Question 1

Cockatoos in Sydney have begun to open suburban rubbish bins.
悉尼的凤头鹦鹉已经开始飞向郊区的垃圾箱觅食了。

Sulphur-crested cockatoo opening a household bin (Barbara Klump/Max Planck Institute of Animal Behavior)
硫冠凤头鹦鹉正在打开家用垃圾箱

Problem 1. What type of behaviour causes cockatoos to search for food?
题目 1： 什么行为导致凤头鹦鹉寻找食物？

1 mark

B

Choose ONE 单选

a) Reasoning 推理

b) Instinct 本能

c) Social Learning 社会学习

d) Habituation 习惯化

e) Reflex 反射

f) Imprinting 印随

Humans have started protecting their bins from the cockatoos.
人们开始采取措施防止垃圾桶被凤头鹦鹉打开

Running shoes wedged into the hinge of the bin lid (Barbara Klump/Current Biology)
用跑鞋卡住垃圾桶的盖子

Problem 2. What type of learning is this?

题目 2： 这是什么类型的学习？

1 mark

Choose ONE 单选

a) Reasoning 推理

b) Instinct 本能

c) Social Learning 社会学习

d) Habituation 习惯化

e) Reflex 反射

f) Imprinting 铭记

Problem 3. Some cockatoos figured out how to overcome the bin protections. They then shared this knowledge with other cockatoos in their neighbourhood. What type of learning is this?

题目 3： 一些凤头鹦鹉想出如何克服对垃圾箱的保护措施，然后，它们将这种方法与附近的其他凤头鹦鹉分享。这是什么类型的学习？

1 mark

Choose ONE 单选

a) Reasoning 推理

b) Instinct 本能

c) Social Learning 社会学习

d) Habituation 习惯化

e) Reflex 反射

f) Imprinting 铭记

Question 2

Are these true or false? 判断正误

3 marks

Mark the following as TRUE or FALSE 判断正误

Problem 4. Phototropism in plants involves the bending of plant organs towards, or away from, sources of light

题目 4： 植物的向光性包括植物器官趋向光源或远离光源进行弯曲。

a) TRUE 正确 b) FALSE 错误

Problem 5. Plants require symbiotic bacteria to fix inorganic nitrogen from the atmosphere

题目 5： 植物需要共生细菌来固定大气中的无机氮。

a) TRUE 正确 b) FALSE 错误

a **Problem 6.** CAM photosynthesis involves the opening of stomata at night
题目 6： CAM 光合作用包括夜间气孔的开放。

a) TRUE 正确 b) FALSE 错误

a **Problem 7.** Apomixis (the generation of seeds without fertilisation) results in offspring that are genetically identical to the parent plant
题目 7： 无融合生殖（产生无性种子）会产生与亲本植物基因相同的后代。

a) TRUE 正确 b) FALSE 错误

Are these true or false?判断正误

3 marks
Mark the following as TRUE or FALSE 判断正误

a **Problem 8.** The process of digestion in animals involves the breakdown of food into smaller molecules that can be absorbed and used by the body
题目 8： 动物的消化过程包括将食物分解成可以被身体吸收并利用的更小分子

a) TRUE 正确 b) FALSE 错误

b **Problem 9.** All animals have a closed circulatory system for transporting blood
题目 9： 所有动物都有一个用于运输血液的封闭循环系统

a) TRUE 正确 b) FALSE 错误

b **Problem 10.** Animals always reproduce sexually
题目 10： 动物都是有性繁殖

a) TRUE 正确 b) FALSE 错误

a **Problem 11.** Thermoregulation involves a negative feedback loop to maintain body temperature
题目 11： 体温调节中包括一个负反馈回路来维持体温

a) TRUE 正确 b) FALSE 错误

b **Problem 12.** Animal behaviours are always learnt
题目 12： 动物的行为总是习得的

a) TRUE 正确 b) FALSE 错误

Question 3

C

Problem 13. Which of the following polymerisation reactions release H_2O?
题目 13： 以下哪种聚合反应会释放 H_2O?

2 marks
Choose as many as appropriate 选出所有正确的选项

a) Nucleotides to DNA 核苷酸生成 DNA

b) Glucose to starch 葡萄糖转化为淀粉

c) Amino acids to proteins 氨基酸转化为蛋白质

d) Triglycerides to fatty acids 甘油三酯转化为脂肪酸

Problem 14. Which of the following bonds break when heated to 100°C?
题目 14： 当加热到 100°C 时，以下哪种键会断裂？

c, d.

2 marks
Choose as many as appropriate 选出所有正确的选项

a) Ionic 离子键

b) Covalent 共价键

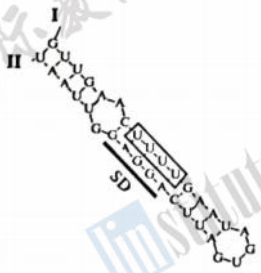
c) Hydrogen 氢键

d) Disulphide bridges 二硫键

e) Hydrophobic interactions 疏水相互作用

Single-stranded mRNA can form secondary structures. One example of this is the 4U sequence in bacteria. The 4 uracils bind the Shine-Dalgarno sequence (AGGAGG) of mRNA. Usually, bacterial ribosomes bind to the Shine-Dalgarno sequence. This mRNA secondary structure is stable at 20°C but not at 40°C.

单链信使核糖核酸可以形成二级结构。其中一个例子是细菌中的 4U 序列。这 4 种尿嘧啶结合信使核糖核酸的 SD 序列（AGGAGG）。通常，细菌的核糖体与 SD 序列结合。这种信使核糖核酸二级结构在 20°C 时保持稳定，但在 40°C 时不稳定。



4U RNA secondary structure
4U RNA 的二级结构

Are these true or false? 判断正误

4 marks

Mark the following as TRUE or FALSE 判断正误

Problem 15. RNA with a secondary structure is less likely to be damaged and broken down

a

题目 15： 具有二级结构的 RNA 被破坏和分解的可能性更小

a) TRUE 正确　　b) FALSE 错误

Problem 16. The 4U secondary structure acts as an RNA thermometer which prevents translation at low temperatures

a

题目 16： 4U 二级结构充当 RNA 温度计，防止低温下的翻译过程

a) TRUE 正确　　b) FALSE 错误

Problem 17. It is likely this mRNA codes for a heat shock protein

a

题目 17： 这类 mRNA 很可能是编码一种热休克蛋白

a) TRUE 正确　　b) FALSE 错误

Problem 18. Position I is 3' and position II is 5'

b

题目 18： 位置 I 为 3'，位置 II 为 5'

a) TRUE 正确　　b) FALSE 错误

Problem 19. Mutating the fourth U to a G would make the secondary structure more stable

a

题目 19： 将第四个 U 突变为 G 将会使二级结构更加稳定

a) TRUE 正确　　b) FALSE 错误

Problem 20. Mutating the Shine-Delgarno sequence would strongly reduce translation

b

题目 20： SD 序列突变将极大减少翻译过程

a) TRUE 正确　　b) FALSE 错误

Problem 21. Other RNA switches could form secondary structures which bind to particular metabolites

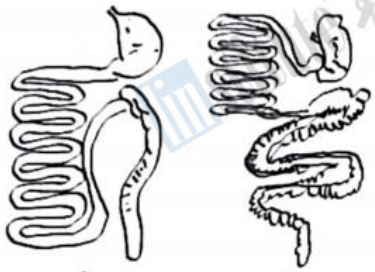
a

题目 21： 其他核糖核酸开关可以形成与特定代谢物结合的二级结构

a) TRUE 正确　　b) FALSE 错误

Question 4

An animal's anatomy is closely linked with its lifestyle. For example, cows eat only poor-quality grass. Therefore, it has a large stomach to house bacteria to break down the grass.
动物的身体结构与其生活方式密切相关。例如，奶牛只吃低质量的草。因此，它有一个很大的胃容纳细菌来分解草。



Schematics of the digestive tract of two animal species
两种动物的消化道示意图

Which of the following lifestyles are associated with A and B?
以下哪种生活方式与 A 和 B 有关?

2 marks
Groups 将选项中的内容按照题干进行分组，若该组别无对应选项，可不作答。

Problem 22. A
C
题目 22： 与 A 有关

A. Foregut-fermenter 前肠发酵者

B. Hindgut-fermenter 后肠发酵者

C. Carnivore 食肉动物

Problem 23. B
B
题目 23： 与 B 有关

A. Foregut-fermenter 前肠发酵者

B. Hindgut-fermenter 后肠发酵者

C. Carnivore 食肉动物

Problem 24. Animal A, B, and a cow, each eat a sugar cube. Which animals would be able to absorb all the sugar into their blood? *Check all that apply*
题目 24： 动物 A、动物 B 和一头奶牛，各吃一块方糖。哪些动物能够将全部糖吸收到血液中？"选出所有正确答案"

By Michael Gäbler, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=9875161
图像来源：By Michael Gäbler, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=9875161

a

1 mark
Choose as many as appropriate 选出所有正确的选项
a) A
b) B
c) Cow 牛

Are these true or false? 判断正误

2 marks
Mark the following as TRUE or FALSE 判断正误

a

Problem 25. Animal A would extract more nutrition from cooked food over uncooked food
题目 25： 动物 A 从煮熟的食物中摄取的营养比从没有煮熟的食物中摄取的更多

a) TRUE 正确 b) FALSE 错误

b

Problem 26. Animal A may eat its faeces to gain extra nutrients
题目 26： 动物 A 可能会吃掉它的粪便来补充营养

a) TRUE 正确 b) FALSE 错误

a

Problem 27. Animal B may eat its faeces to gain extra nutrients
题目 27： 动物 B 可能会吃掉它的粪便来补充营养

a) TRUE 正确 b) FALSE 错误

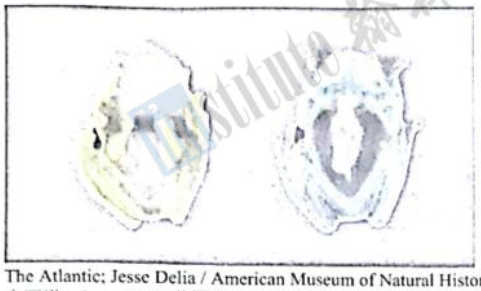
a.

Problem 28. Animal B prefers new plant shoots and buds to tough old leaves
题目 28： 比起坚硬的老叶，动物 B 更喜欢新鲜的植物嫩芽

a) TRUE 正确 b) FALSE 错误

Question 5

Glass frogs are famous for their ability to appear almost transparent, especially when sleeping. The recordings show a glass frog from underneath when it's awake (left) and asleep (right).
玻璃蛙因为看起来几乎透明而众所周知，尤其是在它睡觉的时候。如图所示，是从一只玻璃青蛙底部向上拍摄的图片，左下图是清醒时的照片，右下图是睡觉时的照片。



The Atlantic; Jesse Delia / American Museum of Natural History
大西洋；Jesse Delia/美国自然历史博物馆

As frogs fall asleep, they condense almost all of their red blood cells into their liver, and coat their liver with a layer of shiny reflective crystals.
当玻璃蛙入睡时，它们将几乎所有的红细胞浓缩到肝脏中，并在肝脏上覆盖一层闪亮的反光晶体。

Are these likely true or false? 判断正误

3 marks
Mark the following as TRUE or FALSE 判断正误

a **Problem 29.** Glass frogs probably sleep during the daytime.
题目 29： 玻璃蛙可能在白天睡觉。

a) TRUE 正确　　b) FALSE 错误

a **Problem 30.** Glass frog organs can probably survive prolonged periods without oxygen.
题目 30： 玻璃蛙的器官在没有氧气的情况下可能长时间存活。

a) TRUE 正确　　b) FALSE 错误

b **Problem 31.** Glass frogs are probably warm blooded.
题目 31： 玻璃蛙很可能是恒温动物。

a) TRUE 正确　　b) FALSE 错误

a **Problem 32.** Glass frog blood is probably less able to clot than human blood.
题目 32： 玻璃蛙的血凝结能力可能比人类更差。

a) TRUE 正确　　b) FALSE 错误

a **Problem 33.** The main reason glass frogs go transparent is probably to hide from predators.
题目 33： 玻璃蛙透明的主要原因可能是为了躲避捕食者。

a) TRUE 正确　　b) FALSE 错误

Question 6

Problem 34. The proportion of each base in 5 different genome sequences (i-v) are given in the table.
题目 34： 这个表中给出了 5 个不同基因组序列（i-v）中每个碱基的比例。

碱基 Base	Proportion of sequence 序列比例			
	A	T	C	G	U
i	0.22	0.28	0.18	0.32	0
ii	0.29	0.29	0.21	0.21	0
iii	0.32	0	0.26	0.12	0.3
iv	0.15	0.31	0.12	0.35	0.07
v	0	0	0.46	0.54	0

Which sequences are certainly from a virus (as opposed to another type of organism or a mistake)?
哪些序列一定来自于病毒（而不是另一种类型的生物体或者由于错误造成的）？

a.c.

