger the release of a neurotransmitter.

B. At plasma solute concentrations above 285 mOs/kg, nerve electrical impulses begin to cross the synaptic gap between the osmoreceptor and the magnocellular neuron.

C. At plasma solute concentrations above 285 mOs/kg, the frequency of nerve electrical impulses in the magnocellular neuron will trigger increased release of ADH.

D. At plasma solute concentrations between 270 and 285 mOs/kg, the osmoreceptors do not detect changes.

Question 15

An experiment was conducted to test the following two hypotheses about the effect of the plant growth regulator indoleacetic acid (IAA):

- Hypothesis 1 – Low concentrations of IAA stimulate root growth and have no effect on shoot growth.
- Hypothesis 2 – Concentrations of IAA above 0.01 parts per million stimulate shoot growth but inhibit root growth.

In the experiment, radish seedlings were grown in different concentrations of IAA, as indicated in the table below.

Concentration of IAA (parts per million)	Stimulation (+)/ inhibition (–) of shoot growth (%)	Stimulation (+)/ inhibition (–) of root growth (%)
0	0	0
0.00001	+0.10	–30
0.0001	+6	–50
0.001	–20	–70
0.01	–60	–85
1	–70	–90
10	–80	–95
100	–90	–100

Which one of the following is a reasonable conclusion to draw from the results of the experiment?

A. Only Hypothesis 1 is supported.
B. Only Hypothesis 2 is supported.
C. Hypotheses 1 and 2 are both supported.
D. Hypotheses 1 and 2 are both not supported.

Question 16

Which one of the following is a catabolic process?

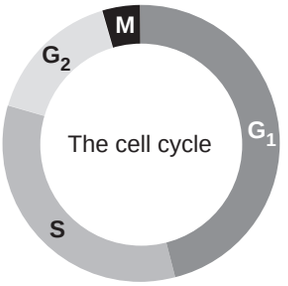
A. the conversion of glycogen to glucose
B. the production of carbohydrates during photosynthesis
C. the synthesis of a polypeptide hormone from amino acids
D. the formation of a triglyceride from glycerol and fatty acids

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

Use the following information to answer Questions 17 and 18.

The cell cycle for a eukaryotic cell can be subdivided into the phases shown in the diagram below.



Question 17

During the G_1 and G_2 phases of the cell cycle, most of the activity is directed towards

A. DNA replication.

B. resting for the next phase.

C. synthesis of the nuclear membrane.

D. synthesis of organelles and growth of the cell.

Question 18

Cytokinesis is part of the cell cycle and

A. usually follows nuclear division.

B. will occur between the G_1 and S phases of the cell cycle.

C. in plant cells it begins with the formation of a very rigid lipid bilayer within the divided cell.

D. in animal cells it begins with the plasma membrane being pulled inwards towards the cell plate.

Question 19

A biologist was working with a cell culture. He viewed a cell just before it entered mitosis and he counted 18 chromosomes. Later, the nucleus of one of the daughter cells was found to contain 19 molecules of DNA and the nucleus of the other daughter cell contained 17 molecules of DNA.

The most likely explanation for this observation is

A. the microtubules of the spindle apparatus did not connect to the centromeres of two of the chromosomes.

B. during anaphase, sister chromatids of one chromosome failed to separate.

C. during prophase, two of the chromosomes failed to line up.

D. at the end of telophase, cytokinesis failed to occur.

Question 20

The inflammatory response is a defence mechanism that evolved in higher organisms to protect them from infection and injury.

This response

A. includes phagocyte migration to the site of the injury.

B. is part of the adaptive immune system.

C. is specific to the type of foreign body.

D. involves the production of lymphocytes.

Use the following information to answer Questions 21 and 22.

In early 2016, there was an outbreak of food poisoning in Victoria linked to the consumption of prepackaged lettuce. In investigations carried out by the Department of Health and Human Services, several products tested positive for the prokaryote *Salmonella anatum*.

Question 21

It is reasonable to say that *S. anatum* is

A. a virus.

B. a prion.

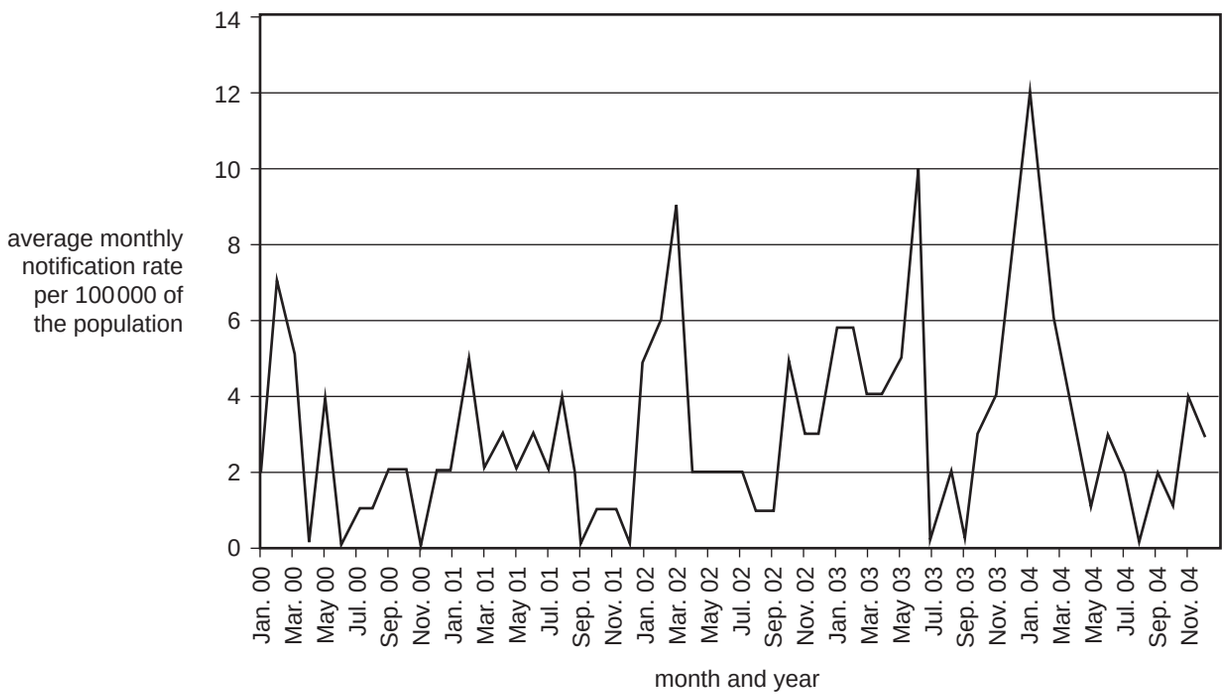
C. an insect.

