

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

Question.	Answer	Explanations and Notes
1	B	Tertiary structure is a description of the overall three-dimensional shape of a protein. The active site is an example of this.
2	B	The repressor in an operon binds to an operator. Operators are a feature of prokaryotic operons but are not found in eukaryotic genes.
3	D	Since lactose is a disaccharide, it is larger than glucose; a monosaccharide.
4	C	Enzyme N is RNA polymerase. Process O is transcription (or RNA processing). Structure Q is a ribosome (it cannot be rough ER since bacteria lack ER).
5	B	cDNA contains no introns.
6	A	On average there are 3.2 codons specifying each amino acid.
7	B	Epinephrine, being a peptide hormone is hydrophilic and too large to cross a plasma membrane, or to move through a protein channel.
8	B	A limitation is the extent to which the results can be extrapolated to represent reality.
9	A	The Calvin cycle is another name for the light dependent reactions – which take place in the grana
10	D	Carbon dioxide and alcohol are the outputs of anaerobic respiration in yeast.
11	A	B, C and D are all benefits to the environment of photosynthesis in plants. But the reason plants photosynthesise is to produce sugars for their own use.
12	D	Blue and red light are preferentially used by Chlorophyll A – especially blue light.

13	D	C pairs with G in all species. It shows nothing.
14	C	There will always be a limiting factor; a factor that prevents photosynthesis occurring at a faster rate. If light intensity is increased but this has no effect on the rate of photosynthesis, this must be because something else is the limiting factor.
15	A	The intrinsic apoptotic pathway is also called the mitochondrial pathway for this reason. Death ligands are involved in the <i>extrinsic</i> pathway not the intrinsic pathway. Caspases are involved in all apoptosis. Both pathways involve caspase 3. The intrinsic pathway involves caspase 9, the extrinsic pathway involves caspase 8. Apoptosis is a process that allows a cell to die <i>without</i> spilling its contents into the surrounding tissues, as many proteins within cells are dangerous if spilled into the surroundings.
16	C	Two NADH are produced during glycolysis as well as two ATP.
17	B	Endocrine signalling differs from paracrine signalling because the target tissue is distant to the gland producing the signalling molecule.
18	C	Histamines cause an inflammation response including the dilation of blood vessels and leakage of plasma into the tissue fluid, both of which cause swelling.
19	D	Once the death ligand binds to the FasL receptor, a molecular cascade is initiated which involves FADD and Caspase 8 and finally the activation of caspase 3 which cuts up the proteins that comprise the cytoskeleton of the cell. It is the breakdown of the cytoskeleton that paves the way for blebbing to begin.
20	A	Steroids are small lipids which, because they are non-polar are lipophilic. Like all lipids, steroids are organic, much smaller than phospholipids or fats, they contain seventeen carbons in four rings, with two oxygens and hydrogen.
21	C	Autoantibodies are antibodies which have been produced against one's own tissues.
22	C	Hematopoietic stem cells which give rise to T cells with immunoglobulins complementary to one of the body's own self markers should die by apoptosis. When this fails to happen, an autoimmune disorder can result.
23	A	Although macrophages prime the adaptive immune response as antigen presenting cells, their chief function is non-specific. The other cells listed are all specific and

