

**Hong Kong Joint School Biology Olympiad**

**HKJSBO**

**Hong Kong Joint School Biology Olympiad 2017-18**

**Round One Multiple Choice Question Paper**

**Date: October 7, 2017 (Saturday)**

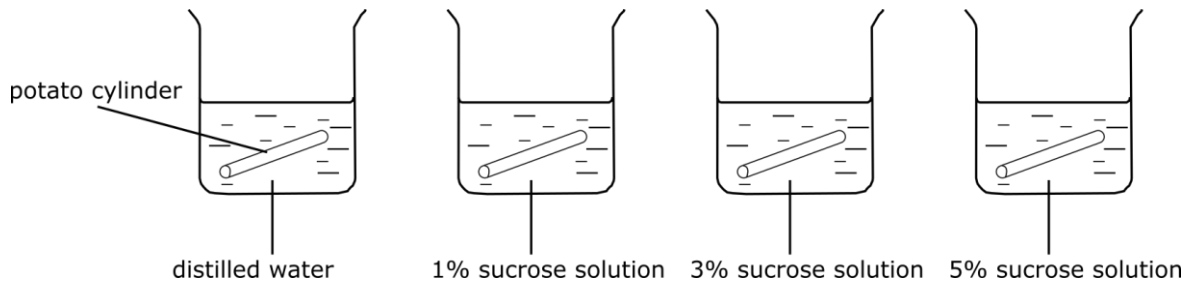
**Duration: 120 minutes**

**Instructions**

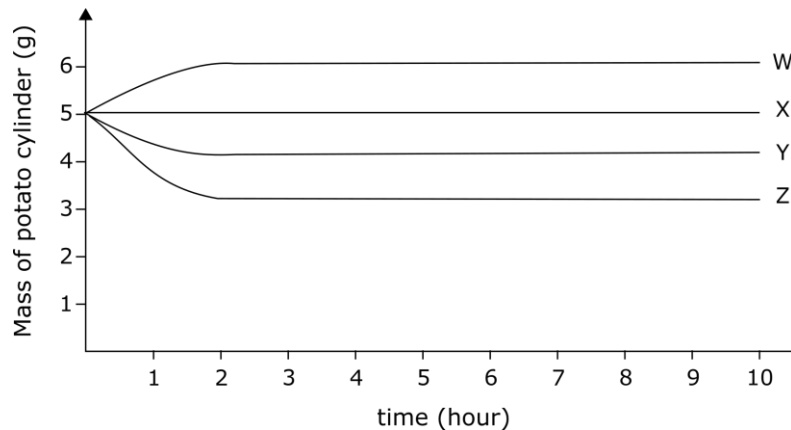
1. Attempt ALL questions in this paper.
2. Indicate your answers on the separate Multiple Choice Answer Sheet provided.
3. Read the instructions on the Multiple Choice Answer Sheet.
4. You may use a calculator in your exam.
5. Marks will not be deducted for incorrect answers.
6. You may not leave the exam room until one hour after the start and before the last 15 minutes of the exam.
7. This question paper must not be taken out of the exam room.
8. GOOD LUCK.

## Multiple Choice Questions (55 marks)

**Directions:** Questions 1 and 2 refer to the experiment shown in the diagram below. Four potato cylinders with equal length and mass were freshly prepared from a peeled potato. They were placed in four beakers as shown below:



Potato cylinders were recovered from the solution at different time points and the masses were recorded and presented graphically as shown below:



- Which of the curves shows the result obtained from the beaker with 3% sucrose solution (蔗糖溶液)?
  - W
  - X
  - Y
  - Z
- With reference to the graph, what is the water potential (水勢) of the cells of the potato cylinder in the distilled water at the start and after three hours of the experiment?
 

<i>At the start</i>	<i>After three hours</i>
A. Equal to the water potential of 1% sucrose solution	0
B. Equal to the water potential of 5% sucrose solution	Equal to the water potential of 6% sucrose solution

C. 0

Equal to the water potential of 1% sucrose solution

D. 0

0

3. The table below shows the results of an investigation into the effect of temperature on egg-laying in red spider mites.

Temperature (°C)	Average length of egg laying period (days)	Average number of eggs laid per female during egg laying period
20	24	72
25	18	72
30	12	72

According to the above table, as the temperature increases, which of the following is correct?

- The average number of eggs laid per female per day increases
  - The average size of eggs decreases.
  - The mites will hatch from the eggs faster.
- A. 1 only  
B. 1 and 2 only  
C. 2 and 3 only  
D. 1, 2 and 3
4. In 1952, Chargaff studied the proportions of the four bases in the DNA in different organisms. The table below shows some of his data obtained.

Organism	%A	%G	%C	%T
Maize	26.8	22.8	23.2	27.2
Octopus	33.2	17.6	17.6	31.6
Chicken	28.0	22.0	21.6	28.4
Rat	28.6	21.4	20.5	28.4
Human	29.3	20.7	20.0	30.0

The rules Chargaff worked out with his data were found almost universally correct. According to these rules, if the percentage of T in the DNA of an organism X is approximately 30%, what is the approximate percentage of G in the DNA?

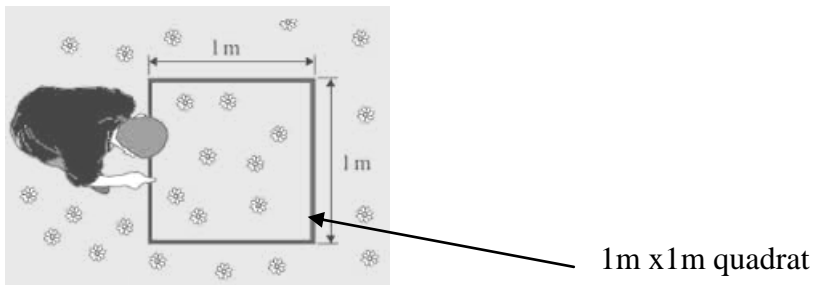
- A. 20%
- B. 30%
- C. 40%
- D. not known

5. A virus (病毒) was found violating Chargaff's rules with the base proportion shown below.

Organism	% A	% G	% C	% T
Virus B	24.0	23.3	21.5	31.2

Which of the following is the most likely explanation for that finding?

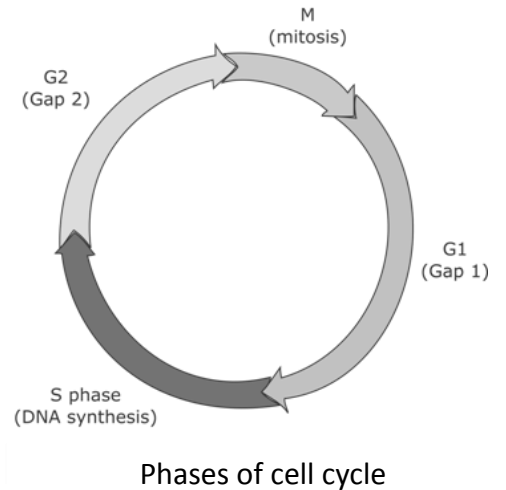
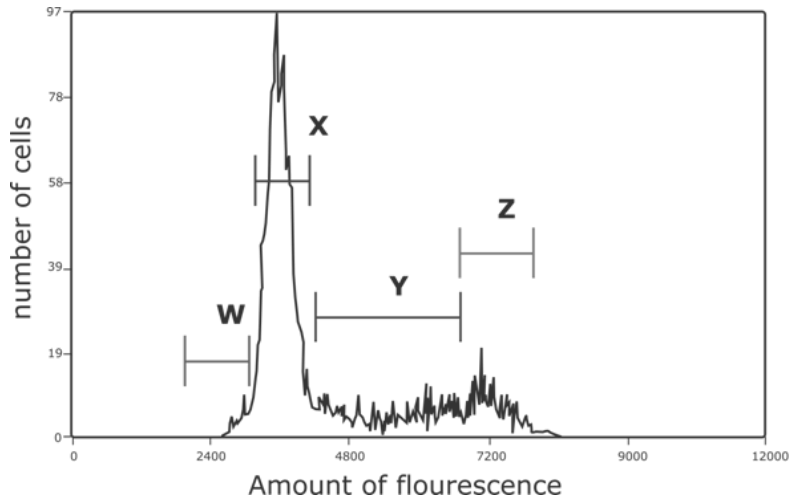
- A. The base pairing rules between the two strands (股) of DNA do not apply in this virus.
  - B. The DNA of the virus B is single-stranded.
  - C. The genetic material of the virus is RNA.
  - D. The virus undergoes many mutations in its DNA.
6. A student used a quadrat (樣方) to estimate the abundance of buttercups (a plant) in a field. He threw out the quadrat randomly three times in the field and measured the abundance of buttercups, if any, in the quadrat.



Which of the following can make the results better reflect the abundance of buttercups in the field?

1. Throw out the quadrat for ten times.
  2. Use a larger quadrat.
  3. Only place the quadrat at locations with buttercups.
- A. 1 only
  - B. 1 and 2 only
  - C. 2 and 3 only
  - D. 1, 2 and 3

**Directions:** Question 7 and 8 refers to the diagrams below. When the DNA of a cell is stained (染色) by a fluorescent dye, the amount of fluorescence a cell emits indicates the amount of DNA inside the cell. The graph below shows the fluorescence emitted by a population of cells at different phases of the cell cycle.



7. Which phase(s) of the cell cycle are most of the cells in X and Z in?

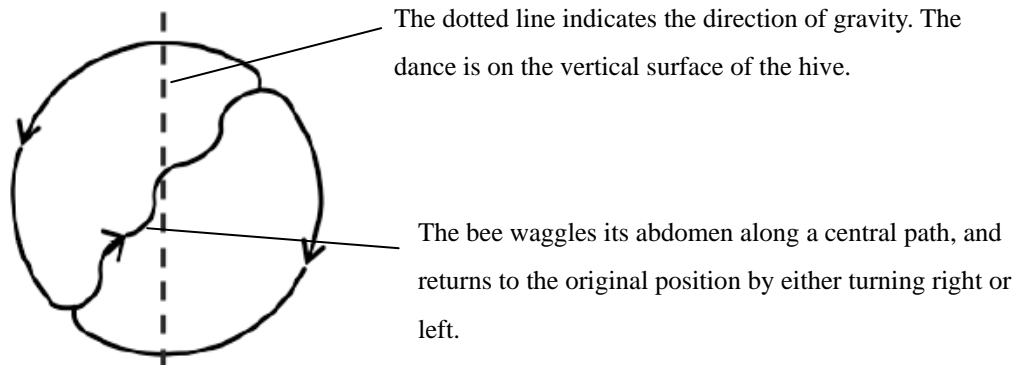
	<u>X</u>	<u>Z</u>
A	S	M
B	G1	G2 and M
C	S	G1
D	G1	S

8. With reference to the graph, which of the following can be concluded about the cells in Y?

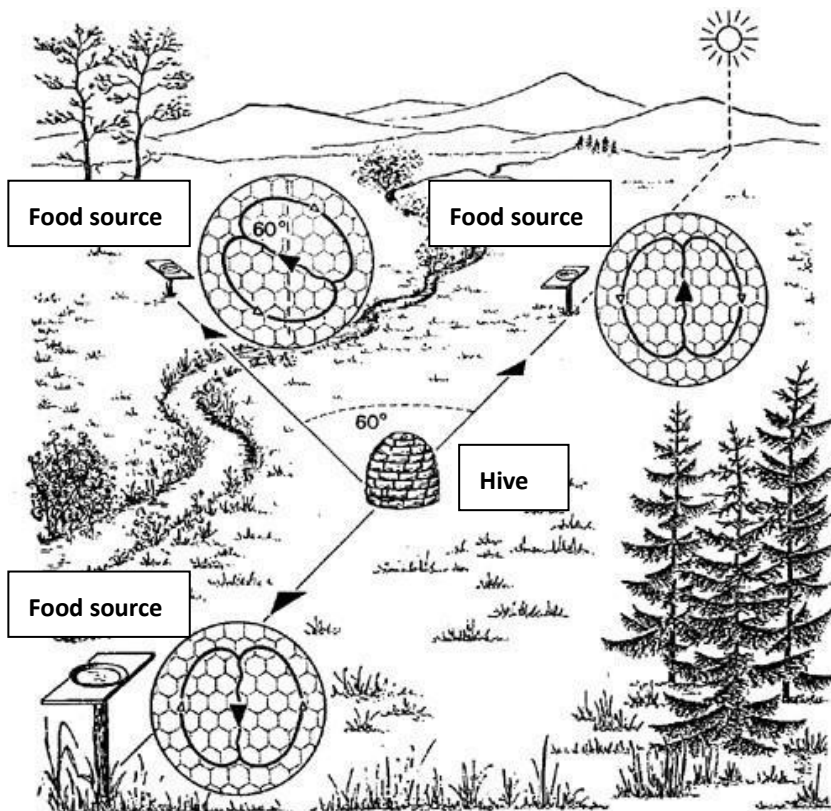
1. Cells in Y are most variable in their DNA contents.
2. Cells in Y are replicating (複製) their DNA.
3. Cells in Y have the smallest amount of DNA.

