Neap

Trial Examination 2020

VCE Biology Units 3&4

Written Examination

Question and Answer Booklet

Reading time: 15 minutes
Writing time: 2 hours 30 minutes

Student's Name: _____

Teacher's Name: _____

Structure of booklet

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	40	40	40
B	11	11	80
			Total 120

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 booklet of 35 pages

Answer sheet for multiple-choice questions

Instructions

Write your **name** and your **teacher's name** in the space provided above on this page, and on the answer sheet for multiple-choice questions.

Unless otherwise indicated, the diagrams in this booklet are **not** drawn to scale.

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 booklet.

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

SECTION A – MULTIPLE-CHOICE QUESTIONS

Instructions for Section A

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.

Choose the response that is **correct** or that **best answers** the question.

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

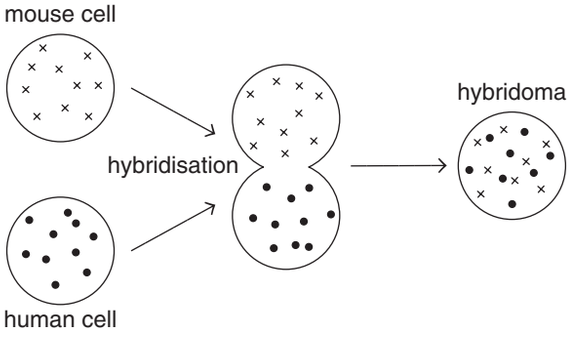
Marks will **not** be deducted for incorrect answers.

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

Unless otherwise indicated, the diagrams in this booklet are **not** drawn to scale.

Question 1

A mouse cell and a human cell were hybridised together. Eventually the membrane proteins from each original cell were evenly distributed across the surface. The diagram below shows the distribution of the proteins throughout the duration of the experiment.



This information shows

A. that hydrophilic proteins are rigidly bound to the cell surface.

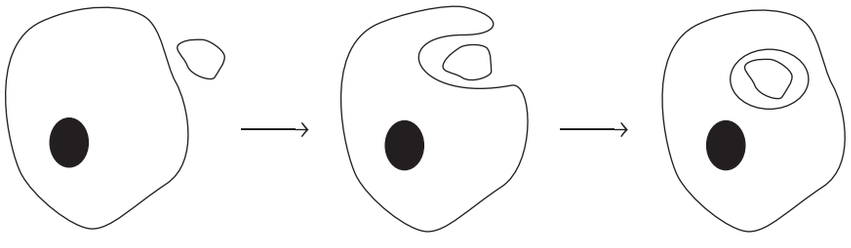
B. evidence in support of the fluid mosaic model of membrane structure.

C. that the hydrophobic tails of the membrane face the external environment.

D. that cholesterol is an important component of all membranes.

Question 2

Consider the process shown in the diagram below.



This diagram represents

A. exocytosis.

B. necrosis.

C. endocytosis.

D. active transport.

Use the following information to answer Questions 3–5.

The table below shows the different mRNA codons for a variety of amino acids.

Amino acid	Codon(s)
Leucine (leu)	CUU, CUA, CUG, CUC
Methionine (met)	AUG
Isoleucine (ile)	AUU, AUA, AUC
Glycine (gly)	GGU, GGA, GGC, GGG

The following is an unknown polypeptide consisting of these amino acids.

met–leu–ile–gly–gly–leu

Question 3

Which one of the following DNA template strands would provide a blueprint for the polypeptide above?

A. ATG CTA ATA GGT GGG CTT

B. AUG CUU AUU GGA GGC CUG

C. TAC GAG TAA CCA GGU GAT

D. TAC GAA TAT CCC CCT GAA

Question 4

There are more codons available than there are amino acids.

This demonstrates

A. the degeneracy in the code.

B. that proteins are more complex than nucleic acids.

C. that the product of translation requires tRNA for the process.

D. that a larger number of nucleotides provides the blueprint for a smaller number of amino acids.

Question 5

If there was a point mutation at the polypeptide's sixth DNA nucleotide, what effect would this have on the polypeptide?

A. There would be a change in the amino acid in the second position.

B. There would be a change in each amino acid after methionine.

C. There would be no change in the primary sequence of the polypeptide.

D. All the amino acids after leucine would be changed to glycine.

Question 6

A proteome

A. is very similar to a genome.

B. is not related to a genome.

C. is less complicated than a genome.

D. relates to the proteins and their interactions within a single cell of a multicellular organism.

Question 7

Which one of the following is **not** a ribonucleic acid?

A. tRNA carrying an anticodon

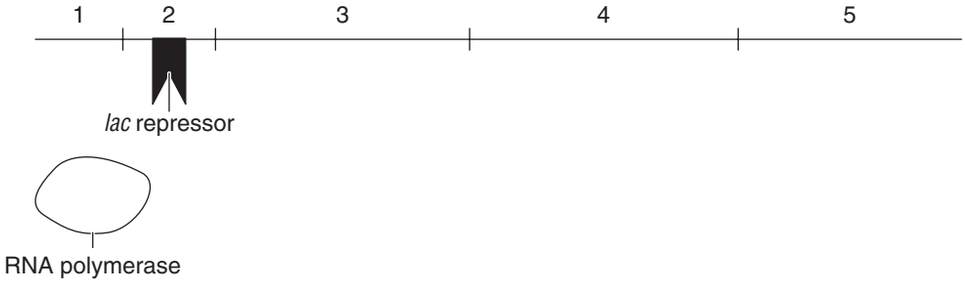
B. mRNA comprised of codons

C. mtRNA inherited down the maternal line

D. rRNA forming a structural part of the ribosome

Use the following information to answer Questions 8 and 9.

The diagram below represents the *lac* operon – the gene-controlling segment located in some bacteria.



Question 8

Which row gives reasonable names for the parts of the lac operon labelled 1–5?

	1	2	3	4	5
A.	promotor	operator	*lac* Z gene	*lac* Y gene	*lac* A gene
B.	operator	promotor	*lac* Z gene	*lac* A gene	*lac* Y gene
C.	promotor	*lac* Z gene	*lac* A gene	operator	*lac* Y gene
D.	operator	*lac* Z gene	*lac* Y gene	*lac* A gene	promotor

Question 9

In an environment of lactose, it would be expected that the

A. RNA polymerase would change shape and bind to section 1.

B. RNA polymerase would take the place of the *lac* repressor at section 2.

C. *lac* repressor would change shape and detach from section 2.

D. *lac* repressor would bind to section 1 and the RNA polymerase would bind to section 2.

Question 10

A signalling molecule that is secreted from a gland and moved through the bloodstream to eventually bind to receptors on a target cell is defined as a

A. pheromone.

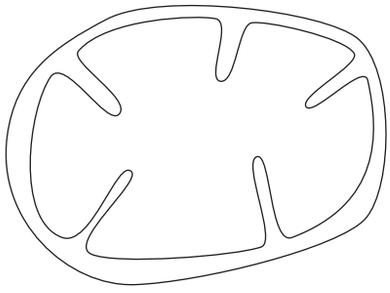
B. cytokine.

