TSSM
Creating VCE Success

2021 Trial Examination

THIS BOX IS FOR ILLUSTRATIVE PURPOSES ONLY

STUDENT NUMBER									Letter

BIOLOGY

Units 3 & 4 – Written examination

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

QUESTION & ANSWER BOOK

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	40	40	40
B	10	10	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 white out liquid/tape.
- No calculator is permitted in this examination.

Materials supplied

- Question and answer book of 31 pages.

Instructions

- Print your name in the space provided on the top of this page.
- All written responses must be in English.

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

SECTION A – Multiple-choice questions

Instructions for Section A
Answer all questions in Section A by circling the correct answer
Choose the response that is correct, or that best answers the question
A correct answer will be awarded 1 mark, and incorrect answer will score 0 marks
Marks will not be deducted for incorrect answers
No marks will be awarded if more than one answer is selected for any question

Question 1

Oxygen is a small, non-polar molecule essential for aerobic respiration. By which method do oxygen molecules enter a cell?

A. endocytosis
B. facilitated diffusion
C. simple diffusion
D. osmosis

Question 2

In certain species of moth, male moths can, in their antennae, trap and detect chemical signals given off by female moths to indicate they are ready to mate. This type of chemical signalling is an example of

A. pheromone signalling
B. autocrine signalling
C. endocrine signalling
D. paracrine signalling

Question 3

Photosynthesis involves several processes and chemical reactions. Which of the below options lists the processes of photosynthesis in the correct order?

A.	NADPH enters the stroma	water molecules are broken up	oxygen exits the cell	glucose is synthesised
B.	water molecules are broken up	oxygen exits the cell	NADPH enters the stroma	glucose is synthesised
C	water molecules are broken up	NADPH enters the stroma	glucose is synthesised	oxygen exits the cell
D	NADPH enters the stroma	water molecules are broken up	glucose is synthesised	oxygen exits the cell

Question 4
Which of the following is true for B plasma cells?

A. they secrete free antibodies
B. they release antigens
C. they form a part of the innate immune response
D. they are found in large concentrations near entry points to pathogens

The following information applies to Questions 5-8

Amylase is an enzyme found in saliva that catalyses the breakdown of starch into glucose. Two students wanted to investigate the effect of temperature on the activity of amylase.

The students prepared three test tubes, filled with an identical solution of starch and amylase. The three test tubes were immersed in water baths of different temperatures for 20 minutes. Test tube 1 was immersed in a water bath at 15^{o}C, test tube 2 at a temperature of 35^{o}C, and test tube 3 at a temperature of 90^{o}C.

After 20 minutes, the students tested for the presence of starch by adding a few drops of iodine to the mixture. Iodine turns blue in the presence of starch. The following results were observed.

Test Tube	Colour after adding iodine
1	Pale blue
2	Clear
3	Dark blue

Question 5
Which of the following best describes the role of amylase in this reaction?

A. it increases the rate of reaction by increasing the activation energy
B. it increases the rate of reaction by lowering the activation energy
C. it reacts with starch to produce glucose
D. it acts as a substrate for glucose

Question 6
Which of the following may be concluded from the results?

A. amylase denatures at 15^0C
B. at 35^0C, there was a high amount of starch present after 20 minutes
C. the rate of reaction was highest at 35^0C
D. there was no starch present in the 15^0C test tube

Question 7
The substrate in this reaction was:

A. starch
B. glucose
C. amylase
D. water

Question 8
The independent variable in this experiment is:

A. the amount of amylase
B. the amount of glucose produced
C. the volume of water in the test tubes
D. the temperature that the test tubes were incubated at

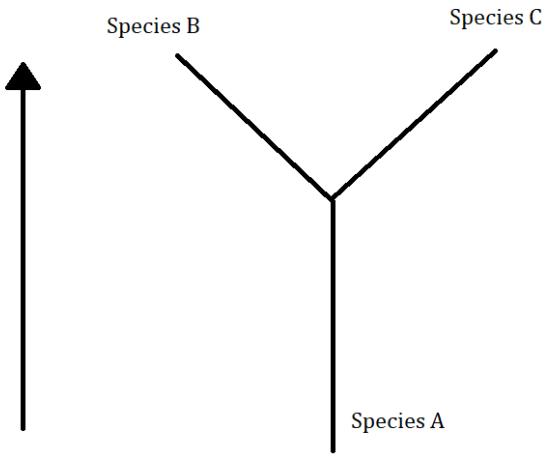
Question 9
Tom was bitten by a venomous snake and was given antivenom. Antivenom contains antibodies against the snake venom. Which statement is true for antivenom?

