ACCESS EDUCATION

# 2022 Unit 3&4 Trial Paper

## Suggested answers

## Section A – Multiple-choice

| Question. | Answer | Explanations and Notes |
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| 1 | B | All proteins are a polymer of amino acid monomers. All enzymes are proteins but not all proteins are enzymes. Many proteins are synthesised in a cell for use within the cell and are not secreted out of the cell. Only proteins composed of more than a single polypeptide chain have quaternary structure. |
| 2 | C | The RNA polymerase attaches at the promoter at the 5' end of a gene in both prokaryotes and eukaryotes. Operators are only found in prokaryotes. RNA processing only takes place in eukaryotes. Introns are only found in eukaryotic genes. |
| 3 | A | The genetic code is each of these things, but the feature that describes a single amino acid being encoded by more than a single codon is degenerate (also called redundant). |
| 4 | C | rRNA, together with protein forms ribosomes, whereas mRNA is translated to synthesise a protein. |
| 5 | D | This question is challenging because students are not likely to be able to distinguish between ribose and deoxyribose (ribose would have an OH group on the 2' carbon), however, they should know that the phosphate of a nucleotide (moiety 1) is at the 5' end of the nucleotide and therefore have been able to confidently choose option A as the correct response. Students should also be able to identify that moiety 2 is a nitrogenous base (not a pentose sugar) and that moiety 3 is a pentose sugar. Side chains are a feature of amino acids. |
| 6 | B | Competitive reversible inhibitors are displaced (i.e., outcompeted) by substrate if the concentration of substrate is very high. |
| 7 | C | When tryptophan concentration is low, the cell needs to express the structural genes of the operon. Therefore, option C makes sense because the completion of transcription results in gene expression. All the other options reduce the ability of the cell to synthesise tryptophan. |

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| 8 | A | Ligase forms sugar-phosphate (phosphodiester) bonds between the phosphate at the 5' end of one nucleotide and the pentose sugar at the 3' end of the next. |
| 9 | D | Each repeat begins with something other than the PAM sequence. This avoids Cas9 opening the spacer to check whether its sequence is complementary to the gRNA. The bacteria's spacer is complementary to the gRNA. Cas9 cuts both strands of double-stranded DNA. Bacteria do not have a nucleus. |
| 10 | B | 72°C is the optimal temperature for Taq polymerase, which extends the primers by adding nucleotides to the 3' end. At 55°C the primers anneal to single-stranded DNA. At 95°C double stranded DNA becomes single-stranded (or is denatured). |
| 11 | A | $CO_2$ is an output of Krebs cycle. NADH is an output of Krebs cycle, $FADH_2$ is an output of Krebs cycle. Water is an output of the electron transport chain. $NADP^+$ is an input to the light dependent stage of photosynthesis. NADPH is an output of the light independent stage of photosynthesis. |
| 12 | D | Coenzymes are always organic. Coenzymes always bind loosely with the enzyme. Coenzymes are, non-proteins. Since all enzymes are proteins, this means that coenzymes are not enzymes. |
| 13 | B | C3 photosynthesis is inefficient at high temperatures due to increased photorespiration. At high light intensity photosynthesis is faster than at low light intensity, assuming all other requirements are met. |
| 14 | C | CAM photosynthesis allows the plant to keep its stomata closed during the day when water loss is an issue for a plant which cannot easily replace lost water because it has no roots. |
| 15 | A | The loading wells are at the negative electrode because DNA has a negative electric charge and is attracted to the positive electrode through the gel. If a plasmid is cut in one place, one fragment will result. DNA is smaller in band 8 than band 4 because it has moved further through the gel. The DNA in bands 8 and 11 cannot be from the same person because band 8 is in lane iii whereas band 11 is in band iv, and the other bands in these two lanes make it clear that the lanes contain DNA from two different people. |
| 16 | B | Plasmids which lack tetracycline resistance must contain the insulin A gene, because it was the insertion of the insulin A gene that caused part of the tetracycline resistance gene to be lost. |
| 17 | A | Bacteria are 'transformed' if they have taken up any exogenous DNA (DNA from outside the cell). Therefore the bacterium is transformed if it has taken up a plasmid, whether or not the plasmid is a recombinant one. |