C. animal hormone.

D. plant growth regulator.

Use the following information to answer Questions 11–13.

The organelle shown in the diagram below has a critical role in all eukaryotic cells.



Question 11

The reaction that occurs along the cristae

A. generates over ten times as much ATP compared to any other stage of cellular respiration.

B. integrates acetyl coenzyme A into the Krebs cycle.

C. is the breakdown of glucose into lactic acid.

D. cleaves hydrogen from NADPH to form ATP.

Question 12

The organelle has a variety of structures that provide evidence in support of the endosymbiotic theory.

What evidence does the diagram above show that supports the theory?

A. the presence of circular DNA

B. independent reproduction

C. the presence of prokaryote-like ribosomes

D. a visible double membrane

Question 13

The organelle was isolated and mixed with a solution of pyruvic acid and oxygen at optimal temperature and pH.

Chemical changes within the organelle would have been

A. an increased production of glucose and carbon dioxide.

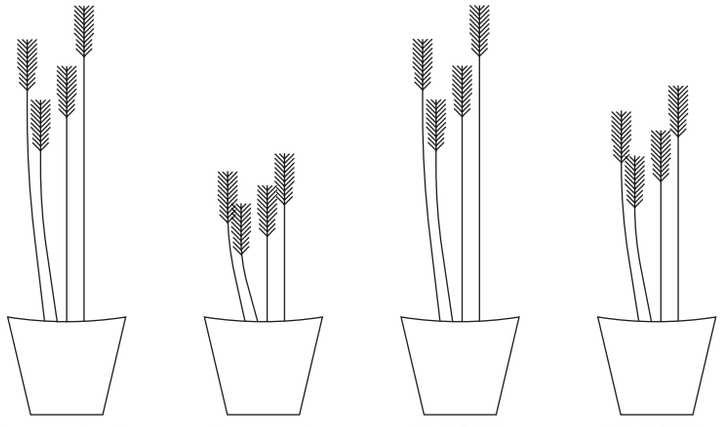
B. an increased production of ATP, carbon dioxide and water.

C. a greater secretion of NADH.

D. negligible, as all the reactants would have been balanced by the products.

Use the following information to answer Questions 14–16.

Plant growth-promoting rhizobacteria (PGPR) hold a promising future for sustainable agriculture, particularly in environments that have been affected by increasing salinity. The presence of PGPR promotes the secretion of the plant hormone abscisic acid (ABA), which leads to the activation of stress-related genes that are advantageous in an environment affected by salinity. To test this idea experimentally, four populations of wheat plant crops were exposed to four conditions. The average results for each condition are illustrated and labelled (I–IV) in the diagram below.



Question 14

Which combination of average results is the most useful for observing the effect of the presence of PGPR with or without salt on growth?

A. I and IV

B. II and IV

C. III and IV

D. II and III

Question 15

ABA is a water-soluble molecule, which means that it will

A. bind to extracellular receptors.

B. always be involved in gene activation within target cells.

C. only act on one type of specialised cell within a plant.

D. bind to intracellular receptors.

Question 16

Water moves to environments with higher ion concentrations. Therefore, salinity in soils could result in a decrease in osmosis (absorbtion of water).

An appropriate salt-tolerant response could be

A. increasing ion content inside root cells by opening gated ion channels, thus enabling the plant to absorb water from salty soil.

B. allowing the stomata to remain open for longer for more prolonged gas and water exchange with the environment.

C. an increased expression of chaperone proteins that allow metabolic proteins to function at higher temperatures.

D. to actively absorb salt from the soil, which will reduce the external salt concentration.

Question 17

Adenosine is a signalling molecule that plays the important role of neuromodulation. When it binds to specific receptors within the central nervous system, neural activity slows down and causes drowsiness. Caffeine has a similar shape to adenosine and, if in the body, will bind competitively to the same receptors, thus speeding up neural activity.

In preparation for his upcoming exams, Taras consumed four cups of coffee, which contains caffeine, before a lengthly session of study.

Based on your knowledge and the information above, it is likely that Taras will

A. fall asleep on his desk exhausted because the caffeine will cause him to lose track of time.

B. be unable to fall asleep due to the excess caffeine in his brain.

C. fall into a deep sleep after he completes his study because the caffeine and adenosine act at the same receptors.

D. be able to maintain concentration due to the adenosine levels still being present in his system.

Question 18

Which one of the following statements is true as a general rule?

A. An individual's self-antigens change during the individual's lifetime.

B. In a human with no history of allergies, an allergen is antigenic.

C. Non-self antigens activate the immune system to respond in a specific manner.

D. If non-self antigens on the surface of a pathogen changed to self-antigens, the immune system would still be activated to respond.

Question 19

Physical, chemical and microbiological barriers exist on and/or in organisms to reduce the chances of pathogenic attack.

Which row shows an appropriate example of each type of barrier?

	Physical barrier	Chemical barrier	Microbiological barrier
A.	unbroken skin on a dog to prevent the easy entry of airborne pathogens into the bloodstream	production of jasmonic acid in leaves subjected to herbivory that, when ingested, causes internal damage to the invader	stomach acidity to reduce the survival chance of pathogenic bacteria
B.	a thick waxy cuticle on the surface of leaves to reduce the chance of foraging caterpillars causing damage	human tears producing antibacterial enzymes to reduce the chance of eye infections such as conjunctivitis	*Staphylococcus aureus* bacteria living on the skin of humans to prevent opportunistic fungal pathogens from growing
C.	sharp pointy prickles on cacti to lower the chance of birds penetrating the cacti's flesh structures	thick sticky mucus lining the respiratory system to prevent the entry of the common cold virus into lung cells	a healthy gut flora to reduce the chance of intestinal infections
D.	thick bark to prevent gnawing creatures transferring pathogens from their mouths into the vascular tissue of the plant	the leaves of the sensitive plant *Mimosa pudica* closing up rapidly in response to direct touch	the presence of bacteria in the soil providing a decoy so that rabbits are less likely to become infected in their burrows

Question 20

An example of a non-cellular pathogen is the

A. influenza A (H5N1) virus, which causes bird flu and has a mortality rate of 60%.

B. almost antibiotic-resistant methicillin-resistant *Staphylococcus aureus* (MRSA) bacteria, which has a mortality rate of 55%.