A. if Tom were to be bitten by the same type of snake in the future, he will be immune to its venom
B. antivenom is an example of active immunity
C. Tom's immune system develops memory B cells in response to the antivenom
D. the immunity provided by the antivenom is short-lived

Question 10
Which of these statements is true for populations?

A. small populations are less susceptible to genetic drift compared to large populations
B. if immigration and emigrations rates are equal, the allele frequencies in the population will remain constant
C. a bottleneck event reduces a populations susceptibility to environmental changes
D. a population in an unstable environment is more likely to evolve compared to a population living in a stable environment

The diagram below depicts the evolution of species



Question 11
Which of the following can be concluded from the diagram?

A. species B and C are less genetically diverse than species A
B. species B and C may have arisen because of geographical isolation
C. if species B and C were brought together to breed, they would be able to produce viable offspring
D. species B and C are a result of convergent evolution

Question 12
Several breeds of domestic dog exist within the genus *Canis*. The development of the various breeds of domestic dogs is an example of

A. artificial selection through human-induced selection pressures
B. natural selection through geographical isolation
C. genetic drift due to bottleneck events
D. natural selection through environmental selection pressures

Question 13
The cell membrane allows certain molecules into and out of the cell. Some of these molecules require channel proteins to cross the cell membrane. An example of this is sodium ions. The inside of the channel protein that enables sodium ions to enter the cell needs to be

A. hydrophobic
B. lipophilic
C. non-polar
D. hydrophilic

The following information applies to Questions 14 – 16

SARS-CoV-2, which causes COVID-19, enters human respiratory cells by binding to ACE2 receptors on the cell surface. The spike protein on the surface of SARS-CoV-2 enables the virus to bind to these receptors.

Question 14
Which of these is true for SARS-CoV-2?

A. it is an intracellular pathogen
B. it contains no genetic material
C. it can be treated with antibiotics
D. it contains mitochondria

Question 15
One type of immune cell that targets SARS-CoV-2 are cytotoxic T cells. Which of the statements below is true for cytotoxic T cells?

A. they engulf pathogens through phagocytosis
B. they initiate apoptosis in a cell
C. they release large quantities of histamine
D. they form part of the innate immune response

Question 16
In developing a vaccine against COVID-19, one option considered is to isolate the spike proteins from SARS-CoV-2, and to use this protein to generate an immune response against the virus. In the vaccine, the spike proteins would act as

A. antibodies
B. pathogens
C. antigens
D. memory cells

Question 17
After a heavy exercise session, Sara finds that the muscles in her legs feel like they have seized up. She concludes that she probably overdid it, and that the muscle cells in her legs have switched to anaerobic respiration, rather than aerobic respiration. Which of these is true for anaerobic respiration in animal cells?

A. anerobic respiration is more efficient than aerobic respiration
B. ethanol is produced as a by-product
C. there is a net input of 32 ATP for every molecule of glucose consumed
D. it occurs in the cytosol of the cell

Question 18
Protein synthesis consists of two main stages: transcription and translation. During transcription, a molecule of pre-mRNA is formed. Before exiting the nucleus, the molecule of pre-mRNA undergoes post-transcription modification. Which of the following is true for the mRNA molecule produced?

A. before exiting the nucleus, exons are spliced out during post-transcription modification
B. the mRNA molecule contains an equal number of adenine and thymine nucleotides
C. alternative splicing allows for many protein variants to be formed from the same gene
D. a guanine tail is added to the mRNA molecule

Question 19
Carbon dioxide is an input into which of the following processes?

A. the breakdown of glucose during glycolysis
B. the splitting of water in the light-dependent reactions of photosynthesis
C. the fermentation of yeast cells
D. the synthesis of glucose in the light-independent reactions of photosynthesis

The following information applies to Questions 20 – 22

Golden rice is a variety of rice produced through genetic engineering to biosynthesise beta-carotene, a precursor of vitamin A, in the edible parts of rice. Golden rice is created by transforming rice with two beta-carotene genes:

- Psy (phytoene synthase) from daffodil (*Narcissus pseudonarcissus*)
- Crt1 (carotene desaturase) from the soil bacterium *Erwinia uredovora*

The Psy and Crt1 genes are isolated, amplified and transferred into the Ti plasmid of the bacterium *Agrobacterium tumefaciens*. The bacteria infect the rice embryos, which eventually grow into plants that exhibit the desired new traits.

Question 20
Which of the following acts as a vector in the production of golden rice?

