



BIOLOGY UNITS 3&4

Question Booklet & Worked Solution Booklet

ATARNotes

A collaboration by:

DANIEL RIBEIRO
GIANNI FARFAGLIA
MICHAEL BARRESE
RACHEL GRAVEN
ROMOLO PERSI

STUDENT NUMBER

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Letter

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BIOLOGY

Written examination

2019

Reading time: 9:00 a.m. to 9:15 a.m. (15 minutes)
Writing time: 9:15 a.m. to 11:45 a.m. (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 36 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 CANNOT freely move across a plasma membrane via the process of diffusion include

- A. Carbon dioxide molecules
- B. Hydrophobic signalling molecules such as steroid hormones
- C. Amino acids
- D. Very small polar molecules such as urea

Question 2

As biological catalysts, how do enzymes speed up chemical reactions?

- A. They increase the amount of energy available to catalyse a reaction
- B. By providing an alternative reaction pathway with a lower activation energy
- C. Acting as an alternative reactant, giving a new reaction with a lower activation energy
- D. By lowering the concentration of competitive inhibitors which lowers reaction rate

Question 3

The smooth endoplasmic is a highly folded internal membrane found within eukaryotic cells, why would this membrane be highly folded?

- A. To allow for the organelle to occupy more space within the cytosol
- B. For thermoregulatory purposes
- C. To increase the number of ribosomes that bind to it
- D. To increase the surface area in which chemical reactions can occur on

Question 4

Which of the following is *not* considered supporting evidence of the endosymbiosis theory?

- A. Mitochondria contain their own ribosomes which are like modern prokaryotes
- B. Chloroplasts can self-replicate via the process of binary fission
- C. Mitochondria can survive on their own outside of a eukaryotic cell
- D. Chloroplasts and mitochondria both contain their own DNA independent of the DNA found in the cell's nucleus

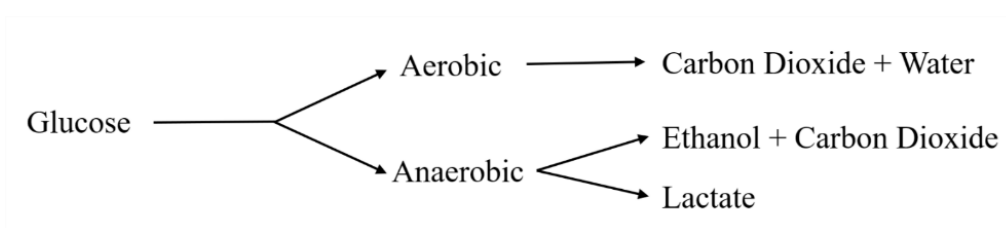
Question 5

Which of the following reactions do nucleic acids undergo to form polymers?

- A. Condensation polymerisation
- B. Endergonic catabolism
- C. Enzyme regulated hydrolysis
- D. Exothermic anabolism

Question 6

When oxygen is plentiful, which best describes the metabolic pathway of yeast cells?



- A. Alcohol fermentation, producing net 2 ATP
- B. Aerobic respiration, producing net 36-38 ATP
- C. Lactic acid fermentation, producing net 2 ATP
- D. Alcohol fermentation, producing net 16-18 ATP

Question 7

Which of the following is true regarding regulatory genes?

- A. Regulatory genes code for inorganic transcription factors rather than proteins
- B. Non-competitive inhibitors for globular enzymes are produced from regulatory genes
- C. Regulatory genes are involved in the production of transcription factors that influence the expression of other genes
- D. The circular chromosome of DNA in prokaryotic cells does not code for any regulatory genes of competitive inhibitors which lower reaction rate

Question 8

A mammalian cell is exposed to an irreversible inhibitor of α -ketoglutarate dehydrogenase, a key enzyme within the Krebs cycle, as a result;

- A. The cell produces 34-36 less ATP than normal
- B. The cell can no longer undertake aerobic respiration and in place produces ethanol as a result of the anaerobic pathway
- C. The electron transport chain still occurs utilising the coenzymes from glycolysis, producing 12-14 ATP
- D. The cell can overcome this by increasing the rate of glycolysis and hence greatly increase the concentration of Acetyl-CoA in the cell

Question 9

The sequence AGU CAU AAG CGC is most likely to be

- A. DNA from the circular chromosome of a mitochondria
- B. A promotor region on a section of DNA in a bacterial cell
- C. A pre-mRNA sample from a prokaryotic cell
- D. RNA from a human pancreatic cell

Question 10

The oxygen produced from photosynthesis arises from which molecule:

- A. Glucose
- B. Water
- C. CO₂
- D. Chloroplasts

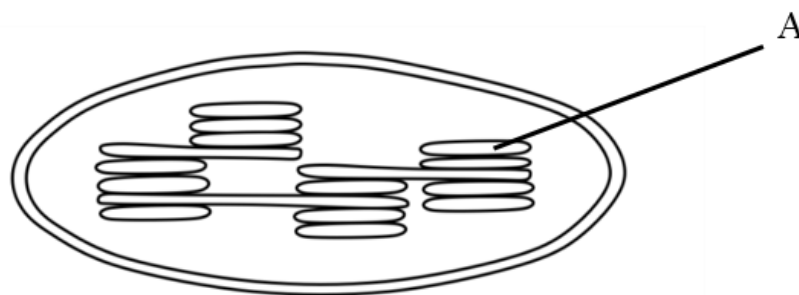
Question 11

The secondary structure of a protein is held together via

- A. Hydrogen bonding between R groups of amino acid residues
- B. Dipole-dipole interactions
- C. Glycosidic bonds
- D. Hydrogen bonding between peptide linkages

Question 12

Why is light required in photosynthesis at site A?



- A. For the chlorophyll to be at optimal temperature for light dependant reactions
- B. In order to provide the energy to split and extract electrons from water molecules
- C. As inhibitors of Rubisco, an important photosynthetic enzyme is inhibited by light
- D. Light is an important stimulant of the light independent reactions

Question 13

Plants and animals alike must defend themselves from pathogen invasion, which of the following best describes an example of the first line of defence in plants?

- A. Intact skin
- B. Ciliated epithelial linings
- C. Waxy cuticle
- D. Secretion of the hormone auxin which promotes cellular elongation

Use the following information to answer Questions 14 and 15.

The bacterial cell wall is made of peptidoglycan, a polymer synthesised from amino acids and carbohydrates which primarily serves a structural role. Penicillin is a non-competitive inhibitor that irreversibly binds to the active site of the enzyme transpeptidase which is involved in the synthesis of cell wall in bacterial cells.

Question 14

In the presence of penicillin, how will the reaction rate of transpeptidase be influenced in bacterial cells?

