

YEAR 12 *Trial Exam Paper*

2018
BIOLOGY

Written examination

Worked solutions

This book presents:

- high-level sample answers
- explanatory notes
- mark allocations
- tips on how to approach the exam.

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SECTION A – Multiple-choice questions

Question 1

Answer: A

Explanatory notes

Cholesterol is a lipid and is therefore hydrophobic. Increasing the concentration of cholesterol in a lipid bilayer increases its hydrophobic nature, making it more difficult for water to diffuse across the membrane. The lipid bilayer of the liver cell has the lowest concentration of cholesterol, enabling water to diffuse across it the most easily.



Tip

- *It is essential to read all of the information in a question very carefully. In this example, the data shows that the mitochondrial cristae have the lowest concentration of cholesterol. However, the question is asking about a plasma membrane, making mitochondrial cristae an incorrect answer.*

Question 2

Answer: D

Explanatory notes

For the protein to stay in the central region of the lipid bilayer it needs to be attracted to the lipids that make up this region. Therefore, the protein would need to be hydrophobic.



Tip

- *When studying VCE Biology, it is essential to have a sound understanding of terminology because there are many examples where different terms have the same meaning. In this question, the terms 'polar' and 'hydrophilic' both refer to the ability of a substance to dissolve in water. Familiarity with these terms should enable options B and C to be eliminated quickly.*

Question 3

Answer: D

Explanatory notes

When a polypeptide chain is released by a ribosome it moves through the rough endoplasmic reticulum before being packaged into a transport vesicle. This is then taken up by a Golgi apparatus where final modification occurs. The protein is then packaged into a secretory vesicle, which then fuses with the plasma membrane and releases the protein into the extracellular region by the process of exocytosis.

Question 4**Answer: A****Explanatory notes**

Option A is correct. Large hydrophilic molecules are unable to diffuse across plasma membranes. Instead, they enter cells by facilitated diffusion or endocytosis.

Option B is incorrect. The cells that make up the capillary walls have a phospholipid bilayer plasma membrane.

Option C is incorrect. The blue dye is not a signalling molecule produced by the animal and therefore there would not be any receptors for the dye.

Option D is incorrect. The blue dye is not produced by the animal and enzymes that break down the dye would not be expected in the brain and spinal cord.

Question 5**Answer: B****Explanatory notes**

The function of the Golgi apparatus is to perform the final modification and packaging of proteins.

Question 6**Answer: C****Explanatory notes**

Option A is incorrect. There is no terminology that refers to the first section of a protein to be translated.

Option B is incorrect. This is the tertiary structure of a protein.

Option C is correct. The primary structure of a protein is the sequence of amino acids that are joined together by a peptide bond as a result of a condensation reaction.

Option D is incorrect. This option identifies the secondary structure of a protein, such as alpha helices and beta pleated sheets.

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

Option A is incorrect. The initial section of a functional gene is called the starter sequence.

Option B is correct. The promoter region is the sequence of DNA to which RNA polymerase binds and initiates transcription.

Option C is incorrect. This is a definition of an operator region, not a promoter region.

Option D is incorrect. Signalling molecules do not generally bind to DNA, and DNA does not change shape in response to cellular signals.

Question 8**Answer: B****Explanatory notes**

Option A is incorrect. While this statement is accurate, the degeneracy of the genetic code does not contribute to the functional diversity of proteins.

Option B is correct. The primary structure of a protein is determined by the order in which the amino acids are assembled.

Option C is incorrect. Most proteins do not change shape, and if they denature they lose the ability to carry out their function. Proteins that can change shape normally carry out variants of the same function (e.g. a repressor protein will either bind to or release an operator region).

Option D is incorrect. Although a polypeptide chain is modified in the Golgi apparatus and results in the formation of a functional protein, the same type of polypeptide chain will be folded in the same way.

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

The current Study Design requires you to be able to differentiate between structural and regulatory genes. Regulatory genes code for proteins that control the expression of one or more other genes. Structural genes code for proteins that do not play a regulatory role. In this example, the p53 gene codes for a protein that regulates a cellular process, rather than affecting the expression of other genes. As a result, p53 is functioning as a structural gene, not a regulatory gene.

Question 10**Answer: C****Explanatory notes**

Option A is incorrect. Chemical reactions are not catalysed by energy removal.

Option B is incorrect. The presence of an enzyme has no effect on the kinetic energy of the particles involved in the chemical reaction being catalysed.

Option C is correct. Enzymes catalyse chemical reactions by lowering the activation energy of the reaction, enabling it to occur at a much faster rate than would otherwise occur.

Option D is incorrect. Enzymes do not catalyse chemical reactions by enabling the release of heat.

Question 11**Answer: C****Explanatory notes**

Option A is incorrect. It is possible for the rate of the reaction to exceed 25 units. Although the reaction reaches an almost constant rate of 25 units, it is still increasing. Additional enzymes would also cause the reaction rate to increase.

Option B is incorrect. The graph shows that the reaction is occurring at an almost constant rate at a concentration of 200 units, rather than ceasing to occur.

Option C is correct. Additional enzymes would increase the number of active sites available. Therefore, the frequency of successful collisions between the enzyme and substrate molecules would increase, causing the reaction rate to increase.

Option D is incorrect. As the concentration of the substrate increases, the number of active sites becomes limiting.