D. a bacterium.

Question 22

S. anatum is not a common cause of food poisoning. Data has been collected and analysed for the occurrence of illness caused by this organism in Queensland over a five-year period.

The graph below displays the average monthly notification rate per 100 000 of the population for the illness caused by *S. anatum*.



Source: The State of Queensland (Queensland Health) 1996–2016

It can be concluded from the data that

A. there are four periods in which the notification rate is greater than six per 100 000.

B. the notification rate is always lowest during September of each year.

C. the notification rate is fairly steady over the five-year period.

D. the notification rate in 2001 was highest in May.

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

Question 23

A park ranger was injected with an antivenom serum to treat a snakebite. The treating doctor explained that the injection would not protect him against future snakebites.

This is because antivenom serum is used to achieve

A. active and natural immunity.

B. passive and natural immunity.

C. active and induced (artificial) immunity.

D. passive and induced (artificial) immunity.

Question 24

In the search for a malaria vaccine, scientists have focused on a protein called circumsporozoite protein (CSP). CSP is secreted by the malaria parasite and is present on its surface.

For the vaccination to work, the scientists want CSP to act as

A. an antigen.

B. an allergen.

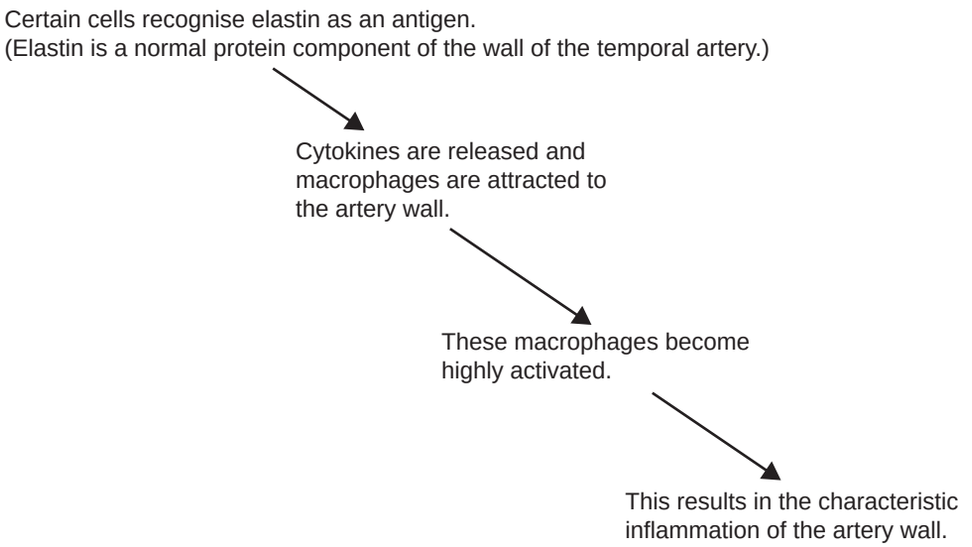
C. an antibody.

D. a complement protein.

Question 25

Temporal arteritis is a human disease in which the temporal arteries become inflamed. This causes headaches and may result in blindness or stroke.

The sequence of responses in this disease is as follows.



Considering the information above, temporal arteritis is

A. an immunodeficiency disease.

B. a pathogenic disease.

C. an allergic response.

D. an autoimmune disease.

Question 26

An inherited form of factor XIII deficiency follows an autosomal recessive pattern of inheritance. A child has factor XIII deficiency. Both of the parents of this child do not have the deficiency. The child has a brother.

The chance that this brother does **not** have any copies of the allele for factor XIII deficiency is

A. one in two.

B. one in four.

C. one in three.

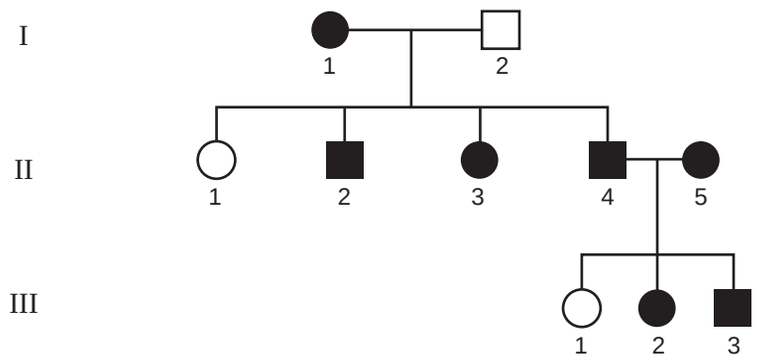
D. three in four.

Question 27

Familial atrial fibrillation is a condition in which individuals have an altered heart rhythm.

Familial atrial fibrillation is an inherited condition that follows an autosomal dominant pattern of inheritance.

Shaded individuals in the following pedigree have this condition.



