

STUDENT NUMBER

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## BIOLOGY

### Written examination

Friday 2 November 2018

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

<i>Section</i>	<i>Number of questions</i>	<i>Number of questions to be answered</i>	<i>Number of marks</i>
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 book of 37 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.
- Unless otherwise indicated, the diagrams in this book 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 book.

**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 book are **not** drawn to scale.

### Question 1

Substances that can move by diffusion directly through the phospholipid bilayer of the plasma membrane include

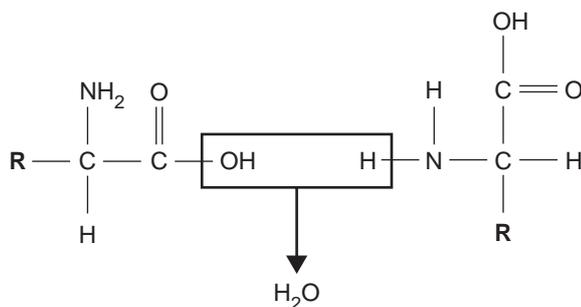
- A. sodium ions.
- B. oxygen molecules.
- C. polar protein molecules.
- D. ribonucleic acid molecules.

### Question 2

The proteome is

- A. the total DNA content that is present within one cell of an organism.
- B. a complete set of chromosomes found inside a cell of an organism.
- C. the entire set of proteins expressed by an organism at a given time.
- D. the four hierarchical levels of protein structure.

### Question 3



The diagram above represents adjacent amino acids being joined together.

The joining of adjacent amino acids

- A. results in the formation of a nucleic acid.
- B. is an energy-releasing reaction.
- C. is catalysed by DNA ligase.
- D. is a condensation reaction.

**Question 4**

The genetic code is described as a degenerate code.

This means that

- A. in almost all organisms the same DNA triplet is translated to the same amino acid.
- B. some amino acids may be encoded by more than one codon.
- C. a single nucleotide cannot be part of two adjacent codons.
- D. three codons are needed to specify one amino acid.

*Use the following information to answer Questions 5 and 6.*

The diagram below represents an aspect of the activity of the *lac* operon, a group of genes found on the chromosome of the bacteria *Escherichia coli*. The diagram shows the events that occur if allolactose, a breakdown product of lactose, is present in the *E. coli* cell.

Due to copyright restrictions,  
this material is not supplied.

Source: adapted from NA Campbell et al., *Biology*, 8th edition (Australian version), Pearson Education Australia, Frenchs Forest (NSW), 2009, p. 356

**Question 5**

Which one of the following statements is correct?

- A. Transacetylase, permease and  $\beta$ -galactosidase are exons that digest allolactose.
- B. Section X is the regulatory gene for the *lac* operon.
- C. Molecule Q is a repressor protein.
- D. Molecule P is a tRNA molecule.

**Question 6**

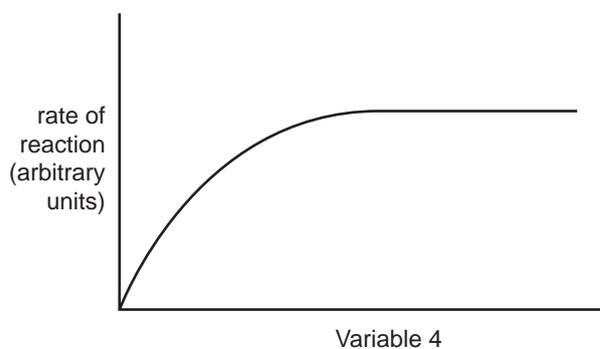
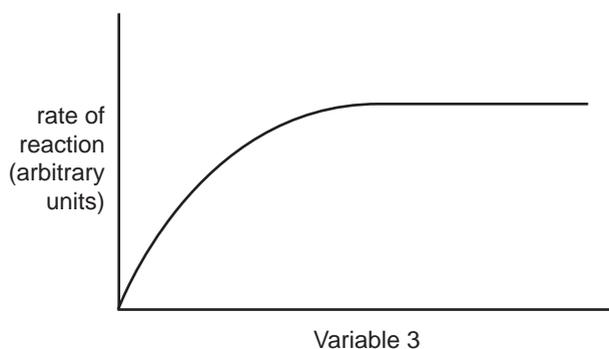
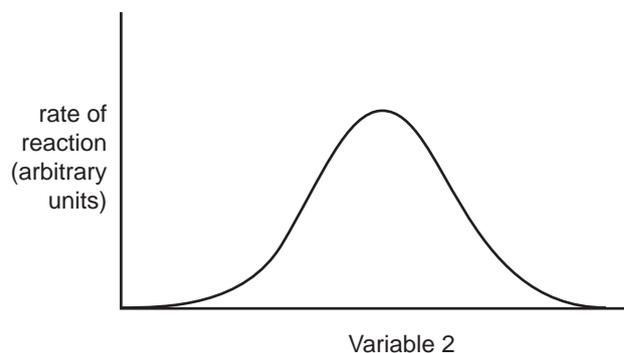
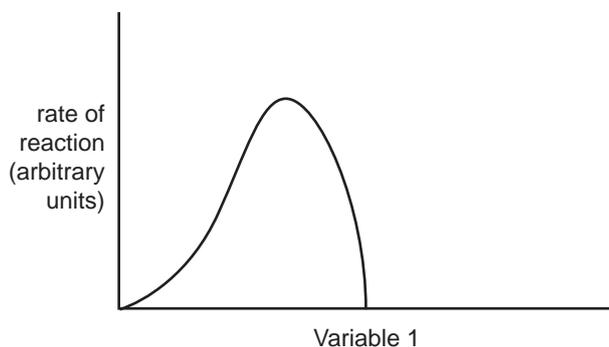
Which one of the following events occurs when allolactose is **not** present in the *E. coli* cell?

- A. *LacZ*, *lacY* and *lacA* genes are switched on.
- B. *LacI* does not receive a start signal to produce Molecule P.
- C. Molecule Q binds to Section X, preventing the transcription of *lacZ*, *lacY* and *lacA* genes.
- D. Transacetylase, permease and  $\beta$ -galactosidase bind to the promoter, inhibiting the *lac* operon.

**SECTION A** – continued  
**TURN OVER**

**Question 7**

Four students performed a series of experiments to investigate the effect of four different variables on the rate of an enzyme-catalysed reaction. In each experiment the students changed one of the following variables: substrate concentration, pH, temperature and enzyme concentration. After recording their data, the students displayed their results in a series of graphs, as shown below. Each graph is a line of best fit for their data.



The students did not label the horizontal axis on any of their graphs. The next day, the students could not agree on which variable should be labelled on the horizontal axis of each graph. The students made the following suggestions as to what each variable could be.

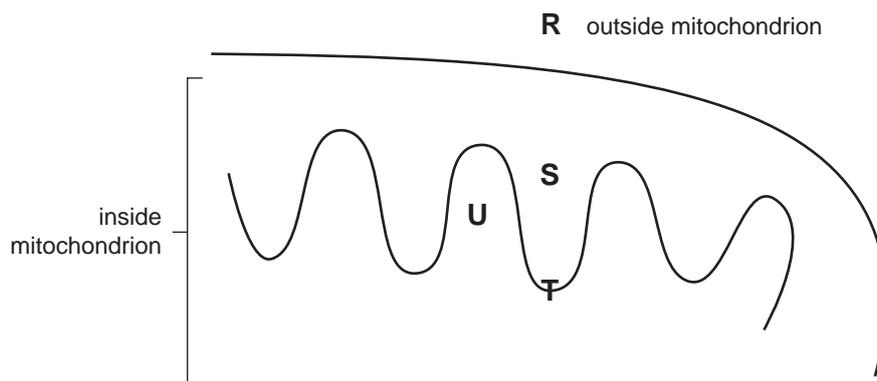
Student	Variable 1	Variable 2	Variable 3	Variable 4
Marcus	substrate concentration	temperature	pH	enzyme concentration
Billy	temperature	substrate concentration	enzyme concentration	pH
Voula	enzyme concentration	temperature	substrate concentration	pH
Sheena	temperature	pH	enzyme concentration	substrate concentration

Which student correctly identified all four variables on the horizontal axes?

- A. Marcus
- B. Billy
- C. Voula
- D. Sheena

**Question 8**

The diagram below shows a section through a part of a mitochondrion.



The sites of the pathways in aerobic respiration are

- A. R – glycolysis, S – Krebs cycle, T – electron transport chain.
- B. U – glycolysis, T – Krebs cycle, R – electron transport chain.
- C. R – glycolysis, U – Krebs cycle, T – electron transport chain.
- D. T – glycolysis, R – Krebs cycle, S – electron transport chain.

**Question 9**

Which of the following gives the inputs and outputs of the electron transport chain in an animal cell?

