Neap

Trial Examination 2023

VCE Biology Units 3&4

Written Examination

Suggested Solutions

SECTION A – MULTIPLE-CHOICE QUESTIONS

1	A	B	**C**	D
2	**A**	B	C	D
3	A	B	C	**D**
4	**A**	B	C	D
5	A	B	**C**	D
6	A	B	C	**D**
7	**A**	B	C	D
8	A	**B**	C	D
9	**A**	B	C	D
10	A	**B**	C	D
11	A	B	**C**	D
12	A	**B**	C	D
13	A	B	C	**D**
14	A	**B**	C	D
15	A	**B**	C	D
16	A	B	C	**D**
17	A	B	**C**	D
18	A	B	C	**D**
19	**A**	B	C	D
20	A	B	**C**	D
21	A	**B**	C	D
22	A	**B**	C	D
23	A	**B**	C	D
24	A	B	**C**	D
25	A	B	**C**	D
26	A	B	C	**D**
27	A	B	**C**	D
28	A	B	**C**	D
29	A	B	C	**D**
30	A	B	C	**D**
31	A	**B**	C	D
32	A	**B**	C	D
33	**A**	B	C	D
34	A	B	**C**	D
35	**A**	B	C	D
36	**A**	B	C	D
37	A	**B**	C	D
38	**A**	B	C	D
39	**A**	B	C	D
40	A	**B**	C	D

Question 1 C

C is correct. The diagram shows the general structure of an amino acid's nucleic acids and proteins. An amino acid comprises an R group, a carboxyl group and an amine group.

A is incorrect. A nucleotide is a component of a nucleic acid and contains a nitrogenous base, deoxyribose sugar and a phosphate.

B is incorrect. rRNA comprises multiple nucleotides.

D is incorrect. A polypeptide comprises multiple amino acids.

Question 2 A

A is correct and **C** is incorrect. The nucleus carries the blueprint for genetic information, DNA, which is first transcribed into mRNA and then translated into a polypeptide.

B and **D** are incorrect. Replication is related to the production of DNA, not the expression of DNA.

Question 3 D

D is correct and **C** is incorrect. The anticodon sequence GUA in a tRNA molecule would have the complementary codon CAU along an mRNA strand. The original DNA template triplet that was transcribed into the mRNA would therefore be GTA.

A is incorrect. This option is the DNA triplet on the coding strand, not the template strand.

B is incorrect. DNA does not contain uracil.

Question 4 A

A is correct. The proteome is the sum of the proteins expressed within a cell at a given time. The number of proteins is larger than the number of genes present (the genome) due to alternative splicing, in which exons can be spliced together in different orders or in different amounts to liberate different polypeptides.

B is incorrect. Post-translational modification refers to chemical changes occurring after translation.

C is incorrect. Even though nucleic acids may be less complex than proteins, this is not related to the size of the proteome in eukaryotic cells.

D is incorrect. Many genes do not code for the same polypeptide.

Question 5 C

The *trp* operon begins with a promoter (1), which enables RNA polymerase to bind to the operon. The next section is the operator (2), which enables a repressor to bind to the operon when tryptophan levels are high. The next section is a leader region (3), which fine-tunes the action of the operon based on the availability of tryptophan. Finally, the structural genes (4) are expressed when tryptophan levels within the cell are low.

Question 6 D

D is correct. For the *trp* operon to be activated, RNA polymerase needs to bind to the promoter and the operator must not bind to the repressor. This allows the RNA polymerase to carry out its function unimpeded and transcribe the structural genes.

A is incorrect. If the repressor is bound to the operator, the structural genes will not be expressed.

B is incorrect. A repressor binds to the operator, not the promoter.

C is incorrect. The process of transcription requires RNA polymerase, not DNA polymerase.

Question 7 A

A is correct. Hairpin loops form in the leader region of the *trp* operon as a means of fine-tuning the expression of the structural genes. If tryptophan levels within the cell are high, it is unnecessary for the structural genes to be expressed as it is a waste of energy. When the repressor is not bound to the operator, a hairpin loop forms to prevent the ribosome from translating the mRNA, thus stopping unnecessary production of the structural genes.