From this information, it would be correct to conclude that

A. individual I-1 must be homozygous.

B. individual II-1 must be heterozygous.

C. individual II-3 must be heterozygous.

D. individual III-2 must be homozygous.

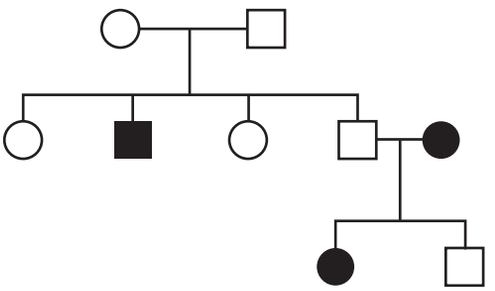
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

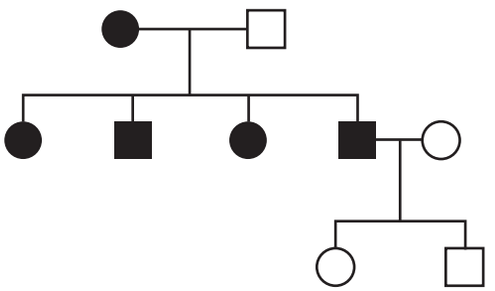
Question 28

In which one of the following pedigrees is an X-linked dominant pattern of inheritance of a trait portrayed? (Individuals showing a trait are shaded.)

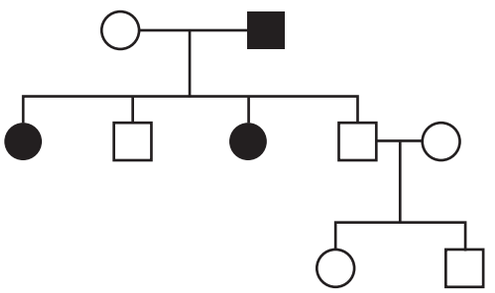
A.



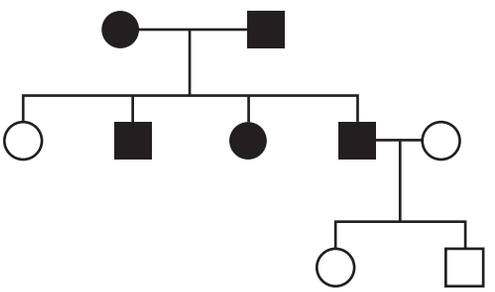
B.



C.

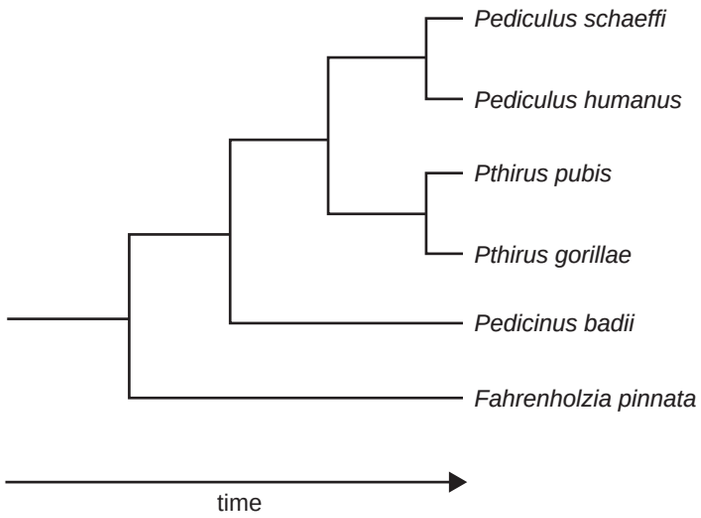


D.



Question 29

Consider the following phylogenetic tree for different species of lice. The tree has been constructed based on molecular and morphological data.



This information suggests that

A. *Pedicinus badii* shares a more recent common ancestor with *Pthirus gorillae* than with *Fahrenholzia pinnata*.

B. *Pediculus humanus* is more closely related to *Pedicinus badii* than it is to *Pthirus pubis*.

C. the six species of lice would have evolved by convergent evolution.

D. *Pediculus schaeffi* is the ancestor of *Pediculus humanus*.

Question 30

Many human traits show continuous variation.

Which one of the following statements is correct for a trait that displays continuous variation?

A. The trait is controlled by a single gene with very few alleles.

B. The trait may be influenced by many genes and the environment.

C. There would be a limited number of phenotypes for individuals to be grouped into.

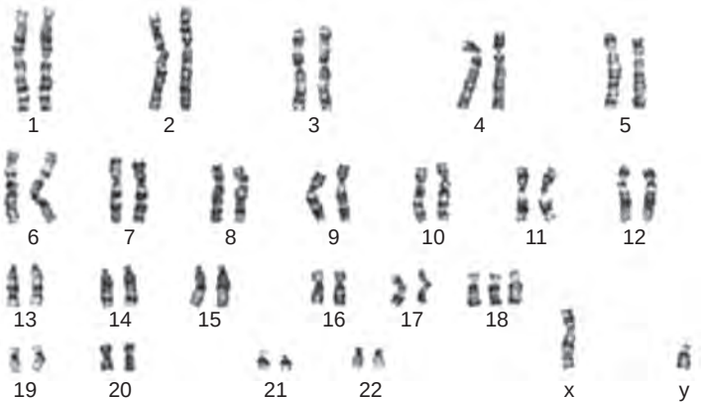
D. There would be equal numbers of individuals with each of the different phenotypes in the population.

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

Question 31

Consider the following karyotype.



Source: MA Hill

The cell from which these chromosomes were taken

A. has a diploid number of 44.

B. comes from a human female.

C. has two copies of each of the genes found on chromosome 18.

D. has inherited one chromosome number 4 from the mother and inherited one chromosome number 4 from the father.

Question 32

Which one of the following statements about gene regulation is correct?

A. Regulator genes are composed of mRNA.

B. Gene regulation is expressed only during the process of meiosis.

C. Regulator genes produce factors that alter the expression of another gene.

D. Gene regulation is not affected by environmental factors external to the cell.

Use the following information to answer Questions 33 and 34.

Purple or white flowers can be seen in a particular plant species. In this species, the colour of the flower is controlled by one gene.

In experiments to investigate the inheritance of flower colour in this plant species, four crosses were carried out. The phenotypes of the parents in each cross were recorded.

In each cross, 40 offspring were produced. The phenotypes of the offspring were recorded and the results are displayed in the table below.

