

BIOLOGY

UNITS 3 & 4

Student name

Student ID

Letter

Structure of book

Section	Number of questions	Number of marks
A	40	40
B	8	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 calculators are allowed in this examination.

Materials supplied

- Question and answer book of 28 pages, with a detachable answer sheet for multiple-choice questions inside the front cover.

Instructions

- Detach the answer sheet for multiple-choice questions during reading time.
- Write your name and student ID in the space provided above on this page and on the answer sheet for multiple-choice questions.
- Unless otherwise indicated, the diagrams in this book are not drawn to scale.
- All written responses should be in English.

At the end of the examination

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

STAV

2023

BIOLOGY

Units 3 & 4 Trial Examination

MULTIPLE CHOICE ANSWER SHEET

STUDENT NAME:	
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INSTRUCTIONS:

USE PENCIL ONLY

- Write your name in the space provided above.
- Use a **PENCIL** for **ALL** entries.
- If you make a mistake, **ERASE** it – **DO NOT** cross it out.
- Marks will **NOT** be deducted for incorrect answers.
- **NO MARK** will be given if more than **ONE** answer is completed for any question.
- Mark your answer by **SHADING** the letter of your choice.

	ONE ANSWER PER LINE		ONE ANSWER PER LINE		ONE ANSWER PER LINE
1	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	15	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	28	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D
2	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	16	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	29	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D
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8	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	22	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	35	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D
9	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	23	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	36	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D
10	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	24	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	37	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D
11	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	25	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	38	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D
12	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	26	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	39	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D
13	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	27	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	40	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D
14	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D				

SECTION A – Multiple-choice questions**Instructions for Section A**

Answer **all** questions 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

The role of transfer RNA (tRNA) is to

- A. transfer the genetic code from the nucleus to the ribosome.
- B. carry free nucleotides to the smooth endoplasmic reticulum.
- C. carry amino acids to the ribosome.
- D. provide the structural component of the ribosome.

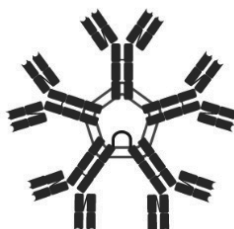
Question 2

Following translation, proteins undergo further modification prior to export. Final modification of the protein may include:

- A. addition of carbohydrate groups at the rough endoplasmic reticulum
- B. removal of introns
- C. packaging into secretory vesicles
- D. addition of a methyl cap to the 3' end and a poly A tail to the 5' end

Question 3

The image below is of an IgM molecule.



Source biorender.com

The level of protein structure shown is

- A. primary
- B. secondary
- C. tertiary
- D. quaternary

Question 4

The genetic code can be referred to as redundant. This means that

- A. multiple codons code for the same amino acid.
- B. the same codon codes for the same amino acid in all organisms.
- C. all organisms have the same amino acid sequence.
- D. the codon for trp is only found in bacteria.

Question 5

Short tandem repeats (STRs), also known as microsatellites, are short sequences of DNA that are repeated in tandem despite not coding for a functional protein product. They are typically composed of 2 to 6 base pairs that are repeated multiple times. The number of repeats at a given locus can vary between individuals and, as they are inherited, they are useful for genetic analysis and individual identification.

Why do STRs persist in the population?

- A. STRs are an advantageous trait.
- B. STRs are found within introns.
- C. They are essential to our survival.
- D. They are useful for identification.

Question 6

At the height of the Covid pandemic, the World Health Organization (WHO) recommended the use of PCR testing as the gold standard for COVID-19 diagnosis. The test played a critical role in the global response to the pandemic as new cases could be quickly and accurately identified.

What is the purpose of PCR?

- A. To separate DNA fragments based upon their size and charge.
- B. To compare DNA sequences between individuals to determine relatedness.
- C. To create many copies of DNA for analysis and / or testing.
- D. To store a copy in the crDNA locus for reference in the case of subsequent exposure.

Question 7

CRISPR DNA (crDNA) contains sequences of spacers and repeats. The purpose of these different segments is

- A. the spacers become gRNA and the repeats contain the PAM sequence.
- B. the spacers contain the genetic code for the Cas-9 enzyme and the repeats code for the bacteriophage DNA.
- C. the spacers contain the memory of the bacteriophage DNA whereas the repeats separate the spacers.
- D. the spacers are transcribed into gRNA and the repeats are translated into tRNA.

Question 8

Sugar cane is one of Australia's major agricultural commodities and plays a significant role in the economy. It is predominantly cultivated in the tropical and subtropical regions of Queensland. Australia is one of the world's largest sugar producers, typically ranking in the top ten globally. The annual sugar cane production varies depending on factors such as weather conditions and market demand. In recent years, the average sugarcane production has been around 30 to 35 million tonnes.

Sugar cane is a C₄ plant. This means that

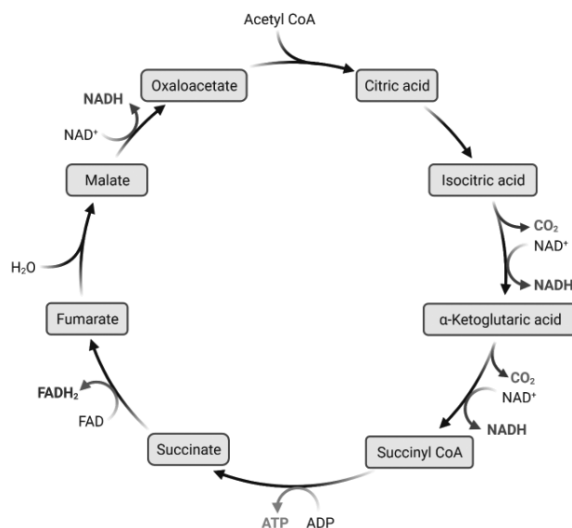
- A. the Calvin cycle occurs in the mesophyll cells.
- B. Rubisco is responsible for initial carbon fixation.
- C. PEP carboxylase is abundant in the thylakoid membranes.
- D. sugar cane has adaptations to minimise photorespiration.