B is incorrect. When tryptophan binds to the repressor, the repressor then attaches to the operator.

C is incorrect. The structural genes are not attenuated; attenuation occurs before the structural genes are expressed.

D is incorrect. The repressor is always expressed. Whether the repressor can or cannot bind to the operator determines whether a hairpin loop is produced; the synthesis of the repressor does not determine this.

Question 8 B

B is correct. If the electrodes were connected the wrong way around, this would be deemed as a random error. This error would result in the DNA being pushed up, rather than down (according to the tank shown in the diagram), resulting in no bands in the gel.

A is incorrect. The switching on of the power source would be a random, not systematic, error. The power source not being connected at all would be a systematic error as it would skew all results in the same direction (that is, to complete zero); in contrast, a random error scatters results in different directions.

C is incorrect. Different volumes of DNA being added to the wells would be a random error but would still lead to similar band patterns in the gel.

D is incorrect. Piercing a hole in the wells would be unlikely to penetrate through the gel and it would be regarded as a random, not systematic, error.

Question 9 A

Adam has the largest (19 repeats) and smallest (4 repeats) fragments compared to the others. Both Chris and Jared have fragments that are close together (7 and 6 repeats and 12 and 14 repeats, respectively); however, as Chris's fragments are smaller than Jared's, they travel further than Jared's.

Question 10 B

B is correct. Justice refers to everyone having an equal opportunity for treatment and no particular group being burdened. In this case, only one of 10 people had a profile consistent with the crime scene sample. However, many other people may also have the same fragment sizes for the two short tandem repeats (STRs). More STRs should have been investigated.

A is incorrect. Plenty of DNA can be extracted from a small blood sample. This does not relate to the concept of justice as it does not relate to equal opportunity for all peoples and no people are unfairly burdened.

C is incorrect. A greater voltage would push the DNA through the gel faster, resulting in poorer resolution of the bands. This does not relate to the concept of justice as it does not relate to equal opportunity for all peoples and no people are unfairly burdened.

D is incorrect. Gel electrophoresis is expensive; however, it is not the reason why the evidence was thrown out and the individual free to go. More testing would be an appropriate and non-negotiable expense. This does not relate to the concept of justice as it does not relate to equal opportunity for all peoples and no people are unfairly burdened.

Question 11 C

The process of polymerase chain reaction (PCR) begins with DNA denaturation followed by primer annealing and finally *taq* polymerase functions to extend (or replicate) the DNA.

Question 12 B

B is correct. Controlled variables are the variables in an investigation that are the same for each trial. These are usually mentioned in an investigation's methodology. In this case, the volume and concentration of the solution was kept the same for each reaction.

A is incorrect. In this investigation, temperature was the independent variable and the number of relative fluorescence units (RFU) was the dependent variable.

C is incorrect. RFU was the dependent variable, and the period of incubation was a controlled variable.

D is incorrect. These factors were not mentioned as potential extraneous variables in the methodology.

Question 13 D

D is correct. A larger volume of the solution would have led to more product being produced in the same incubation period. The increased amount of product would result in a much higher RFU than was present in the trials that used the correct volume of the solution.

A is incorrect. Carbon dioxide was only one of the substrates; the concentrations of both substrates would need to be increased to produce a higher RFU.

B is incorrect. A lower incubation temperature would have led to a lower RFU.

C is incorrect. A shorter incubation period would have led to less product being formed, which would have led to a lower RFU.

Question 14 B

B is correct. A conclusion summarises the findings of an experiment. In this experiment, as the temperature increased, carbon dioxide and RuBP collided more frequently with Rubisco, forming more PGA and thus obtaining higher RFUs.

A is incorrect. Denaturation would lead to a lower RFU.

C is incorrect. A higher RFU indicates increased enzyme activity.

D is incorrect. When Rubisco is functioning optimally, it would be expected to produce a high RFU. A temperature of 30°C resulted in the highest RFU in each trial; therefore, temperatures between 20°C and 30°C are too low for the optimal functioning of Rubisco.

