

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

Question.	Answer	Explanations and Notes
1	B	Testosterone is a steroid hormone and therefore able to diffuse across the plasma membrane because it is lipid-soluble. Carbon dioxide and oxygen are both non-polar and small enough to also diffuse across the phospholipid bilayer. Glucose is large and polar. It enters a cell through a specific carrier protein called Glut-1.
2	A	On average, each gene in the human genome encodes 10 proteins. After translation, the polypeptide is folded into a precise three-dimensional shape, and depending on the factors in the cell involved, this can produce a variety of functional proteins from the same primary structure.
3	D	DNA polymerase catalyses the condensation polymerization of DNA nucleotides during DNA replication. mRNA is synthesised by RNA polymerase, amino acids are linked together by ribosomes. Okazaki fragments are joined by ligase.
4	C	This demonstrates that a particular codon will always specify the same amino acid and never any other. A shows that the genetic code is degenerate (or redundant). D also shows that it is degenerate. B shows that it is universal.
5	A	An operon is a series of genes that are separate genes, but they are all transcribed together (or not at all) because they share a promoter.
6	D	Primary structure is the sequence of amino acids. Secondary structure refers to α helices and β pleated sheets. Tertiary structure describes the overall three-dimensional shape of the protein.
7	C	Even after the solution was diluted, the enzyme was still saturated by substrate. When an enzyme is saturated with substrate, the concentration of the substrate does not affect the rate of reaction. A is incorrect because substrate concentration does (in a general sense) affect the rate of reaction. There is no reason to think that the temperature was different. The independent variable is the concentration of substrate.
8	D	The light dependent stage takes place on the thylakoid membrane. The cristae and matrix are in mitochondrial features.

9	C	Oxygen is an input to the light <i>independent</i> stage not the light dependent stage.
10	D	Oxygen is an output of photosynthesis.
11	C	Glycolysis, in which glucose is broken into two pyruvate molecules, is the first stage of both processes.
12	B	A relates to the validity of the experiment. Limitations are the extent to which the results can be extrapolated/applied to other situations. If there are uncontrolled extraneous variables the experiment is invalid.
13	B	While it is true that they both contain ribosomes, this is not evidence of the endosymbiotic theory as all living cells contain ribosomes, and since mitochondria contain DNA they need to also contain ribosomes so that the genes in the mtDNA can be expressed. Each of the other features of mitochondria, however, is at odds with the nature of the eukaryotic cells in which they exist.
14	A	38 is the theoretical maximum yield of <i>aerobic</i> cellular respiration in striated muscle cells. 36 is the theoretical maximum yield of <i>aerobic</i> cellular respiration in most other cells. Recent research shows that the actual ATP yield of most cells is much lower than 36 and is closer to 32. <i>Anaerobic</i> respiration only yields 2 ATP (from glycolysis).
15	A	All apoptosis involves caspases (there are various caspases involved in different pathways). Likewise, blebbing is a feature of all apoptosis. The mitochondrial pathway is another term for the intrinsic pathway.
16	B	Tc cells in an autoimmune disease specifically attack a particular type of cell in the body. Dendritic cells, mast cells and complement are non-specific.
17	D	Water moves from roots to leaves through xylem vessels. Water escapes from leaves by transpiration through stomata. Phloem is for the transport of sugars (dissolved in water) from the leaves to the roots. Sieve tube cells are part of the phloem.
18	B	CRF is a neurohormone. It is secreted in the hypothalamus and travels via very short specialized capillaries to the anterior pituitary (millimeters away). Cortisone is a steroid so it does not need to bind to an extracellular receptor but will bind to an intracellular receptor. ACTH is a polypeptide, so it is hydrophilic. ACTH is a signaling molecule. Second messengers are found within cells.
19	D	A hormone reaches all cells in the body. Cells which respond, do so because they have specific receptors for that hormone. All somatic cells in the body have the same set of genes.