Question 12**Answer: D****Explanatory notes**

The graph shows that the uptake of oxygen gas during the period of darkness (when the plant cannot be photosynthesising) is 60 mL/h. Because it has been assumed that the rate of aerobic cellular respiration remained constant during the entire period, the answer is $60 \text{ mL/h} \times 24 \text{ h} = 1440 \text{ mL}$.

Question 13**Answer: B****Explanatory notes**

Option A is incorrect. Light does not supply electrons to the chloroplasts.

Option B is correct. Light is used as an energy source to activate chlorophyll, which then facilitates the reactions that occur during the light-dependent stage of photosynthesis.

Option C is incorrect. Water molecules are not broken down into hydrogen ions and oxygen gas from being heated.

Option D is incorrect. NADPH is moved from the grana to the stroma by the proton gradient.

Question 14**Answer: D****Explanatory notes**

Option A is incorrect. The purpose of this tube is to be able to determine the difference in oxygen production that occurs when the elodea is exposed to sodium bicarbonate compared to when it isn't.

Option B is incorrect. The dependent variable is the outcome that is measured; it is not a variable whose effect will be established.

Option C is incorrect. Elodea does not produce carbon dioxide as a result of being supplied with sodium bicarbonate. The carbon dioxide is produced as a result of the sodium bicarbonate breaking down.

Option D is correct. All of the test tubes initially contained deoxygenated water. Because the test tube without elodea did not contain any oxygen at the end of the experiment and both of the test tubes containing elodea did contain oxygen, we can conclude that the oxygen in these two test tubes at the end of the experiment must have been produced by the elodea.

Question 15**Answer: C****Explanatory notes**

Option A is incorrect. The elodea exposed to the sodium bicarbonate produced more oxygen than the elodea not exposed to the sodium bicarbonate. Therefore, providing the elodea with sodium bicarbonate increased the rate of photosynthesis rather than decreased it. Therefore, it is not a toxin.

Option B is incorrect. Nutrients are not inputs of photosynthesis and would not cause the rate of photosynthesis to increase.

Option C is correct. Carbon dioxide concentration is one of the factors that affect the rate of photosynthesis. Supplying carbon dioxide in an alternative form provides more of the input required for photosynthesis, increasing the rate of photosynthesis and therefore increasing the amount of oxygen produced.

Option D is incorrect. Sodium bicarbonate is an inorganic substance; therefore, it cannot act as a coenzyme.

Question 16**Answer: B****Explanatory notes**

Option A is incorrect. Viruses contain nucleic acids.

Option B is correct. Viruses are not considered to be alive because they cannot reproduce by themselves; they have to invade a host cell. Because viruses are not alive, they are not considered to be cellular pathogens.

Option C is incorrect. Although viruses cannot produce their own proteins (they rely on their hosts to produce viral proteins), the ability to produce proteins is not used to differentiate between cellular and non-cellular pathogens.

Option D is incorrect. Although viruses do not have membrane-bound organelles, the presence of these organelles is not used to differentiate between cellular and non-cellular pathogens. Bacterial cells lack membrane-bound organelles but are still considered to be cellular pathogens.

Question 17**Answer: D****Explanatory notes**

Lysosomes contain digestive enzymes and their role is to digest worn out organelles and engulfed foreign substances. Therefore, cells that carry out phagocytosis would be expected to contain large numbers of lysosomes.

Question 18**Answer: C****Explanatory notes**

Option A is incorrect. Antigens are not presented to B plasma cells by macrophages or dendritic cells.

Option B is incorrect. Lymphocytes and dendritic cells do not directly catalyse clonal expansion.

Option C is correct. The macrophages and dendritic cells in this area can recognise, process and present foreign antigens.

Option D is incorrect. Although lymph fluid is filtered as it passes through the specified region, phagocytes and dendritic cells do not carry out this process.

Question 19**Answer: D****Explanatory notes**

Primary lymphatic tissues are the sites where lymphocytes are formed and mature. These sites include red bone marrow and the thymus gland. Secondary lymphatic tissue is where the activation of lymphocytes and clonal expansion occur. Lymph nodes are the sites of clonal expansion and are therefore an example of secondary lymphatic tissue.

Question 20**Answer: B****Explanatory notes**

Option A is incorrect. VEGF is secreted by tumour cells, it does not bind to them.

Option B is correct. The supplied information states that VEGF enables the development of blood vessels and that the monoclonal antibody binds to VEGF. This would neutralise the effect of VEGF.

Option C is incorrect. There is no indication that capillaries have VEGF receptors, and if they did, this would facilitate the formation of additional capillaries.

Option D is incorrect. The tumour cells secrete VEGF and would not have VEGF receptors.

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

Option A is incorrect. A repressor protein would prevent the gene that produces anthocyanin from being expressed.

Option B is correct. A point mutation can cause the production of a protein with a similar conformation that causes a similar effect.

Option C is incorrect. The information provided states that the plant that produces the yellow flowers is a member of the same species as the plants that produce purple flowers.

Option D is incorrect. If this statement were true, all of the flowers on all of the plants would be yellow after rainfall, not just the flowers on one plant.

Question 22**Answer: B****Explanatory notes**

The change in allele frequency was identified as being due to genetic drift, which is non-selective. Therefore, the allele frequency in a population changes randomly. So, options A, C and D are all incorrect because these would cause non-random changes in the allele frequency. Genetic drift is more likely to occur in a small population because each individual in a small population makes a comparatively large contribution to the gene pool and changes to the population size enable allele frequencies to change rapidly.