Question 15 B

B is correct. Coenzymes are organic chemicals that facilitate the action of enzymes by binding to the enzymes, thus enabling substrates to better bind to and react with the enzymes. Cellular respiration uses coenzymes such as ADP, which binds with Pi to form ATP, and NAD, which binds with hydrogen to form NADH.

A and **C** are incorrect. NADP is used in photosynthesis, not cellular respiration.

D is incorrect. Acetyl CoA is a substrate, not a coenzyme. ATP is a product of cellular respiration.

Question 16 D

D is correct. Glycolysis is the process by which glucose is broken down into pyruvate and occurs in the cytosol.

A is incorrect. The stroma is the site of the light independent reaction of photosynthesis.

B is incorrect. The matrix is the site of the Krebs Cycle.

C is incorrect. The cristae is the location of the electron transport chain.

Question 17 C

C is correct. Isolated mitochondria absorb pyruvate, which converts into acetyl CoA and acts as a substrate for the Krebs Cycle. They also absorb oxygen as a final electron acceptor for the electron transport chain. Mitochondria best perform these functions at 37°C and a pH of 7 as these are optimal conditions in the human body.

A is incorrect. Glucose is broken down by glycolysis in the cytosol to form pyruvate.

B is incorrect. 30°C is not the optimal temperature in the human body.

D is incorrect. A pH of 10 is too alkaline for effective mitochondria function, and glucose is used to form pyruvate.

Question 18 D

D is correct. Non-competitive inhibitors bind to an enzyme at a site that is a distance from the active site; thus, in this case, cyanide does not 'compete' with oxygen in the reaction. Instead, once the cyanide is bound to the enzyme, the active site changes shape, which prevents oxygen from binding to the active site.

A is incorrect. As cyanide inhibits the electron transport chain, it reduces the production of ATP.

B is incorrect. Cyanide binds away from the active site and does not have a similar shape to oxygen.

C is incorrect. Glycolysis still occurs as this pathway is not inhibited by cyanide.

Question 19 A

A is correct and **C** is incorrect. Lactic acid is the only product of anaerobic respiration in animal cells such as human muscle cells. It is a three-carbon molecule formed from pyruvate.

B is incorrect. Carbon dioxide and water are the products of aerobic respiration.

D is incorrect. Carbon dioxide and ethanol are the products of anaerobic respiration in plant and fungal cells.

Question 20 C

The correct order of steps is as follows.

1. Y: Expose broken-down starch to a warm and neutral environment.
2. Z: Add a source of enzymes to the environment.
3. W: Provide an anaerobic environment.
4. X: Purify the ethanol.

The conditions required to carry out this metabolic process are warm, neutral conditions where enzymes are present. The substrate in the reaction (glucose) needs to be exposed to an anaerobic environment to form ethanol.

Question 21 B

B is correct and **D** is incorrect. *Staphylococcus epidermidis* is a microorganism; hence, the presence of *Staphylococcus epidermidis* on human skin is an example of a microbiota barrier that gives the body a natural defence against pathogens.

A is incorrect. Chemical barriers are chemicals, such as sebum, that offer protection against pathogens.

C is incorrect. Physical barriers are layers of cells, such as skin, that offer protection against pathogens.

Question 22 B

B is correct. Eosinophils degranulate to release an array of cytotoxic proteins that can induce the destruction of multicellular parasites.

A and **C** are incorrect. Neutrophils and macrophages can phagocytose pathogens but are unable to affect large, multicellular parasites.

D is incorrect. Natural killer cells kill abnormal and virally infected self-cells, not multicellular pathogens.

Question 23 B

B is correct. Cellular pathogens are pathogens that metabolise and reproduce. Viruses and prions are not regarded as cellular, but bacteria and eukaryotic pathogens are. Therefore, the human immunodeficiency virus (HIV) that causes acquired immunodeficiency syndrome, the coronavirus that causes COVID-19 and the prion that causes Creutzfeldt–Jakob disease are all non-cellular pathogens.

