HWA CHONG INSTITUTION
JC2 Preliminary Examination
Higher 2

CANDIDATE NAME		**CT GROUP**	**12S7____**
CENTRE NUMBER		**INDEX NUMBER**	

BIOLOGY

9648 / 03

Paper 3 Applications Paper and Planning Question

23 September 2013

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

STRUCTURED QUESTIONS

Answer **all** three questions. Write your answers on the lines provided.

PLANNING QUESTION

Answer the question in booklet **IV**. Write your answers on the lines / in the spaces provided.

FREE RESPONSE QUESTION

Answer the 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.

INFORMATION FOR CANDIDATES

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

Calculators may be used.

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

For Examiners' Use	
Question	**Marks**
1	**/ 14**
2	**/ 12**
3	**/ 14**
4	**/ 12**
5	**/ 20**
Total	**/ 72**

BOOKLET I

STRUCTURED QUESTIONS

QUESTION 1

Tobacco plants are vulnerable to tobacco mosaic virus (TMV). It is a RNA virus, which upon infection leads to death. Scientists have used genetic engineering to overcome this problem by creating transgenic plants that are resistant to TMV. This technique involves the use of *Agrobacterium tumefaciens* (that naturally infects plant cells) and the Ti plasmid as shown in Fig. 1.1. These transgenic plants can express the viral gene coding for TMV coat protein. The coat protein will provoke a response from the plants, resulting in resistance to TMV.