Question 9

During the electron transport chain

- A. hydrogen ions are unloaded in the matrix and travel through ATP synthase to the intermembrane space.
- B. hydrogen ions are accepted by oxygen molecules to form water.
- C. a net 30 ATP is produced.
- D. FAD becomes loaded to become FADH₂.

Question 10



Source <https://app.biorender.com/biorender-templates/figures/all/t-5e1de0a7215de00086dd403f-krebs-cycle>

The diagram above shows a biochemical pathway that

- A. occurs in the matrix of the mitochondria.
- B. occurs in both prokaryotes and eukaryotes.
- C. produces 6 oxygen molecules.
- D. produces 26 or 28 ATP molecules per glucose molecule.

Question 11

An enzyme, substrate and unknown substance were added to a beaker, with pH and temperature both being within the optimal range. Increasing amounts of substrate was added to the beaker, however the rate of reaction did not change. The unknown substance is

- A. a competitive inhibitor.
- B. bound to the allosteric site.
- C. the same shape as the active site.
- D. an enzyme.

Question 12

Anaerobic fermentation can be used to produce biofuel from biomass. First generation biomass refers to plant matter that is also consumed as foods, such as corn, sugar cane or wheat.

An advantage of using biomass as the initial energy source for bioethanol production is

- A. biomass is a finite resource.
- B. carbon dioxide produced in bioethanol production is greater than the carbon dioxide used in photosynthesis.
- C. it allows livestock to obtain an alternative food source.
- D. there is a net reduction in the amount of atmospheric carbon dioxide in comparison to traditional fuel sources.

Question 13

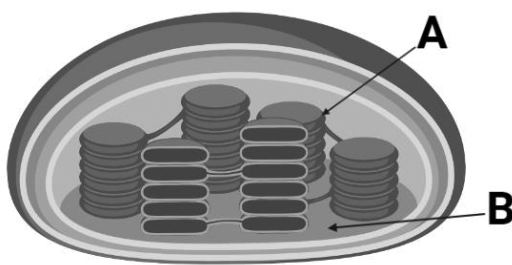
A student investigated bioethanol production for their Unit 4 AOS 3 extended practical investigation. They selected four different types of biomass and added them to a yeast and enzyme solution. The student's teacher suggested the student conduct the experiment in a 37 °C water bath. The purpose of this is to

- A. allow a conformation change in shape of the enzymes active site, increasing the affinity of the enzyme to the substrate.
- B. provide the maximum amount of enzyme and substrate collisions.
- C. provide a baseline to compare to conditions in the human body.
- D. minimise any changes to pH that could affect the rate of reaction.

Question 14

In CAM plants, initial carbon fixation occurs

- A. in the mesophyll, with PEP carboxylase converting carbon dioxide into a 4-carbon molecule, malate.
- B. in the bundle sheath cells with PEP carboxylase converting oxygen into carbon dioxide to be used in the Calvin cycle.
- C. during the day with the Calvin cycle occurring at night.
- D. in the light dependent reaction with the conversion of a 4-carbon molecule into glucose occurring in the light independent reaction.

Question 15

Source <https://app.biorender.com/illustrations/6496330eccdd0a66247facc2>

The diagram above shows an organelle involved in a biochemical pathway. This organelle

- A. produces a total of 30 or 32 ATP molecules for every glucose molecule.
- B. is more abundant in shaded areas than areas with consistently high levels of light.
- C. has two major reactions, the light dependent reaction that occurs at location A and the Krebs cycle that occurs at location B.
- D. is found in all plant cells.

Question 16

Lysozyme is an enzyme found in saliva, mucus and tears and is an integral part of the first line of defence in humans. At a pH of 6, lysozyme was found to have the highest rate of reaction. For a reaction to occur, the substrate binds to

- A. an allosteric site.
- B. a disulfide bridge.
- C. the binding site.
- D. the active site.

Question 17

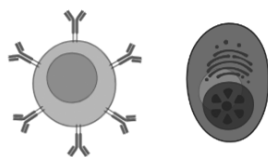
A chemical defence in plants is

- A. closed stomata.
- B. waxy cuticles.
- C. defensins.
- D. vertical hanging leaves.

Question 18

To stimulate clonal expansion in B cells

- A. mast cells secrete histamine.
- B. cytotoxic T cells bind to the B cell receptor and release perforin and granzyme.
- C. helper T cells release cytokines.
- D. macrophages present antigenic fragments on their MHC I markers.

Question 19

Source <https://app.biorender.com/illustrations/6496330eccdd0a66247face2>

The cells shown above are involved in the adaptive immune response. Specifically, they are

- A. memory B and plasma cells that are made and mature in the bone marrow.
- B. neutrophils and dendritic cells, both examples of antigen presenting cells.
- C. cytotoxic T and natural killer cells that target extracellular pathogens.
- D. complement cells that release histamine to promote an inflammatory response.

Question 20

Smallpox, a highly contagious and often deadly infectious disease, was introduced into Australia with the arrival of European colonists in the late 18th century. The disease had devastating effects on the indigenous populations, with a significant proportion of the adult population succumbing to the virus. One reason for the significant decline in the population due to smallpox is

- A. Indigenous Australians are more likely to be immunocompromised.
- B. a lack of memory cells against smallpox in the Indigenous Australian population.
- C. a lack of plasma cells against smallpox in the Indigenous Australian population.
- D. that smallpox only infected Indigenous Australians.

Use the following information to answer Questions 21 and 22.

In October 2020, a cholera outbreak occurred in Haiti, a small Caribbean island. The cholera outbreak was caused by the introduction of *Vibrio cholerae*, the bacterium responsible for cholera, into the country. It is believed that the strain of cholera was brought to Haiti by United Nations peacekeeping troops from Nepal, who were stationed in an area with inadequate sanitation facilities. Improper waste disposal by the troops contaminated a nearby river, which served as a source of drinking water for local communities.

Question 21

Which of the following would be the most effective strategy to control the spread of cholera?

- A. Implement lockdowns in areas where cholera was present.
- B. Mandate the use of face masks and social distancing.
- C. Provide economic support for those unable to work due to being infected by cholera.
- D. Conduct an education campaign to inform residents on how cholera is transmitted.


