HWA CHONG INSTITUTION
JC2 Preliminary Examinations
Higher 2

CANDIDATE NAME		**CT GROUP**	**16S7 ___**

CENTRE NUMBER					**INDEX NUMBER**				

BIOLOGY

9744/03

Paper 3 Long Structured and Free-response Questions

13 September 2017

No Additional Materials are required.

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 your **name** and **CT group** on the lines provided at the top of the cover page of Booklets **II, III and IV**.

SECTION A

This section contains **three** structured questions. Answer **all** parts in the spaces provided on the question paper.

SECTION B

This section contains **two** free-response questions. Answer **any one** question. Your answer must be in continuous prose, where appropriate.

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	**/ 25**
2	**/ 10**
3	**/ 15**
4 or **5**	**/ 25**
Final Mark	**/ 75**

This document consists of **19** printed pages and **5** blank pages.

BOOKLET I

SECTION A

QUESTION 1

Plants harvest light energy from the sun for photosynthesis, producing biomass that is used as food. Such biomass can also be used as 'biofuels', which include wood, ethanol, biodiesel and biogas. Biofuels offer plant-based solutions to the Earth's growing energy problems.

Oats and wheat, commonly grown in temperate regions, are C3 plants. Most plants are C3 plants and are so-called because their first photosynthetic product is a three carbon compound.

Corn, sorghum and sugarcane are C4 plants. They are common food crops of tropical regions.

The enzyme ribulose bisphosphate carboxylase oxygenase (rubisco) catalyses the fixation of carbon dioxide in the Calvin cycle and is used by both C3 and C4 plants. Each molecule of rubisco is made up of eight large polypeptides and eight small polypeptides. Fig. 1.1 shows a side view of the molecule.

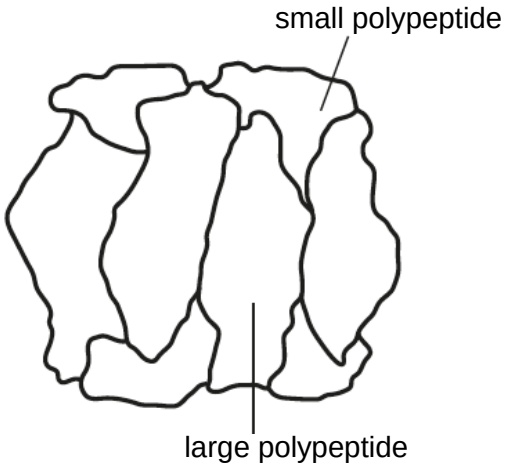

Fig. 1.1

(a) (i) State why rubisco is said to have quaternary structure.

.....

..... [1]

(ii) Explain what makes a molecule such as rubisco soluble.

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..... [2]

(b) In the absence of light, rubisco changes shape from an active form to an inactive form.

Explain why rubisco does **not** need to be in an active form in the absence of light.

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..... [3]

(c) The active sites of rubisco accept ribulose bisphosphate (RuBP) and **either** carbon dioxide **or** oxygen and can catalyse the two reactions shown:

either

RuBP + CO_2 → unstable intermediate compound → 2GP (PGA)

or

RuBP + $2O_2$ → unstable intermediate compound → GP (PGA) + $2CO_2$

Explain the consequences to the plant of the reaction involving oxygen.

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..... [3]

Fig. 1.2 shows the temperatures and carbon dioxide concentrations at which growth of C3 or C4 plants are favoured, based on the yield of photosynthesis.