Cross	Phenotype of Parent 1	Phenotype of Parent 2	Number of offspring and their phenotypes
1	purple	white	40 purple offspring
2	purple	purple	31 purple and 9 white offspring
3	white	white	40 white offspring
4	purple	white	21 purple and 19 white offspring

Question 33

Consider the inheritance of flower colour in this plant species.

From the information given, it can be stated that

A. both parents in cross 1 are homozygous.

B. the two parents with white flowers in cross 3 will have different genotypes.

C. one parent in cross 2 will be heterozygous and the other parent will be homozygous.

D. the parent with purple flowers in cross 1 will have the same genotype as the parent with purple flowers in cross 4.

Question 34

In a further experiment on the inheritance of flower colour in this plant species, a test cross was performed.

A test cross would

A. involve crossing two heterozygous individuals.

B. be a cross between two plants that produce white flowers.

C. be valid if a large number of offspring were produced in the cross.

D. enable the determination of the genotype of a plant with purple flowers.

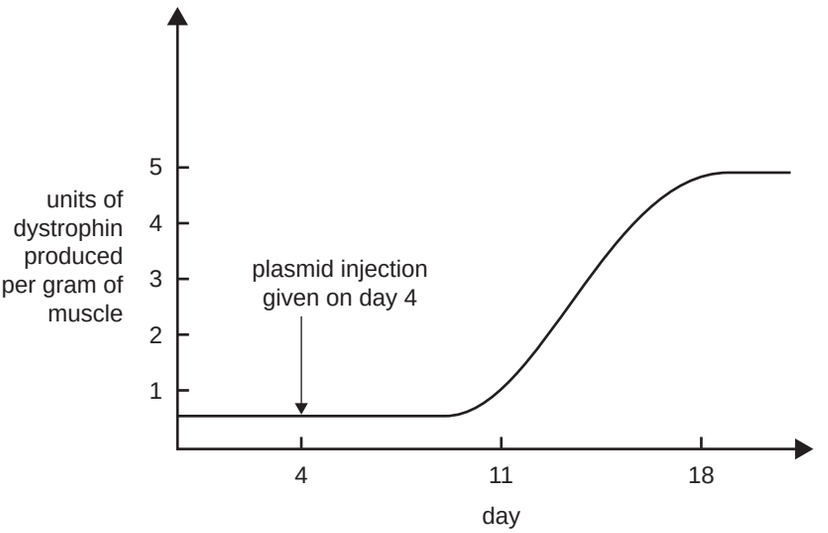
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

Use the following information to answer Questions 35 and 36.

Some mice suffer from a disease called Duchenne muscular dystrophy, where the muscles waste away due to inadequate production of a protein called dystrophin. Researchers isolated the gene for dystrophin production and then inserted it into a plasmid extracted from a bacterium. A concentrated solution of these recombinant plasmids was then injected into the muscles of diseased mice.

A graph of dystrophin production in these treated mice is shown below.



Question 35

The function of the plasmids in this disease treatment is to

A. stimulate a humoral immune response to the bacteria in the treated mice.

B. deliver the dystrophin protein directly to the muscles of the treated mice.

C. act as a vector for the delivery of dystrophin genes to the muscle cells of the treated mice.

D. create a strain of genetically engineered bacteria that will cure Duchenne muscular dystrophy.

Question 36

During the preparation of the recombinant plasmids, researchers used the enzyme DNA ligase.

The function of DNA ligase for this purpose is to

A. manufacture an antigen that will be recognised by T-helper cells.

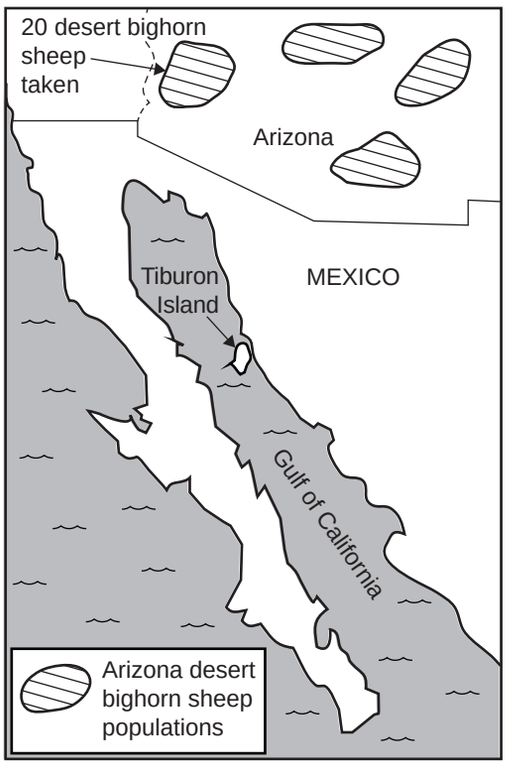
B. join the dystrophin gene to the plasmid DNA at complementary sticky ends.

C. clone the plasmid in order to produce enough plasmids to ensure effective treatment.

D. cut the DNA of the plasmid and the dystrophin gene in the same manner in order to produce matching sticky ends.

Question 37

Tiburon is an isolated island off the coast of Mexico. Desert bighorn sheep became extinct on this island hundreds of years ago. In 1975, 20 desert bighorn sheep were taken from a population in the American state of Arizona (shown on the map below) and were re-introduced to Tiburon Island. By 1999, the population of desert bighorn sheep on Tiburon Island had risen to 650.



Which one of the following statements about this 1999 population of desert bighorn sheep on Tiburon Island is correct?

A. The gene pool of this population will be identical to the gene pool of the Arizona populations.

B. This population has less genetic variation than the Arizona populations and is an example of the founder effect.

C. This population will have become a new species because the mutation rate on Tiburon Island will be much higher than in Arizona.

D. Having been through a population bottleneck, the current population will now show increased genetic variation compared to the Arizona populations.

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

Question 38

In India, a group of scientists was studying fossils from a coal deposit formed during the Permian period (290–245 million years ago). They found three fossil species from the same genus in different levels (strata) of the coal. When radiocarbon dating on these fossils was performed, it showed exactly the same levels of carbon-14 in all three fossil species. The data is summarised in the table below.