Question 22

Which of the following treatments would be suitable to prescribe to individuals that have contracted cholera?

- A. antibiotics
- B. antifungals
- C. antivirals
- D. antihistamines

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Use the following information to answer Questions 23–25.



World Health Organization


The Malaria Vaccine Implementation Programme is a collaboration of the Ministries of Health in Ghana, Kenya and Malawi, WHO, PATH, GSK, UNICEF and partners.

The RTS,S Malaria Vaccine

A WHO recommended vaccine for added protection against malaria to improve child health, save lives and strengthen malaria control in Africa

Malaria: An enduring health challenge

Malaria remains a primary cause of childhood illness and death in Africa and holds back prosperity in the region.




400K+
DEATHS
per year

African children are at highest risk

260K+
CHILD DEATHS
PER YEAR

Malaria has a negative impact on economies




USD \$12 BILLION in lost productivity annually worldwide

70% LOWER per capita income levels in endemic countries

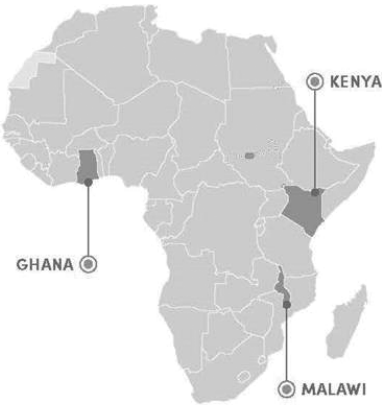
UP TO 40% of public health budget of some African countries goes to treating malaria

Malaria progress has stalled. A tailored, optimal mix of tools – including RTS,S – can get malaria control back on track.



The RTS,S/AS01 malaria vaccine

Significantly reduces malaria and life-threatening severe malaria. Since 2019, delivered in childhood vaccination in 3 country-led pilots.



GHANA KENYA MALAWI

IN 2+ YEARS
2.3 Million+
DOSES


800K+ CHILDREN VACCINATED

Estimated to be cost-effective in areas of moderate to high malaria transmission

30 YEARS The result of 30 years of research & development


The RTS,S vaccine can be delivered through the existing platform of childhood vaccination that reaches about 80% of children in sub-Saharan Africa.

What we know about the RTS,S malaria vaccine in routine use




Feasibility

- Delivery of the vaccine is feasible.
- High, equitable vaccine coverage shown in routine use indicates community demand and the capacity of countries to effectively deliver it.
- No negative impact of vaccination on insecticide-treated bednet (ITN) use, uptake of other childhood vaccines, or care-seeking behaviour




Equity

- Increases equity in access to malaria prevention: in routine use, the vaccine reached more than two-thirds of children who are not sleeping under a bednet (ITN)
- Layering the tools results in over 90% of children benefitting from at least one preventive intervention (ITN or the malaria vaccine)



Impact

- 30% reduction in deadly severe malaria in routine use
- 40% reduction in malaria episodes
- Impact optimized in highly seasonal malaria settings by providing doses prior to peak “rainy” season



To date, more than 2.3 million doses of the vaccine have been administered in 3 African countries – the vaccine has a favorable safety profile.

Thank you

Thank you to the Ministries of Health of Ghana, Kenya and Malawi for their leadership and commitment to the RTS,S/AS01 malaria vaccine pilot programme. Thank you to Gavi, the Vaccine Alliance, the Global Fund to Fight AIDS, Tuberculosis and Malaria and Unitaidd for their generous support.

Source [https://cdn.who.int/media/images/default-source/global-malaria-program-\(gmp\)/who_mvi_infographic_100421_v3.jpg?sfvrsn=47738315_7](https://cdn.who.int/media/images/default-source/global-malaria-program-(gmp)/who_mvi_infographic_100421_v3.jpg?sfvrsn=47738315_7)

Question 23

Where is it most cost effective to vaccinate children against malaria in Africa?

- A. in areas of low to moderate transmission
- B. in areas of moderate to high transmission
- C. in areas of high to extreme transmission
- D. in all areas where malaria is transmitted

Question 24

The impact of the vaccine was optimised in highly seasonal malaria settings by providing doses prior to the peak 'rainy' season. Why is this an effective strategy to reduce the spread of malaria?

- A. During times of high rainfall it is more difficult for people to travel to vaccination centres.
- B. People stay indoors more when it rains, increasing the chance of spreading malaria within the household.
- C. The number of mosquitoes, which act as a vector for malaria, increases in wet weather.
- D. Medical professionals schedule their holidays during the wetter seasons of the year.

Question 25

On average, how many doses of the malaria vaccine is each child receiving?

- A. 1
- B. 2
- C. 3
- D. 4

Question 26

Acute inflammation is an innate response that occurs in response to localised damaged. Inflammation is often characterised by redness, heat, swelling and pain. The cause of these symptoms is

- A. the release of cytokines from T helper cells, stimulating clonal selection.
- B. an increased volume of lymph fluid to the lymph nodes to increase the chance of clonal selection and expansion.
- C. faulty valves preventing the return of lymph fluid to the circulatory system.
- D. the release of histamine from mast cells causing vasodilation.

Question 27

During the extended Covid lockdowns, many families chose to add a dog to their family. For those who chose a pure-bred, the dogs' lineage can be traced and interbreeding only occurs with members of the same breed. Such breeding

- A. decreases genetic diversity.
- B. increases genetic diversity.
- C. has no influence on genetic diversity.
- D. is subject to natural selection pressures.

Question 28

For the process of natural selection to occur

- A. a physical barrier must separate two populations of the same species.
- B. two populations of the same species become reproductively isolated.
- C. variation exists within the population.
- D. a small group of individuals become separated from a larger population.

Question 29

The Naracoorte Caves is a renowned limestone cave system located in the Limestone Coast region of South Australia, near the Victorian border. The Naracoorte Caves are significant as they contain an extensive range of fossilised remains, providing insights into Australia's past biodiversity. Fossils found in the caves date back as far as 500,000 years and include megafauna, extinct marsupials, birds, reptiles, and more.

