



FUKIEN SECONDARY SCHOOL

S6 Mock Examination (2021-2022) Biology Paper 2

(1 hour)

Date: 26th January 2022 Time: 11:30a.m. - 12:30p.m.

Name:_____ Class: _____ No.: _____

INSTRUCTIONS

- 1 There are **FOUR** sections, A, B, C and D in this Paper. Attempt **ALL** questions in any <u>**TWO**</u> sections.
- 2 Write your answers in the Answer Book 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 A kidney transplant is often the treatment choice for kidney failure. However, there are problems associated with kidney transplants. Scientists are now trying to develop a bioartificial kidney as a better solution to kidney failure. Ideally, it would be a small, implantable device that performs the functions of the natural kidney. An early design of bioartificial kidney is shown below.



The hemofilter consists of membranes, which rely on the body's blood pressure to form ultrafiltrate. The blood and ultrafiltrate then enter the bioreactor, which contains renal tubule cells derived from stem cells of the patient to perform functions of the first coiled tubule. The processed blood will return to the patient's body and the urine produced will be passed to the urinary bladder for removal.

- i Name the part(s) of the nephron that perform(s) the same function as the hemofilter. (1 mark)
- ii One of the functions of the bioreactor is to concentrate the ultrafiltrate into urine with a relatively high urea concentration. Based on your biological knowledge, suggest how this can be achieved by the bioreactor. (5 marks)
- iii Give *two* advantages of using a bioartificial kidney over a kidney transplant.

(2 marks)

iv Some of the predicted side effects of using a bioartificial kidney include frequent thirst and production of large volumes of urine. It is caused by the fact that the bioartificial kidney does not have the ability to respond to the hormone ADH. Suggest how this causes the predicted side effects. (2 marks) 1 b During the luteal phase of the menstrual cycle (day 17 to 28), the temperature set point of women is usually raised above the normal level by 0.2–0.5°C due to the increase in progesterone level. Based on this knowledge, some scientists proposed that the increased progesterone level during the luteal phase makes the thermoregulatory centre less sensitive to changes in body temperature. An investigation was then carried out to test this idea.

In the investigation, 12 young and healthy women were tested twice throughout one menstrual cycle, once during the middle follicular phase (day 6 to 9) and once during the luteal phase of their menstrual cycle. They were asked to sit quietly inside a room set at a temperature of 41°C and a relative humidity of 21% for 30 minutes. Their body temperature, skin blood flow rate at the forehead and sweating rate at the forehead were measured at regular intervals. The results are shown below.



- i Briefly explain why the body temperature of the subjects increases during the investigation. (2 marks)
- ii Explain why there is an increase in blood flow to the skin of the forehead during the investigation. (3 marks)
- iii Do the results support the hypothesis of the investigation? Explain your answer. (3 marks)
- iv Apart from maintaining the thickness of the uterine lining, suggest *another* importance of the high level of progesterone during the luteal phase to the survival of the foetus. (2 marks)

SECTION B Applied Ecology

Answer **ALL** parts of the question.

2 a Scientists investigated the effects of adding different amounts of inorganic nitrogen, phosphorus and potassium (NPK) fertilizers and compost into the soil on the growth and crop yield of wheat. They carried out the investigation by dividing a piece of farmland into five plots of the same area and the same number of wheat plants was grown on each plot. They measured the yield of grain and the yield of straw in each plot after 150 days. Straw consists mostly of dried stalks and leaves left after the grains are harvested.

Plot	Fertilizer added	Yield of grain (kg per hectare)	Yield of straw (kg per hectare)
А	1 part of NPK fertilizer	208.2	106.7
В	1 part of NPK fertilizer + 1 part of compost	262.6	177.7
С	1 part of NPK fertilizer + 2 parts of compost	320.8	193.3
D	1 part of NPK fertilizer + 3 parts of compost	320.6	238.1
Е	1 part of inorganic nitrogen fertilizer	130.6	56.8

The results are shown in the table below.

i Describe the overall relationship between the yield of straw and yield of grain of wheat plants. Suggest a possible reason for such a relationship. (2 marks)

ii Discuss the effectiveness of adding different amounts of compost on the crop yield of wheat. Explain your answer with supporting evidence from the results.

(4 marks)

In the investigation, the scientists also traced the fate of nitrogen in the fertilizers in various plots of the farmland for two years. Two of the key findings are as follows.