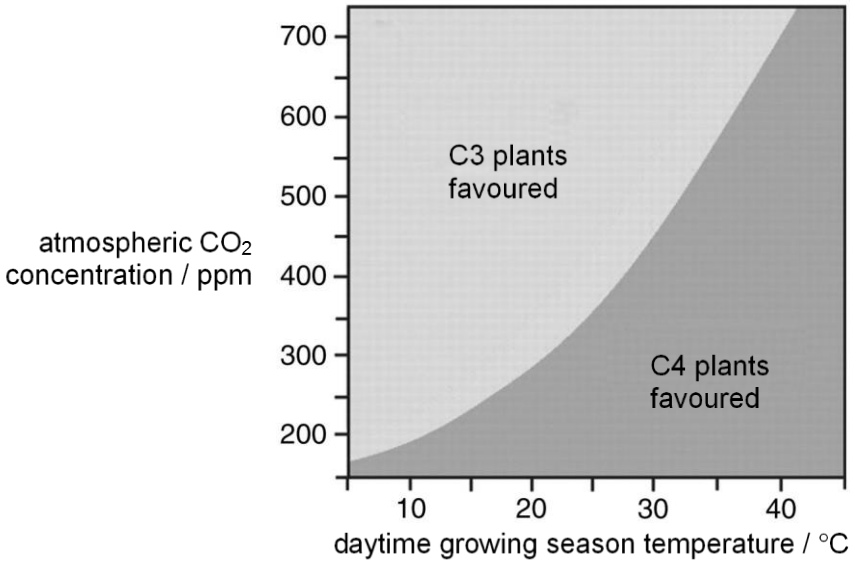

Fig. 1.2

The annual mean carbon dioxide concentration measured at Mauna Loa Baseline Atmospheric Observatory, Hawaii, has increased over the last 50 years to 404.21 ppm in 2016.

(d) With reference to Fig. 1.2, predict whether C3 or C4 plants are favoured in the context of global warming in the tropics. Explain how these plants are better adapted physiologically.

[5]

Biofuels have been around as long as cars have. At the start of the 20th century, Henry Ford planned to fuel his Model Ts with ethanol, and early diesel engines were shown to run on peanut oil.

Discoveries of huge petroleum deposits kept petrol and diesel cheap for decades, however, and biofuels were largely forgotten. With the recent rise in oil prices, along with growing concern about global warming caused by carbon dioxide emissions, biofuels have been regaining popularity.

Corn is a crop grown in the 'Corn Belt' of the United States Midwest for food and biofuel.

Fig. 1.3 shows the industrial process of manufacturing ethanol from corn starch. Ethanol can be mixed with petrol to make gasohol.

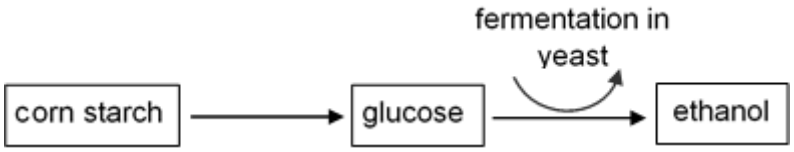

Fig. 1.3

(e) (i) Describe how yeast converts glucose to ethanol.

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..... [2]

(ii) Explain why it may be better in the long term to use ethanol made from corn starch, rather than petrol, as a fuel for cars.

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..... [2]

Transport in Britain accounted for 21% of all greenhouse gas emissions in 2007. In order to reduce greenhouse gas emissions, the UK Government has set a target of 10% of transport energy to come from sustainable sources by 2020. Biofuels, including biodiesel, are expected to provide a significant part of this 10%.

Reliance on biofuels is controversial for the following reasons:

- Some carbon dioxide is still released because energy is used during the production (cultivation, harvesting, processing) and distribution of biofuels.
- Large areas of land may need to be taken out of food production to grow the crops. It is estimated that all such land in the UK would only meet about 10% of its total diesel needs.
- The change in land use, such as from tropical rainforest to palm plantation, may release large amounts of carbon dioxide.

Table 1.1 is an assessment of the carbon dioxide released during the cultivation, processing and distribution of plant-derived biodiesel as well as the annual emissions from any change of land use, assuming these are spread over 20 years. In Britain all diesel, now must include 3.3% biodiesel. As Table 1.1 shows, there is a wide range of sources.

Table 1.1

crop	country	grams carbon dioxide equivalent released / MJ biodiesel produced			
		emissions due to change of land use			emissions from cultivation, processing and distribution
		existing crop land	grassland	forest	
oilseed rape	UK	0	154	583	79
soy	Brazil	0	683	2466	71
soy	USA	0	122	1127	53
palm	Indonesia	0	127	224	41
palm	Malaysia	0	57	176	41

(f) (i) With reference to Table 1.1, suggest the source of biodiesel chosen by an oil company if reduction of greenhouse gas emissions were the sole criterion.