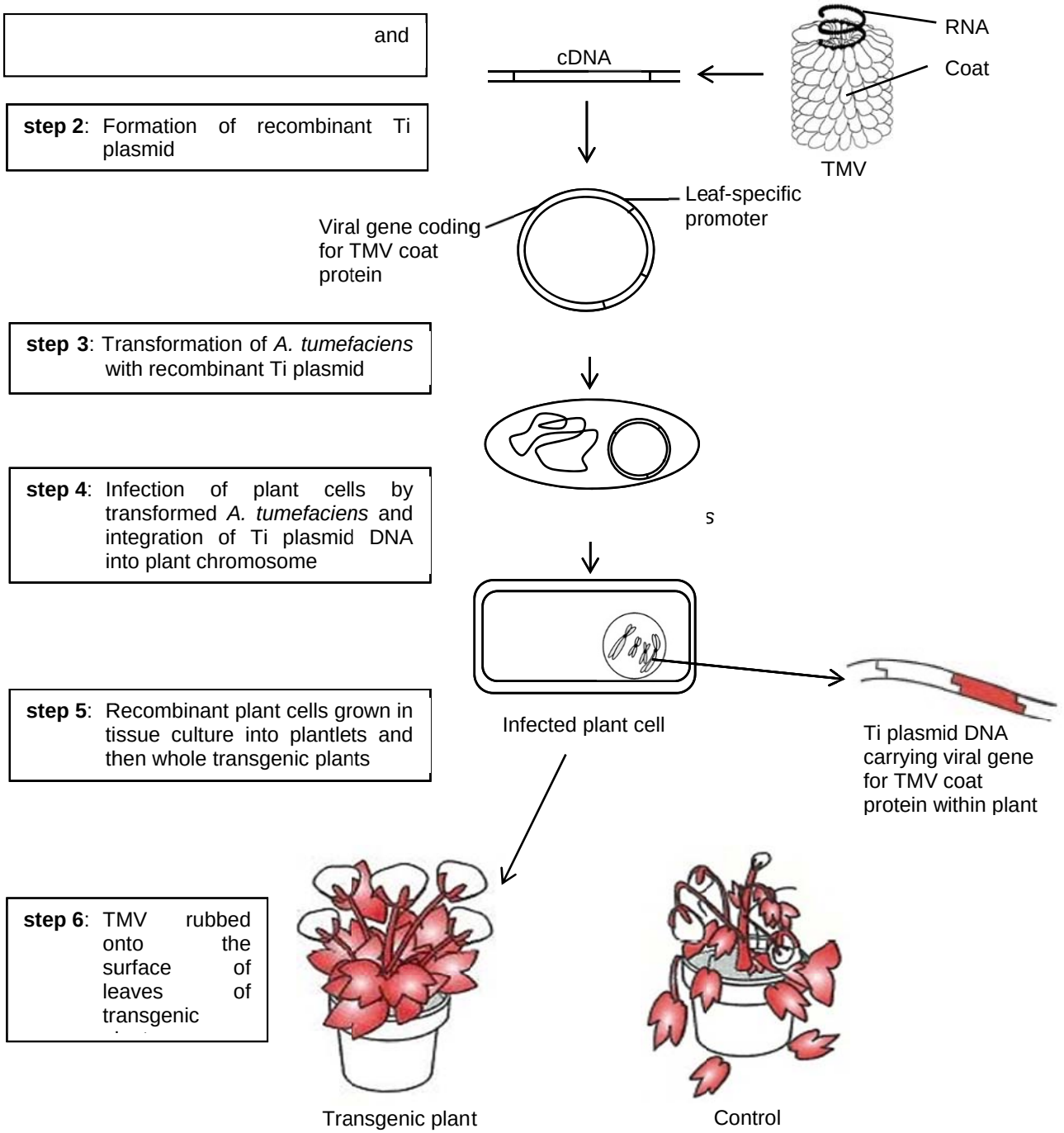

Fig. 1.1

(a) Outline how the isolated viral RNA can be converted into a double-stranded cDNA in **step 1**. [2]

(b) **(i)** Explain how the recombinant Ti plasmid in **step 2** can be formed. [3]

(ii) Explain the purpose of having a leaf-specific promoter in the recombinant Ti plasmid formed in **step 2**. [2]

One important role of *A. tumefaciens* is to infect plant cells to facilitate the integration of Ti plasmid DNA into plant chromosomes in **step 4**.

(c) Suggest another important role of *A. tumefaciens* in the process of creating transgenic plants which are resistant to TMV.
[1]

Recombinant plant cells are grown using tissue culture into plantlets and then whole transgenic plants in **step 5**. The initial stages involve growing the plant cells in growth media supplemented with different ingredients, such as inorganic nutrients, before a change of environment is required for the newly formed plantlets in the final stage.

(d) **(i)** Describe the functions of two other named ingredients in the growth media in the development of plant tissues. [4]

(ii) Explain the significance of the change of environment for the newly formed plantlets in the final stage of tissue culture. [2]

[Total: 14]

NAME: _____ CT GROUP: 12S7 ___

BOOKLET II

STRUCTURED QUESTIONS (continued)

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QUESTION 2

A couple's first child is affected by cystic fibrosis. As they are trying for a second child by *in vitro* fertilisation, they underwent genetic testing for the mutant *cystic fibrosis transmembrane conductance regulator* (*CFTR*) allele in three-day-old embryos.

(a) State what is meant by *genetic testing*. [1]

The *CFTR* alleles of each family member are amplified by polymerase chain reaction (PCR). Fig. 2.1 shows the results of gel electrophoresis performed on each DNA sample.

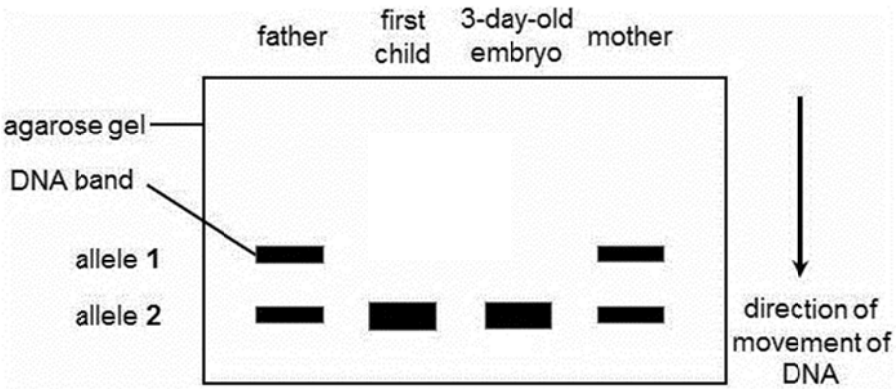

Fig. 2.1

(b) Using the information given in Fig. 2.1, explain why

(i) the three-day-old embryo will develop into a child affected by cystic fibrosis. [2]

(ii) the position of allele **2** on the agarose gel indicates that it contains a deletion in comparison with allele **1**. [2]

The couple's first child undergoes liposome-mediated gene therapy. Fig. 2.2 shows the normal *CFTR* alleles being transferred into his tracheal epithelial cells.

