



YEAR 12 Trial Exam Paper

2019 BIOLOGY

Written examination

Worked solutions

This book presents:

- high-level sample answers
- explanatory notes
- mark allocations
- tips.

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SECTION A – Multiple-choice questions

Question 1

Answer: D

Explanatory notes

Option A is incorrect because although all nucleotides contain a phosphate group, a sugar and a base, the identity of the sugar and the base are not the same in all nucleotides.

Option B is incorrect because although the nucleotide could contain thymine, thymine is not an amino acid.

Option C is incorrect because there is insufficient information provided to determine whether this nucleotide is located in DNA or RNA. The identity of the sugar and the base would need to be known to make this determination.

Option D is correct because nucleotides join together when condensation occurs.



Tip

- *It is important to read through all the information carefully before selecting an option. Some distractors will contain information that is mostly correct but contains a fundamental error. In this example, it would be correct to state that a nucleotide could have a thymine base; however, thymine is not an amino acid. Focusing on the word 'thymine' and not processing the entire sentence could lead to selecting this incorrect option.*

Question 2

Answer: C

Explanatory notes

Option A is incorrect because this describes the primary structure.

Option B is incorrect because this describes a peptide bond.

Option C is correct because quaternary structure occurs when two or more polypeptides bind to produce a single functional protein.

Option D is incorrect because this describes the tertiary structure.

Question 3

Answer: C

Explanatory notes

Option A is incorrect because this assumes that cytosol only contains water and sodium chloride, which is inaccurate.

Option B is incorrect because there is insufficient information to determine whether or not this is the case.

Option C is correct because the tonicity of the surrounding solutions enables the movement of water across the plasma membrane of the cells, resulting in the increase or decrease of the mass of the cells in the potato cylinder.

Option D is incorrect because the change in the mass of the potato cells is due to the movement of water, not to the movement of sodium chloride.

Question 4

Answer: B

Explanatory notes

After the polypeptide chain has been modified into a protein by the Golgi apparatus, the protein is packaged into a secretory vesicle (II). The secretory vesicle moves towards the plasma membrane (I) before fusing with it (III). Because both the membrane of the vesicle and the plasma membrane are made up of a phospholipid bilayer, the action of fusion enables the protein to be released into the extracellular fluid (IV).

Question 5

Answer: D

Explanatory notes

All small molecules can diffuse across the plasma membrane, regardless of their polarity; therefore, the solutes in solutions 1 and 3 would be able to diffuse across the plasma membrane of the cells in these solutions, causing the cells to become radioactive. All non-polar substances can diffuse across the plasma membrane regardless of their size; therefore, the solutes in solutions 3 and 4 would be able to diffuse across the plasma membrane of the cells in these solutions, causing the cells to become radioactive.



Tip

- *There are several topics in Biology where multiple terms have the same meaning. It is important to be aware of this and to be familiar with all terms that are commonly used. In this example, the solute molecules are referred to as polar or non-polar. However, polar substances are also referred to as being hydrophilic and non-polar substances are hydrophobic.*

Question 6**Answer: A****Explanatory notes**

Option A is correct because a repressor protein needs to be able to change shape. The protein will have one conformation when it is bound to the operator region of the gene but must change shape to release the operator region.

Option B is incorrect because the term 'structural' relates to the gene, not the protein.

Option C is incorrect because a regulatory region is an area of DNA and would not bind to cells.

Option D is incorrect because the term 'regulatory' also relates to genes not proteins. A regulatory gene is one that codes for the production of a protein that regulates the expression of other genes. In this example, the CTBP1 gene is a regulatory gene because the CTBP1 protein affects the transcription of other genes.

Question 7**Answer: B****Explanatory notes**

If the concentration of enzyme X were increased then the rate at which substance 1 is converted into substance 2 would also increase. However, the amount of the final product, substance 4, that is produced depends on the amount of substrate supplied at the start of the reaction, not the speed at which the reactions occur.

Question 8**Answer: D****Explanatory notes**

This question is about the structure of substances A and B.

Option A is incorrect. The rate of the reaction would be decreased if substance B were an inhibitor. If substance B were a non-competitive inhibitor, it would bind to the regulatory region of the enzyme, causing the active site to change shape, as in option C. However, the similarity in shape between structures A and B means that this is unlikely.

Option B is irrelevant because it refers to pH.

Option C is incorrect because repressor proteins regulate transcription, not the rate of enzyme catalysed reactions.

Option D is correct because the lower segments of the two substances are similar in shape. This enables substance B to act as a competitive inhibitor, binding to the active site of the enzyme and blocking some of the substance A molecules from binding to the enzyme.

Question 9***Answer: A*****Explanatory notes**

The aerobic stages of cellular respiration include the Krebs's cycle and the electron transport chain. However, if the electron transport chain is non-functional, then the Krebs's cycle will also not function. Therefore, aerobic cellular respiration will not occur. Glycolysis can still occur and produces net 2 ATP. However, this question specifically asks about the amount of ATP produced aerobically, which is zero.

Question 10***Answer: B*****Explanatory notes**

The fact that the rate at which the substance crosses the plasma membrane decreases when the cell's ability to produce energy is decreased indicates that energy is required for the substance to be transported. Therefore, active transport is the only possible answer because all the other processes referred to are passive.

Question 11***Answer: B*****Explanatory notes**

Option A is incorrect because most plant cells do not contain chloroplasts and therefore cannot carry out photosynthesis.

Option B is correct because ATP is produced during both processes. ATP is produced during the light-dependent stage of photosynthesis and in the matrix and cristae of mitochondria.

Option C is incorrect because only photosynthesis is endergonic; cellular respiration is exergonic.

Option D is incorrect because although NADH is produced during glycolysis and the Krebs cycle, it is NADPH that is produced during the light-dependent stage of photosynthesis.

Question 12**Answer: C****Explanatory notes**

Option A is incorrect because there is no information that supports this conclusion.

Option B is incorrect because neither of the cells would be carrying out aerobic cellular respiration as the surrounding solution does not contain any oxygen.

Option C is correct. The concentration of carbon dioxide in the solution around cell type 1 has not increased, and therefore the type 1 cells are not producing any carbon dioxide. The concentration of carbon dioxide surrounding the type 2 cells has increased, indicating that these cells are producing carbon dioxide. Because there is no oxygen, both cells will be carrying out anaerobic respiration. Animal cells produce lactic acid under these conditions, but plant cells produce ethanol and carbon dioxide.