2 marks
Choose as many as appropriate 选出所有正确的选项

a) i

b) ii

c) iii

d) iv

e) v

Question 7

Equal lengths of three different blood vessels were threaded onto the horizontal arm of a retort stand. Weights were then hooked on the vessels until they broke.
将长度相同的三根不同血管连接在蒸馏器支架的水平臂上，然后将重物挂在血管上，直到它们断裂。

Predict the results of the experiment. *Match the vessel to the maximum weight it bore before snapping*
预测实验结果。*断裂前，将血管与它能承受的最大重量相匹配*

2 marks
Groups 将选项中的内容按照题干进行分组，若该组别无对应选项，可不作答。

b

Problem 35. 800 g
题目 35： 800 g

a) Aorta 主动脉

b) Vena Cava 腔静脉

c) Pulmonary Artery 肺动脉

C

Problem 36. 3500 g
题目 36： 3500 g

a) Aorta 主动脉

b) Vena Cava 腔静脉

c) Pulmonary Artery 肺动脉

Problem 37. 5000 g
题目 37： 5000 g

a

a) Aorta 主动脉
b) Vena Cava 腔静脉
c) Pulmonary Artery 肺动脉

Question 8

The following logic puzzles are based on *defining characteristics* and *shared traits* of branches of the tree of life. For example, vertebrate animals share many characteristics (pairs of appendages, spinal cords, digestive tract below backbone), some of which may be unique to them, but they are *defined* by having a backbone divided into jointed vertebrae.
以下逻辑题的设置基于生命树分支的“定义特征”和“共同特征”。例如，脊椎动物有许多共同特征（成对的附肢、脊髓、脊柱下方的消化道），其中一些可能是独有的，但它们被定义为拥有节状椎骨组成的脊柱。

C

Problem 38. *Mitochondria are to Eukaryotes as X are to plants.* What is X?
题目 38： *线粒体对于真核生物的作用就如同 X 对于植物一样，X 是什么？

1 mark
Choose ONE 单选

a) Cell walls 细胞壁
b) Leaves 叶子
c) Plastids (e.g. chloroplasts) 质体（如叶绿体）
d) Vacuoles 液泡
e) Nuclei 细胞核

Problem 39. *Milk glands are to mammals as X are to birds.* What is X?
题目 39： *乳腺对哺乳动物的作用就如同 X 对鸟类的作用一样”，X 是什么？

b

1 mark
Choose ONE 单选

a) Eggs 卵
b) Beaks 喙
c) Feathers 羽毛
d) Wings 翅膀
e) Warm bloodedness 温血

c

Problem 40. *Mushrooms are to fungi as X are to plants.* What is X?
题目 40： *蘑菇对于真菌如同 X 对于植物一样，X 是什么？

1 mark
Choose ONE 单选

a) Roots 根
b) Seed pods 种荚
c) Flowers 花
d) Leaves 叶
e) Chloroplasts 叶绿体

Complete these analogies. 请完成以下类比。

d

Problem 41. *Whales are to fish as X are to birds.* What is X?
题目 41： *鲸鱼对于鱼类，就如同 X 对于鸟类一样，X 是什么？

1 mark
Choose ONE 单选

a) Parrots 鹦鹉
b) Reptiles 爬行动物
c) Eggs 卵
d) Bats 蝙蝠
e) Snakes 蛇

e

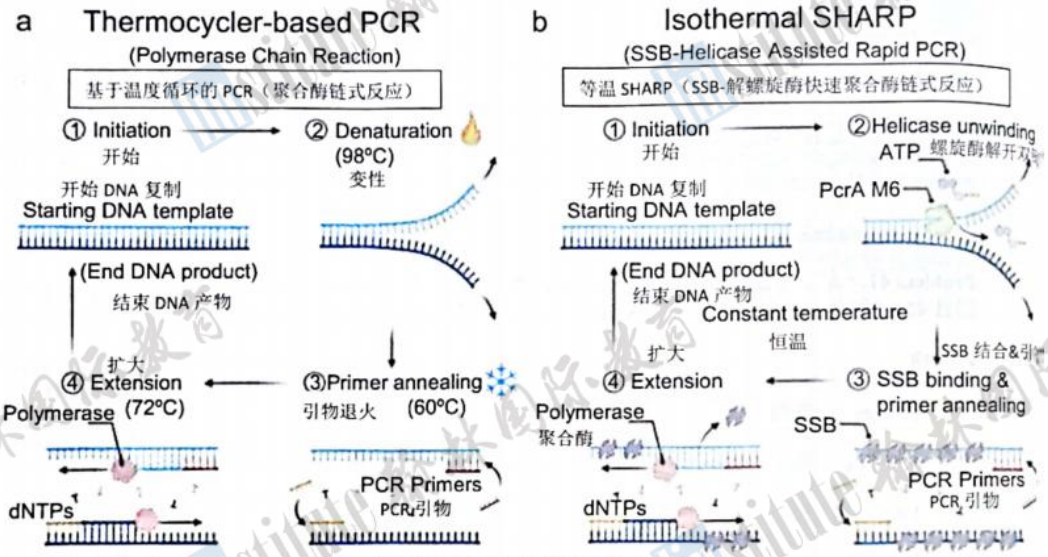
Problem 42. *Light is to plants as X are to chemolithotrophs* What is X?
题目 42： *光对植物的作用就像 X 对于化能无机营养型生物的作用一样" X 是什么？

1 mark
Choose ONE 单选

a) Prey 猎物
b) Water 水
c) Heat 热量
d) Plants 植物
e) Rocks 岩石

Question 9

PCR is a staple laboratory technique for the amplification of DNA. Recently, a new method for the amplification of DNA was invented which can be done at constant temperature in a single test tube. *Helicase is an enzyme, and SSB is 'single strand binding protein'.*
聚合酶链式反应（PCR）是放大扩增 DNA 的主要实验室技术。最近，发明出一种新型 DNA 扩增方法，可以在恒温下的单个试管中进行。*螺旋酶是一种酶，SSB 是"单链结合蛋白"



Part 2 of 2

3 marks

Groups 将选项中的内容按照题干进行分组，若该组别无对应选项，可不作答。

Problem 43. Traditional PCR

题目 43： 只有传统聚合酶链式反应才具备的特征

a) Temperature is lowered to allow primer binding
降低温度以允许引物结合

b) Requires ATP
需要 ATP

c) Amplification is semi-exponential
放大倍数是指数的一半

d) Requires reverse- transcriptase
需要反向-转录酶

e) Heat is used to separate double- stranded DNA
通过加热分开双链 DNA

f) SSB is used to keep DNA strands separated
SSB 用于保持 DNA 链条分开的状态

a.e

f

Problem 44. SHARP PCR SHARP

题目 44： 只有 SHARP 聚合酶链式反应才具备的特征

a) Temperature is lowered to allow primer binding
降低温度以允许引物结合

b) Requires ATP
需要 ATP

c) Amplification is semi-exponential
放大倍数是指数的一半

d) Requires reverse- transcriptase
需要反向-转录酶

e) Heat is used to separate double- stranded DNA
通过加热分开双链 DNA

f) SSB is used to keep DNA strands separated
SSB 用于保持 DNA 链条分开的状态

C

Problem 45. Both

题目 45： 既符合传统聚合酶链式反应也符合 SHARP 聚合酶链式反应

a) Temperature is lowered to allow primer binding
降低温度以允许引物结合

b) Requires ATP
需要 ATP

c) Amplification is semi-exponential
放大倍数是指数的一半

d) Requires reverse- transcriptase
需要反向-转录酶

e) Heat is used to separate double- stranded DNA
通过加热分开双链 DNA

f) SSB is used to keep DNA strands separated
SSB 用于保持 DNA 链条分开的状态

b. d

Problem 46. Neither

题目 46： 既不符合传统聚合酶链式反应也不符合 SHARP 聚合酶链式反应

a) Temperature is lowered to allow primer binding
降低温度以允许引物结合

b) Requires ATP
需要 ATP

c) Amplification is semi-exponential
放大倍数是指数的一半

d) Requires reverse- transcriptase
需要反向-转录酶

e) Heat is used to separate double- stranded DNA
通过加热分开双链 DNA

f) SSB is used to keep DNA strands separated
SSB 用于保持 DNA 链条分开的状态

Question 10

Ecologists used laser scanning and 3D reconstruction (LIDAR) to non-destructively measure the size of every tree in an Wytham Woods, Oxford. Overall, they found 815 trees within the 1.4 ha study area.
生态学家使用激光扫描和 3D 重建（LIDAR）无损伤地测量了位于牛津郡威瑟姆森林中每棵树的大小。他们在 1.4 公顷研究区域内总计发现了 815 棵树。

备注：树木种类参考中文
Acer pseudoplatanus 欧亚槭
Fraxinus excelsior 白蜡树
Quercus robur 夏栎
Unknown 未知物种
Corylus avellana 欧榛
Crataegus monogyna 单子山楂
Acer campestre 栓皮槭

Problem 47. Which species has the tallest tree?
题目 47：哪类树长得最高？

1 mark
Choose ONE 单选

a

a) Acer pseudoplatanus (Sycamore) 欧亚槭（梧桐）
b) Fraxinus excelsior (Ash) 白蜡树（桉）
c) Corylus avellana (Hazel) 欧榛（榛树）
d) Quercus robur (Oak) 夏栎（橡树）
e) Crataegus monogyna (Hawthorn) 单子山楂（山楂）
f) Acer campestre (Field maple) 栓皮槭（枫木）

Problem 48. Which species is most likely to be shade tolerant?
题目 48：哪类树最可能耐阴？

C

1 mark
Choose ONE 单选

a) Acer pseudoplatanus (Sycamore) 欧亚槭（梧桐）
b) Fraxinus excelsior (Ash) 白蜡树（桉）
c) Quercus robur (Oak) 夏栎（橡树）
d) Crataegus monogyna (Hawthorn) 单子山楂（山楂）

Problem 49. Which species is most likely to be a main source of food for deer?
题目 49：哪类树最有可能成为鹿的主要食物来源？

d

1 mark
Choose ONE 单选

a) Acer pseudoplatanus (Sycamore) 欧亚槭（梧桐）
b) Fraxinus excelsior (Ash) 白蜡树（桉）
c) Quercus robur (Oak) 夏栎（橡树）
d) Crataegus monogyna (Hawthorn) 单子山楂（山楂）

d

Problem 50. Which species is likely to be the main food source for caterpillars?
题目 50：哪类树可能是毛虫的主要食物来源？

1 mark
Choose ONE 单选

a) Acer pseudoplatanus (Sycamore) 欧亚槭（梧桐）

b) Fraxinus excelsior (Ash) 白蜡树（梣）

c) Corylus avellana (Hazel) 欧榛（榛树）

d) Quercus robur (Oak) 夏栎（橡树）

e) Crataegus monogyna (Hawthorn) 单子山楂（山楂）

f) Acer campestre (Field maple) 栓皮槭（枫木）

Problem 51. Does *Fraxinus excelsior* or *Quercus robur* have a greater *range* in height?
题目 51：哪类树的高度差异更大，白蜡树还是夏栎？

a

1 mark
Choose ONE 单选

a) *Fraxinus excelsior* 白蜡树

b) *Quercus robur* 夏栎

The data in the graphic can also be displayed as a table.
图形中的数据也可以用表格来表示。

```
**Species**|**Count**
:-----:|:-----:
Acer pseudoplatanus |532
Fraxinus excelsior |84
Corylus avellana |67
Quercus robur |35
Crataegus monogyna |24
Acer campestre |2
Unknown|71
```

物种	**数量**
欧亚槭	532
白蜡树	84
欧榛	67
夏栎	35
单子山楂	24
栓皮槭	2
未知物种	71

This data can be used to calculate the Simpson's Diversity Index. Simpson's Diversity is a measure of diversity within an ecosystem which takes into account both richness and evenness. Simpson's Diversity is calculated as
这些数据可用于计算辛普森多样性指数。辛普森多样性指数是同时考虑物种丰富性和均匀性，用于衡量生态系统内多样性的指标。辛普森多样性指数的计算公式：

Simpson's Diversity Index = $\sum (n/N)^2$
辛普森多样性指数

where n is the number of individuals in a species, and N is the total number of individuals. *Treat unknown as a single species for this particular example*
其中 n 是一个物种中个体的数量，N 是个体总数。*在这个特定例子中，将未知物种看作一个物种。

What is the Simpson's Diversity Index of Wytham Woods to *three significant figures*?
威萨姆森林的辛普森多样性指数是多少？（保留三位有效数字）

3 marks
Problem 52. *Write something below*
题目 52： *请在下方填入答案*

0.44

Problem 53. Would the Simpson's Diversity Index increase or decrease, if unknown was composed of two species not one?
题目 53： 如果未知物种由两个物种而不是一个物种组成，辛普森多样性指数会增加还是减少？

1 mark
b
Choose ONE 单选
a) Increase 增加

b) Decrease 减少

c) Depends on the ratio of individuals in the two species 取决于两个物种中个体的比例

Problem 54. What would Simpson's Diversity Index tend to when the number of different species becomes extremely large? *Type a number*
题目 54： 当不同物种的数量变得极其庞大时，辛普森多样性指数会变为多少？（请用数字作答）

1 mark
Write something below 请在下方填入答案

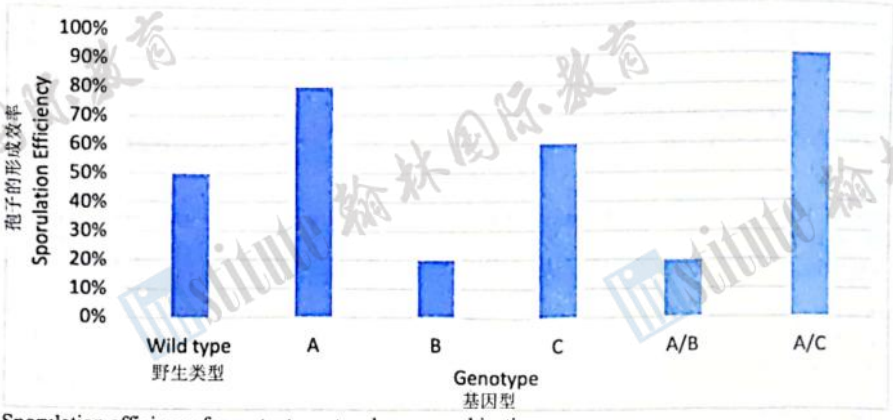
0

Question 11

Baker's yeast (*Saccharomyces cerevisiae*) sporulates in response to nutrient deprivation. The fraction of cells that sporulate in a culture, called the sporulation efficiency, varies heritably among yeast strains. For example, the best-studied laboratory strain, S288c, is a notoriously poor sporulator, so most studies of sporulation employ the efficient sporulator, SK1.
面包酵母菌（*面包酵母*）由于缺乏营养而形成孢子。培养物中形成孢子的细胞比例，称为孢子形成效率，它在不同的酵母菌株中，具有不同的遗传性。例如，最为广泛研究的实验室菌株 S288c 的孢子形成能力极差，因此大多数产孢研究都会使用有效的产孢菌株 SK1。


Saccharomyces cerevisiae

Scientists found three mutations which affected sporulation efficiency. One mutant (A) stopped the production of the protein RME1, and two mutations (B & C) affected IME1. A - RME1 Knockout B - IME1 Knockout C - IME1 Protein structural change
科学家发现了影响孢子形成效率的三种突变。其中突变（A）阻止蛋白质 RME1 的产生，另外两个突变（B&C）会影响 IME1。A-RME1 基因敲除 B-IME1 基因敲除 C-IME1 蛋白结构变化



Sporulation efficiency for mutant yeast and some combinations
突变酵母和某些混合体的孢子产生效率

For each mutation, decide whether the mutation increased, decreased or had no effect on sporulation
对于每种突变，判断突变增加孢子的形成、减少孢子的形成还是对其没有影响。

1 mark

Groups 将选项中的内容按照题干进行分组，若该组别无对应选项，可不作答

Problem 55. C

a

题目 55： C

a) Increased 增加

b) Decreased 减少

c) Had no effect 没有影响

Problem 56. A

a

题目 56： A

a) Increased 增加

b) Decreased 减少

c) Had no effect 没有影响

Problem 57. B

b

题目 57： B

a) Increased 增加

b) Decreased 减少

c) Had no effect 没有影响

Which unmutated proteins increase, decrease or have no effect on sporulation?
以下非突变蛋白质会增加孢子的形成、减少孢子的形成还是对孢子形成没有影响？

1 mark
Groups 将选项中的内容按照题干进行分组，若该组别无对应选项，可不作答

Problem 58. RME1
题目 58： RME1

b

a) Increase 增加
b) Decrease 减少
c) No effect 没有影响

Problem 59. IME1
题目 59： IME1

a

a) Increase 增加
b) Decrease 减少
c) No effect 没有影响

Problem 60. Does RME1 work upstream, downstream or in a different pathway to IME1?
题目 60： RME1 对 IME1 的作用是在前期、后期还是其他途径？

b

1 mark
Choose ONE 单选

a) Upstream 前期
b) Downstream 后期
c) In a different pathway 其他途径

Problem 61. What do you expect the sporulation efficiency of a combined B/C mutant plant to be? *Give an answer in numerals. The unit is % (it doesn't matter whether you type the unit)*
题目 61： 请预计 B/C 突变植物组合体的孢子形成效率是多少？*请用数字回答，单位为 %（无需填写单位）”

