

HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY  
HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2022

**BIOLOGY PAPER 2**

11:45 am – 12:45 pm (1 hour)  
This paper must be answered in English

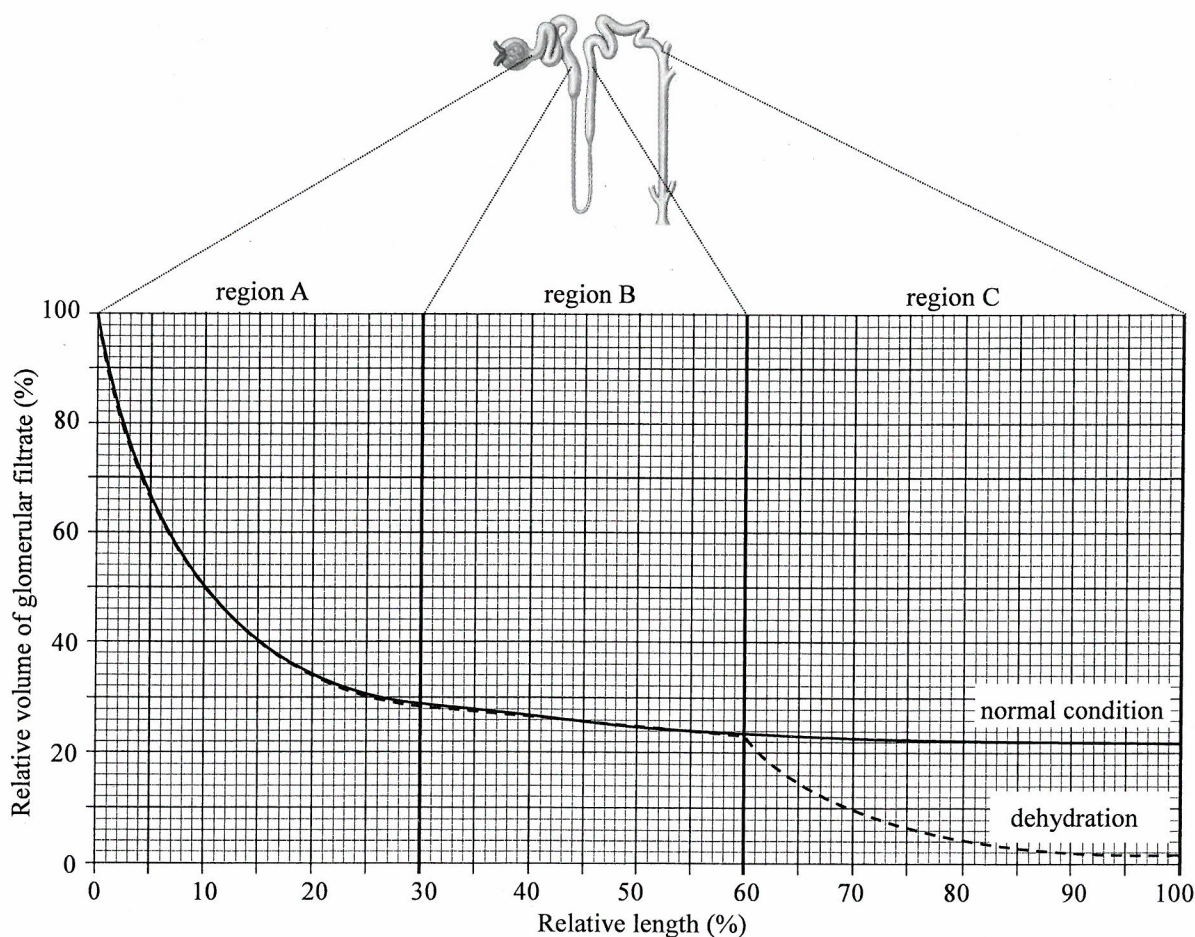
**INSTRUCTIONS**

- (1) There are **FOUR** sections, A, B, C and D in this Paper. Attempt **ALL** questions in any **TWO** sections.
- (2) Write your answers in the Answer Book DSE (C) provided. Start each question (not part of a question) on a new page.
- (3) Present your answers in paragraphs wherever appropriate.
- (4) Illustrate your answers with diagrams wherever appropriate.
- (5) The diagrams in this paper are **NOT** necessarily drawn to scale.