Option D is incorrect because the type 1 cells are not producing carbon dioxide. This is indicated by the fact that the graph shows that the concentration of carbon dioxide did not change over the course of the experiment.

Question 13**Answer: D****Explanatory notes**

Option A is incorrect because the graph shows that photosynthesis is occurring, and therefore the plant would still be producing oxygen gas.

Option B is incorrect because oxygen is not an input of photosynthesis and therefore cannot become a limiting factor.

Option C is incorrect because carbon dioxide was initially a limiting factor, but as the availability of carbon dioxide increased, it ceased to be a limiting factor.

Option D is correct. Initially there was a low concentration of carbon dioxide, and therefore carbon dioxide was a limiting factor, in the reaction. However, as the concentration of carbon dioxide increased, it ceased to be a limiting factor and a different factor, such as light intensity, became limiting.

**Tip**

- *The ability to read graphs and interpret the information correctly is a vital skill to have because graphs that are similar in shape frequently convey different information. The axis labels provide crucial information about what the graph is conveying and enables the dependent and independent variables to be identified.*

Question 14**Answer: C****Explanatory notes**

Option A is incorrect because HGH does not cause individual cells to increase in size.

Option B is incorrect because HGH is hydrophilic, therefore the hormone is unable to diffuse across the plasma membrane, so the receptor cannot be located in the cytosol of the target cell.

Option C is correct because the information provided states that HGH is hydrophilic, which means that it is a peptide hormone. The receptor will be located on the external surface of the target cell. Reception of the hormone triggers a second messenger inside the cell.

Option D is incorrect as this is the mode of action of steroid hormones and HGH is a peptide hormone.

Question 15**Answer: A****Explanatory notes**

Bax and Bak are able to pierce the mitochondrial outer membrane to mediate cell death by apoptosis. Following a variety of stress signals, they convert into pore-forming proteins by changing conformation forming pores in the mitochondrial membrane. Proteins from the mitochondrial intermembrane space then empty into the cytosol to activate proteases that dismantle the cell.

Question 16**Answer: D****Explanatory notes**

The fact that the cells carry out two different responses means that they are responding to two different signalling molecules. It is useful to apply knowledge that blood glucose regulation is governed by the antagonistic hormones insulin and glucagon.

Question 17**Answer: C****Explanatory notes**

Option A is incorrect because clonal expansion occurs after B cells are presented with antigenic fragments.

Option B is incorrect because antibodies are produced by B plasma cells.

Option C is correct because complement binds to pathogens and increases the ability of phagocytes to clear bacteria.

Option D is incorrect because complement does not act as a cellular barrier.

Question 18**Answer: A****Explanatory notes**

Option A is correct because cytotoxic cells are able to recognise specific viral antigens and act against cells that have been invaded by a specific virus. Natural killer cannot recognise specific antigens and play a role in the innate immune system.

Option B is incorrect because neither of these cells produce antibodies.

Option C is incorrect because although both of these cells play similar roles in acting against virally infected cells and tumour cells, they are different to each other.

Option D is incorrect because cytotoxic cells do not produce toxins that act against pathogens, they produce perforins which cause the production of holes in the plasma membrane of an affected cell. Natural killer cells do not engulf pathogens.

Question 19**Answer: C****Explanatory notes**

Option A is incorrect because the information provided states that the individual has already been exposed to the pollen. Also, pollen is antigenic and is not an antibody.

Option B is incorrect because a drug binding to mast cells would not have this effect.

Option C is correct because if the drug binds to the histamine receptors then histamine cannot bind these receptors and the symptoms should not occur.

Option D is incorrect because IgE antibodies bind to the mast cells after the initial exposure to the pollen allergen. The person would not experience any symptoms at this point.

Question 20**Answer: A****Explanatory notes**

Option A is correct because the graph shows that antibody production increases after day 11. It is possible that this could have occurred as a result of a booster shot because these contain antigens.

Option B is incorrect because although the person has been exposed to the same antigen twice, this does not have to have been a pathogen. The response could have been the result of exposure to an antigenic fragment or a toxin.

Option C is incorrect because the graph indicates that the production of antibodies is highest on day 16. This does not mean that the person is experiencing any symptoms.

Option D is incorrect because antibody production occurs due to exposure to an antigen. Passive immunity occurs when an individual is exposed to antibodies from a different organism.

**Tip**

- *Always be wary when absolute words such as 'only', 'never', 'must' or 'always' are used in a multiple-choice option. These mean that there is no other possibility and these options are more likely to be incorrect than correct.*

Question 21**Answer: B****Explanatory notes**

Option A is incorrect because radiocarbon dating is only useful for dating organic remains up to approximately 70 000 years old.

Option B is correct because potassium-to-argon dating can be used to date objects of this age.

Option C is incorrect because determining the extent of structural similarity of the fossil to other fossils will not provide any information about the age of the fossil.

Option D is incorrect because this option describes relative dating, not absolute dating.

Question 22**Answer: D****Explanatory notes**

Option A is incorrect because a fire is usually a local event and would not cause a mass extinction.

Option B is incorrect because only prokaryotic organisms existed at this time and therefore there are unlikely to be any fossils present.

Option C is incorrect because the fact that the stratum originated in a lake has no link to a mass extinction having occurred.

Option D is correct because lack of fossils in a layer surrounded by two layers abundant in fossils indicates that a mass extinction must have occurred.

Question 23**Answer: A****Explanatory notes**

Option A is correct because evolution is defined as a change in allele frequency over a period of many generations.

Option B is incorrect because the complexity of modern organisms varies, with some very simple organisms still existing.

Option C is incorrect because this describes natural selection, which is a mechanism of evolution but is not the definition of evolution.

Option D is incorrect because this describes the effect of mutations and natural selection.

Question 24**Answer: B****Explanatory notes**

The action of the bees favours the survival of the plants that produce pink flowers. Removal of the bees removes the selective advantage conferred by pink pigmentation. As a result, it would be expected that the prevalence of white flowering plants would increase.

Question 25

Answer: A

Explanatory notes

Option A is correct because mutations, such as the one referred to, may cause the production of new alleles.

Option B is incorrect because denaturation is caused by heating proteins or exposing them to extreme pH conditions. Mutations do not cause proteins to denature.

Option C is incorrect because the mutation is a deletion mutation, not an addition mutation. The sequence in the affected individual is missing one base pair compared with that of the unaffected individual.

Option D is incorrect because there is no information to indicate that the gene is not expressed.