A. the bacterium *Agrobacterium tumefaciens*
B. the daffodil *Narcissus pseudonarcissus*
C. the bacterium *Erwinia uredovora*
D. beta-carotene

Question 21
Golden rice can be considered a transgenic organism because

A. its genome has been artificially modified
B. it contains DNA from *Narcissus pseudonarcissus* and *Erwinia uredovora*
C. it contains a higher portion of beta-carotene compared to other strains of rice
D. it contains more vitamin A than it would if not for genetic modification

Question 22
Which of the processes below may be used to amplify the Psy and Crt1 genes?

A. gel electrophoresis
B. polymerase chain reaction
C. restriction enzymes
D. centrifuging

Question 23
Multicellular organisms rely on communication between cells for the organism to function. This often involves ligands, or signal molecules, which bind to receptor molecules. Adrenaline is a hydrophilic protein that binds to certain cells in times of stress, to initiate a response. It is reasonable to infer that adrenaline binds to

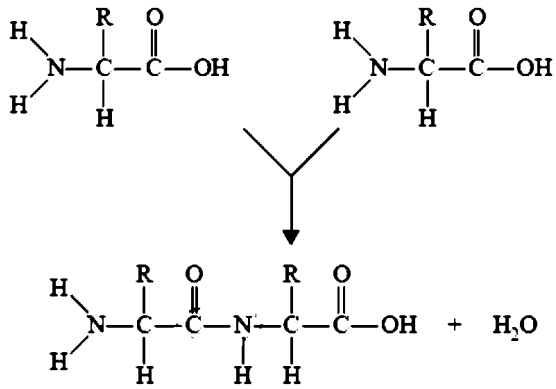
A. an intracellular receptor
B. a transmembrane receptor
C. a cytoplasmic receptor
D. a nuclear receptor

Question 24
Signalling between neurons is an example of which type of cellular signalling?

A. paracrine signalling
B. autocrine signalling
C. pheromone signalling
D. endocrine signalling

The following information applies to Questions 25 and 26

Consider the reaction below, showing two monomers joining to form part of a polymer



Question 25

The reaction above can be described as a/an

A. anabolic reaction
B. hydrolysis reaction
C. exergonic reaction
D. combustion reaction

Question 26

The molecule formed in this reaction could form part of

A. mRNA
B. an enzyme
C. starch
D. a phospholipid

Question 27

The grey reef shark and the bottlenose dolphin, despite being only distantly related, both display countershading. Countershading is an adaptation shown by many groups of marine animals, in which the top of the animal is dark, and the underside is light. This makes it more difficult for the animal to be seen from either above or below by predators or prey. This adaptation has evolved independently in several evolutionary groups.

Countershading in the grey reef shark and the bottlenose dolphin is an example of

A. divergent evolution
B. allopatric speciation
C. maladaptation
D. convergent evolution

Question 28

Which of the following statements is correct regarding the gene structure in eukaryotic cells?

A. introns are translated, but not transcribed
B. DNA polymerase binds to the upstream region of the gene to produce an mRNA molecule
C. transcription factors may bind to nucleotides found in the promoter region of the gene
D. introns contain nucleotide sequences that code for the production of protein

Question 29

Glucose is a water-soluble molecule that is an input to cellular respiration. By what route does glucose pass through the cell membrane?

A. it is transferred into the cell via carrier proteins
B. it diffuses directly through the phospholipid bilayer
C. it enters through the process of pinocytosis
D. it enters via a vesicle

Question 30

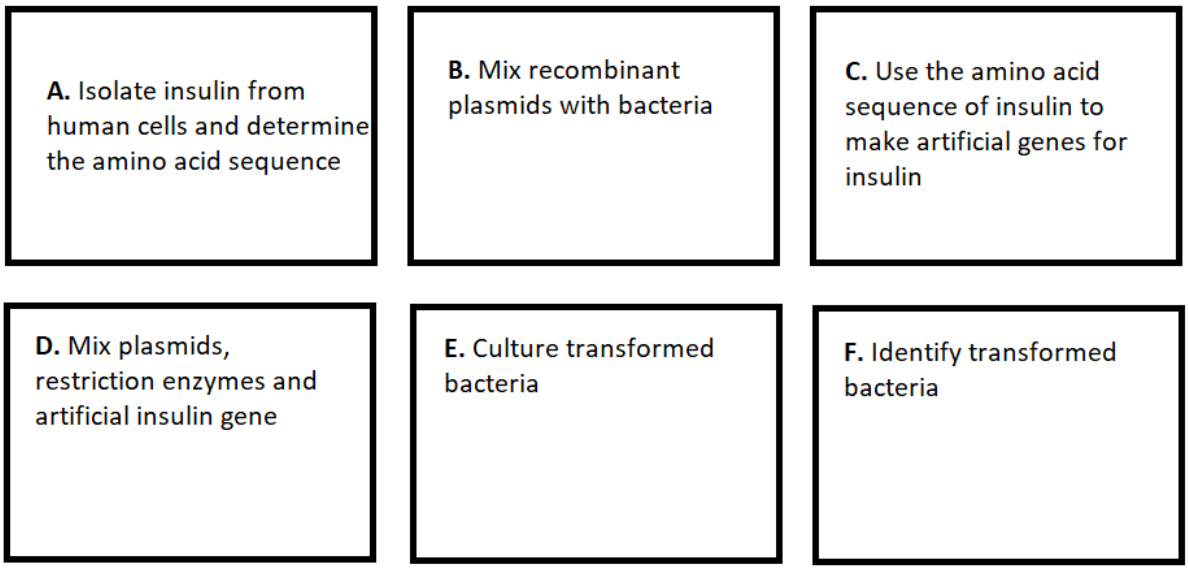
Which one of the following is a catabolic process?

