

HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY
HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2021

BIOLOGY PAPER 2

11:45 am – 12:45 pm (1 hour)

This paper must be answered in English

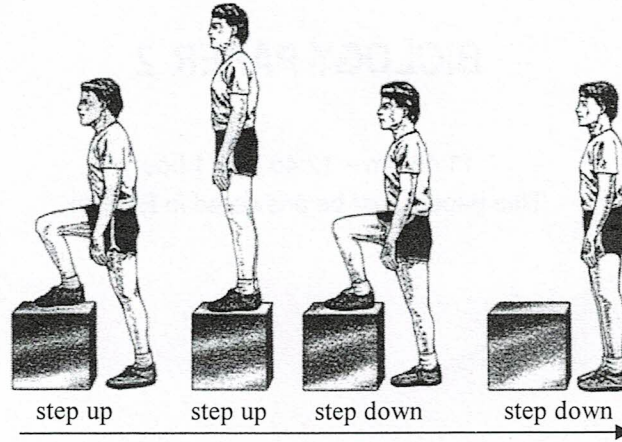
INSTRUCTIONS

- (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) Two young students, Alice and Billy, carried out a series of step-up exercises of increasing intensity. Each exercise lasted for three minutes by stepping up and down on a wooden box at a fixed speed (i.e. 2, 6 or 10 step-ups per 10 seconds) as shown in the diagram below:

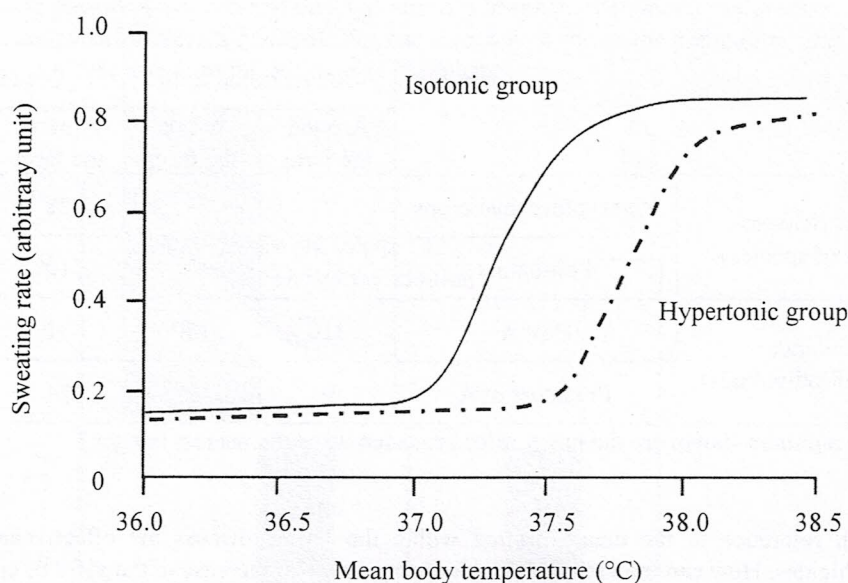


Their heart rates and blood lactate concentrations were measured at rest and immediately after each exercise. Before the start of the next exercise, the students were allowed to rest until their heart rate and blood lactate concentration returned to their levels at rest. The results are shown in the table below:

Intensity of exercise (No. of step-ups per 10s)	Heart rate (beat min ⁻¹)		Blood lactate concentration (mmol L ⁻¹)	
	Alice	Billy	Alice	Billy
0 (at rest)	58	80	0.42	0.43
2	64	91	0.63	0.82
6	94	132	0.82	2.40
10	130	178	1.20	5.80

- (i) Describe the overall effects of increasing the intensity of exercise on the heart rate and blood lactate concentration. (1 mark)
- (ii) According to your answers in (i), explain the change in blood lactate concentration during the exercise. (3 marks)
- (iii) According to your answer in (i), describe how the nervous system brings about the change in heart rate during the exercise. (4 marks)
- (iv) Alice is a trained athlete. Give *two* pieces of supporting evidence from the data. (2 marks)

