



YEAR 12 *Trial Exam Paper*

2022

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	Answer
1	<i>C</i>
2	<i>B</i>
3	<i>D</i>
4	<i>D</i>
5	<i>A</i>
6	<i>B</i>
7	<i>D</i>
8	<i>D</i>
9	<i>C</i>
10	<i>A</i>
11	<i>C</i>
12	<i>A</i>
13	<i>D</i>
14	<i>C</i>
15	<i>A</i>
16	<i>A</i>
17	<i>B</i>
18	<i>B</i>
19	<i>D</i>
20	<i>B</i>

Question	Answer
21	<i>D</i>
22	<i>C</i>
23	<i>A</i>
24	<i>C</i>
25	<i>C</i>
26	<i>C</i>
27	<i>A</i>
28	<i>D</i>
29	<i>A</i>
30	<i>D</i>
31	<i>D</i>
32	<i>B</i>
33	<i>A</i>
34	<i>B</i>
35	<i>C</i>
36	<i>B</i>
37	<i>B</i>
38	<i>C</i>
39	<i>A</i>
40	<i>C</i>

Question 1**Answer: C****Explanatory notes**

Option A is incorrect because only DNA has a double helix structure. Option B is incorrect because the pentose in DNA is deoxyribose, not ribose. Option D is incorrect because mRNA has uracil instead of thymine. Option C is correct because all nucleic acid molecules have a sugar-phosphate backbone.

Question 2**Answer: B****Explanatory notes**

The information provided shows that there are six codons that code for leucine. This demonstrates the degeneracy (redundancy) of the genetic code.

**Tip**

- *Although the information provided is frequently useful in determining the answer to a question, sometimes part of the information is irrelevant. In this example, the only relevant information is that there are six codons that code for leucine. The information about the anticodons is not relevant to the concept being tested: the degeneracy of the genetic code.*

Question 3**Answer: D****Explanatory notes**

Inserting DNA into a plasmid produces a recombinant plasmid. Any bacteria that take up the recombinant plasmid now have the ability to produce human insulin, an ability they previously did not have. Therefore, the bacteria are referred to as being transformed.

Question 4**Answer: D****Explanatory notes**

Proteins have quaternary structure when two or more polypeptides are bound together to produce a single functional protein. Insulin has an alpha chain and a beta chain and therefore has quaternary structure.

Question 5**Answer: A****Explanatory notes**

Structure 1 is a Golgi body, Structure 2 is a mitochondrion, Structure 3 is rough endoplasmic reticulum (ER) and Structure 4 is smooth ER. Ribosomes embedded on the rough ER carry out translation and the Golgi body is responsible for the final modification and packaging of the protein before it is secreted from the cell.

Question 6**Answer: B****Explanatory notes**

The proteome is defined as the entire set of proteins produced by an organism.

**Tip**

- *Biology is a subject that has a lot of terminology. Therefore, it is useful to have written a glossary of terms studied in Units 3 and 4 in preparation for answering this type of question.*

Question 7**Answer: D****Explanatory notes**

The two most important structures in a molecule of tRNA are the exposed anticodon and the amino acid attachment site. This diagram shows an amino acid attached to the tRNA molecule.

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

Option A is incorrect because the DNA does not need to be unwound to expose the two template strands; this occurs because of the high temperature used in the denaturation stage. Option B is incorrect because although endonucleases are used to cut DNA, that does not happen during PCR. Option C is incorrect because DNA ligase is used to anneal strands of DNA together, not bind primers to DNA. Option D is correct because a specific form of DNA polymerase, called *Taq* polymerase, is used during the extension stage of PCR.

Question 9**Answer: C****Explanatory notes**

Insecticide usage decreased from 0.35 kg/ha (when Bt maize was not planted) to 0.01 kg/ha, when the percentage of land growing Bt maize increased to 80%.