	<b>Inputs</b>	<b>Outputs</b>
A.	NADH, ADP, oxygen, P <sub>i</sub>	ATP, NAD <sup>+</sup> , water
B.	NADH, ADP, water, P <sub>i</sub>	ATP, NAD <sup>+</sup> , oxygen
C.	NAD <sup>+</sup> , ADP, oxygen, P <sub>i</sub>	NADH, ATP, water
D.	NADPH, ADP, water, P <sub>i</sub>	NADP <sup>+</sup> , ATP, oxygen

**Question 10**

Which pair of molecules contains the greatest amount of stored energy?

- A. NADH and ATP
- B. NAD<sup>+</sup> and ATP
- C. NAD<sup>+</sup> and ADP
- D. NADH and ADP

Use the following information to answer Questions 11 and 12.

Four groups of students carried out an experiment in which the effect of glucose concentration on the fermentation rate of yeast was measured. The fermentation rate was determined by the rate of temperature change of the fermenting mixture.

Before beginning the experiment, each group practised measuring the temperature of water and checked the group's thermometer against an electronic thermometer that gave a true measure of temperature.

The following results were obtained during the practice.

Group	Each group's thermometer readings (°C)			Electronic thermometer reading (°C)
	1st measurement	2nd measurement	3rd measurement	
1	18.0	17.0	17.5	20.1
2	18.0	18.0	18.5	20.5
3	21.0	21.0	20.5	19.9
4	18.0	19.0	21.0	20.2

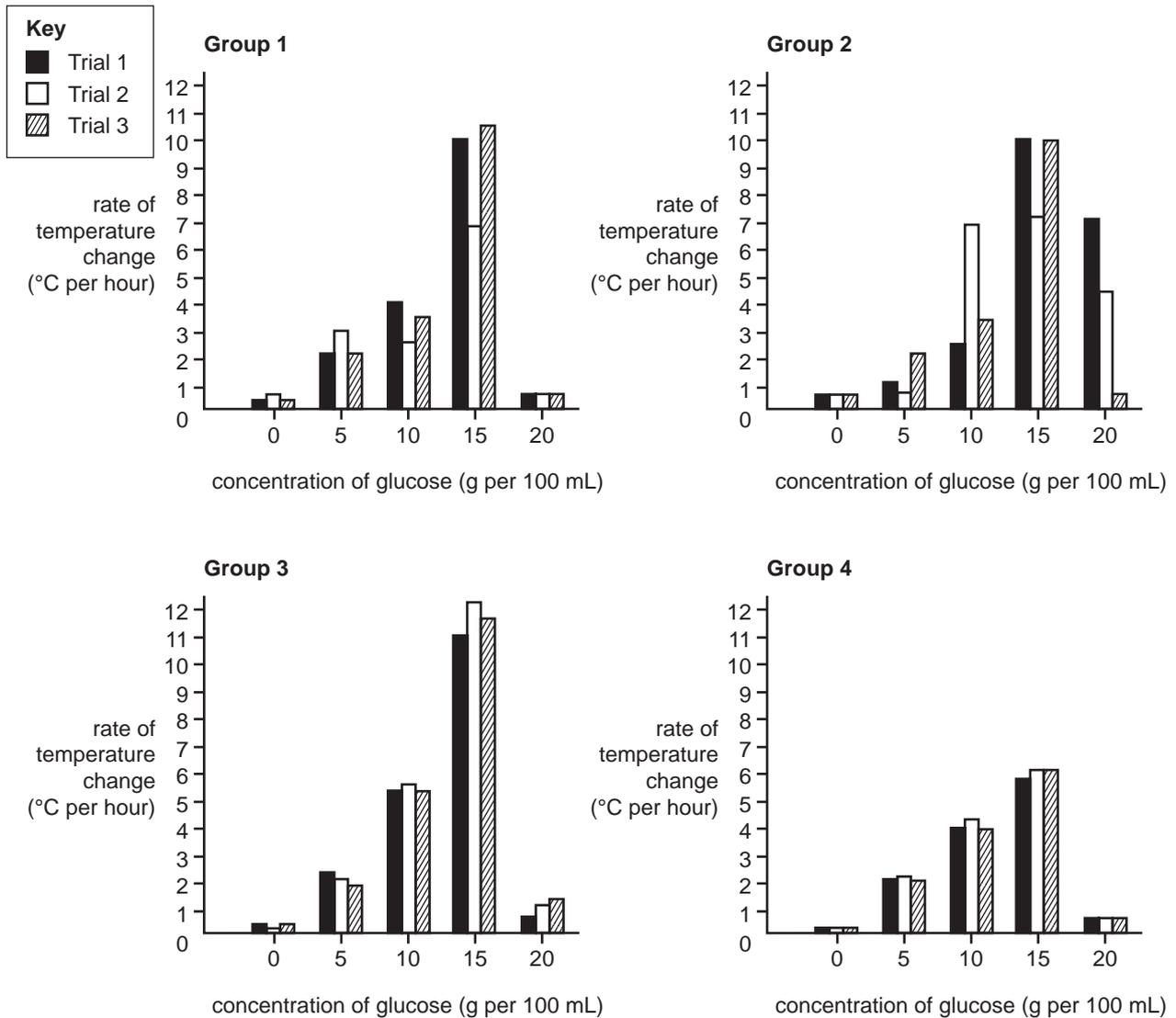
### Question 11

Which one of the following statements is correct?

- A. Group 1's measurements are the most accurate but the least precise.
- B. Group 2's measurements are accurate but not precise.
- C. Group 3's measurements are precise but not accurate.
- D. Group 4's measurements are both accurate and precise.

**Question 12**

Each group conducted the experiment three times (Trial 1, Trial 2, Trial 3). Five different concentrations of glucose were used in each trial. Each group plotted its results on a graph. The black bar represents Trial 1, the white bar represents Trial 2 and the striped bar represents Trial 3.

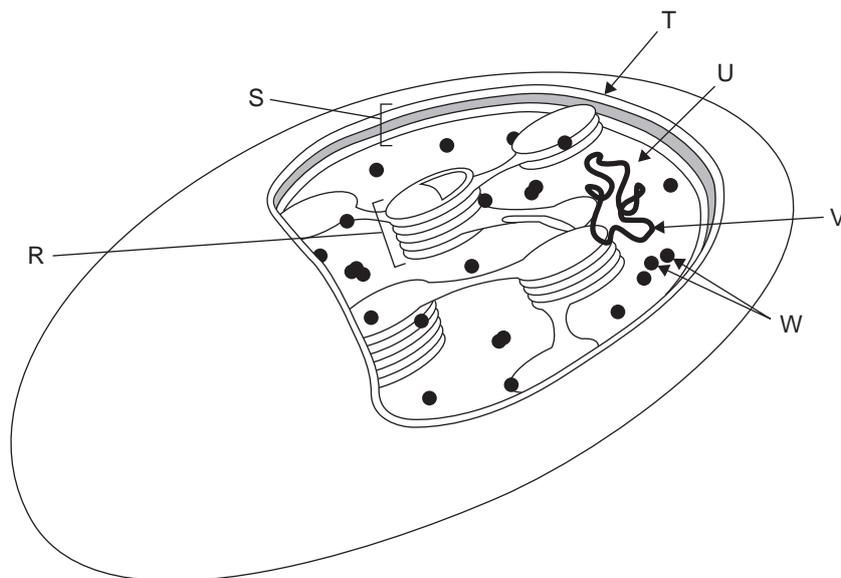


Which one of the following statements about the experiment's results can be concluded from the graphs?

- A. Group 1's results are more valid than the other groups', but less reliable.
- B. Group 2's results are less reliable, but more precise and accurate.
- C. Group 3's results are the most accurate and reliable.
- D. Group 4's results are more reliable than the other groups'.

Use the following information to answer Questions 13 and 14.

The diagram below shows the structures of a chloroplast, labelled R–W.



Source: adapted from Kelvinsong (own work)/Wikimedia Commons/CC-BY-3.0

**Question 13**

Which combination of two structures could be used as evidence for the bacterial origin of chloroplasts?

