

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

| Question. | Answer | Notes                                                                                                                                                                                                                                                                                                                                                                                                |
|-----------|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1         | C      | Nucleic acids contain carbon, oxygen and hydrogen in their sugar, carbon, oxygen carbon, hydrogen and nitrogen in their base and phosphorus and oxygen in their phosphate group.                                                                                                                                                                                                                     |
| 2         | C      | The area circled is a nitrogen-containing base. Adenine is the only nitrogen-containing base among the options. Amine groups also contain nitrogen, but are found in amino acids, not nucleotides. Ribose and deoxyribose also contain five carbons.                                                                                                                                                 |
| 3         | C      |                                                                                                                                                                                                                                                                                                                                                                                                      |
| 4         | A      | Active transport requires the use of ATP as it moves molecules against a concentration gradient. Active transport does not take place through a channel protein, but via a carrier protein.                                                                                                                                                                                                          |
| 5         | B      | Since each test tube has its temperature raised to 25°C, $\beta$ – amylase will convert starch to maltose, unless the enzyme has been denatured at 40°C. Therefore, maltose would be seen in tubes 1 and 4 but not 2 or 3.                                                                                                                                                                           |
| 6         | D      | Although the rate of maltose production is falling, the amount of maltose that has accumulated will continue to rise, if the reaction continues. Therefore, the concentration of maltose will continue to rise, even as the rate of reaction continues to fall.                                                                                                                                      |
| 7         | B      | Secondary structure refers to the presence of $\alpha$ -helices and $\beta$ -pleated sheets.                                                                                                                                                                                                                                                                                                         |
| 8         | A      | A polymer (or in this case, dimer) occupies less space or more “condensed” than the monomers from which it was built, because part of each monomer was lost. Many people wrongly associate condensation with the formation of water droplets (such as on a cold car windscreen). The apparent relationship between condensation and water is coincidental. Water droplets forming on glass is called |

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|    |   | condensation because liquid water occupies less space than water vapor. Other polymers are also formed by condensation bonds in which not water, but another molecule is released as a byproduct. This is the case in nucleotide polymerization, where pyrophosphate is released.                                                                                                    |
| 9  | D | At X the plant will be producing more carbon dioxide than it is using.                                                                                                                                                                                                                                                                                                               |
| 10 | B | Glycolysis takes place in the cytoplasm outside the mitochondria. Electron transport uses (not produces) NADH (not NADPH). 12 water molecules are the reagent for the light dependent reactions of photosynthesis, not cellular respiration.                                                                                                                                         |
| 11 | D | Apoptosis is carefully orchestrated to prevent the contents of the cell (many of which are toxic outside the cell) are not leaked into the extracellular fluid.                                                                                                                                                                                                                      |
| 12 | A | Degenerate (or redundant) means that more than one codon specifies the addition of the same amino acid to a polypeptide. Option B speaks to the unambiguity of the genetic code, C speaks to its universality.                                                                                                                                                                       |
| 13 | C | “universal” refers to the fact that the same codon specifies the same amino acid in all species. It does not refer to the fact that all species have DNA with the same four bases (although that is true).                                                                                                                                                                           |
| 14 | A | It is artificial because it came about due to medical intervention and it is active because the vaccine recipient’s own immune system produces the antibodies.                                                                                                                                                                                                                       |
| 15 | C | The process shown is phagocytosis. Neutrophils are phagocytes.                                                                                                                                                                                                                                                                                                                       |
| 16 | B | Each antibody has two heavy chains and two light chains. The antigen-binding site is always the same on each side of the antibody.                                                                                                                                                                                                                                                   |
| 17 | B | Mast cells will degranulate in response to any tissue damage, irrespective of the cause. It is therefore innate. Some students think it is adaptive, because IgE antibodies attached to a mast cell make that mast cell very sensitive to a specific antigen. It is, however, the production of the antibodies which is adaptive. The action of the mast cells themselves is innate. |
| 18 | D | Hypersensitivity or allergies are caused by an overproduction of IgE, which make the mast cells very                                                                                                                                                                                                                                                                                 |

