

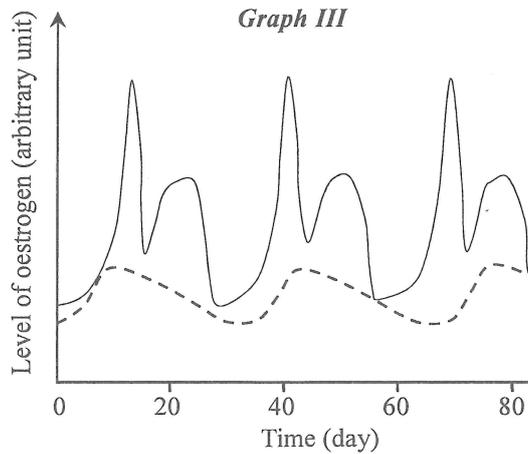
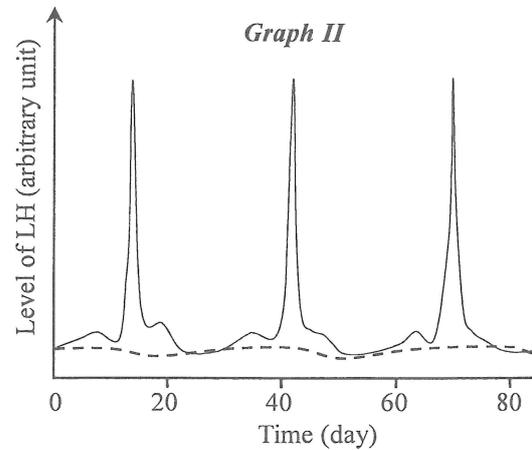
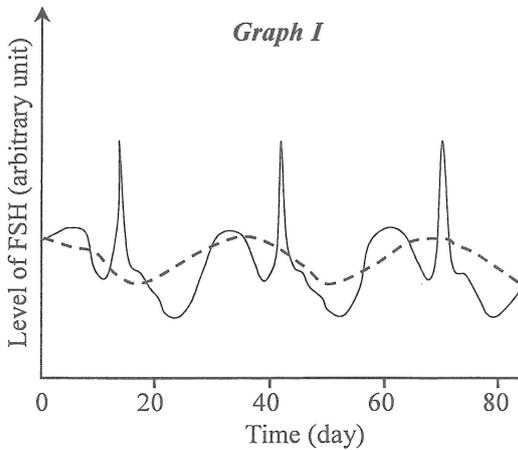
SECTION A Human Physiology: Regulation and Control

Answer ALL parts of the question.

1(a) A contraceptive pill contains a synthetic hormone X. The graphs below show the plasma levels of three hormones in a woman during normal menstrual cycles and those when she was taking the pill daily:

Graph I: follicle stimulating hormone (FSH)
 Graph II: luteinising hormone (LH)
 Graph III: oestrogen

Key:
 — hormone level during normal cycles
 - - - hormone level when taking the pill daily



