THE HONG KONG POLYTECHNIC UNIVERSITY 香港理工大學

Secondary School Mathematics & Science Competition 2014

Biology

Date : 11th May, 2014 Total no. of pages : 26

Time allowed : 9:30 am - 10:45 am (1hour 15 minutes) Total marks : 75

1. Write your Candidate Number, Centre Number, Name (both in English and Chinese), Name of School, Form, Date, Gender, Language and Subject in the spaces provided on the MC Answer Sheet and the Part B Answer Sheet.

2. When told to open this question paper, you should check that all the questions are there. Look for the words '**END OF PAPER**' after the last question.

3. **ANSWER ALL QUESTIONS** in both Part A and Part B.

4. Part A consists of multiple choice questions. Part B contains structured questions.

   Part A (Multiple Choice Questions)

   (a) You are advised to use an **HB** pencil to mark all your answers on the MC Answer Sheet.

   (b) Each question carries one mark.

   (c) You should mark only **ONE** answer for each question. If you mark more than one answer, you will receive **NO MARK** for that question.

   Part B (Structured Questions)

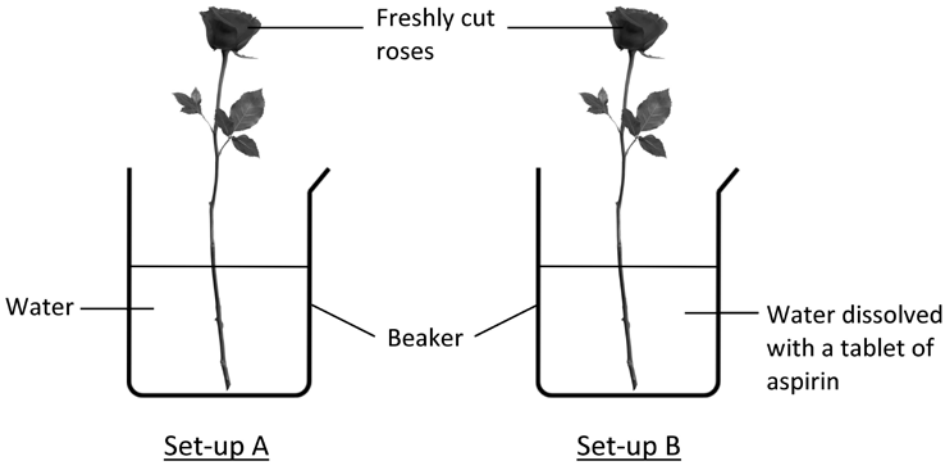
   (a) Answers should be written in the space provided on the Part B Answer Sheet.

5. No mark will be deducted for wrong answers.

6. Diagrams in this paper are **NOT** necessarily drawn to scale.

Part A：Multiple Choice Questions (60 marks)

Directions for Questions 1 to 3: The diagram below illustrates the set-ups used to test the hypothesis that aspirin prolongs the life span of cut flowers. The two set-ups were kept at 30°C and the number of days the rose lasted (i.e. before the rose started to wilt) was recorded.



1. Which of the following variables of the experiment should be kept constant?

   (1) Amount of water used.
   (2) Roses from the same plant.
   (3) Total number of leaves on the rose.

   A. (1) and (2) only
   B. (1) and (3) only
   C. (2) and (3) only
   D. (1), (2) and (3)

2. Which of the following precautions are ***not*** necessary in the above experiment?

   (1) Submerge the rose stems and cut under water.
   (2) Boil the water before use.
   (3) Illuminate the two set-ups with direct sunlight for 8 hours every day.

   A. (1) and (2) only
   B. (1) and (3) only
   C. (2) and (3) only
   D. (1), (2) and (3)

3. If the rose in set-up A lasted longer than set-up B, which of the following conclusion should be made?

   A. Aspirin prolongs the life span of cut flowers.
   B. The hypothesis is not supported.
   C. The design of experiment is wrong.
   D. Soil should be used instead of water.

4. How many fatty acid residues are usually found in a phospholipid molecule?

   A. 2
   B. 3
   C. 4
   D. 5

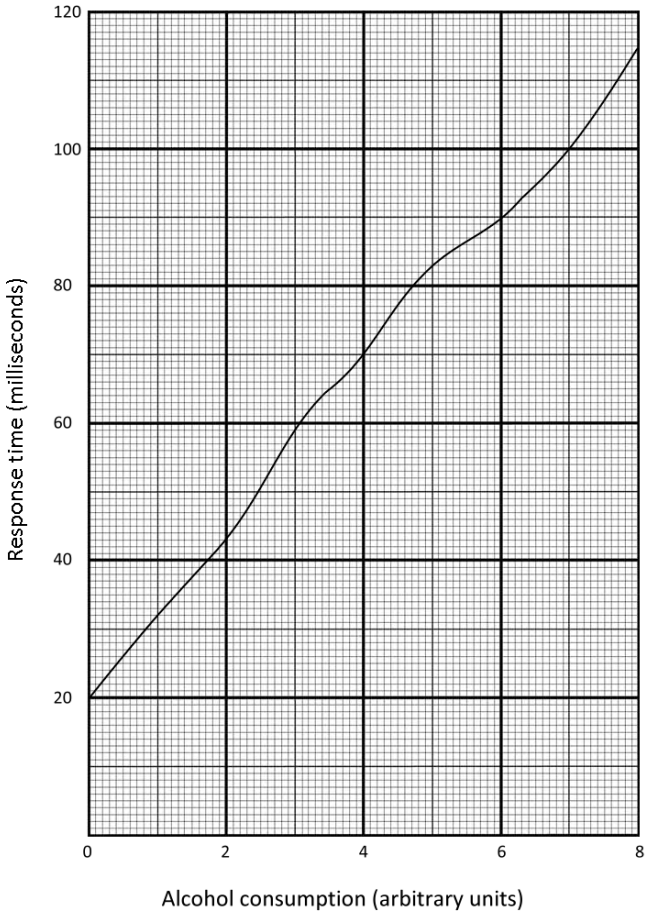
5. The following table shows the structural differences between amino acids and nucleotides:

Structure	Amino acid	Nucleotide
Pentose sugar	Absent	Present
X	Absent	Present
Y	Present	Absent
Z	May be present	Absent

Which of the following is the ***correct*** combination of X, Y and Z respectively?

	X	**Y**	**Z**
A.	Organic bases	Carboxyl group	Phosphate group
B.	Phosphate group	Organic bases	Polar side chain
C.	Phosphate group	Carboxyl group	Polar side chain
D.	Phosphate group	Polar side chain	Carboxyl group

Directions for Questions 6 to 7: The graph below shows the effect of alcohol on a person's response time. In this experiment, a man was asked to drink an increasing amount of alcohol and respond to a computer signal by pressing a button as quickly as he could.