C. most pathogenic disease on the planet caused by the malarial plasmodium, which was responsible for 400 000 deaths in 2018.

D. *Vibrio cholerae* bacterium, which causes cholera and is responsible for 50 000 deaths per year.

Question 21

Which one of the following statements correctly identifies the role of a component of the innate immune response?

A. Complement proteins combine on the surface of bacteria, which results in a fever.

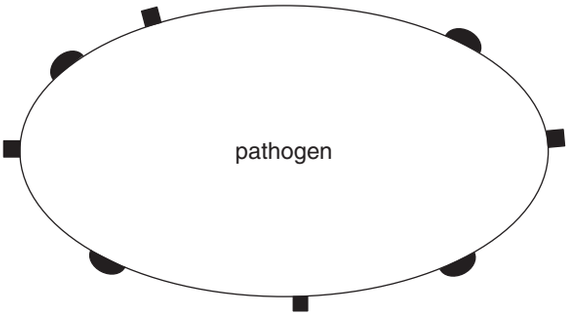
B. When macrophages encounter a pathogenic cell, they respond to the cytokines released by the pathogen.

C. Mast cells secrete histamines, which stimulate an inflammatory response.

D. Neutrophils are the last components of the innate immune response to migrate to the site of an infection.

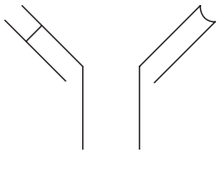
Question 22

The diagram below shows a pathogenic chlamydia bacterium that was transmitted into a koala through sexual contact. The shapes on the surface of the bacteria were recognised as non-self.

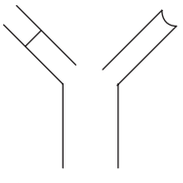


Which one of the following shows an appropriate active immune response to the bacterium?

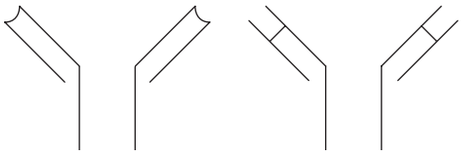
A.



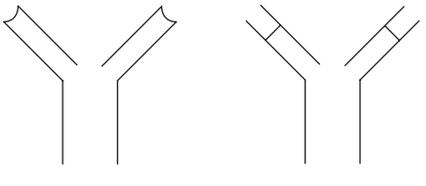
B.



C.



D.



Question 23

When receiving an influenza vaccine, three or four different influenza antigens can be injected into the body with only one needle, which significantly reduces the risk of contracting the disease.

This vaccine is a form of

A. artificial passive immunity.

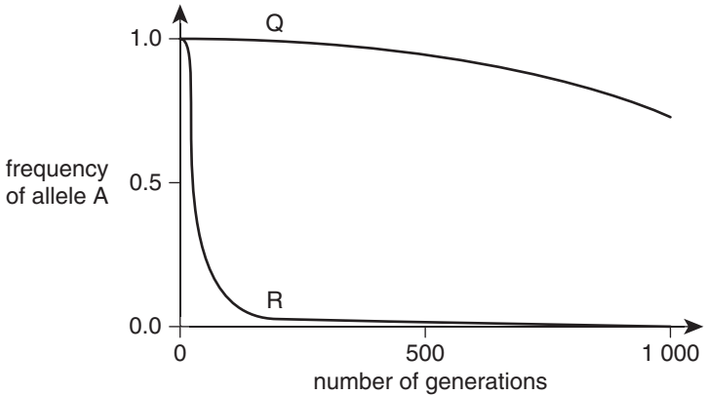
B. artificial active immunity.

C. natural passive immunity.

D. natural active immunity.

Question 24

The graph below demonstrates the changes in the frequency of allele A within two reproductively isolated insect populations (Q and R) over many generations.



Based on the information in the graph, which one of the following conclusions can be reached?

A. Populations Q and R underwent gene flow after 200 generations.

B. The rapid decline of allele A in population R was due to a population bottleneck.

C. The slow decline of allele A in population Q was due to the founder effect.

D. After 1000 generations, population Q and R underwent speciation.

Question 25

When a land bridge formed connecting North America to South America about three million years ago, a snapping shrimp population was split into two by being geographically isolated from each other. There are now several species of shrimp on either side of the land bridge.

An explanation for the existance of these multiple species is that

A. in the shallow ocean on the Pacific side of the land bridge, the shrimp grew larger and faster to avoid deep-sea predators.

B. in the waters on the Caribbean side of the land bridge, the shrimp mutated to suit their environment.

C. the variants that were most suited to either environment on either side of the land bridge became the ancestors to the current species.

D. the larger shrimp on either side of the land bridge underwent artificial selection due to human fishing practices.

Question 26

The following DNA strand, displayed as a single strand for simplicity, was exposed to a high dose of X-rays so that the effect on the mutation rate in an actively dividing cell line of human cells could be observed.

AAG GCG AGG CTT TGA TGA CAT GAT CA

After five cellular divisions, the same strand was measured again. The sequence was as follows.

AAG GCG AGA GTT TCG TGA CAT GAT CA

This type of mutation is a

A. substitution mutation.

B. inversion mutation.

C. addition mutation.

D. point mutation.

Question 27

At the turn of the nineteenth century, more than 100 000 cheetahs were estimated to have been inhabiting Africa, the Middle East, and elsewhere in Asia. In 2020, cheetahs are only found in the wild in several locations (Africa and Iran). Scientists estimate that fewer than 8000 cheetahs exist today, which positions them as critically endangered and in severe danger of extinction. Captive breeding programs are attempting to increase those numbers by breeding cheetahs with the greatest genetic variety.

This history of the cheetah is an example of

A. the founder effect.

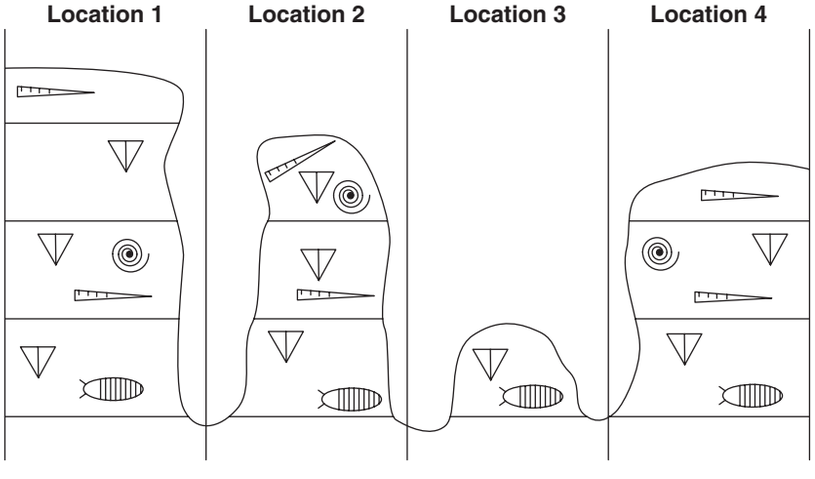
B. natural selection.