A. the conversion of glycogen into glucose
B. the synthesis of glucose during photosynthesis
C. the formation of a peptide chain from amino acids
D. the conversion of ADP into ATP

Question 31
Individuals with Trisomy 21, or Down Syndrome, have an additional copy of chromosome 21. Trisomy 21 is an example of

A. polyploidy
B. a block mutation
C. a frameshift mutation
D. aneuploidy

Question 32
Bacteria can be transformed with an artificial insulin gene and cultured to make insulin in commercial quantities. The steps taken to produce genetically engineered insulin are summarised below but are mixed up in order.



The correct order of sequences is

A. B, F, E, A, C, D
B. A, C, D, B, F, E
C. A, C, B, D, F, E
D. A, B, C, D, F, E

The following information applies to Questions 33 and 34

Homo erectus was a species of hominin that evolved in Africa approximately 2 million years ago. *Homo erectus* displayed several traits seen in humans today, such as tool use, bipedalism, and large brains compared to other primates.

Question 33
Which of the following traits is exclusive to hominins?

A. upright stance
B. larger brains
C. tool use
D. bipedalism

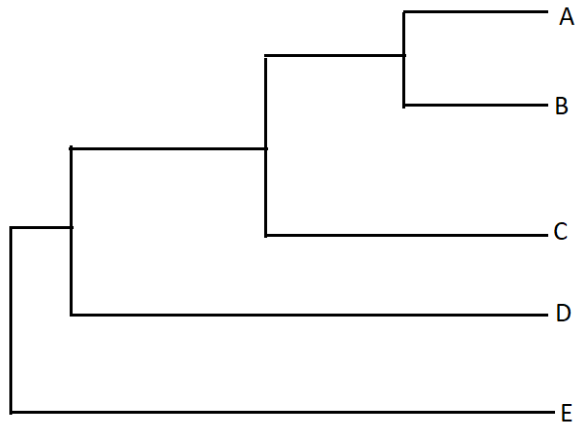
Question 34
Which of the following features of a *Homo erectus* fossil could be used to infer bipedalism?

A. flat feet
B. a more centrally positioned foramen magnum
C. large cranial capacity
D. small pelvis

Question 35
Malfunctions in the cell cycle can influence the chance of a cell becoming cancerous. These malfunctions may include changes to apoptotic pathways in the cell. Which of the following situations could result in the growth of a cancerous tumour?

A. an increase in apoptosis
B. increased activation of cytotoxic T cells
C. increased inflammation
D. a decrease in apoptosis

Question 36
Examine the phylogenetic tree below



With which of the following species does species C share its most recent common ancestor?

A. species A
B. species D
C. species E
D. the information cannot be determined from the provided information

Question 37
The HIV virus targets T helper cells. This can develop into the disease AIDS. AIDS can be described as a/an

A. autoimmune disease
B. immunodeficiency disease
C. allergic reaction
D. type of cancer

The following information applies to Questions 37 and 38

In a culture of bacteria, there are some bacterial cells that, due to a gene mutation, are resistant to the antibiotic penicillin. In normal bacterial cells, a particular section of DNA has the sequence ACA. In the penicillin-resistant bacteria, this section has the sequence ACC.

Question 38
This mutation could best be described as a

A. silent mutation
B. chromosomal deletion
C. translocation
D. missense mutation

Question 39
The corresponding mRNA sequence on the bacteria with this mutation would be

A. TGG
B. TGT
C. UGG
D. UCC

Question 40
Which of the following processes produces the greatest number of ATP molecules?

