HWA CHONG INSTITUTION
JC2 Preliminary Examination
Higher 2

CANDIDATE NAME		**CT GROUP**	**14S ___**
CENTRE NUMBER		**INDEX NUMBER**	

BIOLOGY

9648 / 02

Paper 2 Core Paper

27 August 2015

Additional Materials: Writing Paper

2 hours

INSTRUCTIONS TO CANDIDATES

There are **four** question booklets (**I** to **IV)** to this paper. Write your **name**, **CT group**, **Centre number** and **index number** in the spaces provided at the top of this cover page and on the lines provided at the top of the cover page of Booklets **II**, **III** and **IV**.

SECTION A

This section contains **eight** questions. Answer **all** questions.
Write your answers on the lines / in the spaces provided.

SECTION B

This section contains **two** questions. Answer any **one** question.
Your answers must be in continuous prose, where appropriate.
Write your answers on the writing paper provided.

BEGIN EACH PART ON A FRESH SHEET OF WRITING PAPER.

A **NIL RETURN** is required for parts not answered.

INFORMATION FOR CANDIDATES

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

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.

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

For Examiners' Use	
Question	**Marks**
1	**/ 9**
2	**/ 10**
3	**/ 10**
4	**/ 9**
5	**/ 12**
6	**/ 9**
7	**/ 10**
8	**/ 11**
9 / 10	**/ 20**
Total	**/ 100**

BOOKLET I

SECTION A: STRUCTURED QUESTIONS

QUESTION 1

Fig. 1.1 shows a molecule of haemoglobin. The haem group plays an important role in the function of haemoglobin.

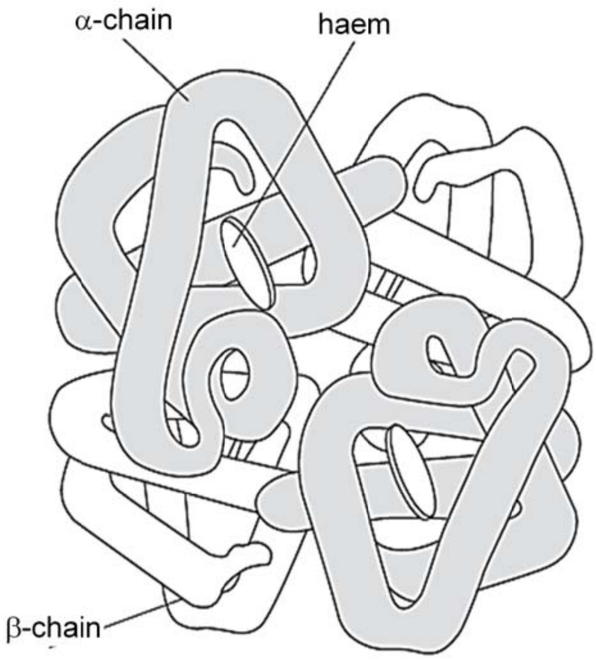

Fig. 1.1

(a) Describe the role of the *haem* group in haemoglobin. [2]

(b) Discuss the advantages of having four subunits in haemoglobin. [3]

The Greylag goose and the Andean goose have different haemoglobin structures. Possession of a haemoglobin with high oxygen affinity helps the Andean goose to adapt to high altitudes. Greylag goose lives in the Indian plains, whereas the Andean goose lives in the High Andes. The haemoglobin of the Andean goose differs from that of the Greylag goose by nine replacements in the α-chain and seven in the β-chain.

(c) Explain how the differences in haemoglobin structure of the Greylag and Andean geese contribute to their different oxygen affinities. [4]

[Total: 9]

QUESTION 2

Fig. 2.1 shows how DNA polymerase interacts with a DNA molecule during the S phase of the cell cycle.

