Neap:

Trial Examination 2014

# 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 |

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## SECTION A: MULTIPLE-CHOICE QUESTIONS

**Question 1 A**

Monomers are the single components that make up polymers. **A** (proteins are polymers of amino acids) and **B** (DNA is a polymer of nucleotides) are both correct but **C** and **D** are not. Ribosomes are about 60% RNA, but not DNA, making **B** incorrect. RNA polymerase is an enzyme and therefore a protein.

**Question 2 C**

The joining of amino acids occurs at the ribosome via the process of translation. When the ribosomes are embedded within the endoplasmic reticulum, translation still occurs in the ribosomes and the protein is eventually left in the lumen. So it is incorrect to say the amino acids are joined in the lumen. Protein synthesis is an example of a condensation reaction, giving off water as a by-product. Exergonic reactions/ catabolic and hydrolysis is the opposite to this.

**Question 3 D**

A point mutation is when one nucleotide changes in a gene which leads to a change in a single amino acid. This leads to a change in the primary structure of the protein as this is the amino acid order. Due to their different R groups the sequence of amino acids will fold for stability, and this is referred to as the secondary structure. A different amino acid in a specific position may change the folding. If the folding is different the final three-dimensional shape may also be different; this is referred to as the tertiary structure.

**Question 4 A**

Phospholipids have two ends with different properties. The phosphate head is charged and polar, which means it mixes well with water (also polar) and so faces outwards in a phospholipid bilayer. The fatty acid tails are not charged, which means they do not mix well with water and so face inwards in a phospholipid bilayer.

**Question 5 B**

Paramecium is a freshwater protist whose contractile vacuole would be optimally active in its natural environment. As the protist has cytosol that would be hypertonic to the fresh water, the paramecium would be absorbing water due to osmosis. The contractile vacuole would need to be active to remove the absorbed water, thus keeping the paramecium at an optimal volume. If the external environment became less hypotonic (or more hypertonic), then the contracting of the vacuole would become slower.

**Question 6 C**

Enzymes lower the activation energy regardless of the type of chemical reaction (anabolic or catabolic). One enzyme generally catalyses (speeds up) one reaction only, and so the active site is complementary to one substrate only. This may be contradicted slightly when looking at the induced fit hypothesis (higher level) rather than the lock and key hypothesis (VCE level). Enzymes are located throughout the cell, both within organelles (like the mitochondria) and in the cytosol.


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**Question 7 D**

This question is investigating the factors that speed up chemical reactions. As the enzyme in question is located in the mouth there are a variety of actions that may promote the action of the enzyme. Hot coffee would probably be at a higher-than-optimal temperature for amylase and so the breakdown of starch would be slower. The same applies to drinking cold orange juice where lower temperature and pH would probably be outside the optimal range for amylase. Drinking water that is lukewarm would dilute the enzyme and so it would probably take longer to break down a certain amount of starch. Chewing the bread without consuming anything extra would be the most efficient. The mouth is 37 degrees and about pH 7, and this would be expected to be the optimum conditions for amylase.

**Question 8 A**

Students should be aware of factors that control enzyme activity. This includes competitive (complementary shape to the active site) inhibitors that bind to the active site and slow down the reaction. It also includes non-competitive inhibitors that bind to a site away from the active site, which leads to a change in the shape of the active site. Students should also be aware of designed drugs that affect the functioning of enzymes. In this case the drug competes with the substrate and so would have a shape complementary to the active site.

**Question 9 D**

The ATP cycle is a two-way reaction. One way is the catabolic/exergonic/exothermic/hydrolysis reaction of converting ATP into ADP and using the energy for whatever reason is necessary. The other way is the anabolic/endergonic/endothermic/condensation reaction converting ADP into ATP. The energy to do this generally comes from cellular respiration.

**Question 10 C**

Students are expected to know the structure and function of both the chloroplast and the mitochondria. This question demands a structural understanding. Structure *G* is the mitochondrial cristae that increase the inner surface area for more efficient respiration. Area *H* is the matrix of the mitochondria and the site of the Kreb's cycle. Structure *I* is a stack of grana within the chloroplast, where the light-dependent reactions of photosynthesis occurs. Area *K* is the stroma of the chloroplast and the site of the light-independent reactions of photosynthesis.