|    |   |                                                                                                                                                                                                                                                                                         |
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|    |   | sensitive to the allergen that binds to the IgE antibodies.                                                                                                                                                                                                                             |
| 19 | C |                                                                                                                                                                                                                                                                                         |
| 20 | D | Some plant hormones are just a small hydrocarbon (Eg. ethylene is C <sub>2</sub> H <sub>4</sub> ). No plant hormones are peptides or steroids.                                                                                                                                          |
| 21 | C | Many single-base substitutions are silent mutations due to the redundancy in the genetic code.                                                                                                                                                                                          |
| 22 | A | Selective breeding reduces the frequency of alleles for economically undesirable traits.                                                                                                                                                                                                |
| 23 | B | Dominant traits are always expressed in the phenotype of an individual even if the genotype is heterozygous. Therefore natural selection disadvantages any individual containing any alleles for the trait.                                                                             |
| 24 | A | The presence of a Y chromosome determines maleness. Males normally have one X chromosome. This karyotype shows two X chromosomes.                                                                                                                                                       |
| 25 | C | The New Guinea harpy eagle is a selecting agent, predation is the selection pressure.                                                                                                                                                                                                   |
| 26 | B |                                                                                                                                                                                                                                                                                         |
| 27 | A | <i>Zea mays</i> and <i>Sorghum halapense</i> only differ by two bases. The other combinations differ by more than two.                                                                                                                                                                  |
| 28 | C | Not all primates have grasping feet. Humans are an example. Not all primates have a prominent heel bone Chimpanzees are an example. Many primates do not walk on two legs.                                                                                                              |
| 29 | B | mtDNA is inherited through the maternal line. The mutation rate in mtDNA is faster than in non-coding nuclear DNA. Mutation is the only source of new alleles for any DNA. So while this is true of mtDNA, this fact does not make mtDNA more useful than nuclear DNA for this purpose. |
| 30 | A | In cladogram A, one doesn't have to go back as far to find the common ancestor of the cheetah and the leopard.                                                                                                                                                                          |
| 31 | B | TTATAA is a 6-base genetic palindrome. Most (not all) restriction enzymes cut at 6-base palindromic sequences.                                                                                                                                                                          |
| 32 | C | The number of copies doubles with each cycle: 2, 4, 8, 16, 32, 64, 128, 256.                                                                                                                                                                                                            |

|    |   |                                                                                                                                                                                                                                                                   |
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| 33 | C | Since plasmids are circular, there may be one restriction site in plasmid D or there may be none. Either way we would end up with one band in the gel.                                                                                                            |
| 34 | A | DNA ligase joins Okazaki fragments, and is employed by geneticists to join DNA fragments in the laboratory in the same way.                                                                                                                                       |
| 35 | B | The child has two alleles. One of these came from the mother. The other came from the (true) father. This man does not have that allele, so cannot be the true father.                                                                                            |
| 36 | D | Taq polymerase is an enzyme and therefore has an optimal pH. This ensures that the optimal pH is maintained.                                                                                                                                                      |
| 37 | A | It is not transgenic because it does not contain a gene from another species. "Transformed" is a term only applied to genetic modification using a plasmid as a vector (in bacteria). The use of a plasmid vector in a eukaryotic cell is called transfection.    |
| 38 | B | Antibiotics act against bacteria only.                                                                                                                                                                                                                            |
| 39 | C | Pandemics are distinguished from epidemics because they spread on a worldwide scale.                                                                                                                                                                              |
| 40 | C | Many drugs will bind to a target enzyme or receptor because of complementary shape and charge. What makes a rationally designed drug different is that the drug was designed specifically for this purpose, after first mapping the shape of the target molecule. |

## Section B – Short-answer

### Question 1.

- a.**     **n.** ribosome. Site of synthesis of the proteins that will be exported from the cell. (1 mark)
- o.** Golgi body. Modifies and packages protein product into vesicles ready for export from the cell. (1 mark)
- p.** Mitochondrion. Provides ATP required by ribosomes to build the protein product that will be exported from the cell. (1 mark)
- b.** Active transport.
- c.** It does not require ATP because the movement of W is down a concentration gradient.
- d.** Carrier protein.

## Question 2

**a.** Pre-mRNA (or primary transcript)

**b.** (One of) There are introns in molecule Q but not in molecule R. Molecule R has a methyl cap on the 5' end whereas molecule Q does not. Molecule R has a poly-A tail on the 5' end, whereas molecule Q does not.

**c.** As the mRNA threads through the ribosome (5'-3') tRNA molecules, each carrying a specific amino acid (1 mark), pair with the codons in mRNA because they have a complementary anticodon (1 mark). As each amino acid is brought into place a peptide bond is formed between it and the preceding amino acid, forming a polypeptide (1 mark).

**d.** Primary structure.

## Question 3

**a.** When a cell becomes cancerous it should die by apoptosis, stimulated by both the intrinsic and extrinsic pathways. If apoptosis fails to occur, the cancer cell can continue to divide and develop into a tumor.

**b.** Signal cascade or molecular cascade. Note: signal transduction is not an acceptable answer since the question does not specify that apoptosis is stimulated by a death ligand/FasL molecule.