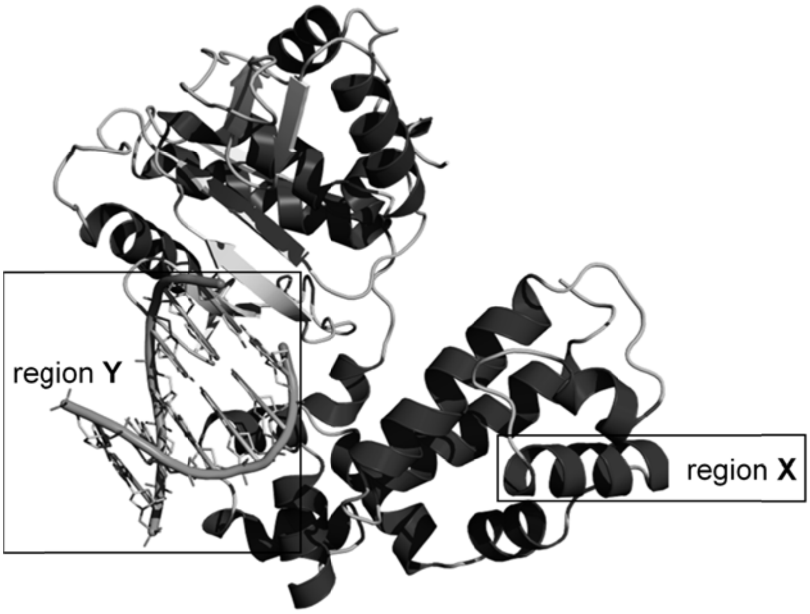

Fig. 2.1

(a) Distinguish between the helical structures shown in regions **X** and **Y**. [2]

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(b) Describe the roles of DNA polymerase in the S phase of the cell cycle. [2]

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Fig. 2.2 shows the structure of dideoxycytidine triphosphate (ddCTP), a potential replication substrate.

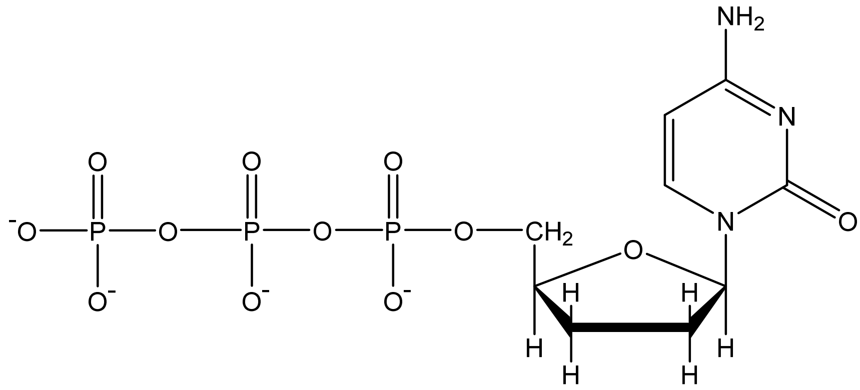

Fig. 2.2

(c) ddCTP was added to a DNA replication reaction in large excess over the concentration of deoxycytidine triphosphates (dCTP).

Explain how the addition of ddCTP would affect DNA replication. [4]

(d) ddCTP is used in DNA sequencing reactions to determine the DNA base sequence. In such reactions, ddCTP is added at 10% the concentration of the dCTP.

Suggest how ddCTP facilitates the determination of DNA base sequence. [2]

[Total: 10]

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BOOKLET II (SECTION A CONTINUED)

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QUESTION 3

Human T-lymphotropic virus type 1 (HTLV-1) is a retrovirus that brings about a form of cancer called T-cell leukaemia. Like the human immunodeficiency virus (HIV), HTLV-1 predominantly infects $CD4^+$ T cells.

Fig. 3.1 shows the structure of a mature HTLV-1 particle.