- A. The reaction rate will increase and then plateau at a lower rate than without the inhibitor present
- B. The reaction will cease to proceed
- C. The reaction rate will continue to increase until the concentration of product reaches a certain threshold
- D. The reaction rate will increase slower but then plateau at the same maximum rate as the uninhibited reaction

Question 15

This inhibitor however is not effective in *Thermus aquaticus*, a species of aquatic bacteria which live near volcanic vents on the ocean floor. Which of the following is incorrect?

- A. At the temperature where *Thermus aquaticus* reside, penicillin is denatured
- B. The Penicillin protein is not complementary to the transpeptidase of *Thermus aquaticus*
- C. *Thermus aquaticus* does not have a cell wall therefore Penicillin has no effect
- D. The bacterial capsid of *Thermus aquaticus* prevents Penicillin from binding to the transpeptidase

Question 16

A key feature of phagocytes is that

- A. They are immune to all viruses
- B. They contain specific enzymes that lyse pathogens such as bacteria
- C. They are all antigen presenting cells which have MHC II markers embedded within their membrane
- D. They are included in the first line of defence as a chemical barrier

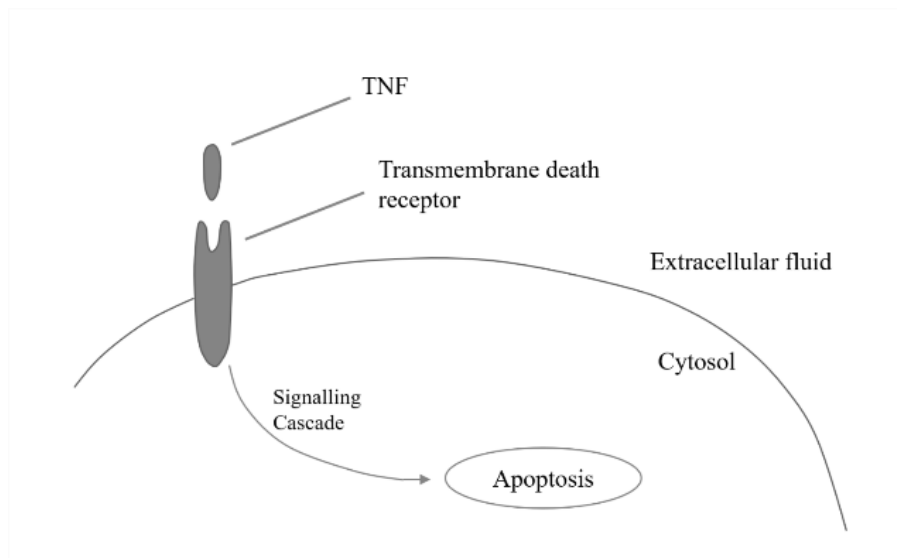
Question 17

Infectious bursal disease (IBD) is a highly contagious disease that primarily affects young chickens, the disease is characterised by the death of cells within a specialised organ called the bursa of Fabricius. Within this organ B and T lymphocytes develop. Why would the mortality rate of affected chickens be close to 100 percent?

- A. The secondary line of defence is compromised so the chickens lack an innate immune system
- B. The chickens are unable to produce B memory cells and will likely die on repeated exposure to pathogens
- C. Extensive apoptosis results in an auto-immune like response from cytotoxic T cells
- D. The chickens are unable to produce antibodies to combat the invasion of pathogens

Question 18

Tumour necrosis factor (TNF) is a signalling molecule involved in the extrinsic pathway of apoptosis, it binds to a transmembrane death receptor as shown below.



TNF is most likely to be

- A. Derived from cholesterol
- B. Hydrophilic in nature
- C. A secondary messenger molecule
- D. An exocytotic cytokine

Question 19

Tim has recently had a kidney transplant and was treated with immunosuppressant drugs which decrease the chances of his body rejecting the newly transplanted organ, why would it be important for Tim's family and friends to be vaccinated against the flu virus?

- A. The chance of Tim's family and friends passing on the flu to him are reduced as they have a lower chance of becoming infected
- B. Tim's completely lacks an adaptive immune system so is more susceptible to becoming infected
- C. If Tim were to require antibodies against the flu virus, they could be given to him from a family member
- D. His family and friends being vaccinated provides herd immunity enhancing Tim's immunity

Question 20

The red harvester ant *Pogonomyrmex barbatus* can excrete trail pheromones while searching for food, the purpose of this is to

- A. Communicate and elicit a behavioural response in other red harvester ants
- B. Warn away predators
- C. Deter other species of ants from a food source
- D. Promote the growth of plants that make up the food source of the red harvester ant

Question 21

Monoclonal antibodies are laboratory produced and are used to treat a variety of diseases such as cancer, lupus (it's never lupus) and multiple sclerosis. Which of the following options is not an action of monoclonal antibodies?

- A. Stopping new blood vessels forming around tumours
- B. Enhancing the allergic response by increasing the sensitivity of mast cells
- C. Increasing the chance foreign cells are engulfed by immune cells by marking them
- D. Blocking cellular pathways of problematic cells by inactivating their surface receptors

Question 22

Beta cells of the pancreas release the hormone insulin into the bloodstream which binds to cell surface receptors on liver and skeletal muscle cells causing an increase their uptake of glucose from the blood. Why do liver and skeletal muscle cells respond to insulin while other cells in the body don't?

- A. Insulin can only cross the plasma membrane of liver and skeletal muscle cells
- B. Insulin is a paracrine signalling molecule, so can only elicit a response from nearby cells
- C. Only liver and skeletal muscle cells contain receptors specific for insulin
- D. Other cells don't have the ability to increase their uptake of glucose

Question 23

The lymphatic system is an extensive network of nodes, glands and vessels. Which of the following statements best reflects the relationship between dendritic cells and the lymphatic system?

- A. Dendritic cells are only found in the lymphatic system as they can only engulf pathogens in lymph fluid
- B. The lymphatic system regulates the differentiation of macrophages into dendritic cells
- C. Dendritic cells activate T helper cells in the lymph nodes of the lymphatic system by presenting them with an antigen
- D. Once in the thymus, B cells stimulate proliferation of dendritic cells

Question 24

The gene pool of a population varies significantly over time through random fluctuations, natural events or human intervention. One way this can occur is through the founder effect, the founder effect is?

- A. A natural disaster has caused a sudden drop in population size resulting in a significant decrease in genetic variability in the smaller population
- B. Random fluctuations in allele frequencies over time
- C. A small proportion of a population has migrated to form a new population that's allele frequencies vary greatly from the parent population.
- D. A sudden change in environmental conditions leads to a change in selection pressures

Question 25

Golden rice is a GMO that contains modified daffodil genes, this greatly increases the amount of beta-carotene in the rice which is used as a precursor to vitamin A. Which of the following is an environmental problem associated with the commercial farming of golden rice?