- A. U and R
- B. S and V
- C. U and W
- D. W and T

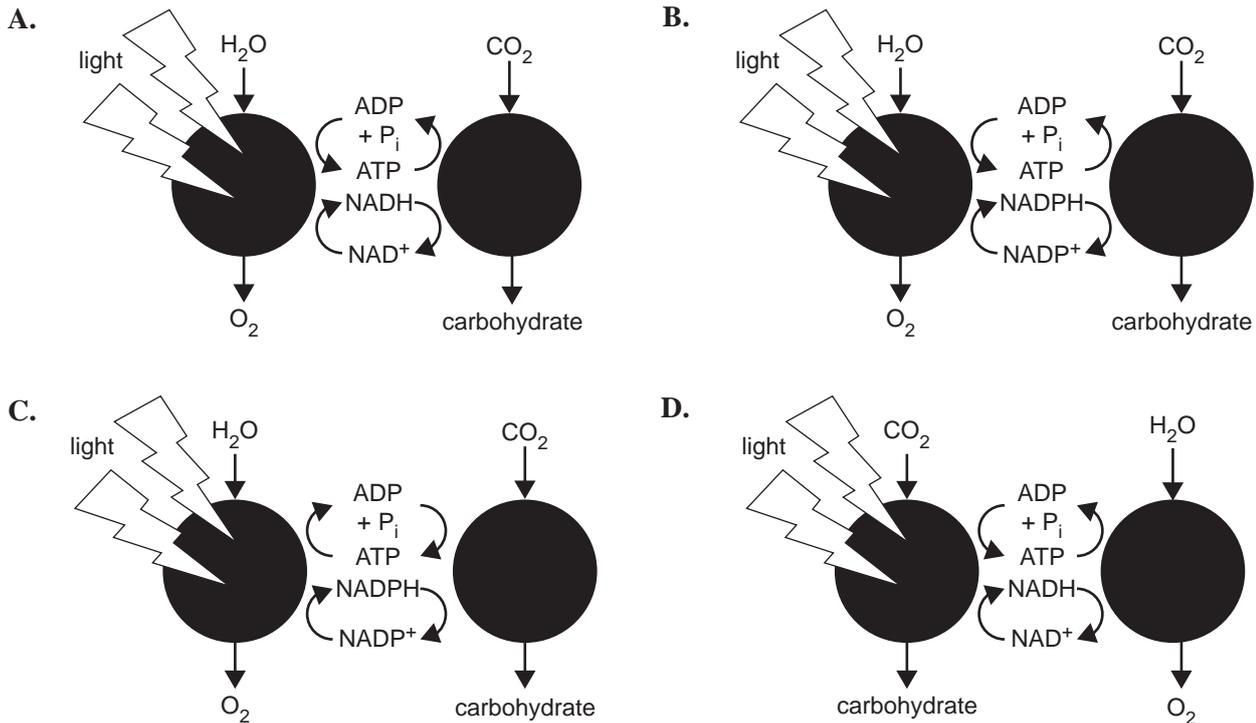
**Question 14**

The light-independent reaction of photosynthesis occurs at

- A. T.
- B. U.
- C. V.
- D. W.

**Question 15**

Which one of the following diagrams correctly represents the inputs and outputs of photosynthesis?

**Question 16**

Lupus is a condition that results in the increased secretion of antibodies that attach themselves to healthy cells in a patient's body. The accumulation of these antibodies causes inflammation, joint pain, rash, fatigue and fever.

Lupus is an example of

- A. an allergic reaction.
- B. an autoimmune disease.
- C. an immune deficiency disease.
- D. a complement protein response.

**Question 17**

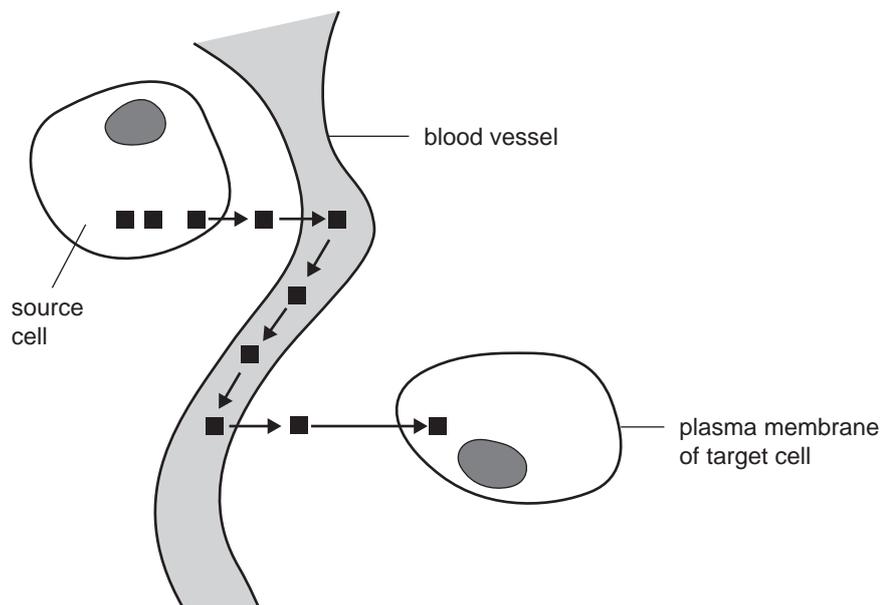
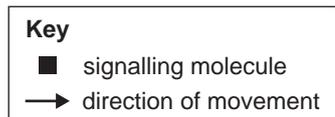
Antigen-presenting cells deliver antigens to lymphocytes found within lymphoid tissue. These lymphocytes recognise these antigens as being non-self, causing the lymphocytes to become activated and increase in number.

Which of the following lymphocytes are activated by antigen-presenting cells?

- A. T helper cells
- B. dendritic cells
- C. plasma cells
- D. neutrophils

Use the following information to answer Questions 18 and 19.

A signalling molecule is produced by a source cell and transfers to a target cell, as shown in the diagram below.



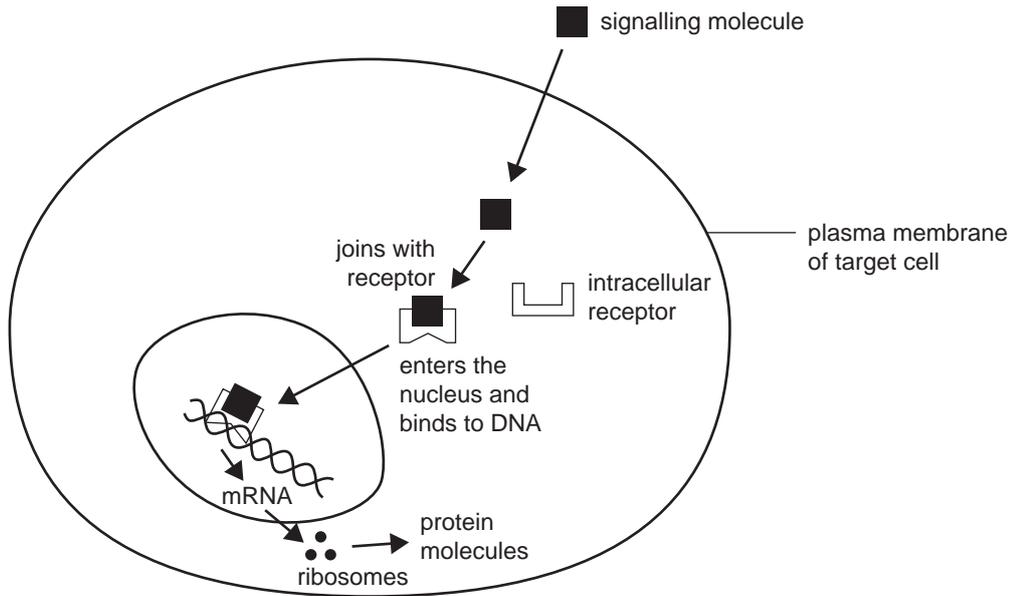
**Question 18**

The signalling molecule is most likely

- A. an antibody.
- B. a pheromone.
- C. a neurotransmitter.
- D. an animal hormone.

**Question 19**

Consider the diagram below of a signalling molecule interacting within a target cell.



In the interaction between the signalling molecule and the target cell

- the signalling molecule must be hydrophilic.
- the original signal is amplified during signal transduction.
- the response of the target cell is increased gene expression.
- second messengers are produced during signal transduction.

Use the following information to answer Questions 20 and 21.

		Second letter				
		U	C	A	G	
First letter	U	UUU } phe UUC } UUA } leu UUG }	UCU } UCC } ser UCA } UCG }	UAU } tyr UAC } UAA STOP UAG STOP	UGU } cys UGC } UGA STOP UGG trp	U C A G
	C	CUU } CUC } leu CUA } CUG }	CCU } CCC } pro CCA } CCG }	CAU } his CAC } CAA } gln CAG }	CGU } CGC } arg CGA } CGG }	U C A G
	A	AUU } AUC } ile AUA } AUG met	ACU } ACC } thr ACA } ACG }	AAU } asn AAC } AAA } lys AAG }	AGU } ser AGC } AGA } arg AGG }	U C A G
	G	GUU } GUC } val GUA } GUG }	GCU } GCC } ala GCA } GCG }	GAU } asp GAC } GAA } glu GAG }	GGU } GGC } gly GGA } GGG }	U C A G

Consider the following sequence of six amino acids that make up part of a polypeptide.

----- [ phe ] ----- [ leu ] ----- [ pro ] ----- [ val ] ----- [ tyr ] ----- [ ala ] -----

A mutation within the gene coding for this sequence of six amino acids resulted in the following six amino acids in the same position.