Fossil species	Depth at which fossil was found in the coal deposit (m)	Proportion of carbon-14 (%)
Gangamopteris major	6.2	0.0001
Gangamopteris obliqua	8.1	0.0001
Gangamopteris clarkeana	4.7	0.0001

Which one of the following is the correct conclusion to draw from these findings?

A. There is no evolutionary relationship between these three fossil species.

B. *G. clarkeana* is the common evolutionary ancestor of *G. major* and *G. obliqua*.

C. As carbon dating is a more reliable dating technique than analysis of strata in coal deposits, the fossils of *G. major*, *G. obliqua* and *G. clarkeana* are all of the same age.

D. An analysis of strata in coal deposits is a more reliable dating technique than carbon dating for Permian fossils; the fossil of *G. major* is younger than the fossil of *G. obliqua*.

Use the following information to answer Questions 39 and 40.

Cytochrome c is a protein that consists of 104 amino acids. Many of these 104 sites on cytochrome c contain exactly the same amino acid across a large range of organisms. There are, however, some differences at certain sites. It is hypothesised that different organisms, all containing cytochrome c proteins, descended from a primitive microbe that lived over 2 billion years ago.

The table below uses the three-letter codes for various amino acids found at specific sites for each organism.

Molecular homology of cytochrome c

Organism	Site 1	Site 4	Site 11	Site 15	Site 22
human	Gly	Glu	Ile	Ser	Lys
pig	Gly	Glu	Val	Ala	Lys
dogfish	Gly	Glu	Val	Ala	Asn
chicken	Gly	Glu	Val	Ser	Lys
Drosophila	Gly	Glu	Val	Ala	Ala
yeast	Gly	Lys	Val	Glu	Lys
wheat	Gly	Asp	Lys	Ala	Ala

Question 39

Using only the data for the molecular homology of cytochrome c, which one of the following organisms is most closely related to the dogfish?

A. *Drosophila*
B. chicken
C. human
D. yeast

Question 40

Using only the data for the molecular homology of cytochrome c, which pair of organisms is most distantly related to wheat?

A. dogfish and *Drosophila*
B. *Drosophila* and yeast
C. *Drosophila* and pig
D. human and yeast

DO NOT WRITE IN THIS AREA

END OF SECTION A

DO NOT WRITE IN THIS AREA

SECTION B – Short-answer questions

Instructions for Section B

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

Question 1 (5 marks)

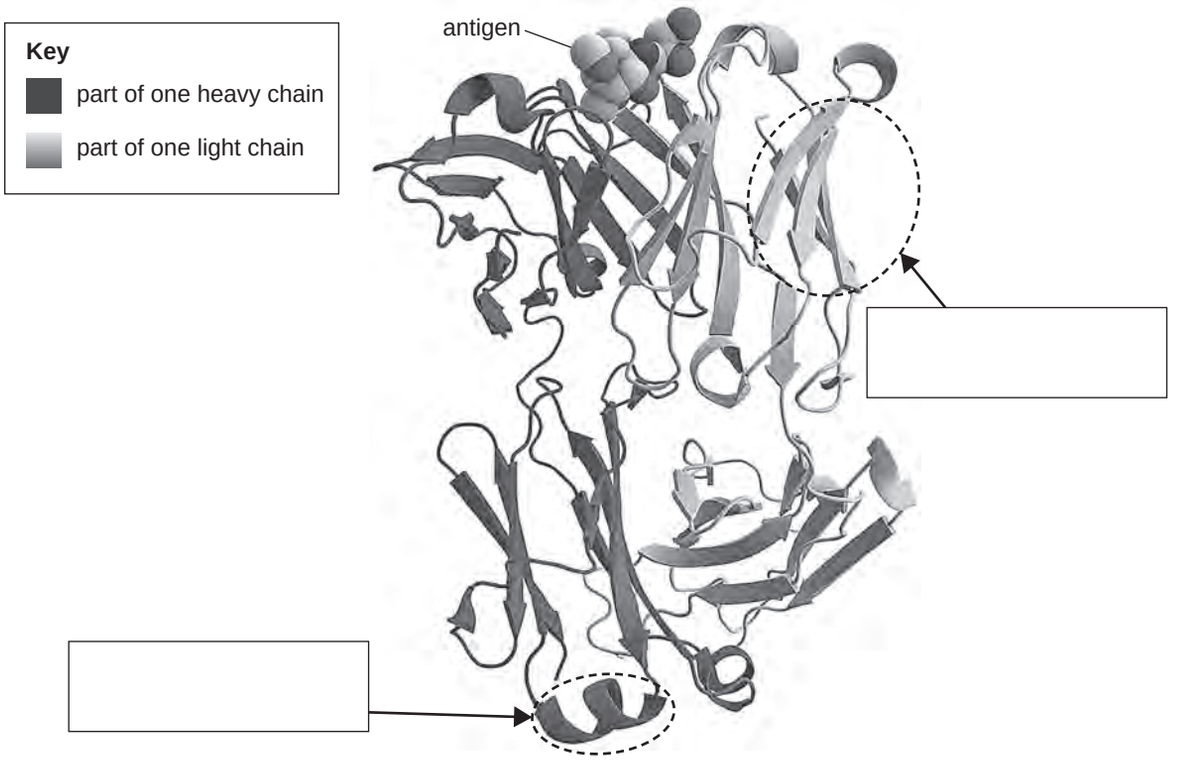
Immunoglobulins, or antibody molecules, have an important role in the immune system. They are made up of two heavy chains and two light chains.

a. Name the molecular monomer of these chains. 1 mark

_____

b. Part of a mouse immunoglobulin molecule bound to an antigen is shown in the diagram below. Two arrows point to two different types of secondary structures of the immunoglobulin molecule.

Give the name of each structure in the boxes provided. 2 marks



Source: Thomas Splettstoesser (www.scistyle.com)

c. Immunoglobulin molecules also display a tertiary structure and a quaternary structure.