A, **C** and **D** are incorrect. Fungal spores, plasmodia and bacteria are cellular pathogens.

Question 24 C

C is correct. An antigen-presenting cell (APC) displays non-self antigens on major histocompatibility complex (MHC) II markers for eventual presentation to B or T cells. The APC also needs to display MHC I markers for self-identification.

A and **B** are incorrect. Self-markers are MHC I and if they are blocked, the APC would be rejected.

D is incorrect. Non-self markers trigger an immune response, and non-self antigens are bound to MHC II.

Question 25 C

C is correct. The histamine test serves to measure the level of allergic reaction of all the allergens tested, but histamine is not an allergen itself. The purpose of the histamine test was to observe the effect of the chemical on the skin and to compare this reaction to the other tests. Tiara could be determined to be allergic to an allergen if it produced a red rash that was equal to or larger than the patch produced by the histamine.

A is incorrect. The histamine test is not a negative control as it produces a reaction.

B is incorrect. The histamine test does not prevent allergic reactions, nor does it indicate whether an individual will have an anaphylactic reaction to an allergen.

D is incorrect. Skin prick tests are performed under controlled conditions, but the purpose of the histamine test was not to observe an anaphylactic reaction.

Question 26 D

D is correct. When an allergen enters the body of an allergic individual, the allergen binds to the immunoglobin E (IgE) antibodies on the surface of mast cells. This stimulates the mast cells to degranulate and release histamine, which causes inflammation and possibly an anaphylactic response.

A is incorrect. Eosinophils can play a role in allergic reactions, but they do not release histamine.

B is incorrect. T cells do not release histamine.

C is incorrect. Cytotoxic T cells are formed specifically against antigens on the surface of foreign cells so that the foreign cells can be targeted for destruction.

Question 27 C

C is correct and **D** is incorrect. Tiara's test showed that she had allergic reactions to milk, chocolate and peanuts, which are all ingredients in peanut and chocolate ice-cream, so she should avoid eating these foods.

A and **B** are incorrect. Tiara did not have allergic reactions to cat fur, pollen or dust.

Question 28 C

C is correct. A vaccine introduces antigens from a pathogen into the body to activate the immune system to produce antibodies against the antigens. The memory B and T cells that remain in the body are better equipped to respond if the pathogen enters the body in the future. Vaccination is therefore artificial active immunity.

A is incorrect. Natural active immunity refers to when immunity is developed as a result of contracting a disease.

B is incorrect. Natural passive immunity refers to obtaining antibodies naturally; for example, when infants consume breast milk.

D is incorrect. Artificial passive immunity refers to obtaining antibodies artificially; for example, when antivenom is injected after a snake bite.

Question 29 D

D is correct. Plasma B cells manufacture and secrete antibodies. The peak level of antibodies is in region P, which is soon after the exposure to the pathogen. This is when the memory cells that were produced after the vaccination have been activated to proliferate into many plasma B cells.

A is incorrect. Shortly after the vaccine has been administered, only a few plasma B cells are present.

B is incorrect. Though the antibody level increases after vaccination, it is not as high as the antibody level after exposure to the pathogen.

C is incorrect. Once the antigen from the vaccine leaves the body, the plasma B cell level drops and antibody production falls.

Question 30 D

D is correct. The secondary response occurs after exposure to the pathogen. At this time, there are many memory cells present as a result of the vaccine. Therefore, there is a greater change of memory cells interacting with the antigens, meaning a faster and stronger response will occur to remove the pathogen faster.

A is incorrect. The secondary response is stronger than the primary response.

B is incorrect. The secondary response is faster than the primary response.

C is incorrect. The secondary response is stronger due to the presence of more memory cells; the antigen concentration on the pathogen is not the driving factor.

Question 31 B

Reading from the graph, the number of measles cases in 2002 was between 500 000 and 1 000 000; upon close inspection, the total is closest to 600 000.

Question 32 B

B is correct and **C** is incorrect. A drop in vaccination rates would lower herd immunity and result in an increased number of measles cases.

A is incorrect. Genetic drift refers to changed allele frequencies due to chance events.