----- [ phe ] ----- [ leu ] ----- [ ala ] ----- [ val ] ----- [ tyr ] ----- [ ala ] -----

### Question 20

This change in the sequence of amino acids was caused by

- a deletion of a nucleotide.
- an insertion of a nucleotide.
- a substitution of a nucleotide.
- an inversion of adjacent nucleotides.

**Question 21**

Another mutation within the original gene resulted in a shortened protein. The protein was truncated (cut short) after the amino acid valine, as shown below.



This truncated protein resulted from the codon

- A. UAU changing to UAA.
- B. UAC changing to UGC.
- C. GUA changing to UGA.
- D. GUG changing to UGG.

**Question 22**

In humans, Duchenne muscular dystrophy (DMD) is caused by mutations in the dystrophin-encoding DMD gene. The DMD gene contains 79 exons. In some patients, duplication of one exon occurs.

If the number of nucleotides in the duplicated exon is divisible by three, the

- A. transcribed mRNA will contain many stop codons.
- B. length of each of the 79 exons will increase by three nucleotides.
- C. translated protein will be longer than the dystrophin protein found in a person without DMD.
- D. dystrophin of these patients will show one amino acid change in the sequence compared to normal dystrophin.

**Question 23**

Rabies is a viral disease spread to people by infected animals. A person bitten by an infected animal should be given an injection of specific antibodies.

Following the injection, this person should have

- A. natural active immunity.
- B. artificial active immunity.
- C. natural passive immunity.
- D. artificial passive immunity.

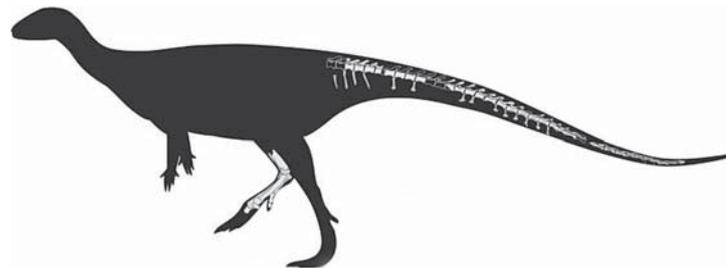
**Question 24**

Monoclonal antibodies can be produced and used to treat different types of cancers.

Which one of the following is a correct statement about monoclonal antibodies?

- A. Monoclonal antibodies are carbohydrate molecules.
- B. Monoclonal antibodies produced from the same clone of a cell are specific to the same antigen.
- C. Monoclonal antibodies pass through the plasma membrane of a cancer cell and attach to an antigen within the cell.
- D. Monoclonal antibodies produced to treat stomach cancer will be identical to monoclonal antibodies produced to treat breast cancer.

Use the following information to answer Questions 25 and 26.



Sources: Stephen Poropat/Museums Victoria, <<https://collections.museumvictoria.com.au/specimens/1572890>> (left); MC Herne, AM Tait, V Weisbecker, M Hall, JP Nair, M Cleeland, SW Salisbury/Wikimedia Commons/CC-BY-4.0 (right)

The photograph shows a fossil of the ornithopod dinosaur *Diluvicursor pickeringi* found in 113-million-year-old rock in western Victoria. The fossil consists of a tail, a partial hind limb and some vertebrae. *D. pickeringi* grew to 2.3 m long. The diagram on the right is a reconstruction of the complete dinosaur. Evidence suggests that the dinosaur was fossilised in a log-filled hollow at the bottom of an ancient riverbed. Two stratigraphically younger fossils that had been found previously at a nearby site are closely related to *D. pickeringi*.

### Question 25

It is most probable that the two stratigraphically younger fossils would have been found in a layer of rock that

- A. was closer to the present-day ground surface than the rock surrounding the *D. pickeringi* fossil.
- B. contained a smaller quantity of carbon-14 than the rock surrounding the *D. pickeringi* fossil.
- C. was located at a depth of 2.3 m below the ancient riverbed.
- D. was formed from extremely hot, volcanic lava flow.

### Question 26

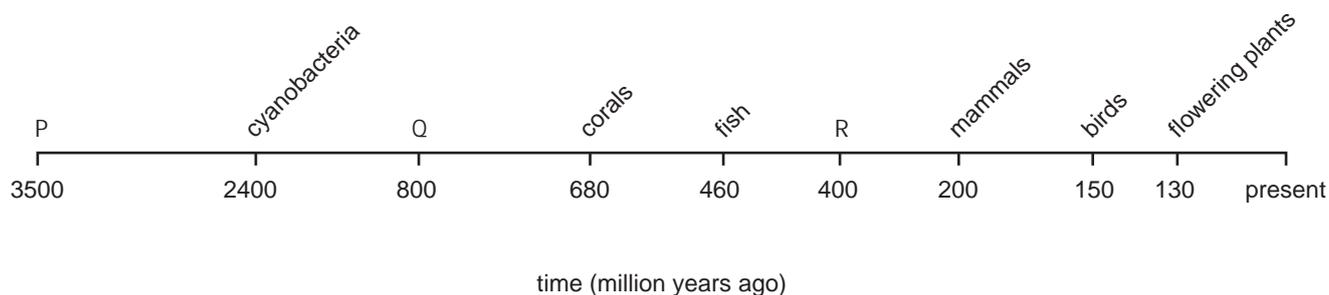
Palaeontologists believe that the Victorian ornithopods shared a close common ancestor with several ornithopod fossils found in Antarctica, South America and Africa.

Which one of the following is the most likely explanation for the distribution of these fossils?

- A. Antarctica, South America and Africa were joined to Australia in the distant past.
- B. The strong tails of the ornithopods enabled them to swim for sustained periods of time.
- C. The small forelimbs of the ornithopods suggest that they were evolving wings for flight.
- D. Seagoing, scavenger birds carried the fossil bones of the ornithopods to other continents.

**Question 27**

The timeline below summarises the first appearance of some major groups of organisms in the evolution of life on Earth, as indicated by the fossil record. Three major groups are missing from the timeline and are represented by the letters P, Q and R.

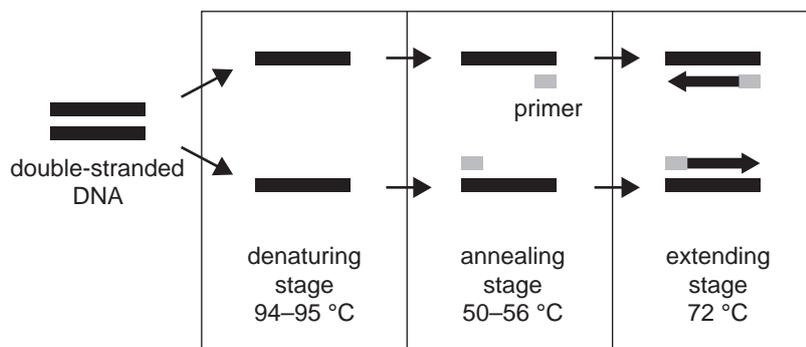


What are the correct groups of organisms labelled P, Q and R?

	<b>P</b>	<b>Q</b>	<b>R</b>
A.	bacteria	multicellular organisms	insects
B.	prokaryotes	non-flowering land plants	eukaryotes
C.	bacteria	reptiles	dinosaurs
D.	unicellular organisms	insects	non-flowering land plants

**Question 28**

The diagram below represents a method of DNA manipulation.



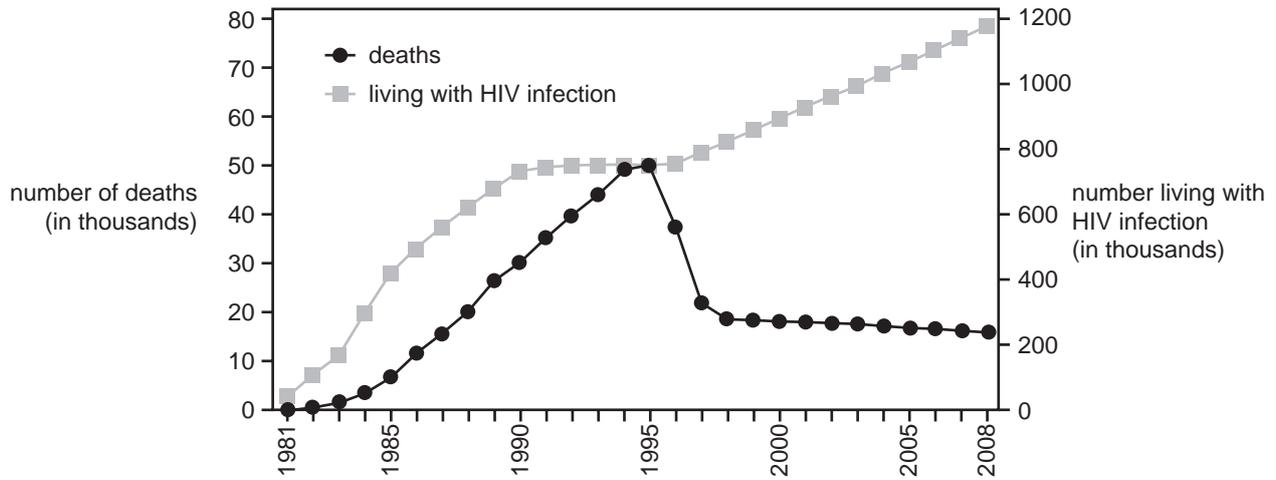
Source: Genome Research Limited, in Your Genome, <[www.yourgenome.org](http://www.yourgenome.org)>

The method represented is

- A. gel electrophoresis.
- B. DNA transformation.
- C. bacterial transformation.
- D. polymerase chain reaction.