- A. 1 only
- B. 1 and 2 only
- C. 2 and 3
- D. 1, 2 and 3

**Directions:** Some bee species (物種) will display a wobble dance in the hive to inform other bees the direction of the food. The figure below shows one form of dance by a bee species.



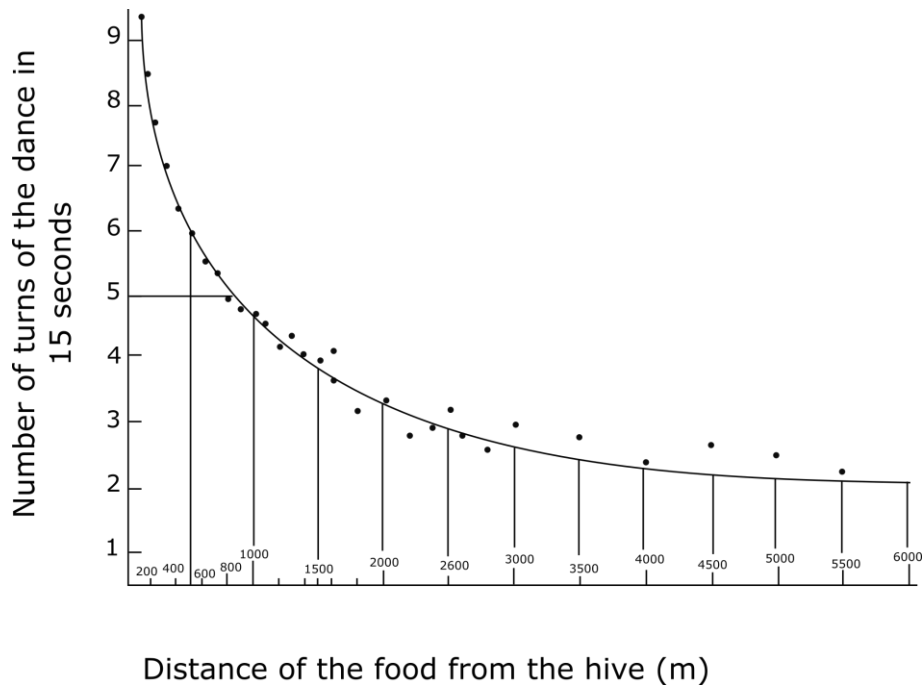
The figure below shows the dances made by the bees to indicate the directions of three food sources.



9. With reference to the information in the above figure, how does the bee dance indicate the direction of the food source?

- A. The food source is in the direction of the central path of the dance.
- B. The food source is  $60^\circ$  to the left of the central path of the dance.
- C. The food source is in the middle between the central path and the direction of the sun.
- D. The food source is at an angle to the sun, which equals to the angle between the central path of the dance and the line of gravity.

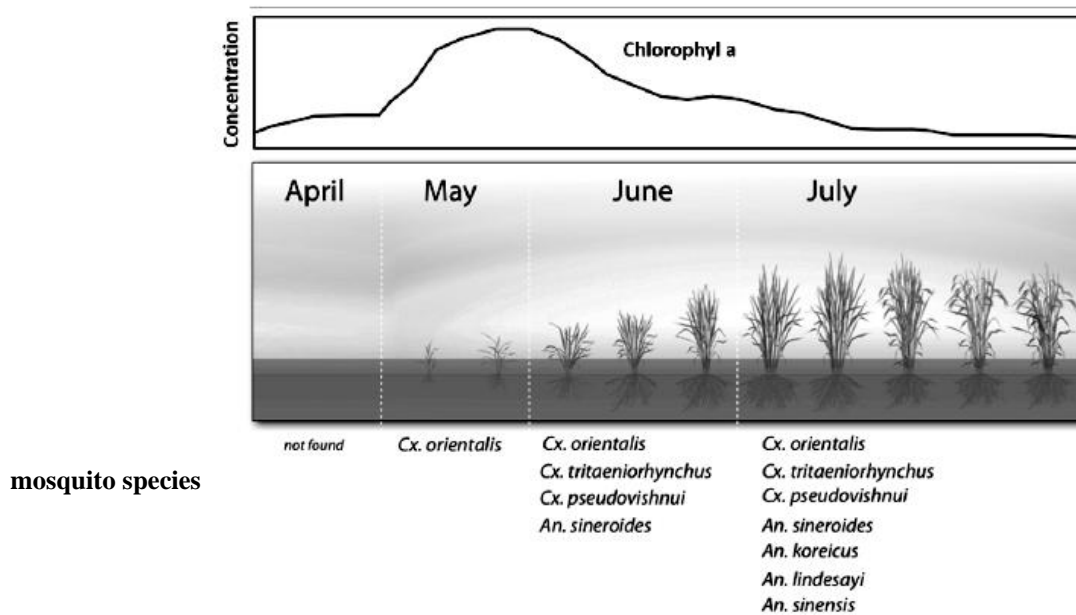
10. About 4000 bees were observed for their dance and the distance of the food it indicated. The results are shown in the graph below.



Which of the following can be concluded from the above graph?

1. The faster a bee dances, the closer the food is.
  2. The dance cannot indicate the distance of the food, but only its direction.
  3. The farther the food is, the less accurate is the dance to show the distance of the food.
- 
- A. 1 only
  - B. 2 only
  - C. 3 only
  - D. 1 and 3 only

11. Rice fields are habitats (生境) for many aquatic (水生) organisms, including mosquito larvae and phytoplankton (浮游植物) (photosynthetic microscopic organisms). The figure below shows the changes in the amount of phytoplankton (expressed as chlorophyll a concentration) and the mosquito species found from April to July in a rice field.



Based on the information provided in the above figure, which of the following is/are correct about the rice field ecosystem (生態系統)?

1. The amount of phytoplankton decreased from June because they were eaten by the mosquito larvae in water.
2. The number of mosquito species is positively correlated with the rice biomass (生物量).
3. The rice field ecosystem has a greater biodiversity (生物多樣性) in July than in May.

- A. 1 only
- B. 1 and 2 only
- C. 2 and 3 only
- D. 1, 2 and 3



12. Below is the RNA codon (密碼子) table, which shows the amino acids encoded by the 3-base codons on mRNA.

**Codons in mRNA**

First Base	Second Base								Third Base
	U	C	A	G	U	C	A	G	
	UUU	Phenylalanine	UCU	Serine	UAU	Tyrosine	UGU	Cysteine	U
U	UUC	Phenylalanine	UCC	Serine	UAC	Tyrosine	UGC	Cysteine	C
	UUA	Leucine	UCA	Serine	UAA	Stop	UGA	Stop	A
	UUG	Leucine	UCG	Serine	UAG	Stop	UGG	Tryptophan	G
	CUU	Leucine	CCU	Proline	CAU	Histidine	CGU	Arginine	U
C	CUC	Leucine	CCC	Proline	CAC	Histidine	CGC	Arginine	C
	CUA	Leucine	CCA	Proline	CAA	Glutamine	CGA	Arginine	A
	CUG	Leucine	CCG	Proline	CAG	Glutamine	CGG	Arginine	G
	AUU	Isoleucine	ACU	Threonine	AAU	Asparagine	AGU	Serine	U
A	AUC	Isoleucine	ACC	Threonine	AAC	Asparagine	AGC	Serine	C
	AUA	Isoleucine	ACA	Threonine	AAA	Lysine	AGA	Arginine	A
	AUG	Methionine or start	ACG	Threonine	AAG	Lysine	AGG	Arginine	G
	GUU	Valine	GCU	Alanine	GAU	Aspartic Acid	GGU	Glycine	U
G	GUC	Valine	GCC	Alanine	GAC	Aspartic Acid	GGC	Glycine	C
	GUA	Valine	GCA	Alanine	GAA	Glutamic Acid	GGA	Glycine	A
	GUG	Valine	GCG	Alanine	GAG	Glutamic Acid	GGG	Glycine	G

A protein is translated (轉譯) from the template strand (模板股) of a DNA consisting of the following segment:

5' - AGCGAACTAGGATCGCGAAGATCC- 3' coding strand (編碼股)  
 3' - TCGCTTGAT CCTAGCGCTTCTAGG- 5' template strand  
 1 4 7 10 13 16 19 22 nucleotide (核苷酸) number

What would happen to the protein when the following two mutations occur simultaneously in the template strand of this segment of DNA:

- ♦ Substitution (取代) of C by T at nucleotide number 10
  - ♦ Deletion (缺失) of G at nucleotide number 16.
1. The glycine encoded by the codon at nucleotide number 10-12 is replaced by an arginine.
  2. Most of the original amino acids will change to other amino acids after the nucleotide number 16.
  3. The protein likely loses its function.

- A. 1 only
- B. 1 and 2 only
- C. 2 and 3 only
- D. 1, 2 and 3

13. The duck-billed platypus (鴨嘴獸) was first found in the 18th century. Scientists once thought it was a hoax because they did not know how to classify it. According to the classification system at that time, all hairy endotherms\* (內溫動物) that give birth and feed milk to live young are mammals, while feathery endotherms that lay eggs are birds. Platypus is an endotherm that has hair and feeds milk to the young, but it lays eggs! Scientists later classified platypus as mammals by creating a special group of egg-laying mammals called monotremes (單孔目動物).

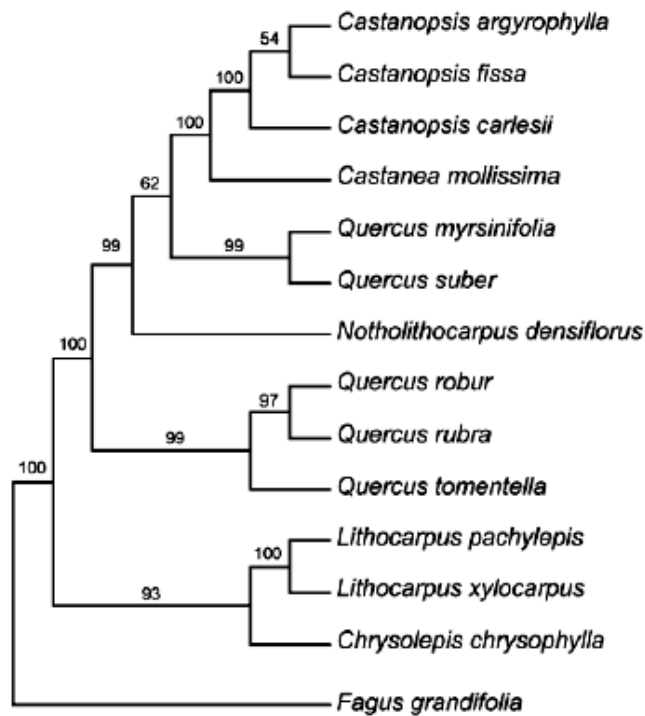
\* endotherm: animals whose body temperature is mainly controlled by the heat they produce rather than by the environment.