A. synthesis of polypeptide molecules
B. electron transport chain in cellular respiration
C. breakdown of glucose in glycolysis
D. conversion of $NADP^+$ to NADPH

END OF SECTION A
TURN OVER

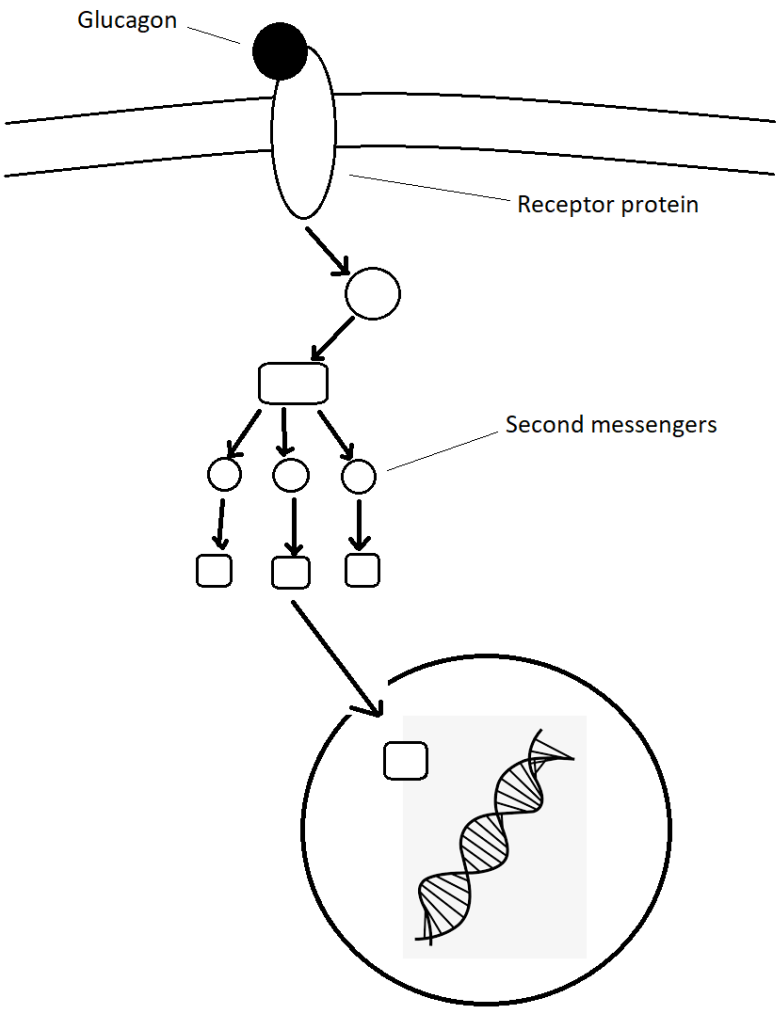
SECTION B – Short-Answer Questions

Instructions for Section B
Answer all questions in the spaces provided
Unless otherwise indicated, diagrams are not drawn to scale

Question 1 (8 marks)

When blood sugar levels are low, glucagon, a hydrophilic hormone, is secreted by the pancreas. Glucagon targets liver cells, where it stimulates glycogen to break down into glucose. The liver cells then release glucose molecules into the bloodstream.

The diagram below illustrates the signal transduction pathway of glucagon.



a. Explain why the receptor protein for glucagon is located in the cell membrane, rather than in the cytoplasm.

2 marks

b. What is the purpose of the secondary messengers?

1 mark

c. Glucose exits liver cells via facilitated diffusion. Explain how facilitated diffusion works.

2 marks

d. Describe what would happen to the concentration of glucagon in the bloodstream as the concentration of glucose increased.

1 mark

e. This situation is an example of endocrine signaling. Identify two ways in which endocrine signaling differs from paracrine signaling.

2 marks

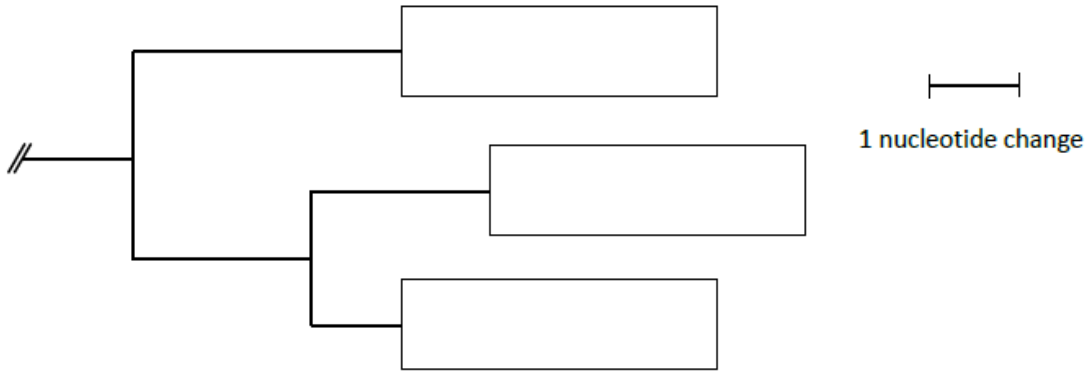
Question 2 (11 marks)

Species relatedness can be determined using molecular homology. A multiple sequence alignment of segments of the first 20 nucleotides of the same gene from three related species is shown below.

