A

International Biology Olympiad – Hong Kong Contest 2018

國際生物奧林匹克 – 香港區比賽 2018

Co-organised by 合辦

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The Hong Kong University of Science and Technology

香港科技大學

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Rules and Regulations 競賽規則

1. The paper consists of 50 multiple-choice questions in bilingual versions. There are Version A and Version B of the question book, each consisting identical content, only in different question number sequence. Contestants should have the same version of multiple-choice answer sheet and question book.
   全卷共有 50 題多項選擇題，所有題目中英對照。題目簿分為 A 及 B 兩個版本，題目內容相同，惟題號順序有異，參賽者會獲發相同版本的選擇題答題紙與題目簿。

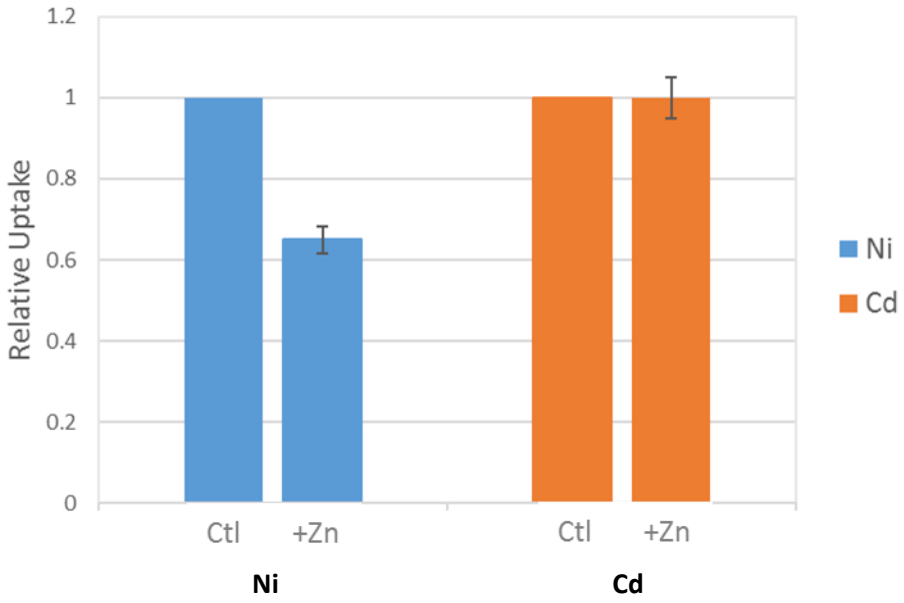
2. The Contest is a 2-hour written test.
   比賽時限為兩小時。

3. On the multiple-choice answer sheet, please write and fill in the 8-digit Contestant Number, English Name, and School Number.
   在選擇題答題紙上，請填上你的 8 位數字參賽者號碼、英文姓名、及學校名稱。

4. After you have made the choice in answering a multiple choice question, fill the corresponding circle on the multiple-choice answer sheet fully using a HB pencil. Any answers written on the question book are not considered.
   選定選擇題的答案後，請將選擇題答題紙上相應的圓圈用 HB 鉛筆完全塗黑。任何寫在問題簿上的答案將不獲考慮。

5. The questions have been translated from English into Chinese. If there is any inconsistency or ambiguity between the English version and the Chinese version, the English version shall prevail.
   中文版題目為英文版譯本，如中、英文兩個版本有任何抵觸或不相符之處，應以英文版本為準。

1. Some plants actively take up heavy metals from the soil via root ion transporters. Below shows data of an experiment demonstrating Ni and Cd uptake performance of a plant species in the absence (ctl) or presence of Zn (+Zn). When Zn is added, it is added at the same concentration as the heavy metal of interest.



Based on the above histogram, which of the following statement(s) is/are correct?

(1) Ni and Zn compete for the same root ion transporter for up-taking.
(2) Cd and Zn play the same role in the plant and can replace each other.
(3) In the absence of Zn, the plant uptakes equal amount of Cd and Ni.

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

2. A kind of insect larvae is consistently found at the landfill among lumps of plastics. A series of experiments was done to the larvae and below are the results.

   i. When the larvae were mixed with plastic sheets for 30 days without other food supplement, the larvae increased in mass as the plastic sheets decreased in mass.
   ii. When the larvae extract was prepared by grounding larvae in water at room temperature. The extract melted away plastic sheets.
   iii. When the larvae extract was prepared by grounding worms in water at 95^{o}C. The extract did not melt away plastic sheets.
   iv. The larvae were fed with low dose antibiotics with ordinary food for 3 days, the larvae look healthy and active. Then the larvae extract was prepared at room temperature. The extract did not melt away plastic sheets.

   Based on the information above, which of the following statement(s) is/re correct?

   (1) The larvae can consume plastics as food.
   (2) The plastic degrading capability in larvae must involve enzymatic activity.
   (3) The larvae's plastic digestion relies on gut bacteria.
   (4) The adult form of the larvae must be capable of consuming plastics.

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

Q3 – 4. Length of hair is controlled by the number of rounds of cell cycle undergone by the hair follicle cells. As well, cell cycle is related to regular turnover of hair, which is necessary to maintain healthy looking fur for an animal. Cyclin D is a cell cycle regulator that remains at high levels when cells are actively dividing. To detect if the follicle cells are actively dividing, the amounts of Cyclin D in the cells can be measured by flow cytometry. Cyclin D is first stained with a florescent dye and the intensity of florescence emitted from each cell is measured. Two batches of hair follicle cells are collected from animals at the 14th day after birth (infant) and at sexually maturity (adult). Exactly ten thousand (10,000) hair follicle cells are counted and analyzed for each batch.

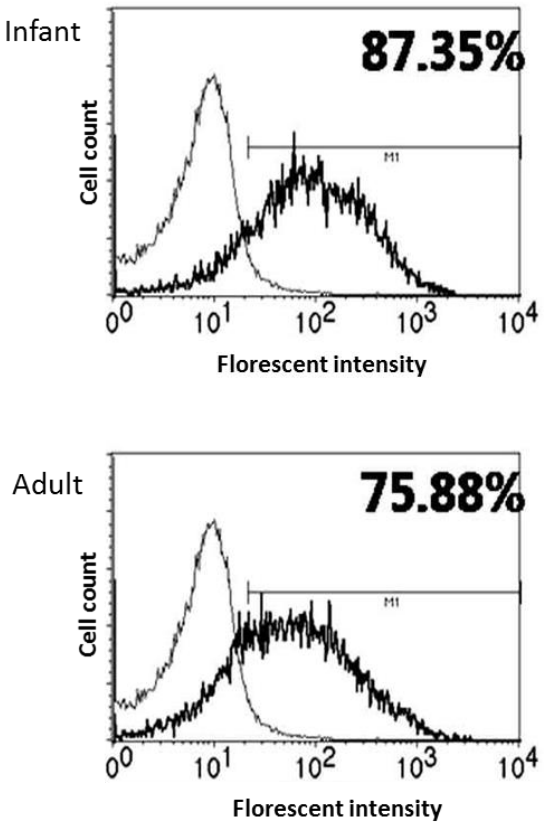


Figure 1. Flow cytometry analysis of the hair follicle cells on the levels of cyclin D by its florescent intensity. The peak on the left is unstained hair follicle cells serving as the control. The adult and infant have respectively 75.88% and 87.35% of cells that have more than 20 units of florescent intensity.

3. What is/are the role(s) of the control in this experiment?

(1) It shows the amount of florescence that is not emitted by the florescent dye.

(2) It shows that some cell structures and molecules other than Cyclin D have been stained by the florescent dye.

(3) It shows the background level of Cyclin D inside a cell when it is not actively dividing.

A. 1 only

B. 2 only

C. 1 and 3 only

D. 1, 2 and 3

4. Based on the information in the graph, which of the following statement(s) is/are correct?

(1) The infant has approximately 11% more cells that are in active cell cycle than the adult.

(2) The control cells have produced less Cyclin D than the experimental cells.

(3) Infant animal has longer hairs compared to adult animals.

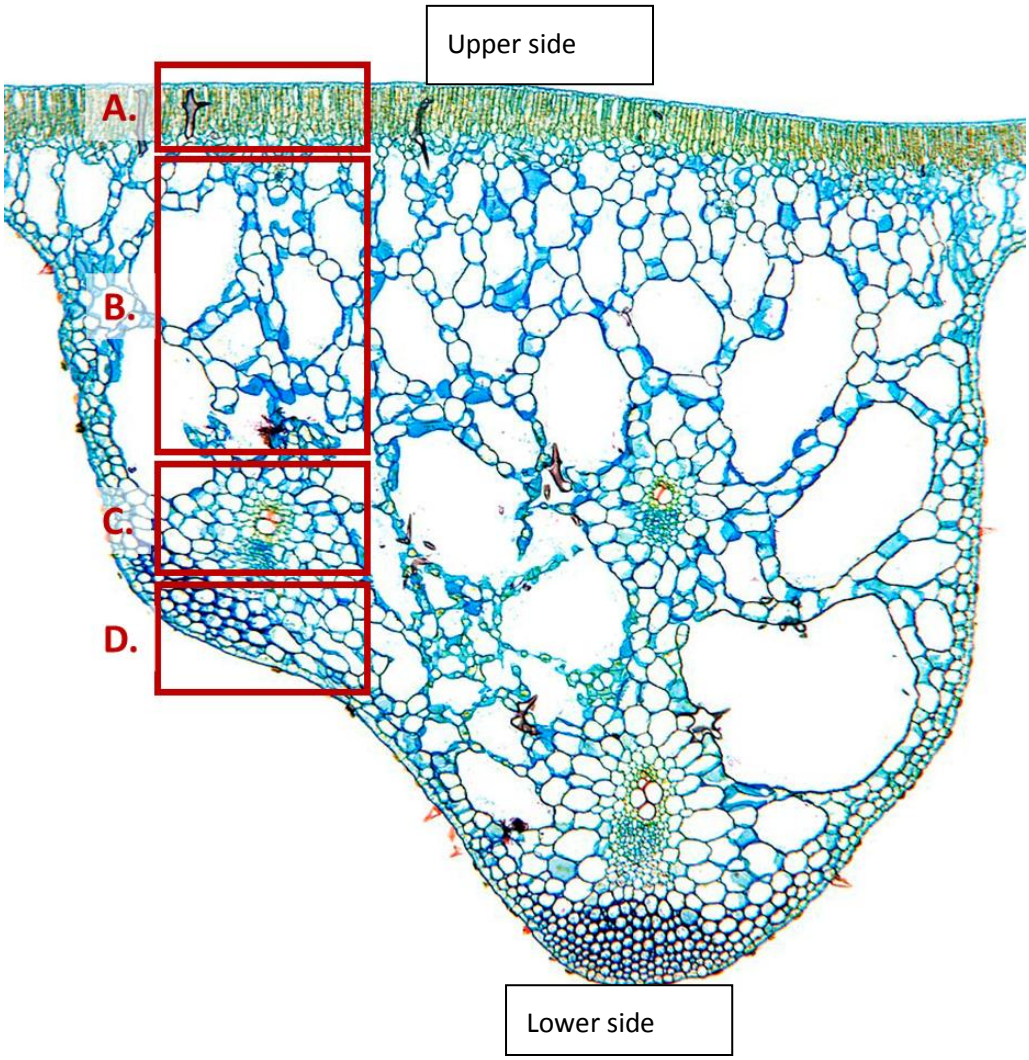
A. 1 only

B. 2 only

C. 1 and 3 only

D. 1, 2 and 3

Q5-6. Below is a cross section of a giant water lily leaf. The leaf floats on fresh water surface.



5. Based on the image above, which of the following is/are the adaptation(s) of the leaf to its habitat?

(1) The photosynthetic tissues are tightly packed at A to maximize light absorption.
(2) The extensive air space at B provides the leaf with buoyancy to float on the water surface.
(3) The xylem vessels at C are prominent to allow efficient transport of water.

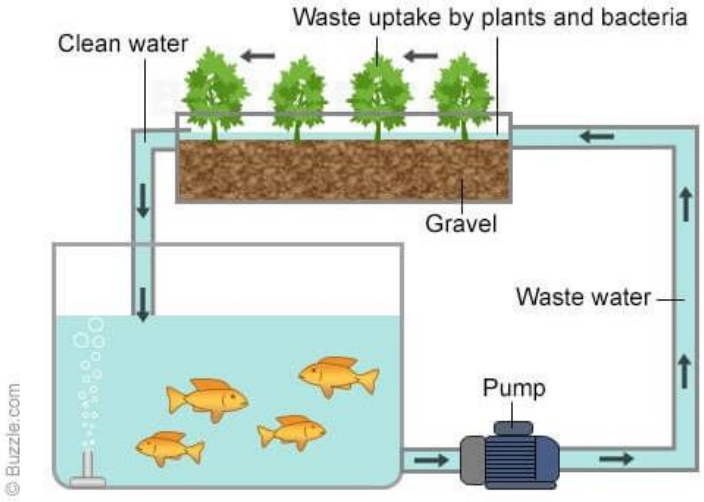
A. (1) only
B. (1) and (2) only
C. (2) and (3) only
D. (1), (2) and (3)

6. Which of the following shows the location that the stomata are most likely found and the reason for it?

A. Area A, because the stomata there will result in faster transpiration and thus more efficient transport of water from the root.
B. Area D, because the stomata there will have less water loss by transpiration.
C. Area A, because the stomata there will allow carbon dioxide to diffuse into the leaf for photosynthesis.
D. Area D, because the stomata there are connected with extensive air space.

Q7-9. Aquaponics is the combination of aquaculture (raising fish) and hydroponics (cultivating crops in water) that grows fish and plants together in one integrated system. The water from the fish tank is pumped to hydrate the crop roots to provide nutrients from fish wastes. Then the root-filtered water is returned to the fish tank. Aquaponics is a closed system that no fresh water is added and no used water is removed from the system until the day of harvest.

The figure below shows one aquaponics system.



7. Which of the following is/are correct about the system?

(1) The fish releases nitrates into water, which is then absorbed by the root of the plants.
(2) The plants provide food to the fish through the water returning back to the tank.
(3) Nitrifying bacteria is involved to convert fish waste into nutrients for plants.

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

8. The table below summarizes the setups of 4 aquaponics systems and the results. The setups are identical, but the numbers of fish and plant growing in the system vary. The fish are of similar size and age. Gender of fish is irrelevant. The crops are lettuce at rapid growth phase and have been grown for similar period after germination.

Setup	Aquaculture	Hydroponics	Results
1	20 fish	No plant	All fish died after 7 days of setup.
2	20 fish	20 plants	Some fish died after 14 days of setup. The plants grow normally.
3	20 fish	40 plants	Both fish and plants grow normally.
4	40 fish	40 plants	All fish and plants died after 14 days of setup.

Apart from the factors mentioned, what are the other factors that need to be kept identical between different setups?

(1) Food fed to the fish
(2) Amount of light received by the plants
(3) Types of gravel
(4) The genetic makeup of the fish

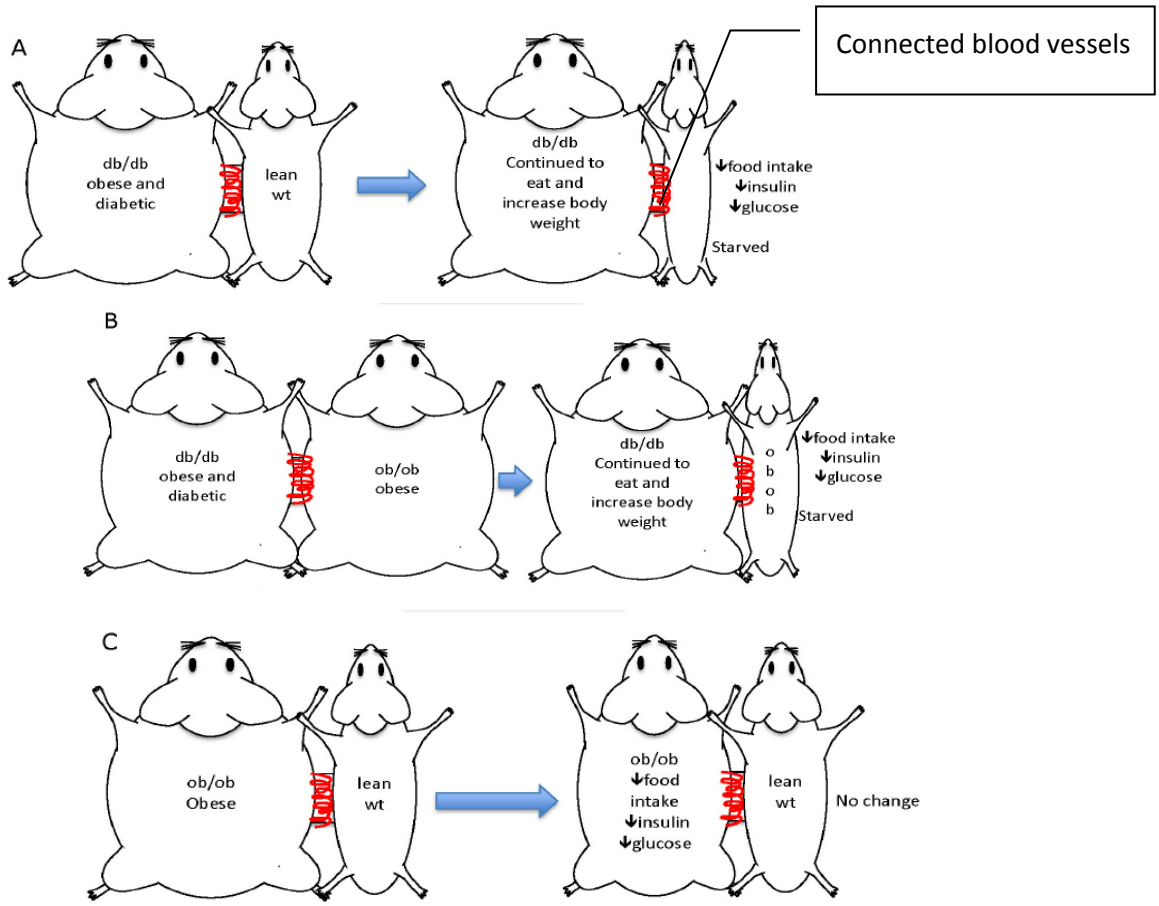
A. (1) and (2) only
B. (2) and (3) only
C. (1), (2) and (3) only
D. (1), (2), (3) and (4)

9. Based on the above results, which of the following is/are the appropriate conclusion(s) of the experiment?

(1) The survival of fish in the system is determined by the ratio of fish to plant, regardless of the number of fish and plants.
(2) The survival of plant in the system is determined by the number of fish, regardless of the ratio of fish to plant.
(3) The system can only keep a maximum of 20 fish and 40 plants alive.