		therefore not part of the innate immune response.
24	A	Helper T cells secrete Interleukin I, a hydrophobic cytokine which stimulates 'selected' B cells to proliferate.
25	D	S is referred to as the variable region.
26	A	Memory B cells from the first vaccination will be present and will mean that it takes much less time for an immune response than the first time when there may have only been a small number of B cells in the body with matching antibodies for the antigen in the vaccine.
27	C	Mutations in introns will have no effect on the polypeptide produced since introns are cut out of the primary transcript before translation. A single base deletion is more likely to have a significant effect than a single base substitution because it causes a frameshift mutation.
28	A	Operons are only found in bacteria; regulatory genes are those which produce a product that affects the expression of other genes. An exon is one coding region within a gene, whereas GLP-1 is a whole gene.
29	B	Natural selection acts on the phenotype and like all selection reduces genetic diversity in the population by eliminating phenotypes which are unfit. In some cases, it favours individuals which are camouflaged, but only in cases where camouflage gives a selective advantage.
30	D	Both UAC and UAU code for Tyr. Therefore, the change in the DNA from G to A will have no effect. Tyr will still be encoded.
31	A	They are an example of analogy, produced through the process of convergent evolution.
32	D	<i>Ptiloris</i> and <i>Seleucidus</i> are more closely related than <i>Ptiloris</i> and <i>Epimachus</i> because less time has elapsed since they diverged from a common ancestor. It would therefore be expected that their DNA would contain fewer differences.
33	C	Since foxes cannot swim, there has been no gene flow between the island fox and the mainland gray fox for the time that the Channel Islands have been separated by sea.
34	D	Twenty primers are required: two to bracket each region being amplified.
35	C	<i>Homo erectus</i> evolved in Africa and was the ancestor of <i>H. sapiens</i> , <i>H. neanderthalensis</i> , and <i>H. heidelbergensis</i>

36	B	All primates have forward facing eyes. Some primates are nocturnal (but most are diurnal), all primates have colour vision. Primates tend to have flat fingernails, rather than sharp claws.
37	A	Phosphate PO_4^{2-} has a negative electric charge and therefore DNA moves toward the positive electrode, since opposite electric charges attract.
38	D	Herd immunity refers to a state in which so many members of a population are immune to a pathogen, that even those who are unvaccinated are protected because they are very unlikely to come into contact with the pathogen.
39	D	They are almost all found within non-coding regions (with a few exceptions), they are no more or less easy to amplify than other regions of DNA. They are more polymorphic than most regions of DNA which makes them very useful for this purpose. The reason for their high polymorphism is their relatively high mutation rate.
40	A	They are not transgenic since the gene inserted into the tomato cells does not come from another species. Transformed is a term we only use for bacteria which have taken up a genetically modified plasmid. Recombinant refers to the DNA itself, not the tomato that contains it.

Section B – Short-answer

Question 1.

- a. There are more than 100 different serotypes of the common cold (1 mark).
Therefore, even though a person will develop an immunity to one serotype, they will still be likely to get a cold the next year when exposed to a different serotype (1 mark)
- b. Endocytosis
- c. A glycoprotein is a protein with an attached carbohydrate chain.
- d. ICAM-1 has a shape which is complementary to the shape of the canyon between VP1 and VP3
- e. It is fluid.
- f. Amino acids
- g. Mitochondrion (1 mark) – is the organelle in which the ATP needed to synthesise proteins is produced (1 mark). (Any other suitable answer would also be acceptable).

- h.** RNA polymerase (1 mark). It is the enzyme responsible for 'reading' the viral DNA integrated into the host DNA and producing a mRNA molecule which will later be translated. (1 mark)
- i.**
 - i.** One successful target would be integrase which integrates the viral DNA into the host cell's DNA. (students may have alternatively chosen another target such as reverse transcriptase)
 - ii.** If a designed drug were produced which blocked the integrase enzyme, the viral DNA reverse-transcribed from the viral RNA would not be able to be integrated into the host cell's genome. It would therefore not be able to be expressed, and new virus particles would not be able to be made (1 mark). This would help in the treatment of the common cold by slowing down the rate at which it can infect new cells (1 mark).

Question 2.