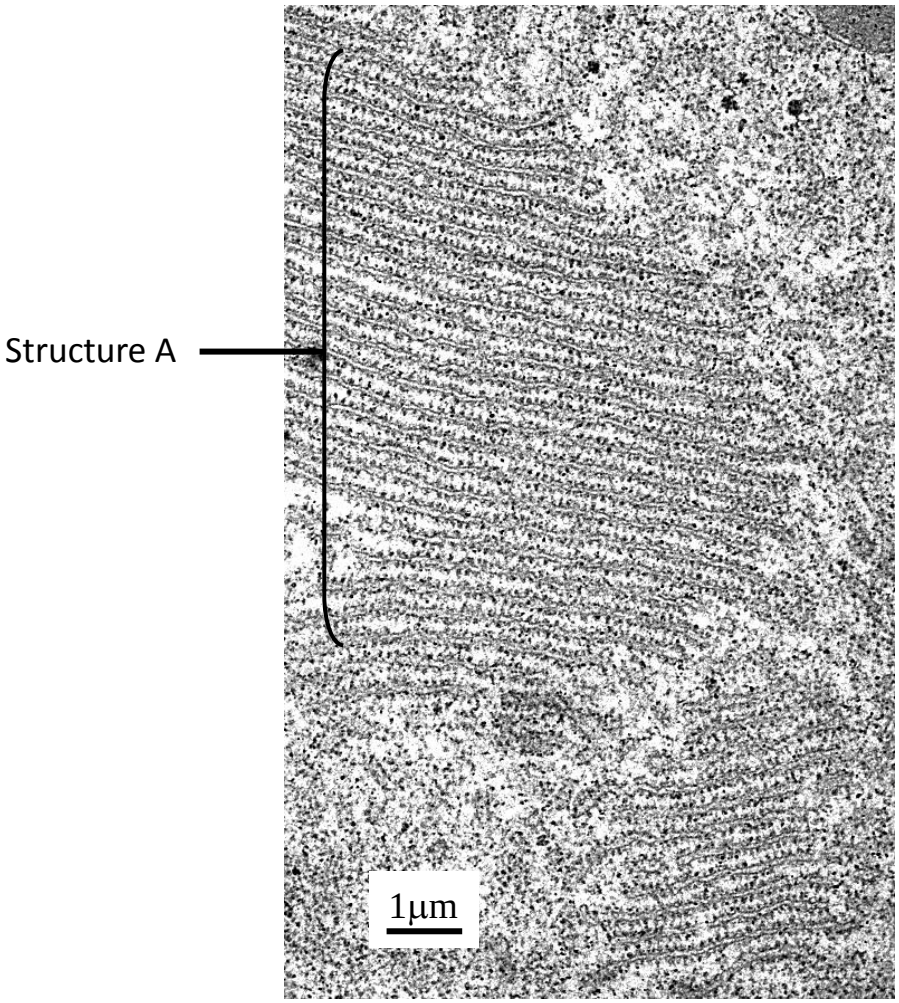
6. What was the man's response time (in milliseconds) after he had drunk three glasses of beer each containing two units of alcohol?

   A. 43
   B. 59
   C. 70
   D. 90

7. Which of the following can be deduced from the graph above?

   A. Length of response time is inversely proportional to amount of alcohol consumed.
   B. Drinking alcohol leads to delayed response time.
   C. Drinking alcohol leads to poorer muscular control.
   D. Drinking alcohol increases the risk of liver cancer.

Directions for Questions 8 and 9: The photomicrograph below shows an image of a cellular structure obtained from a transmission electron microscope:



8. Calculate the magnification shown in the photomicrograph.

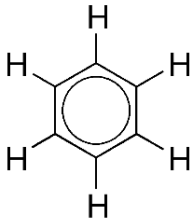
   A. x1,000
   B. x10,000
   C. x100,000
   D. x1,000,000

9. What is the major function of structure A?

   A. Transcription.
   B. Translation.
   C. Modify, transport and repack the macromolecules inside.
   D. Contain hydrolytic enzyme for autolysis.

10. Which of the following molecules diffuses across the cell membrane most rapidly?

A.



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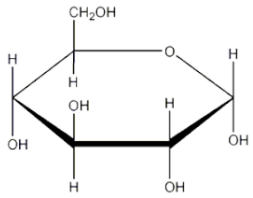
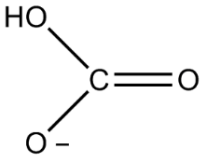
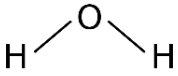


C.



D.

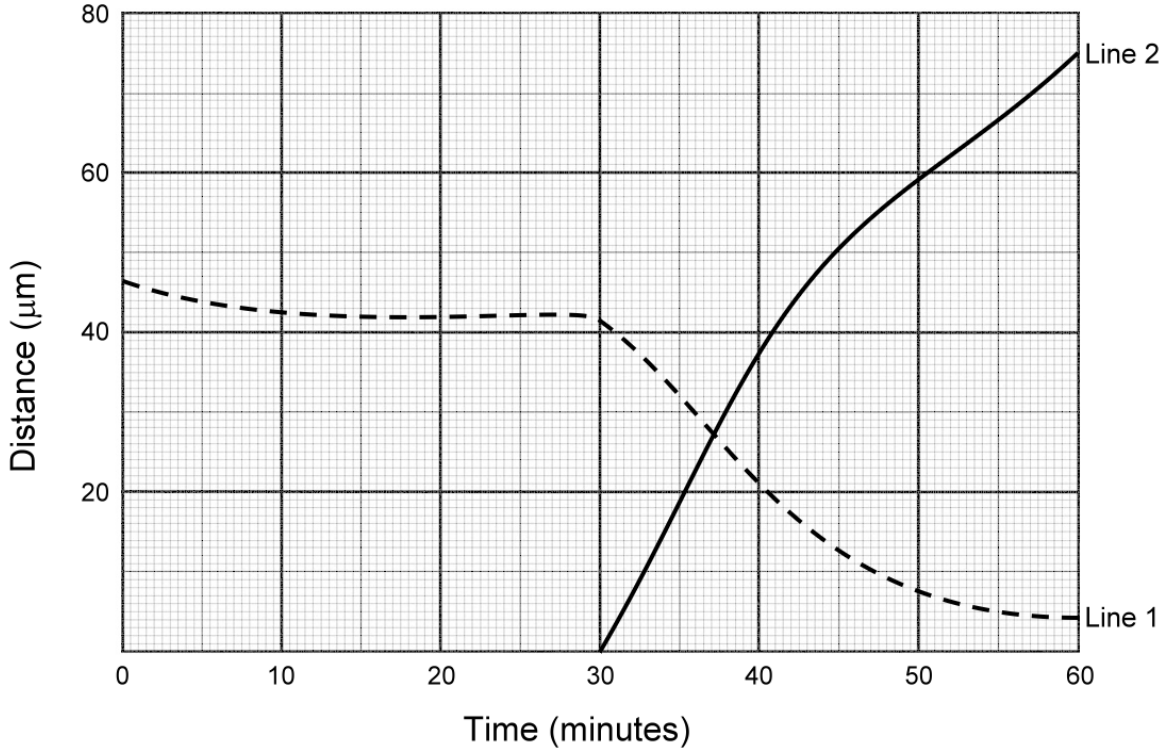


11. The diagram below shows an amoeba feeding on a prey:

Which of the following best describes the feeding process?

A. Facilitated diffusion
B. Pinocyctosis
C. Phagocytosis
D. Exocytosis

Directions for Questions 12 and 13: The graph below shows the distance between two structures of a mammalian body cell during mitosis:



Line 1 represents the distance between chromosomes and their respective poles.
Line 2 represents the distance between sister chromatids.
When time equals zero, all chromosomes line up on the equator.