Question 10**Answer: A****Explanatory notes**

Option A includes the only advantage in that column. The requirement for research is a disadvantage because of the amount of time and money that is still needed to make further progress in biofuels research.

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

The apples are genetically modified because their PPO gene has been silenced. However, they are not transgenic because they do not contain any foreign DNA.

Question 12**Answer: A****Explanatory notes**

It is essential to use the same restriction enzyme to cut through the plasmid and around the gene of interest. This eliminates Options C and D. Both pieces of DNA need to be cut with the same restriction enzyme so that complementary sticky ends are produced. Bam HI produces sticky ends, whereas SmaI does not.

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

Each child's profile has one band in common with each of the parents; therefore, they have inherited half of their DNA from each parent. Option A is incorrect because although these two children both have the same patterns, the number of loci being compared is small and it is likely that all the siblings will have the same patterns at some loci.

**Tip**

- *When a question asks you to determine if one or more children are the biological children of both parents, it is useful to start with the mother first. Rule a line through the bars in the mother's pattern and see if the children have a bar in the same position. Then compare the other bar of each child to the father's pattern.*

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

Inhibitor 1 has not bound to the active site, but has caused the shape of the enzyme to change. Therefore, Inhibitor 1 is non-competitive. Inhibitor 2 has bound to the active site of the enzyme; therefore, it is a competitive inhibitor.

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

Although the graph shows a higher reaction rate at 55°C than at 65°C, at 65°C the enzyme will be substantially denatured. Lowering the temperature from 65°C to 55°C will not reverse this, so the rate of reaction will not change.

Question 16**Answer: A****Explanatory notes**

The light-dependent stage supplies ATP and NADPH to the light-independent stage.

Question 17**Answer: B****Explanatory notes**

Malonic acid has a similar shape to succinic acid and is also able to bind to succinate dehydrogenase. Therefore, malonic acid is a competitive inhibitor.

**Tip**

- *Always look for words that do not allow for any alternatives, e.g. 'never', 'always', 'must'. In Option C, the word 'cannot' means that the presence of malonic acid prevents the breakdown of succinic acid. The extent to which this is true will be determined by the concentration of malonic acid.*

Question 18**Answer: B****Explanatory notes**

When NAD^+ accepts an electron from glucose, it becomes NADH, the reduced form of the molecule. The NADH molecule transports this electron to mitochondria where it then donates the electron to oxygen, converting back to NAD^+ . This occurs during the electron transport chain, which occurs in the cristae of the mitochondria.

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

The majority of the energy initially present in glucose remains in the bonds of the pyruvate molecules.

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

Options A and D both state that a greater amount of energy is released anaerobically than aerobically. This is incorrect. The products of fermentation carried out by yeast cells are ethanol and carbon dioxide.

Question 21**Answer: D****Explanatory notes**

Passive immunity involves obtaining antibodies from another organism. Because there is no exposure to antigens, memory cells are not produced.

Question 22**Answer: C****Explanatory notes**

The diagram shows a secondary response to Antigen A and a primary response to Antigen B. The secondary response occurs as a result of memory cells being produced, which is the result of a previous exposure to Antigen A.

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

Antibiotics have no effect upon viruses, so viruses are not sensitive to their use.

Question 24**Answer: C****Explanatory notes**

If B memory cells are exposed to an antigen that they recognise, then they will undergo division, producing large numbers of B plasma cells and a few memory cells.

Question 25**Answer: C****Explanatory notes**

One of the uses of monoclonal antibodies is in the treatment of rheumatoid arthritis. They play a role in reducing inflammation.

Question 26**Answer: C****Explanatory notes**

The researchers would observe that swelling of the lymph nodes only occurred in mice that had mast cells. The fact that the swelling occurred in mice that initially lacked mast cells but were provided with them lends support to this conclusion.

**Tip**

- *Always read all the options carefully before selecting your answer. Although Option D may be correct, the use of 'must' in this option means that it is not the best choice.*

Question 27**Answer: A****Explanatory notes**

A gene pool is the sum total of alleles in a population.