- a.** Caspases are the enzymes involved in the signal cascade that leads to apoptosis. Caspase 3 is the enzyme that finally digests the proteins of the cytoskeleton.
- b.** Because caspases are integral as second messengers in the apoptotic pathway. If they are not being produced in sufficient numbers, then although the signal cascade leading to apoptosis may be initiated, it may not successfully conclude in apoptosis.
- c.** Cytotoxic T (Tc) cells or other suitable answer. Most immune cells including neutrophils, eosinophils, and even mast cells and T helper cells.
- d.** A signal cascade is a sequence of biochemical reactions within a cell, each ending in a product which is the reagent for the next reaction, until a final target molecule is produced.
- e.** If there are fewer TNFR-1 receptors on the surface of a cell, it is less likely that a TNF α molecule will encounter one, and therefore apoptosis is less likely to be initiated.
- f.** Decoy death receptors are likely to bind any TNF α molecules, thereby preventing them from contacting TNFR-1 receptors and initiating apoptosis
- g.** Attaching radioactive particles to monoclonal antibodies means that the radiation is focused on the cancer cells, meaning that much lower doses of radiation can be used, which causes fewer side-effects for the patient, while still exposing cancer cells to a high dose of radiation.
- h.** If failure in apoptosis is due to reduced sensitivity to death ligands (the extrinsic apoptotic pathway), radiation may stimulate the intrinsic pathway, killing the cell (1 mark). But if the failure in apoptosis is due to the down-regulation of caspases, radiation may not help since caspases are involved in all apoptotic pathways (1 mark).

Question 3.

- a. Glyphosate inhibits the production of EPSP, which is needed to synthesise three essential amino acids (1 mark). Without these three amino acids, many important enzymes and other important proteins cannot be made, leading to the death of the plant (1 mark).
- b. It binds to the active site because it is a competitive inhibitor, and this is what competitive inhibitors do.
- c. EPSP synthase does not have quaternary structure, because it is made of a single polypeptide chain.
- d. Alpha helix
- e. It must have a different shape that glyphosate cannot bind to.
- f. The farmer would be able to spray his/her crops with Roundup® to kill weeds (1 mark), without killing the canola crop (1 mark).
- g. Any reasonable answer that is (a) consistent with the information presented, (b) consistent with the biology learned in Unit 3 & 4. For example,

If the Roundup Ready® canola escapes into the wild, it may become a weed which is difficult to control due to its resistance to glyphosate.

Farmers producing Roundup Ready® canola will have much higher yields (due to less weeds competing for nutrients), which will help them outcompete farmers growing traditional canola – and create pressure for other farmers to also grow Roundup Ready® canola.

Some farmers may prefer to grow non-GMO canola for a market that is prepared to pay more for non-GMO food. If neighboring farmers are using Roundup Ready® canola, cross-fertilisation between neighboring farms may mean the farmer loses the right to label their produce “non-GMO”.

- h. (*The process is natural selection*) There were already some agrobacteria which had the CP4 CPSPS enzyme due to prior mutations (1 mark), although previously it was selectively neutral. When the agrobacteria were exposed to glyphosate in the production facility, the glyphosate created a strong selective advantage for those bacteria which had the CP4 CPSPS enzyme (1 mark) as they were resistant to glyphosate, whereas those with CPSP synthase were susceptible to the poison. Therefore, the agrobacteria containing CP4 CPSPS contributed their genetic material to the gene pool of the next generation more than those with the CPSP synthase enzyme. Over time the frequency of the CP4 CPSPS enzyme variety increased in the population (1 mark).

Question 4.

- a. Students could have answered for any one of the three toxins.

Example 1: Toxin: Prothrombin activator. Explanation: Prothrombin activator causes blood clotting. If a clot formed and this blocked a blood vessel that carries oxygen to the heart muscle, it may result in a cardiac arrest.

Example 2: Toxin: Pseudonajatoxin. Explanation: Pseudonajatoxin binds to acetylcholine receptors on muscle cells. If this toxin bound to these receptors on heart tissues, they may not respond to signals regulating heart rate which may cause an irregular heart rate (arrhythmia) which may lead to cardiac arrest.

b. (any reasonable answer).

Example: Difficulty breathing. Breathing is effected by contractions of the diaphragm muscle. If nervous messages were not being sent to the diaphragm muscle (because textilotoxin interferes with secretion of neurotransmitter) then the diaphragm may not contract properly.