Referring to the diagram, explain what 'quaternary' means. 2 marks

_____

_____

_____

Question 2 (8 marks)

Plant materials containing cellulose and other polysaccharides are reacted with acids to break them down to produce glucose. This glucose is then used by yeast cells for fermentation.

a. Why is fermentation important for yeast cells? 1 mark

b. What are the products of fermentation in yeast cells? 1 mark

A by-product of the acid treatment of plant materials is a group of chemical compounds called furans. It has been observed that as the concentration of furans increases, the rate of fermentation decreases. The enzyme alcohol dehydrogenase is required for the process of fermentation.

c. Design an experiment to test the hypothesis that one of the furans, called furfural, is an inhibitor of the enzyme alcohol dehydrogenase. Assume that the experiment will be repeated many times and that environmental factors are kept constant. 4 marks

d. Scientists have proposed that furfural is a competitive inhibitor of the enzyme alcohol dehydrogenase.

Explain how furfural could act as a competitive inhibitor of the enzyme alcohol dehydrogenase. 2 marks

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

Question 3 (6 marks)

Following a cut or a burn to your skin, a highly coordinated set of processes begins to heal the wound. The processes are coordinated by molecules that are produced by cells in and around the wound. One of the molecules involved in wound healing is called epidermal growth factor (EGF).

Epidermal growth factor receptor (EGFR) molecules are found on the membranes of many cells, including special cells in the skin called fibroblasts.

The binding of EGF to EGFR on the fibroblasts results in a number of cellular responses. These cellular responses include:

- cell division of fibroblasts
- movement of fibroblasts to the wound
- resistance of fibroblasts to apoptosis
- secretion of the protein collagen by fibroblasts.

a. What name is given to the process by which EGF causes the fibroblasts' cellular responses? 1 mark

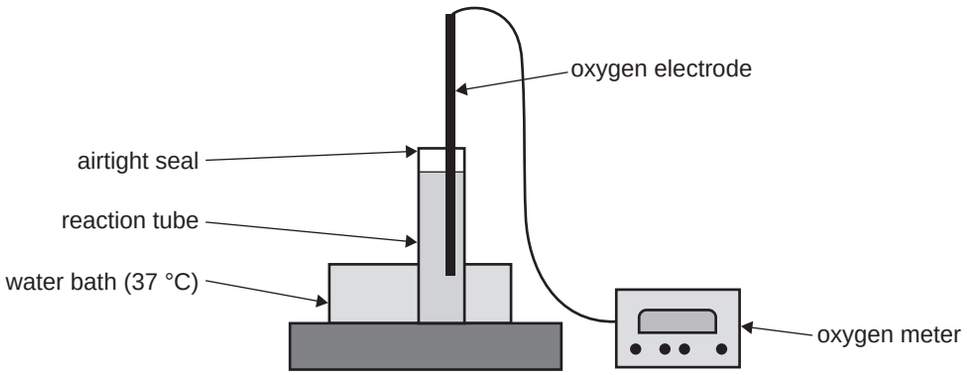
b. Name **two** cell organelles that would be activated by the EGF signal and state the role that each organelle would play in the fibroblasts' cellular responses. 2 marks

c. As a wound heals, cells that are no longer needed for the healing process are removed by apoptosis. Apoptosis is stimulated by external cell signalling from cells such as cytotoxic T cells (T_c).

Outline the main stages in cell apoptosis once stimulated by the T_c cells. 3 marks

Question 4 (6 marks)

The apparatus shown below was used in a series of experiments to study aerobic respiration.



In three different experiments, the reaction tube initially contained the following:

1. suspension of mitochondria
2. cytosol of cells from which the mitochondria had been removed
3. suspension of mitochondria and cytosol of cells

The temperatures and pH of the mixtures within the reaction tubes were carefully controlled so as not to damage the mitochondrial structure or any of the enzymes.

In each experiment, a solution containing glucose was first added to the mixture in the reaction tube and the oxygen concentration was measured for three minutes. Then, a pyruvate solution was added and the oxygen concentration was measured again for three minutes.

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

Using your knowledge and understanding of aerobic respiration and mitochondria, complete the tables below with your prediction of the change in oxygen concentration of the mixture in the reaction tube after the addition of each substance and give a reason for your prediction.

Experiment 1 – Suspension of mitochondria

Substance added	Change in oxygen concentration (increase/decrease/no change)	Reason
glucose		
pyruvate		

Experiment 2 – Cytosol of cells from which the mitochondria had been removed

Substance added	Change in oxygen concentration (increase/decrease/no change)	Reason
glucose		
pyruvate		

Experiment 3 – Suspension of mitochondria and cytosol of cells

Substance added	Change in oxygen concentration (increase/decrease/no change)	Reason
glucose		
pyruvate		

Question 5 (7 marks)

Yellow fever is a potentially fatal, mosquito-borne, viral disease that occurs in many countries in Africa, the Caribbean, and Central and South America. An effective and safe vaccine has been available since 1938.

a. What is a vaccine? 1 mark

b. For the vaccine to be effective, it is recommended that travellers to these regions have the vaccination approximately two to four weeks before travelling.

Why is this time frame recommended? 2 marks

c. Recent research shows that the vaccine gives lifelong immunity.

Name two different cell types that would be important in providing lifelong immunity and explain the role of each in providing lifelong immunity. 4 marks

Name of cell type 1 _____

Role _____

Name of cell type 2 _____

Role _____

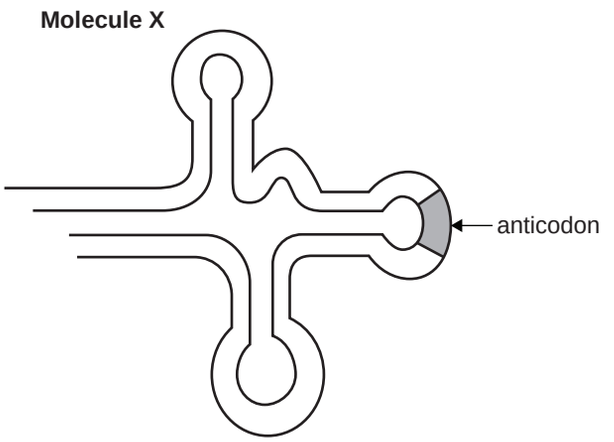
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

Question 6 (7 marks)

The hormone insulin is a relatively small protein. Researchers studying the production of insulin in the cells of the pancreas noted that one of the early steps in this process was the formation of a polypeptide called preproinsulin.