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| 18 | D | At light intensity 12, light intensity is not the limiting factor. This is clear because at light intensity 13 the rate of photosynthesis is the same. If light intensity were the limiting factor at intensity 12, then an increase in light intensity would result in an increase in the rate of photosynthesis. At light intensity 1, photosynthesis is taking place but at a very low rate. Since the graph is not -100 au. At light intensity 4, the limiting factor is light intensity. Therefore, increasing $CO_2$ concentration would not be expected to increase the rate of photosynthesis. At light intensity 11 photosynthesis is occurring at the greatest rate in the experiment. |
| 19 | B | NADH must be recycled to $NAD^+$ for glycolysis to continue. This is the purpose of anaerobic fermentation. $CO_2$ is a product of anaerobic fermentation in yeasts, not in animals. Pyruvate is converted to Acetyl CoA in the link reaction of the Krebs cycle in the mitochondrion. This does not take place in anaerobic fermentation. 30 or 32 ATP are produced in the electron transport chain, not anaerobic fermentation. |
| 20 | C | The E in "E10" stands for ethanol. |
| 21 | A | Lysozyme destroys bacterial cell walls, preventing them from entering the body through the eyes. The first line of defence includes all such barriers to entry of pathogens, whereas all the other options are part of the body's immune response to pathogens that have penetrated the first line of defence and are inside the body. |
| 22 | C | A dendritic cell will react to a non-self-antigen, not the absence of a self-antigen (if there is no self-antigen there is nothing to detect). |
| 23 | C | Histamines cause dilation of blood vessels, and increased permeability of blood vessels. It is interferons (not histamines) that cause the downregulation of protein synthesis in nearby cells. |
| 24 | A | Antigen must be presented on MHC II for Th cells to respond and initiate an adaptive immune response. Macrophages have MHC II, but neutrophils do not. Both macrophages and neutrophils digest what they engulf, and both can be found in any body tissue. |
| 25 | C | n is a light chain; q is a constant region and p is a variable region. |
| 26 | A | A humoral immune response involves Th, B cells and their clones (Bm and plasma cells) |
| 27 | A | It is artificial because the immunity has been induced by medical technology. It is active because the antibodies a person has are produced by the person's own plasma cells. |

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| 28 | C | Antigenic drift is the result of mutations over time causing minor changes in the shape of the protein. Antigenic shift occurs when a large change takes place because a single host cell is infected with two different viral strains and makes virus particles that contain features of both. |
| 29 | B | Herd immunity is a term used to describe community immunity. |
| 30 | C | A monoclonal antibody (or in fact any antibody) has two antigen binding sites, but both of those are identically shaped. |
| 31 | B | Mutation is the source of all new alleles. |
| 32 | A | A genetic bottleneck is a kind of genetic drift that results from the near extinction of a species or population. Genetic drift is not an incorrect response, therefore, but it is a less precise answer than genetic bottleneck. Students should be advised, when two answers seem correct, to choose the one that is most specific. |
| 33 | B | This confuses some students because pharmaceutical antibiotics are not 'natural' in the way a predator or disease might be considered natural. But because the intention of using antibiotics is not to select for super-bugs, this cannot be considered selective breeding. Selective breeding is a term that describes when humans deliberately select for a desired trait in a species. Immunity is not involved, but resistance to the antibiotic (a genetic trait, rather than an acquired immunity). |
| 34 | A | Fish were the first vertebrates, followed by amphibians, reptiles (including dinosaurs), mammals and finally birds, which evolved from dinosaurs. |
| 35 | D | For a fossil to be a useful index fossil it must have been abundant, occupied a wide geographical range, be easily distinguishable from other species and have existed for only a short period of geologic history. |
| 36 | B | A is referring to gene flow. C is referring to allopatric speciation and D is referring to natural selection. |
| 37 | D | Bone 4 is vestigial since it serves no function in the horse but is homologous to a bone that does serve a function in other species such as humans. |
| 38 | C | Homologous structures are structures which share a similar fundamental anatomy but fulfil a different function in two different species, and thereby provide evidence of common ancestry. Analogy is when structures with a different fundamental anatomy fulfil the same essential function. Pentadactyly refers to the limbs of animals that have five fingers. Although the foreleg of a horse and the hand of a human are each an example of a pentadactyl limb, this does not answer the question. Adaptive radiation is rapid allopatric speciation. |

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| 39 | B | A is incorrect because most primates are social. C is incorrect because most primates are diurnal. D is incorrect because most primate species exhibit sexual dimorphism. |
| 40 | C | The general trend in hominin evolution is toward smaller teeth. Since *Australopithecus afarensis* is older than *Homo*, its teeth would be expected to be larger. It is unlikely that the fossil is *H. erectus* because *H. erectus* is not the earliest *Homo* species, being predated by several others such as *Homo habilis*. Regarding cranial capacity, the trend has been generally toward larger cranial capacity and *Homo neanderthalensis* had a very large cranial capacity. The general trend in jaw shape has been toward a parabolic shape, so it is unlikely that the earliest *Homo* would have had a more parabolic shape than *H. sapiens*. |

# Section B – Short-answer

**Question 1.**

**a.** AUG AAU UUC CAA

**b.** Met – Asn – Phe – Gln

**c.** Yes, it will be included in the mRNA (1 mark). If the mRNA did not include the RBS then translation would not be able to be completed by a ribosome which needs the RBS to bind to (1 mark).