C. gene flow.

D. a genetic bottleneck.

Question 28

Consider the diagram below of strata layers found in four different geographic locations.



Based on the information in the diagram, what is the most appropriate fossil to use as an index fossil?

A. 

B.

C. 

D. 

Question 29

A small sample of igneous rock was found to have 0.06 units of the potassium isotope used in potassium–argon dating, compared to 1 unit found in fresh igneous rock. The half-life of potassium is 1.3 billion years.

The small sample of igneous rock is

A. 1.3 billion years old.

B. 2.6 billion years old.

C. 3.9 billion years old.

D. probably from a meteor.

Question 30

For a fossil to form from the remains of an animal, the most important condition required is

A. a rapid burial.

B. a high decomposition rate.

C. minimal downward pressure.

D. that the fossil is of teeth and bones.

Question 31

The table below refers to the nucleotide bases from the same section of a short sequence of DNA from four different but related species (L, M, N and O).

Species L	A	T	A	G	G	C	C	T	T	A	G	C
Species M	A	T	A	C	G	C	C	T	T	A	G	C
Species N	A	T	A	G	G	C	G	T	G	A	C	C
Species O	T	T	A	G	G	G	G	C	T	A	G	T

Based on the information in the table, the two species that shared the most recent common ancestor are

A. L and M.

B. M and N.

C. N and O.

D. L and O.

Question 32

Humans are

A. hominins but not hominids.

B. primates but not hominids.

C. hominids as well as hominins.

D. hominins but not primates.

Question 33

When the *Australopithecine* genera are compared to the *Homo* genera, it can be concluded that the *Australopithecine* has a

A. more elongated pelvis than the *Homo.*

B. more central foramen magnum than the *Homo.*

C. more opposable thumb than the *Homo.*

D. smaller cranial capacity than the *Homo.*

Question 34

During the process of polymerase chain reaction (PCR),

A. specific primers anneal to multiple sections of the genome.

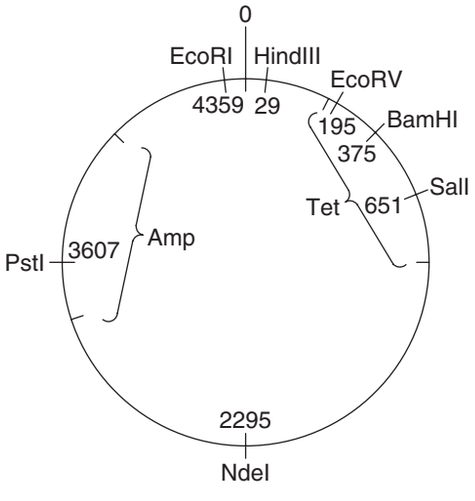
B. replication of the target DNA occurs at temperatures over 90°C.

C. denaturation of the target DNA occurs at temperatures below 60°C.

D. Taq polymerase binds to the primer prior to replication.

Use the following information to answer Questions 35–37.

The diagram below is a representation of the pBR322 plasmid, one of the first plasmids used as a cloning vector. The plasmid is about 4500 nucleotides long. The cutting sites for a variety of restriction enzymes and the regions of antibiotic resistance Ampicillin (Amp) and Tetracycline (Tet) are shown.



Question 35

If each restriction enzyme were mixed with a pBR322 plasmid, how many fragments of DNA would be liberated?

A. 5

B. 6

C. 7

D. 8

Question 36

In an experiment, a gene was inserted into multiple pBR322 plasmids after they were cleaved with PstI, and then the modified plasmids were inserted into cultures of bacteria exposed to optimal conditions for transformation. The bacteria cultures were then spread onto a series of agar plates, as shown in the table below.

Plate 1	control withoutt any antibiotic added
Plate 2	Amp added
Plate 3	Tet added

In this experiment, transformed bacteria would be expected to grow on

A. plates 1 and 2.

B. plates 1 and 3.

C. plate 1 only.

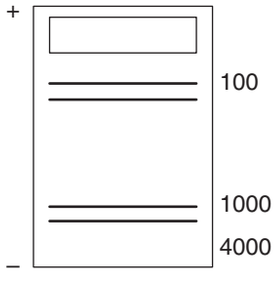
D. plates 1, 2 and 3.

Question 37

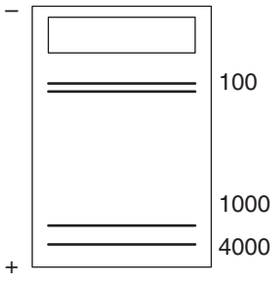
Restriction enzymes SalI, EcoR1, BamHI and NdeI were mixed with a pBR322 plasmid and then run on a gel.

Which one of the following is the most accurate representation of the expected band pattern?

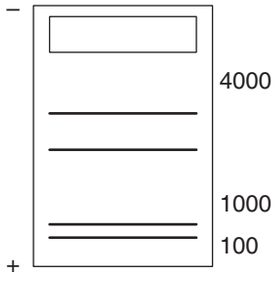
A.



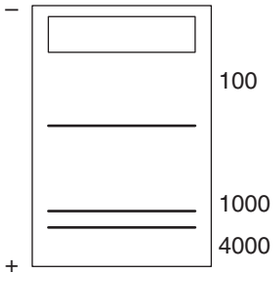
B.



C.



D.



Question 38

A simple blood test for Down syndrome now exists for pregnant mothers. The new test flags genetic markers of Down syndrome that have passed from the mother to the baby, and a genetic profile can be constructed. The new test is often conducted at the 15–20 week stage of pregnancy, which is up to six weeks later than the traditional test that is routinely used. However, the traditional test is subsidised by the Australian government, while the new test is not.