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

The aim of studying the viruses is to attempt to control the emergence of new strains. This can only be accomplished by monitoring genetic changes.

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

Antigenic shift causes viruses to have different antigens from previously existing strains. As people would not have been previously exposed to the new strains, they would not have immunity to the antigens associated with those strains.

Question 30**Answer: D****Explanatory notes**

Option A is incorrect; Diagram 1 does not represent the speciation of Darwin's finches because they would have been shown as present on different land masses. Option B is incorrect because both could represent speciation. Diagram 1 could represent sympatric speciation and Diagram 2 could represent allopatric speciation. Option C is incorrect because the barrier would prevent gene flow occurring. Option D is correct because the different colours represent different species. This diagram is a representation of sympatric speciation.

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

Index fossils must be common and abundant, and the species must have existed for a comparatively short period of time.

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

New species often arise on islands because they are isolated, so gene flow is prevented.

Question 33

Answer: A

Explanatory notes

Vestigial structures are those that have lost most or all of their original function. The pelvis connects the legs to the trunk of individuals who walk. The ancestral species of whales were able to walk, but whales cannot do so. Therefore, the pelvis is a vestigial structure.

Question 34

Answer: B

Explanatory notes

A homologous structure is one that has common ancestry in multiple organisms. Given the length of time dinosaurs have been extinct, birds and dinosaurs could not have shared a very recent common ancestor. However, it is now believed that dinosaurs had many physical traits and behaviours in common with modern birds.

Question 35

Answer: C

Explanatory notes

As the fossil of Species X was found in a lower rock stratum, Species Y must have existed more recently than Species X.

Question 36

Answer: B

Explanatory notes

The presence of marine fossils at Coober Pedy indicates that this area was once under seawater.

Question 37

Answer: B

Explanatory notes

Organisms that are bipedal can use their arms for other functions, such as carrying food or offspring.

Question 38

Answer: C

Explanatory notes

The strong regional patterns indicate that once an ancestral group reached a specific area, their descendants tended to stay there.

Question 39***Answer: A*****Explanatory notes**

The phylogenetic tree shows that *Homo sapiens*, Neanderthals and Denisovans all share a recent common ancestor. *Homo sapiens* did not descend from either Neanderthals or Denisovans.

Question 40***Answer: C*****Explanatory notes**

There was a long-held belief that interbreeding between *Homo sapiens* and Neanderthals never took place. However, the presence of Neanderthal genomic DNA in many populations of modern humans indicates that interbreeding must have occurred.

SECTION B

Question 1a.

Worked solution

The repressor protein will bind to the operator region when tryptophan is available to the bacteria.

Mark allocation: 1 mark

- 1 mark for stating that the repressor protein binds to the operator region when tryptophan is present

Question 1b.

Worked solution

When tryptophan is present, the repressor protein binds to the operator, blocking the action of RNA polymerase and preventing transcription. In the absence of tryptophan, the repressor protein changes shape and releases the operator. RNA polymerase is able to read the DNA template and transcription occurs, and the *trp* genes are expressed.

Mark allocation: 4 marks

- 1 mark for stating that when tryptophan is present, it binds to the repressor protein
- 1 mark for stating that the repressor protein binds to the operator, blocking RNA polymerase from carrying out its function, therefore preventing transcription
- 1 mark for stating that when tryptophan is absent, the repressor protein changes shape and releases the operator
- 1 mark for stating that RNA polymerase is now able to read the DNA template, so the *trp* genes are expressed

Question 1c.

Worked solution

The eukaryotic gene has coding and non-coding regions called exons and introns. The *trp* operon does not have non-coding regions.