Caves provide ideal environments for fossilisation to occur as

- A. the environment is humid.
- B. sediment can quickly cover remains.
- C. the environment is aerobic.
- D. scavengers move the remains so they can be easily found.

Question 30

Howeas are a genus of palms native to Lord Howe Island, located in the Tasman Sea, east of Australia. There are two main species of *Howeas*: *Howea forsteriana* (Kentia palm) and *Howea belmoreana* (Sentry palm). Both *Howea* species are endemic to Lord Howe Island and evolved from a common ancestor that arrived on the island millions of years ago. Once they colonised the island, they underwent divergent evolution, resulting in the two distinct species we see today.

The name of this type of evolution is known as

- A. allopatric speciation.
- B. natural selection.
- C. the founder effect.
- D. sympatric speciation.

Question 31

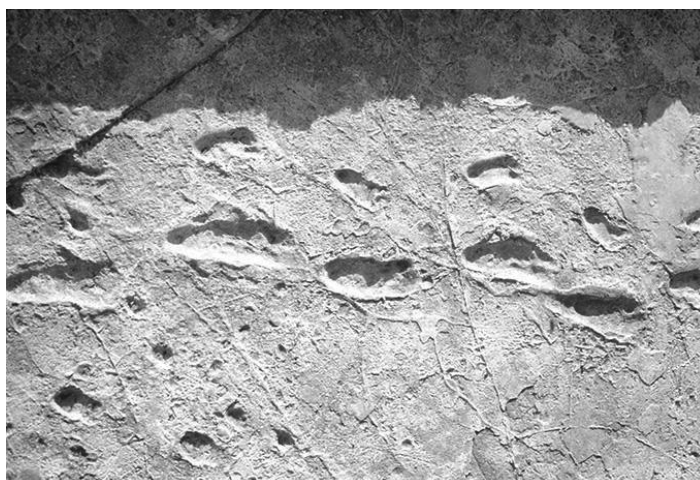
The bushfires of 2019–2020 saw extensive habitat destruction and loss of native wildlife in regions of New South Wales and Victoria. The number of native wildlife decreased significantly in this period and those remaining individuals are not representative of the original population.

The phenomenon that occurred is known as

- A. the bottleneck effect.
- B. the founder effect.
- C. allopatric speciation.
- D. gene flow.

Question 32

In 1976, a team of scientists discovered a series of well-preserved footprints at the Laetoli site in Tanzania, shown below. These footprints were estimated to be around 3.6 million years old and were attributed to early hominins, possibly *Australopithecus afarensis*. The footprints provided direct evidence of bipedal locomotion in early human ancestors and contributed significantly to our understanding of human evolution.



Source <https://www.sciencenews.org/century/milestone/laetoli-footprints>

How would the leg structure of *Australopithecus afarensis* differ to that of *Homo sapiens*?

- A. *Australopithecus afarensis* would have an inward facing femur when compared to *Homo sapiens*.
- B. *Australopithecus afarensis* would have longer legs than arms when compared to *Homo sapiens*.
- C. *Australopithecus afarensis* would have shorter legs than arms when compared to *Homo sapiens*.
- D. *Australopithecus afarensis* would have a longer femur when compared to *Homo sapiens*.

Question 33

Primates belong to the class *Mammalia*. A characteristic that differentiates primates from the class mammalia is

- A. body hair.
- B. an opposable thumb.
- C. the ability to feed young milk.
- D. the presence of nails / claws.

Question 34

Phylogenetic trees show that hominin evolution is continually being reviewed and refined. This is due to

- A. advances in molecular technology.
- B. the fact that all discoveries relating to hominin evolution have been made.
- C. the fossil record being complete.
- D. the fact that hominins are no longer evolving.

Use the following information to answer Questions 35–37.

An experiment was conducted to investigate the effect of temperature on anaerobic respiration in yeast. Different temperatures were tested to determine their effect on the rate of anaerobic respiration. The method followed is shown below.

1. Label a set of test tubes for each desired temperature. Place a rubber stopper with a tube in each vessel to allow gas collection.
2. Set up a water bath at 10 °C, 20 °C, 30 °C, 40 °C, and 50 °C. Use a thermometer to monitor and maintain the temperatures throughout the experiment.
3. In each labelled test tube, add 10 mL of yeast suspension and 10 mL of glucose solution. Mix gently to ensure uniform distribution.
4. Place the test tubes in the corresponding water bath and allow the samples to incubate for 10 minutes.
5. Attach an inverted graduated cylinder to each vessel to collect the gas produced during fermentation. Start the timer and record the volume of gas collected every minute for 20 minutes.
6. Calculate the rate of anaerobic respiration by dividing the volume of gas produced by the time elapsed.

Question 35

What is the independent variable (IV) and the dependent variable (DV) in this experiment?

- A. the IV is gas production and the DV is temperature
- B. the IV is the volume of the glucose solution and the DV is the volume of the yeast solution
- C. the IV is temperature and the DV is the displacement of water
- D. the IVs are time, pH and using the same scales and the DV is temperature

Question 36

What is the purpose of the stopper being added to the test tubes?

- A. to prevent carbon dioxide from entering the test tube
- B. to prevent oxygen from entering the test tube
- C. to minimise mess when gently stirring the solution
- D. to assist in maintaining a consistent temperature by minimising air flow in the test tube