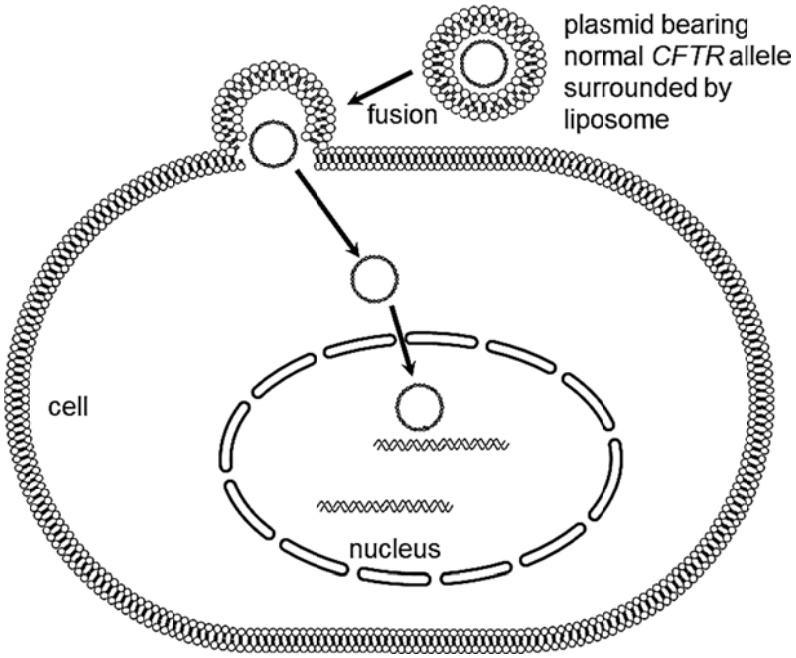

Fig. 2.2

(c) Suggest why the child cannot pass on the normal *CFTR* allele to his offspring. [1]

(d) State one limitation of liposome-mediated gene therapy and suggest one improvement to this limitation.

[2]

limitation:

improvement:

Linkage analysis using RFLP markers provided evidence for the existence of the *CFTR* locus on human chromosome 7. Fig. 2.3 shows the position of the *CFTR* locus in relation to RFLP markers. The asterix (*) indicates the position of a *Taq* I restriction site that can be lost by mutation.

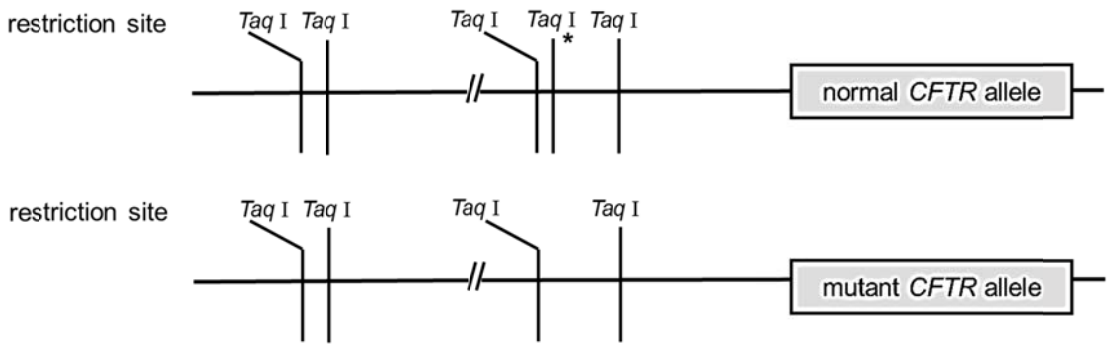

Fig. 2.3

(e) Describe how RFLP analysis facilitated linkage mapping of the *CFTR* gene on chromosome 7. [4]

[Total: 12]

NAME: _____ CT GROUP: 12S7 ___

BOOKLET III

STRUCTURED QUESTIONS (continued)

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QUESTION 3

A new class of RNA, called microRNA (miRNA), was discovered in 1993. These small RNA molecules have an important role in controlling the translation of mRNA. This type of control is called RNA interference.

Fig. 3.1 shows how miRNA is formed from a precursor RNA molecule that folds into a double-stranded hairpin structure. The hairpin is then processed to give a shorter molecule by the enzymes **Drosha** and **Dicer**. One strand of this short molecule attaches to **R**ISC proteins and the resulting complex binds to target mRNA molecule.