**Question 11 B**

Functionally, structure *K* is the stroma and the site of the Calvin cycle (light-independent reaction). Area *F* is the intermembrane space where hydrogen ions accumulate to provide a gradient that drives ATPase to produce ATP. Area *H* is the site of the Kreb's cycle within the mitochondria. Structure *J* is a granum, a small membrane-enclosed thylakoid that is the area of the light-dependent reaction of photosynthesis.

**Question 12 B**

In a stimulus–response model the effector is the place where the message is sent to. In a typical reflex arc this would usually be a muscle that contracts. For example, if you touch something hot the heat receptors in the skin would detect a signal that is transferred (an action potential) to the CNS via sensory nerves. This message is branched out via motor nerves to the correct muscle group (effector), which respond with a coordinated combination of contractions that remove the hand from the heat source.

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**Question 13 D**

The structure and function of the synapse are important aspects of the functioning of the nervous system. Structure *Q* is a vesicle with neurotransmitters inside. Upon stimulation, these are released into the synaptic cleft via exocytosis. Neurotransmitters, like hormones, are signalling molecules, but they carry out different roles and so are classified separately.

**Question 14 C**

Students should be aware of the concept of signal transduction. This is where a signalling molecule initially binds to a receptor and triggers a series of intracellular events that lead to a specific response. In this situation, the neurotransmitter (chemical *R*) binds to the receptor (structure *S*) on the post-synaptic membrane. This leads to an internal cellular change which would be an action potential along the next nerve.

**Question 15 B**

Signalling molecules are a broad group of chemicals that bind to receptors (like a lock and key) and lead to a particular response. They can be different types of chemicals (protein and lipid) found in a variety of organisms (plants and animals) that lead to a myriad of responses. Signalling molecules include pheromones, hormones, neurotransmitters and plant growth regulators. The binding of the signalling molecule to the receptor depends on the properties of the signalling molecule. Protein signalling molecules bind to surface receptors but steroid hormones bind to receptors within the cell.

**Question 16 D**

For a plant to germinate and grow, a variety of events would need to occur. It would be reasonable to assume energy would be required for this process. The seed in the soil would be unable to photosynthesise, and so it would need a constant supply of glucose so that respiration could provide the energy. Seeds contain starch, which would need to be mobilised with the activation of amylase, and this would be a reasonable response due to GA. Once the energy is available for the seed to germinate, growth would occur. The two ways which growth could occur are due to cell elongation or increased mitotic divisions.

**Question 17 D**

Physical barriers in humans that reduce infection include unbroken skin and epithelial cells lining the lungs. The chemical barriers include secretions such as stomach acidity, mucus as well as a lysozyme. This is an antibacterial chemical secreted in tears that reduces the incidence of bacterial infections in the eye.

**Question 18 A**

Students should be aware of the quaternary structure of antibodies. There are four polypeptide chains that make one antibody, two short (light chains) and two long (heavy chains). They are connected to each other with a series of disulphide bonds and the end result is a Y-shaped molecule with two identical antigen binding sites at the top end of the Y. These regions are formed due to hypervariable sections at the end of each chain. This is coded for by a series of genes and is the central idea behind the clonal expansion theory. The light chains are placed on the outside of the antibody molecule.

**Question 19 C**

The cell-mediated immune response is generated against cells that pose a threat to the body. A cellular response is needed so the cell threat can be easily eradicated. This type of response is against virally infected cells, bacteria, eukaryotic pathogens and transplanted cells. The cell-mediated response involves the T cells. These can be cytotoxic T, repressor T, memory T or helper T cells.


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**Question 20 B**

It is clear from the data that breast-fed babies are about four times less likely to suffer gastrointestinal disease early in their life. A conclusion about vaccination cannot be made based on the available data, so **A** is incorrect. All newborn babies have a poorly developed immune system for the first year of their lives. This is why a vaccination program does not start as soon as a baby is born. Bottle-fed babies may be more prone to consuming pathogens due to poor hygiene in the preparation of the bottled milk, but it probably would not cause the dramatic difference expressed in the data. Breast-fed babies consume antibodies that the mother has produced, and these provide short-term passive resistance against pathogens which the babies may be naturally exposed to.

**Question 21 D**

The cell cycle during mitosis contains a division phase (mitotic phase) and a functioning phase (interphase). Interphase has a G1 phase (growth) where the cells grow and function normally, an S phase (replication) where the DNA replicates completely, and a G2 phase (pre-mitotic) where the replicated DNA coils to form chromosomes. Once the chromosomes are visible, the cell is in mitosis. After telophase the chromosomes uncoil and the cell is then in G1 phase again.