Mark allocation: 1 mark

- 1 mark for providing a correct comparison, such as the presence of introns in eukaryotic genes and the lack of introns in the *trp* operon



Tip

- Questions that require a comparison must include a reference to both things being compared. Sometimes a question will include the word 'compare', but, in other questions, such as this one, the requirement for a comparison is implied. An answer such as 'the eukaryotic gene has introns' is incomplete and may result in a mark not being awarded.

Question 1d.**Worked solution**

Methylated cap	Exon 1	Exon 2	Exon 3	Exon 4	Poly-A tail
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Mark allocation: 2 marks

- 1 mark for including the four exons in the mRNA
- 1 mark for including any other modification, such as the methylated cap or the poly-A tail

Question 1e.

Golgi body

Mark allocation: 1 mark

- 1 mark for identifying the Golgi body/complex/apparatus

**Tip**

- *When answering questions in a Biology exam, it is important to be aware of the appropriate length and quality of answer required. Being able to write concise but appropriately detailed answers is a valuable skill. In this example, two words are sufficient to gain the marks. If the student had written a full sentence, such as 'The cellular structure where sulfation occurs is called the Golgi body', the result would have been the same as for just writing 'Golgi body' and they would have used up time for no extra marks.*

Question 2a.**Worked solution**

Initially the rate of photosynthesis increased as light intensity increased because light intensity was the limiting factor. When light intensity reached around 4 arbitrary units, the rate of photosynthesis became constant. This occurred because carbon dioxide concentration, or another factor, became limiting.

Mark allocation: 2 marks

- 1 mark for describing that the reaction rate initially increased as light intensity increased and then became constant
- 1 mark for explaining that the rate initially increased because light intensity was a limiting factor, but then become constant when light intensity was no longer limiting

Question 2b.**Worked solution**

After light intensity increased to approximately 0.5 units, the rate of photosynthesis was always higher in Experiment 1 than in Experiment 2. This occurred because carbon dioxide is an input for photosynthesis. Carbon dioxide was present at a higher concentration in Experiment 1 than it was in Experiment 2; therefore, the reaction rate was higher in Experiment 1.

Note: It could also be suggested that the concentration of carbon dioxide becomes limiting much earlier when present in lower concentrations than when present in higher concentrations.

Mark allocation: 2 marks

- 1 mark for stating that carbon dioxide is a requirement for photosynthesis
- 1 mark for providing a plausible explanation as to why the reaction rate differs, such as the increased concentration of carbon dioxide in Experiment 1 resulting in a higher reaction rate

Question 3a.**Worked solution**

The data indicates that there were 140 000 cases per year in the 1940s and about 57 000 cases per year in the 1950s. This decreased to almost no cases in the 1970s and 1980s before increasing to nearly 40 000 cases per year in the 2010s and about 42 000 cases per year in 2020–2021.

Mark allocation: 1 mark

- 1 mark for using the data to show that large numbers of cases occurred annually between the 1920s and the 1950s, before decreasing in the 1970s and 1980s and then increasing again afterwards

Question 3b.**Worked solution**

Large numbers of people are able to travel to many places in the world very quickly. This enables the rapid spread of pathogens.

Mark allocation: 1 mark

- 1 mark for referring to the ability of a large number of people to travel around the world very quickly

OR

- 1 mark for any other valid point, such as people who oppose vaccination spreading their beliefs more extensively and rapidly via the internet than would otherwise be possible

Question 3c.**Worked solution**

After an infection occurs, mast cells in the damaged tissue release histamines. The action of histamines causes the surrounding blood vessels to dilate and increase in permeability. Substances such as plasma and plasma proteins, as well as cells such as neutrophils, are able to leak from the bloodstream into the site of the injury. This causes the symptoms of the inflammatory response, such as redness and swelling.

Mark allocation: 2 marks

- 1 mark for stating that mast cells release histamines
- 1 mark for explaining the role of histamines in the inflammatory response

Question 3d.**Worked solution**

Macrophages remove infectious pathogens from the body by the process of phagocytosis.

