HWA CHONG INSTITUTION (COLLEGE SECTION)
2022 JC2 9744 H2 BIOLOGY
PRELIMINARY EXAMINATIONS PAPER 3 MARK SCHEME

QUESTION 1

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

1 ***NE** method**;**

Any 2:
2 Ref to **increased quantity** of prey caught /eaten / AW;
3 Ref to **conserving energy** by not using additional energy for electrical discharge;
4 **AVP ;**

5 ***TT** method;

Any 2:
6 Ref combination of both electrical and chemical methods to **increase effectiveness** in immobilising prey;
7 Ref to electrical discharge causing **immediate immobilisation** of prey;
8 Ref to **more effective** since **direct injection of toxin/ electrical signal into prey**;
9 **AVP ;**

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

1 (specificity) Ref. to **conotoxins having a specific complementary 3D conformations / complementary to a membrane bound receptor**;
2 (variety) Ref to **higher chance of binding to a receptor/ increase variety of membrane bound receptors** that conotoxins can bind to;
3 (effectiveness) Ref. to, conotoxins targeting **different prey / many different types of cells in one prey** thus increasing success of capturing killing prey ;
4 Single toxin may lead to development of **resistance in fish**;
5 AVP ;

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

1 Binding of insulin to **RTK** triggers aggregation, and **dimerization** of RTK ;
2 Ref to **autophosphorylation/ cross phosphorylation/ phosphorylation of tyrosine residues**;
3 Cytoplasmic **relay proteins bind** and get **activated** triggering signal transduction pathways / Activated **relay proteins** acts on **downstream proteins** and **activates** them **;**
4 Ref to correct **description** of **one cellular response ;**
- **GLUT4 channels / glucose transporters** added to **cell membranes increasing glucose uptake** into cells
- Increased **use of glucose in respiration** / **increased** rate of **glycolysis**
- **increases conversion glucose to glycogen / glycogenesis**
- **Amino acid absorption/ protein synthesis / lipogenesis;**

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

As concentration of ρ-TIA **increased from $4x10^{-9}$ to $5x10^{-6}$M**, escape response of zebrafish **decreased gradually from 9 to 2** (A: lower limit range as values between 2 to 3);

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

1 ***Group 3 ;**
2 Quote effect of ρ-TIA on escape response:
ie: Increase of modified ρ-TIA from **5 $x10^{-9}$M to $1x10^{-6}$M** resulted in a reduction of escape response score of **9 to 8 ;**
R: comparison between group 3 and other groups
3 (effect on protein) ref. to deletion of amino acid sequence resulting in **non-functional ρ-TIA** / ρ-TIA **no longer complementary to receptors / AW** ;
4 (effect on fish) Thus **unable to prevent flow of calcium into muscle cells/ does not inhibit muscle cells from functioning ;**

Note: no marks awarded if wrong group identified, or, no group identified even if MP2 to 4 present

(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]

*any **two** from:*

1 (ethics) **similar response in zebrafish and humans/ good representation ;**
2 (ethics) ref. to no need for human volunteer, **sanctity / respect for human life ;**
R: vague ref to "ethical issue" with no elaboration on humans
3 **Quick reproduction rate;**
4 **AVP ;**

(e) With reference to Fig. 1.3,

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

1 Ref. to **high habitat diversity / complex habitat ;**
2 Ref. to **niches/ abundant microhabitats** ;
3 Ref. to coral reefs **providing shelter /camouflage** against currents/predators
4 AVP;

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

MP1 / MP2 required for full marks
1 (Fig. 1.3a) Quote **poleward movement** of cone snail species *C. tulipa, C. geographus and C. kinoshitai* ;
2 (Fig. 1.3b) Quote temperature range will **increase above current temperature 25.5-31.0°C**;
A: increase in global temp will beyond 30.8°C
3 (Fig. 1.3c) Cone snail species with black shells are **disadvantaged as they absorb more heat** / ORA ;

4 Ref to effect of **increasing temp on cone snail** (e.g denaturation of enzymes) ;
5 Cone snail species can **undergo selection in new environment/ risk extinction** ;
R: disappearance (vague)
6 Global warming causing **coral bleaching leading to loss of habitat**;
7 **AVP ;**