**Question 22 A**

When DNA is replicated it is a semi-conservative process. This means the original DNA double-helix unwinds to expose each strand. These strands then become templates for two new strands to be formed along them. In this way, two new double-helix molecules are formed that are identical to each other. These new strands will then be passed to the two new daughter cells. This process continues from one cell cycle to the next. However, the original strand of DNA only had two strands, and after five cell divisions these two strands would still be present.

**Question 23 D**

Pre-mRNA is the direct product of transcription. Beyond that, introns are removed and stabilising factors are added prior to mRNA forming. A methylated cap is added to the 5' end to enable the mRNA to bind to the ribosome and a poly-A-tail is added to the 3' end to allow the mRNA to detach from the ribosome.

**Question 24 A**

To convert the polypeptide sequence into an mRNA sequence the codon table needs to be used. Look up the appropriate amino acid code then use the table to determine the first, second and third nucleotide in the codon. There are quite a few combinations possible due to the redundancy in the code. **B** cannot be correct because thymine is not a nucleotide found in RNA.

**Question 25 A**

Val has the codons GUA, GUU, GUC, GUG.

Leu has the codons CUA, CUU, CUC, CUG, UUA, UUG.

The most likely change in the nucleotide sequence would be to the first nucleotide (whether it is C or U). If the G changed to a C then Leu would be coded for instead of Val. If the second nucleotide changed, Leu would not be the replacement amino acid, and if the final nucleotide was changed the same amino acid would be coded for in this example.

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**Question 26 C**

Students should be able to understand the diagram; even though the lac operon is not required knowledge, gene regulation is an important part of the course. Numbers 6, 7 and 8 are clearly the genes to be activated. This means that 1 is likely to be RNA polymerase (making either **C** or **D** correct). Due to the lock and key shape of 2 and 4, iIt is likely that 2, if bound to 4, would stop transcription. Therefore 2 would act as a repressor protein. To detach the repressor, lactose needs to be present and so 5 must be the lactose.
*Note: Knowledge of promoters and operators is not expected and even though this is part of the question, it is not important in determining the answer.*

**Question 27 B**

Knowledge of blood typing is not required but an understanding of the terms genotype, alleles and genes is. This is a dihybrid cross relating to blood typing and a person who is blood type A positive could have a variety of genotypes. They could be homozygous blood type A ($I^AI^A$) or they could be heterozygous blood type A ($I^AI^a$). They could be homozygous for Rhesus factor (RR) or they could be heterozygous (Rr). This gives four possible genotype combinations.

**Question 28 D**

The genotypes of both individuals in the question are $I^AI^BRr$. As their fathers were Rhesus negative they must be heterozygous for Rhesus factor. This question is best worked out with a Punnet square to ensure mistakes are minimised. This leaves a $\frac{1}{16}$ chance of a B negative blood type.

Genotype: $I^AI^BRr \times I^AI^BRr$

Gametes: $I^AR$, $I^Ar$, $I^BR$, $I^Br \times I^AR$, $I^Ar$, $I^BR$, $I^Br$

| | $\mathbf{I^AR}$ | $\mathbf{I^Ar}$ | $\mathbf{I^BR}$ | $\mathbf{I^Br}$ |
|---|---|---|---|---|
| $\mathbf{I^AR}$ | A pos | A pos | AB pos | AB pos |
| $\mathbf{I^Ar}$ | A pos | A neg | AB pos | AB neg |
| $\mathbf{I^BR}$ | AB pos | AB pos | B pos | B pos |
| $\mathbf{I^Br}$ | AB pos | AB neg | B pos | B neg ($I^BI^Brr$) |

**Question 29 B**

Students are told in the stem of the question that the trait is autosomal as well as being rare. Carriers/heterozygotes would be unaffected and should follow the family line from generation to generation. As the trait is rare it would not be expected that individuals such as II-2, II-6, III-3 and III-4 would be heterozygous. However, the recessive allele has been passed through several generations in this case study and so I-1 and I-2 must be carriers. II-5 must have inherited a copy of the recessive allele and passed it to III-5, who in turn passed it to IV-2. III-2 must have inherited the faulty allele from his affected father and passed it to IV-1. This gives I-1, I2, II-5, III-1, III-2, III-5, IV-1, and IV-1.