**SECTION A Human Physiology: Regulation and Control**

Answer ALL parts of the question.

1(a) The graph below shows the change in volume of the glomerular filtrate along different regions of the kidney tubule under normal and dehydrated conditions:



- (i) Describe how the glomerular filtrate is formed in the Bowman's capsule. (2 marks)
- (ii) With reference to the above graph, state the region of the kidney tubule in which most water is reabsorbed. (1 mark)
- (iii) If the average volume of the glomerular filtrate formed each day is 180 L, what is the volume of water reabsorbed daily in the region stated in (ii)? (1 mark)
- (iv) Explain how water is reabsorbed into the blood from the glomerular filtrate within the region stated in (ii). (3 marks)
- (v) With reference to the hormonal control of osmoregulation, explain the difference in the relative volume of the glomerular filtrate at the end of region C of the kidney tubule under the two different conditions mentioned above. (4 marks)

- 1(b) An experiment was conducted to investigate the respiratory responses during exercise in healthy persons and in patients with hardening of lung tissue. They were asked to ride a cycling machine set at the same resistance, holding a slow constant speed for ten minutes. Their breathing rates, breathing depths and plasma gas levels were continuously monitored throughout the experiment. The results are shown in the table below:

Time (min)	Breathing rate (breath min <sup>-1</sup> )		Breathing depth (L)		Plasma oxygen level (arbitrary unit)		Plasma carbon dioxide level (arbitrary unit)	
	Healthy persons	Patients	Healthy persons	Patients	Healthy persons	Patients	Healthy persons	Patients
0	14	20	0.9	0.7	82.5	75.8	42.5	42.0
2	16	29	1.8	1.0	83.9	70.2	43.2	42.4
4	18	35	2.2	1.1	84.0	67.1	43.3	43.5
6	19	37	2.3	1.2	84.3	63.2	43.8	43.6
8	20	40	2.4	1.2	84.3	62.0	43.9	43.7
10	20	44	2.4	1.2	84.3	60.5	43.9	43.7

- (i) State how the breathing depth of the patients was different from that of the healthy persons. (2 marks)
- (ii) Based on the condition of the patients, suggest an explanation for the difference stated in (i). (2 marks)
- (iii) With reference to the data shown, deduce with reasons which parameter, plasma oxygen level or plasma carbon dioxide level, was more significant in bringing about changes in the breathing rate of the patients after six minutes. (3 marks)
- (iv) With reference to the plasma gas levels, explain why patients would feel dizzy if the experiment continued for another ten minutes. (2 marks)

**SECTION B Applied Ecology**

Answer ALL parts of the question.

2(a) The major purpose of deforestation in the tropical rainforest is to turn it into a grassland for cattle farming.

(i) The table below shows the comparison of plant communities within a primary rainforest and a grassland formed after deforestation:

Type of plant community	Average plant height (m)	Number of plant species	* Percent coverage (%) of individual plant species	
			Primary rainforest	28
Species B	19			
Species C	12			
Species D	20			
Species E	14			
Grassland	0.3	3	Species H	95

\* Only species with at least 10% of coverage are included.