Mark allocation: 1 mark

- 1 mark for stating that macrophages carry out phagocytosis

Question 3e.**Worked solution**

Complement proteins opsonise pathogens, increasing the ability of phagocytes to recognise and engulf pathogens.

Natural killer cells can recognise cells that have been invaded by pathogens. Natural killer cells then secrete perforins, which cause the infected cells to lyse.

Mark allocation: 2 marks

- 1 mark for identifying a role of complement proteins. This could include the opsonisation of bacteria, the activation of the inflammatory response, enhancing clearance of antigen–antibody complexes or facilitating the formation of a membrane attack complex that causes the formation of cytotoxic pores on the surface of the pathogen
- 1 mark for identifying a role of natural killer cells, such as triggering apoptosis in infected cells and maintaining or increasing the inflammatory response

Question 3f.**Worked solution**

B cells become activated when they are presented with or become exposed to specific antigens. The activated B cells rapidly divide, producing large numbers of B plasma cells and a few memory cells. The plasma cells secrete antibodies that bind to and neutralise the pathogens. The B memory cells remain in the lymphatic system and assist in providing protection in the case of re-exposure to an antigen. If the antigen is encountered again, the B memory cells act to facilitate a faster and stronger response by the rapid production of B plasma cells.

Mark allocation: 3 marks

- 1 mark for stating that B cells are activated as a result of exposure to a foreign antigen
- 1 mark for explaining the role of B plasma cells during an infection
- 1 mark for explaining the role of B memory cells in providing protection against future infections by the same pathogen

Question 4a.**Worked solution**

natural selection

Mark allocation: 1 mark

- 1 mark for identifying natural selection as the process

Question 4b.**Worked solution**

The increasing incidence of tusklessness in female elephants is an example of natural selection. Poachers and other hunters kill elephants for their tusks, so being tuskless increases the biological fitness of the tuskless females. These females are more likely to survive and have offspring than the tusked females, leading to an increase in the trait of being tuskless in future generations.

Mark allocation: 3 marks

- 1 mark for stating that being tuskless increases biological fitness
- 1 mark for stating that tuskless females are more likely to survive and have offspring
- 1 mark for stating that the incidence of tusklessness in females should continue to increase

**Tip**

- *One of the important skills to have is the ability to apply existing knowledge to unfamiliar situations. In this question, the increasing incidence of tusklessness in female elephants is an example of natural selection. Once you recognise this, it is just a matter of applying the generic series of statements about natural selection to the specific example.*

Question 4c.**Worked solution**

The female offspring of the female elephants with the *AMELX* mutation have a 50% chance of having the same mutation. Because these females are more likely to survive and have offspring than their tusked counterparts, the biological consequence is a continuing increase in the incidence of tusklessness in females. The *AMELX* mutation is lethal in males, so could lead to a gender imbalance in the herds in Gorongosa. A decreasing male population could lead to an overall decrease in the elephant population.

Mark allocation: 2 marks

- 1 mark for describing a plausible consequence for the female members of the elephant population
- 1 mark for describing a plausible consequence for the male members of the elephant population

Question 4d.**Worked solution**

It was essential to sequence DNA from tusked and tuskless females in order to identify the genetic differences that caused the tuskless phenotype.

Mark allocation: 1 mark

- 1 mark for providing a plausible reason for sequencing genomic DNA from tusked and tuskless females

Question 5a.**Worked solution**

Identify trees that show the highest degree of resistance to the budworm. Use these trees as the parents of the next generation of trees.

Identify the offspring with the highest degree of resistance to the budworm and use these trees as the parents of the next generation of trees.

Continue this process over many generations of trees.

Mark allocation: 3 marks

- 1 mark for explaining that trees with the highest degree of resistance should be chosen to be the parents of the next generation
- 1 mark for explaining that the offspring with the highest degree of resistance should then be chosen as the parents of the next generation
- 1 mark for stating that this process should be repeated over many generations

Question 5b.**Worked solution**

The population of trees resistant to the budworm would increase, leaving fewer trees available for the budworm to infect.