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

1 Reference to **subjectivity/ difficulty in determining differences/ non-quantitative**;

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

1 Ref to **adjusting for insertions / deletions** in some sequences ;

I: comparisons to be done easily / more clearly (vague)

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

Any 3:
1 Ref to example with **correct species quoted + correct no. of differences in bases ;**
2 Ref to **smaller the number of differences** being **more closely related**/ **more recently diverged** / **ORA;**
3 all the species **share a recent common ancestor** ;
4 **AVP;**

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

Any 2:
1 the **nucleotide sequences** are only a **small fraction** of the whole genome ;
2 **use of figures** to support ; e.g. 20 nucleotides equivalent to, (only) 6 amino acids
3 **cytochrome is likely to be a larger, polypeptide** / protein / ref. to length of gene ;
4 there will be **variation within each species** ;
5 these sequences come from **one individual** from each species ;
6 AVP ;

[Total: 30]

QUESTION 2

(a) State and explain the potency of the pituitary stem cell in Fig. 2.1. [2]

1. **multipotent ;** R: pluripotent / totipotent
2. as it can only **differentiate into a** limited **number of /** 6 **different cell types** / **specialized cells /** AW **;**

NB: No credit awarded at all if level of potency is incorrect

(b) Explain how one feature of stem cells enables them to be a possible preferred treatment over hGH injections. [2]

1. *stem cells can undergo **long-term, self-renewal / proliferation by mitotic divisions;** A: long periods of time
   R: unlimited / indefinite
2. producing a **constant pool of stem cells ;**

3. *stem cells can **differentiate into specialized cells ;**
4. **producing / expressing hGH ;**

5. ref. to **hGH from injections** being **degraded** by the body over time / **need for daily injections to sustain hGH levels** in the body **;**

NB: *MP1 or MP3 is compulsory for full credits

(c)(i) Suggest why mRNA was collected for this study instead of DNA. [1]

any 1

1. ref. to presence of **mRNA indicates that the gene(s) were expressed / transcribed** / AW **;**
2. 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]

1. 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)*
2. **quoting of correct data** from Table 2.1 **;**

any 1

- e.g. **during the day,** group of people with sleep-wake **pattern 2** has **134 genes with increased expression,** which is **fewer** than**,** the **661 genes** with increased expression for group of people with sleep-wake **pattern 1 ;**
- e.g. **during the night,** group of people with sleep-wake **pattern 2** has **95 genes with increased expression,** which is **fewer** than**,** the **733 genes** with increased expression for group of people with sleep-wake **pattern 1 ;**
- e.g. **all the time,** group of people with sleep-wake **pattern 2** has **8 genes with increased expression,** which is **fewer** than**,** the **108 genes** with increased expression for group of people with sleep-wake **pattern 1 ;**

(iii) Explain how light can result in increased or decreased gene expression at certain times of the day. [3]

1 *ref. to any **correct pair of quoted data / trend** from Table 2.1 **+ correct conclusion on effect of light on gene expression ;**

any 1

- e.g. **during the day,** group of **people** (with sleep-wake pattern 2) **who are asleep** has **134 genes with increased expression,** which is **fewer** than**,** the **661 genes** with increased expression for group of **people** (with sleep-wake pattern 1) **who are awake +** meaning that **light results in increased gene expression during day ;**
- e.g. **during the night,** group of **people** (with sleep-wake pattern 2) **who are awake** has **95 genes with increased expression,** which is **fewer** than**,** the **733 genes** with increased expression for group of **people** (with sleep-wake pattern 1) **who are asleep +** meaning that **light results in decreased gene expression during night ;**
- e.g. group of **people** (with sleep-wake pattern 1) **who are awake during the day** has **661 genes with increased expression,** which is **fewer** than**,** the **733 genes** with increased expression **for same group of people who are asleep during the night +** meaning that **light results in decreased gene expression during day ;**
- e.g. group of **people** (with sleep-wake pattern 2) **who are awake during the night** has **95 genes with increased expression,** which is **fewer** than**,** the **134 genes** with increased expression **for same group of people who are asleep during the day +** meaning that **light results in decreased gene expression during night ;**