**d.** If the third nucleotide in the second codon were changed from U to C, this codon would still code for Asn. OR If the third nucleotide in the third codon changed from C to U, this codon would still code for Phe. OR if the third codon in the fourth codon changed from A to G, this codon would still code for Gln.

**e.** A nonsense mutation is one that creates a stop codon.

**f.** If the first nucleotide (A) in the second codon of the DNA (AAT) changed from A to T, this would result in a stop codon in the mRNA (UAU). OR if the first nucleotide (C) in the fourth codon of the DNA (CAA) changed to T, this would result in a stop codon in the mRNA (UAA).

**Question 2.**

**a.**

**i.** Attenuator

**ii.** Guanine and cytosine are held together more strongly than adenine and uracil. The mRNA needs to be able to be easily pulled away from the attenuator, during attenuation – and for this reason weaker A-U pairs are used instead of stronger C-G pairs.

**b.** The ribosome will proceed past points U and V and stop at point W, overlapping parts of regions 1 and 2 (1 mark). This prevents region 2 forming an anti-attenuator loop with region 3 (1 mark). Consequently, region 3 is free to form an attenuator loop with region 4 once RNA polymerase completes the transcription of region 4 (1 mark). When region 4 pulls toward region 3 because they have complementary sequences, the tension pulls the mRNA away from the DNA at point X, ending transcription (1 mark).

**c.** It saves energy that would be wasted making tryptophan if it is not needed.

**Question 3.**

**a.** An extrachromosomal loop of DNA.

**b.** The colonies will be blue if they have taken up this plasmid, because the plasmid contains the β-gal gene, which means they will produce β-galactosidase. The bacteria are cultured on a plate containing X-gal which turns blue in the presence of β-galactosidase.

**c.**

**i.** RNA polymerase

**ii.** A protein composed of a single polypeptide that normally would be two separate polypeptides.

**iii.** The stop codon was removed from the β-gal gene so that when the ribosome reaches the end of the β-gal gene, instead of stopping it continues to end of the insulin A gene, resulting in a polypeptide that contains both β-galactosidase and insulin A.

**iv.** The fusion protein protects the small insulin A polypeptide from being harmed by enzymes in bacteria that rapidly degrade small polypeptides but do not degrade large proteins.

**Question 4.**

**a.** Krebs cycle (or citric acid cycle)

**b.** Molecule d = ADP. Molecule e = ATP. Molecule f = $NAD^+$. Molecule g = NADH

**c.**

**i.** Pyruvate

**ii.** Carbon dioxide (or $CO_2$)

**d.** In the mitochondrial matrix.

**e.** $FADH_2$ carries two hydrogens and their associated electrons to the cristae for electron transport.

**f.** Active transport (or any other endergonic process that requires ATP).

**g.** The light dependent stage of photosynthesis (is the source of NADPH).

**Question 5.**

**a.** Light intensity OR distance from the light source.

**b.** Temperature inside the conical flask. (Other reasonable responses are possible).

**c.** The flasks located 1 cm from the light globe may have been heated up so much by their proximity to the light globe, that the plants began to photorespire, making photosynthesis much less efficient than in the flasks that were located 30 cm from the globe.

**Question 6.**

**a.** The PERV genes are no longer able to be expressed.

**b.** Zoonosis

**c.** Two of: It cuts DNA. It is a protein. It is found naturally in bacteria. It gives bacteria a natural defence against infection by viruses. (1 mark each)

**d.** While a restriction enzyme always cuts DNA at the same specific base sequence, the base sequence at which Cas9 cuts can be changed depending on the gRNA contained within the Cas9 enzyme.

**e.**

**i.** The pig heart cells contain antigens that are recognised by a human immune system as non-self (1 mark). Cytotoxic T cells will launch a cell-mediated immune response and kill the pig cells (1 mark).

**ii.** CRISPR-Cas9 may be able to be used to knock out or alter the genes of pig cells that encode the foreign antigens so that the pig heart cells are recognised as self by the human immune system.

**f.** Animal rights activists may consider that growing pigs to harvest their organs for human transplants is unethical. OR transplant recipients may experience emotional distress knowing that they have a pig's heart. OR any other specific, reasonable issue.

**Question 7.**

**a.** Scarlet fever would be treatable with antibiotics AND because it is bacterial, and antibiotics are effective against bacterial diseases.

**b.** Children are less likely to wash their hands frequently than adults. OR Children are less likely to keep their distance from others than adults. OR any other reasonable comparative statement.

**c.** Children under the age of 3 do not usually go to school and are therefore less likely than school-aged children to be exposed to the bacteria. Other acceptable responses are also possible.