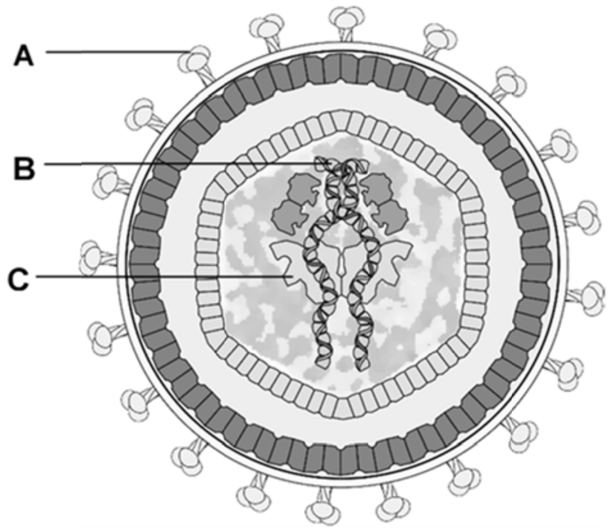

Fig. 3.1

(a) With reference to Fig. 3.1,

(i) suggest why structure **C**, the first viral enzyme involved in the reproductive cycle of HTLV-1, is crucial in its classification as a retrovirus. [1]

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(ii) describe the roles of structures **A** and **B** in the reproductive cycle of HTLV-1 in $CD4^+$ T cells. [2]

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(b) Suggest how HTLV-1 infection could lead to the onset of T-cell leukaemia. [1]

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HIV is another retrovirus that leads to Acquired Immunodeficiency Syndrome (AIDS). Full blown AIDS occurs ten years on average after infection.

Fig. 3.2 shows the infection stages of HIV in humans whereby **X**, **Y** and **Z** represent three different time periods.

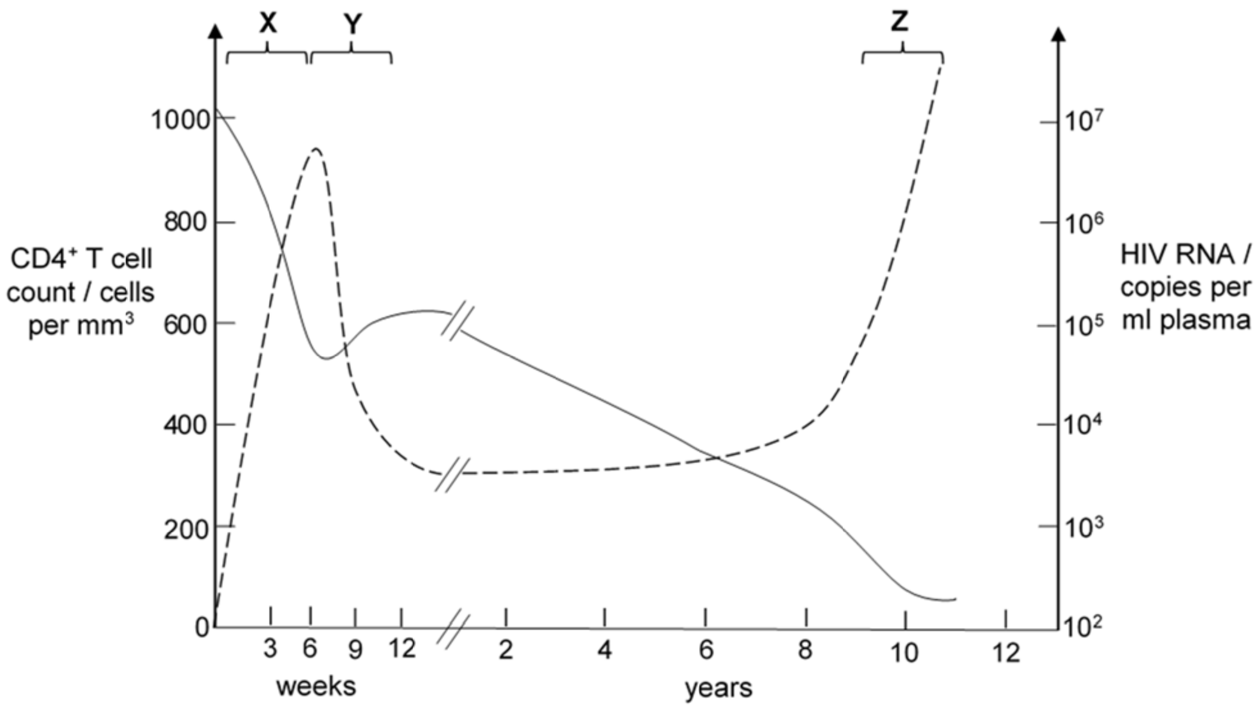

Fig. 3.2

Fig. 3.3 shows infected CD4$^+$ T cells with immature HIV particles in the late stage of its reproductive cycle.

