**2021 H2 Biology Paper 2 9744/02**

**1**

**(a)** Name the structures labelled **A**, **B** and **C** in Fig. 1.1. [3]

A middle lamella of cell wall
B cytoplasm
C chloroplasts

**(b)** The magnification of the photomicrograph is x560. Calculate the length of cell **X** in μm, along the line **Y**–**Z**.

Show your working.

magnification = Picture length Y-Z in mm x1000/ actual length = x 560

actual length = picture length in um/560

length of cell X =…… μm [2]

**(c)** The leaves of mosses typically consist only of a single sheet of photosynthetic tissue that is one cell thick across its entire surface. There are no air spaces.

**(i)** Describe how carbon dioxide in the air travels to the site of photosynthesis in the leaves of the mosses. [3]

1. Carbon dioxide dissolves at the film of water surrounding/ at the cell wall and diffuses into the cytoplasm;
2. down a carbon dioxide concentration gradient;
3. Dissolved carbon dioxide further diffuses into stroma across the double membrane of chloroplast;
4. where carbon fixation takes place via Calvin cycle of photosynthesis;

*R: across the stomata as the leaf is single cell thick*

**(ii)** Suggest why moss plants require damp conditions in which to grow. [2]

1. Absence of vascular bundle/xylem and thus moss plants depend on water moving into cells from the surrounding via osmosis;
2. Damp conditions prevent water from being lost to surrounding via evaporation thus preventing the plant from drying up;
3. Water is needed for ***photolysis**** during ***non-cyclic photophosphorylation****
4. It is also needed as a medium for diffusion of molecules and other biochemical reactions within the cell;

[Total: 10]

**2**

**(a)** escribe the relationship between the speed of the ants and the temperature, as shown in Fig. 2.1. [3]

1. As temperatures increase from 9°C to 26°C, speed of ant movement increase gradually from 0.4 $cms^{-1}$ to 2.8 $cms^{-1}$;
2. As temperatures increase further from 26°C to 32 °C, speed of ant movement increase more sharply from 2.8 $cms^{-1}$ to 4 $cms^{-1}$;
3. As temperatures increase from 32°C to 38°C, speed of ant movement experience the steepest increase from 3.8 $cms^{-1}$ to 6.6 $cms^{-1}$;

**(b)** Explain the effect of temperature on the speed of the ants, as shown in Fig. 2.1. [4]

1. As temperature increase from $9^0$C to $38^0$C, there is increase in kinetic energy;
2. which increases ***frequency of effective collisions**** between substrate and enzyme active sites thus rate of formation of ***enzyme-substrate complex**** increases;
3. increasing temperature also increases number of molecules having sufficient energy to overcome activation energy barrier to form products of metabolic reaction;
4. Rate of reaction could possibly be at maximum $38^0$C with most of ***active sites**** of enzymes being saturated with substrate;

**(c)** Suggest **and** explain what will happen to the speed of the ants as the temperature continues to increase above 40°C. [4]

1. As the temperature increases above 40°C, there will be further increase in kinetic energy thus resulting in greater (intramolecular) vibrations/ thermal agitation of the enzymes;
2. which breaks hydrogen, ionic bonds and other weak interactions that stabilizes the 3D conformation resulting in ***denaturation*;**
3. ***Active site**** of enzymes may no longer ***complementary in conformation**** and charge to substrates and;
4. speed of ant movement may decrease steeply from 6.6 $cms^{-1}$;

[Total: 11]

**3**

**(a)** Describe the features and functions of myeloid **stem** cells. [3]

1. Myeloid stem cells are ***undifferentiated**** and ***unspecialized**** cells which are ***multipotent**;*
2. They have ability to do ***self-renew**** and proliferate and to ***differentiate**** into specialised cells;
3. They are able to do self renewal to ensure a constant pool of stem cells;
4. for growth and development;
5. Their ability to differentiate into specialised cells helps to regenerate/replace cells that are lost due cell death and injury;