- 1(b) An investigation was carried out to study the effect of the water content of blood on the thermoregulatory response. Volunteers were divided into two groups with the blood water content of one group maintained at isotonic condition while the other group at hypertonic condition. They were asked to immerse their bodies in hot water to mid-chest level for 30 minutes. The rate of sweating at the forehead and the body temperature of the volunteers were continuously monitored throughout the experiment. The relationship between these two parameters of the groups is shown in the graph below:



- (i) State the receptor and effector involved in the thermoregulatory response of the isotonic group. (2 marks)
- (ii) With reference to the thermoregulatory response of the isotonic group shown in the above graph, explain why the change brought about by this response is regarded as an example of negative feedback. (4 marks)
(Note: The nervous coordination of the response is *not* required.)
- (iii) With reference to the above graph, deduce the effect of the hypertonic condition of blood on the negative feedback mechanism of the thermoregulation of the volunteers. (2 marks)
- (iv) The effect described in (iii) is beneficial in regulating water balance in the hypertonic group of volunteers. Explain why. (2 marks)

SECTION B Applied Ecology

Answer **ALL** parts of the question.

- 2(a) Conventional farming engages the use of artificial chemicals such as herbicides and insecticides while organic farming does not. A survey comparing a conventional farm and an organic farm was conducted. The survey involved random sampling in areas within the farm and the areas around the farm at different times of a year. The data are shown in the table below:

		Conventional farm		Organic farm	
		Around the farm	Within the farm	Around the farm	Within the farm
Species richness (number of species)	Plants other than crops	7	3	28	18
	Pollinators	1	0	10	6
Abundance (number of individuals)	Pest A	310	160	51	49
	Predators of A	9	3	24	11

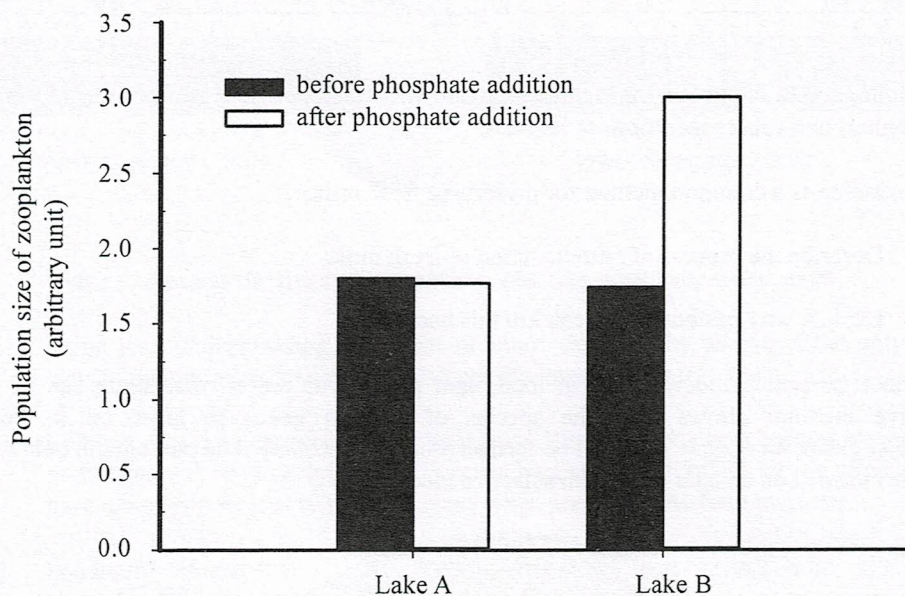
(Note: The numbers shown are the mean values rounded up to the nearest integer.)