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**Question 30 C**

Individuals IV-1 and IV-2 have common great-grandparents and so there is a greater chance of each of them being heterozygous compared to random people meeting in the general population. However, when looking at the original parents, the same conclusion cannot be made because we cannot see their ancestors. Rare genetic disorders do appear every so often in the general population. IV-1 and IV-2 are both heterozygous and they would each have a 50% chance of being a carrier. It is true to say recessive traits tend to 'skip' generations but this is not always the case.

**Question 31 A**

There are clearly three geographically isolated regions of the rodents in central South America. The rodents with the diploid number of 10 are separated from the other populations by a large distance, making them geographically isolated. The rodents with a diploid number of 16 are found in the same location as rodents with other diploid numbers (15 and 14), and so gene flow could occur. The evidence of gene flow would be in the rodents with a diploid number of 15 (perhaps a hybrid of the 16 reproducing with the 14). There is no evidence to support hybrids between 10 and 16 and to conclude there are four distinct species is reasonable based on diploid numbers, but there clearly seems to be gene flow. If there is gene flow then a definite conclusion of this nature cannot be made.

**Question 32 A**

The gene pool in a population is the sum of all alleles within the group in the area. Altering the gene pool is less likely in large populations compared to small populations because in a small population a few individuals leaving can affect the proportion of alleles significantly (founder effect). If the environment changes it may still be within the tolerance range of the general population, meaning the gene pool will not change. If the resources favoured particular individuals then there may be a change in the gene pool, but there is no evidence of this. A mutagen may or may not cause a change.

**Question 33 C**

Fossilisation, as the question states, is a rare event. However, most fossils are formed in sedimentary rock. The process that leads to the most effective fossilisation would be: an organism dies and falls into water (or is in water); the organism sinks to the bottom of the water with other sediments; the organism is rapidly covered with sediments. The bottom of a body of water is cold (low decomposition), low in oxygen (anaerobic) and has high pressure. Under the sediments, scavenging is less likely. If the body of water is stationary the fossil will be more likely to remain intact. High pressures will solidify the sediments within and around the organism, and a fossil is formed.

**Question 34 C**

The most likely scenario for a particular group to evolve (like the birds, marsupials or amphibians) is that one ancestral group possessed the appropriate phenotype (due to a pre-existing mutation) which provided an advantage in a changing environment. In the case of marsupials, this would have occurred in one location, and divergent evolution would have then led to their current diversity. As they are mainly terrestrial, swimming thousands of kilometres is unrealistic, and even though land bridges are plausible, these are unlikely to have existed between Australia and South America. The most logical scenario is that marsupials evolved before Gondwanaland broke apart completely.

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**Question 35 A**

The individuals with more similarity in their amino acid sequences are likely to be more closely related because the mutations leading to these changes have had less time to accumulate. This means the rat, mouse and human are on a different line to the chicken. This eliminates **B** and **C**. The mouse and rat are more closely related to the human than the chicken and so they should branch off the human line reasonably close to the modern human.

**Question 36 D**

The evolutionary tree shows the vertebrates currently existing because their lineage carries on until the recent section. Any group that is extinct has a lineage that stops. In this evolutionary tree there are eight groups that are now extinct.

**Question 37 C**

Using the timeline and a ruler, the events occurring within a time period can be seen. The width of the black line is the key to solving this question. The number of primate genera decreased slightly, showing that there were selection pressures on them. The number of carnivore genera was gradually increasing, showing that there were selection pressures active on that group as well. There is no evidence in this type of evolutionary tree to illustrate convergent evolution; the cladogram illustrates the divergence of the vertebrates. The rodent genera significantly increased during this time, illustrating a wide variety of environments to exploit.

**Question 38 C**

DNA hybridisation is a procedure that determines the similarity in homologous strands of DNA from different individuals. In this case it is comparing human, Neanderthal and chimpanzee fragments of DNA. The DNA is heated to break the hydrogen bonds, then mixed together with fragments from the other individuals, and finally re-melted to determine the amount of hybridisation. The graph shows that the percent of pairs of nucleotides that were different in the human–Neanderthal hybrids was 17.5%.

**Question 39 A**

The human and Neanderthal (both hominins) co-existed for a very long time but there is little evidence to illustrate that they should be classified as only one species. Due to their location, body structure and in the case of this question, DNA, the two groups should remain as two different species. There is very little overlap between the hybridised DNA of the human–Neanderthal compared to the human–human. This means the DNA in the Neanderthals is significantly different, suggesting they were reproductively isolated groups with very little gene flow. If this was not the case there should be more overlap with the hybridised data.