- (1) The percentage loss of nitrogen from plot A is less than that from plot E.
- (2) The percentage loss of nitrogen from plot B is less than that from plot A.
- iii Based on your biological knowledge, suggest *one* possible explanation to each of the above findings. (2 marks)
- iv Explain an ecological impact of the excessive loss of nitrogen from the soil on a river nearby. (2 marks)

2 b Fung shui woods (風水林) are characteristic of villages in Southern China. In Hong Kong, when the early settlers set up their villages, they preserved the original vegetation (trees and shrubs) behind the villages. Later, they planted fruit trees, bamboos and some other trees which they thought could bring good luck. Eventually, the two types of vegetation merged to form fung shui woods. The drawing below shows a typical set-up of fung shui woods.



village

- i Suggest two practical benefits that fung shui woods can provide to local villagers. (2 marks)
- ii Nowadays, many fung shui woods in Hong Kong have been designated as SSSIs. What is the scientific value of these fung shui woods? (1 mark)

Scientists conducted a survey to investigate the relationship between deforestation and malaria risk. The survey used data of the percentage area that experienced forest loss within 30 km of various villages in country L and the incidence of malaria in these villages. The relative malaria risk is calculated by using the malaria incidence of villages that experienced no forest loss nearby as the baseline. The results are shown below.



iii What is the vector of malaria?

(1 mark)

- iv Describe *two* human activities which result in the loss of forest. (2 marks)
- v With reference to the data given, discuss the relationships between forest loss and malaria risk. Suggest possible reasons to explain the relationships.(4 marks)

SECTION CMicroorganisms and HumansAnswer ALL parts of the question.

3 a Scientists carried out an investigation to study the effect of two bacteriophages (P1 and P2) against *Escherichia coli*. They added the bacteriophages into different flasks containing *E. coli* and cultured the mixtures in an incubator at 37°C. Samples of the cultures were then transferred to small tube-like glass containers at regular intervals to measure their optical density (OD) using a spectrophotometer. The results are shown in the table below.

Time	Optical density (measured at 600 nm)			
(hour)	Added with P1	Added with P2	Added with P1 and P2	E. coli only
0	0.02	0.02	0.02	0.02
2	0.05	0.10	0.05	0.16
4	0.02	0.01	0.01	0.32
6	0.01	0.02	0.01	0.38
8	0.12	0.10	0.01	0.39
10	0.31	0.17	0.01	0.40
12	0.38	0.23	0.01	0.41
14	0.38	0.30	0.02	0.42
16	0.39	0.32	0.02	0.43
18	0.39	0.34	0.02	0.43
20	0.40	0.35	0.02	0.43

i

Aseptic techniques must be used when transferring the cultures into small tube-like glass containers for measuring OD.

(1) Describe *two* aseptic techniques involved in the transfer of cultures.

(2 marks)

(2) What is the significance of using aseptic techniques in this process?

(2 marks)

- (3) Give *one* advantage of measuring OD over viable cell count in this investigation. (1 mark)
- ii According to the results, suggest a treatment which would be effective in treating infection caused by *E. coli* in humans. Support your answer with evidence. (3 marks)
- iii Explain why there is an increase in OD in the first two hours even after bacteriophages have been added. (1 mark)
- iv The scientists repeat the investigation with the bacterium *Vibrio cholerae* but both bacteriophages seem to be ineffective against it. Suggest a possible reason for this. (1 mark)

3 b Peritoneal tuberculosis (TB) (結核性腹膜炎) is caused by the bacterium *Mycobacterium bovis*. The bacterium primarily infects cattle. However, humans can also be infected, mainly through the consumption of unpasteurized or raw milk from infected cows.

Scientists carried out an investigation to determine how long a milk sample has to be treated at a particular temperature in order to kill all *M. bovis* bacteria and to denature enzymes A and B. Both enzymes are naturally present in raw milk and their activities can be determined quickly by chemical tests. The results are shown in the graph below.



- i Which type of food-borne illness, food poisoning or food-borne infection, can peritoneal TB be classified into? (1 mark)
- ii (1) One method of pasteurization is carried out at 72°C. By referring to the graph, what is the minimum duration that the raw milk should be treated in order to prevent peritoneal TB? (1 mark)
 - (2) Scientists have an idea of using the activities of enzymes in raw milk as an indicator to assess whether pasteurization has been done properly and all the *M. bovis* bacteria in the milk have been killed. Which enzyme (A or B) is more suitable? Explain your answer.