Question 23**Answer: D****Explanatory notes**

Option A is incorrect. Although inbreeding may be occurring, this would not cause the decline in numbers.

Option B is incorrect. Selective breeding involves humans breeding specific organisms to perpetuate a desired trait. The only purpose of the captive breeding programs in this example is to increase the population size.

Option C is incorrect. The founder effect occurs when a small sample of a larger population leaves the larger population and interbreeds, which results in a population that has a different allele frequency from that of the parent population.

Option D is correct. A population bottleneck occurs when a large population is dramatically reduced in size by a non-selective event. Genetic diversity in the reduced population is decreased compared with that of the original population.

Question 24**Answer: A****Explanatory notes**

One of the consequences of a population bottleneck is that the genetic diversity of the surviving population decreases due to the non-selective loss of a large proportion of the population.

Question 25**Answer: B****Explanatory notes**

Option A is incorrect. The forelimb of a dog and the arm and hand of a human do not fulfil the same function.

Option B is correct. Both organisms are mammals and therefore share a recent common ancestor.

Option C is incorrect. The bones are clearly not anatomically identical.

Option D is incorrect. The structures are not similar enough to have been produced by similar selection pressures.

Question 26**Answer: A****Explanatory notes**

As the animals were moving into a new environment, additional niches became available to them. Evolution enables organisms to take advantage of these niches and results in increased biodiversity.

**Tip**

- *It is useful to be able to apply specific ideas to a range of situations. The course requires you to be familiar with Darwin's finches and the cichlid fish. Both are examples of adaptive radiation. Being familiar with these examples makes it easier to identify similar examples.*

Question 27**Answer: D****Explanatory notes**

Divergence is most likely to occur when the populations on the islands remain reproductively isolated. If seeds can float, become airborne or stick to organisms such as birds then they are likely to be transported between the islands. Therefore, plants that originate on one island can have offspring that interbreed with plants on the other island, enabling gene flow to occur. The seeds of the coco de mer plant are so large that they stay where they have fallen from the parent tree. Therefore, populations of this species are more likely to remain reproductively isolated than any of the other species.

Question 28**Answer: A****Explanatory notes**

Option A is correct. Red pandas are members of the raccoon (Procyonidae) family and giant pandas are members of the bear (Ursidae) family. It is believed that they evolved similar adaptations because they experienced similar environmental conditions.

Option B is incorrect. If a common ancestor had both traits then you would expect raccoons and bears to also have the same traits.

Option C is incorrect. The two species do not have exactly the same DNA.

Option D is incorrect. Panda is not a species name. The diagram shows that they are members of different species. The scientific name of the red panda is *Ailurus fulgens* and the scientific name of the giant panda is *Ailuropoda melanoleuca*.

Question 29**Answer: C****Explanatory notes**

Option A is incorrect. The dates of previous extinctions are estimates. They did not occur at exact intervals in the past and the time at which a future mass extinction event will occur cannot be accurately predicted.

Option B is incorrect. The trend line shows that the rate of extinctions is increasing.

Option C is correct. Extinction events seem to be followed by a period of rapid evolution. It is hypothesised that this occurs because many niches become available after an extinction event.

Option D is incorrect. Worldwide catastrophes are believed to be the cause of mass extinctions.

Question 30**Answer: A****Explanatory notes**

It is estimated that sea levels decreased by approximately 120 metres during this ice age. The reduction in sea level caused water to move away from existing coast lines and exposed a substantial area of the continental shelves. Species that lived on rock platforms would be unable to survive when their habitat disappeared.

Question 31**Answer: D****Explanatory notes**

Option A is incorrect. The size of the DNA would only affect the ease with which it can be sequenced.

Option B is incorrect. Mitochondrial DNA does not recombine.

Option C is incorrect. The number of exons a segment of DNA is irrelevant to its use as a molecular clock.

Option D is correct. The concept of a molecular clock is based on the idea that mutations occur at a known rate.

Question 32**Answer: C****Explanatory notes**

Option A is incorrect. The question asked for an interpretation of data from the diagram. A connection between *Homo floresiensis* and *Homo erectus* is not shown.

Option B is incorrect. The diagram shows that the ancestors of some modern humans never left Africa.

Option C is correct. The diagram shows that *Homo sapiens*, *Homo neanderthalensis* and *Homo denisova* all share a common ancestor in *Homo heidelbergensis*. However, the ancestor of both *Homo denisova* and *Homo neanderthalensis* diverged earlier than that of *Homo sapiens*.

Option D is incorrect. The diagram shows that *Homo erectus* was in Eurasia and *Homo heidelbergensis* was in Africa during this time.

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

Lane 3 contains the DNA sample from the couple's child. The first two bands in this fingerprint match the man and the last two bands match the woman.

Lane 4 contains the DNA sample from the adopted child. None of the bands in this fingerprint match the fingerprints of the adults.

Lane 5 contains the DNA sample from the woman's child. The first and last bars in this fingerprint match the woman's fingerprint and the remaining bars do not match the man's fingerprint.

**Tip**

- When analysing a genetic fingerprint to determine parentage, it is important to remember that a child inherits 50% of their DNA from each parent. It is easiest to compare the bars of the mother's DNA to those of the child; the remaining bars should match the bars of the father's DNA.