Researchers noted that the formation of this polypeptide required repeated use of different types of Molecule X, shown below.



a. **i.** What is the name of Molecule X? 1 mark

ii. How does Molecule X play a role in the production of preproinsulin? 3 marks

b. The coding information in the DNA molecule for preproinsulin is initially transferred to another molecule (Molecule W). However, Molecule W has a different nucleotide sequence from the coding section of the DNA molecule.

Describe how Molecule W is synthesised. 3 marks

Question 7 (7 marks)

In a rat population, three different fur colours can be observed. The rats can have grey, black or white fur.

The production of fur colour pigment in these rats is controlled by two genes. The two genes are not linked.

a. What conclusion can be made about the location of the two genes on the chromosomes of these rats? 1 mark

The two genes controlling the production of fur colour pigment have the following alleles.

Gene 1	G	grey pigment	Gene 2	A	pigment produced
	g	black pigment		a	no pigment produced

The presence of at least one A allele allows for the production of pigment. White fur is seen in rats without a copy of the A allele.

b. A rat has black fur.

What are all the possible genotypes for this rat? 2 marks

c. Two rats heterozygous with respect to Gene 1 and Gene 2 for fur colour were crossed.

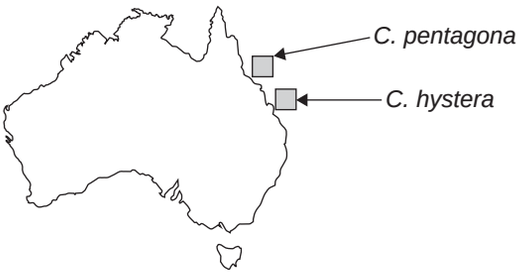
What are the possible genotypes and phenotypes of the offspring? Show your working and state the ratio for the phenotypes of the offspring. 4 marks

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

Question 8 (6 marks)

Two species of *Cryptasterina* sea stars are found in coastal Queensland. *Cryptasterina pentagona* is found in warmer water further north, while *Cryptasterina hystera* is found further south in cooler water.



Researchers have concluded that these two species arose from a recent common ancestor via natural selection. They believe that, over thousands of years, the sea environment has changed, with the boundary line between cold water and warm water moving further north. They have found that water temperature and predation of sea star larvae by cold-water predators are important selection pressures for these sea stars.

a. Using the information **above**, explain how natural selection can lead to differences in phenotypes between these two sea star species. 4 marks

b. One of the phenotypic differences between these two species of sea stars is their method of reproduction. *C. pentagona* reproduces sexually and its sperm and eggs are free-floating in the ocean. *C. hystera* self-fertilises and its fertilised eggs are kept within the sea star until maturity.

The researchers found that one species of *Cryptasterina* has a significantly higher diversity of alleles in its gene pool than the other species.

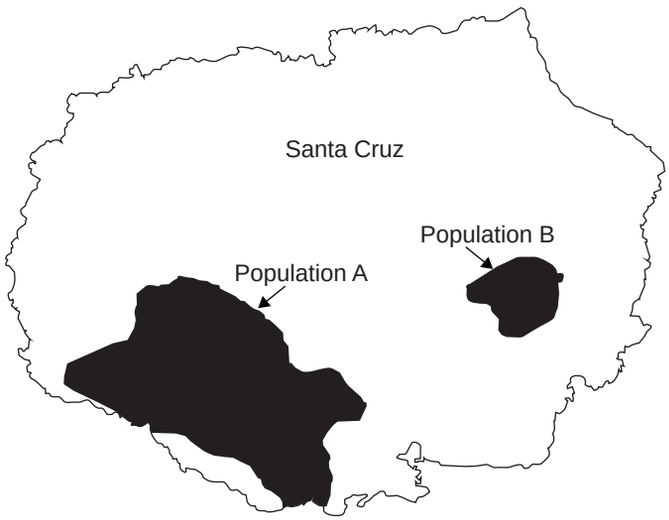
Using this information about reproduction strategies, which species of *Cryptasterina* would you expect to have the highest diversity of alleles? Explain your answer. 2 marks

Question 9 (7 marks)

Galápagos tortoises (*Chelonoidis* spp.) can be found on many of the islands that make up the Galápagos Islands. Originally, 14 different species were identified based on the islands on which they lived and on their morphology.

Santa Cruz, the second largest of the Galápagos Islands, has two isolated tortoise populations. Population A contains more than 2000 individuals covering an area of 156 square kilometres. Population B is a small population of 250 individuals covering an area of 40 square kilometres.

The position of the two populations on the island of Santa Cruz is shown below. The two populations are separated by a distance of 20 kilometres.



In 2015, scientists investigated whether the individuals of the two populations belong to the same species or whether they are two different species.

Average measurements of skull size were calculated for tortoises belonging to both populations A and B. The skulls were measured in six different places. The six measurements were also compared to average measurements taken from skulls of other Galápagos tortoise species. The results are shown in the table below. Comparisons have been made with three other Galápagos tortoise species.

Measurement position	**Average skull measurement (mm)**				
	Population B	**Population A**	***Chelonoidis vicina***	***Chelonoidis chathamensis***	***Chelonoidis ephippium***
1	118	98	86	80	74
2	40	37	28	27	25
3	21	18	16	14	12
4	26	23	21	18	17
5	10	9	8	7	6
6	19	17	16	14	13

Source (map and table): adapted from N Poulakakis, DL Edwards, Y Chiari, RC Garrick, MA Russello, E Benavides et al., 'Description of a New Galápagos Giant Tortoise Species (*Chelonoidis*; Testudines: Testudinidae) from Cerro Fatal on Santa Cruz Island', *PLoS ONE*, 10(10): e0138779, doi:10.1371/journal.pone.0138779, 21 October 2015

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

a. Consider the data given.