- (i) With reference to the data collected within the farms, discuss the effectiveness of the use of herbicides. How can the use of herbicides bring about an increase in the yield of crop production? (3 marks)
- (ii) According to the data collected within the farms, discuss the effectiveness of chemical control and biological control on the population of pests. Explain your answer with supporting evidence from the data. (4 marks)
- (iii) With reference to species richness, explain why organic farming is beneficial to the sustainable development of communities in the areas around the farm. (3 marks)

2(b) Algal bloom commonly occurs when an aquatic ecosystem is polluted by domestic sewage. Lakes A and B have similar environmental conditions while the frequency of occurrence of algal bloom in Lake B is lower than that in Lake A. The major food chains of the two lakes are shown below:

Lake A: phytoplankton → zooplankton → Fish Species 1
Lake B: phytoplankton → zooplankton → Fish Species 1 → Fish Species 2

It is hypothesised that the number of trophic levels of the food chain affects the frequency of occurrence of algal bloom in the two lakes. To test this hypothesis, phosphate was added to the lakes and the population sizes of the zooplankton were monitored. The bar chart below shows the population sizes of zooplankton in Lakes A and B before and after the addition of phosphate:



- (i) What would be the effect of phosphate addition on the population size of phytoplankton? Explain your answer. (2 marks)
- (ii) With reference to the bar chart, suggest why the frequency of occurrence of algal bloom in Lake B is lower than that in Lake A. (3 marks)
- (iii) Based on the food chain of Lake B, explain why there is a higher zooplankton biomass in Lake B after phosphate addition. (3 marks)
- (iv) Explain why algal bloom leads to the reduction of dissolved oxygen in water at night. (2 marks)

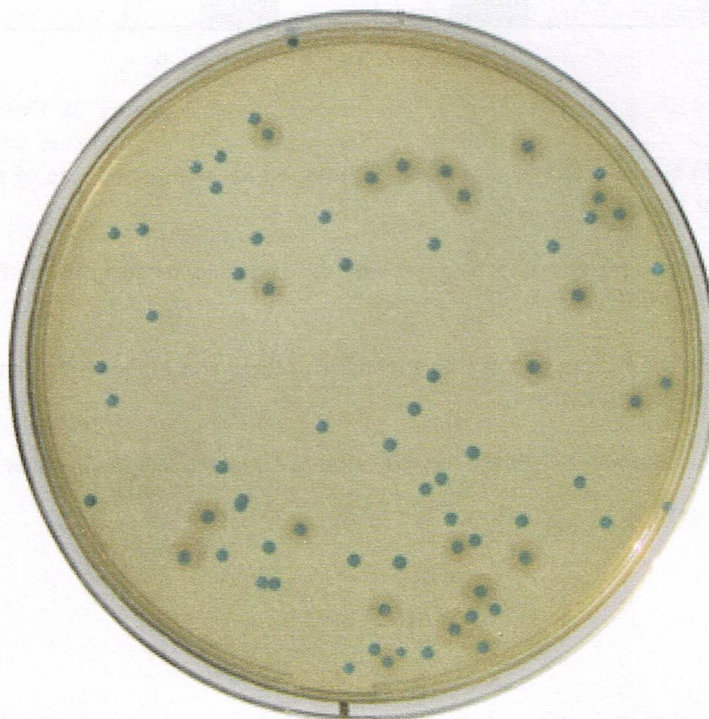
SECTION C Microorganisms and Humans

Answer **ALL** parts of the question.

3(a) *Listeria monocytogenes* is a foodborne pathogen which is commonly found in various food products. Ready-to-eat food products that require refrigeration such as fresh milk and yoghurt are at high risk of spreading *Listeria monocytogenes*. The table below lists the temperature range for the growth of this bacterium:

	Lower limit	Optimum	Upper limit
Temperature (°C)	-1.5	30 - 37	45

- (i) With reference to the above information, explain why this bacterium is often spread via fresh milk and yoghurt and causes infections to humans. (4 marks)
- (ii) Pasteurisation is a common method for preserving fresh milk.
 - (1) Describe the process of pasteurisation of fresh milk. (2 marks)
 - (2) Explain why pasteurisation can kill this bacterium. (1 mark)
- (iii) To detect *Listeria monocytogenes* in food, agar plates with selective medium can be used. The selective medium allows only the species of *Listeria* genus to grow on it. For *Listeria monocytogenes*, an opaque area will be formed around the colony. The photograph below shows the colonies formed on an agar plate with selective medium:

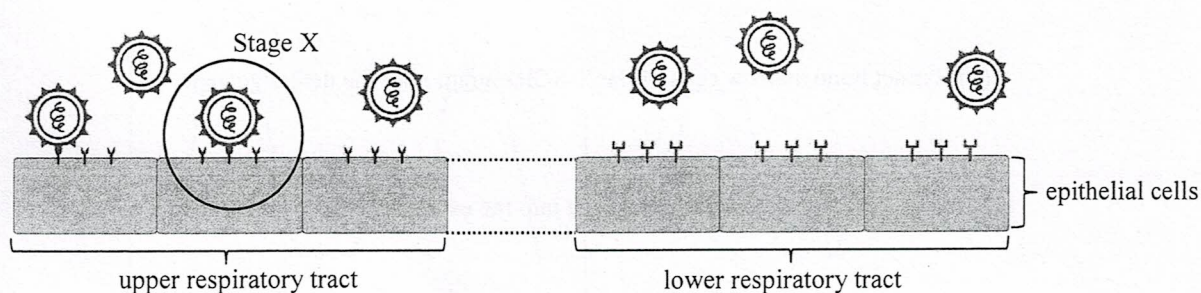


- (1) Count the number of *Listeria monocytogenes* colonies. (1 mark)
- (2) Suggest **one** safety measure that should be taken to dispose of the agar plates after the experiment in order to avoid contamination of the environment. (1 mark)

3(b) Viruses are host-specific because they can only infect certain types of cells. The following diagram shows a virus which infects epithelial cells in the upper but not the lower respiratory tract in human:

Key:

- ▼ protein on the viral surface
- Y protein on the surface of epithelial cells in the upper respiratory tract
- T protein on the surface of epithelial cells in the lower respiratory tract

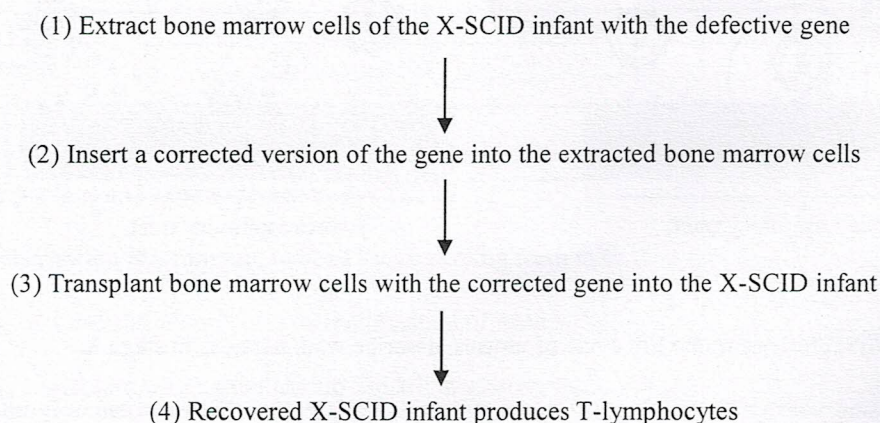


- (i) With reference to the life cycle of viruses, describe what happens in stage X. (1 mark)
- (ii) Using your understanding of protein structure, explain why this virus can only infect the epithelial cells of the upper respiratory tract but not the lower respiratory tract. (2 marks)
- (iii) Fish and pigs may carry viruses of their own. Viruses of one host species can go through a series of mutations and become infectious to other host species. Explain which viruses, from fish or pigs, have a higher potential to infect humans when present in the food products. (3 marks)
- (iv) Foodborne illnesses of microbial origin, especially bacterial infections, is a serious food safety problem. Scientists have proposed the use of bacteriophages to eliminate bacterial pathogens present in food.
 - (1) Describe how a bacteriophage could eliminate the whole population of a bacterial pathogen in food even if only one bacterial pathogen is infected by the bacteriophage. (4 marks)
 - (2) With reference to the host-specificity of viral infection, state **one** advantage of using bacteriophages in this approach to eliminate bacterial pathogens in food. (1 mark)

SECTION D Biotechnology

Answer **ALL** parts of the question.