- A. Long-term health risks associated with the consumption of GMOs like golden rice is unknown
- B. Golden rice seeds may blow in the wind and grow in the wild, interfering with fragile ecosystems
- C. Farmers that don't have access to golden rice seeds would have their products at a disadvantage in the market
- D. Large establishments may not allow the growth of golden rice by all if they patent the genome of this GMO

Question 26

The following sequence of DNA has been “cut” in a lab using a certain tool used by lab staff to cleave the phosphodiester bonds between nucleotides.

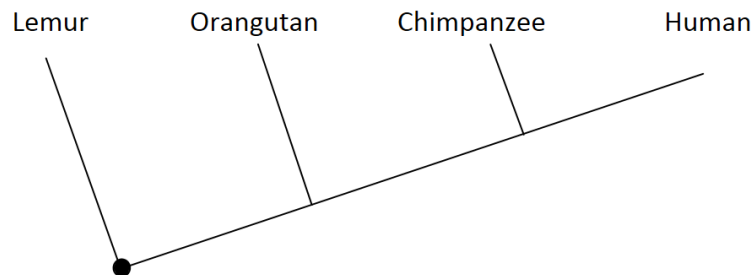


Which is the genetic tool called and how has it cut the DNA

- A. Restriction enzymes creating sticky ends
- B. Restriction enzymes creating blunt ends
- C. DNA peptidase creating sticky ends
- D. DNA peptidase creating blunt ends

Question 27

The following phylogenetic tree shows the relationship between some modern primates. Which of the following conclusions can be drawn from this diagram?



- A. Humans convergently evolved with chimpanzees
- B. All primates have opposable thumbs which enhances dexterity
- C. The selection pressures faced by modern lemurs and orangutans are similar
- D. Orangutans and Lemurs share a common ancestor

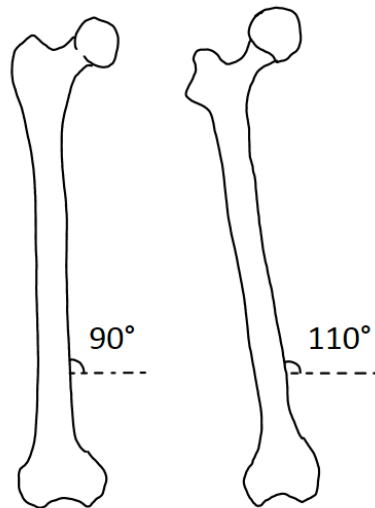
Question 28

In gel electrophoresis what is the determining factor as to how far a DNA fragment travel through the agarose gel?

- A. DNA charge
- B. Base composition of the DNA fragment
- C. Size of the DNA fragment
- D. The specific R group of the nucleotides present

Question 29

The following diagram depicts the femur bone of two extinct hominoids. Which of the following statements is correct?



- A. The right femur is likely to be from a hominoid with a central foramen magnum
- B. The left femur is likely to be from a late *A. afarensis* specimen
- C. Both femurs belong to bipedal hominoids
- D. The position of the foramen magnum cannot be inferred from these specimens

Question 30

Which of the following mutations is an example of a point mutation?

- A. Inversion
- B. Duplication
- C. Translocation
- D. Frameshift

Question 31

In Australia there has been an outbreak of the bacteria *C. jejuni* which is commonly associated with bacterial gastroenteritis, a short-term illness characterised by the inflammation of the digestive system. The distribution of reported cases is shown by the striped area in the following map. What term best describes this outbreak?



- A. Infection
- B. Epidemic
- C. National outbreak
- D. Pandemic

Question 32

Which of the following factors may *not* contribute to allopatric speciation?

- A. Geographic Isolation
- B. Differing selection pressures
- C. Selective breeding
- D. Gene flow

Question 33

A patient at a hospital insists on being prescribed amoxicillin (an antibiotic) with hope that it will alleviate a runny nose and sore throat as this treatment has previously proven effective however a doctor explains that for her infection amoxicillin won't be a suitable treatment option. Which of the following statements is the most correct?

- A. Amoxicillin only works once as the bacteria gain antibiotic resistance
- B. If the infection is from transgenic bacteria antibiotics will be ineffective
- C. Her symptoms could be from a viral infection, antiviral medication may be a suitable treatment option
- D. Amoxicillin was developed through the process of rational drug design

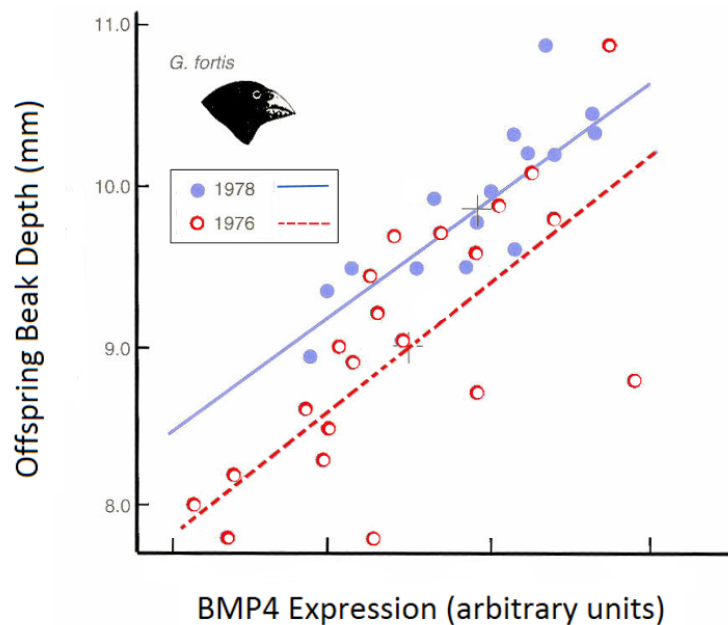
Question 34

Which the following supports Darwin's theory of natural selection?

- A. In a population of animals, physical strength and size are *always* favourable
- B. Cosmetic traits like the colour of an animal have no effect on selection
- C. An individual exposed to certain conditions all their life will themselves undergo evolution in response.
- D. A trait which greatly enhances an individual's chances of reproduction but results in subsequent death is selected for

Question 35

The beak depth of Galapagos finches is dependent of the expression of BMP4, a gene found in most animals. The beak depth of *Geospiza fortis*, a species of finch endemic to the Galapagos islands limits which foods it can consume. A smaller beak depth is associated with a diet of cactus fruit while a larger beak depth is associated with a seed-based diet. The following graph compares BMP4 expression and the beak depth of different *G. fortis* offspring over two years. In 1977 there was a disease outbreak that killed 90% the fruit bearing cacti. Which of the following statements best describes the relationship between offspring beak depth and BMP4 expression?