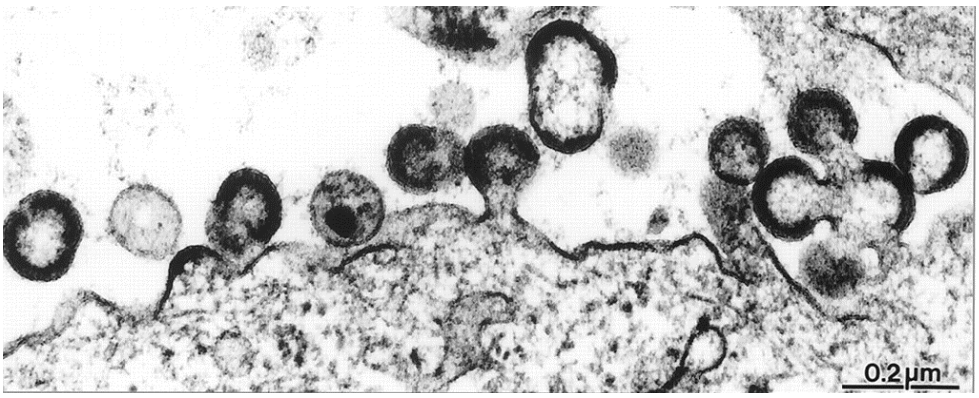

Fig. 3.3

(c) With reference to Fig. 3.2 and 3.3,

(i) identify the time period(s) which correspond(s) to this late stage of HIV reproductive cycle shown in Fig. 3.3.
[1]

(ii) describe what happens during this stage of HIV reproductive cycle. [3]

(iii) suggest how infection by HIV could cause diseases in time period **Z**. [2]

[Total: 10]

QUESTION 4

The *α-fetoprotein (AFP)* gene codes for proteins that are expressed only in the human foetus but not in the adult.

Blood serum AFP is commonly used as a biomarker for the detection of liver cancer.

Fig. 4.1 shows the blood serum levels of AFP in the various stages of life.