2 *presence of **light detected by** (photo)**receptors, triggering signal transduction pathway ;**

3 resulting in cellular response of **increased production of activator / repressor proteins,** which **bind to enhancers / silencers** / resulting in a **more / less stable TIC;**

4 AVP **;**

NB: *No marks awarded if no ref made to any correct pair of quoted data / trend from Table 2.1
NB: *MP 1 and MP 2 are compulsory for full credits

[Total: 10]

QUESTION 3

Tuberculosis (TB) is the leading cause of death in people living with HIV globally. Early screening for either TB in HIV patients or HIV in TB patients is important as patients may not exhibit symptoms until at a later stage, resulting in higher mortality rate.

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

1 ref. to HIV **forming provirus** in T_H / macrophage **+** *M. tuberculosis* **forming granuloma / tubercles** in alveolar macrophages **;**
A: Escape phagocytosis / prevent lysosomal fusion, in alveolar macrophages
R: ref. lysogenic / lytic cycle
R: both HIV and *M. tuberculosis* form proviruses - only HIV is a virus
R: TB forming granuloma / tubercles - TB is the disease, it is not the bacterium that cause the disease

2 ref. to HIV and *M. tuberculosis* **remaining latent ;**
A: dormant (awarded on BOD)

3 ref. to symptoms appearing **only when sufficient / AW, T_H / macrophage / alveolar macrophages** are **damaged ;**
I: ref. to HIV and *M. tuberculosis* successfully evading host immune response

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

N does **not** support **;**
N1 (rebuttal) **much larger proportion** of people who died from TB **were not infected with HIV ;**
N2 (evidence) deaths of people from TB with HIV/AIDS is **0.25 million out of 1.5 million** deaths from TB **;**
A: deaths of people from TB without HIV/AIDS is **1.25 million out of 1.5 million** deaths from TB
A: (difference) **1 million more** deaths of people from TB without HIV/AIDS **than** deaths of people from TB with HIV/AIDS
N3 (reasoning) **other factors may cause more deaths from TB ;**
A: ref. to **different modes of transmission** of HIV and *M. tuberculosis,* thus controlling spread of HIV might not control spread of *M. tuberculosis* correspondingly
A: not enough information

S support **;**
S1 (support) **large number / significant proportion,** of deaths of people with HIV/AIDS is **due to TB ;**
S2 (evidence) deaths of people with HIV/AIDS due to TB is **0.25 million out of 0.75 million** deaths of people with HIV/AIDS **;**
A: (proportion) **one-third** of deaths of people with HIV/AIDS is **due to TB**
S3 (reasoning) **other factors may cause more deaths from TB ;**
A: ref. to **fewer people being immunocompromised** due to AIDS, thus lower mortality

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

max three from:
1 **ref. to opportunistic infections** by *M. tuberculosis* causing death **;**

2 (role of T-helper cells) ref. to **lower levels of cytokines** secreted / AW **;**

any one consequence of less T-helper cells from:
3a **macrophages not activated ;**
3b **B-lymphocytes / plasma cells / humoral response**, **not activated**, hence **lower levels of antibody** secreted **;**
3c **T-cytotoxic / T-killer cells, not activated ;**
3d **fewer memory cells** to fight future infections **;**

4 hence **less *M. tuberculosis* eliminated /** AW **;**

[Total: 10]

QUESTION 4

Cell division enables the continuity of life based on the production of different types of cells via mitosis and meiosis. These processes are crucial for evolution to occur.