**Question 40 A**

Gene therapy is a biotechnological technique which students need to be aware of, along with how this technique has affected our evolution. The example used here is somatic gene therapy, which is not heritable and so should not impact on our evolution (where the gene pool changes). Germ line gene therapy is illegal (in most parts of the world) as it is heritable and likely to have a more significant effect on the gene pool. The prospect of gene therapy is huge, as is the prospect of stem cell therapy, and so it would be unwise to place one ahead of the other in terms of merit. Once the modified T cells are placed back in the body, there is a chance if they divide that the inserted gene would be passed onto their daughter cells, and so on. The diagram shows that two T cells were modified and four were produced from them, supporting this argument.

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## SECTION B: SHORT-ANSWER QUESTIONS

### Question 1 (6 marks)

**a.** *Any two of:*

- provide a barrier between an internal and external environment (or the inside and outside of an organelle)
- allow chemicals to move across them via osmosis, diffusion, facilitated diffusion, active transport, endocytosis or exocytosis
- receive messages and transfer these into a form the cell can respond to self-identification

2 marks

**b.** If the temperature is too high the membrane has too much fluidity and may not be able to hold together, which would compromise the function of the membrane. 1 mark

If the temperature is too low the membrane does not have enough fluidity and may compromise the movement of components/chemicals through it. 1 mark

**c.** **i.** lipid (steroid) 1 mark

**ii.** In the cold environment of the Arctic, the salmon need their membranes to have optimal fluidity. Increased cholesterol in the membrane increases the fluidity of it in the colder environment. 1 mark

*The second sentence or words to that effect are required.*

### Question 2 (9 marks)

**a.** ribosomes (in the chloroplast as well as in the cytosol) 1 mark

**b.** **i.** Reactant 1: ATP 1 mark

**ii.** Reactant 2: NADPH 1 mark

*Note: Also accept hydrogen ions.*

**c.** Split the RuBisCO into five equally sized amounts and place each into a variety of pH solutions (for example, set pH of 3, 5, 7, 9 and 11). This is the independent variable. 1 mark

Place the RuBisCO into a container with the substrates (ribulose 1,5 biphosphate, carbon dioxide and water) and measure the:

- depletion of carbon dioxide
- depletion of water
- production of glycerate biphosphate

This is the dependent variable. 1 mark

Make sure other potential variables such as temperature, concentration of RuBisCO and concentration of substrates remains constant. 1 mark

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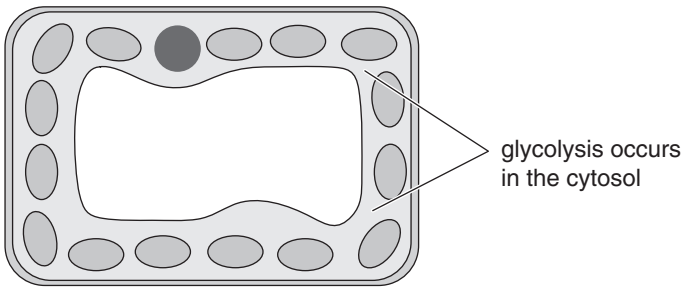
**d.** **i.**




1 mark

**ii.** For carbon fixation (a part of photosynthesis) to occur, light needs to be available to provide the requirements for it. Therefore water and carbon dioxide would need to be available. For glycolysis (a part of respiration) to occur, glucose would need to be available. 1 mark

All of the carbon dioxide, water and glucose would need to be available in equal amounts so that the processes can proceed at the same rate. 1 mark

**Question 3 (5 marks)**

**a.** $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + ATP$ (36 or 38)

2 marks
*1 mark for inputs/outputs*
*1 mark for mentioning energy/ATP*

**b.** When the seeds are respiring they produce $CO_2$, which is absorbed by the potassium hydroxide. This creates a negative pressure which forces the water up the tube. 1 mark

**c.** The water moves the furthest distance of 55 mm. This means the enzyme is moving rapidly within the seeds, colliding with substrates at the optimal speed. 1 mark

If the temperature was any warmer the three-dimensional shape of the active site would start to change, as there would be pressure on the chemical bonds holding the enzyme together. 1 mark

**Question 4 (6 marks)**

**a.** Glucagon is a protein and is water soluble. It binds to receptors on the surface of the muscle cell plasma membrane. 1 mark