Species A	A T A T G A T T C G A T C C G T A G A T
Species B	A T A T G A T C C G A T C C G T A G T T
Species C	A A C T G A C T G G A G C C G T A G A A

a. Use the data above to label the three species on the phylogenetic tree below

3 marks



b. Suggest which one of the above species (Species A, B or C) diverged from a common ancestor first. Explain your answer.

2 marks

c. Describe how the molecular clock theory might be used to estimate when the species diverged from each other

2 marks

d. Another method of determining the relatedness of species is through DNA hybridisation. Describe the process of this technique.

3 marks

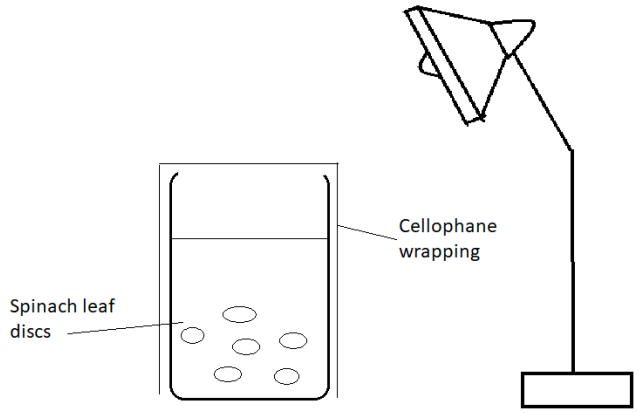
e. In molecular homology, often mitochondrial DNA is used rather than nuclear DNA. Identify one reason why mitochondrial DNA is more useful.

1 mark

Question 3 (13 marks)

An experiment was set up to test the effect of the colour of light on photosynthesis rates in spinach leaves. Four beakers were prepared, each containing 20 spinach leaf discs, with the air removed. One beaker was wrapped in red cellophane, one in blue cellophane, one in green cellophane, and one in yellow cellophane.

White light from a lamp was shone on each beaker. The rate of photosynthesis in the spinach leaves in each beaker was measured in terms of the number of floating leaf discs after 10 minutes. The figure below illustrates the experimental setup.



The following results were obtained

Colour	Number of floating leaf discs after 10 minutes
Red	16
Yellow	11
Green	9
Blue	14

a. Identify the independent and dependent variables in this experiment

2 marks

b. What caused the discs to float, and why was this able to be used as an indirect measure of the rate of photosynthesis?

2 marks

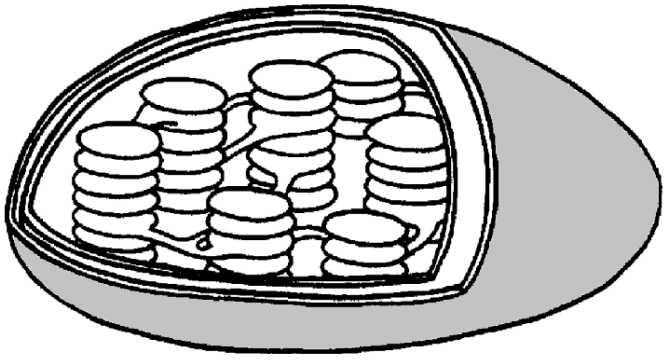
c. What can be concluded from the results?

2 marks

d. Identify two variables that would need to be controlled for in this experiment

2 marks

e. The figure below depicts the structure of a chloroplast. On the image, circle a structure in which the reactions occur that release oxygen gas.