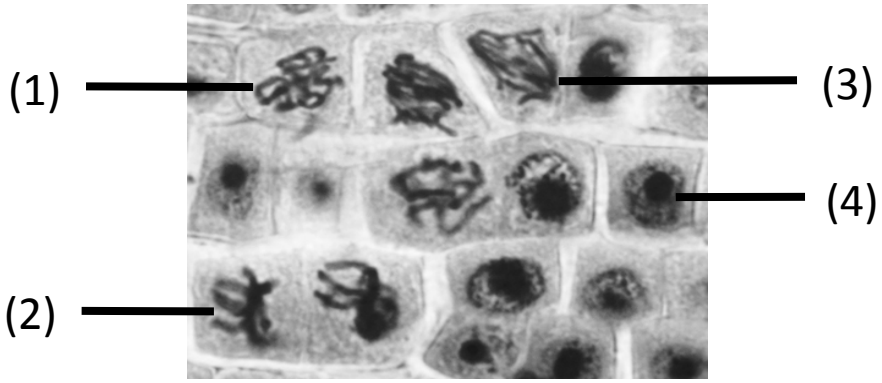
12. The stage of mitotic division at time equals 30 minutes is

    A. prophase.
    B. metaphase.
    C. anaphase.
    D. telophase.

13. If n represents the amount of DNA of a gamete of this mammal, what is the amount of DNA of the cell at the stage when time equals to 10 minutes?

    A. n
    B. 2n
    C. 3n
    D. 4n

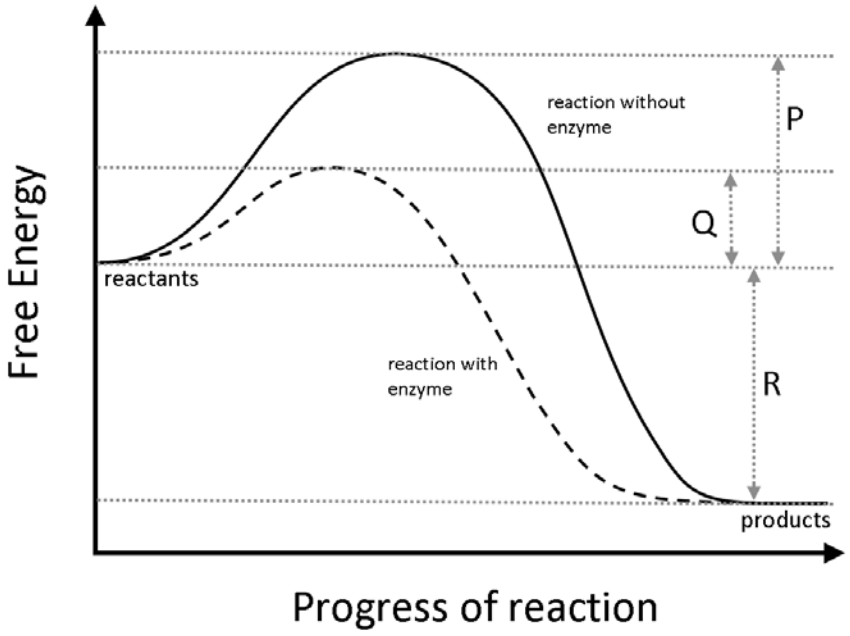
14. The diagram below shows the different stages of mitotic division of root tip cells:



Which of the following is the ***correct*** sequence of mitosis?

A. (2), (1), (4), (3)
B. (4), (3), (1), (2)
C. (1), (3), (2), (4)
D. (4), (1), (2), (3)

15. The following diagram illustrates the effect of an enzyme in a reaction:



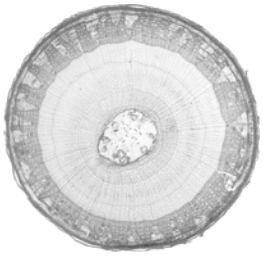
Which of the following is a ***correct*** combination?

	Lowering of the activation energy	Energy changed in the reaction
A.	P-Q	Q+R
B.	P-Q	R
C.	P-R	Q+R
D.	P-R	R

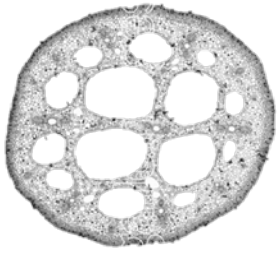
16. The diagram below shows the water plant that can be seen very often on the pond surface:

Which of the following cross-sectional diagrams belongs to the stem of the above water plant?

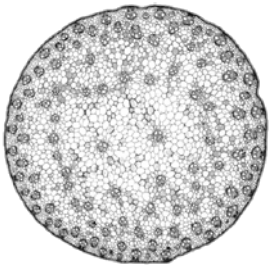
A.



B.



C.



D.

17. Guard cell regulates the size of the stomatal pores. Which of the following are involved in the mechanisms that control the opening and closure of stomata by the guard cells?

(1) Concentration of carbon dioxide
(2) Light
(3) Potassium ions
(4) Abscisic acid

A. (1), (2) and (3) only
B. (1), (2) and (4) only
C. (2), (3) and (4) only
D. (1), (2), (3) and (4)

18. Which of the following is ***not*** correct during the light reaction of photosynthesis?

A. It occurs at the thylakoids of the chloroplast.
B. Oxygen is split to release water.
C. NADPH is formed to donate hydrogen in carbon fixation.
D. An ATP is formed.

19. Which of the following is ***not*** a common feature of aerobic respiration and burning?

A. Energy is released
B. Oxygen is required
C. Combustion takes place
D. Carbon dioxide is produced

20. Peter, Tom and Mary were arguing about the number of ATP generated in the aerobic respiration of a glucose molecule. The table below shows their calculation:

	No. of ATP generated		
	Peter's calculation	Tom's calculation	Mary's calculation
Glycolysis	6	6	8
From pyruvate to Acetyl CoA	6	6	6
Krebs cycle	22	24	24
Total	34	36	38

Which of the following statements can account for their differences?

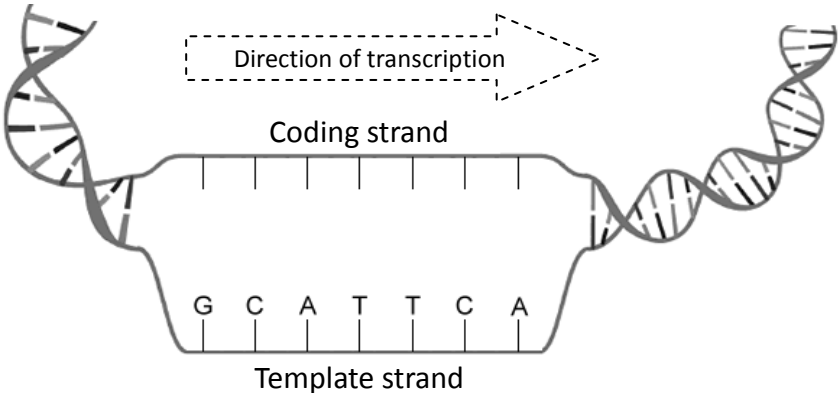
(1) Peter referred to the ATP that generated by NADH + H^+ and $FADH_2$ from the aerobic respiration process only.
(2) Tom referred to the ***net*** ATP that produced from the aerobic respiration process.
(3) Mary did not count the ATP molecules that were used during glycolysis.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

21. Which of the following processes does ***not*** require ATP?

A. DNA replication
B. Fermentation of glucose into lactic acid
C. Calvin cycle
D. Enzyme production

22. The diagram below shows a segment of DNA during transcription:



Which of the following sequences of mRNA should be produced?