Question 26

Answer: B

Explanatory notes

Option A is incorrect because genetic equilibrium is irrelevant in causing speciation.

Option B is correct because gene flow between the different finch populations needs to be prevented for speciation to occur.

Option C is incorrect because if the finches are located on separate islands, then they will not be competing with each other.

Option D is incorrect because a number of islands were colonised, not just one island.

Question 27**Answer: C****Explanatory notes**

The warbler finch has a short, narrow beak. The short beak was caused by low expression of the *CaM* gene and the narrow beak was caused by low expression of the *BMP4* gene.

Question 28**Answer: D****Explanatory notes**

The melting temperature of a DNA hybrid is a direct reflection of the strength of the bonds between the strands of the two different species. Species that are closely related have greater similarity in DNA and therefore the DNA in the hybrid is more strongly bound, causing a higher melting temperature. Species A and D are the least related, and therefore the bonding in this hybrid would be the weakest and would have the lowest melting temperature.

Question 29**Answer: A****Explanatory notes**

Option A is correct because cartilage is a soft tissue, so is not hard enough to fossilise.

Option B is incorrect because megalodons lived in a marine environment, which provides excellent conditions for fossilisation.

Option C is incorrect because there is no information provided to support this.

Option D is incorrect because the depth at which megalodons lived is unknown.

Question 30**Answer: B****Explanatory notes**

Option A is incorrect because *Homo sapiens* and *Homo neanderthalensis* both existed in Europe at the same time.

Option B is correct because *Homo sapiens* and *Homo neanderthalensis* were contemporaries and were able to interbreed with each other. Therefore, *Homo neanderthalensis* could not have been the ancestor of *Homo sapiens*.

Option C is incorrect because *Homo sapiens* and *Homo neanderthalensis* are both believed to be descended from *Homo heidelbergensis*.

Option D is incorrect because it has been proved that all modern humans, with the exception of those whose ancestors never left Africa, have some genes derived from *Homo neanderthalensis*.

Question 31**Answer: C****Explanatory notes**

Mitochondrial DNA is passed down the maternal line, and therefore the male will have different mtDNA compared with his father and grandfather. The daughter of the unknown male will have inherited her mtDNA from her mother, not her father. The unknown male and his sister would have inherited the same mtDNA from their mother. The male's niece would also have inherited this mtDNA from her mother. Therefore, this would be the best comparison.

Question 32**Answer: B****Explanatory notes**

The amino acid sequences from closely related organisms will be more similar to each other than those of less related organisms. There is only one difference between the sequence from species 1 compared with the sequence from the human. Therefore, this sequence is most likely to have come from a chimpanzee.

Question 33**Answer: D****Explanatory notes**

Option A is incorrect because vascular plants are believed to have appeared about 450 million years ago, flowering plants are believed to have appeared between 150 and 100 million years ago.

Option B is incorrect because photosynthetic bacteria did not appear until about 2.4 billion years ago, whereas non-photosynthetic prokaryotes appeared about 3.5 billion years ago.

Option C is incorrect because less complex prokaryotes appeared before eukaryotes.

Option D is correct because endosymbiosis refers to eukaryotic cells taking up prehistoric bacteria that subsequently became chloroplasts and mitochondria.

Question 34**Answer: B****Explanatory notes**

Option A is incorrect because although this is possible, it is not certain. Even if this did occur, it would have nothing to do with the time spent in space.

Option B is correct because all organisms are capable of acclimatising to changes in their environment. Acclimatisation is not permanent.

Option C is incorrect because selection pressures cause change over many generations, not in a single individual over a short period.

Option D is incorrect because if the increase in height were due to a mutation then the effect of this mutation would not be temporary.

Question 35**Answer: A****Explanatory notes**

Option A is correct because modern humans are the only living species known to have a chin.

Option B is incorrect because there are many species that have a foramen magnum in the base of their skull; however, the foramen magnum in a human skull occupies a more central position than that of other primates.

Option C is incorrect because the angle of thigh bone (femur) between the hips and the knees is not 90 °; the femur actually angles inwards from the hips to the knees. This is referred to as the carrying angle and it is an adaptation that facilitates bipedalism.

Option D is incorrect because many hominoids and primates are also pentadactyl.

Question 36**Answer: C****Explanatory notes**

Option A is incorrect because many species live in social groups without having the ability to speak with each other.

Option B is incorrect because there are some other species that are capable of developing tools for specific tasks. For example, chimpanzees create a simple tool that enables them to extract termites from mounds.

Option C is correct because the fact that burial rites and ceremonies were carried out indicates that the people who did this had the ability to speak with each other.

Option D is incorrect because there are many species that carry out hunting or gathering in groups.

Question 37**Answer: B****Explanatory notes**

Recombinant DNA is produced when DNA from two or more sources is annealed to make a single construct.

Question 38**Answer: D****Explanatory notes**

Option A is incorrect as primers bind to DNA to enable transcription to occur.

Option B is incorrect as restriction enzymes (endonucleases) are used to cut DNA into fragments.

Option C is incorrect as DNA ligase is used to anneal fragments of DNA together.

Option D is correct because vectors, such as plasmids, are used to transport recombinant DNA into target cells.

Question 39

Answer: A

Explanatory notes

The information provided states that EcoRI was used to cut around the gene of interest. Therefore, EcoRI is the only restriction enzyme that should be used to cut the plasmid open. It is necessary to use the same restriction enzyme to make both cuts so that complementary sticky ends are produced that enable the gene of interest to be annealed into the plasmid.

Question 40

Answer: B

Explanatory notes

Option A is incorrect because although a designed drug may bind to the active site of an enzyme, it does not have to do so.

Option B is correct because the purpose of producing a drug is for it to have a therapeutic effect.

Option C is incorrect because a drug may be designed to act against a bacterial or viral infection. However, none of the drugs currently produced act against both bacterial and viral infections.

Option D is incorrect because the drug does not have to have the same chemical constituents of the pathogen it was constructed to act against. It does have to be designed to bind to a target molecule to provide a therapeutic benefit.

SECTION B

Question 1a.

Worked solution

amino acids

Amino acids are joined together by a condensation reaction. As two amino acids are joined together, a water molecule is released. (The bond that occurs between two amino acids is called a peptide bond.)

Mark allocation: 2 marks

- 1 mark is awarded for identifying amino acids as the sub-units of proteins
- 1 mark is awarded for identifying that they are joined together as a result of a condensation reaction, and for stating that a molecule of water is released as each bond is formed

Question 1b.