1 mark
Write something below 请在下方填入答案

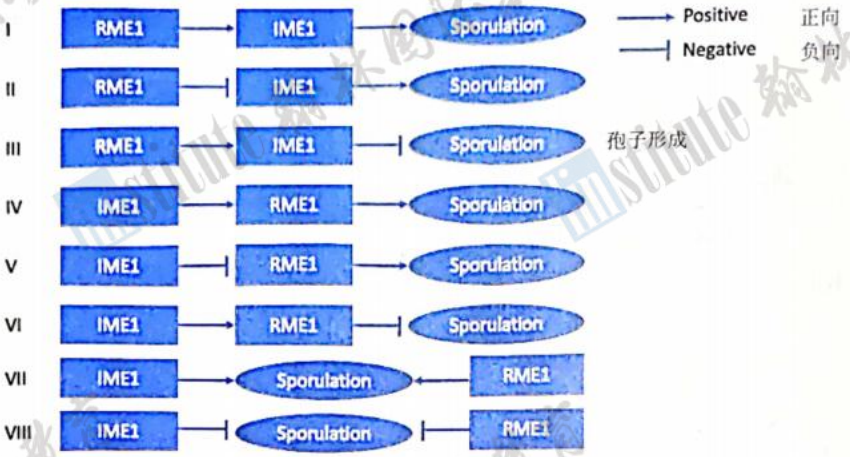
20

Problem 62. What do you expect the sporulation efficiency of a combined A/B/C mutant to be? *Give an answer in numerals. The unit is % (it doesn't matter whether you type the unit)*
题目 62： 请预计 A/B/C 突变组合体的产孢效率是多少？*请用数字回答，单位为 %（无需填写单位）”

2 marks
Write something below 请在下方填入答案

20

Problem 63. Which of the following genetic diagrams show the pathway of sporulation?
题目 63： 以下哪个遗传图显示了孢子形成的途径？



1 mark
Choose ONE 单选

b

a) I b) II c) III d) IV

e) V f) VI g) VII h) VIII

Problem 64. Which of the following is the most likely genotype of S288c?
题目 64： 以下哪个最有可能是 S288c 的基因型？

b

1 mark
Choose ONE 单选

a) Wild type 野生型

b) A/B

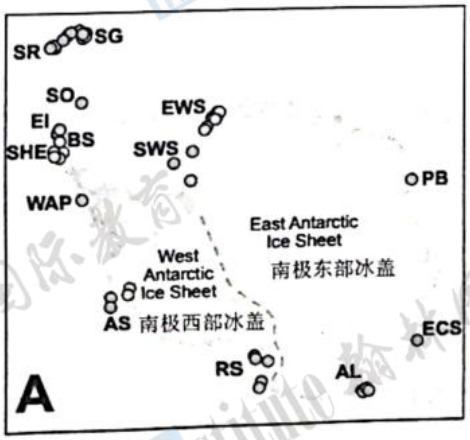
c) C

Question 12

The Royal Research Ship (submarine) *Boaty McBoatface* is exploring the underside of Thwaites glacier in Amundsen Sea in West Antarctica. This 'doomsday glacier' has become highly unstable, and the focus of global concern. The collapse of Thwaites glacier would raise sea-levels 0.9 m within decades, devastating costal ecosystems. However, it also braces the entire West Antarctic ice sheet against flowing into the sea. Following the loss of Thwaites glacier, it would take centuries for the West Antarctic ice sheet itself to collapse into the sea, but the process would be irreversible and raise sea levels by >3 m. Scientists are debating whether the West Antarctic ice sheet collapsed 125000 years ago when temperatures were last as hot as they are today. The enormous weight of ice in Antarctica pushes the ground below sea level, so if the ice melts, channels of water can link distant parts of the continent. Turquet's Octopus (*Pareledone turqueti*) has populations scattered around the coastline of Antarctica. Scientists collected genome sequences of octopi from each population and produced a statistical model of the size of each population through time, and the rate of interbreeding between each population.

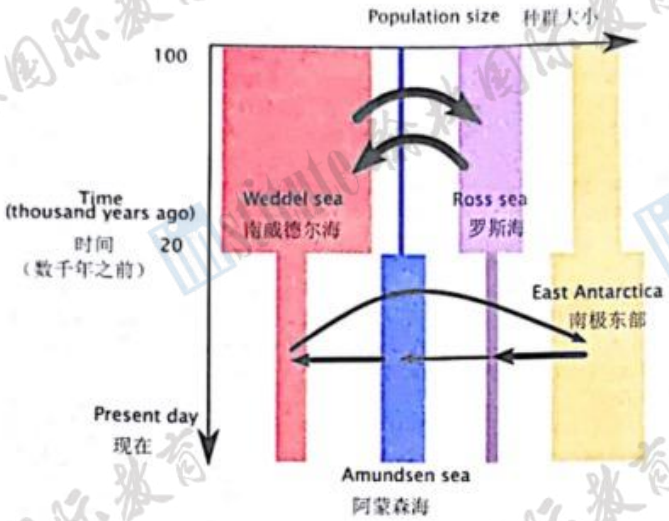
英国考察船（潜艇）“Boaty McBoatface”正在探索南极洲西部阿蒙森海的思韦茨冰川的底部。这座“世界末日冰川”已变得非常不稳定，成为了全球关注的焦点。思韦茨冰川的崩塌将在几十年内使海平面上升 0.9 米，并破坏沿海生态系统。然而，它也支撑着整个南极西部冰盖，防止其流入大海。思韦茨冰川消失后，南极西部冰盖会在几个世纪内坍塌进入大海，但这一过程将不可逆转，并使海平面上升 3 米以上。科学家正在争论南极西部冰盖是否在 12.5 万年前崩塌，如果当时的气温持续现在如此高的温度。南极洲巨大的冰量将地面推到海平面以下，因此如果冰融化，水流可以连接大陆偏远地区。Turquet 章鱼 (Pareledone turqueti) 的种群分布在南极洲的海岸线上。科学家从每个种群中收集了章鱼的基因组序列，并建立了不同时间每个种群的大小以及每个种群之间杂交率的统计模型。

Dots show Octopi populations SWS = South Weddel Sea AS = Amundsen Sea RS = Ross Sea
圆点表示章鱼种群 SWS = 南威德尔海 AS = 阿蒙森海 RS = 罗斯海



The output of the model is shown below. Arrows show the direction of allele flow. Arrow thickness shows the rate of allele flow.

输出模型如下所示。箭头表示等位基因流动的方向，箭头的粗细表示等位基因的流动速率。



2 marks

Mark the following as TRUE or FALSE 判断正误

Problem 65. The West Antarctic ice sheet was likely melted ~100,000 years ago.
题目 65： 南极洲西部冰盖可能在大约 10 万年前融化。

b

a) TRUE 正确 b) FALSE 错误

Problem 66. Currents currently circulate mostly anticlockwise around the Antarctic coast.
题目 66： 洋流目前主要沿南极海岸逆时针方向流动。

b

a) TRUE 正确 b) FALSE 错误

Problem 67. The octopi prefer to travel through very deep oceanic water than shallow costal water.
题目 67： 章鱼更喜欢在非常深的海水中游行，而不是在海岸浅水中游行。

a

a) TRUE 正确 b) FALSE 错误

Problem 68. The octopi are better adapted to the warmer oceans of the past.
题目 68： 章鱼更加适应过去温暖的海洋。

b

a) TRUE 正确 b) FALSE 错误

Problem 69. Octopi in the Weddel Sea and Ross Sea are likely to look more similar today than they did in the past.
题目 69： 现在威德尔海和罗斯海中的章鱼可能比过去外形更相似。

a

a) TRUE 正确 b) FALSE 错误

Scientists discovered bacteria and animals living on rocks under 1 km ice floating on 500 m ocean, and ~150 miles from the edge of the ice shelf.
科学家们发现了生活在位于海平面以下 500 米、被 1 千米厚的冰层覆盖并距离冰架边缘约 150 英里的岩石上的细菌和动物。

Problem 70. What are the organisms in this food chain likely to be? *Check all that apply*
题目 70： 这个食物链中的生物可能是什么？（选出所有正确答案）

1 mark
Choose as many as appropriate 选出所有正确的选项

a.b.c.d.

a) Primary producers 初级生产者
b) Detritivores 腐生生物
c) Herbivores 食草动物
d) Carnivores 食肉动物
e) Warm blooded (endotherms) 温血动物（恒温动物）

What adaptations do animals adapted to extreme-cold tend to have, compared to animals in tropical climates? *Sort them into those associated with warm-blooded or cold-blooded animals, or neither*
与热带气候下的动物相比，适应极寒环境的动物通常会有哪些适应性特征？按照温血动物、冷血动物或者既不是温血动物也不是冷血动物的适应性特征进行划分。

3 marks
Groups 将选项中的内容按照题干进行分组，若该组别无对应选项，可不作答
Problem 71. Warm-blooded
题目 71： 温血动物的适应性特征

a.c.f

a) Travelling long distances for food 长距离觅食
b) Lower oxygen carrying capacity of blood 血液携氧能力较低
c) Huddling 聚群
d) Lower metabolic rate 代谢率较低
e) Hibernation 冬眠
f) Thick fur / blubber 厚毛皮/鲸脂
g) Faster generation times 迭代时间更快

Problem 72. Cold-blooded
题目 72： 冷血动物的适应性特征

b.d.e

a) Travelling long distances for food 长距离觅食
b) Lower oxygen carrying capacity of blood 血液携氧能力较低
c) Huddling 聚群
d) Lower metabolic rate 代谢率较低
e) Hibernation 冬眠
f) Thick fur / blubber 厚毛皮/鲸脂
g) Faster generation times 迭代时间更快

Problem 73. Neither

题目 73： 既不是温血动物，也不是冷血动物的适应性特征

S

a) Travelling long distances for food 长距离觅食

b) Lower oxygen carrying capacity of blood 血液携氧能力较低

c) Huddling 聚群

d) Lower metabolic rate 代谢率较低

e) Hibernation 冬眠

f) Thick fur / blubber 厚毛皮/鲸脂

g) Faster generation times 迭代时间更快

Question 13

Bacteria (*Bacillus subtilis*) were treated with a chemical which changes their membrane properties when stimulated with laser light. When pulsed with light, the membrane rapidly depolarises (as seen with blue colouring in the video). The membrane then rapidly repolarises. *B. subtilis* normally lives in the soil and guts of mammals.

用一种化学物质处理细菌（枯草芽孢杆菌）的细胞膜，使其在受到激光刺激时改变特性。当受到光脉冲作用时，膜会迅速去极化（见图中蓝色部分），随后迅速复极。“枯草芽孢杆菌”通常生活在土壤和哺乳动物的肠道中。

Problem 74. How frequently was the light pulsed?

题目 74： 光脉冲的频率是多少？

C

1 mark

Choose ONE 单选

a) 1 minute 1 分钟

b) 5 minutes 5 分钟

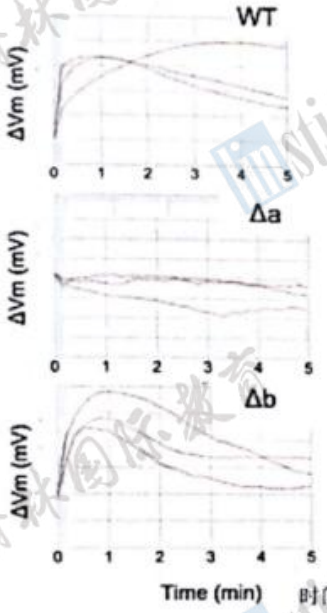
c) 10 minutes 10 分钟

d) 20 minutes 20 分钟

e) 30 minutes 30 分钟

f) 60 minutes 60 分钟

The scientists wanted to see which channels were important for response to light stimulation. They looked at two mutant bacteria which had Gene A (Δa) or Gene B (Δb) deleted.
科学家想知道哪些方式对光刺激的反应很重要。他们观察了缺失基因 A (Δa) 或基因 B (Δb)的两种突变细菌。



Problem 75. Which genes were required for response to light?
题目 75： 对光刺激的反应需要哪些基因？

a

1 mark
Choose ONE 单选

a) a

b) b

Problem 76. Roughly how long does it take for *Bacillus subtilis* to divide?
题目 76： “枯草芽孢杆菌”分裂大约需要多长时间？

C

3 marks
Choose ONE 单选

a) 15 minutes 15 分钟

b) 30 minutes 30 分钟

c) 45 minutes 45 分钟

d) 60 minutes 60 分钟

e) 75 minutes 75 分钟

f) 90 minutes 90 分钟

Problem 77. This experiment was carried out at room temperature (22°C). What effect would repeating it at 37°C have?
题目 77：这个实验在室温（22°C）下进行，如果在 37°C 的温度下重复这个实验会带来什么影响？

1 mark
Choose ONE 单选

a

a) Faster cell division 细胞分裂速度更快

b) Slower cell division 细胞分裂速度更慢

c) No change on cell division 细胞分裂没有发生变化

d) No cell division 无细胞分裂

Problem 78. This experiment was carried out at room temperature (22°C). What effect would repeating it at 70°C have?
题目 78：这个实验在室温（22°C）下进行，如果在 70°C 的温度下重复这个实验会带来什么影响？

d

1 mark
Choose ONE 单选

a) Faster cell division 细胞分裂速度更快

b) Slower cell division 细胞分裂速度更慢

c) No change on cell division 细胞分裂没有发生变化

d) No cell division 无细胞分裂

Problem 79. This experiment was carried out at room temperature (22°C). What effect would repeating it at 37°C have?
题目 79：这个实验在室温（22°C）下进行，如果在 37°C 的温度下重复这个实验会带来什么影响？

a

1 mark
Choose ONE 单选

a) Faster repolarisation 复极化的速度更快

b) Slower repolarisation 复极化的速度更慢

c) No change on polarisation 复极化的速度没有变化

Problem 80. Assume membrane polarisation in *B. subtilis* is controlled similarly to human neurons.
题目 80： 假设“枯草芽孢杆菌”细胞膜极化的控制方式与人体神经元相似。

1 mark

Choose ONE 单选

a

a) The light pulses cause sodium ion channels to briefly open quickly
光脉冲导致钠离子通道快速短暂地打开

b) The light pulses cause sodium ion channels to briefly open slowly
光脉冲导致钠离子通道缓慢短暂地开放

c) The light pulses cause sodium ion channels to briefly shut
光脉冲导致钠离子通道短暂关闭

d) The light pulses cause sodium/potassium ATPase to turn on
光脉冲导致钠/钾 ATP 酶通道打开

Problem 81. Assume membrane polarisation in *B. subtilis* is controlled similarly to human neurons.
题目 81： 假设“枯草芽孢杆菌”细胞膜极化的控制方式与人体神经元相似。

b

1 mark

Choose ONE 单选

a) The light pulses cause potassium ion channels to briefly open quickly
光脉冲导致钾离子通道快速短暂地开放

b) The light pulses cause potassium ion channels to briefly open slowly
光脉冲导致钾离子通道缓慢短暂地开放

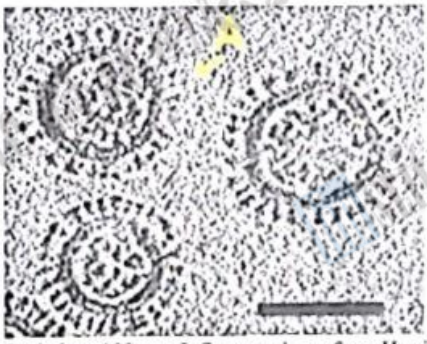
c) The light pulses cause potassium ion channels to briefly shut
光脉冲导致钾离子通道短暂关闭

d) The light pulses cause sodium/potassium ATPase to turn *off*
光脉冲导致钠/钾 ATP 酶通道关闭

Question 14

Pandemic flus are frequently caused by the recombination of human and avian strains of flu. Flu can be classified by the hemagglutinin (H) and neuraminidase (N) proteins. For example, two human flus are: H1N1 and H3N1. * Hemagglutinin binds to receptors on host cells. It is the spikes on the image below. * Neuraminidase is an enzyme which helps viral entry and allows daughter virus to be released by cutting the receptors hemagglutinin binds to. Generally, bird flus cannot infect humans and vice versa. This is fortunate, as a pandemic bird flu is currently devastating many species of birds. Up to 2/3 of British seabirds have died over the past year, and poultry has been in a strict lockdown for months. Flu virions contain 8 genetic strands, each encoding different proteins. When a cell is infected with two strains, these are combined into daughter virions randomly. Below is an electron micrograph of influenza viron (scale bar: 100 nm).