Question 34**Answer: A****Explanatory notes**

Social issues relate to the opinions and actions of individuals.

Option A is correct. Whether or not to eat genetically modified food is an individual choice.

Option B is incorrect. The production of a higher yield is not considered to be an issue.

Option C is incorrect. Cross-pollination is a biological issue, not a social issue.

Option D is incorrect. The production of proteins is a biological issue, not a social issue.

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

Option A is correct. DNA ligase facilitates the ligation (or annealing) of DNA fragments.

Option B is incorrect. This description refers to a vector.

Option C is incorrect. DNA ligase does not play a direct role in gene cloning.

Option D is incorrect. This option refers to a polymerase chain reaction.

Question 36**Answer: D****Explanatory notes**

Option A is incorrect. The diagram only shows a single restriction site for each enzyme. If a single enzyme were to be used, the result would be a single fragment, not multiple sections.

Option B is incorrect. The presence of restriction sites has no bearing on the ability to insert the plasmid into host cells.

Option C is incorrect. A single gene is usually inserted into a laboratory plasmid rather than multiple genes.

Option D is correct. The same restriction enzyme must be used to cut around the gene to be inserted into the plasmid and to cut an opening in the plasmid. Having multiple different recognition sites in the plasmid increases the chance that one of these enzymes will be able to cut around a gene of interest.

Question 37**Answer: A****Explanatory notes**

Primers must be present for PCR to occur. Primers provide a binding site for DNA (taq) polymerase, which then reads and copies the DNA template.

Question 38**Answer: C****Explanatory notes**

Option A is incorrect. This is an example of an emerging disease.

Option B is incorrect. This is a description of a pandemic.

Option C is correct. An epidemic is defined as a disease that rapidly spreads throughout a community.

Option D is incorrect. The lethality of a disease is not used to define an epidemic.

Question 39**Answer: D****Explanatory notes**

Option A is incorrect. Transgenic organisms are those into which DNA from a different species has been inserted. In this example, the inserted DNA came from bacteria of the same species.

Option B is incorrect. This term refers to infecting a cell with free DNA.

Option C is incorrect. This term is not used.

Option D is correct. The bacteria have been modified because DNA has been inserted into their genomes, but because the DNA originated in the species, it is not considered foreign DNA.

Question 40**Answer: D****Explanatory notes**

Option A is incorrect. Ceasing to use the antibiotic would not be expected to have a negative effect on MRSA.

Option B is incorrect. It is far more likely that an effect would occur.

Option C is incorrect. There is no longer a benefit to the bacteria being resistant to antibiotics.

Option D is correct. The bacteria that are sensitive to the antibiotics are better able to survive in the absence of the antibiotics, leading to the proportion of sensitive bacteria increasing.

SECTION B

Question 1a.

Worked solution

Location A

Location B has glycolipids and glycoproteins, which are located on the external surface of the plasma membrane and protrude into the extracellular fluid. Therefore, the cytosol has to be on the other side of the plasma membrane.

Mark allocation: 1 mark

- 1 mark for providing both the correct location and a correct reason

Note: No marks for only stating the location without also providing a supporting reason.

Question 1b.

Worked solution

Glucose cannot diffuse across the plasma membrane because it is a large hydrophilic (polar) molecule.

Structure 4 is a carrier protein (known as a glucose transporter), which enables glucose to enter cells by facilitated diffusion or active transport. Glucose binds to the transporter, which causes the transporter to change shape and release the glucose on the other side of the membrane.

Mark allocation: 2 marks

- 1 mark for stating that glucose is too large and polar to diffuse across the plasma membrane
- 1 mark for stating that structure 4 is a carrier protein and explaining facilitated diffusion or active transport

Question 1c.

Worked solution

This substance is a glycolipid.

Glycolipids play an important role in cellular recognition by enabling the immune system to identify self-cells.

Mark allocation: 2 marks

- 1 mark for stating that structure 8 is a glycolipid
- 1 mark for describing the role played by glycolipids



Tip

- Care must be taken when reading questions to make sure that you have understood them correctly. For example, this question asks what type of substance structure 8 is, not what the name of structure 8 is. If this question is not read correctly, an incorrect response such as 'Class I MHC marker' may be provided.

Question 2a.**Worked solution**

Because the experiment tested the effect of glucose concentration on ATP production, cells with mitochondria were required. Muscle cells have large numbers of mitochondria, making them an appropriate choice.

Mark allocation: 1 mark

- 1 mark for providing an answer that links the purpose of the experiment to the requirement for cells with mitochondria

**Tip**

- *Experimental design and analysis have become increasingly important in the VCE Biology course. It is beneficial for you to be familiar with experimental design and analysis, as well as the associated terminology, to apply this information to specific scenarios.*

Question 2b.**Worked solution**

The concentration of glucose in g/L

Mark allocation: 1 mark

- 1 mark for stating glucose concentration

**Tip**

- *It is important that all answers are precise because incomplete answers may not be awarded a mark. In this example, writing 'glucose' as the answer would be insufficient.*

Question 2c.**Worked solution**

The mass of ATP produced

Mark allocation: 1 mark

- 1 mark for stating the amount of ATP as the dependent variable

Question 2d.**Worked solution**

The mass of muscle cells used in each tissue culture flask

The muscle cells are responsible for carrying out aerobic cellular respiration. If the mass of cells were to be varied in each flask then this would introduce an additional independent variable to the experiment and we would not be sure whether the change in the amount of ATP was due to glucose concentration or muscle mass.