Worked solution

The mRNA would be expected to be 4395 bases in length.

Each amino acid is coded for by a codon (triplet) of bases. The final codon in the mRNA is a stop codon that codes for a release factor instead of an amino acid. Therefore, there should be 1465 codons in the mRNA. Because each codon is made up of three bases, the length of the mRNA would be 1465×3 .

Mark allocation: 2 marks

- 1 mark is awarded for stating that the mRNA would be expected to be 4395 bases in length
- 1 mark is awarded for explaining that the number of bases was determined by explaining that the mRNA would have been made up of 1465 codons and that the number of bases was determined by multiplying this number by 3



Tip

- *It is important to provide full details in your answer to any question that requires an explanation because consequential marks may be awarded. In this example, the existence of the stop codon may have been overlooked, leading to an answer of 4392 bases in length. No mark would be awarded for this. However, if you explained that you had reached this answer by multiplying the number of codons by 3 as each codon is made up of a triplet of bases then a consequential mark would be awarded.*

Question 1c.**Worked solution**

The information provided states that the DNA is 18 000 base pairs long, but the mRNA has been calculated as being 4395 bases long. There is a discrepancy of 13 605 bases.

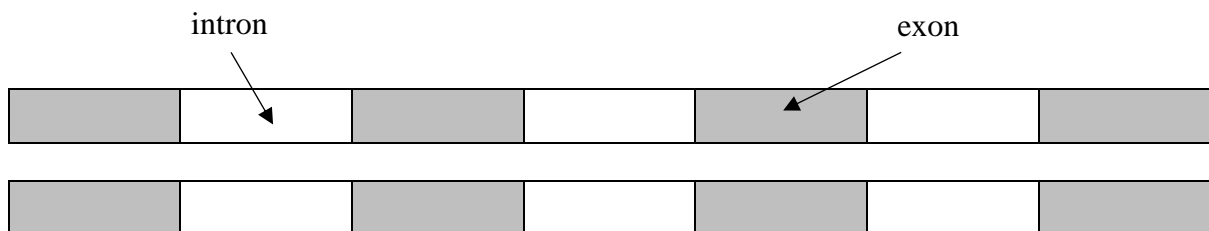
Mark allocation: 1 mark

- 1 mark is awarded for identifying the substantial difference between the length of the DNA and the calculated length of the mRNA

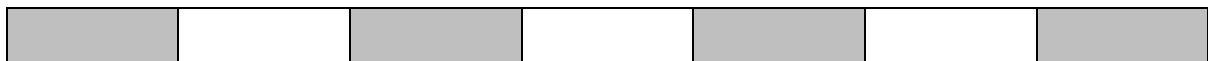
Note: Reference to the provided data is required. It is not enough to state that the DNA is longer than the mRNA.

Question 1d.**Worked solution**

The double-stranded template strand of DNA contains both introns and exons.



A primary transcript (premRNA) is produced after the leading strand of DNA is transcribed. This strand of RNA contains both introns (non-coding regions) and exons (coding regions).



During post-transcriptional modification, the introns are removed and the exons are spliced together. Because mRNA only contains exons, this molecule will be shorter than the template strand of DNA and the premRNA.

**Mark allocation: 2 marks**

- 1 mark is awarded for producing a diagram showing the double-stranded DNA as well as the single-stranded premRNA. It is essential to show the difference between the introns and the exons. The accompanying notation should refer to the process of transcription and identify that the premRNA contains both introns and exons.
- 1 mark is awarded for drawing an appropriate diagram representing mRNA. The accompanying notation should explain that the introns are removed from the premRNA during post transcriptional modification and therefore the mRNA molecule will be shorter than the template strand of DNA because it only contains exons.

Note: A methylated cap and poly A tail may also be drawn (as this would be more accurate), however, based on the context of the question, these structures are not required.

Question 2a.**Worked solution**

The plant experiencing magnesium deficiency has less extensive thylakoid discs (grana) than the plant that is provided with sufficient magnesium.

Grana carry out the light-dependent stage of photosynthesis. Decreasing the extent of grana decreases the amount of light the plant can absorb, thereby decreasing the rate of the reactions occurring in this stage. As a result, the rate of the entire process will also decrease.

Mark allocation: 2 marks

- 1 mark is awarded for comparing the extent of thylakoid discs in the magnesium-deficient plant with those in the plant supplied with sufficient magnesium
- 1 mark is awarded for identifying that the grana are responsible for carrying out the light-dependent stage of photosynthesis and discussing that decreasing the surface area of the grana will decrease the rate of the reactions that occur in the light-dependent stage and decrease the rate of the overall reaction

Question 2b.**Worked solution**

Magnesium ions are a cofactor. Coenzymes are organic, cofactors are inorganic. Magnesium ions are inorganic.

Mark allocation: 2 marks

- 1 mark is awarded for identifying magnesium ions as being a cofactor because they are inorganic rather than being organic
- 1 mark is awarded for explaining that coenzymes are organic, and cofactors are inorganic, and for stating that this is why magnesium ions are a cofactor

Question 2c.**Worked solution**

Translocation is partially dependent on phloem vessels being able to take up magnesium ions. When magnesium deficiency occurs, the rate of translocation decreases and sugars are not moved from the leaves as quickly, which results in the accumulation of sugars in the leaves.

Mark allocation: 1 mark

- 1 mark is awarded for identifying that magnesium deficiency causes a decrease in the rate of translocation, which results in the accumulation of sugars in the leaves

Question 2d.**Worked solution**

Due to the decrease in the rate of translocation, the amount of glucose that is delivered to the cells also decreases. Glucose is a reactant for cellular respiration, which produces ATP.

ATP is the energy used by organisms to accomplish processes, including growth. Because the root cells are not able to generate as much energy as normal, the rate of cellular proliferation in the roots also decreases.

Mark allocation: 2 marks

- 1 mark is awarded for stating that glucose needs to be supplied to the roots for these cells to carry out cellular respiration and produce ATP
- 1 mark is awarded for stating that ATP energy is required for cellular proliferation to occur. Decreasing the rate of cellular respiration means that the plant has less energy to produce new cells, resulting in the plant having a smaller root system than plants with sufficient magnesium.

Question 3a.**Worked solution**

Delivery of oxygen to the tissues is more efficient. This is necessary for the cells to carry out aerobic cellular respiration, producing sufficient ATP in order to carry out the metabolic processes that sustain life.