流行性流感通常是由人流感毒株和禽流感毒株的重组引起的。流感可以分为血凝素（H）蛋白和神经氨酸酶（N）蛋白。例如，两种人流感毒株是：H1N1 和 H3N1。*血凝素与宿主细胞上的受体结合，见下图中的尖状物。*神经氨酸酶是一种帮助病毒进入的酶，通过切割血凝素结合的受体来释放子病毒。一般来说，禽流感不会感染人，人流感也不会感染禽类。这是幸运的，因为流行性禽流感目前正在使许多鸟类灭绝。过去一年里，多达 2/3 的英国海鸟死亡，家禽也被严格封锁了数月。流感病毒粒子包含 8 条基因链，每条基因链编码不同的蛋白质。当一个细胞被两种菌株感染时，它们会随机组合成子病毒粒子。以下是流感病毒的电子显微照片（比例尺：100 纳米）。



Scale bar: 100 nm. Influenza virons from Harris et al 2006
比例尺：100 纳米。

Problem 82. What is the diameter of the flu viron labelled A?
题目 82：标记为 A 的流感病毒粒子的直径是多少？

C

1 mark
Choose ONE 单选

a) 10 nm 10 纳米

b) 50 nm 50 纳米

c) 100 nm 100 纳米

d) 150 nm 150 纳米

e) 200 nm 200 纳米

f) 100 µm 100 微米

Problem 83. There are 18 types of Hemagglutinin and 11 types of Neuraminidase. How many different H/N combinations can there be? *Type an answer in Arabic numerals*
题目 83： 血凝素有 18 种类型，神经氨酸酶有 11 种类型。可以有多少种不同的 H/N 组合？“请用阿拉伯数字作答”

2 marks
Write something below 请在下方填入答案
198

Problem 84. Two flu virions which share none of the same genetic strands invade the same cell. How many different genotypes can the daughter virions have? Assume there is no 'crossing over'. *Type an answer in Arabic numerals*
题目 84： 两种没有相同基因链的流感病毒侵入同一细胞。子病毒粒子可以有多少种不同的基因型？假设没有“杂交”。*请用阿拉伯数字作答

2 marks
Write something below 请在下方填入答案
256

Flu receptor proteins are glycosylated (have sugars attached). * Human viruses bind to SAα2,6-Gal linked receptors. * Avian viruses tend to bind to SAα2,3-Gal linked receptors. * Mink, ferrets and pigs can be infected by both human and avian viruses
流感受体蛋白会糖基化（附加上糖）。*人类病毒与 SAα2, 6-Gal 连接受体结合。*禽病毒倾向于与 SAα2, 3-Gal 连接受体结合。*水貂、雪貂和猪都可能被人类和禽类两种病毒感染。


A National Trust ranger in the UK clears dead puffins
英国的一个护林员在清理死亡的角嘴海雀

Sort the animals into the receptor groups
按不同的受体将选项中的动物进行分类
2 marks
Groups 将选项中的内容按照题干进行分组，若该组别无对应选项，可不作答
Problem 85. Only SAα2,6-Gal
C
题目 85： 仅 SAα2,6-Gal

a) Pig 猪
b) Ferret 雪貂
c) Humans 人类
d) Mink 水貂
e) Birds 鸟类

e

Problem 86. Only SAα2,3-Gal

题目 86： 仅 SAα2,3-Gal

a) Pig 猪
b) Ferret 雪貂
c) Humans 人类
d) Mink 水貂
e) Birds 鸟类

a. b. d.

Problem 87. Both SAα2,6-Gal and SAα2,3-Gal

题目 87： SAα2,6-Gal 和 SAα2,3-Gal 两者

a) Pig 猪
b) Ferret 雪貂
c) Humans 人类
d) Mink 水貂
e) Birds 鸟类

Problem 88. Neither

题目 88： SAα2,6-Gal 和 SAα2,3-Gal 两者都不

a) Pig 猪
b) Ferret 雪貂
c) Humans 人类
d) Mink 水貂
e) Birds 鸟类

Are these true or false? 判断正误

3 marks

Mark the following as TRUE or FALSE 判断正误

Problem 89. Bird flu pandemics are more likely to spread directly into humans than via intermediate animals (such as mink)

b

题目 89： 禽流感更可能直接传播给人类，而不是通过中间动物（如水貂）来传播。

a) TRUE 正确　　b) FALSE 错误

Problem 90. Bird flu adaptation to humans requires adaptation of hemagglutinin

a

题目 90： 禽流感要适应人体需要适应血凝素。

a) TRUE 正确　　b) FALSE 错误

Problem 91. Bird flu adaptation to humans requires adaptation of neuraminidase

b

题目 91： 禽流感要适应人体需要适应神经氨酸酶。

a) TRUE 正确　　b) FALSE 错误

Problem 92. Hemagglutinin is the best target for antibodies which 'neutralise' flu particles

a

题目 92： 血凝素对于"中和"流感病毒颗粒的抗体是最佳靶点。

a) TRUE 正确　　b) FALSE 错误

Problem 93. Neuraminidase is a good target for drugs against flu

b

题目 93： 神经氨酸酶是抗流感药物的良好靶点。

a) TRUE 正确　　b) FALSE 错误

British Biology Olympiad 2023 Paper 2

Question 15

In a healthy person, when glucose levels are high, what are the levels of each of these factors?
对于健康人来说，当血糖水平较高时，以下每一项的水平如何变化？

2 marks
Groups 将选项中的内容按照题干进行分组，若该组别无对应选项，可不作答

Problem 94. High
题目 94： 升高

b.d

a)	Glycogen synthase activity	糖原合酶的活性
b)	Lipase activity	脂肪酶的活性
c)	Glucagon levels	胰高血糖素水平
d)	Insulin	胰岛素
e)	Glycogen phosphorylase activity	糖原磷酸化酶活性

Problem 95. Low
题目 95： 降低

a.c.e

a)	Glycogen synthase activity	糖原合酶的活性
b)	Lipase activity	脂肪酶的活性
c)	Glucagon levels	胰高血糖素水平
d)	Insulin	胰岛素
e)	Glycogen phosphorylase activity	糖原磷酸化酶活性

Some people have tumours made of pancreatic beta cells. In these patients, what are the levels of each of these factors?
有些人的肿瘤是由胰岛细胞 β构成的。对于这些患者，以下每一项的水平如何变化？

3 marks
Groups 将选项中的内容按照题干进行分组，若该组别无对应选项，可不作答

Problem 96. High
题目 96： 升高

a.b.c.d

a)	Glucose levels	血糖水平
b)	Lipase activity	脂肪酶的活性
c)	Glucagon levels	胰高血糖素水平
d)	Glycogen synthase activity	糖原合酶的活性

c) Insulin 胰岛素

f) Glycogen phosphorylase activity 糖原磷酸化酶活性

Problem 97. Low

题目 97： 降低

a) Glucose levels 血糖水平

b) Lipase activity 脂肪酶的活性

c) Glucagon levels 胰高血糖素水平

d) Glycogen synthase activity 糖原合酶的活性

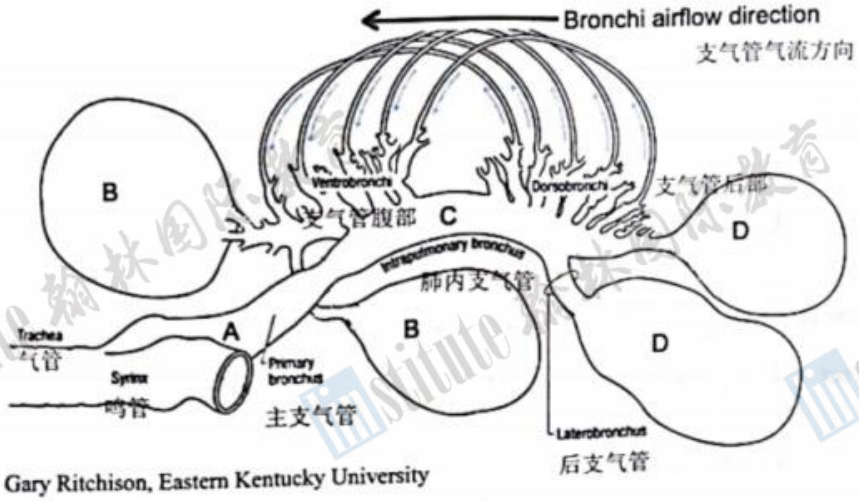
e) Insulin 胰岛素

f) Glycogen phosphorylase activity 糖原磷酸化酶活性

Question 16

The anatomy of bird lungs is very different to that of mammals. Birds have unidirectional flow of air through the bronchi. Similar to humans, birds have a two-step breathing (in through the beak and then out through the beak).

鸟类的肺部结构与哺乳动物有很大不同。鸟类的支气管有单向气流。与人类一样，鸟类呼吸需要两步（通过喙呼入，然后通过喙呼出）。



Gary Ritchison, Eastern Kentucky University

For each position in the diagram, sort them into the appropriate group.
请将图中的每个位置和对应的组别进行匹配。

3 marks
Groups 将选项中的内容按照题干进行分组，若该组别无对应选项，可不作答

Problem 98. Only fresh air
题目 98： 只有新鲜空气

a. d.

a) D
b) B
c) Human alveoli 人体肺泡
d) A

Problem 99. Only 'spent' air
题目 99： 只有"交换后的"空气

b.

a) D
b) B
c) Human alveoli 人体肺泡
d) A

Problem 100. A mix of air
题目 100： 既有新鲜空气，又有"交换后的"空气

C

a) D
b) B
c) Human alveoli 人体肺泡
d) A

Are these true or false? 判断正误

2 marks
Mark the following as TRUE or FALSE 判断正误

Problem 101. Birds can extract more oxygen for each ml of air inhaled than mammals
题目 101： 每吸入一毫升空气，鸟类比哺乳动物能获取更多的氧气

a

a) TRUE 正确　　b) FALSE 错误

Problem 102. Birds require valves to control the direction of airflow within their lungs
题目 102： 鸟类需要阀门来控制肺部的气流方向

a

a) TRUE 正确　　b) FALSE 错误

Problem 103. The direction of blood flow alongside the bronchi will be in the same direction as the air
题目 103： 沿支气管的血液流动方向与空气的方向相同

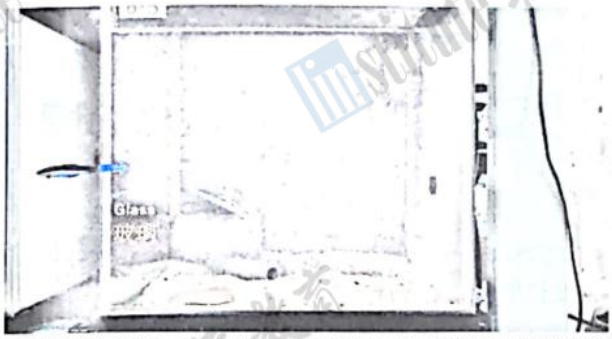
b

a) TRUE 正确　　b) FALSE 错误

Question 17

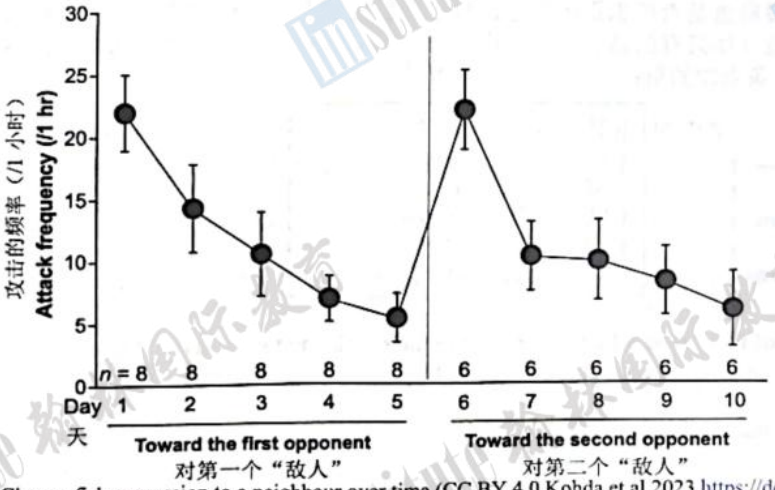
The cleaner fish, *Labroides dimidiatus*, uses visual cues to identify between different individual members within social groups. Kohda and colleagues looked at aggressive fish behaviours (rushing, bumping and biting) with other fish and images of themselves with and without mirrors.

“裂唇鱼”利用视觉线索来识别社会群体中的不同个体。Kohda 和同事观察了裂唇鱼与其他鱼类的攻击行为（冲、撞和咬），以及它们在有镜子和没有镜子情况下的样子。



First, the scientists carried out a "dear enemy experiment" to see whether a cleaner fish habituated to a neighbour.