**(b)** Outline the series of events that occurs during the formation of plasma cells from a B lymphocyte. [4]

1. Each B lymphocyte has one specific type of B cell receptor (BCR) on its cell surface that can recognise an epitope which is ***complementary**** in conformation and bind to the specific antigen;
2. BCR together with bound antigen are taken into the B lymphocyte by endocytosis;
3. The antigen is processed into short peptides and attached to MHC proteins;
4. The peptide:MHC complexes are transported to cell surface membrane of B lymphocyte where the peptide is recognised by antigen-specific helper T cell;
5. Interaction between helper T cell and B lymphocyte stimulate cytokine secretion from helper T cell;
6. In turn, these cytokines activates the antigen-specific B lymphocyte to ***undergo clonal expansion and differentiation**** into antibody-secreting plasma cells**;**

**(c)** State the main differences between myeloid stem cells and lymphoid stem cells. [3]

1. Myeloid stem cells can be differentiated into many different types of blood cells including megakaryocytes, erythrocyte, myeloblast and mast cell whereas lymphoid stems cells can be differentiated into T lymphocytes and B lymphocytes;
2. Myeloid stem cells form blood cells which have multi-lobed nucleus, e.g. neutrophil and eosinophil whereas lymphoid stem cells form blood cells which do not have a lobed nucleus;
3. Myeloid stem cells form blood cells which have granular cytoplasm e.g. basophil and macrophage whereas lymphoid stem cells form blood cells which do not have a granular cytoplasm;
4. Myeloid stem cells form blood cells which are circulated in the blood but lymphoid stem cells form lymphocytes are circulated in the lymph;

[Total: 10]

**4**

**(a)** Name the structures labelled **D**, **E** and **F** in Fig. 4.1. [3]

D: (Icosahedral) ***capsid**** head
E: Double-stranded DNA
F: Tail fibre

**(b)** Fig. 4.2 represents the two types of reproductive cycle that lambda phage viruses can carry out.

**(i)** Name the **two** types of lambda phage reproductive cycle labelled **P** and **Q** in Fig. 4.2. [2]

**P**: ***Lytic**** cycle
**Q**: ***Lysogenic**** cycle

**(ii)** Describe what happens in stage **R** of the lambda phage reproductive cycle shown in Fig. 4.2. [3]

1. When tail fibres of lambda phage attaches to specific receptors with ***complementary**** shape on the bacterial host cell wall;
2. It will release ***lysozyme****, an enzyme which digests the bacterial cell wall resulting in release of molecules that changes base plate conformation;
3. This in turn causes the tail sheath to contract and thrust hollow tube through the bacterial cell wall;
   *(R bacterial cell membrane)*;
4. Viral DNA genome will then be injected into the bacterial host cell via the hollow tube. The original linear phage DNA forms a circle;

**(iii)** Describe the results of the two types of reproductive cycle shown in Fig. 4.2, for the host cells **and** for the virus. [4]

Reproductive cycle **P**

1. Enzyme ***lysozyme**** which is released by phage to digest bacterial cell wall to trigger ***lysis**** of host cell;
2. Newly formed/ assembled viruses are released to infect other host bacterial cells;

Reproductive cycle **Q**

1. Lambda phage DNA is integrated into bacterial DNA forming a ***prophage*;***
2. every time the host cell's machinery replicates bacterial chromosome, it also replicates prophage DNA along with it;
3. Host bacteria is not killed, and the prophage will be found in all progeny bacterial cells, where it remains latent;

[Total: 12]

**5**

**(a)** Name the stages of meiosis labelled **J** and **K** in Fig. 5.1 **and** describe the events that occur in each of these stages. [4]

name of stage **J** Anaphase I/ anaphase of meiosis I
description of events in **J**
separation of a pair of homologous chromosomes to opposite poles of a cell

name of stage **K** Anaphase II/ anaphase of meiosis II
description of events in **K**
separation of sister chromatids to opposite poles to opposite poles of a cell

