

Suggested answers**Section A – Multiple-choice**

Question.	Answer	Explanations and Notes
1	B	The independent variable is the variable that the researcher is deliberately changing, in order to test the effect of doing so.
2	C	Tube B was kept in the refrigerator, it is likely that they were in complete darkness unless the researcher installed a light in the fridge that had equal brightness to the light in the room outside the fridge (we have not been told that this is the case).
3	A	A random error is an error which may be too high or too low based on variations in the way measurements are made or the experiment is conducted. In this case, Amy might mismatch the colours in either direction depending on room lighting, etc. (things sometimes look a different colour under fluorescent light than they do in natural light) etc.
4	B	Carbon dioxide is small and non-polar. Glucose is too large to move through the phospholipid bilayer and it is polar. Proteins are much too large to diffuse through the membrane bilayer, and chloride ions cross the membrane by facilitated diffusion because they are charged particles and are resisted strongly by the non-polar fatty acid tails of the phospholipids.
5	B	The Golgi apparatus is the organelle in which proteins are modified and packaged for export from the cell.
6	A	An operon is a series of genes that share a promoter. Therefore, when one gene in the operon is transcribed, they all are.
7	B	Facilitated diffusion - because the lactose moves down a concentration gradient (so it's passive) and through a protein channel.
8	C	All enzymes are proteins, and proteins contain nitrogen since the amino acids of which they are composed each contain an amine group (with a nitrogen in it).
9	A	They both contain phosphate alternating with a 5-carbon sugar (DNA has deoxyribose, mRNA has ribose).
10	D	The coenzyme involved in photosynthesis is NADPH. The only outputs of electron transport in cellular respiration are water and ATP

11	A	Paracrine signalling is a term used to describe the signalling between a cell which produces the signalling molecule and the an adjacent target cell (a cell that is right near it). This is the case in a synapse.
12	A	1 is a macrophage, 2 is a red blood cell (erythrocyte), 3 is a T lymphocyte, 4 is a neutrophil and 5 is a B lymphocyte.
13	D	It is <i>fortunate</i> for animals that plants make oxygen in photosynthesis, but that is not the <i>reason</i> that plants do so. They photosynthesise in order to make glucose for their own metabolic requirements.
14	C	The main antigen presenting cells are macrophages and dendritic cells. They have both MHC I and MHC II markers. It is plasma cells that produce and secrete antibodies.
15	B	All apoptosis involves caspases. Death resulting from trauma and acute injury is not apoptosis but necrosis. Apoptosis initiated by a death ligand is the extrinsic pathway.
16	C	Failure in apoptosis has been linked to cancer because cancerous cells which are usually killed by natural killer cells via the extrinsic apoptotic pathway. A mutation to CASP3 will mean the procaspase 3 protein is likely to have an altered shape and may not be activated by caspase 8 causing a failure in apoptosis. A mutation in a liver cell (somatic mutation) will not affect apoptosis in the webbing between fingers and toes.
17	D	Helper T cells are only involved in the adaptive immune response.
18	C	IgE antibodies are the antibodies that embed in mast cells, potentially making them hypersensitive to specific antigens.
19	B	T lymphocytes get the “T” in their name from this fact that they mature in this lymphoid tissue.
20	D	Monoclonal antibodies can be used for a number of things, but they are all produced in a similar way as described.
21	D	Herd immunity is a state where such a high proportion of the community has immunity that susceptible individuals are unlikely to come into contact with the virus. Social distancing also reduces the chance of a susceptible individual coming in contact with the virus, but not because other individuals are immune. Passive immunity is the immunity a person has by being injected with antibodies. Convalescence means recovery from illness.