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

Q10-12. A mutation of a gene called db will produce obese mouse called db/db mouse. A mutation of another gene, ob, will also produce obese mouse called ob/ob mouse. Scientists conducted the following experiments in order to find out if the obesity is caused by a substance in blood. They connected the blood vessels of two mice and observed their changes in body weights. The results are shown below.



10. Which of the following is/are the appropriate conclusion(s) of this experiment? (A/H)

(1) In the blood of db/db mouse, there is a substance that causes a mouse to lose weight.

(2) In the blood of ob/ob mouse, there is a substance that causes a mouse to gain weight.

(3) In the blood of normal lean mouse, there is a substance that causes a mouse to lose weight, but its concentration is not as high as in db/db mouse.

A. 1 only

B. 2 only

C. 1 and 3 only

D. 1,2 and 3

11. It was later found that a hormone called leptin is responsible for the obesity of the mutant mice. Leptin is secreted by adipose tissues and acts on the hypothalamus to control food eating and energy use. The hypothalamus has receptors for leptin. High concentration of leptin is found in the blood of db/db mouse but it is absent in ob/ob mouse.

Which of the following is/are correct about the roles of leptin in the mutant obese mice?

(1) The db gene codes for a receptor on the surface of leptin sensitive cells. Therefore, the db/db mice develop leptin resistance and the adipose cells respond by producing more leptin.
(2) The ob gene codes for leptin. Therefore, the adipose tissues of ob/ob mice fail to produce leptin.
(3) Leptin stimulates the hypothalamus to produce signals of hunger.

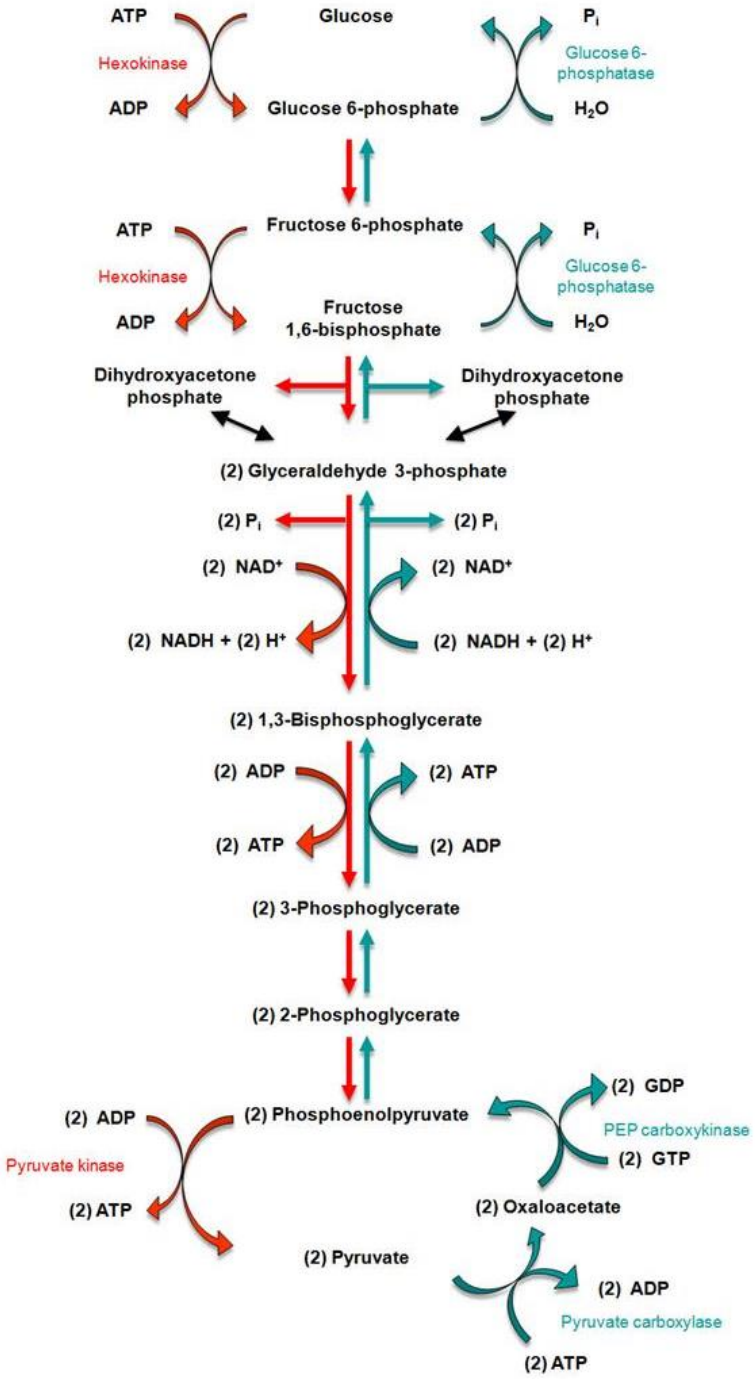
A. 1 only
B. 1 and 2 only
C. 2 and 3 only
D. 1, 2 and 3

12. Some think that leptin can be used to reduce the body weight of obese people. However, injection of leptin is found having very little effect on the weight of most obese people. Which of the following is/are likely the explanation of it?

(1) The leptin levels of humans are found positively correlated with the degree of obesity.
(2) The leptin gene of most obese people does not have mutation.
(3) Leptin in humans has functions much different from that in the mice.

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

Q13-15. Proper control of glucose levels is important for the production and storage of energy as well as maintenance of plasma glucose levels. Our body has come up with an efficient way to utilize enzymes to produce and break down glucose. The figure shows the metabolic pathways of glycolysis and gluconeogenesis – production of glucose from pyruvate and non-carbohydrate carbon substrates. In the metabolic pathways, some steps use different enzymes for glycolysis and gluconeogenesis (glucose synthesis), while the rest use the same enzyme (no enzyme names shown).



13. With reference to the above figure, which of the following is/are correct?

(1) Gluconeogenesis is exactly the reversed process of glycolysis.

(2) Gluconeogenesis is an energy-absorbing process while glycolysis is an energy-releasing process.

(3) Gluconeogenesis would not occur without PEP carboxykinase.

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

14. If individuals lack the pyruvate kinase, what would you expect to happen to the concentration of 2-phosphoglycerate?

A. Increase
B. Decrease
C. The same
D. It's not possible to determine from the information given.

15. Insulin and glucagon are two hormones regulating blood glucose levels. Based on the hormones' overall effects on blood glucose levels, which of the following is/are likely the effects of the hormones on the enzymes in glycolysis and gluconeogenesis?

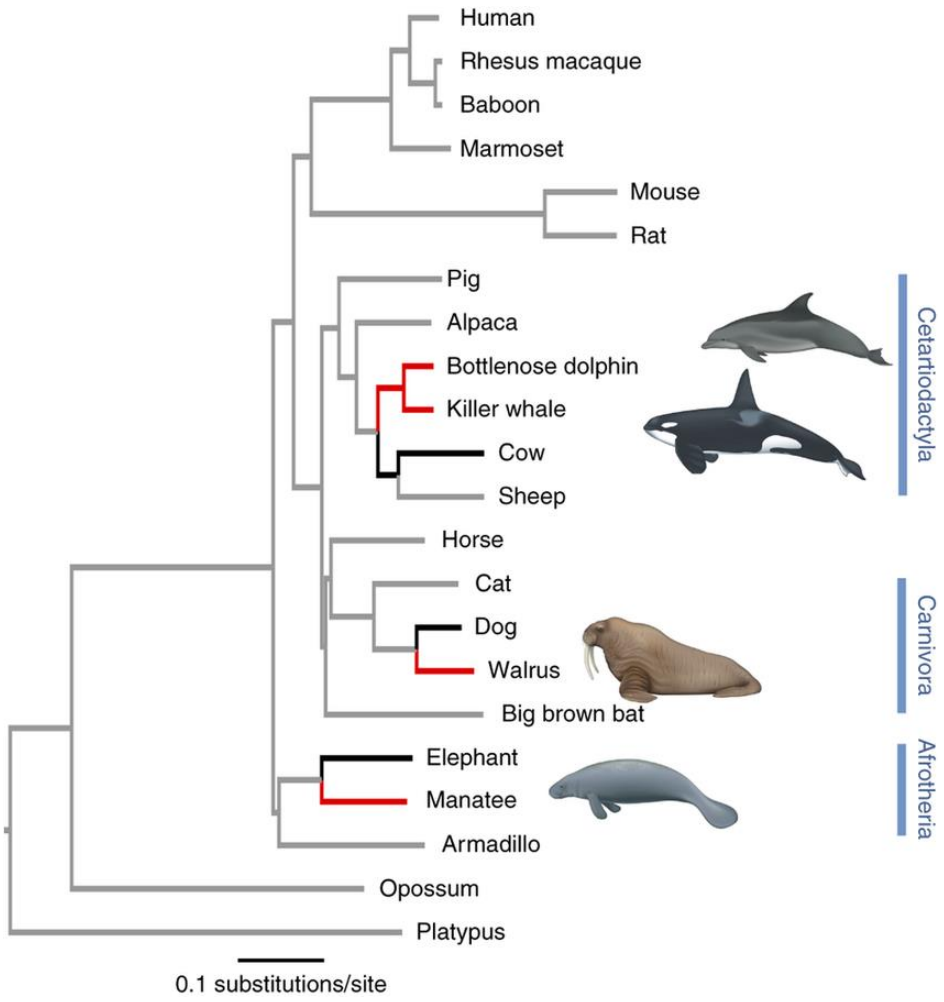
(1) Insulin inhibits PEP carboxykinase.

(2) Glucagon activates fructose-1,6-bisphosphatase.

(3) Glucagon inactivates pyruvate kinase.

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

Q16-17. The figure below is a phylogeny inferred for 20 eutherian mammal species based on genome sequences. The phylogeny was rooted with a marsupial outgroup. This phylogeny was used to understand the evolution of an aquatic lifestyle in eutherian mammals.



16. Based on the principle of parsimony, what is the most likely number of times that an aquatic lifestyle evolved within eutherian mammals?

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

17. Based on the above phylogeny, what statement is false?

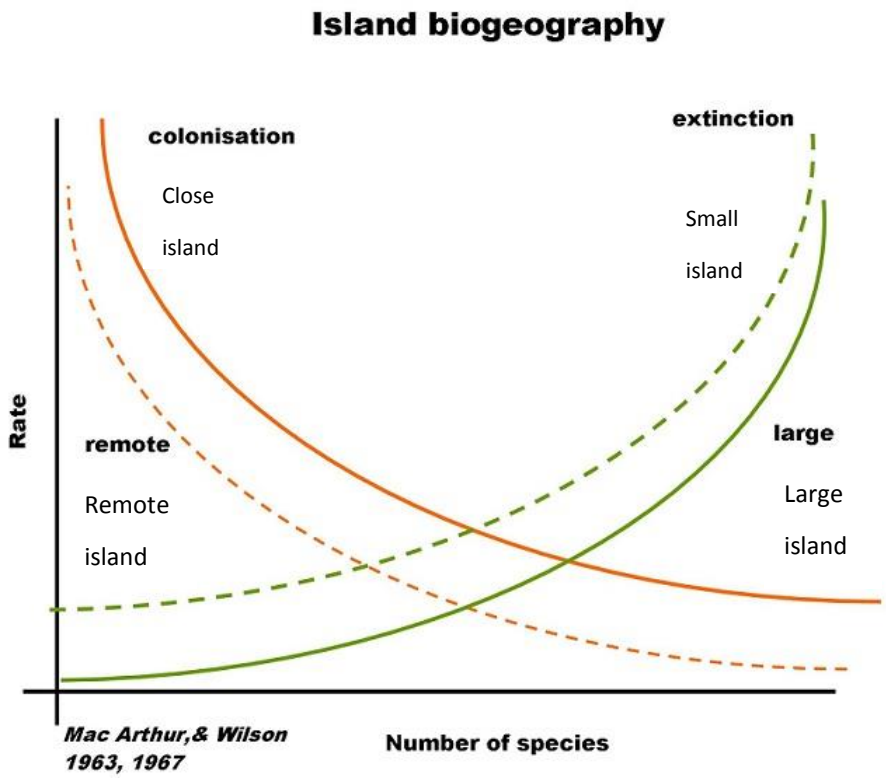
A. Dog is the most closely related species to Walrus.

B. Rheus macaque is the most closely related species to Human.

C. Elephant, Manatee, and Armadillo share a common ancestor.

D. Opossum and all eutherian mammal species share a common ancestor.

Q18-20. The graph below describes the **theory of island biogeography**. This theory states that the number of species expected on an island is determined by an equilibrium between the rates of colonisation (new species arriving at the island) and extinction. Colonization is further affected by the distance the island is away from mainland or other islands, while extinction rate is further affected by the size of the island.



18. Based on the above graph, which of the following statement is incorrect?

A. The rate of colonization decreases as the number of species increases.

B. The closer an island is to the mainland, the more species they will share.

C. The smaller an island, the slower the rate of extinction.

D. The rate of extinction increases as the number of species increases.

19. Based on the above graph, on which type of island would you expect to see the most number of species?

A. Remote, large island

B. Remote, small island

C. Close, large island

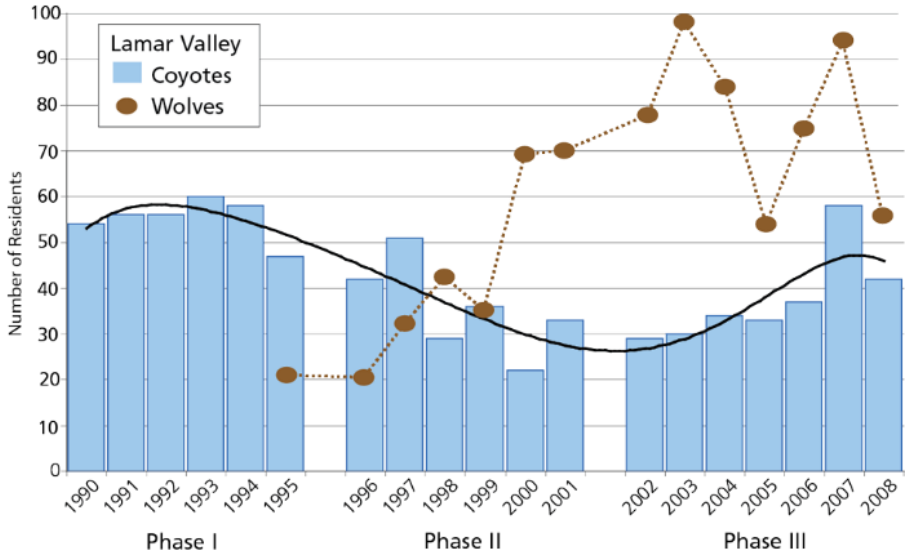
D. Close, small island

20. The theory of island biogeography has recently been criticized to be oversimplified. Which of the following is/are valid criticism of the theory?

(1) The colonization of an island is not only determined by its distance from the mainland, but also by the dispersal ability of the organisms - a remote island is more likely colonized by birds than frogs
(2) Habitat quality of an island impacts the number of species of an island, and can result in a close island with poor habitat to have less species than a remote island with good habitat.
(3) The composition and interactions of different species of an island also affect its total number of species.
(4) Extinction of species is affected by a number of factors rather than only by the size of an island.

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

Q21-22. Wolves were native to the northwestern United States, but in the late 1800s they were hunted to local extinction. In 1995 a group of 20 wolves was reintroduced into Yellowstone National Park in Wyoming, USA. The graph below shows the population sizes of wolves and coyotes (a smaller carnivorous member of the dog family) from 1990 until 2008.



21. Which of the following statements best describes the pattern of population growth in coyotes following the introduction of wolves into Yellowstone National Park in 1995?

A. The population size of coyotes was not affected by the introduction of wolves.
B. The population size of coyotes increased to two maximums in 2003 and 2007.
C. The populations size of coyotes decreased to a minimum in 2000 and then increased.
D. The population size of coyotes remained constant.

22. Which of the following ecological interaction(s) could explain the pattern observed in question 21?

(1) Coyotes and wolves are competitor for food resources.
(2) Wolves are predators of coyotes.
(3) Coyotes and wolves are mutualists.

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

Q23-24. *Maieta guianensis*, a small shrub found in the Amazon rainforest are often observed to have many ants (*Pheidole mimutula*) "patrolling" their leaves. In fact, researchers observed that there were special pouches on the underside of the leaves which served as "homes" for the ants. Further investigation showed that the ants were predators of herbivorous insects attempting to feed on the shrubs leaves.