A. CGTAAGT
B. GCATTCA
C. CGUAAGU
D. GCUTTCU

23. A DNA marker (or ladder) is usually run on an individual lane of the agarose gel during electrophoresis with an aim to

A. determine the size of DNA samples on the gel.
B. indicate how far the DNA have reached.
C. measure the weight of DNA samples on the gel.
D. give fluorescence to DNA samples upon ultraviolet illumination.

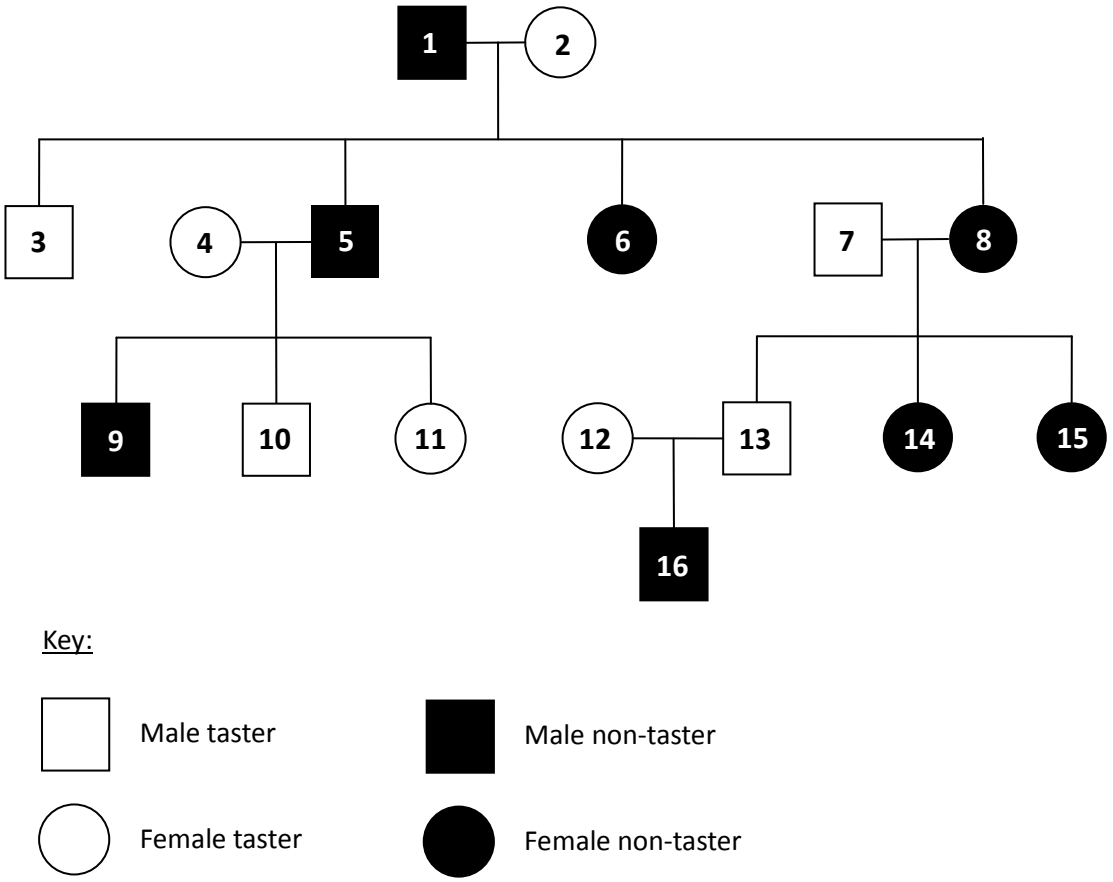
24. A mother in a family has given birth to three boys already. She is pregnant again, what is the probability that the fetus she bears is a boy?

A. 6.25%
B. 25%
C. 50%
D. 100%

25. Which of the following traits in human is ***not*** a polygenic inheritance?

A. Intelligence
B. Skin color
C. ABO blood group
D. High blood pressure

Directions for Questions 26 to 27: The pedigree below shows a person's ability to taste the bitterness of Phenylthiocarbamide (PTC). The ability to taste PTC is controlled by a pair of alleles.



26. Which of the following crosses can be used to deduce that the tasting allele is dominant to the non-tasting allele?

	Cross between individuals
A.	1 and 2
B.	4 and 5
C.	7 and 8
D.	12 and 13

27. Which of the following evidences can sufficiently explain that the gene which controls the tasting and non-tasting of PTC is ***not*** sex-linked?

    (1) Individuals 2 and 6 can explain that the gene is not located on X chromosome.
    (2) Individuals 5 and 10 can explain that the gene is not located on Y chromosome.
    (3) Individuals 8 and 13 can explain that the gene is not located on X chromosome.

    A. (1) and (2) only
    B. (1) and (3) only
    C. (2) and (3) only
    D. (1), (2) and (3)

28. Inbreeding inside a tribe often results in children with many deformities because they are likely to inherit

    A. two copies of the same mutated recessive alleles for a trait.
    B. two dominant alleles for a trait.
    C. only a single allele for a trait.
    D. homologous chromosomes without independent assortment from each parent.

29. Lichen shows a symbiotic relationship between

    A. plant and bacteria.
    B. bacteria and fungi.
    C. algae and fungi.
    D. plant and algae.

30. In a microbiological examination of a patient's fecal sample, two types of bacteria namely *Escherichia coli* and *Campylobacter coli* are isolated.
    Which of the following statements regarding those two types of bacteria in scientific classification is ***correct***?

    A. Both types of bacteria belong to the same Species.
    B. Both types of bacteria belong to the same Genus.
    C. Both types of bacteria belong to the same Family.
    D. Both types of bacteria belong to the same Domain.

31. Which of the following factors can change the allele and genotype frequencies in populations and are regarded as agents of evolution?

    (1) Gene mutation
    (2) Genetic drift
    (3) Artificial selection

    A. (1) and (2) only
    B. (1) and (3) only
    C. (2) and (3) only
    D. (1), (2) and (3)

32. Which of the following is ***not*** a vegetative reproduction organ?

    A. Potato
    B. Onion
    C. Ginger
    D. Apple

33. Which of the following statements about asexual reproduction is ***correct***?

    (1) The genetic content of daughter organism is the same as the parent.
    (2) The daughter and parent have the same number of chromosomes.
    (3) Offspring is derived from meiosis.