20	C	The deletion of one, two or four adjacent nucleotides will cause a shift in the reading frame (a frameshift mutation) which will alter the polypeptide extensively. The deletion of three bases, will result in the omission of a single amino acid from the polypeptide, but usually <i>most</i> of the polypeptide will be unchanged.
21	C	One amino acid is encoded by three bases. Note that the last codon is a STOP codon and does not add a nucleotide to the polypeptide.
22	A	This deletion will result in the fifth codon changing from ACG to ACA. This will not affect the amino acid sequence since both codons code for Cys (even if it coded for a different amino acid it still would not <i>shorten</i> the polypeptide. Each of the other mutations would create a STOP codon and prematurely terminate the polypeptide.
23	A	Newborn babies are not administered influenza vaccines as their immune systems are too immature. For the same reason the baby will not have developed its own natural active immunity to influenza. The baby has natural (not artificial) passive immunity.
24	D	Monoclonal antibodies are produced in a laboratory in tissue culture and are injected into the patient. They often carry a payload of a toxin (a chemotherapy drug) intended to kill the cells to which they attach.
25	D	This apparatus is a vertical gel electrophoresis chamber. This is evident from the power supply, the sample wells into which DNA is loaded, the agarose gel and buffer which are found in all electrophoresis chambers.
26	B	100 million years is too old to measure using radiocarbon dating.
27	C	There is no indication in the question that the fossil strata have been inverted (though this does happen from time to time in rare situations). It is far more reasonable to assume from the information that the fossils of <i>Cunninghamites</i> are younger than those of <i>Fostoria</i> and therefore were deposited on top.
28	A	A is correct. B – Reptiles preceded mammals. C – Fish preceded ferns. D – Ferns preceded flowering plants.
29	D	A – If anything, people were probably <i>more</i> likely to tell their doctor in 2009, as there was less of a stigma attached to sexually transmitted disease then, than in the 1970s and more awareness that treatments are effective. B – Antiviral drugs are ineffective against bacterial diseases. C - It is not possible for a community to develop herd immunity when there is no vaccine available.

30	A	It is common for antibiotics to lose their effectiveness over time as bacteria evolve resistance to them. B – Even if people <i>did</i> develop resistance to gonorrhea this would not result in an <i>increase</i> in the number of reported cases but a <i>decrease</i> . C – It is unlikely that people not be embarrassed to report a sexually transmitted disease. D – The population of the USA is growing, but the graph shows the rate of reported cases (per 100,000 of population) not the total <i>number</i> of cases.
31	D	Six. The number of copies doubles with each PCR cycle. (2 – 4 – 8 – 16 – 32 – 64)
32	C	“Epidemic” and “pandemic” would involve many more than six cases. “Endemic” is not a word used in the context of disease.
33	A	Water is released as the nucleotides in Okazaki fragments only have a single phosphate, unlike deoxynucleoside triphosphates (dNTPs) used by DNA helicase in DNA replication. B – Ligase joins adjacent sugar and phosphate - it does not join bases on opposing strands. Ligase is used in the laboratory for some applications but in PCR there is no need to join fragments of DNA together. D – ligase does not need a specific recognition sequence the way restriction endonucleases do.
34	C	C is a genetic palindrome. The two opposing strands of DNA read the same in a 5’ to 3’ direction. 5’- ACTAGT -3’ 3’- TGATCA -5’ Many restriction endonucleases cut at a six-base palindromic sequence.
35	A	The foetus has the same number of genes as each parent (i.e. two CFTR genes). The parents are heterozygous, so their alleles appear as two separate bands. The foetus is homozygous so all the DNA migrates the same distance through the gel.
36	B	Both copies of the foetus’ CFTR gene have the three-base deletion. This is why both copies have moved further down the gel. C – multiple STRs are used to match suspects to evidence, a different genetic application (despite using the same tools).
37	A	B – a tail is absent from some primates such as humans! C – some primates have uneven teeth sizes, consider the large sharp canine teeth of baboons. D – Humans have longer legs than arms.
38	C	Hominins include all living humans and our upright-walking, bipedal ancestors including those in genus <i>Homo</i> , <i>Australopithecus</i> , <i>Paranthropus</i> , and <i>Ardipithecus</i> . There is no evidence of tool making prior to <i>Homo habilis</i> or burial of dead in species prior to <i>Homo neanderthalensis</i> .
39	A	In general, cranial capacity has increased over time, molar teeth have become smaller, brow ridges have become less pronounced and jaw bones have become less heavy.