D is incorrect. An ineffective batch of vaccines would not cause a spike in cases for a single year.

Question 33 A

A is correct. The population is initially 60% black rabbits and 40% white rabbits. As there is a selective advantage towards the white rabbits, it would be expected that, over time, the proportion of white rabbits in the population would increase.

B is incorrect. The gene pool would change given that there is a selective advantage to a phenotype within it.

C is incorrect. The white rabbits have a selective advantage.

D is incorrect. Mutations do not occur in response to the environment.

Question 34 C

C is correct. The best conditions for fossilisation are rapid burial in an environment where decomposition is minimal, as the rapid burial reduces scavenging. These conditions are often found in water with sedimentary layers that exert pressure.

A is incorrect. A fast-flowing river would potentially destroy the organism.

B is incorrect. A sandy, windy area would mean the organism is very exposed.

D is incorrect. Bones could be subject to scavenging.

Question 35 A

A is correct. According to stratigraphic correlation, the deeper the strata, the older the fossil in the strata. Thus, index fossils can be used to determine the relative ages of fossils in strata in different locations. Index fossils should have been in existence for a short period and be found in many locations. The best example of an index fossil in the diagram fossil N, which appears in the same strata in all four locations.

B is incorrect. Fossil O is found in all of the strata layers in location 2, so it does not fulfil the requirement of being in existence for a short period.

C is incorrect. Fossil P is found in all of the locations, but in a range of strata layers; thus, it is not likely to be a suitable index fossil.

D is incorrect. Fossil Q is only found in one strata layer in location 1, so it does not fulfil either requirement of being an index fossil.

Question 36 A

The answer can be obtained by determining the number of half-lives that have occurred and then reading from the graph to find the proportion of carbon-14 remaining.

As the mammoth is 23 000 years old:

After one half-life (5730 years), 0.5 remains.

After two half-lives (11 460 years), 0.25 remains.

After three half-lives (17 190 years), 0.125 remains.

After four half-lives (22 920 years), 0.1 remains.

Question 37 B

B is correct and **A** is incorrect. For fossil finds to have credibility, multiple fossils must reflect the same conclusion. If fossil samples from multiple *Homo floresiensis* were found in the same strata as *Homo sapiens* fossils, this could suggest that they existed simultaneously and lead to changes in our understanding of the hominin evolutionary tree.

C is incorrect. Fossils being found close to volcanic rock is not related to the presence or absence of *Homo sapiens* fossils.

D is incorrect. Strata positioning may indicate that an organism existed at different times but it does not provide an absolute time of existence. If *Homo floresiensis* fossils were found in strata that do not overlap with the timeframe of the strata that *Homo sapiens* fossils were found in, this would indicate that they did not exist at the same time.

Question 38 A

A is correct. Similar band patterns on chromosomes from different species show a higher degree of homology than different band patterns. In the diagram, the band patterns along human chromosome 2 show homology with both chimpanzee chromosomes 2A and 2B. Thus, it is reasonable to conclude that the two organisms have a close ancestry.

B is incorrect. There is no evidence of a translocation mutation between chimpanzee chromosomes 2A and 2B.

C is incorrect. The human and chimpanzee chromosomes share the majority of the bands shown in the pattern, which indicates homology.

D is incorrect. Using DNA or proteins to examine molecular homologies would provide more quantitative data, which would be stronger evidence than a chromosome band pattern.

Question 39 A

A is correct and **B** is incorrect. mtDNA shows variation due to mutation that occurs at a set rate over generations. It would be expected that groups inhabiting an area for a longer time period, such as Australia's First Nations peoples, would show more differences in their mtDNA (that is, less homology) than groups that have inhabited an area for a shorter period of time, such as Indigenous South Americans.

C is incorrect. Like any other section of DNA, homologous regions are subject to change.

D is incorrect. Gene mutations, regardless of their location, have a high chance of being detrimental.

Question 40 B

B is correct. The mud nests may have been built soon after the painting was completed, meaning that the painting could be 17 300 years old. However, the painting may have been present for a long time before the nests were built, so it could be much older than the nests.