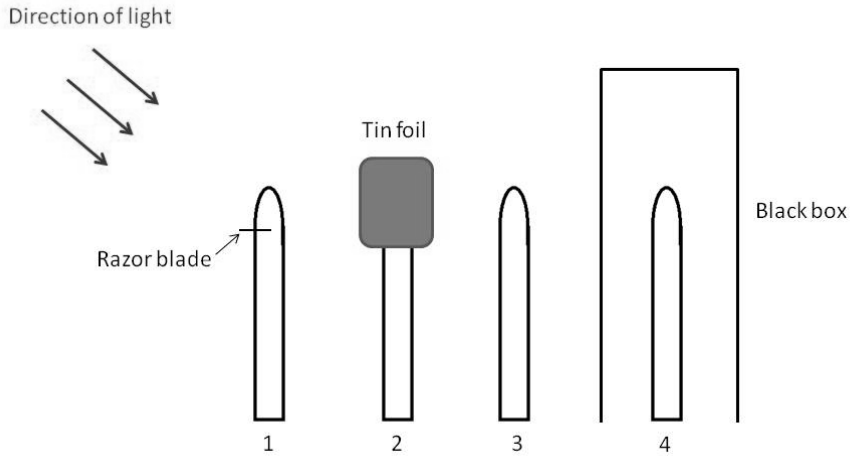
    A. (1) and (2) only
    B. (1) and (3) only
    C. (2) and (3) only
    D. (1), (2) and (3)

34. Which of the following statements about seed germination are ***correct***?

    (1) It requires sunshine.
    (2) The radicle is the first part of the seed to develop.
    (3) Enzymes convert insoluble food in cotyledons into soluble form.

    A. (1) and (2) only
    B. (1) and (3) only
    C. (2) and (3) only
    D. (1), (2) and (3)

Directions for Questions 35, 36 and 37: An experiment was set up by a student to investigate the growth of four young coleoptiles under different conditions:



35. Which of the following coleoptiles will have a straight vertical appearance after growing for 7 days?

    A. (1) and (2) only
    B. (2) and (3) only
    C. (2) and (4) only
    D. (3) and (4) only

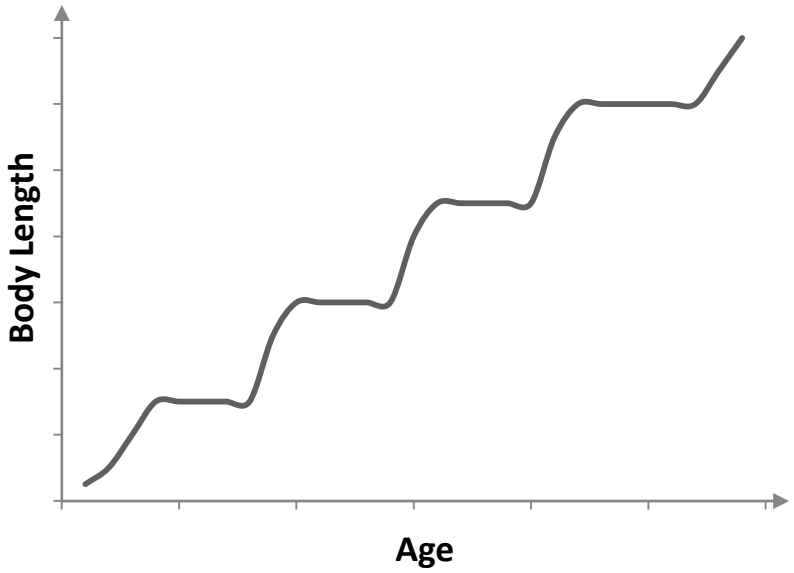
36. Which coleoptile will be the tallest after 7 days?

    A. 1
    B. 2
    C. 3
    D. 4

37. The student repeated the experiment again with coleoptile 1 completely decapitated. What will be the appearance of coleoptile 1 after 7 days?

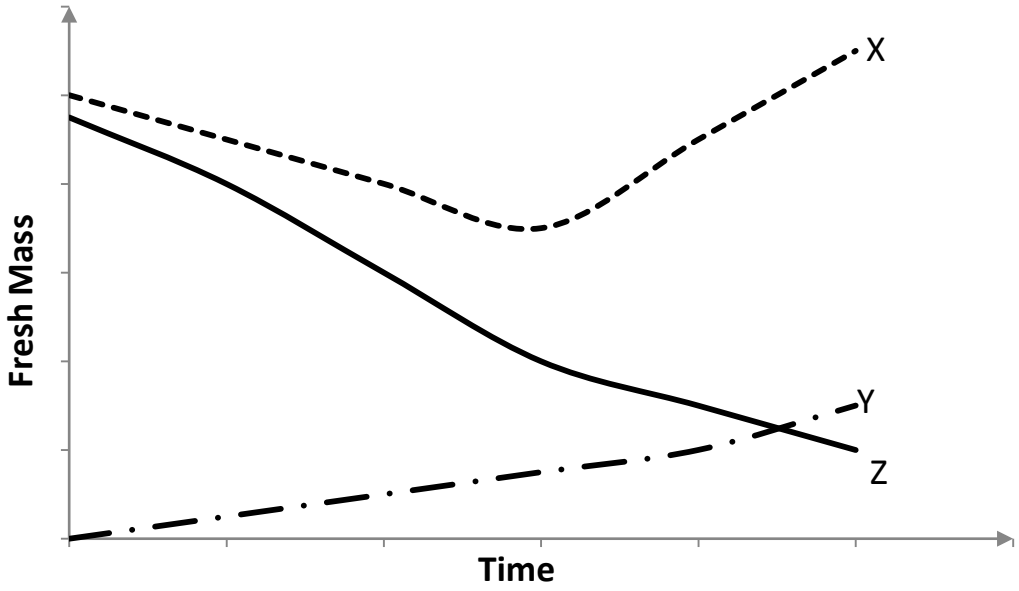
    A. shoot bending to the right
    B. shoot bending to the left
    C. shoot growing vertically upward
    D. no growth

38. Which of the following animals does the following growth curve belong to?



A. Rabbit
B. Crab
C. Fish
D. Cow

39. A student measured the fresh mass of different parts of a seed during germination. The results are shown in the graph below:



Identify X, Y and Z.

	X	Y	Z
A.	Whole seedling	Cotyledons	Radicle
B.	Leaves	Radicle	Cotyledons
C.	Whole seedling	Radicle	Cotyledons
D.	Leaves	Cotyledons	Radicle

40. How our eyes accommodate in order to focus on a distant object in dim light condition?

A. Pupil dilates and ciliary muscles relax to reduce curvature of lens.
B. Pupil constricts and ciliary muscles relax to reduce curvature of lens.
C. Pupil constricts and ciliary muscles contract to increase curvature of lens.
D. Pupil dilates and ciliary muscles contract to increase curvature of lens.

41. Which of the following actions does ***not*** involve cerebrum?

A. Knee-jerk reflex
B. Blinking of an eye
C. Breathing
D. Swallowing of saliva

42. The functions of placenta involve

(1) Separate the mother's and the fetus' blood.
(2) Provide nutrients to the fetus.
(3) Secrete hormones to maintain the thickness of uterine lining.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

43. Which of the following are the outcomes of removal of ovaries in a human female?

(1) That female cannot reproduce naturally anymore.
(2) The hormone balance in that female is disrupted.
(3) That female will have an increase in the risk of osteoporosis.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

44. A student looked at a clock and saw that it is a half past nine. Which of the following images is formed on his/her retina?

A. 

B. 

C. 

D. 