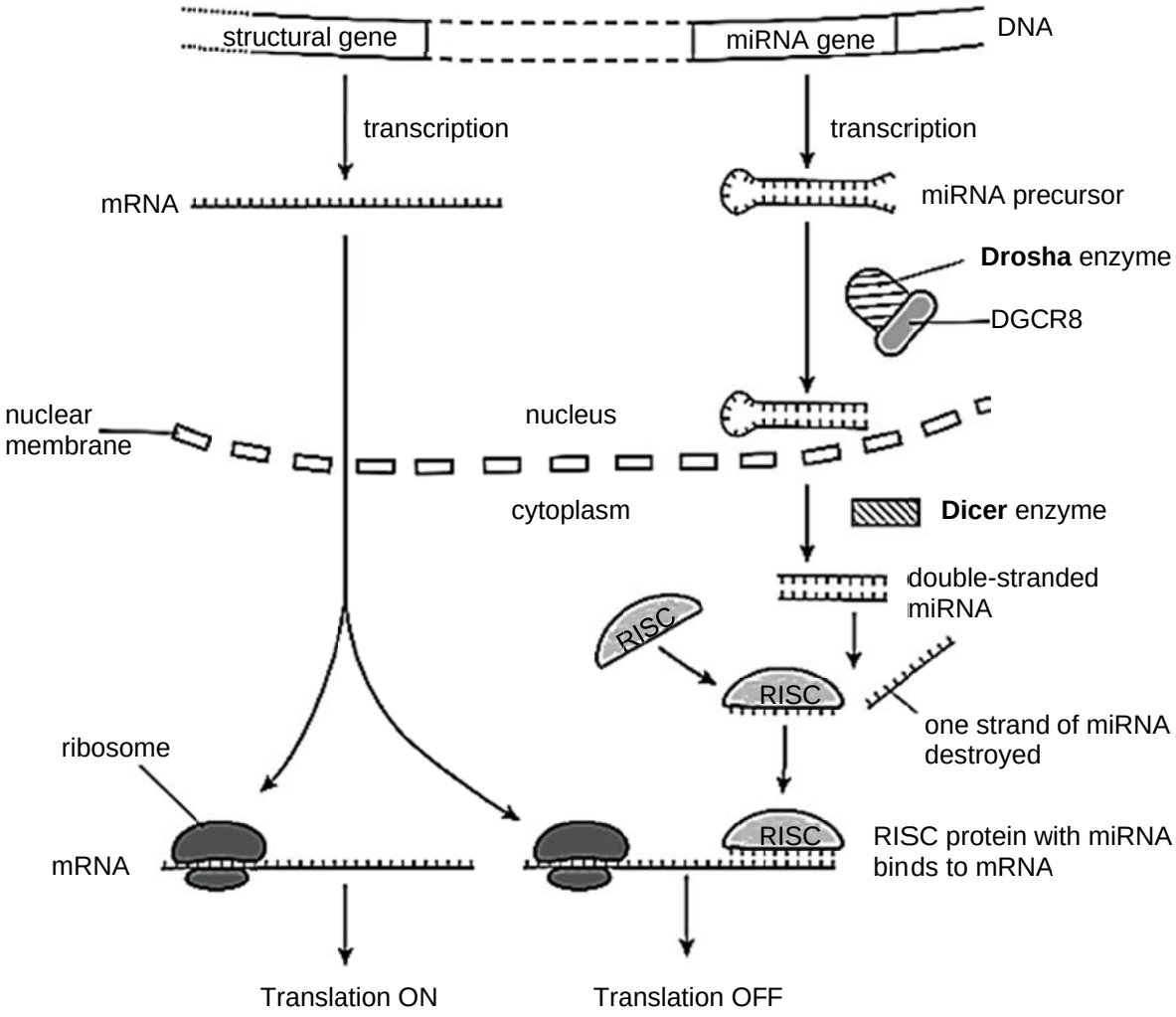

Fig. 3.1

(a) Describe how the expression of the miRNA gene controls the expression of the structural gene. [3]

(b) Researchers believe that cancer cells may have mutations in some of the miRNA genes. With reference to proto-oncogenes, suggest how these mutations may have contributed to the progression of cancer.
[2]

Recent research has investigated the importance of miRNA in controlling the fate of stem cells in adult organisms. To determine the role of miRNAs in these processes, stem cells were modified to "knock out" miRNA production. These miRNA knockout cells lack the protein DGCR8, an activator of **Drosha**.

(c) State a role of stem cells in an adult organism. [1]

(d) Describe how the knockout of DGCR8 affects RNA interference. [2]

In further work, the differentiation of knockout and normal cells was studied by inducing the stem cells to differentiate. Analysis was carried out on the levels of specific marker molecules whose presence is associated with either self-renewal or differentiation. Results are shown in Fig. 3.2.