A is incorrect. As the painting must have existed before the nests were built, it cannot be less than 17 300 years old.

C is incorrect. The painting could be exactly 17 300 years old.

D is incorrect. The paining cannot be less than 17 300 years old and could be more than 18 000 years old.

SECTION B

Question 1 (7 marks)

a. **Process:** translation 1 mark

Location: ribosomes 1 mark

b. **i.** Every living cell carries the same molecule (DNA) that provides a blueprint for proteins. 1 mark

ii. The polypeptide sequence would be the same as the protein should carry out the same function in all individuals. 1 mark

However, the codons may be different due to redundancy in the genetic code, as multiple codons can code for the same amino acid. 1 mark

c. The *(rough)* endoplasmic reticulum provides a network of tubes to transport the protein within the cell. 1 mark

The Golgi apparatus packages the protein into vesicles for eventual secretion from the cell. 1 mark

Question 2 (9 marks)

a. *For example, any one of:*

- consequences-based approach 1 mark

  The scientists could have been guided by a desire to prioritise positive outcomes and minimise negative outcomes. 1 mark

  This could be achieved by ensuring that patients who received a placebo/were not given the drugs were not subjected to excessive pain or suffering as a result of not receiving the drugs. 1 mark

- duty- and/or rule-based approach 1 mark

  The scientists may have adopted a rule-based approach and strictly adhered to the official ethical guidelines set by the scientific community. 1 mark

  This could be achieved by ensuring all patients took the drugs regularly, even if this was somewhat inconvenient for certain patients, so that the effects could be measured. 1 mark

- virtues-based approach 1 mark

  The scientists may have focused on personal moral values and prioritised the ethics of a 'good person'. 1 mark

  This could be achieved by carefully selecting and offering counselling to patients to ensure no patient experiencing the advanced stages of transthyretin amyloidosis would experience undue suffering or get their hopes up about the potential of the drugs. 1 mark

b. Single guide RNA 1 mark
anneals to the target DNA and is also bound to Cas9. 1 mark

Cas9 endonuclease 1 mark
cuts the target DNA. 1 mark

c. Beneficence is the act of doing good for the patient and includes ensuring their continued wellbeing, minimising harm and maximising benefits. 1 mark

In this case, the CRISPR-Cas9 treatment reduces symptoms at a higher rate than Onpattro (96% reduction versus 80% reduction); therefore, in terms of beneficence, the CRISPR-Cas9 treatment is more beneficial and should be used. 1 mark

Question 3 (8 marks)

a. Nuclear DNA contains both introns and exons. 1 mark

The insulin A and B gene segments only contain exons, so they are smaller than nuclear DNA gene segments. 1 mark

b. The insulin A gene is mixed with EcoRI, which cuts the gene at either end, forming two sticky ends. 1 mark

The untransformed plasmid is mixed with EcoRI, which cuts the plasmid once adjacent to the β-galactosidase gene, forming two sticky ends. 1 mark

The restricted, untransformed plasmid is mixed with the restricted insulin A gene. Ligase is added to anneal the complementary sticky ends, forming the recombinant plasmid. 1 mark

c. The insulin A and B polypeptides are removed and combined together to naturally form the functional protein. 1 mark

d. The ampicillin resistance gene (amp) only allows genetically modified bacteria to grow. 1 mark

The X-gal causes colonies of the genetically modified bacteria to be white and the bacteria that have not been transformed to be blue. 1 mark

Question 4 (7 marks)

a. *For example, any two of:*

- the Krebs Cycle
- the formation of most of the NADH coenzyme
- the formation of most of the carbon dioxide product

2 marks

Note: Accept other suitable responses.

b. Glycolysis: two ATP molecules per glucose molecule 1 mark

Krebs Cycle: two ATP molecules per glucose molecule 1 mark

Electron transport chain: 26 **OR** 28 ATP molecules per glucose molecule 1 mark

c. Biofuel is produced from the anaerobic fermentation of biomass. 1 mark

In this process, the glucose in the biomass is broken down by microbes in the absence of oxygen to produce ethanol. 1 mark