Mark allocation: 1 mark

- 1 mark is awarded for identifying that smaller cells are better able to absorb oxygen than larger cells. This enables the aerobic cellular respiration to occur at a rate that provides sufficient ATP to sustain life.

Question 3b.**Worked solution**

There is no information provided as to what the x -axis refers to.

It would appear that different areas of the animals have been tested, but there is no indication as to which areas of the animal the data relates to.

Note: This is just one example of an issue with this graph. Other answers, such as the lack of a title, could be provided.

Mark allocation: 2 marks

- 1 mark is awarded for identifying an error
- 1 mark is awarded for explaining how this lack of information referred to affects a reader's ability to interpret and understand the information being conveyed

Question 3c.**Worked solution**

The hypothesis that the yak's coat provides insulation was supported.

OR

The data provided shows that the yak's temperature was always higher at the surface of the body than halfway through the fibres or at the end of the fibres. This effect occurs due to the insulation provided by the fibres.

Mark allocation: 1 mark

- 1 mark is awarded for identifying the fact that the conclusion is supported, or for any reasonable suggestion, such as the second option presented

Question 3d.**Worked solution**

This difference occurred as a result of natural selection. Initially, the number of red blood cells in the members of a population of yaks would have varied.

As a result of living in a low oxygen environment, the yaks with more red blood cells had a higher degree of biological fitness than those with fewer red blood cells.

The yaks with more red blood cells were more likely to survive and reproduce than those with fewer red blood cells. Their offspring would be more likely to have this trait and pass it on to their offspring. This leads to an increase in the number of red blood cells in the population of yaks living in high altitudes.

Mark allocation: 3 marks

- 1 mark is awarded for identifying natural selection as the process and for stating that the number of red blood cells in the initial population of yaks would have varied
- 1 mark is awarded for identifying that having more red blood cells confers a greater degree of biological fitness in an oxygen-poor environment
- 1 mark is awarded for stating that the yaks with more red blood cells are more likely to survive and reproduce than those with fewer red blood cells. Their offspring are more likely to have this trait and pass it on to their offspring, leading to an increase in the incidence of this trait.

**Tip**

- *Many of the concepts studied in Biology are sequential processes. Using reading time to plan a logical answer is more likely to result in the marks being awarded than if the answer appears rushed and lacking in detail or thought.*

Question 4a.**Worked solution**

According to the information presented, the symptoms of DGS vary widely between affected individuals. There are a wide range of symptoms and conditions that affected individuals may or may not have; this lends itself to misdiagnosis.

For example, an individual with DGS may have an obvious cardiac abnormality and no other obvious symptoms. Unless further testing were done, DGS would not be diagnosed.

Note: A sample answer has been provided; however, there are a range of possible answers.

Mark allocation: 2 marks

- 1 mark is awarded for using the information to support the statement
- 1 mark is awarded for explaining how the information provided supports the statement

Question 4b.**Worked solution**

People with DGS have abnormally small or missing thymus glands. T-lymphocytes mature in the thymus gland. Therefore, the number of mature T cells that can be produced is less than in unaffected individuals.

Mark allocation: 1 mark

- 1 mark is awarded for explaining that T cells mature in the thymus gland, so having a small or missing thymus gland will result in a lymphocyte deficiency

Question 4c.**Worked solution**

People with DGS produce lower than normal numbers of T helper cells. These play an essential role in activating cytotoxic T cells.

Cytotoxic T cells are able to specifically identify and act against virally infected cells. People with DGS either don't have cytotoxic T cells or have them in lower numbers, reducing their specific defence against viruses.

Mark allocation: 2 marks

- 1 mark is awarded for identifying that individuals with DGS will have fewer T helper cells or cytotoxic T cells
- 1 mark is awarded for explaining the role that T helper cells play in activating cytotoxic T cells as well as the role that cytotoxic T cells play in attacking cells which have been invaded by a virus

Note: T helper cells also play an essential role in activating B cells; however, because the question relates to viral infections, an answer relating to cytotoxic T cells would be more accurate. An answer outlining the link between T helper cells, clonal expansion and antibody production would also be accepted.

Question 4d.**Worked solution**

polymerase chain reaction

Mark allocation: 1 mark

- 1 mark is awarded for stating the name of the process

**Tip**

- *If you read the assessor's report you will find that it is permitted to use the abbreviation for chemicals, such as DNA. However, if a question asks for a name to be provided, then the full name must be provided. In this example, the answer must be polymerase chain reaction. It cannot be PCR because that is an abbreviation, not a name.*

Question 4e.**Worked solution**

This provides a confirmation of the diagnosis and enables management plans to be put into place as soon as possible.

Mark allocation: 1 mark

- 1 mark is awarded for discussing the fact that early diagnosis enables management plans to be implemented as soon as possible

Question 4f.**Worked solution**

An example of an ethical issue is the question of whether the child will have access to this information in the future.

Mark allocation: 1 mark

- 1 mark is awarded for identifying an ethical issue

Note: An example has been provided, however other common examples include querying who will have access to the data or whether the child's right to medical privacy has been respected.

Question 5a.**Worked solution**

A population bottleneck is a sharp reduction in the size of a population caused by chance, random environmental events or human action. As a result, the genetic diversity of the population decreases.

Mark allocation: 1 mark

- 1 mark is awarded for identifying the fact that the genetic diversity decreases as a result of a bottleneck occurring

Question 5b.**Worked solution**

The lack of genetic diversity in the population of bananas, means that all plants would be equally affected by a disease caused by an emerging pathogen. This could result in the extinction of the species.

Mark allocation: 1 mark

- 1 mark is awarded for explaining that the lack of genetic diversity in the species renders all plants equally vulnerable to infection that could lead to their extinction

Question 5c.**Worked solution**

A human-induced genetic bottleneck could occur as a result of reducing the population size by culling plants that did not have desired traits and then carrying out a selective breeding program.

Note: Many banana plants are produced by carrying out seedless grafts, so effectively banana plants are clones of each other.

Mark allocation: 1 mark

- 1 mark is awarded for explaining that a bottleneck is the result of an activity that results in the death of a large percentage of the population and for identifying a specific way in which this could be accomplished

Question 5d.**Worked solution**

epidemic

Although BBW spread through a large area of Uganda, the spread is not sufficiently large to be considered a pandemic.