Mark allocation: 1 mark

- 1 mark for any plausible suggestion, such as an increase in profit due to more wood being available or less wood being damaged by the actions of the budworm

Question 5c.**Worked solution**

thick cuticle

Mark allocation: 1 mark

- 1 mark for any plausible suggestion, such as thick bark, thorns, a protective layer of resin or having thin spines instead of leaves

Question 6a.**Worked solution**

Expose the plasmid and gene of interest to the same restriction enzyme, so that they have complementary sticky ends.



Mix the cut plasmid and the segment containing the gene of interest under conditions that favour the annealing of the gene of interest into the plasmid.



Treat the plasmid with DNA ligase in order for the insert to be completely annealed (note this causes the covalent phosphodiester bonds to reform between the two pieces of DNA).

Note: This is an example of an accepted answer. Determining the validity of a student's answer is at the discretion of the assessor.

Mark allocation: 3 marks

- 1 mark for stating that the plasmid and gene have to be exposed to the same restriction enzyme
- 1 mark for referring to the gene and plasmid annealing (binding together at the complementary sticky ends)
- 1 mark for referring to the use of DNA ligase to seal the gene insert into the plasmid

Question 6b.**Worked solution**

gel electrophoresis

Mark allocation: 1 mark

- 1 mark for identifying gel electrophoresis as an appropriate technique

Question 6c.**Worked solution**

The plasmid is a means of delivering the gene of interest into a bacterial cell.

Mark allocation: 1 mark

- 1 mark for explaining what a vector is in the context of gene technology

Question 6d.**Worked solution**

Grow all of the bacteria exposed to the recombinant plasmid in agar that contains ampicillin.

The bacteria that survive this can only do so because they have the ampicillin resistance gene incorporated into the plasmid. This means that they must be the transformed bacteria because all bacteria that were not transformed would have been killed by exposure to ampicillin.

Mark allocation: 2 marks

- 1 mark for identifying that the potentially transformed bacteria should be cultured onto agar that also contains ampicillin (or tetracycline)
- 1 mark for explaining that the transformed bacteria will survive this process because they have the antibiotic resistance gene from the recombinant plasmid. Bacteria that did not transform will not survive this process.

Question 6e.**Worked solution**

The biggest concern with the use of antibiotic resistance genes in gene technology is that these genes will spread to other bacteria, conferring resistance, and reducing the efficiency of antibiotics as a means of treating bacterial infections. This could lead to the development of superbugs – strains of bacteria that have become resistant to antibiotics.

Mark allocation: 1 mark

- 1 mark for explaining that there is a concern that the use of antibiotic resistance genes in the production of transgenic bacteria will result in a decrease in the efficiency of antibiotics against bacterial infections

Question 7a.**Worked solution**

The distance between Islands B and C is only about 100 km; therefore, the birds would be able to fly between them. Island A is hundreds of kilometres away from Islands B and C and it would be difficult for the birds to travel that far across open seas.

Mark allocation: 1 mark

- 1 mark for explaining that the birds could easily travel between Islands B and C but that travel to and from Island A would be difficult for them, which would tend to prevent gene flow

Question 7b.**Worked solution**

The birds on Islands B and C are the most genetically similar to each other (because they are still members of the same species).

The birds on Island A are less genetically similar to Populations B and C than either of these populations are to each other.

Mark allocation: 2 marks

- 1 mark for stating that the birds on Islands B and C are genetically similar to each other
- 1 mark for stating that the birds on Island A are not as genetically similar to Populations B or C as Populations B and C are to each other

Question 7c.

This is an example of allopatric speciation.

The ancestors of the birds on Island A became geographically isolated from the ancestors of the birds on Islands B and C. As a result, these birds became reproductively isolated.

The birds on Island A were subjected to different selection pressures compared to the birds on Islands B and C.