In order to examine how the ants were affecting the shrubs, scientists conducted an experiment in which they studied two groups of plants. In the first group they removed ants from some plants and kept them off for one year. In the second group they did not change the number of ants found living on the plants.

After one year the scientists counted the number of fruits produced by the two groups of plants. The results are as below:

	number of fruits produced per plant
First group -- Ants removed	0.5
Second group -- Ants present	22.6

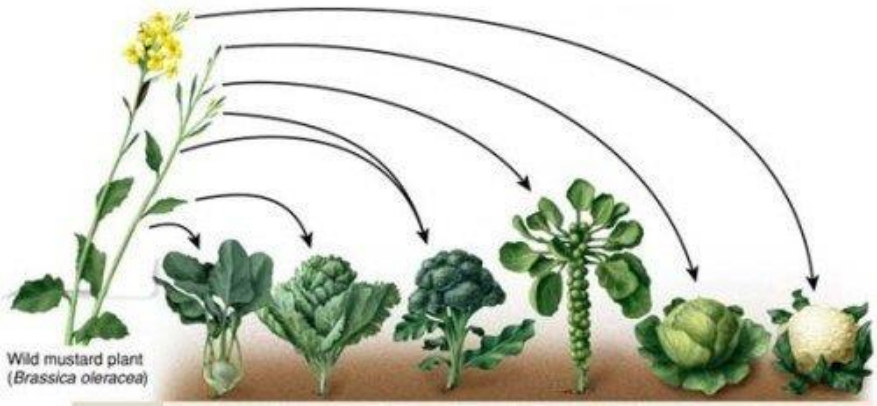
23. Which of the following is the appropriate conclusion based on the data of the experiment and the information about the plants and the ants? (E/M)

A. Removing ants increased the number of fruits produced by plants because ants feed on the flowers.
B. Removing ants increased the number of fruits per plant because the ants were feeding on the leaves of the plant.
C. Removing ants decreased the number of fruits per plant because the ants protected the plants from herbivorous insects.
D. Removing ants decreased the number of fruits per plant because the herbivorous insects are important pollinators.

24. Which of the following best describes the relationship between the shrub and the ants?

A. Competition
B. Parasitism
C. Mutualism
D. Commensalism

Q25-26. Many of the vegetables we eat, including Kohlrabi, kale, broccoli, Brussels sprouts, cabbage, and cauliflower are members of the same species, a wild mustard plant (*Brassica oleraceae*). The variety of vegetables derived from the wild mustard plant is a result of the farmers' artificial selection.



Strain	Kohlrabi	Kale	Broccoli	Brussels sprouts	Cabbage	Cauliflower
Modified trait	Stem	Leaves	Flower buds and stem	Lateral leaf buds	Terminal leaf bud	Flower buds

25. How did farmers produce modern Kale from the wild mustard ancestor?

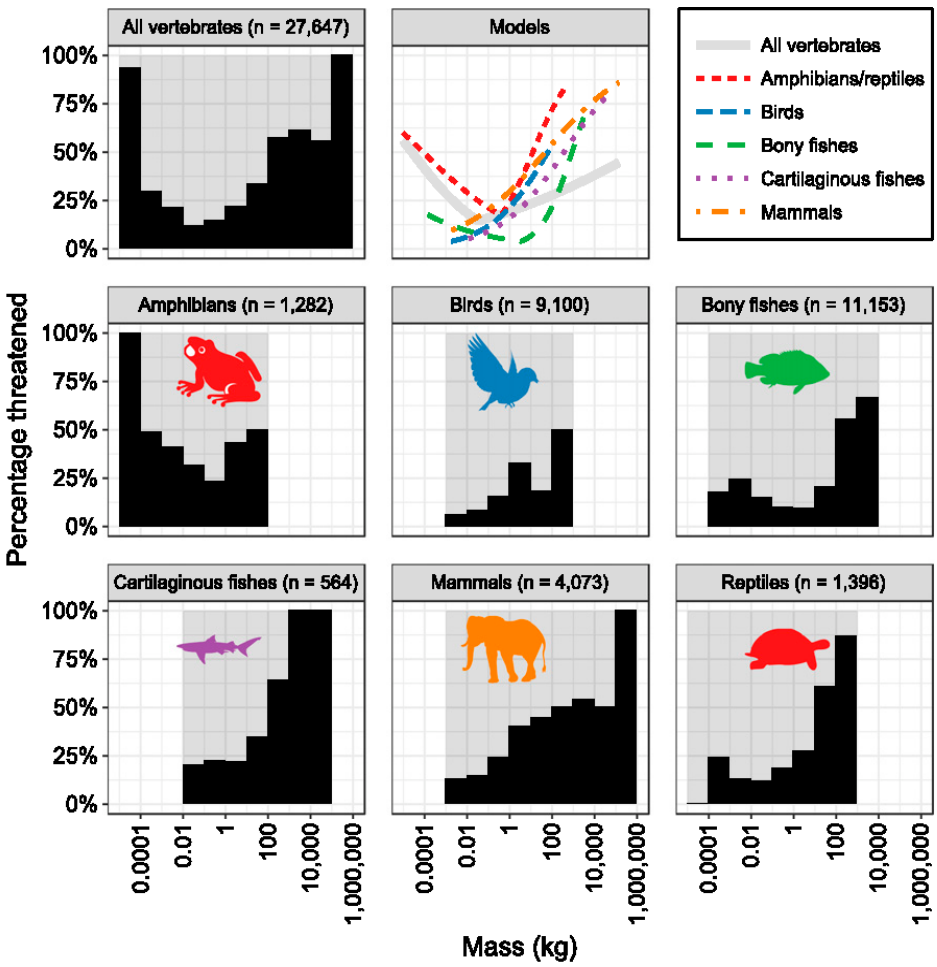
A. They provide the optimal conditions to support leaf growth.
B. They removed all excess stems, flowers, and fruits so that all resources were spent on leaves.
C. They selected mustard plants with large leaves and transferred pollens among their flowers.
D. They found natural variants with large leaves in the wild and then reproduced them asexually.

26. Which of the following is/are the condition(s) required by artificial selection?

(1) variation in phenotypes
(2) selective breeding of particular traits
(3) the phenotypes are inheritable

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

Q27-28. The graphs below show how body mass is related to the percentage of threatened species in different groups of vertebrates.



27. Which of the following best describes the pattern shown by the graphs above?

(1) Large cartilaginous fish face greater threat risk than bony fish of similar body mass.
(2) For amphibians, species with intermediate body mass have lower threat risk
(3) Except for amphibians, the threat risk of a species increases with body mass for each vertebrate group.

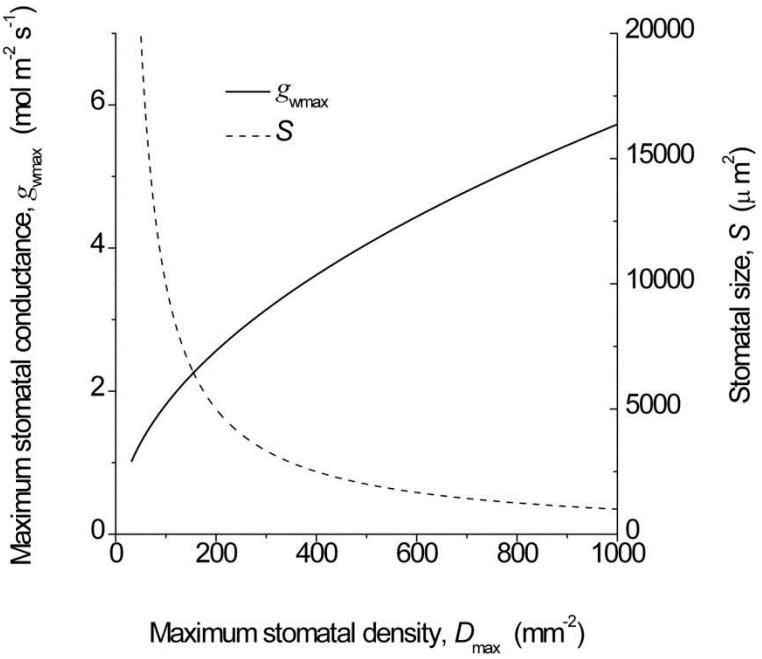
A. 1 only
B. 3 only
C. 1 and 3 only
D. 1,2 and 3

28. Which of the following is/are reasonable explanation(s) for the patterns shown by the graphs?

(1) Larger species of vertebrates tend to have lower population density, which increases their threat risk.
(2) Larger species of mammals tend to have lower reproduction rate, which increases their threat risk.
(3) Larger cartilaginous fish face greater threat risk partly because they are usually the target of human hunting.

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

Q29-30. The following graph shows the theoretical relationships between stomatal size, stomatal density and maximum conductance for water vapour (g_{wmax}) in plants. For each stomatal size, there is a maximum stomata density in a fixed leaf area. Conductance represents the rate of water vapour diffusing through the stomatal pores per unit area. The conductance of carbon dioxide is similar to that of water vapour.



Source: http://www.pnas.org/content/106/25/10343

29. With reference to the above graph, which of the following is/are correct?

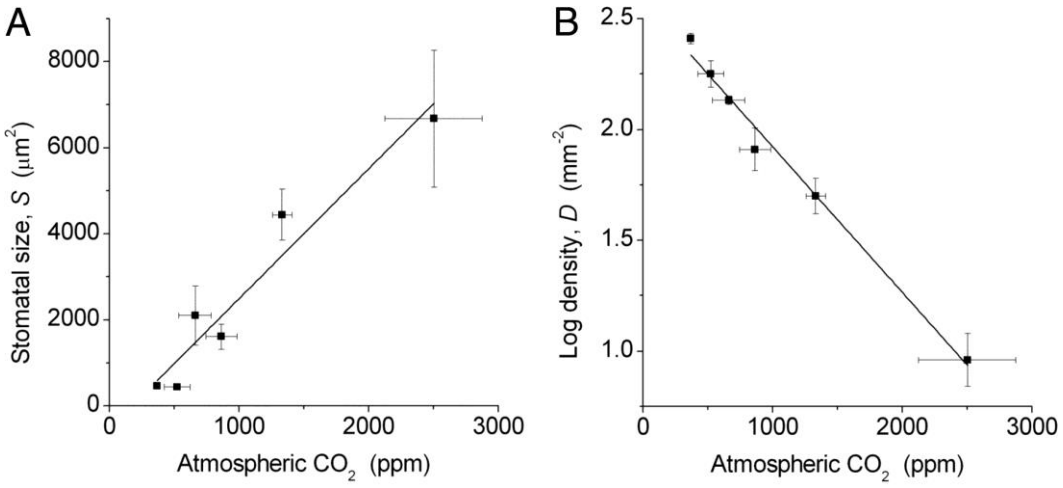
(1) For a fixed leaf area, the smaller the stomatal pores, the higher the density of stomata it can have.

(2) The diffusion rate of water vapour into stomatal pores is positively proportional to the stomatal density.

(3) The diffusion rate of water vapour into stomatal pores is negatively proportional to the stomatal size.

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

30. The figures below show how atmospheric carbon dioxide concentration is related to stomatal size and log density in fossil plants over hundreds of millions of years.



Source: http://www.pnas.org/content/106/25/10343

With the help of the information in Q29, which of the following is/are the probable explanations of these relationships?

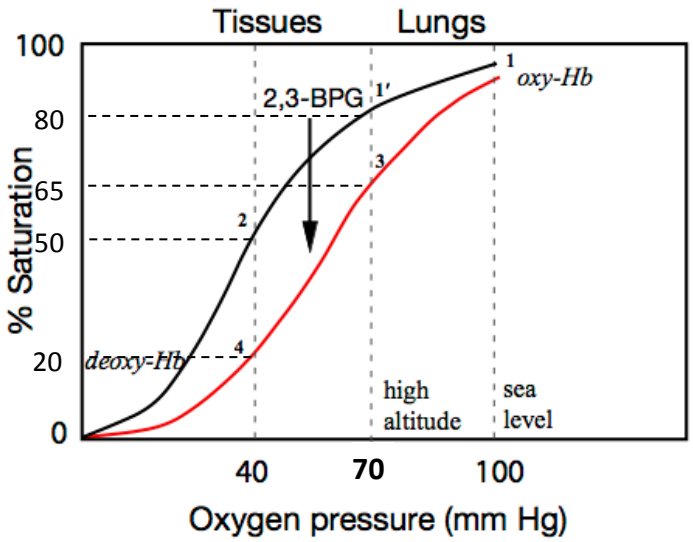
(1) Over the past hundreds of millions of years, the atmospheric carbon dioxide concentration has been increasing due to global warming. Larger stomata allowed the plants to have faster transpiration to cool down its leaves.

(2) Larger stomatal pores allowed the plants to take in more carbon dioxide as an adaptation to the increasing atmospheric carbon dioxide concentration.

(3) A higher density of smaller stomata allowed the plants to have adequate supply of carbon dioxide during the periods of lower atmospheric carbon dioxide.

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

Q31-32. Below is an oxygen haemoglobin dissociation curve of humans. It shows the percentage of oxygen that is taken up by haemoglobin at different oxygen pressure. When humans live at high altitude for some time, the body adapts to the low oxygen environment by producing 2,3-BPG, which will shift the curve to the right.



31. For a normal person living at sea level, what percentage of oxygen in the blood can be supplied to the tissue when he is at high altitude?

A. 30%
B. 45%
C. 65%
D. 100%

32. After some period of living at high altitude, the body produces 2,3-BPG as an adaptation. Which of the following is/are correct about the role of 2,3-BPG?

(1) It decreases the oxygen uptake at lungs.
(2) It lowers the affinity of haemoglobin to oxygen.
(3) It allows additional 15% of oxygen from blood supplying to the tissue.

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

Q33-34. Ruben conducted an experiment aimed at finding out the source of oxygen produced in photosynthesis. He labeled the water molecule with ^{18}O atoms. In nature, 99.76% of the oxygen atoms are ^{16}O and only 0.20% of them are the heavier isotope ^{18}O.

The labeled water was then supplied to algae for photosynthesis and the amount of isotopes in different chemicals were measured after some time. He conducted the second experiment by labeling the carbon dioxide with ^{18}O atoms. The results were as follows:

		% of ^{18}O		
Experiment		H_2O	CO_2	O_2
1 (H_2O*)	start	0.85	0.20	
	finish	0.85	0.61	0.86
2 (CO^*_2)	Start	0.20	0.68	
	finish	0.20	0.57	0.20

33. Which of the following is/are correct conclusions from the above results?

(1) The results of experiment 1 proved that oxygen produced in photosynthesis comes from water.
(2) The results of experiment 2 ruled out that oxygen produced in photosynthesis comes from carbon dioxide.
(3) The results of experiment 1 and 2 showed that oxygen produced in photosynthesis comes from both carbon dioxide and water.

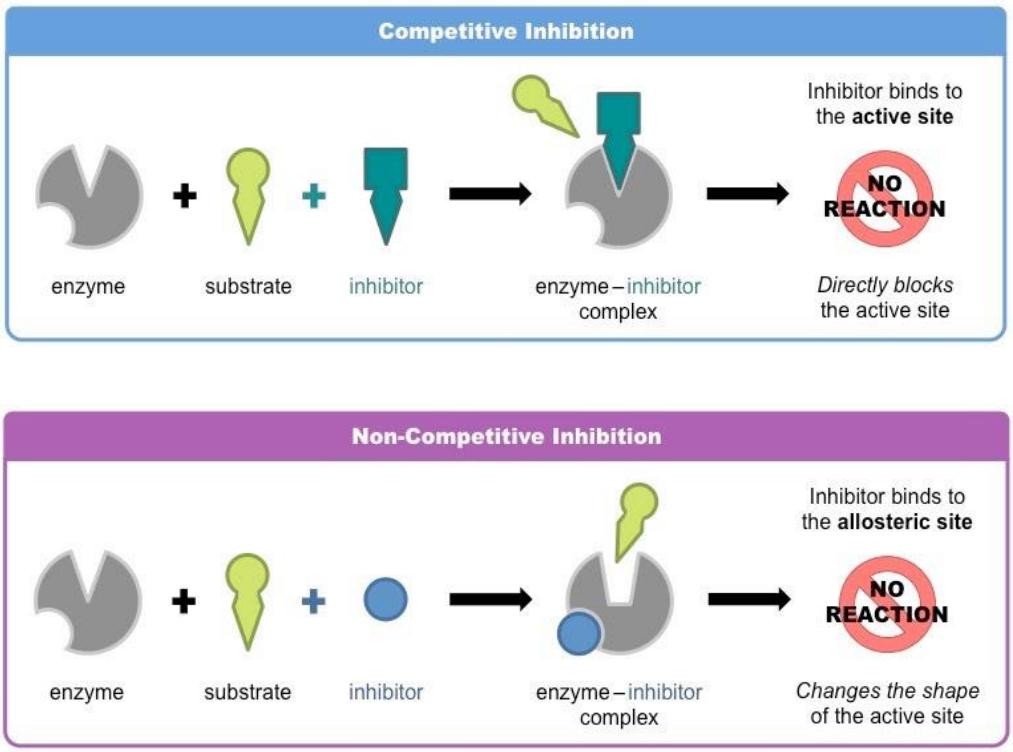
A. 1 only
B. 3 only
C. 1 and 2 only
D. 1,2 and 3

34. In experiment 2, which of the following molecules of the algae are expected to show greater than 0.2% of ^{18}O after long period of growth?