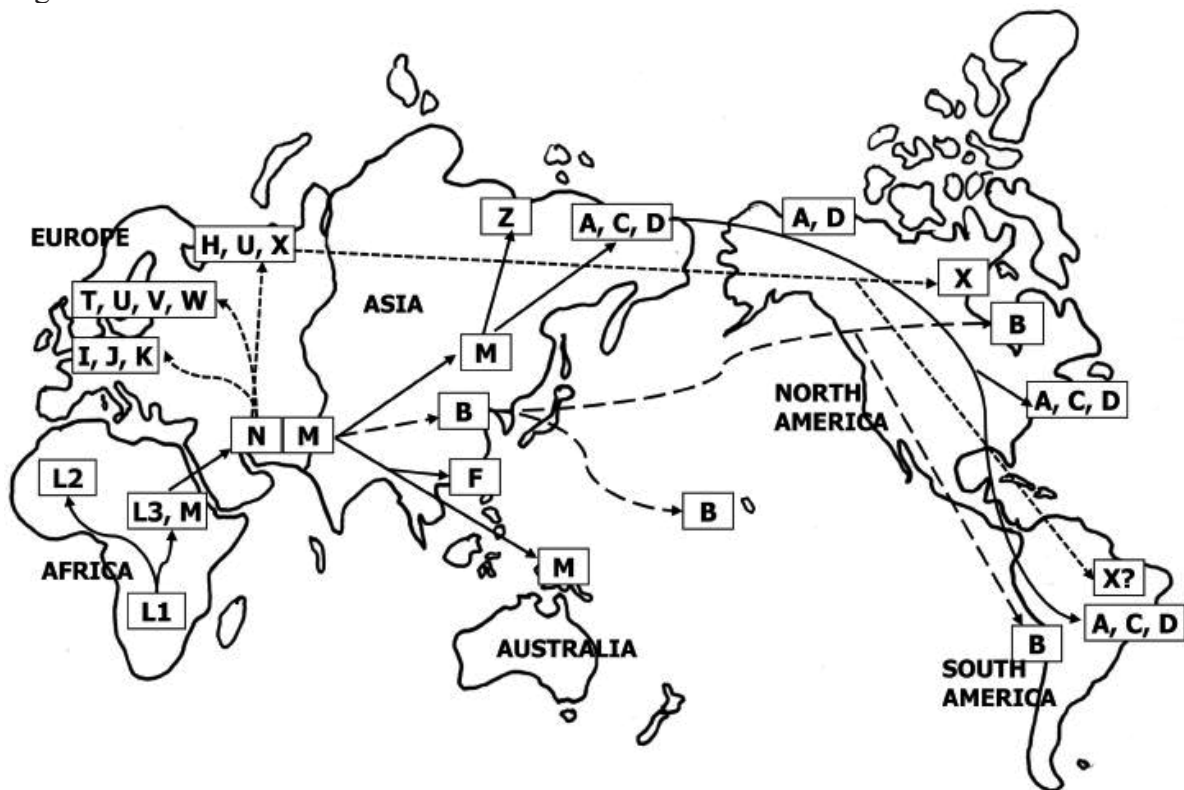
Question 37

When allotting the glucose solution into each test tube, a student realised that they had not been looking at the measurement from a perpendicular angle. This type of error is known as

- A. systematic error.
- B. random error.
- C. human error.
- D. personal error.

Use the following information and diagram to answer Questions 38–40.

The diagram below shows the mitochondrial haplogroups of different groups of *Homo sapiens*. A haplogroup is a small group of linked genes that are inherited together, and as such, show the degree of relatedness between individuals.



Source <https://humgenomics.biomedcentral.com/articles/10.1186/1479-7364-3-1-71/figures/1>

Question 38

Haplogroup L0 is thought to have given rise to haplogroups L1, L2 and L3. Indigenous Australians are primarily haplogroups M and N. When comparing haplogroup M and N to L1, it is fair to assume

- A. M and N are more similar to each other than they are to L1.
- B. M and N would have the least similarities as they diverged first.
- C. M and N are most prominent in all Indigenous populations throughout the world.
- D. that all Australian Indigenous populations would have the same haplogroups.

Question 39

It has been suggested that to increase the genetic data of Indigenous populations, all individuals with Indigenous heritage have a small sample of DNA stored at the time of birth. This data will then be analysed and a genetic library maintained. This breaches the ethical concept of

- A. integrity.
- B. justice.
- C. respect.
- D. beneficence.

Question 40

Which haplogroup would be expected to have shown the greatest amount of change since its origination?

- A. A
- B. X
- C. L1
- D. M

END OF SECTION A

SECTION B**Instructions for Section B**

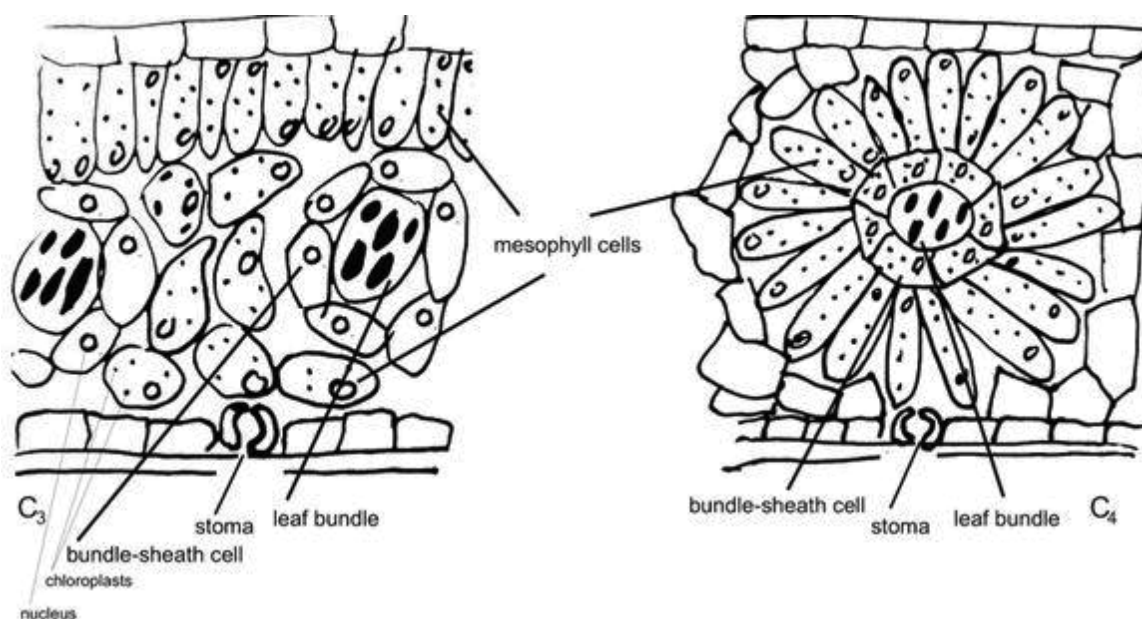
Answer **all** questions in the spaces provided.