Mark allocation: 2 marks

- 1 mark for stating a factor that would need to be controlled (e.g. length of time or volume of nutrients supplied)
- 1 mark for explaining how that factor will affect the result of the experiment

**Tip**

- *In questions such as this one, precise reasons need to be provided. For example, an answer such as 'to ensure that there is only a single independent variable' would not be sufficient because this is a generic answer that does not relate to the specific variable.*

Question 2e.**Worked solution**

The amount of ATP produced increases linearly as glucose concentration increases.

Glucose is an input of aerobic cellular respiration (specifically glycolysis), and ATP is an output of aerobic cellular respiration. If the glucose input is increased then the ATP output should also increase.

Mark allocation: 2 marks

- 1 mark for correctly stating the trend
- 1 mark for explaining why the trend occurred

Question 2f.**Worked solution**

The researcher should have performed the experiment several more times.

This action should have been taken to see whether or not the results were concordant. If the experiment were to be repeated several times and the results were concordant then it is unlikely that the ATP production at 0 g/L glucose concentration is an error and so it should be included on the graph.

Mark allocation: 2 marks

- 1 mark for stating the action that should be taken
- 1 mark for explaining why this action should be taken

Question 3a.**Worked solution**

An exon is a coding region of DNA that will be transcribed and translated. An intron is a non-coding region that will be transcribed but not translated.

Mark allocation: 1 mark

- 1 mark for correctly comparing an intron and an exon

**Tip**

- *Care needs to be taken with comparison questions because the word 'compare' may not be included in the question. The requirement for a comparison may be implied, as in this question. It is essential that both of the items being compared are mentioned in the response.*

Question 3b.**Worked solution**

A methylated cap is added to the 5' end of the molecule.

A polyA tail is added to the 3' end of the molecule.

Mark allocation: 2 marks

- 1 mark for each modification correctly identified (up to 2 marks)

Question 3c.**Worked solution**

DNA is double stranded and mRNA is single stranded.

mRNA has a polyA tail (or methylated cap) while tRNA does not (it has an amino acid attachment site).

Mark allocation: 2 marks

- 1 mark for providing a correct structural comparison between DNA and mRNA
- 1 mark for providing a correct structural comparison between mRNA and tRNA

Question 3d.**Worked solution**

A condensation reaction

Mark allocation: 1 mark

- 1 mark for correctly stating the type of reaction

Question 3e.**Worked solution**

The genetic code is redundant (or degenerate).

Change the second codon from CUC to CUU. Both of these codons code for leucine, so the DNA sequence would change but the structure of the protein would be unaffected.

Mark allocation: 2 marks

- 1 mark for stating that the genetic code is redundant or degenerate
- 1 mark for providing an example where two codons code for the same amino acid

**Tip**

- *Questions such as this will often ask for an example. This must be provided to be awarded the mark. For example, an answer such as 'changing a single codon would alter the DNA sequence without altering the polypeptide chain' would not be acceptable because, although a correct understanding of the concept has been demonstrated, correct interpretation of the question has not.*

Question 4a.**Worked solution**

Oestrogen diffuses across the plasma membrane and binds to the receptor in the cytosol to form a hormone–receptor complex.

The hormone–receptor complex moves to the nucleus and binds to a segment of DNA called a steroid response element.

As a result, transcription is initiated in the target cell, causing the cell to produce a specific protein.

Mark allocation: 3 marks

- 1 mark for explaining how the hormone reaches the receptor and for stating that the receptor is located in the cytosol (or the nucleus)
- 1 mark for explaining how the complex interacts with DNA
- 1 mark for explaining the effect on the target cell

**Tip**

- *The Study Design states that you must be familiar with the stimulus–response model and the difference between signal transduction for hydrophilic and hydrophobic signalling molecules. A generic understanding of each can be applied to specific examples.*

Question 4b.**Worked solution**

A receptor has a specific shape that is complementary to the shape of the hormone.

Testosterone has a minor difference in chemical structure compared with oestrogen. Therefore, the two hormones bind to different intracellular receptors. This means that the hormone–receptor complexes are different and will therefore bind to different steroid response elements in the nucleus.

As a result, the target cells will be triggered to synthesise different proteins, which will cause different cellular responses.

Mark allocation: 3 marks

- 1 mark for stating that hormones bind to specific receptors
- 1 mark for stating that the chemical structure of testosterone differs to that of oestrogen
- 1 mark for stating that the hormones will bind to different receptors, therefore causing different cellular responses

**Tip**

- *Care needs to be taken when responding to questions that contain the word 'explain' because students frequently supply a statement instead of an explanation. Words such as 'because' and 'therefore' are useful in answers to this type of question because they are associated with explaining and making links. The presence of these types of words in an answer is a good indicator that an explanation has been provided.*

Question 4c.**Worked solution**

Some of the components of endoxifen, the active form of tamoxifen, have a similar structure (or shape) to oestrogen.

Endoxifen is therefore able to bind to the same receptors as oestrogen. In doing so, it acts as a competitive inhibitor (or antagonist) because it blocks oestrogen from binding to the receptor.

Therefore, the oestrogen receptor complex will not be formed and will not move to the nucleus to bind to the DNA. As a result, the cellular responses of growth and division do not occur, thereby reducing the growth rate of the tumour cells.