**Question 29**

The graph below shows the death rates from acquired immune deficiency syndrome (AIDS) and also the number of people infected with the human immunodeficiency virus (HIV). Before 1995 many people infected with the virus went on to develop AIDS, which led to their deaths.



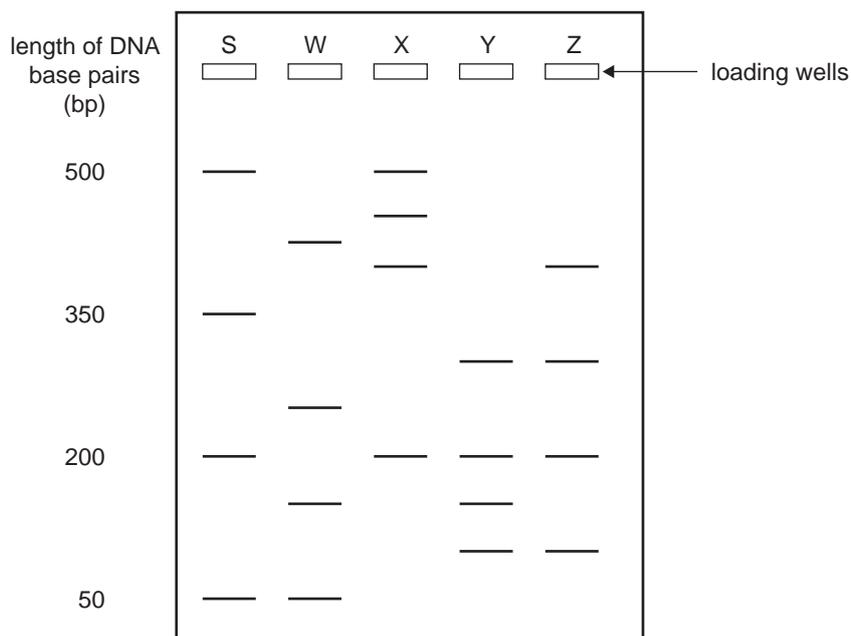
Source: National Institute on Drug Abuse, 'How does drug abuse affect the HIV epidemic?', research report, <[www.drugabuse.gov](http://www.drugabuse.gov)>

Based on the information in the graph, what is the most likely reason for the change in death rates, even though infection rates continued to climb after 1995?

- A. People had access to new antiviral drugs.
- B. People were educated about what caused HIV infection.
- C. People infected with HIV were isolated from the rest of the public.
- D. A widespread vaccination program for HIV was introduced within a targeted population.

Use the following information to answer Questions 30 and 31.

Four samples of DNA were loaded into four different wells in lanes W, X, Y and Z. A standard ladder was loaded into the well in lane S. The results of gel electrophoresis are shown below.



### Question 30

Which lane represents a sample that was loaded with DNA fragments of four different lengths: 100 bp, 150 bp, 200 bp and 300 bp?

- A. W
- B. X
- C. Y
- D. Z

### Question 31

Which lane contains the band that is closest to the negative electrode?

- A. W
- B. X
- C. Y
- D. Z

Use the following information to answer Questions 32 and 33.

The table below compares how eight diseases spread and the number of people likely to be infected by one other infected person.

<b>Disease</b>	measles	whooping cough	rubella	polio	smallpox	mumps	severe acute respiratory syndrome (SARS)	Ebola
<b>How it spreads</b>	airborne droplets	airborne droplets	airborne droplets	fecal–oral route	airborne droplets	airborne droplets	airborne droplets	bodily fluids
<b>Number of people infected from one other person</b>	12 to 18	12 to 17	6 to 7	5 to 7	5 to 7	4 to 7	2 to 4	1 to 4

Data: © 2018 Thomson Reuters

### Question 32

What would be the most effective method of preventing the spread of measles during an outbreak?

- A. Wash hands thoroughly after going to the toilet.
- B. Establish a ‘clean needle’ exchange program.
- C. Vaccinate all infected people.
- D. Isolate all infected people.

### Question 33

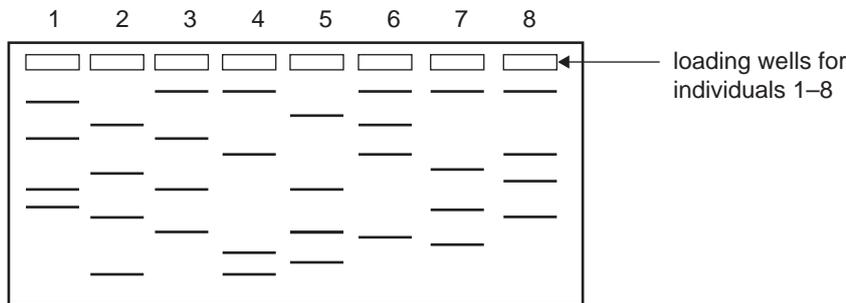
Based on the information in the table, which one of the following statements is correct?

- A. Ebola is the most contagious disease.
- B. Polio and smallpox have a similar infection rate.
- C. More people would die from measles than any other disease shown.
- D. The fecal–oral route is the most effective means of spreading pathogens.

**Question 34**

Genetic testing can be used to test for the allele for Huntington's disease (HD). The onset of HD predominantly occurs in adulthood.

Eight individual family members were tested for the HD allele. The diagram below shows the electrophoresis gel results of a test for the presence of the allele. Individuals 4 and 8 have been diagnosed with the disease.



Which other individual is likely to suffer from HD now or in the future?

- A. 1
- B. 2
- C. 5
- D. 6

**Question 35**

The emergence of antibiotic-resistant diseases in humans means that

- A. antibiotics are causing resistance mutations in bacteria.
- B. some bacteria are less sensitive to antibiotics.
- C. viruses are becoming resistant to antibiotics.
- D. humans are less sensitive to antibiotics.

**Question 36**

Chagas' disease, a potentially life-threatening illness in humans, is caused by the protozoan parasite *Trypanosoma cruzi*. The disease is found mainly in Latin American countries, where the parasite is spread by an insect called a triatomine.

In this example, the role of the triatomine is to

- A. introduce a virus into the protozoan parasite.
- B. infect the insect with Chagas' disease.
- C. introduce a gene into a bacterium.
- D. enable *T. cruzi* to enter the host.

**Question 37**

Members of the order Primates are mammals.

Which combination of features is common to all primates and distinguishes them from other mammals?

	Feature 1	Feature 2	Feature 3
A.	forward-facing eyes	sloping forehead	fur or hair
B.	binocular vision	opposable thumbs	fully rotating shoulder joints
C.	parabolic jaw	tail	nails instead of claws
D.	even-sized teeth	arms longer than legs	bipedal stance

**Question 38**

Consider the evolution of hominins.

Which one of the following statements about hominin evolution is correct?

- A. *Homo sapiens* and *Homo neanderthalensis* are the only present-day hominin species.
- B. Members of the *Australopithecus* genus are not classified as hominins.
- C. *Homo erectus* was a bipedal primate.
- D. All hominoids are also hominins.

**Question 39**

Which general trend is shown by hominin fossils?

- A. The older the fossil, the more central the position of the foramen magnum in the skull.
- B. The older the fossil, the smaller the braincase that surrounds the cerebral cortex.
- C. The more recent the fossil, the less bowl-shaped the pelvis.
- D. The more recent the fossil, the larger the jaw bones.

**Question 40**

Biologists have suggested that the development of bipedalism was a factor contributing to cultural evolution in hominins.

The advantage of bipedalism that had the greatest impact on cultural evolution was that it allowed

- A. improved teamwork and social bonding during ritual dances.
- B. food sources to be seen from long distances.
- C. the free use of hands to manipulate objects.
- D. fast escape from predators.

**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 book are **not** drawn to scale.

**Question 1** (6 marks)

Tryptase is an enzyme that is released, along with histamine and other chemicals, from human mast cells.  
 Nucleic acids encode instructions for the synthesis of tryptase in a mast cell.

- a.** Outline the steps of translation in the synthesis of tryptase. 3 marks

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- b.** After being synthesised, tryptase is released from mast cells via exocytosis.