Testosterone is a steroid and is water insoluble. It binds to receptors in the cytosol of the muscle cell. 1 mark

**b.** Glucagon binds to a receptor and, via a series of intermediate messengers, activates glycogen phosphorylase. 1 mark

The active enzyme speeds up the hydrolysis of muscle glycogen stores, which makes glucose available for respiration and the energy can be used for muscle development. 1 mark

**c.** Glucagon activates an enzyme, and once the enzymes can no longer function there will be less available for hydrolysis of glycogen, which explains why it is short lasting. It acts fast because the enzyme is already in the cell. 1 mark

Testosterone activates a gene and for it to express a protein takes more time. It is long-lasting as the mRNA will remain for a greater duration and each mRNA strand can express many proteins. 1 mark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**Question 5 (6 marks)**

**a.** The allergen will have a specific shape which will bind to an antibody on the surface of a specific B cell and, as a result, the B cell will divide. 1 mark

The B cells will differentiate into plasma cells and produce many antibodies against the allergen (antigen). 1 mark

**b.** **i.** Upon contact to the antibodies on the surface of the mast cell, it degranulates and releases histamines into the local area. 1 mark

The histamines lead to inflammation by dilating local blood vessels. The area then gets red and swollen, which can be very dangerous. 1 mark

**ii.** Memory B cells remain in the body and when the allergen is introduced to the body in the future, they respond more quickly (clone and differentiate) and generate more antibodies. 1 mark

These will then bind to receptors on the surface of a greater amount of mast cells, generating a more severe response. 1 mark

**Question 6 (6 marks)**

**a.** **i.** A bacteria is a prokaryotic organism lacking membrane-bound organelles and it has one large circular chromosome. 1 mark

**ii.** Do not prepare food in water that is faecally contaminated because this is where the cholera bacteria are located. 1 mark

**b.** **i.** The bacteria is no longer able to divide and cause disease. 1 mark

The cholera antigens are still on the surface of the bacteria, which means the immune system will be able to recognise it as non-self. 1 mark

**ii.** The lymphatic system contains lymph nodes that contain a high concentration of lymphocytes. 1 mark

The chance of an interaction between the antibodies on the surface of the correct B cell/T cell and the cholera antigens is much higher. 1 mark

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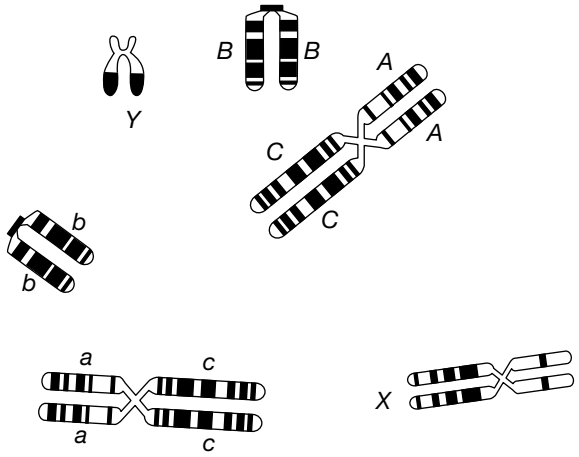
**Question 7 (5 marks)**

**a.** The genotypes show they are autosomal.




**i.** See diagram above. 1 mark

*1 mark for showing that the genes are independently inherited (on different chromosomes).*

**ii.** See diagram above. 1 mark

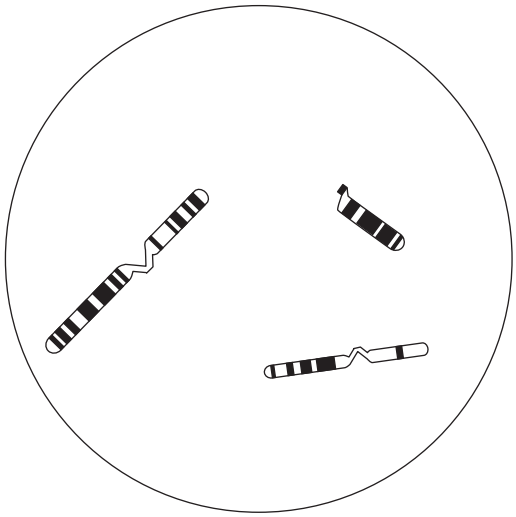
*1 mark for noting the genes are linked and so gene C is on the same chromosome as gene A.*

*Points to look for: individual chromatids from the one chromosome are labelled with the same alleles, the loci remain consistent for each gene, the sex chromosomes are not labelled*

**iii.** 8 1 mark

(Each pair can assort in two ways and due to independent inheritance, three pairs can assort in $2 \times 2 \times 2$ ways.)