45. Which of the following are human physiological responses to cold temperature?

(1) Shivering
(2) Restriction of peripheral blood flow
(3) Increased production of metabolic heat

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

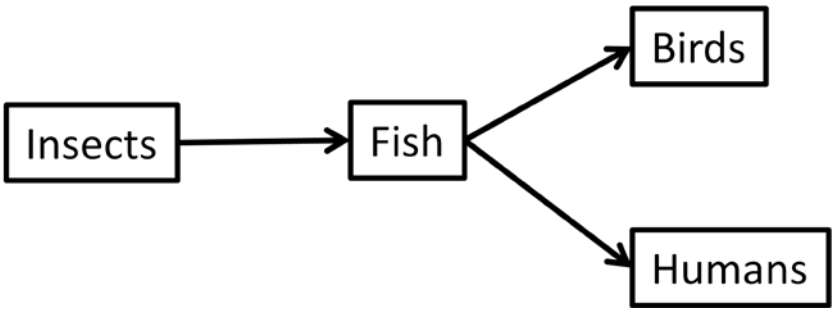
46. Which of the following is a climax community?

A. Forest
B. Grassland
C. Shrubland
D. Plantation

47. In a normal grassland ecosystem, which of the following will have the largest total biomass?

A. Grasshopper
B. Snake
C. Fox
D. Eagle

Directions for Questions 48 and 49: the following diagram shows a lake in Africa which has a simple ecosystem with a simple food web:



48. Two days ago, an international organization sprayed a pesticide in that lake to control Malaria and killed off 90% of the insects. Other than the decrease in the insect population, which of the following changes you would also expect to see at the lake today?

    A. No other changes
    B. Fish population increase
    C. Bird population decrease
    D. Local people complain of decreasing fish catch

49. Which of the following changes will take place at that lake one year later?

    (1) Insect population will increase
    (2) Bird population will decrease
    (3) Local people will have less fish to eat

    A. (1) and (2) only
    B. (1) and (3) only
    C. (2) and (3) only
    D. (1), (2) and (3)

50. Which of the following ecological organization in ascending order is ***correct***?

    A. Individuals, Community, Population, Ecosystem
    B. Community, Individuals, Population, Ecosystem
    C. Community, Population, Individuals, Ecosystem
    D. Individuals, Population, Community, Ecosystem

51. Which of the following features is ***highly unlikely*** to be possessed by a nocturnal animal?

A. Good olfactory sensors
B. Echo location
C. Good color vision
D. Large eyes

52. The body mass index (BMI) is a measure of body fat proportion based on height and weight that applies to adult men and women. It can be calculated using the formula below:

$$\text{BMI} = \frac{\text{weight (kg)}}{\text{height}^2\ (\text{m}^2)}$$

The BMI categories are shown in the table below.

BMI	Category
< 18.5	underweight
18.5-25	normal
25.1-29.9	overweight
≥ 30	obese

Peter is 190 cm tall and weighs 65 kg. What action should he take to restore his BMI to normal?

A. Do more exercises.
B. Increase the energy intake.
C. Decrease the sugary and fatty food intake.
D. Increase the intake of food which is rich in Vitamin C.

53. Which of the following combination of the infectious disease and its respective pathogen is ***correct***?

	Diphtheria	Hepatitis B	Athlete's foot
A.	bacterium	virus	fungi
B.	bacterium	fungi	virus
C.	virus	bacterium	fungi
D.	virus	fungi	bacterium

54. Which of the following methods may help to acquire active immunity?

    (1) having a disease
    (2) receiving a serum injection
    (3) receiving a vaccine injection

    A. (1) and (2) only
    B. (1) and (3) only
    C. (2) and (3) only
    D. (1), (2) and (3)

55. Which of the following statements about secondary immune response is ***not*** correct?

    A. Antibodies are made quickly and in great amounts than in a primary immune response.
    B. High level of antibodies can last longer than in a primary immune response.
    C. Antibodies produced from primary immune response are reusable.
    D. It stimulates lymphocyte and causes humoral immune response or cell-mediated immune response.

56. Which of the following white blood cells ***cannot*** carry out phagocytosis?

    A. Neutrophils
    B. Lymphocytes
    C. Monocytes
    D. Macrophages

57. Which of the following substances are produced in non-specific immune responses?

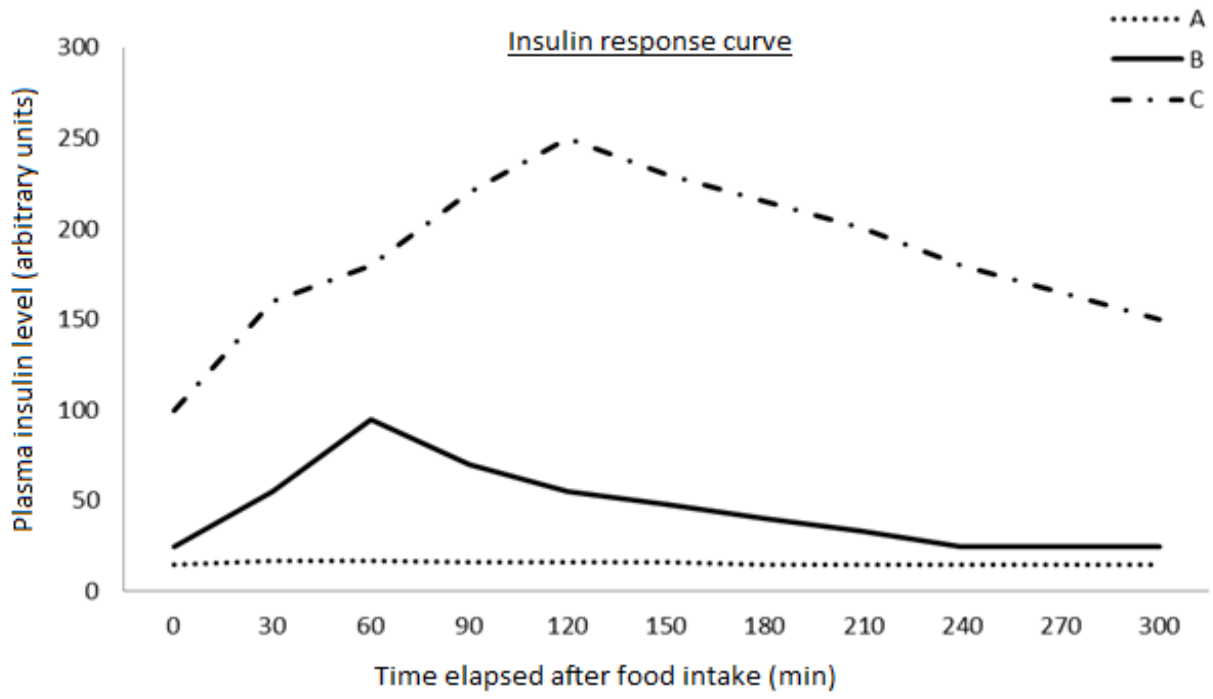
    (1) production of histamine by mast cell
    (2) production of fibrinogen for blood clotting
    (3) production of antibody from plasma cell

    A. (1) and (2) only
    B. (1) and (3) only
    C. (2) and (3) only
    D. (1), (2) and (3)

58. Which of the following combination about the form of cancer and its screening method is ***correct***?

	Pap smear	**Red blood cells in faeces**
A.	ovarian cancer	liver cancer
B.	cervical cancer	pancreatic cancer
C.	ovarian cancer	stomach cancer
D.	cervical cancer	colon and rectal cancer

Directions for Questions 59 and 60: The graph below shows three insulin response curves, which belongs to three persons A, B and C respectively. Given that curve B belongs to a healthy person, and the other two persons are suffering from diabetes mellitus.