1 mark

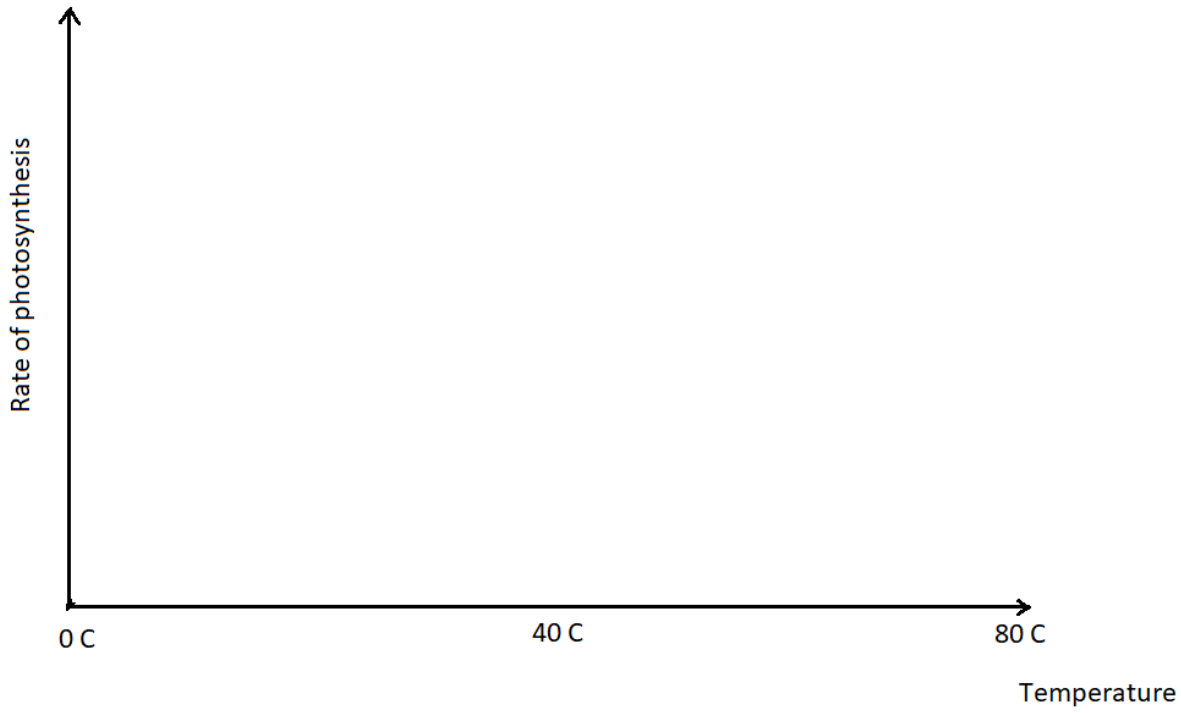
f. Name the structure identified in part e)

1 mark

_____

g. In another experiment, the students examined how temperature affected rates of photosynthesis. On the axes below, draw a line graph illustrating how rates of photosynthesis would be expected to vary according to temperature

1 mark



h. Explain the shape of the graph you drew in part g)

2 marks

_____

_____

_____

_____

Question 4 (5 marks)

The HIV virus, which causes the disease AIDS, primarily targets T helper cells. This compromises the adaptive immune response, making the individual susceptible to infection and disease. The virus binds to receptors on the surface of T helper cells, enabling the genetic material of the virus to enter the host cell.

a. T helper cells are found in the lymph nodes. Lymph nodes are a secondary lymphatic tissue. Name another secondary lymphatic tissue.

1 mark

b. Describe the role of T helper cells in the immune response.

2 marks

c. Cytotoxic T cells also play a critical role in defending the body against viruses. Describe how a cytotoxic T cell targets viruses.

2 marks

Question 5 (14 marks)

Homo erectus was a species of hominin that existed from approximately 1.6 million to 250 000 years ago. An earlier species of hominin, *Australopithecus afarensis*, existed approximately 3.9 – 2.9 million years ago. *Homo erectus* fossils and remains show evidence of cultural evolution.

a. When comparing a fossil of *Homo erectus* and a fossil of *Australopithecus afarensis*, describe how you would expect the following traits to differ between the two species.

8 marks

Trait	***A. afarensis***	***H. erectus***
Cranium		
Position of foramen magnum		
Angle of femurs		
Jaw and teeth		

b. As hominins evolved, there was a trend towards bipedalism.

i. Describe a source of evidence for bipedalism and explain why this feature would have supported bipedalism.

2 marks

ii. Identify a selection pressure that would have favoured bipedalism.

1 mark

iii. Explain what is meant by "cultural evolution."

1 mark

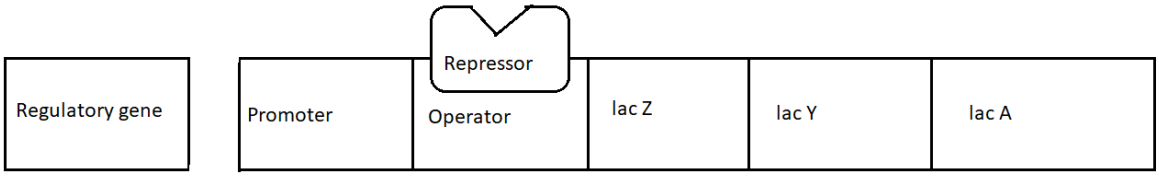
c. Describe how the diet of *Homo erectus* differed to the diet of *Australopithecus afarensis.* In your answer, refer to at least one of the traits you identified in part a) as a source of evidence for this.