首先，科学家进行了一项“亲密敌人实验”，以观察一条裂唇鱼是否会适应“邻居”。



Cleaner fish aggression to a neighbour over time (CC BY 4.0 Kohda et al 2023 https://doi.org/10.1073/pnas.2208420120)

随时间推移，裂唇鱼对“邻居”的攻击变化图

3 marks

Mark the following as TRUE or FALSE 判断正误

a

Problem 104. Cleaner fish can recognise their neighbour

题目 104：裂唇鱼能识别它们的“邻居”

a) TRUE 正确　　b) FALSE 错误

a

Problem 105. Cleaner fish become less aggressive to their neighbour when they get used to their company

题目 105：裂唇鱼适应“邻居”的陪伴后，对它们的攻击性会降低

a) TRUE 正确　　b) FALSE 错误

b

Problem 106. Cleaner fish become less aggressive to all other fish when they get used to company

题目 106：裂唇鱼习惯了陪伴后，它们对所有其他鱼的攻击性会降低

a) TRUE 正确　　b) FALSE 错误

b

Problem 107. Cleaner fish get less aggressive as they get older

题目 107：裂唇鱼的年龄越大，攻击性越小

a) TRUE 正确　　b) FALSE 错误

a

Problem 108. Cleaner fish adapt to having a new neighbour more quickly after having had one before

题目 108：裂唇鱼在以前有过新“邻居”后，能更快地适应新邻居

a) TRUE 正确　　b) FALSE 错误

Next, the scientists wanted to know if the cleaner fish could recognise themselves. They showed the fish pictures of themselves and counted the aggressive behaviours shown (if any). The pictures were made up of two halves (head and body) and each half could either be of themselves or an unknown fish:

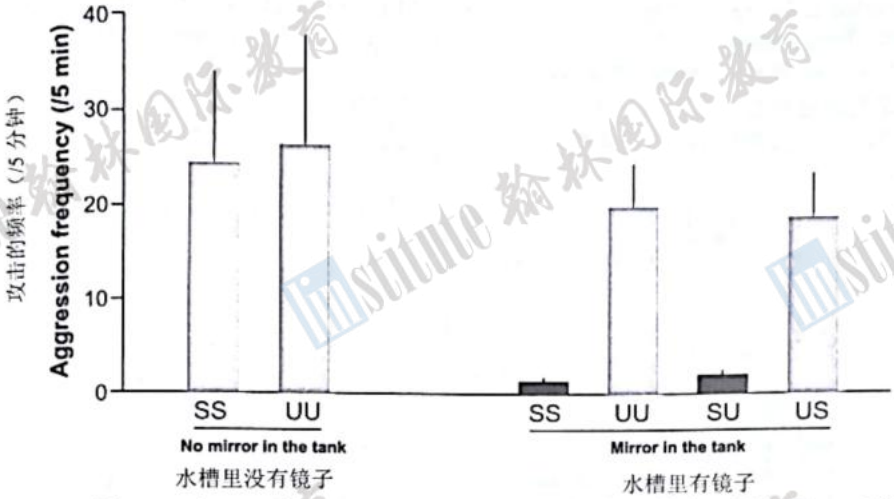
接下来，科学家想探究这些裂唇鱼是否能识别出自己。科学家给裂唇鱼呈现它们的照片，并统计了它们表现出攻击行为的次数（如果有的话）。照片由两部分（头部和躯体）组成，其中一部分可能属于自己，也可能属于一条未知的鱼：

Key	Head	Body
SS	Self	Self
SU	Self	Unknown
US	Unknown	Self
UU	Unknown	Unknown

图例	头部	躯体
SS	自己	自己
SU	自己	未知鱼
US	未知鱼	自己
UU	未知鱼	未知鱼

Finally, they looked at two sets of fish, those who had a mirror in their tank and those who did not.

最后，他们观察这两组鱼，一组鱼的水槽里有镜子，另一组鱼的水槽里没有镜子。



Cleaner fish aggression to a photo (CC BY 4.0 Kohda et al 2023 https://doi.org/10.1073/pnas.2208420120)
裂唇鱼对图片的攻击

What can we ascertain for certain from the data above only?
仅仅根据上面的数据，我们能确定什么？

4 marks
Mark the following as TRUE or FALSE 判断正误。

Problem 109. Cleaner fish attack unknown fish
题目 109： 裂唇鱼会攻击未知的鱼类

a

a) TRUE 正确　　b) FALSE 错误

Problem 110. Cleaner fish know what they look like without a mirror
题目 110： 在没有镜子的情况下，裂唇鱼知道自己的样子

b

a) TRUE 正确　　b) FALSE 错误

Problem 111. With a mirror, cleaner fish recognise themselves as familiar
题目 111： 在有镜子的情况下，裂唇鱼会将自己识别为熟悉的鱼

a

a) TRUE 正确　　b) FALSE 错误

Problem 112. With a mirror, cleaner fish recognise themselves as themselves
题目 112： 在有镜子的情况下，裂唇鱼可以识别出自己

a

a) TRUE 正确　　b) FALSE 错误

Problem 113. Cleaner fish can recognise their own body
题目 113： 裂唇鱼可以识别自己的躯体

b

a) TRUE 正确　　b) FALSE 错误

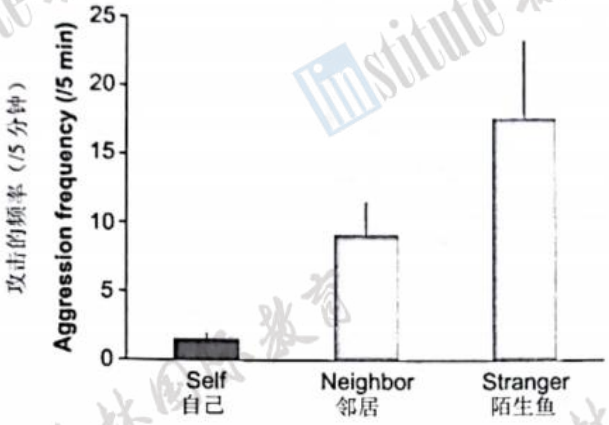
Problem 114. Cleaner fish use facial features for recognition
题目 114： 裂唇鱼使用面部特征进行识别

a

a) TRUE 正确　　b) FALSE 错误

Finally, the scientists wanted to know whether the cleaner fish could tell themselves in the mirror apart from familiar neighbours. They presented fish with mirrors in their tanks three photos: one of themselves, one of a neighbour and one of an unknown fish (stranger).

最后，科学家想知道这些裂唇鱼是否能在镜子里区别出自己与熟悉的“邻居”。他们向带镜子水箱里的鱼展示了三张照片：一张是它们自己的照片，一张是“邻居”的照片，还有一张是一条未知鱼（陌生鱼）的照片。



Cleaner fish aggression to photos (CC BY 4.0 Kohda et al 2023 https://doi.org/10.1073/pnas.2208420120)
裂唇鱼对图片的攻击

Problem 115. Do cleaner fish have self-recognition or do they think the fish in the mirror is just a neighbour?

题目 115：裂唇鱼能识别出镜子里的鱼是自己，还是会认为镜子里的鱼只是“邻居”？

a

1 mark

Choose ONE 单选

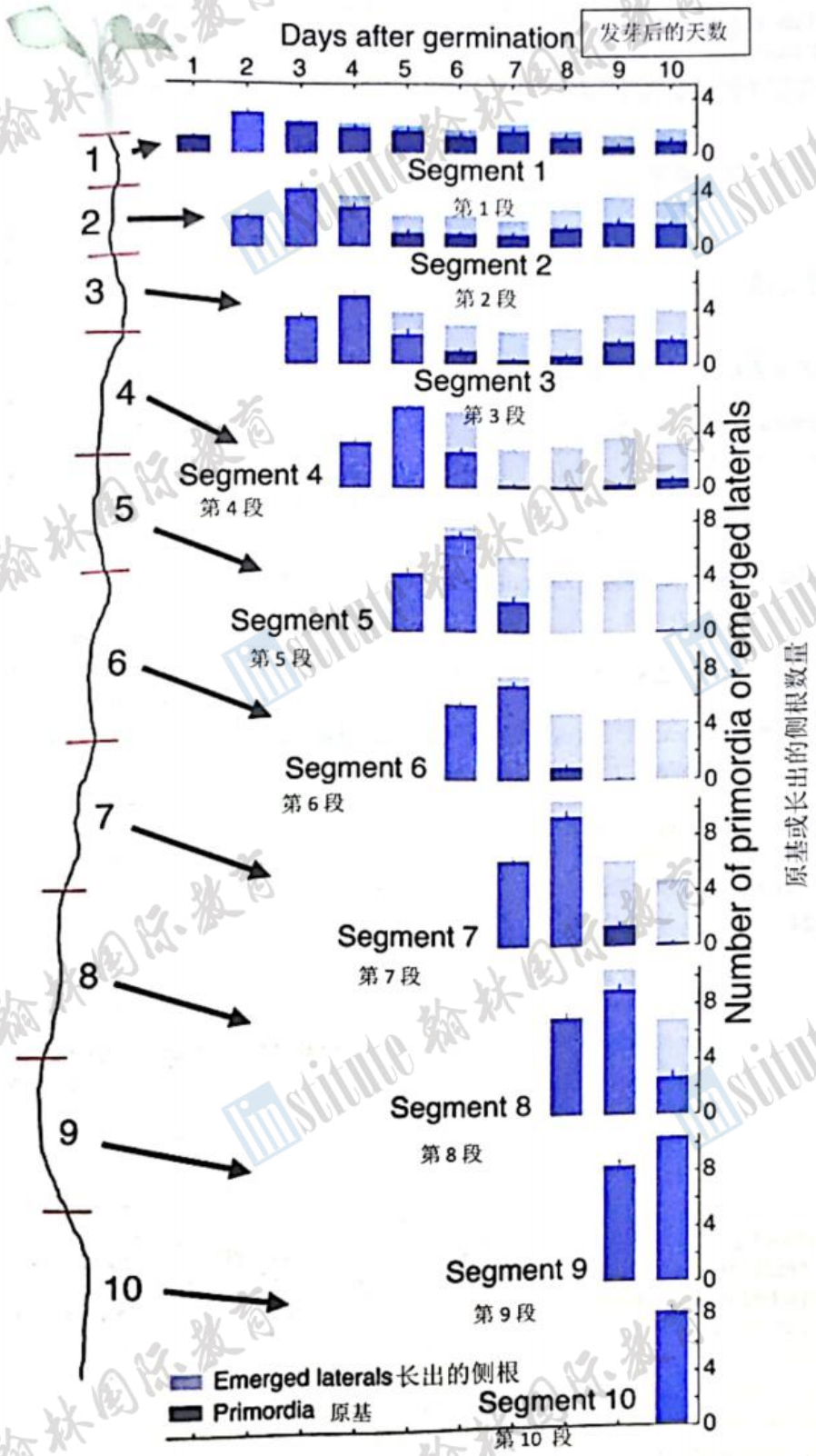
a) Self-recognition 识别出是自己

b) Neighbour 认为是“邻居”

Question 18

Root anatomy changes as plants mature. As roots grow, lateral roots grow from the primary (roots). Many lateral roots can grow from one primary root, and each lateral root grows from a single primordium. A primordium can be thought of as a lateral root bud. To study plant root growth, scientists grew *Arabidopsis thaliana* plants for 10 days. Each day they marked how far the root grew, and how many root primordia there were within each days' growth. Every day they checked whether or not the primordia had developed into lateral roots.

根的结构会随着植株的成熟而变化。随着根的生长，侧根会从主根（根）位置长出来。许多侧根可以从一个主根上长出，每个侧根都从一个原基开始生长。原基可以看作是一个侧根芽。为了研究植物根系的生长，科学家种植拟南芥植物共 10 天。每天，他们都会标记出根生长的长度，以及在每天生长过程中根原基的数量，并每天检查原基是否已经发育成侧根。



Problem 116. At the end of the experiment, how old were the cells found in segment 7 of the root? (Give your answer in Arabic numerals)

题目 116： 实验结束时，在第 7 段根中发现的细胞的年龄是多少？（请用阿拉伯数字作答）

1 mark

Write something below 请在下方填入答案

4

Are these true or false? 判断正误

4 marks

Mark the following as TRUE or FALSE 判断正误。

Problem 117. The root grew quicker on day 9 than it did on day 2

题目 117： 根在第 9 天比第 2 天生长得更快

a

a) TRUE 正确 b) FALSE 错误

Problem 118. Root primordia can only be created and not destroyed

题目 118： 根的原基只能生成而不能被破坏

b

a) TRUE 正确 b) FALSE 错误

Problem 119. Root primordia are guaranteed to eventually become lateral roots

题目 119： 根的原基最终一定会成为侧根

b

a) TRUE 正确 b) FALSE 错误

Problem 120. Lateral roots require at least 24h to emerge from primordia

题目 120： 侧根至少需要 24 小时才能从原基中长出

b

a) TRUE 正确 b) FALSE 错误

Problem 121. At the end of the experiment, there were more lateral roots in segment 6 than segment 4

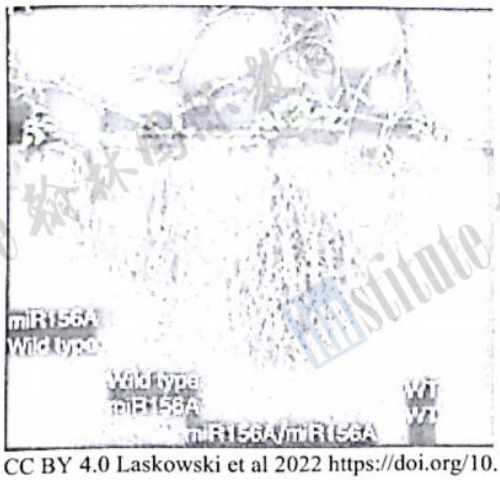
题目 121： 实验结束时，第 6 段中的侧根比第 4 段中的更多

a

a) TRUE 正确 b) FALSE 错误

To study how a gene *miR156A* affects plant development, scientists then created an *Arabidopsis* plant which did not contain the *miR156A* gene. In a technique called grafting, plants are cut in half and different genotypes are re-attached between roots (stock) and shoots (scion). In the figure below, the first name describes the scion and the second name describes the stock. WT are wild-type plants, and miR156A are *miR156A* mutant plants.

为了研究基因*miR156A*如何影响植物的发育，科学家创造了一种不含*miR156A*基因的拟南芥植物。一种嫁接技术中，植物被切成两半，不同的基因型被重新连接在根和芽之间。在下图中，第一个名称描述芽，第二个名称描述根。WT 是野生型植物，miR156A 是*miR156A*突变植物。



Are these true or false? 判断正误

3 marks

Mark the following as TRUE or FALSE 判断正误。

Problem 122. The miR156A gene increases root growth

a

题目 122： miR156A 基因促进根的生长

a) TRUE 正确　　b) FALSE 错误

Problem 123. miR156A must be expressed in the roots to change root development

b

题目 123： miR156A 必须在根中被表达才能改变根的发育

a) TRUE 正确　　b) FALSE 错误

Problem 124. The severity of the effect of *miR156A* mutations varies with the amount of miR156A made

a

题目 124： *miR156A*突变影响的严重程度随着 miR156A 的产生数量而变化

a) TRUE 正确　　b) FALSE 错误

Problem 125. miR156A is also involved in leaf development

a

题目 125： miR156A 也参与叶子发育

a) TRUE 正确　　b) FALSE 错误

Problem 126. Plants with no miR156A could have more lateral root primordia

b

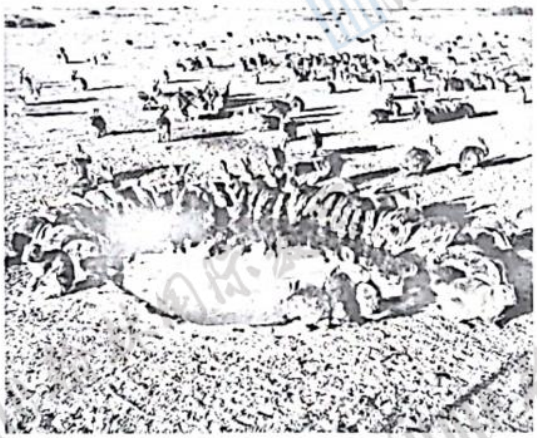
题目 126： 没有 miR156A 的植物可能会有更多的侧根原基

a) TRUE 正确　　b) FALSE 错误

Question 19

Rabbits were originally only wild in Spain and France. The Romans domesticated French rabbits, and introduced them to Britain (and the rest of Europe). During the Imperial era, rabbits were introduced to Australia. Rabbits spread across Australia explosively, causing catastrophic damage to Australian habitats. Scientists in Cambridge investigated where feral Australian rabbits came from.