**(b)** Describe the main differences between meiosis and mitosis. [4]

1. Mitosis will result in the production of 2 genetically identical daughter cells whereas meioisis will produce 4 genetically different daughter cells;
2. After mitosis, the daughter cells will have the same number of chromosomes as parent cell but in meiosis the daughter cells have half the number of chromosome as parent cell;
3. There is only 1 nuclear division in mitosis but there are 2 nuclear divisions in meiosis;
4. At prophase of mitosis, there is no pairing of homologous chromosomes, no chiasma formation and no crossing over but pairing of homologous chromosomes, chiasma formation and crossing over occur in prophase 1 of meiosis;
5. At metaphase of mitosis, chromosomes are arranged singly in a row on metaphase plate but in metaphase 1 of meiosis, the homologues align in pairs along metaphase plate;
6. At anaphase of mitosis, centromere divides and sister chromatids separate but in anaphase 1 of meiosis, centromeres do not divide and homologous chromosomes separate;

**(c)** In the absence of chromosomal aberration or gene mutation, explain how events during and after meiosis lead to genetic variation between offspring of the same parents. [3]

1. ***Independent assortment of homologous chromosomes**** at ***metaphase plate / equator**** during ***metaphase I****;
2. And separation of homologous chromosomes at ***anaphase I**** results in different combinations of parental chromosomes in gametes;
3. ***Crossing over*** *of ***non-sister chromatids between homologous chromosomes**** during ***prophase I**** at chiasmata;
4. Where equivalent portions of chromatids break and rejoin, resulting in exchange of alleles, hence new combination of alleles on chromatid/chromosome;
5. These non-identical sister chromatids will align randomly along ***metaphase plate / equator**** during metaphase 2 and separate during anaphase II, ultimately into different gametes;
6. Random fusion of genetically different gametes results in even greater genotypic variation in zygote.

[Total: 11]

**6**

Using the symbols $X^R$ for the allele for red eyes and $X^r$ for the allele for white eyes, show two other crosses (cross 2 and cross 3) that T.H. Morgan carried out, by:

**(a)** completing Table 6.2. [4]

**(b)** completing Table 6.3. [4]

**Table 6.2**

**cross 2:**

| | | | | |
|---|---|---|---|---|
| parental phenotypes | white-eyed male x red-eyed female (offspring of cross 1) | | | |
| parental genotypes | $X^rY$ and $X^RX^r$ | | | |
| offspring genotypes and corresponding phenotypes | $X^RX^r$ red-eyed female | $X^rX^r$ white-eyed female | $X^RY$ red-eyed male | $X^rY$ white-eyed male |
| phenotypic ratio of offspring | 1 red-eyed female: 1 white-eyed female: 1 red-eyed male: 1 white-eyed male | | | |

**Table 6.3**

**cross 3:**

| | | | | |
|---|---|---|---|---|
| parental phenotypes | red-eyed male x red-eyed female | | | |
| parental genotypes | $X^RY$ and $X^RX^r$ | | | |
| offspring genotypes and corresponding phenotypes | $X^RX^R$ red-eyed female | $X^RX^r$ red-eyed female | $X^RY$ red-eyed male | $X^rY$ white-eyed male |
| phenotypic ratio of offspring | 1 white-eyed male : 1 red-eyed male : 2 red-eyed females | | | |

[Total: 8]

**7**

**(a)** Glucagon receptors and insulin receptors are both glycoproteins that span the cell surface membrane.

State **three other** similarities between glucagon receptors and insulin receptors. [3]

1. Both have a specific ligand binding site which is ***complementary in shape**** to their specific ligand on the extracellular domain;
2. Cytoplasmic domain/ intracellular domain of both receptors can change their 3D conformation upon binding of the ligand;
3. Cytoplasmic domain/intracellular domain of both receptors have binding sites for other relay proteins, e.g. G protein;
4. Both are ***globular**** proteins with unique 3D conformation;

**(b)** Explain why it is important that the receptors **and** channel shown in Fig. 7.1 completely span the cell surface membrane. [4]

1. The ligands and glucose molecules are polar / hydrophilic, hence repelled by ***hydrophobic core**** of the phospholipid bilayer and cannot cross phospholipid bilayer;
2. Hence, the transmembrane channel protein with a hydrophilic channel can transport glucose from outside of the cell into cell cytosol;
3. Receptors need to be transmembrane as when ligand binds to ligand binding site on extracellular domain;
4. Signal can be transduced to cytoplasmic side of the cell through change in intracellular domain;