**c.** caspases

**d.** **i.** Monoclonal antibodies specifically attach themselves to cancer cells. Since the radioactive particle is attached to the monoclonal antibodies, cancer cells will receive a much higher level of exposure to radiation than other cells (1 mark). Therefore, lower doses can be given to the patient overall, thereby reducing the side effects, while the dose reaching the cancer cells is maintained. (1 mark)

**ii.** Intrinsic pathway (1 mark). The mitochondria can detect damage to the cell resulting from radiation and release compounds that stimulate apoptosis without a signal from outside the cell (1 mark)..

**e.** Protein.

**f.** Soluble FasR secreted by the cancer cell will bind to the FasL (death ligand) secreted by NK cells, before the FasL reaches the cancer cell. This will prevent the FasL from stimulating the extrinsic apoptotic pathway.

## Question 4

**a.** Yellow fever is caused by a virus. Antibiotics only work against bacteria. Therefore they are unlikely to be an effective treatment for yellow fever.

**b.** It would involve injecting the patient with antibodies against the yellow fever virus. This gives the patient immunity to a disease, but it is passive because the antibodies are not produced by the patient's own immune system.

**c.** Yellow fever develops suddenly and rapidly. By the time a patient is sick and seeks treatment, the virus has likely already spread throughout the body and infected many cells. Since the disease is short lived, passive immunisation will do little to help.

**d.** Helper T cells. (or any other reasonable answer)

**e.** Vaccination gives a person active immunity, which includes the production of memory B cells (1 mark). Memory B cells live a long time in the body. If therefore the person is later infected with the yellow fever virus, it will soon encounter a memory B cell, and a secondary immune response will occur rapidly, before the virus has time to cause the symptoms of the disease (1 mark).

**f.** Interferons, released by infected cells stimulate metabolic changes in nearby cells that make them more resistant to infection by viruses. Therefore an injection of interferons is likely to also be effective in slowing the progression of some viral diseases.

**g.** When a vaccination is first given there is a time lag, before the person will develop effective antibody levels (1 mark). Therefore, waiting for 10 days is advised to ensure that the person is immune to the virus before being exposed to it (1 mark).

**h.** Attenuated means the virus is still able to reproduce, but is less able to cause the disease it normally causes.

**i.** (Any of)

- wear insect repellent to avoid being bitten by mosquitos
- wear long trousers and sleeves to avoid being bitten by mosquitos
- sleep under a mosquito net
- stay indoors at night when mosquitos are most active
- any other reasonable answer.

### **Question 5**

**a.** It contains Uracil (U)

**b.** cDNA will not contain introns that are found in the original DNA.

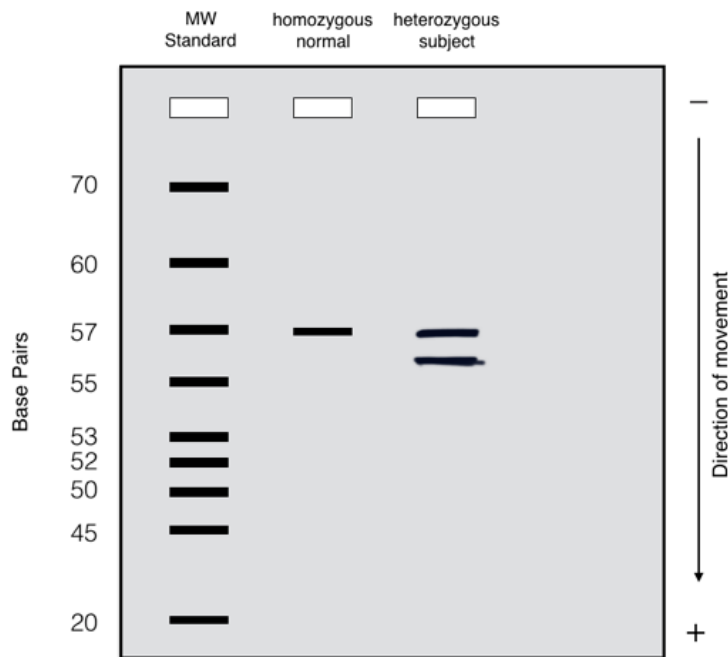
**c.** TAC TTA ACC TTC

**d.** RNA viruses (or retroviruses)

**e.** **i.** It will result in the amino acid Lys being replaced by Arg (1 mark) and cause a frameshift mutation resulting in every amino acid from that point on being changed (1 mark).

ii. It will result in the replacement of the amino Arg with the amino acid Met. Other than that, there will be no change.

f.



g. There needs to be some DNA either side of the region of interest for the primers to attach to.

h. It would not be useful (1 mark). The G27X mutation does not change the length of the gene. Therefore, electrophoresis would not distinguish the mutant allele from the normal allele (1 mark).

