HWA CHONG INSTITUTION
JC2 Preliminary Examinations
Higher 2

CANDIDATE NAME		CT GROUP	21S7 ___

CENTRE NUMBER					INDEX NUMBER				

BIOLOGY **9744/03**

Paper 3   Long Structured and Free-response Questions

13 September 2022

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

INSTRUCTIONS TO CANDIDATES

Write your **name**, **CT group**, **Centre number** and **index number** in the spaces at the top of this cover page.

Section A

Answer **all** questions in the spaces provided on the Question Paper.

Section B

Answer any **one** question in the spaces provided on the Question Paper.

INFORMATION FOR CANDIDATES

The use of an approved scientific calculator is expected, where appropriate.

You may lose marks if you do not show your working or if you do not use appropriate units.

The number of marks is given in brackets [ ] at the end of each question or part question.

You are reminded of the need for good English and clear presentation in your answers.

For Examiners' Use	
1	**/ 30**
2	**/ 10**
3	**/ 10**
4 or **5**	**/ 25**
Total	**/ 75**

This document consists of **20** printed pages.

BOOKLET I

**SECTION A**

Answer **all** the questions in this section.

QUESTION 1

Tropical cone snails are small, slow-moving marine animals. They are carnivores, which hunt and kill prey that include fish.

Fig. 1.1 shows two different hunting behaviours exhibited by cone snails. Both hunting behaviours use conotoxins that are made up of a cocktail of different types of proteins.

The hunting behaviours include:

● taser-and-tether (TT), where electricity and conotoxins are discharged resulting in instantaneous immobilization of prey
● net-engulfment (NE), where a cloud of conotoxins is released to stun nearby fish and the muscular walls of the rostrum (false mouth) extends out to form a massive funnel to engulf multiple prey fish.

taser-and-tether (TT)   net engulfment (NE)
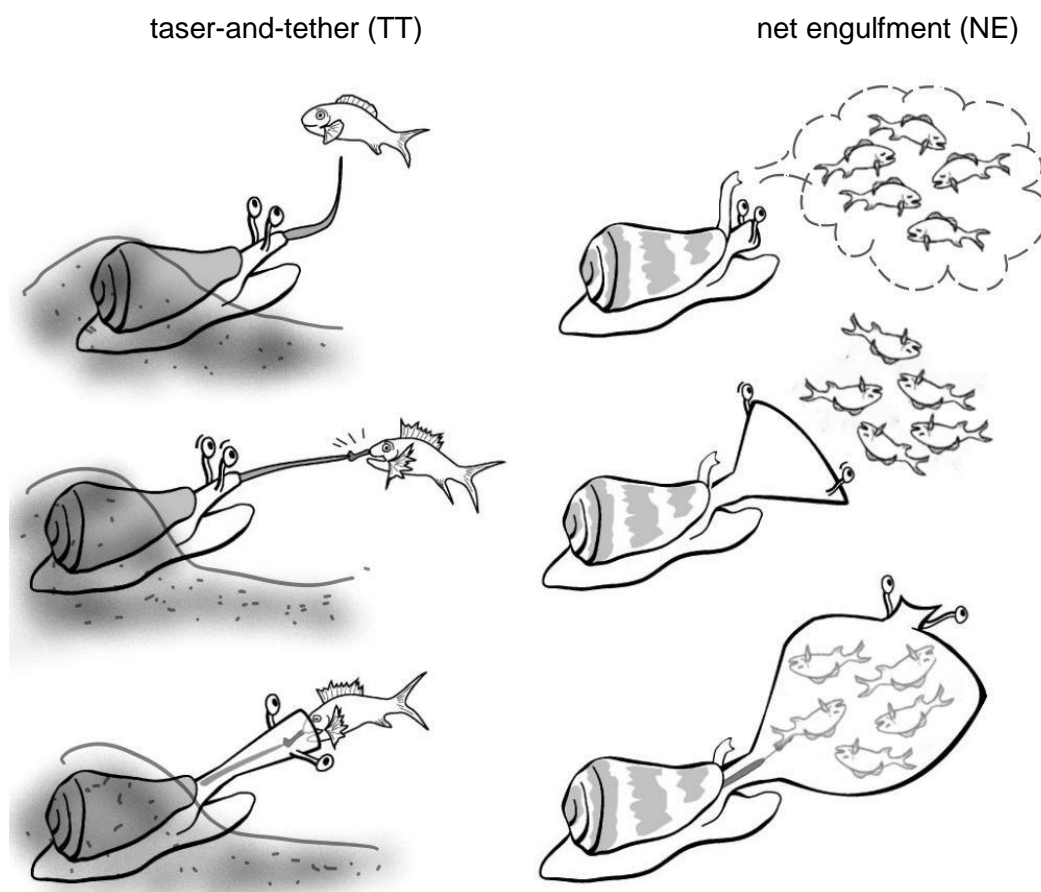
Fig. 1.1