Complete the table below by naming three different organelles directly associated with the transport of the synthesised tryptase within or from mast cells and state the role of each organelle in this process. 3 marks

Organelle	Role

**Question 2** (6 marks)

The scanning electron micrograph below shows a cell in the early stages of programmed cell death. The cell is beginning to change shape and blebs can be seen on the plasma membrane.



Source: © 2014 Pearson Education, Inc.

A signal from within the cell or outside the cell can initiate programmed cell death.

- a.** Consider a signal coming from within the cell, which initiates programmed cell death. Describe **two** changes that would occur within the cell to bring about its death. 2 marks

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- b.** State **two** advantages of programmed cell death for a multicellular organism. 2 marks

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- c.** In some human diseases, malfunctions in programmed cell death result in the death of too many cells. Explain, at a cellular level, what may have gone wrong to bring about this excessive cell death. 2 marks

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**Question 3** (6 marks)

Plants are a rich source of nutrients for many organisms, including bacteria, fungi and viruses. Although plants lack an immune system that is comparable to animals, plants have evolved chemical barriers to stop invading pathogens from causing significant damage.

- a. Describe **two** chemical barriers that could be present in a plant that is protecting itself from an invading pathogen. 2 marks

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- b. Humans have a sophisticated immune response to invading pathogens.  
State **two** ways that pathogens are prevented from entering the internal environment of the human body. 2 marks

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- c. Outline how complement proteins and natural killer cells protect the human body once a pathogen has gained entry to the internal environment. 2 marks

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**Question 4** (6 marks)

Botulinum toxin is produced by the bacterium *Clostridium botulinum*. In large concentrations, botulinum toxin causes the disease botulism in humans. Botulinum toxin gains entry into nerve cells through endocytosis.

- a.** Draw a labelled diagram to illustrate endocytosis of botulinum toxin into nerve cells. 2 marks

- b.** Once botulinum toxin has entered nerve cells, it binds to a specific protein, resulting in the inhibition of the release of neurotransmitter by the nerve cells. This specific protein has a complex quaternary structure made from four polypeptide sequences.

Suggest an effect that botulinum toxin could have on the structure of this specific protein. 1 mark

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- c.** Botox injections are a cosmetic treatment that reduces facial wrinkles by paralysing the muscles connected to nerve cells. Botox injections contain small amounts of weakened botulinum toxin. The muscle paralysis from the initial injections lasts for about four months. Muscle paralysis from subsequent injections lasts for shorter periods of time.

Why would the effectiveness of the subsequent botox injections decrease over time? 3 marks

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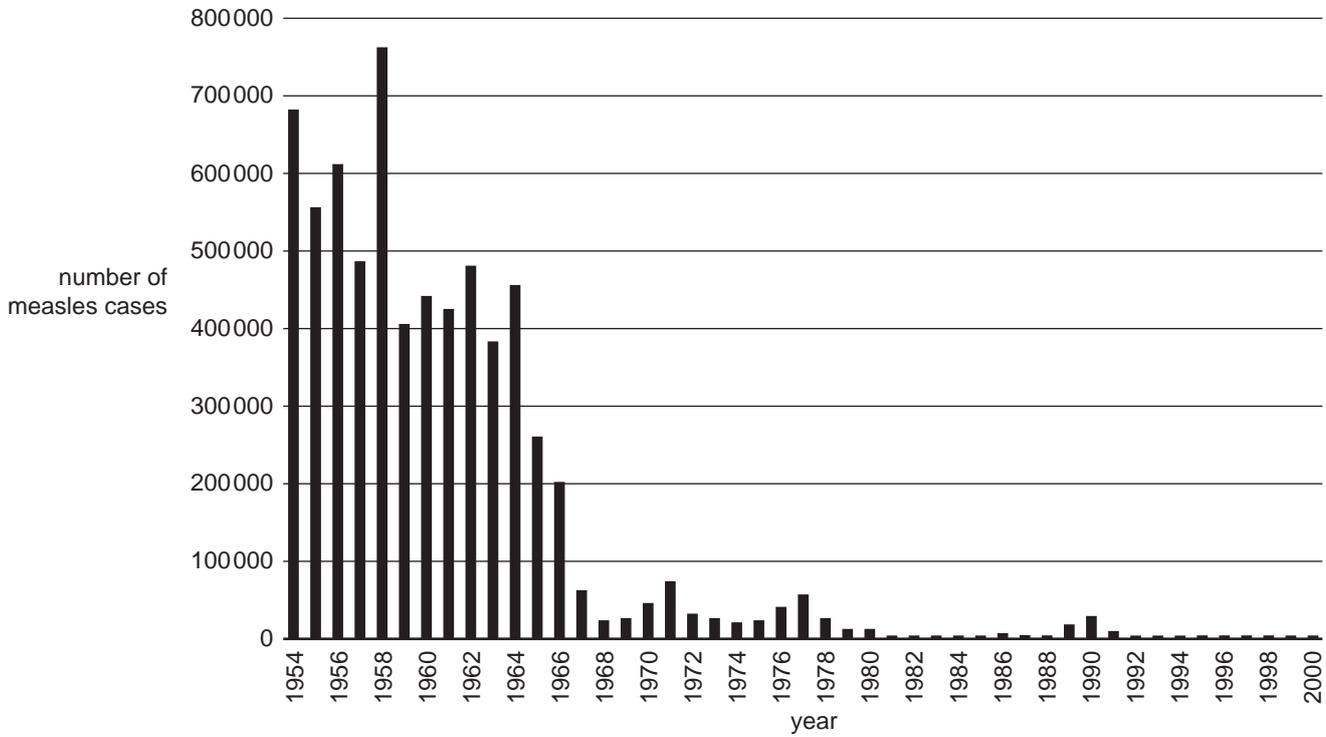
**SECTION B – continued**  
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**Question 5** (5 marks)

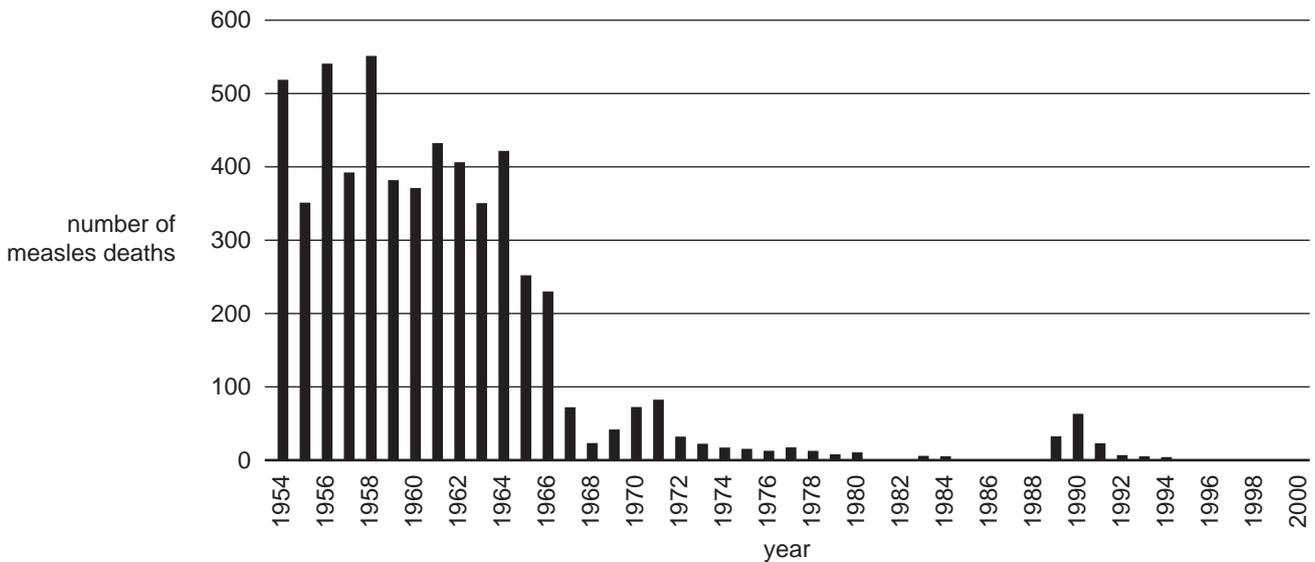
Measles is a highly infectious and dangerous disease. Young children and individuals with impaired immunity are especially susceptible to measles.

Analyse the following graphs that show the number of people in the United States of America (USA) who were infected with measles during the period 1954–2000 and the number of people who died as a result of having measles during the same period.

**Reported measles cases by year**



**Reported measles deaths by year**



Data: ProCon.org

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- a. i.** Which year had the greatest number of reported measles cases? 1 mark

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- ii.** What trends can be observed when the two graphs are compared? 2 marks

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- b.** Controlling the number of measles cases in a population relies on herd immunity.