.....[1]

(ii) Explain your answer to **(f)(i)**.

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.....[2]

(g) Identify **two** criteria, apart from cost, that should also be considered in choosing a source of biodiesel. Explain the significance of each criterion.

[4]

[Total: 25]

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BOOKLET II

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QUESTION 2

Li-Fraumeni syndrome is a rare disorder that greatly increases the risk of developing several types of cancer, particularly in children and young adults.

In a pedigree study by a genetic counsellor, it was suggested that Li-Fraumeni syndrome runs in Jane's family. Jane provided a sample of blood to conduct DNA analysis on the *p53* gene. Fig. 2.1 shows her DNA with *p53* gene amplified using PCR and digested with a restriction endonuclease at the mutated site.

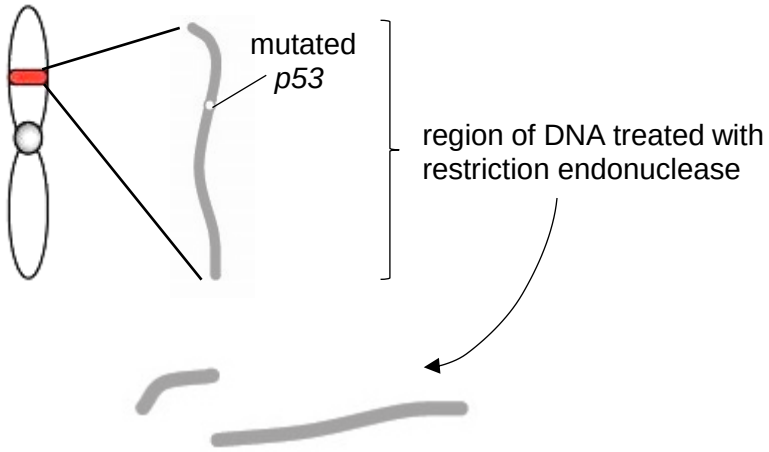
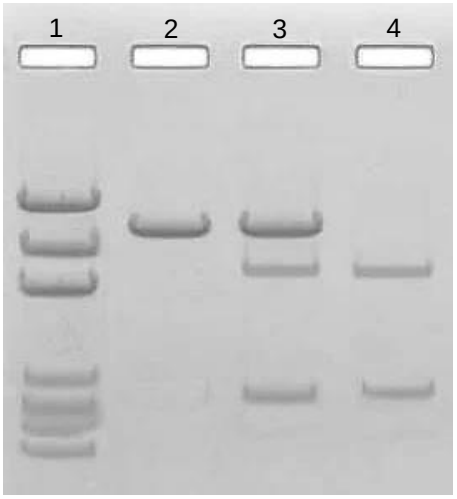


Fig. 2.1

The pre-digested samples were separated by gel electrophoresis and stained. Fig. 2.2 shows the DNA profiles obtained from an unrelated normal individual, Jane and tumour tissue from a family member suffering from breast cancer.



Key
Lane 1: DNA markers
Lane 2: Unrelated normal individual
Lane 3: Jane
Lane 4: Jane's family member with cancer

Fig. 2.2

(a) Outline how gel electrophoresis separates DNA fragments.

[4]

(b) With reference to Fig. 2.1 and 2.2, explain the DNA profile of Jane.

[3]

(c) With reference to development of cancer as a multi-step process, describe how Jane might develop breast cancer.

[3]

[Total: 10]

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BOOKLET III

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QUESTION 3

The total number of antibody specificities available to an individual is known as the antibody repertoire. In humans, the antibody repertoire is at least 10^{11}.

Fig. 3.1 is a schematic diagram of the production of a heavy chain polypeptide for an antibody. At the top is the chromosomal arrangement found in an immature B cell, at the bottom is shown the heavy chain polypeptide.