- (1) What would be the effect of converting a tropical rainforest to a grassland on the average plant height and number of plant species? (1 mark)
  - (2) For estimating the relative abundance of plant species in the above case, why was percent coverage a better measurement than the number of individual species? (1 mark)
  - (3) With reference to the percent coverage of individual plant species, what was the effect of deforestation on the composition of the plant community? (3 marks)
- (ii) Soil porosity (space between soil particles) was determined for soil samples collected from the rainforest and grassland. The soil samples were then incubated in the laboratory for 7 days. After that, the net changes in the amounts of ammonium content and inorganic nitrogen (i.e. nitrate and nitrite) were calculated. The results are shown in the table below:

Soil sample	Soil porosity (%)	Amount of ammonium (mg kg <sup>-1</sup> soil)	Amount of inorganic nitrogen (mg kg <sup>-1</sup> soil)
Primary rainforest	80	13	14
Grassland	60	7.3	9.8

- (1) Based on the information in the table, deduce the effect of deforestation on the oxygen level of the soil. (2 marks)
- (2) With reference to the nitrogen cycle and the answer in (1), answer the following questions:
  - (I) Explain the difference in the amount of ammonium between the samples taken from the primary rainforest and the grassland. (2 marks)
  - (II) Explain the difference in the amount of inorganic nitrogen between the samples taken from the primary rainforest and the grassland. (2 marks)

2(b) During World War II, much of the forests in Hong Kong had been cleared for firewood. After the war, the Government began to build new reservoirs and restore the existing ones. At that time, imported tree species were planted in areas around these reservoirs.

- (i) Explain why planting trees in the area nearby is important to the functioning of reservoirs. (2 marks)
- (ii) Tai Po Kau Nature Reserve comprises a secondary forest with native tree species and an afforestation area with imported tree species. A survey about the bird community was conducted in these two areas. The results are shown in the table below:

	Secondary forest with native tree species	Afforestation area with imported tree species
Total number of bird species	44	46
Number of forest-dependent bird species	16	9
Number of migrating bird species	28	37
Number of species nested in the forest	12	2
Number of individual birds per hectare	44	12

- (1) What is meant by a secondary forest? (1 mark)
- (2) In what ways are forests important to bird communities? State *two* of them. (1 mark)
- (3) Suggest *one* way by which birds are beneficial to tree communities. (1 mark)
- (4) Based on the above results, deduce which type of tree, native tree species or imported tree species, has a greater contribution to the local bird community. (4 marks)

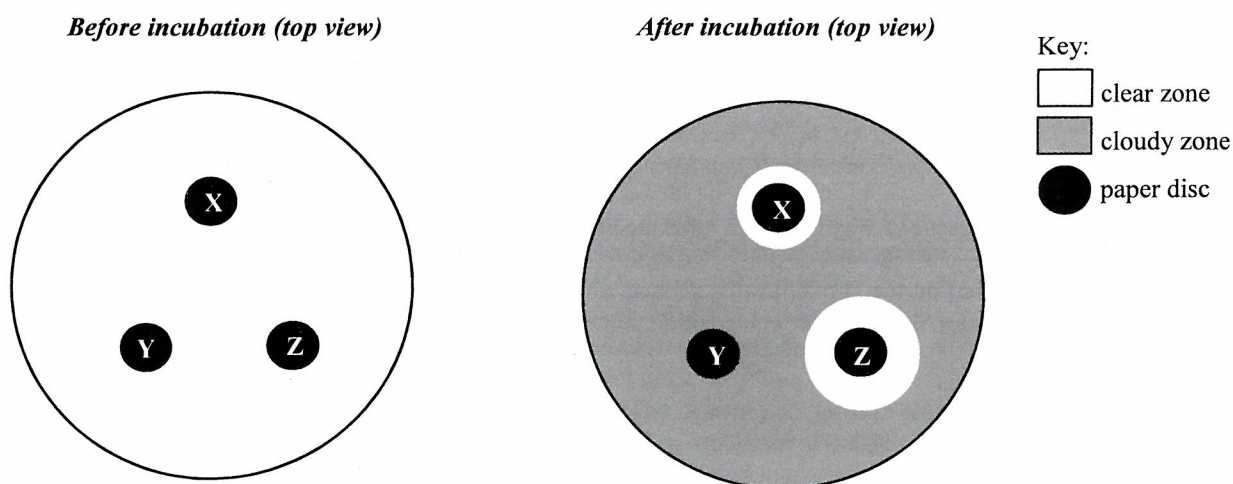
## SECTION C Microorganisms and Humans

Answer ALL parts of the question.