What is herd immunity and how does it help control the number of cases of this disease? 2 marks

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**Question 6** (6 marks)

- a.** Describe the functional difference between a structural gene and a regulatory gene. 2 marks

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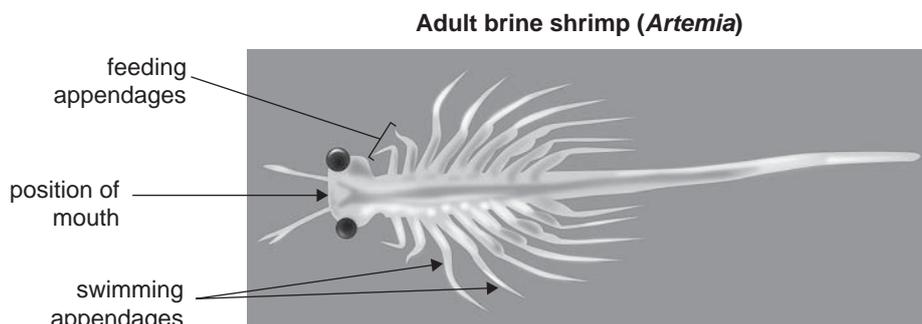
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The *Hox* genes are master regulatory genes that influence cells in a particular location of an animal embryo in order to develop structures for that part of the body.

In the brine shrimp, *Artemia*, the expression of the *Hox* genes *Ubx* and *Scr* results in the growth of either a swimming appendage or a feeding appendage, depending on whether the genes are expressed in cells that are in the mid-region of the body or that are near the mouth. These specialised appendages are labelled in the diagram below.



Source: patrimonio designs ltd/Shutterstock.com

- b.** Describe **one** way that genes are regulated so that the same genes can produce different appendages when the genes are expressed in different locations in the *Artemia* embryo. 1 mark

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- c.** The gene BMP4 is a master gene in the Galápagos finches and the African cichlid fish. Outline the function of the BMP4 gene and explain its evolutionary significance in **either** the Galápagos finches **or** the African cichlid fish. 3 marks

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**Question 7** (7 marks)

Populations of the lizard species *Anolis sagrei* are found on the many islands of the Bahamas. There is natural variation between the phenotypes of individuals within each population.

- a. Explain how natural variation can exist between individuals within a lizard population. 3 marks

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In 2004 a hurricane killed all populations of *A. sagrei* lizards on seven of the smaller islands. Scientists randomly chose seven males and seven females from a remaining population on a large island. They introduced one male and one female to each of the seven smaller islands. Over the next three years, the scientists noted that the size of the populations increased on each of the seven smaller islands. The scientists measured the genetic diversity within each of the populations and found there was lower genetic diversity in each new population compared with the population on the large island.

- b. Explain the reasons for the lower genetic diversity of the new populations on the smaller islands compared with the population on the large island. 2 marks

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- c. The scientists noted that after three years there was a significant decrease in the average length of the hind legs of the lizards living on the smaller islands compared with those on the large island.

Explain what may have happened on the smaller islands to produce this decrease in the average length of hind legs. 2 marks

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**Question 8** (7 marks)

Methotrexate is a drug used in the treatment of some cancers and an autoimmune disease, psoriasis, which affects the skin and sometimes the joints. In both of these diseases, cells grow rapidly. Methotrexate is structurally very similar to folic acid. Methotrexate works by inhibiting an enzyme that catalyses the change of an inactive form of folic acid into an active form. The active form of folic acid is needed for DNA production.

- a.** Based on the information given, explain how methotrexate could be acting as a competitive inhibitor of the enzyme. 2 marks

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- b.** Explain why methotrexate affects cell growth. 3 marks

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- c.** A person with psoriasis visits a doctor and asks for treatment for the disease. Would antibiotics be an effective treatment? Justify your response. 2 marks

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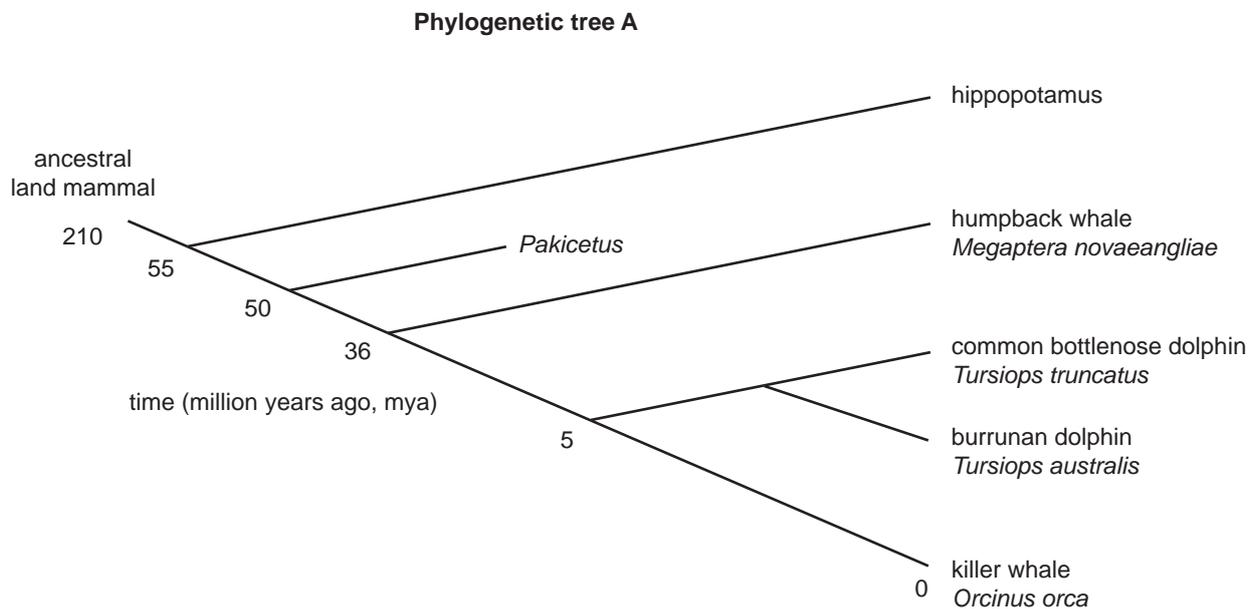
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**Question 9** (12 marks)

Cetaceans (whales, porpoises and dolphins) are marine mammals belonging to the order Artiodactyla (even-toed hoofed mammals). The closest living relatives of cetaceans are hippopotamuses.

Phylogenetic tree A summarises the evolutionary relationships of four present-day cetacean species and the hippopotamus.



- a. What does the length of the line that represents the evolution of *Pakicetus* suggest? 1 mark

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- b. A fossil named *Ambulocetus* was found in 1992 and dated at 49 million years old. Some palaeontologists believe that it is a transitional fossil between the ancestral land mammal shown in Phylogenetic tree A and present-day cetaceans.

Predict **two** structural features of the *Ambulocetus* fossil that would provide evidence to support the hypothesis that it is a transitional fossil and suggest a survival advantage of each feature. 3 marks

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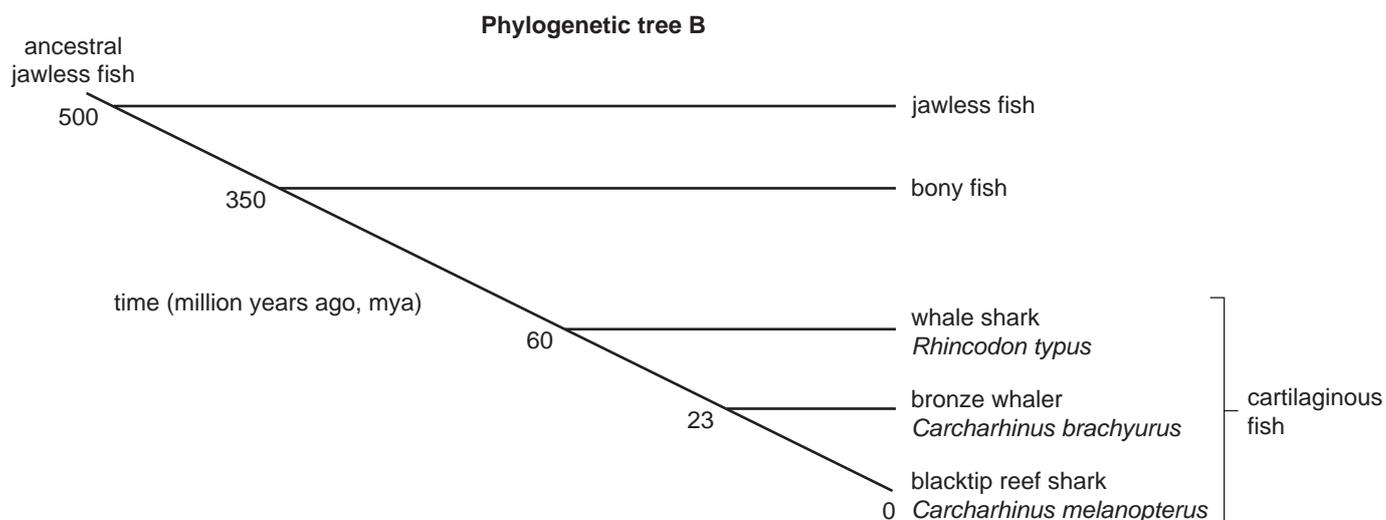
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Sharks are marine fish of the order Chondrichthyes (cartilaginous fish).