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

Question 1

Unlike C₃ plants, C₄ and CAM plants have adaptations that enable them to photosynthesise in harsh environmental conditions such as high temperatures, drought and low carbon dioxide levels.

The diagrams below show a cross section of a leaf in a C₃ plant on the left and in a C₄ plant on the right.



Source <https://www.ceplas.eu/en/discover/planters-punch/2018/how-to-start-a-change-in-leaf-ontogeny-for-a-more-efficient-photosynthesis/>

- a. Rubisco has a high affinity for oxygen at higher temperatures. Name this process.

(1 mark)

- b. With reference to the diagram above, explain how the structure of C₄ plants facilitates the adaptations they have to minimise the process named in part a.

(3 marks)

- c. CAM plants are adapted to arid regions, closing their stomata during the day to minimise water loss. When water is available, describe how CAM plants photosynthesise.

(2 marks)

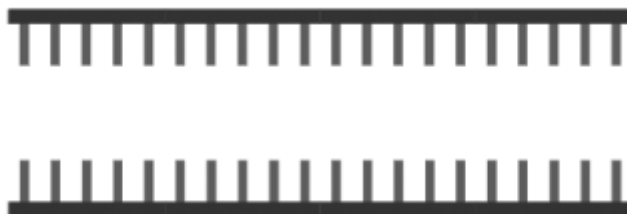
Total 6 marks

Question 2

PCR has revolutionised many areas of biological research, including genetics, microbiology, forensics, and medical diagnostics. It allows scientific researchers to amplify, detect and analyse DNA from a wide range of sources, such as fossils.

The Human Genome Project sequenced the DNA sequence of the entire human genome. The human reference genome provided a blueprint that allowed researchers to develop therapies that resulted in over 2000 new drugs that target specific human genes or proteins.

- a. Annotate the diagram below to show the addition of primers to double stranded DNA. Include the direction of the extension of the DNA by Taq polymerase.



Source <https://app.biorender.com/illustrations/6496330eccdd0a66247facc2>

(2 marks)

- b. *T. aquaticus* is a bacterium that lives in hot springs and hydrothermal vents. It uses *Taq* polymerase to catalyse DNA replication. It has since been used in PCR technology. *Taq* polymerase replaced the DNA polymerase from *E. coli* originally used in PCR. Describe **two** differences in the production of *Taq* polymerase and enzymes found in eukaryotes.

(2 marks)

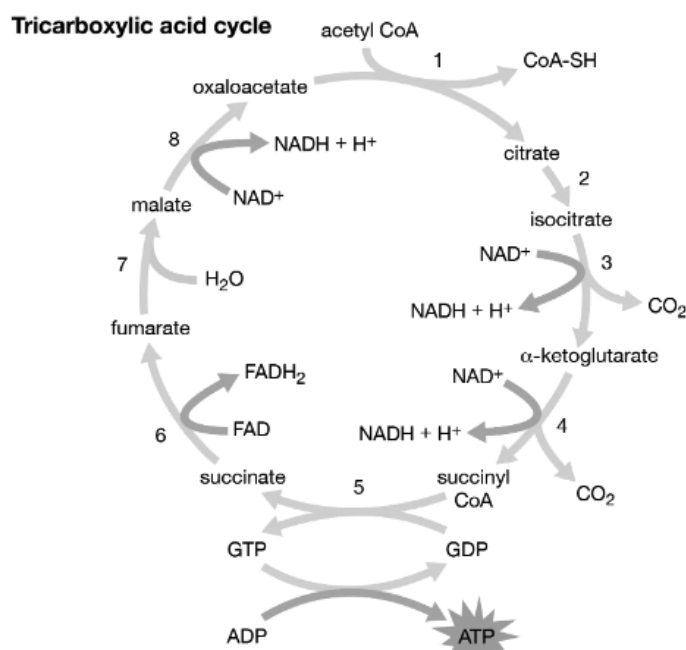
- c. Explain why Taq polymerase is suited to its role in the polymerase chain reaction (PCR).

(3 marks)

Total 7 marks

Question 3

A molecule called malonate inhibits the enzyme succinate dehydrogenase, a key enzyme in the biochemical pathway that is the Krebs cycle. Malonate is structurally similar to the substrate of succinate dehydrogenase, succinate. Succinate dehydrogenase catalyses the conversion of succinate to fumarate in the Krebs cycle.



Source <https://www.britannica.com/science/tricarboxylic-acid-cycle>

When malonate binds to succinate dehydrogenase, the enzyme is unable to function and the conversion of succinate to fumarate is inhibited. This interruption affects the overall energy production and metabolism of the cell.

- a. State the type of inhibitor that malonate is. Justify your response.

(2 marks)

- b.** Describe how the action of malonate affects the overall energy production of the cell.

(3 marks)

- c.** Outline **three** processes that occur in the nucleus to produce succinate dehydrogenase.

(3 marks)

- d.** Name **and** describe the role of **two** organelles that are required if succinate dehydrogenase is to be exported from the cell.

(4 marks)

Total 12 marks

Question 4

In 2017, researchers (Nekrasov et.al) reported they had used CRISPR-Cas9 to develop powdery mildew-resistant wheat by targeting a susceptibility gene in the wheat genome, called ‘susceptibility to powdery mildew 1’ (TaSMP). The aim was to disrupt the function of this gene to make the wheat plants less susceptible to Bgt infection.

Three different copies of the TaSMP gene in the wheat genome were simultaneously targeted. They designed specific guide RNAs to guide the Cas9 enzyme to the target sites in the gene. The resulting mutations introduced by CRISPR-Cas9 led to the disruption of the TaSMP gene, thereby reducing the wheat plant’s susceptibility to powdery mildew.

The plants exhibited significantly reduced disease symptoms compared to the non-edited control plants when exposed to Bgt infection, with the disruption of the TaSMP gene impairing the fungal infection process, providing effective resistance against powdery mildew.