3(a) During the Coronavirus Disease 2019 (COVID-19) pandemic, hand sanitiser was one of the most common anti-pandemic products. The following lists the procedure of a test which assesses the antibacterial effectiveness of hand sanitiser samples X, Y and Z:

1. A bacterial culture was spread evenly over the surface of a sterile agar plate using a sterile spreader.
2. A sterile filter paper disk soaked with 10  $\mu\text{L}$  of hand sanitiser sample was placed on the agar plate.
3. The agar plate was incubated at 37°C for 24 hours.
4. The diameters of the clear zones were measured.

The diagrams below show the appearance of the agar plate before and after incubation:

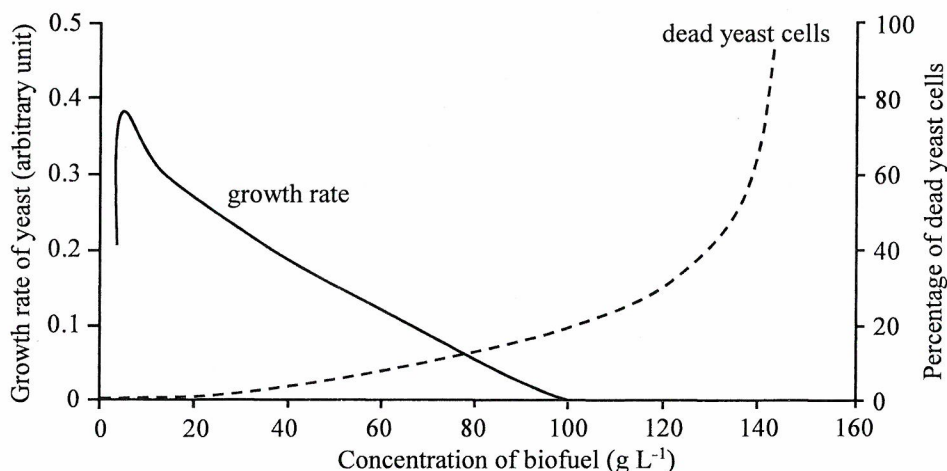


- (i) Explain why there were cloudy and clear regions on the agar plate after incubation. (2 marks)
- (ii) Assuming that the various hand sanitiser samples have the same diffusion rate on the agar plate, arrange the hand sanitiser samples in ascending order of their antibacterial ability. Explain your answer. (2 marks)
- (iii) Do the results truly reflect the effectiveness of the hand sanitiser samples against COVID-19? Why? (2 marks)
- (iv) State *two* aseptic techniques that should be employed during the spreading of bacterial culture over the agar plate. Explain your answer. (4 marks)

3(b) Biofuel can be produced in yeast fermentation.

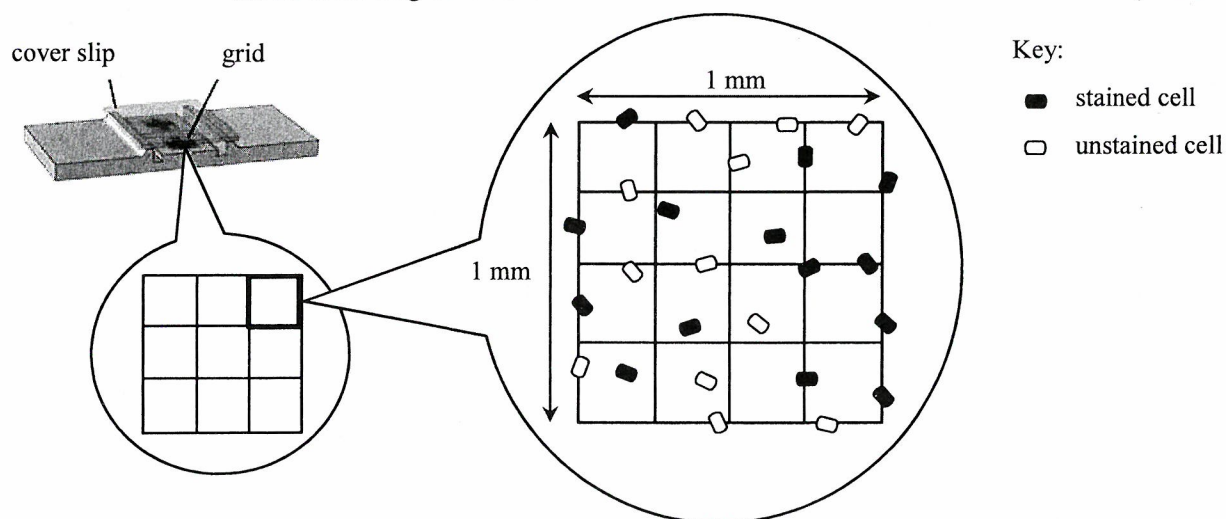
(i) Write the word equation for the yeast fermentation. (2 marks)