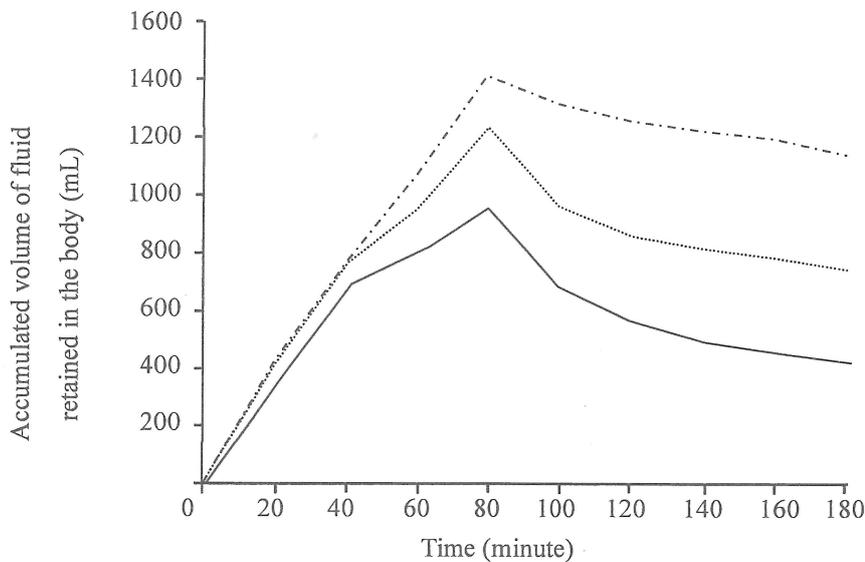
- (i) With reference to Graph I and Graph II, explain how this contraceptive pill works. (4 marks)
- (ii) The effect of this synthetic hormone X is similar to one of the female sex hormones. Which female sex hormone is it? Explain your answer. (2 marks)
- (iii) Another effect of taking this contraceptive pill is that the uterine lining becomes thinner. Explain why this phenomenon also contributes to contraception. (1 mark)
- (iv) With reference to Graph III, explain why the uterine lining became thinner when she was taking the pill daily. (2 marks)

- 1(b) In a study to compare the ability to stay hydrated after drinking different types of drinks, healthy participants were required to consume the same diet and undergo the same physical activities on the day before the experiment.

On the day of the experiment, they emptied their bladders and then sat quietly for 20 minutes. The participants were divided into three groups. Each consumed a different drink (water, sports drink with glycerol and sports drink with salt). 500 mL of the drink was consumed at 0, 20, 40 and 60 minutes while urine was collected every 20 minutes for 180 minutes. Throughout the experiment, the participants sat quietly in the laboratory and were exposed to the same settings of temperature and humidity. The change in the accumulated volume of fluid retained in the body are shown in the graph below:

Key:

- drinking water only
- drinking sports drink with glycerol
- . - . - . drinking sports drink with salt



- (i) In this experiment, the ability to stay hydrated is expressed in terms of the accumulated volume of fluid retained in the body after consuming the drinks. Give a word formula to show how to calculate the accumulated volume of fluid retained from the data collected. (1 mark)
- (ii) Explain the difference in the accumulated volume of fluid retained between the group which consumed water and the group which consumed the salt solution. (4 marks)
- (iii) The ability to stay hydrated is crucial for marathon runners because access to water is limited. Explain why retaining more water is advantageous to marathon runners. (3 marks)
- (iv) Suggest *two* modifications to the experiment to verify your answer in (iii). (2 marks)
- (v) Suggest another advantage marathon runners have when drinking sports drinks with glycerol. (1 mark)

SECTION B Applied Ecology

Answer **ALL** parts of the question.

2(a) Every year, migratory birds travel long distances between breeding grounds in the north and wintering grounds in the south. During their long journeys, wetlands along the coastal areas are important stopovers. Hong Kong is one of these stopovers.

(i) Yellow-breasted bunting, *Emberiza aureola*, is one of these migratory birds which visit Hong Kong during the winter. The following table shows the change in the conservation status of yellow-breasted bunting according to the International Union for Conservation of Nature:

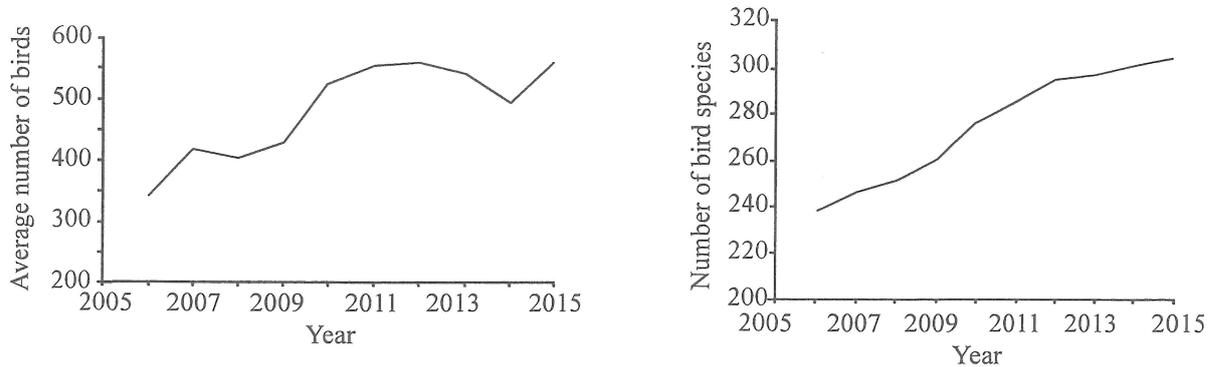
<i>Year</i>	<i>Conservation status</i>
2000	Least concern
2004	Near threatened
2008	Vulnerable
2013	Endangered
2017	Critically endangered