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

[3]

The conotoxins bind to the membrane-bound receptors on the muscle cells in fish to immobilise them.

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

[3]

Insulin and ρ-TIA are two types of proteins commonly found in conotoxins.

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

[4]

ρ-TIA binds to the receptors on the muscle cells preventing the flow of calcium ions into the muscle cells, rendering them ineffective.

To investigate the effects of conotoxins, ρ-TIA protein was administered on zebrafish to evaluate the escape response of the fish.

Details of the study includes:
- the use of four groups of zebrafish labelled groups 1 to 4
- group 1 zebrafish was administered with different concentrations of unmodified ρ-TIA protein
- groups 2 to 4 were each administered with different concentrations of modified ρ-TIA protein, where each group was given ρ-TIA protein with different amino acid sequences deleted
- the escape response of zebrafish were then recorded where a higher score corresponded to a higher chance of escape.

Fig. 1.2 shows the results of the study.
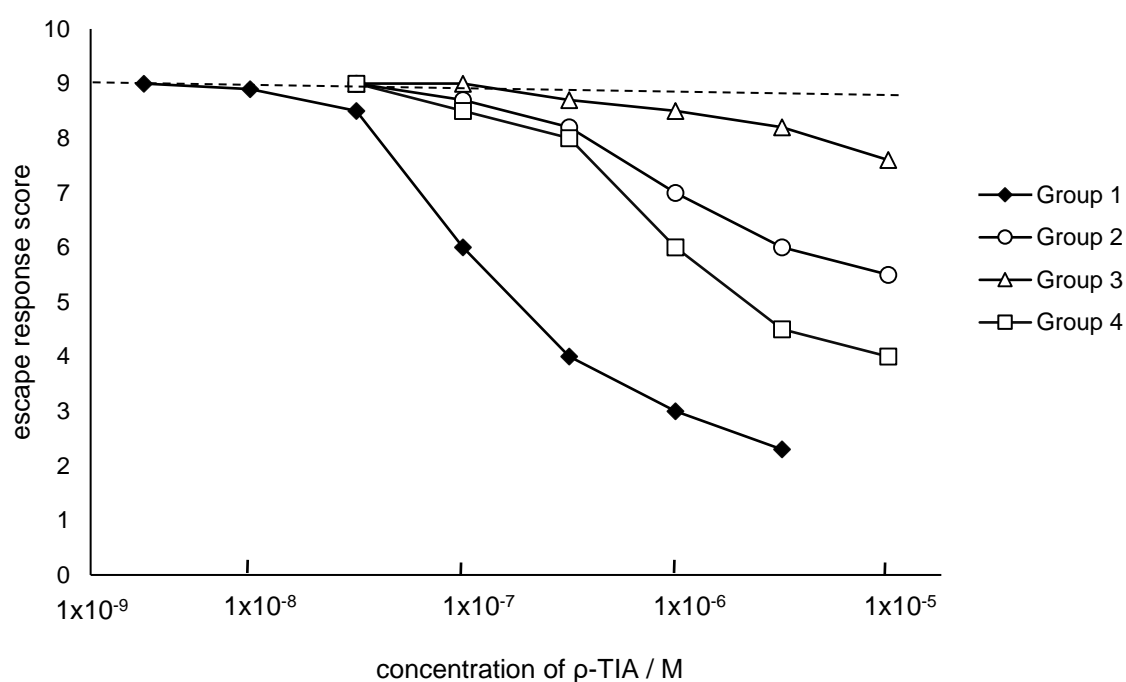
Fig. 1.2

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

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.... [1]

(ii) Explain which deletion in the modified 〉-TIA has the greatest impact on its function.

[4]

(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.