Which of the following is correct about the classification of the platypus ?

- A. Classification of the platypus as mammals is entirely based on the personal opinions of the scientists. The creation of monotremes as a subgroup of mammals is entirely arbitrary (人為的) and subjective(主觀的).
- B. Classification of the platypus as mammals is entirely based on the objective facts (客觀事實) about the platypus. Monotremes as a subgroup of mammals exist in nature already, but this subgroup was discovered after the platypus was found.
- C. Classification of the platypus as mammals is based on both the objective facts and opinions of the scientists. Monotremes as a subgroup of mammals is created by the scientists based on some objective facts.
- D. The platypus is a special animal so it is classified in a special way. But the subgroup monotremes does not affect the principles for the classification of mammals.

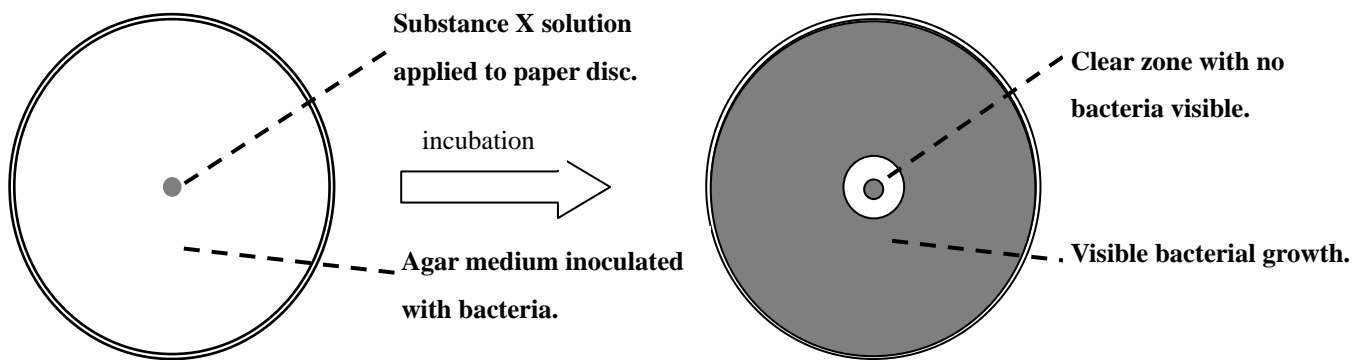
14. Which of the following is correct about the classification of the platypus in the future?
- A. Platypus may be re-classified into other groups when there are enough scientists who change their opinions, even though the facts are the same.
  - B. Platypus will only be re-classified into other groups when there are new discoveries related to the animal.
  - C. Platypus as a mammal under the subgroup of monotremes is an objective fact that will not change in the future.
  - D. Platypus as a mammal under the subgroup of monotremes is a consensus among scientists. Therefore it will not change in the future.
15. The diagram below shows the phylogenetic relationships (系統發生的關係) of the species of the plant family Fagaceae.



- Which of the following species has the closest evolutionary (進化) relationship with *Quercus suber*?
- A. *Castanea mollissima*
  - B. *Notholithocarpus densiflorus*
  - C. *Quercus robur*
  - D. *Lithocarpus pachylepis*

**Directions:** Questions 16 to 18 refer to the experiment shown in the diagrams below. In order to measure its sensitivity as an antibacterial agent (抗菌劑), solution of Substance X was applied to an agar plate (瓊脂平板) which had been inoculated (接種) with a test bacterial strain (細菌系).

After incubation, the diameter of the clear zone (without visible growth of bacteria) around the paper disc was recorded.

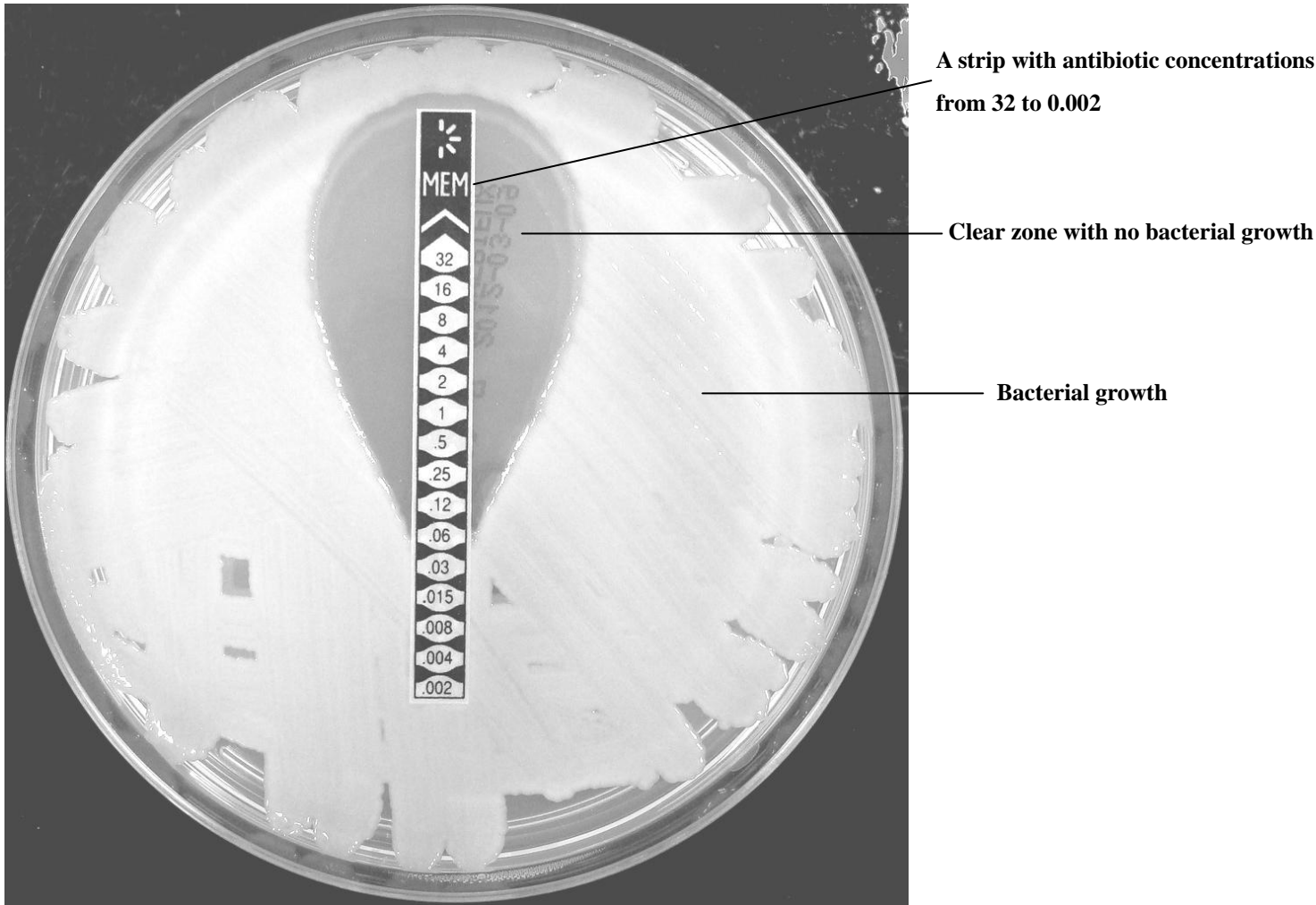


16. Using this technique, which of the following is the best way to find out the \*minimum inhibitory concentration (MIC) of Substance X against a bacterial strain?

\* MIC is the lowest concentration of a substance that prevents the growth of a bacterial strain.

- A. At least five repeats of the same experiment, using the same concentration of Substance X.
  - B. The same concentration of Substance X, together with solutions of a range of known antibiotics (抗生素), applied to separate paper discs on the same agar plate.
  - C. Solution of different concentrations of Substance X applied to separate paper discs on the same agar plate.
  - D. The same concentration of Substance X applied to several agar plates inoculated with different concentrations of the bacteria.
17. Which of the following is/are the assumptions (假定) underlying this test?
- 1. The test substance is soluble in the agar.
  - 2. There is no interaction between the test substance and the agar medium.
  - 3. The bacteria grow evenly on agar plates.
- A. 1 only
  - B. 1 and 3 only
  - C. 2 and 3 only
  - D. 1, 2 and 3

18. A paper strip is developed to assess the sensitivity of an antibiotic conveniently. This is a strip with a gradient of concentrations of an antibiotic. When it is placed on an agar plate inoculated with bacteria, the following result may be observed after incubation.



Which of the following is/are correct with reference to the results shown in the above figure?

1. The antibiotic can inhibit the growth of the bacteria.
2. The inhibitory effect of the antibiotic depends on its concentration.
3. At a concentration of 0.008, the antibiotic cannot inhibit the growth of the bacteria.

- A. 1 only
- B. 1 and 2 only
- C. 2 and 3 only
- D. 1, 2 and 3

**Directions:** Questions 19 and 20 refer to the following formula of the Bray-Curtis index ( $BC_d$ ). This index is used to express the *ecological dissimilarity* (生態不相似) between two different sites.

$$BC_d = \frac{\sum |x_i - x_j|}{\sum (x_i + x_j)}$$

here,

$X_i$  is the number of individuals of each species (物種) found at site  $i$ ;

$X_j$  is the number of individuals of each species found at site  $j$ ;

$\sum |x_i - x_j|$  is the sum of the differences of number of individuals of each species between two sites  $i$  and  $j$ , without regard to its positive or negative signs.

$\sum (x_i + x_j)$  is the sum of the total numbers of individuals of each species in the two sites  $i$  and  $j$

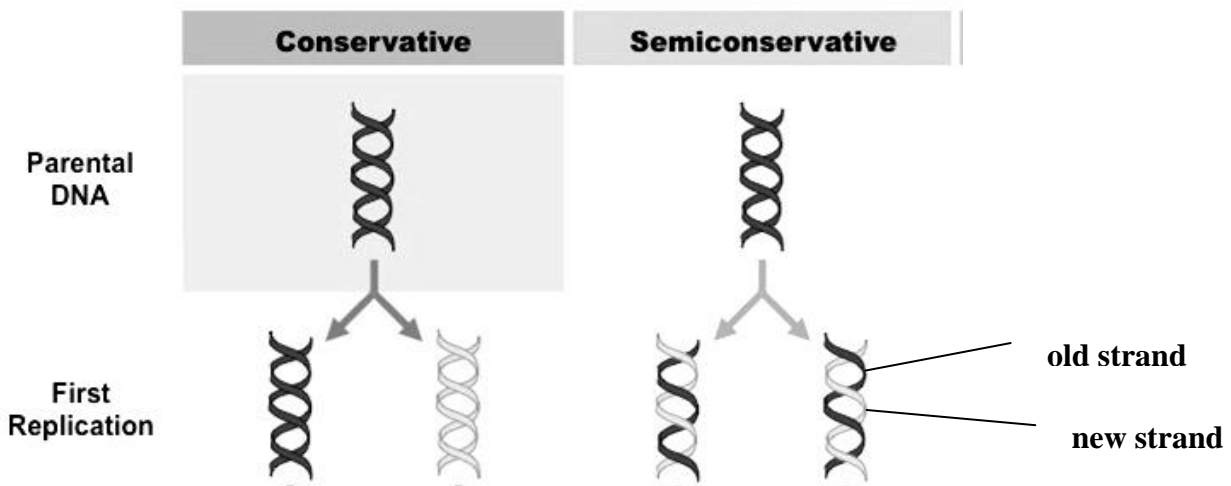
19. What is the Bray-Curtis index between site L and M?