(Sourced from https://www.mun.ca/biology/scarr/Geospiza_heritability.html)

- A. After the hatching of *G. fortis* chicks, beak depth becomes dependent on BMP4 expression
- B. Offspring beak depth is independent from the expression of the BMP4 genes in the parents
- C. For the same level of BMP4 expression, offspring beak depth is the same in all chicks
- D. The expression on BMP4 in a chick could be used to roughly predict the chick's beak depth as an adult

Question 36

After 3 PCR cycles what percentage is of the attained genetic material is the original DNA?

- A. 100%
- B. 50%
- C. 25%
- D. 12.5%

Question 37

Multiple sclerosis (MS) is a disease characterized by the degeneration of myelin, a fatty substance that insulates neurons allowing for a faster transmission of the electrical signal the travels along the neuron. Which of the following options best describes multiple sclerosis?



- A. An allergic reaction to self-antigens
- B. A specific variant of cancer which can be treated through the action of monoclonal antibodies
- C. A progressive autoimmune disease
- D. A neurodegenerative disease of the brain

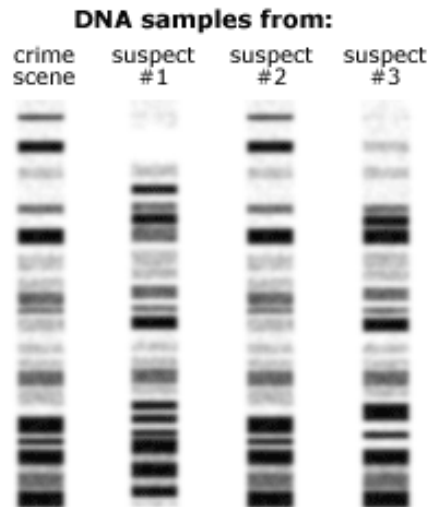
Question 38

Synthetic human insulin is currently used by type 1 diabetics worldwide to regulate their blood glucose levels when they beta cells of the pancreas are unable to produce sufficient levels of insulin. Synthetic insulin takes advantage of recombinant DNA technology to utilise recombinant bacterial cells to produce synthetic insulin. Which is not a step in commonly associated with recombinant DNA technology?

- A. The gene of interest and plasmid are cut with the same restriction enzymes
- B. Electroporation or heat shock therapy is utilised to influence the bacteria to take up the recombinant plasmid
- C. Ligase is an enzyme used to fuse the plasmid and gene of interest
- D. Bacteria integrate the gene of interest directly into their nucleoid for it to be expressed

Question 39

DNA profiling is an important part of forensic science; the following profiles were obtained via the process of gel electrophoresis. A DNA sample from a crime scene and that of three possible suspects were run, the results are pictured below. Which of the following statements is correct?



(Sourced from https://evolution.berkeley.edu/evolibrary/news/060301_crime)

- A. Consistencies within the profiles of the suspects suggests that they are related
- B. The DNA tested from the crime scene could be from a skin sample and the DNA tested from suspect 2 could be from a cheek swab
- C. The DNA from suspects 1 and 3 is from the same person
- D. The DNA profile of suspect 1 is contaminated

Question 40

The concept of rational drug design emphasises the importance of designing a drug to exploit a aspect of the biology of the target organism/virus which does not affect another system. Which of the following does *not* follow the principals of rational drug design?

- A. Designing antibiotic agents to selectively target bacterial ribosomes
- B. Radiation therapy: using ionising radiation to non-selectively kill cell, including cancer cells
- C. Relenza, a drug complementary to the active site of neuraminidase, an enzyme important for the spread of the influenza virus.
- D. Ventolin, binding specifically to adrenoreceptors opening up the bronchioles (airways) of the lungs

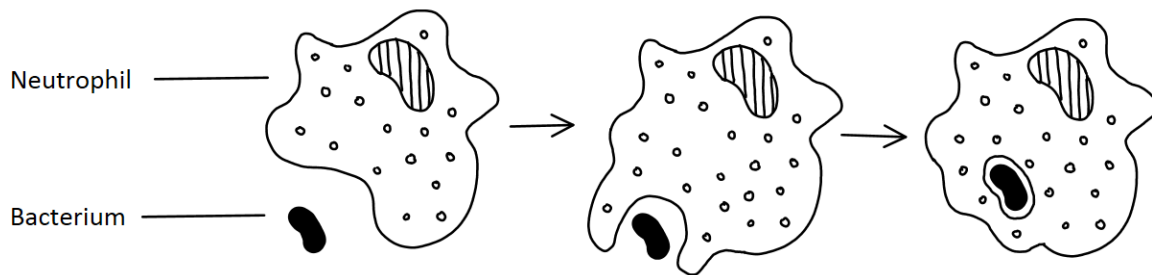
SECTION B

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)

The diagram below depicts the process of a neutrophil engulfing a pathogenic bacterium; the first step in the process of phagocytosis.



- a. Phagocytes such as neutrophils have a flexible plasma membrane which assists their locomotion and allows for them to engulf pathogens such as bacteria, which molecule primarily regulates membrane fluidity?

1 mark

- b. Would a molecule of glucose be able to freely diffuse across the plasma membrane of a neutrophil? Explain your reasoning.

1 mark

- c. After engulfing the bacteria, the phagosome the bacteria is trapped in binds with a lysosome, in this hybrid vesicle the bacteria is broken down by the action of lysozymes. Would this neutrophil present an antigen from the bacterium to a helper T cell? Explain your reasoning

1 mark

d. How was the neutrophil able to identify the bacterium as a threat to the body?

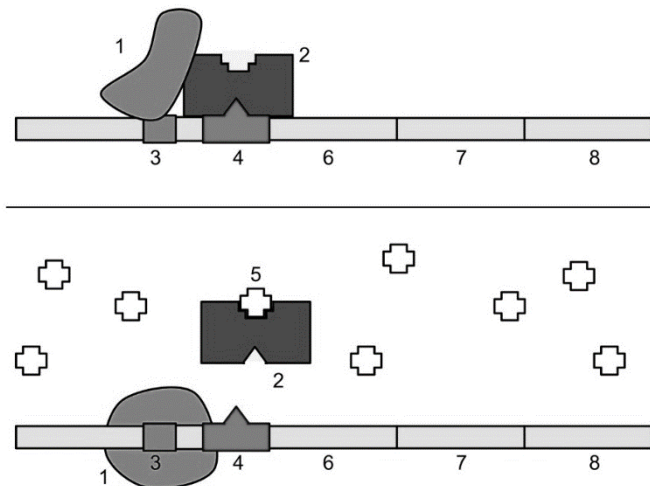
1 mark

e. Neutrophils are a key component of the inflammatory response, briefly explain this non-specific process after the skin is broken by a splinter.

2 marks

Question 2 (8 marks)

The lac operon is a simple prokaryotic system that allows for the expression of certain genes that code the production of enzymes involved in the digestion of lactose but only when lactose is present within the intracellular environment. The following diagram of the lac operon is labelled as follows: 1 - RNA Polymerase, 2 - Repressor, 3 - Promoter, 4 - Operator, 5 - Lactose, 6 - lacZ, 7 - lacY, 8 - lacA.