Suggest why zebrafish is used.

[2]

Marine cone snails are found in tropical marine environments and are particularly prominent around coral reefs and other shallow-water tropical marine habitats. A single coral reef may have over 30 different species of *Conus.*

Fig 1.3 shows:
(a) the distribution of three common species of cone snails, *C. tulipa, C. geographus* and *C. kinoshitai*, which are endemic to the Philippine islands
(b) the annual temperature range of the waters around the Philippine islands
(c) shells of some cone snails collected around the Philippine islands.
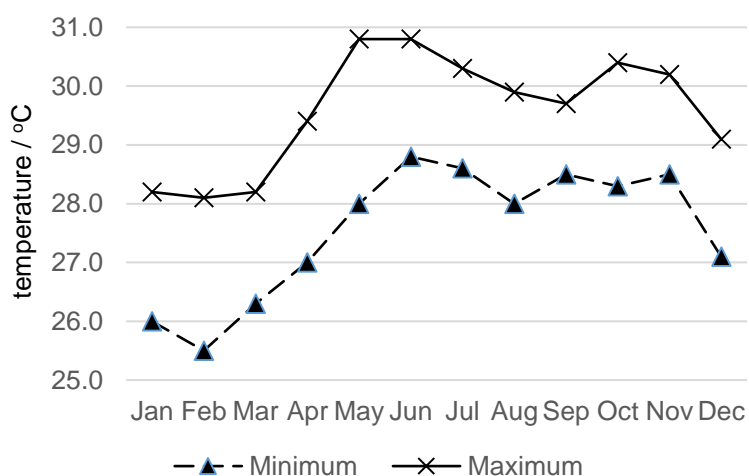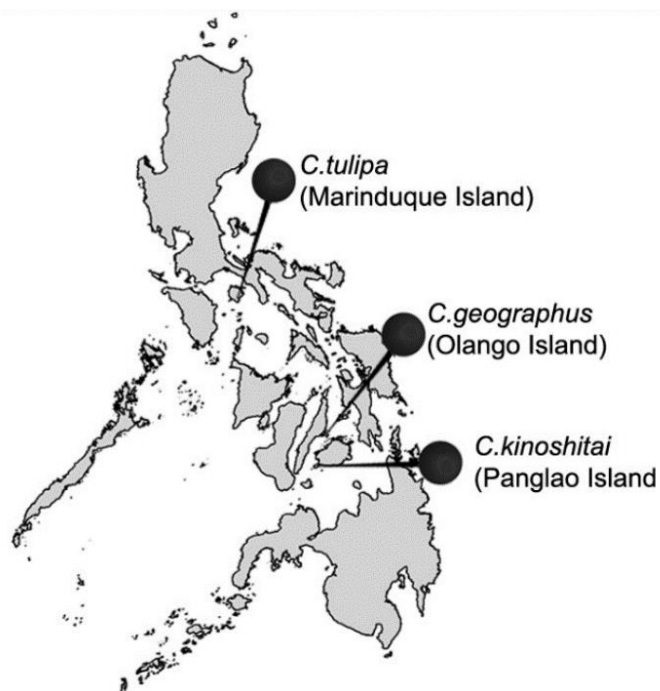
Fig 1.3(a)
Fig 1.3(b)
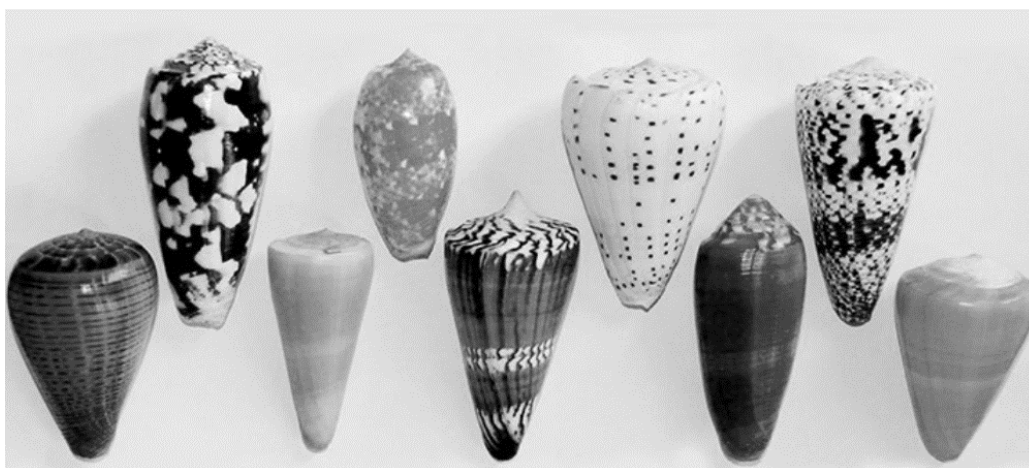
Fig. 1.3(c)