(1) Carbohydrates
(2) Protein
(3) Lipid
(4) DNA

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

35. There are two types of enzyme inhibition: competitive and non-competitive.

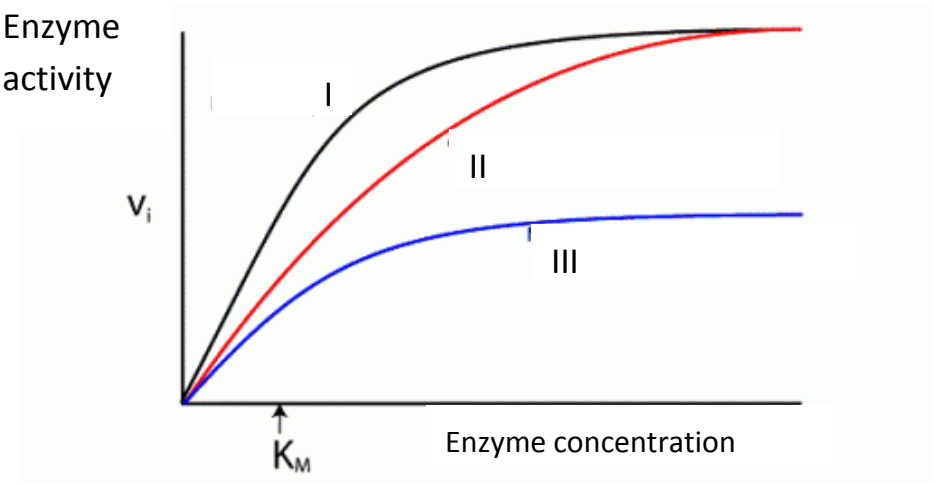


Which of the following is/are correct about these two types of enzyme inhibition?

(1) In competitive enzyme inhibition, the inhibitor has to be in similar shape with the substrate.
(2) In non-competitive enzyme inhibition, the inhibitor binds to the active site.
(3) For both competitive and non-competitive enzyme inhibition, the shape of active site is altered by the inhibitor.

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

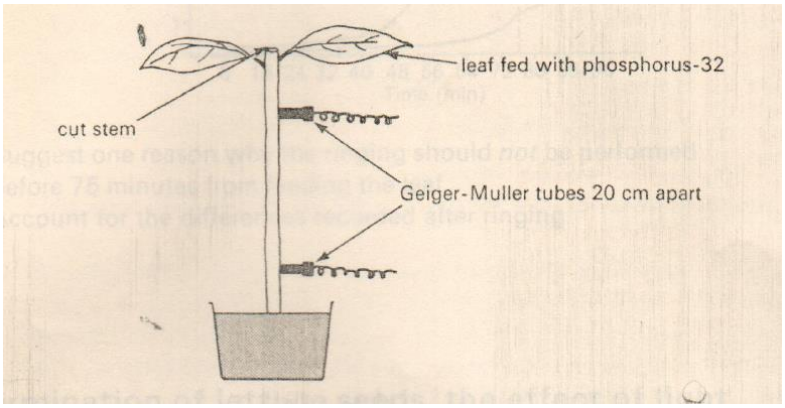
36. The graphs below show an enzyme reaction that is inhibited by different kinds of inhibitors.



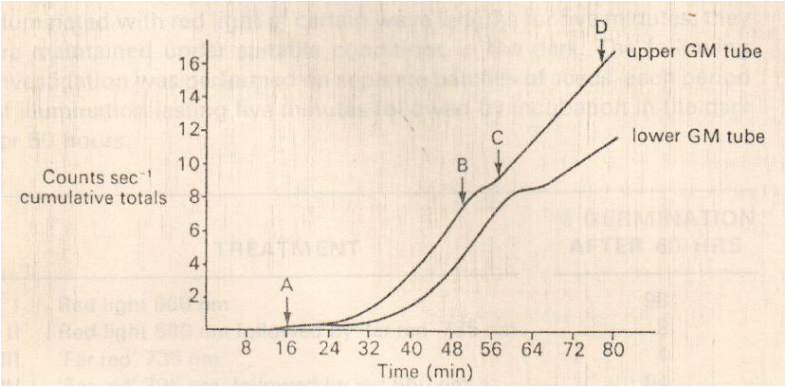
Which of the following is correct?

	I	II	III
A	No inhibitor	Competitive inhibitor	Non-competitive inhibitor
B	No inhibitor	Non-competitive inhibitor	Competitive inhibitor
C	Non-competitive inhibitor	Competitive inhibitor	No inhibitor
D	Competitive inhibitor	Non-competitive inhibitor	No inhibitor

Q37-38. An experiment was done to investigate the translocation of organic food in plants. One leaf was fed with radioactive phosphorus, while all the leaves above this leaf were removed. Two radioactive sensors were placed below the fed leaf, with about 20cm apart.



The results obtained are:



37. Which of the following is/are correct about the design of the experiment?

(1) The compounds labeled by the radioactive phosphorus in the leaf are mainly sugar phosphate.
(2) The purpose of removing the leaves above the fed leaf is to avoid the labeled compounds to be translocated upward.
(3) The amount of radioactivity detected by the two sensors shows the amount of labeled compounds from the fed leaf.

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

38. What can be concluded from the results?

(1) Photosynthetic products with phosphorus are translocated from leaves to root.
(2) The rate of translocation is about 1 cm per minute within the period of 40-48 minutes.
(3) The sieve tubes of the plants are responsible for the translocation of the photosynthetic products.

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

Q39-40. An experiment was designed to study the uptake of glucose by the small intestine of rat. A length of the small intestine was cut off from the rat, turned inside out and tied off both ends into a sac. Glucose solution was put inside the sac. The sac was bathed in the same glucose solution for an hour. Both the volume and glucose concentration of the solutions inside and outside the gut sac were measured. The results are as follows:

	Bathing solution outside the gut sac		Solution inside the gut sac	
	Volume (cm3)	Glucose concentration (mg/100cm3)	Volume (cm3)	Glucose concentration (mg/100cm3)
At the start	15	500	5	500
After one hour	13	350	7	770

39. Which of the following provides the evidence for the conclusion that glucose is actively absorbed by the small intestine against concentration gradient?

(1) The glucose concentration of the solution inside the sac is higher than that of the bathing solution after an hour.
(2) The volume of the solution inside the sac increased after an hour.
(3) Glucose can provide energy for active transport.

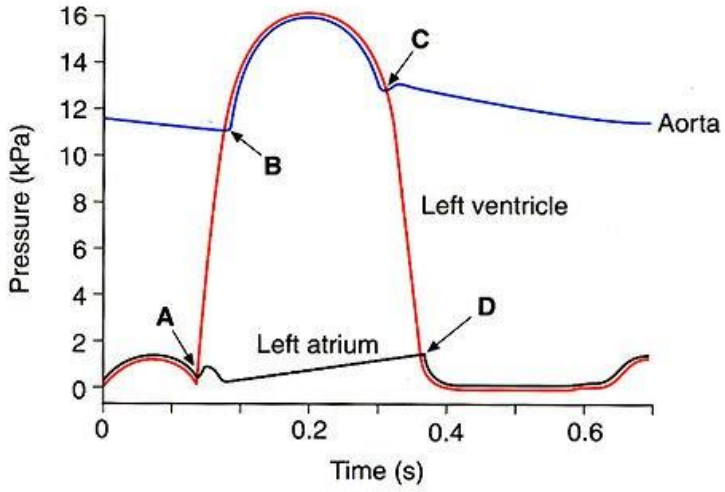
A. 1 only
B. 3 only
C. 1 and 2 only
D. 1,2 and 3

40. The experiment was replicated with cyanide added in the glucose solution. Cyanide is a respiratory inhibitor. What changes of the results are expected?

(1) The volume of the solution inside the sac would be larger than that of the original experiment after an hour.
(2) The glucose concentration inside the sac after an hour would be lower than that of the original experiment.
(3) The volume of the solution inside and outside the sac would be the same.

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

Q41-42. The graph below shows the changes in blood pressure of the ventricles, atria and aorta during the cardiac cycle of humans.



41. Which of the following is/are correct?

(1) From A to B, blood is flowing from left ventricle to aorta.
(2) From B to C, left ventricle is contracting while left atrium is relaxing.
(3) Heart valves close at A and C.

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

42. The systolic and diastolic blood pressures of the aorta are 120 and 80 respectively. However, when the aortic valve cannot close completely, blood will flow back from aorta to left ventricle during diastole. This will change the aortic blood pressures to 160 and 60. Which of the following is/are the correct explanations of these changes?

(1) The left ventricle is filled in more blood during diastole, making it contract more forcibly into aorta.
(2) The aortic blood is leaking back to left ventricle during diastole, thus lowering its diastolic pressure.
(3) The aorta will contract during systole and relax during diastole.

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

Q43-45. A species of shore crab was studied on their aggressive behavior. The crabs sometimes stay close together in crevices, but sometimes are very aggressive to each other. In an experiment, four crabs were placed in a bowl with rocks and water. They were observed for their frequency of aggressive contacts. The setup was replicated with different sex of crabs. The data collected were shown below:

		Average number of aggressive contacts of each group per hour	
Number of groups	Sex of crabs	In water	Out of water
4	female	16	5
4	male	27	6
6	Male and female	22	1

43. What can be concluded from the data?
(1) Male crabs are more aggressive to each other than are the females.
(2) Aggressive contacts are more likely to occur in water.
(3) Males are more aggressive than females when they encounter.

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

44. Which of the following is/are likely the significance of the behavior of the crabs?

(1) The aggressive behavior in water enables the crabs to compete for food and mates.
(2) Aggressive contacts between males and females are part of the courtship behavior.
(3) Crabs need to aggregate inside crevices when out of water in order to prevent water loss and shelter against wave action.

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

45. Which of the following would limit the validity of the conclusions in natural habitats?

(1) In natural habitats, crabs will not be confined in a small bowl but disperse out.
(2) In natural habitats, there are constant wave action and strong sunlight that are absent in the setup.
(3) In natural community of crabs, they will develop some hierarchy to avoid frequent aggressive contacts.

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

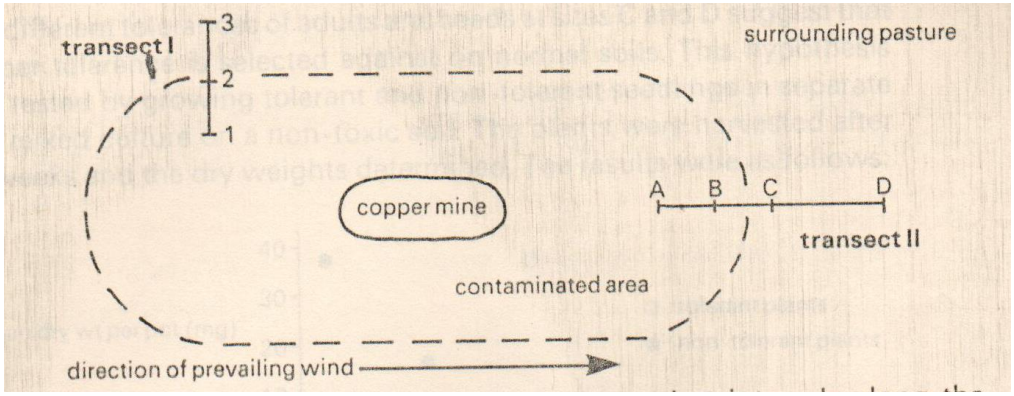
46. There found two types of amylase in animals: A1, A2, which differ slightly in structure. Some animals have both types of amylase. It is hypothesized that the two types of amylase are controlled by a pair of alleles that are not dominant or recessives to each other. Below are the crosses done to test the hypothesis.

	F1 phenotypes		
cross	A1	A2	A1A2
I. A1 X A1	10	0	0
II. A1 X A2	0	0	37
III. A1 X A1A2	33	0	28
IV. A1A2 X A1A2	4	4	13

Which of the above crosses support the hypothesis?

A. I and II only
B. II and III only
C. I, II, IV only
D. I, II, III and IV

Q47-48. The copper tolerance of a grass species around the copper mine was studied. The grasses were collected along two transect lines. To show tolerance, the growth of root in solutions with and without copper were measured. The copper content of the soil around the plants were measured.



	Site	Distance from contaminated area (m)	Soil copper (ppm)	Mean tolerance of plants
Transect I	1	0	2700	56
	2	7	900	51
	3	30	156	16
Transect II	A	0	700	44
	B	60	300	42
	C	80	136	33
	D	155	52	20

47. What conclusion(s) can be drawn from the data?

(1) Within a transect line, the tolerance increases when the plant is closer to the contaminated area.

(2) Within a transect line, the tolerance decreases when there is less copper in soil.

(3) Tolerance is more related to soil copper concentration than the distance from contamination.

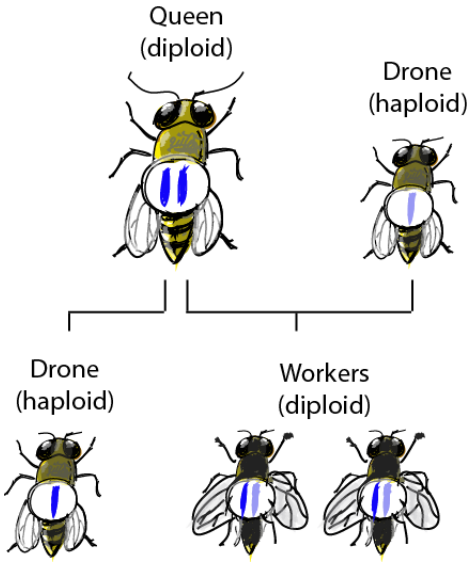
A. 1 only
B. 2 only
C. 1 and 2 only
D. 1, 2 and 3

48. Plants in site C show much greater tolerance than those in site 3. Which of the following is/are the correct explanation of it?

(1) Soil of site C has higher copper concentration than that of site 3.
(2) Site C is farther away from contaminated area than site 3.
(3) The prevailing wind will carry pollens from tolerant plants to site C, while it will not for site 3.

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

Q49-50. Sex determination of honey bees is special – diploid is largely female (queen or worker) and haploid is male (drone). Eggs that are fertilized will mostly develop into female, while unfertilized eggs will develop into males.



49. Which of the following is/are correct?

(1) In drones, sperms are produced by mitosis.
(2) Each worker bee will receive all the DNA of its father but only half of its mother.
(3) The change in number of genes of bees is smaller as compared to that of humans.

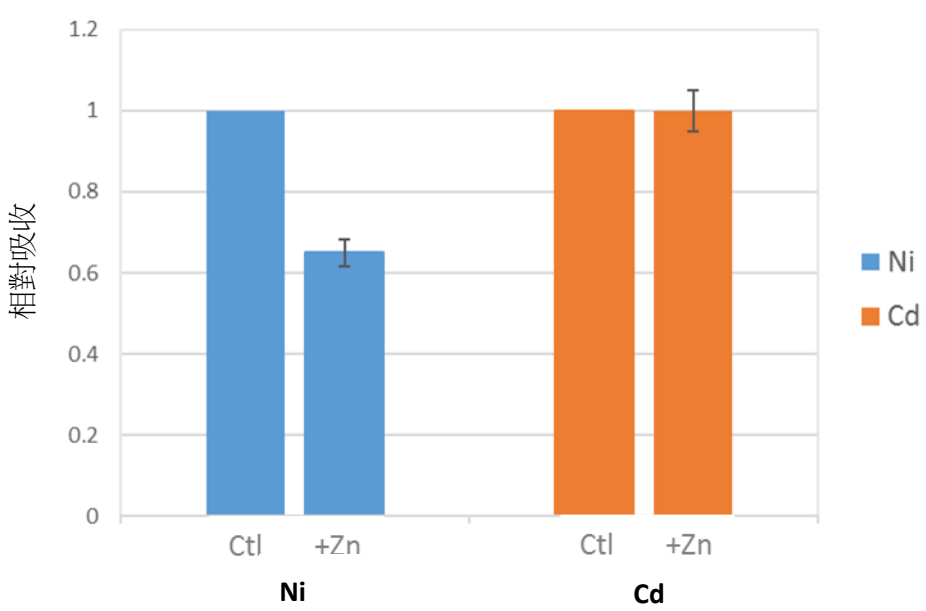
A. 1 only
B. 2 only
C. 2 and 3 only
D. 1, 2 and 3

50. In bees, a pair of alleles control the body colour: Yellow is dominant to black. Which of the following is/are the correct predictions of the F1 offspring from the cross between a heterozygous yellow queen and a black drone?

(1) Half of the drones are black, while half of the workers are yellow.
(2) There are 25% of black workers.
(3) The male to female ratio cannot be predicted.