- iii In the Western world, there are people who advocate the consumption of raw milk. They thought that raw milk is healthier, more nutritious than pasteurized milk and can be a better choice for people with lactose intolerance. Do you agree with them? Give reasons to support your answer. (3 marks)
- iv Suggest *another* method that is commonly used in treating milk to extend its shelf life. Briefly describe its principle. (2 marks)

SECTION D Biotechnology

Answer **ALL** parts of the question.

4 a Huntington's disease is an autosomal dominant genetic disorder that leads to a loss in brain functions and eventually death. It is caused by mutations in the HTT gene. Patients with Huntington's disease usually have large numbers of repeats of the base sequence CAG in the gene.

Since the early 1990s, a genetic test has been available to predict whether a person will develop Huntington's disease or not and when the disease onset will be. It involves finding out the number of CAG repeats in the HTT gene by DNA fingerprinting. The table below shows the relationship between the number of CAG repeats, the predicted risk and possible onset time of Huntington's disease.

Number of CAG repeats	Predicted risk of Huntington's disease	Possible onset time
≤ 26	Very low	Old age
27–35	Low	Old age
36–39	Intermediate	Old age
40–59	High	Adulthood
≥ 60	Very high	Childhood or juvenile

i Before the genetic test, polymerase chain reaction (PCR) is often performed on the DNA samples. The diagram below shows part of the DNA sequence of a normal HTT gene.

 \rightarrow direction of DNA extension

...CCTTCGAGTCCCTCAAGTCCTTCCAGCAGCAGCAGCAGCAGCAACA GCCGCCACCGCCG...

- (1) How many CAG repeats are there in the gene? (1 mark)
- (2) The base sequence below belongs to one of the primers used in PCR:

CGGCGGTGGCGGCTGTTG

State the region on the HTT gene that the primer would anneal to.

(1 mark)

The diagram below shows the results of five individuals in the genetic test for Huntington's disease. The numbers of CAG repeats of individuals 1 and 2 are given as reference.



- ii Which band, A or B, in the DNA fingerprint of individual 1 represents the DNA fragments with 39 CAG repeats? Explain your answer with reference to the principle of gel electrophoresis. (4 marks)
- iii Explain why there is only one band in the DNA fingerprint of individual 3.

(1 mark)

- iv (1) Describe the test result of individual 4. (1 mark)
 - (2) Should individual 4 disclose the test result to his wife and his daughter? Give a reason to support your answer.(2 marks)

4 b *Bt* maize is a genetically modified (GM) crop plant that contains the *Bt* gene from the bacterium *Bacillus thuringiensis*. The gene codes for a protein (*Bt* toxin) that poisons the larvae of some insect pests that feed on the plant.

Scientists use Agrobacterium to transfer the Bt gene into the cells of maize plants. The bacterium contains a plasmid with the gene for resistance against a chemical called kanamycin. The flow chart below shows the main steps involved in the production of Bt maize.



- i The maize tissues used are obtained from meristematic tissues of the maize plants. State *one* property of the cells in meristematic tissues that allows them to be suitable for use in producing GM maize plants. (1 mark)
- ii (1) Kanamycin is present in agar plate B. Suggest how it can be used to screen for transformed maize cells. (2 marks)
 - (2) Other than kanamycin, suggest, with reasons, *two* ingredients that should be present in agar plate B. (4 marks)

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iii Scientists carried out an experiment to investigate the effect of growing Bt maize plants in a piece of farmland on the population of non-target insect species (e.g. caddisflies) in a nearby river. In the laboratory, they fed caddisfly larvae with maize leaves containing certain concentrations of Bt toxins for 15 weeks and measured the death rate of the caddisfly larvae. The results are shown in the graph on the next page.



- (1) Briefly describe the effect of feeding caddisfly larvae with *Bt* maize leaves. (1 mark)
- (2) Based on the results, some environmentalists warn that *Bt* crops can lead to a decrease in the populations of other non-target species (e.g. caddisflies) and thus have long-term negative effects on the nearby freshwater communities. However, some scientists argue that the design of the investigation fails to reflect the reality and the ecological effects of planting *Bt* crops are inconclusive. Suggest the reasons behind the scientists' claim. (2 marks)

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