59. What type of diabetes mellitus does curve A and C correspond to?

	Curve A	Curve C
A.	non-insulin dependent diabetes	insulin dependent diabetes
B.	insulin dependent diabetes	non-insulin dependent diabetes
C.	insulin independent diabetes	high insulin diabetes
D.	high insulin diabetes	insulin independent diabetes

60. Which of the following symptoms is ***not*** commonly seen in diabetic patients such as Person C?

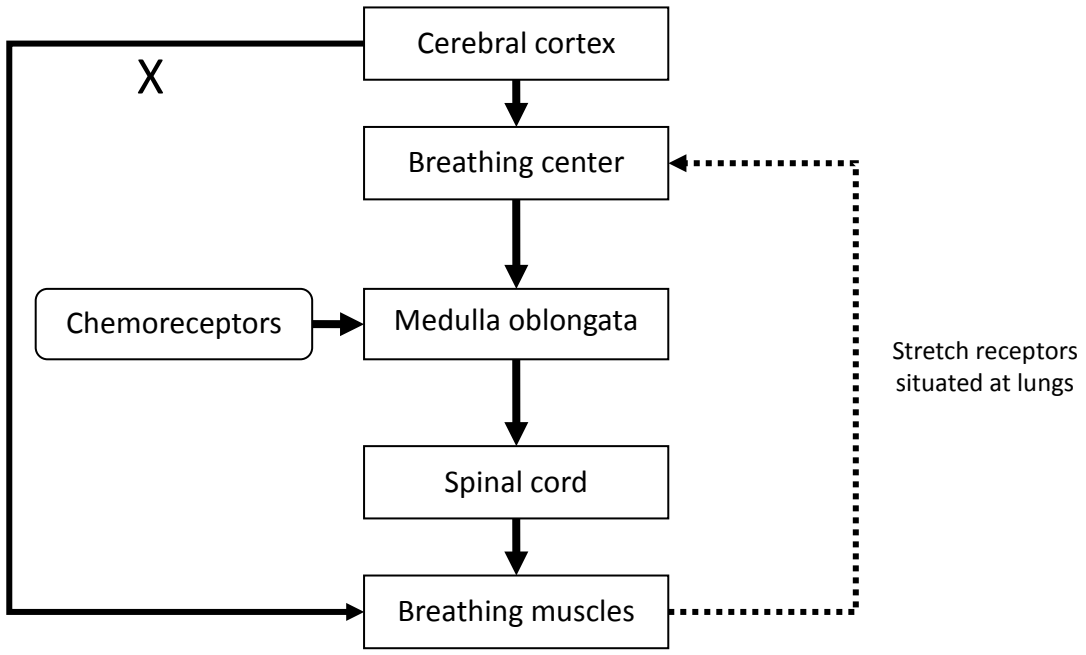
A. Increased thirst
B. Frequent urination
C. Strong fruity breath odor
D. Unexplained weight loss

End of Part A

Part B：Structured Questions (15 marks)

Answers to all questions should be written in the spaces provided on Part B answer sheet.

1. The following diagram represents the regulation of ventilation by the central nervous system (CNS). The breathing process involves sensory, association and motor components.



(a) Name ***one*** kind of breathing muscle. (1 mark)

(b) What kind of feedback mechanism does the dotted line represent? (1 mark)

(c) State one place in the breathing system where the chemoreceptors are located. (1 mark)

(d) What kind of control does the 'X' represent in the diagram? (1 mark)

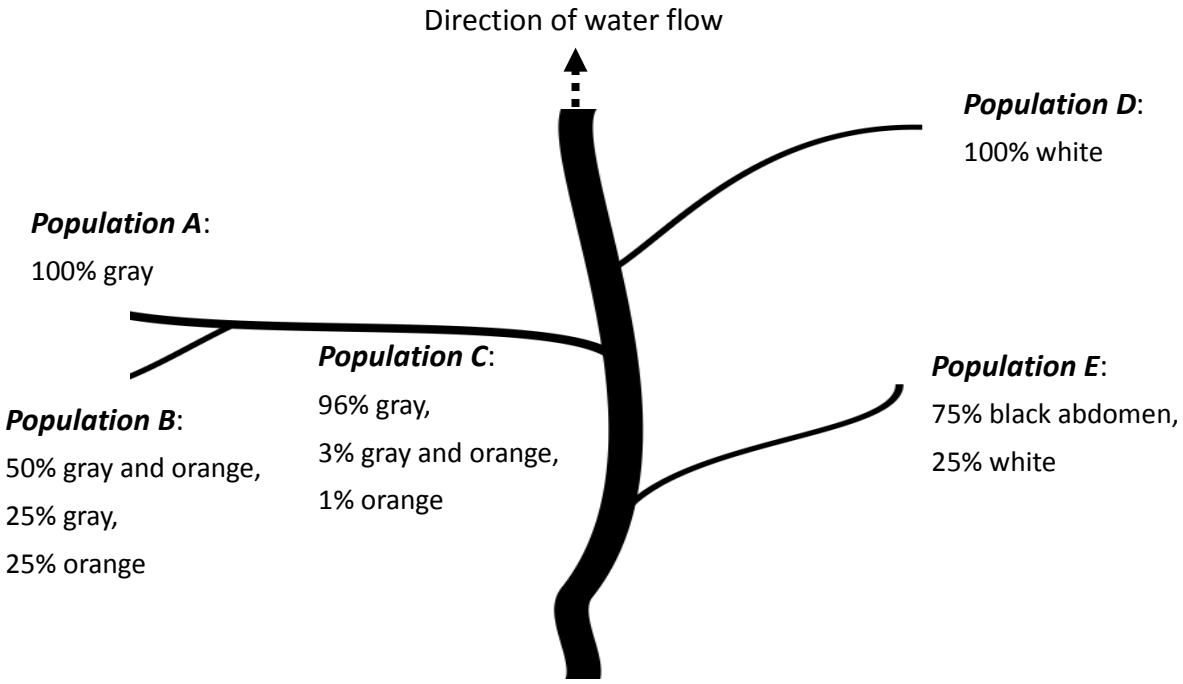
(e) At breathing centre, expiratory centre often inhibits the inspiratory centre. Why is it important to us? (1 mark)

2. Medaka fish has different colored phenotypes. Their body color is controlled by a pair of alleles. Four different alleles are found and listed below:

Allele	phenotype
gr	gray back
bl	black abdomen
wh	white body
or	orange body

Allele *wh* is recessive while the other three alleles are co-dominant.