Question 5 (7 marks)

a. *For example:*

Mesophyll cells 1 mark
are where carbon dioxide absorbed from the air forms a C4 compound, which separates oxygen (also from the air) from Rubisco. 1 mark

Bundle sheath cells 1 mark
are where the C4 compound from mesophyll cells is absorbed, providing a source of carbon dioxide for carbon fixation using Rubisco that is in the bundle sheath cells. 1 mark

Note: Accept other suitable responses.

b. **i.** biomass change (%) 1 mark

ii. There would have been some stored glucose in each plant that provided a source of energy for some growth. 1 mark

The conditions (temperature and water availability) and plant type (corn or tomato) would have varied the plants' abilities to metabolise via photosynthesis and respiration, but the level of glucose produced would never be lower than the level of glucose required for growth. 1 mark

Question 6 (8 marks)

a. Each body cell *(not including red blood cells)* has self-antigens (MHC I) on its surface, which identifies the cell as belonging to the individual. As a result, these cells do not activate the immune system. 1 mark

If a cell has a non-self antigen displayed on its surface – in the case of COVID-19, it is left there as a viral fragment – the immune system is activated. 1 mark

b.

Immune cell	Innate, adaptive or both	Justification
natural killer cells	**innate immune system**	**Natural killer cells are non-specific. They bind to a cell that displays foreign antigens or has too much of a particular antigen. This leads to the destruction of the cell (apoptosis) regardless of the shape of the antigen.**
plasma cells	**adaptive immune system**	**Plasma cells are specific. After being clonally selected and expanding, they are involved in the production of specific antibodies. The antibodies have complementary shapes to specific antigens, and each different antigen activates a different type of active immunity.**

4 marks
1 mark for each correct cell.

c. *Any one of the following functions of ducts leading to the lymph nodes:*

- They carry APCs that display antigens on the MHC II molecules.
- They carry free-floating antigens.

1 mark

Any one of the following functions of ducts leading from the lymph nodes:

- They carry specific cytotoxic T cells.
- They carry specific helper T cells.
- They carry specific antibodies.

1 mark

Question 7 (8 marks)

a. autoimmune disease 1 mark

b. adaptive immune response **OR** cell-mediated response 1 mark

c. **i.** A helper T cell releases cytokines to activate B cells and cytotoxic T cells. 1 mark

ii. A cytotoxic T cell kills intracellular pathogens and eliminates mutated and cancerous cells. 1 mark

d. The antigens on the surface of a T cell can be isolated and then injected into an animal (such as a mouse or rabbit). 1 mark

The animal's immune system will develop an active immune response against the antigen by forming antibodies from clonally selected B plasma cells. 1 mark

The animal's blood could then be taken and the specific B plasma cells isolated. These are then fused with a cancer cell and the resultant hybridomas are grown in culture. 1 mark

The hybridomas will make specific antibodies that can be extracted and purified to be used as a form of treatment. 1 mark

Question 8 (8 marks)

a. Mutations occur randomly in the TBX3 gene in a pre-existing population. 1 mark

Some mutations in the TBX3 gene would have offered a survival advantage in environments where long legs are a more suitable adaptation. 1 mark

Horses with longer legs would have been more likely to survive to reproductive age and produce offspring with longer legs. 1 mark

Over generations, the continued survival advantage of the long leg phenotype leads to *Equus* having long legs. 1 mark

b. **i.** vestigial 1 mark

ii. The remnant digits did not change size, but the middle digit increased in size. Thus, it is more appropriate to suggest that the mutations that resulted in the larger middle digit have been selected for. 1 mark

c. *For example, any two of:*

- The length of the middle bone would need to be between that of *Mesohippus* and *Merychippus*.
- The width of the middle bone would need to be between that of *Mesohippus* and *Merychippus*.
- The size of the hoof would need to be bigger than that of *Mesohippus* but smaller than *Merychippus*.

2 marks

Note: Accept other suitable responses.