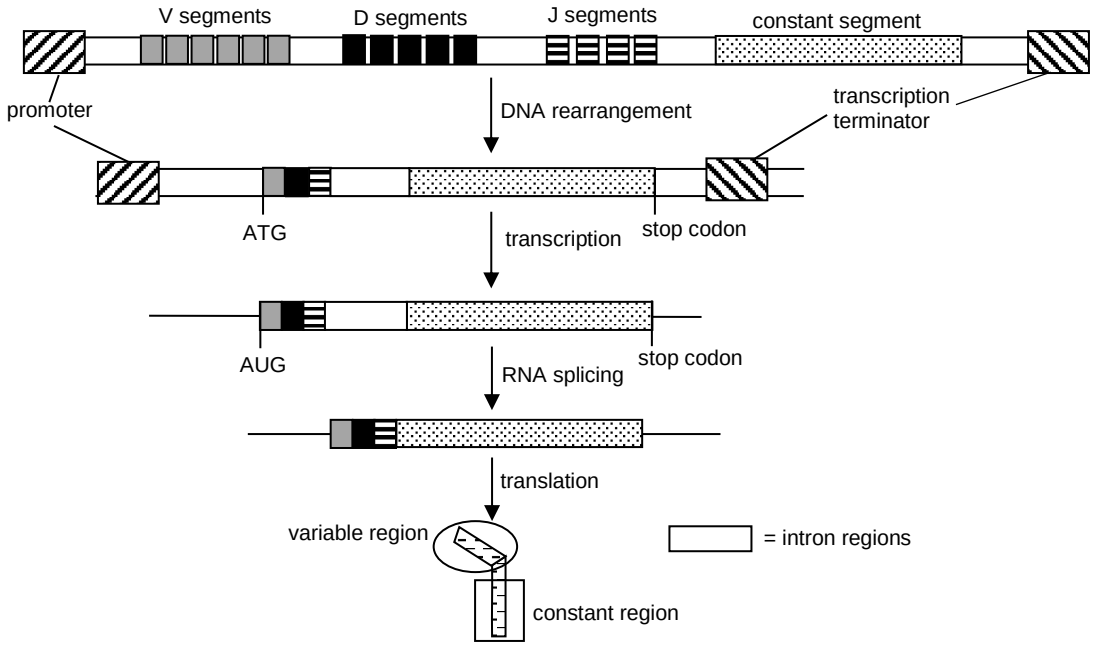

Fig. 3.1

(a) With reference to Fig. 3.1, explain how somatic recombination during B cell development results in the formation of millions of different antibody molecules.

[4]

Whooping cough is a disease that is particularly serious in young children. Whooping cough is caused by the bacterium *Bordetella pertussis*. Children may be vaccinated against whooping cough.

In an investigation, a group of rats was vaccinated. Sixty days later, these rats were infected with *B. pertussis*. In this investigation, the levels of antibodies raised against antigen X and antigen Y in the blood of the rats were measured. Fig. 3.2 shows the mean levels of anti-X antibodies and anti-Y antibodies.

