 **HWA CHONG INSTITUTION (COLLEGE SECTION)**  
**2022 JC2 9744 H2 BIOLOGY**  
**PRELIMINARY EXAMINATIONS PAPER 1 MARK SCHEME**

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**MULTIPLE CHOICE QUESTIONS**

QUESTION	CORRECT ANSWER
1	D
2	B
3	C
4	A
5	B
6	D
7	B
8	B
9	B
10	D
11	B
12	C
13	A
14	D
15	A

QUESTION	CORRECT ANSWER
16	B
17	C
18	A
19	D
20	C
21	B
22	C
23	A
24	B
25	A
26	C
27	D
28	A
29	D
30	B



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**PRELIMINARY EXAMINATIONS PAPER 2 MARK SCHEME**

**QUESTION 1**

(a) Describe the main features of amylose visible in Fig. 1.1 [2]

- Ref to  $\alpha$  (1, 4) glycosidic bonds between glucose units
- Ref to helical structure, with 6 glucose units per turn

(b) Explain how the structure of amylose makes it suitable for its function. [2]

- Ref to large amylose, thus insoluble in water, does not exert osmotic influence in the cell
- Ref to hundreds to thousands of glucose, thus a large source of carbon
- Ref to  $\alpha$  (1, 4) glycosidic bonds, being easily hydrolysed
- Ref to amylose being helical and thus compact
- Ref to anomeric carbon involved in glycosidic bond formation, thus unreactive / chemically-stable

(c) Suggest how double helix structure of amylose is formed. [1]

Ref to via hydrogen bonds between adjacent amylose molecules

(d) (i) State two ways in which the structure of collagen differs from the structure of starch. [2]

	Collagen		Starch
1a	Made up of amino acids	1b	Made up of $\alpha$ -glucose
2a	Linked by peptide bonds	2b	Linked by $\alpha$ (1,4) glycosidic bonds
3a	Triple helix tropocollagen	3b	Helical amylose, highly branched amylopectin
4a	ref to unbranched	4b	Ref to branched

(ii) Explain how one of the differences stated in (d)(i) allows collagen to perform its function. [2]

- Ref to glycine-X-Y, glycine with small R group can fit in / packed tightly together
- Ref to providing high tensile strength
- Ref to extensive hydrogen bonds within tropocollagen, between NH group of Gly in one  $\alpha$ -chain and CO group of another amino acid in next  $\alpha$ -chain
- Ref to providing high tensile strength

[Total: 9]

**QUESTION 2**

With reference to Fig. 2.1,

(a) (i) explain why calcium ions do not pass through the phospholipid bilayer. [2]

- Calcium ions are water soluble/ hydrophilic
- unable to pass through hydrophobic core of the phospholipid bilayer

(ii) state and describe the process by which calcium ions are moved across the membrane. [4]

- Active transport
- Intracellular  $\text{Ca}^{2+}$  binds to the binding sites of the calcium pump/ carrier protein
- Upon binding of  $\text{Ca}^{2+}$ , carrier protein undergoes conformational change
- $\text{Ca}^{2+}$  is transported against the concentration gradient from cytoplasm to outside the cell
- Ref. to usage of ATP as an energy source

(b) With respect to the fluid mosaic model, discuss how high temperature affects membrane permeability. [3]

- At high temperature, kinetic energy of the hydrocarbon chains of the phospholipids increases, and increase lateral movements
- Ref. to overcoming hydrophobic interactions between phospholipids, increase transient gaps between adjacent phospholipids
- Ref. to correct explanation following denaturation of membrane proteins at high temperature
- Ref. to increase membrane permeability

[Total: 9]

**QUESTION 3**

(a) State the Central Dogma of Molecular Biology. [3]

- unidirectional flow from DNA to RNA to polypeptide
- DNA transcribed to form RNA
- mRNA translated to form polypeptides

(b) Explain how a molecule of telomerase synthesises additional lengths of DNA. [4]

- template RNA binds to region X
- in the active site of telomerase
- free nucleotides bind to DNA template via hydrogen bonds
- complementary base pairs such as to A–T and C–G and U–A
- phosphodiester bonds formed between nucleotides
- telomerase moves in the direction of the arrow

(c) Explain why the action of telomerase challenges the Central Dogma of Molecular Biology. [2]

- RNA acts as a template
- reverse flow of genetic information

(d) Suggest why prokaryotes do not have telomerase. [2]