最初只在西班牙和法国有野生兔。罗马人驯养了法国的兔子，并将其引入英国（以及欧洲其他地区）。在帝国时代，兔子被引入澳大利亚后，在澳大利亚各地爆发式繁殖，对澳大利亚的栖息地造成灾难性的破坏。剑桥科学家们调查了澳大利亚野生兔子的来源。



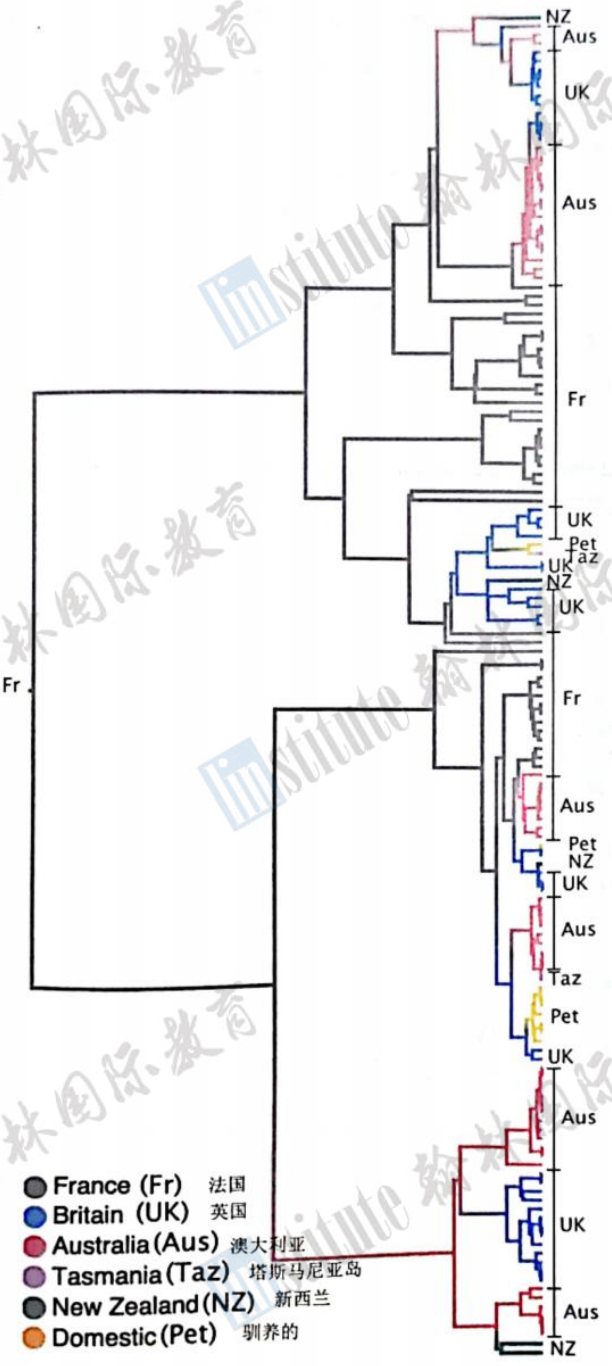
Rabbits around a waterhole during myxomatosis trials, Wardang Island, South Australia, 1938
1938 年，在南澳大利亚瓦丹岛，粘液瘤病试验期间兔子围在水坑四周

Historical records show: * A ship carried 5 domestic rabbits from Britain and released them in Sydney in 1788. * Between 1788 and 1850, at least 90 different ships carried domestic rabbits into Australia from Europe. * Tasmania (an island just off the Australian coast) was full of feral rabbits from 1810 onwards. * New Zealand was full of feral rabbits from 1820 onwards. * In 1859, an Englishman transported 24 wild rabbits, collected across England, to Melbourne for sport hunting. * By 1870, South Western Australia (including Melbourne and Sydney) were full of feral rabbits. * By 1880, feral rabbits had reached Eastern Australia.

历史记录显示：*1788 年，一艘船从英国运来 5 只家兔，并在悉尼将它们放生。*1788 年至 1850 年间，至少有 90 艘不同的船从欧洲将家兔运送到澳大利亚。*从 1810 年起，塔斯马尼亚岛（澳大利亚海岸附近的一个岛屿）到处都是野兔。*从 1820 年开始，新西兰到处都是野兔。*1859 年，一位英国人将 24 只在英格兰各地收集的野兔运到墨尔本进行狩猎活动。*一直到 1870 年，澳大利亚西南部（包括墨尔本和悉尼）到处都是野兔。*至 1880 年，野生兔子已经遍及澳大利亚东部。

To work out where Australian feral rabbits came from, a genetic tree of the different rabbit populations was constructed. The length of each branch is proportional to the number of genetic changes.

为了探究澳大利亚野兔的来源，我们建立了不同兔子种群的基因树。每个分支的长度与基因改变的数量成正比。


NZ
Aus
UK
Aus
Fr
UK
Pet
Taz
UK
NZ
UK
Fr
Fr
Aus
Pet
NZ
UK
Aus
Taz
Pet
UK
Aus
UK
Aus
NZ
France (Fr) 法国
Britain (UK) 英国
Australia (Aus) 澳大利亚
Tasmania (Taz) 塔斯马尼亚岛
New Zealand (NZ) 新西兰
Domestic (Pet) 驯养的

Problem 127. Where did Australian feral rabbits come from?
题目 127： 澳大利亚的野生兔子是从哪里来的？

2 marks
Choose ONE 单选

a

a) French wild rabbits 法国的野兔

b) British wild rabbits 英国的野兔

c) Domestic rabbits 家兔

d) New Zealand 新西兰

e) Tasmania 塔斯马尼亚岛

f) Inconclusive / other 不确定/其他地方

Problem 128. Does this tree prove feral rabbits in Australia came from multiple different shippings?
题目 128： 这棵基因树能证明澳大利亚的野生兔子来自多个不同的船运吗？

a

1 mark
Choose ONE 单选

a) Yes 是

b) No 否

Problem 129. List the following populations in terms of how genetically diverse you expect them to be.
Put the most diverse population at the top, and the least diverse at the bottom.
题目 129： 根据期望的基因多样性，排列以下种群。按照种群多样性，从高到低进行排列

2 marks
Put into the correct order 按照正确的顺序排列

a) Feral rabbits in South Western Australia 澳大利亚西南部的野兔

b) British wild rabbits 英国的野兔

c) Feral rabbits in Eastern Australia 澳大利亚东部的野兔

d) Domestic rabbits 家兔

e) French wild rabbits 法国的野兔

e b a c d.

Problem 130. In the case of rabbits invading Australia, which factor was most important for the success of the invading population?

题目 130： 如果兔子入侵澳大利亚，对于种群入侵成功最重要的是哪个因素？

C

2 marks

Choose ONE 单选

a) The number of animals in the initial population
初始种群中动物的数量

b) Whether the initial population was released in a hospitable location
初始种群是否放在一个舒适的地方

c) The genetic fitness of the initial population
初始种群的遗传适应程度

d) Whether the initial population was the first to arrive in Australia
初始种群是否最先到达澳大利亚

e) Repeated re-invasion to top-up the initial population
反复再次入侵以补充初始种群

Australian governments have tried many ways to control the rabbit population. In 1950, they released an extremely lethal strain of myxomatosis virus, which killed >99.8% of infected rabbits within a few days. However, over many years, the lethality of this strain on Australian rabbits was found to decrease, and Australian strains of myxomatosis were also found to be less lethal than the original strain. In the 1990s, the Australian government was testing the safety of *rabbit haemorrhagic disease virus*. In 1995, the virus escaped quarantine and killed >10 million rabbits within 8 weeks. Now, the Australian government periodically re-introduces rabbit haemorrhagic disease viruses.

澳大利亚政府尝试了多种方法来控制兔子的数量。1950 年，他们运用一种极其致命的粘液瘤病菌株，在几天内杀死了超过 99.8% 受感染的兔子。然而，多年来，人们发现这种菌株对澳大利亚野兔的致死率有所下降，而且澳大利亚的粘液瘤病菌株的致死率也低于原始菌株。20 世纪 90 年代，澳大利亚政府一直在测试“兔病毒性出血病病毒”的安全性。1995 年，该病毒没有被检疫出来，在 8 周内杀死了 1000 多万只兔子。现在，澳大利亚政府定期再次引入兔病毒性出血病病毒。

Releasing infected rabbits. By CSIRO, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=35461394
释放受感染的兔子

Problem 131. Which of these factors help prevent the eradication of rabbits via viruses?

题目 131：以下哪些因素有助于阻止病毒完全消灭兔子？

2 marks

Choose as many as appropriate 选出所有正确的选项

a. d.

a) High genetic diversity of Australian rabbits
澳大利亚的兔子具有较高的遗传多样性

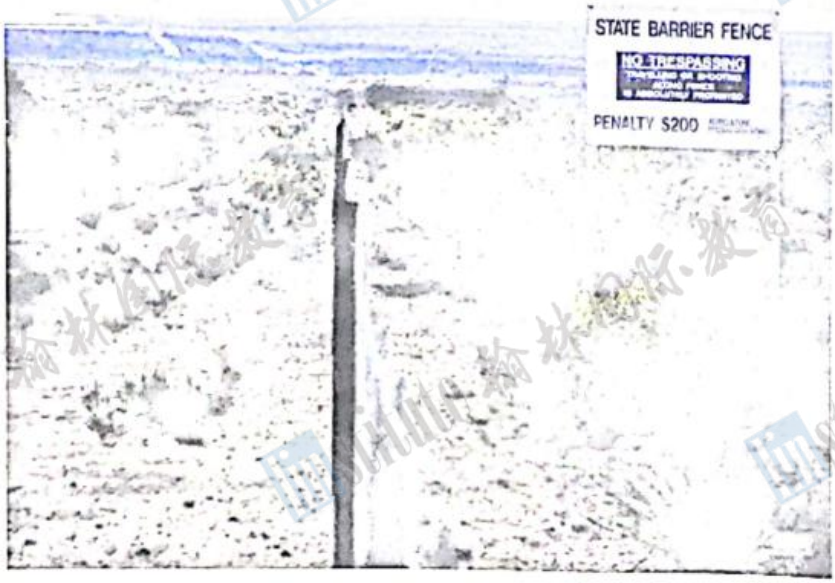
b) New mutations arising in a very large population of Australian rabbits
大量澳大利亚兔子中出现新的突变

c) Natural (/ artificial) selection by the viruses acting on rabbits
病毒对于兔子的自然（/人工）选择

d) Viruses which are **more** lethal tend to be fitter than viruses which are less lethal
致命性更强的病毒比致命性较弱的病毒更合适

e) Viruses usually go extinct within a few decades
病毒通常会在几十年内灭绝

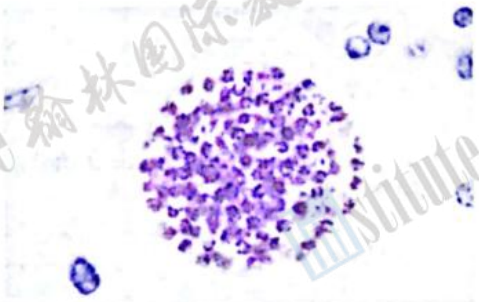
f) Viruses do badly in the Australian climate
澳大利亚的气候条件下，病毒的作用较差



Question 20

Toxoplasma gondii is a single-celled organism which lives within mammals. *T. gondii* is spread by eating infected meat. It can spread asexually within infected mammals, but tends to form permanent semi-dormant cysts, except in the severely immunocompromised. *T. gondii* can **only** reproduce sexually in cats (domestic cats, lions, cougars etc). Therefore, semi-dormant *T. gondii* manipulates the behaviour of infected cat prey-animals (e.g. mice, rats) to make them unafraid of cats; infected mice will run repeatedly toward cats. In humans, and other non-prey mammals, *T. gondii* has less obvious and more controversial effects, but is widely reported to increase recklessness, road-rage etc. Up to 1/3 of humans are infected with *T. gondii*, especially where rare meat is eaten.

*弓形虫是一种生活在哺乳动物体内的单细胞生物。*弓形虫通过食用受感染的肉类进行传播，并且可以在受感染的哺乳动物体内进行无性繁殖，但往往会形成永久的半休眠孢囊，除免疫功能严重受损的情况外。*弓形虫只能在一些猫科动物（家猫、狮子、美洲狮等）体内进行有性繁殖。因此，半休眠的弓形虫可以操纵受感染猫科动物的猎物（如老鼠）的行为，使它们不怕猫；受感染的老鼠会反复跑向猫。对于人类和其他非猎物哺乳动物来说，弓形虫的影响没有这么明显，却更有争议性。据广泛报道，它会增加人们的鲁莽和路怒行为等。多达三分之一的人感染了弓形虫，尤其是在吃稀有动物肉类的地方。



Toxoplasma cyst in mouse brain 老鼠脑内的弓形虫囊

Problem 132. Which terms describe the relationship between *T. gondii* and mammals?

题目 132：哪些术语可以描述弓形虫和哺乳动物之间的关系？

d

2 marks

Choose as many as appropriate 选出所有正确的选项

a) Symbiosis 共生

b) Mutualism 互惠共生

c) Altruism 利他行为

d) Parasitism 寄生关系

e) Commensalism 偏利共生

f) Endosymbiosis 内共生

g) Mimicry 拟态伪装

Yellowstone National Park contains very well studied wolf packs. Some wolves live near cougars and steal their prey, or even eat cougars. The wolves in Yellowstone are monitored throughout their lives, and their location and status within pack hierarchies is recorded. 228 random wolves also had blood taken to test whether they were infected with *T. gondii*. * 8 male wolves were infected with *T. gondii*. * 92 male wolves were not infected with *T. gondii*. * 7 wolf-pack leaders were infected with *T. gondii*. * 8 wolf-pack leaders were not infected with *T. gondii*.