Species	Site L	Site M
rabbits	10	0
voles	4	5
squirrels	0	3
mice	0	6
sparrows	6	2
toads	2	2
TOTAL	22	18

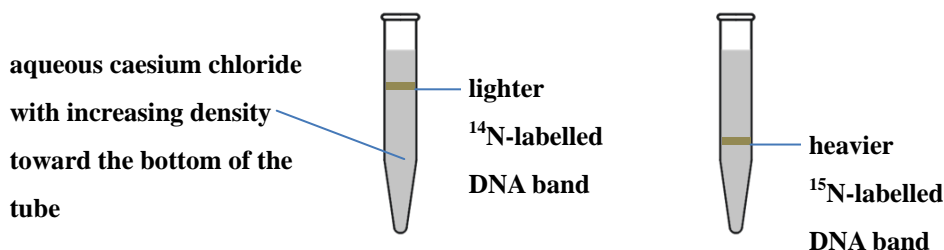
- A. 0.1
- B. 0.3
- C. 0.6
- D. 0.9

20. Which of the following is correct when the Bray-Curtis index is 0 between two sites?
1. The two sites have the same species of organisms.
  2. The two sites have the same number of species.
  3. The two sites have the same number of individuals of each species.
- A. 1 only  
 B. 1 and 3 only  
 C. 2 and 3 only  
 D. 1, 2 and 3


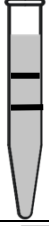

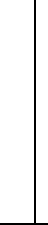
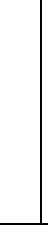
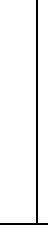






**Directions:** Questions 21 -22 refer to the experiment performed by Meselson and Stahl in 1958. They aimed to find out whether DNA replication (複製) is conservative (保守) or semi-conservative (半保留). In the conservative mechanism, a new DNA consisting of two new strands is produced. In a semi-conservative mechanism, each new DNA consists of one new and one old strand.



In their experiment, the bacteria were first incubated for 14 generations (代) in a medium containing radioactive  $^{15}\text{NH}_4\text{Cl}$  as the only nitrogen source. As such, the bacterial DNA consisted of  $^{15}\text{N}$ . Then, the medium was abruptly changed to  $^{14}\text{N}$ . From this time on, the newly synthesized DNA consisted of  $^{14}\text{N}$ , which was a little lighter than the DNA consisted of  $^{15}\text{N}$ . To separate the heavier and lighter DNA, the bacterial DNA was then sampled at regular intervals and centrifuged (離心分離) in caesium chloride solution. The caesium chloride solution forms a density gradient upon centrifugation so that the heavier DNA molecules will stop at lower position. The positions of the DNA bands were observed under ultraviolet radiation.

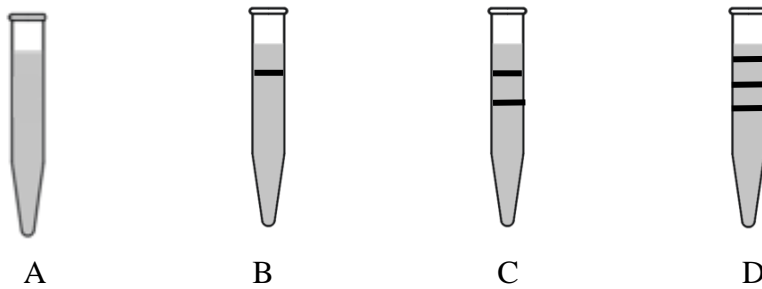
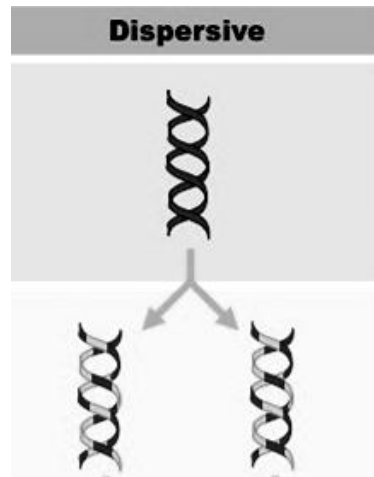


21. Which of the following shows the expected observations for conservative or semi-conservative replication, assuming that all the bacteria are replicating their DNA at the same time?

	Proposed mechanism of DNA replication	Before replication in the $^{14}\text{N}$ medium	after 1 <sup>st</sup> replication in the $^{14}\text{N}$ medium	after 2 <sup>nd</sup> replication in the $^{14}\text{N}$ medium
A	conservative			
B	conservative			
C	semi-conservative			
D	semi-conservative			



22. At the time, there was a third model of DNA replication proposed - dispersive model. This model hypothesizes that the old DNA materials are distributed randomly in the newly replicated DNA. According to the dispersive model, what is the expected observation obtained from the above experiment after the 2<sup>nd</sup> replication in the <sup>14</sup>N medium?



23. Giant pandas differ from other herbivores (草食性動物) in many ways. The amounts of the food eaten by horse and giant panda are compared in the table below:

	Dry mass of plant matter eaten per day per 100 kg body weight (kg)
Horse	1.3*
Giant panda	12.5

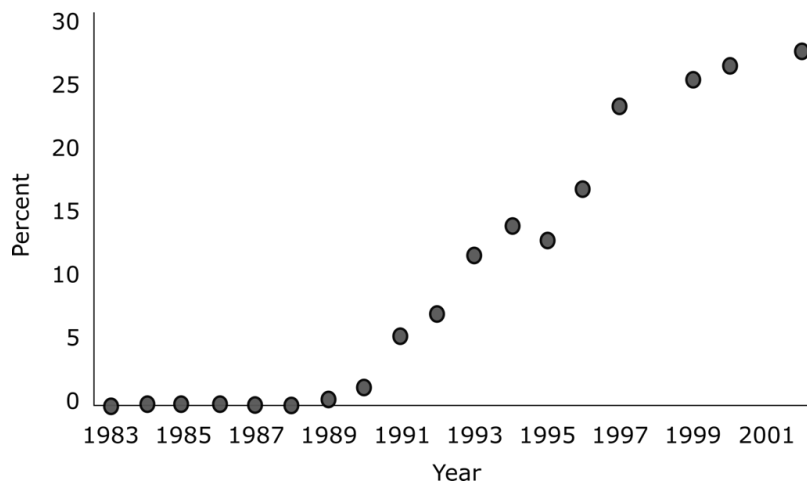
\* Adult horse on light work

Scientists suspect that giant pandas need to eat much more food than horse because their digestive system is not efficient to digest and absorb the nutrients in bamboos - the main food of giant pandas. Which of the following can support this hypothesis?

1. The faeces (糞便) of the giant pandas contains a higher proportion of undigested food than the horse.
  2. In the digestive tract of the giant pandas, there are no cellulose-digesting (消化纖維素的) bacteria found in horse.
  3. The digestive tract of the giant pandas is much shorter than that of the horse.
  4. The time between food is eaten and passed out as faeces is much shorter in the giant pandas than that in the horse.
- A. 1 and 2 only  
B. 2 and 3 only  
C. 1, 2 and 3 only  
D. 1, 2, 3 and 4
24. Some people argue that giant pandas are an evolutionary dead-end. That means, even without the interference of humans, it is doomed to extinction naturally. Which of the following supports that giant pandas are driven to extinction because of human interference rather than a natural process of evolution (進化)?
1. Giant pandas started to eat bamboos as their main food about 2 million years ago. The bamboos eaten by giant pandas will naturally flower and die off every 15 to 100 years.
  2. Giant pandas have relatively high levels of genetic variation (遺傳變異).
  3. The habitats of giant pandas have been seriously fragmented by roads and farmlands.
- A. 1 only  
B. 3 only  
C. 1 and 3 only  
D. 1, 2 and 3

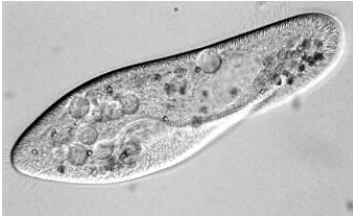
**Directions:** Questions 25 -26 refer to the figure below. Vancomycin is an antibiotic (抗生素) that has been used to fight bacterial infections in the United States since the early 1980s. The graph below shows the percentage of *Staphylococcus* bacteria that were found resistant to vancomycin from 1983 to 2001 in the intensive care unit (ICU) of the US hospitals.

Resistance to the antibiotic Vancomycin rose dramatically over the 1990s in us hospital intensive care units.

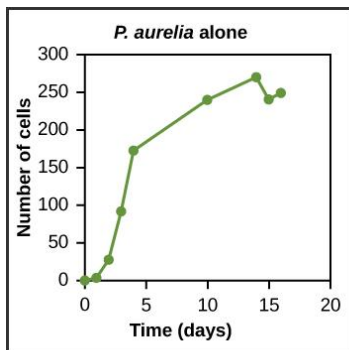


25. Which of the following statement(s) best describes the pattern shown in the above graph?
- From 1983 to 1988, there were no bacteria resistant to vancomycin found in the US hospital ICU.
  - From 1989 to 2001, the percentages of bacteria found to be resistant to vancomycin are increasing.
  - From 1997 to 2001, the rate of increase of the percentage of bacteria resistant to vancomycin is lower than before.
- 1 only
  - 3 only
  - 1 and 3 only
  - 1, 2 and 3
26. Which of the following are needed for the occurrence and spread of vancomycin resistant bacteria?
- Vancomycin is increasingly used to treat bacterial infections.
  - Some bacteria had taken up the plasmids (質粒) with vancomycin resistant genes (抗性基因).
  - Random mutations occur in the genes of the bacteria, making them resistant to vancomycin.
  - The vancomycin resistant bacteria survive and reproduce better than the same strain of bacteria without the resistance in any environment.
- 1 and 2 only
  - 3 and 4 only
  - 1, 2 and 3 only
  - 1, 2, 3 and 4

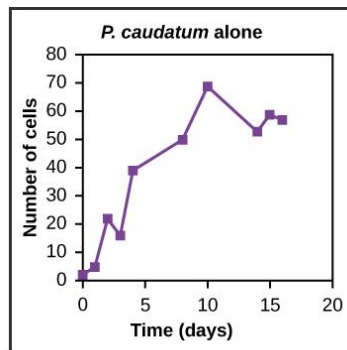
**Directions:** Questions 27-28 refer to the results of the experiment below. The graphs below show how the population size of two species of *Paramecium* (草履蟲) (single-celled organisms) changes over time when growing alone and when grown together in glass flasks filled with liquid growth media.



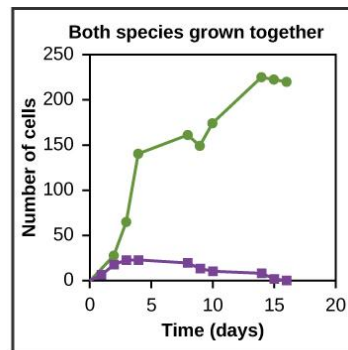
A *Paramecium*



(a)



(b)



(c)

27. Which of the following can support that the two species of *Paramecium* is having competition (競爭) when grown together?

1. When grown together, *P. aurelia* grows faster than *P. caudatum*.
2. *P. caudatum* grows more slowly when grown with *P. aurelia* than when it is grown alone.
3. *P. aurelia* grows more slowly when grown with *P. caudatum* than when it is grown alone.