- prokaryotes have, circular DNA
- prokaryotes do not have telomeres

[Total:11]

**QUESTION 4**

(a) Compare the structures of SARS-CoV-2 and influenza virus. [3]

- Both contain RNA
- Both have viral envelope with glycoproteins on its surface
- There are 8 segments of RNA in influenza but 1 RNA for SARS-CoV-2
- HA glycoprotein is embedded on viral envelope of SARS-CoV-2 whereas S glycoprotein is embedded in the viral envelope of COVID-19

(b) Describe how the SARS-CoV-2 virus enters a host cell. [3]

- S glycoprotein on the viral membrane binds to ACE2 and PRS2 receptors on the host cell membrane
- The virus enters the host cell by receptor-mediated endocytosis
- Ref. to subsequent viral envelope fusing with vesicle membrane and releasing the nucleocapsid into cytoplasm

(c) There are at least three variants of the SARS-CoV-2 virus since its discovery in 2019.

Identify and describe one type of variation in viral genomes that may lead to the formation of new strains of the SARS-CoV-2 virus. [3]

- Ref. to antigenic shift / antigenic drift
- (for antigenic shift) Reassortment of viral genome with that of a different antigenic type results in the formation of a new COVID-19 strain
- (for antigenic drift) Gradual accumulation of minor mutations results in changes to the genes for the glycoprotein receptors
- Ref. to change of 3D conformation / shape of proteins
- Ref. to lack of proofreading mechanism associated with the enzyme of the virus

[Total: 9]

**QUESTION 5**

(a) Explain how this mutation causes the HbS to form fibres. [3]

- ref. to change in  $\beta$ -globin gene and amino acid
- ref. to HbS sticking together

(b) Suggest why PCR may be needed before the extracted DNA can be profiled. [2]

- ref. to small amount of DNA to be amplified

(c)(i) Describe the role of primers in PCR. [2]

- ref. to binding to DNA to be amplified

(ii) Explain how the use of two specific primers allows the detection of the normal, sickle cell anaemia and SCT genotypes. [3]

- ref. to binding of specific primers for the respective genotypes

[Total: 10]

**QUESTION 6**

(a) Outline how cancer is caused. [3]

- Ref. to accumulation of mutations
- Ref. to the dysregulation of cell cycle checkpoints
- Ref. to uncontrolled cell division

(b) Describe the normal role of the *BRCA2* gene. [3]

- Ref. to the tumour suppressor gene *BRCA2* coding for the BRCA2 protein

The tumour suppressor protein / BRCA2 protein

- takes part in the cell-signaling pathways to inhibit the cell cycle
- halts cell division if DNA is damaged

(c) Discuss the extent to which Fig. 6.1 provides evidence that a faulty *BRCA2* allele increases the risk of a person developing cancer. [4]

- Ref. to the idea that the overall data in Fig. 6.1 is inconclusive

Data that shows *BRCA2* allele might increase the risk of a person developing cancer

- Individual 3 or 4 may have had the, *BRCA2* allele / Any individual from 8 to 11 may have inherited, *BRCA* allele, from 3 or 4
- Individual 15 has cancer, *BRCA2* allele

Data that shows *BRCA2* allele might not increase the risk of a person developing cancer (i.e. data is inconclusive)

- Individual 8 or 11, has *BRCA2* allele, but does not have cancer
- No evidence / unknown, that individuals (apart from 15) with cancer, have *BRCA2* allele

[Total: 10]