Over time, genetic changes accumulated, ultimately resulting in speciation.

Mark allocation: 3 marks

- 1 mark for identifying the process as allopatric speciation
- 1 mark for explaining that the birds on Island A are geographically/reproductively isolated from the birds on the other islands
- 1 mark for explaining that genetic changes accumulated in the birds on Island A as a result of them experiencing different selection pressures from the birds on Islands B and C

Question 8a.**Worked solution**

potassium to argon dating

Mark allocation: 1 mark

- 1 mark for identifying an appropriate absolute dating method

Question 8b.**Worked solution**

The diagram shows a later divergence from the common ancestor with *H. neanderthalensis*.

The line indicating the position of *H. longi* is not as long as that of *H. sapiens* because *H. longi* is extinct.

Mark allocation: 2 marks

- 1 mark for any valid conclusion (up to 2 marks)

Question 8c.**Worked solution**

Our understanding of human evolution is open to different interpretations, particularly when new evidence is found, such as the skull of *H. longi*.

Mark allocation: 1 mark

- 1 mark for stating that our understanding of human evolution is open to different interpretations and therefore these differences would be reflected in the phylogenetic trees constructed based on those interpretations.

Note: This is particularly the case because the fossil record for hominins is scanty due to their terrestrial habitat.

Question 8d.**Worked solution**

<i>H. longi</i> feature	Comparison with modern human
Cranial capacity (brain size)	Similar
Brow ridges	Larger/thicker
Limb structure	Shorter legs/longer arms

Mark allocation: 3 marks

- 1 mark for identifying that the cranial capacity of *H. longi* is likely to have been similar (possibly slightly smaller or larger) to that of *H. sapiens*
- 1 mark for identifying that brow ridges were larger, thicker and/or more prominent than those of *H. sapiens*
- 1 mark for identifying that *H. longi* were likely to have had shorter legs and/or longer arms than *H. sapiens*

**Tip**

- You may not be aware of all of the different hominins. However, the writers of the examinations frequently use up-to-date information; therefore, being widely read can be an advantage. You are required to be aware of the major trends in hominin evolution, and should be able to apply this knowledge to unknown examples. The statement that *H. longi* have 'typical archaic human features' and the information indicating that they share a recent common ancestor with *H. neanderthalensis* as well as *H. sapiens* should assist you to answer questions such as this one.

Question 9a.**Worked solution**

The CRISPR-Cas9 system provides bacteria with an immunological memory of specific pathogens just as the human immune system has immunological memory due to having B memory cells.

The CRISPR-Cas9 system responds to the presence of an antigen by secreting a protein that cuts the foreign DNA. The human immune system also responds to the presence of an antigen by secreting proteins.

Mark allocation: 2 marks

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

Question 9b.**Worked solution**

CRISPR arrays include a series of DNA sequences from previously encountered viruses. These short sequences of DNA are known as spacers.

When the CRISPR arrays undergo transcription, guide RNA is produced that is specific for the viral DNA that the spacers were derived from.

If the same virus invades again, the guide RNA guides the Cas molecule to the viral DNA, which is then cut by the Cas molecule.

Mark allocation: 3 marks

- 1 mark for explaining that viral DNA is incorporated as spacers in the CRISPR array
- 1 mark for explaining that transcription of the array results in the production of guide RNA
- 1 mark for explaining that the guide RNA guides the Cas molecule to the complementary DNA of a re-invading virus and cuts that DNA into pieces

Question 9c.**Worked solution**

An off-target modification occurs when Cas9 cuts at unintended locations in the genome.

Mark allocation: 1 mark

- 1 mark for explaining what an off-target modification is

Question 9d.**Worked solution**

Off-target modifications are a matter of concern because if the sequence of another gene is interrupted, then the expression of that gene may be prevented.

Mark allocation: 1 mark

- 1 mark for explaining why off-target modifications are an issue of concern

Question 9e.**Worked solution**

Producing a strain of crops with increased disease resistance could increase the yield of that crop.