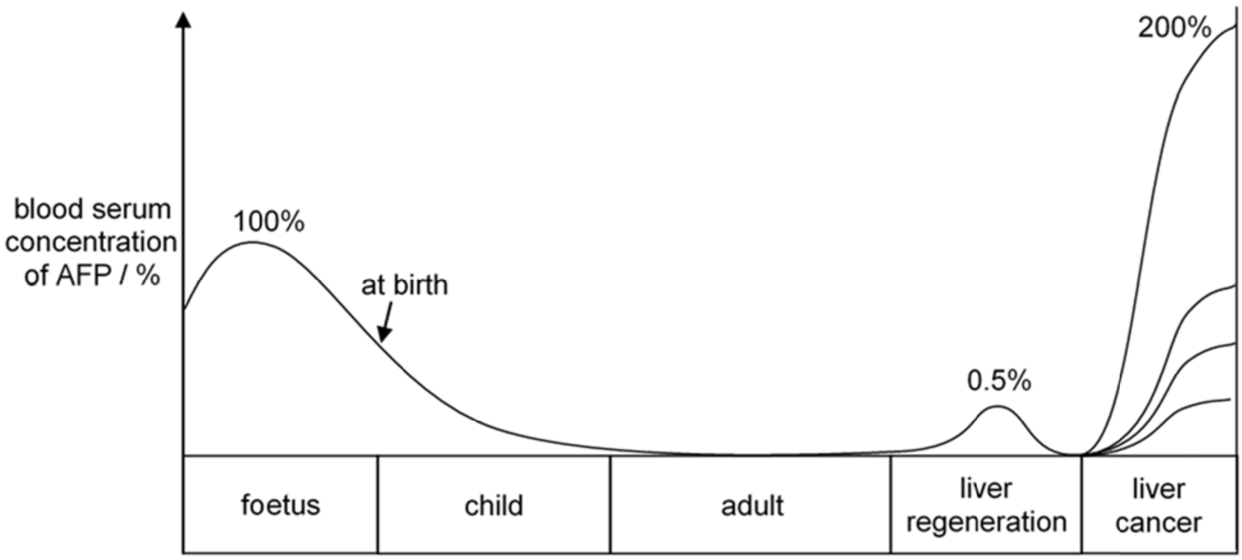

Fig. 4.1

(a) DNA exists in two forms, euchromatin and heterochromatin.

(i) State whether the *AFP* gene is found in the euchromatic or heterochromatic region in the nucleus of a foetal cell.
[1]

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(ii) Explain your answer in **(a)(i)**. [3]

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Upon birth, levels of cellular *AFP* mRNA and proteins decrease significantly eventually resulting in an absence of blood serum AFP in normal adult life.

(b) **(i)** Explain how chromatin remodelling can lead to a significant decrease in cellular *AFP* mRNA upon birth. [2]

(ii) Explain how cellular AFP proteins declines in the absence of *AFP* mRNA. [2]

(c) State one limitation of using AFP as a biomarker in the detection of liver cancer. [1]

[Total: 9]

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BOOKLET III (SECTION A CONTINUED)

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QUESTION 5

In a variety of cucumber plant, heart-shaped leaves (**h**) are recessive to normal leaves (**H**) and having many fruit spines (**f**) is recessive to having few fruit spines (**F**). Fig. 5.1 shows the chromosomes from this variety of cucumber plant with structures **P** and **Q** labelled.

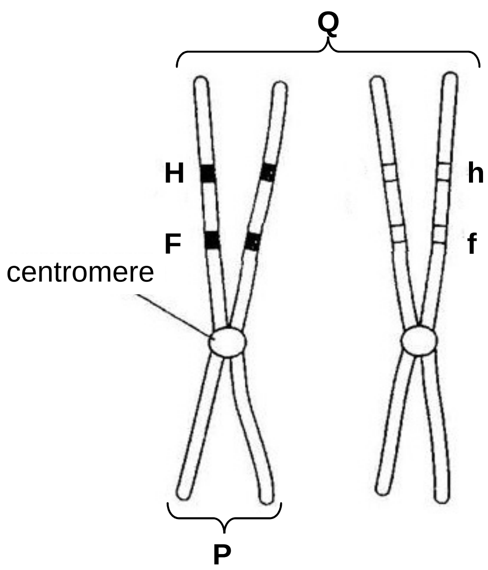

Fig. 5.1

(a) Describe how structures **P** differ from structures **Q**. [2]

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A farmer collected two cucumber plants, **A** and **B**, which were produced from crosses between different pure-breeding plants in his garden. Both have normal leaves and fruits with few spines. He conducted a test cross on each plant. Table 5.1 shows the results of these crosses.

Table 5.1

phenotype	observed numbers	
	plant **A**	plant **B**
heart-shaped leaves and many spines	122	2
normal-shaped leaves and many spines	6	82
heart-shaped leaves and few spines	4	85
normal-shaped leaves and few spines	124	4

(b) **(i)** Draw a genetic diagram to explain the results of the test cross for plant **B**. [4]

(ii) Account for the different test cross results obtained from plants **A** and **B**. [2]

(c) **(i)** Explain how the distance between two linked genes on a chromosome can affect the products of meiosis. [2]

(ii) Given that the loci for leaf shape and number of spines in plant **A** are 32.6 map units apart, complete Table 5.2 to show the expected proportions of progeny in each phenotype. [1]

The distance between two loci on a chromosome can be calculated by the using the following formula:

[Total number of recombinants / Total number of progeny] x 100 %

Table 5.2

phenotype	expected proportion / %
heart-shaped leaves and many spines	
normal-shaped leaves and many spines	
heart-shaped leaves and few spines	
normal-shaped leaves and few spines	

(iii) Suggest why the observed numbers recorded for plant **A** in Table 5.1 do not exactly match the expected proportions. [1]

[Total: 12]

QUESTION 6

Studies were carried out on soil-dwelling aerobic and anaerobic bacteria. Samples were taken from different depths at intervals of one month and six months after the soil was put into a large heap for storage.