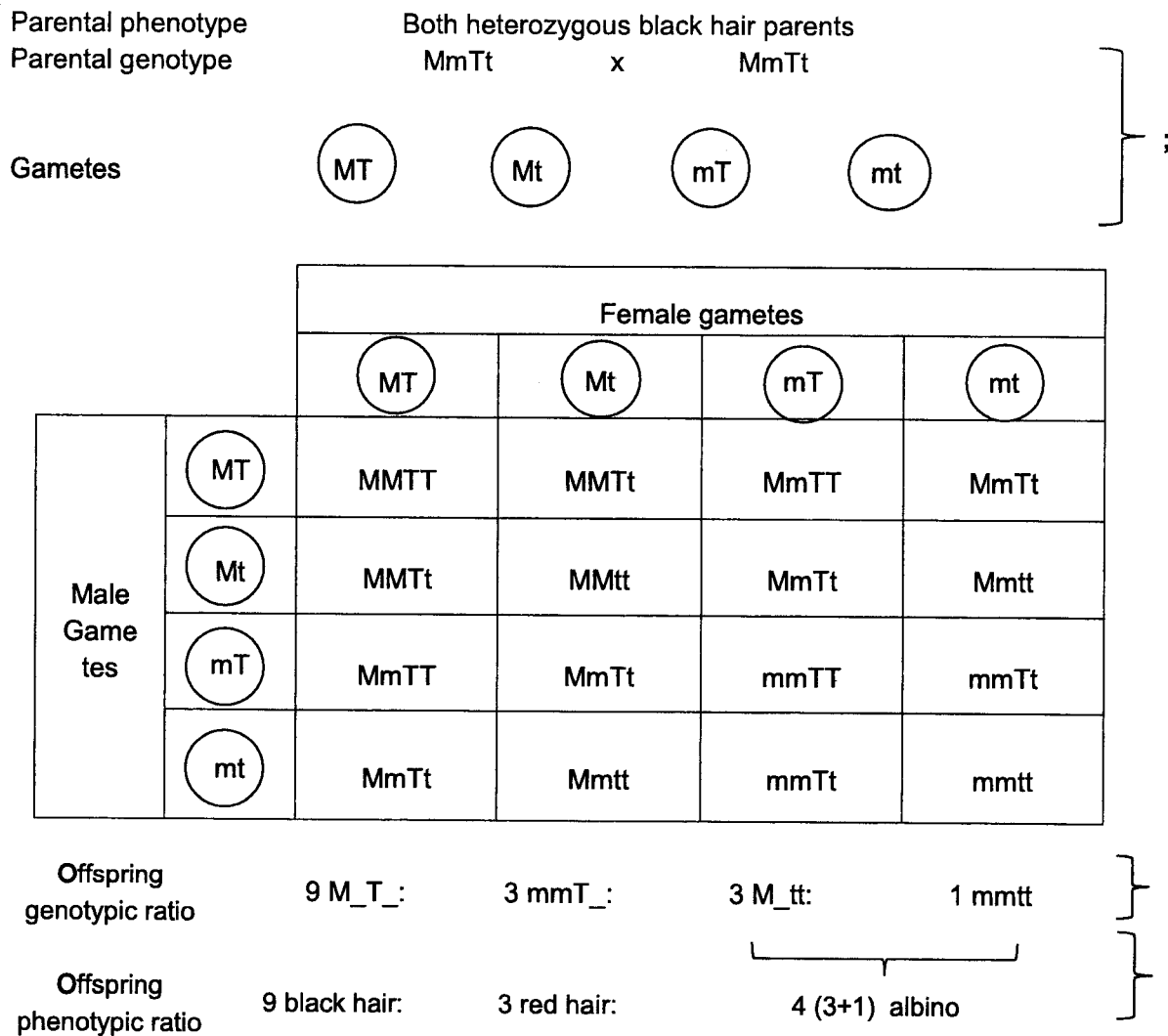
## QUESTION 7

(a) Explain the term *epistatic gene interaction* in this context. [2]

- The expression of *tt* masks the expression of alleles at the *M/m* locus
- Ref to presence of *T* allele being required for expression of red / black hair /ORA

(b) A couple with black hair has three children, each with a different hair colour.

Draw a genetic diagram to explain these results. [4]



(c)(i) Complete Table 7.1 to show the expected numbers of individuals with each phenotype. [1]

hair colour	observed number of individuals	expected number of individuals
black	579	540
red	165	180
albino	216	240

(c)(ii) Using the formula above, calculate the  $\chi^2$  value for the observed results. Show your working clearly. [1]

$$\chi^2_{\text{calc}} = (540-579)^2/540 + (180-165)^2/180 + (240-216)^2/240 \\ = 6.47$$

(c)(iii) Explain the conclusion that may be drawn from your  $\chi^2$  value in (c)(ii). [3]

- At  $df=2$ ,  $\chi^2_{\text{calculated}} = 6.47 > \chi^2_{\text{critical}} = 5.99$  ;
- there is less than 5% probability that there is difference between observed and expected results is due to chance ;
- Thus the distribution of hair types shows significant difference from 9:3:4/ does not follow the predicted ratio of 9: 3: 4/ there is a larger distribution of dark haired individuals at the equator;

[Total: 11]

## QUESTION 8

(a) Explain the roles of proteins involved in the light-dependent reaction of photosynthesis. [2]