(Sourced from https://en.wikipedia.org/wiki/Lac_operon#/media/File:Lac_Operon.svg)

- a.** Explain how the transcription of lacZ, lacY and lacA would be altered in the absence of lactose if there was a point mutation in operator region that prevented it from binding to the repressor molecule.

1 mark

- b.** Would there be introns present in the lacZ, lacY and lacA structural genes? Explain your reasoning.

1 mark

- c.** Name and describe the purpose of two post transcriptional modifications that occur in eukaryotic cells.

2 marks

- d.**
- i.** After the transcription of the three structural genes, three strands of mRNA are produced. Referencing this scenario, explain the process of translation

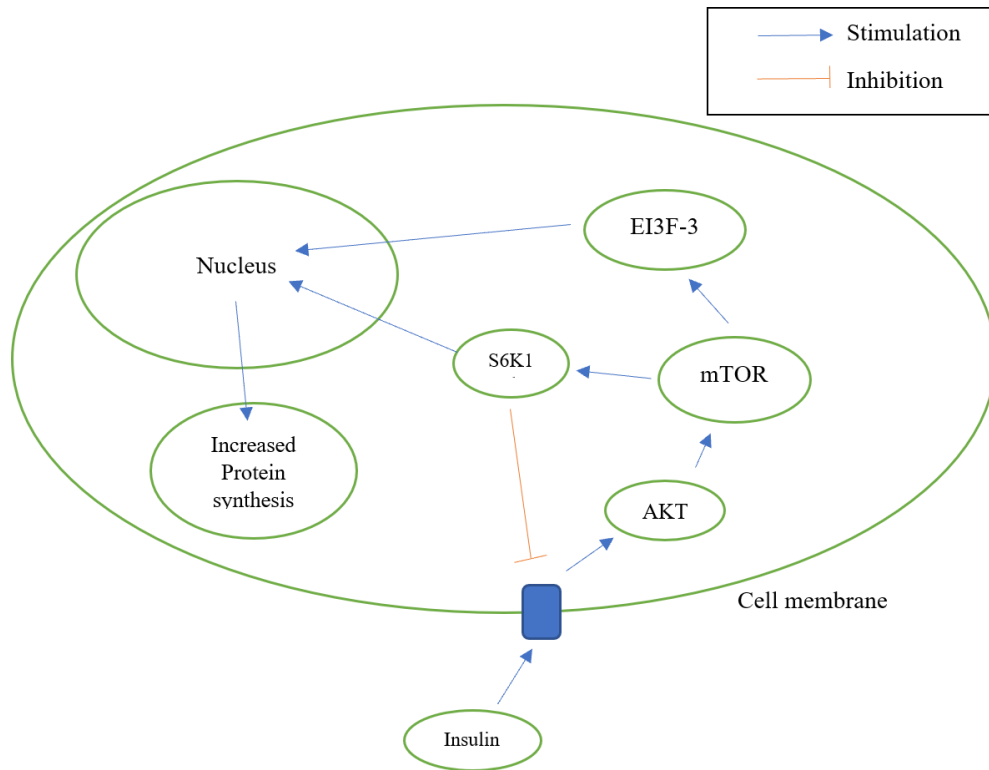
3 marks

- ii.** State the function of the final product

1 mark

Question 3 (7 marks)

mTOR is a major regulator of protein synthesis in mammalian cells specifically working to increase protein synthesis stimulated by amino acid intake and in post exercise recovery. Following a recent discovery, it has been found that mTOR also responds to insulin via the pathway outlined in the diagram below



a. What type of signalling molecule is insulin? 1 mark

b. What role do AKT, mTOR, EI3F-3 and S6K1 play in the signal transduction pathway? 1 mark

c. Why does insulin bind to a surface receptor instead of an intracellular receptor? 1 mark

d. Fill in the blanks of the pathway depicted below.

2 marks

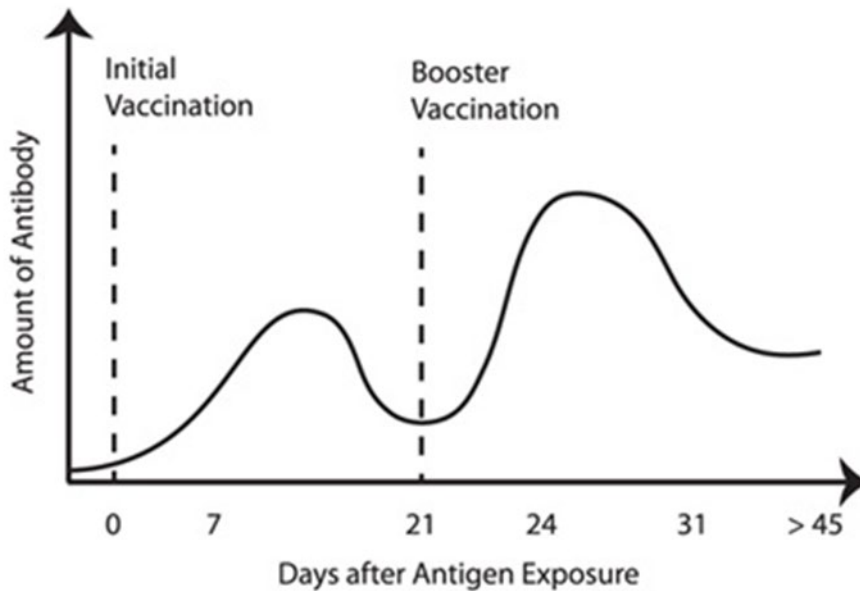
Reception	
	Change in conformation of insulin receptor activates a cascade of secondary messages which bring about a cellular response
Response	

e. By what mechanisms may protein synthesis be increased by this pathway?

2 marks

Question 4 (6 marks)

The bacteria *Clostridium tetani* can cause tetanus, a disease that causes painful muscle spasms. For an infection to develop, bacteria spores need to enter the body through an open wound where they can mature into adult bacteria and release toxins. Children are commonly vaccinated multiple times against this toxin to enhance their immunity, as tetanus can be fatal if left untreated. The following graph shows the amount of antibody present against the toxin in a young child who initially received a vaccination and then a subsequent booster vaccination three weeks later.



(Sourced from: https://aces.nmsu.edu/pubs/_b/B222/welcome.html)

- a. Explain the purpose of booster vaccinations.

1 mark

- b.** Robert, who has not received a booster vaccination for tetanus in 15 years accidentally cut his hand while gardening. *C. tetani* spores from the soil entered his wound and infected him. Using Robert as an example, give a brief outline of the humoral response that is likely to follow his infection.

3 marks

- c.** Even if a large portion of the population has received their tetanus vaccinations and boosters, herd immunity is still unable to be achieved. Why?