Mark allocation: 3 marks

- 1 mark for explaining that endoxifen and oestrogen have sections that are similar in shape
- 1 mark for explaining that endoxifen acts as a competitive inhibitor (or antagonist) to oestrogen
- 1 mark for explaining why the competitive inhibitor affects the growth rate of the tumour cells

Question 5a.**Worked solution**

The father's exposure to chicken pox antigens when he was vaccinated caused him to produce B memory cells that have remained in his lymphatic system. If the father encounters the antigen again, his immune system can produce a faster and stronger response. This is an example of artificial active immunity.

The mother was exposed to chicken pox antigens when she contracted the disease as a child. This also resulted in the production of B memory cells enabling a faster and stronger secondary response if she encounters the antigen again. This is an example of natural active immunity.

Mark allocation: 2 marks

- 1 mark for explaining why the father would not expect to develop the disease, with reference to artificial active immunity
- 1 mark for explaining why the mother would not expect to develop the disease, with reference to natural active immunity

Question 5b.**Worked solution**

The advice that it was unnecessary to vaccinate the two older children was based on the fact that they had already contracted the disease and therefore would have produced their own B memory cells, which would remain in their lymphatic system.

The youngest child should be vaccinated because they have not developed any symptoms of chicken pox and it is probable that they have not been exposed to the antigen. Vaccinating the youngest child will expose them to the antigen without causing the disease and enable them to produce B memory cells.

Mark allocation: 2 marks

- 1 mark for explaining why it would be unnecessary to vaccinate the two older children
- 1 mark for explaining why the youngest child should be vaccinated

Question 5c.**Worked solution**

Macrophages encounter the antigens and then ingest and process them. Antigenic fragments are combined with the class II MHC marker and are displayed on the external surface of the macrophage. Cytokines are produced to attract T-helper cells.

The macrophage presents the antigen to a T-helper cell.

The T-helper cell presents the antigen to a B cell, which proliferates and produces many antibody-producing plasma cells and a few memory cells that remain in the lymph nodes.

Mark allocation: 3 marks

- 1 mark for describing the role of an antigen presenting cell, such as a macrophage or dendritic cell
- 1 mark for describing the role of the T-helper cell
- 1 mark for describing clonal expansion and the production of antibodies

Question 5d.**Worked solution**

A person only contracts an infectious disease after being exposed to a pathogen or pathogenic agent. The vaccine only contains antigenic fragments; therefore, there is nothing in the vaccine that can cause an infection.

Mark allocation: 1 mark

- 1 mark for explaining that an antigen is not a pathogen – just because a substance is antigenic does not mean that it is pathogenic (e.g. allergens are antigenic but not pathogenic)

Question 5e.**Worked solution**

Vaccination programs are designed to ensure that most of the community is immune to infectious diseases, which is known as herd immunity.

If the number of vaccinated individuals decreases to less than 95% of the population then the number of individuals who are vulnerable to infection increases and the chance of a vulnerable person being exposed to the pathogen or pathogenic agent increases. As a result, the infection is better able to spread through the community.

Mark allocation: 2 marks

- 1 mark for explaining the link between vaccination programs and herd immunity
- 1 mark for explaining that choosing not to be vaccinated may prevent herd immunity from being achieved and result in an increase of infectious diseases

Question 6a.**Worked solution**

The midtown area has acted as a barrier to gene flow between the uptown and downtown rats.

As a result, members of each rat population only interbreed with others in the same population. Each rat population is subjected to different selection pressures and therefore genetic changes accumulate in the two populations, increasing the degree of diversity between them.

Mark allocation: 2 marks

- 1 mark for stating that there is a barrier to gene flow
- 1 mark for explaining why the two different populations of rats develop genetic differences

Question 6b.**Worked solution**

Because the rats only travel short distances, gene flow is unlikely to occur between the populations, and the gene pool of each population remains stable.

Mark allocation: 1 mark

- 1 mark for explaining how the lack of migration affects the stability of each gene pool

Question 6c.**Worked solution**

Initially, all of the Manhattan rats were descended from the group of rats that were accidentally introduced from Europe. As urbanisation increased, the rats became isolated in different areas of the island and gene flow between each of the sub-populations ceased.

Each sub-population was then exposed to different selection pressures and genetic differences began to accumulate.

Eventually, the genetic changes will accumulate to such an extent that the rats may develop into different species. This will have been achieved if rats from the two different areas are unable to mate and produce viable offspring.

Mark allocation: 3 marks

- 1 mark for stating that a single population was split into smaller sub-populations and that gene flow stopped occurring between these populations
- 1 mark for stating that the separated populations are exposed to different selection pressures, which result in genetic changes
- 1 mark for stating that speciation will eventually occur and is demonstrated when members of the different populations cannot successfully interbreed

Question 7a.**Worked solution**

The non-coding regions are not expressed and will not have any effect on the phenotype of the individuals.

Mark allocation: 1 mark

- 1 mark for stating a plausible reason why the researchers did not include information about the non-coding areas of DNA

Question 7b.**Worked solution**

Three nucleotides are required to code for each amino acid, so there would be more nucleotides to compare than amino acids.

Due to the degeneracy of the genetic code, changes can occur in the DNA sequence without a change occurring to the polypeptide chain.