- enzymatic role
- electron transport chain
- active transport for chemiosmosis
- photosystems with ability to carry pigment for absorption of light

(b)(i) Describe and explain the pattern of results obtained between  $0.25 \text{ mol dm}^{-3}$  and  $1.25 \text{ mol dm}^{-3}$  of sodium hydrogencarbonate solution. [4]

- increasing trend because  $\text{CO}_2$  concentration is limiting
- subsequent plateau because  $\text{CO}_2$  concentration is no longer limiting

(ii) Suggest reasons for this negative value. [2]

- low photosynthesis as low  $\text{CO}_2$ , respiration uses up oxygen

(iii) To minimise temperature changes, the student decided to use an LED lamp as a light source. LED lamps release very little heat energy.

Explain the importance of minimising temperature changes in this experiment. [3]

- so that  $\text{CO}_2$  is the only independent variable
- high temperature may denature enzyme

[Total: 11]



**QUESTION 9**

(a) (i) State why the two bee species share the first name *Bombus*. [1]

Same genus

(a) (ii) Describe how it is possible to confirm, over a longer period of time, whether *Bombus pratorum* and *Bombus terrestris* belong to different species. [2]

- Check if *Bombus pratorum* and *Bombus terrestris* interbreed
- Determine if offspring are viable and fertile
- Conclusion, i.e. if offspring are infertile, then they are different species

(b)(i) Name the process by which new species are formed within the same geographical location. [1]

- Sympatric speciation

(b)(ii) Using Fig. 9.1 and Table 9.1, and the information given, suggest how an ancestral species might have evolved into the two species, *B. pratorum* and *B. terrestris*. [5]

- Ref to seasonal / temporal difference in breeding of males and queens in different populations with data quoted from Fig. 9.1
- Ref to behavioural difference / visit different types of flowers / feed at different times / feed on different food types with data quoted from Table 9.1
- Ecological isolation
- Gene flow restricted
- Natural selection, resulting from different adaptations under different selection pressures
- Accumulation of sufficient reproductive isolating mechanisms, genetic diversity and adaptations
- Reproductive isolation

[Total: 9]

**QUESTION 10**

(a) Describe the innate immune response. [2]

- combats microbes immediately upon infection / mediates the initial protection against infections
- ref. to specific named cells and molecules involved, e.g. macrophages, chemokines, cytokines, complement system

(b) Explain which immune responses are impaired in Patients A and B [3]

- Patient A - innate / innate and adaptive, Patient B - adaptive
- ref. to non functional innate immune response, leading to high number / exponential increase of microorganism count
- ref. to functional innate but non functional adaptive, hence slow rise at the start, microorganism count continues to rise

[Total: 5]

**QUESTION 11**

(a) With reference to the information provided, suggest and explain how climate change scientists can estimate atmospheric carbon dioxide concentrations 10 000 years ago. [2]

- ref. to how carbon dioxide air bubbles is a good sample / indicator of atmospheric carbon dioxide levels
- ref to extracting ice samples from different depths of ice sheets and determine the age of the ice samples

(b) Use Fig. 11.2 to comment on changes in temperature over the last 800 000 years. [2]

- Rise and fall of ratio of  $^1\text{H}$  to  $^2\text{H}$  corresponds with the percentage concentration of carbon dioxide
- Carbon dioxide is a greenhouse gas, increased concentration in the atmosphere lead to more heat being trapped, rise and fall of temperature as the concentration of carbon dioxide changes

(c) Explain why the data in Fig. 11.2 do not provide enough evidence to conclude that increased concentrations of greenhouse gases cause climate change. [2]

- Carbon dioxide is not the only greenhouse gas / unable to identify which gas is causing the change
- ref. to temperature not the only factor in climate change
- ref. to correlation does not imply causation

[Total: 6]

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**QUESTION 1**

(a) Suggest and explain which hunting method is more efficient. [3]

- NE method / TT method

For NE

- Ref to increased quantity of prey caught /eaten / AW;
- Ref to conserving energy by not using additional energy for electrical discharge;

For TT

- Ref combination of both electrical and chemical methods to increase effectiveness;
- Ref to electrical discharge causing immediate immobilization of prey;

(b) Suggest how a cocktail of proteins instead of a single protein is advantageous for the cone snail. [3]

- Ref. to conotoxins having a complementary shape to membrane bound receptor;
- Ref to higher chance of binding to a receptor/ AW;
- Ref. to, conotoxins targeting different prey / AW;