Does the data support the hypothesis that individuals in Population A belong to a different species from individuals in Population B? Explain your answer. 2 marks

b. Scientists have carried out genetic studies on the two populations.

Give an example of genetic evidence that may be produced by scientists to support the hypothesis that individuals of the two populations belong to different species. Explain your answer. 2 marks

c. Some scientists thought that allopatric speciation may have occurred on the island of Santa Cruz.

i. Name a feature that scientists would look for in the island environment to support the occurrence of allopatric speciation. 1 mark

ii. Explain how the feature named in **part c.i.** could contribute to allopatric speciation. 2 marks

Question 10 (7 marks)

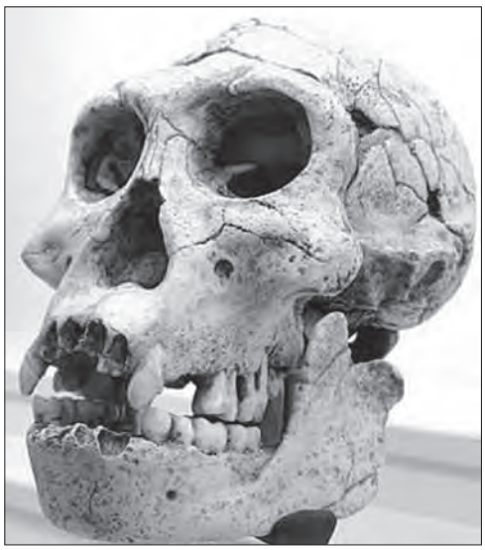
Over the past 20 years, a number of new hominin fossils have been discovered. *Homo erectus georgicus* was found near the banks of the Black Sea in Georgia and *Homo naledi* was found in a cave in South Africa.

a. Consider the conditions that may have led to the fossilisation of members of these species.

Complete the table below by identifying one condition in the environment of each species that will have made fossilisation possible. The same answer cannot be used for both species. 2 marks

Species	Environment	Condition
H. erectus georgicus	near the banks of the Black Sea	
H. naledi	cave in South Africa	

Shown below is a photograph of a skull of *H. erectus georgicus*. Scientists compared this skull to that of modern humans (*Homo sapiens sapiens*).



Source: Rama

b. Describe any **two** features of the skull shown in the photograph above that allowed scientists to determine that this was a much earlier species of the genus *Homo* than modern humans (*H. sapiens sapiens*). 2 marks

DO NOT WRITE IN THIS AREA

c. Describe **one** structural feature (other than skull structure) of *H. naledi* that would indicate it is a more modern species than members of the genus *Australopithecus*. 1 mark

d. Fifteen different skeletons of *H. naledi* were found in the cave. It was noted that they were all of different ages.

Describe **two** pieces of evidence that scientists could have looked for in the cave to indicate cultural evolution within this species. 2 marks

DO NOT WRITE IN THIS AREA

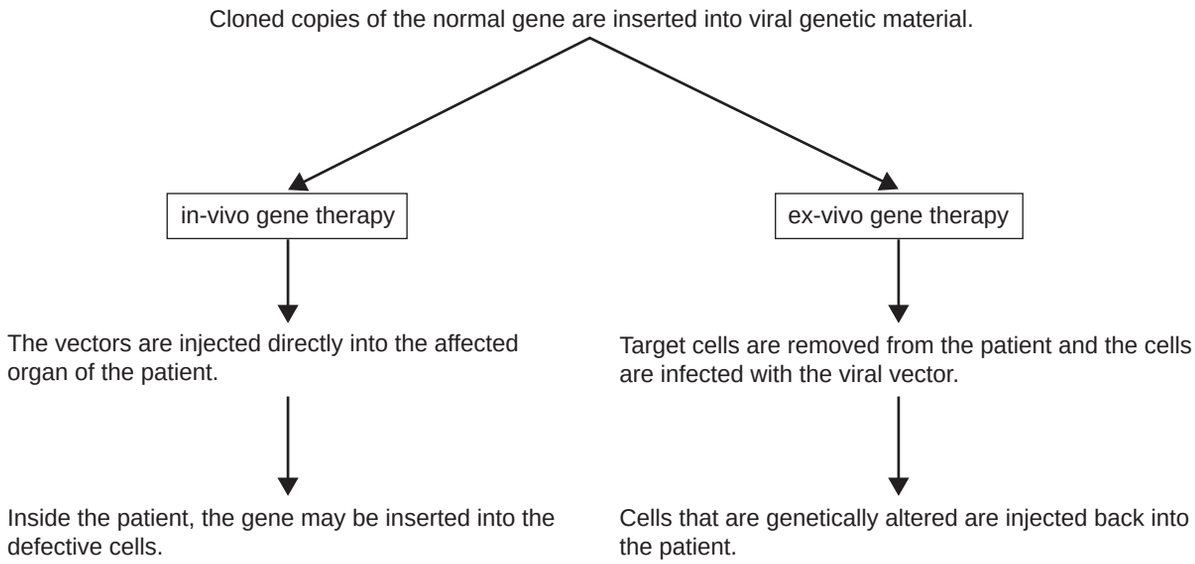
Question 11 (4 marks)

Gene therapy can be used to introduce normal genes into cells to replace missing or defective genes in order to treat or prevent disease. Scientists have taken a number of different approaches to using gene therapy. The following are two of these approaches:

- germline gene therapy – embryonic cells are treated to correct a missing or defective gene
- somatic cell gene therapy – a normal gene is inserted into somatic (body) cells to correct a missing or defective gene

a. Identify **one** issue that would make scientists cautious about using germline gene therapy. 1 mark

Viral vectors (adenoviruses and retroviruses) are often used in gene therapy to insert a normal gene into target cells. Two processes that can be used are outlined below.



b. **i.** What evidence, at a cellular level, would confirm that the processes above were successful? 2 marks

ii. What is **one** advantage that ex-vivo gene therapy has over in-vivo gene therapy? 1 mark

DO NOT WRITE IN THIS AREA

END OF QUESTION AND ANSWER BOOK