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

1. 有些植物會利用根部的離子轉運蛋白吸收泥土裡的重金屬。以下實驗數據顯示其中一種植物在有鋅 (+Zn) 或沒有鋅(ctl)的情況下對鎳(Ni)和鎘(Cd)的吸收情況。當加入鋅，鋅的濃度是與實驗中的相關重金屬離子濃度相同。



按以上直方圖，以下哪項陳述正確？

(1) 鎳(Ni)和鋅(Zn) 由同一個離子轉運蛋白吸收，會互相競爭
(2) 鎘(Cd)和鋅(Zn) 在植物裡有同一功用，可以互相取代
(3) 在沒有鋅(Zn)的情況下，植物吸收等量的鎳(Ni)和鎘(Cd)

A. 只有 1
B. 只有 1 和 3
C. 只有 2 和 3
D. 1, 2, 和 3

2. 有一種昆蟲的幼蟲經常在堆填區的塑膠廢料中找到。科學家對這種幼蟲進行一系列的實驗，以下是其實驗結果。

i. 當沒有供應其他食物，把幼蟲和塑膠片放在一起 30 天，幼蟲體重增加，而塑膠片重量減少。

ii. 把幼蟲和室温的清水混合並磨碎，所得到的提取物能夠溶掉塑膠片 。

iii. 把幼蟲和 95ºC 的清水混合並磨碎，所得到提取物不能夠溶掉塑膠片 。

iv. 幼蟲被餵食一般食物及低劑量抗生素三天，幼蟲表現健康活躍。用室温水提取幼蟲提取物，提取物不能夠溶掉塑膠片 。

按以上資料，以下哪項陳述正確？

(1) 幼蟲能以塑膠片為食物。

(2) 幼蟲降解塑膠的能力一定涉及蟲酶作用。

(3) 幼蟲靠腸道細菌消化塑膠。

(4) 這幼蟲的成蟲一定能進食塑膠。

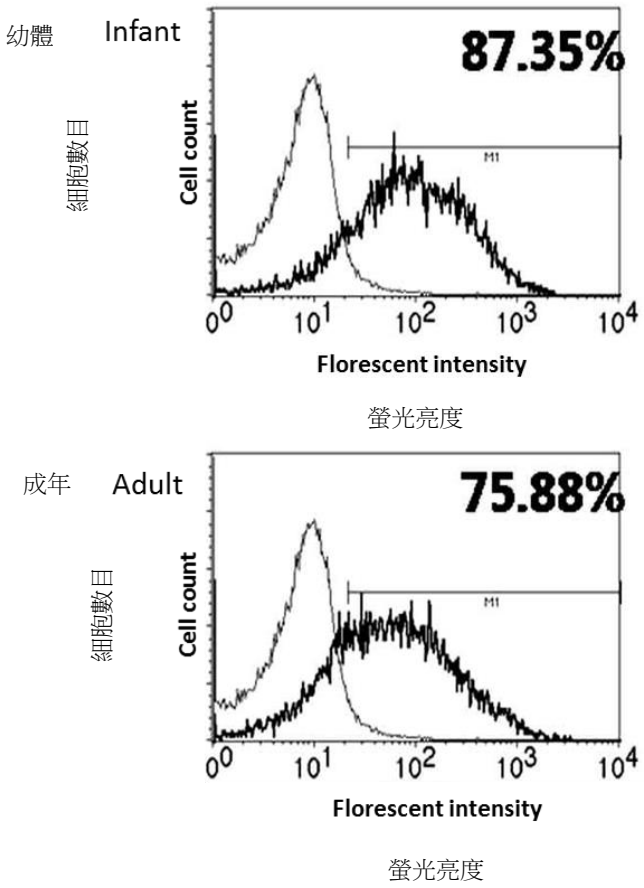
A. 只有 1

B. 只有 1 和 3

C. 只有 2 和 3

D. 只有 1, 2, 和 4

題 3-4. 頭髮的長度受毛囊細胞的複製週期次數控制。同時，細胞週期影響毛髮的定時更替，是動物維持毛髮健康外表的關鍵。週期蛋白 D 是細胞週期調節器。當細胞積極地進行分裂，週期蛋白 D 會持續處於高水平。利用流式細胞儀量度週期蛋白 D 的水平可以知道毛囊細胞是否積極地進行細胞分裂。週期蛋白 D 會先染上螢光染料，每個細胞的螢光亮度會被量度。收集兩批分別來自 14 日大(幼體)和性成熟(成年)動物的毛囊細胞，每批包含一萬粒的毛囊細胞都會被精確地點算和分析。



圖一，用流式細胞儀分析毛囊細胞內週期蛋白 D 的螢光亮度。左邊的峯是沒有染上螢光的控制組細胞。成年動物和幼體分別有 75.88% 和 87.35% 的細胞，其螢光亮度達 20 度或以上。

3. 在這實驗中，控制組細胞的功能是甚麼？

(1) 控制組細胞顯示不是從螢光染料而來的螢光亮度。

(2) 控制組細胞顯示有些週期蛋白 D 以外的細胞構造和粒子會被螢光染料染色。

(3) 控制組細胞顯示細胞沒有積極地進行細胞分裂時週期蛋白 D 的量。

A. 只有 1

B. 只有 2

C. 只有 1 和 3

D. 1, 2, 和 3

4. 按以上圖表的資料，以下哪項陳述正確？

(1) 幼體比成年動物有多 11%的毛囊細胞積極地進行細胞分裂。

(2) 控制組細胞比實驗組細胞製造較少的週期蛋白 D。

(3) 幼體的毛髮比成年動物的長。

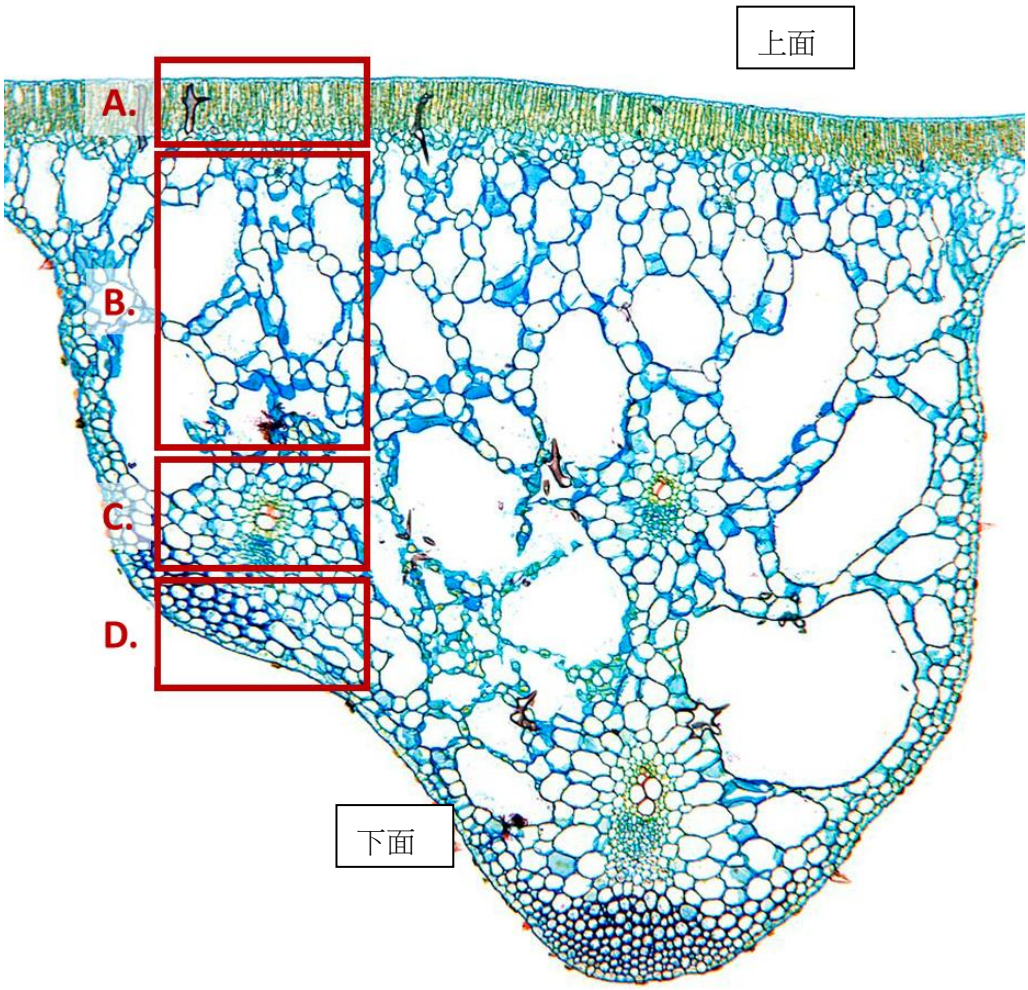
A. 只有 1

B. 只有 2

C. 只有 1 和 3

D. 1, 2, 和 3

題 5-6. 下圖是巨型睡蓮葉的垂直切面，這種植物的葉是浮在淡水面。



5. 按上圖，以下哪項是葉片對其原生環境的適應措施？

(1) 光合作用組織緊密地聚集在範圍 A 以吸收最多光。

(2) 範圍 B 有很多氣室令葉片浮在水面。

(3) 範圍 C 的木質導管在非常顯眼，可高效率地運送水分。

A. 只有 1

B. 只有 1 和 2

C. 只有 2 和 3

D. 1, 2, 和 3

6. 以下哪一範圍最有機會找到氣孔和其原因？

A. 範圍 A ，因為氣孔在這位置可以加快蒸騰作用以更有效地從根部運送水分。

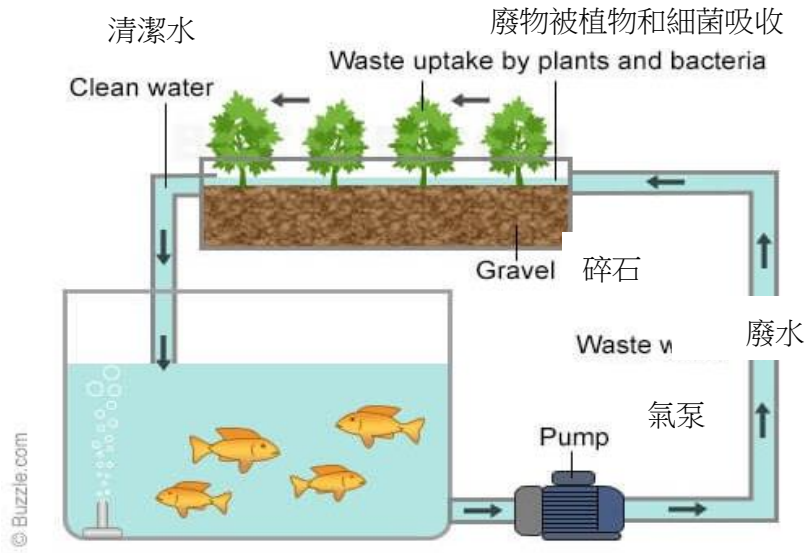
B. 範圍 D ，因為氣孔在這位置可以減少因蒸騰作用而流失的水分。

C. 範圍 A ，因為氣孔在這位置可以容許二氧化碳擴散到葉內進行光合作用。

D. 範圍 D ，因為氣孔在這位置可以與廣闊氣室連接。

題 7-9. 魚菜共生系統是結合水產養殖（養魚）和水耕法（水中種植）在一個綜合系統中同時養魚和種植。魚池水會被泵去供水給農作物的根，魚的排泄物亦可為植物提供營養。被植物根部過濾了的水會被送回魚池中。魚菜共生系統是一個封閉系統，無需添加新鮮水或排走廢水，直至收成的日子。

下圖顯示一個魚菜共生系統。



7. 以下哪項魚菜共生系統的陳述正確？

(1) 魚釋放硝酸鹽到水裡，硝酸鹽被植物的根吸收。

(2) 植物透過回流到魚缸的水為魚提供食物。

(3) 硝化细菌將魚所排泄的廢物轉化為營養供給植物。

A. 只有 1

B. 只有 3

C. 只有 1 和 3

D. 1, 2, 和 3

8. 以下表列總結 4 個魚菜共生系統的組成和實驗結果。4 個魚菜共生系統完全相同，但魚和植物的量就各有不同。魚的大小和年齡相似。魚的性別在是次實驗中是不相關的。 植物是正值快速生長期的生菜，從發芽起計算生菜的年齡相若。

系統	水產養殖	水耕	結果
1	20 尾魚	無植物	所有魚在系統建立 7 日後死亡
2	20 尾魚	20 棵植物	有些魚在系統建立 14 日後死亡，植物正常地生長
3	20 尾魚	40 棵植物	魚和植物都正常地生長
4	40 尾魚	40 棵植物	魚和植物都在系統建立 14 日後死亡

除已描述的因素以外，系統間還有甚麼其他因素需要維持一致？

(1) 餵飼魚的魚糧
(2) 植物接收到的光量
(3) 碎石的種類
(4) 魚的組成基因

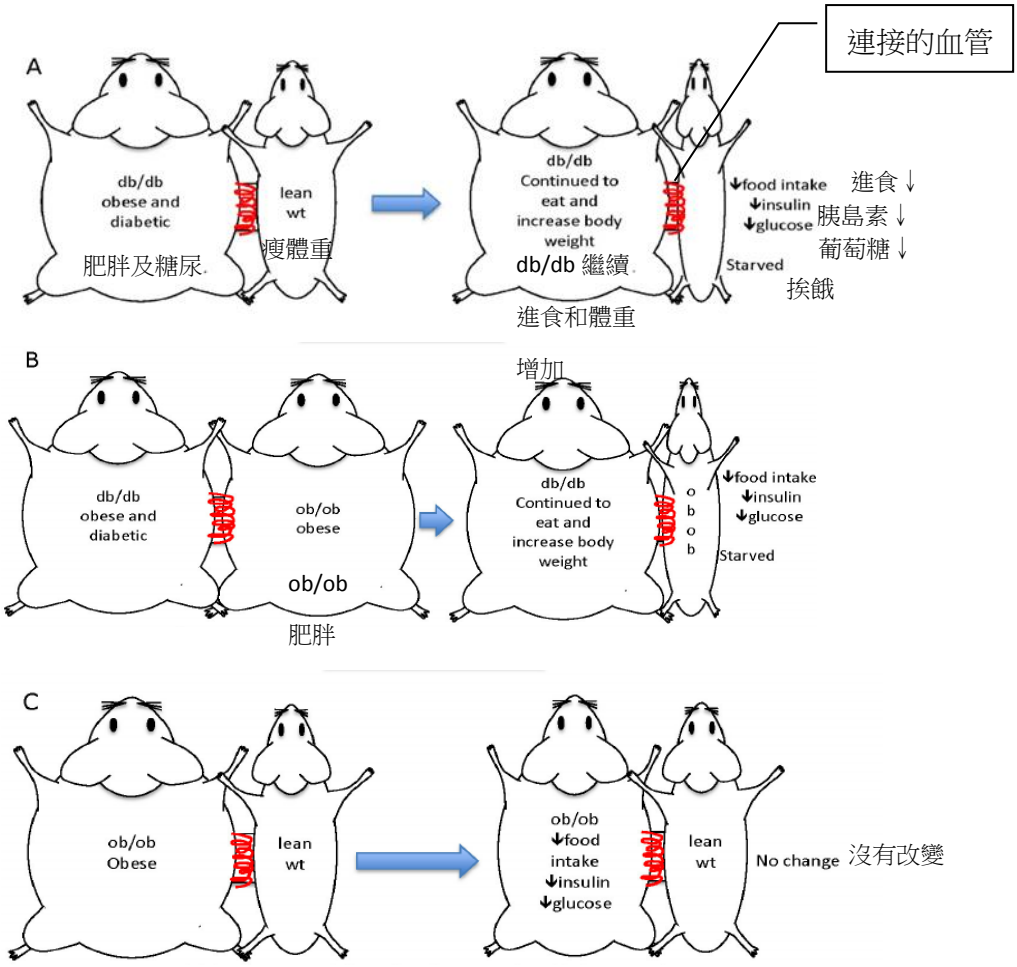
A. 只有 1 和 2
B. 只有 2 和 3
C. 只有 1, 2 和 3
D. 1, 2, 3 和 4

9. 按以上實驗結果，以下哪項是恰當的結論？

(1) 魚在系統內是否能夠生存取決於魚和植物的比例，魚和植物的數量並不重要。
(2) 植物在系統內是否能夠生存取決於魚的數量，魚和植物的比例並不重要。
(3) 系統最多只可有 20 尾魚和 40 棵植物。

A. 只有 1
B. 只有 2
C. 只有 2 和 3
D. 1, 2 和 3

題 10-12. 基因 db 的突變可以製造稱為 db/db 的肥胖老鼠。 基因 ob 的突變也可以製造稱為 ob/ob 的肥胖老鼠。科學家透過以下實驗去了解是否血液裡的物質導致肥胖。科學家連接兩隻老鼠的血管，然後觀察兩隻老鼠的體重變化。實驗結果在下圖。



10. 以下哪項是恰當的實驗結論？

(1) db/db 老鼠的血液有令老鼠體重減輕的物質。

(2) ob/ob 老鼠的血液有令老鼠體重增加的物質。

(3) 正常瘦的老鼠血液有令老鼠體重減輕的物質，但這物質的量不及 db/db 老鼠多。

A. 只有 1

B. 只有 2

C. 只有 1 和 3

D. 1, 2 和 3

11. 其後發現老鼠肥胖是因為一個叫瘦素的荷爾蒙。瘦素由脂肪組織分泌，在下丘腦發生作用去控制進食和能量運用。下丘腦有瘦素受體。高濃度的瘦素可以在 db/db 老鼠的血液找到， ob/ob 的血液中則沒有。

以下哪項關於瘦素對突變肥胖老鼠的影響的陳述正確？

(1) db 基因製造瘦素敏感細胞表面的瘦素受體。 所以 db/db 老鼠發展出瘦素抵抗性，脂肪組織因此分泌更多瘦素。
(2) ob 基因製造瘦素。所以 ob/ob 老鼠的脂肪組織不能夠分泌瘦素。
(3) 瘦素刺激下丘腦去產生飢餓的訊號。