(e) With reference to Fig. 1.3,

(i) suggest reasons for the high number of species found at the coral reefs.

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.... [2]

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

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.... [4]

(iii) identify one challenge of using morphology to classify cone snails.

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.... [1]

Fig. 1.4 shows the nucleotide base sequences of a length of DNA from the gene coding for cytochrome protein in six of the closely-related cone snail species found in the Philippine islands.

Conus geographus	A	-	-	-	-	-	-	-	-	-	-	-	-	-	T	C	T	G	G	A
Conus abbreviatus	G	-	-	-	-	-	-	-	-	-	-	-	-	A	T	C	T	G	G	C
Conus ammiralis	G	A	C	A	T	G	G	T	A	T	A	T	G	A	T	C	T	G	G	G
Conus catus	T	A	C	A	T	G	G	A	A	T	A	T	G	A	T	C	T	G	G	A
Conus auricomus	C	-	-	A	T	G	G	T	A	T	A	T	G	A	T	C	T	G	G	G
Conus distans	A	A	C	G	T	G	G	A	A	T	G	T	G	A	T	C	C	G	G	A

Fig. 1.4

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

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.... [1]

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

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.... [3]

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

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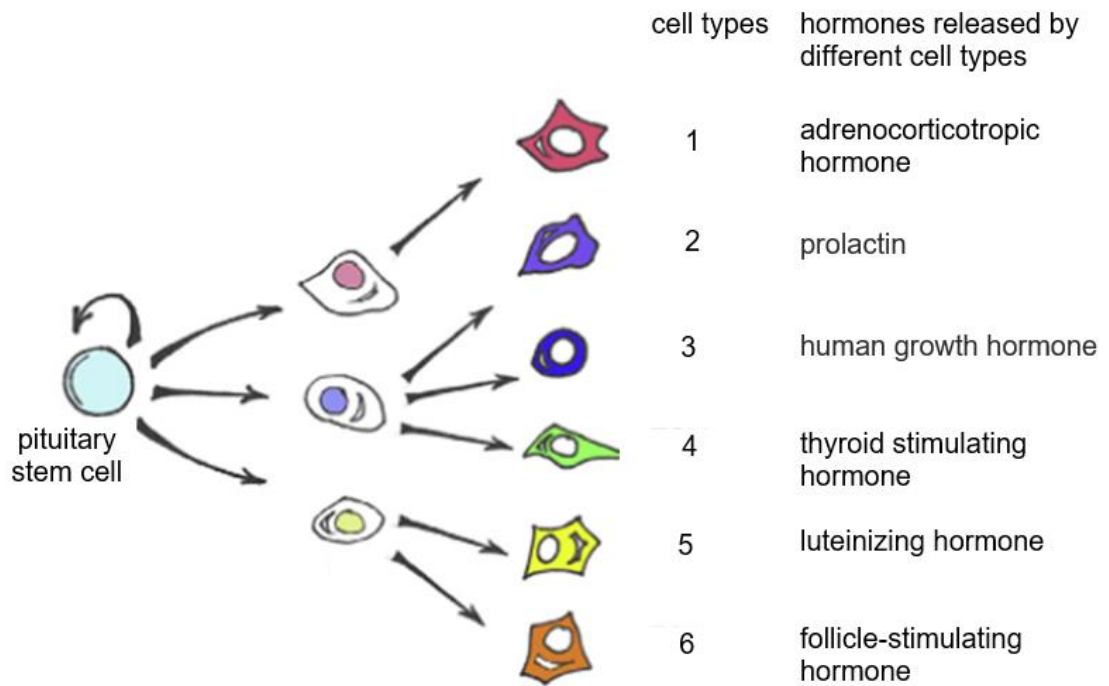.. [2]

[Total: 30]

QUESTION 2

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

cell types	hormones released by different cell types
1	adrenocorticotropic hormone
2	prolactin
3	human growth hormone
4	thyroid stimulating hormone
5	luteinizing hormone
6	follicle-stimulating hormone

Fig. 2.1

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

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.... [2]

Human growth hormone (hGH) is a peptide hormone that has important roles in growth during childhood. Children who do not produce enough hGH are described as hGH-deficient and grow slower than other children.