Table 6.1 shows the numbers of aerobic and anaerobic bacteria at different depths in the stored soil.

Table 6.1

depth in soil store / m	mean number of bacteria per gram of stored soil $\times 10^7$			
	aerobic bacteria		anaerobic bacteria	
	after one month	after six months	after one month	after six months
0.0	12.4	12.5	0.4	0.6
0.5	10.1	8.3	0.6	1.0
1.0	9.8	5.9	0.8	3.8
1.5	9.7	3.1	0.8	7.6
2.0	10.5	0.8	0.7	8.1
2.5	10.8	0.7	0.8	8.5
3.0	10.2	0.9	0.6	8.8

(a) **(i)** Account for the trends shown by the distribution of the two types of bacteria after six months. [3]

(ii) Describe how aerobic bacteria are structurally adapted for cellular respiration. [2]

In a further study, soil samples were taken at two depths, **A** and **B**, in the soil store. The samples were taken at intervals over six years. Soil samples of equal mass were used to determine the activity of dehydrogenases in the Krebs cycle of the aerobic bacteria.

Fig. 6.1 shows the mean dehydrogenase activity of the bacteria in these samples.

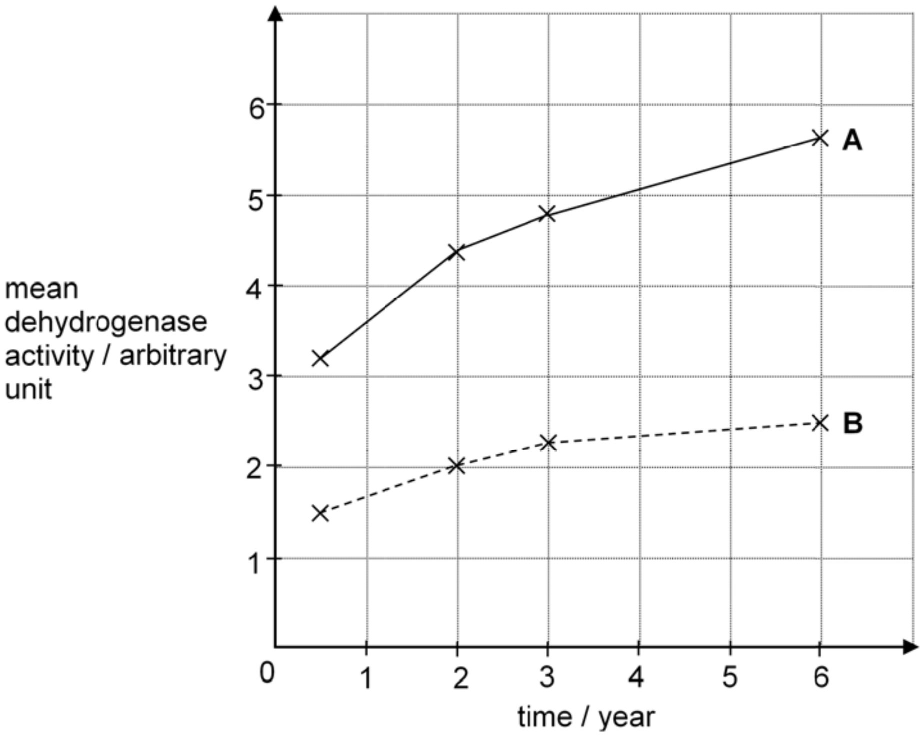

Fig. 6.1

(b) **(i)** State with evidence from Fig. 6.1 which depth, **A** or **B**, were samples taken from a greater depth.
[2]

(ii) Explain the roles of dehydrogenases in the Krebs cycle of aerobic bacteria. [2]

[Total: 9]

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BOOKLET IV (SECTION A CONTINUED)

QUESTION 7

The cell membrane and its associated proteins play an integral part in impulse transmission down a myelinated motor neurone.