22	B	The most likely history of the Bursa of Fabricus is that it evolved in the lineage leading to birds) since they are the only taxon to have this structure. Where this happened is unclear, but evidence suggests that it was after birds/dinosaurs diverged from crocodiles, since crocodiles lack the structure. So option A is possible but cannot be concluded. It can however be concluded that early anapsids lacked the Bursa of Fabricus, otherwise we might expect turtles to have it.
23	B	The common ancestor of birds and crocodiles is more recent than the common ancestor of crocodiles and lizards.
24	A	Genetic drift is only thought to affect small populations. As the population size increases, it is increasingly unlikely that a chance event will significantly affect allele frequencies.
25	D	There would be more differences in the DNA than the proteins, because some mutations in the DNA do not cause a change in the proteome (silent mutations) due to the degenerate nature of the genetic code. But there will not be three times as many differences, since the chance of a silent mutation is (at most) 1/21 (I.e. 3/63 because there are 64 possible codons, so a change to a single base in any codon can only change it to the other three codons which share the other two bases in the codon). Insertion and deletion mutations cause frameshifts, which are never silent mutations.
26	C	The founder effect and a genetic bottleneck are types of genetic drift.
27	D	The universality of the genetic code means that the gene will be transcribed to the same polypeptide in other species.
28	C	The fossil is made of stone, from sediments that have filled the original mold left where the trilobite temporarily existed.
29	B	Potassium-Argon and Uranium-Lead dating can only be used on volcanic (igneous) rocks. The sedimentary rock layer containing the fossil has been dated by assuming that it is older than rock layers above it and younger than those beneath. Some of those other rock layers may have been dated using radiometric dating. The fossil is much too old to be dated using radiocarbon dating.
30	A	<i>Pan troglodytes</i> (Chimpanzees) are not considered hominins by Australian taxonomists.
31	A	Molecules bind to target molecules based on complementary shape and charge. The stem tells us that both viruses are RNA viruses. All viruses are non-living (though some biologists consider them living – but even if that is the case, the two viruses would be considered equally living). Viruses are metabolically inactive. They do not secrete anything.

32	C	Opposable thumbs are a feature shared by all primates. Primates tend to have very flexible shoulders, small olfactory regions, and a large brain relative to body size.
33	A	The general trends in hominins is to larger cranial capacity, smaller brow ridges, smaller teeth, and taller stature. <i>Homo neanderthalensis</i> falls outside this trend because even though it is more primitive than <i>H. sapiens</i> , it had a larger cranial capacity and stood taller than <i>H. sapiens</i> . Consistent with the trend however, it did have larger brows and larger molars.
34	D	There is no <i>H. neanderthalensis</i> DNA in the genome of modern Africans because <i>H. neanderthalensis</i> never lived in Africa. It did live in Asia and Europe, however, and modern populations of <i>H. sapiens</i> from Asia and Europe have <i>H. neanderthalensis</i> DNA in their genomes.
35	A	Resistance is not immunity. So B and D are not appropriate responses. When people started using chloroquine, some <i>P. falciparum</i> individuals had pre-existing mutations that made them resistant to the drug. These individuals would have a selective advantage, surviving longer and passing their alleles for resistance to chloroquine to the next generation in greater frequency than individuals with alleles that made them susceptible. Over time, the frequency of the allele for chloroquine resistance increased in the population. This is a perfect example of natural selection in action.
36	D	Eukaryotic cells that contain DNA from another source that was introduced by viral vector (or another vector) are referred to as transfected. Bacteria which have taken up a plasmid containing a foreign gene are called transformed. The whole organism has not been genetically altered so the terms GMO and TGO are not appropriate.
37	B	They are extrachromosomal – in that they are not part of the chromosome in a bacterium. They are found naturally in bacteria (not in viruses), contain genes and are made of DNA (I.e. they are not enzymes).
38	A	If a plasmid (loop) is cut in three places, there will be three fragments, and hence three bands in the gel.
39	B	A pandemic is similar to an epidemic but means the disease has spread beyond country borders/is international. Usually a disease is only labelled a pandemic if it has crossed numerous country borders (becomes worldwide).
40	B	The most likely point at which mutation takes place is during DNA replication or transcription, as this is where a mismatching of nucleotides or other copying error may happen. The chance of a change to DNA while the DNA is sitting inactive in a virus is relatively small.

Section B – Short-answer

Question 1.

- a. amino acids
- b. primary
- c. 39 (three nucleotides in DNA code for one amino acid).
- d. (either) nitrogen or sulfur.
- e. Peptide bond (covalent bond is also acceptable).
- f. Condensation polymerisation (other acceptable answers include protein synthesis or amino acid condensation polymerisation).

Question 2.