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

Similarities

S1. In both **prophase I / prophase II of meiosis and prophase of mitosis, chromosomes condense / become discrete ;**
S2. In both **metaphase II of meiosis and metaphase of mitosis**, **chromosomes line up singly along the metaphase plate** ;
S3. In both **anaphase II of meiosis and anaphase of mitosis**,
   a. centromeres divide and **sister chromatids separate into daughter chromosomes ;**
   b. **daughter chromosomes pulled to opposite poles** centromeres leading **;**
   c. ref. to both having **characteristic V-shaped pattern ;**
S4. In both **telophase I / telophase II of meiosis and telophase of mitosis, chromosomes decondense** into chromatin **;**
S5. AVP ;
   e.g. ref. to **behavior of chromosomes in mitosis is similar to meiosis II** ;

Differences

D1. In **prophase I of meiosis,**
   a. **homologous chromosomes pair up / formation of, bivalent / tetrad, occurs** which **does not occur in prophase of mitosis;**
   b. ref. to **synapsis** / exchange of alleles during **crossing over between non-sister chromatids / formation of chiasmata occurs** which **does not occur in prophase of mitosis ;**
D2. In **metaphase I** of meiosis, **homologous chromosomes / bivalents line up at the metaphase plate** while in mitosis, **chromosomes line up singly** at the metaphase plate ;
D3. In **metaphase I** of meiosis, **independent assortment** of homologous chromosomes **occurs**, which **does not occur in metaphase of mitosis;**
D4. In **anaphase I** of meiosis,
   a. **homologous chromosomes separate** while in anaphase of mitosis, **sister chromatids separate** ;
   b. **homologous chromosomes are pulled to opposite poles, while in** anaphase of mitosis, **daughter chromosomes** (R: sister chromatids) **are pulled to opposite poles** ;
   c. **sister chromatids remain attached to each other**, while in anaphase of mitosis, sister chromatids are no longer attached (A: ref to centromeres separate);
   R: centromeres split
D5. AVP ;
   e.g. ref. to **behavior of chromosomes in mitosis is different in meiosis I** ;

QWC: Good spread of knowledge communicated without ambiguity which correctly identifies at least 2 similarities and 2 differences between the two types of cell division

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

Significance of meiotic cell cycle:

1. In prophase I of meiosis, formation of **bivalents / crossing over** between non-sister chromatids allows for formation of **new combinations of paternal and maternal alleles** ;
2. In metaphase I of meiosis, **independent assortment** of homologous chromosome pairs allows for **random distribution of paternal and maternal chromosomes** in each gamete ;
3. AVP ;

Link between genetic variation and natural selection **[compulsory to get at least 1 from this segment for full marks]**

4. *This **increases genetic variation in gametes** formed ;
5. *And hence **genetic variation in the genotype and phenotype** of offspring produced by random fertilization of gametes ;
6. *Most of the **genetic variation in a population arises from variation in individuals** as a result of meiosis which produces the gametes required for sexual reproduction;

Genetic variation crucial for evolution to occur:

7. Ref. to **genetic variation is necessary for natural selection to occur** ;
8. the environment selects for pre-existing forms which have a **selective advantage ;**
   A: ref. to selective pressures
9. Individuals with **favourable alleles best adapted to the environment** are **more likely to survive to sexual maturity and reproduce / AW** ;
10. *with each succeeding generation, **proportion of individuals within the population with favorable alleles increases, leading to changes in allelic / genotype frequency over (a long period of) time, hence, microevolution occurs / AW ;**
11. AVP ;
    max 1 for ref. to errors in DNA replication leading to formation of new alleles / polyploidy leading to sympatric speciation

QWC: Good spread of knowledge communicated without ambiguity discussing both (1) significance of meiotic cell cycle in leading to variation, (2) link between genetic variation and natural selection (at least 1 from MP 4 – 6) as well as (3) how genetic variation is crucial for evolution to occur (MP10 must be present) ;

[Total: 25]

QUESTION 5

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

Similarities

S1 (process) ref. to **glycolysis** ;
S2 (substrate) where 1 molecule of **glucose** is broken down to 2 molecules of **pyruvate** and 2 **ATP** and 2 **NADH** ;
S3 (process) where 2 ATP is released via **substrate-level phosphorylation** ;
S4 (product) ref. to reduction **of NAD to NADH** as coenzymes ;
S5 (location) occurs in the **cytoplasm** / **cytosol** ;
S6 ref. to **enzyme-**catalyzed reaction ;
S7 AVP ;