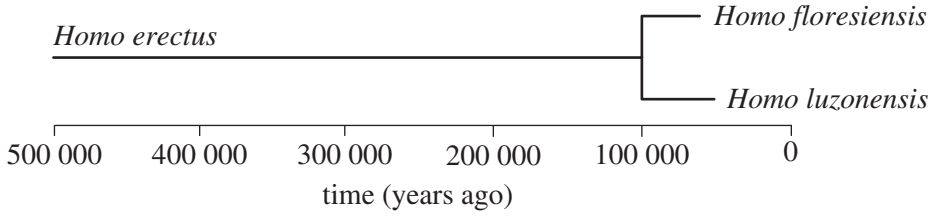
Question 9 (8 marks)

a. Hominin refers to the modern human group and all its bipedal ancestors. 1 mark

b. absolute dating **OR** radio isotopic dating 1 mark

This method compares the amount of a radioisotope remaining in a fossil (or in volcanic rock surrounding a fossil) to the amount that was originally present in the sample. Using the isotope's half-life, the age of the fossil can be determined. 1 mark

c.



3 marks

1 mark for drawing a scaled line dating back to 500 000 years ago.
1 mark for including all three species.
1 mark for indicating each species' time period accurately (Homo erectus starting 500 000 years ago and ending 100 000 years ago; Homo floresiensis branching off 100 000 years ago and ending 60 000 years ago; Homo luzonensis branching off 100 000 years ago and ending 50 000 years ago).
Note: Accept diagrams that are drawn differently but still convey the information shown in the sample response. Note that even though the earliest Homo luzonensis fossils were dated to 70 000–50 000 years ago, the species must have existed before then to have splintered from Homo erectus 100 000 years ago.

d. Since the Denisovan genome has been sequenced, some Denisovan DNA should be present in some Southeast Asian genomes. 1 mark

Since the *Homo erectus* genome has not been sequenced, genome material of unknown origin should be present in some Southeast Asian genomes. These unknown segments could come from *Homo erectus*. 1 mark

Question 10 (10 marks)

a. *For example:*

Different types of sugars and sugar substitutes will produce different rates of cellular respiration and amounts of heat in yeast. 1 mark

b. *For example, any one of:*

- pH of the mixtures
  These were not measured and, if they did vary, then the temperature changes could have been due to this rather than the type of sugar/sugar substitute.
- tap water
  Distilled water should have been used rather than tap water because, if there was an impurity in the tap water, the temperature changes could have been due to this and not the type of sugar/sugar substitute.
- ambient temperature of the room
  This was not measured and, if this did vary, the initial temperatures of the mixtures may have varied, which would have affected how much the temperatures changed.

2 marks

1 mark for identifying the variable that should have been controlled.
1 mark for outlining how the variable may have affected the data.

c. The student's statement is incorrect. The experiment was repeated but not reproduced. 1 mark

Repetition is the completion of an experiment multiple times under the exact same conditions. The experiment was repeated three times. An experiment is reproduced when it is conducted under changed conditions such as by a different experimenter using different equipment, which did not occur. 1 mark

d. 20°C *(29.2 – 9.2 = 20)* 1 mark

e. *For example, any four of:*

- All results show an increase in temperature, which indicates that the yeast was respiring in all flasks regardless of the type of sugar/sugar substitute.
- Glucose produced the biggest temperature changes, meaning that the yeast produced the most amount of heat when exposed to glucose. Thus, glucose caused a higher respiration rate and was metabolised more effectively than the other sugars/sugar substitutes.
- Stevia produced the smallest temperature changes, meaning that the yeast produced the least amount of heat when exposed to stevia. Thus, stevia caused a lower respiration rate and was metabolised less effectively than the other sugars/sugar substitutes.
- All sugars/sugar substitutes increased in temperature at 30 minutes, then decreased in temperature at 120 minutes due to the sugar/sugar substitute being depleted.
- The precision of the results is high as there is very little difference between each trial at each temperature.

4 marks

1 mark for each aspect of the data analysed.
Note: Analysis requires the selection of aspects of the data and explaining their implications. Responses must analyse at least four aspects of the data in order to obtain full marks.