Several codons code for release factors and do not affect the amino acid sequence in the polypeptide chain.

Mark allocation: 2 marks

- 1 mark for each plausible reason (up to 2 marks)

Question 7c.**Worked solution**

The hybrid that was made using mouse and yeast DNA

There are the greatest number of differences between the mouse DNA and yeast DNA: 119 differences compared with 9, 31, 58 or 77 differences for the other species. The mouse DNA and yeast DNA sequences will be less complementary than the hybrids containing mouse DNA and the DNA from the other four species. Therefore, the binding between the two strands will be the weakest, resulting in the hybrid having the lowest melting point.

Mark allocation: 2 marks

- 1 mark for stating the correct hybrid
- 1 mark for explaining why the hybrid will have the lowest melting point.

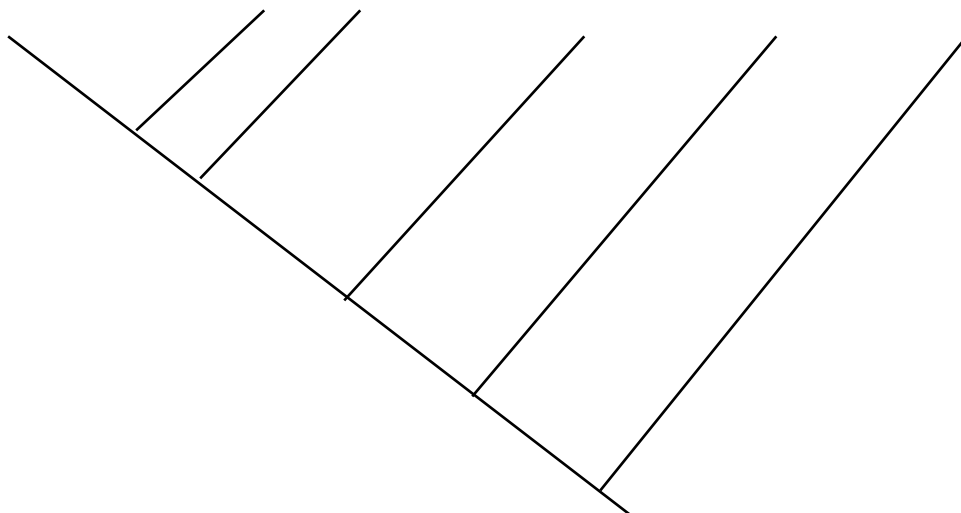
Note: The data must be referred to in the answer.

**Tip**

- When answering a question that includes a statement about referring to the data, it is essential to use the data in your answer. An answer such as 'there are the greatest number of differences between the mouse and yeast DNA' is incomplete because, although it shows that the data has been interpreted, the data has not been used in the answer.

Question 7d.**Worked solution**

Human Mouse Rat Chicken Fruit fly Yeast

**Mark allocation: 2 marks**

- 1 mark for placing organisms in the correct order
- 1 mark for attempting an appropriate scale

Question 8a.**Worked solution**

The development of bipedalism freed the hands and enabled more complex tools to be produced. This enabled hominins to successfully hunt for larger prey as well as to process and eat this prey.

This may have led to the consumption of a diet that was higher in protein than had previously been the case, leading to an increase in brain size.

Mark allocation: 2 marks

- 1 mark for stating that bipedalism resulted in hands being freed to accomplish other tasks
- 1 mark for stating the link between tool making and a diet higher in protein

Question 8b.**Worked solution**

Cognitive changes led to a change in lifestyle from being nomadic hunter-gatherers to having settlements of permanent dwellings with domesticated animals and agricultural practices.

Mark allocation: 1 mark

- 1 mark for discussing any plausible link between cognitive changes and cultural evolution

Question 8c.**Worked solution**

Potassium to argon dating is a technique used to date rocks and minerals based on the radioactive decay of potassium-40 rather than organic material. Therefore, the rocks or minerals surrounding the fossils were required to date the fossils.

Mark allocation: 1 mark

- 1 mark for explaining that potassium to argon dating is used to date the rocks surrounding fossils, not the fossils themselves

Question 8d.**Worked solution**

Any two of the following attributes are acceptable

- The jaw would be parabolic in shape.
- Brow ridges would be small or absent.
- The foramen magnum would occupy a more central position in the base of the skull.
- The size of the canine teeth would be reduced.
- The cranial capacity would be comparatively large.

Mark allocation: 2 marks

- 1 mark for each accurate response (up to 2 marks)

**Tip**

- *You must read the question carefully so that accurate but irrelevant information is not provided in your answer. For example, stating that legs are longer than arms would be incorrect because this information does not relate to the skull.*

Question 9a.**Worked solution**

EcoRI, BamHI or HindIII

Each of these enzymes cut the DNA in such a way that sticky ends are produced.

Mark allocation: 2 marks

- 1 mark for identifying a restriction enzyme that would result in the production of DNA with sticky ends
- 1 mark for stating that the restriction enzyme selected had to cut DNA in such a way that sticky ends were produced

Question 9b.**Worked solution**

Yes

The same type of restriction enzyme should be used to cut the plasmid open and cut around the gene of interest so that the fragments of DNA will have complementary sticky ends that enable the gene of interest to be annealed into the plasmid.

Mark allocation: 1 mark

- 1 mark for explaining why the same type of restriction enzyme needs to be used to cut both pieces of DNA.