**d.** The child's skin may have small cuts or abrasions that allow the bacteria to penetrate the skin. OR the child may touch an infected child and then rub their eyes or put their fingers in their mouth, allowing the bacteria to enter living tissue.

**e.**

**i.** Natural (1 mark) active (1 mark) immunity.

**ii.** B memory cell (Bm). T memory cell (Tm) was also an acceptable answer.

**iii.** When the child was infected, antigen bound to a B lymphocyte's B cell antigen receptor (or "antibody") (1 mark). A helper T lymphocyte (Th) stimulated the B lymphocyte to undergo clonal expansion (1 mark) resulting in the production of B memory cells that last a very long time, giving the person lasting natural active immunity. *Since the question asks about lasting immunity it was not necessary to discuss plasma cells, however marks should not be deducted if a student did discuss these.*

**f.** Many reasonable responses are possible. For example: Student's temperatures could be measured when they arrive each day to screen for infected children. OR teachers could remind students to wash their hands regularly. OR all play that involves

students touching each other could be suspended. OR the school could be shut down for a few weeks and students taught by remote learning.

**Question 8.**

**a.** Autoimmune disease

**b.** Cytotoxic T cells (Tc)

**c.** Low blood pressure (other answers are also possible).

**d.** It is not a reasonable suggestion because the antigen that stimulates an immune response in Addison's disease is a protein that is found on the surface of one of the body's own tissues (1 mark). Therefore, it is difficult to make a vaccine because in a healthy person, the antigen is seen as 'self' by the immune system, and it should not produce an immune response so the vaccine would not work (1 mark).

**e.** Antibodies specific to proteins on the surface of adrenal cortex cells.

**f.** A person with Addison's disease will have antibodies to the proteins on the cells of the adrenal cortex because their immune system has mistakenly identified these proteins as 'non-self' and produced an immune response to them. In a healthy person the same proteins are seen as 'self' and no immune response will have occurred, so there should be no such antibodies in the person's blood.

**Question 9.**

**a.** It binds to the active site of BTK.

**b.** Traditional chemotherapy drugs kill many cells in the body including cancerous B lymphocytes. This makes a patient sick. Imbruvica specifically targets B lymphocytes and does not kill other cells so the patient should experience fewer side effects.

**c.** BTK is necessary for B cell proliferation which is an important part of the humoral immune response. Therefore, if the patient gets an infection, they will not be able to produce antibodies to fight off the infection very effectively.

**Question 10.**

**a.** Mutation

**b.**

**i.** The founder effect

**ii.** Because the new population in Oahu was founded by just 36 individuals, if some of them had the allele for greater reflectance, this represents a larger frequency in the gene pool of that small population than that in the parent population in Kenya. (1 mark). As the population grew larger, the relatively allele frequencies were maintained (1 mark).

**iii.** There was genetic variation in the chameleon population in Oahu with some individuals having the higher reflectance phenotype and others having a

lower reflectance phenotype (1 mark). An environmental selection pressure exists in that Females prefer to mate with brighter coloured males giving the males with higher reflectance a selective advantage (1 mark). Because the more reflectant males mate more often, they contribute their alleles to the gene pool of the next generation more than duller males. Therefore, over time the frequency of the allele for higher reflectance increases in the population and thus the higher reflectance phenotype becomes more common (1 mark).

**Question 11.**

**a.** The lucifer blackbelly lanternshark is more closely related to the spinner shark, because they share a more recent common ancestor.

**b.** The table should be completed as follows:

| Species compared | More than 25 base differences | 25 base differences | Fewer than 25 base differences |
|---|---|---|---|
| Great white shark and Blackmouth catshark | | ✓ | |
| Great white shark and Lucifer blackbelly lantern shark | ✓ | | |
| Great white shark and hammerhead shark | | ✓ | |

**c.** Some mutations that have occurred since the two shark lines diverged were silent mutations because the genetic code is redundant. Such mutations result in a base sequence difference in the CTNNBL gene, but not in an amino acid sequence difference in the β-Catenin-like-protein.

**Question 12.**

**a.** It is not possible, because radiocarbon dating can be used to date organic material that is up to 50,000 years old. The tooth is about 140,000 years old, which is outside this range.

**b.** DNA could be sequenced and compared to known sequences from *Homo neanderthalensis* and Denisovan DNA.

**c.** The ancestors of the Ayta Magbukon people migrated out of Africa and passed through Asia before eventually colonizing the Philippines. As they moved through Asia, they interbred with Denisovans who already occupied Asia.

**d.** Two of: more sloping face, larger brow ridges, smaller cranial capacity in proportion to body size, thicker zygomatic arches, less central foramen magnum. Other answers are also possible if they reflected the trends seen in hominin evolution (1 mark each).