(c) Describe how insulin is able to trigger a response inside the muscle cell. [4]

- Binding of insulin to RTK ;
- Ref to autophosphorylation / AW;
- Cytoplasmic relay proteins bind and get activated triggering signal transduction pathways ;
- Ref to cellular response ;

(d)(i) Describe the effect of unmodified  $\rho$ -TIA on the escape response of zebrafish. [1]

Accept appropriate data quoted ;

(ii) Explain which deletion in the modified  $\rho$ -TIA has the greatest impact on its function. [4]

- Group 3 ;
- Ref. to proper data quoted;
- Ref. to deletion of amino acid sequence resulting in non-functional  $\rho$ -TIA /AW ;
- Ref. to correct consequence, e.g. unable to prevent flow of calcium into muscle cells;

(iii) Conotoxins are used to develop potential drugs for humans.  
 These drugs can be tested on zebrafish that are good model organisms since they share 70 percent of their genes with humans.

State why zebrafish is used. [2]

- Ref. to good representation since similar to humans ;
- Ref. to no need for human volunteer ;
- AVP (e.g lower cost etc) ;

(e) With reference to Fig. 1.3

(i) Suggest reasons for the high number of species found at the coral reefs. [2]

- Ref. to high habitat diversity / complex habitat ;
- Ref. to specialisation by different closely related species ;
- Example of specialisation ; prey type, size, feeding methods
- Ref. to lack of / reduced interspecific competition / competitive exclusion

(ii) describe and explain the predicted effect of global warming on the distribution of cone snails within the Philippines. [4]

- Quote poleward movement of cone snail species ;
- Quote appropriate temperature range ;
- Cone snail species with black shells are disadvantaged as they absorb more heat / ORA ;
- Ref to effect of increasing temp on cone snail ;
- Cone snail species can adapt to new environment or risk extinction ;

(iii) Identify one challenge of using morphology to classify cone snails. [1]

Ref. subjectivity in determining differences;

(f) (i) Suggest why it is useful to include gaps as indicated by dashes in Fig. 1.4 when aligning the nucleotide sequences. [1]

- Ref to adjusting for indels in some sequences ;

(ii) Explain what conclusions can be drawn from the data in Fig 1.4. [3]

- examples with data quoted on no. of differences in bases ;
- the smaller the number of differences the, more closely related / more recently divergence occurred / ORA;
- all the species share a recent common ancestor ;

(iii) Explain why there is insufficient evidence from Fig 1.4 to draw conclusions about the evolutionary relationships between cone snails. [2]

- the nucleotide sequences are only a small fraction of the whole genome ;
- use of figures to support ;

[Total: 30]

**QUESTION 2**

Fig. 2.1 shows the terminal differentiation of different cell types derived from a pituitary stem cell.

- (a) State and explain the potency of the pituitary stem cell in Fig. 2.1.  
[2]
- multipotent ;
  - as it can only differentiate into a limited number of cell types ;
- (b) Explain how one feature of stem cells enables them to be a possible preferred treatment over hGH injections. [2]
- stem cells can undergo long-term, self-renewal / proliferation by mitotic divisions;
  - stem cells can differentiate into specialized cells ;
- (c)(i) Suggest why mRNA was collected for this study instead of DNA. [1]
- ref. to presence of mRNA indicates that the gene(s) were expressed / transcribed / AW ;
  - ref. to presence of DNA will not be able to reflect if the gene(s) were expressed / transcribed / AW ;
- (ii) Describe how changing the sleep-wake pattern from pattern 1 to pattern 2 affects the number of genes expressed. [2]
- ref. to fewer genes have increased expression, during the day, during the night, and all the time for sleep-wake pattern 2 ; (*NB: all or none*)
  - quoting of correct data from Table 2.1 ;
- (iii) Explain how light can result in increased or decreased gene expression at certain times of the day. [3]
- ref. to any correct pair of quoted data / trend from Table 2.1 + correct conclusion on effect of light on gene expression ;
  - presence of light detected by (photo)receptors, triggering signal transduction pathway ;
  - resulting in cellular response of increased production of activator / repressor proteins, which bind to enhancers / silencers / resulting in a more / less stable TIC;

[Total: 10]

**QUESTION 3**

(a) Explain why symptoms of HIV and TB only appear at the later stages of infection. [3]