Note: No marks will be awarded for a response without a supporting reason.

Question 9c.**Worked solution**

A DNA standard or ladder or marker solution

The solution contains DNA fragments of known size. Because DNA fragments that are the same size move through the gel to the same extent, the position of fragments of unknown size can be approximately determined by comparing the position of the fragments of unknown size to the fragments of known size.

Mark allocation: 2 marks

- 1 mark for stating that lane 1 contains a DNA standard solution
- 1 mark for explaining how standard solutions are used to identify the size of other DNA fragments in the same gel

Question 9d.**Worked solution**

The fragment closest to the negative terminal (or closest to the top of the diagram)

Larger fragments do not travel as easily (or as far) through an electrophoresis gel as smaller fragments. The plasmid combined with the gene of interest is larger than any other fragment and therefore would stay closest to the wells near the negative terminal.

Mark allocation: 2 marks

- 1 mark for identifying the correct fragment
- 1 mark for explaining why the larger fragment does not move as far as the smaller fragment

Question 9e.**Worked solution**

The researcher included the ampicillin in the agar to act as a selective agent that enables transformed bacteria to be identified.

The gene for ampicillin resistance is located in the same plasmid as the gene of interest. Therefore, only the bacteria that have taken up the recombinant plasmid will be able to survive in the ampicillin-rich environment. All other bacteria will be sensitive to ampicillin and die. Each of the colonies of bacteria that are alive 24 hours later are the descendants of a single transformed bacterium.

Mark allocation: 2 marks

- 1 mark for stating the purpose of including ampicillin in the agar
- 1 mark for explaining how the presence of ampicillin in the agar affects the bacterial culture

Question 9f.**Worked solution**

70% ethanol is the most bactericidal concentration of ethanol. It is used as a disinfectant that sterilises the work area and prevents any other microbes present from causing contamination.

Mark allocation: 1 mark

- 1 mark for explaining that 70% ethanol is used as a disinfectant to prevent contamination

Question 10a.**Worked solution**

If a domed tortoise and a saddleback tortoise interbred and produced viable offspring then they must be members of the same species.

Mark allocation: 1 mark

- 1 mark for stating that members of the same species are capable of interbreeding and producing viable offspring

Note: It is essential that the word ‘viable’ or similar is included in the answer.

Question 10b.**Worked solution**

The tortoises that migrated away from Isabela Island either had carapaces of varied heights and legs of varied lengths or a mutation caused this variation after they migrated away from Isabela Island.

The lack of ground vegetation on the outer islands meant that the tortoises with the highest carapaces and longest legs were better able to reach the available food, making them more biologically fit and giving them a higher chance of surviving and reproducing than the tortoises with lower carapaces and shorter legs. Their offspring would inherit these traits and pass them on.

As a result, the prevalence of higher carapaces and longer legs increased in subsequent generations of the tortoise populations in the outer islands compared to those on Isabela Island.

Mark allocation: 3 marks

- 1 mark for discussing the variation in the population of tortoises
- 1 mark for identifying the trait that conferred the greatest degree of fitness and hence survival and reproduction
- 1 mark for stating that the prevalence of the traits that confer biological fitness (or reproductive advantage) increases over time

**Tip**

- *Some of the processes that you will have learned, such as natural selection, are sequential in nature. It is useful to develop an understanding of the sequential nature of these processes because it makes them easier to remember and apply to specific scenarios.*

Question 11a.**Worked solution**

An enzyme

Mark allocation: 1 mark

- 1 mark for stating that an enzyme would be responsible for catalysing the reaction in which phenylalanine is converted to tyrosine

Question 11b.**Worked solution**

The symptoms of phenylketonuria are serious. There is no cure and damage cannot be reversed. Because phenylketonuria can be controlled by diet, early diagnosis is essential to minimise the effects of the condition.

Mark allocation: 1 mark

- 1 mark for providing a plausible reason relating to the early diagnosis of phenylketonuria

Question 11c.**Worked solution**

Possible responses include:

- Parents may be reluctant to have their children screened.
- Any individual who has tested as positive will require ongoing modifications to their lifestyle.
- The relationship between parent and child may be compromised if the diagnosis is not correctly understood.

Mark allocation: 1 mark

- 1 mark for any plausible response

Question 11d.**Worked solution**

The blood sample of a baby with phenylketonuria will have a substantially higher concentration of phenylalanine (or a lower concentration of tyrosine) than a baby who does not have phenylketonuria.

Mark allocation: 1 mark

- 1 mark for correctly comparing the concentration of phenylalanine (or the concentration of tyrosine) in the blood of babies with and without phenylketonuria

Question 11e.**Worked solution**

Although individuals with phenylketonuria should not consume proteins that contain phenylalanine, they will still consume proteins that contain tyrosine. Therefore, they will produce some melanin. Individuals with albinism are incapable of producing any melanin.

An individual who has phenylketonuria will have less tyrosine available to convert into melanin than an unaffected person, and will produce less pigmentation and have lighter colouring than would otherwise occur.

Mark allocation: 2 marks

- 1 mark for stating that individuals can still produce melanin if they ingest tyrosine
- 1 mark for explaining that individuals who have phenylketonuria will only be able to obtain tyrosine through their diet and not from metabolic processes and will therefore have less tyrosine, produce less melanin and have a paler colouration than an unaffected person

END OF WORKED SOLUTIONS