## Question 6

a. Block mutation (or block deletion mutation) (1 mark). For part of a gene to go missing, it is likely that a large section of the DNA was deleted, including most of the haemoglobin gene (1 mark). (nonsense mutation or the creation of a stop codon were not acceptable answers because these might explain how a protein was truncated, but not how a gene is truncated).

b. There was already preexisting variation in the size of icefish hearts (1 mark). When icefish lost their haemoglobin, this created a selection pressure because it was difficult to efficiently transport oxygen around the body (1 mark). Those icefishes which had larger hearts, were fitter because they could pump blood more efficiently than the icefish with small hearts (1 mark). This meant that the icefish with larger hearts were more likely to survive and reproduce and so pass their alleles for a larger heart on to the next generation in greater numbers. Therefore, the frequency of the allele for a large heart increased in the population and so did the large heart phenotype (1 mark).

c. cellular respiration

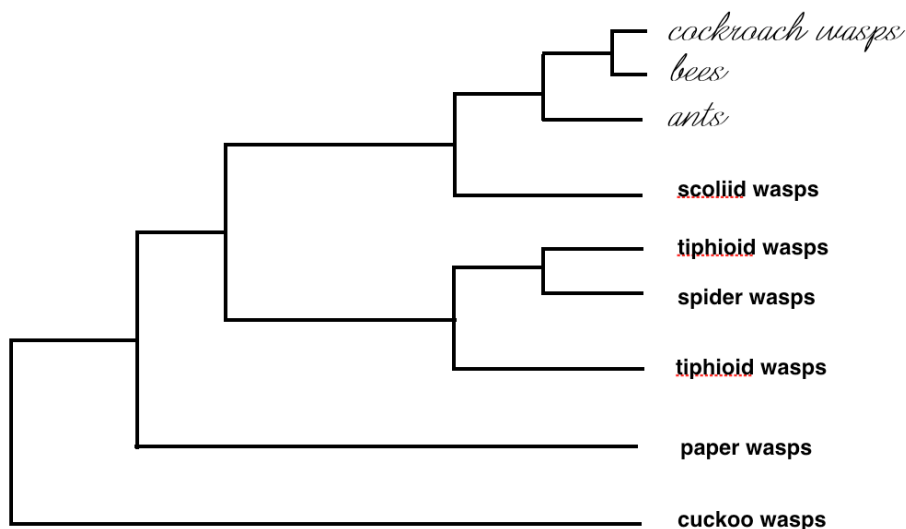
d. It saves energy; the fish are not wasting energy making cells that have no function.

e. They are likely to become extinct (1 mark) because warmer water contains less oxygen. Therefore, because their blood does not transport oxygen very efficiently, they are unlikely to survive if the water gets warmer (1 mark).

(An answer such as “they would evolve to have haemoglobin again” is not acceptable, since it is extremely unlikely that a gene which has been lost would reappear in the genome.)

### Question 7

a.



b. i. More closely related to bees.

ii. Because paper wasps share a more recent common ancestor with bees, than they do with cuckoo wasps.

c. It was previously assumed that all the tiphioid wasps were closely related because they looked alike, and they were all classified in the same family (1 mark). This study has revealed, however, that there are two separate, distantly related groups, whose similar features are the result of convergent evolution and they are not closely related as it was previously thought (1 mark).

d. Analogous (1 mark). There are insects that are more closely related to both bees and spider wasps that do not have stingers. It is therefore reasonable to suggest that stingers have evolved independently in each family by convergent evolution (2 marks).

e. Homologous (1 mark). Bees and ants are very closely related so it is likely that their common ancestor had a sting, and they have both inherited the sting from that common ancestor (1 mark).

### Question 8

a. i. Drawing B

ii. Feature: the femurs angle inward so the knees and lower legs are beneath the pelvis (1 mark). Explanation: The structure of the leg bones in drawing B evolved as an adaptation to bipedalism in hominins (like *Homo neanderthalensis*), because each lower leg is beneath the center of gravity. In this way, when walking, one leg can be lifted without the animal losing balance (1 mark).

b. *Homo neanderthalensis* would have a prominent heel bone, whereas *Pan troglodytes* would not.

c. France (1 mark) because *Homo neanderthalensis* evolved in Europe from *Homo erectus* (or *Homo heidelbergensis*) and there is no evidence that *H. neanderthalensis* ever inhabited Africa (1 mark).

d. (two of)

- The relatively large brow ridge.
- The relatively large nasal bone projection,
- The relatively backward sloping chin,
- The relatively backward sloping forehead,
- The relatively small cranial capacity.

(note: “relatively large cranial capacity” or “relatively large brain case” was not acceptable since *H. neanderthalensis* had a larger cranial capacity than *Homo sapiens*).

e. Radiocarbon dating

f. They may not have liked each other due to cultural differences (or anything reasonable). It was not acceptable to say “they did not meet each other” because the stem of the question says that they coexisted and sometimes interbred.