- A. 1 only
- B. 1 and 2 only
- C. 2 and 3 only
- D. 1, 2 and 3

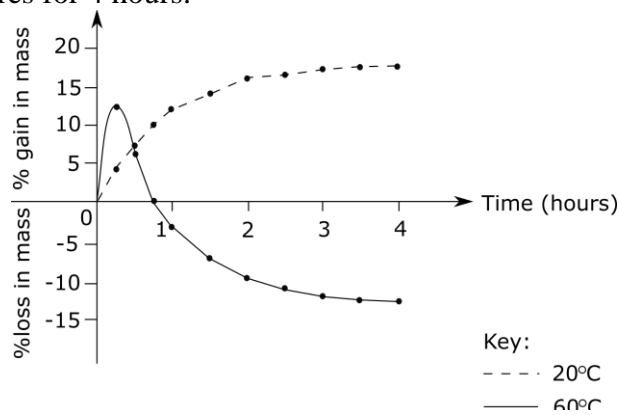
28. A scientist proposed a hypothesis (假説) that *P. aurelia* releases a water soluble chemical that kills *P. caudatum* when grown together. The scientist designed an experiment to test the hypothesis. The two species were grown in the same flask but separate them with a filter. The filter has pores that allow water to pass through but not for the *Paramecium*.

Which of the following result(s) of the experiment can reject this hypothesis? (The information in question 27 can be made reference.)

1. The population (種群) of *P. aurelia* grows as fast as when it was grown alone.
2. The population of *P. caudatum* grows as fast as when it was grown alone.
3. The population of *P. caudatum* shows similar growth as when it was grown together with *P. aurelia*.

- A. 1 only
- B. 2 only
- C. 1 and 2 only
- D. 1 and 3 only

29. The graph below shows the change in mass of 10 potato cylinders when placed in distilled water at two different temperatures for 4 hours:

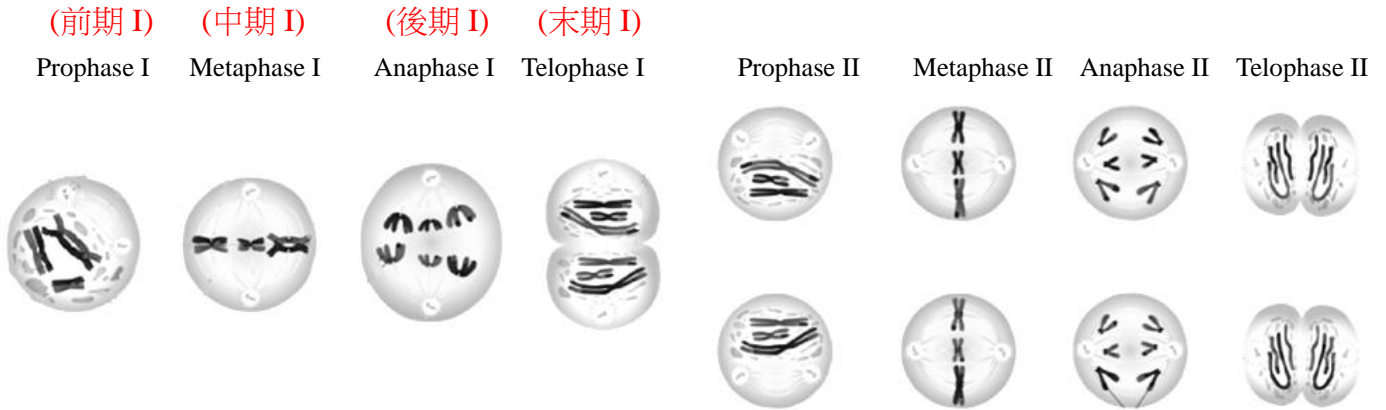


Which of the following is a correct explanation of the findings in the graph?

1. The rate of osmosis (滲透) at 20°C is lowest from 2 to 4 hours.
2. In the first half an hour, osmosis occurs faster at 60°C than at 20°C because some enzymes in the cells become more active.
3. After the first hour, potato cylinders at 60°C are losing mass because water was drawn out from the potato cells by osmosis.

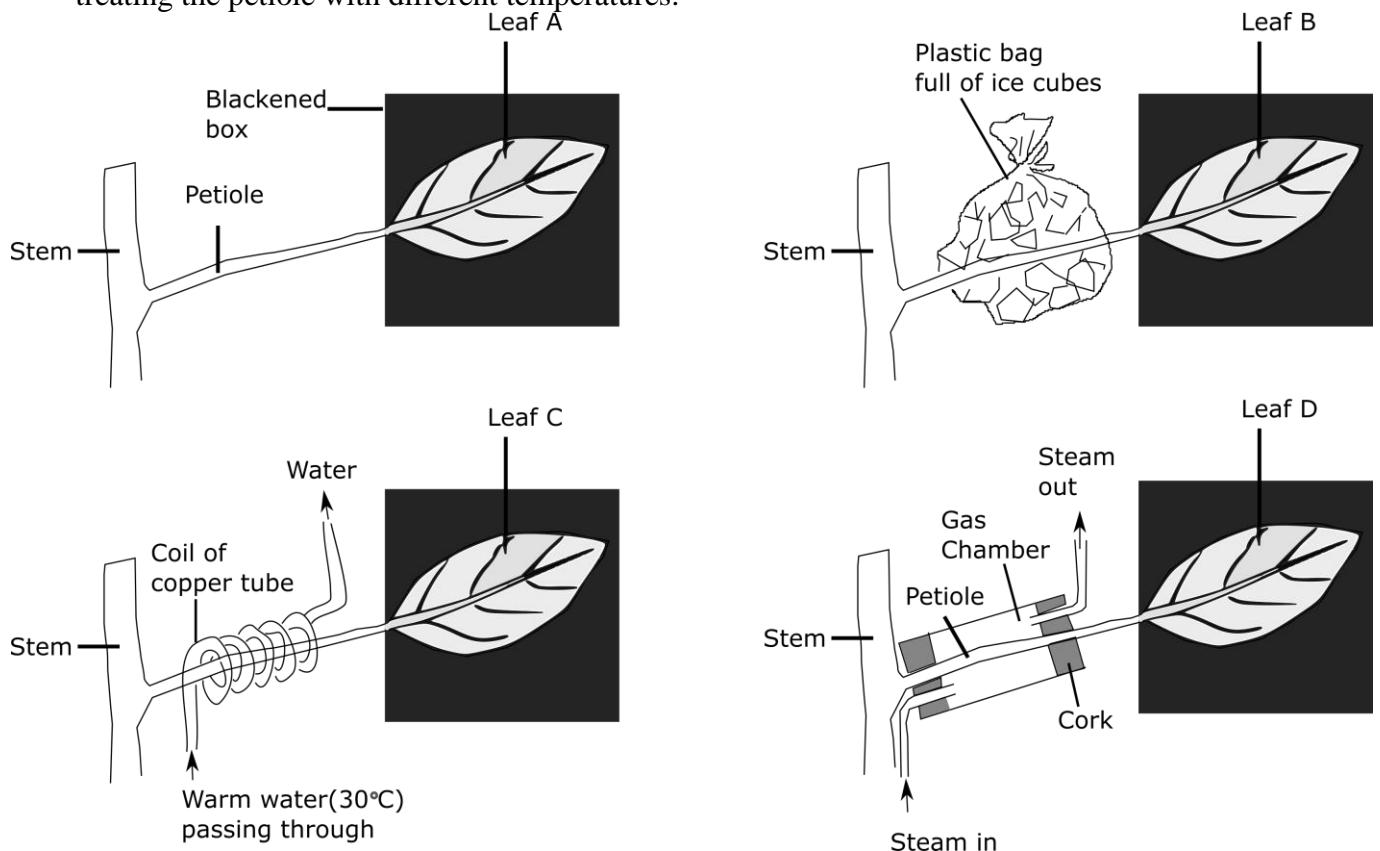
- A. 1 only
- B. 2 only
- C. 2 and 3 only
- D. 1, 2, and 3

30. The figure below shows the different phases of meiosis (減數分裂). If the chromosome number of a cell right before a meiotic division is represented as  $2N$ , in which of the phases of the meiotic division do the cells have a chromosome number represented as  $N$ ?



- A. Metaphase I and the phases after it
- B. Telophase I and the phases after it
- C. Metaphase II and the phases after it
- D. Telophase II

31. In photosynthetic (光合作用的) experiments, the plants need to be first destarched (脫澱粉) in a dark box. The following experiment investigates how the rate of destarching a leaf is affected by treating the petiole with different temperatures.



Which of the following is the most valid design for this experiment?

- A. Leaf A to D are four similar leaves of the same plant, which are treated at the same time.

- B. Leaf A to D are four similar leaves of the same plant, which are treated one by one.
- C. Leaf A to D are four similar leaves from four similar plants, which are treated at the same time.
- D. Leaf A to D are the same leaf receiving different treatments one by one.

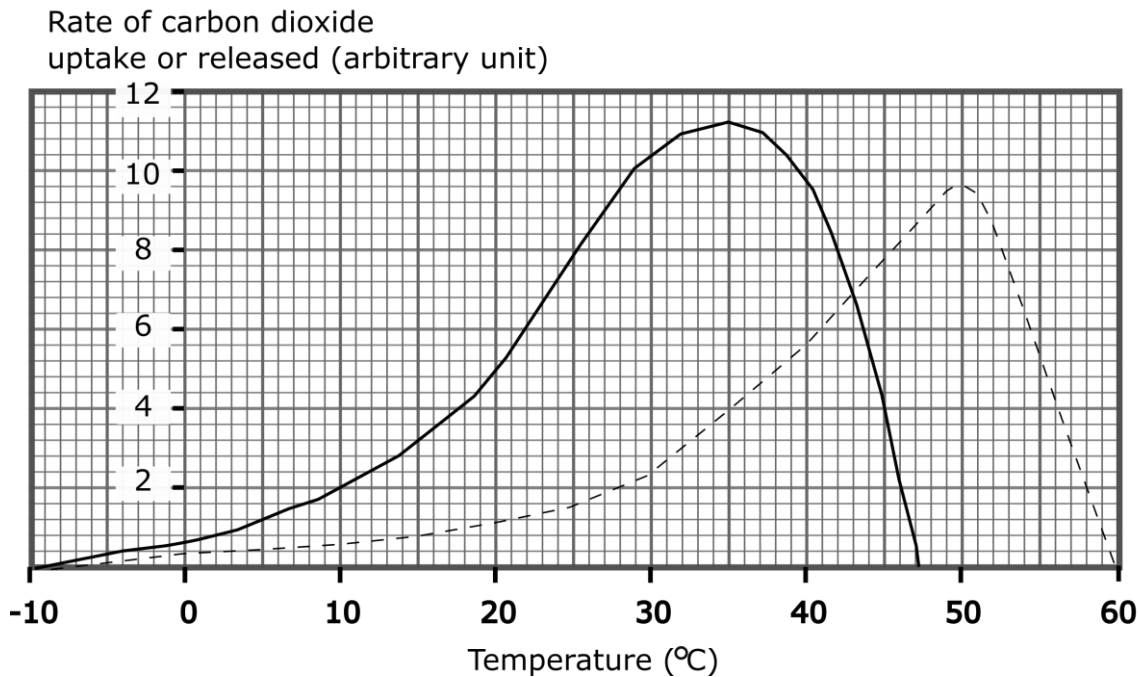
32. When the experiment was done in a valid way, what would be the expected results if the transport of sugars in petiole is an active process by living cells?