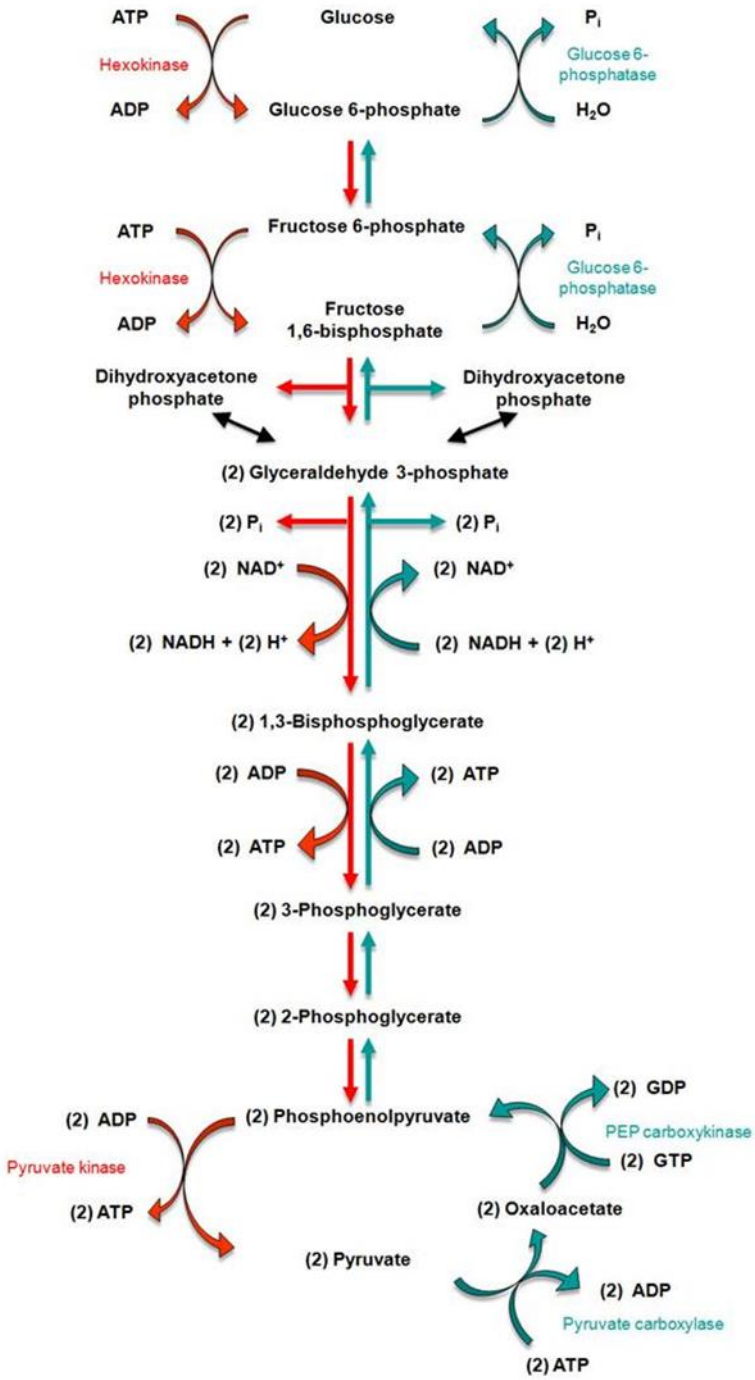
A. 只有 1
B. 只有 1 和 2
C. 只有 2 和 3
D. 1, 2 和 3

12. 有人認為瘦素可以令肥胖人士的體重減輕。但為肥胖者注射瘦素對體重的影響很微。以下哪項是最能解釋這現象？

(1) 人類的瘦素水平跟有多肥胖有正向關係。
(2) 大部分肥胖者的瘦素基因沒有發生突變。
(3) 瘦素於人體的功能跟在老鼠身上不同。

A. 只有 1
B. 只有 2
C. 只有 1 和 3
D. 只有 2 和 3

題 13-15. 適當控制葡萄糖水平對產生和儲存能量、以及維持血清的葡萄糖水平很重要。我們的身體能非常有效地利用酶去製造和降解葡萄糖。下圖顯示糖酵解作用和糖原異生 (由丙酮酸脂(pyruvate)和非醣類的碳源去製造葡萄糖) 的代謝路徑。在代謝路徑中，有些糖酵解作用和糖原異生的步驟使用不同的酶，其他步驟使用相同的酶 (酶的名稱沒有標示)。



13. 參考上圖，以下哪項正確？

(1) 糖原異生正好是糖酵解作用相反過程。
(2) 糖原異生是能量吸收的過程，而糖酵解作用是能量釋放的過程。
(3) 沒有磷酸烯醇丙酮酸羧化激酶 (PEP carboxykinase)，糖原異生不會發生。

A. 只有 1
B. 只有 2
C. 只有 2 和 3
D. 1, 2 和 3

14. 如果人體內缺乏丙酮酸脂激酶 (pyruvate kinase)，試預測 2-磷酸甘油酸 (2-phosphoglycerate)的濃度的變化。

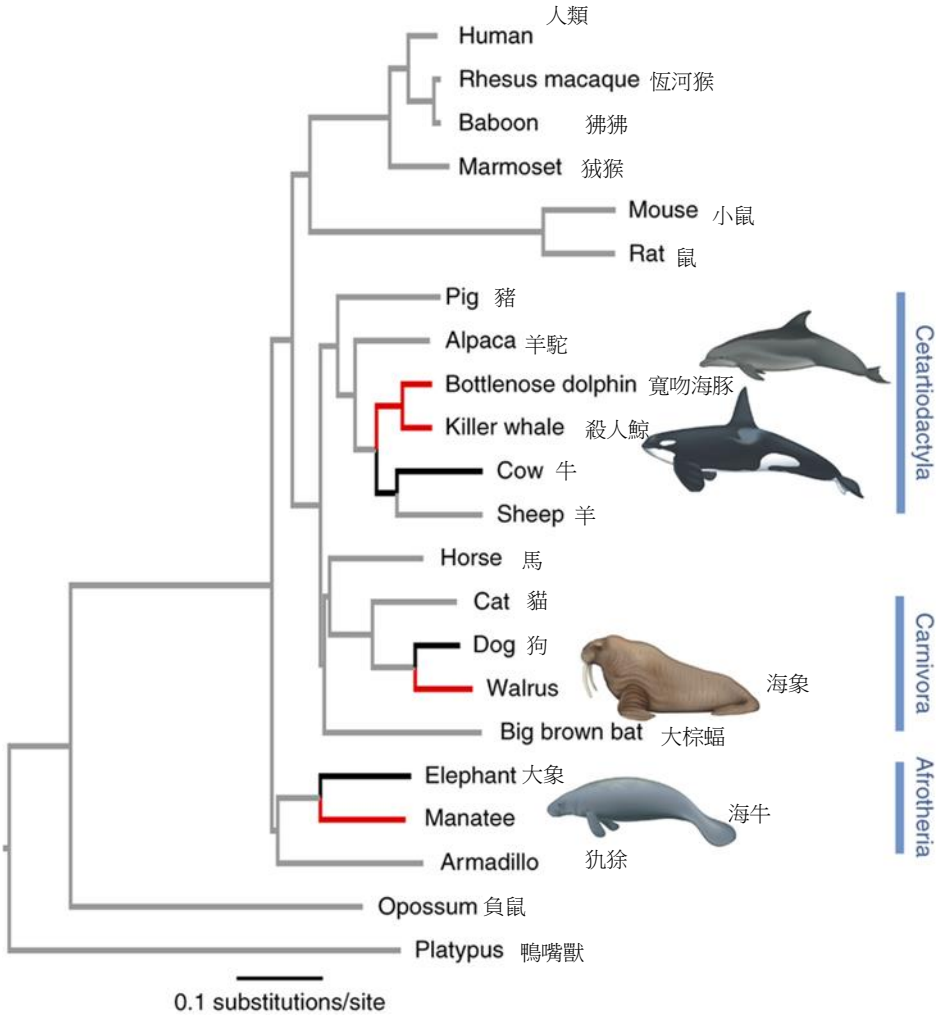
A. 增加
B. 下降
C. 不變
D. 單靠已提供的資料不可能作預測。

15. 胰島素和胰高血糖素是兩種控制血糖水平的激素。按激素對血糖水平的整體效果，以下哪項最有可能是激素對糖酵解作用和糖原異生酶的影響？

(1) 胰島素抑制磷酸烯醇丙酮酸羧化激酶 (PEP carboxykinase)。
(2) 胰高血糖素激活果糖 1,6-雙磷酸酶 (fructose-1,6-bisphosphatase)。
(3) 胰高血糖素減弱丙酮酸激酶 (pyruvate kinase) 的活性。

A. 只有 1
B. 只有 2
C. 只有 2 和 3
D. 1, 2 和 3

題 16-17. 以下是 20 種胎盤哺乳類按基因體定序而編的種系發生樹。種系發生樹以有袋動物為外群作根據。這種系發生樹用於了解胎盤哺乳類水生生活方式的演化。



16. 按簡約原則，胎盤哺乳類動物中演化出水生生活方式的次數最有可能是多少？

A. 1 次

B. 2 次

C. 3 次

D. 4 次

17. 按以上的種系發生樹，哪一項論述是不正確的？

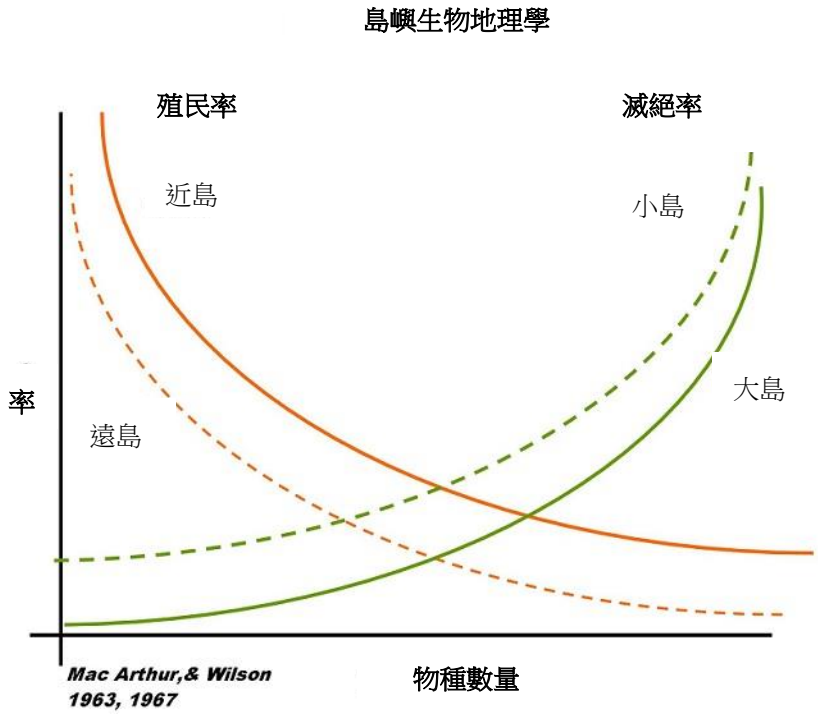
A. 狗是海象最親近的物種。

B. 恒河猴是人類最親近的物種。

C. 大象，海牛和犰狳源於同一個祖先。

D. 負鼠和所有胎盤哺乳類源於同一個祖先。

題 18-20. 下圖表述島嶼生物地理學理論。按這理論，島嶼上物種的預測數量是取決於殖民率 (新物種抵達島嶼)和滅絕率的平衡。殖民率亦受島嶼離大陸或其他島嶼的距離影響，而滅絕率也受島嶼的面積影響。



18. 按上圖，哪一項論述是不正確的？

A. 當物種數量上升，殖民率會下降。

B. 島嶼離大陸愈近，愈多共同物種。

C. 島嶼面積越細，滅絕率愈慢。

D. 當物種數量上升，滅絕率會上升。

19. 按上圖，你預計哪一種島嶼上物種數量會最多？

A. 偏遠，大島嶼

B. 偏遠，小島嶼

C. 近，大島嶼

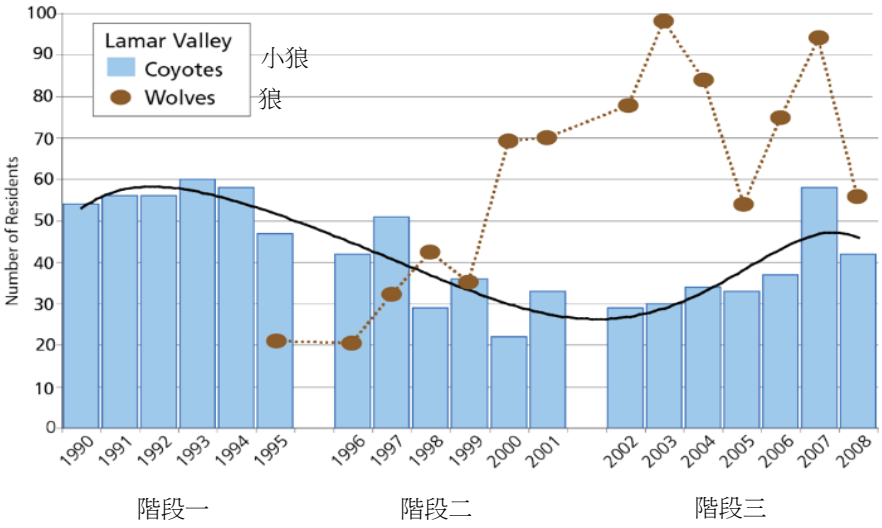
D. 近，小島嶼

20. 島嶼生物地理學理論最近被批評過於簡化。以下哪一項是對這理論合理的批評？

(1) 島嶼的殖民率不單受離大陸的距離影響，也受物種擴散能力影響。相比於蛙類，偏遠島嶼比較容易被雀鳥殖民。
(2) 島嶼生境的質素會影響物種的數量，生境質素欠佳的近島嶼較生境優良的偏遠島嶼有較少的物種。
(3) 島嶼上不同物種的組成和互動也會影響整體物種的數量。
(4) 物種的滅絕有若干個因素而非單純受島嶼的面積影響。

A. 只有 1 和 2
B. 只有 2 和 3
C. 只有 1, 3 和 4
D. 1, 2, 3 和 4

題 21-22. 狼(Wolves)是美國西北部的原生物種，但在 19 世紀被狩獵至局部地區滅絕。於 1995 年，一組 20 頭的狼被重新野放到美國懷俄明黃石國家公園。下圖顯示 1990 至 2008 年狼和小狼 (Coyotes，小型肉食犬類) 的族群數量。



21. 以下哪一項陳述最能陳述 1995 年狼被重新野放到黃石國家公園後，小狼族群的增長模式？

A. 小狼族群大小，不受重新野放的狼的影響。

B. 小狼族群大小於 2003 和 2007 年增長至最多。

C. 小狼族群大小於 2000 年減少至最少然後回升。

D. 小狼族群大小維持平穩。

22. 以下哪個種間關係可以解釋題 21 觀察到的模式？

(1) 小狼和狼是食物競爭對手。
(2) 狼是小狼的獵食者。
(3) 小狼和狼是互惠共生。

A. 只有 1
B. 只有 2
C. 只有 3
D. 只有 1 和 2

題 23-24. *Maieta guianensis* 是亞馬遜熱帶雨林內找到的一種小型灌木，經常觀察到有很多螞蟻 (*Pheidole mimutula)*在葉片上巡邏。事實上，科學家發現葉片底部有特殊的袋狀構造可用作螞蟻的家。深入研究顯示螞蟻會獵食企圖以灌木樹葉為食物的草食昆蟲。

為了研究螞蟻對灌木的影響，科學家對兩組植物進行實驗。科學家將第一組植物的螞蟻移除，並讓螞蟻消失一年。而第二組，就沒有改變植物上螞蟻的數目。

一年後，科學家統計兩組植物果實的數量。結果如下：

	每棵植物的果實數量
第一組: 移除螞蟻	0.5
第二組: 有螞蟻	22.6

23. 按實驗結果和灌木與螞蟻的資料，以下哪一項是合理結論？

A. 移除螞蟻可增加灌木果實的數量，因為螞蟻進食花朵。

B. 移除螞蟻可增加每棵植物果實的數量，因為螞蟻進食灌木的葉片 。

C. 移除螞蟻可減少每棵植物果實的數量，因為螞蟻保護灌木免受草食昆蟲襲擊。

D. 移除螞蟻可減少灌木果實的數量，因為草食昆蟲是重要的傳粉媒介。

24. 以下哪一項最適合形容灌木和螞蟻的關係？

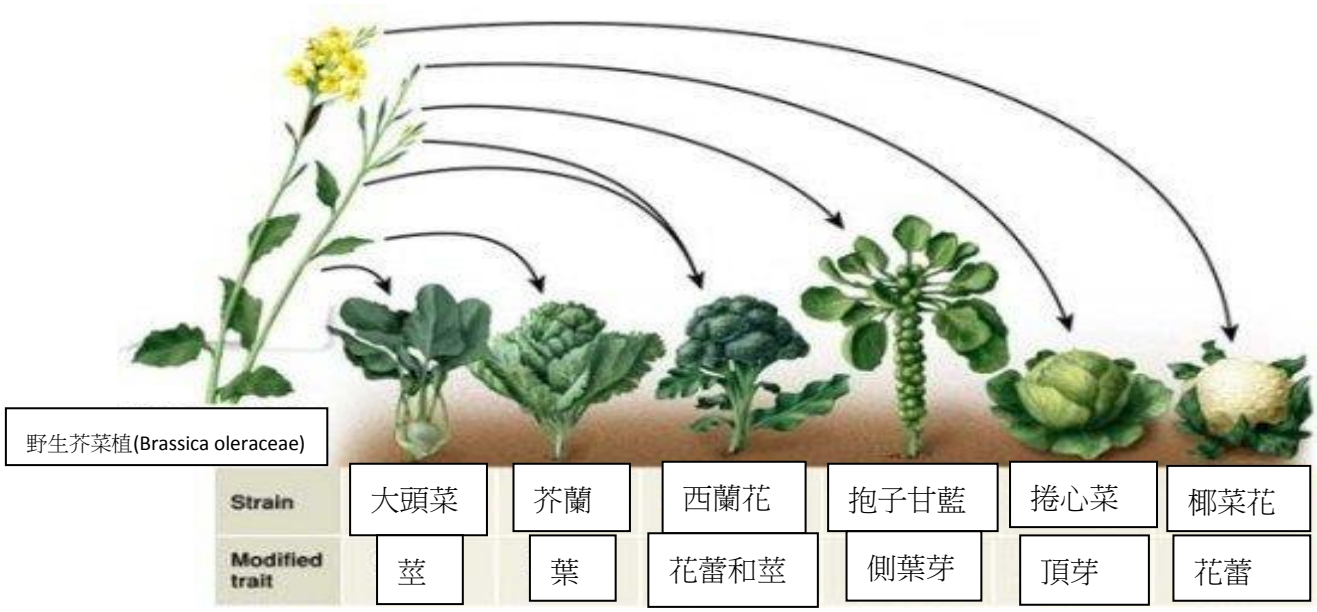
A. 競爭

B. 寄生

C. 互惠共生

D. 片利共生

題 25-26. 好多我們進食的蔬菜，包括大頭菜，芥蘭，西蘭花，抱子甘藍，捲心菜和椰菜花都屬同一品種 – 野生芥菜植物 (*Brassica oleraceae*)。從野生芥菜植物發展出各種蔬菜是農夫人為選擇的結果。