Current treatment involves daily injections of hGH to increase growth rate. An alternative treatment still being researched on is stem cell therapy where stem cells carrying the normal allele for hGH is introduced to induce expression in hGH-deficient children.

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

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.... [2]

hGH is one of many proteins in the body whose secretion or production is controlled by a person's sleep-wake pattern.

The sleep-wake pattern describes when, during a 24 hour day, a person is asleep and when they are awake. For example:

- pattern 1 – asleep during the night and awake during the day (normal)
- pattern 2 – asleep during the day and awake during the night.

Researchers identified genes that have their expression changed by a person's sleep-wake pattern. They collected mRNA from:

- a group of people with sleep-wake pattern 1
- the same group of people whose sleep-wake pattern was changed to pattern 2.

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

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.... [1]

A summary of the results is shown in Table 2.1.

Table 2.1

sleep-wake pattern	number of genes with increased expression		
	during the day	during the night	all the time
pattern 1	661	733	108
pattern 2	134	95	8

(ii) Describe how changing the sleep-wake pattern from pattern 1 to pattern 2 affects the number of genes expressed.

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.... [2]

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

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.... [3]

[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]

The World Health Organisation (WHO) introduced a strategy in 2015 to end the global TB epidemic. An important part of the strategy is to:

- identify people at risk of becoming infected with TB
- use methods to prevent transmission of TB.

Four years later in 2019, the World Health Organization (WHO) Global Tuberculosis Report for 2019 published data on the estimated number of deaths from TB and HIV/AIDS in 2018. All deaths of people from TB who were infected with HIV were also counted as deaths of people with HIV/AIDS.

Fig. 3.1 shows these data. The dark grey boxes show the estimated number of deaths of people from TB who were also counted as deaths of people with HIV/AIDS.
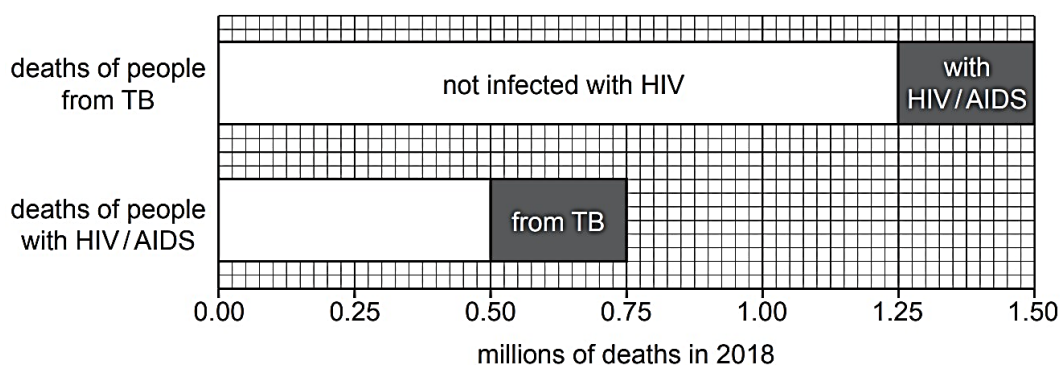
Fig. 3.1

A student used the data in Fig. 3.1 to predict that measures to control the spread of HIV will decrease the number of deaths from TB.

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

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....[4]

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.

(c) 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.

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....[3]

[Total: 10]

--- END OF SECTION A ---

SECTION B

Answer **one** question in this section.

Write your answers on the lined paper provided at the end of this Question Paper.

Your answer should be illustrated by large, clearly labelled diagrams, where appropriate.

Your answers must be in continuous prose, where appropriate.

Your answers must be set out in parts **(a)** and **(b)**, as indicated in the question.

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 essential for evolution to occur.

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

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

[Total: 25]

QUESTION 5

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

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

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

[Total: 25]

--- END OF SECTION B ---

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