**(c)** Describe **and** explain how glucose enters cells through glucose channels, such as GLUT1. [3]

1. Polar and hydrophilic glucose will diffuse down a concentration gradient;
2. through the hydrophilic channel in the GLUT1 transporter;
3. via ***facilitated diffusion****;

[Total: 10]

**8**

**(a)** Describe **and** explain the change in the energy supplied to muscles by the phosphate system during the first 20 seconds of strenuous activity, as shown in Fig. 8.1. [2]

*Describe*

1. Energy supplied by the phosphate system decreased exponentially from 5 arbitrary units at 0s to 1.4 arbitrary units at 20s;
   (Must quote data)

*Explain*

2. Stored ATP was depleted and it was dephosphorylated / converted to ADP to provide energy to muscle contraction;
3. Stored phosphocreatine was depleted as it was dephosphorylated and used to phosphorylate ADP to produce ATP;

**(b)** Explain why respiration under anaerobic conditions **cannot** be the main source of energy for muscles in the long term. [2]

1. Anaerobic respiration produces only a small number /2 ATP per molecule of glucose via ***glycolysis****;
2. Lactic acid fermentation involves conversion of ***pyruvate**** to ***lactic acid**** to regenerate ***NAD**** for glycolysis to continue;
3. Continuous production of ***lactic acid**** leads to muscle fatigue;

**(c)** Suggest why the supply of energy from respiration under aerobic conditions does not begin to increase until 10 seconds after the start of strenuous exercise. [2]

1. Time is required for increased uptake of oxygen / inspiration of oxygen and for oxygen to be delivered to the muscle cells;
2. Oxygen is required as a ***final electron acceptor**** in electron transport chain / in oxidative phosphorylation to produce ATP;

**(d)** When yeast switches from respiration under anaerobic conditions to respiration under aerobic conditions, the rate of utilisation of glucose decreases.

Explain why the rate of utilisation of glucose decreases. [3]

1. Under aerobic conditions, complete breakdown of glucose produces ***38 ATP**** molecules per glucose molecule as compared to ***2 ATP**** molecules in anaerobic respiration;
2. Hence, under anaerobic conditions, 19 glucose molecules will be needed to generate same amount of energy that 1 glucose molecule can yield under aerobic conditions;
3. Under aerobic conditions, ***link reaction**** and ***Krebs cycle**** produce ***NADH**** that will be oxidised and hence regenerated by the ***electron transport chain**** during ***oxidative phosphorylation****, generating additional ATP;
4. However, under anaerobic conditions, glycolysis only produces a ***net of 2 ATP molecules**** for each glucose molecule oxidized and ***$NAD^+$**** and is only regenerated through fermentation processes to allow only ***glycolysis**** to continue;

[Total: 9]

**9**

**(a)** Describe the relationship between the number of species of *Scalesia* on each island and the relative **age** of the islands, as shown in Fig. 9.1.

Suggest an explanation for this relationship. [3]

1. Age of islands do not have a significant effect on the number of species of *Scalesia*;
2. (quote data)
    - Islands with just 1 species can be of age 1, 3.5, or 5 au
    - Islands with 2 species can be of age 1, 2, 3 or 4 au
    - Islands with 3 species can be of age 3.5 or 6 au
3. There are other factors that could affect the number of species such as island size, and proximity to mainland;

**(b)** Describe the relationship between the number of species of *Scalesia* on each island and the relative **size** of the islands, as shown in Fig. 9.1.

Suggest an explanation for this relationship. [3]

1. Generally the larger the island, the greater the number of species;
2. (quote data) e.g. islands with relative size of 1 arbitrary unit have 1 species, whereas islands with relative size of 3 arbitrary units have an average of 3 species;
3. The larger the island, the more different niches there are with greater variety of selection pressures;

**(c)** Describe the advantages of using genome sequences to reconstruct a phylogeny for *Scalesia* on the Galapagos Islands. [3]

1. Nucleotide data are objective. Molecular character states are unambiguous as A, C, G and T are easily recognisable and cannot be confused;
2. Nucleotide data are quantitative. Molecular data are easily converted to numerical form and are amenable to mathematical and statistical analysis and hence computation. Degree of relatedness can be inferred and quantified by calculating nucleotide differences between species;
3. Nucleotide data can be used to compare species which are morphologically indistinguishable especially if they are very closely related like the finches;
4. As changes in nucleotide sequences accumulate over time with clockwork regularity. We can estimate time of speciation and place speciation events on a timescale above;

[Total: 9]

**10**

The influenza virus causes disease in humans when it enters epithelial cells of the respiratory tract.