25. 農夫是怎樣從野生芥菜植物祖先發展出現代芥蘭？

A. 他們提供適合環境去支持葉的生長。

B. 他們去除所有多餘的莖，花和果實，以致所有資源都用於葉的生長。

C. 他們揀選大葉的芥菜植物並將花粉在這些植物的花朵間傳播。

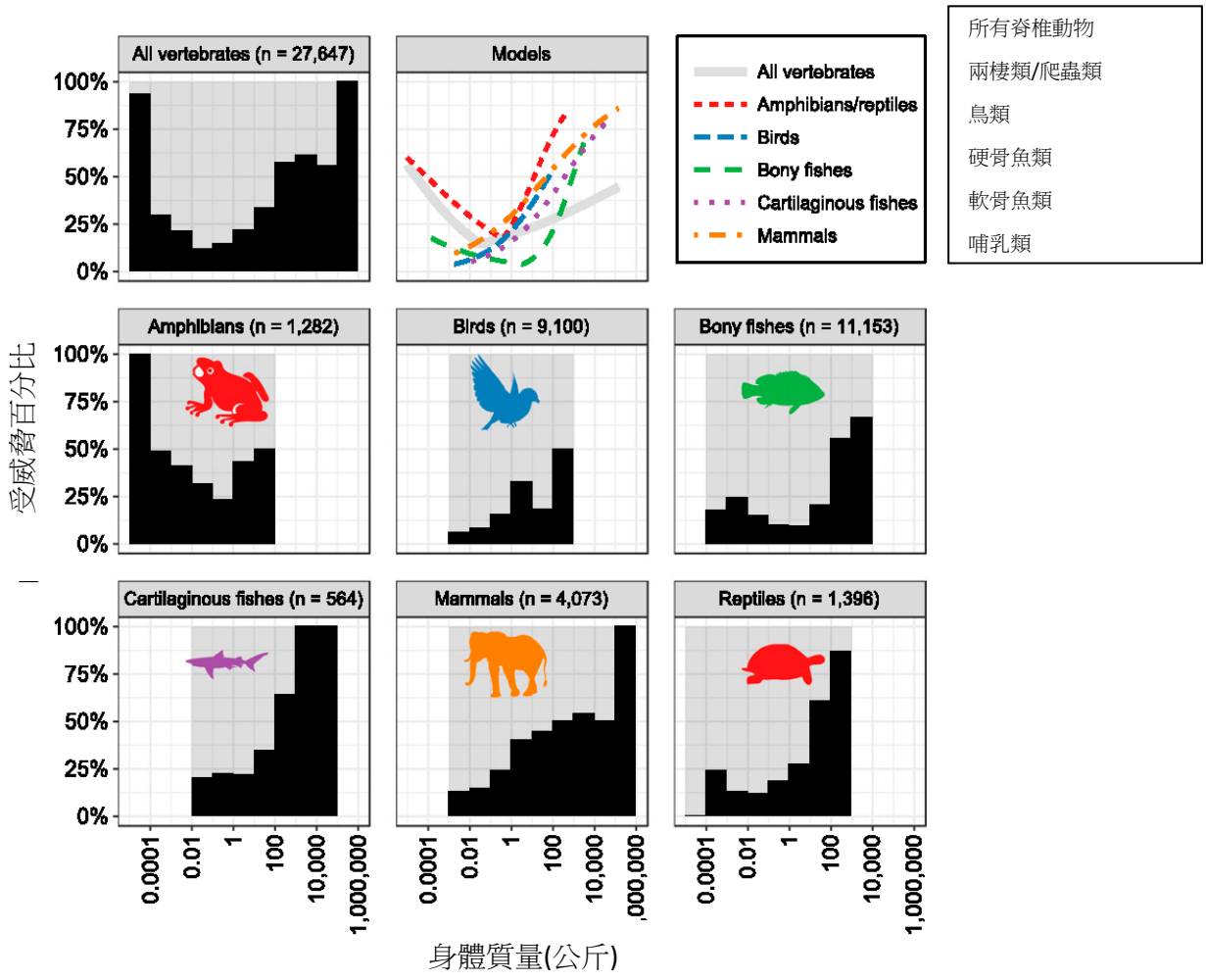
D. 他們在野外找到天然的大葉變種，跟著進行無性繁殖。

26. 以下哪項是人為選擇需要的條件？

(1) 表現型間的差異
(2) 選擇繁殖個別特徵
(3) 表現型是可遺傳的

A. 只有 1
B. 只有 2
C. 只有 1 和 3
D. 1, 2 和 3

題 27-28. 下圖表示在不同脊椎動物組別之間身體質量與受威脅物種的百分比的關係。



27. 以下哪項描述最適合上圖顯示的模式？

(1) 大型軟骨魚類較相同身體質量的硬骨魚類面對更大威脅。
(2) 就兩棲類動物而言，體型中等的物種面對較少的威脅。
(3) 除兩棲類動物外，脊椎動物的身體質量愈高，物種面對的威脅亦愈大。

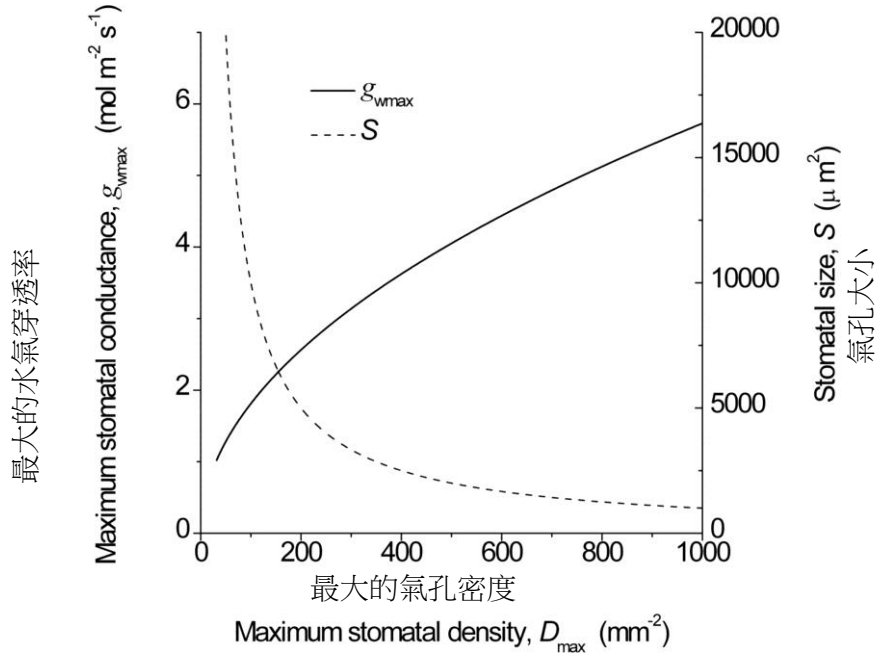
A. 只有 1
B. 只有 3
C. 只有 1 和 3
D. 1, 2 和 3

28. 以下哪項是圖表樣式的合理解釋？

(1) 較大的脊椎動物傾向有較低的族群密度，令牠們受到較大的威脅。
(2) 較大的哺乳動物傾向有較低的繁殖率，令牠們受到較大的威脅。
(3) 較大的軟骨魚類會面對較大的威脅，其中一個原因是牠們經常是人類狩獵的對象。

A. 只有 1
B. 只有 2
C. 只有 1 和 2
D. 1, 2 和 3

題 29-30. 下圖顯示植物氣孔大小、氣孔密度和最大水氣穿透率 (g_{wmax}) 的理論關係。在固定的葉面積內，每一個氣孔大小都有最大的氣孔密度。穿透率是每單位面積水氣經過氣孔擴散的速度。二氧化碳的穿透率跟水氣的相似。



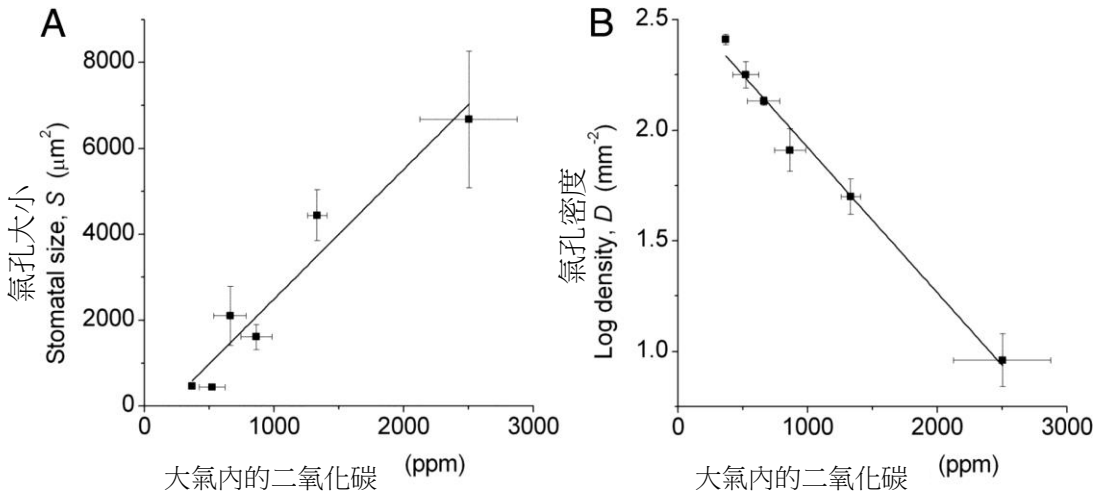
Source: http://www.pnas.org/content/106/25/10343

29. 按上圖，以下哪項正確？

(1) 在固定的葉面積內，氣孔愈小，氣孔密度就可以愈高。
(2) 水氣擴散進氣孔的速度與氣孔的密度成正比。
(3) 水氣擴散進氣孔的速度與氣孔大小成反比。

A. 只有 1
B. 只有 2
C. 只有 1 和 2
D. 1, 2 和 3

30. 下圖顯示以往千萬年內大氣內的二氧化碳濃度與化石植物的氣孔大小和密度的關係。



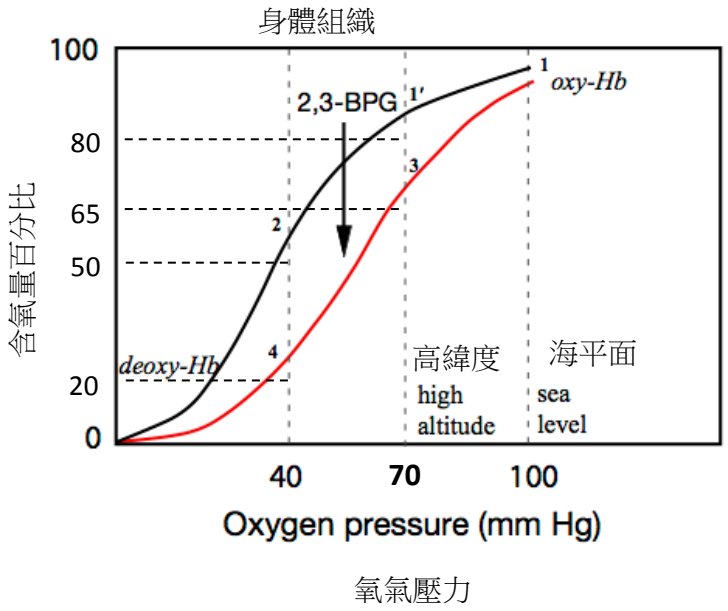
Source: http://www.pnas.org/content/106/25/10343

綜合題 29 的資料，以下哪一項是這關係的可能解釋？

(1) 因為全球暖化，以往千萬年大氣內的二氧化碳濃度增加。較大的氣孔讓植物加快蒸騰作用去冷卻葉片。
(2) 較大的氣孔讓植物吸收更多二氧化碳以適應大氣中愈來愈高濃度的二氧化碳。
(3) 高密度的小氣孔讓植物在二氧化碳濃度低時仍吸收到足夠的二氧化碳。

A. 只有 1
B. 只有 3
C. 只有 1 和 3
D. 1, 2 和 3

題 31-32. 以下是人類的血紅素氧離曲線。這曲線顯示不同的氧氣壓力下，氧氣與血紅素結合的百分比。當人類在高緯度生活一段時間，身體會製造 2,3-BPG 去適應低氧環境，下圖的血紅素氧離曲線會向右移。



31. 對於生活在海平面的常人，在高緯度的地方有幾多百分比的氧氣供應到身體組織？

A. 30%
B. 45%
C. 65%
D. 100%

32. 在高緯度地方生活一段時間後，身體製造 2,3-BPG 作為適應方法。以下哪項關於 2,3-BPG 是正確？

(1) 它減少肺部所攝取的氧氣。
(2) 它降低血紅素對氧氣的黏附力。
(3) 它讓額外 15%的氧氣從血液供應到身體組織。

A. 只有 1
B. 只有 2
C. 只有 1 和 2
D. 1, 2 和 3

題 33-34. 魯本進行一個實驗以找出光合作用中氧的來源。他將水分子用 ^{18}O 粒子來標記。在大自然，99.76%的氧氣分子是 ^{16}O，只有 0.2%是較重的同位素 ^{18}O。

將帶標記的水給藻類進行光合作用，一段時間後，量度不同物質同位素的量。另外，他進行第二個實驗，將二氧化碳用 ^{18}O 粒子來標記。實驗結果如下：

		^{18}O 的 %		
實驗		H_2O	CO_2	O_2
1 (H_2O*)	開始	0.85	0.20	
	結束	0.85	0.61	0.86
2 (CO^*_2)	開始	0.20	0.68	
	結束	0.20	0.57	0.20

33. 按以上實驗結果，哪項是正確結論？

(1) 實驗 1 的結果証明光合作用所產生的氧是從水而來。
(2) 實驗 2 的結果排除光合作用所產生的氧是從二氧化碳而來。
(3) 實驗 1 和 2 的結果顯示光合作用所產生的氧是從二氧化碳和水而來。

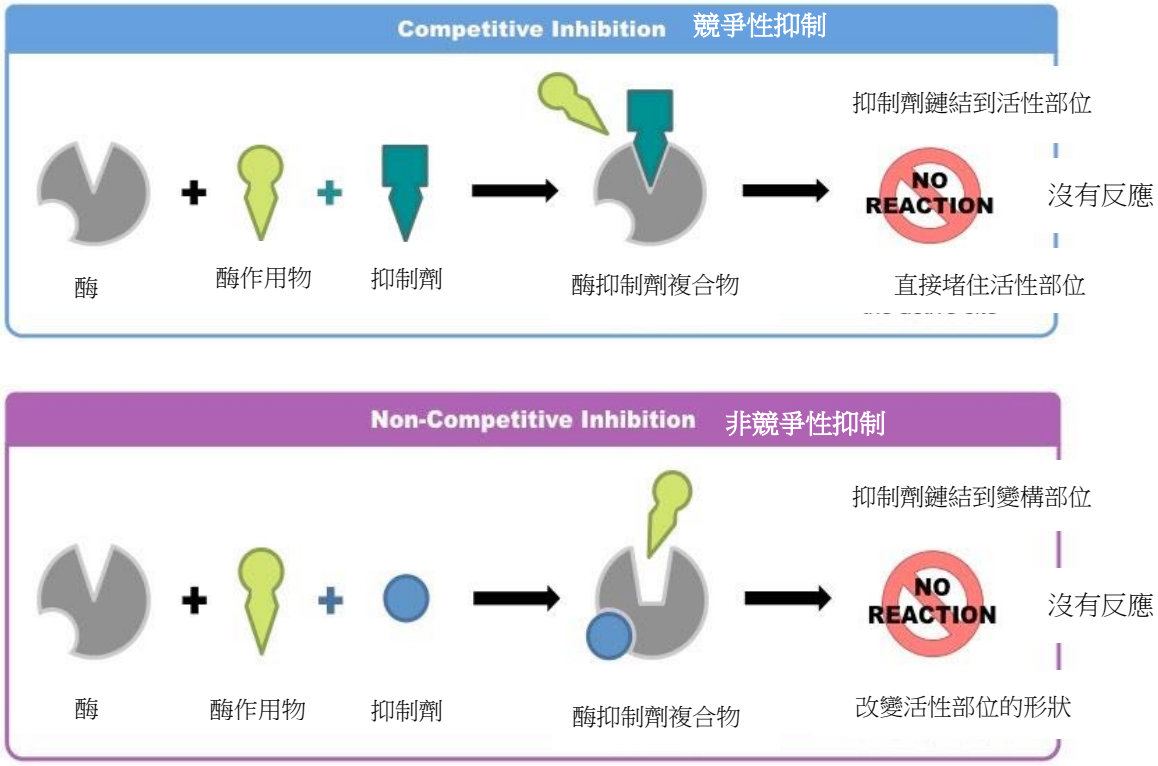
A. 只有 1
B. 只有 3
C. 只有 1 和 2
D. 1, 2 和 3

34. 在實驗 2，藻類經過長時間生長後，以下哪個分子估計有大於 0.2%的 ^{18}O？

(1) 碳水化合物
(2) 蛋白質
(3) 脂肪
(4) 脫氧核糖核酸 (DNA)