Differences

D1 (process) aerobic respiration **involves glycolysis, link reaction, Krebs cycle and oxidative phosphorylation**, while anaerobic respiration only involves **glycolysis** ;
D2 (process) aerobic respiration occurs in the **presence of oxygen**, while anaerobic respiration occurs in the **absence of oxygen** ;
D3 (product) aerobic respiration releases **36 / 38 ATP per molecule of glucose** while anaerobic respiration only **releases 2 ATP per molecule of glucose** ;
D4 (product) **carbon dioxide and water** are the products of aerobic respiration, while **lactate / ethanol** are products of anaerobic respiration ;

D5 **oxygen** is the final **electron acceptor** in aerobic respiration, while **pyruvate** is the **final electron acceptor** in anaerobic respiration ;
D6 (location) aerobic respiration occurs in the **cytoplasm and mitochondria**, while anaerobic respiration only occurs in the **cytosol** ;
D7 (process) aerobic respiration produces ATP by both **substrate-level phosphorylation and oxidative** phosphorylation, while anaerobic respiration produces ATP only through **substrate-level phosphorylation** ;
D8 (product) pyruvate is converted to **acetyl-coA** in link reaction / during aerobic respiration, while pyruvate is converted to either **lactate or ethanol** in anaerobic respiration ;
D9 (product) aerobic respiration involves the use of **NADH and $FADH_2$** as electron carriers, while anaerobic respiration only involve the use of **NADH** ;
D10 (role of NADH) NADH is used in aerobic respiration to **transfer high-energy electrons to the electron transport chain** for oxidative phosphorylation, while NADH is used in anaerobic respiration to **reduce pyruvate to lactate / ethanol** to allow anaerobic respiration to continue ;
D11 ref. to **chemiosmosis** occurring in aerobic respiration, while no chemiosmosis occurs in anaerobic respiration to form ATP ;
D12 **oxidative decarboxylation** occurs in aerobic respiration during link reaction and the Krebs cycle, while **oxidative** decarboxylation **does not occur during lactic acid fermentation** ;
D13 glucose is **fully oxidized** in aerobic respiration and energy is fully released, while a lot of chemical energy is still trapped in the products of anaerobic respiration as it is **not fully oxidized** ;
D14 AVP ;

QWC: Good spread of knowledge communicated without ambiguity comparing (1) both similarities and differences, and (2) with clear points of comparison.

(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]

1. ref. to climate change as the **large-scale, long-term shift** in average **temperature** and **precipitation** ;
2. ref. to biodiversity as **diversity** of **species**, **genes** and the **ecosystems** they are in ;

<u>Habitat level</u>
3. ref. to increase in more frequent, intense and longer **extreme events** (e.g. drought, flooding, forest fires) ;
4. increased temperature leading to **shifts in geographic ranges** upwards towards the poles away from the tropics ;
5. ref. to reduction **in amount and availability** of habitat / biomes (e.g. rising sea levels destroying freshwater plants, Amazonian forest replaced by savannahs)
6. ref. to loss of **ecosystem diversity** ;

<u>Organism level</u>
7. ref. to plants **unable to adapt / without proper physiological adaptations** to these changes will be selected against and die (e.g. selection of C4 plants over C3) ;
8. ref. to increased **temperature leading to higher environmental stress on plants** ;
9. leading to more **susceptibility to disease / insect outbreaks** ;
10. ref. to **shifts** in timing of seasons leading to **phenological shifts in flowering time**, causing **mismatch** between plant and pollinator populations ;
11. ref. to **impact on insects** (e.g. increased pest activity for insects feeding on plants, death of pollinators)

Consequences
12. *ref. to climate change **decreasing** biodiversity in the **tropics** ;
13. ref. to **extinction** of plant species, lowering **species diversity**;
14. ref. to **decrease gene pool**, leading to loss of **genetic diversity** ;
15. AVP *;*

QWC: Good spread of knowledge communicated without ambiguity discussing the impact of climate change on (1) both the habitat and the organisms in the tropics, and (2) link between the effects of climate change on biodiversity.

[Total:25]