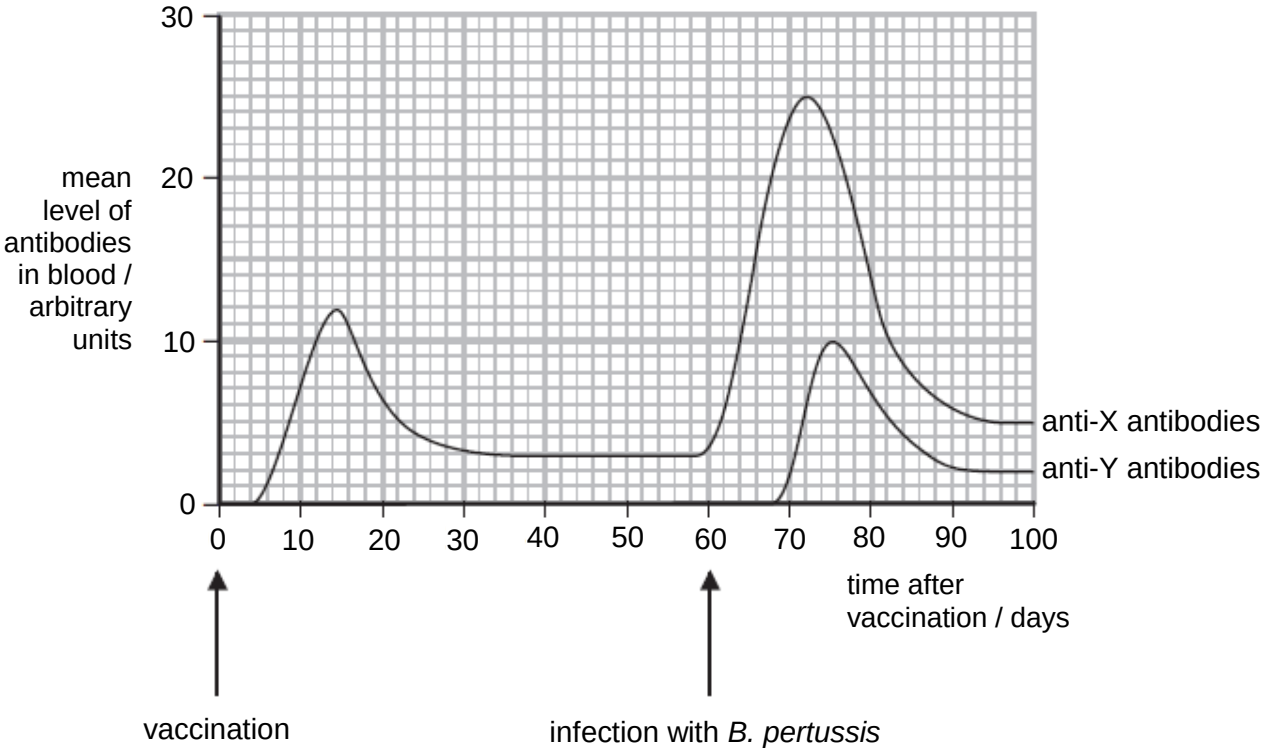

Fig. 3.2

(b) (i) Compare the increase in mean level of anti-X antibodies after vaccination and after infection with *B. pertussis*.

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..... [2]

(ii) Explain the changes in mean level of anti-X antibodies after infection with *B. pertussis*.

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..... [2]

(c) (i) Suggest why anti-Y antibodies were not present in the blood of these rats until after infection with *B. pertussis*.

.....

..... [1]

(ii) Place a tick in the box next to the term that describes the type of immunity that results in the production of anti-Y antibodies. [1]

- ☐ artificial active
- ☐ artificial passive
- ☐ natural active
- ☐ natural passive

Early in the immune response to antigen X, B cells express immunoglobulin M (IgM). Later, in the response to the same antigen, class switching allows for the formation of IgG.

(d) Explain how class switching allows for formation of IgG.

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..... [3]

(e) Comment on the reliability of the data shown in Fig. 3.2.

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..... [2]

[Total: 15]

--- END OF SECTION A ---

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BOOKLET IV

4 or **5**

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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 answer must be in continuous prose, where appropriate.

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

QUESTION 4

(a) Describe and explain gene mutation and chromosomal aberration. Using a suitable named example, explain how chromosomal aberration can result in a diseased phenotype in humans. [13]

(b) The genotype of an organism is not always directly expressed in the phenotype. Gene expression and the resultant phenotype are often modified through the interaction between an individual's particular genotype and the environment.

Discuss how the genotype of an organism is linked to its phenotype and using suitable named examples, explain how the environment may affect the phenotype of an organism. [12]

[Total: 25]

QUESTION 5

(a) Using a named example each, describe and explain directional and disruptive selection. Suggest, with reasons, which of these two forms of natural selection might contribute to the emergence and subsequent development of a new species. [13]

(b) The fossil record reveals that the evolutionary history of life on Earth has been episodic, with long, relatively stable periods punctuated by brief, cataclysmic ones. During these upheavals, macroevolutionary events occur where new species are formed through adaptive radiation and others die out in great numbers through mass extinctions.

Discuss mechanisms that trigger adaptive radiation and mass extinctions, and explain how microevolution can be linked to these macroevolutionary events. [12]

[Total: 25]

--- END OF SECTION B ---

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