Phylogenetic tree B summarises the evolutionary relationships of three present-day shark species and main fish classes.



The table below provides information about the present-day species shown in phylogenetic trees A and B.

Marine animal		Average length (m)	Diet
	humpback whale <i>Megaptera novaeangliae</i>	16	filters plankton and krill by sucking water into mouth through baleen plates
	common bottlenose dolphin <i>Tursiops truncatus</i>	4	hunts fish, squid and crustaceans
	burrunan dolphin <i>Tursiops australis</i>	3	hunts fish and squid
	killer whale <i>Orcinus orca</i>	10	hunts sea birds, squid, seals, baleen whales, dolphins, fish, sharks and sea turtles depending on location
	whale shark <i>Rhincodon typus</i>	12	filters plankton, small squid and fish through filter pads and 300 rows of teeth
	bronze whaler <i>Carcharhinus brachyurus</i>	3	hunts squid, bony fish and other cartilaginous fish
	blacktip reef shark <i>Carcharhinus melanopterus</i>	2	hunts small bony fish, squid and shrimp

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- c. i. Give a specific example of **divergent** evolution using **two** animals from the information provided on pages 31 and 32, and justify your response. 2 marks

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- ii. Give a specific example of **convergent** evolution using **two** animals from the information provided on pages 31 and 32, and justify your response. 2 marks

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In 2011, Australian scientists identified the burrunan dolphin as a separate species from the common bottlenose dolphin. They gathered evidence from living dolphin populations as well as museum specimens.

- d. Briefly describe **two** types of evidence that the scientists would have used to establish whether the burrunan dolphin is a separate species from the common bottlenose dolphin. 2 marks

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- e. Burrunan dolphins are found only in Port Phillip Bay and the Gippsland Lakes in Victoria. There are only 150 burrunan dolphins alive today. The Port Phillip Bay population is very isolated and rarely mixes with dolphins outside the bay. Port Phillip Bay is impacted by the human population and industry of Melbourne and surrounding towns, and is used heavily for recreation, fishing and shipping.

Suggest **two** possible future outcomes for the Port Phillip Bay population of burrunan dolphins. Justify each outcome. 2 marks

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**Question 10** (8 marks)**Should we grow GM crops?**

by Mary Nguyen

More than 25 years after genetically modified (GM) food first appeared, growing GM crops remains a hotly debated topic. Some people argue that GM crops are the only way to feed the growing world population and to minimise environmental harm. Other people express different views.

Bt cotton is a type of cotton that contains two genes from a soil bacterium, *Bacillus thuringiensis*, enabling it to produce insect-resistant proteins. Australian farmers of Bt cotton use only 15% of the quantity of the insecticide that was once needed to protect their cotton crops\*. However, Bt cotton is not as resistant to the main insect pest of cotton crops, *Helicoverpa*, as it has been in the past\*.

In Australia, Bt cotton is picked by machine, but in India, it is picked by hand. Workers in India have developed skin allergies, which have been attributed to Bt cotton proteins.

Traditionally, farmers have saved money by keeping seed from one year's crop to plant the following year. However, it is illegal for farmers to keep Bt cotton seeds because these seeds have been declared the legal property of the company Monsanto. Every year, cotton farmers must buy more seeds from Monsanto.

Unlike Monsanto, the company that produces the GM food crop Golden Rice allows farmers to replant the rice they harvested the previous year. By inserting a gene from the bacteria *Erwinia uredovora* and another from a daffodil, *Narcissus pseudonarcissus*, into white rice, scientists produced Golden Rice – a rice variety containing higher levels of vitamin A<sup>†</sup>. People who eat Golden Rice avoid vitamin A deficiency. Trials conducted in several countries have shown that Golden Rice is safe to eat<sup>‡</sup>.

References: \*CSIRO, 'Cotton pest management', case study, <www.csiro.au>; <sup>†</sup>JA Paine et al., 'Improving the nutritional value of Golden Rice through increased pro-vitamin A content', *Nature Biotechnology*, 23, 27 March 2005, pp. 482–487; <sup>‡</sup>A Coghlan, 'Golden Rice gets approval in the US', *NewScientist*, magazine issue 3180, 2 June 2018

- a.** Bt cotton and Golden Rice are genetically modified organisms but are they also transgenic organisms? Support your response with evidence from the article above. 3 marks

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- b.** How can planting a Bt cotton crop lead to an increase in crop yield? 1 mark

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- c. Using information from the article, complete the table below by describing one social and one biological implication relevant to the use of Bt cotton and Golden Rice. The same implication should **not** be used twice.

4 marks

	Social implication	Biological implication
Bt cotton		
Golden Rice		

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**Question 11** (11 marks)

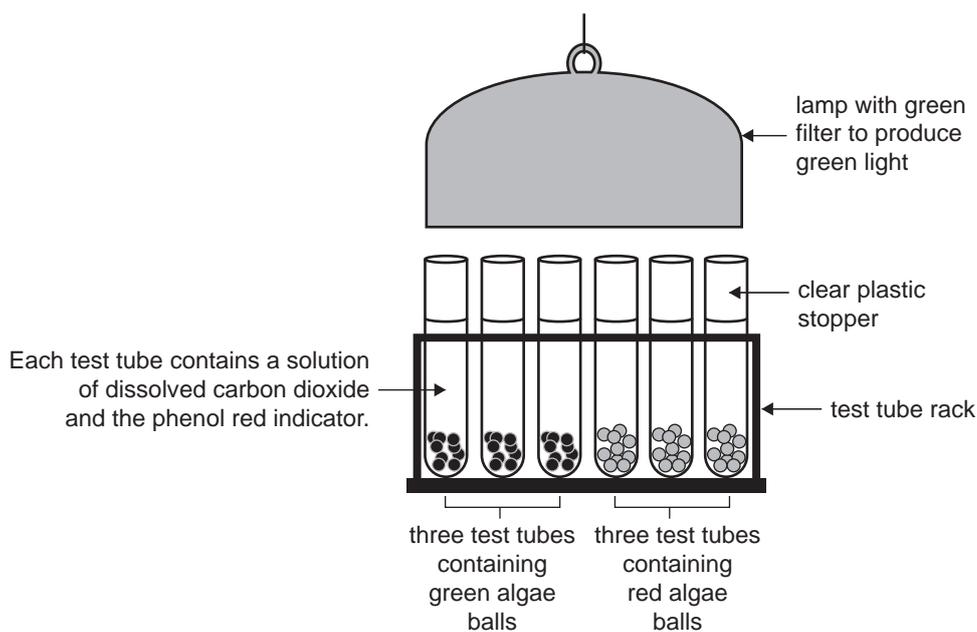
Elsa read that red algae survive at greater water depths than green algae because of a pigment in the red algae called phycoerythrin. This pigment enables the algae to absorb more of the green light available at greater water depths. Elsa decided to investigate this by carrying out an experiment.

Using a standard technique, the single-celled algae were trapped in jelly balls. One set of balls contained green algae and another set contained red algae.

To measure the rate of photosynthesis, Elsa used a stopwatch and the pH indicator phenol red. Phenol red changes colour in solutions with different concentrations of carbon dioxide. In low carbon dioxide concentrations, phenol red is pink and in higher carbon dioxide concentrations it is yellow.

Elsa placed the jelly balls into test tubes and covered them with a solution containing dissolved carbon dioxide. Phenol red indicator was added to each solution.

The diagram below shows the set-up of Elsa's experiment.



a. State the hypothesis that Elsa was testing.

1 mark

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b. List three variables that would need to be controlled to ensure the experiment produced valid results.

3 marks

1. \_\_\_\_\_

2. \_\_\_\_\_

3. \_\_\_\_\_

- c. State the independent variable and the dependent variable in this experiment. 2 marks

Independent variable \_\_\_\_\_

Dependent variable \_\_\_\_\_

- d. What results would disprove the hypothesis of Elsa's experiment? 2 marks

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- e. Elsa's laboratory partner suggested that they should also set up an identical experiment but keep the test tubes and their contents in the dark.

Explain why this is a good suggestion.

1 mark

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- f. Elsa's teacher said that even if the students completed the additional experiment in the dark and even if all of those results supported the hypothesis, there may still be other plausible explanations for their results.

Suggest **two** other explanations to which the teacher could be referring.

2 marks

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