***Time needed for destarching the leaf  
(from the longest to the shortest time)***

- A A -> B -> C -> D
- B B -> D -> C -> A
- C B -> A -> C -> D
- D D -> B -> C -> A

33. In a study about the growth of a plant in a greenhouse, the rate of carbon dioxide uptake by photosynthesis and the rate of carbon dioxide released by respiration at different temperatures were determined. The results are shown in the graph below:

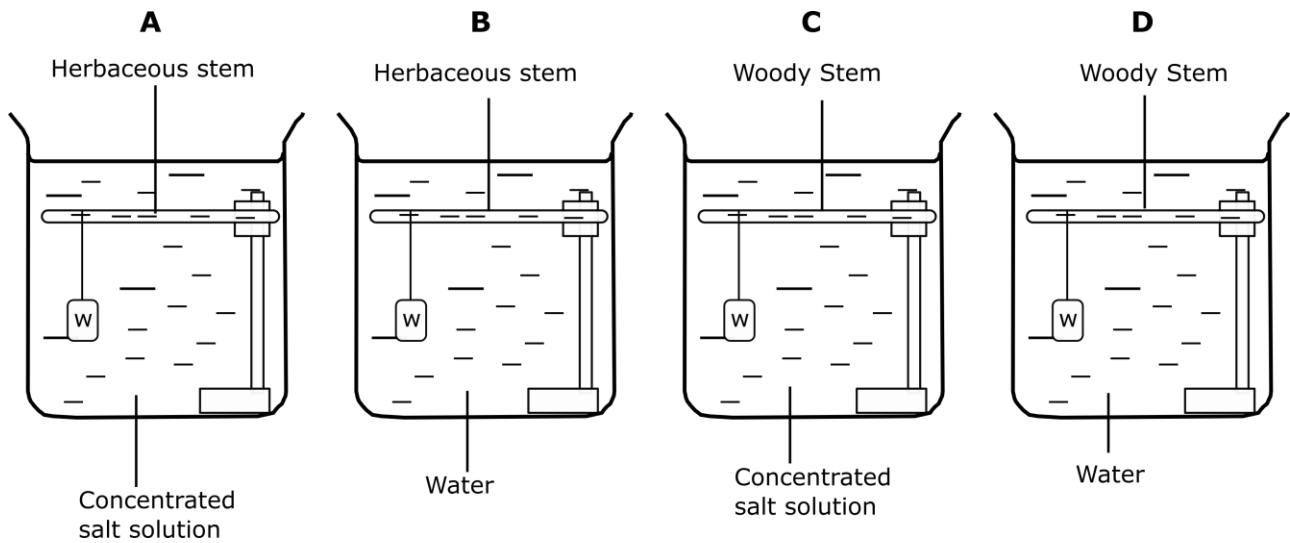
Key: ——— rate of carbon dioxide uptake  
 - - - rate of carbon dioxide released



With reference to the above results, what is the optimum (最適的) temperature for the growth of the plant?

- A. 31°C
- B. 35°C
- C. 43°C
- D. 50°C

**Directions:** Questions 34-35 refer to the following experiment that tests the support of woody and herbaceous stems (草本莖) in water and salt solution. The maximum weights that a stem can support in setups A to D in 3 hours were recorded as  $W_a$ ,  $W_b$ ,  $W_c$  and  $W_d$  respectively.



34. Which of the following can be concluded when the value of  $(W_b - W_a)$  is positive, the value of  $(W_d - W_c)$  is zero, and the value of  $(W_c - W_b)$  is positive?

1. The support given by a herbaceous stem partly comes from the turgidity (膨脹度) of cells.
2. The support given by a woody stem is unrelated to the turgidity of cells.
3. The support given by a woody stem is higher than a herbaceous stem.

- A. 1 only
- B. 1 and 2 only
- C. 2 and 3 only
- D. 1, 2 and 3

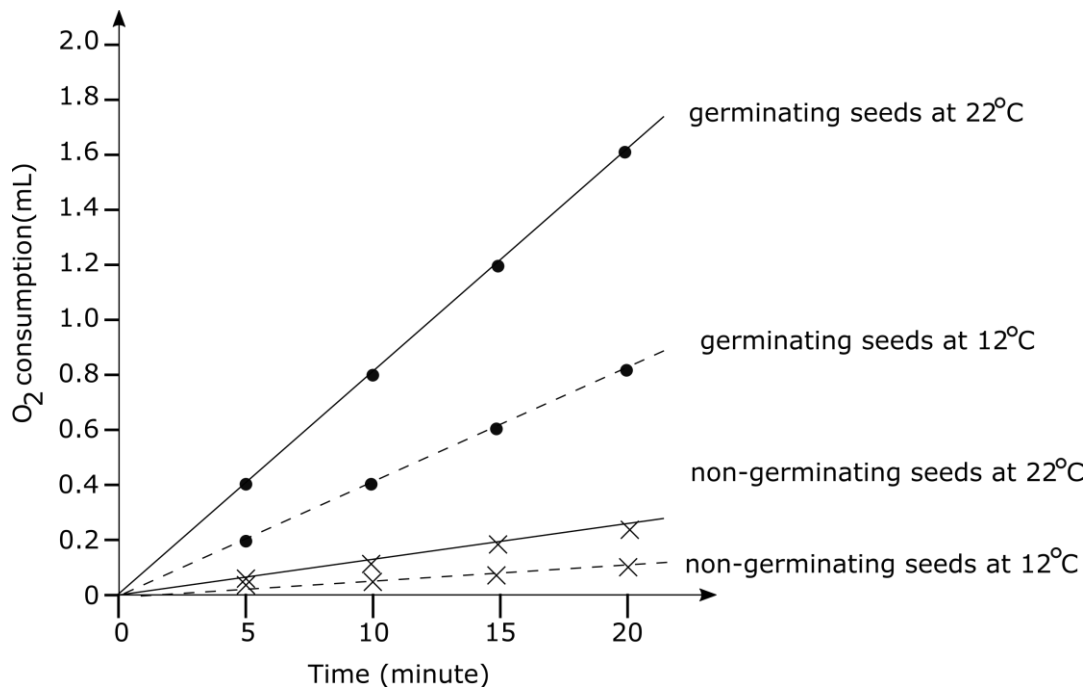
35. What is/are the assumption(s) (假定) of the design of this experiment?

1. The buoyancy given by the salt solution and water does not affect the weight a stem can support.
2. The stem is permeable to water.
3. The lengths of the stem between the weight and the stand are the same in different setups.

- A. 1 only
- B. 1 and 2 only
- C. 2 and 3 only
- D. 1, 2 and 3



**Directon:** Questions 36-37 refer to the graph below which shows the results of an investigation on oxygen consumption rate of germinating seeds:



36. What is/are the independent variable(s) (自變量/獨立變量) of the investigation?

1. Time
2. Temperature
3. Seeds that are germinating or not

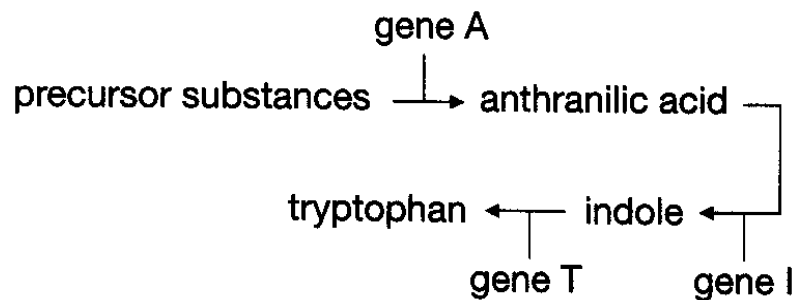
- A. 1 only
- B. 2 only
- C. 1 and 2 only
- D. 2 and 3 only

37. What conclusion(s) can be drawn from these results?

1. Seeds consume more oxygen during germination. .
2. Seeds consume more oxygen at higher temperature.
3. Temperature has greater effect on the oxygen consumption rate of seeds when the seeds are germinating.

- A. 1 only
- B. 1 and 2 only
- C. 2 and 3 only
- D. 1, 2 and 3

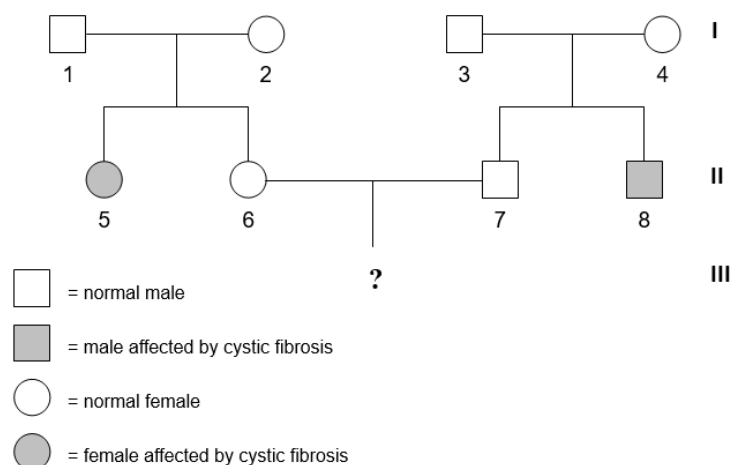
**Directions:** Questions 38 refer to the diagram below. It illustrates the synthetic pathway of the amino acid (氨基酸) tryptophan in the fungus (真菌) *Neurospora*. The pathways are controlled by the enzymes encoded by genes A, I and T.



38. A mutant variety (突變體品種) of *Neurospora* fails to produce tryptophan. But when indole is added to the culture medium, tryptophan is produced again. Based on this finding, what can be concluded about the mutation (突變) of the genes A, I and T of the fungus?

1. Gene I has mutated
  2. Gene T has not mutated
  3. Either gene A or gene I, or both has mutated
- A. 1 only  
 B. 2 only  
 C. 2 and 3 only  
 D. 1, 2 and 3

39. Cystic fibrosis (囊性纖維變性) is an inherited disorder (遺傳障礙) in humans. This disorder is due to a recessive allele of CFTR gene on the chromosome 7. The following diagrams show the pedigrees (譜系) of two random families who are associated by marriage (individuals 6 & 7):



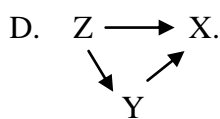
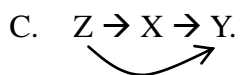
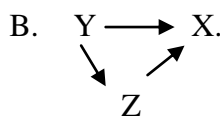
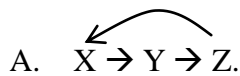
Individual 6 and 7 are planning to have a child. With no prior genetic diagnosis (遺傳診斷), what is the chance of this couple would have a child with cystic fibrosis?

- A. 6%      B. 11%      C. 25%      D. 50%

40. An experiment was performed to investigate a certain food chain (食物鏈) involving three insects X, Y and Z. The insects were placed in three glass jars and observed for 2 days. The results are recorded in the table below:

<i>Jar</i>	<i>Organisms at the beginning</i>	<i>Results</i>
I	X and Y	X disappeared and Y still survived
II	X and Z	X still survived and Z was partly eaten
III	Y and Z	Y survived and Z disappeared

The possible food chains that can be concluded from the experiment are:



**Directions:** Questions 41-42 refer to the story of James Lind who conducted probably the first clinical trial in history. He wanted to know how to treat a mysterious disease called scurvy (壞血病) that was often found among sailors.

The experiment involved 12 similar sailors with scurvy, who were put in the same room of the ship and given the same basic diet for two weeks. The 12 men were divided into six groups and each group of two were given one of the following six treatments:

- (1) 1100 ml of cider (an alcohol drink made from apple) every day.
- (2) 25 ml of dilute sulphuric acid every day.
- (3) 18 ml of vinegar three times a day.
- (4) 280 ml of sea water every day.
- (5) two oranges and one lemon every day.
- (6) a medicine made up of garlic, mustard seed, dried radish root and gum myrrh every day.