40	B	Both <i>H. sapiens</i> and <i>H. neanderthalensis</i> appear in the fossil record after <i>H. heidelbergensis</i> . Species can only evolve from a pre-existing species.
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Section B – Short-answer

Question 1.

- a. RNA polymerase assembles at the promoter upstream of the IL4 gene and runs along the template strand of the DNA in a 3' – 5' direction. (1) As it does so it pairs nucleotides to the exposed nucleotides on the template strand according to complementary base pairing rules (1) to produce a pre-mRNA copy of the DNA's complementary strand (1).
- b. (Two of) Introns are cut out of the pre-mRNA, a methyl cap is added to the 5' end and a poly-A tail is added to the 3' end.
- c. tRNA molecules pair with mRNA codons complementary to their anticodons at a ribosome (1), linking specific amino acids together to create a polypeptide that is subsequently folded to become IL4(2).
- d. Alpha helix
- f. It does not. Proteins are said to have quaternary structure when they are composed of more than a single polypeptide. IL4 only has a single polypeptide, therefore it does not have quaternary structure.

Question 2.

- a. Hydrophilic. It binds to an extracellular receptor because it is unable to diffuse through the phospholipid bilayer. If it were hydrophobic it would not need to do this.
- b. Complementary shape (1). Complementary charges (1)
- c. Either AHP1 or ARR1.
- d. Transcription
- e. (Any two of) It does not travel in general circulation in the bloodstream. It is not produced by an endocrine gland. It is not a protein. Any other reasonable answer.

Question 3.

- a. It is adaptive, because they respond to any infection in the same way.
- b. When a cell dies by apoptosis, the cell contents are contained within membranous sacs called apoptotic bodies.
- c. (Either of) By engulfing the apoptotic bodies they remove their contents, some of which are toxic. By engulfing apoptotic bodies, they gain antigens to present on their MHC II markers.
- d. They present bacterial antigen on their MHC II markers in order to present them to helper T lymphocytes.
- e. Dendritic cells and B lymphocytes.
- f. Since they engulf foreign bodies, it is easy for microbes to get inside phagocytes.

- g.** They do not live long enough for a parasite to complete its life cycle. This interrupts the life cycle of the parasite and prevents it spreading to other cells.

Question 4.

- a.** A second vaccination gives a child a secondary immune response, resulting in more antibodies and more B memory cells than would result from a single vaccination which produces a primary immune response.
- b.** If a child gets rubella whilst young, she will have natural active immunity against it, and will be very unlikely to get rubella later in life when she might be pregnant.
- c.** It means that the virus is still viable and therefore able to infect cells in order to reproduce (1) but has been treated to make it less virulent so that it does not cause disease (1).
- d.** (Two of) babies, people with HIV, people with compromised immune systems, people undergoing chemotherapy, people who have had their spleen removed, or any other reasonable answer.
- e.** Because fewer people in Byron Bay are vaccinated than in Melbourne, the Byron Bay community does not have herd immunity. Therefore an unvaccinated person is more likely to encounter a person who carries measles.

Question 5.

- a.** (Either) H_2O or CO_2
- b.** A high concentration of bicarbonate ions causes water to move into the eye by osmosis, increasing fluid pressure in the eye.
- c.** Rational drug design.
- d.** (Either) It may bind to and block the active site of carbonic anhydrase (1) preventing the substrate from entering the active site (1) OR it may bind to an allosteric site on carbonic anhydrase and change the shape of the enzyme (1) so that the active site no longer fits its substrates (1).

Question 6.

- a.** A regulatory gene encodes a product that controls the expression of another gene (1) whereas a structural gene is any gene that is not a regulatory gene (1).
- b.** The amount (1) of BMP4 synthesised and the timing (1) of when it is synthesised during development of the fish, affects the expression of structural genes which contribute to cranio-facial development.