- a. (any two of) circular chromosome, genes without introns, no membrane-bound organelles, similar size, other reasonable answers possible.
- b. Cellular respiration.
- c. If hydrogen cannot be removed from NADH, the hydrogen cannot enter the electron transport chain, and therefore no ATP will be produced (1). Without a constant supply of ATP, essential anabolic processes such as protein synthesis and active transport cannot take place and cells will die (1).
- d. In the matrix
- e. On the cristae / cristal membrane OR on the inner mitochondrial membrane.
- f. Ribosomes are the site of protein synthesis.

Question 3.

- a. An intact skin (1) has an outer layer composed of dead skin cells that cannot be infected by a virus. As a result, it is possible to come into contact with SARS-CoV-2 but for those virus particles to never enter the body or come into contact with living cells that they might infect (1). **OR** Mucous membranes (1) line the airways and secrete a layer of mucous which traps impurities in inhaled air. If a virus particle is breathed in but gets stuck in the mucous, it may be carried up the trachea in mucous, swallowed and destroyed in the stomach, without the opportunity to infect cells of the respiratory tract. (1)
- b. (any of) neutrophil, macrophage, dendritic cell, or other reasonable phagocytic cell.
- c. You would not expect the baby to have the same level of immunity (1) because only IgG antibodies are able to cross the placenta. Therefore, the mother will have IgA antibodies which the baby lacks. IgA antibodies are found in mucous, whereas IgG are not. Since SARS-CoV-2 targets the upper respiratory tract, the presence of IgA antibodies in the mother's mucous will offer a higher level of protection to her than the baby will have without them. (1)

- d. If too many IgE antibodies are produced, their population on mast cells around the body will be higher than they should be, and this will make the mast cells hypersensitive to the antigen that caused the production of the antibodies (1). This causes an allergy in the person. (1)
- e. Plasma cells.

Question 4.

- a. Autoimmune disorder
- b. Cytotoxic T cells
- c. Multiple sclerosis
- d. Induced passive immunity
- e. The antibodies in REGN-EB3 will bind to the ebola virus particles in the patient's body (1), preventing them from infecting cells and marking them for destruction by phagocytes. (1)
- f. Induced active immunity
- g. rVSV-ZEBOV binds to an antibody on a B lymphocyte, stimulating it to clone itself to make plasma cells and importantly, B memory cells (1). The B memory cells give the person lasting immunity to EVD. (1)

Question 5.

- a. Phospholipid
- b. Protein channel. (1) It allows the passive movement through the membrane, of molecules too large, charged or polar to cross the phospholipid bilayer by simple diffusion. (1)
- c. Molecule c
- d. It means that it is a protein with a carbohydrate chain attached.
- e. They are important for cell to cell recognition.
- f. It maintains the fluidity of the membrane, preventing the membrane from becoming either too fluid or not fluid enough.
- g. Exocytosis

Question 6.

- a. A translocation

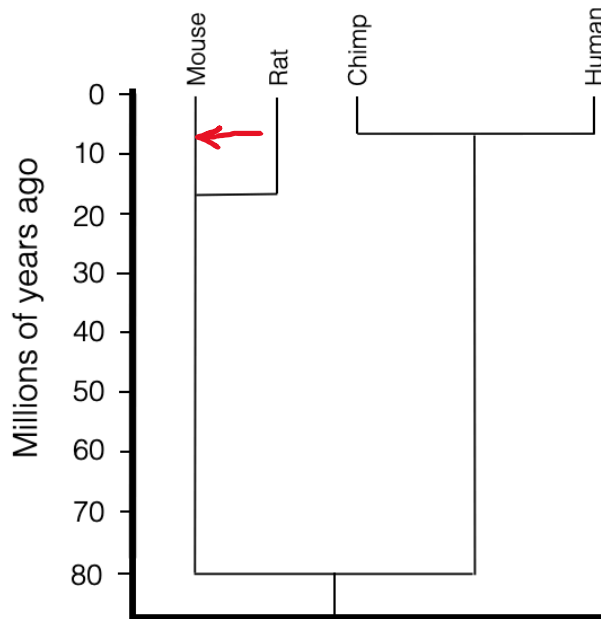
- b. Each chromosome still has a homologous chromosome to pair with during meiosis. Therefore, a person with familial Down's syndrome is still able to produce gametes by meiosis.
- c. GCA UAU AGG AUA CGG GGA CUG
- d. Between the 8th and 9th nucleotide in the original sequence, there has been an insertion of the four bases TATC
- e. It is not a block mutation because it does not contain multiple genes. It is a point mutation because it affects only a few bases within a gene.
- f. Because the number of bases inserted in the mutation is not a multiple of three (1) it causes a frameshift. This shifting of the reading frame will change all codons downstream of the mutation and cause many amino acids to change. (1)
- g. The function of a protein is dependent on its shape. If the amino acid sequence changes, the shape and therefore the function of the polypeptide is likely to also be affected.