After 6 days of the experiment, only the two men in Group 5 became much better, but the men in other groups were still sick. At that time, people knew nothing about vitamins and deficiency diseases.

41. Which of the following conclusion(s) could be reasonably made from the results of the experiment at the time of James Lind?

1. Vitamin C is an essential component of a healthy diet.
2. Fresh fruits can cure scurvy.
3. Oranges can cure scurvy.

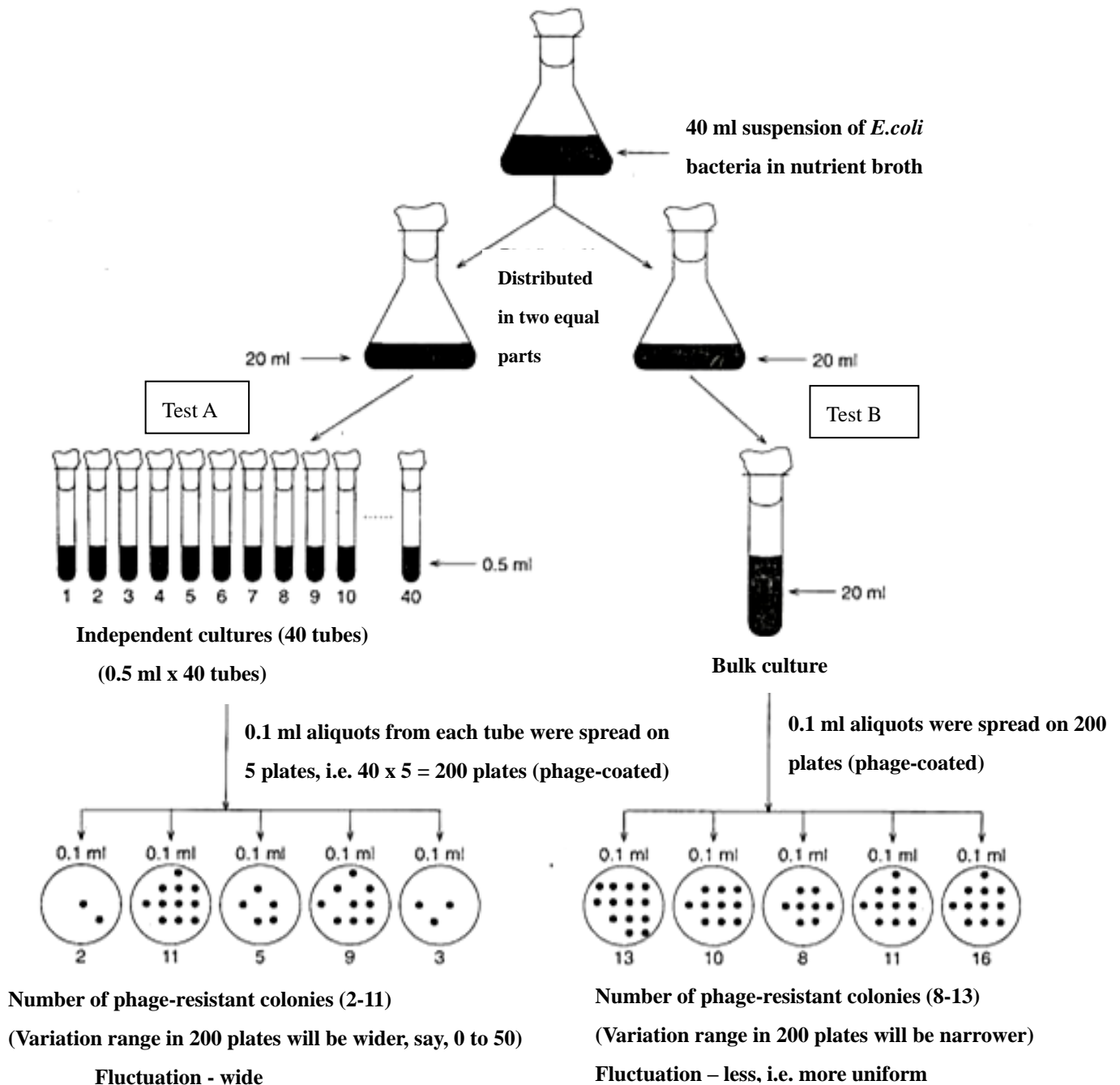
- A. 1 only.
- B. 2 only.
- C. 2 and 3 only.
- D. none of them

42. Which of the following are the problems with the design of this experiment?

1. Each treatment group had only two men, which is not enough.
2. There was no control group.
3. The experiment used humans rather than animals, which was unethical.
4. James Lind himself decided if the men were getting better or not, but not by another doctor who did not know the treatment the patients received.

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

**Directions:** Questions 43-44 refer to the following experiment conducted by Max Delbrück and Salvador Luria in 1943. At that time, it was found that bacteria would develop resistance (抵抗性) to phage (噬菌體) (virus that kills bacteria) as a result of mutation (突變). They wanted to know if the mutation was induced by the existence of the phage (Lamarckian) or occurred spontaneously and randomly without the presence of phage (Darwinian). The experiment was as follows:



43. In Test A, the agar plates differed greatly in the numbers of resistant bacterial colonies. But in Test B, the numbers of the resistant bacterial colonies in different agar plates were similar. Which of the following are the reasonable explanations of the results?

1. The mutation of resistance was induced by the phage in the agar plates. But the mutation was random, so different agar plates would show different numbers of resistant bacterial colonies. The differences between Test A and B were also a result of randomness.
2. In Test B, the mutation of resistance occurred randomly before the bacteria were added to the agar plates. The resistant bacteria were evenly spread in the bulk culture tube. Therefore, each agar plate was added with similar numbers of resistant bacteria.
3. In Test A, mutation of resistance occurred randomly before the bacteria were added to the agar plates. Since the mutation occurred at different times randomly, the earlier the mutation occurred, the more resistant bacteria were reproduced. Therefore, the agar plates varied largely in the number of resistant bacterial colonies.

- A. 1 only
- B. 2 only
- C. 2 and 3 only
- D. 1, 2 and 3

44. Based on the results of both Test A and B, are the following two hypotheses (假說) supported or rejected?

Hypothesis 1: the mutation of resistance is induced by the phage

Hypothesis 2: the mutation of resistance occur randomly before the bacteria are exposed to the phage

- A. Hypothesis 1 is supported while hypothesis 2 is rejected.
- B. Hypothesis 2 is supported while hypothesis 1 is rejected.
- C. Both hypotheses 1 and 2 are supported.
- D. Both hypotheses 1 and 2 are rejected.

45. Mary and John have a little boy who looks more like his mother than his father. Which of the following is/are the correct explanation(s)?

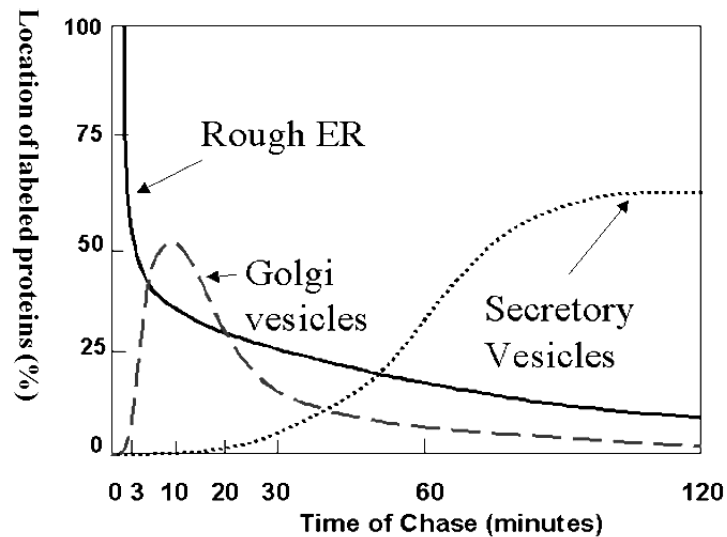
1. For genes (基因) encoding the body appearance of the boy, many alleles (等位基因) from the mother are dominant (顯性) over those from the father.
2. The alleles encoding the body appearance of the boy mostly come from the mother.
3. The boy receives a higher number of chromosomes (染色體) from his mother than his father.

4. The boy is fed with the breast milk of the mother. The milk of the mother gives the boy additional DNA that affect his appearance.
- A. 1 only
  - B. 1 and 2 only
  - C. 1, 2 and 3 only
  - D. 2, 3 and 4 only

**Directions:** Questions 46-47 are about the pulse-chase experiment. It is a method used to follow protein movement in the cell. The experiment is based on two steps:

1. The 'pulse' period – expose experimental cells to radioactively labeled amino acids so that all the protein synthesized during that period will be radioactive.
2. The 'chase' period – replace the medium with non-radioactive amino acids so that the protein synthesized after the pulse period is not radioactive.

The following diagram shows the relative abundance of radioactivity in three different organelles (細胞器) during the chase period.

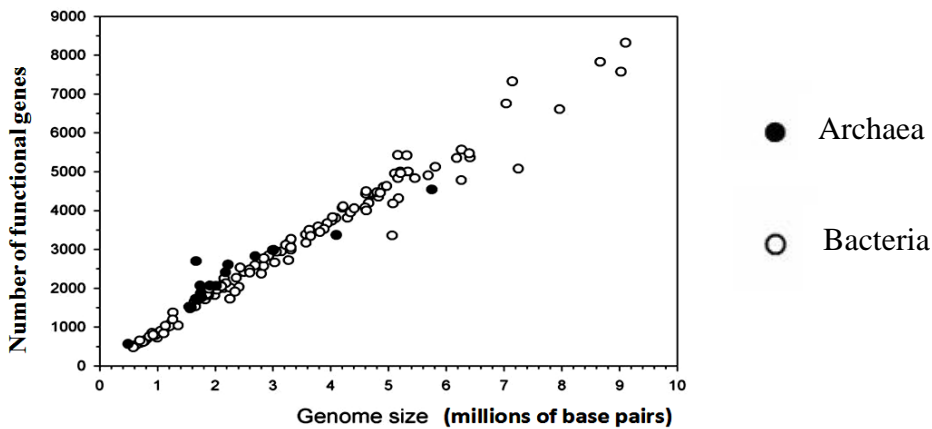


46. Which of the following can be concluded from the graph about the order that protein is synthesized and transported at different locations within a cell?
- A. Rough ER (粗糙內質網) --> Secretory vesicles (分泌囊泡) --> Golgi vesicles (高爾基體囊泡)
  - B. Rough ER --> Golgi vesicles --> Secretory vesicles
  - C. Golgi vesicles --> Secretory vesicles --> Rough ER
  - D. Secretory vesicles --> Rough ER--> Golgi vesicles

47. What would happen to the graph if the radioactive amino acids are not replaced by non-radioactive amino acids in the chase period?

1. The curve of the secretory vesicles will rise at earlier time.
  2. The curve of the rough ER will not drop at the beginning.
  3. The curve of the Golgi vesicles will continue to rise after 10 minutes.
- A. 1 and 2 only  
B. 1 and 3 only  
C. 2 and 3 only  
D. 1, 2, 3

48. The figure below shows the relationship between genome (基因組) size and number of functional genes in bacteria (細菌) and Archaea (古細菌).