Question 7.

- a. Mutations cause new alleles, including the tuskless phenotype.
- b. Tusks give an elephant several advantages including the ability to find food. Therefore, tuskless elephants are at a selective disadvantage. The tusked phenotype is favoured by natural selection.
- c. Prior to hunting, there was already variation in the size of elephant tusks in the population (1). Under the selection pressure of hunting, elephants with larger tusks were more likely to be killed than those with small tusks (1). Therefore smaller-tusked elephants were more likely to reproduce more times and pass their alleles for smaller tusks to their offspring (1). Over time, the frequency of the allele for tusklessness increased in the gene pool and consequently the frequency of the tuskless phenotype increased in the population (1).
- d. The percentage of female elephants with the tuskless trait will have fallen (1). Since poaching has been controlled, the selective advantage for tusklessness has been reduced. Elephants with tusks have been favoured by natural selection in recent years, so the frequency of tusked elephants will be increasing (1).

Question 8.

- a. The bones must have been rapidly covered with sediment (1). The fossils must have been left undisturbed for a very long time (1). (any other valid points should be awarded marks)
- b. (Any two of) It is possible that the fossil has been damaged so only some parts of it remain (I.e. it may be an incomplete fossil of a complete specimen) (1). It is possible that the *Homo erectus* animal was broken apart by predators, and only a few bones fell in a location conducive to fossilization. (I.e. it may be a complete fossil of an incomplete specimen) (1). It may be that the other bones were not found by Eugène Dubois but were still in the river bed (1). (other reasonable answers should be awarded marks)
- c. Radiocarbon dating / carbon-14 dating / carbon dating.
- d. Radiocarbon dating is only useful for fossils 50,000 years old or younger. Java man was 14 times this age, so there would be too little carbon-14 left to give a reliable measurement.

Question 9.

- a. Cats were able to spread from Europe through the middle east and into Africa because they are very close together. Likewise, they were able to spread from North America to South America as those continents are now joined together. The distance from Australia to any other continent, however, is too great for cats to swim.
- b. The domestic cat is more closely related to the cheetah (1), as the common ancestor of domestic cats and cheetahs is more recent (6.7 MYA) than the common ancestor of domestic cats and ocelots (8 MYA) (1).
- c. 5.9 MYA.
- d. The hybrid DNA of the Canadian lynx and the Eurasian lynx would have melted at a lower temperature than the hybrid DNA of the Canadian lynx and the bobcat.
- e. They do not mate in nature and produce viable, fertile offspring.

- f. Allopatric speciation (1). An ancestral big cat which lived in both Asia and Africa, was separated into two populations by a geographical barrier (1) such that there was no gene flow between the two populations. Over time, each population continued to evolve by natural selection under the different selection pressures that operated on each population (1). Over time, the two populations became so different that even if they were to encounter each other in the wild they would not successfully interbreed (1).
- g. It is analogous (1), because *Thylacoleo* and the leopard are not closely related. They did not inherit the sheathed claw from a common ancestor. Rather the sheathed claw evolved independently in each lineage (1).

Question 10.

- a. It is necessary to use the same restriction enzyme as different enzymes cut at different restriction sites. By using the same enzyme, the sticky ends of the DNA will be complementary.
- b. pBR322. The recognition site for SphI is located within one of the antibiotic resistance genes.
- c. Ligase (1) is used to join the DNA fragments (1).
- d. Transformed
- e. Ampicillin (1). Any bacteria which took up a plasmid will be resistant to ampicillin, while those that did not take up a plasmid will be susceptible to ampicillin. By culturing the bacteria on an agar plate containing ampicillin, only bacteria which have successfully been transformed will grow (1).
- f. Bacteria are transferred to a second agar plate containing tetracycline (1). If bacteria grow in this environment, they must have an intact TcR gene and therefore have taken up a non-recombinant plasmid, since recombinant plasmids do not have a functional TcR gene (1).
- g. They will use the bacteria to produce thrombopoietin as a pharmaceutical product for the benefit of people whose kidneys and liver do not produce it. Other reasonable answers are also possible.