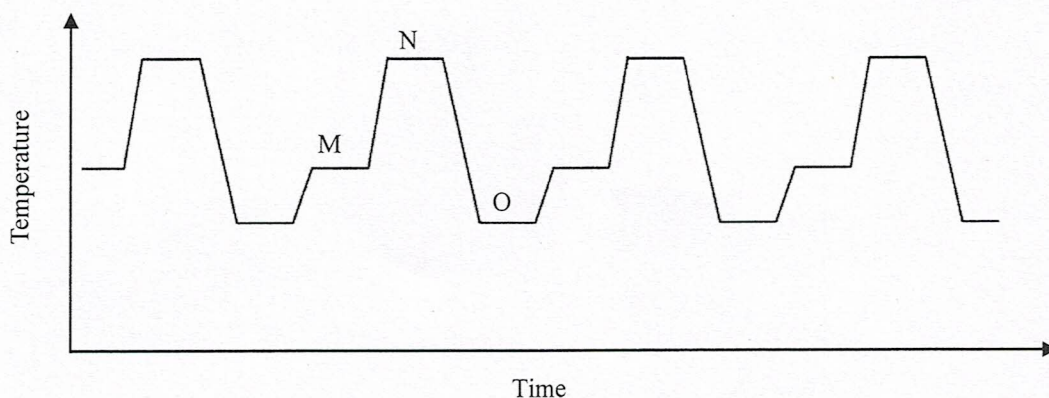
- 4(a) X-linked severe combined immunodeficiency (X-SCID) is a recessive genetic disorder which is due to a defective gene located on the X chromosome. X-SCID infants fail to produce T-lymphocytes. As a result, infections become life-threatening to X-SCID infants. In recent years, a new gene therapy has been developed for treating X-SCID patients. A simplified flowchart of the gene therapy is shown below:



- (i) In gene therapy, a specific type of cells will be selected depending on the defective gene to be corrected. In the above case, bone marrow cells fulfill the criteria for the gene therapy. State *two* general criteria for selecting a suitable type of cells in gene therapy. (2 marks)
- (ii) Suggest a suitable method for inserting the corrected version of the gene into the extracted bone marrow cells. State one advantage and one disadvantage of this method. (3 marks)
- (iii) An X-SCID boy has recovered after receiving the gene therapy. If, after 20 years, he marries a healthy woman, will he pass the defective gene to his offspring in the future? Explain your answer. (3 marks)
- (iv) Both gene therapy and production of transgenic animals involve recombinant DNA technology. Discuss why the gene therapy shown above is generally less controversial than the production of transgenic animals. (2 marks)

4(b) In the production of genetically modified organisms (GMO), antibiotic resistance genes are often used for the screening of successful transformation. A student collected some food products and wanted to determine if these food products are made from GMO. With primers corresponding to these antibiotic resistance genes, the student performed a polymerase chain reaction (PCR) on the food samples to check for the presence of the genes.

(i) The graph below shows the change in temperature during PCR cycles:



(1) Which stage (M, N or O) represents annealing? With reference to the events in a PCR cycle, explain your answer. (3 marks)

(2) Draw a simple labelled diagram to show what happens in the annealing stage. (2 marks)

(ii) The diagram below shows part of the DNA sequence of an antibiotic resistance gene X. The sequences shown are the corresponding regions for primer annealing:

Direction of primer extension



... GGATCAGCTG ACTCGCCTGG CACGCGGAGG AGCGTGCGCG ...
 |-----> 600 base pairs <-----|

Which of the following primers (I, II, III or IV) should be used for amplifying gene X? (2 marks)

- Primer I: GGTCCGCTCA GTCGACTAGG
- Primer II: CCTAGTCGAC TGAGCGGACC
- Primer III: GTGCGCCTCC TCGCACGCGC
- Primer IV: GCGCGTGCGA GGAGGCGCAC

(iii) Describe how you can use the principle of gel electrophoresis to confirm if the PCR product is gene X. (3 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.