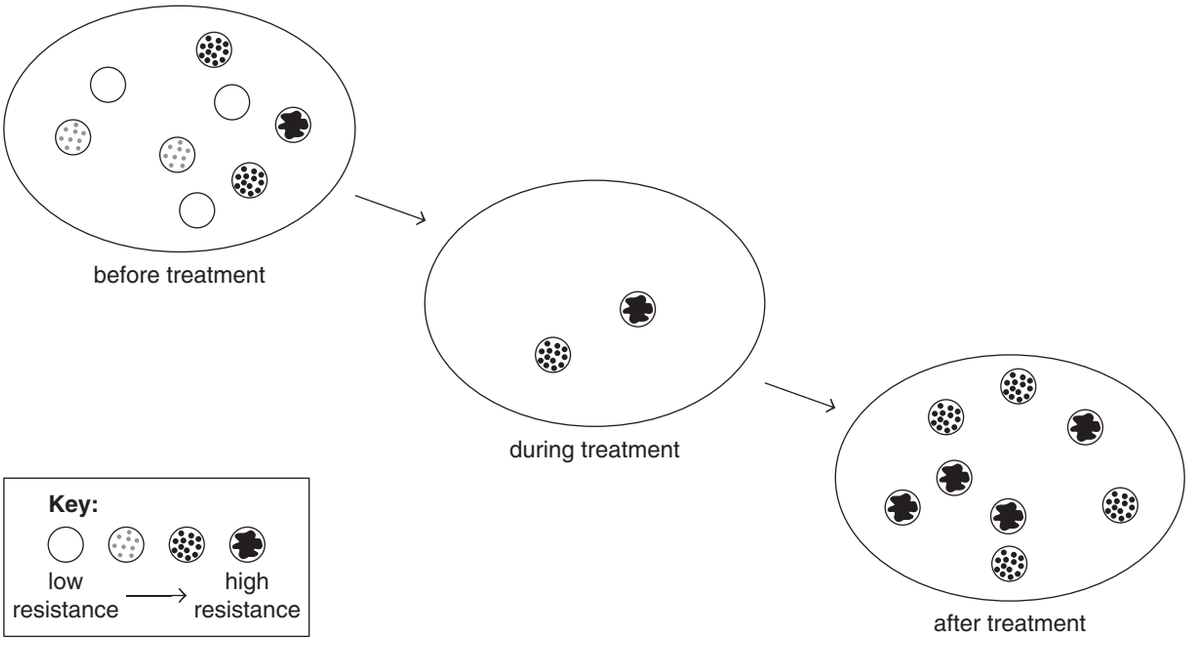
The new test has a 75% success rate, which gives families the opportunity to make informed decisions later in the pregnancy. Some people object to these technologies and others support them.

Which row gives appropriate arguments **against** the new test?

	Economic argument	Biological argument	Social argument
A.	$500 is a lot of money when compared to the other subsidised tests available.	As a result of the test becoming available, more individuals will be removed from the gene pool.	There is a 25% chance of the test being incorrect, which causes stress to families.
B.	It is an affordable test for most individuals, making it reasonable to undertake.	Unsuccessful genes will be removed from the gene pool by the testing.	There is a 75% chance of a correct result, which relieves a family's stress.
C.	The test is too late in the pregnancy to justify the $500 cost.	Only 75% of the genes are identified, making it a false test.	Families will be ostracised as a result of testing.
D.	The 75% chance of a successful diagnosis justifies the $500 cost.	People with Down's syndrome are usually infertile, so they have little impact on the gene pool.	The discriminatory effect on the unborn child cannot be justified.

Question 39

An antibiotic was prescribed to treat a bacterial infection. Swabs were taken before, during and after treatment to see the effect of the antibiotic on bacterial antibiotic resistance. The diagram below shows the results of the testing. Each circle represents a colony of bacteria.



Based on the information in the diagram, it would be appropriate to conclude that

A. bacteria develop resistance after being exposed to antibiotics.

B. the source of resistance is due to a pre-existing mutation.

C. all the bacterial colonies are genetically the same after treatment.

D. the antibiotics should have been prescribed for longer.

Question 40

Scientific investigations require rigorous planning to confirm that valid conclusions can be made.

During a scientific investigation, the data obtained is more likely to be accurate if

A. the investigation is reproduced by different investigators as well as repeated by multiple individual investigators.

B. several investigators complete the experiment once each.

C. more than one independent variable is tested to ensure validity of results.

D. each experiment is repeated twice so that precision is high.

END OF SECTION A

SECTION B

Instructions for Section B

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

Unless otherwise indicated, the diagrams in this booklet are **not** drawn to scale.

Question 1 (7 marks)

The enzyme ATP synthase converts ADP and P_i into ATP. It is located in the inner mitochondrial membrane and the thylakoid membrane in chloroplasts. ATP synthase is made of up to 20 polypeptide chains.

a. Name the monomers of ATP synthase. 1 mark

b. Discuss how the secondary and quaternary levels of protein structure relate to ATP synthase. 2 marks

c. Discuss the importance of ATP synthase within a plant cell in relation to the reactions in both the inner mitochondrial membrane and the thylakoid membrane. 2 marks

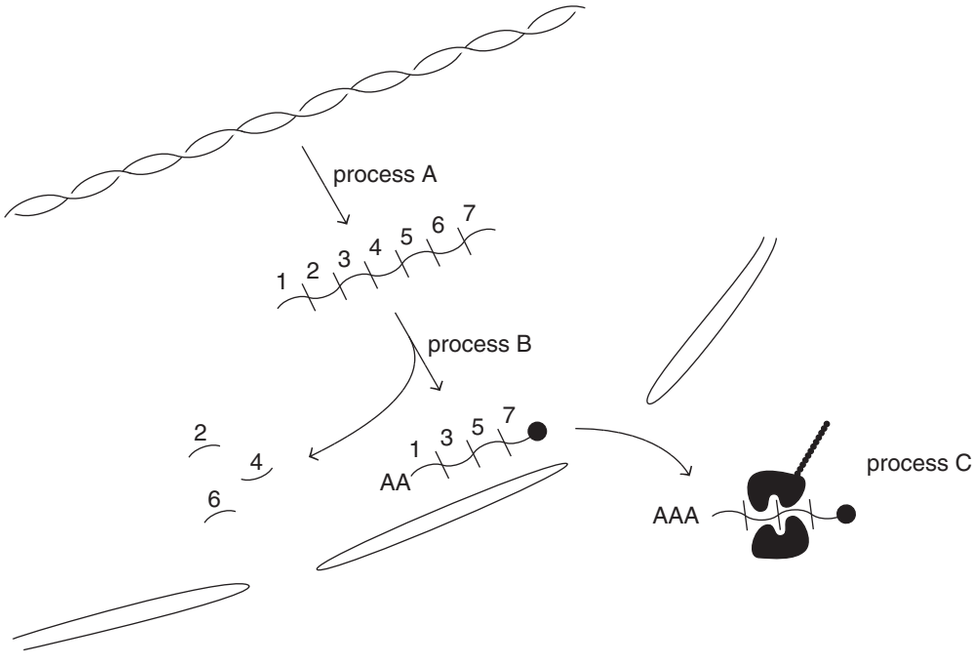
d. A group of cells were being investigated for the presence of the reactions described in **part c.**. The cells being investigated included

- a eucalypt mesophyll cell
- a guard cell from the stomata of a daffodil plant
- an epidermal cell from the aquatic plant alga elodea
- a cyanobacteria

Which cell from the list above would **not** contain the ATP synthase-dependant reactions described in **part c.**? Justify your response. 2 marks

Question 2 (7 marks)

The diagram below represents the different stages of gene expression (summarised as processes A, B and C) in a eukaryotic cell.



a. Outline the main steps of process A. 3 marks

b. Once process B ends, the product has been reduced in size.