(ii) The graph below shows the impact of the production of biofuel on the yeast culture:



(1) With reference to the graph, what is the impact of biofuel production on the yeast? (2 marks)

(2) The percentage of dead cells can be estimated by using a cell counter (a hemocytometer). The diagram below shows the appearance of a diluted yeast culture sample stained with a blue dye which stains dead cells. Count the number and calculate the percentage of dead yeast cells as shown in the diagram below: (2 marks)



(3) The large square measures 1 mm x 1 mm and has a depth of 0.1 mm. The yeast sample has been diluted with a dilution factor of  $10^4$ . Calculate the total cell count per  $\text{cm}^3$  of the original yeast culture. (2 marks)

(iii) Traditionally, biofuel was produced from the edible part of corn or sugarcane. A genetically modified (GM) yeast with the ability to convert cellulose to biofuel has been developed. State *two* advantages of using this GM yeast over a traditional yeast strain for biofuel production. (2 marks)

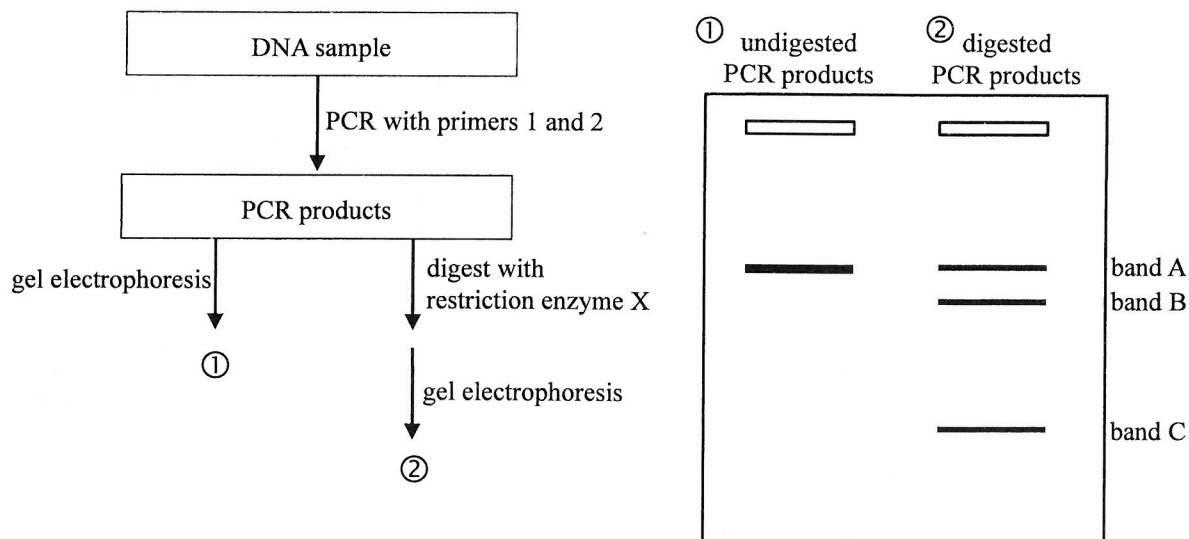
**SECTION D Biotechnology**

Answer ALL parts of the question.