黄石国家公园里有研究非常完善的狼群。一些狼生活在美洲狮附近，它们偷走美洲狮的猎物，甚至吃掉美洲狮。黄石公园的狼，一生都会被监控并记录它们在狼群等级中的地位。我们从中随机抽取 228 只狼的血液，检测是否感染了弓形虫。*8 只雄狼感染了弓形虫 *92 只雄狼没有感染弓形虫。 *7 名狼群首领感染了弓形虫。*8 名狼群首领没有感染弓形虫。

Problem 133. How many fold does *T. gondii* increase the probability of becoming a pack leader? *Give your answer (in Arabic numerals) to the nearest whole number*

题目 133：感染弓形虫使得一只狼能成为狼群首领的概率增加了多少倍？（请用阿拉伯数字作答，并将答案四舍五入为最接近的整数）

2 marks

Write something below 请在下方填入答案

10

Problem 134. Calculate the Chi-square statistic to test whether pack-leader status is independent of *T. gondii* infection. *Type a number (in Arabic numerals) to the nearest whole number*

题目 134：计算卡方统计量，以检验首领地位是否与弓形虫感染无关。（请用阿拉伯数字作答，并将答案四舍五入为最接近的整数）

3 marks

Write something below 请在下方填入答案

Wolves infected with *T. gondii* were found to be 3-fold (on average) more likely to leave their pack and disperse across Yellowstone, than uninfected wolves.

研究发现，感染弓形虫的狼比没有感染的狼离开狼群并分散在黄石公园的可能性（平均）高出 3 倍。

Problem 135. In this study, the Chi-square statistic was calculated to be 6.467. The critical value for 1 degree of freedom and 95% confidence is 3.841. Are wolves infected with *T. gondii* significantly more likely to disperse?

题目 135：在这项研究中，计算得到的卡方统计量为 6.467。自由度为 1 和置信度为 95% 的临界值为 3.841。感染弓形虫的狼是否更可能分散在各个地方？

a

1 mark

Choose ONE 单选

a) Yes 是

b) No 否

c) Undetermined 无法确定

Problem 136. Statistics *can* tell you whether an observation is due to random chance, but they *cannot* tell you what causes that observation. *Only* a well-designed scientific study can tell you what causes an effect. What factors should the ecologists control for when determining whether *T. gondii* infection makes wolves more likely to be **pack leaders**?

题目 136：统计数据可以得出观察结果是否是随机的，但不能得出导致观察结果的原因。只有设计严谨的科学研究才能得到导致结果的原因。在探究弓形虫感染是否使得狼成为狼群首领的可能性更大，生态学家应该控制什么因素？

2 marks

Choose as many as appropriate 选出所有正确的选项

a. b. c. d.

a) Differences in infection rates in wolves of different ages
不同年龄狼的感染率差异

b) Differences in infection rates in wolves of different sexes
不同性别狼的感染率差异

c) Differences in infection rates between packs in different locations
不同位置的狼群之间的感染率差异

d) Whether wolves with bolder behaviour are more likely to become infected
行为更冒险的狼是否更容易被感染

e) Whether cougars are more likely to hunt pack leaders
美洲狮猎杀狼群首领的可能性是否更大

Recently, ecologists have realised that apex predators are overwhelmingly important for the proper functioning of ecosystems. For example, the loss of whales severely reduces nutrient circulation in the oceans, leading to large declines in plankton and fish. The loss of wolves from Scotland has contributed to the highlands becoming a barren wilderness. In 1970, 40 wolves were re-introduced to Yellowstone, after being hunted to near-extinction across the USA.

最近，生态学家已经意识到，顶级捕食者对生态系统的正常运作至关重要。例如，鲸鱼的减少极大降低了海洋中的营养物循环，导致浮游生物和鱼类的大量减少。苏格兰狼群的减少导致高地变成了一片贫瘠的荒野。1970 年，狼在美国各地被猎杀至濒临灭绝后，40 只狼被重新引入黄石公园。

Problem 137. Put the following *trophic cascade* in order, from re-introduction of wolves at the top, to the present day at the bottom.

题目 137：按照从再次引入狼开始到现在的时间顺序，将以下"营养级联"进行排列。

2 marks

Put into the correct order 按照正确的顺序排列

a) River beds stabilise, deepen and pools form
河床稳定、加深并形成水池

b) Ungulates primarily graze inaccessible slopes rather than open planes and valleys
无蹄类动物主要在人迹罕至的山坡上，而不是开阔的地面和山谷上吃草

c) Population of ungulates (elk, deer etc) shrinks and becomes fitter
有蹄类动物（麋鹿、鹿等）的数量减少，变得更加强健

d) Diversity of plants increases and trees grow along river banks
植物多样性增加，树木沿河岸边生长

e) Ecosystem becomes more robust to perturbations (e.g. extreme weather or invasive species)
生态系统对干扰（如极端天气或入侵物种）的抵抗力更强

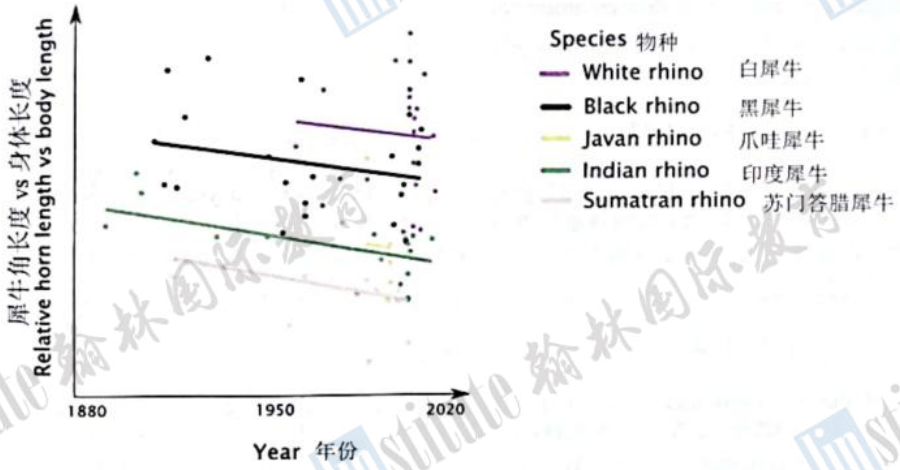
f) Diversity of fish, insects, birds and mammals increases
鱼类、昆虫、鸟类和哺乳动物的多样性增加

c. b d. a. f. e.

Question 21

Scientists collected illustrations and photographs of rhinoceros species from museums. In side-on images, they measured the length of the rhino's horn compared to its body length. The relative length of the rhino horn has been plotted against the date when the image was produced. **Note: rhinos reach adulthood at around 4 years old, and live for approximately 50 years. Poachers receive much more money for larger rhino horns than smaller horns.**

科学家从博物馆收集了犀牛物种的插图和照片。在左侧图中，他们测量了犀牛角的长度与身体长度的对比。犀牛角的相对长度已经按照日期绘制出来。注：犀牛在 4 岁左右成年，寿命约为 50 岁。偷猎者从大犀牛角比小犀牛角中获利更多。



Think about the patterns in this data, how the data was produced, and how it could be interpreted. Are these statements more likely to be true, or false?

思考这些数据模型，数据是如何产生以及如何解释的。以下陈述是正确还是错误的？

7 marks

Mark the following as TRUE or FALSE 判断正误。

Problem 138. Rhino horns have tended to increase in size, relative to body length, over the past 100 years

题目 138： 在过去 100 年里，犀牛角的长度相对于身体长度有增加的趋势

b

a) TRUE 正确　　b) FALSE 错误

Problem 139. White rhinos have larger horns, relative to body length, than other rhino species

题目 139： 相对于身体长度，白犀牛的角比其他犀牛的更长

a

a) TRUE 正确　　b) FALSE 错误

Problem 140. The trend in horn length is more certain for Indian rhinos compared to white rhinos

题目 140： 与白犀牛相比，印度犀牛角的长度变化趋势更为确定

a

a) TRUE 正确　　b) FALSE 错误

Problem 141. The trend in horn length is more certain for Javan rhinos compared to white rhinos

题目 141： 与白犀牛相比，爪哇犀牛角的长度变化趋势更为确定

b

a) TRUE 正确　　b) FALSE 错误

a

Problem 142. Artificial selection could explain the trends

题目 142： 人工选择可以解释这种趋势

a) TRUE 正确　　b) FALSE 错误

a

Problem 143. Habitat degradation, leading to malnutrition, could explain the trends

题目 143： 栖息地环境恶化导致的营养不良可以解释这种趋势

a) TRUE 正确　　b) FALSE 错误

b

Problem 144. If rhino body mass has stayed constant over the past 100 years, this supports the hypothesis that the trend in horn length is genetic, rather than environmental

题目 144： 如果犀牛的体重在过去 100 年里一直保持恒定，这就支持了犀牛角长度的变化趋势是遗传的，而不是受环境影响的假设

a) TRUE 正确　　b) FALSE 错误

a

Problem 145. If rhinos only reached adulthood at 30 years old, and lived for 100 years, this would support the hypothesis that the trend in horn length is genetic, rather than environmental

题目 145： 如果犀牛在 30 岁时才成年，寿命为 100 岁，这就支持了犀牛角长度的变化趋势是遗传的，而不是受环境影响的假设

a) TRUE 正确　　b) FALSE 错误

b

Problem 146. If all of the pre-1950 images are illustrations, and all of the post-1950 images are photographs, this increases our confidence that the trend is real

题目 146： 如果 1950 年前的所有图像都是插图，1950 年后的所有图像都是照片，这就让我们更加相信这一趋势是真实的

a) TRUE 正确　　b) FALSE 错误

b

Problem 147. If a mix of captive and wild rhinos were measured, this increases our confidence that the trend is real

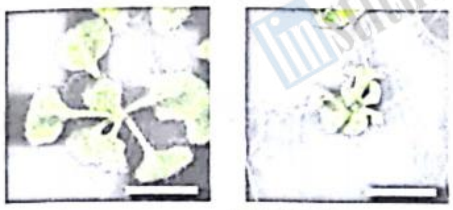
题目 147： 如果测量的是圈养和野生犀牛混合群体，这就让我们更加相信这一趋势是真实的

a) TRUE 正确　　b) FALSE 错误

Question 22

PDLP1 is a protein found in the plasmodesmata (membrane lined inter-cellular channels) in plants. Over-expression of PDLP1 causes dwarfism. In addition, it also causes an overaccumulation of callose (similar to starch) within the plasmodesmata, blocking the channel.

PDLP1 是一种在植物的胞间连丝（内衬在细胞间通道的膜）中发现的蛋白质。PDLP1 的过度表达会导致侏儒症。此外，这还导致胼胝质（类似于淀粉）在胞间连丝内过度积累，阻断植物内通道。



Wild type
野生类型

PDLP1
Over-expression
PDLP1 过度表达

Scale = 0.5 cm. The Proteins Found at Plasmodesmata and the Interactions Between Them (M Johnston, 2021)
比例尺 = 0.5 cm。在胞间连丝处发现的蛋白质及它们之间的相互作用（M Johnston，2021）

Problem 148. Which of the following are reasonable *hypotheses* from the data?
题目 148： 以下哪项是从数据中得出的合理假设？

b

2 marks
Choose as many as appropriate 选出所有正确的选项

a) The overaccumulation of callose causes dwarfism
胼胝质的过度积累会导致侏儒症

b) PDLP1 is a negative regulator of plant growth
PDLP1 是植物生长的负调节蛋白

c) PDLP1 is a positive regulator of plant growth
PDLP1 是植物生长的正调节蛋白

d) PDLP1 is required for normal plant development
PDLP1 对于植物正常生长是必需的

Problem 149. Which of the following are reasonable *conclusions* from the data?
题目 149： 以下哪项是从数据中得出的合理结论？

a

2 marks
Choose ONE 单选

a) The overaccumulation of callose causes dwarfism
胼胝质的过度积累会导致侏儒症

b) PDLP1 is a negative regulator of plant growth
PDLP1 是植物生长的负调节蛋白

c) PDLP1 is a positive regulator of plant growth
PDLP1 是植物生长的正调节蛋白

d) PDLP1 is required for normal plant development

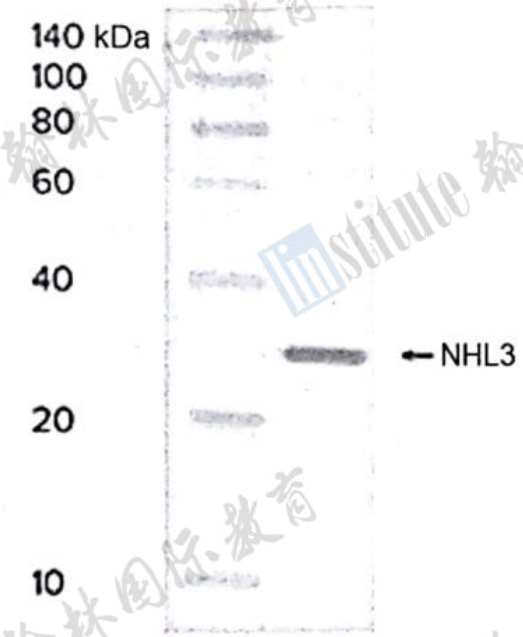
PDLP1 对于植物正常生长是必需的

To find out how PDLP1 over-expression leads to callose deposition, Scientist searched for proteins which interact with PDLP1. They found NHL3 interacts with PDLP1. NHL3 is a short protein with no catalytic domains. NHL3 was run on a Western blot gel against a ladder, shown below.

为了探究 PDLP1 过度表达如何导致胼胝体沉积，科学家寻找了与 PDLP1 相互作用的蛋白质，并发现 NHL3 与 PDLP1 相互作用。NHL3 是一种没有催化结构域的短蛋白。NHL3 在 Western 印迹胶上与分子量标准品一起被检测，如下图所示。

Problem 150. How large is NHL3 to the nearest 10 kDa? *Type an answer in numerals*

题目 150： NHL3 有多大，精确到 10kDa？（请用数字作答）



NHL3 run on a Western blot against a ladder
NHL3 在 Western 印迹胶上与分子量标准品一起被检测

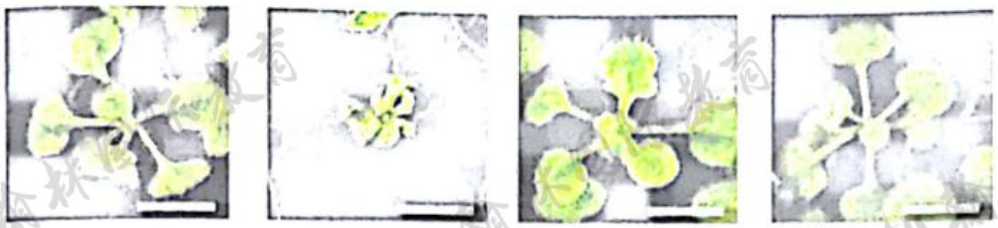
1 mark

Write something below 请在下方填入答案

30

Plants with no functioning NHL3 (*nhl3*) are normal size with normal callose levels. Plants both over-expressing PDLP1, and with no functioning NHL3 (*nhl3*), are also normal size with normal callose levels.