Identify process B and explain why the product is reduced in size following the process. In your response, refer to the structures labelled 1–7 in the diagram above. 2 marks

c. The output molecule of process C consists of a sequence of 20 different types of monomers, but the input molecule is comprised of only four different types of monomers.

Based on the information given, how can the output molecule have a specific sequence of monomers? 2 marks

Question 3 (9 marks)

A method to reduce the amount of fat absorbed into the bloodstream is to take regular doses of the prescription drug Orlistat just before meals. Orlistat is a competitive inhibitor of the lipase enzyme secreted from the pancreas into the small intestine. Lipase usually enables the breakdown of fat into glycerol and fatty acids.

a. **i.** Is the chemical reaction that lipase is involved in hydrolysis or condensation? Justify your answer. 1 mark

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ii. Identify **four** conditions that are required for the optimal action of lipase in the small intestine of a human. 2 marks

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b. Draw a labelled diagram of the action of Orlistat as a competitive inhibitor of lipase. 2 marks

c. Before Orlistat was approved for use over 20 years ago, it had to be clinically tested for effectiveness as well as side effects.

How would a control group be used when clinically testing Orlistat? 2 marks

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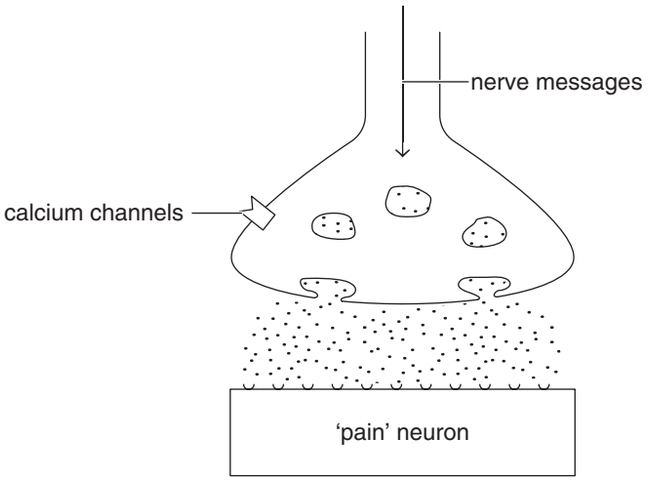
d. Some of the side effects of the long-term intake of Orlistat are shown in the table below. Complete the table below by identifying a biological reason for each side effect. 2 marks

Side effect	Biological reason for the side effect
oily bowel movement	
weakness	

Question 4 (6 marks)

The cone shell (*Conus magus*) is predatory and venomous. It has an effective form of chemical defence against external interference. If a human were to pick up a cone shell, it could inject them with a powerful neurotoxin, causing great pain. The nerve message from the site of venom injection activates a gated calcium channel before exocytosis from the axon can occur. Subsequently, the nerve message makes its way to the pain centre of the brain. The diagram below illustrates a functioning synapse.



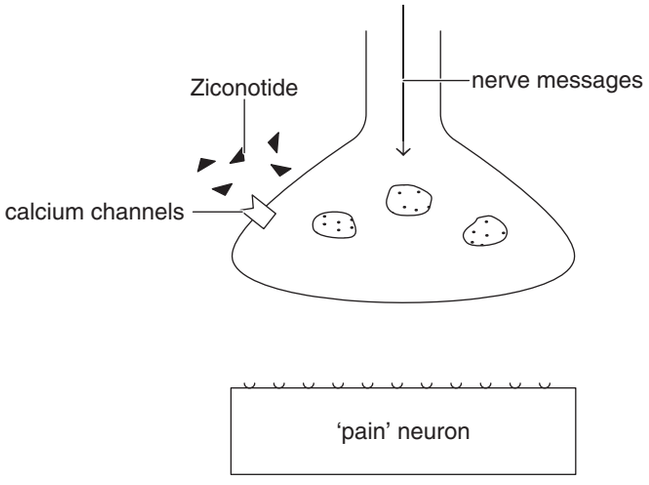
a. Label the following components on the diagram above:

- vesicle
- synaptic cleft
- neurotransmitters
- post synaptic receptor

2 marks

b. Describe the action of the neurotransmitters at the 'pain' neuron. 2 marks

c. Analysis of the cone shell toxin has led to the manufacture of Ziconotide, which is a water-soluble chemical and an effective pain reliever that is 1000 times more powerful than morphine. The diagram below shows the interaction of Ziconotide with a neuron and its subsequent effect as a pain reliever.



The Ziconotide binds to the calcium gated channels on the neuron, preventing calcium entering the axon.

Outline how this interaction relieves pain. 2 marks

Question 5 (6 marks)

Cells that threaten the health of the human body are usually quickly removed by apoptosis. Apoptosis can be stimulated by both internal and external pathways.

a. **i.** Identify **one** specific situation that would lead to apoptosis by an internal pathway. 1 mark

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ii. Identify **one** specific situation that would lead to apoptosis by an external pathway. 1 mark

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b. One of the intracellular steps of apoptosis is to activate caspase.

Describe the action of caspase that leads to the formation of apoptotic bodies. 2 marks

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c. Jennifer had a wound on the heel of her foot that became red and painful over the course of a week. She went to her doctor for a consultation, and she was given two reasons for the red colouration of her wound.

State **two** reasons the doctor may have given Jennifer. 2 marks

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Question 6 (6 marks)

The lymphatic system is a one-way network of vessels that lymph flows through from the capillary beds to empty back into the bloodstream near the heart.

a. **i.** Identify **one** feature of lymphatic vessels that enable them to transport lymph in only one direction. 1 mark

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ii. Identify the function of the lymph nodes that are located along the lymphatic vessels. 1 mark

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A dendritic cell migrated into a lymphatic vessel from an area infected by a pathogen. On its surface were antigens bound to MHC2 markers.

b. Describe how dendritic cells, once at the lymph nodes, stimulate a cell-mediated immune response against the pathogen. 3 marks

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c. Describe how T helper cells assist the immune response on subsequent future exposures to the same antigen. 1 mark