(a) Describe the role of membranes in maintaining the resting membrane potential. [2]

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Muscarine is a natural product found in certain mushrooms such as the deadly *Clitocybe dealbata* and acts on neurones. Muscarine mimics the action of the neurotransmitter acetylcholine by binding to muscarinic M1 receptors.

Fig. 7.1 shows the signalling pathway of muscarine via the muscarinic M1 receptor.

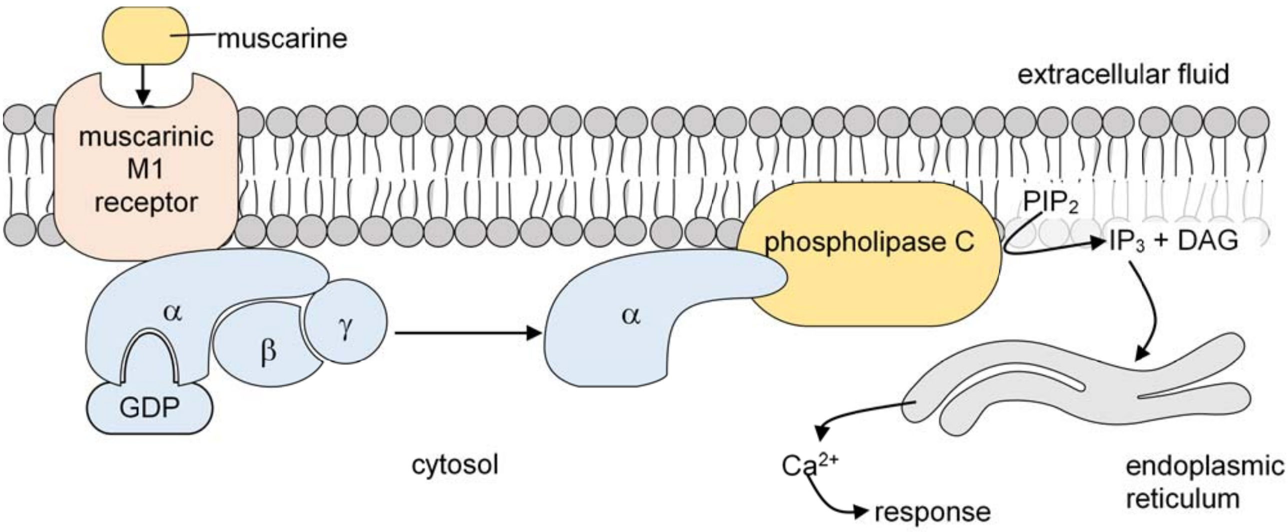

Fig. 7.1

(b) **(i)** State the site of action of muscarine. [1]

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(ii) Describe how muscarine changes the resting membrane potential when it binds to the muscarinic M1 receptor. [2]

Fig. 7.2 shows the effect of addition of muscarine at time **X** on a neurone's membrane potential. Activity of the neurone is measured by the occurrence of peaks such as that seen at time **Y**.

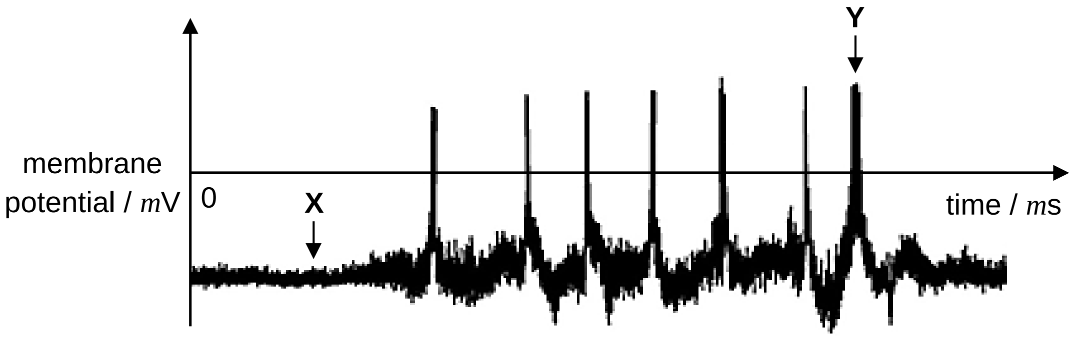

Fig. 7.2

(c) **(i)** Explain how ion channels cause a change in membrane potential after **Y**. [2]