Mark allocation: 1 mark

- 1 mark for identifying a way in which the use of CRISPR-Cas9 technology could increase crop yield, such as by improving the quality of the crop or conferring herbicide resistance

Question 9f.**Worked solution**

producing a strain of sheep with higher quality wool

Mark allocation: 1 mark

- 1 mark for identifying a way in which the use of CRISPR-Cas9 technology could improve productive traits in animals, such as by increasing the quantity or quality of milk or meat from cattle

Question 9g.**Worked solution**

The use of the CRISPR array to target particular DNA sequences improves the precision of gene editing.

CRISPR technology improves the ability to carry out genetic modification because it can be used to add a desirable DNA sequence into a genome, remove an undesirable sequence or modify a mutation in order to correct a DNA sequence.

Mark allocation: 2 marks

- 1 mark for discussing how CRISPR technology improves precision
- 1 mark for discussing how CRISPR technology enables easier modification of DNA in living organisms

Question 10a.**Worked solution**

Independent variable: Temperature of the hydrogen peroxide solution

Dependent variable: Height of the foam

Mark allocation: 2 marks

- 1 mark for identifying temperature as the independent variable
- 1 mark for identifying the height of the foam as the dependent variable

Question 10b.**Worked solution**

The rate of the reaction increased more rapidly when the temperature increased from 10 °C to 20 °C and from 20 °C to 30 °C than when the temperature was increased from 30 °C to 40 °C and 40 °C to 50 °C.

The rate of the reaction increased the most rapidly when the temperature increased from 20 °C to 30 °C.

After 30 °C, the rate of the reaction continued to increase at a constant rate. The rate of the reaction continued to increase as the temperature increased from 30 °C to 50 °C.

Based on these results, the optimum temperature for amylase appears to be 50 °C or higher.

Mark allocation: 3 marks

- 1 mark for an appropriate statement made based on the data (up to 3 marks)

Question 10c.**Worked solution**

The results do not support the hypothesis.

The increasing height of the foam as the temperature increased from 40 °C to 50 °C indicates that the reaction rate increased after the temperature passed 37 °C instead of decreasing as predicted.

Mark allocation: 2 marks

- 1 mark for stating that the height of the foam was expected to be lower at 50 °C than at 30 °C
- 1 mark for stating that the optimum temperature for catalase was expected to be 37 °C and therefore the height of the foam should have been at its highest at 30 °C or 40 °C

Question 10d.**Worked solution**

The student specifically referred to the temperature of 37 °C in their hypothesis, but they did not use a water bath at this temperature in their experiment. Therefore, they have no data relating to the reaction rate at 37 °C.

Mark allocation: 1 mark

- 1 mark for explaining the hypothesis was not tested because none of the treatment groups were exposed to a temperature of 37 °C

Question 10e.**Worked solution**

All specimens were apparently placed into the water baths at the same time. It would be impossible to measure all of the data at the same time.

Using a staggered start approach would give sufficient time to obtain the results relating to each sample.

Mark allocation: 2 marks

- 1 mark for identifying any limitation in the method, with the exception of the limitation identified in **part d**.
- 1 mark for suggesting how this limitation could be addressed

Question 10f.**Worked solution**

All graphs should have the independent variable (temperature) on the x -axis and the dependent variable (foam height) on the y -axis. The student who produced this graph has put the data relating to the dependent and independent variables on the wrong axes.

Mark allocation: 1 mark

- 1 mark for identifying that the variables are on the wrong axes

Question 10g.**Worked solution**

Possible answers include:

The same volume of hydrogen peroxide was used in each test tube.

The same concentration of hydrogen peroxide was used in each test tube.

Each sample was exposed to the treatment for the same length of time.

The length of the potato cylinder was the same in each treatment group.

Mark allocation: 2 marks

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

END OF SAMPLE RESPONSES