Source Nekrasov, V., Wang, C., Win, J., Lanz, C., Weigel, D., & Kamoun, S. (2017). Rapid generation of a transgene-free powdery mildew resistant tomato by genome deletion. *Scientific reports*, 7(1), 1-6.

- a.** Name the enzyme in CRISPR technology that cuts the DNA to disrupt the gene.

(1 mark)

- b.** Explain how the enzyme named in part **a.** identifies the correct location to cut.

(3 marks)

- c.** Name the ethical **approach** that has been used with this application of CRISPR. Justify your response.

(2 marks)

A local environmental group outlined concerns about the use of CRISPR technology to modify wheat crops. They state that the role of fungus within an ecosystem is essential as it returns nutrients to the soil. They propose that instead of growing wheat in areas prone to the fungal infection, an alternative cereal crop, such as barley, be planted instead.

- d. Name **and** describe an ethical **concept** that could be raised for the farmers using the CRISPR technology for their wheat crops. Suggest a solution to this issue.

(4 marks)

Total 10 marks

Question 5

Galls in plants are abnormal growths or swellings that occur in response to infections by various organisms, such as bacteria, fungi, nematodes, or insects. These infections can trigger the plant's first line of defence mechanisms, resulting in the formation of galls that can isolate the infection and prevent further damage to the plant.

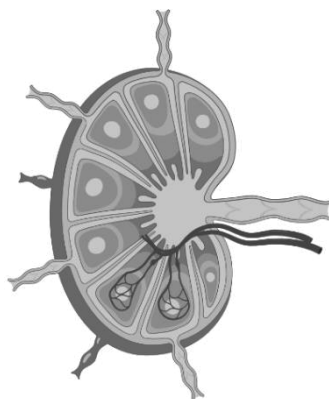
- a. Apart from galls, state an innate barrier in plants.

(1 mark)

- b. Describe **two** ways in which plant immune defences differ from humans.

(2 marks)

The organ shown below, a lymph node, is a secondary lymphoid organ.



Source <https://app.biorender.com/illustrations/64574f7bea0f89d16e35c59f>

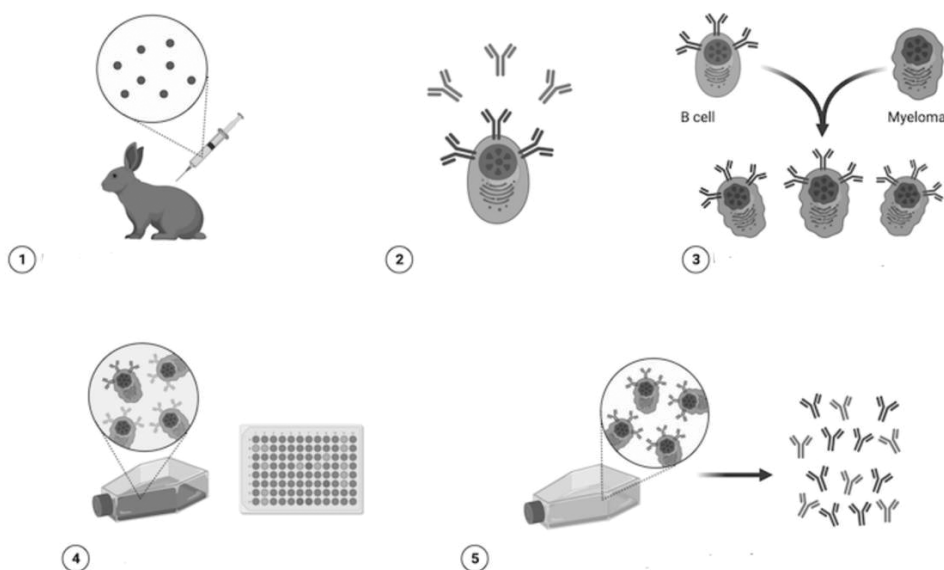
- c. Outline the sequence of events that occurs to link the innate and adaptive immune response at this structure.

(4 marks)

- d. Identify the purpose of the valves in the lymph nodes.

(1 mark)

When undergoing a routine check-up at her General Practitioner (GP), an individual aged in their 20s discovered that they had cancerous cells in their thymus. It was suggested that they undergo monoclonal antibody therapy to treat the early-stage cancer. The diagram below shows the process to produce monoclonal antibodies.



Source <https://blog.addgene.org/antibodies-101-monoclonal-antibodies>

The first step shows a mouse being immunised with antigens specific to the cancerous cell antigens.

- e. Briefly state what is occurring at steps 2–5.

(4 marks)

Total 12 marks

Question 6

Superbugs are a leading global health risk: UN report

Superbugs are now a leading global health risk. Major industries like the pharmaceutical and agricultural industries are largely responsible for this growing threat, inadvertently driving dangerous pathogens to evolve to outsmart currently available medications.

Antimicrobials, which include antibiotics, antivirals, antifungals and antiparasitics are commonly used to prevent and treat infections in humans, animals and crops. However, their overuse and misuse have led to the development of antimicrobial resistance (AMR) in the world, where microorganisms become resistant to treatments that were once effective. AMR has been identified by the World Health Organization as one of the top 10 threats to global health, with the potential to cause significant harm to human health, food security and the environment.

In 2019, an estimated 1.3 million deaths were directly linked to drug-resistant infections; nearly 5 million deaths were associated with AMR. At this pace, researchers estimate that by 2050 there could be up to 10 million additional deaths per year. The economic toll could result in a Gross Domestic Product (GDP) drop of at least USD 3.4 trillion annually by 2030 as well, according to the report.

AMR is not only a public health issue, but also has ties to the environment.

“Environment plays really a key role in the development, transmission and spread of antimicrobial resistance,” said Jacqueline Alvarez, Chief of the Chemicals and Health Branch, United Nations Environment Programme. The report mentions that, “AMR is closely linked to the triple planetary crisis of climate change, biodiversity loss, and pollution and waste,” which are “driven by human activity and unsustainable consumption and production patterns.”

Governments should also consider placing regulatory limits on the use of antimicrobials on farms, discharge of wastewater from pharmaceutical companies, improving wastewater management and beefing up safer sanitation practices, the report further urged.