**b.**



2 marks

*1 mark for three chromosomes present OR six chromatids (either way students are giving half of what is present in the question, which is incorrect but deserves credit)*

*1 mark for three chromatids present (haploid)*

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**Question 8 (6 marks)**

**a.** The phenotype is defined as the expressed characteristic, which is a combination of the genes inherited as well as the environmental influence on them. 1 mark

**b.** **i.** cross 2 1 mark

**ii.** Both parents in cross 2 do not have tails and one of their offspring is tailed, which means both parents must be heterozygous. 1 mark

Cross 1 gives results suggesting both parents are homozygous. It is not possible to predict from cross 3 which individual is heterozygous and which is homozygous. 1 mark

**c.** Both parents in cross 2 are heterozygous and it would be expected that the offspring phenotypic ratio produced would be 3 tailless : 1 tailed. 1 mark

The ratio of 2 tailless : 1 tailed could be explained by a lethal combination of alleles. Out of the four possible genotypes, one would be homozygous dominant (2 tailless alleles). If this did not survive (lethal) then there would only be heterozygous tailless cats in the offspring, making the ratio of tailless to tailed 2 : 1. 1 mark

**Question 9 (6 marks)**

**a.** The DNA code is universal. The same four nucleotides are found in all organisms, which code for protein synthesis in the same way. 1 mark

**b.**

jellyfish

**PCR: to extract and amplify the GFP gene**

**Restriction enzymes: to cut the GFP and vector at each end**

**Vector: mix the GFP gene with the vector**

**Ligase: integrates the GFP into the vector**

rabbit

3 marks

*Each technique needs to be discussed and it needs to be in order.*
*Subtract 1 mark for each error.*

**c.** The plasmids are inserted into bacteria so the genes can be expressed when the bacteria are plated on agar. 1 mark

If the agar is mixed with the antibiotic the plasmid codes for the surviving bacteria not only have resistance to the antibiotic, but they will also carry the GFP gene. 1 mark

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**Question 10 (5 marks)**

**a.** More virulent bacteria are surviving in an environment with antibiotics because more people are presenting with infections requiring antibiotic treatment. Initially there may have been less virulent bacteria in the population, but over time they were at a selective disadvantage. 1 mark

**b.** There is variation in the bacteria with respect to bacterial resistance. 1 mark

In an antibiotic-rich environment, the resistant bacteria are more likely to survive and reproduce. 1 mark

This means the proportion of resistant bacteria will increase in the population. 1 mark

**c.** Cultural evolution is the exchange of behaviours between individuals and generations. The use of antibiotics is an example of cultural evolution because if it helps, this is communicated to others. 1 mark

**Question 11 (4 marks)**

**a.** The fossils in layer *A* are younger than the fossils in layer *B*. 1 mark

**b.** **i.** Volcanic rock contains radioactive isotopes of potassium that decay into argon at a known rate, and this is measured using a term called the half-life. 1 mark

By comparing the amount of potassium found in fresh volcanic rock and the rock layer in question, the age of the rock layer can be determined. 1 mark

**ii.** The age of fossil *B* is somewhere between 520 million years old and 545 million years old. 1 mark

**Question 12 (6 marks)**

**a.** **i.** tDNA shows variation due to mutation only. 1 mark

Nuclear DNA shows variation due to mutation as well as events during meiosis that contribute to variation, such as independent assortment as well as crossover. 1 mark

**ii.** Mutations occur at a set rate, and the number of differences in nucleotides between individuals would be a reasonable measure of how long ago they diverged because their ancestor would have had the same mtDNA. 1 mark

**b.** If the genes in mtDNA mutated, it may place the individual at a disadvantage; however, mutations in non-coding regions are more likely to be passed onto the next generation as they are less likely to place the individual at a selective disadvantage. 1 mark

**c.** There would be more mutations in the HVR1 in the African population as they appeared 150 000 years ago, followed by the Middle East (100 000), and then a branch to Asians and Europeans. 1 mark

The data suggests that humans evolved first in Africa, then migrated out of Africa to the Middle East. They then diverged to Asia and Europe. 1 mark

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