Mark allocation: 1 mark

- 1 mark is awarded for identifying this as an epidemic and explaining that this identification was based on the extent of the area where infections occurred

**Tip**

- *The general rule is that there is one mark awarded per point that is made. However, sometimes either/or questions such as the one above may be asked and only one mark is awarded. Although the first part of the question still needs to be answered to achieve the mark, in this case no mark is awarded for only stating that this is an example of an epidemic. To be awarded the mark, you must also provide a supporting reason.*

Question 5e.**Worked solution**

These bananas are both genetically modified and transgenic.

Genetically modified organisms are those organisms whose genetic material has been artificially modified. Transgenic organisms are produced by inserting DNA from another species into the genome of an organism.

These bananas contain DNA from green peppers and another species of banana. Because this is foreign DNA from two different species, the bananas are both genetically modified and transgenic.

Mark allocation: 3 marks

- 1 mark is awarded for identifying that the bananas are both genetically modified and transgenic
- 1 mark is awarded for explaining the difference between the terms ‘genetically modified’ and ‘transgenic’
- 1 mark is awarded for using the information provided to explain why these bananas are both genetically modified and transgenic

Question 5f.**Worked solution**

Using the GM bananas results in an increase of the crop yield as they are now BBW resistant. This means that farmers will continue to make an income from selling their crops and that a supply of the staple food will be available to the community.

OR

The GM bananas have a higher amount of vitamin A. This means that there is a greater nutritional benefit of consuming the bananas, limiting the effects of malnutrition.

Mark allocation: 2 marks

- 1 mark is awarded for identifying a specific benefit of using GM bananas
- 1 mark is awarded for discussing the specific benefit of using the GM bananas

**Tip**

- *For questions of this nature, it is essential to provide additional information other than that which is supplied. In this case, it would not be sufficient to state that the GM bananas are resistant to BBW because that information has been supplied. You must use the information provided to identify a specific benefit.*

Question 5g.**Worked solution**

Biological issue: Cross pollination could occur between the GM banana and other plants, such as weeds.

Weeds previously affected by the wilt would not be presently. Changing the genome of the banana plants could have an impact on the food chain; for example, higher levels of vitamin A could be toxic to smaller organisms.

OR

Biological issue: New allergens will be created.

Incorporating new genes enabling the bananas to produce new proteins may result in the production of altered proteins that cause allergic reactions.

OR

Social issue: The GM bananas are not natural.

People tend to have a preference for natural, organic foodstuffs. Some people are reluctant to consume food that is unnatural because they do not understand how the food has been modified and what effect consuming it could have. This reluctance may affect a farmer's ability to sell their crop.

OR

Social issue: Small-scale farmers will suffer at the hands of big business.

Farmers who depend on GM crops for their livelihoods are seen as being at the mercy of large companies; for example, instead of saving seeds and using these to plant their crops they may have to keep buying seeds.

Mark allocation: 2 marks

- 1 mark is awarded for identifying a specific biological or social issue raised by the use of GM bananas
- 1 mark is awarded for explaining a problem caused by this issue

Question 6a.**Worked solution**

There are multiple alleles because the Huntington's gene may contain anywhere from 10 to 120 CAG repeats. Mutations commonly occur, resulting in the production of alleles with various numbers of CAG repeats.

Mark allocation: 1 mark

- 1 mark is awarded for stating that the number of CAG repeats varies extensively, resulting in the formation of a large number of alleles

Question 6b.**Worked solution**

A gene pool is the sum total of all alleles in a population at a specific time. Because symptoms do not occur until adulthood, affected individuals have usually had children by the time they realise they have the condition. This enables the alleles that cause the condition to be passed on. The selection pressure against Huntington's is therefore very weak.

Mark allocation: 2 marks

- 1 mark is awarded for providing an appropriate definition of a gene pool
- 1 mark is awarded for providing a reason to explain why the alleles that cause Huntington's disease remain in the human gene pool

Question 6c.**Worked solution**

Electrophoresis can be used to diagnose Huntington's disease because electrophoresis is used to separate DNA fragments based on their size. Because the number of CAG repeats in the Huntington's gene differs, electrophoresis can be used to separate these fragments and estimate their size.

Mark allocation: 1 mark

- 1 mark is awarded for explaining that the number of CAG repeats affects the extent to which a DNA fragment will migrate through an electrophoresis gel, with smaller fragments moving further through the gel than larger fragments

Question 6d.**Worked solution**

The gel run of an affected individual would have one or more bars that remain close to the origin wells, while the gel run of the unaffected individual would show that all bars have migrated a significant distance towards the positive terminal.

The difference would occur because the size of a DNA fragment determines the distance it will travel through a gel. A fragment with a large number of CAG repeats will remain close to the origin and a fragment with a small number of CAG repeats will travel much further through the gel.

Mark allocation: 2 marks

- 1 mark is awarded for explaining how the gels would differ in appearance
- 1 mark is awarded for explaining why DNA fragments separate when run through an electrophoresis gel

**Tip**

- *Remember that it is permissible to use diagrams in place of, or in addition to, text in an answer. If you use diagrams, they should be clearly and fully labelled. In a question such as the one above, drawing a labelled diagram may be an easier way of gaining the marks than a written description of the appearance of the gel runs.*

Question 6e.**Worked solution**

The founder effect

A single individual in a small population makes a substantial contribution to the gene pool of that population. The fact that the affected woman had a large number of offspring caused the frequency of the alleles that caused Huntington's disease to increase to an unusually high level. The allele was passed down through many generations resulting in the current high prevalence of Huntington's disease in the population surrounding Lake Maraciabo.

Mark allocation: 2 marks

- 1 mark is awarded for identifying the founder effect
- 1 mark is awarded for discussing how the founder effect led to the unusually high prevalence of Huntington's disease in the populations surrounding Lake Maraciabo

Question 7a.**Worked solution**

Any two of the following:

- phagocytosis
- inflammation
- complement
- interferon

Mark allocation: 1 mark

- 1 mark is awarded for correctly identifying two examples of the second line of defence

Question 7b.**Worked solution**Waxy cuticle

This provides a physical barrier that prevents pathogens from entering the leaves of a plant.

Stomata

The presence of certain pathogens acts as a trigger causing the stomata to close. This may prevent the pathogen from entering the leaf. This is known as stomatal defence.

Defensins

These chemicals are a type of antibiotic produced by plants. They act against bacteria and fungi by binding to their membranes and increasing their permeability.

Galls

Growths that occur in plants that contain infectious pathogens, preventing them from spreading throughout the plant.

Note: Although several examples have been provided, other answers are possible.