Adapted from <https://abcnews.go.com/Health/superbugs-leading-global-health-risk-report/story?id=96948748>

- a. Describe the process by which overuse of antibiotics has caused antimicrobial resistance (AMR).

(4 marks)

- b.** Describe how a lack of gene flow produces a decrease in biodiversity.

(1 mark)

- c.** Explain how molecular homology provides evidence of AMR in bacteria.

(2 marks)

- d.** Antimicrobial use on farms has been linked to increasing AMR in pathogens. State **two** characteristics of farming that would contribute to this.

(2 marks)

Total 9 marks

Question 7

The fossil record is a crucial source of information about the history of life on Earth, containing the remains of preserved organisms. The fossil record includes the preserved physical remains or traces of ancient plants, animals and other organisms. Fossils can be found in sedimentary rocks, which form from the accumulation of sediments over time.

The Sumatran tiger (*Panthera tigris sumatrae*) was listed as critically endangered by the International Union for Conservation of Nature (IUCN). Native to the Indonesian island of Sumatra, habitat loss due to human activities and poaching has led to a significant decline in their numbers.

Sightings of the tigers are rare, with researchers relying on scratch marks on trees to provide evidence of their presence.

- a. Identify the type of evidence indicated by scratch marks **and** describe how they differ from traditional fossils.

(3 marks)

- b. Tigers, like *Homo sapiens*, are classified as mammals, however at this point they diverge. Provide **three** pieces of evidence that demonstrate that the Sumatran tiger is not classified as a primate.

(3 marks)

- c. Explain how faunal succession provides a record of evidence of our evolutionary past.

(3 marks)

The Sumatran tiger is endemic to certain areas of the Indonesian island of Sumatra, shown shaded on the map below. Most other tiger species are found on mainland Asia or Africa.



By AtikuX - Wikicommons (P tigris sumatrae map.png), Public Domain
<https://commons.wikimedia.org/w/index.php?curid=4802964>

- d. Suggest how the Sumatran tiger's location has contributed to its risk of extinction.

(3 marks)

Total 12 marks

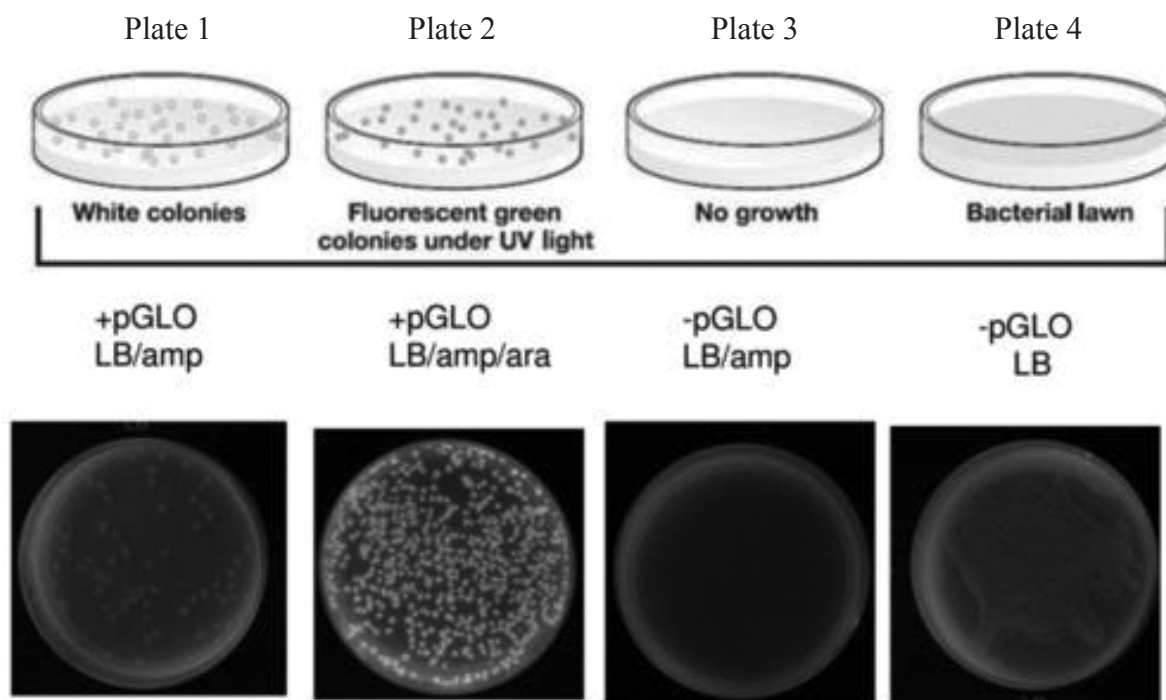
Question 8

A group of students wished to transform bacteria by inserting the Green Fluorescent Protein (GFP) gene, that would allow the bacteria to express the gene that allows it to glow.

Initially the students grew a culture of *E. coli* bacteria. They also prepared a plasmid containing the GFP gene, an antibiotic resistance gene for ampicillin, and arabinose, a gene required to express the GFP gene.

The bacteria and the plasmid were incubated together and exposed to heat shock to allow the uptake of the plasmid into the bacteria. The bacteria were then plated on agar, some which contained LB broth and incubated for 24 hours. If the bacteria were successfully transformed, they glowed green under UV light.

The following results were obtained.



Source <https://quizlet.com/579665401/lap-exam-2-micro-flash-cards/>

- a. Identify the term used to describe the bacteria that have successfully taken up the plasmid.

(1 mark)

- b. Discuss the characteristics of DNA that allow for the transfer and expression of genes between different organisms.

(2 marks)

- c. State the agar plate(s) being used as a control in the experiment. Justify your response.

(3 marks)

- d. Identify one limitation in this investigation and suggest a way that it could be overcome in future experiments.

(2 marks)

- e. Name the type of data collected in this experiment. Justify your response.

(2 marks)

- f. State **two** ways in which the bacteria produced in pGLO differ from the production of insulin using bacteria.

(2 marks)
Total 12 marks

END OF TRIAL EXAMINATION