Explain **one** human activity that might have threatened the yellow-breasted bunting. (1 mark)

(ii) In 2005, the government and local green groups worked together to implement habitat management measures for the abandoned fresh water wetland in Long Valley (northern part of the New Territories). The photographs below show the habitats before and after the measures:

<i>Before the measures</i>	<i>After the measures</i>	
 Abandoned farmland	 Dry farmland	 Wet farmland
 Dried wetland	 Marsh	 Water flea pond
	 Lotus pond	 Fish pond

The graphs below show the average number of birds recorded and the number of bird species recorded annually from 2006 to 2015 in Long Valley:



- (1) Based on the data shown, what can you conclude about the effect of the habitat management on the conservation for migratory birds? (4 marks)
- (2) Explain why the habitat management is important in bringing about the changes shown in the graphs. (4 marks)

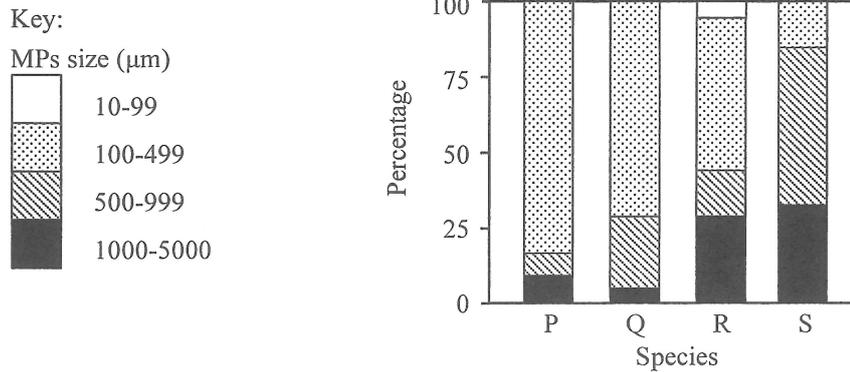
2(b) Microplastics (MPs) are small plastic pieces (less than five millimeters). They can be plastic debris resulting from the breakdown of large plastic wastes or microbeads in cosmetic and cleansing products. They can be harmful to aquatic environments. Scientists are looking for biological ways to monitor and solve MPs pollution.

- (i) Suggest why sessile (immovable) organisms are more suitable than movable organisms for use in monitoring MPs pollution in aquatic environments. (2 marks)
- (ii) The table below shows the occurrence of four species of sessile organisms which are commonly found in Hong Kong waters:

<i>Site</i>	<i>Habitat</i>	<i>Species</i>
1	Rocky shore	A
2	Rocky shore	A, B
3	Rocky shore	A, B
4	Rocky shore	A, C
5	Mudflat	C
6	Mudflat	C
7	Mudflat	D
8	Mudflat	D
9	Pier	C
10	Pier	C
11	Pier	D
12	Pier	D