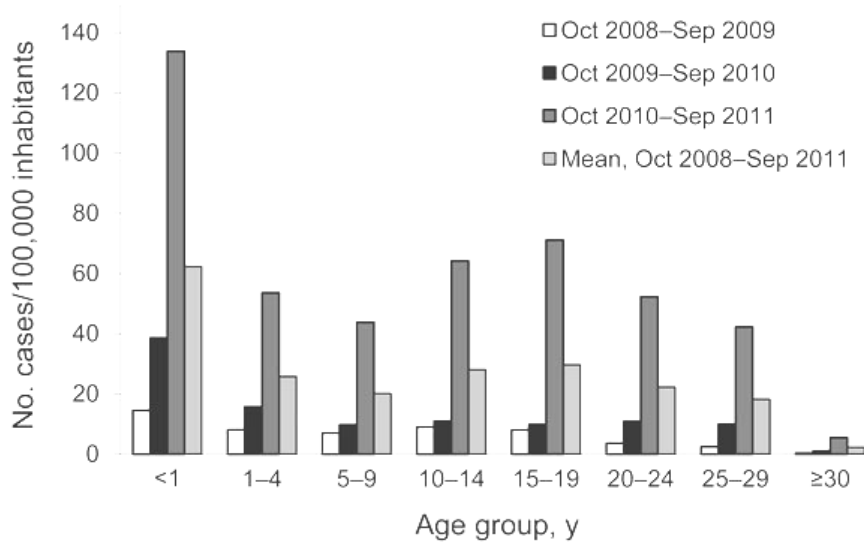


Which of the following statement(s) is/are correct based on the above graph?

1. Some bacteria have larger genome size than Archaea.
  2. The number of functional genes is positively correlated with the genome size in both archaea and bacteria.
  3. The average size of a functional gene is about 1000 base pairs in Archaea, assuming that the genome does not have non-functional genes.
- A. 1 only  
B. 1 and 2 only  
C. 2 and 3 only  
D. 1, 2 and 3



**Directions:** Questions 49-50 refer to the figure below. It shows the number of measles (麻疹) cases during the 3 epidemic outbreaks (流行波) in France in 2008-2011. Measles can be prevented by vaccine (疫苗), but the two doses are normally taken after the first year of birth and in 4-6 years of age.



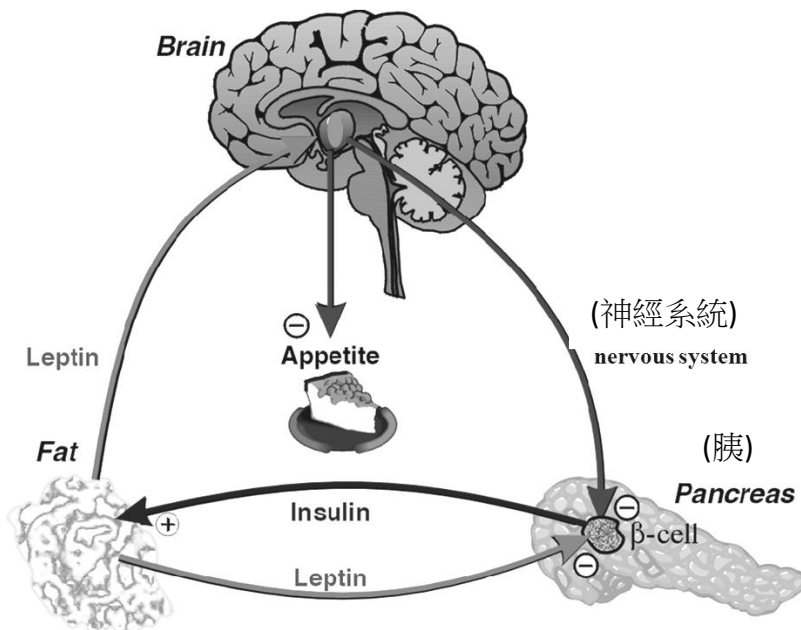
49. Which of the following statement(s) is/are correct explanation(s) of the measles outbreaks shown in the above graph?
1. Children under 1 year of age had the highest numbers of measles cases than other age groups because most of them had not been vaccinated against measles.
  2. From 2008 to 2011, the measles outbreaks became increasingly larger because the measles virus (病毒) had developed resistance to the vaccine.
  3. People at the age of 30 or above were least infected by measles because they have fully developed immune system.
- A. 1 only  
 B. 2 only  
 C. 2 and 3 only  
 D. 1, 2, 3

50. The first dose of measles vaccine is recommended to be taken one year after birth. It was found that the presence of antibodies (抗體) in blood will weaken the action of the respective vaccine. Which of the following statement(s) is/are correct about why the first dose of measles vaccine should be taken 12 months after birth?

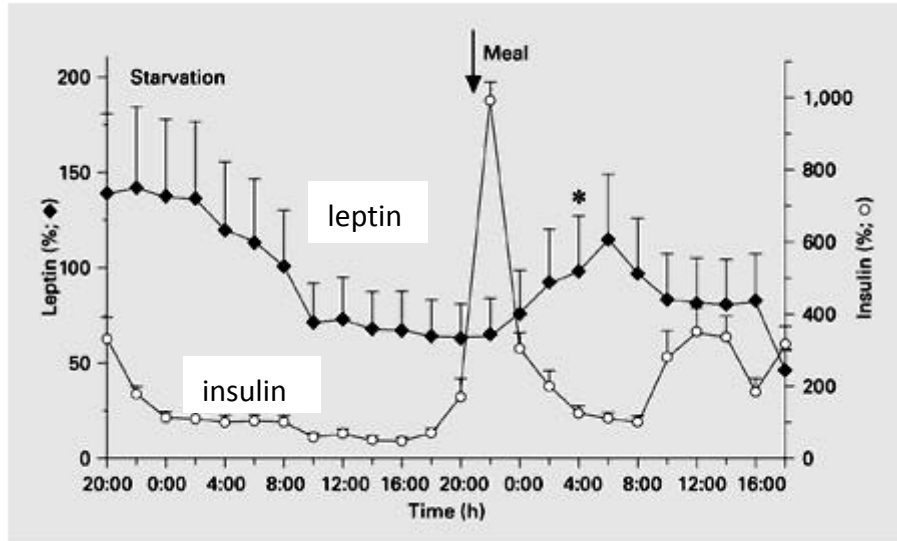
1. The mother's antibodies will enter the baby's body through placenta (胎盤) and inhibit the antibody production stimulated by the measles vaccine.
2. The baby's immune system (免疫系統) is not fully developed in the first 12 months and therefore cannot produce full immunity when stimulated by the antigen (抗原) in the vaccine.
3. In the first 12 months after birth, the baby is still protected by the mother's antibodies against measles.

- A. 1 only
- B. 2 only
- C. 2 and 3 only
- D. 1, 2 and 3

**Directions:** Question 51-52 refer to the function of a hormone (激素) called **leptin**. It is a hormone secreted by fat tissues and is commonly called the 'starvation hormone'. It has important role in the regulation of body weight. The diagram shows how leptin and insulin (胰島素) interact by feedback loops. A '+' indicates a stimulation and a '-' indicates an inhibition.



51. The graph below shows the changes of the blood levels of leptin and insulin in a group of persons. They were first fasted for 24 hours and then had meals in the second day. With reference to the information provided in the above figure and your knowledge, which of the following statement(s) is/are correct about the graph?



1. In the first day, the level of leptin continued to decrease because the mass of fat tissues decreased during fasting.
2. After meal, the leptin level increased steadily because of the high level of insulin and increased fat mass.
3. In the second day from 0:00 to 8:00, the insulin levels continued to drop partly because of the increasing levels of leptin.

- A. 1 only
- B. 2 only
- C. 1 and 3 only
- D. 1, 2, 3

52. Leptin plays an important role in regulating the body weight. It is found that obese (肥胖) people have high levels of leptin in the blood but they still have strong appetite (desire to eat). Which of the following is/are correct about the roles of leptin in obesity?

1. Obese people have more fat tissues so that more leptin is produced.
2. Obese people have problems in some part of the brain that they failed to respond to leptin to cut down their appetite.
3. Injection of leptin can help obese people to reduce body weight.

- A. 1 only
- B. 1 and 2 only
- C. 1 and 3 only
- D. 1, 2, 3

**Directions:** Questions 53-54 is about **epistasis**, which is a phenomenon in which the phenotypic (表現型的) effect of a gene is masked by the genetic status of another gene. The coat colour of a dog, Labrador retrievers, is an example of epistasis. The coat colour can be black, brown and yellow, which is determined by two genes B and E. B gene determines if the coat color is black or brown with the dominant allele (顯性等位基因) (B) for black and the recessive allele (隱性等位基因) (b) for brown. Gene E affects whether gene B will have its phenotypic effect. When gene E is homozygous recessive (隱性純合型), gene B will not express its phenotype and the coat color is yellow.

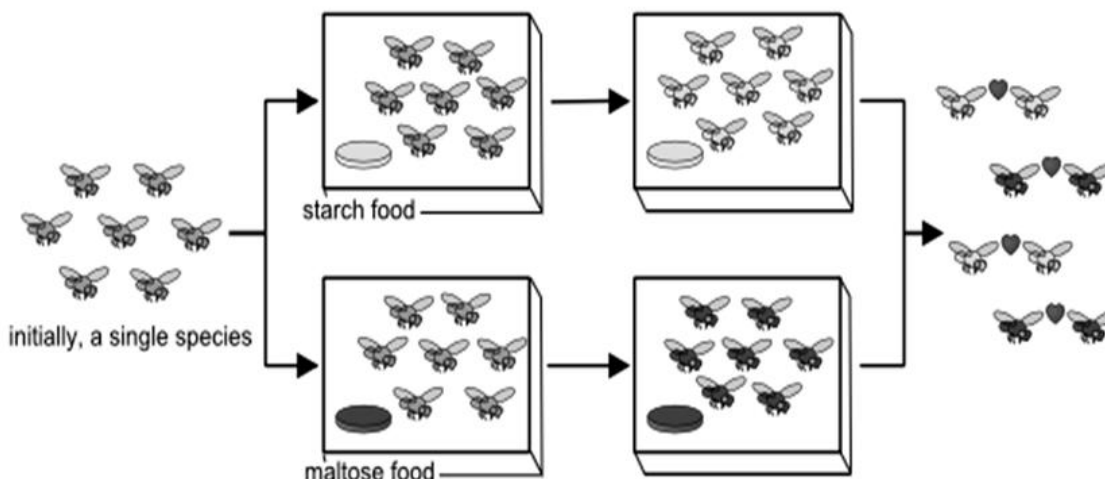
53. Which of the following shows the correct genotypes (基因型) of the three coat colors of the dogs?

	<b>Black</b>	<b>Brown</b>	<b>Yellow</b>
A.	BBee	BbEe	bbee
B.	BbEe	bbee	BBEE
C.	bbee	Bbee	BbEe
D.	BbEe	bbEE	Bbee

54. If Labrador retrievers heterozygous (雜合的) at both loci (基因位點) are crossed, what will be the phenotypic ratio (表現型比) of the offspring?

	<b>Black</b>	<b>Brown</b>	<b>Yellow</b>
A.	12	: 3	: 1
B.	9	: 3	: 4
C.	3	: 12	: 1
D.	3	: 9	: 4

55. A population of the fruit fly was divided into two equal populations. One population was reared on a starch medium (澱粉培養基) and the other on a maltose medium (麥芽糖培養基). After many generations, the two populations were put together again. It was found that two populations had less interbreeding than within their own population.



Which of the following is the cause of the observation that the two populations of fruit flies had less interbreeding than within their own population after many generation of separated rearing?

- A. The different foods, starch or maltose, had induced changes of the genes of the fruit flies, which made them reproduce differently.
- B. The breeding between fruit flies that eat the same type of food is an advantage that their offspring only need one type of food.
- C. The two populations of fruit flies had become two different species through evolution by natural selection.
- D. Different mutations occurred randomly in the two populations when they were reared separately. These mutations make them somewhat reproductively incompatible.

**THE END**