没有正常运作 NHL3（nhl3）的植物大小与胼胝质水平正常。过度表达 PDLP1 和没有正常运作的 NHL3（*nhl3*）的植物，大小与胼胝质水平正常。



Scale = 0.5 cm. The Proteins Found at Plasmodesmata and the Interactions Between Them (M Johnston, 2021)
比例尺 = 0.5 cm。胞间连丝处发现的蛋白质及它们之间的相互作用（M Johnston，2021）

Problem 151. Which of the following are reasonable **hypotheses** from the data?
题目 151： 以下哪项是从数据中得出的合理假设？

3 marks
Choose as many as appropriate 选出所有正确的选项

a) The overaccumulation of callose causes dwarfism
胼胝质的过度积累会导致侏儒症

b) NHL3 is required for callose deposition
胼胝质沉积需要 NHL3

c) NHL3 is required for PDLP-mediated callose deposition
PDLP 引起的胼胝体沉积需要 NHL3

d) Overexpression of NHL3 would lead to the overaccumulation of callose
NHL3 的过度表达会导致胼胝质的过度积累

e) PDLP1 acts upstream of NHL3
PDLP1 作用于 NHL3 的上游

f) PDLP1 acts downstream of NHL3
PDLP1 作用于 NHL3 的下游

g) NHL3 produces callose
NHL3 会产生胼胝体

b, c, d

Problem 152. Which of the following are reasonable **conclusions** from the data?
题目 152： 以下哪项是从数据中得出的合理结论？

2 marks
Choose as many as appropriate 选出所有正确的选项

a) The overaccumulation of callose causes dwarfism
胼胝质的过度积累会导致侏儒症

b) NHL3 is required for callose deposition
胼胝质沉积需要 NHL3

c) NHL3 is required for PDLP-mediated callose deposition
PDLP 介导的胼胝体沉积需要 NHL3

d) Overexpression of NHL3 would lead to the overaccumulation of callose
NHL3 的过度表达会导致胼胝质的过度积累

e) PDLP1 acts upstream of NHL3
PDLP1 作用于 NHL3 的上游

f) PDLP1 acts downstream of NHL3
PDLP1 作用于 NHL3 的下游

g) NHL3 produces callose
NHL3 会产生胼胝体

f

Question 23

Problem 153. Order the steps of protein synthesis from DNA (at the top) to protein (at the bottom).
题目 153： 按照从 DNA 到蛋白质的顺序对蛋白质合成过程进行排列。

1 mark
Put into the correct order 按照正确的顺序排列

a) Protein folding and modification 蛋白质折叠和修饰
b) Transcription 转录
c) mRNA processing mRNA 加工
d) Translation 翻译

b. c. d. a.

Problem 154. Order the levels of organisation in living systems from smallest (at the top) to largest (at the bottom).
题目 154： 将生物系统的组织层级从小到大进行排列。

1 mark
Put into the correct order 按照正确的顺序排列

a) Organisms 生物体
b) Organs 器官
c) Populations 种群
d) Organelles 细胞器
e) Habitats 栖息地
f) Cells 细胞
g) Ecosystems 生态系统
h) Tissues 组织

d. f. h. b. a. e. c. g

Problem 155. Order the types of immune responses from earliest (top) to most prolonged (bottom)
题目 155：将下列免疫反应按照从最早到最晚进行排列

3 marks
Put into the correct order 按照正确的顺序排列

a) Production of potent cell-killing adaptive immune cells
产生强效杀死细胞的适应性免疫细胞

b) Production of memory T and B cells
产生记忆 T 细胞和 B 细胞

c) Activation of naive (never used before) adaptive immune cells
适应性免疫细胞首次（从未使用过）激活

d) Activation of complement system of innate immunity
先天免疫补体系统的激活

e) Production of low-affinity antibodies
产生低亲和力抗体

f) Killing and internalisation by innate immune cells
被先天免疫细胞杀死和内化

d. f. c. a. e. b.

Problem 156. Order the steps of blood clotting from injury (top) to healing (bottom).
题目 156：按照从受伤到愈合的过程，对凝血过程进行排序。

3 marks
Put into the correct order 按照正确的顺序排列

a) Platelet aggregation and formation of fibrin network
血小板聚集与纤维蛋白网的形成

b) Recruitment of immune cells and chondrocytes (collagen producing cells)
免疫细胞和软骨细胞（胶原蛋白产生的细胞）的聚集

c) Platelet activation and activation of clotting factors
血小板和凝血因子被激活

d) Activation of stem cells and remodelling (cell growth, movement, death and phagocytosis)
干细胞的激活和重塑（细胞生长、运动、死亡和吞噬作用）

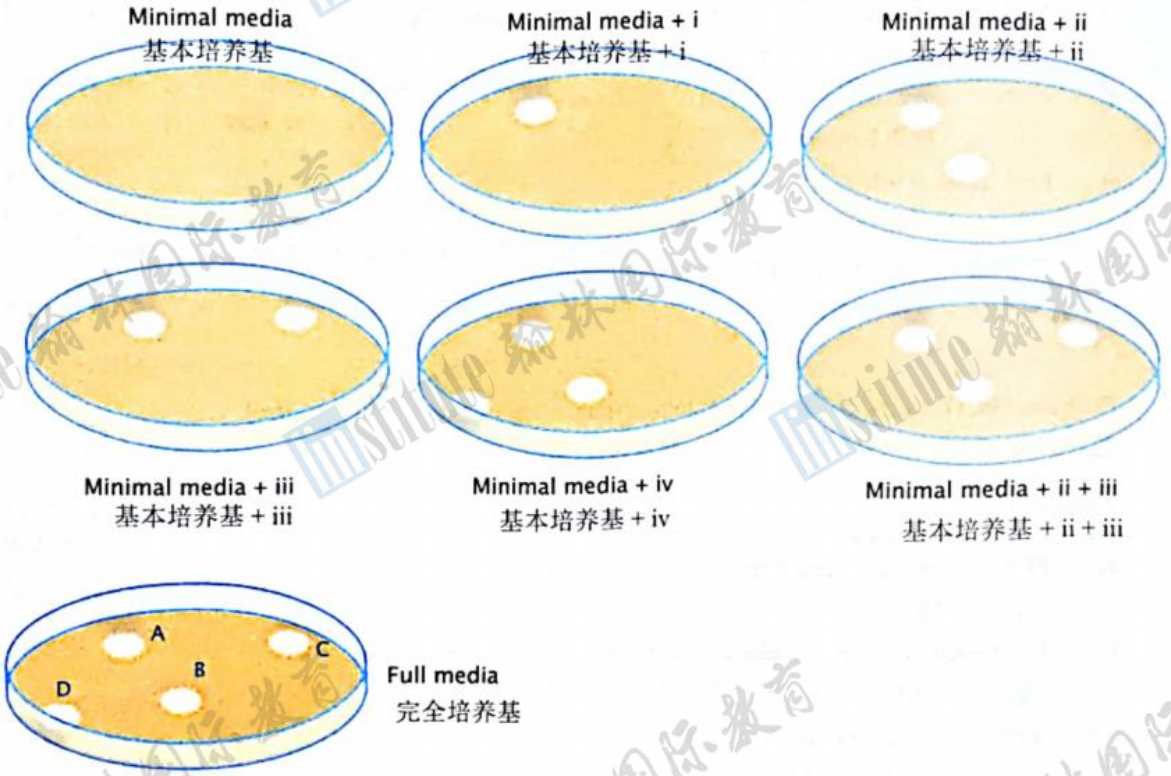
e) Exposure of components of tissue and blood vessel walls
组织和血管壁的结构暴露

e. b. c. a. d.

Question 24

E. coli can normally grow on minimal media. You expose some *E. coli* to UV light which creates a single point mutation in each bacterium. You dilute the *E. coli* and grow it on full media so all colonies can grow. You 'stamp' replica plates onto plates containing minimal media, or minimal media containing supplements *i-iv*. Only some colonies can grow on each plate.

“大肠杆菌”通常可以在基本培养基中生长。将一些“大肠杆菌”暴露在紫外线下，从而在每种细菌中产生单点突变。稀释“大肠杆菌”，并在完全培养基中生长，这样所有菌落都可以生长。可以将复制盘“压印”到基本培养基的器皿中，或含补充剂 *i-iv* 的基本培养基上。每个器皿中只能生长一些菌落。



Full media
完全培养基

This type of genetic analysis can be used to dissect the steps in a biosynthesis pathway. For example, here it can be seen that the gene product (enzyme) lost in colony A is involved in the synthesis of compound *i*, and all compounds *ii-iv* are made from *i*.

这类遗传分析可以用于研究生物合成途径中的步骤。例如，我们可以得出菌落 A 中缺失的基因产物（酶）参与了化合物“ i”的合成，并且所有化合物“ii-iv”都由“i”制成。

Sketch a pathway for the synthesis of compounds *i-iv*. Label the steps with enzymes *A-D*. *Note, the pathway may have branches.* Are the following true or false?

绘制化合物“i-iv”的合成途径。用酶“A-D”标记各个步骤。注意，这个合成路径可能有分支。判断下列陈述是正确的还是错误的？

5 marks

Mark the following as TRUE or FALSE 判断正误

Problem 157. *B* synthesises *ii* from *i*.

a

题目 157： “B”将“i”合成为“ii”。

a) TRUE 正确　　b) FALSE 错误

Problem 158. *B* synthesises *iv*.

b

题目 158： “B”合成“iv”。

a) TRUE 正确　　b) FALSE 错误

b

Problem 159. *D* synthesises *iv* from *i*.

题目 159： “D”将“i”合成为“iv”。

a) TRUE 正确　　b) FALSE 错误

b

Problem 160. *D* synthesises *iv* from *ii*.

题目 160： “D”将“ii”合成为“iv”。

a) TRUE 正确　　b) FALSE 错误

b

Problem 161. *D* synthesises *iv* from *iii*.

题目 161： “D”将“iii”合成为“iv”。

a) TRUE 正确　　b) FALSE 错误

a

Problem 162. *C* synthesises *iii*.

题目 162： “C”合成“iii”。

a) TRUE 正确　　b) FALSE 错误

b

Problem 163. *C* synthesises *ii*.

题目 163： “C”合成“ii”。

a) TRUE 正确　　b) FALSE 错误

a

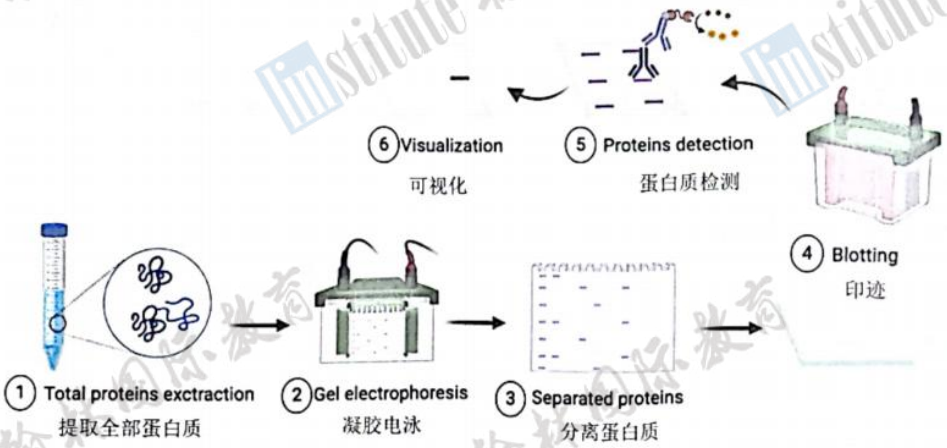
Problem 164. *i* is the substrate for *C*.

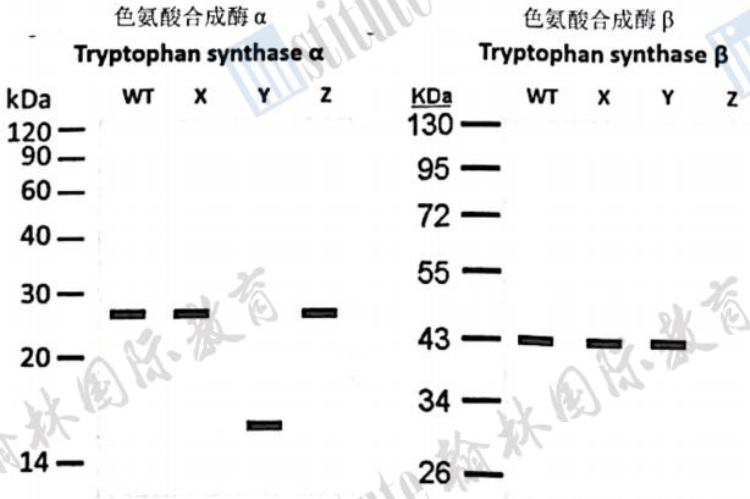
题目 164： “i”是“C”的底物。

a) TRUE 正确　　b) FALSE 错误

A similar experiment identified that *E. coli* mutants *X*, *Y* and *Z* have one mutation in the α or β subunits of tryptophan synthase. You carry out a western blot to visualise tryptophan synthase in these mutants, and wildtype (WT; not mutated) *E. coli*.

一项类似实验表明“大肠杆菌”突变体“X”、“Y”和“Z”在色氨酸合成酶 α 或 β 亚基中有一个突变。通过使用蛋白质印迹法，使得这些突变体和野生型（WT；未突变）“大肠杆菌”中的色氨酸合成酶可以被看见。





1 mark

Mark the following as TRUE or FALSE 判断正误

Problem 165. Unmutated tryptophan synthase α is a longer gene than unmutated tryptophan synthase β.

题目 165：未突变色氨酸合成酶 α 的基因比未突变的色氨酸合成酶 β 更长。

a) TRUE 正确　　b) FALSE 错误

Problem 166. Check all the types of mutation which *X* could likely have according to these data.
题目 166：根据这些数据，找出“X”可能具有的所有突变类型。

2 marks
Choose as many as appropriate 选出所有正确的选项

C

a) Frameshift (deletion or insertion of one base)
移码突变（去除或插入一个碱基）

b) Nonsense (creation of Stop codon)
无义突变（产生终止密码子）

c) Missense (swapping one amino acid for another)
错义突变（将一个氨基酸替换为另一个氨基酸）

d) Mutation in regulatory region (e.g. promoter)
调节区突变（如启动子）

e) No mutation
无突变

Problem 167. Check all the types of mutation which *Y* could likely have according to these data.
题目 167：根据这些数据，找出“Y”可能具有的所有突变类型。

2 marks
Choose as many as appropriate 选出所有正确的选项

a. b.

a) Frameshift (deletion or insertion of one base)
移码突变（去除或插入一个碱基）

b) Nonsense (creation of Stop codon)
无义突变（产生终止密码子）

c) Missense (swapping one amino acid for another)
错义突变（将一个氨基酸替换为另一个氨基酸）

d) Mutation in regulatory region (e.g. promoter)
调节区突变（如启动子）

e) No mutation
无突变

Problem 168. Check all the types of mutation which *Z* could likely have according to these data.
题目 168：根据这些数据，找出“Z”可能具有的所有突变类型。

2 marks
Choose as many as appropriate 选出所有正确的选项

a) Frameshift (deletion or insertion of one base) 移码突变（去除或插入一个碱基）

b) Nonsense (creation of Stop codon) 无义突变（产生终止密码子）

c) No mutation 无突变