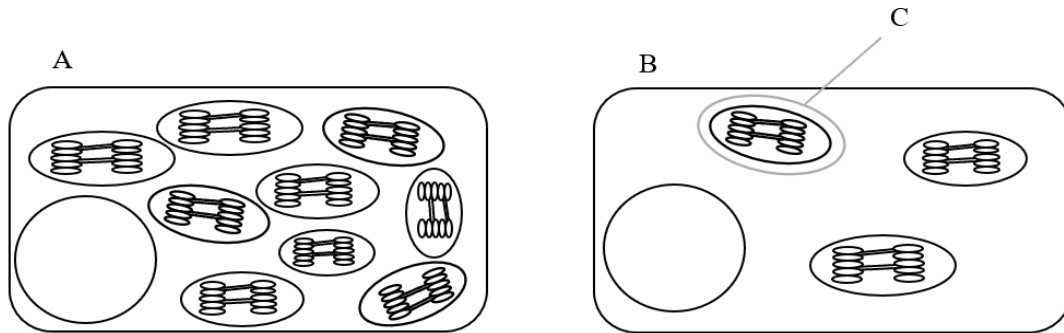
1 mark

- d.** An unvaccinated child was diagnosed with tetanus after he suffered severe muscle contractions. When administered to hospital he was given serum intravenously. This serum contained antibodies against the toxin released by the bacteria. What type of immunity is involved in this scenario?

1 mark

Question 5 (8 marks)

Allocasuarina verticillata, also known as drooping sheoak, is a nitrogen fixing tree native to South-East Australia typically found to grow best in direct sunlight. Contrastingly, the *Dracaena* is a plant which needs comparatively much less sunlight exposure, often used as an indoor household plant. The following figure represents cells from the leaves of two plants, one is the *Allocasuarina verticillata* and the other *Dracaena*.



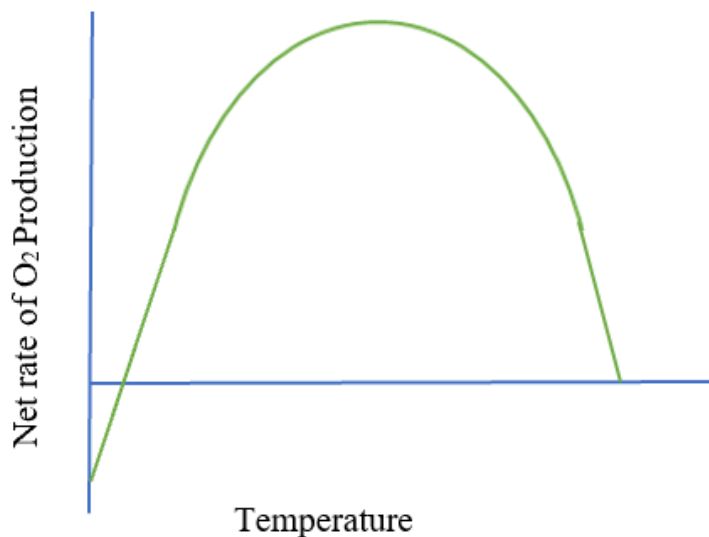
- a.
i. What organelle is represented by label C

1 mark

- ii. Which cell (A or B) belongs to *Allocasuarina verticillata*?

1 mark

- b. Joshua, a savvy biology student, has measured the rate of photosynthesis in *Allocasuarina verticillate* every day for the past year by measuring the amount of oxygen produced per unit of time. He has found that, generally, the rate of photosynthesis is higher on a hot day than a cold day. However, at very hot days the rate of photosynthesis decreases.



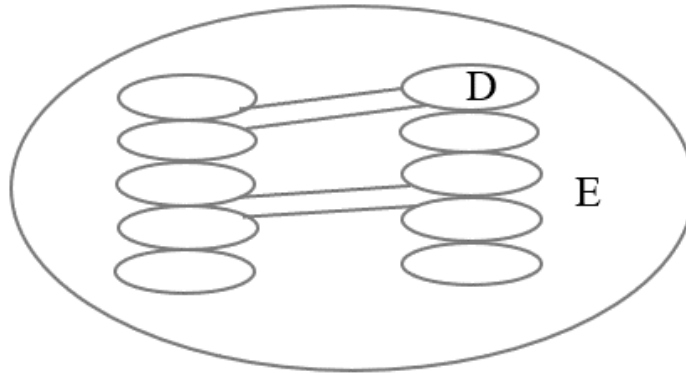
- i. State two reasons why the rate of photosynthesis is seen to decrease as temperature rises above a certain point.

2 marks

- ii. Why does the rate of production of O₂ become negative at very low temperatures?

2 marks

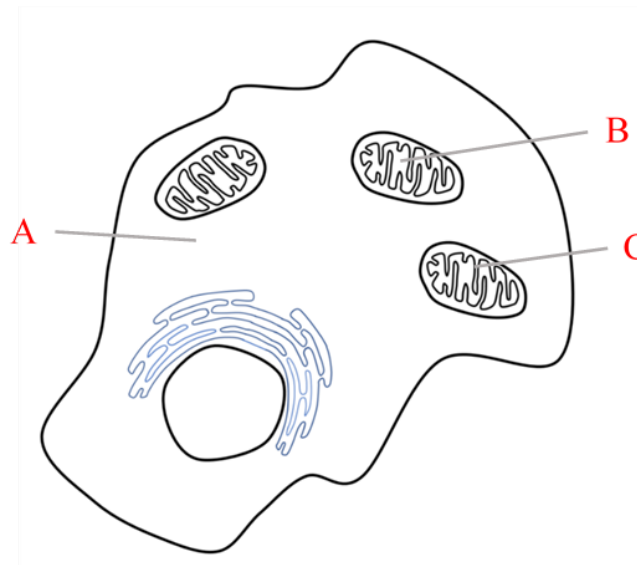
- c. While conducting another experiment, Joshua accidentally spills a test tube of xylulose-1,5-bisphosphate (XuBP) on the plant. XuBP is a strong inhibitor of the reactions occurring at site E (in the diagram below) but has no direct effect elsewhere in the cell. Do the reactions at site D still occur? Explain.



2 marks

Question 6 (11 marks)

Cellular respiration is a fundamental biochemical process that is important in sustaining all forms of life. It facilitates the production of a high energy compound known as ATP which is utilised as a source of energy for all cellular processes. Below is a diagram of a mitochondria containing cell.



- a. What are the coenzymes produced by the at structures A and B that are fundamental for the process at structure C?