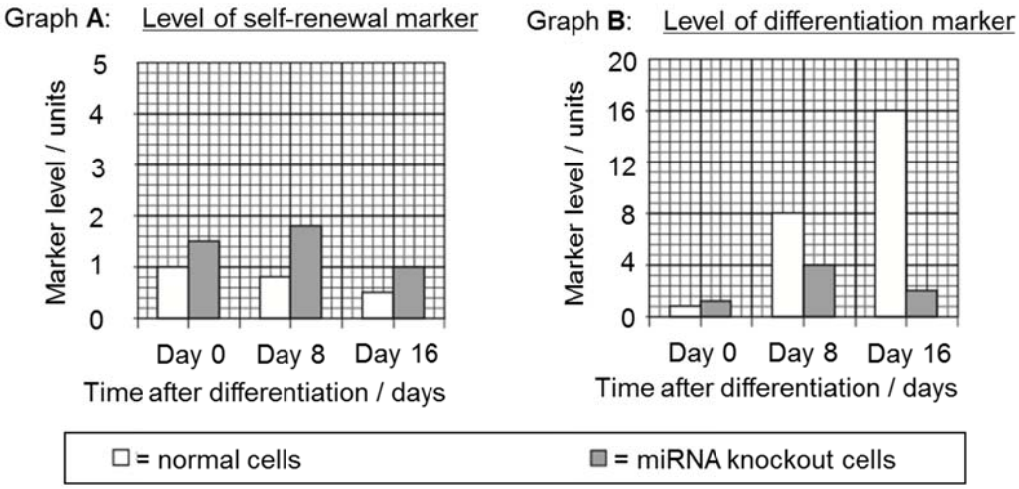

Fig. 3.2

(e) **(i)** Describe how self-renewal in stem cells allows for their proliferation and subsequent differentiation. [2]

(ii) Account for the results obtained. [4]

[Total: 14]

NAME: _____ **CT GROUP: 12S7** ___

BOOKLET IV

PLANNING QUESTION

QUESTION 4

The yield of many cultivated varieties of crop plants such as the onion, *Allium cepa*, is reduced by the presence of relatively high concentrations of salts, particularly sodium chloride, in the soil. There are, however, salt-tolerant varieties of onion, which can be grown successfully in such places. One possible explanation for this is that the fluid in the cell vacuoles of plants of the tolerant varieties differs in solute potential from that of non-tolerant varieties. To measure the solute potential of the cell vacuole, one can make use of the concept of incipient plasmolysis. Incipient plasmolysis is the point where 50 % of plant cells are plasmolysed. At incipient plasmolysis, the water potential of plant cells is equal to the solute potential as the pressure potential is zero.

Plan an investigation to find out whether or not the solute potentials of the cell vacuoles of epidermal cells of the bulbs of salt-tolerant onions differ from those of their non-tolerant counter parts.

You are provided with the following equipment. Choose your equipment from this list. You may **not** use any additional equipment.

- an unlimited supply of 1.0 mol dm^{-3} sodium chloride solution
- an unlimited supply of bulbs of two varieties of onion, one salt-tolerant and the other non-salt tolerant
- unlimited supply of distilled or deionized water
- beakers of various sizes
- glass specimen tubes
- microscopic slides and coverslips
- measuring cylinders of various sizes
- graduated pipettes of various sizes, and pipette fillers
- dropping pipettes
- light microscope with low (x100), medium (x200) and high (x400) magnification and built in illumination
- wash bottle
- marker pen
- stopwatch
- scalpel
- forceps
- glass rods for stirring
- mounted needles
- iodine in potassium iodide solution as a stain

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it,
- identify the independent and dependent variables,
- describe the method with the scientific reasoning used to decide the method so that results are as accurate and reliable as possible,
- include layout of results tables and graphs with clear headings and labels,
- use the correct technical and scientific terms,
- include reference to safety measures to minimise any risks associated with the proposed experiment.

[Total: 12]

FREE RESPONSE QUESTION

Your answers must be in continuous prose, where appropriate.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Write your answers in the writing paper provided.
BEGIN EACH PART ON A FRESH SHEET OF WRITING PAPER.
A **NIL RETURN** is required.

QUESTION 5

(a) Describe the polymerase chain reaction and explain one limitation of this procedure. [8]

(b) Explain the problems associated with the expression of eukaryotic genes in prokaryotes and how these problems are overcome. [6]

(c) Discuss the benefits and difficult ethical concerns of the human genome project for humans. [6]

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