(ii) Explain how the graph in Fig. 7.2 would differ if acetylcholine was added together with muscarine at **X**. [3]

[Total: 10]

QUESTION 8

A long-term breeding experiment to investigate the genetic basis of tame (friendly) behaviour was carried out in a population of silver foxes. The foxes were bred each year and the resulting young foxes assessed each month between the ages of one and eight months to see how tame they were.

Table 8.1 shows how the foxes were put into categories according to their tameness.

Table 8.1

tameness class	description of behaviour towards human
3	Not tame – these foxes run away from humans or bite when handled
2	Neutral – these foxes allow handling by humans but show no emotionally friendly response
1	Tame – these foxes are friendly to humans. They wag their tails and whine for attention.
elite	Very tame – these foxes are eager for human contact. They whimper to attract attention and sniff and lick humans.

The tamest 5% of the male foxes and the 20% tamest of the female foxes in each generation were used for breeding to produce the next generation. This was repeated over forty generations.

(a) **(i)** State the name given to the process in which only a certain percentage of adult foxes were chosen by humans to breed in each generation. [1]

(ii) Compare the process in **(a)(i)** and natural selection. [2]

(iii) Suggest why 20% of the female foxes were used for breeding but only 5% of the male foxes. [1]

Table 8.2 shows the number of foxes in the elite tameness class during the long-term experiment.

Table 8.2

number of generations	foxes in elite class / %
10	18
20	35
35	75

(b) Explain how the percentage of foxes in elite class increases with increasing number of generations as shown in Table 8.2. [3]

Similar changes in tameness, colour and body shape are believed to have occurred in the 11 000 year period during which the grey wolf species, *Canis lupus*, evolved into the domesticated dog species, *Canis familiaris.*

(c) Suggest how two different types of reproductive isolating mechanisms allowed dogs to evolve separately from wolves.
[2]

In the past, some scientists hypothesised that the golden jackal is more closely related to the domesticated dog than the grey wolf. Fig. 8.1 shows a segment of homologous DNA sequences from the golden jackal, coyote, grey wolf and dog.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
golden jackal	A	G	C	T	G	T	C	G	A	T	T	C	C	A
coyote	A	G	C	T	A	T	G	G	A	A	T	C	G	A
grey wolf	T	G	C	T	A	T	G	G	A	T	T	C	C	T
dog	T	G	G	T	A	T	G	G	A	T	T	C	C	A

Fig 8.1

(d) Justify if the hypothesis that the golden jackal is more closely related to the domesticated dog than the grey wolf is correct.
[2]

[Total: 11]

--- End of Section A ---

SECTION B: FREE RESPONSE QUESTION

Answer **one** question.

BEGIN EACH PART ON A FRESH SHEET OF WRITING PAPER.

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

Your answer must be in continuous prose, where appropriate.

You answer must be set out in parts **(a)**, **(b)** etc., as indicated in the question

A **NIL RETURN** is required for any parts not answered.

QUESTION 9

(a) Describe the structure of a bacterial chromosome. [6]

(b) Explain the significance of genetic exchange in bacteria. [6]

(c) Outline the differences between prokaryotic control of gene expression with the eukaryotic model. [8]

[Total: 20]

QUESTION 10

(a) Describe the homeostatic regulation of blood glucose concentration. [8]

(b) Outline the differences between a named proto-oncogene and a named tumour suppressor gene in their contribution to cancer. [8]

(c) Explain the advantages of having a cell signalling system in multicellular organism. [4]

[Total: 20]

--- End of Section B ---

--- End of Paper ---