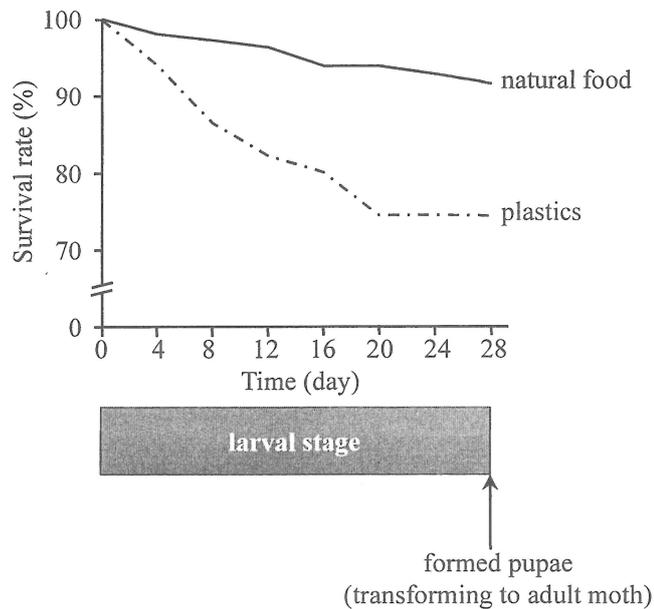
Based on the data in the table, which species should be chosen for monitoring MPs pollution? Explain your answer. (3 marks)

- (iii) The diagram below shows the relative portions of different sized MPs retained in the guts of four species of sessile organisms:



Based on the data shown in the diagram, which species (P, Q, R or S) should be used for monitoring MPs pollution? Explain your answer. (3 marks)

- (iv) The larvae of a certain species of wax moth (*Achroia grisella*) was found to be able to feed on and degrade plastics. In an investigation, two groups of *A. grisella* larvae were fed with plastics and natural food separately and their survival rates were recorded until the larvae formed pupae. The results are shown below:



- With reference to the data shown, do the data support that the larvae can obtain nutrients from plastics? Explain your answer with evidence. (1 mark)
- To study the feasibility of a large-scale application of *A. grisella* in treating plastic pollution, suggest another measurement for the investigation. Explain your answer. (2 marks)