2 marks

Question 6 (8 marks)

The lac operon is a regulatory gene found in many prokaryotes, such as *Escherichia coli.* It enables the organism to metabolize lactose. When there is no lactose present in the cell, the proteins to metabolize lactose are not transcribed.

The figure below depicts the general structure of the lac operon.



a. Explain why, when there is no lactose present in the cell, the lac Z, lac Y and lac A genes are not transcribed.

2 marks

b. Describe what occurs when lactose is present in the cell.

2 marks

c. Describe the differences between a structural gene and a regulatory gene.

2 marks

d. Genes are segments of DNA. Identify two ways in which the DNA of prokaryotes differs from the DNA of eukaryotic cells.

2 marks

Question 7 (6 marks)

In Australia, several genetic conditions can be screened for during pregnancy. One such condition is Down Syndrome, which is typically screened for between week 15 and week 20 of pregnancy.

a. Explain the difference between genetic screening and genetic testing.

1 mark

b. Describe an ethical issue that could arise from genetic screening for Down Syndrome.

1 mark

c. When testing DNA for the presence of a genetic condition, the DNA is amplified using polymerase chain reaction (PCR). Outline the steps of PCR for one cycle.

4 marks

Question 8 (5 marks)

Populations of a species of a small species of skink are found distributed throughout five small islands. On island number three, a king tide event wipes out much of the population of skinks. The other four islands are unaffected. Over the next year, the population of skinks on island number three re-established to become close to its original size. Scientists then conducted a genetic analysis of the populations on each island.

a. Genetic analysis of the skinks revealed that the genetic diversity of the population on island number three was lower than that of the other four islands. Suggest why.

2 marks

b. Explain why a lower genetic diversity puts the population of skinks on island number three at greater risk of local extinction.

2 marks

c. How could the genetic diversity of the island three population be increased?

1 mark

Question 9 (4 marks)

Radiocarbon dating is one technique used to measure the date of fossils. In radiocarbon dating, the ratio of carbon-14 to nitrogen-14 in the fossil is determined and compared with the ratio of carbon-14 to nitrogen-14 in living organisms. Carbon-14 has a half-life of approximately 5 730 years.

a. A fossil of an ancestral wombat species was found to contain a half the amount of carbon-14 compared to the amount of carbon-14 in the skull a recently deceased wombat. How old is the fossil?

1 mark

b. Another fossil is dated to be 11 460 years old. How much carbon-14 would this fossil contain when compared to the wombat skull?

1 mark

c. Stromatolite fossils found in Western Australia have been estimated to be over 3 billion years old. Explain why radiocarbon dating would not be suitable for dating these fossils.

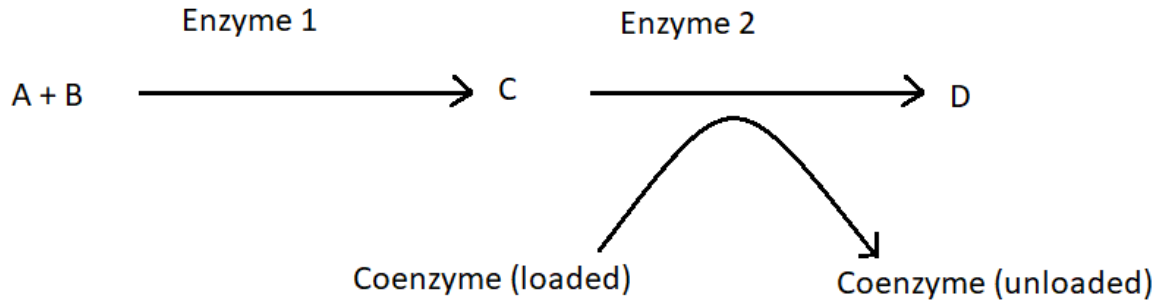
1 mark

d. Radiocarbon dating is a form of absolute dating. Describe how the law of superposition may be used as a form of relative dating.

1 mark

Question 10 (6 marks)

The following diagram depicts a two-step reaction, which produces molecule D. The reaction is catalyzed by enzymes 1 and 2.



a. If there was no unloaded coenzyme available, how would this affect:

i. The amount of molecule C?

1 mark

ii. The production of molecule D?

1 mark

b. Justify your response to part a)

1 mark

c. Another molecule, molecule X, acts as a non-competitive inhibitor to enzyme 1.

i. How would the presence of molecule X affect the concentrations of molecule C?

1 mark

ii. Describe how non-competitive inhibition of an enzyme differs from competitive inhibition.

2 marks

END OF QUESTION AND ANSWER BOOK