Question 7.

- a. Stratigraphy (1). Fossils of this age cannot be dated using radiocarbon dating, and other radioisotope dating methods can only be used on igneous rock. This fossil was discovered in sedimentary rock, so the rock layer would have been dated by comparing it to other rock layers in the same location which are igneous, or to sedimentary rock layers in other locations based on index fossils in the rock layer. (1)
- b. An elaphrosaur would have to have died and fallen into water (1), where it was rapidly covered by sediment, excluding oxygen from the specimen (1). It would then have to be left undisturbed for a long period of time. (1)
- c. The skeleton of the elaphrosaur may have been washed down the rapid flowing river and distributed over a very wide area. Some of the bones may have been fossilized and others not. (other reasonable answers may also be awarded marks).

Question 8.

- a. In rodents, the fourth amino acid is alanine, whereas in hominoids the fourth amino acid is serine.
- b. The DNA sequences are likely to show more than six differences, because some differences result in no change to the amino acid due to the degenerate nature of the genetic code.
- c. The amino acid sequence does support the phylogram, because humans and chimps have an identical amino acid sequence, whereas there are 2 differences between the amino acid sequences of rats and mice, which is evidence that rats and mice diverged from a common ancestor earlier than humans and chimps did.
- d. The first nucleotide in the 178th codon of the mouse is changed from cytosine to adenine.



e.

Question 9.

- a. gene regulation refers to a cell turning certain genes off when not needed to save energy and/or prevent an overdose of the gene product and on when the gene product is needed by the cell.
- b. PCBs are lipophilic and therefore able to move through the phospholipid bilayer by simple diffusion and bind with an intracellular receptor, whereas molecules that are not able to cross the phospholipid bilayer must bind to an extracellular receptor.
- c. Its shape must be different/changed.
- d. Natural selection
- e. Some tomcods had the AHR2-1 mutation prior to the introduction of PCBs into the environment, due to a random mutation in the past. (1) When PCBs were dumped in the river, those individuals which had the AHR2-1 allele had a selective advantage, because their embryos were unaffected by the PCBs. Those embryos were more likely to reach maturity than the embryos of fish with the normal AHR2 allele. (1) Because of this, fish with the AHR2-1 allele were more likely to reproduce in the next generation and pass their alleles on to the following generation in greater frequency. Over a number of generations, the frequency of fish with the AHR2-1 allele increased in the population until nearly the whole tomcod population had that allele. (1)
- f. Fish from the Hudson river population swam to the other nearby rivers.
- g. Gene flow.
- h. The Squamscott River is further away from the Hudson River than the other two rivers and the tomcods don't swim that far.

Question 10.

- a. Gene cloning.
- b. So that the sticky ends produced by AatII are complementary.
- c. Recombinant.
- d. The culture of bacteria was grown on a medium containing tetracycline (1). Any bacteria which had not taken up a plasmid at all would not have resistance to tetracycline and would not grow on the medium (1).
- e. Bacterial colonies that had grown on the medium containing tetracycline were transferred to a medium containing ampicillin. (1) Any colonies which do not grow there, must have taken up a recombinant plasmid, (1) because recombinant plasmids have an ampicillin resistance gene that has been disrupted by the insertion of the G6PC1 gene. Whereas colonies which do grow on the ampicillin-medium must have taken up a regular plasmid without the G6PC1 gene.

Question 11

1. Test tube 4 is a control that shows the starch would not be digested without amylase.
2. Temperature. (or any other reasonable answer).
3. Digestion rate
4. Yes, the hypothesis was supported.
5. Anything reasonable. For example:
 - They should repeat the experiment numerous times, averaging the results to minimise the impact of random errors and natural variation in the results.
 - The control (test tube 4) should have had 0.1ml 0.2% calcium acetate added to it (without enzymes), otherwise it is not a true control, since the other test tubes had enzyme added *in a 0.2% calcium acetate solution*.