A. 只有 1 和 2
B. 只有 2 和 3
C. 只有 1, 2 和 3
D. 1, 2, 3 和 4

35. 酶抑制劑有兩類，競爭性和非競爭性。

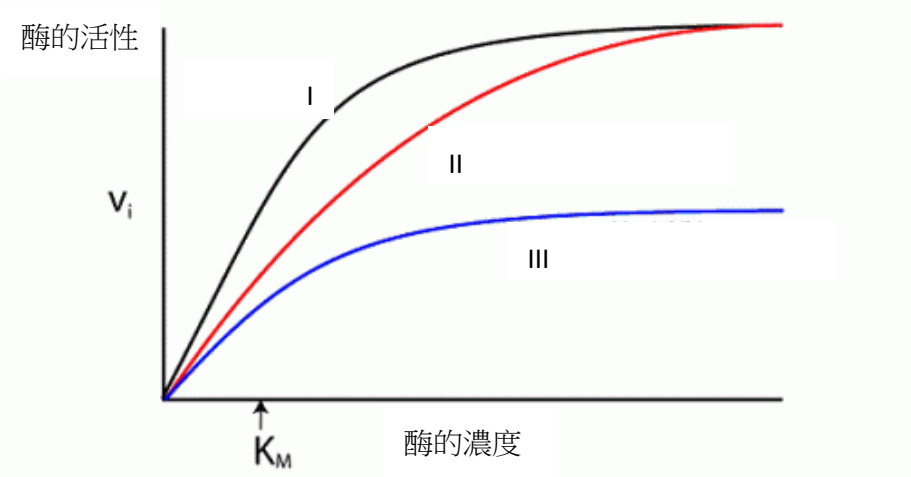


以下哪項關於這兩類酶抑制劑是正確？

(1) 在競爭性抑制作用，抑制劑的形狀需要和基質相似。
(2) 在非競爭性抑制作用，抑制劑鏈結到活性部位。
(3) 在競爭性和非競爭性酶抑制作用，抑制劑改變活性部位的形狀。

A. 只有 1
B. 只有 3
C. 只有 1 和 2
D. 1, 2 和 3

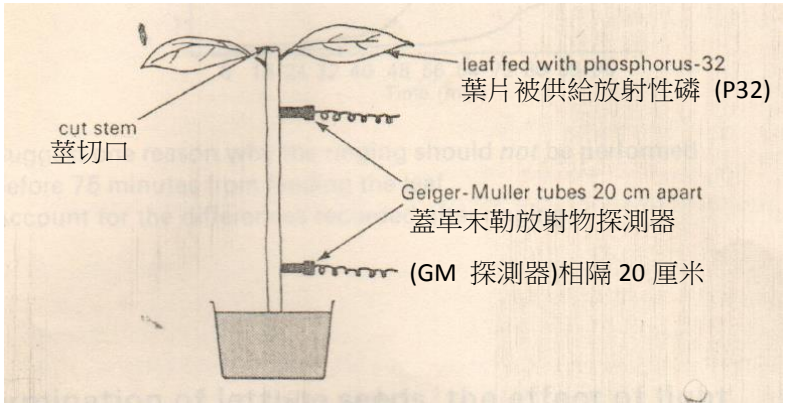
36. 下圖顯示被不同的抑制劑抑制的酶反應。



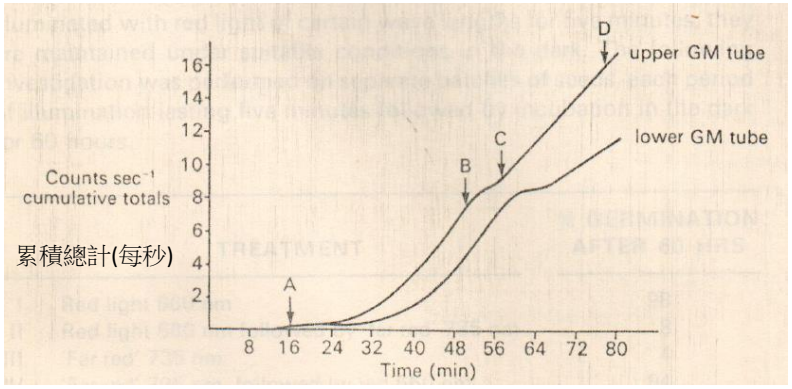
以下哪一項正確？

	I	II	III
A	沒有抑制劑	競爭性抑制劑	非競爭性抑制劑
B	沒有抑制劑	非競爭性抑制劑	競爭性抑制劑
C	非競爭性抑制劑	競爭性抑制劑	沒有抑制劑
D	競爭性抑制劑	非競爭性抑制劑	沒有抑制劑

題 37-38. 以下實驗用來研究植物裡有機食物的位置轉移。其中一塊葉被供給放射性磷，葉片以上的其他葉都被移除。放射物探測器放在葉片之下，兩個探測器相隔 20 厘米。



實驗結果如下：



上方 GM 探測器

下方 GM 探測器

37. 以下哪項關於實驗設計的描述是正確的？

(1) 葉片中被放射性磷標記的複合物主要是糖磷酸鹽。
(2) 移除實驗葉片以上的葉的目的是防止被標記的複合物向上轉移。
(3) 兩個放射物探測器可偵測到的放射性活度，可顯示從實驗葉片而來的放射性複合物的量。

A. 只有 1
B. 只有 3
C. 只有 1 和 2
D. 1, 2 和 3

38. 從這個實驗可以得出其甚麼結論？

(1) 帶磷的光合作用產物是從葉轉移到根。
(2) 在 40-48 分鐘之間，轉移速度大概是每分鐘 1 厘米。
(3) 植物的篩管負責轉移光合作用的產物。

A. 只有 1
B. 只有 3
C. 只有 1 和 2
D. 1, 2 和 3

題 39-40. 以下實驗的目的是研究大鼠小腸對葡萄糖的吸收。一段小腸被切出後將內部反出，然後將兩端綁住形成一個囊。將葡萄糖水放到囊裡面，再將整個囊在相同的葡萄糖水中浸一小時。量度囊裡面和外面的葡萄糖水容量和濃度，結果如下：

	腸囊外面的葡萄糖水		腸囊裡面的葡萄糖水	
	容量(cm^3)	葡萄糖濃度 ($mg/100cm^3$)	容量 (cm^3)	葡萄糖濃度 ($mg/100cm^3$)
開始	15	500	5	500
一小時後	13	350	7	770

39. 以下哪項為小腸主動吸收葡萄糖並不受濃度梯階影響這結論提供證據？

(1) 一小時後，腸囊裡面的葡萄糖濃度比外面的高。
(2) 一小時後，腸囊裡面的液體容量增加。
(3) 葡萄糖可提供主動運輸需要的能量。

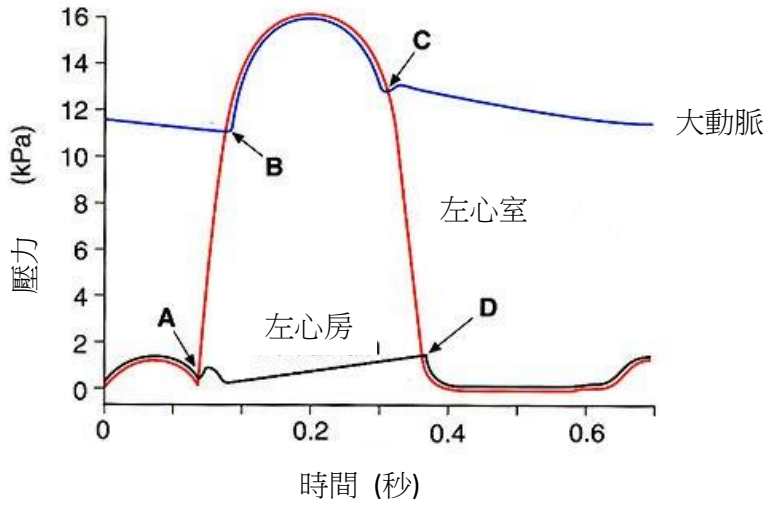
A. 只有 1
B. 只有 3
C. 只有 1 和 2
D. 1, 2 和 3

40. 將氰化物加到葡萄糖水再重複實驗。氰化物是呼吸抑制劑。實驗結果估計有甚麼改變？

(1) 一小時後，腸囊裡面的液體容量比原本的實驗更多。
(2) 一小時後，腸囊裡面的液體濃度比原本的實驗更低。
(3) 腸囊裡面和外面的液體容量會是一樣。

A. 只有 1
B. 只有 2
C. 只有 1 和 2
D. 1, 2 和 3

題 41-42. 下圖顯示人類心搏週期中，心室、心房和大動脈血壓的改變。



41. 以下哪項正確？

(1) 從 A 到 B，血液從左心室流到大動脈。
(2) 從 B 到 C，左心室收縮，同時左心房放鬆。
(3) 心瓣在 A 和 C 點合上。

A. 只有 1
B. 只有 1 和 2
C. 只有 2 和 3
D. 1, 2 和 3

42. 大動脈的上壓和下壓分別是 120 和 80。但當大動脈瓣不能完全合上時，血液會在舒張期從大動脈倒流到心室，令血壓變成 160 和 60。以下哪項是這個轉變的正確解釋？

(1) 左心室在舒張期被更多的血充滿，促使它更用力向大動脈收縮。
(2) 大動脈的血液在舒張期回流到左心室，令下壓降低。
(3) 大動脈在心縮期收縮，在舒張期放鬆。

A. 只有 1
B. 只有 2
C. 只有 1 和 2
D. 只有 2 和 3

題 43-45. 以下研究的目的是觀察岸蟹的攻擊行為。蟹有時會在岩石的裂縫聚結，有時會互相攻擊。實驗中，4 隻蟹被放到一隻有石頭和水的碗內，然後觀察他們的攻擊行為的頻率。不同性別的蟹會在相同的裝置重複實驗。實驗結果如下：

		每組平均每小時的攻擊行為數量	
蟹的數量	蟹的性別	在水中	不在水中
4	雌性	16	5
4	雄性	27	6
6	雄性和雌性	22	1

43. 實驗數據可以得出甚麼結論？

(1) 相對雌性蟹，雄性蟹更多互相攻擊。
(2) 攻擊性行為較多在水裡發生。
(3) 當雄性跟雌性接觸，雄性蟹比雌性蟹更具攻擊性。

A. 只有 1
B. 只有 2
C. 只有 1 和 2
D. 1, 2 和 3

44. 蟹的行為有以下哪項重要目標？

(1) 水中的攻擊行為可以讓蟹爭取到食物和伴侶。
(2) 雄性和雌性間的攻擊性行為是求偶行為的一部分。
(3) 離開水時，蟹需要在岩石的裂縫聚結去避免水分流失和躲避波浪。

A. 只有 1
B. 只有 2
C. 只有 1 和 2
D. 只有 1 和 3

45. 在自然生境中，以下哪項會限制結論的有效性？

(1) 在自然生境中，蟹會擴散，不會局限在小碗中。
(2) 在自然生境中有波浪作用和猛烈陽光，在現時的裝置中是沒有的。
(3) 在自然生境中的蟹群，會發展出一些階級去避免經常的攻擊行為。

A. 只有 1
B. 只有 2
C. 只有 1 和 2
D. 1, 2 和 3

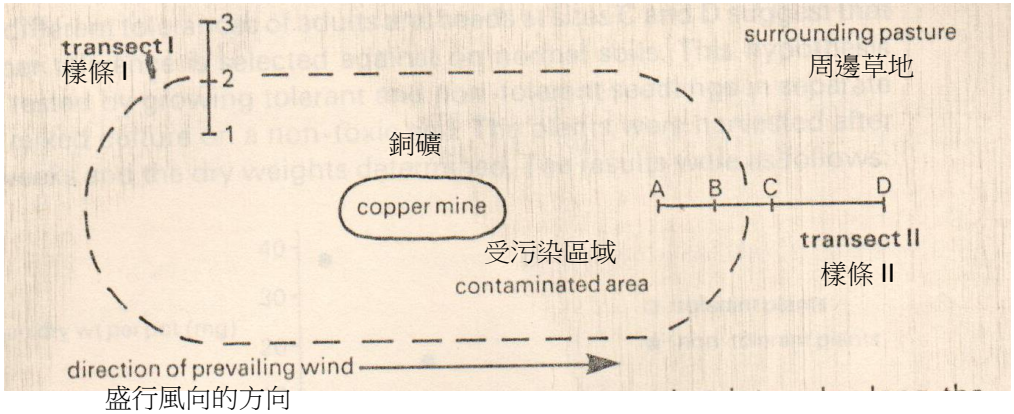
46. 動物中找到兩種澱粉酶 A1 和 A2，這兩種酶結構上有少許差別。有些動物同時有這兩種酶，假設這兩種酶是受一對等位基因控制，而這對等位基因並沒有一個是顯性或隱性。以下是用雜交去驗証這假設。

	第一代表現型		
雜交	A1	A2	A1A2
I. A1 X A1	10	0	0
II. A1 X A2	0	0	37
III. A1 X A1A2	33	0	28
IV. A1A2 X A1A2	4	4	13

以上哪一個雜交的組合支持假設？

A. 只有 I 和 II
B. 只有 II 和 III
C. 只有 I， II 和 IV
D. I，II，III 和 IV

題 47-48. 以下實驗是要研究一個草品種對銅離子的耐受性。沿著兩條樣條線收集草的樣本。在含銅離子與否的環境量度根的生長去顯示其耐受性，並同時量度植物周圍銅離子的量。



	地點	離受污染區域的距離 (米)	泥土銅離子 (ppm)	植物平均耐受性
樣條 I	1	0	2700	56
	2	7	900	51
	3	30	156	16
樣條 II	A	0	700	44
	B	60	300	42
	C	80	136	33
	D	155	52	20

47. 實驗數據可以得出甚麼結論？

(1) 在一條樣條內，愈接近受污染區域植物的耐受性愈高。
(2) 在一條樣條內，泥土愈少銅離子，植物耐受性會降低。
(3) 耐受性與泥土銅離子的量之間的關係，比與離受污染區域的距離的關係更密切。

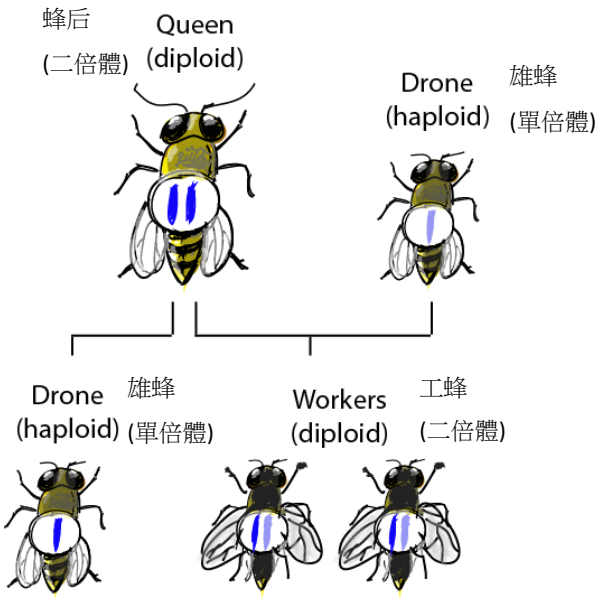
A. 只有 1
B. 只有 2
C. 只有 1 和 2
D. 1, 2 和 3

48. 在地點 C 的植物比在地點 3 的有更高耐受性，以下哪項是正確解釋？

(1) 地點 C 的泥土比地點 3 的有更高銅濃度。
(2) 地點 C 比地點 3 離受污染區域更遠。
(3) 盛行風將高耐受性植物的花粉帶到地點 C，但不會帶到地點 3 。

A. 只有 1
B. 只有 2
C. 只有 3
D. 只有 2 和 3

題 49-50. 蜜蜂有特別的性別決定系統，二倍體大多是雌性 (蜂后或是工蜂)，單倍體的是雄性(雄蜂)。受精卵大部分會發展成雌性，而沒有受精的卵子會發展成雄性。



49. 以下哪項正確？

(1) 雄蜂是透過有絲分裂去製造精子。
(2) 每一隻工蜂都有父親全部的染色體，但只有母親一半的染色體。
(3) 蜜蜂的基因變量性比人類少。

A. 只有 1
B. 只有 2
C. 只有 2 和 3
D. 只有 1, 2 和 3

50. 蜜蜂有一對等位基因控制身體的顏色。相對黑色，黃色是顯性。假設雜合的黃色蜂后和黑色的雄蜂交配，以下哪項正確估算 F1 後代的顏色？

(1) 一半雄蜂是黑色，一半工蜂是黃色。
(2) 有 25%是黑色工蜂。
(3) 雌性和雄性比例不可預測。

A. 只有 1
B. 只有 1 和 2
C. 只有 2 和 3
D. 只有 1, 2 和 3

Question	Answer
1	A
2	B
3	A
4	A
5	B
6	C
7	B
8	C
9	B
10	C
11	B
12	C
13	C
14	A
15	D
16	C
17	B
18	C
19	C
20	D
21	C
22	D
23	C
24	C
25	C
26	D
27	D
28	D
29	D
30	B
31	A
32	D
33	C
34	D
35	A
36	A

37	D
38	A
39	C
40	B
41	C
42	C
43	C
44	D
45	D
46	D
47	D
48	C
49	D
50	A