- 4(a) Sickle cell anemia is an autosomal genetic disorder caused by a recessive mutation in the gene coding for a polypeptide chain of haemoglobin. With this mutation, the seventh amino acid of the polypeptide is changed to another amino acid. Part of the DNA sequence of the mutated allele is shown below:

	primer 1 →	number of bases
AGTCAGGGCA	GAGCCATCTA TTGCTTACAT TTGCTTCTGA CACAACGTG	50
TTCCTAGCA	ACCTCAAACA GACACC <u>AT</u> GG TGCATCTGAC TCCTGTGGAG	100
AAGTCTGCCG	TACTGCCCT GTGGGGCAAG GTGAACGTGG ATGAAGTTGG	150
TGGTGAGGCC	CTGGGCAGGT TGGTATCAAG GTTACAAGAC AGGTTTAAGG	200
AGACCAATAG	AAACTGGGCA TGTGGAGACA GAGAAGACTC TTGGGTTTCT	250
GATAGGCACT	GACTCTCTCT GCCTATTGGT CTATTTTCCC ACCCTTAGGC	300
TGCTGGTGGT	CTACCCTTGG ACCCAGAGGT TCTTTGAGTC CTTTGGGGAT	350
CTGTCCACTC	CTGATGCTGT TATGGGCAAC CCTAAGGTGA AGGCTCATGG	400
CAAGAAAGTG	CTCGGTGCCT TTAGTGATGG CCTGGCTC	438
	← primer 2	

- (i) The start of the polypeptide is encoded by genetic code ATG underlined in the above diagram. Write down the genetic code in which the mutation has occurred. (1 mark)
- (ii) With reference to the above diagram, what is the expected size of the PCR product when primers 1 and 2 are used to amplify the mutated allele? Give the unit for the size of the PCR product. (2 marks)
- (iii) It is known that the recognition site of restriction enzyme X is present in the normal allele but has been destroyed in the mutated allele. A DNA sample was obtained from an individual who is a carrier of sickle cell anemia for the following analysis:





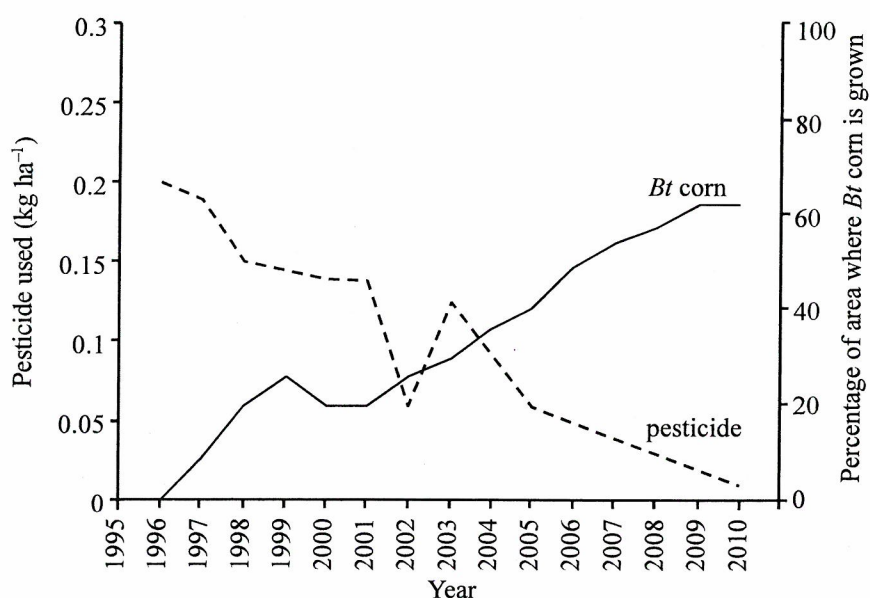
- (1) Explain why three DNA bands were detected in the gel electrophoresis of digested PCR products. (3 marks)
- (2) Which band(s) correspond(s) to the mutated allele? Explain your answer. (3 marks)
- (iv) Based on a DNA sequencing project, the table below shows the frequencies of this mutation in two human populations:

Population	Number of people	Number of mutations	Number of people who are homozygotes
African	12 482	1 121	4
East Asian	9 961	0	0

From which population was the DNA sample in (iii) most likely taken from? (1 mark)

4(b) *Bt* corn is a transgenic crop which contains a *Bt* gene obtained from a certain bacterium. This *Bt* gene can produce a protein which is toxic to certain insect pests.

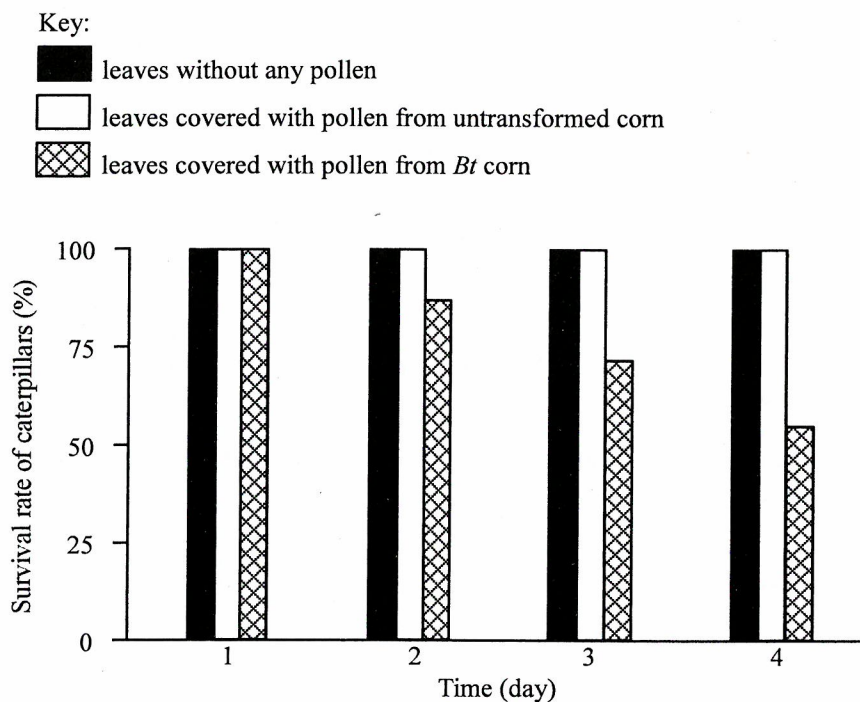
- (i) Agrobacterium transformation is commonly used in the production of transgenic plants. State *two* limitations of this method. (2 marks)
- (ii) The graphs below show the adoption rate of *Bt* corn and the use of pesticides in the farms of the United States:



- (1) Explain the relationship between the adoption rate of *Bt* corn and the use of pesticides. (3 marks)
- (2) State *one* advantage for farmers on adopting *Bt* corn. (1 mark)

(iii) A rapid decline in the population of a butterfly species M was noted after *Bt* corn was introduced to the field. *Bt* corn was blamed for the decline.

(1) In a laboratory study, caterpillars of M were divided into three groups, each fed with a different type of leaves. The survival rates of the three groups of caterpillars are shown below:



Based on the results of this study, suggest a possible explanation for the decline of the population of M. (2 marks)

(2) Later, large-scale field studies were conducted by placing caterpillars of M at different distances away from the edge of *Bt* corn fields and untransformed corn fields. It was discovered that there was no significant difference in the survival rates of these caterpillars.

Scientists cast doubt on the validity of the laboratory findings in (1). Suggest *two* conditions in the fields which may affect the validity of the laboratory findings. (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.