- ref. to HIV forming provirus in  $T_H$  / macrophage + *M. tuberculosis* forming granuloma / tubercles in alveolar macrophages ;
- ref. to HIV and *M. tuberculosis* remaining latent ;
- ref. to symptoms appearing only when sufficient / AW,  $T_H$  / macrophage / alveolar macrophages are damaged ;

(b) Discuss whether the data in Fig. 3.1 support this prediction. [4]

Does not support

- Much larger proportion do not have HIV / AIDS / AW ;
- Data to support ;
- Other factors may cause more deaths from TB ;

Support

- Large proportion of deaths of people with HIV / AIDS / are caused by TB ;
- Data to support ;
- Fewer people will be immunocompromised ;

(c) In healthy people, the number of T-helper cells ranges from 500 to 1200 cells per  $\text{cm}^3$  of blood. In untreated people infected with HIV, the number of T-helper cells can decrease to below 200 cells per  $\text{cm}^3$  of blood.

Explain how a low number of T-helper cells makes it more likely that untreated people infected with HIV will die if they are also infected with TB. [3]

- Ref. to opportunistic infections causing death ;
- Low levels of / less, cytokine, secreted / AW ;
- Two from:
  - activity of macrophages not stimulated
  - B-lymphocyte / plasma cells / humoral response, not stimulated
  - (so) lower concentrations of / less / no, antibody, produced / secreted ;
  - stimulates, T-cytotoxic / T-killer, cells ;
- fewer, bacteria killed / viruses eliminated / pathogens killed ;
- Fewer memory cells (to fight future infection) ;

[Total: 10]

**QUESTION 4**

(a) Compare the behavior of chromosomes in the two different types of cell division. [15]

Similarities

- In prophase for both, chromosomes condense
- In metaphase for both, chromosomes line up along the metaphase plate
- In anaphase for both, centromeres divide / forming daughter chromosomes which are pulled to opposite poles
- In telophase for both, chromosomes decondense

Differences

- homologous chromosomes pair up / crossing over in meiosis which does not occur in mitosis
- bivalents line up in meiosis while in mitosis, chromosomes line up singly at metaphase plate
- independent assortment in meiosis but not mitosis
- differences in chromosome behavior during anaphase i.e. sister chromatids do not separate in meiosis I

(b) Discuss how the meiotic cell cycle is crucial for evolution to occur. [10]

- crossing over allows for formation of new combinations of alleles
- independent assortment allows for random distribution of chromosomes
- leads to genetic variation in gametes, genotype and phenotype of offspring
- leads to genetic variation in a population
- genetic variation is necessary for natural selection
- individuals with favourable alleles best adapted to the environment are more likely to survive to sexual maturity
- leading to changes in allelic frequency over time, hence, microevolution occurs

**QUESTION 5**

(a) Compare the processes in which energy is released in aerobic and anaerobic respiration. [15]

*Similarities*

- ref. to glycolysis
- glucose broken down to pyruvate and 2 ATP and 2 NADH
- substrate-level phosphorylation
- reduction of NAD to NADH
- occurs in the cytoplasm / cytosol
- ref. to enzyme-catalyzed reaction

*Differences*

- ref. to involves glycolysis, link reaction, Krebs cycle and oxidative phosphorylation
- ref. to presence / absence of oxygen
- ref. to 36 / 38 ATP vs 2 ATP
- ref. to products of respiration in glycolysis
- ref. to products of aerobic vs anaerobic respiration
- ref. to final electron acceptor
- ref. to location
- ref. to substrate level phosphorylation vs oxidative phosphorylation
- ref. to different roles of NADH
- ref. to chemiosmosis occurring or lack of it
- ref. to oxidative decarboxylation or lack of it
- ref. to complete / incomplete oxidation of glucose

(b) Plants are important indicators used by scientists to study the effects of environmental stress caused by climate change.

Discuss the effects of climate change on the rich biodiversity of plants in the tropics. [10]

- ref. to definition of climate change
- ref. to definition of biodiversity
- ref. to increase in frequency of extreme weather events
- ref. to shifts in geographic ranges
- ref. to reduction in amount and availability of habitat / biomes
- ref. to loss of ecosystem diversity
- ref. to plants selection against plants unable to adapt
- ref. to increased temperature leading to higher environmental stress on plants
- ref. to shifts in flowering time of plants
- ref. to impact on insects
- ref. to climate change decreasing biodiversity in the tropics
- ref. to resulting in extinction of plant species
- ref to decrease gene pool