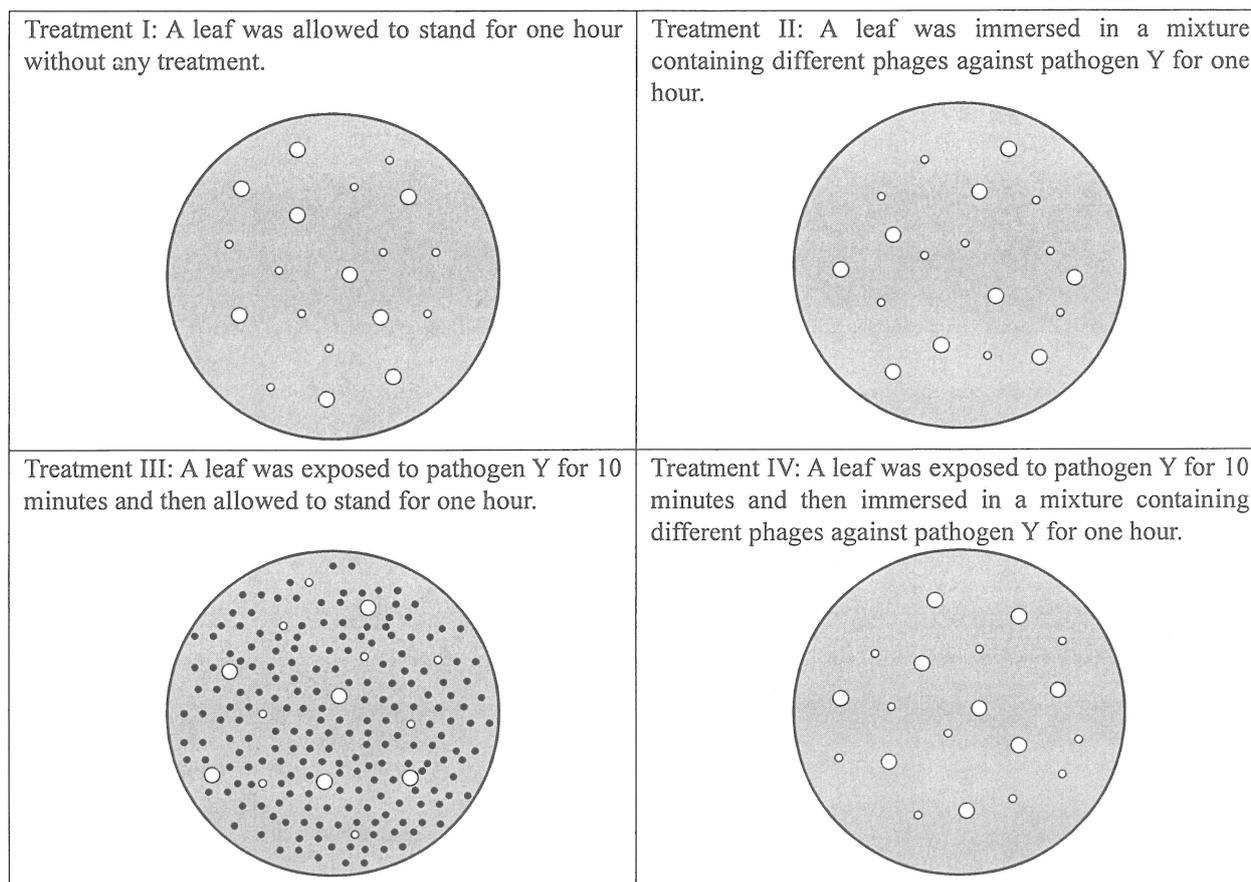
SECTION C Microorganisms and Humans

Answer **ALL** parts of the question.

3(a) An experiment was conducted to illustrate how bacteriophages can be used to fight against pathogenic bacteria. This phage therapy may be an alternative way to combat bacteria with multiple antibiotic resistance. In the experiment, leaf surfaces of a plant were subjected to different treatments. After that, bacterial samples were taken from the leaf surface and transferred to an agar plate for incubation. Colonies of bacterial pathogen Y in the agar plate would stain red. Below are the four different treatments and the results obtained:

Key:

- red colony
- white colony



(i) By comparing the results of the following pairs of treatment, what can be deduced? Tabulate your answer in the answer book according to the following format. (4 marks)

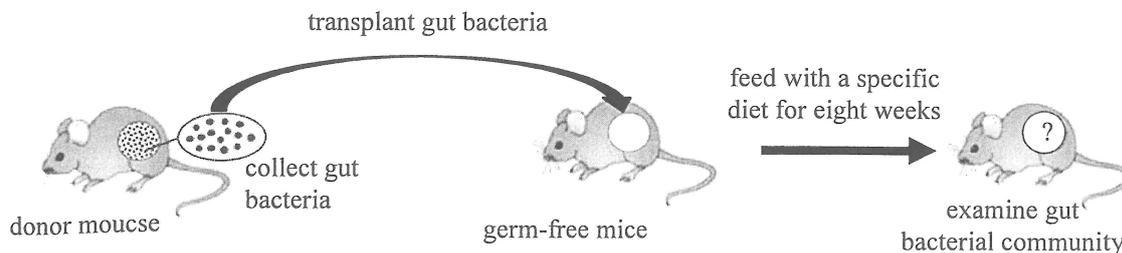
<i>Treatments</i>	<i>Comparison of results</i>	<i>Deduction</i>
I and II		
III and IV		

(ii) According to the results of the experiment, suggest the advantage of using phage therapy to treat bacterial infection over traditional antibiotic treatment. (2 marks)

(iii) Describe how the bacterial sample from the surface of the leaf can be obtained. (2 marks)

(iv) Describe *two* aseptic techniques that should be adopted during plate spreading in order to avoid contamination from the environment. (2 marks)

3(b) Recently, increasing evidence linking obesity to the gut bacterial community has been reported. To investigate the interrelationship between diet, gut bacterial community and energy balance, a group of germ-free mouse siblings received a transplant of gut bacterial community from a donor mouse, followed by a specific diet for eight weeks. After that, their gut bacterial communities were examined. The diagram below shows the workflow:



- (i) (1) Suggest why mouse siblings were used in the investigation. (1 mark)
- (2) Suggest and explain *two* experimental procedures which are necessary for producing germ-free mice. (2 marks)
- (ii) The following table shows a summary of the treatments and the results obtained:

	<i>Experimental group</i>	<i>Control group</i>
Diet of the donor mouse	Diet rich in plant polysaccharides	
Diet used to feed the recipient mice for eight weeks	High-fat and high-sugar diet	Diet rich in plant polysaccharides
Average body mass gained (g)	5.3	1.5
Average body fat (%)	3.7	1.7
Composition of gut bacterial community	<p>Key:</p> <p> </p>	

- (1) Which group of mice represented the obese group? (1 mark)
- (2) Describe how the high-fat and high-sugar diet has modified the composition of the gut bacterial community of the experimental group. (2 marks)
- (3) It is known that a certain group of the gut bacteria in the experimental group can convert some indigestible materials into fatty acids which are then absorbed by the mice. Which group of bacteria is likely to be capable of such conversion? Explain your answer. (2 marks)

- (iii) To test if the gut bacterial community induced by the 'high-fat high-sugar' diet increases nutrient absorption as stated in (ii)(3), another experiment was conducted as shown in the table below:

	<i>Experimental group</i>	<i>Control group</i>
Diet of the donor mouse	High-fat and high-sugar diet	Diet rich in plant polysaccharides
Diet used to feed the recipient mice for eight weeks	Diet rich in plant polysaccharides	

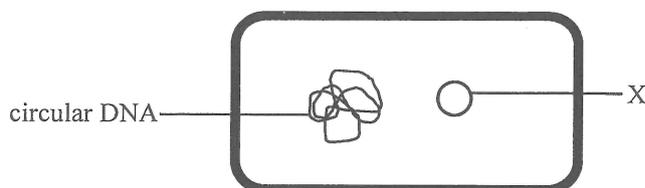
After eight weeks, the experimental group had an average body mass and body fat percentage which were significantly higher than the control group. What conclusion can be drawn? Explain your answer. (2 marks)

SECTION D Biotechnology

Answer ALL parts of the question.

- 4(a) Fish oil contains specific types of polyunsaturated fatty acids (PUFAs) which are beneficial to human health. A biotechnology company successfully isolated a key gene encoding the enzyme responsible for the production of PUFAs. Using agrobacterium, the foreign gene was transferred to three different seed crops (A, B and C).

- (i) The schematic diagram below shows the structures of an agrobacterium:



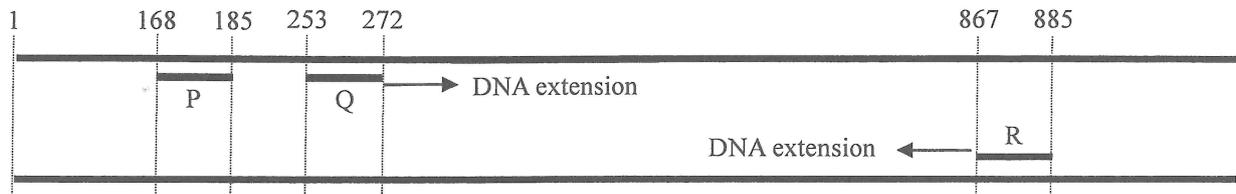
What is structure X? Describe the role of this structure in the transformation process. (2 marks)

- (ii) In a greenhouse trial, the following data were obtained for the three different types of genetically modified (GM) crops.