- c.** Artificial active immunity. It is artificial immunity because the venom is injected into the horse using a syringe (1 mark). It is active immunity (1 mark) because the antibodies which a horse has in its blood, are produced by the horse's own humoral immune response to the venom.
- d.** The antivenom binds to IgE antibodies which are on mast cells throughout the body causing the mast cells to release histamine (1 mark). Histamine causes blood vessels to dilate and become 'leaky' leading to a fall in blood pressure. Histamine also causes the restriction of airways. These are the symptoms of anaphylactic shock.
- e.** Antivenom can cause an acute allergic reaction in many people. There is no point risking a dangerous anaphylactic reaction in a person who has been bitten by an eastern brown snake, unless it is certain that they have been envenomated, and need the antivenom.
- f.** (Any of) Lymph nodes are an important site for antigen recognition by lymphocytes. OR the lymphatic system provides an important transport system for antigen presenting cells such as dendritic cells and macrophages, OR the thymus gland – which is a primary lymphoid organ - is important because it is here where T cells mature.
- g.** Lymph moves through the lymphatic system due to contractions of surrounding muscles (unlike the circulatory system in which blood moves by the beating of the heart and contraction of artery walls). Immobilising the limb will prevent muscle contractions, thereby slowing the movement of the venom around the body.

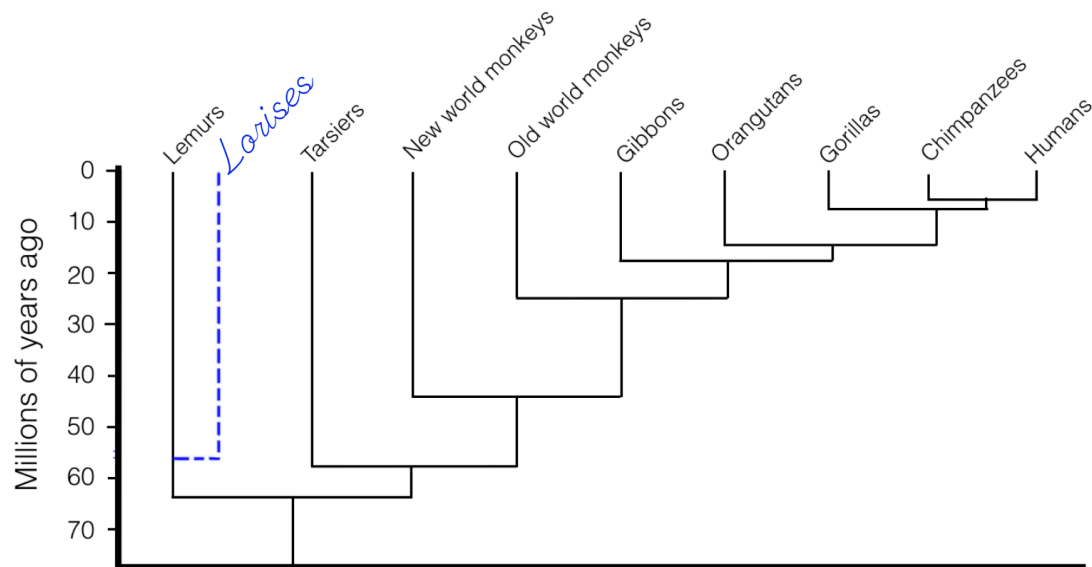
Question 5.

- a.** Peripatopsidae evolved in Gondwana before it broke apart. Therefore, there are representatives of the family in both Australia and Africa since they were once part of Gondwana.
- b.** If Peripatidae evolved in Laurasia (Central America, Asia) it has only spread to South America since South America connected to Central America (1 mark). Unlike South America, Australia is still separate from the continents that made up Laurasia, so the Peripatidae have not been able to spread to Australia (1 mark).

- c. It is possible, because India was once part of Gondwana, so it is possible that it would have species from family Peripatopsidae, as do the other lands that once formed Gondwana.

Question 6.

- a. Analogous structures (or Analogies) or homoplasies.
- b. Lorises and tarsiers both live in similar habitats, eat similar food and are both nocturnal. Also, they both live in the same geographic region and therefore probably have similar predators (1 mark). Because the selection pressures acting on the two species are similar, they have evolved by natural selection, similar adaptations to those selection pressures.
- c.