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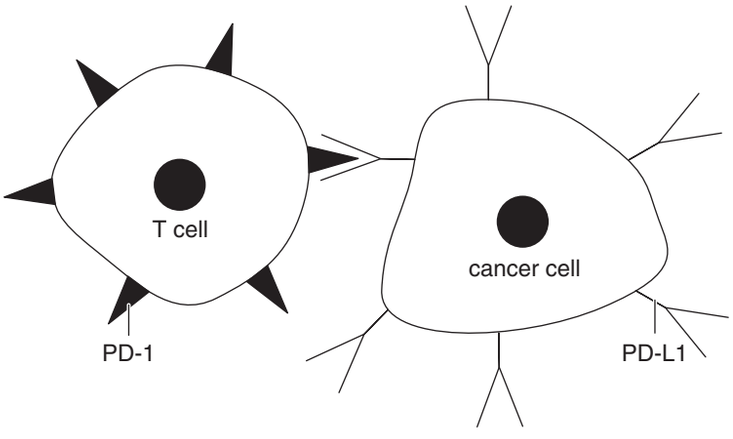
Question 7 (5 marks)

Immune cells are able to determine self-antigens on the surface of somatic cells via the interaction between the PD-1 proteins (on the T cell) and PD-L1 proteins (on somatic cells). If this interaction occurs, the somatic cell is accepted as self.

Cancerous cells are often able to evade the immune system by having marker proteins on their surface that enable cancerous celsl to be recognised as self. The diagram below illustrates this with respect to the PD-1 and PD-L1 protein interaction.



a. What would happen to a cancer cell in the body if there were no interaction between the PD-1 and PD-L1 proteins? 1 mark

Blocking the PD-1 proteins is proving to be a promising therapy for the reduction of some types of cancers, including melanomas. A monoclonal antibody called Pembrolizumab has been manufactured that will specifically bind to the PD-1 protein, thus blocking its interaction with PD-L1. The steps involved in the production of a monoclonal antibody against PD-1 are listed below in an incorrect order.

A	The mouse makes antibodies against the PD-1 antigens.
B	Specific B cells are isolated from the mouse blood samples.
C	Specific B cells are hybridised with tumour cells.
D	Specific B cells against the PD-1 antigens clone and differentiate.
E	Antibodies against PD-1 are extracted and used for therapy.
F	Blood samples are taken from the mouse.
G	A mouse is injected with the PD-1 antigens.
H	A cell line of hybridomas are grown in culture.

b. Using the letters (**A**–**H**) from the table above, list the correct order of steps involved in monoclonal antibody production. 2 marks

c. A clinical trial with advanced melanoma patients compared the effect of Pembrolizumab with another monoclonal antibody (Ipilimumab). The results of the clinical trial are shown in the table below.

Monoclonal antibody involved	Number of individuals in trial	Number of individuals alive after two years	Number of individuals with smaller tumours after two years
Pembrolizumab	279	185	91
Ipilimumab	278	166	33

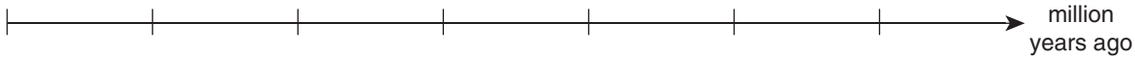
Using the data from the table above, explain why it can be concluded that Pembrolizumab is a more effective form of immunotherapy than Ipilimumab. 2 marks

Question 8 (9 marks)

Marsupials such as koalas, wombats and kangaroos evolved from a common ancestor. Kangaroos evolved first about 50 million years ago. Koalas and wombats then evolved about 35 million years ago.

a. What general features would the common ancestor display that enables it to be classified as the common ancestor? 2 marks

b. Using the space and scale below, construct a scaled phylogenetic tree of the common ancestor, kangaroos, wombats and koalas. 3 marks



c. There are three subspecies of the common, or bare-nosed, wombat (*Vombatus ursinus*). There are two species of hairy-nosed wombats – the northern hairy-nosed (*Lasiorhinus krefftii*) and southern hairy-nosed (*Lasiorhinus latifrons*). The northern and southern hairy-nose wombats were recently classified as different species.

Describe the evidence needed to classify the two species of hairy-nosed wombats as two distinct species. 1 mark

Present-day wombats are much smaller than some of their extinct ancestors. Fossil evidence provides evidence of the *Diprotodon* (giant wombat), which existed from about two million years ago until its rapid disappearance between 40 000–50 000 years ago. The giant wombat was over 4 metres long and weighed as much as a small car. While the circumstances of the *Diprotodon* extinction are currently unknown, one leading theory is that their extinction would follow a pattern that was repeated often – that is, the largest animals on a land mass becoming extinct after humans arrived.

d. **i.** Could the fossils of a piece of leg bone, a cranium fragment and a tooth be used to predict the size and weight of a once-living organism such as the *Diprotodon*? Justify your response. 2 marks

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ii. Megaherbivores like the *Diprotodon* were widespread for a long time in Australia, but became extinct relatively quickly.

Using the information above, identify what may have caused the rapid disappearance of the *Diprotodon*. 1 mark

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Question 9 (8 marks)

Discussions about our human origins have been ongoing for decades. New discoveries as well as new technologies mean that there is often new evidence to consider. For example, modern human migrations are debated as to whether they allowed interbreeding with other hominins.

Evidence for interbreeding between modern humans and Neanderthals illuminates the expansion of modern humans out of Africa. Non-African modern humans share about 1–4% of their genomes with Neanderthals, none of which is shared with modern Africans. None of this shared DNA is found within the mtDNA of modern humans; instead, it is found in the nuclear DNA. As Neanderthals evolved and lived exclusively in Eurasia, they could not have bred with humans living in Africa at that time, which is supported by their DNA not appearing in the genome of modern African humans.

In 2016, researchers published new evidence of modern human–Neanderthal interbreeding, which they found evidence for as far back as 100 000 years ago. This new information pushed back the previous estimates of human migration out of Africa, previously thought to be about 50 000 years ago.

These discoveries refute many previous hypotheses in which modern humans replaced archaic hominins like Neanderthals without any interbreeding.

a. Define the term 'hominin'. 1 mark

b. Using evidence from the information above, justify the theory that modern humans evolved in Africa and then migrated out of Africa. 2 marks

c. **i.** mtDNA is passed from mother to child.