1 mark

- b. Name and describe the process that occurs at structure C

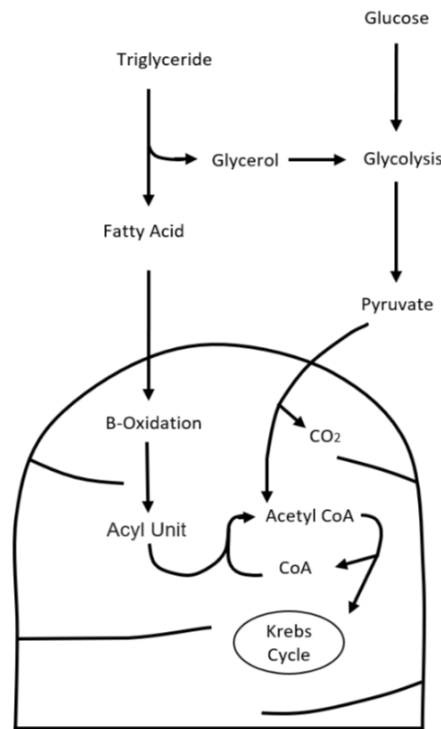
3 marks

- c. A metabolic research lab whilst conducting research on these eukaryotic cells discovered that there were various components present in eukaryotic mitochondria which were atypical of other eukaryotic organelles, they suggested that this organelle may not have originally evolved alongside the rest of the eukaryotic cell.

What is an example of a finding that may have suggested this? And what is the process called that may have led to these differences?

2 marks

- d. This research lab found that there is an alternative pathway that in certain circumstances may feed the citric acid/krebs cycle. Triglycerides are the substrate for this pathway depicted below. One assistant researcher suggests this an alternative pathway used when the electron transport chains inhibited.



Is the assistant researcher correct? Explain your reasoning.

2 marks

- e. This assistant researcher then went on to isolate yeast cells and cells of a species of protozoa which functions metabolically like mammalian cells and separated them in two different vessels, however in the researchers rush they forgot to label which container was which. Both organisms have a very similar appearance and the researcher has been tasked by his superiors to find out which vessel contains the yeast and which the protozoa.

Design an experiment that the student may use to determine which vessel contains the protozoa. State results that would support your predictions.

3 marks

Question 7 (6 marks)

In 1971 five pairs of Italian wall lizards, native to Pod Kopiste, an island in the sea Adriatic Sea, were introduced by evolutionary scientists to the neighbouring island of Pod Mrcaru. Whilst geographically close, Pod Mrcaru has a very different environment and its own indigenous lizard population. Subsequently due to the eruption of the Croatian War of Independence the researchers were not able to access the island for a substantial period. Returning in 2004 following the resurgence of tourist activity the researchers found that the Italian wall lizard population had dramatically increased in number and wiped out the indigenous population throughout competing them for available resources.



The Italian wall lizards were seen to undergo various adaptations including shifting their insect-based diet to primarily vegetarian. A larger head size resulting in a stronger bite and changes giving to their digestive tract allowing for more time for the stomach microflora to break down the vegetation.

- a.** What effect may have led to a change in allele frequencies of the Italian wall lizard population on Pod Mrcaru compared to the original population after its introduction? 1 mark

- b.** Why was the introduced population of Italian wall lizard at risk of extinction initially after its introduction? 2 marks

- c.** Explain the process of natural selection that has occurred in the population of Italian wall lizards over the 33-year period resulting in their larger head size? 3 marks

Question 8 (8 marks)

Severe Combined Immunodeficiency and Newborn Screening

Severe Combined Immunodeficiency (SCID) is a condition that is caused by a genetic mutation resulting in a loss of T lymphocytes and B lymphocytes. Because of this, patients with SCID have increased susceptibility to infection and therefore experience recurrent bacterial, viral, fungal or protozoal infections, with most symptoms beginning in the first 6 months of life. Some other symptoms and complications include, but are not limited to: failure to thrive, blood disorders, autoimmunity, arthritis, and anorexia.

If patients do not receive treatment for SCID they usually die within their first year of life.

To cure SCID, the only available procedure is a bone marrow transplant, yet this operation is not without complications, so there is no guaranteed long-term survival. However, if it is done within the first 3.5 months of life, there is a 95% survival rate.

Other forms of treatment include: antibody administration, antimicrobial drugs to prevent or treat infection, and anti-inflammatory drugs.

The incidence (occurrence of disease) is reported to be 1 in 58,000 live births.

Currently in Australia, there is no newborn screening program for SCID. So, children born with the condition may only be diagnosed once they start exhibiting symptoms at around 6 months. Some health and medical professionals are currently pushing to implement a newborn screening program for SCID in Australia.

PMID: 30969584

<http://www.idfa.org.au/support-newborn-screening-for-severe-combined-immune-deficiency-scid/>

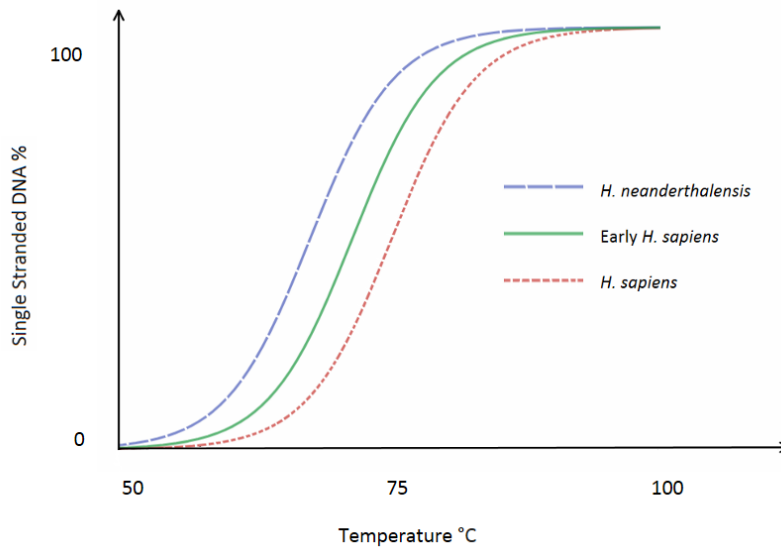
- a. Using the above information and your knowledge of Biology, fill in the below table regarding issues to be considered when implementing a newborn screening program for SCID

2 marks

Social Implication	
Ethical Implication	

Question 9 (5 marks)

Molecular homology can be used as evidence of relatedness between species. Australian researchers stationed in South-West Russia are attempting to determine the relatedness between *H. sapiens* and a very well-preserved *H. neanderthalensis* specimen which was identified via morphological features, to do this the researchers used the DNA hybridisation technique in a field lab. A DNA sample from an early *H. sapiens* was also graphed as well as a sample from one of the researchers which was used as a control. From the obtained data, the following graph was produced.



- a. The sample of *H. neanderthalensis* DNA that was recovered was initially below the amount the researchers required to produce a large enough number of trials in the DNA hybridisation experiment. A senior researcher suggested that they use the PCR (polymerase chain reaction) process so that they can produce the required amount of DNA, what is the function of the primer in this process, what temperature does it anneal to the single stranded DNA strand?