Mark allocation: 1 mark

- 1 mark is awarded for identifying a correct example and providing an explanation

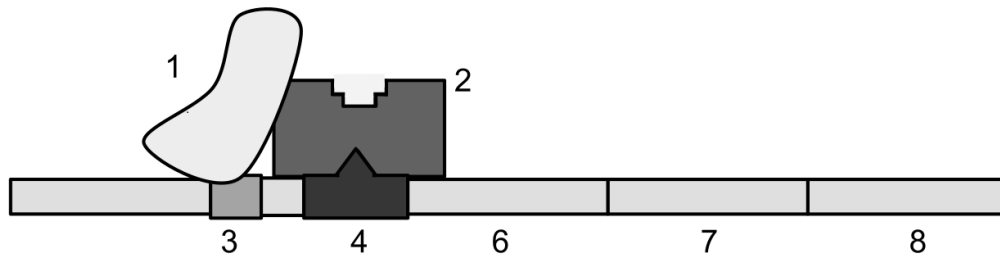
Question 7c.**Worked solution**

Cell or chemical	Role
T helper cell	These cells activate or present antigens to naïve B cells and cytotoxic cells.
B plasma cell	These cells produce antibodies that bind to and neutralise antigens.
B memory cell	These cells remain in the lymphatic system. They are capable of recognising one specific antigen. If this antigen is encountered in the future, they can produce antibodies at a much faster rate.
Antibody	This is a chemical secreted by B plasma cells. Antibodies bind to and neutralise antigens, facilitating phagocytosis and action by complement.
Cytotoxic T cell	Cytotoxic T cells kill target cells. These may be cells that have been invaded by a virus or transplanted organs.

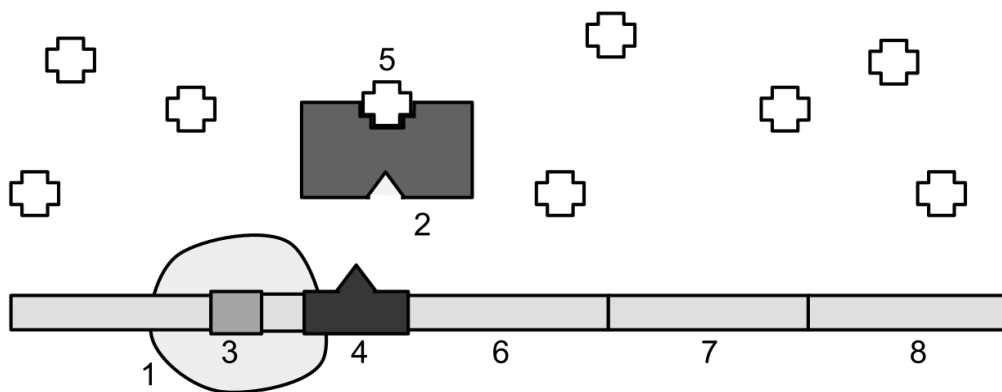
Mark allocation: 3 marks

- 1 mark is awarded for each row completed (up to 3 marks)

Note: To gain the mark, the line must have a correct cell or chemical and a description of the role of that cell or chemical.

Question 8a.**Worked solution**

In the absence of lactose, the repressor protein binds to the operator, upstream of the three structural genes. The presence of the repressor protein prevents RNA polymerase from binding to the operator region of the operon and prevent transcription from occurring.



"The lac operon" by A T Raju available at https://en.wikipedia.org/wiki/Lac_operon#/media/File:Lac_Operon.svg under a Creative Commons Attribution-Share Alike 3.0 Unported license.
Full terms at <https://creativecommons.org/licenses/by-sa/3.0/deed.en>.

When lactose is present it binds to the repressor protein, causing it to change shape and release the operator. RNA polymerase is now able to bind to the promoter region and transcription of the structural genes occurs.

Note: In the diagram, structures are as follows: 1, RNA polymerase; 2, repressor protein; 3, promoter region; 4, operator; 5, lactose; 6, 7 and 8, structural genes lacZ, lacY and lacA.

Mark allocation: 2 marks

- 1 mark is awarded for providing a diagram that shows the repressor protein bound to the operator region in the absence of lactose
- 1 mark is awarded for providing a diagram that shows the repressor protein changing shape and releasing the operator region in the presence of lactose

Note: Annotations must be provided to be awarded each mark.

**Tip**

- *One of the most common mistakes involves misunderstanding the difference between the operator and promoter regions of the operon. The promoter is the area of the operon to which RNA polymerase binds. The operator is the regulatory sequence to which the repressor protein binds to. It is important to remember the difference.*

Question 8b.**Worked solution**

Protein synthesis is an endergonic process. Prevention of the expression of the structural genes in the absence of lactose enables the bacterium to conserve energy that can be used for other life-sustaining processes.

Mark allocation: 1 mark

- 1 mark is awarded for providing an answer that demonstrates that protein synthesis is a process that uses energy and for explaining an advantage, such as enabling energy conservation

Question 8c.**Worked solution**

Regulatory genes code for the production of proteins that regulate the expression of other genes. Structural genes code for the production of any protein that plays a structural or functional role in an organism.

In the lac operon, regulatory genes code for the production of the repressor protein, which regulates transcription. The three genes (lac Z, lac Y and lac A) are structural genes because they code for the production of the enzymes that facilitate the metabolism of lactose.

Mark allocation: 2 marks

- 1 mark is awarded for explaining the distinction between structural and regulatory genes
- 1 mark is awarded for identifying examples of structural and regulatory genes in the lac operon

**Tip**

- *Some questions require a generic answer and other questions require a specific answer. In this question, the definition component of the question requires a generic answer. However, the second part of the question requires theoretical knowledge to be applied to the specific example. The most common mistake when answering this type of question is providing a generic example instead of an answer that specifically relates to the lac operon.*

Question 9a.**Worked solution**

Humans (*Homo sapiens*) and gorillas are an example of divergent evolution. Both species share a recent common ancestor and diverged approximately 7 million years ago.

Mark allocation: 1 mark

- 1 mark is awarded for identifying any correct example of divergent evolution shown in the phylogenetic tree and for stating that the two species share a recent common ancestor and for stating when the two species diverged

Question 9b.**Worked solution**

DNA analysis, or sequencing or DNA bar coding

The sequence of specific regions of DNA are determined and compared with similar regions in other species of lemur. If the DNA from the organisms being tested is sufficiently different from that of known species, then the new species is confirmed.