<i>GM crop</i>	<i>Seed yield (g per crop)</i>	<i>Content of PUFAs (arbitrary unit per g of seed)</i>	<i>Time required to reach seed harvest stage (month)</i>
GM-A	50	9	6
GM-B	150	3	3
GM-C	100	4	8

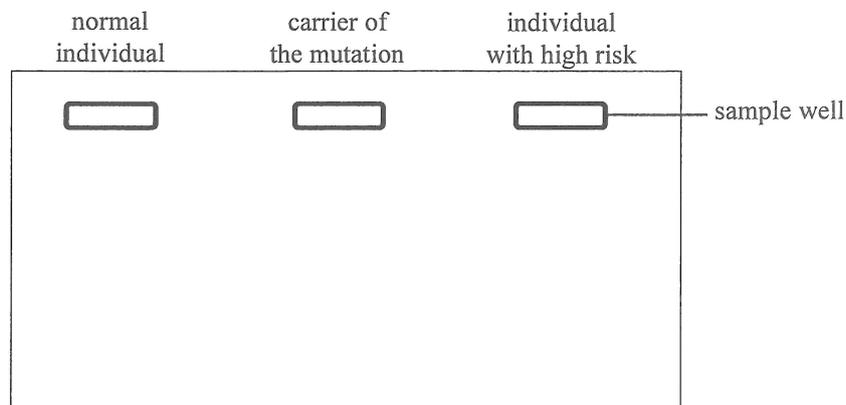
- (1) The three GM crops grow equally well. Based on the data shown, which one would you select for PUFAs production in the greenhouse? Show how you arrived at your answer. (3 marks)
- (2) Some people firmly believe that GM crops are not safe for consumption because they contain foreign genes which may have harmful effects on humans. How would you convince them that it is safe to consume PUFAs extracted from the GM seeds? (2 marks)
- (iii) The biotechnology company selected a suitable GM crop for PUFAs production in the field. However, an environmental group strongly opposed to the cultivation in the field because there was a wild relative of such GM crop near the proposed area.
- (1) What may be the major argument underlying the objection? (1 mark)
- (2) Briefly describe an experiment to test whether the argument mentioned above is correct. (3 marks)

- 4(b) A gene fragment in the human genome is shown in the diagram below. A mutation at position 285 (nucleotide number) of this gene fragment has been found in 0.05% Asians. This mutation destroys the cut site of a restriction enzyme. Individuals with two copies of such mutation have an increased risk of developing a certain lung cancer.

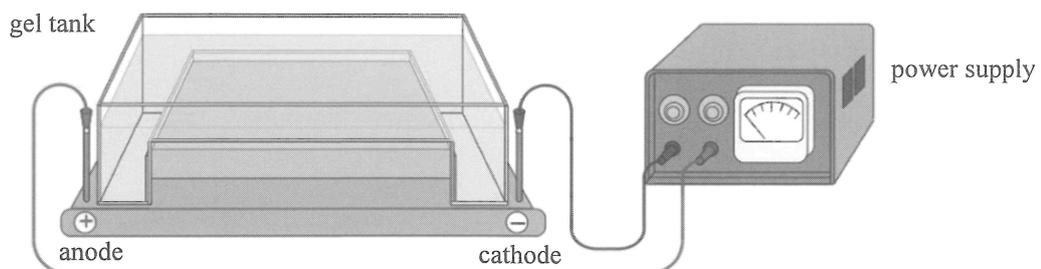


You were given three primers (P, Q and R) for polymerase chain reaction (PCR). The positions where they anneal are shown in the above diagram. With the help of gel electrophoresis, DNA samples obtained from individuals can be used to identify their genotypes for this gene.

- Using the above information, briefly describe how you can identify their genotypes and state clearly the purposes of methods used. (3 marks)
- Considering the annealing positions of the primers and the position of the mutation, explain which primer should *not* be used for this purpose. (1 mark)
- Copy the following diagram of agarose gel onto your answer book. Draw the DNA bands that would be produced by samples from the three types of individuals. (3 marks)



- The diagram below shows the equipment used to produce the results in (ii):



When the agarose gel is placed, on which side should the sample wells rest? Explain your answer. (2 marks)

END OF PAPER

Sources of materials used in this paper will be acknowledged in the *HKDSE Question Papers* booklet published by the Hong Kong Examinations and Assessment Authority at a later stage.