2 mark

- b. The researchers required 16 μg of *H. neanderthalensis* DNA and initially had 2 μg , how many cycles of PCR are required to produce the desired amount of DNA?

1 mark

c.

- i. Using the data provided, explain why early *H. sapiens* are more closely related to *H. sapiens* in comparison to *H. neanderthalensis*

1 mark

- ii. It is thought that interspecies breeding that produced viable offspring occurred between early *H. sapiens* and *H. neanderthalensis*, explain evidence that would support this.

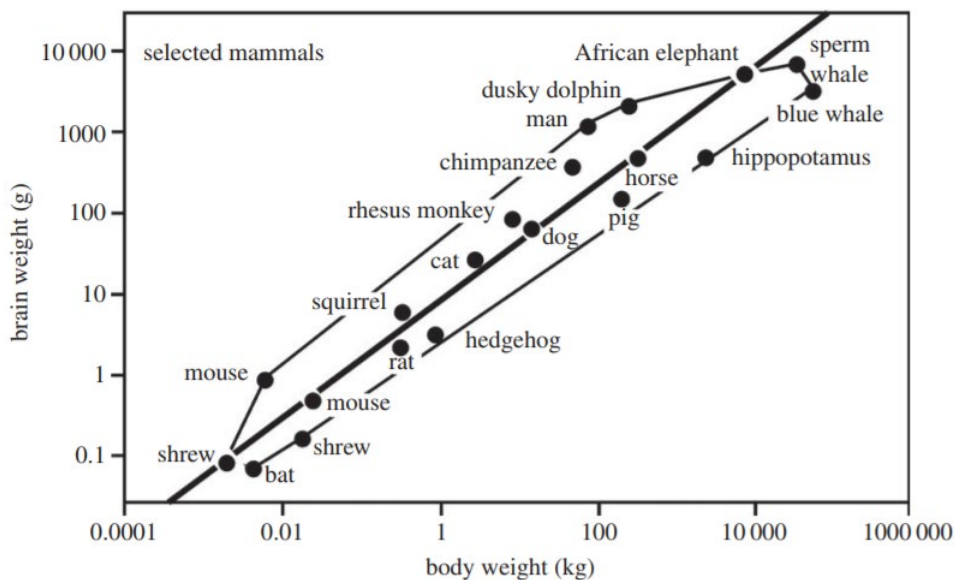
1 mark

- d. The *H. neanderthalensis* specimen was determined to be 45,000 years old. Which dating method was likely to be used?

1 mark

Question 10 (7 marks)

The following diagram shows the relationship between body weight and brain weight in a range of vertebrates. Note the position of *H. sapiens* labelled 'man' on the graph.



(Sourced from: <https://royalsocietypublishing.org/doi/pdf/10.1098/rstb.2015.0180>)

- a.** The African elephant has a substantially larger brain weight in comparison to modern humans however, African elephants lack the advanced cognitive abilities of humans. Explain why this is the case.

1 mark

- b.** All the primates on the graph are placed above the line of best fit as they have a higher brain to body weight ratio. This allows for critical thinking which encourages the use of tools. What shared feature of primate hands allows for the advanced dexterity required for tool making?

1 mark

- c.** The evolution of bipedal hominins progressed from a quadrupedal ancestor. Describe the change in position of the foramen magnum from early hominins to modern humans and explain an advantage of bipedalism.

2 marks

- d.** Cultural evolution is thought to have originated in early hominins, provide an example of cultural evolution and a piece of evidence that would support this

2 mark

- e.** Evolution of the homo genus is thought to have progressed from shifts in selection pressures. What likely change in lifestyle allowed for the development of a larger brain to body weight ratio and smaller teeth in hominins?

1 mark

Question 11 (7 marks)

A 39-year-old man was found dead at a crime scene. There is no direct evidence of the perpetrator, but it is suspected to be the victim's housemate. A bloody knife was found in the housemate's room, but he testified that the blood was his from when he cut himself whilst cooking. Forensic scientists decided to investigate the sample.

The sample of DNA is small and as a result in order to forensic analysis they first need to amplify the amount of DNA present utilising Polymerase Chain Reaction (PCR).

- a.** What is the key enzyme used in the elongation phase of PCR?

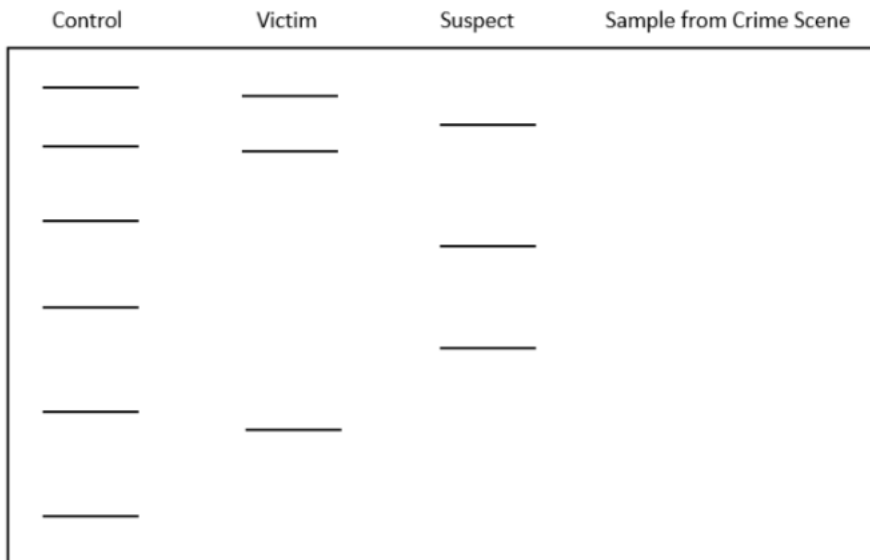
1 mark

- b.** Subsequently electrophoresis was performed to determine who the blood sample belonged to.

Describe the process of separation of a DNA sample by electrophoresis, including the direction of travel of the DNA.

3 marks

- c. Indicate on the following diagram results that would support that the suspect is guilty. 1 mark



- d. Afterwards the forensic staff performed detailed genetic sequencing of the sample DNA it was found that there was a mutation in a single gene on chromosome 12, specifically the resulting in a defect in the enzyme phenylalanine hydroxylase. Causing the individual to display phenotypic symptoms of Phenylketonuria. The genetic sequence of the normal allele and the samples mutated allele is seen below.

Normal	Mutant
5' - ATACCGTAAACTAGGTC - 3'	5' - ATACCGTAAGACTAGGTC - 3'
3' - TATGGCATTGATCCAG - 5'	3' - TATGGCATTCTGATCCAG - 5'

What kind of mutation has occurred?

1 mark

- e. Why this more potentially more harmful than a substitution mutation? 1 mark

END OF QUESTION AND ANSWER BOOK