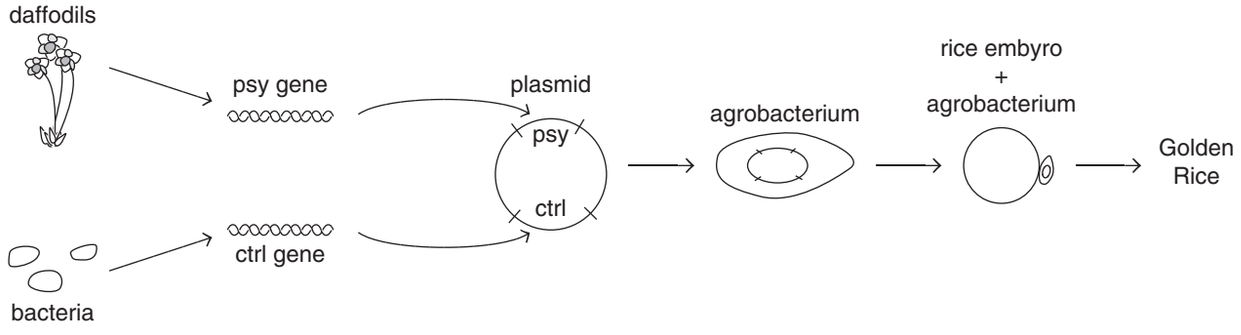
Using this information, outline why there is no Neanderthal mtDNA in modern humans, but some shared nuclear DNA. 2 marks

ii. Identify how a chromosomal block mutation could leave evidence of Neanderthal DNA within the nuclear DNA of modern humans. 1 mark

d. How could molecular homology data be interpreted to date human–Neanderthal interbreeding as far back as 100 000 years, rather than 50 000 as originally thought? 2 marks

Question 10 (7 marks)

Rice is a staple food crop for over half of the world's population, providing 30–72% of the energy intake for many people in Asian countries. It is becoming an effective crop for targeting vitamin deficiencies. Vitamin A deficiency is estimated to kill 670 000 children under the age of five annually and cause an additional 500 000 cases of irreversible childhood blindness each year. In the 1990s, biotechnologists delivered genes into rice genomes enabling them to synthesise vitamin A. This gave the engineered rice grains a golden colour and so the name 'Golden Rice' was coined. The diagram below shows how golden rice was produced.



a. Describe the methods used to transfer the psy gene from a daffodil into a plasmid. 3 marks

b. Explain why Golden Rice is an example of both a genetically modified organism and a transgenic organism. 2 marks

c. On 10 December 2019, the government of the Philippines authorised the direct use of Golden Rice 2 in food, feed and for processing. Golden Rice 2 produces 23 times more vitamin A than the original Golden Rice. Golden Rice 2 now competes more favourably than Golden Rice with other foods such as sweet potato, cassava and corn as a sustainable and effective source of vitamin A. This is one of the reasons why the Phillipine sgovernment authorised its use.

State **two** other reasons the Philippines government might have had for approving the use of Golden Rice 2. 2 marks

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Question 11 (10 marks)

Algal balls can be used as experimental models of photosynthesis and respiration. A single-celled algae called chlorella is mixed with a solution of agar, and the liquid solution is dripped into water to solidify into balls (hence the name algal balls). 100 algal balls were used in an experiment that tested the effect of light intensity on the production of carbon dioxide. The following method was used:

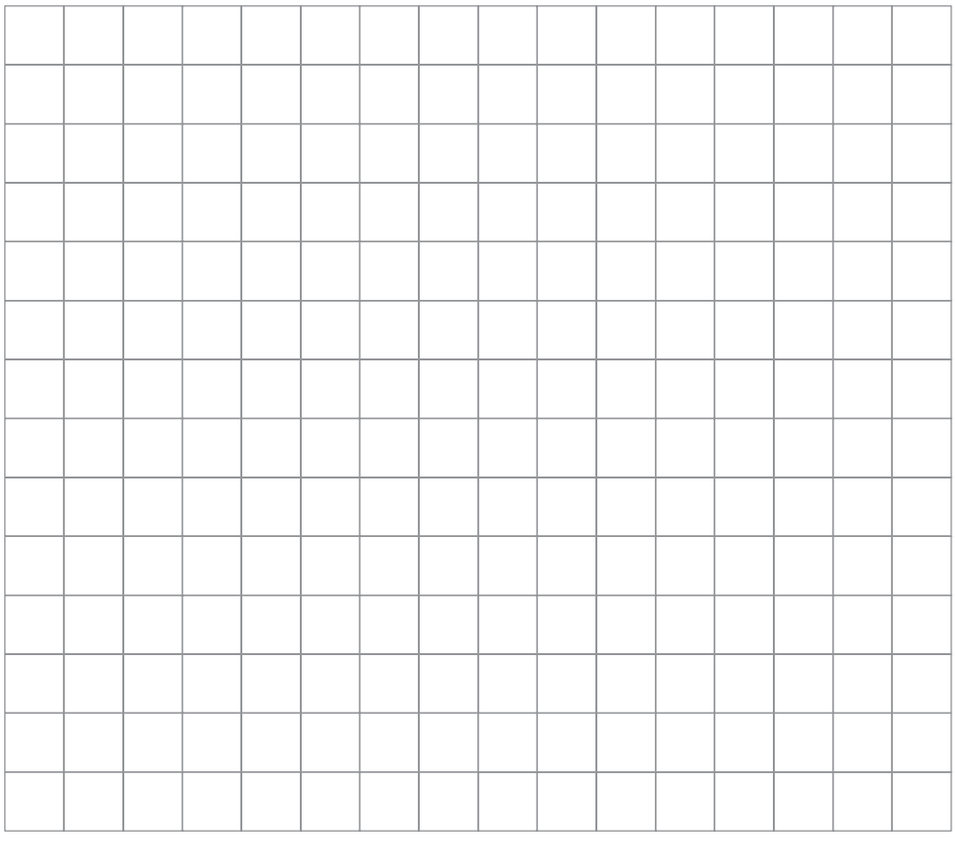
1. Six test tubes, each with 20 algal balls, were prepared with 10 ml pH 7 buffer solution.
2. Five of the test tubes were placed at different distances from a light source, and one test tube was placed in the dark.
3. The test tubes were left for 12 hours.
4. The final pH of each solution was measured with an electronic pH meter.
5. The differences in pH were recorded.

Note: A lower level of carbon dioxide in the solution leads to a higher pH.

The results of the experiment are shown in the table below:

Distance from light source (cm)	Final pH	Change in pH
20	9.8	+2.8
30	8.2	+1.2
50	7.1	+0.1
100	6.1	–0.9
200	5.8	–1.2
not exposed to light	4.9	–2.1

a. Using the data in the table, plot and label a graph of the data on the grid below. 3 marks



b. Explain the results of the agar ball experiment. In your response, refer to both respiration and photosynthesis. 3 marks

c. State **two** modifications that could have been applied to the method that would have led to a greater level of reliability. 2 marks

d. Researcher A stated that the results of the experiment were valid, but Researcher B disagreed and said that the results were precise.

Discuss which researcher is correct and which is incorrect when it comes to the interpretation of these terms with respect to this experiment. 2 marks

END OF QUESTION AND ANSWER BOOKLET