- d. The DNA of each species is made single stranded and mixed together to form duplex DNA (one strand of each species) this duplex DNA is then heated and the temperature at which the strands separate is measured (1 mark). The higher the temperature required to separate the strands of the duplex DNA, the more similar the DNA must be, and the more closely related the two species (1 mark)
- e. They would compare non-coding DNA. Non-coding DNA is used for this purpose because mutations to non-coding DNA do not have a phenotypic effect and are neither selected for nor against by natural selection. For this reason, they are more useful as a molecular clock. (Natural selection often removes mutations from the gene pool).
- f. Lorises and tarsiers live in arboreal habitats in forests, where fossilisation is very unlikely.

Question 7.

- a. (Anything reasonable). Example: Finding out that she has the BRCA2 mutation, means she has the option of having her other ovary and breasts removed preemptively, even though she does not have cancer in those tissues, yet.
- b. (Anything reasonable). Example: Knowing that she has the BRCA2 mutation, may alert others in her family to the possibility that they may also have the mutation. This may make them more vigilant in (for example) checking their breasts regularly so they detect breast cancer early.
- c. (Anything reasonable). Example: She may find it difficult to get life insurance if she does not already have it, as insurance companies require a person to inform them of the results of any genetic tests.
- d. (Anything reasonable). Example: Claire may fear that her ability to get health insurance will be jeopardized, or the premiums increased, when insurance companies find out that a family member has the BRCA2 mutation.

Question 8.

- a. Incisor tooth (1 mark). In Australopithecus, the incisors are much longer in proportion to the incisors and premolars (1 mark). Other reasonable answers acceptable.
- b. Stratigraphy in which they dated the rock layer in which the fossil was found, using index fossils of a known age which were found in the same rock layer. Alternatively, students could have described a radiometric dating method such as Potassium-Argon dating. Radiocarbon dating was not acceptable since the fossil is more than 50,000 years old.
- c. 100,000 years ago
- d. Either:

It does not, because the Out of Africa hypothesis describes the ancestral origins of living non-African peoples in the world. The ancestors of living non-African people groups are still thought to have left Africa 100,000 years ago, as described by the Out of Africa hypothesis. This new discovery does not change that.

or

It does, because the Out of Africa hypothesis states that *H. sapiens* first moved out of Africa into Eurasia 100,000 years ago. This new discovery shows that at least on one occasion *H. sapiens* had moved out of Africa prior to 100,000 years ago.

Question 9.

- a. The concept of gene therapy is to insert genetic material into a cell, to cause the cell to produce different proteins. This is what viruses do, naturally, in order to reproduce.
- b. A palindromic sequence is a length of DNA which reads the same in a 5' to 3' direction on the template strand as it does on the antiparallel, complementary strand. (1 mark).

Eg. 5'– CAGCTG –3'
 3'– GTCGAC –5' (1 mark)

- c. Using the same restriction enzyme will result in complementary sticky ends so the human DNA fragment can join to the plasmid DNA.
- d. Restriction enzymes are proteins which are permanently denatured by excessive heat.
- e. If the restriction enzymes were not denatured, they would continue to cut at the restriction site, so that even when a human DNA fragment joins a plasmid, it would be cut out again! This is prevented by inactivating the enzymes.
- f. DNA ligase completes the joining of DNA fragments, by forming the phosphodiester bonds (or sugar-phosphate) bonds on the side-rails of the DNA.
- g. Recombinant.
- h. Transformed.
- i. The bacteria are grown on a plate containing antibiotic A (1 mark). Only bacteria that have taken up a plasmid will have the gene for resistance to antibiotic A and be able to grow (1 mark).
- j. Scientists use antibiotic B to determine which bacteria have taken up a plasmid with the human gene (1 mark). Some bacteria are transferred from a colony on the plate containing antibiotic A to a plate containing antibiotic B. If they do NOT grow there, the scientist knows that the plasmid taken up by the bacteria in that colony has the human DNA fragment within the gene for resistance to antibiotic B (1 mark).