Five differently colored populations of Medaka fish are found in a stream as shown in the daigram below:



(a) How does a new allele arise in Medaka fish? (1 mark)

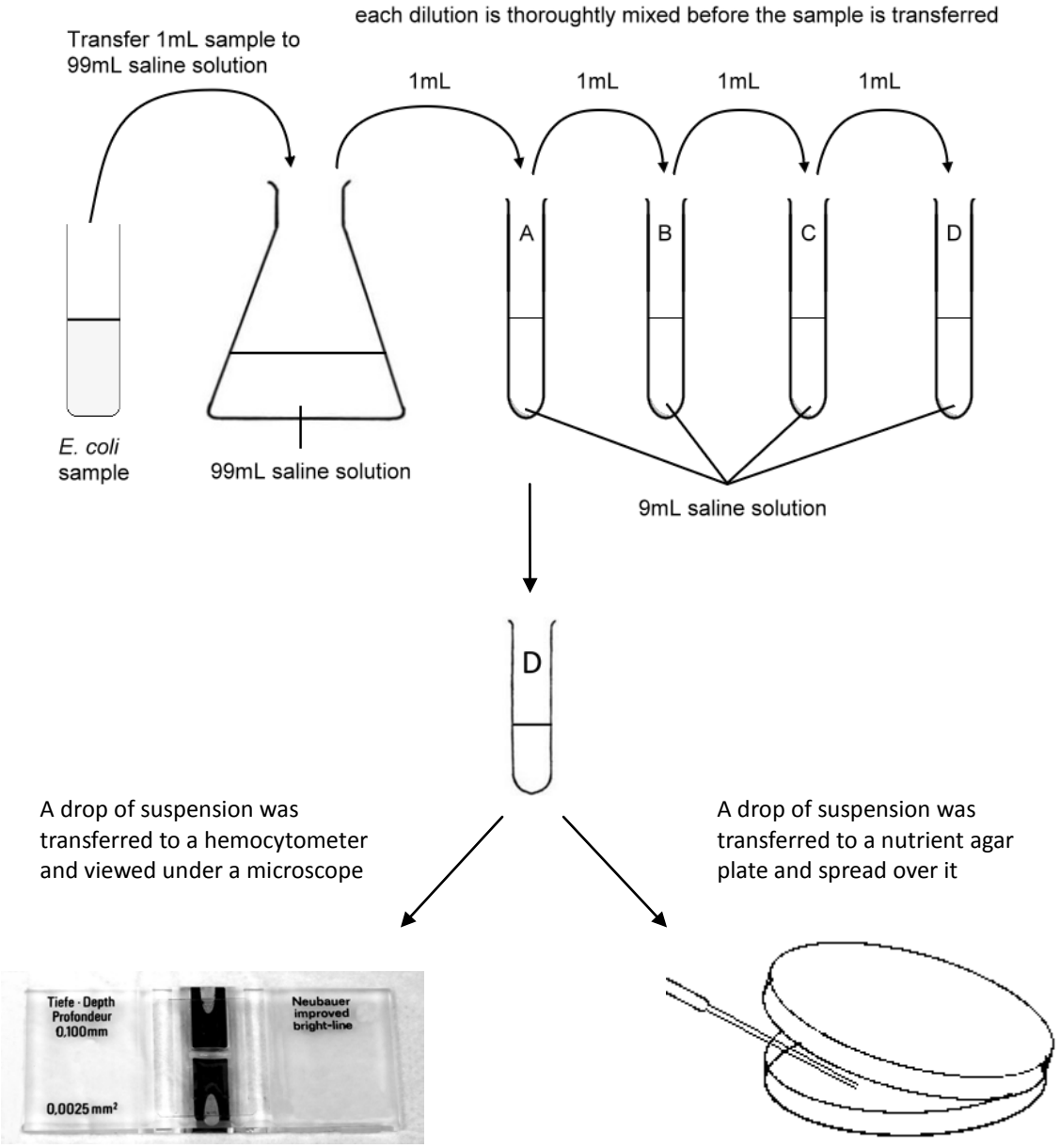
(b) Given that an individual of Medaka fish has the genotype *blwh*, what is the phenotype of it? (1 mark)

(c) How many genotypes can an orange individual possibly have? (1 mark)

(d) Which populations have no interbreeding with population D? (1 mark)

(e) A student collects 100 male fish from population A and another 100 female fish from population E. He mixes all the fish together and allows them to breed. What is the expected percentage of fish that will be white in the offspring? (1 mark)

3. A laboratory technician was provided with a small tube of *E. coli* sample and was asked to determine its concentration. He used aseptic techniques to perform a serial dilution first and then used a hemocytometer as well as the spread plate method to count the number of bacterial cells. The following diagram shows the procedures:



(a) (i) Why dilution is necessary before cell counting? (1 mark)

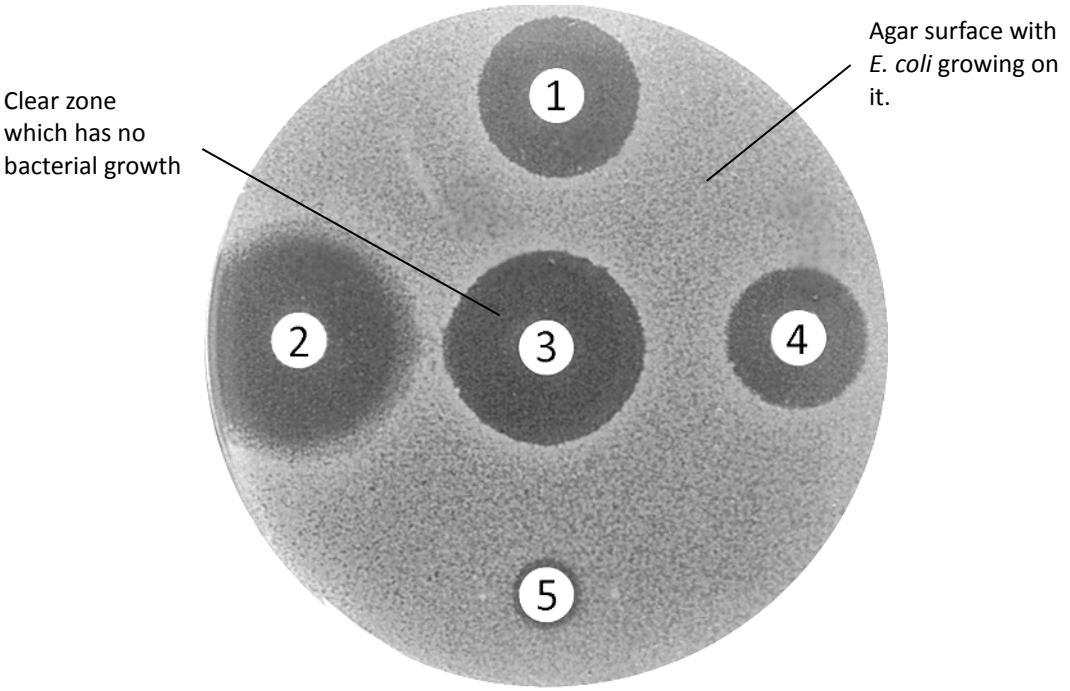
(ii) Calculate the dilution factor of sample in test tube D.
(Express your answer in index form) (1 mark)

Later, the technician found that the bacterial cell count by hemocytometer was always slightly higher than that of the spread plate method, even though he had repeated the experiment several times.

(b) Give ***one*** reason to account for the difference. (1 mark)

(c) State another method that can measure cell count. (1 mark)

In order to find out which antimicrobial agent is most effective in killing the *E. coli*, he put 5 antibiotic discs on the agar plate which had a thin layer of *E. coli* spread on the surface. The following diagram illustrates the result:



(d) Which antibiotic is most effective in killing the *E. coli*? (1 mark)

END OF PAPER