**(a)** Explain how the influenza virus damages epithelial cells. [2]

1. Virus destroys epithelial cells after budding of newly formed viruses leads to extensive plasma membrane loss;
2. Replication of influenza viruses in epithelial cells lead to usage of RNA nucleotides to make viral RNA genome, and amino acids used to make viral proteins, depriving host cell of these monomers for their own use;

**(b)** The damage caused by the influenza virus increases the risk of bacterial infections of the respiratory tract.

Explain why the risk of bacterial infection increases. [3]

1. Influenza virus infect the epithelial cells and destroy them causing a build-up of dead epithelial cells and mucus in the airways causing symptoms of running nose and sore throat
2. Weakening of the epithelial layer caused by viral replication can make the respiratory passage more susceptible to secondary bacterial infections
3. Because this create an environment for bacteria to grow
4. With secondary bacterial infections, this can lead to diseases like pneumonia which can be fatal

[Total: 5]

**11**

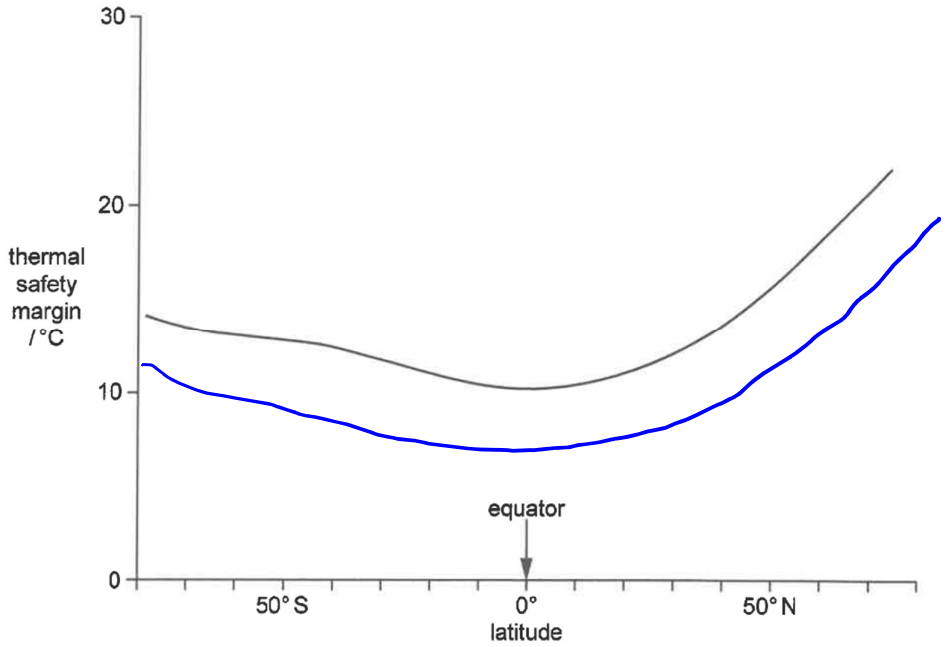


**Fig. 11.1**

**(a)** On Fig. 11.1, sketch a line to represent the thermal safety margin that you would predict in the future as a result of climate change. [1]

Line follow same shape below line in Fig. 1.1.

**(b)** Outline how human activities contribute to climate change. [4]

1. Human activities contribute to increased production of $CO_2$ – e.g. of activities include:
   human induced burning of fossil fuels releases $CO_2$;
   increase in decomposing materials, e.g in landfills/sewage increase $CO_2$ release,
   industrial processes, such as in cement works, release $CO_2$;
   burning land and vegetation to clear land for agriculture;
2. $CO_2$ is a greenhouse gas which contribute to the greenhouse effect;
3. Infrared radiation / heat emitted from Earth's surface is absorbed and re-emitted by greenhouse gases,
4. trapping the infrared radiation / heat in the atmosphere resulting in global warming;

[Total: 5]