OR

the inability to mate and produce viable fertile offspring

The waiting period may have been needed to observe that any offspring produced were hybrids that could not produce offspring.

Mark allocation: 2 marks

- 1 mark is awarded for identifying an appropriate piece of evidence that would be used by scientists
- 1 mark is awarded for discussing how the evidence is used to confirm that the lemurs discovered were members of a new species

Question 9c.**Worked solution**

The species is likely to become endangered or extinct. It occupies a limited niche and is vulnerable to issues caused by humans such as deforestation, poaching and habitat loss.

OR

Examples of this species could be included in a captive breeding program. Extensive efforts are being made to conserve endangered species. Because this species occupies a limited niche in two small areas, it is most likely that it will be endangered. The species may be conserved if sufficient numbers are bred and released back into the wild.

OR

The species will have a low genetic diversity. Because these organisms occupy a limited niche in two small areas, the population will be limited in size. They are limited to breeding with others in the national park in which they live. Because gene flow cannot occur with lemurs from the other national park, a decrease in genetic diversity is likely to occur.

Note: Three different model solutions have been provided but other answers are possible.

Mark allocation: 2 marks

- 1 mark is awarded for identifying a plausible future outcome
- 1 mark is awarded for providing a logical reason to support your initial answer

Question 10a.**Worked solution**

The DNA extracted from Cheddar Man could be compared with that from a sample of modern-day British people. The degree of similarity between DNA samples could be used to support this claim.

Mark allocation: 1 mark

- 1 mark is awarded for stating that DNA from both groups could be analysed to determine if they had made any contributions to the genome of modern Britons

Question 10b.**Worked solution**

narrow

Information regarding the narrow shape of the pelvis was as expected because the narrow anatomically modern pelvis first appeared in *Homo sapiens* in Africa and the Middle East approximately 200 000 years ago.

Mark allocation: 2 marks

- 1 mark is awarded for identifying the narrow pelvis shape
- 1 mark is awarded providing an answer that refers to the comparatively narrow pelvis of modern *Homo sapiens* and stating that the pelvis shape of Cheddar Man was as expected

Question 10c.**Worked solution**

The prevalence of lactose intolerance is much lower in the modern Caucasian population compared with that of Cheddar Man (according to the data, the extent of lactose intolerance decreased from 100% to about 21%).

A mutation resulting in the production of an enzyme that enabled humans to digest lactose occurred at some point after the time when Cheddar Man lived in Britain.

Mark allocation: 2 marks

- 1 mark is awarded for identifying that the prevalence of lactose intolerance decreased from 100% to approximately 20%
- 1 mark is awarded for suggesting an appropriate cause, such as a mutation

Question 10d.**Worked solution**

Possible examples include:

The presence of the red deer skull-caps

The evidence indicates that the people who existed at this time had the necessary cognitive ability to use tools to create these caps.

OR

The engraved shale pendant

The evidence indicates that the people who existed at this time had the necessary cognitive ability to make and use the tools required to produce this type of ornament.

OR

Carrying out rituals

Carrying out rituals indicates that the people had given thought to events and had the cognitive ability to create, and carry out those rituals as well as communicate with others.

Mark allocation: 2 marks

- 1 mark is awarded for identifying an example of cultural evolution from the article
- 1 mark is awarded for stating that the people concerned had the cognitive ability required to carry out this example

**Tip**

- *It is important to make sure that you read all questions carefully. The most common mistake is to identify an example of cultural evolution that is not referred to in the article, such as the use of fire.*

Question 11a.**Worked solution**

A control group is a group of subjects that are not exposed to the independent variable. The purpose of a control group is to provide a baseline of comparison so that any differences in results between the control and treatment groups can be attributed to the independent variable.

Mark allocation: 1 mark

- 1 mark is awarded for providing a complete explanation of the purpose of using a control group in a fair test experiment

**Tip**

- *When answering questions relating to experimental design, it is essential to be familiar with all the terminology and provide complete answers. A common error involves a failure to fully explain the purpose of the control group. Answers such as 'the purpose of the control group is to provide a baseline of comparison' are commonly provided. However, this is not a complete answer because it fails to state what is being compared and what the significance of the comparison is.*

Question 11b.**Worked solution**

Repeating the experiments increases the reliability of the results; any outliers can be identified and it is possible that the experimental process could be improved.

Note: Improved accuracy is not provided by repeating an experiment. An answer relating to accuracy should not be accepted.

Mark allocation: 1 mark

- 1 mark is awarded for providing a logical/valid reason that explains the benefits of carrying out the same experiment multiple times

Question 11c.**Worked solution**

Only a single independent variable is used in a standard fair test experiment. This experiment uses several independent variables: the temperature the hair was subjected to, the length of time the hair was subjected to the treatment and the distance of the hair dryer from the hair.

Mark allocation: 2 marks

- 1 mark is awarded for stating that the standard procedure is to use a single independent variable, while several independent variables are being used in this experiment
- 1 mark is awarded for providing examples of at least two independent variables in this experiment

Question 11d.**Worked solution**

The statement is accurate. In terms of the design, the experiment has some validity because the method being used to obtain the results (use of the electron microscope) is measuring what it is intended to measure. However, the investigation is flawed because data that has been gathered has been affected by more than one independent variable.

Mark allocation: 2 marks

- 1 mark is awarded for identifying that the statement is accurate
- 1 mark is awarded for explaining why the results of this experiment were not valid

Note: As per the Study Design, 'both experimental design and the implementation should be considered when evaluating validity'.

Question 11e.**Worked solution**

osmosis

Water diffused from an area of high water concentration in the fluid surrounding the hair fibres to an area of low water concentration in the CMC. The influx of water caused the bulging of the CMC.

Mark allocation: 2 marks

- 1 mark for stating that this is an example of osmosis
- 1 mark for explaining how the diffusion of water down its concentration gradient caused an increase in volume of the CMC, resulting in the bulging

Question 11f.**Worked solution**

Possible examples include:

- Using a hair dryer caused more damage to the surface of the hair than was caused by natural drying.
- Natural drying causes more damage to the CMC than using a hair dryer.
- The least amount of damage is achieved by using a hair dryer to dry your hair. This should be for 60 seconds at a distance of 15 cm from the hair.
- Using a hair dryer may promote split ends and roughness, but natural drying could lead to an increased loss of hair.

Mark allocation: 2 marks

- 1 mark is awarded for identifying each accurate conclusion (up to 2 marks)

END OF WORKED SOLUTIONS